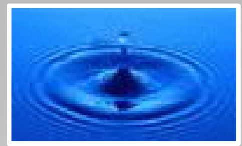


STORMWATER AND WATER EFFICIENCY
A GLOBAL PERSPECTIVE

10/12/2017

BLOSSOM CONSULTING AND ENGINEERING INC.

BACKGROUND

- Northern Arizona University (NAU)
- University of Newcastle, Australia
- Williamsburg Environmental Group Inc.
- Stantec Consulting Services Inc.
- Society of American Military Engineers
- Virginia Floodplain Management Association

“THE HEATLH OF OUR WATERS IS THE PRINCIPLE MEASURE OF HOW WE LIVE ON THE LAND”
-LUNA LEOPOLD

BCE

LEADERSHIP IN ENERGY AND ENVIRONMENTAL DESIGN (LEED)

- SSc6.1: STORMWATER QUANTITY
  - OPTION 1: DESIGN STORMS
    - CASE 1: Sites with 50% Impervious or Less
      - Path 1: Manage Rate and Quantity for 1 & 2 year, to PRE-Development OR
      - Path 2: Plan to Protect Receiving Channels, Stream Restoration/Stabilization
    - CASE 2: Sites with 50% Impervious of More
      - Path 1: 25% Decrease in the 2 Year Runoff Volume
  - OPTION 2: PERCENTILE RAINFALL EVENTS
    - CASE 1: Non-Zero Lot Line Project
      - Manage On-Site Runoff for the 95th Percentile Rainfall Event Using LID or GI (Replicate Natural Site Hydrology)
    - CASE 2: Zero Lot Line Project
      - Manage On-Site Runoff for the 95th Percentile Rainfall Event Using LID or GI (Replicate Natural Site Hydrology)

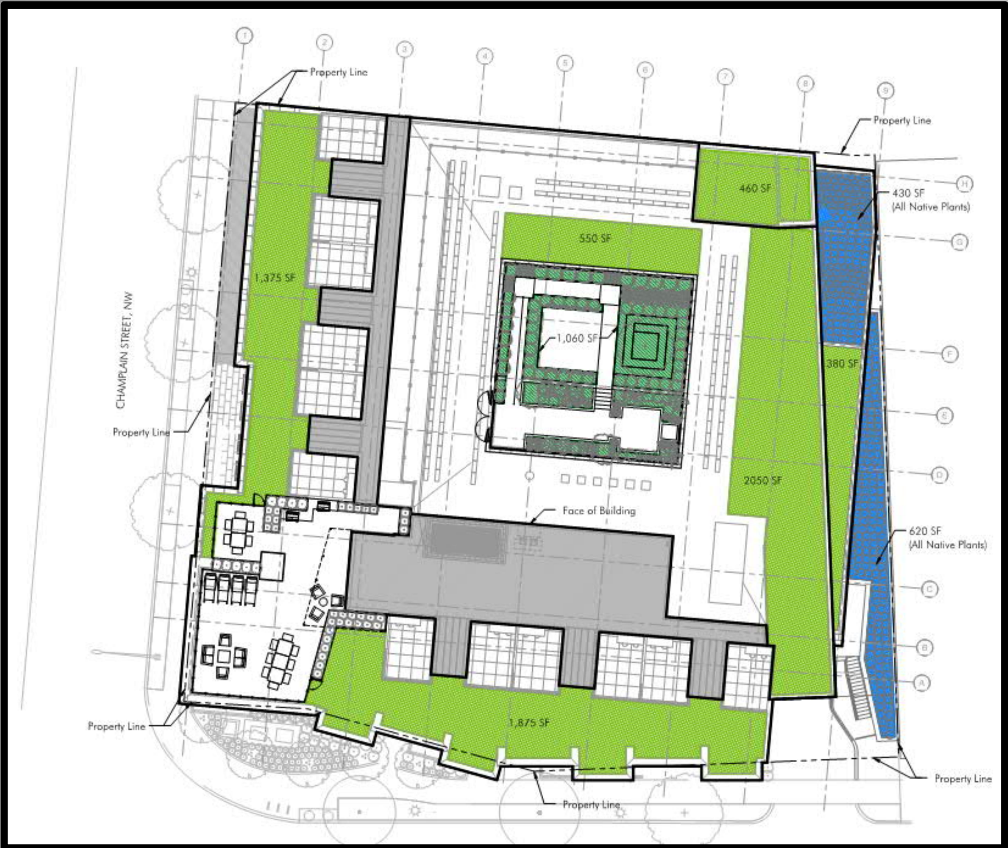
LEADERSHIP IN ENERGY AND ENVIRONMENTAL DESIGN (LEED)

- SSc6.2: STORMWATER QUALITY
- Implement a stormwater management plan that reduces impervious cover, promotes infiltration and captures and treats the stormwater runoff from 90% of the average annual rainfall[1] using acceptable best management practices (BMPs).
- BMPs used to treat runoff must be capable of removing 80% of the average annual postdevelopment total suspended solids (TSS) load based on existing monitoring reports. BMPs are considered to meet these criteria if:
  - They are designed in accordance with standards and specifications from a state or local program that has adopted these performance standards.
  - OR
  - There exists infield performance monitoring data demonstrating compliance with the criteria. Data must conform to accepted protocol (e.g., Technology Acceptance Reciprocity Partnership [TARP], Washington State Department of Ecology) for BMP monitoring.

LEADERSHIP IN ENERGY AND ENVIRONMENTAL DESIGN (LEED)

- (WEc1) WATER EFFICIENT LANDSCAPING
- To limit or eliminate the use of potable water or other natural surface or subsurface water resources available on or near the project site for landscape irrigation.
  - OPTION 1: Reduce by 50% (2 points)
    - Reduce potable water consumption for irrigation by 50% from a calculated midsummer baseline case or using the month with the highest irrigation demand.
  - Option 2: No potable water use or irrigation[1] (4 points)
    - PATH 1
    - Use only captured rainwater, recycled wastewater, recycled graywater or water treated and conveyed by a public agency specifically for nonpotable uses for irrigation.
    - PATH 2
    - Install landscaping that does not require permanent irrigation systems. Temporary irrigation systems used for plant establishment are allowed only if removed within a period not to exceed 18 months of installation

WASHINGTON, D.C.



LEGEND

Area	Plant Qty.	Symbol	Description
6,690 SF	N/A		8" Depth Intensive Green Roof - LiveRoof modular trays
1,060 SF	98		24"-36" Depth Intensive Green Roof - Planters with Lightweight soils
1,050 SF	333		36" Depth Bio Retention Area

- ½ ACRE SITE
- MULTI-FAMILY APARTMENTS
- URBAN CORE
- ACCESSIBLE GREEN COURTYARDS
- STREESIDE BIOFILTRATION (L2)

- * APPROX. 40 INCHES ANNUAL

WASHINGTON, D.C.

OPTION 1. DESIGN STORMS

Select one of the following:

- ○ **Case 1.** Sites with existing imperviousness 50% or less.
- ◉ **Case 2.** Sites with existing imperviousness more than 50%.

CASE 2. EXISTING IMPERVIOUSNESS MORE THAN 50%

Table SSc6.1-3. Site Runoff: Two-Year, 24-Hour Design Storm

	Quantity (cf/storm)
Predevelopment	5,162
Postdevelopment	1,598
Percent reduction *(Must be at least 25%)*	69.04

- SUSTAINABLE SITES
  - SSc6.1 (QUANTITY)
  - CASE 2
  - OPTION 1: DESIGN STORMS

- RE-DEVELOPMENT WITH
  "HYDROLOGIC IMPROVEMENT"

- HIGH PERFORMANCE TECHNOLOGY IN CONFINED/CONSTRAINED SETTING

WASHINGTON, D.C.

Table WEc1-2. Irrigation Design Case (month with the highest irrigation demand)

Note: Click "Calculate" in the summary section of the table to perform the water savings calculations. "Calculate" must be clicked after any or all the data is entered in the table to refresh the calculated values and obtain accurate information.

