University of Tennessee Outdoor Cultural and Recreational Center at Cherokee Landing

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DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING
CE 399S/400 SENIOR DESIGN COURSE PROJECT- SPRING 2022

Mission Statement

Big Orange Builders' mission is to advance personalized learning by providing access to natural resources and innovative infrastructure while pursuing a collaborative and sustainable future. We strive toward the ASCE BOK outcomes of ethical responsibilities and sustainability. To build on these overall outcomes, each member of our team brings a diverse area of knowledge that highlights foundational, engineering fundamentals, technical, and professional outcomes. Big Orange Builders addresses the NAE Grand Challenges by practicing personalized learning with every project. This includes learning from every project and being open and accepting all aspects of project considerations. Big Orange Builders also strives to apply the knowledge gained from experience in the field and apply it through each design. Each project is value-engineered with the client's best interest in mind. These values aid our design efforts to produce projects that can impact the client and community socially and culturally. Additionally, through our sustainable and collaborative design solutions, our team is cognizant of the global, economic, and environmental impacts in every project.

Disclaimer

The following engineering report consists of student work performed by students in the College of Civil and Environmental Engineering senior design course at The University of Tennessee for academic purposes only. The team, including students, faculty, and mentors assume no liability for the work presented within. Construction or engineering recommendations found in this report have not been verified by a licensed civil engineer. If any information is found to be adequate for use, please verify all calculations and review with the Project Engineer for approval before proceeding.

Acknowledgments

Big Orange Builders would like to recognize community partner project leads Rickey McCallum and Tom Rogers, technical mentor Greg Presnell, senior design faculty advisor Dr. Jenny Retherford, and project stakeholders Dr. Kandi Hollenbach and James Rose. The support and guidance from all parties allowed successful completion of the project.

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1. Project Introduction

The University of Tennessee Research Park (UT Research Park) at Cherokee Farm is an expanding site with room for innovation and a broad range of capabilities. The Park has experienced economic growth and development and is looking to improve recreational amenities to be accessible for park tenants and the public. The UT Research Park contains archeological artifacts across the entire property, significant to (12) tribes, influencing opportunity for development of the site. The Big Orange Builders were tasked to design the Outdoor Cultural and Recreation Center at Cherokee Landing, with adequate parking and dock access, while preserving the existing artifacts. Portions of the project were developed in conjunction with an architectural design-build studio and final design solutions were prepared integrating architectural influence and archaeological consideration to create safe water access to the Tennessee River.

2. Existing Site Conditions

The Outdoor Cultural and Recreational Center's site is located along the shore of the Tennessee River and consists of tall grass and scattered tree coverage along the site, as shown in Figure 2. The site includes a pre-existing road network and underground utilities servicing the UT Research Park buildings. The underground utilities accessible to the site include water, stormwater, sewer, and electric. The site is positioned along Cherokee Farm Way which runs approximately parallel to the river waterfront. The site contains a plateaued area that falls into a steep slope, which then levels with the riverbed (Figure 1). Archaeological artifacts in the plateau region of the site exist at varying depths and locations across the site. Riprap has been placed along the shoreline (Figure 3) and covers approximately 15 feet of width, protecting the slope at most average river water depth conditions.

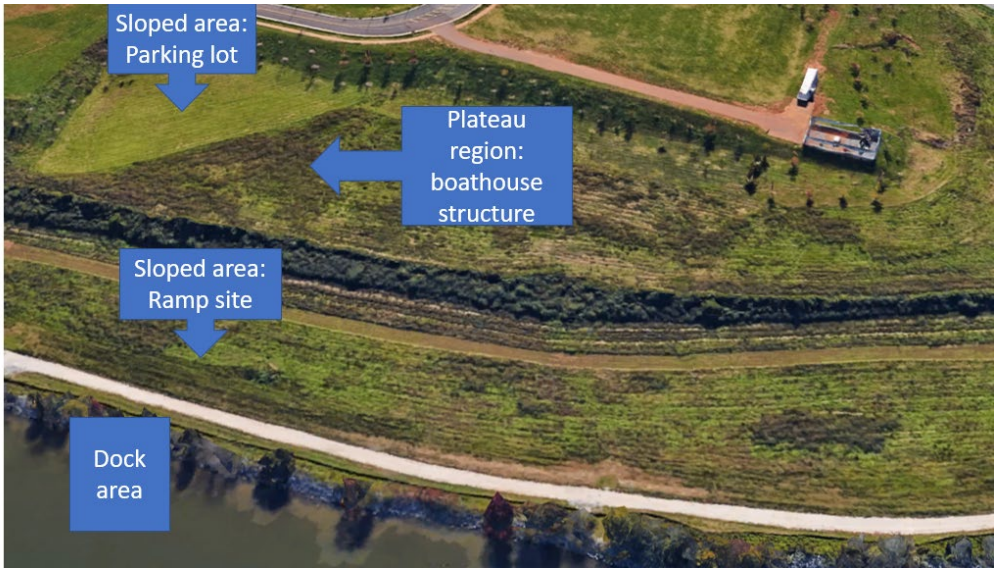

Figure 1: Aerial View of Project Site

Figure 2: Current Site Ground Cover Conditions

Figure 3: Bank at Low Water River Conditions

3. Project Background

Collaborations between unique partners, such as the Colleges of Archeology, Architecture, and Engineering, have supported the UT Research Park missions of diversity and engagement. Rickey McCallum, the Vice President of Business Development at the Research Park, created a strategic overall plan to enact long-term goals for the park which included build-out of the property influenced by academic partners at the UT Knoxville campus. Since the Joint Institute for Advanced Materials (JIAM) building, now known as IAMMs, was conceptualized in 2004, archeological testing was performed throughout the site. Dr. Kandace Hollenbach performed “shovel tests” at 30-foot intervals on the majority of the Research Park to determine locations of archeological deposits. In January 2022, her team performed a more extensive test in closer proximity to a site recommended for an Outdoor Cultural and

Recreational Center to gain full insight into the exact locations of deposits in the vicinity (Appendix A). Prior to the January 2022 archeological work, a team of civil engineering undergraduate seniors (Big Orange Builders) began project design work for the Center in collaboration with Dr. Hollenbach and students participating in an architectural design-build studio managed by Mr. Rose. The Outdoor Cultural and Recreational Center's proposed location was confirmed by testing results by Dr. Hollenbach, and the engineering team was encouraged to perform site development design influenced by these positive findings. The architecture students created three different designs for the Center and a single civil design was pursued based on a client-preferred architectural design (Figure 4). The Outdoor Cultural and Recreational Center project is a hallmark example of the quality of ingenuity and partnership made possible by the leadership at the UT Research Park.

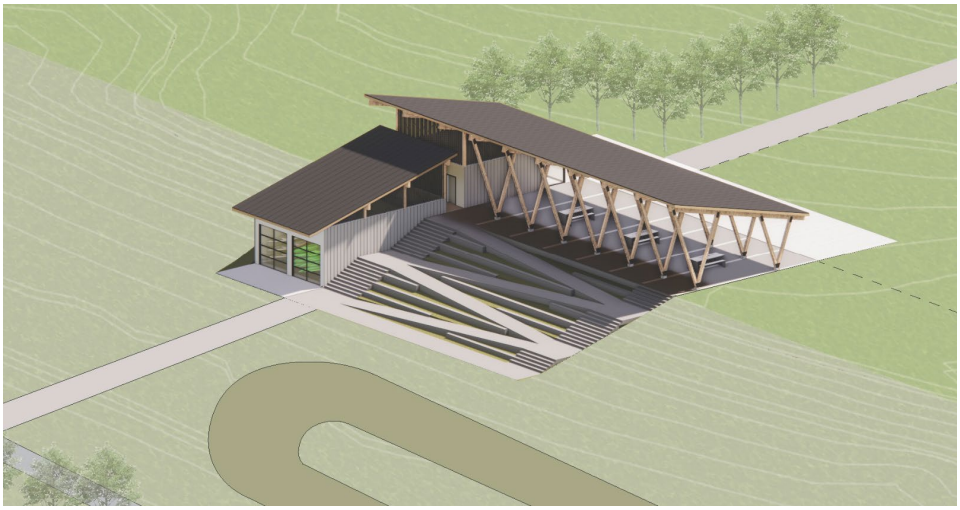

Figure 4: Architectural Concept Pursued by Engineering Design Team

4. Team Introduction

Big Orange Builders is a team composed of six senior civil engineering students at the University of Tennessee Knoxville (Figure 5). Sunny DeFOE has more than seventeen years of civil site experience in excavation and grading, among many other professional responsibilities. Brian Engel completed four co-op terms with field and project management responsibilities for multiple project types. Marshal Evins participated in a summer internship performing construction services and a second internship assisting with structural design calculations and related design work. Chase Kerr served as a summer intern performing geotechnical design work. Macayla Dwyer served as a site superintendent intern and as a structural design intern in two distinct internships. Meredith King completed a summer internship with TDOT and worked as an undergraduate research assistant in intelligent mobility and connected and automated vehicles. Each member had a specific role for the project based on their experiences and expertise (Table 1). Big Orange Builders worked with stakeholders, project lead consultants, and engineering and architectural mentors (Figure 6) to perform engineering services for this project.

Figure 5: Student Team (left to right): Chase Kerr, Marshal Evins, Brian Engel, Macayla Dwyer, Meredith King, Sunny DeFOE

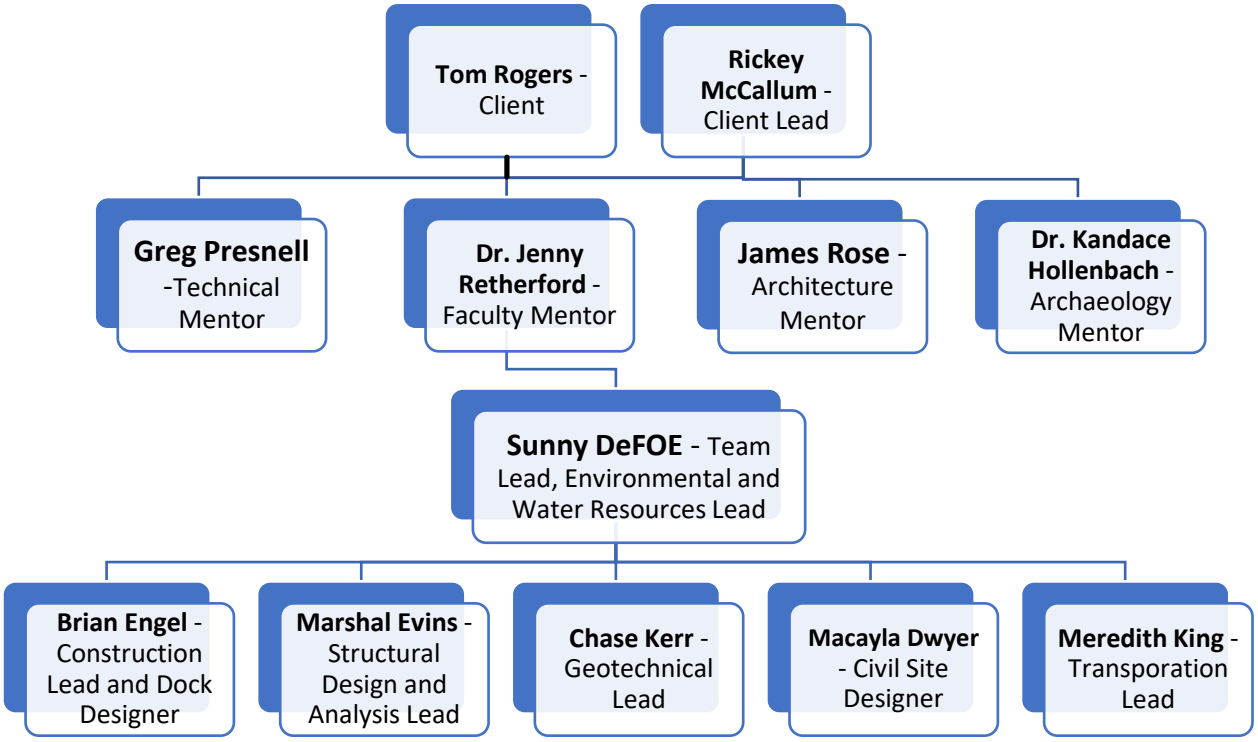

Figure 6: Team Organizational Chart

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Table 1: Team Member, Mentors, and Clients' Roles and Contact List

Name	Affiliation	Email
Sunny DeFOE	UTK Civil Engineering Student	cdefoe@vols.utk.edu
Macayla Dwyer	UTK Civil Engineering Student	mdwyer3@vols.utk.edu
Brian Engel	UTK Civil Engineering Student	bengel1@vols.utk.edu1
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Chase Kerr	UTK Civil Engineering Student	ckerr7@vols.utk.edu
Meredith King	UTK Civil Engineering Student	mking63@vols.utk.edu
Rickey McCallum	UT Research Park	rmccallum@utfi.org
Tom Rogers	UT Research Park	tom@tnresearchpark.org
Greg Presnell	Civil & Environmental Consultants, Inc.	gpresnell@cecinc.com
James Rose	UTK College of Architecture	jrose18@utk.edu
Dr. Kandi Hollenbach	UTK College of Anthropology	kdh@utk.edu
Dr. Jennifer Retherford	UTK Tickle College of Engineering	jretherf@utk.edu

5. Technical Scope of Work

Big Orange Builders was tasked to analyze the site and design the Outdoor Cultural and Recreational Center and boat dock. Civil site work design was conducted to create a new grading plan, utility plan, and an erosion prevention and sediment control plan for the proposed development. Transportation analysis was performed to create boathouse access and included design of ADA-compliant pedestrian pathways, and a parking lot layout; trip generation and traffic forecasting were performed to recognize the relationship between the new access and existing roadway network. Hydrological and hydraulic engineering analysis was performed to design new drainage infrastructure according to the City of Knoxville's Land Development Manual, Chapter 22. Structural engineering analysis included design for the outdoor recreational center building and floating dock. Geotechnical analysis was performed to determine the site's soil properties and design the structural foundations. Construction management services included creating an estimate of construction probable cost and schedule.

6. Site Work

Civil site work services were performed to develop the site to support the Outdoor Cultural and Recreational Center. A new grading plan was developed to provide proper stormwater runoff and balanced site was attempted in order to minimize fill quantities. Due to the proximity to the Tennessee River, an erosion prevention and sediment control (EPSC) plan was designed in accordance with the Tennessee Department of Environment and Conservation (TDEC) criteria for both construction and long-term conditions for the proposed development. A utility plan was created to provide domestic water and sanitary force main sewer services to serve the restroom facility and outside yard hydrant.

A grading plan was designed to allow proper drainage on site and cut and fill quantities were determined for the proposed grading plan. Placement of the boathouse, parking, access drive, and dock was determined during generation of the grading plan in order to minimize required cutting of the existing grade to preserve the archeological artifacts present at the site. The most suitable location for the site's

footprint was determined to have to boathouse structure within the sloped bank parallel to the river to avoid archeological deposits for the foundations and to be able to cut into the slope and have the parking lot behind the boathouse structure over the flatter plane of the site which minimized the need for fill. The total values of cut, stripping, and fill were determined using the InSite software (Table 2) and a ground elevation map was created (Appendix A) to show the different elevations on site for the proposed new grading plan, see accompanying construction ready drawings. ADA regulations and storm water runoff were considered during the creation of the grading plan. The team opted for a design with pervious concrete in the parking stalls and impervious concrete in the driveways. The grading plan was created to have a 2-5% grade on the driveways; the runoff water will drain into the pervious concrete zones, which will then be directed to exit the lot at the outfall locations.

Table 2: Cut & Fill Values

	Value (cy)
Fill	19935
Stripping	4776
Cut	864
Import Fill	19452

The EPSC plan was designed to include best management practices (BMP) and a landscape plan to retain erosion. EPSC control measures were utilized to reduce lake pollutants and control proper waste removal. BMPs and Sediment Control Measures (SCM) were used to increase removal of total suspended solids to meet City of Knoxville's minimum design standards according to the Best Management Practices Manual (BMPM). Tennessee Department of Environment and Conservation (TDEC) guidelines outlined in the Construction General Permit were also used in selecting BMPs and SCMs for this project. The EPSC plan was created to be a three-phase process, which consisted of initiation and planning, specification development, and implementation (see accompanying construction ready drawings). A landscape plan was created to incorporate landscape that will provide long-term stabilization for the soil on site by reducing erosion and enhancing infiltration. Removal of trees was required along the path of the future roadway that connects from the street to the parking lot, however, based on the Knoxville Municipal code, all those that are living can be reused and considered in the landscape criteria, where overall 33 trees would need to be removed (Table 3). Landscape criteria for new construction in Knoxville was used to determine the required amount of landscape in site, outlining that 30% of the square footage of the building had to be represented as landscape and a maximum of 40% of that value could be used for permeable landscape material (Appendix A). The landscape plan was designed to include trees, grass, and river rock, see accompanying construction ready drawings. To ensure all landscape codes were followed, the total number on landscape was determined using the grading plan and found to encompass 2994 ft^2 of landscape (Tables 4 and 5).

Table 3: Tree Removal Count

Tree	Amount	Type
American Holly	8	Medium
American Hophornbeam	1	Medium
American Sycamore	4	Large
Red Oak	8	Large
Sugar Maple	4	Medium
Tulip Tree	8	Medium
Total	33	

Table 4: Total Amount of Landscape-Trees

Type of Tree	**Number of Trees**	**Radius (ft)**	**Total Area (ft^2)**
Medium Trees	100	1.5	706.9
Large Trees	15	3.5	577.3

Table 5: Total Amount of Other Landscaping

Type of Landscaping	**Number of Sections**	**Area per Section (ft^2)**	**Total Area (ft^2)**
River Rock	4	89.13716694	356.5486678
Grass	8	89.13716694	713.0973355
Grass	4	160	640

A utility plan was created to supply domestic water and sewer services for the site. The domestic water and sewage lines were tied into the existing service lines on site. From the water meter, supplied by the Knoxville Utilities Board (KUB), a service line was designed to be 1 inch to supply domestic water for the site. Using the pump performance curves provided by the pump manufacturer, an E-one grinder pump was selected to be 0.5 horsepower to convey sewage from the site to the existing gravity sanitary sewer main.

7. Transportation

The transportation engineering services rendered on this project included design of parking facilities and evaluation of traffic impacts for the proposed development. Trip generation and traffic forecasting to determine the impact of the development on traffic flows on roads in the vicinity, including Alcoa Highway, was performed and an abbreviated traffic impact study was developed. The design of the parking lot was performed considering ADA criteria and city of Knoxville Municipal Codes.

Trip generation predictions were calculated for morning and afternoon peak hours and average daily traffic using the ITE manual; see figures in Appendix B (Hooper 2019). Using Land Use 495, the weekday average daily demand is 250 vehicles, the weekday morning peak hour demand is 50 vehicles,

and the weekday afternoon peak hour is 38 vehicles, as shown in Table 6. On Saturdays, the peak hour demand is 8 vehicles and on Sundays the peak hour demand is 13 vehicles. Note that these calculations do not consider traffic demands from special events held at the boathouse facility. Historic traffic data from TDOT count stations (TDOT 2022) was used to evaluate historic traffic trends and determine an appropriate growth rate for the study area. TDOT count station 47000317 showed an AADT of 25,466 vehicles northbound and 25,776 vehicles southbound on Alcoa Highway in 2018 (the most recent year for both directions). The two-way station data gives an overall two-way AADT of 44,047 in 2020. Trendlines were developed in Excel to map the average growth rate of Alcoa highway, and the data showed decreasing rates of increase since 1986. The team applied a constant growth rate of 1%, which is the average growth rate since 1986, but this is a conservative estimate, and traffic may not reach this value. Assuming this constant growth, Alcoa Highway is estimated to reach an AADT of 51,137 vehicles in 2035. Morning and afternoon peak hour turn count data was collected at the northbound and southbound ramps off Alcoa Highway. This data was used to determine the existing trip distribution, which showed over 60% of trips were directed toward JRTU (opposite the boathouse). Considering the high traffic volumes on Alcoa Highway, the low number of predicted trips generated, and the existing trip distribution, this development is unlikely to significantly impact the roadway's level of service; see the transportation impact study in Appendix B for more information regarding existing traffic conditions, calculations, and turning movement counts.

Table 6: Summary of Trip Generation Values

ITE LUC	Land Use	Density	AADT	AM Peak Hour	PM Peak Hour	Weekend Peak Hour
495	Recreational Community Center	8515	250	50	38	13

Features of the parking lot layout, including spaces and driveways, as well as pedestrian and cyclist amenities, were designed in compliance with ADA and PROWAG criteria and City of Knoxville Municipal Codes (City of Knoxville 2021). Required minimum and maximum parking spaces per Article 11 of the Knoxville Municipal Code were determined as a minimum of 4 parking spaces per 1000 square feet of ground floor area (GFA) and a maximum of 5 spaces per 1000 square feet of GFA. With a square footage of 8,515, including the dock, the maximum number of allowable spaces was calculated to be 51 (see appendix B for space calculations and specific codes). The maximum allowable number of spaces was designed so that adequate parking is available for special events hosted at the facility. To optimize the available space while providing space and allowing for vehicle circulation, the parking lot was designed with two islands perpendicular to the building's front face with 16 9' by 18' parking stalls on each side and a sidewalk in the middle. Nine 10' by 50' pull-through trailer parking spots were designed at the west end of the lot. As shown in Table 7, the 51 total spots were calculated as 10,768 square feet in area (about twice the area of a basketball court). Areas for specific vehicle types were designed and provided in case the layout of the parking lot needs to be changed. Sidewalk widths were determined in accordance with ADA standards and PROWAG recommendations, and a five-foot-wide sidewalk was designed for all

pathways on the project. Per ADA stipulations, the sidewalk was designed as 5 feet wide with a cross-slope less than 2%. Accessible spaces were inserted along the front edge of the lot, including two van spaces and three car spaces. To accommodate motorcycle and bicycle users, 4 motorcycle spaces and bicycle racks were added to the front edge. Per City of Knoxville Municipal Codes of Ordinances Table 11-6, located in Appendix C, the driveways were designed to be 26 feet wide. Two entrances were implemented into the parking lot design: one at the eastern end and one at the southern end (see accompanying construction-ready drawings).

Table 7: Parking Space Count and Area

Space Type	Count	Area (SF)	Total Area (SF)
Regular	33	162	5346
ADA- Car	3	162	486
ADA- Van	2	162	324
Motorcycle	4	28	112
Trailer	9	500	4500
Total	51	**Total square footage of parking spaces**	10768

8. Hydrological and Hydraulic

Hydrological and hydraulic engineering services were performed to manage new stormwater runoff on the property and to ensure current infrastructure can sustain post-development conditions. Stormwater runoff calculations were performed for the proposed drainage infrastructure watersheds using the Rational Method with AMC II curve numbers as defined by the City of Knoxville's Land Development Manual. Hydraulic analysis was performed to confirm discharge velocities and volumes could be dissipated through the existing stormwater infrastructure.

Hydrological stormwater design was performed in order to properly design the site's multiple watersheds. The amount of pervious vs. impervious space for each watershed was analyzed to identify the composite C, curve number, value for each watershed. Drainage watershed areas were outlined in AutoCAD and used to calculate how much flow entered each storm drain basin (Table 8). Each watershed's flow was calculated using the Rational Method, and a velocity was determined by dividing the discharge by the area of the grate inlet. Based on Rational Method runoff coefficients (Appendix C), calculations for type B and C soils were calculated to determine sizes of infrastructure needed due to the site requiring fill material. Due to type C soils typically exhibiting slightly higher run-off values, infrastructure was sized based on type C soils and the 100-year design storm. Based on the hydrological analysis, the proposed stormwater infrastructure placement was designed and can be found in the accompanying construction ready drawings.

Table 8: Watershed Area Calculations

	Structure	Watershed Area (Ac.)	Cumulative Area (Ac.)
Line A	CI-1	.2121	.2121
	CI-2	.2121	.4242
	MH-2.5	.0000	.4242
LINE B	CI-5	.1485	.1485
	CI-4	.0308	.1793
LINE A (TIE-IN B)	CB-3	.0308	.6035
	CI-6	.1643	.7678
	RRA-2	.2856	1.0534
LINE C	CI-7	.0634	.0634
	CI-8	.1793	.2427
	CI-9	.0420	.2847
	AD-10	.1077	.3924

Hydraulic analysis of the proposed drainage infrastructure was performed to evaluate its ability to retain and convey the 100-year storm without overflowing. HDPE piping was selected to convey the stormwater to each outfall. The principle of mass energy balance was applied in Bernoulli's equation indicating that flow in equals flow out as shown in Figures 7, 8, and 9. Hydraulic analysis follows Manning's equation parameters and assumptions for open channel flow calculations. Each outfall is sized to dissipate run-off velocities using rip rap underlaid with non-woven geo-textile fabric that also helps eliminate scouring of the underlying soil. Rip rap aprons, comprised of crushed limestone, were sized per the City of Knoxville Land Development Manual specifications.

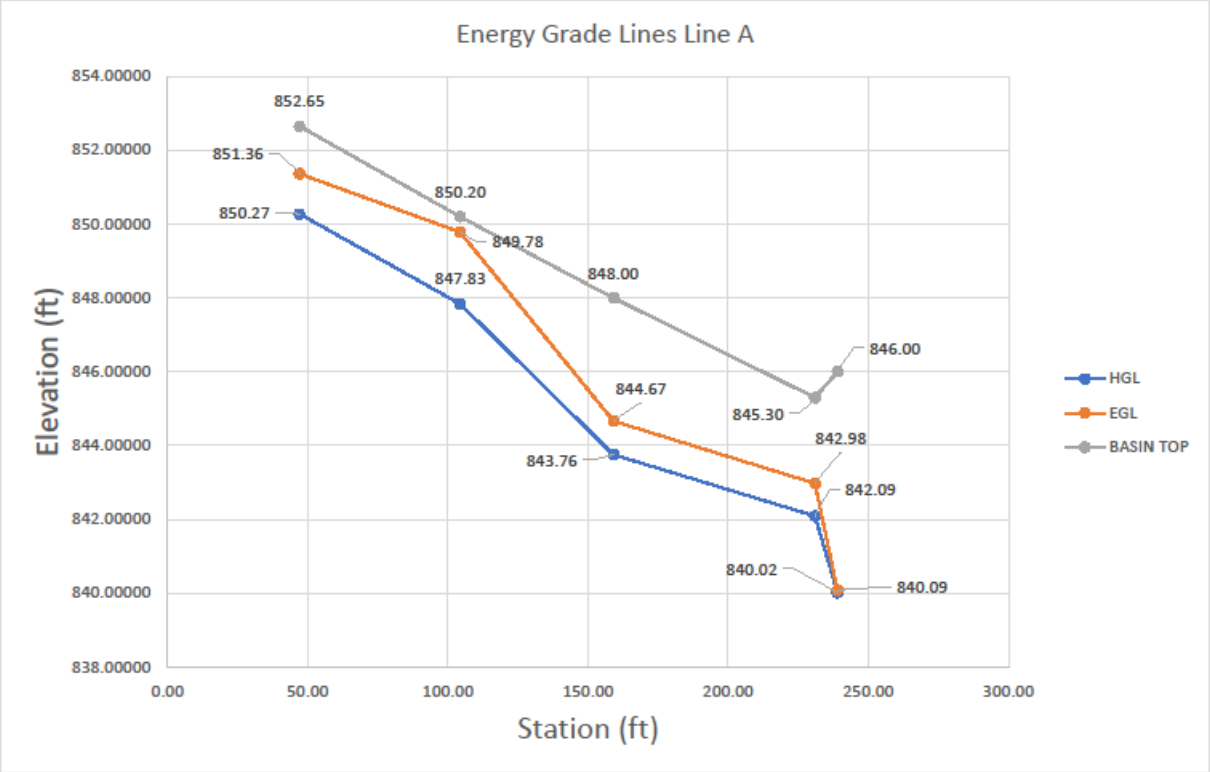


Figure 7: Line A Grade Lines

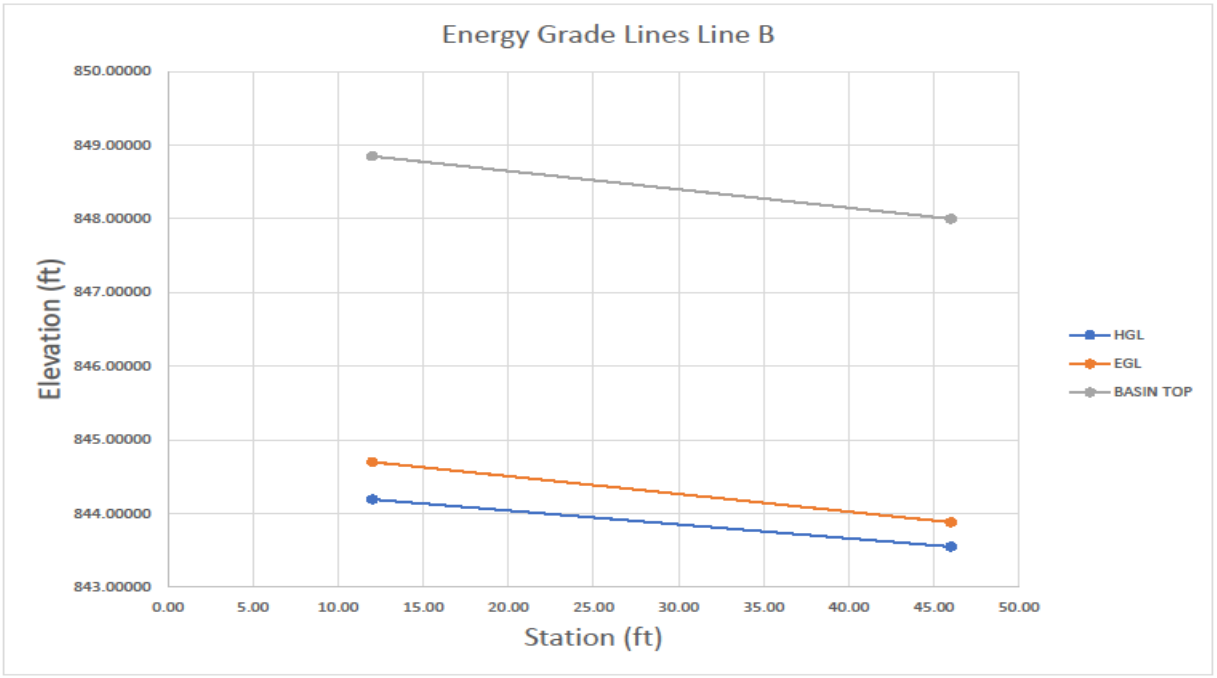


Figure 8: Line B Grade Lines

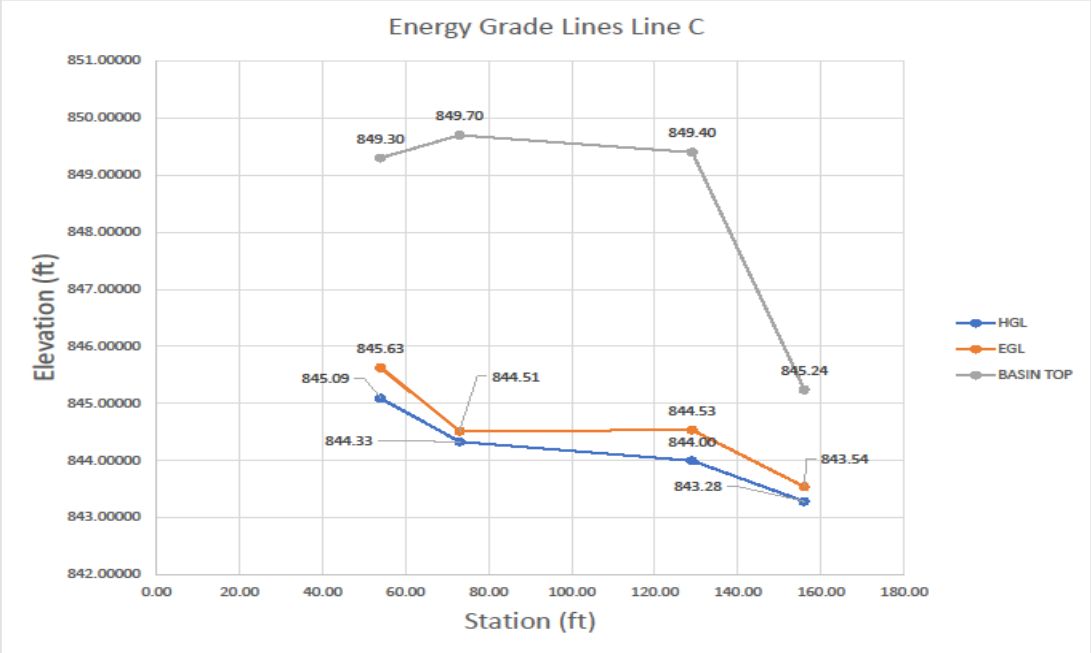


Figure 9: Line C Grade Lines

9. Structural

Structural engineering services included design for the Outdoor Cultural and Recreational Center and floating dock. Required design loads were determined for each structure using the International Building Code 2018. Structural analysis was performed, and member sizes were designed to safely resist the applied loads. Analysis and design of a floating dock and concrete anchoring structure was performed using hand calculations and RISA structural software.

Required design loads were determined for each structure using IBC 2018 and ASCE 7-16. Classification of the usage for the recreational center and dock was determined based on community input to determine the required loads and Risk Category for the structures. The building structure was classified as a Risk Category II building per Table 1.5.1 of ASCE 7-16. The gravity loads were analyzed to include live load, dead load, snow load, and rain intensities. Live load was computed to include a load based on the function and size of the structures in compliance with IBC 2018 and ASCE 7-16. Dead loads were calculated based on the structures' function of being a community assembly area; however, the self-weight of different components of the structure needed to be added and analyzed to perform analysis calculations. Snow loads for the structures were calculated based on previsions highlighted in Chapter 7 of ASCE 7-16 to check for ground snow load and snow load on roofs based on geometry and slope. The rain intensities were determined by utilizing the ASCE 7 Hazard Tool generated by ASCE. Intensities generated were calculated based on 15- and 60-minute precipitation intensities. Lateral force for wind and wave force was determined based on previsions in ASCE 7-16, and seismic variables needed for analysis were determined utilizing the ASCE 7 Hazard Tool (Appendix D). Wind load was determined based on Chapter 26 of ASCE 7-16 to accommodate for changes in the structures' heights. Load cases were determined, and load factors, per ASCE 7-16, were applied to the load combinations to perform structural

analysis for relevant limit states (Appendix D). Final loads experienced on the building, floating dock, and dock anchoring structure were calculated and are summarized in Table 9 and 10.

Table 9: Structural Loads and Capabilities for Building

Load Type	Magnitude (psf)
Roof Live Load	12.0
Roof Dead Load	15.0
Roof Snow Load	10.1
Floor Live Load	100.0
Floor Dead Load	15.0
Ground Snow Load	10.0
Mean Roof Height Wind Load	16.3
Rain Design Variables	Magnitude (in/hr)
15-minute Precipitation Intensity	5.75
60-minute Precipitation Intensity	3.03

Table 10: Structural Loads and Capacities for Dock

Load Type	Magnitude (psf)
Live Load	85.0
Dead Load	15.0
Snow Load	10.0
Wind Load	16.3
Wave Force Load	1908.0

Structural analysis was performed using statics to determine internal forces due to the loads applied on the structures. Load tracing was performed to determine internal forces and reactions on different components of each structure. RISA software was utilized to create the internal force and deflection calculations for the timber framing system based on the architectural rendering initially given. Maximum shear, moment, and compressions were determined from the RISA models based on the free body diagrams. These maximums were calculated using shear and moment diagrams for wall members, floor members, and beam members based on statics to support design work (Appendix D).

Detailed design additions and checks for the building and dock structures were completed in accordance with NDS 2018, AISC 15th Edition, and ACI 318-19. Provisions highlighted in NDS 2018 were used to design the timber beams, columns, and stud walls based on the experienced internal forces on the building structure. Design tables were used to pick timber dimensioning to resist the ultimate shear, moment, and axial forces in the members, see structural drawings schedule for beam and column selections. Steel design was performed in accordance with AISC 15th Edition. Steel W-shape beams were designed to support the loads experienced on the floor system and the self-weight of the concrete. Shear, moment, and deflections were calculated for each beam that was spaced 6 ft throughout the building structure, see structural drawings for accurate placement of steel beams. Shear and moment capacities were determined based on Chapter 16 of the AISC manual, and the deflection limit was calculated to satisfy a deflection limit of span length divided by 240. Steel H-piles were needed to support the dock concrete anchoring structure that was designed to act as a reinforced concrete slab on grade. Design of the H-piles was determined based on previsions highlighted in AISC for axial compression (Appendix D). A

connection was also determined to attach the floating dock gangway to the concrete ramp anchoring system for the dock, see structural drawings for plate and bolt designation. A Vulcraft composite floor deck was designed based on the superimposed live load experienced on the floor system and the span length, see structural drawings for composite deck designation. Reinforced concrete foundation walls and slabs were created according to ACI 318-19. The reinforced concrete wall for the building was designed as a basement retaining wall. Proper reinforcement was calculated to satisfy the soil pressure the building experiences. To allow access to the floating dock, a reinforcement concrete ramp was designed for the site. Reinforcement was determined for the dock concrete anchoring structure to withstand the gravity loads and lateral loads including wind and wave force on the structure.

10. Geotechnical

Geotechnical services for this project included soil analysis, design of a concrete landing for the dock, and analysis and design for the building foundation. Soil characterization and soil strength parameters were determined using existing soil reports and analysis of new soil samples. A reinforced concrete landing for the dock was designed using ACI 318-19. Column and wall foundations were designed for the proposed building structure.

Soil characterization was performed on the project using existing soil reports, soil sampling, and soil testing to determine the strength properties of the site's existing soils. A general characterization of the types of soil on site was found using a Web Soil Survey and existing soil report (Appendix E). Soil sampling and testing was performed to improve upon the general characterization and develop more accurate data to use for the design of the site. A soil sampling plan was created to identify the locations of extracting samples (Appendix E) and to select the appropriate equipment for the site. The archaeological deposits on the site and variations in steep slopes were considered and the use of handheld tools was chosen as opposed to a heavy drill rig. Soil samples were collected with hand augers and post hole diggers. Boring logs for sample A and sample B were created during the sampling process (Appendix E). A map of the precise location of the two boring samples was drafted and can be found in the accompanying set of construction ready drawings. Soil samples were brought to the University's Geotechnical Engineering Lab. Hydrometer, specific gravity, Atterberg limits tests were performed to classify the soil and find the bearing capacity of the soil at Cherokee Landing. The hydrometer test followed ASTM C117, D422, D6913, D7928, and C136 standards to find the relative density of soils; a grain size distribution graph was created from the relative densities found (see Figure 10). The specific gravity and Atterberg limits tests, followed using ASTM D421, D4318, D2487, D2488, D854, and D6026, were used to classify the soils; the specific gravity, liquid limit, plastic limit, plasticity index, plasticity description, and soil classification values for these tests can be seen in Table 11. A soil classification of a low plasticity silt was concluded based on the Atterberg limits test (Appendix E). A 2000 psf allowable bearing capacity was selected based on a conservative value from the approximated allowable range of 1500 – 4000 psf expressed in standard soil literature (Appendix E).

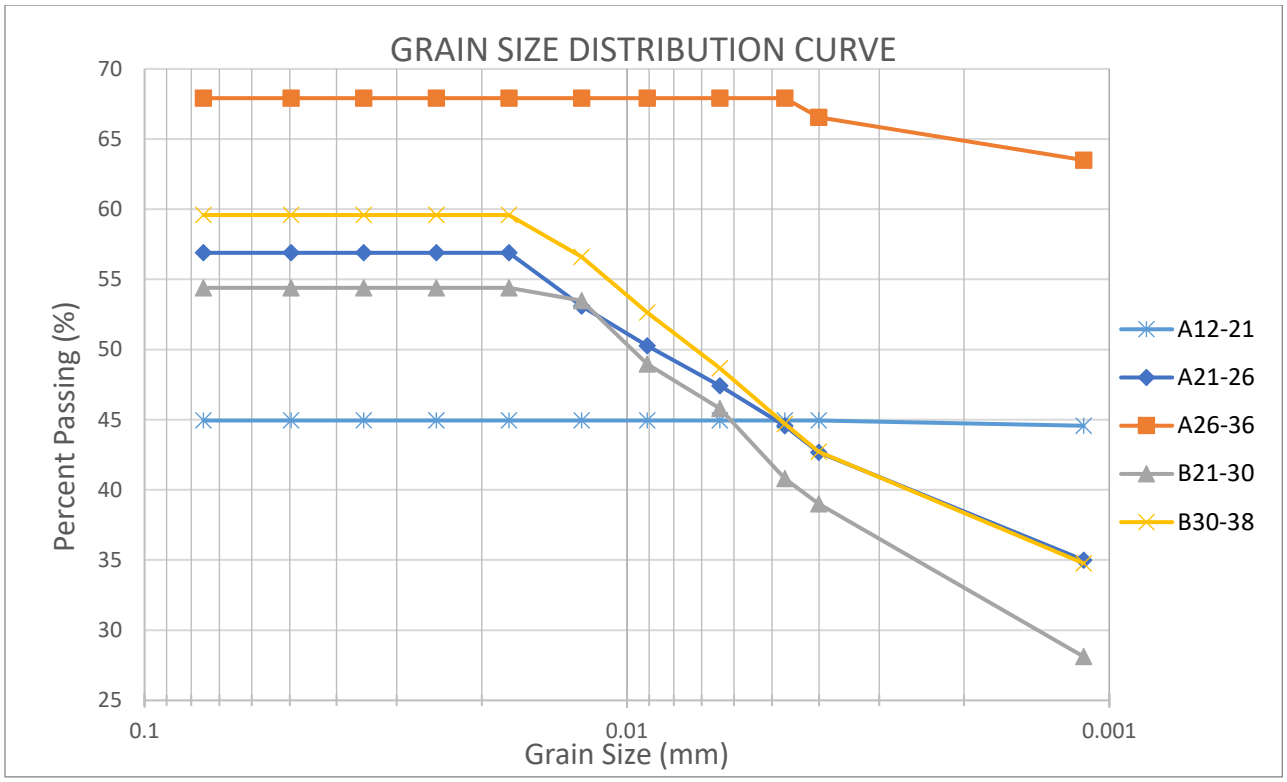


Figure 10: Grain Size Distribution Curve

Table 11: Soil Classification Results

	SOIL SAMPLE				
	A12-21	**A21-26**	**A26-36**	**B21-30**	**B30-38**
Gs	2.696	2.66	2.621	2.652	2.65
LL	28.62	33.42	26.88	24.89	26.76
PL	25.45	24.87	24.28	19.88	23.6
PI	3.17	8.55	2.6	5.01	3.19
PLASTICITY DESCRIPTION	SLIGHTLY PLASTIC	LOW PLASTICITY	SLIGHTLY PLASTIC	LOW PLASTICITY	SLIGHTLY PLASTIC
SOIL CLASSIFICATION	ML or OL	ML or OL	ML or OL	CL - ML	ML or OL

The concrete landing for the dock was designed similar to a slab on grade to hold the dock structure to the shore. The precise design of the concrete landing is a triangular beam that is 4.25 ft tall, 4 ft wide, and 25 ft long; the team simplified the beam to a rectangular beam in order to get an initial design. The acting vertical live loads, dead loads, and bearing capacity were used to design the vertical reinforcements. The horizontal reinforcements, found in the structures section, and vertical reinforcements were combined to result in a concrete landing that can withstand all acting forces. The vertical force reinforcements were designed to have 5 number 8 bars in the upper compression portion and 8 number

9 bars in the lower tension portion (Appendix E). The concrete landing's foundation can be found in the accompanying construction ready drawings.

The foundation design of the building was designed to have shallow square and continuous foundations to reliably support the buildings loads. The design of the building foundation began by using ACI 318-19 to calculate the combined live and dead vertical load on the columns and wall of the building and by using the soil bearing capacity. The maximum vertical load acting on the building, 177.6 kips, was used to design the whole foundation system. The square foundation was designed to be 9.5 ft by 9.5 ft wide with a depth of 24 in. The steel reinforcement for the foundation was designed to have 6 number 8 bars spaced at 22 inches in both directions. The continuous foundation was designed to wrap around the majority of the building's perimeter. The continuous foundation was designed to have the same width, 9.5 ft, as the square foundation; this created easier constructability of both foundations (Appendix E). The depth was designed to be shallow to ensure the archaeological artifacts would have minimal disturbance. The building foundation can be found in the accompanying construction ready drawings.

11. Construction

Construction management services performed included development of an estimate of the probable cost and construction schedule for the boathouse facility and dock structure. The probable construction cost was estimated from quantities and unit cost data of materials, machinery, and labor. Critical Path Method was used to develop a construction schedule comprised of efforts in both the building and dock construction.

An estimate of probable cost was created for the boathouse and dock structures by developing a quantities take-off and applying unit price data. The material quantities were calculated in the take-off with industry standard units of pricing measurements. Material unit costs were determined from TDOT Average Unit Prices of Awarded Contracts in 2021 account for the entire contract value including labor, machinery, and other installation costs. Material unit prices not listed in the TDOT report were determined from available market prices of materials (Appendix F). Final pricing was compiled and the costs for the building and dock were separated to be used in pursuing TVA 26a and general building permit requirements (Table 12).

Table 12: Summary of Estimation of Construction Costs

	Estimation of Probable Cost
Dock System	$185,306
Boathouse Facility	$1,792,723

A construction schedule was created using the Critical Path Method to compile tasks, task sequencing, and task durations into an overall project duration. The tasks and sequencing of tasks required for the construction schedule were determined utilizing an industry example construction schedule for a similar project (Appendix F). The durations of tasks were induced by adjusting the model schedule durations for the scale of project specific material quantities. The task critical path sequence was

compiled using the Critical Path Method. The overall construction duration was calculated by summing critical path task durations. Overall construction duration for the building and dock was compiled separately due to the independent task sequencing for each structure (Table 13).

Table 13: Summary of Estimation of Construction Durations

	Construction Duration (days)
Dock System	18
Boathouse Facility	238

12. Conclusion

Big Orange Builders was tasked to perform civil engineering design services to create the Outdoor Cultural and Recreation Center. A grading, stormwater utilities, and Erosion Prevention and Sediment Control plans were created to ensure proper drainage onsite. Transportation engineering was performed to design ADA compliant paths and parking and to predict the future traffic flow in the nearby roadway network after construction of the new facility. Hydrological engineering services were rendered to design the stormwater drainage system for the site. The building structure and dock were designed using structural analysis and design and all applicable strength and serviceability limit states were satisfied by the final proposed solutions. Soil testing was performed to determine the strength parameters for the soil on site, and foundation elements were designed to satisfy the loading conditions from the structures while maintaining adequate load distribution to the soil subgrade. A construction schedule was created for the site preparation and construction for the project infrastructure, and a probable cost of nearly $2 million was estimated for the Center. Design services rendered for the project included a comprehensive civil engineering design effort and successful development of the site is anticipated for the client.

References

Site Work

ArborPro Community - UT Knoxville, <https://hosted.arborprousa.com/KNOX/ >

"Best management practices (BMP) manual." *City of Knoxville, Tennessee,*

<https://www.knoxvilletn.gov/government/city_departments_offices/engineering/stormwater_engineering_division/bmp_manual>

City of Knoxville Municode Library,

<https://library.municode.com/tn/knoxville/codes/code_of_ordinances>

E/One. (2022). "Environment one corporation." *Environment One Corporation | EOne.com*, E/One – Environment One Corporation, <https://eone.com/>

International Code Council. *International Building Code*. Falls Church, Va.: International Code Council, 2018.

Transportation

Americans with Disabilities Act (ADA). (2010). Pub D. § 35.151. Retrieved from https://www.ada.gov/regs2010/titleII_2010/titleII_2010_regulations.htm, December 2, 2021.

City of Knoxville. (2021). "Code of Ordinances." Article 11 – Off-street Parking. Knoxville, TN. Retrieved from Municode Online Library, December 2, 2021. https://library.municode.com/tn/knoxville/codes/code_of_ordinancesnodeId=APXBZOCO_ART11OREPA_11.6DEOREPAFA

Hooper, K. G. (2019). Parking Generation, 5th Edition, ITE.

TDOT. (2022). "Transportation Data Management System." <https://tdot.public.ms2soft.com/tcds/tsearch.asp?loc=Tdot&mod=TCDS>. (March 27, 2022).

Hydrological and Hydraulic

A-382.36 (4)-2 Runoff Coefficients. Detail A.

Wisconsin Department of Transportation (WDOT), Facilities Development Manual (July 2, 1979), Procedure 13-10-5.

ADS, Inc. Drainage Handbook, ADS N-12 WT IB PIPE (per AASHTO) SPECIFICATION Specifications 1-9, 1-10, July 2008

City of Knoxville, Tennessee, Stormwater Division, Land Development Manual

<https://www.knoxvilletn.gov/government/city_departments_offices/engineering/stormwater_engineering_division/land_development_manual > (Feb. 2022).

U.S.D.A. Natural Resources Conservation Service Part 630 Hydrology "National Engineering Handbook",

Chapter 9 Hydrological Soil-Cover Complexes, 210-VI-NEH, July 2004

Structural

2018 National Design Specification for Wood Construction. (2018). American Wood Council, Leesburg, VA.

ACI 318-19: Building code requirements for structural concrete: CCOMMENTARY on building code requirements for structural concrete (ACI 318R-19). (2019). American Concrete Institute, Farmington Hills, MI.

American Society of Civil Engineers (ASCE). 2013. Minimum Design Loads for Buildings and Other

Structures.

Steel Construction Manual. (2017). American Institute of Steel Construction, Chicago, IL.

Geotechnical

"24 CFR § 3285.202 - soil classifications and bearing capacity." (n.d.). Legal Information Institute, Legal Information Institute, <https://www.law.cornell.edu/cfr/text/24/3285.202> (Mar. 28, 2022).

"Allowable soil bearing capacity chart: Rock, Sand, Clay & More." (2021). DICA, DICA Outrigger Pads, <https://dicausa.com/soil-bearing-capacity/> (Mar. 28, 2022).

ASTM C117, Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing

ASTM D422, Standard Test Method for Particle-Size Analysis of Soils

ASTM D6913, Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

ASTM D7928, Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis

ASTM C136, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates

ASTM D421, Dry Preparation of Soil Samples

ASTM D4318, Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

ASTM D2487, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

ASTM D2488, Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)

ASTM D854, Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer

ASTM D6026, Standard Practice for Using Significant Digits in Geotechnical Data

GEO Services, LLC. (n.d.). Report of Geotechnical and Geophysical Exploration.

"Web Soil Survey Soil Map." (2019). Web soil survey, United States Department of Agriculture, <https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx> (Dec. 1, 2021).

Construction

"Average unit prices - 01JAN2021 thru 31DEC2021 - tn.gov." (n.d.). Tennessee Department of Transportation, <https://www.tn.gov/content/dam/tn/tdot/construction/previous_lettings/Const_aup2021.pdf> (May 1, 2022).

Peurifoy, R. L., Robert Schmitt, Schexnayder, C., and Shapira, A. (2018). *Construction planning, equipment, and methods*. McGraw-Hill, New York.

Appendix A: Site Work

Other Areas

Figures 13 and 16 show both prehistoric and historic artifacts outside of the boundaries of sites 40KN45 and 40KN112. This material is summarized in Table 3. The prehistoric artifacts are classified as Isolated Finds. Both are located close to the boundary of 40KN45, but are on higher terrace formations and are not considered part of the site.

Table 3. Isolated Artifacts.

STP #	Description	Count	Raw Material for Chipped Stone
4-4	Secondary Flake	1	Knox
	FCR	1	
4-4 NE Radial	FCR	1	
	slag/cinder	1	
4-4 E Radial	Blocky Shatter	1	Knox
201	Coal	1	
	Fence wire	3	
205	Coal	2	
208	Indeterminate metal	1	
	Clear container glass	1	
216	Metal buckle/harness?	1	
218	Indeterminate medial nail fragment	1	
225	Clear flat glass	1	
	Tertiary flake	1	Indeterminate
Total		17	

Almost all of the historic artifacts marked on Figure 16 outside of the two site boundaries are from a single field. During the initial fieldwork conducted in the spring of 2005, this field was recently fertilized with manure from the barns, typically containing in excess of 30 cm of material on top of the plowzone. As such, the field was not surveyed at that time. When the field was shovel tested in the spring of 2006, the material had composted somewhat and had been mixed in to the plowzone by disking. All of the historic "artifacts" recovered during shovel testing are interpreted to have been recently deposited, within the last two to three years. Therefore, they are not considered part of either archaeological site.

CORING

Soil profiles were systematically collected by a Geoprobe 5410 truck-mounted hydraulic coring rig along 21 transects that extended perpendicular to the Tennessee River. Transects located on the upland landsurfaces were oriented across topographic depressions to examine potential buried surfaces that may be present in sinkholes. A deeply buried soil is defined here as a surface horizon encountered greater than 70 cmbs (beyond the effective reach of a shovel test) that is located under agricultural fill, alluvium or colluvium. For the geoarchaeological survey, a total of 134 cores were collected from the ground surface to depths ranging from 115 to 550 cmbs. Depth of refusal for the prepobe ranged from 960 cmbs along the lower elevations along the river to 1400 cmbs on the upland positions adjacent to the manure fields.

The transects extended from the lowest elevations adjacent to the river channel to upland positions where upland slopes exceeded 15 percent, or when manure fields were encountered. Since duplicate observations were produced by close interval sampling, seven transects (Transects 21, 11, 13, 15, 22, 18 and 20) were selected as representative cross-sections of upland and terrace landforms within the project area (Figure 26). From these transects, detailed descriptions of 44 cores (comprised of 131 individual sections) were used to identify deeply buried soils (>70 cmbs), degree of pedogenic development, and relative landform age, and provide insight into evolution of landforms along the Tennessee River (e.g., Birkeland 1999; Catt 1986; Foss and Segovia 1984; Foss et al. 1995; Holliday 2004; Huggett 1998; Lewin and Macklin 2003; Phillips et al. 2001). Detailed morphological descriptions of soil horizons were made for each profile and are located in Appendix B.

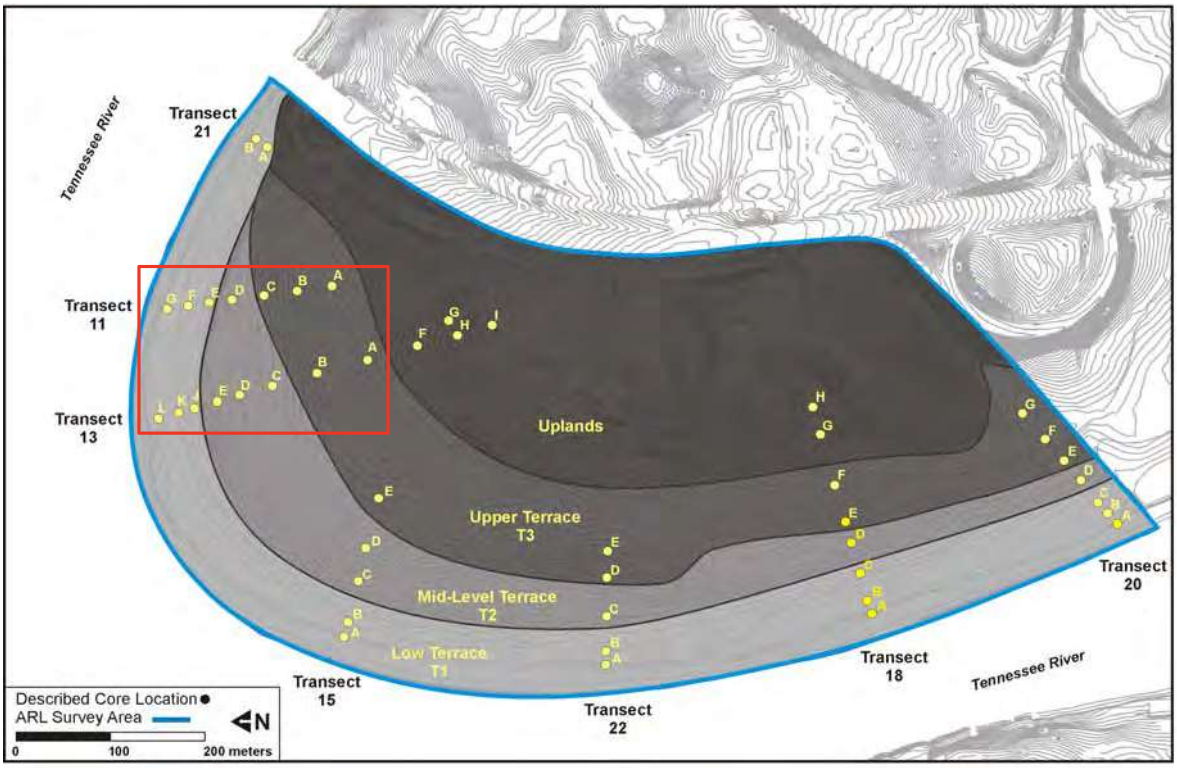


Figure 26. Location of representative cores and transects described during the study.

Upland Landforms

The upland landforms are described as those that lie between ~270-290 m AMSL (880-950 ft). The uplands are characterized by undulating karst topography with convex ridgetops and irregular depressions that formed in weathering limestone. The soils within this position are classified as Typic Paleudults, such as the Waynesboro series, and are mapped on eroded, higher elevations where slopes range from 12 to 25 percent. Cores 13-F and 13-I in Transect 13 sampled the upland landforms and represent characteristic soil morphologies for profiles observed in this area (Table 4).

The upland landform soils typically have a variable plowzone (Ap) that is 10 to 40 cm and is underlain by a well-developed argillic horizon (Bt). The Bt horizon extends to at least 115 cmbs. Cores 13-G and 13-H in Transect 13 were placed within a sinkhole on the uplands. Within the sinkhole, a relatively thick plowzone and transitional subsurface overlay an older buried plowzone (2Apb), which originates ~55 cmbs and extends to ~80 cmbs. Charcoal and ash layers were observed within the core profile buried plowzone but archaeological materials were not observed in the core samples. A second argillic subsurface horizon (2Btb) underlies the buried plowzone.

Table 4 lists cores described on the upland landform and estimates the potential for deeply buried archaeological deposits, the horizon in which they could be located and the minimum and maximum depth. The BA and 2Ab horizons within the sinkholes have moderate potential to contain buried archaeological deposits due to accumulation of sediment and development of soils within the depressions. The Bt horizons of the upland soils have a low potential to contain deeply buried (>70 cmbs) archaeological deposits since they are likely Pleistocene and predate human occupation within this region. Archaeological features (e.g. refuse or storage pits, hearths, post molds) may originate at the base of the Ap and intrude into the Bt horizon within the upland landforms.

Table 4. Potential for Encountering Buried Artifacts on the Upland Landform.

Transect-Core	Buried Artifact Potential	Soil Horizon	Min Depth (cmbs)	Max Depth (cmbs)	Comments
13-G	Moderate	BA	20	56	Sinkhole, Subsurface
13-G	Moderate	2Ab	56	85	Sinkhole, Buried Soil 1
13-H	Moderate	BA	47	62	Sinkhole, Subsurface
13-H	Moderate	2Ab	62	80	Sinkhole, Buried Soil 1
13-G	Low	2Btb	85	180	Sinkhole, Argillic Subsurface
13-H	Low	2Btb	80	180	Sinkhole, Argillic Subsurface
13-F	Low	Bt	40	115	Argillic Subsurface
13-I	Low	Bt	12	115	Argillic Subsurface
13-F	None	Ap	0	40	Plowzone
13-G	None	Ap	0	20	Plowzone
13-H	None	Ap	0	47	Plowzone
13-I	None	Ap	0	12	Plowzone

Upper Terrace Landforms (T3)

The upper terrace landforms (T3) are those that lie between elevations of ~260-270 m AMSL (850-880 ft). The T3 upper terraces are characterized by relatively level to undulating landsurfaces that slope (~12 percent) toward the river channel. The Waynesboro series is the dominant pedon mapped within this landscape position. On the T3, the Waynesboro consists of very deep soils that formed in alluvium likely deposited during the late Pleistocene. Cores 11-D, 13-B, 15-E, 22-D, 18-E and 20-G are representative soil profiles for the upper terrace landforms (Appendix B).

Along the northeastern portion of the project area (Transects 11, 13) the T3 landform typically has a thin plowzone (15-25 cm thick) that overlies a thick (50 cm) transitional surface horizon (BA). The BA horizon on the T3 may represent colluvial material or slopewash from the upland landforms and is considered as having low potential for intact

archaeological deposits. To the southwest, the plowzone is underlain by a well-developed argillic horizon (Bt) that extends to at least 115 cmbs. Soils with an Ap-Bt horizonation have low potential to contain deeply buried archaeological deposits since the soils are likely Pleistocene in age. Transect 11 and Transect 20 encountered sinkholes within the T3 landform (Cores 11-F, 20-G). These areas have moderate potential to contain buried archaeological materials due to infilling within the depressions (Table 5). Archaeological features may originate at the base of the Ap and intrude into the Bt horizon on the upper terrace landforms.

Mid-Level Terrace Landforms (T2)

The mid-level terrace landforms (T2) are those that lie between elevations of ~250-260 mAMSL (830-850 ft). The T2 terraces are characterized by relatively level to undulating landsurfaces that slope (~5 percent) to the river channel. The Shady series and Whitwell series are the dominant pedons mapped on the T2 terrace. These series represent very deep soils that formed in loamy alluvium deposited during the late Pleistocene to Holocene. Cores 11-H, 13-D, 15-C, 22-C, 18-D and 20-D are representative soil profiles of the mid-level terraces (Appendix B). Along the northern portion of the edge of the project area (Transects 11, 13) this landform typically has a variable plowzone (~10-40 cm thick) that overlies a series of argillic horizons (Bt). To the southwest (Transect 15) the plowzone on the T2 is underlain by a series of weakly-developed transitional soil/sediment horizons (BA-BC) that are sandy loam in texture.

The BC horizons lack structural development, and with increasing depth (>115 cmbs) grade into unmodified alluvial sediments (C). The BA and Bw horizons within Core 18-D are considered to have high potential for buried archaeological deposits due to its location on a relatively level portion of the T2 terrace. Here, the BA horizons represent alluvial deposits that have undergone slight pedogenic development and may have a high potential for intact archaeological deposits. The C horizons have low potential to contain deeply buried archaeological deposits since they represent unmodified fluvial deposits (Table 6).

Low Terrace Landforms (T1)

The low terrace landforms (T1) (i.e., floodplain) are those that lie between elevations of ~245-250 m AMSL (810-830 ft). The T1 terraces are characterized by relatively level floodplains that gently slope (~2 percent) to the river channel. The Shady-Whitwell complex is the dominant pedon mapped on the T1 terrace. These series represent very deep soils that formed in loamy alluvium deposited during the Holocene.

Cores 11-K, 13-L, 15-A, 22-A, 18-A and 20-A are representative soil profiles of the low terrace (T1) (Appendix B). This landform typically has a very thick plowzone, up to 70 cmbs that may overlie a flood deposit (C horizon in core 11-K), a buried surface horizon (2Ab in core 15-A) or an older plowzone (2Apb in core 20-A). The buried surface horizon (2Ab) typically originates 70 to 90 cmbs on the T1 terrace. A second deeper buried surface horizon (3Ab) originates 140 to 230 cmbs. The buried surface horizons are underlain by transitional soil/sediments (BC) that grade into unmodified fluvial sediments (C).

Table 5. Potential for Encountering Buried Artifacts on the Upper Terrace (T3).

Transect-Core	Buried Artifact Potential	Soil Horizon	Min Depth (cmbs)	Max Depth (cmbs)	Comments
20-F	Moderate	2Ab	22	60	Buried Soil 1
20-G	Moderate	2Ab	59	110	Buried Soil 1
11-A	Low	BA	15	30	Transitional Subsurface
11-A	Low	Bt	30	110	Argillic Subsurface
11-B	Low	BA	10	50	Transitional Subsurface
11-B	Low	Bt	50	110	Argillic Subsurface
11-C	Low	BA	10	25	Transitional Subsurface
11-C	Low	Bt	25	110	Argillic Subsurface
11-D	Low	BA	15	40	Transitional Subsurface
11-D	Low	Bt	40	110	Argillic Subsurface
11-E	Low	BA	20	40	Transitional Subsurface
11-E	Low	Bt	40	110	Argillic Subsurface
11-F	Low	BA	35	65	Transitional Subsurface
11-F	Low	Bt	65	120	Argillic Subsurface
11-G	Low	BA	40	65	Transitional Subsurface
11-G	Low	Bt	65	120	Argillic Subsurface
13-A	Low	BA	10	25	Transitional Subsurface
13-A	Low	Bt	25	110	Argillic Subsurface
13-B	Low	BA	10	50	Transitional Subsurface
13-B	Low	Bt	50	110	Argillic Subsurface
15-D	Low	BA	20	40	Transitional Subsurface
15-D	Low	Bt	40	115	Argillic Subsurface
15-E	Low	Bt	15	115	Argillic Subsurface
18-E	Low	Bt	25	115	Argillic Subsurface
18-F	Low	Bt	25	115	Argillic Subsurface
20-F	Low	2Btb	60	230	Sinkhole, Argillic Subsurface
20-G	Low	2Btb	110	210	Sinkhole, Argillic Subsurface
22-D	Low	Bt	7	115	Argillic Subsurface
22-E	Low	Bt	15	115	Argillic Subsurface
11-D	None	Ap	0	15	Plowzone
11-F	None	Ap	0	35	Plowzone
11-G	None	Ap	0	40	Plowzone
13-A	None	Ap	0	10	Plowzone
13-B	None	Ap	0	10	Plowzone
15-D	None	Ap	0	20	Plowzone
15-E	None	Ap	0	15	Plowzone
18-E	None	Ap	0	25	Plowzone
18-F	None	Ap	0	25	Plowzone
20-E	None	Ap	0	20	Plowzone
20-F	None	Ap	0	22	Plowzone
20-G	None	Ap	0	59	Plowzone
22-D	None	Ap	0	7	Plowzone
22-E	None	Ap	0	15	Plowzone

Table 6. Potential for Encountering Buried Artifacts on the Mid-Level Terrace (T2).

Transect-Core	Buried Artifact Potential	Soil Horizon	Min Depth (cmbs)	Max Depth (cmbs)	Comments
18-D	High	BA	30	70	Transitional Subsurface
18-D	High	Bw	70	150	Cambic Subsurface
11-H	Moderate	Bt	40	120	Argillic Subsurface
13-D	Moderate	Bt	10	110	Argillic Subsurface
13-D	Moderate	BC	110	155	Transitional Soil/ Sediment
13-E	Moderate	Bt	40	120	Argillic Subsurface
13-E	Moderate	BC	120	150	Transitional Soil/ Sediment
15-C	Moderate	BA	7	22	Transitional Subsurface
15-C	Moderate	BC	22	115	Transitional Soil/ Sediment
20-D	Moderate	Bt	23	180	Argillic Subsurface
20-E	Moderate	Bt	20	115	Argillic Subsurface
22-C	Moderate	Bw	36	81	Cambic Subsurface
22-C	Moderate	Bt	81	220	Argillic Subsurface
11-H	Moderate	BC	120	160	Transitional Soil/ Sediment
13-C	Moderate	BA	30	60	Transitional Subsurface
13-C	Moderate	Bt	60	120	Argillic Subsurface
18-D	Moderate	BC	150	210	Transitional Soil/ Sediment
11-H	None	Ap	0	40	Plowzone
13-C	None	Ap	0	30	Plowzone
13-D	None	Ap	0	10	Plowzone
13-E	None	Ap	0	40	Plowzone
15-C	None	Ap	0	7	Plowzone
18-D	None	Ap	0	30	Plowzone
20-D	None	Ap	0	23	Plowzone
22-C	None	Ap	0	36	Plowzone

All horizons, except those characterized as C horizons have a high potential to contain buried archaeological deposits due to the mid-Holocene to recent age and aggradational nature of the T1 terrace (Table 7). The C horizons have low potential to contain intact deeply buried archaeological deposits since they represent unmodified fluvial deposits deposited during flood events.

Table 7. Potential for Encountering Buried Artifacts on the Low Terrace (T1).

Transect-Core	Buried Artifact Potential	Soil Horizon	Min Depth (cmbs)	Max Depth (cmbs)	Comments
11-I	High	BA	40	70	Transitional Subsurface
11-I	High	Bw	70	115	Cambic Subsurface
11-J	High	BC	55	120	Transitional Soil/ Sediment
11-J	High	2Ab	120	180	Buried Soil 1
11-K	High	BA	40	90	Transitional Subsurface
11-K	High	2Ab	155	230	Buried Soil 1
11-K	High	3Ab	230	350	Buried Soil 2
13-K	High	BC	50	115	Transitional Soil/ Sediment
13-K	High	2Ab	115	170	Buried Soil 1
13-L	High	BA	40	85	Transitional Subsurface
13-L	High	2Ab	85	230	Buried Soil 1
13-L	High	3Ab	230	330	Buried Soil 2
15-A	High	2Ab	70	150	Buried Soil 1
15-A	High	3Ab	150	300	Buried Soil 2
15-B	High	2Ab	20	100	Buried Soil 1
18-A	High	2Ab	55	190	Buried Soil 1
18-A	High	3Ab	190	330	Buried Soil 2
18-B	High	2Ab	57	200	Buried Soil 1
18-B	High	3Ab	200	290	Buried Soil 2
18-C	High	BA	40	80	Transitional Subsurface
18-C	High	Bw	80	130	Cambic Subsurface
20-A	High	2Ab	42	170	Buried Soil 1
20-B	High	BA	29	64	Transitional Subsurface
20-B	High	2Ab	64	140	Buried Soil 1
20-B	High	3Ab	140	309	Buried Soil 2
20-C	High	BA	39	70	Transitional Subsurface
20-C	High	2Ab	70	330	Buried Soil 1
21-A	High	Bw	75	100	Cambic Subsurface
21-A	High	BC	100	130	Transitional Soil/ Sediment
21-B	High	Bw	80	160	Cambic Subsurface
21-B	High	BC	160	195	Transitional Soil/ Sediment
21-B	High	2Ab	195	330	Buried Soil 1
22-A	High	2Ab	65	300	Buried Soil 1
22-A	High	3Ab	300	430	Buried Soil 2
22-B	High	BA	30	87	Transitional Subsurface
22-B	High	2Ab	87	160	Buried Soil 1
11-I	High	BC	115	180	Transitional Soil/ Sediment
13-J	High	Bw	63	115	Cambic Subsurface
13-J	High	BC	115	170	Transitional Soil/ Sediment
18-C	High	BC	130	190	Transitional Soil/ Sediment
11-I	Moderate-Low	C	180	480	Sedimentary Deposit
11-J	Moderate-Low	C	180	460	Sedimentary Deposit
11-K	Moderate-Low	C	400	460	Sedimentary Deposit
13-J	Moderate-Low	C	170	480	Sedimentary Deposit
13-K	Moderate-Low	C	170	440	Sedimentary Deposit

Table 7. Potential for Encountering Buried Artifacts on the Low Terrace (T1). (continued)

Transect-Core	Buried Artifact Potential	Soil Horizon	Min Depth (cmbs)	Max Depth (cmbs)	Comments
13-L	Moderate-Low	C	330	440	Sedimentary Deposit
15-A	Moderate-Low	C	300	550	Sedimentary Deposit
15-B	Moderate-Low	C	100	440	Sedimentary Deposit
18-A	Moderate-Low	C	330	440	Sedimentary Deposit
18-B	Moderate-Low	C	290	450	Sedimentary Deposit
18-C	Moderate-Low	C	190	330	Sedimentary Deposit
20-A	Moderate-Low	C	340	440	Sedimentary Deposit
20-B	Moderate-Low	C	309	404	Sedimentary Deposit
20-C	Moderate-Low	C	330	440	Sedimentary Deposit
21-A	Moderate-Low	C	130	300	Sedimentary Deposit
21-B	Moderate-Low	C	330	440	Sedimentary Deposit
22-A	Moderate-Low	C	430	440	Sedimentary Deposit
22-B	Moderate-Low	C	160	330	Sedimentary Deposit
11-I	None	Ap	0	40	Plowzone
11-J	None	Ap	0	55	Plowzone
11-K	None	Ap	0	40	Plowzone
13-J	None	Ap	0	63	Plowzone
13-K	None	Ap	0	50	Plowzone
13-L	None	Ap	0	40	Plowzone
15-A	None	Ap	0	70	Plowzone
15-B	None	Ap	0	20	Plowzone
18-A	None	Ap	0	55	Plowzone
18-B	None	Ap	0	57	Plowzone
18-C	None	Ap	0	40	Plowzone
20-A	None	Ap	0	42	Plowzone
20-B	None	Ap	0	29	Plowzone
20-C	None	Ap	0	39	Plowzone
21-A	None	Ap	0	75	Plowzone
21-B	None	Ap	0	80	Plowzone
22-A	None	Ap	0	65	Plowzone
22-B	None	Ap	0	30	Plowzone

Discussion

The landforms characterized within the project area were determined by examining soil morphology of cores and generalized in regard to geomorphic position, processes and potential for containing buried (>70 cmbs) archaeological deposits (Figure 27). Detailed morphological descriptions for cores inspected are located in Appendix B. Due to relative consistent soil morphology, soil horizonation was generalized to group soil characteristics and processes by depth.

Section Cut & Fill Report

JOB: 0089 OUTDOOR CULTURAL & RECREATION CENTER SECTION: 02 REV EX CONTOURS
Grid Size: 5.00 X 5.00 Ft Subgrid Size: 2.50 X 2.50
Section Size: 798.6 X 879.3 Ft
Area of Cut: 17338 SqFt Area of Fill: 178544 SqFt Total Work Area: 196181 SqFt
(Cut Area Threshold: 0.01Ft Fill Area Threshold: 0.01Ft)

Section Balance Analysis

	Bank (CY)	Compacted (CY)	Expanded (CY)
Fill Required		19935	
Repl Topsoil Rqd		2270	
Stripping Total	4776	4776	4776
Cut Total	864	788	868
Fill Obtained On Site	558	483	562
Repl Topsoil Obtained On Site	2270	2270	2270
Import Repl Topsoil		0	
Import Fill		19452	
Export Stripping		2506	2506
Export Fill		305	305
Total Export		2812	2812

Cut Quantity by Stratum

	TOPSOIL	CLAYFIL	SANDYCL	ROCK
Bank Cut (CY)	304	334	184	40
Compacted Cut (CY)	304	284	157	42
Expanded Cut (CY)	304	334	184	44
Bank Strip (CY)	4776	0	0	0
Cmpcted Strip (CY)	4776	0	0	0
Expanded Strip (CY)	4776	0	0	0

Shrinkage and Expansion

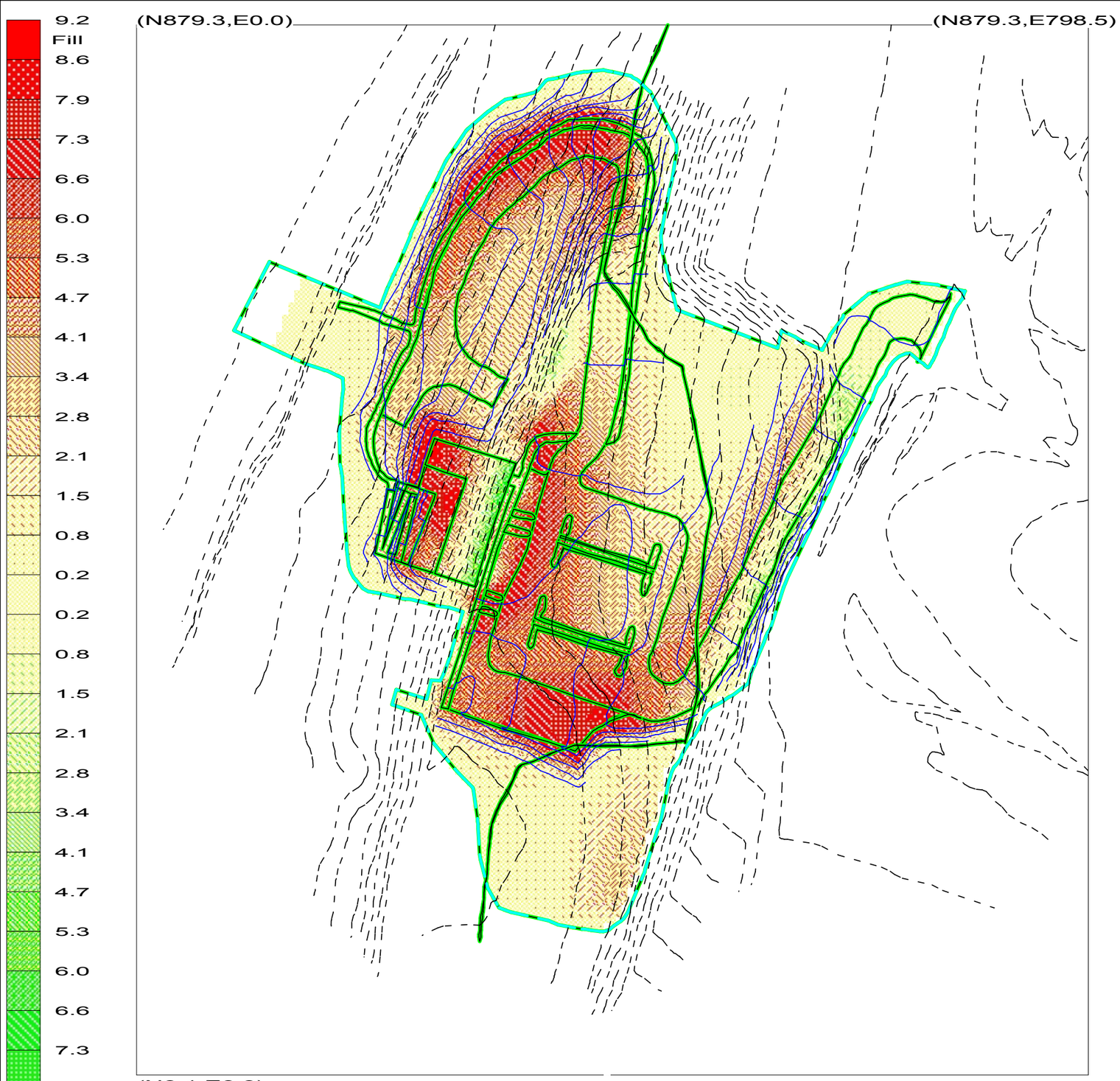
	TOPSOIL	CLAYFIL	SANDYCL	ROCK
Shrinkage (%)	0	15	15	-5
Expansion (%)	0	0	0	10
Repl Topsoil Shrink (%)	0			

Section Subgrade Cut & Fill Report
Run Date 04-25-2022
Run Time 22:31:38
Job Number: 0089
Job Name: OUTDOOR CULTURAL & RECREATION CENTER
Section Number: 02
Section Description: REV EX CONTOURS

Subgrade Number		Description	Type	Value (Ft)	Fill (CY)	Soil State	Total Cut (CY)	TOPSOIL	CLAYFIL	SANDYCL	ROCK
	1		Repl Top (Ft)	0.5	8738	Bank |	347	150	150	47	0
						Compacted |	317	150	127	40	0
	20	HD PAVING	Depth (Ft)	1	6644	Bank |	250	112	121	18	0
						Compacted |	230	112	103	15	0
	23	LD PAVING	Depth (Ft)	0.79	1922	Bank |	0	0	0	0	0
						Compacted |	0	0	0	0	0
	25	SW	Depth (Ft)	0.66	1790	Bank |	0	0	0	0	0
						Compacted |	0	0	0	0	0
	27		Repl Top (Ft)	0.5	378	Bank |	0	0	0	0	0
						Compacted |	0	0	0	0	0
	28	BLDG FFE 835.00	Elevation (Ft)	834.33	416	Bank |	267	42	64	120	41
						Compacted |	242	42	55	102	43
	36	ARCHEOLOGICAL BOUNDARY	Depth (Ft)	.	49	Bank |	0	0	0	0	0
						Compacted |	0	0	0	0	0
ALL Subgrades					19936	Bank |	865	304	335	185	41
						Compacted |	789	304	284	157	43

Section Subgrade Materials Report
Run Date 04-25-2022
Run Time 22:31:44
Job Number: 0089
Job Name: OUTDOOR CULTURAL & RECREATION CENTER
Section Number: 02
Section Description: REV EX CONTOURS

Subgrade #		Description	Area (SF)	Material	Volume (CY)
	1		122979.3		
	20	HD PAVING	49365.88	TOP	229
				BINDER	380
				PUG	1207
	23	LD PAVING	8256.784	TOP	38
				BINDER	51
				PUG	153
	25	SW	10434.51	CONC	128
				GRAVEL	128
	27		1879.652		
	28	BLDG FFE 835.00	4614.715	CONC	56
				GRAVEL	56
	36	ARCHEOLOGICAL BOUNDARY	414.7669		
ALL Subgrades				TOP	267
				BINDER	431
				PUG	1360
				CONC	184
				GRAVEL	184

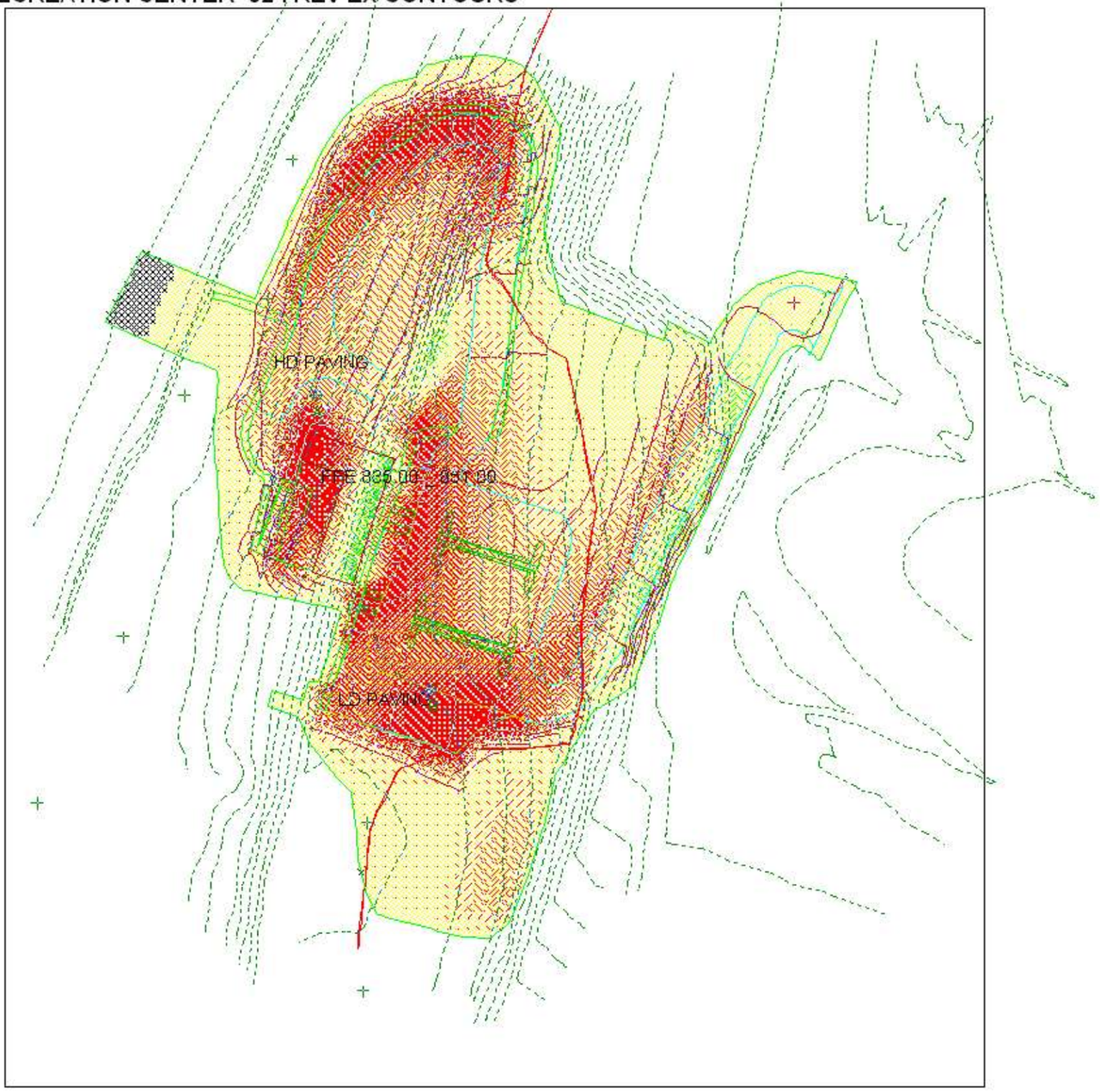


JOB: 0089 OUTDOOR CULTURAL & RECREATION CEN
SECTION: 02 REV EX CONTOURS
X-SCALE: 93.64 ft/in (Auto)
Y-SCALE: 93.64 ft/in (Auto)
RUN DATE: 04-25-2022 RUN TIME: 22:34:48
COMPANY:
ESTIMATOR:

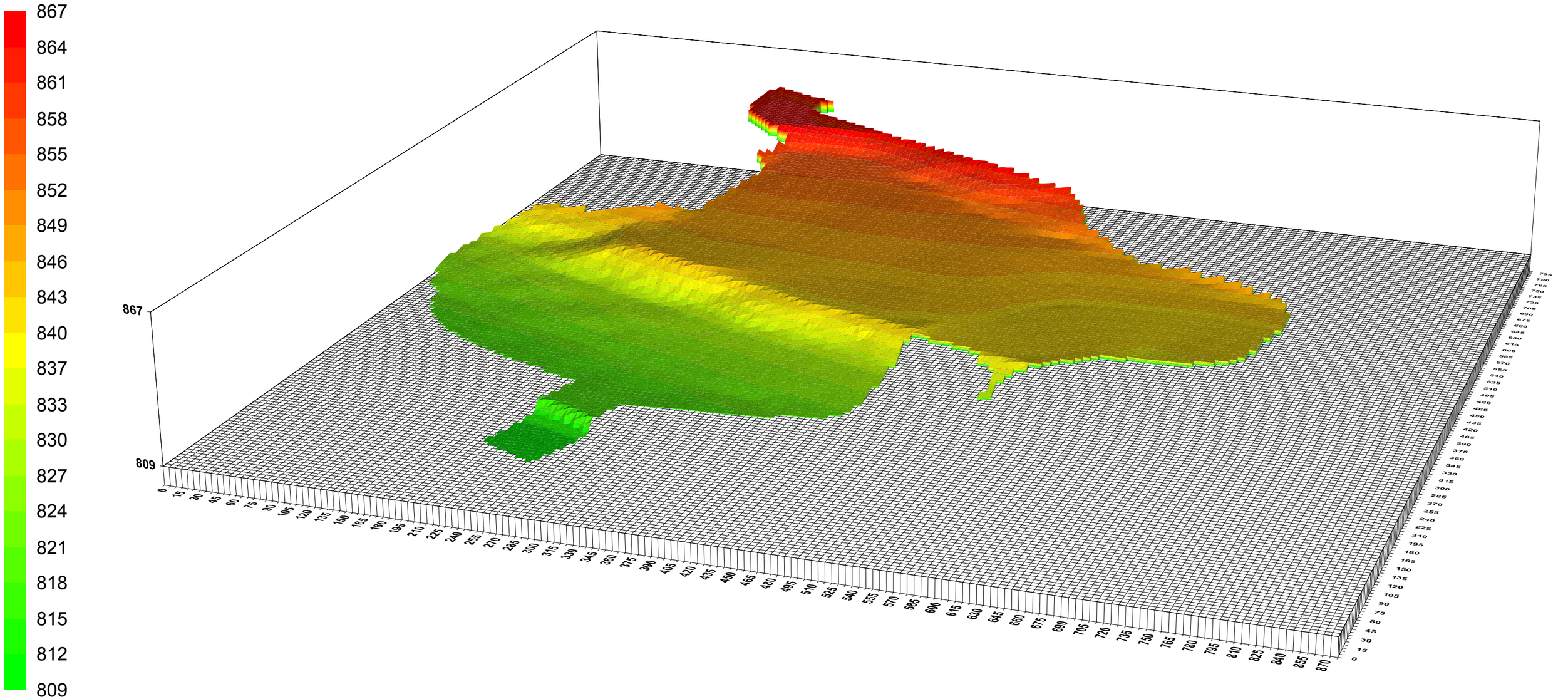
Run Time 22:31:52

0089: OUTDOOR CULTURAL & RECREATION CENTER 02 : REV EX CONTOURS

Run Date 04-25-2022

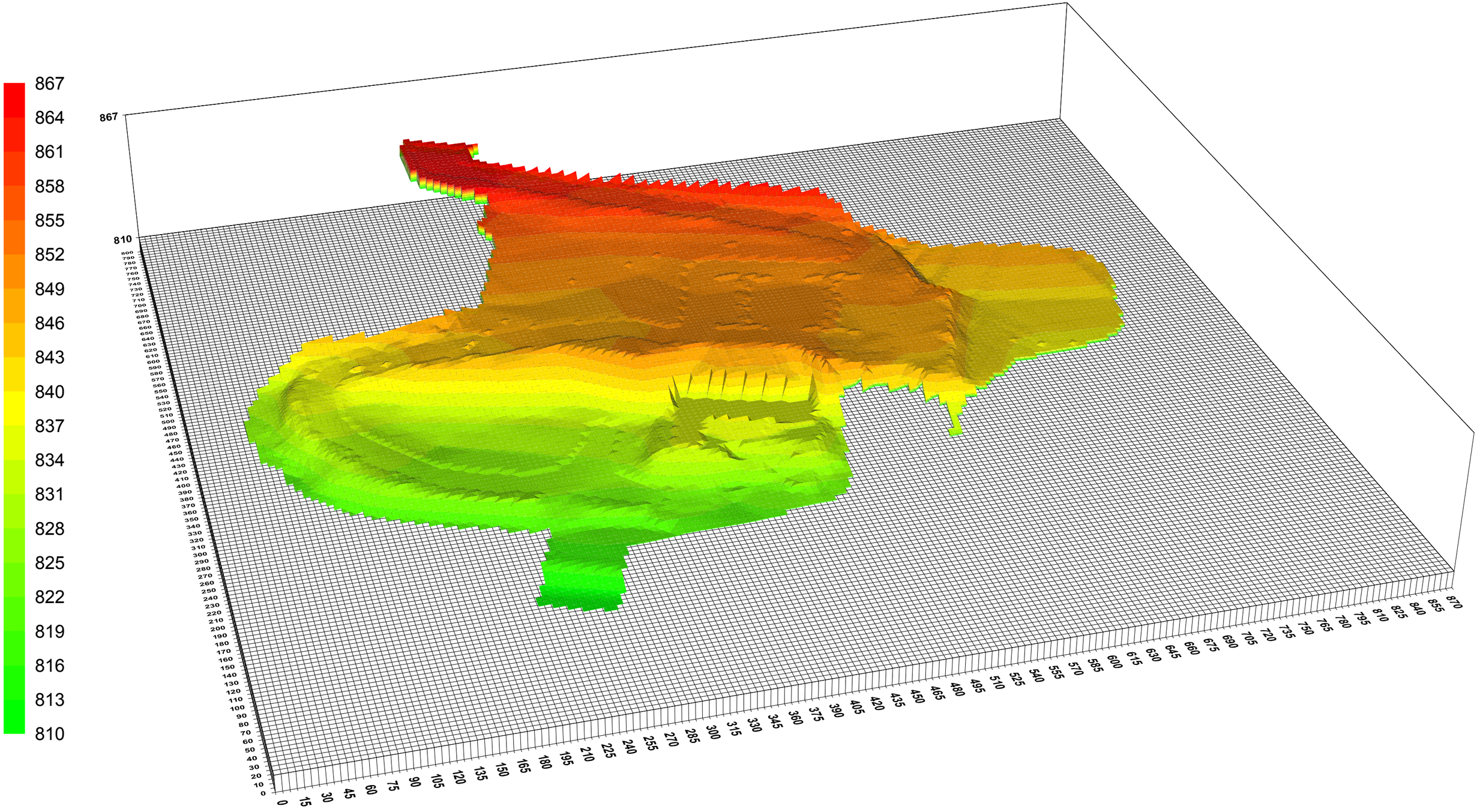


JOB: 0089 OUTDOOR CULTURAL & RECREATION CENTER SECTION: 02 REV EX CONTOURS



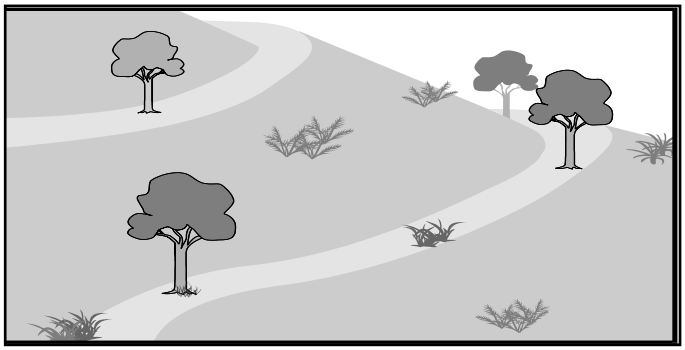
EXISTING GRADES

JOB: 0089 OUTDOOR CULTURAL & RECREATION CENTER SECTION: 02 REV EX CONTOURS



SUBGRADE GRADES

ACTIVITY: Trees, Shrubs and Vines	ES – 10



CITY OF KNOXVILLE

Targeted Constituents				
● Significant Benefit	◗ Partial Benefit	○ Low or Unknown Benefit		
● Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances	
◗ Nutrients	○ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Description

Planting trees, shrubs, vines and other ground covers will provide long-term stabilization of soil. The primary functions of permanent vegetation is to improve aesthetics, reduce erosion by slowing runoff velocities, enhance infiltration and transpiration, trap sediment and other particulates, protect soil from raindrop impact, and provide habitat for wildlife. This management practice is likely to create a significant reduction in sediment.

Suitable Applications

- Appropriate for site stabilization both during construction and after construction
- Open areas and slopes, such as parks or playgrounds
- Landscaping corridors and buffer areas
- Near buildings and structures, to provide shade and aesthetics

Approach

See AM-03, Preservation of Existing Vegetation, in order to plan removal of existing vegetation during construction projects. Existing vegetation should be preserved whenever possible, particularly native species which are aesthetically pleasing and provide wildlife habitats. In addition, Table AM-03-1 contains a brief description of tree location requirements for obtaining a grading permit, building permit, preliminary plan review or construction within right-of-way.

Prior to the planting of trees, consult Table AM-03-1 which contains the Knoxville Tree Protection Ordinance. The following list includes some of the major points in the ordinance:

Section 14-28 - Definition of a tree
Section 14-29 - Applies to every property except for single-family dwelling units
Section 14-34 - Maximum limit on the destruction or removal of trees
Section 14-35 - Protection of trees in historical areas or if botanically important
Section 14-36 - Minimum rate of tree planting
Section 14-37 - Maintain and replace planted trees up to 18 months later

Table ES-10-1 contains the suggested list of tree species for planting within the city, as recommended by the Knoxville Tree Board. This list contains the most common types of trees planted in this area; other trees may be approved by the city horticulturist.

Selecting the right type of vegetation to be planted depends on many factors such as sunlight or shade, water requirements, allowable room, soil pH, amount of soil available, tolerance to automobile emissions or street deicing salts, fertilizer and other maintenance

requirements, preference for deciduous or evergreen trees, and aesthetic considerations. For instance, some trees may grow considerably and create problems for overhead utilities or underground pipes.

Trees in particular are essential for improving the urban environment. They provide shade and protection from the elements for humans and for wildlife. Trees greatly improve ground temperatures, air temperatures, the movement of air, humidity, and the transmission of urban noise.

This BMP contains general guidance for selecting and for planting the various types of vegetation. Extensive guidance is available from the UT Agricultural Extension Office on the 5th floor of the City County Building (and from the website located at http://www.utextension.utk.edu/knox/). There are many publications available in paper copy and at the website for topics such as native trees, urban trees, small trees, trees for poorly drained soils, fruit trees, etc.

There are also many different species of vines and ground covers from which to choose, but care must be taken in their selection. It is essential to select planting materials suited to both the intended use and specific site characteristics. Additional information can be obtained from local nurserymen, landscape architects, and the UT Agricultural Extension Office.

For construction projects, planting should be performed as soon as final grading is completed, unless there is a specific planting time recommended for a particular plant. In areas where no activity is performed, vegetation may be maintained or established along landscaped corridors and buffer zones to act as filter strips.

Permanent planting during the construction stage of projects will require careful coordination between the local agency inspectors, project managers, construction managers, and landscape contractor. Protocols for site access and construction staging are the responsibility of the site owner or his designated site manager.

Trees and Shrubs

Selection: Trees and shrubs, when properly selected, are low-maintenance plantings that stabilize adjacent soils, moderate the adjacent air and ground temperatures, filter air pollutants, and serve as a barrier to wind. Some desirable characteristics to consider in selecting species for trees and shrubs include vigor, potential size and shape, tolerance to man-made environment, adaptability, climate, wildlife habitat, etc.

Sites for new plantings should be evaluated for prior land use, potential for soil contamination, adverse soil conditions such as poor drainage or acidity, exposure to wind, temperature extremes, location of utilities or pavement, and proximity to traffic.

Transplanting: In general, autumn is the preferred time for transplanting small trees. Evergreen trees can also be transplanted in spring. Seedlings (although not usually specified for an urban setting) can generally be planted in the early spring or early autumn to take advantage of moderate temperatures. Proper transplanting for a tree or shrub includes the conservation of as much of the root system as possible. Soil adhering to the roots should be damp when the tree is dug, and kept moist until replanting. The soil ball should be 12 inches in diameter for each inch of diameter of the trunk. Most transplanted trees and shrubs will need artificial support to prevent excessive swaying. Soil around the tree should be thoroughly watered after the tree is set in place, and then watered deeply once a week during summer and dry periods. Mulching at the base of a tree or shrub is helpful in preventing roots from drying out.

Vines and Ground Covers

Selection: Vines and ground covers can quickly spread and stabilize a slope, preventing erosion from occurring. Vine and ground covers come in many types, colors, and growth habits. Some vines and ground covers are suitable only as part of a small well-maintained landscape area, while others can stabilize large areas with little maintenance. Flowers do not provide erosion control but may be planted to add color and beauty. Vines and ground covers provide food and habitat for many types of wildlife.

Site Preparation: Ground covers are plants that naturally grow very close together, which may create competition for space, nutrients and water. Soil for ground covers should be well prepared. The entire area should be spaded, disked, or rototilled to a depth of 6 inches. Approximately 2 to 3 inches of organic material, such as good topsoil or peat, should be spread over the entire area.

General Planting Guidelines

The following general steps will help ensure good plant growth:

1. Position the plantings to follow the contours of the land, taking into account drainage patterns and the potential for heavy winds.
2. Dig the holes approximately 1/3 larger than the plant root ball.
3. Use good topsoil or soil mixture with a lot of organic matter. Fill hole approximately ¼ full and gently shake plants to settle soil among roots.
4. Leave a saucer-shaped depression around the plant to hold water. Use mulch to protect the soil from erosion and to retain soil moisture.
5. Water thoroughly and regularly. Stake and support trees or other vegetation as necessary until root systems are capable of firmly infiltrating the subgrade.

Figures ES-10-1 and ES-10-2 show a typical details for planting a shrub or vine and also for planting a tree (balled-and-burlapped). Plants grown in containers are handled in a similar manner. Acclimate plants to outdoor conditions prior to transplanting.

The importance of properly supporting and staking a tree or shrub cannot be overemphasized. Although some trees may take root after a few months, other trees may need to be supported for a couple years. Therefore use proper materials and methods that will both remain functional and look attractive.

Maintenance

- Water trees regularly once a week, particularly during summer months or dry periods. Young trees should receive an inch of water each week for the first two years after planting. Fertilizing may be required for some types of trees and shrubs, in late autumn or early spring. Mulch applied to the base of a tree will help to reduce weeds and retain soil moisture.
- Proper pruning, watering, and application of fertilizer is necessary to maintain healthy and vigorous shrubs. A heavy layer of mulch applied around the shrubs reduces weeds and increases the retention of soil moisture.
- Vines and ground covers will require pruning and watering during the summer months. Vines and ground covers may not provide sufficient erosion control during winter months.
- Trees and shrubs with thin bark may require additional protection from insects and small animals. Spraying may be necessary for some types of trees and shrubs. Repair wounds and abrasions by either tree paint or by removing limbs. Consult an

arborist or horticulturist as necessary for the care of trees or shrubs.

Limitations

- If the site is susceptible to erosion, additional control measures may be necessary during the establishment of vegetation. Caution should be exercised in selecting non-native vegetation because of potential impacts to native vegetation on adjacent lands. Non-native species may quickly spread and compete with originally undisturbed vegetation.
- Overapplication of fertilizers, herbicides and pesticides may create stormwater pollution. Follow the guidelines in AM-13 (Pesticides, Herbicides, and Fertilizer Use) to prevent misuse of these materials. Follow package instructions carefully.
- Construction activities are likely to injure or kill trees unless adequate protective measures are taken. Direct contact by equipment is the most obvious problem, but damage is also caused by root stress from filling, excavation, or compacting soil near trees. Follow guidelines in AM-03, Preservation of Existing Vegetation.

References **8, 30, 33, 34, 35, 43, 63, 114, 125, 135, 136, 141, 144**

(see BMP Manual Chapter 10 for list)

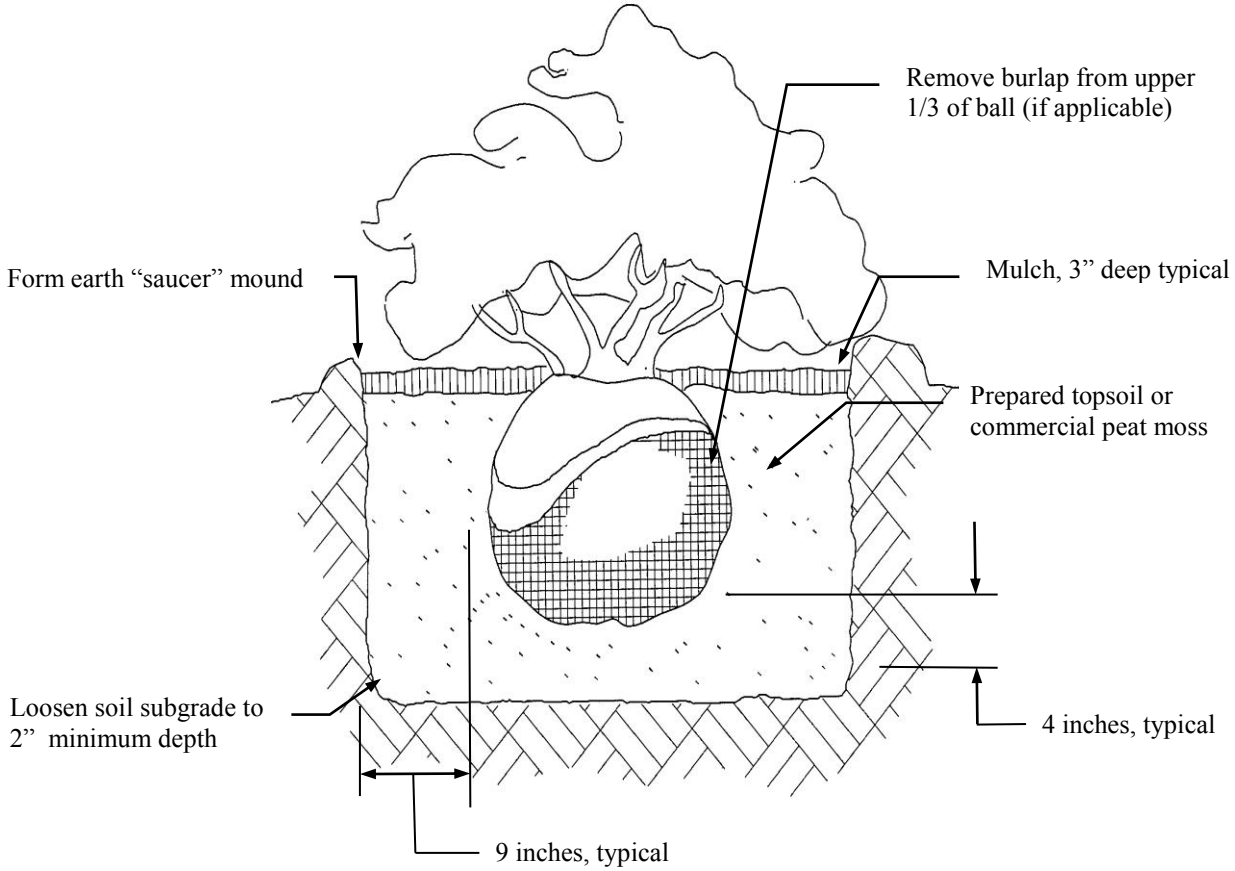


Figure ES-10-1
Typical Planting Detail – Shrub or Vine

Notes:

1. Balled-and-burlapped (B&B) stock from nurseries shall meet the standards of ANSI Z60.1, American Standard for Nursery Stock.
2. Young deciduous trees may be wrapped from the base of the tree to the height of the lowest branches. Wrap shall consist of 4-inch wide rolls of bituminous impregnated tape which is specially manufactured to resist insects.
3. Alternative materials for staking trees include common garden hose, sliced open and fitted around trunk, and galvanized wire, 12-gauge or thicker.

