Curb Ramps

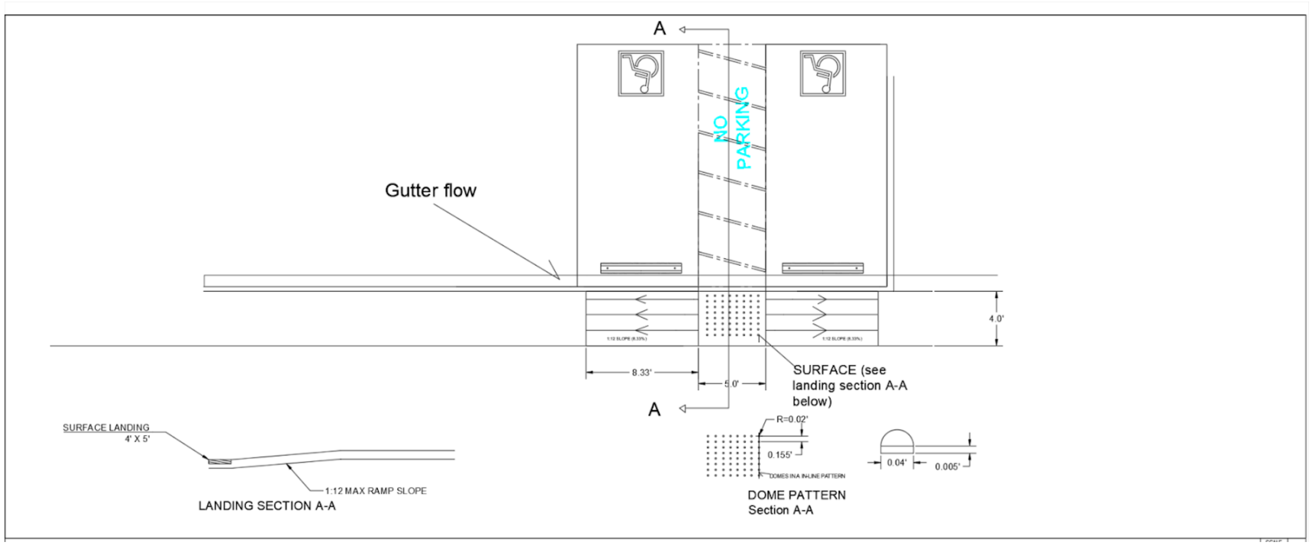


Figure 215: Curb Ramp

Curb and Gutter, Sidewalk

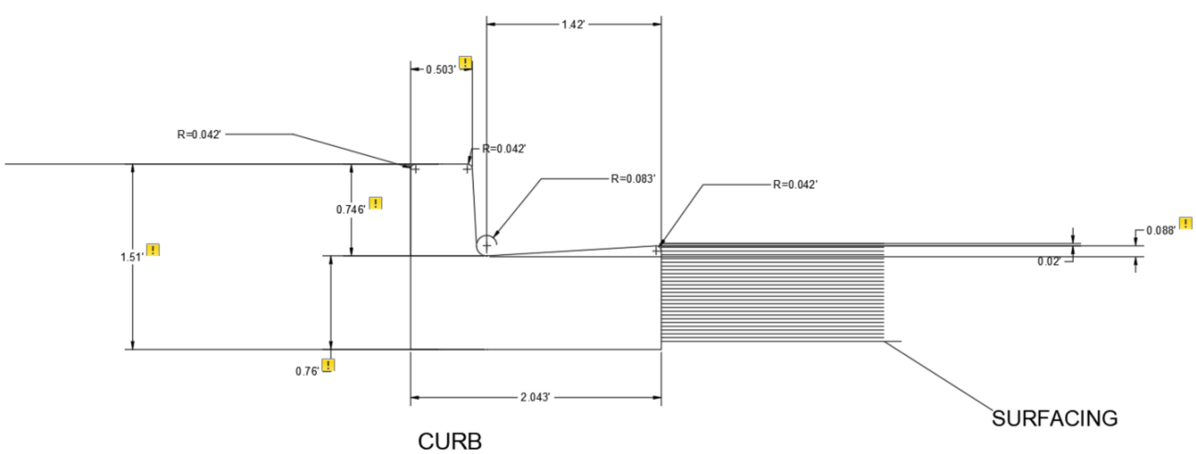


Figure 216: Curb and gutter

Landscaping

Referenced in drawing.

Relevant Codes

11B-406.3.2 Turning Space. A turning space 48 inches minimum by 48 inches minimum shall be provided at the bottom of A turning space 48 inches (1219 mm) minimum by 48 inches (1219 mm) minimum shall be provided at the bottom of the curb ramp. The slope of the turning space in all directions shall be 1:48 maximum.

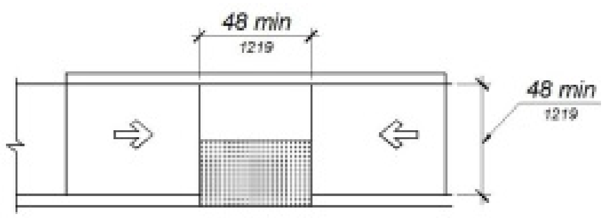


Figure 217: Parallel Curb Ramps

11B-406.5.1 Location. Curb ramps and the flared sides of curb ramps shall be located so that they do not project into vehicular traffic lanes, parking spaces or parking access aisles. Curb ramps at marked crossings shall be wholly contained within the markings, excluding any flared sides. **Exception:** Diagonal curb ramps shall comply with Section 11B-406.5.9.

11B-406.5.2 Width. The clear width of curb ramp runs (excluding any flared sides), blended transitions, and turning spaces shall be 48 inches (1219 mm) minimum.

11B-406.5.3 Landings. Landings shall be provided at the tops of curb ramps and blended transitions. The landing clear length shall be 48 inches (1219 mm) minimum. The landing clear width shall be at least as wide as the curb ramp, excluding any flared sides, or the blended transition leading to the landing. The slope of the landing in all directions shall be 1:48 maximum. **Exception:** Parallel curb ramps shall not be required to comply with Section 11B-406.5.3.

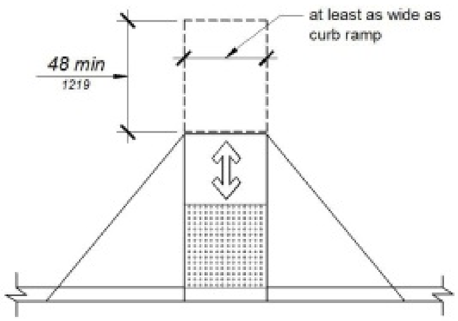


Figure 218: Landings At the Top of Curb Ramps

11B-502.3.3 Marking. Access aisles shall be marked with a blue painted borderline around their perimeter. The area within the blue borderlines shall be marked with hatched lines a maximum of 36 inches (914 mm) on center in a color contrasting with that of the aisle surface, preferably blue or white. The words "NO PARKING" shall be painted on the surface within each access aisle in white letters a minimum of 12 inches (305 mm) in height and located to be visible from the adjacent vehicular way. Access aisle markings may extend beyond the minimum required length.

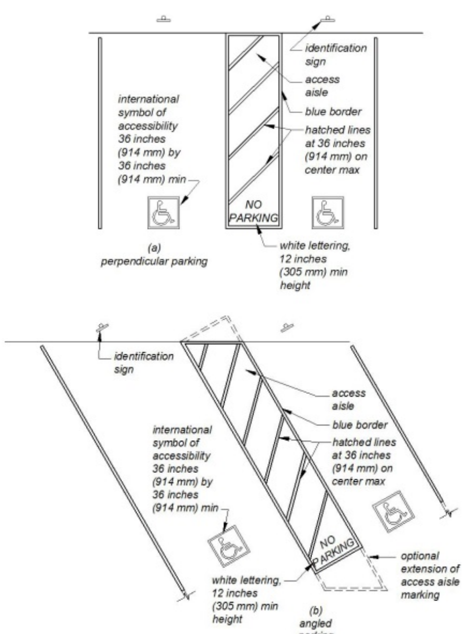


Figure 219: Angled and Perpendicular Parking Identification

11B-502.3.1 Width. Access aisles serving car and van parking spaces shall be 60 inches (1524 mm) wide minimum.

11B-502.3.2 Length. Access aisles shall extend the full required length of the parking spaces they serve.

11B-502.4 Floor or Ground Surfaces. Parking spaces and access aisles serving them shall comply with Section 11B-302. Access aisles shall be at the same level as the parking spaces they serve. Changes in level, slopes exceeding 1:48, and detectable warnings shall not be permitted.

11B-502.5 Vertical Clearance. Parking spaces, access aisles and vehicular routes serving them shall provide a vertical clearance of 98 inches (2489 mm) minimum. **Exception:** In existing multistory parking facilities, car parking spaces, access aisles and vehicular routes serving them shall provide a vertical clearance of 80 inches (2032 mm) minimum. Existing vertical clearance in excess of 80 inches (2032 mm) and less than 98 inches (2489 mm) shall be maintained. This exception shall not apply to van parking spaces, access aisles or vehicular routes serving them.

11B-502.6 Identification. Parking space identification signs shall include the International Symbol of Accessibility complying with Section 11B-703.7.2.1 in white on a blue background. Signs identifying van parking spaces shall contain additional language or an additional sign with the designation "van accessible". Signs shall be 60 inches (1524 mm) minimum above the finish floor or ground surface measured to the bottom of the sign. Exception: Signs located within a circulation path shall be a minimum of 80 inches (2032 mm) above the finish floor or ground surface measured to the bottom of the sign.

11B-502.6.4 Marking. Each accessible car and van space shall have surface identification complying with either Section 11B-502.6.4.1 or 11B-502.6.4.2.

11B-502.6.4.1. The parking space shall be marked with an International Symbol of Accessibility complying with Section 11B-703.7.2.1 in white on a blue background a minimum 36 inches wide by 36 inches high (914 mm by 914 mm). The centerline of the International Symbol of Accessibility shall be a maximum of 6 inches (152 mm) from the centerline of the parking space, its sides parallel to the length of the parking space and its lower corner at, or lower side aligned with, the end of the parking space length.

11B-502.6.4.2. The parking space shall be outlined in blue or painted blue and shall be marked with an International Symbol of Accessibility complying with Section 11B-703.7.2.1 a minimum 36 inches wide by 36 inches high (914 mm by 914 mm) in white or a suitable contrasting color. The centerline of the International Symbol of Accessibility shall be a maximum of 6 inches (152 mm) from the centerline of the parking space, its sides parallel to the length of the parking space and its lower corner at, or lower side aligned with, the end of the parking space.

11B-502.2 Vehicle Spaces. Car and van parking spaces shall be 216 inches (5486 mm) long minimum. Car parking spaces shall be 108 inches (2743 mm) wide minimum and van parking spaces shall be 144 inches (3658 mm) wide minimum, shall be marked to define the width, and shall have an adjacent access aisle complying with Section 11B-502.3.

Exception: Van parking spaces shall be permitted to be 108 inches (2743 mm) wide minimum where the access aisle is 96 inches (2438 mm) wide minimum.

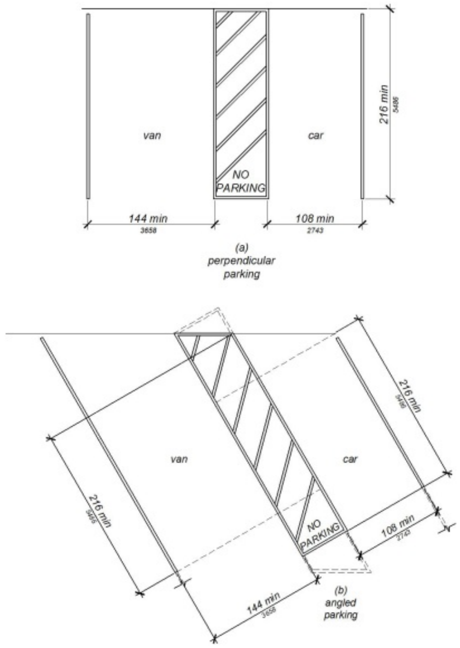


Figure 220: Vehicle Parking Spaces

11B-502.3 Access Aisle.

Diagram. Access aisles serving parking spaces shall comply with Section 11B-502.3. Access aisles shall adjoin an accessible route. Two parking spaces or one parking space and one electric vehicle charging space shall be permitted to share a common access aisle.

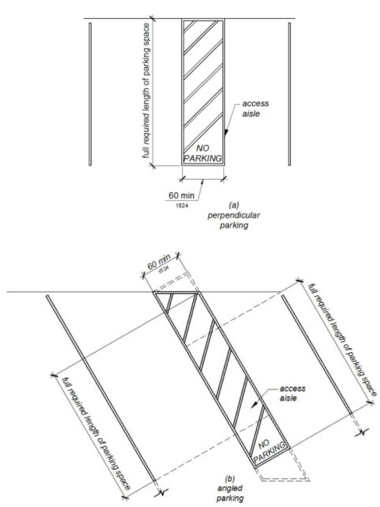


Figure 221: Parking Space Access Aisle

11B-502.7 Relationship to Accessible Routes. Parking spaces and access aisles shall be designed so that cars and vans, when parked, cannot obstruct the required clear width of adjacent accessible routes.

11B-502.7.1 Arrangement. Parking spaces and access aisles shall be designed so that persons using them are not required to travel behind parking spaces other than to pass behind the parking space in which they parked.

11B-502.7.2 Wheel Stops. A curb or wheel stop shall be provided if required to prevent encroachment of vehicles over the required clear width of adjacent accessible routes.

11B-503.3 Access Aisle. Passenger drop-off and loading zones shall provide access aisles complying with Section 11B-503 adjacent and parallel to the vehicle pull-up space. Access aisles shall adjoin an accessible route and shall not overlap the vehicular way.

11B-503.3.1 Width. Access aisles serving vehicle pull-up spaces shall be 60 inches (1524 mm) wide minimum.

11B-503.5 Vertical Clearance. Vehicle pull-up spaces, access aisles serving them and a vehicular route from an entrance to the passenger drop-off and loading zone and from the passenger drop-off and loading zone to a vehicular exit shall provide a vertical clearance of 114 inches (2896 mm) minimum.

11B-503.3.3 Marking. Access aisles shall be marked with a painted borderline around their perimeter. The area within the borderlines shall be marked with hatched lines a maximum of 36 inches (914 mm) on center in a color contrasting with that of the aisle surface.

11B-503.2 Vehicle Pull-Up Space. Passenger drop-off and loading zones shall provide a vehicular pull-up space 96 inches (2438 mm) wide minimum and 20 feet (6096 mm) long minimum.

11B-705.1.2.2.2.1 One Entrance/Exit Point. Where the turning space has one entrance/exit point other than the sloped ramp segments, detectable warnings shall be 36 inches (914 mm) deep, as measured perpendicular to the curb, and the turning space shall provide a minimum 36 inches (914 mm) wide portion without detectable warnings to allow pedestrian travel in the direction of the sidewalk without traveling over the detectable warnings.

Exceptions:

1. Where it is technically infeasible to provide a minimum 72 inches (1828 mm) wide turning space, as measured perpendicular to the curb, the depth of detectable warnings may be reduced to 24 inches (610 mm) minimum.
2. Existing parallel curb ramps with detectable warnings in compliance with the code requirements in effect at the time of installation shall not be required to provide a minimum 36 inches (914 mm) wide portion of the turning space without detectable warnings.

11B-705.1.2.2.2.2 Two Entrance/Exit Points. Where the turning space has two entrance/exit points other than the sloped ramp segments, detectable warnings shall be 36 inches (914 mm) deep at both entrance/exit points, as measured perpendicular to the curb, and the turning space shall provide a minimum 36 inches (914 mm) wide portion without detectable warnings to allow pedestrian travel in the direction of the sidewalk without traveling over the detectable warnings.

Exceptions:

1. Where it is technically infeasible to provide a minimum 108 inches (2743 mm) wide turning space, as measured perpendicular to the curb, the depth of detectable warnings may be reduced to 24 inches (610 mm) minimum.

2. Existing parallel curb ramps with detectable warnings in compliance with the code requirements in effect at the time of installation shall not be required to provide a minimum 36 inches (914 mm) wide portion of the turning space without detectable warnings.

1110A.1 General. When a building or portion of a building is required to be accessible or adaptable, an accessible route shall be provided to all portions of the building, accessible building entrances and between the building and the public way. The accessible route shall be the most practical direct route and to the maximum extent feasible, coincide with the route for the general public and building residents.

Exterior accessible routes shall be provided as follows:

1. At least one accessible route within the boundary of the site shall be provided from public transportation stops, accessible parking and accessible passenger loading and unloading zones, and public streets or sidewalks to the accessible building entrance they serve. Where more than one route of travel is provided, all routes shall be accessible.
2. At least one accessible route shall connect accessible buildings, facilities, elements and spaces that are on the same site. Accessible routes shall be provided between accessible buildings and accessible site facilities when more than one building or facility is located on a site.
3. At least one accessible route shall connect accessible building or facility entrances with all accessible spaces, elements and covered multifamily dwelling units.
4. An accessible route shall connect at least one accessible entrance of each covered multifamily dwelling unit with exterior spaces and facilities that serve the dwelling unit.

5. Where elevators are provided for vertical access, all elevators shall be accessible. See Section 1124A.
    a. Note: If the slope of the finished grade between covered multifamily dwellings and site arrival points, public use or common use facilities (including parking) exceeds 1 unit vertical in 12 units horizontal (8.33-percent slope), or where other physical barriers (natural or artificial) or legal restrictions, all of which are outside the control of the owner, prevent the installation of an accessible route, an acceptable alternative is to provide access by a vehicular route, provided:
        i. There is accessible parking on an accessible route for at least 2 percent of the covered multifamily dwelling units, and
        ii. Necessary site provisions such as parking spaces and curb ramps are provided at the public use or common use facility.

Section 1111A Changes in Level on Accessible Routes.

1111A.1 Changes in Level Not Exceeding 1/2 Inch. Abrupt changes in level along any accessible route shall not exceed 1/2 inch (12.7 mm). When changes in level do occur, they shall be beveled with a slope no greater than 1 unit vertical in 2 units horizontal (50-percent slope). Changes in level not exceeding 1/4 inch (6.35 mm) may be vertical.

1111A.2 Changes Greater Than 1/2 Inch. Changes in level greater than 1/2 inch (12.7 mm) shall be made by means of a sloped surface not greater than 1 unit vertical in 20 units horizontal (5-percent slope), or a curb ramp, ramp, elevator or platform (wheelchair) lift. Stairs shall not be part of an accessible route. When stairs are located along or adjacent to an accessible route they shall comply with Section 1115A for exterior stairways.

1110A.2 Signs. At every primary public entrance and at every major junction where the accessible route diverges from the circulation path along or leading to an accessible route, entrance or facility, there shall be a sign displaying the "International Symbol of Accessibility." Signs shall indicate the direction to accessible building entrances and facilities and shall comply with the requirements found in Section 1143A.

1114A.4.1 Location of Landings. Landings shall be provided at the top and bottom of each ramp. Intermediate landings shall be provided at intervals not exceeding 30 inches (762 mm) of vertical rise and at each change of direction. Landings are not considered in determining the maximum horizontal distance of each ramp.

Note: Examples of ramp dimensions are:

Table 137: Ramp Dimensions

Slope (Grading %)	Maximum Rise (Inches)	Maximum Horizontal Projection (Feet)
1:12 (8.33%)	30	30
1:15 (6.67%)	30	37.5
1:16 (6.25%)	30	40
1:20 (5.00%)	30	50

Pavement Design

Pavements allow goods and services to be transported across roadways and are a vital part of any engineering project. All roads have a design life that affects its serviceability. If a street cannot support the truck traffic loads, it could create catastrophic failures for road users and for surrounding businesses. Per the Highway Design Manual Topic 613 - Traffic Considerations (Caltrans, 22), there are several factors that need to be considered to ensure safe and sustainable roadways.

Equivalent Single Axle Load (ESAL)

The Equivalent Single Axle Load (ESAL) constants represent the estimated total cumulative traffic loading for each of the four vehicle types by axle classification during the pavement design life (Caltrans, 22). This value is a useful tool that is used to calculate the traffic index and helps transportation engineers design adequate pavement thicknesses. CalTrans provides traffic volumes for all vehicles on California State Highways under their Traffic Census Program (Caltrans, 2020 & 2018). Caltrans also provides the Annual Average Daily Traffic (AADT) which is the mean traffic volume across all days for a year for a given location along a roadway (U.S. Department of Transportation & Federal Highway Administration, 2018). Using the data from 2020-AADT & 2018-AADT, the averages can be calculated due to compensating for lower volumes during the COVID pandemic. Under the California Road System (CRS): Cabrillo Park Drive is a Minor Arterial Road, Parkcourt Place is a Major Collector Road, E Fruit Street is a Local Road and E 4th St is the other Other Principal Arterial Road (Caltrans, 2022). Because of this classification, only 4th Street was included in the 2020 AADT Data. From CalTrans 2020 AADT Data, 4th St's AADT was 196,800 vehicles per year.

4th Street - Between Santa Ana Freeway and Tustin Ave. Because the Caltrans data included the entirety of 4th street throughout Santa Ana, we decided to use the average daily traffic values (ADT) from the City of Santa Ana's ArcGIS Open Data. Typically, when researching, data should be no older than 5 years to get an accurate design. The ArcGIS data we obtained contained data from 1995 - 2015 and had values from two segments of 4th Street, from Santa Freeway to Cabrillo Park Drive (Segment 1) and Cabrillo Park Drive to Tustin Ave (Segment 2).

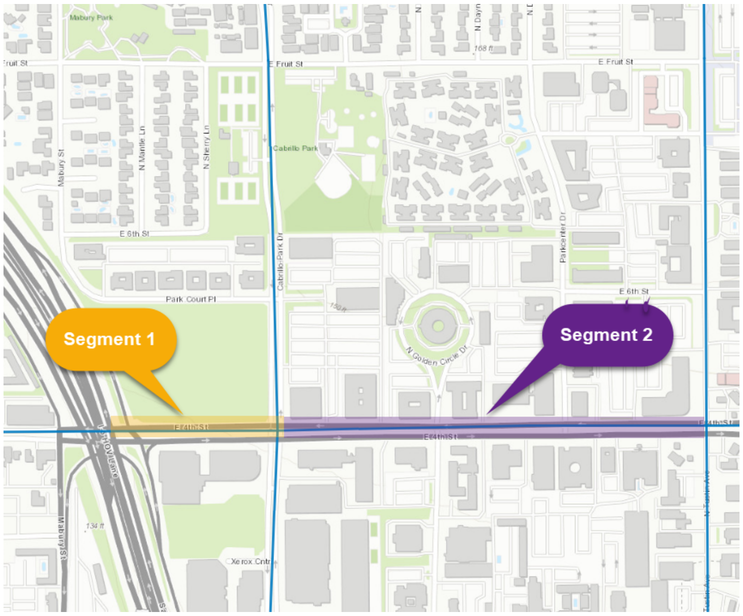


Figure 222: City of Santa Ana ArcGIS Map

We input the ADT's from both segments for the years 1995 - 2015 into Excel and calculated the averages to get the most accurate representation of traffic volumes.

4th - CPD to Tustin			4th - Santa Ana FWY to CPD	
Year	ADT		Year	ADT
2015	23,828		2015	18,463
2013	20,236		2013	26,539
2011	19,892		2011	27,372
2009	20,727		2009	26,842
2007	22,371		2007	30,822
2005	21,692		2005	29,830
2003	20,326		2003	28,568
2001	27,770		2001	25,973
1997	21,419		1997	24,480
1995	21,867		1995	23,123

4th - CPD to Tustin (Averages)					
Year	ADT	% Pop Growth	Population Growth		
2015	21,146	-10	t	7	years
2013	23,388	-1	ADT		
2011	23,632	-1	2022	20,636	vpd
2009	23,785	-11			
2007	26,597	3			
2005	25,761	5			
2003	24,447	-9			
2001	26,872	17			
1997	22,950	2			
1995	22,495				
r		-0.348			

Figure 223: Excel Screenshot of ADT Data

Once we calculated the average ADT for each year, we calculated the population growth rate by using this formula:

$$\left(\frac{ADT_{initial} - ADT_{previous}}{ADT_{previous}}\right) \times 100 = Population\ Growth\ Rate\ \%$$

For all years 1995 - 2015. Then we took the average of the calculated population growth rates to obtain a growth rate percentage that would include the fluctuating population growth rates r. Using r we calculated the population growth for the ADT for 2022 using:

$$ADT(t) = ADT_{initial} \times (1 + r)^{t}$$

Where:

$ADT_{initial}$ = 21,146 vpd (year 2015)

r = -0.348%

t = 7 years

Therefore, ADT for 2022 = 20,636 vehicles per day (vpd) for 4th Street between Santa Ana Freeway and Tustin Avenue.

To calculate the ESAL, we used the following values:

- Available ADT: 20,636 vpd
- ADT Year: 2022
- EOC Year: 2024
- Directional Distribution: 50%
- Lane Distribution: 70% (AASHTO recommends 50-80% for 6+ lanes (3+ per direction)
- Design ADT: 10,735 vpd (calculated by using a default of 2% growth rate from year of the provided ADT to EOC).

- Growth Rates: 2% (cars) & 2% (trucks)
- Design Life: 20 years
- Roadway Functional Class: Urban Other Principal Arterial

Using the ESAL calculator provided in our Transportation Engineering course, we calculated an Urban ESAL value of 1,342,171 (W18) which is the predicted number of 18-kip equivalent single axle load applications to the roadway over a 20 year design life for flexible pavement design.

General Information	
Project Number	0010-0090
Project Description	Senior Design Project - Apex
Town(s)	Santa Ana
Pavement Scope Description	Full Depth Reconstruction (20-year)
Completed By	Hayden Robbins
Reviewed By	Group 2
Company Name	Group 2 - Transportation Engineers
Road Name	4th Street
Pavement Surface Age	20 years

Legend
= automatically calculated or linked value (do not edit)
= user input
= solution(s)
= accumulated ESALs for the designated functional class
= not applicable

Step		Value	Unit	Variable Definition
Step 1: Available ADT		20,636	vpd (vehicles per day)	Available ADT (Average Daily Traffic) is the measured total volume of vehicle traffic on the subject roadway in *both directions*. The top link, below, contains an interactive AADT map for all roadways in CT that can be used to locate traffic data. The bottom link contains expressway ADT maps for limited access facilities as well as ADT maps for towns. https://portal.ct.gov/DOT/PP_SysInfo/Traffic-Monitoring https://portal.ct.gov/DOT/PP_Bureau/Documents/Maps
Step 2: Year	ADT Year	2022		Year for the available ADT data
	EOC Year	2024		End of construction (EOC) year for the project
Step 3: Directional Distribution		50	%	Directional distribution is the percentage of traffic traveling in one direction along the roadway. 50% is the default value for two-way traffic on undivided roadways, or if using combined directional data for a divided highway. Please enter 100% for a one-way road design (ramps, roundabouts, etc.), or if using single direction traffic data for a divided highway (i.e. using northbound data on a N/S expressway).
Step 4: Lane Distribution		70	%	Lane distribution is the percentage of traffic that will be carried in the design lane proposed in the *final* project configuration, not the existing lane conditions (check the project final plans and/or coordinate with the designer or traffic engineer if necessary). "Lanes" refers to the through lanes only, not auxiliary lanes (turning, passing, climbing, acceleration/deceleration, etc.)

	Percent of ESALs in Design Lane	
Number of Lanes	CTDOT	AASHTO
2 lanes (1 per direction)	100%	100%
4 lanes (2 per direction)	90%	80-100%
6+ lanes (3+ per direction)	70%	50-80%

Step		Value	Unit	Variable Definition
Step 5: Design ADT		10,735	vpd (vehicles per day)	Design ADT is a calculated value that will be used to determine the accumulated ESALs in the design lane
Step 6: Growth Rates		2.0	% (cars)	Annual growth rate of cars over the design period
		2.0	% (trucks)	Annual growth rate of all heavy vehicle types over the design period
Step 7: Design Life		20	years	Period of time for which the pavement design/analysis is to be conducted
Step 8: Roadway Functional Class		Urban Other Principal Arterial	*(please click green cell and then choose drop down selection)*	A roadway functional class (FC) is the designation of a roadway into systems according to the character of service it provides in relation to the total roadway network. Please note that in this case the "Multi-lane" class is equivalent to an interstate highway. The link below is an interactive GIS map which includes the FC of the roadways in Connecticut: https://connecticut-ctdot.opendata.arcgis.com/apps/functional-classification-interactive-app/explor
Step 9: Accumulated ESALs	Rural	FALSE	ESALs (W18)	Predicted number of 18-kip equivalent single axle load applications to the roadway over the selected design life. This value should only be used for flexible (asphalt) pavement design calculations. Design ESALs for rigid (concrete) or composite (asphalt on concrete) pavement design will require an adjustment to this value (accumulated ESALs multiplied by a factor of 1.5). See Rigid-Composite Design Tool for implementation
	Urban	1,342,171	ESALs (W18)	

Figure 224: ESAL Calculator per AASHTO Guidelines - 4th Street

Cabrillo Park Drive - Between 4th Street & Fruit Street. Due to the lack of current traffic volume data for Santa Ana, we found the Average Daily Traffic Volumes for Cabrillo Park Dr between 4th St & Fruit St from 1995 - 2015 from the City of Santa Ana's GIS Open Data. From the older reported volumes, we calculated the population growth rate by using this formula:

$$\left(\frac{ADT_{initial} - ADT_{previous}}{ADT_{previous}}\right) \times 100 = \ Population\ Growth\ Rate\ \%$$

For all years 1995 - 2015. Then we took the average of the calculated population growth rates to obtain a growth rate percentage that would include the fluctuating population growth rates r. Using r we calculated the population growth for the ADT for 2022 using:

$$ADT(t) = ADT_{initial} \times \ (1 + r)^t$$

Where:

$ADT_{initial}$ = 10,621 vpd (year 2015)

r = 0.708%

t = 7 years

Therefore, ADT for 2022 = 11,159 vpd.

To calculate the ESAL, we used the following values:

- Available ADT: 11,159 vpd
- ADT Year: 2022
- EOC Year: 2024
- Directional Distribution: 50%
- Lane Distribution: 90% (AASHTO recommends 80-100% for 4 lanes (2 per direction)

- Design ADT: 5,805 vpd (calculated by using a default of 2% growth rate from year of the provided ADT to EOC).
- Growth Rates: 2% (cars) & 2% (trucks)
- Design Life: 20 years
- Roadway Functional Class: Urban Minor Arterial

Using the ESAL calculator provided in our Transportation Engineering course, we calculated an Urban ESAL value of 2,345,960 (W18) which is the predicted number of 18-kip equivalent single axle load applications to the roadway over a 20 year design life for flexible pavement design.

Finding the ESAL for existing roads and potential new roads is a vital part of any transportation engineer design. If you are designing a structure that invites higher volumes of traffic than its current capacity, such as a mall or a sports venue, the existing roads may not be able to support the influx in traffic/loads if the initial calculated ESAL is not high enough or the design service year is close to expiring. From the ESAL's we calculated above for Cabrillo Parking Drive and 4th Street, we can see that these roads were designed to support high volumes of traffic.

Driving around you have probably seen signs that say "NoTrucks Allowed," a big reason behind this is because the roads may not have been designed to support high ESALs. Allowing higher load vehicles (such as 4-axle and above) could impair the integrity of the road and result in catastrophic and fatal accidents. The higher the ESAL value by road classification, the greater loads of vehicles the road can support.

General Information	
Project Number	0010-0090
Project Description	Senior Design Project - Apex
Town(s)	Santa Ana
Pavement Scope Description	Full Depth Reconstruction (20-year)
Completed By	Hayden Robbins
Reviewed By	Group 2
Company Name	Group 2 - Transportation Engineers
Road Name	Cabrillo Park Drive
Pavement Surface Age	20 years

Legend
- automatically calculated or linked value (do not edit)
- user input
- solution(s)
- accumulated ESALs for the designated functional class
- not applicable

Step		Value	Unit	Variable Definition
Step 1: Available ADT		11,159	vpd (vehicles per day)	Available ADT (Average Daily Traffic) is the measured total volume of vehicle traffic on the subject roadway in *both directions*. The top link, below, contains an interactive AADT map for all roadways in CT that can be used to locate traffic data. The bottom link contains expressway ADT maps for limited access facilities as well as ADT maps for towns. https://portal.ct.gov/DOT/PP_SysInfo/Traffic-Monitoring https://portal.ct.gov/DOT/PP_Bureau/Documents/Maps
Step 2: Year	ADT Year	2022		Year for the available ADT data
	EOC Year	2024		End of construction (EOC) year for the project
Step 3: Directional Distribution		50	%	Directional distribution is the percentage of traffic traveling in one direction along the roadway. 50% is the default value for two-way traffic on undivided roadways, or if using combined directional data for a divided highway. Please enter 100% for a one-way road design (ramps, roundabouts, etc.), or if using single direction traffic data for a divided highway (i.e. using northbound data on a N/S expressway).
Step 4: Lane Distribution		90	%	Lane distribution is the percentage of traffic that will be carried in the design lane proposed in the *final* project configuration, not the existing lane conditions (check the project final plans and/or coordinate with the designer or traffic engineer if necessary). "Lanes" refers to the through lanes only, not auxiliary lanes (turning, passing, climbing, acceleration/deceleration, etc.)

	Percent of ESALs in Design Lane	
Number of Lanes	CTDOT	AASHTO
2 lanes (1 per direction)	100%	100%
4 lanes (2 per direction)	90%	80-100%
6+ lanes (3+ per direction)	70%	50-80%

Step		Value	Unit	Variable Definition
Step 5: Design ADT		5,805	vpd (vehicles per day)	Design ADT is a calculated value that will be used to determine the accumulated ESALs in the design lane
Step 6: Growth Rates		2.0	% (cars)	Annual growth rate of cars over the design period
		2.0	% (trucks)	Annual growth rate of all heavy vehicle types over the design period
Step 7: Design Life		20	years	Period of time for which the pavement design/analysis is to be conducted
Step 8: Roadway Functional Class		Urban Minor Arterial	*(please click green cell and then choose drop down selection)*	A roadway functional class (FC) is the designation of a roadway into systems according to the character of service it provides in relation to the total roadway network. Please note that in this case the "Multi-lane" class is equivalent to an interstate highway. The link below is an interactive GIS map which includes the FC of the roadways in Connecticut: https://connecticut-ctdot.opendata.arcgis.com/apps/functional-classification-interactive-app/explor
Step 9: Accumulated ESALs	Rural	FALSE	ESALs (W18)	Predicted number of 18-kip equivalent single axle load applications to the roadway over the selected design life. This value should only be used for flexible (asphalt) pavement design calculations. Design ESALs for rigid (concrete) or composite (asphalt on concrete) pavement design will require an adjustment to this value (accumulated ESALs multiplied by a factor of 1.5). See Rigid-Composite Design Tool for implementation
	Urban	2,345,960	ESALs (W18)	

Figure 225: ESAL Calculator Per AASHTO Guidelines - Cabrillo Park Drive

Traffic Index (TI).

The Traffic Index (TI) is a measure of the number ESALs expected in the traffic lane over the pavement design life of the facility (Highway Design Manual (HDM) | Caltrans, 2017). The TI is rounded up to the nearest 0.5 and is calculated using:

$$TI = 9.0 \times \left(\frac{ESAL \times LDF}{10^6}\right)^{0.119}$$

Where:

TI = Traffic Index for a given design life

$ESAL$ = Total number of cumulative 18-kip Equivalent Single Axle Loads for all truck/bus types over the design life of the pavement structure calculated using the ESAL constants given in Table 613.3A.

LDF = Lane Distribution Factor (see Table 613.3B)

4th Street - Between Santa Ana Freeway and Tustin Ave. Using the equation for TI:

$$TI = 9.0 \times \left(\frac{1{,}342{,}171 \times 0.8}{10^6}\right)^{0.119} = 9.08 \sim 9.50$$

Cabrillo Park Drive - Between 4th Street & Fruit Street. Using the equation for TI:

$$TI = 9.0 \times \left(\frac{2{,}345{,}960 \times 0.8}{10^6}\right)^{0.119} = 9.70 \sim 10$$

According to Highway Design Manual 10, the TI is rounded up to the nearest 0.5 (Caltrans, 22). Because the modern world around us is constantly changing, businesses come and go, recreational parks become parking lots, open fields have shopping centers constructed on top of them, designing a TI for facilities with a longer service life, such as 30 or 40 years, is not recommended.

Table 613.3A
ESAL Constants

Vehicle Type (by Axle Classification)	10-Year Constants	20-Year Constants	30-Year Constants	40-Year Constants
Two-axle trucks or buses	690	1,380	2,070	2,760
Three-axle trucks or buses	1,840	3,680	5,520	7,360
Four-axle trucks	2,940	5,880	8,820	11,760
Five or more-axle trucks	6,890	13,780	20,670	27,560
Two-axle buses (1)	1,380	2,760	4,140	5,520
Three-axle buses (1)	6,808	13,616	20,424	27,232

NOTES:

(1) New constants added in in response to recent passing of AB 1250 in October 2015.

Figure 226: ESAL Constants from HDM 2010

Table 613.3B
Lane Distribution Factors for Multilane Highways

Number of Mixed Flow Lanes in One Direction (2)	Factors to be Applied to Projected One-Way Annual Average Daily Truck Traffic (AADTT) (3)			
	Mixed Flow Lanes (6), (7)			
	Lane 1 (1)	Lane 2	Lane 3	Lane 4
One	1.0	-	-	-
Two	1.0	1.0	-	-
Three	0.2 (4), (5)	0.8	0.8	-
Four	0.2 (4), (5)	0.2 (4), (5)	0.8	0.8

NOTES:

(1) Lane 1 is next to the centerline or median.

(2) For more than four lanes in one direction, use a factor of 0.8 for the outer two lanes plus any auxiliary/collector lanes and, a factor of 0.2 for other mixed flow through lanes, HOV lanes and other inside lanes (non truck lanes).

(3) Projected one-way AADTT is the truck traffic volume expected to use the lane during the design life for the facility.

(4) TI for non-truck permitted lanes must not exceed 11 for 20-year pavement design life and 12 for 40-year pavement design life.

(5) If HOV or other inside lanes are designated (signage required) for truck use, they must be designed to the same standards as found in this table for the outside lanes.

(6) For lanes devoted exclusively to buses and/or trucks, use a factor of 1.0 based on projected AADTT of mixed-flow lanes for auxiliary and truck lanes, and a separate AADTT based on expected bus traffic for exclusive bus-only lanes.

(7) The lane distribution factors in this table represent minimum factors and, based on knowledge of local traffic conditions and sound engineering judgment, higher values may be used for specific locations when warranted.

Figure 227: Lane Distribution Factors for Multilane Highways from HDM 2010

Determine the Thickness for the Hot Mix Asphalt (HMA)

The HDM has various design calculations for Flexible Pavement. Flexible Pavements are engineered to transmit and distribute vehicle loads to the underlying layers. The highest quality later is the surface course (generally asphalt binder mixes) which may or may not incorporate underlying layers of base and subbase. These type of pavements are called “flexible” because the total pavement structure bends or flexes to accommodate deflection bending under vehicle loads (Highway Design Manual (HDM) | Caltrans, 2017). Using Design Example 3: Drained Pavement Structures Which Include Treated Permeable Bases (HMA/ATPB/AB/AS) we were able to find the following values based on the calculated TI and selecting the California R-value of 50. By selecting a California R-value of 50, the type of material is Aggregate Base, Abbreviation is AS-Class 2, Resilient Modulus M_r = 30,000 psi and the Poisson's Ratio (v) is 0.35 based on Table 663.3 from the HDM.

