Brown University
School of Engineering Expansion Study

PAYETTE

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I EXECUTIVE SUMMARY

Introduction

In November 2012, Payette was retained by Brown to undertake an assessment of space needs for the School of Engineering, to work with the University to develop scenarios of potential programming solutions, and to test those scenarios, technically and financially, against the capabilities and limitations of the campus. Over the next several years, Engineering will be one of Brown's key areas of strategic growth. Brown needs to address critical space deficiencies in its existing building inventory as well as add new state-of-the-art resources to expand the School's capabilities. Key areas of growth anticipated in Engineering include micro/nano-technology; biomedical engineering; energy, environment and entrepreneurship.

Strategic Planning

Concurrently, Brown commissioned a separate study to update its master planning and campus development efforts. As part of this work, Brown considered whether the School of Engineering ought to remain on College Hill, where it would continue to benefit from its historic proximity to the undergraduate campus core, or be relocated to the Jewelry District of downtown Providence, a developing knowledge and innovation district that is home to Brown's Alpert Medical School and other research entities.

To support this decision, this study explored growth potential for Engineering on sites on or adjacent to the School's existing facilities in Barus & Holley and Prince Labs. It was determined that, with careful planning and a phased approach, Engineering's space needs can be met on College Hill for the foreseeable future. Accommodating these needs will require the relocation or demolition of a number of existing buildings and other departments will be impacted by the School's expansion. These collateral impacts were also carefully assessed as this study progressed.

As a result of these efforts, the School of Engineering will remain on College Hill. This recognizes the degree to which Engineering is integrated with the core undergraduate curriculum; the degree to which Engineering faculty are committed to both research and teaching, particularly at the undergraduate level; and the highly interdisciplinary nature of the Engineering faculty itself, which has led to a high level of research collaboration with others on campus.

Engineering Space Program

To develop a summary facility program, the study team conducted tours of existing facilities and met with designated faculty representatives. The team assessed how existing space is used, what functional and organizational adjacencies are considered critical, and which constraints pose the most significant impediments to change. Because Engineering occupies space in a number of university facilities outside the Barus & Holley and Prince core, one of the main objectives articulated by the School at the outset of the study was the reintegration of as much of the School as possible into one consolidated complex.

These investigations culminated in a program document which outlines future growth needs in summary level detail, and provides a conceptual overview of how the entities represented in the program are envisioned to relate to each other and to the university community at large.

The space program envisions growth in a number of key areas. Foremost among Engineering's needs are the types of very high-technology spaces, such as microelectronics and biological clean rooms, imaging facilities and nano-tool fabrication facilities, that the School's existing buildings are simply not adequately equipped to provide. Engineering also requires expansion space for new types of faculty research, such as biomedical engineering, that frequently combine the most complex technical requirements of wet and dry labs. On the lower technology side of the spectrum, needs center on the lack of adequate facilities for student/faculty interaction, such as breakout and informal meeting space, which were largely absent from engineering buildings such as Barus & Holley and Prince constructed in the 1960s. Engineering also has a need for improved "maker" spaces—shop and engineering studio facilities which allow students to design and create, as well as "incubator" type spaces for those students looking to apply their engineering discoveries at the next level. One of the most rapidly growing areas within Engineering is its nascent Center for Entrepreneurial Innovation, the progeny of the Program in Innovation Management and Entrepreneurship.

Implementation: Phase I

This growth will be implemented over several phases of new construction and strategic renovation. Phase I will address the most critical needs for Engineering.

Because Brown's existing Engineering buildings date to the 1960s, the University has assigned highest priority to the construction of new, state-of-the-art, high-technology faculty research and core facility space. These kinds of spaces cannot be accommodated within Brown's existing buildings. As a result, Phase I will commence with the construction of a new 80,000 gross square foot building designed to house the most demanding components of the Engineering program. These include microelectronics and biological clean rooms, imaging facilities and nano-tool fabrication facilities, and approximately 18-20 labs intended to accommodate a wide range of wet to dry research for both new recruits and existing faculty being relocated from Barus & Holley, Prince or one of the other nearby lab buildings in which the School currently occupies space.

The designated location for this new building is adjacent to Barus & Holley, on a site bounded by Manning Walk to the north, Brook Street to the west and 180/182 George Street to the south. The four existing structures currently on this site will be relocated or demolished. This location is strategically important because it represents the opportunity to extend Engineering around the remaining 'open' side of Manning Walk, Engineering's historic connection to the campus; Manning Walk itself will be transformed into a new signature campus green space as part of this phase. By locating program components with visual interest to the public at the ground floor—such as the clean room—a new building here has the potential to animate the entire Science Quadrant in a new way. This site also facilitates a bridge connection to Barus & Holley; by allowing floor levels within the old and new buildings to function as a single "superfloor," this will enhance collaboration between researchers.

In Phase I, Brown will also continue to invest in critical infrastructure improvements to Barus & Holley. These have been identified in a separate study, the Brown University Barus & Holley/Prince Laboratories Infrastructure Upgrade Study, completed in 2012 by Imai Keller Moore Architects (hereafter referred to as the 'IKM Study'). As described in that study, the scope of this work consists of needed HVAC, plumbing, fire protection, electrical and IT upgrades, in addition to toilet room renovations. The IKM Study also defined a range of potential long-term use occupancy scenarios, ranging from an increase in the building's wet lab use to its conversion to an all-dry lab facility. While it is most likely that Barus & Holley will continue to accommodate both wet and dry research in the future, Brown will defer this decision (and any additional mechanical system renovations resulting from it) until Phase II of the renovation. Aside from the general infrastructure scope described above, Phase I work will be confined to programmatic renovations on Level 1 to create a new Center for Entrepreneurial Innovation, along with enabling renovations to facilitate the relocation of Physics teaching labs from Level 1.

With the completion of initial electrical and mechanical upgrades outlined in the IKM Study in September 2013, much of the key infrastructure for the Engineering complex has recently been consolidated in Prince Lab. As the new engineering building comes on line, existing research labs on the lower level of Prince will gradually be phased out, leaving space behind better-suited to lower-technology needs. This will create an opportunity in Phase I to selectively renovate key spaces on the main floor of Prince to function as highly visible student workshops, research and design studios, and student club facilities. Additionally, expanding Prince's existing mezzanine, which overlooks the main floor area, could add between 4,000 to 6,000 square feet for dry lab use. Finally, replacing portions of the exterior masonry wall with glass could provide for a more direct visual connection to the new campus landscape space to the south, as well as an opportunity to create a new entrance into Prince.

While the renovations in Prince are mainly geared towards low-technology programs, they have the potential to transform the building into a highly visible locus of student activity. This is particularly appropriate in light of Brown's historic emphasis on undergraduate education; Prince affords Brown with an ideal means of putting what engineers do on public display.

Investment in Prince will be directed primarily to its eastern half, anticipating that the portion of the building closest to Brook Street might someday be demolished for a new structure.

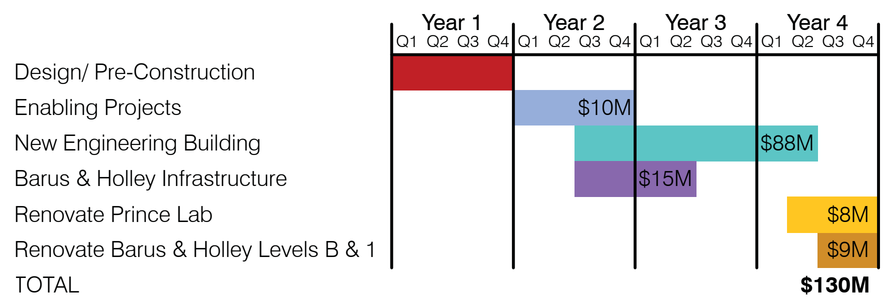

Figure 1.1 Anticipated time frame and costs for Phase I

Implementation Beyond Phase I

When Phase I of Engineering's expansion is complete, Brown will have satisfied many, but not all, of its programmatic aspirations for Engineering. Key needs in high-technology research and core lab space, including that for new faculty recruits, will be fulfilled; the entrepreneurship program will have a new home; and Prince will be functioning much more effectively as a student-oriented, maker space.

Renovation of existing faculty research space in Barus & Holley, which Engineering shares with the Department of Physics, could commence at this point, offering Brown an opportunity to improve the efficiency of the typical research floor. Alternatively, Brown could choose to commence a second phase of new construction at this juncture, eventually facilitating a swifter, multi-floor renovation of B&H.

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1 Costs in this study are estimated Project Costs in 2013 dollars, escalated as per the schedule noted above assuming a Q1 2014 start. Project Cost includes construction cost plus "soft costs" such as project management, design and technical consultant fees, furniture and equipment, occupant protection and relocation internal to the building, and owner's project contingency. It does not include cost of relocating occupants outside of the building.

2 MASTER PLANNING

Existing Conditions

While the School of Engineering occupies space in a number of buildings on the Brown campus, their primary home is in the Barus & Holley building and Prince Lab. These sit on the eastern edge of the campus in the area where much of the physical and applied sciences are located on a block bounded by Brook, Waterman, George and Hope Streets. Although this block is home to a number of other university departments, and while it is composed of buildings that range considerably in size, age and architectural character, it is dominated by these two large buildings that lie at its geographic center. Barus & Holley is 207,000 gross square feet and was constructed in 1965 (expanded in 1990); Prince Lab is 57,000 gross square feet and was constructed in 1962. The School of Engineering occupies about half of Barus & Holley and occupies all of Prince.

Historically, the complex has been connected to the Brown campus via Manning Walk, a principal east-west campus axis that extends eastward from College Street through University Hall and terminates in the Giancarlo addition entrance to Barus & Holley. A number of important campus green spaces are located along this axis. The block's eastern edge marks the eastern boundary of the campus, and Hope Street is lined with many large houses of historic significance. While the block is somewhat porous to pedestrians in the east-west direction, it does not readily accommodate pedestrian circulation in the north-south direction. The blocks immediately north and south are not part of the Brown campus.

This Study examined this block in its totality to understand where and how future growth could be accommodated.

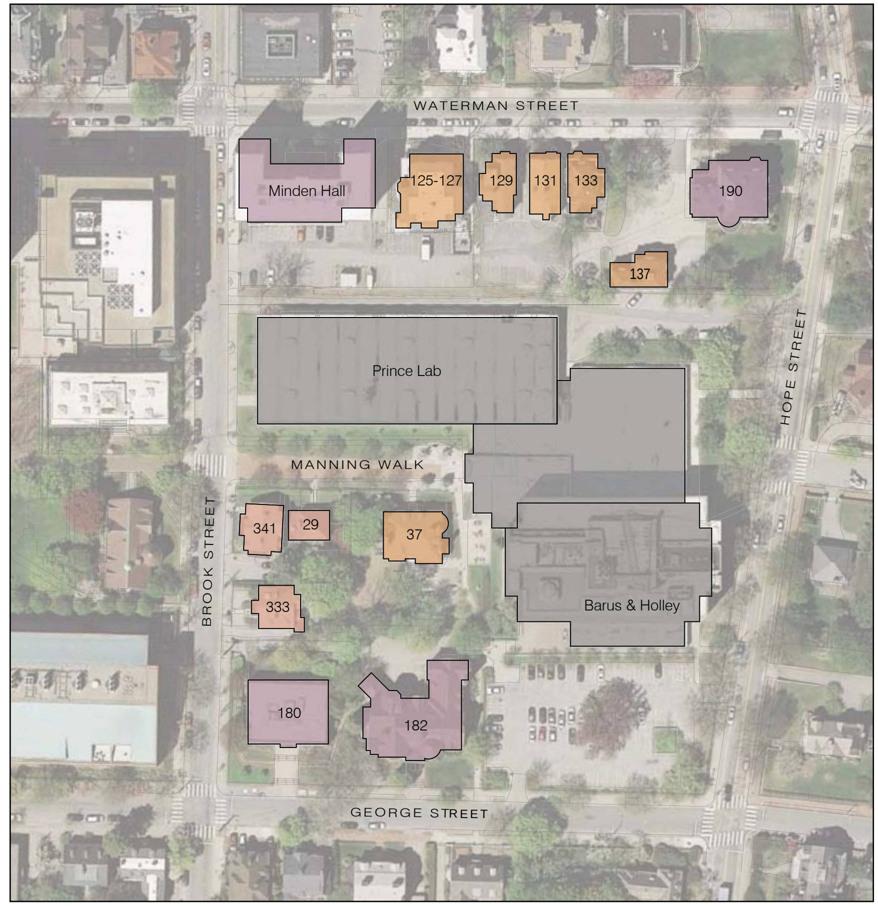


Figure 2.1 Existing conditions

Existing Structures

A pair of parking lots—one behind Prince Lab and another at the intersection of George and Hope Streets—are the only undeveloped sites on the block. Neither of these, however, is large enough to accommodate Engineering's expansion without impacting the other existing structures on the block. These structures include the following (refer to Figure 2.1):

- Minden Hall. This eight-story building is currently occupied as a residence hall.
- 125 Waterman Street (previously known as 125-127 Waterman Street). Brown recently renovated this building, a large historic duplex, for visiting scholars. While a candidate for relocation, it could only be moved to a very nearby location.
- 129, 131, 133 and 137 Waterman Street. 129, 131, and 133 are houses from the 1850's to 1880's while 137 is a carriage house built in 1910. 129 is currently vacant and in need of significant renovation. 131 and 133 are occupied as academic and administrative offices. The carriage house at 137 is used for storage and support by Anthropology. All are too small for Brown to make efficient use of. Their narrow width, however, makes them good candidates for relocation.
- 190 Hope Street. This historic house, which falls within the Hope Street Historic District, is occupied by two Brown academic departments and is considered of long-term value to the University. In addition, extension of the Historic District further south along Hope Street is under consideration.
- 182 George Street. This imposing stone residence is of historic significance and provides Brown with valuable academic space for Applied Math (an Engineering collaborator). It is too large to relocate. One of its unique features is its rear porte-cochère, which could easily be incorporated into a future campus green space.
- 180 George Street. Designed by Phillip Johnson, this small building, which is home to the Center for Computation and Visualization, will also remain.
- 333 & 341 Brook Street. 333 is currently occupied by Applied Math while 341 Brook is used for temporary office functions. Because they are relatively wide, these houses will be difficult to move. In addition, 341 is in need of substantial code upgrades, probably making any future relocation for Brown office use an unwise investment.

- 29 Manning Walk. This building, occupied by Urban Studies, is very small and has limited value.
- 37 Manning Walk. This large older house is also occupied by Applied Math. It would make a suitable addition to Hope Street if it could be relocated to the Barus & Holley parking lot, but its large size and construction (brick masonry) could make this prohibitively expensive.

Regulatory Requirements

The block sits in an I-2 zone (Institutional Floating Zone, Educational), which has a height limit of 75 feet/six stories. The maximum height is reduced to 40 feet/3 stories where it abuts the adjacent Residential zones along Waterman Street (R-3, Three Family District) and Hope and George Streets (R-1, One Family District). The maximum building height can be increased by one foot for every one foot setback from the property line up to a maximum height of 75 feet/six stories.

The block is encompassed by two national historic districts. While most of it falls within the College Hill Historic District, the block's northeast corner falls inside the Hope Street Historic District. While the University will be required to submit an amendment to its Institutional Master Plan for the proposed new engineering building, there are no oversight or approval requirements for new construction in a national historic district unless the project is federally funded.

Planning Principles and Goals

At the outset of the master planning phase of the Study, and working in concert with a parallel effort looking at planning issues campus-wide, a number of planning principals and goals were developed for the block. These included:

- Honor and reinforce the historic character of Hope Street. The historic character of Hope Street has been defined by significant houses on large lots. Hope Street should be thought of as the eastern edge of the Brown campus, and any new development along this edge should ease the transition from campus to residential neighborhood.
- Celebrate the Brown scale: buildings and open space. There is a certain intimate scale - not too big and not too small - that represents Brown at its best. When the university has operated outside of this scale, for example in small houses or imposing science facilities, an essential aspect of the campus's nature is compromised. While the university must always prioritize functional need in new facilities, it should encourage innovative design solutions which meet these needs in a manner that is most consistent with the scale of the beloved campus core. This character includes porosity on the ground plane, smaller footprint buildings that maximize efficiency, and contextual massing that respects neighboring uses and scale. It speaks to block size and the importance of mid-block connections where the urban street network has been interrupted.
- Connect the campus. The open space and road network are critical conduits of activity. Given the emphasis throughout Brown on collaboration, the ability of people to easily move between neighborhoods, districts, and campus communities is a basic requirement for the success of the institution. Interconnected green spaces on College Hill reinforce the notion of a cohesive campus and should be augmented. Likewise, city streets and sidewalks are critical to campus mobility.

The ideal floor plate for a stand-alone engineering research building is in the neighborhood of 20,000 gross square feet. This is generally considered large enough to support a critical mass of activity on a typical floor and permits an arrangement of labs that can be flexibly configured for a range of both senior and junior lab groups. However, this footprint, which roughly corresponds to that of Prince Lab, is considered too large for the scale of the Brown campus. Recognizing this, the Study examined strategies to optimize building footprints for engineering needs while preserving the appropriate scale and character of the campus.

Physical connections between buildings, in the form of elevated bridges or below-grade tunnels, are one means of overcoming the limitations associated with a smaller building footprint. Such connections can enable adjacent floors within separate buildings to function as larger entities, or as "super-floors." Maintaining through-access on multiple floors, rather than limiting connections to a single level and using elevators to reach the other levels, contributes to the success of these linkages. They function equally well between pairs of new buildings as they do between new and existing buildings, and can help to create new synergies. The existing research floors in Barus & Holley, which will remain well-suited to dry and certain types of hybrid labs, become more relevant when paired with technology-rich labs in the adjacent new building, thereby allowing high- and low-technology researchers collaborating on common problem areas to be located in close proximity to one another.

When created between new buildings, such connections are a potential means of overcoming the inefficiencies associated with a smaller building footprint. Two new buildings with a significant enough physical connection between them could share key infrastructure, such as an elevator, egress stairs, penthouse and/or mechanical systems. Depending upon the nature of the physical connection(s), research groups could be organized both horizontally and vertically within this type of configuration, thus permitting great flexibility in accommodating both problem-based and discipline-based methods of organization.

Master Plan Strategies for the Block

The Study examined two different strategies for developing additional capacity on the current city block. In large part, the two strategies reflect the fact that Manning Walk divides the block into a northern and southern half. Considering the disposition of existing structures on the block, the two halves are not equal from a development point of view (Figure 2.2). Whereas the northern half has more overall development capacity, the southern half presents fewer impediments to implementation.

Figure 2.2 Development zones

Strategy A - Expanding Westward Towards Brook Street and the Central Campus

Strategy A focuses new development on and around the area of Manning Walk. By transforming Manning Walk into a new signature campus landscape space at the center of a new School of Engineering comprised of both new and existing buildings, this strategy celebrates and reaffirms the symbolic importance of Engineering's link to the rest of the campus.

Strategy A commences with the construction of a new building set back from the southern edge of the existing walk, which is a relatively accessible site (Figure 2.3) from a development perspective. The occupants in 341 Brook and 29 Manning will need to be relocated; the most significant physical impediment to this site is the relocation or replacement of 37 Manning. A site for its relocation has been identified in the Barus & Holley parking lot along Hope Street. Although the site footprint of the first new Engineering building encompasses the areas between Prince Lab and the George Street buildings, and includes the Manning Walk area itself, the height, scale and massing of the new building will need to be responsive to a number of important site constraints and considerations. These are discussed in more detail in Section 5 of this report.

Figure 2.3 Strategy A Phase I

Subsequent phases of development under this scenario would focus on sites on and around Prince Lab. Because Prince, at two stories, occupies only a portion of its potential zoning envelope, it underutilizes a highly valuable site near the campus core. One such future building site would run parallel to Brook Street, immediately south of Minden Hall. Accessing this site would require removing a portion of Prince. While a significant amount of campus utility infrastructure is located in Prince, it is consolidated at its eastern end, and it may be possible to remove several bays from its western side (Figure 2.4). Brook Street is not subject to the 40 foot/3 story zoning height limitation, so this site could potentially accommodate a higher building than other locations on the block (subject to the planning principles articulated earlier). Similarly, this site may afford the opportunity to construct a new building with a relatively deep footprint (90 to 100 feet). This could prove advantageous for wet research needs, which generally require more lab support space than dry labs and hence benefit from added building depth.

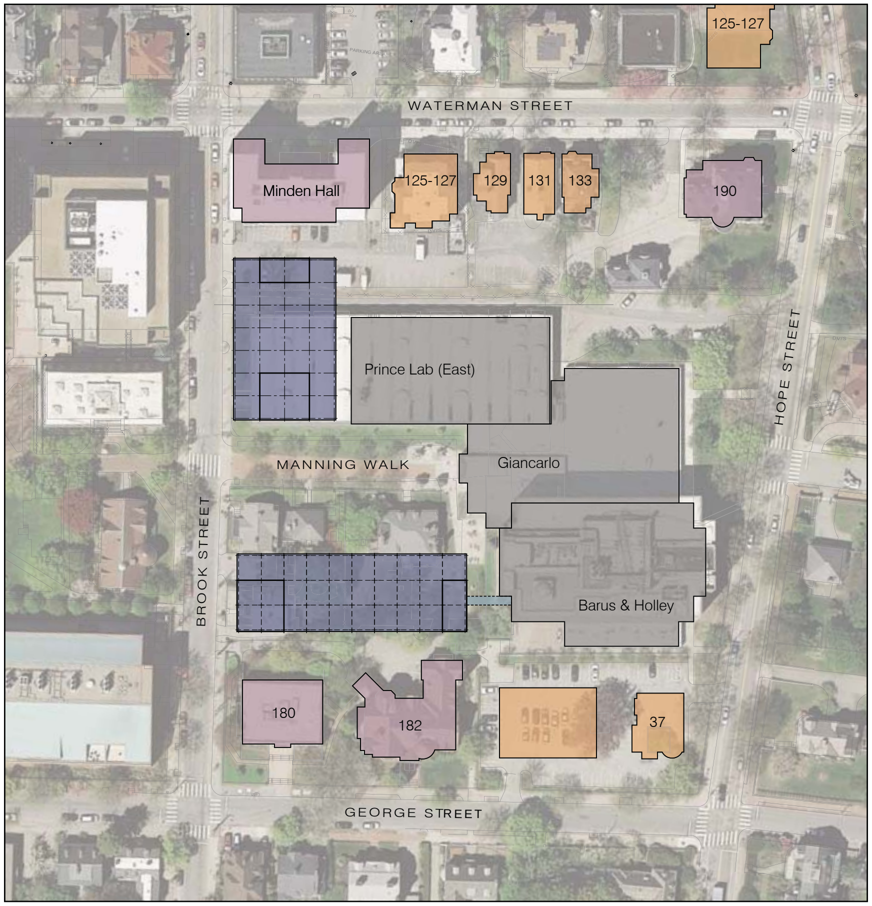


Figure 2.4 Strategy A subsequent to Phase I

Eventually, Strategy A culminates in maximizing the full potential of the Prince site by removing the remainder of the existing building and replacing it with a new building, connected both to the new Brook Street building and to the existing Barus & Holley complex, which is assumed to remain in all the scenarios that were evaluated. Collectively, the two new buildings north of the new campus landscape space at the center of the block could help to create a new, mid-block internal green connection anticipating future campus growth northwards (Figure 2.5).

One of the most appealing aspects of Strategy A is that the new construction associated with it would be highly visible and nearest to the core of campus. It concentrates new development on the potential building sites which are closest to the main campus and other applied science disciplines, and focuses this development around a new signature campus landscape space. It does not add new development along Hope or Waterman Streets, the areas of the site most prone to generate concerns from the neighboring residential community. Also, new buildings associated with this strategy could be serviced from Brook Street, which already provides service access to other science facilities.

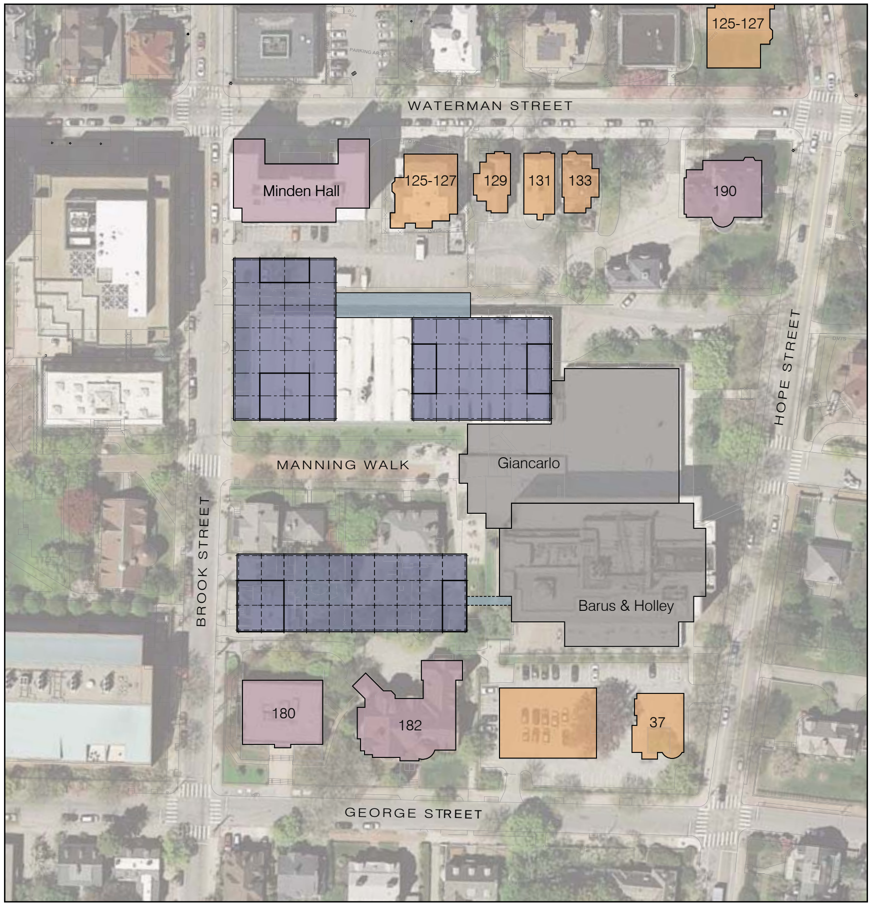


Figure 2.5 Strategy A culmination

Also, by locating new development to either side of the existing Manning Walk and to either side of Barus & Holley and Prince, this strategy has the potential to revitalize the existing science buildings on the block by leaving them at the geographic center of the Engineering complex.

Strategy A is particularly well-suited to an overall development plan which limits its first-phase need to approximately 80,000-90,000 gross square feet. This is the largest building footprint that is considered realistic for the initial development site. Because subsequent phases of new development would require at least the partial demolition of Prince Lab, this would not occur until the University is prepared to replace the special kinds of facilities which are located in this building.

Strategy B - Expand Engineering North Towards Waterman Street and Potential Campus Growth

Strategy B examined an alternative approach by concentrating new construction along Waterman Street. In part, this strategy was developed to explore the implications of needing to build more than 90,000 gross square feet in the first phase.

By relocating or demolishing several existing houses along this edge of the block, a mid-block building site can be created between Waterman Street and Prince Lab. The overall dimensions of this site favor an interconnected complex of smaller buildings over a larger, singular structure (Figure 2.6). Also, by orienting the new buildings in the north-south direction, this planning concept leads towards a new, mid-block campus landscape space, eventually connecting Manning Walk to Waterman Street and potential future campus development beyond. In future phases of development, this landscape space between the new buildings along Waterman (which could cover program space below) could be extended southwards to merge with the new signature campus green space on the site of the former Manning Walk (Figure 2.7).

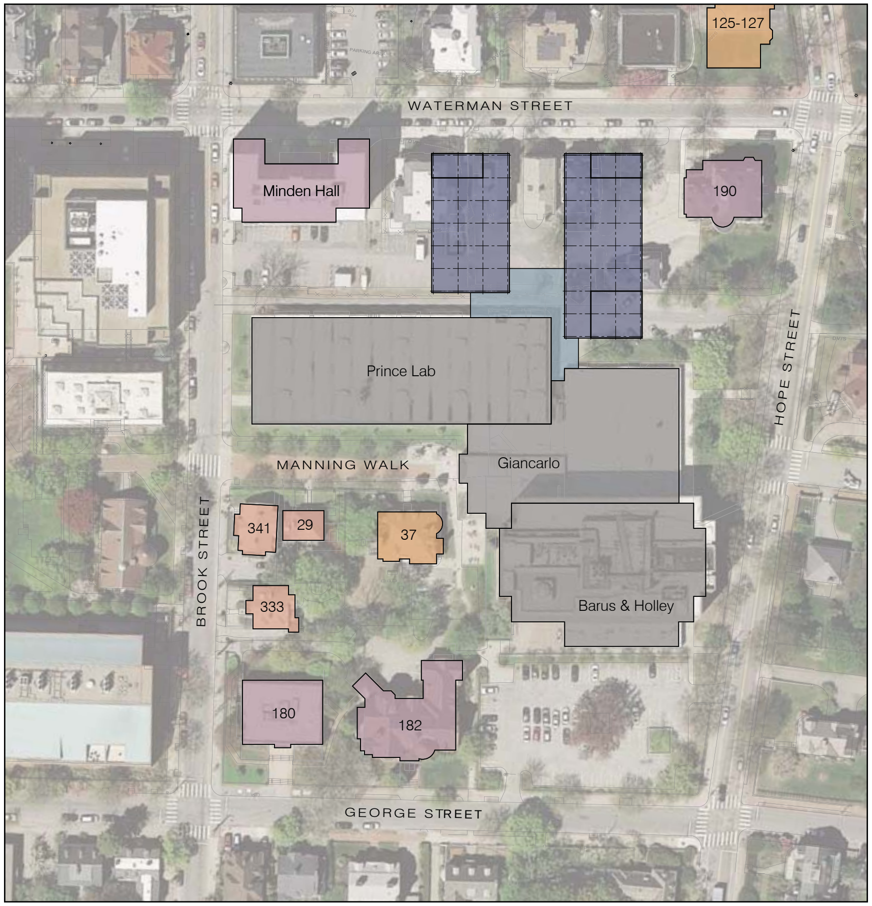


Figure 2.6 Strategy B Phase I

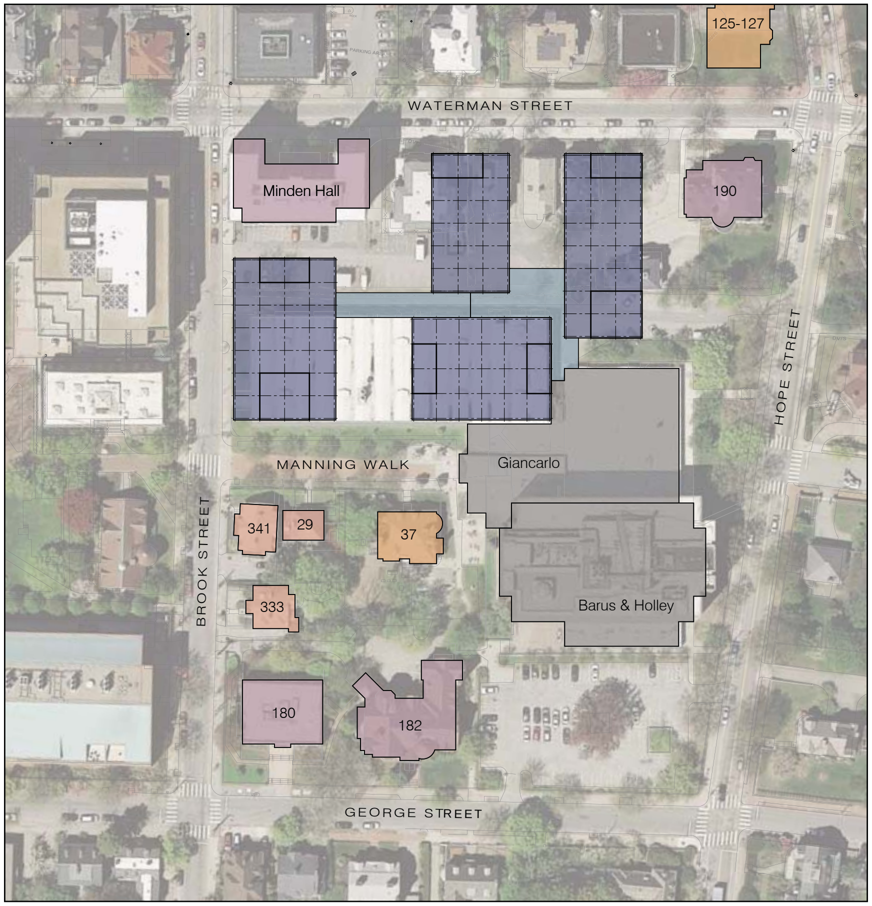


Figure 2.7 Strategy B subsequent to Phase I

The configuration of the new buildings in this strategy raises a different set of questions about appropriate building scale, height and size. It is assumed that Prince remains in place for at least its initial phases, meaning that a connection would need to be created from the main portion of the complex to the new sites through or past Prince. Also, because these sites abut the Residential zone across Waterman Street, the maximum building height is limited to 40 feet/three stories within the setback zone. While the buildings could increase in height towards the middle of the block, this could affect the overall efficiency of the floor plate.While articulated as independent structures in the accompanying planning diagrams, the buildings in this strategy would largely function as a singular entity, sharing elevators, egress stairs and major mechanical systems. Beyond these efficiencies, the above-grade connections would also be developed to foster social interaction between occupants by locating lounges and other common amenities within or adjacent to them. To provide for the kinds of large-footprint core and research spaces that the removal of Prince might someday require, the two new buildings along Waterman Street would share a common basement extending underneath the landscaped court between them.

This strategy was explored with and without Prince Lab remaining for the long term. If it were to remain, it may be possible to develop a new public circulation spine along its north side and remove enough of the masonry infill to permit views inside.

In the long-term future of the site, and considering other possible needs in this sector of campus, it is possible that the two strategies eventually merge to become one (Figure 2.8).

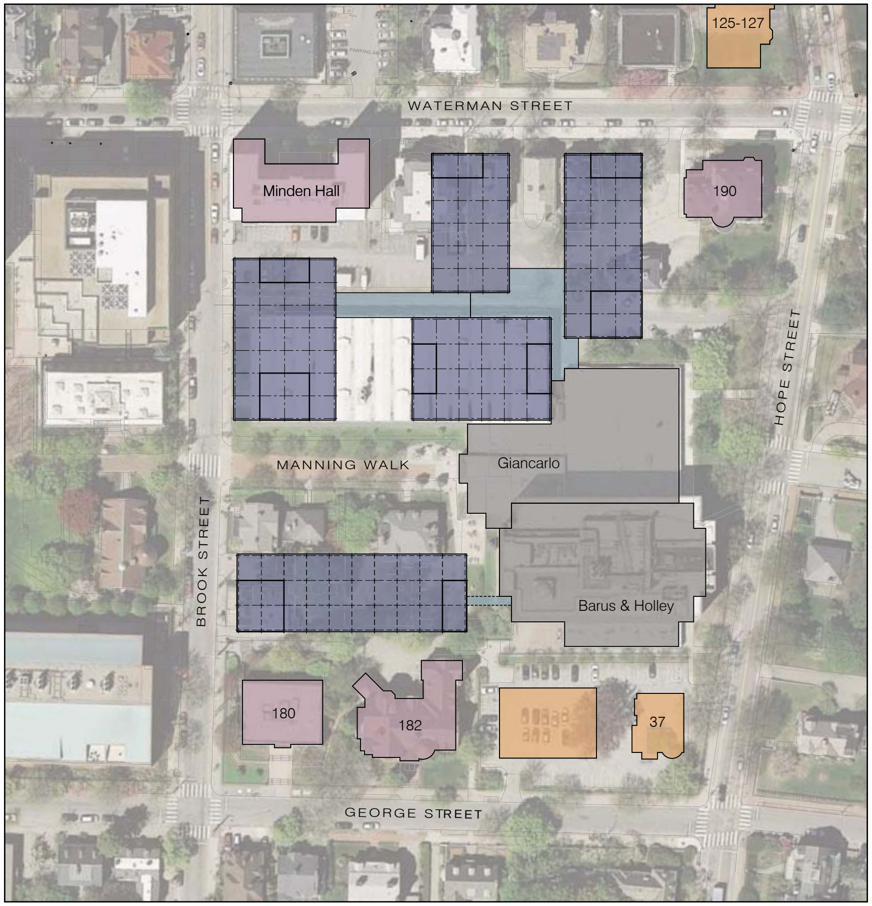


Figure 2.8 Strategy B culmination

3 SPACE PROGRAM

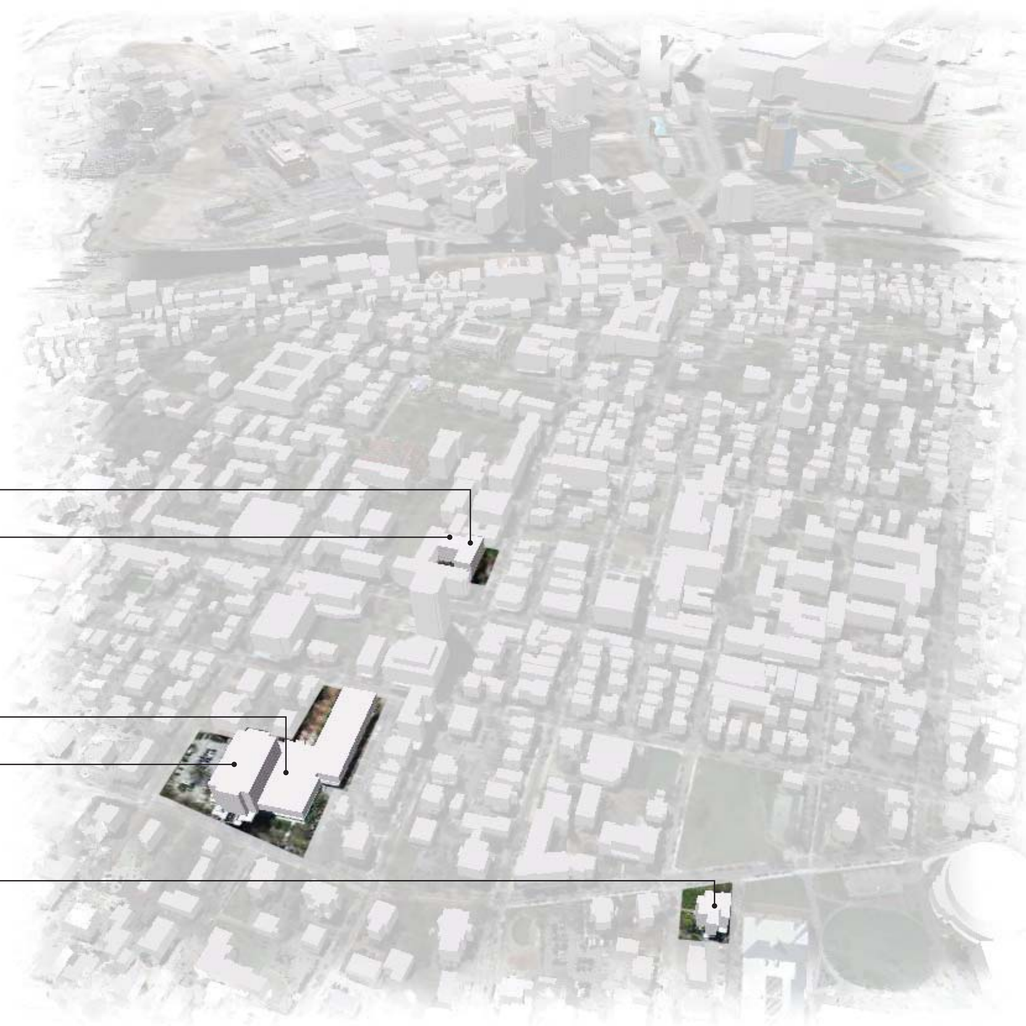


Figure 3.1 Engineering facilities on campus

Existing Facilities & Organization

The School of Engineering currently occupies approximately 120,000 assignable square feet in six buildings on the Brown campus and one off-campus facility (Figure 3.1). Roughly 80% of this assignable area is located in the Barus & Holley and Prince Lab complex. Most of the remainder is distributed in smaller increments in several nearby campus buildings (Figure 3.2). The School also has a small amount of space off-campus in the Tockwotten Studios building.

The School is not organized into conventional departments by discipline, as is typical at other schools of engineering. Rather, the research faculty is loosely organized into six different areas of common interest (Figure 3.3), with many individual researchers affiliating themselves with more than one area (Figure 3.4). A tour of existing faculty research labs reveals a wide array of lab types. These range from very dry computation labs, to conventional wet labs, to a significant number of "hybrid" labs that often combine elements of wet labs, such as fume hoods, with large floor equipment, optics tables and/or other light-sensitive instrumentation (Figure 3.5).

In 2013, the School initiated a wave of hiring that resulted in a 4 FTE increase in the size of the faculty, bringing the total to 48. By the time the first phase of Engineering's physical expansion is complete in four to five years, Brown anticipates adding another 10 FTEs, bringing the total to 58.

