Whitemans Creek Water Conservation & Drought Contingency Planning

Water Adaptation Management and Quality Initiative

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on behalf of the Brant County Federation of Agriculture

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Acronyms and Abbreviations

BCFA	Brant County Federation of Agriculture
BMP	Best Management Practices
ET	Evapotranspiration
FFCO	Farm and Food Care Ontario
GRCA	Grand River Conservation Authority
OFA	Ontario Federation of Agriculture
OLWR	Ontario Low Water Response
OMAFRA	Ontario Ministry of Agriculture, Food, and Rural Affairs
MOECC	Ministry of the Environment and Climate Change
MNRF	Ministry of Natural Resources and Forestry
PTTW	Permit to Take Water
BRWQP	Brant Rural Water Quality Program
VWC	Volumetric Water Content
WAMQI	Water Adaptation Management and Quality Initiative
WRAMI	Water Resource Adaptation and Management Initiative

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Summary

This proactive drought preparedness project addressed the reoccurring issue of low water in the Whitemans Creek subwatershed, a highly productive agricultural area. The 2014 WAMQI project built on the success of the 2013 WRAMI project, providing the agricultural community with a broader suite of cost effective tools to help satisfy irrigation demand - particularly during drought conditions. The project took place over eight months and all Permit To Take Water holders in the subwatershed were notified of the project's commencement to provide a fair opportunity for all irrigators to participate.

The project addressed water conservation assessments through the completion of irrigation assessments and ongoing water use monitoring. The project increased access to off-line irrigation water sources and improved contingency groundwater sources. Four farmers showed interest and participated in pond renovation through cost-sharing initiatives to create or modify contingency sources. The project continued to demonstrate how soil moisture instruments can help apply the right irrigation amount with the added intention of improving shallow groundwater quality through reduced nutrient leaching. Six farmers participated in this soil moisture monitoring, monitoring six different crop types (seedling ginseng, two-year-old ginseng, three-year-old ginseng, tomato, pepper, sweet potatoes, two potato, and two tobacco) on ten different fields. As well, there was a continued demonstration of an atmometer (measuring evapotranspiration) as it relates to irrigation application amount. Overall, staff increased communications and outreach regarding water efficiency and water quality through group meetings, regular individual site visits and social media. This project has supported Ontario Low Water Response by developing drought resilience.

1 Introduction

The Whitemans Creek subwatershed in the Grand River watershed is an area with a rich variety of agricultural production (Figure 1). Low water conditions are a perennial issue in this subwatershed impacting both agriculture and the cold water trout fishery and wildlife that depend on Creek flows. In 2007 and 2012, the Creek fell to Ontario Low Water Response Level 3 conditions (less than 30% of average summer low flow and receiving less than 40% of long term average precipitation in a 30-60 day period). In cooperation with the Grand River Conservation Authority Low Water Response team, agencies and partners have been working with the irrigators for many years trying to help cope with low water issues.

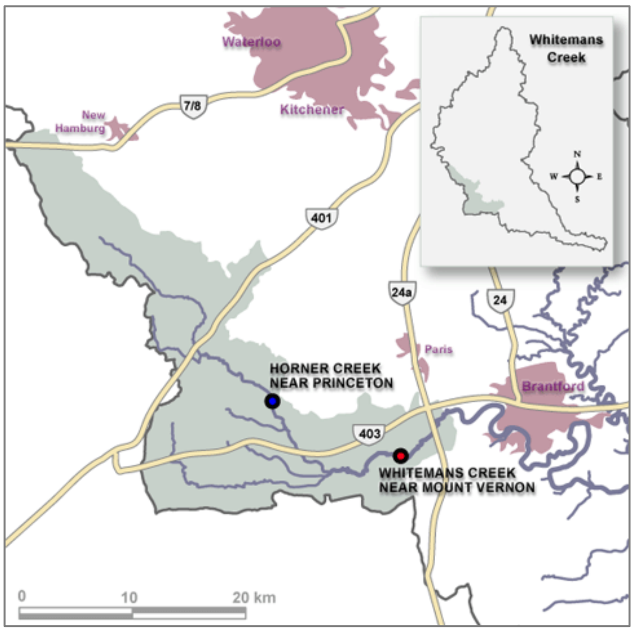

Figure 1 Whitemans Creek Subwatershed.

During the February 11th, 2013 Whitemans Creek Irrigators debriefing with the Brant County Federation of Agriculture at the Burford Fairgrounds, agencies discussed with local farmers the numerous irrigation Permits to Take Water from the Whitemans Creek area and how they affect Creek flows during times of drought. As a result of this meeting, a multi-agency steering committee was formed that later coordinated the 2013 Whitemans Creek Drought Contingency Project, funded by Farm and Food Care Ontario. The pilot provided landowners with assistance in creating Permits To Take Water, promoted water conservation, measured irrigation efficiency, increased outreach, monitored soil moisture, and helped landowners identify and renovate alternative water sources. Staff actively participated in social media (@Plan4Droughts) as part of the pilot project and created two promotional YouTube videos with Farm & Food Care. For further details please refer to the complete report by Kovacs (2013) on the GRCA Low Water Response webpage.

Building on the success of 2013, the multi-agency steering committee applied to the 2014 Water Adaptation Management and Quality Initiative (WAMQI) program, a Growing Forward 2 federal-provincial-territorial initiative, administered by Farm & Food Care Ontario. Thanks to the support of landowners and the success of the pilot in 2013, the Whitemans Creek Water Conservation & Drought Contingency Planning project was selected as one of the 28 projects in the province to receive funding in 2014. The GRCA hired a Drought Contingency Planning Assistant to conduct field work while GRCA staff completed liaison and coordination work. Many of the deliverables from the 2013 pilot were included in the 2014 project work plan to further efforts to improve agricultural water use efficiency and better our understanding of water use in the Whitemans subwatershed.

2 Drought Contingency Planning

The irrigators in the Whitemans Creek subwatershed are considered to be responsible water users, especially during irrigation events. Farmers are constantly under the stress of producing quality, high yielding crops with the least amount of inputs to maximize their revenue. Pressures are especially high during times of drought when decisions become more serious and the fate of the crop is at stake. This is why proactive thinking and planning ahead for a drought is so beneficial. When a drought happens, farmers need to be prepared to implement plans; rather than trying to pull one together in the middle of a stressful event.

The findings of the ***2013 Whitemans Creek Drought Contingency Pilot Project (Kovacs, 2013)*** indicate that an agricultural drought contingency plan includes good preparation that should consist of four steps:

1) Making sure an irrigation system is in place and working accurately,
2) Using Best Management Practices (BMPs) year round,
3) Securing a reliable water source with a Permit To Take Water before a drought, and
4) Writing down what options exist if the regular water supply is not able to provide the water needed (this is the contingency plan)

(Kovacs, 2013)

During a drought, actions 1 and 2 should be reviewed and the main supply water levels should be monitored (how they are decreasing/recovering). Contingency Plan options may need to be acted on depending on these observations. Acting on a contingency plan might include reducing irrigation amount, requesting to use a neighbour's pond, or even trucking in water. For the complete plan developed in the 2013 pilot, please refer to the full report by ***Kovacs (2013)***.

Throughout the duration of this project, these steps to a contingency plan were promoted in the agricultural community.

2.1 Agricultural Irrigation

2.1.1 Irrigation Efficiency

The soil type in the Whitemans Creek subwatershed supports a variety of crop types that vary in irrigation needs. As a result, the subwatershed contains a wide range of irrigation systems from overhead guns to sub-surface drip systems. Irrigation system assessments are an excellent way to determine if an irrigation system is functioning efficiently ***(Kovacs, 2013)***. Through the in-kind work of OMAFRA staff, the project continued to offer free irrigation systems assessments, a continuation from the 2013 pilot, to all irrigators of the subwatershed. Conducting these assessments gives the irrigator an insight on how equally the water is spread on the field. If certain sections are not getting as much water as others, adjustments need to be made to the system.

For an example of an irrigation assessment, see Case Study #1 in the Appendix.

2.1.2 Best Management Practices

Best Management Practices (BMPs) are practical and affordable approaches to conserving soil and water resources without sacrificing productivity. Staff have continued to analyze existing irrigation practices and direct farmers to the ***BMP books developed by OMAFRA*** where needed. For example, timing irrigation events to occur in low wind conditions and preferably at night are some of the ways to minimize water loss and ensure that the amount of water applied will actually make it to the crop. For a summary of the relevant irrigation and crop production BMPs, refer to ***Appendix 3 in Kovacs (2013)***.

Interested in getting a copy of your own BMP books?

If you are an Ontario farmer, single copies of each title are available at no cost at your nearest Ontario Ministry Agriculture, Food and Rural Affairs office. For more info:
Toll Free: 1-877-424-1300 **E-mail:** ag.info.omafra@ontario.ca

2.1.3 Sub-surface Drip Irrigation

Building on research done previously by OMAFRA (including work by Eugenia Banks OMAFRA potato specialist) the project wanted to showcase water efficiency through an irrigation demonstration site that compared overhead irrigation to surface and subsurface drip irrigation. The project cost was estimated to be $30,000, depending on the amount of land converted to subsurface drip, with the farmer paying 80% of the cost. Installing subsurface drip systems can cost about $1,900/acre for larger (75-100 acre) scenarios. The landowner whose operation was most fit to demonstrate the new subsurface drip system in comparison to his existing overhead and surface drip systems was a pepper and tomato farmer. After researching the effects of subsurface drip on pepper and tomato yields, it was determined that the landowner would not gain enough yields to offset the cost of installing subsurface drip. Surface drip and overhead systems provide greater yields for both tomatoes and red peppers while green pepper yields are equal with either method (B. Ball-Coelho et al., unpublished).

2.1.4 Variable Rate Pivot Irrigation

The proposed pilot was identified to build on the experiences shared by the 2013 WRAMI project in Innisfil by establishing a Variable Rate Irrigation (VRI) center pivot system to compare its benefits to the traditional systems on potato farms. The project cost was estimated to be $30,000, with the farmer paying 50% of the cost. Unfortunately, this project was not completed because the interested landowner made investments into furthering their operations and was unable to contribute to the VRI system as planned. We still hope to showcase this innovative VRI technology in coming projects and will continue to work with the interested landowner should later funding be received.

One of the ponds renovated (Case Study #3 in the Appendix) with WAMQI funding in 2014 actually irrigates 37 acres of corn via sub-surface drip (installed in 2014), while the remaining 48 are irrigated via overhead travelling guns. His pond recharge used to take about 12 hours and the pond cleaned out to a depth of 12 feet conducted under WAMQI has increased his capacity and recharge rate to sustain his sub-surface drip irrigation.

2.2 Reliable Water Resources

The 2013 pilot really highlighted the importance of switching agricultural irrigation sources off-line (not connected to a creek/river). Making the switch to off-line sources, or at least establishing an alternative groundwater contingency source, is ideally done *prior* to a drought. Groundwater is not as easily affected by droughts as on-line surface water sources which are primarily influenced by rainfall and snow melt. The 2014 project continued to support irrigators willing to switch to off-line sources or those who wanted to improve their existing groundwater sources through cost-sharing initiatives.

For details on the pond renovations, see Case Studies #2 through #5 in the Appendix.

In addition to improving the off-line water sources, in Case Study #5 we also improved the quality of the pond's discharge into the adjacent Provincially Significant Wetland where Rest Acres Creek, a trout spawning area, flows through the Apps Mill Nature Centre. In addition to cleaning the irrigation pond to a total depth of 12ft to increase water storage and improve recharge, the outlet drainage was redesigned to flow through an 8' AgriDrain in-line water control structure. This helps reduce the temperature of the water leaving the pond and stops beavers from clogging the outlets (a flaw in the previous outlet design). Case Study #5 would not have been possible without the collaboration and funding support of three (3) partners that complimented the WAMQI funding: RBC's Blue Water Project, the Brant Rural Water Quality Program's (BRWQP) Erosion Control Structures cost-sharing grant, and MNRF's Aquatic Improvements grant. As well, during the 2013 WRAMI pilot project, $5,000 was contributed towards purchasing supplies for this project in anticipation of its completion in 2015.

