AgNorth Modular Farm Concept

Phase 2

Pilot Project

Implementation Planning

EXECUTIVE SUMMARY

Food security in Canada's north has been identified as a priority by all levels of government and the public at large. AgNorth is a scalable, modular farm system that uses highly efficient light emitting diode (LED) lighting and hydroponics technologies to grow fruit and vegetable crops indoors on a year-round basis. The concept is based on technology developed from research in advanced life support systems led by COM DEV Canada and the University of Guelph.

In 2012-13, the Aurora Research Institute (ARI) completed a feasibility study to look at whether it would be practical, technically and commercially, to establish an AgNorth farm station in the NWT. This work was funded by CanNor and GNWT-ITI.

In 2013-14, ARI and its partners (COM DEV Canada and the University of Guelph) focused on stakeholder engagement and planning activities for a proposed AgNorth pilot project while a complementary project to assemble and test a prototype modular production system was underway at the U. of Guelph.

This document summarizes the pilot project planning and implementation work that was completed, based on the input received from stakeholders. The results from the stakeholder engagement work are summarized in a separate report.

Section 2 provides an update on the ongoing research work at the University of Guelph's Controlled Environment Systems Research Facility (CESRF). Areas of focus include advanced light emitting diode (LED) lighting systems, hydroponic nutrient solution management based on novel ion sensor technology and innovative environment control strategies designed to homogeneously distribute control of temperature and humidity in the proposed high density modular food production systems.

As well, lessons learned in the research work were exploited in evolving the engineering requirements for a prototype high density modular plant production system that is being constructed as part of research collaboration agreement between CESRF and the Kuwait Institute for Scientific Research (KISR). This research and prototype work will help fine tune the "recipes" for control of light quality and provide the basis for continued technology transfer to the AgNorth initiative.

Section 3 outlines the intended purpose and objectives for the pilot project and provides background information on the Territorial Farmers Association (TFA)'s proposed Northern Farm Training Institute (NFTI) Living Classroom farm campus. This farm campus, which the TFA and the Town of Hay River are proposing to build on an old agricultural site 10 km south of Hay River, is intended to support the NWT agriculture sector through research activities and by providing hands-on training and incubation of small-scale agriculture businesses.

Preliminary discussions between the AgNorth team and the TFA indicate that the AgNorth pilot project would be a good fit within the context of the proposed NFTI Living Classroom farm campus.

Specifically, the pilot project could be housed within a larger, multi-purpose building which would also have a common area space (offices, storage, bathroom, produce handling etc.) and a south-facing greenhouse.

Co-locating the pilot project on the NFTI farm campus will allow both projects to use the common space and share in capital costs, horticultural expertise, labour and utility costs . As well, excess heat from the AgNorth pilot project can be captured and used to heat the greenhouse.

The remainder of section 3 summarizes the engineering and design work done to date and provides an update on various ideas for making the multi-use building energy efficient. Some preliminary ideas for generating heat and power on-site (to reduce utility costs) are also noted.

The preliminary estimate of the capital cost required to set up the pilot project is $685,000 in direct costs and $265,000 in labour costs, for a total cost of about $950, 000. Applying a contingency factor of 25% would bring the total capital cost closer to $1.2 million.

In terms of next steps, the TFA is currently seeking multi-year funding support (i.e. 2014/15 and 2015/16) for the development of the NFTI farm campus, which would include the cost of the multi-purpose building.

Once the TFA receives confirmation that its funding is in place, additional meetings and collaboration between the AgNorth team and the TFA will be required to further develop the design and layout of the multi-purpose building and address other related items such as utility services, greenhouse design and cost-sharing of operational costs.

Additional work on forecasting potential operating revenues and costs (for the pilot project) will be undertaken once the design details for the multi-use building are known and the AgNorth team has had opportunities to discuss cost-sharing arrangements with the TFA.

TABLE OF CONTENTS

1 INTRODUCTION ... 1

1.1 Technical Planning & Stakeholder Input ... 1

1.2 Organization of the Report ... 2

2 PROTOTYPE DEVELOPMENT ... 3

2.1 Research Activities ... 3

2.2 Prototype Project ... 5

3 NWT PILOT PROJECT ... 6

3.1 Purpose & Objectives ... 6

3.2 Northern Farm Training Institute – Background Information ... 7

3.3 Site Information ... 8

3.4 Multi-Purpose Building ... 9

3.5 Pilot Project Work Plan ... 10

3.6 Technical Details ... 12

3.6.1 Pilot Project Components and Systems ... 12

3.6.2 Environmental Sustainability ... 14

3.6.3 Greenhouse ... 17

3.7 Capital and Operating Budgets ... 18

3.7.1 Capital Budget ... 18

3.7.2 Operating Budget ... 19

4 CONCLUSION AND NEXT STEPS ... 19

APPENDIX A: REFERENCE DOCUMENTS ... 21

APPENDIX B: DIAGRAMS ... 22

1 INTRODUCTION

Food security in Canada's north has been identified as a priority by all levels of government and the public at large. Fresh produce consumed in the Northwest Territories (NWT) comes from farms as far south as Columbia in the winter months, taking an average of 10 days to make it from the field to Yellowknife (or longer for some of the territory's more remote communities). The long distances and travel times significantly inflate costs and reduce the quality of produce in NWT communities. These barriers limit access to quality produce that could help improve diet and reduce the prevalence of diet-related chronic diseases.

AgNorth is a scalable, modular farm system that uses highly efficient light emitting diode (LED) lighting and hydroponics technologies to grow fruit and vegetable crops indoors on a year-round basis. The concept is based on technology developed from research in advanced life support systems led by COM DEV Canada and the University of Guelph.

In 2012-13, with funding from CanNor and GNWT-ITI, the Aurora Research Institute (ARI) carried out a feasibility study (Phase 1) to look at whether it would be practical, technically and commercially, to establish an AgNorth farm station in the NWT. A productivity model was developed that estimates the costs involved to grow different types of produce. The analyses considered a number of different options and took into account future in high efficiency LED technology.

Key findings from the Phase 1 work indicated that the size of the facility, specific crops grown and cost of power were the most important factors in determining the operating costs. The assessment found that Yellowknife, Hay River and Fort Smith were likely the best communities for locating an AgNorth farm.

For 2013-14, ARI and its partners (University of Guelph and COM DEV Canada) focused on stakeholder engagement and planning activities for a proposed AgNorth pilot project.

1.1 Technical Planning & Stakeholder Input

The purpose of this document is to record the results of the technical planning and implementation work completed during 2013-14 for a proposed AgNorth pilot project. The results from the stakeholder engagement work are summarized in a separate report.