Barus & Holley

Giancarlo

Prince Laboratory

Medical Research Laboratory

271 Tockwotten Street

Arnold Laboratory

Figure 3.2 Brown Engineering Facilities

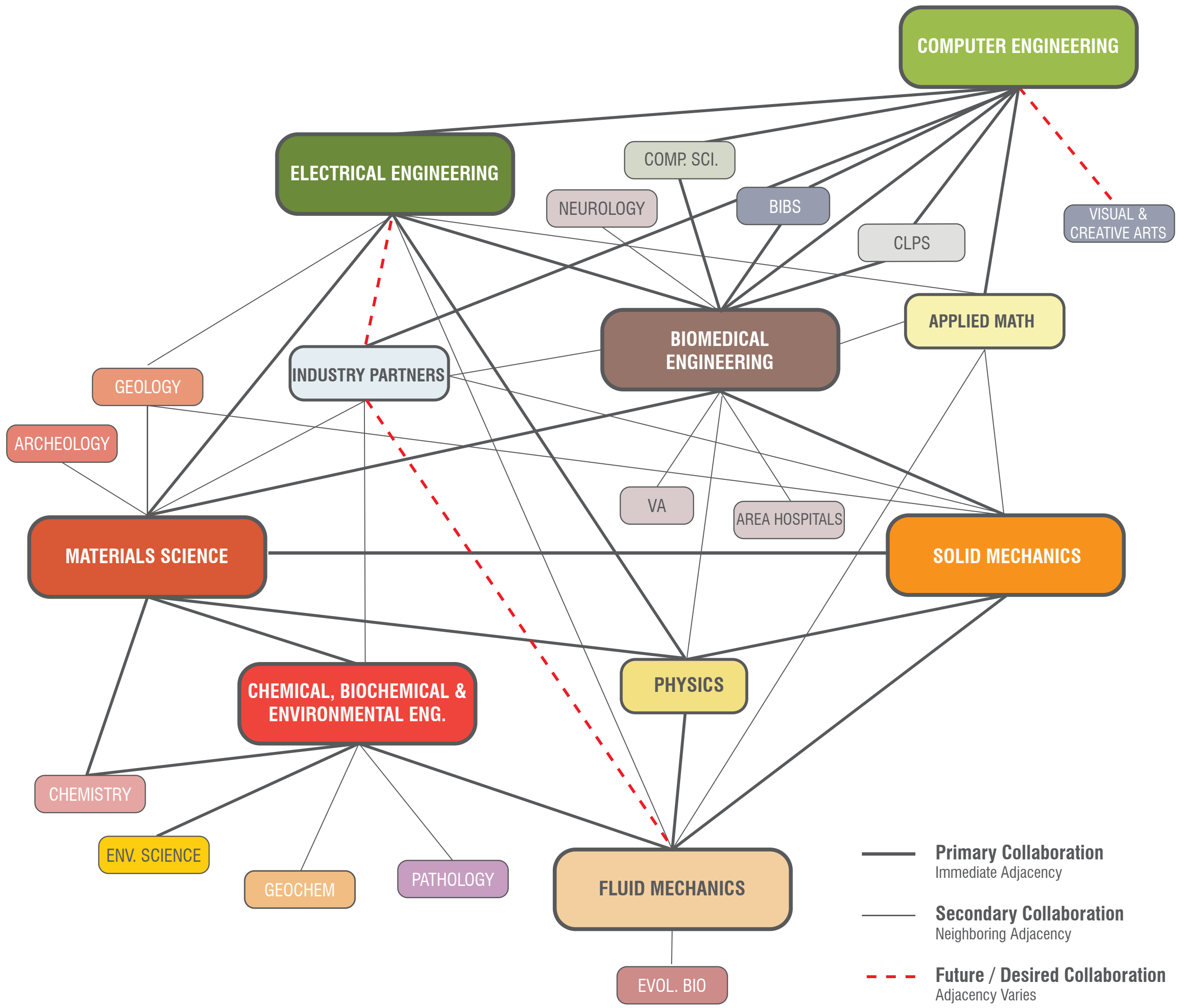


Figure 3.3 Faculty research collaboration

RB Ruth Iris Bahar
LL Larry Larson
DP Domenico Pacifici
JR Jacob Rosenstein
JX Jimmy Xu
AZ Alexander Zaslavsky
RZ Rashid Zia

RB Rod Beresford
DC David Cooper
PF Pedro F. Felzenszwalb
BK Benjamin Kimia
JM Joseph Mundy
SR Sherief Reda
HS Harvey Silverman
GT Gabriel Taubin

SD Seon Deoni
CF Christian Franck
LH Leigh Hochberg
AN Arto V. Nurmikko
AT Anubhav Tripathi

KB Kenneth Breuer
JL Joseph T.C. Liu
SM Shreyas Mandre
PV Petia Valhovska

JB Janet Blume
AB Allan Bower
RC Rodney Clifton
HG Huajian Gao
PG Pradeep Guduru
HK Haneesh Kesari
KK Kyung-Suk Kim
TP Thomas Powers

EC Eric Chason
AK Angus Kingon
SK Sharvan Kumar
NP Nitin P. Padture
DP David Paine
TP Tayhas Palmore
AW Axel van de Walle

BH Robert Hurt
IK Indrek Külaots
AP Andrew Peterson
BS Brian Sheldon
ES Eric Suuberg

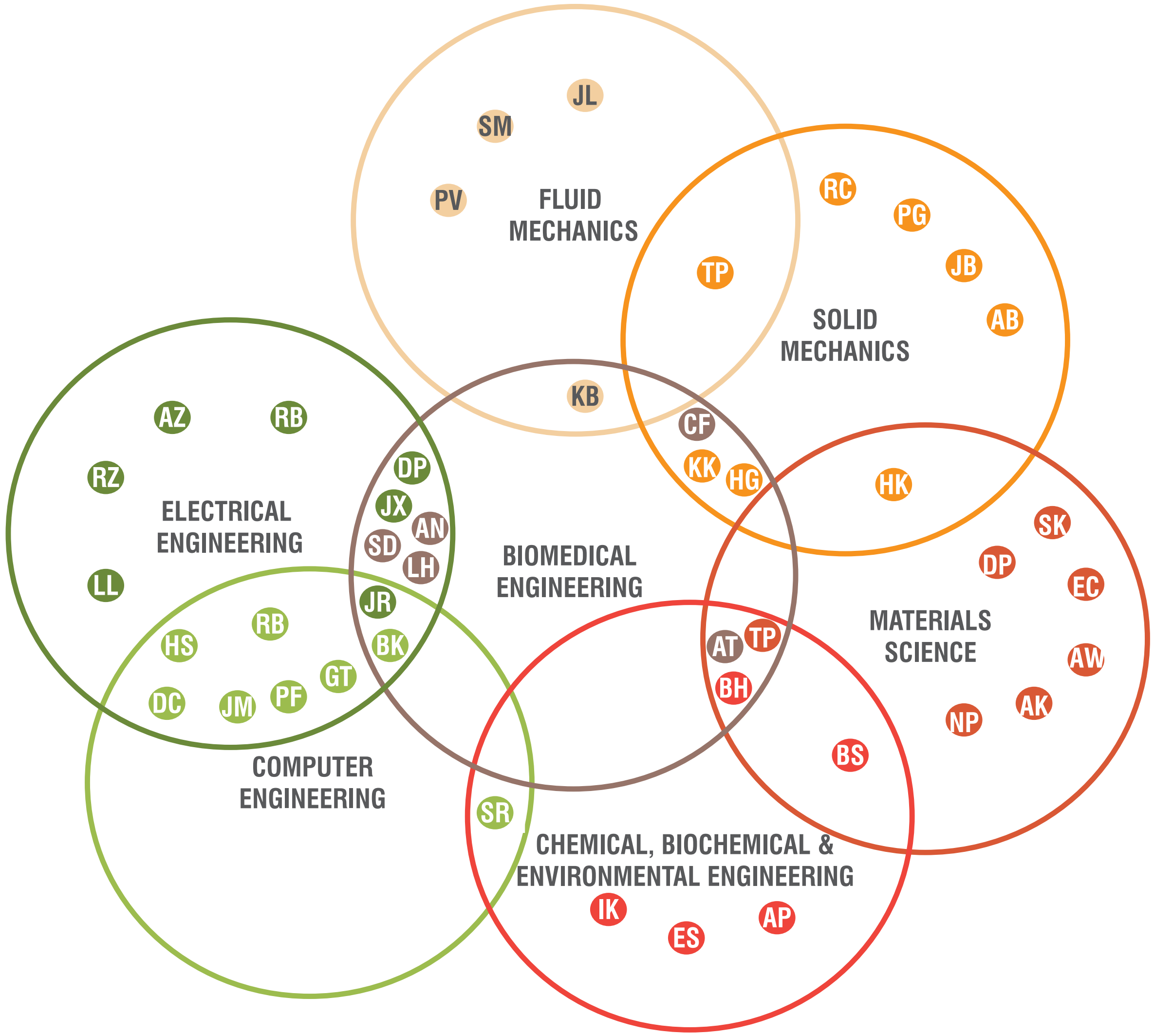
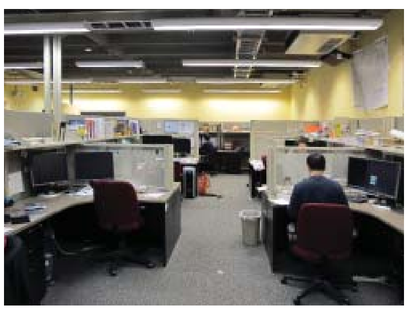


Figure 3.4 Faculty research collaboration

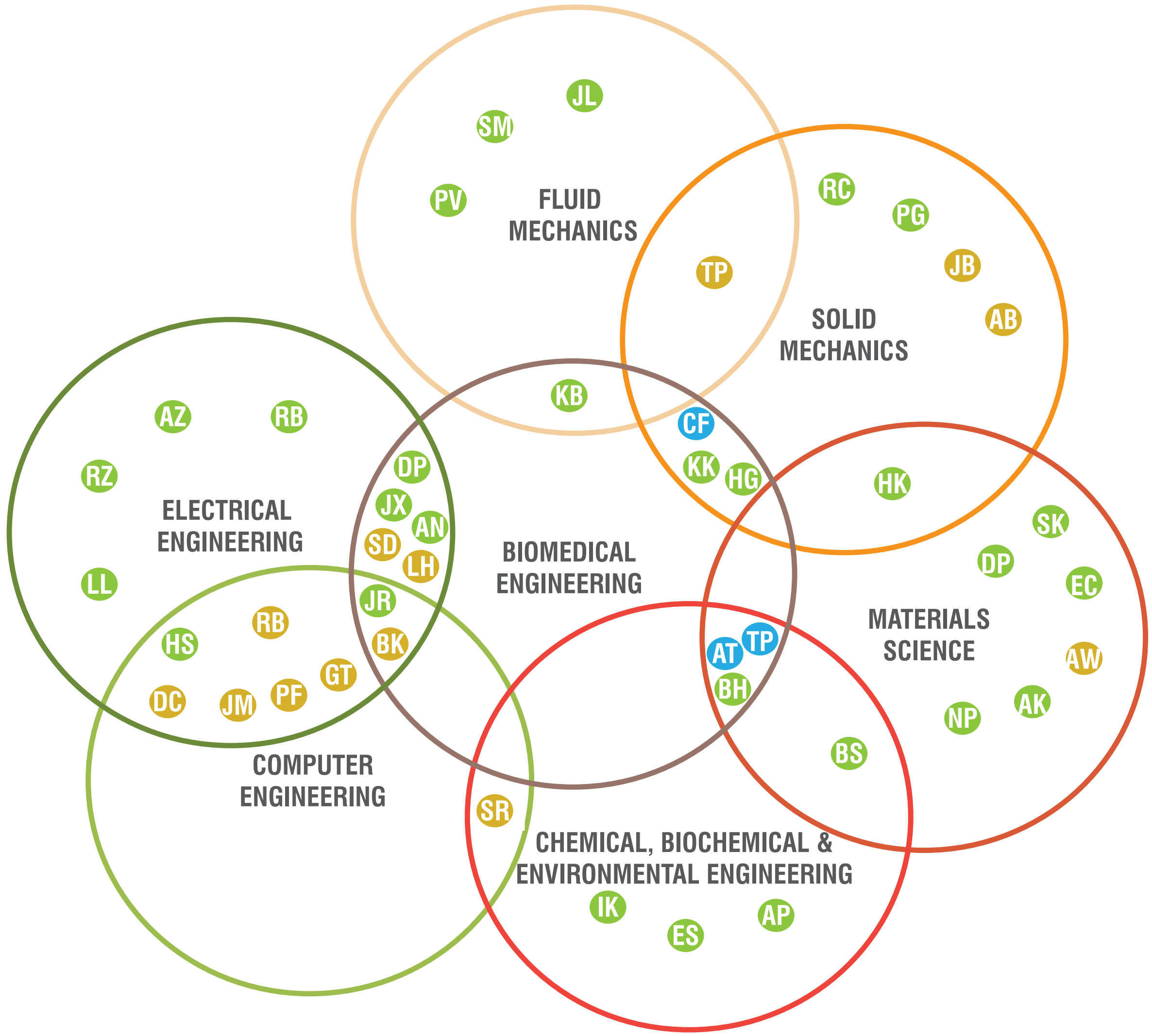
Typical Hybrid Laboratory

Typical Wet Laboratory



Typical Dry Computation Laboratory

Figure 3.5 Faculty by lab type



Space Program

Payette developed the Engineering facility program by identifying unmet needs above and beyond the School's existing space resources, and by accounting for the needs represented by the increase in the faculty size noted above. While the programming process did not afford an opportunity to meet with each faculty member, the team met with groups of faculty members representing the major areas of research within the School (minutes of these meetings are included in Appendix A). This effort yielded a summary level program at a level of detail sufficient to support the overall master planning effort. It is important to note that a more detailed, space-by-space programming will need to be undertaken as the project proceeds into the next stages.

In summary, the program identifies a total space need for Engineering of approximately 170,000 assignable square feet. Of this total, approximately 70,000 assignable square feet represents requirements for new types of facilities—i.e. space functions that need to be provided either through new construction or significant renovations to existing facilities. Growth is anticipated in a number of different areas.

In the area of Administration, the School's existing administrative support functions should be relocated from 'spillover' locations within the corridors of Barus & Holley into a proper suite. Engineering's different support functions, such as Communications, Grants and Contracts, IT and Engineering Services, should be consolidated into a single location where they could benefit from common amenities, such as shared conference and copier rooms. These are currently distributed throughout the building, wherever space was available.

In the area of Education, many of the School's teaching labs are located in the Giancarlo portion of Barus & Holley and are consequently among the most recent spaces to come on line. While no expansion of these facilities is anticipated, a new multidisciplinary graduate teaching lab and an adjacent student project/prep space should be provided. Also, the inclusion of a technology enhanced active learning (TEAL)-type lab for 72 students anticipates future educational trends in engineering. Key functions of the School's existing student machine shop, student project lab, prototyping lab and student club space (currently located off-campus in the Tockwotten building) should be consolidated into a new "maker" space. Ideally, this would be located in close proximity to the masters student desk room.

In the area of Entrepreneurship and Innovation, a significant expansion of the space allocated to the new Center for Entrepreneurial Innovation (CEI), currently known as the Program in Innovation Management and Entrepreneurship (PRIME), is anticipated. This program requires masters student cohort space (where each student in the program would be assigned a desk), multiple small group meeting/collaboration spaces, adjacent space for faculty and a stepped 'case study' style classroom for 80 students, the projected future size of the program. It is possible that this classroom could be made available to other users outside CEI course hours.

In the area of Research, space for both new faculty and an expansion of existing research groups as noted above is required. New faculty hires are anticipated in the areas of Biomedical Engineering, Micro/Nano Technologies; and Energy, Environment and Infrastructure. In addition, both formal and informal interaction space for faculty and students is needed outside the lab environment. Nearly all Engineering faculty members teach, and few if any spaces exist outside the labs to conduct group-based problem sessions aside from their private offices.

In the area of Office and Support, additional conference and meeting space is needed, as well as shared student/faculty interaction spaces, which are almost entirely absent from the School today. Most of the School's existing dedicated meeting spaces were converted into offices long ago.

In the area of Shared Facilities, significant growth is envisioned in several key places. The existing clean room will be replaced with a significantly larger one and equipped with appropriate ancillary spaces for materials storage, gowning, staff office functions and mechanical chases, as well as an adjacent loading dock. An adjacent bio-cleanroom will share many of these ancillary functions. A new nano-tools lab will provide a central location for consolidating equipment and tools that currently exist within numerous individual labs. While these tools do not need to be located in clean space, they are used in many micro- and nano-processes, and so this facility would ideally be located adjacent to the clean room. Similarly, a new imaging facility, ideally located adjacent to the clean room, is required. This facility would likely house an FEI Titan, an advanced S/TEM that requires NIST A criteria space. Consequently, the imaging facility will need to be located on grade.

SCHOOL OF ENGINEERING PROGRAM	EXISTING		CURRENT PROPOSED GROWTH				TOTAL FUTURE NEED			
Program Element	**Occupants**	**NASF**	**Occupants**	**# of Unit**	**Unit NASF**	**Total NASF**	**Total Occupants**	**Total NASF**	**Future Location**	**Comments**
ADMINISTRATION										
Executive Suite										
Dean's Office	1	330					1	330	B&H	
Chief Admin Officer	1	163			37	37	1	200	B&H	If this space is relocated, should be built to office standard
Assoc. Dean	1	162			38	38	1	200	B&H	"
Managers Office	1	81			79	79	1	160	B&H	"
Staff Office	3	240	1	1	260	260	4	500	B&H	if space is relocated, 4 offices at 125 NSF, 1 is new
Student Affairs										
Managers Office	1	99			61	61	1	160	B&H	If this space is relocated, should be built to office standard
Staff Office	1	80	1	1	170	170	2	250	B&H	If this space is relocated, 2 offices at 125 NSF, 1 is new
Interview/Meeting				2	75	150		150	B&H	
Communications										
Managers Office	1	102			58	58	1	160	B&H	If this space is relocated, should be built to office standard
Staff Office	1	53			72	72	1	125	B&H	"
Storage/ Files				1	250	250		250	B&H	
Grants and Contracts										
Managers Office	1	99			61	61	1	160	B&H	If this space is relocated, should be built to office standard
Staff Office	3	280	2	2	345	345	5	625	B&H	if space is relocated, 5 offices at 125 NSF, 2 are new
Storage/ Files				1	125	125		125	B&H	
Information Technologies										
Managers Office	1	162					1	162	B&H	
Staff Office	3	323			52	52	3	375	B&H	if space is relocated, 3 offices at 125 NSF
Student Work Area				2	50	100		100	B&H	
Storage/ Files				1	125	125		125	B&H	
Engineering Services										
Managers Office	1	81			79	79	1	160	B&H	If this space is relocated, should be built to office standard
Storage/ Files				1	125	125		125	B&H	
Office Support										
Receptionist					120	120		120	B&H	Ideally the Administration offices located in suite with reception desk
Kitchenette		131						131	B&H	
Mailroom/Copy/Fax				2	120	240		240	B&H	
Small Conference Room				2	160	320		320	B&H	
Medium Conference Room		331			69	69		400	B&H	If this space is relocated, room should be larger
	20	**2,717**	**4**			**2,936**	**24**	**5,650**		

SCHOOL OF ENGINEERING PROGRAM	EXISTING		CURRENT PROPOSED GROWTH				TOTAL FUTURE NEED			
Program Element	Occupants	NASF	Occupants	# of Unit	Unit NASF	Total NASF	Total Occupants	Total NASF	Future Location	Comments
EDUCATION										
Learning Studios (Classrooms)										Continue to use Registrar classrooms
Seminar Room (BH190)		928						928	BH	
Teaching Labs and Support										
Multi Media Laboratory (BH092)		569						569	BH	
Fluids & Thermo Laboratory (BH093)		943						943	BH	
Bio-Engineering Laboratory (BH095)		584		1	125	125		709	BH	Ideally room would be larger, or add closet for material storage
Statics, Dynamics & Vibrations Laboratory (BH096)		932						932	BH	
Mechanics Laboratory (BH097)		575						575	BH	
Electronics Laboratory (BH196)		929						929	BH	
Rapid Prototyping (BH195 & BH197)		686		1	500	500		500	PL	Move to Prince Ground Level in Renovation
Computer Laboratory (BH191)		2,145						2,145	BH	
Studio Laboratory (BH194)		972						972	BH	
Student Club Workshop & Office		3,348			2,000	2,000		2,000	PL	Move club space from Tockwotten, smaller w/o machine shop
Student Project Laboratory		4,366			4,000	4,000		4,000	PL	Consolidation of club space w/ student project lab= space savings
Student Machine Shop		1,138						1,138	PL	
Chemical Engineering Instructional Lab (P113C)		774		1	1,800	1,800		1,800	PL	If relocated, should be expanded
Materials Undergraduate Project Lab		1,070		1	1,400	1,400		1,400	PL	If relocated, should be expanded, ideally classroom adjacent
Prep Rooms/ Teaching Support				3	615	1,845		1,845	BH	3 rooms each at 615 NSF allows for multiple uses of Teaching lab
Graduate Teaching Lab				1	1,400	1,400		1,400	BH	
Technology Enabled Active Learning (TEAL) Lab				1	2,000	2,000		2,000	BH	Active learning for 72 students - 8 tables of 9
Student Mailroom/Copy/Fax		279						279	BH	
Teaching Support/ Storage		269		1	131	131		400	BH	Need additional teaching support/storage
		20,507				**15,201**		**25,460**		

SCHOOL OF ENGINEERING PROGRAM	EXISTING		CURRENT PROPOSED GROWTH				TOTAL FUTURE NEED			
Program Element	**Occupants**	**NASF**	**Occupants**	**# of Unit**	**Unit NASF**	**Total NASF**	**Total Occupants**	**Total NASF**	**Future Location**	**Comments**
ENTREPRENEURSHIP & INNOVATION										
Case Study Classroom				1	2,000	2,000		2,000		Seats 80, Implementation not resolved
Masters Student Cohort Room	31	1,242	49	40	1,960	1,960	80	3,200	BH	Desks for 80 each @40 NSF- existing will be relocated and expanded
Faculty Office			1	1	160	160	1	160	BH	
Visitor Office				2	125	250		250	BH	
Staff Office (Administration)	1	90	1	1	160	160	2	250	BH	1 new office at 125NSF plus expansion of existing to office standard
Copy/Fax Office Workroom				1	120	120		120	BH	
Reception		230						230	BH	
Group Breakout Area										
Small Conference Room				6	160	960		960	BH	Conf Rm for 6-8
Medium Conference Room		397		2	400	800		1,197	BH	Conf Rm for 16-20
	32	**1,959**	**51**			**6,410**	**83**	**8,370**		
RESEARCH										
Existing Research		54,410						54,410	Various	Includes Space in B&H, Prince, MRL, Arnold, Stimson & Hunter
Group size increase										Lab group growth from average of 3.5 to 5 per PI accommodated
Subtotal		**54,410**						**54,410**		in existing research space
Future Research Hires										
Biomedical Engineering										
Dry Computational Research (100 NSF/person)										
Dry Equipment/ Hybrid Research (200 NSF/person)				2	1,000	2,000		2,000	NewBuild	Assumes on average 5 grad students per lab, typ
Wet Bench Research (200 NSF/person)				1	1,000	1,000		1,000	NewBuild	Assumes on average 5 grad students per lab, typ
Micro/Nano Technologies										
Dry Computational Research (100 NSF/person)										
Dry Equipment/ Hybrid Research (200 NSF/person)				3	1,000	3,000		3,000	NewBuild	Assumes on average 5 grad students per lab, typ
Wet Bench Research (200 NSF/person)										
Energy Environment & Infrastructure										
Dry Computational Research (100 NSF/person)										
Dry Equipment/ Hybrid Research (200 NSF/person)				2	1,000	2,000		2,000	NewBuild	Assumes on average 5 grad students per lab, typ
Wet Bench Research (200 NSF/person)				1	1,000	1,000		1,000	NewBuild	Assumes on average 5 grad students per lab, typ
10% for growth/turnover					1,300	1,300		1,300		
		54,410		**9**		**10,300**		**64,710**		

SCHOOL OF ENGINEERING PROGRAM	EXISTING		CURRENT PROPOSED GROWTH				TOTAL FUTURE NEED			
Program Element	Occupants	NASF	Occupants	# of Unit	Unit NASF	Total NASF	Total Occupants	Total NASF	Future Location	Comments
OFFICE AND SUPPORT										
Faculty Office										
Full Professors	25	3,860					25	3,860	Various	
Assoc & Assistant Professors	23	3,447					23	3,447	Various	
Future Hires			9	9	160	1,440	9	1,440	NewBuild	
Subtotal	**48**	**7,307**	**9**	**9**	**160**	**1,440**	**57**	**8,747**		48 Existing + 9 New Faculty + 1 New PRIME Faculty
Adjunct Faculty	15	437			363	363	15	800	Various	Ideally one shared office of 800 NSF
Research Faculty	10	1,020	2	2	160	320	12	1,340	Various	Doesn't Include Emeritus
Emeriti Shared Office	6	974		2	240	480	6	480	Various	Create 2 large shared offices, give up individual offices
Post Doc/RA Offices	50	2,634	9	9	80	720	59	3,354	Various	One for every new faculty
PHD Student Desk	131		154	Included in lab area			285			5 for every faculty member
Masters Students Desk Room	33	1,284	27	1	816	816	60	2,100	PL	Open office environment, assigned desks each at 35 NSF
Visitors Office	30	2,696	12	3	240	720	42	3,416	Various	3 new offices in addition to existing, 4 people per office
Staff Office (Lecturers)	6	752					6	752	Various	
Staff Office (Administrative Support)	5	527	2	2	125	250	7	777	BH	2 new offices in addition to existing, move offices out of corridors
Office Support										
Small Conference Room				8	160	1,280		1,280	Various	Conf Rm for 6-8
Medium Conference Room				6	400	2,400		2,400	Various	Conf Rm for 16-20
Large Conference Room		766		3	500	1,500		2,266	Various	Conf Room for 20-30
Copy/Fax Office Workroom		410		6	120	720		1,130	Various	Distributed per floor in upper floors in B&H and new building
Student/Faculty Study Interaction & Kitchenette				6	160	960		960	Various	Distributed in upper floors in B&H and new building
Grad Student Lounge		144		1	600	600		744	BH	
	334	**18,950**	**215**			**12,569**	**549**	**30,540**		

SCHOOL OF ENGINEERING PROGRAM	EXISTING		CURRENT PROPOSED GROWTH				TOTAL FUTURE NEED			
Program Element	Occupants	NASF	Occupants	# of Unit	Unit NASF	Total NASF	Total Occupants	Total NASF	Future Location	Comments
SHARED FACILITIES										
Joint Engineering/Physics Machine Shop		3,365			2,750	2,750		2,750	PL	Some consolidation of storage rooms & equipment could occur
Imaging/ Electron Microscope Facility		2,738			1,600	1,600		1,600	NewBuild	Suite with 7 microscopes adjacent to cleanroom at grade
Microelectronics Cleanroom										Cleanroom proposed in new facility on ground level
Gowning		173		1	230	230		230	NewBuild	Existing cleanroom will be repurposed
Parts Clean/Wipe Down/General Storage		84		1	465	465		465	NewBuild	
Chem & Gas Storage				2	115	230		230	NewBuild	
ISO 6 (Class 1000) Clean Room		807			1,150	1,150		1,150	NewBuild	Bay and Chase design
ISO 5 (Class 100) Clean Rooom		148			475	475		475	NewBuild	
Chase		542			1,120	1,120		1,120	NewBuild	
Bio-Cleanroom				1	750	750		750	NewBuild	Shared Gowning with Microelectronics Cleanroom
Engineering Test Facility		5,915			3,000	3,000		3,000	PL	Will be consolidated on Prince lower level
Wind Tunnel Facility		4,325						4,325	PL	To remain as is
Nano Tools		224		1	750	750		974	NewBuild	Located in new building. Existing incl. XRD which may stay in Prince
MRI Facility										New MRI facility in BIBS program, SOE continue using Sidney Frank
Shared Facilities Technician Offices	10	1,503		1	300	300	10	1,803	Various	Shared office in new building, and offices in Prince remain
Shared Facilities Office Support										
Small Conference Room		533						533	PL	
Copy/Fax Office Workroom		118						118	PL	
Storage				1	300	300		300	PL	
	10	**20,475**				**13,120**	**10**	**19,820**		

SCHOOL OF ENGINEERING PROGRAM	EXISTING		CURRENT PROPOSED GROWTH				TOTAL FUTURE NEED			
Program Element	**Occupants**	**NASF**	**Occupants**	**# of Unit**	**Unit NASF**	**Total NASF**	**Total Occupants**	**Total NASF**	**Future Location**	**Comments**
PUBLIC USE										
Main Lobby					1,000	1,000		1,000	NewBuild	In new building - variety of tables & seating desired
Café					600	600		600	BH	Growth of existing desired. No food prep, warming ovens, deli cases
Main Lobby Student Study										
Small Study Rooms				2	160	320		320	BH	Conf Rm for 6-8
Medium Study Rooms				2	300	600		600	BH	Conf Room for 12-15
Conference Center										
Auditorium for 300				1	3,500	3,500		3,500		This is on the wish list and implementation was not resolved
Break Out Rooms				3	400	1,200		1,200		
Event Room				1	850	850		850		
Catering Kitchen				1	200	200		200		
Conference Support				1	200	200		200		
						8,470		**8,470**		
INCUBATOR SPACE										
Incubator Labs				3	400	1,200		1,200	PL	
Incubator Office				1	250	250		250	PL	Open office environment, desks for 4 people
Small Conference Room				1	160	160		160	PL	Conf Rm for 6-8
Copy/Fax Office Workroom				1	120	120		120	Pl	
						1,730		**1,730**		
BUILDING SUPPORT										
Shipping/Receiving		991		1	350	350		1,341	NewBuild	New allocation (350 SF) in new building
Stock Room				1	600	600		600	BH	More space for central services & support requested in existing
Chemical Storage				1	200	200		200	BH	
Shared Autoclave/Glasswash Room/Ice Machine		96		1	300	300		396	BH	
IT Server Room		435						435	BH	
General Building Storage					800	800		800	BH	
		1,522				**2,250**		**3,770**		
TOTAL BUILDING PROGRAM (NASF)	**396**	**120,540**				**72,990**	**666**	**168,500**		
Building Efficiency Factor		62%						60%		
TOTAL BUILDING PROGRAM (GSF)		193,800						280,800		

4 PHASE I OVERVIEW

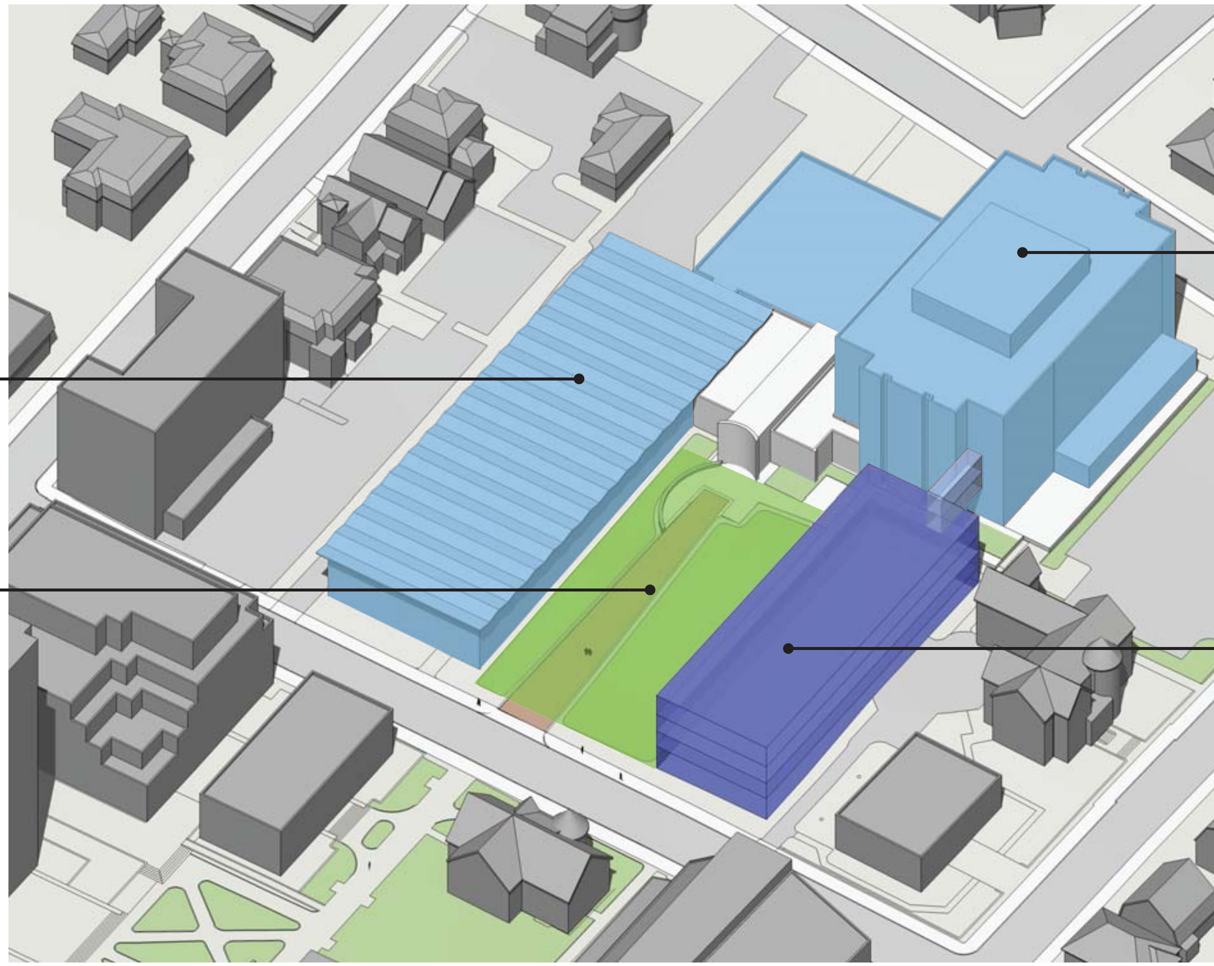


Figure 4.1 Phase I overview isometric

Overview

Accommodating the School of Engineering's growth will occur over a series of phases. The first phase addresses the School's most pressing needs for new facilities and couples these with strategic renovations to support focused program needs in the School's two existing buildings. The overall objective of Phase I is to better align Engineering's program needs with its facility resources. It addresses the question: How can Engineering best utilize its two existing buildings and one new building so that each of these three facilities functions at its highest and best use for the broad range of space needs that the School has?

The School's most pressing needs are in the types of high-technology research and shared core facility space that Barus & Holley and Prince are not adequately equipped to provide. The floor-to-floor height of Barus & Holley precludes significant amounts of mechanical ductwork and services of the type generally associated with high-intensity wet labs. Nor is Barus & Holley's existing HVAC system adequate to supply the quantity of outdoor air that these spaces require without the addition of costly new exterior shafts. While it could be upgraded, this would entail a considerable degree of disruption and cost. Barus & Holley also lacks on-grade loading dock access for a clean room.

On the other hand, Barus & Holley and Prince Lab are each well-suited to satisfy certain types of engineering need. Barus & Holley is very well suited to dry lab and computational space needs, which only require limited amounts of outside air. It is also a prime candidate for a low-energy HVAC system renovation, such as chilled beam technology, that can easily support these kinds of labs without consuming limited ceiling height or triggering intensive air-handling upgrades. Prince Lab offers the kind of high-bay engineering shop space that would need to be purpose-built if relocated elsewhere.

The specific recommendations pertaining to each of these three projects are described in greater detail in the sections that follow.

Phase I is expected to require at least four to five years to fully plan and execute. The major steps are as follows:

- Construction of a new engineering building of approximately 80,000 gross square feet.
- Continued infrastructure upgrades to Barus & Holley (refer to the IKM Study for a detailed description of these), anticipating the eventual full-floor renovations of Levels 2 through 7.

- Limited renovations to Levels 1 and B of Barus & Holley.
- Selective renovations to Prince Lab.
- Expansion of Prince MEP plant to serve the new engineering building.
- Creation of a new signature campus landscape space on the site of the existing Manning Walk; this could include a potential new entry into Prince Lab. This is also a prime opportunity to demonstrate the University's commitment to LEED standards by integrating stormwater systems, utilizing native plantings and creating bio-habitats that could function as a campus learning lab for the sciences.

5 PHASE I NEW ENGINEERING BUILDING

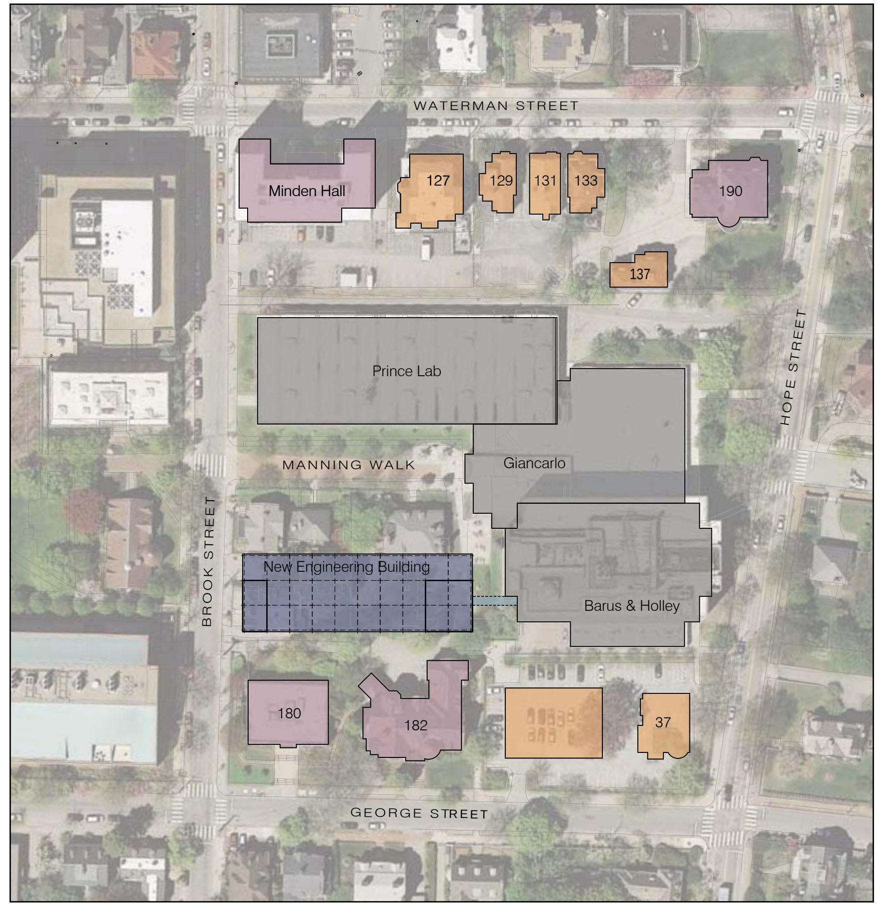


Figure 5.1 Proposed site of engineering building

Overview

Phase I will commence with the construction of an 80,000 gross square foot new engineering building on a site south of the existing Manning Walk (Figure 5.1). This site was selected following an analysis of potential growth opportunities on the Engineering block that is described in more detail in Section 2 of this Study.

The selected site offers the following benefits:

- A high degree of visibility from the central part of campus and other physical and applied science facilities.
- It is insulated from the residential neighborhoods that abut the block on its north, east and south sides.
- In conjunction with a new signature campus landscape space on the site of the existing Manning Walk, a building in this location could 'complete' a three-sided Engineering quadrangle, which is currently bounded on only its north and east sides, and will remain open towards the west.
- Ease of physical connections to Barus & Holley, including above-grade connections on multiple upper research floors; these connections will take the form of social hubs.
- Facilitates the development of an off-street loading dock accessed from Brook Street, which already functions as the service access point for the neighboring Geochemistry Building.

Figure 5.2 Conceptual hybrid lab

On the other hand, this site is constrained by the physical size of its footprint, by the size and scale of the buildings which are in proximity to it, by the topography of the block, and by the campus planning principals articulated at the outset of the Study. In response to these constraints, the following building planning principals have been developed for the new engineering building; they are the criteria against which future design solutions will be evaluated.

- To meet programmatic objectives, the new engineering building will be four stories in height. Special attention must be paid to reducing the apparent scale and massing of the building wherever possible. The building will not include a penthouse; all mechanical equipment will be located below grade; and rooftop equipment or structures will be strictly limited to what cannot be below grade. The Concept Design locates exhaust fans in a sunken mechanical well on Level 4, but the possibility of routing exhaust ductwork across the bridge connection to fans on the roof of Barus & Holley in order to avoid locating fans and stacks on the rooftop of the new building has also been considered
- Vehicular access from Brook Street to the rear of 182 George will need to remain to provide service/loading access for the new facility. This constraint establishes a rear setback for the new building of approximately 45 to 50 feet from 180 George Street.
- The new building's east-west orientation will cause it to cast a shadow across the new campus landscape space to be developed on the site of the existing Manning Walk. Special attention must be paid to the north-facing portion of the new building to minimize the degree to which a deep shadow compromises the quality and functionality of the landscaped space. For example, the roof could be stepped down above the offices, which require less ceiling height and mechanical space.
- The new engineering building will need to mitigate an existing grade change of 8 to 9 feet between Brook Street and the Giancarlo addition entrance of Barus & Holley. To keep the overall height of the new building as low as possible, the ground floor level of the new engineering building could be set to coincide with the elevation of Brook Street (this also facilitates an on-grade loading dock). However, this assumption could change as a function of the location of the building's principal entrance(s), the manner in which the landscape space is developed along the building's northern edge, and how internal ground floor public circulation functions within the new building.

- The ground floor program of the new building, which will need to accommodate the most publically accessible portions of the building's high-technology program—the cleanroom and imaging suite—should also help to energize the campus spaces that it fronts onto. Aside from the fact that these facilities will be used by many different individuals both inside and outside the School of Engineering, this ground-floor location was selected for several reasons: limitations on the storage of hazardous materials require the cleanroom to be located at grade; the imaging facility needs to be located directly on a slab-on-grade foundation; and there enough synergies between the two from a programmatic point of view to collocate them. The clean room and its ancillary spaces (bio-cleanroom and nano-tools lab) should be provided with windows to the exterior and/or to adjacent public circulation spaces. Allowing views from publically accessible portions of the building and landscape space into the new building's high-technology spaces is considered a highly desirable means of engaging the public.

- It is assumed that the basement level will be limited to mechanical spaces. This is to avoid the cost of having to provide services and spaces such as circulation areas and toilet rooms on this level.

- It is assumed that a physical connection will be established between the new building and Barus & Holley on at least one, and possibly several levels. However, because the relatively low floor-to-floor height in Barus & Holley (11'-1 3/8") is not ideal for a contemporary high-technology research building, the floor levels of the new building will not align with those in the existing building. By locating the new building's elevator and main stair core at its eastern end, adjacent to the proposed bridge connection, a circulation hub here could mitigate the different floor levels of the new and existing buildings. This could also be developed as an important social hub by clustering informal interaction spaces such as lounges, kitchenettes and meeting spaces nearby. Because these kinds of social spaces do not exist in Barus & Holley, locating them at the nexus between the new and existing buildings will draw collaborators from both together.

- Research laboratories should be flexible in nature, allowing individual lab groups to either partition off modules or combine them into large, open labs.