Landscape Type	Area (sf)	ks	kd	kmc[1]	K_L	Et_o	ET_L	Irrigation Type	IE	CE[2]	TWA (gal)
Streetscape	510	0.5	1	1	0.5	6.53	3.27	Drip	0.9	0.9	1,039.48
Courtyard	1,060	0.5	1	1	0.5	6.53	3.27	Drip	0.9	0.9	2,160.48
Green Roof	6,690	0.2	1	1	0.2	6.53	1.31	No Required	1	0	0
Total area (sf)	8,260	Design total water applied (TWA) (gal)									3,199.96
Nonpotable water used (gal)											0
Design total potable water applied (TPWA) (gal)											3,199.96

+ - + - + - Calculate

Notes:
1 For each landscape type, the microclimate factor (kmc) must be the same for the baseline and design case.
2 Controller efficiency (CE) may range from 0.7 to 1. If the irrigation system has no weather-based controllers or moisture sensor systems, use a CE value of 1.

Upload WEc1-2. Provide manufacturer documentation or calculations to support the Controller Efficiency (CE) value entered in the table. Upload *Files: 1*

Percentage reduction of potable water: 84.21 %

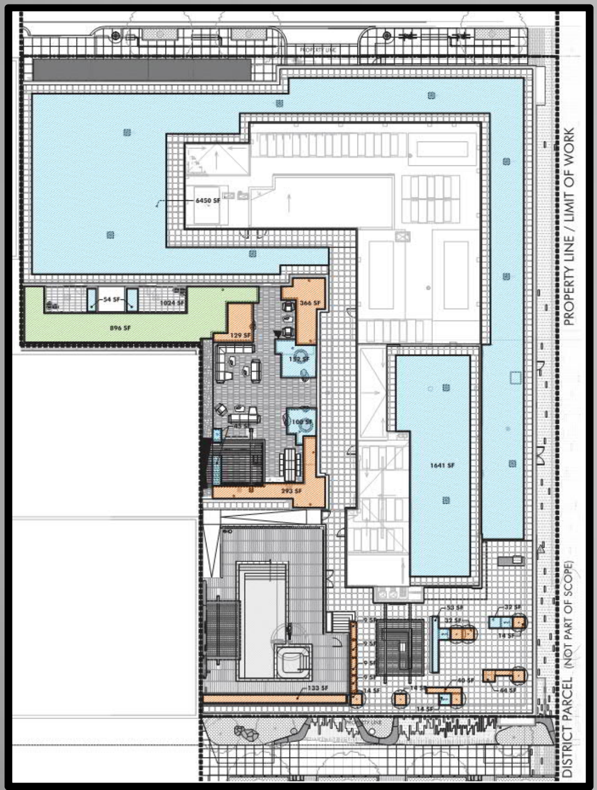
Percentage reduction of total water: 84.21 %

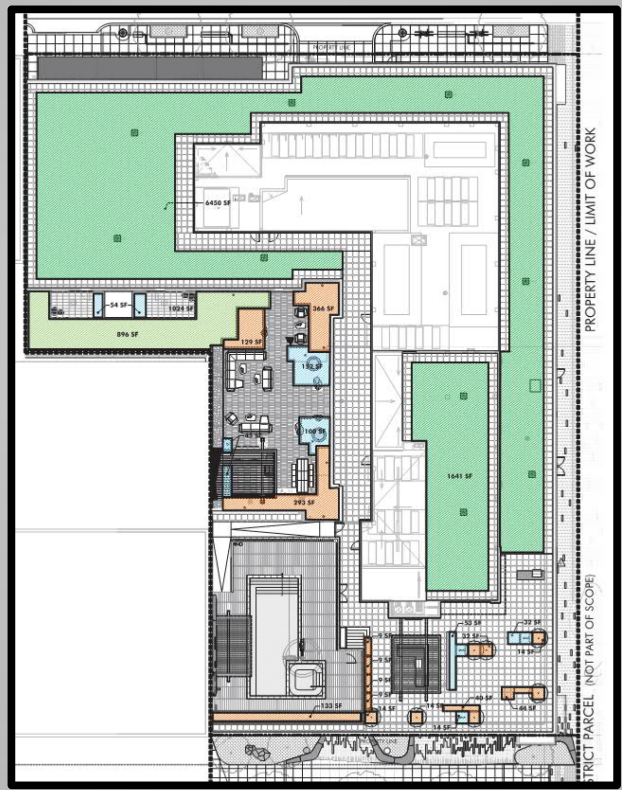
A 50% reduction in potable water use is required for 2 points. A 100% reduction in potable water and a 50% reduction in total water is required for 4 points.

- WATER EFFICIENCY (WEc1)

- IRRIGATION BASELINE CASE (MONTH W/ HIGHEST IRRIGATION DEMAND)
  - 20, 271 GALLONS TOTAL WATER APPLIED
  - BASELINE IS ‘SPRINKLERED’ SYSTEM WITH ‘STANARD’ SPECIES

ARLINGTON, VIRGINIA





- LANDCOVER COMPARISON
- SELECTION OF DROUGHT TOLERANT GREEN ROOF SPECIES
- ‘HIDDEN’ STRUCTURAL ELEMENTS

ARLINGTON, VIRGINIA

Case 2. Existing Imperviousness Greater than 50%

Predevelopment site runoff quantity for two-year, 24-hour design storm (cf/storm)	8,038.37
Postdevelopment site runoff quantity for two-year, 24-hour design storm (cf/storm)	1,706
Percent reduction (%)	78.78

BMP Type/Label	BMP Description and/or Location	In series with BMP above?	Percent Site Treated by BMP (%)	TSS Removal Efficiency (%)	Source of TSS Removal Efficiency Data	Weighted Average TSS Removal Efficiency (%)		
Greenroof	Roof	N/A	31.97	80	Default	25.58	+	-
Cistern	P-1 Level	Yes	100	80	Default	59.54	+	-
Total weighted average TSS removal efficiency (%)						85.12		

- ADDITION OF CISTERN FOR RAINWATER HARVESTING AND TSS REMOVAL
- TREATMENT IN SERIES
- SIMILAR TO VIRGINIA RUNOFF REDUCTION METHODOLOGY (VRRM)

