Source Water Protection Plan
for the
Harmony Hill School Water System

Developed by: Harmony Hill School Source Water Steering Committee

Prepared by: Atlantic States Rural Water and Wastewater Association

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PWS # RI2000059

July 2011

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Primary Contacts:

Gordon Richardson
Facilities Superintendent
Harmony Hill School
63 Harmony Hill Road
Chepachet, RI 02814
401-949-0690

Elizabeth Myre
Atlantic States Rural Water & Wastewater Association
PMB #275, 12 New London Turnpike
Norwich, CT 060360
401-864-0725

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Introduction

The purpose of the Harmony Hill School Source Water Protection Plan is to reduce or eliminate potential and existing risks to the quality of water being supplied by the Harmony Hill School wells. The management plan included here outlines specific actions available to the school to protect the wellhead protection area (WHPA).

The plan was prepared by the Atlantic States Rural Water and Wastewater Association (ASRWWA), in cooperation with the National Rural Water Association. Program funding was provided by the Source Water Protection Program of the Environmental Protection Agency (EPA). The purpose of the program is to provide technical assistance to rural and small communities for the development and implementation of Source Water Protection Plans.

Source Water Protection Plans written as part of this program build on the Source Water Assessment Program of the Rhode Island Department of Health (RI HEALTH), which was completed approximately ten years ago. This program determined the susceptibility of the public water systems in Rhode Island to potential contaminant sources.

In the case of Harmony Hill School, *source water* refers to the groundwater in and around its two wells. Groundwater can be threatened in a variety of manners, as shown in Figure 1. Potential contaminants include nitrate, pathogens, fuels, solvents, herbicides, pesticides, and metals.

Proactively addressing the issue of source water protection helps to protect public health, decrease treatment costs, reduce the chances of water quality violations, and ensure the continued viability of the aquifer for drinking water purposes.

The Harmony Hill School system was chosen for participation in this program not only because of identified risks, but also because of the willingness of the facilities staff to put time and effort towards source water protection.

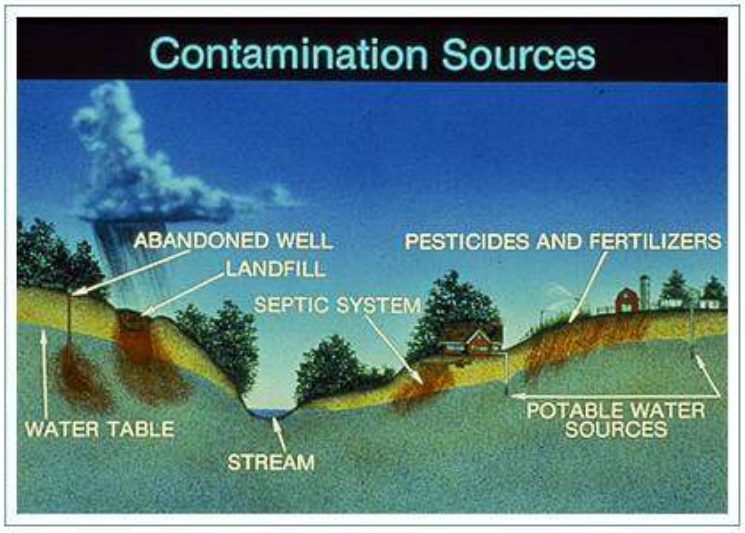

Figure 1. Examples of potential contamination sources.
Source: http://www.epa.gov/ne/eco/drinkwater/pc_sourcewater_assessment.html

Local Source Water Protection Steering Committee

The following people comprise the Harmony Hill School Source Water Protection Steering Committee. They have helped to gather and review the information contained in this plan. This committee will meet once a year to review and update the plan and to assess its progress.

