INNOVATIVE CONSERVATION PROGRAM
Metropolitan Water District of Southern California

DISCLAIMER

This project was conducted with financial assistance from a grant from the Metropolitan Water District of Southern California (Metropolitan) and the Southern California Gas Company through Metropolitan's Innovative Conservation Program (ICP). The ICP provides funding for research to help document water savings and reliability of innovative water savings devices, technologies, and strategies. The findings of this project, summarized in this report, are solely from the project proponent.

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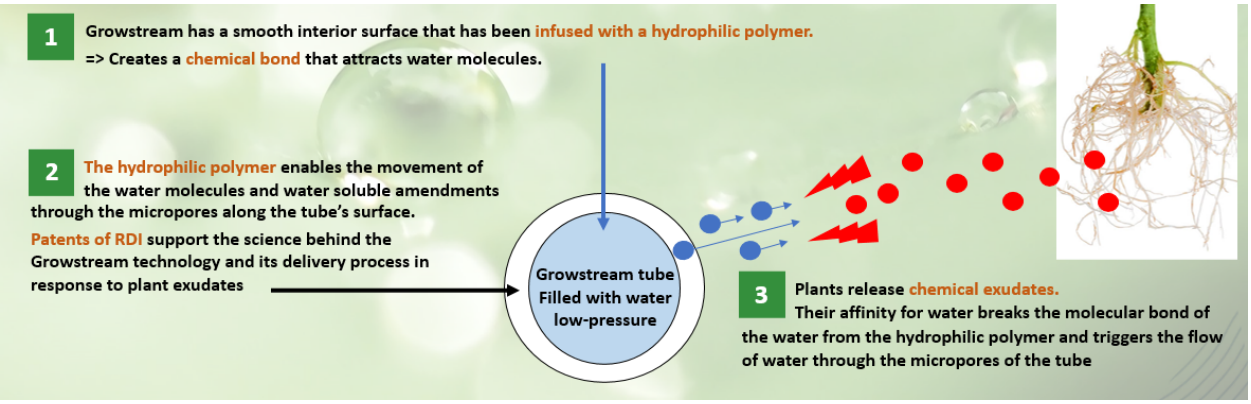
SoCalGas
A Sempra Energy utility

RESPONSIVE DRIP IRRIGATION

Final Report for 2021 Study for Metropolitan Water District

What is RDI's GrowStream™?

GrowStream™ ushers a new generation for water delivery as the world's first truly plant-responsive irrigation system. GrowStream™ interacts with plant roots through the release of exudates to deliver exactly what each plant calls for (water & nutrients), minute-by-minute, plant-by-plant. While standard "forced" irrigation is based upon timed intervals for delivery of set amounts of water, plant-responsive irrigation is based on organic chemistry Interacting directly with the plants' roots to deliver water and amendments on demand. GrowStream™ operates at a constant low pressure, providing a reservoir that plants can access as needed. The diagram below demonstrates in detail how RDI's GrowStream™ interacts with plant exudates.