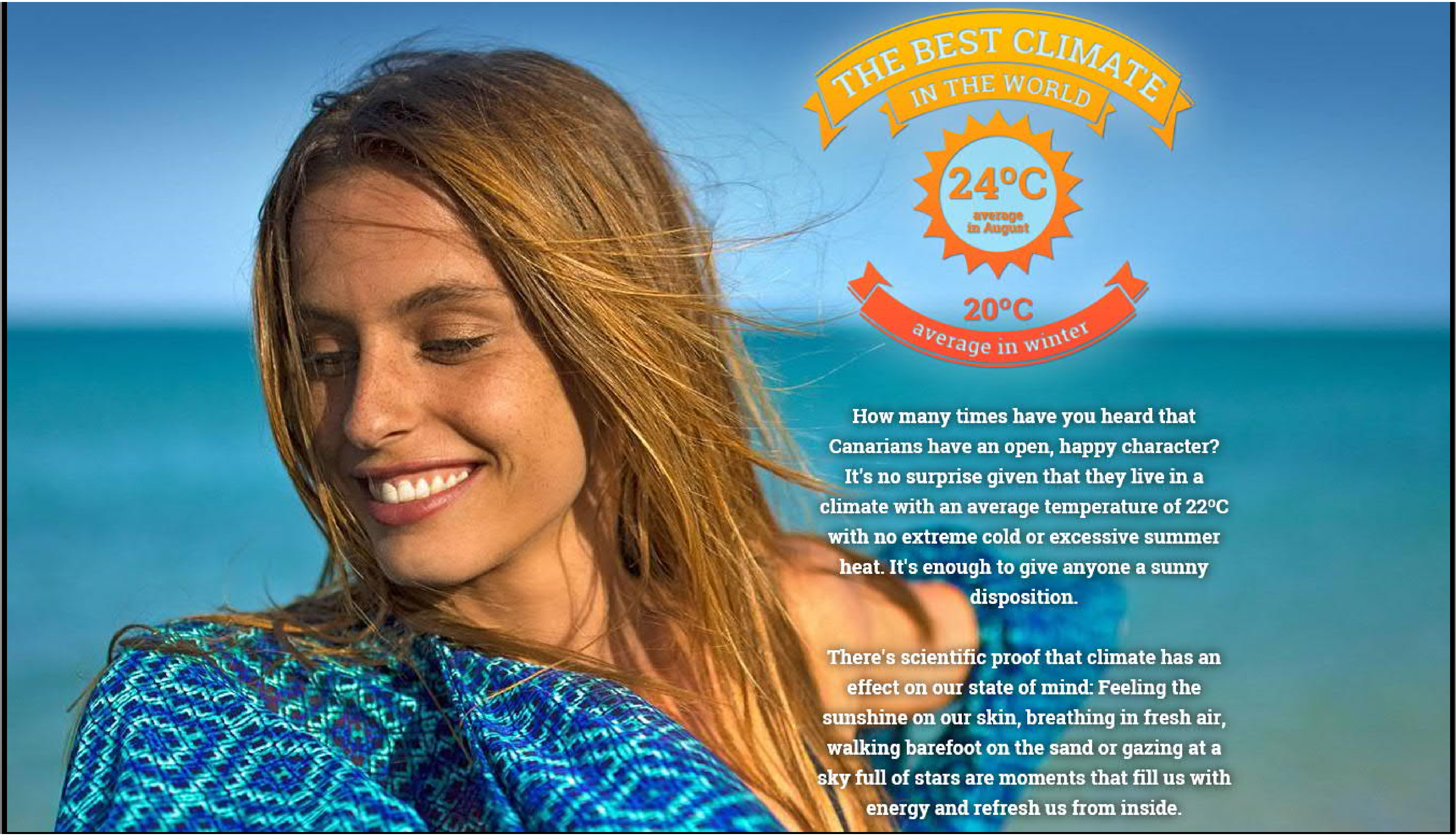
BCE

ST. CROIX, USVI

Christiansted, St. Croix attains on average 1099 mm (43.3 in) of rainfall per year, or 91.6 mm (3.6 in) per month.

LAS PALMAS, CANARY ISLANDS

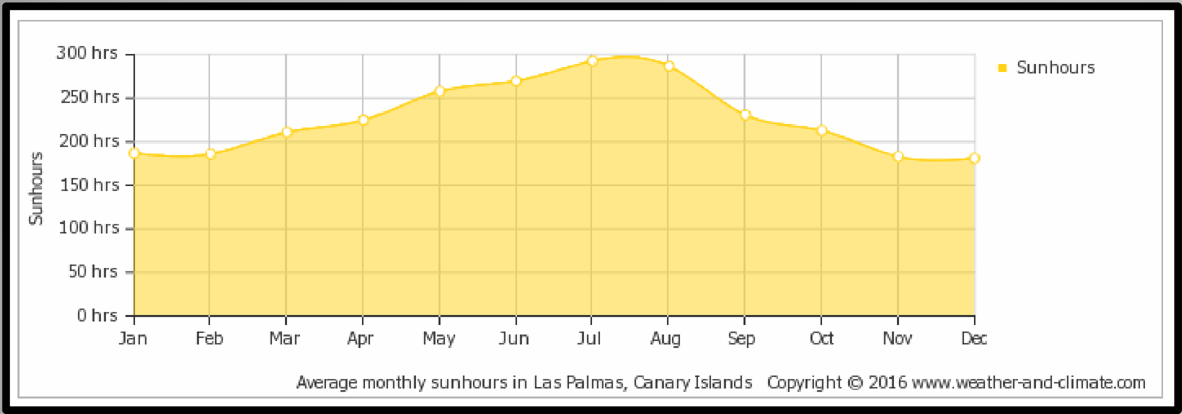
BLOSSOM CONSULTING AND ENGINEERING INC.

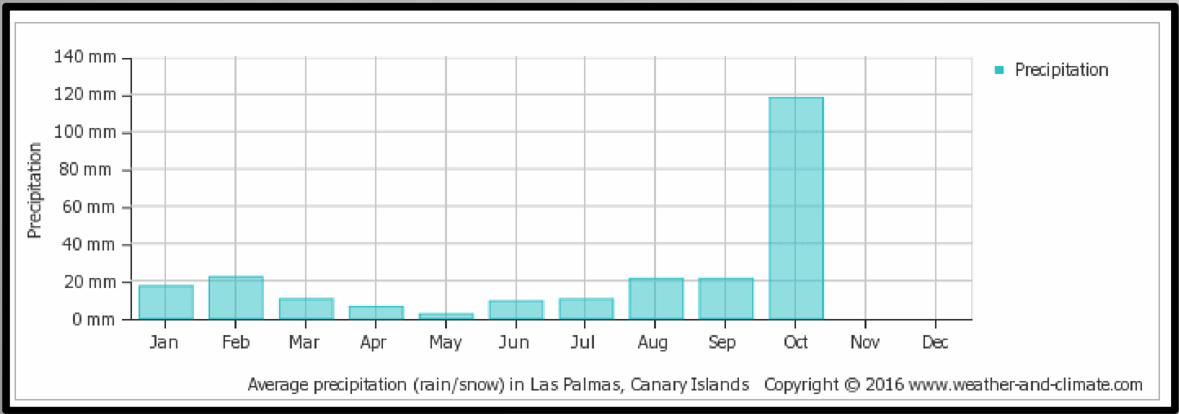


How many times have you heard that Canarians have an open, happy character? It's no surprise given that they live in a climate with an average temperature of 22ºC with no extreme cold or excessive summer heat. It's enough to give anyone a sunny disposition.

There's scientific proof that climate has an effect on our state of mind: Feeling the sunshine on our skin, breathing in fresh air, walking barefoot on the sand or gazing at a sky full of stars are moments that fill us with energy and refresh us from inside.

LAS PALMAS, CANARY ISLANDS





- BEAUTIFUL WEATHER, PLENTY OF SUNSHINE....VERY LITTLE RAIN (12 INCHES/YR AVG.)
- CREATES CHALLENGING WATER RESOURCES MANAGEMENT ISSUES
- IRREGULAR/INTENSE RAINFALL EVENTS

LAS PALMAS, CANARY ISLANDS

T.1: ROYSTONEA REGIA (example)

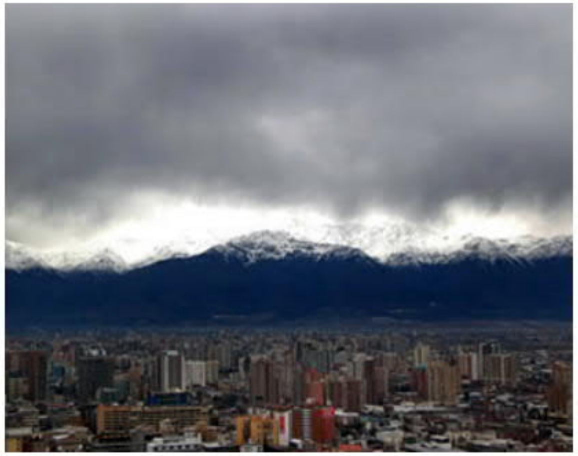
T.2: JACARANDRA MIMOSIFOLIA (example)

SANTIAGO, CHILE

BLOSSOM CONSULTING AND ENGINEERING INC.

SANTIAGO, CHILE

Santiago has a somewhat cool Mediterranean climate: relatively hot dry summers (November to March) with temperatures reaching up to 35 °C (95.0 °F) on the hottest days; winters (June to August) are more humid with cold mornings; typical maximum daily temperatures of 13 °C (55.4 °F), and minimums of a few degrees above freezing.
Mean rainfall is 360 mm (14.2 in) per year and is heavily concentrated in the cooler months. Snowfall is rare in eastern districts, and extremely rare in most of the city.
Among the main climatic features of Santiago is the concentration of about 80% of the precipitation during the austral winter months (May to September), varying between 50 and 80 mm of rainfall during these months.