The future direction of contingency water sources includes the identification and establishment of community irrigation ponds. Draft documents for short term landowner-irrigator agreements have been drafted during the 2013 WRAMI pilot project. These could be used in scenarios where a land owner with an irrigation pond and an active PTTW can accept requests from his neighbouring irrigators to pump from his pond during time of low water (once Level 2 low flows are declared). Since the majority of cash crops do not require irrigation and they may be in rotation on a field with an irrigation pond, that pond could be used by neighbouring irrigators during the year(s) the cash crops are grown. Refer to ***Appendix 6 in Kovacs (2013)*** for the draft "Community Pond Permission Request Procedure" which can apply to any drought sensitive areas.

Figure 2 Flooding after a heavy rain event in a sweet potato field (from the left Courtney Clark and Nadine Gill, photo courtesy of Janet Licskai, OFA)

2.3 Soil Moisture

There is a lot more to soil moisture then saying the field is "dry" after a week of no rain or saying it is "wet" after a rain event that saturates a field (Figure 2). Monitoring soil moisture helps accurately determine when and how much irrigation is needed so farmers do not irrigate too early or wait until the plants are already showing sign of water stress ***(Kovacs, 2013)***.

Staff continued to offer soil moisture monitoring in the 2014 project to interested irrigators of the Whitemans Creek subwatershed as a continuation of efforts from 2013. In order to expand the monitoring program, more farmers were gauged and remote sensing options were also advertised in addition to the travelling FieldScout probes.

The 2014 soil moisture measurements illustrate an interesting point regarding the uptake of water in soil during significant rainfall events. From July 27-28th, almost 5" of rain fell in the Whitemans Creek area. However, this massive input did not bring all of the fields staff monitored to field capacity. Only 2 days after this rain event, the water deficit readings in seven of the ten fields staff monitored was sufficient to trigger an irrigation event (Figure 21, Figure 23, Figure 25, Figure 26, and Figure 29 in the Appendix). This may be a result of heavy rain fall occurring over a short amount of time, not letting the rain percolate into the soils, and creating runoff. Another explanation could be localization of the heavy rain although radar imagery showed a pretty consistent rainfall in the study area.

Some irrigators measure rainfall at their fields to determine when they should irrigate. This is a great tool for assessing soil moisture but even more important to tracking rainfall is regular soil moisture measurements to confirm or refute dry soil conditions. As the above example shows, just because there was a lot of rain fall does not mean the soil will remain wet for a long time.

2.3.1 Field Specific Monitoring – FieldScout TDR 100

Monitoring with a portable FieldScout TDR100 soil moisture meter (Figure 3) was offered three times a week to interested irrigators. Readings were collected at the same time of day, from June through August, analyzed and communicated with irrigators through a weekly soil moisture report. The focus of the report was a graphical presentation of the soil moisture. This graph includes two important reference lines: a recommended "start irrigation" line when the water deficit is 0.65" (blue line) and a "permanent wilting point" warming line when the water deficit is 1.3" (red line). The daily rainfall collected at the Burford Tree Nursery was also presented in these graphs for reference (blue columns).

Figure 3 FieldScout TDR100 Soil Moisture Meter with 8" probes.

The three farmers who participated in the 2013 soil moisture monitoring with their tobacco, pepper, tomato, and ginseng fields continued to show interest, and had their fields monitored in 2014. In addition, three new farmers with tobacco, sweet potato and two potato fields were also monitored in 2014.

The soil moisture reports presented the water deficit, displayed in inches, because this is a relevant unit that irrigators can use to determine how much water to apply during their next irrigation event. This measurement option was available during the Relative Water Content (RWC) setting of the TDR100 where the calibration option allowed the RWC to be converted to the Plant Available Water (PAW). As PAW decreases, water deficit increases, so when soil moisture reaches 50% of the PAW it is an ideal time to start irrigation. At 50% of the PAW, water deficit is equivalent to 0.65", so irrigation was recommended to begin once a field's water deficit was greater than 0.65". For a full description of how the RWC readings are calculated and calibrated, please see ***Kovacs (2013)***.

For details on the field specific soil moisture monitoring, see Case Studies #6 through #12 in the Appendix.

2.3.2 Field Specific Monitoring – Decagon Em50G Remote Sensor

In order to pilot some continuous soil moisture monitoring, a remote Decagon Em50G soil moisture sensor (Figure 4) was offered to one of the interested irrigators located in the northern part of the subwatershed. This remote sensor not only granted a more detailed understanding of their continual soil moisture but it also saved travel time for the field technician who conducted FieldScout monitoring for the other farms. The remote sensor sends the information it collects to computers through a wireless connection. Anyone with the login information can access the website that hosts the live data of the soil moisture probes. The weekly or entire data set can be downloaded from this website and the weekly data is automatically displayed in a graph. Decagon sells additional software, DataTrac 3, to analyze soil moisture and environmental measures that were used to create the graphs presented in the weekly reports to the irrigator (Appendix Figure 29). The focus of this report was also a graphical presentation of the soil moisture. This graph includes the same two important reference lines as the TDR100 weekly soil moisture reports: a recommended "start irrigation" line (blue line) and a "permanent wilting point" warning line (grey line).

Figure 4 Decagon Em50G Remote Sensor on a tobacco field.

For details on the field specific soil moisture monitoring, see Case Study #13 in Appendix A.

A tobacco farmer who had his field monitored with the TDR100 in 2013 was interested in comparing the two technologies and volunteered to have his field monitored. Staff set up an Em50G sensor with 2 probes at depths of 10" and 20" in his tobacco field. Beginning in June, readings were collected every hour and analyzed weekly for a soil moisture report to be delivered to the irrigator.

The soil moisture reports presented the Volumetric Water Content (VWC) displayed in volume of soil water per unit of total volume (m^3/m^3). Since the relevant unit that irrigators use to determine how much water to apply is inches, staff manually determined at which VWC values the PAW equalled 50% and the water deficit equalled 0.65". As determined with the TDR100, this is when irrigation is recommended to commence. We determined that when the soil moisture is 15% the water deficit is 0.65" and irrigation was recommended to start, and when soil moisture is 10% the water deficit is 1.3" and the permanent wilting point may be reached.

2.3.3 Soil Moisture Probe Borrowing Program

Thanks to the funding received during the 2013 WRAMI project, GRCA acquired 10 FieldScout TDR100 soil moisture probes that were used to monitor various fields. Through the WAMQI project, staff are developing a "Soil Moisture Probe Borrowing Program" where interested irrigators can borrow a probe for the growing season – for free! Interested irrigators can contact the GRCA and borrow a TDR100 probe to help monitor soil moisture and plan irrigations events. This borrowing program will continue to be delivered by the GRCA.

Those who borrow a TDR100 receive an information booklet containing instructions, links to our videos, blank graphs to track daily data and soil moisture monitoring brochures. The program was developed to get irrigators familiar with the new monitoring equipment, such as the TDR100, by offering them a season to try out the equipment and implement their findings in their agricultural practices. Those who recognize the benefits of this monitoring equipment will ideally go out to purchase their own set and continue to use monitoring equipment.

Of the irrigators who used the TDR100 in the 2013 growing season, three (3) have purchased their own and used it during the 2014 season. These irrigators compared their readings to those of the Drought Contingency Planning Assistant and found the probes quite easy to use on their own.

2.4 Evapotranspiration

Keeping track of Potential Evapotranspiration (PET) with an Evapotranspiration Gauge (Figure 5) is another way to determine *when* and *how much* to irrigate. PET is the amount of water a crop potentially transpires combined with the water potentially evaporated from the soil and plant surface. PET can be converted to crop stage specific readings by multiplying the reading by the applicable crop factor ***(see omafra.gov.on.ca for details)***. PET helps quantify how much water leaves a field and can be translated to the amount of water that needs to be applied back to the field through irrigation to maintain successful crop growth. Actual evapotranspiration depends on climate, solar radiation, crop cover and the amount of moisture available in the soil.

Just like the soil moisture report recommendations, when the PET reading reaches 0.65", we recommended beginning irrigation. For a drip tape system, irrigation should begin even earlier when PET equals 0.4". If an irrigation event applied the amount of water that was evapotranspirated then assume the field is at capacity and start adding up the PET values once again until it reaches the value that triggers irrigation to start. When using PET values posted online take into account where and how far away the gauge is located.

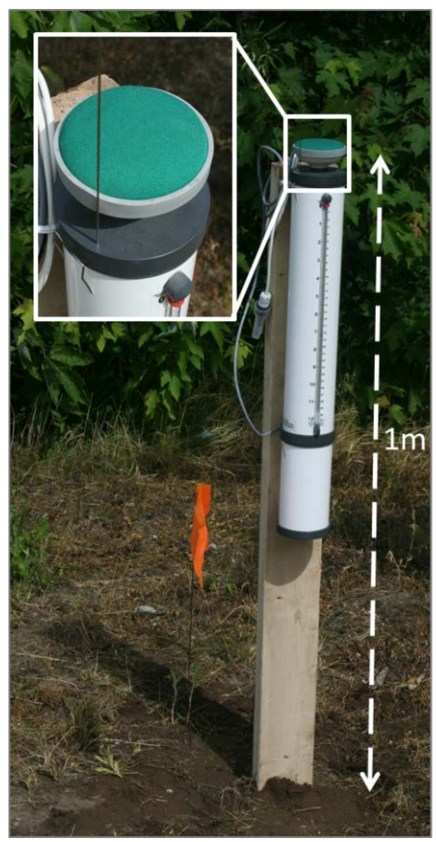

Figure 5 Evapotranspiration gauge set up at the Burford Tree Nursery.

PET rates and air temperature were tracked at the Burford Tree Nursery from mid-June to the beginning of October and were summarized weekly, as shown in the Figure 6. This monitoring period was significantly longer period than in the 2013 pilot (Figure 7 and Figure 8) thanks to the lesson learned from the pilot on setting up and operating the ET Gauge.

The weekly cumulative PET for the 2014 season ranged from 0.21” (week of August 16) to 0.74” (week of June 21) (Figure 6). The average weekly temperature for the season ranged between 12°C (week of September 13) and 22°C (week of June 28). Our findings show a slight positive correlation between PET and air temperature, as temperature increases so does PET (Figure 6), but no correlation with rain fall. Nonetheless, temperature, rainfall, humidity, wind speed and solar radiation can all affect actual evapotranspiration. For example, after a prolonged period of no rain, actual evapotranspiration slows because the tension between the soil and remaining soil water increases so much that it strains the plant to try and draw up the water; this is when symptoms of drought stress like wilting may be noticed.

The weekly cumulative PET values for August 2 through October 2, 2014 compared to those weeks in 2013 were mostly the same or a bit higher (Figure 7). Interesting to note, the week of August 16, 2013 really stood out because PET was four times that of 2014 (Figure 7). The weekly average air temperatures for August 2 through October 2, 2014 closely compared to 2013 and the weekly averages were within 1°C of one another, with the exception of the week of August 16 having a 2°C difference (Figure 7). The biggest obvious differences between 2013 and 2014 are the four weeks in 2014 when the cumulative weekly rainfall was greater than 1” (weeks of July 26, August 30, September 5 and October 3 in Figure 8). One of the most memorable marks of 2014 was the 4.43” downpour in the week of July 26, 2014 (Figure 8). This rain event yielded more rain than the sum of all the rain events monitoring in 2013 between August 2 - October 2.

PET readings are very useful in helping make irrigation decisions. Staff are working to streamline and make PET, temperature and rain data from the Burford Nursery available to the public through a web interface – maybe even a smartphone app.

