Climate Action Planning
CUMTD CAP
2020

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Introduction

The Champaign-Urbana Mass Transit District (CUMTD) is in the process of enacting its climate action plan (CAP) and is currently working towards its sustainability goals. CUMTD has been awarded $1.45 million through the Federal Transit Administration's *Low or No Emission Vehicle Program*; additional Federal and State funding is also made available to them.

Sustainability Goals

1. Zero-emission buses in Champaign-Urbana
2. One-for-one replacement of diesel buses
3. Hydrogen station built to fuel 12 buses (five-year plan)
4. Long-term goal: hydrogen station powered with renewable energy

CUMTD can plan to achieve these goals by addressing two facets of its operations. The objective of this report is to assist in directing efforts to CUMTD's fleet facilities and offer a baseline approach to enact and monitor the organization's CAP.

Means of Operation: Fleet, HQ & Facilities

- District Office: The district HQ located at 1101 E University Avenue, Urbana.
- City-circuit buses: The fleet consisting of hybrid buses, with diesel buses being phased out of commission; Hydrogen buses to be introduced in 2021.
- Facilities:
  - Maintenance Department and Bus Garage
  - Illinois Terminal
  - Wright Street Transit Plaza
  - Downtown Urbana Transfer Point
  - Solar Farm (Planned, on-site); contracted to Trillium
  - Hydrogen Station (Planned, on-site); contracted to Trillium

This report recommends approaches to augment CUMTD's capacity for environmental sustainability through the incorporation of ECMs in the organization's facilities and additional measures to fleet overhauls.

Energy Conservation

The primary consumers of energy for CUMTD are the fleet and the maintenance department, with the district office utilizing energy similar in magnitude to a public institution/office. This section addresses measures that can be undertaken to achieve sustainability goals in terms of fleet and facilities.

Energy Conservation in Facilities

Energy Savings Performance Contracts

The primary deterrents to opting for energy conservation measures in buildings and other facilities are financial and psychological barriers **(Luoma, 2011)**. CUMTD is already opting for energy-efficient strategies pertaining to its fleet and potential local power generation by installing an on-site Hydrogen plant; thus, the only cause of potential aversion would be a substantial capital investment.

Energy Savings Performance Contracts (ESPCs) are designed to address this issue. ESPCs are a financing mechanism approved and authorized by the U.S. Congress designed to accelerate investment in cost-effective energy conservation measures in existing Federal buildings. ESPCs allow participants to accomplish energy savings projects without up-front capital costs while negating the need for special Congressional appropriations. This mechanism can also be adopted by state and local governments/agencies to fast-track green infrastructure investments in their facilities **(U.S. Department of Energy, n.d.)**. Entering an Energy Savings Performance Contract can ensure a budget-neutral approach wherein building improvements can be carried out that reduce energy and water use and increase operational efficiency. By partnering with a certified Energy Service Company (ESCO), CUMTD would be paying for present upgrades in their infrastructure with future savings in energy cost.

Energy Conservation Measures

The supportive framework provided by the Energy Savings Performance Contract can enable CUMTD to incorporate various Energy Conservation Measures (ECMs) into their facilities. These ECMs can be augmented into the broader ESPC to maximize energy cost-saving potential as the ESPC framework also has government-approved monitoring and tracking systems. These performance indicators can be further used to calculate the benefit-cost ratio for incorporated ECMs and used to analyze the efficiency of each measure.

Fleet Overhaul

As part of CUMTD's CAP, the older fleet which was run on diesel is being overhauled. Next-generation Hydrogen Fuel Cell buses (FCEBs) will be incorporated into the fleet on a phased basis. CUMTD has selected FCEBs owing to their exceptional performance and environmental benefits (CUMTD, 2017). Electric-drive vehicles are the predominant zero-emission drive technology in the transportation sector, as stated by CUMTD. The current CUMTD fleet size is 111, with two new hybrid buses being rolled into commission in 2023. The current fleet management strategy is to phase out diesel buses with hybrid buses while incorporating FCEBs in the coming years. The first buses that will be non-diesel consuming are expected to be phased-in in 2020.

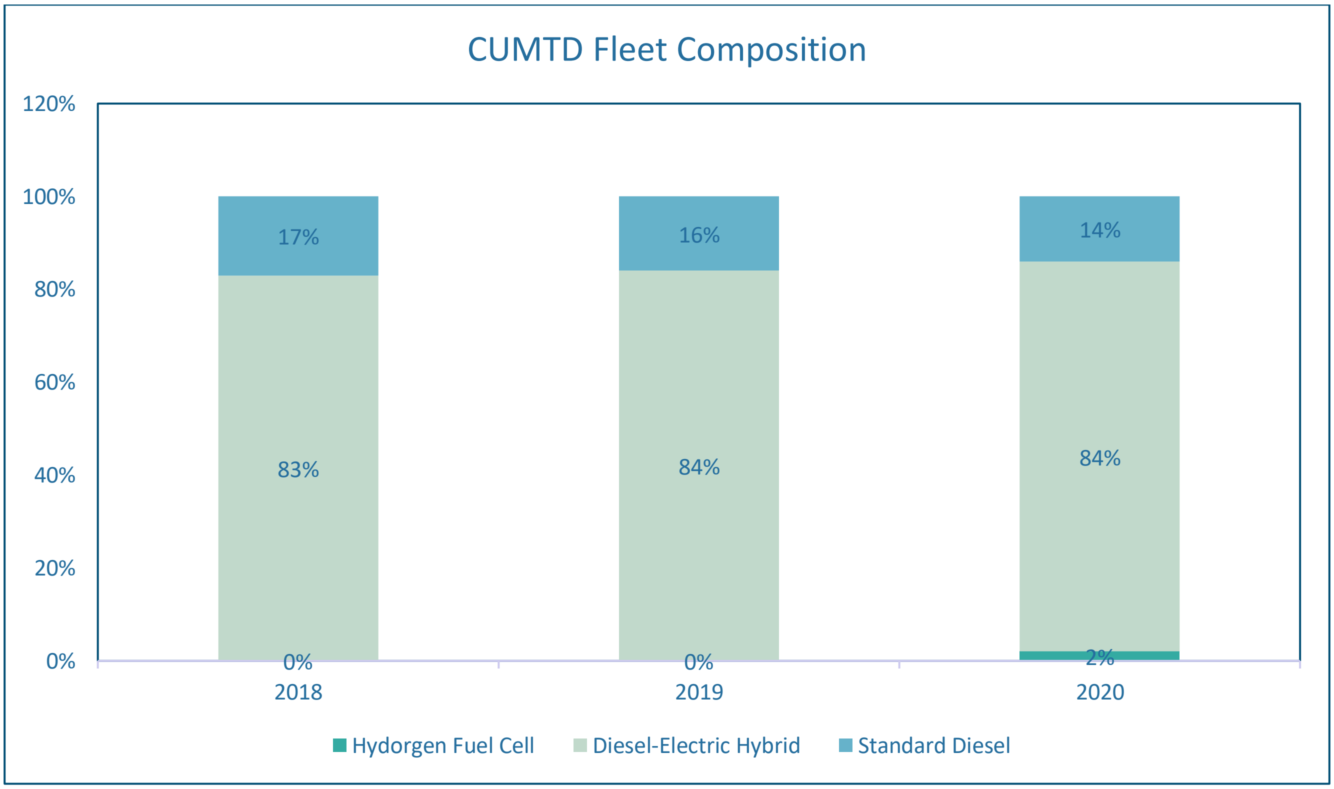


Figure 1 CUMTD Fleet Composition (Labelled Axes)

FCEB Advantages

Range: Fuel cell electric buses can drive up to 300 miles on a single refueling. Battery electric buses have a documented range of up to 204 miles.

Refueling Time: Fuel cell electric buses can refuel continuously in six to 10 minutes. As a comparison, recharging large battery packs take as much as four to five hours.

Weight: Fuel cells are achieving high power densities, are more compact, and lighter in weight. The fuel cell units are approximately one-third of the weight of batteries.

The funding plan for the fleet overhaul is described below.

Current Fleet				Anticipated Purchase				
Vehicle Commission Year	Vehicle Length	Description	Minimum Useful Life	Status	Year	Vehicles	Description	Funding Source
2003	40 ft	New Flyer Diesel	12 Years	Replacement	FY 2020	5	60 ft Hybrid	5307, DOAP[1]
2001	60 ft	New Flyer Diesel	12 Years	Replacement	FY 2020	6	40 ft Hybrid	5307, DOAP
2001	60 ft	New Flyer Diesel	12 Years	Replacement	FY 2021	2	60 ft Fuel Cell	5339[2], 5307, Local[3]
2001	60 ft	New Flyer Diesel	12 Years	Replacement	FY 2022	4	60 ft Fuel Cell	5339, State Capital
2009	30 ft	Gillig Hybrid	12 Years	Replacement	FY 2021	5	30 ft Hybrid	5307, DOAP[4]
2011	40 ft	New Flyer Hybrid	12 Years	Replacement	FY 2023	6	40 ft Fuel Cell	5307, DOAP
2011	40 ft	New Flyer Hybrid	12 Years	Replacement	FY 2023	10	40 ft Hybrid	5307, DOAP
				Expansion	FY 2023	2	40 ft Hybrid	5307, DOAP
2011	40 ft	New Flyer Hybrid	12 Years	Replacement	FY 2024	10	40 ft Hybrid	5307, DOAP
2011	40 ft	New Flyer Hybrid	12 Years	Replacement	FY 2025	10	40 ft Hybrid	5307, DOAP
2009	60 ft	New Flyer Hybrid	12 Years	Replacement	FY 2025	4	60 ft Fuel Cell	5307, DOAP
2013	40 ft	New Flyer Hybrid	12 Years	Replacement	FY 2026	10	Undetermined	Undetermined
2016	40 ft	New Flyer Hybrid	12 Years	Replacement	FY 2028	12	Undetermined	Undetermined
2017	40 ft	New Flyer Hybrid	12 Years	Replacement	FY 2029	22	Undetermined	Undetermined
2018	40 ft	New Flyer Hybrid	12 Years	Replacement	FY 2030	3	Undetermined	Undetermined
2019	40 ft	New Flyer Hybrid	12 Years	Replacement	FY 2031	2	Undetermined	Undetermined

Table 1 Current Fleet vs. Anticipated Purchase

CUMTD will phase out standard diesel buses at the end of their service life (12 years), and no more diesel buses are planned for purchase. An expansion of the fleet by an additional four FCEBs is expected by 2023. The third phase of expansion is anticipated to add six FCEBs, for a total of 12 FCEBs. The strategy is to convert the fleet into FCEBs entirely in the future.

[1] 5307: FTA Section 5307 appropriation

[2] 5339: FTA Low or No Emission Grant Program

[3] Local: Local property tax revenue

[4] DOAP: Illinois Downstate Operating Assistance Program

Energy Generation

Overview

The primary energy generation processes would be directed towards powering the new H2 Cell buses as well as the hybrid buses. CUMTD has contracted Trillium to install a hydrogen fuel generation plant adjacent to its district office. CUMTD has planned to utilize state and federal funding to build the hydrogen station that has the initial capability to fuel up to 12 FCEBs.
Table 2 shows the contracts awarded for every major operation in this process and the sources of funding for the contracts.