We converted the Flexible Pavement Design Example 3 into an Excel sheet and by inputting the values for TI, R and using Table 633.1 from the HDM, we were able to calculate the Hot Mix Asphalt (HMA) thickness and the thickness for the Bases and Subbases. Using the calculations shown below, we calculated a HMA of 0.6 ft for the Alternative 1 and 0.15 ft for Alternative 2.

Table 663.3

Default Resilient Moduli for Bases and Subbases Used in Flexible Pavement Design

Type of Material	Abbreviation	Resilient Modulus, M_r (psi)	California R-value	Poison's Ratio, (ν)
Aggregate Base	AS-Class 2	30,000	50	0.35
	AS-Class 3	25,000	40	0.35
	AB-Class 2	45,000	78	0.35
	AB-Class 3	30,000	50	0.35
Asphalt Treated Permeable Base	ATPB	45,000	NA	NA
Cement Treated Base	CTB-Class A	1,508,000	NA	0.2
	CTB-Class B	1,140,000	80	0.2
Cement Treated Permeable Base	CTPB	1,100,000	NA	0.2
Lean Concrete Base	LCB	1508,000	NA	0.2
Lean Concrete Base Rapid Setting	LCBRS	1508,000	NA	0.2
Lime Stabilized Soil	LSS	$0.124\times UCS^{(1)}+9.98$	NA	0.2
Cement Stabilized Soil	CSS	$1.2\times UCS^{(2)}$	NA	0.2

NOTES:

(1) UCS is the unconfined compressive strength of the lime stabilized material in psi measured according to California Test Method 373 with the modification that samples are oven-cured at 110°F ± 5°F for 7 days.

(2) UCS of the cement stabilized materials in psi measured according to ASTM D 1633, oven-cured at 100±5°F for 7 days.

Legend:
NA = No default value available
UCS = Unconfined Compressive Strength in psi (minimum 300 psi)

Figure 228: Default Resilient Moduli for Bases and Subbases Used in Flexible Pavement Design

Table 633.1

Gravel Equivalents (GE) and Thickness of Structural Layers (ft)

Actual Layer Thickness (ft) (5)	HMA (1), (2)											Base and Subbase (3), (4)					
	Traffic Index (TI)											TI is not a factor					
	5.0 & below	5.5 6.0	6.5 7.0	7.5 8.0	8.5 9.0	9.5 10.0	10.5 11.0	11.5 12.0	12.5 13.0	13.5 14.0	14.5 15.0	LCB	CTPB; CTB (Cl. A)	ATPB	CTB (Cl. B)	AB	AS
	G_f (For HMA thickness equal to or less than 0.5 ft, G_f decreases with TI) (6)											G_f (Constant for any base or subbase material irrespective of TI or thickness)					
	2.54	2.32	2.14	2.01	1.89	1.79	1.71	1.64	1.57	1.52	1.46	1.9	1.7	1.4	1.2	1.1	1.0
	GE for HMA layer (ft)											GE for Base or Subbase layer (ft)					
0.10	0.25	0.23	0.21	0.20	0.19	0.18	0.17	0.16	0.16	0.15	0.15	--	--	--	--	--	--
0.15	0.38	0.35	0.32	0.30	0.28	0.27	0.26	0.25	0.24	0.23	0.22	--	--	--	--	--	--
0.20	0.51	0.46	0.43	0.40	0.38	0.36	0.34	0.33	0.31	0.30	0.29	--	--	--	--	--	--
0.25	0.63	0.58	0.54	0.50	0.47	0.45	0.43	0.41	0.39	0.38	0.37	--	--	0.35	--	--	--
0.30	0.76	0.69	0.64	0.60	0.57	0.54	0.51	0.49	0.47	0.45	0.44	--	--	0.42	--	--	--
0.35	0.89	0.81	0.75	0.70	0.66	0.63	0.60	0.57	0.55	0.53	0.51	0.67	0.60	0.49	0.42	0.39	0.35
0.40	1.01	0.93	0.86	0.80	0.76	0.72	0.68	0.65	0.63	0.61	0.59	0.76	0.68	0.56	0.48	0.44	0.40
0.45	1.14	1.04	0.96	0.90	0.85	0.81	0.77	0.74	0.71	0.68	0.66	0.86	0.77	0.63	0.54	0.50	0.45
0.50	1.27	1.16	1.07	1.00	0.94	0.90	0.85	0.82	0.79	0.76	0.73	0.95	0.85	0.70	0.60	0.55	0.50
0.55	1.41	1.29	1.19	1.12	1.05	1.00	0.95	0.91	0.87	0.84	0.81	1.05	0.94	0.77	0.66	0.61	0.55
0.60	1.58	1.45	1.34	1.25	1.18	1.12	1.07	1.02	0.98	0.95	0.91	1.14	1.02	0.84	0.72	0.66	0.60
0.65	1.76	1.61	1.49	1.39	1.31	1.25	1.19	1.14	1.09	1.05	1.02	1.24	1.11	0.91	0.78	0.72	0.65
0.70	--	1.78	1.64	1.54	1.45	1.38	1.31	1.26	1.21	1.16	1.12	1.33	1.19	--	0.84	0.77	0.70
0.75	--	1.95	1.80	1.69	1.59	1.51	1.44	1.38	1.32	1.27	1.23	1.43	1.28	--	0.90	0.83	0.75
0.80	--	2.12	1.96	1.84	1.73	1.64	1.57	1.50	1.44	1.39	1.34	1.52	1.36	--	0.96	0.88	0.80
0.85	--	--	2.13	1.99	1.88	1.78	1.70	1.63	1.56	1.51	1.46	1.62	1.45	--	1.02	0.94	0.85
0.90	--	--	2.30	2.15	2.03	1.92	1.83	1.76	1.69	1.63	1.57	1.71	1.53	--	1.08	0.99	0.90
0.95	--	--	--	2.31	2.18	2.07	1.97	1.89	1.81	1.75	1.69	1.81	1.62	--	1.14	1.05	0.95
1.00	--	--	--	2.47	2.33	2.21	2.11	2.02	1.94	1.87	1.81	1.90	1.70	--	1.20	1.10	1.00
1.05	--	--	--	2.64	2.49	2.36	2.25	2.16	2.07	2.00	1.93	2.00	1.79	--	1.26	1.16	1.05
1.10	--	--	--	--	2.65	2.51	2.40	2.29	2.20	2.12	2.05	--	--	--	--	--	1.10
1.15	--	--	--	--	2.81	2.67	2.54	2.43	2.34	2.25	2.18	--	--	--	--	--	1.15
1.20	--	--	--	--	2.98	2.82	2.69	2.58	2.48	2.39	2.30	--	--	--	--	--	1.20
1.25	--	--	--	--	--	2.98	2.84	2.72	2.61	2.52	2.43	--	--	--	--	--	1.25
1.30	--	--	--	--	--	3.14	2.99	2.87	2.75	2.65	2.56	--	--	--	--	--	1.30
1.35	--	--	--	--	--	3.30	3.15	3.01	2.90	2.79	2.70	--	--	--	--	--	--
1.40	--	--	--	--	--	--	3.31	3.16	3.04	2.93	2.83	--	--	--	--	--	--
1.45	--	--	--	--	--	--	3.46	3.32	3.19	3.07	2.97	--	--	--	--	--	--
1.50	--	--	--	--	--	--	3.62	3.47	3.33	3.21	3.10	--	--	--	--	--	--
1.55	--	--	--	--	--	--	--	3.62	3.48	3.36	3.24	--	--	--	--	--	--
1.60	--	--	--	--	--	--	--	3.78	3.63	3.50	3.38	--	--	--	--	--	--
1.65	--	--	--	--	--	--	--	3.94	3.79	3.65	3.52	--	--	--	--	--	--
1.70	--	--	--	--	--	--	--	--	3.94	3.80	3.67	--	--	--	--	--	--
1.75	--	--	--	--	--	--	--	--	4.09	3.95	3.81	--	--	--	--	--	--
1.80	--	--	--	--	--	--	--	--	4.25	4.10	3.96	--	--	--	--	--	--
1.85	--	--	--	--	--	--	--	--	--	4.25	4.10	--	--	--	--	--	--
1.90	--	--	--	--	--	--	--	--	--	4.40	4.25	--	--	--	--	--	--
1.95	--	--	--	--	--	--	--	--	--	4.56	4.40	--	--	--	--	--	--
2.00	--	--	--	--	--	--	--	--	--	--	4.55	--	--	--	--	--	--

NOTES:

(1) Open Graded Friction Course (conventional and rubberized) is a non-structural wearing course and provides no structural value.

(2) Top portion of HMA surface layer (maximum 0.20 ft.) may be replaced with equivalent RHMA-G thickness. See Topic 631.3 for additional details.

(3) See Table 663.3 for additional information on Gravel Factors (G_f) and California R-values for base and subbase materials.

(4) When using Hot Mix Asphalt Base (HMAB), the HMAB is considered as part of the HMA layer. Therefore, the HMAB will be assigned the same G_f as the remainder of the HMA in the pavement structure.

(5) For HMA layer, select TI range, then go down to the appropriate GE and across to the thickness column. For base and subbase layer, select material type, then go down to the appropriate GE and across to the thickness column.

Figure 229: Gravel Equivalents and Thickness of Structural Layers from HDM 2010

Determining the Thickness for Base and Subbase. The thicknesses of the base and subbase layers were determined using the Design Example 3: Drained Pavement Structures. The process of finding the thicknesses of the base and subbase layer starts with determining which class of aggregate will be used for the base and subbase as shown in Table 633.1 from the HDM as the California R-Values for the aggregate base and subbase are needed to conduct the calculations. The GE_{Total} (gravel equivalents) is needed to start the calculation for the thicknesses using the following equation:

$$TI = 10,\ R_{\text{Subgrade}} = 10$$

$$GE_{\text{Total}} = 0.0032(TI)(100 - R_{\text{Subgrade}})$$

$$GE_{\text{Total}} = 0.0032(10)(100 - 10)$$

$$GE_{\text{Total}} = 2.88\ ft$$

Once the GE_{Total} for the pavement is calculated we then had to calculate the GE of the combined hot mix asphalt (HMA), treated permeable base (TPB), and base using the following equation and the California R-value of the subbase:

$$R_{\text{Subbase}} = 50$$

$$GE_{\text{HMA+TPB+AB}} = 0.0032(TI)(100 - R_{\text{Subbase}})$$

$$GE_{\text{HMA+TPB+AB}} = 0.0032(10)(100 - 50)$$

$$GE_{\text{HMA+TPB+AB}} = 1.60\ ft$$

The next calculation needed was to determine the GE of the HMA surface layer by multiplying the required GE of the combined HMA, treated permeable base and base layers by 0.4 and adding the safety factor of 0.2:

$$GE_{\text{HMA}} = (GE_{\text{HMA+TPB+AB}})(0.40) + 0.20\ ft$$

$$GE_{\text{HMA}} = (1.60\ ft)(0.40) + 0.20\ ft$$

$$GE_{\text{HMA}} = 0.84\ ft$$

From Table 633.1 Actual GE_{HMA} is $0.81\ ft$ and Actual thickness of HMA is $0.45\ ft$

Once GE_{HMA} is calculated when we look at Table 633.1 from the Highway Design Manual to acquire the actual thickness of the hot mix asphalt. GE for Asphalt Treated Permeable Base (ATPB) is 0.35 ft for a corresponding 0.25 ft layer thickness of ATPB according to Table 633.1 from the Highway Design Manual. The next calculation that was performed was to determine the thickness for the base layer. GE_{AB} (base) is calculated with the following equation:

$$GE_{\text{AB}} = GE_{\text{HMA + ATPB + AB}} - GE_{\text{HMA}} - GE_{\text{ATPB}} + 0.20 \text{ ft.}$$

$$GE_{\text{AB}} = 1.6\,ft - 0.84\,ft - 0.25\,ft + 0.20\,ft$$

$$GE_{\text{AB}} = 0.64\,ft$$

From Table 633.1 Actual thickness of the base layer is $0.80\,ft$

The value of GE_{AB} is then used to determine the thickness of the base layer using Table 633.1 from the Highway Design Manual. The last calculation needed is to determine the GE_{AS} which will help determine the thickness of the subbase layer. The following Equation was used for the calculation:

$$GE_{\text{AS}} = GE_{\text{Total}} - (GE_{\text{HMA}} + GE_{\text{ATPB}} + GE_{\text{AB}})$$

$$GE_{\text{AS}} = 2.88\,ft - (0.81\,ft + 0.25\,ft + 0.64\,ft)$$

$$GE_{\text{AS}} = 1.4\,ft$$

GE_{AS} is equal to the actual thickness of subbase layer

We transformed these equations into an excel sheet and calculated the thicknesses for the parking lot design. The following table represents the pavement thicknesses that were calculated:

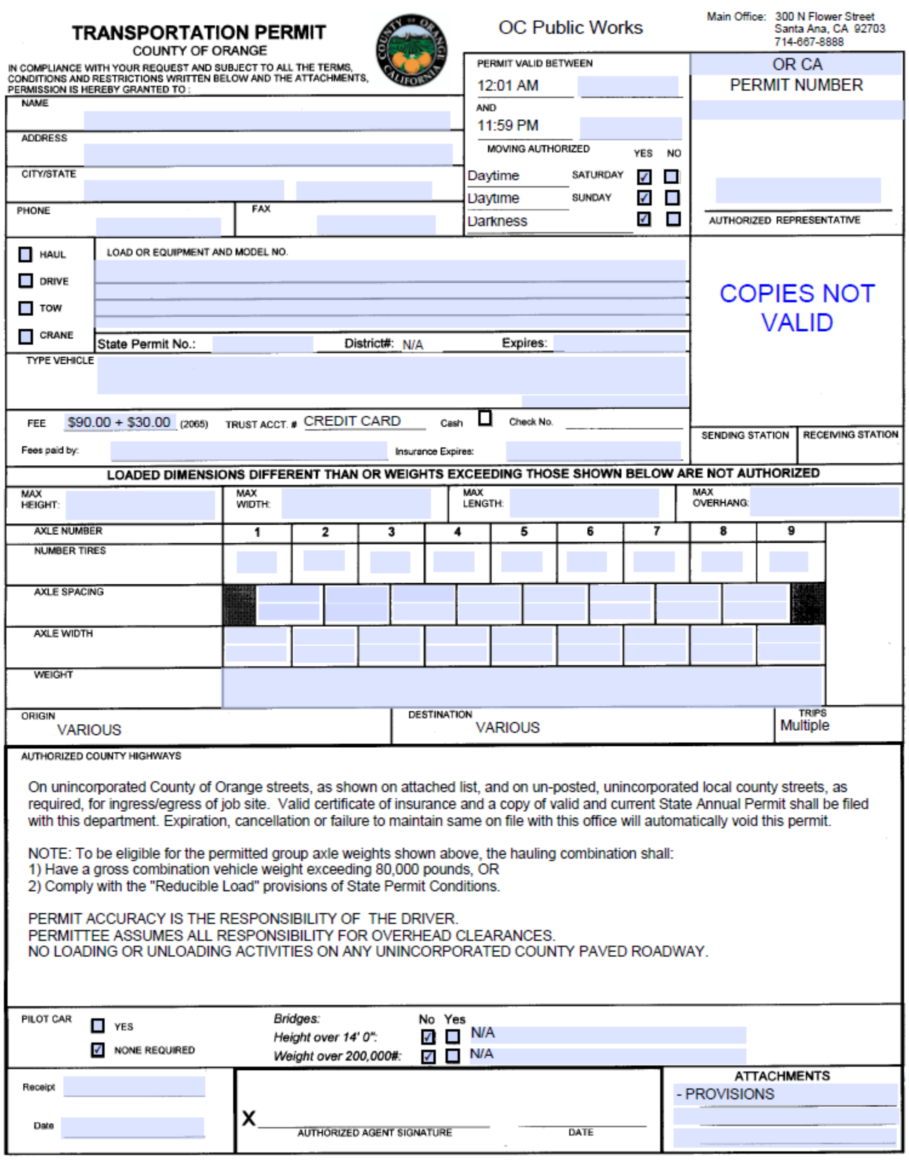
Table 138: Calculated Pavement Thickness

Pavement Thickness

Layer	Alt. 1 (ft)	Alt. 2 (ft)
HMA	0.60	0.15
HMAB		0.45
ATPB	0.25	0.25
AB	0.80	0.80
AS	1.40	1.40

Permits Required

Orange County requires a trip permit for hauling materials on unincorporated County streets (there are several exceptions that did not apply to our location) and require approval from the respective agencies when movements are within cities and/or on State Highways.



TRANSPORTATION PERMIT
COUNTY OF ORANGE
IN COMPLIANCE WITH YOUR REQUEST AND SUBJECT TO ALL THE TERMS, CONDITIONS AND RESTRICTIONS WRITTEN BELOW AND THE ATTACHMENTS, PERMISSION IS HEREBY GRANTED TO:

OC Public Works

Main Office: 300 N Flower Street
Santa Ana, CA 92703
714-667-8888

NAME
ADDRESS
CITY/STATE
PHONE FAX

PERMIT VALID BETWEEN
12:01 AM
AND
11:59 PM

OR CA
PERMIT NUMBER

MOVING AUTHORIZED		YES	NO
Daytime	SATURDAY	☑	☐
Daytime	SUNDAY	☑	☐
Darkness		☑	☐

AUTHORIZED REPRESENTATIVE

☐ HAUL
☐ DRIVE
☐ TOW
☐ CRANE

LOAD OR EQUIPMENT AND MODEL NO.

State Permit No.: District#: N/A Expires:

TYPE VEHICLE

COPIES NOT VALID

FEE $90.00 + $30.00 (2065) TRUST ACCT. # CREDIT CARD Cash ☐ Check No.

Fees paid by: Insurance Expires:

SENDING STATION RECEIVING STATION

LOADED DIMENSIONS DIFFERENT THAN OR WEIGHTS EXCEEDING THOSE SHOWN BELOW ARE NOT AUTHORIZED

MAX HEIGHT: MAX WIDTH: MAX LENGTH: MAX OVERHANG:

AXLE NUMBER	1	2	3	4	5	6	7	8	9
NUMBER TIRES									
AXLE SPACING									
AXLE WIDTH									
WEIGHT									

ORIGIN VARIOUS DESTINATION VARIOUS TRIPS Multiple

AUTHORIZED COUNTY HIGHWAYS

On unincorporated County of Orange streets, as shown on attached list, and on un-posted, unincorporated local county streets, as required, for ingress/egress of job site. Valid certificate of insurance and a copy of valid and current State Annual Permit shall be filed with this department. Expiration, cancellation or failure to maintain same on file with this office will automatically void this permit.

NOTE: To be eligible for the permitted group axle weights shown above, the hauling combination shall:
1) Have a gross combination vehicle weight exceeding 80,000 pounds, OR
2) Comply with the "Reducible Load" provisions of State Permit Conditions.

PERMIT ACCURACY IS THE RESPONSIBILITY OF THE DRIVER.
PERMITTEE ASSUMES ALL RESPONSIBILITY FOR OVERHEAD CLEARANCES.
NO LOADING OR UNLOADING ACTIVITIES ON ANY UNINCORPORATED COUNTY PAVED ROADWAY.

PILOT CAR ☐ YES ☑ NONE REQUIRED

Bridges:	No	Yes	
Height over 14' 0":	☑	☐	N/A
Weight over 200,000#:	☑	☐	N/A

Receipt
Date

X AUTHORIZED AGENT SIGNATURE DATE

ATTACHMENTS
- PROVISIONS

Figure 230: Orange County Transportation Permit

Additional permits for street work and utility are also needed and shown in Transportation Appendices.

Vendor Catalog

All transportation supplies will be selected in conjunction with Caltrans's Authorized Materials Lists (AML) (Caltrans, 2023) and are listed below.

Striping and Pavement Marking Material

- Advanced Traffic Marking, Series 300 and 400
- Brite Line, Series 1000
- Brite Line, "DeltaLine XRP"
- Swarco Industries, "Director 60"
- 3M, "Stamark" 380 IES and 270 ES
- Advanced Traffic Marking, MaxVision Series 300 White & Yellow

Concrete Block

- Concrete Parking Stop Blocks SKU: 18-1603 (Nitterhouse Masonry Products, LLC, n.d.).

Cost Estimation

The cost estimation for our project was conducted using an excel spreadsheet that is used by the City of Santa Ana. The cost unit prices were determined by averaging quotes from contractors that were contracted by the City of Santa Ana. In this cost estimate we included the work for the signing, striping, ADA curb ramp, concrete parking blocks, and the parking lot pavement. Acquiring data and costs for parking lot pavement was difficult to come by so we used square footage as the quantity and priced it by average prices that we were able to find on the web. The total cost we estimated was $73,340.00 for the transportation work that needs to be done. The following is represents a table of the breakdown:

Transportation Cost Estimate

Project: Apex Physical Therapy and Rehabilitation
Estimator: Ruben Adame
Date: 4/28/2023

Item Num	Description	Unit of Measure	Quantity	Engineer's Estimate	Engineer's Estimate
1	Install White Lane Line Extension per City of SA STD. Plan No. 1125B-2. Detail "8".	LF	470	$ 2.00	$ 940.00
2	Install 4" White Pavement Line	LF	290	$ 3.00	$ 870.00
3	Install 4" Blue Pavement Line	LF	200	$ 3.00	$ 600.00
4	Install Yellow Center Line (COSA Detail 6)	LF	0	$ 2.00	$ -
5	12" White Thermoplastic Stop Bar/Limit Line	SF	0	$ 4.00	$ -
6	Install Detail 'D'	EA	0	$ 580.00	$ -
7	Install Thermoplastic Continental Crosswalk	SF	0	$ 4.00	$ -
8	Install Lane Line (COSA Detail 1)	LF	0	$ 2.00	$ -
9	4" Yellow Left Edge Line (CT Detail 24)	LF	0	$ 2.00	$ -
10	4" White Right Edge Line (CT Detail 27)	LF	0	$ 2.00	$ -
11	Install 6" White Chevron or Diagonal Stripe	LF	0	$ 3.00	$ -
12	Install Street Legends and Arrows	EA	10	$ 500.00	$ 5,000.00
13	Remove Conflicting Striping (Grinding/Sandblasting)	LF	0	$ 4.00	$ -
14	Install PCC Parking Block	EA	8	$ 60.00	$ 480.00
15	Install New Sign(s) only.	EA	0	$ 300.00	$ -
16	Install New Sign(s) and Post(s)	EA	5	$ 400.00	$ 2,000.00
17	Install PCC Curb Ramp with Dome	SF	74	$ 30.00	$ 2,220.00
18	Parking Lot Pavement Construction	SF	6123	$ 10.00	$ 61,230.00
				Total	$ 73,340.00

Figure 231: Transportation Cost Estimate

Legal and Ethical Issues

All transportation improvements were designed with Federal, State and Local guidelines in mind. As future transportation engineers, we are expected to design with, “safety first,” and will be legally bound by the American Society of Civil Engineers (ASCE) Code of Ethics. With the first line stating: that engineers; first and foremost, protect the health, safety, and welfare of the public (American Society of Civil Engineers (ASCE), 1914). We have to figure out a way to balance safety, traffic efficiency, and aesthetics when we design any transportation project. Because of our motto: engineering with compassion, safety and traffic efficiency were the first two priorities, as those were the most important to our potential clients. Our design provides as much accessible parking as we were able to physically provide with the small square footage we had available. We also wanted to honor the available parking in the neighboring businesses by designating on-site parking for our Natural Gas Shuttle Van. Because this is a bigger vehicle than a standard compact car, we did not want to take up potential parking for the existing businesses and cause any disagreements with fellow business owners. Community outreach was a big topic we discussed in the initial stages of our design. By keeping a positive rapport with our clients and the other surrounding business owners, we are able to promote our services and be supportive members of the community.

Another important ethical issue is using/applying the Public Health Approaches to Addressing Arthritis (CDC-RFA-DP-23-0001) funding grant. One of our team members was diagnosed with avascular necrosis of her right hip at the age of 19. As the disease progressed, it developed into Osteoarthritis in her right hip and eventually spread to her left hip. She is currently waiting to get a total hip replacement but because of her age, the doctors have been trying alternative medications and therapies to postpone the surgery. She currently lives with chronic pain but remains hopeful and motivated to improve her health and her quality of life. Because of this, she wants to raise awareness about how adults who live with arthritis can improve their social and physical environments while managing their pain naturally. This grant signifies that your ailment does not define your ability to live freely.

Design Constraints

Our first priority was the safety of our clients and visitors, while also being able to accommodate any and all accessible needs. The existing size of the parking lot posed several issues when creating our design. Our parking design became very limited per Santa Ana Municipal Codes. There are numerous codes that we adhered to that dictated how our parking was going to look. We tried many different designs relating to the parking stalls, such as angled parking, but ended up with using 90 degree parking to maximize the amount of parking spaces we would have available for our clients. There also could not be any parking stalls in the 15 foot space from the sidewalk to the site - on the west end of the lot (reference Figure 214: Parking Lot Design). This is why we have a relatively open space west of the elevator. The front of the elevator also has to remain free of parking stalls and of obstructions. We are able to prioritize our clients safety by preventing any accidents from occuring when they are loading and unloading on the elevator. There were several physical limitations with the existing layout that prevented us from creating an exit on the west side of the parking lot. Ideally, allowing two exits to the parking lot would be the most efficient way to compensate for the small size of the lot, but because of underground facilities along the sidewalk and Santa Ana Municipal Codes, we had to use the existing driveway to direct traffic.

Conclusion

Transportation plays a pivotal role in the success of society. It is essential for unifying the population and promoting economic activities. As future transportation engineers, we are responsible for modernizing urban infrastructures and providing sustainable transportation for current and future generations. This project was a great sneak peak to what our transportation engineering future careers hold for us. Analyzing multiple intersections due to the low volume intersection and area was important to show our extensive knowledge we have obtained throughout our courses. Some helpful tips we would give to future classes would be to learn AutoCAD on a more involved level and to try and pick a busier location so there is more data to research and analyze.

Programs Used

For the proposed improvements, we used AutoCAD, AutoCAD Civil 3D, Infraworks and Microstation. For the traffic analyses we used a combination of manual entry of City data into Excel, as well as entering it into Synchro to calculate the LOS, average control delay, etc.

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Appendix: Transportation

1. PERMIT VALIDATION - A STREET WORK PERMIT CONSTITUTES A CONTRACT AND IS NOT VALID UNLESS SIGNED BY THE PUBLIC WORKS AGENCY EXECUTIVE DIRECTOR OR HIS AUTHORIZED REPRESENTATIVE. A COPY OF STREET WORK PERMITS AND APPROVED PLANS MUST BE KEPT AT THE WORKSITE AT ALL TIMES AND SHALL BE PRESENTED TO ANY CITY REPRESENTATIVE UPON REQUEST. A STREET WORK PERMIT SHALL BE VOID UNLESS THE EXCAVATION TO BE MADE PURSUANT THERETO IS COMMENCED WITHIN THIRTY (30) WORKING DAYS FROM THE DATE OF ITS ISSUANCE. A STREET WORK PERMIT IS VALID FOR THE TIME PERIOD STATED PER THE PERMIT NOTES. MAXIMUM ONE YEAR FROM ISSUANCE DATE UNLESS NOTED OTHERWISE ON THE PERMIT. AFTER SAID DATE, THE STREET WORK PERMIT SHALL BE VOID UNLESS THE DIRECTOR HAS GRANTED AN EXTENSION OF TIME FOR GOOD CAUSE.

2. PRIOR TO BEGINNING WORK, A PRECONSTRUCTION MEETING WITH THE CITY INSPECTOR IS REQUIRED.

3. CONSTRUCTION STANDARD - ALL WORK SHALL COMPLY WITH THE CURRENT EDITION OF THE STANDARD SPECIFICATIONS FOR PUBLIC WORKS CONSTRUCTION (GREEN BOOK) AND ALL APPLICABLE CITY ORDINANCES, STANDARDS, AND SPECIFICATIONS CURRENTLY IN EFFECT.

4. GENERAL PROVISIONS COMPLIANCE - THE PERMITTEE ACCEPTS FULL RESPONSIBILITY FOR ALL DAMAGES AND RESTORATION AND AGREES TO REIMBURSE THE CITY FOR PERFORMING ALL WORK AND FURNISHING ALL MATERIALS TO CORRECT ANY FAILURE TO COMPLY WITH THE RULES AND TERMS HEREOF AND ALL APPLICABLE CITY REGULATIONS. FAILURE TO PAY ANY BILLS DUE UNDER ANY PERMIT ISSUED BY THE PUBLIC WORKS AGENCY MAY RESULT IN RENDERING THE PERMITTEE INELIGIBLE FOR ANY OTHER PUBLIC WORKS AGENCY PERMIT UNTIL SUCH BILL IS PAID.

5. LICENSING - ALL WORK SHALL BE DONE BY A STATE LICENSED CONTRACTOR WITH THE APPROPRIATE CLASSIFICATION. IN ADDITION, THE CONTRACTOR SHALL POSSESS A CURRENT CITY BUSINESS LICENSE.

6. TRAFFIC - (A) TRAFFIC SIGNALS, CURB MARKINGS, SIGNING AND STRIPING SHALL COMPLY WITH THE LATEST CITY OF SANTA ANA STANDARD PLANS, THE LATEST CALTRANS STANDARD PLANS AND SPECIFICATIONS, AND THE LATEST CAMUTCD.

   (B) TRAFFIC CONTROL SHALL COMPLY WITH THE LATEST CITY OF SANTA ANA STANDARD PLAN NO. 1125F, THE LATEST CAMUTCD, AND THE LATEST WORK AREA TRAFFIC CONTROL HANDBOOK (WATCH).

   (C) STREET CLOSURE - ANY STREET CLOSURE SHALL COMPLY WITH THE CITY OF SANTA ANA STANDARD PLAN NO. 1125F.

   (D) ALL WORK MUST BE DONE BETWEEN 9:00A.M. AND 3:00 P.M.

7. CONSTRUCTION WATER - FIRE HYDRANT PERMITS SHALL BE OBTAINED FROM THE PUBLIC WORKS AGENCY BEFORE WATER IS OBTAINED FROM ANY PUBLIC HYDRANT.

8. TRENCHING - THE PERMITTEE OR HIS CONTRACTOR MUST PATCH ALL AUTHORIZED STREET CUTS TO CITY STANDARDS, INCLUDING BACKFILLING WITH 95 PERCENT RELATIVE COMPACTION AND TEMPORARY AC PAVEMENT. ALL TEMPORARY AC SHALL BE HOT MIX UNLESS DIRECTED BY ENGINEER. THE PERMITTEE OR HIS CONTRACTOR MUST PLACE A PERMANENT PATCH WITHIN 30 DAYS OF PLACING THE TEMPORARY PATCH. A CITY STREET CONSTRUCTION INSPECTOR MUST BE PRESENT TO INSPECT PLACEMENT OF BACKFILL AND BOTH TEMPORARY AND PERMANENT PATCHES.

PUBLIC WORKS SANTA ANA

APPROVED: DATE: 3-16-22

Zdenek Kekula

CITY ENGINEER

CITY OF SANTA ANA

PUBLIC WORKS AGENCY

DATE		REVISION

STREET WORK AND UTILITY PERMIT GENERAL PROVISIONS

STD. PLAN NUMBER 1160

SHEET 1 OF 3

Figure 232: Street Work and Utility Permit - Sheet 1

9. TREES - ANY TREE(S) IN THE PARKWAY SHALL NOT BE REMOVED, TRIMMED OR ALTERED IN ANY WAY EXCEPT AUTHORIZED ON ISSUED PERMIT BY THE PUBLIC WORKS AGENCY.

10. STORMWATER AND NON-STORMWATER MANAGEMENT - THE PERMITTEE SHALL COMPLY WITH ALL LOCAL, STATE AND FEDERAL REGULATIONS RELATED TO THE CLEAN WATER ACT AND THE CALIFORNIA PORTER-COLOGNE ACT. THE PERMITTEE SHALL DEVELOP AND IMPLEMENT A MANAGEMENT PLAN TO CONTROL EROSION AND SEDIMENT AND TO ADDRESS STORMWATER AND NON-STORMWATER DISCHARGE INTO THE MUNICIPAL STORM DRAIN SYSTEM IN ACCORDANCE WITH THE ORANGE COUNTY STORMWATER PROGRAM - CONSTRUCTION RUNOFF GUIDANCE MANUAL AND THE CALIFORNIA STORMWATER BEST MANAGEMENT PRACTICES (BMP) HANDBOOK.

11. CLEANUP OF JOB SITE - REFUSE, RUBBLE, GRAVEL, DIRT OR UNUSED MATERIALS SHALL BE REMOVED ON A DAILY BASIS AND FINAL CLEANUP SHALL TAKE PLACE WITHIN 3 DAYS AFTER COMPLETION OF THE WORK. IF NOT, THE CITY WILL REMOVE IT AT THE PERMITTEE'S EXPENSE, INCLUDING THE CURRENT CALL-OUT CHARGE.

12. UTILITY MARKINGS - UPON COMPLETION OF THE PROJECT, THE CONTRACTOR SHALL REMOVE ALL PAINTED UTILITY MARKINGS USING THE REMOVAL METHOD ACCEPTABLE TO THE INSPECTOR.

13. WATER AND SEWER - CONTRACTOR SHALL CHISEL A "W" OR "S" IN THE CURB FACE TO MARK ALL WATER SERVICES OR SEWER LATERALS, RESPECTIVELY.

14. NO HOSES ARE TO BE LAID ACRESS TRAVEL LANES.

15. GUARANTEE - THE WORK DONE BY THE PERMITTEE ON STREET WORK PERMITS SHALL BE GUARANTEED FOR A PERIOD OF ONE YEAR UNLESS NOTED OTHERWISE. FAILURE OF THE CITY INSPECTORS TO DETECT FLAWS IN WORK SHALL NOT RELIEVE THE PERMITTEE OF THIS RESPONSIBILITY.

16. CASH DEPOSIT TO SECURE WORK - ALL CASH DEPOSITS WILL BE REFUNDED APPROXIMATELY 45 DAYS AFTER ALL RELATED PERMITS ARE SIGNED OFF BY THE CITY'S CONSTRUCTION INSPECTOR, APPROVAL BY THE CITY OF SANTA ANA, AND THE PASSAGE OF ANY MECHANICS LIEN PERIODS. IN THE EVENT THE SECURED WORK IS NOT COMPLETED WITHIN ONE YEAR OF THE DATE THAT A STREET WORK PERMIT IS SIGNED, PERMITTEE AGREES THAT THE CITY MAY APPLY THE CASH DEPOSIT TO THE COST OF COMPLETING THE WORK AND SUCH WORK MAY BE COMPLETED AT THE SOLE CONVENIENCE OF THE CITY OF SANTA ANA.

17. INDEMNIFICATION - PERMITTEE SHALL INDEMNIFY, DEFEND AND HOLD HARMLESS THE CITY OF SANTA ANA, ITS OFFICERS, AGENTS, VOLUNTEERS, AND EMPLOYEES FROM AND AGAINST ALL SUITS OR ACTIONS AND FROM ANY LOSS, DAMAGE, LIABILITY, COST OR EXPENSE, INCLUDING, BUT NOT LIMITED TO, REASONABLE ATTORNEY FEES FOR ANY DAMAGE TO PROPERTY, OR INJURIES, OR DEATH SUSTAINED BY ANY PERSON OR PERSONS BY OR FROM THE PERMITTEE, HIS/HER SERVANTS, EMPLOYEES OR AGENTS THAT MAY ARISE DURING OR CAUSED IN ANY WAY BY OR IN THE CONSTRUCTION OF THE WORK OR AS A CONSEQUENCE OF ANY NEGLIGENCE OR OMISSION IN GUARDING THE SAME, OR FOR IMPROPER MATERIALS USED IN CONSTRUCTION. THE PERMITTEE SHALL INDEMNIFY AND BE LIABLE FOR ALL COSTS OR EXPENSES, INCLUDING, BUT NOT LIMITED TO, REASONABLE ATTORNEY FEES THAT MAY BE INCURRED IN ENFORCING THIS CLAUSE AGAINST THE PERMITTEE.

APPROVED: DATE: 3-16-22

Zdenek Kekula

CITY ENGINEER

CITY OF SANTA ANA

PUBLIC WORKS AGENCY

PUBLIC WORKS SANTA ANA

DATE		REVISION

STREET WORK AND UTILITY PERMIT GENERAL PROVISIONS

STD. PLAN NUMBER 1160

SHEET 2 OF 3

Figure 233: Street Work and Utility Permit - Sheet 2

18. INSURANCE - WITH RESPECT TO PERFORMANCE OF WORK UNDER STREET WORK PERMITS, PERMITTEE SHALL MAINTAIN AND SHALL REQUIRE ITS SUBCONTRACTORS, IF ANY, TO MAINTAIN COMMERCIAL GENERAL LIABILITY INSURANCE, OR EQUIVALENT FORM, WITH A COMBINED SINGLE LIMIT OF NOT LESS THAN $1,000,000 PER OCCURENCE WITH $2,000,000 IN AGGREGATE. SUCH INSURANCE CONTAINING A GENERAL AGGREGATE SHALL: (1) INCLUDE AN ADDITIONAL INSURED ENDORSEMENT NAMING THE CITY OF SANTA ANA, ITS OFFICERS, AGENTS, REPRESENTATIVES, EMPLOYEES AND VOLUNTEERS AS ADDITIONAL INSUREDS; (2) BE PRIMARY AND NON-CONTRIBUTORY WITH RESPECT TO INSURANCE OR SELF-INSURANCE PROGRAMS MAINTAINED BY THE CITY OF SANTA ANA; (3) CONTAIN STANDARD SEPARATION OF INSUREDS PROVISIONS; AND (4) GIVE TO THE CITY OF SANTA ANA PROMPT AND TIMELY NOTICE OF ANY CLAIM MADE OR SUIT INSTITUTED ARISING OUT OF PERMITTEE'S OPERATIONS HEREUNDER. PERMITTEE SHALL: (A) FURNISH PROPERLY EXECUTED CERTIFICATES OF INSURANCE AND ADDITIONAL INSURED ENDORSEMENTS TO THE CITY OF SANTA ANA PRIOR TO COMMENCEMENT OF WORK UNDER STREET WORK PERMITS, WHICH SHALL CLEARLY EVIDENCE ALL COVERAGES REQUIRED ABOVE, PROVIDED THAT SUCH INSURANCE SHALL NOT BE MATERIALLY CHANGED OR TERMINATED EXCEPT ON 30 DAYS PRIOR WRITTEN NOTICE TO THE CITY OF SANTA ANA; (B) MAINTAIN SUCH INSURANCE FROM THE TIME WORK FIRST COMMENCES UNTIL COMPLETION OF THE WORK UNDER THIS PERMIT; AND (C) REPLACE SUCH CERTIFICATES FOR POLICIES EXPIRING PRIOR TO COMPLETION OF WORK UNDER STREET WORK PERMITS.

