George Mason University

Master Plan
Phase Two Report

Appendix

December 2021

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HERITAGE EVALUATION

CANNONDESIGN

HERITAGE EVALUATION

The heritage evaluation identified and catalogued places of historic and cultural value across the Fairfax campus. It focused on an analysis of some of the oldest buildings on the Fairfax campus to determine their historic architectural value, and the likely ease of their conversion for modern uses. This analysis centered on the six buildings surrounding the original academic quad – East, Fenwick A, Finley, Krug, Lecture Hall, and West buildings. We recognize this is a sensitive topic, particularly as these historic buildings were the first on campus, and represent the totality of the Mason experience for many alumni. At the same time, the buildings must also be looked at through a lens of practicality. Our aim is to identify nostalgic value, historic value, and the likely return on reinvestment. Inherently, older buildings were not always constructed with accessibility or modern learning, research, and working modalities in mind. Furthermore, the cost of addressing deferred maintenance and extensive renovations to bring these buildings up to modern standards may not match the value proposition of replacing the buildings.

The analysis, described on the following pages, determined Fenwick A should be preserved, but the original four historic buildings and the Lecture Hall should be replaced with buildings that can support modern pedagogy and research. Once removed, the buildings should be appropriately memorialized through appropriate virtual and/or physical exhibits.

ACADEMIC CORE – CAMPUS QUAD

SUMMARY

The area of the proposed new northern quadrangle currently holds the original buildings used to establish the university: Finley, West, East, Krug Hall, and the Lecture Hall. Although these buildings have sentimental value because of this history, they can no longer offer the best educational environments needed for 21st century teaching and learning. Due to low ceiling heights, small corridor widths, and outdated mechanical systems, the buildings cannot easily be adapted to other uses. With the exception of Fenwick A, after careful review, we conclude the buildings do not have significant architectural features. Given the significant real estate value in this part of campus, we therefore recommend the demolition (and memorialization) of the four historic buildings and the old Lecture Hall.

OVERALL CONDITION OF OPEN SPACE: GOOD/FAIR

- Trees are in good condition and seem to date to establishment of the buildings
- Open space is landscaped well
- Average drainage towards storm system. No sign of flooding issues.
- Accessibility issues at times at covered walkways.

SUMMARY RECOMMENDATION

The shape of the quad has pleasing proportions relative to the height of its surrounding buildings. Walkways are wide enough to allow for proper pedestrian circulation, and the trees are well maintained (although 20 additional years of growth may negatively affect the space of the trees from each other and from the buildings). We recommend preserving the quad in some fashion so as to acknowledge the history of the campus, and the original trees.

ACADEMIC CORE – FINLEY, WEST, EAST, AND KRUG BUILDINGS

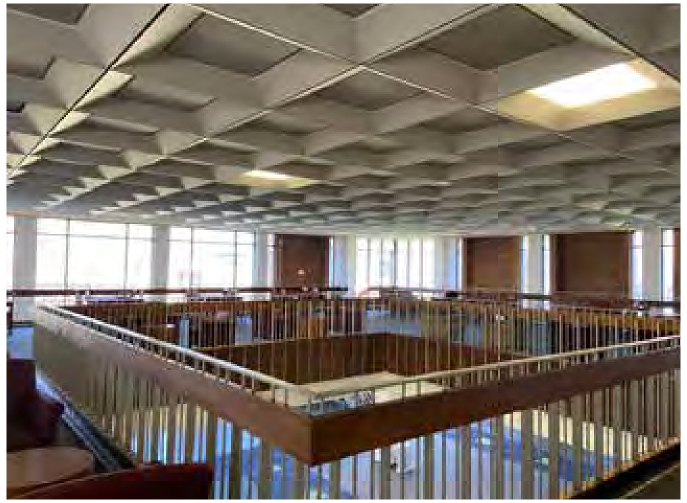
OVERALL CONDITION OF BUILDINGS: POOR

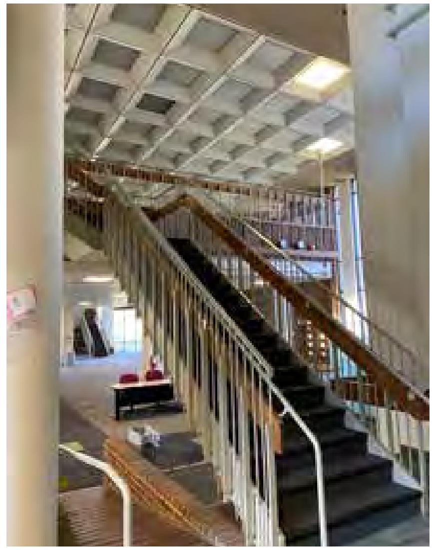
- Single pane windows
- Low floor to floor heights for 21st century learning spaces
- Small classroom sizes
- Narrow corridors
- Not up to ADA accessibility code
- Entry into building is challenging

SUMMARY RECOMMENDATION

These are the buildings of the original campus quad. The condition of the buildings is poor - the low floor-to-floor heights and small classrooms do not make renovation advisable. This location on campus is ideal for new buildings with latest technologies, and more energy efficient systems. We therefore recommend taller buildings that provide greater density and better use of a prime location on campus.

The buildings should be memorialized through appropriate exhibits and/or memorials that could be interpretive, physical, or virtual.



FENWICK A

OVERALL CONDITION: GOOD

- Single pane windows
- Good natural daylight on all sides with large expanses of glazing
- Open center atrium on second floor with unique visual connectivity to the lower floor
- High ceiling
- Not up to ADA accessibility code
- Entry into building is challenging
- Architecture details are reminiscent of its era

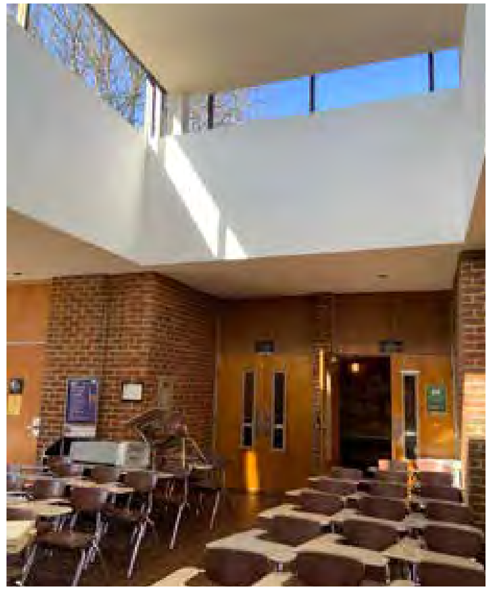
POINTS FOR FURTHER DISCUSSION

- Original building to campus
- The building could be easily adapted to other uses, especially assembly such as a ballroom or conference space. Note that it is currently classified by the Commonwealth for library use only, so this would need to change.

SUMMARY RECOMMENDATION

Fenwick A has a unique interior architecture that is reminiscent of its era. Having large expanses of glass on three sides makes the building desirable. The coffered ceiling and podium-like second floor floating in the space makes it a unique building and also allow for the large room to be easily adapted to other uses such as a ball room or other large event space. The university can also consider demolition of the connector between the A-wing and the towers. This has previously been considered as part of an idea that looked at wrapping the towers to finish the addition of 2015.



LECTURE HALL

OVERALL CONDITION: POOR

- Single pane windows
- Low floor-to-floor heights for 21st century learning spaces
- Small classroom sizes and a 317-seat lecture hall
- Narrow corridors
- Not up to ADA accessibility code
- Lecture Hall has small stage, exposed HVAC ducting and poor acoustics

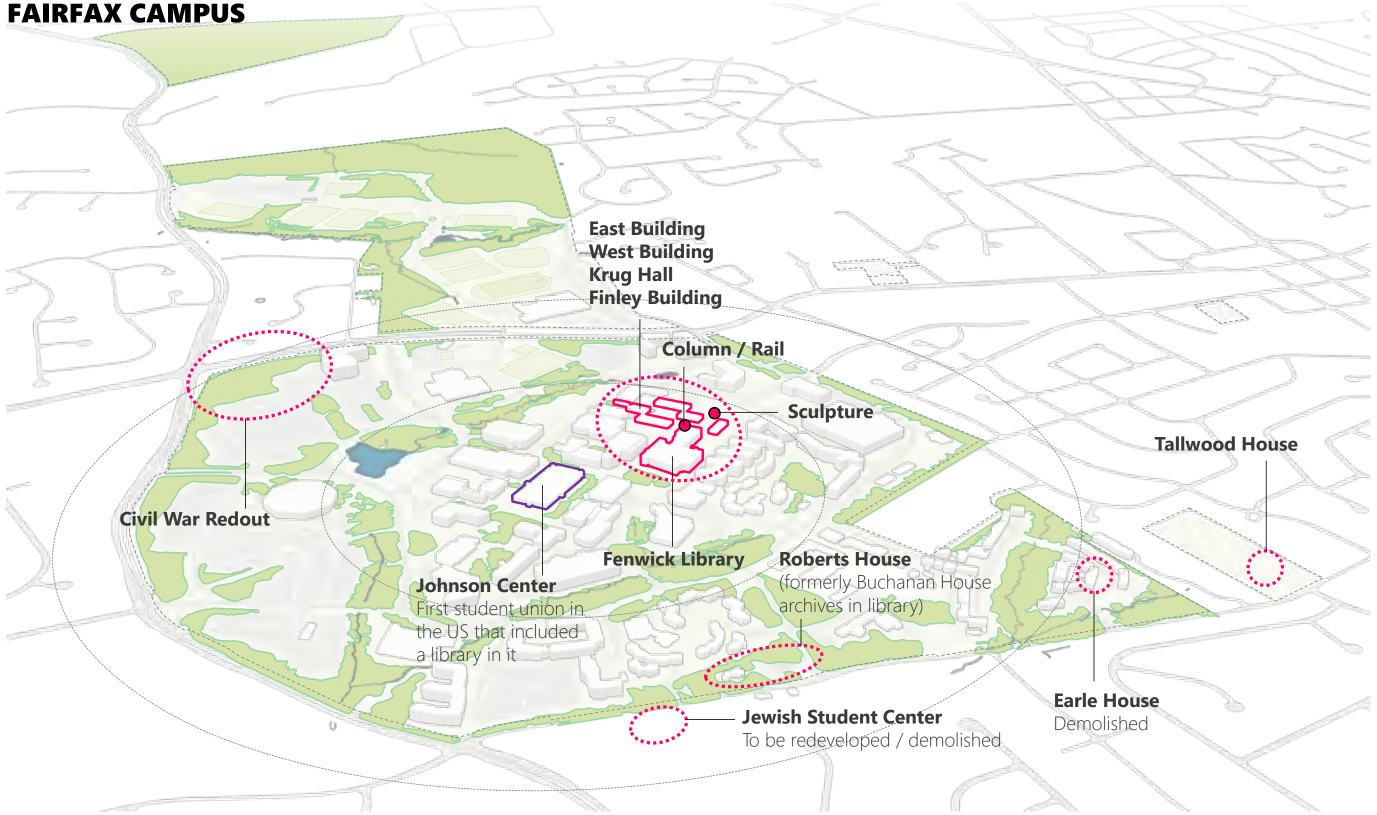
SUMMARY RECOMMENDATION

Due to the prime location of this building near the main entry of campus, the building should be razed for a more ideal building that provides more density and a more ideal learning environment with modern technological advancements.

OTHER HISTORICAL AREAS OF NOTE

ARLINGTON CAMPUS
Department Store: to be demolished

FAIRFAX CAMPUS



SCITECH CAMPUS
Mercer Library: name controversy

OTHER HISTORICAL AREAS OF NOTE

SUMMARY

The Fairfax campus has a rich heritage, and contains several important historical sites. Note that we could not locate all sites listed on the university's internal historic list (the "column/rail" and the "sculpture" in the campus quad). Items dating to the civil-war era have been identified in the wooded lot near the Ox Road and Braddock Road intersection. Note that the civil war redoubt includes historically sensitive areas that extend into Lot K. Any development in this area will therefore likely require an archaeological survey.

ROBERTS HOUSE

OVERALL CONDITION: GOOD

- Single pane windows
- Lap boards have been updated

SUMMARY RECOMMENDATION

Maintain the house and grounds in their current state. As the original President's house, and later home used by a Nobel-Prize-winning professor, the recommendation is to keep and memorialize the house with a historic marker or explanation plaque describing its significance.

MOBILITY

GOROVE SLADE

EXECUTIVE SUMMARY

PLAN GOALS

The transportation element of the master plan aims to accomplish the following goals:

- Improve connectivity within the Fairfax campus and between campus and surrounding areas
- Further the university's sustainability goals by investing in and encouraging the use of low-carbon modes of transportation
- Increase safety for all by reducing conflicts between transportation modes
- Reduce the university's financial burden by avoiding the construction of new parking decks and surface lots where possible
- Accommodate the university's growth and need for new facilities
- Maintain appropriate levels of access for users with accessibility needs

STRATEGIES TO ACCOMPLISH PLAN GOALS

We propose to address these goals through the following primary strategies:

1. Continue Mason's evolution from a car-oriented, commuter campus into a multimodal campus
2. Remove mobility barriers on campus edges
3. Decrease the parking demand on campus per student/employee

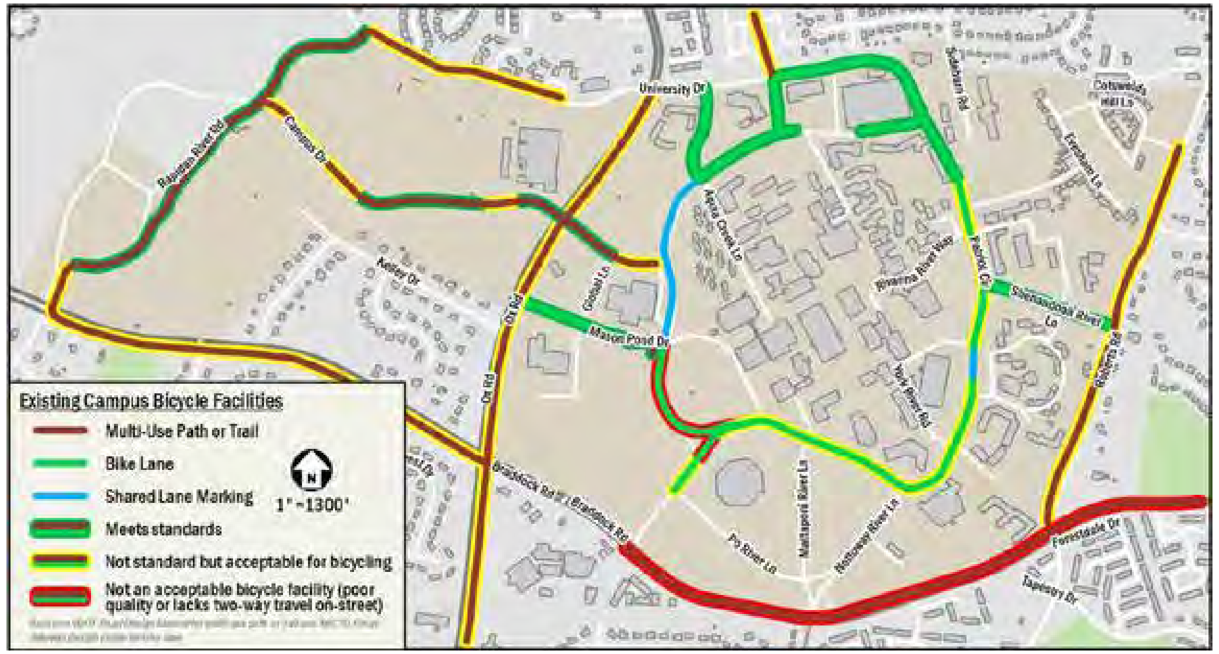


Figure 1.

Figure 2.

CONTINUE THE EVOLUTION OF MASON FROM A CAR-ORIENTED, COMMUTER CAMPUS INTO A MULTIMODAL CAMPUS

Despite the number of students, faculty, and staff living close to the Fairfax campus, the lack of pedestrian and bicycle connections to campus make walking or bicycling inconvenient or unsafe in many places. Roughly 20% of faculty/staff and off-campus students live within a 10-minute bike ride of campus. Still, most nearby residential neighborhoods lack bicycle connections that directly link to campus, as shown in the adjacent diagrams.

As shown in the first diagram on the next page, the neighborhoods to the immediate southeast and northwest of campus contain clusters of off-campus student residences. However, to access campus from these neighborhoods on foot or bike, students must cross a multi-lane highway in either Braddock Road or Ox Road/Chain Bridge Road. Both of these roads lack adequate bicycle and pedestrian facilities. For example, several students live in the Kings Park West neighborhood, which is accessible from the intersection of Braddock Road and Carriagepark Road. On the north side of Braddock Road at this intersection, a staircase leads up a hill into campus. However, no traffic signal or even a crosswalk provides a safe crossing here. Pedestrians clearly cross Braddock Road here and use this staircase to enter campus, as evidenced by the worn ground on the otherwise grassy Braddock Road median. Moreover, this campus entrance is completely inaccessible to wheelchair users and students with mobility issues. Although a multi-use path runs along the south side of Braddock Road, it is narrow and in poor condition. Multimodal connections are lacking at other campus access points as well

Figure 3.

Figure 4.

– on the northern end of campus, University Drive lacks a sidewalk on its north side leading up to Ox Road and has no bicycle facilities west of George Mason Boulevard, both of which create a critical gap in infrastructure.

In an online survey, students, faculty, and staff indicated several locations on campus where they felt unsafe due to roadway conditions. Locations most frequently reported as unsafe include the Ox Road/University Drive intersection, several intersections along Braddock Road adjacent to campus, Patriot Circle between Peterson Hall and University Drive, and the intersection of Patriot Circle and Nottoway River Lane. A map of all survey responses is shown in the lower diagram on the adjacent page.

Objectives of this strategy for the master plan include:

- Promote low-carbon transportation to reach sustainability goals
- Create a multimodal network within the campus.
- Reduce the need for parking facilities
- Accommodate students, faculty and staff living in nearby neighborhoods for convenient, safe, and sustainable travel
- Address safety concerns of campus population
- Manage the impact of event traffic to Eagle Bank Arena and CFA and other venues, particularly on weeknights
- Rework Patriot Circle and its outlet points to accommodate the university expanding its built footprint on campus

REMOVE MOBILITY BARRIERS ON CAMPUS EDGES

As it currently exists, the Fairfax campus lacks a "front door," or in other words, a grand, inviting entrance to campus that is both visually compelling and easily accessible. Most entrances to campus, particularly along Braddock Road at Sideburn Road and at the intersection of Ox Road and University Drive, indicate the location of campus but offer no sense of place and only minimal multimodal facilities. As a result, despite the abundance of pedestrian paths, crosswalks, and bike lanes along Patriot Circle and in the campus core, traveling on foot or bike between the entrance and core is difficult and potentially dangerous.

Not only are connections missing between campus entrances and inner campus, but they are also missing between the campus and nearby points of interest. As discussed in the first strategy, few high-quality multimodal facilities link the Fairfax campus to student and faculty residences nearby, hindering the university's potential for promoting sustainable travel. It is also inconvenient to travel by foot or bike between campus and other nearby destinations such as the University Mall and Old Town Fairfax. For example, to reach the University Mall, pedestrians must cross six (6) or seven (7) lanes of traffic (depending on the side of the street) on a major arterial road along a 90 or 100-foot crosswalk. Long crossing distances discourage and endanger bicyclists and pedestrians, especially across busy roads. Reaching Old Town Fairfax can also be inconvenient – while there is a multi-use path along George Mason Boulevard, there are no bicycle facilities along Ox Road/Chain Bridge Road north of campus, and the path along Roberts Road is in poor condition and is not continuous all the way to Old Town. University Drive is narrower and less busy than Braddock Road; however, the bicycle lanes on Aquia Creek Lane dead end at University at a right-in, right-out only with no place for bicycles or pedestrians to cross the street. This lack of through routes for bicyclists cause many to ride through the campus core, causing conflicts with pedestrians.

Objectives of this strategy for the master plan include:

- Improve convenience of access between campus and Old Town and between campus and nearby residential neighborhoods

- Divert bicycle through-traffic away from campus core

- Reduce conflicts between regional vehicular through traffic on Braddock Road and local multimodal traffic to and from campus

DECREASE THE PARKING DEMAND ON CAMPUS PER COMMUTER

The university has plans to expand its academic footprint on campus. Most of the remaining campus land east of Ox Road that is not used for buildings or environmental conservation is currently occupied by parking. Converting these parking lots into garages or building new lots or garages elsewhere is expensive, and the university aims to maximize the space available on the Fairfax campus. Any new parking lots built would be located in West Campus and may be perceived as less desirable since drivers must take a shuttle or ride a bike from the lot to campus. Therefore, it is essential to reduce the demand for parking on campus so that the university may expand with minimal investment in costly new parking facilities.

Several programs at the university serve to encourage students and employees to use the university's transportation network, including parking resources, in the most efficient way. Known as transportation demand management (TDM), these measures aim to shift the university population's transportation needs to times and locations that are not already at capacity as well as to sustainable modes of travel.

The university has been successful with a variety of programs so far. Providing a shuttle system and offering free rides on the CUE bus allow students to live off-campus without needing to drive to class. Full-time faculty and staff are eligible for the Commuter Choice benefits program where they can receive yearly subsidies for taking public transit or bicycling to work. Although the shuttle and CUE systems connect to the Metrorail Orange Line, student/employee Metrorail and Metrobus rides are not directly subsidized by the university. The VRE commuter-rail service could potentially also be expanded to help reach western commuters.

Several existing incentives also promote bicycling to the campus population. In 2019, the university was recognized as a Bicycle Friendly University, with a silver level distinction for the Fairfax campus and a bronze level distinction for the Arlington campus. The Patriot Bike Check-Out Program provides free one-day bike rentals, and students can purchase Capital Bikeshare memberships at a discounted rate. However, there are no Capital Bikeshare stations within several miles of the Fairfax campus (the city does have near term plans to expand the program). There is a station at the Arlington campus.

Objectives of this strategy for the master plan include:

- Save money by eliminating the need to build expensive garages
- Utilize land currently occupied by surface parking lots for university growth
- Reduce the number of cars on campus and improve safety for all road users
- Encourage sustainable modes of transportation

RECOMMENDATIONS

We propose to execute these strategies through four primary recommendations:

1. Rework the campus roadway network to improve multimodal access with minimal impacts to vehicular operations

2. Create enhanced "front doors" to campus to improve integration with surroundings, provide a landing point and sense of place, and improve multimodal access

3. Continue to encourage the use of non-auto transportation through building upon the existing Transportation Demand Management (TDM) plan

4. Refrain from building additional parking capacity in campus core

Figure 5.

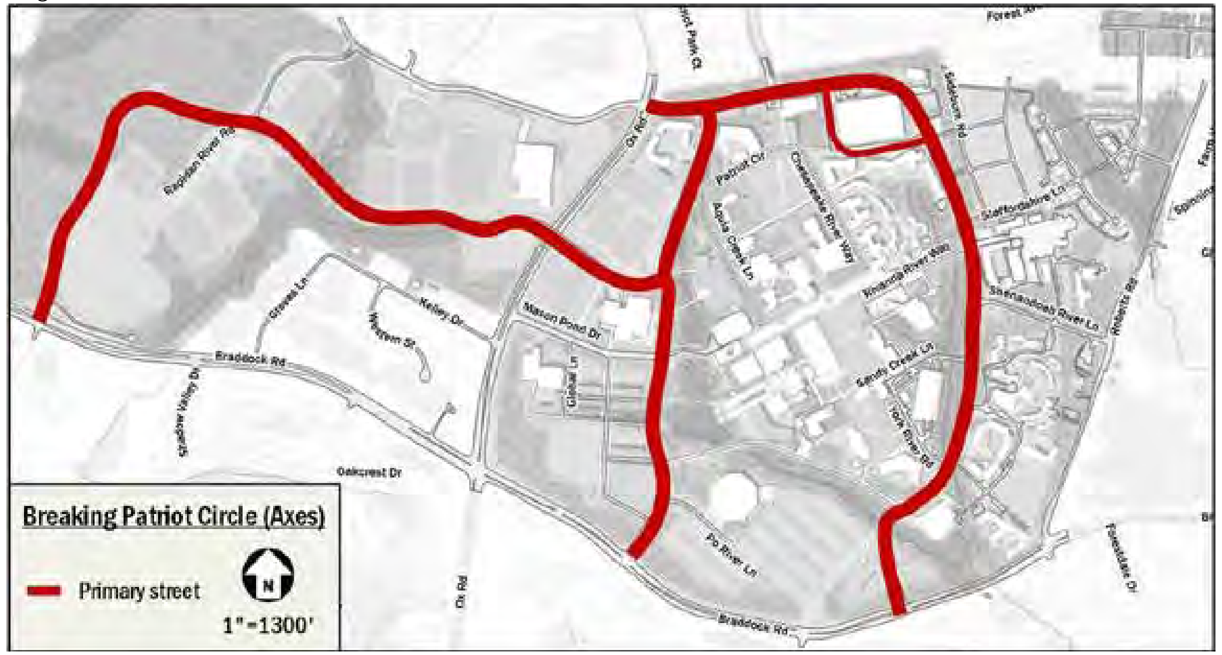


Figure 6.

1. REWORK THE CAMPUS ROADWAY NETWORK TO IMPROVE MULTIMODAL ACCESS WITH MINIMAL IMPACTS TO VEHICULAR OPERATIONS

This plan recommends reorganizing the Fairfax campus roadway system into a three-tiered hierarchy of streets as shown in Figure 5. Main roads, such as University Drive and the north-south axes of Patriot Circle, are primarily oriented towards vehicular traffic but have separated multimodal facilities. The major function of these main roads will be to transport vehicles between campus entrances and parking facilities. Managed streets, such as the east-west axes of Patriot Circle and the portion of Aquia Creek Lane south of Patriot Circle, will function as primary multi-modal corridors. Vehicular access will be restricted to authorized vehicles only during peak travel periods, and access will be controlled by gates or other physical barriers. Managed streets also serve as important transit corridors and may or may not have on-street parking. Finally, secondary roads, including all existing and future minor roads on campus, will serve local traffic at slow speeds with on-street parking on one or both sides of the street.

Also, as part of reworking the roadway network, this plan recommends “breaking the circle” of Patriot Circle so that it functions as two pairs of axes with one oriented east-west and one oriented north-south as shown in Figure 6. As described above, the east-west axes would function as slow, multimodal, restricted-access streets while the north-south axes would function as primary roads, similar to how Patriot Circle functions today.