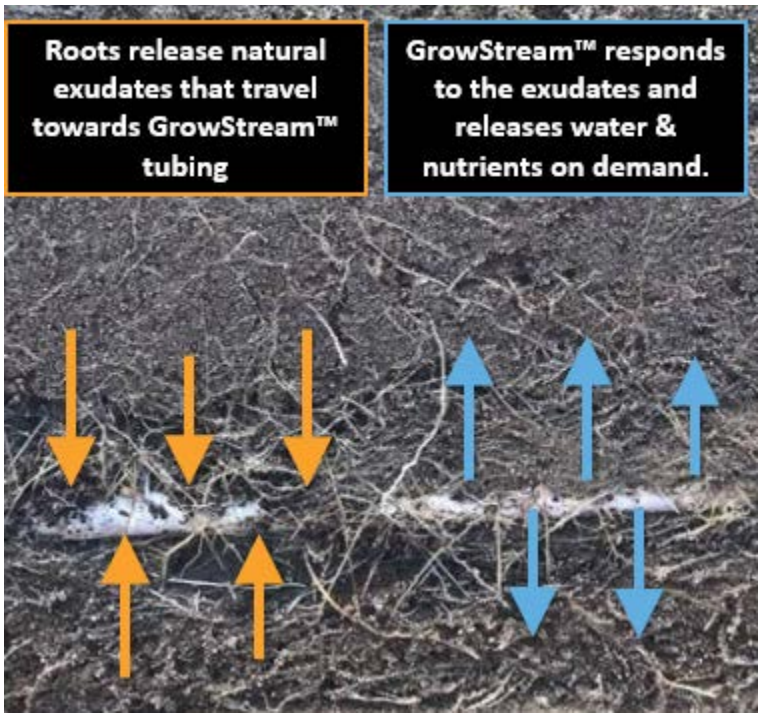
GrowStream™ is used for city landscapes, parks, golf courses, residential areas, along roadways, sports fields, commercial settings as well as the Agriculture industry. It is a new product that was developed by a Canadian chemist that wanted to develop a way to conserve the dwindling water resources observed around the globe. GrowStream™ does not need to be replaced for over 10 years once installed.

RDI RESPONSIVE DRIP IRRIGATION

How GrowStream™ Benefits the Environment

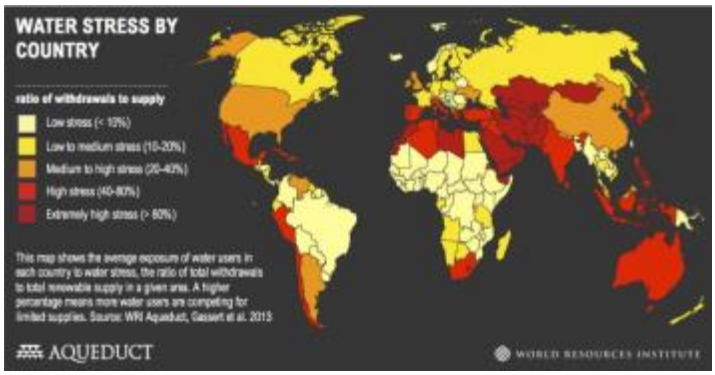
By replacing standard irrigation methods with GrowStream™, water usage is reduced from 30% to 90%, and fertilizer usage reduced up to 75%. There have also been observations of energy reductions by up to 50% to 70%. In addition, grower's in the Agriculture Industry benefit from yield increases up to 388% when growing crops, reduced weed growth, reduced soil erosion and healthier plant growth.

By reducing fertilizer usage, GrowStream™ reduces the amount of excess nitrogen released into the soil. GrowStream™ minimizes fertilizer usage by applying fertilizer directly to the rhizosphere as opposed to topically. This keeps the salt content of the soil from reaching unsafe thresholds, which can kill beneficial bacteria and lower the pH of the soil - which in turn makes it harder for plants to uptake nutrients. Too much fertilizer run-off can also be detrimental to local aquatic environments. Also, as a byproduct of the Nitrogen cycle, excess nitrous oxide is emitted as a direct result of over fertilizing. This is one of the most potent of the greenhouse gases.



RESPONSIVE DRIP IRRIGATION

Reducing water usage helps aid in many of the world's most pressing issues. It is projected that by the year 2025 that two-thirds of the world's population could be living under water stressed conditions. There are 37 countries, currently, that face extremely high levels of water stress. A contributing factor is that 21 of the world's 37 largest aquifers have surpassed their sustainability tipping points. This includes aquifers within the United States. It is estimated that irrigation is responsible for up to 70% of the world's freshwater usage. Being able to reduce the percentage of water used for irrigation is absolutely vital to the future health of the planet.