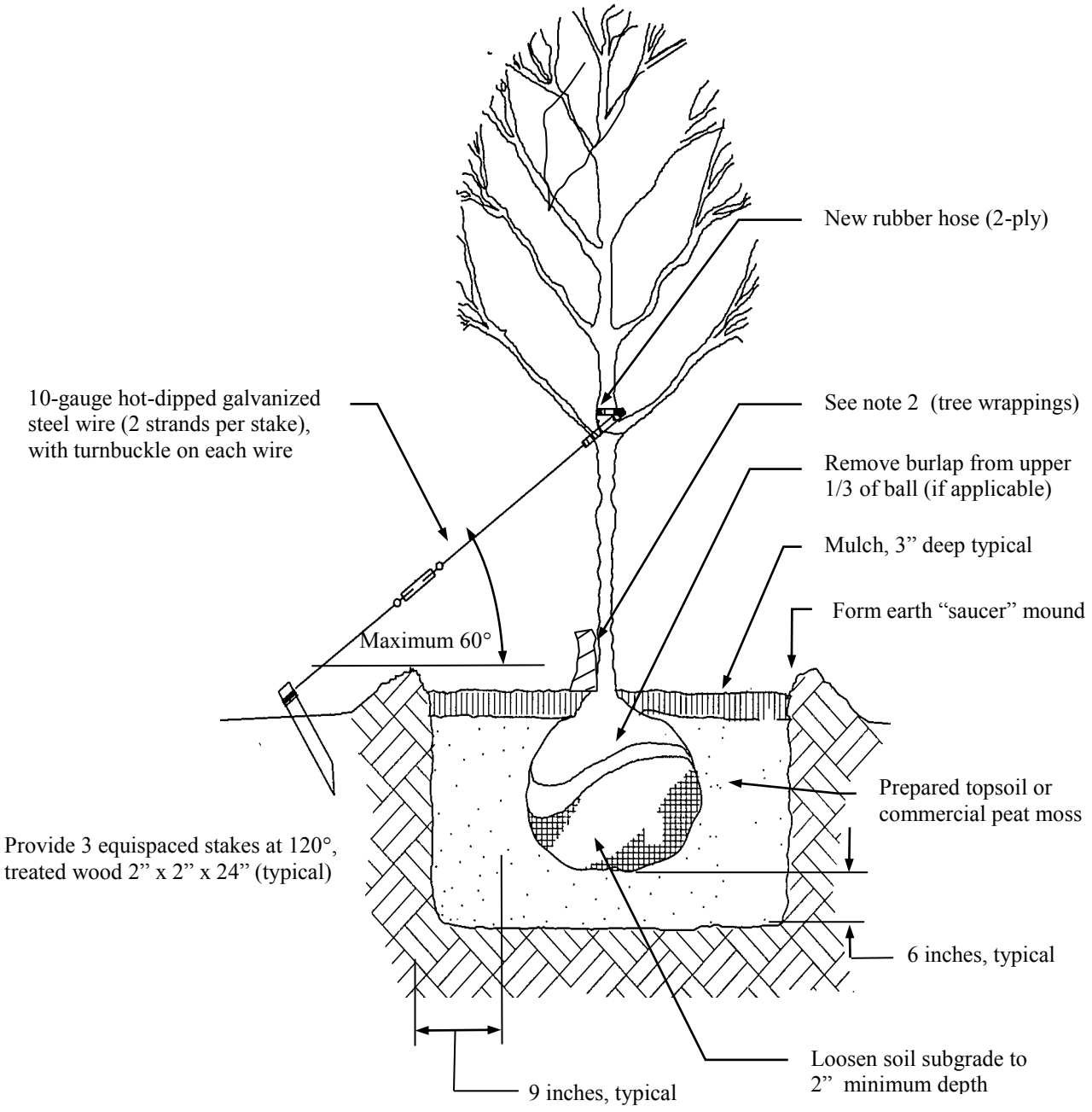


Figure ES-10-2
Typical Planting Detail – Tree

ARTICLE 12. - LANDSCAPE

12.1 - PURPOSE

The landscape standards of this Article are intended to:

A. Create a desirable and functional open space environment for all site users, including pedestrians, bicyclists, and motorists.

B. Preserve unique natural resources, including measures to preserve and protect existing healthy plantings.

C. Design drainage facilities to promote the use and preservation of natural watercourses and patterns of drainage.

D. Establish a natural environment within the City that provides a variety of benefits, including absorbing carbon dioxide and producing oxygen; intercepting stormwater, reducing surface runoff, curtailing erosion, and improving water quality; providing critical wildlife habitat to promote urban biodiversity; and providing shade to aid in passive cooling and the reduction of urban heat island effect.

E. Utilize plant materials suitable to withstand the climatic conditions of the City and microclimate of the site. The use of invasive species is prohibited.

F. Use of screening to minimize the impact of the development on adjacent uses and impact of incompatible uses and certain site elements, and creating a logical transition to adjoining lots and developments.

G. This Article does not apply to routine landscaping or routine maintenance of existing landscaping.

(Ord. No. O-87-2020 , § 1, 5-19-20)

12.2 - LANDSCAPE PLAN

A. **Landscape Plan Required**

A landscape plan is required as part of a site plan review application for multi-family and townhouse development, nonresidential (including mixed-use) development, parking lots, and planned developments. The landscape plan must be approved prior to the issuance of a building permit.

B. **Content of Landscape Plan**

1. North arrow and graphic scale, the location and dimensions of all existing and proposed structures, property lines, easements, parking lots and drives, rights-of-way, refuse disposal and recycling areas, pedestrian and bicycle paths, fences, mechanical equipment, overhead utility wires, underground utilities, retention/detention facilities, and other drainage facilities, such as drainage swales. Identify lines of sight at all access points and at locations adjacent to intersections.
2. The location, quantity, size, name, and condition, both botanical and common, of all existing trees equal to or greater than 2.5 inches in caliper, indicating trees to be retained and to be removed.
3. The location, quantity, size, and name, both botanical and common, of all proposed plant material. This includes lawn and turf applications.
4. The existing and proposed grading of the site indicating contours at two-foot intervals. Any proposed berming, earthwork, or stormwater management basins must also be indicated using two-foot contour intervals.
5. Elevations of all existing and proposed fences, stairs, and retaining walls.
6. Existing and proposed plantings in the right-of-way.
7. Any proposed irrigation plan, if irrigation is provided.

8. Any other details as determined necessary by the review body.

C. **Minor Changes to Approved Landscape Plans**

Minor changes to the landscape plan that do not result in a reduction in the net amount of plant material as specified on the approved landscape plan may be approved by the Zoning Administrator. Changes that reduce the amount of plant materials contained within an approved landscape plan are a major change and must be approved by the body granting approval of the landscape plan initially.

D. **Alternative Landscape Design**

1. These landscape requirements are intended to set minimum standards for quality development and environmental protection. Site conditions or other reasons may justify the need to request an alternate method of compliance. Alternative landscape plans may be considered when an applicant cannot meet one or more of the specific requirements of this Article because:
   a. Strict application of the landscaping requirements would require unreasonable or unnecessary compliance. Such situations could include water features, topography, lot configurations, utility maintenance zones, or unusual site conditions.
   b. The applicant envisions a more creative means to meet the spirit and intent of these requirements.
   c. A comprehensive landscaping plan involving several properties is proposed.
2. The applicant must submit an alternative landscape plan indicating proposed landscaping, that includes a list of landscaping requirements not met, a description of the alternatives proposed, and a written explanation of how the proposed plan fulfills the spirit and intent of the landscape requirements. The Alternative Landscape Plan must be submitted to and reviewed by the Administrative Review Committee. In making a recommendation regarding the alternative landscape plan, the Administrative Review Committee must find that:
   a. The proposed alternative will not present a safety hazard.
   b. That proposed alternative will, upon maturity, provide landscaping that is equal to or better than the standard requirements.
   c. The proposed alternative is designed to address plant health and vigor.
   d. The proposed alternative is reasonably compatible with the natural and topographic features of the site.

(Ord. No. O-87-2020 , § 1, 5-19-20)

12.3 - SELECTION, INSTALLATION AND MAINTENANCE

A. **Selection**

1. All plant materials must be of good quality and meet American Horticulture Industry Association (AmericanHort) or its ANSI accredited successor's standards for minimum acceptable form, quality, and size for species selected.
2. Species must be selected based on those that will survive and thrive in East Tennessee. Trees should be selected from the City of Knoxville's Tree List maintained by the City.
3. The use of native species and drought tolerant species is encouraged.
4. Invasive species are prohibited.

B. **Installation**

1. All landscape materials must be installed in accordance with current nursery industry standards, and must be properly supported to ensure survival. Support devices such as guy wires or stakes must not interfere with pedestrian or vehicular movement.

2. All plant materials must be free of disease and installed so that soil of sufficient volume, composition, and nutrient available to sustain healthy growth. Installation of plant materials during the appropriate growing season is encoura
3. Landscape materials should not conflict with existing overhead and underground utility infrastructure and maintenance zones. Landscape plans should reference the City of Knoxville's Tree List for appropriate species and their respective planting distances from adjacent utility infrastructure. Landscaping should not be selected that at maturity would grow into conflict with the utility maintenance zone. Alternative landscape plans (Section 12.1.D) may be considered when an applicant demonstrates that requirements may conflict with the utility maintenance zones.
    a. Overhead utilities: At maturity, landscaping should not grow within ten feet of primary distribution lines and 25 feet within 69 kV sub-transmission lines.
    b. Utility poles: Trees should not be planted within ten feet of primary distribution poles and 25 feet within 69 kV sub-transmission poles.
    c. Support wires: Trees should not be planted within five feet of supporting guy wires.
    d. Underground utility lines: The minimum distance of tree planting from the utility center line should be a minimum of ten feet. Shrubs and other landscaping vegetation are permitted in this area.
    e. Pad mount transformers: Landscaping should be planted a minimum of six feet away from the side with doors and three feet away from the other sides.
4. If landscape material is located within a utility easement and repair or replacement of the utility is needed, the City or utility is not responsible for the replacement of any landscape that may be damaged.

C. **Curbing**

1. Landscaped areas may be recessed if flush curbs are utilized. If recessed, the landscaped areas must be designed for stormwater management and to prevent erosion and tracking.
2. Landscaped areas must be protected from encroachment of vehicles through use of curbs or wheel stops where necessary.

D. **Maintenance**

1. Landscape materials depicted on approved landscape plans are considered a required site element in the same manner as structures, required parking, lighting, and other improvements. As such, the owner of record or the business or homeowner's association is responsible for the maintenance, repair, and replacement of all landscape materials, fences, steps, retaining walls, and similar landscape elements.
2. All landscape materials must be maintained in good condition, present a healthy appearance, and be kept free of refuse and debris. Any dead, unhealthy, or missing plants must be replaced within 30 days of notification, unless an extension is approved by the City.

(Ord. No. O-87-2020 , § 1, 5-19-20)

12.4 - LANDSCAPE DESIGN STANDARDS

A. **Minimum Planting Sizes**

Minimum planting sizes are as follows. For the purposes of determining trunk size, the caliper is measured at six inches above ground level, unless otherwise specified in current American Standard for Nursery Stock (ANSI Z60.1).

1. Evergreen trees must have a minimum height of eight feet.
2. Shade trees must have a minimum two-inch caliper.

3. Single stem ornamental trees must have a minimum trunk size of 2.5 inches in caliper. Multiple stem ornamental tr have a minimum height of eight feet.
4. Evergreen or deciduous shrubs must have must have a minimum height of 18 inches.

B. **Species Diversity**

Diversity among required plant material is required for visual interest and to reduce the risk of losing a large population of plants due to disease. Table 12-1: Plant Diversity Requirements indicates the percentage of diversity required based on the total quantity of species being used. (For example, if a development requires 45 shade trees, no more than 18 trees (40%) can be of one species, and there must be a minimum of five different species within the 45 trees.) When the calculation of plant diversity requirements results in a fraction, the fraction is rounded up.

Table 12-1: Plant Diversity Requirements

Total Number of Plants per Plant Type	Maximum Number of One Species	Minimum Number of Species
1—4	100%	1
5—10	60%	2
12—15	45%	3
16—75	40%	5
76—500	25%	8
501—1,000	30%	10
1,000+	15%	15

(Ord. No. O-87-2020 , § 1, 5-19-20; Ord. No. O-123-2020 , § 1, 8-25-20)

12.5 - PARKING LOT PERIMETER LANDSCAPE YARD

A perimeter landscape yard, which is established where the parking lot abuts a street right-of-way, is required for all new parking lots of 10,000 square feet or more in area and for any expansions or improvements of existing parking lots when required by Section 11.1.C of 10,000 square feet or more in area. The perimeter landscape yard must be established along the edge of the parking lot to screen vehicle parking from the right-of-way. When an existing parking area is expanded, only the area of expansion shall be required to comply with these landscaping standards. The landscaped area must be improved as follows:

A. Parking lots 20,000 square feet or greater in area require a perimeter yard at least ten feet wide. The width of the perimeter yard may be reduced to six feet for parking lots, including vehicular use areas, of less than 20,000 square feet. Parking lots of less than 10,000 square feet in area are exempt from parking lot perimeter landscape

yard.

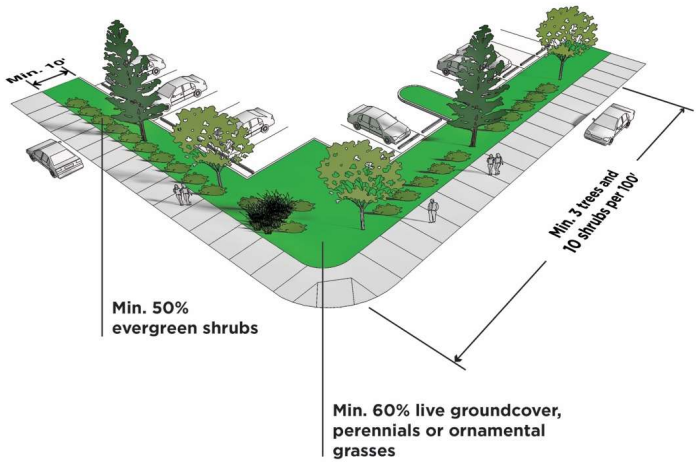
B. The perimeter yard must be planted with a minimum of three shade and/or evergreen trees and ten shrubs for every 100 linear feet. A minimum of 50% of the shrubs must be evergreen. For parking lots, including vehicular use areas, of less than 20,000 square feet in area, the width of the perimeter screening area may be reduced to six feet.

C. 60% of the landscape area outside of shrub and tree masses must be planted in live groundcover, perennials, or ornamental grasses. Stone, mulch, or other permeable landscape materials may be used for any remaining area.

D. Parking lots located on properties developed under a common or unified development plan and/or which have a shared access agreement are not required to provide the perimeter screening area along common property lines where parking areas abut.

E. Areas of off-street parking areas that abut an alley are not required to install a perimeter landscape yard along the alley frontage.

PARKING LOT PERIMETER LANDSCAPE YARD



(Ord. No. O-87-2020 , § 1, 5-19-20; Ord. No. O-123-2020 , § 1, 8-25-20)

12.6 - INTERIOR PARKING LOT LANDSCAPE

Interior parking lot landscape is required for all new parking lots and vehicular use areas of 20,000 square feet or more in area, and for any expansions or improvements of existing parking lots and vehicular use areas of 20,000 square feet or more when required by Section 11.1.C. The landscape required is as follows:

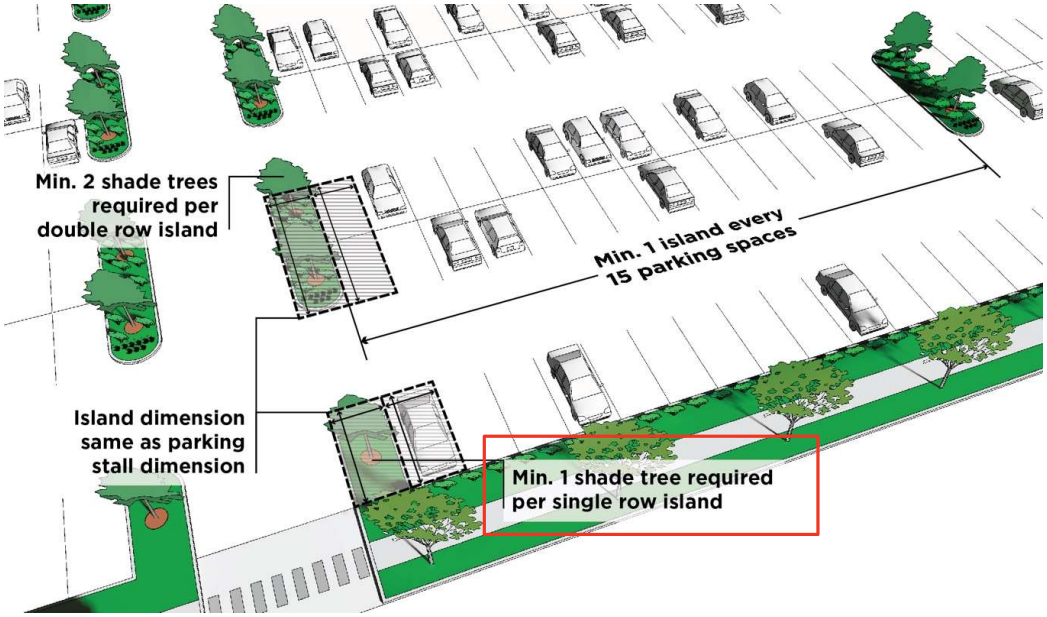
A. Where more than 15 parking stalls are provided in a row, one parking lot island must be provided between every 15 parking spaces. As part of the landscape plan approval, parking lot island locations may be varied based on specific site requirements or design scheme, but the total number of islands must be no less than the amount required of one island for every 15 spaces.

B. Parking lot islands must be a minimum of 120 sf in single rows. Double rows of parking must provide parking lot islands that are a minimum of 240 sf.

C. A minimum of one shade tree must be provided in every parking lot island or landscape area for single row parking lot islands and two shade trees for double row parking lot islands. In addition to the required shade trees, a minimum of 60% of the area of every parking lot island must be planted in shrubs, live groundcover,

perennials, or ornamental grasses, unless the parking lot island or landscape area is designed to facilitate pedestrian access through the parking lot as approved in landscape plan review. Stone, mulch, or other permeable landscape materials may be used for any remaining area.

INTERIOR PARKING LOT LANDSCAPE



12.7 - SITE LANDSCAPE

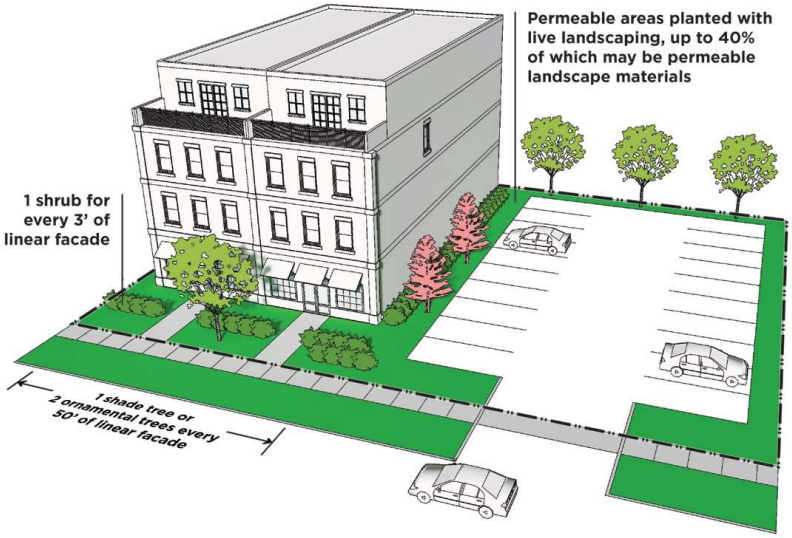
Site landscape requirements apply to new construction and to any additions to a structure existing as of the effective date of this Code of 30% or more in square footage.

A. Areas of any lot that are not covered by structures, pavement, and vehicle parking areas must be planted with live landscaping. Stone, mulch, or other permeable landscape materials may be used to satisfy this requirement, but must not cover more than 40% of the landscape area.

B. Where multi-family and nonresidential (including mixed-use) developments are located ten feet or more from a street lot line and no parking is located in front of the structure or development and where any façade abuts any parking area, foundation landscape must be planted as described below. This planting area is required along 60% of the linear façade area. This percentage may be reduced to accommodate entry design and other building functional operations during landscape plan review.

1. One shrub for every three feet. Shrub locations within the planting area may be varied, but the total number of shrubs must be no less than as required in this section.
2. Shade trees are required in the amount of one tree every 50 feet. Two ornamental trees may be substituted for one shade tree and must be spaced one ornamental tree every 25 feet. Tree locations within the planting area may be varied, but the total number of trees must be no less than as required in this section.
3. 60% of the landscape area outside of shrub and tree masses must be planted in live groundcover, perennials, or ornamental grasses. Stone, mulch, or other permeable landscape materials may be used for the remaining area.
4. Planted pots and/or planter boxes may be used to satisfy up to 30% of the total landscape area requirement.

SITE LANDSCAPE



12.8 - BUFFER YARDS

This section establishes standards for the dimension and required landscape for buffer yards between land uses and/or zoning districts within the rear and/or side yards. Nothing in this section prevents the applicant's voluntary installation of buffer yards where they are not required. Buffer yard requirements apply to new construction and to any additions to a structure existing as of the effective date of this Code of 30% or more in square footage.

A. Buffer yards may be located within required setbacks but must be reserved for the planting of material and installation of screening as required by this section. No parking, driveways, sidewalks, accessory structures, or any impervious surfaces are permitted within the buffer yard area.

B. The two types of buffer yards are as follows:

1. **Class A Buffer**
    a. Minimum Width: Ten feet.
    b. Minimum Required Shrubs: One shrub every five feet. A minimum of 50% of the shrubs must be evergreen.
    c. Minimum Required Trees: One evergreen tree for every 25 feet and one shade tree for every 50 feet.
    d. Planting locations may be varied, but the total number of trees must be no less than as required in this section.
    e. 60% of the landscape area outside of shrub and tree masses must be planted in live groundcover, perennials, or ornamental grasses. Stone, mulch, or other permeable landscape materials may be used for the remaining area.
2. **Class B Buffer**
    a. Minimum Width: Twenty feet.
    b. Minimum Required Shrubs: One shrub every three feet. A minimum of 50% of the shrubs must be evergreen.
    c. Minimum Required Trees: One evergreen tree for every 20 feet and one shade tree for every 30 feet.
    d. Planting locations may be varied, but the total number of trees must be no less than as required in this section.

e. 60% of the landscape area outside of shrub and tree masses must be planted in live groundcover, perennial grasses. Stone, mulch, or other permeable landscape materials may be used for the remaining area.

C. Where the buffer yard incorporates a wall or solid fence, or a combination of such, the buffer yard width may be reduced by 30%.

D. When a wall or solid fence is incorporated into a buffer yard, it must be a minimum of six feet up to a maximum of eight feet. When a wall or solid fence is combined with a berm, the combined height of the wall or solid fence and any berm cannot be less than six feet or exceed eight feet.

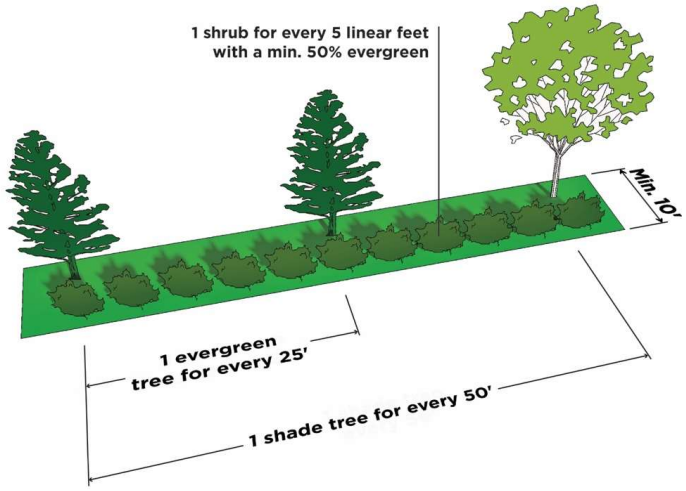
E. Parking lots located on properties developed under a common or unified development plan and/or which have a shared access agreement are not required to provide the buffer yard screening area along common property lines where parking areas abut.

F. Buffer yards are required as described in Table 12-2: Buffer Yard Requirements:

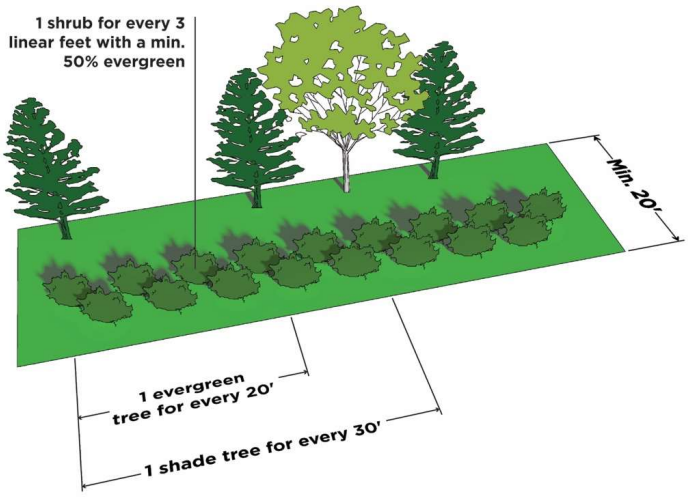
Table 12-2: Buffer Yard Requirements

Development	Buffer Yard Class
Nonresidential use located within residential district	Class A Buffer
Nonresidential district abuts a residential district	Class B Buffer
Parking lot of a multi-family dwelling abutting a RN-3, RN-2, RN-1 or EN residential district	Class A Buffer
Per use standards (Article 9)	As determined in the standards of Article 9

CLASS A BUFFER YARD



CLASS B BUFFER YARD



(Ord. No. O-88-2020 , § 1, 5-19-20)

12.9 - TREE PRESERVATION

Existing healthy trees must be conserved when possible and will be credited toward landscaping requirements, when they are comparable in terms of species to new trees that would be permitted in the proposed location.

A. Credit for conserving existing, healthy trees is subject to Urban Forester approval. The credit approved for each conserved tree is based on a tree's diameter, measured 4.5 feet above the ground, and may be up to the amount indicated below:
   1. Four to eight inches: Two trees credited
   2. Eight to twelve inches: Three trees credited
   3. Twelve to eighteen inches: Four trees credited
   4. Eighteen inches or greater: Five trees credited

B. Existing trees may be used to fulfill some of the perimeter screening requirements, subject to approval by the Zoning Administrator. Existing trees are credited as set forth in this section. Trees to be conserved must be identified on the required landscaping plan. Conserved trees may comprise no more than 50% of the perimeter screening requirements and must be supplemented with new landscaping as required to create an effective screen.

C. If existing trees are being used as credit toward meeting the tree planting standards, a grading permit will not be issued until the following tree preservation protections are installed. Tree preservation includes the preservation of the trees root system within the tree protection zone.
   1. The tree protection zone is determined by measuring one foot in radius away from the trunk of the tree for every one inch in diameter at 4.5 feet in height. No more than 10% of the tree protection zone may be disturbed with fill or grading work. Any impervious area within the existing tree protection zone does not need to be included in preservation measures.
   2. Within the tree protection zone of a tree, there may be no cut or fill material unless a Certified Arborist has evaluated and determined that the disturbance will not impact the health of the tree.
   3. Prior to and during construction, temporary barriers must be erected around all protected trees with barriers a minimum of four feet in height. There may be no storage or movement of equipment, material, debris, or

fill within the fenced, tree-protection zone.

4. During construction, the applicant must prevent the cleaning of equipment or material or the storage and disposal of waste material, such as paints, oils, solvents, asphalt, concrete, motor oil, or any other material, potentially harmful to the tree within the drip line of any protected tree. Nothing within this section is interpreted as an authorization to ignore or violate applicable federal or state hazardous waste laws.
5. No damaging attachment, wires, signs, or permits may be fastened to any protected tree.

LARGE TREE GROUP: Mature height typically more than 50' tall

DISCLAIMER *This list is to be utilized as general guidance in planting projects*	Form	Growth Rate	Aestetic Flowers	Fall Color	Recommended Street Tree	Poor Soil Tolerant	Wet Tolerant	Drought Tolerant	Shade Tolerant
Red Maple* (*Acer rubrum*)	Rounded to Oval	Medium	Yes	Red	Minimal Use	No	Yes	No	Intermediate
Sugar Maple* (*Acer saccharum*)	Rounded	Medium to Slow	No	Yellow	Minimal Use	No	No	No	Yes
Yellow Buckeye* (*Aesculus flava*)	Rounded	Medium to Fast	Yes	Orange	Minimal Use	No	Intermediate	No	Yes
Pecan* (*Carya illinoinensis*)	Oval	Medium	No	Yellow	No	No	Intermediate	Yes	No
Common Hackberry* (*Celtis occidentalis*)	Pyramidal to Round	Medium to Fast	No	Yellow	No	No	No	Yes	Intermediate
American Beech* (*Fagus grandifolia*)	Round to Open	Slow	No	Bronze	No	No	No	No	Yes
European Beech (*Fagus sylvatica*)	Upright to Oval	Slow to Medium	No	Bronze	Minimal Use	No	No	No	Intermediate
Ginkgo (*Ginkgo biloba*)	Pyramidal to Round	Medium	No	Yellow	Yes	Yes	No	Yes	no
Thornless Honeylocust* (*Gleditsia triacanthos*)	Round	Medium to Fast	No	Yellow	Yes	Yes	No	Yes	No
Kentucky Coffeetree* (*Gymnocladus dioica*)	Oval to Open	Slow to Medium	No	Yellow	Yes	Yes	No	Yes	No
Sweetgum* (*Liquidambar styraciflua*)	Pyramidal to Oval	Medium to Fast	No	Various	Yes	No	Yes	No	No
Tulip Poplar* (*Liriodendron tulipifera*)	Pyramidal to Oval	Fast	Yes	Yellow	Yes	No	No	No	No
Cucumbertree Magnolia (*Magnolia acuminata*)	Pyramidal to Spreading	Medium to Fast	Yes	Brown	Minimal Use	No	No	No	Intermediate
Southern Magnolia* (*Magnolia grandiflora*)	Pyramidal	Slow to Medium	Yes	Evergreen	No	No	No	Yes	Intermediate
Dawn Redwood (*Metasequoia glyptostroboides*)	Pyramidal	Medium to Fast	No	Yellow	Yes	No	No	No	No
Blackgum* (*Nyssa sylvatica*)	Pyramidal	Slow to Medium	No	Various	Yes	No	Yes	No	Intermediate
Shortleaf Pine* (*Pinus echinata*)	Conical to Oval	Medium	No	Evergreen	No	No	No	Yes	No
Pitch Pine* (*Pinus rigida*)	Conical to Oval	Medium	No	Evergreen	No	No	No	Yes	No
White Pine* (*Pinus strobus*)	Conical to Oval	Medium to Fast	No	Evergreen	No	No	No	No	Intermediate
Loblolly Pine* (*Pinus taeda*)	Conical to Oval	Fast	No	Evergreen	No	No	Intermediate	Yes	No
Virginia Pine* (*Pinus virginiana*)	Conical to Open	Slow	No	Evergreen	No	No	No	Yes	No
London Planetree (*Platanus X acerifolia*)	Pyramidal to Open	Medium	No	Yellow	Yes	Yes	No	No	Intermediate
American Sycamore* (*Platanus occidentalis*)	Pyramidal to Open	Medium to Fast	No	Yellow	No	No	Yes	No	Intermediate
Sawtooth Oak (*Quercus acutissima*)	Round	Medium	No	Yellow	Yes	Yes	No	Yes	No
White Oak* (*Quercus alba*)	Round to Spreading	Slow to Medium	No	Red	Minimal Use	No	No	No	No
Swamp White Oak* (*Quercus bicolor*)	Round	Medium	No	Yellow	Yes	No	Yes	Yes	No
Southern Red Oak* (*Quercus falcata*)	Spreading	Slow to Medium	No	Red	No	No	No	No	No
Bur Oak* (*Quercus macrocarpa*)	Round to Spreading	Slow	No	Yellow	Minimal Use	No	No	Yes	No
Swamp Chestnut Oak* (*Quercus michauxii*)	Round	Medium	No	Orange	No	No	Yes	No	No
Chinkapin Oak* (*Quercus muehlenbergii*)	Round	Slow to Medium	No	Indistinct	Minimal Use	No	No	No	No
Nuttall Oak (Quercus nuttallii)	Pyramidal to Rounded	Medium to Fast	No	Red	Yes	Yes	Yes	Yes	No
Pin Oak* (*Quercus palustris*)	Pyramidal to Rounded	Medium to Fast	No	Various	No	No	Yes	No	No
Willow Oak* (*Quercus phellos*)	Pyramidal to Rounded	Medium	No	Yellow	Yes	Yes	Yes	Yes	No
Chestnut Oak* (*Quercus prinus*)	Rounded	Medium	No	Orange	Yes	No	No	Yes	No
English Oak (*Quercus robur*)	Upright to Round	Slow to Medium	No	Indistinct	Minimal Use	No	No	No	No
Northern Red Oak* (*Quercus rubra*)	Rounded	Medium to Fast	No	Red	Yes	No	No	No	No
Shumard Oak* (*Quercus shumardii*)	Rounded	Medium	No	Red	Minimal Use	Yes	No	Yes	No
Black Oak* (*Quercus velutina*)	Round to Open	Slow to Medium	No	Red	Minimal Use	No	No	Yes	No
Bald Cypress* (*Taxodium distichum*)	Pyramidal	Medium	No	Orange	Yes	Yes	Yes	No	No
American Basswood* (*Tilia americana*)	Pyramidal to Rounded	Medium	No	Indistinct	Minimal Use	No	No	No	Intermediate
Winged Elm* (*Ulmus alata*)	Vaseshape to Round	Medium	No	Yellow	Minimal Use	No	No	No	No
American Elm* (*Ulmus americana*)	Vaseshape	Medium to Fast	No	Yellow	Yes	Yes	Yes	Yes	Intermediate

* Native to Tennessee

MEDIUM TREE GROUP: Mature height typically 30' - 50' tall

DISCLAIMER *This list is to be utilized as general guidance in planting projects*	Form	Growth Rate	Aestetic Flowers	Fall Color	Recommended Street Tree	Poor Soil Tolerant	Wet Tolerant	Drought Tolerant	Shade Tolerant
Hedge Maple (*Acer campestre*)	Round to Oval	Slow	No	Yellow	Yes	Yes	No	Yes	Intermediate
Trident Maple (*Acer buergerianum*)	Round to Oval	Slow to Medium	No	Orange	Yes	Yes	No	Yes	No
Chalkbark Maple (*Acer leucoderme*)	Round to Oval	Slow to Medium	No	Orange	Minimal Use	No	No	Yes	Yes
Shuntung Maple (*Acer truncatum*)	Round	Slow	No	Yellow	Yes	Yes	No	Yes	No
River Birch* (*Betula nigra*)	Pyramidal to Round	Medium to Fast	No	Yellow	Minimal Use	No	Yes	No	No
European Hornbeam (*Carpinus betulus*)	Upright to Oval	Slow to Medium	No	Yellow	Yes	Yes	No	No	Intermediate
American Hornbeam* (*Carpinus caroliniana*)	Oval	Slow	No	Various	Yes	No	Intermediate	No	Intermediate
Catalpa* (*Catalpa speciosa*)	Oval	Medium to Fast	Yes	Indistinct	Minimal Use	No	No	Yes	Intermediate
Atlas Cedar (*Cedrus atlantica*)	Pyramidal	Slow	No	Evergreen	No	No	No	No	Intermediate
Deodar Cedar (*Cedrus deodara*)	Pyramidal	Medium	No	Evergreen	No	No	No	No	No
Atlantic White Cedar (*Chamaecyparis thyoides*)	Pyramidal to Upright	Medium	No	Evergreen	No	No	Intermediate	No	No
Yellowwood* (*Cladrastis kentukea*)	Round	Medium	Yes	Yellow	Yes	Yes	No	No	No
Turkish Fibert (*Corylus colurna*)	Pyramidal	Medium	No	Indistinct	Yes	Yes	No	yes	No
Cryptomeria (*Cryptomeria japonica*)	Pyramidal	Medium	No	Evergreen	No	No	No	No	Intermediate
American Persimmon* (*Diospyros virginiana*)	Oval	Slow to Medium	No	Yellow	Minimal Use	No	No	No	No
Hardy Rubber Tree (*Eucommia ulmoides*)	Round	Medium	No	Indistinct	Yes	Yes	No	Yes	Intermediate
American Holly* (*Ilex opaca*)	Pyramidal	Slow to Medium	No	Evergreen	Minimal Use	No	No	No	Yes
Eastern Red Cedar* (*Juniperus virginiana*)	Upright to Oval	Medium	No	Evergreen	No	No	No	Yes	No
Golden Raintree (*Koelreuteria paniculata*)	Round	Medium to Fast	Yes	Yellow	Yes	Yes	No	Yes	No
Sweetbay Magnolia* (*Magnolia virginiana*)	Upright to Open	Medium	Yes	Yellow	No	No	Yes	No	Yes
Eastern Hophornbean* (*Ostrya virginiana*)	Pyramidal to Round	Slow	No	Yellow	Yes	Yes	Intermediate	No	Yes
Sourwood* (*Oxydendrum arboreum*)	Pyramidal to Oval	Slow	Yes	Various	Minimal Use	No	No	No	Intermediate
Austrian Pine (*Pinus nigra*)	Pyramidal	Medium	No	Evergreen	No	No	No	Yes	No
Japanese Red Pine (*Pinus densiflora*)	Upright to Open	Slow to Medium	No	Evergreen	No	No	No	No	No
Chinese Pistache (*Pistacia chinensis*)	Round	Medium	No	Orange	Yes	Yes	No	Yes	No
Overcup Oak* (*Quercus lyrata*)	Round to Spreading	Medium	No	Yellow	Yes	Yes	Intermediate	Yes	No
Black Locust* (*Robinia pseudoacacia*)	Upright to Oval	Fast	Yes	Indistinct	No	No	No	Yes	No
Weeping Willow (*Salix babylonica*)	Round to Weeping	Fast	No	Indistinct	No	No	Yes	Yes	No
Sassafras* (*Sassafras albidum*)	Oval to Open	Medium to Fast	Yes	Various	No	No	No	No	No
Japanese Pagoda (*Sophora japonica*)	Upright to Spreading	Medium to Fast	Yes	Indistinct	Yes	Yes	No	Yes	No
Little-leaf Linden (*Tilia cordata*)	Pyramid to Oval	Medium	No	Yellow	No	No	No	Yes	No
Silver Linden (*Tilia tomentosa*)	Pyramid to Oval	Medium	No	Yellow	Yes	Yes	No	Yes	No
Smooth Leaf Elm (*Ulmus carpinifolia*)	Upright to Spreading	Medium	No	Yellow	Yes	Yes	No	No	No
Lace-bark Elm (*Ulmus parvifolia*)	Vaseshape to Spreading	Medium to Fast	No	Yellow	Yes	Yes	No	Yes	No
Zelkova (*Zelkova serrata*)	Vaseshape	Medium	No	Various	Yes	Yes	No	No	No

* Native to Tennessee

Appendix B: Transportation

TRAFFIC IMPACT STUDY

UNIVERSITY OF TENNESSEE OUTDOOOR CULTURAL AND RECREATIONAL CENTER AT CHEROKEE LANDING

PREPARED FOR:

UT RESEARCH PARK

PREPARED BY:

BIG ORANGE BUILDERS

CE 400: SENIOR DESIGN

UNIVERSITY OF TENNESSEE, KNOXVILLE

MAY 2022

1.0 Introduction

1.1 Purpose of Study

The purpose of this condensed traffic impact study is to evaluate the impact of the Outdoor Cultural and Recreational Center on the roadway network under existing conditions. The evaluation will include an assessment of current traffic and roadway conditions. This study is intended to supply data for use by an expanded impact assessment to evaluate future roadway conditions.

1.2 Methodology

This traffic impact study consists of turn-count data collection, determining the number of trips expected to be generated by the development, directional distribution of trips, analyses of the study intersections with the development, and recommendations to mitigate the impacts of the development on the study area roadway network.

1.3 Proposed Development

The project site is located at the University of Tennessee Research Park at the Tennessee Riverfront along Cherokee Farm Way. The proposed development includes the construction of a boathouse structure, a boat ramp, a dock, a parking lot, and pedestrian walkways. The site will be accessed by the northbound and southbound exits to the park from Alcoa Highway. The Project Location Map of the proposed development is shown in Figure 1.

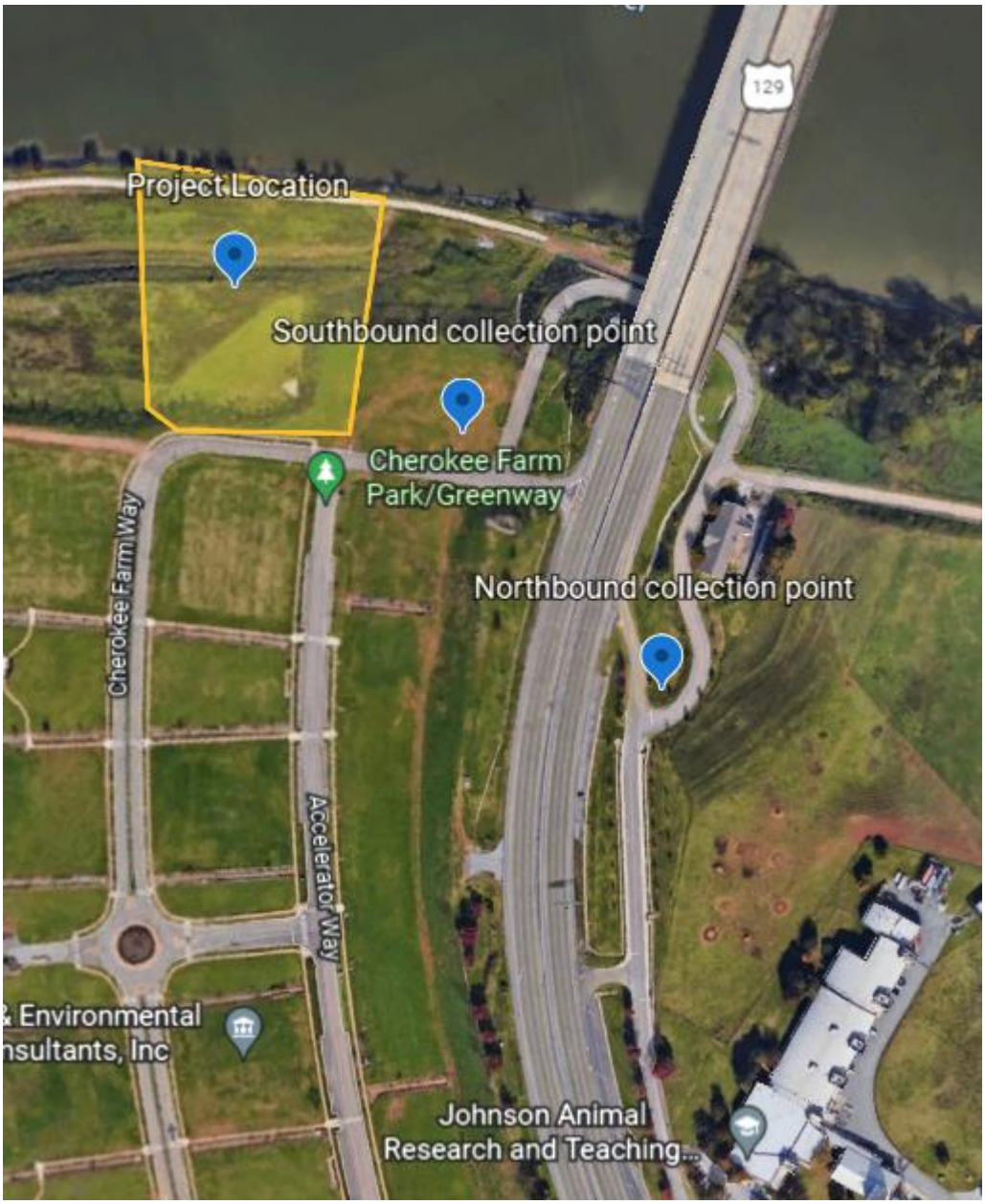


Figure 1: Project Location Map (Google maps)

1.4 Study Area

This development will be primarily accessed through the Northbound and Southbound ramps from Alcoa Highway to the Research Park. Table 1 summarizes the existing traffic control at the study intersections.

Table 1 – Study Intersections	
Intersection	**Existing Traffic Control**
Alcoa Highway Northbound x UTRP (JARTU side of park)	Unsignalized

Alcoa Highway Southbound x UTRP (IAMM side of park)	Unsignalized

2.0 Existing Conditions

2.1 Roadway Network

Roadway geometry and posted speed limits were obtained via a site visit conducted on February 28, 2022, and from Google Earth. Functional classifications were obtained from the TDOT Functional Classification Maps. This information is summarized in Table 2.

Table 2 – Roadway Information				
Roadway	Number of Lanes	Posted Speed Limit	Functional Classification	Roadway Width
Alcoa Highway (NB)	3 (one direction)	55 mph	Major Arterial	36 ft
Alcoa Highway (SB)	3 (one direction)	55 mph	Major Arterial	36 ft
Cherokee Farm Way	2 (2 directions)	30 mph	Minor Collector	29 ft
Performance way	2 (2 directions)	30 mph	Minor Collector	29 ft

2.2 Traffic Data

Turn movement counts were conducted by the student team and include data from April 1, 2022, and April 4, 2022. Traffic counts were supplied for the northbound and southbound exit ramps from Alcoa Highway onto the UT Research Park, and are included in Appendix B. The counts were taken for the northbound ramp at the intersection between Cherokee Farm Way and the road connecting the on and off ramps of Alcoa Highway. The counts were taken for the southbound ramp at the intersection of Cherokee Farm Way and Performance Way. The volumes were collected in 15-minute intervals to find the AM (7:00 AM-9:00 AM) and PM (4:00 PM-6:00 PM) peak hour volumes as well as the peak hour factors. The intersection peak hours are summarized in Table 3 and the existing peak hour volumes are shown in figure 2.

Table 3 – Ramp Peak Hours		
Ramp	AM Peak Hour	PM Peak Hour
Northbound (JARTU)	7:00 – 8:00 AM, PHF = 0.92	4:15 – 5:15 PM, PHF = 0.66
Southbound (IAMM)	7:15 – 8:15 AM, PHF = 0.77	4:00 – 5:00 PM, PHF = 0.79

Figure 2: Existing Peak Hour Volumes

2.3 Pedestrian and Bicycle Network

There are no existing bicycle lanes or pedestrian facilities provided in the study area.

2.4 Transit Network

The University of Tennessee has historically supplied a shuttle service to the IAMM building at the UT Research Park. This route uses the southbound exit into the park. At the time this study is being conducted, this route is not in use, however it may be in operation in the future.

3.0 Background Conditions

3.1 Background Traffic Growth

Historic traffic data from TDOT count stations (TDOT 2022) was used to evaluate historic traffic trends and determine a suitable growth rate for the study area. TDOT count station 47000317 showed an AADT of 25,466 vehicles northbound and 25,776 vehicles southbound on Alcoa Highway in 2018 (the most recent year for both directions). The two-way station data gives an overall two-way AADT of 44,047 in 2020. Trendlines were developed in Excel to map the average growth rate of Alcoa highway, and the data showed decreasing rates of increase since 1986. The team applied a constant growth rate of 1%, which is the average growth rate since 1986, but this is a conservative estimate, and traffic may not reach this value. Assuming this constant growth, Alcoa Highway is estimated to reach an AADT of 51,137 vehicles in 2035. Considering the high traffic volumes on Alcoa Highway, this development is unlikely to generate enough new trips to significantly impact the roadway's level of service. Table 2 displays the expected average daily traffic volumes applying the conservative constant growth rate of 1% per year.

Table 2: Traffic Forecast			
2020	44047	**2028**	47696
2021	44487	**2029**	48173
2022	44932	**2030**	48655
2023	45381	**2031**	49141
2024	45835	**2032**	49633
2025	46293	**2033**	50129
2026	46756	**2034**	50630
2027	47224	**2035**	51137

The figures below display the trendlines used to determine the growth rate of traffic on Alcoa Highway. As shown, the data trends downward or near zero. Thus, for the purposes of projecting growth, a conservative estimate of 1% is used.

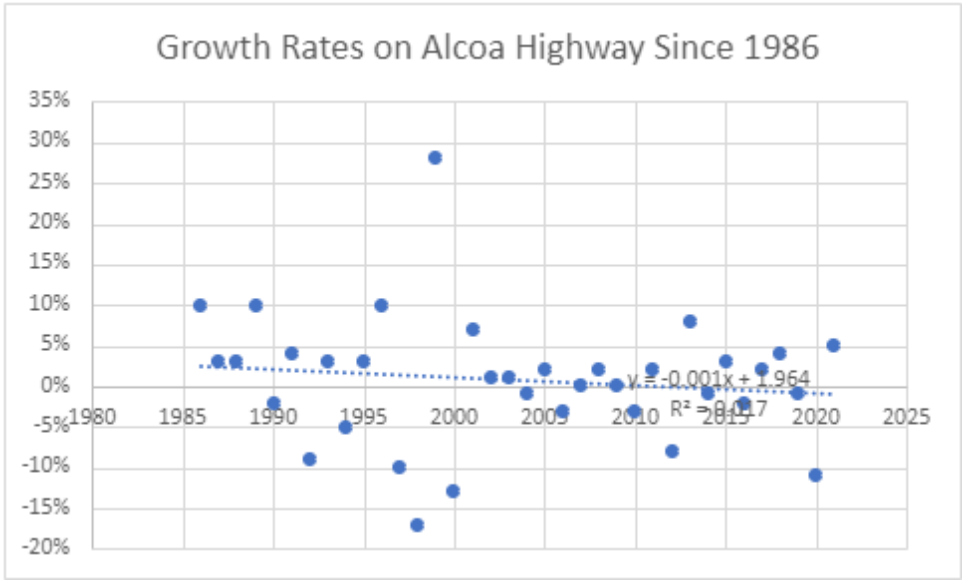


Figure 3

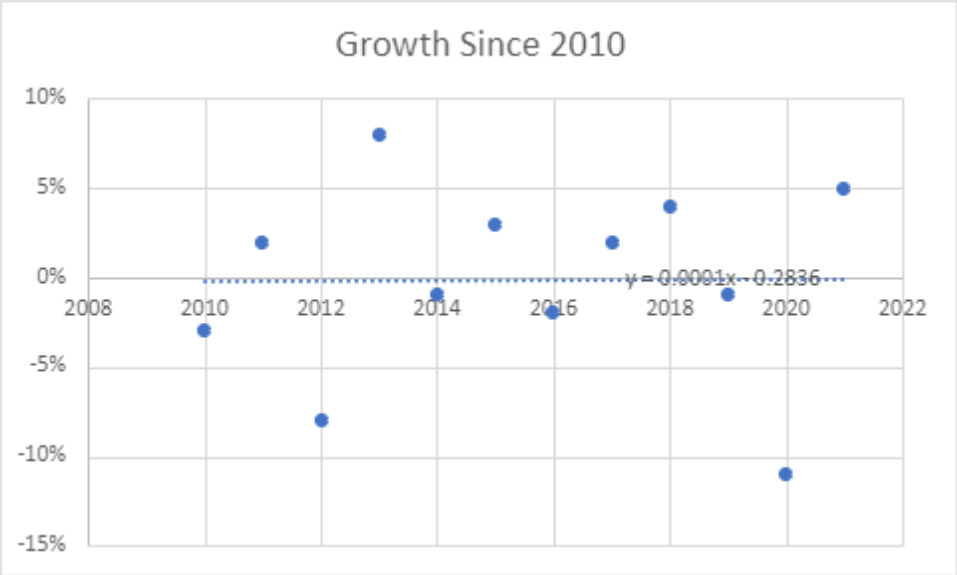


Figure 4

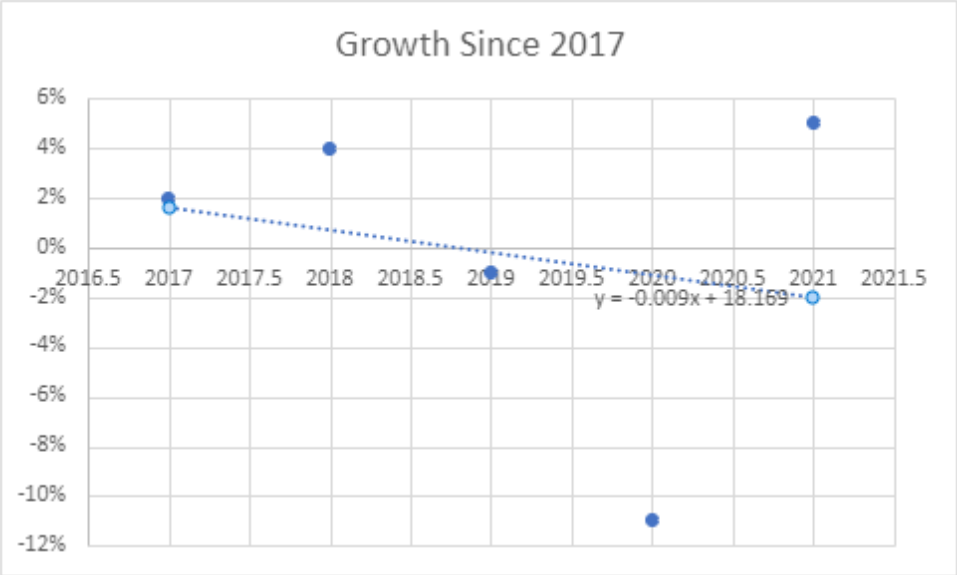


Figure 5

3.2 Planned Roadway Improvements

TDOT is planning an $88 million widening project from Woodson Drive to the Cherokee Trail Interchange, which is expected to be completed by 2026. This 1.6-mile project will widen Alcoa Highway from 4 lanes to 6 lanes and will also include pedestrian and bicycle facilities.

4.0 Project Traffic

Project traffic in this analysis is defined as the vehicle trips expected to be generated by the proposed development distributed onto the study area roadway network. The anticipated traffic associated with the development was forecasted using trip generation, trip distribution, and trip assignment.

4.1 Trip Generation

The team calculated trip generation predictions for morning and afternoon peak hours and average daily traffic using the ITE manual (Hooper 2019). Using Land Use 495, the weekday average daily demand is 250 vehicles, the weekday morning peak hour demand is 50 vehicles, and the weekday afternoon peak hour is 38 vehicles. On Saturdays, the peak hour demand is 8 vehicles and on Sundays, the peak hour demand is 13 vehicles. Calculations for these values are given in Appendix B, and values are shown below in table 2. Note that these calculations do not consider traffic demands from special events held at the boathouse facility.

ITE LUC	Land Use	Density	AADT	AM Peak Hour	PM Peak Hour	Weekend Peak Hour
495	Recreational Community Center	8515	250	50	38	13

The tables below display the calculations used to determine ADT and peak volume values for weekday and weekend traffic demand.

Weekday ADT

GFA	8515.00	SF
Building GFA	8.52	1000s of SF
Average Rate	28.82	veh/day /1000SF
T	245.40	veh/day
Fitted Curve equation	Ln(T)=0.98Ln(X)+3.42	
Ln(T)	5.52	
T	249.38	veh/day

Weekday AM Peak Hour

GFA	8515.00	SF
Building GFA	8.52	1000s of SF

Average Rate	1.76	veh/hr/ 1000SF
T	14.99	veh/hr
Fitted Curve equation	Ln(T)=0.54Ln(X) +2.73	
Ln(T)	3.89	
T	48.74	veh/hr

Weekday PM Peak Hour

GFA	8515.00	SF
Building GFA	8.52	1000s of SF
Average Rate	2.31	veh/hr/ 1000SF
T	19.67	veh/hr
Fitted Curve equation	Ln(T)=0.76Ln(X) +2.00	
Ln(T)	3.63	
T	37.63	veh/hr

Saturday Peak Hour

GFA	8515.00	SF
Building GFA	8.52	1000s of SF
Average Rate	1.07	veh/hr/ 1000SF
T	9.11	veh/hr
Fitted Curve equation	not given	
Ln(T)		
T		

Sunday Peak Hour

GFA	8515.00	SF
Building GFA	8.52	1000s of SF

Average Rate	1.48	veh/hr/ 1000SF
T	12.60	veh/hr
Fitted Curve equation	not given	
Ln(T)		
T		veh/hr

4.2 Trip Distribution and Assignment

The existing trip distribution of the study site is shown in figure 6. As shown, most existing trips are directed toward the JRTU building, which is the opposite side of the park to the OCRC. Figure 7 shows the trip distribution, with PM peak hours slightly adjusted to favor the direction of the boathouse.

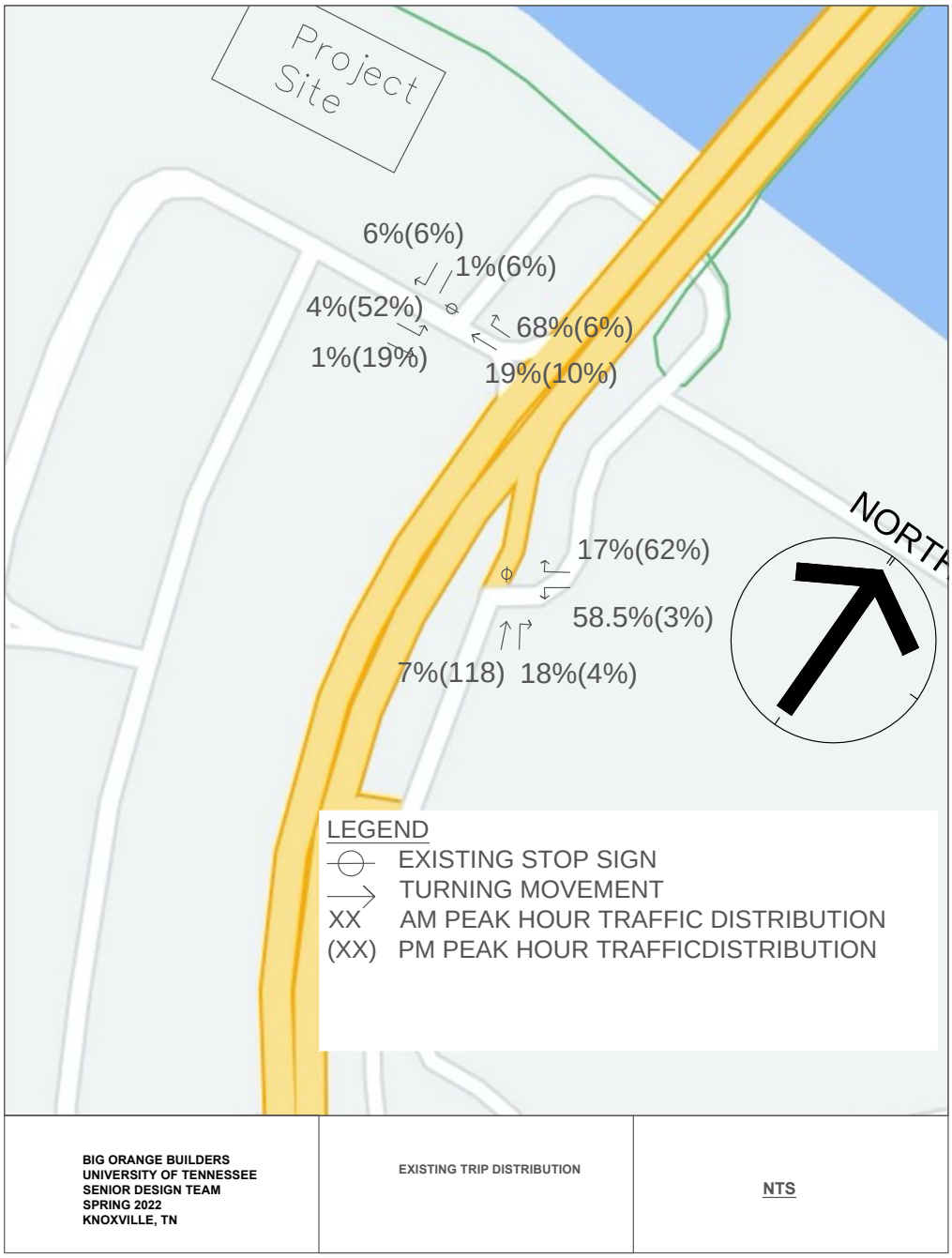

Project Site
6%(6%)
1%(6%)
4%(52%)
68%(6%)
1%(19%)
19%(10%)
17%(62%)
58.5%(3%)
7%(118)
18%(4%)
NORTH
LEGEND
EXISTING STOP SIGN
TURNING MOVEMENT
XX AM PEAK HOUR TRAFFIC DISTRIBUTION
(XX) PM PEAK HOUR TRAFFICDISTRIBUTION
BIG ORANGE BUILDERS
UNIVERSITY OF TENNESSEE
SENIOR DESIGN TEAM
SPRING 2022
KNOXVILLE, TN
EXISTING TRIP DISTRIBUTION
NTS

Figure 6


Project Site
6%(6%)
1%(6%)
4%(32%)
68%(6%)
1%(19%)
19%(30%)
NORTH
17%(62%)
58.5%(3%)
7%(7%)
18%(30%)
LEGEND
EXISTING STOP SIGN
TURNING MOVEMENT
XX AM PEAK HOUR TRAFFIC DISTRIBUTION
(XX) PM PEAK HOUR TRAFFICDISTRIBUTION
BIG ORANGE BUILDERS
UNIVERSITY OF TENNESSEE
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SPRING 2022
KNOXVILLE, TN
EXISTING TRIP DISTRIBUTION
NTS

Figure 7

5.0 Conclusion

This study evaluates current and historic traffic trends on Alcoa Highway to assess the impact of the OCRC on traffic conditions. The ITE manual was used to predict trips generated by a typical recreational facility, which gave a peak of 50 trips. The turn count data collection showed a directional distribution that favored the eastern side of the park (opposite side of the highway from the proposed development). TDOT is also planning to widen Alcoa Highway from 4 lane to 6 lanes. Each of these considerations provide reasonable assurance that the OCRC will not harm the level of service on Alcoa Highway. The data collected and calculations performed in this study can be used in future traffic impact analyses to forecast future conditions and perform Level of Service calculations using the Highway Capacity Manual.

References

https://www.tn.gov/content/dam/tn/tdot/long-range-planning/maps/updated-functional-class-maps/47bKnoxville.pdf

ARTICLE 11. OFF-STREET PARKING

11.1 APPLICABILITY

A. **General Applicability**

1. These regulations are applicable in all zoning districts. If a district has specific off-street parking requirements, those requirements control.

2. The City of Knoxville Department of Engineering may require redesign of parking lots if a traffic safety hazard can be eased or eliminated. Loss of parking spaces resulting from the required redesign will be considered by the Department of Plans Review and Inspections in determining the minimum parking requirements.

3. If the recalculation of parking requirements under Section 11.4 results in parking spaces that exceed any maximums set forth in this Article, the excess parking spaces may continue to be used and are not required to comply with this Article.

4. All parking lots must meet the requirements of sections 11.2, 11.11, and 11.12.

B. **Required Parking for Renovation of Existing Buildings and Change of Use**

1. **Renovations Exceeding 50% of Value**

When the renovation of existing building(s) exceeds 50% of the assessed or appraised value of the lot and building(s) being renovated (whichever is the greater of the two) the following apply:

a. **With a Change of Use or New Addition**

Required parking must be provided according to this Article.

b. **Without a Change of Use or New Addition**

Required parking must be provided according to all requirements of this Article except Sections 11.3, 11.5, 11.6, and 11.7. In such instances, nonconforming parking areas may be continued and counted towards the total parking requirements.

c. **Exemption**

Mixed-use non-residential multi-tenant structures and developments (no residential component) are not subject to Section 11.1.B.1.a if there is no addition to the principal building.

2. **Renovation Less Than 50% of Value**

When the renovation of existing building(s) is 50% or less of the assessed or appraised value of the lot and building(s) being renovated (whichever is the greater of the two) the following apply:

a. **Including a Change of Use or New Addition**

Required parking must be provided according to all requirements of this Article except Sections 11.3, 11.5, 11.6, and 11.7. In such instances, nonconforming parking areas may be continued and counted towards the total parking requirements.

b. **Without a Change of Use or New Addition**

Renovations without a change of use or new addition are subject to section 11.1.A.

C. **Expansion or Improvement of Existing Parking Lots**

1. When an existing parking lot is expanded, the expansion area must be designed and constructed in compliance with the standards of this Article and the landscape requirements of Sections 12.5 and 12.6.

2. When an existing parking lot is improved, the improved area must be designed and constructed in compliance with the standards of this Article and the landscape requirements of Sections 12.5 and 12.6. In addition, the following apply:

   a. If the improvement area is less than 50% of the total parking area, landscape is required only for the improvement area.

   b. If the improvement area is 50% or more of the total parking area, landscape is required for the entire parking lot.

11.2 GENERAL REQUIREMENTS

A. The storage of merchandise, the storage of automobiles or other motor vehicles for sale, or the repair of automobiles or other motor vehicles on required off-street parking facilities is prohibited.

B. Wherever parking is required by this Article, no building permit will be issued prior to approval of access to affected City streets and/or state highways by the appropriate City and/or state official.

11.3 LOCATION AND SETBACKS

A. Off-street parking for uses other than residential uses may be provided on a lot other than that on which the principal use is located if the required number of parking spaces for any land use cannot be provided on the same lot on which the principal use is located, according to the requirements of Section 11.8 below.

B. Parking lots with common frontage on the same block with residentially zoned property and located on roads with less than four existing travel lanes must be setback 25 feet from the street line. However, this setback does not apply to multi-family dwellings.

C. An interior side or rear setback is required in parking lots, as measured from the edge of parking lot to the lot line, as follows. Required site landscape per Article 12 may be located in this setback.

   1. Industrial districts abutting agricultural or residential districts: 20 feet

   2. Office or commercial districts abutting agricultural or residential districts: 20 feet

   3. Multi-family dwellings abutting agricultural or single-family districts: 10 feet

   4. Non-residential use in residential district: 10 feet

D. For single-family and two-family dwellings, parking is prohibited in the front and corner side yard except as follows:

   1. On approved driveways and in approved parking spaces.

   2. A maximum of two vehicles with a current and properly displayed accessible/disabled parking license plate or placard/hang tag.

   3. Temporary loading or unloading.

   4. When construction, remodeling, maintenance, or repairs are being performed on the property, temporary front yard parking cannot exceed the period for which the permit is valid or as necessary to complete the work.

5. Parking for isolated, non-recurring gatherings, parties, or visitors. This exception is not intended to provide permanent or semi-permanent parking for extra cars.

6. Areas within a two-mile radius of Neyland Stadium during University of Tennessee-Knoxville home football games and areas within a one-mile radius of Chilhowee Park and Exposition Center during city-approved events.

E. For single-family and two-family dwellings, approved parking and driveway(s) in the front and corner side yard are limited to the following:

1. On lots with a carport or garage:

a. The driveway leading to a carport or enclosed garage, not to exceed the maximum width allowed, except for flares adequate to access the carport or garage.

b. A connector driveway may extend from a circular driveway to beyond the front wall of the structure. Connector driveways must comply with driveway width requirements.

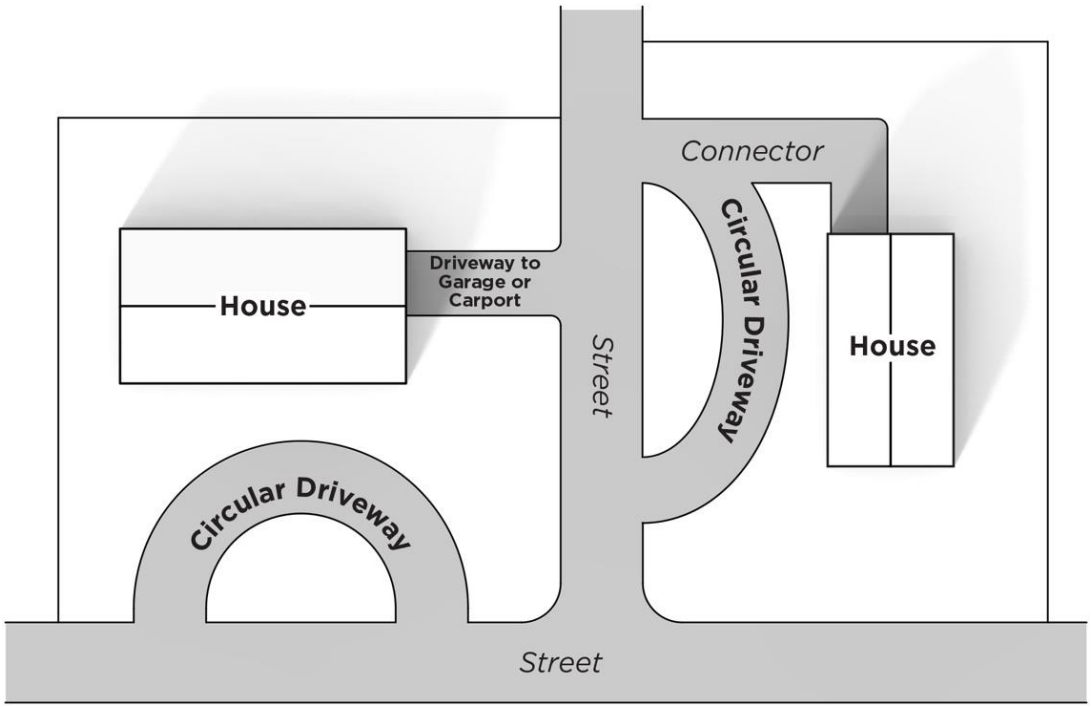
2. On lots with no carport or garage:

a. With lot frontage of 75 feet or less, the driveway must be within ten feet of the side lot line.

b. For lot frontage greater than 75 feet, no driveway, other than a circular driveway, may be constructed in the area between the front wall of the principal structure and the front property line.

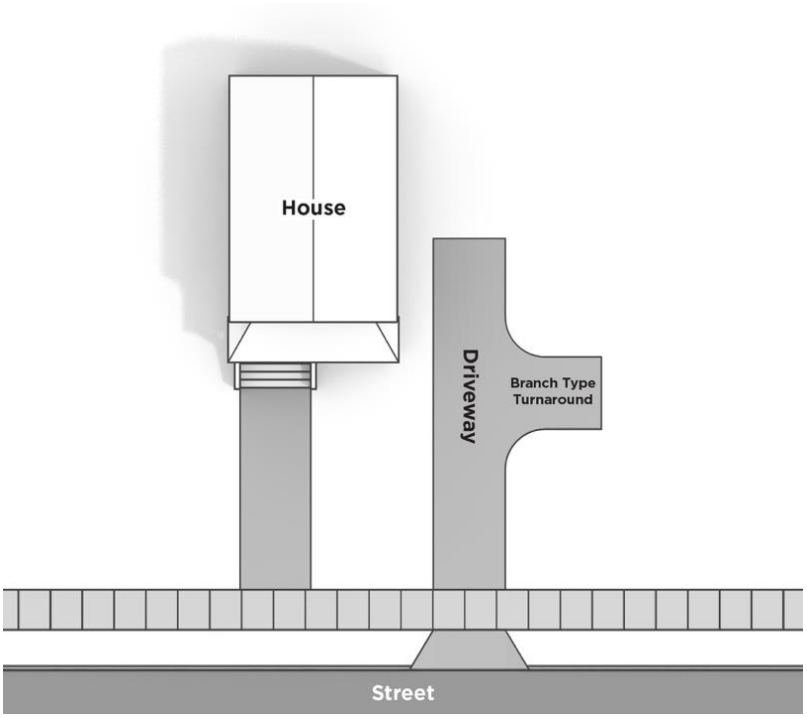
c. For lot frontage greater than 75 feet, a connector driveway may extend from a circular driveway to beyond the front wall of the principal structure. Connector driveways must comply with driveway width requirements.

DRIVEWAYS



3. In addition to any of the above, a branch type turnaround not to exceed 200 square feet is permitted on any lot where City engineering standards can be met.

BRANCH TYPE TURNAROUND



F. For the purpose of this section, lot frontage for any lot except a small lot of record that does not have 75 feet or greater frontage on any street, private right-of-way (joint permanent easement), or access easement, is measured at the front building line.

11.4 REQUIRED OFF-STREET PARKING SPACES

A. **General Application**

1. The minimum and maximum number of off-street vehicle parking spaces shall be determined in accordance with Table 11-2: Required Off-Street Parking, unless otherwise specified in the zoning district.
2. In determining the number of parking spaces, when the result contains a fraction, any fraction less than one-half is disregarded and any fraction of one-half or more is counted as one parking space.
3. Structured parking is not subject to the maximum number of parking spaces set forth in Table 11-2.
4. All parking lot elements required by the Americans with Disabilities Act (ADA) must be accessible. All off-street parking lots must have a number of accessible parking spaces as required by Table 11-3: Required Accessible Parking Spaces, or as amended by ADA:

Table 11-2: Required Off-Street Parking

Use	Minimum Vehicle Parking Required	Maximum Vehicle Parking Allowed
Agriculture (Dwelling On-Premises)	2 per du	No limit
Airport	10 per 1,000 sf GFA of terminal area	No limit
Alternative Correctional Facility	2 per 1,000 sf GFA of office area	8 per 1,000 sf GFA of office area
Amusement Facility—Indoor	4 per 1,000 sf GFA *Bowling alley: 3 per lane* *Movie theater: 0.2 per seat*	5 per 1,000 sf GFA *Bowling alley: 5 per lane* *Movie theater: 0.5 per seat*
Amusement Facility—Outdoor	Commercial recreation: 4 per 1,000 sf GFA *Swimming pool, tennis court: 0.33 per person per design capacity*	Commercial recreation: 5 per 1,000 sf GFA *Swimming pool, tennis court: 0.5 per person per design capacity*
Animal Care Facility—Large Animal	2.5 per 1,000 sf GFA + 2 per 1,000 sf GFA of pet boarding area	3.5 per 1,000 sf GFA + 4 per 1,000 sf GFA of pet boarding area
Animal Care Facility—Small Animal	2.5 per 1,000 sf GFA + 2 per 1,000 sf GFA of pet boarding area	3.5 per 1,000 sf GFA + 4 per 1,000 sf GFA of pet boarding area
Animal Breeder	2 spaces (in addition to dwelling requirements)	4 spaces (in addition to dwelling requirements)
Art Gallery	3 per 1,000 sf display floor area	4 per 1,000 sf display floor area
Arts and Fitness Studio	4 per 1,000 sf GFA	5 per 1,000 sf GFA
Bed and Breakfast	1 per guest room	1.25 per guest room
Body Modification Establishment	3 per 1,000 sf GFA	5 per 1,000 sf GFA
Broadcasting Facility—With or Without Antennae	3 per 1,000 sf GFA of office area	8 per 1,000 sf GFA of office area
Campground	1 per campsite	4 per campsite
Car Wash—With Employees	0.5 per employee on shift of greatest employment	1 per employee on shift of greatest employment
Cemetery	3 per 1,000 sf of office and public assembly area	8 per 1,000 sf of office and public assembly area
Community Center	0.25 per seat in main assembly area	0.5 per seat in main assembly area
Conservation Area	Determined by Dept. of Engineering	Determined by Dept. of Engineering
Country Club	Minimum required sum of uses on-site	Maximum allowed by sum of uses on-site
Cultural Facility	3 per 1,000 sf display floor area	4 per 1,000 sf display floor area
Day Care Center	0.67 per employee on shift of greatest employment + 0.125 off-street loading space per client	1 per employee on shift of greatest employment + 0.167 off-street loading space per client
Day Care Home	0.67 per employee on shift of greatest employment + 0.125 off-street loading space per client	1 per employee on shift of greatest employment + 0.167 off-street loading space per client
Domestic Violence Shelter	2 per 1,000 sf GFA of office area	8 per 1,000 sf GFA of office area
Drug/Alcohol Treatment Facility, Residential	1 per patient room	2.5 per patient room
Drug Treatment Clinic	4 per 1,000 sf GFA	10 per 1,000 sf GFA

Dwelling—Above the Ground Floor	0 to 1 bedroom: 1 per du + guest parking 2 bedrooms: 1.25 per du + guest parking 3 bedrooms: 1.5 per du + guest parking 4+ bedrooms: 2 per du + guest parking Housing development renting by bedroom: 0.67 per bedroom Guest parking (located in areas commonly accessible to all du): 0.2 per du	0 to 1 bedroom: 1.25 per du + guest parking 2 bedrooms: 1.75 per du + guest parking 3 bedrooms: 2.25 per du + guest parking 4+ bedrooms: 2.5 per du + guest parking Housing development renting by bedroom: 1.2 per bedroom Guest parking (located in areas commonly accessible to all du): 0.25 per du
Dwelling—ADU	1	
Dwelling—Manufactured Home	2 per du	No limit
Dwelling—Multi-Family	0 to 1 bedroom: 1 per du + guest parking 2 bedrooms: 1.25 per du + guest parking 3 bedrooms: 1.5 per du + guest parking 4+ bedrooms: 2 per du + guest parking Housing development renting by bedroom: 0.67 per bedroom Guest parking (located in areas commonly accessible to all du): 0.2 per du	0 to 1 bedroom: 1.25 per du + guest parking 2 bedrooms: 1.75 per du + guest parking 3 bedrooms: 2.25 per du + guest parking 4+ bedrooms: 2.5 per du + guest parking Housing development renting by bedroom: 1.2 per bedroom Guest parking (located in areas commonly accessible to all du): 0.25 per du
Dwelling—Single-Family	2 per du	No limit
Dwelling—Townhouse	2 per du + 0.25 per du guest parking	No limit
Dwelling—Two-Family	2 per du	No limit
Educational Facility—Primary	1 per classroom	2 per classroom
Educational Facility—Secondary	0.25 per student at maximum enrollment	0.5 per student at maximum enrollment
Educational Facility—University or College/Vocational	5 per 1,000 sf GFA	6.5 per 1,000 sf GFA
Eating and Drinking Establishment	No drive-through: 8 per 1,000 sf GFA With drive-through: 6 per 1,000 sf GFA	No drive-through: 16 per 1,000 sf GFA With drive-through: 12 per 1,000 sf GFA
Financial Institution	2.5 per 1,000 sf GFA	5 per 1,000 sf GFA
Financial Service, Alternative	2.5 per 1,000 sf GFA	5 per 1,000 sf GFA
Food Bank	3 per 1,000 sf of office	8 per 1,000 sf of office
Food Pantry	2 per 1,000 sf GFA	8 per 1,000 sf GFA
Food Truck Park	1 per mobile food unit	2 per mobile food unit
Fraternity/Sorority	0.33 per resident at maximum occupancy	0.5 per resident at maximum occupancy
Funeral Home	0.33 per person at design capacity	0.67 per person at design capacity

Garden, Market	1 per employee on shift of greatest employment	2 per employee on shift of greatest employment
Gas Station	4 per 1,000 sf GFA of any retail component Gas station with retail & restaurant: 4 per 1,000 sf GFA	8 per 1,000 sf GFA of any retail component Gas station with retail & restaurant: 10 per 1,000 sf GFA
Golf Course/Driving Range	3 per hole	6 per hole
Government Office/Facility	3 per 1,000 sf GFA	8 per 1,000 sf GFA
Greenhouse/Nursery—Retail	1 per 1,000 sf GFA + 1 per 1,000 sf outdoor sales area	2 per 1,000 sf GFA + 2 per 1,000 sf outdoor sales area
Group Home	2 per 1,000 sf GFA of office area	8 per 1,000 sf GFA of office area
Halfway House	2 per 1,000 sf GFA of office area	8 per 1,000 sf GFA of office area
Healthcare Institution	3.25 per bed	5.75 per bed
Heavy Retail, Rental, and Service	1 per 1,000 sf GFA + 1 per 1,000 sf outdoor sales area *Auto, truck, manufactured home, boat, outdoor equipment sales: 3.5 per 1,000 sf of office sales & waiting area* *Building material sales: 1 per 1,000 sf GFA + 1 per 1,000 sf outdoor sales area* *Home improvement superstore: 2.5 per 1,000 sf GFA*	2 per 1,000 sf GFA + 2 per 1,000 sf outdoor sales area *Auto, truck, manufactured home, boat, outdoor equipment sales: 5 per 1,000 sf of office sales & waiting area* *Building material sales: 2 per 1,000 sf GFA + 2 per 1,000 sf outdoor sales area* *Home improvement superstore: 4 per 1,000 sf GFA*
Homeless Shelter	2 per 1,000 sf GFA of office area	8 per 1,000 sf GFA of office area
Hotel	1 per lodging unit	1.25 per lodging unit
Impound Lot	1 per 1,000 sf GFA + 1 per 5,000 sf outdoor storage area	2 per 1,000 sf GFA + 2 per 5,000 sf outdoor storage area
Independent Living Facility	0.65 per unit + guest parking (located in areas commonly accessible to all du): 0.2 per du	1 per unit + guest parking (located in areas commonly accessible to all du): 0.25 per du
Industrial—Craft	2 per 1,000 sf GFA	6 per 1,000 sf GFA
Industrial—General	0.9 per 1,000 sf GFA	6 per 1,000 sf GFA
Industrial—Heavy	0.75 per employee at the largest shift	1 per employee at the largest shift
Industrial Design	3 per 1,000 sf GFA	8 per 1,000 sf GFA
Pre-School/Kindergarten	1 per classroom	2 per classroom
Live Performance Venue	0.2 per seat	0.5 per seat
Live/Work	1 per du + 2 per 1,000 sf GFA	2 per du + 6 per 1,000 sf GFA
Lodge/Meeting Hall	5 per 1,000 sf GFA	6.5 per 1,000 sf GFA
Marina	0.5 per boat slip + requirements for other uses included in development	1 per boat slip + allowances for other uses included in development
Medical/Dental Office/Clinic	4 per 1,000 sf GFA	10 per 1,000 sf GFA
Micro-Brewery/Distillery/Winery	2 per 1,000 sf GFA	6 per 1,000 sf GFA
Nightclub	8 per 1,000 sf GFA	16 per 1,000 sf GFA
Office	3 per 1,000 sf GFA *Call center: 4.5 per 1,000 sf GFA*	8 per 1,000 sf GFA *Call center: 12 per 1,000 sf GFA*

Personal Service Establishment	3 per 1,000 sf GFA	6 per 1,000 sf GFA
Place of Worship	0.25 per seat in the main assembly	0.5 per seat in the main assembly
Public Park	Determined by Dept. of Engineering	Determined by Dept. of Engineering
Public Safety Facility	Determined by Dept. of Engineering	Determined by Dept. of Engineering
Public Works Facility	Determined by Dept. of Engineering	Determined by Dept. of Engineering
Reception Facility	8 per 1,000 sf GFA	16 per 1,000 sf GFA
Research and Development	2 per 1,000 sf GFA	6 per 1,000 sf GFA
Residential Care Facility	0.2 per bed + 1 per employee on shift of greatest employment	0.33 per bed + 1 per employee on shift of greatest employment
Retail Goods Establishment	3 per 1,000 sf GFA *Appliance, carpeting, furniture sales: 2.5 per 1,000 sf gross sales area*	6 per 1,000 sf GFA *Appliance, carpeting, furniture sales: 3.5 per 1,000 sf gross sales area*
Retail Liquor Stores	3 per 1,000 sf GFA	6 per 1,000 sf GFA
Salvage Yard	3 per 1,000 sf office area	4 per 1,000 sf office area
Self-Storage Facility: Enclosed	5 spaces adjacent to office/entry + 0.02 per unit	7 spaces adjacent to office/entry + 0.033 per unit
Self-Storage Facility: Outdoor	5 spaces adjacent to office/entry	7 spaces adjacent to office/entry
Social Service Center	3 per 1,000 sf GFA	8 per 1,000 sf GFA
Solar Farm	2 spaces	Determined by Dept. of Engineering
Vehicle Dealership—Enclosed (Does not include vehicles on display)	2 per 1,000 sf of indoor sales and display area + 4 per service bay	4 per 1,000 sf of indoor sales and display area + 6 per service bay
Vehicle Dealership—With Outdoor Storage/Display (Does not include vehicles on display)	2 per 1,000 sf of indoor sales and display area + 4 per service bay	4 per 1,000 sf of indoor sales and display area + 6 per service bay
Vehicle Operation Facility (Does not include vehicles stored)	3 per 1,000 sf office area	4 per 1,000 sf office area
Vehicle Rental—Enclosed (Does not include vehicles stored for rental)	3 per 1,000 sf office area	4 per 1,000 sf office area
Vehicle Rental—With Outdoor Storage/Display (Does not include vehicles stored for rental)	3 per 1,000 sf office area	4 per 1,000 sf office area
Vehicle Repair/Service- Major	2 per bay	4 per bay
Vehicle Repair/Service—Minor	2 per bay	4 per bay
Warehouse and Distribution	0.5 per 1,000 sf GFA	2 per 1,000 sf GFA
Wholesale Establishment	0.5 per 1,000 sf GFA	2 per 1,000 sf GFA
Wind Energy System	2 spaces	Determined by Dept. of Engineering

Table 11-3: Required Accessible Parking Spaces		
Total Parking Spaces Provided	**Minimum Number of Accessible Parking Spaces Required**	
	Van	**Total (Van + Car)**
1 to 25	1	1
26 to 50	1	2
51 to 75	1	3
76 to 100	1	4
101 to 150	1	5
151 to 200	1	6
201 to 300	2	7
301 to 400	2	8
401 to 500	2	9
501 to 1000	1 for every 6 accessible spaces	2% of total provided parking spaces
1001 and over	1 for every 6 accessible spaces	20, plus 1 for each 100, or fraction thereof, over 1000

B. **Exemptions and Flexibilities**

1. The DK District is exempt from required parking. If parking is provided, then the maximum number of spaces applies in all subdistricts.
2. Minimum vehicle parking reductions apply in the following districts. Bicycle parking requirements may not be reduced.
    a. Required minimum vehicle parking may be reduced by 40% in the C-N District.
    b. Required minimum vehicle parking may be reduced by 20% in the C-G-2 and C-G-3 District.
3. Off-street parking requirements in any district may be reduced up to 30% from the minimum requirements in Table 11-2, provided the development is located within one-fourth of a mile of a transit route. A Knoxville Area Transit approved shelter may be required on or within one-fourth of a mile of the development site. Bicycle parking requirements may not be reduced. This reduction cannot be coupled with any other parking reduction, such as the reductions offered in items 1 and 2 above.
4. Parking lots may exceed the maximum number of spaces in Table 11-2 by up to 20% provided that the spaces exceeding the maximum number and the access aisles accessing those spaces are constructed of pervious materials approved by the Department of Engineering. Parking spaces exceeding the identified maximum may be approved by the Department of Engineering upon submittal of a parking study justifying the need for additional spaces, and the approval of the parking study by Department of Engineering. All excess spaces and their access ways must be constructed of pervious materials. Pervious paving materials may not be required for excess parking on sites with brownfield agreements upon approval by the Department of Engineering.
5. Upon approval by the Department of Engineering of a parking study for the= proposed use(s), the minimum number of parking spaces in Table 11-2 may be reduced.
6. For uses not specifically mentioned herein, off-street parking requirements shall be interpreted by the director of plans review and inspections.

C. **Mixed-Use Multi-Tenant Structure Requirements**

A mixed-use multi-tenant structure is not subject to the individual use calculations for required vehicle parking in Table 11-2. Minimum and maximum parking is calculated as follows:

1. Non-residential gross floor area—minimum parking required: 3 per 1,000 sf GFA;
2. Non-residential gross floor area—maximum parking allowed: 8 per 1,000 sf GFA;
3. Residential units: requirements for "dwelling—above the ground floor" per Table 11-2.

(Ord. No. O-76-2020 , § 1, 5-19-20; Ord. No. O-87-2020 , § 1, 5-19-20)

11.5 DIMENSIONS OF OFF-STREET PARKING FACILITIES

Off-street parking facilities must be laid out in accordance with the following regulations:

A. **Accessible Spaces**

1. Accessible vehicle spaces must be at least eight feet wide with an adjacent pedestrian access aisle of at least five feet in width.
2. Van accessible spaces must be either:
    a. At least 11 feet wide with an adjacent pedestrian access aisle of at least five feet in width.
    b. At least eight feet wide with an adjacent pedestrian access aisle of at least eight feet in width.
3. Pedestrian access aisles must be hatched and include a painted "No Parking" designation.

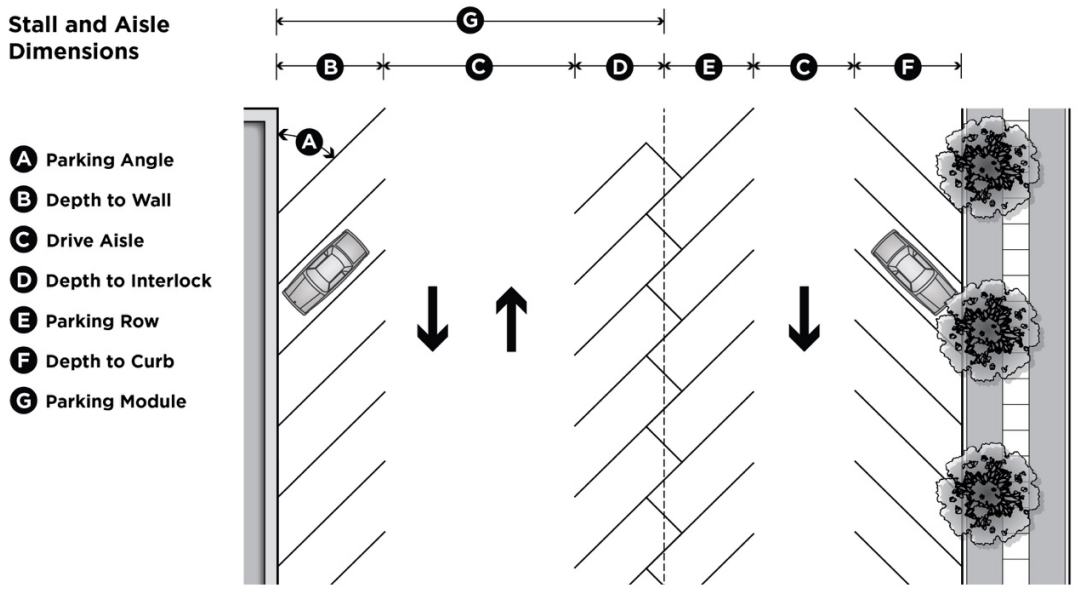
B. **Stall and Aisle Dimensions**

1. The minimum dimensions for parking stalls and aisles is specified in Table 11-6: Minimum Stall and Aisle Dimensions. Maximum dimensions are the minimum value plus four feet.

Parking Angle	Minimum Depth to Wall or Interlock (feet)	Minimum Depth to Curb (feet)	Minimum Stall Width (feet)	Minimum Aisle Width (feet)	
				One-Way	Two-Way
45 degrees	16.5	15.0	9.0	15	26
60 degrees	18.0	16.5	9.0	18	26
75 degrees	18.5	17.5	9.0	22	26
90 degrees	17.5	15.5	9.0	26	26
Parallel	22.5	20.5	9.0	15	25

2. Up to 20% of the total number of parking spaces provided may be designed for compact vehicles. Where possible, these spaces must be clustered together and marked with signs restricting their use to compact vehicles. Compact spaces with a parking angle of 90 degrees must have the following minimum dimensions: eight feet in width, 13.5 feet in depth to curb, and 15.5 feet in depth to a wall or interlock. Other angles will be reviewed on a case by case basis and are subject to the approval of the Department of Engineering.
3. Stall lengths, stall depths, and aisle widths for parking angles, other than those indicated in Table 11-6, shall be consistent with the above values and are subject to the approval of the Department of Engineering.

STALL AND AISLE DIMENSIONS



C. **Pedestrian Access Aisles**

Pedestrian access aisles shall be clearly marked (or indicated).

D. **Encroachments**

Columns, light poles, and/or other protrusions may encroach into a parking module up to a maximum of one foot for modules with parking on one side or a maximum of two feet for modules with parking on two sides, one-foot protrusion into each parking row. The protrusions cannot affect more than 25% of the spaces.

E. **Structured Parking**

Structured parking must comply with the following requirements:

1. Parking spaces must comply with Table 11-6. The City of Knoxville Department of Engineering may approve adjustments to the dimensions while maintaining safety and function.
2. The maximum approach, departure, and ramp angles are subject to the review and approval of the Department of Engineering.

(Ord. No. O-87-2020 , § 1, 5-19-20)

11.6 DESIGN OF OFF-STREET PARKING FACILITIES

A. All areas devoted to off-street parking must be designed so that no vehicle is required to back into a public street or alley to obtain ingress or egress, except for the following:

1. Off-street residential parking for single-family, two-family, and townhouse dwellings when the lot is accessed from a local street or alley.

2. Egress directly from parking spaces to alleys may be allowed when the aisle width, including the alley width, meets the minimum aisle width specified in Table 11-6.

B. The maximum grade in a parking lot is 10%.

C. Surface drainage must be collected so as to preclude uncontrolled drainage onto the paved portion of street rights-of-way as verified by the Department of Engineering.

D. All areas devoted to permanent off-street parking must be surfaced and maintained as to control dust, rutting, erosion as a result of continuous use, and migration of surface materials. Parking spaces must be clearly delineated.

E. Vehicular and pedestrian signs must be MUTCD compliant and approved by the City of Knoxville Department of Engineering.

F. An accessible pathway must be provided from the accessible parking space(s) to the destination that the parking space(s) are intended to serve. The accessible pathway must be located along the shortest accessible route to the accessible door/entrance.

G. In an effort to reduce vehicle/pedestrian conflicts:

1. Parking lots serving a building and having more than one parking row between the fronting street and the building's front entrance should have sidewalks or clearly defined and designated routes connecting the building's main entrance or a central location to the parking lot.

2. A clearly defined and designated accessible route must connect a building's main entrance or central location to a sidewalk in the right-of-way where the cost of providing this route does not exceed 20% of the parking lot improvement cost.

3. Landscaped islands and divider medians must be arranged so as to channel traffic and minimize vehicular and pedestrian conflicts within parking areas. A divider median must be provided at a minimum interval of one median per every six parking rows to channel traffic and minimize vehicular and pedestrian conflicts within interior parking lots.

4. Parking rows must be terminated at both ends with terminal islands.

5. Interior islands must have a minimum area of 120 square feet for each parking row that they interrupt. Islands may be combined for double-parking rows, resulting in an interior island with a minimum area of 240 square feet.

6. In the industrial districts and the DK District, terminal islands, interior islands, and divider medians are not required. This exemption does not apply to parking in industrial districts designated for employees and visitors where the principal building is over 40,000 square feet in gross floor area.

H. Terminal islands, interior islands, and divider medians are not required for structured parking facilities or for parking facilities less than 20,000 square feet.

11.7 ACCESS AND DRIVEWAY DESIGN

These regulations are applicable in zoning districts without access and driveway requirements specific to the zoning district. If the district specifically requires access and driveway design, those requirements control. The Department of Engineering is authorized to develop and implement such policies and procedures as may be necessary and desirable to control the design and construction of driveways that are consistent with this Code.

A. The number of driveways on a given street or access easement is based on the following:

1. Typical developments per Table 11-4: Maximum Number of Driveways for Lot Frontages:

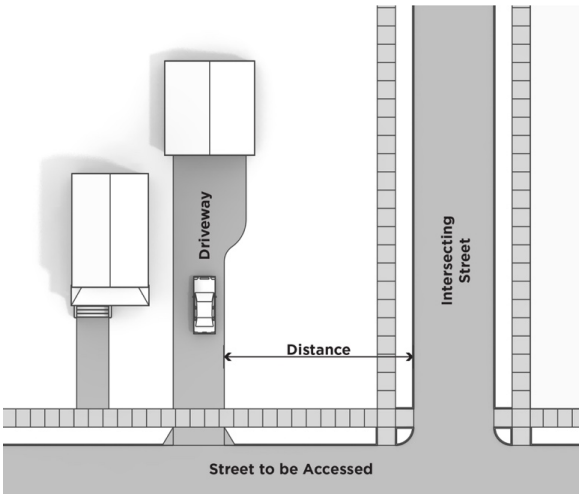
Table 11-4: Maximum Number of Driveways for Lot Frontages	
Lot Frontage	**Maximum Number of Driveways**
Less than 150 feet	1 For single-family dwellings with lot frontages of 100' or more, a circular driveway is allowed
150 feet—450 feet	2
Greater than 450 feet—600 feet	3
Greater than 600 feet—750 feet	4
Greater than 750 feet	Determined by Department of Engineering

2. Gas stations and establishments where services are normally provided to customers without leaving their vehicles may have two driveways.
3. Projects required to prepare a Traffic Impact Study are considered individually based on the recommendation of the study and the approval of the Department of Engineering.
4. Boulevard driveways (with raised median separation), one way driveways, and right-in/right-out driveway pairs will be considered one driveway
5. The Department of Engineering may impose other access and driveway requirements as necessary based on specific site conditions.

B. The minimum distance between a driveway and the intersecting street is described in Table 11-5: Corner Clearance Requirements.

Table 11-5: Corner Clearance Requirements			
Classification of Intersecting Street	**Classification of Street to be Accessed**		
	Arterial	**Collector**	**Local**
Arterial	200'	150'	100'
Collector	150'	100'	50'
Local	100'	50'	50'

CORNER CLEARANCE



1. If the required distance cannot be met due to lot size or other constraint as verified by the Department of Engineering, the driveway must be located as far as possible from the intersecting street.
2. All driveways in a development must be separated by a minimum distance equal to the width of the wider driveway.
3. No curb cut may encroach on the frontage of adjacent property without the written consent of the owner for such encroachment, except where a joint use driveway with the adjacent property is established at the request of both owners.

C. Table 11-6: Driveway Width and Curb Cut Length Standards provides minimum and maximum driveway widths and curb cut lengths.

Table 11-6: Driveway Width and Curb Cut Length Standards

	Driveway Dimensions		**Length of Curb Cut**	
Lot Frontage (feet)	**Min.**	**Max.**	**Min.**	**Max.**
Single-Family, Two-Family, & Townhouse: By Lot Width				
50 feet or less	10'	18'	15'	24'
> 50—74	10'	20'	15'	26'
Greater than 74	10'	25'	15'	32'
A circular driveway can be no wider than 18'				
Other Development				
Land Use: Uses serving a substantial number of large trucks (5/day or 25/week)	20'	40'	60'	90'
Land Use: All other	20'	30'	25'	60'

1. Gas stations may have driveways up to 40 feet wide.
2. Boulevard driveways (with raised median separation), one way driveways, and right-in/right-out driveway pairs are not subject to Table 11-9 and will be reviewed on a case-by-case basis by the Department of Engineering.

3. Access to cell towers, electrical substations, pump stations, etc., defer to the Department of Engineering's Utility Driveway standards.

4. Major traffic generators will be considered as individual cases and are not subject to Table 11-9. A major traffic generator is defined as any facility that is required by this Article to provide 400 or more parking spaces.

5. On state roads, adjustments to the dimensions in Table 11-9 may be granted based on Tennessee Department of Transportation specifications.

D. When a change in use, redevelopment, or alteration of any land or building makes any or all of the driveways unnecessary or noncompliant, the owner of the property must, at their expense, replace all necessary curbs, gutters, sidewalks, and landscape to a condition consistent with current City of Knoxville standards.

(Ord. No. O-87-2020 , § 1, 5-19-20)

11.8 SHARED PARKING

The Director of the City of Knoxville Department of Plans Review and Inspections, or his/her designee, may consider and approve a shared parking plan for uses that are located near one another and that have different peak parking demands and operating hours. All off-site parking arrangements must comply with the following provisions at a minimum. Additional requirements may be imposed by the Director of the City of Knoxville Department of Plans Review and Inspections, or the Director of the City of Knoxville Department of Plans Review and Inspections may deny the shared parking plan for good cause.

A. The uses will not overlap in hours of operation or in demand for the shared spaces.

B. The person or entity requesting the shared parking must submit a shared parking study and site plan to the Department of Engineering for approval.

C. The lot upon which the shared or off-site parking is located is no greater than 500 feet walking distance as measured from the boundary of the property on which the principal use is located to the boundary of the property where the shared parking is located.

D. Any crossing of a roadway at grade with a classification higher than local roadway must be marked per the most recent edition of MUTCD.

E. The off-site parking must be located on land owned by the owner(s) of the principal use it is intended to serve, or under lease or license to the owner(s) of the principal use it is intended to serve, in accordance with the following:

1. If the shared parking accounts for 50% or less of the parking spaces required for the principal use that is unable to meet its requirements on-site, the shared parking agreement must be a parking license with a minimum term of two years. The shared parking license may be revocable and is not required to be recorded; however, a copy of the license must be provided to the City of Knoxville Department of Plans Review and Inspections after approval of parking plans and before issuance of building permit.

2. If the shared parking accounts for more than 50% of the parking spaces required by the principal use that is unable to meet its requirements on-site, the shared parking agreement must be a lease agreement with a minimum term of five years. Such lease agreement is subject to approval by the City of Knoxville Law Department. Where such a lease is involved, a memorandum of lease must be recorded with the Register of Deeds of Knox County with copies furnished to the City of

Knoxville City Law Director and City of Knoxville Department of Plans Review and Inspections after approval of parking plans and before issuance of building permit.

F. Off-site parking must be in a zoning district that permits the principal use it will serve and off-site parking is not located in a residential district.

G. The shared parking spaces must be maintained as long as the uses they serve are in operation.

H. Accessible parking cannot be shared.

11.9 BICYCLE PARKING PROVISIONS

A. Bicycle parking must be provided for all uses where vehicular off-street parking is required and/or provided, with the exception of single-family and two-family dwellings. Bicycle parking must be provided for uses in the amount indicated in Table 11-7: Required Bicycle Parking. In determining the number of bicycle spaces, when the result contains a fraction, any fraction less than one-half is disregarded and any fraction of one-half or more is counted as one space.