This realignment would make significant strides towards achieving the goals of this plan. Firstly, it would increase the size of the pedestrian-friendly campus core. With the southern and northern edges of the circle now turned into easily crossable multimodal

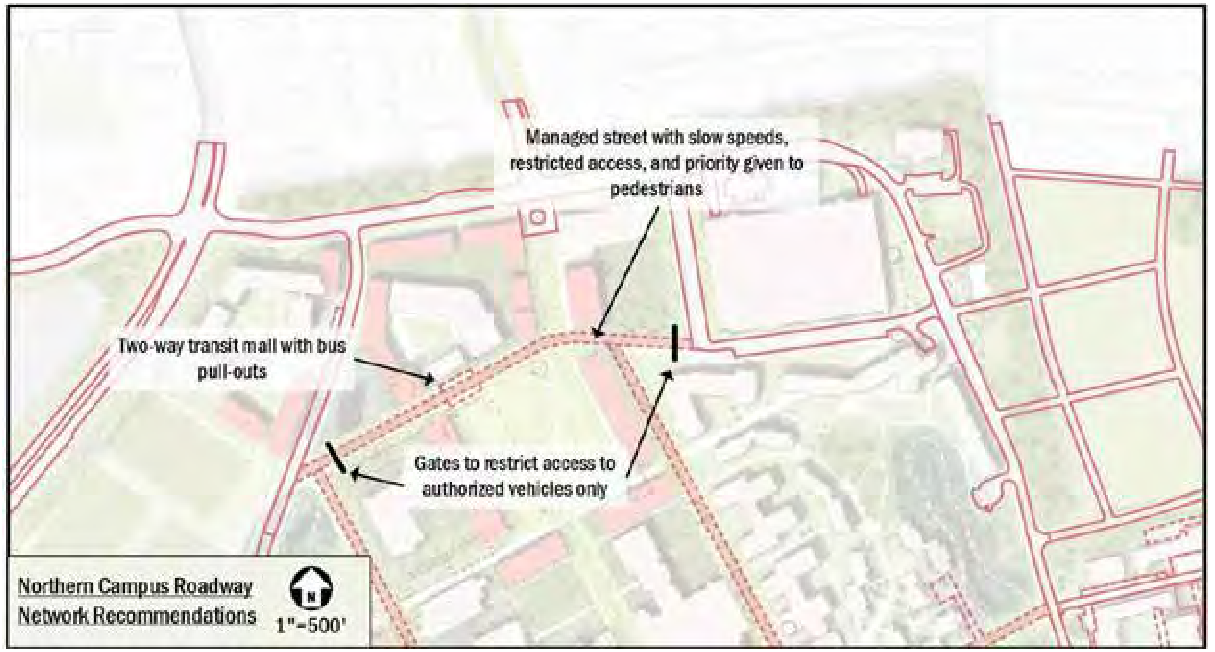


Figure 7.

streets, the mostly car-free heart of the Fairfax campus would extend all the way from University Drive south to Braddock Road. The new roadway network would also greatly reduce intermodal conflicts by prioritizing bicycle and pedestrian safety in some of the most high-conflict spots on campus. Northern Patriot Circle would be safer and more inviting to cross, and the high-activity areas adjacent to it would be easier to reach. As a result of this increased connectivity on the northern side of campus, this plan recommends relocating the Rappahannock River Lane shuttle stop to the Patriot Circle managed street just south of Peterson Hall. As a two-way transit mall with bus pull-outs along the road would simplify shuttle and bus routing, and the new location along the managed street would make it a shorter walk from most spots on campus and safer to access than the current stop location. The specifics of the northern campus recommendations are shown in Figure 7.

These major geometry changes could be accomplished while maintaining access to existing parking facilities. All three major parking garages on the Fairfax campus will be accessible by a primary road, so that commuters can access these garages without needing to request authorization to enter the managed streets. Drivers who use ADA parking spaces or others who need to access the campus core by vehicle can be let into the managed street either by an automatic gate or by a manual operator.

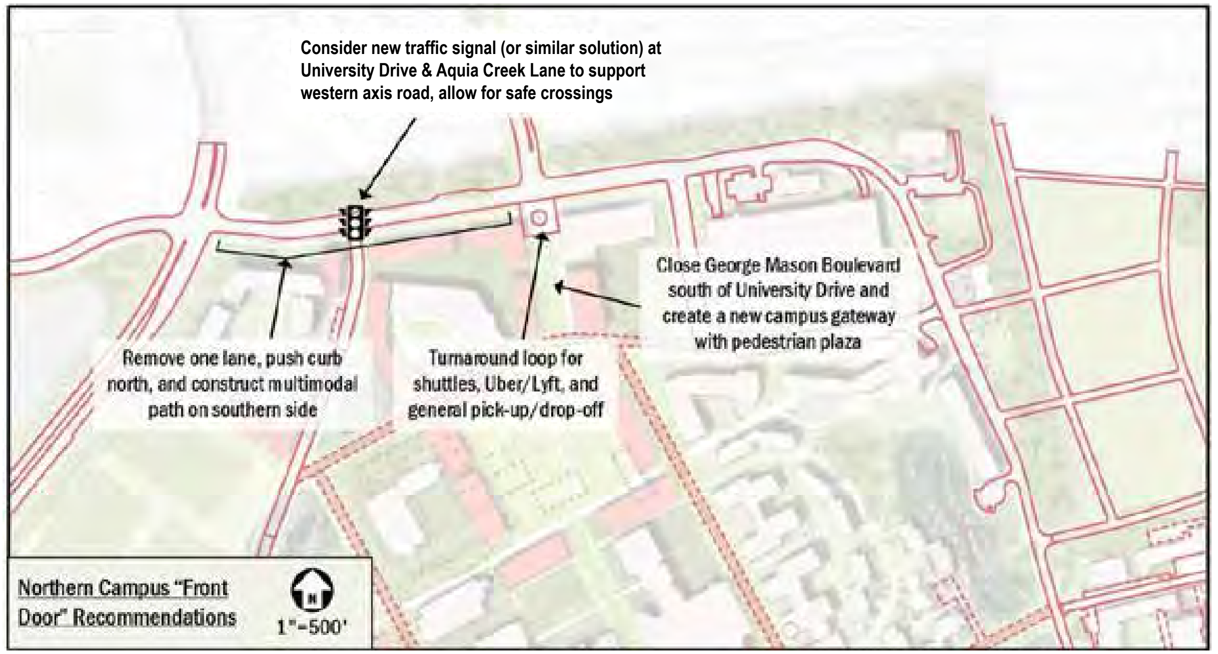


Figure 8.

Figure 9.

2. CREATE ENHANCED "FRONT DOORS" TO CAMPUS TO IMPROVE INTEGRATION WITH SURROUNDINGS, PROVIDE A LANDING POINT AND SENSE OF PLACE, AND IMPROVE MULTIMODAL ACCESS

Most people entering the Fairfax campus arrive from either University Drive or Braddock Road, so these two streets should host the primary gateways into campus. This plan recommends a variety of improvements at each gateway.

At the northern end of campus, this plan recommends closing George Mason Boulevard south of University Drive and in its place, creating a new campus gateway with a pedestrian plaza. This new entryway would signify a grand entrance to drivers arriving from the north along George Mason Boulevard or from the west along University Drive. Space could also be allocated for a turnaround loop for shuttles, Uber/Lyft, and general pick-up/drop-off at the north end of the plaza. Since the northern stretch of Aquia Creek Lane will function as part of the western north/south axis, a new traffic signal at its intersection with University Drive would support the increased volume of traffic along the road as well as allow for safe crossings. The final northern campus recommendation is to reconfigure University Drive west of George Mason Boulevard by removing one traffic lane and constructing a multimodal path on the southern side of the street. These improvements would better integrate University Drive with its neighborhood surroundings while creating safe, comfortable multimodal links and a prominent campus entrance and are shown in Figure 8.

On the southern side of campus, Braddock Road presents a unique set of challenges. Ideally, Braddock would feel more like a safe, inviting street for all users. In addition, realigning the eastern north/south road to intersect Braddock Road at Carriagepark

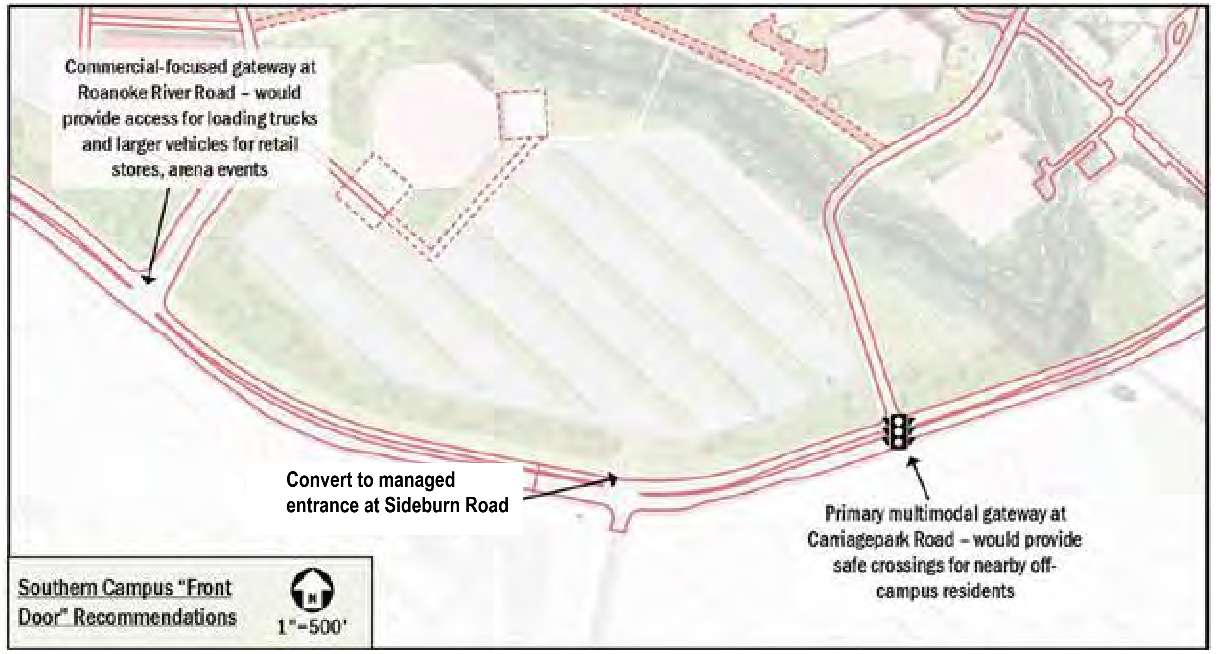


Figure 10.

Road would create a fourth intersection along Braddock with a signalized crosswalk and increase access to nearby student residences as shown in Figure 9.

Each of the gateways to campus along Braddock Road can have their own distinct identities as detailed in Figure 10. At Roanoke River Road, a commercial-focused gateway could provide access for loading trucks and larger vehicles for the planned retail center as well as events at EagleBank Arena. This entrance would likely be wider than the others, with multiple lanes in each direction to accommodate retail track and trucks with wide turning radii. The Sideburn Road entrance, since it no longer is needed for access to the eastern side of Patriot Circle, could be removed. Alternatively, it could be kept as an event-only entrance to handle high traffic volumes in and out of the Arena parking area. The Carriagepark Road entrance would serve as the primary multimodal gateway, providing safe crossings for close-by off-campus residents. This entrance would also have gateway features similar to those at the George Mason Boulevard entrance.

3. CONTINUE TO ENCOURAGE THE USE OF NON-AUTO TRANSPORTATION THROUGH BUILDING UPON THE EXISTING TRANSPORTATION DEMAND MANAGEMENT PLAN

The university currently employs several TDM measures to reduce or shift demand for parking and encourage the use of sustainable modes of transportation. A variety of new strategies are possible that would allow the university to further control this demand as the campus changes and expands.

To shift parking demand away from the campus core, the university could employ dynamic parking pricing. That is, prices of parking permits could be shifted to encourage parking at off-peak times and in less desirable locations such as West Campus. Another way to decrease parking demand and encourage sustainable transportation would be to provide subsidized Metrorail/Metrobus rides through the WMATA U-Pass program. Several universities in the region already participate in the program, and it would greatly increase the ease of taking transit for students who commute longer distances to campus.

Other potential TDM strategies could include:

- On-campus bicycle repair shop and/or an increased number of self-repair stations
- Host transportation events such as "Bike to Campus Day"
- Increase the number of students and faculty who live on campus
- Provide secure long-term bicycle parking with e-bike/scooter chargers at residence halls
- Annual transportation performance monitoring and evaluation program
- Bicycle repair classes
- Expanding Capital Bikeshare to campus
- Adding more showers and changing facilities on campus

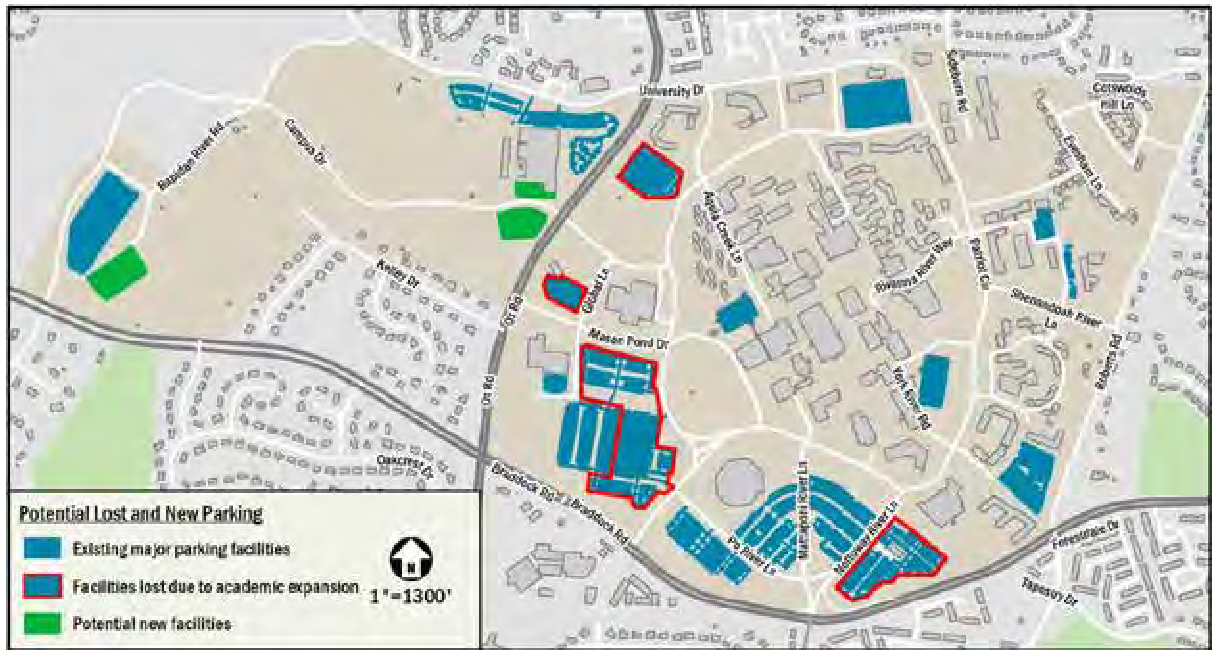


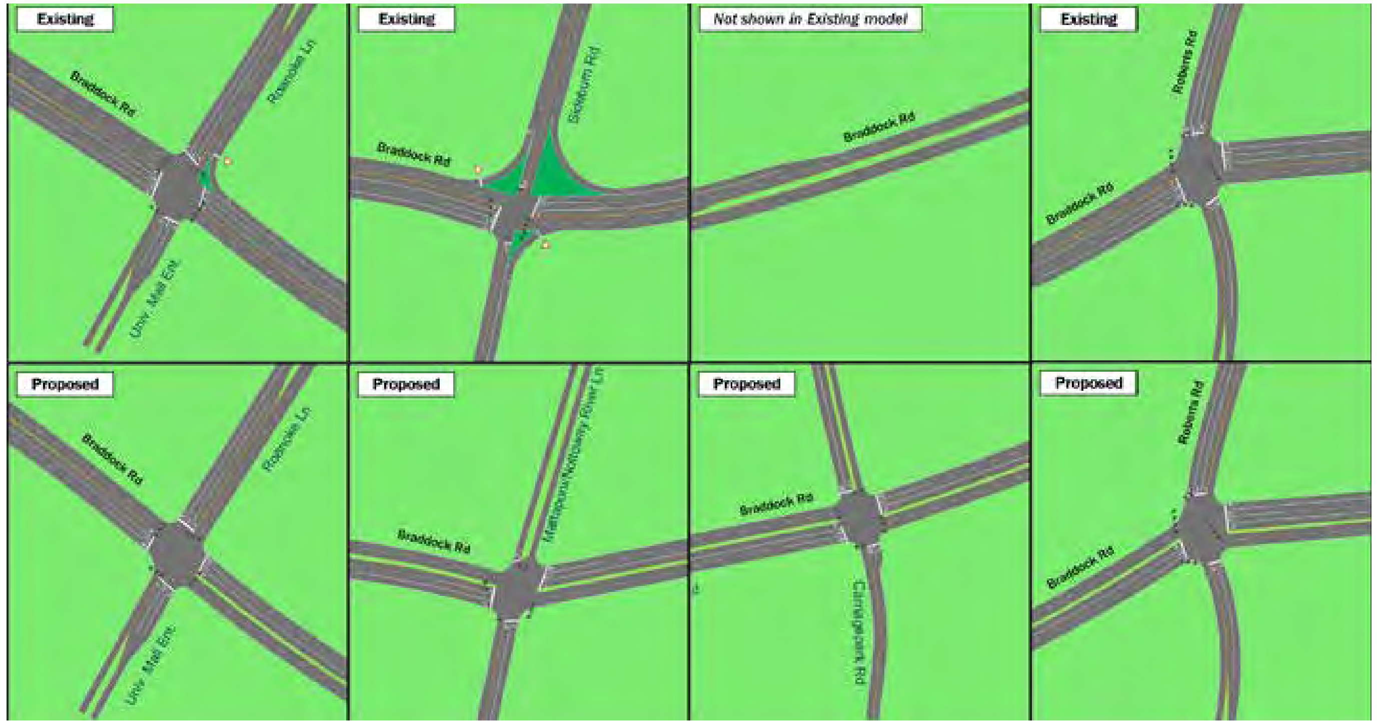
Figure 11.

4. REFRAIN FROM BUILDING ADDITIONAL PARKING CAPACITY IN CAMPUS CORE

If the university is successful in decreasing the demand for parking in the campus core, then it may not be necessary to relocate the parking lots that are removed to make way for new academic buildings. In total, the master plan identifies a total of 1,908 parking spaces (accounting for 16% of the university's total supply) that would be lost to new buildings. Potential lost and new parking locations are shown in Figure 11. If parking demand cannot be reduced, the university would need to construct this many new spaces on West Campus in order to preserve existing capacity. The most feasible user group to shift to West Campus would be long-term parkers, i.e. on-campus residential students and full time commuter students/employees who typically park for a full day and do not need to return to their cars during the middle of the day. Dynamic parking pricing, outlined in the previous recommendation, could be used to increase the attractiveness of West Campus parking. Either way, additional shuttle service would be necessary to transport these commuters to the campus core.

On the other hand, if the university can reduce its overall parking demand by 16%, no additional parking spaces will need to be built. If the strategies from the previous recommendations are fully employed, the university will likely be able to accomplish its transportation goals and expansion plans without needing to shift any parking.

TRANSPORTATION SYSTEM- GEOMETRIC AND OPERATIONAL CHANGES
Synchro graphics



TRANSPORTATION SYSTEM- GEOMETRIC AND OPERATIONAL CHANGES
Synchro graphics

UTILITIES AND INFRASTRUCTURE

ARUP

1. OVERVIEW

This utility masterplan report analyzes the utility changes and/or additions required to accommodate new building developments at George Mason University's (Mason) Fairfax, Science and Technology (SciTech), and Arlington campuses.

The study is focused on Fairfax and SciTech campuses as they are the proposed sites for future building development. Development is to consist of residential, academic, mixed-use, and new recreational space. These are represented in Figures 1 and 2 as pink buildings. Development zones are also identified in these figures.

Figure 1 - Fairfax Campus Development Program

Figure 2 - SciTech Campus Development Program

2. EXECUTIVE SUMMARY

This study considers the existing utility infrastructure at George Mason University's (Mason) Fairfax, Science and Technology (SciTech) and Arlington campuses and the impacts of the proposed development masterplan on these utilities.

The report considers the heating and cooling, power, natural gas, potable water, sanitary sewer, and telecommunications infrastructure required to serve the proposed masterplan. Improvements to utilities serving existing buildings or services were beyond the scope of this study.

Thermal heating and cooling improvements have been considered at Fairfax and SciTech campuses. Two ground source heat pump central plants and borehole fields with new low-temperature hot water and chilled water piping distribution to all new buildings are recommended at the Fairfax campus. Expansion of the existing central plant with high-temperature hot water gas boilers and water-cooled chillers was also considered. At SciTech a different approach is recommended, which incorporates a distributed model of air source heat pumps to each building or buildings.

Natural gas network expansion is not considered at any of the campuses, on the assumption that future buildings will have no domestic need for it. Impacts to existing services are not considered due to limited information being made available by gas providers.

Potable water network expansion and reconfiguration is advised at both Fairfax and SciTech campuses. This is to add service to new buildings, realign existing mains beyond the footprint of the proposed development and to add network resilience. The existing network is believed to have sufficient capacity and pressure to serve the planned development program, however this will ultimately need to be confirmed by Fairfax Water. Impacts to the potable water network has not been evaluated at the Arlington campus.

Sanitary sewer network expansion and reconfiguration is advised at both Fairfax and SciTech campuses. An upsizing of an existing sewer main is also recommended at Fairfax. The recommended improvements are designed to add service to new buildings, realign existing mains beyond the footprint of the proposed development and to ensure the planned development program can be accommodated within the on-site network. Impacts to the sanitary sewer network have not been evaluated at the Arlington campus.

3. EXISTING INFRASTRUCTURE ASSESSMENT

The following section describes the existing utilities serving the Mason campuses.

3.1 HEATING AND COOLING

This section discusses the heating and cooling infrastructure with some commentary on its potential to support additional new development as part of the of masterplan. Thermal heating and cooling networks were reviewed at the Fairfax campus only. There are currently no centralized heating and cooling networks at the SciTech or Arlington campuses.

3.1.1 FAIRFAX CAMPUS

The Fairfax campus has an existing central utility plant (CUP) with high temperature hot water natural gas boilers and water-cooled chillers - see Tables 1 and 2 for a list of equipment. The existing system serves 71 of 106 campus buildings (76.6% of total GSF) as shown in Figure 3. We did not receive clear metered hourly data, but given the information we received, we can assume there is some additional capacity remaining in the existing system. Nevertheless, the new masterplan will require new boilers and chillers to meet the proposed additional demand (see Section 3.1). Additionally, some of the boilers and chillers will be nearing their end-of-life within the next 5-10 years – see Tables 1 and 2.

	YEAR BUILT	END OF LIFE DATE	TYPE	CAPACITY
Steel water tube - hot water	2005	2029	gas/oil	25,000 btu/hr
Steel water tube - hot water	2009	2033	gas/oil	25,000 btu/hr
Steel water tube - hot water	1988	2012	gas/oil	25,000 btu/hr
Steel water tube - hot water	1994	2026	gas/oil	25,000 btu/hr
Steel water tube - hot water	2015	2039	gas/oil	25,000 btu/hr

Table 1 - Existing Plant Heating Infrastructure

	TYPE	CAPACITY (TONS)	REFRIGERANT TYPE	REFRIGERANT (LBS)	END OF LIFE DATE	REBUILD EVERY 10 YEARS
chcp chiller-1	centrifugal	1060	r-123	2000	year 2025	2022
chcp chiller-2	centrifugal	1060	r-123	2000	year 2025	2022
chcp chiller-3	centrifugal	1470	r-123	2400	year 2030	2021
chcp chiller-4	centrifugal	1470	r-123	2400	year 2030	2021
chcp chiller-5	screw	520	r-134A	683	year 2031	2021
chcp chiller-6	screw	520	r-134A	850	**year 2020**	**due for replacement**
chcp chiller-7	screw	520	r-134A	850	**year 2020**	**due for replacement**
chcp chiller-8	screw	520	r-134A	850	**year 2020**	**due for replacement**
chcp chiller-9	centrifugal	1470	r-123	2600	year 2034	2019
chcp chiller-10	centrifugal	1470	r-123	2700	year 2039	2024

Table 2 - Existing Plant Cooling Infrastructure

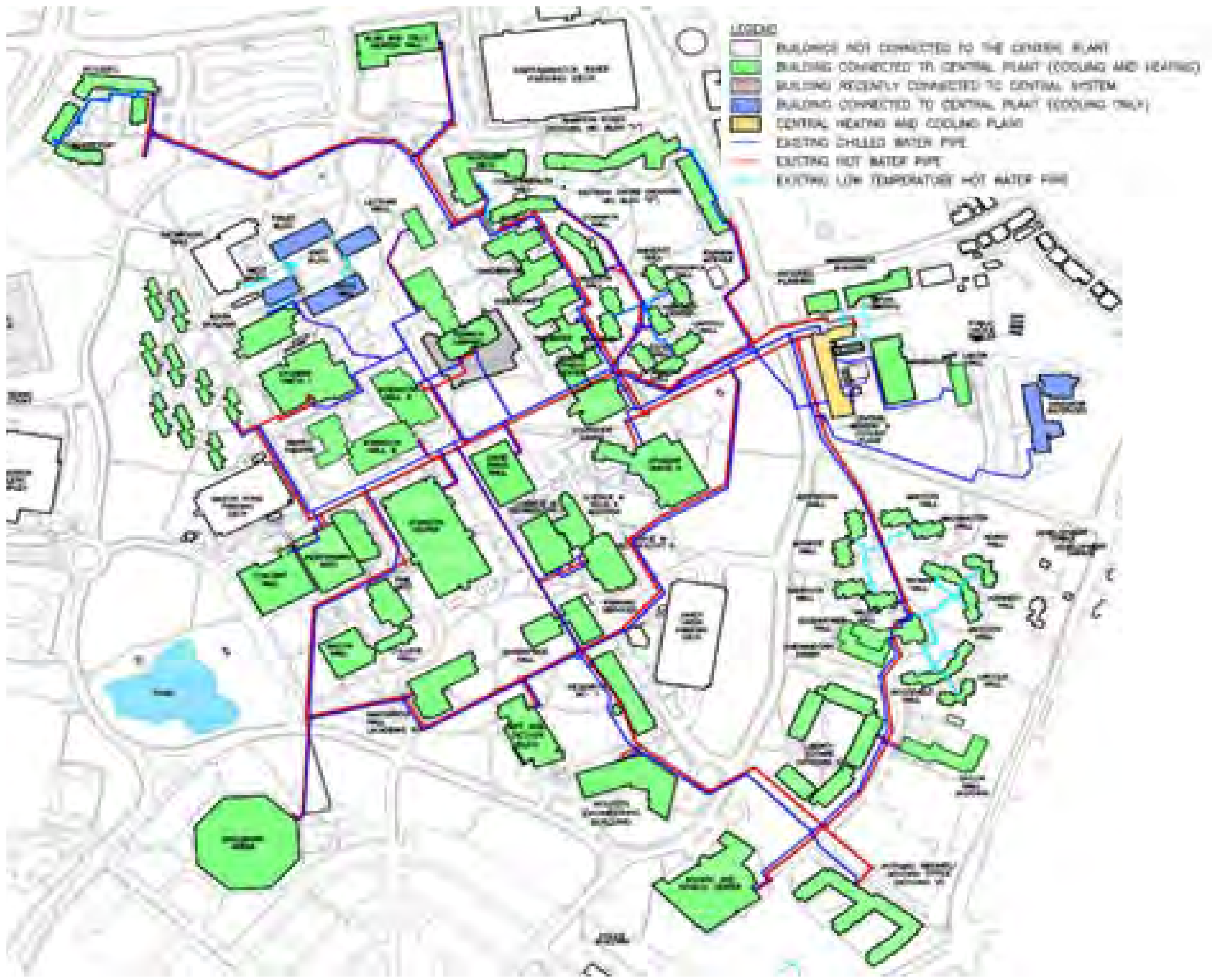


Figure 3 - Existing Central Plant and Distribution Network

It is understood that different building-by-building terminal heating and cooling systems are in place and a significant number have heat exchangers to interconnect. Since this study focuses on the new masterplan buildings – the interconnectivity of the new central plant(s) to the existing buildings will be studied further in the Climate Action Plan.

