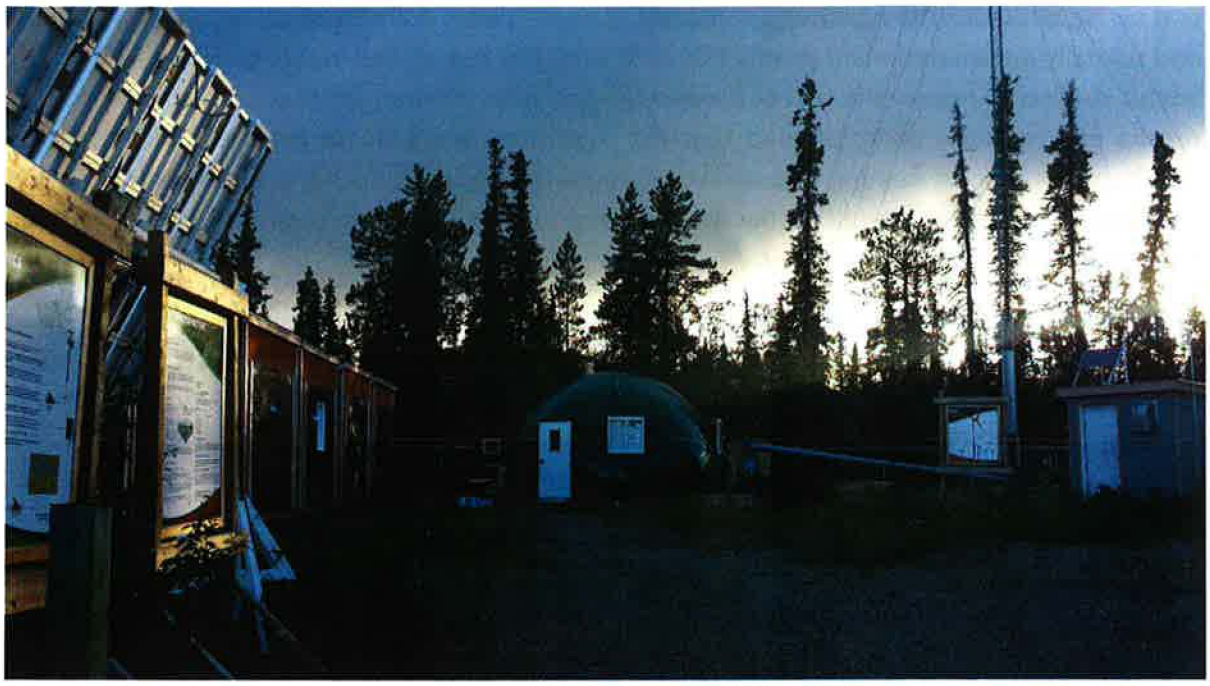
AgriDome Operations & Best Practices, Summer 2015



A report by Glenn J. Scott, Founder of Agri-Arctic Yukon Inc. to Yukon Agriculture

Revision 1.1

Submitted February 1st, 2016

Summary

To address the need for productive, year-round food production systems in remote, northern communities, the 'AgriDome Feasibility Study' was conducted at Yukon College during the winter and spring of 2015. The AgriDome consisted of an insulated dome, vertical aeroponics systems and partially automated plant production that aimed to reduce the inputs of power, water and labour in order to reduce the cost of producing vegetables in harsh, northern environments. The results of this study demonstrated that the AgriDome was able to exceed expectations by significantly reducing heating and water expenditures while producing a variety of plants and vegetables. However, overall productivity needed to be improved in order to demonstrate the feasibility of the AgriDome systems.

With support from Yukon Agriculture's 'Growing Forward2' program, continued support from Yukon Research Centre – Cold Climate Innovation and contributions from Agri-Arctic, this study continued until January 31st, 2016. The objective of this phase of the feasibility study was to improve practices and continue to develop the AgriDome's systems to boost productivity to acceptable levels.

Improvements were made to the grow unit, the computer interface, the lighting system and the organization of work that made significant progress towards reducing inputs and improving productivity. Although productivity was still too low to justify the cost of production, simple improvements will be made to the AgriDome's systems over the course of further research and development that are likely to continue to improve productivity.

Strategies

Vertical Grow Unit

Figure 1 Side view of the old grow unit.