Sources: *worldbank.org, worldvision.org, wri.org, worldwaterday.org, washingtonpost.com, zerohedge.com, fao.org, agu.org, nasa.gov*

Purpose of This Study

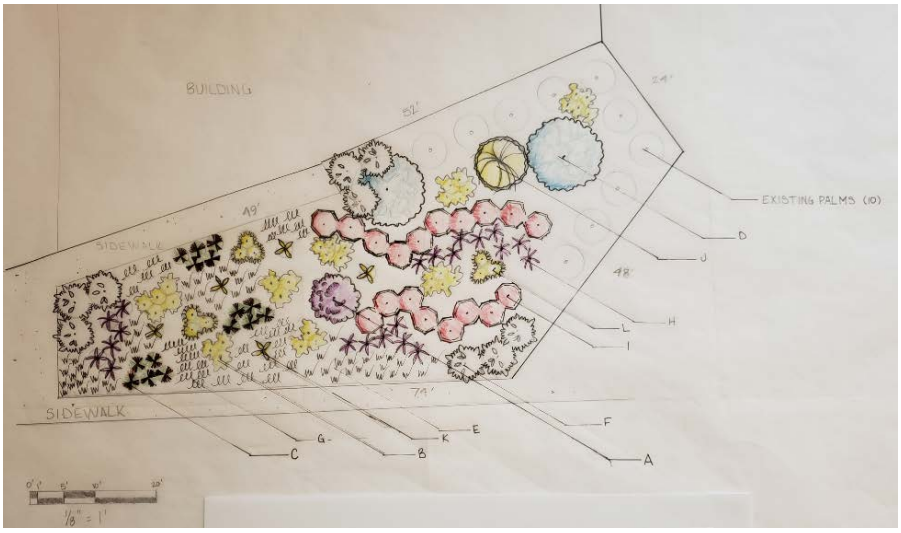
In 2021 a comparative study was conducted at the OC Fair & Event Center in Costa Mesa, CA by Responsive Drip Irrigation, funded by the State of California - Metropolitan Water District. The comparison was between Responsive Drip Irrigation's GrowStream™ and Netafim's standard drip tape - focusing on which product produced the healthiest plants, as well as which used less water and fertilizers.

Trial Protocol (Initial Installation - May 2021)

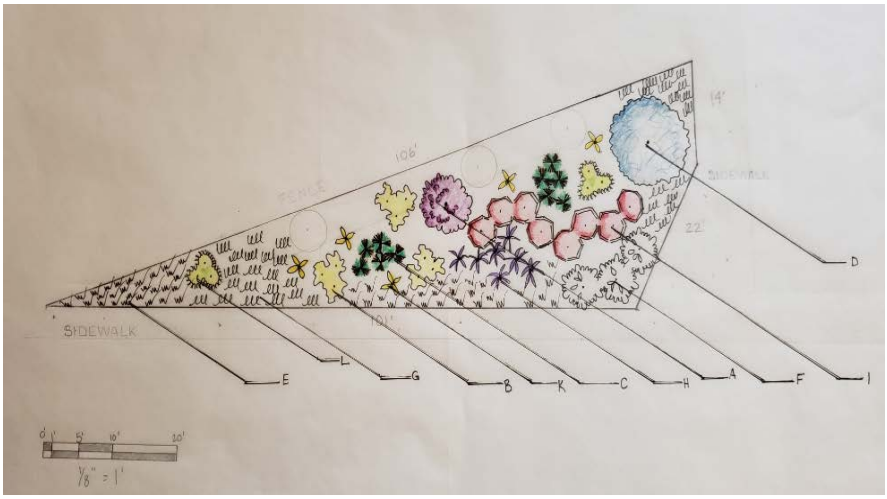
For this study, there were two plots of land provided by the OC Fair and Event Center (3,500 ft^2 to be used for RDI's GrowStream™ system and 1,750 ft^2 to be used for Netafim's standard drip system). Prior to the installation of each system, the designed layout designates what plants were to be used for both plots. Since the plot size for the Netafim standard drip irrigation trial was half the size of the plot used for the GrowStream™ trial, there would be exactly half the plants used for the Netafim plot – with placement of the plants to be almost identical.