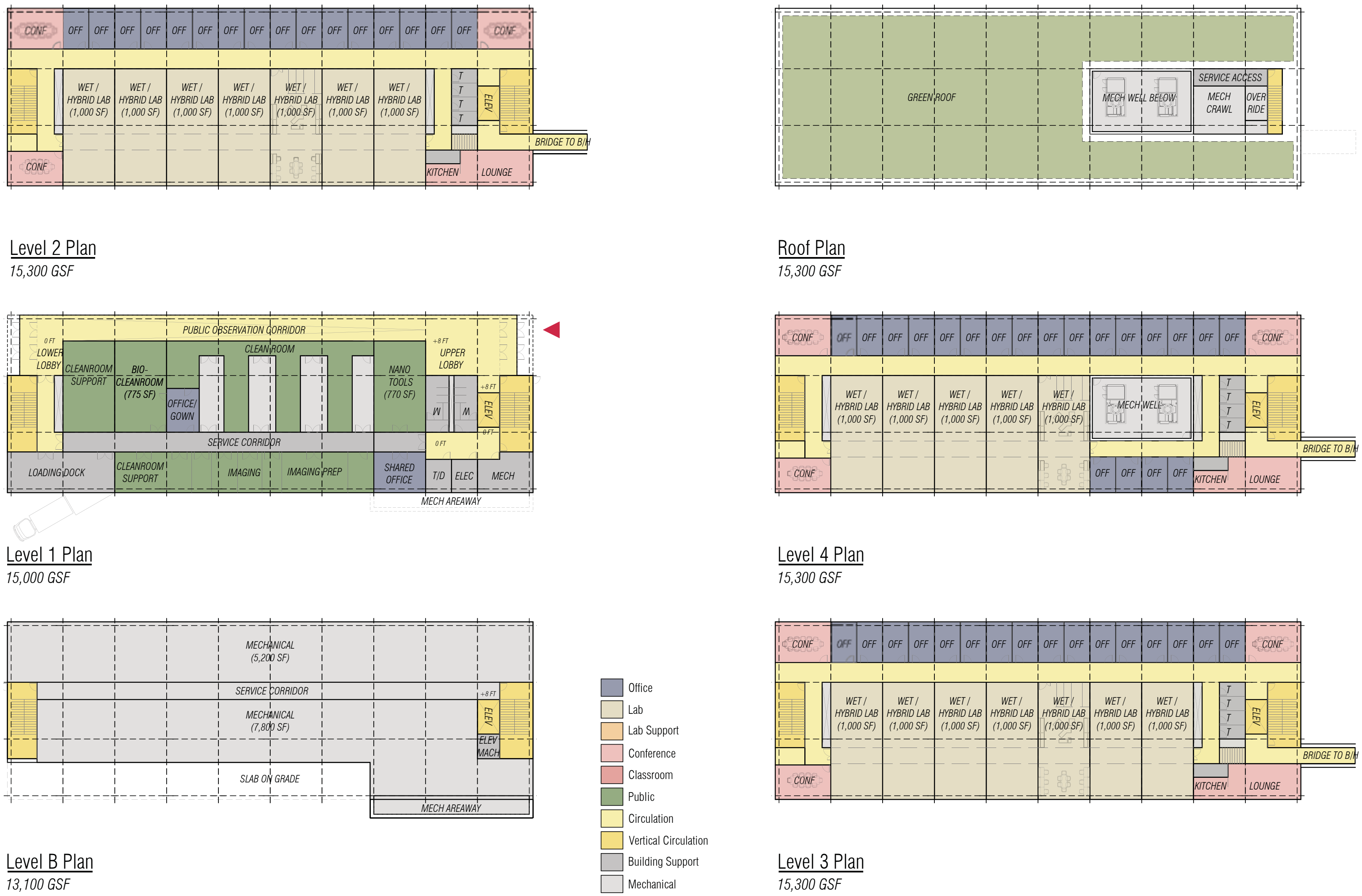


Figure 5.3 Conceptual building plans

Programmatic requirements for Phase I new building are as follows:

Component	*NASF*
Microelectronics cleanroom	5,000
Bio-cleanroom	1,000
Nano-tools facility	1,000
Imaging facility	2,000
18-20 hybrid research labs	20,000
(including graduate student workstations)	
Offices, conference rooms, kitchenettes and breakout space	10,000
Public lobby and building support	5,000
Total approximate assignable square feet	44,000
Building efficiency assumption	55%
Total approximate gross square feet	80,000

The Concept Design shown here accommodates these requirements with an approximate building footprint of 15,000-16,000 gross square feet. The Concept Design shown here is intended to illustrate at least one approach to the program and site. While its generic footprint and massing are intended to provide maximum flexibility to the selected designer, the Concept Design does incorporate a number of deliberate planning considerations that could prove useful:

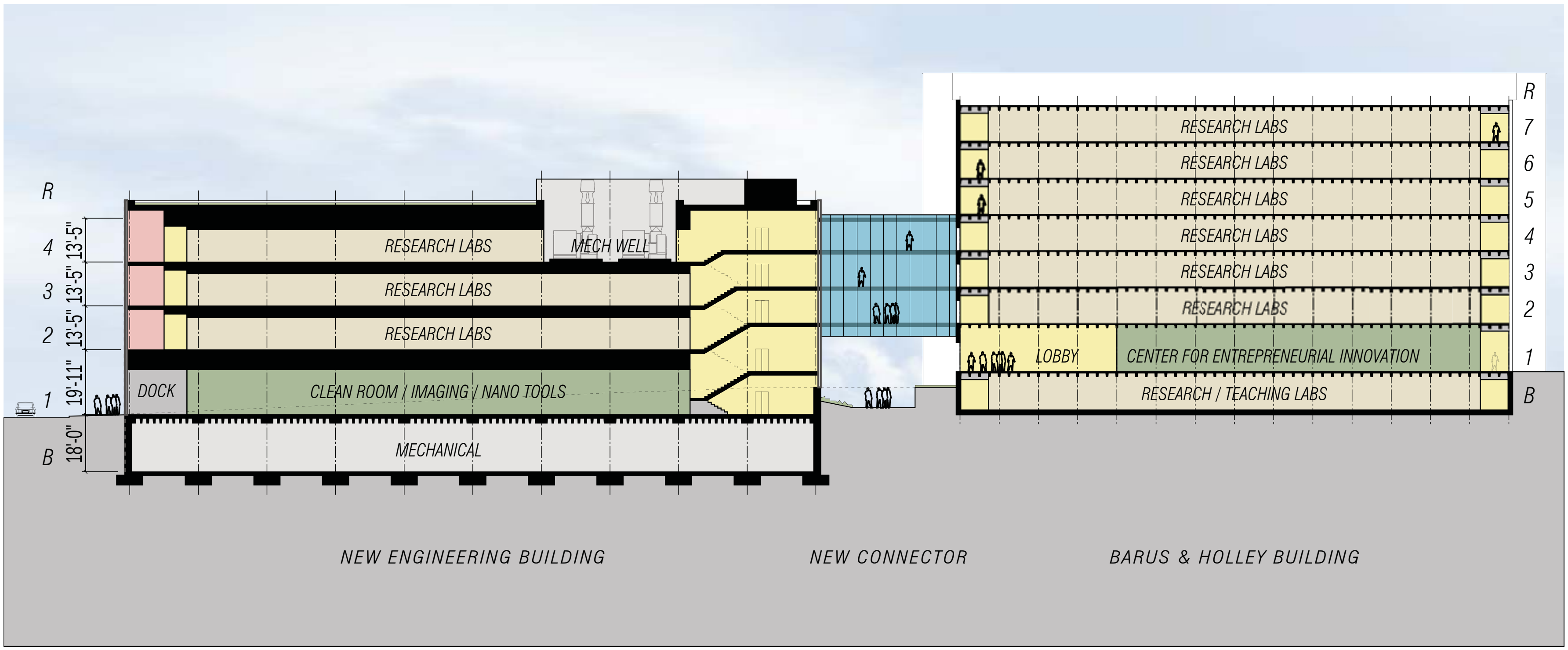


Figure 5.6 Conceptual section

- A structural bay of 21 feet is considered a minimum width for labs which require conventional benches. While not all the labs are expected to be bench labs, it is assumed that at least some will require this capability.
- The typical research floor plan is organized around the concept of an asymmetric double-loaded corridor with private offices on one side and relatively deep lab bays on the other, in lieu of a more conventional center location double-loaded corridor with shallower lab bays of equivalent depth to either side. This strategy provides for a significant degree of flexibility within the lab as illustrated by the different configuration options shown in Figure 5.3. Lab modules could function either individually or grouped together in shared labs. The student desk areas and private offices are less mechanically intensive than the lab areas and could be provided with simpler HVAC systems as an energy-reducing strategy.
- The building core is located at the east end where it facilitates connections to Barus & Holley. It is assumed that the new building will utilize a higher floor-to-floor height than Barus & Holley (11'-1 3/8"). These plans envision extending the Barus & Holley floor levels across the horizontal bridge connections and providing a double-sided elevator within the new building to mitigate the resulting level changes.

Figure 5.5 Conceptual Cleanroom

Figure 5.4 Conceptual Cleanroom plan

6 PHASE I RENOVATIONS TO BARUS & HOLLEY

Figure 6.1 Conceptual TEAL room

Phase I – Renovations to Barus & Holley

Barus & Holley was constructed in 1965 and expanded in 1990 with the addition of the Giancarlo Laboratories. It was the subject of a 2012 study commissioned by Brown and completed by Imai Keller Moore Architects (the IKM Study) that detailed needed improvements to basic building infrastructure. Since the completion of the IKM Study, an initial stage of infrastructure improvements has already been executed. These planned renovations will continue, with further upgrades to vertical services, mechanical, electrical and IT infrastructure, plumbing, and toilet rooms as outlined in the IKM Study anticipated to be completed in Phase I of the School of Engineering expansion project.

The IKM Study bracketed a range of long-term use scenarios for Barus & Holley. These ranged from mostly dry lab use on the low-intensity side—assuming the elimination of all existing fume hoods in the building— to a doubling of the number of existing fume hoods on the high-intensity side. A range of MEP system upgrade alternatives paralleled these program use scenarios. Because the original building utilized low-pressure ductwork and because the existing vertical shafts are limited in size, the use scenarios that require pushing significantly more outside air throughout the building trigger a more extensive mechanical distribution system, comprised of new medium pressure exterior duct risers at the four corners of the building.

It has since been determined that the most likely future use scenario falls somewhere between these two extremes. Because Phase I will not provide the School of Engineering with enough new lab space to relocate all research into the new building, Barus & Holley will continue to function as a research building, primarily for dry and hybrid use. Fume hood usage is expected to remain approximately the same as what exists today. This will be reassessed as the initial phase of expansion proceeds and as the School's research priorities continue to evolve.

Existing Conditions

Levels 2 through 7 of Barus & Holley are divided evenly between Engineering and the Department of Physics, with both entities occupying portions of each floor (Appendix E summarizes the precise makeup of each floor by researcher, department, lab type and approximate renovation history). A typical research floor is 19,600 gross square feet in area and is organized around a double-loaded racetrack corridor (Figure 6.2). Offices line the north and south perimeter of the building; service cores flank the east and west ends; and a large internal block of labs occupies the middle of the floor. A central utility corridor, accessible from either end, spans the lab block from east to west and divides the floor evenly into two halves. Currently, all vertical building infrastructure runs through this utility corridor. Access to daylight and exterior views is limited to the narrow windows in private offices and at the building's four corners.

Barus & Holley has not been comprehensively renovated in its lifetime. While individual labs have been renovated, frequently in conjunction with the arrival of new recruits, many spaces are essentially in their original condition, and as a result, many lab spaces are not efficiently utilized. The building's concrete masonry demising walls also hinder flexibility, with many lab groups inefficiently occupying multiple spaces that could be better consolidated if renovated. Student desks are typically located in converted private offices on the perimeter of the building and in many cases are not adjacent to lab spaces. The scarcity of windows or interior borrowed lights and the opacity of the concrete masonry block partitions render the program spaces impenetrable to public view. Aside from a departmental library/lounge, there are no social spaces on the research floors and few if any spaces for graduate students to small-group teach.

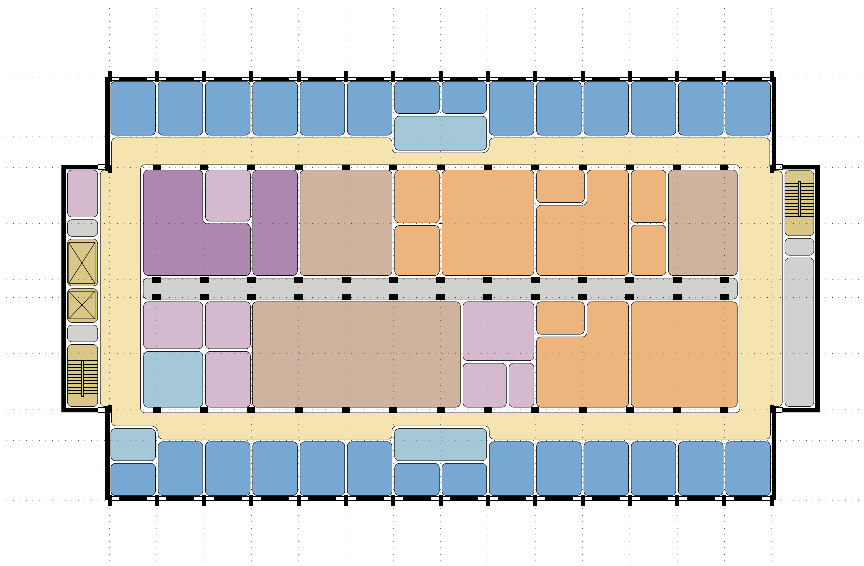


Figure 6.2 Existing typical lab floor

Figure 6.3 Proposed typical lab floor

CIRCULATION
VERT CIRCULATION
BUILDING SUPPORT
DRY LAB (EQUIPMENT)
DRY LAB (COMPUTATION)
WET LAB
LAB SUPPORT
OFFICE
STUDENT WORKSTATION
CONFERENCE
LOUNGE
ENTRY

Renovations to Upper Levels

Future research floor renovations should deal with both needed infrastructure improvements—such as new horizontal ductwork distribution—and basic improvements to efficiency and quality of life. Given the mild intensity of future fume hood use anticipated, a hydronic cooling system, such as that associated with chilled beams, could be implemented without lowering ceiling heights to unreasonable levels

The prototypical approach to a renovated floor could employ two basic planning concepts (Figure 6.3). The first concept is to connect the north and south sides of the building by creating openings through the utility corridor. While outright elimination of the utility corridor would be ideal, this is considered unlikely because it would require the entire building to be vacated for the duration of a renovation so that vertical services could be consolidated into one or more shafts. On the other hand, creating periodic openings through the utility corridor to connect the two sides may be feasible if the vertical services within the utility corridor can be locally clustered, floor by floor, in a phased renovation.

The second concept is to incorporate one of the building's two perimeter corridors into the lab zone. Private offices could be converted into open student workstation areas; the existing masonry corridor walls could be replaced with more flexible partitions, such as a transparent glass wall with sliding doors, to permit daylight and more visual connectivity into the lab areas beyond. The other side of the floor could remain largely unchanged. In conjunction with the first concept described above, this would effectively create a singular, highly flexible lab environment with close visual proximity between lab and office areas. Also, incorporating the corridor into the lab zone would increase the floor plate's overall efficiency.

To foster internal collaboration, both Engineering and Physics would prefer to migrate towards a model where each occupies three full floors in lieu of each sharing six floors (the Basement level will remain shared). The renovation of Barus & Holley should also be viewed as an opportunity to group faculty by discipline/area of research interest. Taking into consideration these idealized adjacencies (refer to the adjacency diagram in Section 3 of this Study), Figure 6.5 illustrates one potential model for stacking Barus & Holley post-renovation. This model proposes to consolidate Engineering on Levels 2 through 4 because these are the floors which are assumed to connect to the new engineering building via bridges. This model takes into account a preliminary list of faculty who would be relocated to the new building, and assumes that the renovation sequence would commence with Level 2 and continue upwards one floor at a time.

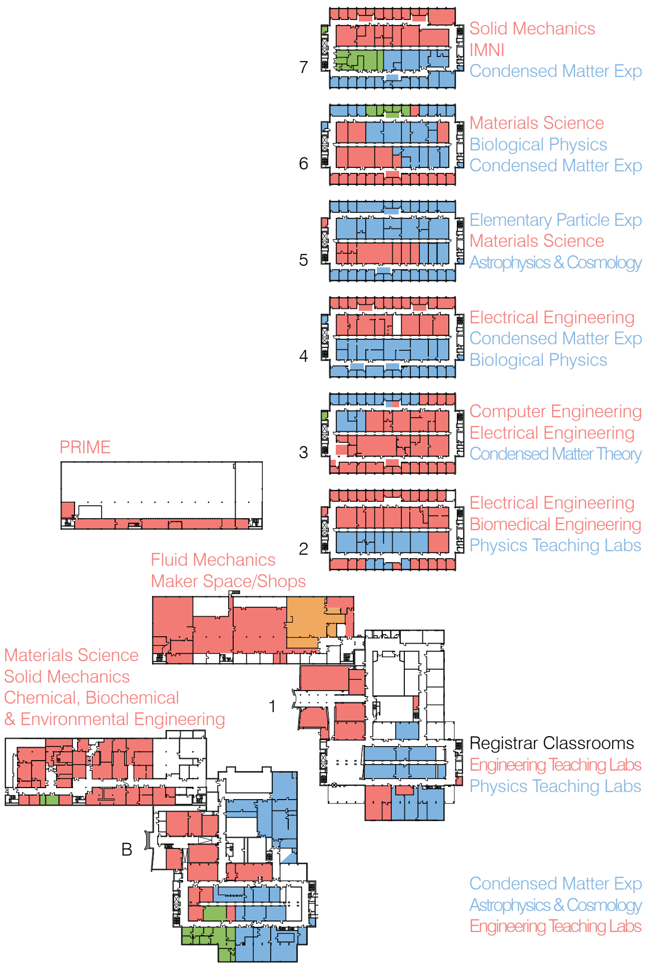


Figure 6.4 Existing stacking diagram

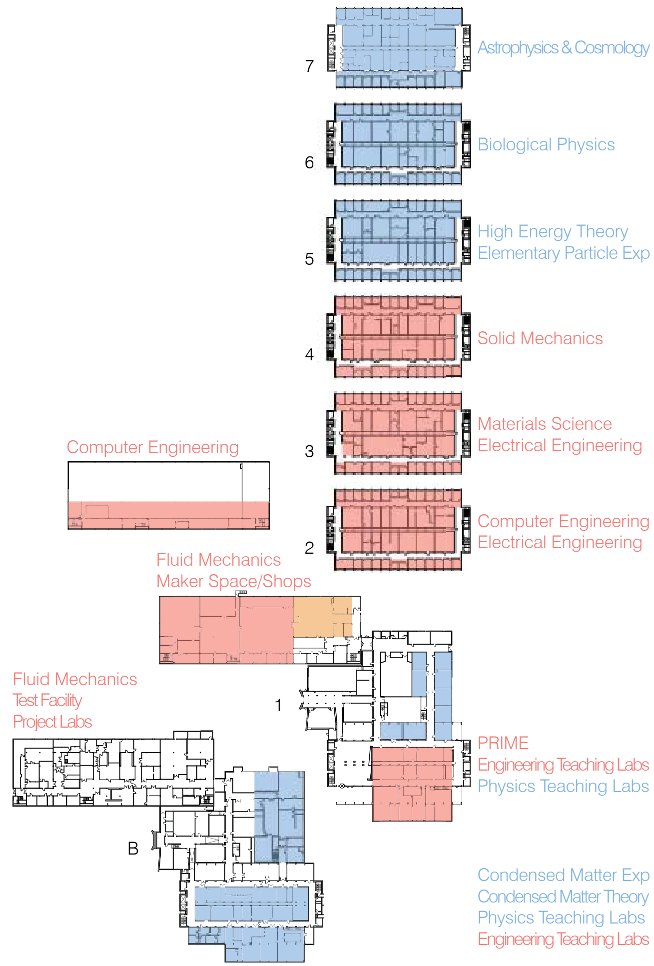


Figure 6.5 Proposed stacking diagram

Renovations to Ground and Basement Levels

The existing Registrar classrooms and Engineering teaching labs on the Basement and Ground levels of the Giancarlo Laboratory wing were constructed in 1990. No work is anticipated in these spaces.

Aside from the main lobby, the remainder of the Ground level of Barus & Holley is occupied by Physics teaching labs and highly utilized centrally-scheduled classrooms. The Basement level of Barus & Holley is comprised of a mix of un-renovated and recently-renovated research labs. The relocation of some existing faculty to the new engineering building, coupled with the relocation of the imaging facility to the new building, should create space vacancies on the Basement level.

Relocating the Physics teaching labs to the Basement Level could enable space in the central and southern portions of Level 1, behind the main lobby, to be renovated as a new suite for the Center for Entrepreneurial Innovation (CEI) (Figures 6.6 and 6.7). This location is considered highly desirable for CEI, one of the swiftest growing and exciting areas within Engineering, because of its public visibility.

Ideally, CEI would have a case study-type classroom available for its use. No such room exists on the block now. It would be difficult to construct such a room within Barus & Holley; these typically require stepped floors and ramps for accessibility, and it may be more cost-effective to provide this type of room in one of the future phases of new construction. In lieu of the case study room, CEI may be able to make use of a technology enhanced active learning (TEAL)-style classroom, which provides an alternative means of accommodating group-work and problem-solving sessions. Locating a TEAL classroom here, in a highly public and visible location within the building, would make it available for use by others as well. Two configurations are depicted in Figures 6.6 and 6.7. The optimum location for the TEAL classroom is in the center of the floor (Figure 6.6). However, this would require creating relatively large openings through the central utility corridor, which may or may not be feasible. This would need to be explored in conjunction with future planned alterations to the building's vertical infrastructure. An alternative location is depicted in Figure 6.7.

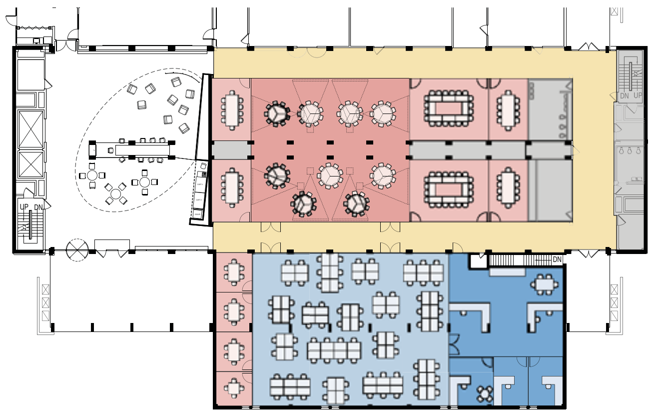


Figure 6.6 PRIME with central TEAL room

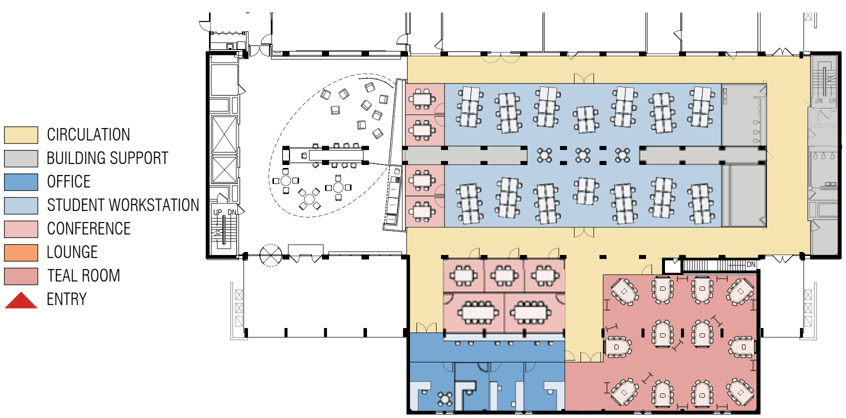


Figure 6.7 PRIME with central cohort room

Exterior Renovations

The IKM Study included provisions for exterior envelope repair for Barus & Holley. These were largely intended to address relatively minor window and precast concrete panel repairs. Similar to many buildings from its era, the building's structural concrete frame is exposed and not thermally broken to the interior. It is likely that this condition makes Barus & Holley one of the less energy efficient buildings on campus.

If Barus & Holley is gradually renovated for mostly dry and limited wet lab use as anticipated, it would be a good candidate for a hydronic HVAC system, such as chilled beam. Because the HVAC loads in these types of spaces are generally not driven by ventilation rates, the energy efficiency of the exterior skin will play a more significant role in determining the overall required capacity of the mechanical system. A more energy efficient skin (such as an insulated curtain wall applied over top of the exterior structural system) would translate into a smaller overall system size. A preliminary energy assessment conducted as part of this Study determined that the payback (installed cost versus difference in mechanical system cost plus calculated energy consumption savings) did not fall within the University's threshold for implementation, but this could be revisited if any of the major variables (such as the cost basis of energy) were to change significantly from 2013 rates.

7 PHASE I RENOVATIONS TO PRINCE LAB

Figure 7.1 Conceptual section perspective of Prince lab

Phase I – Renovations to Prince Lab

Prince Lab, constructed in 1962, has 57,000 square feet of laboratories, high bay space, shops and offices on two levels and a mezzanine originally intended to function as an observation gallery onto the labs below. It was built to support research in structure and materials, thermodynamics and fluid mechanics, and continues to house a wind tunnel facility. At 270 feet long and 90 feet wide, Prince occupies an unusually large footprint for the Brown campus. Prince has been ideally suited for the kinds of large-scale shop space that engineering schools have always had a need for.

Over time, as research space became increasingly unavailable in Barus & Holley, Prince accumulated more and more research labs on its Lower level. The result of these changes is that while initially conceived of as a building for large engineering instruments and equipment, testing facilities and shop spaces, Prince has been gradually adapted for wider uses, including high-technology, wet research and teaching labs. This trend has taxed the building's mechanical infrastructure to a point where a significant level of reinvestment will be needed if these high-technology uses are to remain. Because Brown has committed to accommodating such high-intensity uses in a purpose-built new engineering building, and will relocate most or all of the high-technology research labs from the Lower level of Prince into the new building, there is an opportunity to repurpose Prince again in a manner that better capitalizes upon its unique characteristics and attributes.

The key to making the most of this opportunity is to accept the fact that Prince should be a 'low-technology' 'workhorse' building. This calls for exercising a considerable degree of restraint in the planning, design and execution of modifications to the building so as not to overinvest in its systems, finishes and envelope.

Main Level

The Main level of Prince is currently home to a number of machine shop facilities, the engineering test facility, the student project lab and the thermodynamics wind tunnel facility. These occupy the sprawling expanse of the Main floor, with only partial height walls separating these different areas of use. Because there are no well-defined circulation spaces, however, the different program areas are not clearly differentiated from one another. Windows are positioned high on the wall in the triangular folds of the roof structure, precluding any views to the exterior, which contributes to this general sense of disorientation. On the other hand, visitors to Prince experience the Main floor as a singular, vast open space under a continuous roof structure. In spite of being relatively closed to the campus outside, inside Prince continues to effectively foster the impression of engineering occurring on a monumental scale (Figure 7.2).

The primary objective for the renovation of the Main level of Prince is to fill it with activities that encourage active student use.   While some of the existing spaces on the main level are oriented towards student use, such as the machine shops and project labs, many are not. Where possible, these kinds of uses should be relocated to the Lower level once the research labs on this level are vacated by faculty moving to the new building. Examples of existing uses that could be relocated to the Lower level include the Engineering Test Facility, which occupies a significant footprint on the Main level but is only used by a handful of individuals.

In their place, the Main floor should be reconfigured to accommodate student “maker”-type spaces (Figure 7.3). A maker space combines the various attributes of a shop, student project lab, prototyping lab and student club facility. In many ways, the Main floor of Prince is perfectly suited for these kinds of low-tech uses. Animated by the right kinds of student activity, its large open expanse could allow it to function as a beehive, affording visitors multiple vantage points from which to see engineering students at work. In the lower spaces under the south-side Mezzanine floor, an adjacent incubator lab could provide space for students to apply their research at more advanced levels and a masters student desk room could bring yet more student buzz into the building.

Given the specialized nature of the wind tunnel facility and the mechanical infrastructure that supports it, no modifications are planned for the west portion of the Main floor.

Figure 7.3   Conceptual maker space

Figure 7.2 Current Prince interior

Lower Level

The Lower level is currently home to an array of both high- and low-technology labs and shared facilities. Some of these will be relocated to the new building, freeing up space for existing uses, such as the Engineering Test Facility, to migrate from the Main floor above (Figure 7.5). The MEP plant has also recently been expanded on this level as part of the IKM Study recommendations.

A number of the existing uses on this level that should remain, like the Materials Science and Chemical Engineering Teaching Labs, are in need of substantial renovation. Other labs, particularly those at the west end, have recently been renovated for high-technology/wet lab use and remain generally suitable for this purpose. Alterations to the public circulation areas and common facilities (restrooms) are envisioned to be relatively modest in nature.

Mezzanine Level

Main Level

Lower Level

Figure 7.4 Existing Prince plan

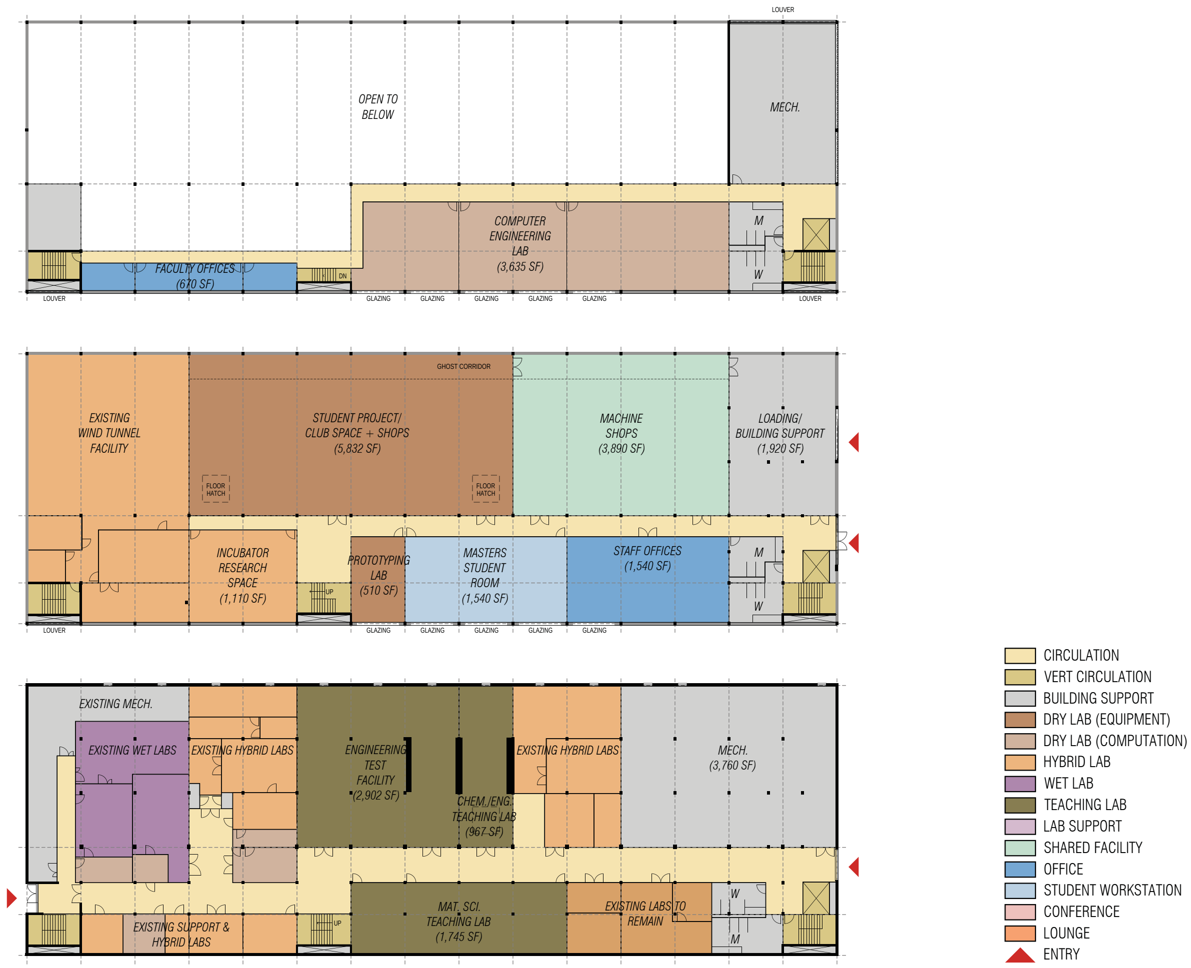


Figure 7.5 Proposed Prince plan

Mezzanine Level

The existing mezzanine extends a total of 216 feet along the south side of the building. It currently houses the Program in Innovation Management and Entrepreneurship (PRIME). Because the mezzanine is so narrow in width (13’-7”), the spaces along it, which include student desk areas and meeting rooms, need to be accessed in railroad car fashion. While daylight is admitted via clerestory windows in the folds of the roof structure above, these spaces only have views onto the shop floor below.

It is possible to consider enlarging the mezzanine by approximately 22 feet northwards to column line D (see Appendix B for detailed information). Preliminary indications are that this expansion could be accomplished without triggering significant foundation reinforcement (further geotechnical data would be required to validate the assumption). This expansion would add between 4,000 and 6,000 square feet of program space, depending upon the westward extent of the expansion.

While this alteration would cause the mezzanine level to be viewed as a second floor from a building and life safety code perspective, triggering fire rating and/or atrium provisions, it could provide enough added floor area and building depth to accommodate valuable dry lab use. This space could be particularly desirable for researchers who make frequent use of the shop facilities on the Main floor below, such as those involved in robotics work. However, because an elevator would be required to make this space accessible, further economic analysis will be required to validate the concept’s overall viability and to determine whether this level of intervention contradicts the dictum to not overspend in Prince.

Figure 7.6 Conceptual maker space

Exterior Envelope

The existing windows within Prince are of two types: large expanses of glazing within the folds of the concrete roof structure, and about 160 small windows embedded in the masonry infill wall at the Main level. While the high windows afford some measure of daylight, the lower windows are too small to provide adequate visual connectivity to the outside world.

One of the most significant qualitative alterations that could be considered in Prince is the selective replacement of the infill masonry with glazing along the building's south façade. This alteration would allow more daylight to enter the building, give occupants a completely new view of the campus (looking out to the new landscape space in front of the new engineering building), and expose more of the School's activity to view from the outside. Technically, this could be accomplished with relative ease in accordance with building code requirements by adding several braced frames to compensate for the removal of the building's existing lateral force resisting elements (see Appendix B). While this change would also require the expenditure of significant renovation funds, it would dramatically alter how users experience the building.

Another strategy that would make a noteworthy difference in the overall functionality of the building is the addition of a new entrance from the Manning Walk side. Prince is currently entered at its western end, along Brook Street, via a single door into the Lower level, or from within the Giancarlo addition of Barus & Holley. Neither entrance is inviting to the public. A new entrance from the Manning Walk side could substantially improve access to Prince from the other buildings on the block, and could underscore the public nature of the new programs within.

If this entrance is ultimately executed, the design of the new landscape space between Prince and the new engineering building should make it accessible to wheelchairs and other mobility-impaired persons. Currently, grade along the Manning Walk side of Prince falls midway between the Lower and Main levels.

Infrastructure

Renovation work in Prince may be limited to its eastern half, where it abuts Barus & Holley. This is because recent mechanical and electrical infrastructure upgrades have been consolidated in this portion of the Lower level, and because in the long term Brown may elect to remove the western portion of Prince to make room for a new building along Brook Street as part of a later phase of Engineering's expansion.

APPENDIX A ENGINEERING SCHOOL INTERVIEWS

Materials Engineering
December 5, 2012

Brown Faculty Present:
David Paine, Professor
Eric Chason, Professor
Haneesh Kesari, Assistant Professor
Sharvan Kumar, Professor
Chris Bull, Senior Research Engineer, Senior Lecturer
Nitin Padture, Professor

Brown Facilities/Staff:
Cheryl Carvalho, Manager, School of Engineering Services
Ginelle Lang, Planner

Payette:
Sarah Holton
Brian Spangler

Do you teach? Undergrads? 1-2 years or 2-4 years? Master Students? Grad students? In a teaching lab or classroom?

- Teaching commitments fluctuate consistently
- All faculty teach, most faculty teach all levels
- Experimental research faculty tend to teach classes with experimental activities (and utilize teaching labs)

Please describe the percentage of your time, and the average time of your group spent at the desk space, laboratory bench and at equipment.

- Expected: 45% teaching, 45% research, 10% service
- Faculty Typically teach 1 course per semester – 3 contact hours/week

Can you project what additional spaces, if any, will be required for your group in the future?

- More storage and space for PV panels, wind turbines, extended life battery research (renewable energy theme)

What are the current deficiencies in your space?

Infrastructure

- Need more fume hoods - Materials science (experimental) PIs all need at least 1 fume hood, also lots of glove box use
- Need chilled water. Water and power requirements are big problem- currently will cost $100,000 to put a chilled water line in- need to plan for the future to allow these types of cooling
- Need more flexibility with infrastructure- Reconfigurable services (gas, air, electric, data, etc)
- Need to plan for continuous expansion of equipment/ machines

Research lab needs

- Need to continue to have some high-bay research spaces
- Would be ideal to have cranes working again to move heavy material in Testing Facility
- Microscope labs need minimal vibration
- Labs need moveable benches/furniture
- Need to avoid locating near electromagnetic fields – currently use field cancellation
- Each faculty member needs a “nucleus”

- Need noise/vibration isolation in fabrication facility
- For 4 people, 600 NSF lab seems to be enough space- includes benches for 4 people
- Need flexibility for each professor/researcher to grow

Office and Amenity Space

- Central, common area is needed
- Need space to meet with visitors as well as common work areas (with screen, plugs, table for 4)
- Need informal meeting space
- Would like to see all materials student had a common area/space
- Need adequate grad office space- currently 4 students share office
- Faculty desire for some mixing of grad students by PI for cross fertilization
- Need to instigate more faculty/staff/student collaboration
    - Does not happen much - Only on entering/leaving people do you meet people
    - See Metcalf common space

What are desirable features in your current spaces that you would like to retain?

- Faculty offices adjacent to each other and their labs
- Graduate student offices near lab as well
- Differentiate between course labs and project labs
-

Do you use animals? What kinds?

- No

Who do you collaborate with and where? What are the most important adjacencies for your group now? How will this change in the future?

- Electrical Engineering
- Microelectronics

Are there core research facilities that you currently use and would need to remain near? What proximity is acceptable?

Need/Use 3 types of central facilities (Ideally these facilities would be located near each other)

- Characterization facility (X-ray, TEM)
- Processing facility (Microelectronics central facility/lab is both Processing and Characterization facility)
- Testing Facility (Energy is growing research area and generally takes up lots of space. Could we potentially use roof space (ex- for photovoltaics)
- Very important for researchers to continue to be located in same building as central facilities

Ideal Locations

- Mechanical Testing Facility- has equipment that might leak & creates vibrations- don't located sensitive labs below.
- Electron Microscope facility wants to avoid electromagnetic fields
- Clean room needs to be located in low vibration space
- The Materials Teaching lab has several capabilities that grad students use. (Microscopes/ polishing tools, etc) Students don't use central facilities very often.

How would you feel about moving to the Jewelry District? What are the pros and cons of this?

- Would be a challenge to separate teaching from research spaces
- Teaching component would have to stay on main campus, labs would go to Jewelry. This is possible but not ideal.
- The one benefit to moving to Jewelry District would be the potential to expand industrial collaboration (Industries would also use centralized facilities)

Individual Interview
December 5, 2012

Brown Faculty Present:
Joe Mundy, Research Professor

Brown Facilities/Staff:
Cheryl Carvalho, Manager, School of Engineering Services
Ginelle Lang, Planner

Payette:
Sarah Holton
Brian Spangler

Please identify your group and describe briefly the nature of your activities.

- Does smart office meeting room research
- Part of LEMS group
- Rarely uses machine shop (3 projects over 10 years)
- Does a lot of computing ("GPU Architecture")
- Complaints about noise – Loud voices/arguing

Do you teach? Undergrads? 1-2 years or 2-4 years? Master Students? Grad students? In a teaching lab or classroom?

- Mostly graduate students, very few undergraduates (if any, would be in the summertime)
- About 20 students per semester
- Usually teaches first year graduate students in classrooms (about 30 people)

Please describe the percentage of your time, and the average time of your group spent at the desk space, laboratory bench and at equipment.

- Varies depending on specific research
- Some students never require experimental setup, some have lots
- Some projects require large amount of space (i.e. video wall)

Can you project what additional spaces, if any, will be required for your group in the future?

- Transfers software to sponsors (Lockheed Martin), would like to use Amazon cloud
- Video feeds taken, analysis done on the video feeds- Would like to have studio where they can set up 4D video simulations (~60 cameras)

What are the current deficiencies in your space?

- Need a combined meeting room / lab
- Need more space for experimental equipment
- Equipment stays indeterminately, lots of extra equipment (common storage area?)
- In general, short on storage
- Doesn't have a significant amount of collaboration
- Doesn't use existing faculty lounge (724/723) because it's not an inviting space, Wouldn't use a faculty lounge anyway
- Suggests 10'-0" ceiling height, minimum
- Office space is small, would like blackboard and small visitor table and office to be 50% larger. Office is currently BH351 (~162sf)
- Meets with up to 3 students at a time

What are desirable features in your current spaces that you would like to retain?

- Multiple ways of using the meeting room space
    - Professors meet with students as a group every few weeks, meet with students individually more regularly
    - Uses meeting room to meet with students and to take exams
    - Meeting room used to host customers and/or sponsor(s)
    - Meeting room used as laboratory from time-to-time

Are there spaces that you have interacted with either on or off campus that might be particularly successful, and that provide a 'model' for what you would like to see in your space?

- Would like to have a multi-use space/lab/construction area with moveable partitions
    - Niskyuna NY, GE building good example of moveable partitions

Who do you collaborate with and where? What are the most important adjacencies for your group now? How will this change in the future?

- Need more informal meeting spaces, Most people go off campus (Starbucks and Bookstore Café) for informal meetings/collaboration
- Collaborates with electrical sciences group
- Mostly e-mail contact, periodic meetings in person
- Sometimes goes to applied math building – Not a big barrier since building is close

How would you feel about moving to the Jewelry District? What are the pros and cons of this?

