Great Kids Farm

Physical Needs Assessment Report of Findings

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Friends of Great Kids Farm

Great Kids Farm
Green Houses 1, 2, & 3
6501 Baltimore National Pike
Catonsville, MD 21228

Acknowledgement

Many thanks are due to the people who shared their time, passion and expertise informing this report including:

- The staff at Great Kids Farm – Chrissa, Brooks and Beth were all very generous with their time and information.
- Ed Snodgrass and Dominique Bayne of Emory Knolls Farm shared their decades of experience and lessons learned, particularly regarding the greenhouse glazing as well as heating and ventilation strategies.
- Jim Franklin of Maryland Plants and Supplies provided advisement on material pricing as well as heating and ventilation strategies.
- Barry Cullen and Matt Tao of Luther Contracting consulted on the durability of Greenhouse 3 and Head house, particularly regarding the masonry and roof.
- Andrew Truitt of Truitt Renewable Energy Consulting provided insights on solar thermal and solar photovoltaics.
- Todd Humora (Electrical Engineer) advised on automating controls.

Executive Summary

Overview

Great Kids Farm (GKF) is a working farm used to educate "students of all ages about healthy eating, sustainable agriculture and the natural sciences." Elysian Energy, LLC was retained by Friends of Great Kids Farm to provide advisement for improving three existing greenhouses at Great Kids Farm to expand their utility, efficiency and production capacity. Greenhouse One (GH1) is currently the primary greenhouse for GKF while Greenhouse Two (GH2) is used sparingly. Currently GKF uses these greenhouses to produce micro-greens for sale to restaurants as well as seedlings for planting on the farm and distribution to school gardens. Greenhouse Three and adjacent Head House (GH3) is in significant disrepair and unusable.

The evaluative criteria included safety, durability, usability, energy efficiency and production capacity.

All of the greenhouses require significant improvements to restore functionally reliable, year-round production and building safety. We recommend the following improvements.

- Identify and map electrical, natural gas and water service lines
- Replaceall plate glass glazing
- Upgrade heating and ventilation systems
- Improve electrical systems
- Implement backup generator(s)
- Add controls to monitor and remotely control critical functions
- Improve windows (GH3) and doors (GH1, GH2 and GH3)

Greenhouse 3 requires additional significant structural and functional improvements.

GH3 Structural

- Comprehensive masonry repair to Head House and foundation walls of green house
- Repairs to cinder block supports of tables in green house
- New roof on head house

GH3 Functional

- Renovate restroom
- New water heater
- New utility sink

- New garage door
- New refrigeration unit
- Install preparation, storage and staging areas for transfer

Additional consideration and research was performed for the following demonstration projects:

- Green roofs
- Solar heating
- Solar electricity
- Interactive, educational website

Additional Considerations

1. We were unable to calculate energy intensity for the Greenhouses because available utility data included the administrative building, which is outside the scope of this report.
2. The recommendations in this report are based on good/better/best opportunities incorporating information from GKF site staff, publicly available best practices, interviews with leaders in the field, as well as financial considerations.
3. Maryland has a robust incentive landscape for ECMs. The electric utility that serves Great Kids Farm, BGE, has significant incentives for lighting, HVAC and refrigeration. These incentives were not included for several reasons:
    1. Specificity. BGE does not guarantee a specific incentive amount until their engineers review projects and issue a rebate reservation letter.
    2. Funding. BGE's programs, while well funded when compared to other states' programs, are not unlimited, and funds are reserved on a first-come, first-served basis.
    3. Timeliness. The rebate reservation letter only reserves the rebates for 6 months before they expire. Depending on which projects make the most sense, delaying the submission of project details to BGE will likely sync timelines so that GKF doesn't need to reapply.
4. Additional sources of funding may be available from the Maryland Energy Administration. Two programs of note:
    1. Jane E. Lawton Conservation Loan Program (http://energy.maryland.gov/Govt/janeelawton.html)
    2. Kathleen A.P. Mathias Agriculture Energy Efficiency Program (http://energy.maryland.gov/Business/MathiasAg14.htm) Dean Fisher at 410-260-2605

