

Preliminary Design Considerations

# EcoLadder Consulting LLC



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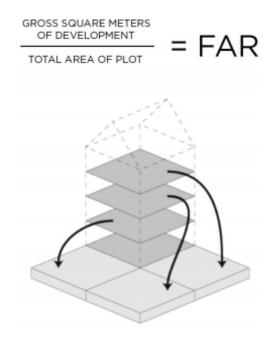
# **Terms and Definitions**

**Scale Jumping:** Solutions beyond project footprint. Can be in the form of an overlay of shared infrastructure between adjacent buildings to achieve Living Building status.

**Transect:** Classification of zones by density of development. The Living Transect is an adaptation of this concept.

**Living Transect L3:** Relatively low density mixed used development. **Living Transect L4:** Light to medium density mixed used development found at the edge of larger cities.

**Floor Area Ratio (FAR):** Gross building area to project area ratio. Used for Transect Designation and Urban Agriculture requirement related to the scale and density of the project.



Greyfield: Previously developed property not contaminated to the level of 'Brownfield' classification.

**Embodied Carbon:** Impact from construction and materials as expressed in either contained CO2 or C. Requires one-time offset through Living Building Challenge approved provider.

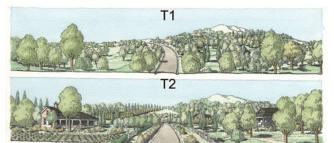
**Energy Usage Intensity (EUI):** Calculated in kBTUs/ft2. Standard representation of the energy usage efficiency of the building.

**Variable Air Volume (VAV):** Type of HVAC system wherein air flow is varied while maintaining a constant temperature. Allows for precise energy usage control and lower consumption.

Potable: Water treated to standards that allow for human consumption and exposure.

Greywater: Relatively clean effluent from showers, sinks, kitchen appliances and the like.

**Blackwater:** Water that has fecal contamination. Some code and regulation does not allow for treatment and reuse as potable water, but can be used for irrigation of agriculture not intended for human consumption.



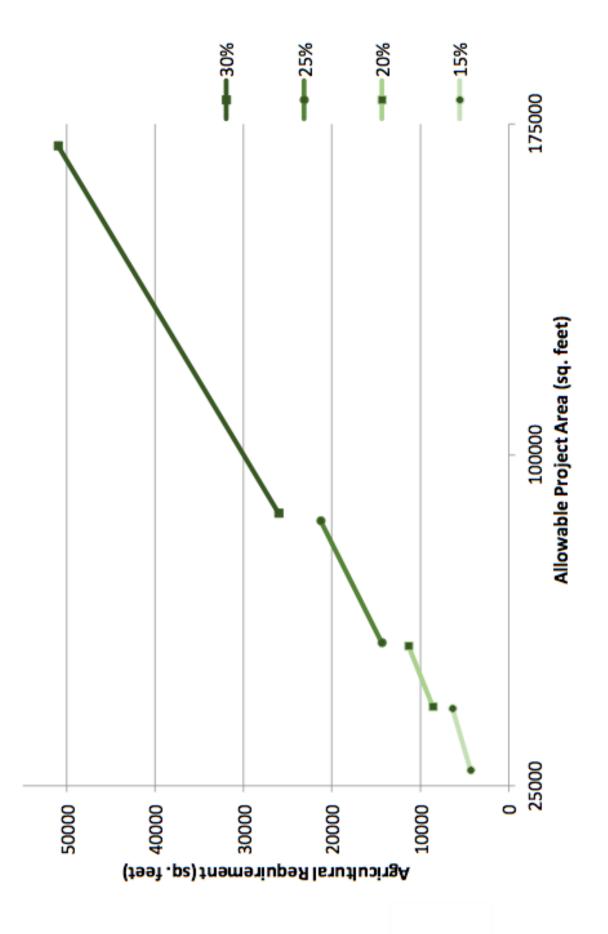












Foundations & Footings	Best Case	Mid-Tier Case	Worst Case	
Foundation Wall	Concrete Block	Concrete Block	Cast-in-place concrete	
Foundation Slab	4" Poured Concrete Slab	4" Poured Concrete Slab	4" Poured Concrete Slab	
Footing	Poured Concrete Footing	Poured Concrete Footing	Poured Concrete Footing	
Columns & Beams				
Non-Load Bearing Walls	Precast Concrete Column/ Precast Concrete Beam	WF column/WF beam	Concrete column/Concrete beam	
Intermediate Floors	Open-web Steel Joist w/ concrete topping	Precast Double T w/ concrete topping	Suspended concrete slab	
Exterior Walls				
Cast-in Place Concrete	Stucco Cladding	Brick Cladding	Steel Cladding	
Windows	Vinyl-clad Wood	Vinyl	Aluminum	
Roof	Precast hollow-core concrete	Precast Double T	Suspended concrete slab	