19. HOLIDAY MORATORIUM - NO MAJOR CONSTRUCTION WILL BE ALLOWED ON ARTERIALS OR COLLECTOR STREETS BETWEEN THE WEEKS OF THANKSGIVING DAY AND NEW YEAR'S DAY HOLIDAY'S. DEVIATION FROM THIS REQUIREMENT SHALL NOT BE PERMITTED WITHOUT THE PRIOR APPROVAL OF THE CITY ENGINEER, EXCEPT IN EMERGENCIES INVOLVING IMMEDIATE HAZARD TO PERSONS, PROPERTY, OR SPECIAL CIRCUMSTANCES.

20. CANCELLATION - IN CASE OF PERMIT CANCELLATION, ONLY INSPECTION FEES ARE REFUNDABLE.

21. COMPLETION - APPLICANT MUST COMPLETE ALL WORK TO THE SATISFACTION OF THE CITY ENGINEER. A CALL FOR FINAL INSPECTION IS REQUIRED ON ALL PERMITS.

APPROVED: DATE: 3-16-22

CITY ENGINEER

CITY OF SANTA ANA

PUBLIC WORKS AGENCY

PUBLIC WORKS · SANTA ANA

DATE		REVISION

STREET WORK AND UTILITY PERMIT GENERAL PROVISIONS

STD. PLAN NUMBER 1160

SHEET 3 OF 3

Figure 234: Street Work and Utility Permit - Sheet 3

OMB Number: 2900-0820
Exp. Date: Feb., 2019
Respondent Burden: 20 minutes

Department of Veterans Affairs

ADAPTIVE SPORT GRANT APPLICATION

PRIVACY ACT: The information requested on this form is solicited under the authority of Title 38, U.S.C., and Sections 1710, 1712, and 1722. It is being collected to enable us to determine your eligibility for benefits and will be used for that purpose. The information you supply may be verified through a computer matching program at any time and information may be disclosed outside the VA as permitted by law. VA may make a routine use disclosure of the information as outlined in the Privacy Act system of records identified as 58VA21/22/28, Compensation, Pension, Education and Vocational Rehabilitation and Employment Records - VA, published in the Federal Register. Your obligation to respond is voluntary; however, the information is required in order for us to determine your eligibility for the benefit for which you have applied. Failure to furnish the information will have no adverse affect on any other benefits to which you may be entitled.

RESPONDENT BURDEN: The Paperwork Reduction Act of 1995 requires us to notify you that this information collection is in accordance with the clearance requirements of Section 3507 of the Paperwork Reduction Act of 1995. We may not conduct or sponsor, and you are not required to respond to, a collection of information unless it displays a valid OMB number. We anticipate that the time expended by all individuals who must complete this application will average 20 minutes. This includes the time it will take to read instructions, gather the necessary facts and fill out the forms.

SECTION A - ORGANIZATION AND GRANT INFORMATION

1. ORGANIZATION AND MAILING ADDRESS	2. PROGRAM NAME AND TITLE	3. GRANT AMOUNT REQUESTED
Apex R 1801 Parkcourt Pl. Santa Ana, CA 92701	Apex Physical Therapy & Rehabilitation	$750,000.00

SECTION B - CONTACT INFORMATION

4. PRIMARY CONTACT	5. PRIMARY PHONE NUMBER	6. ALTERNATE PHONE NUMBER
Hayden Robbins	(562) 444-4444	

7. EMAIL
hayden.robbins@apexrehab.com

SECTION C - PROGRAM AND OTHER INFORMATION

8. DUNS NUMBER *(Must provide a DUNS number before any payment is disbursed)*	9. CONGRESSIONAL DISTRICT	10. SAM CAGE CODE NUMBER	11. EIN NUMBER
123456789012	46th District of California	12345	12-3456789

12. PROJECTED START DATE	13. PROJECTED COMPLETION DATE	14. TARGET GEOGRAPHIC AREA(S)
05/01/2023	05/01/2024	Orange County

15. CATEGORY
☒ INITIAL ☐ RENEWAL ☐ NON-COMPETITIVE

16. PROGRAM HISTORY
☒ NEW ☐ 1-2 YEARS ☐ 3-5 YEARS ☐ 5+ YEARS

17. DISABILITY GROUPS
☒ AMPUTEE ☒ SPINAL CORD INJURY ☒ TBI/STROKE
☒ BLIND/VI ☒ PTSD ☐ OTHER

18. EXPERIENCE WITH DISABLED VETERANS?
☒ YES ☐ NO

19. COMPLEMENTARY FUNDING?
FEDERAL: ☐ YES ☒ NO AMOUNT:
NON-FEDERAL: ☐ YES ☒ NO AMOUNT:

20. DOES YOUR ORGANIZATION HAVE EXPERIENCE IN MANAGING FEDERAL FUNDS? ☒ YES ☐ NO

Program Details

1. Program Past Performance:
Applicant must demonstrate eligibility to receive a grant award in accordance with 38 USC 77(2). Limit response to one written page.

2. Program Specifics:
Applicant must clearly describe specific aspects of the proposed program to include: type of adaptive sport(s) provided (community/national events, introductory/competitive events, local/or requires travel), frequency and duration of occurrence, location(s) of programming, estimated number of unique Veterans/ Service Members served (required to be reported by last name, first name and zip code on quarterly reports), type of disabilities served by the proposed adaptive sport, and benefits of the programming to participants. Limit responses to 2 pages.

VA FORM FEB 2016 **10096**

Figure 235: Example of Grant Application

Water Resources

Scope of Work

The water distribution, sewage, and storm drainage analysis and design of a 2-story building located at 1801 Park Court Pl, Building A, Santa Ana, CA 92701. The function of the physical therapy and rehabilitation center is to aid in the recovery of people through physical activities. The building will need a water distribution system with restrooms and drinking fountains, a sewage line to remove waste, and a storm drain system to channel water into the proper location.

Water Distribution

Water Distribution Layout

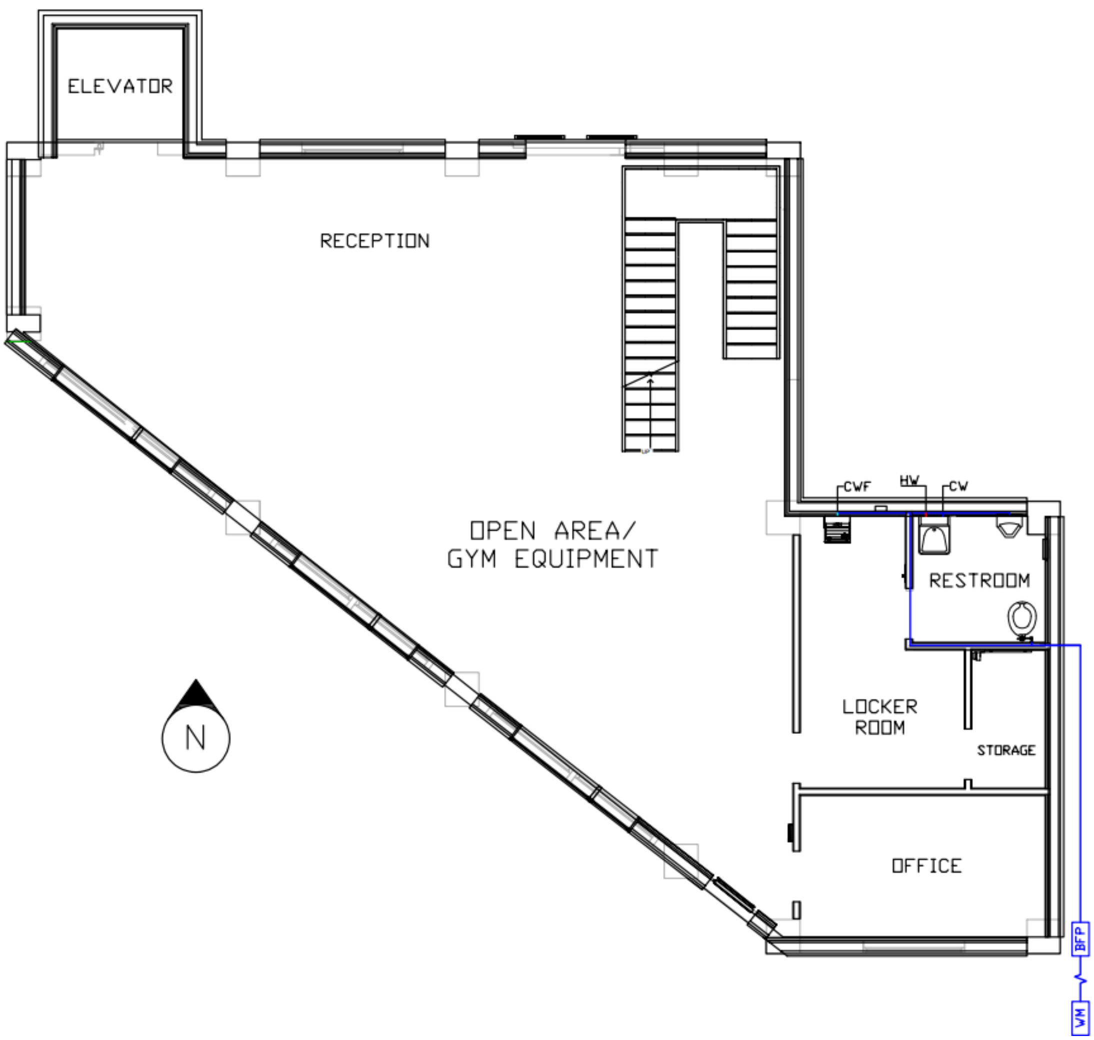

Figure 236: Water Distribution System Layout Floor 1

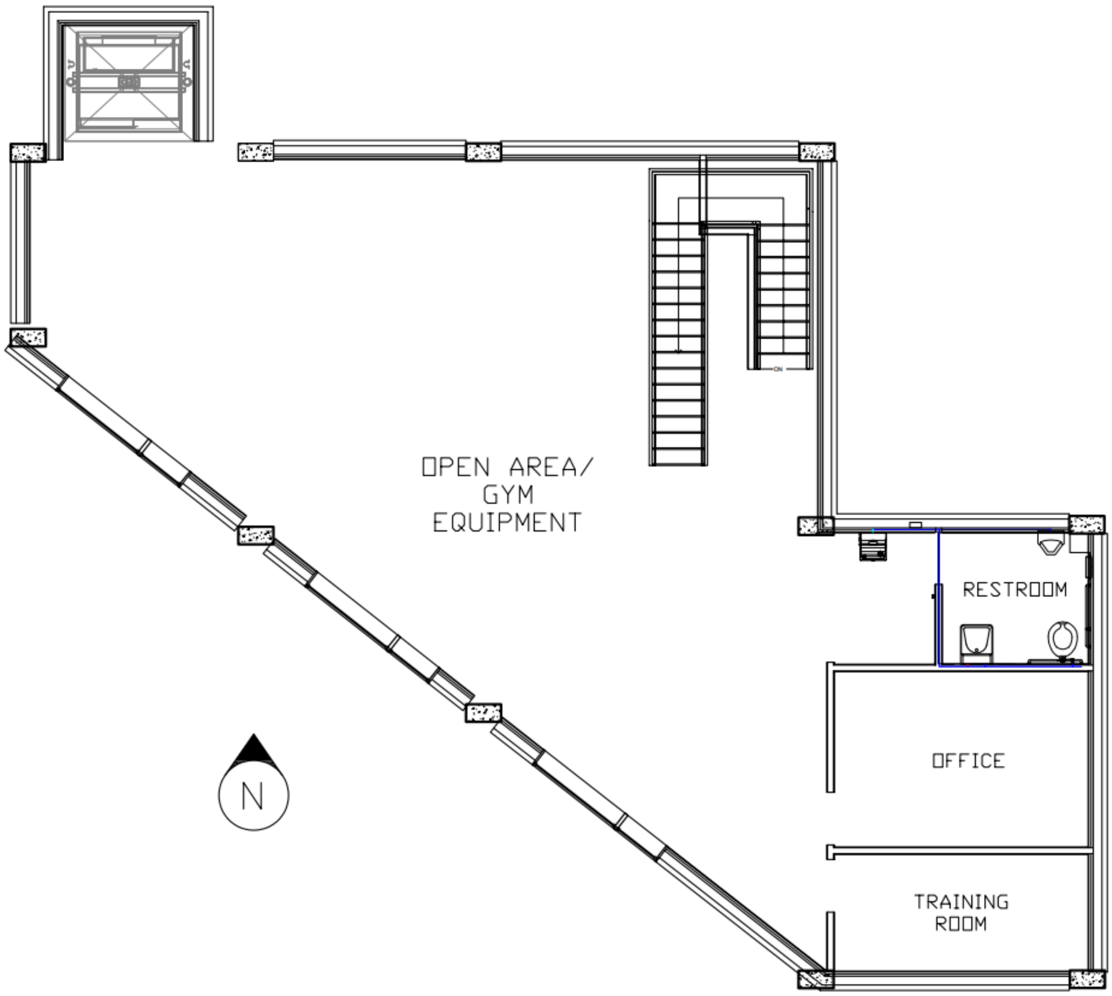

Figure 237: Water Distribution System Layout Floor 2

The water distribution system layout in Figure 236 and Figure 237 were drafted using AutoCAD and includes hot water, cold water, and cold filtered water pipe layout. As well as the 1.5” water meter and 1.5” backflow prevention device location, these devices are necessary per California Plumbing Code to protect the City’s distribution system from contamination. Figure 238 below displays a 3D isometric view of the water distribution system depicting each supply pipe connection to its respective water fixtures.

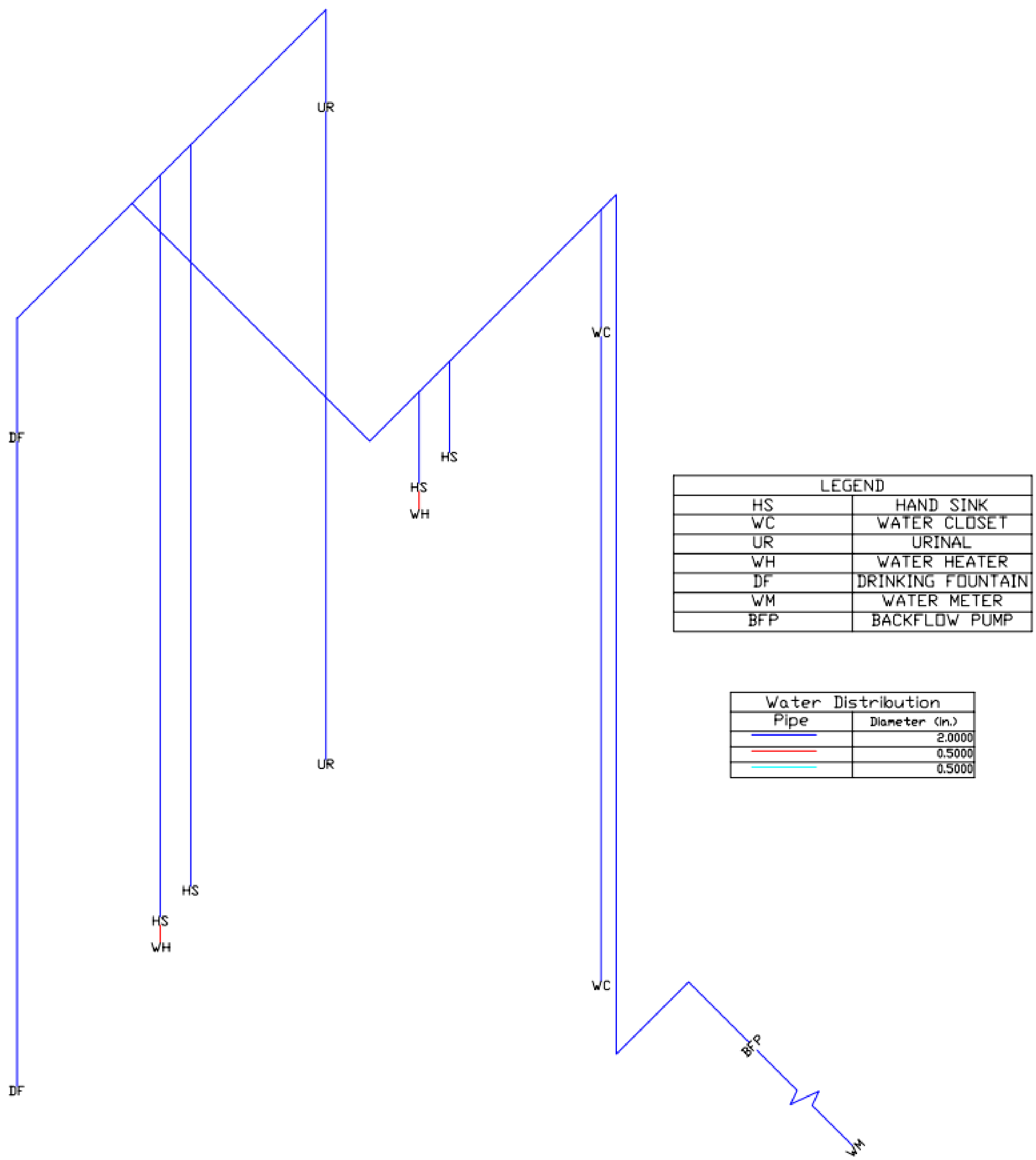

Figure 238: 3D Isometric of the Water Distribution System

Water Supply Fixture Units

Once the amount of water fixtures were determined that will be utilized within the rehabilitation center, Table A103.1 and P2903.6 in Figure 239 and Figure 240 of the California Plumbing Code 2022 and International Residential Code 2021 were used to determine the water supply fixture units (WSFU) for each fixture. The total amount of each type of fixture was determined first. Furthermore, using Table A103.1, Table 139 tabulates the cold and hot fixture units as summed and multiplied by ¼ to calculate the combined water fixture supply units which are presented in Table 139. The total combined WSFU for flushometer valve and other fixtures are 16 and 2.5. Utilizing the Hunter's Curve from Chart A 103.1(1) and A 103.1(2) in Figure 241 and Figure 242, the WSFU for the flushometer valve was converted into 30 gallons per minute (GPM). From Chart 12-2 in Figure 243, the WSFU for the other fixtures were converted into 5 GPM. Therefore, Table 140 depicts the total demand in gallons per minute for the water distribution system, with a total of 35 GPM.

TABLE A 103.1
WATER SUPPLY FIXTURE UNITS (WSFU) AND MINIMUM FIXTURE BRANCH PIPE SIZES[3]

APPLIANCES, APPURTENANCES, OR FIXTURES[2]	MINIMUM FIXTURE BRANCH PIPE SIZE[1,4] (inches)	Private	Public	ASSEMBLY[6]
Bathtub or Combination Bath/Shower (fill)	1/2	4.0	4.0	-
3/4 inch Bathtub Fill Valve	3/4	10.0	10.0	-
Bidet	1/2	1.0	-	-
Clothes Washer	1/2	4.0	4.0	-
Dental Unit, cuspidor	1/2	-	1.0	-
Dishwasher, domestic	1/2	1.5	1.5	-
Drinking Fountain or Water Cooler	1/2	0.5	0.5	0.75
Hose Bibb	1/2	2.5	2.5	-
Hose Bibb, each additionat[7]	1/2	1.0	1.0	-
Lavatory	1/2	1.0	1.0	1.0
Lawn Sprinkler, each head[5]	-	1.0	1.0	-
Mobile Home, each (minimum)	-	12.0	-	-
Sinks	-	-	-	-
Bar	1/2	1.0	2.0	-
Clinical Faucet	1/2	-	3.0	-
Clinical Flushometer Valve with or without faucet	1	-	8.0	-
Kitchen, domestic	1/2	1.5	1.5	-
Laundry	1/2	1.5	1.5	-
Service or Mop Basin	1/2	1.5	3.0	-
Washup, each set of faucets	1/2	-	2.0	-
Shower per head	1/2	2.0	2.0	-
Urinal, 1.0 GPF Flushometer Valve	3/4	3.0	4.0	5.0
Urinal, greater than 1.0 GPF Flushometer Valve	3/4	4.0	5.0	6.0
Urinal, flush tank	1/2	2.0	2.0	3.0
Wash Fountain, circular spray	3/4	-	4.0	-
Water Closet, 1.6 GPF Gravity Tank	1/2	2.5	2.5	3.5
Water Closet, 1.6 GPF Flushometer Tank	1/2	2.5	2.5	3.5
Water Closet, 1.6 GPF Flushometer Valve	1	5.0	5.0	8.0
Water Closet, greater than 1.6 GPF Gravity Tank	1/2	3.0	5.5	7.0
Water Closet, greater than 1.6 GPF Flushometer Valve	1	7.0	8.0	10.0

For SI units: 1 inch = 25 mm

Figure 239: California Plumbing Code 2022 Table A103.1 Water Supply Fixture Units and Sizing

TABLE P2903.6 WATER SUPPLY FIXTURE UNIT VALUES FOR VARIOUS PLUMBING FIXTURES AND FIXTURE GROUPS

TYPE OF FIXTURES OR GROUP OF FIXTURES	WATER-SUPPLY FIXTURE-UNIT VALUE (w.s.f.u.)		
	Hot	Cold	Combined
Bathtub (with/without overhead shower head)	1.0	1.0	1.4
Clothes washer	1.0	1.0	1.4
Dishwasher	1.4	—	1.4
Full-bath group with bathtub (with/without shower head) or shower stall	1.5	2.7	3.6
Half-bath group (water closet and lavatory)	0.5	2.5	2.6
Hose bibb (sillcock)[a]	—	2.5	2.5
Kitchen group (dishwasher and sink with or without food-waste disposer)	1.9	1.0	2.5
Kitchen sink	1.0	1.0	1.4
Laundry group (clothes washer standpipe and laundry tub)	1.8	1.8	2.5
Laundry tub	1.0	1.0	1.4
Lavatory	0.5	0.5	0.7
Shower stall	1.0	1.0	1.4
Water closet (tank type)	—	2.2	2.2

For SI: 1 gallon per minute = 3.785 L/m.

a. The fixture-unit value 2.5 assumes a flow demand of 2.5 gallons per minute, such as for an individual lawn sprinkler device. If a hose bibb or sill cock will be required to furnish a greater flow, the equivalent fixture-unit value may be obtained from this table or Table P2903.6(1).

Figure 240: International Residential Code 2021 for Water Supply Fixture Units Chart

Table 139: Water Supply Fixture Units Chart

Description	Quantity	Public Use WSFU	Demand - CW	Demand - HW	Demand - CWF	WSFU
Urinal, 1.0 GPF Flushometer Valve	1	4	3	-	-	3
Water Closet Flushometer Valve, 1.6 GPF	1	5	5	-	-	5
Lavatory	1	0.5	0.375	0.375	-	0.75
Drinking Fountain	1	0.5	-	-	0.5	0.5
Urinal, 1.0 GPF Flushometer Valve	1	4	3	-	-	3
Water Closet Flushometer Valve, 1.6 GPF	1	5	5	-	-	5
Lavatory	1	0.5	0.375	0.375	-	0.75
Drinking Fountain	1	0.5	-	-	0.5	0.5
					TOTAL:	18.5

Table 140: Total Gallons Per Minute (GPM) Demand

	WSFU	GPM
Flushometer Valve	16	30
Other Fixtures	2.5	5
TOTAL:	18.5	35

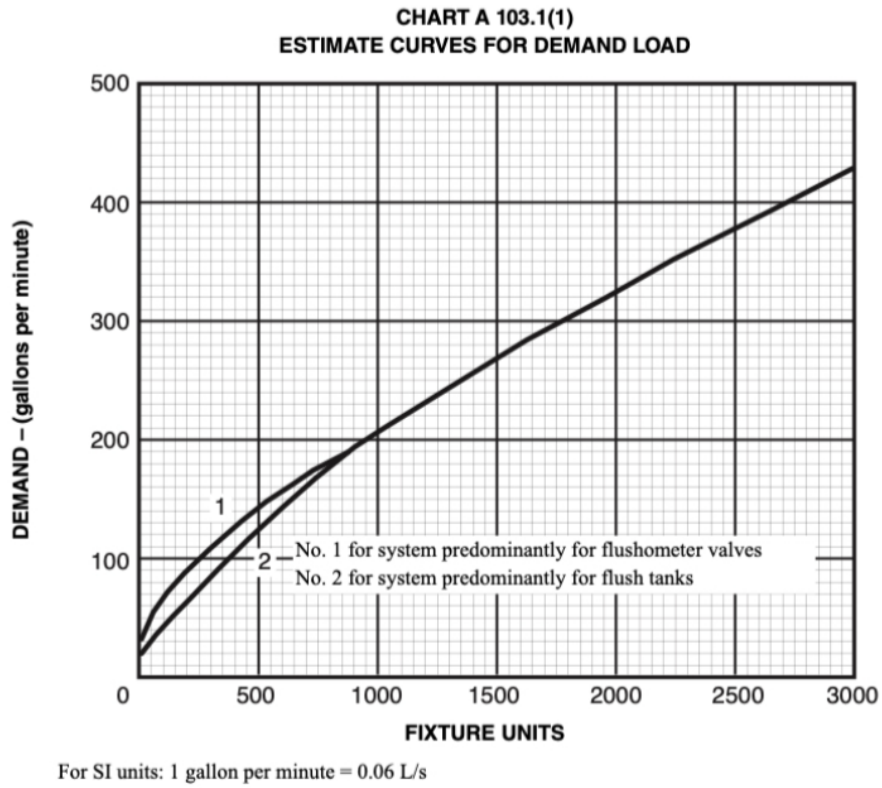

Figure 241: California Plumbing Code 2022 Hunter's Curve for Flushometer Valve and Flush Tanks

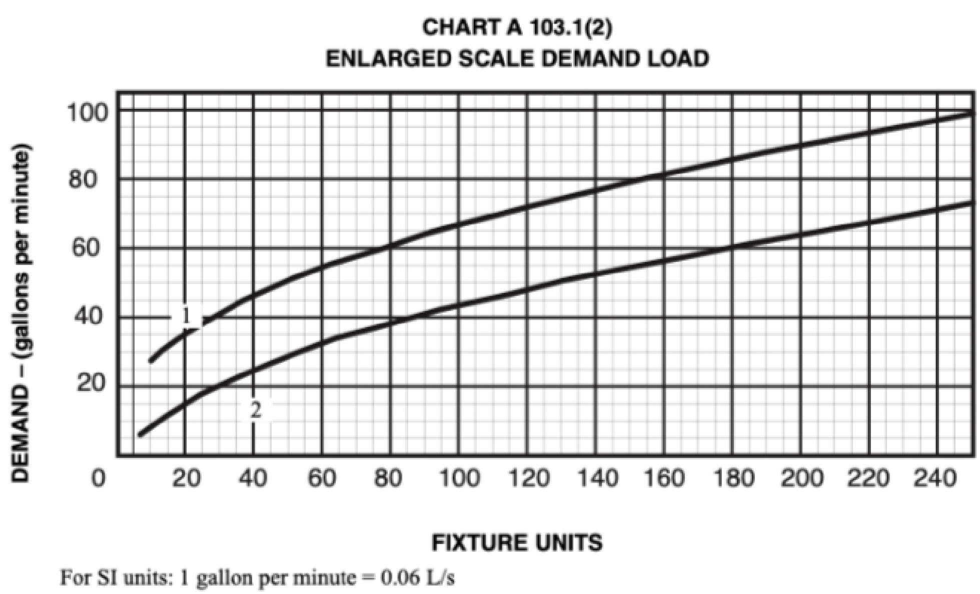

Figure 242: California Plumbing Code 2022 Enlarged Hunter's Curve for Flushometer Valve and Flush Tanks

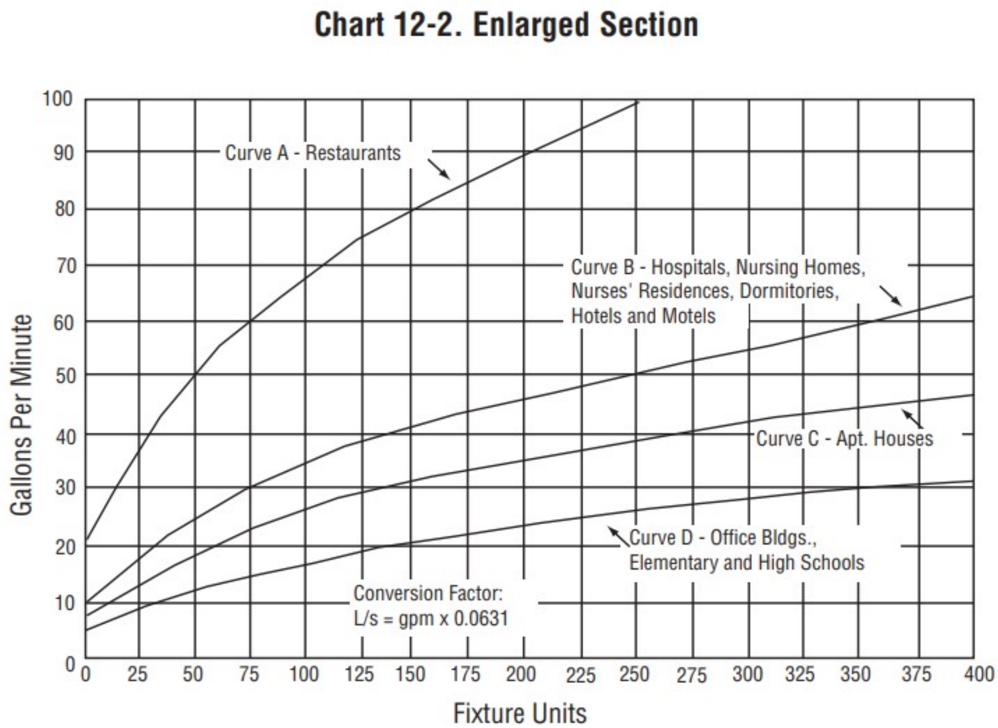

Figure 243: ASHRAE Modified Hunter's Curve Chart 12-2 Enlarged Section

Water Pipe Sizing

The branch pipe minimum requirements were acquired using California Plumbing Code Table A 103.1 Water Supply Fixture Units and Sizing in Figure 239. The size of the branching water distribution pipe for the rehabilitation center is listed in Table 141, the actual pipe diameter was calculated by utilizing California Plumbing Code 2022 Chart A 105.1 in Figure 244. The development lengths were determined by adding the straight pipe lengths and the equivalent lengths of the fittings using California Plumbing Code 2022 Table A 104.4(1) in Figure 245 for the cold water, hot water, and cold water filtered. The 90 degree elbow and tee fittings were decided to be made of copper.

The length of the water meter to the most remote fixture, otherwise known as development length, was determined for cold water, hot water, and cold water filtered pipes; these values were 158.96, 107.02, and 110.89 feet, note that the hot and cold water filter are theoretical development lengths if it ran close to the water meter. Since we included a tankless water heater under each sink our hot water pipe was roughly 6 inches and cold water filter was included in the drinking fountain which was a length of 5 inches. From California Plumbing Code 2022 Chart A 105.1(1) in Figure 244, the copper pipe diameter sizing of each supply pipe was determined by using the GPM and maximum velocity of 8 ft/s for cold water and 5 ft/s for hot water and cold water filtered to calculate the pipe diameter. The maximum velocity was specified in California Plumbing Code 2022 610.12.1 Figure 248. Using the chart provided a diameter of 2 inches for cold water, 0.75 inches for hot water, and 0.75 inches for cold water filtered. The material best suited for the supply pipes was determined to be copper type L. Lastly, the minimum plumbing facilities required based on the expected occupancy of the building was found using California Plumbing Code 2022 Table 422.1 in Figure 246. This led to our design requiring 2 urinals, 2 water closets, and 2 lavatories.

Table 141: Minimum Sizes of Water Fixture Supply Pipes

Minimum Sizes of Water Fixture Supply Pipes		
	Actual Pipe Diameter (in.)	Min. Pipe Diameter (in.)
Lavatory	0.5	0.5
Drinking Fountain	0.5	0.5
Urinal, 1.0 GPF Flushometer Valve	1.5	0.75
Water Closet Flushometer Valve, 1.6 GPF	1.5	1

Table 142: Water Demand Table

	Demand - CW	Demand - HW	Demand - CWF
Water Main Pressure (psi)	50	50	50
Developed Length (ft)	159	107	111
Capacities of Pipe (gpm)	35	2.5	2.5
Diameter of the pipe (in)	2	0.5	0.5
Velocity (ft/s)	8	5	5
Material	Copper - Type L	Copper - Type L	Copper - Type L

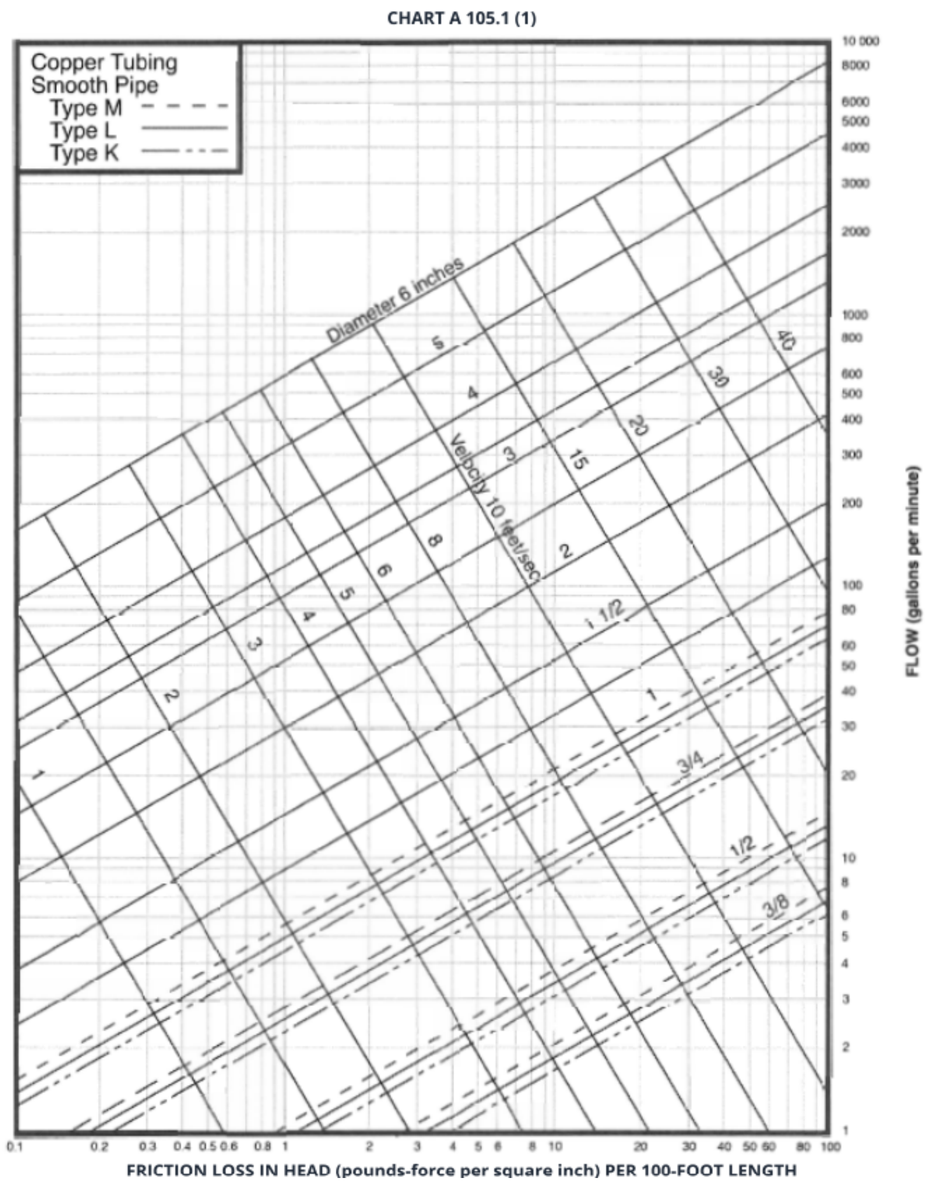

Figure 244: California Plumbing Code 2022 Pipe Sizing Chart A 105.1 (1)

TABLE A 104.4(1)
ALLOWANCE IN EQUIVALENT LENGTH OF PIPE FOR FRICTION LOSS IN VALVES AND THREADED FITTINGS*
EQUIVALENT LENGTH OF PIPE FOR VARIOUS FITTINGS

DIAMETER OF FITTING (inches)	90° STANDARD ELBOW (feet)	45° STANDARD ELBOW (feet)	90° STANDARD TEE (feet)	COUPLING OR STRAIGHT RUN OF TEE (feet)	GATE VALVE (feet)	GLOBE VALVE (feet)	ANGLE VALVE (feet)
⅜	1.0	0.6	1.5	0.3	0.2	8	4
½	2.0	1.2	3.0	0.6	0.4	15	8
¾	2.5	1.5	4.0	0.8	0.5	20	12
1	3.0	1.8	5.0	0.9	0.6	25	15
1¼	4.0	2.4	6.0	1.2	0.8	35	18
1½	5.0	3.0	7.0	1.5	1.0	45	22
2	7.0	4.0	10.0	2.0	1.3	55	28
2½	8.0	5.0	12.0	2.5	1.6	65	34
3	10.0	6.0	15.0	3.0	2.0	80	40
4	14.0	8.0	21.0	4.0	2.7	125	55
5	17.0	10.0	25.0	5.0	3.3	140	70
6	20.0	12.0	30.0	6.0	4.0	165	80

For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1 degree = 0.017 rad
* Allowances are based on nonrecessed threaded fittings. Use one-half the allowances for recessed threaded fittings or streamlined solder fittings.