- Would not want to travel between Jewelry district and main campus

Individual Interview
December 5, 2012

Brown Faculty Present:
Harvey Silverman, Professor, Former Department Chair

Brown Facilities/Staff:
Cheryl Carvalho, Manager, School of Engineering Services
Ginelle Lang, Planner

Payette:
Sarah Holton
Brian Spangler

Please identify your group and describe briefly the nature of your activities.

- Split between computer /electrical engineering & programming (with more focus more on the programming side)
- Students work at desk stations
- Does a lot of building – Constructing electronics/electromechanical - lots of noise
- Uses microscopes to see small parts

Do you teach? Undergrads? 1-2 years or 2-4 years? Master Students? Grad students? In a teaching lab or classroom?

- Current semester - 3 PhD , Independent Study, A few masters students
- Undergraduates are mostly juniors and seniors

Can you project what additional spaces, if any, will be required for your group in the future?

- Encourage group projects and interdisciplinary activity

What are the current deficiencies in your space?

- Needs a dedicated room for microphones / sound testing
- Would like to have more project "construction" space
- Need more storage for parts - metals, plastics
- Need first-class electronics construction facility
- Needs more workbenches
- Need dedicated areas for projects – Currently share space
    - Pre-project development is key - use many shared facilities in this step.
- Would be nice to have discussion alcoves with:
    - Public blackboards
    - Public announcements
    - Digital boards

What are desirable features in your current spaces that you would like to retain?

- Grad student desk needs to remain near lab/project area
- Faculty office near lab is key

Who do you collaborate with and where? What are the most important adjacencies for your group now? How will this change in the future?

- Uses machine shops downstairs for large projects
- Uses rapid prototyping for electronics
- Machine shop in Prince
- Building lab in Barus & Holley
- Speech recognition
- Biomedical (97 Waterman)
- Computer engineering
- Electrical engineering
- Advanced baby imaging lab- but minimal experimentation with infants – Happens at hospital downtown

How would you feel about moving to the Jewelry District? What are the pros and cons of this?

- Being part of the central campus is key
- Student access to advisors/professors is critical – School is small enough to do that
- Declare major not until end of sophomore year, until then students taking classes everywhere
- Cooperative, collaborative environment on college hill campus
- All students in first 2 years take courses all over campus
- Prince Lab located on the campus well, but does not accommodate needs well. A new building on this site should be explored

Solid Mechanics
December 6, 2012

Brown Faculty Present:
Rod Clifton, Professor Emeritus
Haneesh Kesari, Assistant Professor
Allan Bower, Professor
Tom Powers, Professor
Pradeep Guduru
James R. Rice, Associate Professor
Janet Blume, Associate Professor

Brown Facilities/Staff:
Cheryl Carvalho, Manager, School of Engineering Services
Ginelle Lang, Planner

Payette:
Sarah Holton
Brian Spangler

Do you teach? Undergrads? 1-2 years or 2-4 years? Master Students? Grad students? In a teaching lab or classroom?

- Faculty teach all levels (undergrad, grad., post-doc.)
- Teach in research labs and lecture halls/classrooms

Please describe the percentage of your time, and the average time of your group spent at the desk space, laboratory bench and at equipment.

- Spend 3-7 hrs. teaching/ week
- Spend 2-10 hrs. offices hours/week
- Periodic day-long meetings with students for projects in labs
- Regularly meet grad. students and advisees

If applicable, how many people are in your group? What is the composition of the group (number of grad students, Post-docs, staff etc.)?

- 30 students total
- 15 post-docs
- Normally at 10-11 faculty members (3 or 4:1 ratio)

Can you project what additional spaces, if any, will be required for your group in the future?

- Need a 'flexible' classroom; One with the ability to accommodate both lecture and group style teaching
- Potentially need separate space for sound/motion recording/capturing – Studies in this area are expanding
- Fume hoods should be located in all experimental labs in the future
- How to get "Off Campus" to become "The Campus"
- Need infrastructural "plug-and-play" - Modular / flexible organization
- Have graduate instructional lab space separate from undergraduate instruction
- Restricted access needed at the graduate level
- Foresee increasing collaboration with chemistry

What are the current deficiencies in your space?

- Need more experimental area
- Need space for undergraduate and independent research spaces – Graduate students should be co-located with these spaces.
- Current multi-media room good size for undergraduate research

- No common areas or meeting spaces
- Formal and informal space needs
- Need a space to showcase work
- Need offices for visiting professors and post-docs
- Need infrastructural upgrades and flexibility (outlets, cooling, etc.)
- Carpet creates static electricity and damages equipment; Should be removed
- Lab space needs to be multi-functional
- Space needs character – How can you tell this is an engineering facility?
- Need a "good amount" of additional classrooms
- Want to increase interaction between students and other departments on campus and in the building
- No space for students to break from their work space, informal "hang-out" space (specifically graduate students)
- Grad students and post-doc office space should either be in the lab or very close
- Need more overall lab/project research space
- Faculty offices should be in neutral or casual spaces to encourage interaction
- Need spaces to meet with 10-20 students out of the lab
- Studio classrooms (192) can work and lecture
- Particularly difficult to setup temporary demonstrations/projects
- Flexible teaching spaces (scheduling and physical flexibility)
- More ways to easily interact with other faculty/students
- Need conference rooms for contract reviews and phone conferences
- Space for short-term visitors (1 day / 1 week) No place to meet or entertain them
- Need space for big student groups in shops
- Problematic that Formula 1 club is far from campus
- High-bay space may be necessary from time-to-time, but not a large area

What are desirable features in your current spaces that you would like to retain?

- Graduate student/TA accessibility
- Faculty are accessible to students – "Open-door" policy
- Like ad-hoc space like Prince Lab

Are there spaces that you have interacted with either on or off campus that might be particularly successful, and that provide a 'model' for what you would like to see in your space?

- Northwestern – Ford Center for Design
- Need Lots of space for group projects – Visibility is key - 3rd floor of Science Library – Collaborative space
- Brandeis
- Rensselaer

Who do you collaborate with and where? What are the most important adjacencies for your group now? How will this change in the future?

- Mechanics and Materials labs a critical adjacency
- Students from both depts. share labs
- Micro (nano) fabrication
- Electron Microscopy
- Mechanical Testing
- Fluids (Tom)
- Physics (Tom)
- Applied Math (lowest priority)
- Research shouldn't be separated from teaching labs
- Work with bio-mechanics/biomedical engineering a lot, need access to wet labs

Are there core research facilities that you currently use and would need to remain near? What proximity is acceptable?

- Micro (nano) fabrication facilities (needs to be same building / adjacent building)
- Electron Microscopy (needs to be same building / adjacent building)
- Mechanical Testing (needs to be same building / adjacent building)
- Having a shared, dedicated instructional lab would be useful

How would you feel about moving to the Jewelry District? What are the pros and cons of this?

- Separating teaching and research would be difficult, but possible
- Would prefer to be on main campus
- Undergraduate student experience is crucial

Computer Engineering
December 6, 2012

Brown Faculty Present:
Ruth Iris Bahar, Professor
Pedro Felzenswalb, Associate Professor
Ben Kimia, Professor
Sherief Reda, Assistant Professor
Gabriel Taubin, Associate Professor

Brown Facilities/Staff:
Cheryl Carvalho, Manager, School of Engineering Services
Ginelle Lang, Planner

Payette:
Sarah Holton
Brian Spangler

Can you project what additional spaces, if any, will be required for your group in the future?

- Could use separate space for sound/motion recording/capturing

What are the current deficiencies in your space?

- Not enough experimental area
- Undergraduate and independent research space should be co-located with graduate research space students
- Current multi-media room good size for undergraduate research
- Security issue with equipment
- No common areas or meeting spaces
- Formal and informal space needs – Should be separate from the faculty office area
- Flexible space needed
- Need a space to showcase work
- Need space for visiting professors and post-docs, specifically offices
- Want to increase interaction
- Need informal meeting spaces
- No space for students to break from their work space, informal "hang-out" space (specifically graduate students)
- Need to anticipate issues with infrastructure (outlets, cooling, etc.)
- Carpet creates static electricity and it damages equipment
- Lab space needs to be multi-functional and flexible
- Need ability to accommodate multiple teaching styles
- Space needs character – How can you tell this is an engineering facility?
- Need a "good amount" of classrooms
- Students like the "fishbowl" idea
- Want to increase physical interaction and collaboration
- Feel they don't think they fit the identity of the school
- Don't like the term "theorist"
- Undergraduate students need to be extremely accessible to faculty/TA's

What are desirable features in your current spaces that you would like to retain?

- Graduate student/TA accessibility to students

Are there spaces that you have interacted with either on or off campus that might be particularly successful, and that provide a 'model' for what you would like to see in your space?

- Computer lab 191 works well – Need a common computer lab for collaboration
- Science Center 3rd floor is a good model for meeting/informal space
- Basement of science library is good model for collaborative computer lab
- CS building – Has character, spaces are nice to work in

Who do you collaborate with and where? What are the most important adjacencies for your group now? How will this change in the future?

- Use multi-media lab (archaeological simulation project)
- Interested in collaborating/communicating the work that is happening in the comp. sci. department across the University
- Visual / Creative Arts Center
- Medical School
- BIBS
- Applied Math (critical)
- Computer Science
- Cognitive Science (critical)
- No spontaneous interaction with hospital downtown, but work with hospital downtown from time-to-time

Does your group share instrumentation or support space with other groups? Please specify the types of spaces (tissue culture, microscopy, etc.)

- Microscopy

Are there core research facilities that you currently use and would need to remain near? What proximity is acceptable?

- Microscopy (Biomed)
- "The Cave" (Visualization Facility)
- MRI (3 TMR in Sidney Frank, for medical imaging)
- Used intensely, infrequently
- Computing Cluster

How would you feel about moving to the Jewelry District? What are the pros and cons of this?

- Faculty who teach in different departments or buildings – Would be difficult for them to go back-and-forth
- Don't mind teaching anywhere on main campus
- Graduate student/TA availability
- Students need to be near grad./TA's
- Undergraduates need adjacency to the lab

Electrical Engineering
December 6, 2012

Brown Faculty Present:
Alex Zaslavsky, Professor
Rashid Zia, Assistant Professor
Jimmy Xu, Professor

Brown Facilities/Staff:
Cheryl Carvalho, Manager, School of Engineering Services
Ginelle Lang, Planner

Payette:
Sarah Holton
Brian Spangler

Do you teach? Undergrads? 1-2 years or 2-4 years? Master Students? Grad students? In a teaching lab or classroom?

- Typically teach one undergraduate and one graduate course per semester

Can you project what additional spaces, if any, will be required for your group in the future?

- Need mechanical preparation hood (room with hoods). Can be relatively small
- Limited meeting space – need more

What are the current deficiencies in your space?

- Needs lab and student office spaces near each other – Faculty offices don't necessarily need to be adjacent to lab
- Limited power – Need lots of outlets and capacity and capability to move outlets frequently
- Intermittent power outages damage equipment
- Exhaust/pressurized gas needs
- Ceiling clearance needs to be a few feet more than they have now
- Recommend RFID on doors
- Larger, Reconfigurable spaces would be beneficial
- Short on teaching classrooms
- Dedicated space for laser (large space)
- Some equipment could be in a semi-public space because it is used frequently
- Would be nice to have a showcase lab where sponsors can be enticed by the fact that their research will be on display during development
- Teaching and research should not be in two locations
- Faculty set up demonstrations – Make it difficult to travel

Are there spaces that you have interacted with either on or off campus that might be particularly successful, and that provide a 'model' for what you would like to see in your space?

- Notre Dame
- Cornell

Who do you collaborate with and where? What are the most important adjacencies for your group now? How will this change in the future?

- Materials Science
- Biology
- Biomedical
- Geology
- Applied Math
- Industry partners/sponsors

Are there core research facilities that you currently use and would need to remain near? What proximity is acceptable?

- Use electron microscopy frequently
- XRD used, but infrequently
- Would like to have semi-public space where commonly used machines can be used
- Need much bigger clean room – should be "showcase" space
    - Use vibration sensitive equipment
    - Litho room needs to be much larger
    - Need chemistry room
    - Need at least 2 processing rooms (10 pieces of equipment 4 x 4 with associated pumps etc. per processing room)
    - Ideally cleanroom and microscopy are adjacent

Interview with Past/Current Deans
December 6, 2012

Brown Faculty Present:
Larry Larson, Dean, SoE
Rod Clifton, Former Dean, Emeritus Professor, SoE

Brown Facilities/Staff:
Cheryl Carvalho, Manager, School of Engineering Services
Ginelle Lang, Planner

Payette:
Sarah Holton
Brian Spangler

General Questions:

Overall comments on the status of the School.

- Brown Engineering is disproportionately small compared to Ivy League peers; Dartmouth is closest to Brown in terms of size. Brown Engineering needs to grow to be competitive.
- Prince built in 1960, Barus & Holley built in 1965. Equipment and buildings antiquated
- Engineering should be an integral part of the university

Can you project what additional spaces, if any, will be required for the school in the future?

- Hazardous materials are increasingly becoming present
    - Exhaust, fume hoods, BSC's, etc.
- Growth in "Energy and Environment"
    - "Green" chemistry – Making the manufacturing of creams, etc. process environmentally friendly – i.e. Find a process that makes a certain chemical compound that does not emit toxic gases, whereas the current manufacturing process emits toxic gases
- Needs for teaching laboratories that are at a more sophisticated level
- Increasing student interest in design projects
- Visual arts connection?
    - Similar fabrication needs
    - Video walls, 3D caves
- Faculty growth needs to be considered
- Previous planning models have been anticipating the following:
    - 48,000 – 50,000 GSF
    - 50% Faculty growth (25 faculty plus dean's office)
    - 175 SF per faculty office
    - 800 SF of lab space (junior faculty) – 2,000 SF of lab space (senior faculty)
    - 75 grad students (projected growth) (Assumed 50 sf /grad office)
    - 20 post docs (projected growth) (Assumed 80 sf/ post doc office)
- Need for new Nanofabrication facilities
    - Cornell is a good model

What are the current deficiencies in the school?

- As size of machines/equipment go down, cost goes up. Shared facilities play an important role
- Nano / atomic scale will be critical
- Liked modular concept at Northwest
    - Had infrastructure that anticipated growth
    - Allowed spaces to expand/shrink according to needs
- Not enough space height to accommodate needed utilities
- Instructional Labs
    - Never want more than 15:1 ratio

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Continued from page 87.

Are there spaces that you have interacted with either on or off campus that might be particularly successful, and that provide a 'model' for what you would like to see in your space?

- KAUST (King Abdul University for Science and Technology)
    - Good core facilities model
- Cornell
    - Good nanofabrication facility model

Who does the school collaborate with and where? What are the most important adjacencies? How will this change in the future?

- "Research has changed" - Stronger, critical connection to life sciences (biology)
- Physics
- Chemistry
- Computer science
- Applied Mathematics
- Geology
- Social sciences and archaeology should/could be related, but not well connected now
- Civil engineering is getting phased out (Will fall into chemical and bio-chemical engineering)

How would you feel about moving to the Jewelry District? What are the pros and cons of this?

- Critical to keep new building on main campus
- '93 plan shows physical sciences growth extending toward campus green- good model
- Proximity is a key factor in collaboration

Staff
December 6, 2012

Brown Faculty Present:
Peter Murphy, Asst. Manager of Administration
Nancy Carroll, Chief Administrative Officer
Douglas Wilkie, Manager of Research and Finance
Gordon Morton, Manager of Communications
Tony McCormick Manager of Electron Microscope Facility
Barbara Simoneau, Systems Programmer
Priscilla Ruscito, Grants and Contracts Coordinator
Tina Trahan, Executive Coordinator
Stephanie Gesualdi, Administrative Assistant
Sandra Van Wagoner, Administrative Assistant
Diane Felber, Administrative Assistant
Jonathan Galli, Assistant to the Dean

Brown Facilities/Staff:
Cheryl Carvalho, Manager, School of Engineering Services
Ginelle Lang, Planner

Payette:
Sarah Holton
Brian Spangler

What are the current deficiencies in your space?

General
- Would be really helpful to have all adminstrative office together in suite with space for shared printers, faxes, etc.
- The School admin. suite should have a front-person / receptionist
- Administrative assistants need to be near faculty they serve - not in suite
- Space would ideally be removed from high-traffic areas
- Need conference rooms! (several different sized rooms) Need for small conference rooms to meet casually with 1-5 people
- Need better social spaces for staff
- Parking is limited, this is a challenge
- Need Storage for
    - Chairs
    - Gen. meeting room needs
    - Instructional equipment, Podia, Movable furniture
- Large Conf. room for larger events like retreats (a little larger than Rm. BH190)
- Kitchenettes are necessary – Need more
    - Grad. students currently use BH190 kitchenette
    - Kitchenettes need Frig., Microwave, sink at minimum
    - Access control an issue – Some kitchenettes get trashed
    - Need separate or larger kitchen services for functions and staff
- Students have to submit homework outside of class
    - This happens in boxes on the floor in the hallway, would be better in suite

Confidentiality and privacy is an issue for admins. writing e-mail or talking to people on behalf of school administration

Student Affairs (services)
- Need direct access to student foot traffic
- Need for private rooms for consultation/interview

IT
- Students need a computer station within IT space to use while getting help
    - Need storage for paper, printers, files, hardware, monitors, CPU's, desks
    - Server room could be remote from IT offices/work stations but close enough for daily checks. Needs raised floors and to be able to accommodate growth
- Need computer lab for students to share / work in
    - No carpet in computer lab areas for dust/dirt control

Communications
- Needs storage space for publications
- Photo equipment
- Would be great to have a meeting space in the building before student tours

Shipping & Receiving –
- Need better loading dock/ shipping /receiving area – No "dock" currently exists
- Problematic when deliveries assume building has a proper dock, and there are added delivery costs to get truck with lift
- Office with window so you can see approaching trucks
- Stock room would have to be larger if building were in Jewelry district

Electron Microscope Facility
- Electron Microscopes need to be located in areas of least vibration, usually basements

Individual Interview
December 11, 2012

Brown Faculty Present:
Arto Nurmikko, Professor, Engineering

Brown Facilities/Staff:
Cheryl Carvalho, Manager, School of Engineering Services
Ginelle Lang, Planner

Payette:
Sarah Holton
Brian Spangler

General comments:

- Currently has space in Barus & Holley (mostly physical science research with lasers and electronic devices) and in MRL and Bio Med Center (brain science research- with animals, live/active cells).
- 2/3 of research is focused on Brain Science which is a significant source of funding
- Difficult to bring any brain science work to Barus&Holley- wasn't designed for animal research
- Uses Central Facilities- Electron Microscope Facility, Microelectronics Facility and Imaging facilities (MRI in Sidney Frank) for testing implanted devices
- Collaborates heavily with John Donoghue/BIBS (brain science research)
- Would like to see new structure on campus - personal preference to relocate parking lot and create new integrated building for physical and bio sciences
- Research aspect could move to Jewelry district however the educational mission would be compromised- students currently gain by being immersed within Social Sciences- creates broad minded students
- Small geographic area of the school creates college hill community- unlike MIT or UC Berkeley

How many people are in your group? What is the composition of the group (number of grad students, Post-docs, staff etc.)? Do all of the people in your group get dedicated space? How do you see this changing in the future?

- 4-5 graduate students and post-docs in the Nurmikko research group
- Has 3-4 undergrads per year, currently has 2 (These would be senior students doing thesis work)
- Overall has 20 people (including support staff)
- Grad students have desks
- Need a common place for students to gather outside the lab, "a collective home"

Can you project what additional spaces, if any, will be required for your group in the future?

- Biomedical engineering is growing fast- including neuroengineering

What are the current deficiencies in your space?

- Lack of clean space, labs with appropriate infrastructure
- Difficult to bring brain science work to Barus & Holley, so research group is split between several buildings

Do you use animals? What kinds?

- Research labs are mostly within B&H, but there are also a couple of labs in Biomed Center Building (5th Floor) where research on monkeys is performed. Research Space is owned by BioMed/BIBS, not Engineering (in space J.Donoghue vacated when Sidney Frank was occupied)
- Has a lab in MRL (semi-life science building) where rat and mouse work is completed, but he cannot house animals at the MRL, have to transport animals back to Animal Care building
- Rats are carried back and forth in black box from Animal Care Facility to research labs
- Small animal storage at B&H, carry animals back-and-forth to Biomed Center, would like animal facility adjacent to where the work is performed
- Performs surgery (implanting devices/probes) on rats and mice in the MRL (rodent facility)
- Implant devices that work with the cages, cages in B&H are proxy cages used to test the implant devices
- Makes devices to probe brain circuits. 1st- test on bench in Barus&Holley, then often test on rats on 2nd floor of Barus&Holley but usually test in lab in MRL with rodents. Finally do research on Monkeys. Monkey research- expensive, logically challenging.
- Animal Imaging- device implant work in monkeys needs access to MRI facilities- use Sidney Frank Building

Are there any spaces or buildings (at Brown or elsewhere) that you think are a good model for the kind of spaces you think Brown should have?

- Italian Institute of Technology
    - 6-story building near Genoa
    - Engineering and BIBS combined
    - Multiple layers of program designed to have full integration with materials, electrical, and biomedical engineering

Who do you collaborate with and where? What are the most important adjacencies for your group now? How will this change in the future?

- Strong ties to neuroscience/brain science - ideally located next to BIBS in future
- Strong ties to physical sciences as well- A.Nurmikko has dual appointment with Physics and Engineering
- Works with hospital, clinicians come to Brown for meetings
- Teaches students getting degrees in:
    - Biomedical
    - Electrical
    - Chemistry
    - Physics
    - Neuroscience

Are there core research facilities that you currently use and would need to remain near? What proximity is acceptable?

- Wants more proximity and integration with animal facilities
- Characterization and advanced measurement facilities
- Microelectronics- critical to build new facility
- Electron microscopy

Joe Liu & Kenny Breuer
December 11, 2012

Brown Faculty Present:
Joe Liu
Kenny Breuer, Associate Dean

Brown Facilities/Staff:
Cheryl Carvalho, Manager, School of Engineering Services
Ginelle Lang, Planner

Payette:
Sarah Holton
Brian Spangler

General Comments:

- Needs quiet place to work
- Liu: Teaches about 44 grad. students in Rm. 163, would be nice to have a bigger room
- Liu: Does not teach in any of the lab spaces
- Wind tunnel facility is a cost center
- Ecology and evolutionary biology use wind tunnel – Can fly animals in the wind tunnel
- Research space:
    - Wanted to be near wind tunnel
    - Needs dark, quiet, vibration free space
    - Has micro-fluids lab (don't want windows)
    - Wind tunnels need access to the space where experiments are performed
    - Could have more space
- Possible to move wind tunnels
- Two wind tunnels and fluids tester make up the Fluids Testing Facility
- Bats live in animal care facility in Biomed
- Likes the current suite setup
- Students who work in the space work on the 300 level
- Would like to have large, collaborative lab space
    - Hatsopolis fluids lab in mechanical engineering at MIT (in building 2), good model for collaborative lab
    - Good example of common, but private space
    - Frank Center at Univ. of Chicago (physics and chemistry)
    - Johns Hopkins Univ. used by Mech. Engineering, Robinson Hall?
    - Big, open area with common research and projects
    - Offices and labs occupy perimeter
- Need quiet, dark, private space
- Instructional space:
- Project area 222
    - Has small student wind-tunnel
    - Students should be able to work/build next to machines
    - A bit crowded
    - Students can come and go and keep their project in the room
    - Hours designated for group work
    - All engineering in this space (250 engineering students)
    - Wind turbines, cars in disrepair
    - No good place to keep projects in progress
    - Areas could be divided by use and machine type
    - Layout should be reconfigurable
    - Need more cabinets, for student storage cabinets
    - Students complain about no group meeting space for clubs and project groups
- Need more space for informal interaction and meeting
- Current layout is not designed for increased interaction
- Dean in the Lobby – Ways to get students to talk to administration
- Grad. students want office spaces – Would like to see grad. students mixed; Not necessarily divided by PI
- Ph.D. students tend to be "holed up" in labs
- Works with:
    - Physics
    - Evolutionary biology
    - Solid mechanics
    - Applied math
    - Physics
    - Geosciences (Geophysical) (would like to expand this connection)
- Would be problematic to move away from evolutionary biology

- Would prefer to have undergraduate teaching in the Jewelry district (if research were there)
- Campus should expand, not just have a research park
- 5 faculty focusing on fluids
    - Would like to expand
- Wouldn't push to have animal facilities in bioengineering/engineering facilities
- Micron fluid mechanics
    - Needs micro-fabrication (is currently inadequate, needs to be at least four times bigger)
- Need two fabrication facilities
    - (1) High-end sub-micron scale
    - (2) Utilitarian, lower resolution micro fabrication (gets heavy use by fluids group)
    - Same needs as bio-med engineers
    - Could have separate clean room (with bio-med), doesn't have to be ultra clean
- Does not like that certain people have had to create their own capabilities rather than sharing capabilities, leads to lots of unnecessary duplication of facilities

IMNI
December 11, 2012

Brown Faculty Present:
Bob Hurt, Professor of Engineering
Kim Cavanaugh, Manager of Finance & Administration, IMNI
Charlie Vickers, Manager, JEPIS
David Paine, Professor of Engineering
Bill Paterson, Senior Research Engineer
Sue Prendergast, Assistant Director of Research Opportunities, IMNI
G. Tayhas Palmore, Professor of Engineering
(Unknown)
(Unknown)

Brown Facilities/Staff:
Cheryl Carvalho, Manager, School of Engineering Services
Ginelle Lang, Planner

Payette:
Sarah Holton
Brian Spangler

General Comments:

- IMNI 4 facilities
    - Electron microscope facility
    - Electronics fabrication facilities
    - Nanotools facilities (virtual facility), equipment distributed in labs (XRD part of this)
    - JEPIS machine shop
- Users of electron microscopy
    - Chemistry
    - Physics
    - Geology
    - Archaeology
    - Biomed
- Want to consolidate facilities, master fabrication characterization facility
- IMNI does primarily research service
    - Helps faculty with proposals, need adjacency to faculty offices
    - Students also involved with paperwork
- Researchers bill time, research center cover costs, researchers enter account numbers
- Not a big undergraduate presence in IMNI
- Would be nice for startup space to be near research space
- Startup space would be great to have symposium space
- Entrepreneurship should be near engineering facilities
- Would like to have capacity to harbor start-up entrepreneurship efforts
- Work with U. of RI – Shared facilities with other universities?
- Need quick, informal meeting space
- Biomedical and micro-electronic fabrication growing
- Need proximity to research grad. students' offices
    - Would like to follow the main core of the research activity
    - Could see satellite offices elsewhere in order to accommodate other program
    -
    - Need to be near chemistry and physics
- Micro-electronic fabrication has specific ventilation needs

Machine shop

- Engineering
- Physics
- Biomed
- Neuroscience
- Plant operations
- Are a cost facility, charge an hourly rate
- Shop used primarily by car team, brown facilities, etc.
- Engineering use is heavily on the research side
- Unsure about whether shop could be separated from research efforts
- Student shop currently overseen by Brown faculty at low cost, once students are trained, not much need for Brown paid staff, would have to be staffed if shop were available to undergraduates
- Nothing in place to train engineering students on machine shop

- Like having students get direct support, students forced to work with other students in other disciplines to be able to get access to the machine shop
- If fabrication shop were off site or in two places, it would be hard to trouble-shoot problems
- Physical space of the shop works very well
- Would like to see upgrading of existing equipment; no change to footprint
- Main shop vs. student shop
- Use crane extensively, but needs repair
- Space doesn't have to be as high; Recommends 12'-15' ceiling height
- Lights are too high in the space
- Ideally car team would be near shop
- Use CNC heavily
- Assembly of parts done at other facility

Nano-tools

- Primarily research efforts
- Wet FM for biological research
- Has general materials research grants
- Needs space for core facility- currently tools are in researcher's labs
- Works with chemistry
- Has lots of new equipment and technology
- Would like to display this new equipment as a marketing tool
- Visitors/sponsors want to see research in action

Clean room

- Photolithography area is too small, would like to replace aligner with higher resolution capability (needs another 4'x4' space)
- Wants to target Class 10 for lithography area; currently between 1 and 200
- Room has not been in balance for 3 or 4 years
- Class 1000 would be good around most of the tools during use
- Vibration is not an issue right now; currently float lithography tools on air table; new lithography tool would be self-contained with self-floating mechanism
- Researchers come from:
  - Predominantly research (grad.) work, some undergrads. (4-5) doing honors work, Physics (50%), Engineering (50%)
  - Biology (some consistent use)
- Mostly preparation of things like micro-channel structures, structures for growing neurons and cell cultures

Chemistry (Palmore)

- New center for chemical innovation
- Measures strain and polymer films (had to be moved to the building, interference with elevator)
- Does synthesis
- Runs research lab with grads. and undergrads.
- Does not need much core facilities
- Need autoclave
- Spectroscopy, microscopy, fabrication
- Would like to consolidate facilities with IMNI
- Students could get trained to use equipment, would not have to hire faculty to run consolidated facility
- Consolidate equipment with special needs, un-clutters labs, open bench space
- Teaches some undergraduate courses and would like to have lab work for this (classes of 12 or so students)
- Needs chemical hoods (currently have (5) 4'-0" hoods, would like to have (8) 4'-0" hoods)

Adjacencies:

- Engineering
- Chemistry
- Use clean room
- High-res microscopy
- Does biological work (no animals, all cell culturing)

Biomedical Engineering
December 11, 2012

Brown Faculty Present:
Leigh Hochberg, Associate Professor of Engineering
Anubhav Tripathi, Co-Director, Center for Biomedical Engineering
Sean Deoni, Assistant Professor of Engineering
Christian Franck, Assistant Professor of Engineering

Brown Facilities/Staff:
Cheryl Carvalho, Manager, School of Engineering Services
Ginelle Lang, Planner

Payette:
Sarah Holton
Brian Spangler

General Comments:

- Center for Biomedical Engineering composed of the following research focus areas:
    - Biomechanical
    - Biology medicine
    - Neuroscience
    - Biophotonics
    - Biotransport
    - Tissue Engineering/Regenerative Medicine
    - 30 faculty amongst all areas
- Biomedical Engineering is interdisciplinary research- goes beyond engineering
- Need space to attract and retain faculty
- Researchers are open to sharing labs
    - Contamination issues potentially – Each would have own freezers to hold infectious diseases

How many people are in your group? What is the composition of the group Do all of the people in your group get dedicated space? How do you see this changing in the future?

- 50 PhD students
- 8 or 9 dedicated faculty now, many more collaborating faculty

Can you project what additional spaces, if any, will be required for your group in the future?

- Have a need for surgical suite
- Need biotechnology lab
- Want central lounge/informal space, Coffee shop!
- Future space should be allocated for clinical research
- Need dedicated masters facilities/labs/offices
- Need rooms for robotics, computers, spontaneous meeting space, data security, space security, open facility may cause security challenges
- Would like to have some biomechanical labs, very short on lab space for the various areas on biomedical
- Need dedicated IT support for BME, local processing of data would be beneficial
    - Analyzing neural data (imaging)
    - Typically 500 GB per day from a person with electrode nodes connected to brain

What are the current deficiencies in your space?

- Need more capstone design & testing in a laboratory space
- Short on teaching labs/facilities
    - Don't have any lab/core support spaces nearby, but need it
    - Would want to accommodate 20-25 students
    - Need for lots of equipment

Do you use animals/ live subjects? What kinds?

- Mice, rats, monkeys,
- Children (Baby Imaging Lab)
    - Currently image on average (15) 3mo.-5 year olds per week
    - Use Sidney Frank MRI facility
    - Scan from 7pm – 2am
    - Babies staged in the hall - major security issue
    - Space needs to be secure for parent

- Need to move sleeping babies
- MRI suite can be pretty far from day-to-day lab, ideally would be located closer
- Babies come back for follow-up appointments, need space for that
- No parking for parents
- The concurrent study BIBS Planning study may also address these needs as it is planning for an additional MRI Facility.
- The needs of the Baby Imaging Lab may not be able to be covered within the scope of the Engineering Study. Ideally they would be addressed in the Sidney Frank building.

Are there any spaces or buildings (at Brown or elsewhere) that you think are a good model for the kind of spaces you think Brown should have?

- Good Biomed case study: Case Western, University of Penn
- Yale Biomedical building/department has good resources

Questions to understand critical adjacencies and constraints

Who do you collaborate with and where? What are the most important adjacencies for your group now? How will this change in the future?

- Would like to be located near Brain Science research (BIBS)
    - Willing to go to Jewelry district
    - If research would move off of main campus, space for masters students would go with research
- Works heavily with VA and several area hospitals. These relationships will grow
- Having proximity to clinical professionals is critical, fosters a different type of successful research
    - If Biomedical Engineering stays on hill, arrangements must be made for clinical staff and patients to visit more easily
- Researchers also work with
    - Applied math
    - Computer Science
    - Cognitive Science
    - Neurology
- Biomedical engineering connects “big-time” to industry
    - Boston is 2nd biggest bio-tech hub
    - Next generation biotech lab could attract industry sponsors/donors

Core facility needs:

- Bioinformatics cluster, would like to have a local cluster from a control stand point (working with patient sensitive data)
- MRI
- Microfabrication
    - Clean room (Harvard and Cornell are good models)
    - Bio-cleanroom should be separate but immediately adjacent
    - Currently outsource biochip production
    - Need to make medical-grade, certifiable devices, currently engage outside companies to produce prototypes
- Robotics/Prosthetics core
- Need access to small animal care facility
- Non-human primate facility – Have had several new faculty applicants request need for this facility, particularly in neuro-engineering
- Would like BSL-2 facility/suite
    - Uses blood from human donors
    - Need a facility to handle this

Chemical, Biochemical and Environmental Engineering
December 11, 2012

Brown Faculty Present:
Robert Hurt, Professor of Engineering
Eric Suuberg, Professor of Engineering
Indrek Külaots, Professor of Engineering

Brown Facilities/Staff:
Cheryl Carvalho, Manager, School of Engineering Services
Ginelle Lang, Planner

Payette:
Sarah Holton
Brian Spangler

General Comments

- Like the idea that the school is under one roof
- Would like to retain the low barriers between the disciplines; No "silo" departments
- Accommodate computing folk and experimentalists
- Grad. student offices in the lab (no dedicated office space)
- Could see shared labs with PI specific support spaces adjacent
- Do not need autoclave, tissue culture (like bio…)
- About 3 dedicated faculty members, some others are involved in multiple departments

How many people are in your group? What is the composition of the group? Do all of the people in your group get dedicated space? How do you see this changing in the future?

- CBE has approx.15-16 undergrads per year; 10 grad students. per year
- Work with lots of grad students from Chemistry. They sit in CBE's space even while enrolled as Chemistry major.

What are the current deficiencies in your space?

- Instructional lab is not functional for instructional purpose
- Environmental research is growing
    - Hiring of environmental folk with Chem. E. focus would go in Hunter?
    - Hunter does not have enough fume hoods for this purpose
- Need fume hoods and biosafety cabinets for instructional and research uses
    - Currently have (4) 5'-0" – 6'-0" fume hoods
    - For a typical 600 SF lab, would desire (2) fume hoods
    - Typically use small quantities of toxic materials

What are desirable features in your current spaces that you would like to retain?

- Research labs should be adjacent to undergraduate teaching labs to share equipment between teaching and research efforts, also shared fume hoods (model works for small group)
- Ability to move between instructional and research space would be ideal for small CBE group
- If research were separated from teaching, would be difficult to transport equipment back and forth
- High percentage of Chemical Engineering undergrads do a semester or summer-long research effort – Facilities being together is ideal

Are there any spaces or buildings (at Brown or elsewhere) that you think are a good model for the kind of spaces you think Brown should have?

- Chemical Engineering building at MIT, open plan for chem-engineering

Who do you collaborate with and where? What are the most important adjacencies for your group now? How will this change in the future?

- Connections to Materials, Chemistry, and Pathology
- Want more interaction with Environmental Science
- Have connections to Ship St. through block grant with Molecular Medicine
- Would like more industry connections (Draper labs in Cambridge wants energy research center)
- Does not use plate impact which is nearby CBE faculty, does not need to be near Rod Clifton in future
- Collaborators:
    - Environmental Science
    - Chemistry (used to use X-Ray Diffraction [XRD])
    - olectron Microscopy
    - Analytical facilities in Geochemistry Building
    - Materials Science
    - Pathology (Ship St. grant)

Are there core research facilities that you currently use and would need to remain near? What proximity is acceptable?

- 90% of the grad students use Engineering's central facilities (XRD, microscopy, etc.)
- Shared cores labs/hubs would have to continue to be staffed and centrally managed
- Would be great to consider creation of porous and powder material characterization core

Graduate Student Council
December 13, 2012

Brown Students Present:
Brandon (4th yr. PhD, computer vision)
Dan (2nd yr. PhD, solid mech.)
Steve (2nd yr. materials)
Ginkinn (5th year biomed)
Vineet (3rd year, Mtls Eng.)
Megan (Chemical, Env.)
Dave (3rd year PhD Biomed)
Joe (Post-Doc, Physics)

Brown Facilities/Staff:
Cheryl Carvalho, Manager, School of Engineering Services
Ginelle Lang, Planner

Payette:
Sarah Holton
Brian Spangler

Comments on Public Spaces:

- Would like break rooms separate from lab space
- Common meeting room needs:
  - Large table
  - Kitchenette: Microwave, Frig., Sink, Coffee
- 3rd floor of CIT building is a good office example
  - Offices at perimeter
  - Common spaces at the core
- Want windows!
- Want smaller study rooms, do lots of computing
- Students working at Ship St.
  - Huge time management logistical challenge
  - Very difficult to schedule time
  - Covered bike racks are critical – Use bikes frequently
- Need showers
- Group space in Sidney Frank works well – Can come right out of lab space and relax / find a quiet place
- Need lots of electrical / data outlets in common areas
- Want informal meeting alcoves in hallways with white boards, people walking by can break out a discussion

Comments on Research Spaces:

- Like to have desk space separate from lab, can bring food/drink into the lab space
- Wouldn't use desk as much if it weren't next to lab or attached to lab
- Like the fact that a separate office offers some noise isolation
- Like having group space with people working on similar work
- BH 646 / 650 is a good lab/office setup
- 511 is a poor example
- Want grounding rod in every room
- Against large group offices because of frequent meeting with undergrads.
- Some hold office hours in lab
- LEMS lab has a separate conference room for undergrads. to meet with TA
- Want to keep TA space separate from grad. offices
- More work table space (Multi-media lab doesn't have enough space)
- Need space for storage of in-progress projects
- Having advisor near grad. students is critical
  - Hard to catch the professors
  - Students like to be able to quickly see when professors are available
- "Separate, but close"
- Like seating outside
- CIT has nice break-out space with foosball, ping-pong, etc.
- Like breakout spaces in Metcalf (Half open lounge / half enclosed room with glass wall)
- Need a space to accommodate the Monthly Graduate social
- Need at least 9'-0" ceiling height
- Need device in classroom (like pulley) to lift equipment

Individual Interview
December 13, 2012

Brown Faculty Present:
Larry Larson, Dean, School of Engineering

Brown Facilities/Staff:
Cheryl Carvalho, Manager, School of Engineering Services
Ginelle Lang, Planner

Payette:
Sarah Holton
Brian Spangler
Peter Vieira

General Comments:

- Fabrication of work is done outside university because it's expensive
- Collaborates with Arto Nurmikko, computer engineering (Iris, Sharif, etc.)
- Faculty & research hires
    - 25 faculty hires in the next 10-15 years
    - ½ would be 1st year associate faculty
    - ½ would be Assistant/Associate Professors
    - Thinks almost all faculty will be experimentalists in the future
    - Bio and environmental areas will see the most growth (will double and triple in next 10-15 yrs.)
    - Electronics and mechanics will see minimal growth
    - Can't hire until new building
    - Some new hires will go to Hunter (MRL)
    - 2012 hires will max. out the School of Engineering, will have to hold off on new hires until new building is built
- Experimental work will be increasingly computational
    - Fabrication work will happen in big, core facilities across the country
- Shared core space will be an increasingly large fraction of what the school does
    - Clean room, Nanotools, XRD, TEM/microscopy, Mass Spec., etc.
    - NNI/NSF – Setup coordination mechanism so universities can collaborate, universities develop a specialty
    - IMNI folk would have best insight into creating a national lab hub at Brown
- Faculty teaching is taken very seriously, focus on spending time with students
- Would like to see engineering disciplines centered together, as opposed to the current condition
- New building should have some historical tie to the university, like the Dynamo house
- Key thing with alums. and donors is to communicate a historical tie
- New building
    - Flexible, low maintenance building
    - Easy to re-configure
    - Lasting feel (50 – 100 yrs.)
    - Liked visibility
- Entrepreneurial initiative is very important
- 2010 Plan for growth
    - 30% growth on 44 faculty (11-12 faculty)
    - 9 New faculty by end of Phase 2 (tenure / tenure-track faculty)
    - 3 tenure/tenure-track per research faculty
    - 2-3 new research faculty
    - John and Larry paper assumes this growth plus the growth of BIBS
    - 9 from engineering / 3 from BIBS
- 2012 Plan for Growth
    - 50 % growth
    - Would like to see all of BIBS and all of Engineering (difference from 2010 ideas)
    - Provost would like to see one big building versus small building
    - 10 biomedical engineers
    - Connection to bio is critical, but also connected to other disciplines
- Has strong ties to Physics, wouldn't want to break that tie
- Physics, Computer Science, Applied Math., Chemistry are critical ties
- Connection to hospitals for BIBS group are critical
    - Parking issues need to be resolved in order to attract test subjects
- Need conference center for about 300-500 people, seated auditorium, could split into multiple conference rooms
- Against having animal care facilities in the new building
- Does not like staged phasing because small groups move at a time and get isolated, those that get left behind must be thought of
- Difficult for fundraising if scope of multiple, staged projects would be too small
- Too much to expect the entire school would go down to JD
- Faculty want to stay on the hill and they will need to be convinced there is no more space on campus
- Biology and medicine have much lighter teaching loads than those in engineering, engineering has much higher undergraduate involvement, Ship. St. model does not work for engineering, could work better for brain science/BIBS because they don't have robust teaching loads

Individual Interview
December 11, 2012

Brown Faculty Present:
Barrett Hazeltine, Adjunct Professor, Former Chariman, Engineering

Brown Facilities/Staff:
Cheryl Carvalho, Manager, School of Engineering Services
Ginelle Lang, Planner

Payette:
Sarah Holton
Brian Spangler

General comments

- Previously taught electrical engineering, now teaches a university-wide course in management (largest course in the university, open to all students)
- Lectures 3 times a day each Tuesday and Thursday
- Doesn't like traveling across campus to multiple buildings
- Would be better if university had more rooms with 100 + seats for lectures
- Uses Rm190 in Giancarlo when it is available
- Engineering going towards projects and group work, students collaborate more
- Lobby in B&H has been a space for students to work together
- Basement of Science Library is good model for collaborative space
- Teaches "Appropriate Technology"
- Helpful to be near metal working shop for this
- Students work on group projects
- Promotes entrepreneurship heavily
- Bader Spring is a successful incubator downtown
- Horizontal cross-fertilization
- Mostly students at the graduate level involved in start-up, but some younger groups also
- Believes current quality of space is very low
- Would like to see the car project brought back on campus, was a good marketing space for prospective students
- Rapid Prototyping Facility would be a good marketing space, but it is not very public
- Ease of scheduling flexible and informal meeting space is key
- Flexibility to accommodate new teaching methods
- Flexible displays
- Flexible benches
- Studio-type learning (several groups, lecture in the middle)
- Local projector screens

Can you project what additional spaces, if any, will be required for your group in the future?