The vertical grow unit that was used during the initial feasibility study was based on low pressure aeroponics and the use of PVC pipes that had been cut in half and lined with reflective tape to provide a growing surface for the plants. I was felt that the use of reflective, hemispherical surfaces would improve heating and lighting efficiency by focusing short and long wave energy directly onto the plants. However, this design proved to be difficult to clean, did not provide for enough plants to be grown and was

Figure 2 The new grow unit.

prone to leaks (figure one). As well, the dome was already exceeding heating efficiency expectations and the plants were already receiving enough heat. Thus, a new design was constructed that utilized flat surfaces, smaller plant pots that allowed for up to 1100 plants to be grown and eavestroughing to effectively channel water back into the reservoirs (figure two).

Computer Interface & Planting Organization

Online data collection and archiving had been established earlier in this project. *LoggerNet* software was purchased through Campbell Scientific that significantly improved automated data collection and the display of key measurements in the AgriDome. Password protected web pages were developed that allowed for the real-time display of these measurements to dome users. Algorithms were developed in PHP that allowed the display of 'flags' when problems were encountered. As well, simple scheduling and inventory management systems were added to these pages to improve organization and work flow.

Lighting System

Figure 3 HPS lamp positioned in front of side of grow unit. Increases in productivity were immediately noticeable with the repositioning of the lights..

Initially, 1400 W of HPS lights were used which were mounted on the top of each side of the grow unit for plant production. Plant growth was slower than expected and, because the lights were mounted directly above the plants as opposed to directly in front of them, significant gradients were observed with the plants at the bottom of the grow unit clearly not receiving enough light. More lights were purchased to provide up to 2200 W of light. Importantly, these lights were mounted directly in front of the sides of the grow unit to reduce lighting gradients and improve plant production at lower heights (figure three).

Misting System (Internal & External)

Figure 4 Interior misting system for old grow unit.

The original grow unit used a system of PEX pipes to spray the plant roots with water and nutrient solution (figure four). This was a significant cause of leaks, the nozzles were prone to clogging and the spray tended to be very uneven. Therefore, a new system was constructed that was based on hydroponics and channeled water down the inside of the grow racks (figure five). This water was then collected at the bottom of the racks and allowed to drained back into the reservoirs.

An external misting system was planned for this phase of the feasibility study but could not be realized due to the new position of the HPS lights.

Results

Grow Unit, Hydroponics and Plant Productivity

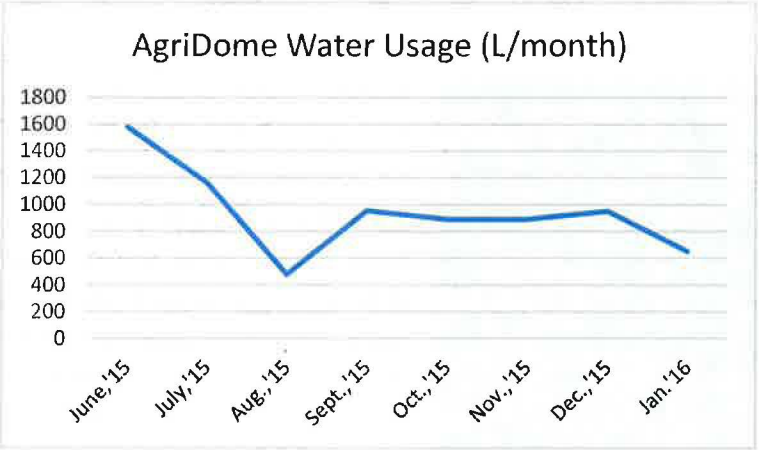


Chart 1 Fewer plants were being grown during June and July. The decrease in water usage during August, 2015 was due to the construction of the new grow unit. Lower water usage was observed during the last four months of this project with more plants growing.

The new design for the grow unit proved to be a significant improvement; Leaks were halted, water usage decreased and the plants were evenly watered (chart one). The new system was fully operational by October and large increases in plant productivity were observed (table one). The plants were much healthier and robust leaf, root and stem development were noted (figures five & six). As well, the new system allowed for better organization of different crops which facilitated the production of key crops including red russian kale, swiss chard, a variety of lettuces, cinnamon and dolly basil, hungarian cheese peppers and manitoba bush tomatoes.

Lighting System

Figure 5 Leaf size and structure of swiss chard, red Russian kale and cinnamon basil improved significantly in the new grow unit.

The 2200 W lighting system worked very well and only a moderate increase in power usage was noted (chart two). In terms of plant productivity, this amount of light is adequate for 1100 plants in a highly reflective dome structure and the previously observed growth gradient was greatly reduced.

