The Living Building Challenge at Georgia Tech

Preliminary Design Considerations

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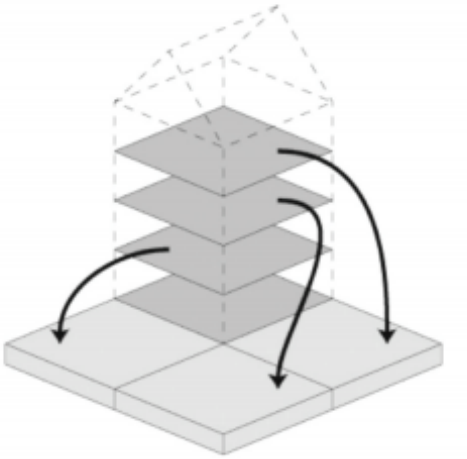
Terms and Definitions

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.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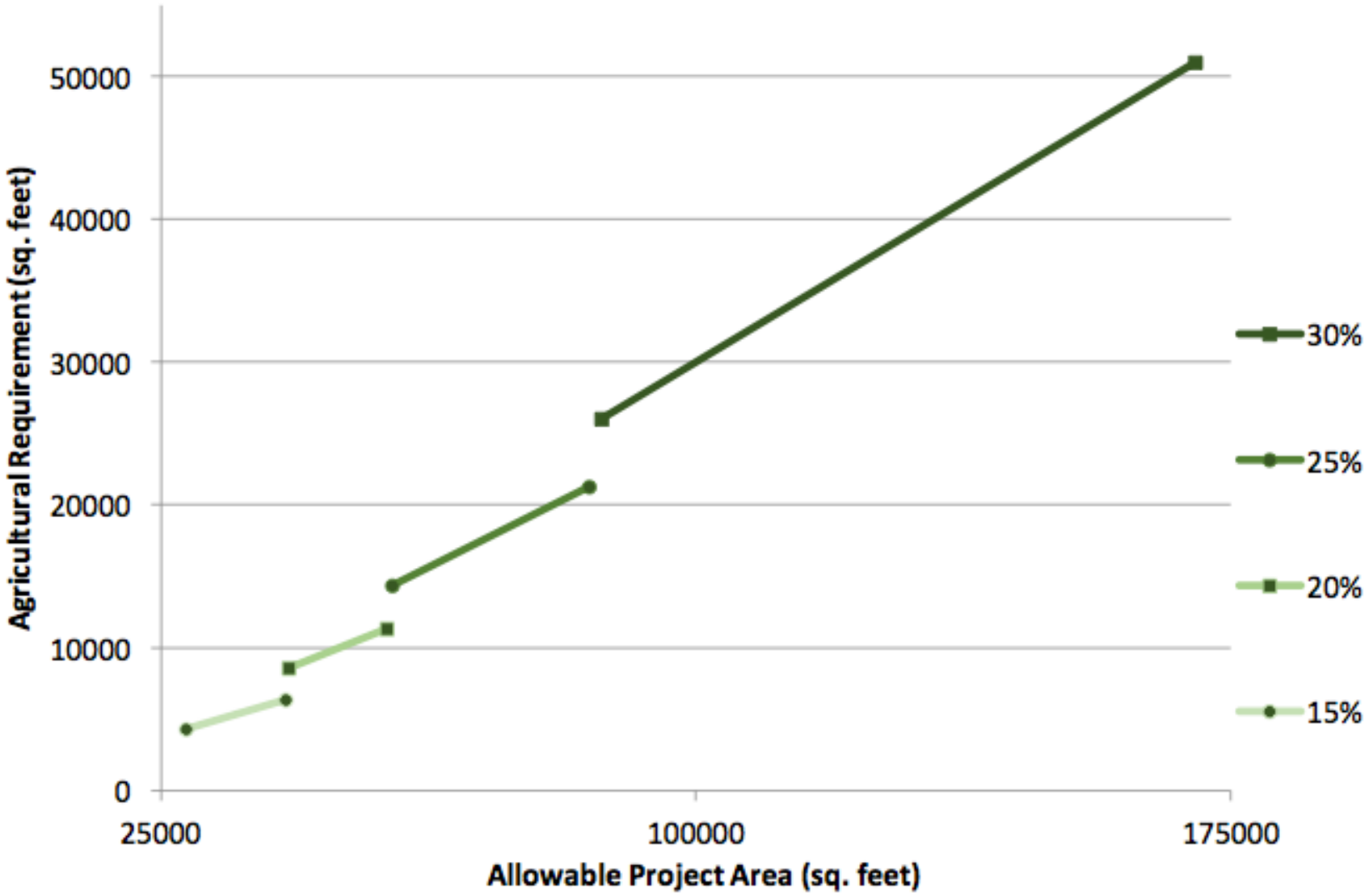
50000
40000
30000
20000
10000
0
Agricultural Requirement (sq. feet)
25000
100000
175000
Allowable Project Area (sq. feet)
30%
25%
20%
15%