Contracting			Funding		
Operation	**Contractor**	**Total**	**Federal**	**State**	**Local**
Quality Assurance & Inspection, Project Management & Technical Assistance	CTE	$ 523,225	NA	NA	$ 523,225
Facility Design & Engineering	Fiedler Group	$ 436,900	NA	NA	$ 436,900
Bus Procurement	New Flyer	$ 3,087,084	$ 1,080,479	$ 2,006,605	NA
Hydrogen Fueling Station	Trillium	$ 7,918,092	$ 2,771,332	$ 5,146,760	NA

Table 2 Contracting & Funding

The total estimated project cost is $11,965,301, with funding from federal (32%), state (60%), and local government (8%) **(CUMTD Fleet Management Plan, 2019).**

Energy Generation Facilities

Hydrogen Plant

As a fuel source, hydrogen is clean, abundant and can be reformed from natural gas or created from renewable sources such as wind or solar energy through electrolysis. The primary emissions from hydrogen-fueled vehicles is water. Furthermore, the sourcing of hydrogen is not environmentally intrusive, thus making it a sustainable alternative. The proposed plant is to be located close to the CUMTD District Office (Refer Appendix).

Solar Photo Voltaic Arrays

CUMTD has installed Solar Photo Voltaic (SPV) panels on the rooftop of the bus maintenance depot, which is in close proximity to the district office. This localized power generation can be utilized to power the district office in addition to the maintenance depot. Power supply from this green energy source combined with the ECMs incorporated under the Energy Savings Performance Contract will enable the district office to be virtually carbon neutral. If capacity permits, then the power generated in excess can be sold back to the local government for energy credits.

Transportation

Strategy

CUMTD is a public mass transit organization, and it is already undertaking fleet overhaul measures. The Energy Conservation section covers this aspect of the Climate Action Plan; this section outlines transportation efficiency strategies for vehicles other than the CUMTD fleet. Thus, the primary strategy pertaining to transportation efficiency is to address employee commute by private vehicles.

Facility Overview

CUMTD Office

The District Office maintained by CUMTD is a one-story structure similar in size and layout to a commercial strip mall. The office is spread over an area of 28,302 m^2. The building occupies an area of 5,455 m^2.

CUMTD Maintenance Department

The maintenance department serves as a garage/depot for the MTD fleet and is used to service the diesel and hybrid buses. The facility is partly powered by rooftop SPV arrays, which account for 25% of the facility's energy. The facility underwent an 88,000 sq. feet expansion in 2015-2017 **(CUMTD, 2018)**.

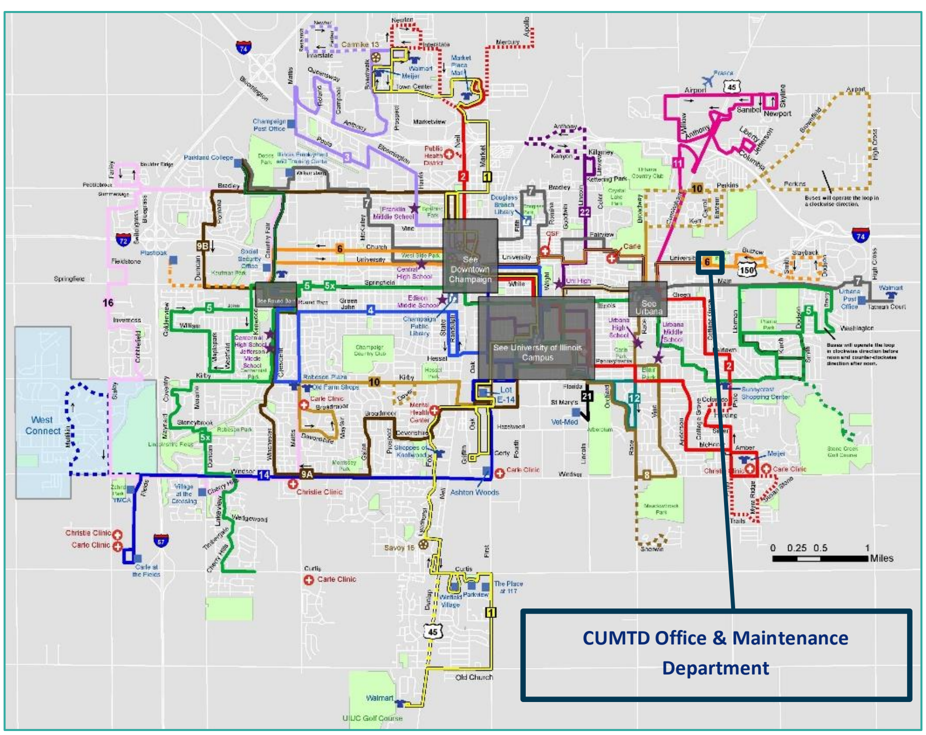


Figure 2 MTD Route Map

Figure 3 CUMTD Facilities

Figure 4 CUMTD Office

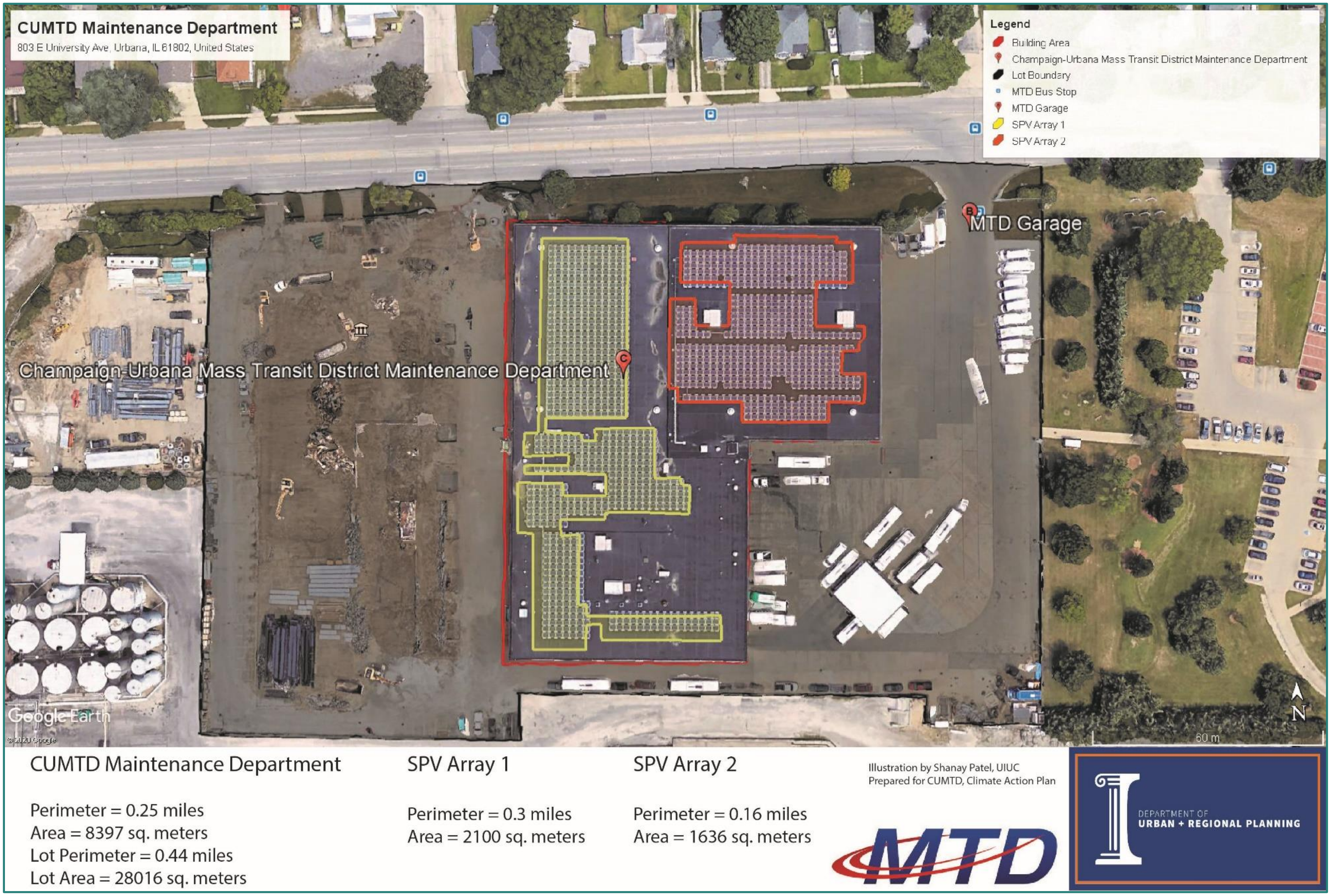


Figure 5 CUMTD Maintenance Department

Employee Commute

CUMTD employees can either commute to-and-from work by bus, private vehicles, or ride-sharing. All these modes of transit have disparate effects in terms of annual GHG emissions, and thus, analysis of alternative options is necessary to determine optimal solutions. Average miles of employee commute are determined based on the following method, which accounts for twelve points of origin (P_n) across Champaign-Urbana:

$$\boldsymbol{D = n \times 2 \times \left\{\sum (P_1 - P_{12})\right\}/12}$$

Where, n = Number of employees (CUMTD Office personnel)
P_1-P_{12} = Points of origin (multiplied by a factor of 2 to account for trips to-and-from point of origin)