Steering Committee

Gordon Richardson – Harmony Hill School Facilities Superintendent
Scott Tucker – Harmony Hill School Facilities Staff
James Mogayzel – Harmony Hill School Facilities Staff
Dave Beagin – Harmony Hill School
Elizabeth Myre – ASRWWA

Harmony Hill School – Chepachet, RI

Background

The following was taken from Harmony Hill School's website:

> *[Harmony Hill School is a] comprehensive residential, day and community treatment program that offers a variety of therapeutic and psycho-educational services for socially, emotionally and behaviorally challenged boys ages 8 – 18… Since its inception in 1962, and incorporation as a non-profit 501(c)(3) organization in 1976, Harmony Hill School has stood in the vanguard of youth service providers in Rhode Island… Our mission is to provide treatment and education for behaviorally and emotionally disordered children, youth and their families who are experiencing disruptive life situations.*

Source Water Inventory and WHPA

The Harmony Hill School water system is fed by two bedrock wells. Well #1, near the Gregson Family Center, is believed to be 300 ft deep (year unknown). Well #2, near the pump building, is 600 feet deep, and was drilled in 1988. The water is filtered and pH is adjusted.

The population drinking the water includes:

- residential students – 64 total capacity, currently approximately 52
- day students – 30 total capacity, currently approximately 20
- staff – 150 total capacity, currently approximately 140

As can be seen in Figure 2, areas of two different sizes have been delineated around the wells.

Figure 2. WHPA and ARPs of the Harmony Hill School public water system.
Based on the topography of the surrounding area, groundwater is assumed to flow from west to east.

The larger area, which extends beyond the boundaries of the school campus, is the Wellhead Protection Area (WHPA). A WHPA is the land area from which groundwater will flow to a well under pumping conditions. A WHPA is defined by the Rhode Island Department of Environmental Management (RI DEM) as "the critical portion of a three-dimensional zone surrounding a public well or wellfield through which water will move toward and reach such well or wellfield." The WHPA for the Harmony Hill School water system is a nearly circular shape roughly 1750 ft north to south and 1950 ft east to west. The size of the WHPA is determined by RI DEM.

The fact that the entire campus is contained within the WHPA is significant. This means that activity anywhere on campus has the potential to effect drinking water quality and therefore the health of those consuming water from the system.

In Figure 2, the smaller circles with a radius of 200 ft represent the "area reserved for protection of the water quality of the well" (ARP). (In some states, this is called the "inner protective radius".) The term *ARP* comes from the RI HEALTH Rules and Regulations Pertaining to Public Drinking Water [R46-13-DWQ].

Section 3.3 of the Rules and Regulations describes part of the requirements for developing a new bedrock well for a public water supply:

> *3.3 In the case of a proposed drilled (rock), driven, or dug well, the site plan shall show pertinent information within at least 1750 feet of the proposed well including, but not limited to, the location of existing and proposed sewage disposal systems and any other existing or proposed potential sources of pollution including but not limited to those listed in Appendix 4. Generally, the land within two hundred (200) feet of such wells shall be reserved for protection of the water quality of the well, and shall be delineated on the site plan by a topographic mapping of the two hundred (200) foot area to an appropriate scale. This distance may be modified at the discretion of the Director taking into consideration such factors as the volume and type of waste material to be disposed or stored in close proximity to the land area reserved for protection of the well, the depth below grade to impervious formation, the depth below grade to the water table, the type of soil in the area, or any other factors the Director deems pertinent.*

After drilling the new well, Section 3.7 describes the requirement to continue protecting the ARP:

> *3.7 It is the responsibility of the water supplier to maintain the protective well area free from potential sources of contamination as listed in Appendix 4.*

Appendix A contains the list of potential sources of contamination mentioned in both of the above excerpts.

For ease of understanding, the figures throughout this document have blue circles of radius 200 ft drawn around each well to signify the ARP, as shown in Figure 3. However, as these circles were drawn by ASRWWA for illustrative purposes only, their exact size and location should not be assumed to accurately represent the area considered the ARP by RI HEALTH.

Figure 3. ARPs of the two Harmony Hill School wells.

RI HEALTH Source Water Assessment

Approximately ten years ago, RI HEALTH completed a state-wide survey of public drinking water supplies under the Source Water Assessment Program. This program was mandated with the 1996 reauthorization of the Safe Drinking Water Act. The purpose of the program was to evaluate the susceptibility to contamination of each public drinking water source in Rhode Island and communicate the results to the public.

