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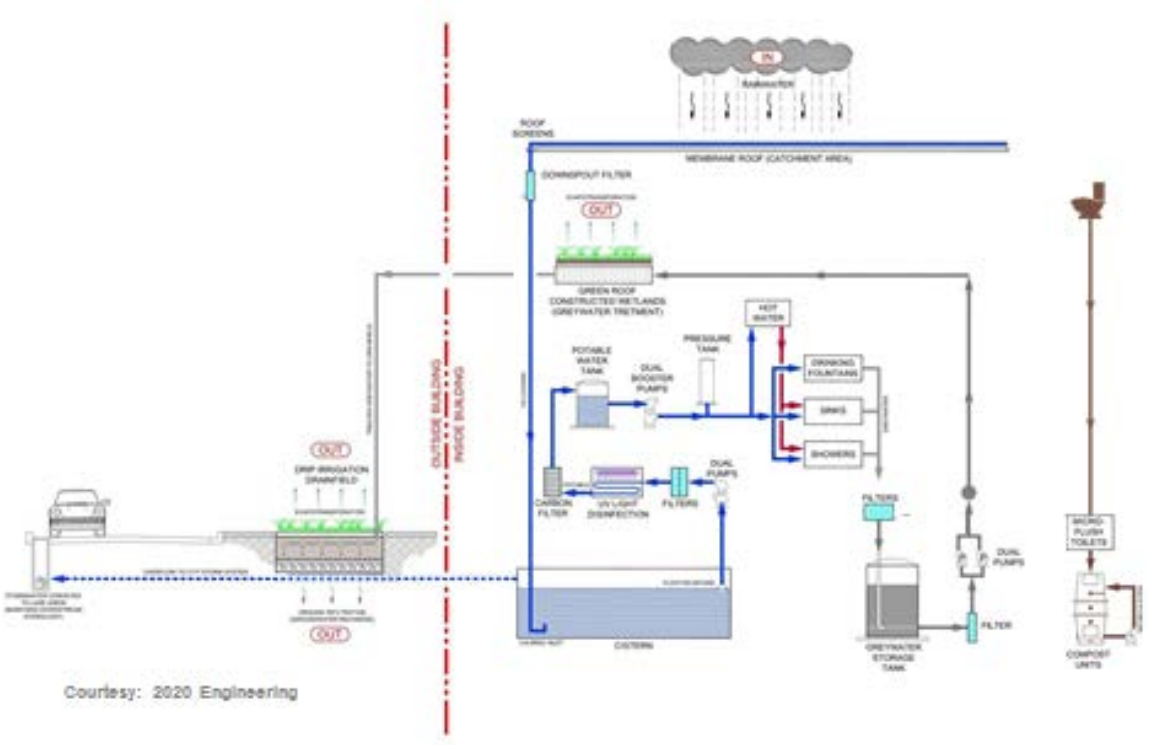
Water Smart Innovations 2012

Dynamic Simulation of On-site Harvesting, Wastewater Treatment, and Reuse Strategies

Thursday, October 4, 2012
10:40am - 11:10am



Alfredo Fernandez-Gonzalez
Natural Energies Advanced Technologies (NEAT) Laboratory at UNLV

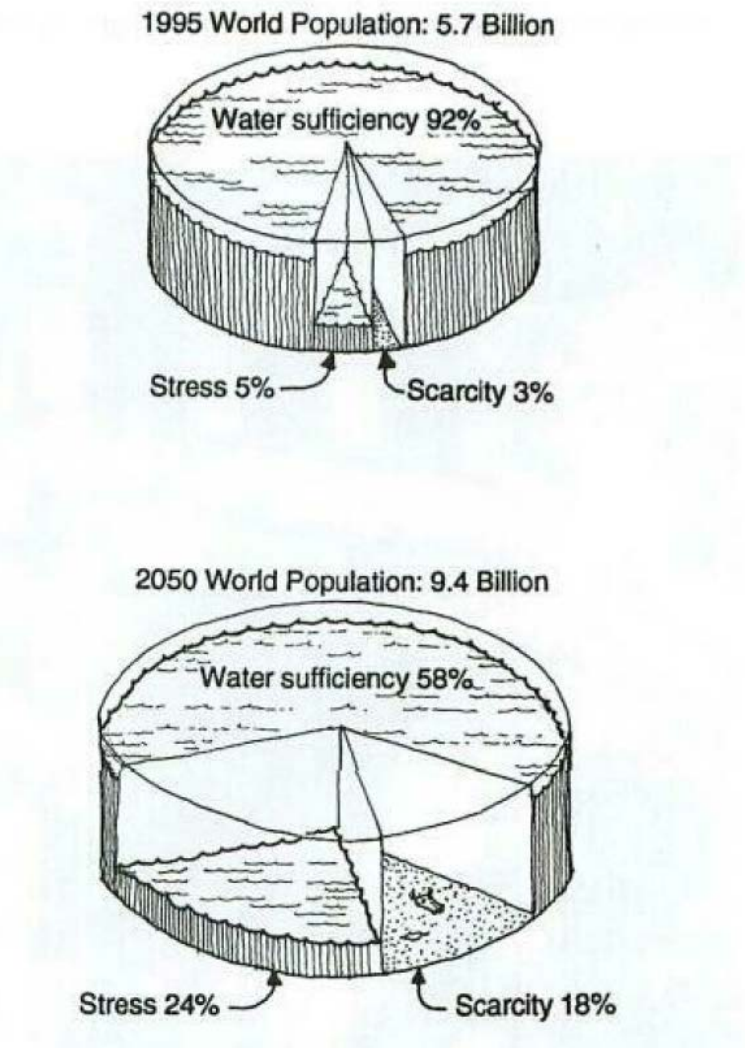
David Morillón Gálvez
Instituto de Ingeniería, UNAM

The Issues: Population & Water Scarcity

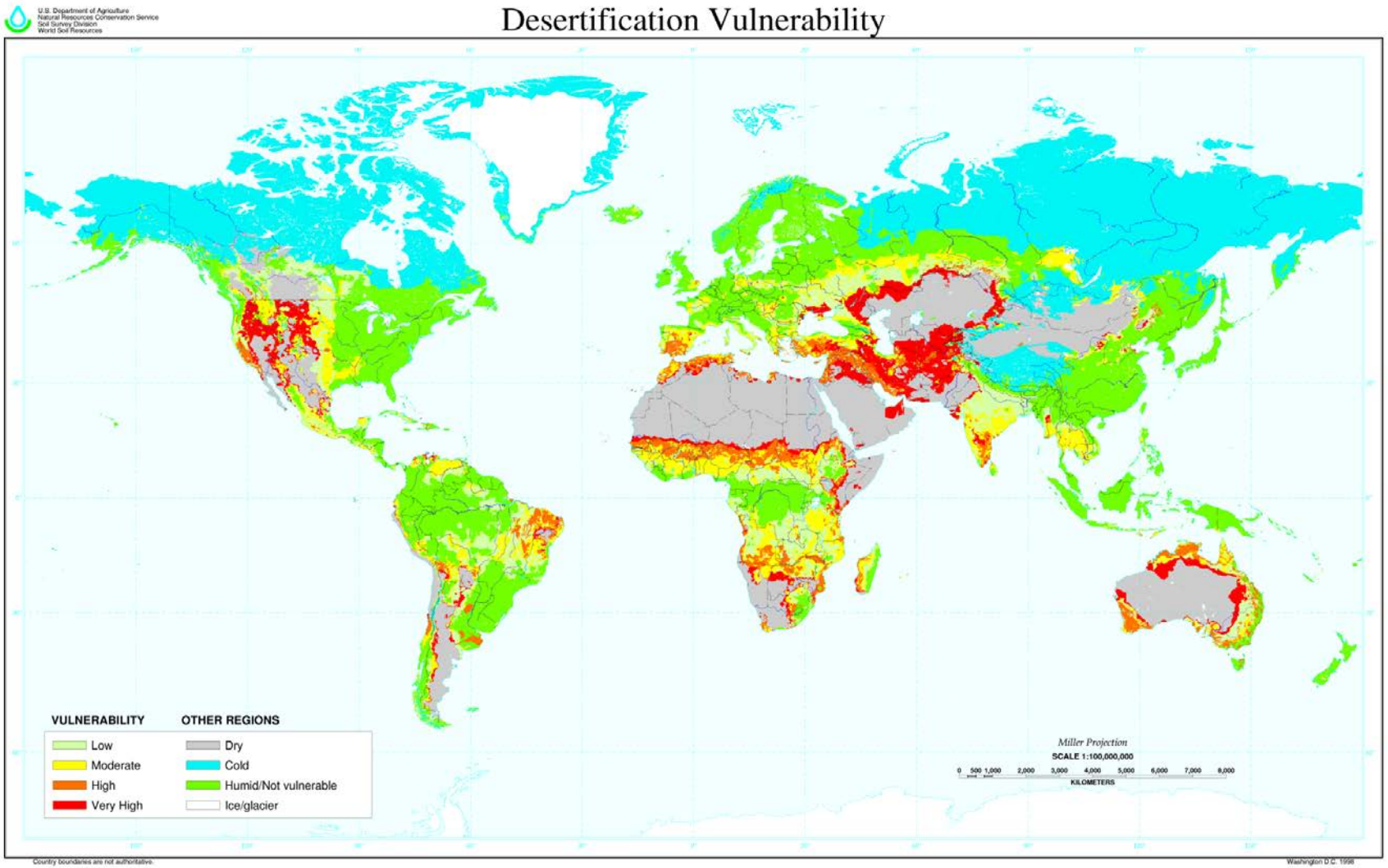
The impending crisis of supply and treatment of water in urban areas.