RDI RESPONSIVE DRIP IRRIGATION

Below is the initial design for the GrowStream™ plot:



Below is the initial design for the Netafim plot:



Key	Botanical Name	Common Name
A	Amorpha fruticosa	False Indigobush
B	Asclepias fascicularis	Narrow-Leaf Milkweed
C	Carex spissa	San Diego Sedge
D	Ceanothus griseus 'Louis Edmunds'	Mountain Lilac
E	Erigeron glaucus 'Wayne Roderick'	Beach Aster
F	Erigononum fasciculatum 'Dana	Dana Point Buckwheat
G	Oenothera fruticose	Sun Drops
H	Penstemon spectabilis	Showy Penstemon
I	Salvia greggii	Autumn Sage
K	Solidago californica	California Goldenrod
L	Lobelia laxiflora	Mexican Cardinal Flower

After these plans were approved and plants were ordered, a professional landscaping team completed the installation of both irrigation systems as well as the planting. The major difference in installation between the two systems is that Netafim's standard drip system is laid above ground and the GrowStream™ system is sub-surface irrigation - aesthetically more appealing. The table below quantifies the number of each plant species that was planted at each plot:

Botanical Name	Quantity for RDI	Quantity for Drip	Total number of plants installed
Amorpha fruticosa	2	1	3
Asclepias fascicularis	18	9	27
Carex spissa	20	10	30
Ceanothus griseus 'Louis Edmunds'	2	1	3
Erigeron glaucus 'Wayne Roderick'	60	30	90
Erigononum fasciculatum 'Dana Point'	6	3	9
Oenothera fruticose	50	25	75
Penstemon spectabilis	24	12	36
Salvia greggii	16	8	24
Solidago californica	10	5	15
Lobelia laxiflora	12	6	18
Total	**220**	**110**	**330**

To measure the amount of water running through each of the systems, a water meter was installed at the header of each system. The water meter on the Netafim system was not installed until 7 days after the trial started. RDI's Technical Support Specialist, Mr. Wierzba, checked both plots and made weekly observations. Observations were also made by OC Fair & Event Center Landscape Supervisor, Ms. Gregerson.

RDI RESPONSIVE DRIP IRRIGATION

Pictured Below is the RDI plot immediately following installation:

Pictured below is the Netafim plot immediately following installation:

RDI RESPONSIVE DRIP IRRIGATION

Trial Observations (Initial Installation)

Unfortunately, there were several issues following the initial installation that eventually led to replanting many of the plants in each plot. It is important to note that this did not affect water usage data as neither of the systems were ever turned off. The observations made during this period are written in detail below:

Per Ms. Gregerson at the beginning of this project in May, there were several factors that created hurdles to overcome but have since been corrected - resulting in the plants growing well in both gardens.

In May, the landscape company that was hired (prep the ground, install the irrigation systems, plant, and apply mulch) unfortunately did a subpar job. The mulch the landscape company chose was of poor-quality. Once all the plants were planted and the mulch was applied, it was noticed Nutsedge started to sprout. The amount of Nutsedge was significant on the Netafim garden and present on the RDI garden. There were other weeds that started to sprout, as well. Sedgehammer herbicide was applied, and the remaining weeds were pulled by hand. It is believed that these weeds were the result of the poor-quality mulch because these areas did not have Nutsedge or other weeds before this project began.

It is suspected that the landscape company sprayed a broad spectrum weed killer to help control and kill the weeds. Several plants had signs of damage from weed killer, which is much different than plants that suffer from over or under watering. There were also several plants, for instance Saliva, Carex, and Lobelia that should have flourished at that time of year and did not. It appears this is a direct result of damage due to weed killer, resulting in more than 50% of plant loss.

Once the plants were in place, gopher holes were observed. Mr. Wierzba applied Predator Pee in both areas to eradicate the gophers. After a couple of applications, the gophers appeared to have left the area.

There have been minimal insect problems, except on the Netafim side. The Asclepias was infested with aphids. Mr. Wierzba sprayed for aphids, and it was observed at that time there were ladybug pupas on the underside of the leaves. The plants recovered and began to flourish. Butterflies were present at the end of the trial and should have laid eggs shortly thereafter.