Table 3.12: Materials composition for each analysis

Table 3.11: Summary	of Embodies	Carbon and	Energy Calculati	ons
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Assembly	Total Area	Total Fossi	l Fuel Consur	nption (MJ)		Global Wa Potential ons CO2e	Ũ
	(sqft)	Best	Mid-Tier	Worst	Best	Mid- Tier	Worst
Foundations & Footings	15665	1,258,151	1,258,151	1,324,992	137.09	137.09	151.10
Columns & Beams	6080	235,819	336,425	699,776	22.36	17.38	54.86
Intermediate Floors	31875	2,923,703	2,632,853	4,907,048	216.00	268.41	488.22
Exterior Walls	4536	455,188	523,652	1,160,735	43.54	48.94	101.42
Windows	10584	2,630,781	3,916,284	5,219,714	268.52	352.17	468.04
Roof	10625	2,144,310	1,957,786	3,005,497	104.46	83.82	194.36
	Total	9,647,955	10,625,154	16,317,764	791.96	907.81	1458.01

Table 4.2: The max and ideal occupancy based on space type and total floor area

Space Co	omponent	Space Type	Total Sq. Ft.	Max Occupancy	Ideal Occupancy
		Auditorium	3000	125	100
	Design Studio         Instructional Space         Student/Community Center         Research and Industry Partnership         Component         Multipurpose/Exhibit Space/Even         Support         Lobby/Display Area and Kiosks	Classrooms	3000	100	75
	Classrooms	Seminar Rooms	1200	32	25
	nstructional Space Class Laboratories Design Studio Instructional Space Student/Community Center esearch and Industry Partnership Component altipurpose/Exhibit Space/Event Support	Breakout/Group Study Rooms	720	12	8
		Classroom Support	Classrooms3000100Seminar Rooms1200321Dut/Group Study Rooms7201212Classroom Support2400801tational/Biology ClassLab2400801salab Staff and Support600101assLab/Maker Space900151Slab Staff and Support4507.51Center150015001501oport Areas (storage, catering kitchen, etc.)75012.51Quiet Study Areas6001011on/Innovation Learning Area75012.51all Team Study Room280511studios3001011all Team Study Room280511Lab Support6001011Lab Support6001011Lab Support180018011Opisplay Area and Kiosks3003011Display Area and Kiosks3003031Ching Manager/Support Staff300311Addent Work Stations7212121Com/Copy/Storage/Files240211Com/Copy/Storage/Files240211Coffice5600661Com/Copy/Storage/Files240321Coffice555 <td>2</td>	2	
	Class Laboratories	Computational/Biology ClassLab	Seminar Rooms120032Breakout/Group Study Rooms72012Classroom Support2404Computational/Biology ClassLab240080ClassLab Staff and Support60010ClassLab/Maker Space90015ClassLab Staff and Support4507.5ClassLab Staff and Support45012.5ClassLab Staff and Support75012.5Center150010aboration/Innovation Learning Area75012.5Quiet Study Areas60010aboration/Innovation Learning Area30010Small Team Study Room2805mputational/Light Biology Res. Lab1800600Lab Support60010Lab Staff60010Guity Office2803Center- Director's Suite (office, reception, waiting)600Center- Director's Suite (office, reception, waiting)600Center Director's Suite (office, reception, waiting)600Center Office240Student Work Stations72Pactivities (Office Space, reception, waiting)240Copen Office240Pactivities (Office Space, reception, waiting)600Center Office Space, reception, waiting600Center Office Space, reception, waiting600Center Office Space, reception, waiting600Center Office Space, reception, waiting600Center Office Space, reception, waiting	40	
	Instructional Space Class Laboratories Design Studio Instructional Space Student/Community Center essearch and Industry Partnership Component ultipurpose/Exhibit Space/Event Support Lobby/Display Area and Kiosks	ClassLab Staff and Support	600	10	2
			900	15	2
	Instructional Space	Auditorium3000125Classrooms30001000Seminar Rooms1200322Breakout/Group Study Rooms72012Classroom Support24044OriesComputational/Biology ClassLab2400800ClassLab Staff and Support60010010Breakout/Group Study Rooms7201212OriesComputational/Biology ClassLab240080010Breakout/Group Study Roport6001001010Breakout/Group Areas (storage, catering kitchen, etc.)75012.512Quiet Study Areas6001001010Collaboration/Innovation Learning Area Studios75012.512Peer to Peer/Project Based Learning Studios30010010Image: Singli Team Study Room280510Computational/Light Biology Res. Lab180060010Lab Staff6001001010FeretMultipurpose/Exhibit Space/Event Support180030010Student Work Stations300303010Student Work Stations72121212Break Room/Copy/Storage/Files24031212Group Coffice2403303030Student Work Stations72121212Break Room/Copy/Storage/Files2402212Group Office1602<	2		
		Center	1500	150	25
			750	12.5	1
Student/Com	munity Center	Quiet Study Areas	600	10	10
	munity contor	· · · · ·	750	12.5	8
			300	10	8
		Small Team Study Room	280	5	5
		Computational/Light Biology Res. Lab	1800	60	30
Multipurpose/Exhibit Space/Event		Lab Support	600	10	2
		Lab Staff	600	10	2
		-	280	3	1
	—		1800	180	10
Lobby/Display	Area and Kiosks		300	30	10
			600	6	2
		Office- Related Programs Support Staff	450	5	1
			300	3	1
		Open Office	240	3	1
		Student Work Stations	72	12	10
			240	2	1
			600	6	2
		Office	450	6	1
		Open Office	160	2	1
		Student Work Stations	72	12	10
		Break Room/Copy/Storage/Files	240	2	1
			Totals:	937.5	399