- ***In 1800 only 3% of the world population lived in urban areas.***
- ***By 1900 it was 14%.***
- ***In 2007 half of the global population (50%) lives in urban areas.***

(Source: Stein et al., 2006)

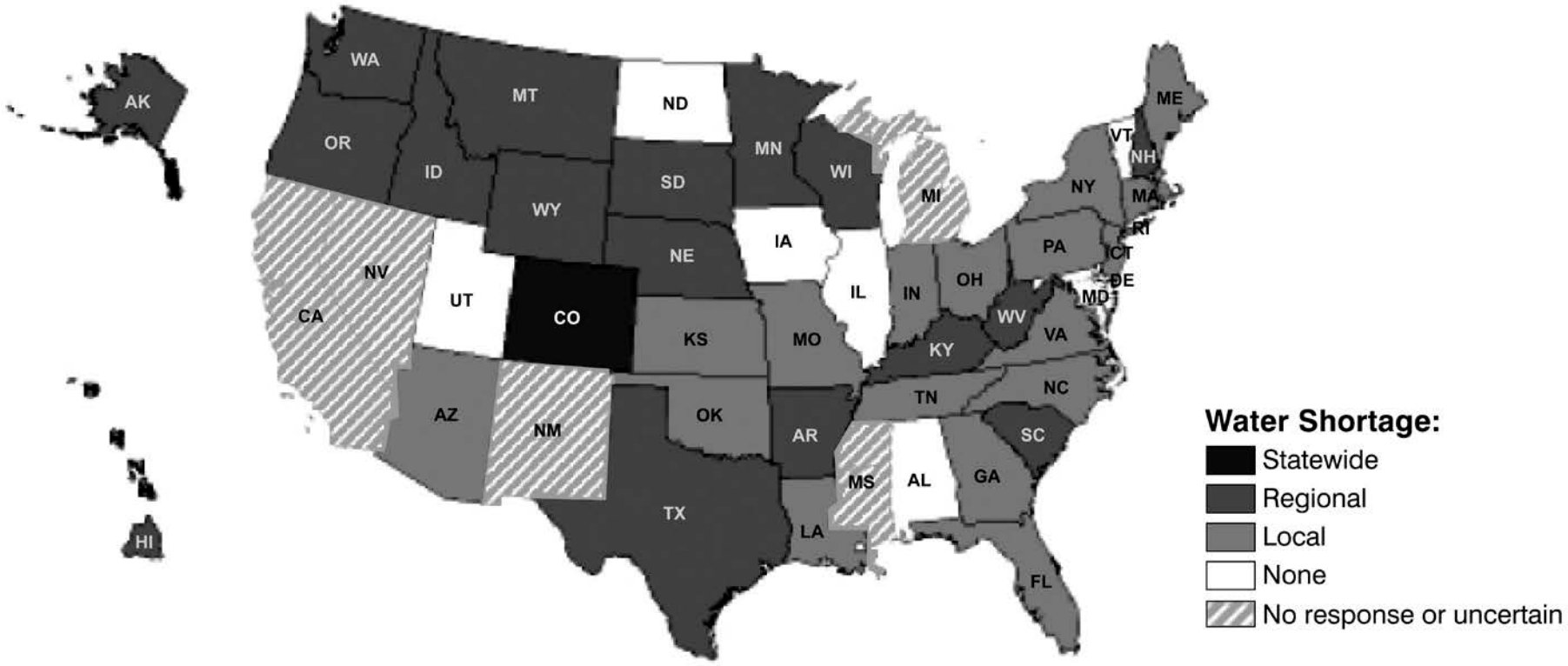


The Issues: Population & Water Scarcity



(Source: http://soils.usda.gov/use/worldsoils/mapindex/desert.html)

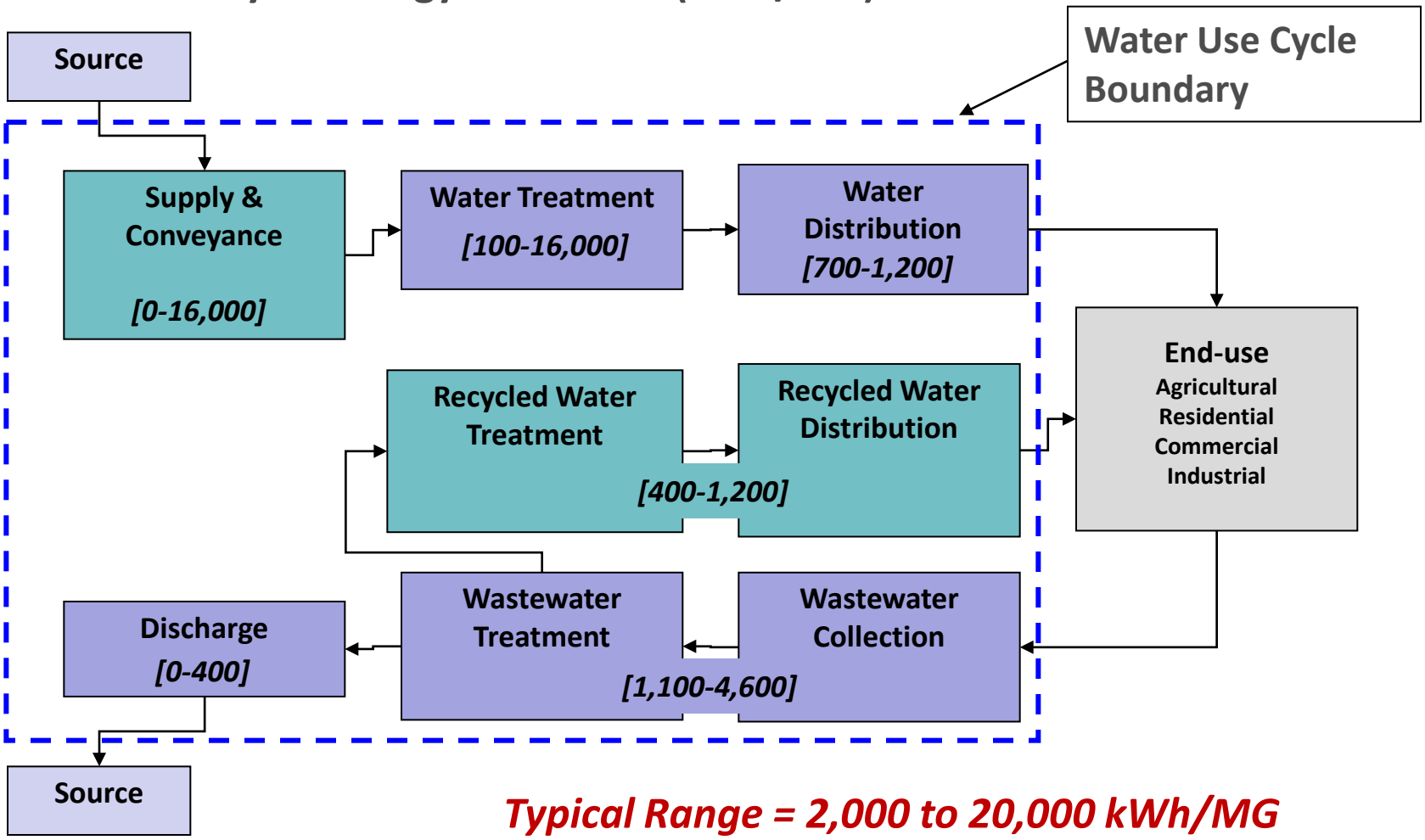
The Issues: Population & Water Scarcity



States where water scarcity is expected over the next 10 years (Source: GAO, 2003).