Harmony Hill School was rated as a system with "low risk" of potential contamination. As the Source Water Assessment pointed out, *"A low rating does NOT mean that the source is free from contamination risk. Without sufficient protection, ANY water supply can become contaminated."* The complete Source Water Assessment for Harmony Hill School is included as Appendix B.

Confirmed Contaminant Detects of Concern in Source Water

Nitrate

Nitrate levels in Harmony Hill School source water have been rising slowly but steadily since the late 1990s, as shown in Figure 4. (Note: This discussion of nitrate levels does not include the 2011 data, although the new data *is* included in Figure 4. The 2011 data is discussed in the "Test Each Well Separately for Nitrate" section, below.) At the current level, the water is safe to drink. However, the clear increase is a sign that the water is being affected by activity in the area.

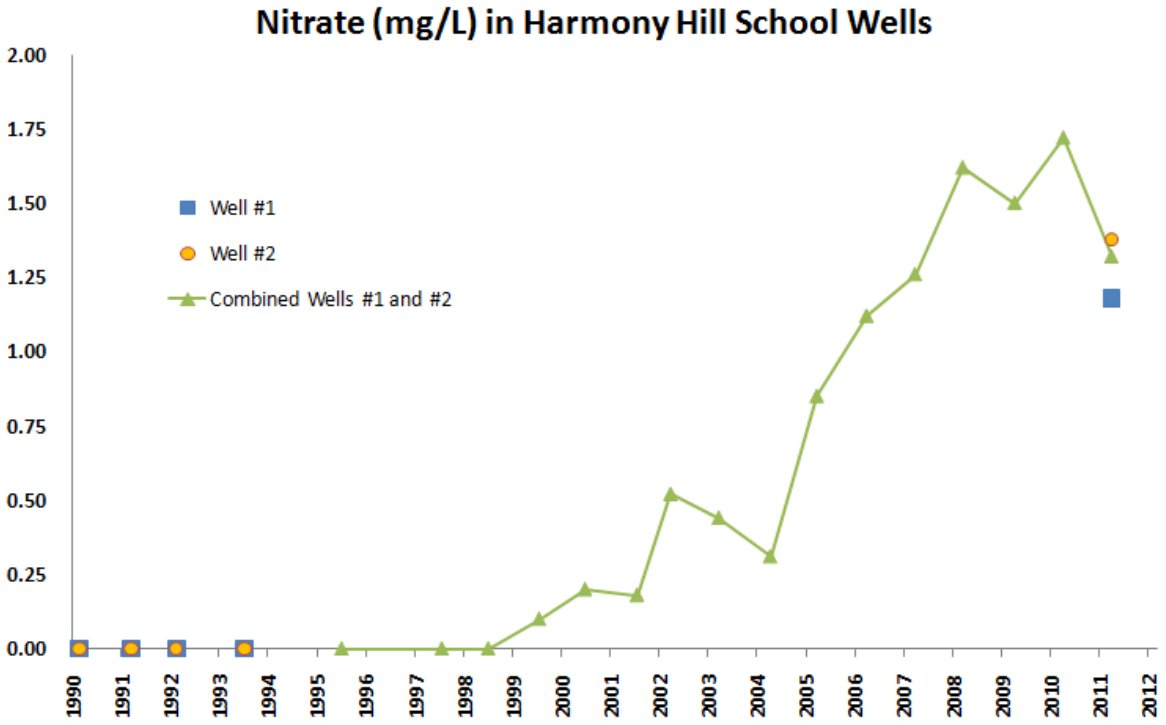

Figure 4. Nitrate levels in the Harmony Hill School wells.

The drinking water standard for nitrate is 10 mg/L. Above this level, there is a concern that infants may be at risk for "blue baby syndrome", where nitrate replaces oxygen in the blood. In order to prevent this, when a water supply reaches 5 mg/L, more frequent monitoring is required by RI HEALTH.

If the nitrate levels in the Harmony Hill School wells continue to rise at the current rate, they will hit the 5 mg/L level in approximately twenty years. This additional monitoring will be an added expense for the school.