- Need nicer meeting spaces, conference rooms (Can be embarrassing to host sponsors)
- Retired faculty want a place where they can be a part of the university
- Meet with colleagues
- Assist with research
- A dedicated, larger suite or lounge
- Yale has an older building dedicated to retired faculty

What are the current deficiencies in your space?

- Could use more storage space for experimental and instructional equipment

Are there any spaces or buildings (at Brown or elsewhere) that you think are a good model for the kind of spaces you think Brown should have?

- University of Colorado did a nice job of making labs attractive and accessible
- Questions to understand critical adjacencies and constraints
-

Who do you collaborate with and where? What are the most important adjacencies for your group now? How will this change in the future?

- Never gets to see other faculty, current faculty lounge is not used
- Too far away
- No amenities in the lounge

Individual Interview
December 13, 2012

Brown Faculty Present:
Andy Peterson, Assistant Professor, Engineering

Brown Facilities/Staff:
Cheryl Carvalho, Manager, School of Engineering Services
Ginelle Lang, Planner

Payette:
Sarah Holton
Brian Spangler

General comments:

- Research is based on trying to catalyze the conversion of renewable resources into fuel sources
- Uses explosion proof enclosure for experiments
- High pressure, high temperature experiments, uses water as medium
- Thinks interaction with students is good
- Currently teaches an undergrad. class of 18 students
- Goes to lab between classes – Would not be ideal if research was separated from teaching facilities
- Likes living near campus and being able to walk into work

How many people are in your group? What is the composition of the group (number of grad students, Post-docs, staff etc.)? Do all of the people in your group get dedicated space? How do you see this changing in the future?

- Would like capacity for 8 people in lab
- Currently some people have desks in lab in Prince, others in space in Arnold- not ideal
- Office immediately adjacent to lab is good idea – Would like a larger office space

Can you project what additional spaces, if any, will be required for your group in the future?

- High-performance computing will be an increasing need
- Would like more meeting space
- Believes CBE needs more wet-bench biology-related facilities

What are the current deficiencies in your space?

- Would like larger sink
- Hood limitations, would like floor-to-ceiling hood

Are there any spaces or buildings (at Brown or elsewhere) that you think are a good model for the kind of spaces you think Brown should have?

- Imperial College (London), laid out well

Who do you collaborate with and where? What are the most important adjacencies for your group now? How will this change in the future?

- Wants to be near other CBE researchers
- Collaborates with Chemistry frequently, travels to chemistry building, meets researchers in labs
- Uses Applied Math's supercomputer, but accesses remotely
- Would also generally like to be near Physics

Are there core research facilities that you currently use and would need to remain near? What proximity is acceptable?

- Uses XRD
- Shared UCMS, planning to use Mass Spec.

Programming Interview: Undergraduates
December 13, 2012

Brown Students:
Steven , Mech. Eng. , Senior
Ryan, Mech. Eng., Senior
Max, Master's, Solid Mech.
(Unknown)

Brown Staff:
Cheryl
Ginelle Lang

Payette:
Sarah Holton
Brian Spangler
Peter Vieira

General Comments:

- Liked the close distance between the engineering school and the rest of the campus (like liberal arts)
- Community was very important, like how engineers interact amongst each other
- Liked discussion outside of concentration
- Moving to Jewelry District would be a 'disaster'
- Think the computer lab is the heart and social center in Giancarlo addition
    - Go here for the software
    - Can use it any time of the day
    - Best feature is that you can see outside
    - Mostly undergraduate use, minimal grad. use
    - Eating in computer lab is a critical aspect
- Would like more seating in the B+H lobby, like the bar style seating
    - Can't really do group work in the space
    - Need plugs for computer work
    - Data ports
- Need meeting areas where you can make noise
- Student machine shop
    - Lots of student groups use that space
    - Like the tool room
    - Lots of heavy work benches
    - Hard to find a space to leave projects in Prince – Need storage
- Tokwatten (Car team space)
    - Shared with Creative Arts
    - Difficult to transport parts
    - Too far!
    - 20 min. walk to get from campus to the building
    - Engineering van to get from campus to building very helpful
- Need ventilation in classrooms
- 190 is a good room for smaller events, a little less formal than lecture halls
- Like sliding black-boards, need multiple sliders
- Need for a large lecture hall (200-250 student capacity)
- 3rd floor science library is a good modular space
- Take about 1-2 classes outside of the major per semester
- Labs usually happen in afternoons, spend time in computer lab, etc.
- Classes often at different times of the day
- Adjunct elective classes in the evening
- Computer lab is used heavily because it is located in transient zone, students often use it between classes
- More instructional computer space would be nice, would also be nice to have more instructional computer courses
- All lectures taught by faculty
- Like informal meeting alcove in hallway, have blackboards on the wall in the corridors
- Faculty offices need to be easily accessible

Continued on page 104.

Continued from page 103.

- Declare major at the end of the sophomore year
- Have a lot of transition in and out of engineering program
- Undergrads. don't need lab space near where office hours are held
- Not many inter-disciplinary courses, maybe 2 or 3 for upper-year undergrads.
- The future will integrate multiple engineering disciplines
- Science tours:
    - B&H
        - Congregate in lobby, move to Giancarlo addition
        - Move into Prince Lab, take them through shop space
        - Don't show clean room
- Don't really use rapid prototyping lab
- Having a "home base" is key
- Bike racks aren't usually full
- Durability of the spaces (character?)
- Like the idea of glass corridors, like the "Fishbowl" lab
- Like the exposure of the clean room at Harvard's Pierce bldg.
- Like offices in upper floors of CIT

APPENDIX B ODEH ENGINEERS STRUCTURAL SKETCHES AND NARRATIVE FOR PRINCE MEZZANINE EXPANSION

1223 Mineral Spring Avenue
North Providence, Rhode Island 02904

odeh engineers

September 23, 2013

Mr. Peter Vieira, AIA, LEED AP
Associate Principal
Payette
290 Congress St. Fifth Floor
Boston, MA 02210

RE: Prince Laboratory

Transmitted via email (pvieira@payette.com)

Dear Peter:

Per your request, we have prepared this structural design narrative for the proposed renovations to the south exterior wall and mezzanine extension in Prince Laboratory at Brown University.

Standard of Care and Use of Report

Please note that the results of this investigation are limited to visual observations of the accessible areas of the building as well as a review of the original architectural and structural drawings titled "Physical Science Center Brown University" issued October 31, 1960 by Sherwood, Mills and Smith Architects. While we have made our best efforts to investigate the building structure, many conditions were concealed by architectural finishes or were otherwise inaccessible, and therefore additional damage or other unforeseen conditions not included in this report may be present. The findings of this report therefore represent our best professional opinion based on the information available to us at this time. This report is for use by Payette to understand the scope and rough order of magnitude of pricing of structural work required for the proposed renovations.

1 GENERAL STRUCTURAL CRITERIA

1.1 Building Description

Prince Laboratory was constructed around 1960 as an engineering and physics laboratory building. The building has a full basement level and one main floor above grade with high-bay lab space. The floor slabs and columns are primarily constructed out of reinforced concrete. There is also a mezzanine level above the main floor level that is currently used as mechanical space and office space. This mezzanine extends one bay (13'-7") from lines F to G on the south side of the lab and runs 12 bays from lines 2 to 14 (216'-0") in the east-west direction. The north edge of the mezzanine is supported by 4"x 1 ¼" hangers at 18 inches on center. Each hanger is welded to a C12x30, which is tied to a 14 inch by 12 inch concrete column with 4 #6 longitudinal bars at #3 ties at 12 inches on center by an L4x4x1/4. W12x36 members span between the concrete columns on the south edge. The slab has total thickness of 10 ½ inches with a nine inch deck. Based on the architectural plans, the exterior walls of the building are constructed out of 8" concrete masonry units.

This narrative is based on schematic design drawings prepared by your office and sent to us via email on September 16, 2013. Based on this information, we understand that the project will comprise the following key elements:

- Alternate 1: The mezzanine in Prince Lab will be extended north to grid line D between grid lines 7 and 14. In this alternate there is no change to the existing mezzanine between grid lines 2 and 7. Full height glazing will replace the south exterior masonry wall between grid lines 7 and 12 (5 bays total).
- Alternate 2: The mezzanine in Prince Lab will be extended north to grid line D between grid lines 2 and 14. Full height glazing will replace the south exterior masonry wall between grid lines 2 and 6 and grid lines 7 and 12 (9 bays total)

All structural design criteria for the building will be based on the building codes and standards listed below, and by criteria specified by the owner and architect.

1.2 Building Codes and Standards

1.1.1 State Building Code

- Rhode Island State Building Code - SBC-1, 11th Edition (IBC 2012 with amendments), and its referenced standards.
- Rhode Island State Rehabilitation Building and Fire Code for Existing Buildings and Structures – SRC-1, 2002.

1.1.2 Industry Reference Standards

- American Concrete Institute, "ACI 530-08 Building Code Requirements for Masonry Structures"
- American Institute of Steel Construction, "Steel Construction Manual, Fourteenth Edition"
- American Institute of Steel Construction, "Design Guide 11 - Floor Vibrations Due To Human Activity"
- American Concrete Institute, "ACI 318-08 Building Code Requirements for Reinforced Concrete"
- American Society of Civil Engineers, "ASCE 7-10 Minimum Design Loads for Buildings and Other Structures"

2 STRUCTURAL SYSTEMS

2.1 Extended Mezzanine Floor Framing

In Alternate 1, the mezzanine floor will be extended to grid line D between lines 7 and 14 and in Alternate 2 the mezzanine floor will be extended to grid line D between lines 2 and 14. In each alternate new steel framing will be required to support the extended mezzanine area. New lines of steel framing will be required along lines D and F in the bays of the mezzanine extension. North-south beams spaced 9'-0" on center will frame between lines D and F. Since new beams and girders frame into the existing concrete columns along line D, these columns may require reinforcement with new steel plates.

Prior to proceeding with final design, the concrete in these columns, as well as the basement columns below the mezzanine, must be tested for strength as part of the next phase of this project in order to determine the amount of reinforcement required. The existing hangers between the roof and the mezzanine will be removed and the top of the existing steel channel member along line F will be cut to create a flush top of slab in the effected bays. New steel columns will be added along line F below the extended mezzanine. A composite slab on metal deck will be poured in the new mezzanine areas.

2.2 Lateral Force Resisting System

In Alternate 1, full height glazing will replace the south exterior masonry wall between grid lines 7 and 12 (5 bays total) and in Alternate 2 full height glazing will replace the south masonry wall between gird lines 2 and 6 and lines 7 and 12 (9 bays total).

While the existing structural design drawings do not explicitly indicate a lateral force resisting system, it is our professional opinion that the existing masonry walls act to resist lateral loads (wind, seismic, and crane loading) in the longitudinal direction of the building plan. Thus, if these walls are removed, there will be a loss of capacity in the lateral force resisting system. We believe that such an alteration to the structure is permitted by the applicable building code for this project, provided that sufficient reinforcement of the existing structure is provided to ensure that the overall capacity of the lateral force resisting system is not diminished, and is capable of resisting the prescribed wind and seismic loads in the code.

Therefore, in order to compensate for the reduction in capacity due to the removal of the existing masonry infill walls, we recommend that a new structural steel bracing system be introduced to supplement the remaining elements of the lateral force resisting system. Based on our current understanding of the proposed scope of work, we believe that the following approach can be implemented to satisfy the requirements of the building code while allowing for the removal of the existing masonry walls (refer to attached structural sketches for referenced grid lines and illustrations of the bracing system):

- For Alternate 1: Introduce new steel braced frames along line D, at lines 8-9 and 11-12. These braced frames will consist of X-bracing from the roof to the basement, 3 stories total. Along the roof, collector elements must be introduced in order to transfer the lateral forces from the existing concrete roof into the new braced frames. The collectors may be comprised of triangular steel assemblies formed by three steel beams. Each assembly will sit flush with the underside of roof and be mechanically anchored into the roof concrete. These collectors will be required in each bay from line 6 to 13. New lateral bracing will also be required along line G. New steel cable braces will be added directly behind the glazing between lines 7-8 and 11-12. Steel HSS tube frames will be attached to the faces of columns and the foundation wall to surround the new cable braces. The cables will attach to the existing beams at the mezzanine level along line G, which will require reinforcement with steel plates. Collector elements at the roof will be required along line G similar to line D.
- For Alternate 2: In ADDITION to the new braced frames, cable braces and collector elements added in Alternate 1, add two more braced frames between lines 3-4 and 5-6, and two more cable braces between lines 2-3 and 5-6. New collector elements for Alternate 2 will be required from line 1 to line 13 along lines D and G.

2.3 Foundations

Based on the original structural design drawings, we believe that the existing foundation system for Prince Lab consists of interior spread footings and continuous perimeter wall footings. This office performed a preliminary evaluation of the existing foundation capacity to support the proposed new mezzanine construction and alterations to the lateral force resisting system described above. For the purposes of this evaluation, we assumed that the soil has an allowable bearing capacity of 4000 psf, however additional exploration must be performed as part of the next phase of this project to confirm this assumption and also to identify any other potential geotechnical considerations related to the proposed scope of work.

Based on the presumed bearing capacity and the proposed architectural changes, the spread footings subject only to additional gravity load appear to have enough capacity to support the additional gravity load from the mezzanine expansion without reinforcement. However, spread footings supporting columns at new braced frame locations on line D will likely require reinforcement. Refer to attached structural sketches for grid locations. Reinforcement may include new concrete added adjacent to and above the existing footings. At this time it does not appear that reinforcement is required at the existing south perimeter foundation along line G.

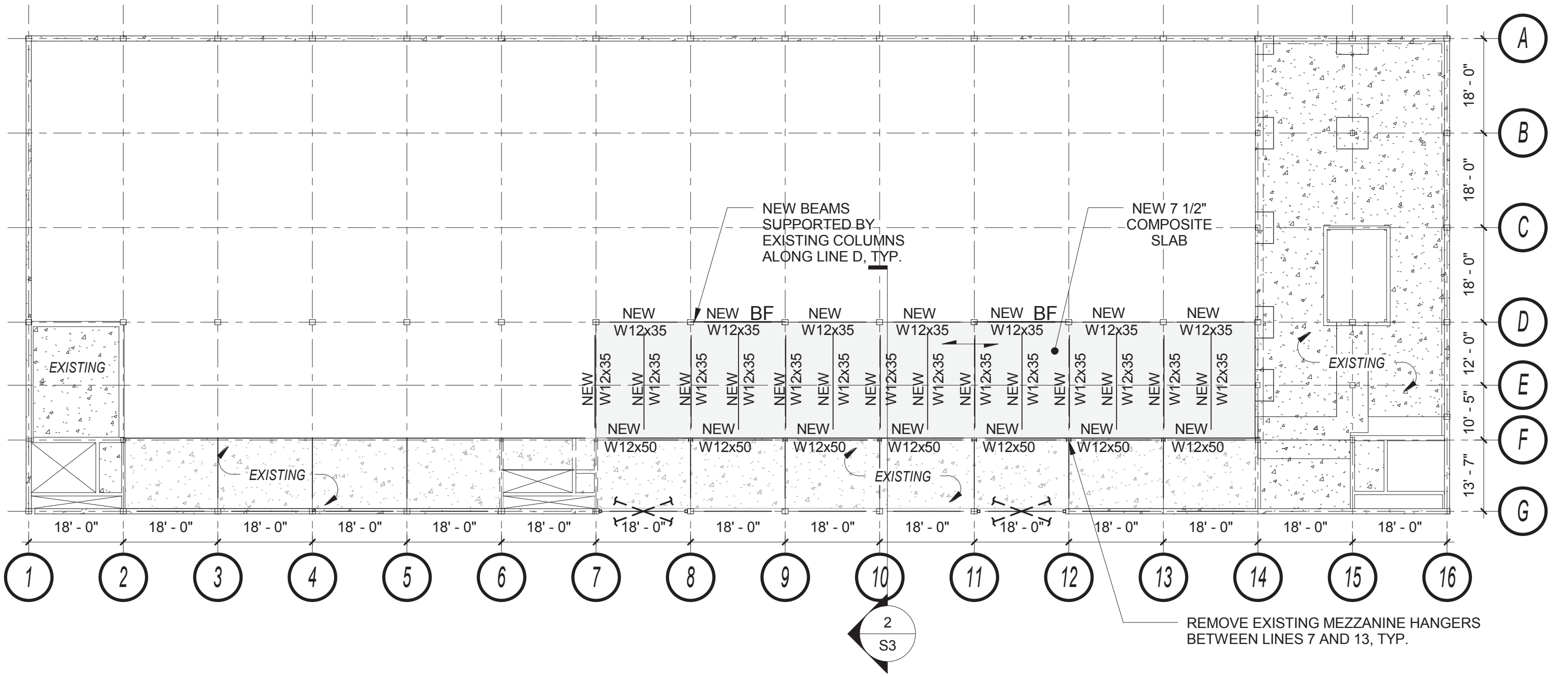
Please refer to the accompanying "2013-09-23 Prince Lab Proposed Renovations Structural Sheets" document for an illustration of the structural modifications described in this narrative as well as more detailed information about the approximate sizes of steel members required.

Should you have any questions or require additional information, please do not hesitate to contact this office at 401/724-1771.

Sincerely,

Julie Marton, EIT
Project Engineer

David J. Odeh, PE, SECB, F.SEI
Principal in Charge



1 MEZZ. FRAMING PLAN - ALT. 1

SCALE: 3/64" = 1'-0"

odeh engineers

1223 Mineral Spring Avenue
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PROJECT TITLE

PRINCE LABORATORY

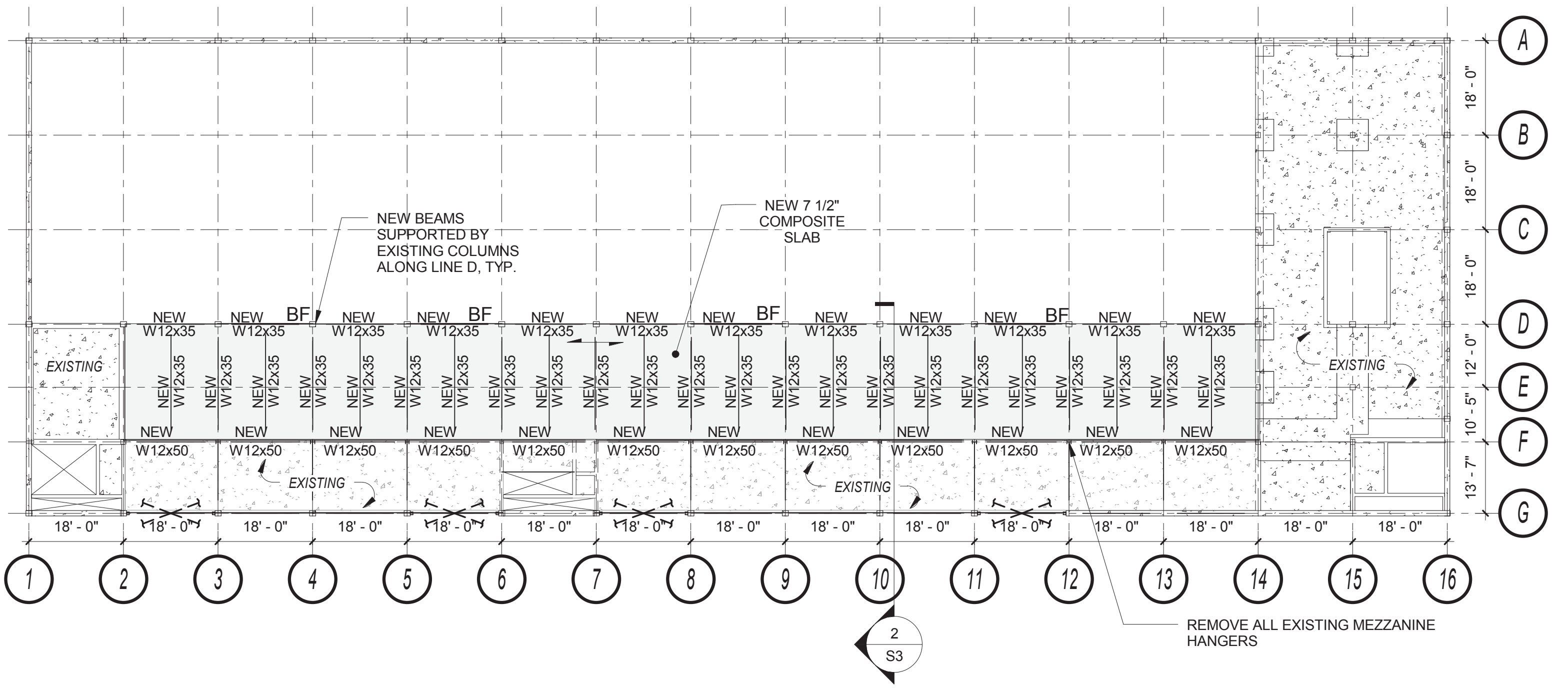
09-23-2013 FOR PRICING

180 HOPE STREET
PROVIDENCE, RI

SHEET CONTENTS

MEZZANINE FRAMING PLAN - ALTERNATE 1

SCALE	3/64" = 1'-0"
DRAWN BY	JAM
CHECKED BY	DJO
DATE	09/20/13
PROJECT NO.	2013-000138
DRAWING NO.	S1



1 MEZZ. FRAMING PLAN - ALT. 2

SCALE: 3/64" = 1'-0"

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PROJECT TITLE

PRINCE LABORATORY

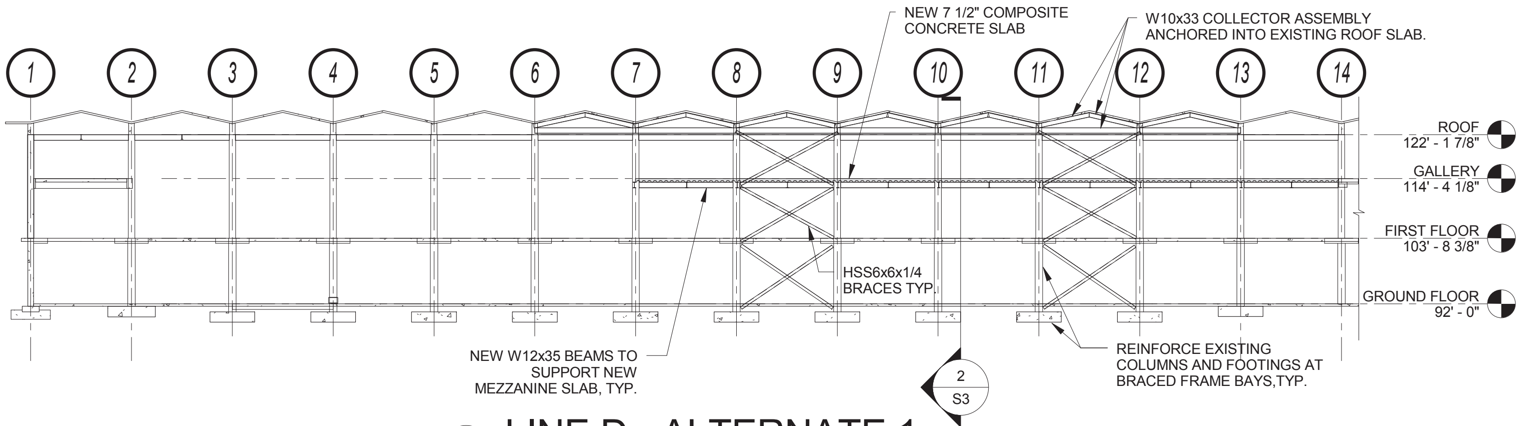
09-23-2013 FOR PRICING

180 HOPE STREET PROVIDENCE, RI

SHEET CONTENTS

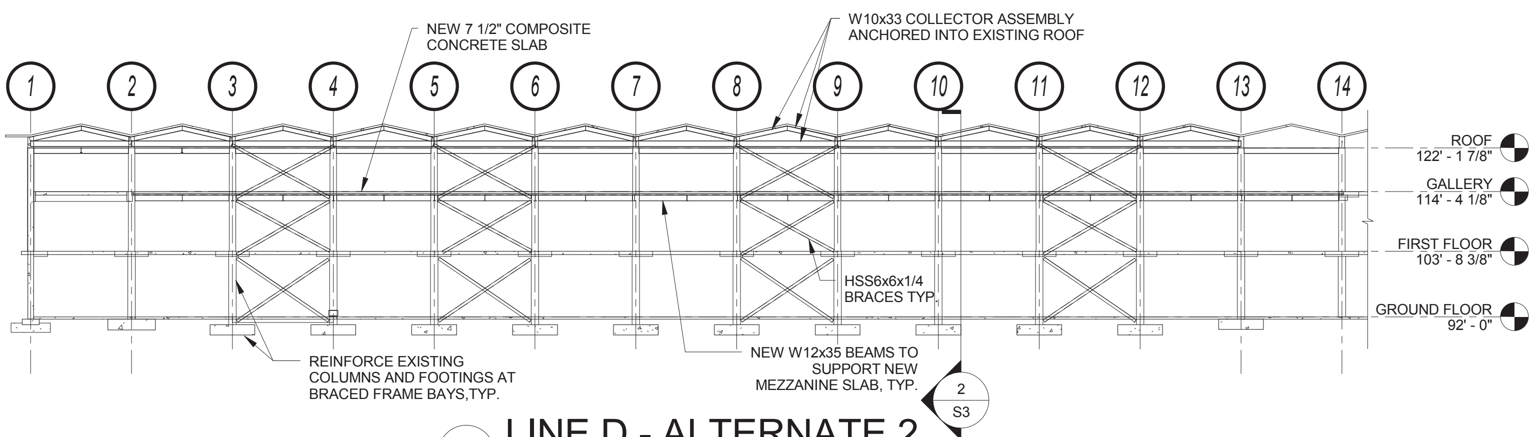
MEZZANINE FRAMING PLAN - ALTERNATE 2

SCALE	3/64" = 1'-0"
DRAWN BY	JAM
CHECKED BY	DJO
DATE	09/20/13
PROJECT NO.	2013-000138
DRAWING NO.	S2



1 LINE D - ALTERNATE 1

SCALE: 1" = 20'-0"



2 LINE D - ALTERNATE 2

SCALE: 1" = 20'-0"

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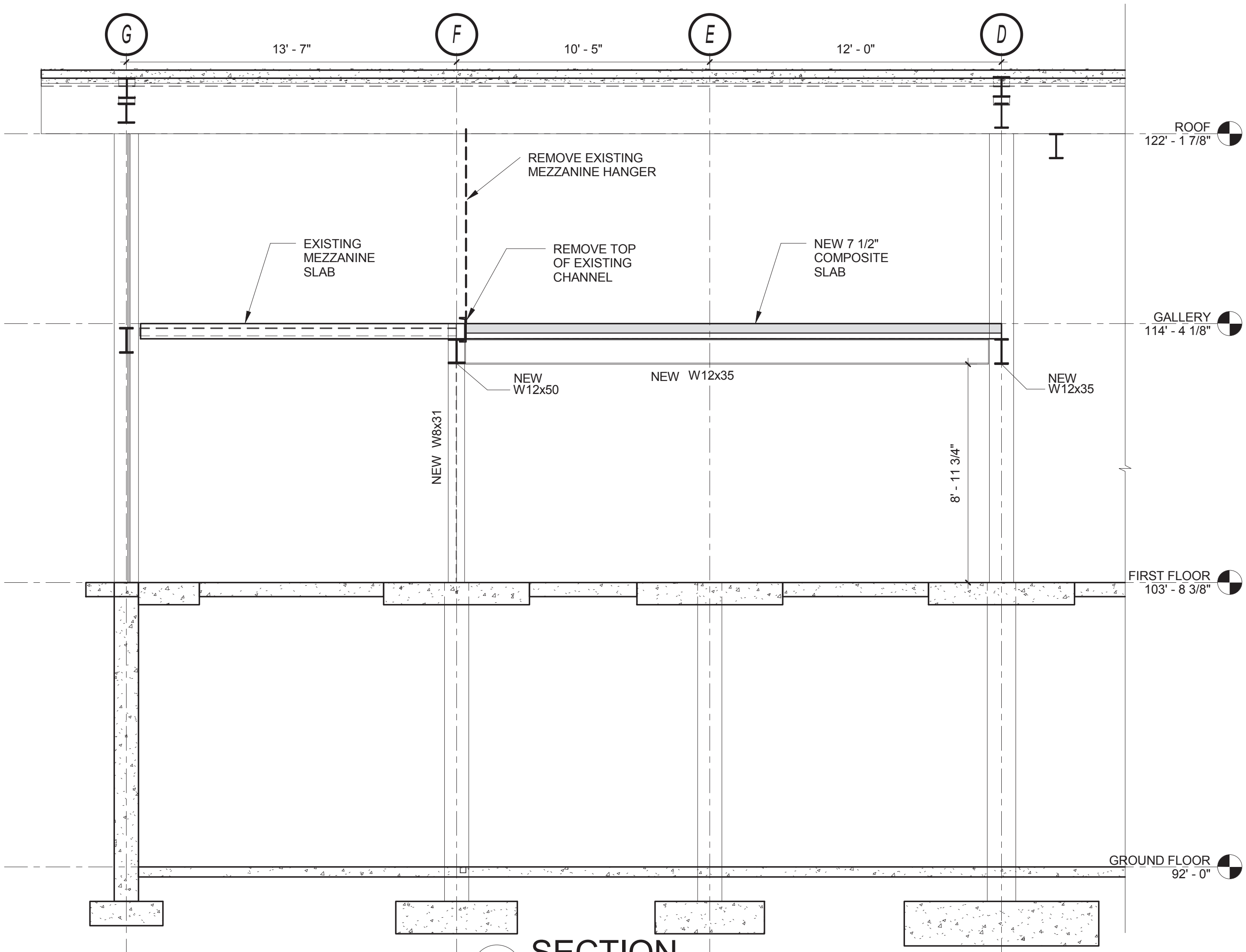
PROJECT TITLE
PRINCE LABORATORY

09-23-2013 FOR PRICING

180 HOPE STREET
PROVIDENCE, RI

SHEET CONTENTS
LINE D SECTION

SCALE	1" = 20'-0"
DRAWN BY	JAM
CHECKED BY	DJO
DATE	09/20/13
PROJECT NO.	2013-000138
DRAWING NO.	S4



2 SECTION

SCALE: 1/4" = 1'-0"

odeh engineers
1223 Mineral Spring Avenue
North Providence, RI 02904
Phone: 401.724.1771
Fax: 401.724.1981
www.odehengineers.com

PROJECT TITLE

PRINCE LABORATORY

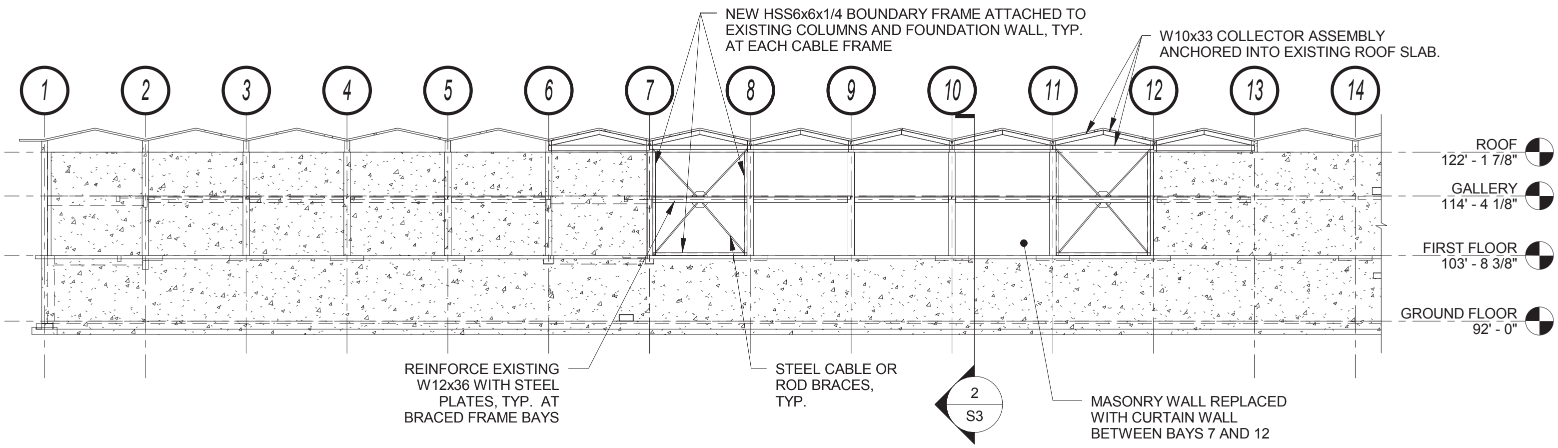
09-23-2013
FOR PRICING

180 HOPE STREET
PROVIDENCE, RI

SHEET CONTENTS

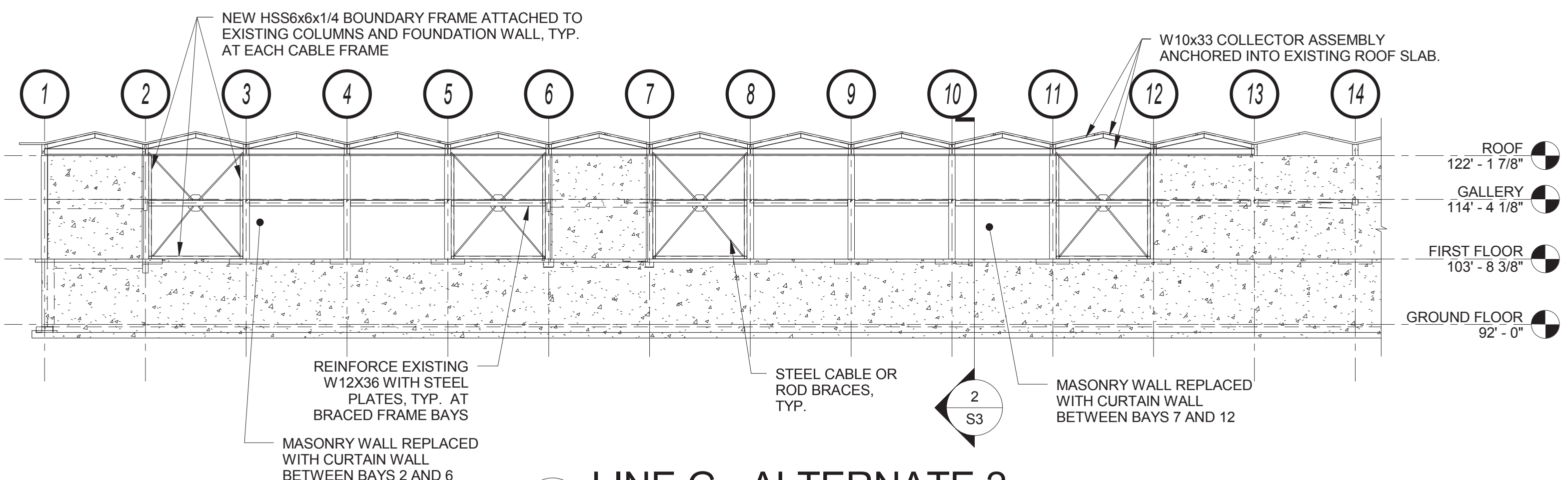
BUILDING SECTION

SCALE	1/4" = 1'-0"
DRAWN BY	JAM
CHECKED BY	DJO
DATE	09/20/13
PROJECT NO.	2013-000138
DRAWING NO.	S3



1 LINE G - ALTERNATE 1

SCALE: 1" = 20'-0"



2 LINE G - ALTERNATE 2

SCALE: 1" = 20'-0"

odeh engineers

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PROJECT TITLE

PRINCE LABORATORY

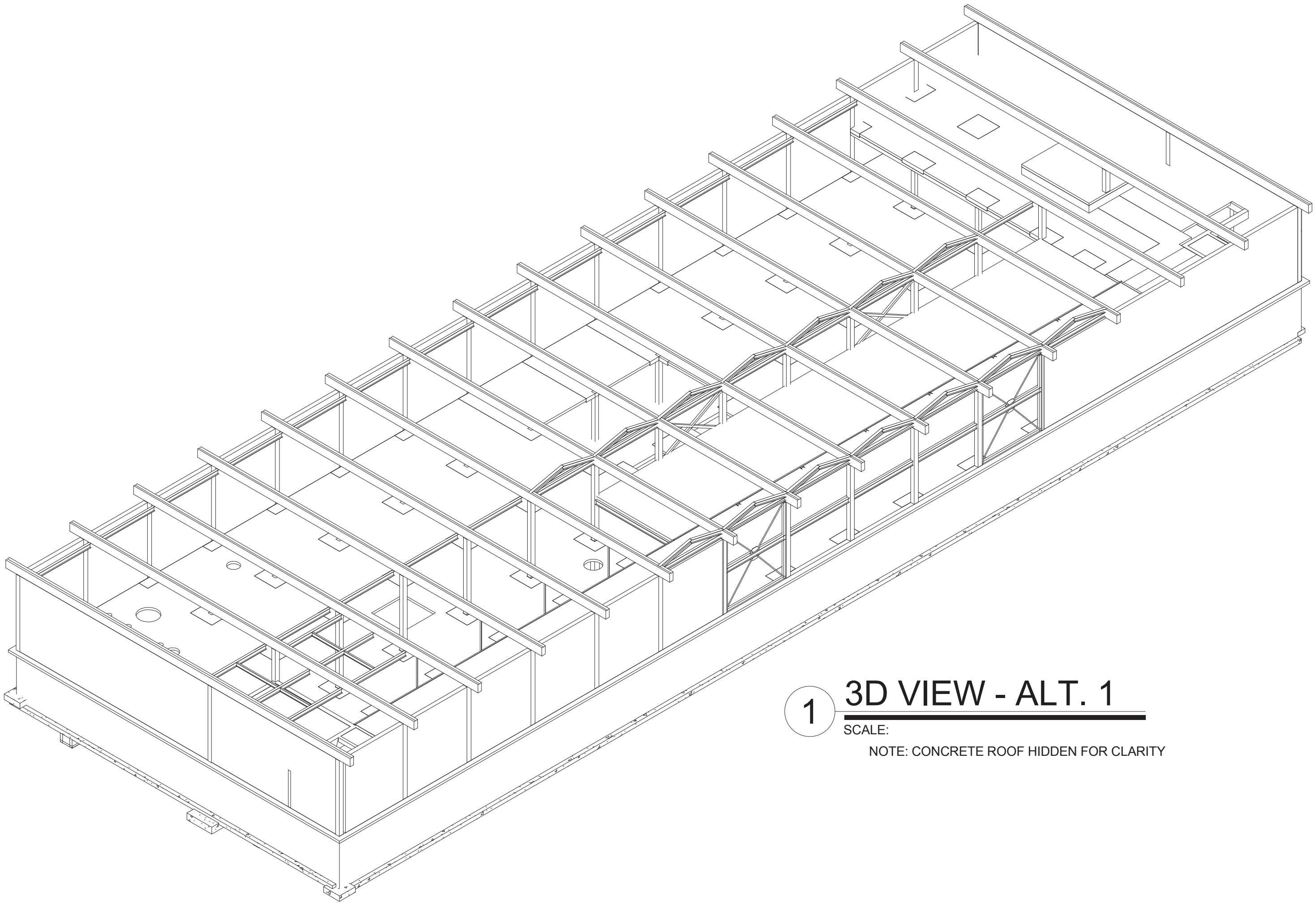
09-23-2013 FOR PRICING

180 HOPE STREET PROVIDENCE, RI

SHEET CONTENTS

LINE G SECTION

SCALE	1" = 20'-0"
DRAWN BY	JAM
CHECKED BY	DJO
DATE	09/20/13
PROJECT NO.	2013-000138
DRAWING NO.	S5



1 3D VIEW - ALT. 1

SCALE:

NOTE: CONCRETE ROOF HIDDEN FOR CLARITY

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PROJECT TITLE

PRINCE LABORATORY

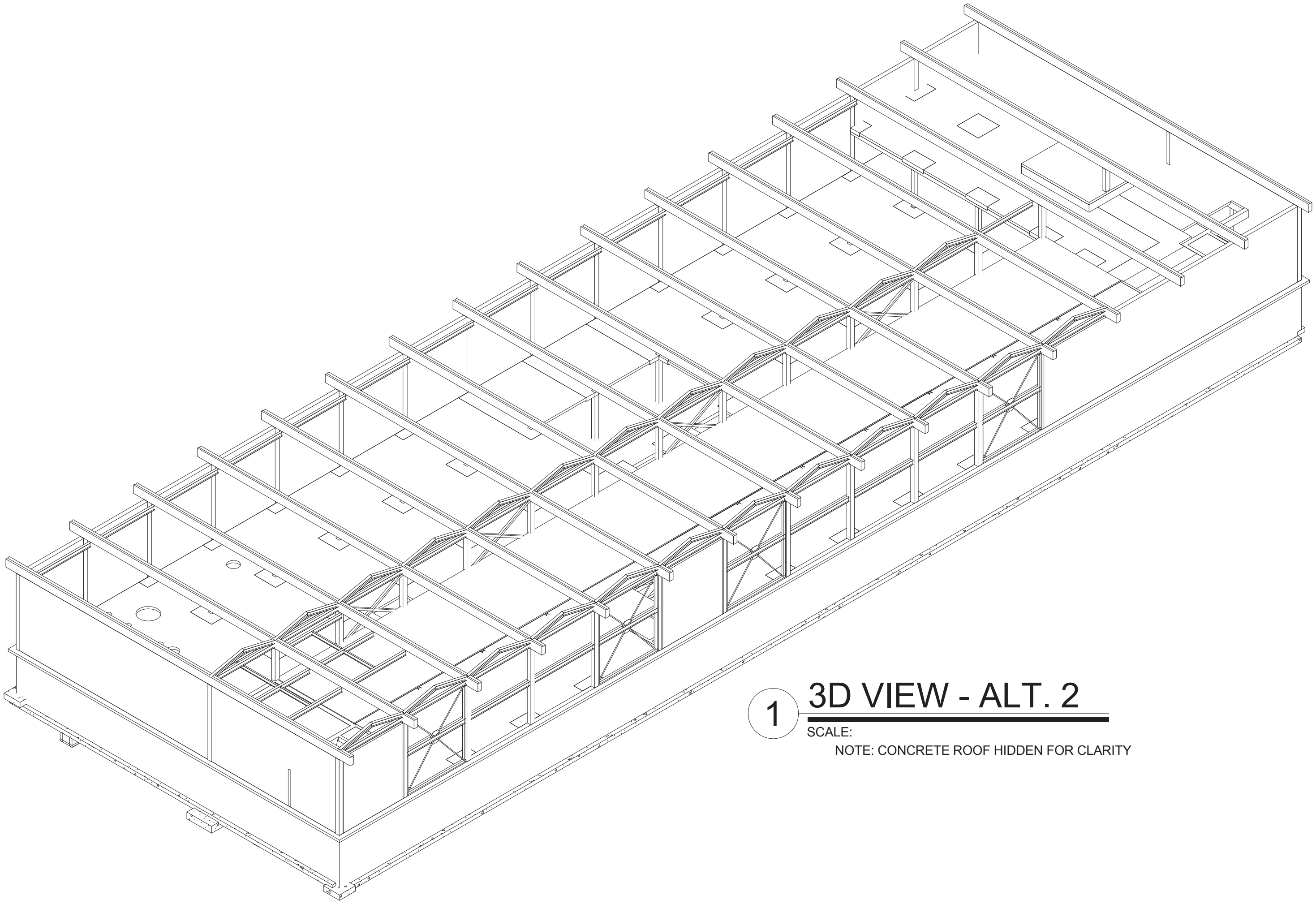
09-23-2013
FOR PRICING

180 HOPE STREET
PROVIDENCE, RI

SHEET CONTENTS

3D VIEWS - ALTERNATE 1

SCALE	
DRAWN BY	JAM
CHECKED BY	DJO
DATE	09/20/13
PROJECT NO.	2013-000138
DRAWING NO.	S6



1 3D VIEW - ALT. 2

SCALE:

NOTE: CONCRETE ROOF HIDDEN FOR CLARITY

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1223 Mineral Spring Avenue
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Phone: 401.724.1771
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PROJECT TITLE

PRINCE LABORATORY

09-23-2013 FOR PRICING

180 HOPE STREET PROVIDENCE, RI

SHEET CONTENTS

3D VIEWS - ALTERNATE 2

SCALE	
DRAWN BY	JAM
CHECKED BY	DJO
DATE	09/20/13
PROJECT NO.	2013-000138
DRAWING NO.	S7

APPENDIX C VERMEULENS COST ESTIMATES AND RELATED DOCUMENTS

Introduction to the Cost Estimate Appendix

Conceptual cost estimates were prepared by Vermeulens Cost Consultants for each of the three Phase I projects described in this study. These are included in this section of the report.