The Issues: Water-Energy Nexus

Water Use Cycle Energy Intensities (kWh/MG)

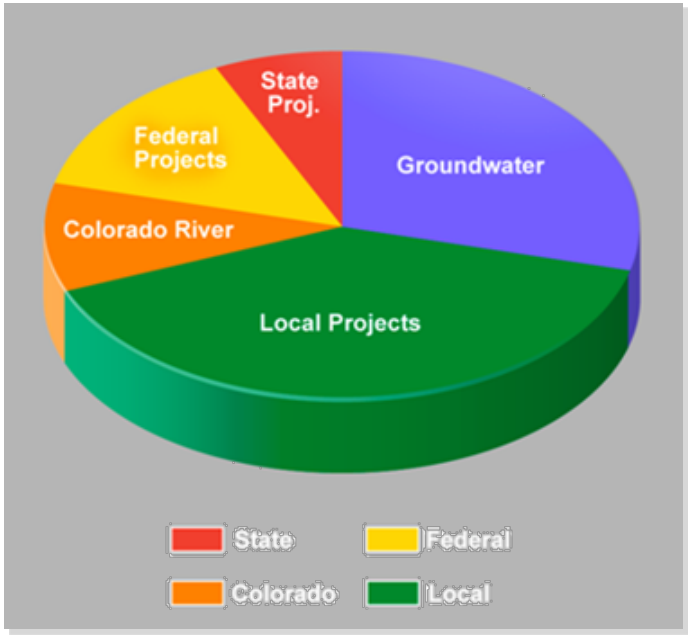


Typical Range = 2,000 to 20,000 kWh/MG

(Source: California Energy Commission, 2005 Integrated Energy Policy Report)

The Issues: Water-Energy Nexus

California's Water Supply Systems



(Source: Lester Snow, California Department of Water Resources)

The Issues: Water-Energy Nexus

Water-Related Electricity Use in CA (2001)

	Electricity (GWh)
Water Supply and Treatment	
Urban	7,554
Agricultural	3,188
End Uses	
Agricultural	7,372
Residential	27,887
Commercial	
Industrial	
Wastewater Treatment	2,012
Totals	**48,012**
2001 Consumption	**250,494**
Percent of Energy Use	**19%**

CO_2 e (Million Metric Tons) **56**

Approximately 25% of the country's energy use is related to water in some form.

(Source: California Energy Commission, 2005 Integrated Energy Policy Report)

The Issues: Water-Energy Nexus

Regional Differences in Water-Related Electricity Use

	Northern California kWh/MG	Southern California kWh/MG
Supply & Conveyance	150	8,900
Water Treatment	100	100
Distribution	1,200	1,200
Wastewater Treatment	2,500	2,500
Regional Total	3,950	12,700

(Source: California Energy Commission, 2005 Integrated Energy Policy Report)

Living Building Challenge

Living Building Challenge

Living Building Challenge 2.0

Net Zero Water

- ***One hundred percent of occupants' water use must come from captured precipitation or closed loop water systems that account for downstream ecosystem impacts and that are appropriately purified without the use of chemicals.***

(Source: https://ilbi.org/lbc/LBC%20Documents/LBC2-0.pdf)

Living Building Challenge

Living Building Challenge 2.0

Ecological Water Flow

- ***One hundred percent of storm water and building water discharge must be managed onsite to feed the project's internal water demands or released onto adjacent sites for management through acceptable natural time-scale surface flow, groundwater recharge, agricultural use or adjacent building needs.***

(Source: https://ilbi.org/lbc/LBC%20Documents/LBC2-0.pdf)

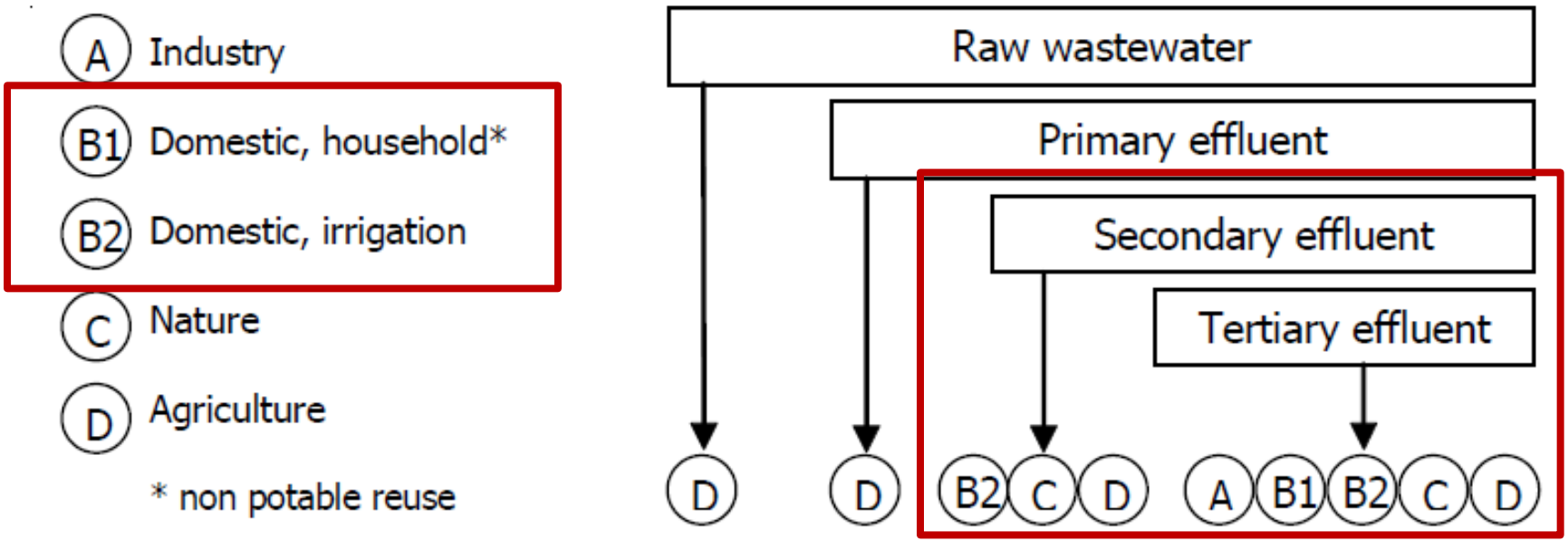
Research Objective

To develop a suitable methodology for the design and sustainable management of water in buildings located in urban areas.

Solaire **Apartment Building in New York**

Research Objective

Characterization and assessment of water treatment technologies for reuse.



(Source: J. de Koning et al., 2008)

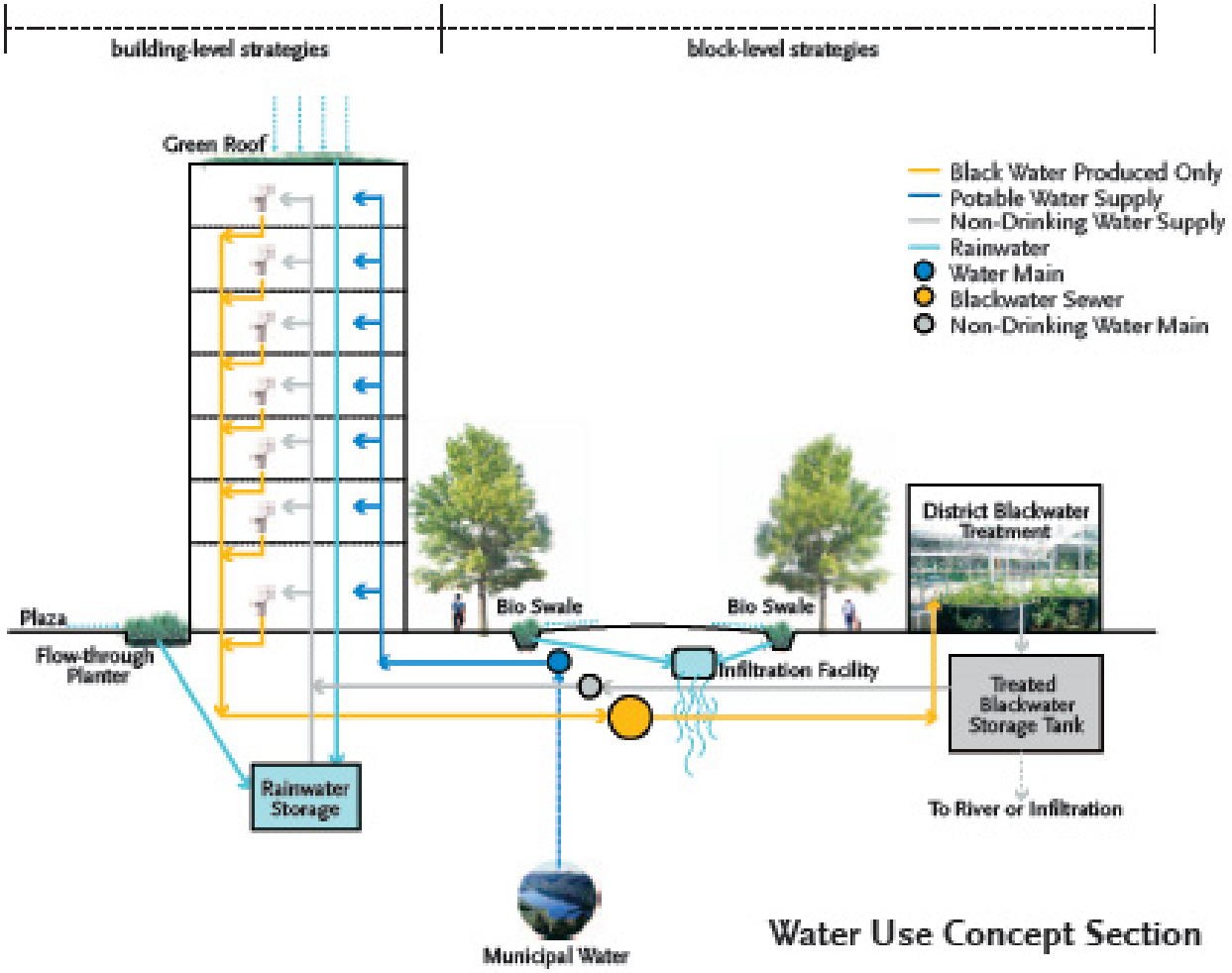
Proposed Design Methodology

1. Harvest all economically available on-site water supply.
2. Integrate, filter, treat, and re-use on-site harvested water sources.
3. 24/7 on demand storage.
4. Digital controlled distribution.
5. Drip/subsurface irrigation for green roofs, walls, and landscapes.
6. Minimize grid dependence: re-use and limit waste.