Other factors that may have contributed to the poor success rate of both gardens were the events that took place during the summer for the OC Fair. Portable toilets were placed on the edge of the RDI garden where people left trash, food, and cigarette butts. Also, near the RDI garden, are the doors to the catering warehouse, where there is considerable activity during the summer months. It

was noticed that a lot of cigarette butts were thrown into the garden, along with tire tracks from the carts not using the sidewalk. In addition, there was considerable foot traffic from individuals not using the sidewalks, causing plants appearing to be “stomped”.

There was plant loss from ‘missing plants’ that was contributed to theft. Sometimes plants became missing without explanation. These gardens are on the perimeter of the fairgrounds and are accessible to the public at all hours of the day and night.

Trial Protocol (September Re-Plant)

In September, due to the issues that were listed previously, new plants were planted on both the RDI and Netafim gardens in proportion to their respective areas. Other than the addition of 2 new plant species (Asclepias speciosa and Asclepias ericocarpa), nothing has changed about the testing protocol. The new plants that were purchased and installed are listed in the table below:

Botanical Name	Quantity for RDI	Quantity for Drip	Total number of plants installed
Asclepias fascicularis	18	9	27
Asclepias spciosa	14	7	21
Asclepias eriocarpa	14	7	21
Carex spissa	20	10	30
Erigononum fasciculatum 'Dana Point'	6	3	9
Calyophus hartwegii	50	25	75
Penstemon spectabilis	24	12	36
Salvia greggii	16	8	24
Solidago californica	10	5	15
Lobelia laxiflora	12	6	18
Total	**184**	**92**	**276**

RDI RESPONSIVE DRIP IRRIGATION

Trial Observations (September Re-Plant)

The RDI garden displays good growth. Most areas are thriving and doing well, looking full and lush. The plants have adapted well to GrowStream™, the plant-responsive irrigation system. There are a few small areas showing stress due to the amount of foot-traffic in the garden, due to the events at OC Fair & Event Center (i.e., OC Fair in July and August, catering events, etc.). The following observations were made by Ms. Gregerson:

- The Amorpha has branched nicely with good growth. Some areas near heavy foot-traffic appear to be struggling.
- The Salvia and Eriogonum are growing well, with very nice blooms.
- The Solidago is growing well and blooming profusely.
- The Carex is growing quickly and filling out nicely.
- The Ceanothus is thriving and appears very healthy.
- The Penstemon is blooming with good growth. It looks healthy and is thriving in most of the areas of the RDI side.
- The Lobelia has growth that is spotty. Some areas are very lush and blooming, looking healthy. Other areas are struggling. Lobelia tends to like a lot of water.

Below is a picture of RDI's plot during the trial and at the end of the trial:

RDI Plot During Trial

RDI RESPONSIVE DRIP IRRIGATION

RDI Plot End of Trial

RDI RESPONSIVE DRIP IRRIGATION

In comparison to RDI's GrowStream™, the Netafim side appears sparse in growth. While the plants look healthy, they appear to be growing much slower in this plot with considerable weed growth. The following observations were made by Ms. Gregerson:

- The Amorpha is full, branching nicely, and appears healthy.
- The Salvia appears healthy and has started to fill out.
- The Solidago is blooming well and appears healthy.
- The Carex appears healthy and appears to be growing well.
- The Ceanothus seems to be dying. It is yellow and is not growing. This could be from too much water, not enough water, or a plant disease that was unforeseen when it was planted. If a plant has a virus, it will usually appear when the plant is stressed.
- The Eriogonum is blooming nicely and has good but slow growth.