Computer Interface and Work Organization

The new computer interface was successful at improving 'situational awareness' and the organization of work. This proved critical to the development of planting strategies and effective communication with a research technician who had been provided by YRC – CCI to assist with this project for part of the summer. Importantly, the real-time interface also improved the security of the AgriDome by allowing users to monitor it at any time of the day.

Figure 6 Prolific root development was observed; Roots often exceeded 2 m in length. Mature stems of cinnamon basil exceeded 1 cm in diameter.

Humidity and the Dome

A condensation problem developed during the onset of winter that resulted in puddles on the floor of the dome and unusual amounts of ice forming on the door. The puddles were the result of an ineffective vapour barrier that was allowing humid air to flow past the insulation and form frostings on the interior of the dome shell which would melt during warming events. Icings formed on the external door for a similar reason because the internal door that was not airtight. However, this problem was mitigated by recovering the water from the dehumidifier and adding back into the water distribution system. This allowed the dehumidifier to operate indefinitely without the risk of filling its own reservoir and failing.

The Use of Peat Plugs and an Early End to Production

Vegetable production was planned during the last part of this study. However, peat plugs rather than rockwool were used for a crop cycle at the beginning of January in the hopes of reducing costs. When the peat plugs were installed in to the grow unit, an infestation of white fungus almost immediately appeared (<12 hours) which took two weeks to remediate with anti-fungal spray. The plants recovered but at least two weeks of production were lost which meant that they would not be able to fruit by the agreed upon deadline of January 31st.

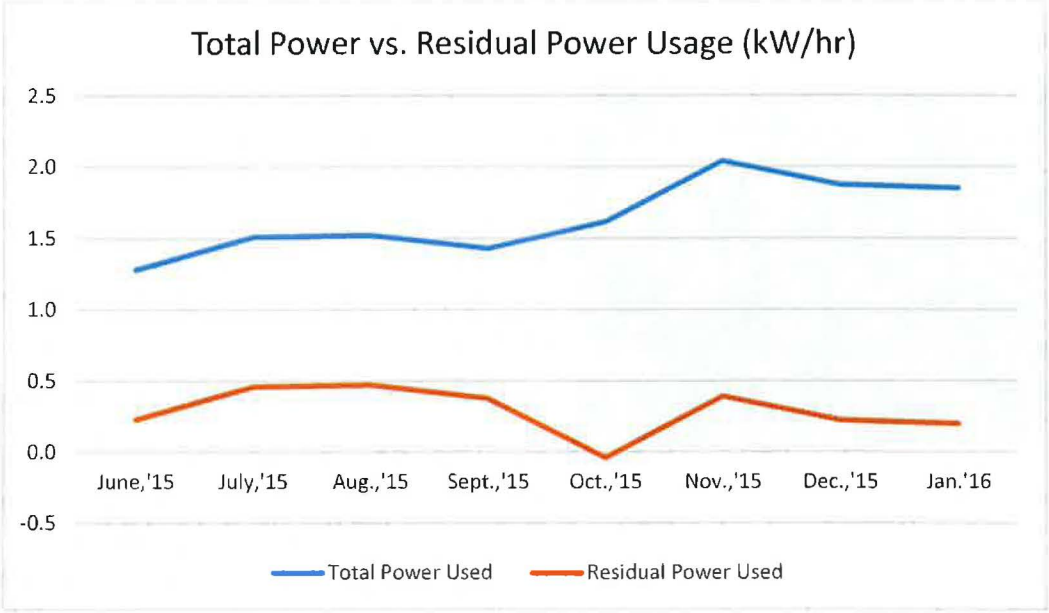


Chart 2 The total power used by the AgriDome over the course of the project was usually below 2.0 kWhr continuous. Residual power used was calculated by subtracting the known draw of the lights (1400 W during the first half of the project and 2200 W during the last half) from the total power used. Residual power reflects the draw of all other equipment including the HVAC unit. The addition of the extra lights only added approximately 0.5 kWhr to the total power used and reduced the residual power usage by approximately 0.25 kWhr.

Analysis

What was grown and when?