Lastly, and most importantly, Great Kids Farm has an extraordinary opportunity to nurture healthy and successful Baltimore City School students to be healthy and productive members of society. It's a meaningful task—nearly one in four Baltimore's school-age children live in a food desert[1]. The pages that follow include improvements to the physical spaces that will be able to host not only additional production of plants but also additional or enhanced programming for the students. While programming is outside the scope of this physical needs assessment, the opportunities at the intersection of improving the greenhouses and improved/expanded programming experiences are many. Expanded uses for the greenhouses may include:

- Year-round production
- Production of seedlings for distribution to school gardens including:
    - Propagation of cuttings from GKF orchard and
    - Distribution of other garden supports
- Greater skills practice opportunities for interns
- Aquaponics
- Remote monitoring of greenhouses by GKF staff
- Distance learning and continued student engagement via webinars, webcam feeds.

[1] Baltimore Food Policy Initiative - http://archive.baltimorecity.gov/Government/AgenciesDepartments/Planning/BaltimoreFoodPolicyInitiative/FoodDeserts.aspx

Recommended Improvements

GH1, GH2 and GH3 have general construction characteristics in common; however GH3 is unused and in significant disrepair. The recommendations that follow are separated into the following parts: Part I describes systemic or "farm-wide" recommendations; Part II identifies and explains recommendations for GH3 (including Head House improvements); and Part III lists costs for GH1, GH2 and GH3 respectively.

Part 1: Farm-wide Improvements

Utility Line Mapping

As part of the needs assessment, Elysian Energy contacted the utility mapping service, Miss Utility. A summary of utility line markings and conflicts is attached. GKF should archive the markings for later use. and with BPS. (See Miss Utility Ticket Check Status 15526052 in Supporting Information Section of this report). Care will need to be taken by contractors providing the following improvements that relate to gas, water and/or electricity to avoid disturbing these services.

Replacement of all plate glass in GH1, GH2 and GH3

Replacing plate glass is strongly encouraged to minimize safety risks. The plate glass breaks regularly (a member of the site staff indicated several panels are replaced per month). Natural event- (e.g. windfall, hail, bird strikes) and person-made (e.g. a thrown rock) breakage will continue to happen, and it would be irresponsible to continue to use them in light of safety concerns. Contemporary greenhouse designers use two synthetic materials that permit the requisite solar gain and eliminate the risk of broken glass—*polyethylene* and *polycarbonate*.

Type I Polyethylene sheeting (also known as "Greenhouse film")

Polyethylene sheeting is a plastic film that is available in many thicknesses and UV tolerances (i.e. durability), with directly proportionate costs for longevity. For year-round production, polyethylene sheets are installed with two layers that are fastened at the edges and inflated to create an insulating space. (All insulation works by trapping heat in an air space.) We recommend installing a heavier duty (i.e. "4-year" rated polyethylene) sheeting system over the pitched roofs of GH1, GH2 and GH3. The heavier duty polyethylene is more expensive initially than thinner types, but is designed to eliminate annual (re-)installation costs. We recommend less expensive polyethylene sheeting for the sidewalls (i.e. "six-month" film) as it is not unlikely that they may incur damage from normal greenhouse operations (i.e. from both farm staff as well as students and interns). Additionally, the sidewalls may be raised or pulled back regularly during the warmer months for better ventilation. Annual replacement is likely for the sidewall polyethylene sheeting.

Type II Polycarbonate

Polycarbonate is a rigid, durable, minimally opaque and UV-resistant rigid plastic to replace the plate glass. More durable than polyethylene, it is more expensive, with typical warranties ranging from ten to fifteen years. Polycarbonate comes in a corrugated single layer or flat twin-wall "honeycomb" construction. The twin-wall construction is recommended because it incorporates the insulating space. These panels can be worked by tools and are installed in a panelized manner into extruded aluminum channels, resulting in a longer time horizon between replacements.

Regardless of which type you choose for the roofs and sidewalls, we recommend Polycarbonate for the end walls. While both polyethylene and polycarbonate can be patched quickly with foil tape, the wear and tear on the end walls will be higher due to foot traffic as well as stresses from ventilation fans and wind load. The greater initial cost of the polycarbonate is justified through avoided replacement costs for the less durable polyethylene in the end walls.