Table 11-7: Required Bicycle Parking

Land Use Category	**Total Required Motor Vehicle Parking Spaces (Minimum)**	**Required Number of Bicycle Parking Spaces**
Non-Residential *Shopping centers and mixed-use multi-tenant structures are to be considered as a whole, not as individual tenants; bike racks must be spaced throughout the shopping center*	Less than 50	4
	51—100	8
	101—500	12
	501—1,000	16
	1,001 or more	16 for the first 1,000 + 8 for every 500 thereafter of vehicle parking spaces over 1,000
Land Use Category	**Residential Dwelling Type**	**Required Number of Bicycle Parking Spaces**
Residential	Single-family or two-family dwellings	0
	Multi-family or townhouse	0.25 per unit, or none if interior storage space is provided for each unit

B. In the DK District, bicycle parking is required. The number of bicycle parking spaces required is based on the minimum number of vehicle parking spaces that the proposed use(s) would be required to provide in Table 11-2.

C. One required vehicle parking space may be used as a space for providing required bicycle parking.

D. The required bicycle parking spaces must be located in a convenient and visible area within 50 feet of a principal entrance or other location approved by the Department of Engineering. Bicycle parking facilities must be sufficiently separated from motor vehicle parking areas to protect parked bicycles from damage by motor vehicles. The separation may be accomplished through grade separation, distance or physical barrier, such as curbs, wheel stops, poles or other similar features.

E. Users cannot be required to climb or descend stairs in order to access the bicycle parking facility unless there is a bicycle wheel trough parallel to the stairs.

F. Connections to bicycle networks may be required by the Department of Engineering.

G. Bicycle parking cannot impede pedestrian or accessible routes.

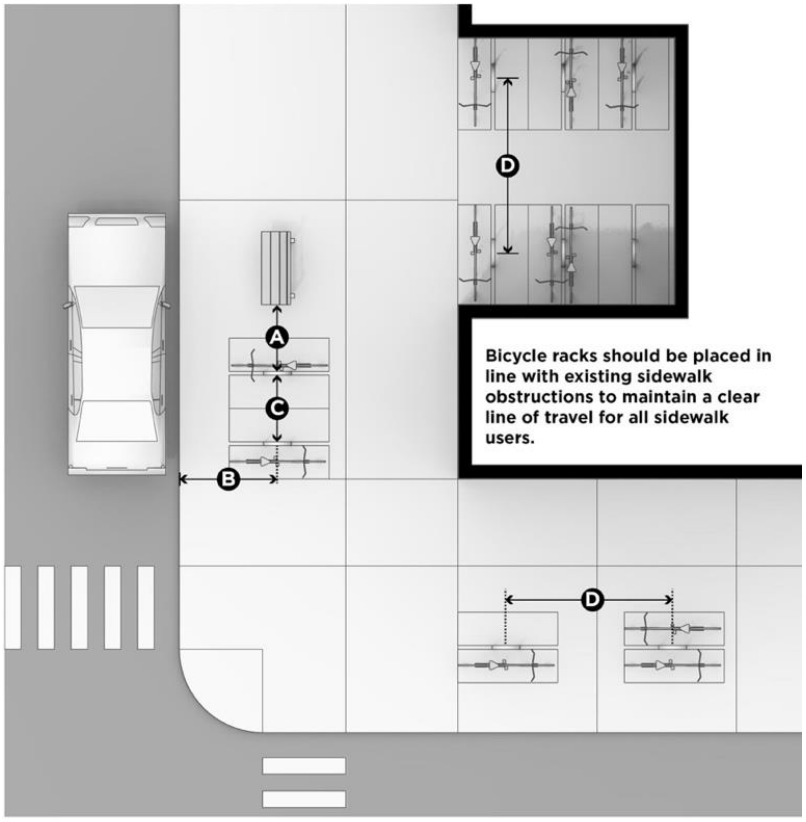
H. Bicycle parking spaces must include a rack which permits the locking of the bicycle frame and one wheel to a rack or fixture and must support a bicycle in a stable position without damage to the wheels, frame, or components. Racks must be securely anchored to prevent the racks from being removed from the location.

I. Bicycle racks must be installed according to the following minimum standards:

1. Three feet from the side of the rack to any obstruction.
2. Three feet forwards or backwards from the centerline of the rack to any obstruction.
3. Four feet from the side of the rack to another bike rack.
4. Ten feet forwards or backwards from the centerline of the rack to the centerline of another bike rack.
5. Alternatives to these standards may be approved by the Department of Engineering.

J. Bicycle parking and access to bicycle parking must be constructed in accordance with the applicable standards of Section 11.6.D.

BICYCLE RACK INSTALLATION



A From the side of the rack to any obstruction

B Centerline of the rack to any obstruction

C Side of the rack to another bike rack

D Centerline of the rack to the centerline of another bike rack

(Ord. No. O-87-2020 , § 1, 5-19-20)

11.10 REQUIRED OFF-STREET LOADING SPACES

A. Off-street loading spaces must be provided for any use that distributes or receives materials or merchandise by trucks or other commercial vehicles in accordance with Table 11-8: Off-Street Loading Requirements. In the case of multi-tenant developments, required loading spaces are calculated on the basis of each individual tenant.

B. No structure is required to provide more than five loading spaces.

C. All multi-family dwellings, regardless of size, are required to provide a site plan that shows ingress/egress for moving trucks.

D. Off-street loading spaces must be designed as follows:

1. All required off-street loading spaces must be a minimum of 12 feet in width, a minimum of 35 feet in length, exclusive of aisle and maneuvering space, and have a minimum vertical clearance of 15 feet.

2. All off-street loading spaces must be surfaced with a durable, all-weather material.

3. Off-street loading facilities must be drained to eliminate standing water and prevent damage to abutting property and/or public streets and alleys.

4. Each required off-street loading space must be designed with adequate means of vehicular access to a street or alley and in a manner that will minimize interference with traffic movement.

Table 11-8: Off-Street Loading Requirements

Use Type	Number of Spaces Required
Multi-Family Dwelling	
Total of 50 dwelling units or more	1 loading space
Commercial & Institutional Use	
20,000—100,000 sf GFA	1 loading space
100,001—200,000 sf GFA	2 loading spaces
Each additional 50,000 sf of floor area (This applies only for each additional full 50,000 sf over 200,000 sf)	1 additional loading space
Industrial Use	
10,000—40,000 sf GFA	1 loading space
40,001—100,000 sf GFA	2 loading spaces
Each additional 50,000 sf of floor area (This applies only for each additional full 50,000 sf over 100,000 sf)	1 additional loading space

(Ord. No. O-87-2020 , § 1, 5-19-20)

11.11 STORAGE AND PARKING OF TRAILERS, RECREATIONAL VEHICLES, COMMERCIAL VEHICLES, AND SCHOOL BUSES

Commercial vehicles hauling trailers, boat trailers, recreational vehicles, and school buses hall not be parked or stored on any lot improved with a dwelling or on any lot zoned residential, except in accordance with the following provisions:

A. One each lot, only one of the following vehicles may be parked or stored per household living on the premises:

1. A commercial vehicle, which does not exceed 26,000 pounds, gross vehicle weight.

2. A school bus.

B. On property on which a church or school is located, operable buses may be parked in accordance with the following provisions:

1. Buses shall not be parked so as to block emergency access drives.

2. Buses shall not be parked so as to block line of sight at any drive or street intersection.

3. Areas in which buses are continually parked shall be screened from adjacent residential uses and from public streets with a Class A buffer. For the purposes of this requirement "continually parked" shall mean buses are parked on a regular and on-going basis, or are parked overnight.

C. The following vehicles are prohibited:

1. A three-axle combination commercial vehicle cab.

2. Any commercial vehicle used for hauling explosives, gasoline, or liquefied petroleum products.

D. On each lot, a total of two (one from any two of the subsections listed below) of the following vehicles may be parked or stored per household living on the premises, and said trailer, or recreational vehicle, shall not exceed 45 feet in length or nine feet in width; and further provided that said trailer, or recreational vehicle, shall not be parked or stored for more than 48 hours unless it is located behind the front of the primary structure on the lot:

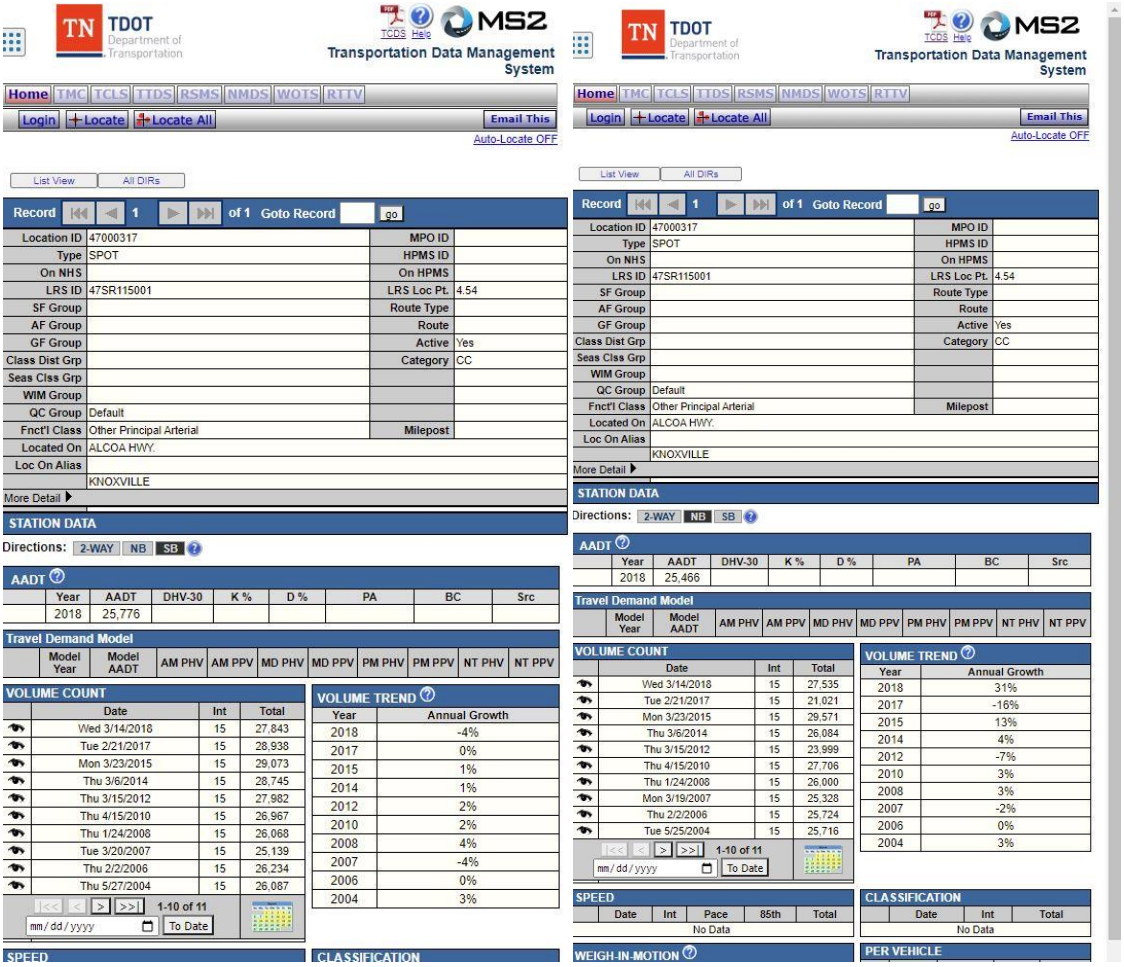
1. Recreational vehicle.

2. Hauling trailer.

3. Boat trailer.

E. A recreational vehicle shall not be occupied either temporarily or permanently while it is parked or stored in any area except in a travel trailer court or other location authorized under this ordinance.

(Ord. No. O-43-2020 , § 1, 3-24-20)



TN TDOT Department of Transportation

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Record 1 of 1 Goto Record go

Location ID	47000317	MPO ID	
Type	SPOT	HPMS ID	
On NHS		On HPMS	
LRS ID	47SR115001	LRS Loc Pt.	4.54
SF Group		Route Type	
AF Group		Route	
GF Group		Active	Yes
Class Dist Grp		Category	CC
Seas Clss Grp			
WIM Group			
QC Group	Default		
Fnct'l Class	Other Principal Arterial	Milepost	
Located On	ALCOA HWY.		
Loc On Alias			
	KNOXVILLE		

More Detail

STATION DATA

Directions: 2-WAY | NB | SB

AADT

Year	AADT	DHV-30	K %	D %	PA	BC	Src
2018	25,776						

Travel Demand Model

Model Year	Model AADT	AM PHV	AM PPV	MD PHV	MD PPV	PM PHV	PM PPV	NT PHV	NT PPV

VOLUME COUNT

Date	Int	Total
Wed 3/14/2018	15	27,843
Tue 2/21/2017	15	28,938
Mon 3/23/2015	15	29,073
Thu 3/6/2014	15	28,745
Thu 3/15/2012	15	27,982
Thu 4/15/2010	15	26,967
Thu 1/24/2008	15	26,068
Tue 3/20/2007	15	25,139
Thu 2/2/2006	15	26,234
Thu 5/27/2004	15	26,087

1-10 of 11

mm/dd/yyyy To Date

VOLUME TREND

Year	Annual Growth
2018	-4%
2017	0%
2015	1%
2014	1%
2012	2%
2010	2%
2008	4%
2007	-4%
2006	0%
2004	3%

SPEED

CLASSIFICATION

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Location ID	47000317	MPO ID	
Type	SPOT	HPMS ID	
On NHS		On HPMS	
LRS ID	47SR115001	LRS Loc Pt.	4.54
SF Group		Route Type	
AF Group		Route	
GF Group		Active	Yes
Class Dist Grp		Category	CC
Seas Clss Grp			
WIM Group			
QC Group	Default		
Fnct'l Class	Other Principal Arterial	Milepost	
Located On	ALCOA HWY.		
Loc On Alias			
	KNOXVILLE		

More Detail

STATION DATA

Directions: 2-WAY | NB | SB

AADT

Year	AADT	DHV-30	K %	D %	PA	BC	Src
2018	25,466						

Travel Demand Model

Model Year	Model AADT	AM PHV	AM PPV	MD PHV	MD PPV	PM PHV	PM PPV	NT PHV	NT PPV

VOLUME COUNT

Date	Int	Total
Wed 3/14/2018	15	27,535
Tue 2/21/2017	15	21,021
Mon 3/23/2015	15	29,571
Thu 3/6/2014	15	26,084
Thu 3/15/2012	15	23,999
Thu 4/15/2010	15	27,706
Thu 1/24/2008	15	26,000
Mon 3/19/2007	15	25,328
Thu 2/2/2006	15	25,724
Tue 5/25/2004	15	25,716

1-10 of 11

mm/dd/yyyy To Date

VOLUME TREND

Year	Annual Growth
2018	31%
2017	-16%
2015	13%
2014	4%
2012	-7%
2010	3%
2008	3%
2007	-2%
2006	0%
2004	3%

SPEED

Date	Int	Pace	85th	Total
No Data				

CLASSIFICATION

Date	Int	Total
No Data		

WEIGH-IN-MOTION

PER VEHICLE

TN TDOT Department of Transportation

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Record 1 of 1 Goto Record go

Location ID	47000317	MPO ID	
Type	SPOT	HPMS ID	
On NHS		On HPMS	
LRS ID	47SR115001	LRS Loc Pt.	4.54
SF Group	Urban	Route Type	
AF Group	14	Route	
GF Group	Knox	Active	Yes
Class Dist Grp	14	Category	CC
Seas Clss Grp			
WIM Group			
QC Group	Default		
Fnct'l Class	Other Principal Arterial	Milepost	
Located On	ALCOA HWY.		
Loc On Alias			
	KNOXVILLE		
More Detail			

STATION DATA

Directions: 2-WAY | NB | SB

AADT

Year	AADT	DHV-30	K %	D %	PA	BC	Src
2020	44,047[3]		11	58	40,172 (91%)	3,875 (9%)	Grown from 2019
2019	49,603[2]		11	58			
2018	49,973		9	58			
2017	47,961		11	61			
2016	46,844[2]						

<< < > >> 1-5 of 37

Travel Demand Model

Model Year	Model AADT	AM PHV	AM PPV	MD PHV	MD PPV	PM PHV	PM PPV	NT PHV	NT PPV

VOLUME COUNT

Date	Int	Total
Wed 3/14/2018	60	55,378
Tue 2/21/2017	60	49,959
Mon 3/23/2015	60	58,644
Thu 3/6/2014	60	54,829
Thu 3/15/2012	60	51,981
Thu 4/15/2010	60	54,673
Thu 1/24/2008	60	52,068
Tue 3/20/2007	60	50,467
Thu 2/2/2006	60	51,958
Mon 3/10/2003	60	50,190

VOLUME TREND

Year	Annual Growth
2021	5%
2020	-11%
2019	-1%
2018	4%
2017	2%
2016	-2%
2015	3%
2014	-1%
2013	8%
2012	-8%

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Land Use: 495
Recreational Community Center

Description

A recreational community center is a stand-alone public facility similar to and including YMCAs. These facilities often include classes and clubs for adults and children; a day care or nursery school; meeting rooms; swimming pools and whirlpools; saunas; tennis, racquetball, handball, basketball and volleyball courts; outdoor athletic fields/courts; exercise classes; weightlifting and gymnastics equipment; locker rooms; and a restaurant or snack bar. Public access is typically allowed but a fee may be charged. Racquet/tennis club (Land Use 491), health/fitness club (Land Use 492), and athletic club (Land Use 493) are related land uses.

Additional Data

Time-of-day distribution data for this land use are presented in Appendix A. For the one general urban/suburban site with data, the overall highest vehicle volumes during the AM and PM on a weekday were counted between 7:30 and 8:30 a.m. and 5:00 and 6:00 p.m., respectively.

The average numbers of person trips per vehicle trip at the four general urban/suburban sites at which both person trip and vehicle trip data were collected, were as follows:

- 1.86 during Weekday, Peak Hour of Adjacent Street Traffic, one hour between 7 and 9 a.m.
- 1.69 during Weekday, AM Peak Hour of Generator
- 1.82 during Weekday, Peak Hour of Adjacent Street Traffic, one hour between 4 and 6 p.m.
- 1.82 during Weekday, PM Peak Hour of Generator

The sites were surveyed in the 1980s, the 1990s, the 2000s, and the 2010s in Alberta (CAN), Arizona, Indiana, Minnesota, New Hampshire, New York, Oregon, Pennsylvania, and Utah.

Source Numbers

281, 410, 443, 571, 618, 705, 719, 850, 866, 971

Recreational Community Center
(495)

Vehicle Trip Ends vs: **1000 Sq. Ft. GFA**
On a: **Weekday**

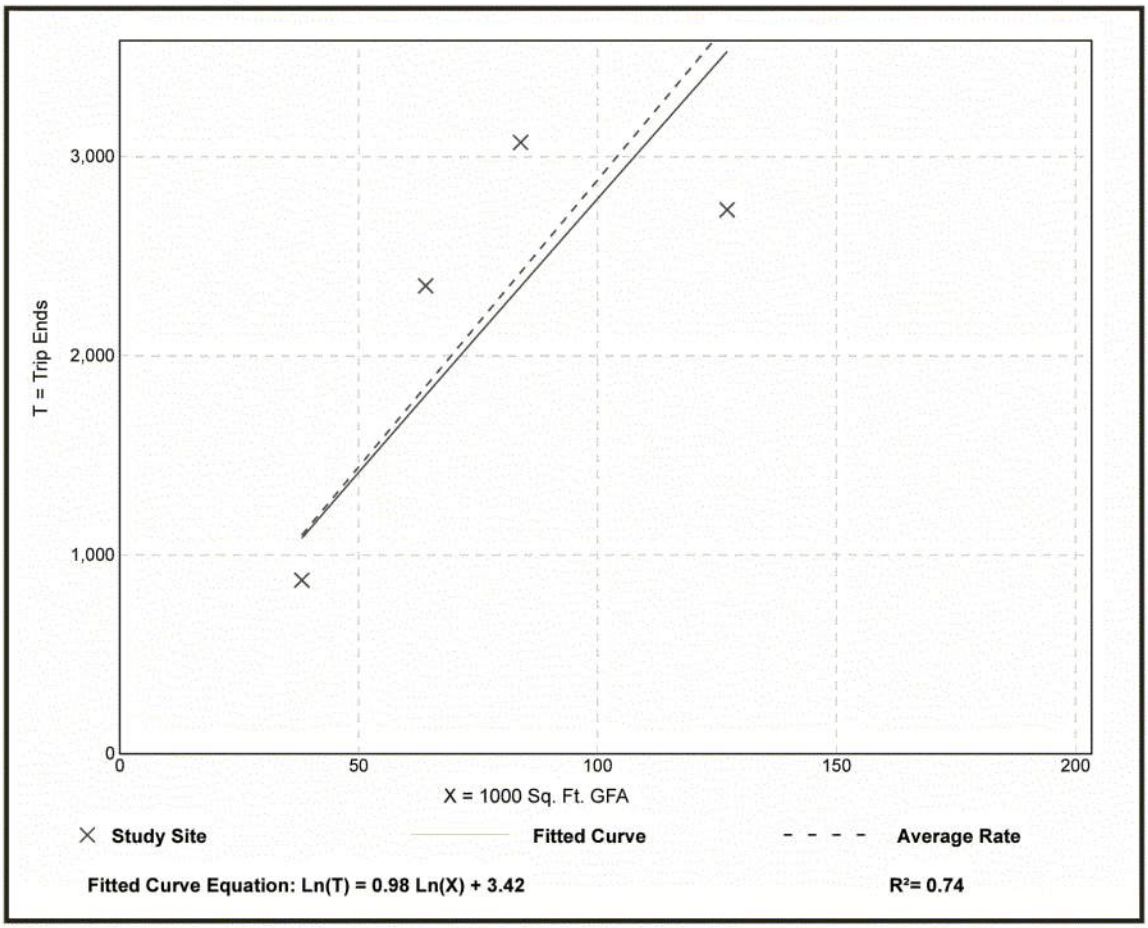
Setting/Location: **General Urban/Suburban**
Number of Studies: 4
1000 Sq. Ft. GFA: 78
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
28.82	21.49 - 36.71	8.56

Data Plot and Equation

Caution – Small Sample Size



Fitted Curve Equation: Ln(T) = 0.98 Ln(X) + 3.42

R^2= 0.74

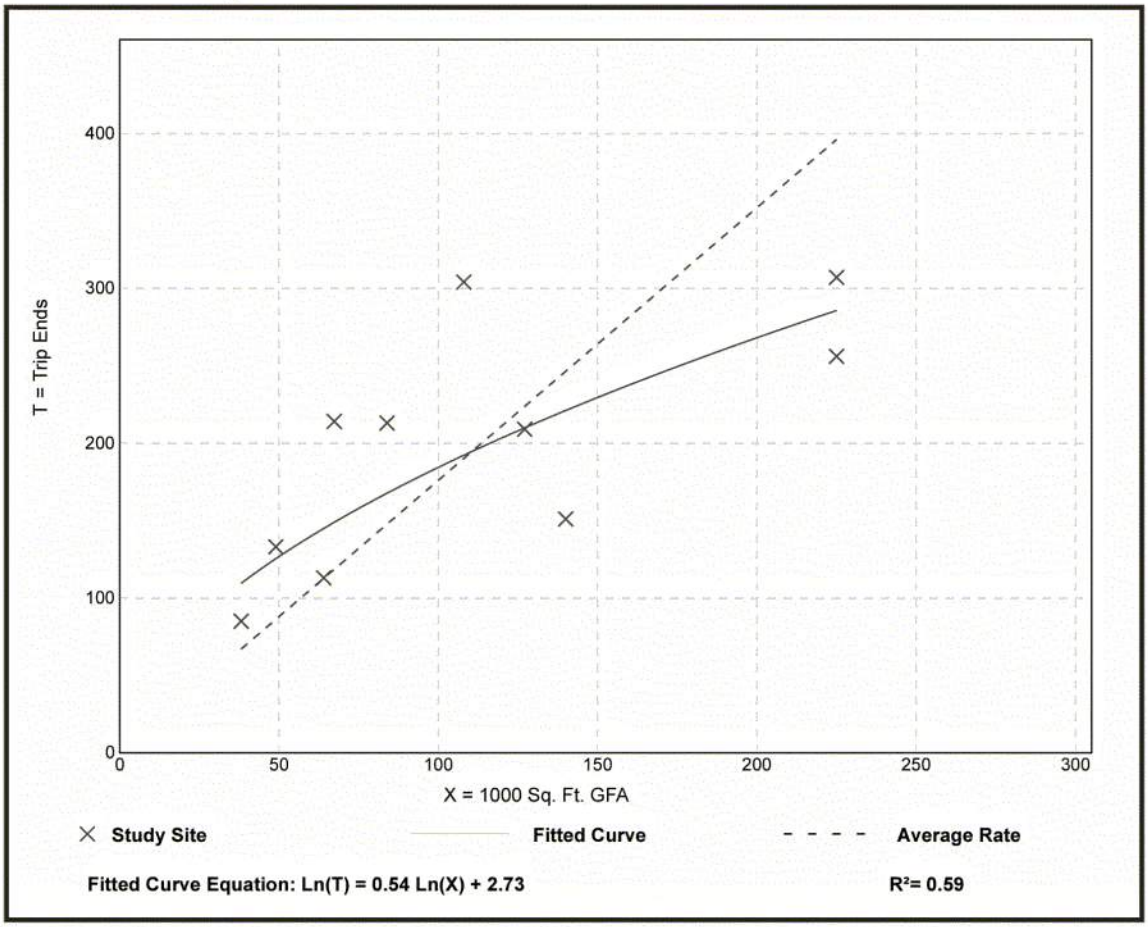
Recreational Community Center
(495)

Vehicle Trip Ends vs:	**1000 Sq. Ft. GFA**
On a:	**Weekday,**
	Peak Hour of Adjacent Street Traffic,
	One Hour Between 7 and 9 a.m.
Setting/Location:	**General Urban/Suburban**
Number of Studies:	10
1000 Sq. Ft. GFA:	113
Directional Distribution:	66% entering, 34% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
1.76	1.08 - 3.18	0.74

Data Plot and Equation



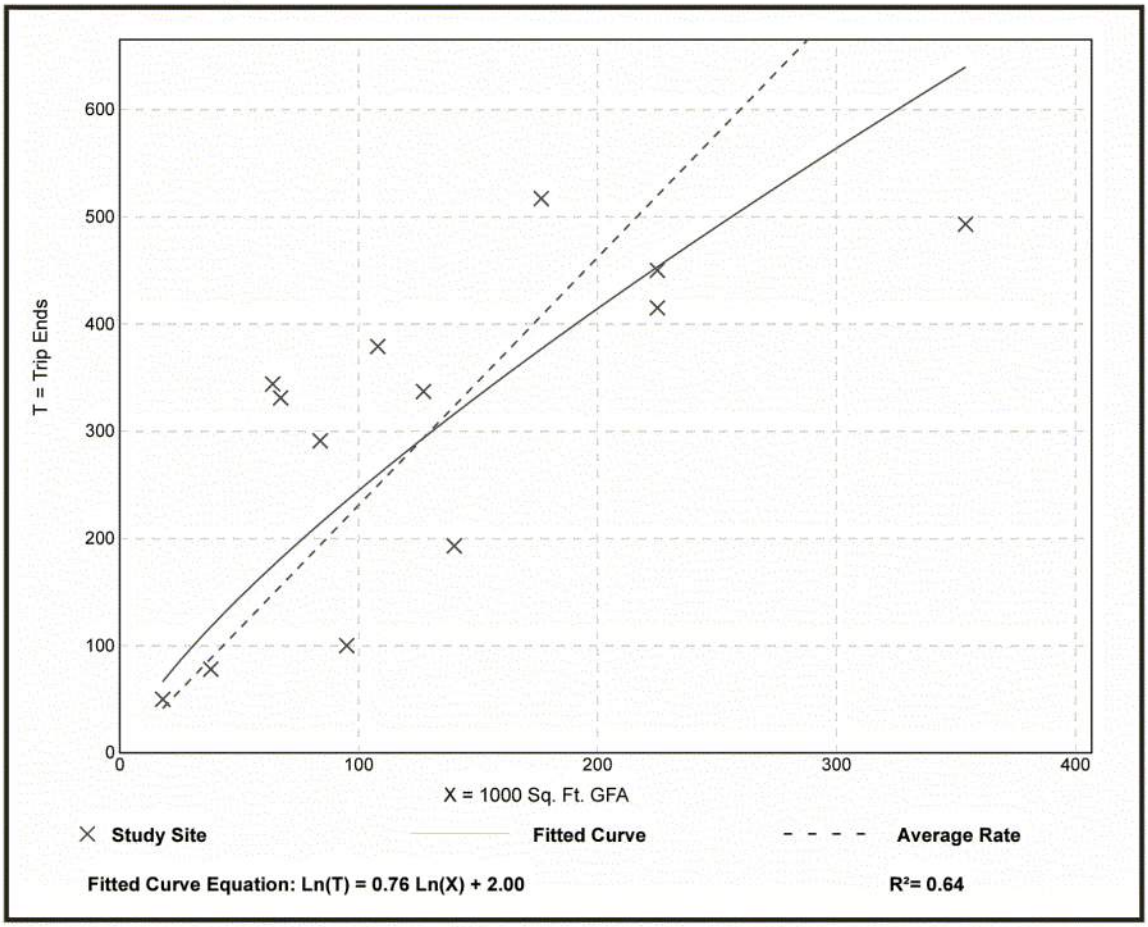
Recreational Community Center
(495)

Vehicle Trip Ends vs: **1000 Sq. Ft. GFA**
On a: **Weekday,**
Peak Hour of Adjacent Street Traffic,
One Hour Between 4 and 6 p.m.
Setting/Location: **General Urban/Suburban**
Number of Studies: 13
1000 Sq. Ft. GFA: 132
Directional Distribution: 47% entering, 53% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
2.31	1.05 - 5.37	1.14

Data Plot and Equation



Recreational Community Center
(495)

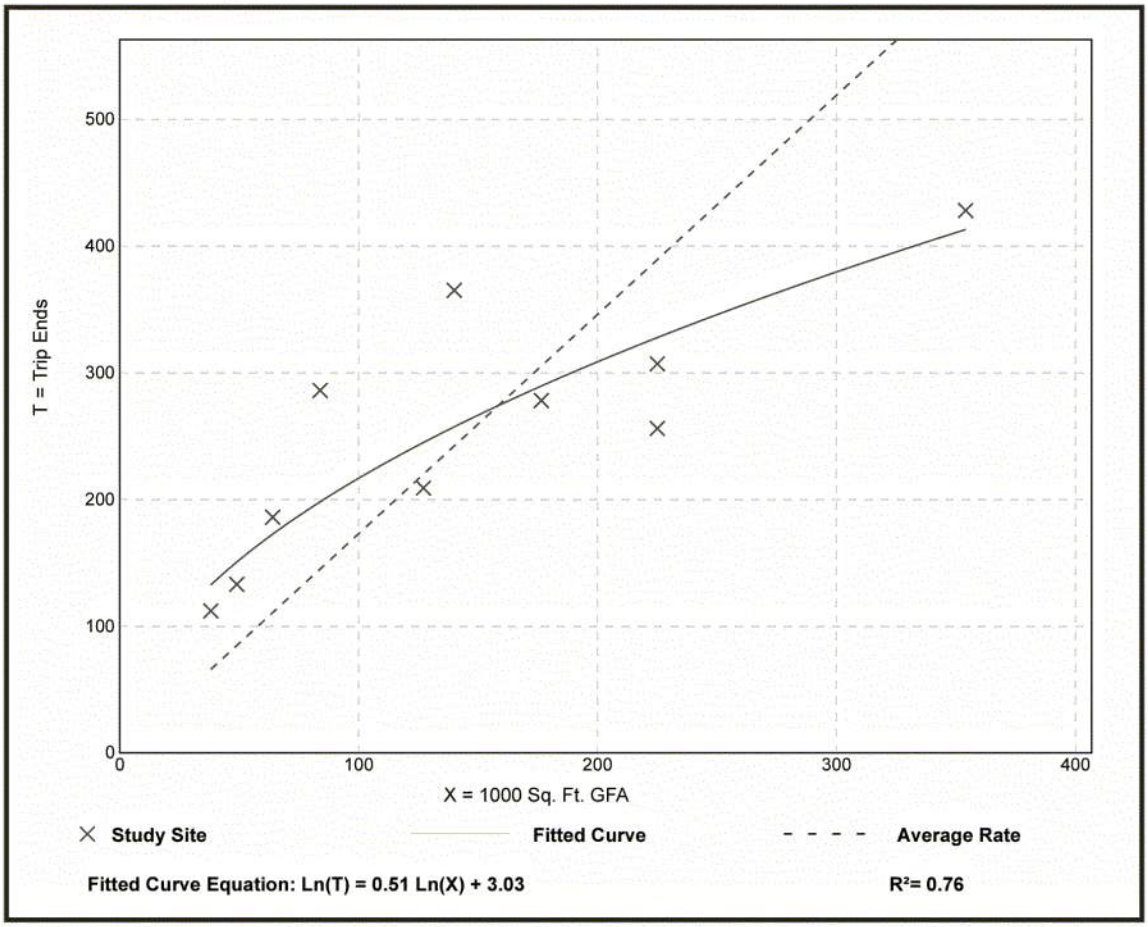
Vehicle Trip Ends vs: **1000 Sq. Ft. GFA**
On a: **Weekday,**
AM Peak Hour of Generator

Setting/Location: **General Urban/Suburban**
Number of Studies: 10
1000 Sq. Ft. GFA: 148
Directional Distribution: 63% entering, 37% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
1.73	1.14 - 3.41	0.75

Data Plot and Equation



Recreational Community Center
(495)

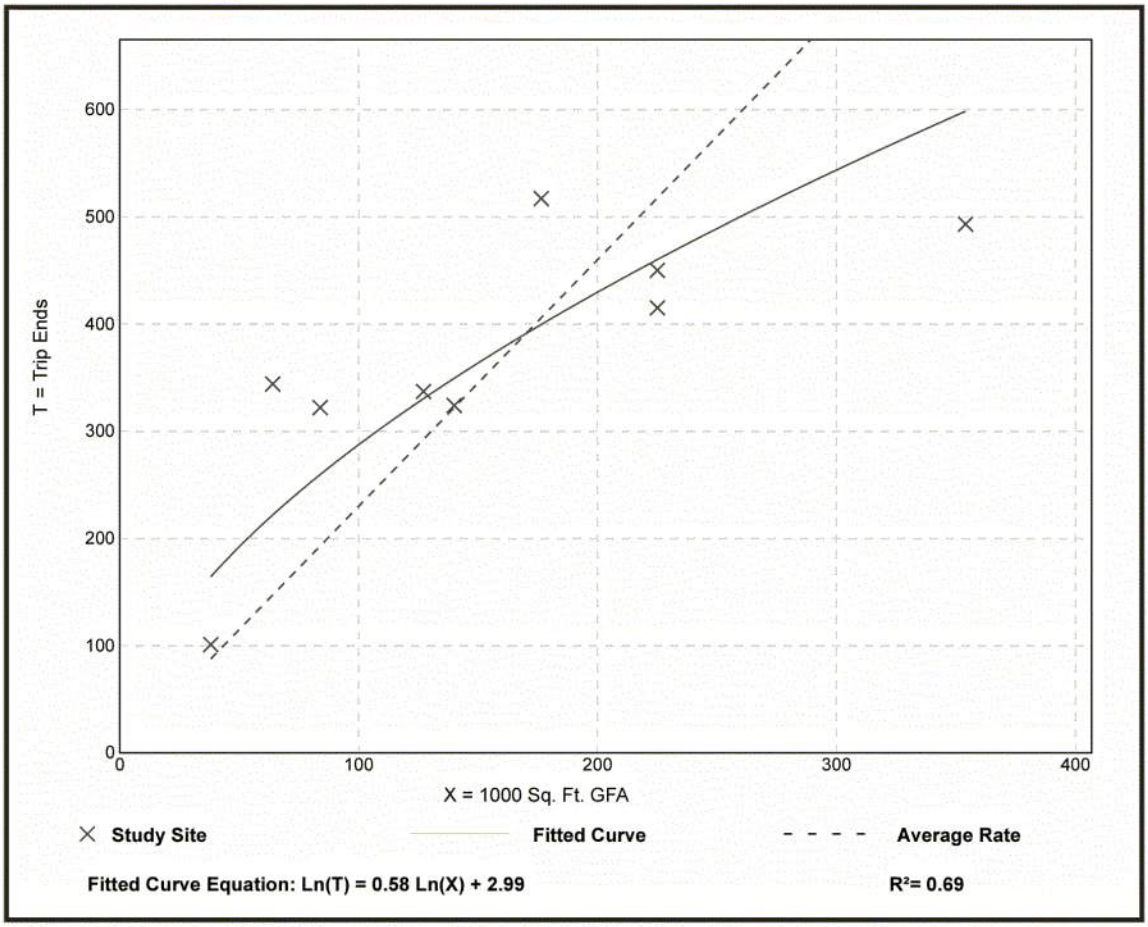
Vehicle Trip Ends vs: **1000 Sq. Ft. GFA**
On a: **Weekday,**
PM Peak Hour of Generator

Setting/Location: **General Urban/Suburban**
Number of Studies: 9
1000 Sq. Ft. GFA: 159
Directional Distribution: 46% entering, 54% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
2.30	1.39 - 5.37	0.99

Data Plot and Equation



Recreational Community Center
(495)

Vehicle Trip Ends vs: **1000 Sq. Ft. GFA**
On a: **Saturday**

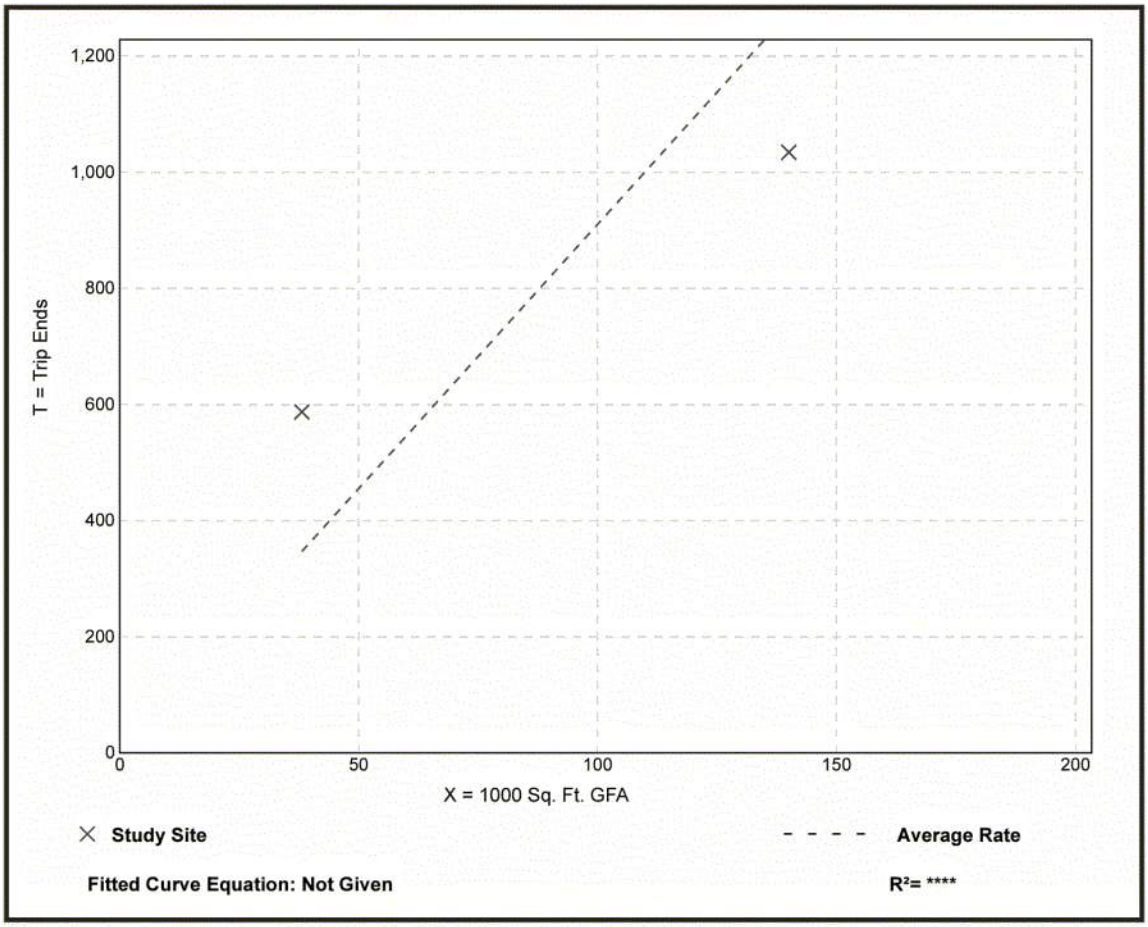
Setting/Location: **General Urban/Suburban**
Number of Studies: 2
1000 Sq. Ft. GFA: 89
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
9.10	7.39 - 15.40	*

Data Plot and Equation

Caution – Small Sample Size



Recreational Community Center
(495)

Vehicle Trip Ends vs: **1000 Sq. Ft. GFA**
On a: **Saturday, Peak Hour of Generator**

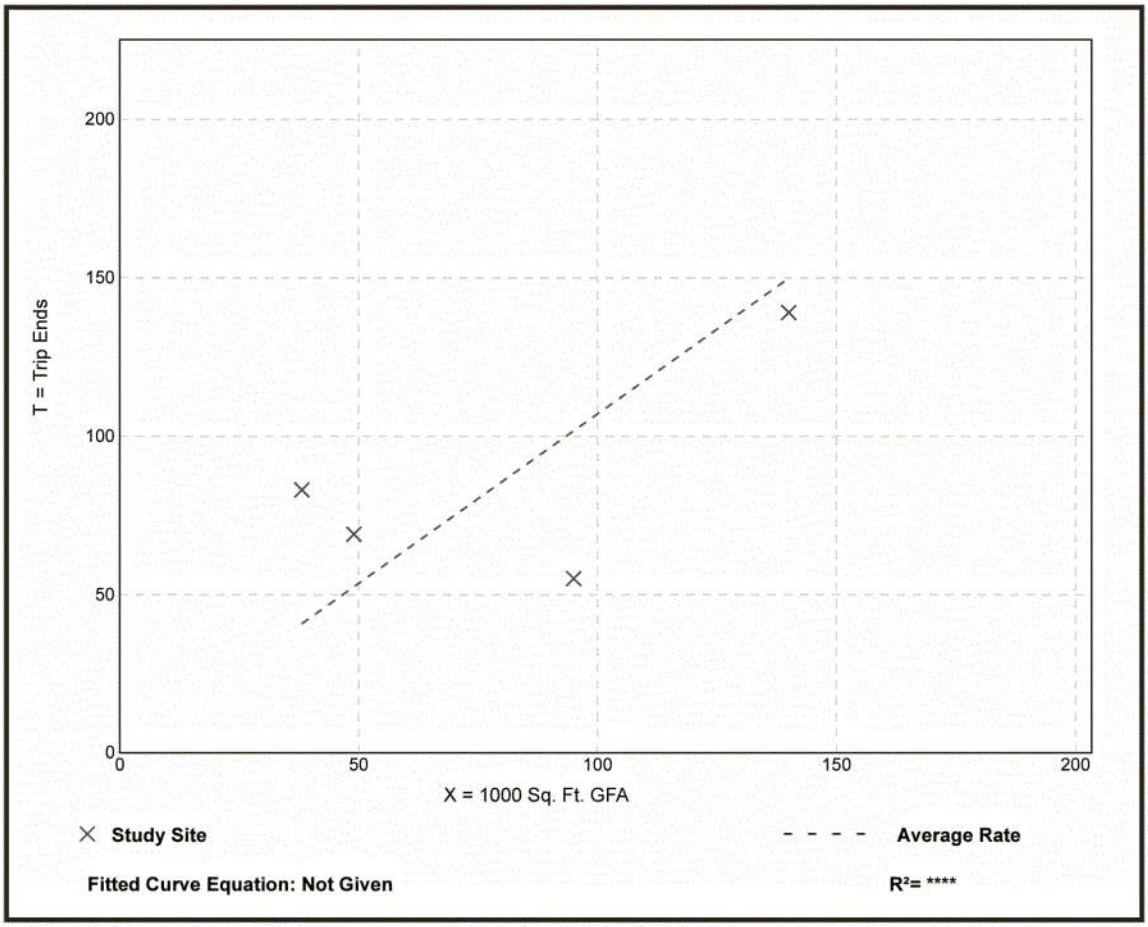
Setting/Location: **General Urban/Suburban**
Number of Studies: 4
1000 Sq. Ft. GFA: 81
Directional Distribution: 54% entering, 46% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
1.07	0.58 - 2.18	0.56

Data Plot and Equation

Caution – Small Sample Size



Recreational Community Center
(495)

Vehicle Trip Ends vs: **1000 Sq. Ft. GFA**
On a: **Sunday**

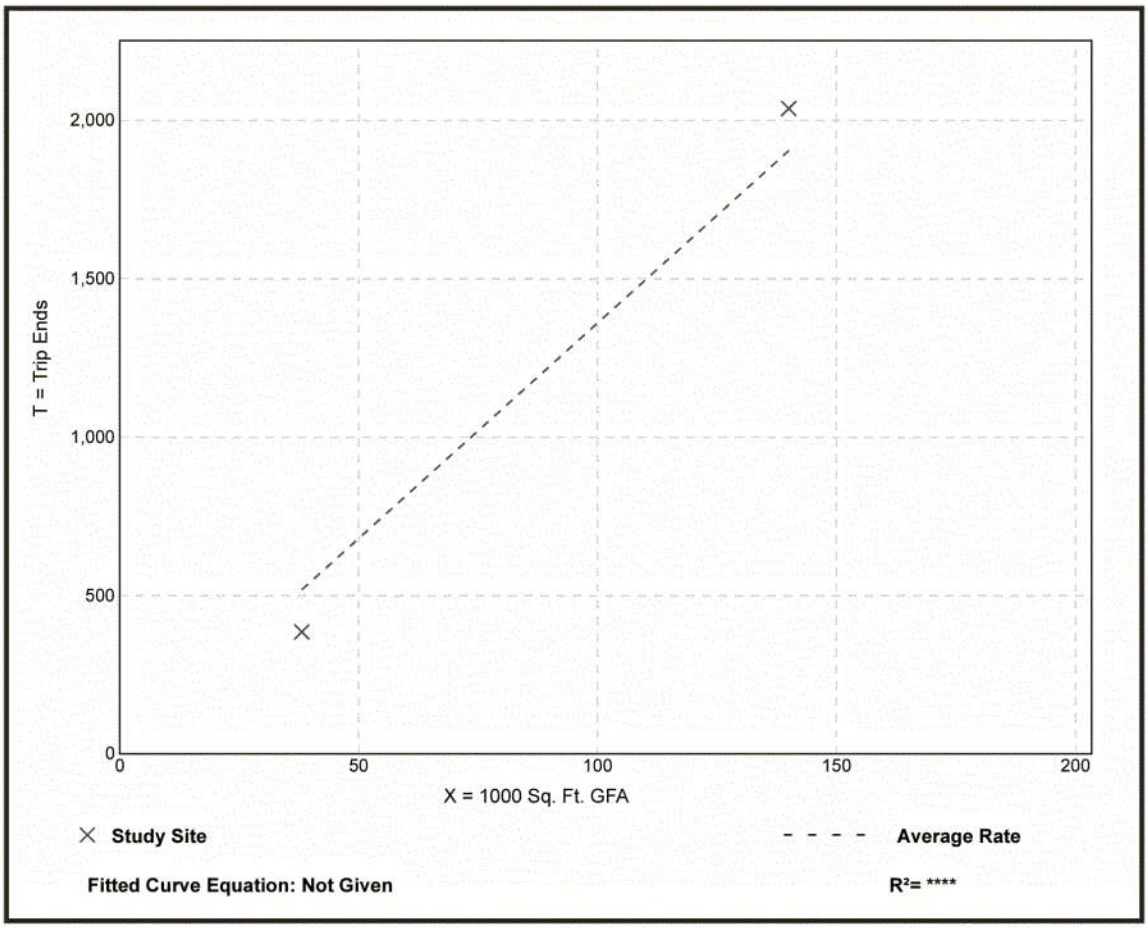
Setting/Location: **General Urban/Suburban**
Number of Studies: 2
1000 Sq. Ft. GFA: 89
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
13.60	10.10 - 14.55	*

Data Plot and Equation

Caution – Small Sample Size



Fitted Curve Equation: Not Given

R^2= **

Recreational Community Center
(495)

Vehicle Trip Ends vs: **1000 Sq. Ft. GFA**
On a: **Sunday, Peak Hour of Generator**

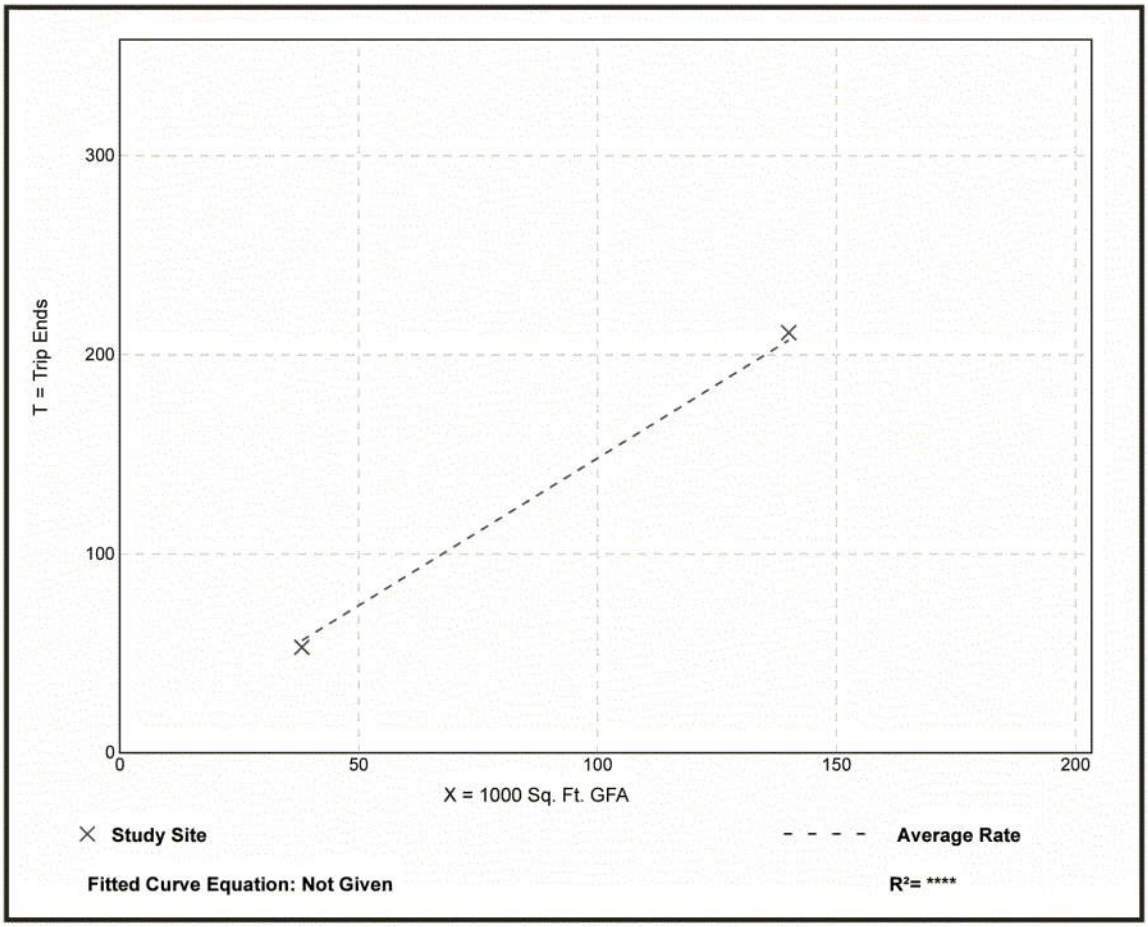
Setting/Location: **General Urban/Suburban**
Number of Studies: 2
1000 Sq. Ft. GFA: 89
Directional Distribution: 56% entering, 44% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
1.48	1.39 - 1.51	*

Data Plot and Equation

Caution – Small Sample Size



Recreational Community Center
(495)

Vehicle Trip Ends vs: **Employees**
On a: **Weekday**

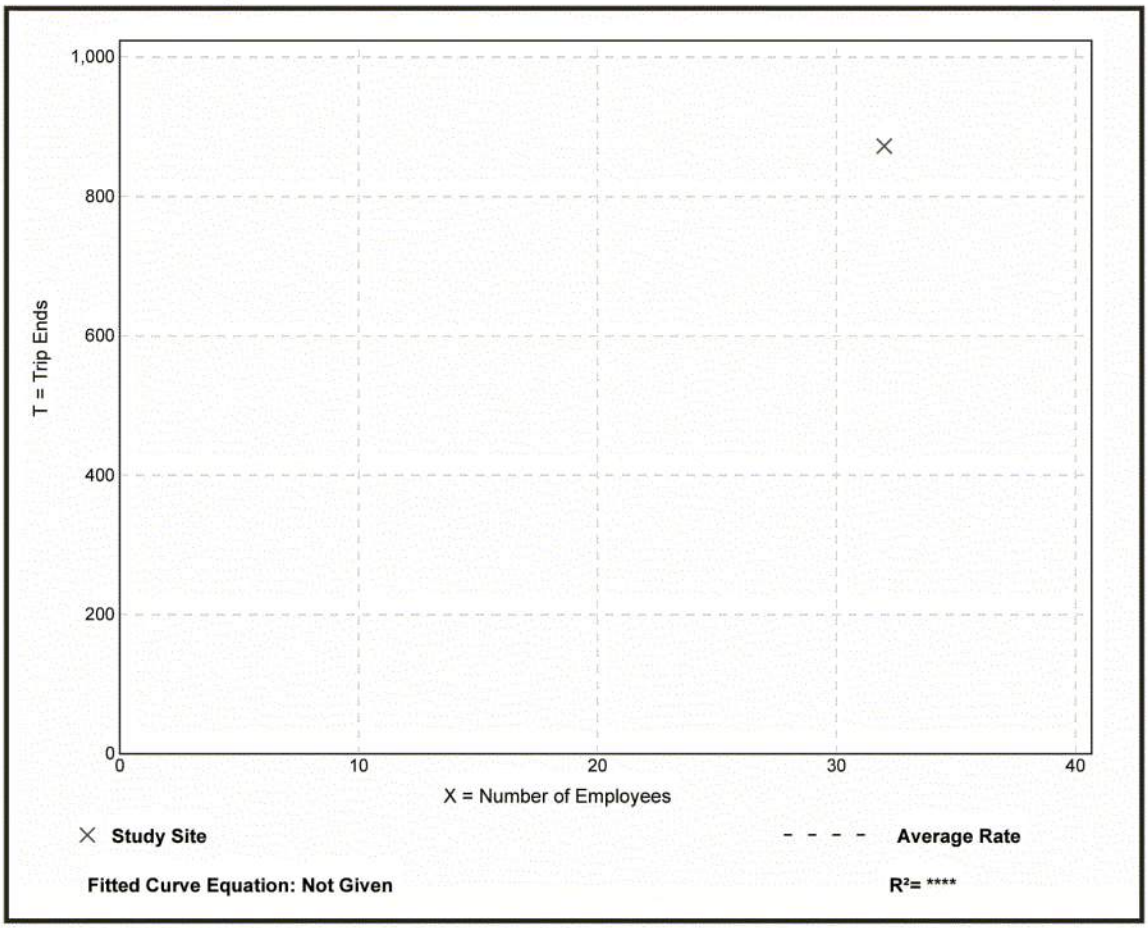
Setting/Location: **General Urban/Suburban**
Number of Studies: 1
Avg. Num. of Employees: 32
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per Employee

Average Rate	Range of Rates	Standard Deviation
27.25	27.25 - 27.25	*

Data Plot and Equation

Caution – Small Sample Size



Recreational Community Center
(495)

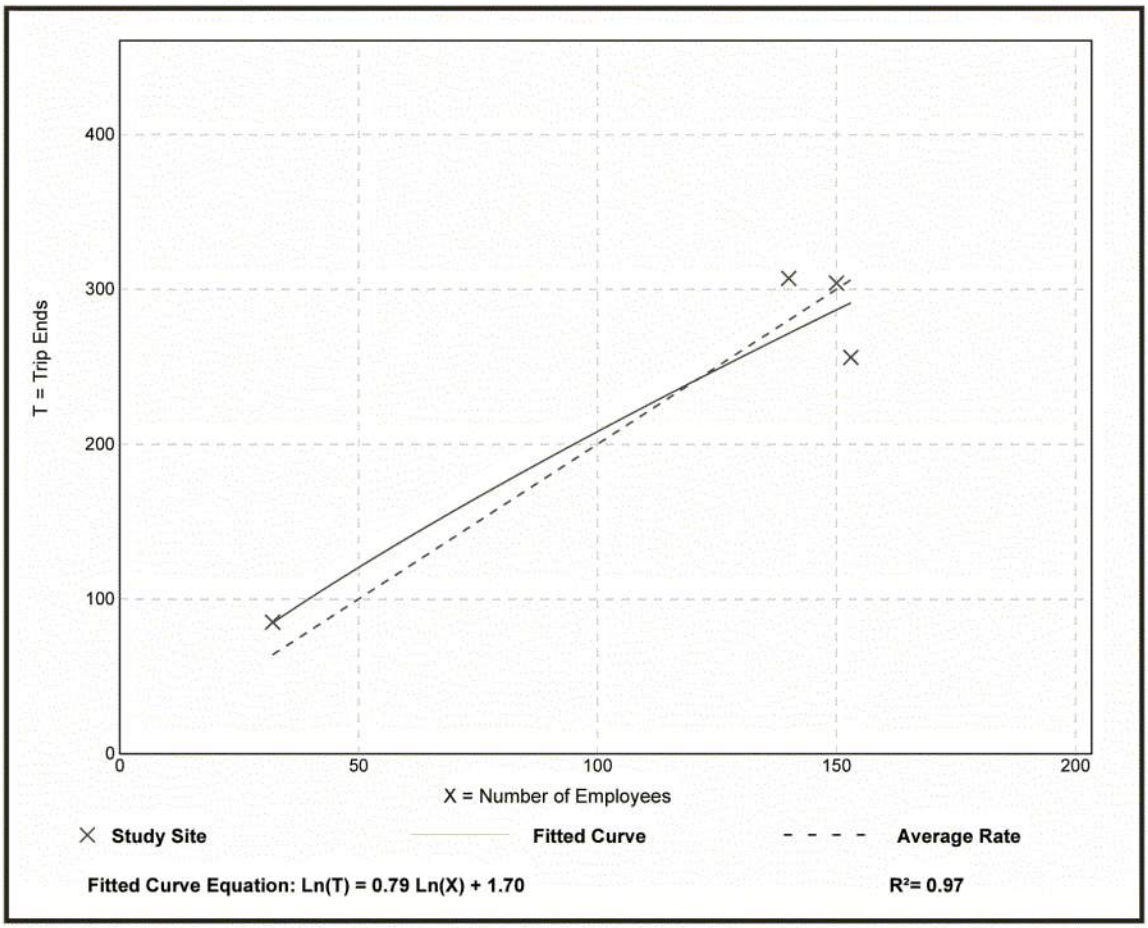
Vehicle Trip Ends vs: **Employees**
On a: **Weekday,**
Peak Hour of Adjacent Street Traffic,
One Hour Between 7 and 9 a.m.
Setting/Location: **General Urban/Suburban**
Number of Studies: 4
Avg. Num. of Employees: 119
Directional Distribution: 67% entering, 33% exiting

Vehicle Trip Generation per Employee

Average Rate	Range of Rates	Standard Deviation
2.00	1.67 - 2.66	0.32

Data Plot and Equation

Caution – Small Sample Size



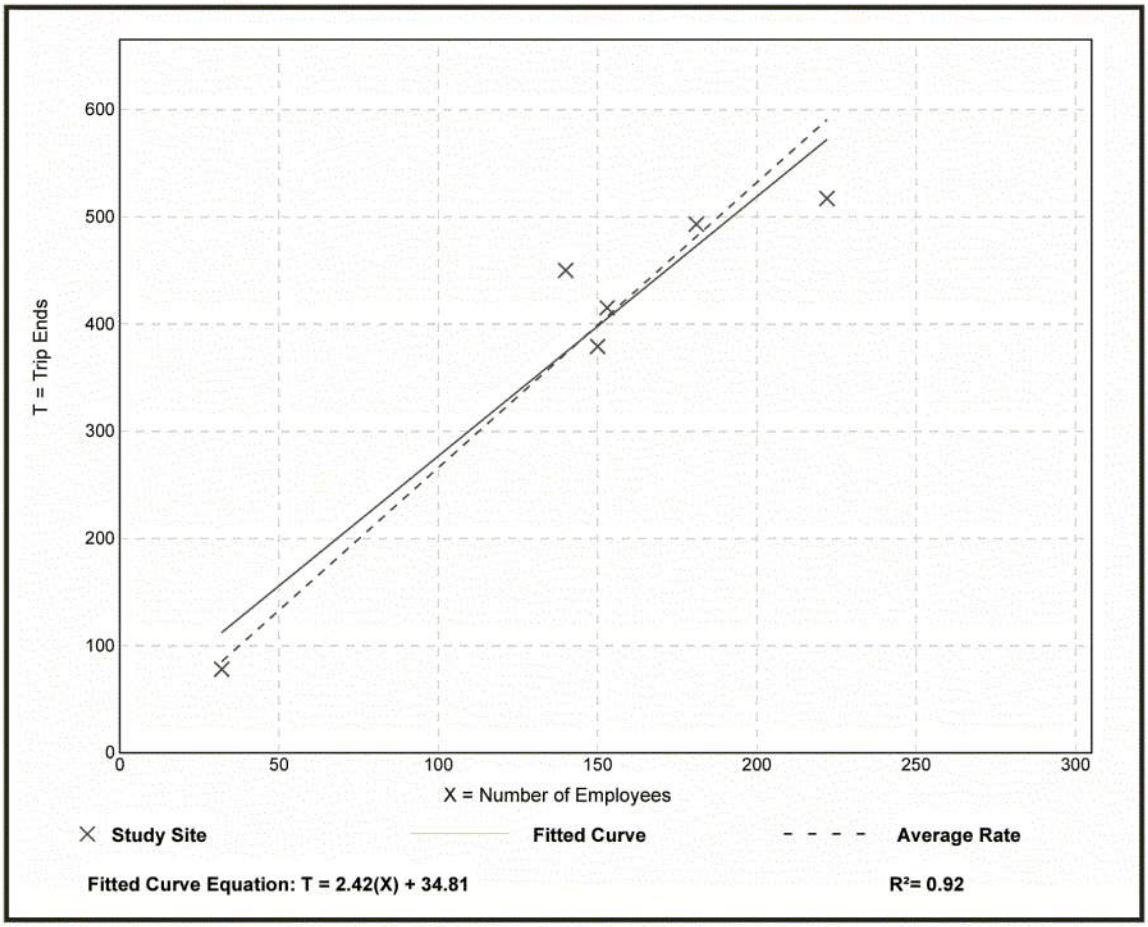
Recreational Community Center
(495)

Vehicle Trip Ends vs:	**Employees**
On a:	**Weekday,**
	Peak Hour of Adjacent Street Traffic,
	One Hour Between 4 and 6 p.m.
Setting/Location:	**General Urban/Suburban**
Number of Studies:	6
Avg. Num. of Employees:	146
Directional Distribution:	44% entering, 56% exiting

Vehicle Trip Generation per Employee

Average Rate	Range of Rates	Standard Deviation
2.66	2.33 - 3.21	0.32

Data Plot and Equation



Recreational Community Center
(495)

Vehicle Trip Ends vs: **Employees**
On a: **Weekday,**
AM Peak Hour of Generator

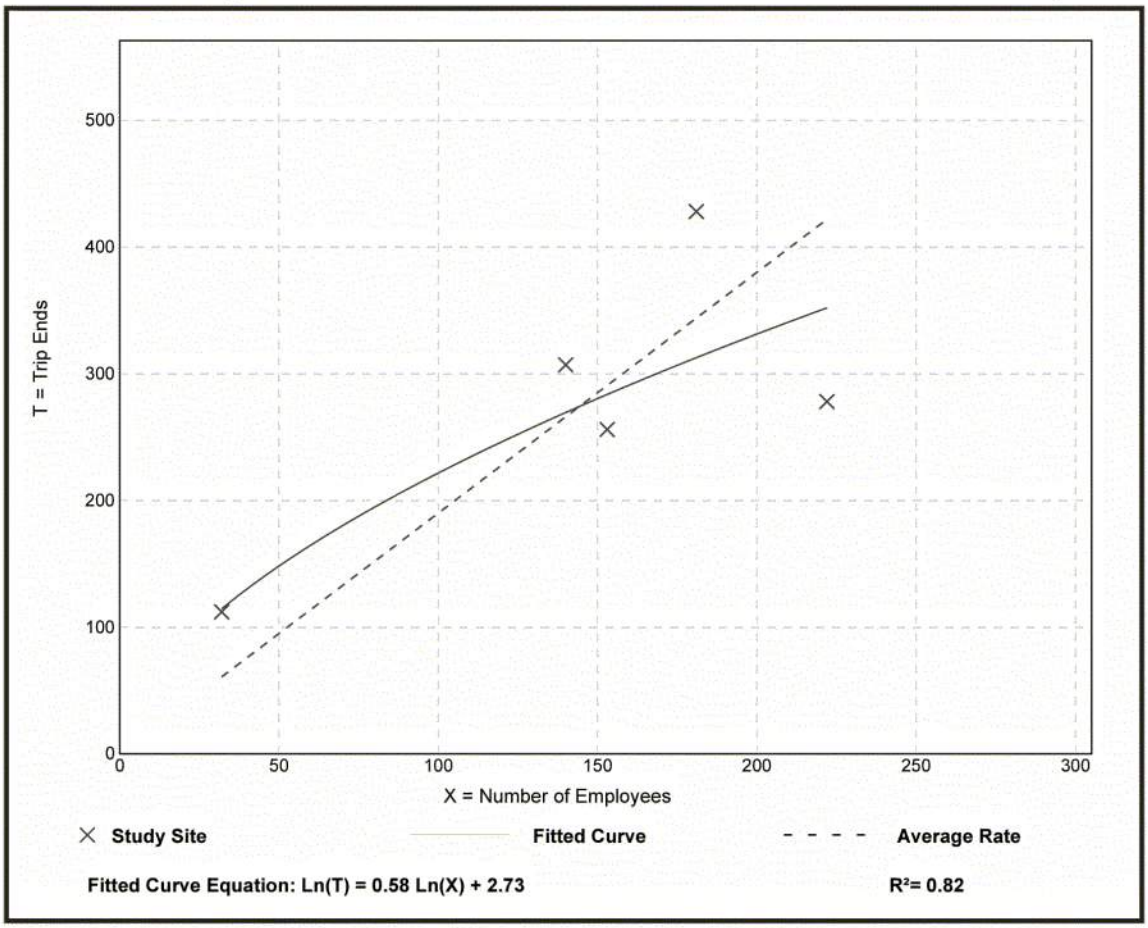
Setting/Location: **General Urban/Suburban**
Number of Studies: 5
Avg. Num. of Employees: 146
Directional Distribution: 65% entering, 35% exiting

Vehicle Trip Generation per Employee

Average Rate	Range of Rates	Standard Deviation
1.90	1.25 - 3.50	0.63

Data Plot and Equation

Caution – Small Sample Size



Recreational Community Center
(495)

Vehicle Trip Ends vs: **Employees**
On a: **Weekday,**
PM Peak Hour of Generator

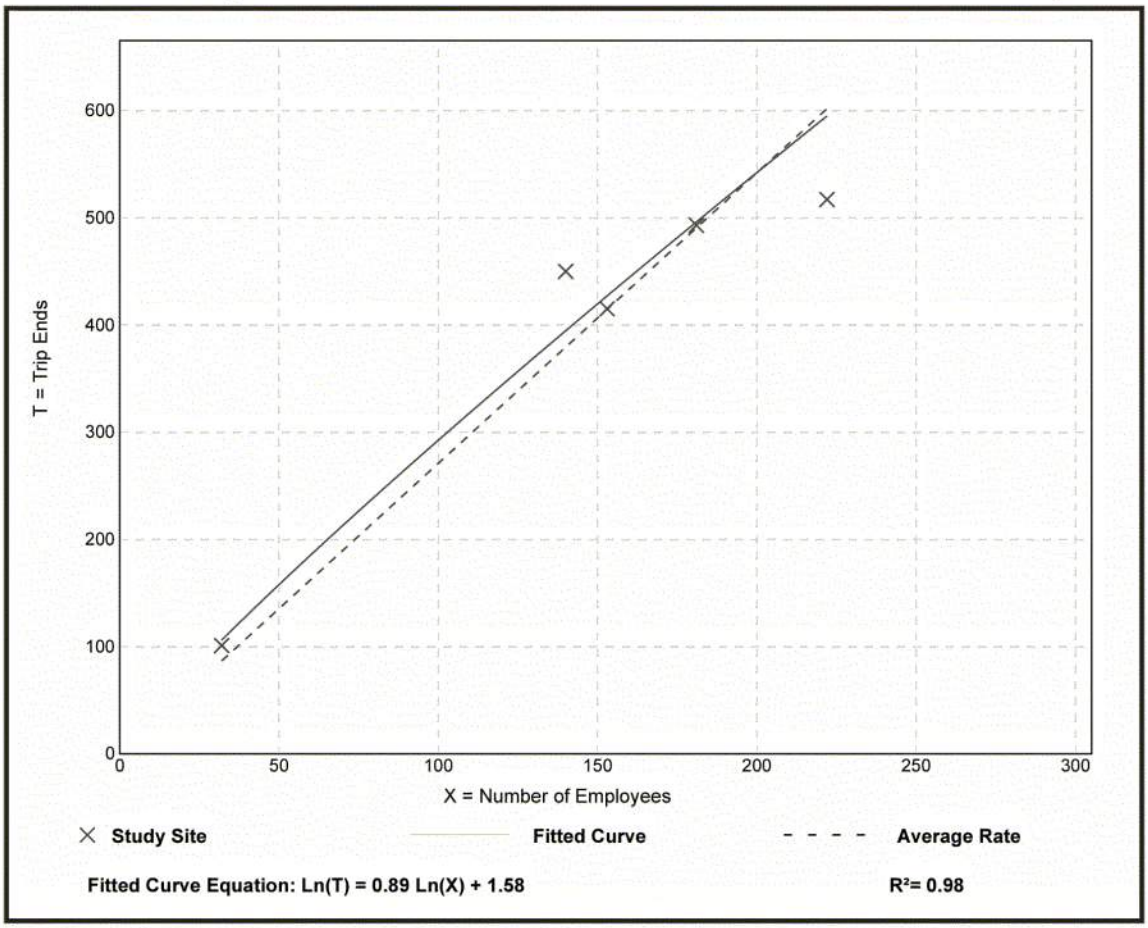
Setting/Location: **General Urban/Suburban**
Number of Studies: 5
Avg. Num. of Employees: 146
Directional Distribution: 43% entering, 57% exiting

Vehicle Trip Generation per Employee

Average Rate	Range of Rates	Standard Deviation
2.71	2.33 - 3.21	0.36

Data Plot and Equation

Caution – Small Sample Size



Recreational Community Center
(495)

Vehicle Trip Ends vs: **Employees**
On a: **Saturday**

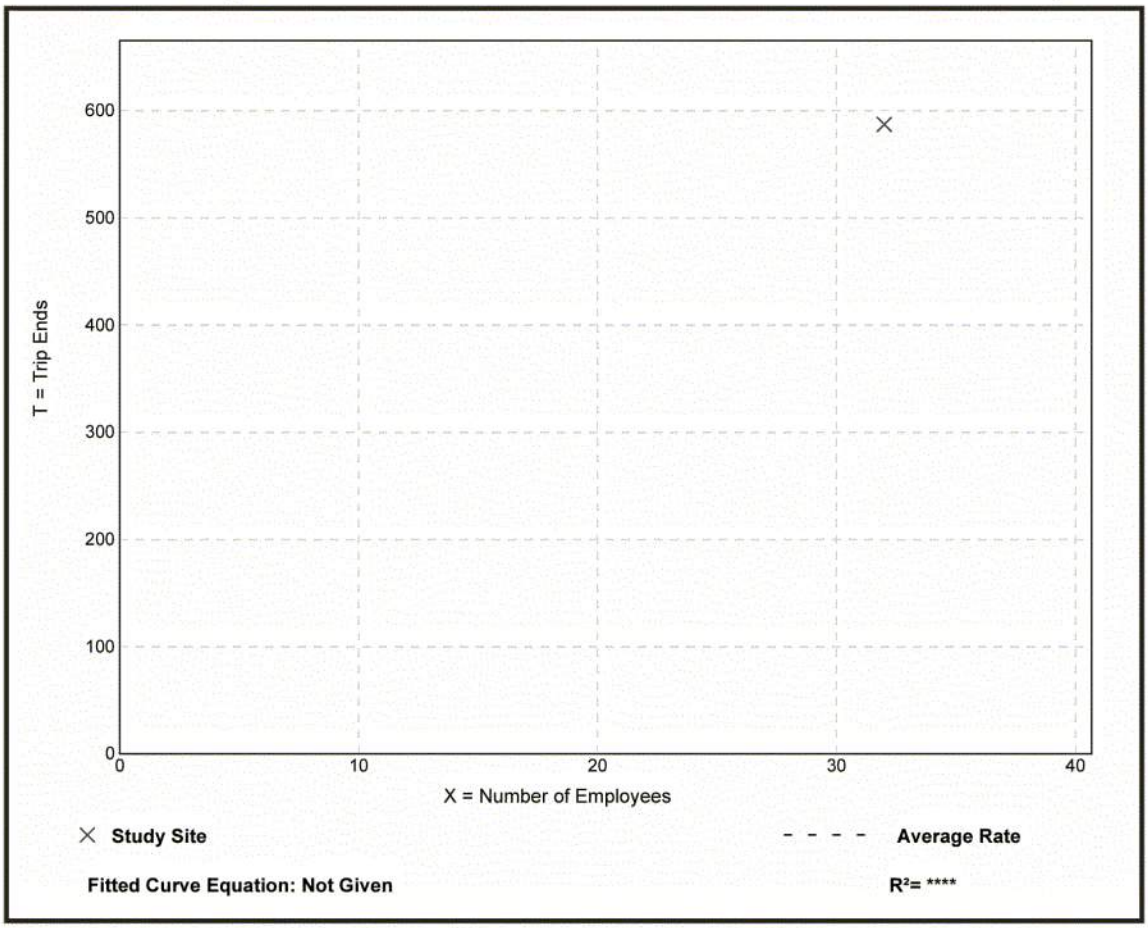
Setting/Location: **General Urban/Suburban**
Number of Studies: 1
Avg. Num. of Employees: 32
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per Employee

Average Rate	Range of Rates	Standard Deviation
18.34	18.34 - 18.34	*

Data Plot and Equation

Caution – Small Sample Size



Fitted Curve Equation: Not Given

R^2= **

Recreational Community Center
(495)

Vehicle Trip Ends vs: **Employees**
On a: **Saturday, Peak Hour of Generator**

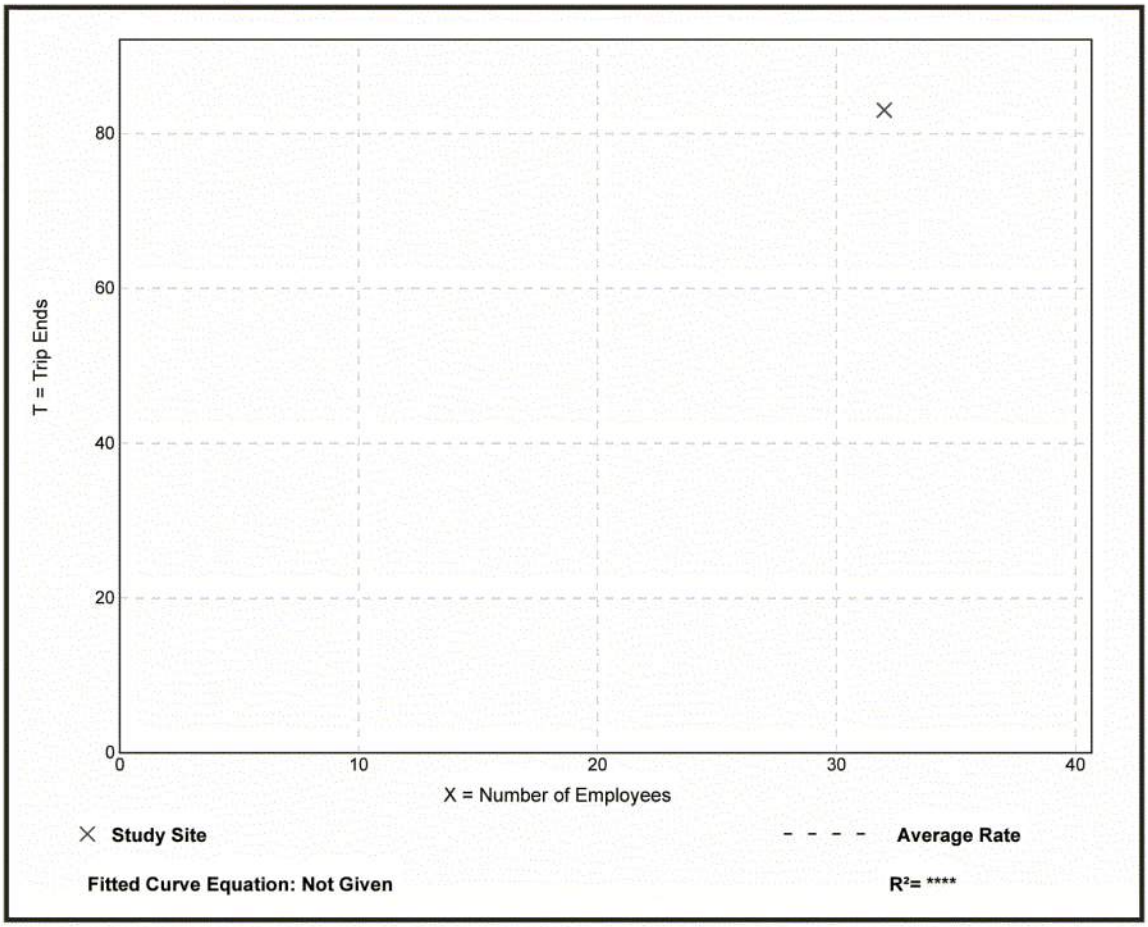
Setting/Location: **General Urban/Suburban**
Number of Studies: 1
Avg. Num. of Employees: 32
Directional Distribution: 53% entering, 47% exiting

Vehicle Trip Generation per Employee

Average Rate	Range of Rates	Standard Deviation
2.59	2.59 - 2.59	*

Data Plot and Equation

Caution – Small Sample Size



Recreational Community Center
(495)

Vehicle Trip Ends vs: **Employees**
On a: **Sunday**

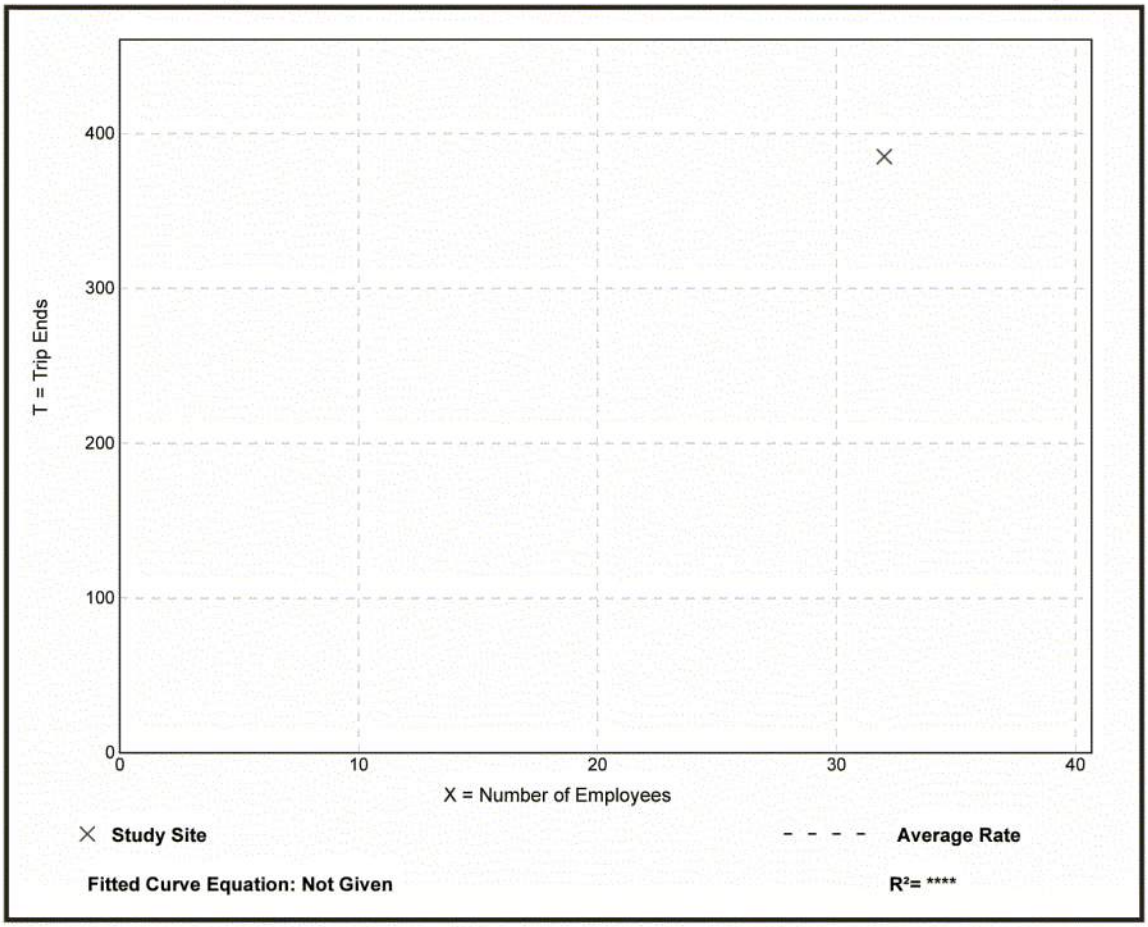
Setting/Location: **General Urban/Suburban**
Number of Studies: 1
Avg. Num. of Employees: 32
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per Employee

Average Rate	Range of Rates	Standard Deviation
12.03	12.03 - 12.03	*

Data Plot and Equation

Caution – Small Sample Size



Recreational Community Center
(495)

Vehicle Trip Ends vs: **Employees**
On a: **Sunday, Peak Hour of Generator**

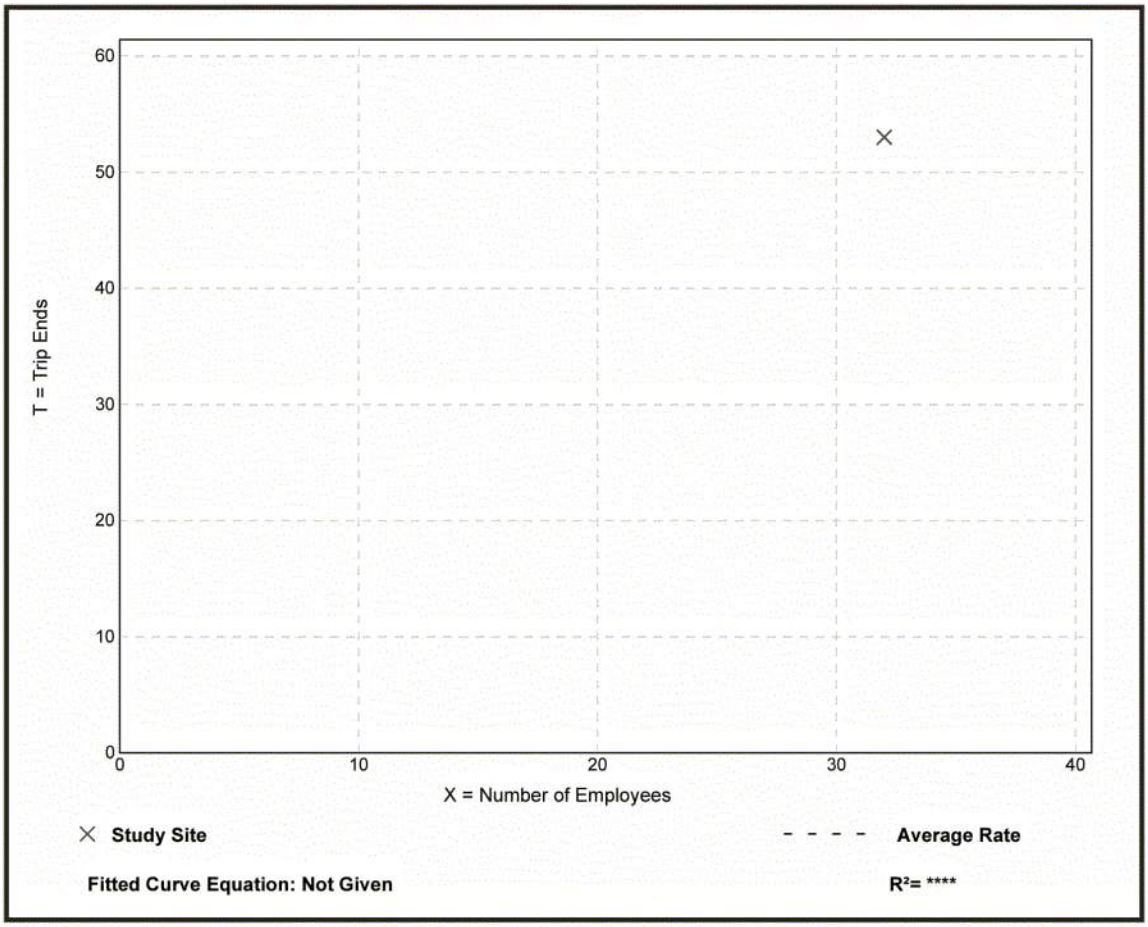
Setting/Location: **General Urban/Suburban**
Number of Studies: 1
Avg. Num. of Employees: 32
Directional Distribution: 43% entering, 57% exiting

Vehicle Trip Generation per Employee

Average Rate	Range of Rates	Standard Deviation
1.66	1.66 - 1.66	*

Data Plot and Equation

Caution – Small Sample Size



Recreational Community Center
(495)

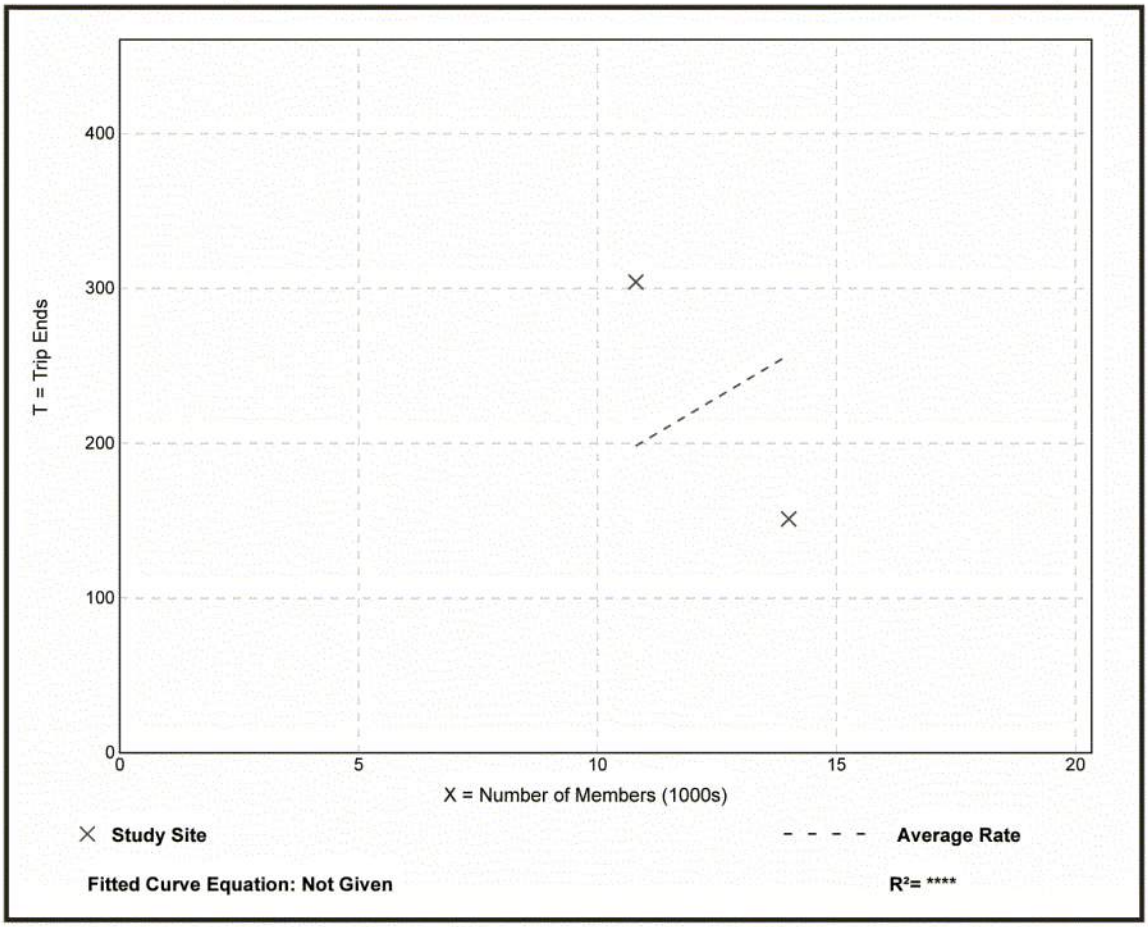
Vehicle Trip Ends vs: **Members (1000s)**
On a: **Weekday,**
Peak Hour of Adjacent Street Traffic,
One Hour Between 7 and 9 a.m.
Setting/Location: **General Urban/Suburban**
Number of Studies: 2
Avg. Num. of Members (1000s): 12
Directional Distribution: 55% entering, 45% exiting

Vehicle Trip Generation per Member (1000s)

Average Rate	Range of Rates	Standard Deviation
18.35	10.79 - 28.15	*

Data Plot and Equation

Caution – Small Sample Size



Recreational Community Center
(495)

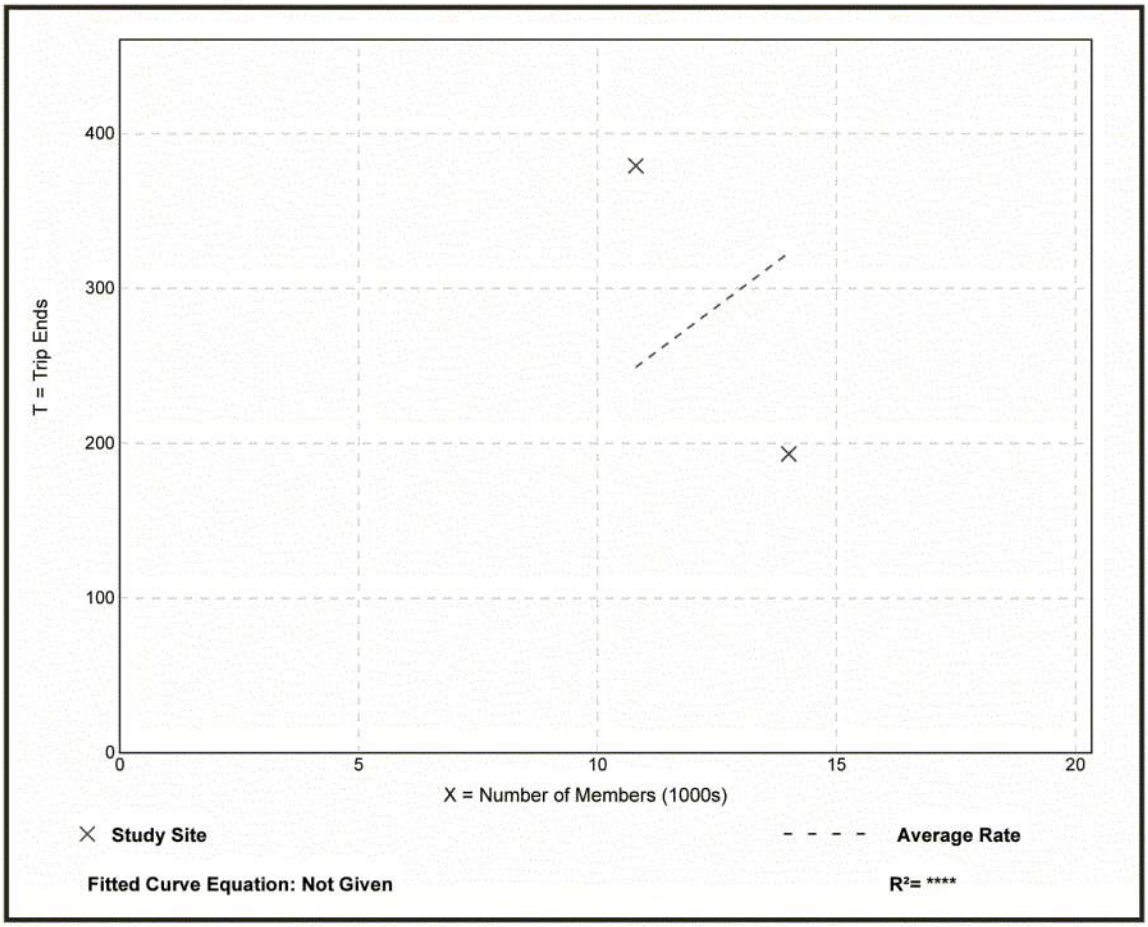
Vehicle Trip Ends vs:	**Members (1000s)**
On a:	**Weekday,**
	Peak Hour of Adjacent Street Traffic,
	One Hour Between 4 and 6 p.m.
Setting/Location:	**General Urban/Suburban**
Number of Studies:	2
Avg. Num. of Members (1000s):	12
Directional Distribution:	44% entering, 56% exiting

Vehicle Trip Generation per Member (1000s)

Average Rate	Range of Rates	Standard Deviation
23.06	13.79 - 35.09	*

Data Plot and Equation

Caution – Small Sample Size



Recreational Community Center
(495)

Vehicle Trip Ends vs: **Members (1000s)**
On a: **Weekday,**
AM Peak Hour of Generator

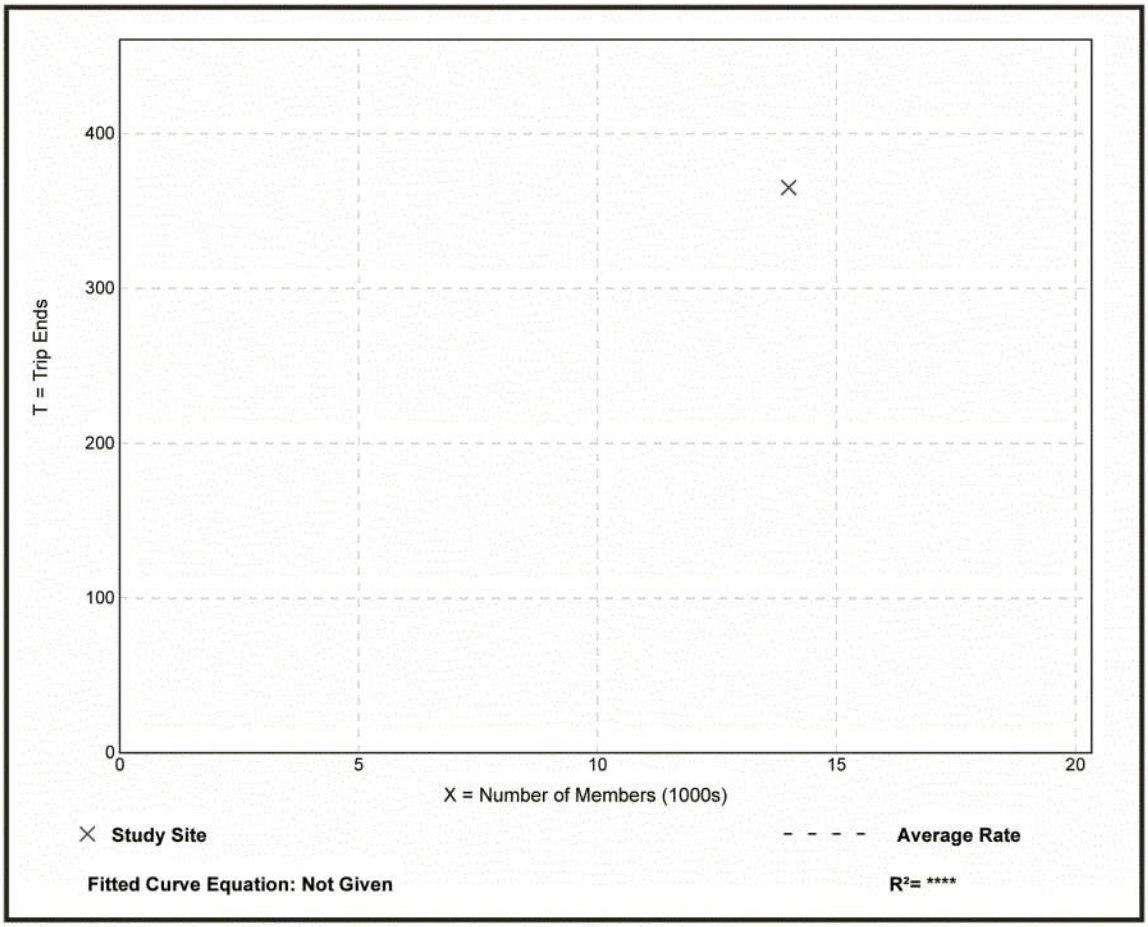
Setting/Location: **General Urban/Suburban**
Number of Studies: 1
Avg. Num. of Members (1000s): 14
Directional Distribution: 58% entering, 42% exiting

Vehicle Trip Generation per Member (1000s)

Average Rate	Range of Rates	Standard Deviation
26.07	26.07 - 26.07	*

Data Plot and Equation

Caution – Small Sample Size



Recreational Community Center
(495)

Vehicle Trip Ends vs: **Members (1000s)**
On a: **Weekday,**
PM Peak Hour of Generator

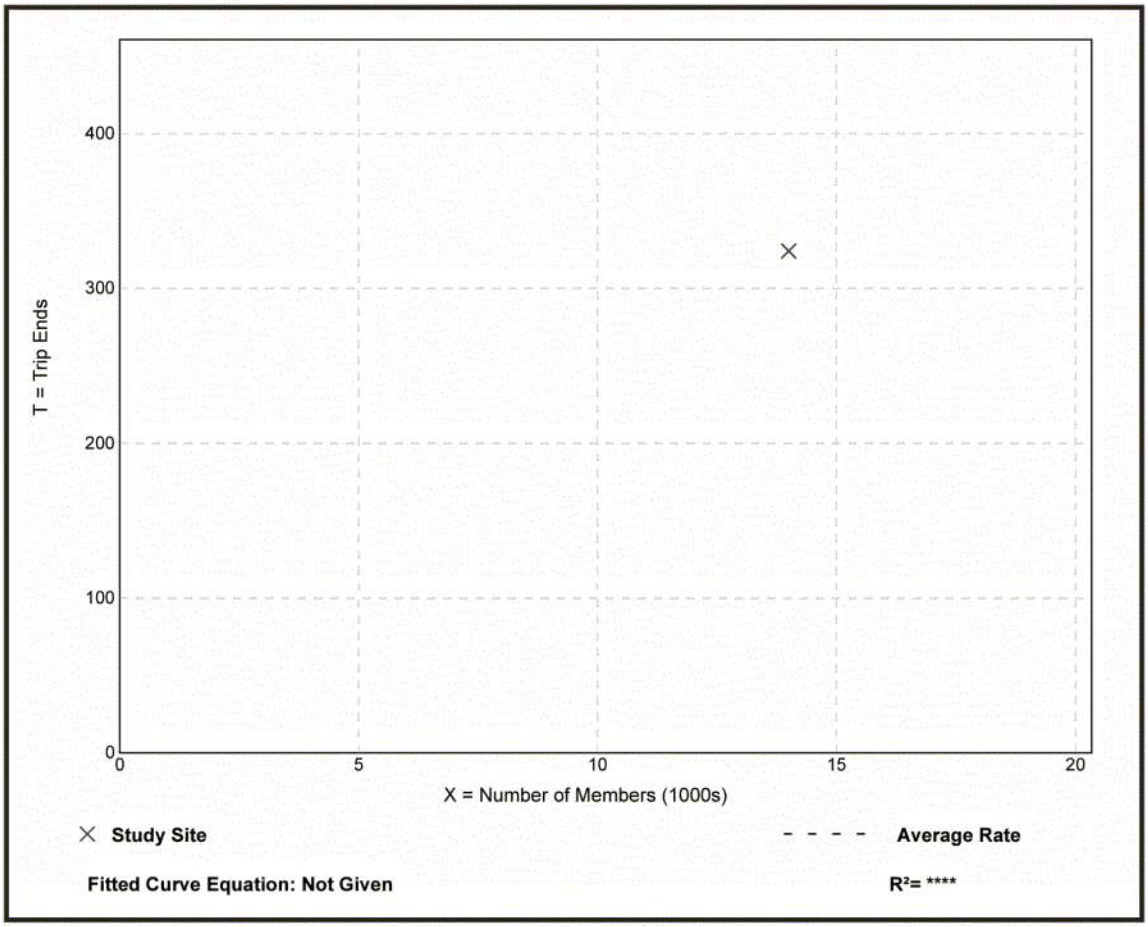
Setting/Location: **General Urban/Suburban**
Number of Studies: 1
Avg. Num. of Members (1000s): 14
Directional Distribution: 39% entering, 61% exiting

Vehicle Trip Generation per Member (1000s)

Average Rate	Range of Rates	Standard Deviation
23.14	23.14 - 23.14	*

Data Plot and Equation

Caution – Small Sample Size



Recreational Community Center
(495)

Vehicle Trip Ends vs: **Members (1000s)**
On a: **Saturday**

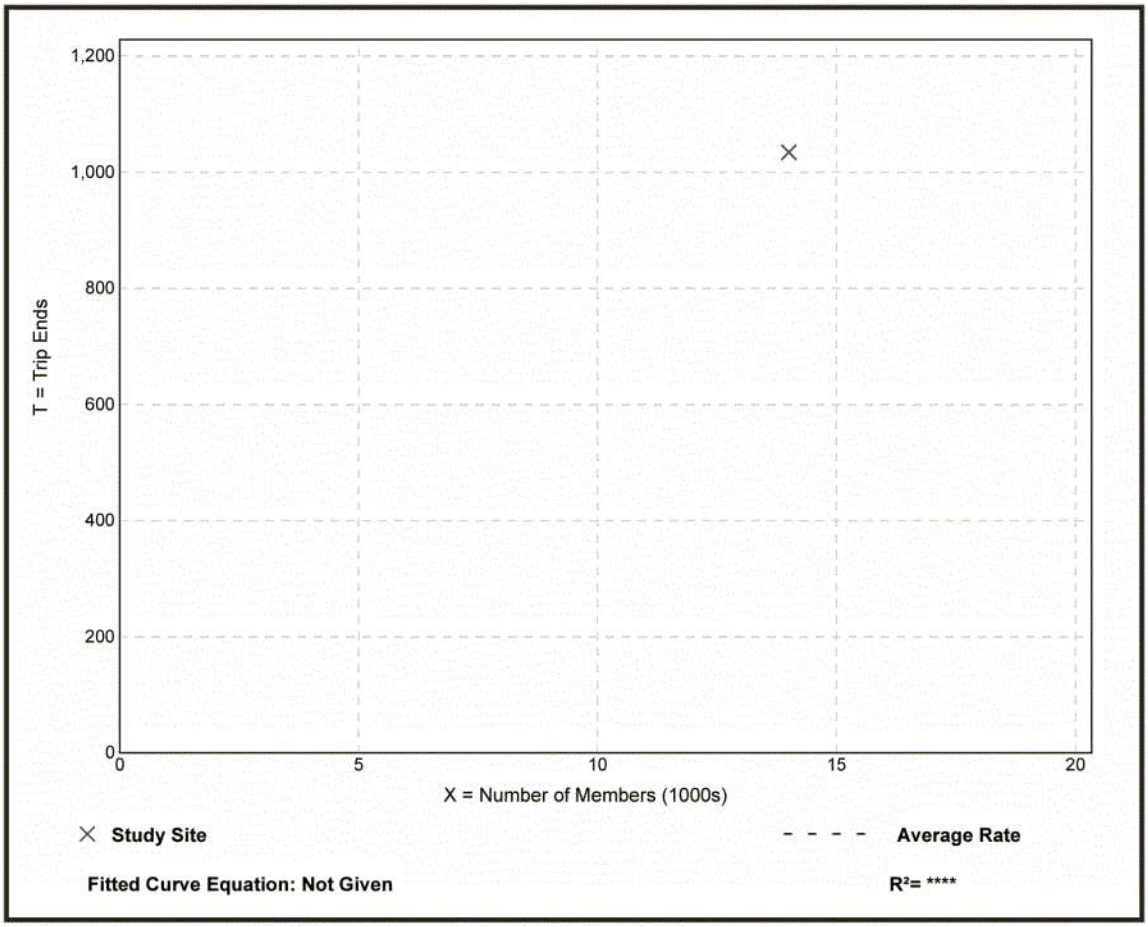
Setting/Location: **General Urban/Suburban**
Number of Studies: 1
Avg. Num. of Members (1000s): 14
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per Member (1000s)