Prior to October, 2015 a number of different leafy greens, tomatoes and peppers were successfully grown. However, with changes to the systems and generally low rates of production, it was difficult to properly track their productivity. Starting in October, the new management tools available on the website that assisted with the organization of carefully monitored crop cycles using key species. The strategy was to plant leafy greens such as red Russian kale, Swiss chard and cinnamon basil first, monitor the performance of the system and then proceed to fruiting vegetables such as peppers and tomatoes. Daily productivity for each species was calculated by dividing the harvest yield by the number of days between planting and harvest thus resulting in productivity estimates of grams/day (Appendix A). This was then cross referenced with the measured inputs of electricity, water, nutrients and labour to generate a 'cost of production' for each successfully grown species.

What were the inputs?

Over the course of this phase of the project, all inputs of power, water, nutrients and labour were carefully monitored, recorded and analyzed (table one). These were subsequently converted into dollar values based on costs that are typical in the Yukon.

Month	Monthly Tot. kWhr Used:	Monthly Total Water Used (L):	Monthly Total Labour Used (hr):	Daily Avg, kWhr Used:	Daily Cont. kW/hr Used:	Res. Power Usage (kWhr):	Daily Average Water Used (L):	Daily Average Labour Used (hr):
June,'15	923	1582	27	30.8	1.3	0.2	52.7	0.90
July,'15	1126	1160	20	36.3	1.5	0.5	37.4	0.65
Aug.,'15	1097	478	20	36.6	1.5	0.5	15.9	0.67
Sept.,'15	1064	955	23	34.3	1.4	0.4	30.8	0.74
Oct.,'15	1202	890	21.5	38.8	1.6	0.0	28.7	0.69
Nov.,'15	1470	891	22.5	49.0	2.0	0.4	29.7	0.75
Dec.,'15	1395	950	21.5	45.0	1.9	0.2	30.6	0.69
Jan.'16	1155	650	20.5	44.4	1.9	0.2	25.0	0.79

Table 1 ***Measured inputs****. Power was recorded with a standard household meter, water was measured by observing the level in the storage tank and labour was carefully recorded on the web-based management system. Residual power was calculated by subtracting the known power usage of the lights from the measured power usage; Therefore, the residual represents the power that was used by all other AgriDome Systems including the HVAC, pumps and monitoring system.*

What did the inputs cost and what was the resulting cost of production for different species?

Daily productivity was calculated only for red Russian kale, cinnamon basil and swiss chard over the final half of this project because they were the most productive. Each productivity value (appendix A) was upscaled to 1100 plants to reflect the maximum monthly productivity that would be available if the entire grow unit was producing that particular crop. The total dollar value of the inputs as documented in Table One was divided by the total expected yield for each species to generate a $/kg value (table two). Each of the values is well in excess of the typical market value for each of these species; For instance, the present price/kg for kale at the Iqaluit Northern grocery store is $5.85/kg which suggests that future improvements will be required to commercialize the AgriDome system.

	Power	Water	Labour	Supplies*	Total:	Kale	Sw. Chard	Cin. Basil
Oct.	$ 116.32	$ 43.04	$ 249.68	$ 100.00	**$ 509.04**	$ 13.01	$ 10.95	$ 15.66
Nov.	$ 147.00	$ 44.55	$ 270.00	$ 100.00	**$ 561.55**	$ 14.35	$ 12.08	$ 17.28
Dec.	$ 135.00	$ 45.97	$ 249.68	$ 100.00	**$ 530.65**	$ 13.56	$ 11.42	$ 16.33
Jan.	$ 133.27	$ 37.50	$ 283.85	$ 100.00	**$ 554.62**	$ 14.18	$ 11.93	$ 17.06

Table 2 ***Cost of Production****. Supplies are an estimation of the cost of nutrients, pH solutions, rockwool and cleaning supplies.*

Lessons & Future Direction

Although the productivity results were too low compared to the cost of production, there are relatively simple improvements that will be made to these systems that will aid in the commercialization potential of this technology. They include:

- ***The development of an improved grow unit***: Although the grow unit that was developed during this study was a significant improvement over the previous model, there are still a number of simple modifications that can be made to it. Future developments will include the use of custom designed flow channels, a proper filtration system, reduced light into the reservoirs and a modularized 'slat' system to accommodate the production of different vegetable and root crops. However, the basic design has shown great promise and will remain largely the same.
- ***The use of spray foam insulation***: The problems that were encountered with the vapour barrier can be eliminated with the use of a preformed, modularized foam insulation system that can be installed on the inside of the dome shell. This will prevent humid air from coming into contact with cold surfaces and provide an excellent opportunity to recover most of the water from evapotranspiration.
- ***Improved pest & pathogen protocols***: Peppers and tomatoes had been successfully grown in the AgriDome earlier in the summer, but it was very disappointing to not be able to productively grow vegetable crops due to the inadvertent introduction of a fungus. This fungus was the direct result of the introduction of peat plugs into this system. Therefore, no further potentially living organisms can be introduced into a controlled-environment agricultural system and rockwool cubes will continue to be used despite their higher cost.