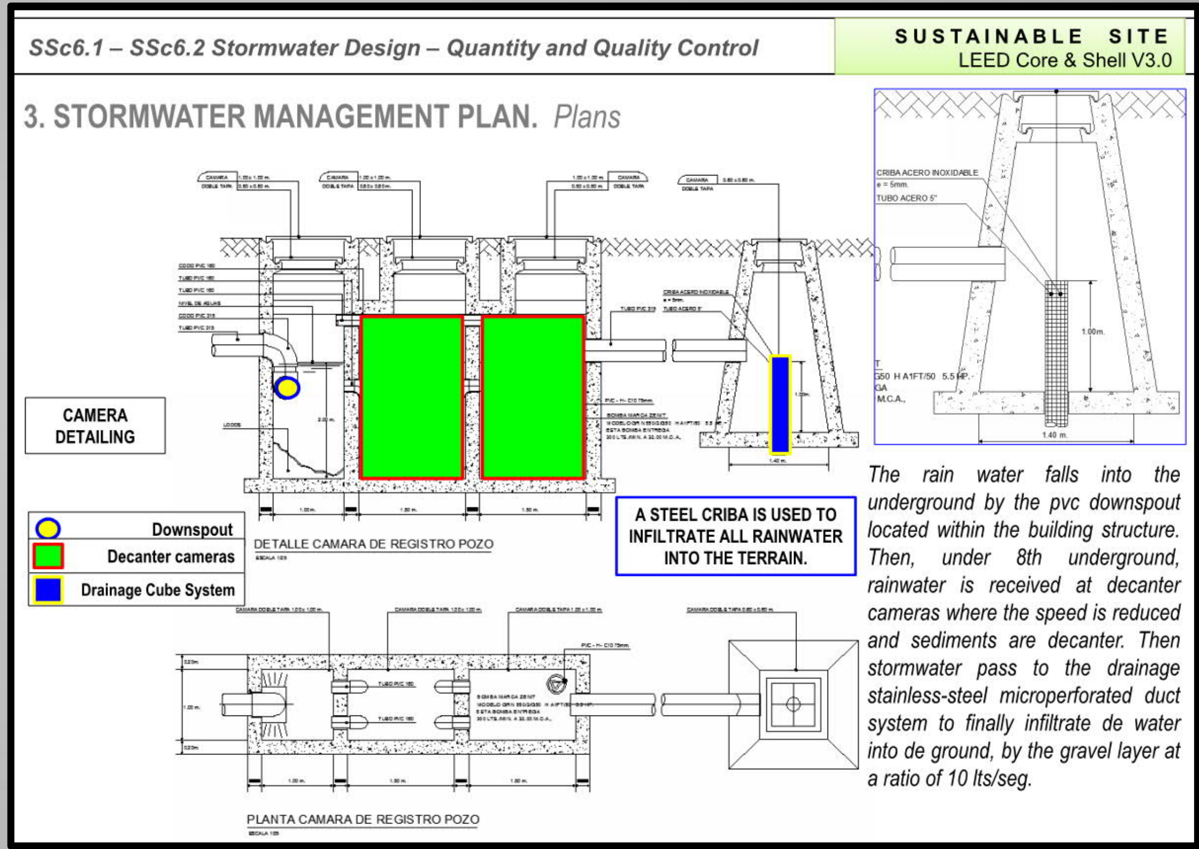


Climate data for Santiago (1971–2000 period) [hide]

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record high °C (°F)	36 (97)	37 (99)	34 (93)	31 (88)	31 (88)	27 (81)	27 (81)	29 (84)	31 (88)	33 (91)	36 (97)	37 (99)	37 (99)
Average high °C (°F)	29.7 (85.5)	29.1 (84.4)	26.9 (80.4)	23.3 (73.9)	18.7 (65.7)	15.2 (59.4)	14.9 (58.8)	16.7 (62.1)	19.0 (66.2)	22.3 (72.1)	25.4 (77.7)	28.4 (83.1)	22.47 (72.44)
Average low °C (°F)	13.0 (55.4)	12.4 (54.3)	10.7 (51.3)	8.0 (46.4)	6.3 (43.3)	4.3 (39.7)	3.9 (39.0)	4.8 (40.6)	6.1 (43.0)	8.2 (46.8)	10.1 (50.2)	12.0 (53.6)	8.32 (46.97)
Record low °C (°F)	6 (43)	6 (43)	3 (37)	1 (34)	−3 (27)	−5 (23)	−7 (19)	−6 (21)	−2 (28)	−1 (30)	2 (36)	2 (36)	−7 (19)
Precipitation mm (inches)	0.4 (0.016)	0.8 (0.031)	3.2 (0.126)	10.4 (0.409)	42.2 (1.661)	70.4 (2.772)	86.6 (3.409)	51.8 (2.039)	22.0 (0.866)	13.4 (0.528)	9.2 (0.362)	2.1 (0.083)	312.5 (12.303)
% humidity	54	59	63	68	75	79	76	75	72	67	58	53	66.6
Avg. rainy days	1	1	2	2	6	7	8	6	4	2	2	1	42
Mean monthly sunshine hours	322.4	279.7	263.5	186.0	117.8	90.0	108.5	139.5	159.0	207.7	267.0	322.4	2,463.5

Source #1: World Meteorological Organization[15]
Source #2: BBC Weather[16] *for record highs, lows and humidity*

SANTIAGO, CHILE



KARACHI, PAKISTAN

- 7 INCHES AVG. ANNUAL RAINFALL

KARACHI, PAKISTAN

Pakistan has a variable climate, ranging from arid (33-254mm annual rainfall) in the south to humid (1016-2032mm annual rainfall), sub-humid (508-1016mm annual rainfall) and semi-arid (254-508mm annual rainfall) in the north. The Indus River that originates from the north along with its tributaries irrigates the great plains of the country including Central Punjab. Chaudhry and Rasul found that about 2/3 of the total agriculture area lies in the arid climate. [1]

- MINIMAL RAINFALL (ARID SOUTH)
- HIGHER ET
- ‘TOUCHED’ BY MONSOONS

- CORPORATE TOWER

KIRACHI, PAKISTAN

Table WEc1-2. Irrigation Design Case (month with the highest irrigation demand)

Note: Click "Calculate" in the summary section of the table to perform the water savings calculations. "Calculate" must be clicked after any or all the data is entered in the table to refresh the calculated values and obtain accurate information.

Landscape Type	Area (sf)	ks	kd	kmc[1]	K_L	Et_o	ET_L	Irrigation Type	IE	CE[2]	TWA (gal)
Shrubs-high kmc	485.67	0.2	0.5	1.3	0.13	5.5	0.72	Manual Hanc	0.5	1	436
Shrubs-low kmc	52.21	0.2	0.5	0.5	0.05	5.5	0.28	Manual Hanc	0.5	1	18
Ground Cover-av	2,144.46	0.2	0.5	1	0.1	5.5	0.55	Manual Hanc	0.5	1	1,470
Ground Cover-hig	402.43	0.2	0.5	1.2	0.12	5.5	0.66	Manual Hanc	0.5	1	331
Mixed	139.56	0.2	1.3	0.5	0.13	5.5	0.72	Manual Hanc	0.5	1	125
Total area (sf)	3,224.33									Design total water applied (TWA) (gal)	2,380
										Nonpotable water used (gal)	0
										Design total potable water applied (TPWA) (gal)	2,380

Notes:
1 For each landscape type, the microclimate factor (kmc) must be the same for the baseline and design case.
2 Controller efficiency (CE) may range from 0.7 to 1. If the irrigation system has no weather-based controllers or moisture sensor systems, use a CE value of 1.