Average Rate	Range of Rates	Standard Deviation
73.86	73.86 - 73.86	*

Data Plot and Equation

Caution – Small Sample Size



Fitted Curve Equation: Not Given

R^2= **

Recreational Community Center
(495)

Vehicle Trip Ends vs: **Members (1000s)**
On a: **Sunday**

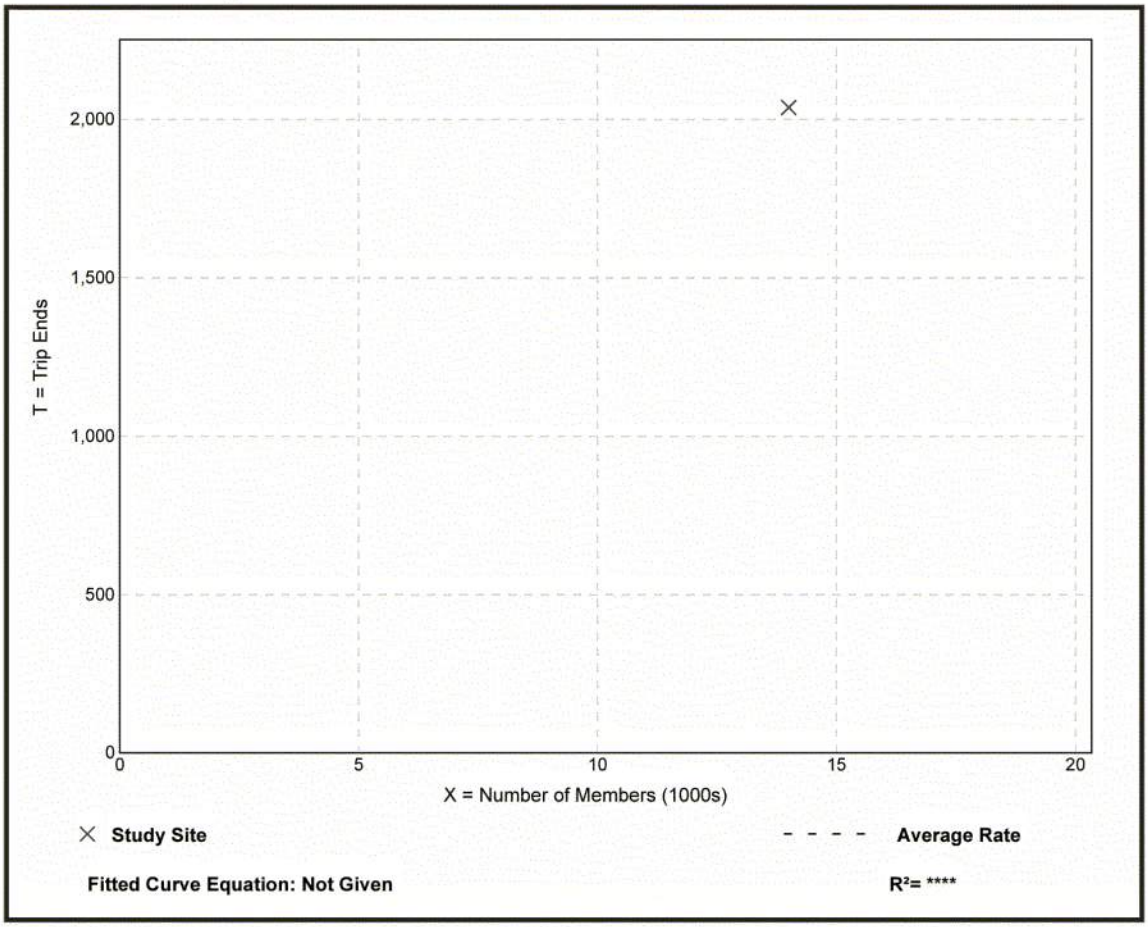
Setting/Location: **General Urban/Suburban**
Number of Studies: 1
Avg. Num. of Members (1000s): 14
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per Member (1000s)

Average Rate	Range of Rates	Standard Deviation
145.50	145.50 - 145.50	*

Data Plot and Equation

Caution – Small Sample Size



Fitted Curve Equation: Not Given

R^2= **

Recreational Community Center
(495)

Vehicle Trip Ends vs: **Members (1000s)**
On a: **Sunday, Peak Hour of Generator**

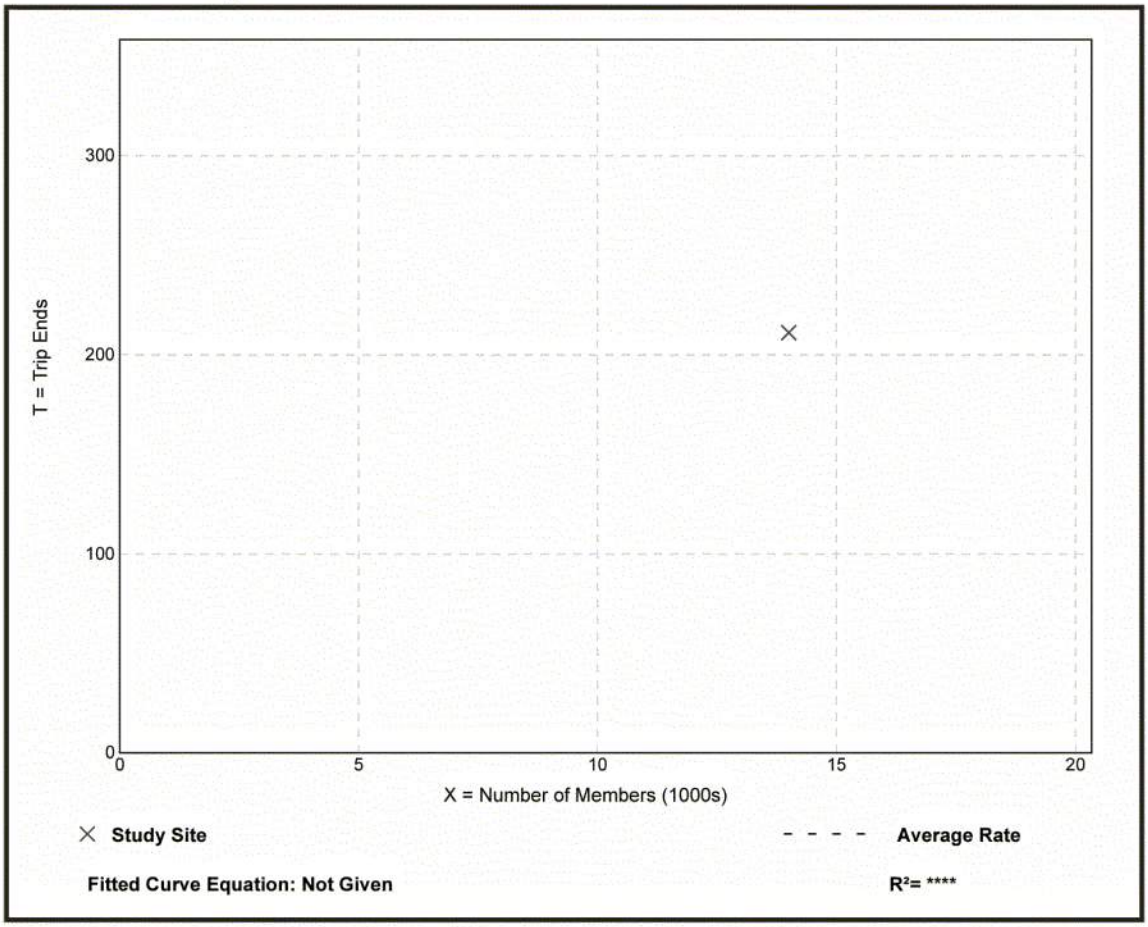
Setting/Location: **General Urban/Suburban**
Number of Studies: 1
Avg. Num. of Members (1000s): 14
Directional Distribution: 60% entering, 40% exiting

Vehicle Trip Generation per Member (1000s)

Average Rate	Range of Rates	Standard Deviation
15.07	15.07 - 15.07	*

Data Plot and Equation

Caution – Small Sample Size



Fitted Curve Equation: Not Given

R^2= **

Recreational Community Center
(495)

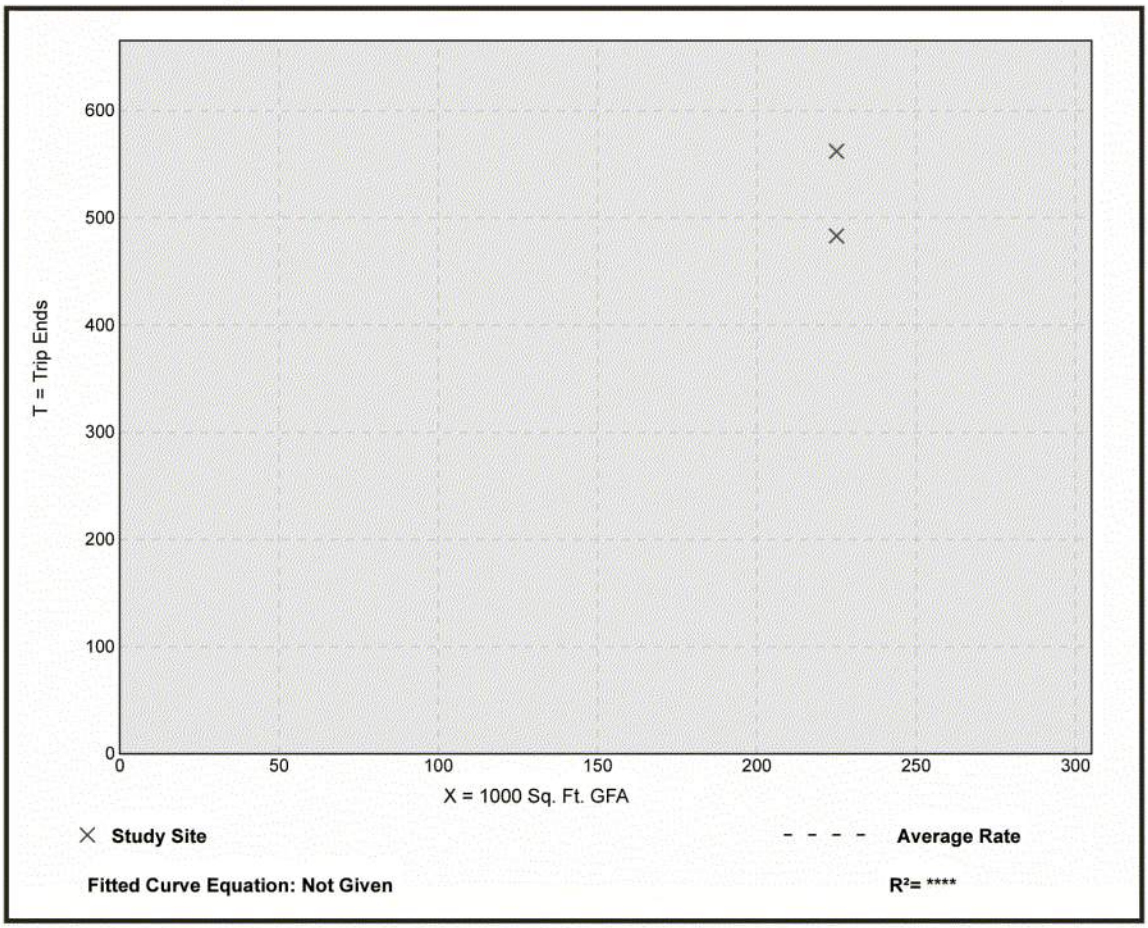
Person Trip Ends vs:	**1000 Sq. Ft. GFA**
On a:	**Weekday,**
	Peak Hour of Adjacent Street Traffic,
	One Hour Between 7 and 9 a.m.
Setting/Location:	**General Urban/Suburban**
Number of Studies:	2
1000 Sq. Ft. GFA:	225
Directional Distribution:	74% entering, 26% exiting

Person Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
2.32	2.15 - 2.50	*

Data Plot and Equation

Caution – Small Sample Size



Recreational Community Center
(495)

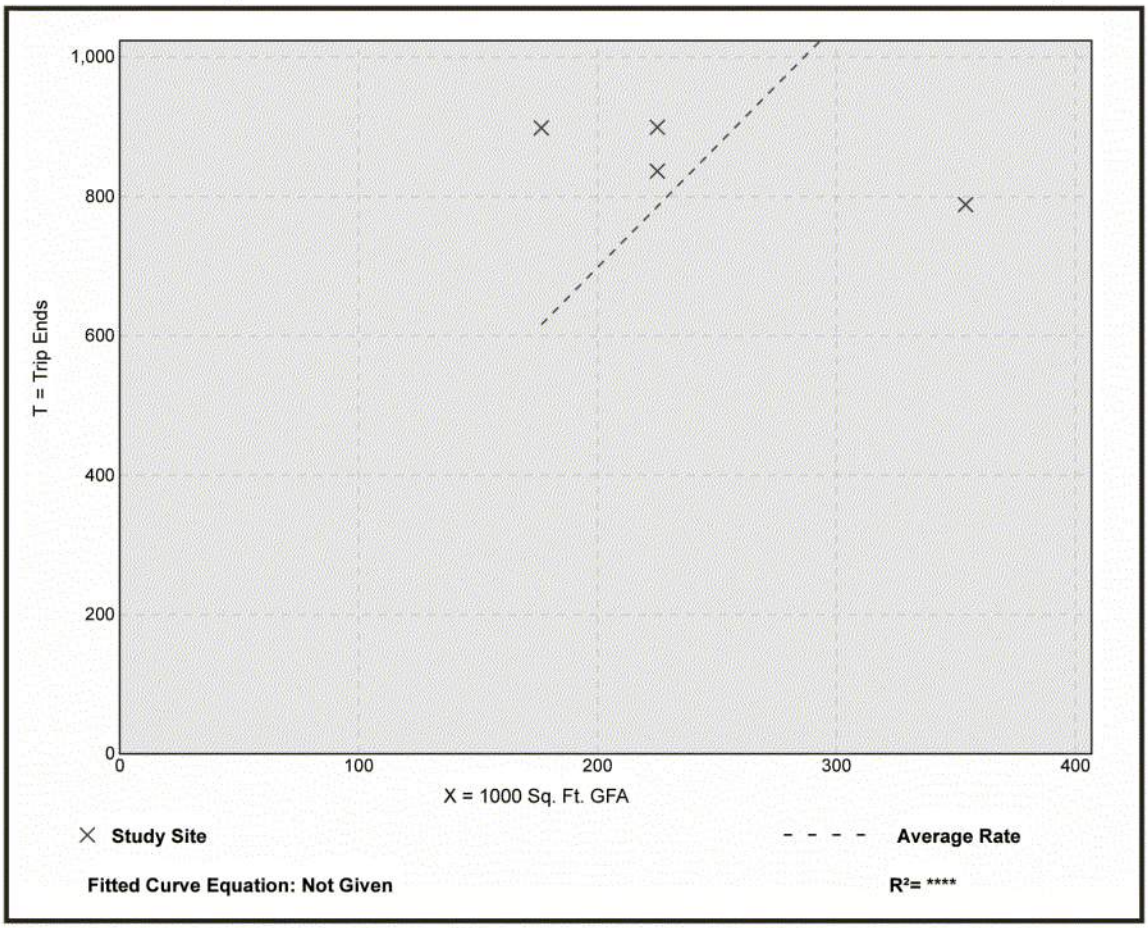
Person Trip Ends vs: **1000 Sq. Ft. GFA**
On a: **Weekday,**
Peak Hour of Adjacent Street Traffic,
One Hour Between 4 and 6 p.m.
Setting/Location: **General Urban/Suburban**
Number of Studies: 4
1000 Sq. Ft. GFA: 245
Directional Distribution: 43% entering, 57% exiting

Person Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
3.49	2.23 - 5.09	1.22

Data Plot and Equation

Caution – Small Sample Size



Recreational Community Center
(495)

Person Trip Ends vs: **1000 Sq. Ft. GFA**
On a: **Weekday,**
AM Peak Hour of Generator

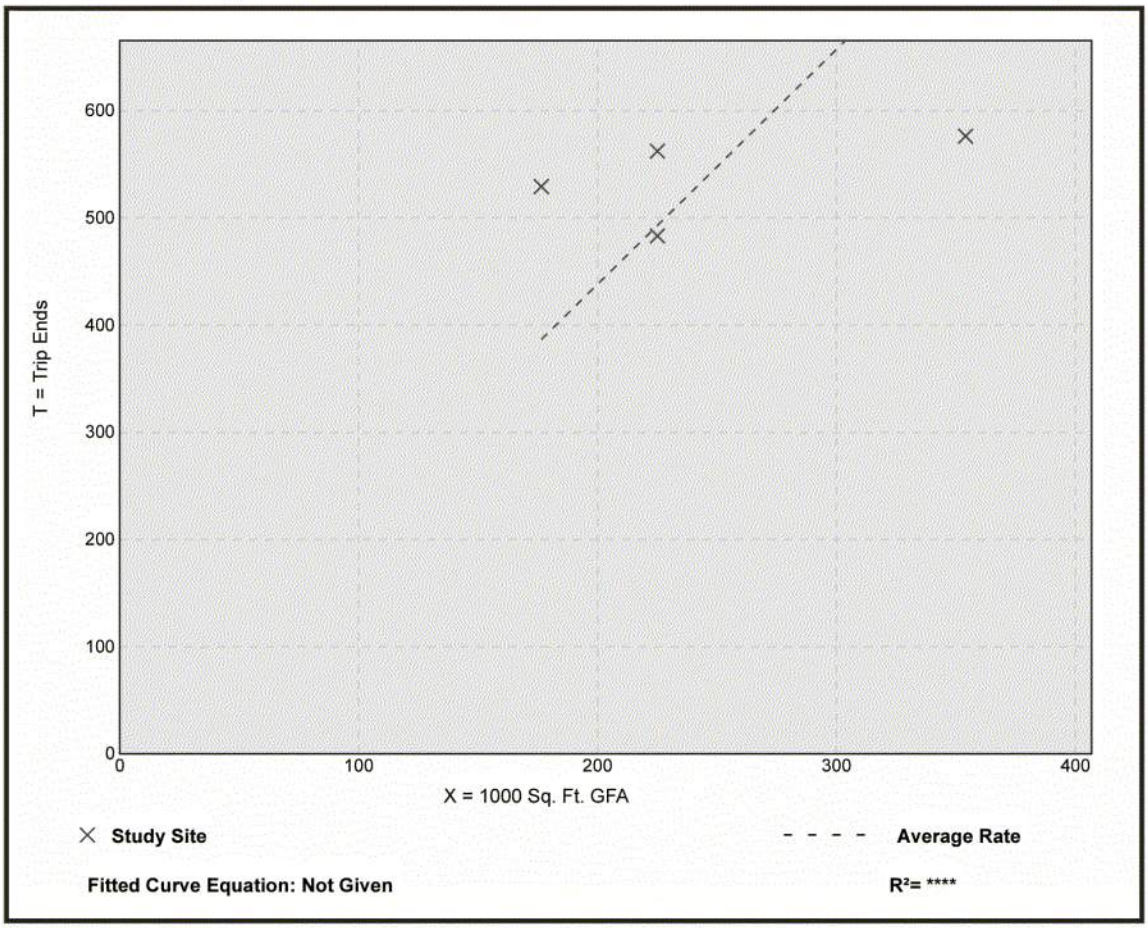
Setting/Location: **General Urban/Suburban**
Number of Studies: 4
1000 Sq. Ft. GFA: 245
Directional Distribution: 68% entering, 32% exiting

Person Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
2.19	1.63 - 3.00	0.58

Data Plot and Equation

Caution – Small Sample Size



Fitted Curve Equation: Not Given

R^2= ****

Recreational Community Center
(495)

Person Trip Ends vs: **1000 Sq. Ft. GFA**
On a: **Weekday,**
PM Peak Hour of Generator

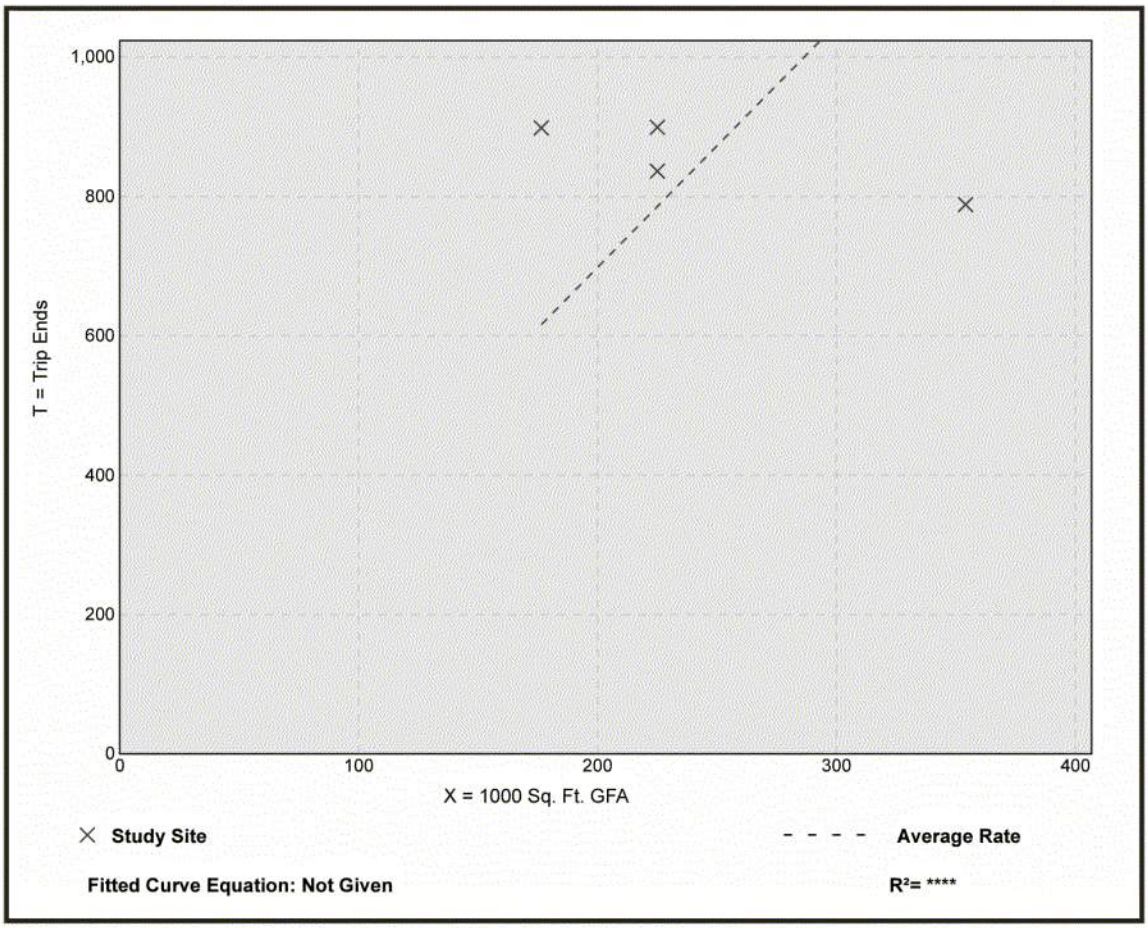
Setting/Location: **General Urban/Suburban**
Number of Studies: 4
1000 Sq. Ft. GFA: 245
Directional Distribution: 43% entering, 57% exiting

Person Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
3.49	2.23 - 5.09	1.22

Data Plot and Equation

Caution – Small Sample Size



Fitted Curve Equation: Not Given

R^2= ****

Recreational Community Center
(495)

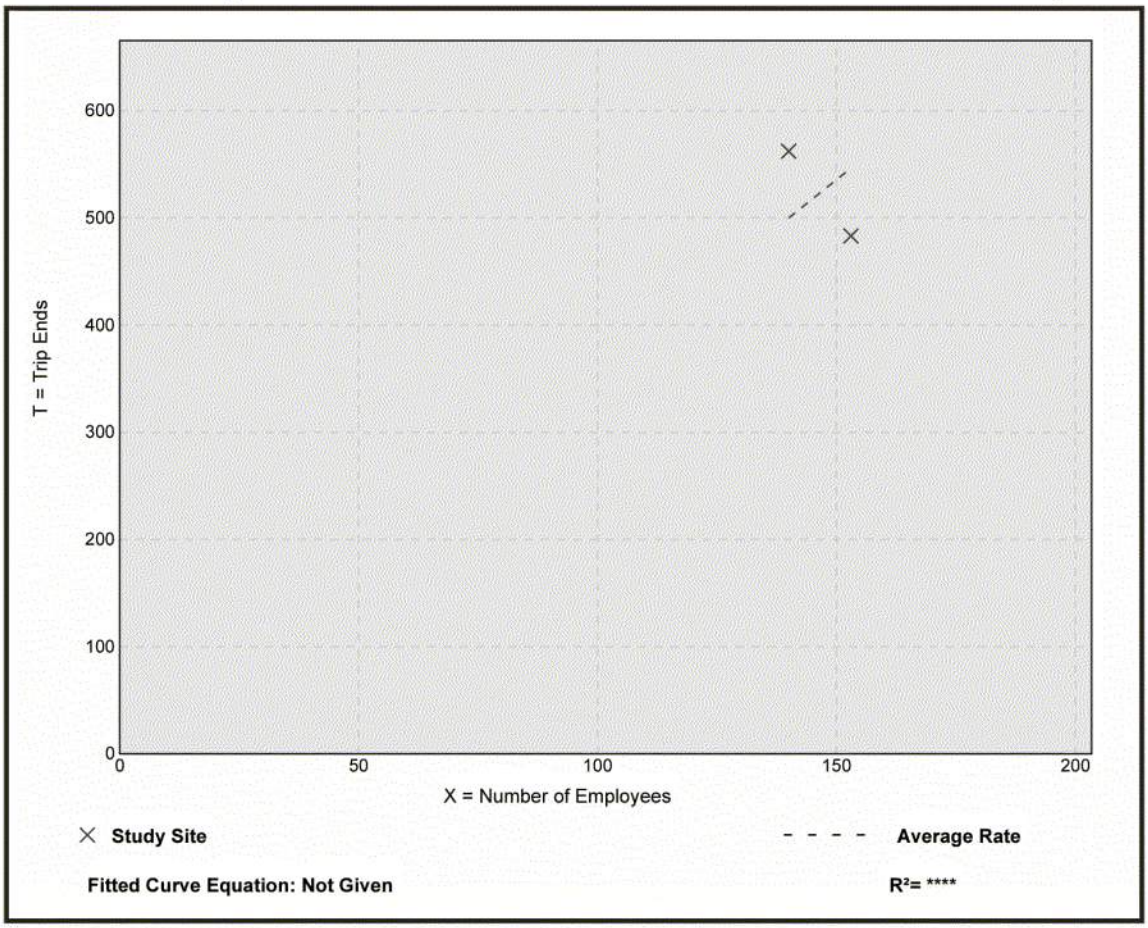
Person Trip Ends vs: **Employees**
On a: **Weekday,**
Peak Hour of Adjacent Street Traffic,
One Hour Between 7 and 9 a.m.
Setting/Location: **General Urban/Suburban**
Number of Studies: 2
Avg. Num. of Employees: 147
Directional Distribution: 74% entering, 26% exiting

Person Trip Generation per Employee

Average Rate	Range of Rates	Standard Deviation
3.57	3.16 - 4.01	*

Data Plot and Equation

Caution – Small Sample Size



Recreational Community Center
(495)

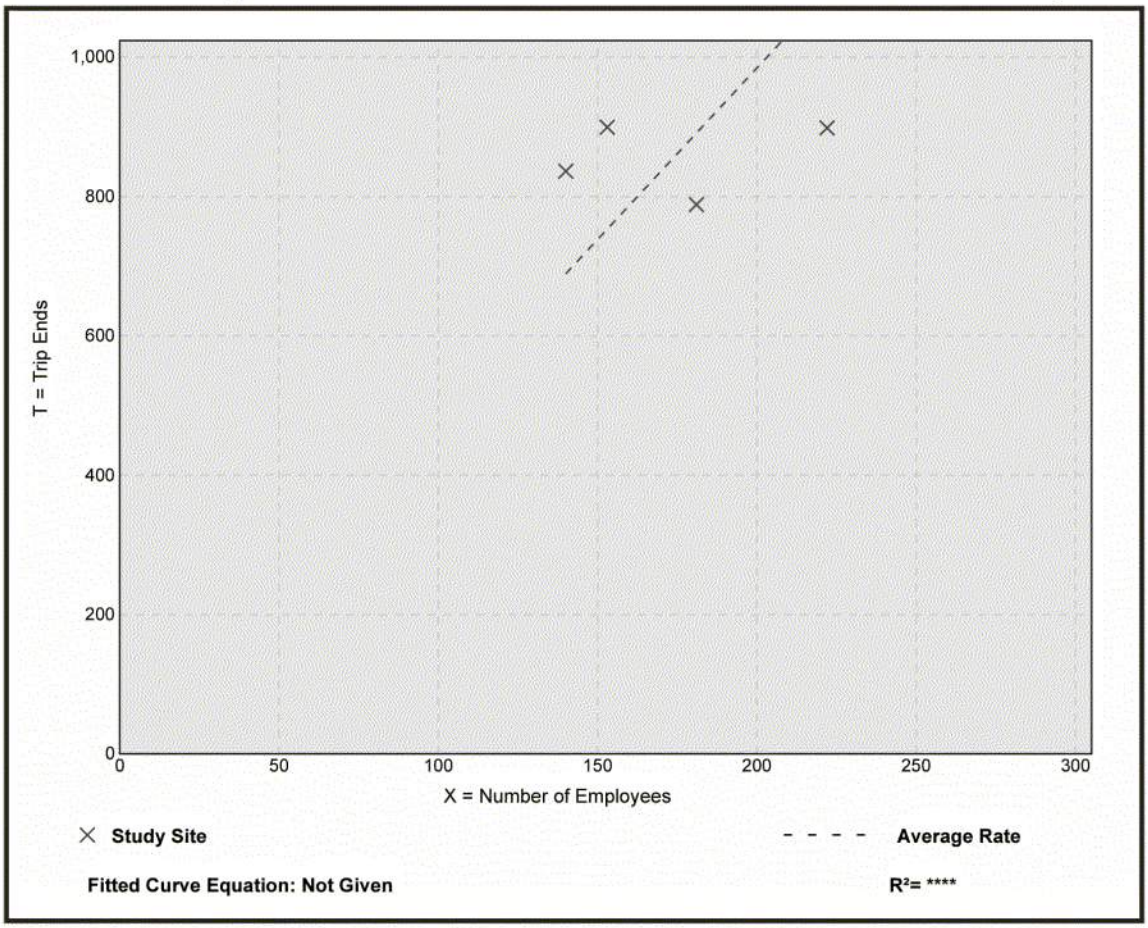
Person Trip Ends vs:	**Employees**
On a:	**Weekday,**
	Peak Hour of Adjacent Street Traffic,
	One Hour Between 4 and 6 p.m.
Setting/Location:	**General Urban/Suburban**
Number of Studies:	4
Avg. Num. of Employees:	174
Directional Distribution:	43% entering, 57% exiting

Person Trip Generation per Employee

Average Rate	Range of Rates	Standard Deviation
4.92	4.05 - 5.97	1.00

Data Plot and Equation

Caution – Small Sample Size



Fitted Curve Equation: Not Given

R^2= ****

Recreational Community Center
(495)

Person Trip Ends vs: **Employees**
On a: **Weekday,**
AM Peak Hour of Generator

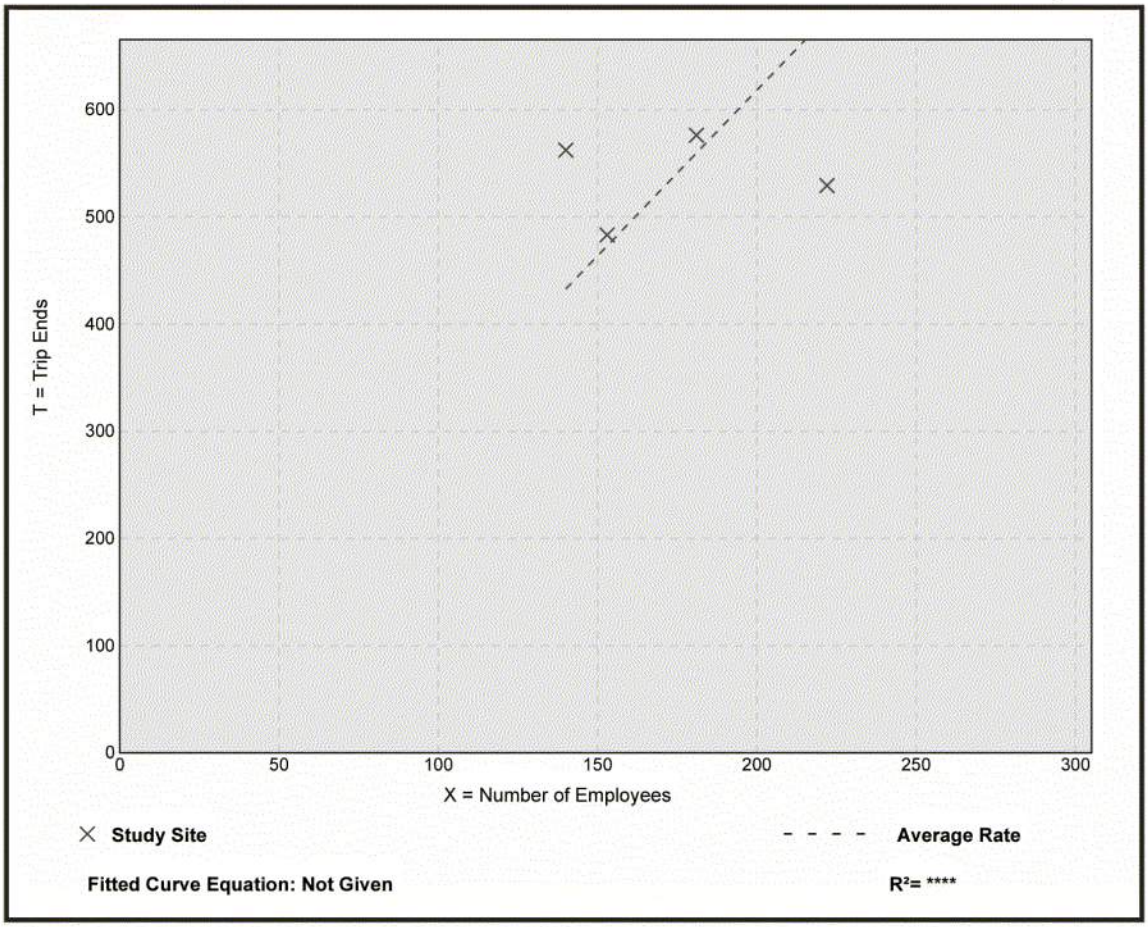
Setting/Location: **General Urban/Suburban**
Number of Studies: 4
Avg. Num. of Employees: 174
Directional Distribution: 68% entering, 32% exiting

Person Trip Generation per Employee

Average Rate	Range of Rates	Standard Deviation
3.09	2.38 - 4.01	0.67

Data Plot and Equation

Caution – Small Sample Size



Fitted Curve Equation: Not Given

R^2= ****

Recreational Community Center
(495)

Person Trip Ends vs: **Employees**
On a: **Weekday,**
PM Peak Hour of Generator

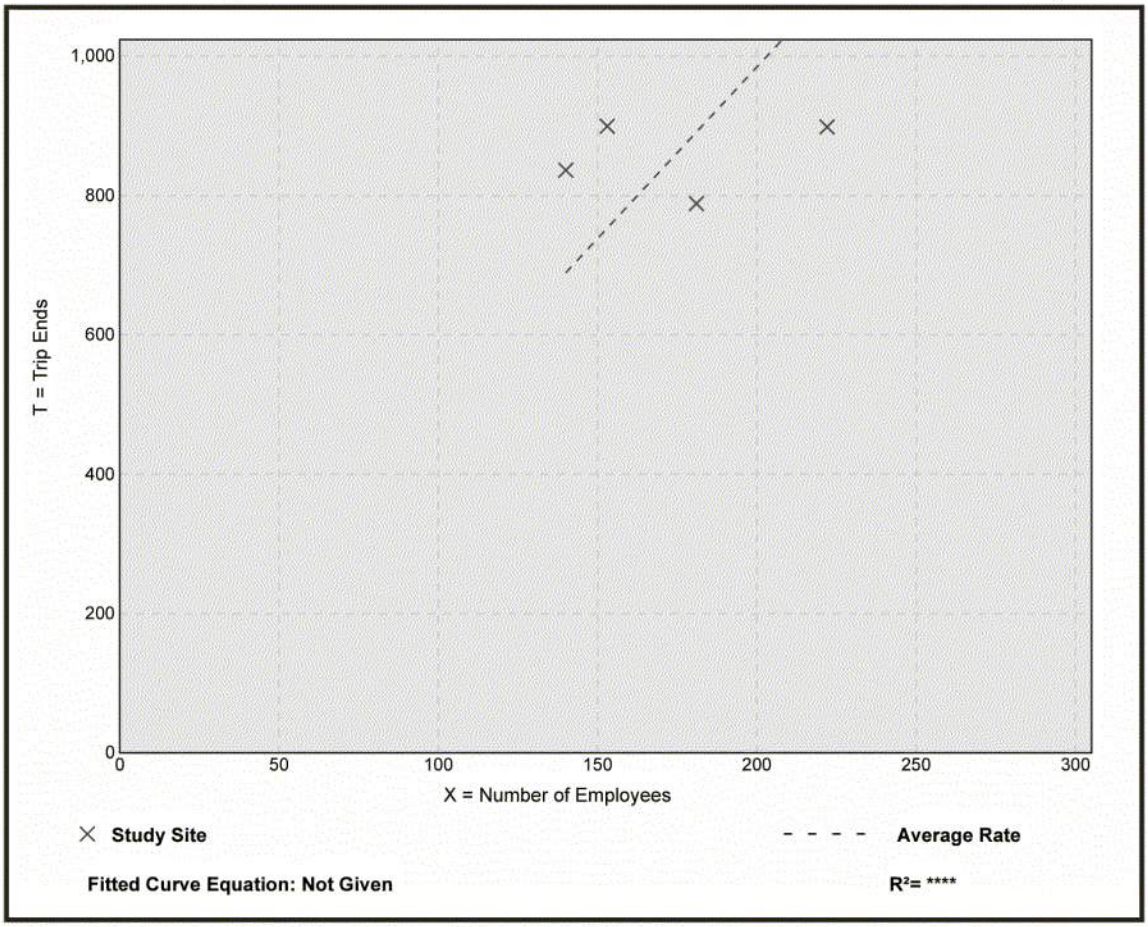
Setting/Location: **General Urban/Suburban**
Number of Studies: 4
Avg. Num. of Employees: 174
Directional Distribution: 43% entering, 57% exiting

Person Trip Generation per Employee

Average Rate	Range of Rates	Standard Deviation
4.92	4.05 - 5.97	1.00

Data Plot and Equation

Caution – Small Sample Size



Fitted Curve Equation: Not Given

R^2= ****

Location ID	47000317	**MPO ID**	
Type	SPOT	**HPMS ID**	
On NHS		**On HPMS**	
LRS ID	47SR115001	**LRS Loc Pt.**	4.54
SF Group	Urban	**Route Type**	
AF Group	14	**Route**	
GF Group	Knox	**Active**	Yes
Class Dist Grp	14	**Category**	CC
Seas Clss Grp			
WIM Group			
QC Group	Default		
Fnct'l Class	Other Principal	**Milepost**	
Located On	ALCOA HWY.		
Loc On Alias			
	KNOXVILLE		

AADT

Year	AADT	DHV-30	K %	D %	PA	BC	Src
2020	44,047[3]		11	58	40,172 (91%	3,875 (9%)	Grown from 2
2019	49,603[2]		11	58			
2018	49,973		9	58			
2017	47,961		11	61			
2016	46,844[2]						

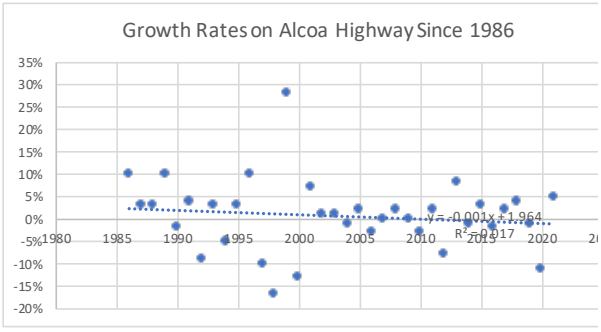
VOLUME TREND

Year	Annual Growth
2021	5%
2020	-11%
2019	-1%
2018	4%
2017	2%
2016	-2%
2015	3%
2014	-1%
2013	8%
2012	-8%
2011	2%
2010	-3%
2009	0%
2008	2%
2007	0%
2006	-3%
2005	2%
2004	-1%
2003	1%
2002	1%
2001	7%
2000	-13%
1999	28%
1998	-17%
1997	-10%
1996	10%
1995	3%
1994	-5%
1993	3%
1992	-9%
1991	4%
1990	-2%
1989	10%
1988	3%
1987	3%
1986	10%
Average	1%

Growth rate	1.0%	per year	

Traffic Forecast

2020	44047	**2028**	47696.59
2021	44487.47	**2029**	48173.56
2022	44932.34	**2030**	48655.29
2023	45381.67	**2031**	49141.84
2024	45835.48	**2032**	49633.26
2025	46293.84	**2033**	50129.59
2026	46756.78	**2034**	50630.89
2027	47224.35	**2035**	51137.2



AADT (NB)

Year	AADT	DHV-30	K %	D %	PA	BC	Src
2018	25,466						

AADT (SB)

Year	AADT	DHV-30	K %	D %	PA	BC	Src
2018	25,776						

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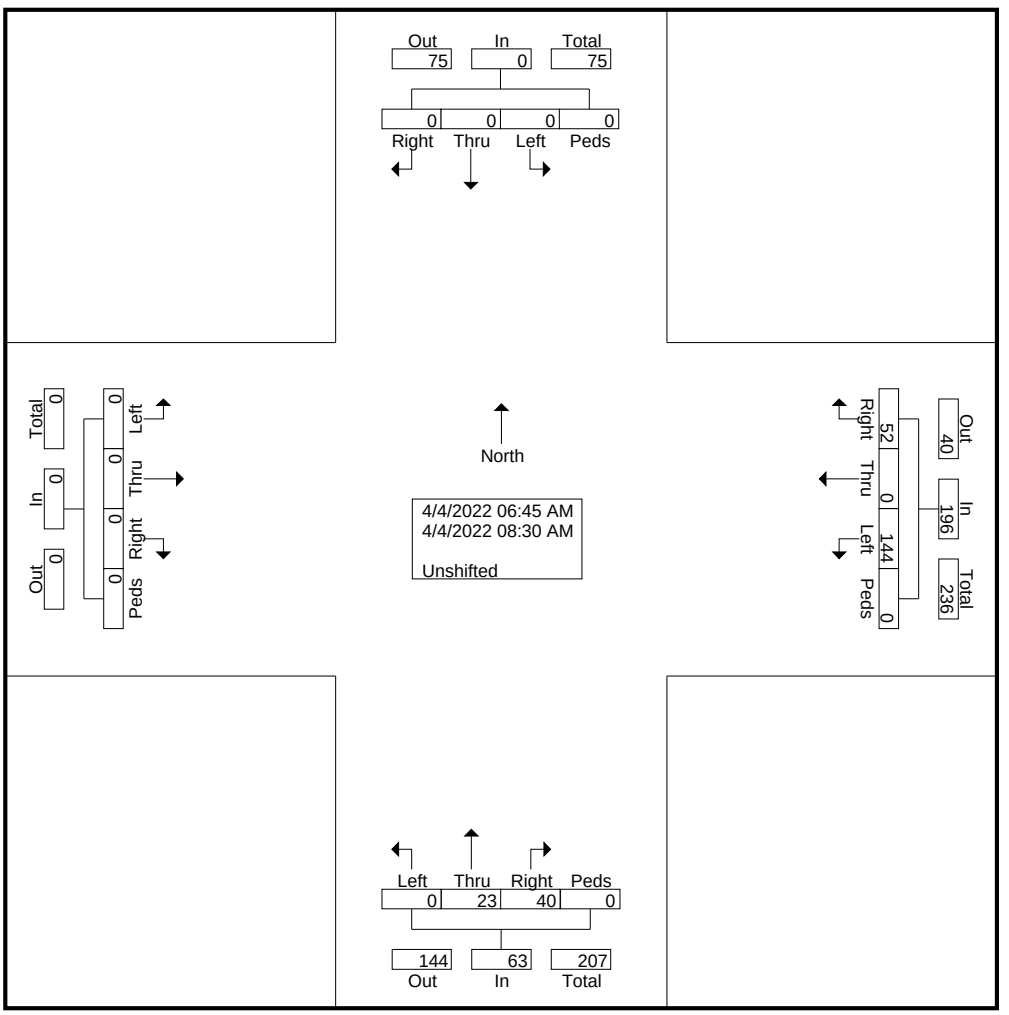
07:00 AM	0	0	0	0	0	5	0	25	0	30	8	4	0	0	12	0	0	0	0	0	42
07:15 AM	0	0	0	0	0	7	0	28	0	35	5	3	0	0	8	0	0	0	0	0	43
07:30 AM	0	0	0	0	0	7	0	24	0	31	10	1	0	0	11	0	0	0	0	0	42
07:45 AM	0	0	0	0	0	8	0	16	0	24	5	3	0	0	8	0	0	0	0	0	32
Total	0	0	0	0	0	27	0	93	0	120	28	11	0	0	39	0	0	0	0	0	159
08:00 AM	0	0	0	0	0	5	0	15	0	20	4	3	0	0	7	0	0	0	0	0	27
08:15 AM	0	0	0	0	0	5	0	5	0	10	3	4	0	0	7	0	0	0	0	0	17
08:30 AM	0	0	0	0	0	7	0	14	0	21	2	3	0	0	5	0	0	0	0	0	26
Grand Total	0	0	0	0	0	52	0	144	0	196	40	23	0	0	63	0	0	0	0	0	259
Apprch %	0	0	0	0		26.5	0	73.5	0		63.5	36.5	0	0		0	0	0	0		
Total %	0	0	0	0	0	20.1	0	55.6	0	75.7	15.4	8.9	0	0	24.3	0	0	0	0	0	



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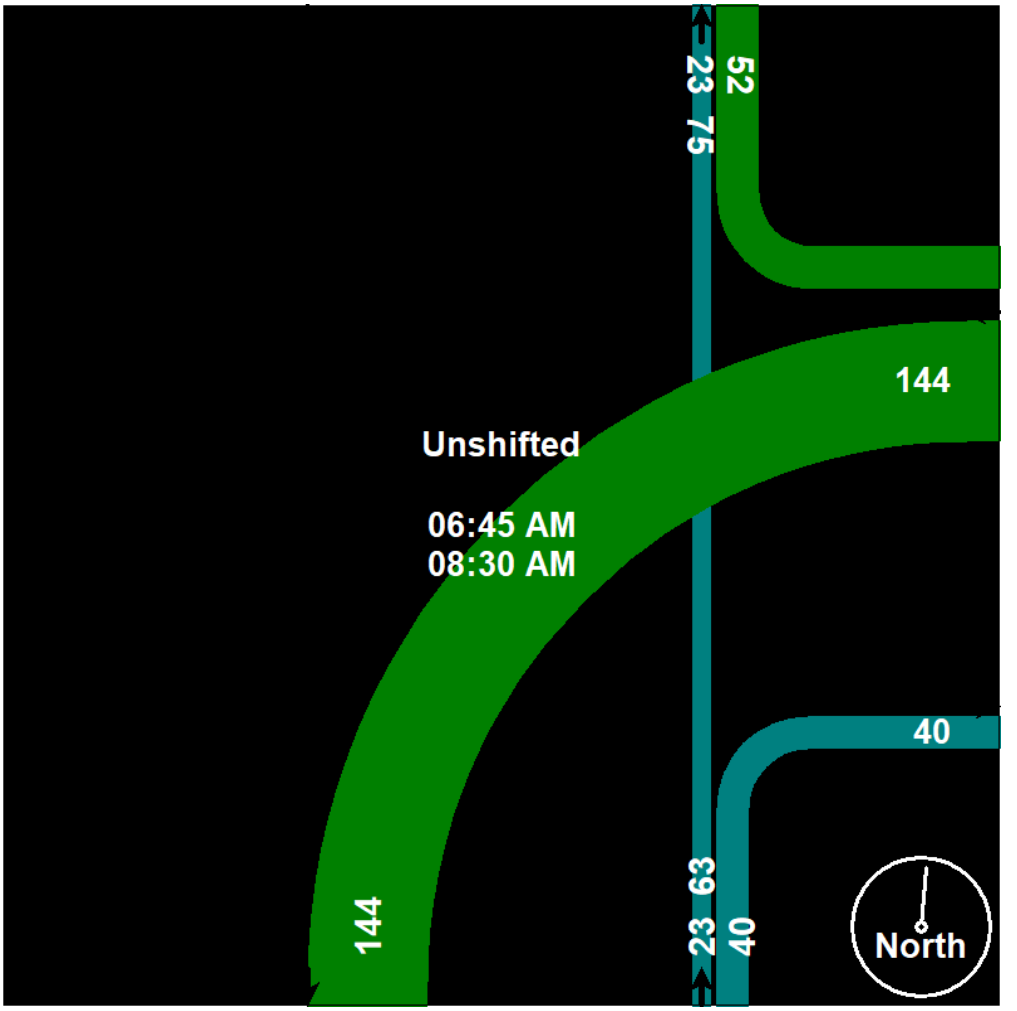

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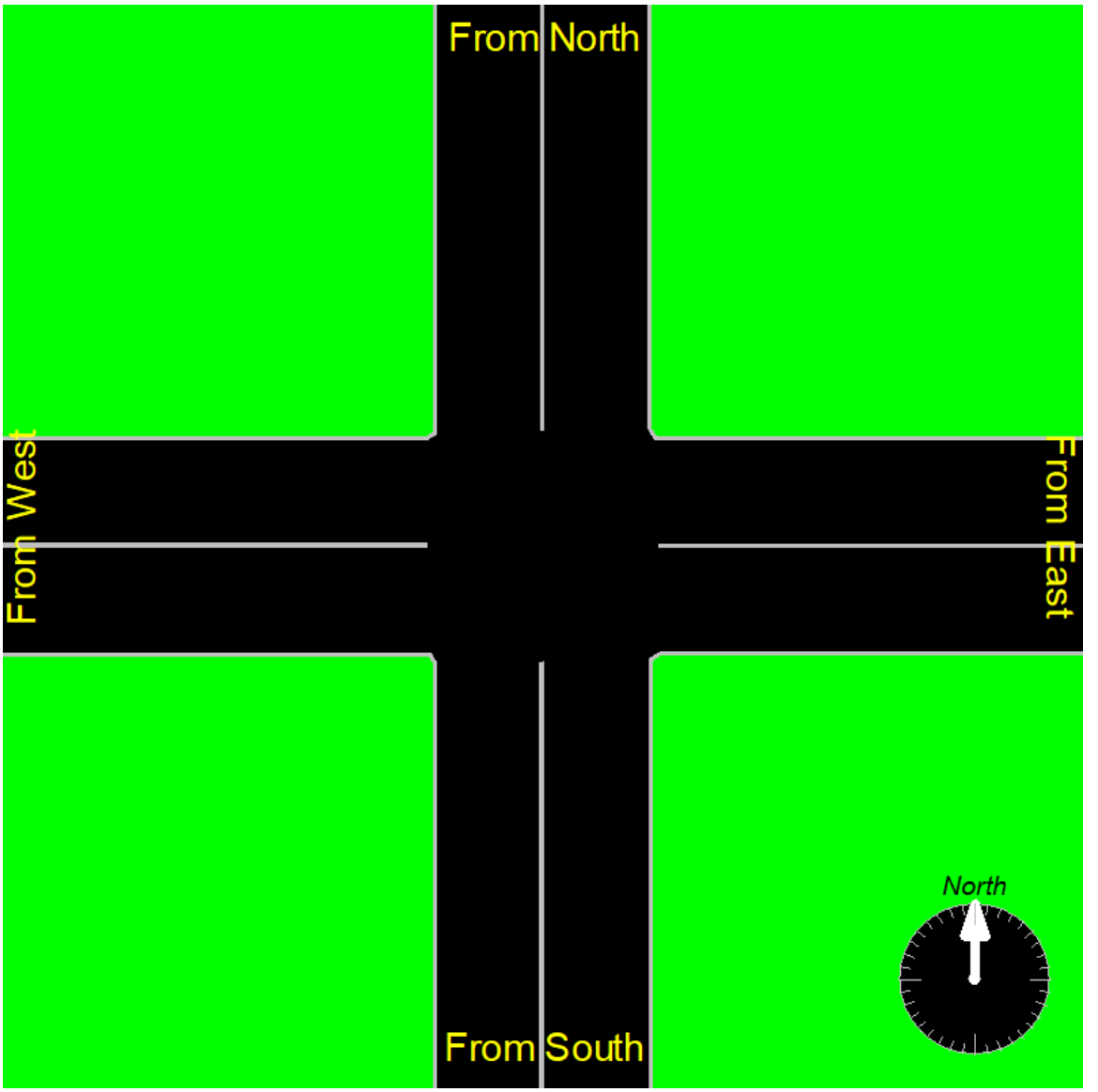

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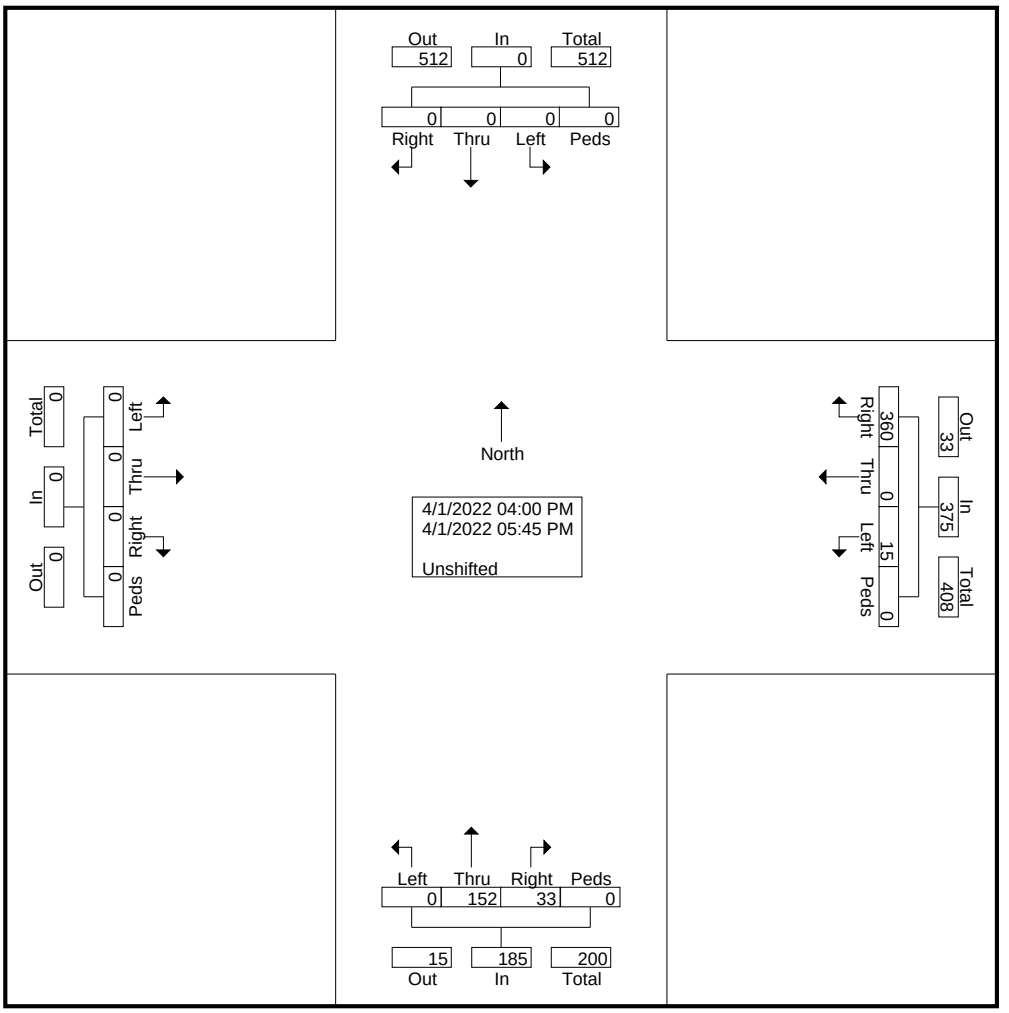
04:30 PM	0	0	0	0	0	87	0	1	0	88	5	50	0	0	55	0	0	0	0	0	143
04:45 PM	0	0	0	0	0	51	0	3	0	54	4	19	0	0	23	0	0	0	0	0	77
Total	0	0	0	0	0	228	0	8	0	236	20	105	0	0	125	0	0	0	0	0	361
05:00 PM	0	0	0	0	0	46	0	4	0	50	4	23	0	0	27	0	0	0	0	0	77
05:15 PM	0	0	0	0	0	38	0	1	0	39	5	12	0	0	17	0	0	0	0	0	56
05:30 PM	0	0	0	0	0	25	0	0	0	25	2	6	0	0	8	0	0	0	0	0	33
05:45 PM	0	0	0	0	0	23	0	2	0	25	2	6	0	0	8	0	0	0	0	0	33
Total	0	0	0	0	0	132	0	7	0	139	13	47	0	0	60	0	0	0	0	0	199
Grand Total	0	0	0	0	0	360	0	15	0	375	33	152	0	0	185	0	0	0	0	0	560
Apprch %	0	0	0	0		96	0	4	0		17.8	82.2	0	0		0	0	0	0		
Total %	0	0	0	0	0	64.3	0	2.7	0	67	5.9	27.1	0	0	33	0	0	0	0	0	



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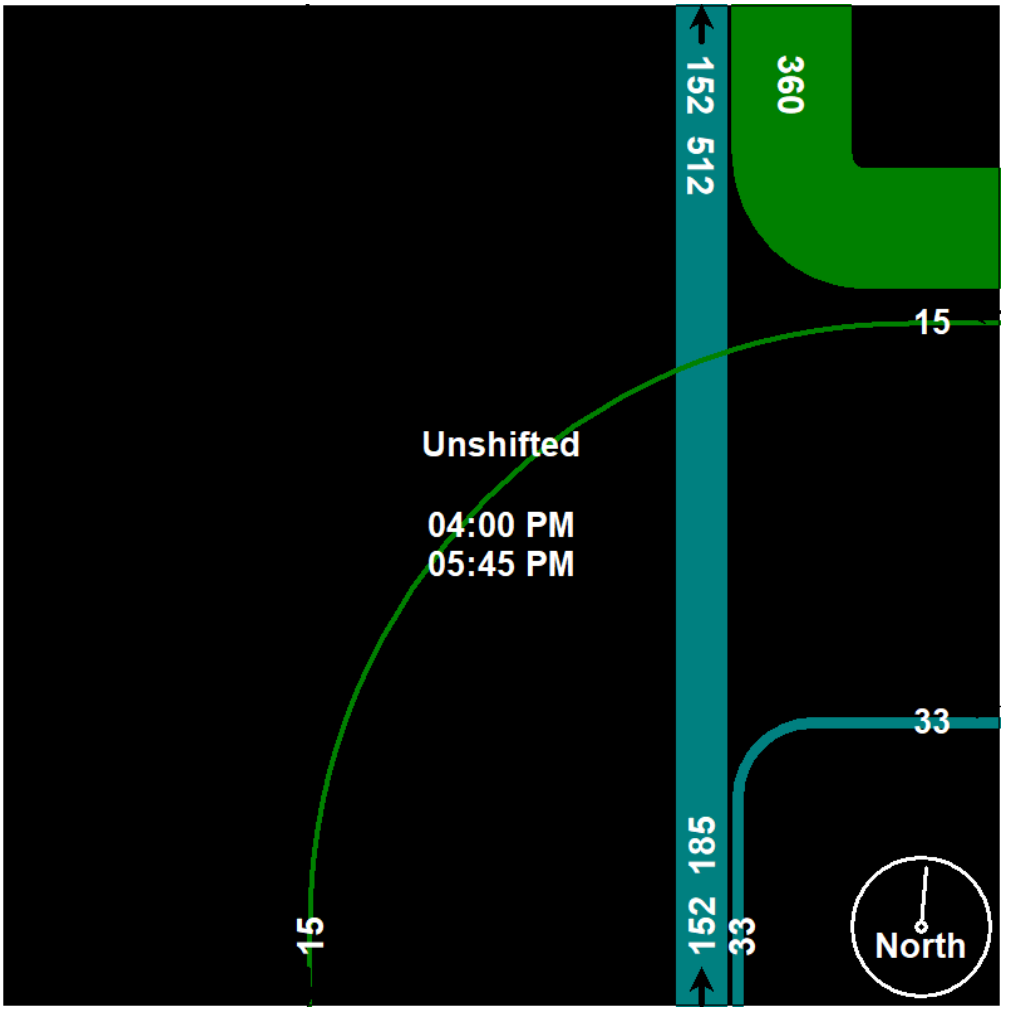

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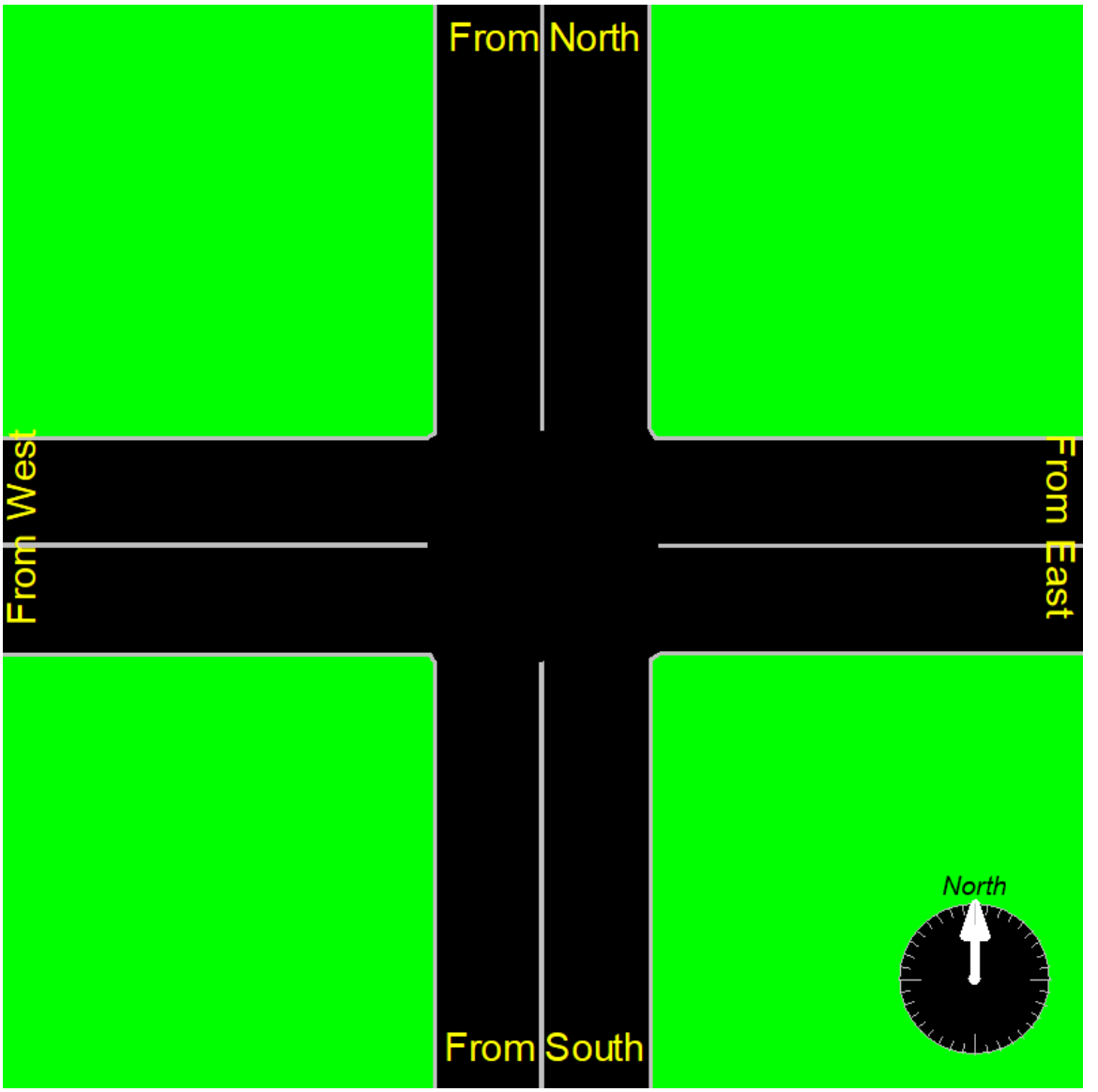

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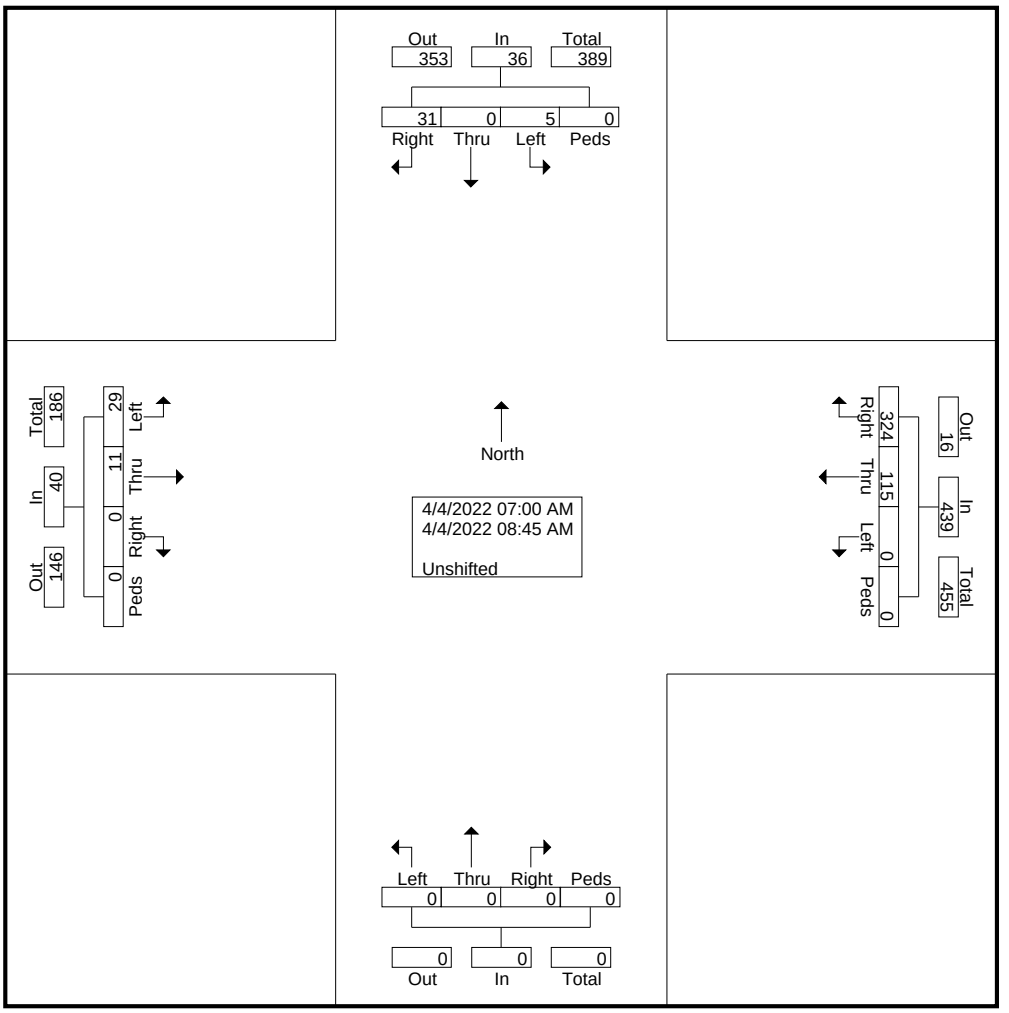
07:15 AM	5	0	2	0	7	53	13	0	0	66	0	0	0	0	0	0	0	6	0	6	79
07:30 AM	3	0	1	0	4	63	17	0	0	80	0	0	0	0	0	0	3	0	0	3	87
07:45 AM	8	0	1	0	9	74	23	0	0	97	0	0	0	0	0	0	1	7	0	8	114
Total	20	0	4	0	24	226	65	0	0	291	0	0	0	0	0	0	4	14	0	18	333
08:00 AM	5	0	1	0	6	48	13	0	0	61	0	0	0	0	0	0	1	2	0	3	70
08:15 AM	3	0	0	0	3	25	12	0	0	37	0	0	0	0	0	0	2	3	0	5	45
08:30 AM	1	0	0	0	1	17	12	0	0	29	0	0	0	0	0	0	3	3	0	6	36
08:45 AM	2	0	0	0	2	8	13	0	0	21	0	0	0	0	0	0	1	7	0	8	31
Total	11	0	1	0	12	98	50	0	0	148	0	0	0	0	0	0	7	15	0	22	182
Grand Total	31	0	5	0	36	324	115	0	0	439	0	0	0	0	0	0	11	29	0	40	515
Apprch %	86.1	0	13.9	0		73.8	26.2	0	0		0	0	0	0		0	27.5	72.5	0		
Total %	6	0	1	0	7	62.9	22.3	0	0	85.2	0	0	0	0	0	0	2.1	5.6	0	7.8	



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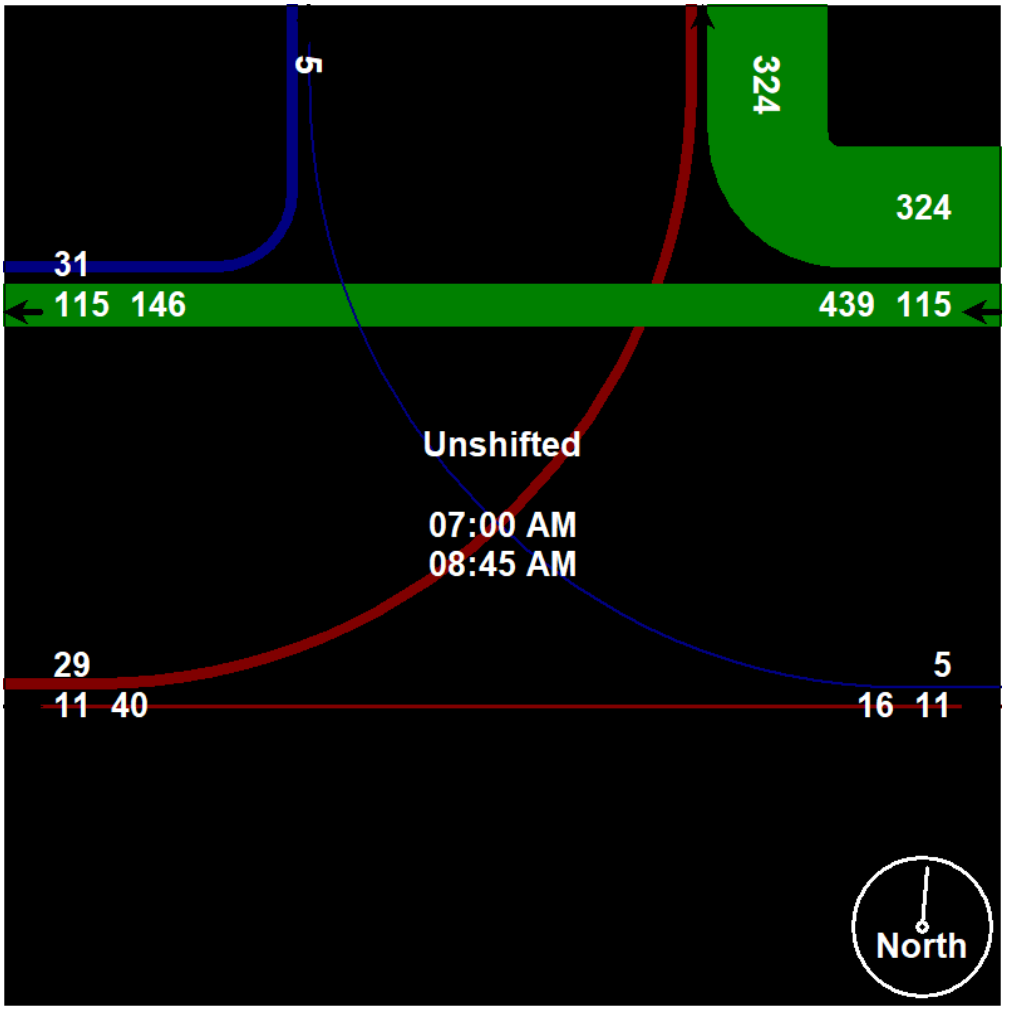

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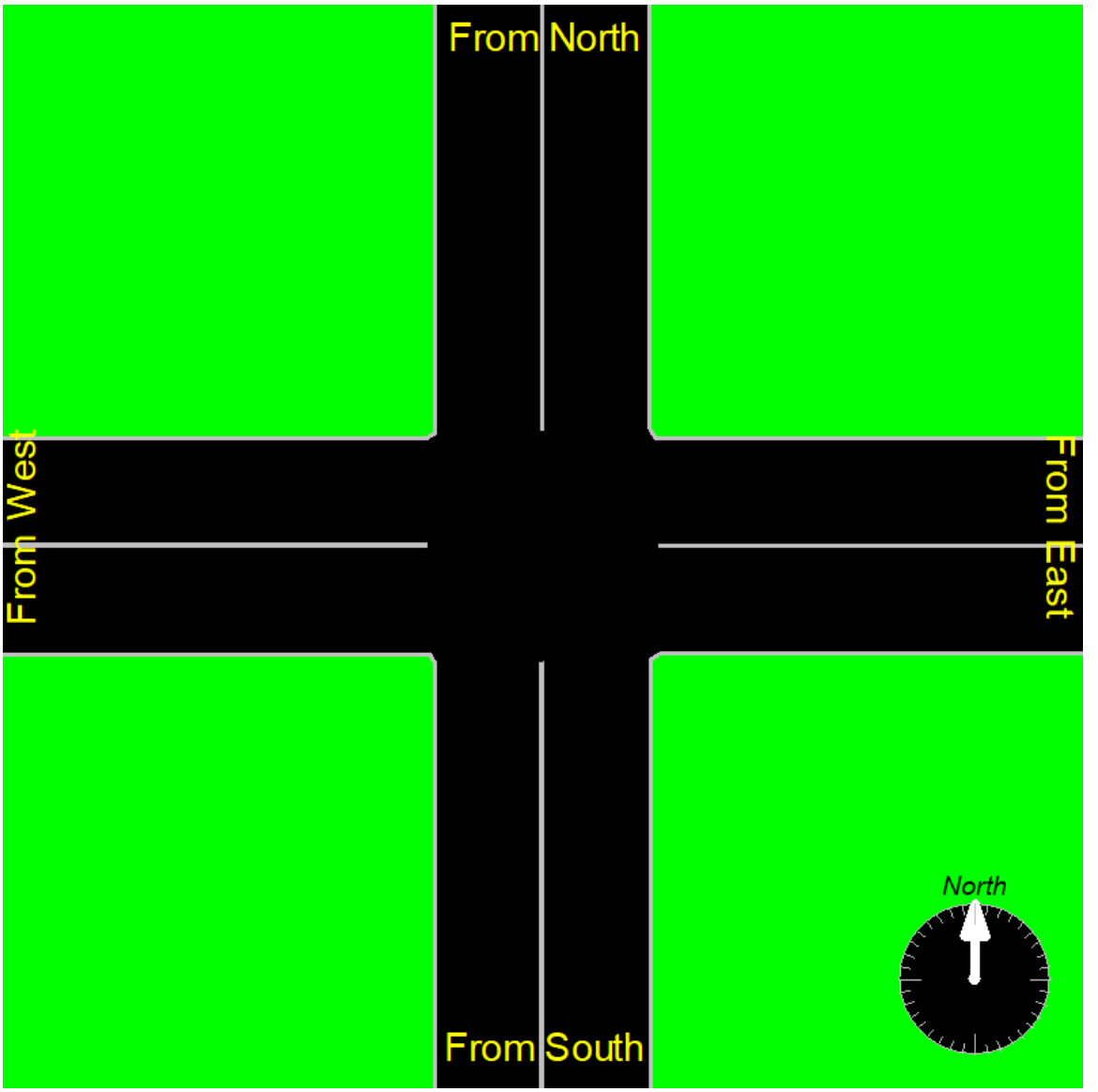

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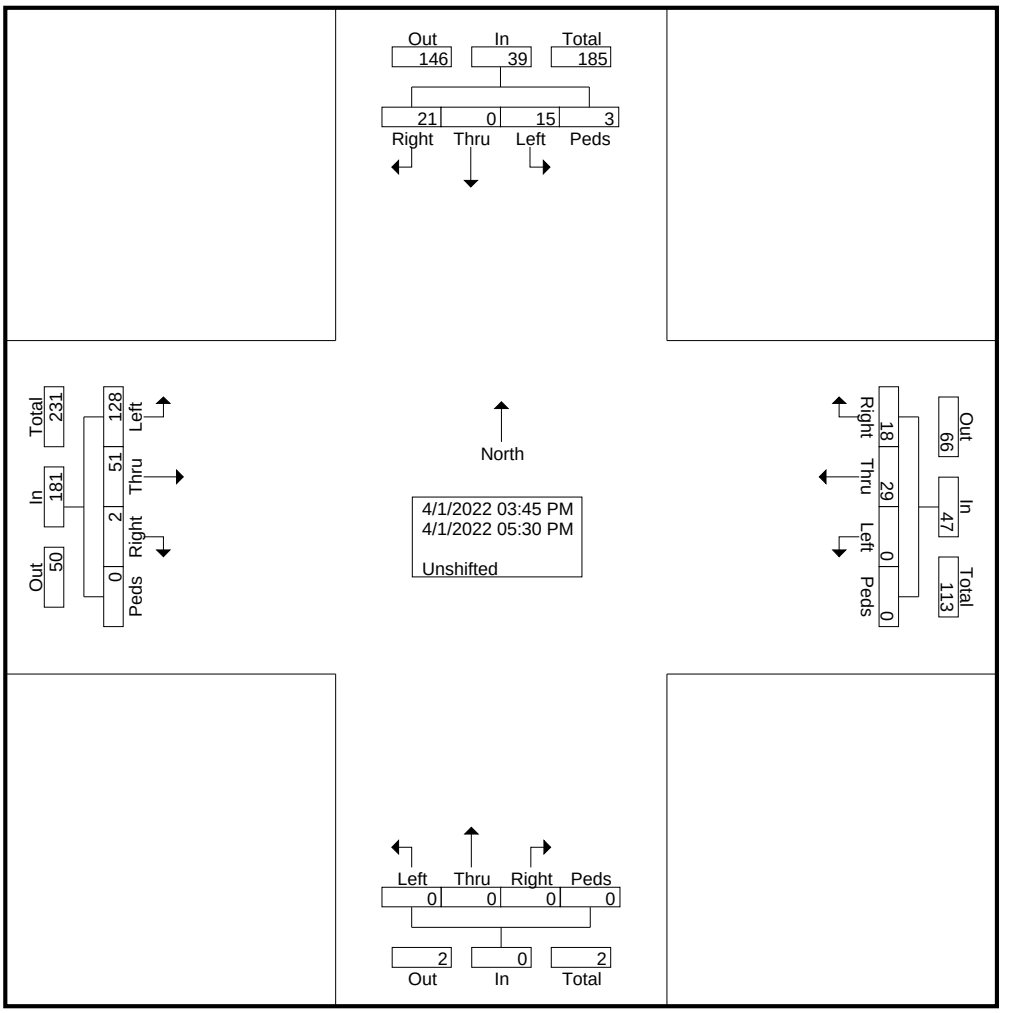
04:00 PM	0	0	3	0	3	4	6	0	0	10	0	0	0	0	0	0	3	12	0	15	28
04:15 PM	5	0	1	0	6	2	5	0	0	7	0	0	0	0	0	1	11	24	0	36	49
04:30 PM	2	0	3	0	5	3	3	0	0	6	0	0	0	0	0	0	8	22	0	30	41
04:45 PM	3	0	3	0	6	1	2	0	0	3	0	0	0	0	0	0	6	22	0	28	37
Total	10	0	10	0	20	10	16	0	0	26	0	0	0	0	0	1	28	80	0	109	155
05:00 PM	2	0	1	0	3	3	3	0	0	6	0	0	0	0	0	0	5	11	0	16	25
05:15 PM	1	0	1	0	2	1	5	0	0	6	0	0	0	0	0	0	7	14	0	21	29
05:30 PM	3	0	0	0	3	3	3	0	0	6	0	0	0	0	0	0	9	15	0	24	33
Grand Total	21	0	15	3	39	18	29	0	0	47	0	0	0	0	0	2	51	128	0	181	267
Apprch %	53.8	0	38.5	7.7		38.3	61.7	0	0		0	0	0	0		1.1	28.2	70.7	0		
Total %	7.9	0	5.6	1.1	14.6	6.7	10.9	0	0	17.6	0	0	0	0	0	0.7	19.1	47.9	0	67.8	



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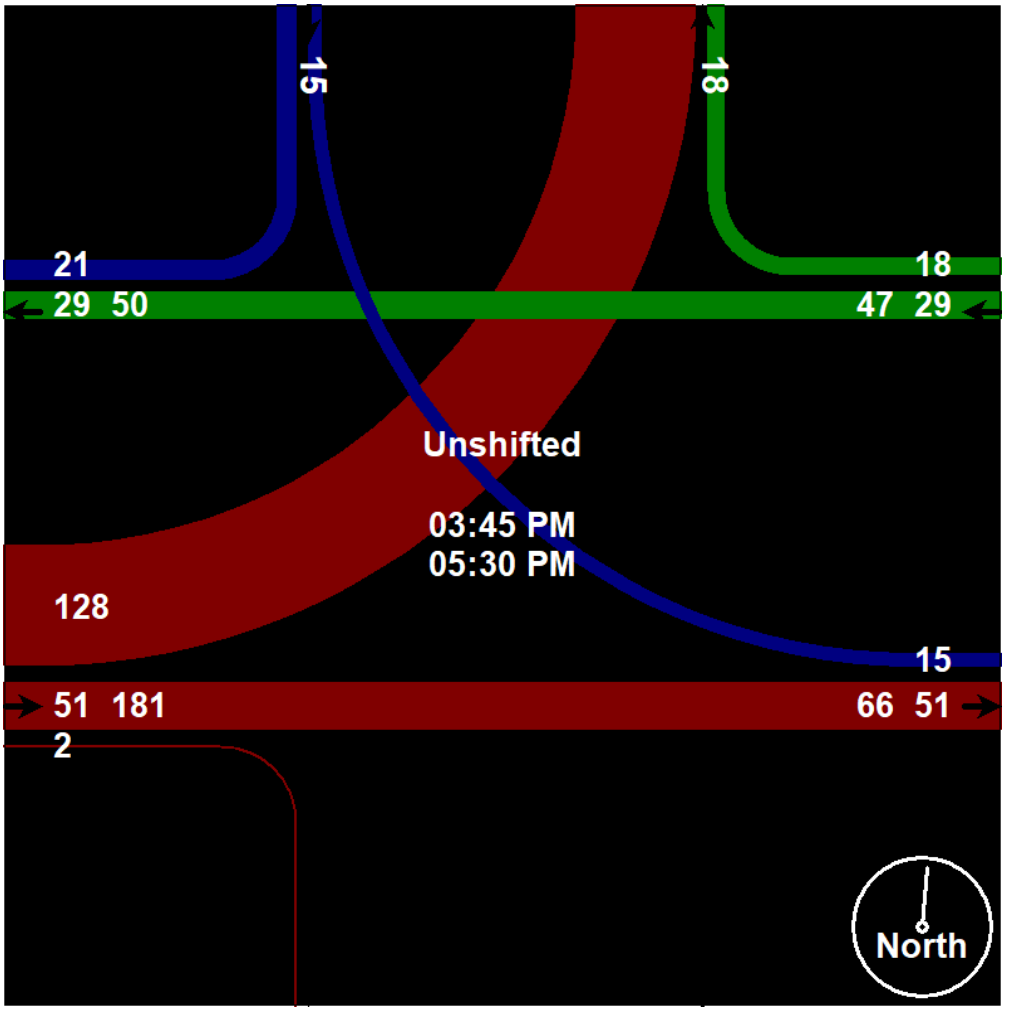

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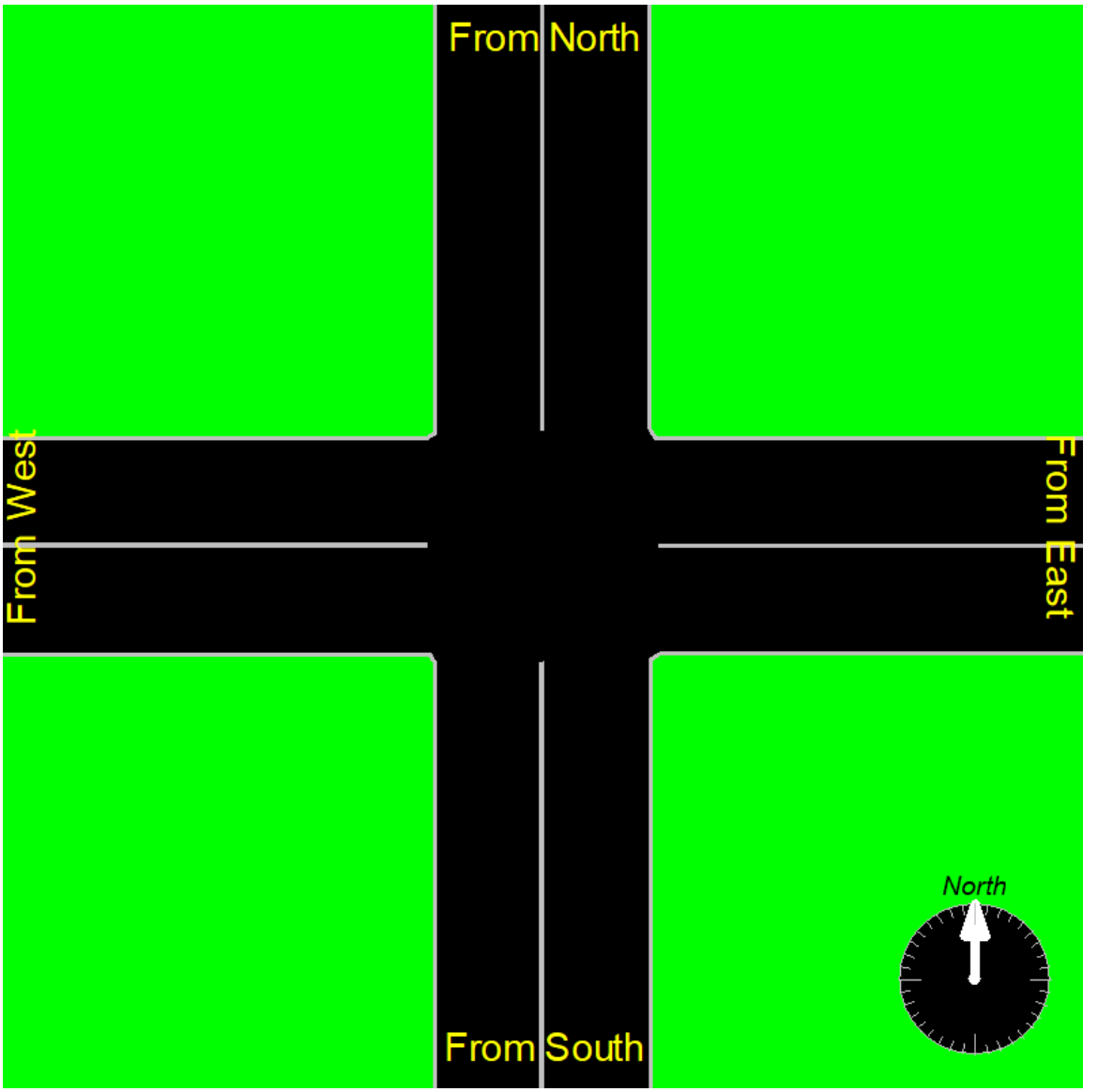
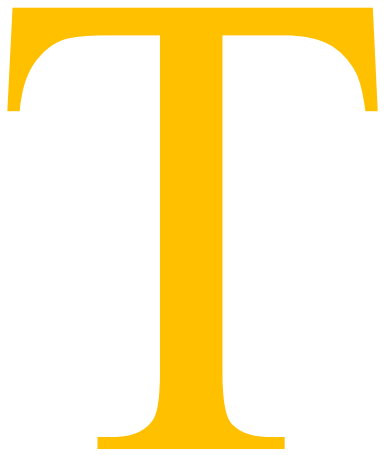


Appendix C: Hydrological and Hydraulic

Stormwater Calculations for University of Tennessee Outdoor Cultural & Recreational Center at Cherokee Landing



Prepared by: Big Orange Builders, Sunny DeFOE

Date prepared: 4-28-2022

Disclaimer: The calculations contained herein were done by an engineer intern without oversight from a licensed P.E. All calculations must be verified by a licensed civil engineer prior to implementation for above referenced project.

STRUCTURE	TOP	INV OUT	INV IN	INV IN	DEPTH		
CI-1	853.85	850.35			3.50		
CI-2	852.65	848.15	849.25		4.50		
MH-2.5	850.20	846.05	846.15		4.15		
CB-3	848.00	843.20	843.30	844.80	4.80		
CI-4	848.85	843.64	843.74		5.21		
CI-5	848.90	844.25			4.65		
CI-6	845.30	842.08	842.18		3.22		
CI-7	848.60	845.10			3.50		
CI-8	849.30	844.46	844.56		4.84		
CI-9	849.70	844.17	844.27		5.53		
AD-10	849.40	843.51	843.61		5.89		
RRA 1	850.40	843.24	843.24		7.16		
RRA 2	847.00	842.00	842.00		5.00		
	ALL LENGTHS MEASURED TO CENTER OF STRUCTURE						
	ALL GRADES FIGURED FROM CENTER TO CENTER OF STRUCTURE						
	GRADES MAY NEED FIELD ADJUSTMENT***						
	GUTTER DRAINS FOR MAIN BUILDING NOT SHOWN -						
FROM	TO	LENGTH	INV BELOW	INV ABOVE	SLOPE %	SIZE (in)	MATERIAL
RRA 2	CI-6	8.00	842.00	842.08	1.0000	48	HDPE
CI-6	CB-3	72.00	842.18	843.20	1.4167	24	HDPE
CB-3	CI-4	34.00	843.30	843.64	1.0000	15	HDPE
CI-4	CI-5	12.00	843.74	844.25	4.2500	15	HDPE

CB-3	MH-2.5	54.60	843.30	846.05	5.0366	15	HDPE
MH 2.5	CI-2	57.40	846.15	848.15	3.4843	15	HDPE
CI-2	CI-1	47.00	849.25	850.35	2.3404	15	HDPE
RRA-1	AD-10	27.00	843.24	843.51	1.0000	24	HDPE
AD-10	CI-9	56.00	843.61	844.17	1.0000	18	HDPE
CI-9	CI-8	19.00	844.27	844.46	1.0000	18	HDPE
CI-8	CI-7	54.00	844.56	845.10	1.0000	15	HDPE

Table 3-7. Recommended Runoff Coefficient Values for Rational Method

Land Use	Runoff Coefficient (C) by Hydrologic Soil Group and Ground Slope											
	A			B			C			D		
	<2%	2 - 6%	>6%	<2%	2 - 6%	>6%	<2%	2 - 6%	>6%	<2%	2 - 6%	>6%
Forest	0.08	0.11	0.14	0.10	0.14	0.18	0.12	0.16	0.20	0.15	0.20	0.25
Meadow	0.14	0.22	0.30	0.20	0.28	0.37	0.26	0.35	0.44	0.30	0.40	0.50
Pasture	0.15	0.25	0.37	0.23	0.34	0.45	0.30	0.42	0.52	0.37	0.50	0.62
Farmland	0.14	0.18	0.22	0.16	0.21	0.28	0.20	0.25	0.34	0.24	0.29	0.41
Res. 1 acre	0.22	0.26	0.29	0.24	0.28	0.34	0.28	0.32	0.40	0.31	0.35	0.46
Res. 1/2 acre	0.25	0.29	0.32	0.28	0.32	0.36	0.31	0.35	0.42	0.34	0.38	0.46
Res. 1/3 acre	0.28	0.32	0.35	0.30	0.35	0.39	0.33	0.38	0.45	0.36	0.40	0.50
Res. 1/4 acre	0.30	0.34	0.37	0.33	0.37	0.42	0.36	0.40	0.47	0.38	0.42	0.52
Res. 1/8 acre	0.33	0.37	0.40	0.35	0.39	0.44	0.38	0.42	0.49	0.41	0.45	0.54
Industrial	0.85	0.85	0.86	0.85	0.86	0.86	0.86	0.86	0.87	0.86	0.86	0.88
Commercial	0.88	0.88	0.89	0.89	0.89	0.89	0.89	0.89	0.90	0.89	0.89	0.90
Streets: ROW	0.76	0.77	0.79	0.80	0.82	0.84	0.84	0.85	0.89	0.89	0.91	0.95
Parking	0.95	0.96	0.97	0.95	0.96	0.97	0.95	0.96	0.97	0.95	0.96	0.97
Disturbed Area	0.65	0.67	0.69	0.66	0.68	0.70	0.68	0.70	0.72	0.69	0.72	0.75

A–382.36 (4)–2. RUNOFF COEFFICIENTS. Tables Detail A and B are for using the rational formula.

DETAIL A: RUNOFF COEFFICIENTS (C), RATIONAL FORMULA

Land Use	Percent Impervious Area	Design Storm 24–Hour Event	Hydrologic Soil Group											
			A			B			C			D		
			Slope Range (%)			Slope Range (%)			Slope Range (%)			Slope Range (%)		
			0–2	2–6	> 6	0–2	2–6	> 6	0–2	2–6	> 6	0–2	2–6	> 6
Industrial	90	2– and 10–year	0.67	0.58	0.68	0.68	0.68	0.69	0.68	0.69	0.69	0.69	0.69	0.70
		25–, 50–, and 100–year	0.85	0.85	0.86	0.85	0.86	0.86	0.86	0.86	0.87	0.86	0.86	0.88
Commercial	95	2– and 10–year	0.71	0.71	0.72	0.71	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
		25–, 50–, and 100–year	0.88	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.90
Residential: gh–density (>6 units/ acre)	60	2– and 10–year	0.47	0.49	0.50	0.48	0.50	0.52	0.49	0.51	0.54	0.51	0.53	0.56
		25–, 50–, and 100–year	0.58	0.60	0.61	0.59	0.61	0.64	0.60	0.62	0.66	0.62	0.66	0.69
Medium–density (2–6 units/acre)	30	2– and 10–year	0.25	0.28	0.31	0.27	0.30	0.35	0.30	0.33	0.38	0.33	0.36	0.42
		25–, 50–, and 100–year	0.33	0.37	0.40	0.35	0.39	0.44	0.38	0.42	0.49	0.41	0.45	0.54
Low–density (0.7–2 units/ acre)	15	2– and 10–year	0.14	0.19	0.22	0.17	0.21	0.26	0.20	0.25	0.31	0.24	0.28	0.35
		25–, 50–, and 100–year	0.22	0.26	0.29	0.24	0.28	0.34	0.28	0.32	0.40	0.31	0.35	0.46
Agriculture	5	2– and 10–year	0.08	0.13	0.16	0.11	0.15	0.21	0.14	0.19	0.26	0.18	0.23	0.31
		25–, 50–, and 100–year	0.14	0.18	0.22	0.16	0.21	0.28	0.20	0.25	0.34	0.24	0.29	0.41
Open Space	2	2– and 10–year	0.05	0.10	0.14	0.08	0.13	0.19	0.12	0.17	0.24	0.16	0.21	0.28
		25–, 50–, and 100–year	0.11	0.16	0.20	0.14	0.19	0.26	0.18	0.23	0.32	0.22	0.27	0.39
Freeways and Expressways	70	2– and 10–year	0.57	0.59	0.60	0.58	0.60	0.61	0.59	0.61	0.63	0.60	0.62	0.64
		25–, 50–, and 100–year	0.70	0.71	0.72	0.71	0.72	0.74	0.72	0.72	0.73	0.76	0.75	0.78

Source: Wisconsin department of transportation (WDOT), Facilities Development Manual (July 2, 1979), Procedure 13–10–5.