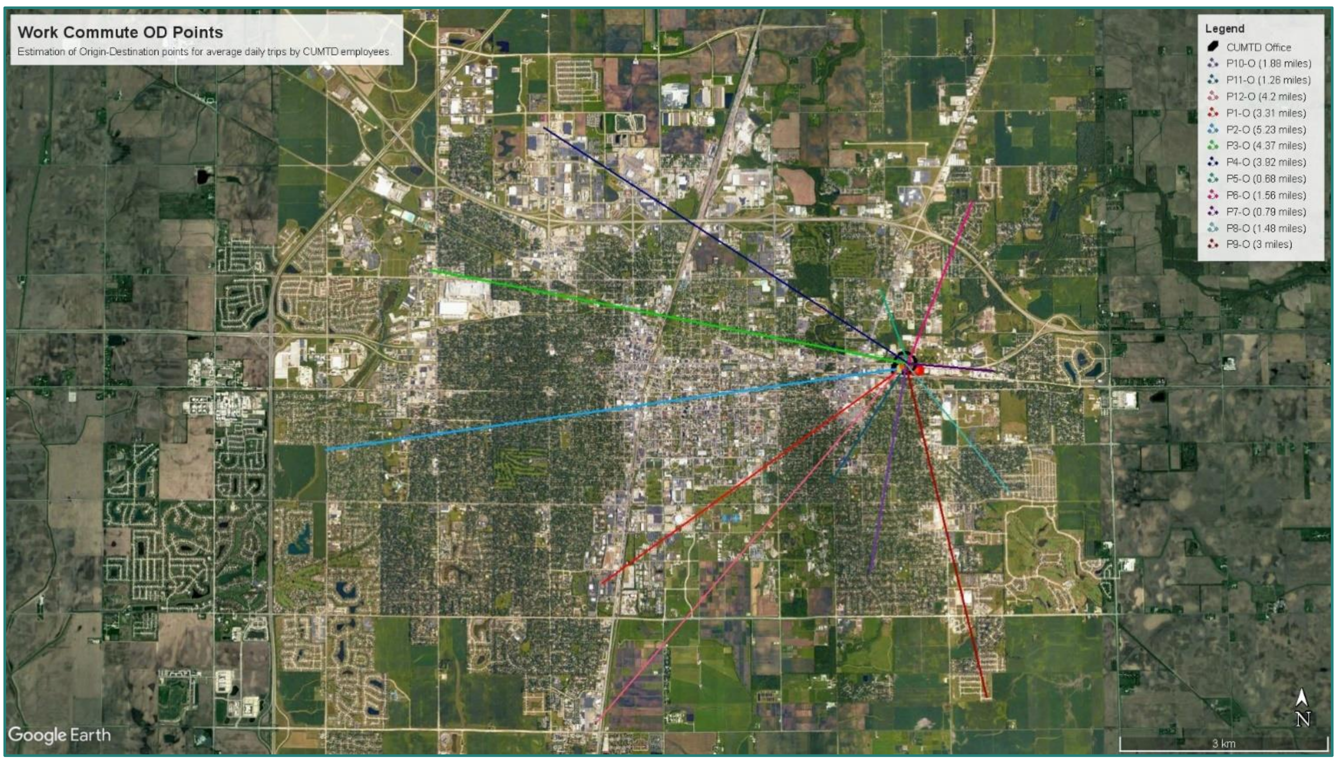


Figure 6 Work Commute OD Points

$$\boldsymbol{D = 33}^{5} \boldsymbol{\times 2 \times \{31.68\}/12}$$
$$\boldsymbol{\therefore D = 174.24\ average\ miles\ per\ day}$$

Thus, annual miles traveled for 303 days amounts to 52,795 miles (per capita average is 1600 miles/person/year)

[5] Reference for employee number: Owler. Retrieved from https://www.owler.com/company/cumtd

Figure 7 CUMTD Office Parking

Comparative Scenarios

This report analyzes three scenarios of employee commute to-and-from work to conceptualize disparities in GHG emissions in different cases. For this section, the entire employee pool of the organization, which is 377 employees, is considered, which is not limited to office personnel and would include drivers and maintenance staff, among others. An average passenger vehicle emits 4.6 CO_2E/year or 411 grams of CO_2 per mile **(EPA, 2018)**. Two units of calculation are used to give a range of estimates.

1. Private Vehicle Commute

This scenario assumes every single employee owns a 4-seater car (377 private vehicles) and uses it to commute to-and-from work.

Conservative Estimate:

GHG Emissions = 4.6 x 377 = 1734.2 CO_2E/year

Optimistic Estimate:

GHG Emissions = 411 x 1600 x 377 = 247,915,200 grams of CO_2/year = 273.3 CO_2E/year

2. Probable Scenario

The probable scenario is based on the amount of parking space available on site (Refer Figure 7). The total number of parking spots available is 243, and 126 are observed to be occupied. To account for peak occupancy and visitors, probable occupancy for this analysis is considered to be:

[126 x 1.3 (peak)] – 10 (visitors) ≈ 154

Conservative Estimate:

GHG Emissions = 4.6 x 154 = 708.4 CO_2E/year

Optimistic Estimate:

GHG Emissions = 411 x 1600 x 154 = 101,270,400 grams of CO_2/year = 101.3 CO_2E/year

3. Ride Sharing

This scenario assumes four employees share a 4-seater car (94 private vehicles) for commuting to-and-from work.

Conservative Estimate:

GHG Emissions = 4.6 x 94 = 432.4 CO_2E/year

Optimistic Estimate:

GHG Emissions = 411 x 1600 x 94 = 61814400 grams of CO_2/year = 68.1 CO_2E/year

Scenario	Conservative Estimate (CO_2E/year)	Optimistic Estimate (CO_2E/year)
Private Vehicle Commute	1734.2	273.3
Probable Scenario	708.4	101.3
Ride Sharing	432.4	68.1

Table 3 Emission Scenarios

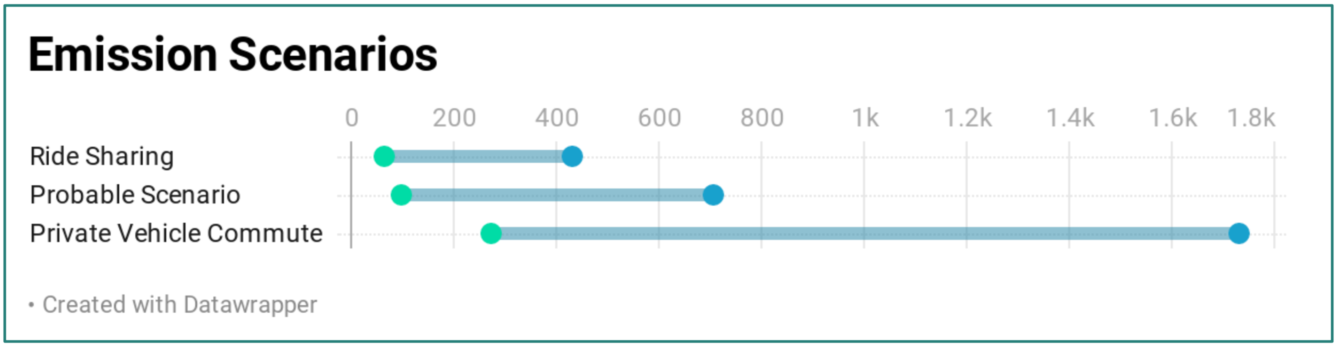


Figure 8 Emission Scenarios Range Chart

Scenario	% Change from Probable Scenario	% Change from Probable Scenario	Average % Change (Baseline)
Private Vehicle Commute	145%	170%	157%
Probable Scenario	0	0	0%
Ride Sharing	-39%	-33%	-36%

Table 4 Percentage Changes from Probable Scenario

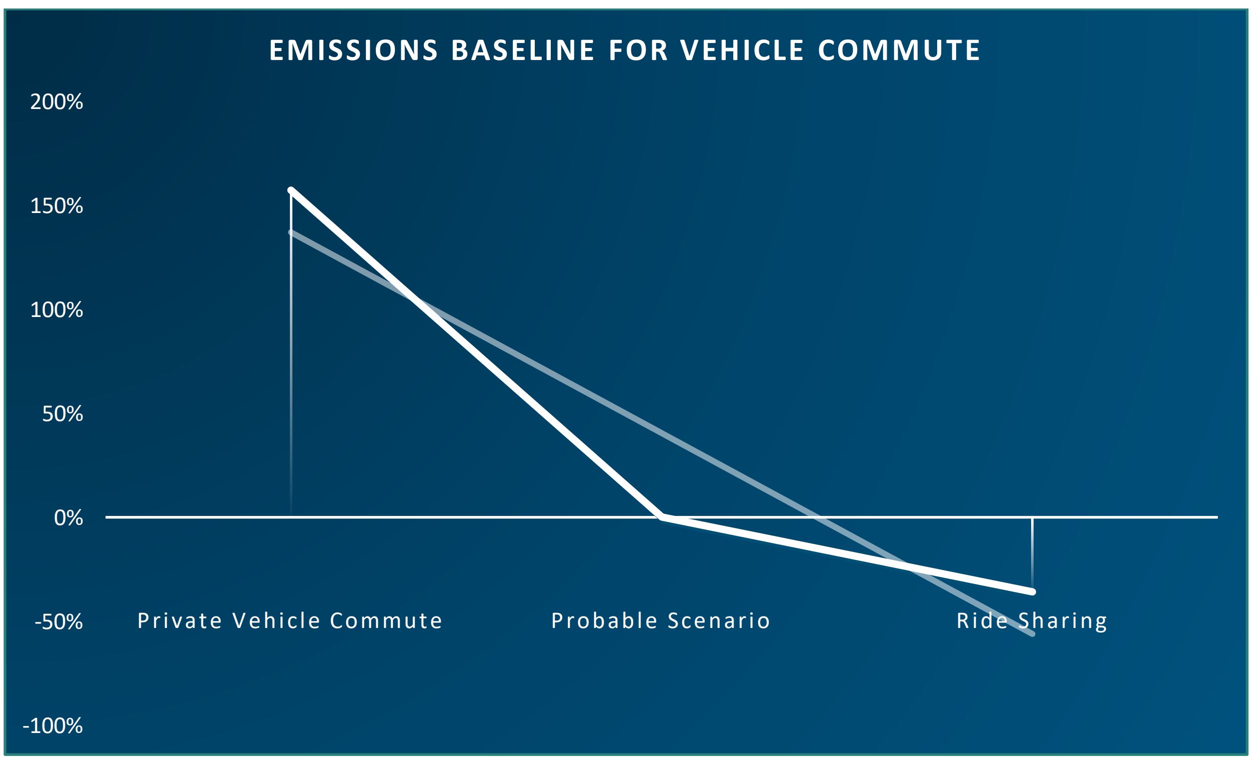


Figure 8 Emissions Baseline for Vehicle Commute

Bus Mileage

The CUMTD fleet has 111 buses – 94 hybrid and 17 diesel buses. For this analysis, the hybrid buses are assumed to run on the mileage of 5.7 miles per gallon (MPG), and the diesel buses are assumed to get a 3 MPG mileage **(Kacich, 2013)**. The buses are expected to annually travel 26,155 miles per bus at an average speed of 11.9 miles per hour (MPH) **(Pierce & Moser, 1995)**.

Alternative options for buses are **Standard Diesel**, **Hybrid-Electric,** and **CNG**. These options are analyzed in this section for their impacts on the environment. For a benchmark reference, the figures obtained from a comparative study undertaken by the Altoona Bus Research & Testing Center (ABRTC) are incorporated in this analysis. For this Climate Action Plan, the figures for the New Flyer buses are considered **(M.J. Bradely & Associates, 2013)**.

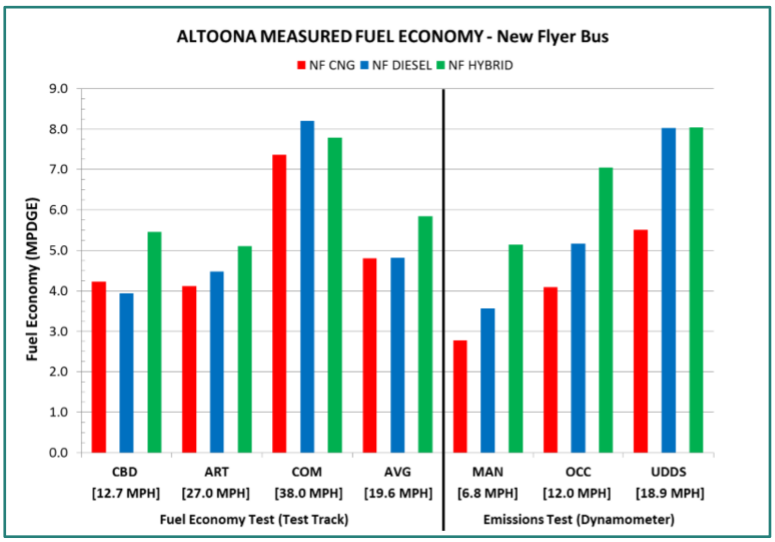


Figure 9 Altoona Measured Fuel Economy - New Flyer Bus. Src: MJB&A

The adjacent chart shows the fuel economies of New Flyer buses operating in Altoona at the time of the study. The testing cycles used by the ABRTC are described in Table 3. The NF Hybrid fares better than the NF Diesel in every testing run except the commuter cycle (COM), which might be the most suitable cycle for the MTD's 'Hopper' buses. The arterial (ART) and average (AVG) cycles have thus been considered for regular MTD buses.