Percentage reduction of potable water: 74.14 %

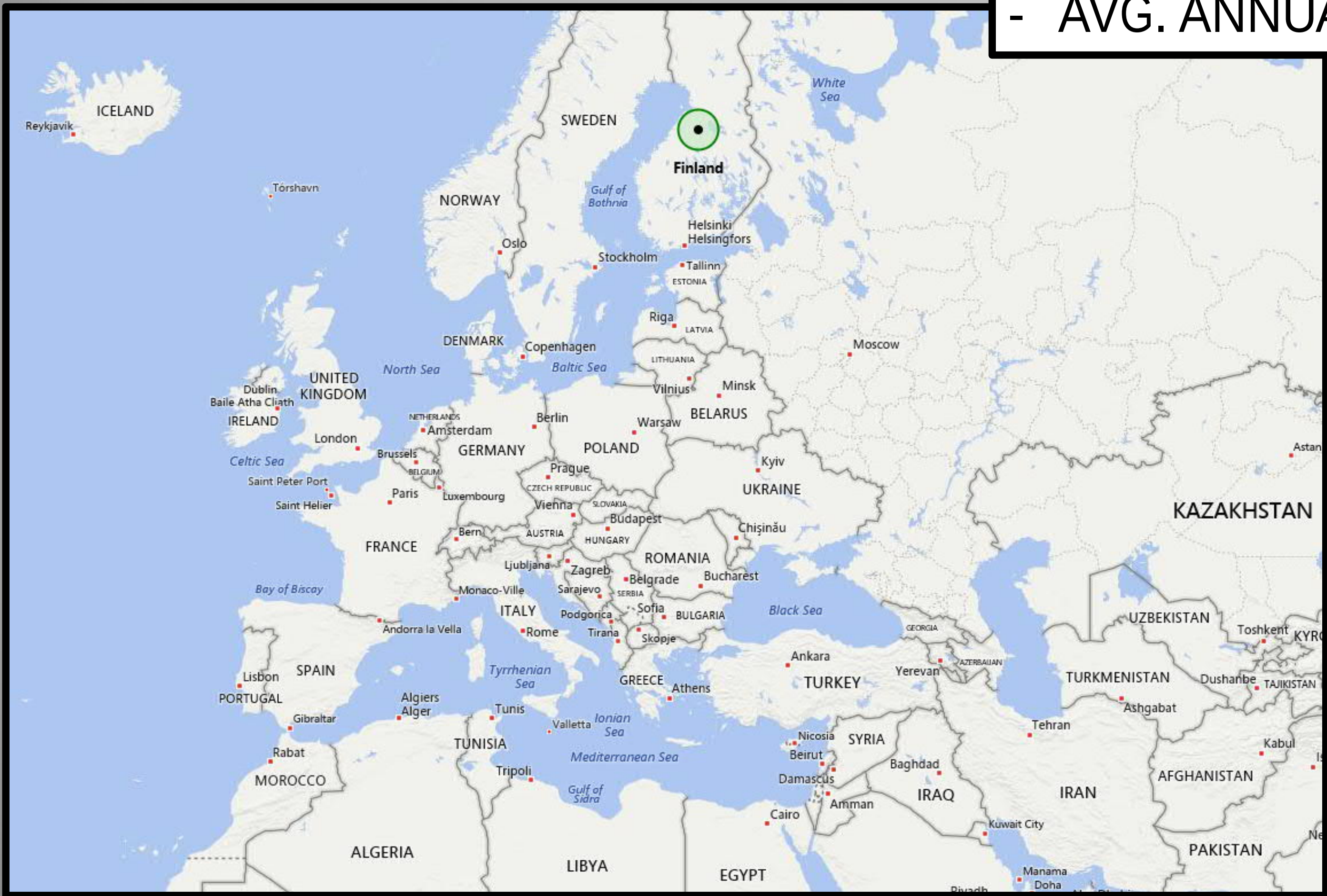
Percentage reduction of total water: 74.14 %

A 50% reduction in potable water use is required for 2 points. A 100% reduction in potable water and a 50% reduction in total water is required for 4 points.

BCE

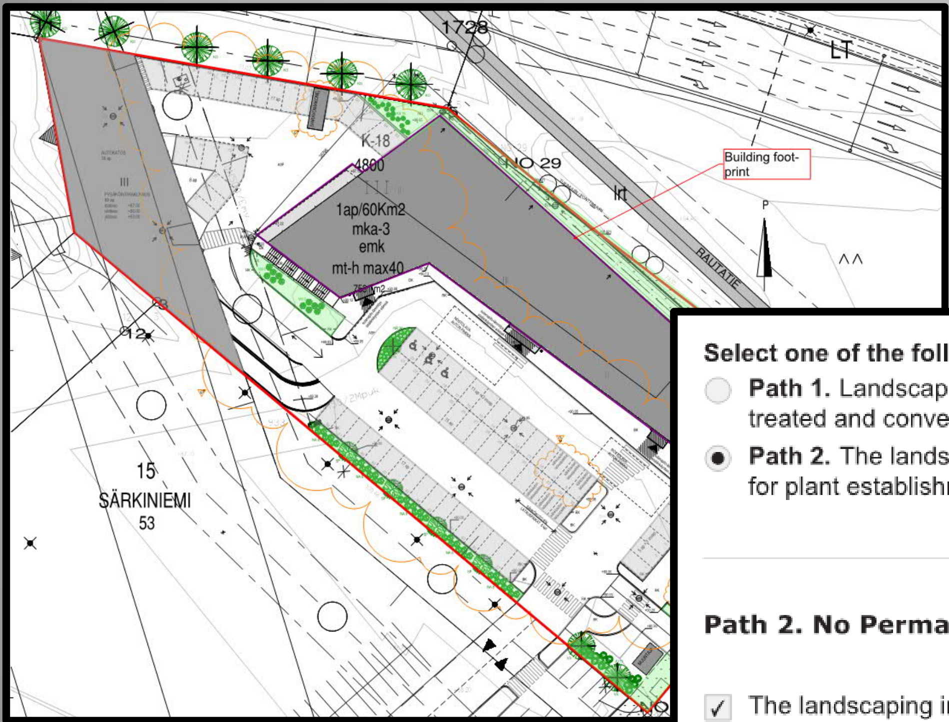
FINLAND

- AVG. ANNUAL PRECIPITATION = 17-30 IN



Of the land area, 0.6% has a temperate/ mesothermal climate with significant precipitation in all seasons (Cf), 92.7% has a continental/ microthermal climate with significant precipitation in all seasons (Df), 6.7% has a polar climate (E).

FINLAND



- WATER EFFICIENCY CREDIT 1
- COMPLIANCE PATHWAY 2
- SIMPLY “NO IRRIGATION”
- COOLER CLIMATE, LOWER ET

Select one of the following:

○ **Path 1.** Landscaping irrigation uses only captured rainwater, recycled wastewater, recycled graywater or water treated and conveyed by a public agency specifically for nonpotable uses.

● **Path 2.** The landscaping installed does not require permanent irrigation systems. Temporary irrigation systems used for plant establishment will be removed within eighteen months of installation.

Path 2. No Permanent Irrigation

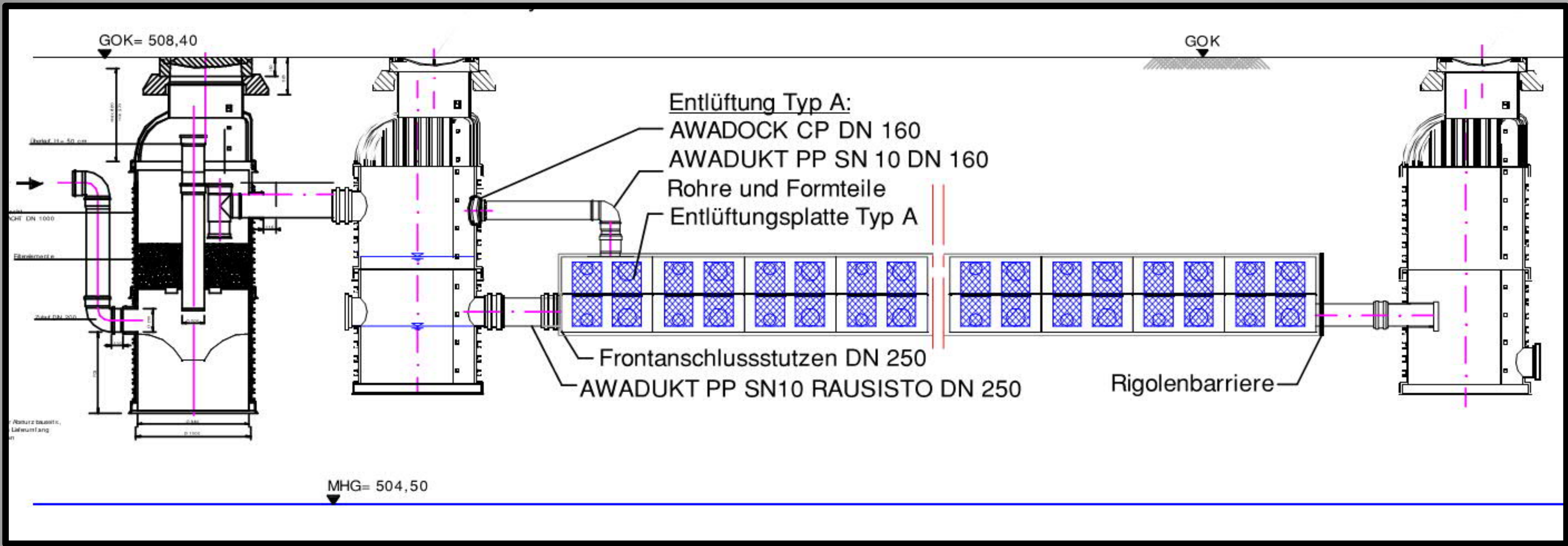
☑ The landscaping installed for the building in which the project is located and associated grounds does not require permanent irrigation systems. Temporary irrigation systems used for plant establishment will be removed within eighteen months of installation.