Appendix A

Crop Cycles

Crop Number:	Species:	Starting Count:	Date Germinated:	Tray:	Seedlings Survived:	Date Planted:	Rack #:	Harvest Weights (g):	Final Harvest:	Productivity (g/day):
1	Swiss Chard	120	20150920	1	116	20151005	1	6353	20151206	154.95
2	Basil (Cinnamon)	120	20150920	2	120	20151005	3	3966	20151225	48.96
3	Basil (Cinnamon)	120	20150920	3	110	20151005	8	8776	20160126	108.35
4	Kale (Red Russian)	60	20151013	1	60	20151101	2	987	20151225	18.28
5	Kale (Red Russian)	60	20151013	2	59	20151101	2			
6	Basil (Dolly)	60	20151013	3	55	20151110	6	3156	20151225	70.13
7	Basil (Dolly)	60	20151013	4	56	20151110	6			
8	Lettuce (Grand Rapids)	60	20151020	6		20151110	4	413	20151224	9.39
9	Lettuce (Grand Rapids)	60	20151024	8		20151110	5	248	20151224	5.64
10	Lettuce (Grand Rapids)	60	20151024	10		20151110	7	332	20151225	7.38
11	Kale (Red Russian)	60	20151111	2	53	20151126	3	7955	20160126	130.41
12	Kale (Red Russian)	60	20151111	7	52	20151126	3		20160126	
13	Lettuce (Drunken Woman)	60	20151110	4	30	20151209	1	310	20160107	10.69
14	Peppers (Hungarian Cheese Blend)	60	20151110	3	33	20151213	4	D	20160126	
15	Basil (Cinnamon)	60	20151111	1	55	20151213	6	2786	20160126	63.32
16	Assorted flowers	24	20151111	9		20151213	4	Successful	20160126	
17	Kale (DarkiborF1)	50	20151111	5	35	20151225	6	521	20160126	16.81
18	Tomato (MB Bush)	49	20151225	8	48	20160107	7	D	20160126	
19	Peppers (Hungarian Cheese)	50	20151225	1	44	20160107	4	D	20160126	
20	Swiss Chard (Magenta Sunset)	50	20151225	4		20160107	8	D	20160126	
21	Lettuce (Darkness)	60	20151225	9		20160107	8	D	20160126	
22	Swiss Chard (Magenta Sunset)	50	20151225	10		20160107	8	D	20160126	
23	Lettuce (Darkness)	50	20151225	2		20160107		D	20160126	
24	Lettuce (Grand Rapids)	60	20151020	5	D					
25	Lettuce (Grand Rapids)	60	20151024	7	D					
26	Lettuce (Grand Rapids)	60	20151024	9	D					

Appendix B

Total Project Expenditures (May 23rd to January 26th, 2016)

AgriArctic Yukon Inc.