Test Type	Cycle	Abbreviation	Max Speed (MPH)	Avg. Speed (MPH)	Stops/Minute
Fuel Economy	Central Business District	CBD	20	12.7	7
	Arterial	ART	40	27	2
	Commuter	COM	40	38	0.3
	Average	AVG	40	19.6	2.4
Emissions	Manhattan Cycle	MAN	25.4	6.8	10
	Orange Cycle	OCC	41	12	5
	Urban Dynamometer Drive Cycle	UDDS	58	18.9	1.3

Table 5 Testing Cycles. Src: Altoona Bus Research & Testing Center

Based on the results of the ABRTC study, this report establishes an approximate baseline of GHG emissions from the MTD fleet and produce a comparative scenario of emission reduction. The results of the study are shown in Figure 5. The Manhattan Cycle was developed based on actually observed driving patterns of urban transit buses in the Manhattan core of New York City. Frequent stops and low speed characterize the cycle. The Orange County Bus Cycle is a chassis dynamometer test for heavy-duty vehicles. It has been developed by the West Virginia University (WVU), based on the driving patterns of urban transit buses in the Los Angeles, California area. The UDDS Cycles vary from 20-60 MPH, and hence would not be the likely case for CUMTD buses **(DieselNet, 2000)**. Thus, the most probable cycle for Champaign-Urbana can be considered to be the Manhattan Cycle with reduced potentialities than Manhattan's urban core.

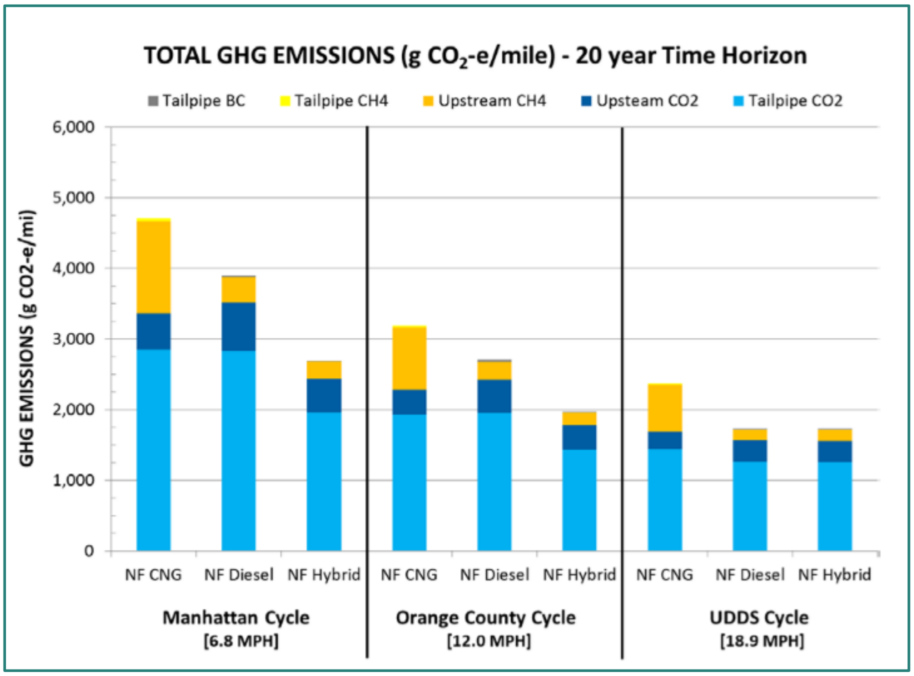


Figure 10 Total GHG Emissions (20-year). Src: MJB&A

It is observed that methane (a short-term climate forcer) is the most significant GHG emitted after CO_2 in the CNG buses. However, CNG also yields lower CO_2 emissions in the short-term. Thus, this report recommends considering between CNG or Hybrid-Electric alternatives, taking into account the associated tradeoffs. Agency costs and social costs associated with each fuel type are discussed in the next section.

Waste

CUMTD operates numerous facilities to operate and support Champaign-Urbana's transit service. The waste generation potential from minimum to maximum is identified below.

Buses **District Office** **Facilities**

Multi-pronged Waste Management Strategy

Two types of biofuel compositions are discussed in a study conducted by Carnegie Mellon – B20 (20% Biodiesel, 80% Diesel) and B100 (100% Biodiesel). Biodiesel is usually made from vegetable oils, animal fats, or recycled grease. Currently, producing biodiesel is expensive, and the supply might be limited **(CMU, 2019).** The Climate Action Report recommends a waste management strategy to address waste generated from the district office and ancillary facilities and convert it into biofuel for buses.

Table 4 summarizes different types of buses categorized by fuel and the agency costs incurred along with the associated social costs (adjusted for 2019 inflation levels), which are considered an externality.

Aspect	Standard Diesel	Hybrid-Electric	B20	B100	Electric (RC)	Electric (SC)	CNG	LNG
Agency Cost ($1000/Bus/Year)	64.7	61.6	65.6	70.7	48.9	52.1	65	74
Social Cost ($1000/Bus/Year)	5	4.7	5	3	5.1	6.3	6.9	8.4

Table 6 Fuel Types & Associated Costs

Table 4 shows that biofuel-powered buses have the least associated social costs, albeit with a slight bump in costs incurred by the agency. Social costs are relatively small compared to agency costs, but alternative fuel technologies that use much coal-based electricity have higher social costs. Figure 14 shows the relationship between the costs incurred by the agency and the social costs associated with a fuel type. Electric Battery-powered buses may have the lowest agency costs. However, they have the lowest overall life cycle cost. They also have the shortest driving range, which would need to improve before they are widely adopted **(CMU, 2019)**. Thus, an alternative B100 approach is recommended to augment CUMTD's existing fleet, which has incorporated biodiesel (soybean biofuel). Locally generated waste can be composted to produce biofuel for the B100 buses. Large methane emissions characterize CNG buses, as discussed in the previous section. This disadvantage should be considered while examining alternatives and associated tradeoffs.

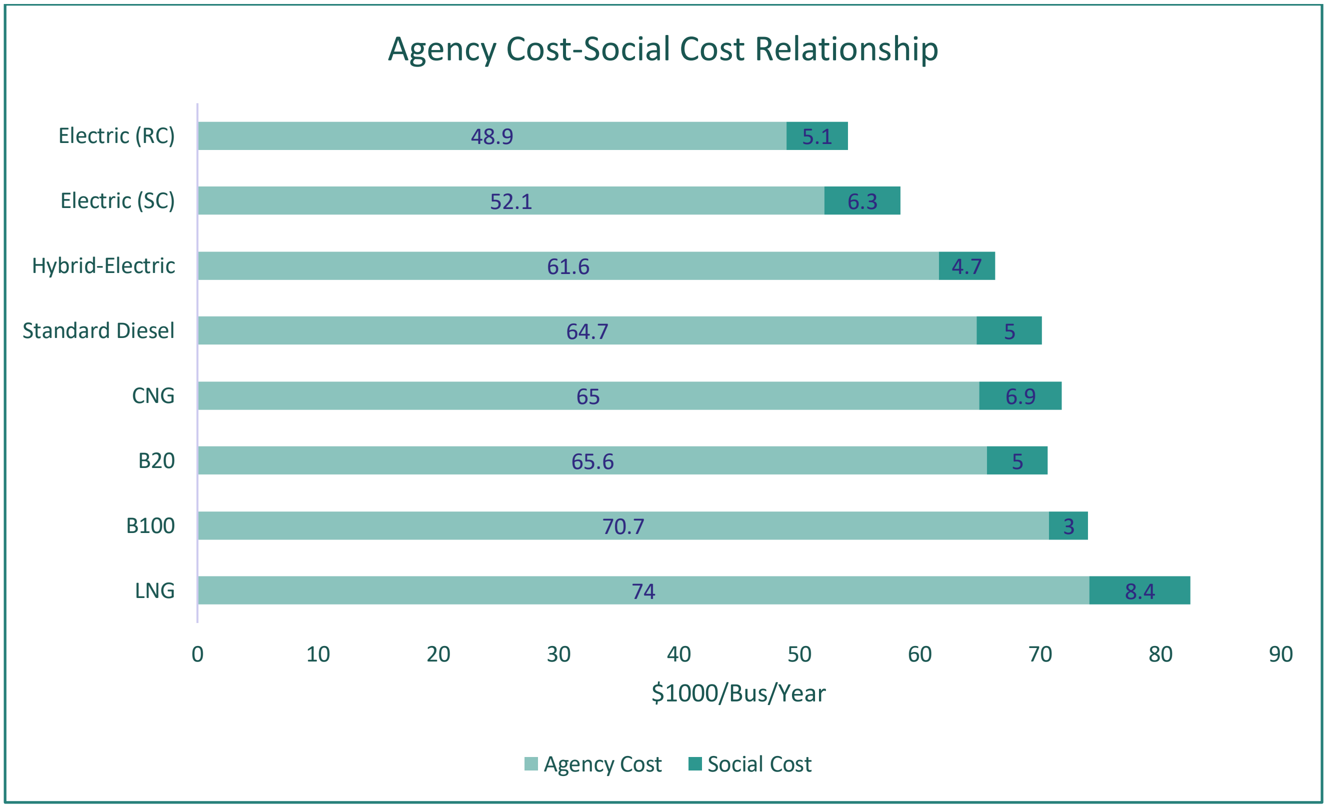


Figure 11 Agency Cost-Social Cost Relationship

Green Landscapes

Figure 12 CUMTD Office & Maintenance Facility Green Landscape Design

Water & Stormwater

This section focuses on stormwater management and water conservation by comparing two approaches to managing stormwater effectively. The two scenarios are used to assist in the selection of the best practice for stormwater management. They may be further used to aid cost-benefit analysis for both system approaches. The HydroModel considers four scenarios, out of which only two are relevant for this report:

Scenario 1 – Pre-Development: The first scenario which considers conditions at the Douglas Square site as it may have been before human settlement.

Scenario 2 – Greenfield: This scenario considers conditions on the site if it was being used primarily for agricultural uses.

Scenario 3 – Conventional: This scenario considers conditions on the site accounting for the existing site (CUMTD's District Office and the Maintenance Facility).

Scenario 4 – Green: This is an alternative scenario that uses stormwater management BMPs to reduce the quantity and rate of runoff generated by development on the site.