As the worksheets in this section will further explain, a ‘systems’ cost model was generated by applying $/SF unit costs for the major construction components of the building to the areas shown in the conceptual floor plans, sections and program information provided to the estimators. For the new engineering building, allowances for both articulation and additional building area were also made to account for the anticipated architectural development of the concept plan represented in this report. These are clearly identified as such herein.

For the new engineering building and planned renovations to Barus & Holley, the preliminary construction costs cited in this study come directly from these conceptual estimates. The Barus & Holley estimate is organized into different sections corresponding to infrastructure, typical upper levels, the ground level and the lower level, as it is anticipated that the work in Barus & Holley will be implemented in phases.

For Prince Lab, the preliminary construction costs cited in this study differ from the attached conceptual estimate. This is because the architectural and cost control strategies that Brown anticipates employing to limit the degree of intervention in Prince Lab are difficult to capture in a systems-based, $/SF-basis conceptual estimate.

Costs in this study are estimated Project Costs in 2013 dollars, escalated as per the schedule shown in the Executive Summary, and assuming a Q1 2014 start. Project Cost includes construction cost plus “soft costs” such as project management, design and technical consultant fees, furniture and equipment, occupant protection and relocation internal to the building, and owner’s project contingency. It does not include cost of relocating occupants outside of the building.

October 18, 2013

Payette
290 Congress St., Fifth Floor
Boston, MA 02210-1005

Attention: Peter Viera

Re: Brown University – Eng / IBS

Dear Peter,

Please find enclosed our draft cost estimate for the above project based on preliminary design.

	Area (sf)	$/sf	$000's
Base	80,000	798	63,835
Bridge	1,170	909	1,064
Articulation			1,569
Alternate 2	**81,170**	**819**	**66,468**

This estimate includes all direct construction costs, general contractor's overhead and profit, design and construction contingencies. Cost escalation assumes a 3rd Quarter 2015 construction start. The estimate includes for the following annual escalation rates, 2013 – 8%, 2014 – 8%, 2015 – 6%.

Excluded from the estimate are: hazardous waste removal, loose furnishings and equipment, project contingency, architect's and engineer's fees, moving, administrative and financing costs.

Bidding conditions are expected to reflect one construction manager, open bidding for sub-contractors, open specifications for materials and manufacturers.

This estimate is based on bids received in this market for comparable work. Projected changes in design and inflation are covered by contingency. Variances from these projections can occur due to lack or surplus of bidders at time of bid, proprietary specifications, contractual and procurement practice, documentation and tendering changes, contractor's errors and omissions etc. We expect bids received to be within 5 - 10% of estimated values 19 times out of 20 recognizing the above.

If you have any questions or require further analysis please do not hesitate to contact us.

Yours very truly,

James Vermeulen, PQS
Co-CEO

LEVEL 2 ELEMENTAL SUMMARY	$/sf	Element $	%	Base		Bridge		Articulation	
GROSS FLOOR AREA		81,170 sf		$/sf	80,000	$/sf	1,170	$/sf	0
A1 SUBSTRUCTURE	44.47	3,609,600	5%	45.12	3,609,600	0.00	0		0
A2 STRUCTURE	55.85	4,533,128	7%	55.75	4,459,958	62.54	73,170		0
A3 ENCLOSURE	130.30	10,576,669	16%	111.20	8,895,989	495.91	580,215		1,100,465
B1 PARTITIONS & DOORS	34.78	2,823,185	4%	34.93	2,794,325	24.67	28,860		0
B2 FINISHES	25.13	2,039,842	3%	25.30	2,023,790	13.72	16,052		0
B3 FITTINGS & EQUIPMENT	32.32	2,623,386	4%	32.78	2,622,625	0.65	761		0
C1 MECHANICAL	146.73	11,909,853	18%	148.48	11,878,030	27.20	31,823		0
C2 ELECTRICAL	71.59	5,810,710	9%	72.44	5,795,500	13.00	15,210		0
D1 SITE WORK	33.08	2,685,000	4%	33.56	2,685,000	0.00	0		0
DIRECT CONSTRUCTION COST	574.24	46,611,372	70%	559.56	44,764,817	637.68	746,090		1,100,465
Z1 GENERAL REQUIREMENTS	92.45	7,504,431	11%	90.09	7,207,135	102.67	120,120		177,175
Z2 CONTINGENCIES	152.17	12,352,014	19%	148.28	11,862,677	168.99	197,714		291,623
Z3 OTHER COSTS	0.00	0	0%	0.00	0	0.00	0		0
TOTAL CONSTRUCTION COST	818.87	66,467,816	100%	797.93	63,834,628	909.34	1,063,924		1,569,263

ELEMENTAL SUMMARY	Level 3 Element $	$/sf	Base		Bridge		Articulation	
GROSS FLOOR AREA			$/sf	80,000	$/sf	1,170	$/sf	0
A1 SUBSTRUCTURE								
A11 Foundations	424,000	5.22	5.30	424,000	0.00	0		0
A12 Building Excavation	3,185,600	39.25	39.82	3,185,600	0.00	0		0
A2 STRUCTURE								
A21 Lowest Floor Structure	159,960	1.97	2.00	159,960	0.00	0		0
A22 Upper Floor Structure	3,580,735	44.11	44.08	3,526,148	46.66	54,588		0
A23 Roof Structure	792,433	9.76	9.67	773,850	15.88	18,583		0
A3 ENCLOSURE								
A31 Walls Below Grade	773,674	9.53	9.67	773,674	0.00	0		0
A32 Walls Above Grade	1,745,149	21.50	18.81	1,504,904	0.00	0		240,245
A33 Windows & Entrances	6,862,120	84.54	68.37	5,469,460	455.08	532,440		860,220
A34 Roof Covering	373,275	4.60	4.56	364,500	7.50	8,775		0
A35 Projections	822,451	10.13	9.79	783,451	33.33	39,000		0
B1 PARTITIONS & DOORS								
B11 Partitions	2,270,685	27.97	28.25	2,260,225	8.94	10,460		0
B12 Doors	552,500	6.81	6.68	534,100	15.73	18,400		0
B2 FINISHES								
B21 Floor Finishes	1,008,829	12.43	12.48	998,042	9.22	10,787		0
B22 Ceiling Finishes	633,063	7.80	7.85	627,798	4.50	5,265		0
B23 Wall Finishes	397,950	4.90	4.97	397,950	0.00	0		0
B3 FITTINGS & EQUIPMENT								
B31 Fittings	1,803,886	22.22	22.54	1,803,125	0.65	761		0
B32 Equipment	549,500	6.77	6.87	549,500	0.00	0		0
B33 Conveying Systems	270,000	3.33	3.38	270,000	0.00	0		0
C1 MECHANICAL								
C11 Plumbing & Drainage	1,357,530	16.72	16.97	1,357,530	0.00	0		0
C12 Fire Protection	510,026	6.28	6.30	504,000	5.15	6,026		0
C13 HVAC	8,837,617	108.88	110.21	8,816,500	18.05	21,117		0
C14 Controls	1,204,680	14.84	15.00	1,200,000	4.00	4,680		0
C2 ELECTRICAL								
C21 Service & Distribution	3,387,500	41.73	42.34	3,387,500	0.00	0		0
C22 Lighting & Devices	1,551,700	19.12	19.25	1,540,000	10.00	11,700		0
C23 Systems	871,510	10.74	10.85	868,000	3.00	3,510		0

ELEMENTAL SUMMARY		Level 3 Element $	$/sf				Base		Bridge		Articulation	
GROSS FLOOR AREA							$/sf	80,000	$/sf	1,170	$/sf	0
D1 SITE WORK												
D11 Site Development		1,250,000	15.40				15.63	1,250,000	0.00	0		0
D12 Mechanical Site Services		960,000	11.83				12.00	960,000	0.00	0		0
D13 Electrical Site Services		475,000	5.85				5.94	475,000	0.00	0		0
DIRECT CONSTRUCTION COST							559.56	44,764,817	637.68	746,090		1,100,465
Z1 GENERAL REQUIREMENTS												
Z11 General Requirements	13.1%	6,106,090	75.23				73.30	5,864,191	83.54	97,738		144,161
Z12 Fee	3.0%	1,398,341	17.23				16.79	1,342,945	19.13	22,383		33,014
Z2 CONTINGENCIES												
Z21 Estimating Contingency	10.0%	4,661,137	57.42				55.96	4,476,482	63.77	74,609		110,047
Z22 Escalation Contingency	13.5%	6,292,535	77.52				75.54	6,043,251	86.09	100,722		148,563
Z23 Construction Contingency	3.0%	1,398,341	17.23				16.79	1,342,945	19.13	22,383		33,014
Z3 OTHER COSTS												
Z31 Other Costs	0.0%	0	0.00				0.00	0	0.00	0		0
TOTAL CONSTRUCTION COST				818.87	66,467,816	100%	797.93	63,834,628	909.34	1,063,924		1,569,263

ELEMENTAL ESTIMATE Description	Trade	Quantity		Rate	$	Base Quantity	Base $	Bridge Quantity	Bridge $	Articulation Quantity	Articulation $
GROSS FLOOR AREA											
Level B2		0	sf								
Level B		14,200	sf			14,200					
First Floor		16,200	sf			16,200					
Second Floor		16,590	sf			16,200		390			
Third Floor		16,590	sf			16,200		390			
Fourth Floor		16,590	sf			16,200		390			
PH		1,000	sf			1,000					
TOTAL GROSS FLOOR AREA		81,170	sf			80,000		1,170		0	

REPORT NOTES

ELEMENTAL ESTIMATE							Base		Bridge		Articulation	
Description	Trade		Quantity		Rate	$	Quantity	$	Quantity	$	Quantity	$
A1 SUBSTRUCTURE												
A11 Foundations												
Foundations												
assume conventional strip and pad footings, generally normal bearing capacity soil, including allowances for perimeter & underslab drainage	03010	+	14,000	sf	24.00	336,000	14,000	336,000		0		0
36" mat slab	03010	+	2,200	sf	40.00	88,000	2,200	88,000		0		0
Subtotal Foundations			16,200	sf	26.17	424,000	16,200	424,000	0	0	0	0
Total A11 Foundations			81,170	sf	5.22	424,000	5.30	424,000	0.00	0	#Num!	0
A12 Building Excavation												
Earthwork												
bulk excavation	02020	+	11,801	cy	10.00	118,010	11,801	118,010		0		0
foundation excavation	02020	+	1,843	cy	10.00	18,430	1,843	18,430		0		0
working space excavation	02020	+	3,667	cy	10.00	36,670	3,667	36,670		0		0
imported backfill - foundations	02020		1,843	cy	35.00	64,505	1,843	64,505		0		0
imported backfill - working space	02020		3,667	cy	35.00	128,345	3,667	128,345		0		0
imported backfill - u/s slab on grade	02020		307	cy	35.00	10,745	307	10,745		0		0
obstruction removal - allow	02020		100,000	ls	1.00	100,000	100,000	100,000		0		0
dewatering - allow	02020		100,000	ls	1.00	100,000	100,000	100,000		0		0
soil disposal - out of state	02020		29,429	ton	30.00	882,870	29,429	882,870		0		0
hauling - out of state	02020		29,429	ton	25.00	735,725	29,429	735,725		0		0
Subtotal Earthwork			17,311	cy	126.82	2,195,300	17,311	2,195,300	0	0	0	0
Retention												
soil retention, av 32' dp including toe		+	19,806	sf	50.00	990,300	19,806	990,300		0		0

ELEMENTAL ESTIMATE						Base		Bridge		Articulation	
Description	Trade	Quantity		Rate	$	Quantity	$	Quantity	$	Quantity	$
Subtotal Retention		19,806	sf	50.00	990,300	19,806	990,300	0	0	0	0
Total A12 Building Excavation		81,170	sf	39.25	3,185,600	39.82	3,185,600	0.00	0	#Num!	0
TOTAL A1 SUBSTRUCTURE					3,609,600		3,609,600		0		0

ELEMENTAL ESTIMATE						Base		Bridge		Articulation	
Description	Trade		Quantity	Rate	$	Quantity	$	Quantity	$	Quantity	$
A2 STRUCTURE											
A21 Lowest Floor Structure											
On Grade											
6" slab on grade including u/s rigid insulation, vapor barrier	03010	+	16,200 sf	6.50	105,300	16,200	105,300		0		0
houskeeping pads, allow	03010		2,295 sf	8.00	18,360	2,295	18,360		0		0
elevator pits,	03010		1 no	12,000.00	12,000	1	12,000		0		0
miscellaneous pits, pads, detailing	03010		16,200 sf	1.50	24,300	16,200	24,300		0		0
Subtotal On Grade			16,200 sf	9.87	159,960	16,200	159,960	0	0	0	0
Total A21 Lowest Floor Structure			81,170 sf	1.97	159,960	2.00	159,960	0.00	0	#Num!	0
A22 Upper Floor Structure											
Floor Structure											
12" concrete waffle slab	03010	+	15,000 sf	55.00	825,000	15,000	825,000		0		0
3-1/4" concrete topping	03010		51,140 sf	6.50	332,410	49,970	324,805	1,170	7,605		0
3" metal deck	03020	+	51,140 sf	3.00	153,420	49,970	149,910	1,170	3,510		0
houskeeping pads, allow	03010		5,000 sf	8.00	40,000	5,000	40,000		0		0
structural steel - 18 psf	03020		461 ton	3,500.00	1,613,500	450	1,575,000	11	38,500		0
beam penetration - allow	03020		84,000 ls	1.00	84,000	84,000	84,000		0		0
fireproofing	03020		51,140 sf	2.25	115,065	49,970	112,433	1,170	2,633		0
Subtotal Floor Structure			66,140 sf	47.83	3,163,395	64,970	3,111,148	1,170	52,248	0	0
Stairs, Miscellaneous											
feature stairs	03020		6 flt	35,000.00	210,000	6	210,000		0		0
egress stairs	03020		3 flt	15,000.00	45,000	3	45,000		0		0
miscellaneous metals	03020	+	81,170 sf	2.00	162,340	80,000	160,000	1,170	2,340		0
Subtotal Stairs, Miscellaneous			81,170 sf	5.14	417,340	80,000	415,000	1,170	2,340	0	0

ELEMENTAL ESTIMATE						Base		Bridge		Articulation	
Description	Trade		Quantity	Rate	$	Quantity	$	Quantity	$	Quantity	$
Total A22 Upper Floor Structure			81,170 sf	44.11	3,580,735	44.08	3,526,148	46.66	54,588	#Num!	0
A23 Roof Structure											
Roof Structure											
3-1/4" concrete topping	03010		16,590 sf	6.50	107,835	16,200	105,300	390	2,535		0
3" metal deck	03020	+	16,590 sf	3.00	49,770	16,200	48,600	390	1,170		0
structural steel - 18 psf	03020		149 ton	3,500.00	521,500	145	507,500	4	14,000		0
fireproofing	03020		16,590 sf	2.25	37,328	16,200	36,450	390	878		0
dunnage - allow	03020		50,000 ls	1.00	50,000	50,000	50,000		0		0
roof davits - allow	03020		40 no	650.00	26,000	40	26,000		0		0
Subtotal Roof Structure			16,590 sf	47.77	792,433	16,200	773,850	390	18,583	0	0
Total A23 Roof Structure			81,170 sf	9.76	792,433	9.67	773,850	15.88	18,583	#Num!	0
TOTAL A2 STRUCTURE					4,533,128		4,459,958		73,170		0

ELEMENTAL ESTIMATE						Base		Bridge		Articulation	
Description	Trade		Quantity	Rate	$	Quantity	$	Quantity	$	Quantity	$
A3 ENCLOSURE											
A31 Walls Below Grade											
Basement Walls											
18" foundation wall, 6 psf	03010	+	12,788 sf	45.00	575,460	12,788	575,460		0		0
drainage	03010		12,788 sf	4.00	51,152	12,788	51,152		0		0
insulation	03010		12,788 sf	3.50	44,758	12,788	44,758		0		0
waterproofing	03010		12,788 sf	5.00	63,940	12,788	63,940		0		0
furring & drywall	07010		12,788 sf	3.00	38,364	12,788	38,364		0		0
Subtotal Basement Walls			12,788 sf	60.50	773,674	12,788	773,674	0	0	0	0
Total A31 Walls Below Grade			81,170 sf	9.53	773,674	9.67	773,674	0.00	0	#Num!	0
A32 Walls Above Grade											
Cladding											
terracotta	06010	+	12,835 sf	90.00	1,155,150	12,835	1,155,150		0		0
articulation - 15%	06010	+	2,049 sf	90.00	184,410		0		0	2,049	184,410
Subtotal Cladding			14,884 sf	90.00	1,339,560	12,835	1,155,150	0	0	2,049	184,410
Backup											
6" lgmf	06010	+	12,835 sf	12.00	154,020	12,835	154,020		0		0
gypboard	07010		12,835 sf	2.00	25,670	12,835	25,670		0		0
wood blocking	07010		12,835 sf	1.00	12,835	12,835	12,835		0		0
air/vapor barrier	06010		12,835 sf	4.00	51,340	12,835	51,340		0		0
rigid insulation	06010		12,835 sf	3.75	48,131	12,835	48,131		0		0
sealing & caulking	06020		12,835 sf	1.25	16,044	12,835	16,044		0		0
steel angles	03020		12,835 sf	3.25	41,714	12,835	41,714		0		0
articulation - 15%	06010	+	2,049 sf	27.25	55,835		0		0	2,049	55,835
Subtotal Backup			14,884 sf	27.25	405,589	12,835	349,754	0	0	2,049	55,835

ELEMENTAL ESTIMATE

Description	Trade	Quantity	Rate	$	Base Quantity	Base $	Bridge Quantity	Bridge $	Articulation Quantity	Articulation $
Total A32 Walls Above Grade		81,170 sf	21.50	1,745,149	18.81	1,504,904	0.00	0	#Div/0!	240,245
A33 Windows & Entrances										
Windows										
curtain wall	06020 +	32,905 sf	180.00	5,922,900	29,947	5,390,460	2,958	532,440		0
articulation - 15%	06020 +	4,779 sf	180.00	860,220		0		0	4,779	860,220
Subtotal Windows		37,684 sf	180.00	6,783,120	29,947	5,390,460	2,958	532,440	4,779	860,220
Entrances										
hollow metal doors	06020 +	2 no	1,500.00	3,000	2	3,000		0		0
glazed aluminum doors	06020 +	8 no	4,500.00	36,000	8	36,000		0		0
allow for auto openers	06020	4 no	5,000.00	20,000	4	20,000		0		0
overhead doors - allow	06020 +	1 no	20,000.00	20,000	1	20,000		0		0
Subtotal Entrances		11 no	7,181.82	79,000	11	79,000	0	0	0	0
Total A33 Windows & Entrances		81,170 sf	84.54	6,862,120	68.37	5,469,460	455.08	532,440	#Div/0!	860,220
A34 Roof Covering										
Roofing										
tpo	06030 +	16,590 sf	20.00	331,800	16,200	324,000	390	7,800		0
flashings & accessories	06030	16,590 sf	2.50	41,475	16,200	40,500	390	975		0
Subtotal Roofing		16,590 sf	22.50	373,275	16,200	364,500	390	8,775	0	0
Total A34 Roof Covering		81,170 sf	4.60	373,275	4.56	364,500	7.50	8,775	#Num!	0
A35 Projections										
Projections - Area Based										

ELEMENTAL ESTIMATE					Base		Bridge		Articulation	
Description	Trade	Quantity	Rate	$	Quantity	$	Quantity	$	Quantity	$
areaway										
foundations		433 sf	24.00	10,392	433	10,392		0		0
slab on grade		433 sf	8.00	3,464	433	3,464		0		0
area way concrete walls		1,432 sf	57.50	82,340	1,432	82,340		0		0
guard rail		80 lf	125.00	10,000	80	10,000		0		0
bridge soffit		390 sf	100.00	39,000		0	390	39,000		0
loading dock - allow		93 sf	100.00	9,300	93	9,300		0		0
entrance canopy - allow (50' x 25')		1,250 sf	175.00	218,750	1,250	218,750		0		0
sunshades - allow		29,947 sf	15.00	449,205	29,947	449,205		0		0
			0.00	0		0		0		0
Subtotal Projections - Area Based				822,451	0	783,451	0	39,000	0	0
Total A35 Projections		81,170 sf	10.13	822,451	9.79	783,451	33.33	39,000	#Num!	0
TOTAL A3 ENCLOSURE				10,576,669		8,895,989		580,215		1,100,465

ELEMENTAL ESTIMATE					Base		Bridge		Articulation	
Description	Trade	Quantity	Rate	$	Quantity	$	Quantity	$	Quantity	$
B1 PARTITIONS & DOORS										
B11 Partitions										
Partitions										
block assemblies	+	700 sf	18.00	12,600	700	12,600		0		0
typical - stud, gyp (1) bs, batt	+	26,700 sf	7.75	206,925	26,700	206,925		0		0
corridor - stud, gyp (2) os, gyp (1) os	+	53,300 sf	8.75	466,375	53,300	466,375		0		0
chase - stud (2), gyp (1) bs, batt (2)	+	2,900 sf	12.00	34,800	2,900	34,800		0		0
rated - stud, gyp (2) bs, batt	+	14,900 sf	10.50	156,450	14,900	156,450		0		0
shaft - stud, gyp (2) os, shaft liner (1) os	+	10,400 sf	11.50	119,600	10,400	119,600		0		0
premium for imaging shielding		2,000 sf	15.00	30,000	2,000	30,000		0		0
fire rated assembly	+	523 sf	20.00	10,460		0	523	10,460		0
glazing - vestibule entry	+	1,250 sf	65.00	81,250	1,250	81,250		0		0
glazing - full height	+	50 sf	60.00	3,000	50	3,000		0		0
glazing - borrowed, allow		10,900 sf	60.00	654,000	10,900	654,000		0		0
articulation	+	12,300 sf	10.00	123,000	12,300	123,000		0		0
wood blocking		123,000 sf	1.00	123,000	123,000	123,000		0		0
sealing & firetopping		123,000 sf	0.75	92,250	123,000	92,250		0		0
furring & boxing		123,000 sf	0.45	55,350	123,000	55,350		0		0
Subtotal Partitions		123,023 sf	17.63	2,169,060	122,500	2,158,600	523	10,460	0	0
Railings										
egress - guardrail and handrail	+	335 lf	225.00	75,375	335	75,375		0		0
egress - handrail	+	310 lf	50.00	15,500	310	15,500		0		0
ramp - handrail	+	215 lf	50.00	10,750	215	10,750		0		0
ramp - case study	+	lf	150.00	0		0		0		0
Subtotal Railings		860 lf	118.17	101,625	860	101,625	0	0	0	0
Total B11 Partitions		81,170 sf	27.97	2,270,685	28.25	2,260,225	8.94	10,460	#Num!	0
B12 Doors										

ELEMENTAL ESTIMATE						Base		Bridge		Articulation	
Description	Trade	Quantity		Rate	$	Quantity	$	Quantity	$	Quantity	$
Doors, Frames, Hardware											
glazed - vestibule entry	*	16	no	3,000.00	48,000	16	48,000		0		0
clean air lock	*	10	no	5,250.00	52,500	10	52,500		0		0
imaging	*	2	no	3,000.00	6,000	2	6,000		0		0
roll down shutter, allow	*	1	no	15,000.00	15,000	1	15,000		0		0
egress	*	14	no	2,100.00	29,400	10	21,000	4	8,400		0
lab	*	70	no	1,600.00	112,000	70	112,000		0		0
lab, sliding	*	5	no	1,300.00	6,500	5	6,500		0		0
major	*	15	no	2,100.00	31,500	15	31,500		0		0
offices	*	64	no	1,850.00	118,400	64	118,400		0		0
typical	*	27	no	1,600.00	43,200	27	43,200		0		0
auto openers		18	no	5,000.00	90,000	16	80,000	2	10,000		0
Subtotal Doors, Frames, Hardware		224	no	2,466.52	552,500	220	534,100	4	18,400	0	0
Total B12 Doors		81,170	sf	6.81	552,500	6.68	534,100	15.73	18,400	#Num!	0
TOTAL B1 PARTITIONS & DOORS					2,823,185		2,794,325		28,860		0

ELEMENTAL ESTIMATE					Base		Bridge		Articulation	
Description	Trade	Quantity	Rate	$	Quantity	$	Quantity	$	Quantity	$
B2 FINISHES										
B21 Floor Finishes										
Flooring										
coating - dex-o-tex	+	1,234 sf	0.00	0	1,234	0		0		0
coating - epoxy	+	5,250 sf	15.00	78,750	5,250	78,750		0		0
coating - sealed concrete	+	7,250 sf	0.75	5,438	7,250	5,438		0		0
misc - entrance mat	+	200 sf	50.00	10,000	200	10,000		0		0
resilient - carpet sheet	+	23,016 sf	4.25	97,818	23,016	97,818		0		0
resilient - rubber tread & riser	+	3,500 sf	15.00	52,500	3,500	52,500		0		0
resilient - sheet flooring	+	13,346 sf	9.75	130,124	12,293	119,857	1,053	10,267		0
seamless - clean room	+	8,467 sf	15.00	127,005	8,467	127,005		0		0
resilient - vinyl tile	+	3,250 sf	3.25	10,563	3,250	10,563		0		0
tile - ceramic tile	+	2,025 sf	12.00	24,300	2,025	24,300		0		0
tile - terrazzo	+	3,515 sf	37.50	131,813	3,515	131,813		0		0
floor prep, moisture mitigation		70,000 sf	4.00	280,000	70,000	280,000		0		0
Subtotal Flooring		71,053 sf	13.35	948,309	70,000	938,042	1,053	10,267	0	0
Base										
bases, allow	+	15,130 lf	4.00	60,520	15,000	60,000	130	520		0
Subtotal Base		15,130 lf	4.00	60,520	15,000	60,000	130	520	0	0
Total B21 Floor Finishes		81,170 sf	12.43	1,008,829	12.48	998,042	9.22	10,787	#Num!	0
B22 Ceiling Finishes										
Ceilings										
acoustic - wood, Decoustics	+	2,000 sf	75.00	150,000	2,000	150,000		0		0
gyp - painted	+	3,500 sf	10.00	35,000	3,500	35,000		0		0
lay-in - acoustic tile	+	56,319 sf	5.00	281,595	55,266	276,330	1,053	5,265		0
lay-in - metal	+	1,000 sf	40.00	40,000	1,000	40,000		0		0
paint - exposed	+	8,234 sf	2.00	16,468	8,234	16,468		0		0

ELEMENTAL ESTIMATE					Base		Bridge		Articulation	
Description	Trade	Quantity	Rate	$	Quantity	$	Quantity	$	Quantity	$
bulkheads, soffits, details		110,000 ls	1.00	110,000	110,000	110,000		0		0
Subtotal Ceilings		71,053 sf	8.91	633,063	70,000	627,798	1,053	5,265	0	0
Total B22 Ceiling Finishes		81,170 sf	7.80	633,063	7.85	627,798	4.50	5,265	#Num!	0
B23 Wall Finishes										
Wall Finishes										
acoustic - fabric wall panel	+	650 sf	15.00	9,750	650	9,750		0		0
paint - prep, level 4	+	120,000 sf	0.75	90,000	120,000	90,000		0		0
tile - ceramic	+	7,500 sf	14.00	105,000	7,500	105,000		0		0
epoxy - wall system	+	19,000 sf	6.00	114,000	19,000	114,000		0		0
wall protection - allow		79,200 sf	1.00	79,200	79,200	79,200		0		0
Subtotal Wall Finishes		147,150 sf	2.70	397,950	147,150	397,950	0	0	0	0
Total B23 Wall Finishes		81,170 sf	4.90	397,950	4.97	397,950	0.00	0	#Num!	0
TOTAL B2 FINISHES				2,039,842		2,023,790		16,052		0

ELEMENTAL ESTIMATE					Base		Bridge		Articulation	
Description	Trade	Quantity	Rate	$	Quantity	$	Quantity	$	Quantity	$
B3 FITTINGS & EQUIPMENT										
B31 Fittings										
Casework - Specialty										
demonstration bench	+	lf	750.00	0		0		0		0
base cabinet	+	780 lf	500.00	390,000	780	390,000		0		0
table @ clean, stainless steel	+	95 lf	500.00	47,500	95	47,500		0		0
table @ work	+	35 lf	275.00	9,625	35	9,625		0		0
table w/shelving @ lab	+	650 lf	600.00	390,000	650	390,000		0		0
bench, ss @ material growth	+	30 lf	500.00	15,000	30	15,000		0		0
work counter with supports	+	25 lf	250.00	6,250	25	6,250		0		0
upper cabinet	+	635 lf	300.00	190,500	635	190,500		0		0
full height cabinet - bookbag storage	+	210 lf	650.00	136,500	210	136,500		0		0
overhead service panels, allow		80 no	1,250.00	100,000	80	100,000		0		0
miscellaneous casework	+	150 lf	500.00	75,000	150	75,000		0		0
Subtotal Casework - Specialty		2,610 lf	521.22	1,360,375	2,610	1,360,375	0	0	0	0
Casework - General										
vanity	+	55 lf	350.00	19,250	55	19,250		0		0
credenza, allow	+	20 lf	500.00	10,000	20	10,000		0		0
lecture, curved	+	lf	400.00	0		0		0		0
Subtotal Casework - General		75 lf	390.00	29,250	75	29,250	0	0	0	0
Specialties										
accessories - washrooms		50 no	300.00	15,000	50	15,000		0		0
accessories - lab sinks		30 no	500.00	15,000	30	15,000		0		0
partition - toilet		30 no	1,500.00	45,000	30	45,000		0		0
misc - trench drain		20 no	200.00	4,000	20	4,000		0		0
miscellaneous	+	80,000 sf	1.00	80,000	80,000	80,000		0		0
Subtotal Specialties		80,000 sf	1.99	159,000	80,000	159,000	0	0	0	0

ELEMENTAL ESTIMATE					Base		Bridge		Articulation	
Description	Trade	Quantity	Rate	$	Quantity	$	Quantity	$	Quantity	$
Furnishings										
projection screen & mount		3 no	3,500.00	10,500	3	10,500		0		0
visual display		80,000 sf	0.15	12,000	80,000	12,000		0		0
window treatment		12,000 sf	15.00	180,000	12,000	180,000		0		0
fire protection		81,170 sf	0.15	12,176	80,000	12,000	1,170	176		0
signage & wayfinding		81,170 sf	0.50	40,585	80,000	40,000	1,170	585		0
Subtotal Furnishings				255,261	0	254,500	0	761	0	0
Total B31 Fittings		81,170 sf	22.22	1,803,886	22.54	1,803,125	0.65	761	#Num!	0
B32 Equipment										
Equipment - Specialty										
biosafety cabinet, 4'		3 no	10,500.00	31,500	3	31,500		0		0
fume hood, 6'-0"		38 no	8,500.00	323,000	38	323,000		0		0
fume hood, clean room, nanotools, imaging prep		10 no	12,500.00	125,000	10	125,000		0		0
miscellaneous - ice machines, OFCI		35,000 ls	1.00	35,000	35,000	35,000		0		0
Subtotal Equipment - Specialty				514,500	0	514,500	0	0	0	0
Equipment - Other										
loading dock equipment		1 no	20,000.00	20,000	1	20,000		0		0
domestic kitchen equipment		3 no	5,000.00	15,000	3	15,000		0		0
Subtotal Equipment - Other				35,000	0	35,000	0	0	0	0
Total B32 Equipment		81,170 sf	6.77	549,500	6.87	549,500	0.00	0	#Num!	0
B33 Conveying Systems										
Elevators										

ELEMENTAL ESTIMATE					Base		Bridge		Articulation	
Description	Trade	Quantity	Rate	$	Quantity	$	Quantity	$	Quantity	$
elevator	*	9 stp	30,000.00	270,000	9	270,000		0		0
Subtotal Elevators		9 stp	30,000.00	270,000	9	270,000	0	0	0	0
Total B33 Conveying Systems		81,170 sf	3.33	270,000	3.38	270,000	0.00	0	#Num!	0
TOTAL B3 FITTINGS & EQUIPMENT				2,623,386		2,622,625		761		0

ELEMENTAL ESTIMATE					Base		Bridge		Articulation	
Description	Trade	Quantity	Rate	$	Quantity	$	Quantity	$	Quantity	$
C1 MECHANICAL										
C11 Plumbing & Drainage										
Equipment										
domestic equipment		85,000 ls	1.00	85,000	85,000	85,000		0		0
Subtotal Equipment				85,000	0	85,000	0	0	0	0
Major Domestic Fixtures										
water closets, lavatories, urinals, electric water coolers, sinks, janitor sinks	*	43 no	1,230.00	52,890	43	52,890		0		0
Subtotal Major Domestic Fixtures		43 no	1,230.00	52,890	43	52,890	0	0	0	0
Minor Domestic Fixtures										
floor drains, roof drains, hose bibs, wall hydrants	*	54 no	520.00	28,080	54	28,080		0		0
Subtotal Minor Domestic Fixtures		54 no	520.00	28,080	54	28,080	0	0	0	0
Piping										
water, waste & vent, storm drainage	+	4,550 lf	54.00	245,700	4,550	245,700		0		0
Subtotal Piping		4,550 lf	54.00	245,700	4,550	245,700	0	0	0	0
Lab Equipment										
vacuum pumps, air compressors, RO system, manifolds, non-potable water heaters, pH neutralization		350,000 ls	1.00	350,000	350,000	350,000		0		0
Subtotal Lab Equipment				350,000	0	350,000	0	0	0	0

ELEMENTAL ESTIMATE					Base		Bridge		Articulation	
Description	Trade	Quantity	Rate	$	Quantity	$	Quantity	$	Quantity	$
Lab Fixtures										
lab sink connections, fumehood connections, lab bench/ceiling panel connections, other lab equipment connections, acid resistant floor drains	*	215 no	400.00	86,000	215	86,000		0		0
Subtotal Lab Fixtures		215 no	400.00	86,000	215	86,000	0	0	0	0
Lab Piping										
non-potable water, compressed air (riser), vacuum (riser), gas (riser), RO, tempered water, special gas, lab waste & vent	+	9,620 lf	53.00	509,860	9,620	509,860		0		0
Subtotal Lab Piping		9,620 lf	53.00	509,860	9,620	509,860	0	0	0	0
Total C11 Plumbing & Drainage		81,170 sf	16.72	1,357,530	16.97	1,357,530	0.00	0	#Num!	0
C12 Fire Protection										
Sprinklers										
fire pump		1 no	55,000.00	55,000	1	55,000		0		0
double check valve assembly		1 no	12,000.00	12,000	1	12,000		0		0
complete sprinkler coverage	+	81,170 sf	5.15	418,026	80,000	412,000	1,170	6,026		0
allow for special systems		25,000 ls	1.00	25,000	25,000	25,000		0		0
Subtotal Sprinklers		81,170 sf	6.28	510,026	80,000	504,000	1,170	6,026	0	0
Total C12 Fire Protection		81,170 sf	6.28	510,026	6.30	504,000	5.15	6,026	#Num!	0
C13 HVAC										
Air Handling Units										

ELEMENTAL ESTIMATE					Base		Bridge		Articulation	
Description	Trade	Quantity	Rate	$	Quantity	$	Quantity	$	Quantity	$
air handling unit capacity w/heat recovery, VFDs and sound attenuation, including HEPA filtration	+	95,000 cf	10.80	1,026,000	95,000	1,026,000		0		0
Subtotal Air Handling Units		95,000 cfm	10.80	1,026,000	95,000	1,026,000	0	0	0	0
Fans										
lab exhaust fans	+	50,000 cf	4.00	200,000	50,000	200,000		0		0
energy recovery coils		100,000 ls	1.00	100,000	100,000	100,000		0		0
general supply and exhaust fans	+	50,000 cf	1.50	75,000	50,000	75,000		0		0
Subtotal Fans		100,000 cfm	3.75	375,000	100,000	375,000	0	0	0	0
Heating Plant										
boilers, hot water pumps w/VFDs, expansion tanks, air separators, boiler breeching, chemical treatment	*	5,500 mb	40.00	220,000	5,500	220,000		0		0
Subtotal Heating Plant		5,500 mbh	40.00	220,000	5,500	220,000	0	0	0	0
Cooling Plant										
chillers, cooling towers, chilled and condensor water pumps w/VFDs, expansion tanks, air separators, winter heat exchanger, chemical treatment, filters	*	700 tns	1,500.00	1,050,000	700	1,050,000		0		0
Subtotal Cooling Plant		700 tns	1,500.00	1,050,000	700	1,050,000	0	0	0	0
Air Distribution										
ductwork, ss ductwork, insulation, air mixing boxes and valves, registers, grilles, diffusers, plenums, dampers	*	165,600 lbs	15.50	2,566,800	165,000	2,557,500	600	9,300		0

ELEMENTAL ESTIMATE					Base		Bridge		Articulation	
Description	Trade	Quantity	Rate	$	Quantity	$	Quantity	$	Quantity	$
Subtotal Air Distribution		165,600 lbs	15.50	2,566,800	165,000	2,557,500	600	9,300	0	0
Terminal Units										
reheat coils, perimeter radiation, dedicated cooling units, chilled beams	+	80,000 sf	14.00	1,120,000	80,000	1,120,000		0		0
reheat coils, perimeter radiation, dedicated cooling units, chilled beams	+	1,170 sf	3.50	4,095		0	1,170	4,095		0
Subtotal Terminal Units		81,170 sf	13.85	1,124,095	80,000	1,120,000	1,170	4,095	0	0
Piping										
chilled water, condensor water, hot water, steam, gas	+	80,000 sf	20.00	1,600,000	80,000	1,600,000		0		0
headend and terminal equipment connections		80,000 sf	6.50	520,000	80,000	520,000		0		0
allow	+	1,170 sf	5.00	5,850		0	1,170	5,850		0
Subtotal Piping		81,170 sf	26.19	2,125,850	80,000	2,120,000	1,170	5,850	0	0
Miscellaneous										
emergency generator accessories		1,500 kw	120.00	180,000	1,500	180,000		0		0
testing, balancing, coordination, as-builts, and 3rd party assist commissioning		81,170 sf	1.60	129,872	80,000	128,000	1,170	1,872		0
metering, change filters, etc		40,000 ls	1.00	40,000	40,000	40,000		0		0
Subtotal Miscellaneous				349,872	0	348,000	0	1,872	0	0
Total C13 HVAC		81,170 sf	108.88	8,837,617	110.21	8,816,500	18.05	21,117	#Num!	0
C14 Controls										
Controls										
controls	+	80,000 sf	15.00	1,200,000	80,000	1,200,000		0		0

