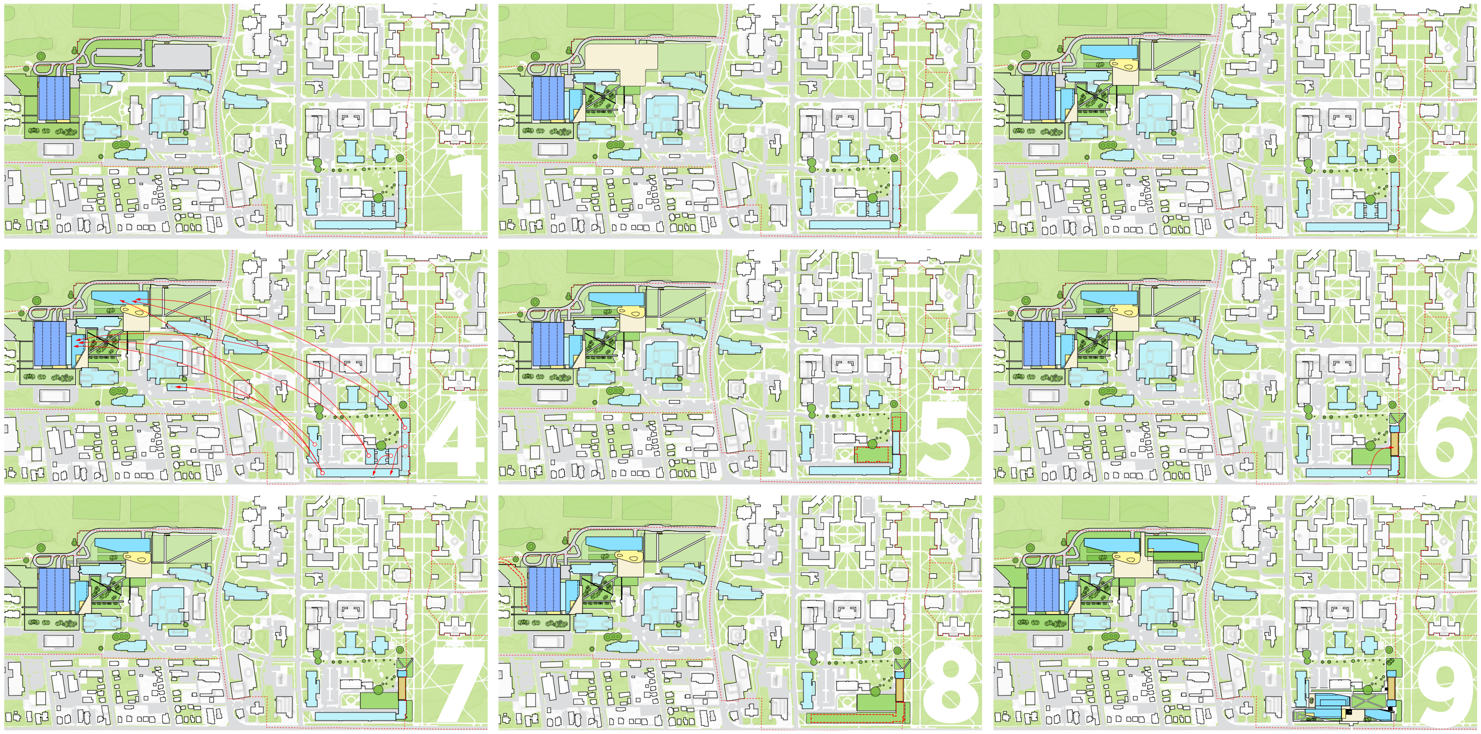
MASTER PLAN — IMPLEMENTATION

5



The goal of this study is a carefully considered, planned, and actionable Master Plan that can be implemented within the approved budget for the 2018-2023 capital funding cycle.

PHASING & PROGRAM

PHASING

Whereas Chapter 4 is focused on the overall vision and strategy of the Master Plan, Chapter 5 is concerned with the specifics of how this vision can be implemented over time and within the budget established for Penn State's 2018-2023 capital funding cycle. The following pages provide a graphical overview of Phase 1 and Phase 2, which correspond to the first two capital funding cycles for 2018-2023 and 2023-2028, respectively, building up to the long-term vision for the West Campus and Core Campus. Following that overview is a step-by-step description of how Phase 1 will be implemented in terms of new buildings, landscape, utilities, and identification of other constraints.

Chapter 5 then turns to a more detailed description of the program for the renewal of the Sackett Building. This deeper dive was necessary, given this historically important building's idiosyncratic nature and close ties with the campus infrastructure systems that need to remain operational. It also informed a more detailed cost estimate for this important part of the Phase 1 program.

PROGRAM

Chapter 5 uses the programmatic growth projections from Chapter 3 to construct a test case for how programs could occupy the new and renovated buildings in Phases 1 and 2. These projections were understood to be rough-order-of-magnitude, allowing the project team to develop building profiles that could be used during the master planning process to develop square footage targets, EUI projections, engineering requirements and cost estimates.

These programmatic assumptions were further investigated in the detailed programming phase undertaken subsequent to the Master Planning process. The findings from this detailed programming process are documented in the "April 2019, Phase 1 Programming Report;" and modify some of the programming assumptions made in this report. Some key changes include:

- General purpose classroom space need has been reduced across the West and Core Campuses
- Office and administrative space needs have been reduced across the West and Core Campuses
- Learning Factory and Fame Lab will be part of West 2 Building
- Additional swing space is not needed at the end of Phase 1

Aerial Rendering of Future State Master Plan

EXISTING

PHASE 1 PHASE 2 FUTURE

2018-2023 Capital Funding Cycle

- *West 1*
- *West 2*
- *Sackett Renovation and North Wing Addition (shelled)*

PHASE 1

2018-2023 Capital Funding Cycle

- *West 1*
- *West 2*
- *Sackett Renovation and North Wing Addition (shelled)*

PHASE 2

2023-2028 Capital Funding Cycle

- *Sackett South Wing Addition*
- *Core 1*
- *Core 2*
- *West 3*

FUTURE

PHASE 1

2018-2023 Capital Funding Cycle

- *West 1*
- *West 2*
- *Sackett Renovation and North Wing Addition (shelled)*

PHASE 2

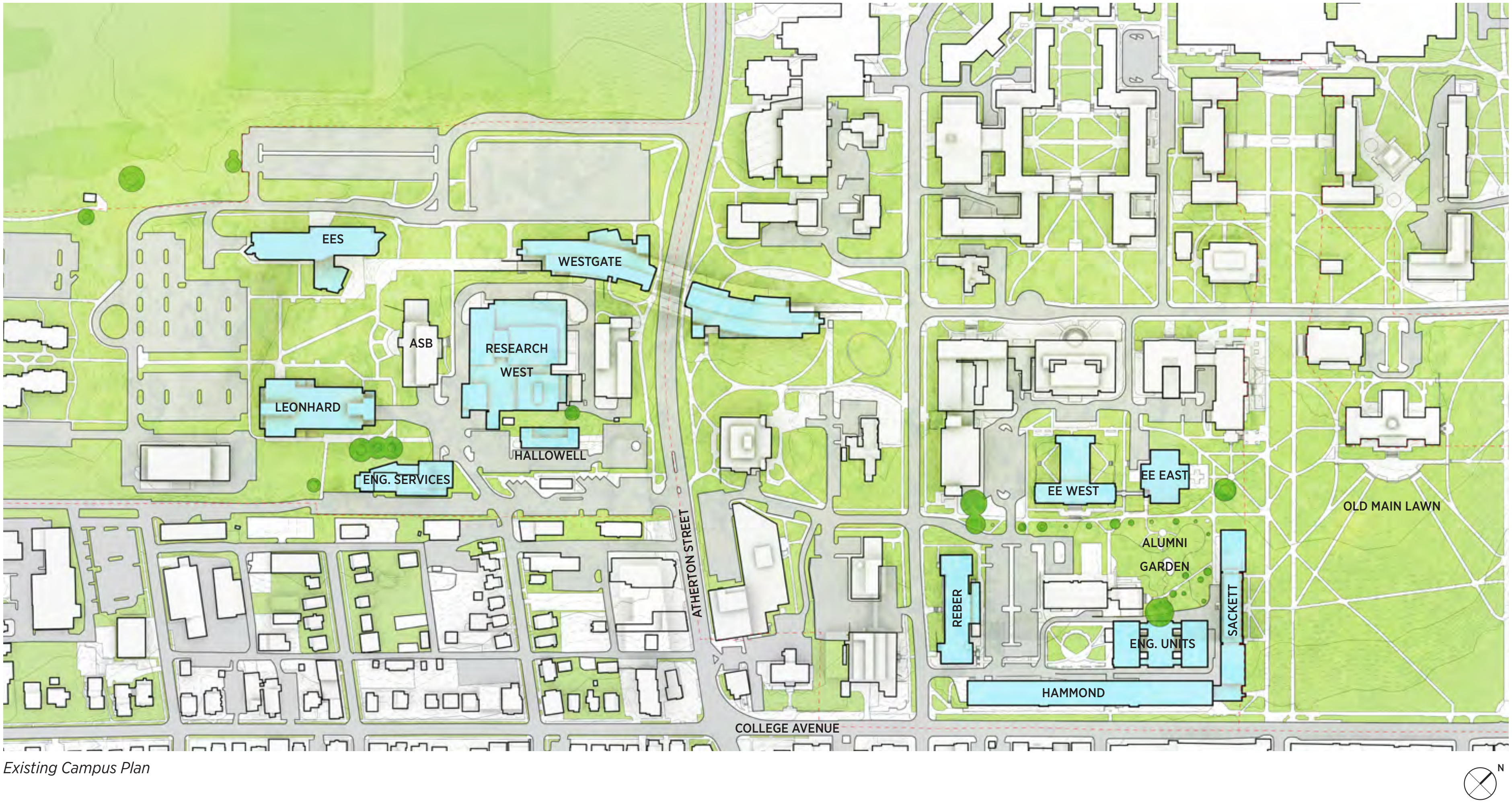
2023-2028 Capital Funding Cycle

- *Sackett South Wing Addition*
- *Core 1*
- *Core 2*
- *West 3*

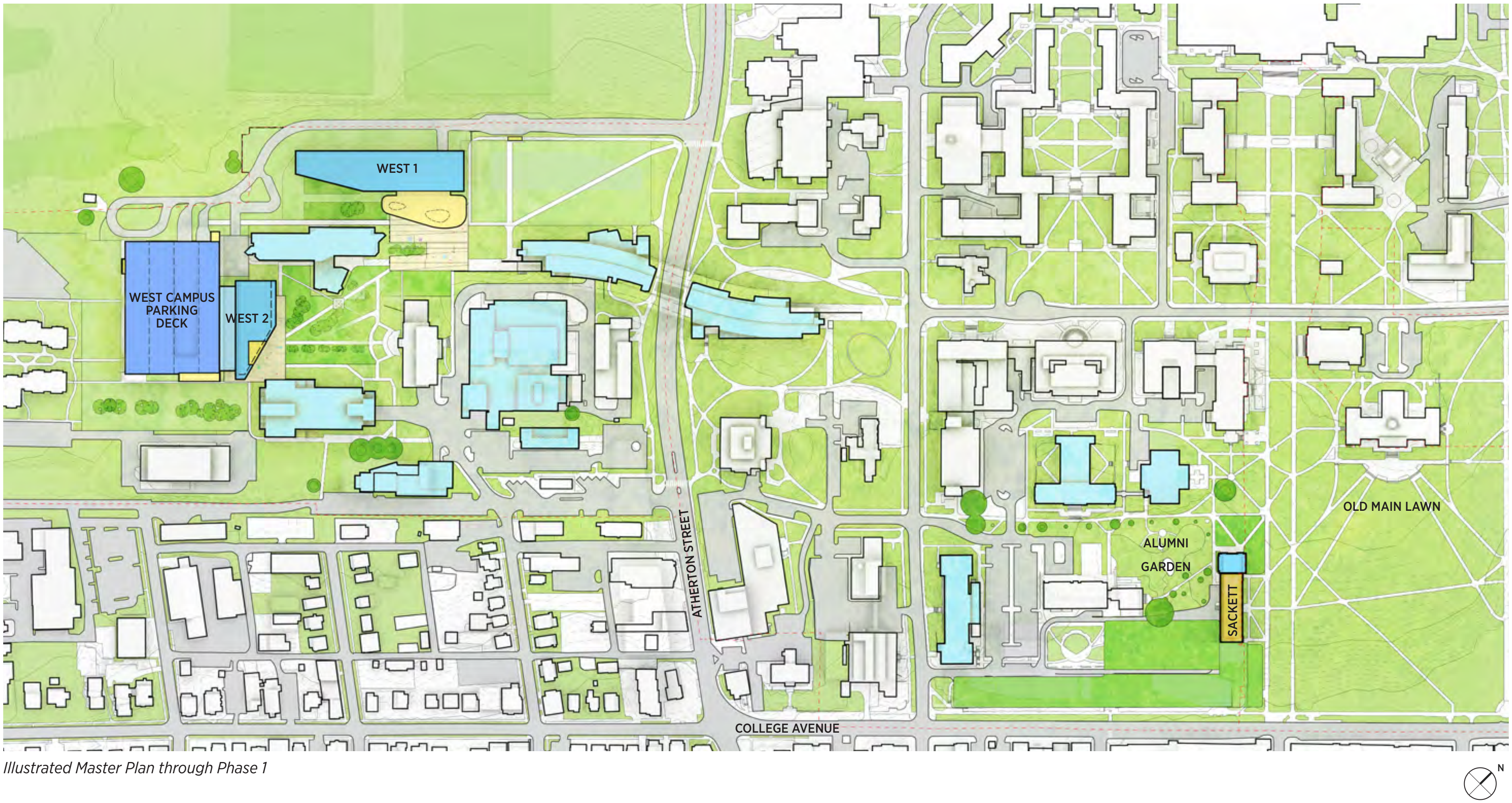
FUTURE

2028 and Beyond

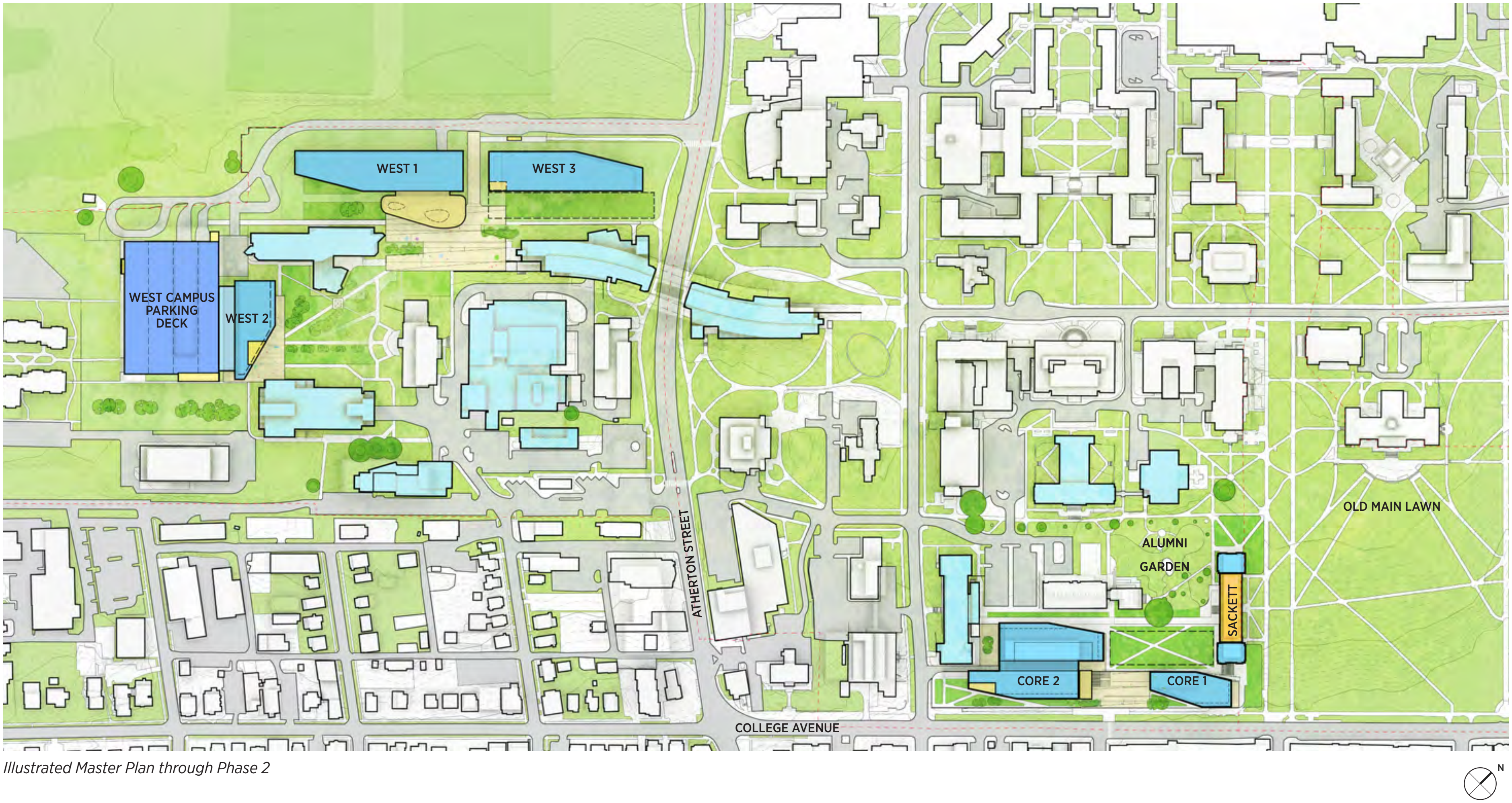
- *EE East Replacement*
- *West 4, 5, and 6*