Assessment of Threats

On-Site Wastewater Treatment Systems

Because Harmony Hill School is not connected to a public sewer system, all of its buildings are served by On-site Wastewater Treatment Systems (OWTSs), also known as septic systems. There are multiple septic systems on campus, as shown in Figure 5. There is still one cesspool that has not been replaced by a properly functioning septic system.

In Figure 5, which is based on the extent of the facilities superintendent's knowledge, the green circles indicate septic tanks and grease traps, the green rectangles represent leachfields, and the red circle is the cesspool. Cesspools do not treat wastewater that passes through them. Because this cesspool is located within the 200 ft ARP of a public drinking water well, the Rhode Island Cesspool Act of 2007

requires that it be replaced by a functioning septic system by January 1, 2013. In addition, any cesspool at Harmony Hill School would be considered a large capacity cesspool[1], and large capacity cesspools are not allowed in the state, regardless of whether they are located near a source of public drinking water.

Figure 5. On-site Wastewater Treatment Systems at Harmony Hill School.

Traditional septic systems such as those found at Harmony Hill School are not designed to reduce nitrate levels in wastewater. Effluent from septic systems can therefore be a source of nitrate to groundwater.

Several of the septic systems at Harmony Hill School have been retrofitted with the White Night tank aeration system in order to rehabilitate clogged leachfields. Although it has been claimed by some that the White Night system significantly reduces nitrate in septic tank effluent, the product is not considered a nitrogen-reducing technology by RI DEM.

There has not been a recent increase in student population, so increased use of the septic systems by more students cannot account for the rising nitrate levels found in the wells.

To the best of the facilities superintendent's knowledge, all floor drains are connected to a septic system. This helps to protect source water by preventing floor spills (e.g., an overflowing toilet) from being discharged directly into the ground.

[1] RI DEM defines a large capacity cesspool as "a cesspool that serves any non-residential facility that has the capacity to serve more than twenty (20) people per day or serves any multi-family residence or apartment building."

(Update – During a recent pumpout of the system considered to be a cesspool, it was noted by the facilities superintendent that the system is actually a concrete tank. This system will need to be inspected by a certified inspector to determine whether it meets the requirements to be considered a septic system.)

Construction and Earthworks

Over the years, Harmony Hill School has continued to construct new buildings on its campus. Figure 6 shows the year in which each structure was built. Considering that nitrate levels in the wells began to rise around 1998, it is interesting to note that the three buildings closest to the wells (and at least one of the associated septic tanks) have all been built since the mid-1990s. In fact, the building built in 1996 is located almost directly on top of Well #1. Altered patterns of surface water runoff and groundwater infiltration could be exposing the wells to sources of nitrate to which they were previously less susceptible.