The results derived from the stakeholder engagement work have helped the AgNorth team refine the concept and details for the proposed AgNorth pilot project in several important ways. These include:

Scale – initially, the AgNorth team was considering the deployment of up to twenty (20) growing modules that would be organized in two (2) benches. Due to cost and other factors, the proposed number of growing modules has been reduced to ten (10) which is considered the minimum number required to conduct adequate testing of the technology.

Location – one of the most important topics during the stakeholder engagement discussions was the question of where to best locate the proposed pilot project. Determining the "right" answer to this question involved numerous factors including land or facility availability, access to local agricultural expertise and knowledge, power costs and potential partners. The AgNorth team believes that a property just south of Hay River (referred to as the "Northern Pork" site) represents the best combination of factors available to support the pilot project.

Greenhouse Component – the original concept for an AgNorth project (either a pilot or commercial-scale facility) did not contemplate the inclusion of a standard greenhouse component. However, based on input from key stakeholders, several compelling reasons were identified for adding a greenhouse component, including the opportunity to make use of excess heat (generated by the LED lighting) and to expand the scope of the pilot project in terms of testing how the AgNorth system may be best deployed (i.e. growing seedlings or other plants in addition to fruits and vegetables).

Key Partners – in addition to the site mentioned above, Hay River has several other advantages that are attractive and supportive of the AgNorth pilot project. One advantage is the extent of agricultural activity already located in and around Hay River and the fact that the Town is implementing a Hay River Agriculture Plan to foster and strengthen additional agricultural endeavours. The second advantage is the Territorial Farmers Association (TFA)'s proposed Northern Farm Training Initiative (NFTI) Living Classroom which is planned for the same site.

The NFTI campus would serve as an excellent "home" for the AgNorth pilot project and provide much-needed agricultural expertise. The Town of Hay River and the TFA have expressed interest in partnering with the AgNorth team to locate the pilot project at the Northern Pork site as a component of the NFTI campus.

In summary, the AgNorth team received very valuable information and suggestions from different stakeholders and would like to express its gratitude to everyone involved for the time and expertise that was provided during various meetings and workshops.

1.2 Organization of the Report

Section 2 – summarizes the results of the ongoing research being conducted at the University of Guelph and the prototype development work underway for a similar project in Kuwait.

Section 3 – summarizes the technical and planning work completed to date for a proposed NWT AgNorth pilot project.

Section 4 – outlines the suggested next steps for the project.

2 PROTOTYPE DEVELOPMENT

As described in detail in the AgNorth feasibility study done in 2012/13, the concept of an AgNorth modular farm system has been derived from years of research at the University of Guelph's Controlled Environment Systems Research Facility and modeling and engineering work provided by COM DEV Canada.

The current technology development activities at the U. of Guelph entitled "Innovative Technologies in Challenging Environments" (InTICE) is a joint NSERC and Canadian Space Agency funded Collaborative Research and Development (CRD) project with partners COM DEV International and the U. of Guelph. The project objectives are "pulled" by the technical challenge of space exploration and life support requirements (dominated by food requirements) for long term missions to the Moon and Mars. The (almost equally) challenging environments of Canada's north and the deserts of the middle east provide an excellent context to exploit technology transfer opportunities from this space exploration motivated program to applications in terrestrial agri-food sectors.

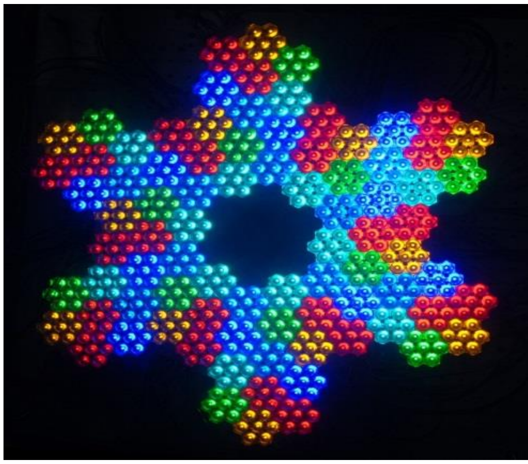
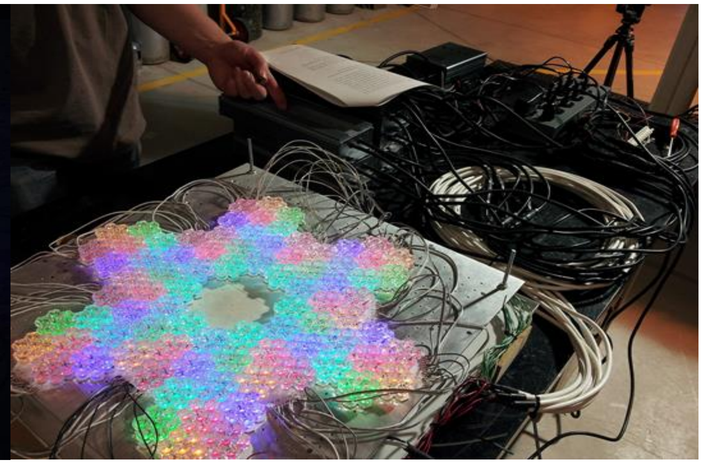
In the context of this ongoing technology development program, a research collaboration agreement was reached with the Kuwait Institute for Scientific Research (KISR). The perceptions of food security issues in the Middle East are remarkably similar to those in Canada's north and it became evident that the technical solutions were equally similar. A project to develop and test a prototype modular food production system was conceived and, although funded by others, was directly relevant and complementary to the technical objectives of the AgNorth initiative in the NWT.

This work is ongoing and vital to the continued development and refinement of the technology and the reduction of technology-related risks. In addition, the resulting research infrastructure at the U. of Guelph will continue to provide a technology transfer platform for AgNorth activities in the future.