2.5 Water Quality

The project continued to demonstrate how soil moisture instruments can help apply the right irrigation amount with the added intention of improving shallow groundwater quality through reduced nutrient leaching.

The 2014 project linked with water quality improvement activities of the GRCA’s BRWQP and promoted cost sharing for stream buffers and erosion control structures. A workshop was to be held in the area to address the specific water quality issues with nitrogen but did not end up taking place. Growers will be encouraged to implement new actions being introduced through the BRWQP, such as cost share contributions to cover crops like annual rye grass to promote soil health on tobacco fields and to provide greater organic content for retaining soil moisture.

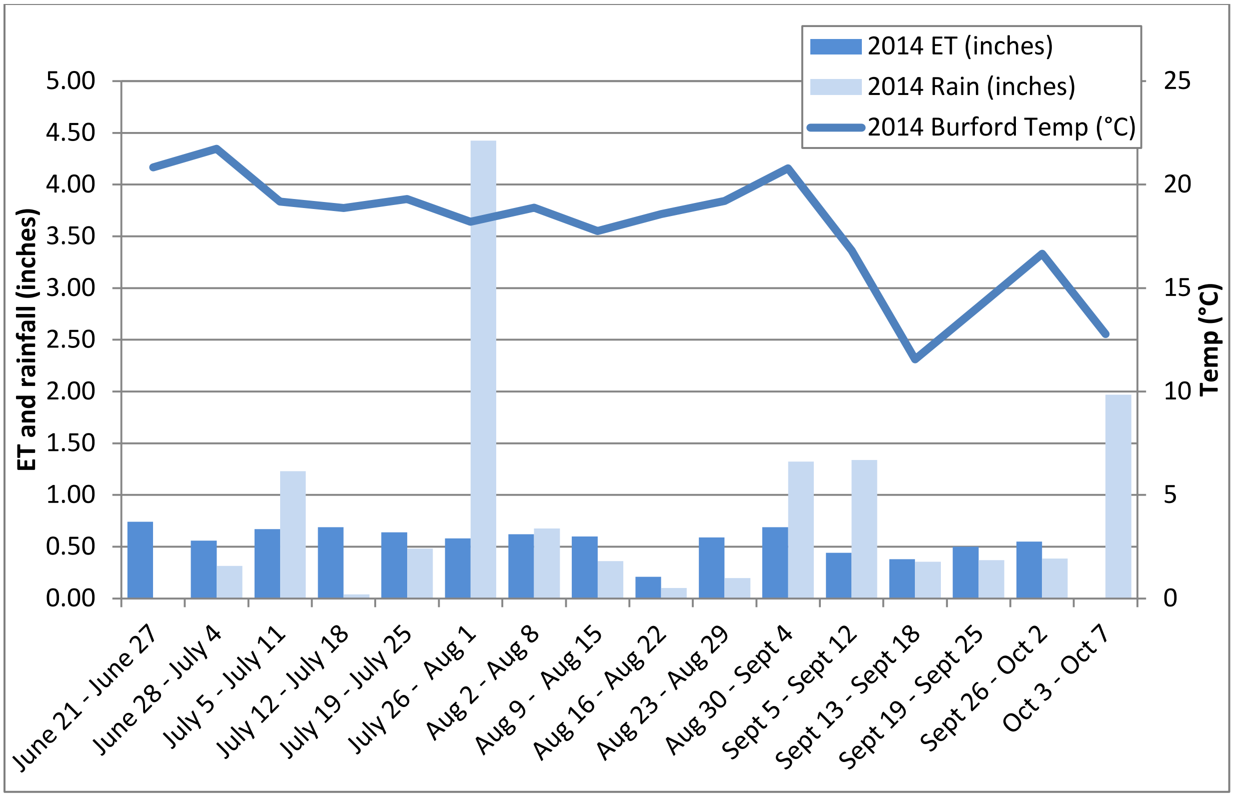

Figure 6 The 2014 evapotranspiration, rainfall and temperature at the Burford Tree Nursery.

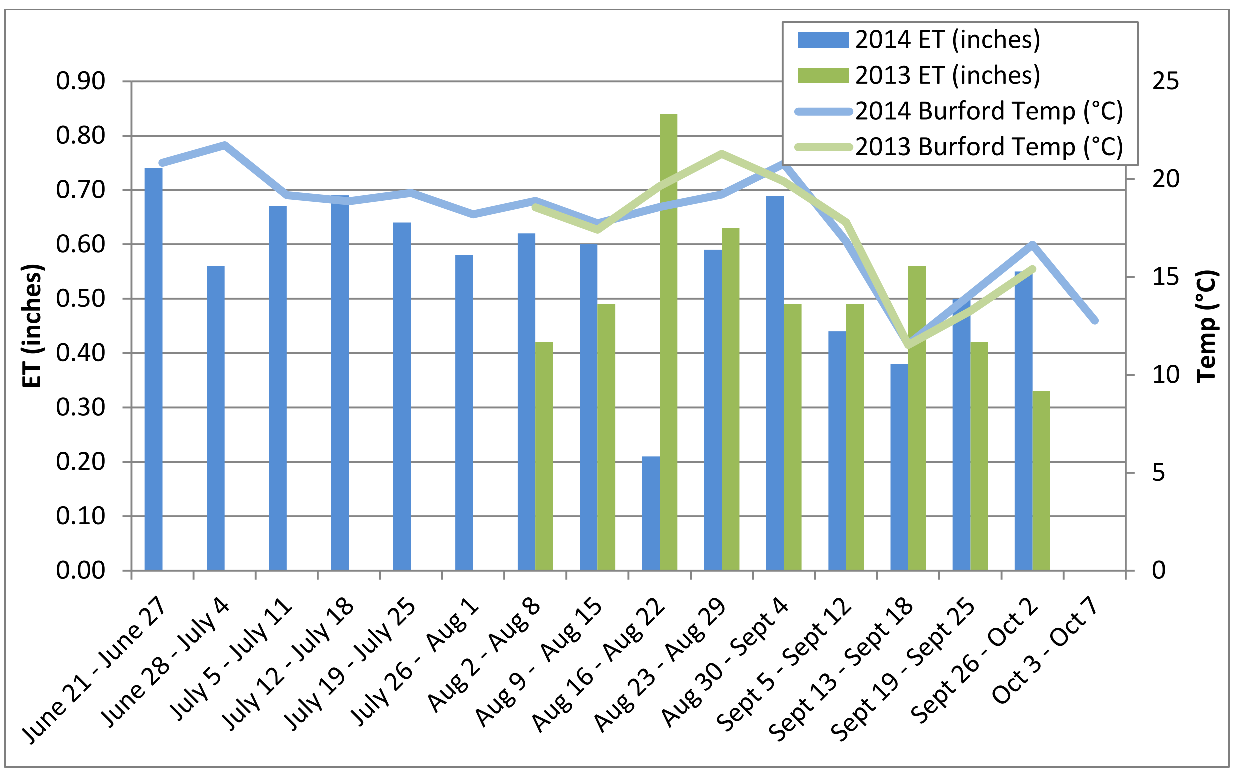

Figure 7 The 2014 evapotranspiration and temperature data at the Burford Tree Nursery compared to 2013.

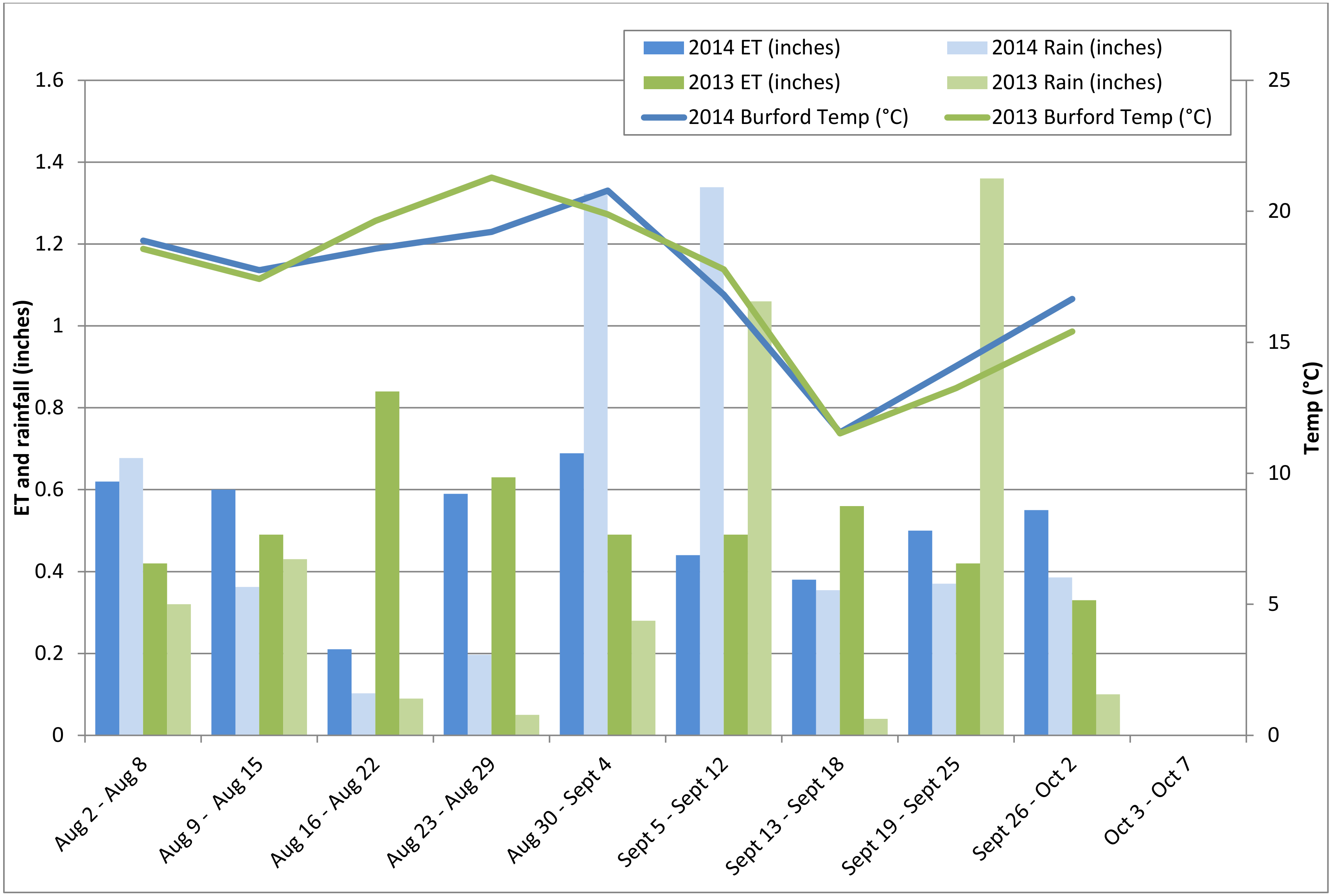

Figure 8 The 2014 evapotranspiration, temperature and rain data at the Burford Tree Nursery compared to 2013.

3 Communication

3.1 Field Visits

To help promote the landowner relationships built over the years, particularly those from the 2013 pilot, GRCA staff continued to meet with irrigators in the field to discuss drought contingency planning. Whether it was providing informational brochures, invitations to workshops or soil moisture monitoring, staff were only a phone call away for irrigators seeking more involvement and support. The GRCA hired a Drought Contingency Planning Assistant to conduct field work while GRCA staff completed liaison and coordination work. Their work helped continue growing the relationships of the watershed landowners and our agencies.

3.2 Workshops

On July 3, 2014 the GRCA hosted a workshop at the Burford Tree Nursery for landowners who irrigate. The workshop discussions included:

- The 2013 results from the pilot program,
- Identifying and creating alternative water sources,
- The PTTW program, and
- Measuring irrigation efficiency.

The workshop was very successful with almost 20 attendees, including staff. Participants enjoyed the workshop and asked lots of questions from the steering committee regarding irrigation, PTTWs, and alternative sources.