FROM	TO	WS	LENGTH	INV BELOW	INV ABOVE	SLOPE %	SIZE (in)	MATERIAL	AREA (Ac.)	i (in/24 hr)	c B	Q (cfs) B	c C	Q (cfs) C	Area (full)	Rh (full)	Manning's n	V max (ft/s)	Q max (cfs)
RRA 2	CI-6	5-2	8.00	842.00	842.08	1.0000	48	HDPE	0.2856	6.3000	92	6.8972	92	6.8972	12.57	1.0000	0.012	66.934	841.112
CI-6	CB-3	5-1	72.00	842.18	843.20	1.4167	24	HDPE	0.1643	6.3000	64	2.7602	67	2.8896	3.14	0.5000	0.012	19.917	62.570
CB-3	CI-4	4-3	34.00	843.30	843.64	1.0000	15	HDPE	0.0308	6.3000	94	0.7600	94	0.7600	1.23	0.3125	0.012	6.536	8.021
CI-4	CI-5	4-2	12.00	843.74	844.25	4.2500	15	HDPE	0.1485	6.3000	94	3.6642	94	3.6642	1.23	0.3125	0.012	13.475	16.537
CB-3	MH-2.5	2 /2	54.60	843.30	846.05	5.0366	15	HDPE	0.2121	6.3000	72	4.0087	74	4.1200	1.23	0.3125	0.012	14.669	18.002
MH-2.5	CI-2	0	57.40	846.15	848.15	3.4843	15	HDPE	0.0000	6.3000	0	0.0000	0	0.0000	1.23	0.3125	0.012	12.201	14.973
CI-2	CI-1	2 /2	47.00	849.25	850.35	2.3404	15	HDPE	0.2121	6.3000	72	4.0087	74	4.1200	1.23	0.3125	0.012	10.000	12.272
								TOTAL	1.0534									
RRA 1	AD-10	3-3	27.00	843.24	843.51	1.0000	24	HDPE	0.1077	6.3000	42	1.1874	96	2.7140	3.14	0.5000	0.012	16.733	52.570
AD-10	CI-9	3-2	56.00	843.61	844.17	1.0000	18	HDPE	0.0420	6.3000	50	0.5513	66	0.7277	1.77	0.3750	0.012	9.413	16.633
CI-9	CI-8	3-1	19.00	844.27	844.46	1.0000	18	HDPE	0.1793	6.3000	85	4.0006	86	4.0477	1.77	0.3750	0.012	9.413	16.633
CI-8	CI-7	4-1	54.00	844.56	845.10	1.0000	15	HDPE	0.0634	6.3000	88	1.4645	88	1.4645	1.23	0.3125	0.012	6.536	8.021
								TOTAL	0.3924									

WATERSHED	% AREA	c	%Ac	DESCRIPTION	SOIL GROUP	WATERSHED	% AREA	c	%Ac	DESCRIPTION	SOIL GROUP
WS-2	66.00	0.96	63.36	IMPERVIOUS 2 - 6%	D	WS-4-1	100.00	0.96	96.00	IMPERVIOUS 2 - 6%	D
WS-2	33.00	0.26	8.58	OPEN SPACE > 6%	B	WS-4-1	0.00	0.00	0.00		B
		COMP. c	71.94					COMP. c	96.00		
WS-2	66.00	0.96	63.36	IMPERVIOUS 2 - 6%	D	WS-4-1	100.00	0.96	96.00	IMPERVIOUS 2 - 6%	D
WS-2	33.00	0.32	10.56	OPEN SPACE > 6%	C	WS-4-1	0.00	0.00	0.00		C
		COMP. c	73.92					COMP. c	96.00		
WS-4-2	98.00	0.96	94.08	IMPERVIOUS 2 - 6%	D	WS 3-1	53.00	0.96	50.88	IMPERVIOUS 2 - 6%	D
WS-4-2	2.00	0.14	0.28	OPEN SPACE < 2%	B	WS 3-1	47.00	0.26	12.22	OPEN SPACE > 6%	B
		COMP. c	94.36					COMP. c	63.10		
WS-4-2	98.00	0.96	94.08	IMPERVIOUS 2 - 6%	D	WS-3-1	53.00	0.96	50.88	IMPERVIOUS 2 - 6%	D

WS-4-2	2.00		0.18	0.36	OPEN SPACE < 2%		C		WS-3-1	47.00		0.32	15.04	OPEN SPACE 2 - 6%			C	
			COMP. c	94.44								COMP. c	65.92					
WS-4-3	98.00		0.96	94.08	IMPERVIOUS 2 - 6%		D		WS-3-2	87.00		0.96	83.52	IMPERVIOUS < 2%			D	
WS-4-3	2.00		0.14	0.28	OPEN SPACE < 2%		B		WS-3-2	13.00		0.14	1.82	OPEN SPACE <2%			B	
			COMP. c	94.36								COMP. c	85.34					
WS-4-3	98.00		0.96	94.08	IMPERVIOUS 2 - 6%		D		WS-3-2	87.00		0.96	83.52	IMPERVIOUS 2 - 6%			D	
WS-4-3	2.00		0.18	0.36	OPEN SPACE < 2%		C		WS-3-2	13.00		0.18	2.34	OPEN SPACE < 2%			C	
			COMP. c	94.44								COMP. c	85.86					
WS-5-1	54.00		0.96	51.84	IMPERVIOUS 2 - 6%		D		WS-3-3	90.00		0.96	86.40	IMPERVIOUS 2 - 6%			D	
WS-5-1	46.00		0.26	11.96	OPEN SPACE > 6%		B		WS-3-3	10.00		0.14	1.40	OPEN SPACE < 2%			B	
			COMP. c	63.80								COMP. c	87.80					
WS-5-1	54.00		0.96	51.84	IMPERVIOUS 2 - 6%		D		WS-3-3	90.00		0.96	86.40	IMPERVIOUS 2 - 6%			D	
WS-5-1	46.00		0.32	14.72	OPEN SPACE > 6%		C		WS-3-3	10.00		0.18	1.80	OPEN SPACE < 2%			C	
			COMP. c	66.56								COMP. c	88.20					
WS-5-2	95.00		0.96	91.20	IMPERVIOUS 2 - 6%		D		WS- PRE	4.40		0.14	0.62	OPEN SPACE < 2%			B	
WS-5-2	5.00		0.23	1.15	OPEN SPACE > 6%		B		WS- PRE	36.80		0.16	5.89	OPEN SPACE 2 - 6%			B	
			COMP. c	92.35						58.80		0.26	15.29	OPEN SPACE > 6%			B	
												COMP. c	21.79					
WS-5-2	95.00		0.96	91.20	IMPERVIOUS 2 - 6%		D											
WS-5-2	5.00		0.18	0.90	OPEN SPACE 2 - 6%		C		WS- PRE	4.40		0.18	0.79	OPEN SPACE < 2%			C	
			COMP. c	92.10					WS- PRE	36.80		0.23	8.46	OPEN SPACE 2 - 6%			C	
										58.80		0.32	18.82	OPEN SPACE > 6%			C	
												COMP. c	28.07					

100 yr. storm soil group B

Run	Cumulative Qin (cfs)	Area grate (ft2)	V1	V1^2/2g	Z1	Z2	delta z	e/D	D (in)	L (ft)	hf (ft)	V2 (ft/s)	Re	V check	V2^2/2g	Cumulative A2 (ft^2)	y/d	1-2(y/d)	theta	cos (θ/2 - 1)	y2 (ft.)	HGL (ft)	EGL (ft)	cum length
CI-1 to CI-2	4.0087	1.9273	2.0800	0.0672	850.35	849.25	1.10	6.56E-06	15	47.00	0.0773	8.3779	1.93E+05	OK	1.08990	0.47848	0.38990	0.22019	2.69757	0.93979	0.58737	850.27272	851.36262	47.00
CI-2 to MH-2.5	8.0174	1.9273	4.1599	0.2687	848.15	846.15	2.00	6.56E-06	15	57.40	0.3181	11.2081	3.85E+05	OK	1.95064	0.71532	0.58290	-0.16579	3.47471	0.74025	0.46266	847.83193	849.78258	104.40
MH-2.5 to CB 3	0.0000	0.0000	11.2081	1.9506	846.05	844.80	1.25	6.56E-06	15	54.60	2.2915	7.6519	1.04E+06	OK	0.90918	0.00000	0.00000	1.00000	0.00000	0.54030	0.33769	843.75854	844.66772	159.00
CI-5 to CI-4	3.6642	1.9273	1.9012	0.0561	844.25	843.74	0.51	6.56E-06	15	12.00	0.0583	5.7188	1.76E+05	OK	0.50784	0.64073	0.52211	-0.04423	3.23008	0.81675	0.51047	844.19172	844.69956	12.00
CI-4 to CB-3	4.4242	1.9273	2.2956	0.0818	843.64	843.30	0.34	6.56E-06	15	34.00	0.0907	4.6176	2.13E+05	OK	0.33110	0.95811	0.78074	-0.56148	4.33394	0.39294	0.24559	843.54927	843.88037	46.00
CB-3 to CI-6	15.2018	1.9273	7.8877	0.9661	843.20	842.18	1.02	4.10E-06	24	72.00	1.1052	7.5319	1.17E+06	OK	0.88088	2.01834	0.64246	-0.28491	3.71943	0.65266	0.65266	842.09481	842.97569	231.00
CI-6 to RRA-2	22.0991	1.9273	11.4664	2.0416	842.08	842.00	0.08	2.05E-06	48	8.00	2.0579	2.0249	3.40E+06	OK	0.06367	10.91373	0.86849	-0.73697	4.79876	0.17058	0.34116	840.02208	840.08575	239.00
CI-7 to CI-8	1.4645	1.9273	0.7599	0.0090	845.10	844.56	0.54	6.56E-06	15	54.00	0.0105	5.8887	7.04E+04	OK	0.53845	0.24871	0.20266	0.59467	1.86787	0.99782	0.62364	845.08948	845.62793	54.00
CI-8 to CI-9	5.4652	1.9273	2.8357	0.1249	844.46	844.27	0.19	5.47E-06	18	19.00	0.1312	3.4393	3.15E+05	OK	0.18367	1.58905	0.89922	-0.79844	4.99098	0.07524	0.05643	844.32881	844.51249	73.00
CI-9 to AD-10	6.0164	1.9273	3.1217	0.1513	844.17	843.61	0.56	5.47E-06	18	56.00	0.1739	5.8829	3.47E+05	OK	0.53740	1.02269	0.57873	-0.15745	3.45781	0.74590	0.55943	843.99608	844.53349	129.00
AD-10 to RRA-1	7.2038	1.9273	3.7378	0.2169	843.51	843.24	0.27	4.10E-06	24	27.00	0.2287	4.0784	5.54E+05	OK	0.25829	1.76632	0.56224	-0.12448	3.39119	0.76767	0.76767	843.28134	843.53963	156.00

area grate	277.53	in^2
e	0.0025	mm
g	32.2	ft/s^2
dyn. vis 70 F	1.350E-05	ft^2/s

100 YR. STORM SOIL GROUP B - PRE CONSTRUCTION

DISTURBED WATERSHED	8.2706	cfs	
RRA-2 CUM. VELOCITIES	47.1311	ft/s	
AREA RRA-2	1.0534	Ac.	
Q discharge	14.6514	cfs	d50 rip rap 9-12" slope = 1.0% ASSUME FLOWING FULL, d=.75' n = .035 for grassland / herbaceous
RRA-1 CUM. VELOCITIES	19.2893	ft/s	
AREA RRA-1	0.3924	Ac.	
Q discharge	5.4578	cfs	d50 rip rap 9-12" slope = 1.0% ASSUME FLOWING FULL, d=.75' n = .035 for grassland / herbaceous

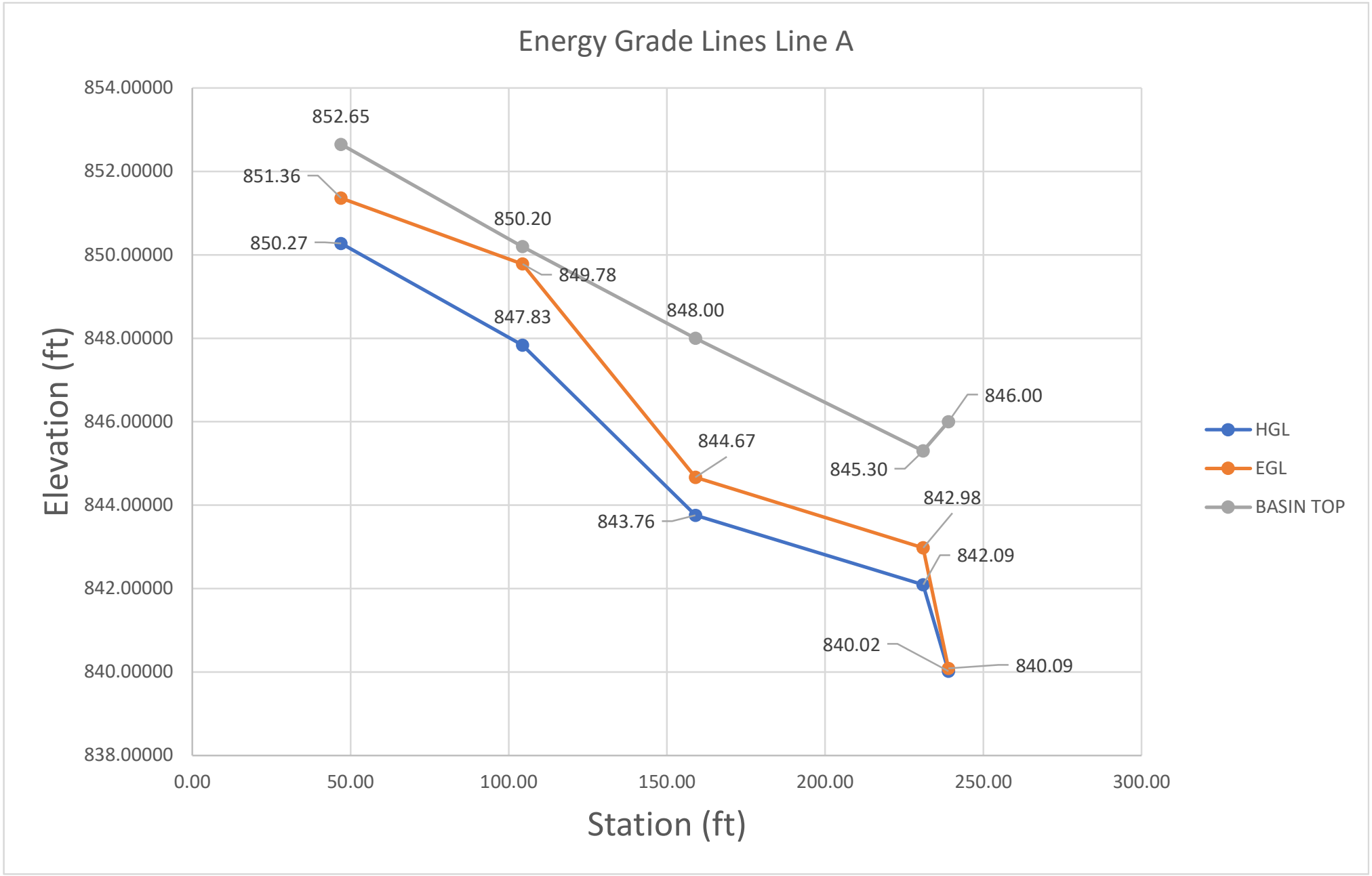
100 yr. storm soil group C

Run	Cumulative Qin (cfs)	Area grate (ft2)	V1	V1^2/2g	Z1	Z2	delta z	e/D	D (in)	L (ft)	hf (ft)	V2 (ft/s)	Re	V check	V2^2/2g	Cumulative A2 (ft^2)	y/d	1-2(y/d)	theta	cos (θ/2 - 1)	y2 (ft.)	HGL (ft)	EGL (ft)	cum length
CI-1 to CI-2	4.1200	1.9273	2.1377	0.0710	850.35	849.25	1.10	6.56E-06	15	47.00	0.0816	8.3757	1.98E+05	OK	1.08933	0.49190	0.40084	0.19832	2.74230	0.93191	0.58244	850.26837	851.35769	47.00
CI-2 to MH-2.5	8.2401	1.9273	4.2755	0.2838	848.15	846.15	2.00	6.56E-06	15	57.40	0.3360	11.2001	3.96E+05	OK	1.94786	0.73571	0.59951	-0.19903	3.54233	0.71710	0.44819	847.81402	849.76188	104.40
MH-2.5 to CB 3	0.0000	0.0000	11.2001	1.9479	846.05	844.80	1.25	6.56E-06	15	54.60	2.2882	7.6539	1.04E+06	OK	0.90967	0.00000	0.00000	1.00000	0.00000	0.54030	0.33769	843.76181	844.67148	159.00
CI-5 to CI-4	3.6642	1.9273	1.9012	0.0561	844.25	843.74	0.51	6.56E-06	15	12.00	0.0583	5.7188	1.76E+05	OK	0.50784	0.64073	0.52211	-0.04423	3.23008	0.81675	0.51047	844.19172	844.69956	12.00
CI-4 to CB-3	4.4242	1.9273	2.2956	0.0818	843.64	843.30	0.34	6.56E-06	15	34.00	0.0907	4.6176	2.13E+05	OK	0.33110	0.95811	0.78074	-0.56148	4.33394	0.39294	0.24559	843.54927	843.88037	46.00
CB-3 to CI-6	15.5539	1.9273	8.0704	1.0113	843.20	842.18	1.02	4.10E-06	24	72.00	1.1570	7.5039	1.20E+06	OK	0.87437	2.07277	0.65978	-0.31957	3.79213	0.62469	0.62469	842.04302	842.91739	231.00
CI-6 to RRA-2	22.4512	1.9273	11.6491	2.1072	842.08	842.00	0.08	2.05E-06	48	8.00	2.1240	2.0165	3.45E+06	OK	0.06314	11.13357	0.88598	-0.77196	4.90544	0.11780	0.23560	839.95598	840.01913	239.00
CI-7 to CI-8	1.4645	1.9273	0.7599	0.0090	845.10	844.56	0.54	6.56E-06	15	54.00	0.0105	5.8887	7.04E+04	OK	0.53845	0.24871	0.20266	0.59467	1.86787	0.99782	0.62364	845.08948	845.62793	54.00
CI-8 to CI-9	5.5122	1.9273	2.8601	0.1270	844.46	844.27	0.19	5.47E-06	18	19.00	0.1335	3.4382	3.18E+05	OK	0.18356	1.60321	0.90723	-0.81446	5.04520	0.04818	0.03613	844.32654	844.51011	73.00
CI-9 to AD-10	6.2399	1.9273	3.2376	0.1628	844.17	843.61	0.56	5.47E-06	18	56.00	0.1871	5.8736	3.60E+05	OK	0.53569	1.06237	0.60118	-0.20236	3.54912	0.71473	0.53605	843.98292	844.51862	129.00
AD-10 to RRA-1	8.9539	1.9273	4.6459	0.3352	843.51	843.24	0.27	4.10E-06	24	27.00	0.3533	4.0277	6.88E+05	OK	0.25190	2.22308	0.70763	-0.41526	3.99804	0.54113	0.54113	843.15675	843.40865	156.00

area grate	277.53	in^2
e	0.0025	mm
g	32.2	ft/s^2
dyn. vis 70 F	1.350E-05	ft^2/s

100 YR. STORM SOIL GROUP C - PRE CONSTRUCTION

DISTURBED WATERSHED	8.2706	cfs	
RRA-2 CUM. VELOCITIES	47.0867	ft/s	
AREA RRA-2	1.0534	Ac.	
Q discharge	14.6514	cfs	d50 rip rap 9-12" slope = 1.0% ASSUME FLOWING FULL, d=.75' n = .035 for grassland / herbaceous
RRA-1 CUM. VELOCITIES	19.2282	ft/s	
AREA RRA-1	0.3924	Ac.	
Q discharge	5.4578	cfs	d50 rip rap 9-12" slope = 1.0% ASSUME FLOWING FULL, d=.75' n = .035 for grassland / herbaceous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Station (ft)
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850.00000
848.00000
846.00000
844.00000
842.00000
840.00000
838.00000
0.00
50.00
100.00
150.00
200.00
250.00
300.00
852.65
851.36
850.27
850.20
849.78
847.83
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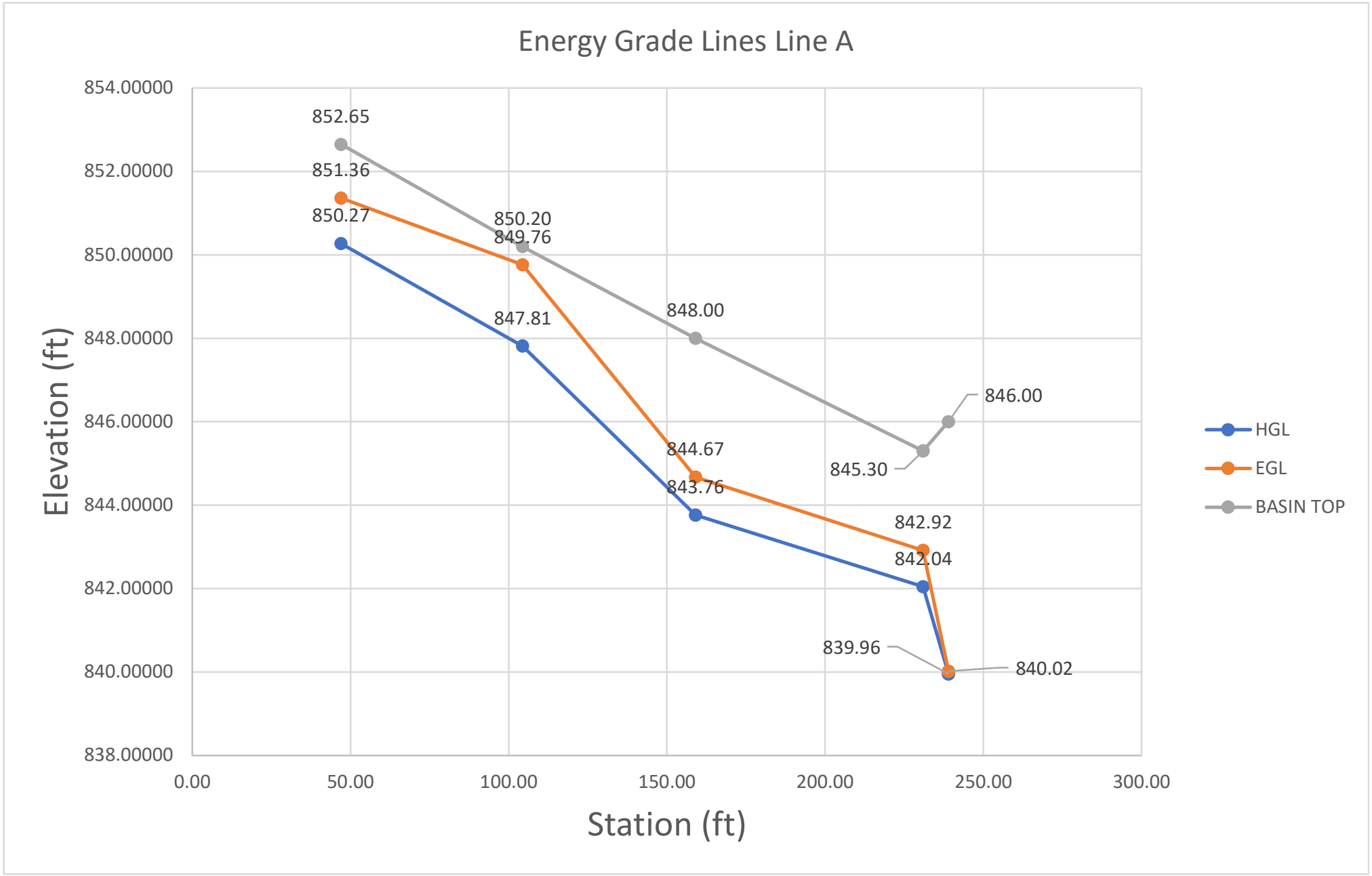
HGL
EGL
BASIN TOP


Energy Grade Lines Line A
Elevation (ft)
Station (ft)
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850.00000
848.00000
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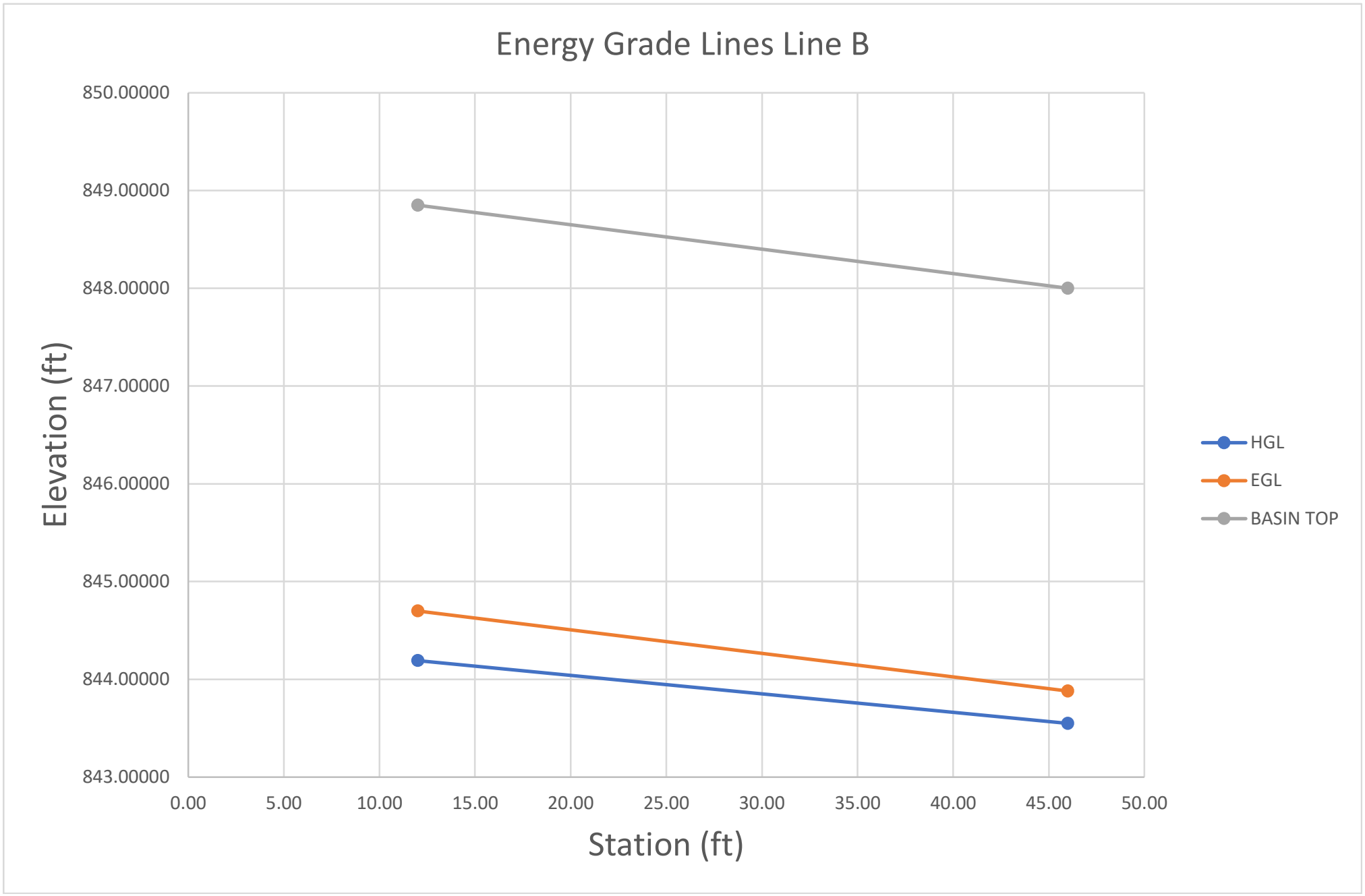
844.00000
842.00000
840.00000
838.00000
0.00
50.00
100.00
150.00
200.00
250.00
300.00
852.65
851.36
850.27
850.20
849.76
848.00
847.81
846.00
845.30
844.67
843.76
842.92
842.04
839.96
840.02
HGL
EGL
BASIN TOP


Energy Grade Lines Line B
850.00000
849.00000
848.00000
847.00000
846.00000
845.00000
844.00000
843.00000
Elevation (ft)
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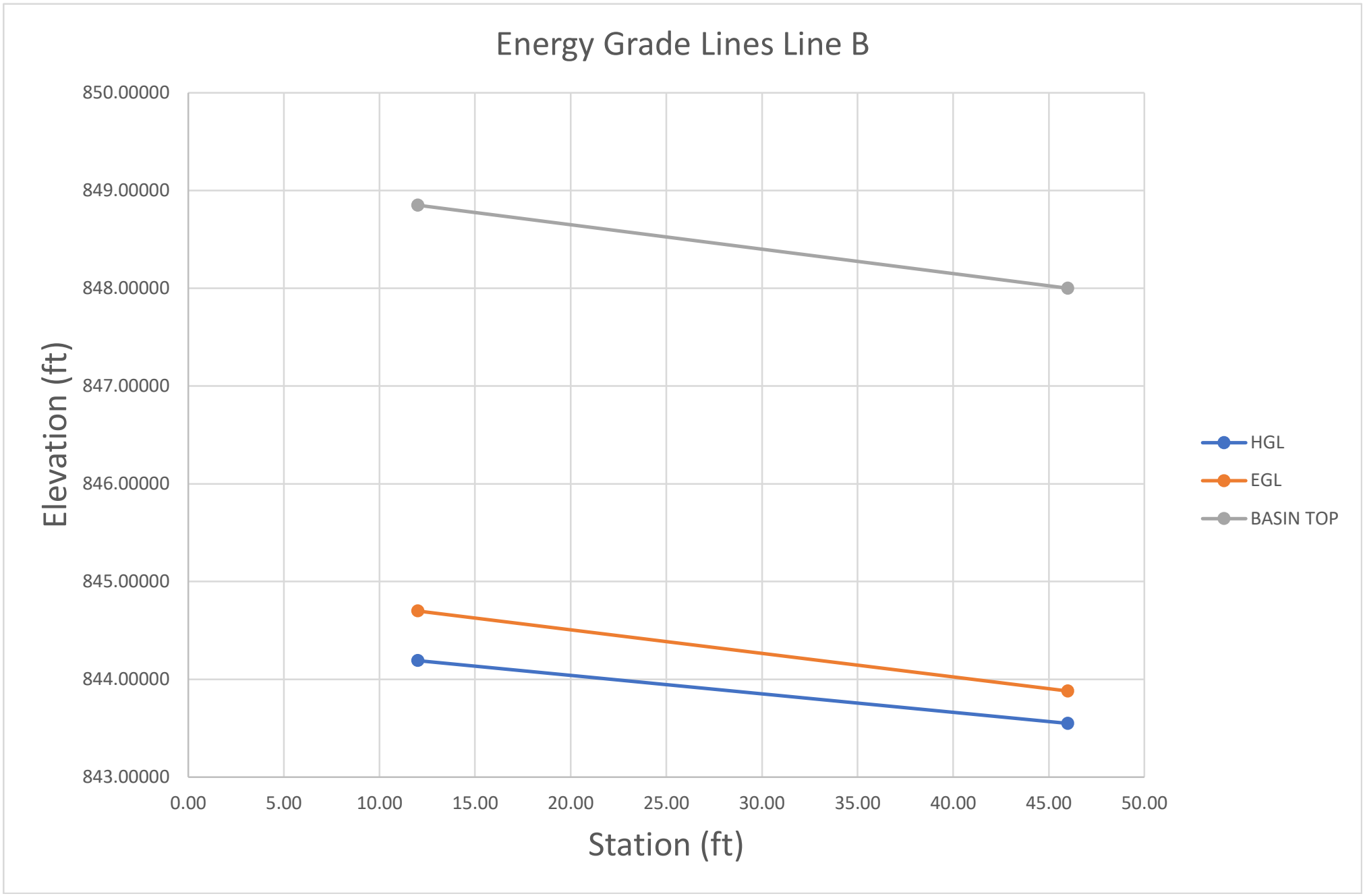
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00
Station (ft)
HGL
EGL
BASIN TOP


Energy Grade Lines Line B
850.00000
849.00000
848.00000
847.00000
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Elevation (ft)
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40.00
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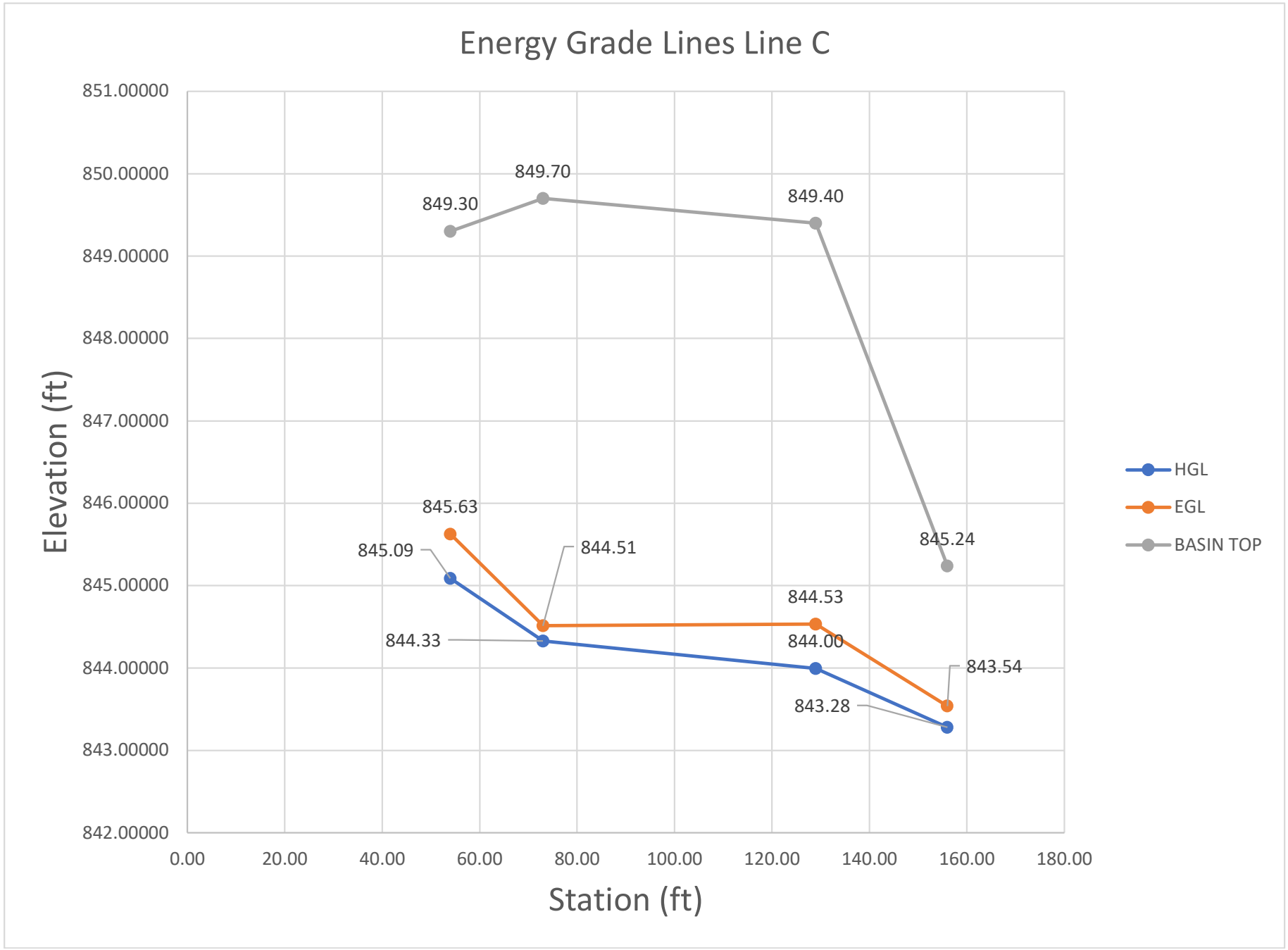
50.00
Station (ft)
HGL
EGL
BASIN TOP


Energy Grade Lines Line C
Elevation (ft)
Station (ft)
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850.00000
849.00000
848.00000
847.00000
846.00000
845.00000
844.00000
843.00000
842.00000
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
849.30
849.70
849.40
845.24
845.63
845.09
844.51
844.53
844.33
844.00
843.54
843.28
HGL
EGL
BASIN TOP

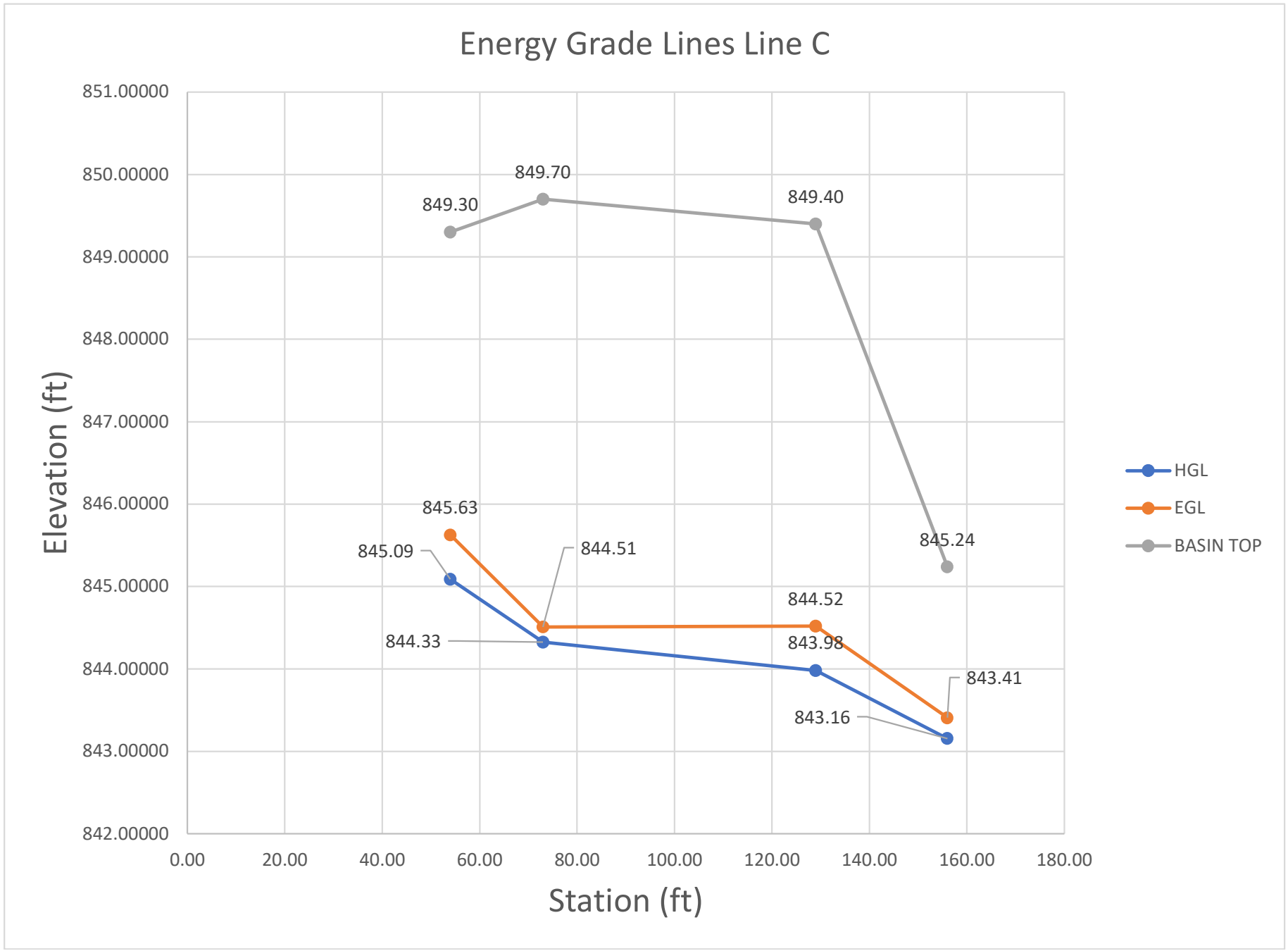

Energy Grade Lines Line C
Elevation (ft)
Station (ft)
851.00000
850.00000
849.00000
848.00000
847.00000
846.00000
845.00000
844.00000
843.00000
842.00000
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
849.30
849.70
849.40
845.24
845.63
845.09
844.51
844.52
844.33
843.98
843.41
843.16
HGL
EGL
BASIN TOP

Table 3-7. Recommended Runoff Coefficient Values for Rational Method

Land Use	Runoff Coefficient (C) by Hydrologic Soil Group and Ground Slope											
	A			B			C			D		
	<2%	2 - 6%	>6%	<2%	2 - 6%	>6%	<2%	2 - 6%	>6%	<2%	2 - 6%	>6%
Forest	0.08	0.11	0.14	0.10	0.14	0.18	0.12	0.16	0.20	0.15	0.20	0.25
Meadow	0.14	0.22	0.30	0.20	0.28	0.37	0.26	0.35	0.44	0.30	0.40	0.50
Pasture	0.15	0.25	0.37	0.23	0.34	0.45	0.30	0.42	0.52	0.37	0.50	0.62
Farmland	0.14	0.18	0.22	0.16	0.21	0.28	0.20	0.25	0.34	0.24	0.29	0.41
Res. 1 acre	0.22	0.26	0.29	0.24	0.28	0.34	0.28	0.32	0.40	0.31	0.35	0.46
Res. 1/2 acre	0.25	0.29	0.32	0.28	0.32	0.36	0.31	0.35	0.42	0.34	0.38	0.46
Res. 1/3 acre	0.28	0.32	0.35	0.30	0.35	0.39	0.33	0.38	0.45	0.36	0.40	0.50
Res. 1/4 acre	0.30	0.34	0.37	0.33	0.37	0.42	0.36	0.40	0.47	0.38	0.42	0.52
Res. 1/8 acre	0.33	0.37	0.40	0.35	0.39	0.44	0.38	0.42	0.49	0.41	0.45	0.54
Industrial	0.85	0.85	0.86	0.85	0.86	0.86	0.86	0.86	0.87	0.86	0.86	0.88
Commercial	0.88	0.88	0.89	0.89	0.89	0.89	0.89	0.89	0.90	0.89	0.89	0.90
Streets: ROW	0.76	0.77	0.79	0.80	0.82	0.84	0.84	0.85	0.89	0.89	0.91	0.95
Parking	0.95	0.96	0.97	0.95	0.96	0.97	0.95	0.96	0.97	0.95	0.96	0.97
Disturbed Area	0.65	0.67	0.69	0.66	0.68	0.70	0.68	0.70	0.72	0.69	0.72	0.75

A–382.36 (4)–2. RUNOFF COEFFICIENTS. Tables Detail A and B are for using the rational formula.

DETAIL A: RUNOFF COEFFICIENTS (C), RATIONAL FORMULA

Land Use	Percent Impervious Area	Design Storm 24–Hour Event	Hydrologic Soil Group											
			A			B			C			D		
			Slope Range (%)			Slope Range (%)			Slope Range (%)			Slope Range (%)		
			0–2	2–6	> 6	0–2	2–6	> 6	0–2	2–6	> 6	0–2	2–6	> 6
Industrial	90	2– and 10–year	0.67	0.58	0.68	0.68	0.68	0.69	0.68	0.69	0.69	0.69	0.69	0.70
		25–, 50–, and 100–year	0.85	0.85	0.86	0.85	0.86	0.86	0.86	0.86	0.87	0.86	0.86	0.88
Commercial	95	2– and 10–year	0.71	0.71	0.72	0.71	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
		25–, 50–, and 100–year	0.88	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.90
Residential: gh–density (>6 units/ acre)	60	2– and 10–year	0.47	0.49	0.50	0.48	0.50	0.52	0.49	0.51	0.54	0.51	0.53	0.56
		25–, 50–, and 100–year	0.58	0.60	0.61	0.59	0.61	0.64	0.60	0.62	0.66	0.62	0.66	0.69
Medium–density (2–6 units/acre)	30	2– and 10–year	0.25	0.28	0.31	0.27	0.30	0.35	0.30	0.33	0.38	0.33	0.36	0.42
		25–, 50–, and 100–year	0.33	0.37	0.40	0.35	0.39	0.44	0.38	0.42	0.49	0.41	0.45	0.54
Low–density (0.7–2 units/ acre)	15	2– and 10–year	0.14	0.19	0.22	0.17	0.21	0.26	0.20	0.25	0.31	0.24	0.28	0.35
		25–, 50–, and 100–year	0.22	0.26	0.29	0.24	0.28	0.34	0.28	0.32	0.40	0.31	0.35	0.46
Agriculture	5	2– and 10–year	0.08	0.13	0.16	0.11	0.15	0.21	0.14	0.19	0.26	0.18	0.23	0.31
		25–, 50–, and 100–year	0.14	0.18	0.22	0.16	0.21	0.28	0.20	0.25	0.34	0.24	0.29	0.41
Open Space	2	2– and 10–year	0.05	0.10	0.14	0.08	0.13	0.19	0.12	0.17	0.24	0.16	0.21	0.28
		25–, 50–, and 100–year	0.11	0.16	0.20	0.14	0.19	0.26	0.18	0.23	0.32	0.22	0.27	0.39
Freeways and Expressways	70	2– and 10–year	0.57	0.59	0.60	0.58	0.60	0.61	0.59	0.61	0.63	0.60	0.62	0.64
		25–, 50–, and 100–year	0.70	0.71	0.72	0.71	0.72	0.74	0.72	0.72	0.73	0.76	0.75	0.78

Source: Wisconsin department of transportation (WDOT), Facilities Development Manual (July 2, 1979), Procedure 13–10–5.

FROM	TO	WS	LENGTH	INV BELOW	INV ABOVE	SLOPE %	SIZE (in)	MATERIAL	AREA (Ac.)	i (in/24 hr)	c B	Q (cfs) B	c C	Q (cfs) C	Area (full)	Rh (full)	Manning's n	V max (ft/s)	Q max (cfs)
RRA 2	CI-6	5-2	8.00	842.00	842.08	1.0000	48	HDPE	0.2856	5.7000	92	6.2404	92	6.2404	12.57	1.0000	0.012	66.934	841.112
CI-6	CB-3	5-1	72.00	842.18	843.20	1.4167	24	HDPE	0.1643	5.7000	64	2.4974	67	2.6144	3.14	0.5000	0.012	19.917	62.570
CB-3	CI-4	4-3	34.00	843.30	843.64	1.0000	15	HDPE	0.0308	5.7000	94	0.6876	94	0.6876	1.23	0.3125	0.012	6.536	8.021
CI-4	CI-5	4-2	12.00	843.74	844.25	4.2500	15	HDPE	0.1485	5.7000	94	3.3153	94	3.3153	1.23	0.3125	0.012	13.475	16.537
CB-3	MH-2.5	2 /2	54.60	843.30	846.05	5.0366	15	HDPE	0.2121	5.7000	72	3.6269	74	3.7277	1.23	0.3125	0.012	14.669	18.002
MH-2.5	CI-2	0	57.40	846.15	848.15	3.4843	15	HDPE	0.0000	5.7000	0	0.0000	0	0.0000	1.23	0.3125	0.012	12.201	14.973
CI-2	CI-1	2 /2	47.00	849.25	850.35	2.3404	15	HDPE	0.2121	5.7000	72	3.6269	74	3.7277	1.23	0.3125	0.012	10.000	12.272
								TOTAL	1.0534									
RRA 1	AD-10	3-3	27.00	843.24	843.51	1.0000	24	HDPE	0.1077	5.7000	42	1.0743	96	2.4556	3.14	0.5000	0.012	16.733	52.570
AD-10	CI-9	3-2	56.00	843.61	844.17	1.0000	18	HDPE	0.0420	5.7000	50	0.4988	66	0.6584	1.77	0.3750	0.012	9.413	16.633
CI-9	CI-8	3-1	19.00	844.27	844.46	1.0000	18	HDPE	0.1793	5.7000	85	3.6196	86	3.6622	1.77	0.3750	0.012	9.413	16.633
CI-8	CI-7	4-1	54.00	844.56	845.10	1.0000	15	HDPE	0.0634	5.7000	88	1.3251	88	1.3251	1.23	0.3125	0.012	6.536	8.021
								TOTAL	0.3924									

WATERSHED	% AREA	c	%Ac	DESCRIPTION	SOIL GROUP
WS-2	66.00	0.96	63.36	IMPERVIOUS 2 - 6%	D
WS-2	33.00	0.26	8.58	OPEN SPACE > 6%	B
		COMP. c	71.94		
WS-2	66.00	0.96	63.36	IMPERVIOUS 2 - 6%	D
WS-2	33.00	0.32	10.56	OPEN SPACE > 6%	C
		COMP. c	73.92		
WS-4-2	98.00	0.96	94.08	IMPERVIOUS 2 - 6%	D
WS-4-2	2.00	0.14	0.28	OPEN SPACE < 2%	B
		COMP. c	94.36		
WS-4-2	98.00	0.96	94.08	IMPERVIOUS 2 - 6%	D

WATERSHED	% AREA	c	%Ac	DESCRIPTION	SOIL GROUP
WS-4-1	100.00	0.96	96.00	IMPERVIOUS 2 - 6%	D
WS-4-1	0.00	0.00	0.00		B
		COMP. c	96.00		
WS-4-1	100.00	0.96	96.00	IMPERVIOUS 2 - 6%	D
WS-4-1	0.00	0.00	0.00		C
		COMP. c	96.00		
WS 3-1	53.00	0.96	50.88	IMPERVIOUS 2 - 6%	D
WS 3-1	47.00	0.26	12.22	OPEN SPACE > 6%	B
		COMP. c	63.10		
WS-3-1	53.00	0.96	50.88	IMPERVIOUS 2 - 6%	D

WS-4-2	2.00		0.18	0.36	OPEN SPACE < 2%		C		WS-3-1	47.00		0.32	15.04	OPEN SPACE 2 - 6%			C	
			COMP. c	94.44								COMP. c	65.92					
WS-4-3	98.00		0.96	94.08	IMPERVIOUS 2 - 6%		D		WS-3-2	87.00		0.96	83.52	IMPERVIOUS < 2%			D	
WS-4-3	2.00		0.14	0.28	OPEN SPACE < 2%		B		WS-3-2	13.00		0.14	1.82	OPEN SPACE <2%			B	
			COMP. c	94.36								COMP. c	85.34					
WS-4-3	98.00		0.96	94.08	IMPERVIOUS 2 - 6%		D		WS-3-2	87.00		0.96	83.52	IMPERVIOUS 2 - 6%			D	
WS-4-3	2.00		0.18	0.36	OPEN SPACE < 2%		C		WS-3-2	13.00		0.18	2.34	OPEN SPACE < 2%			C	
			COMP. c	94.44								COMP. c	85.86					
WS-5-1	54.00		0.96	51.84	IMPERVIOUS 2 - 6%		D		WS-3-3	90.00		0.96	86.40	IMPERVIOUS 2 - 6%			D	
WS-5-1	46.00		0.26	11.96	OPEN SPACE > 6%		B		WS-3-3	10.00		0.14	1.40	OPEN SPACE < 2%			B	
			COMP. c	63.80								COMP. c	87.80					
WS-5-1	54.00		0.96	51.84	IMPERVIOUS 2 - 6%		D		WS-3-3	90.00		0.96	86.40	IMPERVIOUS 2 - 6%			D	
WS-5-1	46.00		0.32	14.72	OPEN SPACE > 6%		C		WS-3-3	10.00		0.18	1.80	OPEN SPACE < 2%			C	
			COMP. c	66.56								COMP. c	88.20					
WS-5-2	95.00		0.96	91.20	IMPERVIOUS 2 - 6%		D		WS- PRE	4.40		0.14	0.62	OPEN SPACE < 2%			B	
WS-5-2	5.00		0.23	1.15	OPEN SPACE > 6%		B		WS- PRE	36.80		0.16	5.89	OPEN SPACE 2 - 6%			B	
			COMP. c	92.35						58.80		0.26	15.29	OPEN SPACE > 6%			B	
												COMP. c	21.79					
WS-5-2	95.00		0.96	91.20	IMPERVIOUS 2 - 6%		D											
WS-5-2	5.00		0.18	0.90	OPEN SPACE 2 - 6%		C		WS- PRE	4.40		0.18	0.79	OPEN SPACE < 2%			C	
			COMP. c	92.10					WS- PRE	36.80		0.23	8.46	OPEN SPACE 2 - 6%			C	
										58.80		0.32	18.82	OPEN SPACE > 6%			C	
												COMP. c	28.07					

50 yr. storm soil group B

Run	Cumulative Qin (cfs)	Area grate (ft2)	V1	V1^2/2g	Z1	Z2	delta z	e/D	D (in)	L (ft)	hf (ft)	V2 (ft/s)	Re	V check	V2^2/2g	Cumulative A2 (ft^2)	y/d	1-2(y/d)	theta	cos (θ/2 - 1)	y2 (ft.)	HGL (ft)	EGL (ft)	cum length
CI-1 to CI-2	3.6269	1.9273	1.8819	0.0550	850.35	849.25	1.10	6.56E-06	15	47.00	0.0633	8.3849	1.74E+05	OK	1.09173	0.43255	0.35247	0.29505	2.54257	0.96343	0.60214	850.28674	851.37847	47.00
CI-2 to MH-2.5	7.2538	1.9273	3.7637	0.2200	848.15	846.15	2.00	6.56E-06	15	57.40	0.2604	11.2338	3.48E+05	OK	1.95960	0.64571	0.52618	-0.05235	3.24634	0.81203	0.50752	847.88963	849.84923	104.40
MH-2.5 to CB 3	0.0000	0.0000	11.2338	1.9596	846.05	844.80	1.25	6.56E-06	15	54.60	2.3020	7.6453	1.04E+06	OK	0.90762	0.00000	0.00000	1.00000	0.00000	0.54030	0.33769	843.74802	844.65564	159.00
CI-5 to CI-4	3.3153	1.9273	1.7202	0.0459	844.25	843.74	0.51	6.56E-06	15	12.00	0.0477	5.7210	1.59E+05	OK	0.50824	0.57949	0.47221	0.05559	3.03036	0.87020	0.54388	844.20229	844.71052	12.00
CI-4 to CB-3	4.0029	1.9273	2.0769	0.0670	843.64	843.30	0.34	6.56E-06	15	34.00	0.0743	4.6289	1.92E+05	OK	0.33271	0.86476	0.70467	-0.40934	3.98504	0.54658	0.34161	843.56573	843.89844	46.00
CB-3 to CI-6	13.7541	1.9273	7.1365	0.7908	843.20	842.18	1.02	4.10E-06	24	72.00	0.9047	7.6390	1.06E+06	OK	0.90612	1.80051	0.57312	-0.14624	3.43512	0.75341	0.75341	842.29530	843.20142	231.00
CI-6 to RRA-2	19.9944	1.9273	10.3744	1.6712	842.08	842.00	0.08	2.05E-06	48	8.00	1.6846	2.0715	3.07E+06	OK	0.06663	9.65229	0.76810	-0.53621	4.27347	0.42056	0.84112	840.39540	840.46203	239.00
CI-7 to CI-8	1.3251	1.9273	0.6875	0.0073	845.10	844.56	0.54	6.56E-06	15	54.00	0.0086	5.8902	6.37E+04	OK	0.53873	0.22496	0.18331	0.63337	1.76979	0.99338	0.62086	845.09139	845.63012	54.00
CI-8 to CI-9	4.9447	1.9273	2.5656	0.1022	844.46	844.27	0.19	5.47E-06	18	19.00	0.1074	3.4500	2.85E+05	OK	0.18482	1.43324	0.81105	-0.62210	4.48443	0.32270	0.24203	844.35261	844.53743	73.00
CI-9 to AD-10	5.4434	1.9273	2.8244	0.1239	844.17	843.61	0.56	5.47E-06	18	56.00	0.1424	5.9053	3.14E+05	OK	0.54150	0.92178	0.52162	-0.04325	3.22811	0.81732	0.61299	844.02763	844.56913	129.00
AD-10 to RRA-1	6.5177	1.9273	3.3818	0.1776	843.51	843.24	0.27	4.10E-06	24	27.00	0.1872	4.0952	5.01E+05	OK	0.26041	1.59157	0.50661	-0.01322	3.16804	0.83425	0.83425	843.32282	843.58323	156.00

area grate	277.53	in^2
e	0.0025	mm
g	32.2	ft/s^2
dyn. vis 70 F	1.350E-05	ft^2/s

50 YR. STORM SOIL GROUP B - PRE CONSTRUCTION

DISTURBED WATERSHED	7.4829	cfs	
RRA-2 CUM. VELOCITIES	47.3244	ft/s	
AREA RRA-2	1.0534	Ac.	
Q discharge	14.6514	cfs	d50 rip rap 9-12" slope = 1.0% ASSUME FLOWING FULL, d=.75' n = .035 for grassland / herbaceous
RRA-1 CUM. VELOCITIES	19.3407	ft/s	
AREA RRA-1	0.3924	Ac.	
Q discharge	5.4578	cfs	d50 rip rap 9-12" slope = 1.0% ASSUME FLOWING FULL, d=.75' n = .035 for grassland / herbaceous

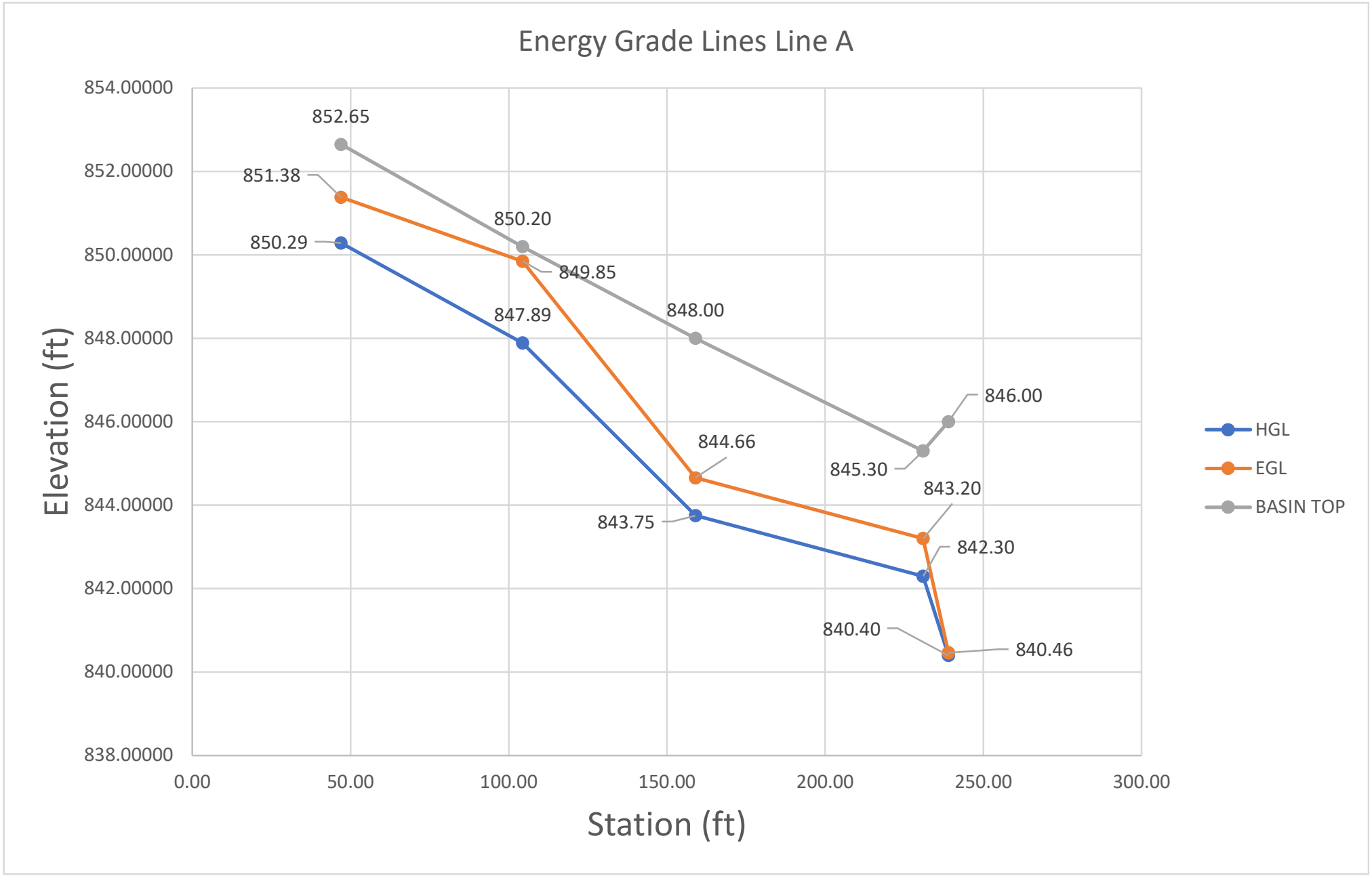
50 yr. storm soil group C

Run	Cumulative Qin (cfs)	Area grate (ft2)	V1	V1^2/2g	Z1	Z2	delta z	e/D	D (in)	L (ft)	hf (ft)	V2 (ft/s)	Re	V check	V2^2/2g	Cumulative A2 (ft^2)	y/d	1-2(y/d)	theta	cos (θ/2 - 1)	y2 (ft.)	HGL (ft)	EGL (ft)	cum length
CI-1 to CI-2	3.7277	1.9273	1.9341	0.0581	850.35	849.25	1.10	6.56E-06	15	47.00	0.0668	8.3832	1.79E+05	OK	1.09126	0.44466	0.36234	0.27532	2.58375	0.95771	0.59857	850.28317	851.37444	47.00
CI-2 to MH-2.5	7.4553	1.9273	3.8683	0.2324	848.15	846.15	2.00	6.56E-06	15	57.40	0.2750	11.2273	3.58E+05	OK	1.95732	0.66404	0.54111	-0.08221	3.30620	0.79420	0.49638	847.87497	849.83229	104.40
MH-2.5 to CB 3	0.0000	0.0000	11.2273	1.9573	846.05	844.80	1.25	6.56E-06	15	54.60	2.2993	7.6470	1.04E+06	OK	0.90802	0.00000	0.00000	1.00000	0.00000	0.54030	0.33769	843.75070	844.65871	159.00
CI-5 to CI-4	3.3153	1.9273	1.7202	0.0459	844.25	843.74	0.51	6.56E-06	15	12.00	0.0477	5.7210	1.59E+05	OK	0.50824	0.57949	0.47221	0.05559	3.03036	0.87020	0.54388	844.20229	844.71052	12.00
CI-4 to CB-3	4.0029	1.9273	2.0769	0.0670	843.64	843.30	0.34	6.56E-06	15	34.00	0.0743	4.6289	1.92E+05	OK	0.33271	0.86476	0.70467	-0.40934	3.98504	0.54658	0.34161	843.56573	843.89844	46.00
CB-3 to CI-6	14.0726	1.9273	7.3018	0.8279	843.20	842.18	1.02	4.10E-06	24	72.00	0.9471	7.6165	1.08E+06	OK	0.90078	1.84766	0.58813	-0.17625	3.49595	0.73307	0.73307	842.25290	843.15369	231.00
CI-6 to RRA-2	20.3130	1.9273	10.5396	1.7249	842.08	842.00	0.08	2.05E-06	48	8.00	1.7387	2.0648	3.12E+06	OK	0.06620	9.83783	0.78287	-0.56574	4.34425	0.38819	0.77639	840.34129	840.40749	239.00
CI-7 to CI-8	1.3251	1.9273	0.6875	0.0073	845.10	844.56	0.54	6.56E-06	15	54.00	0.0086	5.8902	6.37E+04	OK	0.53873	0.22496	0.18331	0.63337	1.76979	0.99338	0.62086	845.09139	845.63012	54.00
CI-8 to CI-9	4.9873	1.9273	2.5877	0.1040	844.46	844.27	0.19	5.47E-06	18	19.00	0.1092	3.4492	2.88E+05	OK	0.18473	1.44593	0.81823	-0.63646	4.52140	0.30515	0.22886	844.35075	844.53548	73.00
CI-9 to AD-10	5.6456	1.9273	2.9293	0.1332	844.17	843.61	0.56	5.47E-06	18	56.00	0.1531	5.8977	3.25E+05	OK	0.54010	0.95726	0.54170	-0.08340	3.30858	0.79348	0.59511	844.01686	844.55696	129.00
AD-10 to RRA-1	8.1012	1.9273	4.2034	0.2744	843.51	843.24	0.27	4.10E-06	24	27.00	0.2892	4.0539	6.23E+05	OK	0.25518	1.99838	0.63610	-0.27221	3.69296	0.66262	0.66262	843.22083	843.47601	156.00

area grate	277.53	in^2
e	0.0025	mm
g	32.2	ft/s^2
dyn. vis 70 F	1.350E-05	ft^2/s

50 YR. STORM SOIL GROUP C - PRE CONSTRUCTION

DISTURBED WATERSHED	7.4829	cfs	
RRA-2 CUM. VELOCITIES	47.2886	ft/s	
AREA RRA-2	1.0534	Ac.	
Q discharge	14.6514	cfs	d50 rip rap 9-12" slope = 1.0% ASSUME FLOWING FULL, d=.75' n = .035 for grassland / herbaceous
RRA-1 CUM. VELOCITIES	19.2909	ft/s	
AREA RRA-1	0.3924	Ac.	
Q discharge	5.4578	cfs	d50 rip rap 9-12" slope = 1.0% ASSUME FLOWING FULL, d=.75' n = .035 for grassland / herbaceous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Elevation (ft)
Station (ft)
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852.00000
850.00000
848.00000
846.00000
844.00000
842.00000
840.00000
838.00000
0.00
50.00
100.00
150.00
200.00
250.00
300.00
852.65
851.38
850.29
850.20
849.85
847.89
848.00
846.00
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845.30
843.20
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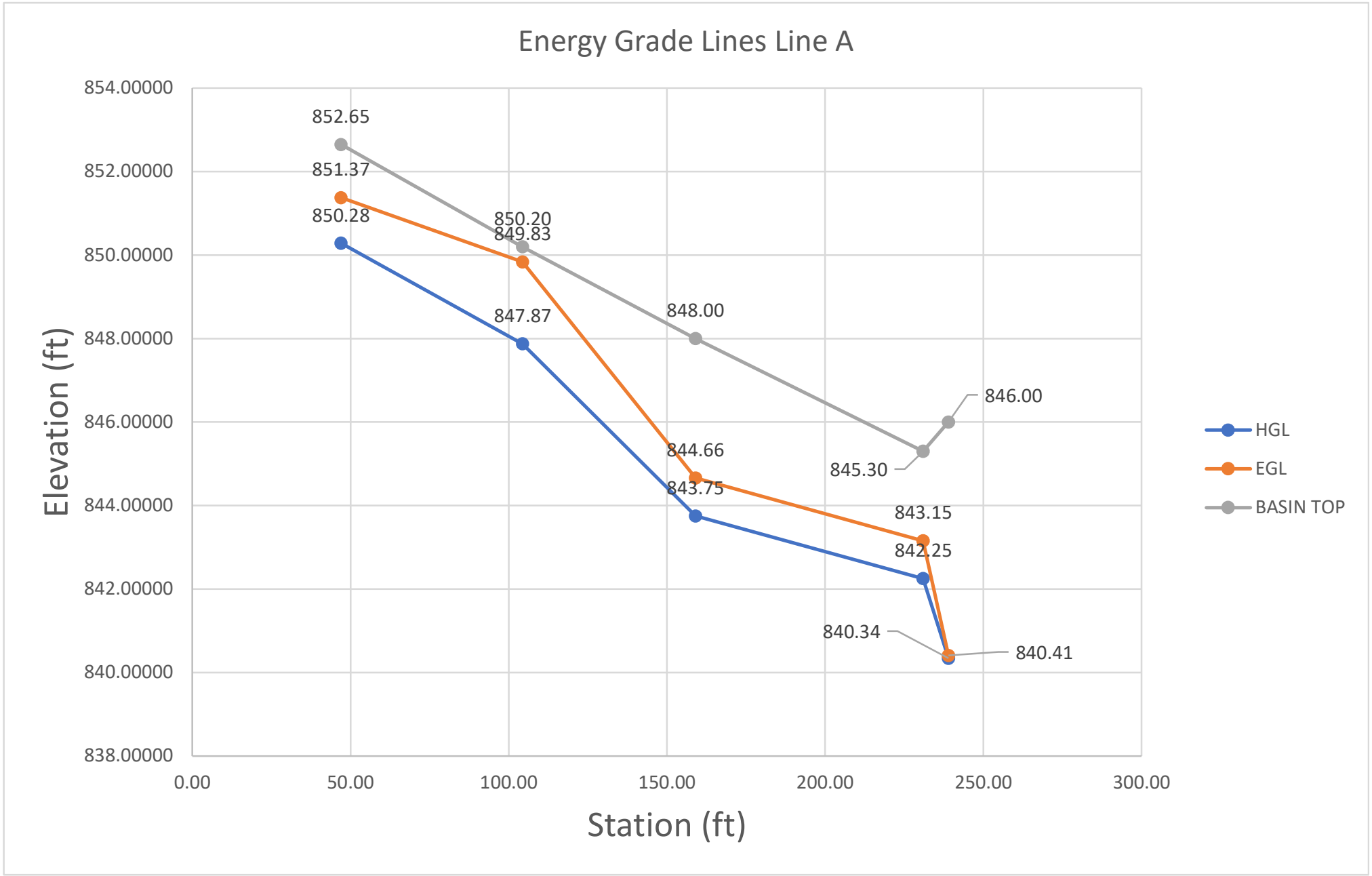
842.30
840.40
840.46
HGL
EGL
BASIN TOP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150.00
200.00
250.00
300.00
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849.83
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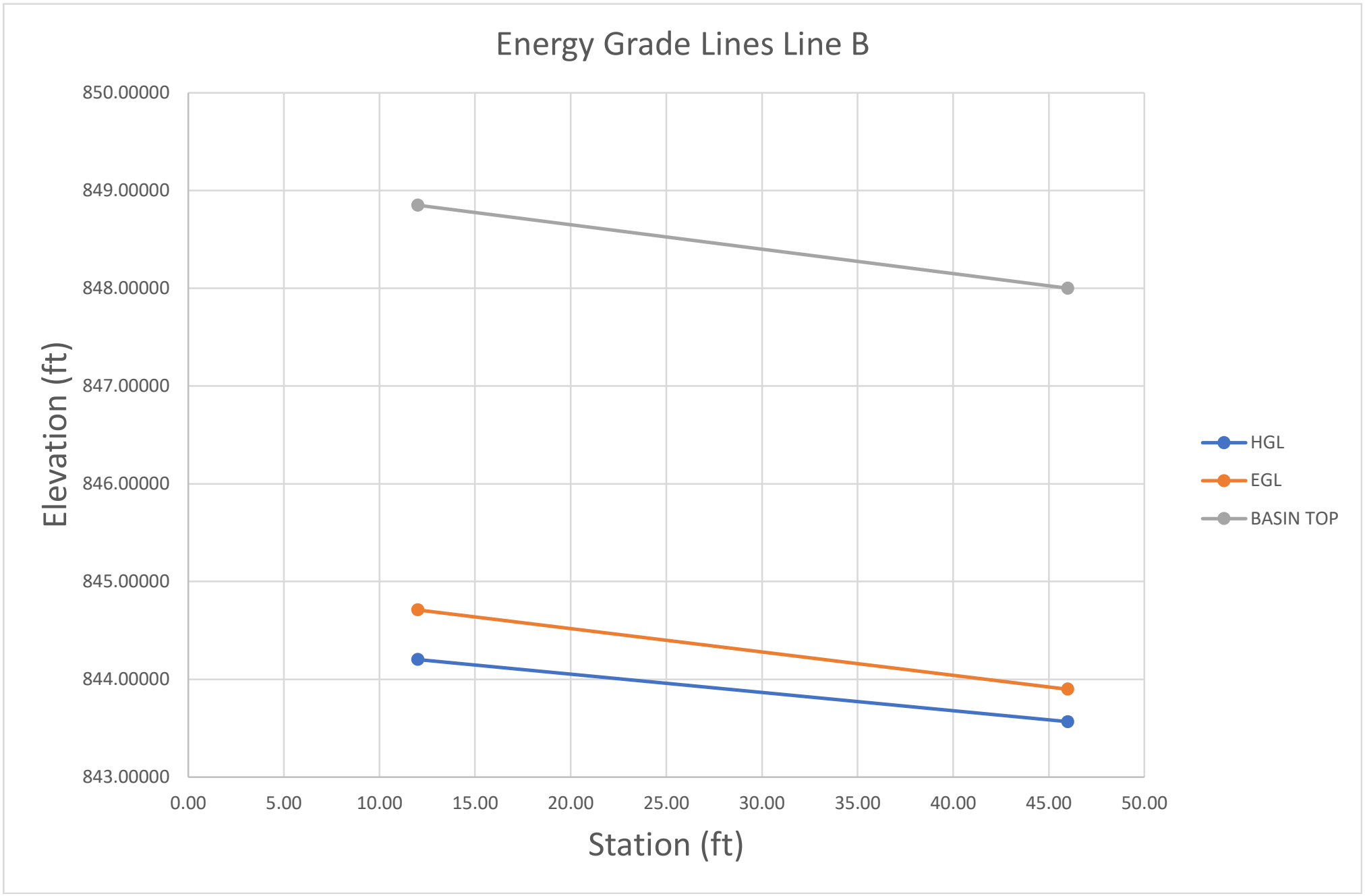
HGL
EGL
BASIN TOP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10.00
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25.00
30.00
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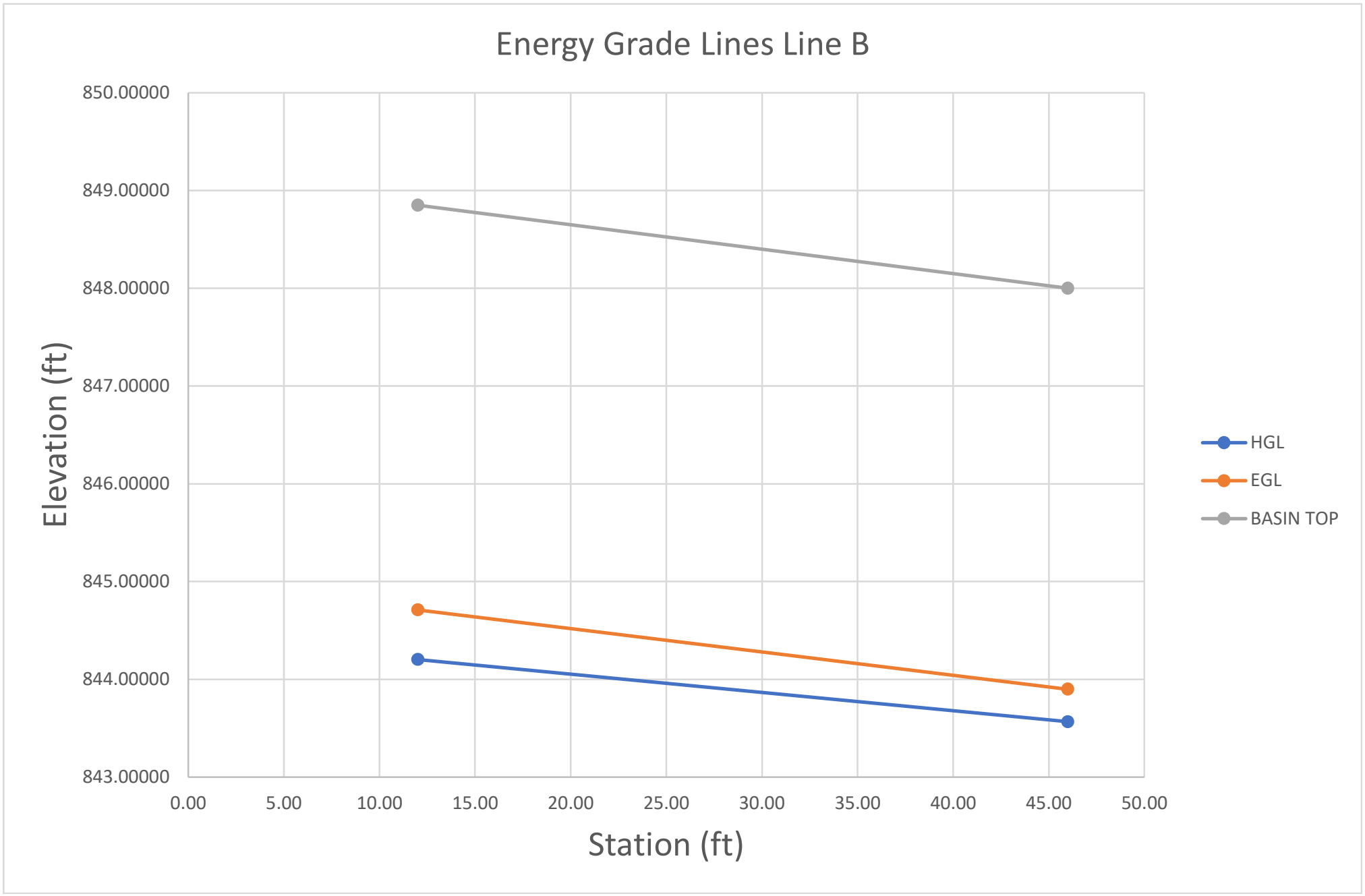
40.00
45.00
50.00
Station (ft)
HGL
EGL
BASIN TOP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Elevation (ft)
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10.00
15.00
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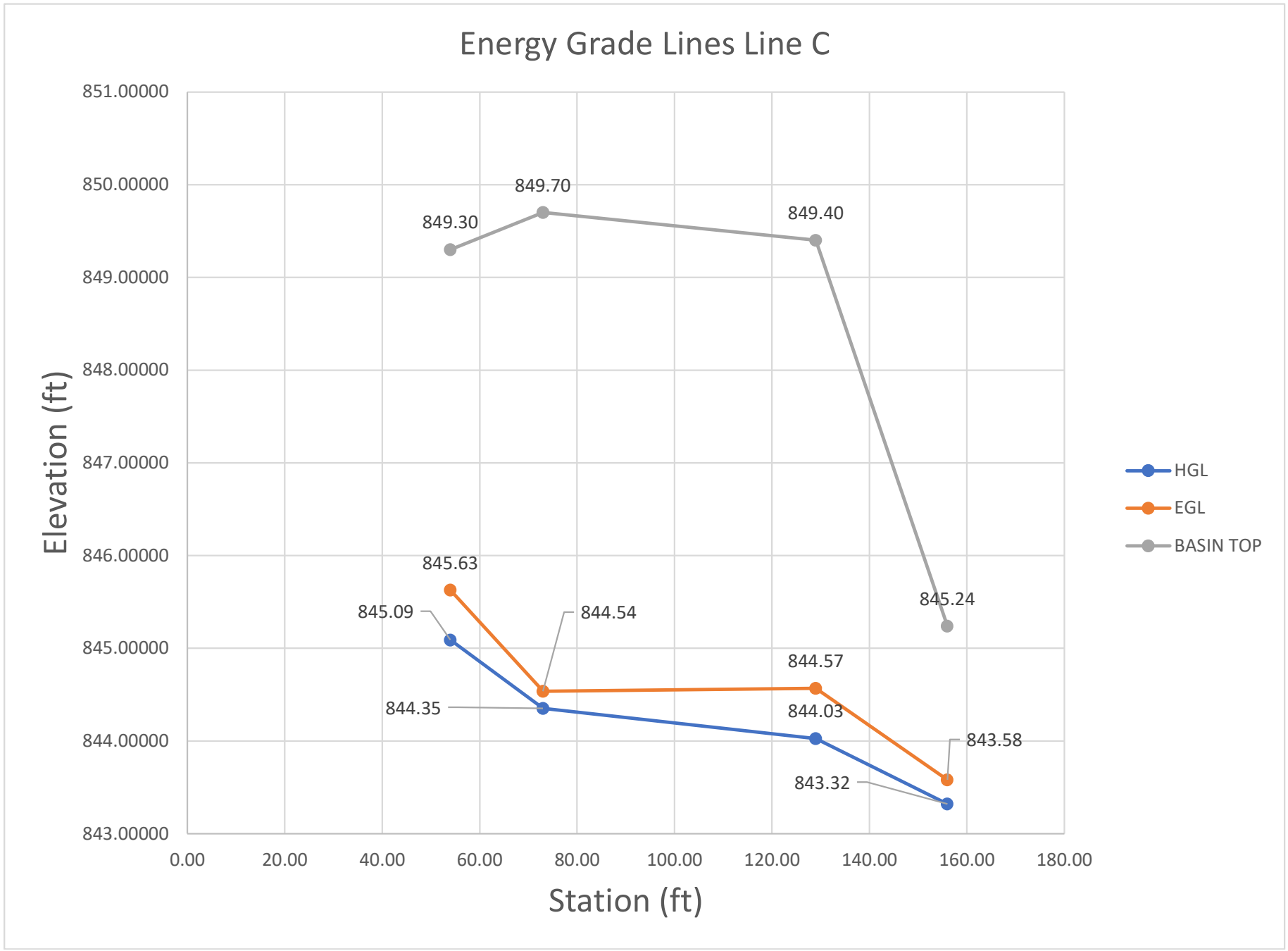
25.00
30.00
35.00
40.00
45.00
50.00
Station (ft)
HGL
EGL
BASIN TOP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Elevation (ft)
Station (ft)
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848.00000
847.00000
846.00000
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843.00000
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
849.30
849.70
849.40
845.24
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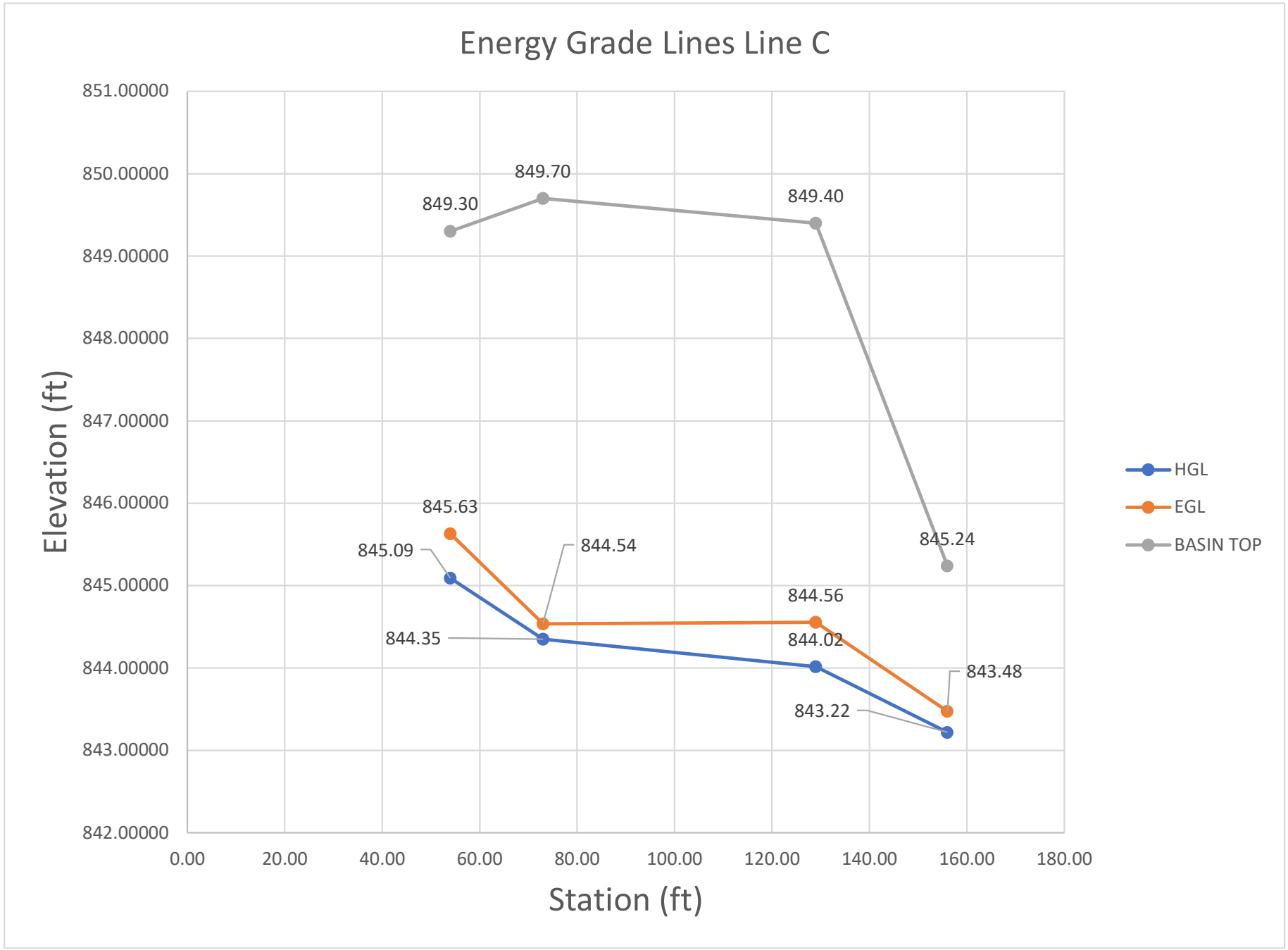
HGL
EGL
BASIN TOP


Energy Grade Lines Line C
Elevation (ft)
Station (ft)
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844.00000
843.00000
842.00000
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
849.30
849.70
849.40
845.24
845.63
845.09
844.54
844.56
844.35
844.02
843.48
843.22
HGL
EGL
BASIN TOP

Table 3-7. Recommended Runoff Coefficient Values for Rational Method

Land Use	Runoff Coefficient (C) by Hydrologic Soil Group and Ground Slope											
	A			B			C			D		
	<2%	2 - 6%	>6%	<2%	2 - 6%	>6%	<2%	2 - 6%	>6%	<2%	2 - 6%	>6%
Forest	0.08	0.11	0.14	0.10	0.14	0.18	0.12	0.16	0.20	0.15	0.20	0.25
Meadow	0.14	0.22	0.30	0.20	0.28	0.37	0.26	0.35	0.44	0.30	0.40	0.50
Pasture	0.15	0.25	0.37	0.23	0.34	0.45	0.30	0.42	0.52	0.37	0.50	0.62
Farmland	0.14	0.18	0.22	0.16	0.21	0.28	0.20	0.25	0.34	0.24	0.29	0.41
Res. 1 acre	0.22	0.26	0.29	0.24	0.28	0.34	0.28	0.32	0.40	0.31	0.35	0.46
Res. 1/2 acre	0.25	0.29	0.32	0.28	0.32	0.36	0.31	0.35	0.42	0.34	0.38	0.46
Res. 1/3 acre	0.28	0.32	0.35	0.30	0.35	0.39	0.33	0.38	0.45	0.36	0.40	0.50
Res. 1/4 acre	0.30	0.34	0.37	0.33	0.37	0.42	0.36	0.40	0.47	0.38	0.42	0.52
Res. 1/8 acre	0.33	0.37	0.40	0.35	0.39	0.44	0.38	0.42	0.49	0.41	0.45	0.54
Industrial	0.85	0.85	0.86	0.85	0.86	0.86	0.86	0.86	0.87	0.86	0.86	0.88
Commercial	0.88	0.88	0.89	0.89	0.89	0.89	0.89	0.89	0.90	0.89	0.89	0.90
Streets: ROW	0.76	0.77	0.79	0.80	0.82	0.84	0.84	0.85	0.89	0.89	0.91	0.95
Parking	0.95	0.96	0.97	0.95	0.96	0.97	0.95	0.96	0.97	0.95	0.96	0.97
Disturbed Area	0.65	0.67	0.69	0.66	0.68	0.70	0.68	0.70	0.72	0.69	0.72	0.75

A–382.36 (4)–2. RUNOFF COEFFICIENTS. Tables Detail A and B are for using the rational formula.

DETAIL A: RUNOFF COEFFICIENTS (C), RATIONAL FORMULA

Land Use	Percent Impervious Area	Design Storm 24–Hour Event	Hydrologic Soil Group											
			A			B			C			D		
			Slope Range (%)			Slope Range (%)			Slope Range (%)			Slope Range (%)		
			0–2	2–6	> 6	0–2	2–6	> 6	0–2	2–6	> 6	0–2	2–6	> 6
Industrial	90	2– and 10–year	0.67	0.58	0.68	0.68	0.68	0.69	0.68	0.69	0.69	0.69	0.69	0.70
		25–, 50–, and 100–year	0.85	0.85	0.86	0.85	0.86	0.86	0.86	0.86	0.87	0.86	0.86	0.88
Commercial	95	2– and 10–year	0.71	0.71	0.72	0.71	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
		25–, 50–, and 100–year	0.88	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.90
Residential: gh–density (>6 units/ acre)	60	2– and 10–year	0.47	0.49	0.50	0.48	0.50	0.52	0.49	0.51	0.54	0.51	0.53	0.56
		25–, 50–, and 100–year	0.58	0.60	0.61	0.59	0.61	0.64	0.60	0.62	0.66	0.62	0.66	0.69
Medium–density (2–6 units/acre)	30	2– and 10–year	0.25	0.28	0.31	0.27	0.30	0.35	0.30	0.33	0.38	0.33	0.36	0.42
		25–, 50–, and 100–year	0.33	0.37	0.40	0.35	0.39	0.44	0.38	0.42	0.49	0.41	0.45	0.54
Low–density (0.7–2 units/ acre)	15	2– and 10–year	0.14	0.19	0.22	0.17	0.21	0.26	0.20	0.25	0.31	0.24	0.28	0.35
		25–, 50–, and 100–year	0.22	0.26	0.29	0.24	0.28	0.34	0.28	0.32	0.40	0.31	0.35	0.46
Agriculture	5	2– and 10–year	0.08	0.13	0.16	0.11	0.15	0.21	0.14	0.19	0.26	0.18	0.23	0.31
		25–, 50–, and 100–year	0.14	0.18	0.22	0.16	0.21	0.28	0.20	0.25	0.34	0.24	0.29	0.41
Open Space	2	2– and 10–year	0.05	0.10	0.14	0.08	0.13	0.19	0.12	0.17	0.24	0.16	0.21	0.28
		25–, 50–, and 100–year	0.11	0.16	0.20	0.14	0.19	0.26	0.18	0.23	0.32	0.22	0.27	0.39
Freeways and Expressways	70	2– and 10–year	0.57	0.59	0.60	0.58	0.60	0.61	0.59	0.61	0.63	0.60	0.62	0.64
		25–, 50–, and 100–year	0.70	0.71	0.72	0.71	0.72	0.74	0.72	0.72	0.73	0.76	0.75	0.78

Source: Wisconsin department of transportation (WDOT), Facilities Development Manual (July 2, 1979), Procedure 13–10–5.

FROM	TO	WS	LENGTH	INV BELOW	INV ABOVE	SLOPE %	SIZE (in)	MATERIAL	AREA (Ac.)	i (in/24 hr)	c B	Q (cfs) B	c C	Q (cfs) C	Area (full)	Rh (full)	Manning's n	V max (ft/s)	Q max (cfs)
RRA 2	CI-6	5-2	8.00	842.00	842.08	1.0000	48	HDPE	0.2856	5.0000	92	5.4740	92	5.4740	12.57	1.0000	0.012	66.934	841.112
CI-6	CB-3	5-1	72.00	842.18	843.20	1.4167	24	HDPE	0.1643	5.0000	64	2.1907	67	2.2934	3.14	0.5000	0.012	19.917	62.570
CB-3	CI-4	4-3	34.00	843.30	843.64	1.0000	15	HDPE	0.0308	5.0000	94	0.6032	94	0.6032	1.23	0.3125	0.012	6.536	8.021
CI-4	CI-5	4-2	12.00	843.74	844.25	4.2500	15	HDPE	0.1485	5.0000	94	2.9081	94	2.9081	1.23	0.3125	0.012	13.475	16.537
CB-3	MH-2.5	2 /2	54.60	843.30	846.05	5.0366	15	HDPE	0.2121	5.0000	72	3.1815	74	3.2699	1.23	0.3125	0.012	14.669	18.002
MH-2.5	CI-2	0	57.40	846.15	848.15	3.4843	15	HDPE	0.0000	5.0000	0	0.0000	0	0.0000	1.23	0.3125	0.012	12.201	14.973
CI-2	CI-1	2 /2	47.00	849.25	850.35	2.3404	15	HDPE	0.2121	5.0000	72	3.1815	74	3.2699	1.23	0.3125	0.012	10.000	12.272
								TOTAL	1.0534									
RRA 1	AD-10	3-3	27.00	843.24	843.51	1.0000	24	HDPE	0.1077	5.0000	42	0.9424	96	2.1540	3.14	0.5000	0.012	16.733	52.570
AD-10	CI-9	3-2	56.00	843.61	844.17	1.0000	18	HDPE	0.0420	5.0000	50	0.4375	66	0.5775	1.77	0.3750	0.012	9.413	16.633
CI-9	CI-8	3-1	19.00	844.27	844.46	1.0000	18	HDPE	0.1793	5.0000	85	3.1751	86	3.2125	1.77	0.3750	0.012	9.413	16.633
CI-8	CI-7	4-1	54.00	844.56	845.10	1.0000	15	HDPE	0.0634	5.0000	88	1.1623	88	1.1623	1.23	0.3125	0.012	6.536	8.021
								TOTAL	0.3924									

WATERSHED	% AREA	c	%Ac	DESCRIPTION	SOIL GROUP
WS-2	66.00	0.96	63.36	IMPERVIOUS 2 - 6%	D
WS-2	33.00	0.26	8.58	OPEN SPACE > 6%	B
		COMP. c	71.94		
WS-2	66.00	0.96	63.36	IMPERVIOUS 2 - 6%	D
WS-2	33.00	0.32	10.56	OPEN SPACE > 6%	C
		COMP. c	73.92		
WS-4-2	98.00	0.96	94.08	IMPERVIOUS 2 - 6%	D
WS-4-2	2.00	0.14	0.28	OPEN SPACE < 2%	B
		COMP. c	94.36		
WS-4-2	98.00	0.96	94.08	IMPERVIOUS 2 - 6%	D

WATERSHED	% AREA	c	%Ac	DESCRIPTION	SOIL GROUP
WS-4-1	100.00	0.96	96.00	IMPERVIOUS 2 - 6%	D
WS-4-1	0.00	0.00	0.00		B
		COMP. c	96.00		
WS-4-1	100.00	0.96	96.00	IMPERVIOUS 2 - 6%	D
WS-4-1	0.00	0.00	0.00		C
		COMP. c	96.00		
WS 3-1	53.00	0.96	50.88	IMPERVIOUS 2 - 6%	D
WS 3-1	47.00	0.26	12.22	OPEN SPACE > 6%	B
		COMP. c	63.10		
WS-3-1	53.00	0.96	50.88	IMPERVIOUS 2 - 6%	D

WS-4-2	2.00		0.18	0.36	OPEN SPACE < 2%		C		WS-3-1	47.00		0.32	15.04	OPEN SPACE 2 - 6%			C	
			COMP. c	94.44								COMP. c	65.92					
WS-4-3	98.00		0.96	94.08	IMPERVIOUS 2 - 6%		D		WS-3-2	87.00		0.96	83.52	IMPERVIOUS < 2%			D	
WS-4-3	2.00		0.14	0.28	OPEN SPACE < 2%		B		WS-3-2	13.00		0.14	1.82	OPEN SPACE <2%			B	
			COMP. c	94.36								COMP. c	85.34					
WS-4-3	98.00		0.96	94.08	IMPERVIOUS 2 - 6%		D		WS-3-2	87.00		0.96	83.52	IMPERVIOUS 2 - 6%			D	
WS-4-3	2.00		0.18	0.36	OPEN SPACE < 2%		C		WS-3-2	13.00		0.18	2.34	OPEN SPACE < 2%			C	
			COMP. c	94.44								COMP. c	85.86					
WS-5-1	54.00		0.96	51.84	IMPERVIOUS 2 - 6%		D		WS-3-3	90.00		0.96	86.40	IMPERVIOUS 2 - 6%			D	
WS-5-1	46.00		0.26	11.96	OPEN SPACE > 6%		B		WS-3-3	10.00		0.14	1.40	OPEN SPACE < 2%			B	
			COMP. c	63.80								COMP. c	87.80					
WS-5-1	54.00		0.96	51.84	IMPERVIOUS 2 - 6%		D		WS-3-3	90.00		0.96	86.40	IMPERVIOUS 2 - 6%			D	
WS-5-1	46.00		0.32	14.72	OPEN SPACE > 6%		C		WS-3-3	10.00		0.18	1.80	OPEN SPACE < 2%			C	
			COMP. c	66.56								COMP. c	88.20					
WS-5-2	95.00		0.96	91.20	IMPERVIOUS 2 - 6%		D		WS- PRE	4.40		0.14	0.62	OPEN SPACE < 2%			B	
WS-5-2	5.00		0.23	1.15	OPEN SPACE > 6%		B		WS- PRE	36.80		0.16	5.89	OPEN SPACE 2 - 6%			B	
			COMP. c	92.35						58.80		0.26	15.29	OPEN SPACE > 6%			B	
												COMP. c	21.79					
WS-5-2	95.00		0.96	91.20	IMPERVIOUS 2 - 6%		D											
WS-5-2	5.00		0.18	0.90	OPEN SPACE 2 - 6%		C		WS- PRE	4.40		0.18	0.79	OPEN SPACE < 2%			C	
			COMP. c	92.10					WS- PRE	36.80		0.23	8.46	OPEN SPACE 2 - 6%			C	
										58.80		0.32	18.82	OPEN SPACE > 6%			C	
												COMP. c	28.07					

25 yr. storm soil group B

Run	Cumulative Qin (cfs)	Area grate (ft2)	V1	V1^2/2g	Z1	Z2	delta z	e/D	D (in)	L (ft)	hf (ft)	V2 (ft/s)	Re	V check	V2^2/2g	Cumulative A2 (ft^2)	y/d	1-2(y/d)	theta	cos (θ/2 - 1)	y2 (ft.)	HGL (ft)	EGL (ft)	cum length
CI-1 to CI-2	3.1815	1.9273	1.6508	0.0423	850.35	849.25	1.10	6.56E-06	15	47.00	0.0487	8.3923	1.53E+05	OK	1.09364	0.37910	0.30892	0.38216	2.35732	0.98408	0.61505	850.30132	851.39496	47.00
CI-2 to MH-2.5	6.3630	1.9273	3.3015	0.1693	848.15	846.15	2.00	6.56E-06	15	57.40	0.2003	11.2605	3.06E+05	OK	1.96891	0.56507	0.46046	0.07907	2.98328	0.88156	0.55097	847.94966	849.91857	104.40
MH-2.5 to CB 3	0.0000	0.0000	11.2605	1.9689	846.05	844.80	1.25	6.56E-06	15	54.60	2.3129	7.6384	1.04E+06	OK	0.90599	0.00000	0.00000	1.00000	0.00000	0.54030	0.33769	843.73708	844.64307	159.00
CI-5 to CI-4	2.9081	1.9273	1.5089	0.0354	844.25	843.74	0.51	6.56E-06	15	12.00	0.0367	5.7233	1.40E+05	OK	0.50864	0.50812	0.41405	0.17190	2.79608	0.92182	0.57614	844.21329	844.72193	12.00
CI-4 to CB-3	3.5113	1.9273	1.8219	0.0515	843.64	843.30	0.34	6.56E-06	15	34.00	0.0571	4.6406	1.69E+05	OK	0.33439	0.75665	0.61657	-0.23315	3.61222	0.69231	0.43269	843.58285	843.91724	46.00
CB-3 to CI-6	12.0650	1.9273	6.2601	0.6085	843.20	842.18	1.02	4.10E-06	24	72.00	0.6961	7.7489	9.27E+05	OK	0.93237	1.55700	0.49561	0.00878	3.12402	0.84618	0.84618	842.50386	843.43623	231.00
CI-6 to RRA-2	17.5390	1.9273	9.1003	1.2860	842.08	842.00	0.08	2.05E-06	48	8.00	1.2962	2.1188	2.70E+06	OK	0.06971	8.27763	0.65871	-0.31743	3.78762	0.62645	1.25289	840.78375	840.85347	239.00
CI-7 to CI-8	1.1623	1.9273	0.6031	0.0056	845.10	844.56	0.54	6.56E-06	15	54.00	0.0066	5.8918	5.58E+04	OK	0.53902	0.19728	0.16076	0.67848	1.65020	0.98474	0.61547	845.09338	845.63240	54.00
CI-8 to CI-9	4.3374	1.9273	2.2505	0.0786	844.46	844.27	0.19	5.47E-06	18	19.00	0.0826	3.4611	2.50E+05	OK	0.18602	1.25319	0.70916	-0.41832	4.00478	0.53829	0.40372	844.37737	844.56338	73.00
CI-9 to AD-10	4.7749	1.9273	2.4775	0.0953	844.17	843.61	0.56	5.47E-06	18	56.00	0.1095	5.9285	2.75E+05	OK	0.54577	0.80542	0.45577	0.08845	2.96445	0.88596	0.66447	844.06045	844.60622	129.00
AD-10 to RRA-1	5.7173	1.9273	2.9665	0.1366	843.51	843.24	0.27	4.10E-06	24	27.00	0.1440	4.1125	4.39E+05	OK	0.26262	1.39022	0.44252	0.11496	2.91117	0.89800	0.89800	843.36597	843.62859	156.00

area grate	277.53	in^2	
e	0.0025	mm	
g	32.2	ft/s^2	
dyn. vis 70 F	1.350E-05	ft^2/s	

25 YR. STORM SOIL GROUP B - PRE CONSTRUCTION

DISTURBED WATERSHED	6.5639	cfs	
RRA-2 CUM. VELOCITIES	47.5228	ft/s	
AREA RRA-2	1.0534	Ac.	
Q discharge	14.6514	cfs	d50 rip rap 9-12" slope = 1.0% ASSUME FLOWING FULL, d=.75' n = .035 for grassland / herbaceous
RRA-1 CUM. VELOCITIES	19.3939	ft/s	
AREA RRA-1	0.3924	Ac.	
Q discharge	5.4578	cfs	d50 rip rap 9-12" slope = 1.0% ASSUME FLOWING FULL, d=.75' n = .035 for grassland / herbaceous