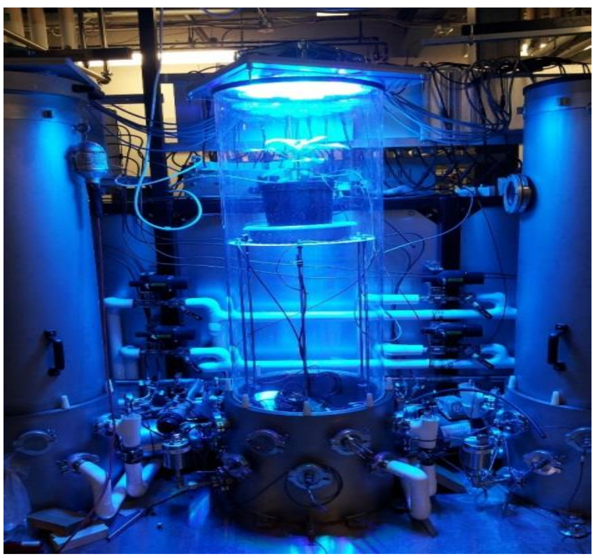
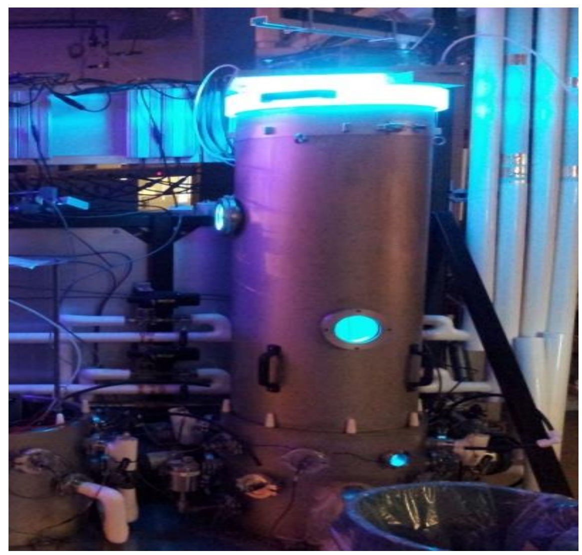
2.1 Research Activities

The InTICE project included the development of key technologies related to the controlled environment production of food. These included advanced light emitting diode (LED) lighting systems, hydroponic nutrient solution management based on novel ion sensor technology and innovative environment control strategies designed to homogeneously distribute control of temperature and humidity (critical!) in the proposed high density modular food production systems.

High intensity and high efficiency LED components were assembled in a unique configuration of up to 9 different wavelengths from ultraviolet to far red. The resulting research tools provided the capability to investigate a wide range of light intensity and spectral quality "recipes" for the production of specific food commodities in controlled environments (Figs. 1-4).

Figures 1 and 2: High intensity LED array with 7 colours (far red and ultraviolet have since been added)

Figures 3 and 4: Sealed controlled environment chambers at the CESRF, U. of Guelph, in which various spectral qualities and light intensities were tested for their influence on plant physiological responses.

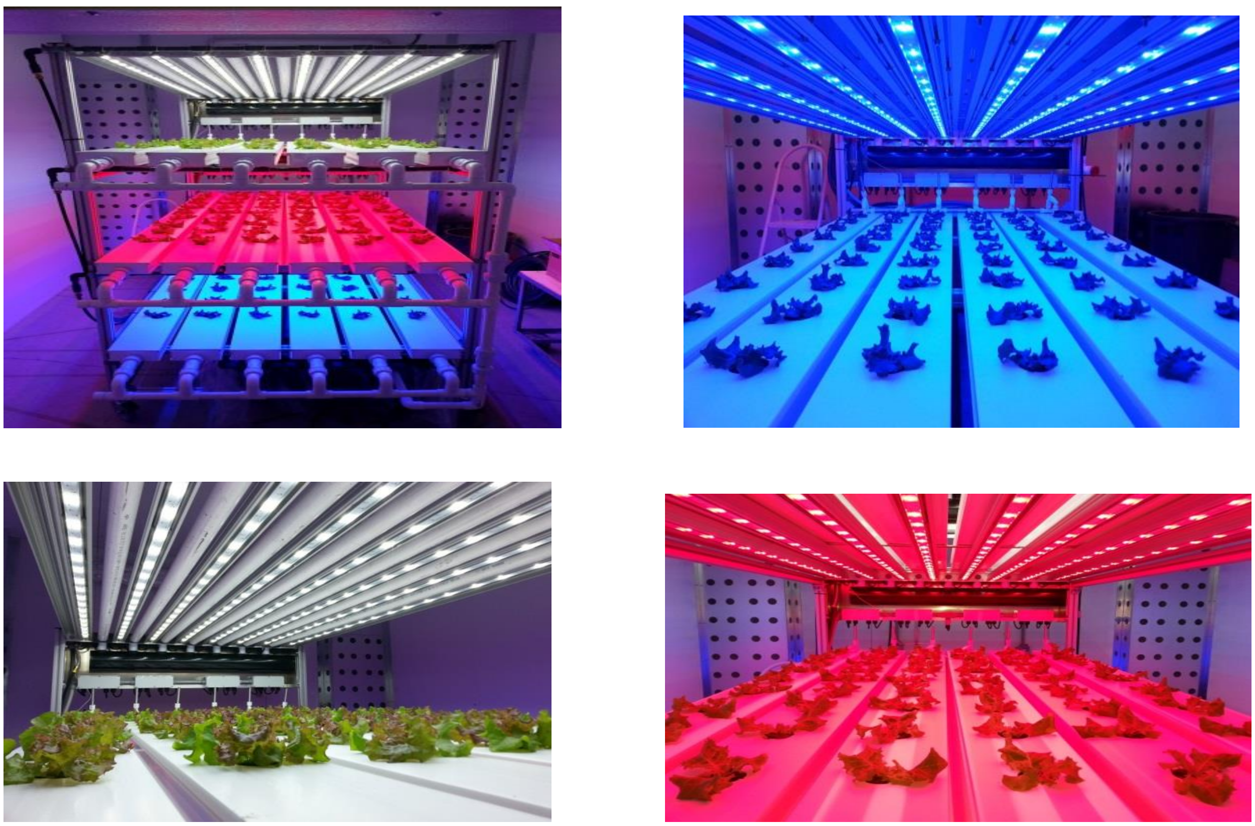
The test configuration of LEDs and related environment control infrastructure were used in a series of experiments on a number of conventional greenhouse commodities (e.g. tomato, lettuce, pepper) to evaluate responses in terms of photosynthesis, respiration and transpiration.

These experiments provided the preliminary data required to select LED components for the prototype modular production system. The resulting 5-wavelength configuration was integrated into the prototype in a custom configuration that included independent water cooled LED arrays and an air handling system which delivered conditioned (temp and humidity) and CO_2 enriched air within the plant canopy to reliably homogenize the aerial environment in the high density production system.

2.2 Prototype Project

Lessons learned in the InTICE project were exploited in evolving the engineering requirements for a prototype high density modular plant production system.

The prototype is a multi-level LED and controlled environment production system using recirculating hydroponic (nutrient film technique) nutrient solution and designed to accommodate a range of high value commodities such as strawberries and cherry tomatoes. The initial configuration was designed to produce relatively small stature plants such as these to optimize plant density and light distribution capabilities of the modular system (Figs. 5-8).