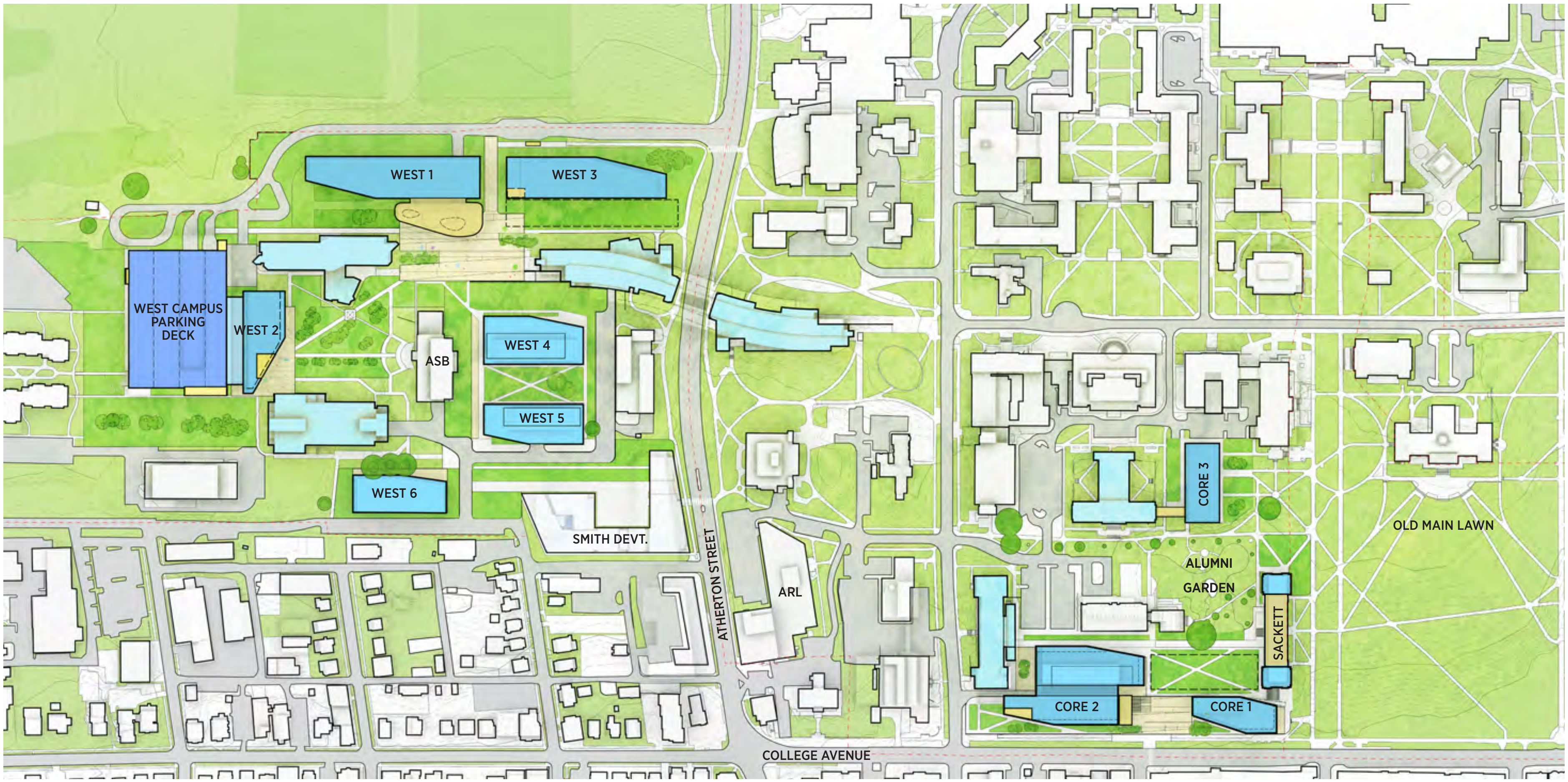
Existing Campus Plan



Illustrated Master Plan through Phase 1

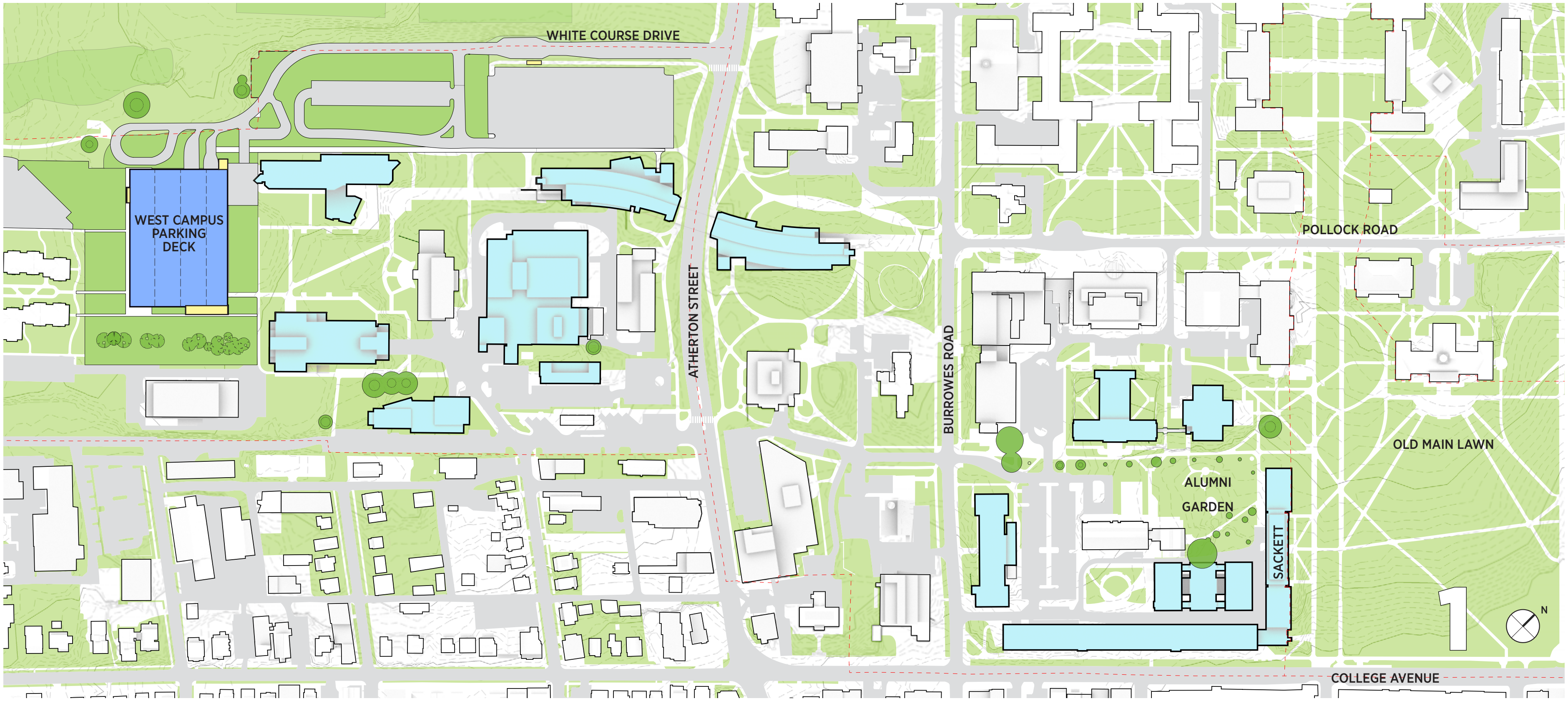


Illustrated Master Plan through Phase 2



Illustrated Master Plan at Future State

PHASE 1: STEP 1

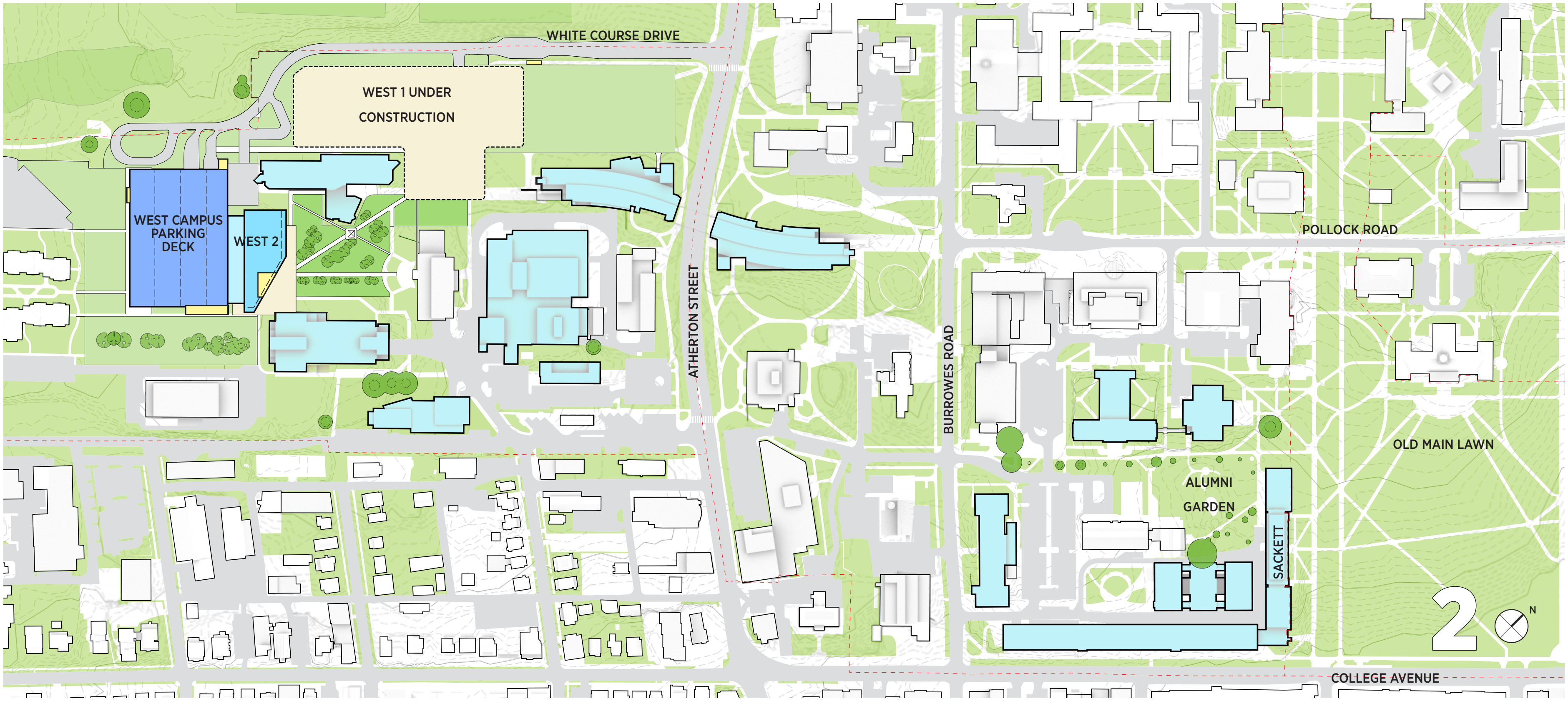


Step 1 for implementing Phase 1 is to construct the new West Campus Parking Deck, in order to replace the existing surface parking lots behind EES and West Gate in preparation for future buildings and to increase overall parking capacity in the West Campus precinct and the whole University Park Campus at-large. All surface lots will be offline as soon as the deck opens for use. Existing trees to the north of the new parking deck will need to be protected during construction.

This step also includes a new roadway alignment for White Course Drive, from the new parking deck to Atherton Street. This new access road will terminate at the new deck and not connect to the existing road that continues west, to address the Borough's concern about the traffic impacts of having a through road. These roads can be connected in the future to allow for limited / controlled access by maintenance and emergency vehicles.

The West Campus Parking Deck project alone has a limited utility impact. Existing water lines will be relocated to fall outside the deck footprint, and a new stormwater conveyance system will direct building run-off to the West Campus Pond. Refer to the Appendix for additional information about utility impacts for the various steps of Phase 1.

PHASE 1: STEP 2



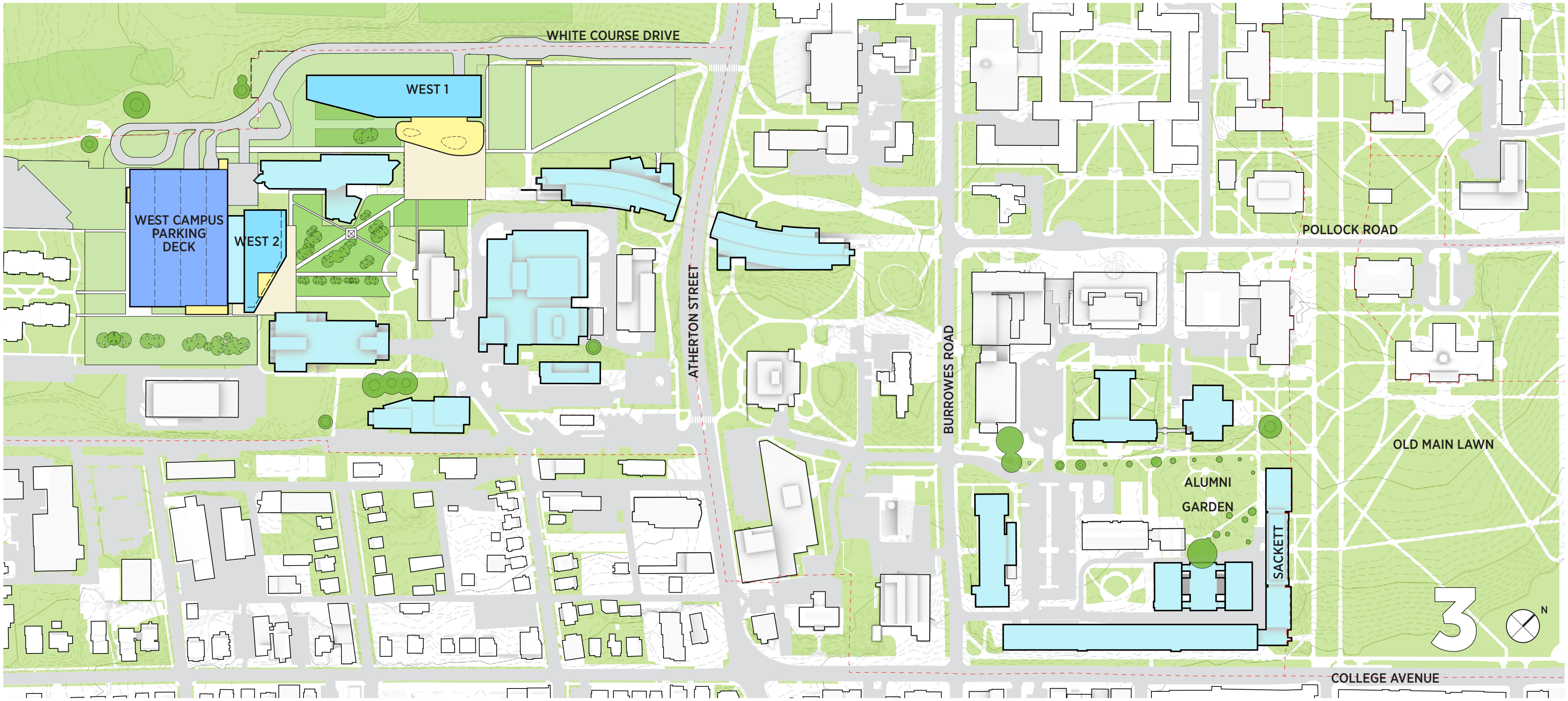
Step 2 is the construction of the West 2 Building, which attaches to the West Campus Parking Deck on its east façade. Also included are landscape improvements to the campus quad between West 2, ASB, EES, and Leonhard, to improve connectivity and campus placemaking.

While West 2 is being implemented, construction will start on West 1. The surface lot next to Atherton Street will have a temporary landscape for erosion control, though some of this area may be needed for construction logistics.

The construction of West 2 includes relocating existing utilities that run north of the West Campus Chiller and west of the Leonhard Building. An approximately 50'-wide utility corridor is planned between West 2 and Leonhard to accommodate steam, chilled water, telecom, water, and electrical distribution lines. Service connections for these utilities must be provided to West 2.

If the programming of West 2 determines that a natural gas line is required, this utility can be brought across the quad from the line running along the west side of ASB or north from the main line that runs north of the West Campus Chiller. A new sewer lateral will need to be extended across the quad to connect to the sewer main that runs south along the west side of ASB.

PHASE 1: STEP 3

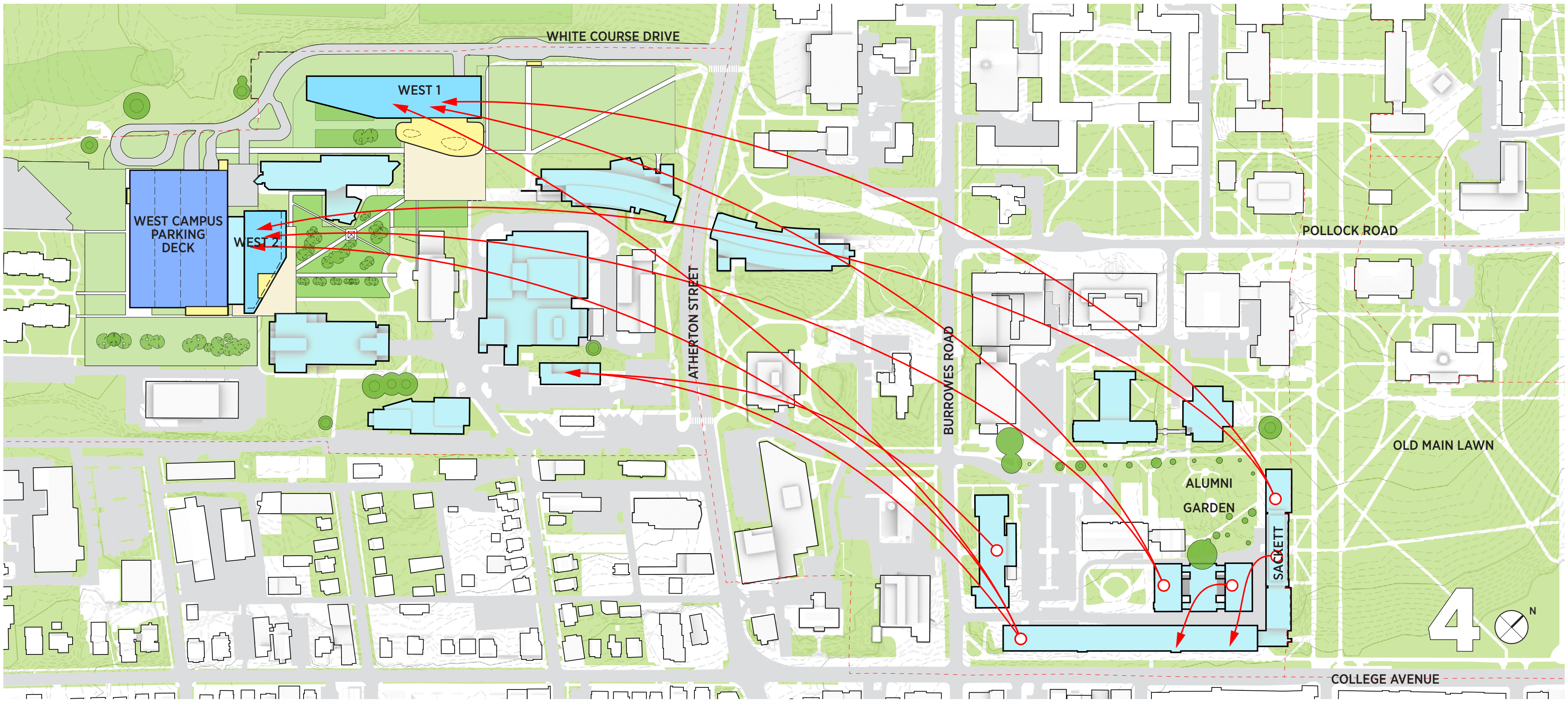


Step 3 is the construction of the West 1 Building, which lies north of EES. Also included are campus landscape improvements, including a new plaza at the western terminus of the Westgate ramp, leading to West 1 and to EES, and a new campus walk from the new CATA bus drop-off near the parking deck, leading to the plaza between West 1 and EES.

Temporary campus walks will be provided across the former surface parking lot to connect to the new plaza from the second CATA bus drop-off at the east end of West 1 and from the intersection of White Course Drive and Atherton Street as required.