Conventional Sewer System

The first approach being the intrusive yet tested conventional sewer system linked to the main sewer line, which funnels stormwater out of the site and into treatment centers/storage facilities. This approach considers a typical development scenario, with 90% of the total land comprised of a built-up area. Standard sewer line sizes are selected, as depicted in the adjacent graph. Discharge capacity is also referenced based on the sizes described in the graph.

Overland Stormwater System

The second approach is to design an overland stormwater system based on on-site suitability characteristics and Best Management Practices (BMPs). The green development scenario considered in the Hydro Model leaves room for woodlands (4% of total area), with the built-up area being reduced to 64% as opposed to 90% built-up area in the conventional scenario. **This stormwater management system depends upon the green landscape layouts described in the previous section.**

The soil profile of the CUMTD District Office site at 1101 E University Ave (Urbana) is referenced from the Douglas Square Apartment site, which is in relatively close proximity, at 414 Nathaniel Burch Dr (Champaign). The composition of the soils is found to be mostly Class B soils (95.1%), with sporadic deposits of Class C soils (4.9%). The analysis of soil composition is required to model stormwater runoff based on soil imperviousness, which may or may not allow surface runoff.

Infiltration	Runoff	Class	Type	Class	Area (%)	Area (Acres)	Class (%)
High	Low	A	149A	B	16.5	9.85	95.1
Moderate	Moderately low	B	152A	B	44.6	26.63	
Slow	Moderately high	C	198A	B	34	20.30	
Very slow	High	D	154A	C	3.6	2.15	4.9
			663B	C	1.2	0.72	
			802B	C	0.1	0.05	

Table 7 Soil Area Composition at the Douglas Square Site

The diagram shown below depicts the contour profile of the area in which the CUMTD District Office is located in.

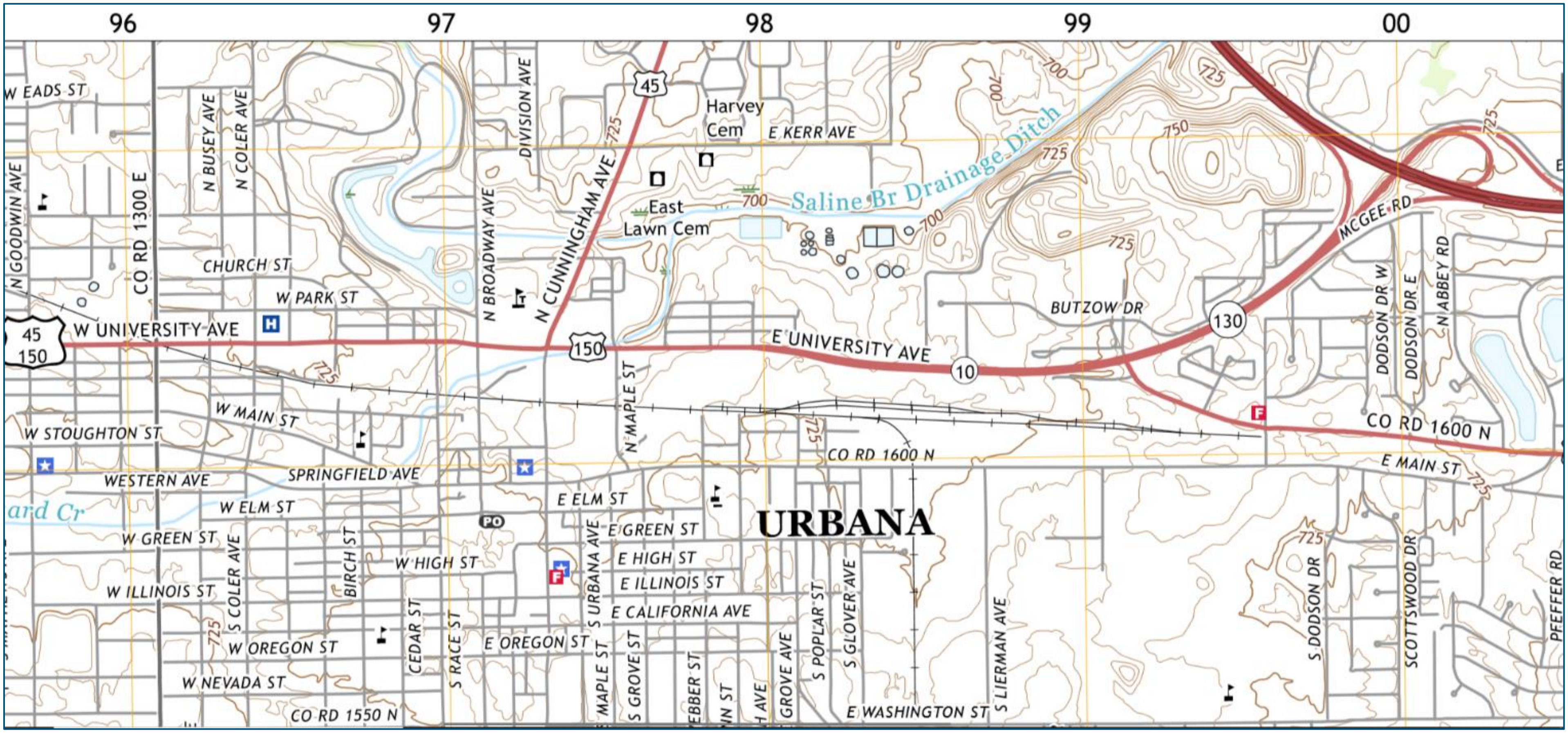


Figure 13 Urbana Topographical Profile. Src: USGS

The diagram below shows the calculated the hydraulic length for the site and estimated the direction the water would flow in; this data is used to situate the retention and detention ponds on the site and estimate the size requirements for the ponds.