Figures 5-8: Top left displays the prototype modular production system with 3 levels of LED arrays displaying a range of capabilities for deploying different spectral qualities of light.

The design of the prototype retains the research capabilities of independent control over 5 different wavelengths at each level such that spectral quality can be modified to suit the crop or physiological stage of the crop being produced. This accounts for the adaptation of different physiological stages of a crop such as cherry tomato or strawberry to respond differently to light spectra during vegetative and reproductive stages.

Fine tuning these “recipes” for control of light quality will be the subject of ongoing research activities at the U. of Guelph and provide the basis for continued technology transfer to the AgNorth initiative.

3 NWT PILOT PROJECT

3.1 Purpose & Objectives

The general purpose for building and operating a Pilot Project is to verify the expected technical and economic performance of the AgNorth concept and provide customers with an opportunity to gauge the quality of the produce grown.

Following are the suggested Objectives for the pilot project (as revised based on stakeholder input):

Technical

- To determine the building requirements, layout and specifications needed to support a commercially-viable AgNorth business;
- To gather operational data to enable additional refinements to be made in critical systems such as the CO^2, humidity, LED lighting, nutrients etc. to ensure optimal growing conditions can be established and maintained; and,
- To confirm the expected horticultural performance (i.e. output, quality, nutritional value).

Socio-Economic

- To obtain operational experience to help determine an optimal scale of operations (or range of options) for a commercial facility;
- To confirm customer satisfaction / interest in longer-term produce supply arrangements and determine the specific crops and wholesale pricing that could form the basis for a commercial facility;
- To determine the conditions under which a commercial-scale AgNorth business would be economically viable; and,
- To understand (and quantify?) the health benefits (improved diet and nutrition) that could be obtained by providing communities with a year-round supply of fresh and affordable fruits and vegetables.

Environmental Sustainability

- To explore options for generating power on-site (to minimize power consumption from the grid);
- To minimize energy use and maximize use of available solar energy;
- To maximize the secondary use of by-products (excess heat, organic waste).

The purpose and objectives for the Pilot Project are being used by the AgNorth team as “guideposts” in completing the technical planning and implementation work detailed below.

3.2 Northern Farm Training Institute – Background Information

The Territorial Farmers Association (TFA) is a registered, not-for-profit society established in 1974.

Some of its key objectives are to:

- Promote and encourage the concept of agriculture;
- Provide for the delivery of lectures and the holding of classes regarding the practice and concept of agriculture;
- Promote and provide for the carrying out of research and experimental work in connection with agriculture and related subjects; and,
- Promote and encourage the research, development and marketing of agriculture in all its forms within the NWT (and elsewhere).

At present, there is a strong demand for fresh produce and a huge potential market for increasing food production in the NWT. However, significant challenges include access to land for agriculture and a general lack of knowledge and experience in agricultural production. To date, very little has been done, either within the private or public sectors, to specifically build the knowledge and expertise base required to increase agricultural endeavours in the NWT.

The TFA is proposing to help fill this gap by establishing the Northern Farm Training Institute (NFTI) Living Classroom which would pursue a combination of applied research/innovation, training/extension and business incubation activities at a farm campus.

Specifically, the NFTI Living Classroom would involve the creation and operation of a farm campus that would pursue the following mission:

- Innovation – applied research to refine northern agricultural practices, with a focus on developing environmentally sustainable systems;
- Extension – providing training, accessible and participatory demonstrations and advisory services; and,
- Incubation – providing opportunities and support for start-up food production and processing businesses.

The intent is to develop a collective body of knowledge about northern agricultural practices through innovation and applied research. That knowledge would be shared with NWT farmers and residents through training and demonstration in the following areas:

- Appropriately scaled and achievable farming models;
- Land clearing and soil fertility improvements;
- Livestock husbandry systems;
- Greenhouse operations;

- Fruit and vegetable production;
- Produce storage and handling;
- Value-added food products; and,
- Farm business management.

The TFA is considering setting up the NFTI Living Classroom as a not-for-profit social enterprise.[1]

In short, the NFTI Living Classroom would, as part of its activities, produce agricultural products to generate revenue that would be used to help cover operating expenses and, over time, could be re-invested in the venture itself to expand the various elements of the campus.

The TFA's Business Plan for the NFTI Living Classroom outlines three key phases and a number of specific activities for establishing the farm campus over the next several years. Of most importance to the AgNorth pilot project is the construction of a building, which is tentatively scheduled to start in 2015.

3.3 Site Information

As noted earlier, the AgNorth team has determined that collaborating with the Town of Hay River and the TFA to locate the AgNorth pilot project on the "Northern Pork" site, as part of the NFTI Living Classroom campus, represents the best option available.

The "Northern Pork" property is an old agriculture site (formerly used for hog production) that is now owned by the Town of Hay River. The property is about 300 acres in size and is located just off the highway, in an oxbow of the Hay River, about 10 km south of the Town of Hay River. Much of the property lies on an alluvial plain which has high crop-production potential.

It is proposed that the NFTI Living Classroom campus be developed on approximately 50 acres of land, about half of which would be on the alluvial floodplain in the lower portion of the property. There is an access road into the site but portions of it may require upgrading due to some boggy and overgrown areas.

Several cleared sites exist that appear suitable for conversion for the NFTI Living Classroom campus. These include:

- Hog Barn – this portion of the site comprises about 3 acres of cleared land and a concrete foundation and external structure of an old hog barn. The barn will need to be torn down but it is hoped that the concrete foundation can be remediated and used as a base for some of the buildings required for the farm campus such as a greenhouse, storage sheds etc.
- Feed Mill – this portion of the site comprises about 4 acres of cleared land and still has an external structure, bins for grain and feed storage and feed processing equipment. It is understood that significant refurbishment would be needed to make these assets operational.

[1] A social enterprise is any business directly involved in the production and selling of goods and services for the dual purpose of generating income and achieving its stated social and environmental objectives.

- Lower Portion – there is an access road leading from the hog barn area to the lower part of the property. Much of this road is now severely overgrown and impassible to any motor vehicle. This land looks very promising for intensive agriculture (Class 3 alluvial soils) but only about 2.6 acres are cleared, with the remainder being native forest. A detailed soil analysis and other field work will be required to better understand the agricultural potential of this area.

The TFA has entered into discussions with the Town of Hay River to secure long-term access to the Northern Pork property for the purposes of establishing the NFTI Living Classroom. The discussions between the TFA and the Town have not yet concluded but there is a high expectation that the Town will support the TFA's request, most likely in the form of a long-term lease arrangement.