MUNICH, GERMANY

- Total annual Precipitation averages 805 mm (31.7 inches)
- which is equivalent to 805 Liters/m²
- (19.74 Gallons/ft²).

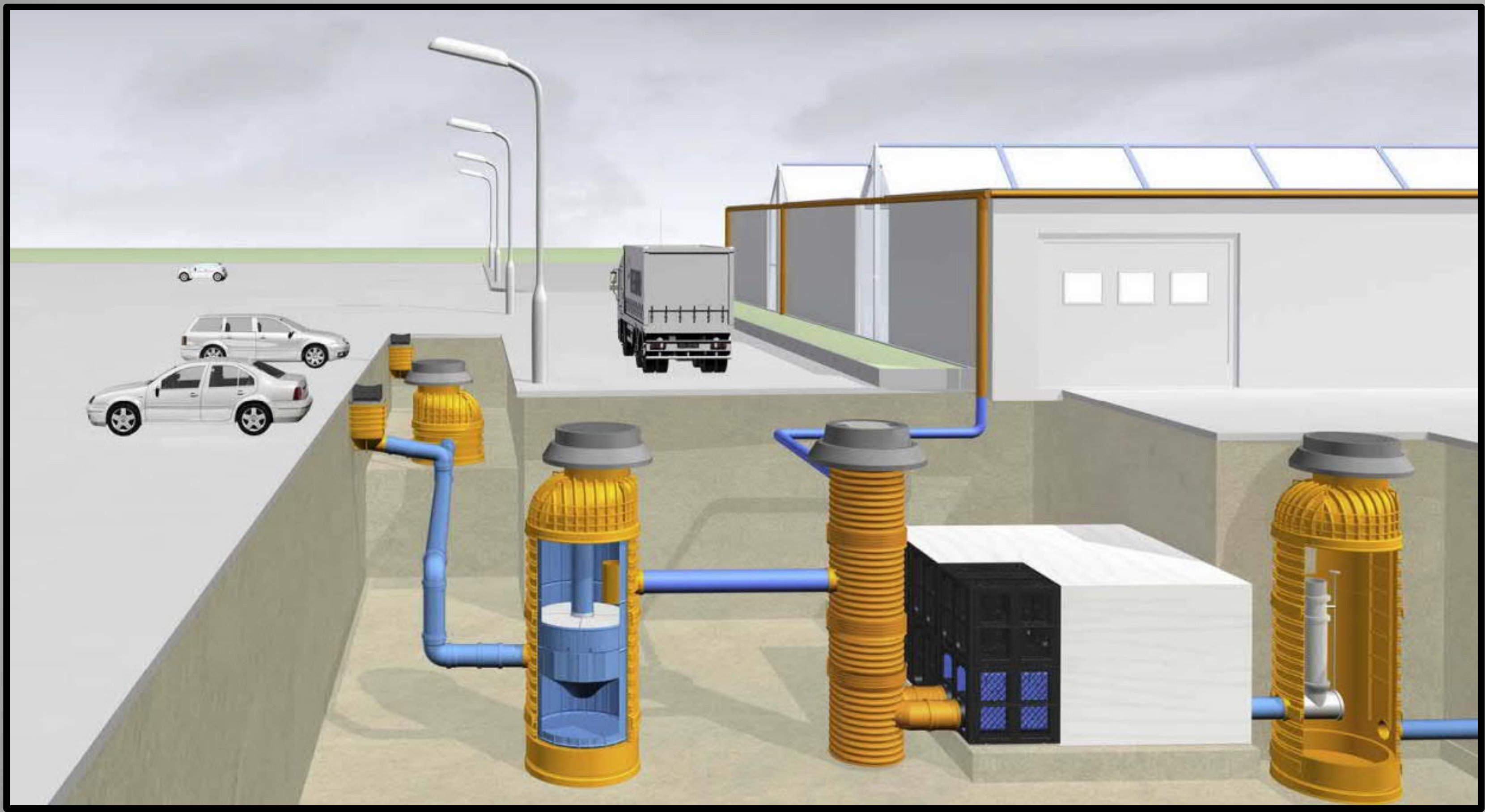
BCE

MUNICH, GERMANY



- 95% OF STORMS ARE EQUAL TO OR LESS THAN 0.89 INCHES OF RAINFALL
- UTILIZED 21 YEARS OF RAINFALL DATA
- SSc6.1 AND SSc6.2 (QUANTITY AND QUALITY)

MUNICH, GERMANY



BEDZIN, POLAND

- Poland sees an average annual rainfall of 600 millimeters (23.6 IN) The highest precipitation is in the mountains and uplands and the lowest occurs in the central, lowland areas of Poland. On the average, precipitation in summer is twice that in winter.

BCE

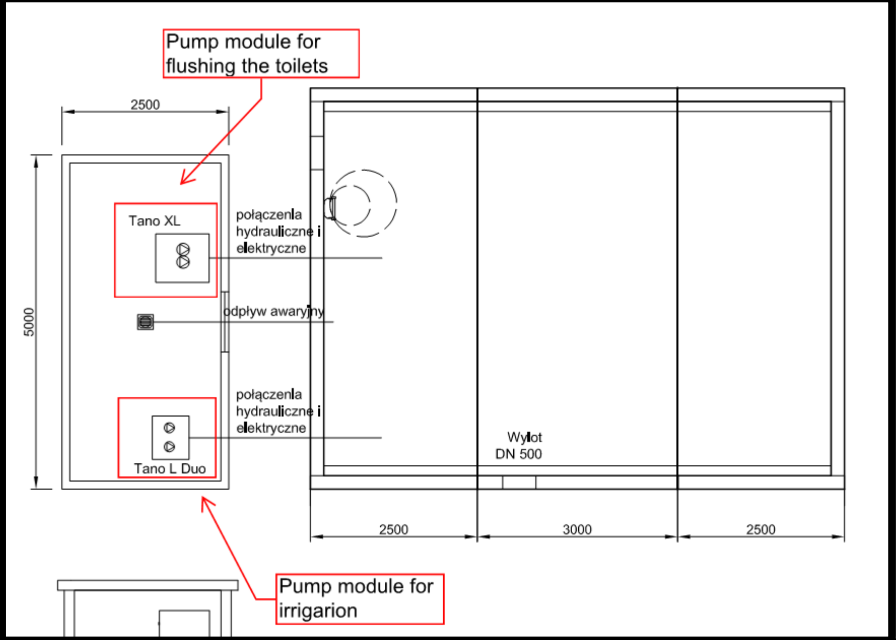
BEDZIN, POLAND

- WATER BUDGETING

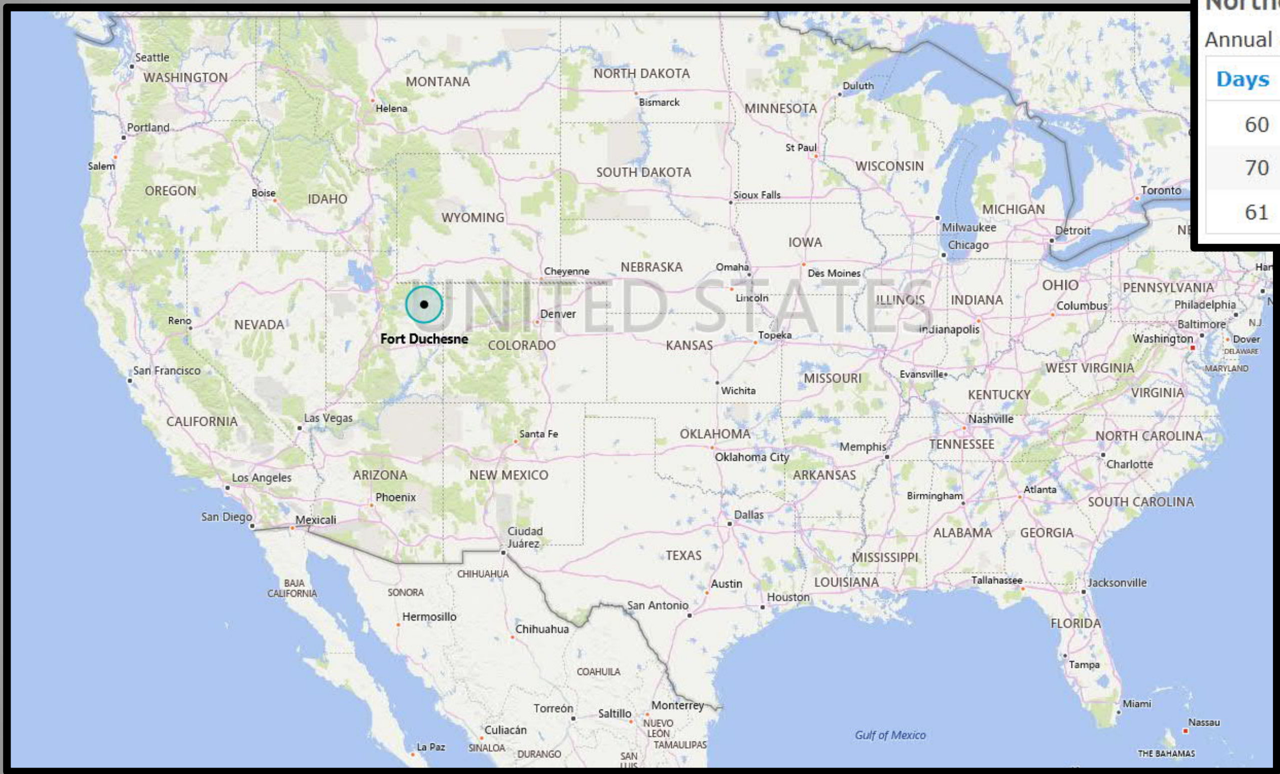
Rainfall event should fill up the tank and provide enough water for irrigation and flushing the toilets and urinals for more than a week (8.7 days). Polish climate is so that there is more than 12 days with rain each month so there should be enough rainfall events to provide water for the whole month. Please see the table above.