Improvements to Ventilation Systems

All of the greenhouses were designed with a passive ventilation strategy with operable vents in the top of the sidewalls and along the ridge (i.e. peak) of the roof. The vents are currently inoperable for one or more of the following reasons:

1. The articulating portions are seized or rusted
2. The actuating cranks, gears and pulleys are not functional
3. The motors are either broken or do not have electrical service

According to staff, adequate ventilation is a top priority as GH1 and GH2 can be intolerably warm. In addition to reducing high temperatures, good ventilation helps manage relative humidity (i.e. airborne water vapor, or % saturation of air at a given temperature) to minimize microclimate variations and to ensure gas concentrations. Moreover, ventilation is required to minimize condensation to avoid fungal diseases, issues with cleanliness, and retard deterioration of structural components.

The National Greenhouse Manufacturer's Association recommends replacing interior air with fresh, outdoor air at a rate equivalent to the volume of the greenhouse every minute during the summer. This is known as 1 air change per minute or 60 air changes per hour (60 ACH). The recommended ventilation rate for the winter is roughly one third of that (i.e. 1 air change every three minutes or 20 ACH).

We recommend that you abandon the sidewall and ridge vents, remove the actuating motors and replace the existing fans with fans and shutters capable of the following ventilation ranges, given in cubic feet per minute (cfm):

Greenhouse	Summer Ventilation (CFM)*	Winter Ventiation (CFM)*
GH1	14,400	4,800
GH2	5,900	2,000
GH3	4,600	13,700

*Rounded to nearest hundred. Calculations in appendix.

For GH1 and GH2, the fans will be located in the North end wall with incoming air being drawn through a shutter box on the South wall. Currently the North walls of the respective greenhouses have fans that are inoperable with the South walls housing the intake shutters. GH1 will require two fans capable of exhausting at least 14,400 cu ft together, and GH2 will require one fan that can exhaust 6,000 cu ft.

GH3 will require installation of three mechanical fans located in the end wall with at least one shutter box in each side wall located as close as possible to the head house. Two of the fans will be located between the end wall door and the north and south sides respectively (i.e. roughly 6-8 feet above the floor of the greenhouse). The third fan will be located above the door as close to the ridge as possible and no lower than two feet above the end wall door (i.e. 2′ between top of door and lower edge of fan) to ensure this fan pulls air from the upper third of the greenhouse to avoid any stratification of heat, gases or moisture in this air and not simply recirculate air from the door.

The use of interior circulating fans ("Horizontal Air Flow Fans") is also required to ensure uniformity of moisture and temperature. (Uniform air quality encourages plant growth by increasing CO2 availability while reducing disease and mildew caused by excessive moisture.) GH1 and GH3 will need four (4) 12″ diameter fans and GH2 will need two 12″ diameter fans for sufficient circulation.

Improvements to Heating Systems

GHI has recently undergone improvements to its hydronic heating system and no improvements are needed; however, it is the opinion of the author that tabletop heating is best. In the interest of uniformity of production and operational strategies, adding radiant tabletop heating is put forward as the best option. The author also recognizes that the current system is sufficient to provide heat to GH1 for year round production (as well as GH2 – see below) provided the glazing, ventilation and door improvements are made.

GH2 is heated by the boiler housed in GHI with hot water being distributed to GH2 from GH1 by way of an underground pipe. During the winter of 2014-2015, GH2 lost heat. The exact cause is currently unknown, but is most likely due to a leak in the underground pipe. Three options exist for GH2 to resume its ability to produce in the winter:

Option 1

Repair the underground pipe. This will require excavation to determine the source of the leak and to replace the deteriorated pipe. Tabletop heating via hydronic heating is possible with the addition of an auxiliary pump for GH2.

Option 2

Install a dedicated boiler for GH2 thereby removing the need to excavate and eliminate the use of GH1's large boiler for GH2's comparatively small load. Tabletop heating would be available.

GH3 is currently outfitted with three hanging forced air heaters in the greenhouse and one in the head house. Two of the three units in the greenhouse are over twenty years old and should be removed. The third unit (the Northeastern-most) is from 2000 and should be cleaned, tuned and confirmed operational when gas service is restored. While it's toward the end of its useful life, it is advisable to keep this unit for heating the air in the greenhouse for air temperature uniformity and to assist in melting any snow from the roof. This furnace will be supplemental to the primary hydronic heating (i.e. boiler) strategy that follows.