Figure 245: California Plumbing Code 2022 Equivalent Length of Pipe Fittings Table A 104.4(1)

TABLE 422.1
MINIMUM PLUMBING FACILITIES[1] (continued)

<table>
<tr><th>TYPE OF OCCUPANCY[2]</th><th colspan="2">WATER CLOSETS (FIXTURES PER PERSON)[3]</th><th>URINALS (FIXTURES PER PERSON)[4]</th><th colspan="2">LAVATORIES (FIXTURES PER PERSON)[5]</th><th>BATHTUBS OR SHOWERS (FIXTURES PER PERSON)</th><th>DRINKING FOUNTAINS/ FACILITIES (FIXTURES PER PERSON)</th><th>OTHER</th></tr>
<tr><td rowspan="2">A-4 Assembly occupancy (indoor activities or sporting events with spectator seating)- swimming pools, skating rinks, arenas, and gymnasiums</td><td>Male
1: 1-100
2: 101-200
3: 201-400</td><td>Female
1: 1-25
2: 26-50
3: 51-100
4: 101-200
6: 201-300
8: 301-400</td><td>Male
1: 1-100
2: 101-200
3: 201-400
4: 401-600</td><td>Male
1: 1-200
2: 201-400
3: 401-750</td><td>Female
1: 1-100
2: 101-200
4: 201-300
5: 301-500
6: 501-750</td><td rowspan="2">—</td><td>1: 1-250
2: 251-500
3: 501-750</td><td rowspan="2">1 service sink or laundry tray</td></tr>
<tr><td colspan="2">Over 400, add 1 fixture for each additional 500 males and 1 fixture for each additional 125 females.</td><td>Over 600, add 1 fixture for each additional 300 males.</td><td colspan="2">Over 750, add 1 fixture for each additional 250 males and 1 fixture for each additional 200 females.</td><td>Over 750, add 1 fixture for each additional 500 persons.</td></tr>
<tr><td rowspan="2">A-5 Assembly occupancy (outdoor activities or sporting events)- amusement parks, grandstands and stadiums</td><td>Male
1: 1-100
2: 101-200
3: 201-400</td><td>Female
1: 1-25
2: 26-50
3: 51-100
4: 101-200
6: 201-300
8: 301-400</td><td>Male
1: 1-100
2: 101-200
3: 201-400
4: 401-600</td><td>Male
1: 1-200
2: 201-400
3: 401-750</td><td>Female
1: 1-100
2: 101-200
4: 201-300
5: 301-500
6: 501-750</td><td rowspan="2">—</td><td>1: 1-250
2: 251-500
3: 501-750</td><td rowspan="2">1 service sink or laundry tray</td></tr>
<tr><td colspan="2">Over 400, add 1 fixture for each additional 500 males and 1 fixture for each additional 125 females.</td><td>Over 600, add 1 fixture for each additional 300 males.</td><td colspan="2">Over 750, add 1 fixture for each additional 250 males and 1 fixture for each additional 200 females.</td><td>Over 750, add 1 fixture for each additional 500 persons.</td></tr>
<tr><td rowspan="2">B Business occupancy (office, professional or service type transactions)- banks, vet clinics, hospitals, car wash, banks, beauty salons, ambulatory health care facilities, laundries and dry cleaning, educational institutions (above high school), or training facilities not located within school, post offices and printing shops</td><td>Male
1: 1-50
2: 51-100
3: 101-200
4: 201-400</td><td>Female
1: 1-15
2: 16-30
3: 31-50
4: 51-100
8: 101-200
11: 201-400</td><td>Male
1: 1-100
2: 101-200
3: 201-400
4: 401-600</td><td>Male
1: 1-75
2: 76-150
3: 151-200
4: 201-300
5: 301-400</td><td>Female
1: 1-50
2: 51-100
3: 101-150
4: 151-200
5: 201-300
6: 301-400</td><td rowspan="2">—</td><td rowspan="2">1 per 150</td><td rowspan="2">1 service sink or laundry tray</td></tr>
<tr><td colspan="2">Over 400, add 1 fixture for each additional 500 males and 1 fixture for each additional 150 females.</td><td>Over 600, add 1 fixture for each additional 300 males.</td><td colspan="2">Over 400, add 1 fixture for each additional 250 males and 1 fixture for each additional 200 females.</td></tr>
</table>

Figure 246: California Plumbing Code 2022 Minimum Required Plumbing Facilities Table 422.1

WaterGEMS Modeling

Utilizing Bentley's WaterGEMS modeling software, the water distribution system was simulated to check if the pipe system would meet and maintain the demand and pressure of at least 20 psi to the most remote fixture. The most remote fixture was the urinal located in the first floor bathroom and it is stated in the California Plumbing Code 2022 that this fixture must not exceed the maximum requirement of 0.125 gallons per flush. The tools used to create this model in Figure 247 were pipes and junctions, which were connected to a reservoir with a pump to mimic the water meter at a minimum pressure of 50 psi from the City of Santa Ana's water meter at the project's location. Certain junctions were used to represent the fixtures used and demands were imputed to these junctions to run the proper water demand simulation.

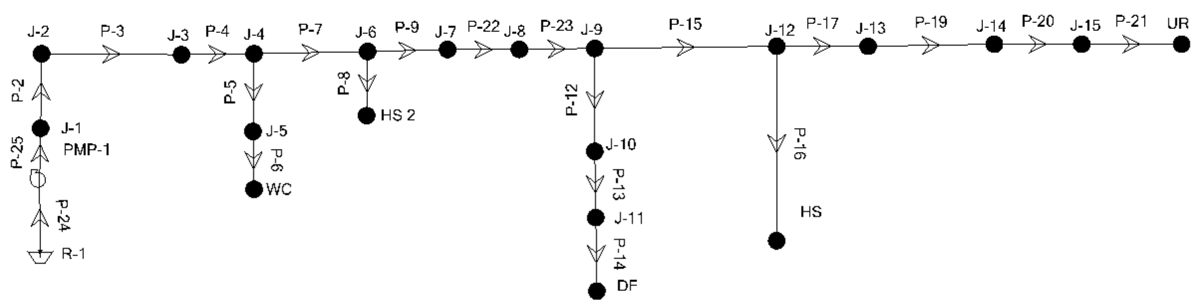

Figure 247: Layout of Water Meter Entry to Each Restroom and Fixture

Two different scenarios were run in WaterGEMS, the first being full flow and second half flow. When looking at the data from each test it was required to check that the pipe velocities did not exceed the maximum allowable pipe velocities for cold water at 8 feet per second and hot water at 5 feet per second as specified in Figure 248 from the California Plumbing Codes 2022. The FlexTable located in Table 143 showcases the full flow model of each pipe. The velocity requirements were met, however, there are some instances within the pipe where the velocity gets low. Moreover, when observing each junction in Table 144, there were issues with the data because WaterGEMS required input for GPM at each junction, this constraint was further elaborated in the constraints section of water resources. Next, the half flow scenario was run and in Table 145 it shows the velocities in each pipe if half the flow demands were met. When comparing both full and half flow scenarios the GPM and velocity were halved.

Table 143: Full Flow Model Pipe FlexTable

		Label	Length (Scaled) (ft)	Start Node	Stop Node	Diameter (in)	Material	Hazen-Williams C	Has Check Valve?	Minor Loss Coefficient (Local)	Flow (gpm)	Velocity (ft/s)	Headloss Gradient (ft/ft)	Has User Defined Length?	Length (User Defined) (ft)
34: P-2	34	P-2	25	J-1	J-2	2.0	Copper	135.0	☐	0.000	11	1.15	0.004	☑	3
36: P-3	36	P-3	48	J-2	J-3	2.0	Copper	135.0	☐	0.000	11	1.15	0.004	☑	21
38: P-4	38	P-4	25	J-3	J-4	2.0	Copper	135.0	☐	0.000	11	1.15	0.004	☑	1
40: P-5	40	P-5	26	J-4	J-5	1.5	Copper	135.0	☐	0.000	2	0.36	0.001	☑	3
42: P-6	42	P-6	20	J-5	WC	1.5	Copper	135.0	☐	0.000	2	0.36	0.001	☑	15
44: P-7	44	P-7	39	J-4	J-6	2.0	Copper	135.0	☐	0.000	9	0.95	0.003	☑	5
46: P-8	46	P-8	22	J-6	HS 2	0.5	Copper	135.0	☐	0.000	2	2.61	0.083	☑	2
48: P-9	48	P-9	27	J-6	J-7	2.0	Copper	135.0	☐	0.000	8	0.79	0.002	☑	1
54: P-12	54	P-12	35	J-9	J-10	0.5	Copper	135.0	☐	0.000	2	2.61	0.083	☑	4
56: P-13	56	P-13	23	J-10	J-11	0.5	Copper	135.0	☐	0.000	2	2.61	0.083	☑	3
58: P-14	58	P-14	25	J-11	DF	0.5	Copper	135.0	☐	0.000	2	2.61	0.083	☑	15
60: P-15	60	P-15	62	J-9	J-12	2.0	Copper	135.0	☐	0.000	6	0.62	0.001	☑	1
62: P-16	62	P-16	66	J-12	HS	0.5	Copper	135.0	☐	0.000	2	2.61	0.083	☑	17
64: P-17	64	P-17	31	J-12	J-13	1.5	Copper	135.0	☐	0.000	5	0.82	0.003	☑	1
68: P-19	68	P-19	43	J-13	J-14	1.5	Copper	135.0	☐	0.000	3	0.45	0.001	☑	5
70: P-20	70	P-20	30	J-14	J-15	1.5	Copper	135.0	☐	0.000	3	0.45	0.001	☑	1
72: P-21	72	P-21	34	J-15	UR	1.5	Copper	135.0	☐	0.000	3	0.45	0.001	☑	15
74: P-22	74	P-22	24	J-7	J-8	2.0	Copper	135.0	☐	0.000	8	0.79	0.002	☑	2
75: P-23	75	P-23	26	J-8	J-9	2.0	Copper	135.0	☐	0.000	8	0.79	0.002	☑	8
77: P-24	77	P-24	13	R-1	PMP-1	2.0	Copper	135.0	☐	0.000	11	1.15	0.004	☑	4
78: P-25	78	P-25	17	PMP-1	J-1	2.0	Copper	135.0	☐	0.000	11	1.15	0.004	☑	19

Table 144: Full Flow Model Junctions FlexTable

	ID	Label	Elevation (ft)	Zone	Demand Collection	Demand (gpm)	Hydraulic Grade (ft)	Pressure (psi)
31: J-1	31	J-1	0.00	<None>	<Collection:	0	99.79	43
33: J-2	33	J-2	0.00	<None>	<Collection:	0	99.78	43
35: J-3	35	J-3	20.00	<None>	<Collection:	0	99.71	34
37: J-4	37	J-4	20.00	<None>	<Collection:	0	99.70	34
39: J-5	39	J-5	15.00	<None>	<Collection:	0	99.70	37
41: WC	41	WC	2.00	<None>	<Collection:	2	99.69	42
43: J-6	43	J-6	20.00	<None>	<Collection:	0	99.69	34
45: HS 2	45	HS 2	18.00	<None>	<Collection:	2	99.52	35
47: J-7	47	J-7	20.00	<None>	<Collection:	0	99.69	34
51: J-9	51	J-9	20.00	<None>	<Collection:	0	99.67	34
53: J-10	53	J-10	20.00	<None>	<Collection:	0	99.34	34
55: J-11	55	J-11	15.00	<None>	<Collection:	0	99.09	36
57: DF	57	DF	3.00	<None>	<Collection:	2	97.85	41
59: J-12	59	J-12	20.00	<None>	<Collection:	0	99.67	34
61: HS	61	HS	3.00	<None>	<Collection:	2	98.26	41
63: J-13	63	J-13	20.00	<None>	<Collection:	2	99.67	34
67: J-14	67	J-14	20.00	<None>	<Collection:	0	99.66	34
69: J-15	69	J-15	19.00	<None>	<Collection:	0	99.66	35
71: UR	71	UR	4.00	<None>	<Collection:	3	99.65	41
73: J-8	73	J-8	20.00	<None>	<Collection:	0	99.68	34

Table 145: Half Flow Model Pipe FlexTable

	ID	Label	Length (Scaled) (ft)	Start Node	Stop Node	Diameter (in)	Material	Hazen-Williams C	Has Check Valve?	Minor Loss Coefficient (Local)	Flow (gpm)	Velocity (ft/s)	Headloss Gradient (ft/ft)	Has User Defined Length?	Length (User Defined) (ft)
34: P-2	34	P-2	25	J-1	J-2	2.0	Copper	135.0	☐	0.000	6	0.64	0.001	☑	3
36: P-3	36	P-3	48	J-2	J-3	2.0	Copper	135.0	☐	0.000	6	0.64	0.001	☑	21
38: P-4	38	P-4	25	J-3	J-4	2.0	Copper	135.0	☐	0.000	6	0.64	0.001	☑	1
40: P-5	40	P-5	26	J-4	J-5	1.5	Copper	135.0	☐	0.000	1	0.18	0.000	☑	3
42: P-6	42	P-6	20	J-5	WC	1.5	Copper	135.0	☐	0.000	1	0.18	0.000	☑	15
44: P-7	44	P-7	39	J-4	J-6	2.0	Copper	135.0	☐	0.000	5	0.54	0.001	☑	5
46: P-8	46	P-8	22	J-6	HS 2	0.5	Copper	135.0	☐	0.000	1	1.63	0.035	☑	2
48: P-9	48	P-9	27	J-6	J-7	2.0	Copper	135.0	☐	0.000	4	0.43	0.001	☑	1
54: P-12	54	P-12	35	J-9	J-10	0.5	Copper	135.0	☐	0.000	1	1.63	0.035	☑	4
56: P-13	56	P-13	23	J-10	J-11	0.5	Copper	135.0	☐	0.000	1	1.63	0.035	☑	3
58: P-14	58	P-14	25	J-11	DF	0.5	Copper	135.0	☐	0.000	1	1.63	0.035	☑	15
60: P-15	60	P-15	62	J-9	J-12	2.0	Copper	135.0	☐	0.000	3	0.33	0.000	☑	1
62: P-16	62	P-16	66	J-12	HS	0.5	Copper	135.0	☐	0.000	1	1.63	0.035	☑	17
64: P-17	64	P-17	31	J-12	J-13	1.5	Copper	135.0	☐	0.000	2	0.41	0.001	☑	1
68: P-19	68	P-19	43	J-13	J-14	1.5	Copper	135.0	☐	0.000	1	0.23	0.000	☑	5
70: P-20	70	P-20	30	J-14	J-15	1.5	Copper	135.0	☐	0.000	1	0.23	0.000	☑	1
72: P-21	72	P-21	34	J-15	UR	1.5	Copper	135.0	☐	0.000	1	0.23	0.000	☑	15
74: P-22	74	P-22	24	J-7	J-8	2.0	Copper	135.0	☐	0.000	4	0.43	0.001	☑	2
75: P-23	75	P-23	26	J-8	J-9	2.0	Copper	135.0	☐	0.000	4	0.43	0.001	☑	8
77: P-24	77	P-24	27	R-1	PMP-1	2.0	Copper	135.0	☐	0.000	6	0.64	0.001	☑	4
78: P-25	78	P-25	17	PMP-1	J-1	2.0	Copper	135.0	☐	0.000	6	0.64	0.001	☑	19

412.1.1 Wall-Mounted Urinals [BSC-CG, DSA-SS & DSA-SS/CC]. *The effective flush volume of wall-mounted urinals shall not exceed 0.125 gallons (0.47 L) per flush in compliance with Chapter 5, Division 5.3, of the California Green Building Standards Code (CAL-Green).*

Fig.: California Plumbing Code 2022 Wall-Mounted Urinals 412.1.1

610.12.1 Copper Tube Systems. Maximum velocities in copper and copper alloy tube and fitting systems shall not exceed 8 feet per second (ft/s) (2.4 m/s) in cold water and 5 ft/s (1.5 m/s) in hot water.

Figure 248: California Plumbing Code 2022 Copper Tub Systems 610.12.1

Sewer Analysis

Sewer Drain Layout

The design of our sewer pipe system was designed in mind that the building that is being worked on is two-stories. The AutoCAD drawing was separated into two drawings, each drawing representing one floor of the building. Figure 249 represents the first floor and Figure 251 represents the second floor of the sewer layout. In the AutoCAD layout drawings the green line represents the sewage pipe that connects to each appliance that leads to the main sewer pipe. Due to the limited amount of drainage units used for the building, all of the piping is routed towards the bathroom on both floors of the building while the cleanout on the first floor is situated on the outside of the building. From the structural team it was decided that the piping would be situated within the insulation of the walls and exposed piping along the east wall on each floor.

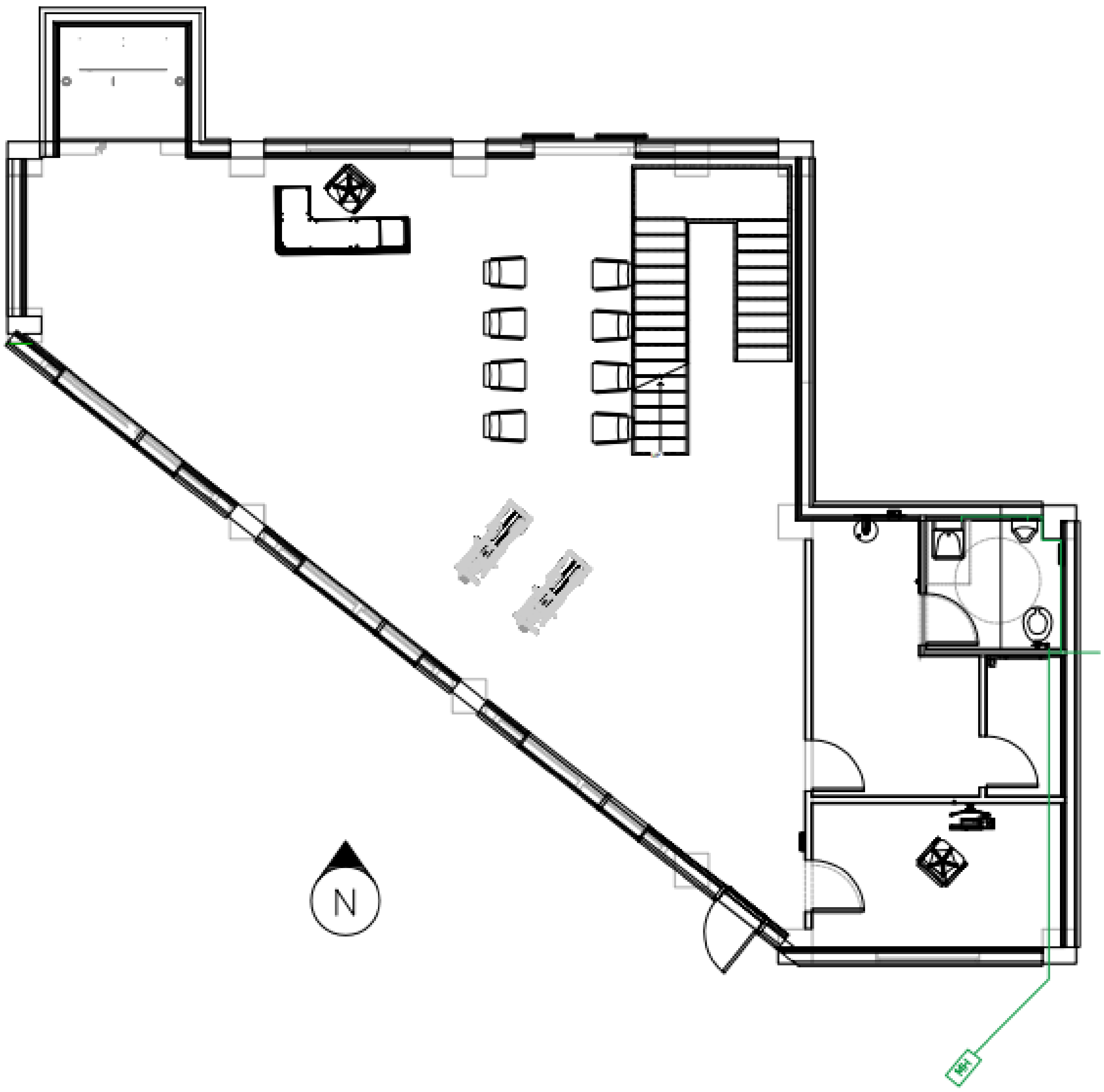

Figure 249: 2D Sewer Pipe System Floor 1

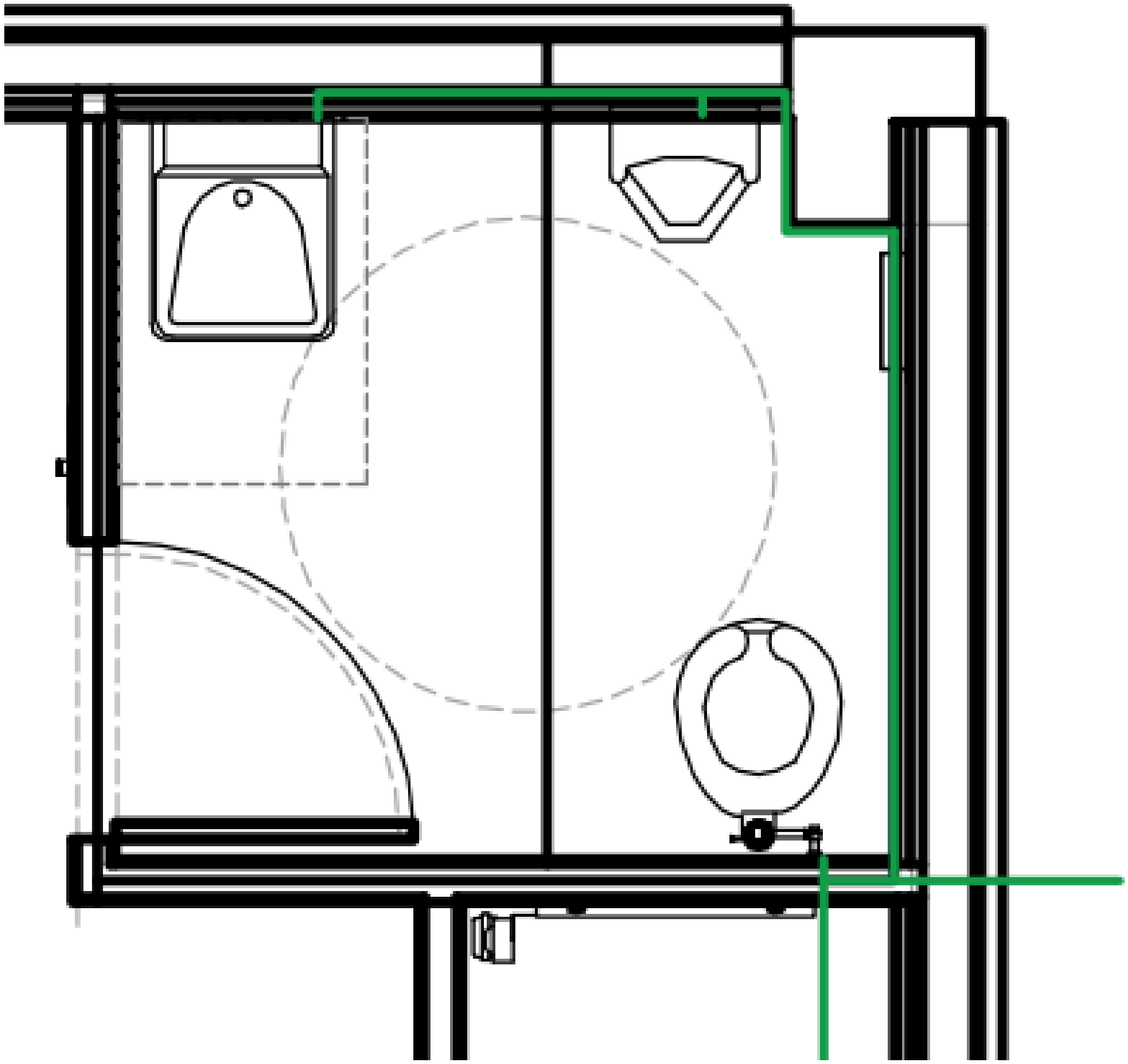

Figure 250: 2D Sewer Pipe System Floor 1 (Enhanced View)

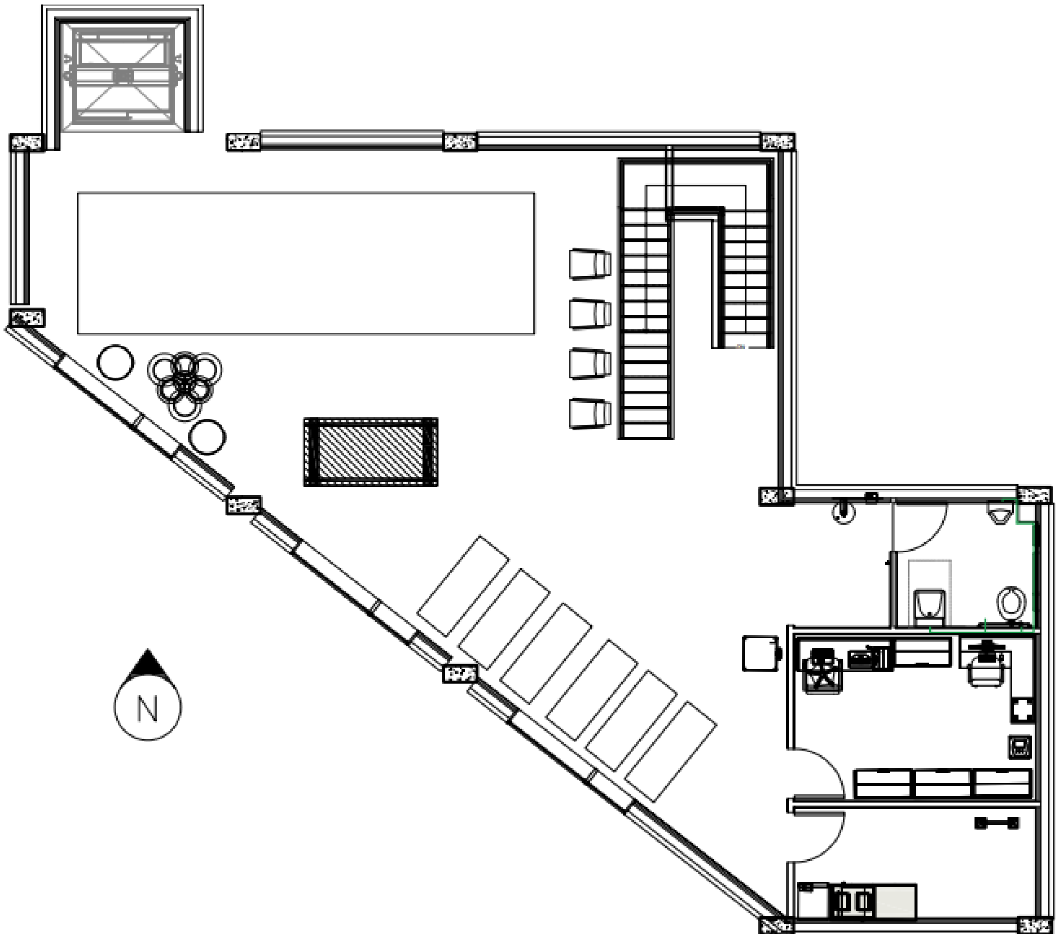

Figure 251: 2D Sewer Pipe System Floor 2

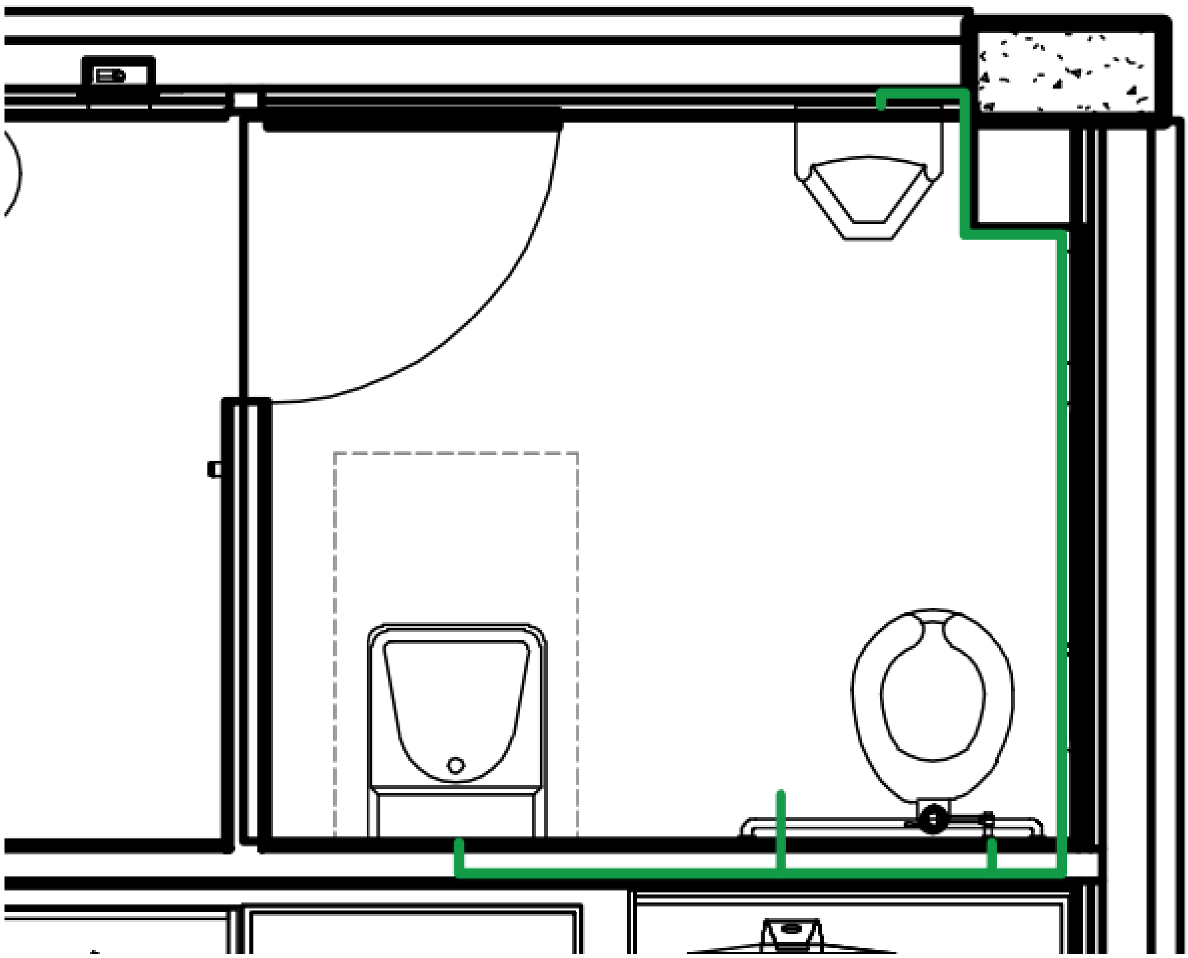

Figure 252: 2D Sewer Pipe System Floor 2 (Enhanced View)

Waste and Vent Isometric Diagram

The isometric design of the vent and sewer pipe system was designed through the use of AutoCAD. Similarly to the layout view of the sewer drawings, the isometric drawings were divided into two drawings. Figure 253 represents floor 1 and Figure 254 represents floor 2 of the isometric view. The purple line above the green line represents the vent pipe system. Each fixture is roughly ⅜ - ½ ft. away from the vent pipe. All of the appliance's vent pipe exits through an exposed vent pipe sitting on the east wall of the building going through straight to the roof. The pipe sizing of the vent pipe will be discussed in the pipe sizing section of the report.

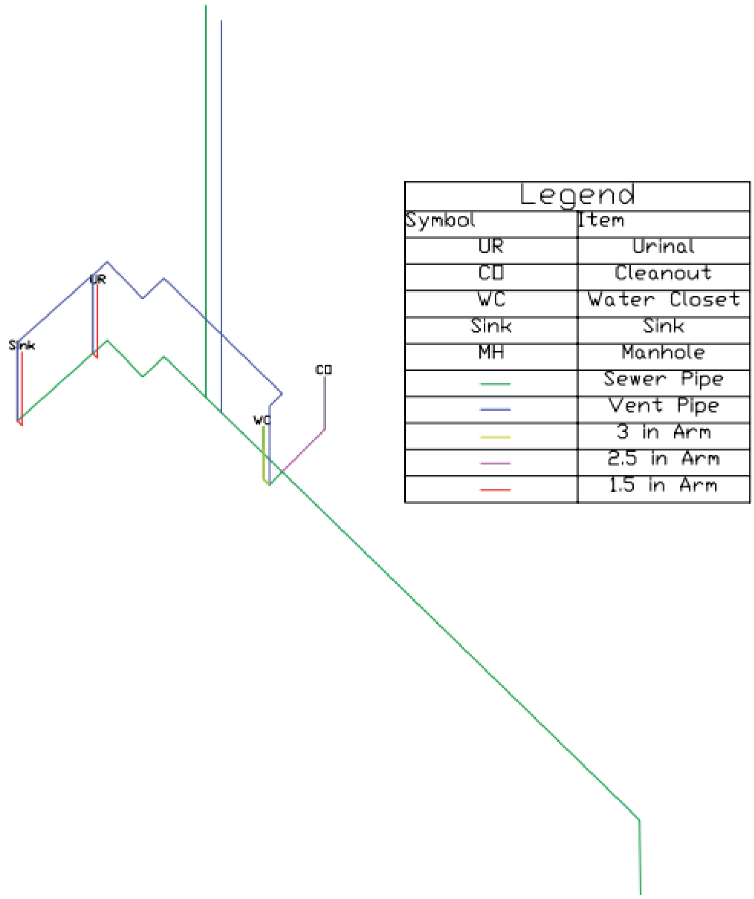

Figure 253:. Isometric View of Sewer and Vent Pipes Floor 1

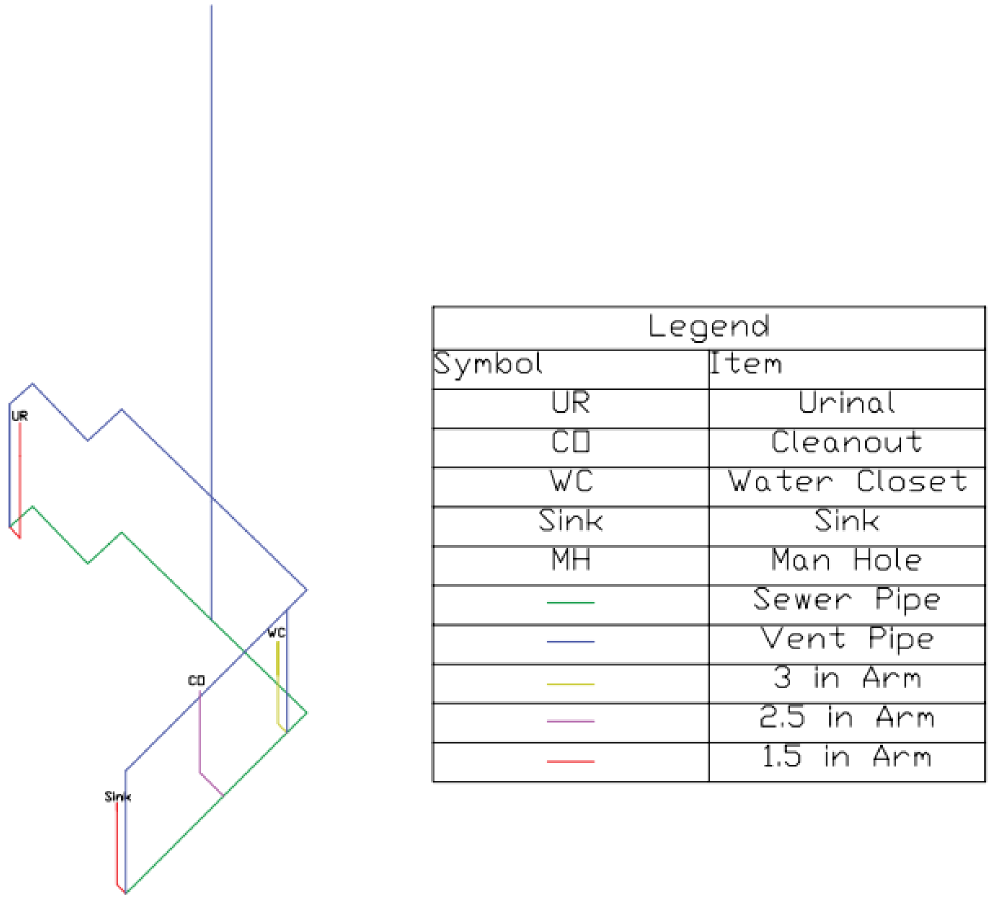

Figure 254: Isometric View of Sewer and Vent Pipes Floor 2

Drainage Fixture Supply Units

The total DFU calculated from the appliances within our building has a total value of 21. Using the 2022 CA plumbing codes, represented in figure 3.3.3(2) and figure 3.3.3(3), the DFU value can be given for each drainage fixture being used within the building. The fixtures that are being used in the building can be found in figure 3.3.3(1) with the associated DFU in 2022 CA plumbing codes. The total DFU is calculated by multiplying the DFU value for a fixture with the total number of fixtures then summing all of the values. This gives 21 DFU for the two story building. With the total DFU identified we calculated pipe sizing for sewer, vent, and trap fixtures.

Table 146: Tabulated DFU Values of Fixtures

Description	Quantity	DFU	Total DFU
Hand Sink	**2**	**2**	**4**
Drinking Fountain	**2**	**.5**	**1**
Urinal, 1.0 GPF Flushometer Valve	**2**	**2**	**4**
Water Closet Flushometer Valve, 1.6 GPF	**2**	**4**	**8**
Floor Drain	**2**	**2**	**4**
Total DFU			**21**

TABLE 702.1
DRAINAGE FIXTURE UNIT VALUES (DFU)

PLUMBING APPLIANCES, APPURTENANCES, OR FIXTURES	MINIMUM SIZE TRAP AND TRAP ARM[7] (inches)	PRIVATE	PUBLIC	ASSEMBLY[8]
Bathtub or Combination Bath/Shower	1½	2.0	2.0	—
Bidet	1¼	1.0	—	—
Bidet	1½	2.0	—	—
Clothes Washer, domestic, standpipe[5]	2	3.0	3.0	3.0
Dental Unit, cuspidor	1¼	—	1.0	1.0
Dishwasher, domestic, with independent drain[2]	1½	2.0	2.0	2.0
Drinking Fountain or Water Cooler	1¼	0.5	0.5	1.0
Food Waste Disposer, commercial	2	—	3.0	3.0
Floor Drain, emergency	2	—	0.0	0.0
Floor Drain (for additional sizes see Section 702.0)	2	2.0	2.0	2.0
Shower, single-head trap	2[9]	2.0	2.0	2.0
Multi-head, each additional	2	1.0	1.0	1.0
Lavatory	1¼	1.0	1.0	1.0
Lavatories in sets	1½	2.0	2.0	2.0
Washfountain	1½	—	2.0	2.0
Washfountain	2	—	3.0	3.0
Mobilehome or Manufactured Home, trap[10]	3	*6.0*	—	—
Receptor, indirect waste[1,3]	1½	See footnote[1,3]		
Receptor, indirect waste[1,4]	2	See footnote[1,4]		
Receptor, indirect waste[1]	3	See footnote[1]		
Sinks	—	—	—	—
Bar	1½	1.0	—	—
Bar[2]	1½	—	2.0	2.0
Clinical	3	—	6.0	6.0
Commercial with food waste[2]	1½	—	3.0	3.0
Exam Room	1½	—	1.0	—
Special Purpose[2]	1½	2.0	3.0	3.0
Special Purpose	2	3.0	4.0	4.0
Special Purpose	3	—	6.0	6.0
Kitchen, domestic[2] (with or without food waste disposer, dishwasher, or both)	1½	2.0	2.0	—
Laundry[2] (with or without discharge from a clothes washer)	1½	2.0	2.0	2.0
Service or Mop Basin	2	—	3.0	3.0
Service or Mop Basin	3	—	3.0	3.0
Service, flushing rim	3	—	6.0	6.0
Wash, each set of faucets	—	—	2.0	2.0
Nonwater Urinal with Drain Cleansing Action	2	1.0	1.0	1.0
Urinal, integral trap 1.0 GPF[2]	2	2.0	2.0	5.0
Urinal, integral trap greater than 1.0 GPF	2	2.0	2.0	6.0
Urinal, exposed trap[2]	1½	2.0	2.0	5.0
Water Closet, 1.6 GPF Gravity Tank[6]	3	3.0	4.0	6.0

2022 CALIFORNIA PLUMBING CODE 167

Figure 255: CA Plumbing Code 2022 DFU Values

TABLE 702.1
DRAINAGE FIXTURE UNIT VALUES (DFU) (continued)

PLUMBING APPLIANCES, APPURTENANCES, OR FIXTURES	MINIMUM SIZE TRAP AND TRAP ARM[7] (inches)	PRIVATE	PUBLIC	ASSEMBLY[8]
Water Closet, 1.6 GPF Flushometer Tank[6]	3	3.0	4.0	6.0
Water Closet, 1.6 GPF Flushometer Valve[6]	3	3.0	4.0	6.0
Water Closet, greater than 1.6 GPF Gravity Tank[6]	3	4.0	6.0	8.0
Water Closet, greater than 1.6 GPF Flushometer Valve[6]	3	4.0	6.0	8.0

For SI units: 1 inch = 25 mm

Notes:

1. Indirect waste receptors shall be sized based on the total drainage capacity of the fixtures that drain thereinto, in accordance with Table 702.2.
2. Provide a 2 inch (50 mm) minimum drain.
3. For refrigerators, coffee urns, water stations, and similar low demands.
4. For commercial sinks, dishwashers, and similar moderate or heavy demands.
5. Buildings having a clothes-washing area with clothes washers in a battery of three or more clothes washers shall be rated at 6 fixture units each for purposes of sizing common horizontal and vertical drainage piping.
6. Water closets shall be computed as 6 fixture units where determining septic tank sizes based on Appendix H of this code.
7. Trap sizes shall not be increased to the point where the fixture discharge is capable of being inadequate to maintain their self-scouring properties.
8. Assembly [Public Use (see Table 422.1)].
9. For a bathtub to shower retrofit, a 1½ inch (40 mm) trap and trap arm shall be permitted with a maximum shower size of 36 inches (914 mm) in width and 60 inches (1524 mm) in length. See Section 408.5 and Section 408.6.
10. *For drainage fixture unit values related to lots within mobilehome parks in all parts of the State of California, see California Code of Regulations, Title 25, Division 1, Chapter 2, Article 5, Section 1268. For drainage fixture unit values related to lots within special occupancy parks in all parts of the State of California, see California Code of Regulations, Title 25, Division 1, Chapter 2.2, Article 5, Section 2268.*

Figure 256: CA Plumbing Code 2022 DFU Values Cont.