3.3 Social Media

Social media is the key to reaching the new generations and connecting with people from around the corner to around the world on topics that need collaboration. Drought contingency planning is definitely one of these topics.

3.3.1 YouTube

Thanks to the tremendous administrative support from FFCO staff, we have been able to produce three new YouTube videos during 2014 in addition to the two videos created in the 2013 pilot. In 2013 we were fortunate to record and, with the help are FFCO, produce a soil moisture monitoring video that introduces the benefits of soil moisture monitoring to agricultural practices. The second video produced in 2013 was on alternative water sources and the reasons groundwater irrigation sources are important, particularly in drought contingency planning. As of January 6, 2015 these videos have had 284 and 585 views, respectively.

The success of these 2013 videos led to the production of three new YouTube videos in 2014 (Figure 9). The first was created to highlight the steps in planning a pond renovation as part of a drought contingency plan. Often landowners are not aware of *all* of the steps they should take, or the order in which to take them, to ensure they abide to all applicable regulations when planning a pond renovation.

The second video focuses on the portable soil moisture probe used in the projects. It is an exceptional tool to help make effective and accurate irrigation scheduling decisions. In order to help promote the probe, we produced a video highlighting the set up and calibration of the FieldScout TDR100, so that anyone can purchase and, within a few minutes, begin to use their TDR100. The third video captures the ecologically benefitting pond renovation that was completed in Brant County. The video focuses on the ways to improve overflow culvert outlets to bottom draw in-line water control structures and the benefits this will have downstream of the pond. These new videos have only been up for a few months and as of January 6, 2015 have 107 and 76, and 72 views.

We look forward to continuing to use these videos through low water scenarios to better prepare the agricultural community for drought preparedness.

3.3.2 Twitter

As requested by interested irrigators in 2013, staff created and have been working to actively participate in social media, particularly Twitter. The Plan4Droughts account created on June 11, 2013 gathered 19 followers by the end of the 2013 pilot. With the continued momentum in 2014 and increased community awareness, as of January 6, 2015 the Plan4Droughts account has grown to 98 followers containing members of the public, people from various agencies, and environmental advocates from across the world. Growing the followers more than 5 times from 2013 is a great success and staff continue to support the Twitter account to promote drought preparedness.

Figure 9 Farm and Food Care created YouTube videos of the steps involved in renovating a pond (top), setting up a FieldScout TDR100 soil moisture probe (middle), and the ecologically benefits of pond renovations (bottom) in 2014.

4 Conclusion

The Whitemans Creek subwatershed is a priority study area because the rich agricultural production and cold water trout fishery in the subwatershed are susceptible to the perennial low water conditions. In preparation for future drought scenarios, staff have worked collaboratively with the community to help landowners establish a successful drought contingency program. In 2014, irrigation contingency planning was linked with the GRCA Rural Water Quality Program and Grand River Fisheries Management Plan; making contingency planning support more sustainable.

Other programs that support water conservation include the Ontario Drinking Water Source Protection Program as per the *Clean Water Act, 2006* which aims to protect municipal water supplies. Municipalities and the MOECC collaborate to create Source Protection policies for the vulnerable areas around municipal water sources to manage and/or prohibit activities that endanger water quantity and quality.

The goals of this project are also reflected in the Grand River Water Management Plan's Integrated Action Plan section C: Ensuring water supplies. Item C4 specifically highlights the importance of agricultural water use in the Whitemans creek area and encourages users to continue long term water conservation best practices to reduce water demand. In C4, the Water Management Plan Project Team recommends that:

a) irrigation water be sourced from off-line storage ponds and/or groundwater to avoid direct withdrawal from surface water streams during low flow periods;

b) water use efficiency advice be available to irrigators to ensure that gun irrigation is timed to minimize evaporation and overspray, piping systems are maintained to minimize losses; soil moisture is assessed prior to irrigation events; and ponds are maintained and sized to satisfy the needs of summer irrigation; and

c) water use information be kept current for all sectors to observe trends in total water use across the watershed.

The feedback from the irrigators involved in the project for a second year, along with those who joined in 2014, spoke highly of the benefits of the proactive community based project. The success of the project can be applied in other sensitive irrigation areas by providing the mentioned resources and agency support to the irrigators. The increased awareness of the agricultural community with our agencies efforts to promote water security continues to build our relationship with the public. We cannot change the fact that water use is essential for life, but when and how we choose to use water, and from what sources, is in our control.

5 Lessons Learned & Next Steps

5.1 Pond Renovations

The irrigation pond renovations continued to be a key aspect of the 2014 WAMQI project and landowners were very pleased with the opportunities that WAMQI's cost-sharing provided. Irrigators have become better prepared for drought by increasing their water storage capacity and moving to off-line water sources. The liaison work required for the pond renovations during the project was coordinated by a Conservation Specialist at GRCA. However, should WAMQI type funding not be available in the future to hire staff to coordinate these pond renovations, GRCA's Conservation Services may include the coordination of these pond renovations in their regular capacity. The limiting factor for this initiative will be getting the capital funding to grant the type of cost-sharing that WAMQI has provided for the renovations.

> **Action:** GRCA staff will seek opportunities and continue to apply for funding to obtain cost-sharing funding for drought preparedness pond renovations.

5.2 Soil Moisture Monitoring

Some irrigators measure rainfall at their fields to determine when they should irrigate. This is a great tool for assessing soil moisture but even more important to tracking rainfall is regular soil moisture measurements to confirm or refute dry soil conditions.

> **Action:** GRCA Conservation Services staff will deliver a "Soil Moisture Probe Borrowing Program" where interested irrigators can borrow a probe for the growing season at no cost.

> **Action:** GRCA staff will work to automate data collection from remote soil moisture sensors in Brant and Oxford County to make soil moisture data available as a drought response tool.

5.3 Permit To Take Water

During discussion with farmers in Brant and Oxford County, there continues to be a lack of awareness about the MOECC PTTW program and who is required to apply for a PTTW and when. This disconnect is one of the main reasons that water quantity studies have a hard time figuring out actual water use and projecting future scenarios. Irrigators are expected to apply for a PTTW for *all water sources* from which they take more than 50,000L/day. They are to apply for amendments if they want to change their takings and general renewals are required every 5-10 years.

> **Action**: GRCA staff will continue to work with MOECC and OMAFRA to promote the need for PTTW workshops to occur year round, preferably throughout winter. These workshops need to be advertised in the newspaper, on local bulletin boards and online as the growing season wraps up so people can plan to attend. The workshop should cover: when a PTTW is needed (ponds need permits too!), the three categories of PTTWs, what forms are need, where to find the forms, how to apply/fill out forms, when to apply for an amendment, how to renew a PTTW, and how and when to submit a PTTW's annual water usage. The workshops and promotions should also highlight the availability of agricultural water efficiency programs outlined in the ***OMAFRA BMP books***.

5.4 Nutrients and Nitrogen Legacy

Agricultural application of Nitrogen is one of the many sources of Nitrogen to the private wells in the Burford area. Nutrients and Nitrogen legacy in these drinking water wells has long been a topic of interest. Lotowater completed the ***"Groundwater Quality Investigation in the Burford Urban Area"*** in 1997 and developed a groundwater protection strategy in 2002. Both studies provide recommendations on how to proceed with nutrient issues in this area ***(Lotowater 1997; Lotowater 2002)***. Brant County has continued to monitor the groundwater quality in Burford since the 2002 study.

The Ontario Drinking Water Source Protection Program recognizes high levels of Nitrogen in municipal wells as an "Issue". An area around the affected well field would be delineated as a "Nitrate Issue Contributing Area" and any activities that handle, store or apply Nitrogen within that area would be subject to Source Protection Policies. However this program only applies to municipal wells so an "Issue Contributing Area" cannot be delineated for private wells and Source Protection Policies cannot be used to help regulate the handling, storage or application of Nitrogen around private well fields. For this reason, preventative and management measures can only be taken voluntarily to help improve the water quality of these private wells.

> **Action:** Growers will be encouraged by the GRCA and OMAFRA to implement new actions being introduced through the BRWQP, such as cost share contributions to use cover crops like annual rye grass to promote soil health on tobacco fields and to provide greater organic content for retaining soil moisture and nutrients.
>
> **Action:** GRCA will promote workshop discussions to consider the Whitemans Creek nitrogen legacy and address specific water quality issues with nitrogen in the subwatershed.
>
> **Action:** The County of Brant should seek monitoring collaboration opportunities with the MOECC to streamline monitoring efforts in the private drinking water wells around Burford.

5.5 Voluntary "No Fishing" Signage

The funding application in 2013 and 2014 included a request to fund Low Water Response signage during low water conditions. Due to two wet summers, this work was not required but it is felt that the proposed signage below linking fishing and low water issues will serve as on ongoing reminder to all water users in the Whitemans subwatershed.

The multi-stakeholder Low Water Response team monitors low flow conditions in the Grand River watershed and decides when it is appropriate to declare one of the three Ontario Low Water Response Levels:

- **Level 1:** Flows < 70% of normal summer low flow.
  - Water users are asked to voluntarily reduce consumption by 10%.
- **Level 2:** Flows < 50% of normal summer low flow.
  - Letters to permit holders asking them to voluntarily reduce consumption by 20%.
- **Level 3:** Flows < 30% of normal summer low flow (potential economic and/or ecosystem harm).
  - Water Response Team may ask Province to impose mandatory restrictions on permit holders.

During the summer months, the flows in Whitemans Creek often decline well below the summer average low flows. In order to protect the cold water fishery, MNRF held a meeting with members of Trout Unlimited Canada, Brantford Steelheaders, Brant Rod & Gun Club, Grand River Fish Management Plan, Middle Grand River Trout Unlimited Chapter, Six Nations, Ontario Federation of Anglers & Hunters, GRCA, and River Watch on Dec. 10, 2014 to discuss voluntary "no fishing" signage. Attendees agreed that the signage is a good idea and should be posted along major crossings of Whitemans Creek. The signs would inform anglers when Low Water Response Levels are declared so that they can voluntarily refraining from fishing to help elevate the pressures of low flow conditions on the coldwater fishery. The signs would be maintained by volunteers and the Brant Rod & Gun Club to indicate which low flow Level (ie. 1, 2, or 3) the Creek is experience; a similar technique to wildfire warning signs.

This project's steering committee has agreed to help this initiative by funding the manufacturing and installation of ten (12"x18") trail head signs and four (5'x7") roadside signs (at two Whitemans Creek crossings). The signs will be designed to promote voluntary "no fishing" bans during Level 2 or 3 low water declarations on Whitemans Creek. The GRCA is working to design and install the signage early in 2015.

> **Action:** GRCA will pursue the opportunity to tie voluntary "no fishing" signs into a branding campaign that would link into the GRCA Low Water Response webpage and possibly some interpretative signage in the future (as other funding comes available). GRCA staff will provide funding from the outstanding balance of the WAMQI project's commitment to design and install voluntary "no fishing" signs at strategic creek crossing locations in order to leverage funding from the Grand River Conservation Foundation for additional interpretative signage at GRCA's Apps Mill Nature Center.

5.6 Recycling Plastics

Irrigators are encouraged to use drip tape irrigation for sensitive crops to reduce the amount of water they take at one time and spread it across along span of time instead. When investing in drip tape, most irrigators also invest in plastic mulch to minimize soil moisture loss. Unfortunately, at the end of the season, both the plastic mulch and drip tape need to be replaced and users have to pay to dispose of their plastic waste. Currently, no recycling program exists in Ontario where this plastic waste could be recycled. Hay bale wrap for example, is recycled in Ontario by ThinkPlastics who uses the material to produce Bale Boards and plastic "lumber".