Space Com	ponent	Space Type	Total Sq. Ft.	kWh/day	kWh/year
		Auditorium	3000	26.57	9698.57
		Classrooms	3000	26.57	9698.57
	Classrooms	Seminar Rooms         1200         10.63           Breakout/Group Study Rooms         720         6.38           Classroom Support         240         2.13           Computational/Biology ClassLab         2400         21.26           ClassLab Staff and Support         600         5.31           ClassLab Staff and Support         600         5.31           ClassLab Staff and Support         450         3.99           ClassLab Staff and Support         450         3.99           Center         1500         11.57           Center support Areas (storage, catering kitchen, etc.)         750         6.11           Quiet Study Areas         600         19.54           Collaboration/Innovation Learning Area         750         12.21           Peer to Peer/Project Based Learning Studios         300         4.89           Small Team Study Room         280         9.12           Computational/Light Biology Res. Lab         1800         15.94           Lab         1800         2.66         14.66           Faculty Office         280         9.12         14.66           Multipurpose/Exhibit Space/Event Support         600         2.66         14.66           Genter- Director's Suite (office, rececep	3879.43		
		Breakout/Group Study Rooms	720	3000       10.63         1200       10.63         720       6.38         240       2.13         2400       21.26         600       5.31         900       7.97         450       3.99         1500       11.57         750       6.11         600       19.54         750       12.21         300       4.89         280       9.12         1800       15.94         600       2.66         280       9.12         1800       6.94         300       4.63         600       2.66         280       9.12         1800       15.94         600       2.66         280       9.12         1800       6.94         300       4.63         600       19.54         450       14.66         300       9.77         240       7.82         72       2.35         240       3.91	2327.66
Instructional Space		Classroom Support	240	2.13	775.89
	Class	Computational/Biology ClassLab	2400	10.63         6.38         2.13         21.26         5.31         7.97         3.99         11.57         6.11         19.54         12.21         4.89         9.12         15.94         2.66         9.12         6.94         4.63         19.54         14.66         9.77         7.82         2.35         3.91         9.77         14.66	7758.86
	laboratories	ClassLab Staff and Support	1200         10.63           1200         10.63           720         6.38           240         2.13           2400         21.26           600         5.31           900         7.97           450         3.99           1500         11.57           750         6.11           600         19.54           750         12.21           600         2.66           300         4.89           280         9.12           1800         15.94           600         2.66           280         9.12           1800         15.94           600         2.66           280         9.12           1800         15.94           600         2.66           280         9.12           1800         19.54           300         4.63           300         4.63           14.66         14.66           300         9.77           240         7.82           72         2.35           240         3.91           450 <t< td=""><td>1939.71</td></t<>	1939.71	