On the assumption that a formal agreement will soon be established between the Town and TFA, the TFA's next step will be to hire an engineering firm to conduct an assessment of the site. The purpose of the site assessment is to identify any potential hazards, evaluate the existing infrastructure (power connection, access road, old buildings etc.) and determine a realistic site development plan (activities, cost, schedule etc.).

3.4 Multi-Purpose Building

One of the TFA's planned components for the NFTI Living Classroom is to erect greenhouses which can be used to demonstrate various technologies, support training and demonstration activities and grow crops which could be sold locally to generate operating revenues.

In March, the AgNorth team met in Hay River with the TFA, the Town and others to explore how the AgNorth pilot project could be incorporated into the NFTI Living Classroom.

The basic concept that appears to make the most sense (for both projects) is to build one large structure, on the hog barn foundation, with approximately 315 m^2 (~3,400 sq. ft.) of space. The space would be divided (roughly) into three separate areas:

- *AgNorth pilot project* – one end of the building would house the containerized "growing area" (with 10 growing modules) which would be set up and operated for a period of five (5) years. The suggested dimensions for the container are 12.3m in length x 2.5 m in width x 2.5 m in height. This would provide 60 m^2 (645 sq. ft.) of growth area available for production. The exterior dimensions of this portion of the building are estimated at 15m (L) x 7m (W) x 4m (H);

- *Common area* – the middle of the building would contain a "header house" for hydroponics, control and HVAC systems (for the AgNorth pilot project) as well as storage space, a produce handling area, a small office, a classroom and a bathroom (all of which could serve both projects). The produce handling area needs to be chilled (3 C) and the balance of the space would be room temperature (18 C). The suggested dimensions of this portion of the building are also estimated at 15m (L) x 7m (W) x 4m (H) ; and,

- *Greenhouse* – the other (south-facing) end of the building would be constructed as a greenhouse with an area of approximately 15m x 7m (~980 sq. ft.).

This would enable the NFTI Living Classroom to grow a variety of crops, conduct training and demonstration activities and generate operating revenue. The suggested dimensions for the greenhouse area could be made larger or smaller depending on the TFA's requirements.

In total, the multi-purpose building would have a suggested footprint of 45m (L) x 7m (W) x 4 m (H) (about 3,400 sq. ft.) A diagram showing the AgNorth growing area and the common area is provided in Appendix B.

The TFA and the AgNorth team see numerous advantages to co-locating the AgNorth pilot project with a NFTI Living Classroom greenhouse. These include:

- Sharing infrastructure costs for an external structure, common header house systems and storage, office and produce-handling areas;
- Extending the operating season for the greenhouse by providing waste heat from the pilot project;
- Sharing key staff such as a trained horticulturalist, administrative support and volunteers; and,
- Jointly exploring options for increasing the overall sustainability of the NFTI Living Classroom farm campus. Specific examples identified for further consideration include recycling of inedible organic materials, passive solar heat gain and on-site power generation.

Until the site assessment work described in section 3.3 has been completed, it is premature to attempt to provide additional information on exactly how a common purpose building should be designed and constructed, given that the hog barn foundation is the starting point.

However, given the large dimensions of the hog barn concrete foundation (~10,000 sq. ft.) and the cleared 3 acre area around the hog barn, no problems are anticipated in being able to determine a location for the building that will allow an optimal south-facing exposure for the greenhouse component.

More detailed design work for the proposed multi-purpose building will be conducted in the next phase in collaboration with the TFA.

3.5 Pilot Project Work Plan

Based on the information provided by the TFA (with respect to the establishment of the NFTI Living Classroom), the AgNorth team prepared a tentative work plan for the pilot project.

The basic plan is to complete the remaining planning and preparation work during 2014/15 and work with the TFA on construction and commissioning of the building in 2015/16. Under this timeline, the actual pilot project period would run from 2016/17 to 2020/21.

Based on these assumptions, a tentative work plan for the next seven (7) years is outlined below:

2014/15 (Planning and Preparations)

- finalization of partnership arrangements (Town of Hay River, TFA, AgNorth, others)
- develop organizational capacity (in conjunction with the TFA)
- site preparations
- secure capital and operating funding
- detailed design and engineering

2015/16 (Construction and Commissioning)

- permitting
- procurement of materials and system / component manufacturing
- installation of the system
- commissioning and de-bugging

2016/17 (Year 1 of Pilot)

- establish baseline operational data
- complete initial experimentation with crops, light spectrum and other environmental factors
- establish greenhouse operations
- sell AgNorth produce at local markets (as it is available)

2017/18 (Year 2 of Pilot)

- continue experimentation with crops, lighting and environmental factors
- complete / fine-tune system integration and heat exchange between AgNorth and the greenhouse and install back-up power system
- establish capability to grow high quality produce on a consistent basis
- sell AgNorth produce at local markets (as it is available)

2018/19 to 2020/21 (Years 3 to 5 of Pilot)

- sell some of the available produce to wholesale and retail customers (on a continual basis) and use the remaining produce for the socio-economic objectives of the pilot project
- experiment with growing other commodities (fodder, transplants, tree seedlings etc.) that may have economic merit and NWT markets
- pursue sustainability objectives (on-site power generation, solar energy, composting etc.)

A more detailed work plan for the AgNorth pilot project will be prepared early in the next phase once an overall site development plan is available for the Northern Pork property and further discussions have been completed with the TFA.

3.6 Technical Details

To help develop the cost estimate presented in section 3.7 below, the AgNorth team contracted COM DEV to complete additional engineering and design work on the various components and systems needed to construct and operate the AgNorth pilot project.

Some preliminary investigations into on-site power generation, energy efficiency, recycling and design parameters for a greenhouse were also completed.

3.6.1 Pilot Project Components and Systems

To re-cap, the AgNorth modular food production concept is a scalable system that uses highly efficient light emitting diode (LED) lighting and hydroponics technologies to grow fruit and vegetable crops indoors on a year-round basis. To optimize production, the system is designed to control and optimize several key factors including light quality and intensity, humidity, nutrient composition and atmospheric conditions (temperature, CO2 levels). Research suggests that optimizing these variables in a controlled environment system can double, or in some cases, even triple standard greenhouse productivity.

As part of COM DEV's work, detailed block diagrams of the main elements of the pilot project have been prepared. However, as these block diagrams contain proprietary information, they have not been included as part of this report (which is intended to be circulated as a public document).