In the interest of productivity and energy efficiency, delivering heat to where it is needed most – to the soil for germination and root development – is recommended. That is, a boiler system that treats each table area in the greenhouse as its own zone makes a lot of sense. This strategy allows each zone (i.e. table top) to call for heat independently of the others by way of it's own thermostat to avoid variable temperatures (i.e. microclimates of excessive or insufficient heat). Moreover, this zonal strategy allows for different soil temperatures to be maintained at the same time of year. GKF staff could diversify their production at the optimal soil temperature for each crop being grown.

This tabletop heating strategy includes a boiler for creating the hot water, pumps and valves to deliver the water to where it is being called and a web of tubes laid out on each table to conduct and radiate heat where needed. The tubes can be butyl or cross-linked polyethylene (PEX), usually ¼" to 3/8" in diameter, spaced about 2" apart. Typical tabletop installation includes a filter fabric laid over the tubing to protect it while short racks are placed over this fabric upon which small containers are placed with soil and seeds. This is less efficient than encasing the tubing in concrete. While encasing the tubes in concrete has a greater initial cost, it makes them much more difficult to damage while also providing more even heat distribution as well as thermal storage. That is, concrete can "hold" heat better than air, and this is especially important because ventilation is so important to manage moisture (i.e. the required ventilation rate will evacuate warm air during the cooler months at a great rate. As stated above, having supplemental forced air heat will help boost heat when needed during severe cold spells or when additional heat is needed to melt snow from the roof.

The head house will be a fifth zone for heating. Adding baseboard fin-tube units to the office, bathroom and main prep area is advised to ensure pipes do not freeze and for durability purposes.

Electrical improvements

All of the greenhouses need electrical upgrades to ensure functionality and productivity related to ventilation and lighting. All of the greenhouses should abandon the current passive ventilation strategies by removing the motors, cranks and/or pulleys for opening the vents to make space available for circulating fans and to minimize shade. When the glazing is replaced, this improvement will remove unnecessary equipment from the space and may make existing wiring available for the horizontal airflow fans.

GH1, GH2 and GH3 will benefit from a screw-in lamp retrofit. Compact Fluorescent lamps are likely the best choice as the weatherproof fixtures may sequester heat that would impair LED performance.

No dedicated electric service was observed at GH2. It is likely that a wire is run from GH1 for GH2; however, diagnostics are required to ensure the lights as well as the ventilation and circulation fans have sufficient current. If GH2 is served by a circuit from GH1, the electrification may be a simple diagnostic and replacement (est. $100). Should the need arise, replacing the panel box in GH1 and installing a subpanel for GH2 could be installed for $1,600.

GH3 needs a new service panel and rewiring throughout. Due to safety concerns, no attempt to turn the main power on at the panel located in the head house was made. Regardless, the panel consisted of fuses for overload protection that no longer meets code. GH3 needs a new service access panel.

Backup generators

GH1 and GH2 could share a backup natural gas generator during power outages to minimize the likelihood of crop failure.

GH3 also has gas service, and a natural gas generator would minimize the likelihood of crop failure but also ensure that the head house would be open for distribution to students and schools regardless of the power outages.

Controls

GH1 and GH2 can share controls as they are adjacent. GH3 would benefit from having its own set of controls as the orientation is different and one system may not be able to communicate over that distance. That is, the wireless networks that facilitate the remote controlling capability may not reach GH3 from GH1/GH2. For example, the Link4 iGrow system includes the ability to remotely irrigate, ventilate, heat and monitor existing conditions. The iGrow system also integrates with an optional Weather Station that can log data over time against sensors inside the greenhouses. This can be very powerful data for tracking and managing productivity. Additionally, the Weather Station can notify, via smartphone app, GKF staff of incoming storms so GKF staff can adjust schedules accordingly. For example, if a strong storm is coming, the ventilation fan schedule can be overridden remotely to avoid excessive water intrusion or damage to the fans/electrical. This system does require wireless service for both locations.

Windows and Doors

GH3 needs new windows and doors throughout while GH1 and GH2 need door replacements and/or repairs. All the exterior doors need mechanical closing mechanisms.

Part 2: Greenhouse 3 Improvements

In addition to the glazing, ventilation, heating, electrical and backup generation recommendations, controls, windows and doors, GH3 requires extensive structural and usability improvements.