	Design Studio	ClassLab/Maker Space	Seminar Rooms         1200         10.63           Seminar Rooms         1200         10.63           eakout/Group Study Rooms         720         6.38           Classroom Support         240         2.13           nputational/Biology ClassLab         2400         21.26           ClassLab Staff and Support         600         5.31           ClassLab Maker Space         900         7.97           ClassLab Staff and Support         450         3.99           Center         1500         11.57           extering kitchen, etc.)         750         6.11           Quiet Study Areas         600         19.54           aboration/Innovation Learning Area         750         12.21           Peer to Peer/Project Based Learning Studios         300         4.89           Small Team Study Room         280         9.12           uputational/Light Biology Res. Lab         1800         15.94           Lab Support         600         2.66           Faculty Office         280         9.12           ipurpose/Exhibit Space/Event Support         1800         19.54           oby/Display Area and Kiosks         300         4.63           nter- Director's Suite (office, reception, waiting) <td>2909.57</td>	2909.57	
	Instructional Space	ClassLab Staff and Support	Seminar Rooms         1200         10.63           Kout/Group Study Rooms         720         6.38         1           Classroom Support         240         2.1.3         1           utational/Biology ClassLab         2400         21.26         1           ssLab Staff and Support         600         5.31         1           classLab/Maker Space         900         7.97         1           ssLab Staff and Support         450         3.99         1           center         1500         11.57         1         1           er support Areas (storage, catering kitchen, etc.)         750         6.11         1           Quiet Study Areas         600         19.54         1         1           pration/Innovation Learning Area         750         12.21         1         1           tational/Light Biology Res. Lab         1800         2.66         1         1           tab Support         600         2.66         1         1         1         1           tab Support         600         2.66         1         1         1         1           tab Support         600         2.66         1         1         1         1         1 <td>1454.79</td>	1454.79	
		Center	1500	11.57	4223.57
			750	6.11	2229.11
		Quiet Study Areas	600	19.54	7133.14
Student/Commu	inity Center		750	12.21	4458.21
		Learning Studios	300	4.89	1783.29
			280	9.12	3328.80
Research and Industry Partnership Component Multipurpose/Exhibit Space/Event Support Lobby/Display Area and Kiosks			1800	15.94	5819.14
		Lab Support	600	2.66	969.86
		Lab Staff	600	2.66	969.86
		•	280	9.12	3328.80
			1800	6.94	2534.14
		••		4.63	1689.43
		· · · ·		19.54	7133.14
		Office- Related Programs Support Staff		14.66	5349.86
		Staff	300		3566.57
		Open Office	240		2853.26
		Student Work Stations	72	2.35	855.98
Office S	pace	Break Room/Copy/Storage/Files	240	3.91	1426.63
Office Space		reception, waiting)	600	9.77	3566.57
		Office	450	14.66	5349.86
		Open Office	160	5.21	1902.17
		Student Work Stations	72	2.35	855.98
		Break Room/Copy/Storage/Files	240	3.91	1426.63
		Structural, Mechanic, Elec. Data, Toilets, Stairs, Custodial	16,996	72.84	26586.60
			Totals:	382.97	139783.63