A brief explanation of each component or system is provided below:

<u>Containerized Growing Area</u>

The growth chamber will be approximately 12.3m (L) x 2.5m (W) x 2.5m (H) in order to fit within the larger building space (assumed to be about 15m (L) x 7m (W) x 4m (H)). Suggested design parameters are as follows:

- Safety – include fire detection and suppression equipment to meet safety standards;
- Health – constructed of materials which are non-nutrient to fungi;
- Accessibility – growth modules will be aligned on rails to allow for access and can be pushed together to minimize light spillover. All plants are to be man-accessible to allow for horticultural management, replanting of seedlings and harvesting;
- Airlocks – a vestibule (with double doors) will be used to maintain atmospheric conditions, prevent exposure of plants to external temperatures and minimize risk of pest infestation; and,
- Air Exchange – the system will provide sufficient airflow to homogenize the air temperature, humidity and composition. Dry airflow will be maintained over all walls to prevent condensation.

Food Production System

The growth chamber will contain ten (10) growing modules. Each module will contain three growing levels measuring 1m x 2m. This will provide a total growing area of 60 m^2. Suggested design parameters include:

- Reliability – the system will be designed to be indefinitely maintained by skilled tradesmen (electrical & plumbing). The system will also be designed to survive a multi-day freeze-up (due to a power outage) without damage;
- Water Supply & Drainage – the design assumes the availability of on-site water supply and septic or sewage facilities. The system will be designed to gravity drain (in the event of a power failure) to prevent line freeze-up;
- Sterilization – a sterilization system will be included so that all interior surfaces can be washed down to limit fungal and microbial contamination;
- Growth Modules – in addition to the three growing levels, each module will contain local power, LED drivers and lighting, local fans, controller equipment and various pumps, sensors and valves;

Header Area

The header area will contain a number of sub-systems that will service the growth chamber including:

- Hydroponics system including nutrient storage tanks and a nutrient holding tank;
- Ozonators for the sterilization system;
- HVAC equipment and system including air heaters, gas analysis, CO^2 source, blowers and a heat pump;
- Fire suppression system; and,
- A "supervisory control and data acquisition" (SCADA) system to monitor and control the various sub- systems.

Hydroponics System

The nutrients for the plants will be delivered using a hydroponics system. Key components will include:

- Nutrient storage tanks and a nutrient holding tank;
- Chilled water supply;
- Manually-operated valves for sampling and quality control;
- Sand filtration system for removal of particulate contaminants;
- Sensor arrays to monitor pH levels, electrical conductivity, dissolved oxygen levels and temperature; and,

- Pumps and piping.

HVAC System

The HVAC system will supply and control the atmospheric conditions within the growth chamber including temperature, humidity and CO^2 levels. Key components will include:

- A heat recovery ventilator (HRV) to pre-heat fresh intake air and minimize energy losses;
- An air handling unit to condition the air (humidity, CO^2) and circulate it within the growth chamber;
- A heat exchanger to remove excess heat (from the nutrient, air and LED glycol loops) and circulate it to an external heat pump.

Control System

The SCADA system will monitor and control the LED lighting, air circulation system, nutrient circulation system and thermal system. Key components include:

- An Internet connection for remote operation and monitoring; and,
- 2 controller units in the header house and 10 controller units in the growth chamber (1 for each module);

3.6.2 Environmental Sustainability

One of the main challenges for the economic viability of the AgNorth concept is the cost of electricity (i.e. the amount of electricity needed to power the LED lights and the high electricity rates in the NWT.)

Other energy and environmental considerations that have been identified and explored (on a preliminary basis) include energy efficiency considerations, HVAC system performance requirements, process and utility issues, heat recovery and distribution and disposal / recycling of organic and inorganic waste.

In recognition of these various energy and environmental considerations, the AgNorth team formulated several environmental sustainability objectives to be pursued during the pilot project (see Section 3.1 for the full list of objectives).

The specific environmental sustainability objectives are to:

- Explore options for generating power on-site (to minimize power consumption from the grid);
- Minimize energy use and maximize use of available solar energy; and,
- To maximize the secondary use of by-products (excess heat, organic waste).

While additional research and design work will be required on these issues during the next phase, the AgNorth team did receive lots of useful advice from the staff at the Arctic Energy Alliance related to power issues, energy efficiency, HVAC considerations and process and utility issues.

The following information is still somewhat general in nature but will re-visited when specific plans for the multi-use building are being prepared (in the next phase):

Power Issues

Given the concept of constructing one multi-purpose building to contain the AgNorth pilot project and the NFTI Living classroom greenhouse, it is obvious that the building will need to be connected to the local power grid.

In winter, the total peak load for the entire building is roughly estimated to be in the range of 50-60 kW, most of which will be used to power the LED lights in the AgNorth pilot project. Other building electric loads will include HVAC systems, general lighting, chillers and coolers and hot water heating.

Potential options for on-site power generation that have been identified include using photovoltaic (PV) panels or a combined heat-and-power (CHP) unit (using either waste vegetable oil or biomass). Given the large power load for the building (50+ kW) and limited solar radiation in winter months, PV panels are not considered viable as a significant and reliable source of on-site power.

One option that merits further investigation and consideration is the use of a CHP (or co-generation) unit. CHP or co-generation refers to the simultaneous generation of electricity and useful heat from the combustion of a single fuel source.

A study completed in 2013 for the City of Yellowknife (see Ko Energy) explored various options for using food waste, sewage and used vegetable oil for heating, electricity and other purposes. Of particular interest, this study found that approximately 130,000 litres of used vegetable oil (UVO) is available yearly in Yellowknife from restaurants and mine kitchens – some of this waste oil is currently shipped south for disposal and the rest ends up in the Yellowknife landfill.

If 130,000 litres of UVO per year could be gathered and diverted to the NFTI Living Classroom site, it would be sufficient to fire a 30 kW CHP unit which would operate at more than 80% efficiency. This would potentially provide the following outputs:

- 35 MWh of electricity per month (420 MWh / year);
- 200 GJ of heat per month (2,400 GJ / year).

An-depth analysis of the technical and economic viability of this option should be undertaken during the next phase once the total power and heat load requirements for the entire building have been estimated.

Other power-related issues which will also need to be investigated further include:

- Whether a three-phase power supply to the site is needed?
- Whether upgrades are required on the existing line and transformer (either for increased capacity reasons and/or 3-phase)?, and,
- Whether there are potential concerns about power quality (voltage and current) that could affect sensitive electronic equipment?