Masonry Repair

The head house and foundation walls of the greenhouse have significant deterioration. The blocks themselves present in salvageable condition, but the entire structure needs mortar to be reinstalled.

Insulation

Option I: Interior Insulation, Head house

The head house is currently uninsulated. The one-time cost of insulation installation is always cost-effective as it reduces operating costs, increases comfort and often helps extend the useful life of materials and equipment in the conditioned space. Adding 2” by 6” framing, 16” on-center with R-19 or greater insulation is recommended on the interior of the head house and finish with drywall. Rockwool does better in moist environments than fiberglass and is only slightly more expensive.

Option II: Exterior Insulation Finish System (EIFS), Head House

To extend the useful life of the structure, increase energy efficiency and leave the maximum amount of usable square footage inside the head house, we recommend an exterior insulation finish system (EIFS). This strategy adds foamboard insulation to the outside of the masonry and is then covered with a course of stucco for durability and drainage.

Option III: EIFS on the head house and on the outside of the foundation wall of the greenhouse

Adding insulation during the repair of the masonry of the greenhouse would help reduce heat loss from the greenhouse. It would also create more usable and conditioned space and minimize temperature fluctuations.

Windows & Doors

As stated above, all of the windows and doors for the GH3 need to be replaced as they are in poor condition. Included in these replacements is the need to reinstall the framing as much of the wood framing has deteriorated.

Head House Roof

The head house needs a new roof as much of the decking was rotting, particularly near the plumbing stack and around the downspout/drain in the NE corner. New drainage will need to be reinstalled.

Restroom renovation

The restroom in the head house needs to be renovated with a new commode, sink and faucet. Be sure to install EPA WaterSense commode and low flow aerator. The addition of an exhaust fan is needed.

Water heater

The water heater needs to be replaced and re-vented to ensure proper exhaust of combustion gases. It is beyond its useful life and showing signs of improper venting. A “power vented” model is specified as this eliminates the possibility of backdrafting that could be an issue when the exhaust vents are operating in the greenhouse.

Utility Sink

The utility sink in the main prep area is broken and needs to be replaced.

Garage Door

The garage door needs to be replaced with a similar rollup model that fits better into the garage door opening as a gap of 1-2" was observed. Ensuring a snug fit is better for energy efficiency, comfort, moisture management, pest control and security.

Prep, Storage & Staging Area(s)

Adding tables with storage underneath is a best practice. Ideally these prep tables will be movable (i.e. have wheels) with one located next to the utility sink and another on the opposite wall located towards the roll up door for staging pickups. Storage cabinets and/or wall storage (e.g. pegboard, hooks) is also needed on the wall with to the greenhouse for tools and supplies.

Office

The office will need to be conditioned for occupant comfort and to avoid overheating conditions for any computers or IT equipment. As indicated in the Heating portion above, a through-the-wall or room AC unit is recommended, and an additional dehumidifier may be needed depending on how the space is used (and particularly if the window to the greenhouse is open regularly.

Refrigeration

We recommend a small walk-in cooler. Even small walk-in coolers provide much more available storage than several refrigerators of the same footprint. A walk-in cooler creates a lot of flexibility for production purposes not only because of the cooler temperature but also because of the dehumidification of cool air.

Lighting Retrofit

The greenhouse lighting fixtures should have the bulbs replaced with compact fluorescent lamps. The head house should have 4 fixtures installed in the prep/staging area spaced throughout the room. Each fixture should have two 48" tubular LED lamps to provide sufficient working light. The office and bathroom should have at least one fixture of the same type (2 48" tubular lamps) respectively. Motion sensors with manual override feature should control each room's lights.

Parking Area

The area adjacent to the North wall of the greenhouse is currently overgrown with vegetation; however it is an excellent location for parking. A stump would need to be removed if the entire area were to be used for parking, and perhaps some minor regarding.

Controls

To optimize productivity, GH3 needs an integrated controller that monitors and manages the heating, humidity and ventilation. The technology to control these systems remotely exists (by computer, smart phone) to give site staff the opportunity to increase their productivity. Moreover, the web portal for this system can be used to engage students both on-site and in the classroom. To ensure this, GH3 will need internet connectivity, as well as specialized hardware, software and wiring. (Please note the recommended controls and controller should be installed by an electrical engineer.)