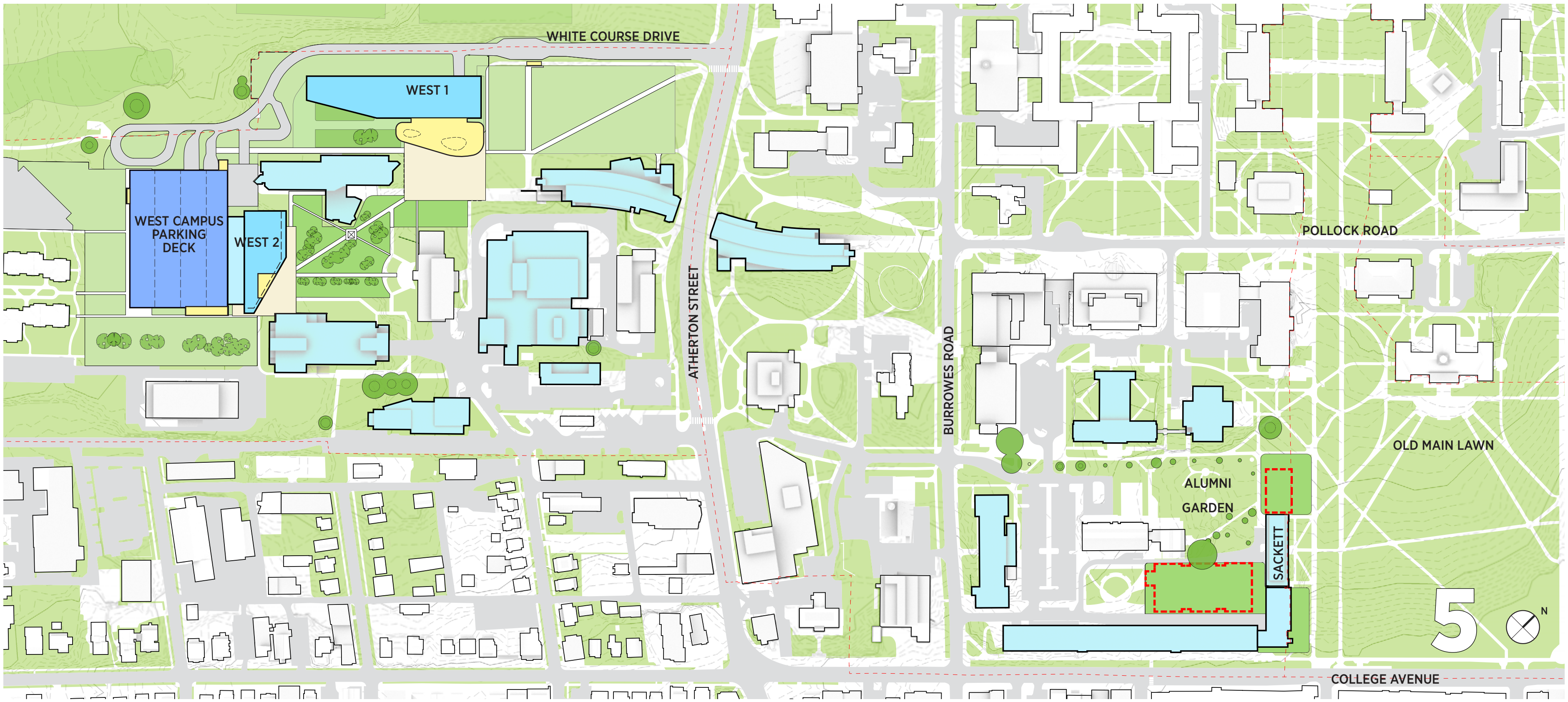
Existing utility impacts for this step are limited to stormwater pipes draining the athletic fields to the north, as well as electrical and tel/com lines serving the parking lot kiosk and athletic fields. New utility connections will need to be provided from existing relocated lines coming from connections near the east end of EES (for electrical and tel/com) or extending north from the utility corridor that runs between Westgate and Research West (steam, water, chilled water). Building downspouts and surface drainage structures will direct stormwater towards the conveyance system in White Course Drive, and a new sewer lateral will need to be provided, connecting to the existing main that runs along the east side of ASB.

PHASE 1: STEP 4



Step 4 relocates various existing programs from the Core Campus to the newly completed West 1 and West 2 Buildings on the West Campus, in order to vacate the Units and Sackett in preparation for demolition (the Units) and redevelopment (Sackett). Some programs will shift to Hammond temporarily, in order to shift back to Sackett upon completion of its renewal.

PHASE 1: STEP 5

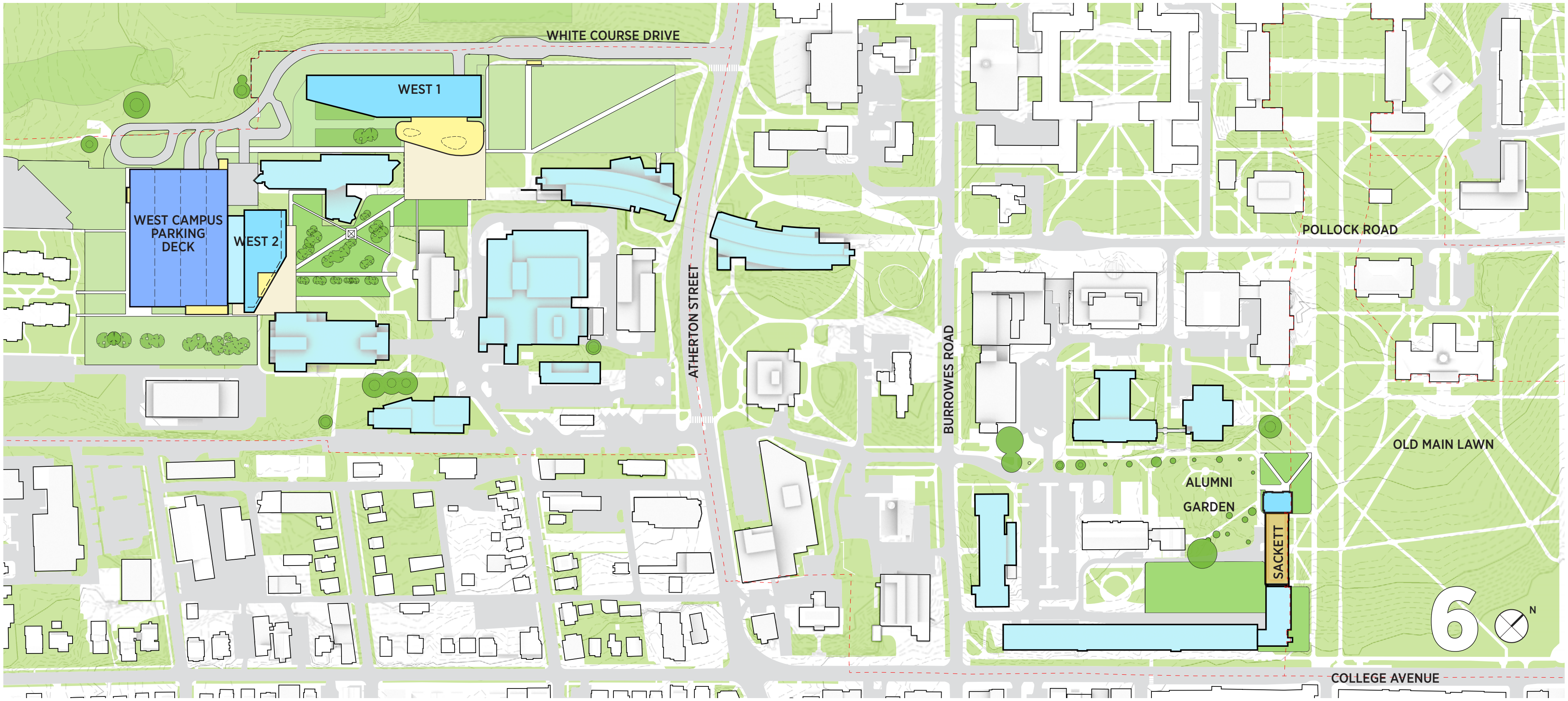


Step 5 demolishes the Units and the North Wing of Sackett. Existing sewer and stormwater pipes run below the Units and will need to be relocated to run along the west side of Sackett and along the east end of Hammond to connect to the mains that run east along College Avenue. These sewer and stormwater pipes are temporary and will need to be relocated further west once Hammond has been demolished and construction of Core 1 begins.

The service laterals connecting to the Units and Sackett will be removed as part of this step. The north basement wall of the Units can be saved or reconstructed to be part of the new utility trench or tunnel that will serve the Sackett Building, bringing services from further west toward Reber. The excavation of the Units basement can also be preserved for the underground stormwater detention that will be required for the new construction in Phase 2, rather than backfilled.

Construction and demolition activities in the vicinity of the Units and Sackett must include protection of existing Heritage Trees in Alumni Garden, as well as protection of Alumni Garden itself.

PHASE 1: STEP 6



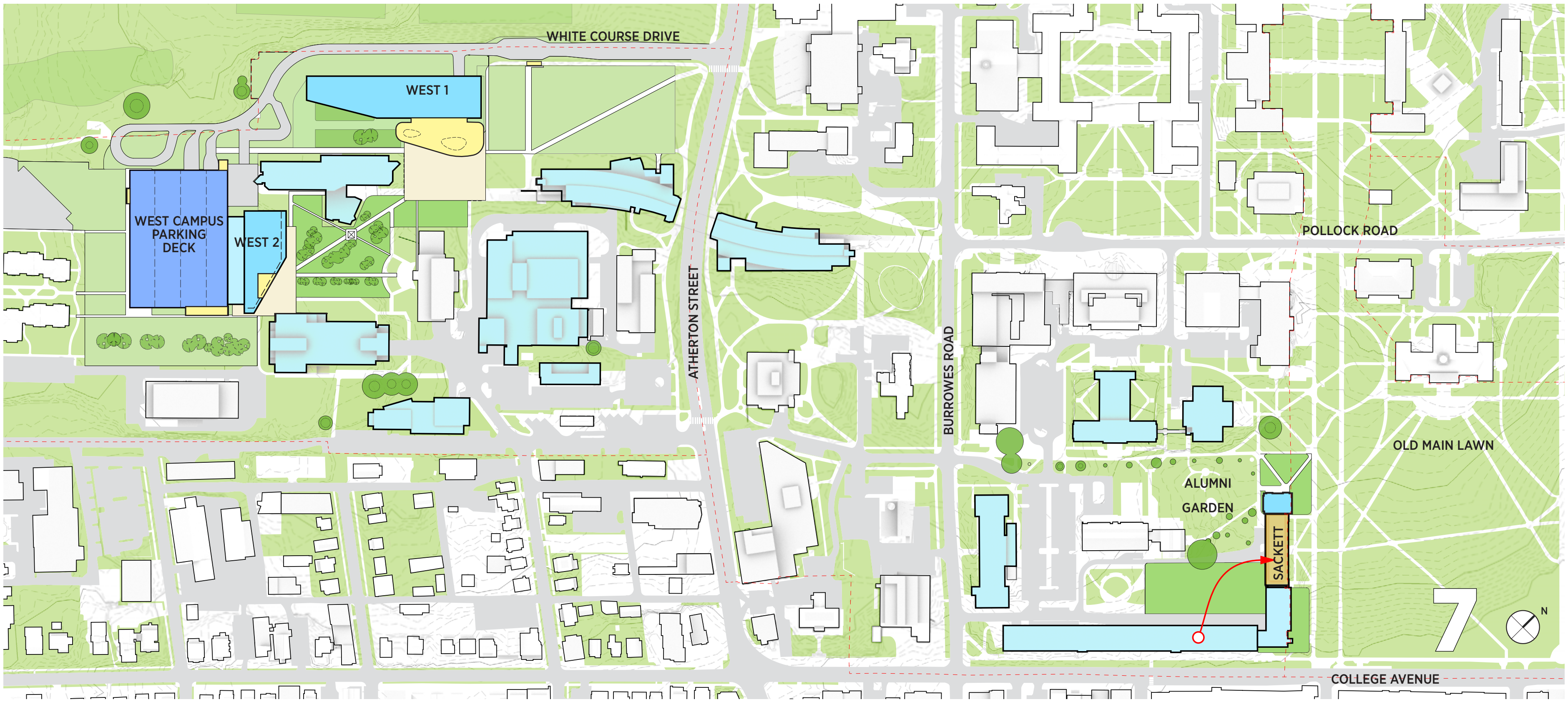
Step 6 is the renovation of the existing Sackett Building and construction of a new North Wing. These activities can commence in parallel with Step 5. Step 6 also includes temporary landscape for erosion control where the Units were demolished. Currently, there is no existing utility corridor servicing Sackett. Instead of dedicated service laterals, utility connections come from other buildings, such as Hammond. A new utility corridor needs to be installed to provide chilled water, electrical power, tel/com, and steam services.

A common utility trench or tunnel running from the back of Reber, along the south side of Hintz Alumni Center, can provide services to Sackett. A new sewer lateral from Sackett can be connected to the existing main that runs along the east side of the building. Rooftop downspouts can be temporarily connected to the existing stormwater conveyance system to the east of Sackett with the long-term plan of connecting to the underground detention facility when it is installed during Phase 2.

The Sackett renovation will include relocating existing steam condensate pumps from the basement of Kunkle Lounge to the sub-basement of Sackett, with a new steam tunnel spur from the main tunnel that runs below Pattee Mall. This will enable the demolition of Kunkle while keeping the campus steam system operational.

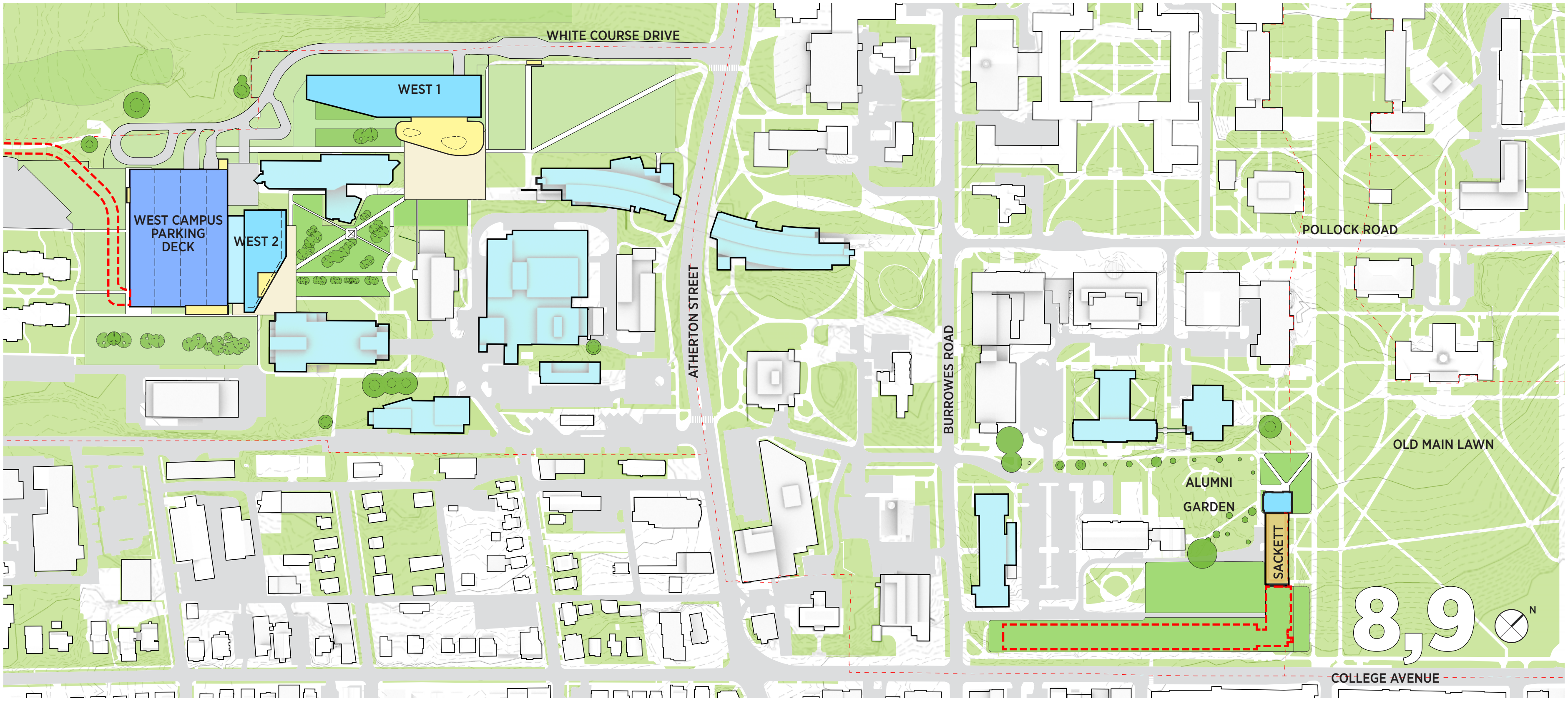
There are Heritage Trees in front of Sackett flanking Old Main Lawn. These trees and their roots must be protected during these construction activities.

PHASE 1: STEP 7



Step 7 relocates programs from Hammond into the renovated and expanded Sackett.

PHASE 1: STEPS 8 AND 9



Step 8 will demolish Hammond, the South Wing of Sackett, and Kunkle Lounge, including removal of the utility service laterals. The existing steam tunnel that runs below the sidewalk along College Avenue, south of Hammond, must be protected and not disturbed during building demolition. About 18,000 ASF of office space will require swing space at the end of Phase 1.

Step 9 includes restoration of sites where buildings were demolished to provide a temporary landscape for erosion control, anticipating further redevelopment of the Core Campus in Phase 2. Alternatively, the construction of Core 1 and 2 could begin as part of this step.

Any future development on the West Campus should not preclude a possible secondary access drive that connects the West Campus Parking Deck to College Avenue via Buckhout Street

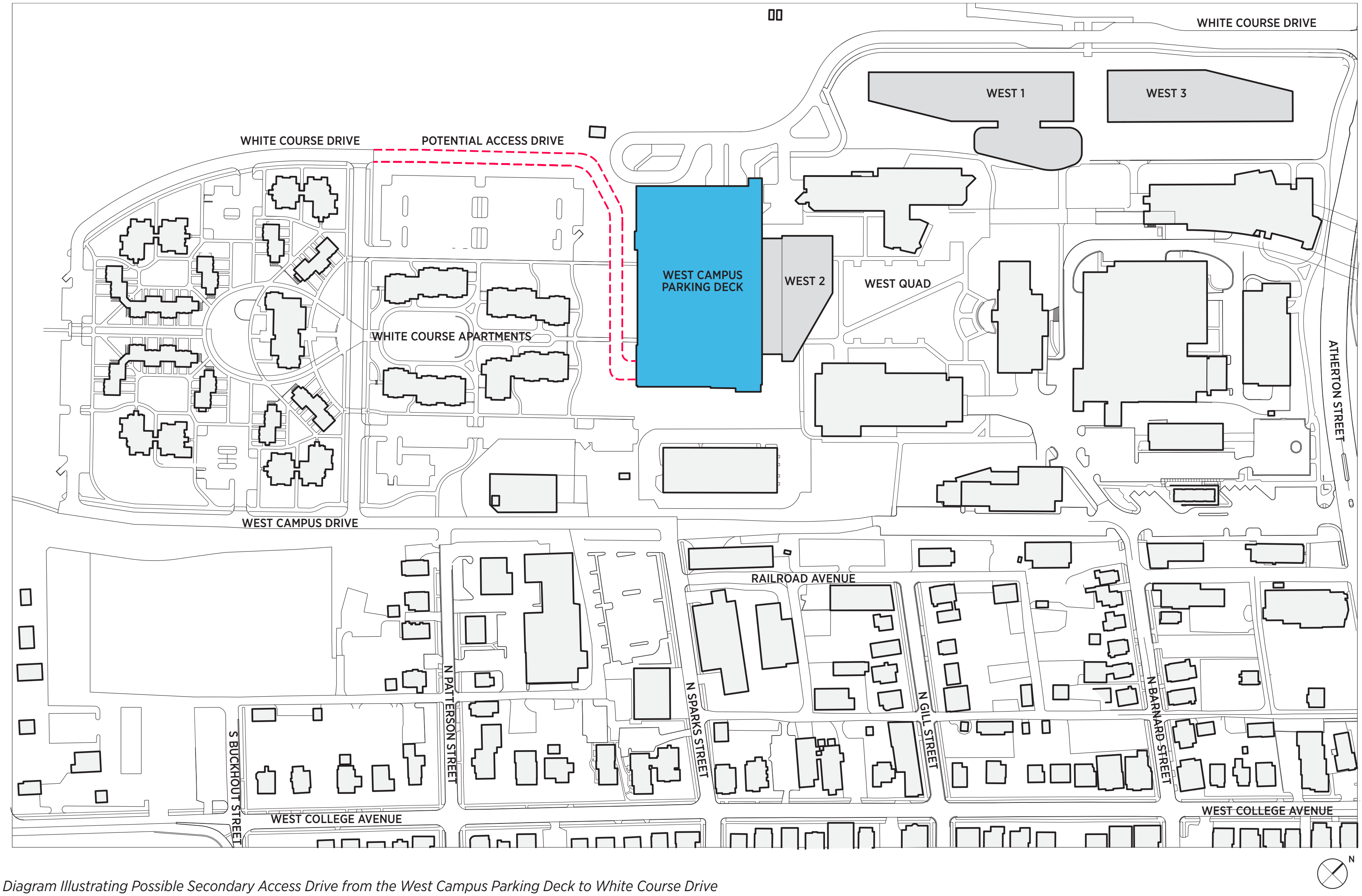


Diagram Illustrating Possible Secondary Access Drive from the West Campus Parking Deck to White Course Drive

POTENTIAL SECONDARY PARKING DECK ACCESS DRIVE

As noted on the previous page, any future development on the West Campus should not preclude a possible secondary access drive that connects the West Campus Parking Deck to College Avenue.