Energy Efficiency

Some initial ideas for minimizing energy and utility use within the multi-purpose building are as follows:

- Insulation
    - Exterior building walls & ceiling – R30 minimum, R40 would be better
    - Growth chamber walls & ceiling – R30 minimum, R40 would be better
    - Walls between heated and chilled space – R30 minimum, R40 would be better
- Common area layout considerations
    - Locate mechanical room next to office or classroom, not the chilled area
    - Chilled area walls should not have any windows
    - Minimize windows on the north side of the building
- LED efficiency of 50% (currently state-of-the-art)
- Heat recovery
    - Use a heat recovery ventilator (HRV) to pre-heat fresh intake air
    - Heat recovered from the chilled area can be used to heat the office / classroom space
    - An industrial heat pump will be used to provide excess heat (recovered from the growth chamber) to a heat exchanger in the greenhouse HVAC system
- Water recovery
    - The de-humidifier (in the growth chamber) would be drained into the nutrient tank to recover water lost through evaporation and transpiration

HVAC System Requirements

The HVAC system design and set-up will be required to maintain three (3) different environments within the building. The basic requirements for each environment are as follows:

- Growth chamber – needs to be maintained at 70% relative humidity and a temperature of 22 C
- Classroom / office / storage space – needs to be maintained at 20%-40% relative humidity and a temperature of 19-22 C
- Produce packing / storage – needs to be maintained at 95% relative humidity and a temperature of 3 C

Process and Utility Issues

Until additional information is available about the existing infrastructure and utility connections on the Northern Pork site, it isn't possible to proceed with any detailed analysis or planning around process and utility issues.

However, some of the early thinking that has been done is summarized below:

- Water
    - What is the water source?
    - How much water is needed?
        - Common area water use = ?? liters / year (to be determined)
        - Cleaning water use = 10,000 liters / year
        - Nutrient water use = 25,000 litres / year
        - Greenhouse water use = ?? liters / year (to be determined)
    - How will water be heated (for plants, processing and general use)?
- Disposal of waste products
    - Organic waste – recycle?
    - Inorganic waste?
    - Waste water – septic system or municipal sewer?
- What is the best source of CO^2?
    - Propane burner – this system doubles as a back-up heater if the lights are not in use or the electricity supply is cut but poses a CO risk (baselined)
    - CO^2 cylinders – this is the simplest approach but need to determine if these are available in Hay River

3.6.3 Greenhouse

The TFA and the Town of Hay River are currently seeking capital funding for the development of the Northern Pork site for the NFTI Living Classroom farm campus.

Once it is confirmed that funding is available and that the NFTI Living Classroom is going ahead, the AgNorth team will need to engage with the TFA to discuss the dimensions, heat requirements, layout and other aspects of the greenhouse.

The final decisions on these considerations will lie with the TFA, however, the AgNorth team will need to know what the TFA is proposing for the greenhouse to ensure the HVAC system for the multi-purpose building is designed in an optimal and cost-effective manner and can provide the maximum amount of heat to the greenhouse.

3.7 Capital and Operating Budgets

This section provides some preliminary information on the capital and operating budgets needed for the AgNorth pilot project.

3.7.1 Capital Budget

Based on the engineering work completed (as summarized in section 3.6 above), following is an estimate of the capital budget that will be required to establish the AgNorth pilot project:

Table1: Capital Cost Estimate

EXPENDITURE TYPE	COST ESTIMATE
Direct Costs	
Argus Control Systems	$75,000
Growth Modules (10 @ $16,000 each)	$160,000
Header Systems	$110,000
Other Costs (electrical, interconnections etc.)	$40,000
Insul-Panel Growth Chamber (incl. permits and assembly)	$300,000
Sub-total	**$685,000**
Labour Costs	
Growth Modules	$100,000
Software Development (Growth Modules)	$10,000
Header Systems	$85,000
Software Development (Facility)	$10,000
Installation and Hookups	$30,000
Testing	$2,500
Project Management	$30,000
Sub-total	**$267,500**
Contingency (25%)	**$240,000**
TOTAL	**$1,192,000**

Adding together the estimated direct costs ($685,000) and labour costs ($267,500), the total estimated capital cost for the AgNorth pilot project is $952,500.

Applying a contingency factor (25%), the total capital cost could be closer to $1.2 million.

3.7.2 Operating Budget

The analysis done in the AgNorth Phase I work indicated that electricity costs and labour were the two most significant operating costs associated with the AgNorth system.

Until a detailed design and layout has been prepared for the proposed multi-use building, it isn't possible to determine what the specific AgNorth pilot project operating costs may be as electricity, water, labour, administration and other operating costs will be shared between this project and the activities of the NFTI Living Classroom campus.

In terms of revenue generation, the ten (10) growing modules that are proposed will have a total growing area of 60 m^2. Depending on the crops grown, the pilot facility may be able to produce up to 10,000 kg of produce per year once it is fully operational. If this level of output can be sold at an average of $5/kg, this would represent $50,000 / year in potential revenue that could be used to help cover operating costs.

Additional work on forecasting potential operating revenues and costs will be undertaken once the design details for the multi-use building are known and the AgNorth team has had opportunities to discuss cost-sharing arrangements with the TFA.

4 CONCLUSION AND NEXT STEPS

In conclusion, Phase II of the AgNorth project was mostly successful in achieving the milestones that were set in the Work Plan for 2013/14.

A summary of the key results includes:

- Completed engagement activities with stakeholders to raise awareness about the project and gather feedback on key project parameters;
- Determined a suitable location for the pilot project (on the Northern Pork site proposed for the TFA's NFTI Living Classroom farm campus);
- Identified partners (Town of Hay River and the TFA) that are interested in supporting the pilot project;
- Refined the scope of the pilot project (10 growing modules) and established a list of Objectives to guide the planning, construction and operation of the pilot project;
- Completed additional design and engineering work (based on the assumption that the pilot project will be located in a multi-use building to be constructed as part of the NFTI farm campus; and,
- Prepared an estimate of the capital cost required to establish the pilot project.

In terms of next steps, the TFA has approached the Town of Hay River to secure access to the Northern Pork site and the Town of Hay River and the TFA are collaborating on the preparation of a joint funding proposal (to be submitted to CanNor) to raise funding for the creation of the NFTI Living Classroom farm campus.

If the Town and TFA are successful in obtaining sufficient funding in 2014/15 to allow work to begin on the design and layout of the NFTI Living Classroom, some funding is expected to be allocated to the AgNorth project to continue the design and engineering work.

At that point, the Aurora Research Institute will no longer have the lead role in managing and overseeing the AgNorth project but will likely stay involved in a general way to assist the Town, the TFA and the other AgNorth team members in integrating the pilot project into the NFTI farm campus.

Once the NFTI farm campus is operational, there may also be opportunities for ARI and NFTI to collaborate on ongoing agriculture-related research activities.