Itemized Research Expense Report

May 21, 2015 to January 26, 2016

Vendor	Date	Type of Expenditure	Vendor Subtotals	Amount
Ajax Steel	2015-05-27	Building Supplies		98.08
Ajax Steel	2015-07-02	Building Supplies		68.83
Ajax Steel	2015-08-04	Aeroponics Supplies: Aluminum for grow unit		14.12
Ajax Steel	2015-09-18	Aeroponics Supplies: Aluminum for grow unit		68.33
Ajax Steel	2015-09-29	Aeroponics Supplies: Aluminum for grow unit		45.19
Ajax Steel Subtotal			**294.55**	
Allied Electronics	2015-05-29	Electrical: Relay		75.32
Allied Electronics	2015-10-10	Electrical: Current Shunt		241.88
Allied Subtotal			**317.20**	
Campbell Scientific	2015-06-18	Monitoring and Control Equipment: Software		818.20
Campbell Scientific Subtotoal			**818.20**	
Canadian Tire	2015-06-02	Aeroponics Supplies: Pipe		4.81
Canadian Tire	2015-06-15	Plant Supplies: Plastic Plant Trays		18.81
Canadian Tire	2015-06-16	Plant Supplies: Flats and Seeds		38.47
Canadian Tire	2015-06-23	Aeroponics Supplies: Aluminum Angle for Grow Unit		5.55
Canadian Tire	2015-06-24	Aeroponics Supplies: Drum and Sleeve Set		18.75
Canadian Tire	2015-07-06	Aeroponics Supplies:		18.67
Canadian Tire	2015-07-06	Aeroponics Supplies: Steel Wool		5.24
Canadian Tire	2015-07-06	Aeroponics Supplies: Brushes and Flats		46.45
Canadian Tire	2015-07-09	Aeroponics Supplies		16.78
Canadian Tire	2015-07-14	Safety Glasses		7.34
Canadian Tire	2015-07-29	Aeroponics Supplies:PVC Pipe, Aluminum & Plants		28.02
Canadian Tire	2015-07-29	Aeroponics Supplies: Aluminum Flats		16.79
Canadian Tire	2015-08-04	Plumbing: Mechanical Float Switch for Grow Unit		41.99
Canadian Tire	2015-08-07	Aluminum for Grow Unit		16.76
Canadian Tire	2015-09-10	Plumbing: Sprinkler		47.87
Canadian Tire	2015-09-14	Plumbing: Hose for Grow Unit		51.44
Canadian Tire	2015-10-01	U Bolts for Grow Unit		28.22

Canadian Tire	2015-10-13	Electrical Supplies: Wire		56.67
Canadian Tire Subtotal			**468.63**	
Caps and Plugs Calgary	2015-08-11	Caps for Grow Unit		416.85
Caps and Plugs Calgary Subtotal			**416.85**	
General Waste Management	2015-06-05	Water Delivery		285.00
General Waste Management	2015-08-31	Water Delivery		253.00
General Waste Mgmt Subtotal			**538.00**	
Great Canadian Dollar Store	2015-06-29	Measuring Cups and Safety Gloves		10.50
Great Canadian Dollar Store	2015-09-11	Vinyl gloves for Cleaning		9.98
Great Cdn Dollar Store Subtotal			**20.48**	
Jon's Plant Factory	2015-09-14	Aeroponics Supplies: Lighting		515.84
Jon's Plant Factory Subtotal			**515.84**	
Keir Hyde	2015-08-01	Dome Rental		500.00
Keir Hyde	2015-09-01	Dome Rental		500.00
Keir Hyde	2015-10-01	Dome Rental		500.00
Keir Hyde	2015-11-01	Dome Rental		500.00
Keir Hyde	2015-12-01	Dome Rental		500.00
Keir Hyde	2016-01-01	Dome Rental		500.00
Keir Hyde Subtotal			**3000.00**	
Porter Creek Indoor Garden Centre	2015--05-28	Plant Supplies: Nutrient		62.25
Porter Creek Indoor Garden Centre	2015-06-01	Plant Supplies		18.76
Porter Creek Indoor Garden Centre	2015-06-08	Plant Supplies: Rockwool		154.82
Porter Creek Indoor Garden Centre	2015-06-08	Plant Supplies		14.20
Porter Creek Indoor Garden Centre	2015-06-15	Plant Supplies		26.73
Porter Creek Indoor Garden Centre	2015-06-16	Plant Supplies		58.33
Porter Creek Indoor Garden Centre	2015-06-18	Plant Supplies		16.61
Porter Creek Indoor Garden Centre	2015-06-29	Plant Supplies		114.62
Porter Creek Indoor Garden Centre	2015-07-09	Plant Supplies: Nutrient		57.00
Porter Creek Indoor Garden Centre	2015-07-20	Plant Supplies: Nutrient		14.20
Porter Creek Indoor Garden Centre	2015-07-24	Plant Supplies: Nutrient		113.93
Porter Creek Indoor Garden Centre	2015-08-04	Plant Supplies: Nutrient		26.89