ELEMENTAL ESTIMATE					Base		Bridge		Articulation	
Description	Trade	Quantity	Rate	$	Quantity	$	Quantity	$	Quantity	$
aircuity system - NIC		80,000 sf	0.00	0	80,000	0		0		0
allow	+	1,170 sf	4.00	4,680		0	1,170	4,680		0
Subtotal Controls		81,170 sf	14.84	1,204,680	80,000	1,200,000	1,170	4,680	0	0
Total C14 Controls		81,170 sf	14.84	1,204,680	15.00	1,200,000	4.00	4,680	#Num!	0

	Total $	Base $	Bridge $	Articulation $
TOTAL C1 MECHANICAL	11,909,853	11,878,030	31,823	0

ELEMENTAL ESTIMATE					Base		Bridge		Articulation	
Description	Trade	Quantity	Rate	$	Quantity	$	Quantity	$	Quantity	$
C2 ELECTRICAL										
C21 Service & Distribution										
Normal Service & Distribution										
double ended switchgear	*	4,000 A	140.00	560,000	4,000	560,000		0		0
distribution boards, panelboards, transformers, feeders		80,000 sf	14.00	1,120,000	80,000	1,120,000		0		0
grounding		20,000 ls	1.00	20,000	20,000	20,000		0		0
Subtotal Normal Service & Distribution		4,000 A	425.00	1,700,000	4,000	1,700,000	0	0	0	0
Emergency Service & Distribution										
emergency generator	*	1,500 kw	385.00	577,500	1,500	577,500		0		0
automatic transfer switches		1,500 kw	100.00	150,000	1,500	150,000		0		0
distribution boards, panelboards, transformers, feeders		80,000 sf	9.00	720,000	80,000	720,000		0		0
UPS distribution system		40 kw	2,000.00	80,000	40	80,000		0		0
Subtotal Emergency Service & Distribution		1,500 kw	1,018.33	1,527,500	1,500	1,527,500	0	0	0	0
Motor Wiring & Control										
motor wiring	+	80,000 sf	2.00	160,000	80,000	160,000		0		0
Subtotal Motor Wiring & Control		80,000 sf	2.00	160,000	80,000	160,000	0	0	0	0
Total C21 Service & Distribution		81,170 sf	41.73	3,387,500	42.34	3,387,500	0.00	0	#Num!	0
C22 Lighting & Devices										
Lighting										
lighting, installation, wiring, swiches	+	80,000 sf	13.00	1,040,000	80,000	1,040,000		0		0
lighting controls		80,000 sf	2.25	180,000	80,000	180,000		0		0
allow	+	1,170 sf	9.00	10,530		0	1,170	10,530		0

ELEMENTAL ESTIMATE					Base		Bridge		Articulation	
Description	Trade	Quantity	Rate	$	Quantity	$	Quantity	$	Quantity	$
Subtotal Lighting		81,170 sf	15.16	1,230,530	80,000	1,220,000	1,170	10,530	0	0
Devices										
devices	+	80,000 sf	4.00	320,000	80,000	320,000		0		0
allow	+	1,170 sf	1.00	1,170		0	1,170	1,170		0
Subtotal Devices		81,170 sf	3.96	321,170	80,000	320,000	1,170	1,170	0	0
Total C22 Lighting & Devices		81,170 sf	19.12	1,551,700	19.25	1,540,000	10.00	11,700	#Num!	0
C23 Systems										
Fire Alarm										
fire alarm system	+	81,170 sf	2.00	162,340	80,000	160,000	1,170	2,340		0
Subtotal Fire Alarm		81,170 sf	2.00	162,340	80,000	160,000	1,170	2,340	0	0
Tel/Data										
telecom raceways	+	80,000 sf	2.50	200,000	80,000	200,000		0		0
telecom cabling & jacks		80,000 sf	3.00	240,000	80,000	240,000		0		0
telecom equipment - by others		80,000 sf	0.00	0	80,000	0		0		0
Subtotal Tel/Data		80,000 sf	5.50	440,000	80,000	440,000	0	0	0	0
Other Systems										
security, complete system		80,000 sf	1.60	128,000	80,000	128,000		0		0
A/V conduit only		80,000 sf	0.20	16,000	80,000	16,000		0		0
lightning protection		80,000 sf	0.55	44,000	80,000	44,000		0		0
miscellaneous electrical & coordination	+	81,170 sf	1.00	81,170	80,000	80,000	1,170	1,170		0
Subtotal Other Systems		81,170 sf	3.32	269,170	80,000	268,000	1,170	1,170	0	0

ELEMENTAL ESTIMATE						Base		Bridge		Articulation	
Description	Trade	Quantity		Rate	$	Quantity	$	Quantity	$	Quantity	$
Total C23 Systems		81,170	sf	10.74	871,510	10.85	868,000	3.00	3,510	#Num!	0
TOTAL C2 ELECTRICAL					5,810,710		5,795,500		15,210		0

ELEMENTAL ESTIMATE					Base		Bridge		Articulation	
Description	Trade	Quantity	Rate	$	Quantity	$	Quantity	$	Quantity	$
D1 SITE WORK										
D11 Site Development										
Site Preparation										
allow		50,000 sf	25.00	1,250,000	50,000	1,250,000		0		0
Subtotal Site Preparation				1,250,000	0	1,250,000	0	0	0	0
Total D11 Site Development		81,170 sf	15.40	1,250,000	15.63	1,250,000	0.00	0	#Num!	0
D12 Mechanical Site Services										
Building Services										
water, fire, and sanitary sewer services		150,000 ls	1.00	150,000	150,000	150,000		0		0
gas - allow for excavation only		10,000 ls	1.00	10,000	10,000	10,000		0		0
chilled water		300,000 ls	1.00	300,000	300,000	300,000		0		0
Subtotal Building Services				460,000	0	460,000	0	0	0	0
Site Drainage & Services										
storm drainage		150,000 ls	1.00	150,000	150,000	150,000		0		0
site wide storm water mitigation		350,000 ls	1.00	350,000	350,000	350,000		0		0
Subtotal Site Drainage & Services				500,000	0	500,000	0	0	0	0
Total D12 Mechanical Site Services		81,170 sf	11.83	960,000	12.00	960,000	0.00	0	#Num!	0
D13 Electrical Site Services										
Building Services										
power ductbanks		75,000 ls	1.00	75,000	75,000	75,000		0		0
telecom ductbanks		50,000 ls	1.00	50,000	50,000	50,000		0		0

ELEMENTAL ESTIMATE					Base		Bridge		Articulation	
Description	Trade	Quantity	Rate	$	Quantity	$	Quantity	$	Quantity	$
incoming HV feeder		200,000 ls	1.00	200,000	200,000	200,000		0		0
incoming telecom - by others			0.00	0		0		0		0
Subtotal Building Services				325,000	0	325,000	0	0	0	0
Site Lighting & Services										
site lighting		150,000 ls	1.00	150,000	150,000	150,000		0		0
Subtotal Site Lighting & Services				150,000	0	150,000	0	0	0	0
Total D13 Electrical Site Services		81,170 sf	5.85	475,000	5.94	475,000	0.00	0	#Num!	0
TOTAL D1 SITE WORK				2,685,000		2,685,000		0		0

ELEMENTAL ESTIMATE					Base		Bridge		Articulation	
Description	Trade	Quantity	Rate	$	Quantity	$	Quantity	$	Quantity	$
DIRECT CONSTRUCTION COST				46,611,372		44,764,817		746,090		1,100,465

Z1 GENERAL REQUIREMENTS

Z11 General Requirements

General Requirements

Z111 Supervision & Labour Expenses

Supervision & Site Staff: Supervision, site staff, superintendent, engineers, watchman and security, attendance on architect or clerk of works, attendance on subcontractors, scheduling, coordination.

Labour Expenses: premium time, overtime, miscellaneous travel and lodging, wage increases; Remote site transportation and accommodations.

Z112 Temporary Facilities

Access: Temporary roads, staging, storage and parking areas, signage and traffic control.

Accommodation: Temporary offices and sheds, temporary toilets, telephone, office and first aid supplies, camp facilities, mobilization and maintenance.

Expenses, Reimbursables: Layout and preparation, documents and photographs, mockups and samples, printing and duplication.

Protection: Temporary fences, hoardings and barricades; Scaffolding, ramps and runways, guard rails, stairs and ladders, temporary partitions and dust screens, wind bracing, temporary fire protection, site protection including sidewalks, curbs, trees, etc.

Temporary Services: Water, power, heat, site drainage.

Equipment: mobile and tower cranes, hoists and temporary elevators, forklifts, trucking, buggies, disposal chutes, other equipment rental and associated costs such as fuel, oil and consumables.

Winter Conditions: Winter concrete premium, snow and ice clearing, tarpaulins, insulation mats, enclosures, etc.

Clean-up: Daily and final cleanup, glass cleaning, dumpster rental and dumping charges.

Z113 Permits, Insurance, Bonds & Other Expenses

Fire, liability and theft insurance, all risk insurance, performance and bid bonds, building permit, miscellaneous permits, taxes and fees, testing and inspection.

Description	Trade	Quantity	Rate	$	Base Quantity	Base $	Bridge Quantity	Bridge $	Articulation Quantity	Articulation $
General Requirements	01010 +	13.0% ls		6,059,478	13.0%	5,819,426	13.0%	96,992	13.0%	143,060
Subtotal General Requirements		0 ls		6,059,478	0	5,819,426	0	96,992	0	143,060

Temporary Power & Light

Description	Trade	Quantity	Rate	$	Base Quantity	Base $	Bridge Quantity	Bridge $	Articulation Quantity	Articulation $
Temporary Power & Light	16010 +	.1% ls		46,611	.1%	44,765	.1%	746	.1%	1,100

ELEMENTAL ESTIMATE					Base		Bridge		Articulation	
Description	Trade	Quantity	Rate	$	Quantity	$	Quantity	$	Quantity	$
Subtotal Temporary Power & Light		0 ls		46,611	0	44,765	0	746	0	1,100
Total Z11 General Requirements		81,170 sf		6,106,089	73.30	5,864,191	83.54	97,738	#Div/0!	144,161
Z12 Fee										
Profit/Fee/Risk										

Z121 Profit/Fee:
Head office overhead, construction manager's fee, general contractors profit.

Z122 Risk:
Warranties, guarantees and liquidated damages.
Labour restrictions & requirements; Strike or lockout delays.
Bidding restrictions and requirements.

Description	Trade	Quantity	Rate	$	Base Quantity	Base $	Bridge Quantity	Bridge $	Articulation Quantity	Articulation $
Profit/Fee/Risk	01020 +	3.0% ls		1,398,341	3.0%	1,342,945	3.0%	22,383	3.0%	33,014
Subtotal Profit/Fee/Risk		0 ls		1,398,341	0	1,342,945	0	22,383	0	33,014
Total Z12 Fee		81,170 sf		1,398,341	16.79	1,342,945	19.13	22,383	#Div/0!	33,014
TOTAL Z1 GENERAL REQUIREMENTS				7,504,431		7,207,135		120,120		177,175

ELEMENTAL ESTIMATE					Base		Bridge		Articulation	
Description	Trade	Quantity	Rate	$	Quantity	$	Quantity	$	Quantity	$

Z2 CONTINGENCIES

Z21 Estimating Contingency

Design Stage Contingency

Design contingency covers unanticipated changes during design and is absorbed as design progresses and more detailed information becomes available and is normally reduced to zero for final documents.

Z211 Documentation
Covers errors and omissions in design documents, definition of lump sum allocations (unmeasured items), development and definition of measured elements, development and definition of details and assemblies.

Z212 Estimating
Covers estimating errors and omissions.

Z213 Program
Covers unforeseen site conditions, program and user scope changes, owner directed design changes, design changes caused by regulatory bodies (excluded - typically with project contingency).

Description	Trade	Quantity	Rate	$	Base Quantity	Base $	Bridge Quantity	Bridge $	Articulation Quantity	Articulation $
Design Stage Contingency	08010 +	10.0% ls		4,661,137	10.0%	4,476,482	10.0%	74,609	10.0%	110,047
Subtotal Design Stage Contingency		0 ls		4,661,137	0	4,476,482	0	74,609	0	110,047
Total Z21 Estimating Contingency		81,170 sf		4,661,137	55.96	4,476,482	63.77	74,609	#Div/0!	110,047

Z22 Escalation Contingency

Escalation Contingency - Q3 - 2015

Escalation contingency covers rate increases from the present to the start of construction and is normally reduced to zero for final documents.

Z221 Inflation:
Covers increases due to inflation (labour and materials) until start of construction.

Z222 Bidding:
Covers increases due to lack of bidders or busy market conditions, variance between actual bid amounts and averages used in estimating.

During periods of unstable market conditions and price volatility, we recommend a bidding contingency (usually 5 - 10 percent) be included to reflect both the sudden upward or downward shifts in the market and the greater spread to be expected in the range of bids.

Description	Trade	Quantity	Rate	$	Base Quantity	Base $	Bridge Quantity	Bridge $	Articulation Quantity	Articulation $
Escalation Contingency - Q3 - 2015	09010 +	13.5% ls		6,292,536	13.5%	6,043,251	13.5%	100,722	13.5%	148,563

ELEMENTAL ESTIMATE					Base		Bridge		Articulation	
Description	Trade	Quantity	Rate	$	Quantity	$	Quantity	$	Quantity	$
Subtotal Escalation Contingency - Q3 - 2015		0 ls		6,292,536	0	6,043,251	0	100,722	0	148,563
Total Z22 Escalation Contingency		81,170 sf		6,292,536	75.54	6,043,251	86.09	100,722	#Div/0!	148,563

Z23 Construction Contingency

Construction Contigency

Construction contingency covers changes during construction.

Z231 Documentation

Covers extra costs during construction due to unforeseen site conditions, errors and omissions in documentation or construction management, etc. (typically included).

Z232 Program

Covers extra costs during construction due to program and user scope modifications, changes caused by regulatory bodies, overrun of cash allowances, etc (excluded - typically with project contingency).

Description	Trade	Quantity	Rate	$	Base Quantity	Base $	Bridge Quantity	Bridge $	Articulation Quantity	Articulation $
Construction Contigency	08020 +	3.0% ls		1,398,341	3.0%	1,342,945	3.0%	22,383	3.0%	33,014
Subtotal Construction Contigency		0 ls		1,398,341	0	1,342,945	0	22,383	0	33,014
Total Z23 Construction Contingency		81,170 sf		1,398,341	16.79	1,342,945	19.13	22,383	#Div/0!	33,014
TOTAL Z2 CONTINGENCIES				12,352,014		11,862,677		197,714		291,623

ELEMENTAL ESTIMATE

Description	Trade		Quantity		Rate	$	Base Quantity	Base $	Bridge Quantity	Bridge $	Articulation Quantity	Articulation $
Z3 OTHER COSTS												
Z31 Other Costs												
Ancillary Costs	08020	+	.0%	ls		0	.0%	0	.0%	0	.0%	0
Subtotal Ancillary Costs				ls		0	0	0	0	0	0	0
Total Z31 Other Costs			81,170	sf		0	0.00	0	0.00	0	#Num!	0
TOTAL Z3 OTHER COSTS						0		0		0		0

Ancillary Costs
(1) Development charges & special taxes – NIC.
(2) Payments to other agencies – NIC,
(3) Hazardous waste removal – NIC,
(4) Occupancy Costs: loose furnishing and equipment – NIC, moving costs – NIC,
(5) Design: preconstruction services – NIC, architects, engineers, and other consultants fees – NIC.
(6) Administrative and financing costs – NIC
(7) Land acquisition – NIC, survey and legal fees – NIC.

ELEMENTAL ESTIMATE					Base		Bridge		Articulation	
Description	Trade	Quantity	Rate	$	Quantity	$	Quantity	$	Quantity	$
INDIRECT CONSTRUCTION COST				19,856,444		19,069,812		317,834		468,798
TOTAL COSTS				$66,467,816		$63,834,628		$1,063,924		$1,569,263

October 9, 2013

Payette
290 Congress St., Fifth Floor
Boston, MA 02210-1005

Attention: Peter Viera

Re: Brown University –Prince Lab

Dear Peter,

Please find enclosed our draft cost estimate for the above project based on preliminary design.

	Area (sf)	**$/sf**	**$000's**
Alternate 1	57,015	221	12,597
Add for Alternate 2	3,352	472	1,582
Alternate 2	**60,367**	**235**	**14,178**

This estimate includes all direct construction costs, general contractor's overhead and profit, design and construction contingencies. Cost escalation assumes an April 2015 construction start.

Excluded from the estimate are: hazardous waste removal, loose furnishings and equipment, project contingency, architect's and engineer's fees, moving, administrative and financing costs.

Bidding conditions are expected to reflect one construction manager, open bidding for sub-contractors, open specifications for materials and manufacturers.

This estimate is based on bids received in this market for comparable work. Projected changes in design and inflation are covered by contingency. Variances from these projections can occur due to lack or surplus of bidders at time of bid, proprietary specifications, contractual and procurement practice, documentation and tendering changes, contractor's errors and omissions etc. We expect bids received to be within 5 - 10% of estimated values 19 times out of 20 recognizing the above.

If you have any questions or require further analysis please do not hesitate to contact us.

Yours very truly,

James Vermeulen, PQS
Co-CEO

LEVEL 2 ELEMENTAL SUMMARY	$/sf	Element $	%	1 Alternate 1		2 Alternate 1b	
GROSS FLOOR AREA		60,367 sf		$/sf	57,015	$/sf	3,352
A1 SUBSTRUCTURE	1.06	64,000	0%	0.56	32,000	9.55	32,000
A2 STRUCTURE	10.95	661,139	5%	8.72	497,020	48.96	164,119
A3 ENCLOSURE	18.78	1,133,763	8%	16.64	948,688	55.21	185,075
B1 PARTITIONS & DOORS	17.36	1,047,930	7%	16.38	933,858	34.03	114,073
B2 FINISHES	7.12	429,653	3%	6.92	394,765	10.41	34,888
B3 FITTINGS & EQUIPMENT	10.20	615,525	4%	10.18	580,357	10.49	35,168
C1 MECHANICAL	54.40	3,283,771	23%	52.84	3,012,899	80.81	270,872
C2 ELECTRICAL	26.12	1,576,951	11%	25.41	1,448,601	38.29	128,350
D1 SITE WORK	2.07	125,000	1%	1.75	100,000	7.46	25,000
D2 ANCILLARY WORK	10.11	610,014	4%	9.38	534,526	22.52	75,488
DIRECT CONSTRUCTION COST	158.16	9,547,745	67%	148.78	8,482,712	317.73	1,065,033
Z1 GENERAL REQUIREMENTS	25.31	1,527,639	11%	23.80	1,357,234	50.84	170,405
Z2 CONTINGENCIES	51.40	3,103,017	22%	48.35	2,756,882	103.26	346,136
Z3 OTHER COSTS	0.00	0	0%	0.00	0	0.00	0
TOTAL CONSTRUCTION COST	234.87	14,178,401	100%	220.94	12,596,828	471.83	1,581,573

ELEMENTAL SUMMARY	Level 3 Elemental $	$/sf	1 Alternate 1		2 Alternate 1b	
GROSS FLOOR AREA			$/sf	57,015	$/sf	3,352
A1 SUBSTRUCTURE						
A11 Foundations	36,000	0.60	0.32	18,000	5.37	18,000
A12 Building Excavation	28,000	0.46	0.25	14,000	4.18	14,000
A2 STRUCTURE						
A21 Lowest Floor Structure	144,575	2.39	2.45	139,455	1.53	5,120
A22 Upper Floor Structure	432,880	7.17	5.17	294,725	41.22	138,155
A23 Roof Structure	83,684	1.39	1.10	62,840	6.22	20,844
A3 ENCLOSURE						
A32 Walls Above Grade	197,423	3.27	3.35	191,098	1.89	6,325
A33 Windows & Entrances	403,000	6.68	3.93	224,250	53.33	178,750
A34 Roof Covering	533,340	8.83	9.35	533,340	0.00	0
A35 Projections	0	0.00	0.00	0	0.00	0
B1 PARTITIONS & DOORS						
B11 Partitions	934,930	15.49	14.48	825,658	32.60	109,273
B12 Doors	113,000	1.87	1.90	108,200	1.43	4,800
B2 FINISHES						
B21 Floor Finishes	226,717	3.76	3.59	204,715	6.56	22,002
B22 Ceiling Finishes	129,611	2.15	2.14	121,975	2.28	7,636
B23 Wall Finishes	73,325	1.21	1.19	68,075	1.57	5,250
B3 FITTINGS & EQUIPMENT						
B31 Fittings	357,525	5.92	5.74	327,357	9.00	30,168
B32 Equipment	108,000	1.79	1.81	103,000	1.49	5,000
B33 Conveying Systems	150,000	2.48	2.63	150,000	0.00	0
C1 MECHANICAL						
C11 Plumbing & Drainage	433,835	7.19	7.05	402,225	9.43	31,610
C12 Fire Protection	301,835	5.00	5.00	285,075	5.00	16,760
C13 HVAC	2,215,740	36.70	35.47	2,022,260	57.72	193,480
C14 Controls	332,361	5.51	5.32	303,339	8.66	29,022
C2 ELECTRICAL						
C21 Service & Distribution	558,740	9.26	8.95	510,370	14.43	48,370

ELEMENTAL SUMMARY		Level 3 Elemental $	$/sf			1 Alternate 1		2 Alternate 1b	
GROSS FLOOR AREA						$/sf	57,015	$/sf	3,352
C22 Lighting & Devices		615,722	10.20			10.00	570,322	13.54	45,400
C23 Systems		402,489	6.67			6.45	367,909	10.32	34,580
D1 SITE WORK									
D11 Site Development		125,000	2.07			1.75	100,000	7.46	25,000
D2 ANCILLARY WORK									
D21 Demolition		610,014	10.11			9.38	534,526	22.52	75,488
DIRECT CONSTRUCTION COST						148.78	8,482,712	317.73	1,065,033
Z1 GENERAL REQUIREMENTS									
Z11 General Requirements	13.0%	1,241,207	20.56			19.34	1,102,753	41.30	138,454
Z12 Fee	3.0%	286,432	4.74			4.46	254,481	9.53	31,951
Z2 CONTINGENCIES									
Z21 Estimating Contingency	15.0%	1,432,162	23.72			22.32	1,272,407	47.66	159,755
Z22 Escalation Contingency	12.5%	1,193,468	19.77			18.60	1,060,339	39.72	133,129
Z23 Construction Contingency	5.0%	477,387	7.91			7.44	424,136	15.89	53,252
Z3 OTHER COSTS									
Z31 Other Costs	0.0%	0	0.00			0.00	0	0.00	0
TOTAL CONSTRUCTION COST				234.87	14,178,401 100%	220.94	12,596,828	471.83	1,581,573

ELEMENTAL ESTIMATE

Description	Trade	Quantity		Rate	$	1 Alternate 1 Quantity	1 Alternate 1 $	2 Alternate 1b Quantity	2 Alternate 1b $
GROSS FLOOR AREA									
Level 0		23,696	sf			23,696			
Level 1		25,060	sf			23,704		1,356	
Level 2 Mezzanine		11,611	sf			9,615		1,996	
TOTAL GROSS FLOOR AREA		60,367	sf			57,015		3,352	

REPORT NOTES

Description	Trade	Quantity	Rate	$	1 Alternate 1 Quantity	1 Alternate 1 $	2 Alternate 1b Quantity	2 Alternate 1b $
A1 SUBSTRUCTURE								
A11 Foundations								
Foundations								
reinforce existing 8' x 8' x 2' pad footings @ bracing locations		8 no	4,500.00	36,000	4	18,000	4	18,000
Subtotal Foundations				36,000	0	18,000	0	18,000
Total A11 Foundations		60,367 sf	0.60	36,000	0.32	18,000	5.37	18,000
A12 Building Excavation								
Earthwork								
excavate existing footings, back fill with clean fill, assume hand excavation	+	56 cy	500.00	28,000	28	14,000	28	14,000
Subtotal Earthwork		56 cy	500.00	28,000	28	14,000	28	14,000
Total A12 Building Excavation		60,367 sf	0.46	28,000	0.25	14,000	4.18	14,000
TOTAL A1 SUBSTRUCTURE				64,000		32,000		32,000

ELEMENTAL ESTIMATE					1 Alternate 1		2 Alternate 1b	
Description	Trade	Quantity	Rate	$	Quantity	$	Quantity	$
A2 STRUCTURE								
A21 Lowest Floor Structure								
On Grade								
cut, patch and repair existing	+	7,289 sf	15.00	109,335	7,289	109,335		0
existing, no work		16,407 sf	0.00	0	16,407	0		0
new slab @ exposed foundations	+	512 sf	20.00	10,240	256	5,120	256	5,120
elevator pit		25,000 ls	1.00	25,000	25,000	25,000		0
Subtotal On Grade		7,801 sf	18.53	144,575	7,545	139,455	256	5,120
Total A21 Lowest Floor Structure		60,367 sf	2.39	144,575	2.45	139,455	1.53	5,120
A22 Upper Floor Structure								
Floor Structure								
4-1/2" concrete topping on 3" metal deck	+	4,690 sf	9.25	43,383	2,694	24,920	1,996	18,463
structural steel beams (8.6 psf)		20 ton	5,000.00	100,000	12	60,000	8	40,000
structural steel columns (1.1 psf)		3 ton	5,000.00	12,500	2	7,500	1	5,000
tube steel bracing (2.58 psf)		6 ton	5,500.00	33,000	3	16,500	3	16,500
tube steel bracing (exterior wall - .86 psf)		2 ton	5,500.00	11,000	1	5,500	1	5,500
reinforce existing columns, steel plate		267 lf	75.00	20,025	133	9,975	134	10,050
reinforce existing W12 x 36 with steel plate		64 lf	75.00	4,800	32	2,400	32	2,400
steel cable bracing		176 lf	150.00	26,400	88	13,200	88	13,200
existing, allow cut, patch, make good	+	27,490 sf	1.50	41,235	26,134	39,201	1,356	2,034
allow for minor framing to penetrations (.5 psf)		9 ton	5,000.00	42,500	7	32,500	2	10,000
existing, no work		7,185 sf	0.00	0	7,185	0		0
fireproofing		4,690 sf	5.00	23,450	2,694	13,470	1,996	9,980
Subtotal Floor Structure		32,180 sf	11.13	358,293	28,828	225,166	3,352	133,127
Stairs, Miscellaneous								
existing stairs, make good		6 sf	2,500.00	15,000	6	15,000		0
miscellaneous metals	+	39,725 sf	1.50	59,588	36,373	54,560	3,352	5,028

ELEMENTAL ESTIMATE

Description	Trade	Quantity		Rate	$	1 Alternate 1 Quantity	1 Alternate 1 $	2 Alternate 1b Quantity	2 Alternate 1b $
Subtotal Stairs, Miscellaneous		39,725	sf	1.88	74,588	36,373	69,560	3,352	5,028
Total A22 Upper Floor Structure		60,367	sf	7.17	432,880	5.17	294,725	41.22	138,155
A23 Roof Structure									
Roof Structure									
make good, allow	+	25,576	sf	1.50	38,364	23,580	35,370	1,996	2,994
new deck / steel to elevator overrun	+	124	sf	30.00	3,720	124	3,720		0
structural steel - collector assembly		8	ton	5,000.00	41,600	5	23,750	4	17,850
Subtotal Roof Structure		25,700	sf	3.26	83,684	23,704	62,840	1,996	20,844
Total A23 Roof Structure		60,367	sf	1.39	83,684	1.10	62,840	6.22	20,844
TOTAL A2 STRUCTURE					661,139		497,020		164,119

ELEMENTAL ESTIMATE					1 Alternate 1		2 Alternate 1b	
Description	Trade	Quantity	Rate	$	Quantity	$	Quantity	$
A3 ENCLOSURE								
A32 Walls Above Grade								
Cladding								
make good exterior wall @ curtain wall perimeter	+	7,179 sf	25.00	179,475	6,949	173,725	230	5,750
Subtotal Cladding		7,179 sf	25.00	179,475	6,949	173,725	230	5,750
Backup								
make good inside face exterior wall		7,179 sf	2.50	17,948	6,949	17,373	230	575
Subtotal Backup				17,948	0	17,373	0	575
Total A32 Walls Above Grade		60,367 sf	3.27	197,423	3.35	191,098	1.89	6,325
A33 Windows & Entrances								
Windows								
curtain wall	+	3,224 sf	125.00	403,000	1,794	224,250	1,430	178,750
existing windows, no work assumed		1,290 sf	0.00	0	1,290	0		0
Subtotal Windows		3,224 sf	125.00	403,000	1,794	224,250	1,430	178,750
Entrances								
no work assumed			0.00	0		0		0
Subtotal Entrances				0	0	0	0	0
Total A33 Windows & Entrances		60,367 sf	6.68	403,000	3.93	224,250	53.33	178,750
A34 Roof Covering								
Roofing								
tpo roofing	+	23,704 sf	20.00	474,080	23,704	474,080		0

ELEMENTAL ESTIMATE						1 Alternate 1		2 Alternate 1b	
Description	Trade	Quantity		Rate	$	Quantity	$	Quantity	$
flashings & accessories		23,704	sf	2.50	59,260	23,704	59,260		0
Subtotal Roofing		23,704	sf	22.50	533,340	23,704	533,340	0	0
Total A34 Roof Covering		60,367	sf	8.83	533,340	9.35	533,340	0.00	0
A35 Projections									
Projections - Area Based									
canopties & sunscren - not required				0.00	0		0		0
Subtotal Projections - Area Based					0	0	0	0	0
Total A35 Projections		60,367	sf	0.00	0	0.00	0	0.00	0
TOTAL A3 ENCLOSURE					1,133,763		948,688		185,075

ELEMENTAL ESTIMATE					1 Alternate 1		2 Alternate 1b	
Description	Trade	Quantity	Rate	$	Quantity	$	Quantity	$
B1 PARTITIONS & DOORS								
B11 Partitions								
Partitions								
existing - no work	+	32,055 sf	0.00	0	32,055	0		0
corridor partitions	+	20,940 sf	8.75	183,225	19,950	174,563	990	8,663
chase partitions	+	570 sf	12.00	6,840	570	6,840		0
rated partitions	+	2,580 sf	10.50	27,090	2,580	27,090		0
shaft partitions	+	2,520 sf	11.50	28,980	2,520	28,980		0
metal mesh partitions	+	4,515 sf	8.00	36,120	3,195	25,560	1,320	10,560
glazing - vestibule	+	165 sf	65.00	10,725	165	10,725		0
glazing - full height hollow metal	+	7,035 sf	60.00	422,100	5,700	342,000	1,335	80,100
articulation	+	3,620 sf	10.00	36,200	3,265	32,650	355	3,550
wood blocking		74,000 sf	0.40	29,600	70,000	28,000	4,000	1,600
sealing & firestopping		74,000 sf	0.75	55,500	70,000	52,500	4,000	3,000
furring & boxing		74,000 sf	0.45	33,300	70,000	31,500	4,000	1,800
Subtotal Partitions		74,000 sf	11.75	869,680	70,000	760,408	4,000	109,273
Railings								
egress - guardrail and handrail	+	130 lf	225.00	29,250	130	29,250		0
egress - handrail	+	135 lf	50.00	6,750	135	6,750		0
void - handrail, glass	+	65 lf	450.00	29,250	65	29,250		0
Subtotal Railings		330 lf	197.73	65,250	330	65,250	0	0
Total B11 Partitions		60,367 sf	15.49	934,930	14.48	825,658	32.60	109,273
B12 Doors								
Doors, Frames, Hardware								
roll-up shutter (12x15)	*	1 no	15,000.00	15,000	1	15,000		0
existing doors	*	81 no	0.00	0	81	0		0
glazed entrances	*	2 no	3,000.00	6,000	2	6,000		0
egress doors	*	8 no	2,100.00	16,800	8	16,800		0
maker space (lab, shop)	*	9 no	1,600.00	14,400	6	9,600	3	4,800

ELEMENTAL ESTIMATE						1 Alternate 1		2 Alternate 1b	
Description	Trade	Quantity		Rate	$	Quantity	$	Quantity	$
typical doors (mep, office, washroom, support)	*	38	no	1,600.00	60,800	38	60,800		0
Subtotal Doors, Frames, Hardware		139	no	812.95	113,000	136	108,200	3	4,800
Total B12 Doors		60,367	sf	1.87	113,000	1.90	108,200	1.43	4,800
TOTAL B1 PARTITIONS & DOORS					1,047,930		933,858		114,073

ELEMENTAL ESTIMATE					1 Alternate 1		2 Alternate 1b	
Description	Trade	Quantity	Rate	$	Quantity	$	Quantity	$
B2 FINISHES								
B21 Floor Finishes								
Flooring								
coat - polished concrete (maker space, lab)	+	6,273 sf	5.00	31,365	3,370	16,850	2,903	14,515
coat - sealed concete (shop)	+	14,340 sf	0.75	10,755	14,340	10,755		0
existing - no work	+	23,093 sf	0.00	0	23,093	0		0
resilient - carpet (office)	+	3,633 sf	4.25	15,440	3,633	15,440		0
resilient - rubber tread & riser	+	856 sf	15.00	12,840	856	12,840		0
tile - ceramic (circulation)	+	6,465 sf	14.00	90,510	6,099	85,386	366	5,124
tile - ceramic (washroom)	+	1,309 sf	12.00	15,708	1,309	15,708		0
floor prep and moisture mitigation		4,489 sf	4.00	17,956	4,489	17,956		0
Subtotal Flooring		55,969 sf	3.48	194,574	52,700	174,935	3,269	19,639
Base								
existing - none	+	4,835 lf	0.00	0	4,835	0		0
resilient - rubber	+	2,806 lf	2.50	7,015	2,456	6,140	350	875
tile - ceramic	+	2,094 lf	12.00	25,128	1,970	23,640	124	1,488
Subtotal Base		9,735 lf	3.30	32,143	9,261	29,780	474	2,363
Total B21 Floor Finishes		60,367 sf	3.76	226,717	3.59	204,715	6.56	22,002
B22 Ceiling Finishes								
Ceilings								
existing - patch & match, mep	+	23,093 sf	1.00	23,093	23,093	23,093		0
gyp - suspended, painted	+	1,309 sf	10.00	13,090	1,309	13,090		0
lay in - acoustic ceiling tile (office, circulation)	+	10,098 sf	5.00	50,490	9,732	48,660	366	1,830
paint - exposed (typical)	+	21,469 sf	2.00	42,938	18,566	37,132	2,903	5,806
Subtotal Ceilings		55,969 sf	2.32	129,611	52,700	121,975	3,269	7,636

ELEMENTAL ESTIMATE

Description	Trade	Quantity		Rate	$	1 Alternate 1 Quantity	1 Alternate 1 $	2 Alternate 1b Quantity	2 Alternate 1b $
Total B22 Ceiling Finishes		60,367	sf	2.15	129,611	2.14	121,975	2.28	7,636
B23 Wall Finishes									
Wall Finishes									
existing - no work	+	72,500	sf	0.00	0	72,500	0		0
paint - prep to gyp	+	67,900	sf	0.75	50,925	60,900	45,675	7,000	5,250
tile - ceramic wainscott	+	1,600	sf	14.00	22,400	1,600	22,400		0
upgraded wall finishes - not required				0.00	0		0		0
Subtotal Wall Finishes		142,000	sf	0.52	73,325	135,000	68,075	7,000	5,250
Total B23 Wall Finishes		60,367	sf	1.21	73,325	1.19	68,075	1.57	5,250
TOTAL B2 FINISHES					429,653		394,765		34,888

ELEMENTAL ESTIMATE

Description	Trade	Quantity	Rate	$	1 Alternate 1 Quantity	1 Alternate 1 $	2 Alternate 1b Quantity	2 Alternate 1b $
B3 FITTINGS & EQUIPMENT								
B31 Fittings								
Casework								
casework - allow		39,725 sf	5.00	198,625	36,373	181,865	3,352	16,760
Subtotal Casework				198,625	0	181,865	0	16,760
Fittings - Misc								
fittings & fixtures		39,725 sf	4.00	158,900	36,373	145,492	3,352	13,408
Subtotal Fittings - Misc				158,900	0	145,492	0	13,408
Total B31 Fittings		60,367 sf	5.92	357,525	5.74	327,357	9.00	30,168
B32 Equipment								
Equipment - Specialty								
fumehoods, 6'		8 no	8,500.00	68,000	8	68,000		0
miscellaneous ofci - allow		40,000 ls	1.00	40,000	35,000	35,000	5,000	5,000
Subtotal Equipment - Specialty				108,000	0	103,000	0	5,000
Total B32 Equipment		60,367 sf	1.79	108,000	1.81	103,000	1.49	5,000
B33 Conveying Systems								
Elevators								
passenger elevator	*	3 stp	50,000.00	150,000	3	150,000		0
Subtotal Elevators		3 stp	50,000.00	150,000	3	150,000	0	0
Total B33 Conveying Systems		60,367 sf	2.48	150,000	2.63	150,000	0.00	0

ELEMENTAL ESTIMATE

Description	Trade	Quantity	Rate	$	1 Alternate 1 Quantity	1 Alternate 1 $	2 Alternate 1b Quantity	2 Alternate 1b $
TOTAL B3 FITTINGS & EQUIPMENT				615,525		580,357		35,168

ELEMENTAL ESTIMATE					1 Alternate 1		2 Alternate 1b	
Description	Trade	Quantity	Rate	$	Quantity	$	Quantity	$
C1 MECHANICAL								
C11 Plumbing & Drainage								
Equipment								
02. Repartition	+	6,699 sf	5.00	33,495	6,699	33,495		0
03. Gut Renovate - office use	+	3,727 sf	5.00	18,635	3,727	18,635		0
04. Gut Renovate - dry lab use	+	7,966 sf	10.00	79,660	4,996	49,960	2,970	29,700
05. Gut Renovate - shop space	+	5,631 sf	10.00	56,310	5,631	56,310		0
06. Gut Renovate - chemical engineering teaching lab	+	1,010 sf	20.00	20,200	1,010	20,200		0
07. Gut Renovate - existing toilet rooms	+	1,573 sf	30.00	47,190	1,573	47,190		0
08. Enclosure/Upgrade - existing stairs	+	1,573 sf	5.00	7,865	1,573	7,865		0
09. Construct - passenger elevator	+	368 sf	5.00	1,840	368	1,840		0
10. Repartition - communicating corridor	+	6,319 sf	5.00	31,595	5,937	29,685	382	1,910
11. Prepare for Mep	+	1,908 sf	10.00	19,080	1,908	19,080		0
work to non-program areas	+	23,593 sf	5.00	117,965	23,593	117,965		0
Subtotal Equipment		60,367 sf	7.19	433,835	57,015	402,225	3,352	31,610
Total C11 Plumbing & Drainage		60,367 sf	7.19	433,835	7.05	402,225	9.43	31,610
C12 Fire Protection								
Sprinklers								
02. Repartition	+	6,699 sf	5.00	33,495	6,699	33,495		0
03. Gut Renovate - office use	+	3,727 sf	5.00	18,635	3,727	18,635		0
04. Gut Renovate - dry lab use	+	7,966 sf	5.00	39,830	4,996	24,980	2,970	14,850
05. Gut Renovate - shop space	+	5,631 sf	5.00	28,155	5,631	28,155		0
06. Gut Renovate - chemical engineering teaching lab	+	1,010 sf	5.00	5,050	1,010	5,050		0
07. Gut Renovate - existing toilet rooms	+	1,573 sf	5.00	7,865	1,573	7,865		0
08. Enclosure/Upgrade - existing stairs	+	1,573 sf	5.00	7,865	1,573	7,865		0
09. Construct - passenger elevator	+	368 sf	5.00	1,840	368	1,840		0
10. Repartition - communicating corridor	+	6,319 sf	5.00	31,595	5,937	29,685	382	1,910
11. Prepare for Mep	+	1,908 sf	5.00	9,540	1,908	9,540		0
work to non-program areas	+	23,593 sf	5.00	117,965	23,593	117,965		0

ELEMENTAL ESTIMATE						1 Alternate 1		2 Alternate 1b	
Description	Trade	Quantity		Rate	$	Quantity	$	Quantity	$
Subtotal Sprinklers		60,367	sf	5.00	301,835	57,015	285,075	3,352	16,760
Total C12 Fire Protection		60,367	sf	5.00	301,835	5.00	285,075	5.00	16,760
C13 HVAC									
Air Handling Units									
02. Repartition	+	6,699	sf	40.00	267,960	6,699	267,960		0
03. Gut Renovate - office use	+	3,727	sf	50.00	186,350	3,727	186,350		0
04. Gut Renovate - dry lab use	+	7,966	sf	60.00	477,960	4,996	299,760	2,970	178,200
05. Gut Renovate - shop space	+	5,631	sf	40.00	225,240	5,631	225,240		0
06. Gut Renovate - chemical engineering teaching lab	+	1,010	sf	100.00	101,000	1,010	101,000		0
07. Gut Renovate - existing toilet rooms	+	1,573	sf	50.00	78,650	1,573	78,650		0
08. Enclosure/Upgrade - existing stairs	+	1,573	sf	40.00	62,920	1,573	62,920		0
09. Construct - passenger elevator	+	368	sf	40.00	14,720	368	14,720		0
10. Repartition - communicating corridor	+	6,319	sf	40.00	252,760	5,937	237,480	382	15,280
11. Prepare for Mep	+	1,908	sf	40.00	76,320	1,908	76,320		0
work to non-program areas	+	23,593	sf	20.00	471,860	23,593	471,860		0
Subtotal Air Handling Units		60,367	sf	36.70	2,215,740	57,015	2,022,260	3,352	193,480
Total C13 HVAC		60,367	sf	36.70	2,215,740	35.47	2,022,260	57.72	193,480
C14 Controls									
Controls									
02. Repartition	+	6,699	sf	6.00	40,194	6,699	40,194		0
03. Gut Renovate - office use	+	3,727	sf	7.50	27,953	3,727	27,953		0
04. Gut Renovate - dry lab use	+	7,966	sf	9.00	71,694	4,996	44,964	2,970	26,730
05. Gut Renovate - shop space	+	5,631	sf	6.00	33,786	5,631	33,786		0
06. Gut Renovate - chemical engineering teaching lab	+	1,010	sf	15.00	15,150	1,010	15,150		0
07. Gut Renovate - existing toilet rooms	+	1,573	sf	7.50	11,798	1,573	11,798		0
08. Enclosure/Upgrade - existing stairs	+	1,573	sf	6.00	9,438	1,573	9,438		0