Waste Line Specifications: Sizing, Materials, Backwater Valve

Sewer Pipes

From Table 146 the DFU value was found to be 21 units which would make the size of the sewer pipe between 2 in. and 3 in. based on Figure 257. Within the AutoCAD drawing the length for sewer and vent pipes respectively were found to be approximately around 70 ft. and 80 ft. represented in Figure 259. The total horizontal length was found to be approximately 150 ft. which lies in between 2 in. and 3 in. sizing. This finalizes the pipe sizing for the sewer pipe to be 3 in. with the accordance of Figure 257. Rounding up to 3 in. was the finalized decision. When implemented into the SewerGEMS model the velocity was under 8.41 ft/s which follows along with the finalized velocity calculations and the requirements for the city of Santa Ana.

According to the city of Santa Ana requirements, represented in Figure 260, the sewer pipe leading to the city's main pipe shall be 0.4 ft per 100 ft. This is based on the 8 in. pipe sizing that was chosen due to the minimum requirement of the city.

TABLE 703.2
MAXIMUM UNIT LOADING AND MAXIMUM LENGTH OF DRAINAGE AND VENT PIPING

SIZE OF PIPE (inches)	1¼	1½	2	3	4	5	6	8	10	12
Maximum Units										
Drainage Piping[1]										
Vertical	1	2[2,7]	16[3]	48[4]	256	600	1380	3600	5600	8400
Horizontal	1	1[7]	8[3]	35[4]	216[5]	428[5]	720[5]	2640[5]	4680[5]	8200[5]
Maximum Length										
Drainage Piping										
Vertical, (feet)	45	65	85	212	300	390	510	750	–	–
Horizontal (unlimited)										
Vent Piping										
Horizontal and Vertical[6]										
Maximum Units	1	8[3]	24	84	256	600	1380	3600	–	–
Maximum Lengths, (feet)	45	60	120	212	300	390	510	750		

For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm

Notes:

[1] Excluding trap arm.

[2] Except for sinks, urinals, and dishwashers – exceeding 1 fixture unit.

[3] Except for six-unit traps or water closets.

[4] Not to exceed five water closets or five six-unit traps.

[5] Based on ¼ inch per foot (20.8 mm/m) slope. For ⅛ of an inch per foot (10.4 mm/m) slope, multiply horizontal fixture units by a factor of 0.8.

[6] The diameter of an individual vent shall be not less than 1¼ inches (32 mm) nor less than one-half the diameter of the drain to which it is connected. Fixture unit load values for drainage and vent piping shall be computed from Table 702.1 and Table 702.2. Not to exceed one-third of the total permitted length of a vent shall be permitted to be installed in a horizontal position. Where vents are increased one pipe size for their entire length, the maximum length limitations specified in this table do not apply. This table is in accordance with the requirements of Section 901.3.

[7] Up to 8 public lavatories are permitted to be installed on a 1½ inch (40 mm) vertical branch or horizontal sanitary branch sloped at ¼ inch per foot (20.8 mm/m).

Figure 257: CA Plumbing Code 2022 for Maximum Length of Drain and Vent Pipes Based on DFU

300.2 MINIMUM SIZE MAINS

The normal minimum size distribution main pipe shall be 8-inch diameter looped line unless otherwise noted and approved. On short cul-de-sac dead-end mains 4-inch (with a maximum of ten (10) each, 1-inch services) or 6-inch (with more than ten (10) each, 1-inch service lines) lines may be allowed, however, 8-inch size main must be used to the last fire hydrant. These smaller mains may be individually approved by the City on dead-end mains without fire hydrants and shall be sized so that sufficient water is regularly drawn to prevent stagnation.

Figure 258: City of Santa Ana Design Guidelines and Standard Drawings for Water and Sewer Facilities 2020 for Design Criteria, Water Facilities

Pipe Sizing				
Type	Size (in)	Slope (%)	Length (ft)	Material
Sewer Pipes	3	0.25	70.375	PVC
Vents	2	N/A	79.0625	PVC
Sewer Pipe to City Pipe	8	0.4	N/A	PVC

Figure 259: Tabulated Sewer and Vent Pipe Sizes

400.3 MINIMUM AND MAXIMUM SLOPE DESIGN

All sewers shall be designed and constructed to provide a mean velocity of not less than two (2) feet per second (fps) when flowing half-full at the estimated peak flow. Peak flows shall be calculated using Manning's formula with an "n" value of 0.013. The following are minimum slopes by pipe size:

Sewer Size (inches)	Minimum Slope in Feet per 100 Feet
8	0.40
10	0.28
12	0.22

These are absolute minimum slopes. Sewers shall be designed to provide steeper slopes whenever possible up to the stated maximum slope.

The maximum allowable slope shall be the slope which generates a maximum flow velocity of eight (8) fps at the peak flow rate.

The maximum slope for sewer laterals is forty (40%) percent. The desirable maximum is ten (10%) percent.

The maximum slope for sewer main lines is 20 (20%) percent. The desirable maximum is ten (10%) percent.

Figure 260: City of Santa Ana Design Guidelines and Standard Drawings for Water and Sewer Facilities 2020 for Minimum and Maximum Slope Sizes

Vent Pipes

The total DFU value from Table 146 gives the value of 21 units. The total length of the vents from Figure 259 gives the length of 79.0625 ft. which was found by looking over the AutoCAD drawings. This can narrow down the pipe size of the ventilation system to 2 in. based on Figure 257the DFU unit of 21 sits between 1.5 in. and 2 in. while the length of 79.0625 ft. sits in between 60 ft. and 120 ft. Therefore it can be rounded up to having a ventilation pipe size of 2 in.

Trap Arms

Using the gathered DFU values from Table 146 and the table 702.1(1) represented in Figure 261 the fixture arm size can be identified. The drinking fountain has a DFU of 0.5 with a corresponding 1.25 in. trap and trap arm. The urinal with the flushometer valve and the sink has a DFU of 2 with a corresponding 1.5 in. trap and trap arm. The water closet with the flushometer valve has a DFU of 4 with a corresponding 3 in. trap and trap arm. In accordance with 2022 CA plumbing codes table 1002.2 for horizontal lengths of trap arms (Figure 262) there are required minimum lengths for finding the trap arm length to the vents. The fixtures that have a trap and trap arm size of 1.25 in. require a minimum distance to vent of 2.5 in. with a maximum length of 30 in. The fixtures that have a trap and trap arm size of 1.5 in. require a minimum distance to vent of 3 in. with a maximum length of 42 in. The fixtures that have a trap and trap arm size of 3 in. require a minimum distance to vent of 6 in. with a maximum length of 72 in.

»

TABLE 702.1(1)
MAXIMUM DRAINAGE FIXTURE UNITS FOR A TRAP AND TRAP ARM*

SIZE OF TRAP AND TRAP ARM (inches)	DRAINAGE FIXTURE UNIT VALUES (DFU)
1¼	1 unit
1½	3 units
2	4 units
3	6 units
4	8 units

For SI Units: 1 inch = 25 mm
* **Exception:** On self-service laundries.

Figure 261: CA Plumbing Code 2022 Fixture Trap and Trap Arm Sizes

TABLE 1002.2
HORIZONTAL LENGTHS OF TRAP ARMS
(EXCEPT FOR WATER CLOSETS AND SIMILAR FIXTURES)[1, 2]

TRAP ARM PIPE DIAMETER (inches)	DISTANCE TRAP TO VENT MINIMUM (inches)	LENGTH MAXIMUM (inches)
1¼	2½	30
1½	3	42
2	4	60
3	6	72
4	8	120
Exceeding 4	2 x Diameter	120

For SI units: 1 inch = 25.4 mm

Notes:

1 Maintain ¼ inch per foot slope (20.8 mm/m).

2 The developed length between the trap of a water closet or similar fixture (measured from the top of the closet flange to the inner edge of the vent) and its vent shall not exceed 6 feet (1829 mm).

Figure 262: CA Plumbing Code 2022 Max Horizontal Length of Trap and Trap Arms

Table 147: Tabulated Trap Fixture Lengths

Fixture Trap Sizes	Size (in)	Length to Vent (ft)	Slope (%)
Urinal (Level 1) 1.0 GPF Flushometer Valve	1.5	3/8	0.02
Water Closet (Level 1) Flushometer Valve, 1.6 GPF	3	1/2	0.02
Sink (Level 1)	1.5	3/8	0.02
Drinking Fountain (Level 1)	1.25	3/8	0.02

Urinal (Level 2) 1.0 GPF Flushometer Valve	1.5	3/8	0.02
Water Closet (Level 2) Flushometer Valve, 1.6 GPF	3	1/2	0.02
Sink (Level 2)	1.5	3/8	0.02
Drinking Fountain (Level 2)	1.25	3/8	0.02

Clean Out

In accordance with the CA plumbing code in figure 3.3.4(8) the size of the cleanout will be 2.5 in. with the corresponding 3 in. pipe sizing for the main sewer pipeline. The location of the cleanouts of each floor are placed after a bend with the case of the first floor situated outside of the building towards the east facing wall.

TABLE 707.1
CLEANOUTS

SIZE OF PIPE (inches)	SIZE OF CLEANOUT (inches)	THREADS (per inches)
1½	1½	11½
2	1½	11½
2½	2½	8
3	2½	8
4 & larger	3½	8

For SI units: 1 inch = 25 mm

Figure 263: CA Plumbing Code 2022 for Size Requirements for Cleanout

707.4 Location. Each horizontal drainage pipe shall be provided with a cleanout at its upper terminal, and each run of piping, that is more than 100 feet (30 480 mm) in total developed length, shall be provided with a cleanout for each 100 feet (30 480 mm), or fraction thereof, in length of such piping. An additional cleanout shall be provided in a drainage line for each aggregate horizontal change in direction exceeding 135 degrees (2.36 rad). A cleanout shall be installed above the fixture connection fitting, serving each urinal, regardless of the location of the urinal in the building.

Figure 264: CA Plumbing Code 2022 for Location of Cleanout

Materials

Following the standards from the City of Santa Ana, located in Figure 265, it stated that sanitary sewer pipes and ventilation pipes shall be made of PVC. Based on the 2022 CA plumbing codes, located in Figure 266, it stated that each of the traps will be made of PVC as well.

6.10 Polyvinyl Chloride (PVC) Sewer Pipe

Installation and construction of PVC sewer main shall conform to all applicable provisions of the ASTM D2321-05 (or later) "Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity Flow Applications," Standard Specifications and these Special Provisions and the construction plans.

Where indicated on the plans, sanitary sewer pipe shall be Polyvinyl Chloride (PVC) sewer pipe with compression joints conforming to Subsection 207-8 of the Standard Specifications.

Underground conduit construction shall conform to all applicable Subsections of Section 306 of the Standard Specifications, the Standard Plans and these Special Provisions.

PVC sewer pipe shall be manufactured by JM Eagle or approved equivalent.

PVC gravity sewer pipe and fittings shall conform to ASTM D3034 for diameters from 4" - 15", and ASTM F679 for 18" - 24", with integral bell gasket joints. Rubber gaskets shall be factory installed and conform to ASTM F477.

Pipe shall be made of PVC plastic having a cell classification of 12454B or 12364B as defined in ASTM D1784 and shall have SDR of 26 and minimum pipe stiffness of 115 psi according to ASTM Test D2412.

Figure 265: City of Santa Ana Design Guidelines and Standard Drawings for Water and Sewer Facilities 2020 for Special Improvements - Sanitary Sewer Improvements

1003.1 General Requirements. Each trap, except for traps within an interceptor or similar device shall be self-cleaning. Traps for bathtubs, showers, lavatories, sinks, laundry tubs, floor drains, urinals, drinking fountains, dental units, and similar fixtures shall be of standard design, weight and shall be of ABS, cast-brass, cast-iron, lead, PP, PVC, or other approved material. An exposed and readily accessible drawn-copper alloy tubing trap, not less than 17 B & S Gauge (0.045 inch) (1.143 mm), shall be permitted to be used on fixtures discharging domestic sewage.

Figure 266: CA Plumbing Code 2022 For Trap and Trap Arm Material

Backwater Valve

Following CA plumbing codes 2022 regarding the installation of a backflow valve, Figure 267 a backwater valve will be installed on the floor level next to the upstream manhole cover of the sewer. This will help maintain the water to remain within the building while preventing flooding and other possible hazards.

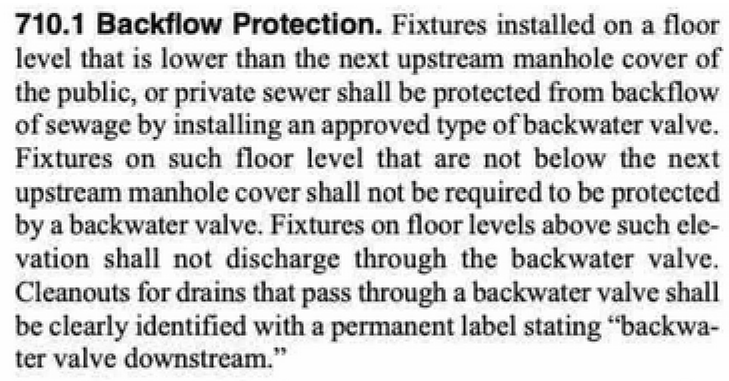
710.1 Backflow Protection. Fixtures installed on a floor level that is lower than the next upstream manhole cover of the public, or private sewer shall be protected from backflow of sewage by installing an approved type of backwater valve. Fixtures on such floor level that are not below the next upstream manhole cover shall not be required to be protected by a backwater valve. Fixtures on floor levels above such elevation shall not discharge through the backwater valve. Cleanouts for drains that pass through a backwater valve shall be clearly identified with a permanent label stating "backwater valve downstream."

Figure 267: CA Plumbing Code 2022 for Backflow Protection

SewerGEMS Model and Results

The creation of the building's sewage pipe system on SewerGEMS was by overlaying the sewer pipe layout from the AutoCAD drawings of the building. First is the creation of the manhole within the model which was set at an elevation of -8 ft. in accordance with the city of Santa Ana represented in Figure 277. Next is creating the pipe layout with the overlapped AutoCAD sewer drawing where each appliance is represented as a pressure pipe. Now that the appliances have been created, SewerGEMS needs to identify the amount of discharge per appliance. This is done through CA 2022 plumbing codes conversion from DFU to GPM represented in Figure 275. The final results in cfs/fixture can be found in Figure 276. Once all of that is completed the validation of our model can be completed to provide the results that are needed to finalize the model.

The results of the SewerGEMS model was a success as the simulations provided the results that we were expecting. The models for floor 1 can be shown in Figure 268 and Figure 269 with the corresponding tables in Figure 270 and Figure 271. The models for floor 2 can be shown in Figure 272 with the corresponding tables in Figure 273 and Figure 274. After performing the calculation to calculate the final velocity for the 3 in. and 8 in. pipes it was determined that the SewerGEMS model has been validated as the velocities within the model were well under 8.41 ft/s and 10 ft/s.

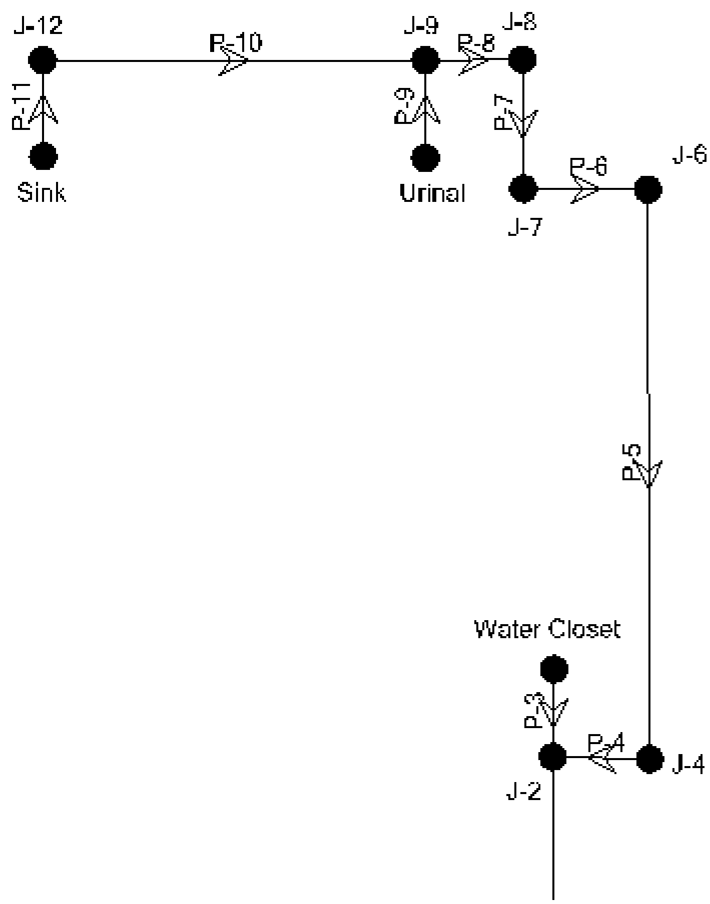

Figure 268: SewerGEMS Floor 1 Layout

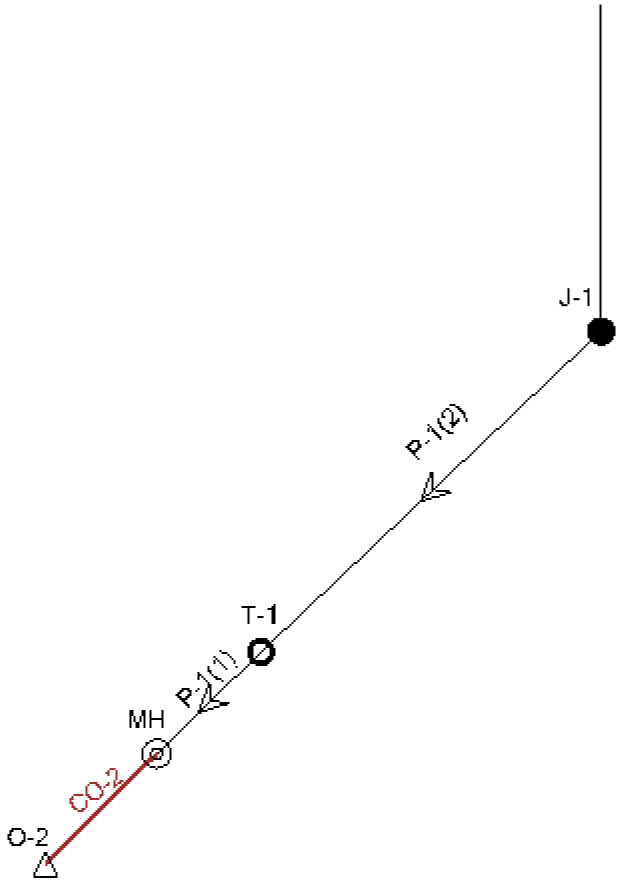

Figure 269: SewerGEMS Floor 1 Layout to City Main Pipe

	ID	Label	Start Node	Stop Node	Has User Defined Length?	Length (User Defined) (ft)	Length (Scaled) (ft)	Diameter (in)	Manning's n	Flow (cfs)	Velocity (ft/s)	Notes
43: P-2	43	P-2	J-2	J-1	☐		19.5	8.0	0.013	0.008	0.39	
45: P-3	45	P-3	Water Closet	J-2	☐		0.9	3.0	0.013	0.004	0.19	
47: P-4	47	P-4	J-4	J-2	☐		1.0	3.0	0.013	0.004	0.19	
50: P-5	50	P-5	J-6	J-4	☐		6.0	3.0	0.013	0.004	0.19	
52: P-6	52	P-6	J-7	J-6	☐		1.3	3.0	0.013	0.004	0.19	
54: P-7	54	P-7	J-8	J-7	☐		1.4	3.0	0.013	0.004	0.19	
56: P-8	56	P-8	J-9	J-8	☐		1.0	3.0	0.013	0.004	0.19	
59: P-9	59	P-9	Urinal	J-9	☐		1.0	1.5	0.013	0.002	0.18	
61: P-10	61	P-10	J-12	J-9	☐		4.0	3.0	0.013	0.002	0.09	
63: P-11	63	P-11	Sink	J-12	☐		1.0	1.5	0.013	0.002	0.18	
65: P-1(1)	65	P-1(1)	MH	T-1	☐		1.5	8.0	0.013	-0.008	-0.59	
66: P-1(2)	66	P-1(2)	J-1	T-1	☐		4.9	8.0	0.013	0.008	0.58	

Figure 270: SewerGEMS Floor 1 Flex Table of Simulation of Sewer Model (Pressure Pipe)

	ID	Label	Elevation (Ground) (ft)	Elevation (ft)	Sanitary Loads	Inflow (Wet) Collection	Hydraulic Grade (ft)	Pressure (Maximum) (psi)	Notes
40: J-1	40	J-1	0.00	0.00	<Collection:	<Collection:	0.01	(N/A)	
42: J-2	42	J-2	0.00	0.00	<Collection:	<Collection:	0.12	(N/A)	
44: Water Close	44	Water Closet	0.00	0.00	<Collection:	<Collection:	0.12	(N/A)	
46: J-4	46	J-4	0.00	0.00	<Collection:	<Collection:	0.12	(N/A)	
49: J-6	49	J-6	0.00	0.00	<Collection:	<Collection:	0.12	(N/A)	
51: J-7	51	J-7	0.00	0.00	<Collection:	<Collection:	0.12	(N/A)	
53: J-8	53	J-8	0.00	0.00	<Collection:	<Collection:	0.12	(N/A)	
55: J-9	55	J-9	0.00	0.00	<Collection:	<Collection:	0.12	(N/A)	
58: Urinal	58	Urinal	0.00	0.00	<Collection:	<Collection:	0.12	(N/A)	
60: J-12	60	J-12	0.00	0.00	<Collection:	<Collection:	0.12	(N/A)	
62: Sink	62	Sink	0.00	0.00	<Collection:	<Collection:	0.12	(N/A)	

Figure 271: SewerGEMS Floor 1 Flex Table of Simulation of Sewer Model (Pressure Junction)

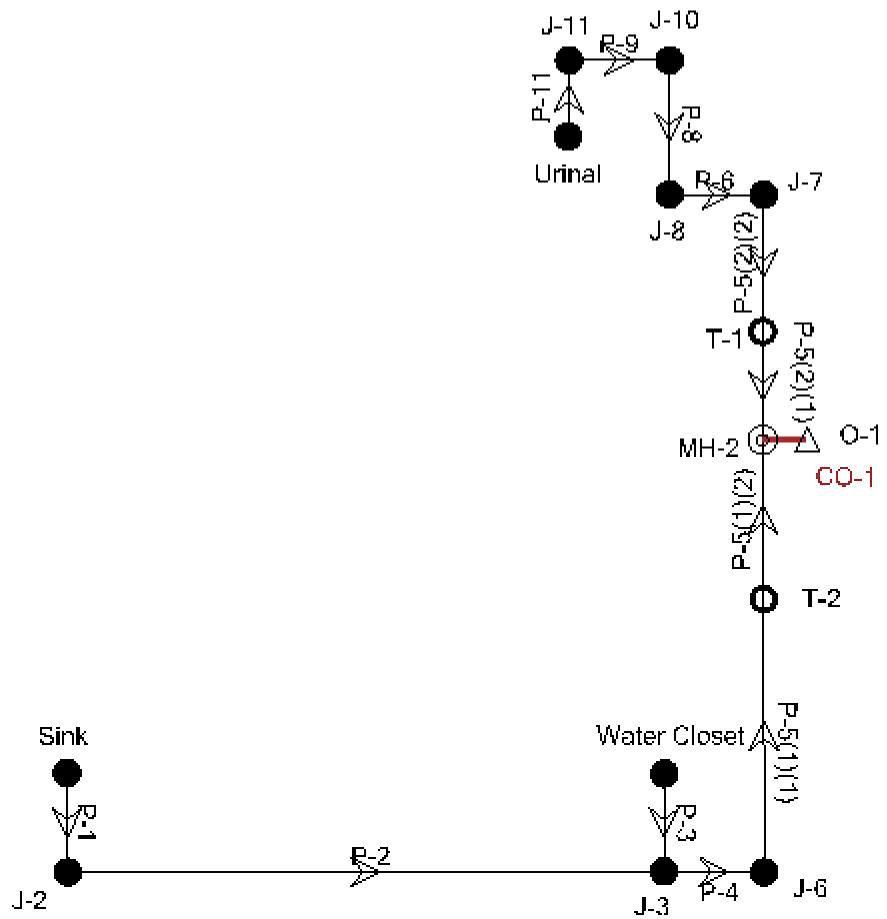

Figure 272: SewerGEMS Floor 2 Layout

	ID	Label	Start Node	Stop Node	Has User Defined Length?	Length (User Defined) (ft)	Length (Scaled) (ft)	Diameter (in)	Manning's n	Flow (cfs)	Velocity (ft/s)	Notes
36: P-1	36	P-1	Sink	J-2	☐		1.0	1.5	0.013	0.002	0.27	
38: P-2	38	P-2	J-2	J-3	☐		6.2	3.0	0.013	0.002	0.39	
40: P-3	40	P-3	Water Closet	J-3	☐		1.0	3.0	0.013	0.004	0.69	
43: P-4	43	P-4	J-3	J-6	☐		1.0	3.0	0.013	0.006	0.57	
47: P-6	47	P-6	J-8	J-7	☐		1.0	3.0	0.013	0.002	0.55	
51: P-8	51	P-8	J-10	J-8	☐		1.4	3.0	0.013	0.002	0.60	
53: P-9	53	P-9	J-11	J-10	☐		1.0	3.0	0.013	0.002	0.63	
57: P-11	57	P-11	Urinal	J-11	☐		0.8	3.0	0.013	0.002	0.63	
65: P-5(2)(1)	65	P-5(2)(1)	MH-2	T-1	☐		1.1	3.0	0.013	-0.002	-0.55	
66: P-5(2)(2)	66	P-5(2)(2)	T-1	J-7	☐		1.4	3.0	0.013	-0.002	-0.53	
68: P-5(1)(1)	68	P-5(1)(1)	J-6	T-2	☐		2.8	3.0	0.013	0.006	0.56	
69: P-5(1)(2)	69	P-5(1)(2)	T-2	MH-2	☐		1.6	3.0	0.013	0.006	0.59	

Figure 273: SewerGEMS Floor 2 Flex Table of Simulation of Sewer Model (Pressure Pipe)

	ID	Label	Elevation (Ground) (ft)	Elevation (ft)	Sanitary Loads	Inflow (Wet) Collection	Hydraulic Grade (ft)	Pressure (Maximum) (psi)	Notes
34: Sink	34	Sink	0.00	0.00	<Collection:	<Collection:	0.12	(N/A)	
35: J-2	35	J-2	0.00	0.00	<Collection:	<Collection:	0.08	(N/A)	
37: J-3	37	J-3	0.00	0.00	<Collection:	<Collection:	0.03	(N/A)	
39: Water Close	39	Water Closet	0.00	0.00	<Collection:	<Collection:	0.04	(N/A)	
42: J-6	42	J-6	0.00	0.00	<Collection:	<Collection:	0.01	(N/A)	
44: J-7	44	J-7	0.00	0.00	<Collection:	<Collection:	0.00	(N/A)	
46: J-8	46	J-8	0.00	0.00	<Collection:	<Collection:	0.02	(N/A)	
50: J-10	50	J-10	0.00	0.00	<Collection:	<Collection:	0.02	(N/A)	
52: J-11	52	J-11	0.00	0.00	<Collection:	<Collection:	0.02	(N/A)	
56: Urinal	56	Urinal	0.00	0.00	<Collection:	<Collection:	0.02	(N/A)	

Figure 274: SewerGEMS Floor 2 Flex Table of Simulation of Sewer Model (Pressure Junction)

709.3 Conversion of GPM Flow to DFU Values

Where discharges to a waste receptor or to a drainage system are only known in gallons per minute (liters per second) values, the *drainage fixture unit* values for those flows shall be computed on the basis that 1 gpm (0.06 L/s) of flow is equivalent to two *drainage fixture units*.

Figure 275: CA Plumbing Code 2022 for GPM to DFU Value Conversion

Description	Quantity	DFU	CFS/Fixture
Urinal 1.0 GPF Flushometer Valve	2	2	0.002118879973
Water Closet Flushometer Valve, 1.6 GPF	2	4	0.004237759946
Sink	2	2	0.002118879973
Drinking Fountain	2	0.5	0.0005570019854

Figure 276: Tabulated Discharge for Fixtures

400.9.2 Manhole Size and Depth

Manholes shall be precast reinforced concrete with eccentric cone in accordance with the City's Standard Plans. Minimum manhole diameter shall be 48-inches. The manhole necking and the frame and cover shall be 24-inches in diameter.

Manhole depth is calculated from finish grade to lowest pipe invert. Minimum manhole depth is to be eight (8) feet, unless otherwise approved by the City.

There are additional requirements for larger diameter manholes where the sewer main is at greater depths.

Figure 277: City of Santa Ana Design Guidelines and Standard Drawings for Water and Sewer Facilities 2020 for Manhole Size and Depth

Calculations

Before calculating the flow rate for each of the pipes in the system, first the velocity of each of the pipes has to be found. Using manning's equation (US units) the velocity for the 3 in. pipe can be found to be 8.32 ft/s. Within the SewerGEMS model all of the sewer pipes with a 3 in. diameter maintained under a velocity under 8.32 ft/s.

$$Velocity = \frac{1.49 \times R^{0.67} \times S^{0.5}}{n} = \frac{1.49 \times 0.25^{0.67} in \times 0.03^{0.5}}{0.013} = 8.32\ ft/s$$

The next velocity that had to be found was for the 8 in. sewer pipe that connected to the city main pipe. Using manning's equation (US units) the velocity for the 8 in. pipe can be found to be 10 ft/s. Within the SewerGEMS model all of the sewer pipes are 8 in. diameter maintained a velocity under 10 ft/s.

$$Velocity = \frac{1.49 \times R^{0.67} \times S^{0.5}}{n} = \frac{1.49 \times 0.67^{0.67} in \times 0.4^{0.5}}{0.013} = 10\ ft/s$$

Next the flow rate of each of the pipe sizes can be found, The flowrate of the sewer water in the 3 in. pipe was found to be 0.491 cu.ft/s.

$$Q = AV = \frac{\pi}{4} \times D^2 \times V = \frac{\pi}{4} \times (3\ in. \times \frac{1\ ft.}{12\ in})^2 \times 8.41\ ft/s = 0.491\ ft^3/s$$

The same equation can be used to find the flowrate of the sewer water in the 8 in. pipe which was found to be 3.49 cu.ft/s.

$$Q = AV = \frac{\pi}{4} \times D^2 \times V = \frac{\pi}{4} \times (8\ in. \times \frac{1\ ft.}{12\ in})^2 \times 10\ ft/s = 3.49 ft^3/s$$

Depth over Diameter Limitation (d/D)

Following the guidelines for the city of Santa Ana regarding the ratio between depth of flow and diameter of our sewer pipe was found to be 0.5 or 50% represented in Figure 278. With an 8 in. pipe connecting to the main city pipeline, the city of Santa Ana states that pipelines that are under 12 in. in diameter must have d/D = 0.5 otherwise the d/D = 0.75. In the sewer model the pipe connecting to the main city pipe was represented with the conduit and the long pressure pipe leading from the manhole to the building. Finalizing the sewer model to having a fully functioning sewer system.

400.4.3 Design Criteria

Design peak flows in pipelines 12 inches in diameter and smaller are to be limited to approximately d/D = 0.5 (½ of full depth). Pipes over 12 inches in diameter are to be limited to approximately d/D = 0.75 (3/4 of full depth) at design peak flows.

Figure 278: City of Santa Ana Design Guidelines and Standard Drawings for Water and Sewer Facilities 2020 for Design Criteria, Sewer Facilities

Stormwater Analysis

Storm Water Plans

Storm Drain Layout

In accordance with 2022 California Plumbing Code, two roof scuppers dimensioned 6" x 6" attached to downspouts will be used. There will be an overflow opening that is 3" for drainage in case scuppers clog.

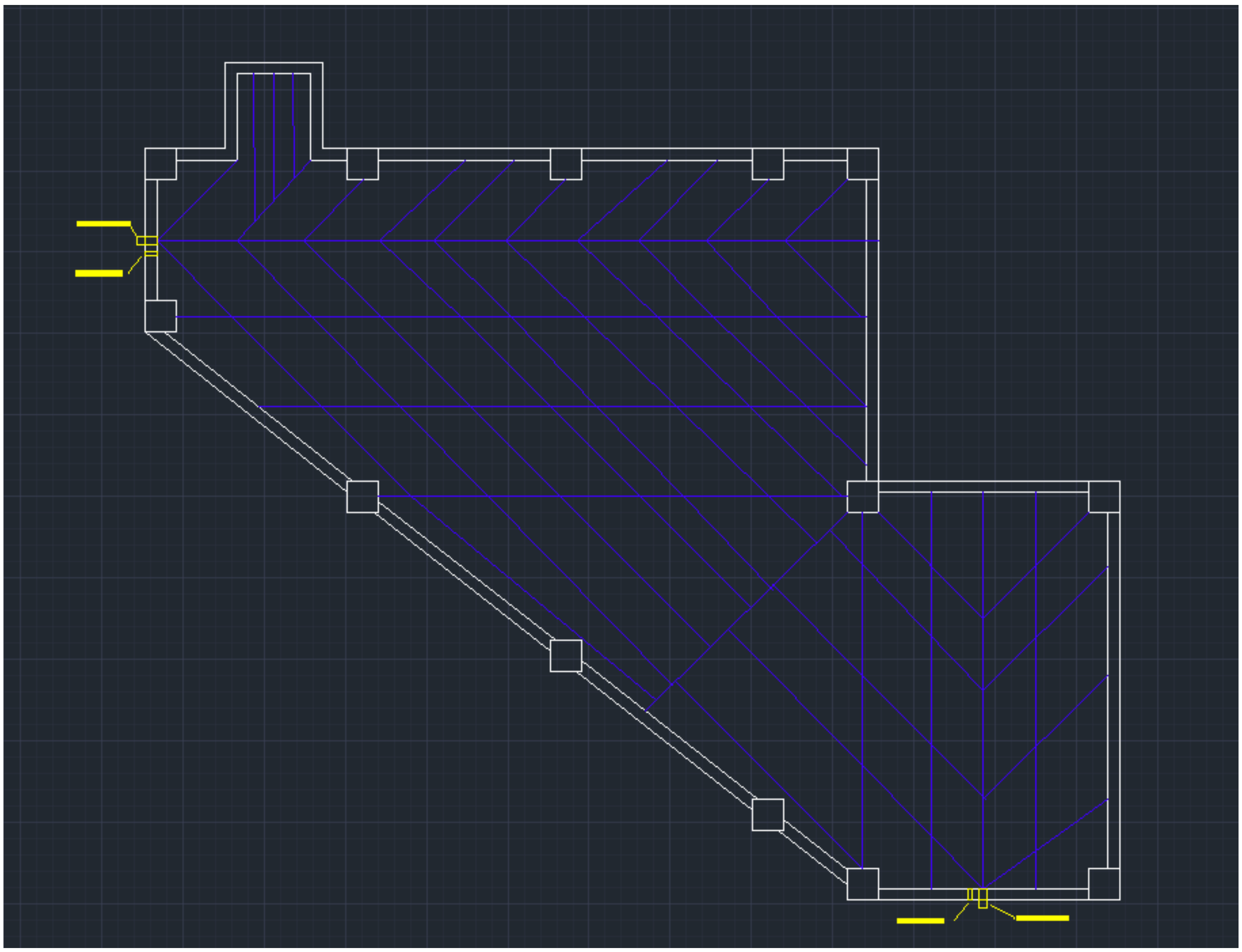

Figure: Storm Drain Layout

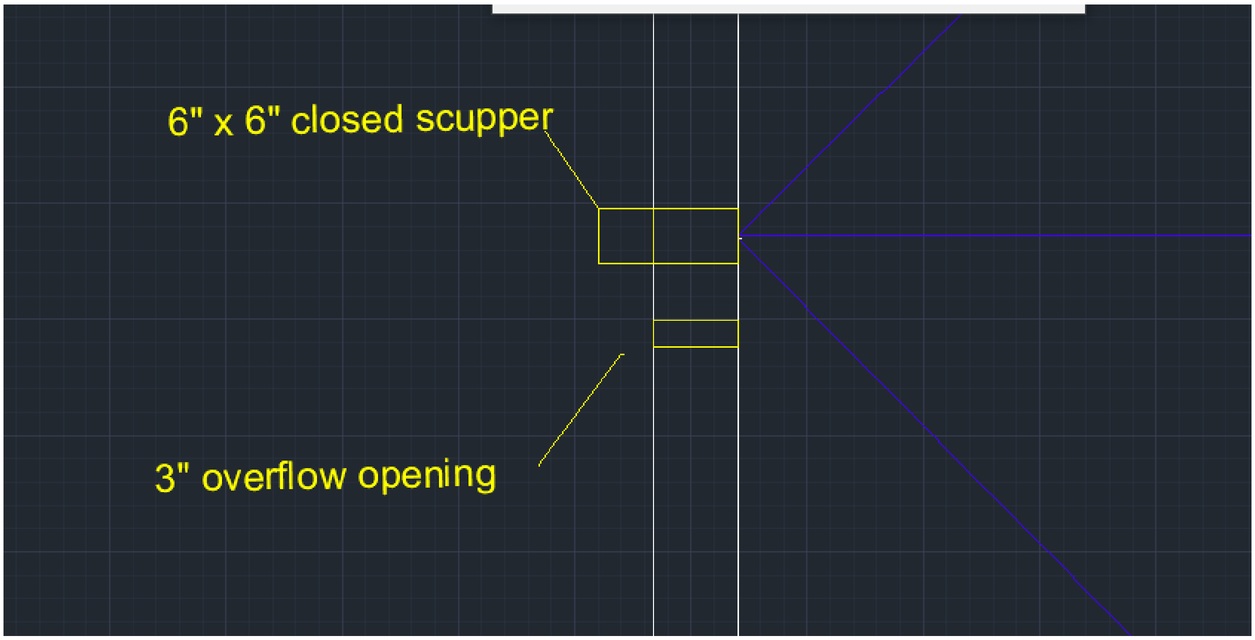

Figure: Storm Drain Layout

Peak Flow Rate vs. Design Flow Rate

Peak flow should be lower than the design flow rate to ensure that storm water on the roof is properly displaced. If the peak flow is lower than the design flow then drains can successfully and efficiently carry the flow that the heaviest rains will provide. Peak flow is calculated using the Rational Method while design flow rate is calculated using Manning Equation.