Porter Creek Indoor Garden Centre	2015-08-04	Plant Supplies: Nutrient		27.44
Porter Creek Indoor Garden Centre	2015-08-24	Plant Supplies		128.73
Porter Creek Indoor Garden Centre	2015-08-24	Plant Supplies		17.17
Porter Creek Indoor Garden Centre	2015-08-28	Plant Supplies: Nutrient		60.46
Porter Creek Indoor Garden Centre	2015-08-31	Plant Supplies		15.11
Porter Creek Indoor Garden Centre	2015-09-02	Plant Supplies: Rockwool		112.01
Porter Creek Indoor Garden Centre	2015-09-07	Plant Supplies: Rockwool		57.28
Porter Creek Indoor Garden Centre	2015-09-08	Plant Supplies		45.85
Porter Creek Indoor Garden Centre	2015-09-10	Plant Supplies: Rockwool		70.26
Porter Creek Indoor Garden Centre	2015-09-17	Plant Supplies		83.13
Porter Creek Indoor Garden Centre	2015-09-21	Plant Supplies: Reflector for Grow Unit		81.65
Porter Creek Indoor Garden Centre	2015-09-30	Plant Supplies: Nutrient		112.36
Porter Creek Indoor Garden Centre	2015-10-14	Plant Supplies: Rockwool		138.10
Porter Creek Indoor Garden Centre	2015-11-03	Plant Supplies		12.41
Porter Creek Indoor Garden Centre	2015-11-26	Plant Supplies: Rockwool and Peat Plugs		118.09
Porter Creek Indoor Garden Centre	2015-12-06	Plant Supplies		10.01
Porter Creek Indoor Garden Centre	2015-12-08	Aeroponics Supplies: Lights		47.04
Porter Creek Indoor Garden Centre	2015-12-09	Plant Supplies: Nutrient		32.28
Porter Creek Indoor Garden Centre	2015-12-16	Plant Supplies: Nutrient		18.76
Porter Creek Indoor Garden Centre	2015-12-21	Plant Supplies: Peat Plugs		52.36
Porter Creek Indoor Garden Centre	2016-01-11	Plant Supplies: Nutrient		33.89
Porter Creek Indoor Garden Centre	2016-01-12	Plant Supplies: Nutrient		41.77
Porter Creek Indoor Subtotal			**1,994.50**	
Staples	2015-07-03	Aeroponics Supplies: Rubber Bands		1.50
Staples	2015-08-14	Shipping Supplies		9.43
Staples	2016-01-08	Printer Cartridges		30.40
Staples Subtotal			**41.33**	
The Greenhouse at Cliffside	2015-05-28	Aeroponics Supplies: Trellis and Twine		8.89
The Greenhouse at Cliffside	2015-08-10	Plant Supplies: Seeds		3.14

The Greenhouse Subtotal			**12.03**	
Walmart	2015-06-15	Building Supplies: Metal Brackets for Shelf		17.82
Walmart	2015-07-06	Maintenance: Janitorial Supplies		9.67
Walmart	2015-07-06	Plastics Curtains for Grow Unit		5.94
Walmart	2015-07-09	Aeroponics Supplies		11.14
Walmart	2015-07-14	Aeroponics Supplies		3.12
Walmart	2015-07-27	Maintenance: Janitorial Supplies		7.94
Walmart	2015-07-27	Maintenance: Janitorial Supplies		2.10
Walmart	2015-08-06	Plant Supplies: Freezer Bags		4.17
Walmart	2015-09-29	Maintenance: Water for Cleaning		4.79
Walmart	2015-09-30	Maintenance: Detergent for Cleaning		12.52
Walmart	2015-10-14	Waste Disposal: Garbage Bags		11.35
Walmart	2015-10-30	Waste Disposal: Garbage Bags		10.65
Walmart	2015-11-16	Maintenance: Vinegar for Cleaning		5.94
Walmart	2015-12-14	Maintenance: Sponges for Cleaning		5.22
Walmart	2015-12-22	Maintenance: Cleaning Supplies		16.59
Walmart	2016-01-12	Maintenance: Cleaning Supplies		2.47
Walmart Subtotal			**131.43**	
West Tech Irrigation Supply	2015-08-31	Dripless System		206.50
West Tech Irrigation Subtotal			**206.50**	
West Coast Seeds	2015-09-15	Plant Supplies: Seeds		26.69
West Coast Seeds	2015-10-30	Plant Supplies: Seeds		31.88
West Coast Seeds	2015-12-09	Plant Supplies: Seeds		43.26
West Coast Seeds Subtotatl			**101.83**	
Whitehorse Home Hardware	2015-06-15	Building Supplies		6.29
Whitehorse Home Hardware	2015-06-16	Building Supplies		13.21
Whitehorse Home Hardware	2015-06-22	Building Supplies		9.44
Whitehorse Home Hardware	2015-06-24	Aeroponics Supplies: Shrink Tubing		11.74
Whitehorse Home Hardware	2015-07-02	Building Supplies		361.36
Whitehorse Home Hardware	2015-07-02	Building Supplies		32.30
Whitehorse Home Hardware	2015-07-03	Building Supplies		69.77
Whitehorse Home Hardware	2015-07-06	Building Supplies		27.24
Whitehorse Home Hardware	2015-07-06	Building Supplies		3.56
Whitehorse Home Hardware	2015-07-13	Aeroponics Supplies: Solvent		8.91
Whitehorse Home Hardware	2015-07-27	Aeroponics Supplies: PVC Pipe		91.29
Whitehorse Home Hardware	2015-07-29	Aeroponics Supplies: PVC Pipe. bolts and Washers		38.81