Optional – Cold Frames

The planter boxes for outdoor sprouting and growth known as the cold frames are excavated and could present a fall hazard. The holes could be filled in with soil, and the pricing is presented for comprehensiveness.

Estimated Costs

Before undertaking any improvements GKF or its contractors will need to contact Miss Utility to locate underground utility lines and pipes. Once attained, these records must be filed at GKF and with BPS.

GH1 Improvement				Est. Cost
Replace plate glass	Replace	Option 1: Polyethylene	$	8,100
		Option 2: Polycarbonate	$	14,960
Heating	Install tabletop heat		$	6,300
Ventilation	Repair or replace		$	2,200
Electrical	Repair		$	100
Back-up generator	Install		$	5,000
Lighting retrofit	Repair or replace to operable conditions		$	300
Doors	Replace (N door) add mechanical closing mechanisms (N, S)		$	800
Controls and web interface	Install for GH1 and GH2		$	6,500
Greenhouse 1 Total Estimated Cost				**$29,300 - $36,160**

GH2 Improvement				Est. Cost
Replace plate glass	Replace	Option 1: Polyethylene	$	5,700
		Option 2: Polycarbonate	$	10,500
	Repair install	Option 1: Repair pipe	$	2,800

GH2 Improvement			Est. Cost
Heating	Repair install Option 2: Install own boiler	$	6,400
	*Convert to encased tabletop	$	4,400
Ventilation	Install	$	1,200
Electrical	Install subpanel	$	1,600
Back-up Generator	Ensure power to avoid crop failure	$	5,000
Doors	Replace	$	200
	Install for GH1 and GH2	$	1,000
Greenhouse 2 Total Estimated Cost			**$17,500 - $30,300**

GH3 Improvement				Est. Cost
Replace plate glass	Replace	Option 1: Polyethylene	$	7,400
		Option 2: Polycarbonate	$	13,600
Heating and ventilation	Repair/replace to operable conditions		$	28,500
Electrical	Repair/replace to operable conditions		$	4,000
Back-up generator	Ensure power to avoid crop failure		$	5,000
Masonry	Repair and repoint		$	7,000
Insulate walls	Intall	Option 1: HH Interior Insulation	$	5,700
		Option 2: HH EIFS	$	8,200
		Option 3: HH & Greenhouse stem wall EIFS	$	13,500
Windows and doors	Replace		$	6,000
New Head House EPDM Roof	Replace		$	6,500
Restroom renovation	Replace including new plumbing supply lines		$	7,000
Water heater	Replace		$	1,100
Utility sink	Replace		$	500
Garage door	Replace door and install motorized opener		$	3,000
Prep, storage, and staging	Install		$	1,500
Walk-in cooler	Install		$	6,000
Lighting retrofit	Repair/replace to operable conditions		$	1,400

GH3 Improvement		Est. Cost
Parking area	Clear and prep	$ 7,000
Controls and web interface	Install	$ 6,500
Fill cold frames	Install	$ 3,500
Greenhouse 3 Total Estimated Cost		$107,600 - $121,600
Grand Total for repairs to GH1, GH2, and GH3		$154,400 - $188,060

Demonstration Projects

The following list of projects was developed based on consistency with the greater mission and vision of Great Kids Farm in mind. It was informed by current and former staff experiences to enhance the experience for BPS students.

Project	Intention		Est. Cost
Green Roof	Replace	Option 1: Polyethylene	$ 4,800
		Option 2: Polycarbonate	$ 1,400
Solar Hot Water	Repair install	Option 1: Repair pipe	$ 9,000
Solar Photovoltaics (4kW System)	Install		$ 16,000
Interactive Website	Install subpanel		$ 4,700
Greenhouse 2 Total Estimated Cost			$17,500 - $30,300

Possible Funding Sources

BGE Rebates

MEA - Jane E. Lawton Conservation Loan Program (http://energy.maryland.gov/Govt/janeelawton.html) Kathleen A.P. Mathias Agriculture Energy Efficiency Program (http://energy.maryland.gov/Business/MathiasAg14.htm) -- Dean Fisher at 410-260-2605

USDA? DOE?