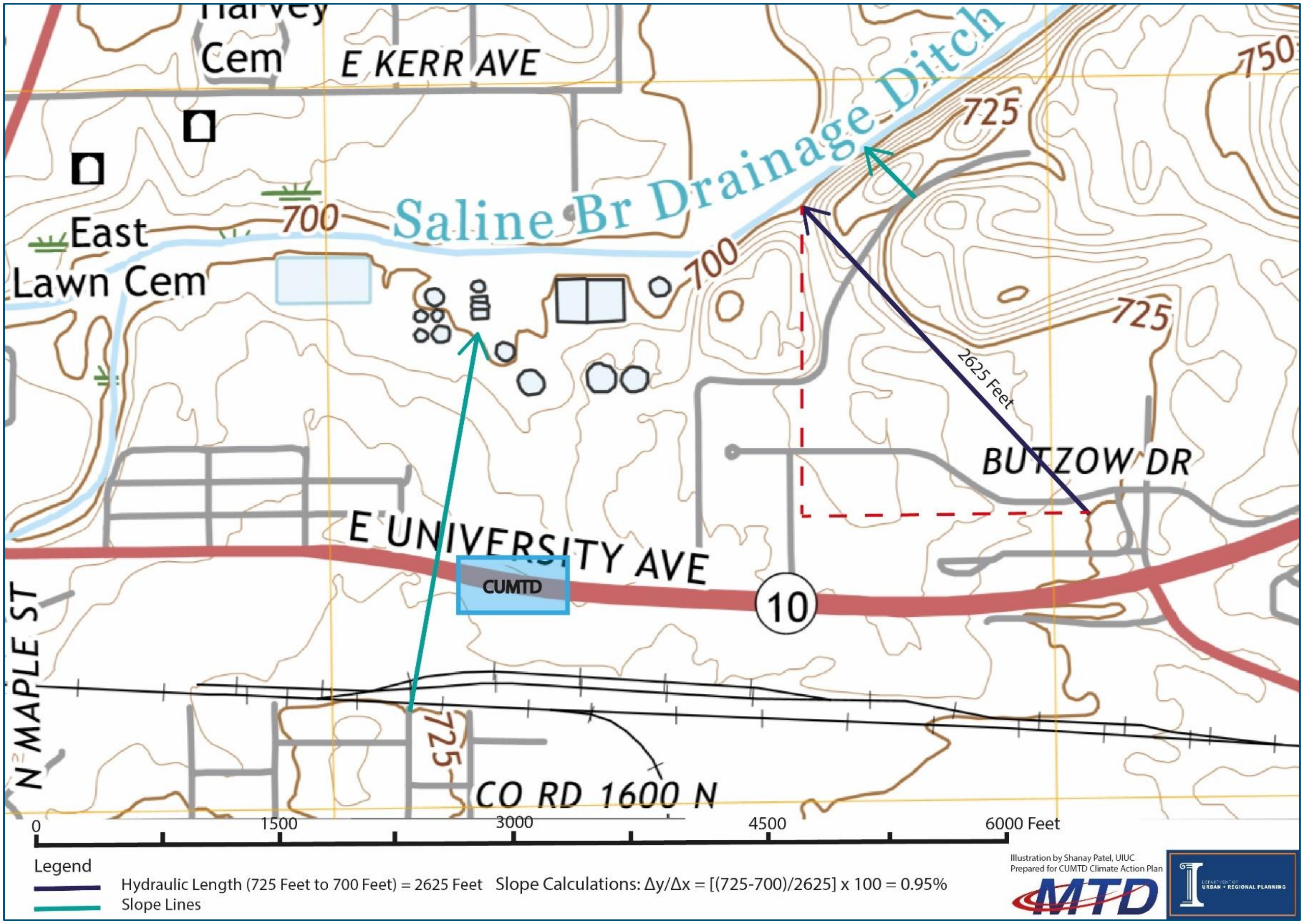


Figure 14 Hydraulic Length & Slope Calculations

HydroModel Results

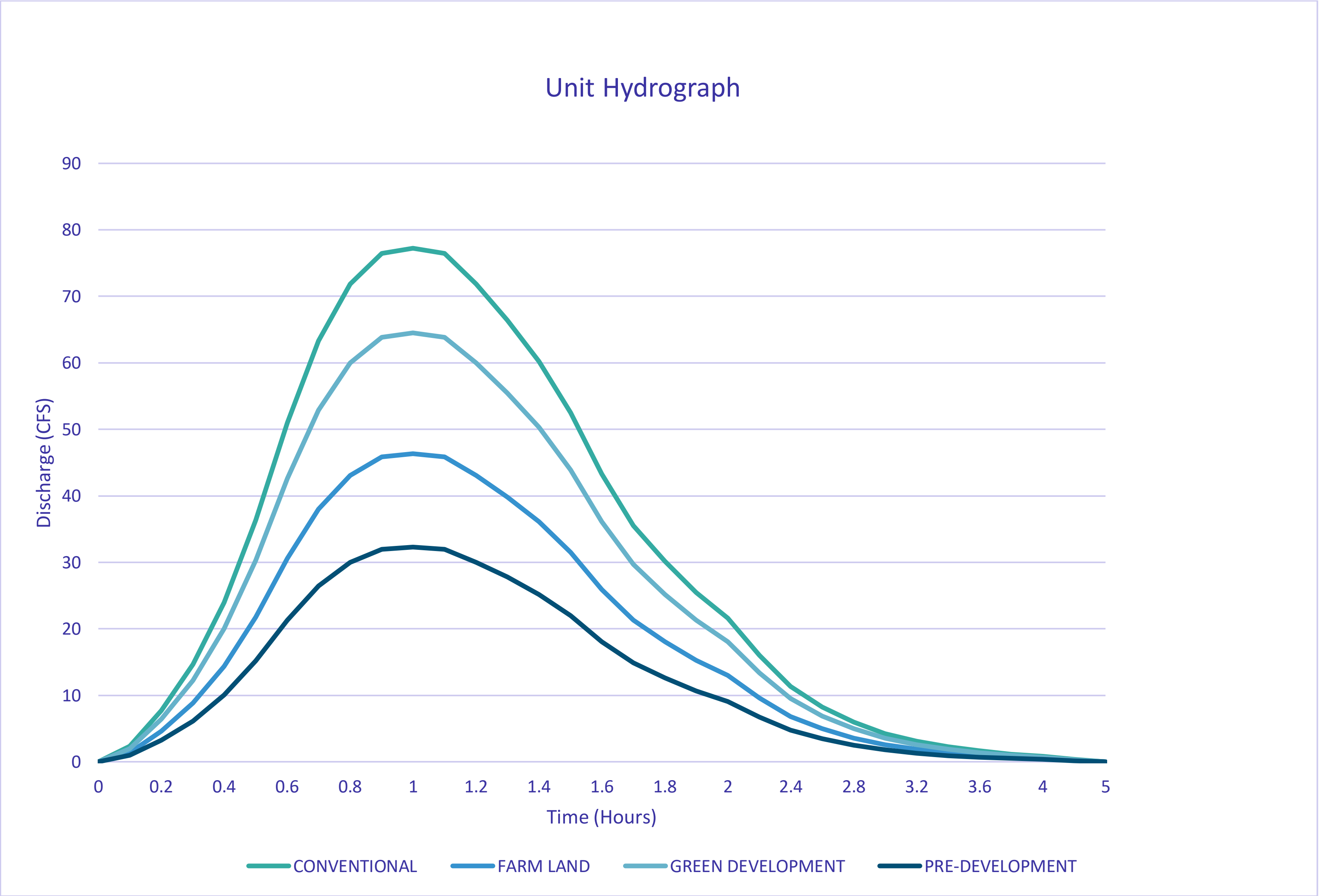


Figure 15 Unit Hydrograph (CUMTD District Office)

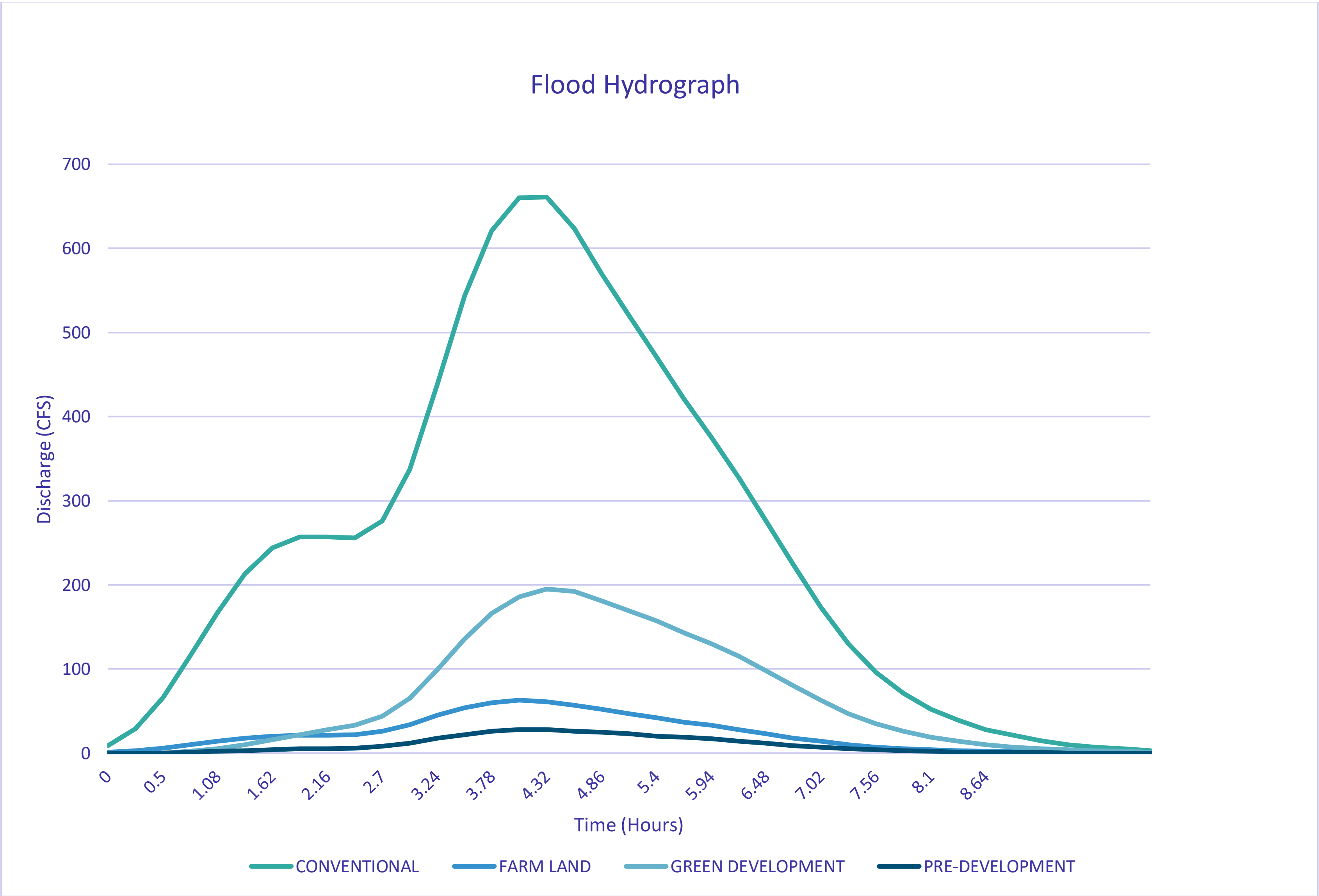


Figure 16 Flood Hydrograph (CUMTD District Office)

Inferences

The unit hydrograph shows a considerable difference in stormwater runoff conditions when viewed through the four different scenarios. The maximum runoff is stated to be approximately 77 CFS peaking relatively quickly at around 1 hour.

Predictably, the lowest runoff conditions are observed in the pre-development scenario. However, the stormwater condition in the green-development scenario trails the conventional development scenario condition by 13 CFS, peaking at 64 CFS.

The flood hydrograph outlines significant differences in the four stormwater runoff scenarios. It shows that Best Management Practices (BMPs) can reduce stormwater runoff from a peak of 660 CFS in 4 hours to 195 CFS.

The report puts a greater emphasis on the results of the flood hydrograph since it shows the worst-case scenarios (storm conditions), and this result can assist in arriving at a conservative estimate for this analysis, and the following basis for the selection of a stormwater system.

Retention & Detention Ponds: Case-I

The tables below show the calculations to arrive at the size of the retention and detention ponds. Reverse calculation of pond area from its volume yields an approximately rounded final volume of the ponds, which will be located on the site based on the direction of water flow.

Development Type	Imperviousness (%)	Retention Pond (Gallons)	Extended Detention (Gallons)
Low-density single family	20	19008	2715
Medium-density single family	35	21723	5431
Multi-family	50	27154	10862
Industrial Office	70	32585	13577
Commercial	**80-90**	**35301**	**21723**

Table 8 Imperviousness for Development Types (Conventional). Ref: UP503 Physical Planning (DURP, UIUC)

Dimension	Volume		Depth	Area	Length	Breadth	Pond Area	Area & %Total	
Unit	*(Gallons)*	*(CUFT)*	*(FT)*	*(SQFT)*	*(FT)*	*(FT)*	*(SQFT)*	*(Acres)*	*(%)*
Retention Pond	35301	4719	7	675	27	25	675	0.016	0.46
Detention Pond	21723	2904	7	415	27	16	432	0.010	0.29
Total Land Area (District Office & Maintenance Facility)								3.43	100

Table 9 Retention & Detention Pond Sizes (Conventional)

For Case-I, the Retention Pond is sized 30 x 25 x 7 feet and can store up to 4719 CUFT or 35301 US Gallons of water. The Detention Pond is sized 27 x 25 x 7 feet and can store up to 2904 CUFT or 21723 US Gallons of water, beyond which it would be required to release the detained water into the sewer system. The primary drainage point is the Saline Branch Drainage Ditch at an elevation 25 feet lower than the site (725-700 feet; steeper slope of 0.95%). These slope conditions would assist in the natural transportation of stormwater from the CUMTD District Office and the Maintenance Facility to the Saline Branch Drainage Ditch up north.

Case – I: Conventional Sewer System

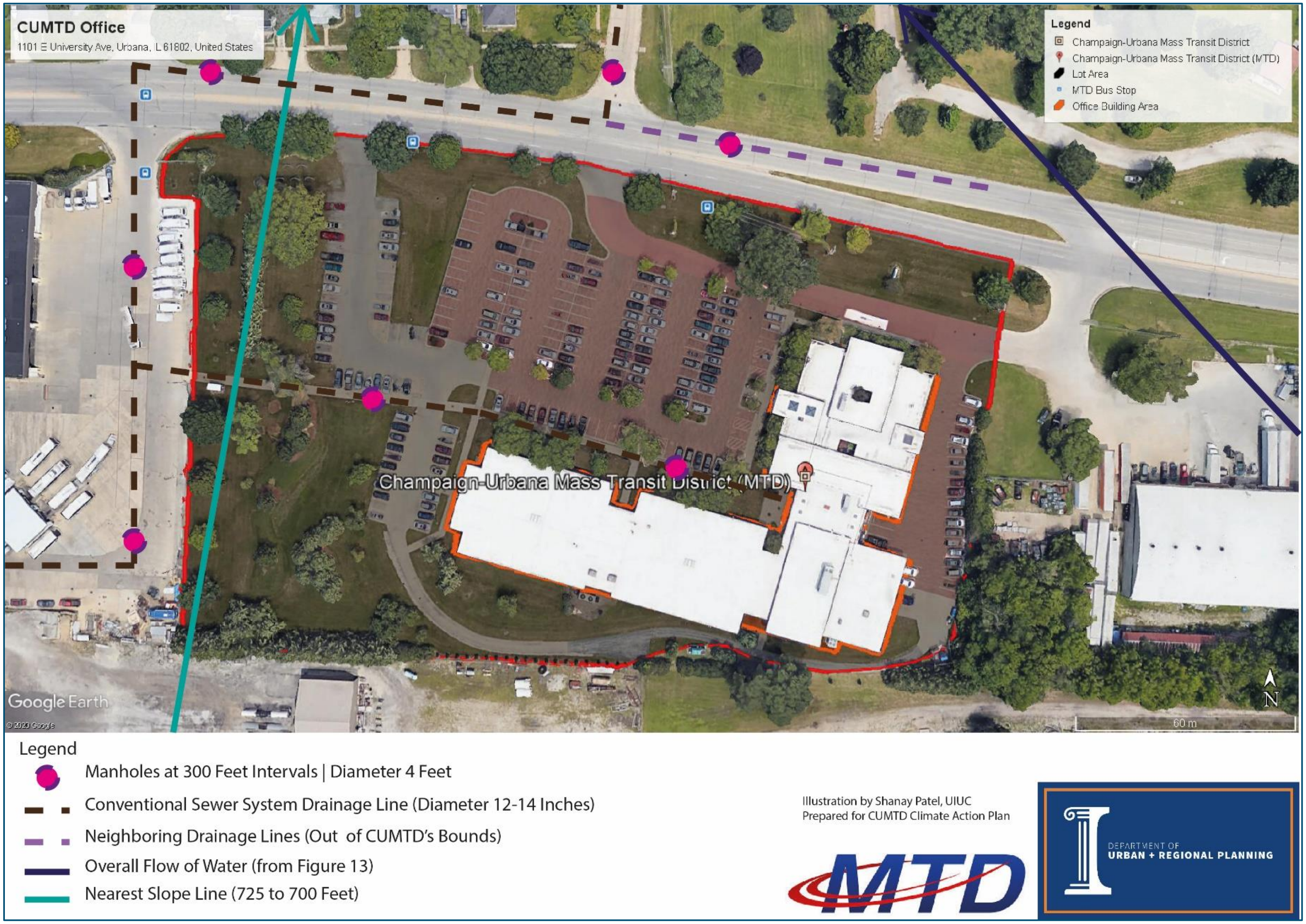


Figure 17 Conventional Sewer System (CUMTD District Office)