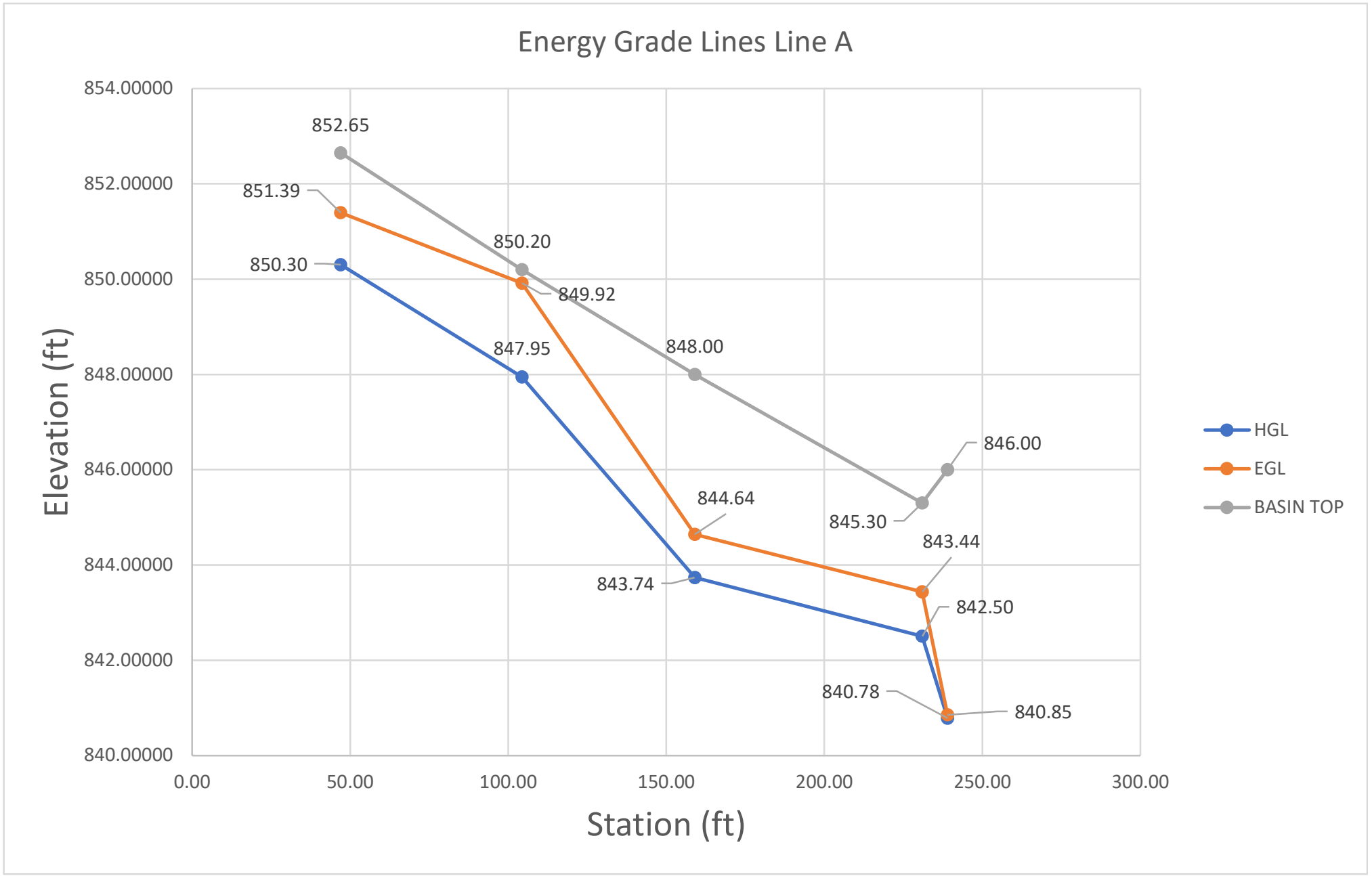
25 yr. storm soil group C

Run	Cumulative Qin (cfs)	Area grate (ft2)	V1	V1^2/2g	Z1	Z2	delta z	e/D	D (in)	L (ft)	hf (ft)	V2 (ft/s)	Re	V check	V2^2/2g	Cumulative A2 (ft^2)	y/d	1-2(y/d)	theta	cos (θ/2 - 1)	y2 (ft.)	HGL (ft)	EGL (ft)	cum length
CI-1 to CI-2	3.2699	1.9273	1.6966	0.0447	850.35	849.25	1.10	6.56E-06	15	47.00	0.0514	8.3909	1.57E+05	OK	1.09328	0.38969	0.31755	0.36490	2.39454	0.98060	0.61288	850.29858	851.39186	47.00
CI-2 to MH-2.5	6.5398	1.9273	3.3932	0.1788	848.15	846.15	2.00	6.56E-06	15	57.40	0.2116	11.2554	3.14E+05	OK	1.96716	0.58103	0.47347	0.05307	3.03541	0.86896	0.54310	847.93837	849.90553	104.40
MH-2.5 to CB 3	0.0000	0.0000	11.2554	1.9672	846.05	844.80	1.25	6.56E-06	15	54.60	2.3109	7.6397	1.04E+06	OK	0.90630	0.00000	0.00000	1.00000	0.00000	0.54030	0.33769	843.73914	844.64544	159.00
CI-5 to CI-4	2.9081	1.9273	1.5089	0.0354	844.25	843.74	0.51	6.56E-06	15	12.00	0.0367	5.7233	1.40E+05	OK	0.50864	0.50812	0.41405	0.17190	2.79608	0.92182	0.57614	844.21329	844.72193	12.00
CI-4 to CB-3	3.5113	1.9273	1.8219	0.0515	843.64	843.30	0.34	6.56E-06	15	34.00	0.0571	4.6406	1.69E+05	OK	0.33439	0.75665	0.61657	-0.23315	3.61222	0.69231	0.43269	843.58285	843.91724	46.00
CB-3 to CI-6	12.3444	1.9273	6.4050	0.6370	843.20	842.18	1.02	4.10E-06	24	72.00	0.7288	7.7318	9.49E+05	OK	0.92827	1.59658	0.50821	-0.01641	3.17442	0.83249	0.83249	842.47124	843.39951	231.00
CI-6 to RRA-2	17.8184	1.9273	9.2453	1.3273	842.08	842.00	0.08	2.05E-06	48	8.00	1.3379	2.1138	2.74E+06	OK	0.06938	8.42951	0.67080	-0.34160	3.83883	0.60629	1.21257	840.74212	840.81150	239.00
CI-7 to CI-8	1.1623	1.9273	0.6031	0.0056	845.10	844.56	0.54	6.56E-06	15	54.00	0.0066	5.8918	5.58E+04	OK	0.53902	0.19728	0.16076	0.67848	1.65020	0.98474	0.61547	845.09338	845.63240	54.00
CI-8 to CI-9	4.3748	1.9273	2.2699	0.0800	844.46	844.27	0.19	5.47E-06	18	19.00	0.0841	3.4605	2.52E+05	OK	0.18595	1.26421	0.71540	-0.43080	4.03235	0.52662	0.39497	844.37594	844.56188	73.00
CI-9 to AD-10	4.9523	1.9273	2.5696	0.1025	844.17	843.61	0.56	5.47E-06	18	56.00	0.1178	5.9227	2.86E+05	OK	0.54469	0.83616	0.47317	0.05366	3.03422	0.86925	0.65194	844.05216	844.59685	129.00
AD-10 to RRA-1	7.1063	1.9273	3.6872	0.2111	843.51	843.24	0.27	4.10E-06	24	27.00	0.2225	4.0809	5.46E+05	OK	0.25860	1.74135	0.55429	-0.10858	3.35918	0.77783	0.77783	843.28749	843.54609	156.00

area grate	277.53	in^2
e	0.0025	mm
g	32.2	ft/s^2
dyn. vis 70 F	1.350E-05	ft^2/s

25 YR. STORM SOIL GROUP C - PRE CONSTRUCTION

DISTURBED WATERSHED	6.5639	cfs	
RRA-2 CUM. VELOCITIES	47.4956	ft/s	
AREA RRA-2	1.0534	Ac.	
Q discharge	14.6514	cfs	d50 rip rap 9-12" slope = 1.0%
			ASSUME FLOWING FULL, d=.75'
			n = .035 for grassland / herbaceous
RRA-1 CUM. VELOCITIES	19.3559	ft/s	
AREA RRA-1	0.3924	Ac.	
Q discharge	5.4578	cfs	d50 rip rap 9-12" slope = 1.0%
			ASSUME FLOWING FULL, d=.75'
			n = .035 for grassland / herbaceous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852.00000
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848.00000
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844.00000
842.00000
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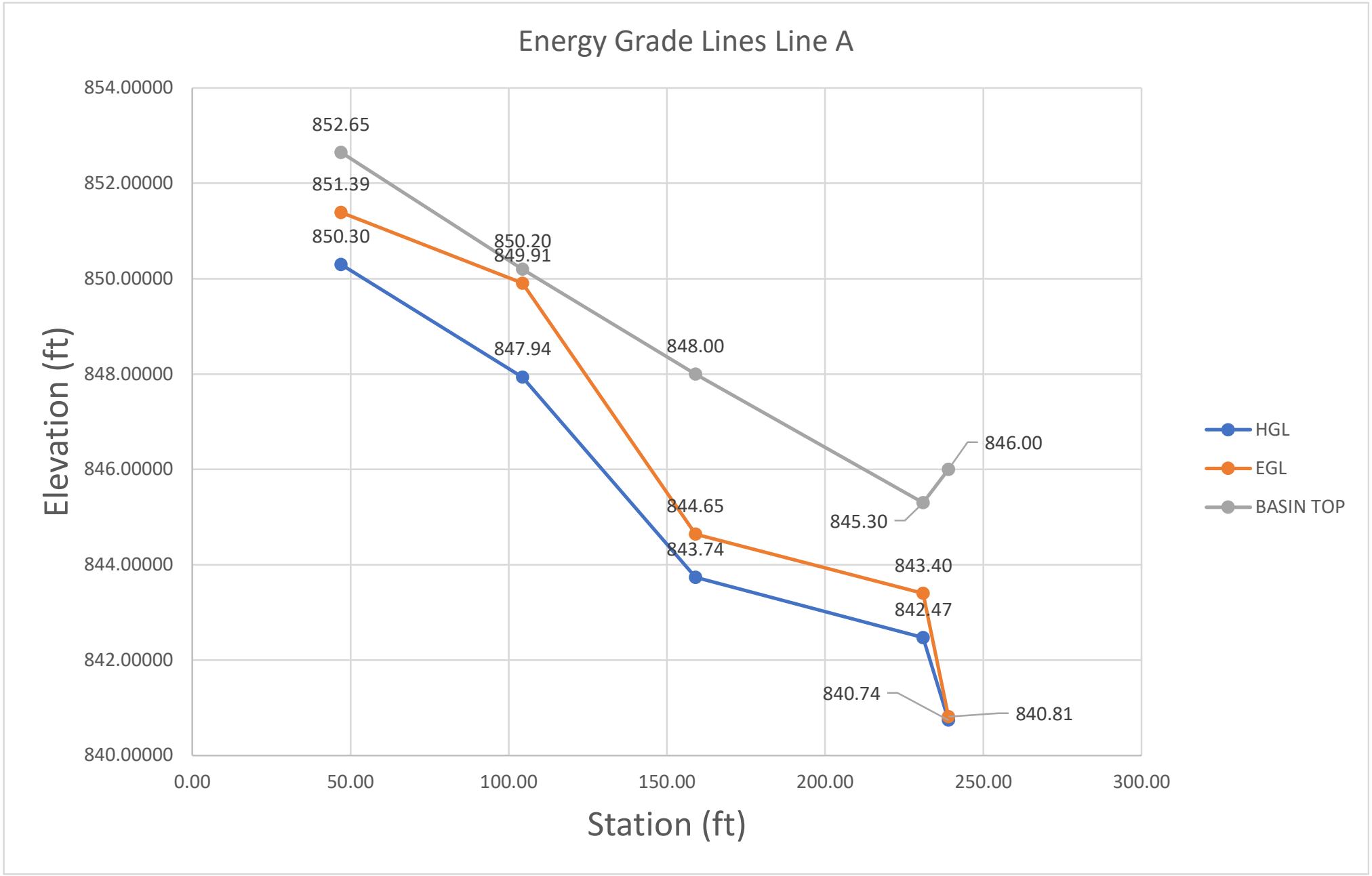
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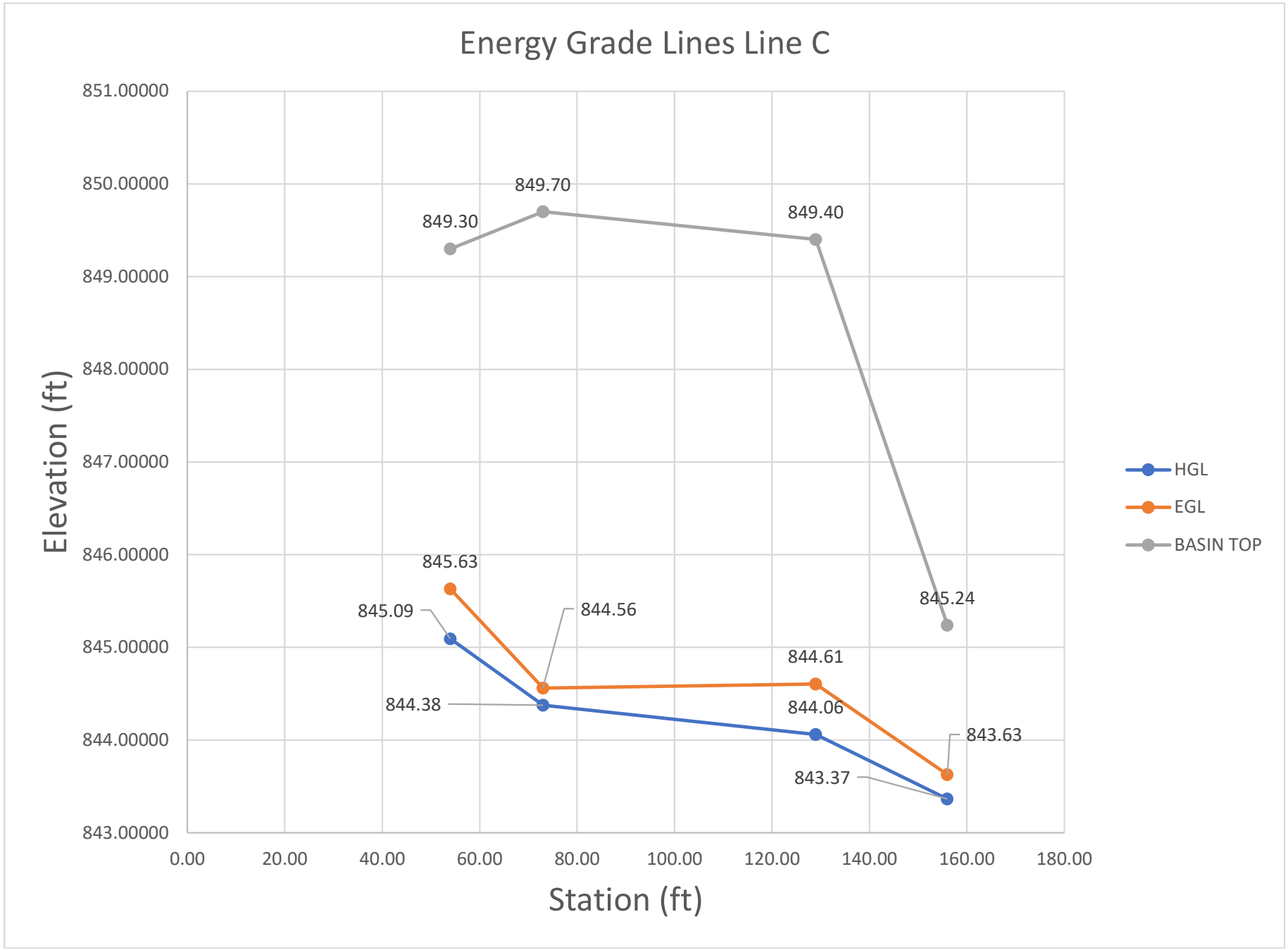
BASIN TOP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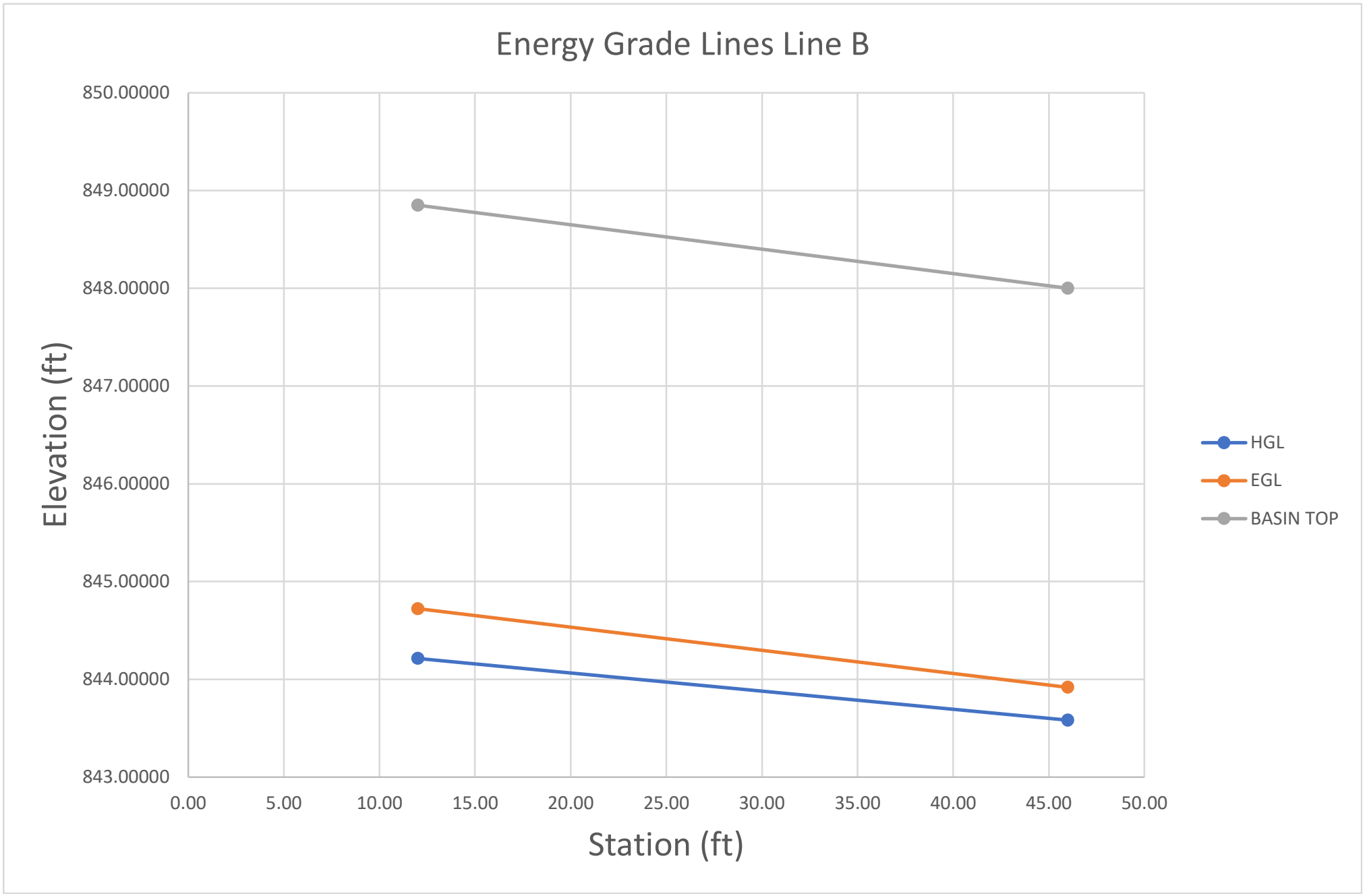
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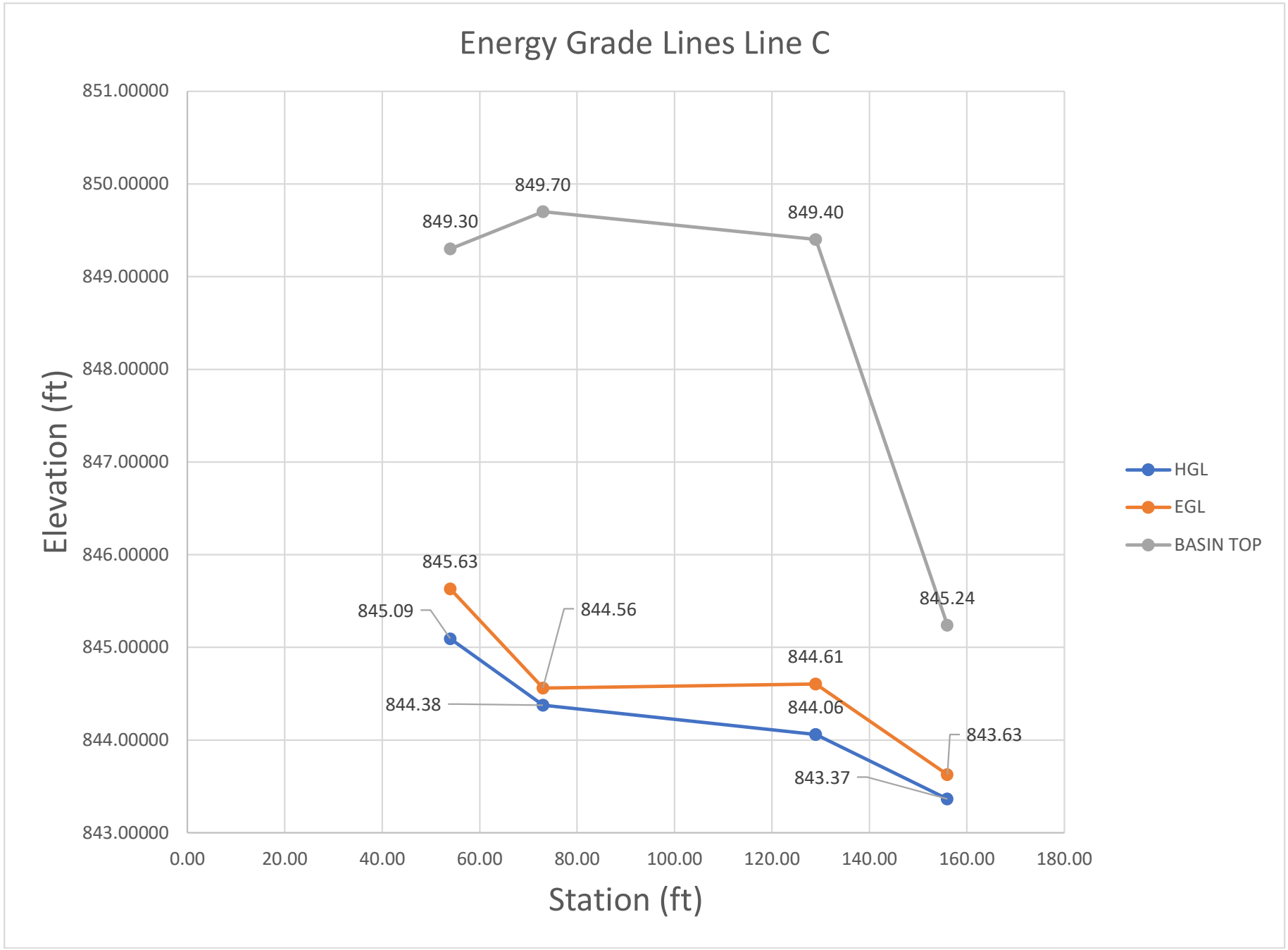
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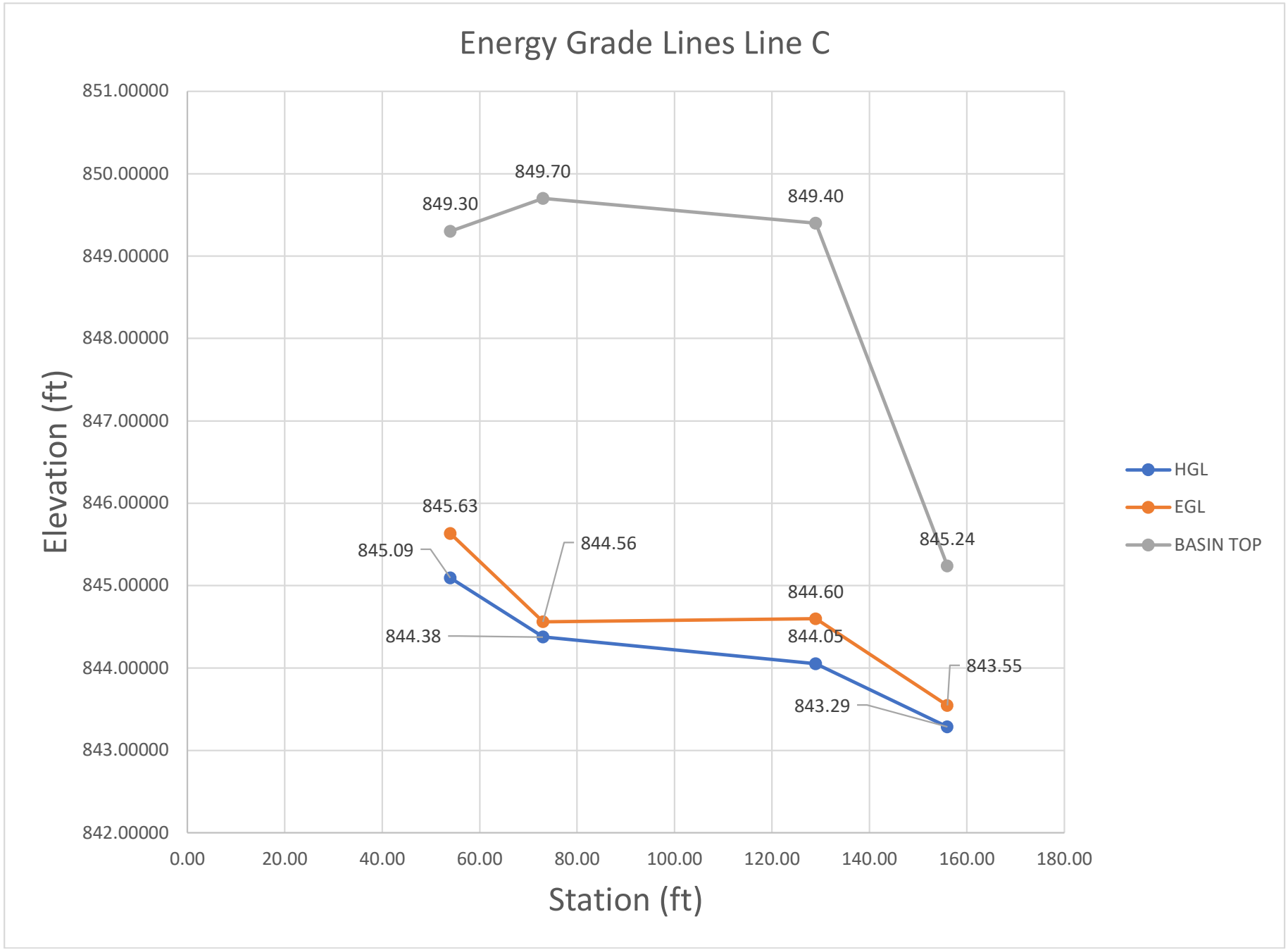
Energy Grade Lines Line C
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Chapter 22.5

STORMWATER AND STREET ORDINANCE

This ordinance was initially issued in June 1997 (Ordinance O-224-97) with further revisions in December 1997 (Ordinance O-666-97), May 1998 (Ordinance O-247-98), May 2003 (Ordinance O-155-03), June 2003 (Ordinance O-264-03), August 2004 (Ordinance O-139-04), January 2005 (Ordinance O-16-05), February 2005 (Ordinance O-45-05), February 2013 (Ordinance O-26-2013), December 2017 (Ordinance O-281-2017) , June 2019 (Ordinance O-83-2019) and October 2020 (O-151-2020) .

ARTICLE I. IN GENERAL

Section 22.5-1. Title of chapter.

This chapter shall be known and may be cited as the "Stormwater and Street Ordinance of the City of Knoxville."

(Ord. No. O-139-04, § 1, 8-17-2004; Ord. No. O-281-2017, § 12-05-17)

Section 22.5-2. Purpose.

The purpose of this chapter is to consolidate all regulations pertaining to the stormwater system and the local street system and to accomplish the following:

Improve stormwater management;
Control the discharge of pollutants to the stormwater system;
Improve public safety;
To comply with the City's National Pollution Discharge Elimination System (NPDES) permit;
Establish procedures to accomplish the above purposes.

(Ord. No. O-139-04, § 1, 8-17-2004; Ord. No. O-281-2017, § 12-05-2017)

Section 22.5-3. Administration of chapter.

The Director and the engineering staff under the Director's supervision shall administer the provisions of this chapter.

(Ord. No. O-139-04, § 1, 8-17-2004; Ord. No. O-281-2017, § 12-05-2017)

Section 22.5-4. Definitions.

Unless specifically defined in this section, words or phrases used in this chapter shall be interpreted so as to give them the meaning they have in common usage and to give this chapter its most appropriate application.

1-year frequency storm. A storm event defined to be two and one-half (2.5) inches in twenty-four (24) hours or other such magnitude the Director shall establish based upon scientific and engineering information.

2-year frequency storm. A storm event with a fifty (50) percent chance of being equaled or exceeded in a given year. Defined to be three (3.0) inches in twenty-four (24) hours or other such magnitude the Director shall establish based upon scientific and engineering information.

5-year frequency storm. A storm event with a twenty (20) percent chance of being equaled or exceeded in any given year. Defined to be three and seven-tenths (3.7) inches in twenty-four (24) hours or other such magnitude the Director shall establish based upon scientific and engineering information.

10-year frequency storm. A storm event with a ten (10) percent chance of being equaled or exceeded in any given year. Defined to be four and three-tenths (4.3) inches in twenty-four (24) hours or other such magnitude the Director shall establish based upon scientific and engineering information.

25-year frequency storm. A storm event with a four (4) percent chance of being equaled or exceeded in any given year. Defined to be five (5.0) inches in twenty-four (24) hours or other such magnitude the Director shall establish based upon scientific and engineering information.

50-year frequency storm. A storm event with a two (2) percent chance of being equaled or exceeded in any given year. Defined to be five and seven-tenths (5.7) inches in twenty-four (24) hours or other such magnitude the Director shall establish based upon scientific and engineering information.

100-year frequency storm. A storm event with a one (1) percent chance of being equaled or exceeded in any given year. Defined to be six and three-tenths (6.3) inches in twenty-four (24) hours or other such magnitude the Director shall establish based upon scientific and engineering information.

500-year frequency storm. A storm event with a one-fifth (1/5) of one (1) percent chance of being equaled or exceeded in any given year. Defined to be eight (8.0) inches in twenty-four (24) hours or other such magnitude the Director shall establish based upon scientific and engineering information.

Administrative plat. A plat prepared and certified by a registered land surveyor licensed to practice in the state of Tennessee and approved or denied for recording by Knoxville-Knox County Planning through staff administrative procedures. A plat shall be classified as an administrative plat when no variance from *The Knoxville-Knox County Subdivision Regulations*, or as amended, is requested and it meets one (1) or more of the following criteria:

(a) It divides one (1) tract into no more than two (2) lots;
(b) It combines existing lots into no more than two (2) lots;
(c) It adjusts the common lot line(s) between two (2) existing recorded lots;
(d) It is for the purpose of recording an easement or other new information and no subdivision of land is involved; or
(e) It qualifies as an exempt or corrected plat as defined by the *Knoxville-Knox County Subdivision Regulations*, or as amended.

Best Management Practices Manual (BMP Manual). A manual produced by the City containing best management practices for use on site development plans and construction projects.

Blue-line stream. Any stream shown on the 7.5 minute USGS quad maps.

Board of Environmental Appeals. Appointed by the mayor and confirmed by council to hear appeals filed by any person incurring a civil penalty or damage assessment imposed pursuant to section 22.5-8. of this chapter.

Covenants by lessee for maintenance of stormwater facilities on leased property. A legal document executed by a lessee and recorded with the Knox County Register of Deeds guaranteeing proper maintenance of stormwater facilities during the term of the lessee's lease and the proper removal of the water quality facilities at the end of the term of the lessee's lease.

Covenants by property owner for permanent maintenance of stormwater facilities. A legal document executed by the property owner and recorded with the Knox County Register of Deeds guaranteeing perpetual and proper maintenance of stormwater facilities.

Declaration Document. A legal deed document, prepared by a surveyor licensed in the State of Tennessee, that grants or releases easements or other property rights.

Detention. A practice to store stormwater runoff by collection as a temporary pool of water and provide for its gradual (attenuated) release and thereby control peak discharge rates.

Development certification. A post-development certification performed by an appropriate design professional validating that the project was constructed per the approved design.

Development, large residential and commercial. Any development, commercial, office, industrial, multiple single family lots, any nonresidential use, or any development of a single residential lot with a disturbed area of ten thousand (10,000) square feet or more.

Development, small single-family residential. Development of a single recorded residential lot with less than ten thousand (10,000) square feet of disturbed area.

Development, utilities. Physical alteration of any location for the purpose of installing utilities. This includes, but is not limited to, providing access to a site, clearing of vegetation, grading, earth moving, providing utilities, other services such as parking, altering land forms, and installing erosion prevention and sediment control systems.

Director. Director of the City of Knoxville Department of Engineering or an authorized representative.

Discharge. Dispose, deposit, spill, pour, inject, seep, dump, leak, or place by any means, or that which is disposed, deposited, spilled, poured, injected, seeped, dumped, leaked, or placed by any means including any direct or indirect entry of any solid or liquid matter into the stormwater system by any means intentional or otherwise.

Disturbed area. Portion of any site that has been altered from existing conditions including, but not limited to, the following: providing access to a site, clearing of vegetation, grading, earth moving, altering land forms, construction, demolition of a structure on the land, providing utilities, or other related work, e.g. parking facilities, stormwater systems, erosion prevention and sediment control measures, potable water systems, and wastewater systems.

Driveway Pipe. A stormwater pipe, typically in the right-of-way of residential development, installed in a roadside ditch to allow access to a property via a driveway.

Erosion. The removal of soil particles by the action of water, wind, ice, or other geological agents, whether naturally occurring or acting in conjunction with or promoted by anthropogenic activities or effects.

Exempt plat. A survey plat or map that divides property in manner that is consistent with exemption from the requirements of The Knoxville- Knox County Subdivision Regulations, or as amended, based on the provisions of Sections 13-3-401 and 13-4-301 of Tennessee Code Annotated, or as amended. Divisions on exempt plats may be eligible for inclusion on the ward map if reviewed and approved by the Department of Engineering.

First flush. The initial or early stages of stormwater runoff from a storm event which commonly delivers a disproportionately large amount of previously accumulated pollutants due to the rapid rate of runoff. The first flush is defined as the first one-half (½) inch of direct runoff from the contributing drainage basin.

Floodplain. For a given flood event, that area of land temporarily covered by water which adjoins a watercourse.

Hot spot. An area where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in stormwater. Examples might include operations producing concrete or asphalt, auto repair shops, auto supply shops, large commercial parking areas, and restaurants.

Hydraulic. Pertaining to, involving, moved, or operated by a fluid, especially water under pressure or under a gravity-driving force.

Hydrologic. Pertaining to the scientific study of the properties, distribution, and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere.

Illicit discharge. Any discharge to the stormwater system that is not composed entirely of stormwater and not specifically exempted in article III.

Impervious area. Impermeable surfaces, such as pavement or rooftops, which prevent the percolation of water into the soil.

Infiltration. A method used to promote the recharge of groundwater by containment and concentration of stormwater in porous soils.

Infiltration basin. An impoundment made by excavation or embankment construction to contain and infiltrate runoff into the soil layer.

Land Development Manual (LDM). Manual produced by the City that provides additional information about the specifics of this chapter.

Large residential development. *See* Development, large residential and commercial.

Lessee. A lessee occupying real property pursuant to a lease agreement entered into prior to February 4, 1987, which contains no contractual provisions requiring the landlord to execute property owner's Covenants, whose site development plan is five (5) acres or less, and whose use of the real property will not create environmental hazards.

Lot of record. A property which is currently shown on the ward map, or which is eligible to be shown on the ward map, as determined by the Director.

Main stream. The Tennessee River, Holston River, or French Broad River.

Mitigation. The creation, restoration, enhancement, or preservation of a stream, riparian buffer zone, adjacent land, or other stormwater facility which offsets expected adverse impacts of development.

Natural Resources Conservation Service (NRCS). An organization within the U.S. Department of Agriculture that has published standard drainage procedures in the form of Technical Release No. 55. Formerly known as the Soil Conservation Service (SCS).

No-fill line. A line one-half (0.5) the linear distance between the floodway line and the 100-year floodplain line

Parking area. The off-street facility including parking spaces along with adequate provision for drivers and aisles for maneuvering and giving access, and for entrance and exit, designed to be usable for the parking of vehicles.

Peak flow. The maximum instantaneous rate of flow of water at a particular point resulting from a storm event.

Peak flow attenuation. The reduction of the peak discharge of stormwater from a development.

Performance and indemnity agreement. A contract between the property owner, lessee, or developer and the City that assures construction and compliance as per site development plans approved by the Department of Engineering and in the case of a lessee, assures the lessee's proper maintenance of stormwater facilities during the term of its lease, and the proper removal of water quality facilities by the lessee at the end of the term of its lease.

Person. Any individual, firm, corporation, partnership, association, organization, or entity, including governmental entities, or any combination thereof.

Plat. A map meeting requirements of *The Knoxville-Knox County Subdivision Regulations*, or as amended, prepared and certified by a registered land surveyor licensed to practice in the state of Tennessee, approved for recording by Knoxville-Knox County Planning, and recorded in the Knox County Register of Deeds Office.

Regulated waters. Any stream, wetland, or other waterbody specified by the Director, where protections are imposed for adjacent land use, development, or vegetative cover.

Restaurant. An establishment or facility where food is prepared and sold.

Retention. A practice designed to store stormwater runoff by collection as a permanent pool of water without release except by means of evaporation, infiltration, or attenuated release when runoff volume exceeds storage capacity of the permanent pool.

Riparian buffer zone. A naturally undisturbed, vegetated, and pervious zone adjacent to regulated waters that is protected from clearing, grading, filling, paving, building, or other destruction of the naturally vegetated state.

Riprap. A combination of large stone, cobbles, and boulders used to line channels, stabilize stream banks, and reduce runoff velocities.

Runoff. The water resulting from precipitation that is not absorbed by the soil.

Sanitary sewer. A system of underground conduits that collect and deliver wastewater to a wastewater treatment plant.

Sinkhole.

(a) A naturally occurring depression where drainage collects in the earth's surface that is a minimum of two (2) feet deep. These depressions are typically denoted as closed contours and are shown as hachured contours on the City's geographic information system, or

(b) A hole, fissure, or other opening in the ground, often underlain with limestone, dolomite, or other rock formation that provides for and is being designated as a natural conduit for the passage of stormwater.

For both (a) and (b), the extent of the area considered to be a sinkhole is at a minimum the limits determined by the water surface elevation, assuming plugged conditions (zero (0) cfs outflow).

Site development. To physically change land (land disturbance). Including, but not limited to, providing access to a site, clearing of vegetation, grading, filling, earth moving, providing utilities and other services such as parking facilities, stormwater management, erosion prevention and sediment control systems, potable water and wastewater systems, altering land forms, and construction or demolition of a structure on the land.

Small residential development. *See* Development, small single family residential.

Stormwater. Runoff from rain, snow, or other forms of precipitation, resulting in surface runoff and drainage.

Stormwater basin. An area used for stormwater detention, retention, or infiltration.

Stormwater facility. A specific regulated component of the stormwater system.

Stormwater system. The system of roadside drainage, roadside curbs and gutters, curb inlets, swales, catch basins, manholes, gutters, ditches, pipes, lakes, sinkholes, channels, creeks, streams, storm drains, detention basins, retention basins, stormwater quality treatment devices, and similar natural or manmade conveyances and facilities located within the city, which, whether owned or operated by the City or other person, are designated or used for collecting, storing, treating, or conveying stormwater or through which stormwater is collected, stored, treated or conveyed.

Stream. Includes any linear surface water conveyance recognized by TDEC as Waters of the State, any blue-line shown on the 7.5 min USGS Quad map, or any waterbody determined to be a stream by a Tennessee Qualified Hydraulic Professional (TN-QHP).

Substantial Investment. The investment of fifty (50) percent or more of the market value (licensed professional appraisal) or tax appraised value of the real property and improvements over a rolling five (5) year duration.

Swale. A natural or manmade depression or wide shallow ditch used to route or filter runoff.

Utilities development. *See* Development, utilities.

Utility, public or private. Any agency which under public franchise, public ownership, or certification of convenience and necessity provides the public with electricity, natural gas, steam, communication, rail transportation, water, sewage collection, or other similar service.

Ward Map. The adopted official map of the City of Knoxville showing the wards, blocks, lots, tracts, and rights-of-way within the corporate limits of the City of Knoxville.

Wastes, industrial/commercial. Liquid or other wastes resulting from any process of industry, manufacture, trade, or business or resulting from the development of any natural resources.

Wastes, other. Decayed wood; sawdust; shavings; fallen bark; fallen leaves; lawn clippings; animal wastes; used or previously applied lime; garbage; trash; refuse; loose used paper, paper products,

plastic containers, or metal containers; ashes; offal; discarded tar; discarded paint; discarded or uncontained solvents; used, discarded, or spilled petroleum products, antifreeze, or motor vehicle fluids; used or discarded tires, gas tanks, or chemicals; or any other used, uncontained, unpackaged, or disposed of materials which may discharge to or otherwise enter the stormwater system.

(Ord. No. O-139-04, § 1, 8-17-2004; Ord. No. O-16-05, § 1, 1-18-2005; Ord. No. O-26-2013, § 1, 2-5-13; Ord. No. O-281-2017, § 12-05-2017)

Section 22.5-5. Performance and indemnity agreement.

In order to ensure that any site development complies with the requirements of this chapter, the Director shall have the authority to require a performance and indemnity agreement, together with a letter of credit, a cashier's check, or a surety bond from an approved financial institution or insurance carrier which guarantees satisfactory completion of the project and names the City as beneficiary, and in the case of a lessee, assures the lessee's proper maintenance of stormwater facilities during the term of its lease and the proper removal of water quality facilities by the lessee at the end of the term of its lease. The security shall be provided by the property owner, lessee, or developer in a form and in an amount to be determined by the Department of Engineering based on submission of plans and actual construction or potential remediation expenses. In addition, a lessee shall pay the City an amount determined by the Director, that in no event shall be less than five thousand dollars ($5,000.00), to compensate the City for any perpetual maintenance that may be required after the expiration of the lessee's lease.

(Ord. No. O-139-04, § 1, 8-17-2004; Ord. No. O-281-2017, § 12-05-2017)

Section 22.5-6. Right of entry.

The Director may enter upon any property which discharges or contributes, or is believed to discharge or contribute, to stormwater runoff or the stormwater system during all reasonable hours to monitor, remove foreign objects or blockages, and to inspect for compliance with the provisions of this chapter.

(Ord. No. O-139-04, § 1, 8-17-2004; Ord. No. O-281-2017, § 12-05-2017)

Section 22.5-7. Notice of violation.

Whenever the Director determines that a violation of any provision of this chapter has occurred, that work does not have a required plan or permit, or that work does not comply with an approved plan or permit, the Director may issue a notice of violation to the property owner, utility, facility operator, lessee, tenant, contractor, permittee, the equipment operator, any other person or entity doing work on the site, or any combination thereof. The notice of violation shall:

(a) Be in writing;
(b) Include a description of the property sufficient for identification of where violation has occurred;
(c) List the violation;
(d) State the action required; and
(e) Provide a deadline for compliance or to stop work.

(Ord. No. O-139-04, § 1, 8-17-2004; Ord. No. O-281-2017, § 12-05-2017)

Section 22.5-8. Penalties (Articles I, II, and III).

(a) Any person violating the provisions of this chapter may be assessed a civil penalty by the City of not less than fifty dollars ($50.00) or more than five thousand dollars ($5,000.00) per violation, per site, per day for each day of violation. A person may be deemed guilty of a separate violation for each day during any continuing violation of any provision of this ordinance, of any regulation, or of any permit issued hereunder. All penalties collected under the provisions of this section

shall inure exclusively to the use and benefit of the Department of Engineering for remediation projects and educational endeavors associated with stormwater activities.

(b) In assessing a civil penalty, the City considers the following:
  (1) The harm done to the public health or the environment;
  (2) Whether the civil penalty imposed will be a substantial economic deterrent to the illegal activity;
  (3) The economic benefit gained by the violator;
  (4) The amount of effort put forth by the violator to remedy this violation;
  (5) Any unusual or extraordinary enforcement costs incurred by the City;
  (6) The amount of penalty established by ordinance or resolution for specific categories of violations;
  (7) Any equities of the situation that outweigh the benefit of imposing any penalty or damage assessment;
  (8) Willingness and cooperation of the violator to remedy this violation and remediate any damage;
  (9) Whether the violation was intentional, negligent, or accidental;
  (10) Costs incurred by the City of Knoxville for any administrative or remediation costs, including the investigative and monitoring activities. This is often computed in terms of number of man-hours necessary to deal with the problem; and
  (11) Prior violations for this violator or at this location.

(c) In addition to the civil penalty, the City may recover all damages proximately caused by the violator to the City, which may include any expenses and attorney's fees incurred in investigating, enforcing, and correcting violations of this chapter.

(d) An expedited order for partial civil penalty assessment may be issued at the time of violation. The amount of the expedited order shall be set by ordinance for specific categories of violations as mentioned in section 22.5-8.b.6.

(e) The Director has the authority to allow a reduction in civil penalty assessments for penalties paid within thirty (30) days of issuance. Reductions shall not be considered for violations that have been repeated within twelve (12) months of the subject violation.

(f) The City may bring legal action to enjoin the continuing violation of this chapter, and the existence of any other remedy, at law or in equity, shall be no defense to any such actions.

(g) The remedies set forth in this section shall be cumulative, not exclusive, and it shall not be a defense to any action, civil or criminal, that one (1) or more of the remedies set forth herein has been sought or granted.

(Ord. No. O-139-04, § 1, 8-17-2004; Ord. No. O-166-2011, § 1, 11-29-2011; Ord. No. O-26-2013, § 2, 2-5-2013; Ord. No. O-281-2017, § 12-05-2017)

Section 22.5-9. Board of Environmental Appeals (Articles I, II, and III).

(a) There is created a Board of Environmental Appeals (BEA) to hear appeals filed by any person incurring a civil penalty or damage assessment imposed pursuant to this chapter.

(b) The BEA may issue subpoenas requiring attendance of witnesses and production of evidence, administer oaths, and take testimony as the BEA deems necessary to fulfill its purpose.

(c) The BEA shall be composed of five (5) members appointed by the mayor and confirmed by council.
  (1) The mayor shall select appointees so that the BEA will consist of individuals with an expertise as follows:
    a. One (1) registered professional engineer licensed to practice in the state of Tennessee with at least three (3) years of engineering experience as a professional engineer;
    b. One (1) registered architect, engineer, landscape architect, or surveyor licensed to practice in the state of Tennessee with at least three (3) years of experience;
    c. One (1) representative of the development or industrial community;

d. One (1) neighborhood representative; and
e. One (1) member at large.

(2) In addition to qualifications a. through e. of section 22.5-9.c.1., one (1) of the five (5) members must have at least three (3) years civil engineering experience, and a second member must have at least three (3) years civil or environmental engineering experience.
(3) BEA members shall serve for a term of five (5) years. A BEA member shall continue to serve, however, until a successor has been appointed or until the BEA member has been reappointed, as the case may be. The terms of the original BEA members shall be staggered so that the term of one (1) member shall expire each year.
(4) An appointment to succeed a BEA member who is unable to serve said member's full term shall be for the remainder of said member's term.
(5) BEA members may be reappointed, but they do not succeed themselves automatically.
(6) BEA members shall serve without compensation.

(d) The BEA shall annually select one (1) of its members to serve as chair and another member to serve as vice-chair of the BEA by a majority vote of all members.
(e) The BEA shall keep complete and accurate records of the proceedings of all their meetings. The Department of Engineering shall designate a person to serve as secretary to the BEA.
(f) No BEA member shall participate in the appeal of any matter in which the member has a direct personal or financial interest.
(g) Three (3) members of the BEA shall constitute a quorum, and the concurrence of a majority of the BEA present and voting in any matter shall be required for a determination of any matter within its jurisdiction.

(Ord. No. O-139-04, § 1, 8-17-2004; O-281-2017, § 12-05-2017)

Section 22.5-10. Appeals (Articles I, II, and III).

Any person aggrieved by the imposition of a civil penalty or damage assessment as provided by this chapter may appeal said civil penalty or damage assessment to the Board of Environmental Appeals (BEA).

(a) The appeal shall be in writing and filed with the Law Department within thirty (30) days after the civil penalty or damage assessment is served in any manner authorized by law.
(b) Upon receipt of an appeal, the BEA shall hold a public hearing for the appellant to present their case within sixty (60) days or a later date mutually agreed upon by the parties, not to exceed one hundred eighty (180) days. After the one hundred eighty (180) days, if a mutually agreed upon date has not been determined, then the appeal will be heard at the next available public hearing where there is a quorum. Ten (10) days prior notice of the time, date, and location of said hearing shall be published in a daily paper of general circulation. Ten (10) days' notice shall be provided to the aggrieved party at the address provided at the time of appeal.
(c) Any alleged violator may appeal a decision of the BEA pursuant to the provisions of title 27, chapter 8 of Tennessee Code Annotated.
(d) If a petition for review of such civil penalty or damage assessment is not filed within thirty (30) days after the civil penalty or damage assessment is served in any manner authorized by law, the violator shall be deemed to have consented to the civil penalty or damage assessment, and it shall become final and is due immediately.

(Ord. No. O-139-04, § 1, 8-17-2004; Ord. No. O-281-2017, § 12-05-2017)

Section 22.5-11. Severability.

Each separate provision of this chapter is deemed independent of all other provisions herein so that if any provision or provisions of this chapter shall be declared invalid, all other provisions thereof shall remain enforceable.

(Ord. No. O-139-04, § 1, 8-17-2004; Ord. No. O-281-2017, § 12-05-2017)

Sections 22.5-12-17. Reserved.

ARTICLE II. STORMWATER REQUIREMENTS

Section 22.5-18. Purpose.

This article is adopted to improve public safety, to control the rate of flow of stormwater, to minimize increases in the peak flow rates of stormwater runoff caused by site development within the city, to control new site development, and to minimize any detrimental effect on water quality during construction or by the completed facility.

(O*rd. No. O-139-04, § 1, 8-17-2004; Ord. No. O-281-2017, § 12-05-2017)*

Section 22.5-19. Declaration document (Deed document).

(a) A declaration document may be used to grant certain easements, on property that is recognized as a lot of record, including but not limited to stormwater facilities, access, and sidewalks.

(b) A declaration document facilitates the process whereby (1) a property owner grants easements, (2) a lessee grants easements running through the term of its lease, and (3) a property owner or lessee relocates or abandons previous easements, when the City of Knoxville is the easement holder, due to changes in the site development or certification.

(c) The declaration document process is completed by recording an approved written legal document, in which the easements are declared, described, and shown on an attached survey map exhibit. All exhibits shall be prepared on letter or legal-sized paper, certified by a licensed land surveyor, and recorded in the Knox County Register of Deeds Office. At the discretion of the Law Director, the written document may be a form document provided by the Law Department or may be a document prepared by the property owner's or lessee's attorney and approved by the Law Department. Survey map exhibits shall be approved by the Department of Engineering.

(d) A declaration document may not be used when the Director determines, in unforeseen or unusual circumstances, that this process shall not be an option.

(Ord. No. O-139-04, § 8-17-2004; Ord. No. O-16-05, § 1-18-2005; Ord. No. O-281-2017, § 12-05-2017)

Section 22.5-20. Plat/easement requirements for the issuance of a building permit.

(a) No building permit shall be issued unless the property shown on the approved site development plan is a single lot of record, except as provided in section 22.5-20.c.

(b) No building permit shall be issued until the required easements for the stormwater facilities and access to the stormwater facilities, identified on the approved site development plan, are dedicated as permanent easements. Easement dedications can be done by Declaration Document per section 22.5-19 or on a recorded subdivision plat, except as provided in section 22.5-20.c. In the case of a Lessee, recorded easements for the stormwater facilities and access to the stormwater facilities run only through the term of the stormwater facilities lease.

(c) In limited situations, extenuating circumstances may exist that prevent the timely recording of a declaration document or a plat. After evaluating these circumstances, the Department of Engineering may approve a building permit based on the approval of a promissory letter from the owner, developer, or surveyor stating their commitment to record the declaration document or plat within a forty-five-day grace period. A fee will be required prior to the approval of the promissory letter. One fifteen-day extension may be granted for an additional fee. The terms for the promissory letter and extension shall be at the director's discretion. The Department of Engineering is in no way obligated to accept promissory letters or extensions. On the expiration of the promissory letter or extension, the Department of Engineering may issue a stop work order to suspend all work on the property until the final declaration document or plat is recorded.

(d) Before a promissory letter is approved, the following minimum requirements must be considered:
  (1) A site development plan must be approvable by the Department of Engineering;
  (2) A final plat must be submitted to the Knoxville-Knox County Planning or a declaration document submitted to the Department of Engineering for recording;

(3) The Department of Engineering must have reviewed the plan and either a declaration document or plat;
(4) The plan and the declaration document or plat must be consistent; and
(5) The property as platted must not be subject to any unapproved variances.

(Ord. No. O-139-04, § 1, 8-17-2004; Ord. No. O-281-2017, § 12-05-2017; Ord. No. O-83-2019 § 6-04-2019; Ord. No. O-151-2020, § 10-20-2020)

Section 22.5-21. General design criteria.

(a) The Director has the authority to adopt site development design criteria.
(b) The standard method of drainage computation shall be as set forth in section 22.5-33.
(c) The stormwater system, excluding stormwater basins, water quality control facilities, systems required to carry stormwater to stormwater basins or water quality control facilities, and sinkholes, shall be designed to accommodate a 10-year frequency storm. For facilities which would flood public roads, a 25-year frequency storm shall be used in the design to prevent flooding of local roads and collectors, and a 50-year frequency storm shall be used in the design to prevent flooding of arterial streets. A 100- year frequency storm shall be used in the design to prevent flooding of all new structures and ensure no additional adverse impact on existing structures. For site development located within the limits of the Flood Insurance Study, the Flood Damage Prevention and Control Ordinance 0-347-90 (Chapter 12 of the Knoxville City Code) shall also apply. All stormwater systems shall be designed to have no additional adverse impact on upstream or adjacent property in the 50-year frequency storm, unless an adequate permanent drainage easement is obtained.
(d) For drainage generated by areas greater than two hundred (200) acres, the flow for a 100-year frequency storm shall be computed. Such flow may exceed the capacity of facilities designed to comply with the requirements of lesser floods as noted in section 22.5-21.c. and shall be contained in the public right-of-way or a permanent drainage easement on the property being improved or developed.
(e) Material for pipes used for conveyance of stormwater within the city shall be in accordance with the following:
    (1) Stormwater pipes installed under City streets, private rights- of-way, joint permanent easements OPEs), or within the roadway prism of City streets and JPEs shall be reinforced concrete pipe (RCP).
    (2) Driveway pipes shall be RCP. However, high-density polyethylene pipe (HDPE), corrugated dual-walled polyvinyl chloride pipe (DWPVC), dual-walled polypropylene pipe (PPP), or corrugated metal pipe (CMP) may be used for single family and duplex development where:
        a. A pipe only conveys water under non-heavily traveled driveways,
        b. A pipe is located outside of the roadway prism, and
        c. The installation would not cause flooding of adjacent properties or rights-of-way in the event of pipe failure.
    (3) RCP is required for all stormwater systems located within new residential developments (includes residential condominium developments).
    (4) RCP, HDPE, DWPVC, and PPP may be used to convey stormwater generated on the particular property (on-site drainage), i.e. parking lots, buildings, etc.
    (5) Any pipe, culvert, or drainage system dedicated to the City, or installed with the intent of dedication to the City, whether inside or outside the right-of-way, shall be constructed of RCP.
    (6) RCP is required for all stormwater pipes and culverts that carry water generated on adjacent properties or areas (off-site water). In the case of common non-residential developments, alternate pipe materials listed m 22.5-21(e) (4) may be used.

(7) RCP is required if the failure of the pipe would cause flooding or potential property damage on adjacent properties.
(8) RCP is required for all stormwater basin outlet structures and for all stormwater outlet pipes that drain through the berm of a stormwater basin continuing to its terminus or the connection to a downstream system. Underground detention facilities that do not have a berm associated with their construction may use HDPE for the pipe material downstream of the outlet structure provided that in the event of a failure of the pipe, no offsite properties will be adversely affected.
(9) Ductile Iron (DI) is an acceptable alternative pipe material for RCP.
(10) For all pipe installations, the pipe shall be designed for the proposed loading conditions.
(11) The Director may approve the use of alternative pipe materials in overlapping rights of way or easements when necessary to accommodate special conditions presented by railroads, pipelines, utilities, unique facilities, or other sensitive areas.

(f) Construction fill that alters the conveyance or storage capacity of the regulated floodplain is prohibited in the flood fringe in an area bounded by the floodway line and the no-fill line. This requirement may be waived if a development occurs on a lake/river regulated by Tennessee Valley Authority (TVA) and where a TVA flowage easement exists or if a drainage study prepared by a registered professional engineer licensed to practice in the state of Tennessee shows a rise of less than one-tenth (0.1) foot on existing properties within one-half (0.5) mile (upstream or downstream) of the proposed development using a method widely accepted among engineering professionals.
(g) When existing or documented flooding problems are present, the Director has authority to condition the approval of a permit upon the compliance with additional requirements, including but not limited to detention, conveyance facilities, or other stormwater management solutions required to reduce the adverse impact of the proposed development on public right-of-way, other properties, or on the subject development.

(Ord. No. O-139-04, § 8-17-2004; Ord. No. O-16-05, § 1-18-2005; Ord. No. O-26-2013, § 2-5-2013; Ord. No. O-281-2017, § 12-05-2017; Ord. No. O-151-2020, § 10-20-2020)

Section 22.5-22. Site development design manuals.

The Department of Engineering is authorized to adopt additional policies, criteria, specifications, and standards for the proper implementation of the requirements of this chapter in a *Land Development Manual* (*LDM*) and a *Best Management Practices Manual* (*BMP Manual*). The policy, criteria, and requirements of the *LDM* and the *BMP Manual*, both as amended by the City's Department of Engineering, shall be enforceable consistent with other provisions of this chapter.

The Department of Engineering is specifically authorized to adopt and update the City of Knoxville Qualified Local Program Construction General Permit policy.

(Ord. No. O-139-04, § 1, 8-17-2004; Ord. No. O-26-2013, § 2-5-2013; Ord. No. O-281-2017, § 12-05-2017)

Section 22.5-23. Stormwater basins.

(a) The requirement for stormwater basins shall apply to the following:
(1) All road construction exceeding one-half (½) acre of impervious area;
(2) All developments of one acre or more of disturbed area;
(3) Developments of five (5) lots or more;
(4) Any site development which contains one-half (½) acre or more of additional impervious area since June 1997.
(5) Any areas of substantial investment which contains one-half (½) acre or more impervious area.

(b) For areas of substantial investment, if the downstream system (routed through the second existing street or alley crossing, a blue- line stream, interstate right-of-way, railroad right-of-way, Tennessee Department of Transportation roadway project, City of Knoxville roadway or drainage

project, or existing stormwater basin, whichever is closest) is examined and found to be adequate to carry the 2-year and 10-year frequency storms, the requirement for detention for areas of substantial investment may be waived. However, if the examination finds inadequate conveyance for the 2-year and 10-year frequency storms, the Director has authority to condition of the approval of a permit upon compliance with additional requirements, including but not limited to detention, conveyance facilities, or other stormwater management solutions required to reduce the adverse impact of the proposed development on the public right-of-way, other properties, or on the subject development. The engineer is charged with determining the predeveloped (before any site development had occurred) conditions, including the curve number. If the engineer cannot determine the predeveloped conditions, then a maximum predeveloped curve number of seventy (70) may be used to compute the predeveloped flow and satisfy the requirement. In areas of substantial investment, detention or retention is required for the entire developed site, not just the portion of the site being redeveloped.

(c) If in the developer's judgment, stormwater detention is unwarranted or impractical, hydrologic and hydraulic computations to support such a conclusion and to demonstrate that stormwater runoff peak rates shall not be increased for storm events identified in the design standards for detention basins in this chapter shall be furnished to the Department of Engineering for review.

(d) Where the development's stormwater discharges directly into a main stream, detention for peak flow attenuations is not required unless deemed necessary by the Department of Engineering.

(e) Exclusions from detention do not exempt the developer from providing water quality requirements.

(f) When existing or documented flooding problems are present, the Director has authority to condition the approval of a permit upon the compliance with additional requirements, including but not limited to detention, conveyance facilities, or other stormwater management solutions required to reduce the adverse impact of the proposed development on the public right-of-way, other properties, or on the subject development.

(g) Stormwater basins located in residential subdivisions must be located on two (2) or more buildable lots or in a common area with a legally established property owners' organization with responsibility for maintenance and repair of the stormwater basin.

(h) Stormwater basins located in non-residential subdivisions must be located on one (1) or more buildable lots or in a common area with a legally established property owners' organization with responsibility for maintenance and repair of the stormwater basin.

(Ord. No. O-139-04, § 1, 8-17-2004; Ord. No. O-281-2017, § 12-05-2017; Ord. No. O-151-2020, § 10-20-2020)

Section 22.5-24. Erosion prevention and sediment control.

(a) In order to protect, maintain, and enhance the immediate and long-term health, safety, and general welfare of the citizens of the City, this article has the following objectives:
  (1) Prevent erosion and sedimentation to limit deposition in streams and other water bodies; and
  (2) Facilitate the removal of pollutants in stormwater runoff to perpetuate the natural functions of streams.

(b) To comply with state, federal, and local regulations, erosion prevention and sediment control shall be regulated by this article because of the following water quality impacts:
  (1) Stormwater runoff can carry pollutants into receiving water bodies, thereby degrading water quality;
  (2) The increase in nutrients in stormwater runoff such as phosphorus and nitrogen accelerates eutrophication of receiving waters;
  (3) Construction requiring land clearing and the alteration of natural topography tend to increase erosion;
  (4) Siltation of water bodies resulting from increased erosion decreases their capacity to hold and transport water, interferes with navigation, harms flora and fauna, destroys habitat, and reduces populations of aquatic species; or

(5) Substantial economic losses can result from these adverse impacts on community waters.

(c) When site development occurs, the following actions are required:
(1) Install, inspect, repair, and maintain all erosion prevention and sediment controls for any site development;
(2) Install, inspect, repair, and maintain all erosion prevention and sediment controls per the requirements of the approved permits and plans.

(Ord. No. O-139-04, § 1, 8-17-2004; Ord. No. O-26-2013, § 5, 2-5-2013; Ord. No. O-281-2017, § 12-05-2017)

Section 22.5-25. Reserved

Section 22.5-26. Site development permit.

(a) A site development permit from the Department of Engineering is required to:
(1) Grade, dump, alter natural or existing topography, move or place fill material, excavate, remove any vegetation not exempted by the Tree Protection Ordinance, or begin any land disturbance activities;
(2) Alter any natural or manmade drainage system so as to divert, constrict, increase, or change in any manner the natural or existing flow of any stream, natural drainage, or existing drainage of any area;
(3) Commence site development or construction of any building or structure; or
(4) Clear any site by means that causes disturbance of soil.

(b) No person shall:
(1) Perform site development equal to or greater than one (1) acre without first obtaining a City of Knoxville Qualified Local Program Construction General Permit; or
(2) Perform site development work beyond the scope of the approved site development plan.

(Ord. No. O-139-04, § 1, 8-17-2004; Ord. No. O-26-2013, § 6, 2-5-13; Ord. No. O-281-2017, § 12-05-2017)

Section 22.5-27. Site development plan.

(a) A site development plan shall be required for any site development except when:
(1) The developed area is used for gardening or agricultural purposes;
(2) The proposed work does not, in the opinion of the Department of Engineering, affect the drainage on the site or the quality of stormwater runoff from the site.

(b) A site development plan shall contain the following:
(1) The name, address, and telephone number of all persons having a legal interest in the property;
(2) The tax map number, group, and parcel number of the property or properties affected; and
(3) Information that complies with the requirements of the Tree Protection Ordinance.

(c) A registered professional engineer licensed to practice in the State of Tennessee must prepare and stamp portions of the site development plan that require hydraulic or hydrology calculations and design, as well as, all roads, private rights-of-way, and joint permanent easements that are required to be designed and built to public road standards.

(d) Additional information is required for site development plans based on the type of development.
(1) Small single-family residential development.
a. A topographic map showing and identifying:
1. The proposed area of land disturbance;
2. The layout of the structure(s);
3. Location of all depressed areas;
4. Blue-line streams and any related lines, e.g. no fill line, riparian buffer zone, floodway, 500-year floodplain, 100-year floodplain, and F-1 zone;
5. Any proposed or existing easements, e.g. stormwater facility easements, access easements, drainage easements, and TVA easements;
6. All existing and proposed components of the stormwater system; and

7. Erosion prevention and sediment control measures.

b. Other information as required by the Director.

(2) Large residential and commercial development.

a. Plans showing and identifying:
   1. Existing and proposed two-foot contours;
   2. Parking lot;
   3. Drainage facilities;
   4. Cut and fill slopes;
   5. All stormwater pipe size, material, slope, and location;
   6. Location of all depressed areas;
   7. Blue-line streams and any related lines, e.g. no fill line, riparian buffer zone, floodway, 500-year floodplain, 100-year floodplain, and F-1 zone;
   8. Any proposed or existing easements, e.g. stormwater facility easements, access easements, drainage easements, and TVA easements;
   9. Erosion prevention and sediment control measures;
   10. Stormwater basin data, e.g. size, location, slope of bottom, outlet, invert, top elevations, spillway size, and elevation;
   11. Catch basin locations and elevations, e.g. top of casting, sump, and invert;
   12. Swales, ditches, and their stabilization treatment;
   13. Building pad contours and building pad elevations; and
   14. Dumpster pad elevations and location.

b. When the site development plan includes a street to be dedicated to the City, a complete set of roadway plans must be submitted including:
   1. Profiles, grades, and K-values;
   2. Horizontal curvature;
   3. Cross sections showing cross slope, limits of construction, clear zones, utility strips, and sidewalks (greenway/pedestrian facilities);
   4. Signage plan;
   5. Street-lighting fixture types; and
   6. Any above-ground fixed objects in the right-of-way.

c. Large residential and commercial development plans that are submitted to the Department of Engineering and that do not include the following items will be rejected and will not be reviewed further until submission standards are met:
   1. A stamp and signature from appropriate design professional;
   2. Plans sheets and supplemental material such as calculations that are legible (for scanning and reproducing);
   3. Constructible designs;
   4. All required hydraulic and hydrologic calculations with assumptions;
   5. Pre- and post- developed contours;
   6. An erosion prevention and sediment control plan;
   7. Required retaining wall calculations;
   8. The Owner's and, if applicable, Lessee's name, address, and phone number;
   9. A vicinity map;
   10. The city block number;
   11. The parcel ID; and
   12. A certified address from the Knoxville-Knox County Planning.

(3) Utilities development.

a. Utilities development requires plans showing the following:
   1. The names and addresses of all property owners;
   2. The name, address, and contact person of the utility;
   3. The name, address, and contact person of the engineering firm;

4. A vicinity map;
5. A graphical scale;
6. The stamp and signature of a registered professional engineer licensed to practice in the state of Tennessee;
7. Total project length in feet;
8. All property lines;
9. Existing easements;
10. Pre- and post- development contours;
11. All water features;
12. All topographic features such as sinkholes;
13. Appropriate delineations, e.g. no-fill line, riparian buffer zone, floodway, and F-1 zone;
14. Appropriate construction details; and
15. An effective erosion prevention and sediment control plan with details adequate for installation and inspection that complies with the TDEC "Erosion and Sediment Control Handbook," Fourth Edition dated August 2012, or the City's *BMP Manual*, current as of the date of the submission of the plans.

b. The site development permit requirements for any utility entity currently subject to a court order or decree shall be determined by the Department of Engineering.

(e) When existing or documented flooding problems are present, the Director has authority to condition the approval of a permit upon the compliance with additional requirements, including but not limited to detention, conveyance facilities, or other stormwater management solutions required to reduce the adverse impact of the proposed development on the public right-of-way, other properties, or on the subject development.

(f) An erosion prevention and sediment control plan must be provided as follows:

(1) Small single-family residential development—Requires no erosion prevention and sediment control plan except if the residential development, exclusive of agricultural, gardening, farming, and similar areas of activity, results in disturbance of more than ten thousand (10,000) square feet or as deemed necessary by the Director. When a plan is deemed necessary, the erosion prevention and sediment controls must comply with the TDEC Erosion and Sediment Control Handbook, Fourth Edition, dated August 2012, or the City's *BMP Manual,* current as of the date of the submission of the plans.

(2) Large residential and commercial development—Requires an erosion prevention and sediment control plan that is stamped by a registered professional engineer, architect, or landscape architect licensed to practice in the state of Tennessee and complies with the TDEC Erosion and Sediment Control Handbook, Fourth Edition, dated August 2012, or the City's *BMP Manual,* current as of the date of the submission of the plans.

(3) Portions of the erosion prevention and sediment control plan that require hydrology or hydraulic calculations and design shall be prepared and stamped by a registered professional engineer licensed to practice in the state of Tennessee.

(g) When the Department of Engineering has determined the site development plan is approvable, it will send written notification authorizing the installation of the erosion prevention and sediment control measures. When the erosion prevention and sediment control plan has been implemented on site, the appropriate design professional required to stamp the erosion prevention and sediment control portion of the site development permit will provide written notification to the Department of Engineering stating that they have inspected the site and the erosion prevention and sediment controls have been implemented as shown on the approved erosion prevention and sediment control plan. This written notification must be signed and sealed by the appropriate design professional.

(h) Stormwater facilities documentation.

(1) An easement is required for proposed stormwater facilities. The easements can be dedicated by either Declaration Document or plat. The Declaration Document or plat shall locate, establish, and define an easement around each facility. The Covenants shall be referenced on the Declaration Document or plat.
(2) In order to provide access to stormwater facilities for personnel, vehicles, and equipment, the property owner or lessee will provide traversable access from a public street to the stormwater facility. Access rights may be granted by either Declaration Document or plat in strict accord with the plan and any conditions required by the Department of Engineering.
(3) A stormwater facility required to comply with a SPAP may not require an easement. Covenants are still required.

(i) Before any residential lot(s) in a platted subdivision may be transferred, the engineer of record must sign and seal a letter stating that all supporting stormwater and street infrastructure and grading has been completed for the subject lot(s), or the development certification may be submitted to and approved by the Department of Engineering. Failure to comply with this requirement may result in any combination the following:
(1) Revocation of the surety bond, cashier's check, or letter of credit thereby revoking the ability to obtain permits;
(2) Cancellation of permits on properties; and
(3) Implementation of all available legal remedies.

(j) A surety bond, cashier's check, or letter of credit must be provided as follows:
(1) A performance and indemnity agreement is required prior to the issuance of a site development permit for rough grading or site development when there is a potential for runoff to adversely impact public rights-of-way or other property, when sites drain into sinkholes, or when the site is used for a borrow pit. The performance and indemnity agreement shall be guaranteed in the form of a cashier's check, a letter of credit, or a surety bond.
(2) A performance and indemnity agreement is required for large residential development when there is a potential for runoff to adversely impact public rights-of-way or other property, when sites drain into sinkholes, when the site is used for a borrow pit, a stormwater basin is required, or there is construction of a joint permanent easement, private right-of-way, or public road. The performance and indemnity agreement shall be guaranteed in the form of a cashier's check, a letter of credit, or a surety bond. The actual amount is based on a remediation and completion estimate as determined by the Department of Engineering, with a minimum amount of fifty thousand dollars ($50,000.00).
(3) A performance and indemnity agreement is required for commercial development when there is a potential for runoff to adversely impact public rights-of-way or other property, when sites drain into sinkholes, when the site is used for a borrow pit, a stormwater basin is required, or there is construction of a joint permanent easement, private right-of-way, or public road. The amount is based on the project cost estimate that includes roadway facilities, drainage facilities, and erosion prevention and sediment control remediation. The performance and indemnity agreement shall be guaranteed in the form of a cashier's check, a letter of credit, or a surety bond. The actual amount is based on a remediation and completion estimate as determined by the Department of Engineering, with a minimum amount of ten thousand dollars ($10,000.00).
(4) A surety bond, cashier's check, or letter of credit is not required for small single-family residential development except when deemed necessary by the Director based on site conditions and the adverse impact on downstream conditions or other properties.
(5) The Director may refuse brokers or financial institutions the right to provide a surety bond, cashier's check, or letter of credit based on past performance, ratings of the financial institution, or other appropriate sources of reference information.

(k) Prior to the release of a bond, a development certification must be completed.

(1) The development certification shall show that the as-built field conditions have been field verified and comply with the approved plans.
(2) The development certification must be stamped by the appropriate design professional required to stamp the original site development permit as stated in section 22.5-27.c. A registered land surveyor licensed to practice in the state of Tennessee must also stamp certifications that include a survey drawing.

(Ord. No. O-139-04, § 8-17-2004; Ord. No. O-16-2005, § 1-18-05; Ord. No. O-045-05, § 2-15-2005; Ord. No. O-281-2017, § 12-05-2017; Ord. No. O-151-2020, § 10-20-2020)

Section 22.5-28. Temporary emergency exemption.

In extreme circumstances, when a delay in construction may cause significant property damage or loss of life, the Director may grant a temporary exemption from a site development permit. Specific instances may include a sinkhole opening up which threatens homes or personal safety or a failure of a storm system where the flooding could cause property damage or loss of life. This exemption is limited to work specific to resolving the dangerous situation(s). Any approval for work granted under this emergency exemption must be issued in writing and approved by the Director. After the emergency has been resolved, a site development permit must be obtained for the emergency work and any additional proposed work. This should be accomplished through the standard review process. This temporary emergency exemption does not provide immunity from any of the design criteria of this ordinance.

(Ord. No. O-139-04, § 8-17-2004; Ord. No. O-281-2017, § 12-05-2017)

Section 22.5-29. Fees.

(a) When a site development plan review is required, the following fee schedule applies and will be required upon the submittal of the plans.
  (1) Site development plans review fees (based on disturbed area):

Small single-family residential	$ 0.00
Less than one (1) acre:	$ 150.00
One (1) acre to five (5) acres:	$ 150.00 + $ 20.00/acre
More than five (5) acres:	$ 250.00 + $ 10.00/acre

The plans review fee for Site Development Plans includes the initial submittal and two (2) resubmittals. Beginning with the fourth resubmittal, an additional plans review fee of one hundred dollars ($100.00) is due for each resubmittal.

(b) When a site development permit is required, the following fee schedule applies and will be required before the issuance of the permit.
  (1) Site development permits without a bond:
    a. Small single-family residential: ..... $ 10.00
    b. All other projects: ..... $ 50.00
  (2) Site development permits with a bond (based on disturbed area):
    a. Less than one (1) acre: ..... $ 375.00
    b. One (1) acre or more: ..... $ 375.00 + $15.00/acre
  (3) Site development permits for utilities (except for utility entities currently subject to a court order or decree, the fees for which shall be determined by the Department of Engineering):
    a. Maintenance: $15.00 per 20 square yards plus $0.50 per each additional square yard.
    b. Construction: $1.00 per linear foot of conduit (e.g., pipe, cable, wire, fiber optics) with a $200.00 minimum.
(c) The fee for a site development permit issued after site development has begun without a permit shall be ten (10) times the standard fee.
(d) A site development permit is valid for one (1) year. A permit may be renewed before it expires at no additional cost. Once a permit expires, the appropriate permitting fee shall be charged for the renewal.

(e) If separate permits for any combination of grading, erosion prevention and sediment control, and/or drainage are requested, the appropriate permitting and review fee will be charged for each permit.

(f) The cost to review each special pollution abatement permit (SPAP) application shall be two hundred dollars ($200.00). Reapplication prior to the expiration date of the permit may be eligible for a fifty (50) percent review fee reduction.

(g) When a final plat review is required, the following fee schedule applies and will be required before approval:
   (1) Administrative plat: ..... $ 80.00
   (2) Exempt subdivision and corrected plats: ..... $ 70.00
   (3) All other plats:
      a. One (1) to fifty (50) lots: ..... $ 100 + $10.00/lot
      b. Fifty-one (51) or more lots:..... $ 600 + $6.00/lot (lots 51+)
      c. Declaration Document: ..... $ 150.00

(h) Mathematical closure checks of property and easement boundaries are performed for all subdivision plat submittals, Exempt plats requiring inclusion on the ward map, and declaration documents that are submitted for review within the City of Knoxville. A $100.00 fee will be assessed on the third submittal and all subsequent submittals, thereafter, for which a misclosure is noted.

(i) The fee for the approval of a promissory letter committing to record a plat or declaration document within forty-five (45) days shall be five hundred dollars ($500.00). A fifteen (15) day extension of this time frame to record a plat shall be an additional two hundred dollar ($200.00) fee.

(j) A fee of five hundred dollars ($500.00) will be required prior to the acceptance of the promissory letter committing to execute the covenants within a 45-day grace period. A fee of two hundred dollars ($200.00) will be required for the consideration of a 15-day extension.

(k) Whenever a construction general permit is required, the following fee schedules apply:
   (1) The following fees shall be charged for general construction application and will be required before the issuance of the permit:
      a. Equal to or greater than one (1) acre but less than five (5) acres, two hundred fifty dollars ($250.00).
      b. Equal to or greater than five (5) acres but less than twenty (20) acres, one thousand dollars ($1,000.00).
      c. Equal to or greater than twenty (20) acres but less than fifty (50) acres, three thousand dollars ($3,000.00).
      d. Equal to or greater than fifty (50) acres but less than one hundred fifty (150) acres, six thousand dollars ($6,000.00).
      e. Equal to or greater than one hundred fifty (150) acres, ten thousand dollars ($10,000.00).
   (2) For all construction general permits issued on or after January 1, 2018, the following permit maintenance fees shall be charged on an annual basis for all construction activities that exceed one (1) year under general permit coverage and shall be collected prior to the renewal of the site development permit
      a. Fee Schedule
         1. Equal to or greater than one (1) acre but less than five (5) acres, one hundred twenty-five dollars ($125.00).
         2. Equal to or greater than five (5) acres but less than twenty (20) acres, five hundred dollars ($500.00).
         3. Equal to or greater than twenty (20) acres but less than fifty (50) acres, one thousand dollars ($1,000.00).
         4. Equal to or greater than fifty (50) acres but less than one hundred fifty (150) acres, two thousand dollars ($2,000.00).

5. Equal to or greater than one hundred fifty (150) acres, three thousand seven hundred fifty dollars ($3,750.00).

b. If the permit maintenance fees are not paid on an annual basis, as required, they may be collected, in full, prior to the approval of the development certification or collected from the bond prior to its release.

(k) All fees and charges collected under the provisions of this section shall inure exclusively to the use and benefit of the Department of Engineering for operations associated with stormwater related activities. The excess of revenues less operating costs may be transferred to the general fund for general operations.

(Ord. No. O-139-04, § 1, 8-17-2004; Ord. No. O-16-05, § 1, 1-18-2005; Ord. No. O-166-2011, § 2, 11-29-2011; Ord. No. O-26-2013, § 7, 2-5-2013; Ord. No. O-281-2017, § 12-05-2017; Ord. No. O-151-2020, § 10-20-2020)

Section 22.5-30. Reserved.

Section 22.5-31. Design standards for detention and/or retention basins.

(a) The calculated peak flow rate of stormwater runoff resulting from a 1-year, 2-year, 5-year, 10-year, 25-year, and 100-year frequency storm shall be no greater after site development of the site than that which would result from a 1-year, 2-year, 5-year, 10-year, 25-year, and 100-year frequency storm on the same site prior to site development.

(b) Adequate attention must be given to safety and sanitation in the design of any detention or retention facility. This includes, but is not limited to, a minimum of two (2) percent slope in the bottom of all stormwater basins, a 3:1 (H:V) or flatter side slope used for traversable access to the basin's bottom for maintenance, proposed contours should reflect fifteen (15) percent additional area for each two-foot contour of the stormwater basin based on the appropriately sized basin for the 1-year, 2-year, 5-year, 10- year, 25-year, and 100-year frequency storms, a minimum of four thousand five hundred (4,500) cubic feet of storage volume, and a minimum of one (1) foot of freeboard from the highest water surface elevation for the largest resulted design storm to the top of the berm before the fifteen (15) percent additional volume is added. An exception can be made to the minimum slope requirement in the bottom of the basin if the first flush requirement is not managed in the quantity detention basin and the basin invert is finished in concrete. The plans shall include sufficient design information to show that the facility will operate as required. This design shall include the predevelopment and postdevelopment peak flow discharges, volumes of stormwater runoff based on the proposed site development, as well as all necessary computations used to determine the reduced peak flow rates for the design storms. The capacity of the facility shall be sufficient to control the volume of stormwater runoff resulting from 1-year, 2-year, 5-year, 10-year, 25-year, and 100-year frequency storms within the peak flow requirements stated in this subsection.

(c) When stormwater pretreatment is utilized to treat the first flush prior to discharging water into a stormwater basin, the basin is not required to have 15% additional volume as required by section 22.5-31.(b).

(d) The plans shall include sufficient design information to show that the facility will operate as required. This design shall include the predevelopment and postdevelopment peak flow discharges, volumes of stormwater runoff based on the proposed site development, as well as all necessary computations used to determine the reduced peak flow rates for the design storms. The capacity of the facility shall be sufficient to control the volume of stormwater runoff resulting from 1-year, 2-year, 5-year, 10-year, 25-year, and 100-year frequency storms within the peak flow requirements stated in this subsection.

(e) Discharge from the stormwater basins shall be routed to a ditch, channel, or stormwater facility of adequate capacity. Calculations showing the capacity of the receiving stormwater facility and its capability to convey a 1-year frequency storm shall be provided. If the receiving stormwater facility is incapable of conveying a 10- year frequency storm, calculations showing the capacity

of the receiving stormwater facility and its capability to convey a 2-year frequency storm shall also be provided. These calculations will show how the flow is routed through the second existing street or alley crossing, a blue-line stream, interstate right-of-way, railroad right-of-way, State or local government project where drainage improvements were made from 1985 to present, or existing stormwater basin, whichever is closest. The Director has authority to condition the approval of a permit upon the compliance with additional requirements, including but not limited to correctly sizing and installing offsite conveyance facilities or other stormwater management solutions required to reduce the adverse impact of the proposed development on other properties or the development.

(Ord. No. O-139-04, § 8-17-04; Ord. No. O-16-05, § 1, 1-18-2005; Ord. No. O-281-2017, § 12-05-2017; Ord. No. O-151-2020, § 10-20-2020)

Section 22.5-32. Requirements for developments draining to a sinkhole.

(a) Site development on property that includes a sinkhole will require copies of the appropriate permits from the Tennessee Department of Environment and Conservation (TDEC) prior to site development approval. After review of the state permit, the Director may require additional information related to structural integrity and flood protection. If the proposed development does not require TDEC approval, a letter from TDEC shall be submitted prior to the issuing of a site development permit, stating that a TDEC permit is not required.

(b) For site development or areas of substantial investment requiring attenuation or retention of the 1-year, 2-year, 5-year, 10-year, 25- year, and a 100-year frequency storms with sinkholes entirely on site, calculations shall be provided showing that 100-year frequency storm will not flood any structures assuming plugged conditions (zero (0) cfs outflow) for the sinkhole. These calculations must include the entire contributing watershed for the sinkhole. An easement is required around the sinkhole to include an area extending to the greater of five (5) feet horizontally outside the 100-year water surface elevation or one (1) foot above the 100-year water surface elevation.

(c) For site development or areas of substantial investment requiring attenuation or retention of the 1-year, 2-year, 5-year, 10-year, 25-year, and 100-year frequency storms with sinkholes partially on site, calculations must be provided showing that there will not be a rise in water surface elevations between the 100-year predeveloped and the 100-year postdeveloped frequency storm assuming plugged conditions (zero (0) cfs outflow) for the sinkhole. An easement is required at a minimum of five (5) feet horizontally outside the 100-year water surface elevation on the section of the sinkhole located on the developed property. A rise in the 100-year water surface elevation is allowable when no structures will be flooded and all parties with ownership of the sinkhole agree in writing to allow the rise. In this case, an easement is required around the sinkhole to include an area extending to the greater of five (5) feet horizontally outside the 100-year water surface elevation or one (1) foot above the 100- year water surface elevation.

(d) Stormwater retention is required for site developments that meet the requirements for stormwater attenuation and are located in one of the following critical watersheds:
   (1) Ten Mile Creek;
   (2) Harrell Hills watershed (near Cranberry Dr., Clairmont Dr., and Gaines Rd.);
   (3) Prosser Road area;
   (4) Pamela Ln.;
   (5) All areas draining to a sinkhole;
   (6) Any area of known flooding where deemed necessary by the Director.

   The retention basin shall be designed so that the overflow in the 1-year, 2-year, 5-year, 10-year, 25-year, and 100-year frequency storms must meet the predeveloped discharges in addition to retaining the difference in the predeveloped and postdeveloped

100-year frequency storm. In basins or sub-basins where there is a documented historical draw down time for the sinkhole or region being drained to, it may be acceptable for a detention basin to be used instead of retention. For detention to be approvable, the draw down time of the detention basin must be a minimum of six (6) days.

(e) When existing or documented flooding problems are present, the Director has authority to condition the approval of a permit upon the compliance with additional requirements, including but not limited to detention, conveyance facilities, or other stormwater management solutions required to reduce the adverse impact of the proposed development on the public right-of-way, other properties, or on the subject development.

(Ord. No. O-139-04, § 8-17-2004; Ord. No. O-281-2017, § 12-05-2017; Ord. No. O-151-2020, § 10-20-2020)

Section 22.5-33. Hydrologic and hydraulic computations.

(a) All hydrologic and hydraulic computations utilized in the design of stormwater detention facilities must be prepared by a registered professional engineer licensed to practice in the State of Tennessee.

(b) The required hydrologic and hydraulic computations shall be in accordance with NRCS (formerly known as the SCS) unit hydrograph procedures using AMC II curve numbers and type II rainfall distribution or other criteria that the Director shall establish based on scientific and engineering information. All postdeveloped conditions must be routed at appropriately small time intervals through the stormwater basin using computer models that are widely accepted among engineering professionals. The *BMP Manual* contains accepted methods and procedures. Other methods may be approved by the Director in the design of curb inlets and small pipe systems when the final result is verified by a SCS method.

(Ord. No. O-139-04, § 1, 8-17-04; Ord. No. O-16-05, § 1, 1-18-05; Ord. No. O-281-2017, § 12-05-17)

Section 22.5-34. Covenant requirements for stormwater facilities.

(a) Property owners and lessees are responsible for maintaining stormwater facilities located on their property.

(b) Prior to the issuance of a site development permit, the property owner shall execute a legal document entitled "Covenants for Permanent Maintenance of Stormwater Facilities," or the lessee shall execute a legal document entitled "Covenants for Maintenance of Stormwater Facilities on Leased Property" ("the Covenants"). The property owner or the lessee, as the case may be, shall record the Covenants in the office of the Knox County Register of Deeds. The location of the facility, the recorded location of the Covenants document, and a note stating the property owner's or lessee's responsibility shall be shown on a plat, or in the case of a lessee, as an exhibit attached to the lessee's Covenants, that is also recorded in the office of the Knox County Register of Deeds.

(c) The Covenants shall specify minimum maintenance requirements to be performed at necessary intervals by the property owner or lessee, as the case may be.

(d) The Covenants shall grant the City permission to enter the property to inspect any stormwater facility for proper functioning and maintenance.

(e) In limited situations, extenuating circumstances may exist that prevent the timely execution of the covenants by the proper party. After evaluating these circumstances, the Department of Engineering may approve a site development or building permit based on the acceptance of a promissory letter from the owner, prospective buyer, or developer stating their commitment to execute the covenants within a 45-day grace period. A fee will be required prior to the acceptance of the promissory letter. One 15- day extension may be granted for an additional fee. The fees authorized herein shall be the same as the fees for a promissory letter and an extension request in the plat requirement. The terms for the promissory letter and extension shall be at the director's discretion. The Department of Engineering is in no way obligated to accept promissory letters or extension. On the expiration of the promissory letter or extension, the Department of Engineering

may issue a stop work order to suspend all work on the property until the executed covenants document is recorded.

(f) Sediment removal and disposal shall be performed in accordance with all local, state, and federal laws. Guidelines for sediment removal and disposal are given in the City's *LDM*. The Director may stipulate additional guidelines if deemed necessary for public safety.

(Ord. No. O-139-04, § 1, 8-17-04; Ord. No. O-16-05, § 1, 1-18-05; Ord. No. O-281-2017, § 12-05-17; Ord. No. O-83-2019 § 1, 6-04-19)

Section 22.5-35. Acceptance of streets and stormwater systems within public rights-of-way.

(a) No street or stormwater system shall be dedicated to the City for public use or maintained by the City as a public street until said street and stormwater facilities have been accepted through completion of the development certification process.

(b) The Director shall only approve streets designed by a registered professional engineer licensed to practice in the state of Tennessee. Streets shall be designed according to publications by the American Association of State Highway and Transportation Officials (AASHTO). The design speed for local streets in residential subdivisions shall be twenty-five (25) miles per hour, unless the Director deems a different design speed appropriate. Additionally, stormwater systems and streets, including pedestrian facilities, must conform to the City standard specifications and the City construction standards.

(Ord. No. O-139-04, § 1, 8-17-04; Ord. No. O-281-2017, § 12-05-17)

Section 22.5-36. First flush requirements for stormwater basins.

(a) The requirements of this section shall not apply to those developments built or approved before June 20, 1997.

(b) All stormwater basins that are required under section 22.5-23. shall be built to manage first flush water quality. The standard management method shall be to collect the first flush or the first four thousand five hundred (4,500) cubic feet, whichever is greater, of stormwater runoff in a vegetated basin and release that runoff over a minimum twenty-four-hour and a maximum of a seventy-two-hour period. The Director may approve other methods of managing first flush water quality including:

(1) Proprietary BMPs may be considered based on full-scale testing, maintenance protocols, etc.

(2) Other designed BMPs based on their merit.

(Ord. No. O-139-04, § 1, 8-17-04; Ord. No. O-281-2017, § 12-05-17)

Section 22.5-37. Requirements for special pollution abatement permits.

(a) Specific land uses, hot spots, are known to produce pollutants that are detrimental to water quality and would not be corrected by the standard first flush requirement. A special pollution abatement permit (SPAP) is required to ensure that structural and management best management practices are used to control water quality for these hot spots. Before the approval of structural stormwater treatment devices, the Director may require valid documentation from full-scale testing by an independent third party to verify that the pollutants of concern will be properly controlled. A SPAP will be valid for a period of five (5) years, and must be renewed before expiration. At the time of renewal, any deficiency in the pollution control methods must be corrected. Any development that occurs without a required permit shall be a violation of this chapter of the code.

(b) A SPAP shall be required for the following land hot spots:

(1) Vehicle, truck, or equipment maintenance, fueling, washing, or storage areas, e.g. automotive dealerships, automotive repair shops, and car wash facilities;

(2) Any development containing more than four hundred (400) surface parking spaces or one hundred twenty thousand (120,000) square feet or more of surface parking area;

(3) Recycling and salvage yard facilities;

(4) Restaurants, grocery stores, and other food service facilities;

(5) Commercial facilities with outside animal housing areas, e.g. animal shelters, fish hatcheries, kennels, livestock stables, veterinary clinics, and zoos; and
(6) Other producers of pollutants identified by the Director.

(c) A SPAP may be required for a specific site due to operational failure, spills, or illicit discharges.
(d) Technical requirements for the SPAP shall be based on the current *BMP Manual* subject to the approval of the Department of Engineering.

(Ord. No. O-139-04, § 1, 8-17-04; O-281-2017, § 12-05-17)

Section 22.5-38. Additional permits required.

Additional permits may be required from various state and federal agencies before a site development permit will be issued by the City.

(Ord. No. O-139-04, § 1, 8-17-04; Ord. No. O-281-2017, § 12-05-17)

Section 22.5-39. National Pollutant Discharge Elimination System permits.

(a) Any person who holds an individual National Pollutant Discharge Elimination System (NPDES) permit shall provide a copy of such permit to the Director no later than sixty (60) calendar days after issuance or renewal of the permit. The permit holder shall also provide copies of all discharge monitoring reports required by the permit for any discharge to the stormwater system upon request.
(b) Any person who holds an NPDES general permit or multi-sector permit (as distinct and different from an individual permit) shall provide either a copy of such permit or the permit number assigned to them by TDEC to the Director no later than sixty (60) calendar days after issuance of the permit.

(Ord. No. O-139-04, § 1, 8-17-04; Ord. No. O-281-2017, § 12-05-17)

Section 22.5-40 Riparian buffer zone.

Riparian buffer zones (RBZ) exist within and adjacent to regulated waters (waters). The City regulates the RBZ to comply with federal mandates, protect stream water quality, and to reduce flood insurance rates.

(a) The RBZ is measured horizontally from the top of bank, extending perpendicular from each bank for the length of the water body. The top of bank is the uppermost limit of the active channel, typically indicated by a change in bank slope from steep to gentle slope. If the top of bank cannot be determined from the change of slope or if there is a dispute in the determination, the top of bank can be determined by submitting approved engineering calculations that determine the width of the stream resulting from the 2-year frequency storm. The width of the RBZ will vary, depending on all of the following criteria:
    (1) If a floodway profile, as part of the flood insurance study, has been adopted for the waters, the RBZ width must be equal to or greater than the width of the floodway at all points.
    (2) Waters with a drainage area of less than one (1) square mile will require a minimum RBZ width of thirty (30) feet.
    (3) Waters with a drainage area of one (1) square mile or more will require a minimum RBZ width of sixty (60) feet. The sixty-foot width of the RBZ can be established on an average width basis for a project, as long as the minimum width of the RBZ is at least thirty (30) feet at any measured location. If RBZ averaging is used, a plat must be recorded showing the limits of the RBZ.
    (4) Waters that are contained within a culvert do not require an RBZ. This exception does not apply to proposed roadway or proposed driveway crossing waters.
    (5) RBZ widths apply where culverts are removed from waters.
    (6) The Director may approve alternate RBZ widths for special circumstances (e.g., existing land uses or existing physical conditions) that conflict with the requirements in sections 22.5-40.a.1. through 5.
    (7) Mitigation must be shown on a recorded plat.

(b) Use of RBZs.
  (1) Acceptable uses of the RBZ may include: yards, picnic areas, walking trails, greenways, landscaped areas, wildlife habitat, primitive areas, roadway and sidewalk stream crossings, or other similar uses approved by the Director.
  (2) Specifically prohibited new uses include, but are not limited to, parking lots, dumpster storage, material storage, grease-bin storage, vehicle storage or maintenance, animal lots or kennels, or other uses known to contribute pollutants to waterways.

(c) Protection of RBZs.
  (1) It is prohibited to disturb an RBZ except when restoring the stream or stream banks, creating or restoring the RBZ, removing/eradicating invasive vegetation, replanting with native vegetation, or when constructing a permitted allowable disturbance.
  (2) All slopes adjacent to waters shall be left in a stabilized condition. No actively eroding, bare, or unstable banks shall remain unless TDEC has determined there is no better alternative (i.e. detrimental to endangered species). Placement of riprap and other hard armor is only allowed when bioengineering alternatives are not technologically feasible.

(d) Allowable disturbances of RBZs.
  (1) The Director may allow new driveways, road crossings, or foundations and columns across or through an RBZ on a case-by-case basis. It must be demonstrated that the encroachment is necessary and that the RBZ will not be impacted excessively. In these cases, the driveway, road crossing, or foundation and columns shall be constructed with careful attention to protecting trees and vegetation and minimizing site grading.
  (2) Approved mitigation is required for removal, encroachment, or disturbances to the RBZ.
  (3) Utility crossings.
    a. Utilities within the RBZ are not exempt from RBZ requirements or mitigation.
    b. All utilities within the RBZ must be subsurface or overhead.
    c. Planting plans must be consistent with guidelines in the *LDM*.
  (4) Installing a new or replacing an existing culvert, pipe, or bridge across waters.
    a. Maintain a natural stream bottom to the maximum extent practicable.
    b. Culverts, pipes, and bridges must span the baseflow channel.
    c. Minimize the length of culverts, pipes, and bridges.
    d. All crossings must be as close to perpendicular to the flow path as possible.

(e) RBZ enhancement, including RBZ creation, may be required if an RBZ does not exist, when an RBZ has excessive invasive vegetation, or if the RBZ contains significant areas of unhealthy, diseased, or dead vegetation. Information on RBZ enhancements can be found in the *LDM*.

(Ord. No. O-26-2013, § 8, 2-5-13; Ord. No. O-281-2017, § 12-05-17)

Sections 22.5-41-49. Reserved.

ARTICLE III. ILLICIT CONNECTIONS AND ILLEGAL DUMPING

Section 22.5-50. Findings of fact.

The City council finds that the uncontrolled discharge of pollutants to the stormwater system has an adverse impact upon the water quality of the receiving waters.

(a) The 1987 amendments to the Federal Water Pollution Control Act, commonly known as the Clean Water Act, established the National Pollutant Discharge Elimination System (NPDES) program, which requires permits for discharges from stormwater systems into waters of the United States. The Environmental Protection Agency (EPA) has promulgated regulations implementing the NPDES program.

(b) The NPDES regulations for stormwater discharges require certain municipalities, including the City, to:

A–382.36 (4)–2. RUNOFF COEFFICIENTS. Tables Detail A and B are for using the rational formula.

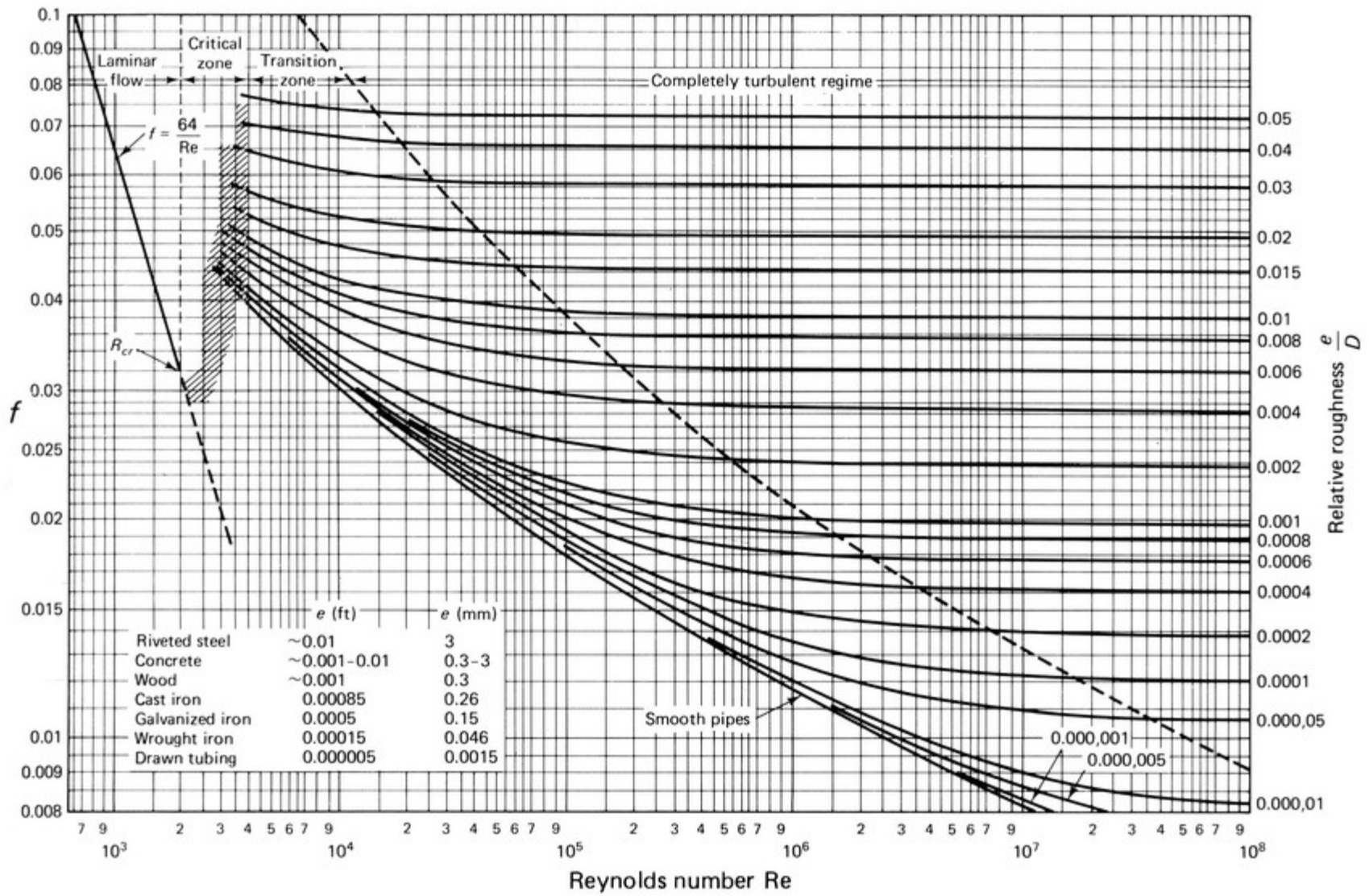
DETAIL A: RUNOFF COEFFICIENTS (C), RATIONAL FORMULA

Land Use	Percent Impervious Area	Design Storm 24–Hour Event	Hydrologic Soil Group											
			A			B			C			D		
			Slope Range (%)			Slope Range (%)			Slope Range (%)			Slope Range (%)		
			0–2	2–6	> 6	0–2	2–6	> 6	0–2	2–6	> 6	0–2	2–6	> 6
Industrial	90	2– and 10–year	0.67	0.58	0.68	0.68	0.68	0.69	0.68	0.69	0.69	0.69	0.69	0.70
		25–, 50–, and 100–year	0.85	0.85	0.86	0.85	0.86	0.86	0.86	0.86	0.87	0.86	0.86	0.88
Commercial	95	2– and 10–year	0.71	0.71	0.72	0.71	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
		25–, 50–, and 100–year	0.88	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.90
Residential: gh–density (>6 units/ acre)	60	2– and 10–year	0.47	0.49	0.50	0.48	0.50	0.52	0.49	0.51	0.54	0.51	0.53	0.56
		25–, 50–, and 100–year	0.58	0.60	0.61	0.59	0.61	0.64	0.60	0.62	0.66	0.62	0.66	0.69
Medium–density (2–6 units/acre)	30	2– and 10–year	0.25	0.28	0.31	0.27	0.30	0.35	0.30	0.33	0.38	0.33	0.36	0.42
		25–, 50–, and 100–year	0.33	0.37	0.40	0.35	0.39	0.44	0.38	0.42	0.49	0.41	0.45	0.54
Low–density (0.7–2 units/ acre)	15	2– and 10–year	0.14	0.19	0.22	0.17	0.21	0.26	0.20	0.25	0.31	0.24	0.28	0.35
		25–, 50–, and 100–year	0.22	0.26	0.29	0.24	0.28	0.34	0.28	0.32	0.40	0.31	0.35	0.46
Agriculture	5	2– and 10–year	0.08	0.13	0.16	0.11	0.15	0.21	0.14	0.19	0.26	0.18	0.23	0.31
		25–, 50–, and 100–year	0.14	0.18	0.22	0.16	0.21	0.28	0.20	0.25	0.34	0.24	0.29	0.41
Open Space	2	2– and 10–year	0.05	0.10	0.14	0.08	0.13	0.19	0.12	0.17	0.24	0.16	0.21	0.28
		25–, 50–, and 100–year	0.11	0.16	0.20	0.14	0.19	0.26	0.18	0.23	0.32	0.22	0.27	0.39
Freeways and Expressways	70	2– and 10–year	0.57	0.59	0.60	0.58	0.60	0.61	0.59	0.61	0.63	0.60	0.62	0.64
		25–, 50–, and 100–year	0.70	0.71	0.72	0.71	0.72	0.74	0.72	0.72	0.73	0.76	0.75	0.78

Source: Wisconsin department of transportation (WDOT), Facilities Development Manual (July 2, 1979), Procedure 13–10–5.

Table 3-7. Recommended Runoff Coefficient Values for Rational Method

Land Use	Runoff Coefficient (C) by Hydrologic Soil Group and Ground Slope											
	A			B			C			D		
	<2%	2 - 6%	>6%	<2%	2 - 6%	>6%	<2%	2 - 6%	>6%	<2%	2 - 6%	>6%
Forest	0.08	0.11	0.14	0.10	0.14	0.18	0.12	0.16	0.20	0.15	0.20	0.25
Meadow	0.14	0.22	0.30	0.20	0.28	0.37	0.26	0.35	0.44	0.30	0.40	0.50
Pasture	0.15	0.25	0.37	0.23	0.34	0.45	0.30	0.42	0.52	0.37	0.50	0.62
Farmland	0.14	0.18	0.22	0.16	0.21	0.28	0.20	0.25	0.34	0.24	0.29	0.41
Res. 1 acre	0.22	0.26	0.29	0.24	0.28	0.34	0.28	0.32	0.40	0.31	0.35	0.46
Res. 1/2 acre	0.25	0.29	0.32	0.28	0.32	0.36	0.31	0.35	0.42	0.34	0.38	0.46
Res. 1/3 acre	0.28	0.32	0.35	0.30	0.35	0.39	0.33	0.38	0.45	0.36	0.40	0.50
Res. 1/4 acre	0.30	0.34	0.37	0.33	0.37	0.42	0.36	0.40	0.47	0.38	0.42	0.52
Res. 1/8 acre	0.33	0.37	0.40	0.35	0.39	0.44	0.38	0.42	0.49	0.41	0.45	0.54
Industrial	0.85	0.85	0.86	0.85	0.86	0.86	0.86	0.86	0.87	0.86	0.86	0.88
Commercial	0.88	0.88	0.89	0.89	0.89	0.89	0.89	0.89	0.90	0.89	0.89	0.90
Streets: ROW	0.76	0.77	0.79	0.80	0.82	0.84	0.84	0.85	0.89	0.89	0.91	0.95
Parking	0.95	0.96	0.97	0.95	0.96	0.97	0.95	0.96	0.97	0.95	0.96	0.97
Disturbed Area	0.65	0.67	0.69	0.66	0.68	0.70	0.68	0.70	0.72	0.69	0.72	0.75


Laminar flow
Critical zone
Transition zone
Completely turbulent regime
$f = \frac{64}{Re}$
R_{cr}
f
Relative roughness $\frac{e}{D}$
Reynolds number Re
Smooth pipes
0.000,001
0.000,005
0.000,01
e (ft) e (mm)
Riveted steel ~0.01 3
Concrete ~0.001-0.01 0.3-3
Wood ~0.001 0.3
Cast iron 0.00085 0.26
Galvanized iron 0.0005 0.15
Wrought iron 0.00015 0.046
Drawn tubing 0.000005 0.0015

ADS N-12® WT IB PIPE (per AASHTO) SPECIFICATION

Scope
This specification describes 4- through 60-inch (100 to 1500 mm) ADS N-12 WT IB pipe (per AASHTO) for use in gravity-flow applications.

Pipe Requirements
N-12 WT IB pipe (per AASHTO) shall have a smooth interior and annular exterior corrugations.
- 4- through 10-inch (100 to 250 mm) shall meet AASHTO M252, Type S.
- 12- through 60-inch (300 to 1500 mm) shall meet AASHTO M294, Type S or ASTM F2306.
- Manning's "n" value for use in design shall be 0.012.

Joint Performance
Pipe shall be joined with the N-12 WT IB joint meeting the requirements of AASHTO M252, AASHTO M294, or ASTM F2306.

4- through 60-inch (100 to 1500 mm) shall be watertight according to the requirements of ASTM D3212. Gaskets shall be made of polyisoprene meeting the requirements of ASTM F477. Gaskets shall be installed by the pipe manufacturer and covered with a removable, protective wrap to ensure the gasket is free from debris. A joint lubricant available from the manufacturer shall be used on the gasket and bell during assembly.

12- through 60-inch (300 to 1500 mm) diameters shall have a reinforced bell with a bell tolerance device. The bell tolerance device shall be installed by the manufacturer.

Fittings
Fittings shall conform to AASHTO M252, AASHTO M294, or ASTM F2306. Bell and spigot connections shall utilize a spun-on or welded bell and valley or saddle gasket meeting the watertight joint performance requirements of AASHTO M252, AASHTO M294 or ASTM F2306.

Field Pipe and Joint Performance
To assure watertightness, field performance verification may be accomplished by testing in accordance with ASTM F2487. Appropriate safety precautions must be used when field-testing any pipe material. Contact the manufacturer for recommended leakage rates.

Material Properties
Virgin material for pipe and fitting production shall be high-density polyethylene conforming with the minimum requirements of cell classification 424420C for 4- through 10-inch (100 to 250 mm) diameters, and 435400C for 12- through 60-inch (300 to 1500 mm) diameters, as defined and described in the latest version of ASTM D3350, except that carbon black content should not exceed 4%. The 12- through 60-inch (300 to 1500 mm) virgin pipe material shall comply with the notched constant ligament-stress (NCLS) test as specified in Sections 9.5 and 5.1 of AASHTO M294 and ASTM F2306 respectively.

Installation
Installation shall be in accordance with ASTM D2321 and ADS's published installation guidelines, with the exception that minimum cover in trafficked areas for 4- through 48-inch (100 to 1200 mm) diameters shall be one foot. (0.3 m) and for 54- and 60-inch (1350 and 1500 mm) diameters, the minimum cover shall be 2 ft. (0.6 m) in single run applications. Backfill for minimum cover situations shall consist of Class 1, Class 2 (minimum 90% SPD) or Class 3 (minimum 90%) material. Maximum fill heights depend on embedment material and compaction level; please refer to Technical Note 2.01. Contact your local ADS representative or visit our website at www.ads-pipe.com for a copy of the latest installation guidelines.