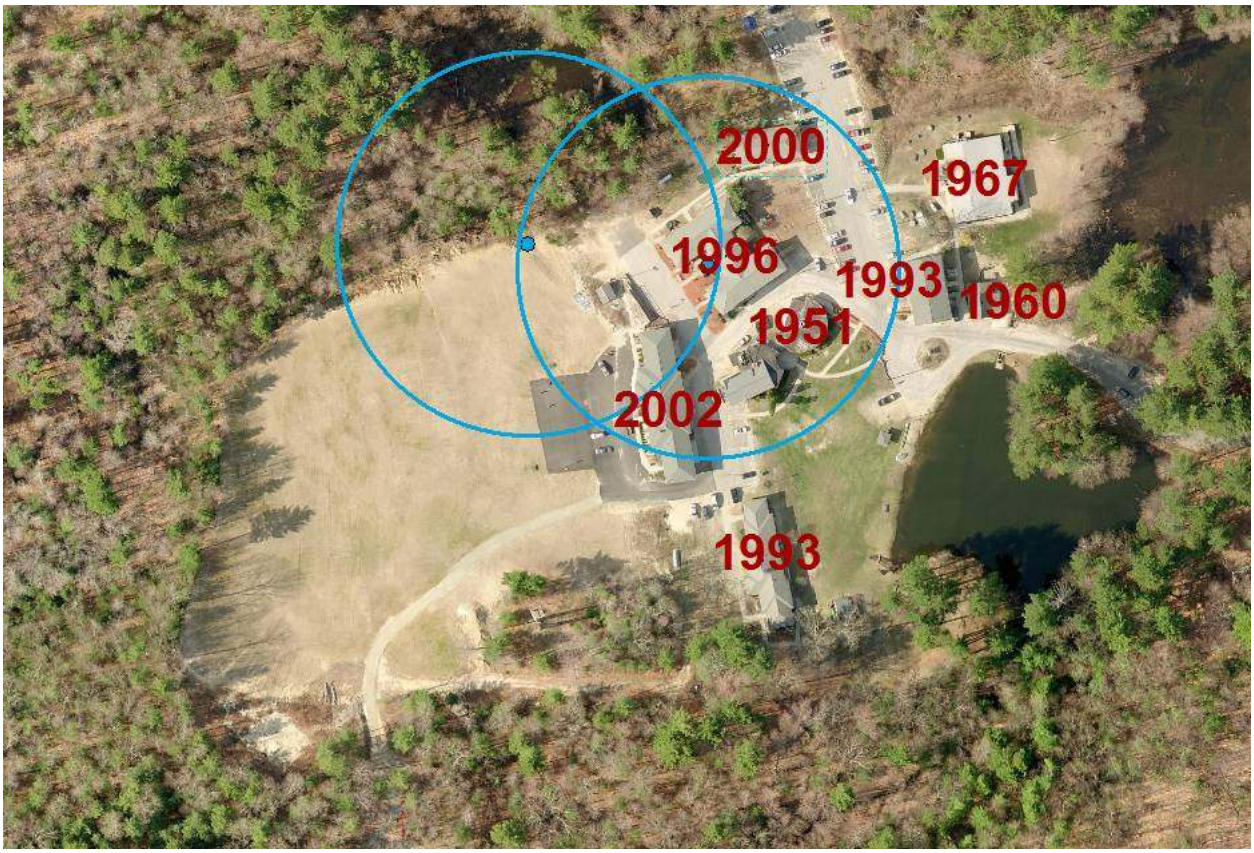

Figure 6. Dates of building construction at Harmony Hill School.

From 2005-2007, the top of the hill located west of the campus buildings was removed and sold as sand. This created a large, flat field, which was then re-seeded with grass twice (see "Landscaping" section, below). The field is at a higher elevation than the two wells.

Landscaping

Landscape care and maintenance often involve the use of fertilizers, herbicides, and pesticides. Most of these products are highly soluble in water and can be transported through groundwater to wells.

Fortunately, Harmony Hill School does not fertilize any of the grassy areas on campus, including the recreational field. However, when hydroseed was spread on the field uphill from the wells, fertilizer was included. This was done in 2007 and again in 2008, because the grass did not survive well in the acidic soil.

School Agricultural Program

Harmony Hill School is in the beginning stages of creating an agricultural program for its students. A greenhouse was built directly uphill of the two wells in 2010. It is approximately 200 ft away from the closest well. It can be seen in Figure 7. The greenhouse was designed to have an impervious floor and a drain that leads to a stormwater discharge area, in order to minimize the potential for impacts on source water quality.

Figure 7. A picture from Google Maps showing the greenhouse during construction.

The gardens will be organic, which is very postive in terms of source water protection. (Update: The school is considering using a small amount of Miracle Grow on corn planted outside the ARP.) The school has begun to create compost as shown in Figure 8. Currently, the compost pile is very close to the Well #2. Although nitrogen will be released from compost more slowly than it would be released from a liquid fertilizer, it still has the potential to affect the wells. RI HEALTH recommends no agricultural activities within the 200 ft ARP.

Figure 8. The compost pile in Fall 2010.

The long-term plan for the agricultural program includes individual garden plots for students, an apple orchard, and small livestock.

Currently, the Harmony Hill School Water System qualifies for a pesticide waiver. This means that it is not required to sample water for pesticides because no pesticides were found in the water during an initial testing period, and none are used in the area. If pesiticides begin to be used, for example on apple trees, not only will this be a risk to the source water, but it will cause the additional expense of sampling for pesticides.

Heating Oil

Leaking heating oil tanks pose a risk to groundwater quality. Over time, water from condensation and sludge from impurities in the oil can cause corrosion, leading to leaks. The legs of above-ground tanks can also break, causing tanks to topple and spill.