The diagram on the facing page illustrates a potential access drive in red.

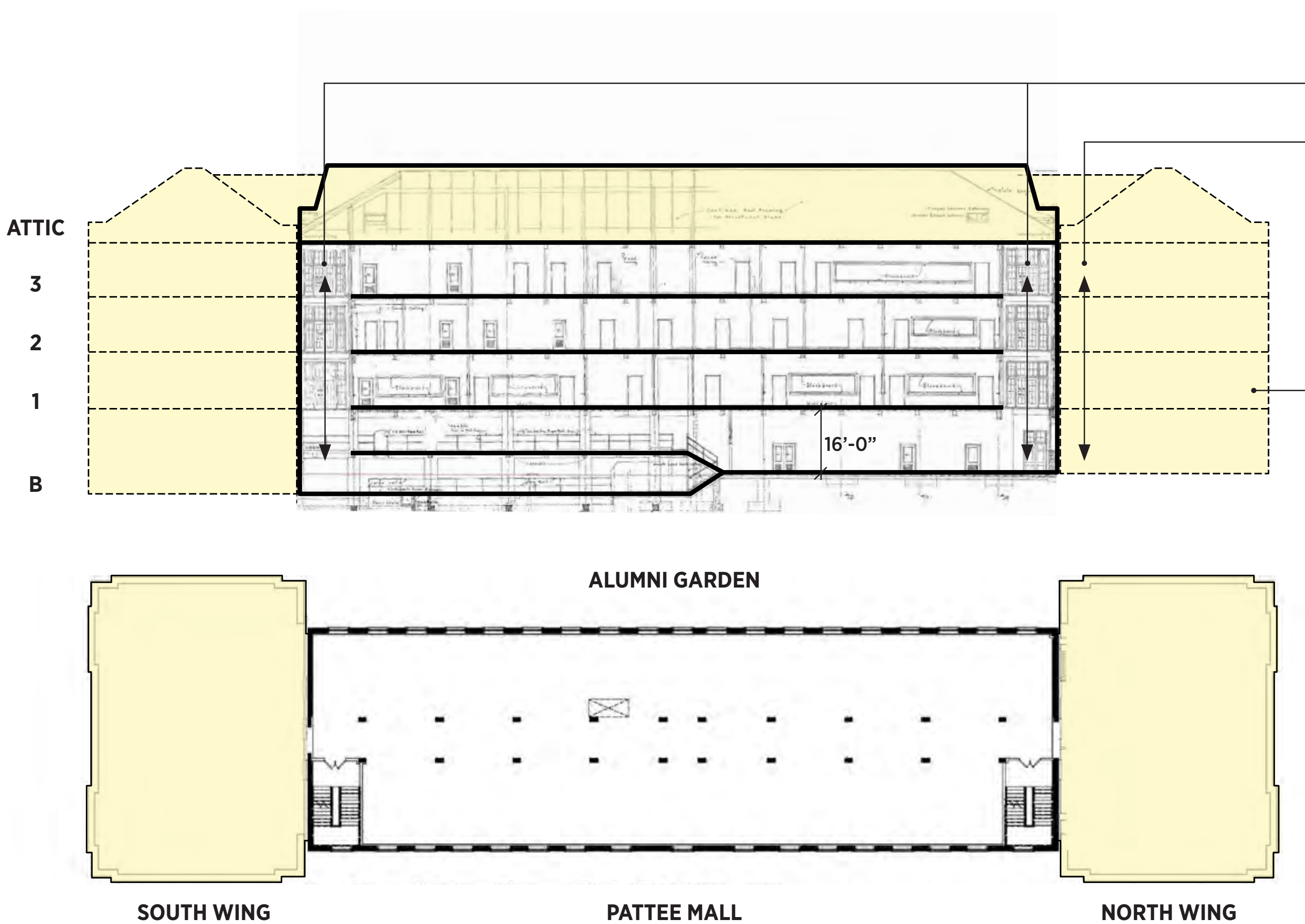
SACKETT IMPLEMENTATION

Built in 1930, the original Sackett Building is one of the historic Charles Klauder Buildings on campus. The building sits on the Pattee Mall facing the Old Main Lawn in direct line of sight from Old Main. The original building plans indicate that two symmetrical wings were planned for the building, matching the building plan for the Reber Building, another Klauder design. Those original wings were never constructed, but in 1958, two modern wings and a replacement of the roof with a 4th floor addition of a glass-walled studio space were added to the building at the same time as the Hammond Building was built.

1958 Sackett Additions: The 1958 addition created an engineering complex comprised of Sackett, Kunkle Lounge and the Hammond Building. Unfortunately, the 1958 wings and 4th floor additions were not of the same quality as the original Sackett construction. The additions were constructed of thin prefabricated panels and single pane glass on the exterior, the corridors were narrowed from the gracious proportions of the original building. Additionally, stepped level changes were created from the original floor levels of the 1930 portion of the building to reduce the floor-to-floor heights of the additions, and small toilet rooms were inserted that do not meet today's codes. The access to the fourth floor was through the existing stairs, but because of the roof slope and design of the 4th level, there are several very low beam conditions in the stairwells and studio space. There is no elevator connection to the 4th floor, but one of the access stairs has an electric stairlift which provides limited accessibility to the 4th floor. These design decisions have created accessibility problems throughout the facility, requiring insertions of steep ramps and circuitous pathways for occupants with mobility impairments. The 4th floor studio space is also extremely hot in summer months and cold in the winter and is not a comfortable space to occupy.

Vision for Sackett: The Master Plan vision for the Sackett Building is to replace the 1958 wings with new symmetrical additions that match the original proportions designed by Klauder to restore his vision for this part of the campus. The roof and the 4th floor addition would also be demolished and replaced with something akin to a Mansard roof addition to provide program space on the 4th floor. A new elevator will be located in the north wing to provide access from the basement through level four of the facility. The original Sackett Building will also be comprehensively renovated and will be converted from a lab and classroom building to a classroom and office building. The new wings will provide locations for large classrooms or office suites that cannot be accommodated in the central portion of the original building due to the existing corridor and column bay grid.

Kunkle Lounge: The Kunkle Lounge is also slated for demolition during this process. However, the basement of the Kunkle Lounge contains the steam condensate pumps for the campus steam lines which serve the broader campus—a key piece of infrastructure that requires relocation. This condensate pump room will be replaced in the renovated sub-basement of Sackett and linked to the existing steam pipe system under the Pattee Mall before this portion of the Kunkle Lounge can be demolished. More discussion of the phasing follows later in this chapter.


EXISTING STAIR
NEW ELEVATOR
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16'-0"
ALUMNI GARDEN
SOUTH WING
PATTEE MALL
NORTH WING

SACKETT: PHASE 1

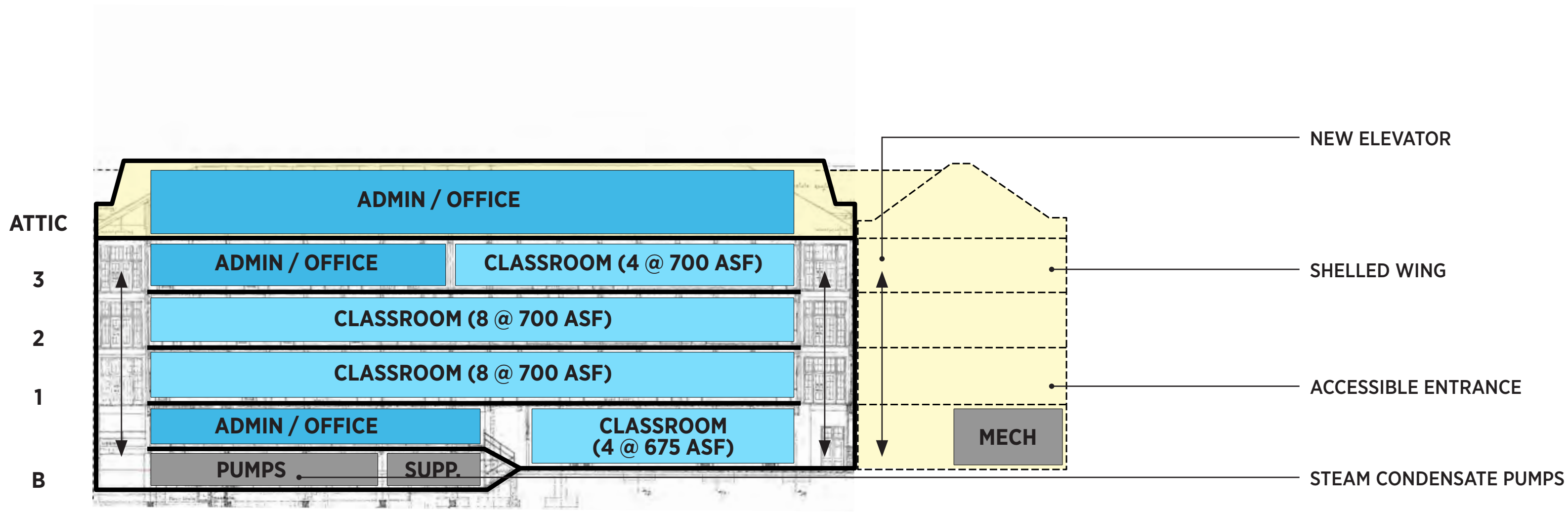
The renovation and new additions to the Sackett Building will be accomplished in two phases:

- Phase 1: North Wing Addition (shelled), replacement of the 4th floor and roof, gut renovation of the original building
- Phase 2: South Wing Addition and fit-out of the North Wing

Sackett Phase 1: Phase 1 can accommodate the following program:

28,000	**TOTAL ASF**
16,800	General Purpose Classrooms (24 @ ~ 700 ASF)
10,700	Office & Conference & Support
500	Building Support

The stacking diagrams and plans on the facing page indicate the concept of programs that could be arrayed in the building. This includes an open office suite on the 4th level, offices and classrooms on levels B through level 4, and the condensate pump rooms and building support spaces located in the sub-basement. The North Wing will contain mechanical space in the basement level that will support the facility, an elevator serving levels B through level 4, and mechanical shafts and support closets serving the facility. The wing has also been planned to accommodate a gender neutral accessible toilet room on every level to complement the stacked gendered toilet rooms located opposite the existing stairs. Due to the level change transition from the basement to the sub-basement, a ramp or wheelchair lift will need to be accommodated in the design of the sub-basement corridor.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CLASSROOM (8 @ 700 ASF)
CLASSROOM (8 @ 700 ASF)
ADMIN / OFFICE
CLASSROOM (4 @ 675 ASF)
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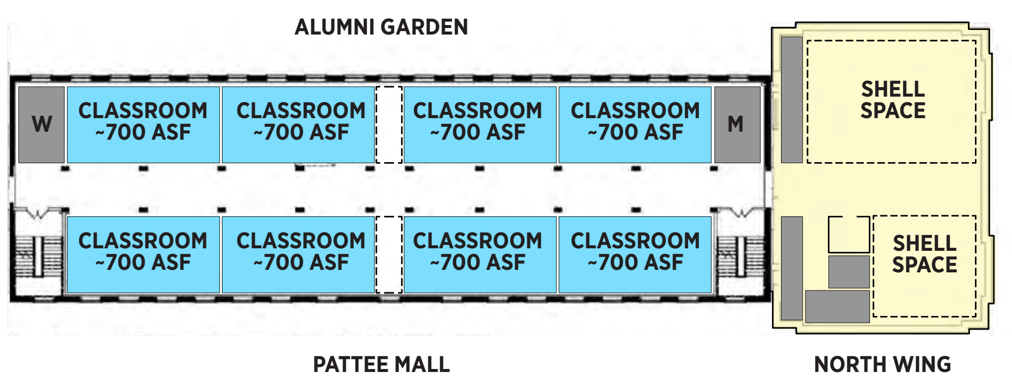
SUPP.
MECH
NEW ELEVATOR
SHELLED WING
ACCESSIBLE ENTRANCE
STEAM CONDENSATE PUMPS


ALUMNI GARDEN
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CLASSROOM ~700 ASF
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SHELL SPACE
CLASSROOM ~700 ASF
CLASSROOM ~700 ASF
CLASSROOM ~700 ASF
CLASSROOM ~700 ASF
SHELL SPACE
PATTEE MALL
NORTH WING

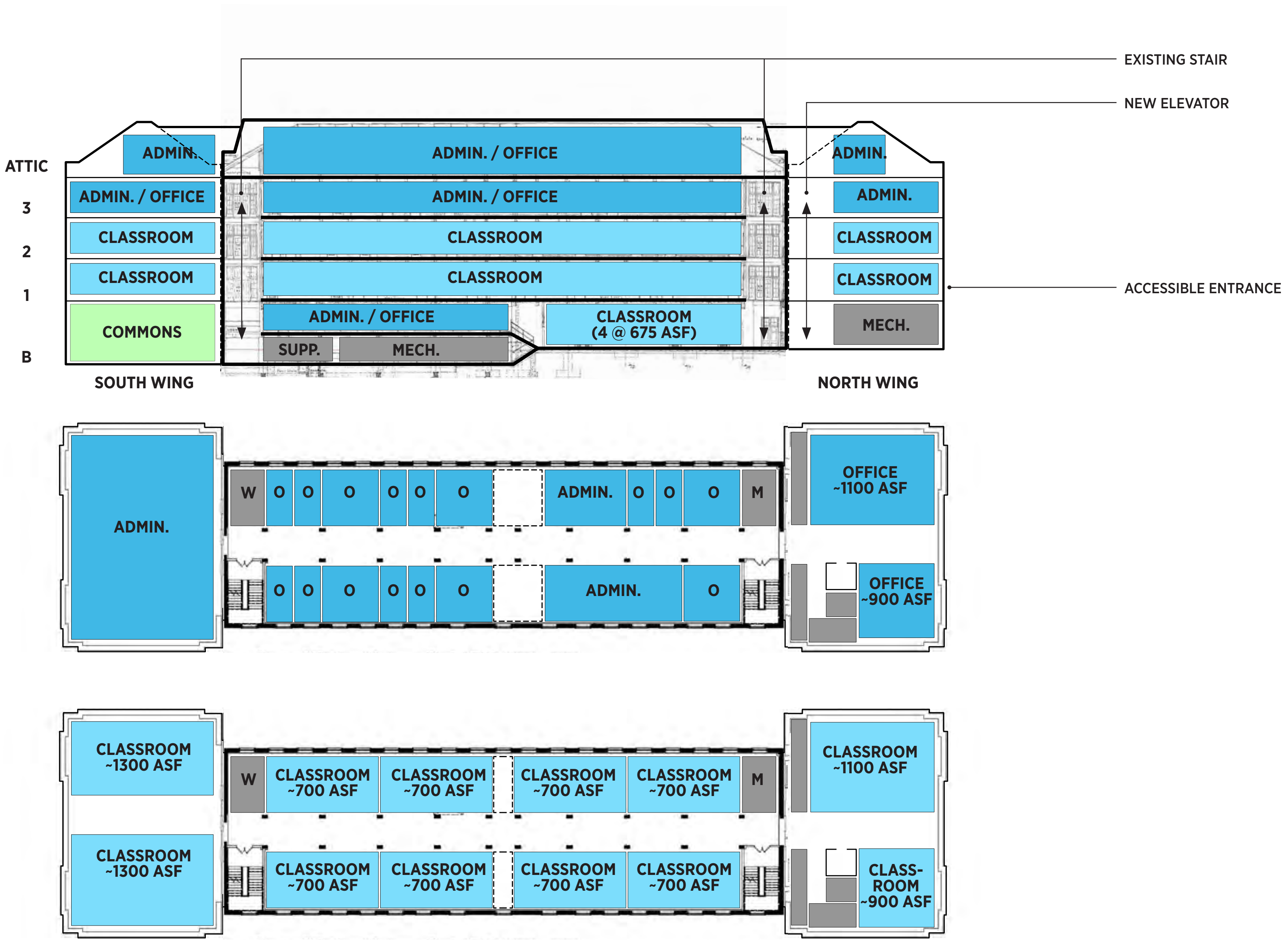
SACKETT: PHASE 2

Sackett Phase 2: The expansion in Phase 2 can accommodate the following program:

50,000	**TOTAL ASF**
19,000	General Purpose Classrooms (24 @ 700 - 1300 ASF)
27,000	Office & Conference & Support
3,000	Student Commons
500	Building Support

The stacking diagrams and plans on the facing page indicate the concept of programs that can potentially be arrayed in the building after the completion of the South Wing and fit-out of the North Wing. The new wings allow for larger classrooms or office suites to be located in the two wings. Some considerations:

- A future connection to Level 2 of Core 1 should be considered during the detailed building design.
- A large student commons could be located on the basement level of the south wing as this location will have prime visibility and access from Old Main Lawn and West College Ave.
- Third floor classrooms built in Phase 1 would need to be converted to office space in Phase 2.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COMMONS
ADMIN. / OFFICE
CLASSROOM (4 @ 675 ASF)
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OFFICE ~900 ASF
CLASSROOM ~1300 ASF
CLASSROOM ~1300 ASF
CLASSROOM ~700 ASF
CLASSROOM ~1100 ASF
CLASS-ROOM ~900 ASF

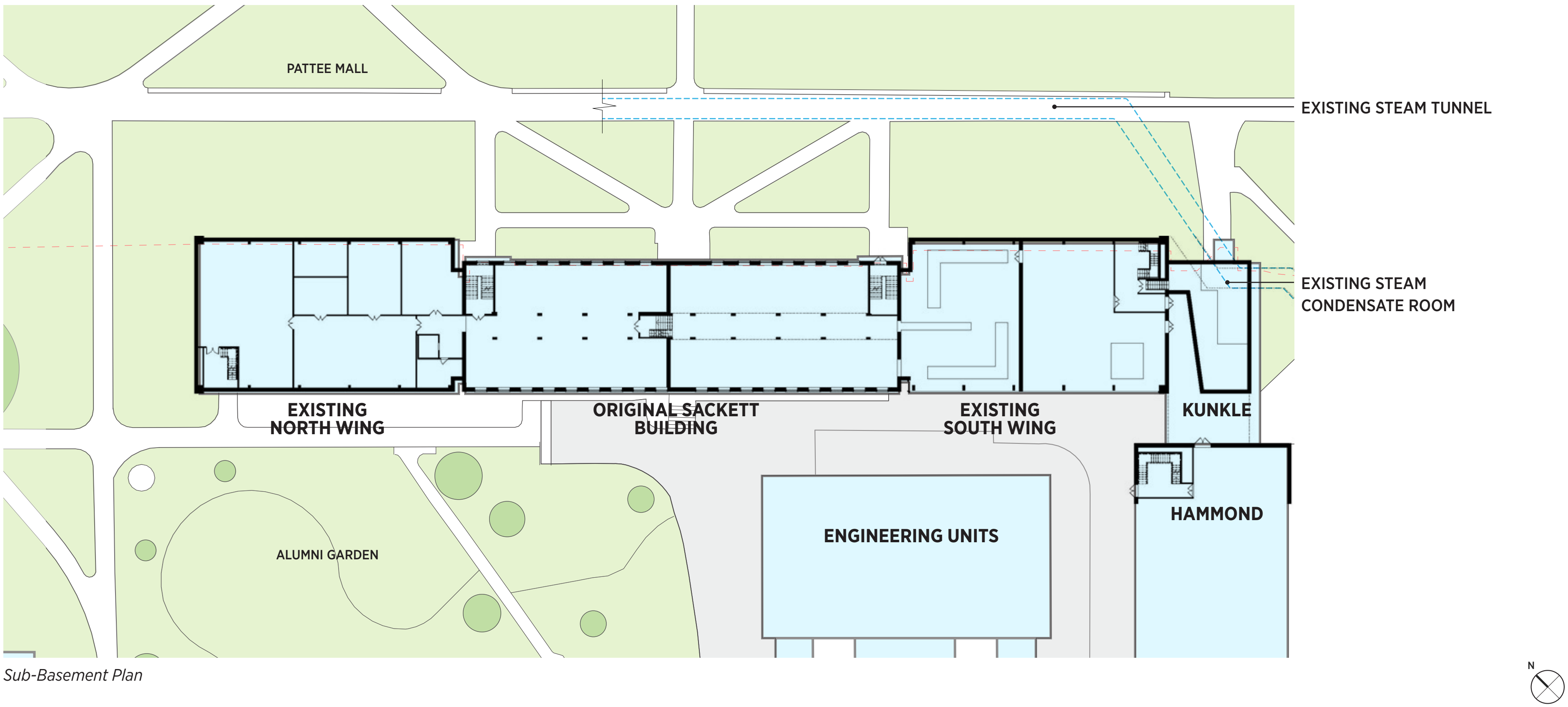
SACKETT WINGS DEMOLITION AND PHASED CONSTRUCTION CONSIDERATIONS:

The construction sequence of the demolition and renovation of Sackett, the Wings and Kunkle Lounge needs to be carefully considered as this is a sensitive corner of campus, and the Steam Condensate Pumps need to remain continuously operational.