Table 3.12: Materials composition for each analysis

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 3.11: Summary of Embodies Carbon and Energy Calculations

Assembly	Total Area (sqft)	Total Fossil Fuel Consumption (MJ)			Total Global Warming Potential (tons CO2eq)		
		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 Component		Space Type	Total Sq. Ft.	Max Occupancy	Ideal Occupancy
Instructional Space	Classrooms	Auditorium	3000	125	100
		Classrooms	3000	100	75
		Seminar Rooms	1200	32	25
		Breakout/Group Study Rooms	720	12	8
		Classroom Support	240	4	2
	Class Laboratories	Computational/Biology ClassLab	2400	80	40
		ClassLab Staff and Support	600	10	2
	Design Studio Instructional Space	ClassLab/Maker Space	900	15	2
		ClassLab Staff and Support	450	7.5	2
Student/Community Center		Center	1500	150	25
		Center support Areas (storage, catering kitchen, etc.)	750	12.5	1
		Quiet Study Areas	600	10	10
		Collaboration/Innovation Learning Area	750	12.5	8
		Peer to Peer/Project Based Learning Studios	300	10	8
		Small Team Study Room	280	5	5
Research and Industry Partnership Component		Computational/Light Biology Res. Lab	1800	60	30
		Lab Support	600	10	2
		Lab Staff	600	10	2
		Faculty Office	280	3	1
Multipurpose/Exhibit Space/Event Support		Multipurpose/Exhibit Space/Event Support	1800	180	10
Lobby/Display Area and Kiosks		Lobby/Display Area and Kiosks	300	30	10
Office Space		Center- Director's Suite (office, reception, waiting)	600	6	2
		Office- Related Programs Support Staff	450	5	1
		Office- Building Manager/Support Staff	300	3	1
		Open Office	240	3	1
		Student Work Stations	72	12	10
		Break Room/Copy/Storage/Files	240	2	1
		QEP Activities (Office Space, reception, waiting)	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

Table 4.3: Ideal loads based on space breakdown

Space Component		Space Type	Total Sq. Ft.	kWh/day	kWh/year
Instructional Space	Classrooms	Auditorium	3000	26.57	9698.57
		Classrooms	3000	26.57	9698.57
		Seminar Rooms	1200	10.63	3879.43
		Breakout/Group Study Rooms	720	6.38	2327.66
		Classroom Support	240	2.13	775.89
	Class laboratories	Computational/Biology ClassLab	2400	21.26	7758.86
		ClassLab Staff and Support	600	5.31	1939.71
	Design Studio Instructional Space	ClassLab/Maker Space	900	7.97	2909.57
		ClassLab Staff and Support	450	3.99	1454.79
Student/Community Center		Center	1500	11.57	4223.57
		Center support Areas (storage, catering kitchen, etc.)	750	6.11	2229.11
		Quiet Study Areas	600	19.54	7133.14
		Collaboration/Innovation Learning Area	750	12.21	4458.21
		Peer to Peer/Project Based Learning Studios	300	4.89	1783.29
		Small Team Study Room	280	9.12	3328.80
Research and Industry Partnership Component		Computational/Light Biology Res. Lab	1800	15.94	5819.14
		Lab Support	600	2.66	969.86
		Lab Staff	600	2.66	969.86
		Faculty Office	280	9.12	3328.80
Multipurpose/Exhibit Space/Event Support		Multipurpose/Exhibit Space/Event Support	1800	6.94	2534.14
Lobby/Display Area and Kiosks		Lobby/Display Area and Kiosks	300	4.63	1689.43
Office Space		Center- Director's Suite (office, reception, waiting)	600	19.54	7133.14
		Office- Related Programs Support Staff	450	14.66	5349.86
		Office- Building Manager/Support Staff	300	9.77	3566.57
		Open Office	240	7.82	2853.26
		Student Work Stations	72	2.35	855.98
		Break Room/Copy/Storage/Files	240	3.91	1426.63
		QEP Activities (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 4.6: The total lighting load in kWh/year