Below is a picture of Netafim's plot during the trial and at the end of the trial::

Netafim Plot During Trial

RDI RESPONSIVE DRIP IRRIGATION

Netafim Plot End of Trial

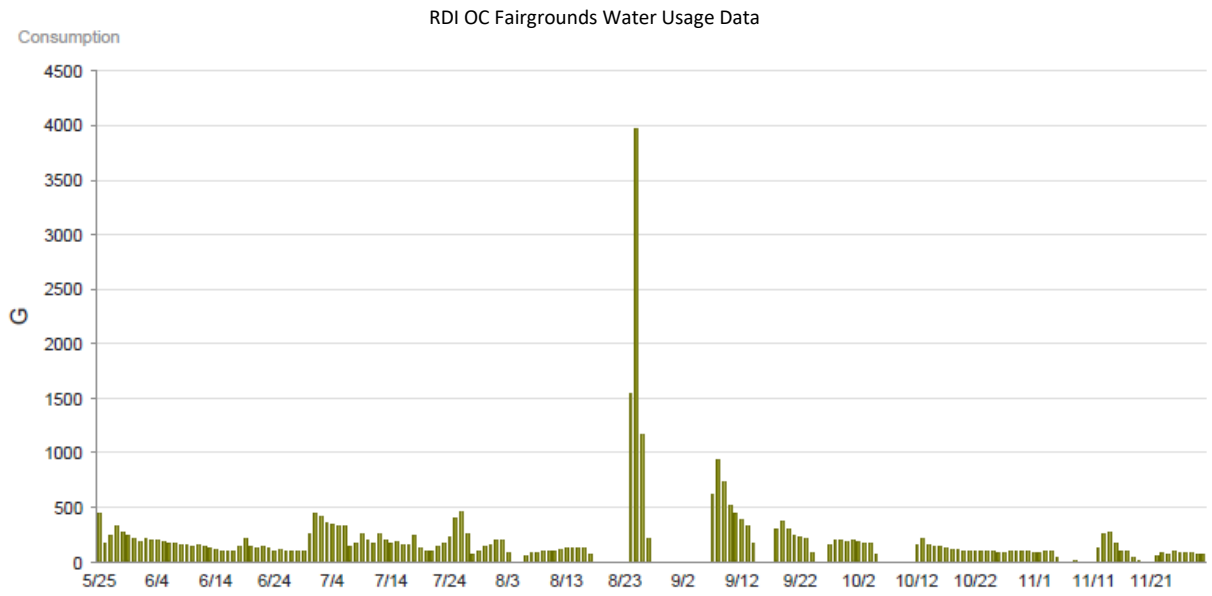
RDI RESPONSIVE DRIP IRRIGATION

Below is a list of the quantities of each plant species remaining when the trial concluded 11/30/2021.

Botanical Name	Final Quantity for RDI	Final Quantity for Drip	Total number of plants Counted
Amorpha fruticosa	2	1	3
Asclepias fascicularis	19	15	34
Carex spissa	23	16	39
Ceanothus griseus 'Louis Edmunds'	2	0	2
Erigeron glaucus 'Wayne Roderick'	33	8	41
Erigononum fasciculatum 'Dana Point'	7	6	13
Oenothera fruticose	23	39	62
Penstemon spectabilis	16	13	29
Salvia greggii	10	11	21
Solidago californica	9	8	17
Lobelia laxiflora	16	8	24
Asclepias speciosa	5	2	7
Asclepias eriocarpa	4	1	5
Total	**169**	**128**	**297**