## Table 4.3: Ideal loads based on space breakdown

Space C	omponent	Space Type	Total Sq. Ft.	kWh/day	kWh/year
		Auditorium	3000	10.29	3754.29
1 Space       Class Laboratories       C         Design Studio Instructional Space       C         Student/Community Center       C         Student/Community Center       C         Research and Industry Partnership Component       C         Multipurpose/Exhibit Kiosks       M         Cont Cont 	Classrooms	3000	10.29	3754.29	
	Seminar Rooms	1200	4.11	1501.71	
	Instructiona 1 Space Class Laboratories Design Studio Instructional Space Student/Community Center Research and Industry Partnership Component Multipurpose/Exhibit Space/Event Support Lobby/Display Area and Kiosks	Breakout/Group Study Rooms	720	2.47	901.03
Instructiona       Classrooms       Ser         1 Space       Class       Breakout/         Class       Computation       Class         Laboratories       ClassLat       ClassLat         Design Studio       Instructional       ClassLat         Student/Community Center       Center support       Quia         Student/Community Center       Computation       Conputation         Research and Industry       Partnership Component       Small T         Multipurpose/Exhibit       Multipurpose       Fa         Multipurpose/Exhibit       Multipurpose       Center- Director         Office- Related       Office- Related       Office- Buildin         Office- Buildin       Confice- Related       Office- Related	Classroom Support	240	0.82	300.34	
Topuce	1 Space       Class         Laboratories       Design Studio         Instructional       Space         Student/Community Center         Research and Industry         Partnership Component         Multipurpose/Exhibit         Space/Event Support         Lobby/Display Area and	Computational/Biology ClassLab	2400	8.23	3003.43
	Laboratories Design Studio Instructional Space	ClassLab Staff and Support	600	2.06	750.86
	Class Laboratories Design Studio Instructional Space Student/Community Center Research and Industry Partnership Component Multipurpose/Exhibit	ClassLab/Maker Space	900	3.09	1126.29
	nstructiona I Space Class Laboratories Design Studio Instructional Space Student/Community Center Research and Industry Partnership Component Multipurpose/Exhibit Space/Event Support Lobby/Display Area and Kiosks	ClassLab Staff and Support	450	1.54	563.14
		Center	1500	6.86	2502.86
		Center support Areas (storage, catering kitchen, etc)	750	2.04	743.04
Student/Com	nmunity Center	Quiet Study Areas	600	6.51	2377.71
		Collaboration/Innovation Learning Area	750	4.07	1486.07
		Peer to Peer/Project Based Learning Studios	300	1.63	594.43
		Small Team Study Room	280	3.04	1109.60
		Computational/Light Biology Res. Lab	1800	6.17	2252.57
	Partnership Component Multipurpose/Exhibit	Lab Support	600	1.03	375.43
Partnershij		Lab Staff	600	1.03	375.43
		Faculty Office	280	3.04	1109.60
Space/Event Support Lobby/Display Area and		Multipurpose/Exhibit Space/Event Support	1800	4.11	1501.71
		Lobby/Display Area and Kiosks	300	2.74	1001.14
		Center- Director's Suite (office, reception, waiting)	600	6.51	2377.71
		Office- Related Programs Support Staff	450	4.89	1783.29
		Office- Building Manager/Support Staff	300	3.26	1188.86
		Open Office	240	2.61	951.09
		Student Work Stations	72	0.78	285.33
		Break Room/Copy/Storage/Files	240	1.30	475.54
		QEP Activities (Office Space, reception, waiting)	600	3.26	1188.86
		Office	450	4.89	1783.29
		Open Office	160	1.74	634.06
		Student Work Stations	72	0.78	285.33
		Break Room/Copy/Storage/Files	240	1.30	475.54
		Structural, Mechanic, Elec. Data, Toilets, Stairs, Custodial	16,996	24.28	8862.20
			Totals:	140.76	51376.04

## Table 4.6: The total lighting load in kWh/year

	Performance Month	-	2	ო	4	ъ	9
Performance Period	Actual Month	Jan.	Feb.	Mar.	Apr.	May.	Jun.
	kWh						
	Photovoltaics (location 1)	13,184.31	15,317.30	22,846.09	28,147.73	30,394.35	31,167.04
	Total Energy Production	13,184.31	15,317.30	22,846.09	28,147.73	30,394.35	31,167.04
	Lighting Power Density	4,363.44	3,941.18	4,363.44	4,222.69	4,363.44	4,222.69
	Equipment Power Density	3,407.78	3,077.99	3,407.78	3,297.85	3,407.78	3,297.85
	Plug Loads (Peak)	4,100.81	3,703.96	4,100.81	3,968.53	4,100.81	3,968.53
	Total Energy Demand	11,872.03	10,723.13	11,872.03	11,489.07	11,872.03	11,489.07
EUI	Project Energy Use Intensity (EUI)	0.953	0.861	0.953	0.922	0.953	0.922
	Energy Storage						
Modelled (cotionel)	Modelled energy production	13,184.31	15,317.30	22,846.09	28,147.73	30,394.35	31,167.04
	Modelled energy demand	11,872.03	10,723.13	11,872.03	11,489.07	11,872.03	11,489.07
	Predicted delta	1,312.28	4,594.17	10,974.06	16,658.66	18,522.32	19,677.97