Roof area from which the rainwater will be collected	22925 m^2
Runoff coefficient	0.95
Avg. monthly rainfall for July	94.53 mm
Available rainwater for collection for July	2089 m^3
Water demand for irrigation and flushing the toilets in July	418.5 m^3 (($5.5m^3$/day+8 m^3/day)*31days)
Water demand for irrigation only in July	170.5 m^3
Days with rain in July	14

Even for months with the lowest rainfall (January, February, March), the available rainwater is still greater than the allocated capacity in the storage tank, so the tank is expected to be full to capacity most of the time (any excess water being pumped to the retention pond on the site – see attached drawing "Rainwater installation scheme.pdf").
The designers made sure that there will be sufficient rainwater throughout the year to avoid the need for the use of any water other than rainwater for irrigation.



FORT DUCHENSE, UTAH

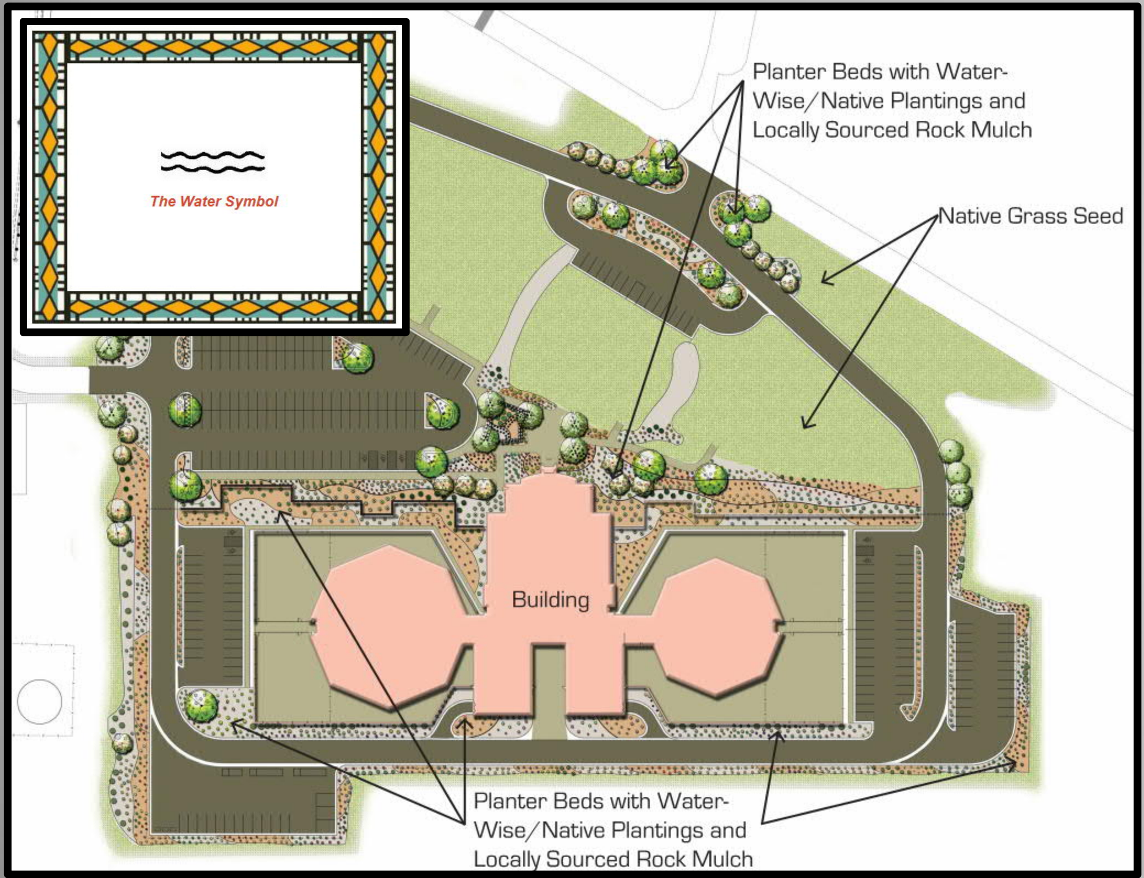


Northeastern Utah

Annual averages for rainfall plus snowfall

Days	Place	Inches	Millimetres
60	Dinosaur National Monument	9.1	230
70	Flaming Gorge Reservoir Dam	12.2	310
61	Roosevelt	7.5	189