Mason has stated that some chilled water and high-temperature hot water pipes were recently upgraded, although specific data was not available at the time of this study. Some of the upgrades would be useful for the future masterplan additions as well.

3.1.2 SCITECH

BUILDING	EQUIPMENT	CONDITION
Bio-med Research Lab (BRL)	Natural gas boilers Water-cooled electric chillers	Heating and cooling generation systems stated to be in good and fair condition, respectively
Discovery Hall	Natural gas boilers Water-cooled electric chillers	Heating and cooling generation systems stated to be in good and fair condition, respectively
Institute Adv Biomed RSCH	No information available	No information available
Charles Colgan Hall	Natural gas boilers Water-cooled electric chillers	Chillers will reach end of useful life in 2022 Heating generation systems stated to be in good condition
Katherine G. Johnson Hall (formally Bull Run Hall)	Natural gas boilers Water-cooled electric chillers	Heating and cooling generation systems stated to be in good and fair condition, respectively
Freedom Recreation Center	Natural gas boilers Water-cooled electric chillers	Chillers in very poor condition and need replacement
Hylton Performing Arts	Natural gas boilers Water-cooled electric chillers	Heating and cooling generation systems stated to be in good and fair condition
Beacon Hall	Natural gas boilers (DHW) Air-source heat-pumps	Heating and cooling generation systems stated to be in good and fair condition

Table 3 - Heating and Cooling Equipment at SciTech Campus

3.2 POWER

Power supply networks were reviewed at each of the three campuses.

3.2.1 FAIRFAX CAMPUS

Dominion Energy primary service is provided at 13.2kV, 3 phase, 3 wire.

SITE CONNECTIONS

Primary electric service enters the Fairfax campus at two locations:

- Braddock Rd near Aquatic and Fitness Center (York River Rd). This service is metered and considered the “Normal Feed”.
- Rt 123 at University Drive, near Rogers Hall. This service is metered and considered the “Emergency Feed”.

Primary electric service is distributed in a central campus loop under Patriot Circle. The central loop serves sub-loops and radial connections to groups of campus buildings.

INFRASTRUCTURE CONDITION

The age and condition of electrical infrastructure at Fairfax campus buildings consistently rates Fair to Good in Mason’s maintenance logs. The corresponding condition of the underground cabling infrastructure was not available for review. Replacements to electric service and distribution equipment at the campus buildings has occurred consistently over the decades from 1965. Only a few campus buildings have reported Poor condition with respect to the electrical infrastructure. Those areas of the campus’s electric infrastructure have not been changed since being installed in the 1960’s.

The Labeling of electric service lines is inconsistent across the campuses. It is anticipated that some existing underground lines are abandoned but have not been labeled as such on the GIS data we reviewed.

3.2.2 SCITECH CAMPUS

SITE CONDITIONS

NOVEC is the primary service provider to the SciTech campus. Electric service enters the campus at the north and serves campus buildings.

INFRASTRUCTURE CONDITION

Aside from a couple of small electric services dating to 1988, most of the SciTech campus electrical infrastructure was installed between the late 1990's and 2015. All installed electrical services are original and reported to be in Good to Excellent condition per Mason's maintenance logs.

3.2.3 ARLINGTON CAMPUS

Dominion Energy is the primary service provider to the Arlington campus. Arlington electric services were installed in 1999 and 2010 and are documented as being in Good to Excellent condition.

3.3 NATURAL GAS

Natural gas networks were reviewed at each of the three campuses.

3.3.1 FAIRFAX CAMPUS

Natural gas infrastructure on the Fairfax campus is owned and maintained by Washington Gas. This is as advised by Mason staff but is to be confirmed by Washington Gas.

Mason's GIS mapping was used to review the existing network. This shows significant gas service, of unknown size and material, on campus between Ox Rd, University Dr, Roberts Rd and Braddock Rd. There are six connections off-campus, four on Roberts Rd, one at the intersection of Ox Rd and Braddock Rd and the other at the intersection of Ox Rd and University Dr.

Limited provider information was available for this study due to Washington Gas information disclosure processes restricting access to service maps at this planning stage.

Future studies should ascertain the diameter and material of the existing network on and off site to guide future design.

3.3.2 SCITECH CAMPUS

Natural gas infrastructure on the SciTech campus is owned and maintained by Colombia Gas. This is as advised by Mason staff but is to be confirmed by Colombia Gas.

Mason's GIS mapping was used to review the existing network. This indicates the full campus is served by a single branch from University Blvd of unknown size and material.

Limited information was available for this study due to Colombia Gas information disclosure processes restricting full access to service maps at this planning stage. A service map was received showing a high-pressure main running north-east beyond the site limit, south of Wellington Rd. A medium-pressure branch is observed connecting to the north-east of campus, or near-to it. This is not observed in Mason's GIS map. Partial service maps provided by Colombia Gas can be seen in the Appendix.

Future studies should ascertain the alignment, diameter and material of the existing network on and off site to guide future design.

3.3.3 ARLINGTON CAMPUS

Natural gas infrastructure on the Arlington campus is owned and maintained by Washington Gas. This is as advised by Mason staff but is to be confirmed by Washington Gas.

Mason's GIS mapping was used to review the existing network. This shows there are likely three connections from main lines to the campus buildings:

- 6in on Washington Blvd
- 4in on restricted access route, on western edge of campus property
- 2in on Fairfax Dr

Limited information was available for this study due to Washington Gas information disclosure processes restricting access to service maps at this planning stage.

Future studies should ascertain the alignment, diameter and material of the wider existing network on and off site to guide future design.

3.4 POTABLE WATER

Potable water networks were reviewed at each of the three campuses.

3.4.1 FAIRFAX CAMPUS

Potable water infrastructure on Mason's Fairfax campus is owned and maintained by Fairfax Water. The site is primarily served by a 24in trunk main on Campus Dr, from Braddock Rd, and a 16in main entering from University Drive at University Park, and is supplemented by a water tank situated between University Dr and Sideburn Rd. Service maps were obtained from Fairfax Water and can be seen in the Appendix.

SITE CONNECTIONS

The potable water network has connections beyond the campus as follows:

- 24in main at Braddock Rd
- 12in main Braddock Rd
- 8in and 16in mains at University Drive
- 3 x 8in mains on Roberts Rd

Fairfax Water performed significant improvement works since 2017 to improve the pressure and reliability of the water network on campus and in surrounding areas. Per a March 30, 2017 memo, obtained as part of this assessment, titled George Mason University System Pressure and Hydrant Flow Before, During, and After the University Tank Replacement Project, it is observed that these improvement works moved Mason's Fairfax campus from being within the Second High pressure zone (Hydraulic Grade Line (HGL) between 525' and 555') to the Third High pressure zone (HGL between 570' and 600').

As part of these works, in the late 2010s, the water tank was replaced and the 24" trunk main off Braddock Rd, along Campus Dr, was installed.

INFRASTRUCTURE AGE

Aside from the improvements noted in late 2010s, the age of the on-campus water network is inferred from the approximated construction timeline of the campus by viewing historical satellite imagery on Google Earth. A detailed timeline of water infrastructure construction is not available.

Historic satellite imagery indicates that some core buildings on East Campus were constructed between 1960s-70s, with the majority of East and West Campus buildout occurring mainly in the 1980s-90s. Networks serving the North-east of the campus, where faculty residences are present, were constructed circa. 2009.

3.4.2 SCITECH CAMPUS

Prince William County owns and maintains the potable water network at SciTech campus. The buildings are served by a 12in branch emanating from a 30in trunk main on Freedom Center Blvd. There is a small loop network serving the Freedom Aquatic and Fitness center spurring from the 12in branch which connects back to the 30in trunk main at Freedom Center Blvd. Most of the SciTech campus is not on a loop network. Service maps provided by Prince William County can be seen in the Appendix.

INFRASTRUCTURE AGE

The age of the on-campus sewer network is inferred from approximated construction timeline of the campus by viewing historical satellite imagery on Google Earth. A detailed timeline of water infrastructure construction is not available.

Historic satellite imagery indicates campus construction began mid/late 1990s and has continued with additions to the Hylton Performing Arts Center.

3.4.3 ARLINGTON CAMPUS

Arlington County owns and maintains the potable water network which serves Mason's Arlington campus. The campus is bounded by 12in water mains on Washington Blvd and North Kirkwood Rd and a 16in main running in Fairfax Dr, with seven connections to Mason buildings observed. Service maps provided by Arlington County can be seen in the Appendix.

INFRASTRUCTURE AGE

The age of the on-campus sewer network is inferred from approximated construction timeline of the campus by viewing historical satellite imagery on Google Earth. A detailed timeline of water infrastructure construction is not available.

Historic satellite imagery indicates the following campus construction dates, and assumed installation of associated water infrastructure:

- Van Metre Hall c.2009
- Vernon Smith Hall c.2003
- Hazel Hall c. 1998
- 'Original Building' pre-1990

3.5 SANITARY SEWER

Sanitary sewer networks were reviewed at each of the three campuses.

3.5.1 FAIRFAX CAMPUS

Sanitary sewer infrastructure on Mason's Fairfax campus is owned and maintained by Fairfax County. The campus is separated into four networks; West, Main Campus West, Main Campus East; Faculty.

SITE CONNECTIONS

The sewer connects to the off-campus sanitary network as follows:

- West: 12in gravity sewer is conveyed to a pump station and outgoing 10" force main at Braddock Rd, east of Campus Dr.
- Main Campus West and East: 10in gravity sewer is conveyed to Braddock Rd, west of Roberts Rd. where it discharges to a 16in sewer, across Braddock Rd.
- Faculty: 8in sewer discharges across Roberts Rd. into a neighboring residential area

There is no sanitary sewer network serving Shirley Gate.

INFRASTRUCTURE AGE

The age of the on-campus sewer network is inferred from the approximated construction timeline of the campus by viewing historical satellite imagery on Google Earth. A detailed timeline of sanitary sewer construction is not available.

Historic satellite imagery indicates that some core buildings on East Campus were constructed between 1960s-70s, with the majority of East and West Campus buildout occurring mainly in the 1980s-90s. Faculty networks were constructed circa. 2009.

3.5.2 SCITECH CAMPUS

Prince William County owns and maintains the sanitary sewer network on Mason's SciTech campus. Two primary networks exist, serving.

Main campus west of Freedom Center Blvd

Biomedical Research Laboratory (BRL) east of Freedom Center Blvd.

Network (1) consists of two 12in branches which ultimately discharge to an 18in sewer which crosses University Blvd at the south of the campus.

Network (2) is a 10in gravity sewer serving only the BRL, which discharges to a 10in main east of Pyramid Place.

Service maps provided by Prince William County can be seen in the Appendix.

INFRASTRUCTURE AGE

The age of the on-campus sewer network is inferred from the approximated construction timeline of the campus by viewing historical satellite imagery on Google Earth. A detailed timeline of sanitary sewer construction is not available.

Historic satellite imagery indicates campus construction began mid/late 1990s and has continued through to today.

3.5.3 ARLINGTON CAMPUS

Arlington County owns and maintains the sanitary sewer network which serves Mason's Arlington campus. The campus is bounded by 8in sewers mains on Washington Blvd and North Kirkwood Rd and a 24in main to the south, in Fairfax Dr. A private 8in sewer is present beneath Van Metre Hall running into Founders Way and discharging to the sewer in North Kirkwood Rd.

Service maps provided by Arlington County can be seen in the Appendix.

INFRASTRUCTURE AGE

The age of the on-campus sewer network is inferred from the approximated construction timeline of the campus by viewing historical satellite imagery on Google Earth. A detailed timeline of sanitary sewer construction is not available.

Historic satellite imagery indicates the following campus construction dates, and assumed installation of associated sewer infrastructure:

- Van Metre Hall c.2009
- Vernon Smith Hall c.2003
- Hazel Hall c. 1998
- 'Original Building' pre-1990

3.6 TELECOMMUNICATIONS

The majority of ITS infrastructure was installed in 1995-1997, as indicated by the university operations team.

3.6.1 FAIRFAX CAMPUS

We received existing GIS records of the current telecom network, an upgrade site plan of OSP new duct banks from March 2020, phase 3 duct bank plan, and wireless Map.

The campus is served by Internet Service Provider and Zayo dark fiber from University Dr with the MPOE located at the police and public safety building at the northeast corner of the campus.

The campus is served by an extensive network of duct banks for all the existing campus buildings. Main data centers and network aggregation cores are located at the Fairfax campus.

There's a need to expand the ITS infrastructure to improve resiliency across campus and introduce a second MPOE for dark fiber or ISP connection at Braddock Road or VA-123. The upgrade site plan of OSP new duct banks from March 2020 indicates extension to the west campus and denser networks on the east campus.

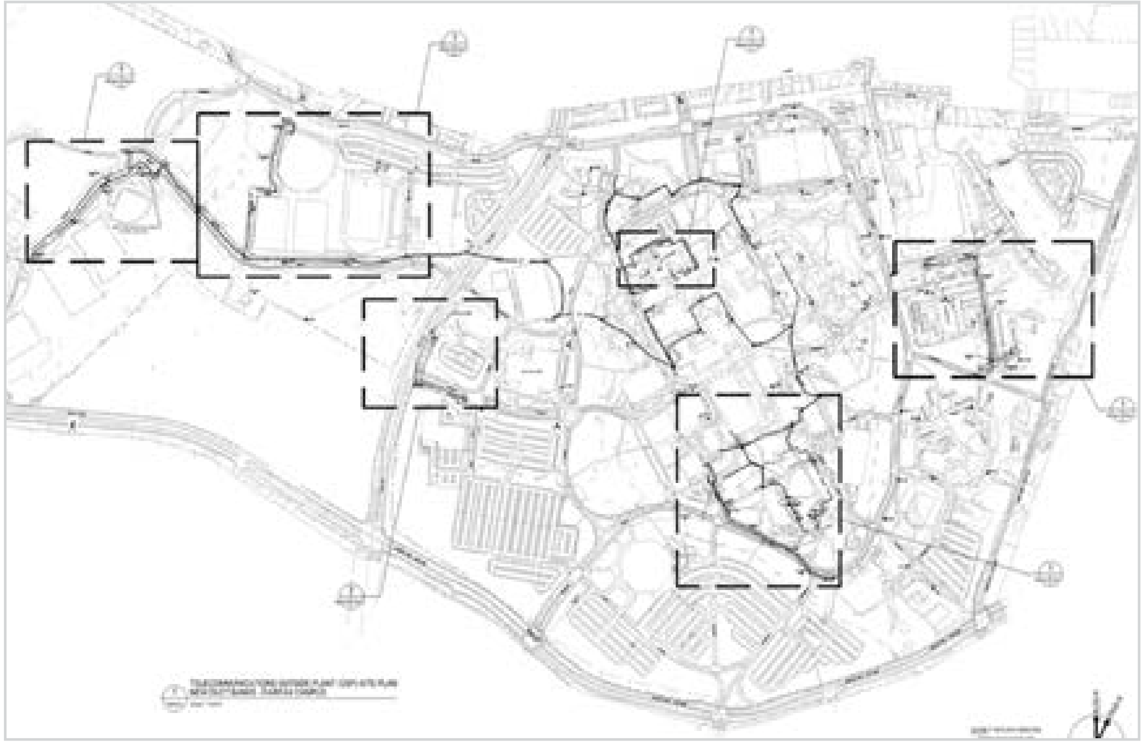


Figure 4 - Recent Duct Bank Upgrades at Fairfax Campus, March 2020

Further extensions have been highlighted in a 3-Phase approach, as shown in Figure 5. These provide a great basis for future campus expansion.

Figure 5 - Fairfax Campus Telecommunication Expansion Potential

3.6.2 ARLINGTON CAMPUS

We received no GIS records of the current telecom network.

The campus is served by Internet Service Provider and Zayo dark fiber with the MPOE located at the Hazel building at the southeast corner of the campus, as indicated by the university operations team.

Arlington campus is connected through its garages and conduits under the bridge.

There's a need to introduce a second MPOE for dark fiber or ISP connection (potentially by Century Link) at the New Building at Mason Square at the southwest corner of the campus.

3.6.3 SCITECH CAMPUS

We received existing GIS records of the current telecom network, phase 3 duct bank plan, and wireless Map. The SciTech campus is connected through a V loop across the campus, as shown in Figure 6.

Figure 6 - Existing Telecommunication Network at SciTech Campus

Further extensions have been highlighted in a 3-Phase approach, as shown in Figure 7. These improve resilience across campus and provide a great basis for future campus expansion.

Figure 7 - SciTech Campus Telecommunication Expansion Potential

4 PROPOSED UTILITIES

The following section describes the proposed utilities to serve the planned buildings in the masterplan.

4.1 HEATING AND COOLING

4.1.1 FAIRFAX CAMPUS

Mason currently has a goal to be carbon neutral by 2050, although this target will likely be revisited by the climate action plan. To achieve this goal with heating, Mason will need to eliminate the burning of natural gas on campus and move to all-electric options. This assumes that the electric grid for the Commonwealth of Virginia becomes cleaner. The Commonwealth has mandated clean power by 2045, which is ambitious and we have made assumptions about whether its achievable in our analysis (discussed in other sections).

In the build-up for future central plant sizes, we assumed a square foot per ton value for the different use types based on IECC 2018 energy code requirements. See the Appendix for all input assumptions to the study. The calculated new central plant capacity, assuming 80% diversity on heating and 70% diversity on cooling, would be:

- 31,400 MBH heating (9,200 kW)
- 3,700 tons cooling (13,000 kW)
- 1,200 kW domestic hot water heating

We have studied 4 different options for heating and cooling for the proposed masterplan on the Fairfax campus. The 4 options being:

1) Additional central high-temperature hot water boilers and water-cooling chillers

2) Central ground-source heat pumps

3) Central electric boilers and water-cooled chillers

4) Distributed air-source heat pumps.

Electric boilers have a very high energy usage rate and require significant electrical infrastructure; therefore, were deemed an unfavorable option. Distributed air-source heat pumps at each building have less piping infrastructure and a lower up-front cost, but the cost and labor of operations and maintenance (O&M) for distributed systems is less favorable. Distributed mechanical systems with additional space required at each building is also understood to make it more challenging to receive funding. There would also be refrigerant in each heat pump, which could increase the risk for leaks. Thus, options 1 and 2 were studied more closely.

OPTION 1 – CUP EXPANSION

For option 1, the current CUP would be expanded to include new boilers and chillers as the current capacity is not sufficient to accommodate all the proposed growth. These technologies are readily available and familiar to the campus, but this option would not be in line with Mason's carbon neutral goals on campus as it would continue to rely on natural gas for heating and hot water. This option would use the existing thermal piping network with the exception of some upgrades to larger sizes in some segments. It would also require new piping distribution to the new buildings. See Figure 8 for this option layout.

OPTION 2 – CENTRALIZED GROUND SOURCE HEAT PUMPS (GSHP)

Option 2 is to use to geo-exchange technology, using the ground as thermal battery to provide heating and cooling to all new buildings. This option would create a new ground-source heat pump central plant on the west side of campus and another to the south-west. This option would not utilize the existing CUP and its distribution network (except for existing buildings). This approach would mean that all new buildings would be carbon-free when the grid is 100% clean, as it is all-electric with no natural gas burning. The ground-source heat pumps (and any carbon-free heating equipment) would circulate low-temperature hot water. This is different than the current Mason infrastructure which circulates high-temperature hot water using smaller diameter pipes. Therefore, new piping distribution would need to be installed from the CUP to new buildings. The main ground-source heat pumps (housed in the new CUPs) require two large fields of boreholes to transfer the heat.

The study estimates the new CUPs would require approximately 350,000 square feet for boreholes. They can be installed under green or paved surfaces like fields or parking lots but would require specific coordination and design to be installed under buildings. It should also be noted that building future structures on top of the boreholes is not possible except with very lightweight buildings with limited foundations. To optimize the borehole field size (and cost) the CUPs would also have backup electric boilers and water-cooled chillers for the peak condition capacity; we sized the field for 50% of the peak heating load. Ultimately it is recommended that both CUPs are connected via the distribution network to provide redundancy. See Figure 9 for this option layout.

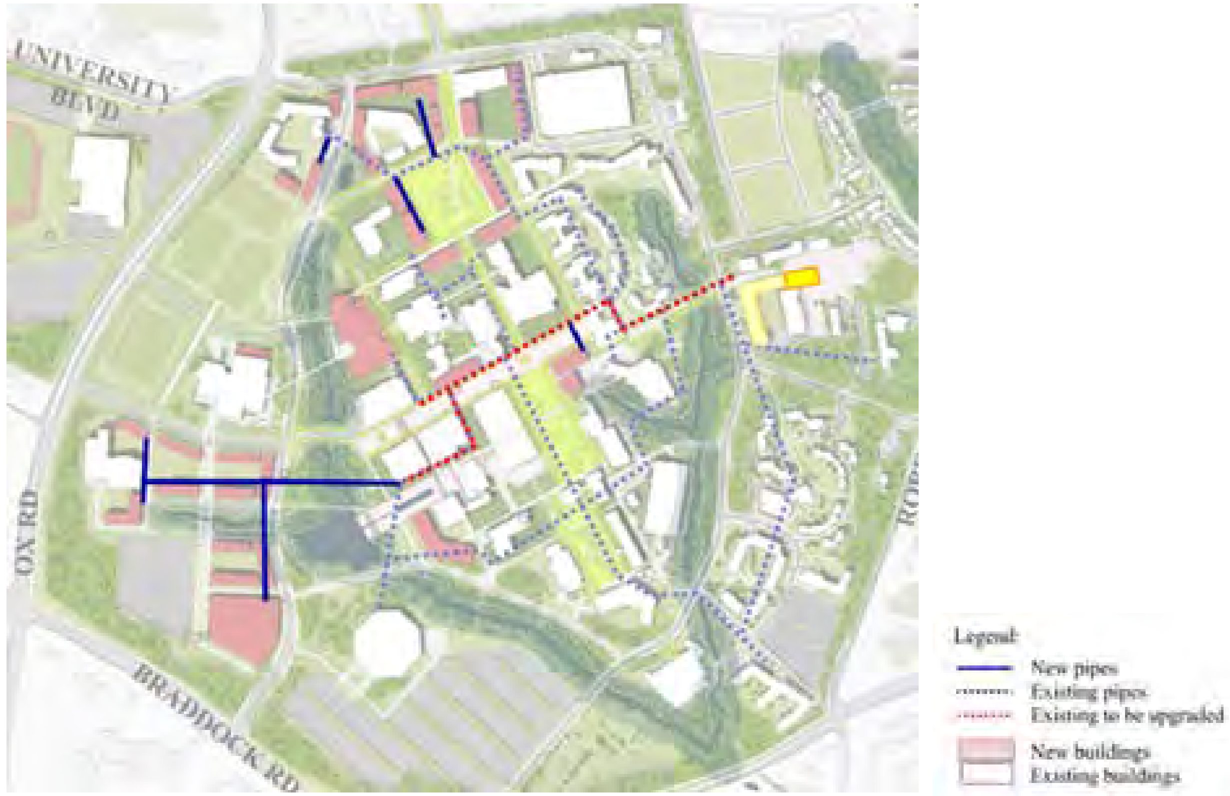


Figure 8 – Option 1 Layout (Expansion of Existing System)

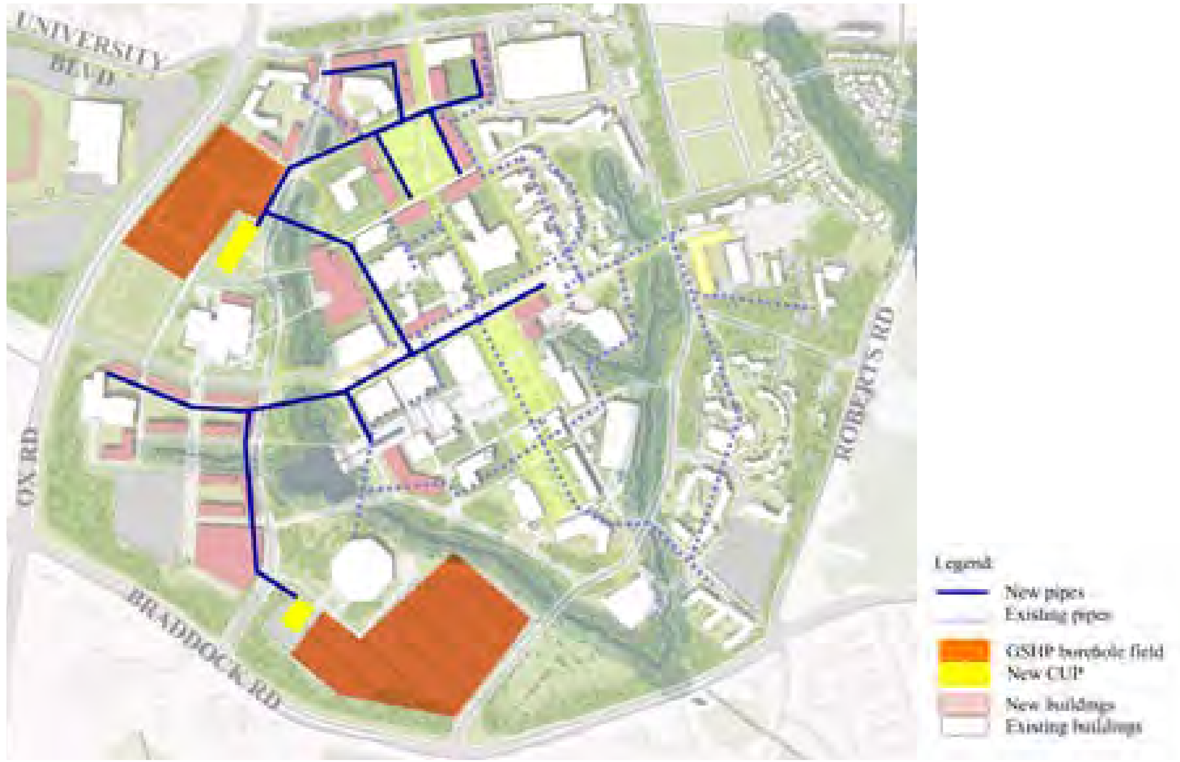


Figure 9 – Option 2 Layout (Central Ground Source Heat Pumps)

PERFORMANCE COMPARISON OF OPTIONS

A high-level costing study was done to compare the capital, annual, and net present value cost comparisons for all options. Their carbon emission performance was also compared. See Supplement A for a list of assumptions made in the cost build up, and Figures 10, 11, and 12 for cost comparisons. For the cost build-up the following assumptions were made:

- NPV includes annual O&M, energy, and carbon costs($ per ton) over 30 yrs
- 4% escalation
- Capital costs are hard costs only
- Option 1 includes an estimate of some piping upgrades
- Option 2 - the GSHP could change to be 2-pipe system and defer capital to building construction
- Option 4 - some ASHP costs are transferred to the building construction
- Costs do not include any electrical upgrade costs.