Our roof was designed to slope into two directions, therefore we used two areas that will displace rain water in its designated drain. An adequate size of scupper, downspout and pipe was chosen in accordance with the 2022 California Plumbing Code. The chosen scupper dimensions of 6”W x 6”H with a 1 ½” water head was chosen, referencing table D 104.1 since a displacement of our rainfall intensity was 22.69 GPM in total, meaning each scupper will receive about 11.50 GPM displacement. Our scupper will provide more than adequate for each area. Therefore, a 6” x 6” commercial downspout will be used to connect a scupper of 5” PVC storm drain pipe.

The flow of stormwater from the roof top to the city street and flows to the city's catch basin. The storm water lands on the roof then flows into a scupper drain and downspout and lastly into a PVC storm drain pipe. The storm drain pipe pours into the city street and lastly into a catch basin. They both have an average of 2% grade and points in the direction of a curb inlet. The intent is to have all storm water drain flow into this curb inlet which drains into the city’s catch basin.

Table 148: 104.1 Discharge from rectangular scuppers

TABLE D 104.1
DISCHARGE FROM RECTANGULAR SCUPPERS (gallons per minute)[1, 2, 3, 4]

WATER HEAD (inches)	WIDTH OF SCUPPER (inches)					
	6	12	18	24	30	36
½	6	13	19	25	32	38
1	17	35	53	71	89	107
1½	31	64	97	130	163	196
2	–	98	149	200	251	302
2½	–	136	207	278	349	420
3	–	177	271	364	458	551
3½	–	–	339	457	575	693
4	–	–	412	556	700	844

For SI units: 1 inch = 25.4 mm, 1 gallon per minute = 0.06 L/s

Notes:

1 Table D 104.1 is based on discharge over a rectangular weir with end contractions.

2 The head is the depth of water above the bottom of the scupper opening.

3 The height of the scupper opening shall be not less than two times the design head.

4 Coordinate the allowable head of water with the structural design of the roof.

Rational Runoff Coefficient and Adjustment

The runoff coefficient C represents the ratio of runoff to rainfall intensity. The components that are taken into consideration when determining the correct coefficient are: Permeability, surface depressions, antecedent moisture, ground cover, ground slopes, and soil types. A formula can be used or we can use the following table to determine the Runoff Coefficient, which we used. We have provided California's fact sheet for runoff Coefficient, but will use Oregon's Table 1, because it is more accurate instead of a range.

Table 149: California Fact Sheet for Coefficient

Land Use	C	Land Use	C
Business: Downtown areas Neighborhood areas	 0.70 - 0.95 0.50 - 0.70	***Lawns:*** Sandy soil, flat, 2% Sandy soil, avg., 2-7% Sandy soil, steep, 7% Heavy soil, flat, 2% Heavy soil, avg., 2-7% Heavy soil, steep, 7%	 0.05 - 0.10 0.10 - 0.15 0.15 - 0.20 0.13 - 0.17 0.18 - 0.22 0.25 - 0.35
Residential: Single-family areas Multi units, detached Munti units, attached Suburban	 0.30 - 0.50 0.40 - 0.60 0.60 - 0.75 0.25 - 0.40	***Agricultural land:*** *Bare packed soil* *Smooth *Rough *Cultivated rows* *Heavy soil, no crop *Heavy soil, with crop *Sandy soil, no crop *Sandy soil, with crop *Pasture* *Heavy soil *Sandy soil Woodlands	 0.30 - 0.60 0.20 - 0.50 0.30 - 0.60 0.20 - 0.50 0.20 - 0.40 0.10 - 0.25 0.15 - 0.45 0.05 - 0.25 0.05 - 0.25

The Clean Water Team Guidance Compendium for Watershed Monitoring and Assessment
State Water Resources Control Board 5.1.3 FS-(RC) 2011

Fact Sheet-5.1.3

Industrial: Light areas Heavy areas	 0.50 - 0.80 0.60 - 0.90	*Streets:* Asphaltic Concrete Brick	 0.70 - 0.95 0.80 - 0.95 0.70 - 0.85
Parks, cemeteries	0.10 - 0.25	Unimproved areas	0.10 - 0.30
Playgrounds	0.20 - 0.35	Drives and walks	0.75 - 0.85
Railroad yard areas	0.20 - 0.40	Roofs	0.75 - 0.95

Table 150: Table 1 Runoff Coefficients for Rational Method

Table 1 Runoff Coefficients for the Rational Method

	FLAT	ROLLING	HILLY
Pavement & Roofs	**0.90**	**0.90**	**0.90**
Earth Shoulders	0.50	0.50	0.50
Drives & Walks	0.75	0.80	**0.85**
Gravel Pavement	**0.85**	**0.85**	**0.85**
City Business Areas	0.80	**0.85**	**0.85**
Apartment Dwelling Areas	0.50	0.60	0.70
Light Residential: 1 to 3 units/acre	0.35	0.40	0.45
Normal Residential: 3 to 6 units/acre	0.50	0.55	0.60
Dense Residential: 6 to 15 units/acre	0.70	0.75	0.80
Lawns	0.17	0.22	0.35
Grass Shoulders	0.25	0.25	0.25
Side Slopes, Earth	0.60	0.60	0.60
Side Slopes, Turf	0.30	0.30	0.30
Median Areas, Turf	0.25	0.30	0.30
Cultivated Land, Clay & Loam	0.50	0.55	0.60
Cultivated Land, Sand & Gravel	0.25	0.30	0.35
Industrial Areas, Light	0.50	0.70	0.80
Industrial Areas, Heavy	0.60	0.80	**0.90**
Parks & Cemeteries	0.10	0.15	0.25
Playgrounds	0.20	0.25	0.30
Woodland & Forests	0.10	0.15	0.20
Meadows & Pasture Land	0.25	0.30	0.35
Unimproved Areas	0.10	0.20	0.30

Note:

- ***Impervious surfaces in bold***
- *Rolling = ground slope between 2 percent to 10 percent*
- *Hilly = ground slope greater than 10 percent*

We have calculated values of Runoff Flows in order to account for the different types of surfaces within our building and landscape. We have calculated values for the roof, landscaping, and parking lot. Our Roof Runoff Flow as well as our Parking Lot runoff coefficient will use a Runoff Flow will have a runoff coefficient of .90 since it is flat and has a consistent slope throughout. Our Landscaping Runoff Flow will use a value of .25 since it consists of rolling grass shoulders. We are required to use a runoff coefficient adjustment factor with a Runoff Coefficient of 1.25 since we are using a recurrence interval of 100 years using the following table.

Table 151: Runoff Coefficient Adjustment Factors

Table 2 Runoff Coefficient Adjustment Factors

RECURRENCE INTERVAL	RUNOFF COEFFICIENT ADJUSTMENT FACTOR
10 years or less	1.0
25 years	1.1
50 years	1.2
100 years	1.25

Intensity Factor

The intensity factor is calculated using the National Oceanic and Atmospheric Administration (NOAA) Weather Service website. We used the following graph to find our intensity factor. We decided to calculate a runoff for a 24 hr duration storm that recurs every 100 years. The intensity factor of 1.26 in/hr was determined

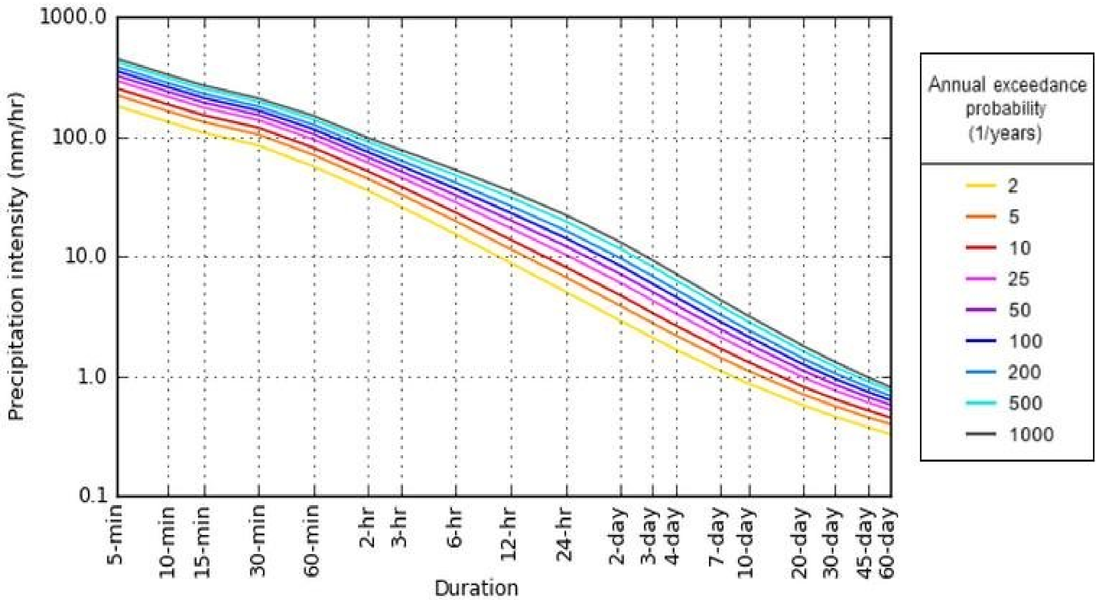

Figure 279: Precipitation Intensity

Area

The area of the roof was determined using AutoCad. The area tool was used to determine the area for roof, parking lot, and landscape. Area for the roof was .03914141 acres. The area for the parking lot was .12354 acres. The area for the landscape was .232581 acres. The total area for roof, parking lot, and landscape runoff flow is .232581 acres.

Calculations

Peak flow rate is calculated using the Rational Method which consists of the following formula.

Q=c*i*A

Where: Q=runoff flow in ft^3/s, C=runoff coefficient, i= rainfall intensity in ft^3/s, and A= area in acres. The following tables summarize the values obtained for the runoff flow of the roof, parking lot and landscaping. The flow rate through a single drainage system is as follows:

Q = 0.0104Ai (C8.3-1)

We determine our rainfall intensity (i) In our site location using hdsc.nws.noaa.gov the rainfall intensity for 1- hour over 100 years and using the area of the roof we could determine the flow rate of water that will accumulate on the roof.

$$i = 1.28\ in/hr$$

$$A_{roof} = 1705\ ft^2$$

Flow rate:

$$Q = 0.0104(A_{roof})(i) \qquad \text{ASCE 7-16 C8.3-1}$$

$$Q = (0.0104)(1705\ ft^2)(1.28\ in/hr)$$

$$Q = 22.6896\ gal/min$$

Although, we used table 1 for the following runoff coefficients to use precise factors.

Table 152: Peak Flow Runoff

Roof Runoff Flow (ft^3/s and GPM)					
Runoff Coefficient	Runoff Coefficient Adjustment	Rainfall Intensity (in/hr)	Area (acres)	Runoff Flow (ft^3/s)	Runoff Flow (GPM)
0.9	1.25	1.28	0.03914141	0.062626256	28.11

Parking lot Runoff Flow (ft^3/s and GPM)					
Runoff Coefficient	Runoff Coefficient Adjustment	Rainfall Intensity (in/hr)	Area (acres)	Runoff Flow (ft^3/s)	Runoff Flow (GPM)
0.9	1.25	1.28	0.12354	0.197664	88.72
Landscape Runoff Flow (ft^3/s and GPM)					
Runoff Coefficient	Runoff Coefficient Adjustment	Rainfall Intensity (in/hr)	Area (acres)	Runoff Flow (ft^3/s)	Runoff Flow (GPM)
0.25	1.25	1.28	0.0699	0.11184	50.2
Total Runoff Flow (ft^3/s and GPM)					
Runoff Coefficient	Runoff Coefficient Adjustment	Rainfall Intensity (in/hr)	Area (acres)	Runoff Flow (ft^3/s)	Runoff Flow (GPM)
		1.28	0.232581	0.37213	167.02

The following table is how we determined the size of our scuppers. We had a GPM of 28 for the roof and a hydraulic head of 1.15 which we rounded to 2".

Table 153: C8.3.3 Flow Rate and Drainage System

Table C8.3-3 Flow Rate, Q, in Gallons Per Minute for Scuppers at Various Hydraulic Heads (d_h) in Inches

	Hydraulic Head, d_h, in.									
Drainage System	**1**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**7**	**8**
6-in. wide channel scupper[a]	18	50	[b]	90	[b]	140	[b]	194	321	393
24-in. wide channel scupper	72	200	[b]	360	[b]	560	[b]	776	1,284	1,572
6-in. wide, 4-in. high, closed scupper[a]	18	50	[b]	90	[b]	140	[b]	177	231	253
24-in. wide, 4-in. high, closed scupper	72	200	[b]	360	[b]	560	[b]	708	924	1,012
6-in. wide, 6-in. high, closed scupper	18	50	[b]	90	[b]	140	[b]	194	303	343
24-in. wide, 6-in. high, closed scupper	72	200	[b]	360	[b]	560	[b]	776	1,212	1,372

[a]Channel scuppers are open-topped (i.e., three-sided). Closed scuppers are four-sided.
[b]Interpolation is appropriate, including between widths of each scupper.
Source: Adapted from FM Global (2012).

Design Flow Rate

The pipes emptying the roof storm water into the parking lot and driveway will have a diameter of 5". Using the Manning equation we were able to calculate the design flow rate which will determine if we have sufficient drainage.

$$Q = 1.49/n * A * R^{2/3} * S^{1/2}$$

Our slope is .25 inches/ft and we need ft/ft so our slope is .02. We have a pipe diameter of 5", which gives us a Q of .41. Our designed flow rate is greater than the peak flow rate from the roof, which means that the drains and pipe networks will be able to successfully carry the storm water from the roof.

The slope and pipe size must satisfy Table 1103.2 of the California Plumbing Code. A slope of ¼ " per foot and a diameter of 5" will satisfy the requirement for drainage as the roof contains a total of 167 GPM of storm water in the event of a 24 hour storm that occurs every 100 years.

Table 154: 1103.1 Sizing of Roof Drain and Vertical Rainwater Piping

TABLE 1103.1
SIZING ROOF DRAINS, LEADERS, AND VERTICAL RAINWATER PIPING[2, 3]

SIZE OF DRAIN, LEADER, OR PIPE	FLOW	MAXIMUM ALLOWABLE HORIZONTAL PROJECTED ROOF AREAS AT VARIOU (square feet)								
inches	gpm[1]	1 (in/h)	2 (in/h)	3 (in/h)	4 (in/h)	5 (in/h)	6 (in/h)	7 (in/h)	8 (in/h)	9 (in/h)
2	30	2880	1440	960	720	575	480	410	360	320
3	92	8800	4400	2930	2200	1760	1470	1260	1100	980
4	192	18 400	9200	6130	4600	3680	3070	2630	2300	2045
5	360	34 600	17 300	11 530	8650	6920	5765	4945	4325	3845
6	563	54 000	27 000	17 995	13 500	10 800	9000	7715	6750	6000
8	1208	116 000	58 000	38 660	29 000	23 200	19 315	16 570	14 500	12 890

For SI units: 1 inch = 25 mm, 1 gallon per minute = 0.06 L/s, 1 inch per hour = 25.4 mm/h, 1 square foot = 0.0929 m^2

Notes:

[1] Maximum discharge capacity, gpm (L/s) with approximately 1¾ inch (44 mm) head of water at the drain.

[2] For rainfall rates other than those listed, determine the allowable roof area by dividing the area given in the 1 inch per hour (25.4 mm/h) column by the desired rainfall rate.

[3] Vertical piping shall be round, square, or rectangular. Square pipe shall be sized to enclose its equivalent round pipe. Rectangular pipe shall have not less than the same cross-sectional area as its equivalent round pipe, except that the ratio of its side dimensions shall not exceed 3 to 1.

Isometric Drawing

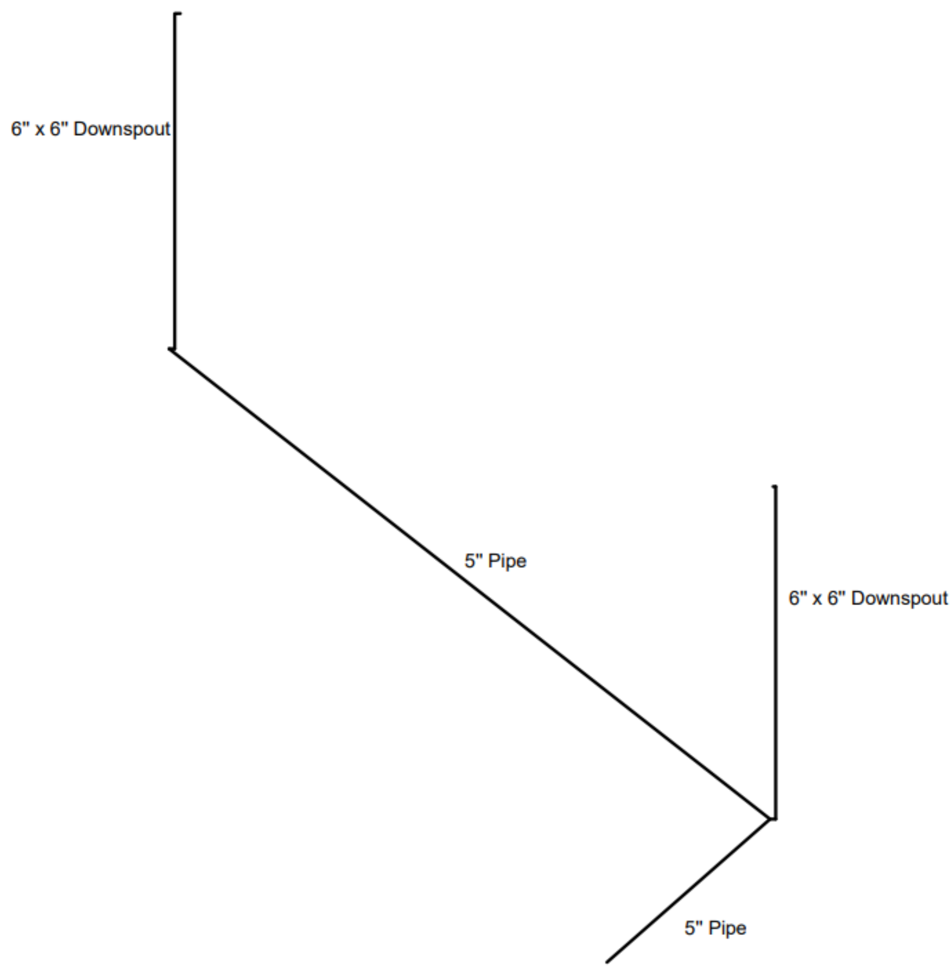

Figure 280: Isometric Model

SWMM Model

We divided our model into two areas and sub catchments to properly use the EPA Storm Management Software. We took the length, junctions, diameter, and roughness of each pipe. The goal was to determine our runoff flow and output.

The total precipitation is our amount of rainfall we received in a 6 hour period. Our continuity was less than 5%, which means we have accurate numbers.

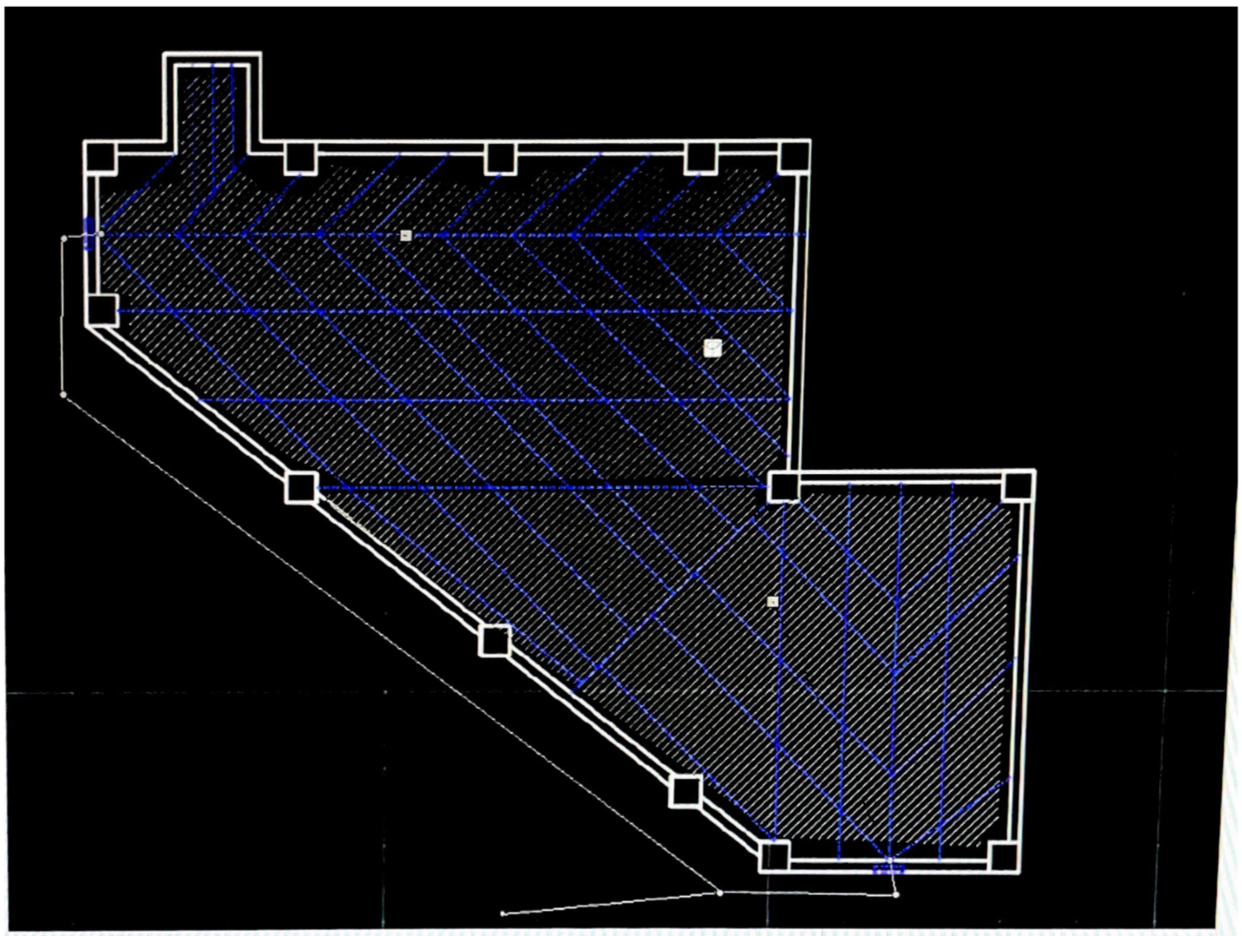

Figure 61: SWMM Model

```
Analysis Options
****************
Flow Units ............... CFS
Process Models:
  Rainfall/Runoff ........ YES
  RDII ................... NO
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ NO
  Water Quality .......... NO
Infiltration Method ...... HORTON
Flow Routing Method ...... DYNWAVE
Surcharge Method ......... EXTRAN
Starting Date ............ 04/28/2023 00:00:00
Ending Date .............. 04/28/2023 06:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:15:00
Wet Time Step ............ 00:05:00
Dry Time Step ............ 01:00:00
Routing Time Step ........ 20.00 sec
Variable Time Step ....... YES
Maximum Trials ........... 8
Number of Threads ........ 1
Head Tolerance ........... 0.005000 ft


**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......        18.000         3.000
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........        12.268         2.045
Surface Runoff ...........         5.125         0.854
Final Storage ............         0.626         0.104
Continuity Error (%) .....        -0.104


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      10^6 gal
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         5.107         1.664
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.000         0.000
Flooding Loss ............         5.099         1.662
Evaporation Loss .........         0.000         0.000
```

```
**************************        Volume         Volume
Flow Routing Continuity        acre-feet       10^6 gal
**************************     ---------      ---------
Dry Weather Inflow .......         0.000          0.000
Wet Weather Inflow .......         5.107          1.664
Groundwater Inflow .......         0.000          0.000
RDII Inflow ..............         0.000          0.000
External Inflow ..........         0.000          0.000
External Outflow .........         0.000          0.000
Flooding Loss ............         5.099          1.662
Evaporation Loss .........         0.000          0.000
Exfiltration Loss ........         0.000          0.000
Initial Stored Volume ....         0.000          0.000
Final Stored Volume ......         0.007          0.002
Continuity Error (%) .....         0.007


***************************
Time-Step Critical Elements
***************************
None


********************************
Highest Flow Instability Indexes
********************************
All links are stable.


*********************************
Most Frequent Nonconverging Nodes
*********************************
Convergence obtained at all time steps.


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     19.50 sec
Average Time Step           :     19.98 sec
Maximum Time Step           :     20.00 sec
% of Time in Steady State   :      0.00
Average Iterations per Step :      2.00
% of Steps Not Converging   :      0.00
Time Step Frequencies       :
   20.000 -   9.564 sec     :    100.00 %
    9.564 -   4.573 sec     :      0.00 %
    4.573 -   2.187 sec     :      0.00 %
    2.187 -   1.046 sec     :      0.00 %
    1.046 -   0.500 sec     :      0.00 %


***************************
Analysis begun on:  Sat Apr 29 18:12:41 2023
Analysis ended on:  Sat Apr 29 18:12:41 2023
Total elapsed time: < 1 sec
```

Figure 62: SWMM Model Analysis

Curb Inlet Capacity

Since we are planning on having a roof, parking lot, and landscaping flow into the street and then flow into the curb inlet that is located further down the street. We must calculate curb inlet capacity, Q, using the Orifice Equation.

$$Q = CohL(2gDe)^{1/2}$$

$$De = d - h/2$$

Table 155: Curb Inlet Coefficient

Inputs		
Width of Curb		
Opening, L	5 ft	
Height of Curb Opening	5 in	.42 ft
Depth of Stormwater	9 in	.750 ft
Curb Inlet Using Orifice Eq. for Calcs d>h		
Orifice Coefficient	.67(typical value)	
Orifice Centroid, de=d-h/2		0.54 ft
Inlet Capacity		8.2972 cfs

The inlet capacity is 8.30 cfs, which is more than the peak flow for the entire area. Therefore, that means the curb inlet will be able to handle the flow of stormwater with ease.

Cost Estimates

Water Supply System	Item	Unit Cost	# of Units	Total Estimate
	Copper Type L Pipe - 2 in x 10 ft	$10.90/ft	8	$872
	Copper Type L Pipe - 1.5 in x 10 ft	$11.7/ft	4	$468
	Copper Type L Pipe - 0.5 in x 10 ft	$2.93/ft	5	$147
	Lavatory	$79	2	$158
	Tankless Water Heater	$319	2	$638
	Drinking Fountain	$1,067	2	$2,134
	Urinal	$299	2	$597
	Water Closet Flushometer valve, 1.6 gpf	$258	2	$515
	Backflow Preventor	$532	1	$532
	2 in 90 degree Elbow Pipe Fitting	$30	6	$182
	1.5 in 90 degree Elbow Pipe Fitting	$16	2	$32
	2 in Standard Tee Pipe Fitting	$33	6	$199
	1.5 in Standard Tee Pipe Fitting	$31	3	$94
	Total Cost Water Distribution			$6,569
Sewer Drainage System	Item	Unit Cost	# of Units	Total Estimate
	PVC Pipe - 3 in x 10 ft	$56.67	8	$453.36
	PVC Pipe - 2.5 in x 10 ft	$15.96		$0.00
	PVC Pipe - 1.5 in x 10 ft	$11.54	4	$46.16
	3 in Schedule 80 PVC 90 Deg Elbow Socket	$26.31	7	$184.17
	3 in Schedule 40 PVC Tee Socket	$21.28	2	$42.56
	3 in P-Trap	$17.97	2	$35.94
	1.5 in P-Trap	$7.96	4	$31.84
	Total Cost Sewage Drain System			$794.03
Storm Drain System	Item	Unit Cost	# of Units	Total Estimate
	6" x 6" Roof Scupper	$115	2	$230
	6" x 6" Commercial Downspout	$125	2	$250
	6" x 6" x 5" Downsput adapter	$20	2	$40
	5" PVC Storm Drain 90 Degree Bend	$45	2	$90
	5" x 20' PVC Storm Drain Pipe	$350	3	$1,050
	Curb Inlet & Catch Basin	$8,000	1	$8,000
	Total Cost Storm Drain			$16,610

Designs Constraints

The design constraints that were encountered in the sewer system took into account how to implement the pipes when there were shear walls. For this constraint ideally the piping would be placed within the walls, but for the final decision it was a combination between hidden and exposed piping in the bathroom. Another design constraint was when designing the SewerGEMS model there were no options to change the material to PVC. This might've played a factor to the numbers that were produced from the simulation. The final constraint within the SewerGEMS model was modeling a two-story pipe system, for this a manhole and outflow were placed in the junction where the first floor pipe and second floor pipe. This would produce numbers that would be close to what is ideal. For stormwater we couldn't add another scupper because of window sizing, but it ended up being okay. Our design flow rate is just a bit larger than peak flow, which is okay. A design constraint for the WaterGEMS model is the use of a tank for modeling pipe flow, because it does not compute flow unless a water demand is determined. Also, the usage of pumps for various locations on waterGEMS was needed to compute flow.

Conclusion

The water distribution and sewage system were designed in accordance with the 2022 California Plumbing Codes and the City of Santa Ana Codes. The city of Santa Ana had many codes we had to follow, but it was all in accordance with the California Codes as well. Programs such as WaterGEMS, SewerGEMS, and SWMM were used to model flow of water, waste, and stormwater. AutoCAD was used to draft the layout and 3D isometric views of each system. We used various charts for water, sewage, and stormwater to accurately design a purposeful building that was up to date with codes.

References

Hydrology Manual:

Ocip.ocpublicworks.com

IRC. “2021 International Residential Code (IRC) | ICC Digital Codes.” ICC Digital Codes, 29 Jan. 2021, https://codes.iccsafe.org/content/IRC2021P1/chapter-27-plumbing-fixtures.

IAMPO Group. “2022 California Plumbing Code.” *Iapmo.org*, IAMPO Group, 1 July 2022, https://www.iapmo.org/hidden/state-adopted-codes/cpc-2022/.

Environmental

Section 5: Environmental Engineering

- Section 5.1 Introduction

Our proposed project is located at 1801 Park Court Pl, Santa Ana, CA 92701 and we will turn the already existing structure on the site into a wellness center for elders and people who are trying to recover or just simply daily exercising activities.

The score can be used to submit for LEED certification or recertification. A LEED performance score of 40–49 means you're performing at the LEED Certified level, 50–59 corresponds with LEED Silver, 60–69 corresponds with LEED Gold and 80+ corresponds with LEED Platinum. A score of 100 means your building is net zero in energy, water and waste.

- Section 5.2 Initial LEED Scoreboard

The abbreviation "LEED" stands for Leadership in Energy and Environmental Design and LEED-certified buildings are proven to save money, improve efficiency, lower carbon emissions and create healthier places for people. They are critical to addressing the climate crisis, meeting ESG goals, enhancing resilience, and supporting more equitable communities. In Section 5.2, the environmental team will discuss the initial grade that our project first scored from the ground-up.

Initial Score: Certified (42/110)

Your LEED Scorecard

You've achieved a Certified rating. Just 8 points will get you to Silver!

LEED Scorecard

Certified 42/110

INTEGRATIVE PROCESS	1 / 1
LOCATION AND TRANSPORTATION	9 / 16
SUSTAINABLE SITES	4 / 10
WATER EFFICIENCY	0 / 11
ENERGY & ATMOSPHERE	6 / 33
MATERIALS & RESOURCES	2 / 13
INDOOR ENVIRONMENTAL QUALITY	10 / 16
INNOVATION	6 / 6
REGIONAL PRIORITY CREDITS	4 / 4

LEED Scorecard

Certified 42/110

INTEGRATIVE PROCESS	**1 / 1**
Integrative Process	1 / 1
LOCATION AND TRANSPORTATION	**9 / 16**
LEED for Neighborhood Development Location	0 / 16
Sensitive Land Protection	0 / 1
High Priority Site and Equitable Development	2 / 2
Surrounding Density and Diverse Uses	0 / 5
Access to Quality Transit	5 / 5
Bicycle Facilities	1 / 1
Reduced Parking Footprint	1 / 1
Electric Vehicles	0 / 1
SUSTAINABLE SITES	**4 / 10**
Construction activity pollution prevention	0 / 1
Site Assessment	1 / 1
Protect or Restore Habitat	0 / 2
Open Spaces	0 / 1
Rainwater Management	3 / 3
Heat Island Reduction	0 / 2
Light Pollution Reduction	0 / 1

WATER EFFICIENCY	0 / 11
Outdoor Water Use Reduction	prereq
Indoor Water Use Reduction	prereq
Building-Level Water Metering	prereq
Outdoor Water Use Reduction	0 / 2
Indoor Water Use Reduction	0 / 6
Optimize Process Water Use	0 / 2
Water Metering	0 / 1

ENERGY & ATMOSPHERE	6 / 33
Fundamental Commissioning and Verification	prereq
Minimum Energy Performance	prereq
Building-Level Energy Metering	prereq
Fundamental Refrigerant Management	prereq
Optimize Energy Performance	0 / 18
Enhanced Commissioning	6 / 6
Advanced Energy Metering	0 / 1
Renewable Energy	0 / 5
Enhanced Refrigerant Management	0 / 1
Grid Harmonization	0 / 2

MATERIALS & RESOURCES	2 / 13
Storage and Collection of Recyclables	prereq
Building Life-Cycle Impact Reduction	0 / 5
Environmental Product Declarations	2 / 2
Sourcing of Raw Materials	0 / 2
Material Ingredients	0 / 2
Construction and Demolition Waste Management	0 / 2

INDOOR ENVIRONMENTAL QUALITY	10 / 16
Minimum Indoor Air Quality performance	prereq
Environmental Tobacco Smoke Control	prereq
Enhanced Indoor Air Quality Strategies	2 / 0
Low-Emitting Materials	3 / 0
Construction Indoor Air Quality Management Plan	0 / 0
Indoor Air Quality Assessment	2 / 0
Thermal Comfort	1 / 0
Interior Lighting	2 / 0
Daylight	0 / 0
Quality Views	0 / 0
Acoustic Performance	0 / 0

INNOVATION	6 / 6
Innovation in design	5 / 5
LEED Accredited Professional	1 / 1

REGIONAL PRIORITY CREDITS	4 / 4
Regional Priority Specific Credits	4 / 4

- **Integrative Process (Awarded: 1/1 point)**
  - *Integrative Process (Awarded: 1/1 point)*
    - This credit is intended to support high-performance, cost-effective, equitable project outcomes through an early analysis of the interrelationships among systems
- **Location and Transportation (Awarded: 9/16 point)**
  - *Sensitive Land Protection (Awarded: 0/1 point)*
    - This credit is intended to cultivate community resilience, avoid the development of environmentally sensitive lands that provide critical ecosystem services and reduce the environmental impact from the location of a building on a site.
  - *High Priority Site and Equitable Development (Awarded: 2/2 point)*
    - This credit is intended to build the economic and social vitality of communities, encourage project location in areas with development constraints and promote the ecological, cultural, and community health of the surrounding area while understanding the needs and goals of existing residents and businesses.
  - *Surrounding Density and Diverse Uses (Awarded: 0/5 point)*
    - This credit is intended to conserve land and protect farmland and wildlife habitat by encouraging development in areas with existing infrastructure. It is also intended to support neighborhood and local economies, promote walkability, and low or no carbon transportation, and reduce vehicle distance traveled for all. Furthermore, it is intended to improve public health by encouraging daily physical activity.
  - *Access to Quality Transit (Awarded: 5/5point)*
    - This credit is intended to encourage development in locations shown to have multimodal transportation choices or otherwise reduced motor vehicle use, thereby reducing greenhouse gas emissions, air pollution, and other environmental and public health harms associated with motor vehicle use.
  - *Bicycle Facilities (Awarded: 1/1 point)*

- This credit is intended to promote bicycling and transportation efficiency and reduce vehicle distance traveled. It is also intended to improve public health by encouraging utilitarian and recreational physical activity.

■ *Reduced Parking Footprint (Awarded: 1/1 point)*

- This credit is intended to minimize the environmental harms associated with parking facilities, including automobile dependence, land consumption, and rainwater runoff.

■ *Electric Vehicles (Awarded: 0/1 point)*

- This credit is intended to reduce pollution by promoting alternatives to conventionally fueled automobiles.

○ **Sustainable Sites (Awarded: 4/10 point)**

■ *Construction Activity Pollution Prevention (Prerequisite)*

- This credit is intended to reduce pollution from construction activities by controlling soil erosion, waterway sedimentation, and airborne dust that disproportionately impact frontline communities.

■ *Site Assessment (Awarded: 1/1 point)*

- This credit is intended to assess site conditions, environmental justice concerns, and cultural and social factors, before design to evaluate sustainable options and inform related decisions about site design.

■ *Protect or Restore Habitat (Awarded: 0/2 point)*

- This credit is intended to conserve existing natural areas and restore damaged areas to provide habitat and promote biodiversity.

■ *Open Space (Awarded: 0/1 point)*

- This credit is intended to create exterior open space that encourages interaction with the environment, social interaction, passive recreation, and physical activities.

■ *Rainwater Management (Awarded: 3/3 point)*

        - This credit is intended to reduce runoff volume and improve water quality by replicating the natural hydrology and water balance of the site, based on historical conditions and undeveloped ecosystems in the region to avoid contributing to flooding downstream in frontline communities.

    - *Heat Island Reduction (Awarded: 0/2 point)*

        - This credit is intended to minimize inequitable effects on microclimates and humans, especially frontline communities, and wildlife habitats by reducing heat islands.

    - *Light Pollution Reduction (Awarded: 0/1 point)*

        - This credit is intended to increase night sky access, improve nighttime visibility, and reduce the consequences of development for wildlife and people.

- **Water Efficiency (Awarded: 0/11 point)**

    - *Outdoor Water Use Reduction (Prerequisite)*

        - This credit is intended to reduce outdoor potable water consumption and preserve no and low-cost potable water resources.

    - *Indoor Water Use Reduction (Prerequisite)*

        - This credit is intended to reduce indoor potable water consumption and preserve no and low cost potable water resources.