There was one underground fuel line leak at Harmony Hill School in January 2006. The leaking line was removed, as well as the soil around it. Since then, all underground storage tanks (USTs) at Harmony Hill School have been removed. The heating oil is now located in above-ground 250-275 gallon storage tanks with containment. All but one of the tanks are located indoors. The one tank located outdoors is marked by a purple circle in Figure 9.

Figure 9. The purple circle in the upper right corner shows the location of the outdoor heating oil tank.

Management Plan

A source water protection workshop was held on January 25, 2011 at Harmony Hill School. Participants included staff from Harmony Hill School, ASRWWA, and RI HEALTH. After being presented with a brief overview of source water protection in general and the specific concerns of the school, attendees brainstormed possible reasons for increased nitrate levels, as well as approaches to reducing risk. These ideas have been further developed and prioritized, and the following list of source water protection activities is the result.

Test Each Well Separately for Nitrate

For a public water system with two wells, RI HEALTH does not require the system to sample the water in each well separately if the source water is always mixed (i.e., when water is pumped, both pumps come on and the system never receives water from just one well). This helps to reduce testing costs. For this reason, since 1995, we do not have data on nitrate levels in the individual wells, only in the mixed raw water.

Because it is possible that one of the wells at Harmony Hills School is more affected by nitrate than the other, the facilities staff plans to test both the mixed water and the two wells separately the next time that samples are taken. This will allow them to pinpoint whether one of the wells is more affected than the other, and will contribute to a better understanding of what has caused the rise in nitrate levels. This can be paired with the annual coliform testing.

(Update – On April 21, 2011, samples of the mixed raw water and the water from the individual wells were tested for nitrate. The following nitrate levels were observed: Entry Point (mixed raw water) – 1.32 mg/L, Drilled Well #1 – 1.18 mg/L, and Drilled Well #2 – 1.38 mg/L.

These results, instead of confirming the hypothesis that one well is significantly more impacted by nitrate than the other, actually indicate the opposite. Had one well been severely impacted, it could have become necessary to drill an alternate well, so the most recent water quality results are good news.

In addition, the nitrate level in the mixed raw water has decreased since 2010. Although it is too soon to call the latest results an indication of a downward trend, once can certainly hope that the upward trend is coming to an end.

Harmony Hill School should continue testing the mixed raw water and the water from the individual wells to further track trends.)

Replace Cesspool

According to the Rhode Island Cesspool Act of 2007, all cesspools located within 200 feet of a public drinking water well must be removed from service and replaced with a septic system no later than January 1, 2013. In addition, any cesspool at Harmony Hill School would be considered a large capacity cesspool, and large capacity cesspools are not allowed in the state, regardless of whether they are located near a source of public drinking water. Harmony Hill School understands the importance of removing the remaining cesspool, and plans to comply with this regulation.

(Update – During a recent pumpout of the system considered to be a cesspool, it was noted by the facilities superintendent that the system is actually a concrete tank. This system will need to be inspected by a certified inspector to determine whether it meets the requirements to be considered a septic system.)

Hire a Qualified Inspector for a Complete Inspection of All On-Site Wastewater Treatment Systems

Based on what appears to be the limited use of fertilizers and watering which could cause nitrogen leaching, it is likely that OWTSs are, by far, the major source of nitrogen to groundwater.

A qualified inspector should be hired to conduct inspections of all OWTSs; to evaluate their level of functionality; and to determine whether there is a need for maintenance, repairs, or replacement. Going forward, routine inspections should be conducted regularly, with inspection schedules based on system condition and use as determined by the inspector.

Over time, as the OWTSs at Harmony Hill School reach the end of their useful life or need major repairs, serious consideration should be given to installing advanced treatment systems, in particular systems with nitrogen-reducing capabilities. In addition, to protect nearby surface waters from phosphorus inputs, the use of shallow narrow drainfields should be considered. Advanced treatment systems would cost more to install and to maintain, but would provide an additional level of protection for the drinking water supply.

A licensed OWTSs designer will be able to make further recommendations based on design flows, a nutrient loading analysis, location within the WHPA, and desired effluent concentrations.