Case Studies

Lloyd Crossing Sustainable Urban Design proposed in Portland, OR.

100% of non-potable water supply through rainwater and black water reuse.



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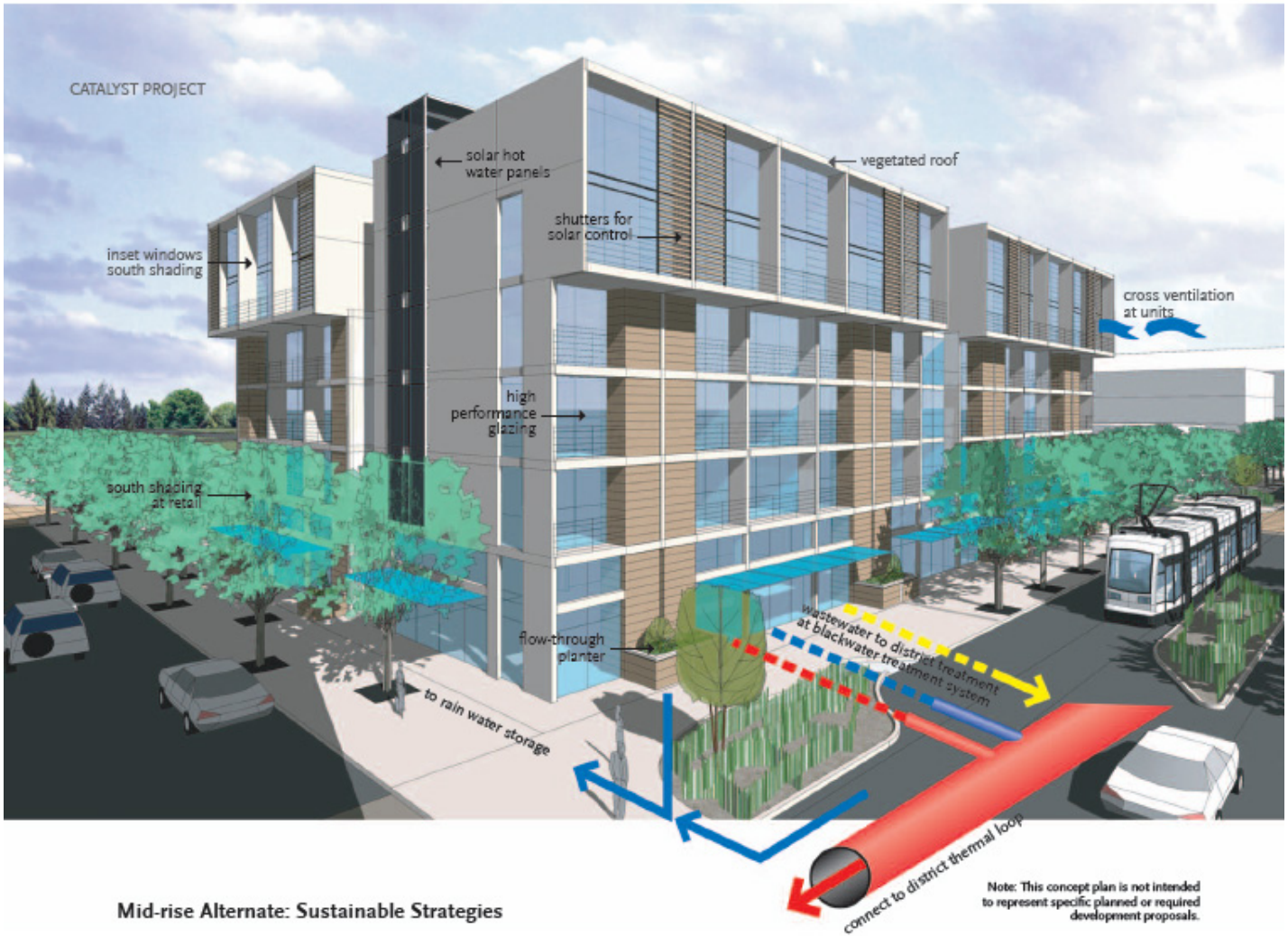


Case Studies

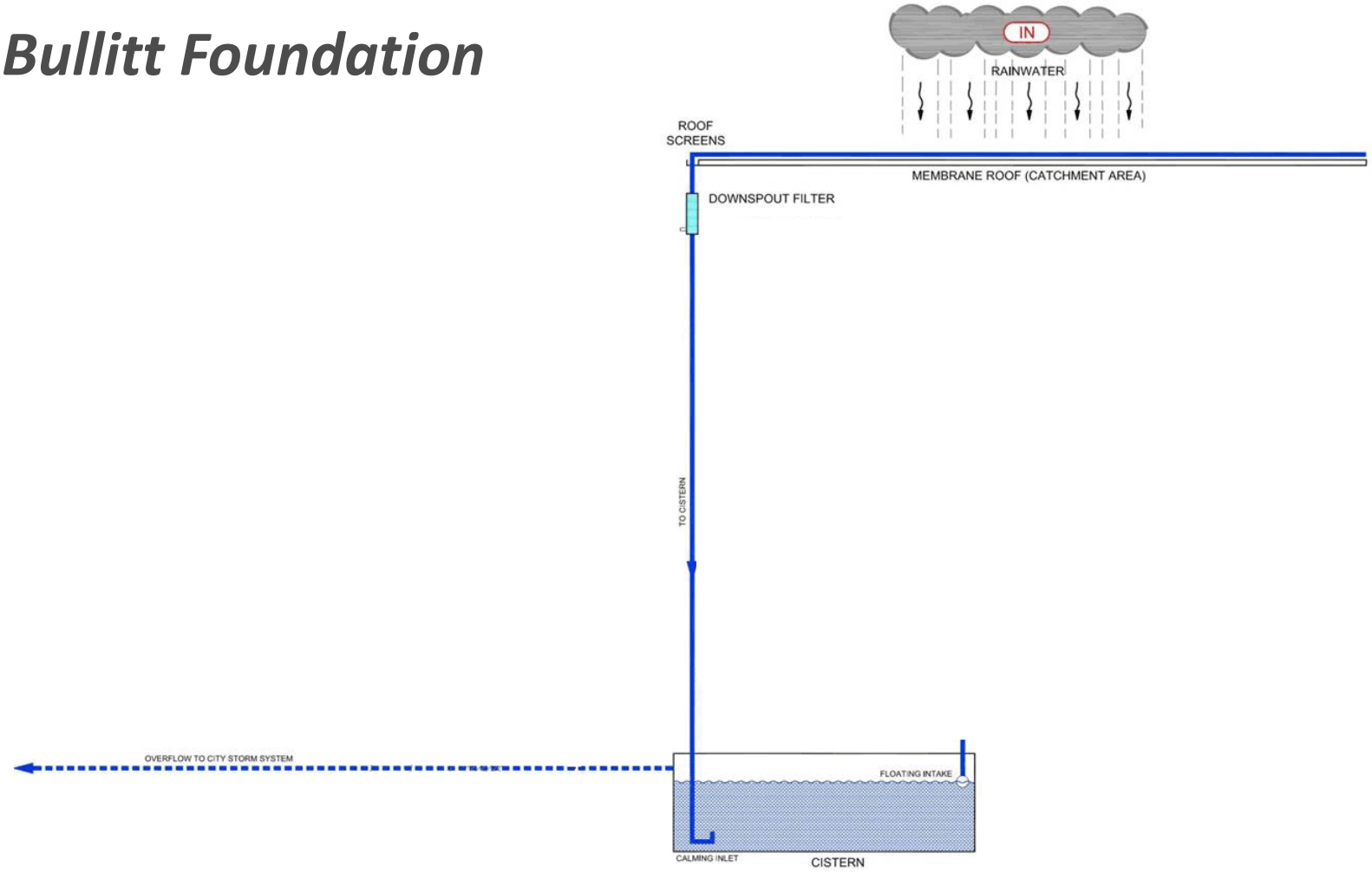
Bullitt Foundation

- *Six-story office building located in Seattle.*
- *Designed to meet the requirements of the Living Building Challenge 2.0.*
- *The building is supplied in its entirety with rainwater (using composting toilets and greywater treatment using the vegetated roof).*