UTE TRIBE, UTAH

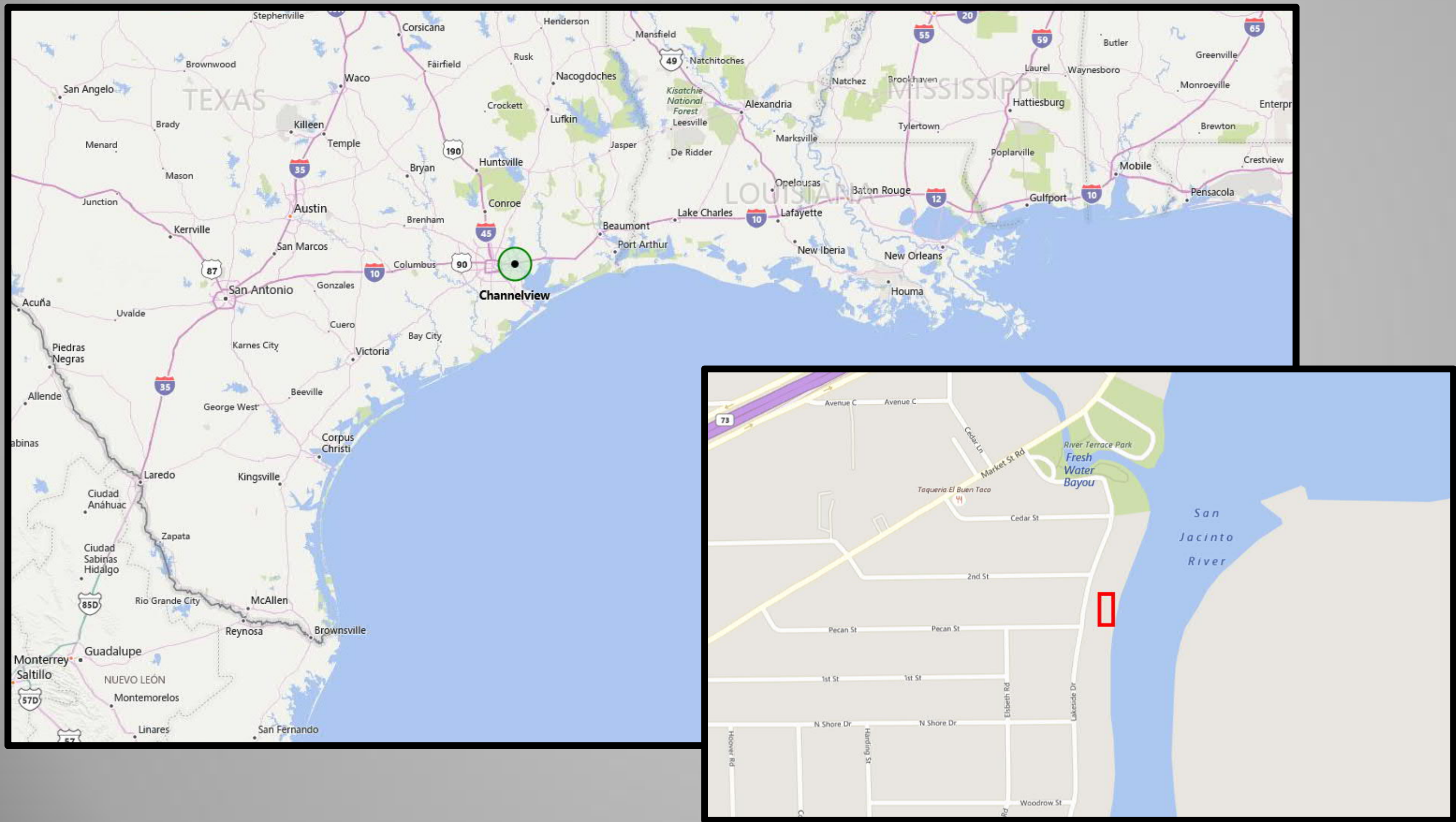


- RESTORATION OF A DEGRADED SITE

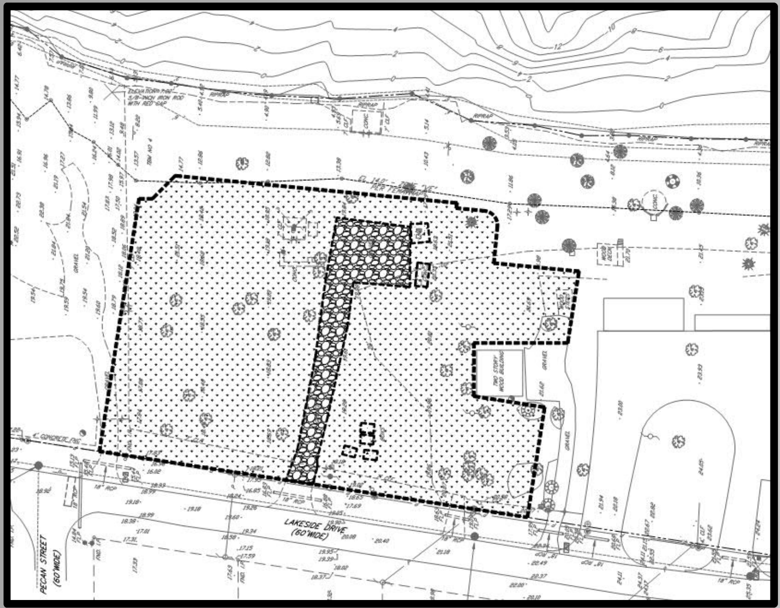
- BASELINE: 1,662,158 GALLONS
- DESIGN: 154,496 GALLONS

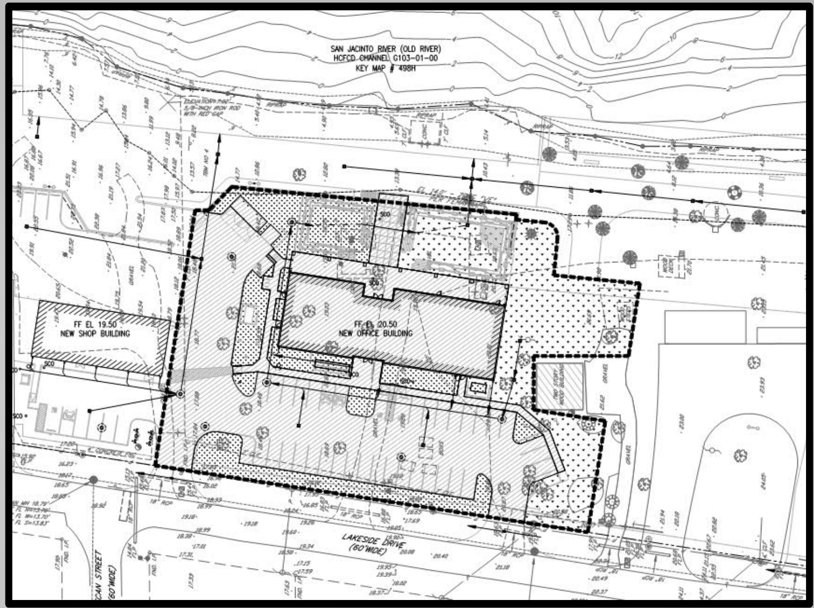
- SHARED METHODOLOGY: POTENTIAL TO HARVEST FOR FIRE SUPPRESSION

CHANNELVIEW, TEXAS



CHANNELVIEW, TEXAS





- LEED SSc6.1 & SSc6.2: PRE AND POST DEVELOPMENT (FREQUENT EVENTS)
- MANY PROJECTS REQUIRE ADDITIONAL 'STRUCTURAL' MEASURES
- FLOODPLAIN AVOIDANCE "PREREQUISITE"

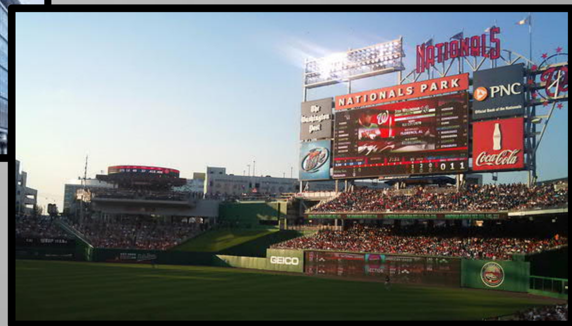
EXTREME EVENTS

- In a four-day period, many areas received more than 40 inches (100 cm) of rain as the system meandered over eastern Texas and adjacent waters, causing catastrophic flooding. With peak accumulations of 64.58 in (164.0 cm), Harvey is the wettest tropical cyclone on record in the United States. The resulting floods inundated hundreds of thousands of homes, displaced more than 30,000 people, and prompted more than 17,000 rescues.

NORFOLK, VIRGINIA

BLOSSOM CONSULTING AND ENGINEERING INC.

CHESAPEAKE BAY



LEADERSHIP IN ENERGY AND ENVIRONMENTAL DESIGN (LEED V4: RAINWATER MANAGEMENT)

- Intent: To reduce runoff volume and improve water quality by replicating the natural hydrology and water balance of the site, based on historical conditions and undeveloped ecosystems in the region.
- Option 1. Percentile of rainfall events
- Path 1. 95th percentile
- In a manner best replicating natural site hydrology processes, manage on site the runoff from the developed site for the 95th percentile of regional or local rainfall events using low-impact development (LID) and green infrastructure.
- Path 2. 98th percentile
- Path 3. Zero lot line projects only – 85th Percentile
- Option 2. Natural land cover conditions
- Manage on site the annual increase in runoff volume from the natural land cover condition to the postdeveloped condition.

LEADERSHIP IN ENERGY AND ENVIRONMENTAL DESIGN (LEED V4: OUTDOOR WATER USE REDUCTION)

- Intent: To reduce outdoor water consumption.
- Option 1. No irrigation required
- Show that the landscape does not require a permanent irrigation system beyond a maximum two-year establishment period.
- OR
- Option 2. Reduced irrigation
- Reduce the project's landscape water requirement (LWR) by at least 50% from the calculated baseline for the site's peak watering month. Reductions must first be achieved through plant species selection and irrigation system efficiency as calculated in the Environmental Protection Agency (EPA) WaterSense Water Budget Tool.
- Additional reductions beyond 30% may be achieved using any combination of efficiency, alternative water sources, and smart scheduling technologies.

THOUGHTS

BLOSSOM CONSULTING AND ENGINEERING INC.

1.) TECHNICAL EXCELLENCE
2.) DISCIPLINE
3.) PERSISTENCE
4.) FORWARD THINKING APPROACH
5.) HIGH PERFORMANCE TEAMS

- THANK YOU!
- SCOTT@BLOSSOMCONSULTING.NET