Evaluate Flow of Stormwater Runoff

Considering all of the recent earthmoving, construction, and subsequent landscaping of the property, the changes in the flow of stormwater runoff should be evaluated as a potential source of contamination. Directing stormwater towards or encouraging ponding near the wells or any element of a septic system should be avoided.

Relocate Planned Garden Areas and Compost Pile, Avoid Storage of Leachable Materials Outside of Greenhouse

The original plan for the student garden plots was to locate them relatively close to the wells. At the source water workshop, it was decided to relocate the plots to the far side of the greenhouse. In addition, the compost pile, which is currently very close to one of the wells, will be moved.

The storage of leachable materials (e.g., [organic] fertilizer) around the outside of the greenhouse should be avoided. Any material that has the potential to leach into the soil should be kept out of the rain and in the greenhouse.

(Update – Harmony Hill School has used logs to mark off a section of the 200 ft radius circle surrounding the well closest to the recreational/agricultural field. This is meant to ensure that no agricultural activity takes place within the ARP.)

Manage Garden Watering Carefully

In areas where nutrient (i.e., nitrogen and/or phosphorus) contamination of groundwater is a concern, gardens and lawns should be watered enough to keep plants healthy, but no more. When excess water is added, water that does not evaporate or get taken up by plants flows through the ground into the aquifer, taking nutrients with it.

When determining the amount of water required by a garden, the amount already received from rain should be subtracted. Luckily, Harmony Hill School has a rain gauge onsite. This should be used to determine the amount of additional water, if any, required by the garden.

Plant Native and Low-Maintenance Fruit Trees Instead of Apple Trees – Consider Pawpaws, Persimmons, Pears, and Hardy Kiwifruits

Harmony Hill School currently plans to create an apple orchard. Unfortunately, apple trees often need to be sprayed with insecticides and fungicides. At the moment, Harmony Hill School does not need to test its water for pesticides because they are not used in the WHPA. If this changes, testing will be required. From both a health standpoint and a financial standpoint, it makes sense to avoid species that need to be sprayed.

The excellent two-volume book set, *Edible Forest Gardens*, by Dave Jacke and Eric Toensmeier (published by Chelsea Green, 2005), suggests planting native and low maintenance species of fruit in

order to reduce the effort required to keep them healthy. Please refer to the books for more suggestions than could be included below.

The following recommendations are from Volume II of the *Edible Forest Gardens* set.

> *p.222 – Consider the challenges you may face growing your desired crop species before finalizing your species list or engaging in much design. Find out what pests and diseases affect them in your region, and which "varmints," or potentially problematic wildlife, live nearby. How can you reduce these problems by design or management? You may want to change your desired species list after learning what you are up against! For example, growing apples can be demanding. They have the biggest pest and disease complex of almost any crop you can grow in North America. Pears have significantly fewer pests and diseases; persimmons have fewer still. Good species and variety selection radically reduces your pest- and disease management work!*
>
> *p. 26 – One of the easiest ways to avoid herbivory is to plant species that are rarely bothered by pests or diseases (like pawpaws, persimmons, and hardy kiwis). There are also delicious, resistant varieties of susceptible species (like scab-resistant apples and blight-resistant hazels). If you decide you must grow apples or other highly susceptible crops, research the pests and diseases prevalent in your area, and track down resistant varieties.*
>
> *p. 55 – Using perennials and self-sowing annuals reduces our workload tremendously. It is a direct strategy for creating self-maintenance. However, let us take it a step further: self-renewing crops can also mean those that need no attention from us to bear year after year. While apples and other fruits need pruning to maintain their productivity over time, crops such as mulberries, persimmons, and pawpaws need less pruning or none at all, yet they bear anyway. Ostrich ferns keep making fiddleheads, despite our complete neglect. Elderberries and juneberries keep on fruiting without our help. Picking such low-input species provides the least amount of work for a yield. Granted, some small amount of tweaking (pruning or other effort) can dramatically increase yields for some of these crops, but if your primary goal is maximal self-maintenance, you should emphasize these species.*

The URI Master Gardener Association (http://www.urimga.org/) is an excellent resource that could connect Harmony Hill School with people knowledgeable about species selection and Integrated Pest Management.