(Courtesy: University of Washington Integrated Design Lab)

Case Studies

Bullitt Foundation

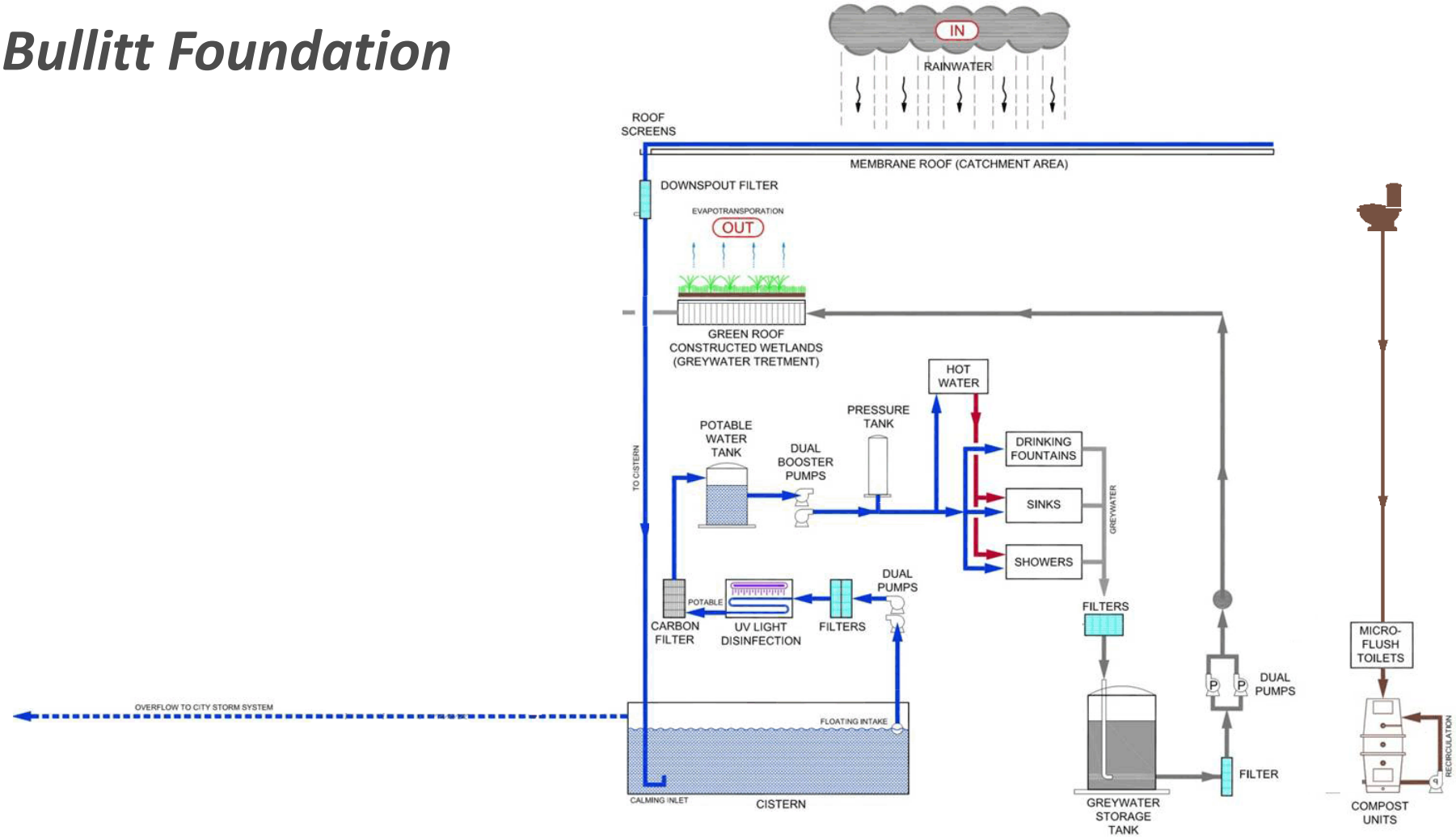


Courtesy: 2020 Engineering

(Courtesy: University of Washington Integrated Design Lab)

Case Studies

Bullitt Foundation



Courtesy: 2020 Engineering

Case Studies

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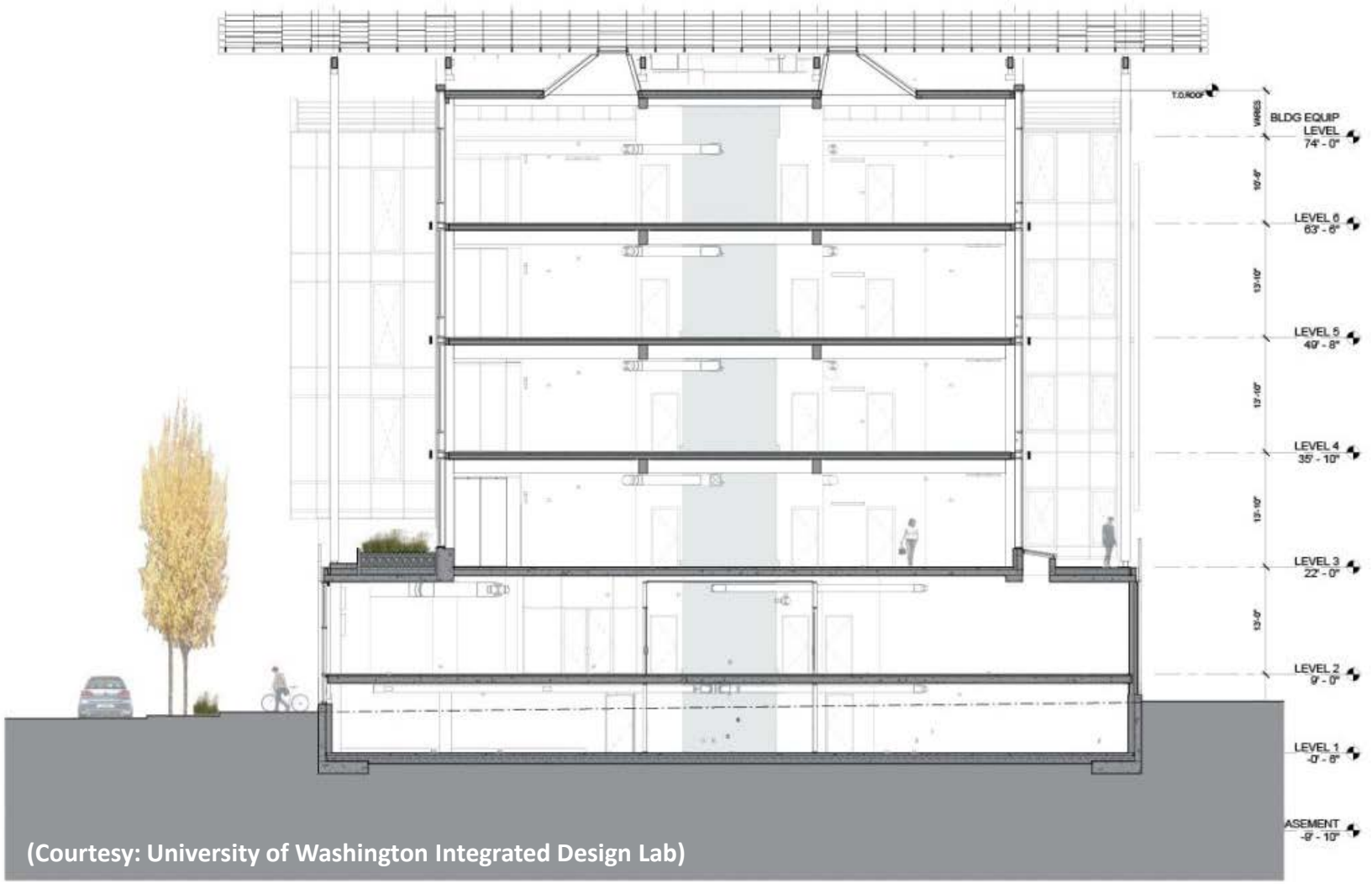