	Darformance Month	7	α	σ	10	-	12
-			D	2	2		15
Pertormance Period	Actual Month	Jul.	Aug.	Sept.	Oct.	Νον.	Dec.
	kWh						
	Photovoltaics (location 1)	30,394.35	27,425.37	23,716.17	20,430.64	13,976.47	11,876
	Total Energy Production	30,394.35	27,425.37	23,716.17	20,430.64	13,976.47	11,876
	Lighting Power Density	4,363.44	4,363.44	4,222.69	4,363.44	4,222.69	4,363.44
	Equipment Power Density	3,407.78	3,407.78	3,297.85	3,407.78	3,297.85	3,407.78
	Plug Loads (Peak)	4,100.81	4,100.81	3,968.53	4,100.81	3,968.53	4,100.81
	Total Energy Demand	11,872.03	11,872.03	11,489.07	11,872.03	11,489.07	11,872.03
EII	Project Energy Use	0 953	0 953	0 0 2 2	0 053	0 0 2 2	0 953
Ē	Intensity (EUI)		0000	0.766		0.766	
	Energy Storage						
	Modelled energy	30 394 35	27 425 37	23 716 17	20 430 64	13 976 47	11 876
Modelled (cetices)	production		L1, TLU.U1	F-0, 1 - 0, 1 - 1	F0, 100, 01	10,010	11,010
	Modelled energy demand	11,872.03	11,872.03	11,489.07	11,872.03	11,489.07	11,872.03
	Predicted delta	18,522.32	15,553.34	12,227.10	8,558.61	2,487.40	4

Table 4.5: Monthly predictions for energy production and demand

**127,818.94** 25,899.16 20,226.80 24,340.31 Annual Total 127,818.94 127,818.94 70,466.27 57.352.67 70,466.27 5.657

Annual B	uilding Water Consumption	Gallons/day	Gallons/month	Gallons/year
	Showers	300.00	9,000.00	109,500.00
	BioLabs	15.00	450.00	5,475.00
Fixtures	Breakrooms	15.00	450.00	5,475.00
Fixtures	Bathroom Sink Faucets	200.00	6,000.00	73,000.00
	Urinals	720.00	21,600.00	262,800.00
	Toilets	1,152.00	34,560.00	420,480.00
HVAC Wate	er Consumption	913.89	27,416.66	333,569.34
Urban Agri	culture	512.33	15,583.33	187,000.00
Total Build	ling Consumption	3,828.22	115,059.9	1,397,300.00

Table 5.1 Annual Building Water Consumption Estimates for Fixtures, HVAC, and Urban Agriculture

Table 5.2 Average Monthly Rainfall and Rainwater Capture Estimates

Month	Jan	Feb	Mar	Apr	May	Jun
Avg Rainfall* (in)	4.20	4.67	4.81	3.36	3.67	3.95
Rooftop Rainwater Capture (gal)	25,036.30	27,838.00	28,672.60	20,029.10	21,877.00	23,546.10
Raingarden Capture (gal)	328,457.20	365,213.10	376,161.70	262,765.80	287,009.00	308,906.20
Month	Jul	Aug	Sep	Oct	Nov	Dec
Avg Rainfall* (in)	5.27	3.90	4.47	3.41	4.10	3.90
Rooftop Rainwater Capture (gal)	31,414.60	23,248.00	26,645.80	20,327.10	24,440.20	23,248.00
Raingarden Capture (gal)	412,135.60	304,996.00	349,572.30	266,676.00	320,636.80	304,996.00