> **Action:** GRCA staff have been involved in discussions with staff from OMAFRA, ThinkPlastics and Clean Farms Inc. to see if opportunities might exist for a recycling program of these particular plastics. Discussions with OMAFRA, ThinkPlastics and Clean Farms Inc. will continue to determine the next steps in moving forward with this initiative in trying to divert these materials from landfills and helping reduce costs of irrigators paying for disposal.

5.7 Whitemans Creek Tier 3 Technical Work

The Ontario Drinking Water Source Protection Program as per the *Clean Water Act, 2006* aims to protect municipal water supplies. Years of technical work have led to the creation of Source Protection policies for vulnerable areas around municipal water sources to manage and/or prohibit activities that endanger water quantity and quality. As component of the technical work, Tier 3 Water Budget and Water Use Modelling Water Quantity research is being conducted to comprehend water use and availability. As of November 2014, Tier 3 water budget work commenced for the Bright and Paris (Bethel Road) municipal wells in the Whitemans Creek subwatershed. By building on the relationships established through the WRAMI and WAMQI pilot projects, GRCA staff and consultants will gather detailed information about agricultural water use to help develop an accurate Whitemans Creek Tier 3 Water Budget model.

Action: GRCA will use the results of the Whitemans Creek Tier 3 Water Budget model to help MOECC, GRCA and local municipal staff determine what Drinking Water Source Protection policies are needed for the subwatershed. The results will also help inform the ongoing objectives in the Grand River Water Management Plan to maintain a sustainable agricultural water supply.

6 References

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7 Appendix – Case Studies

Case Study #1: Irrigation Assessment

On July 25, 2014, the travelling gun irrigation system (Figure 11) of a Brant County farmer was assessed. Catch buckets were set out along the spread of the system to assess its Distribution Uniformity lower quarter (DUlq) (Figure 10). Ideally the DUlq is higher than 0.60. Assuming overlap on the edge rows, staff determined the DUlq of this travelling gun to be 0.88, which is excellent. The range of depth of water applied across the field was between 0.9" to 1.5" with an average depth of 1.1" (Figure 10). The irrigator was applying 1.0" of water so his system delivered just the right amount with an excellent distribution across the land. For more detail on the methods, please refer to "Irrigation Assessments" Appendix 2 of ***Kovacs (2013)***.

Figure 10 Irrigation assessment catch buckets (Photo courtesy of Rebecca Shortt, OMAFRA)

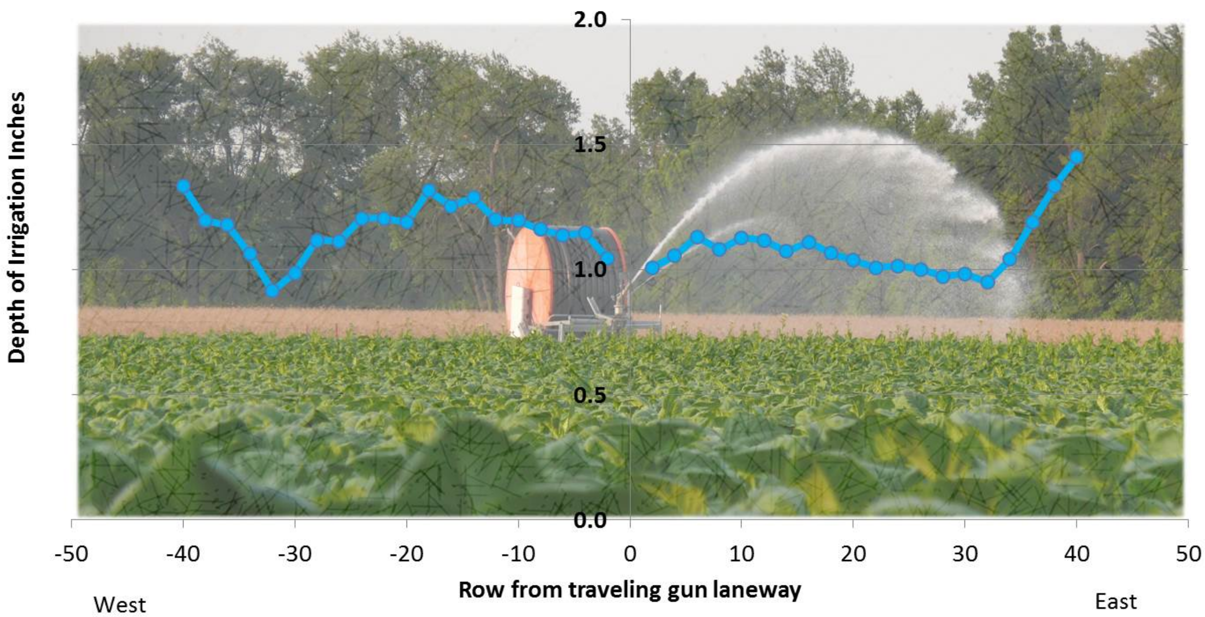

Figure 11 Depth of water collected in irri-gauges for a travelling gun irrigation system. (Original graph and photo courtesy of Rebecca Shortt, OMAFRA)

Case Study #2: Pond Renovation

The landowner owns a large irrigation pond in the center of her tobacco field that had not been used for several decades and it had lost its recharge capacity. The pond used to be the primary irrigation source but the recharge rate diminished from the lack of pond maintenance. The alternative, and now primary, irrigation source is Whitemans Creek which sits at the back of the pond about 200 meters away. A GRCA work permit was acquired prior to starting this renovation. By cleaning out and deepening this pond we increased the water storage and exposed new seeps into the pond that can once again help recharge the water level (Figure 12). Removing the old willow trees around the edges of the pond reduces the amount of litter that will fall into the pond (helping improve water quality) and leaving more water for irrigation. The landowner is investigating various tree and shrubs species that she could plant around the pond to help stabilize the banks. The landowner has had an active PTTW for Whitemans Creek for several years and will be amending it to add this pond to her PTTW as a secondary source. She will not be changing her overall takings but will use the pond as her primary irrigation source and resort to Whitemans only if the pond is not sufficient. This irrigator now has the opportunity to become an "offline" irrigator, using groundwater as the primary irrigation source, which will reduce the pressure on Whitemans Creek in times of low water.

Figure 12 An unused 1960s irrigation pond before (left) and after clean up (right).

Case Study #3: Pond Renovation

The landowner owns a large irrigation pond which is the primary irrigation source for 85 acres of corn. 37 acres of corn are irrigated via sub-surface drip (installed in 2014), while the remaining 48 are irrigated via overhead travelling guns. The landowner has a PTTW for this pond, and another PTTW for a surface water taking from Horner's Creek. The pond did not quite provide the needed supply to irrigate the 85 acres of corn, particularly during drought, and the landowner has laid overland pipe from Whiteman's Creek to his main line to draw sufficient water to irrigate. The pond was originally built 20 years ago and had suffered erosion issues and slumping on the north end which had filled in the pond and diminished its capacity. The pond recharges after 12 hours. No expansion of the pond was deemed necessary and the pond was cleaned out to a depth of 12 feet to increase its capacity (Figure 13). Rip rap was placed at the north end of the pond to mitigate the slumping and achieve a preferred 3:1 slope. As a result of this work, the landowner agreed to divert 50% of his online water taking. If further drip-tape is installed in the next few years as planned, the landowner considers that he could likely agree to divert 100% of his water taking.

Figure 13 Irrigation pond before (left) and after clean up (right).

Case Study #4: Pond Renovation

The landowner owns a large irrigation pond that the primary source to irrigate 30 acres of tobacco, but the pond suffered from poor recharge. During the summer, the pond could take up to three weeks to recharge. In time of drought, the landowner has laid overland pipe from his secondary Permit To Take Water from Whiteman's Creek in order to irrigate the tobacco. The pond was cleaned-out and expanded to expose a suspected spring on the northwest corner and a more gravelly deposit on the northeast corner (Figure 14 and Figure 15). The southern portion of the pond was not cleaned out; access was limited for this area because of a municipal drain and an established windbreak, but this area was also left unmaintained to allow a natural deposition of sediment and improve the slope stability. In addition, a tree and shrub buffer will be planted in spring 2015 along the northern and eastern edges of the pond to delineate the edge of the crop and to help maintain slope stability. This additional work was approved for funding from the Brant Rural Water Quality Program.

Figure 14 Irrigation pond before (left) and after clean up (right).

Figure 15 Irrigation pond before (left) and after clean up (right).

Case Study #5: Pond Renovation

The landowner owns a large irrigation pond with two overflow culvert outlets draining into one of the Provincially Significant Wetlands in Brant County. An ecologist at GRCA identified trout spawning in the channel created downstream of the pond's outlets. This channel becomes Rest Acres Creek and runs through GRCA's Apps Mill Nature Centre on its way to Whitemans Creek. The outlet culverts were prone to debris jams by the local beavers which caused the water level to rise in the pond; putting the pump houses at risk of bank erosion. When the landowner would clean out the debris jams a large rush of water left the pond and was causing soil erosion through the wetland, tipping over trees and gradually carrying silt downstream to Rest Acres Creek. The GRCA permit required for this renovation was obtained in the winter of 2013. Erosion control fencing was installed along the outlet channels and the pond was used as the settling basin during construction. The pond was cleaned to a total depth of 12ft to increase water storage and improve recharge (Figure 16). An 8' AgriDrain in-line water control structure was installed in the West arm (Figure 17) with the inlet pipe reaching to the centre of the pond and the outlet pipe leading into the wetland North of the pond. The control structure reduces the temperature of the water leaving the pond, stops beavers from clogging the outlet and controls the exact water level of the pond. The spoil created from the pond cleaning was used to fill in the West (Figure 18) and East (Figure 19) outlets of the pond. This eliminates the areas where the water was warming up and removed the habitat in which the beavers collected debris and build their damn in front of the old culverts. As well, by filling in the two, rather large, outlet "arms" of the pond, and levelling the surrounding old pathways, the land owner gained about 1.0 acre of crop land. The landowner has had an active PTTW for this pond for several years and will not need to make any amendments to his PTTW since he is not changing his overall takings.

This particular renovation could not have been possible without the collaboration and additional funding support from three (3) partners that complimented the WAMQI funding. With the help of GRCA staff, the project successfully received a $10,000 Community Action Grant from the RBC Blue Water Project, awarded to local or community-based organizations in Canada, the United States or the Caribbean. In addition, the landowner received an Erosion Control Structures cost-sharing grant from the Brant Rural Water Quality Program (BRWQP), administered by the GRCA and funded by the County of Brant and the City of Brantford. Finally, with the help of Partnership Specialists from the MNRF, an Aquatic Improvements grant was provided towards the project to help improve the quality of Rest Acres Creek, and thereby Whitemans Creek.

Figure 16 Completed pond renovation (facing North East).

Figure 17 West pond outlet before (left) and after an 8' in-line water control structure was installed (center) (facing North East).

Figure 18 West pond outlet. Previous state (left), in progress (center), and after renovation (right) (facing South).

Figure 19 East pond outlet. Previous state (left), in progress (center), and after renovation (right) (facing South).

Case Study #6: Ginseng Fields

Figure 20 Monitoring soil moisture on two year old ginseng.

The soil moisture monitoring of seedling, 2 year old (Figure 20) and 3 year old ginseng fields are reported as daily field averages in Figure 21. The readings were determined by taking 9 measurements, in 3 different rows spaced 2 rows apart. Since ginseng is only irrigated in droughts, the soil moisture of ginseng fields is mostly influenced by rainfall events. Figure 21 in the Appendix clearly shows the relationship of soil moisture to rain in the 2014 growing season. For example, the rain events around June 25th significantly improve the water deficit for all of the fields from the June 23rd readings. The fields then began to dry out and the soil moisture dropped until the next rain event occurred.

At the beginning of the 2014 season, the seedling ginseng's water deficit fluctuated below the star irrigation reference line. As a result of rain events near the end of June, improvements in soil moisture climbed above the irrigation reference line and stayed there into early July. The soil moisture then decreased to the irrigation reference line, and that became the average for the remainder of the season. In the last few weeks of August there was another increase in soil moisture and on August 25th readings were very close to field capacity, which is almost too high for optimal ginseng conditions.