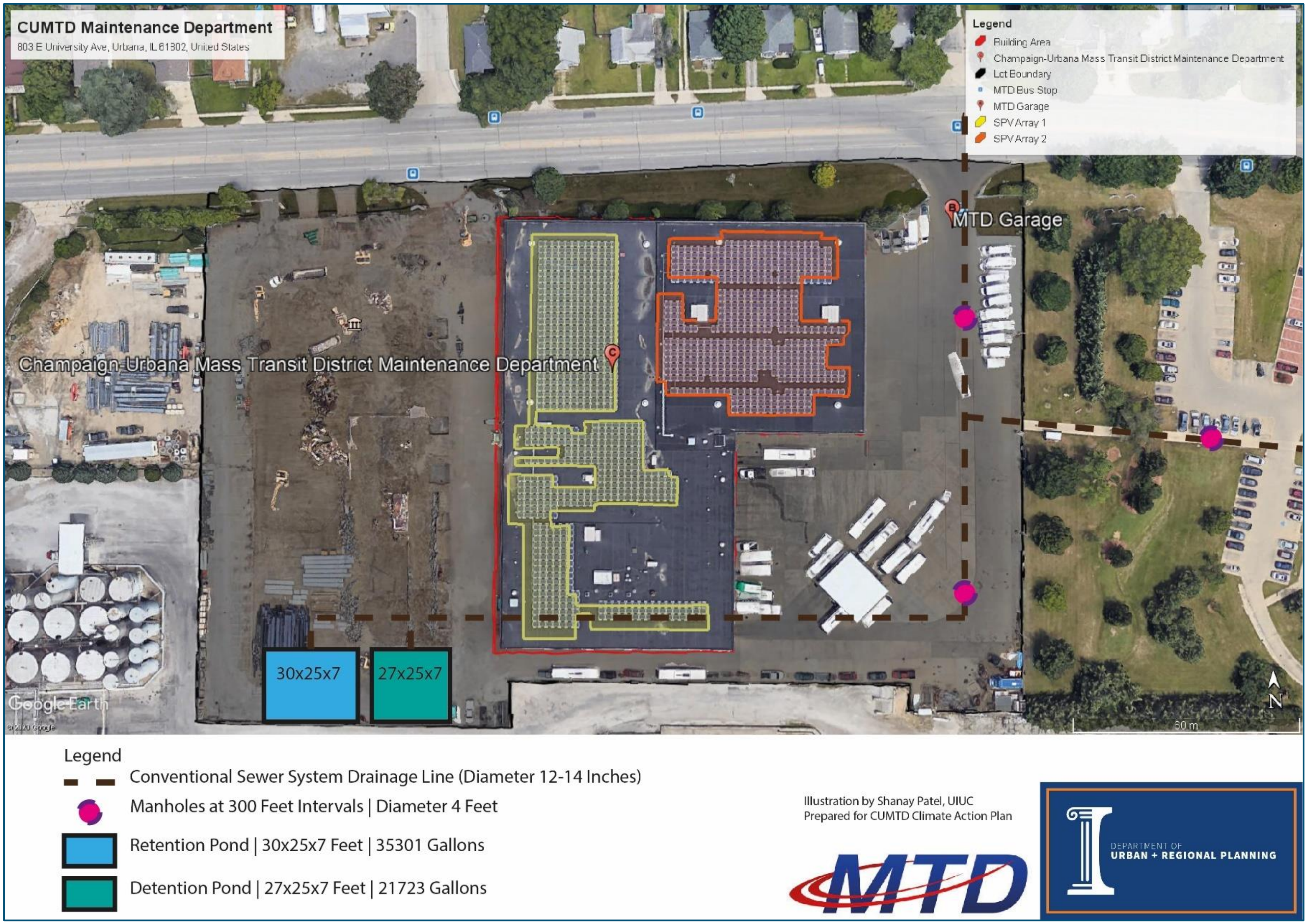


Figure 18 Conventional Sewer System (CUMTD Maintenance Facility)

Retention & Detention Ponds: Case-II

This case considers a 64% built-up area considering green infrastructure criteria. The green infrastructure scenario would result in reduced ponding requirements in terms of area. This is owed to the naturally pervious surfaces co-existing with the built environment.

Development Type	Imperviousness (%)	Retention Pond (Gallons)	Extended Detention (Gallons)
Low-density single family	20	19008	2715
Medium-density single family	35	21723	5431
Multi-family	50	27154	10862
Industrial Office	70	32585	13577
Commercial	**64**	**29870**	**12219**

Table 10 Imperviousness for Development Types (GI). Ref: UP503 Physical Planning (DURP, UIUC)

Dimension	Volume		Depth	Area	Length	Breadth	Pond Area	Area & %Total	
Unit	*(Gallons)*	*(CUFT)*	*(FT)*	*(SQFT)*	*(FT)*	*(FT)*	*(SQFT)*	*(Acres)*	*(%)*
Retention Pond	29870	3993	7	570	25	23	575	0.013	0.38
Detention Pond	12219	1634	7	233	25	10	250	0.006	0.17
Total Land Area								3.43	100

Table 11 Retention & Detention Pond Sizes (GI)

For Case-II, the Retention Pond is sized 25 x 23 x 7 feet and can store up to 3993 CUFT or 29870 US Gallons of water. The Detention Pond is sized 25 x 10 x 7 feet and can store up to 1634 CUFT or 12219 US Gallons of water. The primary drainage point is the Saline Branch Drainage Ditch at an elevation 25 feet lower than the site (725-700 feet; steeper slope of 0.95%), similar to the first case. However, this system will be served by bioswales instead of RCC/metal sewer pipes. A bioswale diagram is shown adjacently, for reference.