ELEMENTAL ESTIMATE

Description	Trade	Quantity	Rate	$	1 Alternate 1 Quantity	1 Alternate 1 $	2 Alternate 1b Quantity	2 Alternate 1b $
09. Construct - passenger elevator	+	368 sf	6.00	2,208	368	2,208		0
10. Repartition - communicating corridor	+	6,319 sf	6.00	37,914	5,937	35,622	382	2,292
11. Prepare for Mep	+	1,908 sf	6.00	11,448	1,908	11,448		0
work to non-program areas	+	23,593 sf	3.00	70,779	23,593	70,779		0
Subtotal Controls		60,367 sf	5.51	332,361	57,015	303,339	3,352	29,022
Total C14 Controls		60,367 sf	5.51	332,361	5.32	303,339	8.66	29,022
TOTAL C1 MECHANICAL				3,283,771		3,012,899		270,872

ELEMENTAL ESTIMATE

Description	Trade	Quantity	Rate	$	1 Alternate 1 Quantity	1 Alternate 1 $	2 Alternate 1b Quantity	2 Alternate 1b $
C2 ELECTRICAL								
C21 Service & Distribution								
Normal Service & Distribution								
02. Repartition	+	6,699 sf	10.00	66,990	6,699	66,990		0
03. Gut Renovate - office use	+	3,727 sf	10.00	37,270	3,727	37,270		0
04. Gut Renovate - dry lab use	+	7,966 sf	15.00	119,490	4,996	74,940	2,970	44,550
05. Gut Renovate - shop space	+	5,631 sf	15.00	84,465	5,631	84,465		0
06. Gut Renovate - chemical engineering teaching lab	+	1,010 sf	15.00	15,150	1,010	15,150		0
07. Gut Renovate - existing toilet rooms	+	1,573 sf	10.00	15,730	1,573	15,730		0
08. Enclosure/Upgrade - existing stairs	+	1,573 sf	10.00	15,730	1,573	15,730		0
09. Construct - passenger elevator	+	368 sf	10.00	3,680	368	3,680		0
10. Repartition - communicating corridor	+	6,319 sf	10.00	63,190	5,937	59,370	382	3,820
11. Prepare for Mep	+	1,908 sf	10.00	19,080	1,908	19,080		0
work to non-program areas	+	23,593 sf	5.00	117,965	23,593	117,965		0
Subtotal Normal Service & Distribution		60,367 sf	9.26	558,740	57,015	510,370	3,352	48,370
Total C21 Service & Distribution		60,367 sf	9.26	558,740	8.95	510,370	14.43	48,370
C22 Lighting & Devices								
Lighting								
02. Repartition	+	6,699 sf	14.00	93,786	6,699	93,786		0
03. Gut Renovate - office use	+	3,727 sf	14.00	52,178	3,727	52,178		0
04. Gut Renovate - dry lab use	+	7,966 sf	14.00	111,524	4,996	69,944	2,970	41,580
05. Gut Renovate - shop space	+	5,631 sf	14.00	78,834	5,631	78,834		0
06. Gut Renovate - chemical engineering teaching lab	+	1,010 sf	14.00	14,140	1,010	14,140		0
07. Gut Renovate - existing toilet rooms	+	1,573 sf	14.00	22,022	1,573	22,022		0
08. Enclosure/Upgrade - existing stairs	+	1,573 sf	10.00	15,730	1,573	15,730		0
09. Construct - passenger elevator	+	368 sf	10.00	3,680	368	3,680		0
10. Repartition - communicating corridor	+	6,319 sf	10.00	63,190	5,937	59,370	382	3,820
11. Prepare for Mep	+	1,908 sf	10.00	19,080	1,908	19,080		0
work to non-program areas	+	23,593 sf	6.00	141,558	23,593	141,558		0

ELEMENTAL ESTIMATE

Description	Trade	Quantity		Rate	$	1 Alternate 1 Quantity	1 Alternate 1 $	2 Alternate 1b Quantity	2 Alternate 1b $
Subtotal Lighting		60,367	sf	10.20	615,722	57,015	570,322	3,352	45,400
Total C22 Lighting & Devices		60,367	sf	10.20	615,722	10.00	570,322	13.54	45,400
C23 Systems									
Other Systems									
02. Repartition	+	6,699	sf	11.00	73,689	6,699	73,689		0
03. Gut Renovate - office use	+	3,727	sf	11.00	40,997	3,727	40,997		0
04. Gut Renovate - dry lab use	+	7,966	sf	11.00	87,626	4,996	54,956	2,970	32,670
05. Gut Renovate - shop space	+	5,631	sf	11.00	61,941	5,631	61,941		0
06. Gut Renovate - chemical engineering teaching lab	+	1,010	sf	11.00	11,110	1,010	11,110		0
07. Gut Renovate - existing toilet rooms	+	1,573	sf	11.00	17,303	1,573	17,303		0
08. Enclosure/Upgrade - existing stairs	+	1,573	sf	5.00	7,865	1,573	7,865		0
09. Construct - passenger elevator	+	368	sf	5.00	1,840	368	1,840		0
10. Repartition - communicating corridor	+	6,319	sf	5.00	31,595	5,937	29,685	382	1,910
11. Prepare for Mep	+	1,908	sf	5.00	9,540	1,908	9,540		0
work to non-program areas	+	23,593	sf	2.50	58,983	23,593	58,983		0
Subtotal Other Systems		60,367	sf	6.67	402,489	57,015	367,909	3,352	34,580
Total C23 Systems		60,367	sf	6.67	402,489	6.45	367,909	10.32	34,580
TOTAL C2 ELECTRICAL					1,576,951		1,448,601		128,350

ELEMENTAL ESTIMATE						1 Alternate 1		2 Alternate 1b	
Description	Trade	Quantity		Rate	$	Quantity	$	Quantity	$
D1 SITE WORK									
D11 Site Development									
Site Preparation									
allow to make good contractor laydown space		125,000	ls	1.00	125,000	100,000	100,000	25,000	25,000
Subtotal Site Preparation					125,000	0	100,000	0	25,000
Total D11 Site Development		60,367	sf	2.07	125,000	1.75	100,000	7.46	25,000
TOTAL D1 SITE WORK					125,000		100,000		25,000

ELEMENTAL ESTIMATE

Description	Trade	Quantity	Rate	$	1 Alternate 1 Quantity	1 Alternate 1 $	2 Alternate 1b Quantity	2 Alternate 1b $
D2 ANCILLARY WORK								
D21 Demolition								
Demolition								
hazardous waste abatement - NIC			0.00	0		0		0
remove partitions		33,225 sf	5.00	166,125	31,245	156,225	1,980	9,900
remove doors		104 no	100.00	10,400	95	9,500	9	900
remove finishes		39,725 sf	2.00	79,450	36,373	72,746	3,352	6,704
remove miscellaneous interiors		39,725 sf	2.00	79,450	36,373	72,746	3,352	6,704
remove exterior masonry, including temp shoring		3,224 sf	30.00	96,720	1,794	53,820	1,430	42,900
remove existing hangers @ mezzanine, 8'		12 no	300.00	3,600	12	3,600		0
remove top of existing channel @ mezzanine		214 lf	35.00	7,490	214	7,490		0
cut existing slab on grade for elevator pit		124 sf	15.00	1,860	124	1,860		0
cut existing deck for elevator pit		368 sf	10.00	3,680	368	3,680		0
mep demolition		39,725 sf	2.50	99,313	36,373	90,933	3,352	8,380
demolition in non program for MEP upgrades		20,642 sf	3.00	61,926	20,642	61,926		0
Subtotal Demolition				610,014	0	534,526	0	75,488
Total D21 Demolition		60,367 sf	10.11	610,014	9.38	534,526	22.52	75,488
TOTAL D2 ANCILLARY WORK				610,014		534,526		75,488

ELEMENTAL ESTIMATE Description	Trade	Quantity	Rate	$	1 Alternate 1 Quantity	$	2 Alternate 1b Quantity	$
DIRECT CONSTRUCTION COST				9,547,745		8,482,712		1,065,033

Z1 GENERAL REQUIREMENTS

Z11 General Requirements

General Requirements

Z111 Supervision & Labour Expenses

Supervision & Site Staff: Supervision, site staff, superintendent, engineers, watchman and security, attendance on architect or clerk of works, attendance on subcontractors, scheduling, coordination.

Labour Expenses: premium time, overtime, miscellaneous travel and lodging, wage increases; Remote site transportation and accommodations.

Z112 Temporary Facilities

Access: Temporary roads, staging, storage and parking areas, signage and traffic control.

Accommodation: Temporary offices and sheds, temporary toilets, telephone, office and first aid supplies, camp facilities, mobilization and maintenance.

Expenses, Reimbursables: Layout and preparation, documents and photographs, mockups and samples, printing and duplication.

Protection: Temporary fences, hoardings and barricades; Scaffolding, ramps and runways, guard rails, stairs and ladders, temporary partitions and dust screens, wind bracing, temporary fire protection, site protection including sidewalks, curbs, trees, etc.

Temporary Services: Water, power, heat, site drainage.

Equipment: mobile and tower cranes, hoists and temporary elevators, forklifts, trucking, buggies, disposal chutes, other equipment rental and associated costs such as fuel, oil and consumables.

Winter Conditions: Winter concrete premium, snow and ice clearing, tarpaulins, insulation mats, enclosures, etc.

Clean-up: Daily and final cleanup, glass cleaning, dumpster rental and dumping charges.

Z113 Permits, Insurance, Bonds & Other Expenses

Fire, liability and theft insurance, all risk insurance, performance and bid bonds, building permit, miscellaneous permits, taxes and fees, testing and inspection.

Description	Trade	Quantity	Rate	$	1 Alternate 1 Quantity	$	2 Alternate 1b Quantity	$
General Requirements	+	13.0% ls		1,241,207	13.0%	1,102,753	13.0%	138,454
Subtotal General Requirements		0 ls		1,241,207	0	1,102,753	0	138,454
Total Z11 General Requirements		60,367 sf		1,241,207	19.34	1,102,753	41.30	138,454

ELEMENTAL ESTIMATE

Description	Trade	Quantity		Rate	$	1 Alternate 1 Quantity	1 Alternate 1 $	2 Alternate 1b Quantity	2 Alternate 1b $
Z12 Fee									
Profit/Fee/Risk									
Z121 Profit/Fee: Head office overhead, construction manager's fee, general contractors profit. Z122 Risk: Warranties, guarantees and liquidated damages. Labour restrictions & requirements; Strike or lockout delays. Bidding restrictions and requirements.									
Profit/Fee/Risk	+	3.0%	ls		286,432	3.0%	254,481	3.0%	31,951
Subtotal Profit/Fee/Risk		0	ls		286,432	0	254,481	0	31,951
Total Z12 Fee		60,367	sf		286,432	4.46	254,481	9.53	31,951
TOTAL Z1 GENERAL REQUIREMENTS					1,527,639		1,357,234		170,405

ELEMENTAL ESTIMATE

Description	Trade	Quantity	Rate	$	1 Alternate 1 Quantity	1 Alternate 1 $	2 Alternate 1b Quantity	2 Alternate 1b $
Z2 CONTINGENCIES								
Z21 Estimating Contingency								

Design Stage Contingency

Design contingency covers unanticipated changes during design and is absorbed as design progresses and more detailed information becomes available and is normally reduced to zero for final documents.

Z211 Documentation
Covers errors and omissions in design documents, definition of lump sum allocations (unmeasured items), development and definition of measured elements, development and definition of details and assemblies.

Z212 Estimating
Covers estimating errors and omissions.

Z213 Program
Covers unforeseen site conditions, program and user scope changes, owner directed design changes, design changes caused by regulatory bodies (excluded - typically with project contingency).

Description	Trade	Quantity	Rate	$	1 Alternate 1 Quantity	1 Alternate 1 $	2 Alternate 1b Quantity	2 Alternate 1b $
Design Stage Contingency	+	15.0% ls		1,432,162	15.0%	1,272,407	15.0%	159,755
Subtotal Design Stage Contingency		0 ls		1,432,162	0	1,272,407	0	159,755
Total Z21 Estimating Contingency		60,367 sf		1,432,162	22.32	1,272,407	47.66	159,755
Z22 Escalation Contingency								

Escalation Contingency

Escalation contingency covers rate increases from the present to the start of construction and is normally reduced to zero for final documents.

Z221 Inflation:
Covers increases due to inflation (labour and materials) until start of construction.

Z222 Bidding:
Covers increases due to lack of bidders or busy market conditions, variance between actual bid amounts and averages used in estimating.

During periods of unstable market conditions and price volatility, we recommend a bidding contingency (usually 5 - 10 percent) be included to reflect both the sudden upward or downward shifts in the market and the greater spread to be expected in the range of bids.

Description	Trade	Quantity	Rate	$	1 Alternate 1 Quantity	1 Alternate 1 $	2 Alternate 1b Quantity	2 Alternate 1b $
Escalation Contingency	+	12.5% ls		1,193,468	12.5%	1,060,339	12.5%	133,129
Subtotal Escalation Contingency		0 ls		1,193,468	0	1,060,339	0	133,129

ELEMENTAL ESTIMATE

Description	Trade	Quantity		Rate	$	1 Alternate 1 Quantity	1 Alternate 1 $	2 Alternate 1b Quantity	2 Alternate 1b $
Total Z22 Escalation Contingency		60,367	sf		1,193,468	18.60	1,060,339	39.72	133,129

Z23 Construction Contingency

Construction Contigency

Construction contingency covers changes during construction.

Z231 Documentation

Covers extra costs during construction due to unforeseen site conditions, errors and omissions in documentation or construction management, etc. (typically included).

Z232 Program

Covers extra costs during construction due to program and user scope modifications, changes caused by regulatory bodies, overrun of cash allowances, etc (excluded - typically with project contingency).

Description	Trade	Quantity		Rate	$	1 Alternate 1 Quantity	1 Alternate 1 $	2 Alternate 1b Quantity	2 Alternate 1b $
Construction Contigency	+	5.0%	ls		477,387	5.0%	424,136	5.0%	53,252
Subtotal Construction Contigency		0	ls		477,387	0	424,136	0	53,252
Total Z23 Construction Contingency		60,367	sf		477,387	7.44	424,136	15.89	53,252
TOTAL Z2 CONTINGENCIES					3,103,017		2,756,882		346,136

ELEMENTAL ESTIMATE

Description	Trade	Quantity	Rate	$	1 Alternate 1 Quantity	1 Alternate 1 $	2 Alternate 1b Quantity	2 Alternate 1b $
Z3 OTHER COSTS								
Z31 Other Costs								
Ancillary Costs								

(1) Development charges & special taxes – NIC.
(2) Payments to other agencies – NIC,
(3) Hazardous waste removal – NIC,
(4) Occupancy Costs: loose furnishing and equipment – NIC, moving costs – NIC,
(5) Design: preconstruction services – NIC, architects, engineers, and other consultants fees – NIC.
(6) Administrative and financing costs – NIC
(7) Land acquisition – NIC, survey and legal fees – NIC.

Description	Trade	Quantity	Rate	$	1 Alternate 1 Quantity	1 Alternate 1 $	2 Alternate 1b Quantity	2 Alternate 1b $
Ancillary Costs	+	.0% ls		0	.0%	0	.0%	0
Subtotal Ancillary Costs		ls		0	0	0	0	0
Total Z31 Other Costs		60,367 sf		0	0.00	0	0.00	0
TOTAL Z3 OTHER COSTS				0		0		0

ELEMENTAL ESTIMATE

Description	Trade	Quantity	Rate	$	1 Alternate 1 Quantity	1 Alternate 1 $	2 Alternate 1b Quantity	2 Alternate 1b $
INDIRECT CONSTRUCTION COST				4,630,656		4,114,116		516,541
TOTAL COSTS				$14,178,401		$12,596,828		$1,581,573

October 9, 2013

Payette
290 Congress St., Fifth Floor
Boston, MA 02210-1005

Attention: Peter Viera

Re: Brown University –B&H Reno

Dear Peter,

Please find enclosed our draft cost estimate for the above project based on preliminary design.

	Area (sf)	$/sf	$000's
Infrastructure	158,078	101	16,005
Floor Renovation			39,485
Facade			4,212
Alternate 2	**158,078**	**378**	**59,702**

This estimate includes all direct construction costs, general contractor's overhead and profit, design and construction contingencies. Cost escalation assumes an April 2015 construction start.

Excluded from the estimate are: hazardous waste removal, loose furnishings and equipment, project contingency, architect's and engineer's fees, moving, administrative and financing costs.

Bidding conditions are expected to reflect one construction manager, open bidding for sub-contractors, open specifications for materials and manufacturers.

This estimate is based on bids received in this market for comparable work. Projected changes in design and inflation are covered by contingency. Variances from these projections can occur due to lack or surplus of bidders at time of bid, proprietary specifications, contractual and procurement practice, documentation and tendering changes, contractor's errors and omissions etc. We expect bids received to be within 5 - 10% of estimated values 19 times out of 20 recognizing the above.

If you have any questions or require further analysis please do not hesitate to contact us.

Yours very truly,

James Vermeulen, PQS
Co-CEO

LEVEL 2 ELEMENTAL SUMMARY	$/sf	Element $	%	Infrastructure		Lvl 2-7	Façade	Level 0	Level 1
GROSS FLOOR AREA		158,078 sf		$/sf	158,078	$/sf 0	$/sf 0	$/sf 0	$/sf 0
A1 SUBSTRUCTURE	0.00	0	0%	0.00	0	0	0	0	0
A2 STRUCTURE	8.46	1,337,597	2%	7.09	1,120,076	217,521	0	0	0
A3 ENCLOSURE	29.79	4,708,567	8%	11.24	1,776,188	252,651	2,679,728	0	0
B1 PARTITIONS & DOORS	26.82	4,239,445	7%	0.00	0	3,673,891	0	225,174	340,379
B2 FINISHES	19.86	3,138,773	5%	0.00	0	2,705,000	0	173,506	260,267
B3 FITTINGS & EQUIPMENT	22.81	3,606,335	6%	0.00	0	3,235,425	0	148,510	222,400
C1 MECHANICAL	91.91	14,529,555	24%	24.32	3,844,880	8,675,349	0	939,517	1,069,810
C2 ELECTRICAL	41.63	6,580,534	11%	19.25	3,042,591	2,497,616	0	480,312	560,016
D2 ANCILLARY WORK	13.05	2,062,528	3%	0.00	0	1,906,038	156,490	0	0
DIRECT CONSTRUCTION COST	254.33	40,203,334	67%	61.89	9,783,734	23,163,492	2,836,218	1,967,018	2,452,872
Z1 GENERAL REQUIREMENTS	40.69	6,432,533	11%	9.90	1,565,397	3,706,159	453,795	314,723	392,459
Z2 CONTINGENCIES	82.66	13,066,083	22%	20.11	3,179,713	7,528,135	921,771	639,281	797,183
Z3 OTHER COSTS	0.00	0	0%	0.00	0	0	0	0	0
INDIRECT CONSTRUCTION COST									
TOTAL CONSTRUCTION COST	377.67	59,701,950	100%	91.91	14,528,845	34,397,786	4,211,783	2,921,022	3,642,514

ELEMENTAL SUMMARY		Level 3 Elemental $	$/sf				Infrastructure		Lvl 2-7	Façade	Level 0	Level 1
GROSS FLOOR AREA							$/sf	158,078	$/sf 0	$/sf 0	$/sf 0	$/sf 0
D22 Alterations		552,570	3.50				0.00	0	552,570	0	0	0
DIRECT CONSTRUCTION COST							61.89	9,783,734	23,163,492	2,836,218	1,967,018	2,452,872
Z1 GENERAL REQUIREMENTS												
Z11 General Requirements	13.0%	5,226,433	33.06				8.05	1,271,885	3,011,254	368,708	255,712	318,873
Z12 Fee	3.0%	1,206,100	7.63				1.86	293,512	694,905	85,087	59,011	73,586
Z2 CONTINGENCIES												
Z21 Estimating Contingency	15.0%	6,030,500	38.15				9.28	1,467,560	3,474,524	425,433	295,053	367,931
Z22 Escalation Contingency	12.5%	5,025,416	31.79				7.74	1,222,967	2,895,436	354,527	245,877	306,609
Z23 Construction Contingency	5.0%	2,010,167	12.72				3.09	489,187	1,158,175	141,811	98,351	122,644
Z3 OTHER COSTS												
Z31 Other Costs	0.0%	0	0.00				0.00	0	0	0	0	0
TOTAL CONSTRUCTION COST				377.67	59,701,950	100%	91.91	14,528,845	34,397,786	4,211,783	2,921,022	3,642,514

ELEMENTAL SUMMARY	Level 3 Elemental $	$/sf	Infrastructure		Lvl 2-7		Façade		Level 0		Level 1	
GROSS FLOOR AREA			$/sf	158,078	$/sf	0	$/sf	0	$/sf	0	$/sf	0
A1 SUBSTRUCTURE												
A11 Foundations	0	0.00	0.00	0		0		0		0		0
A12 Building Excavation	0	0.00	0.00	0		0		0		0		0
A2 STRUCTURE												
A21 Lowest Floor Structure	0	0.00	0.00	0		0		0		0		0
A22 Upper Floor Structure	1,098,994	6.95	5.63	890,293		208,701		0		0		0
A23 Roof Structure	238,603	1.51	1.45	229,783		8,820		0		0		0
A3 ENCLOSURE												
A31 Walls Below Grade	0	0.00	0.00	0		0		0		0		0
A32 Walls Above Grade	80,628	0.51	0.00	0		0		80,628		0		0
A33 Windows & Entrances	3,666,700	23.20	6.75	1,067,600		0		2,599,100		0		0
A34 Roof Covering	526,197	3.33	3.22	508,557		17,640		0		0		0
A35 Projections	435,042	2.75	1.27	200,031		235,011		0		0		0
B1 PARTITIONS & DOORS												
B11 Partitions	3,157,845	19.98	0.00	0		2,737,891		0		167,974		251,979
B12 Doors	1,081,600	6.84	0.00	0		936,000		0		57,200		88,400
B2 FINISHES												
B21 Floor Finishes	1,452,225	9.19	0.00	0		1,250,000		0		80,888		121,338
B22 Ceiling Finishes	987,513	6.25	0.00	0		850,000		0		55,004		82,510
B23 Wall Finishes	699,035	4.42	0.00	0		605,000		0		37,615		56,420
B3 FITTINGS & EQUIPMENT												
B31 Fittings	2,777,480	17.57	0.00	0		2,406,570		0		148,510		222,400
B32 Equipment	828,855	5.24	0.00	0		828,855		0		0		0
B33 Conveying Systems	0	0.00	0.00	0		0		0		0		0
C1 MECHANICAL												
C11 Plumbing & Drainage	2,222,386	14.06	2.92	460,844		1,436,682		0		150,601		174,259
C12 Fire Protection	849,394	5.37	5.37	849,394		0		0		0		0
C13 HVAC	9,842,009	62.26	13.85	2,189,009		6,205,362		0		678,591		769,048
C14 Controls	1,615,766	10.22	2.19	345,633		1,033,306		0		110,325		126,503
C2 ELECTRICAL												
C21 Service & Distribution	2,639,976	16.70	13.78	2,178,508		0		0		209,588		251,881
C22 Lighting & Devices	2,522,867	15.96	3.64	576,055		1,574,825		0		175,121		196,866
C23 Systems	1,417,692	8.97	1.82	288,028		922,792		0		95,603		111,270
D2 ANCILLARY WORK												
D21 Demolition	1,509,958	9.55	0.00	0		1,353,468		156,490		0		0

APPENDIX D CLEANROOM SCOPING DOCUMENTS

School of Engineering: New Nano and Microfabrication facility

Biofabrication Resource Center

1. General Background

Understanding the fundamentals of integrating biologically active components in microfabricated environments is leading to exciting innovations in science and technology. The emerging knowledge is expected to become key technologies in 21st-century medicine, with a broad range of applications varying from point-of-care diagnostic devices, tissue-engineered products, cell-based drug screening tools, to basic molecular biology tools.

Our new Biofabrication Resource Center should offer the local research community access to state-of-the-art biological and microfabrication facilities.

This facility should uniquely allow researchers to integrate use of biologically active components (for example, enzymes, antibodies, nucleic acids and cells) into simple microfabricated devices. Biological components can then be exploited as processing aids to allow the bottom-up fabrication of next-generation microdevices. A small amount of biologically active components can then be assembled within a 'traditional' device to exploit the high-throughput and massively parallel capabilities of microdevices. Additionally, the facility will make it possible to coordinate the assembly of 'soft' micro and nanostructured products that consist primarily of biological components for implantation in the body (e.g. artificial organs). Eventually, the Biofabrication capabilities will allow development of new biosensors that function autonomously and can simultaneously measure the physical, chemical and biological aspects of dynamic biological assays, as well as provide instrumentation for the design and fabrication of novel, 2D and 3D structures used to investigate the microscale interactions of varied cell types, including neurons, stem cells, and benign/malignant cancer cells. The development of these tools will draw from the fields of engineering, biology, nanotechnology, and microfluidics.

2. Description of Research Instrumentation and Needs:

1. DWL 66FS maskless laser lithography system (manufacturer Heidelberg Instruments): All-in-one device for feature design, high-precision alignment, and direct exposure for photolithography (no mask or aligner required). Includes multiple write modes to produce a range of minimum feature sizes, address grids, and pattern areas. Additional features include an exposure mode for creating three-dimensional features. The versatility of this instrument will broaden interest across researchers in Biomed, Engineering, and Lifespan/Rhode Island Hospital. Over 200 research institutes including MIT, Harvard, Princeton, Cornell and Yale have been using this instrument. Based on the research projects, our instruments should have feature resolution from 0.6um±50nm to ~500±0.5um with optical autofocus, vector and grey scale exposure mode. These are all available in DWL66FS.

2. Spin Coater – Cee 200X (manufacturer Cee): Precisely spins a circular substrate wafer to uniformly spread out a coating of photoresist. The substrate is held by a vacuum chuck while a motor spins the substrate and chuck at speeds of between 0 and 12,000 rpm.

3. ContourGT-K0 non-contact optical profiler (manufacturer Bruker Nano Inc.): Non-contact, highly accurate, 3D surface topography measurements using optical interferometry.

4. An upright Nikon E800 microscope

5. An Agilent 2100 (*The Agilent 2100 Bioanalyzer is a microfluidics-based platform for sizing, quantification and quality control of DNA, RNA, proteins and cells.*) with computer station,

6. An inverted Diaphot Nikon microscope with dual camera ports and micromanipulators and microinjectors,

7. Plasma Etcher (Nordson AP-300)

8. Infrastructure needs: Biosafety Hoods (3- bacteria, cell and biomolecules), Chemical Hoods (2), CO2 control hood,

9. Surface Functionalization: +1 chemical hood (silanes, thiols, polymer films, etc)

10. Parylene Deposition (SCS LabCoater 2)

11. Microarray Spotter (Perkin Elmer Piezoarray)

12. Micro 3D Printer (2Ph Polymerization, i.e. Nanoscribe Photonic Professional GT)

3. Impact on Research and Training Infrastructure

Our Biofabrication facility plans to offer the local research community access to state-of-the-art biological and microfabrication facilities. The Biofabrication lab is essential for the success of diverse research efforts in bioengineering, biotechnology, biology and clinical science. The user base for the new Biofabrication facility is centered in the School of Engineering roster of many faculty members and their collaborators at Brown and across the US. The major research areas that will be positively impacted by the Biomicrofabrication Resource Center instruments and some of the associated faculty include:

- Biomicrofludics and diagnostics technologies (Tripathi, Wong, Palmore, Stein, Cu-Uvin et al.)
- Biomechanics and Micromechanics (Frank, Shukla, Darling, Breuer, Tang et al.)
- Biomaterial synthesis (Shukla, Wong, Kane, Sun, Tripathi, Hurt, Tang, Mathiowitz et al.)
- Tissue engineering (Kreutziger, Hoffman-Kim, Darling, Mende, Morgan, Mathiowitz et al.)
- Biological complex fluids (Vlahovska, Tripathi, Frank, Breuer et al.)
- Biosurfaces and biocatalysts (Tripathi, Morgan, Palmore, Sun, Tang, Hurt et al.)
- Biosensors (Pacifici, Morgan, Tripathi, Palmore, Sun, Nurmikko et al.)

Mission Statement

The central mission of Brown Nanofabrication Facility is to enable and support education and research at the frontiers of science and technology through advanced fabrication. To achieve this goal, we aim to provide our users at Brown and throughout the local community with: (1) the tools and training necessary to design, perform, and optimize cutting-edge nanofabrication processes, and (2) a collaborative and cooperative environment that fosters learning and promotes user-to-user interaction.

Ideal Setup / Adjacencies

In terms of facility layout, please see the attached floorplan. Our main goal was to provide good visibility across the whole facility. Visibility helps to promote safety and stimulate cooperation, which is important given the small size of our facility and our emphasis on user learning.

It would be helpful for the cleanroom to be near the Electron Microscopy Facility. This will require careful planning of the layout and electrical conduit routing (e.g. to prevent stray magnetic field noise).

The Nanofabrication Facility will of course need access to a loading dock to receive equipment, gases, and supplies.

Process Bays / Rooms

Adjacent to the gowning area, we would like to have one or two offices (with space for 2 people/room). Ideally, these spaces will have windows that provide direct visibility into the cleanroom.

In the main lab, we ideally need four bays for: (1) characterization, (2) chemical vapor deposition, (3) physical vapor deposition, and (4) reactive ion etching and furnaces.

We need at least two dedicated rooms for: (1) photolithography and (2) wet chemistry. An additional small room to accommodate future expansion is desirable but not necessary.

Support Services

The entire cleanroom should ideally be Class 100, with the possible exception of the chemistry room which will likely be Class 1000, given the fumehood load.

The Facility will need a number of dedicated services, including: dry compressed air, nitrogen gas, and exhaust throughout the facility. We will need deionized/reverse-osmosis (DI/RO) water at 4-5 dedicated locations.

The Facility will need at least 5 fumehoods (3 in the chemistry room, 2 in the photolithography room). For safe hazardous waste removal, these chemical benches will need to be equipped with aspirators that directly take waste to a remotely located chemical-neutralizer waste-storage system. One of the fumehoods needs a dedicated hydrofluoric acid drain.

Finally, the Facility needs ample chase and storage space. A few dedicated pass-throughs, especially between the chemistry room and adjacent chase, would help with the stocking of supplies.

Dirty Processing Room

The Facility should devote a small room near the cleanroom for carrying out dirty processes like wafer dicing, powder blasting, and laser cutting. Such a dirty processing room could potentially house growth ovens for making advanced materials like carbon nanotubes, graphene, organic crystals, etc.

Preliminary Tool List (including existing equipment and immediately likely additions)

Characterization	Status
Ellipsometer (Rudolph, AutoEL II)	Existing in cleanroom
Optical Microscope (Nikon, OptiPhot IC 66)	Existing in cleanroom
Stylus Profilometer (Veeco, Dektak 3)	Existing in cleanroom
Spectroscopic Ellipsometer (JA Woollam, M-2000)	Currently being acquired for cleanroom
Optical Profilometer (Zygo, New View 6000)	Existing in faculty lab
Micro-Raman/Photoluminescence (make/model TBD)	Existing in faculty lab
Nano-Indenter (make/model TBD)	Existing in faculty lab
Electrical Probe Station (make/model TBD)	To be acquired (likely purchase)

Chemical Vapor Deposition (CVD)	Status
Atomic Layer Deposition (Cambridge Nanotech, Fiji 200)	Existing in cleanroom
Plasma-enhanced CVD (PECVD) (PlasmaTherm, 790)	Existing in cleanroom
Organic-Inorganic PECVD (Oxford, Plasma Lab 80 Plus)	Existing in cleanroom
Low-pressure CVD (LPCVD) (Custom built)	Existing in cleanroom
Commercial LPCVD (Tystar, Tytan)	To be acquired (likely purchase)

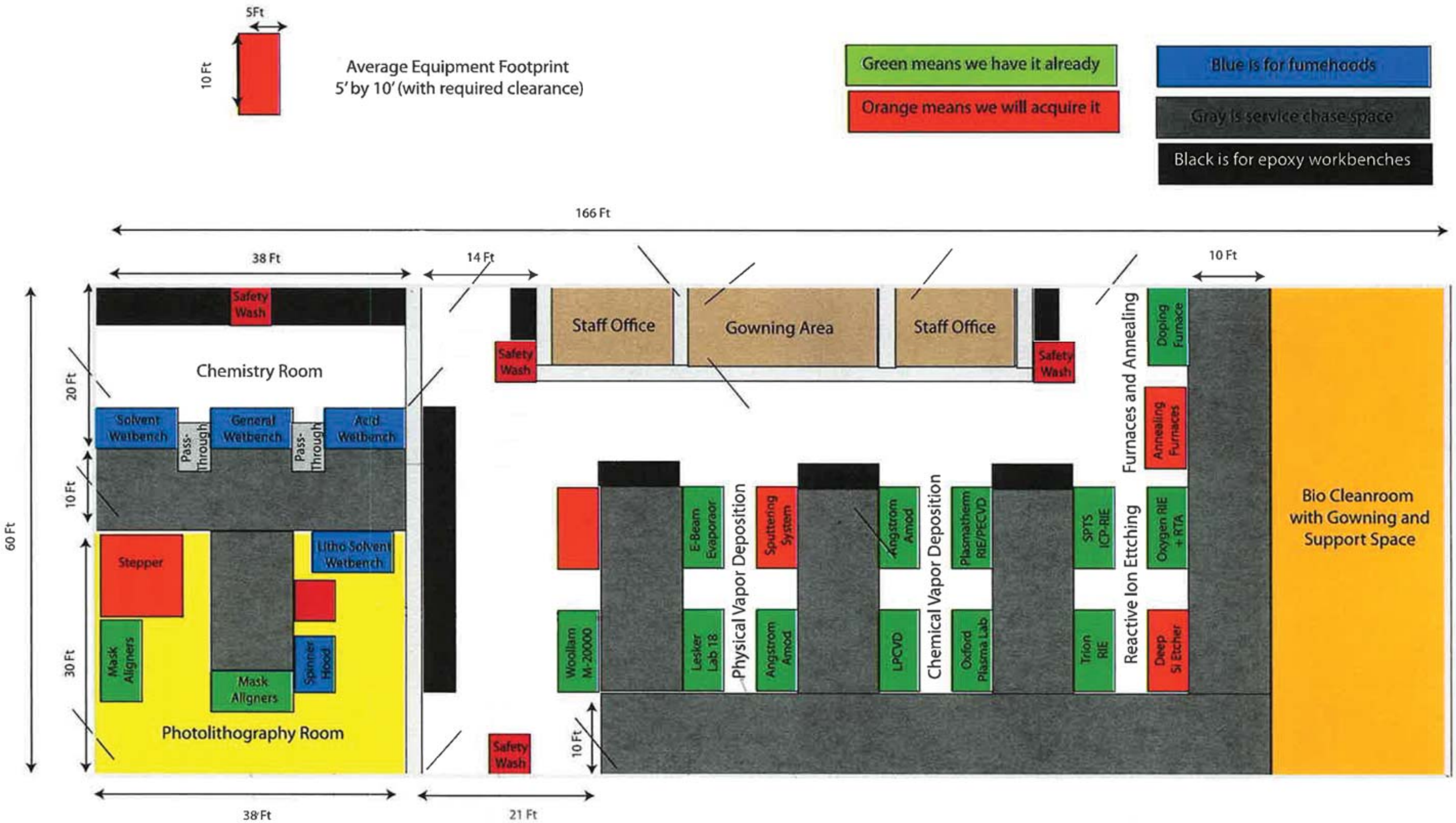
Furnaces	Status
Doping and Oxide Furnaces (Termco, Brute 376)	Existing in cleanroom
Rapid Thermal Annealer (AG Associates, HeatPulse 610)	Existing in cleanroom
Annealing Furnaces (Termco, Brute 376)	Dismantled (lack of space), repurchase

Photolithography Tool Suite	Status
Hard Mask Aligner (Karl Suss, MJB3)	Existing in cleanroom
Transparency Mask Aligner (Newport-Oriel, 500UV)	Existing in cleanroom
Spinner (Brewer Science, Cee-100)	Existing in cleanroom
Small Oven for Pre/Post Exposure (Blue M, OV-8A)	Existing in cleanroom
Thermal Nanoimprint System (NIL Technology, CNI)	Existing in faculty lab
Spinner (Brewer Science, Cee-200CBX)	To be acquired (likely purchase)
Hard Mask Aligner (Karl Suss, MA6)	To be acquired (likely purchase)
Stepper (ASML, model TBD)	To be acquired (likely donation)

Physical Vapor Deposition (PVD)	Status
E-Beam Evaporator (IBM, Custom Tool)	Existing in cleanroom
E-Beam Evap. / RF Sputterer (Lesker, Lab 18)	Existing in cleanroom
Glovebox Thermal Evaporator (Angstrom, Amod)	Existing in cleanroom
Sputtering System (MRC 8667)	Dismantled (lack of space), repurchase
Ion Beam Sputterer (Oxford, Ion Fab 300)	Dismantled (lack of space), repurchase

Reactive Ion Etching (RIE)	Status
Chlorine Chemistry RIE (Trion, Minilock 2)	Existing in cleanroom
Fluorine Chemistry RIE/PECVD (PlasmaTherm, 790)	Existing in cleanroom
Inductively Coupled Plasma RIE (SPTS, LPX-ICP)	Existing in cleanroom
Oxygen Plasma Etcher (make/model TBD)	To be acquired (likely donation)

Wafer Dicing and Cutting	Status
Dicing Saw	Existing in faculty lab
Powder Blaster (Dentek MicroBlaster 500)	Existing in faculty lab
CO2 Laser Cutter (VersaLASER VLS 3.50)	Existing in faculty lab



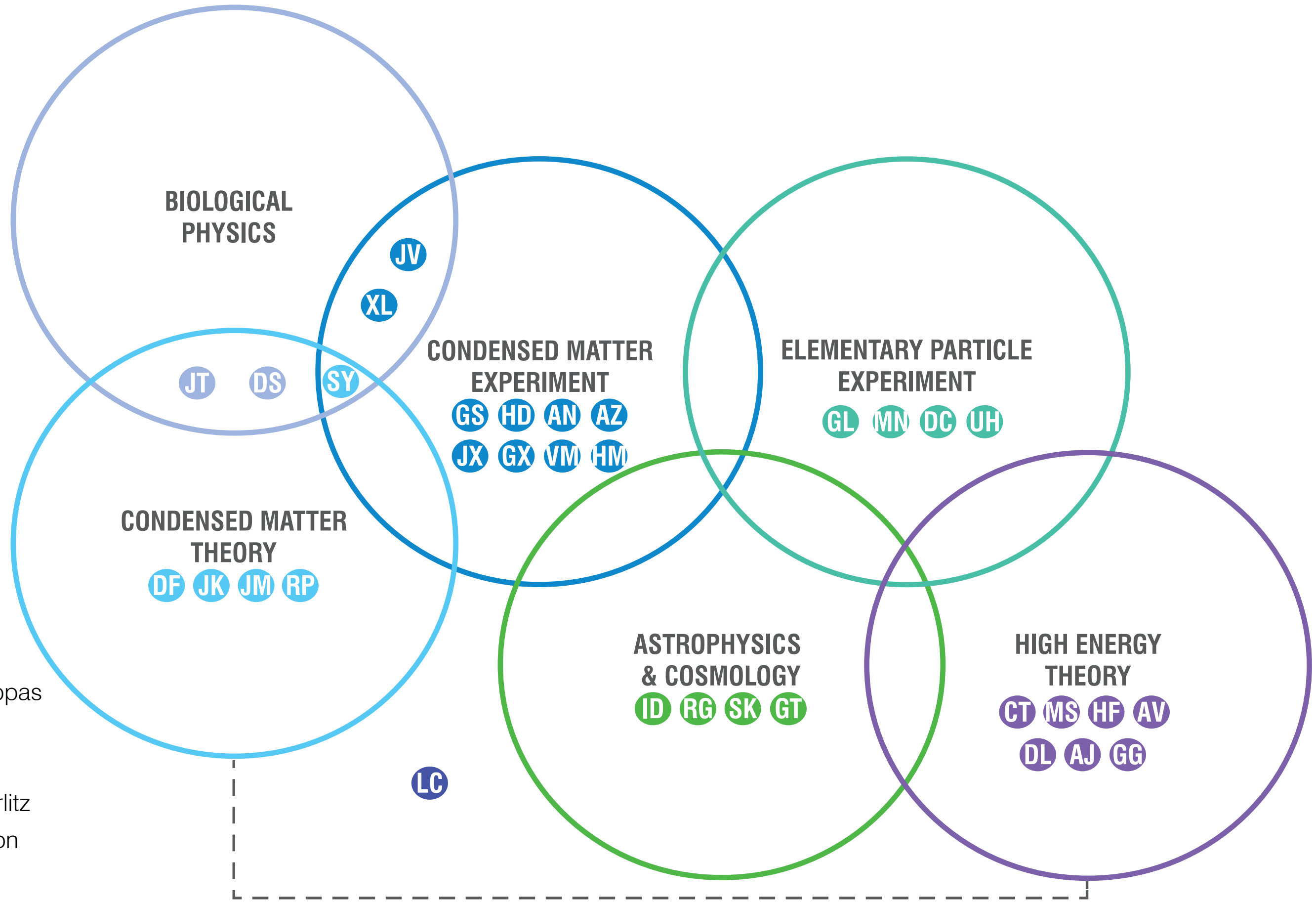
Conceptual clean-room plan

APPENDIX E PHYSICS FACULTY ADJACENCIES

Physics Department Adjacencies

- JV James Valles
- GX Gang Xiao
- JX Jimmy Xu (joint appointment mark)
- XL Xingsheng Sean Ling
- AZ Alexander Zaslavsky (joint appointment mark)
- AN Arto V. Nurmikko (joint appointment mark)
- HD James H. Dickerson
- GS George Seidel
- HM Humphrey Maris
- VM Vesna Mitrovic
- JT Jay Tang
- DS Derek Stein (joint appointment mark)
- DC David Cutts
- UH Ulrich Heintz
- GL Greg Landsberg
- MN Meenashki Narain
- GG Gerald Guralnik
- AJ Antal Jevicki
- DL David Lowe
- MS Marcus Spradlin
- CT Chung-I Tan
- AV Anastasia Volovich
- HF Herbert Fried
- LC Leon Cooper
- ID Ian Dell'Antonio
- RG Richard Gaitskell
- SK Savvas Koushiappas
- GT Gregory Tucker
- DF Dmitri Feldman
- JK J. Michael Kosterlitz
- JM J. Bradley Marston
- RP Robert Pelcovits
- SY See-Chen Ying

Joint appointment in School of Engineering



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