Space Component		Space Type	Total Sq. Ft.	kWh/day	kWh/year
Instructional Space	Classrooms	Auditorium	3000	10.29	3754.29
		Classrooms	3000	10.29	3754.29
		Seminar Rooms	1200	4.11	1501.71
		Breakout/Group Study Rooms	720	2.47	901.03
		Classroom Support	240	0.82	300.34
	Class Laboratories	Computational/Biology ClassLab	2400	8.23	3003.43
		ClassLab Staff and Support	600	2.06	750.86
	Design Studio Instructional Space	ClassLab/Maker Space	900	3.09	1126.29
		ClassLab Staff and Support	450	1.54	563.14
Student/Community Center		Center	1500	6.86	2502.86
		Center support Areas (storage, catering kitchen, etc)	750	2.04	743.04
		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
Research and Industry Partnership Component		Computational/Light Biology Res. Lab	1800	6.17	2252.57
		Lab Support	600	1.03	375.43
		Lab Staff	600	1.03	375.43
		Faculty Office	280	3.04	1109.60
Multipurpose/Exhibit Space/Event Support		Multipurpose/Exhibit Space/Event Support	1800	4.11	1501.71
Lobby/Display Area and Kiosks		Lobby/Display Area and Kiosks	300	2.74	1001.14
Office Space		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 4.5: Monthly predictions for energy production and demand

Performance Period	Performance Month	1	2	3	4	5	6
	Actual Month	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May.*	*Jun.*
	kWh						
Energy Production	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
Energy Demand	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 (optional)	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

Performance Period	Performance Month	7	8	9	10	11	12	Annual Total
	Actual Month	*Jul.*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	
	kWh							
Energy Production	Photovoltaics (location 1)	30,394.35	27,425.37	23,716.17	20,430.64	13,976.47	11,876	127,818.94
	Total Energy Production	30,394.35	27,425.37	23,716.17	20,430.64	13,976.47	11,876	**127,818.94**
Energy Demand	Lighting Power Density	4,363.44	4,363.44	4,222.69	4,363.44	4,222.69	4,363.44	25,899.16
	Equipment Power Density	3,407.78	3,407.78	3,297.85	3,407.78	3,297.85	3,407.78	20,226.80
	Plug Loads (Peak)	4,100.81	4,100.81	3,968.53	4,100.81	3,968.53	4,100.81	24,340.31
	Total Energy Demand	11,872.03	11,872.03	11,489.07	11,872.03	11,489.07	11,872.03	**70,466.27**
EUI	**Project Energy Use Intensity (EUI)**	0.953	0.953	0.922	0.953	0.922	0.953	**5.657**
	Energy Storage							
Modelled (optional)	Modelled energy production	30,394.35	27,425.37	23,716.17	20,430.64	13,976.47	11,876	127,818.94
	Modelled energy demand	11,872.03	11,872.03	11,489.07	11,872.03	11,489.07	11,872.03	70,466.27
	Predicted delta	18,522.32	15,553.34	12,227.10	8,558.61	2,487.40	4	57,352.67

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

Annual Building Water Consumption		Gallons/day	Gallons/month	Gallons/year
Fixtures	Showers	300.00	9,000.00	109,500.00
	BioLabs	15.00	450.00	5,475.00
	Breakrooms	15.00	450.00	5,475.00
	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 Water Consumption		913.89	27,416.66	333,569.34
Urban Agriculture		512.33	15,583.33	187,000.00
Total Building Consumption		3,828.22	115,059.9	1,397,300.00