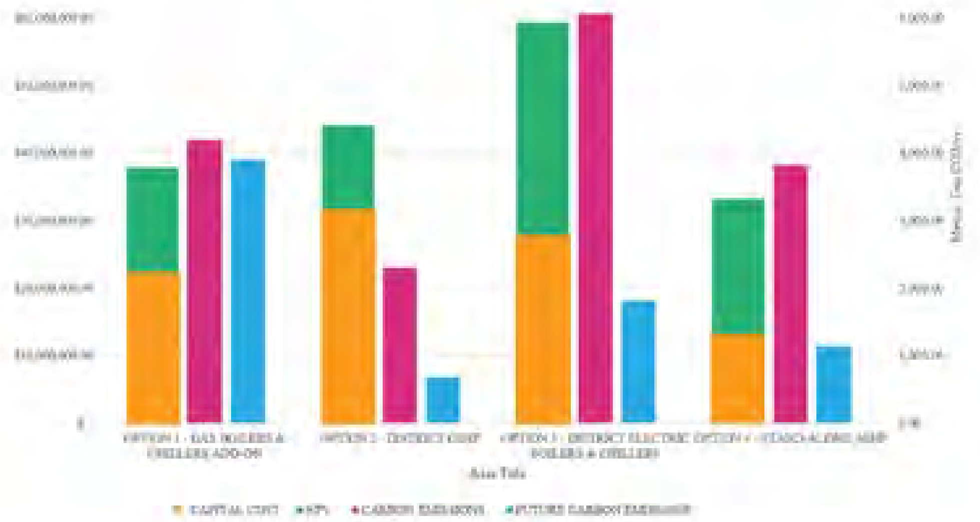


Figure 10 - Total Net Present Value (NPV) versus Carbon Emissions

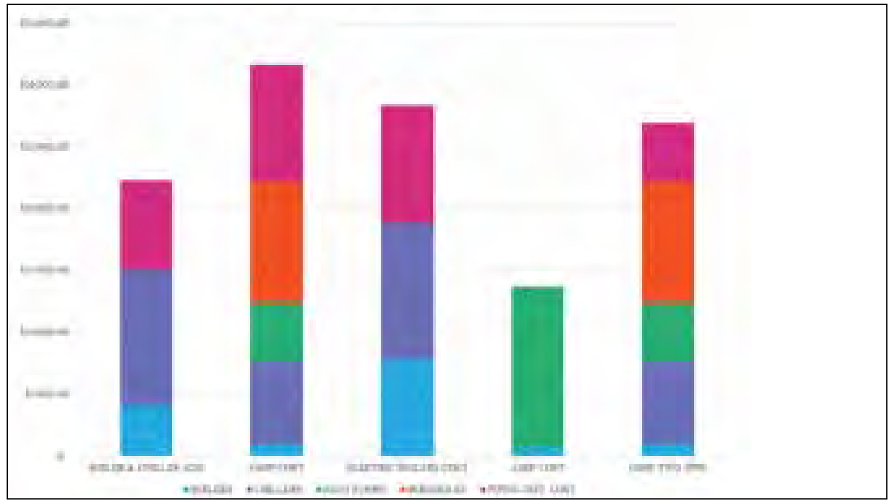


Figure 11 - Preliminary Capital Cost Breakdown

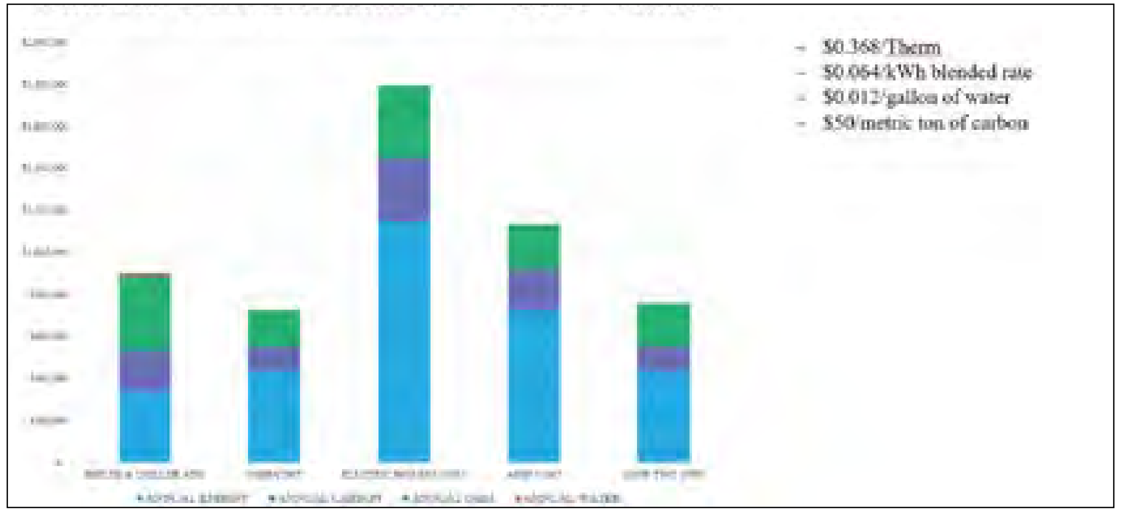


Figure 12 - Preliminary Annual Cost Breakdown - 2021 Values

New buildings in the masterplan will likely be constructed over many years, so the new CUPs and piping construction could be split out into separate timeframes. However, we recommend installing the main borehole field(s) in one construction phase to reduce mobilization and labor costs. Costs that could be delayed to future phases include construction of some heat-pumps, hot or chilled water pumps, or distribution piping.

There is potential for the central plant to add redundancy by offsetting the electrical loads with solar power and/or battery backup. We recommend adding rooftop solar to each new building to add to this offset. There is also an option of adding generators to backup all of or portions of the central plant. The backup scenarios would need to be studied to determine the size of generators.

FUTURE INTEGRATION WITH THE EXISTING BUILDINGS AND INFRASTRUCTURE

The options discussed in the previous sections focus solely on servicing heating and cooling for the proposed new buildings in the masterplan. As previously mentioned, meeting Mason's carbon neutrality goal was a central driver in developing the options. However, integration with the existing campus buildings and CUP was also considered for each option. Appendix A describes, at a high level, potential integration for the two main options (1&2). In both scenarios it would require retrofitting of both the existing buildings and the CUP to accommodate zero carbon technologies. Neither option will be easy unless there is a step change in availability of zero carbon fuels namely hydrogen or biofuels which would enable a potential change at the plant level only. Either way it is recommended that Mason pursues one approach, geo-exchange or alternative fuel to simplify operations.

4.1.2 SCITECH CAMPUS

The SciTech campus does not currently have a central utility plant (CUP) and we estimate the new planned buildings will not generate sufficient demand to make a new CUP economically viable. If Mason were to pursue a CUP at the SciTech campus, our energy and cost trends for the Fairfax campus options would be similar. Since there are fewer buildings at SciTech, air-source heat pumps (option 4) would be a favorable solution. They are carbon-free and efficient options for single-building distribution. Each new building would be designed with air-source heat pump plants at the building, likely with some electric boiler backup. They require more space than gas boilers, so the plant space would need to be considered in early design. See Figure 13 for a proposed layout.

Figure 13 - Air Source Heat Pumps at SciTech Campus

4.1.3 RECOMMENDATIONS

To provide thermal energy to the Fairfax campus' new buildings in accordance with Mason's carbon neutral goal, Option 2 the centralized heat pumps with boreholes are recommended. This option has higher construction and capital costs but will ultimately provide the University with a pathway to carbon neutrality with lower ongoing costs. This is a technology that is proven and is being widely adopted as strategy that is consistent with the cleaning of the electrical power grid.

At the SciTech campus a different approach is recommended that incorporates a distributed model of Air source heat pumps to each building or potentially cluster of buildings.

4.2 POWER

ASSUMPTIONS

To align with Mason's sustainability goals, we have assumed that new buildings will be all-electric, and that natural gas sources will not be used for heating, hot water, steam (such as sterilization at labs), laundry or kitchens.

4.2.1 FAIRFAX CAMPUS

To meet the demands of the full masterplan program, additional campus electric loops will be required to address increased demands. In addition to the campus loops to serve new buildings in geographic groupings, we recommend additional utility service connection(s) from Dominion Energy to balance capacity and resiliency on the electric network.

New loops and utility services can be phased over time, as new structures are constructed. The main drivers of increased load will be the total square footage of residential construction, and the construction of central utilities (or distributed utilities, if desired) to serve the new buildings.

Of the central utility options presented, ground source heat pumps have the least impact to overall operating cost.

CAPACITY ANALYSIS

Roughly 23,000 kW of added electricity is anticipated for the maste rplan building program. The selected central utility plant option selected will further increase the electricity demand.

Figure 14: Program Electricity Needs if Domestic Water Heating Occurs at the Central Utility Plant.

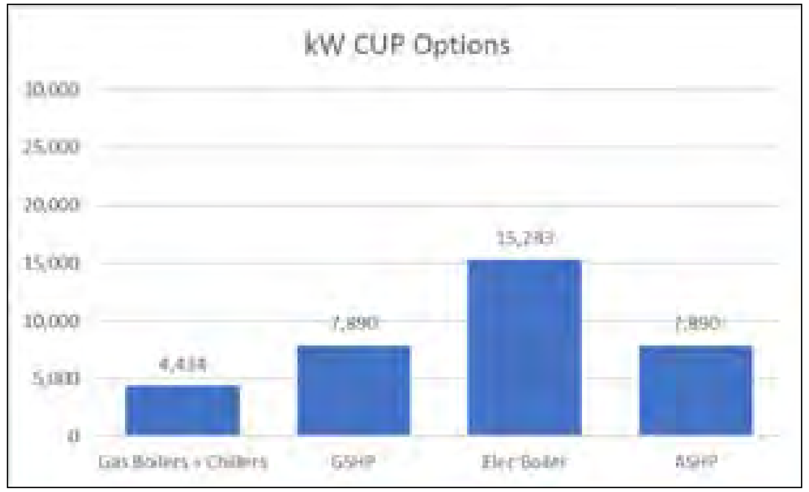


Figure 15: Central Utility Plant Option Electricity Loads (No Gas Boilers)

Figure 16: Program Electricity Needs if Domestic Water Heating Occurs at the Building

Figure 17: Electricity Loads if Domestic Water Heating Occurs at New Buildings and Not the Central Utility Plant

RESILIENCY

New buildings providing electricity to all systems have an increased risk of downtime to hot water and heating services when utility outages occur. It is recommended Mason address these risks by considering generator backup power to heating elements that are essential to freeze protection, and reviewing any shelter-in-place facility requirements to plan sufficient generator backup power accordingly.

CONCLUSION

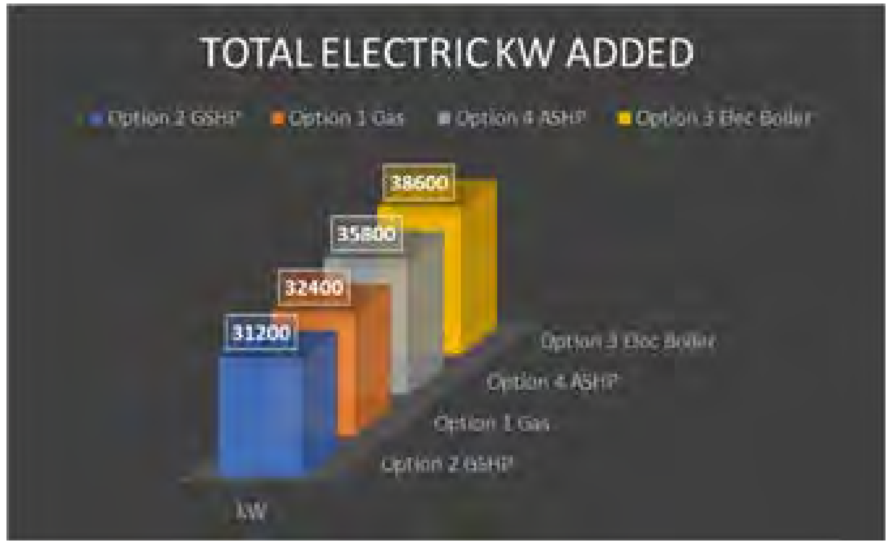


Figure 18 - Total Estimated Program Electricity Demand Summary

The amount of added electrical load ranges from 31,000 kW to 39,000 kW, dependent upon the selected CUP option. Investment in resiliency infrastructure, including campus utility loops, plant backup power and localized generator backup where electric heating serves as freeze protection, are recommended.

4.2.2 SCITECH CAMPUS

The proposed new program for SciTech campus is predominately Academic.

The anticipated electric load increase from new construction buildings is 7,000 kW, assuming the source of domestic hot water is local electric or in combination with local air source heat pump.

If implementing air source heat pumps, the increased electric load from the mechanical plant is anticipated to be just over 2,000 kW.

CONCLUSIONS

Capacity on the existing NOVEC utility service may not be adequate to serve the total electric load increase. A second NOVEC utility feeder to serve the campus will add capacity and resiliency to the electric network.

4.2.3 ELECTRIC VEHICLE CHARGING CAPACITY

In addition to the new buildings and CUP electricity demands, infrastructure to accommodate electric vehicle charging, whether for Mason's fleet vehicles or for personal vehicle charging, should be included in any new requests to the electrical service providers.

Per the Construction and Personal Services Manual, 2021, Commonwealth of Virginia, electric vehicle (EV) charging stations are required to be included with parking based on the occupancy group and year of construction contract notice of award. This requirement is of particular significance at the Fairfax campus where roughly half of the masterplan program space is projected to be residential. The highest density requirements for EV charging apply to residential parking, parking garages and institutional occupancies. Mercantile and assembly occupancies will also trigger EV charging at provided parking.

Further study is recommended to determine Mason's fleet transition to electric, electric charging technologies to be implemented and targets for percentage of existing parking charging capability. These will influence the amount of electricity needed to support EV charging. Considering the EV charging requirements to new construction buildings only, Mason can anticipate 2,000 kW – 3,000 kW connected load from new EV chargers.

4.3 NATURAL GAS

No natural gas improvements are considered in this masterplan.

This is due to the method of heating and cooling negating the need for gas, and the assumption that no future buildings will require gas services for domestic needs.

Impacts to existing gas services from new building construction should be considered in future studies when more information is available from providers. It is recommended that phasing and implementation impacts of each new building on existing gas services should be reviewed with respective providers during early planning stages.

The university will need to consider natural gas needs for teaching and research.

4.4 POTABLE WATER

Potable water improvements have been considered by campus. Improvements only consider areas affected by the proposed masterplan.

Potable Water Improvement Plans for Fairfax and SciTech are provided in the Appendix.

4.4.1 FAIRFAX CAMPUS

DEMAND CALCULATIONS

The additional potable water demand resulting from the proposed masterplan has been calculated and is shown in Table 4. Water demand is inferred from the proposed sanitary demand, which is determined per Virginia Administrative Code, Title 9, Ag. 25, Chp 790, Pt. III, Article 3, 9VAC25-790-460. Standards. Sanitary sewer demand is estimated to be 90% of potable water demand.

Where a flow is not provided for a particular building type, 0.21gpd/ft2 water demand (0.19gpd/ft2 sewer demand) is assumed. This is based upon the design requirements observed at the SciTech campus and maintains uniformity across design.

Ultimately, Fairfax Water must review and approve of the calculation methodology as design progresses.

AREA	QUANTITY	SANITARY DESIGN FLOW FROM NEW DEVELOPMENT	AVERAGE WATER DEMAND FROM NEW DEVELOPMENT (GPD)
North mixed-use	Retail: 125,000 SQ. FT Residential: 1200 beds	Retail: 200 GPD/1000 SQ FT Residential: 75 GPD/Person	127,780
West mixed-use	Target: 109,000 SQ. FT Retail: 139,000 SQ FT Residential: 1400 beds	Target: 200 GPD/1000 SQ. FT Retail: 200 GPD/1000 SQ. FT Residential: 75 GPD/Person	171,780
Upper quad academic	420,000 SQ. FT	0.19 GPD/SQ. FT	88,000
Central quad academic	120,000 SQ. FT	0.19 GPD/SQ. FT	25,200
Faculty	140 Dwellings	100 GPD/UNIT	15,560
Recreation	238,000 SQ. FT	0.19 GPD/SQ. FT	49,980
Innovation	110,000 SQ. FT	0.19 GPD/SQ. FT	23,100
Robinson B Replacement	70,000 SQ. FT	0.19 GPD/SQ. FT	14,700
		NET TOTAL	438,600

Table 4 - Summary of Program Potable Water Demand at Fairfax Campus

CAPACITY ASSESSMENT

It is anticipated that the existing potable water network will be sufficient to provide the necessary capacity and pressure to the site.

This assumption is subject to detailed design and review by Fairfax Water.

RECOMMENDATIONS FOR IMPROVEMENTS

To facilitate new building construction, some modifications to the existing water network are required.

The proposed potable water configuration considers relocations and service additions required to accommodate the footprint of new building development and whether the existing network has sufficient capacity to accommodate the proposed growth.

Figure 19 illustrates the proposed network, with pipe additions annotated. Table 5 details the characteristics of each new pipe, with reference to these annotations.

The purpose of these improvements is listed in the table and defined as follows:

- Diversion: Where the existing pipe is in conflict, or likely in conflict, with the proposed development, a new pipeline is shown to maintain the service
- Close Loop/Resilience: Where an existing branch is observed, a new pipeline is shown to connect this branch to an existing or diverted line. This is to add resilience to the network, in the event of a partial failure of the branch line
- New Service: To supply a new building, a new water main is shown where no water provision is currently provided.

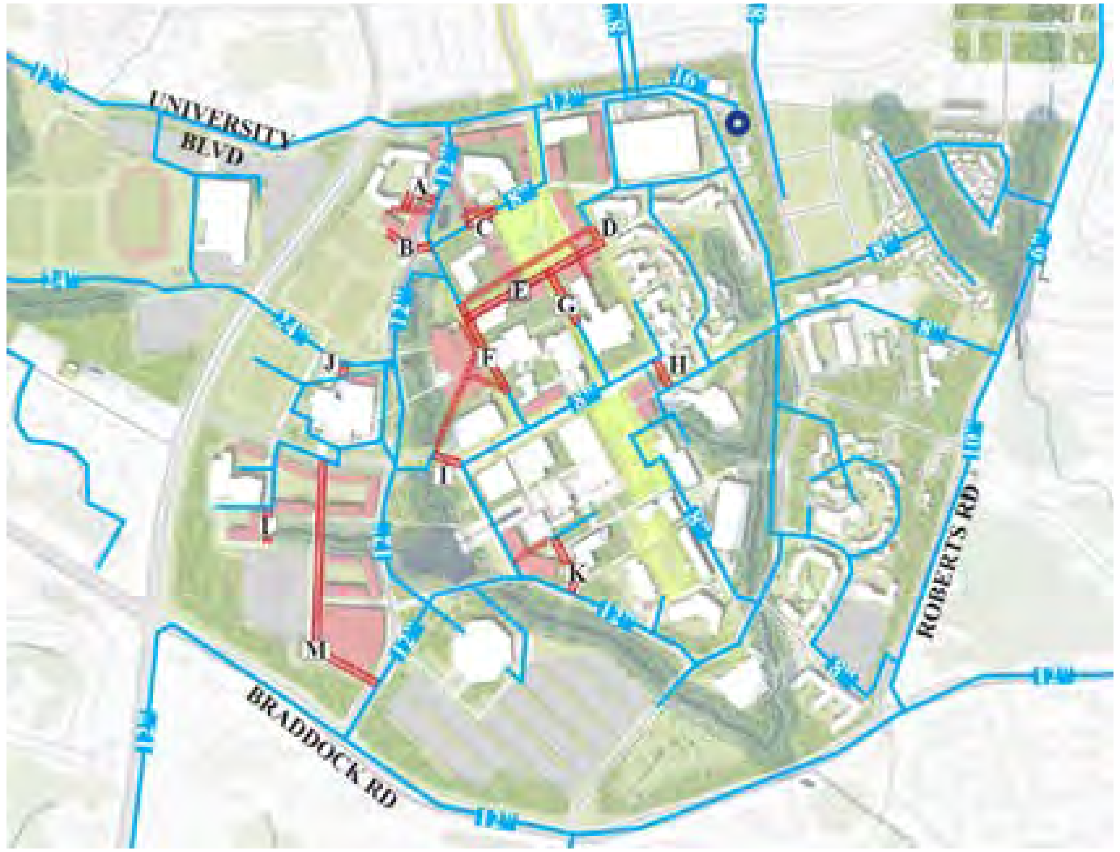


Figure 19 - Proposed Potable Water Improvements at Fairfax Campus

ID	STATUS	PURPOSE	DIAMETER (IN)	EST. LENGTH (FT)
PROPOSED WATER MAINS				
A	Proposed	Diversion	12	250
B	Proposed	New service	8	250
C	Proposed	Diversion	8	150
D	Proposed	Diversion	8	50
E	Proposed	Diversion	8	1000
F	Proposed	Diversion	12	550
G	Proposed	Close loop/Resilience	8	350
H	Proposed	Diversion	8	200
I	Proposed	Diversion	12	120
J	Proposed	Diversion	12	50
K	Proposed	Diversion	8	300
L	Proposed	New service	8	200
M	Proposed	New service	12	1400

Table 5 - Proposed Potable Water Improvements Summary at Fairfax Campus

PHASING OF WORKS

The implementation of the works above can likely be phased or installed on a building-by-building basis. This is due to the improvements serving individual buildings or zones, rather than wholesale network upgrades.

As Fairfax Water owns and maintains existing water mains, phasing and implementation impacts of each new building on existing water services should be reviewed with Fairfax Water in the early planning stages.

4.4.2 SCITECH CAMPUS

DEMAND CALCULATIONS

The additional potable water demand resulting from new buildings has been estimated and is shown in Table 6. Water demand is per Prince William County Service Authority, Water and Sewer Utility Standards Manual, Section 110 General Requirements.

Ultimately, Prince William County must review and approve of the calculation methodology as design progresses.

AREA	QUANTITY	POTABLE WATER DESIGN FLOW FROM NEW DEVELOPMENT	AVERAGE WATER DEMAND FROM NEW DEVELOPMENT (GPD)
Academic	117,000 SQ. FT	0.21 GPD/SQ. FT	31,500
Pavillion	40,000 SQ. FT	0.21 GPD/SQ. FT	8,400
P3 mixed-use	Retail: 37,000 SQ. FT Residential: 420 beds	Retail: 0.21 GPD/SQ. FT Residential: 250 GPD/Unit	42,770
Gateway Academic	166,000 SQ. FT	0.21 GPD/ SQ. FT	34,860
		TOTAL	117,500

Table 6 - Summary of Program Potable Water Demands at SciTech Campus

CAPACITY ASSESSMENT

It is anticipated that the existing potable water network will be sufficient to provide the necessary capacity and pressure to the site.

This assumption is subject to detailed design and review by Prince William County.

RECOMMENDATIONS FOR IMPROVEMENTS

To facilitate new building construction, some modifications to the existing water network are required.

The proposed potable water configuration considers relocations and service additions required to accommodate the footprint of new building development and whether the existing network has sufficient capacity to accommodate the proposed growth.

Figure 20 illustrates the proposed network, with pipe additions annotated. Table 7 details the characteristics of each new pipe, with reference to these annotations.

The purpose of these improvements is listed in the table and defined as follows:

- Diversion: Where the existing pipe is in conflict, or likely in conflict, with the proposed development, a new pipeline is shown to maintain the service
- Close Loop/Resilience: Where an existing branch is observed, a new pipeline is shown to connect this branch to an existing or diverted line. This is to add resilience to the network, in the event of a partial failure of the branch line
- New Service: To supply a new building, a new water main is shown where no water provision is currently provided.

Figure 20 - Proposed Potable Water Improvements at SciTech Campus

ID	STATUS	PURPOSE	DIAMETER (IN)	EST. LENGTH (FT)
ADDITIONAL PROPOSED SEWERS				
A	Proposed	Close loop/Resilience	12	1,400
B	Proposed	New service	8	300
C	Proposed	Diversion/ New service	8	100

Table 7 - Proposed Potable Water Improvements Summary at SciTech Campus

PHASING OF WORKS

The implementation of the works above can likely be phased or installed on a building-by-building basis. This is due to the improvements serving individual buildings or zones, rather than wholesale network upgrades.

As Prince William County (PWC) own and maintain the existing water network, phasing and implementation impacts of each new building on existing water services should be reviewed with PWC in the early planning stages.

4.4.3 ARLINGTON CAMPUS

No potable water works are anticipated at the Arlington campus.

4.4.4 ALTERNATIVE WATER SUPPLY CONSIDERATIONS

We prepared an alternative water supply study to evaluate opportunities for onsite water reuse at the Fairfax and SciTech campuses. We studied two alternative water supply options: 1) rainwater reuse and 2) district-scale wastewater treatment and reuse. Both options consider using alternative water supplies to offset non-potable water demands, including irrigation and toilet flushing.

RAINWATER REUSE

We looked at the potential to capture rainwater from new building roofs in the North Mixed-Use, Upper Quad and West Mixed-Use development areas. Collected rainwater would be stored in a district-scale underground tank and used to irrigate planned landscape within each development area. Collected rainwater would require screen filtration and disinfection prior to reuse in nearby irrigation networks (pending local code review). Figure 21 provides an estimate of rainwater collection potential and irrigation demands in these three planned development areas.

It is estimated that rain collection tanks of approximately 5,000gal per building would adequately serve irrigation demands in the landscape and open space areas in these three planned development areas. Reusing rainwater in all three development areas is estimated to offset approximately 500,000gal of potable water in an average year.

Figure 21 - Estimated Program Rainwater Supply and Irrigation Demands at Fairfax Campus

DISTRICT-SCALE ONSITE WASTEWATER REUSE SYSTEM (OWTS)

As described in the sanitary sewer section below, there is insufficient capacity in the existing 10in sewer main below Mason Pond Dr and Patriot Cir (west) to serve all planned buildings. We therefore considered onsite wastewater treatment as an opportunity to not only offset non-potable demands at new buildings but to mitigate the need to upsize the 10in sewer main.

We evaluated the potential for three district-scale OWTS plants to treat wastewater generated by new buildings and return treated effluent at a non-potable water standard to the same buildings to flush toilets. Three district plant opportunities have been identified for this study: 1) North Mixed-Use / Upper Quad development area (Fairfax North), 2) West Mixed-Use development area (Fairfax West), and 3) the SciTech campus. While there are several available wastewater treatment technologies available in the market, membrane bioreactor (MBR) technology provides the highest effluent water quality in the smallest footprint and is an industry leader.