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Case Studies

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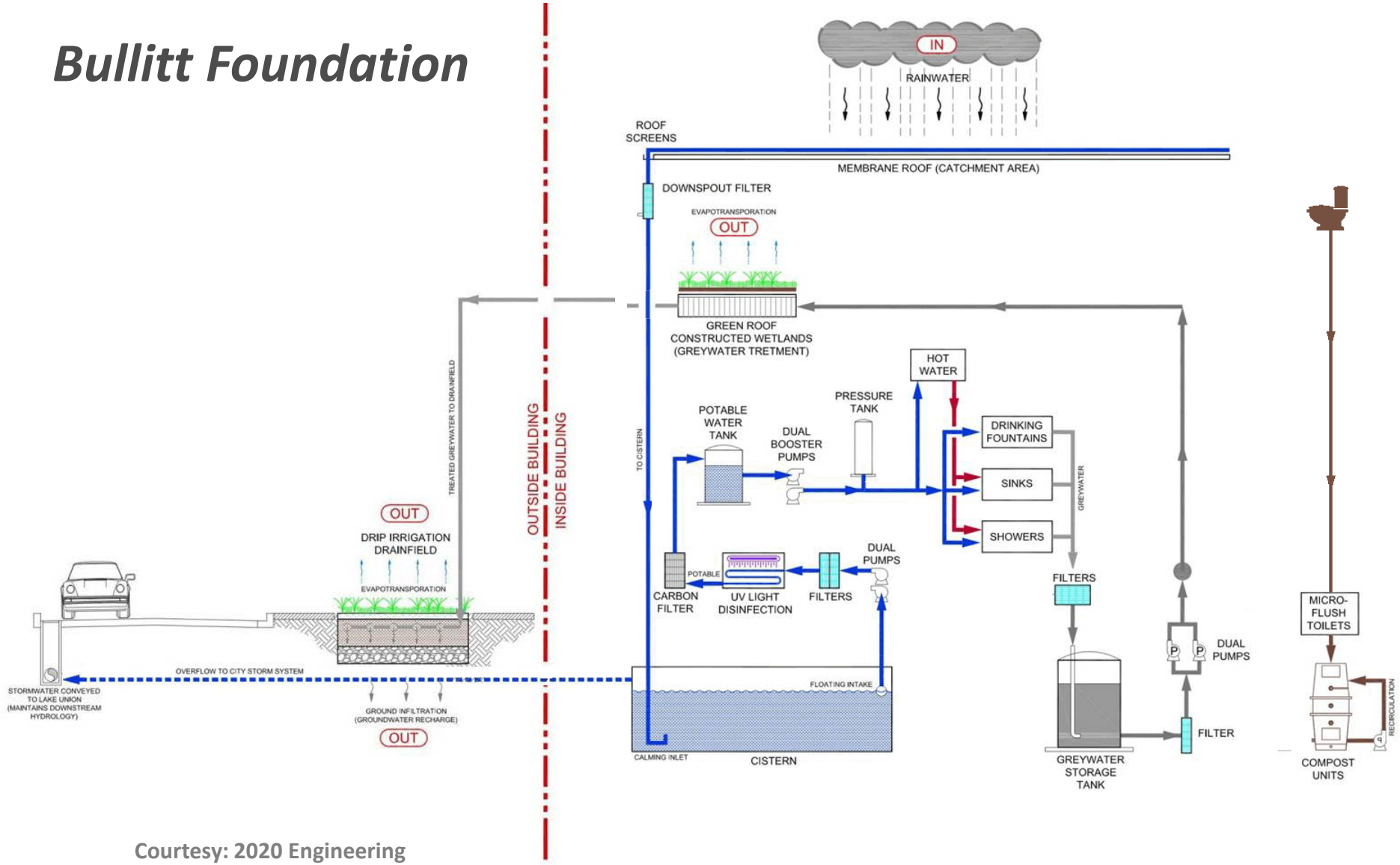


Courtesy: 2020 Engineering

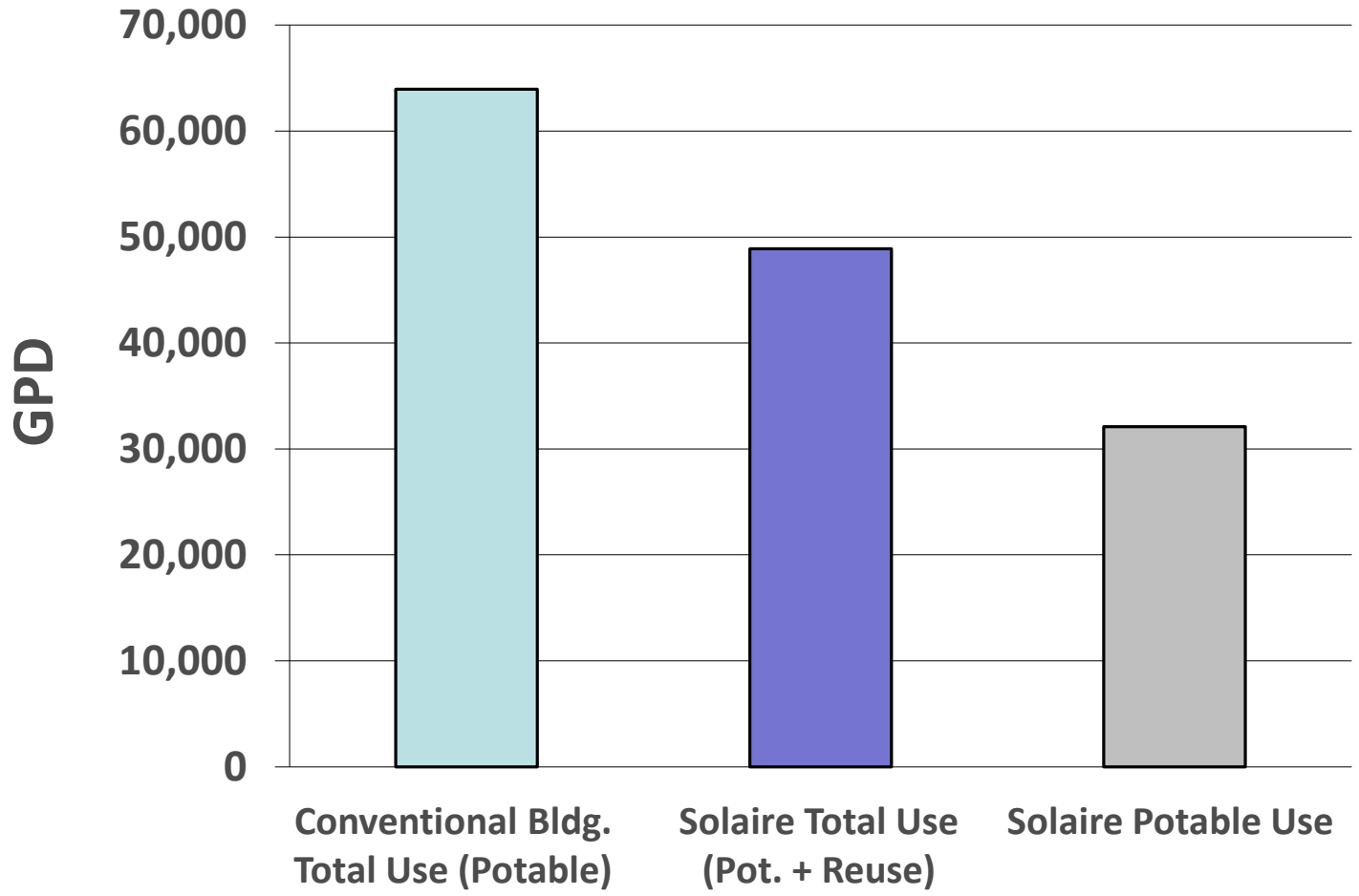
(Courtesy: University of Washington Integrated Design Lab)

Dynamic Simulation: The Solaire

The Solaire

- *27-Story apartment building located in New York.*
- *In operation since 2004.*
- *Results published about this building indicate a reduction in the consumption of potable water of 50%*
- *The results from this building are used to validate a dynamic simulation program of water flows.*

Measured Results: The Solaire

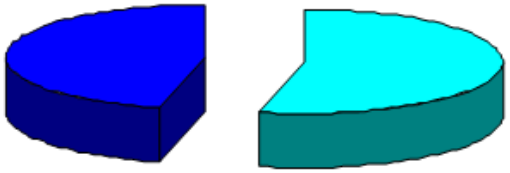


(Source: Zavoda, 2005)

Measured Results: The Solaire

Reclaimed Water Usage

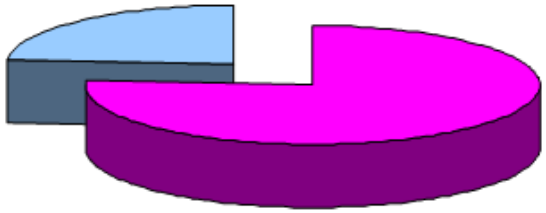
Cooling Tower
Avg. 7,770 gpd



Toilets
Avg. 9,040 gpd

Cooling Tower Usage

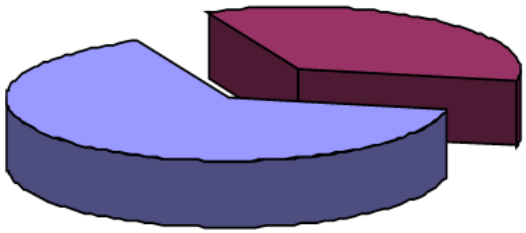
Potable Water
Avg. 2,400 gpd



Reuse Water
Avg. 7,700 gpd

Total Building Consumption

Potable (66%)
Avg. 32,100 gpd



Reuse (34%)
Avg. 16,800 gpd

(Source: Zavoda, 2005)