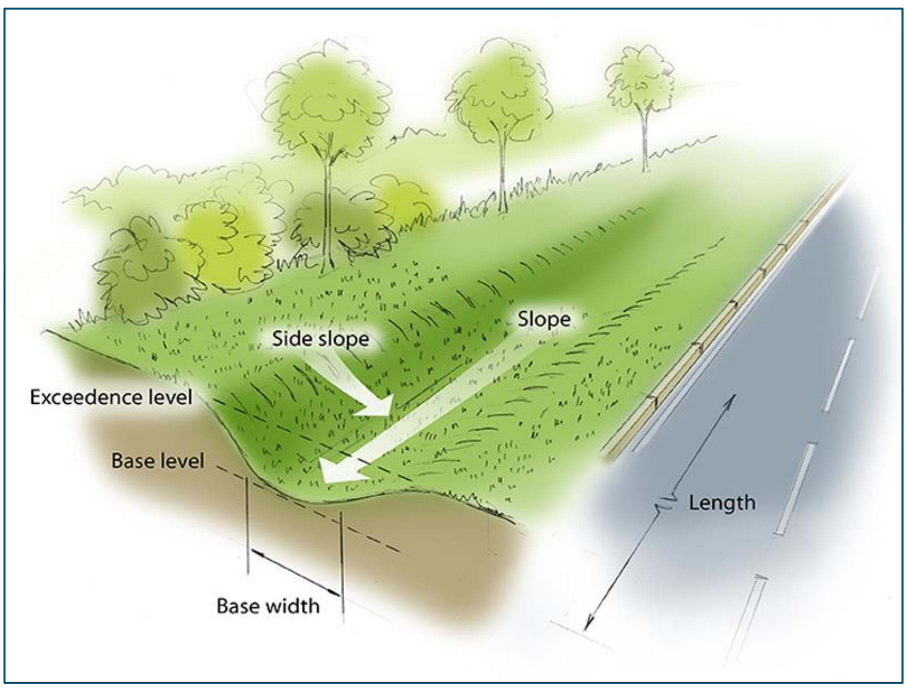


Figure 19 Bioswale. Src: Uncredited

Case – II: Overland Stormwater System

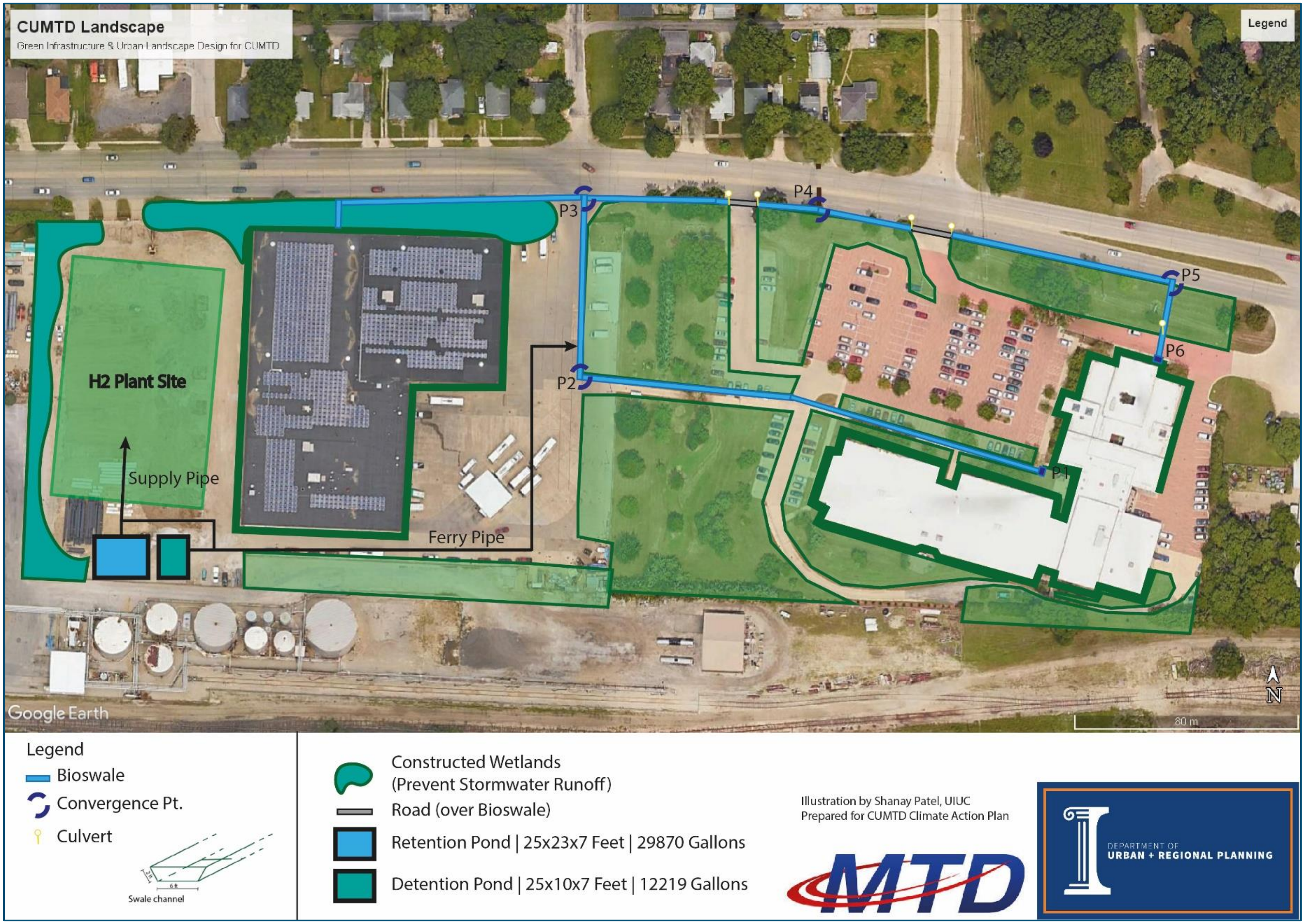
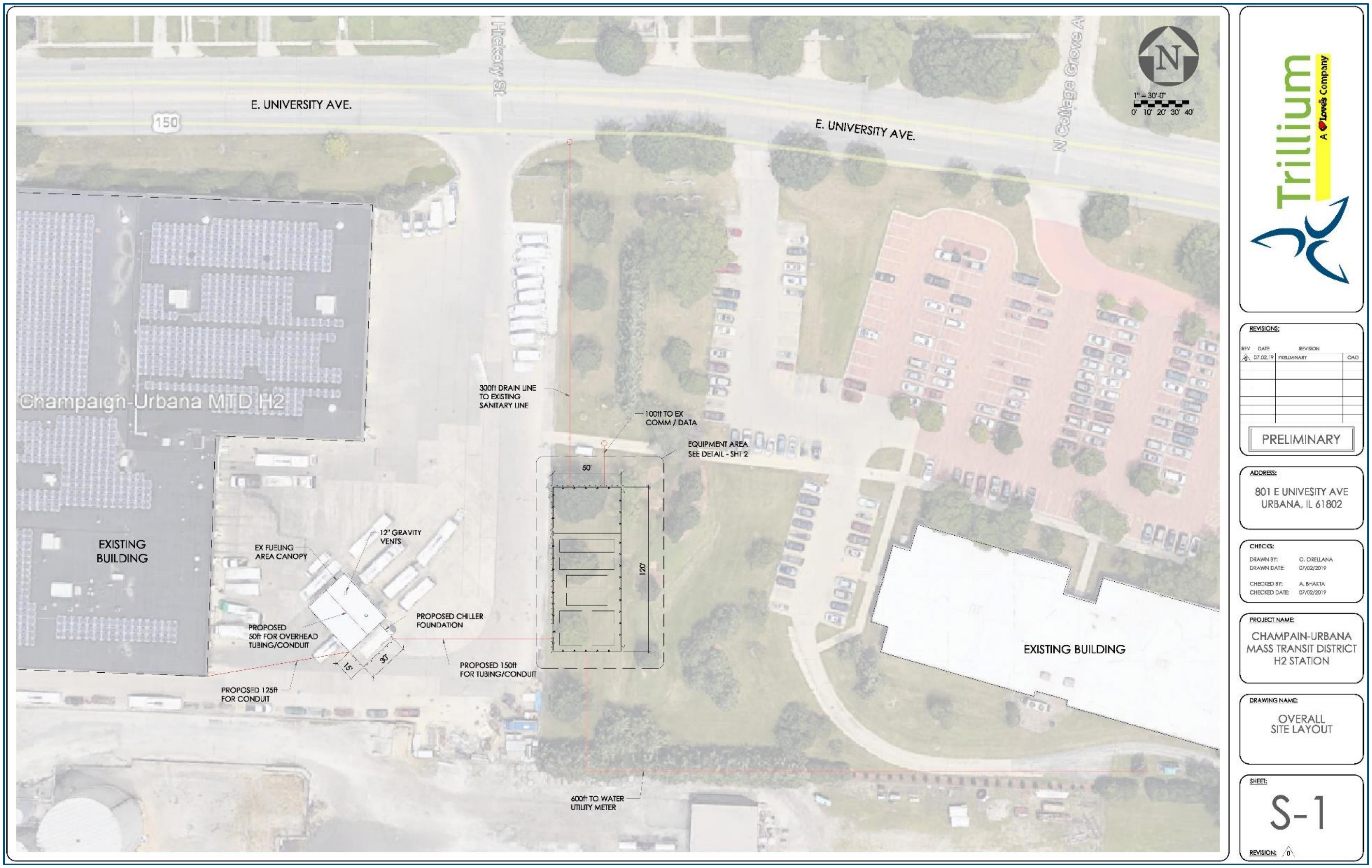


Figure 20 Overland Stormwater System

Conclusion

- For energy savings, power supply generated from the SPV arrays combined with the ECMs incorporated under the Energy Savings Performance Contract will enable the district office to be virtually carbon neutral. Excess power generated can be sold back to the local government for energy credits.
- We recommend considering between CNG or Hybrid-Electric Bus alternatives, considering the associated tradeoffs, in addition to the already planned FCEBs (H_2 Fuel Cell Buses).
- The new green landscape design provides for 80+ new trees, each providing 260 pounds of oxygen per year (upwards of 20,800 pounds of O_2/year). Each person inhales approximately 1.8 pounds of oxygen per day (675 pounds of O_2/year). Therefore, this design would boost sustenance capacity in terms of oxygen for 31 people.
- The stormwater management systems described in the previous section outlines conventional and green development approaches, with the green development approach being significantly less intrusive. Both the systems drain at the Saline Branch Drainage Ditch, north of the site.
- The conventional sewer system is laid out with manholes being provided no more than 600 feet apart. The 0.95% slope in the direction of the Saline Branch Drainage Ditch proves advantageous to both the sewer system. In the case of unfavorable slopes, a light-duty lift station or pumping facility can be provided on-site; however, this will entail additional costs; however, we do not anticipate this possibility due to the results of the slope survey.
- The constructed wetlands/woodlands may be erected in the western zone of the maintenance facility, adjacent to the detention pond. The maintenance of this system may incur relatively higher costs, but the system itself leaves a minimal impact on the surrounding ecology.
- We recommend that the water held in retention and detention ponds be used to supply the H_2 plant as that would potentially provide an excellent return on investment.

Appendix



Appendix 1 Site Layout for H2 Plant (Trillium)

			CONVENTIONAL				GREEN DEVELOPMENT			
Land Use Distribution		Land Use Description	A	B	C	D	A	B	C	D
(%)				95.1%	4.9%			95.1%	4.9%	
		Cultivated land								
		without conservation treatment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		with conservation treatment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Pasture or range land								
		poor condition	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		good condition	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Meadow; good condition	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Wood or forest								
	3	thin stand; poor cover, no mulch	0.00	0.00	0.00	0.00	0.00	2.85	0.15	0.00
	1	good cover	0.00	0.00	0.00	0.00	0.00	0.95	0.05	0.00
		Open spaces, lawns, parks, etc.								
10	17	good condition (75% grass)	0.00	9.51	0.49	0.00	0.00	16.17	0.83	0.00
	6	fair condition (50-75% grass)	0.00	0.00	0.00	0.00	0.00	5.71	0.29	0.00
77	64	Commercial and business (85% imp.)	0.00	73.23	3.77	0.00	0.00	60.86	3.14	0.00
		Industrial (72% impervious)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Residential								
		Average lot % impervious								
		=< 1/8 acre 65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		1/4 acre 38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		1/3 acre 30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		1/2 acre 25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		1 acre 38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	3	Paved parking lots, roofs, etc.	0.00	6.66	0.34	0.00	0.00	2.85	0.15	0.00
		Street and roads								
	2.5	paved with curbs and storm sewers	0.00	2.38	0.12	0.00	0.00	2.38	0.12	0.00
	3	gravel	0.00	2.85	0.15	0.00	0.00	2.85	0.15	0.00
	0.5	dirt	0.00	0.48	0.02	0.00	0.00	0.48	0.02	0.00
		Sub-total	0.00	95.10	4.90	0.00	0.00	95.10	4.90	0.00
		TOTAL		**100.00**				**100.00**		

Appendix 2 HydroModel Inputs (Conventional & Green Development)

			PRE-DEVELOPMENT				FARM LAND			
Land Use Distribution		Land Use Description	A	B	C	D	A	B	C	D
(%)		Class (%)		95.1%	4.9%			95.1%	4.9%	
70		Cultivated land								
	45	without conservation treatment	0.00	0.00	0.00	0.00	0.00	42.80	2.21	0.00
	25	with conservation treatment	0.00	0.00	0.00	0.00	0.00	23.78	1.23	0.00
30		Pasture or range land								
	5	poor condition	0.00	0.00	0.00	0.00	0.00	4.76	0.25	0.00
	25	good condition	0.00	0.00	0.00	0.00	0.00	23.78	1.23	0.00
60		Meadow; good condition	0.00	57.06	2.94	0.00	0.00	0.00	0.00	0.00
40		Wood or forest								
	25	thin stand; poor cover, no mulch	0.00	23.78	1.23	0.00	0.00	0.00	0.00	0.00
	15	good cover	0.00	14.27	0.74	0.00	0.00	0.00	0.00	0.00
		Open spaces, lawns, parks, etc.								
		good condition (75% grass)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		fair condition (50-75% grass)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Commercial and business (85% imp.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Industrial (72% impervious)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Residential								
		Average lot % impervious								
		=< 1/8 acre 65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		1/4 acre 38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		1/3 acre 30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		1/2 acre 25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		1 acre 38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Paved parking lots, roofs, etc.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Street and roads								
		paved with curbs and storm sewers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		gravel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		dirt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Sub-total	0.00	95.10	4.90	0.00	0.00	95.10	4.90	0.00
		TOTAL		**100.00**				**100.00**		

Appendix 3 HydroModel Inputs (Pre-development & Farmland)

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