See Table 8 for preliminary estimates of MBR plant sizes, footprint and capital costs (assuming $40/GPD in 2021 dollars) with potential to serve these three development areas. It is estimated that just one OWTS plant in the Fairfax campus would offset the need to upsize the 10in sewer main under Mason Pond Dr and Patriot Cir (west). Since sewer supply typically exceeds flushing demands, excess non-potable water produced by the OWTS plant may be used to supply irrigation demands in existing and planned landscape and open space areas in the Fairfax campus. Installation of just one district-scale OWTS plants has the potential to save approximately 35Mgal of potable water in an average year. Depending on local water and sewer rates, district-scale plants of 100,000gal or more are often found to have paybacks in the 5-10year range.

	PLANT NAME	OWTS TREATMENT CAPACITY (GAL/DAY)	OWTS (MBR) ESTIMATED CAPEX (US$)	OWTS (MBR) PLANT FOOTPRINT (SQ. FT)	ESTIMATED LAND AREA (INCL. SLUDGE + TANKS + ACCESS) (SQ. FT)	TOTAL ESTIMATED LAND TAKE (ACRE)
A	Fairfax north	120,000	$4,800,000	4,000	16,000	0.37
B	Fairfax south	160,000	$6,400,000	5,333	21,000	0.49
C	SciTech	110,000	$4,400,000	3,667	15,000	0.34

Table 8: Estimated OWTS Sizes, Capital Costs and Footprint at Fairfax and SciTech Campuses

While both the rainwater harvesting and OWTS systems are considered technically feasible, they should be further explored at future designs stages to determine economic viability. Nonetheless, this study shows there to be adequate supply of rainwater and treated wastewater effluent to offset all anticipated non-potable demands from proposed buildings and landscape areas in this masterplan.

4.5 SANITARY SEWER

Sanitary sewer improvements have been considered by campus. Improvements only consider areas affected by the proposed masterplan.

Sanitary Sewer Improvement Plans for Fairfax and SciTech are provided in the Appendix.

4.5.1 FAIRFAX CAMPUS

DEMAND CALCULATIONS

As section 4.4.1, demand is determined per Virginia Administrative Code, Title 9, Ag. 25, Chp 790, Pt. III, Article 3, 9VAC25-790-460. Standards. See estimated demands in Table 9.

Where a flow is not provided for building type, 0.21gpd/ft2 (0.19gpd/ft2 sewer demand) is assumed. This is based upon the design requirements observed at the SciTech campus and to maintain uniformity across design.

A peaking factor of 3 has been used to infer peak flows.

Ultimately, Fairfax County must review and approve of the calculation methodology as design progresses.

AREA	QUANTITY	SANITARY DESIGN FLOW FROM NEW DEVELOPMENT	AVERAGE SEWER DEMAND FROM NEW DEVELOPMENT (GPD)
North mixed-use	Retail: 125,000 SQ. FT Residential: 1200 beds	Retail: 200 GPD/1000 SQ FT Residential: 75 GPD/Person	115,000
West mixed-use	Target: 109,000 SQ. FT Retail: 139,000 SQ FT Residential: 1400 beds	Target: 200 GPD/1000 SQ. FT Retail: 200 GPD/1000 SQ. FT Residential: 75 GPD/Person	154,600
Upper quad academic	420,000 SQ. FT	0.19 GPD/SQ. FT	79,380
Central quad academic	120,000 SQ. FT	0.19 GPD/SQ. FT	22,680
Faculty	140 Dwellings	100 GPD/UNIT	14,000
Recreation	238,000 SQ. FT	0.19 GPD/SQ. FT	44,980
Innovation	110,000 SQ. FT	0.19 GPD/SQ. FT	20,790
Robinson B Replacement	70,000 SQ. FT	0.19 GPD/SQ. FT	13,230
[Building losses]	-370,000 SQ. FT	0.19 GPD/SQ. FT	-69,930
		NET TOTAL	383,300

Table 9 - Summary of Program Sanitary Sewer Demands at Fairfax Campus

CAPACITY ASSESSMENT

To determine the impact of the proposed masterplan on the Fairfax Campus, an approximation of the baseline 2021 peak sanitary sewer flows has been determined, see Table 10. This has been estimated using demand figures from the 2009 Utility Infrastructure Master Plan.

	PEAK SANITARY SEWER DEMAND (GPM)		
ZONE	MAIN CAMPUS WEST	MAIN CAMPUS EAST	FACULTY
Pre-2021	368	795	11
Additions:2009-2021	234	123	0
2021 Pre-development baseline	602	918	11

Table 10 - Pre-development Baseline Peak Sanitary Sewer Demands at Fairfax Campus

Additional demands resulting from the masterplan have been determined as in Table 11. To compare this demand against existing capacity, the capacity has been estimated and shown in Table 12. In estimating capacity, pipe slopes have been assumed to be 1.0%.

No new sanitary demand is anticipated at the West Campus.

	PEAK SANITARY SEWER DEMAND (GPM)			
ZONE	MAIN CAMPUS WEST	MAIN CAMPUS EAST	FACULTY	ASSUMPTIONS
2021 Pre-development baseline	602	918	11	-
North mixed-use	161	89	-	2/3 flows to west network 1/3 flows to east network
West mixed-use	322	-	-	-
Upper quad academic	184	-	-	-
Central quad academic	-	47	-	-
Faculty	-	-	30	-
Recreation	94	-	-	-
Innovation	43	-	-	-
Robinson B Replacement	28	-	-	-
TOTAL	1,305	1018	41	

Table 11 - Proposed Peak Sanitary Sewer Demands at Fairfax Campus

	PIPE CAPACITY AT 1.0% SLOPE (GPM)			
	MAIN CAMPUS WEST (10”)	MAIN CAMPUS EAST (10”)	MAIN CAMPUS WEST + EAST (16”)	FACULTY
Flow (GPM)	1,065	1,065	3,720	585

Table 12 - Existing Sanitary Sewer Pipe Capacity Estimates at Fairfax Campus

If the campus were to experience peak flows simultaneously, the “Main Campus West” 10in sewer main at Mason Pond Dr and Patriot Cir would exceed its available capacity.

A study was undertaken to better estimate when peak flows may occur, to account for opposing diurnal flows generated by different building types. The study assumes 75% of the peak flow from new buildings would not simultaneously occur for mixed-use and academic buildings. The pre-2021 masterplan flows are not modified and remain at 100% as they are beyond the study area.

This study reduces peak sewer flows, but not to a level which reasonably brings new flows to within existing capacity limits the 10in ‘Main Campus West’ sewer main. Results are shown in Table 13. Therefore, upsizing this main to accommodate all new building sewer demands is recommended.

	PEAK SANITARY SEWER DEMAND (GPM)		75% PEAK SANITARY SEWER DEMAND (GPM)	
ZONE	MAIN CAMPUS WEST	MAIN CAMPUS EAST	MAIN CAMPUS WEST	MAIN CAMPUS EAST
2021 Pre-development baseline	602	918	602	918
North mixed-use	161	89	120	67
West mixed-use	322		242	
Upper quad academic	184		124	
Central quad academic		47		35
Recreation	94		41	
Innovation	43		32	
Robinson B Replacement	28		21	
[Building losses]	-109	-36	-121	-36
TOTAL	1,305	1,018	1,102	984

Table 13 - Fairfax Campus East-West Pipe Demand Estimates

RECOMMENDATIONS FOR IMPROVEMENTS

To facilitate new building construction, some modifications to the existing sewer network are required.

The proposed sewer configuration considers relocations and service additions required to accommodate new buildings and whether the existing network has sufficient capacity to accommodate the proposed growth.

Figure 22 illustrates the proposed network, with pipe additions annotated. Table 14 details the characteristics of each new pipe, with reference to these annotations.

The purpose of these improvements is listed in the table and defined as follows:

- Proposed Upgrade: Based upon the findings of this study, an upgrade is recommended to satisfy peak demands.
- Diversion: Where the existing pipe is in conflict, or likely in conflict, with the proposed development, a new pipeline is shown to maintain the service.
- Close Loop/Resilience: Where an existing branch is observed, a new pipeline is shown to connect this branch to an existing or diverted line. This is to add resilience to the network, in the event of a partial failure of the branch line.
- New Service: To supply a new building, a new sewer is shown where no sewer provision is currently located.

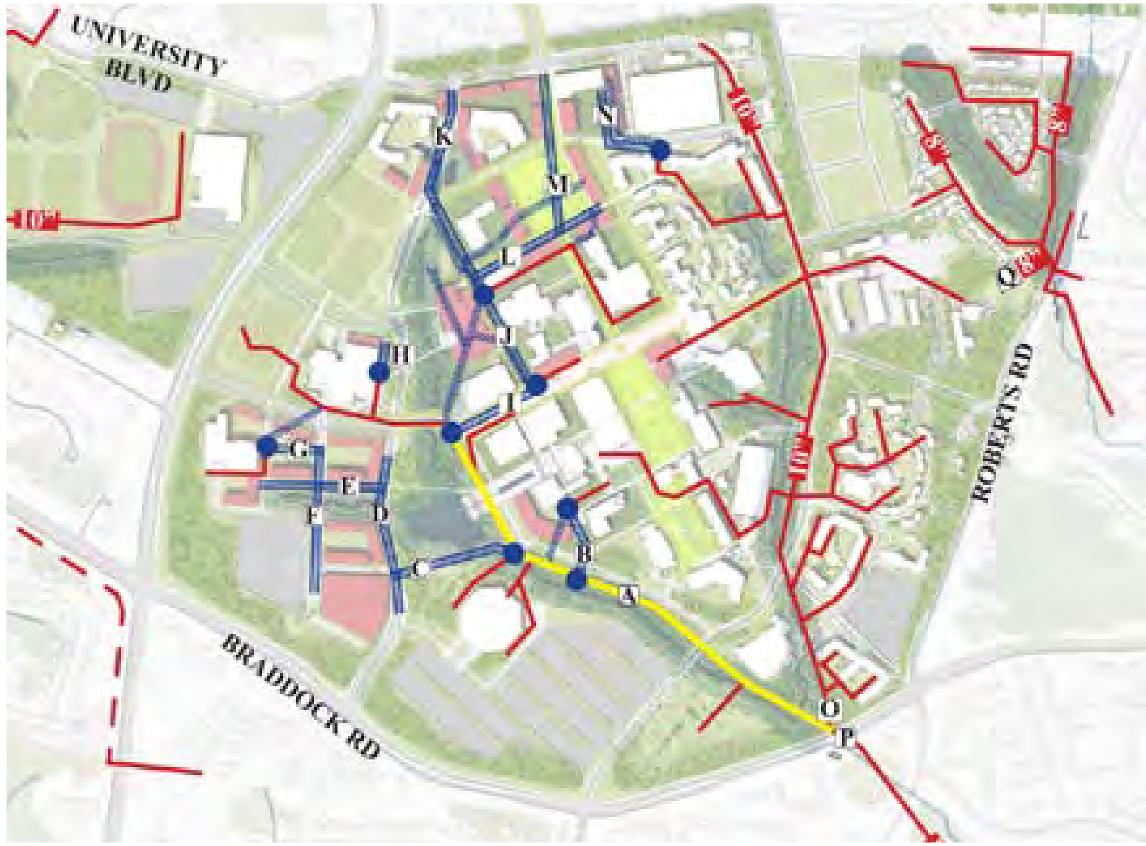


Figure 22 - Proposed Sanitary Sewer Improvements at Fairfax Campus

ID	STATUS	PURPOSE	DIAMETER (IN)	EST. LENGTH (FT)	EST. PEAK FLOW (GPM)	EST. CAPACITY FULL
EXISTING TRUNK SEWERS						
A	Proposed upgrade	Ex. pipe over capactity	12 or 16	2800	1305	74 (12") or 41 (16") (at 1.0% slope)
O	Existing to remain	-	10	-	1018	92 (at 1.0% slope)
P	Existing to remain	-	16	-	2323	64 (at 1.0% slope)

Table 14 - Proposed Sanitary Sewer Improvements Summary at Fairfax Campus

ID	STATUS	PURPOSE	DIAMETER (IN)	EST. LENGTH (FT)	EST. PEAK FLOW (GPM)	EST. CAPACITY FULL
Q	Existing to remain	-	8	-	41	14 (at 1.0% slope)
ADDITIONAL PROPOSED SEWERS						
B	Proposed	Diversion	8	300		
C	Proposed	New service	10	1000		
D	Proposed	New service	10	900		
E	Proposed	New service	8	700		
F	Proposed	New service	8	850		
G	Proposed	Diversion/ New service	8	350		
H	Proposed	New service	8	100		
I	Proposed	Diversion/ New service	10	450		
J	Proposed	Diversion/ New service	10	1250		
K	Proposed	Diversion/ New service	10	550		
L	Proposed	Diversion/ New service	8	850		
M	Proposed	New service	8	1000		
N	Proposed	Diversion/ New service	8	500		

Table 14 (continued) - Proposed Sanitary Sewer Improvements Summary at Fairfax Campus

PHASING OF WORKS

The implementation of the works above can likely be phased or installed on a zone-by-zone (e.g., North Mixed-Use, West Mixed-Use) basis.

The upgrade of Pipe A only need be considered when the cumulative additional load sees the pipe capacity reached. Additional flows can be accommodated within the existing pipe up to that existing capacity limit. The proposed peak demands observed in Table 11 should be contrasted against the pipe capacities in Table 12 to determine, approximately, how much of the development program can be built prior to upsizing being required.

As Fairfax County owns and maintains the existing sewer network, phasing and implementation impacts of each new building on existing sewer services should be reviewed with Fairfax County during early planning stages.

4.5.2 SCITECH CAMPUS

DEMAND CALCULATIONS

The additional sanitary sewer demand resulting from the proposed masterplan has been estimated and is shown in Table 15. Sewer demand is inferred from water demand and is assumed to be 90% of the water demand as calculated in 4.4.2.

A peaking factor of 3 has been used to infer peak flows.

AREA	QUANTITY	POTABLE WATER DESIGN FLOW FROM NEW DEVELOPMENT	AVERAGE SEWER DEMAND FROM NEW DEVELOPMENT (GPD)
Academic	150,000 SQ. FT	0.21 GPD/SQ. FT	28,350
Pavillion	40,000 SQ. FT	0.21 GPD/SQ. FT	7,560
P3 mixed-use	Retail: 37,000 SQ. FT Residential: 420 beds	Retail: 0.21 GPD/SQ. FT Residential: 250 GPD/Unit	38,490
Gateway Academic	166,000 SQ. FT	0.21 GPD/ SQ. FT	31,375
		TOTAL	105,800

Table 15 - Summary of Program Sanitary Sewer Demands at SciTech Campus

CAPACITY ASSESSMENT

To determine the impact of the proposed masterplan on the SciTech campus, this study has determined an approximation of the baseline 2021 peak sanitary sewer flows.

BUILDING	EST. GROSS FLOOR AREA (SQ FT)	EST. WATER USE (GPD/SQ FT)	AVERAGE SANITARY SEWER DEMAND (GPD)	PEAK SANITARY SEWER DEMAND (GPM)
Freedom Aquatic & Fitness Center	154,400	0.21 GPD/SQ. FT	29,180	61
Serious Game Institute/ Katherine G. Johnson Hall	136,200	0.21 GPD/SQ. FT	25,740	54
Mercer Library/ Colgan Hall	104,000	0.21 GPD/SQ. FT	19,650	41
Discovery Hall	67,800	0.21 GPD/SQ. FT	12,810	27
Institute for Advanced Bio-medical Research	78,900	0.21 GPD/SQ. FT	14,900	31
Hylton Performing Arts Center	68,200	0.21 GPD/SQ. FT	12,900	27
Beacon Hall	155,000	0.21 GPD/SQ. FT	29,300	61
		TOTAL	144,480	301

Table 16 - Pre-development Baseline Peak Sanitary Sewer Demands at SciTech Campus

Additional demands for resulting from the masterplan have been determined as in Table 17.:To compare this demand against existing capacity, the capacity has been estimated and shown in Table 18. In estimating capacity, pipe slopes have been assumed to be 1.0%.

BUILDING	AVERAGE SANITARY SEWER DEMAND (GPD)	PEAK SANITARY SEWER DEMAND (GPM)
2021 pre-development baseline	144,480	301
Academic	28,350	59
Pavillion	7,560	16
P3 mixed-use	38,490	80
Gateway Academic	31,375	65
2021 BASELINE + MASTERPLAN	250,260	521

Table 17 - Proposed Peak Sanitary Sewer Demands at SciTech Campus

	PIPE CAPACITY AT 1.0% SLOPE (GPM)		
	12" PIPE	15" PIPE	18" PIPE
Flow (GPM)	1,730	3,135	5,095

Table 18 - SciTech: Estimated Existing Pipe Capacities

RECOMMENDATIONS FOR IMPROVEMENTS

To facilitate new building construction, some modifications to the existing sewer network are required.

The proposed sewer configuration considers relocations and service additions required to accommodate new buildings and whether the existing network has sufficient capacity to accommodate planned growth.

Figure 23 illustrates the proposed network, with pipe additions annotated. Table 19 details the characteristics of each new pipe, with reference to these annotations.

The purpose of these improvements is listed in the table and defined as follows:

- Diversion: Where the existing pipe is in conflict, or likely in conflict, with the proposed development, a new pipeline is shown to maintain the service.
- New Service: To supply a new building, a new sewer is shown where no sewer provision is nearby

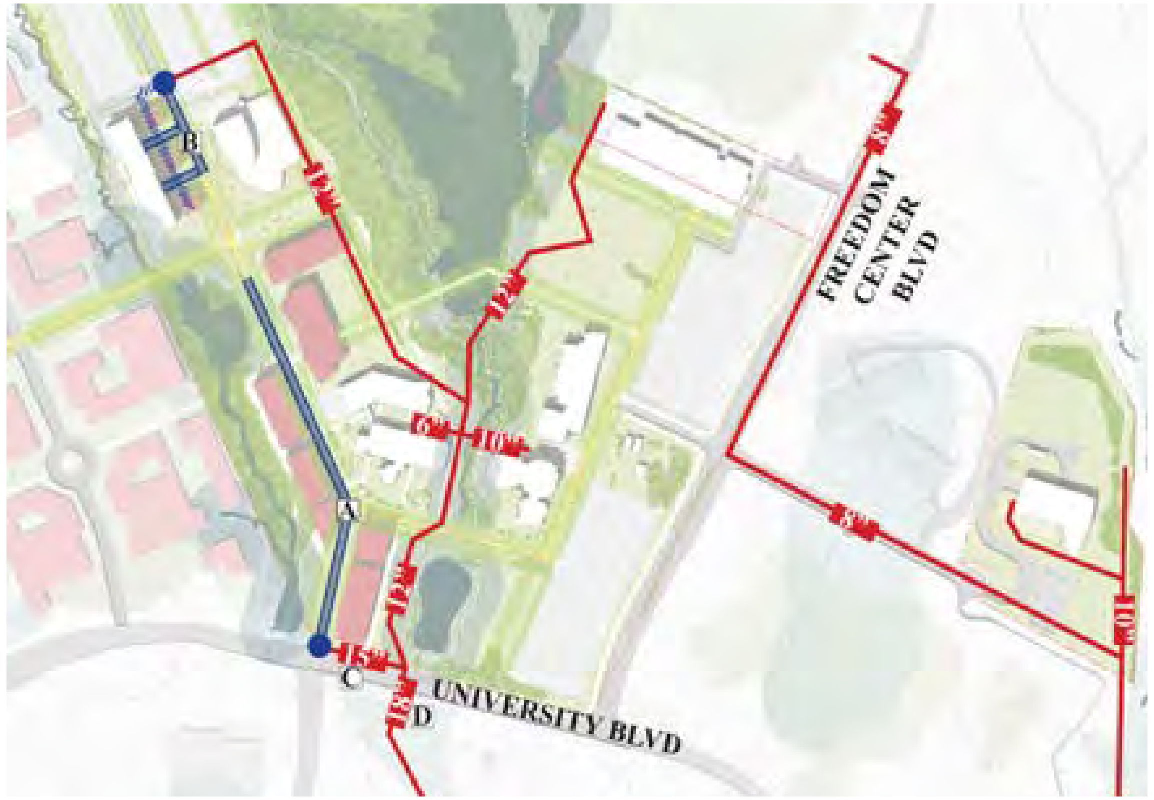


Figure 23 - Proposed Sanitary Sewer Improvements at SciTech Campus

ID	STATUS	PURPOSE	DIAMETER (IN)	EST. LENGTH (FT)	EST. PEAK FLOW (GPM)	CAPACITY FULL (%)
EXISTING TRUNK SEWER						
C	Existing to remain	-	15	-	204	13 (at 1.0% slope)
D	Existing to remain	-	18	-	521	17 (at 1.0% slope)
ADDITIONAL PROPOSED SEWERS						
A	Proposed	New service	12	1300		
B	Proposed	Diversion/ New service	10	400		

Table 19 - Proposed Sanitary Sewer Improvements Summary at SciTech Campus

PHASING OF WORKS

The implementation of the works above can likely be phased or installed on a building-by-building basis. As PWC owns and maintains the existing sewer network, phasing and implementation impacts of each new building on existing sewer services should be reviewed with PWC during early planning stages.

COORDINATION WITH FUTURE DEVELOPMENT

This report is written prior to the formalization of a development plan for the property immediately west of the SciTech campus.

It is known that a future mixed-use private development is proposed, and it is expected that some, or all, sanitary sewer flows would discharge to the existing 15in pipe stub (i.e., Pipe C). This masterplan does not consider inflow from the planned private development. It is noted however, based upon available data, Pipe C is estimated to have ~13% remaining capacity after flows generated by new buildings at the SciTech campus are added.

4.5.3 ARLINGTON CAMPUS

No sanitary sewer works are anticipated at the Arlington campus.

4.6 TELECOMMUNICATIONS

The demand calculation is aligned with fiber duct counts and sizing seen at each building from Mason's telecommunication upgrade plan in March 2020 provision. We also provided a wider perspective of wireless solutions and business models that can be of consideration for Mason.

4.6.1 FAIRFAX

DEMAND CALCULATIONS

Each new building will require (2) 4" - (4) 4" conduit connection based on its final area count.

CAPACITY ASSESSMENT

Existing duct banks need to be further evaluated against consolidated new demand from each building. New conduits will be required for each new building. Existing conduits and fiber for buildings that are to be demolished will need to be removed.

RECOMMENDATIONS FOR IMPROVEMENTS

Upsize existing duct banks in orange, leverage planned duct banks in pink and provide new duct banks in cyan to serve proposed new buildings

PHASING OF WORKS

The implementation of the works can likely be phased or installed on a building-by-building basis.

COORDINATION WITH FUTURE DEVELOPMENT

3-Phase duct bank development needs to coordinate with the master plan development phasing.

Figure 24 - Proposed Telecommunication Duct Banks at Fairfax Campus

4.6.2 ARLINGTON

As there's no new buildings planned for Arlington after construction of the New Building at Mason Square, existing and currently planned duct banks and fiber conduits can be leveraged to support site/ landscaping systems' needs for telecommunication.

4.6.3 SCITECH

DEMAND CALCULATIONS

Existing duct banks need to be further evaluated against consolidated new demand from each building. New conduits will be required for each new building. Existing conduits and fiber for buildings that are to be demolished will need to be removed.

RECOMMENDATIONS FOR IMPROVEMENT

Upsize existing duct banks in orange and leverage planned duct banks in pink to provide new and redundant connections to new buildings.

Figure 25 - Proposed Telecommunication Duct Banks at SciTech Campus

PHASING OF WORKS

The implementation of the works above can likely be phased or installed on a building-by-building basis.

COORDINATION WITH FUTURE DEVELOPMENT

3-Phase duct bank development needs to coordinate with the master plan development phasing.

4.6.4 WIRELESS STRATEGY

We also reviewed a number of wireless telecommunication technologies for Mason to consider in a holistic manner, to streamline services and business models.

Wireless telecommunication technologies include the following categories:

- Cellular - External penetration; Historical cellular deployment was intended for outdoor environments with opportunistic indoor coverage as carriers could reasonably provide from external towers and buildings. Traditional cellular deployment for indoor environments should be considered a secondary/opportunistic strategy.
- 5G - While current deployments of true 5G are typically in exterior environment, the technology itself is ultimately more suited to indoor environments. This is due to the density of antenna and the reality that most users and devices will be located indoors. External penetration of 5G into buildings will be far reduced from the experience today with current 3G/4G generations of cellular. There are either none or very few deployments of ubiquitous indoor 5G and most, if not all, 5G deployments are directly by and for individual carriers. As such, a campus wide multi-carrier mmWave 5G solution is many years in the making as 3rd party DAS manufacturers are not ready to market. 5G enabled phones are forecast to gain up to 70% market share of total phones in the US by end of 2023.
    - Sub-6 5G:This type of 5G uses radio frequency spectrum below 6GHz. Sub-6 5G to be equivalent in name and experience to traditional Cellular coverage.
    - mmWave (millimeter wave) 5G : This type of 5G uses dramatically higher frequencies, ranging above 30GHz. mmWave 5G networks can provide tremendous improved data speeds and ultralow latency allowing for a paradigm shift in applications and user experience. A true mmWave 5G deployment requires a far more dense arrangement of antennas and near line of site coverage and as such is often considered a 'hot spot' technology without ubiquitous coverage.
- CBRS (Citizens Broadband Radio Service) - CBRS is a band of radio-frequency spectrum from 3.5GHz to 3.7GHz that the Federal Communications Commission has designated for sharing among three tiers of users: incumbent users, priority licensees and generally authorized, which is lightly licensed. CBRS technology promises to deliver to campus-like customers the combined benefits of Wi-Fi and cellular. CBRS currently requires CBRS enabled phones and an enterprise provided SIM card communicating over an enterprise owned and operated spectrum. This will inherently provide users secure access to the network and enterprise resources. The technology has greater coverage than Wi-Fi and as such can be more easily deployed both indoors and outdoors. CBRS can deliver quality of service levels equal to Cellular and seamless hand-offs between CBRS and Cellular networks. Currently the downsides of CBRS include the inability to support roaming users (visitors) without a pre-authorized SM card and a CBRS enables phone. However, manufacturers are currently aiming to alleviate these concerns and if solved, would make CBRS a strong candidate for campus-wide indoor/outdoor wireless coverage.
- DAS (Distributed Antenna System) - DAS refers to in-building cellular coverage provided by a purpose-built in-building antenna system. This system may also be used to support multiple buildings or a campus as needed. This network supplements the exterior coverage and requires close carrier coordination for approvals so as not to interfere with the 'macro' external network. This system could be deployed by the owner, a neutral host, a common carrier, or individual carriers. DAS systems are typically expensive to deploy and are often reserved for high density environments such as is currently used at EagleBank Arena. The return on investment improves with the density of subscribers and extent of coverage. It is common for a campus environment to deploy a multi-carrier DAS to supplement external coverage with reliable internal coverage that provides a seamless experience to the users.
- Wi-Fi - This technology has high adoption and for indoor environments and is the typical primary method of indoor wireless connectivity. Wi-Fi uses unlicensed spectrum and thus lives in an increasingly competitive and saturated environment which can reduce performance with no minimum service level guarantee. Wi-Fi is also inherently insecure and requires diligent network administration to preserve the integrity of the network. Ideally, a campus wide solution would cover indoor and outdoor environments but Wi-Fi, due to regulated power output limitations and density of antenna deployment, is not an ideal technology for outdoors.

telecommunication technologies, Mason can consider the following business/funding options:

- Direct to individual carriers - Often preferred by the carriers for large/dense subscriber base environments. While offering the owner a seemingly financially advantageous arrangement, this creates an environment difficult to manage and control over the long term with multiple service agreements, from multiple carriers over multiple deployments and may not serve the owner best interests due to lack of domain control and barriers to make changes. While this is natural in the outdoor environment, the indoor environment problem is exacerbated by needing to install multiple parallel indoor distribution systems that require more power, cooling, space, devices, and associated management. We would typically not recommend this approach when considering a long term master plan strategy.
- Common carrier - On occasion where deemed an attractive option for the carrier, an offer by a single carrier to provide a common DAS to support both itself and its competitors may be possible. This is typically up to the discretion of all of the carriers and there is little guarantee that the primary carrier will adequately support its competition or succeed in finalizing an agreement to carry the other carriers service. Where successful, this can be a good option from both a subsidy and simplicity of deployment perspective. However, much risk is introduced and little negotiation leverage is available to the owner once the system is deployed.
- Neutral host DAS - This option relieves many of the pitfalls of carrier provided system(s) and allows the Owner better leverage in service levels, pricing, upgrades etc. The downside is introducing a for-profit entity that while providing the owner less headaches and better control, there will be less financial return on the model than other options.
- Owner owned/operated - This option provides the owner with maximum authority and control over the wireless network. With respect to funding, there are risks depending upon negotiation on how much, if at all, subsidies will be provided by the carriers. There are a number of 3rd party entities that can aid in the negotiation process with multiple carriers as both an initial and ongoing service seeing as Cellular coverage is not a core business of the University. Deployment planning for both existing and new buildings can be made in a controlled and methodical manner at the discretion of the University according to and in line with the capital improvement master plans. Additionally, the university could elect to employ a managed service provider to operate the system in lieu of self-operated to ease management overhead.
- Grants and Infrastructure bill spending - Further investigation into available/applicable grants should be made to see if there are funding opportunities on the county, state, or federal level for broadband deployment for a public University entity. At the time of this writing, the Bipartisan Infrastructure Framework bill being considered by congress/senate promises to invest $65 billion in 'Broadband Infrastructure' by allocating funds to state and local government.