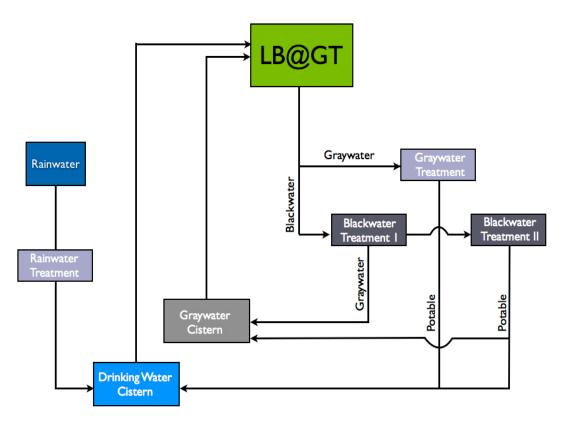


Figure 5.1: Water balance diagram with separate graywater treatment

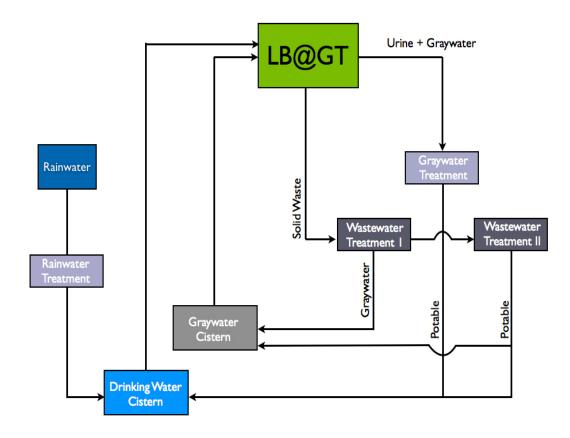
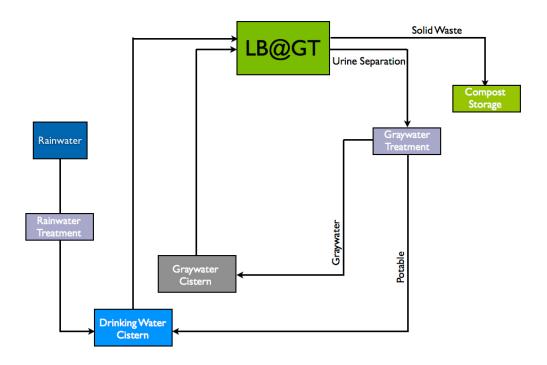
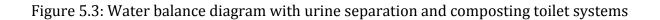


Figure 5.2: Water balance diagram with urine separation system





## **EXECUTIVE SUMMARY**

EcoLadder Environmental Consulting



The Living Building Challenge outstrips all other building efficiency and wellness programs - LEED and similar systems only require certification based on theoretical, selective, and cost effective credits. Although these standards have created a thriving marketplace for building retrofits and environmental awareness, they fail to maximize usage of tools needed to classify buildings as truly sustainable. The Challenge bridges the gap between sustainable and regenerative structures by considering a more holistic and long term approach to this process. By requiring a one-year performance evaluation period before Certification is awarded, the Challenge ensures that the building is environmentally neutral or positive on a scale not often examined during initial start up.

EcoLadder has been tasked with providing the tools and knowledge needed to bring this project from the drawing board to reality. After careful consideration of the various components and individual aspects of the Challenge, Petals were separated thusly: those dominated by engineering constraints and those wherein architectural considerations were the limiting factor. Recommendations and preliminary feasibility assessments have been made for four of the seven required Petals most pertinent to the engineering side of design: Place, Materials, Energy, and Water.

#### Place

Preservation and revitalization of historically significant environmental features

Extension of existing urban agricultural programs and additional educational elements

Community engagement through added amenities catering to an enlarged clientele

#### Water

Enhanced collection through naturalized catchment and diversion systems

Drought resiliency through increased cistern capacities

No-waste water balances through inclusion of composting and separation techniques

### **Materials**

Preferential use of recycled and salvaged materials

Selection of versatile building elements to ensure architectural freedom

Minimizing inherent but hidden embodied carbon contents

## Energy

Solar production and storage that minimizes inefficiencies

Low pressure VAV HVAC system to reduce system loads

Increased worker productivity and comfort with naturalized lighting and ventilation

After examination of the available data and investigation of possible solutions and design alternatives, the premise of a Living Building on Georgia Tech's campus was determined to be feasible within the cost constraints provided. This is not to say that the project will be without its challenges and stumbling blocks; indeed there are too many unknowns at this point of the design to conclusively determine the viability of the proposal. However, the analyses performed within the scope of our work are promising - the generous donation from the Kendeda Fund provides the necessary capital to pursue the Living Building Challenge - and the initial designs contained herein provide a proof of concept for a Living Building at Georgia Tech.

EcoLadder Environmental Consulting, LLC