Measured Results: The Solaire

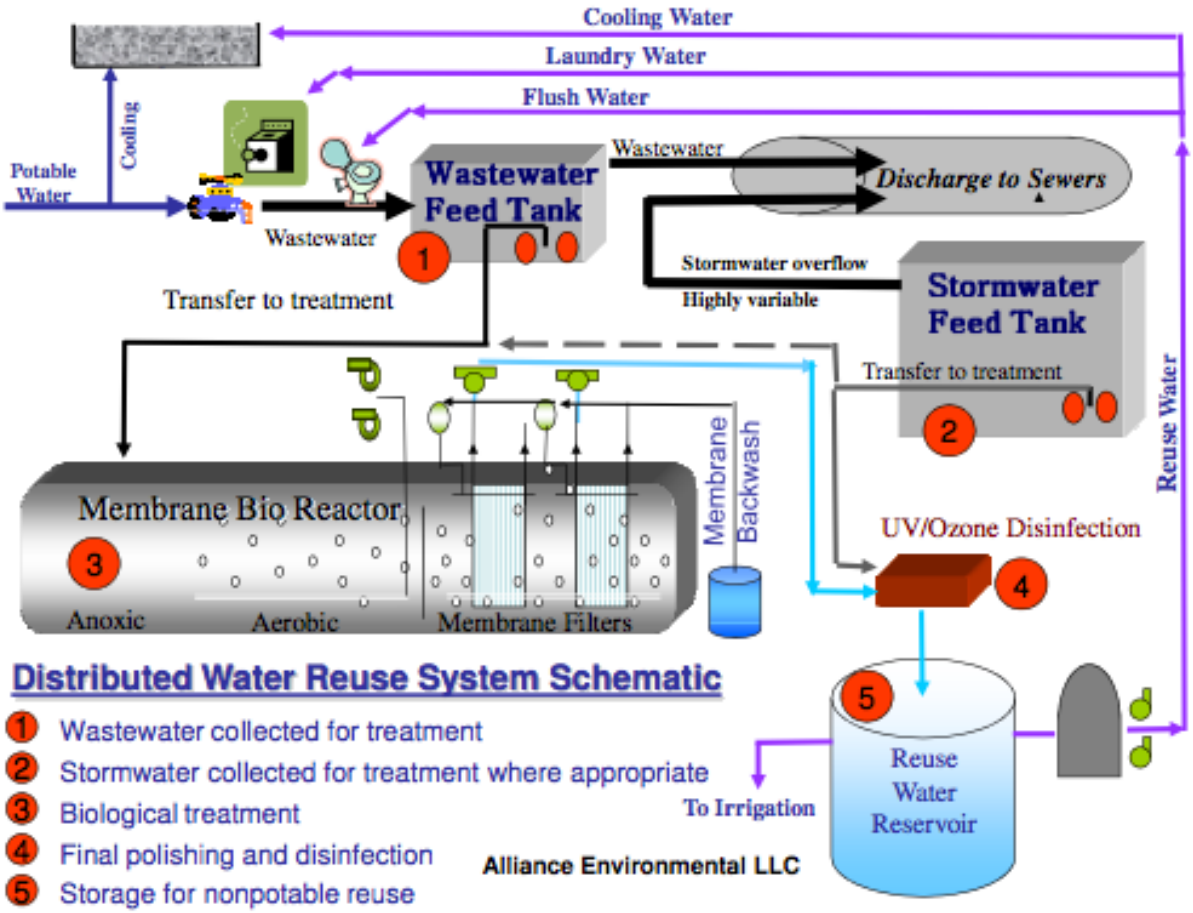
SOLAIRE WATER USE FOR 2007

	Gallons Per Day	Gallons Per Capita Per Day	Gallons Per Day Per Ft^2	Percent of Total	
NYC Potable Supply	33,063	47	0.09	63%	Of All Water Use
Reuse Water Supply	19,555	28	0.05	37%	Of All Water Use
Total Water Use	**52,618**	**75**	**0.15**	**100%**	
Cooling Tower Potable	4,363	6	0.01	13%	Of NYC Supply
Cooling Tower Reuse	4,323	6	0.01	22%	Of Reuse Supply
Total Cooling Supply	**8,686**	**12**	**0.02**	**17%**	Of Total Water Use
Other Uses					
Humidification Supply	583	1		1%	Of Total Water Use
Irrigation	219	0.3		0%	Of Total Water Use

(Source: www.hpbmagazine.com)

Measured Results: The Solaire

Membrane bioreactor (MBR) and UV/Ozone wastewater treatment



(Source: www.werf.org)

Dynamic Simulation Results

	HOURLY SIMULATION Jan - Dec 2004	MEASURED / REPORTED Jan - Dec 2004	
Weather & Cooling Energy Data:			
Annual Precipitation		52.1	Inches
Annual Average DBT		54.3	°F
Annual Air-conditioned Hours (Calculated)	3,798		Hrs.
Annual Cooling Energy Use (Calculated)	2,882,332		KWh
Cooling Tower Water Use:			
Annual Cooling Tower Use (Potable + Recycled Water)	3,298,136		Gallons
Average Daily Cooling Tower Use (Potable + Recycled Water)	**9,011.3**	**9,049.0**	Gallons
Average Daily Cooling Tower Use per Resident (Potable + Recycled Water)	12.3		Gallons/Capita
Annual Cooling Tower Use (Potable Water)	662,750		Gallons
Average Daily Cooling Tower Use (Potable Water)	**1,810.8**	**1,894.0**	Gallons
Average Daily Cooling Tower Use per Resident (Potable Water)	2.5		Gallons/Capita
Annual Cooling Tower Use (Potable Added to Reused)	696,280		Gallons
Average Daily Cooling Tower Use (Potable Added to Reused)	1,902		Gallons
Average Daily Cooling Tower Use per Resident (Potable Added to Reused)	3		Gallons/Capita
Annual Cooling Tower Use (Reused Water)	2,635,385		Gallons
Average Daily Cooling Tower Use (Reused Water)	**7,201**	**7,155**	Gallons
Average Daily Cooling Tower Use per Resident (Reused Water)	10		Gallons/Capita

Solaire inflow/outflow reclamation numbers obtained from: (Zavoda, 2005; Engle ,2006).

Dynamic Simulation Results

Humidification (2007 extrapolated) =	212,795	g / year
Humidification (1% potable) =	102,764	g / year
Hourly Humidification (from 2007) =	**72.8**	gph
Humidification Temp. Set Point =	**45**	°F

Day	Date	Hour	Precipitation (inches)		Precipitation (inches)	DB Temperature (°F)	Humidification (yes=1 / no=0)	Humidification Potable (gph)
Wednesday	20030101	1		0.00	0.000	48.0	0	0.0
		2		0.00	0.000	48.0	0	0.0
		3		0.00	0.000	49.0	0	0.0
		4		0.00	0.000	49.0	0	0.0
		5		0.00	0.000	48.0	0	0.0
		6		0.00	0.000	48.0	0	0.0
		7		0.00	0.000	49.0	0	0.0
		8	T	2.00	0.001	49.0	0	0.0
		9	0.020	1.00	0.020	47.0	0	0.0
		10	0.040	1.00	0.040	46.0	0	0.0
		11	0.030	1.00	0.030	45.0	0	0.0
		12	0.040	1.00	0.040	43.0	1	72.8
		13	0.090	1.00	0.090	42.0	1	72.8
		14	0.050	1.00	0.050	40.0	1	72.8
		15	0.050	1.00	0.050	39.0	1	72.8
		16	0.190	1.00	0.190	38.0	1	72.8
		17	0.100	1.00	0.100	38.0	1	72.8
		18	0.070	1.00	0.070	38.0	1	72.8
		19	0.100	1.00	0.100	38.0	1	72.8
		20	0.200	1.00	0.200	38.0	1	72.8

Dynamic Simulation Results

Building Area =	356,787
No. of Units =	293
Occupants =	730

W.C.		Bathroom Sink		Shower		Bathtub (as Shower)		Batht
506	1.6	624	1.5	133	2.5	421	2.5	421
(total fixtures)	(g. per flush)	(total fixtures)	(gpm)	(total fixtures)	(gpm)	(total fixtures)	(gpm)	(total fixtures)