SUPPLEMENT A

THERMAL CALCULATION INPUTS

THERMAL LOADS

Buildings	SF	Cooling SF/ton	Heating MBTU/SF/YR	DHW W/SF	Heating (MBTU/SF/YR)	Cooling (TON-HR/SF/YR)	DHW (kWh/SF/yr)	Thermal heating MBTU/YR)	Thermal cooling KWH/YR	DHW energy KWH/YR
Academic	350,000	330	22.5	0.19	22.12	0.92	1.12	7,742,817	1,135,310	390,335
Target retail	109,000	385	18	0.19	22.12	0.92	1.12	2,411,335	353,568	121,561
Mixed-use	264,000	385	18	0.19	22.12	0.92	1.12	5,840,297	856,348	294,424
Residential	1,066,000	440	18	0.93	18.96	0.79	3.25	20,213,494	2,963,855	3,467,472
Athletics/rec	238,000	275	22.5	0.19	22.12	0.92	1.12	5,265,116	772,011	265,428
Campus-wide	2,027,000	391.5	391.5	0.6	-	-		41,473,058	6,081,094	4,539,219

UTILITY COSTS

$/THERM	0.368
$/kWh	0.064
On-peak demand charge	10.689
Water cost $/gallon	0.012

EQUIPMENT EFFICIENCIES

District boiler heating	0.8% efficient
Central chiller	5 COP
GSHP heating	3.5 COP
GSHP cooling	3 COP
Stand-alone gas boilers	0.87% EFFICIENCT
Stand-alone ASHP heating	1.8 COP
Stand-alone ASHP cooling	3 COP
DHW boiler heating	0.8% efficient

BOREHOLE FIELD SIZE

Borehole capacity	3 TONS/Borehole
Diversity	0.8%
Ground SD	200 SF/Borehole

EXISTING FIELD SIZE

Boilers	164891 MBH
Chillers	12485 TONS

DISTRIBUTION

Pipe cost	$1,720	$/FT

CARBON EMISSIONS

Natural gas	0.05311 KG CO2/MMbtu
Electricity (SRVC grid)	99.37 KG CO2/MMBtu
Electricity (SRVC grid)	0.3388517 KG CO2/kWh
Future elecricity grid	0.10165551 KG CO2/kWh
Cost of carbon	50$/Metric ton

CAPITAL COSTS

Gas boiler cost	388$/KW
Gas boiler cost	113.782991$/MBH
Electric boiler cost	240$/KW
Chiller cost	2389$/TON
Ground source heat pump	918$/KW
Air source heat pump	918$/KW
GSHP boreholes	6666.66667$/TON
Cooling tower	171$/KW

MAINTENANCE COSTS

NG steam boiler	$/kW	$6.40
Elec steam boiler	$/kW	$1.88
NG HW boiler	$/kW	$6.40
Elec HW Boiler	$/kW	$4.62
Chiller	$/kW	$13.12
GSHP	$/kW	$13.12
ASHP	$/kW	$13.12
ASHP distributed	$/kW	$15.75
Cooling tower	$/kW	$9.88
GSHP distributed	$/kW	$15.75

GSHP OPTIMIZING

% optimizing on heating peak	0.5%
peak GSHP Kw (includes DHW)	5204.10557 KW
peak GSHP Kw (includes DHW)	1478.83333 tons
Boiler peak	4004.10557 KW
Chiller peak	4004.10557 KW
Chiller peak	2221.16667 tons

ECOLOGICAL PLANNING

BIOHABITATS

INTRODUCTION

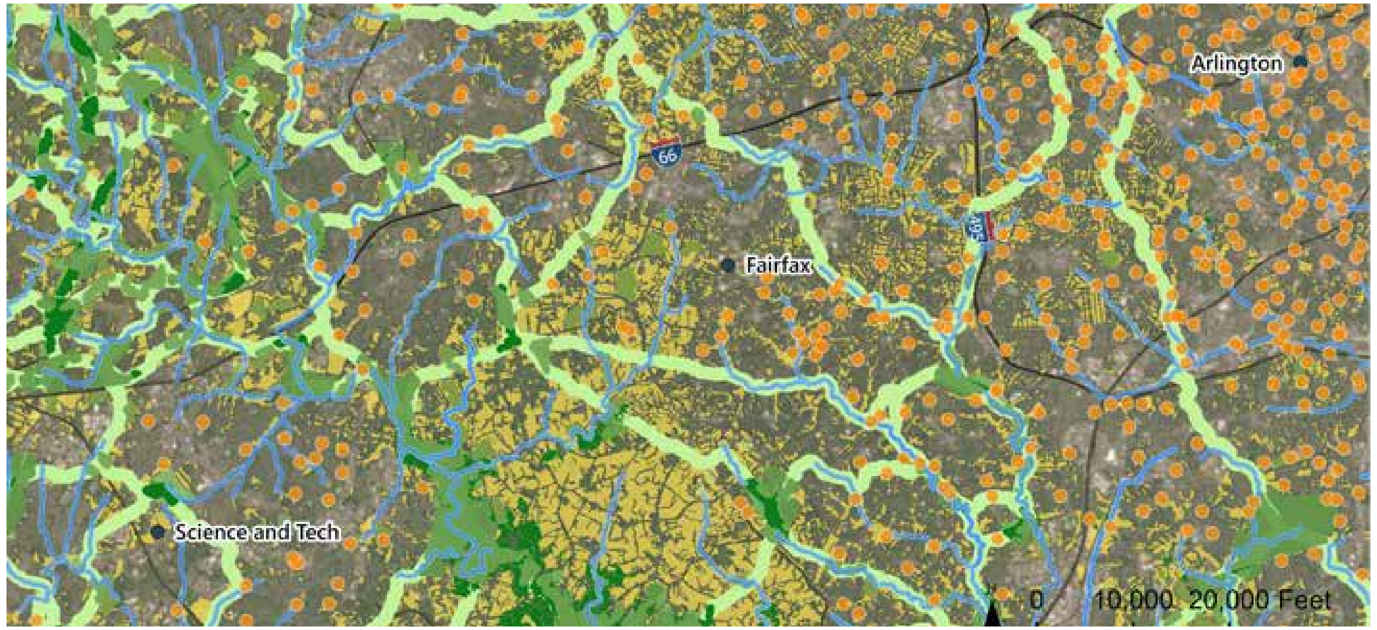
Encompassed by a rich biodiversity from oak-hickory forests to stream corridors and wetlands, George Mason's campuses have been inextricably linked to their natural settings since the Fairfax campus' founding in 1949. Protecting and celebrating George Mason's natural setting has been an enduring ecological planning principle that continues to sustain a strong relationship to nature and engagement through a range of programming and conservation. The master plan continues a tradition of stewardship to engage campus buildings and open spaces with the natural landscape and encourages its incorporation into the academic curriculum.

George Mason's faculty, staff, and students all benefit from a system of campuses that promote a natural landscape that is also ecologically functional. These spaces provide valuable ecosystem services that include:

- flood and erosion control
- groundwater recharge
- carbon sequestration
- climate regulation
- aquatic habitat
- purification of water and air
- seed dispersal
- food sources for native wildlife
- wildlife and pollinator habitats
- pest control
- educational, research and recreational spaces
- cultural, intellectual, and spiritual inspiration

These natural areas define and enhance the identity and aesthetic of George Mason's campuses, provide a space for student recreation to help relieve stress, allow students, faculty and staff to connect with nature, and provide opportunities for learning and research.

CAMPUS REGIONAL CONTEXT: ECOLOGICAL CORRIDORS AND HABITAT FRAGMENTS



- Site Locations
- Virginia Local Park Inventory (points)
- Hydrology Flowlines (National Hydrography Dataset)
- ESRI Green Infrastructure Habitat Cores
- ESRI Green Infrastructure Habitat Connectors
- ESRI Green Infrastructure Habitat Fragments
- The Nature Conservancy Regional Habitat Cores

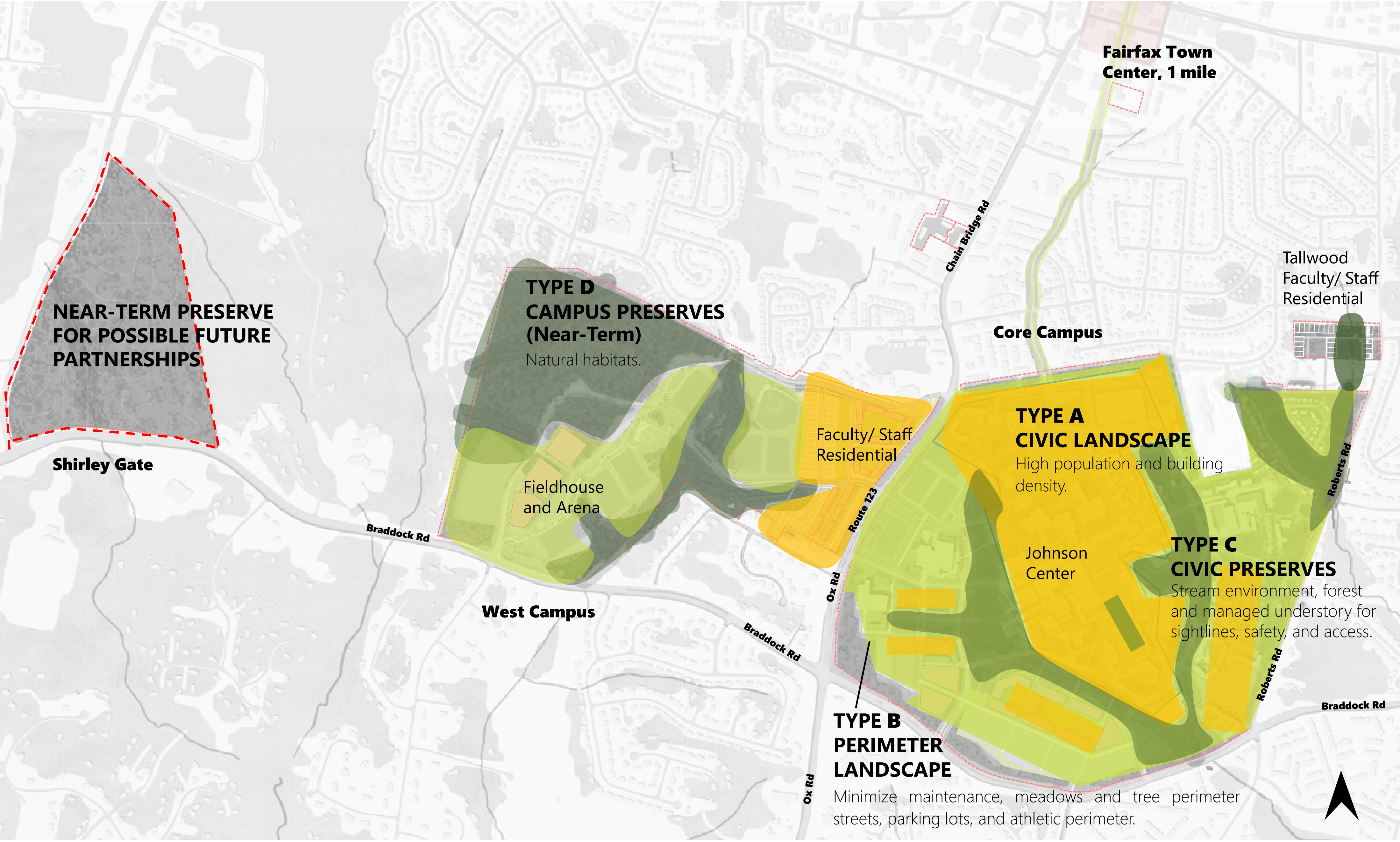
Map: Biohabitats

CORE ECOLOGICAL THEMES

A LIVING CAMPUS

To support framework principles and help Mason realize the full living potential of each campus, the plan's core ecological ideas each encompass a suite of activities in planning, design, and restoration:

- **Protect and Strengthen Ecological Corridors and Connectivity.** Animals move across landscapes and campuses, so finding ways to weave their pathways through and alongside our own is a key ecological theme. Whether placing stormwater planters to allow pollinators to traverse a parking lot or creating the green necklace as a central feature of the Fairfax Campus, this plan connects patches of natural habitats across scales and typologies.
- **Recognize and Celebrate Natural Features.** The streams, meadows, and patches of forest on George Mason campuses support a web of ecological functions. Allowing these salient natural features adequate space to fulfil their potential as ecological refugia and contemplative space can mean buffering streams, considering habitat quality fragmentation in the placement of gathering spaces, or adjusting mowing regimes to accommodate more forms of life.
- **Activate Outdoor Learning.** Inviting students and faculty outside means providing spaces and features that can be integrated into the classroom. These could be natural areas with permanent research plots that monitor ecological trajectories or simply gathering spaces near streams where inspiration from nature can infuse conversation.



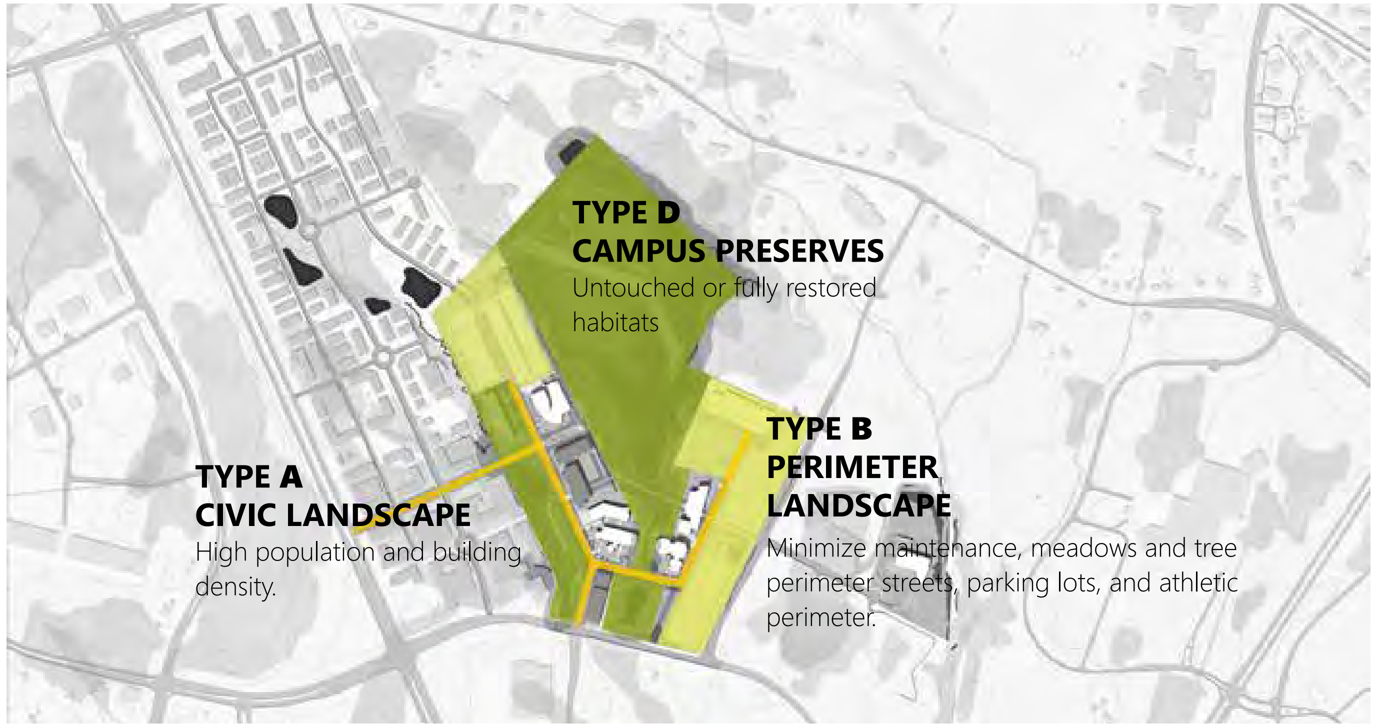
ECOLOGICAL TAXONOMY

Given the multitude of uses and demands on campus spaces, ecological typologies were developed to direct attention to what is possible and appropriate for four different levels of use. These four typologies are depicted in the adjacent map of the Fairfax Campus and include: the Civic Landscape, Perimeter Landscapes, Civic Preserves, and Campus Preserves. Maps defining these typologies for the Sci-Tech and Arlington campuses are provided on subsequent pages.

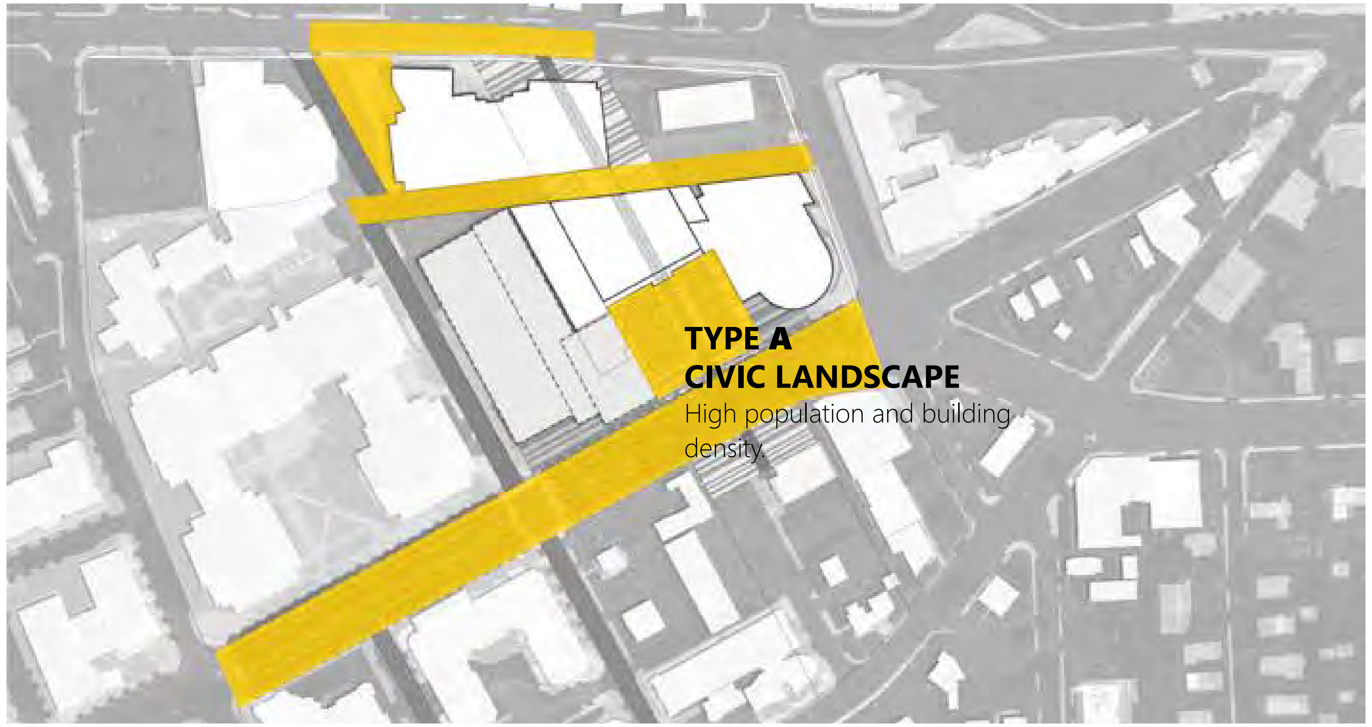
The typological approach is additive along a scale of population density and maintenance efforts. In areas characterized as Civic Landscape, where the focus is on the built landscape, increasing the native species planting palette might be the only plausible improvement, in light of limited space and safety considerations. In less constrained settings, such as Perimeter Landscapes and Civic Preserves, additional management tools such as creating vertical structure in a stand of trees may be possible.

In all typologies, the core ecological themes persist: Protect Ecological Corridors, Celebrate Natural Features, and Activate Outdoor Learning using landscape and design tools appropriate to the typology.

SCI TECH TYPOLOGY MAP



ARLINGTON TYPOLOGY MAP



INTEGRATED GREEN INFRASTRUCTURE CAN ENHANCE THE CIVIC CAMPUS

The Civic Campus Typology is characerized by impervious surfaces (L). Green roofs (Top R) and stormwater planters (Bottom R) can mimic the ecological functions of water absorption and filtration that have been lost.

Photos: J Dowdell, top right; Biohabitats, bottom right.

CIVIC CAMPUS

In the Civic Campus typology, natural forms nestle in the interstices of spaces designed for learning and research. Ecological functions are limited and often supported by engineered structures that mimic natural features and provide those functions within the built environment. Space is limited, so features are composed for multiple benefits. A stream benefits from a protective buffer of vegetation that also provides recreational opportunities via a pedestrian and bike trail along the waterway. Stormwater management features, designed to treat and filter pollutants from stormwater runoff, are planted with a robust mix of native plants to provide pollinator habitat.

INTEGRATED GREEN INFRASTRUCTURE

Treating water as a natural resource and achieving ecological uplift in the dense Civic Campus relies on green infrastructure. Green infrastructure promotes treatment of stormwater runoff throughout the built landscape to better mimic the natural water cycle. For example, when impervious surfaces such as roofs prevent water from infiltrating into the soil, green infrastructure practices such as green roofs can filter and treat stormwater and provide additional layers of ecological habitat and greening on campus. Anywhere there are large areas of impervious cover, runoff should be controlled utilizing multi-benefit stormwater management to limit stormwater pollution and volume, improve aesthetics, and provide pollinator habitat. In addition to green roofs, these stormwater management practices include stormwater planters, rain gardens, permeable pavement, and rainwater harvesting.

CIVIC CAMPUS FOCUS: ARLINGTON

The Arlington Campus is exclusively a Civic Campus space as it is densely developed, mostly paved, and has limited space for ecological uplift. It is therefore a prime example of the typology and the core recommendations for it pertain to the other campuses, as well. Key recommendations for this typology include:

- Specify and utilize a native plant palette, working within County guidelines. A native plant palette should be utilized as landscaping is maintained and right-of-way trees are replaced over time.
- Convert underutilized impervious surfaces to ultra-urban stormwater management practices, such as green roofs and stormwater planters, to improve water quality, provide pollinator habitat, and increase green space. Green roofs should be considered for new or updated structures.
- Replace impervious surfaces with pervious materials. Pervious pavement should be integrated into the heavily built landscape as plazas and walkways are updated and maintained to provide additional onsite stormwater treatment.

CIVIC CAMPUS FOCUS: SCI-TECH UTILITY CORRIDOR

The Sci-Tech Campus includes a utility right-of-way corridor that runs through the northern part of the campus. As a dominant feature of the Sci-Tech campus' landscape, this area presents significant opportunities for both ecological enhancement and recreation.

Utility rights-of-way (ROW) can model multiple benefits if they are managed as both urban infrastructure and native habitat. Importantly, ROW corridors often bisect wooded areas, creating lighter, drier conditions at the edges of the forest. In a fragmented landscape, ROW corridors contribute to additional edge habitat and can be an ecological detriment. However, these areas can be improved by controlling non-native and invasive species and planting understory species to close light gaps. Ecological restoration of ROW corridors is constrained by the requirement to maintain an open area under the lines; however, opportunities still exist to enhance habitat values Opportunities along the ROW at Sci-Tech include both wet meadow and dry upland habitats. In both, there is opportunity to enhance plant species composition, create trails/boardwalks with viewing areas, and provide interpretative signage.

PERIMETER LANDSCAPES

In the Perimeter Landscapes, open spaces and grassy areas preserve sightlines for the campus buildings. Open spaces are often fringed and protected by trees that may have the opposing role of shielding campus setting from neighboring roads. Although site lines and architectural features are important to Perimeter Landscapes, they encompass a lot of space such as parking lots and other peripheral uses. These areas present an opportunity to increase the ecological value of the campuses and provide further protection and restoration of stream corridors. The key recommendations include:

- Meadow management: the open, sunny areas around buildings can be managed as meadows offering native pollinator habitat while preserving views. Convert turf to meadow where programming and safety concerns do not require regularly mown turf.
- Increase vertical diversity in wooded areas. Unlike the Civic Campus, where safety, lighting and sightlines dictate a sparse or open understory, in the Perimeter Landscapes, wooded areas can generally accommodate habitat uplift in the form of a shrub layer and understory cover of native plants.

Restored habitat buffer along pond edge draw from a diverse planting palette.

Image: Biohabitats

PERIMETER LANDSCAPES: FOCUS ON PONDS

Although the Fairfax and Sci-Tech ponds are currently mown to the edge with no or limited emergent vegetation, these areas provide an excellent opportunity for increased ecological value. The shores have shallow slopes making conditions suitable for establishing emergent wetland zones. Such zones enhance the habitat values by offering escape and foraging opportunities to aquatic creatures, and perhaps more importantly, fringing vegetation slows and filters stormwater runoff.