The soil moisture in the 2 year old field was a lot more variable than the seedling field and was continually fluctuating between the irrigation and the permanent wilting point reference lines. Throughout the 2014 season there was only one instance, on June 23rd, where the soil moisture of the 2 year old ginseng had come close to the permanent wilting point, however this point was never crossed.

The 3 year old ginseng field had a more obvious water deficit than the 2 year old and seedling fields, which was expected due to their differences in size. The 3 year old field had multiple occasions where the water deficit passed the permanent wilting point, particularly throughout the month of June (Figure 21). There were 5 consecutive readings below the permanent wilting point from June 11th – 23rd. Even though ginseng does not require much water, being below the permanent wilting point for a prolonged period (in this case 13 days) may not be desirable. The water deficit improved following the intermittent precipitation in the week of June 30th – July 7th. The water deficit began to increase after July 9th but the intense rain events starting at end of July brought readings clear of the permanent wilting point for the rest of the season.

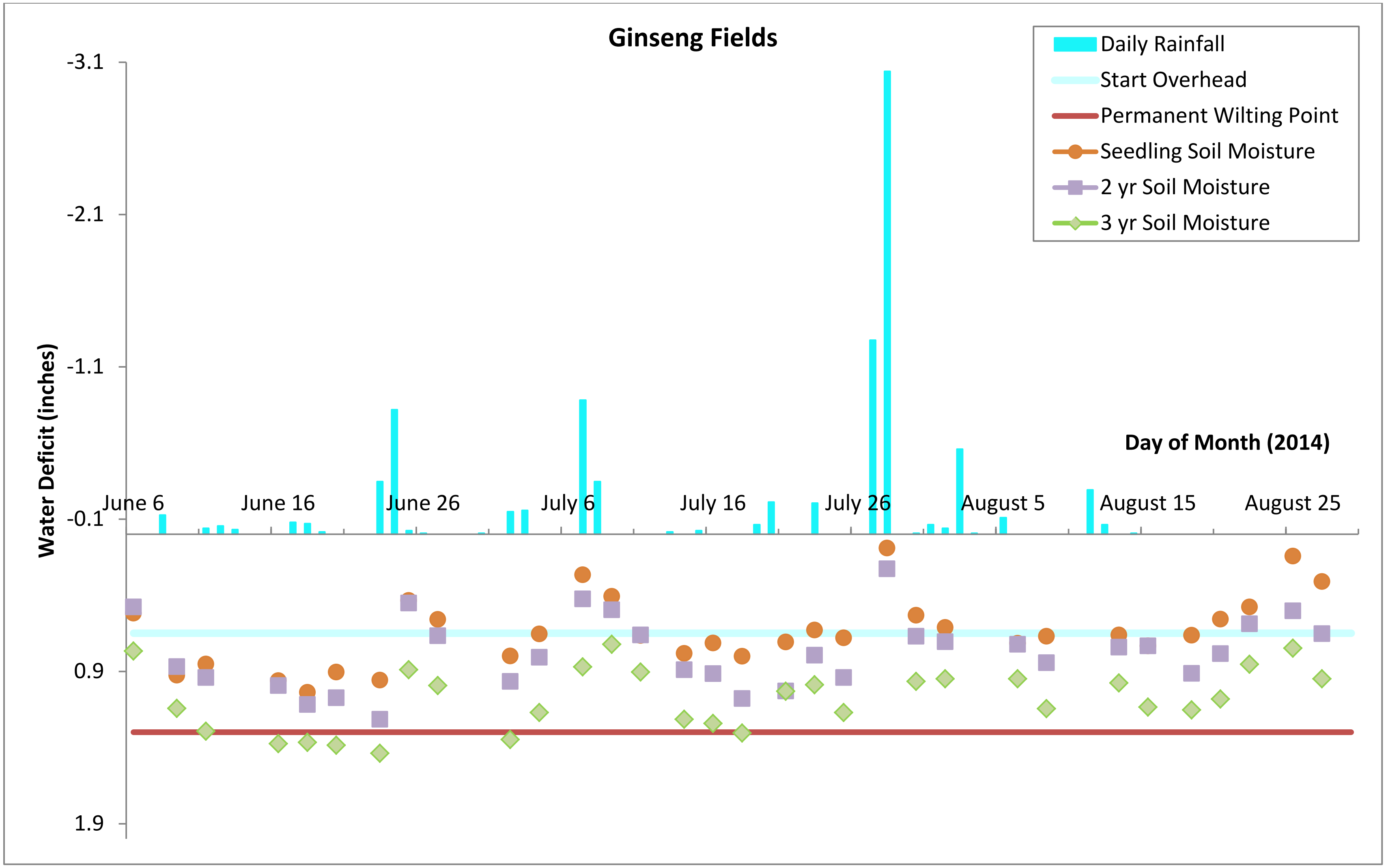

Figure 21 Soil moisture recordings for seedling, 2 year and 3 year old ginseng fields from June – August, 2014.

The soil moisture values represent an average of 9 measurements taken between 3 rows with spacing of 2 rows between each. We recommend that irrigation begin when a water deficit of 0.65 inches is met (blue line). The permanent wilting point occurs at a deficit of roughly 1.3 inches (red line). The blue column represents the daily rainfall collected at the Burford Tree Nursery.

Case Study #7: Tomato Fields

The soil moisture of mulched and non-mulched tomatoes was monitored once again in 2014 (Figure 22). Throughout the majority of the growing season, the tomato field without mulch fluctuated between the irrigation reference line and the permanent wilting point, with a few occasional rises towards field capacity following intense rains (Figure 23). At the beginning of August there was a rapid increase in water deficit following the extreme rainfall on July 28th, and it did not improve until the last few weeks of the month. From August 17th on, we see the climb back towards field capacity just in time for harvest time. Although this season was relatively 'wet', this field was kept closer to the permanent wilting point than to field capacity and could have been irrigated more often.

Figure 22 Tomatoes with plastic mulch (left) and without (right).

The tomato field with mulch was regularly between the irrigation reference line and the permanent wilting point for the 2014 season. The mulched fields had great improvements in water deficit in the last few weeks of August before harvest time and maintained low water deficit levels above the ideal drip irrigation reference line.

The 2014 data actually suggests that about two-thirds of the time the mulched field had a greater water deficit than the field without mulch - the opposite trend the 2013 data showed. This difference is likely due to the irrigation routine between the two systems (not irrigating with the drip system as frequently as with the overhead system). In addition, the mulched tomato plants were growing at a much faster rate than those without mulch which also contributed to a great water demand in the mulched fields. Once the mulched and non-mulched fields reached the same plant stage the differences between their water deficits became unnoticeable.

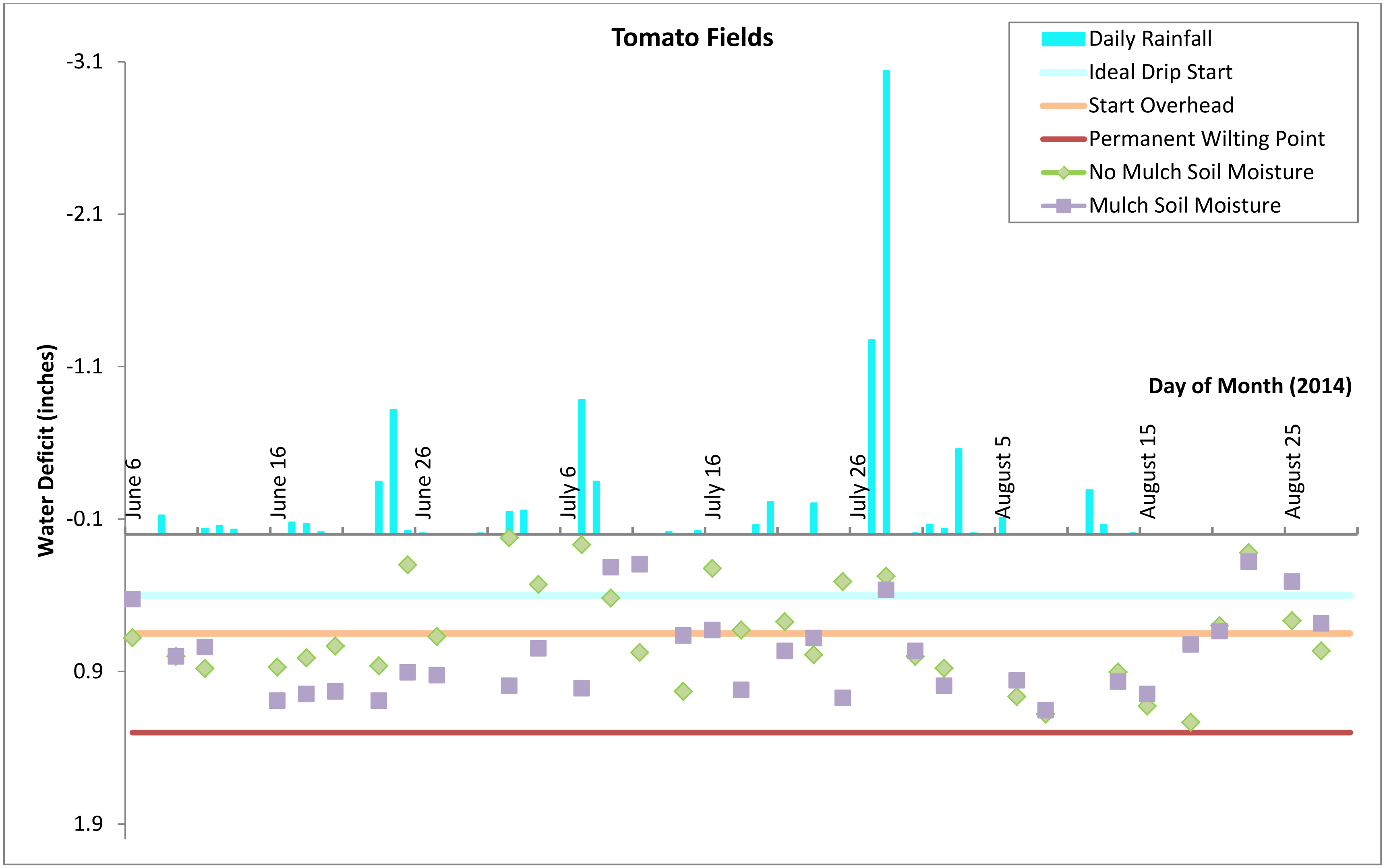

Figure 23 Soil moisture recordings for plastic mulched and non-mulched tomato fields from June – August, 2014.

The soil moisture values represent an average of 9 measurements taken between 3 rows with spacing of 2 rows between each. We recommend that irrigation begin when a water deficit of 0.65 inches is met (orange line). The permanent wilting point occurs at a deficit of roughly 1.3 inches (red line). The blue column represents the daily rainfall collected at the Burford Tree Nursery.

Case Study #8: Pepper Field

The soil moisture in the mulched peppers (Figure 24) monitored in 2014 fluctuated between the ideal drip start and the permanent wilting point for the majority of the season and was influenced by trends in precipitation (Figure 25). Throughout the whole season the pepper field did not get too close to the permanent wilting point. Like the tomato fields, this field could have been irrigated more often as ideally you want to have the soil moisture above the irrigation reference line all season long. That being said, in the latter half of August the soil moisture was more consistently near the irrigation reference line, fluctuating on the other side of the line towards field capacity, which is an ideal trend. The last few weeks also maintained a water deficit close to zero which is excellent for harvest time.

Figure 24 Peppers with plastic mulch.