    - *Building-Level Water Metering (Prerequisite)*

        - This credit is intended to conserve low cost potable water resources and support water management and identify opportunities for additional water savings by tracking water consumption.

    - *Outdoor Water Use Reduction (Awarded: 0/2 point)*

        - This credit is intended to reduce outdoor potable water consumption and preserve no and low-cost potable water resources.

- *Indoor Water Use Reduction (Awarded: 0/6 point)*
  - This credit is intended to reduce indoor potable water consumption and preserve no and low cost potable water resources.
- *Optimize Process Water Use (Awarded: 0/2 point)*
  - This credit is intended to conserve low cost potable water resources used for mechanical processes while controlling corrosion and scale in the condenser water system.
- *Water Metering (Awarded: 0/1 point)*
  - This credit is intended to conserve low cost potable water resources and support water management and identify opportunities for additional water savings by tracking water consumption.

- **Energy & Atmosphere (Awarded: 6/33 point)**
  - *Fundamental Commissioning and Verification (Prerequisite)*
    - This credit is intended to support the design, construction, and eventual operation of a project that meets the owner's project requirements for energy, water, indoor environmental quality, and durability.
  - *Minimum Energy Performance (Prerequisite)*
    - This credit is intended to promote resilience and reduce the environmental and economic harms of excessive energy use that disproportionately impact frontline communities by achieving a minimum level of energy efficiency for the building and its systems.
  - *Building-Level Energy Metering (Prerequisite)*
    - This credit is intended to support energy management and identify opportunities for additional energy savings by tracking building-level energy use.
  - *Fundamental Refrigerant Management (Prerequisite)*

- This credit is intended to reduce ozone depletion and global warming potential and support early compliance with the Kigali Amendment to the Montreal Protocol while minimizing direct contributions to climate change.

■ *Enhanced Commissioning (Awarded: 6/6 point)*

- This credit is intended to further support the design, construction, and eventual operation of a project that meets the owner's project requirements for energy, water, indoor environmental quality, and durability.

■ *Optimize Energy Performance (Awarded: 0/18 point)*

- This credit is intended to achieve increasing levels of energy performance beyond the prerequisite standard to reduce environmental and economic harms associated with excessive energy use that disproportionately impact frontline communities.

■ *Advanced Energy Metering (Awarded: 0/1 point)*

- This credit is intended to support energy management and identify opportunities for additional energy savings by tracking building-level and system-level energy use

■ *Grid Harmonization (Awarded: 0/2 point)*

- This credit is intended to increase participation in demand response technologies and programs that make energy generation and distribution systems more affordable and more efficient, increase grid reliability, and reduce greenhouse gas emissions.

■ *Renewable Energy (Awarded: 0/5 point)*

- This credit is intended to reduce the environmental and economic harms associated with fossil fuel energy and reduce greenhouse gas emissions by increasing the supply of renewable energy projects and fostering a just transition to a green economy.

■ *Enhanced Refrigerant Management (Awarded: 0/1 point)*

        - This credit is intended to eliminate ozone depletion and global warming potential and support early compliance with the Montreal Protocol, including the Kigali Amendment, while minimizing direct contributions to climate change.
- **Materials & Resources** (Awarded: 2/13 point)
    - *Storage and Collection of Recyclables (Prerequisite)*
        - This credit is intended to reduce the disproportionate burden of landfills and incinerators that is generated by building occupants' waste hauled to and disposed of in landfills and incinerators through reduction, reuse and recycling service and education, and to conserve natural resources for future generations
    - *Building Life-Cycle Impact Reduction (Awarded: 0/5 point)*
        - This credit is intended to encourage adaptive reuse and optimize the environmental performance of products and materials.
    - *Environmental Product Declarations (Awarded: 2/2 point)*
        - This credit is intended to encourage the use of products and materials for which life-cycle information is available and that have environmentally, economically, and socially preferable life-cycle impacts. It is also intended to reward project teams for selecting products from manufacturers who have verified improved environmental life-cycle impacts.
    - *Sourcing of Raw Materials (Awarded: 0/2 point)*
        - This credit is intended to encourage the use of products and materials for which life cycle information is available and that have environmentally, economically, and socially preferable life cycle impacts. It is also intended to reward project teams for selecting products verified to have been extracted or sourced in a responsible manner.
    - *Material Ingredients (Awarded: 0/2 point)*
        - This credit is intended to encourage the use of products and materials for which life-cycle information is available and that have environmentally, economically, and socially preferable

life-cycle impacts. It is also intended to reward project teams for selecting products for which the chemical ingredients in the product are inventoried using an accepted methodology and for selecting products verified to minimize the use and generation of harmful substances. Furthermore, it is intended to reward raw material manufacturers who produce products verified to have improved life-cycle impacts.

- *Construction and Demolition Waste Management (Awarded: 0/2 point)*
    - This credit is intended to reduce construction and demolition waste disposed of in landfills and incineration facilities through waste prevention and by reusing, recovering, and recycling materials, and conserving resources for future generations. Furthermore, it is intended to delay the need for new landfill facilities that are often located in frontline communities and create green jobs and materials markets for building construction services.

- **Indoor Environmental Quality (Awarded: 10/16 point)**
    - *Minimum Indoor Air Quality Performance (Prerequisite)*
        - This credit is intended to contribute to the comfort and well-being of all building occupants by establishing minimum standards for indoor air quality (IAQ).
    - *Environmental Tobacco Smoke Control (Prerequisite)*
        - This credit is intended to prevent or minimize exposure of building occupants, indoor surfaces, and ventilation air distribution systems to environmental tobacco smoke.
    - *Low-Emitting Materials (Awarded: 3/0 point)*
        - This credit is intended to reduce concentrations of chemical contaminants that can damage air quality and the environment, and to protect the health, productivity, and comfort of installers and building occupants.
    - *Construction Indoor Air Quality Management Plan (Awarded: 0/0 point)*

- This credit is intended to promote the well-being of construction workers and building occupants by minimizing indoor air quality problems associated with construction and renovation.

- *Indoor Air Quality Assessment (Awarded: 2/0 point)*
    - This credit is intended to establish better quality indoor air in the building after construction and during occupancy to protect human health, productivity, and wellbeing.
- *Thermal Comfort (Awarded: 1/0 point)*
    - This credit is intended to promote occupants' productivity, comfort, and well-being by providing quality thermal comfort.
- *Interior Lighting (Awarded: 2/0 point)*
    - This credit is intended to promote occupants' productivity, comfort, and well-being by providing high-quality lighting
- *Daylight (Awarded: 0/0 point)*
    - This credit is intended to connect building occupants with the outdoors, reinforce circadian rhythms, and reduce the use of electrical lighting by introducing daylight into the space.
- *Quality Views (Awarded: 0/0 point)*
    - This credit is intended to give building occupants a connection to the natural outdoor environment by providing quality views
- *Acoustic Performance (Awarded: 0/0 point)*
    - This credit is intended to provide workspaces and classrooms that promote occupants' well-being, productivity, and communications through effective acoustic design

- **Innovation (Awarded: 6/6 point)**
    - *Innovation (Awarded: 5/5 point)*
        - This credit is intended to encourage projects to achieve exceptional or innovative performance to benefit human and environmental

health and equity. It is also intended to foster LEED expertise throughout building design, construction, and operation and collaboration toward project priorities

        - *LEED Accredited Professional (Awarded: 1/1 point)*
            - This credit is intended to encourage the team integration required by a LEED project and to streamline the application and certification process.
    - **Regional Priority Credits (Awarded: 4/4 point)**
        - *Regional Priority Specific Credits (Awarded: 4/4 point)*
            - These credits are intended to provide an incentive for the achievement of credits that address geographically specific environmental, social equity, and public health priorities

- **Section 5.3 Life Cycle Impact Assessment**
    - **Section 5.3.1 Athena Impact Estimator for Buildings (V5.4)**
        - In North America, the Athena Impact Estimator for Buildings is the only free software tool that is designed to evaluate whole buildings and assemblies based on internationally recognized life cycle assessment (LCA) methodology. Using the Impact Estimator, architects, engineers and others can easily assess and compare the environmental implications of industrial, institutional, commercial and residential designs — both for new buildings and major renovations. Where relevant, the software also distinguishes between owner-occupied and rental facilities.
    - **Section 5.3.2 Engineering Characteristics**
        - Refer to the Athena Report
    - **Section 5.3.3 Instantiating Model**
        - Refer to the Athena Report

- **Section 5.3.4 Projected Energy Demand**
  - Refer to the Athena Report
- **Section 5.3.5 Athena Assemblies**

Constructing the building assemblies for the various sections of a project requires conformance with regulating bodies such as the California Building Codes. Each assembly and their respective regulating codes that enforce design constraints upon the model are listed in Sections below from 5.3.5.1 to 5.3.5.5. The Structural team's design specifications regarding assembly materials may be seen in Section 1.

- **Section 5.3.5.1 Wall Assemblies**

Athena wall assemblies account for which portions of the walls are load bearing vs. non-load bearing, wall openings such as doors and windows, and material envelopes. See Section 1 for Structural determination of design constraints, material compositions, and load distributions. The additional wall assembly constraints imposed by CBC (California Building Codes) when building the Athena model are referenced below.

Per CBC 120.7 the weighted average U-factor of the wall assembly shall not exceed 0.110. This constraint was used to determine the thickness of the insulation within the wall assemblies. Blown cellulose insulation manufactured by Greenfiber was chosen as the insulation to satisfy this U-factor requirement. Refer to the Bill of Meratils in Section 5.3.6 which details the Atna model composition output and includes Manufactures recommended by the Environmental team to satisfy the project requirement.

- **Section 5.3.5.2 Roof Assembly**
  - Refer to the Athena report
- **Section 5.3.5.3 Floor Assembly**

Assume slab on grade that does not impose significant design requirements on client. Follow CBC Table 1607.1

- **Section 5.3.5.4 Columns and Beams**

Refer to the foundations designed in Section 2 by the Geotechnical team for the footing dimensions input into Athena.

- **Section 5.3.5.5 Footings**

Refer to the foundations designed in Section 2 by the Geotechnical team for the footing dimensions input into Athena.

- **Section 5.3.6 Athena Impact Estimator Results**

Athena may output reports for Green Globes and LEED standards, as well as output a bill of materials for the modeled project. Apex wellness center is being evaluated with LEED, thus all reports and figures output by Athena are evaluated with respect to LEED BD+C standards. The Environmental team determined recommended Manufacturers for the project material and provided the Structural team with this bill of material cost list to obtain product specifications.

- **Section 5.3.7 Environmental Design Constraints**

There are many engineering characteristics (EC) that are not fixed constraints in this design that may be varied to achieve project goals. The goal of the Environmental team with this project is to provide the client with a LEED certified building. Energy demand is an EC identified by the Environmental team as having the potential to satisfy sections of both the Energy and Atmosphere and Materials and Resources (MR) sections of the LEED v4.1 Building Design and Construction manual.

- **Section 5.4 Energy Demand Reduction Recommendations**
    - **Section 5.4.1 LEED v4 low flow requirements Certified Water Heater**
        - Instant-Flow C-Micro 0.20 GPM

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CHRONOMITE Since 1966
Electric Tankless Water Heaters

ELECTRIC TANKLESS WATER HEATER - POINT OF USE

INSTANT-FLOW® C-MICRO - LOW ACTIVATION

IDEAL APPLICATION: *bar and utility sink manual, meter, or sensor hand washing faucet(s)*

PRODUCT FEATURES

- *Uses a digital microprocessor for temperature control, Ultra quick response times for temperature variations - 120 times per second. Microprocessor use is the most energy efficient means of heating water*
- *Unlimited hot water*
- *Ideal for sensor /hands-free faucets with the 104°F (40°C) factory preset setting; no mixing valve needed*
- *Ultra Low Flow Activation - 0.20 GPM (0.75 LPM)*
- *Saves water and energy - 99% energy efficient*
- *Meet all CAL GREEN low flow requirements*
- *Meets LEED v4 low flow requirements*
- *Vandal resistant rugged cast aluminum housing*
- *Space saving compact size: 6-1/4" (H) x 9-5/8" x 2-3/4" (159 (H) x 244 x 70mm)*
- *Meets applicable building codes including ADA, UL, IAPMO, UPC, CSA.*
- *Environmentally friendly*
- *Made in the U.S.A.*
- *Patent Pending*
- *Field Adjustable Temperature 104-125°F (40-52°C) (Option -ADJ)*

Chronomite Instant-Flow® C-Micro - Low Activation models are manufactured to provide reliable point-of-use hot water. There is no pressure and temperature relief valve needed (unless required by code), saving time and money on installation.

Housing is fabricated from rugged cast aluminum alloy.

Element assembly is fabricated from Celcon plastic.

Heating coils are nichrome.

Faucet flow controls are supplied with each unit. 3/8" compression fittings are supplied (standard). Optional 1/2" male NPT water connections available.

Instant-Flow® C - Micro - Low Activation

GUIDE SPECIFICATION

Tankless Water Heater shall be a Chronomite Laboratories Model

CM - ____ L / ______ (AMPS, VOLTS) ______ (OPTIONS)

with ______ Amps and ______ Volts

to heat to a preset temperature of:

- ❍ 104°F (40°C)
- ❍ 110°F (43°C) (Meets ADA)
- ❍ Other temperature settings available upon request (specify below) ______
- ❍ 120°F (49°C) (Meets health code)

Unit shall be provided with Celcon waterways, and Nichrome heating coils.
Temperature controlled by microprocessor.

OPTIONS

- ❍ PA 765 ABS Housing (P)
- ❍ Satin Finish Stainless Steel Housing (SS)
- ❍ High Polish Finish Stainless Steel (SSP)
- ❍ Pressure & Temp Relief Valve Assembly (TP)
- ❍ 1/2" Male NPT (NPT08)
- ❍ Field Adjustable Temperature 104° to 125°F (ADJ)
- ❍ Disconnect Switch, Rotary 40A - Lockable Nema 4X (2095-1)
- ❍ Electrical Conduit Metallic (C)
- ❍ Electrical Conduit Non-Metallic (C-NM)
- ❍ Nema 4X Cabinet (N4X) (12" x 8" x 5") 304SS

Member of U.S.Green Building Council — *Water Conserving Product* — *Made in the USA*

Complies with Standards for: LISTED TO: UL STD 499 — CERTIFIED TO: CAN/CSA STD C22.2 NO. 88 — IAPMO — UL US LISTED ELECTRIC HEATING APPLIANCE — ETL Intertek 5001365 — Pb — CALGreen

CHRONOMITE LABORATORIES, INC.
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MEMBER OF MORRIS GROUP INTERNATIONAL

Electric Tankless Water Heaters

INSTANT-FLOW® C-MICRO - LOW ACTIVATION

For the model being selected, please place the corresponding amps and volts values in the Guide Specifications on the first page.

MODEL	AMPS	VOLTS	90°C WIRE	WATTS	ACTIVATION GPM	°F TEMPERATURE RISE @				
						0.35 GPM	0.50 GPM	1.00 GPM	1.50 GPM	2.00 GPM
CM-12L/120	12	120	14 AWG	1440	0.20	28	20	---	---	---
CM-12L/208	12	208	14 AWG	2500	0.20	49	34	---	---	---
CM-12L/240	12	240	14 AWG	2880	0.20	56	39	20	---	---
CM-12L/277	12	277	14 AWG	3320	0.20	65	45	23	---	---
CM-15L/120	15	120	14 AWG	1800	0.20	35	25	---	---	---
CM-15L/208	15	208	14 AWG	3120	0.20	61	43	21	---	---
CM-15L/240	15	240	14 AWG	3600	0.20	70	49	25	---	---
CM-15L/277	15	277	14 AWG	4150	0.20	81	57	28	---	---
CM-20L/120	20	120	12 AWG	2400	0.20	47	33	---	---	---
CM-20L/208	20	208	12 AWG	4160	0.20	81	57	28	---	---
CM-20L/240	20	240	12 AWG	4800	0.20	90+	66	33	22	---
CM-20L/277	20	277	12 AWG	5540	0.20	90+	76	38	25	---
CM-30L/120	30	120	10 AWG	3600	0.20	70	49	25	16	---
CM-30L/208	30	208	10 AWG	6240	0.20	90+	85	43	28	21
CM-30L/240	30	240	10 AWG	7200	0.20	90+	90+	49	33	25
CM-30L/277	30	277	10 AWG	8310	0.20	90+	90+	57	38	28
CM-40L/208	40	208	8 AWG	8320	0.20	90+	90+	57	38	28
CM-40L/240	40	240	8 AWG	9600	0.20	90+	90+	66	44	33

INSTANT-FLOW® C-MICRO - LOW ACTIVATION METRIC CHART

MODEL	AMPS	VOLTS	90°C WIRE	WATTS	ACTIVATION LPM	°C TEMPERATURE RISE @				
						1.30 LPM	2.00 LPM	4.00 LPM	6.00 GPM	8.00 LPM
CM-12L/120	12	120	14 AWG	1440	0.75	16	10	---	---	---
CM-12L/208	12	208	14 AWG	2500	0.75	28	18	---	---	---
CM-12L/240	12	240	14 AWG	2880	0.75	32	21	10	---	---
CM-12L/277	12	277	14 AWG	3320	0.75	37	24	12	---	---
CM-15L/120	15	120	14 AWG	1800	0.75	20	13	---	---	---
CM-15L/208	15	208	14 AWG	3120	0.75	34	22	11	---	---
CM-15L/240	15	240	14 AWG	3600	0.75	40	26	13	---	---
CM-15L/277	15	277	14 AWG	4150	0.75	46	30	15	10	---
CM-20L/120	20	120	12 AWG	2400	0.75	27	17	---	---	---
CM-20L/208	20	208	12 AWG	4160	0.75	46	30	15	10	---
CM-20L/240	20	240	12 AWG	4800	0.75	50+	34	17	11	---
CM-20L/277	20	277	12 AWG	5540	0.75	50+	40	20	13	10
CM-30L/120	30	120	10 AWG	3600	0.75	40	26	13	---	---
CM-30L/208	30	208	10 AWG	6240	0.75	50+	45	22	15	11
CM-30L/240	30	240	10 AWG	7200	0.75	50+	50+	26	17	13
CM-30L/277	30	277	10 AWG	8310	0.75	50+	50+	30	20	15
CM-40L/208	40	208	8 AWG	8320	0.75	50+	50+	30	20	15
CM-40L/240	40	240	8 AWG	9600	0.75	50+	50+	34	23	17

- **Section 5.4.2 Tier 1-10 kWh Solar Panel Installation**

- Our team had decided to go with the Q.CELLS 10kW solar kit 480 XL, SMA inverter
    - **This high-power, low cost solar energy system generates 10,080 watts (10 kW) of grid-tied electricity with (21) 480 watt Q.Cells Q.PEAK XL modules, SMA Sunny Boy inverter, Sunny Portal 24/7 monitoring, disconnect box, rooftop mounting, safety labels, and permit-ready building electrical plans. The XL-size**

solar panels are ideal on larger rooftop or ground mounts for better value with a 30 year power warranty. The grid-tied Sunny Boy inverter is SunSpec Code compliance-ready for rooftop shutdown, or it can have an optional 2,000 watt Emergency Power Supply for daytime power in case of grid outage. Choose the DIY base kit, or add your options for rapid shutdown, ground mounting, backup storage battery, or full-service installation.

- **Specifications:**

MAXIMUM POWER DC (WP): 10,080 watts DC; 10.1 kW

MAXIMUM POWER AC (WP): 9,204 watts AC CEC

ESTIMATED POWER GENERATED: 1,218 kWh AC monthly average

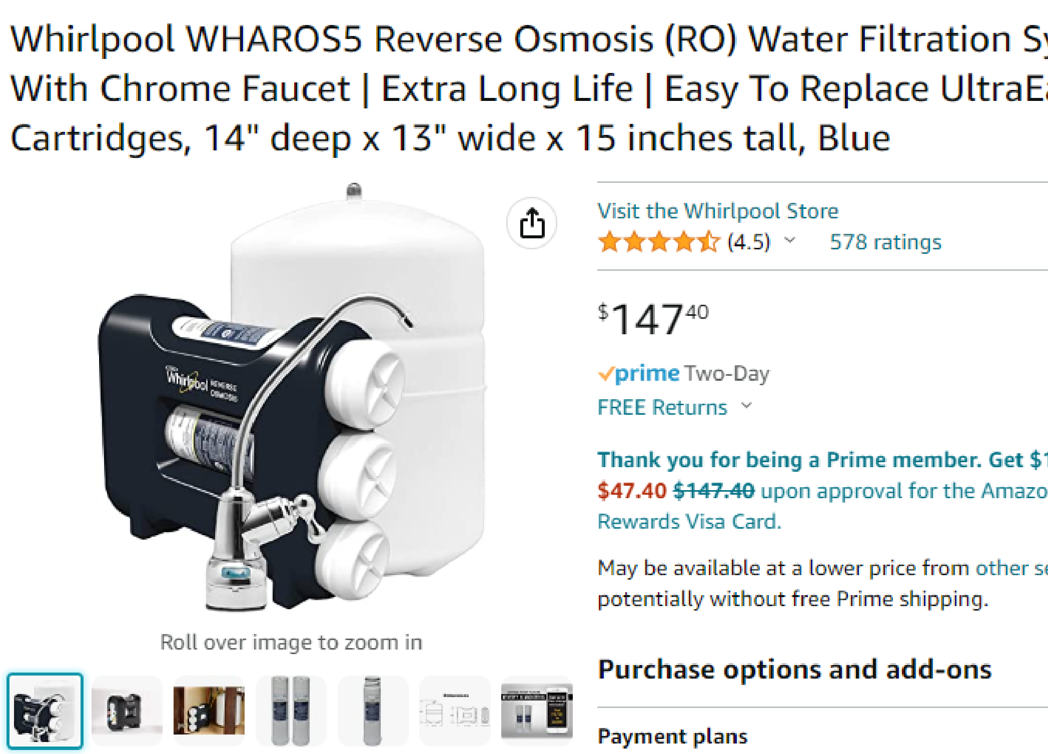
MAXIMUM POWER VOLTAGE VMP (V): 240 Volts

- Installation method
    - **[BS] 1510.7.3 Installation**- Rooftop-mounted photovoltaic panels and modules shall be installed in accordance with the manufacturer's instructions.
    - **[BS] 1510.7.4 Photovoltaic Panels and Modules**- Rooftop-mounted photovoltaic panels and modules shall be listed and labeled in accordance with UL 1703 and shall be installed in accordance with the manufacturer's instructions.
    - Solar Panel System Cost

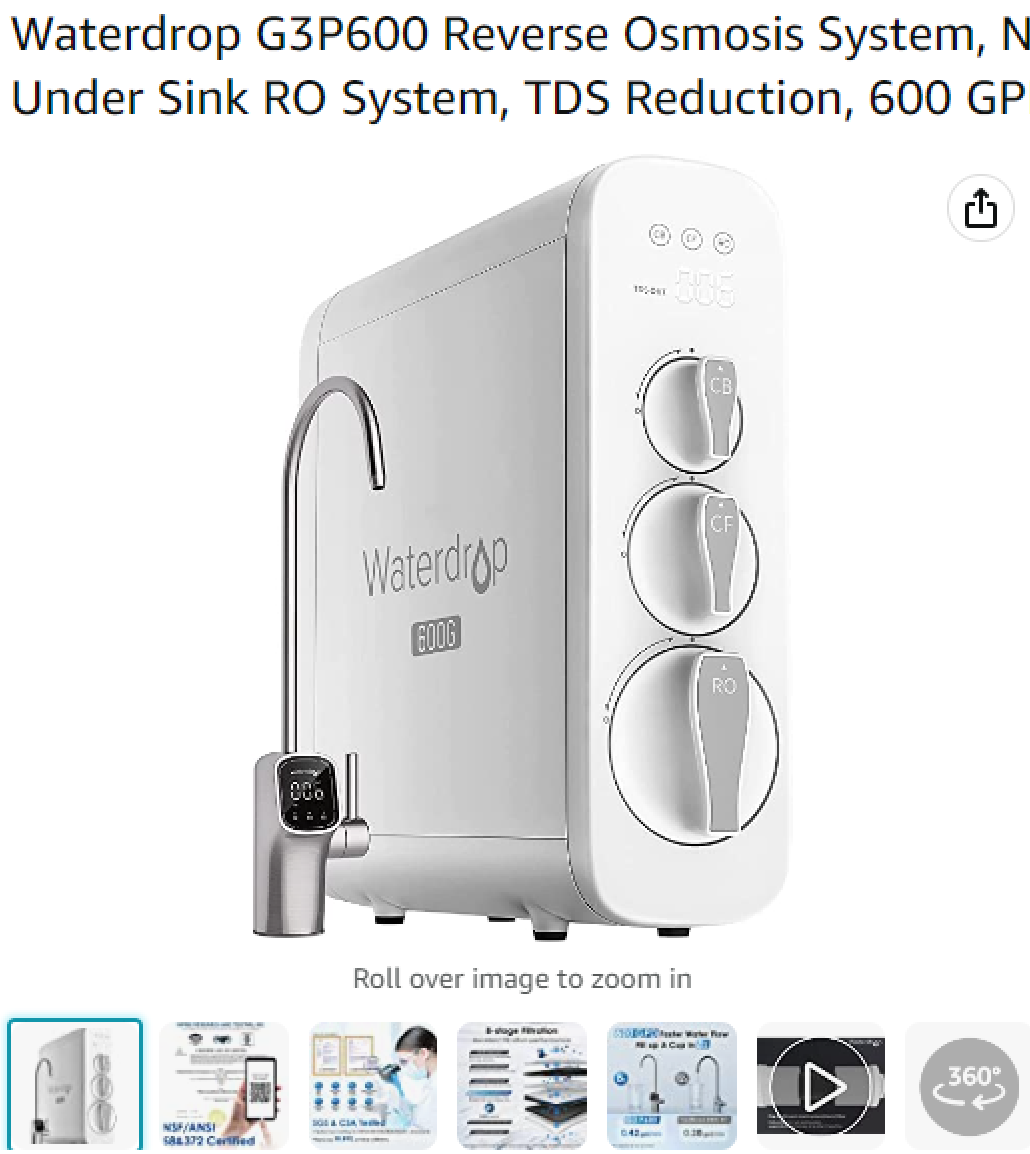
            - $16,500 + $15,000 installation fee+ $1000 Fixed Shipping Cost
    - Section 5.4.3 Results for Athena Model with Proposed Upgrades
        - Section 5.4.3.1 Project Baseline Comparison
            - We were able to improve our project from being certified to silver and lastly gold. First we achieved Silver grading (51/110) by adding 2 water heater systems and 1 reverse osmosis water system into our wellness center. Lastly, we achieved Gold grading (75/110) by spending a little more money on a solar panel system for our flat roof.
- Section 5.5:Reverse Osmosis system (water fountain)
    - Section 5.5.1 Toilet Water Demand
        - Refer to Water team's section
    - Section 5.5.2 B.E.P Results for Toilets
        - Refer to Water team's section
    - Section 5.5.5 Reverse Osmosis system (water fountain)
        - How it work
            - Widely considered one of the most effective water filtration methods, reverse osmosis (RO) creates clean, great-tasting water. RO systems are used in a variety of applications, including filtration for whole houses, faucets, aquariums, and restaurants. No matter what kind of water you start out with, there is likely an RO system that will suit your needs. Reverse osmosis removes

contaminants from unfiltered water, or feed water, when pressure forces it through a semipermeable membrane. Water flows from the more concentrated side (more contaminants) of the RO membrane to the less concentrated side (fewer contaminants) to provide clean drinking water. The fresh water produced is called the permeate. The concentrated water left over is called the waste or brine.

- Vendor
  - Home Depot/ Amazon
- Product Specifications
  - Option 1-Best Budget: **Whirlpool WHAROS5 Reverse Osmosis (RO) Water Filtration System ($148)**



- Option 2- Best Tankless: **Waterdrop G3P600 Reverse Osmosis System ($550)**



- **Section 5.7 Ethical and Legal Issues**
  - Throughout the semester, our group has learned about the components and challenging work that goes into environmental engineering and being LEED Certified. We faced ethical issues during our process to earn the wanted grading.

The factors that have contributed to our decisions such as resources, money, experience, and time. Since our project will not be built, the environmental recommendations are what the team think would be best for the site. An engineer's job is to ensure the safety of the project and people involved. Therefore, we had to make sure that we follow all the Building Codes and laws to prevent problems as much as possible.

- **Section 5.8 Conclusions/ Final LEED Score**

In conclusion, our baseline project was estimated to be around the certified grading within the LEED scorecard criteria in which we were able to achieve 42/110. After adding the water heater and reverse osmosis water system into our Apex Wellness center, we were able to move up 1 grade into Silver in which we achieved 51/110. Lastly, we did another proposal for an even higher grade in which is Gold and for our last attempt we got a score of 75/110.

  - **Section 5.8 Conclusions/ Final LEED Score and Proof of Silver and Gold Grading**

<u>Silver (51/110)</u>

LEED Scorecard

Silver 51/110

INTEGRATIVE PROCESS	1 / 1
LOCATION AND TRANSPORTATION	9 / 16
SUSTAINABLE SITES	4 / 10
WATER EFFICIENCY	9 / 11
ENERGY & ATMOSPHERE	6 / 33
MATERIALS & RESOURCES	2 / 13
INDOOR ENVIRONMENTAL QUALITY	10 / 16
INNOVATION	6 / 6
REGIONAL PRIORITY CREDITS	4 / 4

LEED Scorecard

Silver 51/110

INTEGRATIVE PROCESS	1 / 1
LOCATION AND TRANSPORTATION	9 / 16
LEED for Neighborhood Development Location	0 / 16
Sensitive Land Protection	0 / 1
High Priority Site and Equitable Development	2 / 2
Surrounding Density and Diverse Uses	0 / 5
Access to Quality Transit	5 / 5
Bicycle Facilities	1 / 1
Reduced Parking Footprint	1 / 1
Electric Vehicles	0 / 1

LEED Scorecard

Silver 51/110

INTEGRATIVE PROCESS	1 / 1
LOCATION AND TRANSPORTATION	9 / 16
SUSTAINABLE SITES	4 / 10
Construction activity pollution prevention	0 / 1
Site Assessment	1 / 1
Protect or Restore Habitat	0 / 2
Open Spaces	0 / 1
Rainwater Management	3 / 3
Heat Island Reduction	0 / 2
Light Pollution Reduction	0 / 1

LEED Scorecard

Silver 51/110

INTEGRATIVE PROCESS	1 / 1
LOCATION AND TRANSPORTATION	9 / 16
SUSTAINABLE SITES	4 / 10
WATER EFFICIENCY	9 / 11
Outdoor Water Use Reduction	prereq
Indoor Water Use Reduction	prereq
Building-Level Water Metering	prereq
Outdoor Water Use Reduction	0 / 2
Indoor Water Use Reduction	6 / 6
Optimize Process Water Use	2 / 2
Water Metering	1 / 1

ENERGY & ATMOSPHERE	6 / 33
Fundamental Commissioning and Verification	prereq
Minimum Energy Performance	prereq
Building-Level Energy Metering	prereq
Fundamental Refrigerant Management	prereq
Optimize Energy Performance	0 / 18
Enhanced Commissioning	6 / 6
Advanced Energy Metering	0 / 1
Renewable Energy	0 / 5
Enhanced Refrigerant Management	0 / 1
Grid Harmonization	0 / 2

MATERIALS & RESOURCES	2 / 13
Storage and Collection of Recyclables	prereq
Building Life-Cycle Impact Reduction	0 / 5
Environmental Product Declarations	2 / 2
Sourcing of Raw Materials	0 / 2
Material Ingredients	0 / 2
Construction and Demolition Waste Management	0 / 2

INDOOR ENVIRONMENTAL QUALITY	10 / 16
Minimum Indoor Air Quality performance	prereq
Environmental Tobacco Smoke Control	prereq
Enhanced Indoor Air Quality Strategies	2 / 0
Low-Emitting Materials	3 / 0
Construction Indoor Air Quality Management Plan	0 / 0
Indoor Air Quality Assessment	2 / 0
Thermal Comfort	1 / 0
Interior Lighting	2 / 0
Daylight	0 / 0
Quality Views	0 / 0
Acoustic Performance	0 / 0

INNOVATION	6 / 6
Innovation in design	5 / 5
LEED Accredited Professional	1 / 1

REGIONAL PRIORITY CREDITS	4 / 4
Regional Priority Specific Credits	4 / 4

Gold (75/110)

Your LEED Scorecard

You've achieved a Gold rating. Just 5 points will get you to Platinum!

U.S. GREEN BUILDING COUNCIL
LEED GOLD
USGBC

LEED Scorecard

Gold 75/110

INTEGRATIVE PROCESS	1 / 1
LOCATION AND TRANSPORTATION	9 / 16
SUSTAINABLE SITES	4 / 10
WATER EFFICIENCY	9 / 11
ENERGY & ATMOSPHERE	30 / 33
MATERIALS & RESOURCES	2 / 13
INDOOR ENVIRONMENTAL QUALITY	10 / 16
INNOVATION	6 / 6
REGIONAL PRIORITY CREDITS	4 / 4

LOCATION AND TRANSPORTATION	9 / 16
LEED for Neighborhood Development Location	0 / 16
Sensitive Land Protection	0 / 1
High Priority Site and Equitable Development	2 / 2
Surrounding Density and Diverse Uses	0 / 5
Access to Quality Transit	5 / 5
Bicycle Facilities	1 / 1
Reduced Parking Footprint	1 / 1
Electric Vehicles	0 / 1

SUSTAINABLE SITES	4 / 10
Construction activity pollution prevention	0 / 1
Site Assessment	1 / 1
Protect or Restore Habitat	0 / 2
Open Spaces	0 / 1
Rainwater Management	3 / 3
Heat Island Reduction	0 / 2
Light Pollution Reduction	0 / 1

WATER EFFICIENCY	9 / 11
Outdoor Water Use Reduction	prereq
Indoor Water Use Reduction	prereq
Building-Level Water Metering	prereq
Outdoor Water Use Reduction	0 / 2
Indoor Water Use Reduction	6 / 6
Optimize Process Water Use	2 / 2
Water Metering	1 / 1

ENERGY & ATMOSPHERE	30 / 33
Fundamental Commissioning and Verification	prereq
Minimum Energy Performance	prereq
Building-Level Energy Metering	prereq
Fundamental Refrigerant Management	prereq
Optimize Energy Performance	18 / 18
Enhanced Commissioning	6 / 6
Advanced Energy Metering	1 / 1
Renewable Energy	5 / 5
Enhanced Refrigerant Management	0 / 1
Grid Harmonization	0 / 2

MATERIALS & RESOURCES	2 / 13
Storage and Collection of Recyclables	prereq
Building Life-Cycle Impact Reduction	0 / 5
Environmental Product Declarations	2 / 2
Sourcing of Raw Materials	0 / 2
Material Ingredients	0 / 2
Construction and Demolition Waste Management	0 / 2

INDOOR ENVIRONMENTAL QUALITY	10 / 16
Minimum Indoor Air Quality performance	prereq
Environmental Tobacco Smoke Control	prereq
Enhanced Indoor Air Quality Strategies	2 / 0
Low-Emitting Materials	3 / 0
Construction Indoor Air Quality Management Plan	0 / 0
Indoor Air Quality Assessment	2 / 0
Thermal Comfort	1 / 0
Interior Lighting	2 / 0
Daylight	0 / 0
Quality Views	0 / 0
Acoustic Performance	0 / 0

INNOVATION	6 / 6
Innovation in design	5 / 5
LEED Accredited Professional	1 / 1

- **Section 5.8.1 Final LEED criteria Table**

			/10	/11	/33	/13
LEED Category		LEED Score	Sustainable Sites	Water Efficiency	Energy&Atmosphere	Materials and resources
Certified(Baseline)		42	4	0	6	2
Silver		56	6	9	6	2
Gold		74	6	9	24	2
			/16		/6	/4
			Indoor Environmetal Quality		Innovation	Regional Priority Credtis
certi	40-49		10		6	4
silver	50-59		13		6	4
gold	60-69		13		6	4
Certified	42/110					
Silver	68/110					
Gold	72/110					

- **Section 5.8.2 Final Cost Estimation**
  - Certified > Baseline
  - Silver > 1 grade higher
    - Daikin 4 Ton Light Commercial 15 SEER : $5,009
    - Washbrook Flowise Top Spud 0.125 GPF Urinal system : $310.70
    - Instant- Flow C- micro 0.20 GPM point of Use Electric Tankless flow water heater : $319.05

    Total= $5638.75
  - Gold > 2 grades higher
    - Daikin 4 Ton Light Commercial 15 SEER : $5,009
    - Washbrook Flowise Top Spud 0.125 GPF Urinal system : $310.70
    - Instant- Flow C- micro 0.20 GPM point of Use Electric Tankless flow water heater : $319.05
    - Waterdrop G3P600 Reverse Osmosis System :$550

- 10kW solar kit Q.Cells 480 XL, SMA inverter : $16,500.00 + $1,000.00 (Fixed Shipping Cost) + $13,000 Flat Roof Installation Fee

  Total= $36,688.00

- **Section 5.9 References**

Programs Used

For the proposed improvements, we used Athena Impact Estimator for Buildings 5.4.

- *Images.thdstatic.com* .https://images.thdstatic.com/catalog/pdfImages/b4/b4b085ba-267f-4810-86c8-70bd54ddee67.pdf .
- Puisis, Erica. “The 8 Best Reverse Osmosis Systems for Clean Tap Water.” *The Spruce*, https://www.thespruce.com/best-reverse-osmosis-systems-4586893#toc-best-tankless-waterdrop-reverse-osmosis-drinking-water-filtration-system.
- “Chapter 15: Roof Assemblies and Rooftop Structures, California Building Code 2016 (Vol 1 & 2).” *UpCodes*, https://up.codes/viewer/california/ca-building-code-2016/chapter/15/roof-assemblies-and-rooftop-structures#15.

- “LEED v4.1.” *LEED v4.1 | U.S. Green Building Council*, https://www.usgbc.org/leed/v41#bdc.
- “LEED Scorecard.” *LEED Scorecard | U.S. Green Building Council*, https://www.usgbc.org/leed-tools/scorecard.
- “10kW Solar Kit Q.cells 480 XL, SMA Inverter.” *SunWatts*, https://sunwatts.com/10kw-solar-kit-q-cells-480-xl-sma-inverter/.

- Section 5.10 Athena Project Report
  - Refer to report below

Project Report
LCA results from the Athena Impact Estimator for Buildings

Project name:

Project Site SANTA ANA

Date created:

Apr 29, 2023 at 12:46 PM

Athena
Impact Estimator
for Buildings

www.athenasmi.org

About the Athena Institute

The Athena Institute is a non-profit life cycle assessment (LCA) research organization and the North American leader in carbon footprinting of construction and its materials. Since 1997, the Athena Institute has been advocating for LCA practice in the construction sector and working to make LCA accessible to architects and engineers, to serve our mandate of reducing environmental impacts of materials, buildings and infrastructure. Headquartered in Ottawa, Canada with a US affiliate in Pennsylvania, the Athena Institute has played a leading role on both sides of the border in advancing sustainability practices through a variety of projects, often publicly-funded. Our advocacy, education, and provision of free LCA resources like the Impact Estimator software tool has enabled the uptake of LCA in green building policy and programs across Canada and the US. Our public service work is made possible through the generous support of our members and other funders. Please consider joining our family of supporters at www.athenasmi.org.