W.C.		Bathroom Sink		Shower		Bathtub		Batht
(Flushes / Hour)	(gph)	(Minutes Used)	(gph)	(Minutes Used)	(gph)	(Minutes Used)	(gph)	(Minutes Used)
76	121.6	38	57.0	0	0.0	0	0.0	0
18	28.8	7	10.8	0	0.0	0	0.0	0
15	24.0	6	9.0	0	0.0	0	0.0	0
15	24.0	6	9.0	0	0.0	0	0.0	0
127	203.2	171	257.2	85	212.5	210	525.0	0
506	809.6	759	1,138.5	480	1,200.0	1,518	3,795.0	0
557	891.2	836	1,253.3	138	345.0	378	945.0	0
455	728.0	614	921.4	60	150.0	126	315.0	0
101	161.6	51	75.8	0	0.0	0	0.0	0
101	161.6	51	75.8	0	0.0	0	0.0	0
101	161.6	51	75.8	30	75.0	102	255.0	0
253	404.8	127	189.8	0	0.0	0	0.0	0
278	444.8	139	208.5	0	0.0	0	0.0	0
127	203.2	64	95.3	0	0.0	0	0.0	0
101	161.6	51	75.8	0	0.0	0	0.0	0
253	404.8	127	189.8	0	0.0	0	0.0	0
304	486.4	152	228.0	0	0.0	0	0.0	0
506	809.6	253	379.5	0	0.0	0	0.0	0
506	809.6	253	379.5	0	0.0	0	0.0	87
607	971.2	759	1,138.1	78	195.0	252	630.0	39

Dynamic Simulation Results

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Average Daily Cooling Tower Use per Resident (Reused Water)	10		Gallons/Capita
Space Humidification Water Use:			

Dynamic Simulation Results

Space Humidification Water Use:	HOURLY SIMULATION	MEASURED / REPORTED	
Annual Potable Water Space Humidification Use	188,334		Gallons
Daily Potable Water Space Humidification Use	515		Gallons
Daily Potable Water Space Humidification Use per Resident	1		Gallons/Capita
Residential Water Use:			
Toilet Use:			
Annual Toilet Flushes	2,158,424		Flushes
Daily Toilet Flushes	5,897		Flushes
Daily Toilet Flushes per Resident	8.1		Flushes/Capita
Annual W.C. Use	3,453,478		Gallons
Daily W.C. Use	**9,436**	**9,436.0**	Gallons
Daily W.C. Use per Resident	13		Gallons/Capita
Annual W.C. Use (Potable Added to Reused)	7,947		Gallons
Daily W.C. Use (Potable Added to Reused)	22		Gallons
Daily W.C. Use per Resident (Potable Added to Reused)	0		Gallons/Capita
Annual W.C. Use (Reused Water)	3,445,531		Gallons
Daily W.C. Use (Reused Water)	9,414.0		Gallons
Daily W.C. Use per Resident (Reused Water)	12.9		Gallons/Capita
Lavatories:			
Annual Lavatory Minutes Used	1,973,939		Minutes
Daily Lavatory Minutes Used	5,393		Minutes
Daily Lavatory Minutes Used per Resident	7.4		Minutes/Capita

Dynamic Simulation Results

	HOURLY SIMULATION	MEASURED / REPORTED	
Lavatories:			
Annual Lavatory Minutes Used	1,973,939		Minutes
Daily Lavatory Minutes Used	5,393		Minutes
Daily Lavatory Minutes Used per Resident	7.4		Minutes/Capita
Annual Lavatory Water Use	2,960,908		Gallons
Daily Lavatory Water Use	8,090		Gallons
Daily Lavatory Water Use per Resident	11		Gallons/Capita
Bathing (Includes Shower + Bathtub Use):			
Annual Showering + Bathing Minutes Used	1,455,723		Minutes
Daily Showering + Bathing Minutes Used	3,977		Minutes
Daily Showering + Bathing Minutes Used per Resident	5.4		Minutes/Capita
Annual Bathing Use	4,298,000		Gallons
Daily Bathing Use	11,743		Gallons
Daily Bathing Use per Resident	16		Gallons/Capita
Kitchen Sinks:			
Annual Kitchen Sink Minutes Used	390,258		Minutes
Daily Kitchen Sink Minutes Used	1,066		Minutes
Daily Kitchen Sink Minutes Used per Resident	1.5		Minutes/Capita
Annual Kitchen Sink Use	858,567		Gallons
Daily Kitchen Sink Use	2,346		Gallons
Daily Kitchen Sink Use per Resident	3		Gallons/Capita
Dishwashers:			
Annual Dish Washer Loads	63,621		Loads
Daily Dish Washer Loads	174		Loads
Daily Dish Washer Loads per Resident	0.2		Loads/Capita

Dynamic Simulation Results

	HOURLY SIMULATION	MEASURED / REPORTED	
Residential Water Use Summary:			
Total Annual Potable Water Use	**9,675,983**		**Gallons**
Total Daily Potable Water Use *(excluding humidification)*	**26,437**	**26,956.0**	**Gallons**
Total Daily Potable Water Use per Resident	**36**		**Gallons/Capita**
Total Annual Recycled Water Use	**3,453,478**		**Gallons**
Total Daily Recycled Water Use	**9,436**	**9,436.0**	**Gallons**
Total Daily Recycled Water Use per Resident	**13**		**Gallons/Capita**
Waste Water Treated, Recycled & Discharged:			
Annual Waste Water Produced	13,318,204		Gallons
Daily Waste Water Produced	**36,389**	**36,392.0**	Gallons
Daily Waste Water Produced per Resident	50		Gallons/Capita
Annual Treated Water Recycled *(includes potable supplement)*	6,088,864		Gallons
Daily Treated Water Recycled *(includes potable supplement)*	**16,636**	**16,591.0**	Gallons
Daily Treated Water Recycled per Resident *(includes potable supplement)*	57		Gallons/Capita
Annual Waste Water Discharged to Sewer	7,648,719		Gallons
Daily Waste Water Discharged to Sewer	**20,898**	**19,801.0**	Gallons
Daily Waste Water Discharged to Sewer per Resident	29		Gallons/Capita
Irrigation Water Use (Rainwater Harvesting System):			
Annual Recycled Water Irrigation Use	203,358		Gallons
Daily Recycled Water Irrigation Use	555.6		Gallons
Daily Recycled Water Irrigation Use per Resident	0.8		Gallons/Capita
Annual Rainwater Discharged (Hudson River)	85,156		Gallons
Daily Rainwater Discharged (Hudson River)	**233**	***insignificant***	Gallons
Daily Rainwater Discharged (Hudson River) per Resident	0		Gallons/Capita

Water Smart Innovations 2012

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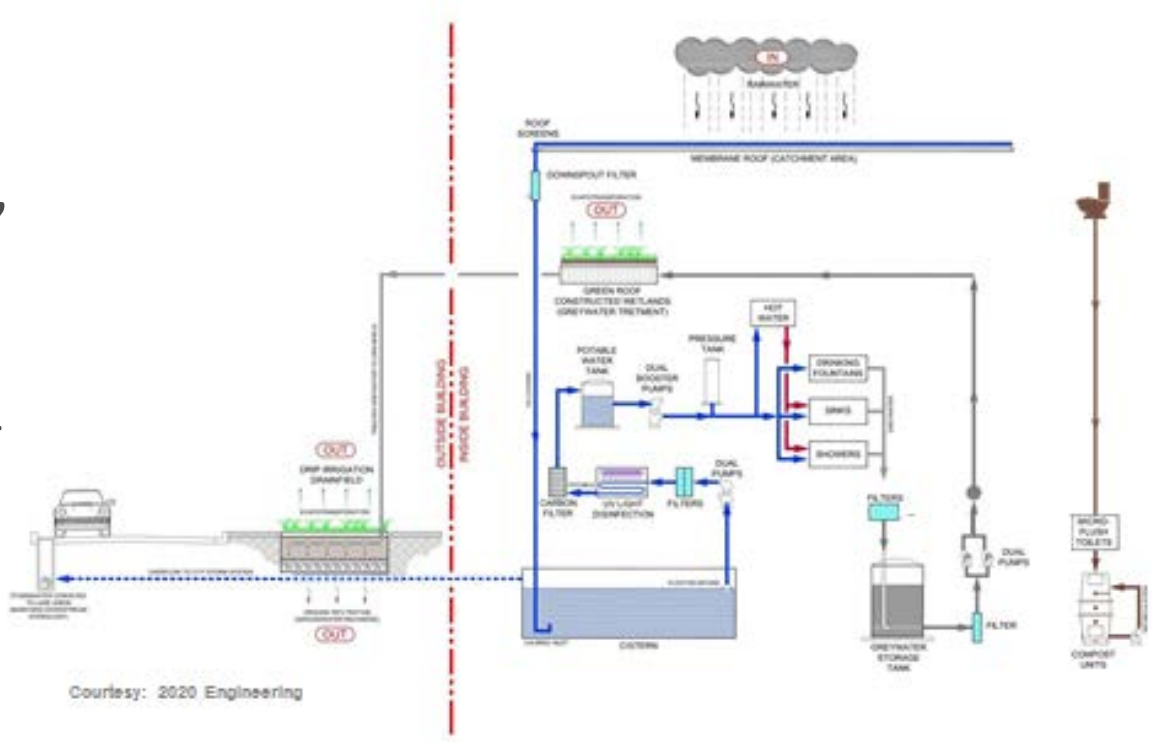
Thursday, October 4, 2012
10:40am - 11:10am



Alfredo Fernandez-Gonzalez
Natural Energies Advanced Technologies (NEAT) Laboratory at UNLV
alfredo.fernandez@unlv.edu

David Morillón Gálvez
Instituto de Ingeniería, UNAM