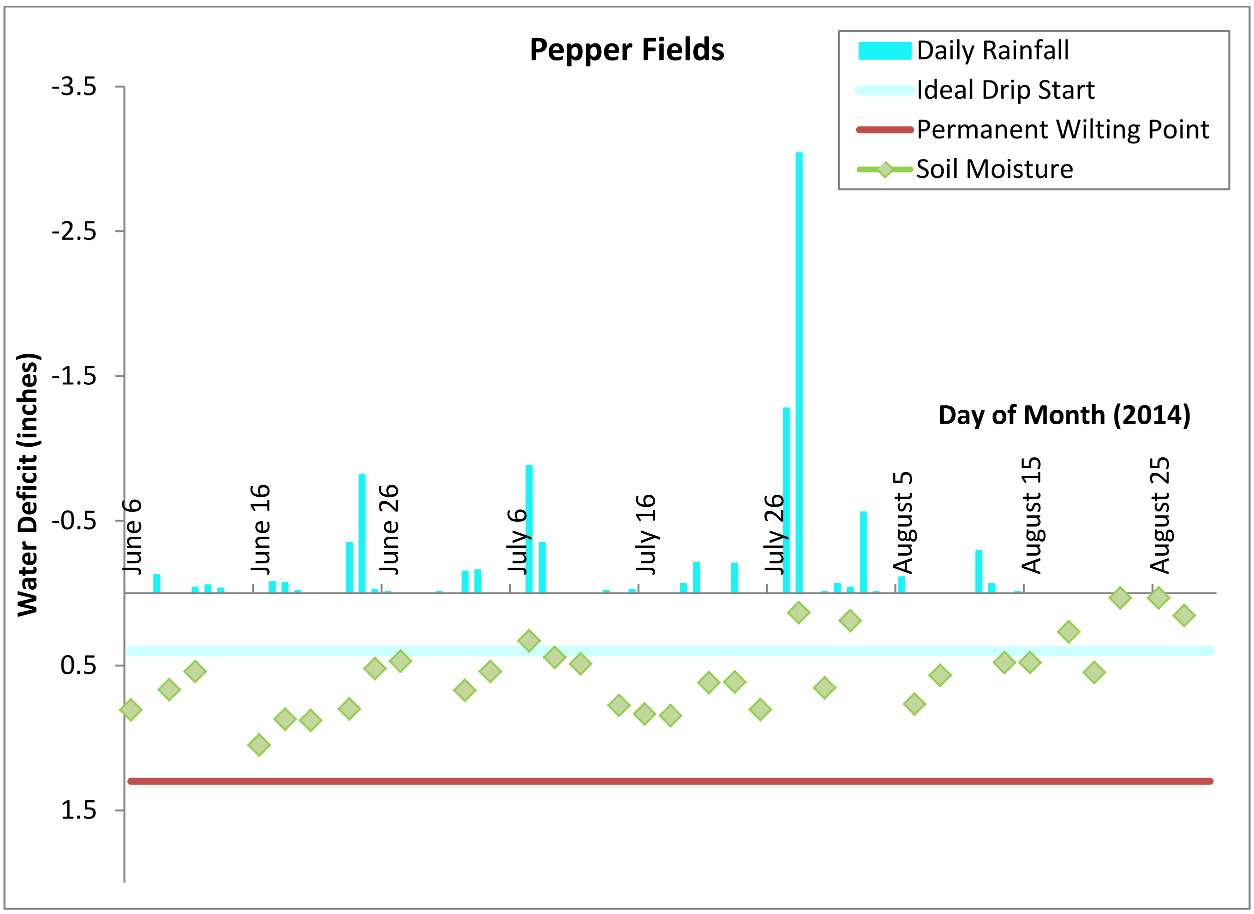

Figure 25 Soil moisture recordings for pepper field with plastic mulch from June – August, 2014.

The soil moisture values represent an average of 9 measurements taken between 3 rows with spacing of 2 rows between each. We recommend that drip irrigation (blue line) begin when a water deficit of 0.4 inches is met. The permanent wilting point occurs at a deficit of roughly 1.3 inches (red line).The blue columns represent the daily rainfall collected at the Burford Tree Nursery.

Case Study #9: Tobacco Field

The soil moisture of the tobacco field was great until June 27th when the water deficit started to fluctuate between the irrigation reference line and the permanent wilting point (Figure 26). With very few occasions the water deficit neared the permanent wilting point on July 14th and August 8th. Since most readings in July were below the irrigation reference line (except following rain events) irrigation could have commenced earlier than scheduled. Irrigating more frequently (and fewer inches per application) may have prevented the initial drop in soil moisture in August and prevented the need to catch up from the deficit throughout the rest of the season. The improvements in water deficit in the last week of August were a great way to end the season and get ready for harvest.

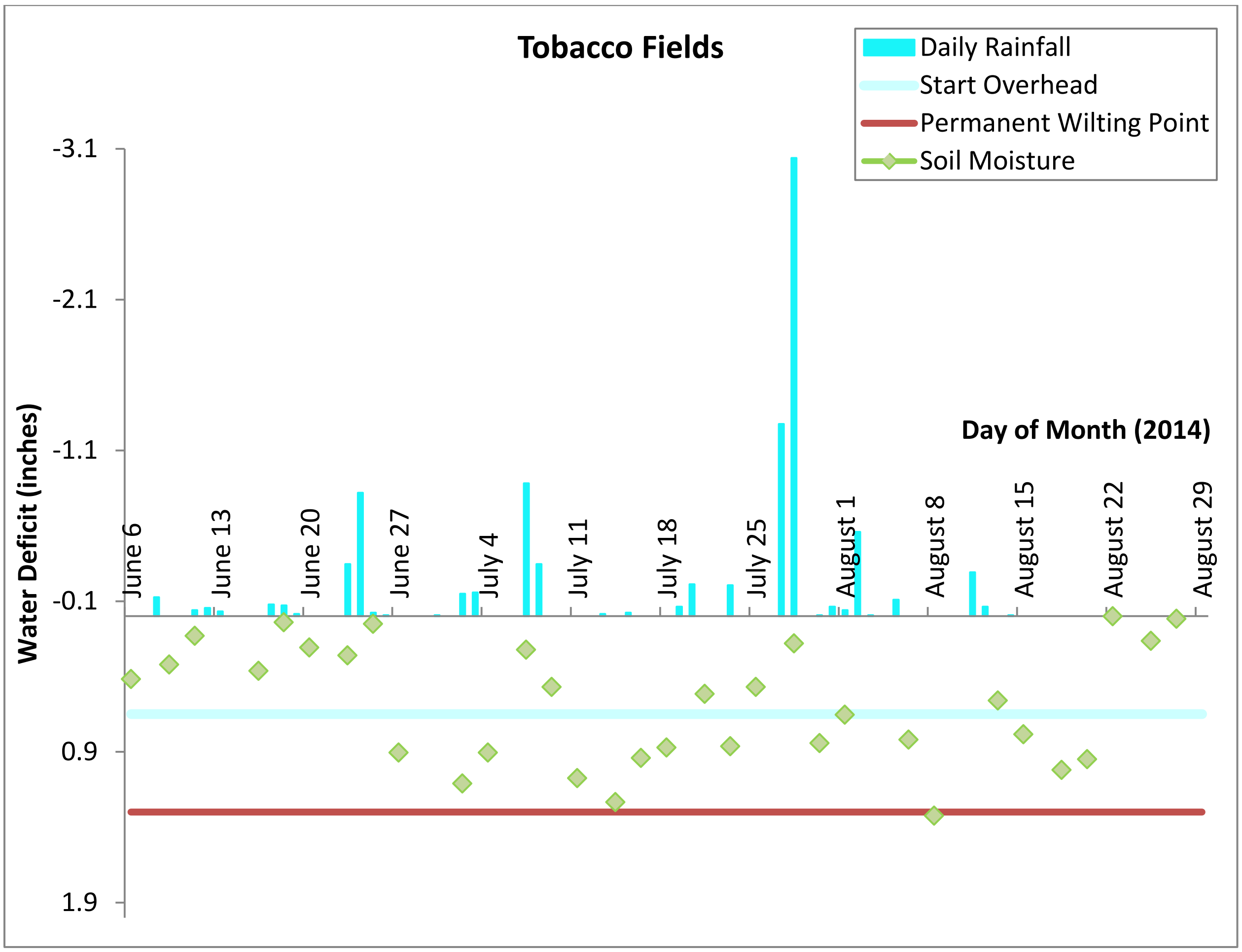

Figure 26 Soil moisture recordings for the tobacco field from June – August, 2014.

The soil moisture values represent an average of 9 measurements taken between 3 rows with spacing of 2 rows between each. We recommend that irrigation begin when a water deficit of 0.65 inches is met (blue line). The permanent wilting point occurs at a deficit of roughly 1.3 inches (red line). The blue columns represent the daily rainfall collected at the Burford Tree Nursery.

Case Study #10: Sweet Potato Field

The sweet potato field had consistently excellent soil moisture throughout the entire growing season. This field had not once passed the irrigation reference line (Figure 27), meaning it did not require any additional irrigation as the plants had sufficient water to grow at their maximum potential.

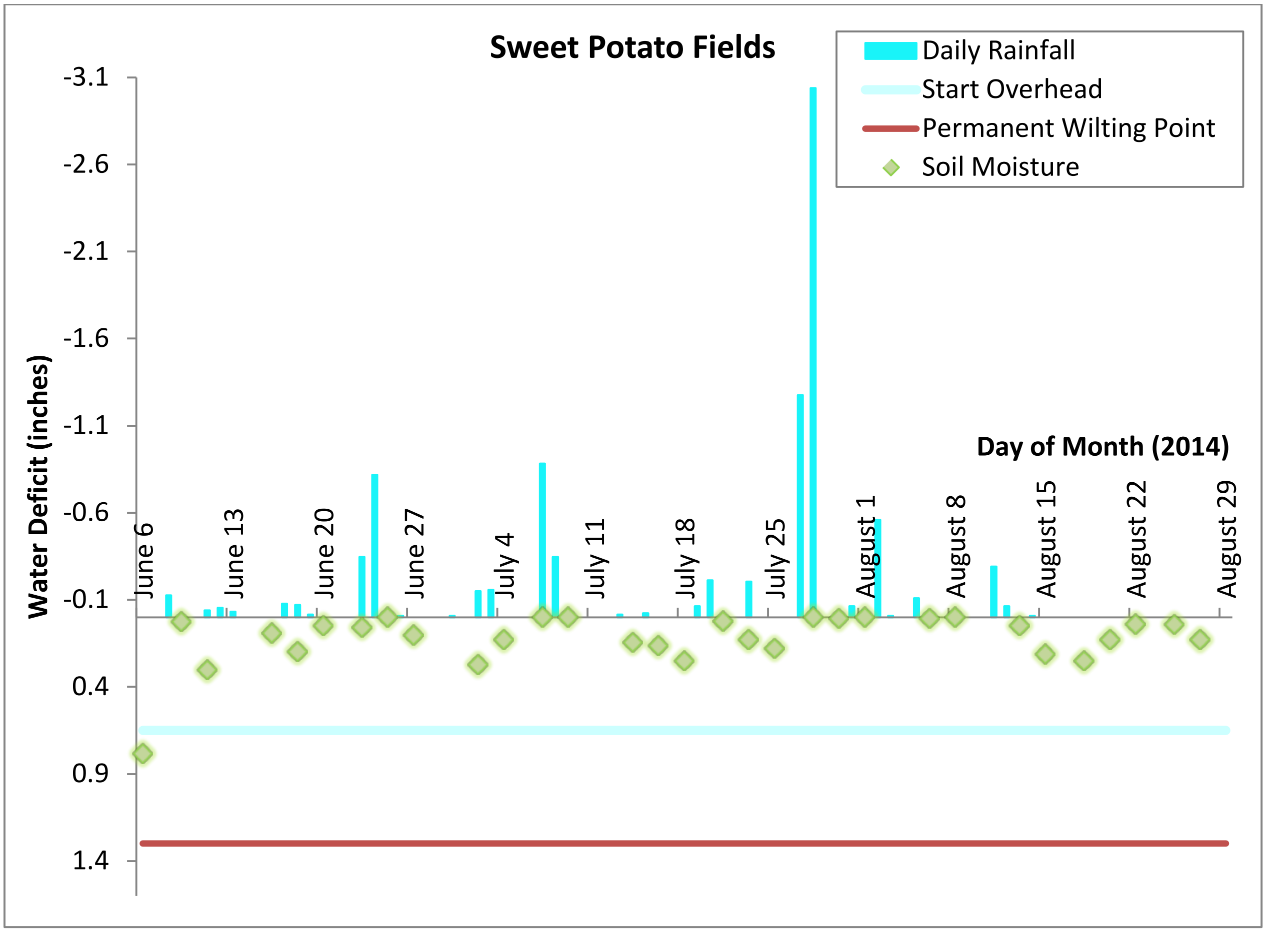

Figure 27 Soil moisture recordings for the sweet potato field from June – August, 2014.