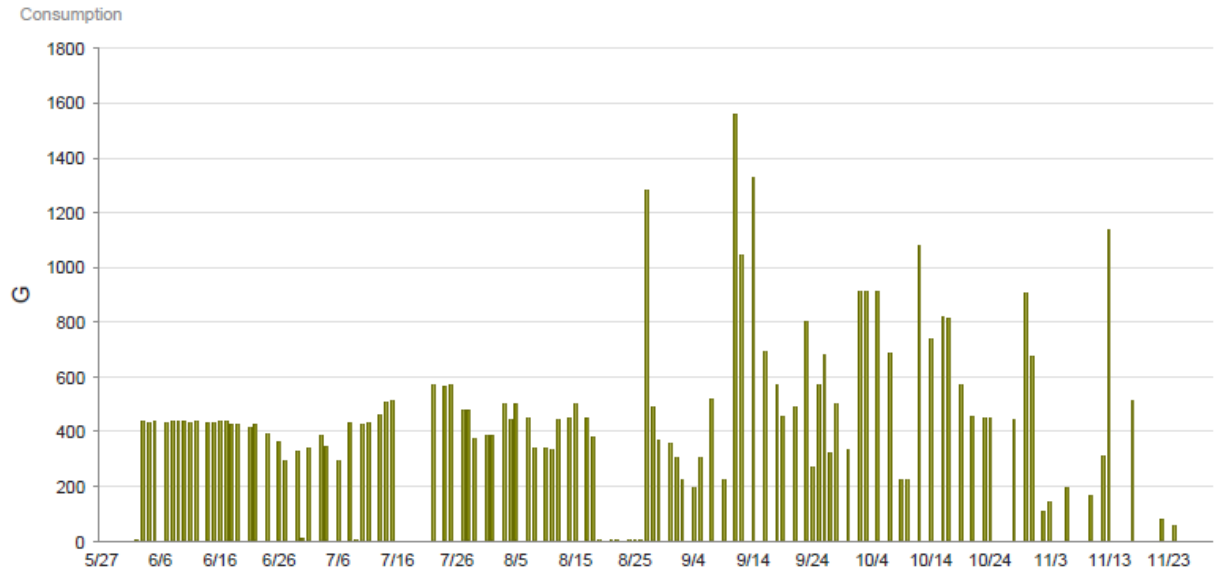
Trial Water Use Data

Below is a graph depicting daily water usage for the RDI Plot from 5/24/21 to 11/30/21:



The total amount of water used in the **RDI garden was 32,611.6 gallons**. It's important to note that the spike in usage observed on August 23rd was due to a gopher biting a hole in the tubing, resulting in excessive water use. The system was turned off briefly and repaired.

Below is a graph depicting daily water usage for the Netafim Plot from 6/1/21 to 11/30/2021:



The total amount of water used in the **Netafim garden was 47,349.1 gallons**. It's important to note that while the system was still functioning on 5/24/21, a water meter was not installed onto the system until 6/1/21 - 7 days after the trial had already begun. Therefore, the total number of gallons used in this trial are higher than indicated (14,827.5 gallons more than RDI).

**Rainbird ICWM series cellular water meters were installed on the header of each irrigation system. These meters uploaded the water readings daily to a database. Both graphs above were constructed based on these readings.*

RDI RESPONSIVE DRIP IRRIGATION

Trial Results

Water usage is immeasurable, when comparing GrowStream™, RDI's plant-responsive system to Netafim's standard drip irrigation system. Keep in mind that RDI's garden is twice the square footage as Netafim's garden. The water data below is during the following period: **5/24/21 to 11/30/21**

	Square Footage	**Water Usage**	**Water Usage Per Sq Ft**
RDI	3,500 square feet	32,611.6 gallons	9.32 gallons per square foot
Netafim	1,750 square feet	47,349.1 gallons*	27.06 gallons per square foot

**A water meter was not installed on the Netafim system until 6/1/21 – 7 days after the trial was started, whereas a water meter was installed on the RDI system on 5/24/21. Therefore, the actual water usage on the Netafim system was higher than recorded by an estimated 410 gallons per day (2,870 gallons total).*

Overall plant health with **RDI's GrowStream™ system** is notably better than Netafim's standard drip irrigation, displaying full and lush plant growth with more blooms – while using ***65% less water***.

There is also the savings of 40%-50% less fertilizer, due to the amendments being delivered directly to the rhizosphere. This allows the plant to uptake the nutrients needed to flourish, with no waste or runoff.

In addition, there was visibly less weed growth, which can be clearly observed in the pictures – 60%-70% less. The reason for this is due to the GrowStream™ system waters the root system, only upon demand where the plant is located. Netafim's standard drip irrigation system has emitters every 10 inches, whether there is a plant there or not. Therefore, the Netafim system is providing water where it is not needed, allowing weeds to germinate and grow profusely.