Whitehorse Home Hardware	2015-08-17	Building Supplies: Tools		11.54
Whitehorse Home Hardware	2015-08-18	Building Supplies: Tools		4.71
Whitehorse Home Hardware	2015-08-24	Drip Irrigation Unit		10.48
Whitehorse Home Hardware	2015-08-27	Building Supplies: Tools		11.01
Whitehorse Home Hardware	2015-09-03	Building Supplies: Eavestroughing for Grow Unit		36.50
Whitehorse Home Hardware	2015-09-08	Plumbing for Grow Unit: Pump		115.49
Whitehorse Home Hardware	2015-09-10	Aeroponics Supplies: PEX connectors for Grow Unit		24.86
Whitehorse Home Hardware	2015-09-14	Plumbing Supplies for Grow Unit: Adapter		1.88
Whitehorse Home Hardware	2015-09-14	Aeroponics Supplies: PEX rings for Grow Unit		14.94
Whitehorse Home Hardware	2015-09-18	Aeroponics Supplies: EMT Conduit for Grow Unit		7.34
Whitehorse Home Hardware	2015-09-18	Building Supplies: Screws		4.29
Whitehorse Home Hardware	2015-09-21	Aeroponics Supplies: Panel for Grow Unit		61.42
Whitehorse Home Hardware	2015-09-21	Aeroponics Supplies: Rods for Grow Unit		35.26
Whitehorse Home Hardware	2015-09-21	Aeroponics Supplies: PEX connectors for Grow Unit		10.15
Whitehorse Home Hardware	2015-09-21	Aeroponics Supplies: PEX connectors for Grow Unit		44.00
Whitehorse Home Hardware	2015-09-22	Aeroponics Supplies: Terminal Connectors		21.05
Whitehorse Home Hardware	2015-09-28	Aeroponics Supplies: Armoured Cable		180.73
Whitehorse Home Hardware	2015-09-30	Aeroponics Supplies: EMT Conduit for Grow Unit		61.45
Whitehorse Home Hardware	2015-10-02	Building Supplies: Tools		7.34
Whitehorse Home Hardware	2015-10-09	Aeroponics Supplies: PEX connectors for Grow Unit		6.29
Whitehorse Home Hardware	2015-10-09	Aeroponics Supplies: PEX connectors for Grow Unit		11.00
Whitehorse Home Hardware	2015-10-13	Electrical: Shrink Tubing		13.80
Whitehorse Home Hardware	2015-10-13	Electrical: Shrink Tubing		7.65
Whitehorse Home Hardware	2015-10-13	Aeroponics Supplies: PEX connectors for Grow Unit		27.39
Whitehorse Home Hardware	2015-10-15	Aeroponics Supplies: Plastic Caps for Grow Unit		7.53
Whitehorse Home Hardware	2015-10-15	Aeroponics Supplies: Glue Brush for Grow Unit		2.82
Home Hardware Subtotal			**1414.84**	

Whitehorse Waste Management	2015-07-07	Waste Disposal Fee		5.00
Whitehorse Waste Management	2015-07-30	Waste Disposal Fee		5.00
Whitehorse Waste Management	2015-08-24	Waste Disposal Fee		5.00
Whitehorse Waste Management	2015-10-14	Waste Disposal Fee		5.00
Whitehorse Waste Management	2015-11-02	Waste Disposal Fee		5.00
Whitehorse Waste Subtotal			**25.00**	
Yukon Gardens	2015-06-15	Plant Supplies: Seeds		6.28
Yukon Gardens Subtotal			**6.28**	
Yukon Pump	2015-09-08	Plumbing: Water System for Grow Unit		63.00
Yukon Pump Subtotal			**63.00**	
Total			**10,386.49**	