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

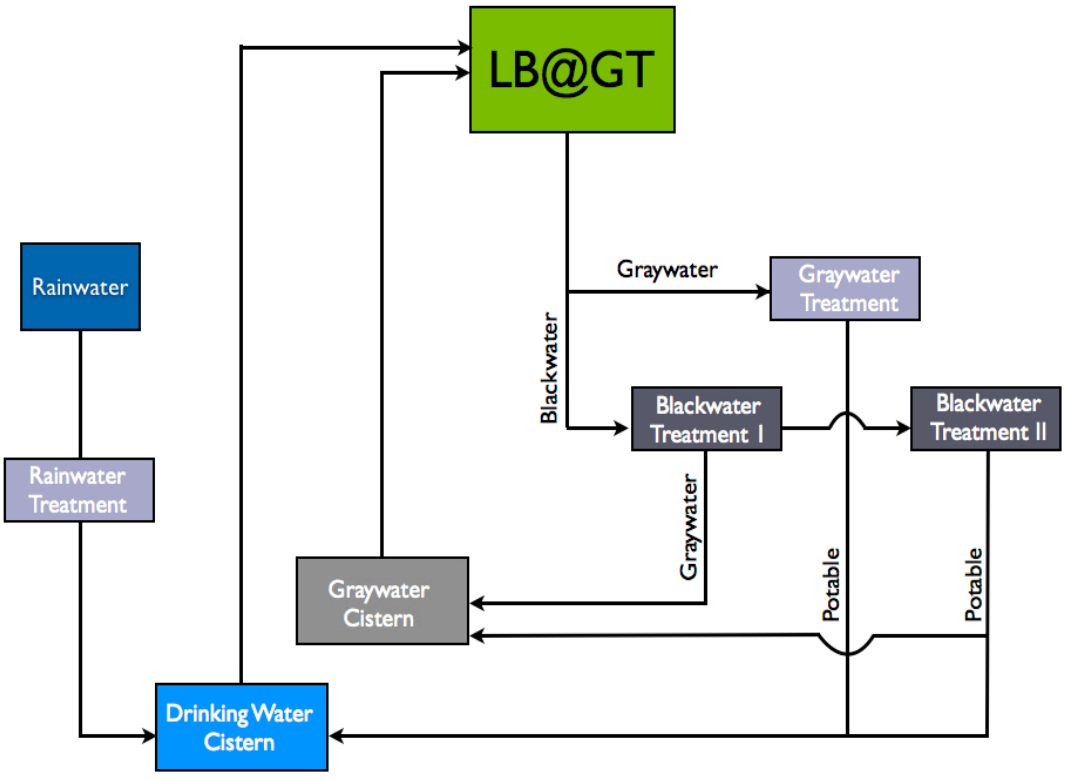

Figure 5.1: Water balance diagram with separate graywater treatment

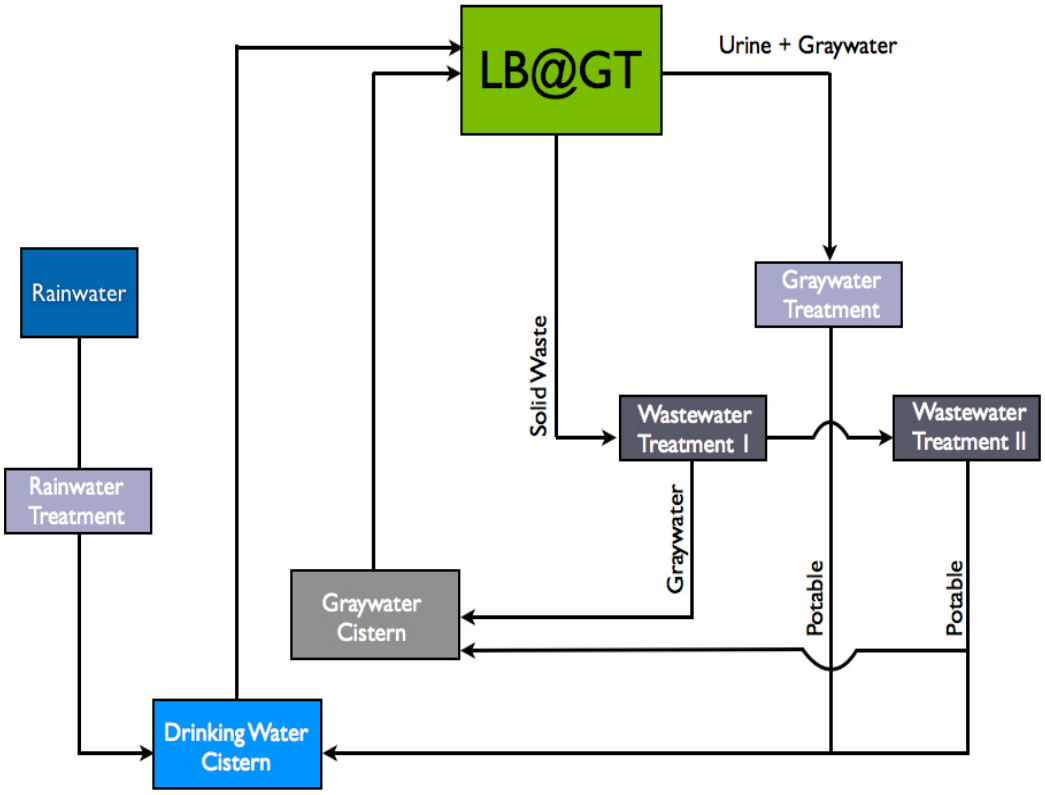

Figure 5.2: Water balance diagram with urine separation system

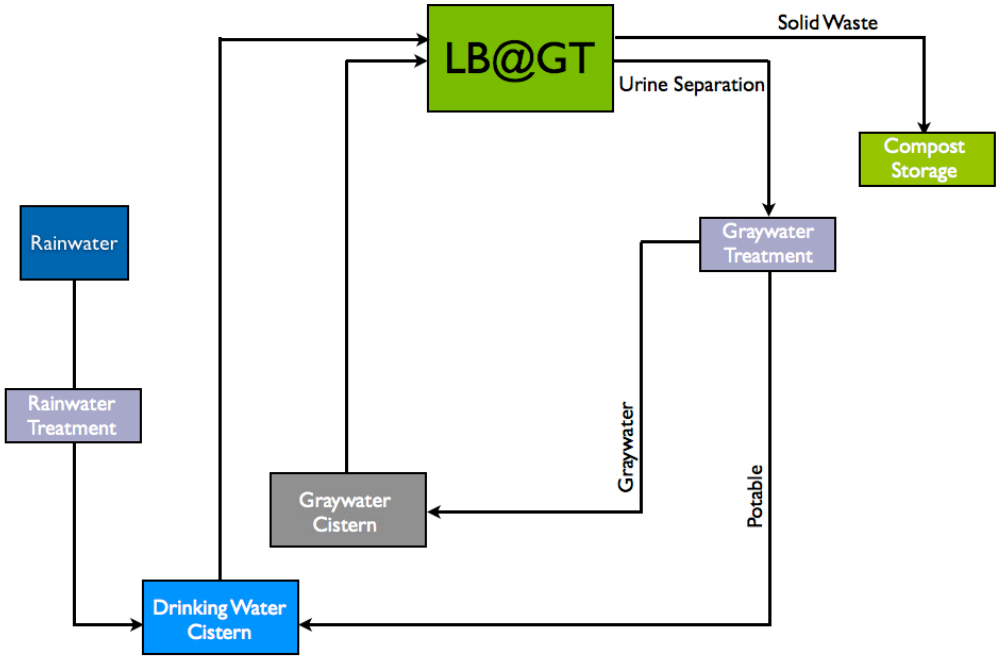

Figure 5.3: Water balance diagram with urine separation and composting toilet systems

EXECUTIVE SUMMARY

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

Materials

Preferential use of recycled and salvaged materials

Selection of versatile building elements to ensure architectural freedom

Minimizing inherent but hidden embodied carbon contents

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

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.