The following phasing sequence would allow for the seamless transition to the new Condensate Pump Room, and also reduce the duration and impact of the site disturbance:

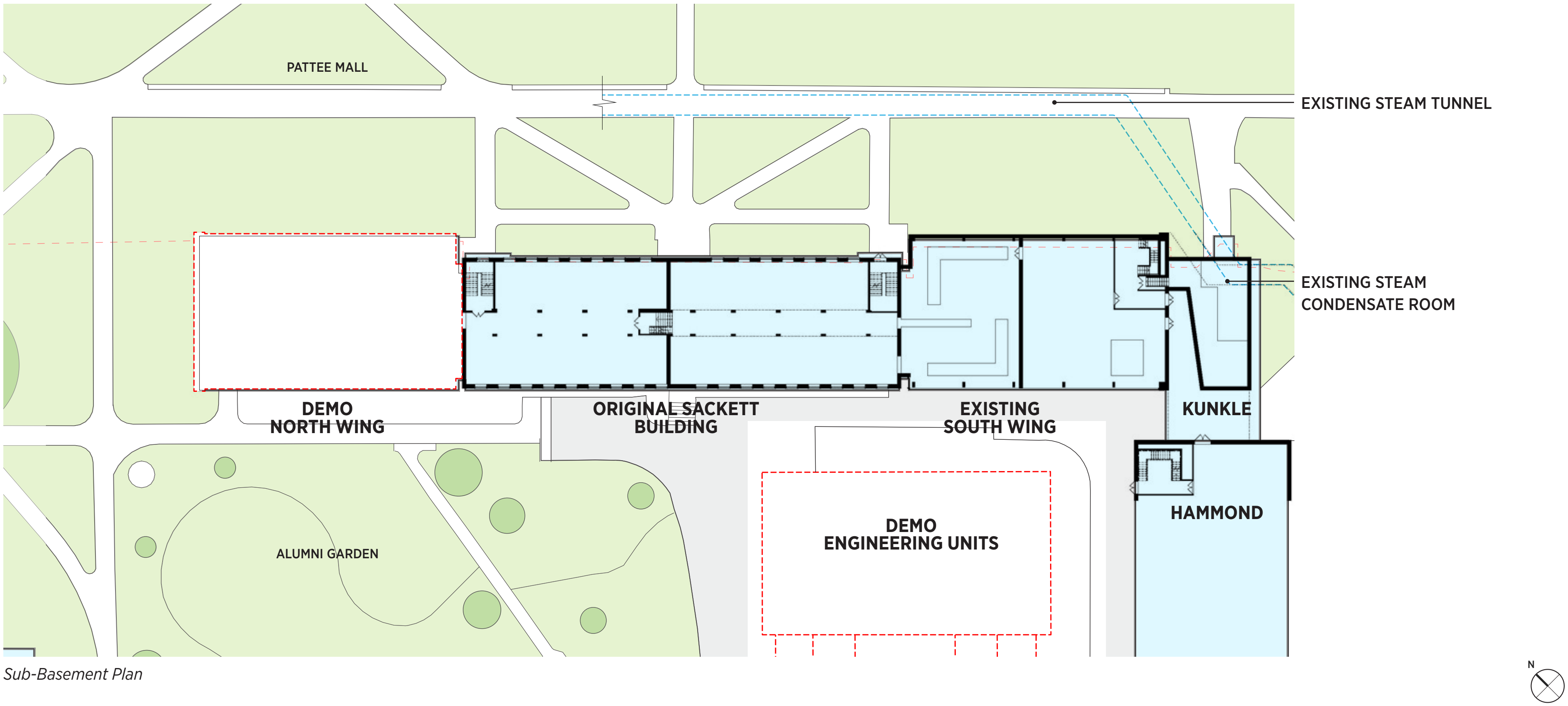
1. Decant Existing Sackett Building and Wings: programs move to the West Campus, or to temporary swing space in Hammond.
2. Demolish the existing north wing of Sackett, gut the original Sackett Building, and remove the existing 4th floor and roof. The Kunkle Lounge and the South Wing of Sackett can remain standing and potentially operational during this demolition.
3. Construct new North Wing, new 4th floor and roof, and complete construction and fit-out of the original Sackett Building including the condensate pump room and connection to the Steam Tunnel.
4. Move new occupants into the facility, and take old Condensate Pump Room offline
5. Demolish 1958 South Wing Addition to Sackett and Kunkle Lounge
6. Restore the south façade of Sackett to await future South Addition or build new South Wing addition and complete the Sackett Building with its two wings.

SACKETT ENABLING SEQUENCE: EXISTING CONDITIONS



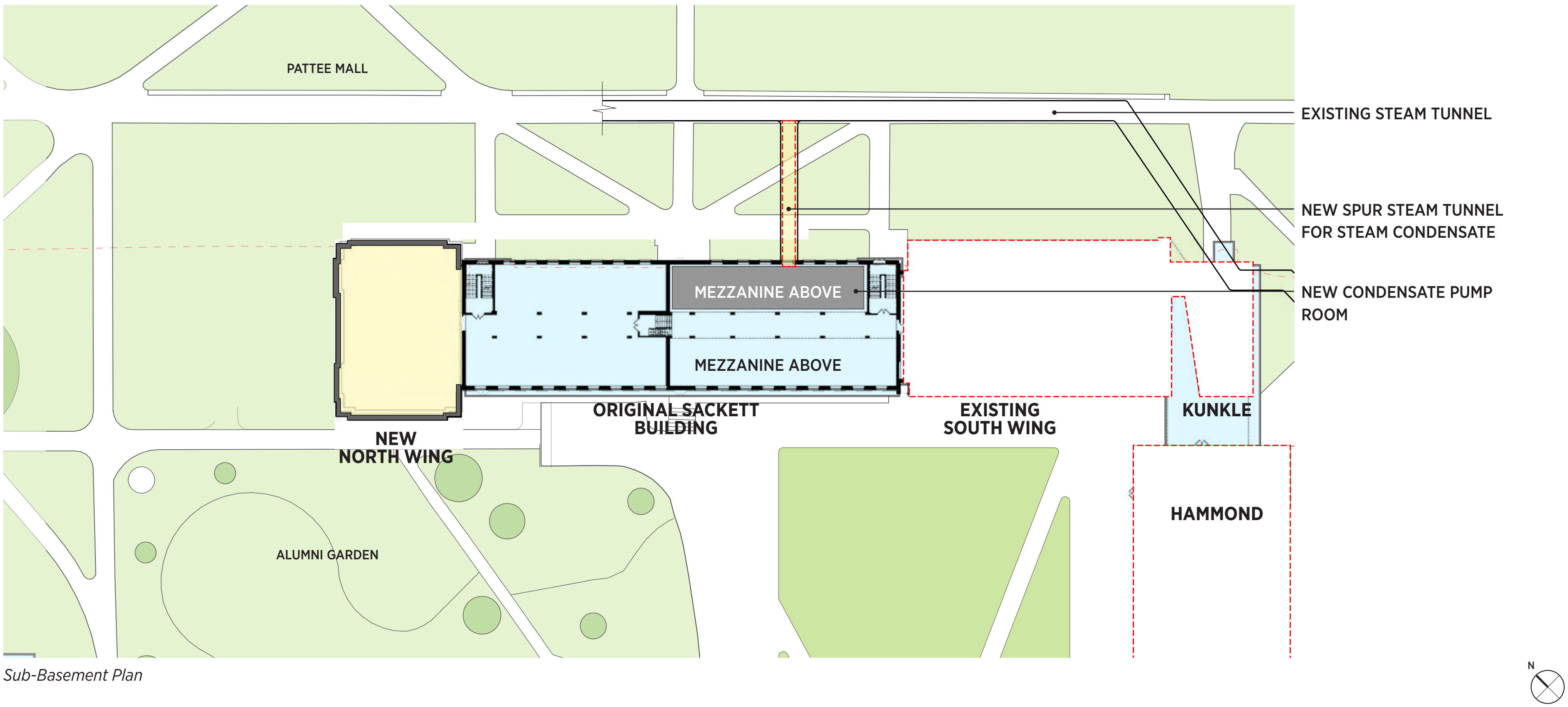
Sub-Basement Plan

SACKETT ENABLING SEQUENCE: DEMO NORTH WING



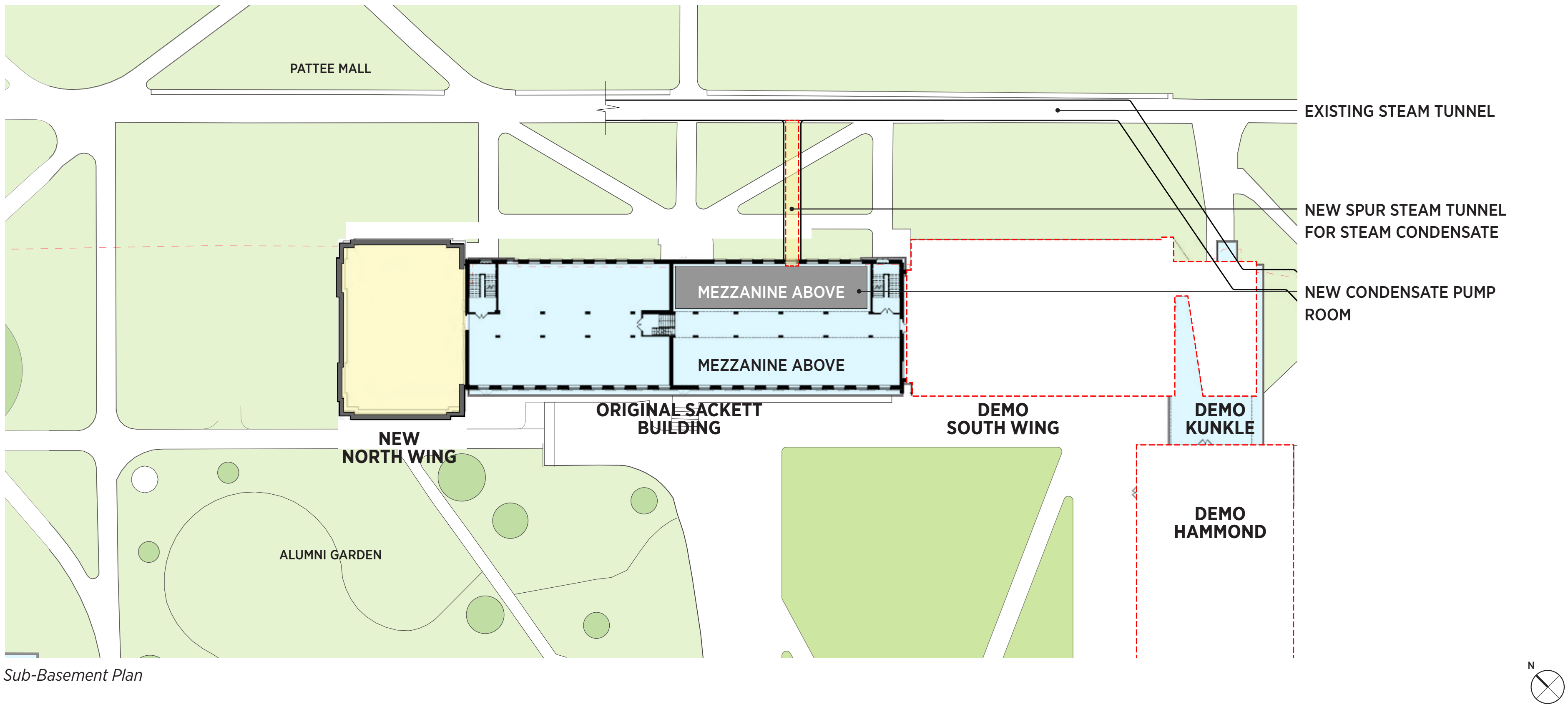
Sub-Basement Plan

SACKETT ENABLING SEQUENCE: AFTER RENOVATION AND NORTH WING ADDITION



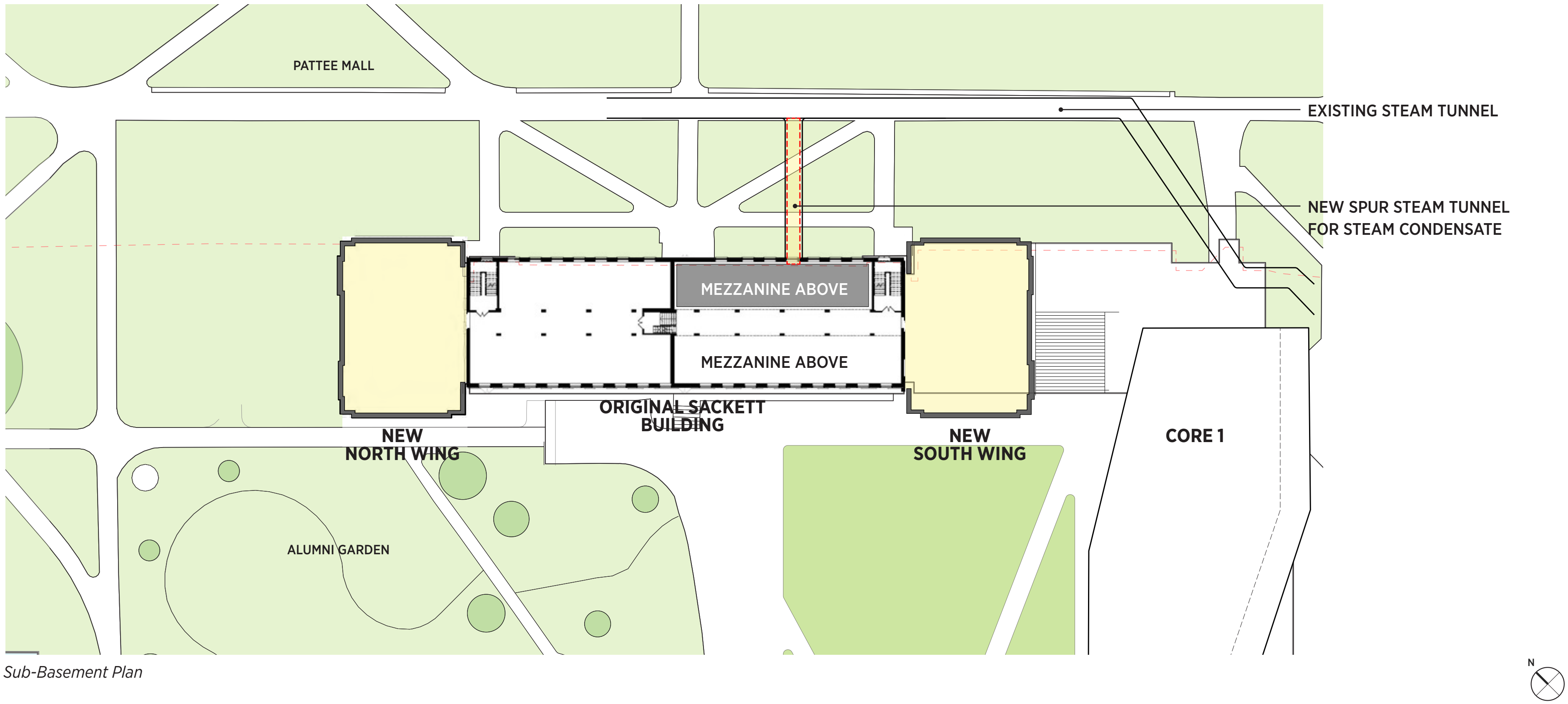
Sub-Basement Plan

SACKETT ENABLING SEQUENCE: DEMOLITION OF KUNKLE LOUNGE AND STEAM CONDENSATE PUMP ROOM



Sub-Basement Plan

SACKETT ENABLING SEQUENCE: DEMOLITION OF KUNKLE LOUNGE AND STEAM CONDENSATE PUMP ROOM



Sub-Basement Plan

COST AND SCHEDULE

METHODOLOGY AND ASSUMPTIONS

The cost estimates for Phase 1 and Phase 2 were developed based on the following methodology and assumptions:

- New construction and renovations are estimated on a cost-per-SF basis, using similar projects in terms of size and program to inform the unit rates. These benchmarks are adjusted to account for geographic location and are expressed in 2018 dollars.
- Based on the benchmarks and a consideration of the anticipated mixed-use nature of some of the planned buildings, cost/SF values are developed to represent three levels of intensity of new buildings: mixed-use buildings with wet research; mixed-use buildings with dry research; and classroom/office buildings.
- Cost estimates for renovations were initially based on a cost/SF basis. However, as the scenario for redeveloping the Sackett Building intensified and incorporated shell space, the master planning team's cost estimator prepared a more refined estimate, broken down at an elemental level: substructure, structure, enclosure, etc.
- The estimates utilize cost/SF for various levels of site development:

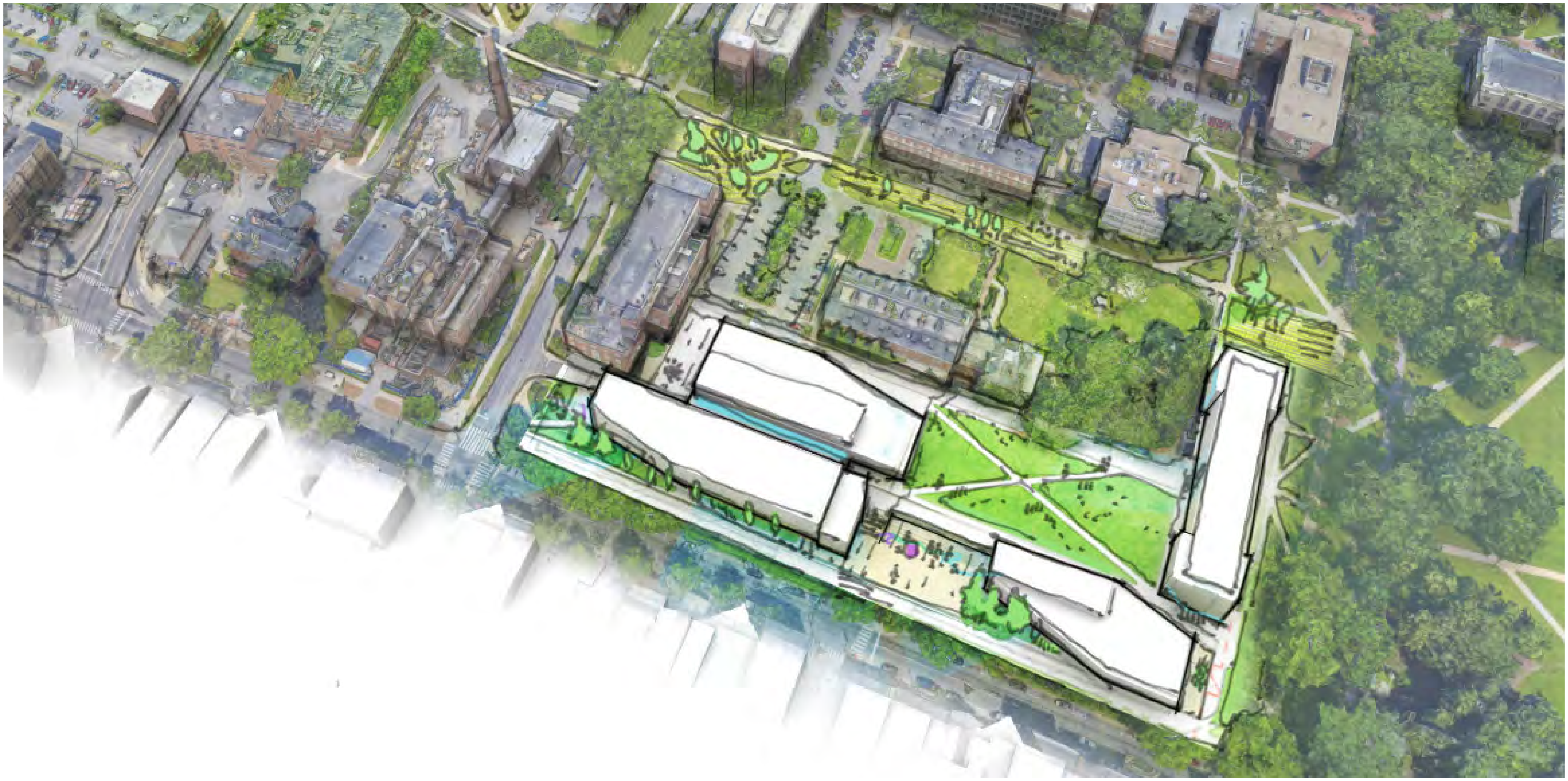
  Campus landscape: quad-type spaces with grass, concrete paths, and new trees

  Plaza landscape: paved plaza with new trees

  Roadways: asphalt, and including concrete sidewalks and new street trees

  Temporary landscape: minimal landscape for erosion control, in anticipation of near-term new construction
- The estimates include detailed estimating for utility work associated with phased construction for Phase 1.
- The estimates assume 4% annual escalation based on long-term historical trends. This annual rate is converted to a monthly rate in order to calculate escalation from a base date of January 1, 2018, to the estimated bid date.
- The estimates utilize construction-cost-to-project-cost multipliers, developed in consultation with Penn State OPP, to arrive at total project cost.

The benchmarks and more detailed renovation estimates noted above can be found in the Appendix.



Aerial Rendering of the Core Campus at the End of Phase 2

PHASE 1 AND PHASE 2 COST ESTIMATES

Cost estimates for Phases 1 and 2 are presented on the following pages, based on the methodology and assumptions noted above, as well as the phasing described earlier in this chapter and the anticipated bid dates shown in the schedule.

SCHEDULE

A combined schedule for Phases 1 and 2 is presented after the cost estimates on the following pages. Timelines for design and construction were developed in consultation with Penn State's OPP and incorporate Penn State's designer selection process and Board of Trustees engagement and approvals. It is important to note that the Board meets five times each year in February, May, July, September, and November. It is assumed that this pattern of Board meetings will extend through the next 10 years. The schedule also presupposes that designer selection and design phases for projects in Phase 2 can commence prior to the start of the 2023-2028 Capital Plan, which starts in July 2023.

As noted in the earlier Phasing section above, the Master Plan recommends that Phase 2 work on Sackett, Core 1, and Core 2 proceed in parallel and as early as possible on the heels of the Phase 1 work on Sackett, so that the Core Campus can achieve a sense of completion, minimize the period of campus disruption, and heal the open scar along College Avenue, due to Hammond's removal, as early as possible.

COST PHASE 1

	West 1				
Cost Component	N:G	ASF	GSF	Cost / SF	Cost
New Construction	57%	159,030	279,000	600	167,400,000
Shelled North Wing					
Fit out Sackett North Wing					
Complete Sackett South Wing					
Renovation					
Abate and Demolish Sackett North Wing					
Abate and Demolish Sacket South Wing + Kunkle (partial / phased)					
Abate and Demolish Hammond					
Abate and Demolish Units					
Site – Temporary Landscape				15	
Site – Campus Landscape			52,700	25	1,317,500
Site – Campus Plaza			24,500	45	1,102,500
Site – Roads			1,200	15	18,000
Subtotal Construction Cost (2018 dollars)				609	169,838,000
Estimated Bid Date				1-Dec-20	
Months of Escalation (from January 1, 2018)				35	
Escalation Contingency					20,591,788
Total Escalated Construction Cost					190,429,788
Project Cost Multiplier				1.20	
Total Project Cost – Buildings and Sitework					**228,515,746**
					Cost
Utilities – See Utilties Spreadsheet in Appendix for detailed breakdown					1,185,063
Utilities – Address Steam Lines at Kunkle (allowance)					
Stormwater					
Subtotal Construction Cost (2018 dollars)					1,185,063
Estimated Bid Date				1-Dec-20	
Months of Escalation (from January 1, 2018)				35	
Escalation Contingency					143,681
Total Escalated Construction Cost					1,328,744
Project Cost Multiplier				1.20	
Total Project Cost – Utilities and Stormwater					**1,594,493**
Total Project Cost					**230,110,239**

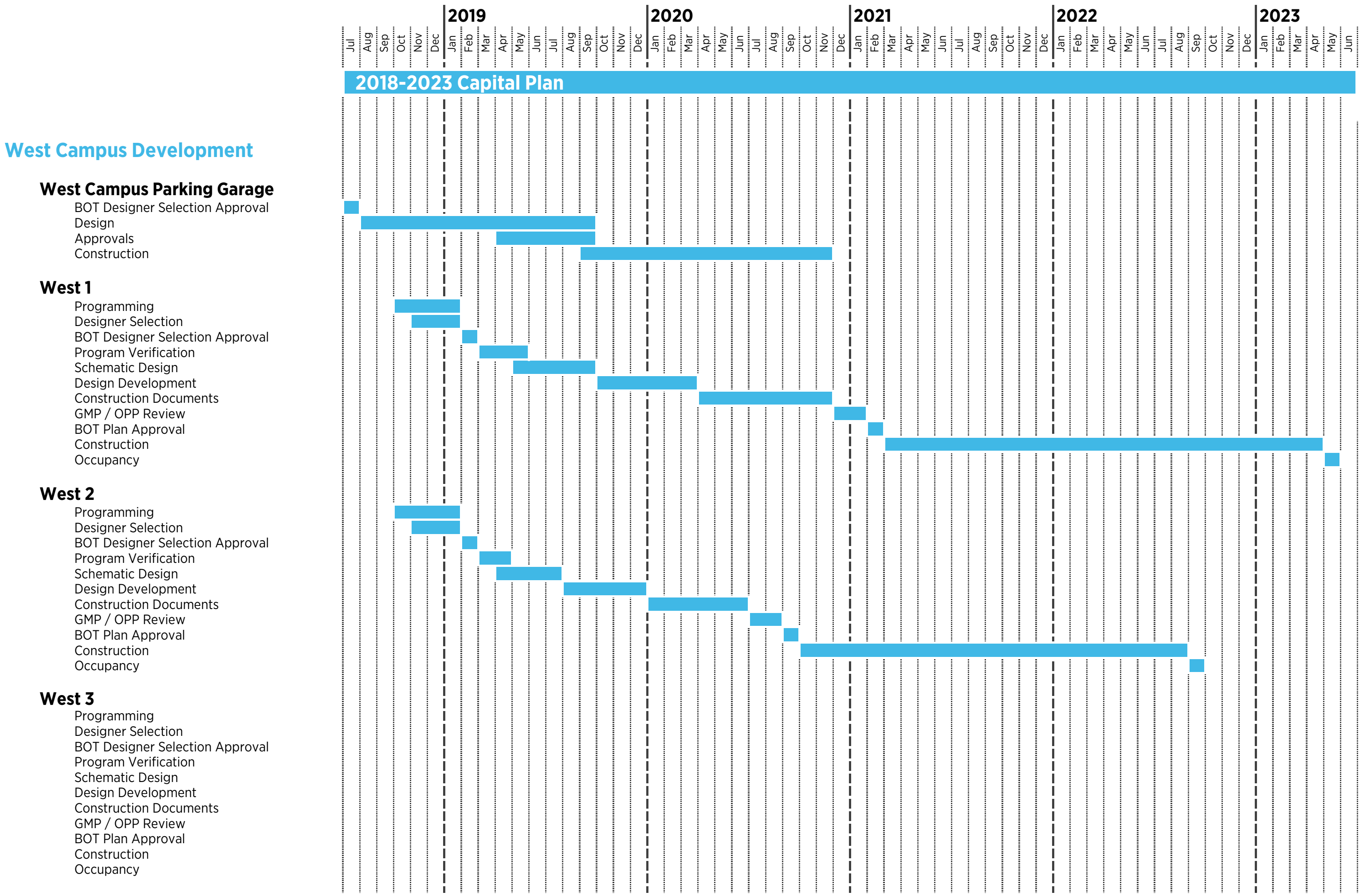
	West 2					Sackett (Renovation + New North Wing, shelled)					Demolition			Total
Cost Component	N:G	ASF	GSF	Cost / SF	Cost	N:G	ASF	GSF	Cost / SF	Cost	SF	Cost / SF	Cost	
New Construction	57%	55,860	98,000	560	54,880,000		4,000	7,500	685	5,139,684				
Shelled North Wing								16,000	532	8,516,446				
Fit out Sackett North Wing								0	250	-				
Complete Sackett South Wing								0	475	-				
Renovation						58%	24,000	41,625	414	17,215,038				
Abate and Demolish Sackett North Wing											26,200	25	655,000	
Abate and Demolish Sacket South Wing + Kunkle (partial / phased)									606.91		34,500	40	1,380,000	
Abate and Demolish Hammond											157,800	25	3,945,000	
Abate and Demolish Units											85,100	25	2,127,500	
Site – Temporary Landscape				15					15	-	93,500	15	1,402,500	
Site – Campus Landscape			81,400	25	2,035,000			48,500	25	1,212,500	6,500	25	162,500	
Site – Campus Plaza			-	45	-			-	45	-	-	45	-	
Site – Roads			7,600	15	114,000			-	15	-	-	15	-	
Subtotal Construction Cost (2018 dollars)				582	57,029,000				4,278	32,083,668			9,672,500	
Estimated Bid Date				1-Jul-20					1-Mar-23			1-Mar-23		
Months of Escalation (from January 1, 2018)				30					62			62		
Escalation Contingency					5,871,742					7,203,499			2,171,692	
Total Escalated Construction Cost					62,900,742					39,287,167			11,844,192	
Project Cost Multiplier				1.20					1.20			1.10		
Total Project Cost – Buildings and Sitework					**75,480,891**					**47,144,600**			**13,028,611**	**364,169,848**
					Cost					Cost			Cost	
Utilities – See Utilties Spreadsheet in Appendix for detailed breakdown					1,006,405					951,679			458,865	
Utilities – Address Steam Lines at Kunkle (allowance)										500,000				
Stormwater														
Subtotal Construction Cost (2018 dollars)					1,006,405					1,451,679			458,865	
Estimated Bid Date				1-Jul-20					1-Mar-23			1-Mar-23		
Months of Escalation (from January 1, 2018)				30					62			62		
Escalation Contingency					103,620					325,934			103,025	
Total Escalated Construction Cost					1,110,025					1,777,613			561,890	
Project Cost Multiplier				1.20					1.20			1.10		
Total Project Cost – Utilities and Stormwater					**1,332,030**					**2,133,136**			**618,079**	**5,677,739**
Total Project Cost					**76,812,921**					**49,277,736**			**13,646,691**	**369,847,587**
												Budget		370,000,000
												Over (Under)		(152,413)
														-0.04%

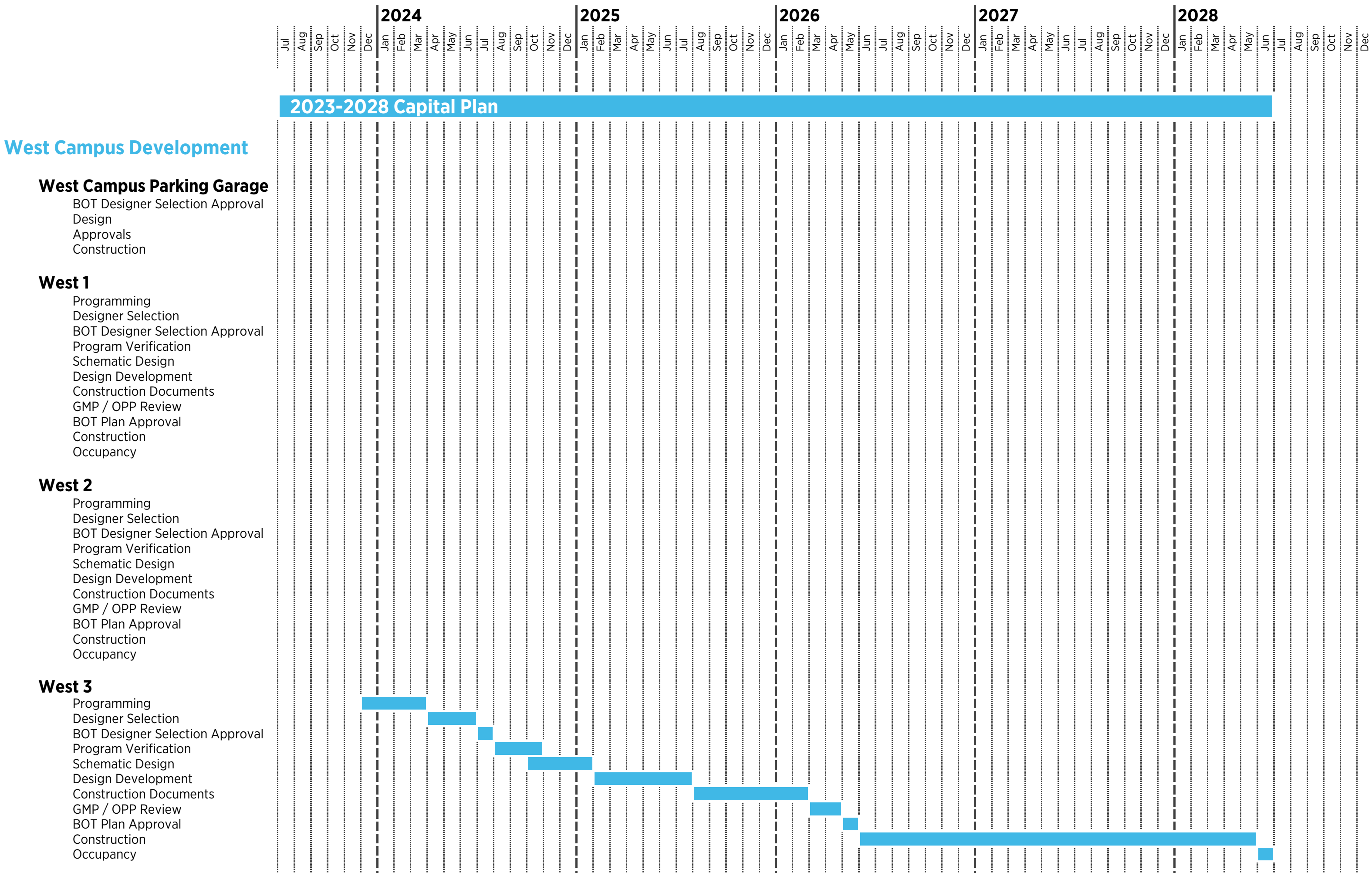
COST PHASE 2

Cost Component	Sackett (North Wing Fit-Out + New South Wing)					Core 1				
	N:G	ASF	GSF	Cost / SF	Cost	N:G	ASF	GSF	Cost / SF	Cost
New Construction	56%	9,000	16,000	450	7,200,000	57%	43,890	77,000	560	43,120,000
Sackett North Wing – Fit Out		7,000		250	1,750,000					
Sackett South Wing										
Site – Temporary Landscape			-	15	-				15	-
Site – Campus Landscape			-	25	-			39,000	25	975,000
Site – Campus Plaza			-	45	-			28,000	45	1,260,000
Site – Roads			-	15	-				15	-
Subtotal Construction Cost (2018 dollars)					8,950,000				589	45,355,000
Estimated Bid Date				1-Mar-25					1-Mar-25	
Months of Escalation (from January 1, 2018)				86					86	
Escalation Contingency					2,905,041					14,721,582
Total Escalated Construction Cost					11,855,041					60,076,582
Project Cost Multiplier				1.20					1.20	
Total Project Cost – Buildings and Sitework					**14,226,050**					**72,091,898**
					Cost					Cost
Site Utilities										
Stormwater										
Subtotal Construction Cost (2018 dollars)					-					-
Estimated Bid Date				1-Mar-25					1-Mar-25	
Months of Escalation (from January 1, 2018)				86					86	
Escalation Contingency					-					-
Total Escalated Construction Cost					-					-
Project Cost Multiplier				1.20					1.20	
Total Project Cost – Utilities and Stormwater					**-**					**-**
Total Project Cost					**14,226,050**					**72,091,898**

Cost Component	Core 2					West 3					Utilties		Total
	N:G	ASF	GSF	Cost / SF	Cost	N:G	ASF	GSF	Cost / SF	Cost	Cost / SF	Cost	
New Construction	57%	111,720	196,000	600	117,600,000	57%	110,580	194,000	600	116,400,000			
Sackett North Wing – Fit Out													
Sackett South Wing													
Site – Temporary Landscape				15	-				15	-			
Site – Campus Landscape			16,000	25	400,000			60,000	25	1,500,000			
Site – Campus Plaza			5,000	45	225,000			20,000	45	900,000			
Site – Roads			-	15	-				15	-			
Subtotal Construction Cost (2018 dollars)				603.19	118,225,000				612	118,800,000			
Estimated Bid Date				1-Mar-25					1-Jun-25		1-Jun-25		
Months of Escalation (from January 1, 2018)				86					89		89		
Escalation Contingency					38,374,137					40,124,121		-	
Total Escalated Construction Cost					156,599,137					158,924,121		-	
Project Cost Multiplier				1.20					1.20		1.20		
Total Project Cost – Buildings and Sitework					**187,918,965**					**190,708,945**		**-**	**464,945,858**
					Cost					Cost	Cost / LF	Cost	
Site Utilities												3,230,000	
Stormwater												2,210,000	
Subtotal Construction Cost (2018 dollars)					-					-		5,440,000	
Estimated Bid Date				1-Mar-25					1-Jun-25		1-Jun-25		
Months of Escalation (from January 1, 2018)				86					89		89		
Escalation Contingency					-					-		1,837,333	
Total Escalated Construction Cost					-					-		7,277,333	
Project Cost Multiplier				1.20					1.20		1.20		
Total Project Cost – Utilities and Stormwater					**-**					**-**		**8,732,800**	**8,732,800**
Total Project Cost					**187,918,965**					**190,708,945**		**8,732,800**	**473,678,658**