About the Impact Estimator for Buildings (IE4B)

The Impact Estimator is a software tool that delivers environmental life cycle-based performance information about buildings, to provide decision support during design and to document life-cycle performance afterwards. Life cycle assessment is the science behind the IE4B and is typically practiced by experts. The IE4B software package is a simplified LCA-based tool that has been developed specifically for architects, engineers and sustainable design consultants. The tool provides access to sophisticated life cycle inventory data and life cycle assessment methods without requiring advanced LCA skills. The software was first released in 2002 and has been continually updated ever since. The Athena Institute provides the Impact Estimator to the sustainable design community for free.

About this report

This report was automatically generated by the Impact Estimator at the request of a user. It provides background information about the software and the inputs and results for the user's project.

How to learn more about LCA, the IE4B, and LCA in green building programs

Learn about life cycle assessment, get the free Impact Estimator and Pavement LCA software tools, access the software User Manual/Transparency documents, find our guide on achieving the LCA credits in green building programs and much more, on our web site: www.athenasmi.org.

How to get in touch with comments about this report format

Have some thoughts on how this report feature in the Impact Estimator can be improved? Let us know: send an email to info@athenasmi.org.

Disclaimer

The Athena Institute provides no warranty for the Impact Estimator software and does not assume any liability for the accuracy, completeness or usefulness of the software. In addition, the Athena Institute has not reviewed the results reported in this document and does not attest as to the accuracy or completeness of the study.

Table of Contents

Software information

This report was generated by the Athena Impact Estimator for Buildings.

Software version and data sources

Software version:	Athena Impact Estimator for Buildings version 5.4.0103
Date this report was created:	Apr 29, 2023 at 12:46 PM
Life cycle inventory (LCI):	LCI data used in this assessment is from the Athena LCI database and is compliant with ISO 14040, 14044 and 21930.
Life cycle scenarios:	Scenarios used in this assessment come from databases developed by the Athena Sustainable Materials Institute.
Geographic relevance:	Canada and the United States. All data is regionally-specific for various Canadian and US cities or regions.
Life cycle impact assessment method:	TRACI v2.1. The software is in accordance with ISO 21930/21931 and EN 15804/15978.
Green program compliance:	The Athena Institute certifies that the Impact Estimator for Buildings complies with the LCA requirements of multiple green building programs, including the following: LEED, Green Globes, CalGreen, Living Building Challenge, CaGBC Zero Carbon Building, ILFI Zero Carbon, City of Vancouver Green Buildings Policy for Rezonings, and Minnesota B3.

Software scope

The Impact Estimator conforms to the EN 15804/15978 system boundary and reporting format.

Building elements

The Impact Estimator can model **any part** of a building where users have provided a bill of materials. Where users don't have a bill of materials, the Impact Estimator can create one, based on simple user inputs, for the following elements:

- Foundations, footings and slabs
- All below and above grade structure and envelope
- Windows and doors
- Interior partitions

IMPORTANT NOTE: The results shown in this report may not reflect a complete building model; the software has no way of knowing. The software user should declare what was included in the model.

Athena IE4B report for Project Site SANTA ANA

System boundary

Capacity of the Impact Estimator per EN 15804/15978 modules:

Information Module	Processes Included
A1 Raw material supply	Primary resource harvesting and mining
A2 Transport	All transportation of materials up to manufacturing plant gate
A3 Manufacturing	Manufacture of raw materials into products
A4 Transport	Transportation of materials from manufacturing plant to site, and construction equipment to site
A5 Construction-installation process	Construction equipment energy use, and A1-A4, C1, C2, C4 effects of construction waste
B1 Installed product in use	n/a (currently insufficient consensus in methodology and data for this module to be addressed)
B2 Maintenance	Painted surfaces are maintained (i.e. repainted periodically), but no other maintenance aspects are included
B3 Repair	n/a (not currently well-supported with data)
B4 Replacement	A1-A5 effects of replacement materials, and C1, C2, C4 effects of replaced materials
B5 Refurbishment	n/a (this module applies to known future refurbishment and needs to be addressed on a case-by-case basis if applicable)
B6 Operational energy use	Energy primary extraction, production, delivery, and use are addressed, if user inputs energy consumption data
B7 Operational water use	This module is not addressed
C1 De-construction demolition	Demolition equipment energy use
C2 Transport	Transportation of materials from site to landfill
C3 Waste Processing	Most material data do not include waste processing effects, therefore this module is not addressed; however, the newer "avoided burden" methodology data for metals does include waste processing effects, but it is not separated into its own C3 module
C4 Disposal	Disposal facility equipment energy use and landfill site effects
D Benefits and loads beyond the system boundary	Carbon sequestration and metals recycling

For further detail on the data and methodology underlying the software, please see the Impact Estimator User Manual and Transparency Document, available for download from the Athena Institute web site www.athenasmi.org.

Athena IE4B report for Project Site SANTA ANA

Project information

Project name:	Project Site SANTA ANA
Location used for analysis:	USA
Building type used for analysis:	Commercial
Building lifetime assumed in analysis (years):	60
Units of measure:	Imperial
Building floor area input:	1,845.00 ft2
Building height input:	33.00 ft
Project Number:	(not specified)
Project Description:	(not specified)

Operating energy inputs, if any:

Energy	Unit	Annual	Total
Electricity	kWh	5,000.00	300,000.00
Natural Gas	m^3	0.00	0.00
Liquified Petroleum Gas	US Gallon	0.00	0.00
Heavy Fuel	US Gallon	0.00	0.00
Diesel	US Gallon	0.00	0.00
Gasoline	US Gallon	0.00	0.00

Results

This section reports results for the user inputs. The Impact Estimator can provide extensive results in reports of varying formats. This section contains key results only; more detail and other reports are available within the software.

The following reports are included here:

1. LCA results by life cycle stage – Condensed table
2. LCA results by life cycle stage – Detailed table
3. LCA results by assembly – table, modules A-C
4. LCA results by assembly – table, modules A-D
5. Global Warming Potential by assembly – graph and table, modules A-C
6. Acidification Potential by assembly – graph and table, modules A-C
7. Eutrophication Potential by assembly – graph and table, modules A-C
8. Smog Potential by assembly – graph and table, modules A-C
9. Ozone Depletion Potential by assembly – graph and table, modules A-C
10. Human Health Particulate by assembly – graph and table, modules A-C
11. Non-renewable Primary Energy by assembly – graph and table, modules A-C
12. Embodied carbon
13. Operating vs embodied GWP – graph and table, modules A-C
14. Operating vs embodied TPE – graph and table, modules A-C

For the types and quantities of materials used in the model, see the bill of materials section at the back of this report.

The Athena Institute is not responsible for user errors and cannot attest to the scope of the model (what elements of the building are included).

Athena IE4B report for Project Site SANTA ANA

LCA results by life cycle stage – Condensed table

		PRODUCT (A1 to A3)	CONSTRUCTION PROCESS (A4 to A5)	USE (B2, B4 & B6)			END OF LIFE (C1 to C4)	BEYOND BUILDING LIFE (D)	TOTAL EFFECTS	
LCA Measures	Unit	Total	Total	Replacement Total	Operational Energy Use Total	Total	Total	Total	A to C	A to D
Global Warming Potential	kg CO2 eq	1.68E+005	2.29E+004	7.96E+003	2.04E+005	2.12E+005	1.02E+004	1.13E+004	**4.13E+005**	**4.25E+005**
Acidification Potential	kg SO2 eq	6.45E+002	1.79E+002	7.74E+001	5.93E+002	6.71E+002	1.25E+002	2.71E+001	**1.62E+003**	**1.65E+003**
HH Particulate	kg PM2.5 eq	2.41E+002	1.44E+001	2.22E+001	6.26E+002	6.48E+002	6.21E+000	1.19E+001	**9.10E+002**	**9.22E+002**
Eutrophication Potential	kg N eq	1.35E+002	1.67E+001	2.61E+000	1.87E+002	1.90E+002	7.78E+000	1.39E+000	**3.49E+002**	**3.51E+002**
Ozone Depletion Potential	kg CFC-11 eq	3.14E-003	1.90E-004	2.91E-006	1.68E-002	1.68E-002	4.11E-007	0.00	**2.01E-002**	**2.01E-002**
Smog Potential	kg O3 eq	9.30E+003	5.19E+003	1.23E+003	4.95E+003	6.19E+003	4.08E+003	2.74E+002	**2.48E+004**	**2.50E+004**
Total Primary Energy	MJ	1.78E+006	2.90E+005	3.68E+005	3.51E+006	3.88E+006	1.50E+005	5.43E+004	**6.10E+006**	**6.16E+006**
Non-Renewable Energy	MJ	1.75E+006	2.87E+005	3.67E+005	3.32E+006	3.69E+006	1.50E+005	5.43E+004	**5.87E+006**	**5.93E+006**
Fossil Fuel Consumption	MJ	1.48E+006	2.81E+005	3.66E+005	2.42E+006	2.79E+006	1.50E+005	1.09E+005	**4.70E+006**	**4.81E+006**

LCA results by life cycle stage – Detailed table

		PRODUCT (A1 to A3)		CONSTRUCTION PROCESS (A4 to A5)		USE (B2, B4 & B6)			END OF LIFE (C1 to C4)		BEYOND BUILDING LIFE (D)	
LCA Measure	Unit	Manufacturing	Transport	Construction Installation Process	Transport	Replacement Manufacturing	Replacement Transport	Operational Energy Use Total	De-construction Demolition Disposal & Waste Processing	Transport	BBL Material	BBL Transport
Global Warming Potential	kg CO2 eq	1.65E+005	2.72E+003	1.33E+004	9.61E+003	7.32E+003	6.37E+002	2.04E+005	6.44E+003	3.73E+003	1.13E+004	0.00
Acidification Potential	kg SO2 eq	6.14E+002	3.09E+001	8.37E+001	9.52E+001	7.07E+001	6.73E+000	5.93E+002	8.90E+001	3.58E+001	2.71E+001	0.00
HH Particulate	kg PM2.5 eq	2.40E+002	1.38E+000	9.18E+000	5.17E+000	2.19E+001	3.52E-001	6.26E+002	4.22E+000	1.98E+000	1.19E+001	0.00
Eutrophication Potential	kg N eq	1.33E+002	1.92E+000	1.08E+001	5.91E+000	2.19E+000	4.17E-001	1.87E+002	5.55E+000	2.23E+000	1.39E+000	0.00
Ozone Depletion Potential	kg CFC-11 eq	3.14E-003	9.95E-008	1.90E-004	3.44E-007	2.89E-006	2.42E-008	1.68E-002	2.81E-007	1.30E-007	0.00	0.00
Smog Potential	kg O3 eq	8.31E+003	9.92E+002	2.18E+003	3.01E+003	1.02E+003	2.14E+002	4.95E+003	2.95E+003	1.13E+003	2.74E+002	0.00
Total Primary Energy	MJ	1.75E+006	3.90E+004	1.50E+005	1.40E+005	3.59E+005	9.26E+003	3.51E+006	9.57E+004	5.43E+004	5.43E+004	0.00
Non-Renewable Energy	MJ	1.71E+006	3.90E+004	1.47E+005	1.40E+005	3.58E+005	9.26E+003	3.32E+006	9.57E+004	5.43E+004	5.43E+004	0.00
Fossil Fuel Consumption	MJ	1.44E+006	3.89E+004	1.42E+005	1.40E+005	3.57E+005	9.24E+003	2.42E+006	9.56E+004	5.42E+004	1.09E+005	0.00

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LCA results by assembly– table, modules A-C

LCA Measure	Unit	Columns & Beams	Floors	Foundations	Roofs	Walls	Project Extra Materials	Total
Global Warming Potential	kg CO2 eq	2.28E+004	6.67E+004	2.18E+004	4.42E+004	5.36E+004	0.00	**2.09E+005**
Acidification Potential	kg SO2 eq	9.91E+001	2.80E+002	8.42E+001	2.39E+002	3.23E+002	0.00	**1.03E+003**
HH Particulate	kg PM2.5 eq	5.56E+001	8.29E+001	2.92E+001	5.58E+001	6.06E+001	0.00	**2.84E+002**
Eutrophication Potential	kg N eq	1.59E+001	6.46E+001	2.05E+001	3.38E+001	2.74E+001	0.00	**1.62E+002**
Ozone Depletion Potential	kg CFC-11 eq	2.86E-004	1.51E-003	4.05E-004	6.04E-004	5.30E-004	0.00	**3.34E-003**
Smog Potential	kg O3 eq	1.90E+003	6.30E+003	1.78E+003	4.16E+003	5.66E+003	0.00	**1.98E+004**
Total Primary Energy	MJ	2.78E+005	6.13E+005	1.95E+005	8.83E+005	6.23E+005	0.00	**2.59E+006**
Non-Renewable Energy	MJ	2.75E+005	5.99E+005	1.90E+005	8.73E+005	6.12E+005	0.00	**2.55E+006**
Fossil Fuel Consumption	MJ	1.92E+005	5.19E+005	1.55E+005	8.32E+005	5.81E+005	0.00	**2.28E+006**

LCA results by assembly – table, modules A-D

LCA Measure	Unit	Columns & Beams	Floors	Foundations	Roofs	Walls	Project Extra Materials	Total
Global Warming Potential	kg CO2 eq	2.76E+004	7.03E+004	2.35E+004	4.54E+004	5.35E+004	0.00	**2.20E+005**
Acidification Potential	kg SO2 eq	1.10E+002	2.88E+002	8.82E+001	2.43E+002	3.23E+002	0.00	**1.05E+003**
HH Particulate	kg PM2.5 eq	6.05E+001	8.65E+001	3.10E+001	5.75E+001	6.06E+001	0.00	**2.96E+002**
Eutrophication Potential	kg N eq	1.64E+001	6.51E+001	2.07E+001	3.40E+001	2.74E+001	0.00	**1.64E+002**
Ozone Depletion Potential	kg CFC-11 eq	2.86E-004	1.51E-003	4.05E-004	6.04E-004	5.30E-004	0.00	**3.34E-003**
Smog Potential	kg O3 eq	2.01E+003	6.39E+003	1.82E+003	4.20E+003	5.66E+003	0.00	**2.01E+004**
Total Primary Energy	MJ	3.00E+005	6.30E+005	2.03E+005	8.91E+005	6.23E+005	0.00	**2.65E+006**
Non-Renewable Energy	MJ	2.97E+005	6.16E+005	1.99E+005	8.81E+005	6.12E+005	0.00	**2.60E+006**
Fossil Fuel Consumption	MJ	2.37E+005	5.52E+005	1.71E+005	8.47E+005	5.81E+005	0.00	**2.39E+006**

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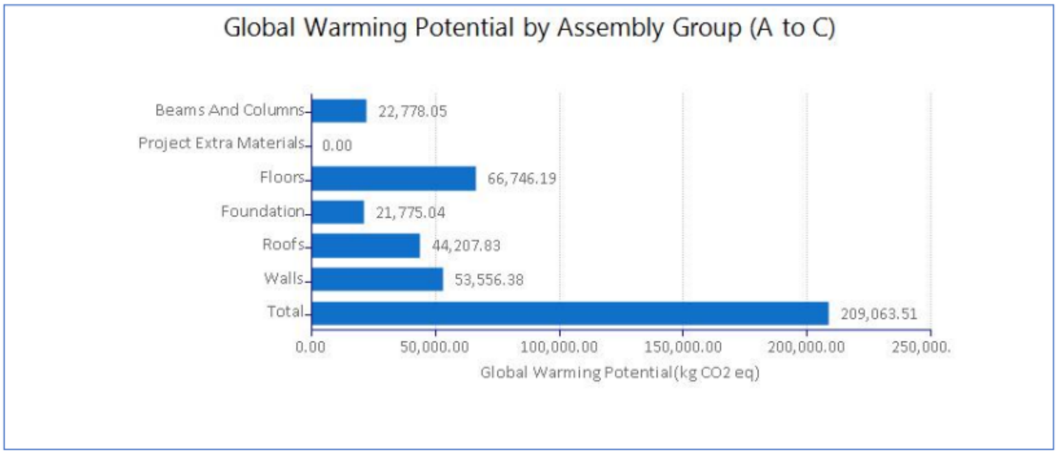
Global Warming Potential by assembly – graph and table, modules A–C



Global Warming Potential		
Assembly Group	**Unit**	**Total**
Beams & Columns	kg CO2 eq	22,778.05
Floors	kg CO2 eq	66,746.19
Foundations	kg CO2 eq	21,775.04
Roofs	kg CO2 eq	44,207.83
Walls	kg CO2 eq	53,556.38
Project Extra Materials	kg CO2 eq	0.00
Global Warming Potential Total	**kg CO2 eq**	**209,063.51**

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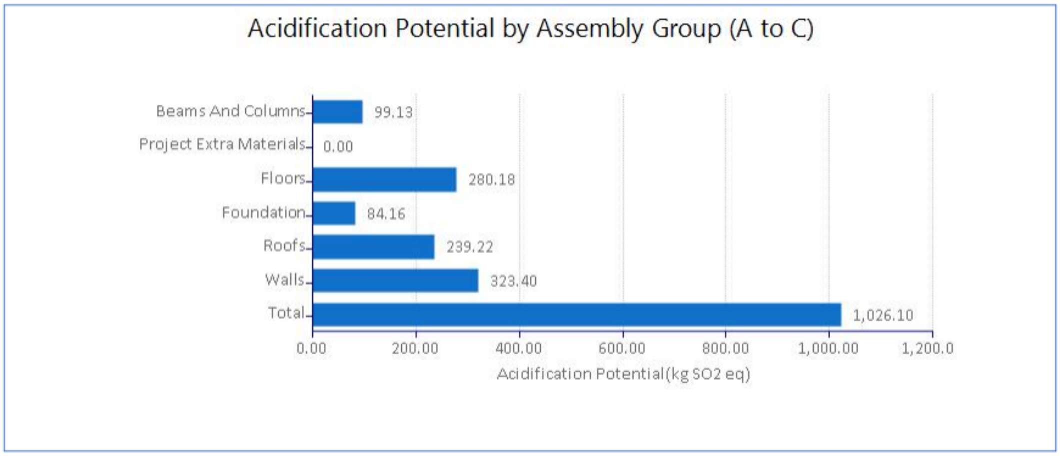
Acidification Potential by assembly – graph and table, modules A–C



Acidification Potential		
Assembly Group	**Unit**	**Total**
Beams & Columns	kg SO2 eq	99.13
Floors	kg SO2 eq	280.18
Foundations	kg SO2 eq	84.16
Roofs	kg SO2 eq	239.22
Walls	kg SO2 eq	323.40
Project Extra Materials	kg SO2 eq	0.00
Acidification Potential Total	**kg SO2 eq**	**1,026.10**

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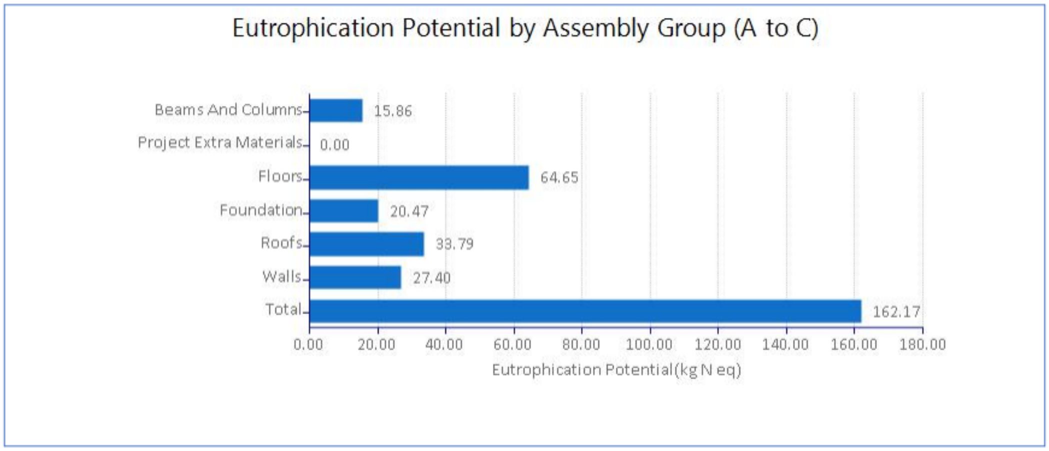
Eutrophication Potential by assembly – graph and table, modules A–C



Eutrophication Potential		
Assembly Group	**Unit**	**Total**
Beams & Columns	kg N eq	15.86
Floors	kg N eq	64.65
Foundations	kg N eq	20.47
Roofs	kg N eq	33.79
Walls	kg N eq	27.40
Project Extra Materials	kg N eq	0.00
Eutrophication Potential Total	**kg N eq**	**162.17**

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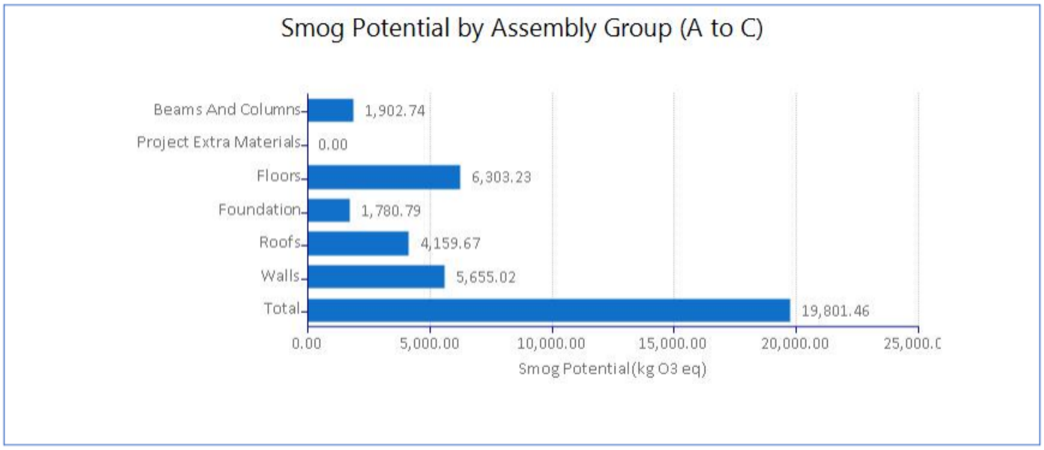
Smog Potential by assembly – graph and table, modules A–C



Smog Potential		
Assembly Group	**Unit**	**Total**
Beams & Columns	kg O3 eq	1,902.74
Floors	kg O3 eq	6,303.23
Foundations	kg O3 eq	1,780.79
Roofs	kg O3 eq	4,159.67
Walls	kg O3 eq	5,655.02
Project Extra Materials	kg O3 eq	0.00
Smog Potential Total	**kg O3 eq**	**19,801.46**

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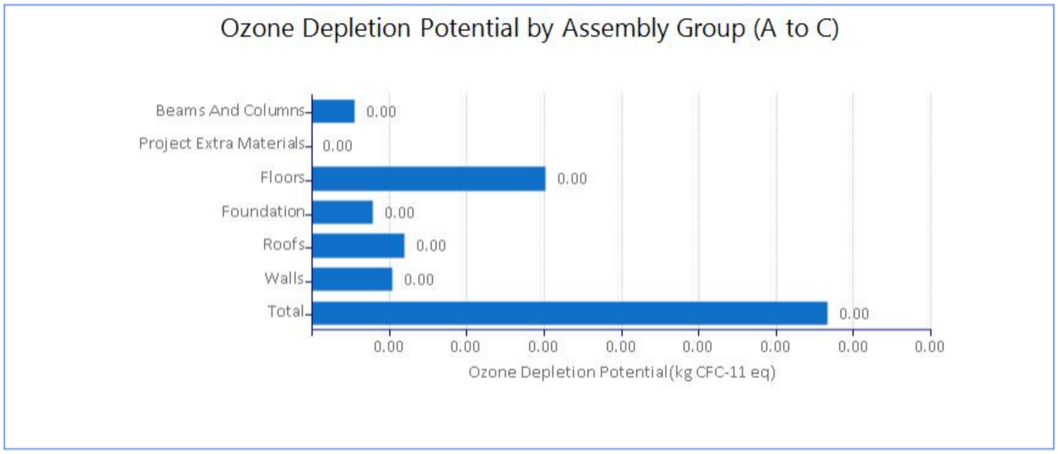
Ozone Depletion Potential by assembly – graph and table, modules A–C



Ozone Depletion Potential		
Assembly Group	**Unit**	**Total**
Beams & Columns	kg CFC-11 eq	0.000286
Floors	kg CFC-11 eq	0.001514
Foundations	kg CFC-11 eq	0.000405
Roofs	kg CFC-11 eq	0.000604
Walls	kg CFC-11 eq	0.000530
Project Extra Materials	kg CFC-11 eq	0.00
Ozone Depletion Potential Total	**kg CFC-11 eq**	**0.003338**

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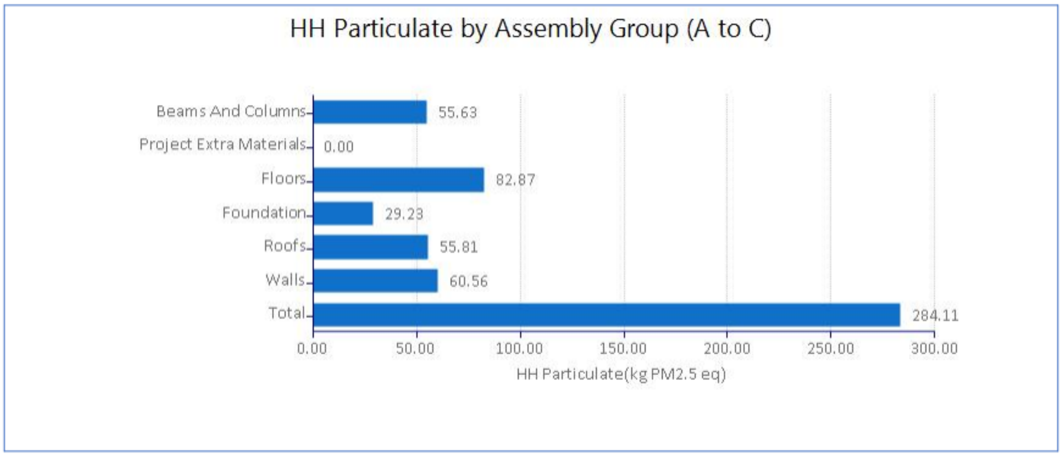
Human Health Particulate by assembly – graph and table, modules A–C



Human Health Particulate Potential		
Assembly Group	**Unit**	**Total**
Beams & Columns	kg PM2.5 eq	55.63
Floors	kg PM2.5 eq	82.87
Foundations	kg PM2.5 eq	29.23
Roofs	kg PM2.5 eq	55.81
Walls	kg PM2.5 eq	60.56
Project Extra Materials	kg PM2.5 eq	0.00
HH Particulate Total	**kg PM2.5 eq**	**284.11**

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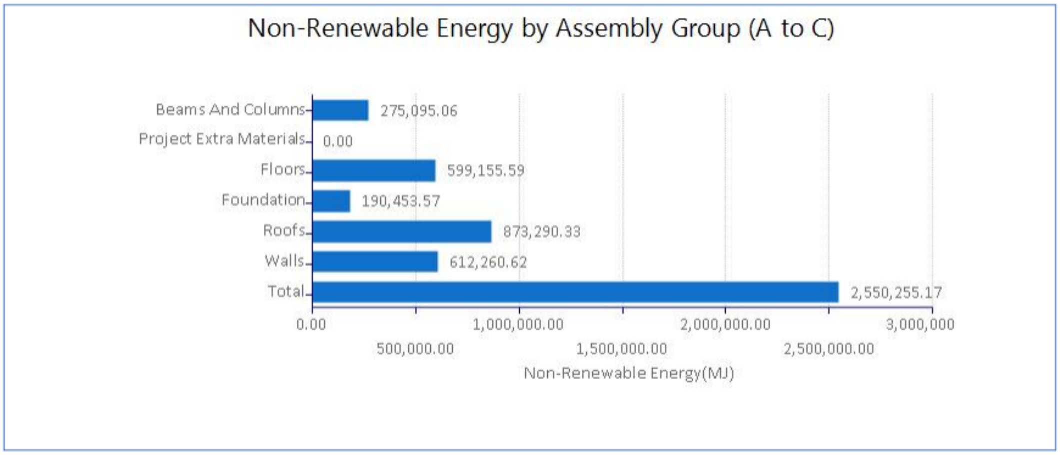
Non–renewable Primary Energy by assembly – graph and table, modules A–C



Non-Renewable Primary Energy		
Assembly Group	**Unit**	**Total**
Beams & Columns	MJ	275,095.06
Floors	MJ	599,155.59
Foundations	MJ	190,453.57
Roofs	MJ	873,290.33
Walls	MJ	612,260.62
Project Extra Materials	MJ	0.00
Non-Renewable Energy Total	**MJ**	**2,550,255.17**

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Embodied carbon

Embodied Carbon		
	Modules A to C	Module D
Lifetime GWP intensity (kg CO2e/m2)	2,411.38	65.73
Annual GWP intensity (kg CO2e/m2-yr)	40.19	1.10
Total project lifetime GWP (kg CO2e)	413,325.72	11,266.59

Project total area (m2): 1,845.00 ft2

Project life (years): 60

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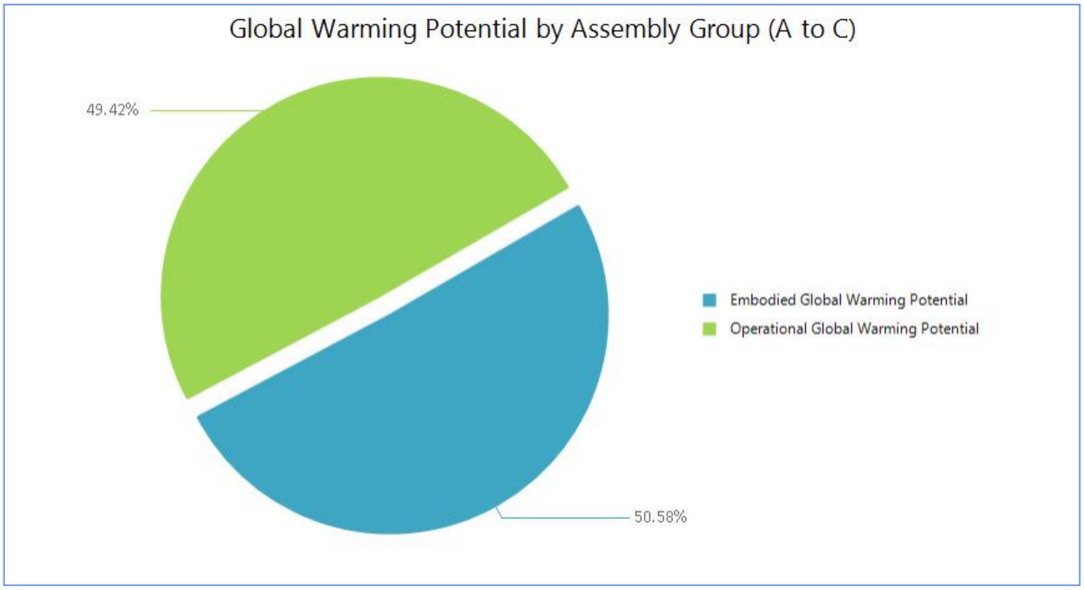
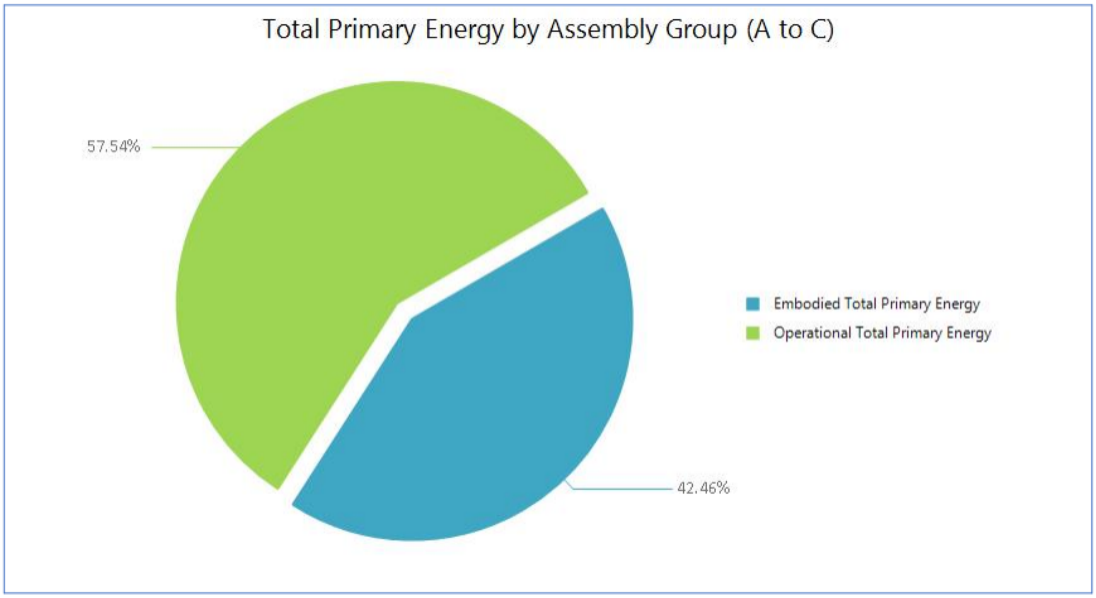
Operating versus embodied impacts

Operating vs embodied GWP – graph and table, modules A-C



Operating versus Embodied Global Warming Potential			
Operational Energy	Embodied Energy	Unit	Total
204,262.21	209,063.51	kg CO2 eq	413,325.72

Operating vs embodied Total Primary Energy Consumption – graph and table, modules A-C



Operating versus Embodied Total Primary Energy Consumption			
Operational GWP	**Embodied GWP**	**Unit**	**Total**
3,512,618.68	2,591,838.24	MJ	6,104,456.92

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Bill of materials

Material	Unit	Total Quantity	Columns & Beams	Floors	Foundations	Roofs	Walls	Project Extra Materials	Mass Value	Mass Unit
#15 Organic Felt	100sf	169.58	0.00	0.00	0.00	169.58	0.00	0.00	1.27	Tons (short)
#30 Organic Felt	100sf	84.79	0.00	0.00	0.00	84.79	0.00	0.00	1.25	Tons (short)
1/2" Moisture Resistant Gypsum Board	sf	2,727.04	0.00	0.00	0.00	2,727.04	0.00	0.00	2.52	Tons (short)
1/2" Glass Mat Gypsum Panel	sf	5,454.09	0.00	5,454.09	0.00	0.00	0.00	0.00	5.53	Tons (short)
3 mil Polyethylene	sf	2,629.86	0.00	0.00	0.00	2,629.86	0.00	0.00	0.02	Tons (short)
5/8" Regular Gypsum Board	sf	6,513.56	0.00	0.00	0.00	0.00	6,513.56	0.00	6.86	Tons (short)
8" Normal Weight Concrete Block	Blocks	7,220.29	0.00	0.00	0.00	0.00	7,220.29	0.00	141.11	Tons (short)
Cold Rolled Sheet	Tons (short)	0.12	0.00	0.00	0.00	0.00	0.12	0.00	0.12	Tons (short)
Concrete Benchmark USA 4000 psi	yd3	354.44	40.74	170.62	57.77	85.31	0.00	0.00	688.97	Tons (short)
Concrete Brick	sf	6,217.49	0.00	0.00	0.00	0.00	6,217.49	0.00	146.45	Tons (short)
Concrete Tile	sf	3,183.20	0.00	0.00	0.00	3,183.20	0.00	0.00	25.43	Tons (short)
Expanded Polystyrene	sf (1")	198.35	0.00	0.00	0.00	0.00	198.35	0.00	0.01	Tons (short)
Extruded Polystyrene	sf (1")	14,418.81	0.00	0.00	0.00	5,181.41	9,237.40	0.00	1.82	Tons (short)
Galvanized Sheet	Tons (short)	0.50	0.00	0.00	0.00	0.25	0.26	0.00	0.50	Tons (short)
Glass Fibre	lbs	173.61	0.00	0.00	0.00	0.00	173.61	0.00	0.09	Tons (short)
Glazing Panel	Tons (short)	0.10	0.00	0.00	0.00	0.00	0.10	0.00	0.10	Tons (short)
Grout-Coarse	yd3	20.72	0.00	0.00	0.00	0.00	20.72	0.00	37.30	Tons (short)
Joint Compound	Tons (short)	0.67	0.00	0.00	0.00	0.00	0.67	0.00	0.67	Tons (short)
Laminated Veneer Lumber	ft3	2.94	0.00	0.00	0.00	0.00	2.94	0.00	0.04	Tons (short)
Modified Bitumen membrane	sf	16,611.22	0.00	0.00	0.00	16,611.22	0.00	0.00	7.09	Tons (short)
Mortar	yd3	30.07	0.00	0.00	0.00	0.00	30.07	0.00	47.84	Tons (short)
Nails	Tons (short)	0.21	0.00	0.00	0.00	0.15	0.06	0.00	0.21	Tons (short)
Paper Tape	Tons (short)	0.007641	0.00	0.00	0.00	0.00	0.007641	0.00	0.007641	Tons (short)
Rebar, Rod, Light Sections	Tons (short)	28.44	10.93	8.09	4.02	4.05	1.36	0.00	28.44	Tons (short)
Roofing Asphalt	lbs	5,636.53	0.00	0.00	0.00	5,636.53	0.00	0.00	2.82	Tons (short)
Screws Nuts & Bolts	Tons (short)	0.005230	0.00	0.005230	0.00	0.00	0.00	0.00	0.005230	Tons (short)
Small Dimension Softwood Lumber, kiln-dried	Mbfm small dimension	1.09	0.00	0.00	0.00	1.02	0.07	0.00	0.78	Tons (short)
Solvent Based Alkyd Paint	Gallons (us)	0.47	0.00	0.00	0.00	0.00	0.47	0.00	0.001475	Tons (short)
Water Based Latex Paint	Gallons (us)	172.78	0.00	172.78	0.00	0.00	0.00	0.00	0.54	Tons (short)

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Conclusion

Overall, this project allowed us to create a building model that would support the needs of our Veterans by giving them community access to a physical therapy and rehabilitation center. Each sub discipline was tasked with the goal of creating and implementing design that was not only efficient to meet the needs of future occupants but also practical by applying building code design requirements. The structural team was in charge of creating a structure to support the loads applied to the building. The Geotechnical team was in charge of distributing the building loads to the soil. The Transportation team was in charge of providing and creating a safe and reliable transportation route to the site. The Water Team was in charge of providing access to efficient and clean water to our site. The environmental team was in charge of implementing design strategies to make our building a more sustainable asset to the community. Overall, we believe that we have implemented our knowledge as best as we could. However, there are always many better ways our designs could have had improvement. We look forward to looking back at this project when we have even more knowledge and experience to think of ways we could have improved our designs.

Discipline	**Cost Estimates**	**Min. Grant Allocation**	**Surplus**
Structural	$178,517		
Geotechnical	$79,851		
Transportation	$73,340		
Water Resources	$23,973		
Environmental	$28,000		
Total	**$383,681**	**$963,000.00**	**$579,319**

Appendix

Table of Figures and Tables

Units and Sizing