SPARSE DISTRIBUTION OF TREES IN PERIMETER TYPOLOGY

VA State Arboretum

Image: Mary Terriberry

PERIMETER LANDSCAPE FOCUS: ARBORETUM

The open character and ongoing maintenance regimen of the perimeter landscape lends itself to hosting an arboretum devoted to specimen plantings of trees and shrubs cultivated for exhibition for both Fairfax and Sci-Tech campuses. Because the plantings are dispersed and can be sculptural, arboretums invite people to inquire and engage with natural forms. As a research and learning tool, they are popular on campuses with botany and natural history courses.

CIVIC PRESERVES

These large patches of natural or naturalized landscapes are readily accessible, offering nearby private and contemplative experiences for the University community. With smaller areas and more built infrastructure than the Campus Preserves, the Civic Preserves balance cultural and ecological benefits. The forest management recommendations are the same for the preserve typologies, but the Civic Preserves, because they are smaller and more heavily used, are more prone to invasion by invasive species and less promising for stream restoration that could lead to mitigation credits. They also can be activated with outdoor learning features.

FOREST MANAGEMENT RECOMMENDATIONS

- Preserve existing forest patches and mature tree canopy
- Increase vertical structure of forest patches where possible; increase biodiversity and overall resilience
- Define interior forest areas, which provide locally rare habitat conditions and may warrant special management such as supplemental planting and invasive species control. Additional consideration should be made for improving and expanding interior forest connections to stream corridors.
- Manage invasive species to promote native vegetative establishment and habitat function
- Integrate outdoor learning and classrooms

CIVIC PRESERVE FOCUS: FAIRFAX CAMPUS GREEN NECKLACE

Stream corridors are a central feature of the Fairfax Campus landscape and are woven throughout its built environment. These areas are critical to the look and feel of the campus and provide respite for students, faculty, staff, and wildlife. Together, these stream corridors form a Green Necklace, an area important to campus connectivity, offering a throughway for plants and animals as well as people. Its long, narrow form also means that ecologically, it has a lot of "edge" habitat that is drier, brighter, and more prone to invasive species than interior and closed canopy forest.

Maintaining and restoring stream corridors as a Green Necklace will enhance their value as an ecological asset and an integral aspect of the Fairfax Campus. These corridors also provide an opportunity to holistically plan with the proposed neighboring mixed-use development by sharing the stream corridor and enabling pedestrian and bicycle modes of travel between both sites.

Recommendations for the Green Necklace include:

- Improve ecological connectivity. Targeted native tree, shrub, and grass plantings should be conducted to fill in gaps and fully connect the stream corridors as a connected Green Necklace that provides wildlife and recreational opportunities throughout the Fairfax campus. Ideally stream corridors will be at a minimum, 100' in width. This buffer width is in alignment with the Chesapeake Preservation Act's Resource Protection Area requirements which specifies that development is not permitted within 100' of perennial streams and adjacent wetlands.
- Enhance vertical structure and diversity of planting within buffer area. Even where it narrows, the Green Necklace vegetation should be managed for species and structural diversity. Features such as standing dead trees (termed snags, and vital for foraging birds) and downed wood allow natural cycles of nutrients and material to unfold, and maintenance should allow them where they don't interfere with other uses.
- Conduct stream restoration. Restoration should be conducted to repair eroded streambanks, protect existing infrastructure, meet regulatory targets for sediment and nutrient reductions, and provide ecological uplift. Stream restoration should be prioritized where there is an opportunity to improve the local plant community (e.g., increase/improve stream buffer, remove invasive plants, and use native plants to enhance habitat) and limit projects where the existing vegetative community is in excellent condition.
- Integrate recreational and educational value through trails and interpretative signage; trail sighting and development should be at least 25' from the stream edge and avoid impacts to native, mature vegetation, where possible.

CAMPUS PRESERVES

Campus Preserves are the wildest component of the George Mason campuses, where uninterrupted extents of forest support the ropes course and the forensics study zone at the Sci-Tech campus, both of which rely on the natural character and native ecology as context for the activities. The Campus Preserves represent locally exceptional tracts of undisturbed land in an urbanizing landscape, making them ecologically important on a regional scale. The natural features include mature forest and good condition streams with vegetation and structure that protect the quality and control the volume of water. The preserves host abundant plant and animal life, including less common species that cannot survive in smaller patches of forest.

Natural processes such as recruitment of tree species in the canopy gaps created by tree falls, can proceed uninterrupted in tracts the size of the preserves. The forest floor is rich with detritus and leaf litter, supporting a wealth of wildlife and associated plants.

Campus preserves present an opportunity to improve riparian buffers and aquatic habitat conditions.

STREAM CORRIDORS IN SCI-TECH

George Mason University has already built momentum around the stewardship of campus streams and water ways. Stream corridors at the Sci-Tech campus should incorporate the stream corridor recommendations outlined for the Fairfax Campus Green Necklace concept. Building on these recommendations, stream corridors in Campus Preserves have ample space to maximize a riparian corridor that has a diverse palette of native species including: wetland species along floodplain benches, herbaceous, woody shrubs, and tree canopy. The stream corridors are particularly striking in the Sci-Tech Campus, where the flat topography and clay soils can support abundant wetlands in the stream's floodplain. Such habitats, which dry down completely at certain times of year, greatly enhance the diversity of the area by supporting an abundance of macroinvertebrate and amphibian life.

CAMPUS PRESERVE FOCUS: WEST CAMPUS & SHIRLEY GATE

Select areas of West Campus have forest with remarkably large, mature trees, robust vertical diversity, and few non-native invasive species. These patches of mature forest in north-central West Campus merit preservation and should be monitored for emerging threats, particularly in light of climate change, which will introduce changes to precipitation and temperature conditions.

These recommendations also apply to Shirley Gate, a George Mason property located to the west of the Fairfax Campus, which has prized interior forest habitat and the potential for other sensitive features, which merit detailed investigation. Its position on the landscape enhances regional habitat patch connectivity.

ATHLETICS, RECREATION AND WELL BEING

CANNONDESIGN

GEORGE MASON UNIVERSITY **RECREATION/ATHLETICS & WELL BEING STUDY**

As discussed in the body of the report, Mason is currently independently investigating various solutions for athletics and recreation. This report documents the alternatives studied directly by the master plan. These options are not intended to be prescriptive.

WHAT WE HEARD

Well-Being

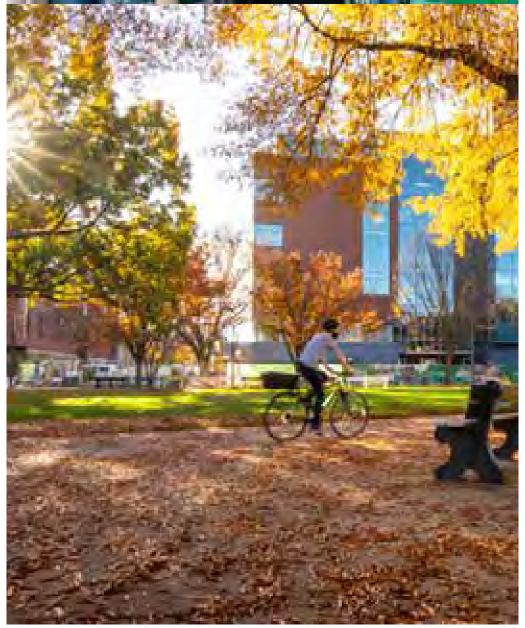
- "We want to be the best well-being university in the country."
- Strategic Goal - Building a life of vitality, purpose, and engagement
- Create a more holistic approach to well-being
- Desire a clear landmark on campus. Assist with the identity on campus
- Students desire centralization of services. Desire connection or co-location of well-being and recreation programs
- Student Health can not provide radiology and orthopedic services
- Provide adequate space for the continued growth of Mental Health services

Athletics

- Desire efficiency between shared athletic and recreation resources. Possibility to avoid shared program space
- Entirely new infrastructure for athletics
- Increased need for Offices, Sports Medicine, and Academic Support space
- Optimize field layout and lighting to expand use
- 30 years ago, the facilities helped recruitment > now they recruit around the facilities
- Athletics does not have a specific presence on campus
- Aging infrastructure needs significant upgrades

Recreation

- Desire to lead Virginia state universities in recreational programs
- One-stop shop between well-being and rec programs
- Utilize rec and well-being adjacency to bring priority back to students, with athletics secondary
- New rec facility to enhance and engage with the outdoors
- Increasing demand for weight and fitness spaces
- Large open spaces for multi-use functions
- Green Machine rehearsal and performance space



PROGRAM **WELL BEING**

Existing Well Being Program

Establishing a baseline for the amount of existing program across the three campuses.

Benchmark Comparison

A benchmark comparison between similar universities allowed for an investigation into deficiencies of GMU's existing programs, as well as establish where growth needs to occur to meet the universities goals.

Program Growth

Utilizing the averages from the benchmark comparision and understanding future growth in student population, the existing program areas were adjusted to reflect the need of campus growth.

WELL-BEING EXISTING PROGRAM

Departments	Fairfax	Arlington	SciTech	Comments
Health Services	9464	1608	1130	
CAPS	7502	0	0	
Well-Being	970	0	0	
Support and Advocacy	3096	110	0	
Disability Services	3722	0	0	
Learning Services	1388	0	0	
Other Uses	0	0	0	
Assignable (ASF)	26,142	1,718	1,130	departmental areas

WELL-BEING BENCHMARK

	Headcount Existing	NSF Student Health	SF/HCNT	NSF CAPS	SF/HCNT	NSF Well-Being	SF/HCNT	Comments
George Mason University	32129	9464	0.29	7502	0.23	3956	0.12	W-B = CAWB & Support/Advocacy
Virginia Tech	37500	19150	0.51	14376	0.38	4842	0.13	renovation
University of Florida	57841	30805	0.53	16780	0.29	3670	0.06	
University of South Florida	48708	30960	0.64	10121	0.21	1640	0.03	
University of Rhode Island	22000	17821	0.81	8990	0.41	4472	0.20	
University of Buffalo	35000	33906	0.97	17444	0.50	11128	0.32	
		average	0.56		0.36		0.15	
		growth factor for other groups	0.15					

WELL-BEING PROGRAM GROWTH

Departments	Existing	Proposed	Delta	Comments
Headcount	32129	36129		
Health Services	9464	20219	-10755	
CAPS	7502	12922	-5420	
Well-Being (CAWB)	970	1300	-330	
Support and Advocacy	2986	4000	-1014	
Disability Services	3722	4000	-278	
Learning Services	1388	1500	-112	
Health Promotions	0	5401	-5401	
Assignable (ASF)	26,032	49,342	-23,310	

PROGRAM **ATHLETICS**

Existing Athletic Program

Establishing a baseline for the amount of existing program across the three campuses.

ATHLETICS EXISTING PROGRAM

Departments	Fairfax	Arlington	SciTech	Comments
AFC	22298	0	0	
RAC	18345	0	0	
Field House	102101	0	0	
Eagle Arena	NA	0	0	study underway
Stadium	NA	0	0	study underway
Other	0	0	0	
Assignable (ASF)	142744	0	0	

Program Growth

The 2010 Athletics Study determined program needs for the field house. The findings of this study were used for the current program.

ATHLETICS PROGRAM GROWTH (PER 2010 STUDY)

FIELD HOUSE

Athletics	Current	Study	Alt	
Offices	10981	20000	5000	Basketball, Volleyball, Tennis
Athletic Training	2747	8500		includes ice and lobby
Physical Therapy	0	2500		
Sports Medicine	0	4500		
Academic Support	0	7500		mezzanine above old racquetball
Weight Room	7115	7000		
Equipment Room	1882	2100		
Wrestling Room	2550	7000		
Crew Room	800	0		
Team Lockers	9927	9500	4000	Basketball, Volleyball, Tennis
Field House	61010	61000		
Indoor Practice	0	0	40000	Basketball, Volleyball
Subtotal	97012	129600		

Recreation		
Rec Lockers	2520	0
Racquetball Courts	3286	0
Subtotal	5806	0
Tota	102818	129600
Difference		26782

Tota	102818	129600	
Difference		26782	49000

RAC

Athletics	Current
Offices	1515
Team Lockers	2611
Cage Gym	14219
Total	**18345**
Total FH & RAC	**121163**

PROGRAM **RECREATION**

Existing Recreation Program

Establishing a baseline for the amount of exisitng program across the three campuses.

RECREATION EXISTING PROGRAM				
Departments	**Fairfax**	**Arlington**	**SciTech**	Comments
AFC	42648	0	0	athletics excluded
RAC	66680	0	0	athletics excluded
Skyline	14261	0	0	
Freedom Center	0	0	80623	public facility
Challenge Course	0	0	0	
Other	0	0	0	
Assignable (ASF)	123,589	0	80,623	
Unassigned(NAF)	41,339			
Usable (USF)	164,928			

Program Growth

Current NIRSA standards were used to determine the program growth based upon future headcount of the University.

RECREATION NATIONAL BENCHMARK						
	Fairfax	**Suggested SF/HC**			**Delta Above Existing**	
	Headcount	9	10	11	124,000 - 188,000	
Fall 2019	32,129	289,161	321,290	353,419	325,000 - 387,000	Minimum needed today
Growth Scenario	36,129	325,161	361,290	397,419		Maximum future need

	Arlington	**Suggested SF/HC**			**Delta Above Existing**	
	Headcount	1	2	3	3,000 - 7,000	
Fall 2019	2,500	2,500	5,000	7,500	10,000 - 15,000	Existing need
Growth Scenario	6,500	6,500	13,000	19,500		Future need

New Program

The new program was generated from the program growth analysis based upon best practices.

NEW RECREATION PROGRAM

PHASE 1

Public/Lobby	2,000	Entry, lounge
Administration	3,000	Admin, intramurals, meeting rms, etc
Gymnasia	44,200	One 4-court gym, one 2-court gym, includes storage
Track	7,000	Meandering track
Aquatics	0	Existing to remain at AFC
Weights/Fitness	22,000	Assumes existing fitness at AFC and Skyline to remain
Well-Being	10,000	Wellness prevention/education, classrooms, etc
Specialized Activity	12,000	Group exercise, cycling, squash/racquetball
Locker Rooms	5,600	Men/Women and private change rooms
Outdoor Pursuits	3,700	Includes climbing wall
Equip/Laundry	1,200	Adj to lockers, equip distribution
Support	1,500	General building storage
Total NSF	112,200	
Total GSF	**160,286**	

PHASE 2

Public/Lobby	1,500	Entry, lounge
Administration	2,000	Admin, intramurals, meeting rms, etc
Gymnasia	16,000	One 2-court gym
MAC Gymnasia	17,000	One 2-court indoor turf gym
Track	1,000	Meandering track
Weights/Fitness	12,000	Assumes exstg fitness at AFC and Skyline to remain
Specialized Activity	4,400	Group exercise, cycling, squash/racquetball
Outdoor Pursuits	500	Includes climbing wall
Total NSF	54,400	
Total GSF	**77,714**	

Grand Total GSF **238,000**

SCENARIO OVERVIEW

Scenario One

Recreation expands at RAC except ROTC

Athletics moves out > add 2 court gym + support to FH or Arena

Athletics expands at Field House

Well-Being > wellness prevention & education relocate to RAC

AFC > remains

Skyline > remains

1

preferred options

Scenario Two

Recreation and ROTC remain

Recreation expands adjacent to SUB1

Athletics stays at RAC

Athletics expands at Field House

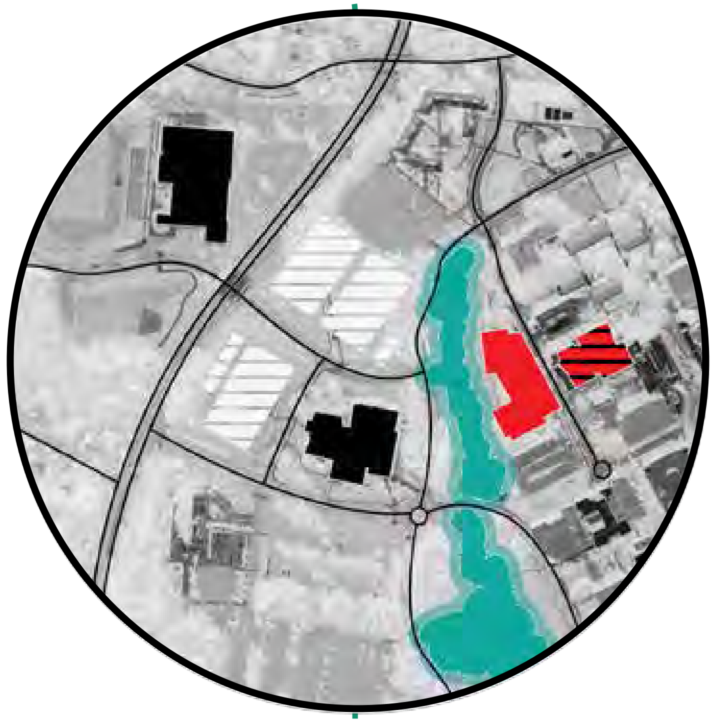
Well-Being > wellness prevention & education expand in SUB1

Admissions / Registrar relocate

AFC > remains

Skyline > remains

2



3

Scenario Three

Recreation relocates adjacent to SUB1

Athletics expands at RAC > ROTC stays

Field House > renovation of key spaces

Well-Being > wellness prevention & education expand in SUB1

Admissions / Registrar relocate

AFC > remains

Skyline > remains

Why Scenario 3 became the focus

Given the exisitng conditions and limitations of both the Field House and RAC, a new recreation center adjacent to SUB 1 allows for a consolidated building around SUB 1 and invigorates the core of campus by establishing a health, well-being, and fitness destination.

SCENARIO
THREE

SCENARIO THREE **SITE PLAN**

Scenario Three

Recreation relocates adjacent to SUB1

Athletics expands at RAC > ROTC remains

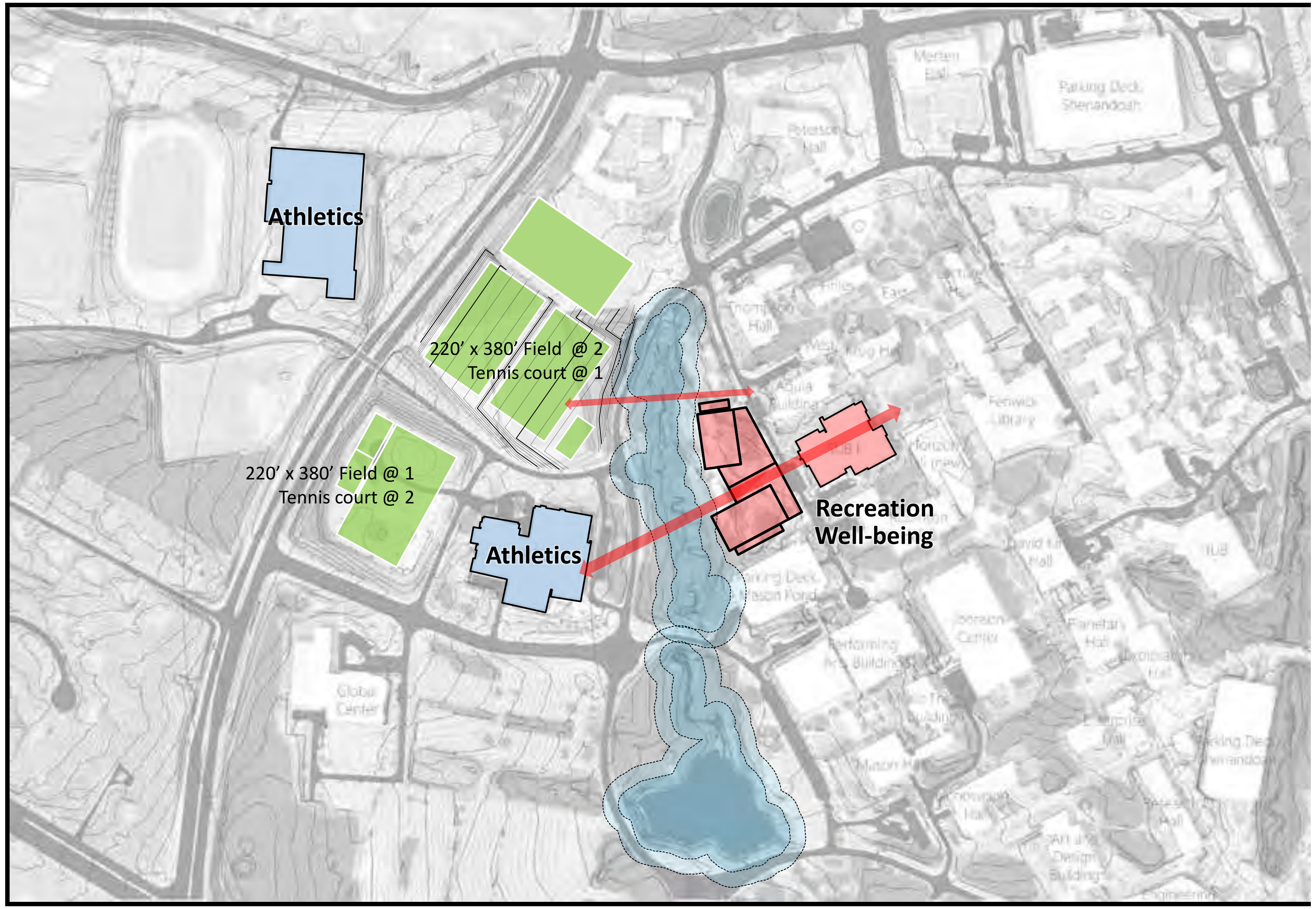
Field House > renovation of key spaces

Well-Being > wellness prevention & education expand in SUB1

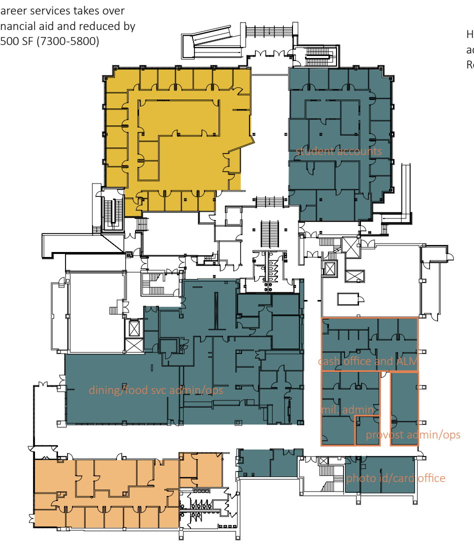
Admissions / Registrar relocate from SUB-I

AFC > remain

Skyline > remain



SCENARIO THREE **SUB1 PLAN** WELLNESS EXPANSION



LEVEL 01 - NEW

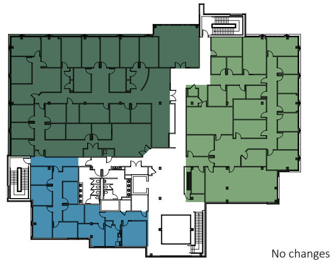
- CAREER SERVICES ~5800 SF
- EARLY IDENTIFICATION ~2900 SF
- GENERAL — STUDENT ACCOUNTS, DINING/FOOD SVC ADMIN/OPS, CASH OFFICE AND ALM, PROVOST ADMIN/OPS, MILITARY SERVICES ADMIN, PHOTO ID/CARD OFFCIE

LEVEL 02 - NEW

- HEALTH SERVICES ~20,200 SF
- SUPPORT & ADVOCACY ~4990 SF
- WELL BEING ~2100 SF
- HEALTH PROMOTIONS ~4900 SF
- RECREATION CONNECTION

LEVEL 03 - NEW

- CAPS ~12,700 SF
- DISABILITY SERVICES ~4900 SF
- LEARNING SERVICES ~1500 SF
- CENTER FOR CULTURE, EQUITY, & EMPOWERMENT ~5500 SF
- MASON CARE NETWORK ~4400 SF
- STUDENT STUDY SPACE ~900 SF