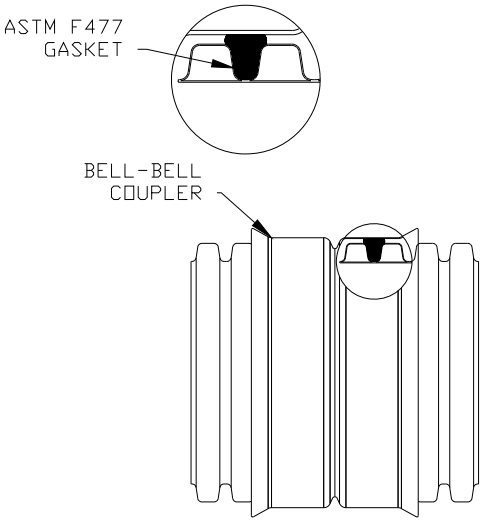
Pipe Dimensions

	Nominal Diameter, in (mm)													
Pipe I.D. in (mm)	4 (100)	6 (150)	8 (200)	10 (250)	12 (300)	15 (375)	18 (450)	24 (600)	30 (750)	36 (900)	42 (1050)	48 (1200)	54* (1350)	60 (1500)
Pipe O.D.** in (mm)	4.8 (122)	6.9 (175)	9.1 (231)	11.4 (290)	14.5 (368)	18 (457)	22 (559)	28 (711)	36 (914)	42 (1067)	48 (1219)	54 (1372)	61 (1549)	67 (1702)
Perforations	All diameters available with or without perforations													

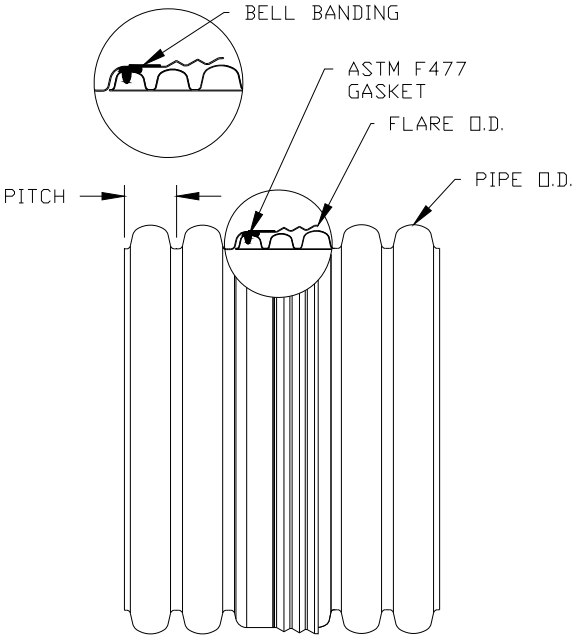
*Check with sales representative for availability by region.
**Pipe O.D. values are provided for reference purposes only, values stated for 12- through 60-inch are ± 1 inch. Contact a sales representative for exact values.

N-12® WT IB (per AASHTO) JOINT SYSTEM

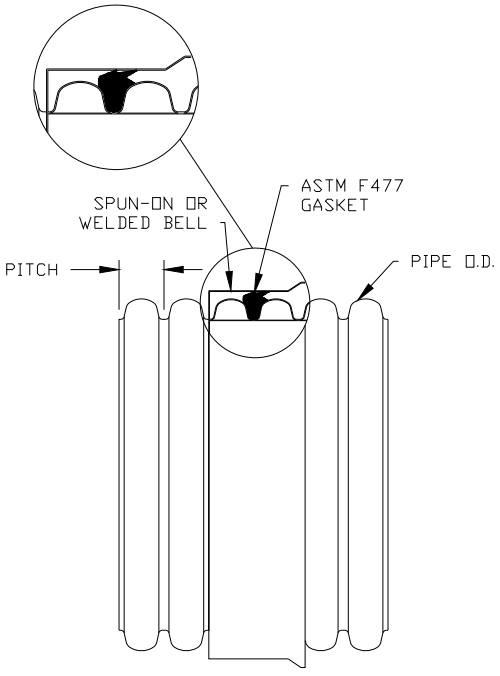
(Joint configuration & availability subject to change without notice. Product detail may differ slightly from actual product appearance.)



4″ - 10″
(100-250 MM)

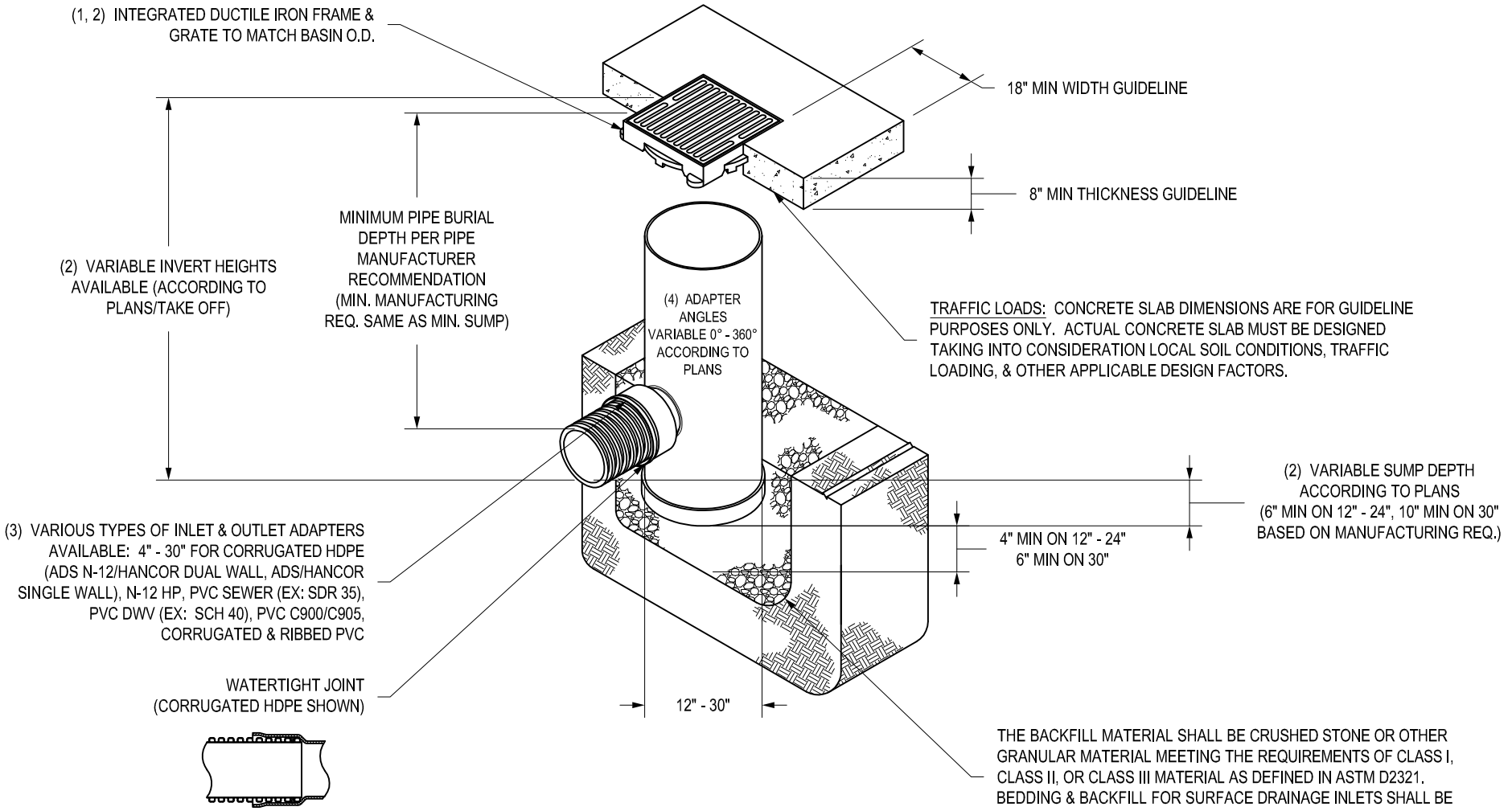


12″ - 60″
(300-1500 MM)



12″ - 60″
(300-1500 MM)

NYLOPLAST 2 FT X 2FT ROAD & HIGHWAY STRUCTURE: 32 _ _ AGS _ _ X

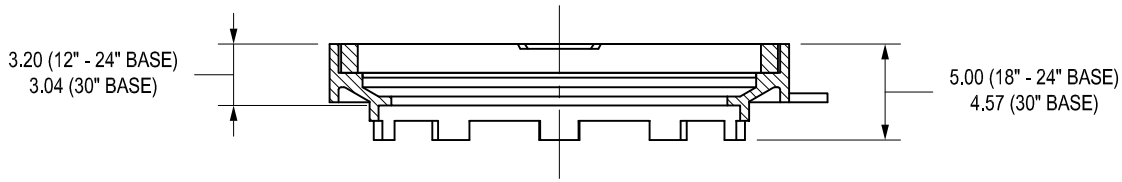


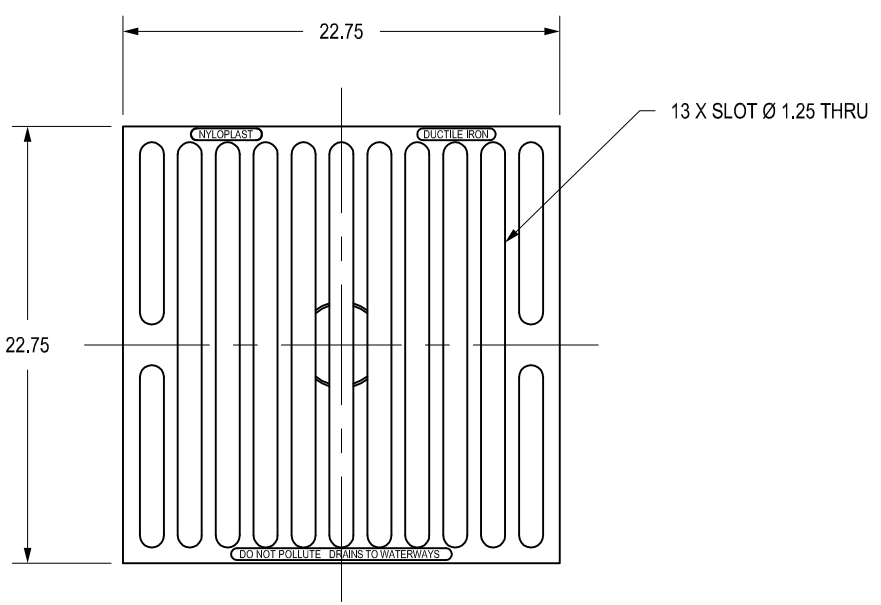
1 - 12" - 30" FRAMES & GRATES SHALL BE DUCTILE IRON PER ASTM A536 GRADE 70-50-05.
2 - DRAIN BASIN TO BE CUSTOM MANUFACTURED ACCORDING TO PLAN DETAILS.
3 - DRAINAGE CONNECTION STUB JOINT TIGHTNESS SHALL CONFORM TO ASTM D3212 FOR CORRUGATED HDPE (ADS N-12/HANCOR DUAL WALL), N-12 HP, & PVC SEWER (4" - 24").
4 - ADAPTERS CAN BE MOUNTED ON ANY ANGLE 0° TO 360°. TO DETERMINE MINIMUM ANGLE BETWEEN ADAPTERS SEE DRAWING NO. 7001-110-012.
5 - ROAD & HIGHWAY GRATE SHALL MEET H-20 LOAD RATING.

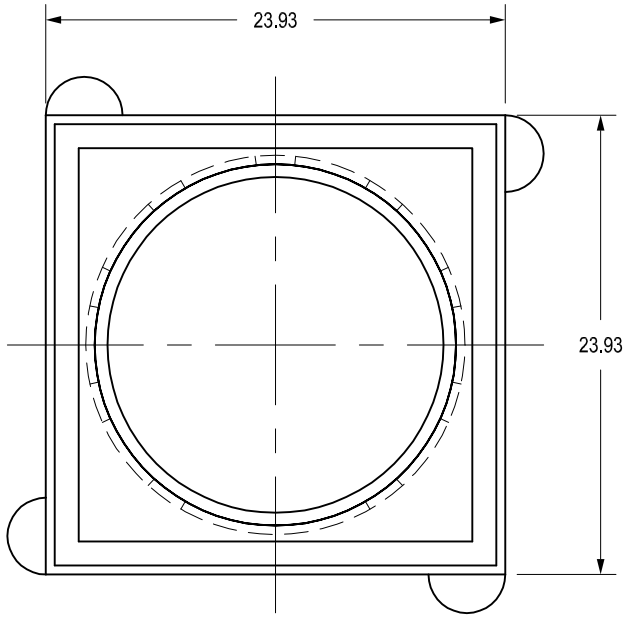
DRAWN BY EBC	MATERIAL	Nyloplast®	3130 VERONA AVE BUFORD, GA 30518 PHN (770) 932-2443 FAX (770) 932-2490 www.nyloplast-us.com
DATE 1-23-06			
REVISED BY NMH	PROJECT NO./NAME	TITLE DRAIN BASIN WITH 2 FT X 2 FT ROAD & HIGHWAY GRATE QUICK SPEC INSTALLATION DETAIL	
DATE 03-16-16			
DWG SIZE A	SCALE 1:40 SHEET 1 OF 1	DWG NO. 7001-110-162	REV G

3299CGSQ

APPROX. DRAIN AREA = 277.53 SQ IN
*APPROX. WEIGHT OF GRATE = 66.50 LBS



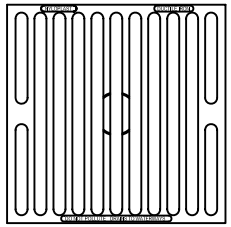




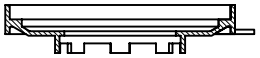
DIMENSIONS ARE FOR REFERENCE ONLY
ACTUAL DIMENSIONS MAY VARY
DIMENSIONS ARE IN INCHES
GRATE MEETS H-20 LOAD RATING
QUALITY: MATERIALS SHALL CONFORM TO ASTM A536 GRADE 70-50-05
PAINT: CASTINGS ARE FURNISHED WITH A BLACK PAINT
LOCKING DEVICE AVAILABLE UPON REQUEST SEE DRAWING NO. 7001-110-238
*WEIGHT DOES NOT INCLUDE FRAME
FRAME WITH 12" BASE : APPROX. 92.00 LBS
FRAME WITH 15" BASE: APPROX. 89.00 LBS
FRAME WITH 18" BASE: APPROX. 86.50 LBS
FRAME WITH 24" BASE: APPROX. 98.50 LBS
FRAME WITH 30" BASE: APPROX. 110.00 LBS

DRAWN BY EBC	MATERIAL	Nyloplast®	3130 VERONA AVE BUFORD, GA 30518 PHN (770) 932-2443 FAX (770) 932-2490 www.nyloplast-us.com
DATE 03-09-06	DUCTILE IRON		
REVISED BY CCA	PROJECT NO./NAME	TITLE	2 FT X 2 FT ROAD & HIGHWAY 2 PIECE GRATE ASSEMBLY
DATE 09-03-13			
DWG SIZE A	SCALE 1:10 SHEET 1 OF 1	DWG NO. 7001-110-224	REV D

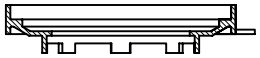
32 _ _ AGS _ _ X



2' X 2' ROAD & HIGHWAY GRATE

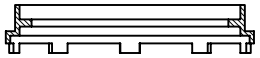


12" FRAME



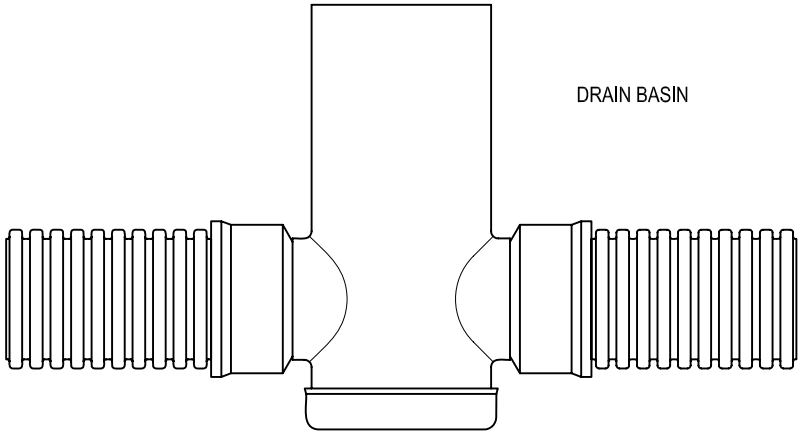
15" FRAME

18" FRAME



24" FRAME

30" FRAME



DRAIN BASIN

DRAWN BY CJA	MATERIAL	Nyloplast®	3130 VERONA AVE BUFORD, GA 30518 PHN (770) 932-2443 FAX (770) 932-2490 www.nyloplast-us.com
DATE 6-21-01			
APPD BY CJA	PROJECT NO./NAME	TITLE	
DATE 6-21-01		2 FT X 2 FT FAMILY	
DWG SIZE A	SCALE 1:20 SHEET 1 OF 1	DWG NO. 7001-110-069	REV E

Section 2724

Engineered Surface Drainage Products

GENERAL

PVC surface drainage inlets shall be of the road and highway structure type as indicated on the contract drawings and referenced within the contract specifications. The **ductile iron frame and grate** for each of these structures is to be considered an integral part of the surface drainage inlet and shall be furnished by the same manufacturer. The road and highway structure shall be as manufactured by Nyloplast a division of Advanced Drainage Systems, Inc. or prior approved equal.

MATERIALS

The road and highway structure required for this contract shall be manufactured from PVC pipe stock, utilizing a thermo-molding process to reform the pipe stock to the specified configuration. The drainage pipe connection stubs shall be manufactured form PVC pipe stock and formed to provide a watertight connection with the specified pipe system. This joint tightness shall conform to ASTM D3212 for joints for drain and sewer plastic pipe using flexible elastomeric seals. The flexible elastomeric seals shall conform to ASTM F477. The pipe bell spigot shall be joined to the main body of the structure. The raw material used to manufacture the pipe stock that is used to manufacture the main body and pipe stubs of the surface drainage inlets shall conform to ASTM D1784 cell class 12454.

The grate and frame for all road and highway structures shall be ductile iron and shall be made specifically for each so as to provide a round bottom flange that closely matches the diameter of the PVC basin body. The grate and frame shall be capable of supporting H-20 wheel loading for traffic areas. The metal used in the manufacture of the castings shall conform to ASTM A536 grade 70-50-05 for ductile iron.

INSTALLATION

The specified PVC road and highway structure shall be installed using conventional flexible pipe backfill materials and procedures. The backfill material shall be crushed stone or other granular material meeting the requirements of class 1, class 2, or class 3 material as defined in ASTM D2321. Bedding and backfill for the road and highway structure shall be placed and compacted uniformly in accordance with ASTM D2321. The road and highway structure body will be cut at the time of the final grade. No brick, stone or concrete block will be required to set the grate to the final grade height. For H-20 load rated installations, a concrete ring will be poured under and around the grate and frame. The concrete slab must be designed taking into consideration local soil conditions, traffic loading, and other applicable design factors. For other installation considerations such as migration of fines, ground water, and soft foundations refer to ASTM D2321 guidelines.

DRAWN BY JJC	MATERIAL	Nyloplast®	3130 VERONA AVE BUFORD, GA 30518 PHN (770) 932-2443 FAX (770) 932-2490 www.nyloplast-us.com
DATE 11-13-13			
REVISED BY NMH	PROJECT NO./NAME	TITLE	2 FT X 2 FT & 2 FT X 3 FT ROAD & HIGHWAY STRUCTURE SPECIFICATIONS
DATE 03-16-16			
DWG SIZE A	SCALE 1:1 SHEET 1 OF 1	DWG NO. 7001-110-077	REV F

Appendix D: Structural

Building Loads

Roof Load (Larger Roof)

4" on 12" slope Roof

Live Load

$L_o = 20 psf$

$A_r = (108ft)(36ft) = 3888 ft^2$

$R_1 = 0.6 \quad A_t \geq 600 ft^2$

$R_2 = 1.0 \quad F \leq 4$ (slope)

$L_r = L_o R_1 R_2$ (IBC 2018 Equation 16-27)

$L_r = (20psf)(0.6)(1.0)$

$\boxed{L_r = 12 psf}$

Dead Load

- Self weight of members and decking

Metal Deck

$15psf + 3.5psf$

Snow Load

ASCE 7-16

$P_g = 10psf$ (Fig. 1608.2 IBC 2018)

$C_e = 1.0$ (Partially Exposed, B roughness ASCE 7)

$C_t = 1.2$ (ASCE 7 - Unheated and open)

$I_s = 1.2$ (Risk Category II, ASCE 7 Table 1.5-2)

$P_f = 0.7 C_e C_t I_s P_g = 0.7(1.0)(1.2)(1.2)(10psf)$

$\underline{P_f = 10.08 psf}$

Sloped Roof Snow Load (ASCE 7-16 7.4)

$P_s = C_s P_f$

$C_s = 1.0$ (Figure 7.4-1 ASCE 7-16)

$P_s = (1.0)(10.08_{psf})$

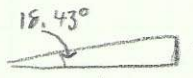
$\underline{P_s = 10.08 psf}$

Rain-on-Snow Surcharge Load (ASCE 7-16 7.10)

$P_g = 10psf$

$w = 36 ft$

$w/50 = \frac{36}{50} = 0.72°$



Slope $> w/50$ ∴ surcharge load not required

Minimum Snow Load For low Slope Roofs (ASCE 7-16 7.3.4)

Slope $= 18.43° > 15°$

∴ Does not apply

REFERENCES	CALCULATIONS	RESULTS
	Wind Load Detailed Calculations based on ASCE 7-16	
	Design Information : Project Name : Outdoor Cultural and Recreational Center Client : Designer : Company : Big Orange Builders Units : Imperial Notes :	
	Project Data The structure is located in **Cherokee Farm Way, Knoxville, TN 37920, USA** categorized as **Exposure B** (assumed to be homogeneous for the selected wind direction). The wind load calculation for the structure - Main Wind Force Resisting System (MWFRS) - is based on the Directional Procedure (Chapter 27) of ASCE 7. Morever, the structure is classified as **Risk Category II**. The location is elevated at **892 ft** above mean sea level.	

Figure 1. Site location.

Additional details of the structure are shown in Table below and illustrated in Figure 2:

Parameter	Value
Building Length, L	30.000 ft
Building Width, B	24.000 ft
Mean Roof Height, h	14.000 ft
Roof Profile	Monoslope
Roof Pitch Angle, θ	18.000°

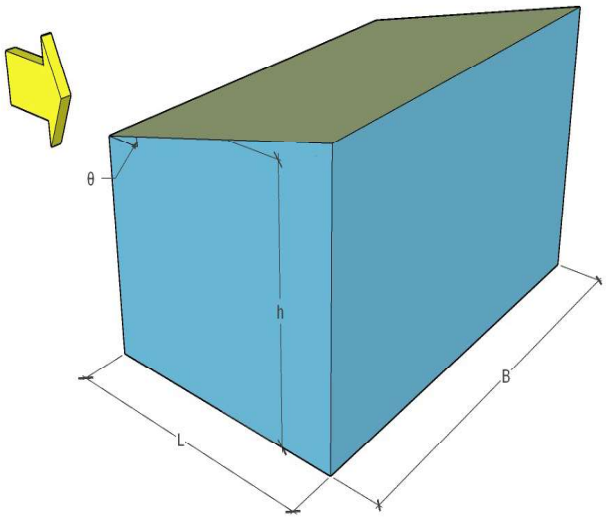


Figure 2. Building parameters.

Figure 26.5-1

Basic Wind Speed, V

Wind speed for the address is **105 mph** for Risk Category II and was calculated using Triangular Interpolation Network (TIN) method from points with known wind speed values based on Figure 26.5-1 of ASCE 7.

$V = 105$ mph

Figure 26.8-1

Topographic Effects, K_{zt}

The topography factor, K_{zt}, have been calculated based on the **wind coming from SW**. K_{zt} was calculated using the following formulas:

$$K_{zt} = (1 + K_1 K_2 K_3)^2$$

$$K_2 = (1 - |x|/\mu L_h)$$

$$K_3 = e^{-yz/L_h}$$

and K_1 - determined from Figure 26.8-1

Since the topography is generally classified as a level surface, K_{zt} is equal to 1.0.

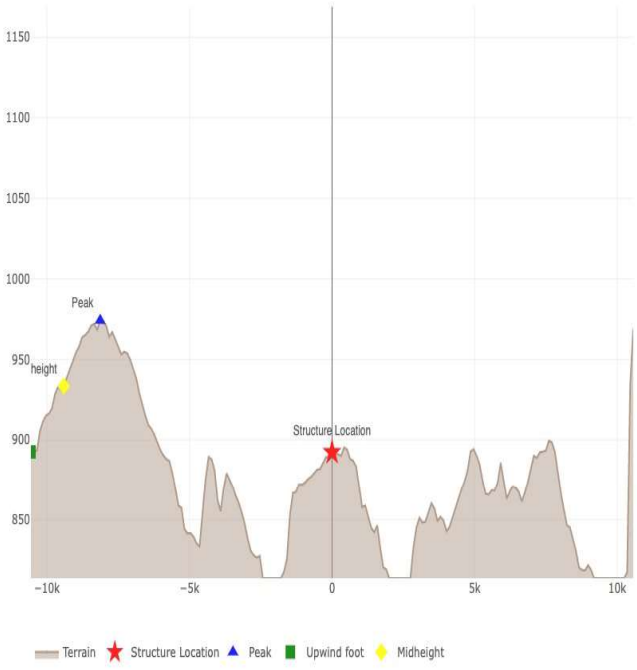


Figure 3. Ground elevation with wind coming from SW.

		$K_{zt} = 1.0$
Table 26.6-1	**Wind Directionality Factor, K_d** The wind directionality factors, K_d, for the structure is equal to **0.85** (for MWFRS, and Components and Claddings) based on Table 26.6-1.	$K_d = 0.85$
Section 26.9.1	**Gust Effect Factor, G** The structure is assumed to be rigid, hence, gust effect factor, G, is set to **0.85** based on Section 26.9.1.	$G = 0.85$
Table 26.9-1	**Groud Elevation Factor, K_e** The location is elevated at 892.18 ft above mean sea level. To account for air density, K_e is calculated in accordance with Table 26.9-1 using the formula: $$K_e = e^{-0.0000362 z_g}$$ $$K_e = e^{-0.0000362(892.18)} = 0.968$$	$K_e = 0.968$
Table 26.13-1	**Internal Pressure Coefficients, GC_{pi}** The structure is classified as **Partially Enclosed Building**, hence, GC_{pi} = **0.55** and **-0.55** based on Table 26.11-1	GC_{pi} = 0.55, -0.55
Section 26.10 *Table 26.10-1*	**Velocity Pressure Exposure Coefficient, K_z and Velocity Pressure, q_z** The velocity pressures, q_z, shall be computed using the equation: $$q_z = 0.00256 K_z K_{zt} K_d K_e V^2$$ $$q_z = 0.00256 K_z (1)(0.85)(0.968)(105)^2$$ where: K_z is calculated for each height using Table 27.3-1 rounded to nearest hundredth. From the formula above, the calculated K_z and q_z per level for **Wind Source Direction SW - Exposure Category B** are as follows:	

Level	Height, ft	K_z	q_z, psf
1	10	0.57	13.24
Mean Roof Height (h)	14	0.57	13.24

	External Pressure Coefficients, C_p	
Figure 27.3-1	**For Walls** The wall pressure coefficients, C_p, are calculated using Figure 27.3-1 as shown in Table 3 below. Note that the values for Leeward wall are interpolated using known values for each L/B value:	

Surface	L/B	C_p
Windward wall	All	0.8
Leeward wall (Wind along L)	1.250	-0.450
Leeward wall (Wind along B)	0.800	-0.500
Side walls	All	-0.7

Figure 27.3-1	**For Roof** The roof pressure coefficients, C_p, are calculated using Figure 27.3-1 as shown in Table below. Note that the values are interpolated using known values for h/L and θ.	

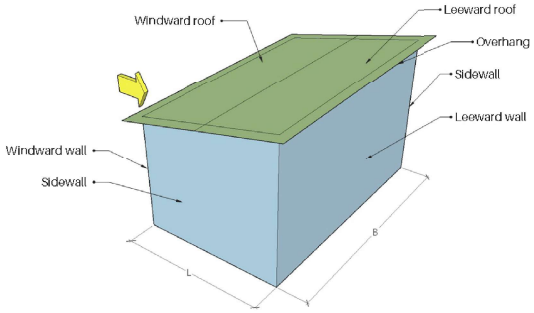
Wind Direction	Surface	h/L	C_p
Wind Along L (Normal to Ridge)	Windward	0.467	-0.046 -0.501
	Leeward		-0.587
Wind Along B (Parallel to Ridge)	to $h/2$	0.583	-0.930 -0.180
	$h/2$ to h		-0.867 -0.180
	h to $2h$		-0.533 -0.180
	$> 2h$		-0.367 -0.180

Additionally, the pressure coefficients, C_p, for **roof overhang soffit** are equal to **0.8 for windward side** and **0.0 for leeward side**. These values will be combined the with windward and leeward pressure coefficients on roof to calculate the net pressure acting on the overhang.

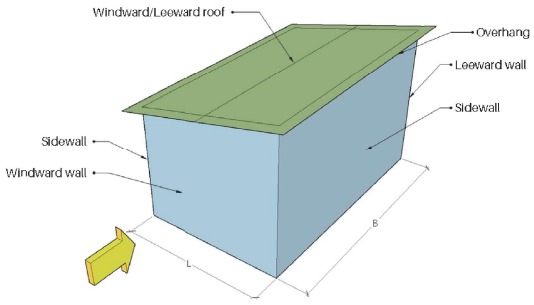
Equation 27.3-1	**Design Wind Pressures (MWFRS), p** The design wind pressures, p, using Equation 27.3-1: $$p = qGC_p - q_i(GC_{pi})$$	

Where:
$q = q_z$ for windward walls evaluated at height z above the ground
$q = q_h$ for leeward, sidewalls, and roofs evaluated at height h (mean roof height)
$q_i = q_h$ for positive and negative internal pressure evaluation
$p_e = qGC_p$ for external pressure
$p_i = q_i(GC_{pi})$ for internal pressure

Surface	Level/Location	Height, ft	p_e, psf	$+p_i$, psf	$-p_i$, psf	$p_e - +p_i$, psf	$p_e - -p_i$, psf
Windward wall	1	10 ft	9.003	7.282	-7.282	1.721	16.285
	Mean Roof Height (h)	14 ft	9.003			1.721	16.285
Leeward wall (along L)	Mean Roof Height, h	14 ft	-5.064			-12.346	2.218
Leeward wall (along B)	Mean Roof Height, h	14 ft	-5.627			-12.909	1.655
Sidewall	Mean Roof Height, h	14 ft	-7.878			-15.160	-0.596
Roof (Normal to Ridge)	Windward	14 ft	-0.522			-7.804	6.760
	Windward		-5.642			-12.924	1.640
	Leeward		-6.602			-13.884	0.680
Roof (Parallel to Ridge)	to $h/2$	14 ft	-10.470			-17.752	-3.188
			-2.026			-9.308	5.256
	$h/2$ to h		-9.753			-17.035	-2.471
			-2.026			-9.308	5.256
	h to $2h$		-6.002			-13.284	1.280
			-2.026			-9.308	5.256
	$> 2h$		-4.126			-11.408	3.156
			-2.026			-9.308	5.256
Net Pressure Roof Overhang (Normal to Ridge)	Windward	14 ft	-9.525	-	-		
	Windward		-14.645	-	-		
	Leeward		-6.602	-	-		
Net Pressure Roof Overhang (Parallel to Ridge)	Windward	14 ft	-11.029	-	-		
	Windward		-19.473	-	-		
	Leeward		-2.026	-	-		
			-6.002	-	-		



Wind along L

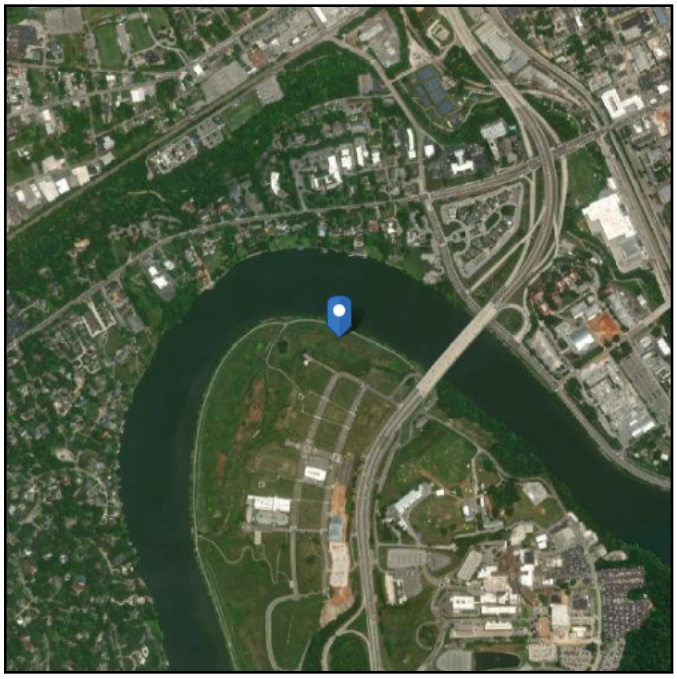


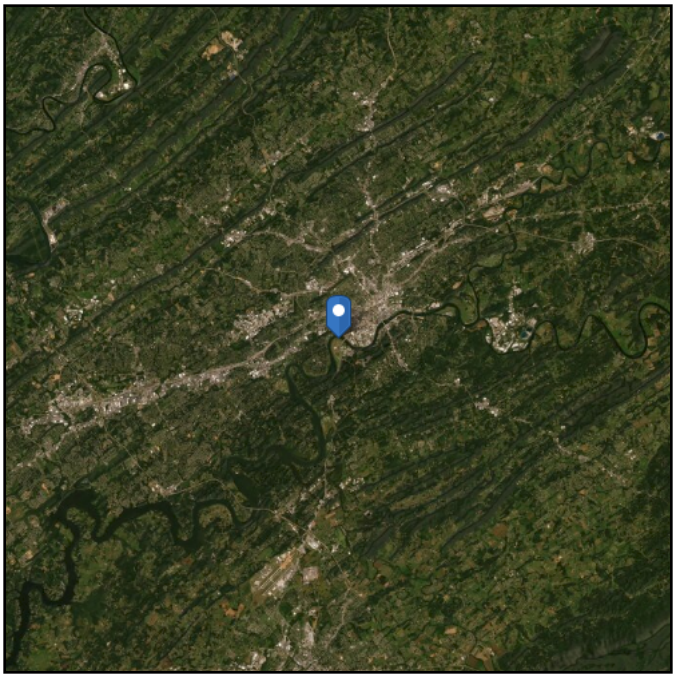
Wind along B

ASCE 7 Hazards Report

Address:
No Address at This Location

Standard:	ASCE/SEI 7-16	**Elevation:**	824.43 ft (NAVD 88)
Risk Category:	II	**Latitude:**	35.947421
Soil Class:	D - Default (see Section 11.4.3)	**Longitude:**	-83.950104





Wind

Results:

Wind Speed	105 Vmph
10-year MRI	72 Vmph
25-year MRI	79 Vmph
50-year MRI	84 Vmph
100-year MRI	89 Vmph

Data Source:	ASCE/SEI 7-16, Fig. 26.5-1B and Figs. CC.2-1–CC.2-4, and Section 26.5.2
Date Accessed:	Thu Mar 03 2022

Value provided is 3-second gust wind speeds at 33 ft above ground for Exposure C Category, based on linear interpolation between contours. Wind speeds are interpolated in accordance with the 7-16 Standard. Wind speeds correspond to approximately a 7% probability of exceedance in 50 years (annual exceedance probability = 0.00143, MRI = 700 years).

Site is not in a hurricane-prone region as defined in ASCE/SEI 7-16 Section 26.2.

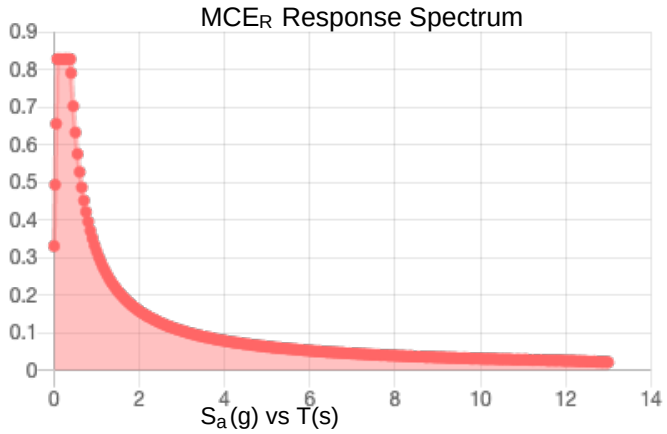
Seismic

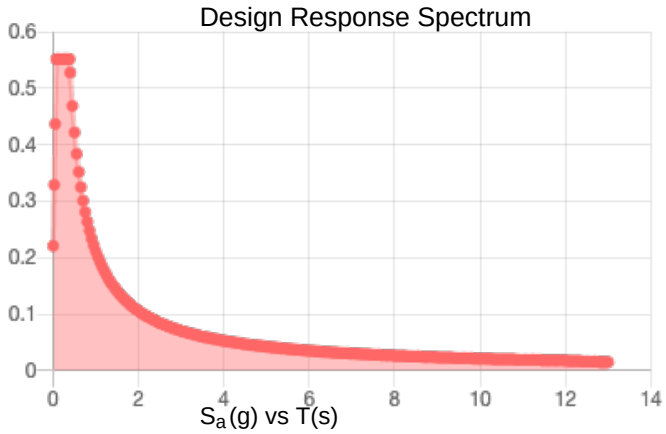
Site Soil Class: D - Default (see Section 11.4.3)

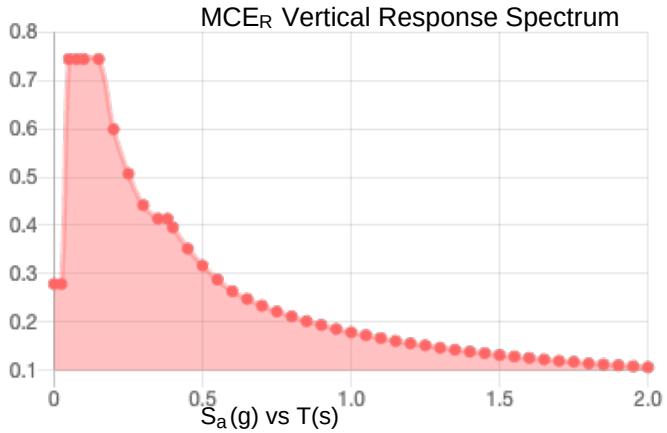
Results:

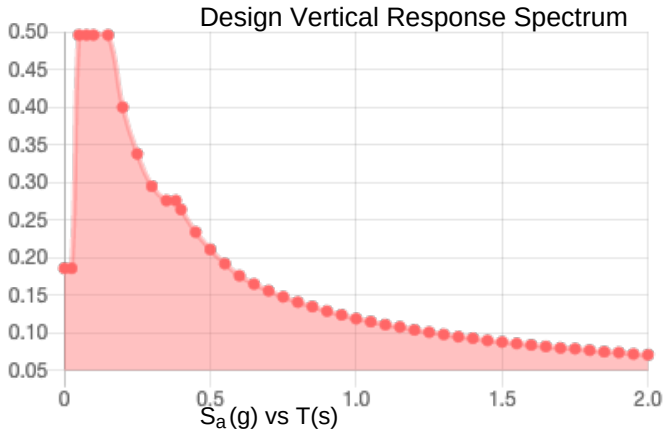
S_S :	0.645	S_{D1} :	0.211
S_1 :	0.136	T_L :	12
F_a :	1.284	PGA :	0.442
F_v :	2.328	PGA_M :	0.531
S_{MS} :	0.828	F_{PGA} :	1.2
S_{M1} :	0.317	I_e :	1
S_{DS} :	0.552	C_v :	1.122

Seismic Design Category D









Data Accessed: **Thu Mar 03 2022**

Date Source:

USGS Seismic Design Maps based on ASCE/SEI 7-16 and ASCE/SEI 7-16 Table 1.5-2. Additional data for site-specific ground motion procedures in accordance with ASCE/SEI 7-16 Ch. 21 are available from USGS.

Snow

Results:

Ground Snow Load, p_g:	10 lb/ft^2
Elevation:	824.4 ft
Data Source:	ASCE/SEI 7-16, Table 7.2-8
Date Accessed:	Thu Mar 03 2022

Values provided are ground snow loads. In areas designated "case study required," extreme local variations in ground snow loads preclude mapping at this scale. Site-specific case studies are required to establish ground snow loads at elevations not covered.

Rain

Results:

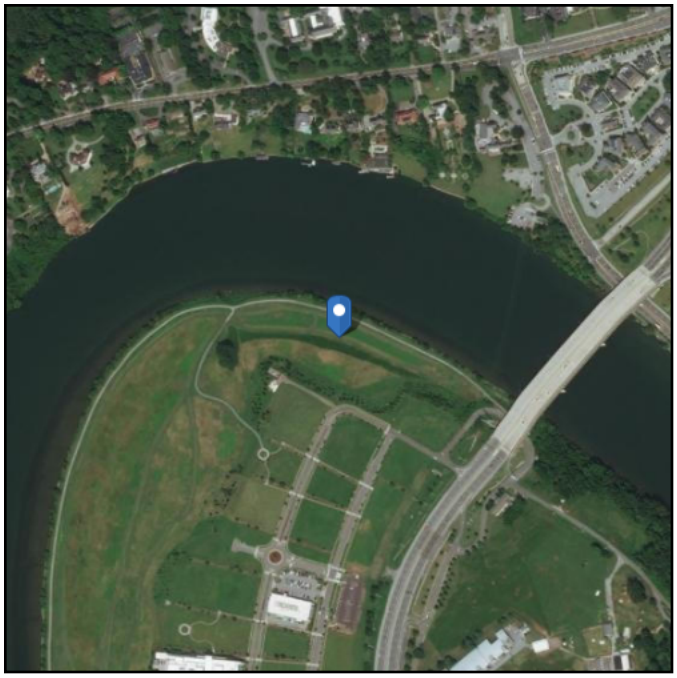
15-minute Precipitation Intensity:	5.75 in./h
60-minute Precipitation Intensity:	3.03 in./h

Data Source:	NOAA National Weather Service, Precipitation Frequency Data Server, Atlas 14 (https://www.nws.noaa.gov/oh/hdsc/)
Date Accessed:	Thu Mar 03 2022

Flood

Results:

Flood Zone Categorization:	X (unshaded)
Base Flood Elevation:	Refer to map for local elevations and interpolate according to the Authority Having Jurisdiction.
Data Source:	FEMA National Flood Hazard Layer - Effective Flood Hazard Layer for US, where modernized (https://msc.fema.gov/portal/search)
Date Accessed:	Thu Mar 03 2022
FIRM Panel:	If available, download FIRM panel here
Insurance Study Note:	Download FEMA Flood Insurance Study for this area here



The ASCE 7 Hazard Tool is provided for your convenience, for informational purposes only, and is provided “as is” and without warranties of any kind. The location data included herein has been obtained from information developed, produced, and maintained by third party providers; or has been extrapolated from maps incorporated in the ASCE 7 standard. While ASCE has made every effort to use data obtained from reliable sources or methodologies, ASCE does not make any representations or warranties as to the accuracy, completeness, reliability, currency, or quality of any data provided herein. Any third-party links provided by this Tool should not be construed as an endorsement, affiliation, relationship, or sponsorship of such third-party content by or from ASCE.

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Building Roof Profile Frame Analysis

Interior Portion of Building

Data Entry

Joint Coordinates

	Label	X [ft]	Y [ft]
1	N1	0	-10
2	N2	0	8
3	N3	15	-10
4	N4	15	6
5	N5	30	-10
6	N6	30	4
7	N7	-6	8.8

Boundary Conditions

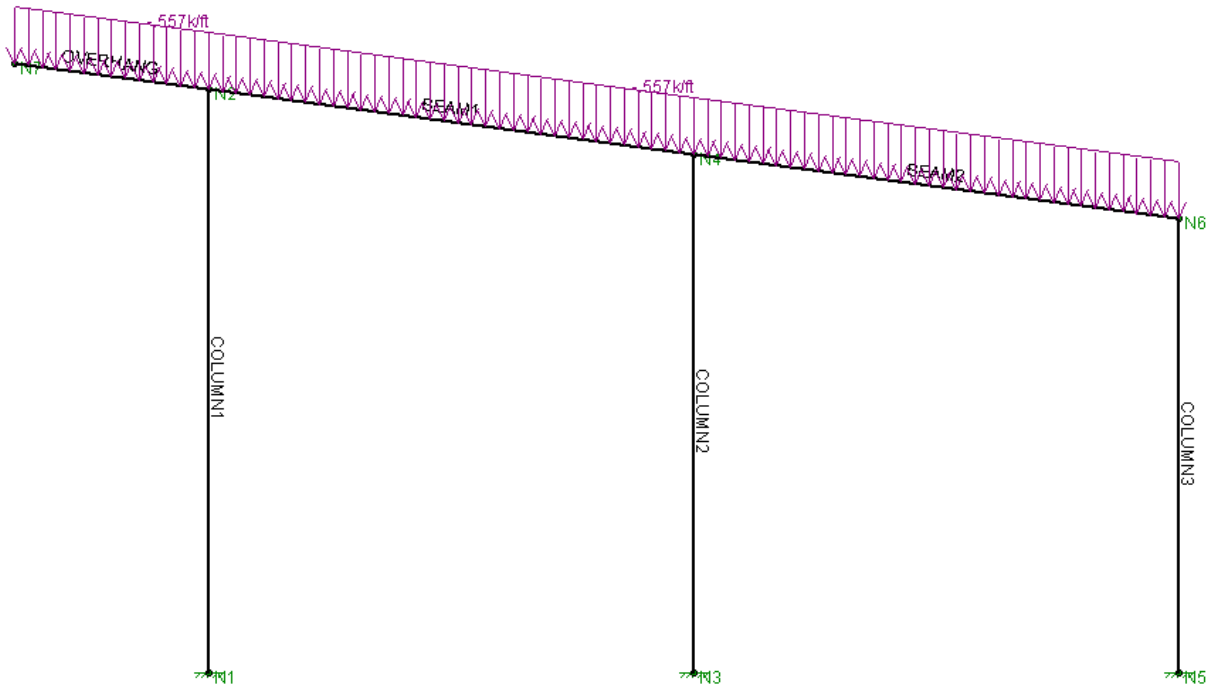
	Joint Label	X [k/in]	Y [k/in]	Rotation[k-...
1	N1	Reaction	Reaction	Reaction
2	N3	Reaction	Reaction	Reaction
3	N5	Reaction	Reaction	Reaction

Members

	Label	I Joint	J Joint	Area[in...	Inertia[...	Young's[ksi]	I Relea...	J Rele...	Length...
1	OVERHANG	N2	N7	64	200.083	2000			6.053
2	BEAM1	N2	N4	64	200.083	2000			15.133
3	BEAM2	N4	N6	64	200.083	2000			15.133
4	COLUMN1	N1	N2	64	200.083	2000			18
5	COLUMN2	N3	N4	64	200.083	2000			16
6	COLUMN3	N5	N6	64	200.083	2000			14

Member Distributed Loads

	Member Label	Directi...	Start Magnitude[k/ft]	End Magni...	Start Locat...	End Locati...
1	OVERHANG	Y	-.557	-.557	0	36
2	BEAM1	Y	-.557	-.557	0	36
3	BEAM2	Y	-.557	-.557	0	36



Results

Joint Reactions

	Joint Label	X [k]	Y [k]	MZ [k-ft]
1	N1	.113	7.587	-1.163
2	N3	.281	8.951	-2.119
3	N5	-.394	3.691	1.033
4	Totals:	0	20.229	-2.25

Joint Deflections

	Joint Label	X [in]	Y [in]	Rotation [r...
1	N1	0	0	0
2	N2	-.342	-.013	9.754e-4
3	N3	0	0	0
4	N4	-.342	-.013	-7.613e-4
5	N5	0	0	0
6	N6	-.341	-.005	8.692e-3
7	N7	-.404	-.48	8.319e-3

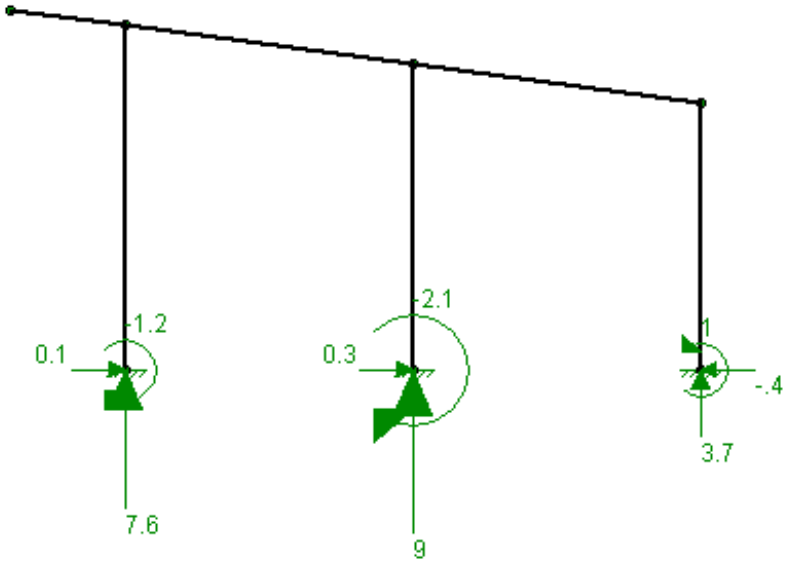
Member Section Forces

	Member Label	Sec	Axial[k]	Shear[k]	Moment[k-ft]
1	OVERHANG	1	.446	-3.342	10.115
2		2	.334	-2.506	5.69
3		3	.223	-1.671	2.529
4		4	.111	-.835	.632
5		5	0	0	0
6	BEAM1	1	-.446	4.194	-10.977
7		2	-.167	2.105	.937
8		3	.111	.016	4.949
9		4	.39	-2.073	1.059
10		5	.668	-4.161	-10.733
11	BEAM2	1	-.236	4.748	-13.117
12		2	.043	2.659	.895
13		3	.321	.571	7.004
14		4	.6	-1.518	5.211
15		5	.878	-3.607	-4.483
16	COLUMN1	1	7.587	-.113	1.163
17		2	7.587	-.113	.657
18		3	7.587	-.113	.151
19		4	7.587	-.113	-.356
20		5	7.587	-.113	-.862
21	COLUMN2	1	8.951	-.281	2.119
22		2	8.951	-.281	.994
23		3	8.951	-.281	-.132
24		4	8.951	-.281	-1.258
25		5	8.951	-.281	-2.384
26	COLUMN3	1	3.691	.394	-1.033
27		2	3.691	.394	.346
28		3	3.691	.394	1.725
29		4	3.691	.394	3.104
30		5	3.691	.394	4.483

Member Section Deflections

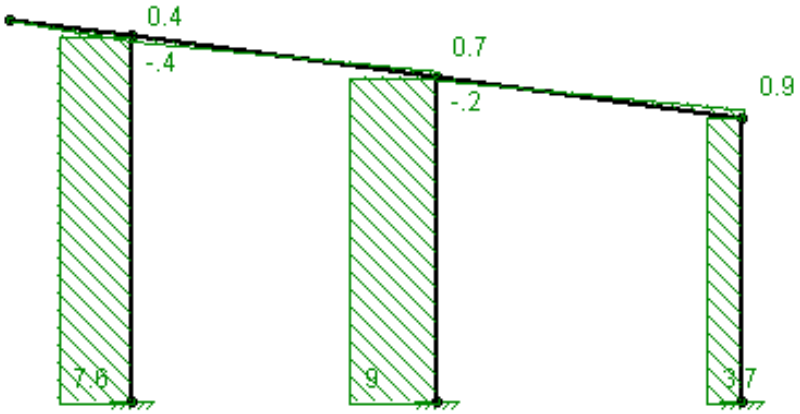
	Member Label	Sec	x [in]	y [in]
1	OVERHANG	1	.337	.058
2		2	.337	.118
3		3	.337	.235
4		4	.337	.378
5		5	.337	.529
6	BEAM1	1	-.337	-.058
7		2	-.337	-.21
8		3	-.337	-.344
9		4	-.337	-.214
10		5	-.337	-.058
11	BEAM2	1	-.337	-.058
12		2	-.337	-.334
13		3	-.337	-.594
14		4	-.337	-.463
15		5	-.337	-.05
16	COLUMN1	1	0	0
17		2	-.003	.043
18		3	-.006	.144
19		4	-.01	.259
20		5	-.013	.342
21	COLUMN2	1	0	0
22		2	-.003	.06
23		3	-.007	.189
24		4	-.01	.309
25		5	-.013	.342
26	COLUMN3	1	0	0
27		2	-.001	-.015
28		3	-.002	-.012
29		4	-.004	.082
30		5	-.005	.341

Reactions



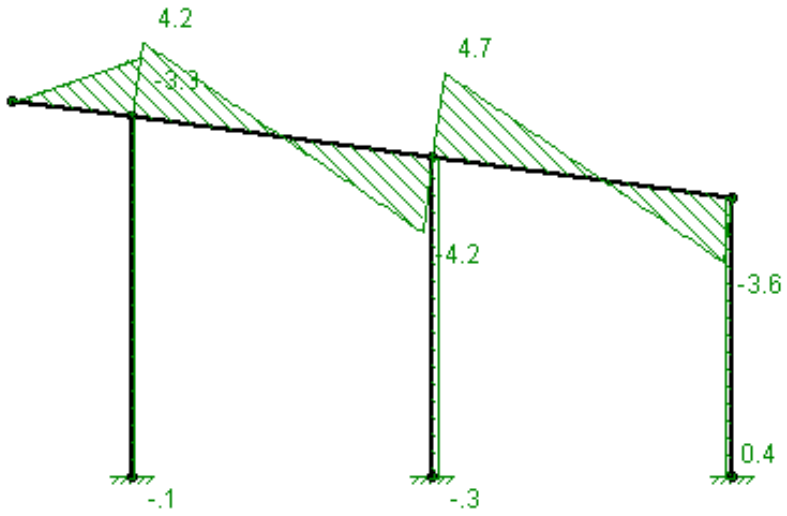
Reaction units are k and k-ft

Axial



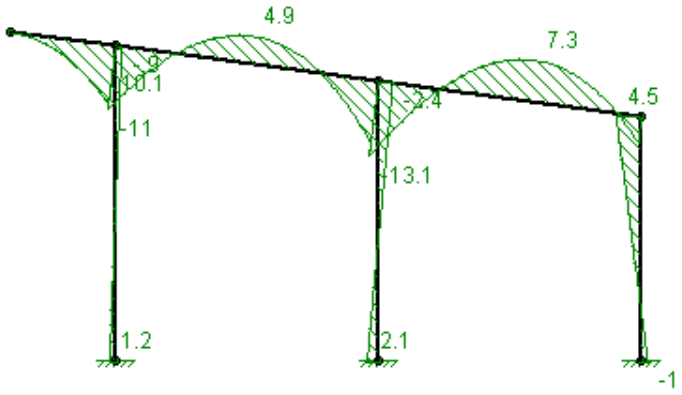
Member Axial Forces (k)

Shear Diagram



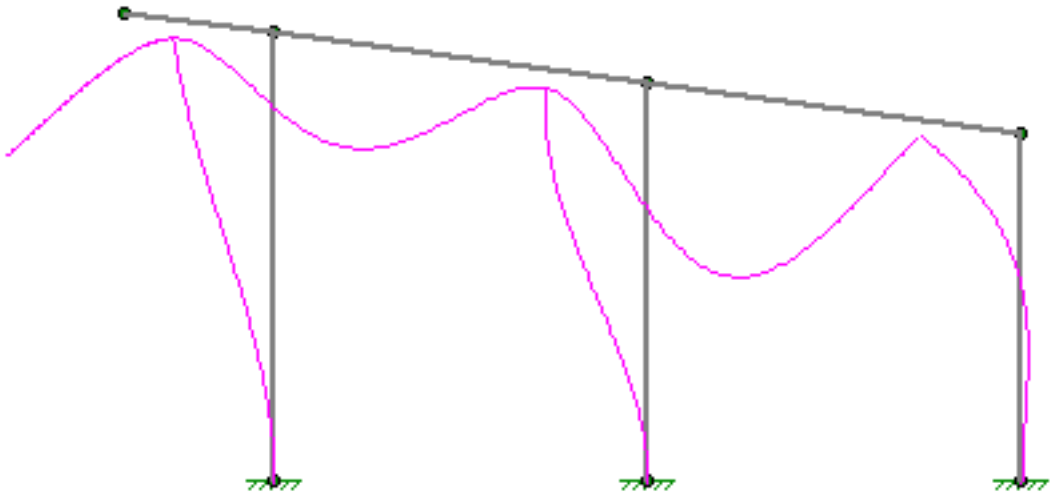
Member Shear Forces (k)

Moment Diagram



Member Bending Moments (k-ft)

Deflection Diagram



Exterior Portion of Building (Pavilion)

Data Entry

Joint Coordinates

	Label	X [ft]	Y [ft]
1	N1	0	18.8
2	N2	6	0
3	N3	12	17.2
4	N4	24	15.6
5	N5	30	0
6	N6	36	14

Boundary Conditions

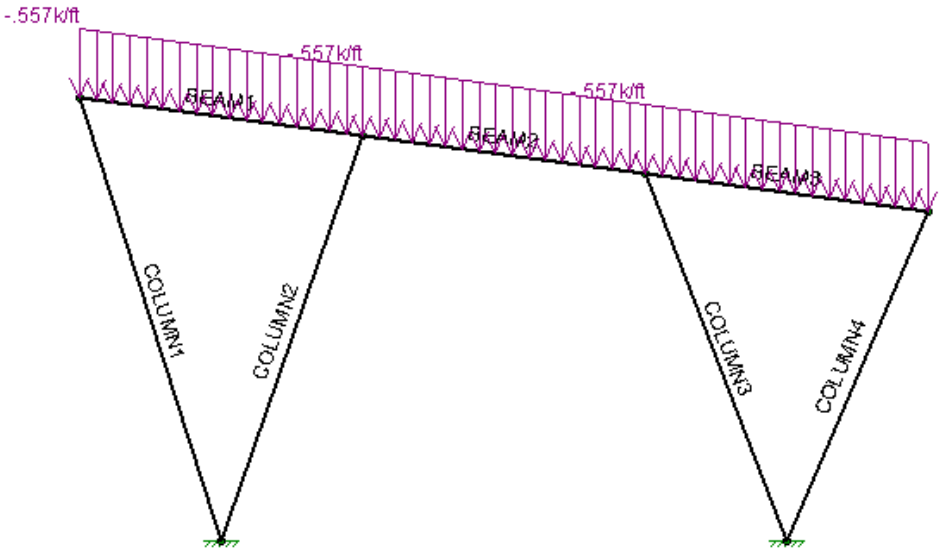
	Joint Label	X [k/in]	Y [k/in]	Rotation[k-...
1	N2	Reaction	Reaction	Reaction
2	N5	Reaction	Reaction	Reaction

Members

	Label	I Joint	J Joint	Area[in...	Inertia[...	Young's[ksi]	I Relea...	J Rele...	Length...
1	BEAM1	N1	N3	49	200.083	2000			12.106
2	BEAM2	N3	N4	49	200.083	2000			12.106
3	BEAM3	N4	N6	49	200.083	2000			12.106
4	COLUMN1	N1	N2	49	200.083	2000			19.734
5	COLUMN2	N2	N3	49	200.083	2000			18.216
6	COLUMN3	N4	N5	49	200.083	2000			16.714
7	COLUMN4	N5	N6	49	200.083	2000			15.232

Member Distributed Loads

	Member Label	Directi...	Start Magnitude[k/ft]	End Magni...	Start Locat...	End Locati...
1	BEAM1	Y	-.557	-.557	0	36
2	BEAM2	Y	-.557	-.557	0	36
3	BEAM3	Y	-.557	-.557	0	36



Results

Joint Reactions

	Joint Label	X [k]	Y [k]	MZ [k-ft]
1	N2	1.733	10.051	-1.791
2	N5	-1.733	10.178	.262
3	Totals:	0	20.229	-1.529

Joint Deflections

	Joint Label	X [in]	Y [in]	Rotation [r...
1	N1	-.124	-.047	-4.107e-3
2	N2	0	0	0
3	N3	-.114	.022	1.046e-3
4	N4	-.128	-.066	-8.196e-4
5	N5	0	0	0
6	N6	-.112	.042	5.385e-3

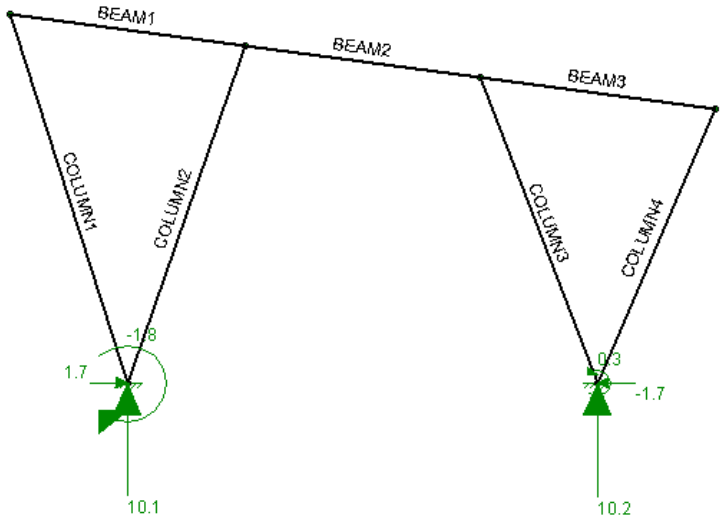
Member Section Forces

	Member Label	Sec	Axial[k]	Shear[k]	Moment[k-ft]
1	BEAM1	1	-1.115	2.884	-2.787
2		2	-.893	1.213	3.413
3		3	-.67	-.458	4.554
4		4	-.447	-2.129	.639
5		5	-.224	-3.8	-8.334
6	BEAM2	1	1.281	3.508	-8.176
7		2	1.504	1.837	-.088
8		3	1.727	.166	2.943
9		4	1.949	-1.505	.917
10		5	2.172	-3.176	-6.167
11	BEAM3	1	-1.423	3.69	-7.425
12		2	-1.201	2.019	1.214
13		3	-.978	.348	4.796
14		4	-.755	-1.323	3.32
15		5	-.532	-2.994	-3.213
16	COLUMN1	1	3.084	-.224	2.787
17		2	3.084	-.224	1.682
18		3	3.084	-.224	.578
19		4	3.084	-.224	-.526
20		5	3.084	-.224	-1.63
21	COLUMN2	1	7.462	0	.161
22		2	7.462	0	.16
23		3	7.462	0	.16
24		4	7.462	0	.159
25		5	7.462	0	.158
26	COLUMN3	1	7.749	-.134	1.258
27		2	7.749	-.134	.697
28		3	7.749	-.134	.136
29		4	7.749	-.134	-.425
30		5	7.749	-.134	-.986
31	COLUMN4	1	3.027	.293	-1.248
32		2	3.027	.293	-.133
33		3	3.027	.293	.982
34		4	3.027	.293	2.097
35		5	3.027	.293	3.213

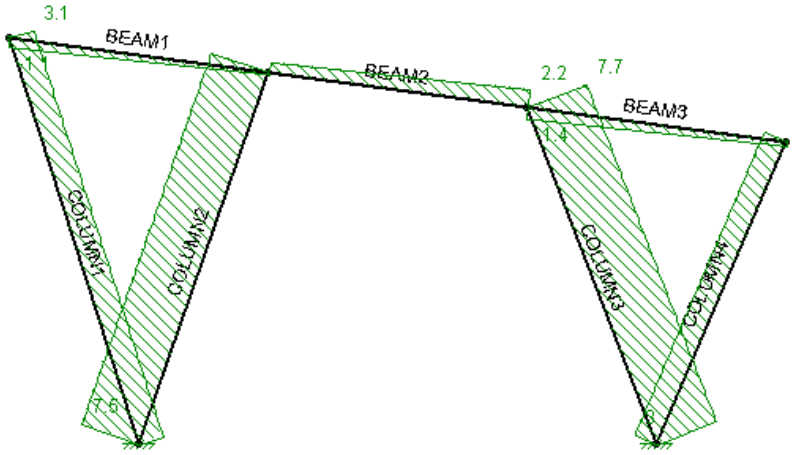
Member Section Deflections

	Member Label	Sec	x [in]	y [in]
1	BEAM1	1	-.117	-.063
2		2	-.116	-.218
3		3	-.116	-.255
4		4	-.116	-.128
5		5	-.116	.007
6	BEAM2	1	-.116	.007
7		2	-.116	-.055
8		3	-.117	-.137
9		4	-.118	-.12
10		5	-.118	-.083
11	BEAM3	1	-.118	-.083
12		2	-.118	-.194
13		3	-.118	-.274
14		4	-.117	-.181
15		5	-.117	.027
16	COLUMN1	1	.007	-.133
17		2	.006	-.249
18		3	.004	-.188
19		4	.002	-.066
20		5	0	0
21	COLUMN2	1	0	0
22		2	-.004	.007
23		3	-.008	.029
24		4	-.012	.065
25		5	-.017	.115
26	COLUMN3	1	.016	-.143
27		2	.012	-.144
28		3	.008	-.092
29		4	.004	-.03
30		5	0	0
31	COLUMN4	1	0	0
32		2	-.001	-.027
33		3	-.003	-.063
34		4	-.004	-.037
35		5	-.006	.12

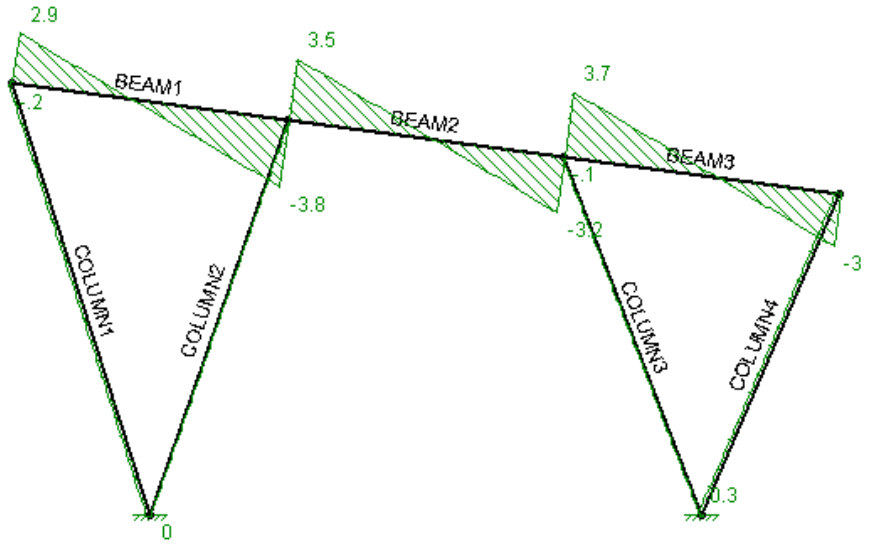
Reactions



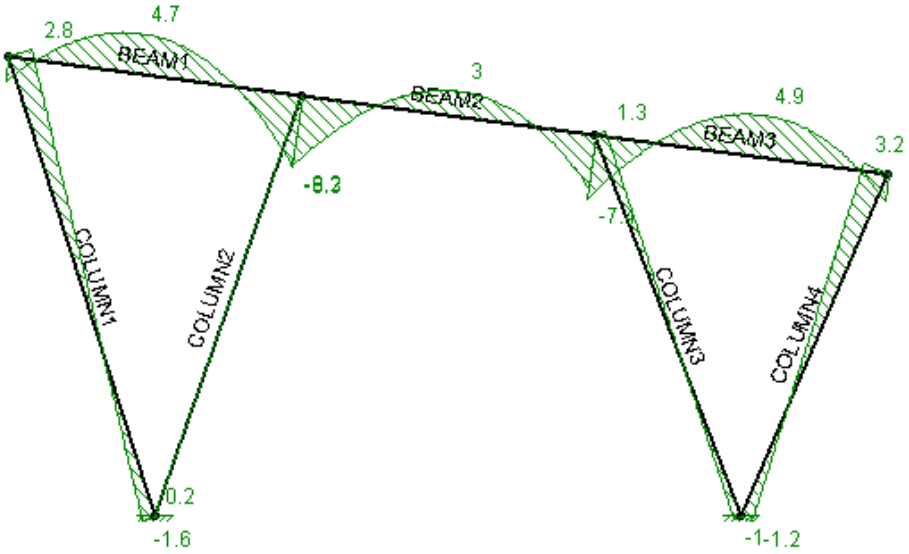
Axial



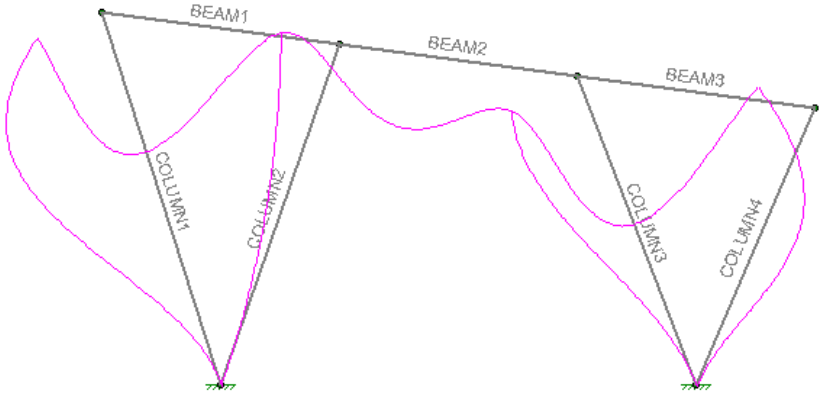
Shear Diagram



Moment Diagram

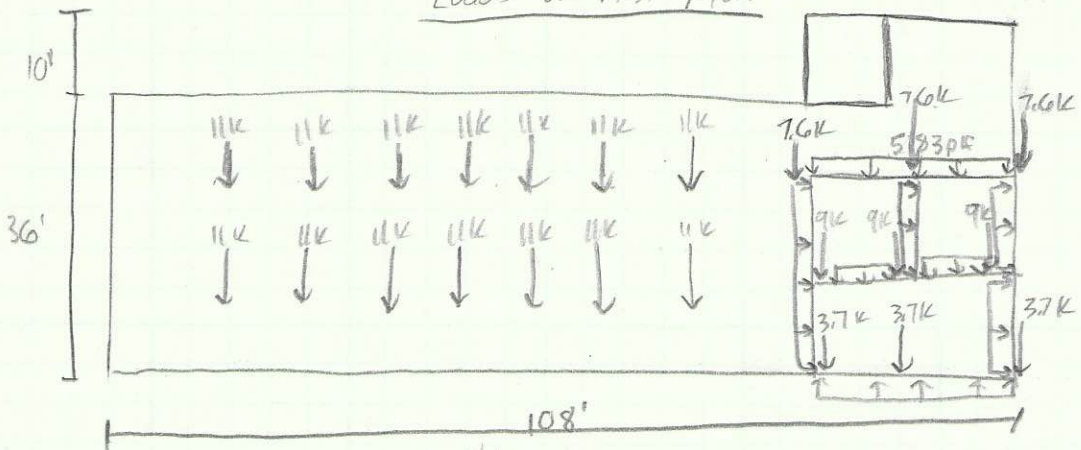


Deflection Diagram



First Floor Analysis

Loads on First Floor



Plan View

- Approximate weight of 2x6 stud/drywall framing plus galvanized steel veneer:

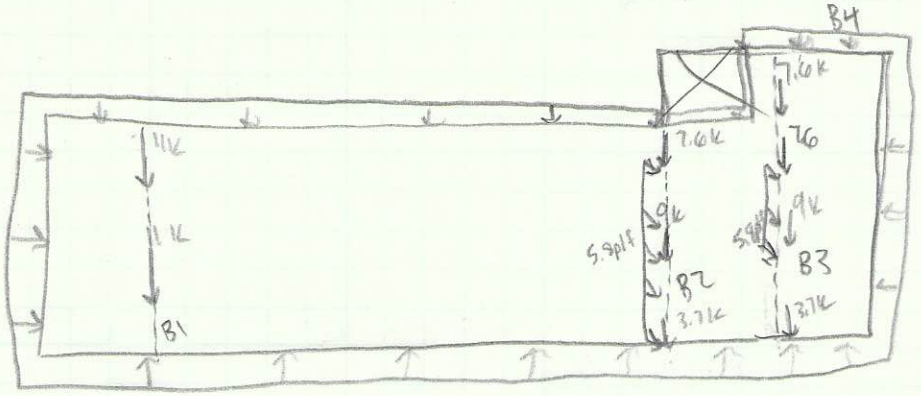
$$2.0 + 2.0 + 6psf = 10psf$$

- Approximate thickness of wall: 7 in

- Uniform load due to timber framing: $(10psf)\left(\frac{7}{12}ft\right) = 5.83\ lb/ft$

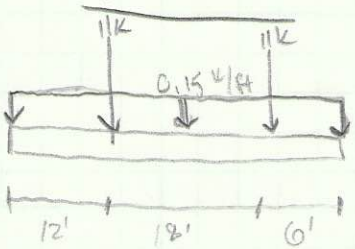
- Point loads generated from RISA analysis of timber beams and columns

- Weight of 1.5 VLR-20 GA Vulcraft composite deck for floor: 25psf

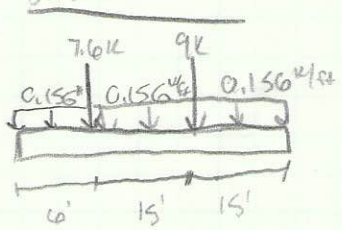


Beam spacing of 6ft produces a U.D.L. of 150plf

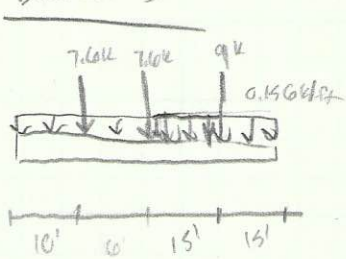
Beam 1



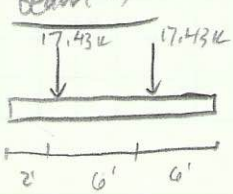
Beam 2



Beam 3



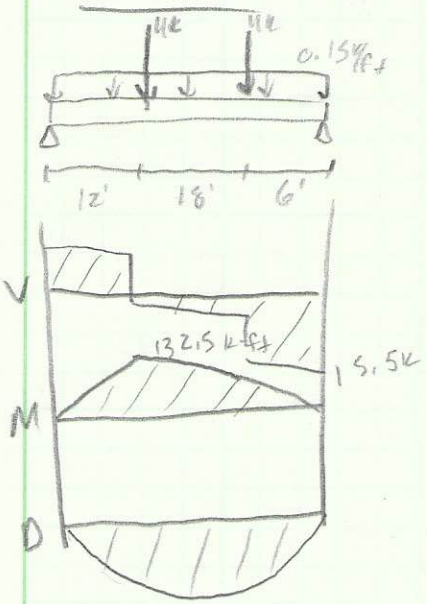
Beam 4



First Floor Analysis

Beam Analysis

Beam 1



$M_{max} = 132.5$ k-ft

$V_{max} = 15.64$ kips

$\Delta_{max} = 1.76$ in

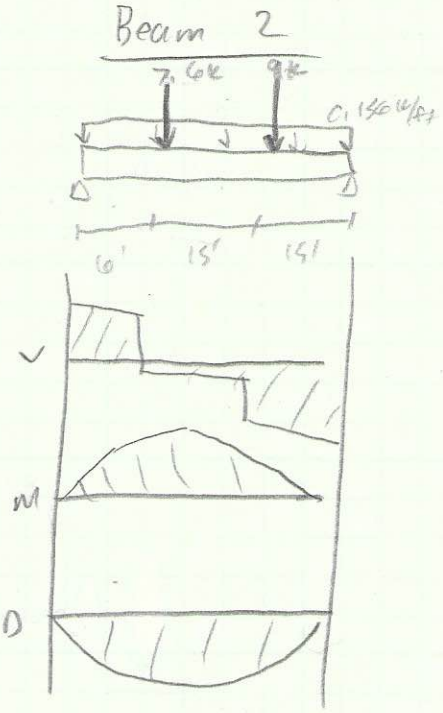
W12x72

Table 3-4 AISC Manual

$I = 597 in^4$

$\Delta_{max} = \frac{L}{240} = \frac{(360)(12)}{240} = 1.8$ in

Beam 2



$M_{max} = 122.32$ k-ft

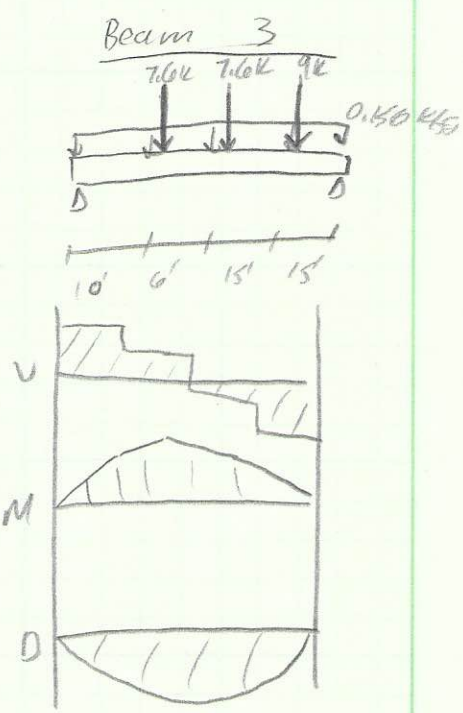
$V_{max} = 12.89$ kip

$\Delta_{max} = 1.53$ in

$\frac{L}{240} = 1.8$ in

W 12x72

Beam 3



$M_{max} = 213.3$ k-ft

$V_{max} = 17.43$ kip

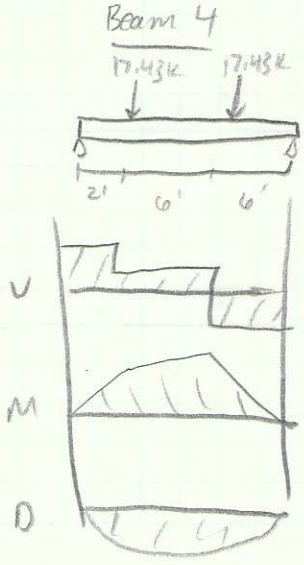
$\Delta_{max} = 2.04$ in

$\frac{L}{240} = 2.3$ in

W14x120

$I = 1380 in^4$

Beam 4



$M_{max} = 74.7$ kip-ft

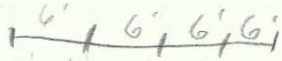
$V_{max} = 22.41$ kip

$\Delta_{max} = 0.33$ in

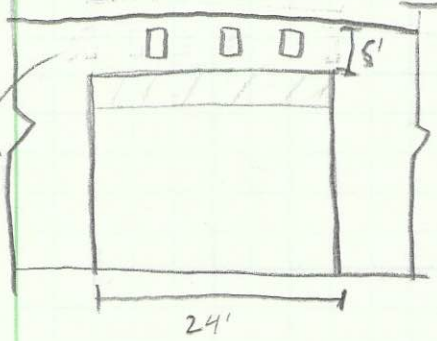
$\frac{L}{240} = 0.7$ in

W10x45

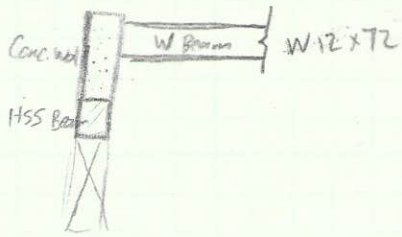
Header Beams

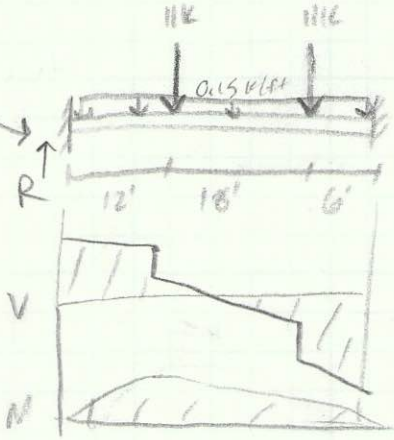


Header Beam Analysis and Design (Garage Opening)



Section view



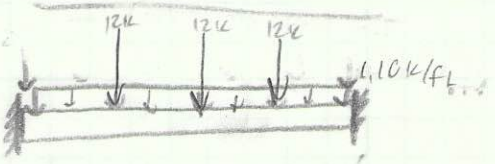


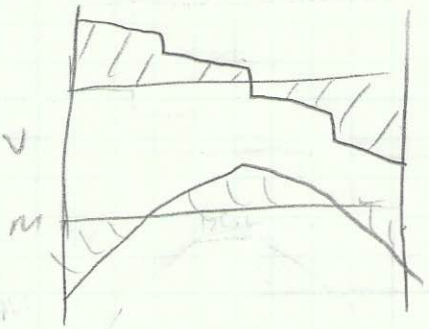
R = 12 kips

(Use as point loads for header beam design)

Concrete Load $= (145 pcf)(5')(1.5') = 1,10\ k/ft$

Header Beam FBD





V_{max} 31.2 kips

$M_{max} = 142.8$ k-ft

Table 3-13 AISC

$\phi M_n > M_u$

177 k-ft > 142.8 k-ft

HSS 10x10x3/8

$V_u < \phi V_n$

$h = H - 3t$

$h = 10 - 3(0.349)$

$h = 8.95$

$\frac{h}{t} = \frac{8.95 in}{0.349} = 24.7$

$1.10\sqrt{\frac{k_v E}{F_y}}$

$1.10\sqrt{\frac{5(29000 ksi)}{50 ksi}} = 59.2$

59.2 > 24.7

$C_{v2} = 1.0$

Header Beams

$$V_n = 0.6 F_y A_w C_{v2}$$

$$V_n = 0.6\,(50\text{ksi})\,(2(8.95)(0.349))\,(1.0)$$

$$V_n = 187.4 \text{ kips}$$

$$\phi V_n = 0.9(187.4 \text{ kips})$$

$$\phi V_n = 168.67 \text{ kips} \checkmark$$

$$\Delta_{max} = \frac{L}{240}$$

$$\Delta_{max} = \frac{(24\text{ft})(12)}{240}$$

$$\Delta_{max} = 1.2 \text{ in}$$

$I = 202 \text{ in}^4$ $E = 29000 \text{ ksi}$

$$\Delta = 0.79 \text{ in} \checkmark$$

$$\phi V_n > V_u \checkmark$$

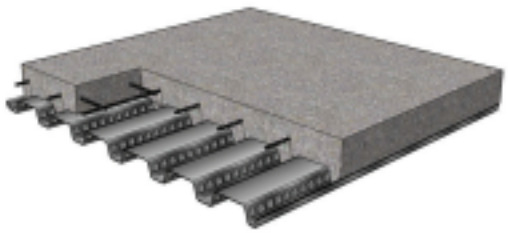
$$\Delta_{max} > \Delta \checkmark$$

HSS 10 x 10 x 3/8

1.5VL / 1.5VLI COMPOSITE DECK

SECTION PROPERTIES

Deck Gauge	Design Thickness	Deck Weight	Section Properties				V_s	F_y
			I_p	S_p	I_n	S_n		
	(in.)	(psf)	(in^4/ft)	(in^3/ft)	(in^4/ft)	(in^3/ft)	(lbs/ft)	(ksi)
22	0.0295	1.67	0.139	0.167	0.173	0.177	2626	50
20	0.0358	2.03	0.182	0.218	0.216	0.226	3171	50
19	0.0418	2.37	0.224	0.259	0.252	0.275	3685	50
18	0.0474	2.69	0.265	0.298	0.286	0.314	4160	50
16	0.0598	3.40	0.362	0.389	0.362	0.396	4156	40



(N = 9.35) NORMAL WEIGHT CONCRETE (145 PCF)

TOTAL SLAB DEPTH	DECK TYPE	SDI Max. Unshored Clear Span			Superimposed Live Load (PSF) Clear Span (ft-in.)														
		1 SPAN	2 SPAN	3 SPAN	5'-0	5'-6	6'-0	6'-6	7'-0	7'-6	8'-0	8'-6	9'-0	9'-6	10'-0	10'-6	11'-0	11'-6	12'-0
3.50 (t=2.00) 33 psf	1.5VL22	6'-4	7'-5	7'-8	314	279	250	206	188	169	154	141	130	120	111	100	87	76	67
	1.5VL20	7'-7	8'-10	9'-0	345	306	275	249	227	208	171	157	144	134	124	108	94	82	73
	1.5VL19	8'-1	9'-10	10'-0	372	330	298	268	244	224	207	171	157	146	134	116	101	88	78
	1.5VL18	8'-7	10'-6	10'-9	395	351	315	285	260	238	220	204	168	156	142	123	107	94	82
	1.5VL16	9'-5	10'-5	10'-10	397	353	316	286	261	239	221	205	190	156	145	135	119	104	92
4.00 (t=2.50) 39 psf	1.5VL22	6'-0	7'-0	7'-2	366	325	291	240	216	196	179	164	151	139	129	119	111	103	96
	1.5VL20	7'-2	8'-5	8'-6	400	356	319	289	263	217	198	182	167	155	143	133	124	115	108
	1.5VL19	7'-8	9'-4	9'-6	400	383	344	311	283	260	215	197	182	168	156	145	135	126	115
	1.5VL18	8'-1	9'-11	10'-2	400	400	365	330	301	276	254	211	195	180	167	156	145	136	122
	1.5VL16	9'-0	9'-11	10'-3	400	400	365	330	301	276	255	236	220	180	167	155	145	136	127
4.50 (t=3.00) 45 psf	1.5VL22	5'-9	6'-9	6'-10	400	373	307	275	248	225	205	188	173	159	147	137	127	118	109
	1.5VL20	6'-10	8'-0	8'-1	400	400	366	331	274	249	227	208	192	177	164	152	142	132	123
	1.5VL19	7'-4	8'-11	9'-1	400	400	393	356	325	269	246	226	208	193	179	166	155	145	135
	1.5VL18	7'-9	9'-8	9'-9	400	400	400	378	344	316	262	241	222	206	191	178	166	155	145
	1.5VL16	8'-7	9'-6	9'-10	400	400	400	377	344	315	291	270	222	205	190	177	165	155	145
5.00 (t=3.50) 51 psf	1.5VL22	5'-6	6'-6	6'-6	400	400	347	311	280	255	232	213	195	180	167	154	143	133	124
	1.5VL20	6'-7	7'-8	7'-9	400	400	400	375	310	281	257	236	217	200	186	172	160	149	139
	1.5VL19	7'-1	8'-8	8'-8	400	400	400	400	387	304	278	255	235	218	202	188	175	163	153
	1.5VL18	7'-6	9'-1	9'-4	400	400	400	400	389	357	297	272	251	233	216	201	187	175	164
	1.5VL16	8'-2	9'-1	9'-5	400	400	400	400	388	356	328	271	250	232	215	200	187	175	164
5.50 (t=4.00) 57 psf	1.5VL22	5'-4	6'-3	6'-4	400	400	388	348	314	285	260	238	219	202	188	173	160	149	138
	1.5VL20	6'-4	7'-5	7'-6	400	400	400	383	346	315	287	263	243	224	208	193	179	167	156
	1.5VL19	6'-10	8'-2	8'-4	400	400	400	400	374	340	311	288	263	243	226	210	196	183	171
	1.5VL18	7'-3	8'-9	9'-0	400	400	400	400	400	363	332	305	281	260	241	225	210	196	183
	1.5VL16	7'-10	8'-9	9'-0	400	400	400	400	400	398	330	303	280	259	240	224	209	195	183
6.00 (t=4.50) 63 psf	1.5VL22	5'-2	6'-0	6'-1	400	400	400	385	348	315	288	263	242	223	207	191	178	166	153
	1.5VL20	6'-1	7'-2	7'-3	400	400	400	400	383	348	318	292	269	248	230	214	199	185	173
	1.5VL19	6'-7	7'-11	8'-0	400	400	400	400	400	377	344	316	291	270	250	233	217	202	189
	1.5VL18	7'-0	8'-5	8'-9	400	400	400	400	400	400	367	337	311	288	267	249	232	217	203
	1.5VL16	7'-7	8'-5	8'-9	400	400	400	400	400	400	365	336	310	286	266	248	231	216	202

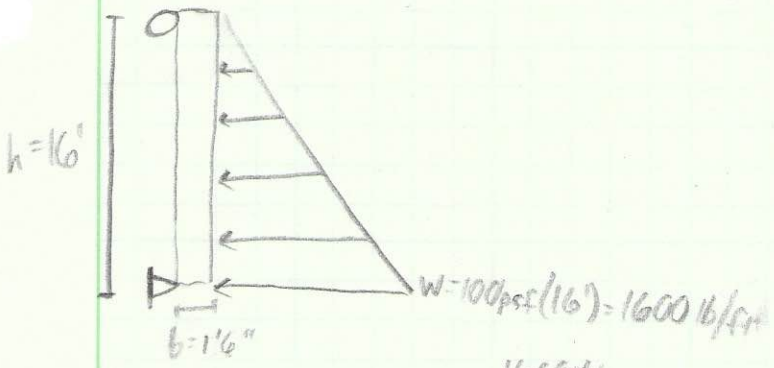
Notes:

1. Maximum unshored spans do not consider web crippling. Required bearing should be determined based on allowable reactions on page 43 or with the Vulcraft Unshored Span Calculator available at www.vulcraft.com/designtools. The following conditions are required to meet the maximum unshored spans shown:
   - •Minimum exterior bearing length of 1.5" for 22 to 16 gage.
   - •Minimum interior bearing length of 2" for 22 to 16 gage.
2. Always contact Vulcraft when using loads in excess of 200 psf. Such loads often result from concentrated, dynamic or "long term" load cases for which reductions due to bond breakage, concrete creep etc. should be evaluated.
3. All fire rated assemblies are subject to an upper live load limit of 250 psf.

COMPOSITE

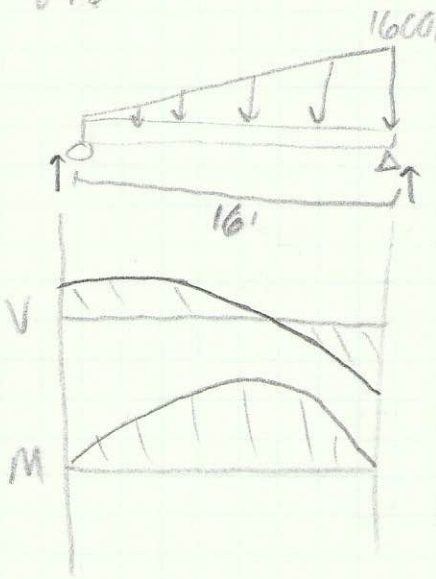
Building Basement Wall

Basement Retaining Wall Analysis



$\phi M_n > M_u$ (Vertical Reinforcement Bars)

$\rho_{min} = 0.0022bh$



#6 bars

$M_u = 26.214$ kip-ft $\quad M_n = A_s f_y \left(d - \frac{a}{2}\right)$

$V_u = 8.53$ kips

$\frac{h_w}{l_w} = \frac{16'}{16'} = 1$ $\quad h_w = 16'$

$\rho_w = \frac{A_s}{b_w d} = \frac{0.44 in^2}{(12.5")\left(\frac{1.25"}{12}\right)} = 0.34$ $\quad \alpha_c = 3$ $\quad h_w/l_w \leq 1.5$

A_{cw} = Area of concrete section
$(1.5')(16') = 24 ft^2$

ACI 318-19 (Section 11.6)

$V_u \leq 0.5 \phi \alpha_c 2\sqrt{f'_c} A_{cw}$

$8.53 \leq 0.5(0.75)(3)(1)(\sqrt{4000psi})(24ft^2 \cdot 144) = 10245.8 lb = 10.2K$

8.53 kips $\leq 10.2K$ ✓

Foundation Wall | Wall Design Check | ACI 318-19

$f'_c = 4000_{psi}$ NWC

$f_y = 60000_{psi}$

Slab thickness = 6 in

Wall thickness = 18 in

Wall length = 84 ft

#6 @ 12 in

- Cast in Place
- Deformed bars greater than #5

Horizontal Reinforcement Check

$$\rho_t = \frac{A_{v,horizontal}}{h \times s_2} = \frac{(2)(0.44\,in^2)}{(18\,in)(12\,in)} = 0.0041$$

$\rho_t = 0.0041$

$\rho_{t,min} = 0.0025$ (Table 11.6.1 ACI 318-19) ✓

$$s_{t,max} = \text{Smallest of} \begin{Bmatrix} 3 \times h \\ 18\,in \\ l_w/5 \end{Bmatrix} = \begin{Bmatrix} 3(18\,in) \\ 18\,in \\ 1008/5 \end{Bmatrix} = \begin{Bmatrix} 54\,in \\ 18\,in \\ 201.6 \end{Bmatrix} = 18\,in$$

$s_{t,provided} = 12\,in \leq s_{t,max} = 18\,in$ ✓

#6 @ 12in

Vertical Reinforcement Check

$$\rho_l = \frac{A_{v,vertical}}{h \times s_l} = \frac{(2)(0.44\,in^2)}{(18\,in)(12\,in)} = 0.0041$$

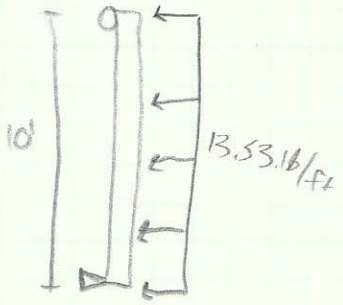
$\rho_{l,min} = 0.0015$ (Table 11.6.1 ACI 318-19) ✓

$$s_{l,max} = \text{Smallest} \begin{Bmatrix} 3h \\ 18\,in \\ l_w/3 \end{Bmatrix} = \begin{Bmatrix} 3(18) \\ 18 \\ 1008/5 \end{Bmatrix} = 18\,in$$

$s_{l,provided} = 12\,in \leq s_{l,max} = 18\,in$ ✓

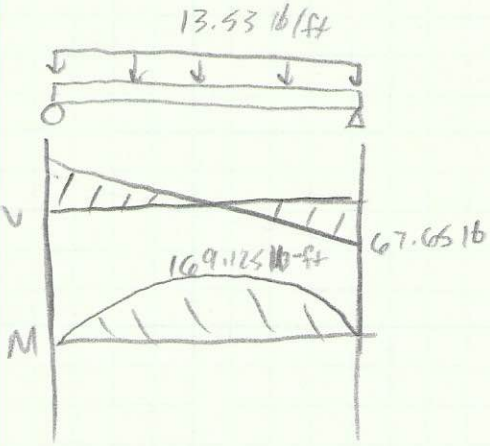
Building Elevator Wall

Reinforced Concrete Wall Analysis



9.017 psf - Wind load from ASCE 7 Wind load report for windward wall.

$9.017 psf \left(\frac{18}{12}\right) = 13.53 plf$ - Pick #5 bars @ 18 in to check for load on 18 in section of wall to obtain a uniform load for analysis.



$M_u = 0.169\ k\text{-}ft$

$V_u = 0.068\ Kips$

ACI 318-19 (Section 11.6)

$\frac{h_w}{l_w} = \frac{10'}{10'} = 1$

$A_{cv} = (12in)(120in)$

$A_{cv} = 1440in^2$

$a_c = 3 \quad h_w/l_w \leq 1.5$

$V_u \leq 0.5 \phi a_c \lambda \sqrt{f'_c} A_{cv}$

$0.068k \leq 0.5(0.75)(3)(1)\sqrt{4000psi}(1440in^2) = 102458lb$

$0.068k \leq 102.5k$ ✓

$f'_c = 4000 psi$ NWC

$f_y = 60000 psi$

Slab thickness = 4 in

Wall thickness = 12 in

Wall length = 15 ft

#5 @ 18 in

Horizontal Reinforcement check

$$\rho_t = \frac{A_{v,horizontal}}{h \times s_2} = \frac{(2)(0.31 in^2)}{(12 in)(18 in)} = 0.0029$$

$$\rho_t = 0.0029$$

$\rho_{t,min} = 0.0025$ (Table 11.6.1 ACI 318-19)

$$s_{t,max} = \text{Smallest of} \begin{Bmatrix} 3h \\ 18 in \\ L_w/5 \end{Bmatrix} = \begin{Bmatrix} 36 in \\ 18 in \\ 36 in \end{Bmatrix} = 18 in$$

$s_{t,provided} = 18 in \leq 18 in$ max ✓

Vertical Reinforcement Check

$$\rho_l = \frac{A_{v,vertical}}{h \times s_l} = \frac{(2)(0.31 in^2)}{(12 in)(18 in)} = 0.0029$$

#5 @ 18 in

$\rho_l = 0.0029$

$\rho_{l,min} = 0.0015$ (Table 11.6.1 ACI 318-19)

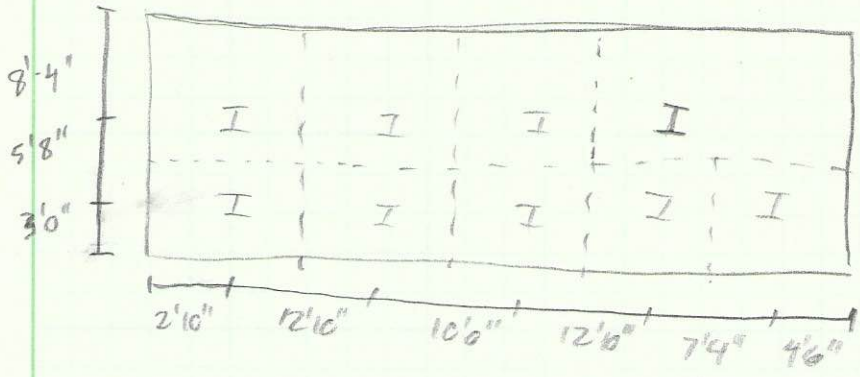
$$s_{l,max} = \text{Smallest of} \begin{Bmatrix} 3h \\ 18 in \\ L_w/3 \end{Bmatrix} = \begin{Bmatrix} 36 in \\ 18 in \\ 60 in \end{Bmatrix} = 18 in$$

$s_{l,provided} = 18 in \leq s_{l,max} = 18 in$ ✓

Dock Support Analysis

- See dock drawings for dimension references

Steel H-Pile Analysis



Max tabulary area =

$\left(\frac{12.83'}{2} + 7.33' + 4.5'\right)\left(\frac{5.67'}{2} + 8.33'\right)$

$= 203.71\ ft^2$

Thickness of slab considered for weight of concrete = 5'

Vertical load due to weight of concrete: $(145pcf)(203.71ft^2)(5ft)$

$= 147689.75\ lb = \underline{147.7\ kips}$

LRFD loads (LL, DL, SL): $1.2(15psf) + 1.6(85psf) + 0.5(10psf) = 159_{psf}$

$159_{psf}(203.71ft^2) = 32389.89\ lb = \underline{32.4\ kips}$

Total Vertical load on H-pile = $147.7K + 32.4K = \underline{180.1\ kips}$

- Use Table 4-2 of AISC 15 Manual to find HP shape that satisfies $\phi_c P_n > P_u$ for LRFD.

$L_c = 20ft$ **HP 10x42**

$\phi_c P_n = 270\ kips > P_u = 180.1\ kips$

Tennessee River Flow Rate Estimation

Equation: F = Q*density*V*C C=.9

River Width (ft)	Douglas Flow Rate (ft^3/s)	Cherokee Flow Rate (ft^3/s)	River Area (ft^2)	River Velocity (ft/s)	Ft. Louden Lake Contuors	TVA Lake Flow Rates
700	17709	11332	9450	7.407407	http://fishi	https://www.tva.com/Environmen
	70,000					
			mph	lbs	lbs/ft	
			5.050505	2299.259	287.4074	

Dock Analysis

Wave Force

Design and construction of buildings and other structures subject to wave loads shall account for the following loads: waves breaking on any portion of the building or structure; uplift forces caused by shoaling waves beneath a building or structure, or portion thereof; wave runup striking any portion of the building or structure; wave-induced drag and inertia forces; and wave-induced scour at the base of a building or structure, or its foundation.

$BFE := 822\ ft$

$G := 810.24\ ft$

$d_s := 0.65 \cdot (BFE - G)$

$d_s = 7.644\ ft$ (Local still water depth)

$H_b := 0.78 \cdot d_s$

(Breaking wave height)

$H_b = 5.962\ ft$

5.4.4.2 Breaking Wave Loads on Vertical Walls

$C_p := 2.8$ (Risk Category II - Table 5.4-1)

$\gamma_w := 62.4\ \frac{lb}{ft^3}$

Max combined static and dynamic wave pressure

$P_{max} := C_p \cdot \gamma_w \cdot d_s + 1.2 \cdot \gamma_w \cdot d_s$

$P_{max} = (1.908 \cdot 10^3)\ \frac{lb}{ft^2}$

Eurzvh#ruHp djhII

Net breaking wave force per unit length of structure

$F_t := 1.1 \cdot C_p \cdot \gamma_w \cdot d_s^{\ 2} + 2.4 \cdot \gamma_w \cdot d_s^{\ 2}$

$F_t = (1.998 \cdot 10^4)\ \frac{lb}{ft}$

Dead Load

The dead load includes that total self-weight of the floating dock and gangway structure.

- Marine-grade 6160 Aluminum
- Proprietary extruded-aluminum frame
- Plastic encapsulated foam floats
- Nylodeck featuring Timberstrong hidden fastening system

$Dock := 3121\ lb$ $DL := \frac{3121\ lb}{600\ ft^2} = 5.202\ \frac{lb}{ft^2}$

Dock Analysis

Live Load

$LL := 85\ psf$ USDA - Floating Trail Bridges and Docks

Wind Load

A uniform wind load should be applied to all projected surfaces for horizontal design loads.

$W := 20\ psf$

Freeboard

A. Floating docks shall provide freeboard under the loading conditions listed below, with no more than 1" loss of freeboard after one year of service.

a. Floatation shall maintain a minimum freeboard of 16" and maximum of 20" under combined dock dead load and supported gangway and utility load.

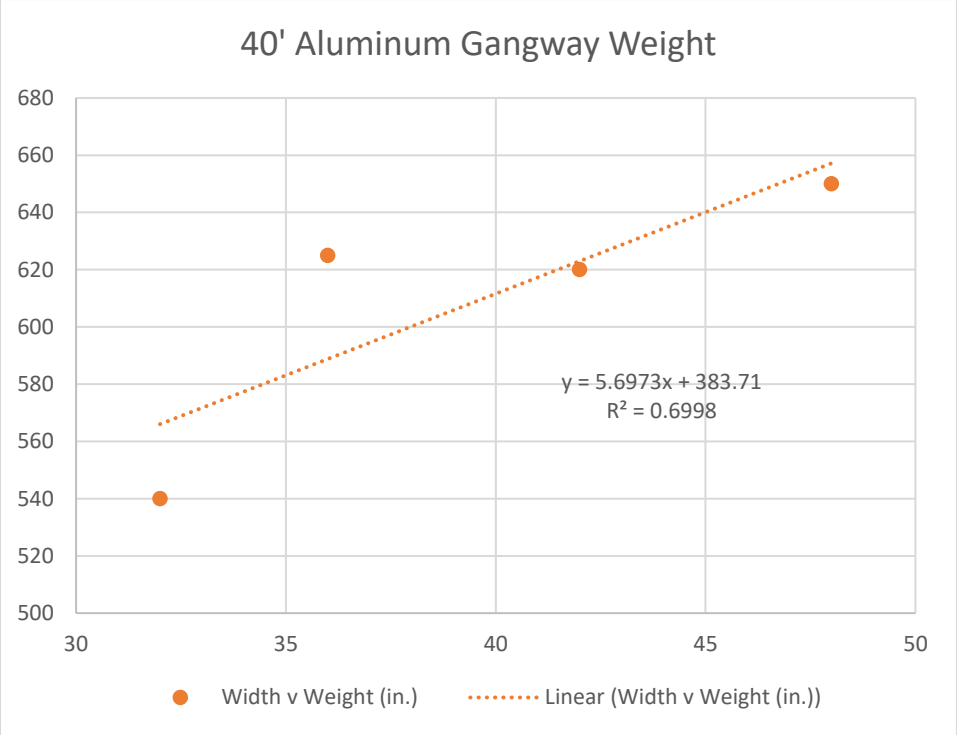
b. Floatation shall maintain freeboard of 8" under the dead load condition plus the live load specified in section 3 D, uniformly distributed across the entire decking.