WEST CAMPUS SCHEDULE

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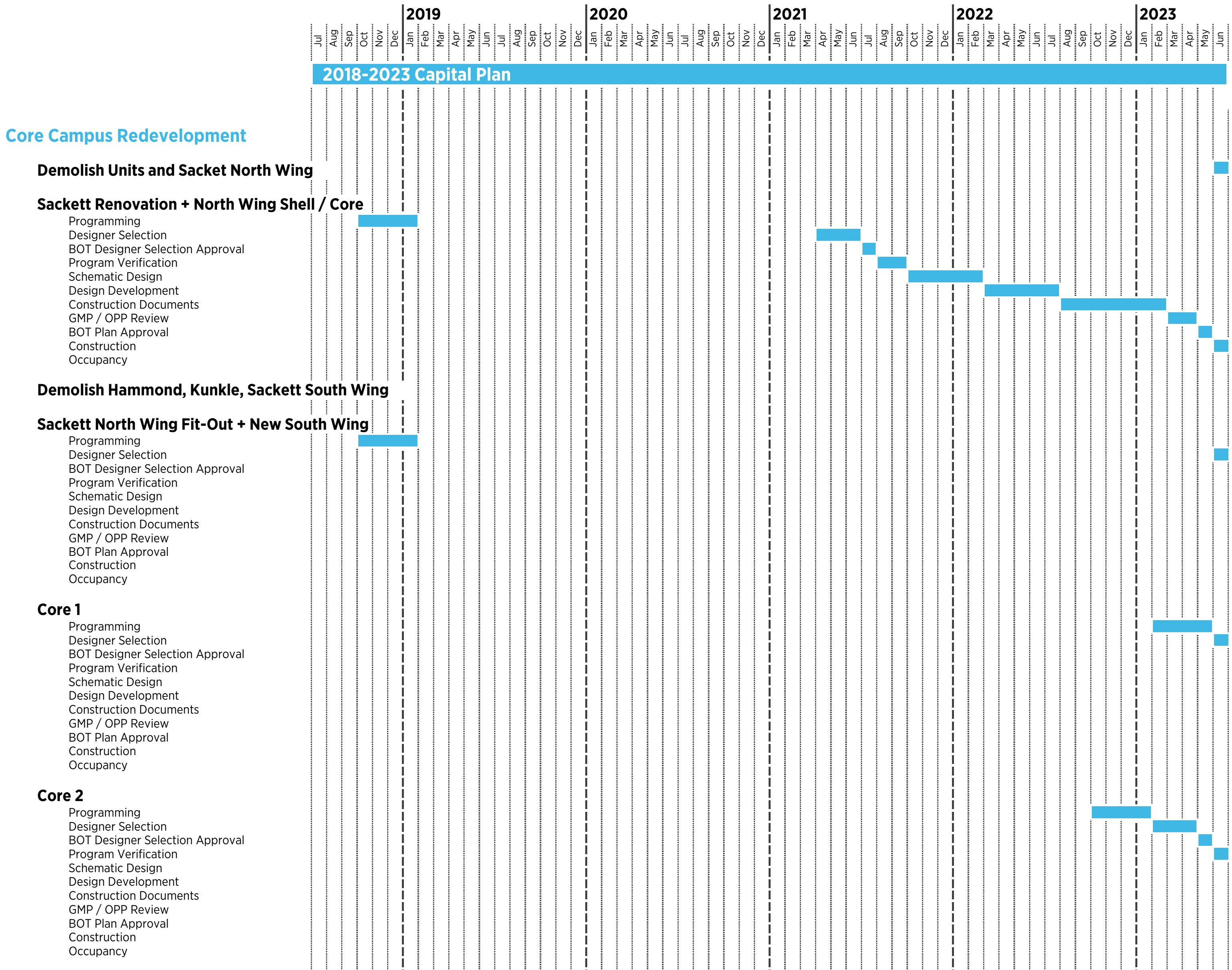
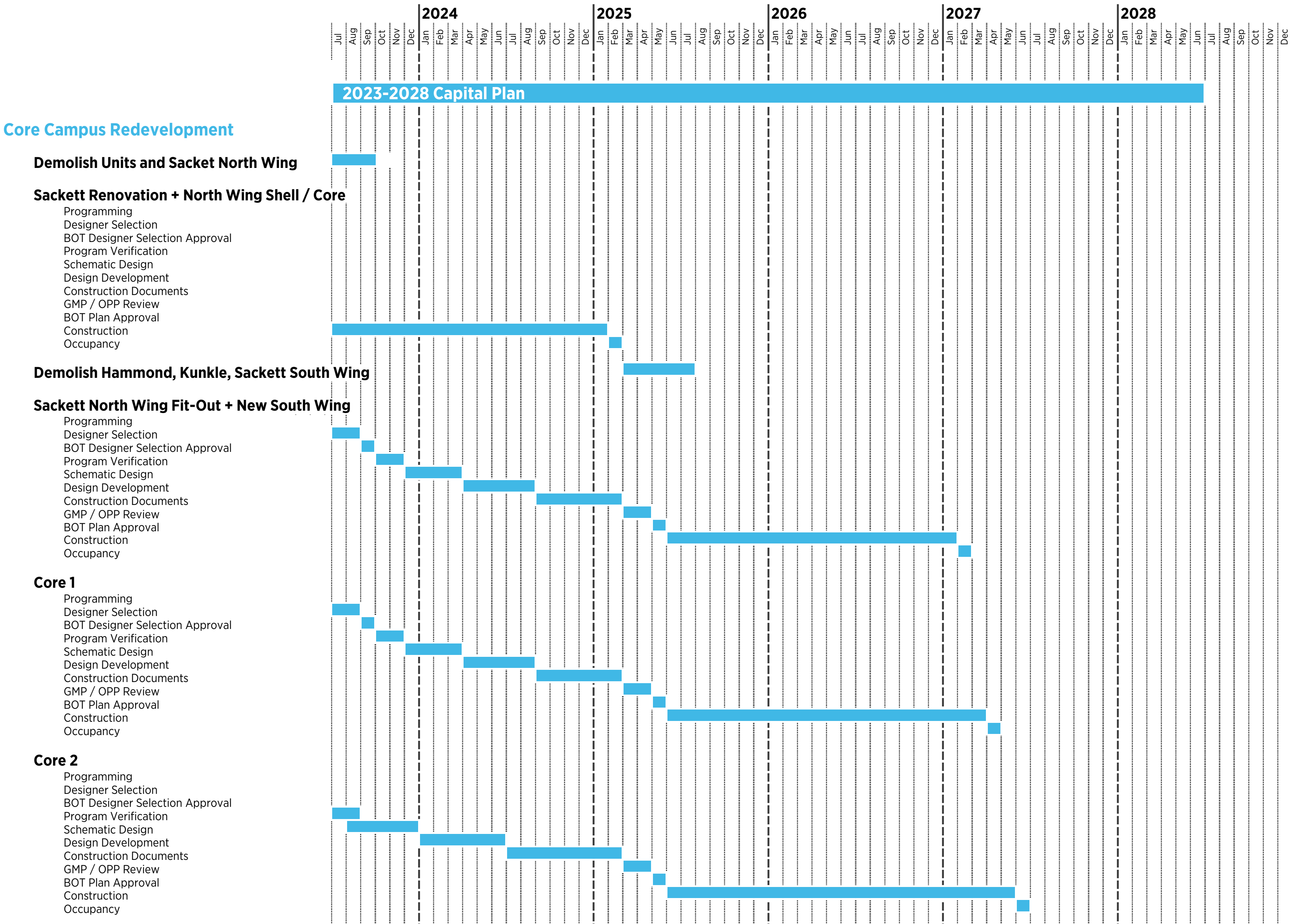
2023-2028 Capital Plan
West Campus Development
West Campus Parking Garage
BOT Designer Selection Approval
Design
Approvals
Construction
West 1
Programming
Designer Selection
BOT Designer Selection Approval
Program Verification
Schematic Design
Design Development
Construction Documents
GMP / OPP Review
BOT Plan Approval
Construction
Occupancy
West 2
Programming
Designer Selection
BOT Designer Selection Approval
Program Verification
Schematic Design
Design Development
Construction Documents
GMP / OPP Review
BOT Plan Approval
Construction
Occupancy
West 3
Programming
Designer Selection
BOT Designer Selection Approval
Program Verification
Schematic Design
Design Development
Construction Documents
GMP / OPP Review
BOT Plan Approval
Construction
Occupancy

CORE CAMPUS SCHEDULE

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2023-2028 Capital Plan
Core Campus Redevelopment
Demolish Units and Sacket North Wing
Sackett Renovation + North Wing Shell / Core
Programming
Designer Selection
BOT Designer Selection Approval
Program Verification
Schematic Design
Design Development
Construction Documents
GMP / OPP Review
BOT Plan Approval
Construction
Occupancy
Demolish Hammond, Kunkle, Sackett South Wing
Sackett North Wing Fit-Out + New South Wing
Programming
Designer Selection
BOT Designer Selection Approval
Program Verification
Schematic Design
Design Development
Construction Documents
GMP / OPP Review
BOT Plan Approval
Construction
Occupancy
Core 1
Programming
Designer Selection
BOT Designer Selection Approval
Program Verification
Schematic Design
Design Development
Construction Documents
GMP / OPP Review
BOT Plan Approval
Construction
Occupancy
Core 2
Programming
Designer Selection
BOT Designer Selection Approval
Program Verification
Schematic Design
Design Development
Construction Documents
GMP / OPP Review
BOT Plan Approval
Construction
Occupancy

PROGRAM DISTRIBUTION

During the master planning process, idealized space allocations were derived for the COE and other occupants of COE occupied buildings to understand the comprehensive space need in 2028 (see Chapter 3). By the end of Phase 2, the COE will have enough space to meet the 2028 need.

As new buildings are completed, and under-performing buildings are demolished as described above, the COE will undergo a shift in the locations of department and programs across the Core and West Campus. In this section we use the space allocations described above to provide a road map for departmental distribution across the Core and West Campus. However, this road map is an idealized filling of the buildings, and it is understood that new opportunities, funds, ideas for new locations, and fine-tuning of the programmatic need through the detailed programming process will modify these allocations and proposed locations. For example, discussions are currently underway as to the final location and size of the Learning Factory as well as the home for the Acoustics Department.

The goal of the Master Plan was to develop a high-level understanding of needs, develop an idealization of how the needs could be met, and test how that the plan could meet the understood needs. The facing pages exhibit diagrams of the idealized locations of departmental "homes" at the end of Phases 1 and 2.

It is envisioned that, while departments will have administrative "homes" located in specific buildings, other spaces, especially research space, will be distributed throughout the facilities, clustered around themes and shared resources. The diagram also notes the number of general purpose classrooms that will be located on each campus (though it should be noted that this figure is also still under active discussion).

The ground rules that determined the proposal for department and program locations were as follows:

- Available funding for the construction, demolition, and site work is limited to the $370M defined by the 2018-2023 Capital Plan
- Hammond should be demolished in Phase 1
- Sackett should be renovated in Phase 1
- Due to the condition of the Units, they are recommended for demolition in Phase 1
- 22–24 general purpose classrooms should remain on Core Campus;
- Swing space demand should be minimized
- Double moves should be avoided or minimized, especially for research space

The constraint of meeting the $370M Capital Funding Budget for 2018-2023, as well as the need to demolish and replace the Hammond Building, Units A, B, C, and vacate the Sackett Building, means that essentially there is enough funding to relocate the occupants of Hammond, Units and Sackett to the West Campus into a space allocation roughly equivalent to the current allocation, but in new, more efficient space. The programming study indicates that the new buildings offer square footage for the right-sizing of departments. Additional impacts include:

- COE Growth is delayed until Phase 2;
- COE Consolidation is delayed until Phase 2;
- Learning Factory is delayed until Phase 2;
- About 18,000 ASF of office space will require swing space at the end of Phase 1.

As new sources of funding and creative solutions and efficiencies are found during the detailed programming process of West 1 and 2, some of these impacts can be mitigated or reconsidered.

Phase 1 includes moving the departments and programs currently residing in Hammond, Units A,B,C and Sackett to the new West 1 and West 2 Buildings. These include:

- Aerospace
- Architectural Engineering
- Civil Engineering
- SEDTAPP
- Engineering Library
- Engineering Shops
- 10 General Purpose Classrooms

Other occupants currently residing in Hammond, Units and Sackett will either backfill existing buildings or occupy spaces in buildings currently under renovation or construction. The OPP Shop, currently in Unit B, is planned to occupy the Steam Plant Addition after it is completed. The newly created Nuclear Engineering Department will backfill space in the Hallowell Building after the Bioengineering Department is moved to the new CBEB Building. The Hallowell Building, currently occupied by the Biomedical Engineering Department, will be vacated when this group moves to the new Chemical and Biomedical Engineering Building (CBEB). It is currently anticipated that the newly independent Nuclear Engineering Department is the most likely group to begin to backfill into Hallowell, as they split from their shared space with Mechanical Engineering. Space needs for Nuclear Engineering will be classified into high, medium, and low priority, for consideration of a move into Hallowell, opening up other spaces in Hammond (short-term), Reber Building, and Research East. The existing general purpose classroom (43 seats) will be maintained in Hallowell, along with an allocation of 1,500 ASF to support the Ancient DNA Lab for Liberal Arts / Anthropology.

Phase 2 allows the COE to achieve the balance of its goals. The buildings planned for Phase 2 slightly exceed the idealized 2028 space needs on the Core and West Campus and allow the COE to:

- Achieve all anticipated growth
- Consolidate all requested spaces to the Core and West Campus.

The vision for West Campus is that with the addition of West 3, the following can be achieved:

- All programs located on the West Campus in Phase 1 can achieve their 2028 idealized ASF on the West Campus
- Acoustics can be located in West 3
- Civil Engineering and Aerospace can be Consolidated to the West Campus

The vision for the Core Campus is that with the completion of Sackett, the Core 1 and Core 2 Buildings, the following can be achieved:

- ME, EE/CSE, NE, and the Administration can achieve their 2028 idealized ASF on Core Campus with requested consolidation
- The Learning Factory can be completed on Core Campus

The charts on the following pages provide detail as to the space allocations and locations for Phase 1 and Phase 2 as well as indicate swing space need and vacated spaces associated with the moves.

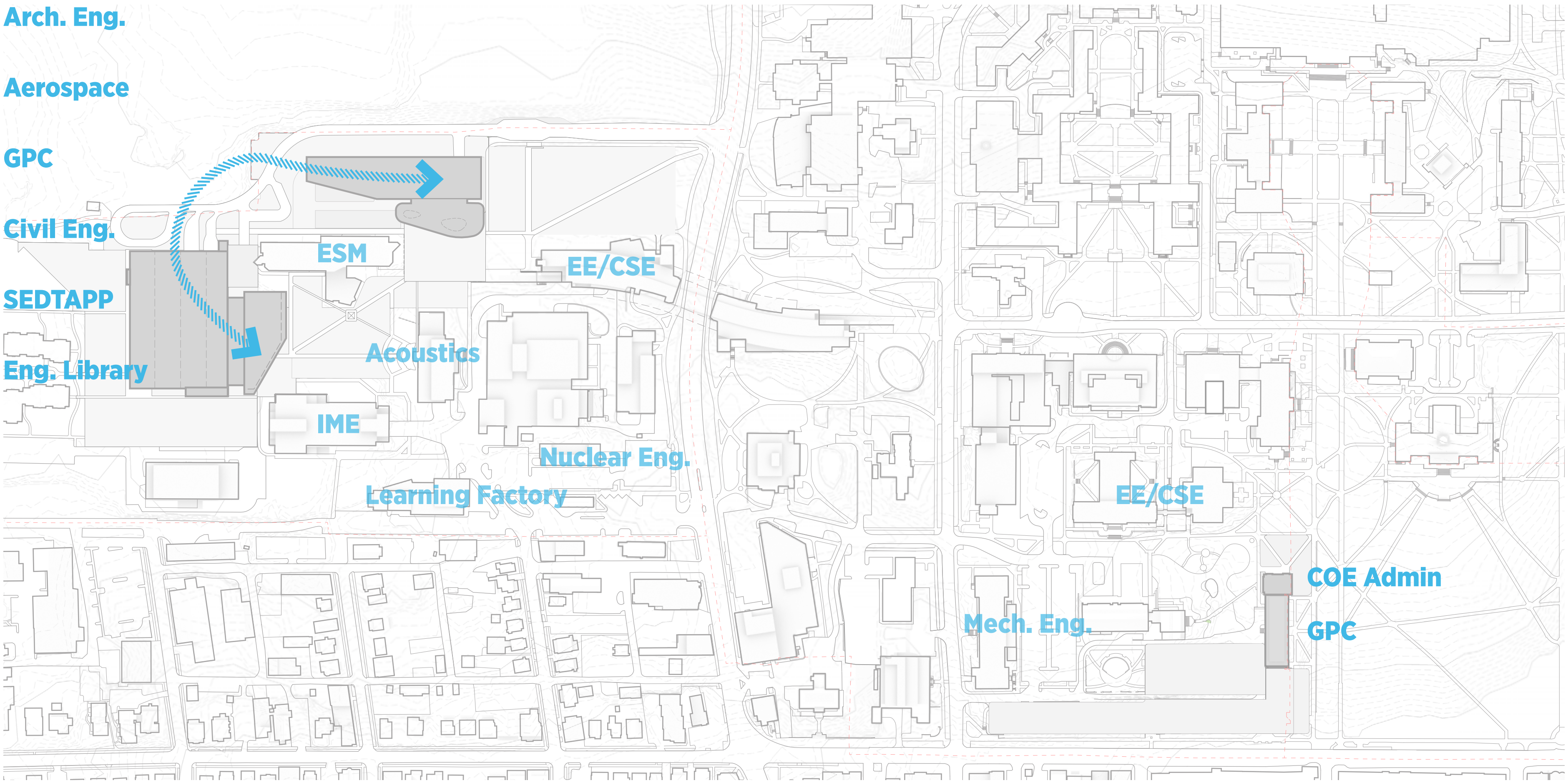
	Existing Conditions Core and West						Projections Core + West		Post- West Campus Move						
	Hammond	**Units**	**Sackett**	**Hallowell**	**Other**	**Existing Total**	**Right-Sized**	**2028**	**West 1 / West 2**	**Hammond**	**Units**	**Sackett**	**Hallowell**	**Other**	**Total**
Acoustics	-	-	-	-	4,400	4,400	8,898	10,485	-	-	-	-	-	4,400	4,400
Aerospace Engineering	26,082	7,875	-	-	734	34,691	38,984	56,474	38,980	-	-	-	-	-	38,980
Architectural Engineering	-	34,545	8,701	-	-	43,246	50,206	58,889	50,210	-	-	-	-	-	50,210
Civil and Environmental Engineering	5,408	1,495	42,318	-	-	49,221	38,067	83,696	38,070	-	-	-	-	-	38,070
School of Electrical Engineering and Computer Science	-	2,319	-	-	102,501	104,820	103,690	120,694	-	-	-	-	2,320	102,501	104,821
Engineering Science + Mechanics	-	-	-	-	55,303	55,303	47,546	66,446	-					55,303	55,303
Industrial and Manufacturing Engineering	-	-	-	-	41,628	41,628	45,698	43,467	-					41,628	41,628
Mechanical Engineering	7,960	4,084	-	-	55,962	68,006	76,518	122,861	6,360	-	-	-	5,684	55,962	68,006
Nuclear Engineering	4,588	-	-	-	3,255	7,843	8,940	22,992	-	-	-	-	8,940	-	8,940
SEDTAPP	21,798	1,438	-	-	-	23,236	39,492	47,901	39,490	-	-	-	-	-	39,490
Administration	26,552	233	4,812	-	-	31,597	26,872	36,667	-	31,597	-	-	-	-	31,597
Office of Digital Learning	-	1,534	-	-	-	1,534	1,834	4,334	-	1,534	-	-	-	-	1,534
Student Organizarions	-	-	-	-	-	-	-	4,000	-	-	-	-	-	-	-
Learning Factory	-	-	-	-	7,257	7,257	14,514	30,000	-	-	-	-	-	7,257	7,257
Engineering Shops	-	-	-	-	7,691	7,691	7,691	7,691	-	-	-	-	-	7,691	7,691
Building Support	-	-	-	-	-	-	12,800	15,600	4,000	-	-	-	-	-	4,000
Strategic Vancancy	-	-	-	-	-	-	12,606	15,856	16,000	-	-	-	-	-	16,000
New Cores	-	-	-	-	-	-	-	2,354	-	-	-	-	-	-	-
Biomedical Engineering	-	-	-	17,162	-	17,162	-	-	-	-	-	-	-	-	-
Chemical Engineering	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Facilities Engineering Institute	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Radiation Science & Engineering Center	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Larson Transportation Institute	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sub-Total COE	**92,388**	**53,523**	**55,831**	**17,162**	**278,731**	**497,635**	**534,356**	**750,407**	**193,110**	**33,131**	**-**	**-**	**16,944**	**274,742**	**517,927**
General Purpose Classrooms	8,040	1,825	15,118	822	29,810	55,615	68,029	76,029	12,000	16,800	-	-	822	29,810	59,432
Engineering Library	9,699	-	-		-	9,699	9,699	9,699	9,700	-	-	-	-	-	9,700
OPP Shop	-	3,666	-			3,666	-	-	-	-	-	-	-	-	-
Others (IST Space, EMS,IST,ARL)	2,362	-	-		113,856	116,218	116,218	116,218	-	2,362	-	-	-	113,856	116,218
Sub-Total Non-COE	**20,101**	**5,491**	**15,118**	**822**	**143,666**	**185,198**	**77,728**	**201,946**	**21,700**	**16,800**	**-**	**-**	**822**	**29,810**	**69,132**
Totals (ASF)	**112,489**	**59,014**	**70,949**	**17,984**	**422,397**	**682,833**	**612,084**	**952,353**	**214,810**	**49,931**	**-**	**-**	**17,766**	**304,552**	**587,059**