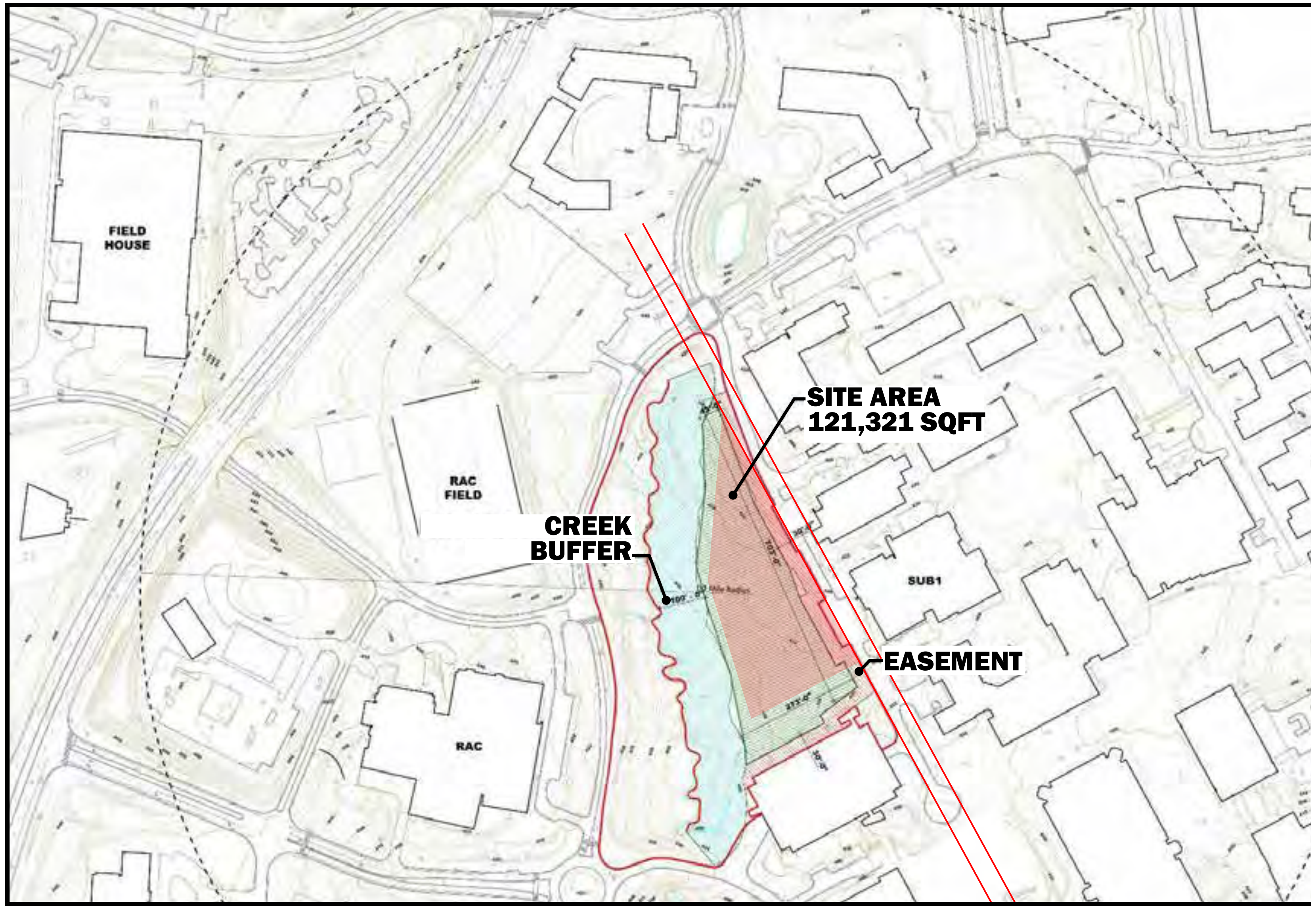
LEVEL 04 - NEW

- UNIVERSITY LIFE ADMIN. ~6500 SF
- ACADEMIC INTEGRITY ~5300 SF
- INTERNATL. PROGRAMS ~1850 SF

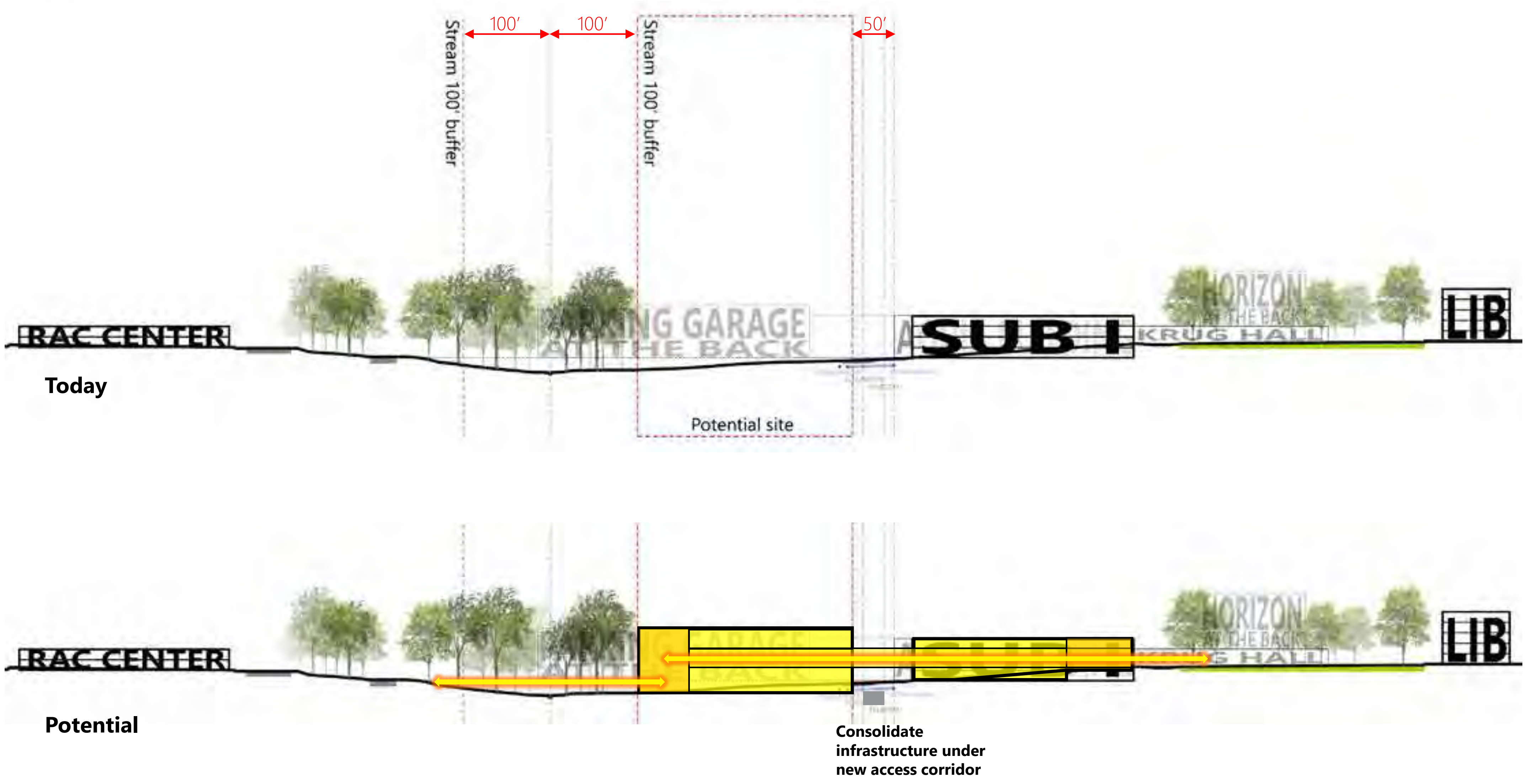
SCENARIO THREE **NEW RECREATION CENTER** SITE

Site Parameters

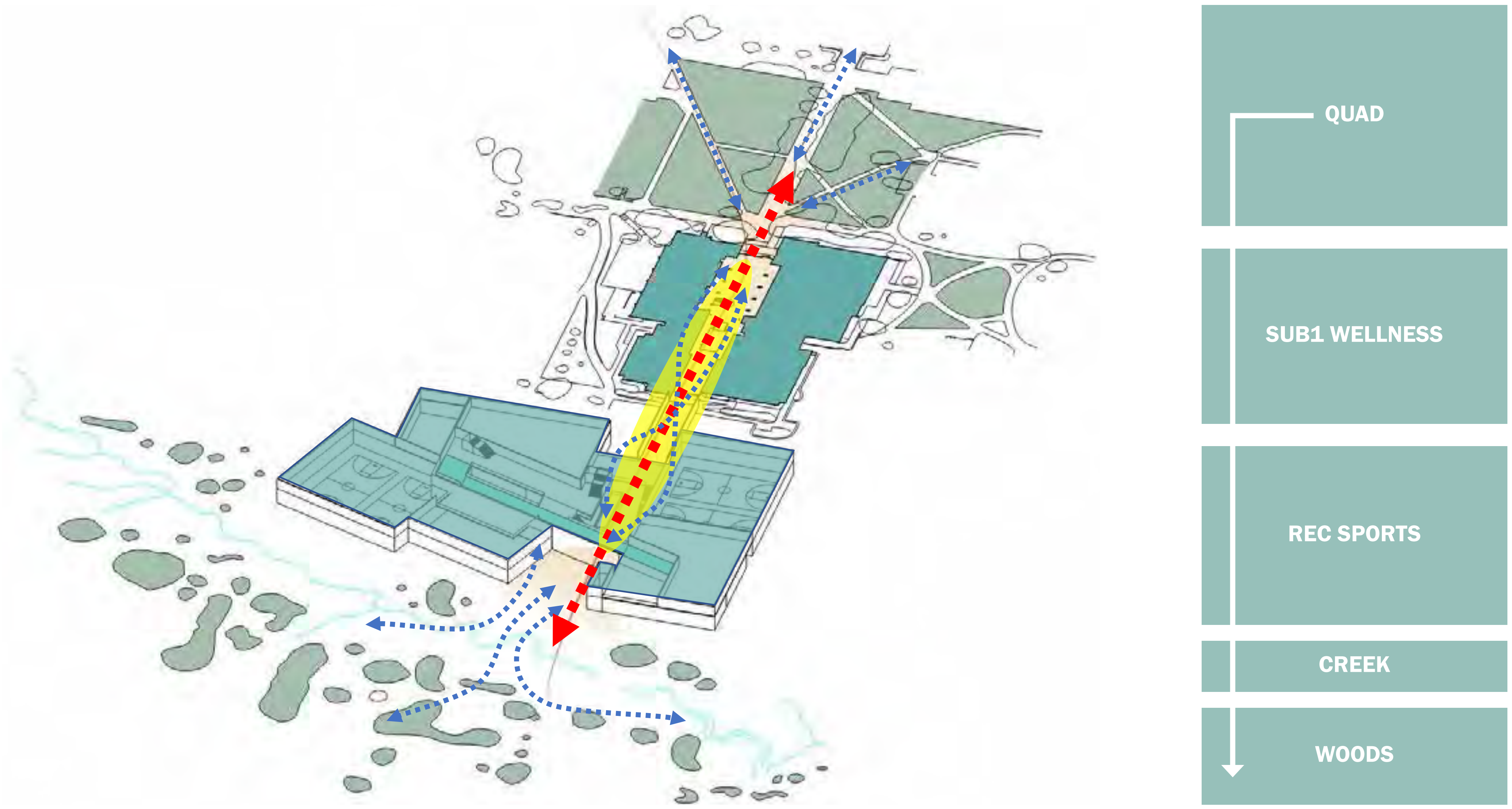
To protect and preserve the creek waterway, a 100' buffer is established to create the site boundary on the western edge. Opposite the western edge, the eastern edge responds to the existing conditions of Aquia Creek Lane.



SCENARIO THREE **NEW RECREATION CENTER** SITE SECTION



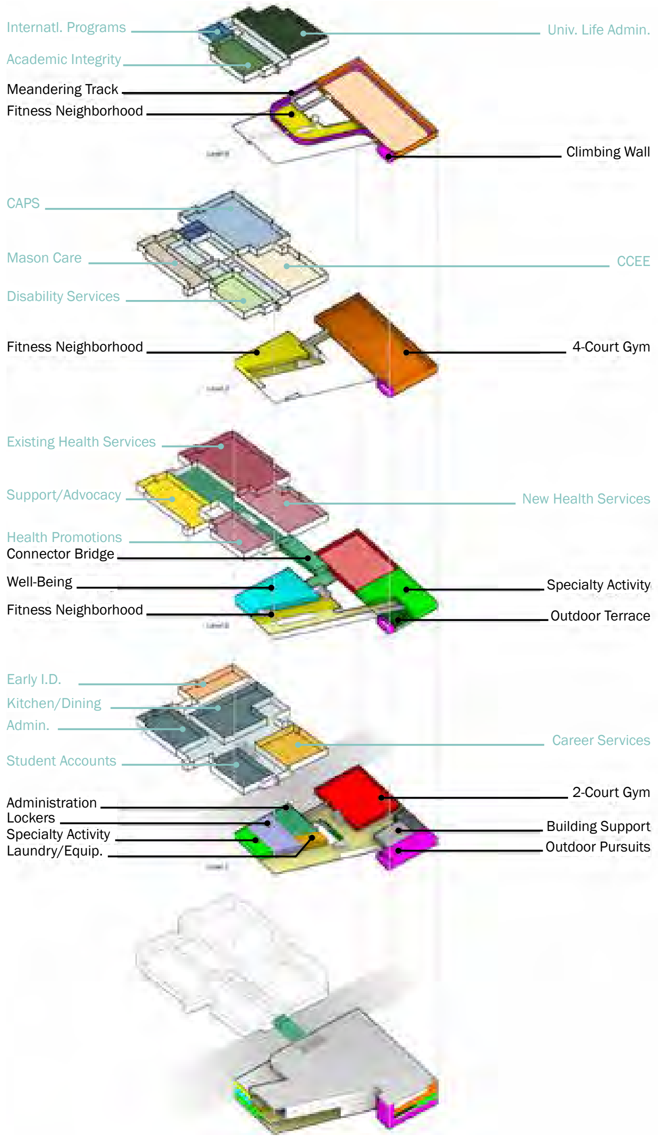
SCENARIO THREE **NEW RECREATION CENTER** SITE DIAGRAM



SCENARIO THREE **NEW RECREATION CENTER** AXONOMETRIC

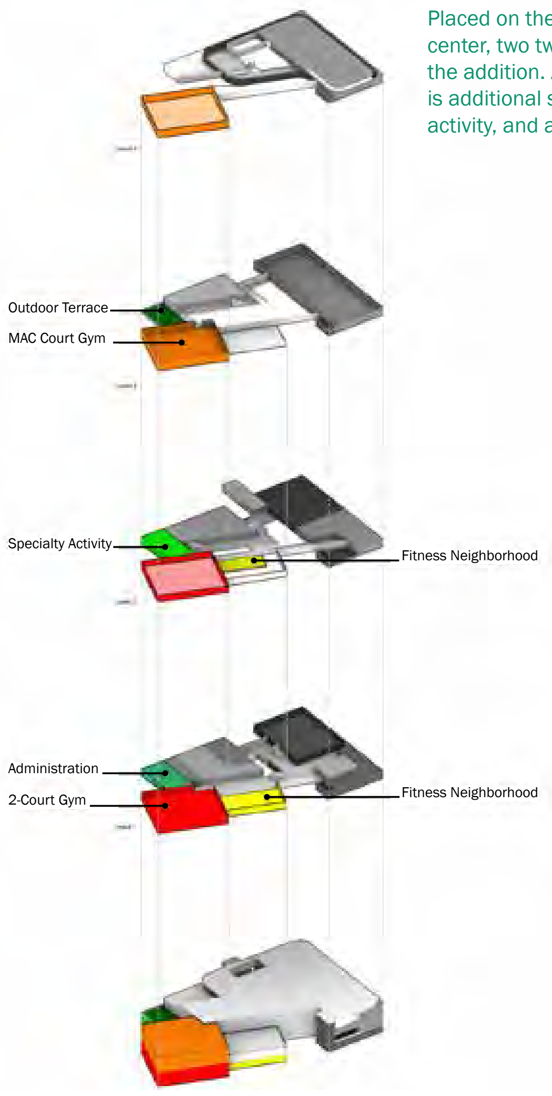
PHASE ONE

An all new 160,000 sf recreation center becomes the link between well-being and recreation. Bridging over Aquia Creek Lane, a connection corridor allows fluid movement from the well-being services provided in the existing SUB1 to the new recreation facility that houses multiple sports courts, various fitness areas, and outdoor programs.



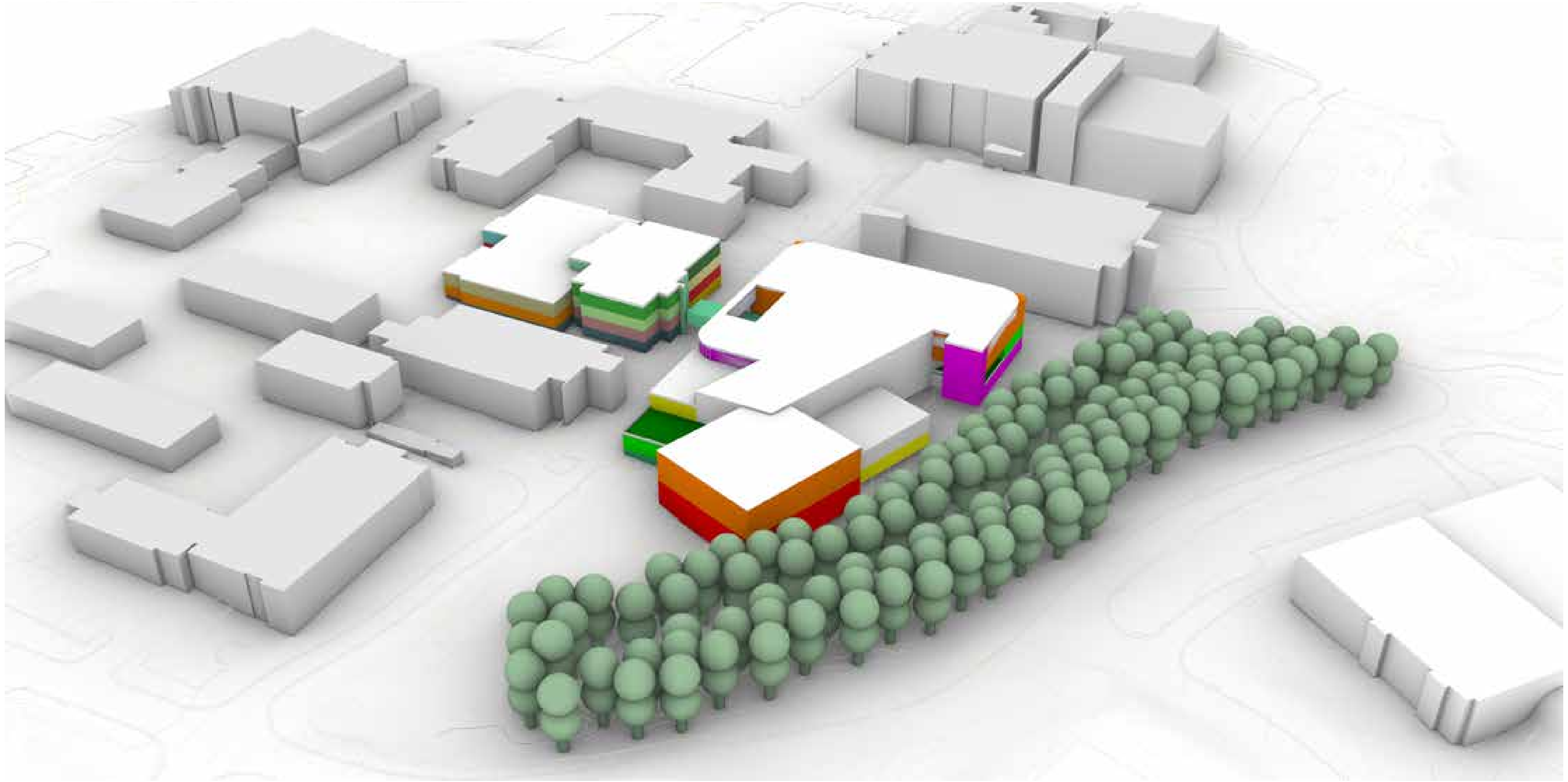
PHASE TWO

Placed on the northern face of the existing center, two two-court gymnasiums anchor the addition. Accompanying the gymnasiums, is additional space for fitness, specialized activity, and administrative offices.



SCENARIO THREE **NEW RECREATION CENTER** MASSING AXON FROM NW

RECREATION & SUB1 CONNECTION

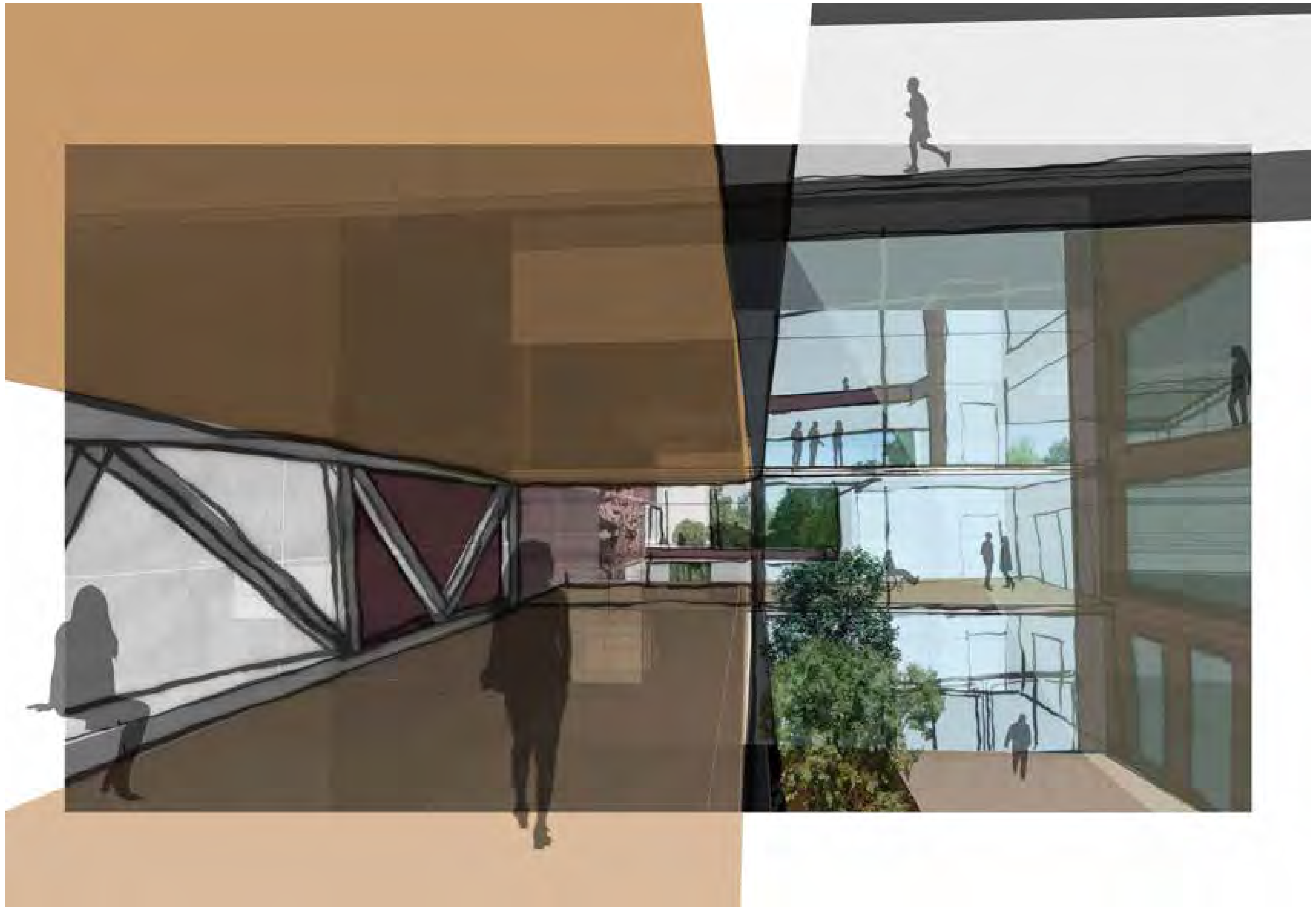


SCENARIO THREE **NEW RECREATION CENTER** MASSING AXON FROM NE

RECREATION & SUB1 CONNECTION

SCENARIO THREE **NEW RECREATION CENTER** BRIDGE FROM SUB1

BUILDING VIGNETTE



SCENARIO THREE **NEW RECREATION CENTER** VIEW FROM WEST WOODS

BUILDING VIGNETTE

SCENARIO THREE **RAC PLAN** ATHLETIC EXPANSION

LEVEL 01 - PROPOSED EXPANSION

- OFFICE ~12,800 SF
- ACADEMIC SUPPORT ~6300 SF
- WEIGHT ROOM ~7800 SF
- WRESTLING ROOM / FLEXIBLE ~4600 SF
- TEAM DINING ~1400 SF
- TEAM LOCKERS ~11,800 SF
- INDOOR TURF FIELD ~11,300 SF
- INDOOR PRACTICE ~14,634 SF

LEVEL 02 - PROPOSED EXPANSION

- OFFICE ~7500 SF
- SPORTS MEDICINE ~4700 SF
- PHYSICAL THERAPY ~2900 SF
- ATHLETIC TRAINING ~9400 SF
- WRESTLING ~7800 SF
- STUDY SPACE ~1879 SF
- ROTC ~5300 SF
- INDOOR PRACTICE ~14,219 SF
- EQUIPMENT ROOM ~2100 SF

MEETING LIST

MEETING LIST
June 2020 to October 2021

Month	Date	Meeting
2020		
June	25	Town Hall 1
	26	Steering Committee
July	8	Senior Leadership Team
	13	Research Council
	14	Enrollment Projections Review
		Residential Life & Recreation
	20	Senior Leadership Team
	24	Steering Committee
August	19	Senior Leadership Team
	21	Steering Committee
September	3	Town Hall 2
	4	Steering Committee
	10	Research Council
	17	Senior Leadership Team
	22	Deans
	30	University Life
October	2	Steering Committee
	8	Town Hall 3
	28	Senior Leadership Team
November	2	Phase II Kickoff
	6	Student Life
	11	Heritage Assessment

Month	Date	Meeting
2020		
December	1	Mason Legacies
	2	Innovation Town Center
	4	Recreation Study Kickoff
	8	Town Hall 4
	9	Residential Life Kickoff
	15	Transportation & Mobility Kickoff
	16	Infrastructure Working Group
	17	Recreation Study Vision
		Innovation Town Center
2021		
January	6	Well-being User Group Interview
		Recreation User Group Interview
		Athletics User Group Interview
	11	Senior Leadership Team
	20	Athletics & Recreation User Group Interviews
	22	Well-being User Group Interview
February	8	Ecology
	10	Recreation & Well-being User Group Interviews
	11	Student Life
	12	Steering Committee
	15	ITS
		Utilities
	24	Transportation & Mobility

Month	Date	Meeting
2021		
March	2	Town Hall 5
	3	Residential Life
	4	Well-being User Group Interview
		Athletics User Group Interview
		Recreation User Group Interview
	22	Alumni Relations
	23	Stormwater Management
April	19	Deans Council
May	4	Stormwater Management
	12	Senior Leadership Team
	21	Steering Committee
	24	Fairfax City & County Engagement Session
	26	Arlington County Engagement Session
	27	SciTech Advisory Board
June	10	Town Hall 6
	17	Fairfax City & County Coordination
	28	Trail Working Group
	29	Alumni Engagement Session
July	6	Senior Leadership Team
	13	Site Visit - Trail Walk
		Student Experience Redesign Space Visioning
	15	Alumni Engagement Sessions
August	2	Eagle Bank Arena Coordination
	9	Steering Committee
	19	Town Hall 7

Month	Date	Meeting
2021		
September	7	Residential Life
	8	The Edge
	13	Transportation
		Infrastructure
	14	Faculty Workspaces & Offices
	16	ITS
	20	Senior Leadership Team
	22	Infrastructure
October	1	Steering Committee
	7	Town Hall 8

STEERING COMMITTEE MEMBERS

University Master Plan - Committee Structure and Members

Senior Leadership Team

Dr. Gregory Washington	University President
Mark Ginsberg	Provost and Executive Vice President
Carol Kissal	Senior Vice President for Finance & Administration
Ken Walsh	Chief of Staff

Steering Committee

Charge:
The University Master Plan will serve as a decision-making framework for the use of physical space at our Fairfax, Arlington, and Science and Technology campuses and support Mason's mission for decades to come. The Master Plan Steering Committee has been formed to assist with master plan progress, review findings & scenarios, act as ambassadors for the plan, and make recommendations to the Senior Leadership Committee.

Members:

Kevin Borek	Vice President & Chief Information Officer
Trishana Bowden	Vice President Advancement & Alumni Relations; President GMUF
Aurali Dade	Interim Vice President for Research, Innovation & Economic Impact
Rick Davis	Dean, CVPA / Executive Director Hylton Performing Arts Center
*Shannon Davis	Former Chair, Faculty Senate
Melissa Broeckelman-Post	Chair, Faculty Senate
Deb Dickenson	Vice President for Finance
Bill Dracos	Associate Vice President for Business Services
Kim Eby	Associate Provost for Faculty Affairs and Development
Brad Edwards	Assistant Vice President/ Director, Intercollegiate Athletics
Greg Farley	Director, University Sustainability
Colby Grant	Staff Senate Representative and Operations Coordinator for Sci Tech
Renate Guilford	Associate Provost, Academic Administration
Traci Kendall	Executive Director, Community and Local Govt Relations
Andre Kinney	Director Real Estate, Fairfax & Sci Tech Campuses
Mark Monson	Alumni Representative
Janette Muir	Assoc Provost, Academic Initiatives and Services
Rose Pascarell	Vice President, University Life
Arthur Pyster	Associate Dean for Research - Volgenau School of Engineering (VSE)
Zach Schrag	Faculty Senator
Juliette Shedd	Associate Dean, School for Conflict Analysis & Resolution (SCAR)
Rene Stewart O'Neal	Associate Vice President for Strategic Planning & Budgeting
Frank Strike	Vice President, Facilities
Bethany Usher	Associate Provost for Undergraduate Education
Tobi Walsh	AVP Capital Strategy & Planning
Tracy White	Director Real Estate & Investments, GMU Foundation
David Wong	Faculty Senator

DUMONTJANKS

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