B. When the floating dock must support a gangway, special condition must be given to ensure that adequate floatation is provided to the floating dock to support the tributary dead load of the gangway.

LOAD CALCULATIONS – FLOATING DOCK

DEAD: – 40' x 5' ALUMINUM GANGWAY

730 lb (ESTIMATED FROM LINEAR REGRESSION BELOW OF AVAILABLE COMMERCIAL OPTIONS)



– 8' x 10' FLOATING DOCK FRAME W/ FLOATS

UNIT WEIGHT = 255 lb, QUANTITY = 5

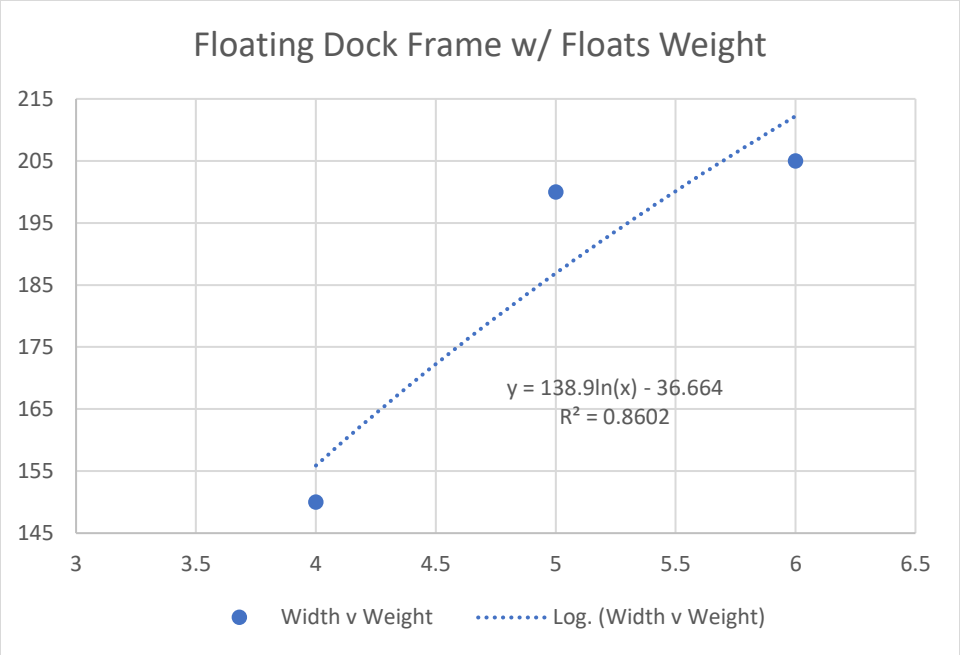
TOTAL WEIGHT = 255 lb x 5 = 1,275 lb

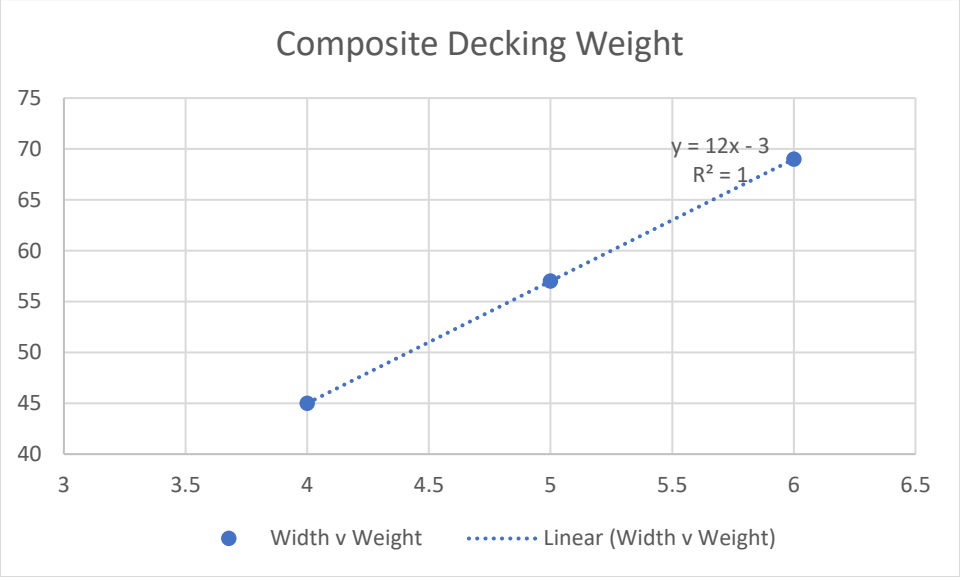
– 8' x 2.5' COMPOSITE DECKING, UNIT WEIGHT = 93 lb

QUANTITY = 20, TOTAL WEIGHT = 93 lb x 20 = 1860 lb

COMBINED TOTAL WEIGHT = 3,135 lb

(UNIT WEIGHTS ESTIMATED FROM LOGARITHMIC AND LINEAR REGRESSIONS BELOW OF AVAILABLE COMMERCIAL OPTIONS)


Floating Dock Frame w/ Floats Weight
215
205
195
185
175
165
155
145
3
3.5
4
4.5
5
5.5
6
6.5
y = 138.9ln(x) - 36.664
R² = 0.8602
Width v Weight
Log. (Width v Weight)


Composite Decking Weight
75
70
65
60
55
50
45
40
3
3.5
4
4.5
5
5.5
6
6.5
y = 12x - 3
R² = 1
Width v Weight
Linear (Width v Weight)

LOAD CALCULATIONS - FLOATING DOCK

DEAD: TOTAL DEAD = 730 lb + 3,135 lb = 3,865 lb

LIVE: 85 psf (FLOATING TRAIL BRIDGES & DOCKS, AVAILABLE IN REFERENCES)

WATER, FLOW: TENNESSEE RIVER WIDTH = 700 ft

AREA = 9450 ft^2

(ESTIMATED FROM FT. LOUDOUN LAKE CONTOURS AVAILABLE IN REFERENCES)

PEAK STREAM FLOW = 70,000 ft^3/s

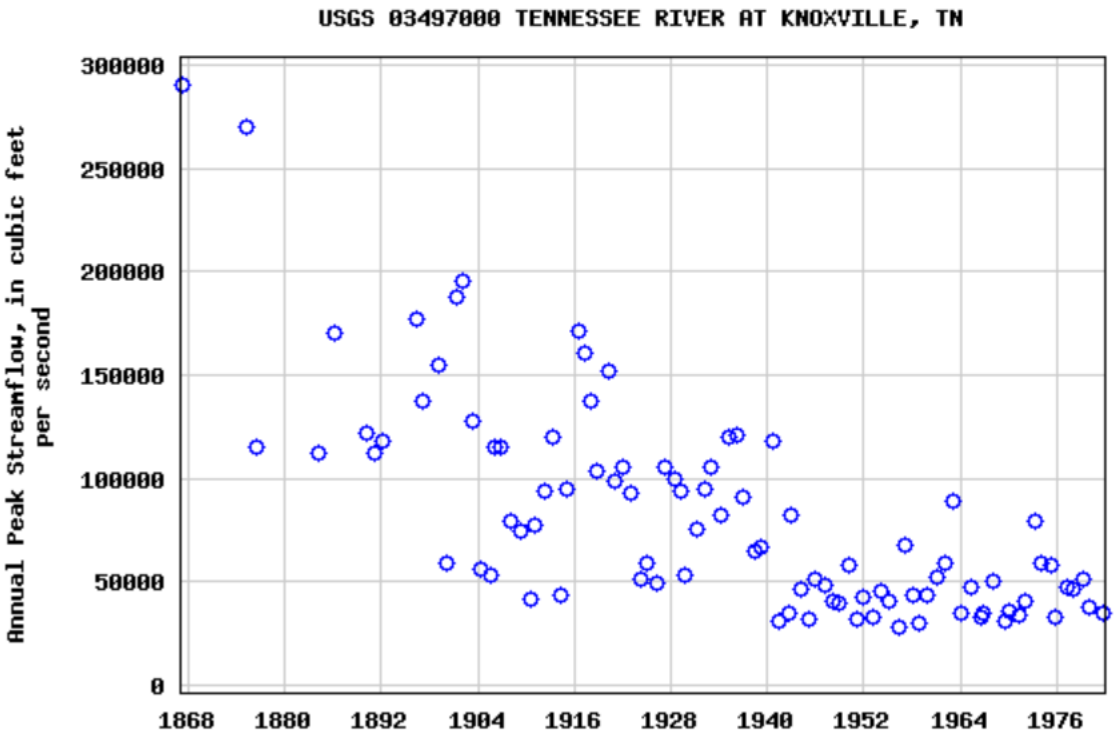
(ESTIMATED FROM PEAK ANNUAL STREAM FLOWS FROM 1950 - NOW CHART BELOW)

AREA OF DOCK FACING STREAM FLOW

$8' \times 3' = 24\ ft^2$

$$F_{FLOW} = \frac{1.94\ lb_m}{ft^3}\left(70{,}000\ \frac{ft^3}{s}\right)\frac{1}{9450\ ft^2}\left(24\ ft^2\right)741\ \frac{ft}{s}\left(\frac{1}{8\ ft}\right)$$

$$= 319.3\ lb/ft \quad \text{ON DOCK FACING FLOW}$$



LOAD CALCULATIONS – FLOATING DOCK

WATER, WAKE: NET BREAKING WAVE FORCE / LENGTH OF STRUCTURE, $F_w = 1.1 \cdot C_p \cdot \gamma_w \cdot d_s^2 + 2.4 \cdot \gamma_w \cdot d_s^2$

$C_p = 2.8$ (RISK CATEGORY II)

d_s = LOCAL STILLWATER DEPTH

$= (822 - 810.24)\,0.65 = 7.64$ ft

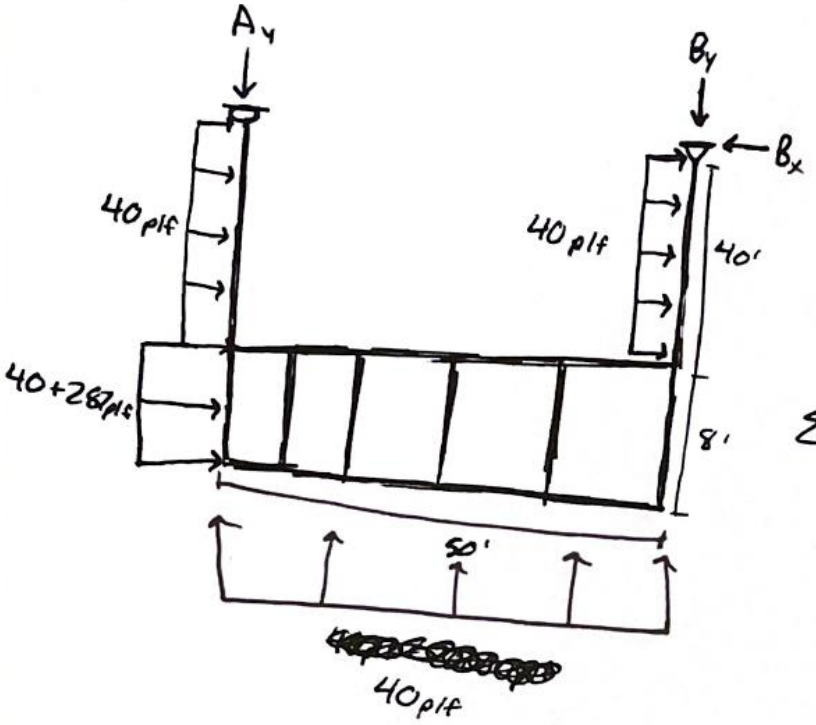
$F_w = 1.1\,(2.8)\,62.4 \frac{\text{lb}}{\text{ft}^3}\,(7.64\text{ ft})^2 + 2.4\,(62.4 \frac{\text{lb}}{\text{ft}^3})(7.64\text{ ft})^2$

$= 19{,}980$ lb/ft

(WAVE FORCE ANALYSIS FROM ASCE 7)

WIND: 20 psf ON ALL SURFACES (FROM TN.GOV TWRA GENERAL SPECIFICATIONS FOR DOCKS)

LOAD CALCULATIONS - FLOATING DOCK (WORST CASE FOR LATERAL LOADS)



$\Sigma M_B = 0 = A_y(50') + (40_{plf})(20')(40')$
$+ (40+287_{plf})(44')(8') - (40_{plf})(25')(50')$
$+ (40_{plf})(20')(40')$

$A_y = -2582.1$ lb

$\Sigma F_y = 0 = -2582.1\text{ lb} - B_y + (40_{plf})(50')$

$B_y = 582.1$ lb

$\Sigma F_x = 0 = (40_{plf})(40') + (40+287_{plf})(8') + (40_{plf})(40') - B_x$

$B_x = 5816$ lb

DOCK BEAM CONNECTION

$R_u = 2582$ lb

$R_n = F_{nv} A_b$, $\phi = .75$ (SHEAR BOLT)

GROUP A - THREAD EXCLUDED, $F_{nv} = 68$ ksi

1 BOLT, $R_u \geq \phi R_n$

$2.582 k \geq .75 (68 ksi) A_b$, $A_b \geq 0.0506 in^2$

$0.0506 \geq \pi r^2$, $r \geq 0.127$ in $\therefore$ $d = 1/2"$

$S_e \geq 3/4"$ (TABLE J3.4) $+ C_2$

$d_{fastener} = 1"$, OVERSIZED HOLE, $C_2 = 1/8"$ (TABLE J3.5)

$S_e \geq 3/4" + 1/8"$, $S_e \geq 7/8"$

$R_n = 2.4 d t F_u$ (BEARING) $\quad \phi = 0.75$

$R_n = 1.2 L_c t F_u$ (TEAROUT)

$R_n = 68 ksi (.196 in^2) = 13.35 k$, $F_u = 58$ ksi (TABLE 2-5)

$13.35 k = 2.4 (.5") t 58 ksi$, $t = 0.19" \Rightarrow 1/4"$

$13.35 k = 1.2 L_c (.25") 58 ksi$, $L_c = 0.767"$

Appendix E: Geotechnical

Knox County, Tennessee (TN093)

Knox County, Tennessee (TN093)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
ShC	Shady loam, 5 to 12 percent slopes	6.1	20.9%
So	Shady-Whitwell complex, 0 to 3 percent slopes, rarely flooded	3.0	10.1%
Uu	Urban land-Udorthents complex	1.7	5.7%
W	Water	4.1	13.9%
WeC	Waynesboro loam, 6 to 15 percent slopes	12.0	41.0%
WeD2	Waynesboro loam, 15 to 25 percent slopes, eroded	2.4	8.4%
Totals for Area of Interest		**29.3**	**100.0%**

Warning: Soil Map may not be valid at this scale.

GEOServices, LLC-Geotechnical and Materials Engineers

June 17, 2019

Realty Trust Group
2220 Sutherland Avenue
Knoxville, TN 37919

ATTENTION: Mr. Mark Miller
mmiller@realtytrustgroup.com

Subject: **REPORT OF GEOTECHNICAL AND GEOPHYSICAL EXPLORATION**
Proposed OTN Medical Office Building
Cherokee Farms Campus
Knoxville, Tennessee
GEOServices Project No. 21-19477

Dear Mr. Miller:

We are submitting the results of the geotechnical and geophysical exploration performed for the subject project. The exploration was performed in accordance with our Proposal No. 11-19287, dated April 30, 2019. The following report presents our findings and recommendations for the proposed project. Should you have any questions regarding this report, or if we can be of any further assistance, please contact us at your convenience.

Sincerely,
GEOServices, LLC

THOMAS BRIAN WILLIAMSON
REGISTERED ENGINEER
AGRICULTURE
COMMERCE
No. 118861
STATE OF TENNESSEE

Matthew B. Haston, P.E.
Senior Geotechnical Engineer

T. Brian Williamson, P.E.
Geotechnical Department Manager
TN 118,861

TBW/MBH:tbw

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relevant only to the time that this exploration was performed. Variations may occur and should be expected at the site.

Surficial

The borings were drilled in the grass covered areas and encountered 2 to 4 inches of topsoil.

Fill

Fill soil was encountered underlying the topsoil in borings B-1, B-2, and B-6 through B-11. Fill is a material which has been placed by man and machine. The fill was encountered to depths ranging from 2 to 5 feet below the ground surface. The fill was manually classified as varying shades of brown fat (high plasticity) clay and lean (lower plasticity) clays with trace amounts of gravel and/or organics. The SPT N-values within the fill soil ranged from 9 to 25 blows per foot (bpf), which corresponds to a soil consistency of stiff to very stiff. Laboratory testing of selected fill soil samples indicated natural moisture content values ranging from 22.9 to 41.3 percent. Plasticity testing of a select fill soil sample resulted in a liquid limit (LL) pf 58 percent and plasticity index (PI) of 31 percent. The tested fill sample classified as fat clay (CH).

Alluvial

Alluvial soil was encountered underlying the topsoil in borings B-1 through B-5 and B-9. Alluvial soil is a material which has been deposited by water. The alluvium was encountered to depths ranging from 17 to 40 feet below the ground surface. The alluvium was manually classified as varying shades of brown fat clay and lean clay with varying amounts of sand and rounded rock fragments and/or poorly graded and well graded sands. The SPT N-values within the alluvial soil ranged from 4 bpf to 50 blows with 1 inches of penetration, which corresponds to a soil consistency (relative density) of soft (very loose) to very hard (very dense). We note the soft soils were isolated to two borings (B-1 at 19 feet and B-9 at 9 feet). Additionally, SPT N-values indicating very hard/dense soils were likely elevated by rock fragments. The alluvial soils are generally firm (loose) to very stiff (medium dense).

Laboratory testing of selected alluvial soil samples indicated moisture content values ranging from 8.1 to 46.7 percent. Plasticity testing of a select alluvial soil sample resulted in a liquid limit (LL) of 46 percent and plasticity index (PI) of 22 percent. The tested sample classifies as lean clay (CL).

Residual Soil

Residual soils were encountered underlying the alluvial soils within the building area (except boring B-2) and below the fill material in the remaining borings (except B-9). Residual soils are derived from the in-place weathering of the parent bedrock. The residual soil was manually classified as varying shades of brown fat and lean clay soils. The residual soils also occasionally contained chert fragments

The SPT-N values within the residual soil ranged from weight of hammer (essentially 0 bpf) to 26 bpf, indicating a consistency of very soft to very stiff. We note the very soft soils (soils with N-values less than 4) were isolated to boring B-3 at depths from about 53 to 68 feet. Laboratory moisture content testing of selected residual soil samples indicated natural moisture content values ranging from approximately 14.2 to 60.8 percent. Atterberg limits testing of a selected residual soil sample indicated a liquid limit (LL) value of 68 percent and corresponding plasticity index (PI) value of 38 percent. The samples tested may be described as fat clay (USCS Group Symbol CH) abased on the Atterberg limits testing alone.

Auger Refusal

Auger refusal was encountered in borings B-2, B-3 and B-5 at depths ranging from 18.5 to 78.5 feet below the existing ground surface. Auger refusal is a designation applied to material that cannot be penetrated by the power auger. Auger refusal at this site could indicate rock pinnacles, ledges or boulders, or the top of continuous bedrock. Coring of the refusal material was beyond the scope of our services; however, we expect the deeper refusals in borings B-3 and B-5 were likely bedrock and the shallow refusal in boring B-2 was a dense alluvial or cobble layer.

Ground Water

Ground water was not encountered in any of the borings at the time of drilling and the borings were backfilled upon completion in consideration of safety. Ground water levels may fluctuate

due to seasonal changes in precipitation amounts, construction activities in the area, and/or the level of nearby water features. The ground water information presented in this report is the information that was collected at the time of our field activities.

Geophysical

Generally, the ERI data correlates rather well with the geotechnical information provided above. In addition, the geotechnical data was utilized to help better refine the analysis of the ERI testing. Overall, the ERI testing indicated a transition from sandy alluvial soils to clayey alluvial overlying residual soils and carbonate bedrock. The data indicates alluvial soils (with varying degrees of open graded clean sand and sand/clay mixed) overlying residual soils and carbonate bedrock. The clean sand and dense cobble layers can be approximated as the 350-400 Ohm-m or greater threshold (when near the surface), the more clayey alluvial materials were generally approximated as the 200 to 350 Ohm-m near surface zones. The alluvial soils were encountered at depths ranging from 10-40 feet beneath the existing ground surface. We anticipate the high resistivity value alluvial soils (approaching 400 Ohm-m, shown as bright red) likely consist of gravel/cobble zones and clean sands. Underlying the alluvial soils, residual clays were approximated as resistivity zones ranging from 35 to 450 Ohm-m and were encountered to depths ranging from 15 to 100+ ft. Underlying the majority of the residual soils, the carbonate bedrock layer was interpolated as resistivity values generally exceeding 400 to 450 Ohm-m. Pinnacled bedrock is interpolated to be at depths ranging from 40 to 70 feet.

4.3 SHALLOW FOUNDATIONS

4.3.1 Shallow Foundations

Foundations for the proposed construction are expected to bear in new structural soil fill, existing alluvial, or residual soils which have been tested and approved as recommended. The recommended allowable soil bearing capacity for design of the foundations is 2,500 pounds per square foot (psf). Some undercutting and replacement of lower consistency existing soils may be required if encountered at the foundation bearing elevation.

We recommend that continuous foundations be a minimum of 18 inches wide and isolated spread footings be a minimum of 24 inches wide to reduce the possibility of a localized punching shear failure. Exterior foundations should be designed to bear at least 18 inches below finished exterior grade to develop the design bearing pressure and to protect against frost heave.

The available lateral capacity of shallow foundations includes a soil lateral pressure and coefficient of friction as described in the IBC, Section 1806. Footings will be embedded in material similar to those described as Class 5 in Table 1806.2. Where footings are cast neat against the sides of excavations, an allowable lateral bearing pressure of 100 psf per foot depth below natural grade may be used in computations. Resistance to lateral sliding represented by a value of adhesion of 130 psf may be used for clays similar to those described as soil Class 5. An increase of one-third in the allowable lateral capacity may be considered for transient load combinations, including wind or earthquake, unless otherwise restricted by design code provisions.

A geotechnical representative should be retained to perform foundation subgrade tests to confirm that the recommendations provided in this report are consistent with the site conditions encountered. A dynamic cone penetrometer (DCP) is commonly utilized to provide information that is compared to the data obtained in the geotechnical report. Where unacceptable materials are encountered, the material should be excavated to the underlying suitable soils or remediated at the geotechnical engineer's direction. Some undercutting of lower consistency soils to correct foundation support conditions should be anticipated.

4.3.2 Slabs-on-Grade

For slab-on-grade construction, the site should be prepared as previously described. The subgrade should be proofrolled and approved prior to the placement of the crushed stone. Based on the conditions encountered on this site, we recommend that the floor slabs be designed using a subgrade modulus of 100 pounds per cubic inch (pci). This modulus is appropriate for small diameter loads (i.e. a 1ft x 1ft plate) and should be adjusted for wider loads. The grade slab should be jointed around columns and along footing supported walls so that the slab and foundations can settle differentially without damage.

4.3.3 Settlement

Based on the results of the geotechnical exploration, we estimate total and differential foundation settlements of less than 1.5 inch and 1 inch, respectively. The settlement estimates where developed considering maximum column and continuous foundation loads on the order of 250 kips and 6 kips per linear foot (kpf), respectively, and an allowable bearing pressure of 2,500 psf. Additionally, this information assumes that the site is prepared in accordance with our recommendations provided in this report. If, during the design of the building, these parameters are determined to be incorrect, we should be notified to reevaluate the settlements for the building.

4.4 SEISMIC DESIGN CRITERIA

4.3.4 Seismic Site Class

In accordance with the International Building Code, 2018, we are providing the following seismic design information. After evaluating the SPT N-value data from the soil test borings, it was determined that the site subsurface conditions most closely matched the description for "Seismic Site Class D" or "Stiff Soil Profile". Table 1 provides the spectral response accelerations for both short and 1-second periods, which may be used for design.

Table 1 – Seismic Design Parameters

Structure	S_s g	S_1 g	S_{DS} g	S_{D1} g
Proposed Medical Office Building	0.650	0.137	0.555	0.212

The short and 1-second period values indicate the structure should be assigned a Seismic Design Category "D" using the published information. The provided values are based on the results of our field exploration and the assumption that the structure will be designed utilizing a Risk Category I, II or III. If these assumptions are incorrect, we should be contacted to reevaluate the seismic design information.

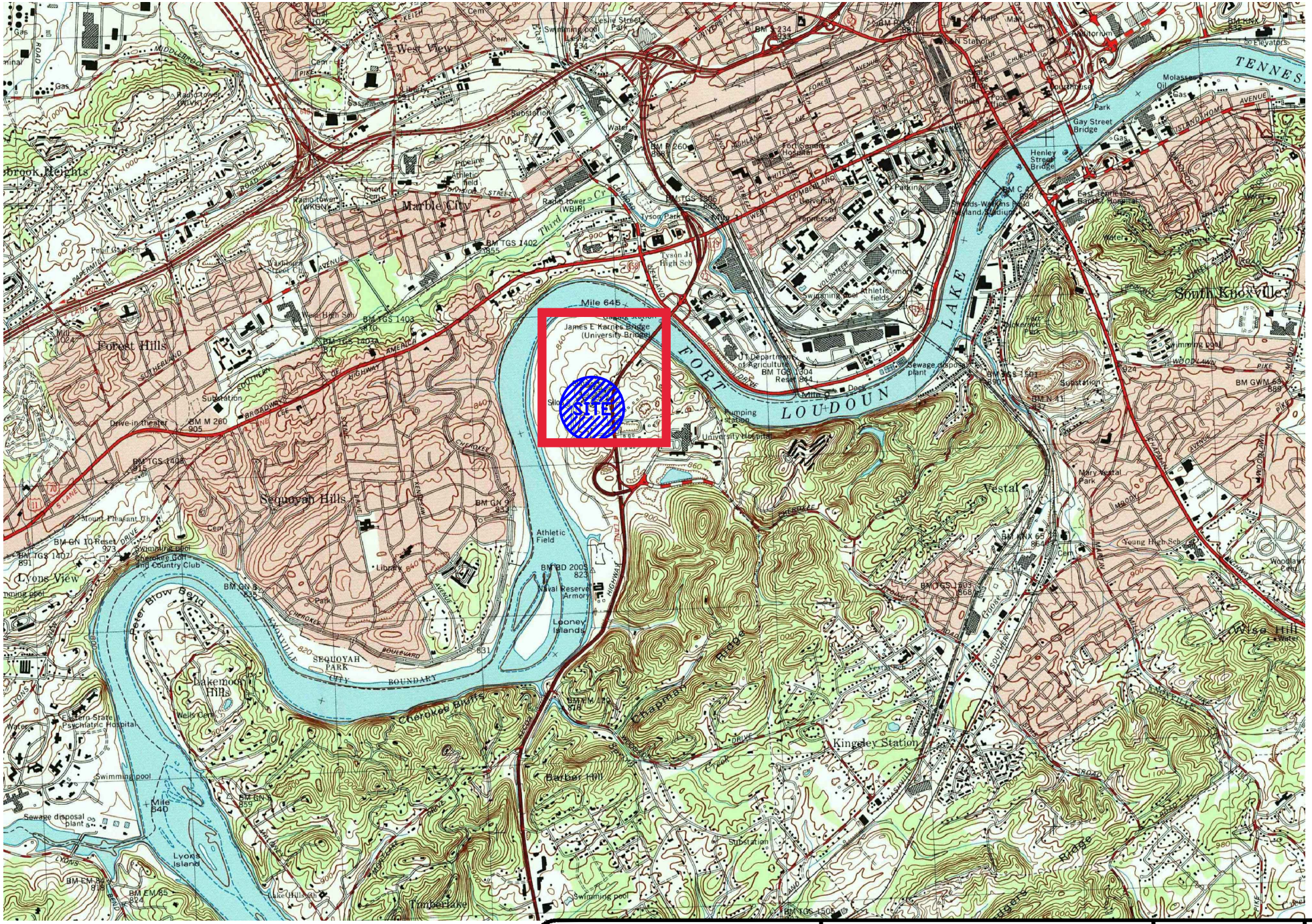
4.5 GEOLOGIC AND SEISMIC HAZARDS

In accordance with the IBC 2018 Sections 1803.5.11 and 1803.5.12, we have provided a discussion on the following geologic and seismic hazards: slope instability, liquefaction, total/differential settlement, soil strength loss, and surface displacement due to faulting or seismically induced lateral spread or lateral flow.

Liquefaction occurs when soil, primarily saturated cohesionless soils, undergo a loss in strength due to monotonic, transient, or repeated disturbance that commonly occurs during a seismic event (Kramer 1996). This loss of strength occurs due to increased pore water pressures caused by an undrained condition. The increase in pore water pressure decreases the effective stress in the soil, thus reducing the soils ability to support any applied loads. For liquefaction to occur, there must be an increase in pore pressure meaning the soil must be saturated and be able to behave in an undrained condition. According to the NHI 2011 Reference Manual on LRFD Seismic Analysis and Design of Transportation Geotechnical Features and Structural Foundations, if any of the following criteria are satisfied then a significant liquefaction hazard does not exist:

- The geologic materials underlying the site are either bedrock or have very low liquefaction susceptibility according to the relative susceptibility ratings shown in the Estimated Susceptibility of Sedimentary Deposits to Liquefaction During Strong Ground Motion table presented by Youd and Perkins in 1978.

- The soils below the groundwater table at the site are one of the following:
    - Clayey soils which have a clay content greater than 15%, liquid limit greater than 35%, or natural water content less than 90% of the liquid limit.



NOTES:

1.) BASE MAP: USGS QUADRANGLE (KNOXVILLE, TENNESSEE)

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers
2561 Willow Point Way
Knoxville, Tennessee 37931
Office: 865-539-8242
Fax: 865-539-8252

SITE VICINITY MAP

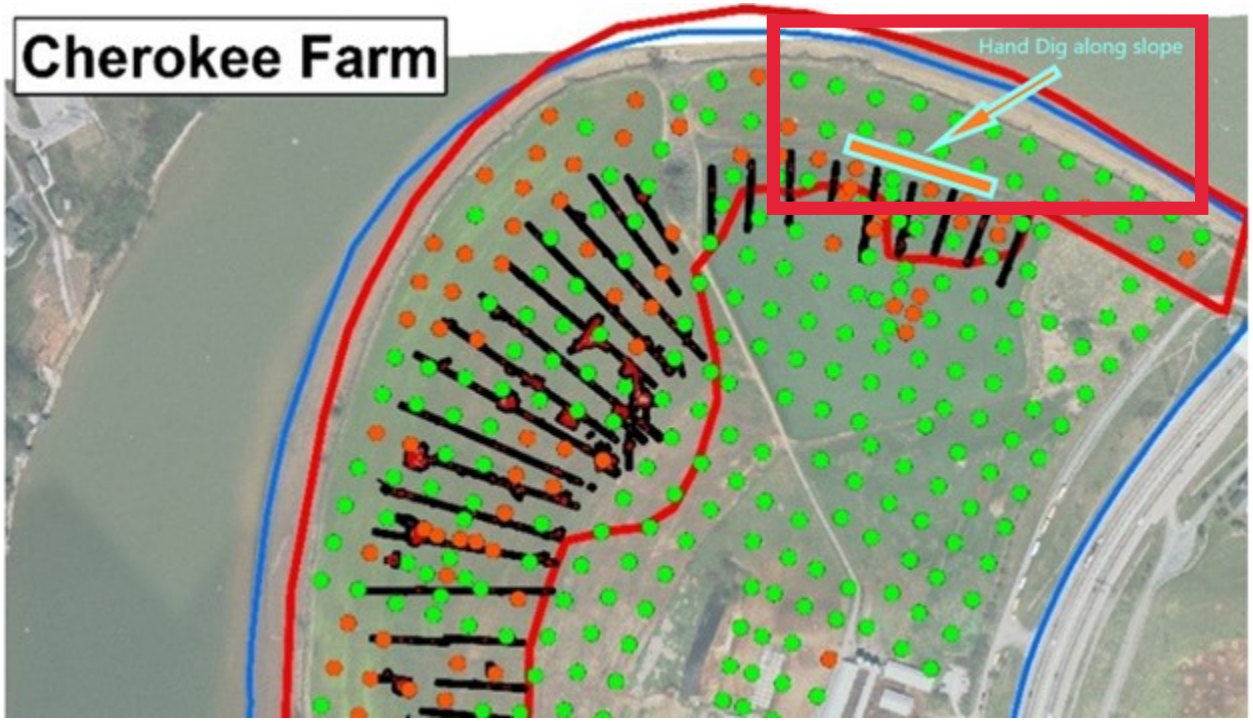
PROPOSED OTN MEDICAL OFFICE BUILDING

CHEROKEE FARMS CAMPUS ALCOA HIGHWAY

KNOXVILLE, TENNESSEE

DRAWN BY:	KSR
APPROVED BY:	MBH
SCALE:	N.T.S.
JOB NO.:	21-19477
DATE:	5/23/2019

FIGURE 1


Cherokee Farm
Hand Dig along slope

Geotechnical Solutions Firm
TIC 211-B
Knoxville Tennessee

BORING NUMBER A

CLIENT _____ **PROJECT NAME** _____

PROJECT NUMBER _____ **PROJECT LOCATION** _____

DATE STARTED 2/28/22 **COMPLETED** 2/28/22 **GROUND ELEVATION** _____ **HOLE SIZE** 6

DRILLING CONTRACTOR CE400 **GROUND WATER LEVELS:**

DRILLING METHOD Hollow Stem Auger **AT TIME OF DRILLING** ---

LOGGED BY CFK **CHECKED BY** SJM **AT END OF DRILLING** ---

NOTES _____ **AFTER DRILLING** ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ 20 40 60 80 / PL MC LL 20 40 60 80 / ☐ FINES CONTENT (%) ☐ 20 40 60 80
0		TOPSOIL						
5								
10								
15		(ML) REDDISH-ORANGE CLAYEY, SANDY						
20								
25		(ML) MORE SANDY						
30		(ML) SANDY						
35								

(Continued Next Page)

BORING NUMBER B

Geotechnical Solutions Firm
TIC 211-B
Knoxville Tennessee

CLIENT _____ **PROJECT NAME** _____

PROJECT NUMBER _____ **PROJECT LOCATION** _____

DATE STARTED 2/28/22 **COMPLETED** 2/28/22 **GROUND ELEVATION** _____ **HOLE SIZE** 6

DRILLING CONTRACTOR CE400 **GROUND WATER LEVELS:**

DRILLING METHOD Hollow Stem Auger **AT TIME OF DRILLING** ---

LOGGED BY CFK **CHECKED BY** SJM **AT END OF DRILLING** ---

NOTES _____ **AFTER DRILLING** ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ 20 40 60 80 / PL MC LL 20 40 60 80 / ☐ FINES CONTENT (%) ☐ 20 40 60 80
0		SILT, (OH) TOPSOIL						
5								
10								
15								
20								
25		(ML) ORANGISH BROWN CLAY WITH TRACE SAND						
30		(ML) ORANGISH BROWN CLAY WITH SAND						
35								

(Continued Next Page)

Project	Senior Design	Location	UTRP
Boring NO	A 12"-21"	Date	3/4/2022

Plastic Limit Determination					
Determination No.	1.00	2.00	3.00	4.00	5.00
Tare No.	25.00	77.00	70.00	78.00	
Mass of wet soil + tare	45.64	49.21	43.65	45.71	
mass of dry soil + tare	40.47	43.32	38.96	40.44	
mass of water	5.17	5.89	4.69	5.27	
mass of tare	22.07	22.50	22.15	22.57	
mass of dry soil	18.40	20.82	16.81	17.87	
Water Content (%)	28.10%	28.29%	27.90%	29.49%	
No. of blows	30.00	26.00	24.00	25.00	

Liquid Limit Determination	
Determination No.	1.00
Tare No.	A20
Mass of wet soil + tare	27.72
mass of dry soil + tare	25.45
mass of water	2.27
mass of tare	16.53
mass of dry soil	8.92
Water Content (%). (PL)	25.45%

Project	Senior Design	Location	UTRP
Boring NO	A 21"-26"	Date	3/1/2022

Plastic Limit Determination					
Determination No.	1.00	2.00	3.00	4.00	5.00
Tare No.	D13	D11	D110	Y28	
Mass of wet soil + tare	33.13	34.31	34.87	46.79	
mass of dry soil + tare	29.18	30.09	30.50	42.20	
mass of water	3.95	4.22	4.37	4.59	
mass of tare	17.00	17.04	12.13	30.63	
mass of dry soil	12.18	13.05	18.37	11.57	
Water Content (%)	32.43%	32.34%	23.79%	39.67%	
No. of blows	30.00	28.00	26.00	23.00	

Liquid Limit Determination	
Determination No.	1.00
Tare No.	Y2
Mass of wet soil + tare	40.39
mass of dry soil + tare	38.41
mass of water	1.98
mass of tare	30.45
mass of dry soil	7.96
Water Content (%). (PL)	24.87%

Project	Senior Design	Location	UTRP
Boring NO	A 26"-36"	Date	3/3/2022

Plastic Limit Determination					
Determination No.	1.00	2.00	3.00	4.00	5.00
Tare No.	H2 C1	C8	L194	A12	
Mass of wet soil + tare	33.16	41.65	37.01	42.32	
mass of dry soil + tare	28.85	35.86	31.35	36.72	
mass of water	4.31	5.79	5.66	5.60	
mass of tare	15.46	15.20	9.39	15.79	
mass of dry soil	13.39	20.66	21.96	20.93	
Water Content (%)	32.19%	28.03%	25.77%	26.76%	
No. of blows	30.00	28.00	26.00	23.00	

Liquid Limit Determination	
Determination No.	1.00
Tare No.	A10
Mass of wet soil + tare	26.07
mass of dry soil + tare	23.30
mass of water	2.77
mass of tare	11.89
mass of dry soil	11.41
Water Content (%). (PL)	24.28%

Project	Senior Design	Location	UTRP
Boring NO	B 21"-30"	Date	3/7/2022

Plastic Limit Determination					
Determination No.	1.00	2.00	3.00	4.00	5.00
Tare No.	L41	A22	15.00	37.00	
Mass of wet soil + tare	59.31	54.76	54.82	50.76	
mass of dry soil + tare	53.29	49.76	48.42	47.07	
mass of water	6.02	5.00	6.40	3.69	
mass of tare	30.55	30.21	22.10	30.72	
mass of dry soil	22.74	19.55	26.32	16.35	
Water Content (%)	26.47%	25.58%	24.32%	22.57%	
No. of blows	21.00	18.00	21.00	47.00	

Liquid Limit Determination	
Determination No.	1.00
Tare No.	62.00
Mass of wet soil + tare	33.91
mass of dry soil + tare	31.98
mass of water	1.93
mass of tare	22.27
mass of dry soil	9.71
Water Content (%). (PL)	19.88%

Project	Senior Design	Location	UTRP
Boring NO	B 30"-38"	Date	3/7/2022

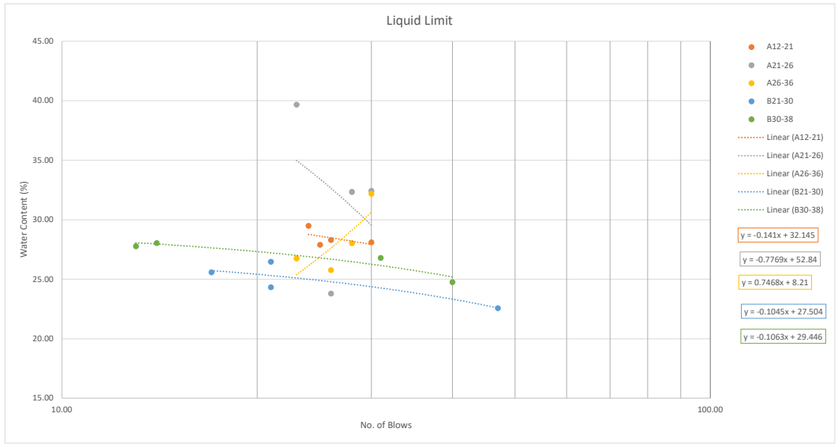
Plastic Limit Determination					
Determination No.	1.00	2.00	3.00	4.00	5.00
Tare No.	25.00	78.00	77.00	70.00	
Mass of wet soil + tare	43.96	48.61	40.19	41.04	
mass of dry soil + tare	39.62	42.94	36.44	36.91	
mass of water	4.34	5.67	3.75	4.13	
mass of tare	22.09	22.52	22.45	22.18	
mass of dry soil	17.53	20.42	13.99	14.73	
Water Content (%)	24.76%	27.77%	26.80%	28.04%	
No. of blows	40.00	13.00	31.00	14.00	

Liquid Limit Determination	
Determination No.	1.00
Tare No.	A 20
Mass of wet soil + tare	28.23
mass of dry soil + tare	26.00
mass of water	2.23
mass of tare	16.55
mass of dry soil	9.45
Water Content (%). (PL)	23.60%

A12-21		A21-26		A26-36		B21-30		B30-36	
NO OF BLOWS	WATER CONTENT	NO OF BLOWS	WATER CONTENT	NO OF BLOWS	WATER CONTENT	NO OF BLOWS	WATER CONTENT	NO OF BLOWS	WATER CONTENT
30.00	28.10	30.00	32.43	30.00	32.19	47.00	22.57	40.00	24.76
26.00	28.29	28.00	32.34	28.00	28.03	21.00	24.32	31.00	26.80
25.00	27.90	26.00	23.79	26.00	25.77	21.00	26.47	14.00	28.04
24.00	29.49	23.00	39.67	23.00	26.76	17.00	25.58	13.00	27.77

	LL	PL	PI	DESCRIPTION	SOIL CLASSIFICATION
A12-21	28.62	25.45	3.17	SLIGHTLY PLASTIC	ML or OL
A21-26	33.42	24.87	8.55	LOW PLASTICITY	ML or OL
A26-36	26.88	24.28	2.6	SLIGHTLY PLASTIC	ML or OL
B21-30	24.89	19.88	5.01	LOW PLASTICITY	CL - ML
B30-36	26.79	23.6	3.19	SLIGHTLY PLASTIC	ML or OL

Specific Gravity	
A12-21	2.696
A21-26	2.66
A26-36	2.621
B21-30	2.652
B30-36	2.65



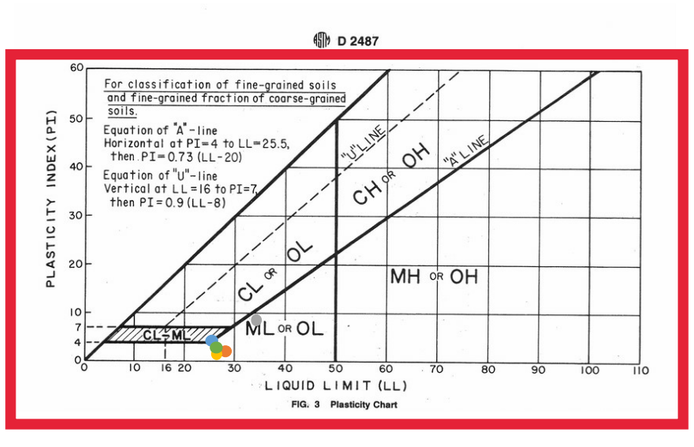


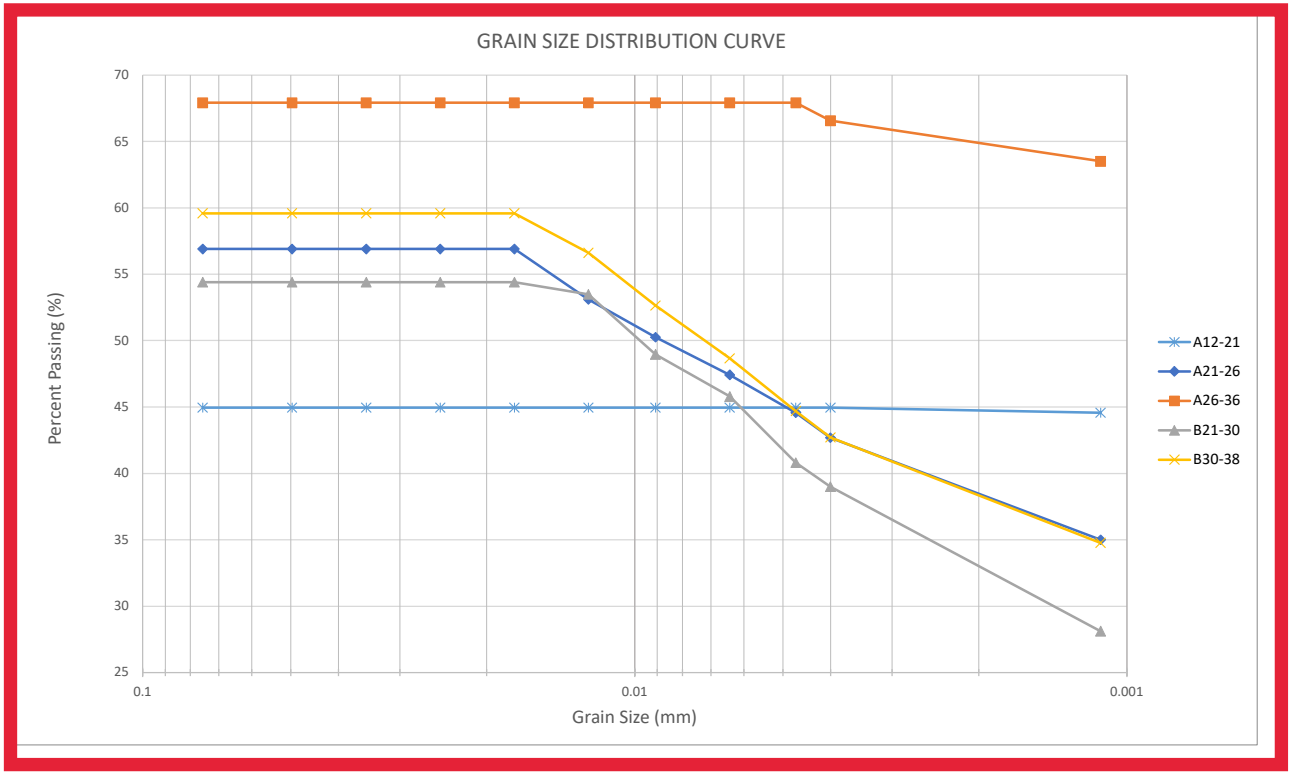
FIG. 3 Plasticity Chart

Estimated Bearing Capacites	
Values Found	Value to Use
1500 psf	2000 psf
1.5 Tsf / 3000 psf	
2000 psf	
4000 psf	

	SOIL SAMPLE				
	A12-21	A21-26	A26-36	B21-30	B30-38
Gs	2.696	2.66	2.621	2.652	2.65
LL	28.62	33.42	26.88	24.89	26.76
PL	25.45	24.87	24.28	19.88	23.6
PI	3.17	8.55	2.6	5.01	3.19
PLASTICITY DESCRIPTION	SLIGHTLY PLASTIC	LOW PLASTICITY	SLIGHTLY PLASTIC	LOW PLASTICITY	SLIGHTLY PLASTIC
SOIL CLASSIFICATION	ML or OL	ML or OL	ML or OL	CL - ML	ML or OL
ESTIMATED BEARING CAPACITY	1500 psf	1.5 tsf / 3000 psf	2000 psf	4000 psf	

DESCRIPTION OF SOIL			DATE		
NAMES OF TEAM MEMBERS					
TRIAL NUMBER	A 12-21	A 21-26	A 26-36	B 21-30	B 30-38
METHOD	ASTM D854	ASTM D854	ASTM D854	ASTM D854	ASTM D854
PYCNOMETER #	2	3	2	2	2
Mp (mass of pycnometer)	285.30	204.44	285.06	285.10	285.10
Vp (volume of pycnometer) ml	1000	1000	1000	1000	1000
t (calibration temp C)	22.0	22.0	22.0	21.0	21.0
pw, c (density of water at calibration temp)	0.99777	0.99777	0.99777	0.99799	0.99799
Mpw,c (mass of pycnometer and water at claibration temp)	1280.11	1199.54	1280.47	1279.89	1279.87
Mass of evaporating dish (g)	42.94	40.30	42.92	587.08	587.68
mass of dry soil and evaporating dish (g)	93.66	90.47	93.04	532.42	535.70
Ms (mass of dry soil) g	50.72	50.17	50.12	54.66	51.38
Mpws (mass of pycnometer, water and soil)	1312.02	1230.85	1311.47	131.94	1311.86
MT (Mpw+Ms) g	1330.83	1249.71	1330.59	1334.55	1331.25
Mw (g)	18.81	18.9	19.1	20.6	19.4
t (test temperature), C	22.0	22.0	22.0	21.0	21.0
pw,t (density of water at test temp)	0.99777	0.99777	0.99777	0.99799	0.99799
K (temperature coefficient)	0.99957	0.99957	0.99957	0.99979	0.99979
Gs (Ms/Mw)	2.696	2.660	2.621	2.652	2.650
KGs (20 C)	2.690	2.659	2.62	2.652	2.649

mm	A12-21	A21-26	A26-36	B21-30	B30-38
0.075476	44.94422	56.89348	67.91457	54.3988	59.58613
0.049684	44.94422	56.89348	67.91457	54.3988	59.58613
0.035132	44.94422	56.89348	67.91457	54.3988	59.58613
0.024842	44.94422	56.89348	67.91457	54.3988	59.58613
0.017566	44.94422	56.89348	67.91457	54.3988	59.58613
0.012421	44.94422	53.1022	67.91457	53.49253	56.60809
0.009071	44.94422	50.25873	67.91457	48.96123	52.63737
0.006414	44.94422	47.41527	67.91457	45.78931	48.66664
0.004707	44.94422	44.5718	67.91457	40.80487	44.69592
0.004004	44.94422	42.67616	66.55685	38.99235	42.71056
0.001131	44.56984	34.9988	63.50199	28.11721	34.76912



FLOW CHART

UNIFIED SOIL CLASSIFICATION SYSTEM

FIELD IDENTIFICATION OF COARSE and FINE GRAINED SOILS

Start Here - To use this chart start on the left and work to the right, using the chart to guide you to the appropriate USCS Symbol, Group Name, and Modifier.

										Symbol	Group Name	Modifier
COARSE-GRAINED SOILS More than half of material (by weight) is of individual grains visible to the naked eye or >50% settles through the water column in 20-30 seconds.	**GRAVEL and GRAVELLY SOILS** More than half of Coarse Fraction (by DRY weight) is larger than 1/4 inch size. **(size of "Lemon" to "Pea")**	**CLEAN GRAVELS** Will not leave a dirt stain on a wet palm	Wide range in grain sizes and substantial amounts of all intermediate particle sizes.							**GW**	Well Graded Gravel	**Add "w/sand" if >=15% sand (1/4 of an inch to 3 inch)**
			Predominantly one size or a range of sizes with some intermediate sizes missing.							**GP**	Poorly Graded Gravel	
		DIRTY GRAVELS Will leave a dirt stain on a wet palm	Nonplastic fines or low-plasticity fines (for identification of fines see characteristics of ML below).							**GM**	Silty Gravel	
			Plastic fines (for identification of fines see characteristics of CL or CH below).							**GC**	Clayey Gravel	
	SAND and SANDY SOILS More than half of Coarse Fraction (by DRY weight) is smaller than 1/4 inch size. **(size of "Pea" to "Salt")**	**CLEAN SANDS** Will not leave a dirt stain on a wet palm	Wide range in grain sizes and substantial amounts of all intermediate particle sizes.							**SW**	Well Graded Sand	**Add "w/gravel" if >=15% gravel (1/200 to 1/4 of an inch)**
			Predominantly one size or a range of sizes with some intermediate sizes missing.							**SP**	Poorly Graded Sand	
		DIRTY SANDS Will leave a dirt stain on a wet palm	Nonplastic fines or low-plasticity fines (for identification of fines see characteristics of ML below).							**SM**	Silty Sand	
			Plastic fines (for identification of fines see characteristics of CL or CH below).							**SC**	Clayey Sand	
FINE-GRAINED SOILS More than half of material (by weight) is of individual grains not visible to the naked eye or <50% settles through the water column in 20-30 seconds.			Liquid Limit (L vs. H)	Dilatancy (L vs H)	Plasticity (M vs. C)	Toughness (M vs. C)	Ribbon (M vs. C)	Shine (M vs. C)	Dry Strength (M vs. C)	**Modifiers for fine grained soils:** **71-85%** passes the #200 then add "**w/gravel**" (%G>%S) or "**w/sand**" (%S>%G) **50-70%** passes the #200 & **%S>%G**, then add "**Sandy _ w/gravel**" (if %G>=15%) or "**Sandy _**" (if %G<15%) **50-70%** passes the #200 & **%S<%G**, then add "**Gravelly _ w/sand**" (if %S>=15%) or "**Gravelly _**" (if %S<15%)		
			1. Add water to dry sample: quick penetration = low LL slow penetration = high LL 2. **Cube test--flood surface and crack open: if water penetrates, sample has low LL; if not, high LL** 3. Wet sample to putty-like consistency: the more water it takes, the higher the LL.	Take the soft, putty-like soil pat and mold into a mass in palm of hand. **Strike** the side of your palm several times with the other hand. In samples with **rapid dilatancy, water appears quickly on the surface, and disappears quickly upon squeezing.**	Dry the soil pat from previous test by adding dry soil until it reaches plastic limit, or PL (rolled thread begins to crack). The **longer it takes to get to the PL, and the more times a thread can be re-rolled or a lump formed** without crumbling, **the higher the plasticity index (C).**	While performing the plasticity test, the **more finger pressure** it takes to roll a thread or form a lump, **the higher the plasticity index (C).** **Low** toughness = soft **Medium** toughness = firm **High** toughness = stiff	With pat of soil near the PL, form a ribbon of soil with thumb and index finger, about 1/2 inch wide and as long as possible. Hold one end and gently shake until it breaks under its own weight. **Rate the ribbon strength. High plasticity (C) soils have high ribbon strength.**	With pat of soil near the PL, cut the pat with a knife blade or stroke it with a knife or fingernail. Observe the degree of shine under direct light. Soils with **high plasticity (C) are shiny,** those with **low plasticity (M) are dull.**	Mold moist soil into a 1/2 inch ball or cube and allow to dry completely. Evaluate by breaking dried cube with finger/thumb pressure, or against hard surface if necessary. Soils with **high plasticity (C) have high dry strength;** soils with **low plasticity (M) have low dry strength.**			
	SILTS & CLAYS (water penetrates = low LL)		Rapid **(2-4 strikes)**	Low to Non Plastic-**NP (can't roll thread)**	Low to None	None **(cannot form ribbon)**	Dull	Low **(crumbles with some finge pressure)**	**ML**	**Silt (PI = 0-15)**	
			Medium to Slow **(4-10 strikes)**	Low to Med. **(can't be rerolled & lump crumbles)**	Medium	Weak **(<3" and may support its own weight)**	Slight to Shiny	Medium to High **(high pressure or hard surface)**	**CL**	**Lean Clay (PI = 10-30)**	
			Slow to None **(>7 strikes)**	Low **(thread barely rolled & lump crumbles).**	Low (Spongy)	None **(cannot form ribbon)**	Dull to Slight	Medium to High **(high pressure or hard surface)**	**OL**	**Organic Silt or Organic Clay**	
	SILTS & CLAYS (Little or no water penetrates = high LL)		Very Slow to None **(> 10 strikes)**	Low to High **(thread and lump may be rerolled)**	Medium to High	Weak to Strong **(<3" and can support itself)**	Slight	Medium **(high pressure to crumble w/fingers)**	**MH**	**Elastic Silt (PI = 5-40)**	
			None	Med. to High **(thread & lump can be rerolled)**	High	Strong **(>3" ribbon that supports itself)**	Shiny	Very High **(not broken with thumb & hard surface)**	**CH**	**Fat Clay (PI = 30-50)**	
			None	Low **(thread barely rolled & lump crumbles).**	Low to Medium (Spongy)	Weak **(<3" and may support its own weight)**	Dull to Slight	High **(can be broken with thum and hard surface)**	**OH**	**Organic Silt or Organic Clay**	
HIGHLY ORGANIC SOILS			Readily identified by color, odor, spongy feel, and frequently by fibrous texture.							**PT**	**Peat**	
***For all soil types - Add with "w/Cobbles" if >= 15% Cobbles (3 - 12 inches)**										****For all soil types - Add with "w/Boulders" if >= 15%**		**Boulders (>12 inches)**

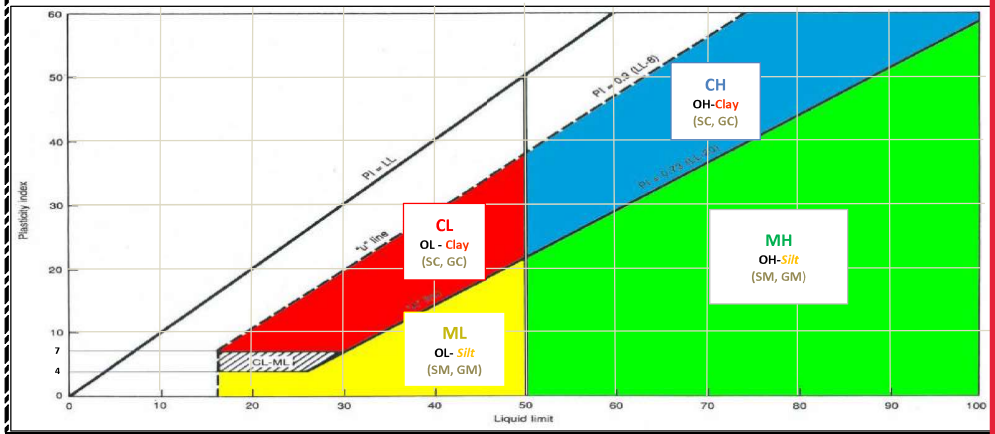
Determining the Unified Soil Classification System (USCS) Symbol and Group Name with Modifier using lab data (ASTM D2487)

Step 1: Use the gradation of the entire sample to determine if a majority of the sample is Fine Grained or Coarse Grained.

FINE-GRAINED (>50% by dry weight passes the #200 sieve)

Step 2: Use Atterberg limits results and plot on plasticity chart.

Step 3: Classify the soil based on the plasticity chart.



Inorganic fines

CL- Lean Clay-LL<50 & PI > 7 and plots on or above "A" line.

ML- Silt-LL<50 & plots on or below the "A" line.

CL-ML- Clayey Silt-LL<50 & PI >4< 7 and plots on or above "A" line.

CH- Fat Clay- LL>50 & plots above the "A" line.

MH- Elastic Silt- LL>50 & plots below the "A" line.

Organic Fines - If LL oven dry / LL air dry is < 0.75

Organic Clay plots above the "A line" and can be an **OL** (LL<50) or an **OH** (LL>50)

Organic Silt plots below the "A line" and can be an **OL** (LL<50) or an **OH** (LL>50)

Pt - Peat is mostly Organic Matter (OM) with little or no inorganic material.

Can be either **Sapric** (<33% OM fibers), **Hemic** (33-67% OM fibers), or **Fibric** (> 67 % OM fibers).

Step 4: Add coarse grained modifiers.

70.1-85% passes the #200 then add "**w/gravel**"(%G>%S) or "**w/sand**"(%S>%G)

50-70% passes the #200 & %S>%G, then add "**Sandy _ w/gravel**" (if %G>=15%) or "**Sandy _**" (if %G<15%)

50-70% passes the #200 & %S<%G, then add "**Gravelly _ w/sand**" (if %S>=15%) or "**Gravelly _**" (if %S<15%)

COARSE-GRAINED (<50% by dry weight passes the #200 sieve)

Step 2: Determine if a majority of the **coarse fraction** is sand or gravel.

SAND-the majority passes the #4 sieve	**GRAVEL- the majority doesn't pass the #4 sieve**

Step 3: determine if it is **Clean** (<5%, <#200), **Dirty** (>12%, <#200), or **Dual class** (5%-12%, <#200).
*See PDF in SM1 Part B.ppt for Dual Class *

"Dirty" Sand with > 12% fines		"Clean" Sand with < 5% fines		"Dirty" Gravel with > 12% fines		"Clean" Gravel with < 5% fines	
Step 4a: Use Atterberg limits results on the fines (<#200) and classify based on whether the fines are plastic or not using the plasticity chart to the left.		**Step 4b**: Use the grain size distribution to obtain the D10, D30, and D60. Calculate the CC and CU. $CC = \frac{D_{30}^2}{D_{10} \times D_{60}}$ $CU = \frac{D_{60}}{D_{10}}$		**Step 4a**: Use Atterberg limits results on the fines (<#200) and classify based on whether the fines are plastic or not using the plasticity chart to the left.		**Step 4b**: Use the grain size distribution to obtain the D10, D30, and D60. Calculate the CC and CU. $CC = \frac{D_{30}^2}{D_{10} \times D_{60}}$ $CU = \frac{D_{60}}{D_{10}}$	
Sand with **>12% fines** that plot **below PI of 4** and **below the A-line**.	**Sand** with **>12% fines** that plot **above PI of 7** and above **the A-line**.	**Sand** with **<5% fines** and a **Cu<6** and / or (**Cc<1 or Cc >3**)	**Sand** with **<5% fines** and a **Cu>=6** and (**Cc >= 1 and Cc <=3**) ***Meets Both***	**Gravel** with **> 12% fines** that plot **below PI of 4** and **below the A-line**.	**Gravel** with **> 12% fines** that plot **above PI of 7** and above **the A-line**.	**Gravel** with **<5% fines** and a **Cu<4** and / or (**Cc<1 or Cc >3**)	**Gravel** with **<5% fines** and a **Cu>=4** and (**Cc >= 1 and Cc <=3**) ***Meets Both***
SM	**SC**	**SP**	**SW**	**GM**	**GC**	**GP**	**GW**
Silty Sand	**Clayey Sand**	**Poorly Graded Sand**	**Well Graded Sand**	**Silty Gravel**	**Clayey Gravel**	**Poorly Graded Gravel**	**Well Graded Gravel**

Step 5: Add Coarse Grained modifier if > 15% of other component.

Add "**w/gravel**" if **>= 15% gravel**	Add "**w/sand**" if **>= 15% sand**

*** To use this chart, start on the top and work your way down using the steps to guide you to the appropriate USCS Symbol, Group Name, and Modifier.**

CE400 Dock Concrete Landings

25 ft long

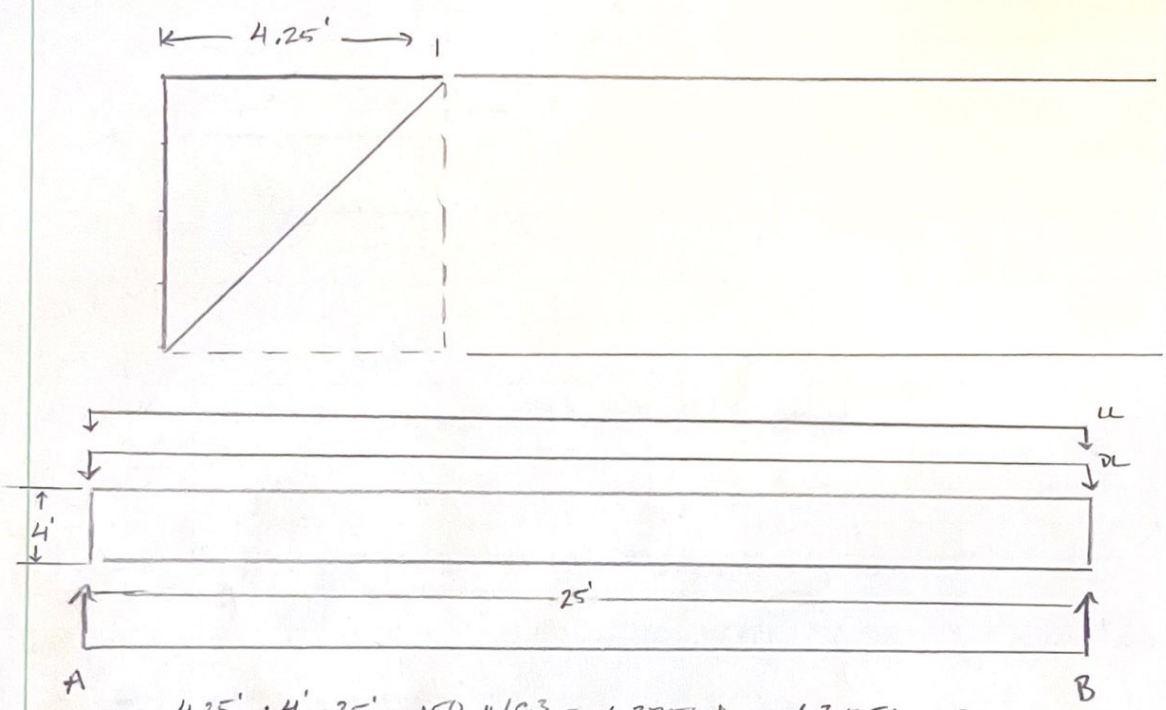
4.25 ft wide } Triangle
4.00 ft Tall }

$f'_c = 4000$ psi $f_y = 60$ ksi

LL = 85 psf DL = 15 psf + Self weight

b = 4.25 ft h = 4.00 ft L = 25 ft

d =



Sw = 4.25' · 4' · 25' · 150 lb/ft³ = 63750 lbs = 63.75 k OR 2550 lb/ft

LL = 85 psf to lbs per linear foot

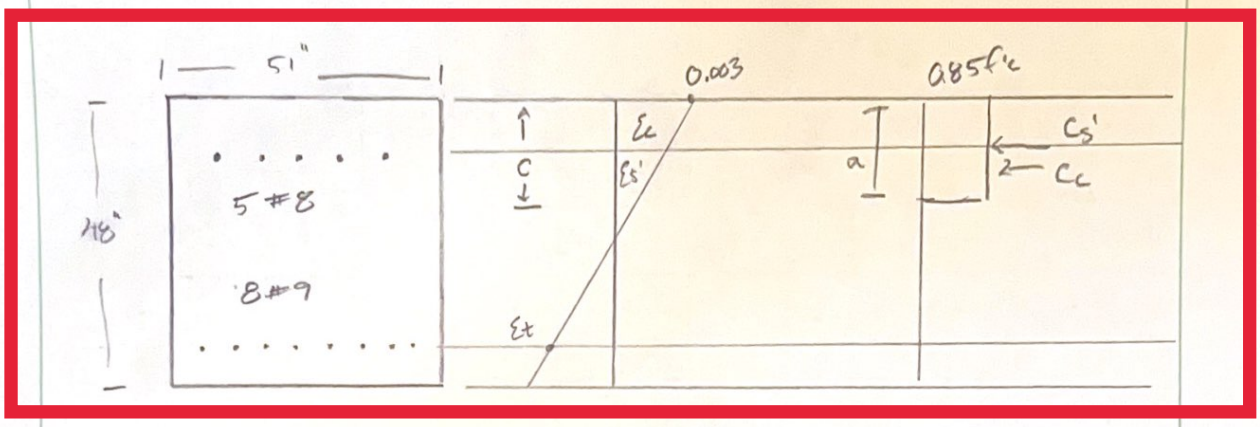
85 psf · 4.25 ft = 361.25 lb/ft

DL = 15 psf to lb/ft = 15 · 4.25 = 63.75 lbs/ft

LL = 9031.25 lbs DL = 1593.75 lbs + self weight

LL = 9.03 k DL = 65.34 k B.C. = 2000 psf · 212500 lbs

BC = 212.5 k



$T_{steel} = 8(1in^2) = 8in^2$ $\quad C_{steel} = 5(0.79) = 3.95in^2$

$\beta = 0.75$

Assume T steel yield

$$\frac{0.003}{c} = \frac{\varepsilon_s'}{c-3''} \qquad \varepsilon_s' = \frac{.003}{c}(c-3)$$

$T = C_c + C_s$ $\quad T = A_s f_s = 8in^2(60ksi) = 480k = T$

$C_c = 0.85(f'c)\cdot a\cdot b = 0.85(4000psi)(51in)(.75\cdot c) = 130.05ck = C_c$

$C_s = A's f_s' - A_s' \cdot 0.85 \cdot f'c = 3.95in^2 \cdot \varepsilon_s' - 3.95in^2 \cdot 0.85 \cdot 4ksi =$

$$480k = 130.05c + 343.65\left(\frac{c-3}{c}\right) - 13.43$$

$$493.43k = 130.05c + 343.65\left(\frac{c-3}{c}\right) \qquad c = 3.45in$$

$a = 3.45in \cdot .75 = 2.588in$

Check

$$\frac{0.003}{c} = \frac{\varepsilon_s}{48-c-c} \qquad \varepsilon_s = \frac{.003(42-3.45in)}{3.45in} \qquad \varepsilon_s = 0.034$$

Tension Steel Yields

$P_u = 177.6\ k$ B.C. = 2000 psf = 2 ksf

Try $9.5' \times 9.5' = 90.25\ ft^2$

Soil pressure reaction: $\frac{177.6\ k}{90.25\ ft^2} = 1.97\ ksf$ ✓ $= q_u$

Assume Thickness = 24 in $d = 24" - 3" - 1" = 20\ in = d$

Assume #8 Bar

- **One Way Shear**

Tributary Area $= 9.5 \left(\frac{9.5\ ft}{2} - \frac{18\ in}{12 \cdot 2} - \frac{32\ in}{12} \right) = 12.67\ ft^2 = A_t$

$V_u = q_u \cdot A_t = 1.97\ ksf \cdot 12.67\ ft^2 = 24.95\ k$

$\phi V_n = \phi (2\sqrt{f'c}\ b_w d)$

$= 0.75 (2\sqrt{4000}\ (9.5' \cdot 12 \cdot 20\ in) = \frac{216299}{1000} = 216\ kip$

$\phi V_n > V_u$ OK

- **Two Way Shear**

$A = 9.5^2 - \left(\frac{18+20}{12} \right)^2 = 80.22\ ft^2$

$V_u = 1.97\ ksf \cdot 80.22\ ft^2 = 158.04\ k$

$b_o = 4(18+20) = 152$ $\beta = \frac{18}{18} = 1$

$\frac{V_c}{\lambda \sqrt{f'c}\ b_o d} = \text{Min}$ $2+4\beta = 6$; $4 = (4)$; $\frac{\alpha_s d}{b_o} + 2 = 7.26$

$\phi V_c = 0.75 \left(4\sqrt{4000} \cdot 152 \cdot \frac{20}{1000} \right) = 5767.9\ k$ $\phi V_c > V_u$ OK

Reinforcements

$$\text{Critical Section} = \frac{114\,ft^2 - 18}{2}/12 = 4$$

$$M_u = q_u \frac{c^2}{2} = 1.97 \cdot 9.5 \cdot \left(\frac{4^2}{2}\right) = 149.72\ k\text{-}ft$$

$$A_s = \frac{M_u}{4d} = \frac{149.72}{4(20in)} = 1.87\ in^2$$

$$A_{s\,min} = 0.0018(20 \cdot (9.5 \cdot 12)) = 4.104\ in^2$$

Use $A_{s,min} = 4.104$

- Try 6 #8 Bars in Both Directions @ $4.74\ in^2$
- Check $\phi M_n > M_u$

$$a = \frac{A_s f_y}{0.85(f'c)b} = \frac{4.74(60)}{0.85(4)(114)} = 0.74"$$

$$c = a/\beta_1 = .74/0.85 = 0.863" \qquad d_t = d = 20$$

$$\frac{\varepsilon_t}{d_t - c} = \frac{0.003}{c} = \varepsilon_t = 0.067 > 0.005 \qquad \phi = 0.9$$

$$\phi M_n = A_s f_y (d - a/2) = 4.74(60)(20 - \tfrac{0.74}{2})(0.9) = 5024.5\ k\text{-}ft$$

$\phi M_n > M_u$ OK

9.5' x 9.5' Square footing w/ 6 #8 Bars @ 22in Spacing Going Both Directions

9.5' wide Continuous Footing w/ 6 #8 Bars @ 22in Spacing

Appendix F: Construction

Outdoor Recreational Boathouse Facility at the University of Tennessee Research Park

Material Take-off - Dock

Material	Size	Unit	Quantity	Unit	Unit Price	Total Cost	Item Number
Class A Concrete			215	C.Y.	$411.07	$88,380.05	604-03.08
Steel Pile	10	IN.	180	L.F.	$60.77	$10,938.60	606-02.03
Steel Rebar			32250	LB.	$1.20	$38,700.00	604-02.02
40' Gangway	48	IN.	1	EA.	$7,820.00	$7,820.00	https://alumidock.com/aluminum-gangways
10'x10' Floating Dock			4	EA.	$1,000.00	$4,000.00	https://www.dockaccents.com/product/floating-dock-kit-10-x-10-ft/
Steel Cable			128.0624847	L.F.	$4.14	$530.18	714-06.08
Clear Rip-rap			850	C.Y.	$10.98	$9,333.00	209-05
Core Drilling for Piles			105	L.F.	$154.96	$16,270.80	204-15
Restore Rip-Rap			850	S.F.	$10.98	$9,333.00	209-05
						$185,305.63	

*Item Number refers to TDOT Average Unit Prices of Awarded Contracts in 2021

Outdoor Recreational Boathouse Facility at the University of Tennessee Research Park

Material Take-off - Boathouse

Material	Size	Unit	Quantity	Unit	Unit Price	Total Cost	Item Number
A60 Steel	W24x162		116640	LB.	$1.81	$211,118.40	602-02.01
	W8x21		1386			$2,508.66	
	W8x24		336			$608.16	
	W8x40		960			$1,737.60	
Concrete			172.3703704	C.Y.	$411.07	$70,856.29	604-03.08
Steel Rebar			25855.55556	LB.	$1.20	$31,026.67	604-02.02
Timber (Glulan - Southern Pine)	8.5x9.625	IN.	376.66	C.F	$25.43	$9,576.58	https://www.runquistsawmillservices.com/store/p132/Pine_Beams_-_8%22x8%22x10%27.html
	6.75x28.875	IN.	713.7	C.F		$18,145.82	
Fill Material			19935	C.Y.	$41.55	$828,299.25	203-15.03
Stripping			4776	C.Y.	$10.98	$52,440.48	209-05
Clearing			4.544	ACRE	$11,000.00	$49,984.00	201-01.02
Excavation			4822.7	C.Y.	$11.41	$55,027.01	203-01.79
Foundation Prep				LS	$40,000.00	$40,000.00	204-10.01
Erosion Control				LS	$2,693.00	$2,693.00	209-99.91
Parking Lot			30189.9	S.F.	$10.46	$315,786.35	701-02
Concrete Curb			1992	L.F.	$17.93	$35,716.56	702-01.02
Concrete Sidewalk			10434.5	S.F.	$6.44	$67,198.18	701-01.01
						$1,792,723.01	

*Item Number refers to TDOT Average Unit Prices of Awarded Contracts in 2021

Floating Dock Kit – 10 X 10 Ft ~ Dock Accents, Inc.

Floating Dock Kit – 10 x 10 ft

$ 1,000.00

Quantity:

1

ADD TO CART

SKU: FDUUIUXIUA

Category: Floating Docks

Share This

Description Additional Information

Description

The **10 x 10' Wood Floating Dock Kit** includes: 6 – 2×4' x 12" dock floats; 6 Angles; 4 Inside Corners; 92 SS Lag Bolt w/washer sets; Material List for all lumber required by customer (to be purchased by customer locally) and Instructions & Diagrams. Floating Dock Hardware is heavy-duty galvanized "commercial grade" hardware. Bolts are Stainless-steel. Additional connecting hardware sold separately. Call us at **1-888-219-0112** with any questions you may have or for a shipping quote. (Note: Shipping for this item cannot be calculated on-line. If ordered on-line, our Sales Dept. will contact you regarding additional shipping charges prior to shipping item(s) ordered.)

Related products

Floating Dock Kit – 12 x 12 ft

$ 1,500.00

ADD TO CART




View Video (https://www.youtube.com/watch?v=rOwgCQ-TjpM)

Aluminum Gangway

$1,352.00 – $6,190.00

Our aluminum marine gangways are light weight yet durable offering easy positioning. No more repainting or replacing unsafe wooden ramps or struggling with heavy, rusty steel walkway units. Our Aluminum Gangways solve the problem by offering quick and easy removal in the event of severe storms or for seasonal storage.

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Like all **Alumidock®** waterfront equipment, our marine gangways are constructed of corrosion-resistant, salt water tested aluminum alloys, and require minimal maintenance. Aluminum gangway installations have proven themselves for over 40 years at coastal locations from United States to the Virgin Islands.

We ship our Aluminum Gangways nationwide and accept

Gangway Features:

- The siderails are a rigid box girder design. The top-truss design increases stability and load capacity and lends support to the rugged aluminum handrail.
- Decking planks are fastened securely to the tubular cross members. Cleats that provide additional foot grip are supplied as a standard feature.
- Ramps are available in standard widths of **32", 36", 42" and 48". Standard lengths range from 12' to 40'** and are handled as stock items. Other widths and longer lengths can be made to order. Please note 24'-40' long gangways shipped in two pieces. Assembly is required
- Comes with standard mounting bracket on shore end and rubber topped aluminum wheels at float end.
- Marine grade corrosion resistant aluminum

Model #	LENGTH	WIDTH	PRICE	WEIGHT
ARMP-12-32-W	12ft	32in	$ 1,735.00 (https://alumidock.com/store/product/330)	163 lbs.
ARMP-12-36-W	12ft	36in	$ 2,011.00 (https://alumidock.com/store/product/331)	170 lbs.
ARMP-12-42-W	12ft	42in	$ 2,276.00 (https://alumidock.com/store/product/332)	180 lbs.
ARMP-12-48-W	12ft	48in	$ 2,745.00 (https://alumidock.com/store/product/333)	190 lbs.
ARMP-14-32-W	14ft	32in	$ 1,996.00 (https://alumidock.com/store/product/335)	185 lbs.
ARMP-14-36-W	14ft	36in	$ 2,287.00 (https://alumidock.com/store/product/337)	195 lbs.
ARMP-14-42-W	14ft	42in	$ 2,629.00 (https://alumidock.com/store/product/336)	210 lbs.
ARMP-14-48-W	14ft	48in	$ 3,629.00 (https://alumidock.com/store/product/340)	220 lbs.

ARMP-16-32-W	16ft	32in	$ 2,233.00 (https://alumidock.com/store/product/338)	200 lbs.
ARMP-16-36-W	16ft	36in	$ 2,511.00 (https://alumidock.com/store/product/339)	215 lbs.
ARMP-16-42-W	16ft	42in	$ 2,929.00 (https://alumidock.com/store/product/341)	230 lbs.
ARMP-16-48-W	16ft	48in	$ 3,629.00 (https://alumidock.com/store/product/347)	245 lbs.
ARMP-18-32-W	18ft	32in	$ 2,469.00 (https://alumidock.com/store/product/350)	225 lbs.
ARMP-18-36-W	18ft	36in	$ 2,668.00 (https://alumidock.com/store/product/343)	234 lbs.
ARMP-18-42-W	18ft	42in	$ 3,262.00 (https://alumidock.com/store/product/344)	252 lbs.
ARMP-18-48-W	18ft	48in	$ 3,967.00 (https://alumidock.com/store/product/353)	279 lbs.
ARMP-20-32-W	20ft	32in	$ 2,684.00 (https://alumidock.com/store/product/346)	240 lbs.
ARMP-20-36-W	20ft	36in	$ 2,931.00 (https://alumidock.com/store/product/348)	255 lbs.
ARMP-20-42-W	20ft	42in	$ 3,562.00 (https://alumidock.com/store/product/349)	280 lbs.
ARMP-20-48-W	20ft	48in	$ 4,202.00 (https://alumidock.com/store/product/351)	312 lbs.
ARMP-22-32-W	22ft	32in	$ 2,923.00 (https://alumidock.com/store/product/357)	255 lbs.
ARMP-22-36-W	22ft	36in	$ 3,204.00 (https://alumidock.com/store/product/355)	270 lbs.
ARMP-22-42-W	22ft	42in	$ 3,783.00 (https://alumidock.com/store/product/356)	295 lbs.
ARMP-22-48-W	22ft	48in	$ 4,383.00 (https://alumidock.com/store/product/366)	325 lbs.
ARMP-24-32-W-2	24ft	32in	$ 3,423.00 (https://alumidock.com/store/product/383)	270 lbs.
ARMP-24-36-W-2	24ft	36in	$ 3,712.00 (https://alumidock.com/store/product/388)	285 lbs.
ARMP-24-42-W-2	24ft	42in	$ 4,235.00 (https://alumidock.com/store/product/389)	310 lbs.
ARMP-24-48-W-2	24ft	48in	$ 4,390.00 (https://alumidock.com/store/product/390)	340 lbs.
ARMP-26-32-W-2	26ft	32in	$ 3,708.00 (https://alumidock.com/store/product/392)	295 lbs.
ARMP-26-36-W-2	26ft	36in	$ 4,022.00 (https://alumidock.com/store/product/393)	310 lbs.
ARMP-26-42-W-2	26ft	42in	$ 4,586.00 (https://alumidock.com/store/product/395)	335 lbs.
ARMP-26-48-W-2	26ft	48in	$ 5,340.00 (https://alumidock.com/store/product/396)	365 lbs.
ARMP-28-32-W-2	28ft	32in	$ 3,992.00 (https://alumidock.com/store/product/397)	330 lbs.
ARMP-28-36-W-2	28ft	36in	$ 4,331.00 (https://alumidock.com/store/product/398)	345 lbs.
ARMP-28-42-W-2	28ft	42in	$ 4,939.00 (https://alumidock.com/store/product/399)	370 lbs.
ARMP-28-48-W-2	28ft	48in	$ 5,753.00 (https://alumidock.com/store/product/394)	400 lbs.
ARMP-30-32-W-2	30ft	32in	$ 4,279.00 (https://alumidock.com/store/product/360)	370 lbs.
ARMP-30-36-W-2	30ft	36in	$ 4,640.00 (https://alumidock.com/store/product/362)	450 lbs.
ARMP-30-42-W-2	30ft	42in	$ 5,295.00 (https://alumidock.com/store/product/359)	410 lbs.
ARMP-30-48-W-2	30ft	48in	$ 6,162.00 (https://alumidock.com/store/product/361)	440 lbs.
ARMP-32-32-W	32ft	32in	$ 4,501.00 (https://alumidock.com/store/product/363)	410 lbs.
ARMP-32-36-W	32ft	36in	$ 4,872.00 (https://alumidock.com/store/product/364)	425 lbs.

ARMP-32-42-W	32ft	42in	$ 5,849.00 (https://alumidock.com/store/product/365)	460 lbs.
ARMP-32-48-W	32ft	48in	$ 6,793.00 (https://alumidock.com/store/product/368)	490 lbs.
ARMP-34-32-W	34ft	32in	$ 4,741.00 (https://alumidock.com/store/product/367)	440 lbs.
ARMP-34-36-W	34ft	36in	$ 5,126.00	465 lbs.
ARMP-34-42-W	34ft	42in	$ 5,849.00 (https://alumidock.com/store/product/370)	500 lbs.
ARMP-34-48-W	34ft	48in	$ 6,793.00 (https://alumidock.com/store/product/372)	530 lbs.
ARMP-36-32-W	36ft	32in	$ 4,979.00 (https://alumidock.com/store/product/375)	470 lbs.
ARMP-36-36-W	36ft	36in	$ 5,372.00 (https://alumidock.com/store/product/376)	505 lbs.
ARMP-36-42-W	36ft	42in	$ 6,152.00 (https://alumidock.com/store/product/378)	540 lbs.
ARMP-36-48-W	36ft	48in	$ 7,131.00 (https://alumidock.com/store/product/377)	570 lbs.
ARMP-38-32-W	38ft	32in	$ 5,226.00 (https://alumidock.com/store/product/380)	500 lbs.
ARMP-38-36-W	38ft	36in	$ 5,626.00 (https://alumidock.com/store/product/386)	545 lbs.
ARMP-38-42-W	38ft	42in	$ 6,423.00 (https://alumidock.com/store/product/385)	580 lbs.
ARMP-38-48-W	38ft	48in	$ 7,483.00 (https://alumidock.com/store/product/385)	610 lbs.
ARMP-40-32-W	40ft	32in	$ 5,452.00 (https://alumidock.com/store/product/379)	540 lbs.
ARMP-40-36-W	40ft	36in	$ 5,864.00 (https://alumidock.com/store/product/382)	625 lbs.
ARMP-40-42-W	40ft	42in	$ 6,704.00 (https://alumidock.com/store/product/384)	620 lbs.
ARMP-40-48-W	40ft	48in	$ 7,8202.00 (https://alumidock.com/store/product/381)	650 lbs.

Testimonials

Mike Taylor (/node/78)

> *Very helpful, patient on ordering. Great pricing, delivered before the date scheduled even. Knowledgeable staff, really made for a great purchase!*

RUNQUIST SAWMILL SERVICES

Pine Beams - 8"x8"x10'

$113.00

SKU: B-P8x8x10

8x8x10 ft. Beams can vary a slight bit in overall size, and they generally have a little wane on some of the outside corners, as seen in the photos.

Note: If there are not enough beams in inventory on the website to accommodate your needs, please call. There is a chance we may have more in stock than what is listed here.

Outdoor Recreational Boathouse Facility at the University

Schedule - Dock

Task ID	Task	Duration (Days)	Predecessor
AA	Clear Rip-rap	1	
AB	Core Drilling for Piles	2	AA
AC	Set Piles	2	AB
AD	FRP Concrete	10	AC
AE	Anchor Floating Dock System	3	AD
AF	Restore Rip-Rap	1	AD

Critical Path - Dock

Task	Duration (Days)
AA	1
AB	2
AC	2
AD	10
AE	3
	18

Outdoor Recreational Boathouse Facility at the University

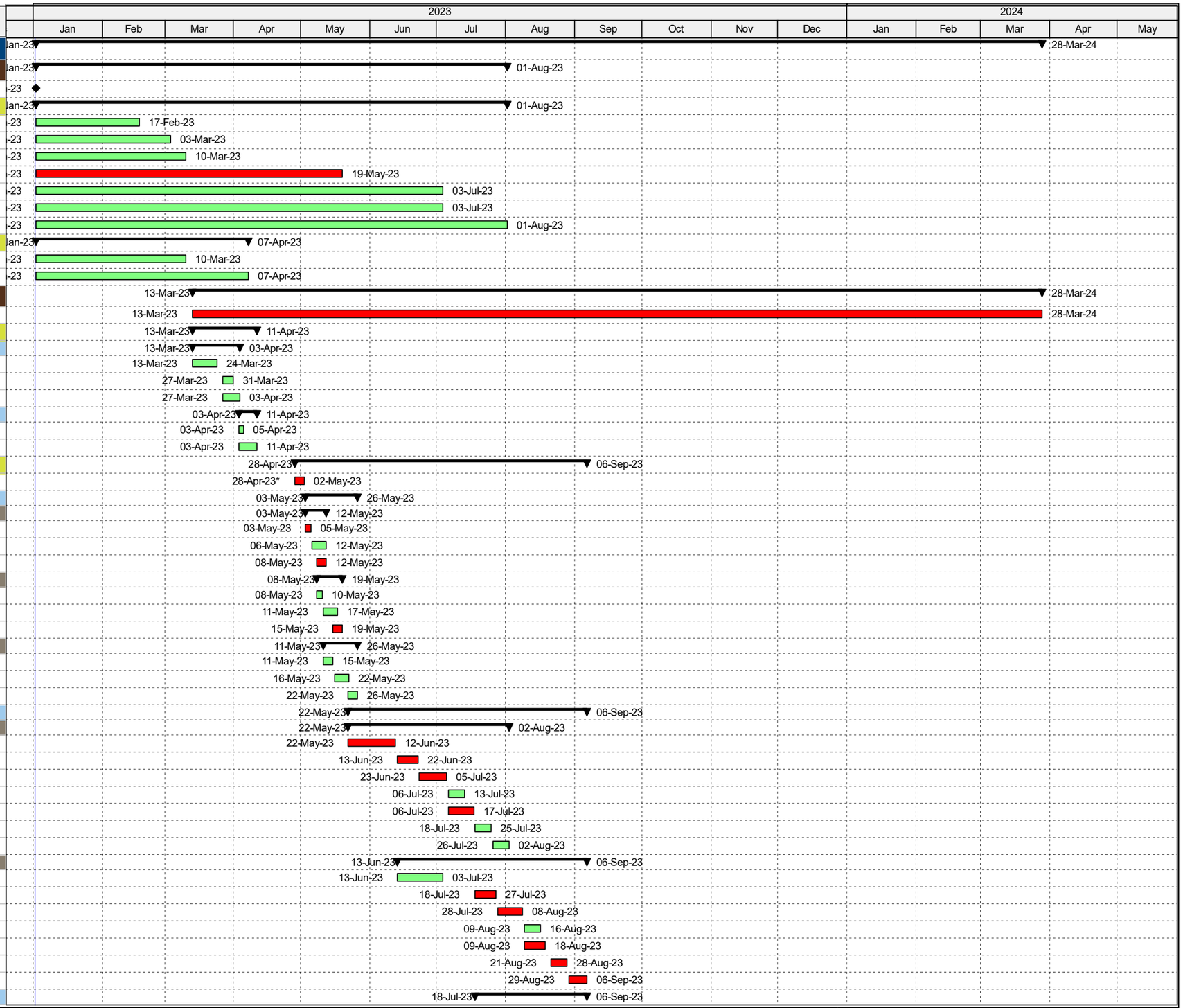
Schedule - Boathouse

Task ID	Task	Duration (Days)	Predecessor
BA	Clearing/Grubbing	5	
BB	Stripping	10	
BC	Grading	35	BB
BD	Erosion Control	1	BC
BE	Site Prep	14	BC
BF	Building Pad Prep	14	BC
BG	Excavation	10	BF
BH	Subgrade Utility Rough-in	5	BG
BI	Foundation FR&P	10	BH
BJ	MEP Rough-in	7	BI
BK	Columns FR&P	5	BI
BL	SOG FR&P	10	BJ
BM	Walls FR&P	5	BL
BN	Structural Steel Install	21	BM
BO	Steel Decking Install	14	BN
BP	Structural Steel Detail	10	BO
BQ	1st FL MEP Rough-in	7	BO
BR	1st FL SOG FR&P	5	BQ
BS	Structural Timber Install	21	BR
BT	Frame Interior Walls	10	BR
BU	Roof Steel Panel Install	14	BS
BV	Install Sheetrock	5	BT
BW	MEP Finish	14	BV
BX	Interior Paint	3	BW
BY	Frame & Sheath Ext. Walls	14	BS
BZ	Install Windows	5	BY
CA	Waterproof Ext. Sheathing	10	BZ
CB	Finish Exterior Skin	14	CA
CC	Sidewalk & Curb FR&P	10	BF
CD	Pave Parking Lot	14	CC
CE	Landscaping	21	CB

Critical Path - Boathouse

Task	Duration (Days)
BB	10
BC	35
BF	14
BG	10
BH	5
BI	10
BJ	7
BL	10
BM	5
BN	21
BO	14
BQ	7
BR	5
BS	21
BY	14
BZ	5
CA	10
CB	14
CE	21
	238

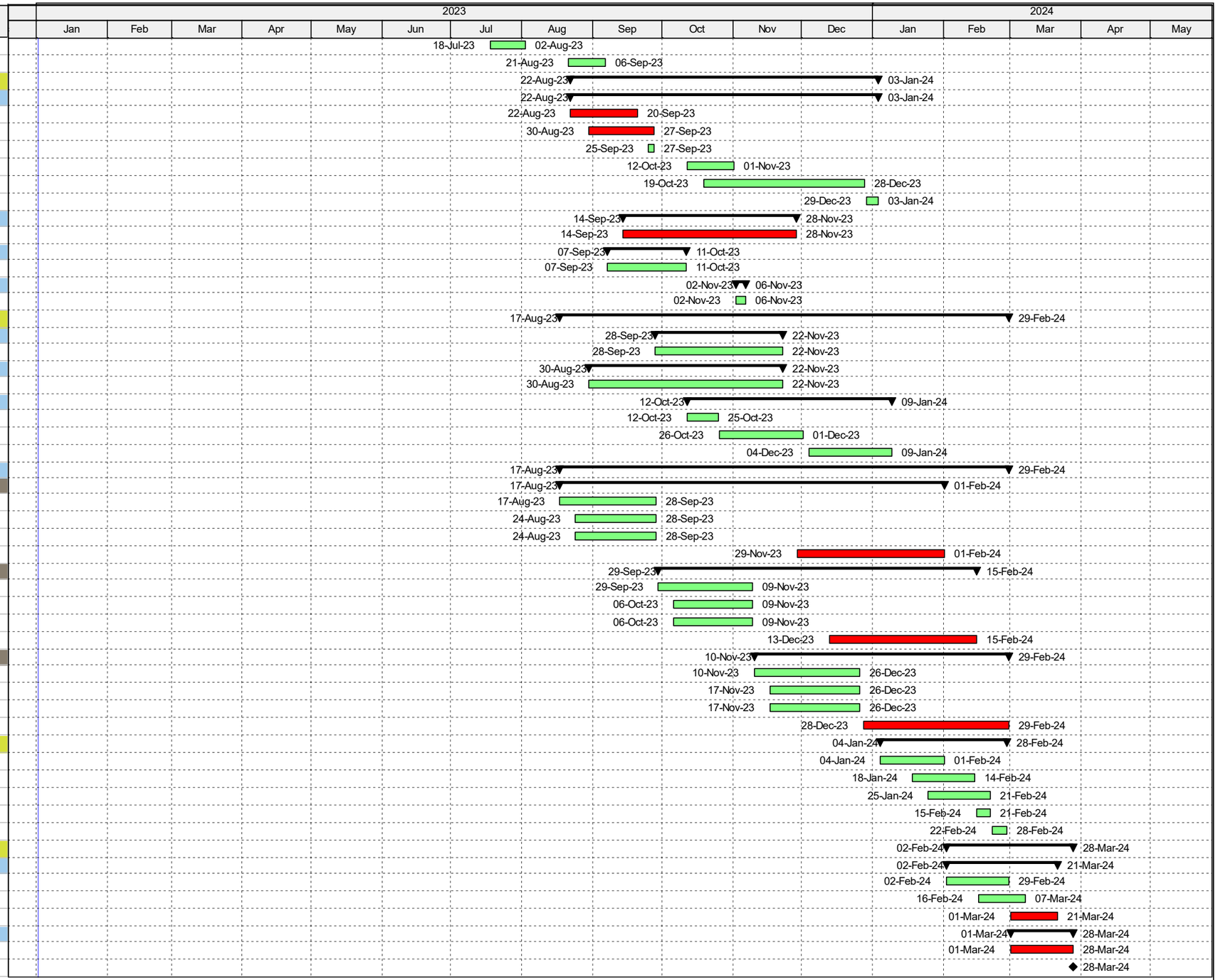
Activity ID	Activity Name	Orig Dur	Start	Finish
BHC Student Project - 04/26/22 RFP Schedule		317	02-Jan-23	28-Mar-24
Preconstruction		150	02-Jan-23	01-Aug-23
A1030	NOTICE TO PROCEED	0	02-Jan-23	
Submittals/Delivery		150	02-Jan-23	01-Aug-23
A1000	Procure Foundations	35	02-Jan-23	17-Feb-23
A1070	Procure Ductwork	45	02-Jan-23	03-Mar-23
A1060	Procure Metal Panels	50	02-Jan-23	10-Mar-23
A1020	Procure Steel (Detailing Occured Prior to NTP)	100	02-Jan-23	19-May-23
A1040	Procure Curtain Wall / Windows	130	02-Jan-23	03-Jul-23
A1050	Procure Roofing Material	130	02-Jan-23	03-Jul-23
A1010	Procure Elevator Equipment	150	02-Jan-23	01-Aug-23
Permitting		70	02-Jan-23	07-Apr-23
A1080	Procure Grading Permit	50	02-Jan-23	10-Mar-23
A1090	Procure Building Permit	70	02-Jan-23	07-Apr-23
Construction		267	13-Mar-23	28-Mar-24
A1730	TOTAL CONSTRUCTION DURATION (CALENDAR DAYS)	382	13-Mar-23	28-Mar-24
Sitework		22	13-Mar-23	11-Apr-23
Excavation		16	13-Mar-23	03-Apr-23
A1100	Prep Building Pad	10	13-Mar-23	24-Mar-23
A1110	Excavate Utility Lines	5	27-Mar-23	31-Mar-23
A1120	Excavate Foundations	6	27-Mar-23	03-Apr-23
Underground Utilities		7	03-Apr-23	11-Apr-23
A1130	Lay Water Service Line	3	03-Apr-23	05-Apr-23
A1140	Lay Sanitary Sewer Line	7	03-Apr-23	11-Apr-23
Structure		91	28-Apr-23	06-Sep-23
A1630	Mobilze Crawler Crane	3	28-Apr-23*	02-May-23
Foundations		18	03-May-23	26-May-23
Area 1		8	03-May-23	12-May-23
A1150	FR&P Foundations	3	03-May-23	05-May-23
A1760	Cure Foundations for Steel Erection	7	06-May-23	12-May-23
A1160	FR&P SOG	5	08-May-23	12-May-23
Area 2		10	08-May-23	19-May-23
A1170	FR&P Foundations	3	08-May-23	10-May-23
A1740	Cure Foundations for Steel Erection	7	11-May-23	17-May-23
A1180	FR&P SOG	5	15-May-23	19-May-23
Area 3		12	11-May-23	26-May-23
A1190	FR&P Foundations	3	11-May-23	15-May-23
A1750	Cure Foundations for Steel Erection	7	16-May-23	22-May-23
A1200	FR&P SOG	5	22-May-23	26-May-23
Erection / Form & Place		75	22-May-23	06-Sep-23
Area 1		51	22-May-23	02-Aug-23
A1210	Erect Steel	15	22-May-23	12-Jun-23
A1220	Deck & Detail L2	8	13-Jun-23	22-Jun-23
A1230	Deck & Detail L3	8	23-Jun-23	05-Jul-23
A1250	Prep & Place SOMD L2	6	06-Jul-23	13-Jul-23
A1240	Deck & Detail Roof	8	06-Jul-23	17-Jul-23
A1260	Prep & Place SOMD L3	6	18-Jul-23	25-Jul-23
A1270	Prep & Place SOMD Roof	6	26-Jul-23	02-Aug-23
Area 2		60	13-Jun-23	06-Sep-23
A1280	Erect Steel	15	13-Jun-23	03-Jul-23
A1290	Deck & Detail L2	8	18-Jul-23	27-Jul-23
A1300	Deck & Detail L3	8	28-Jul-23	08-Aug-23
A1320	Prep & Place SOMD L2	6	09-Aug-23	16-Aug-23
A1310	Deck & Detail Roof	8	09-Aug-23	18-Aug-23
A1330	Prep & Place SOMD L3	6	21-Aug-23	28-Aug-23
A1340	Prep & Place SOMD Roof	6	29-Aug-23	06-Sep-23
Architectural Features		36	18-Jul-23	06-Sep-23



BHC Student Project - 04/26/22 RFP Schedule
Overall Project Schedule

BRASFIELD & GORRIE GENERAL CONTRACTORS

Activity ID	Activity Name	Orig Dur	Start	Finish
A1350	Install Metal Stairs 2	12	18-Jul-23	02-Aug-23
A1640	Install Metal Stairs 1	12	21-Aug-23	06-Sep-23
Exterior Skin / Roofing		92	22-Aug-23	03-Jan-24
Exterior Finishes		92	22-Aug-23	03-Jan-24
A1360	Frame & Sheath Exterior Walls	21	22-Aug-23	20-Sep-23
A1380	Waterproof Exterior Sheathing	20	30-Aug-23	27-Sep-23
A1370	Erect Scaffolding	3	25-Sep-23	27-Sep-23
A1410	Install Metal Panels @ Roof	15	12-Oct-23	01-Nov-23
A1390	Install Brick Veneer	48	19-Oct-23	28-Dec-23
A1400	Install Metal Canopy	3	29-Dec-23	03-Jan-24
Glass & Glazing		52	14-Sep-23	28-Nov-23
A1420	Install Curtainwall & Windows	52	14-Sep-23	28-Nov-23
Roofing / Flashing		25	07-Sep-23	11-Oct-23
A1430	Install Roofing System	25	07-Sep-23	11-Oct-23
Demobilize Crawler Crane		3	02-Nov-23	06-Nov-23
A1440	Demobilize Crane	3	02-Nov-23	06-Nov-23
Interiors		136	17-Aug-23	29-Feb-24
Main Mechanical Rooms		40	28-Sep-23	22-Nov-23
A1450	Buildout Mech Room (Conditioned Air)	40	28-Sep-23	22-Nov-23
Main Electrical Rooms		60	30-Aug-23	22-Nov-23
A1460	Buildout Elect Room (Temp Dry-in Measures)	60	30-Aug-23	22-Nov-23
Elevators / Conveying Equipment		60	12-Oct-23	09-Jan-24
A1470	Install Elevator Equipment	10	12-Oct-23	25-Oct-23
A1480	Install Elevator 1	25	26-Oct-23	01-Dec-23
A1490	Install Elevator 2	25	04-Dec-23	09-Jan-24
Architectural Rough-ins & Finishes		136	17-Aug-23	29-Feb-24
Level 1		116	17-Aug-23	01-Feb-24
A1500	Rough-in OH Mechanical	30	17-Aug-23	28-Sep-23
A1510	Rough-in Electrical	25	24-Aug-23	28-Sep-23
A1520	Rough-in Plumbing	25	24-Aug-23	28-Sep-23
A1530	Install Core Finishes	45	29-Nov-23	01-Feb-24
Level 2		96	29-Sep-23	15-Feb-24
A1650	Rough-in OH Mechanical	30	29-Sep-23	09-Nov-23
A1660	Rough-in Electrical	25	06-Oct-23	09-Nov-23
A1670	Rough-in Plumbing	25	06-Oct-23	09-Nov-23
A1680	Install Core Finishes	45	13-Dec-23	15-Feb-24
Level 3		76	10-Nov-23	29-Feb-24
A1690	Rough-in OH Mechanical	30	10-Nov-23	26-Dec-23
A1700	Rough-in Electrical	25	17-Nov-23	26-Dec-23
A1710	Rough-in Plumbing	25	17-Nov-23	26-Dec-23
A1720	Install Core Finishes	45	28-Dec-23	29-Feb-24
Landscaping / Hardscapes		40	04-Jan-24	28-Feb-24
A1570	FR&P Sidewalks & Curbs	21	04-Jan-24	01-Feb-24
A1550	Install Landscaping	20	18-Jan-24	14-Feb-24
A1540	Rough-in Irrigation	20	25-Jan-24	21-Feb-24
A1580	Parking Lot Asphalt Paving & Striping	5	15-Feb-24	21-Feb-24
A1560	Trim-out Irrigation	5	22-Feb-24	28-Feb-24
Punch & Inspections		40	02-Feb-24	28-Mar-24
Punch		35	02-Feb-24	21-Mar-24
A1590	Punch & Clean L1	20	02-Feb-24	29-Feb-24
A1600	Punch & Clean L2	15	16-Feb-24	07-Mar-24
A1610	Punch & Clean L3	15	01-Mar-24	21-Mar-24
Inspections		20	01-Mar-24	28-Mar-24
A1620	Final Inspections	20	01-Mar-24	28-Mar-24
A1770	SUBSTANTIAL COMPLETION	0		28-Mar-24



BHC Student Project - 04/26/22 RFP Schedule
Overall Project Schedule

BRASFIELD & GORRIE GENERAL CONTRACTORS