The soil moisture values represent an average of 9 measurements taken between 3 rows with spacing of 2 rows between each. We recommend that irrigation begin when a water deficit of 0.65 inches is met (blue line). The permanent wilting point occurs at a deficit of roughly 1.3 inches (red line). The blue columns represent the daily rainfall collected at the Burford Tree Nursery.

Case Study #11: Potato Field A

Potato field A did not have ideal soil moisture conditions over the course of the summer. The water deficit was repeatedly below the irrigation reference line, with regular occurrences crossing the permanent wilting point and rare sightings above the irrigation reference line (Figure 28).

This potato field experienced a dry-spell for the bulk of July as the water deficit was typically at or below the permanent wilting point. Having the soil moisture at this level for a prolonged time can be damaging to both the quality and yield of the crop. By mid-August some improvements occurred, but only to improve the water deficit closer to the irrigation reference line before dropping towards the permanent wilting point once again. Since the soil moisture was less-than-optimal throughout the growing season, for succeeding years irrigating more frequently may improve the yield of this field as well as eliminating the need to play catch up for the rest of the season.

These high water deficit trends may have occurred because the irrigation pond being used had a very slow recharge rate. To avoid waiting longer between large irrigation events, it is recommended to irrigate smaller quantities more frequently as soon as the soil moisture probe reads a water deficit greater than 0.65".

Case Study #12: Potato Field B

Potato Field B was interesting to monitor because half of it had been planted with a winter radish as a trial cover crop to see if it would help improve soil moisture for the 2014 growing season. Interestingly, the cover crop section of the field actually had greater water deficit readings and thus lower soil moisture levels than the non-cover crop section (Figure 28).

The section of the potato field without cover crop fluctuated in water deficit readings between the irrigation reference line and field capacity. Having minimal water deficit is great because the soil rarely got dry enough to need additional irrigation. In fact, the water deficit only crossed the start irrigation reference line on August 17th and 19th (Figure 28).

The section of the potato field that had the winter radish cover crop had less dramatic fluctuations in soil moisture but did not give consistent readings over the long-term. The cover crop field actually had greater water deficit that regularly bordered the irrigation reference line. The site also gave several readings closer to the permanent wilting point when compared to the site without cover crop.

Much of these differences may be due to natural variations between the soil types of the sites (even though the fields are side by side) or irrigation inefficiencies (the cover crop section of the field is located at the edge of the center pivot irrigation system). Even though the differences between the cover crop and non-cover crop field were not very different, we would have expected to at least seen some increase in water retention. It cannot be concluded whether the field differences are due to the cover crop because the irrigation patterns and soil types could also be different. We were unable to determine whether the winter radish improved the soil moisture of these potato fields; further research is needed.

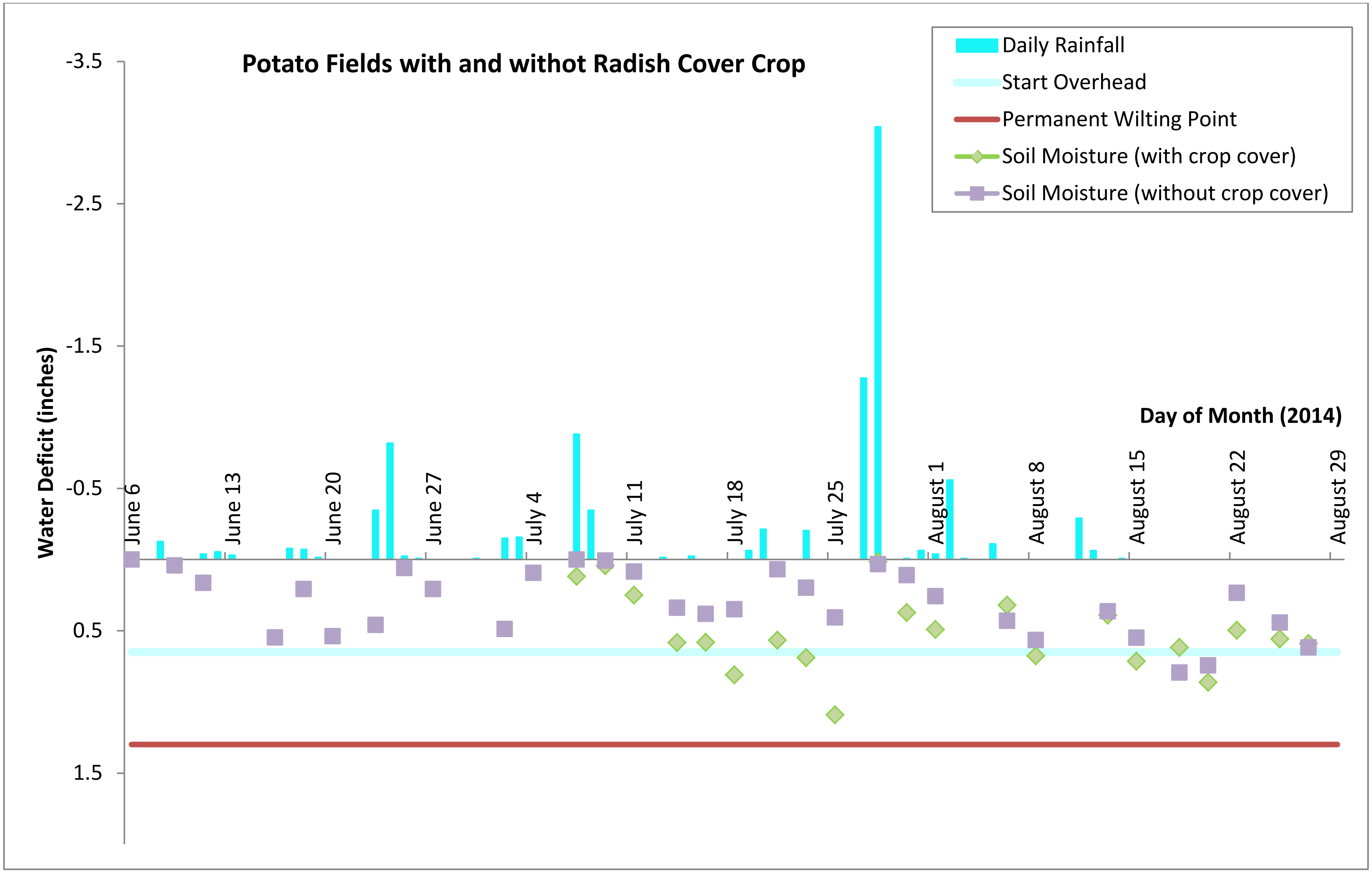

Figure 28 Soil moisture recordings for a potato with and without cover crop from June – August, 2014.

The soil moisture values represent an average of 9 measurements taken between 3 rows with spacing of 2 rows between each. We recommend that irrigation begin when a water deficit of 0.65 inches is met (blue line). The permanent wilting point occurs at a deficit of roughly 1.3 inches (red line). The blue columns represent the daily rainfall collected at the Burford Tree Nursery.

Case Study #13: Tobacco Field

Throughout the growing season, the soil moisture in the tobacco field was kept at a great level as it fluctuated between the start irrigation reference line and field capacity (23% VWC) (Figure 29). The readings passed the irrigation reference line on 6 occasions throughout the season but were restored back to field capacity quite quickly. The readings only came close to the permanent wilting point on July 14th and August 11th. The tobacco field had good soil moisture content throughout the season seeing as readings did not surpass the irrigation reference line too often and for too long.

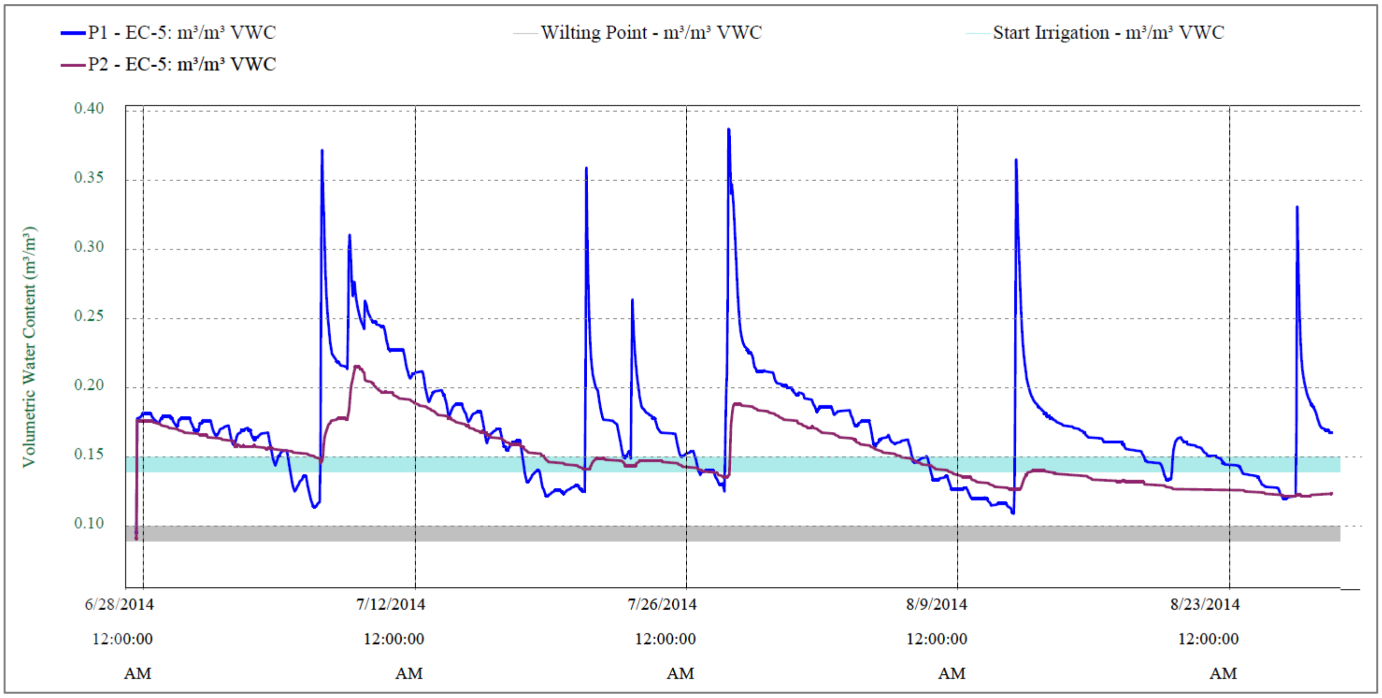

Figure 29 Continuous soil moisture monitoring for a tobacco field from June – August, 2014.

P1 – 10" probe P2 – 20" probe. The soil moisture values represent an average of 9 measurements taken between 3 rows with spacing of 2 rows between each. We recommend that irrigation begin when a water deficit of 15% VWV is met (blue line). The permanent wilting point occurs at a deficit of roughly 10% VWV (grey line).