APPENDIX A: REFERENCE DOCUMENTS

PUBLICATIONS / DOCUMENTS

Aurora Research Institute, "*AgNorth Modular farm Concept: Technical Design and Market Study*", (June 2013)

Aurora Research Institute, "*AgNorth Modular Farm Concept: Phase 2 Stakeholder Engagement Summary Report*", (June 2014)

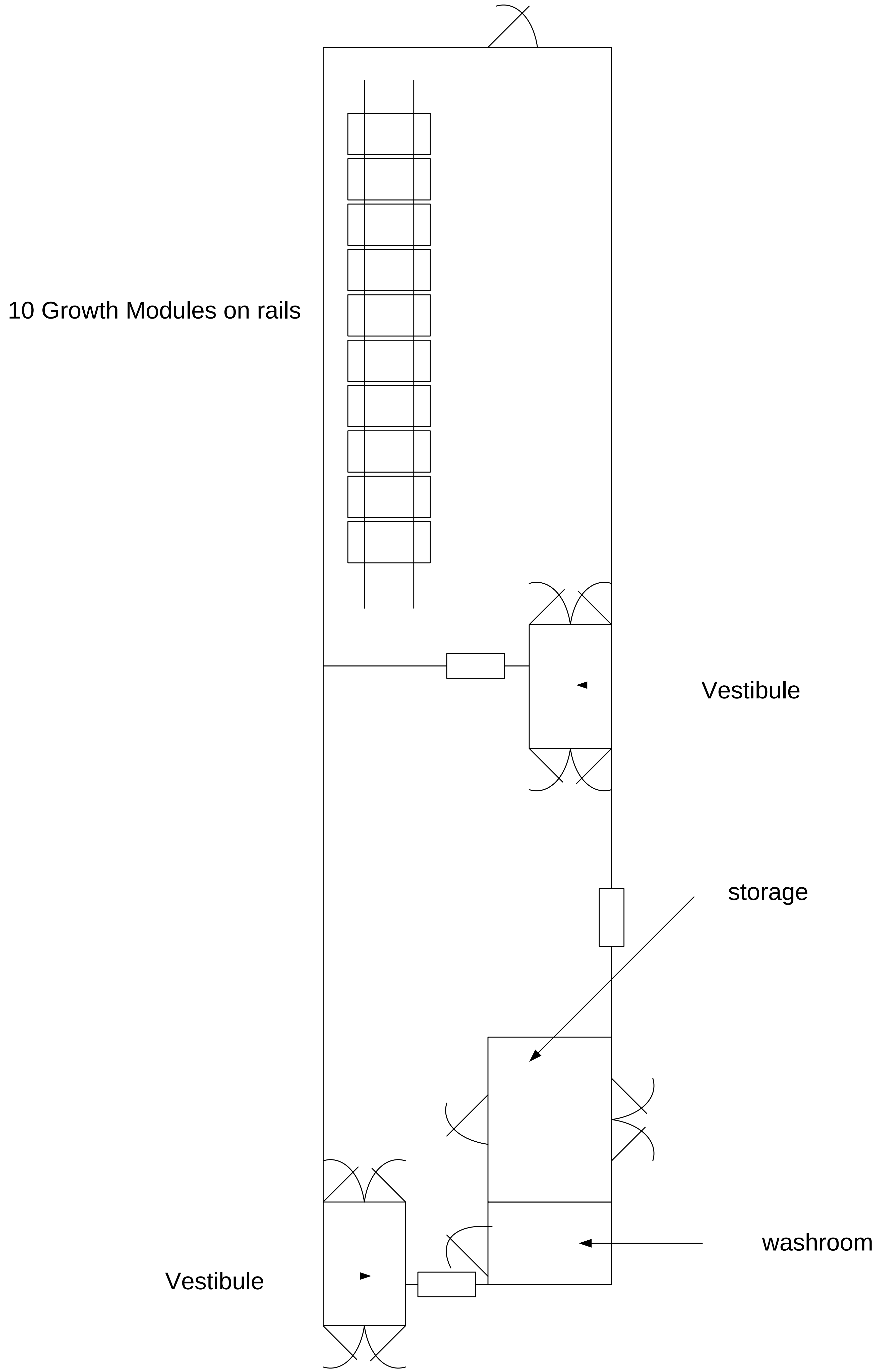
Ko Energy and PlanET Biogas Solutions, "*Liquid and Humid Organic Waste Utilization Study for the City of Yellowknife*", (March 2013)

New Entry Sustainable Farming Project, "*The Farm Incubator Toolkit: Growing the Next Generation of Farmers*", (2013)

Serecon Services Inc., "*NFTI Living Classroom Business Plan*", (March 2014)

Serecon Services Inc., "*Hay River Agriculture Plan*", (February 2014)

APPENDIX B: DIAGRAM OF MULTI-PURPOSE BUILDING



ANGULAR DIMENSIONS	XX °	XX° XX °
ALL ANGLES	+/- 15 °	+/- 5 °
Section Header	MICROINCH	MICRON
	63	1.6

UNTOLERANCED DIMENSIONS LOCATING TRUE POSITION ARE BASIC

INTERPRET DIMENSIONS AND TOLERANCES PER ANSI Y14.5M-1982

PROJECTION

UNLESS NOTED OTHERWISE, DIMENSIONS ARE IN INCHES, MILLIMMETRES ARE IN SQUARE BRACKETS, AND TOLERANCES APPLY AS SHOWN BELOW.

INCHES		
BASIC DIMENSION	DECIMAL PLACE	
	.XX	.XXX
BELOW 6	+/- .01	+/- .005
6 TO 24	+/- .03	+/- .010
OVER 24	+/- .05	+/- .020

MILLIMETRES		
BASIC DIMENSION	DECIMAL PLACE	
	.X	.XX
BELOW 152.4	+/- .3	+/- .13
152.4 TO 609.6	+/- .8	+/- .25
ABOVE 609.6	+/- 1.3	+/- .51

FIRST USED ON	ICD OR OUTLINE No.
NEXT ASSY	
DRAWN BY	DATE
CHECKED BY (DFTG)	DATE
CHECKED BY (ELEC)	DATE
CHECKED BY (MECH)	DATE
APPROVED	DATE
AUTHORIZED FOR PROD	DATE

REV.	DESCRIPTION (ECN No.)	IMPL BY	APVD BY	DATE

REVISIONS

COM DEV

303 TERRY FOX DRIVE
OTTAWA, ONTARIO
CANADA K2K 3J1

TITLE Ag-North Food Production System
Facility Layout

SIZE	FSCM NO	DWG NO	REV
C			

SCALE 1 : 1 | SKETCH | SHEET 12 OF 12