Description of Existing Building Systems

Occupancy

Building Envelope

Lighting Systems

Mechanical Systems

Security, oversight, or operational requirements impacting this effort

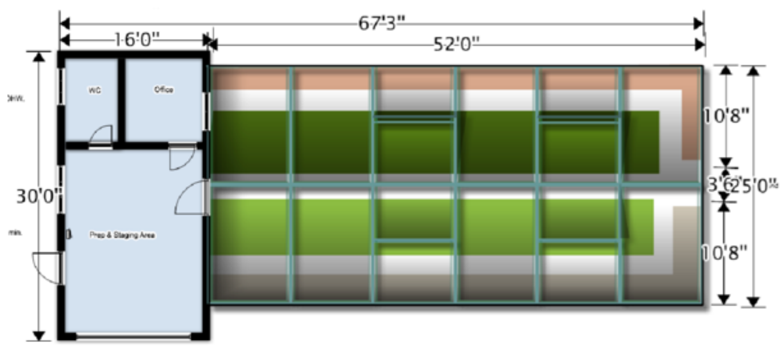
Greenhouse 3

Description of property

The property (G3) consists of two rectangular buildings that adjoin: a plate glass green house with metal framing and cinder block stem walls measures 52 feet long by 25 feet wide with the long axis oriented East-West. The adjoining building, or "Head House" (HH), measures 16' x 30' and is of cinderblock construction. Neither building is insulated. GH3 has been unused for many years and requires significant improvements to meet GKF's objective of increasing the utility and production capacity with the intention of making this property usable year-round.

Head House

HH is a preparation and staging area for distribution of produce. The16'x30' structure consists of a bathroom (5.5' x 9',), an office (10' x 9') and a work/storage/loading area measuring (21' x 16').



The head house is on the Eastern side, and the GH's end wall faces West. The site has significant southern exposure with some shade coming from the Head House to the East and adjacent trees to the West.

Greenhouse I (GH1) is the same construction as GH3's greenhouse: 52' by 25' with a block stem wall and plate glass walls and roof within metal framing; however, there is no head house, and the long axis is oriented N-S.

Greenhouse 2 (GH2) is the same construction type as GH1 and GH3 but is smaller, measuring 31' by 20'9" with the long axis oriented N-S similarly to GH1.

Northeast corner of Head House with Greenhouse in background and potential parking area to the right of the Head House beyond the existing driveway.

North-facing wall of Head House with roll-up door.

Note broken glass panels, the parking area, the furnace exhaust flues (in head house as well as the greenhouse) and the foundation disrepair.

West wall of Greenhouse 3 - New door and extensive masonry work needed. The metal framework is in good condition throughout, and is usable for the foreseeable future as the recommended replacements are lighter than plate glass. Some preparation of the framework will be required to avoid damaging (i.e. puncturing or cutting) the polyethylene or polycarbonate.

Southwest corner of Greenhouse - The lower right corner shows the cinder block edge of a “cold frame” planter used to cultivate plants tolerant of ambient conditions. GKF will need to determine if the cold frames will be used as they are potentially dangerous vis a vis trips and falls as they are several feet deep. Alternately, short barriers and/or signage could be installed to minimize accidents.

North wall of Greenhouse 3 shows broken glazing, deteriorated masonry (especially at the right margin of Head House).

Masonry Issues in Head House.

Ventilation Calculations

Greenhouse Volumes = (length × width × height) + (0.5 × length × width × height)

GH1 = (52 × 25 × 7.83) + (0.5 × 52 × 25 × 6.5) = 10,179 $ft.^3$ + 4,225 $ft.^3$ = 14,404 $ft.^3$

GH2 = (31 × 20.75 × 7.5) + (0.5 × 31 × 20.75 × 3.3) = 4,824 $ft.^3$ + 1,061 $ft.^3$ = 5,885 $ft.^3$

GH3 = (52 × 25 × 7.25) + (0.5 × 52 × 25 × 6.5) = 9,425 $ft.^3$ + 4,225 $ft.^3$ = 13,650 $ft.^3$

Heating Capacity

GH3 currently has 240,000 Btuh capacity in the greenhouse area with another 84,000 Btuh for the head house. The three units in the greenhouse area are: Unit 1, Jackson, and Church.