ASSIGNABLE SQUARE FEET (ASF)

	Phase 1					Swing
	West 1 / West 2	Sackett- P1	Hallowell	Other Buildings	End Phase 1 Total	Swing Phase 1
Acoustics	-	-	-	4,400	4,400	-
Aerospace Engineering	38,980	-	-	734	39,714	-
Architectural Engineering	50,210	-	-	-	50,210	-
Civil and Environmental Engineering	38,070	-	-	-	38,070	-
School of Electrical Engineering and Computer Science	-	-	2,320	102,501	104,821	-
Engineering Science + Mechanics	-	-	-	55,303	55,303	-
Industrial and Manufacturing Engineering	-	-	-	41,628	41,628	-
Mechanical Engineering	6,360	-	5,684	59,217	71,261	-
Nuclear Engineering	-	-	8,940	-	8,940	-
SEDTAPP	39,490	-	-	-	39,490	-
Administration	-	8,900	-	-	8,900	17,972
Office of Digital Learning	-	1,800	-	-	1,800	-
Student Organizarions	-	-	-	-	-	-
Learning Factory	-	-	-	7,257	7,257	-
Engineering Shops	-	-	-	7,691	7,691	-
Building Support	6,000	500	256	-	6,756	-
Strategic Vancancy	10,590	-	-	-	10,590	-
New Cores	-	-	-	-	-	-
Biomedical Engineering	-	-	-	-	-	-
Chemical Engineering	-	-	-	-	-	-
Facilities Engineering Institute	-	-	-	-	-	-
Radiation Science & Engineering Center	-	-	-	-	-	-
Larson Transportation Institute	-	-	-	-	-	-
Sub-Total COE	**189,700**	**11,200**	**17,200**	**278,731**	**496,831**	**17,972**
	137,700	11,200	17,200			
General Purpose Classrooms	14,700	16,800	800	29,810	62,110	
Engineering Library	9,700	-		-	9,700	-
OPP Shop	-	-	-	-	-	-
Others (IST Space, EMS,IST,ARL)	-	-	-	116,218	116,218	-
Sub-Total Non-COE	**24,400**	**16,800**	**800**	**146,028**	**188,028**	**-**
Totals (ASF)	**214,100**	**28,000**	**18,000**	**424,759**	**684,859**	**17,972**

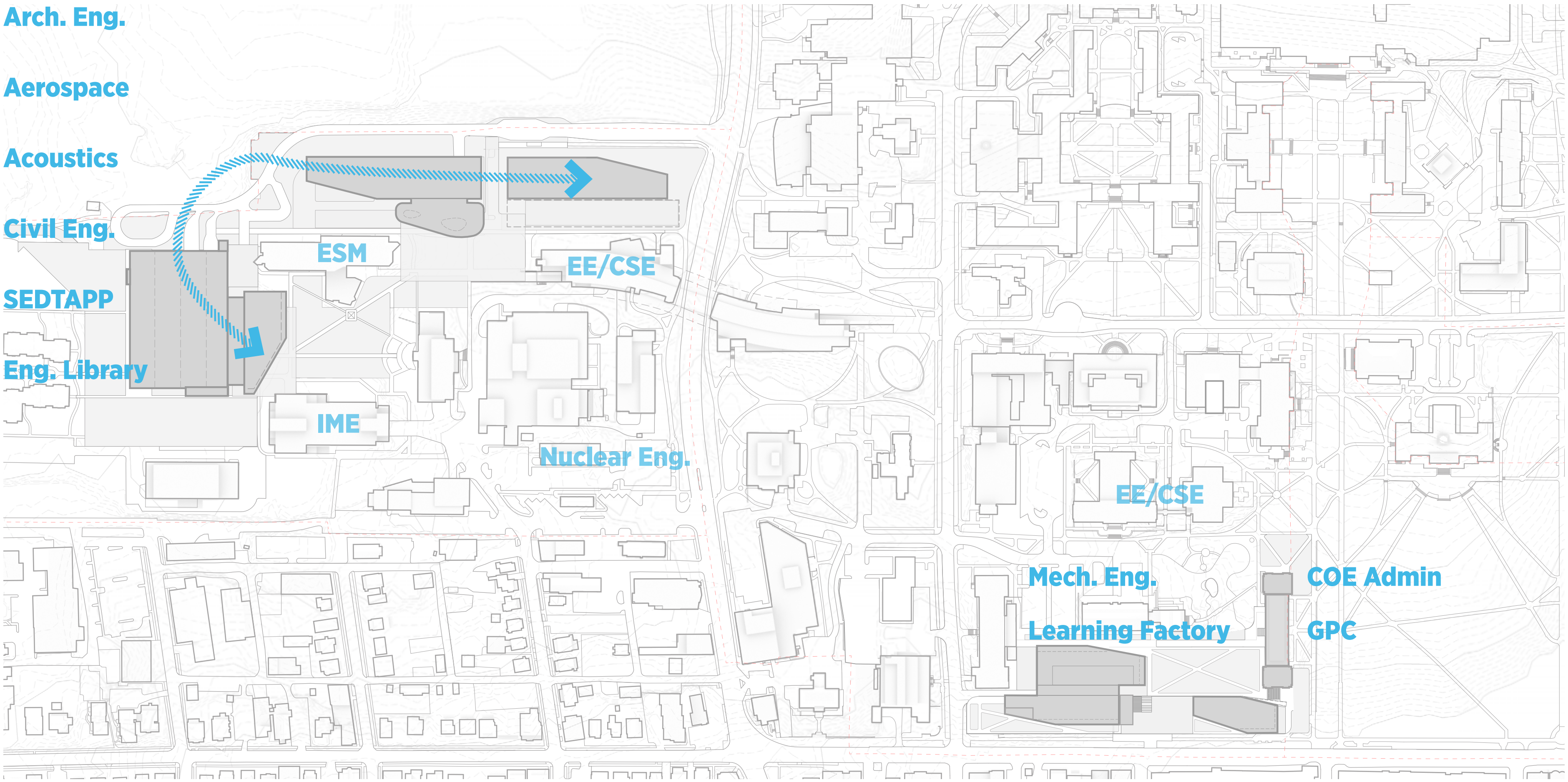
	Phase 2								
	West 1 / West 2	West 3	Sackett-P2	Core 1	Core 2	Hallowell	Other Buildings	Vacated	End Phase 2 Total
Acoustics	-	10,485	-	-	-	-	-	4,400	10,485
Aerospace Engineering	38,980	16,760	-	-	-	-	734		56,474
Architectural Engineering	50,210	8,679	-	-	-	-	-		58,889
Civil and Environmental Engineering	38,070	45,626	-	-	-	-	-		83,696
School of Electrical Engineering and Computer Science	-	-	-	18,193		-	102,501		120,694
Engineering Science + Mechanics	-	11,143	-	-	-	-	55,303		66,446
Industrial and Manufacturing Engineering	1,839	-	-	-	-	-	41,628		43,467
Mechanical Engineering	-	-	-	-	63,644	-	59,217		122,861
Nuclear Engineering	-		-	-	5,992	17,000	-		22,992
SEDTAPP	47,901	-	-	-		-	-		47,901
Administration	-	-	25,600	11,067	-	-	-		36,667
Office of Digital Learning	-	-	4,334	-	-	-	-		4,334
Student Organizarions	2,000	-	2,000	-	-	-	-		4,000
Learning Factory	-	-	-	-	30,000	-	-	7,257	30,000
Engineering Shops	-	-	-	-	-	-	7,691		7,691
Building Support	6,000	4,000	500	1,500	4,500	200	-		16,700
Strategic Vancancy	4,700	11,900	-	-	6,423	-	-		23,023
New Cores	-	2,354	-	-	-	-	-		2,354
Biomedical Engineering	-	-	-	-	-	-	-		-
Chemical Engineering	-	-	-	-	-	-	-		-
Facilities Engineering Institute	-	-	-	-	-	-	-		-
Radiation Science & Engineering Center	-	-	-	-	-	-	-		-
Larson Transportation Institute	-	-	-	-	-	-	-		-
Sub-Total COE	**189,700**	**110,947**	**32,434**	**30,760**	**110,559**	**17,200**	**267,074**	**11,657**	**758,674**
		-		-	-				
General Purpose Classrooms	14,700	-	19,000	11,719	-	800	29,810		76,029
Engineering Library	9,700	-	-	-	-	-	-		9,700
OPP Shop	-	-	-	-	-	-	-		-
Others (IST Space, EMS,IST,ARL)	-	-	-	-	-	-	116,218		116,218
Sub-Total Non-COE	**24,400**	**-**	**19,000**	**11,719**	**-**	**800**	**29,810**		**201,947**
Totals (ASF)	**214,100**	**110,947**	**51,434**	**42,479**	**110,559**	**18,000**	**296,884**	**11,657**	**960,621**

ASSIGNABLE SQUARE FEET (ASF)



Proposed COE Departmental Homes at the End of Phase 1

**This item was revised in the detailed programming phase undertaken subsequent to the master planning process. For more detail, please reference the April 2019, Phase 1 Programming Report.*



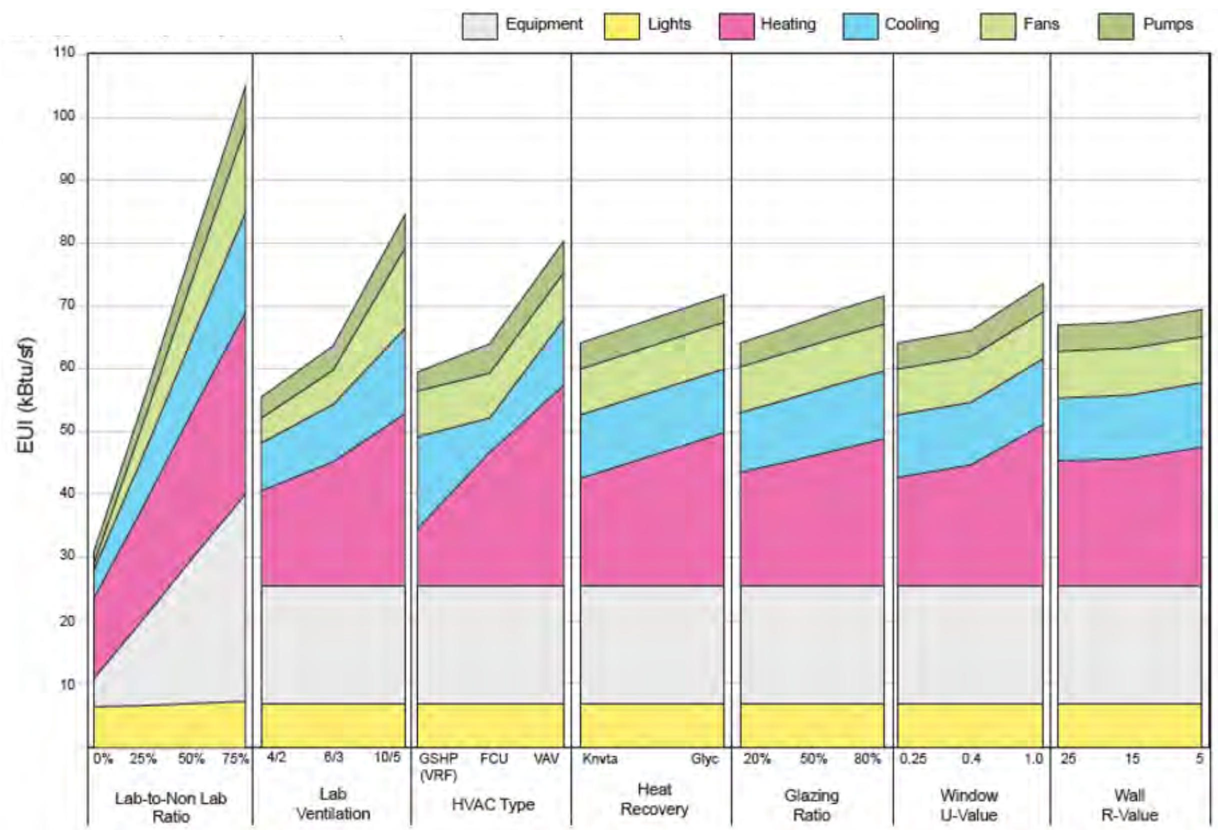
Proposed COE Departmental Homes at End of Phase 2

**This item was revised in the detailed programming phase undertaken subsequent to the master planning process. For more detail, please reference the April 2019, Phase 1 Programming Report.*

SUSTAINABILITY

Key Findings from Energy Analysis

The key takeaway from the energy usage analysis is that energy use is tied to the programmatic intensity of the buildings. Key factors include the lab to non-lab percentage of the building and the ventilation rate. Decoupling space conditioning from ventilation with HVAC systems, like a radiant system or utilizing a geothermal ground source heat pump, could also have a significant reduction in energy usage as compared to a traditional VAV system. The models demonstrated that the least sensitive parameter as related to energy usage was the wall R-value. However, the envelope factors did show they can have a significant impact on peak loads, particularly the percentage glazing and glazing U-value. Controlling the peak loads is important not only to minimize the capital cost of the HVAC system, but also in order to enable the more efficient system like chilled beams and / or eliminating the need for perimeter heating to maintain comfort.



Energy Sensitivity Analysis Summary

Preliminary Design Explorations

One of the challenges of studying energy for a master plan is the range of variables that may still be under consideration at this stage. To address this uncertain nature, Payette conducted over 2,500 parametric energy simulations to study and understand different possible variable combinations – these simulations and their conclusions are discussed extensively below.

The following variables were studied for our energy explorations:

Programmatic:

Wet Lab to Dry Lab/Office Ratio – 0% Wet Lab, 25% Wet Lab, 50% Wet Lab, 75% Wet Lab, 100% Wet Lab

Lab Area Ventilation Rate – 4 air changes per hour, 6 air changes per hour, 10 air changes per hour

Lab Area Equipment Intensity – 6 watts per square foot or 11 watts per square foot

Mechanical Systems:

HVAC Type – VAV system, hydronic system (such as fan coils or chilled beams), and a geothermal ground source heat pump

Heat Recovery Efficiency – 50% efficiency or 75% efficiency

Façade:

Glazing Ratio – 20% of façade area glazed, 40% of façade area glazed, 60% of façade area glazed, 80% of façade area glazed

Window Assembly U-Value – U-0.25, U-0.4 and U-1.0

Wall R-value – R-5, R-15, R-25

In this study, the buildings were oriented along an east/west axis, as is the case with many Penn State buildings.

The results of the energy simulations presented were energy use intensity (EUI), the peak loads, the annual operation cost to Penn State over a 30-year time frame, and the number of roof areas that would be needed to offset the energy usage in order to understand the net-zero energy potential for a scenario.

While the results showed in the report give trends and scenarios, the associated online tool enables Penn State to continue to explore and understand scenarios in the future. The tool is publicly available on Payette's website.*

Inefficient Building Model:

Efficient Building Model:

** Reference 8, Refer to Chapter 6*

EUI Target for Buildings Planning in Phases 1 & 2 of the Master Plan

Based on the programmatic mix and other factors, energy use intensity (EUI) targets have been established for the renovations and new buildings that have been identified in the Master Plan.

The targets in the following table are based on a radiant heating and cooling system that decouples ventilation with a high-performance heat recovery system. It was assumed that the glazing ratio in new buildings would not exceed 40% glazing and that the buildings would be triple glazed. Because of the ventilation intensity of lab buildings, focusing on minimizing the ventilation rates and mechanical system strategies will have the biggest impact on reducing energy usage. However, it is important to also consider a building's peak loads, particularly from the building envelope and equipment intensity. While the envelope itself may not be a significant driver of a lab building's annual energy use intensity, the envelope peak loads can often drive mechanical system selection and if peak loads are too large may preclude more energy efficient options which can significantly impact energy usage.

Building	Target EUI	Notes
West 1	90 kBtu/SF-yr	50% lab space, not fume hood driven, equipment intensive
West 2	90 kBtu/SF-yr	50% lab space, not fume hood driven, equipment intensive
West 3	110 kBtu/SF-yr	75% lab space, not fume hood driven, equipment intensive
Sackett	50 kBtu/SF-yr	100% non-lab space, existing building
Core 1	70 kBtu/SF-yr	25% lab space, not fume hood driven, equipment intensive
Core 2	110 kBtu/SF-yr	75% lab space, not fume hood driven, equipment intensive

Net-Zero Potential

The team studied the net zero potential for the master plan in support of Penn State's efforts to reduce their greenhouse gas emissions. At this time, renewable energy generation is being handled at the campus scale. However, the goal was set that all of the roofs of new structures should be designed to be PV-ready and able to easily add energy generation in the future.

Looking at the solar radiation and assuming a 21% efficient panel with a 78% loss from the inverter, it was found that a flat surface in State College, PA would produce around 68 kBtu/sf annually for photovoltaics and around 310 kBtu/sf for solar thermal. A large scale 400 foot tall turbine would output approximately 11,700,000 kBtus annually. It is worth noting that a wind turbine on the ridge of the mountains adjacent to State College would have significantly higher output due to the higher wind speeds there and are best considered at the campus scale rather than at the precinct scale.

Taking into account the energy analysis and the renewable energy generation potential. It was identified that covering the roof and adjacent parking garage of West 2 would likely be able to make West 2 a net-zero building in the future. Additionally, the front pavilion of West 1 could likely also be a net-zero component of the building.

Key findings from the study include:

- **West 2 has the potential to be designed as a net-zero ready building** if building energy use is minimized and the roof and adjacent parking deck of West 2 are utilized for photovoltaics in the future.
- **The front pavilion of West 1 could likely be a net-zero component of the building.**
- **Any energy generation system shall be evaluated using LCCA** and compared to other energy reduction strategies. LCCA should be used in order to assess the most effective technologies to meet Penn State's energy reduction goals.