Appendix C contains several suggestions for trees that are lower maintenance than apple trees. One of these species is the pawpaw. New England currently only has one pawpaw orchard. Could Harmony Hill School become the second? See Appendix D for an article from *Edible Rhody* about pawpaws in Rhode Island.

Groundwater Education for Students and Teachers

ASRWWA has a groundwater model and can conduct educational sessions for students, teachers, and staff.

Contingency Plan

A contingency plan for the Harmony Hill School system has been written by the Harmony Hill School facilities department and ASRWWA.

Appendix A: RI HEALTH – Rules and Regulations Pertaining to Public Drinking Water [R46-13-DWQ] – Appendix 4

List of Potential Sources of Groundwater Contamination

- Agricultural related activities (pesticide and fertilizer storage and application, machinery maintenance and fueling)
- Airports-commercial (maintenance and repair, fuel storage)
- Animal care and holding areas (stables, kennels, pet shops)
- Asphalt, coal, tar and concrete companies
- Automotive repair shops
- Automotive body shops
- Auto parts stores
- Beauty salons
- Boat builders and refinishers
- Bus and truck terminals
- Chemical manufacturers
- Construction sites
- Dredge disposal sites
- Dry cleaners
- Food processors (meat packers, dairies, bakeries)
- Fuel oil distributors (product storage, equipment maintenance and storage)
- Funeral homes and cemeteries
- Furniture strippers, refinishers
- Golf courses
- Hotels and motels
- Industrial manufacturers
- Junkyard and salvage yards
- Land application of sewage sludge
- Landfills and dumps
- Laundromats
- Machine shops
- Medical facilities (hospitals, clinics, laboratories)
- Metal and drum cleaning/reconditioning
- Military facilities (past and present)
- Nurseries
- Nursing homes
- Paint shops
- Photographic processors
- Pipelines (oil and sewer)
- Printers and blueprint shops
- Prisons
- Railroad yards
- Repair shops (engines, appliances, etc.)
- Research laboratories
- Residential development (lawn care, septic systems)
- Restaurants and taverns

- Retail shopping centers, malls
- Road salt storage
- Rust proofers
- Sand and gravel mining operations
- Sawmills
- Schools, colleges and trade centers
- Service stations (gas stations)
- Storm water management facilities (leaching systems)
- Transmission line rights of way
- Transportation corridors (road deicing, materials transport)
- Utility substations/transformers
- Waste storage, treatment and recycling (hazardous and non-hazardous)
- Water transfer stations
- Wastewater treatment plants (past or present sludge disposal)
- Wood preservers

Appendix B: Source Water Assessment

Rhode Island Department of HEALTH

PROTECT YOUR DRINKING WATER

Safe and healthy lives in safe and healthy communities

Harmony Hill School, Inc.

Pollution Risk Assessment Results

Harmony Hill School, Inc. (PWSID 2000059) is a community water system in Glocester that serves approximately 65 residents, 14 day students and 120 staff through 7 service connections. The water system consists of two drilled wells. Water is discharged to a storage tank and then delivered to 5 pressure tanks. The water is treated for corrosion control. The last sanitary survey was March 4, 1999. For further information contact Terrence Leary at 63 Harmony Hill Road, Chepachet, RI 02814.

Treatment:
Water is filtered through acid neutralizers and cartridge filters for corrosion control.

The Source Protection Area is a circle of radius 1,750 feet, or about 220 acres (see Figure 2 on back). It is mostly wooded with some moderate density residential and institutional development. A developed recreational area is located north of the wells (see Table 1 on back).

Sample Summary (for the previous five years)

- Bacteria have not been detected.
- Nitrate levels in groundwater are somewhat higher than background levels, which may indicate contribution from human activity.
- No violations of the standards for other regulated contaminants have been identified. However, there have been detections below levels considered acceptable by US EPA. This indicates the need for continued monitoring.

This report summarizes assessment results for this water system. The assessment identifies both known and potential sources of pollution occurring in the source protection area, and ranks the water source based on the likelihood of future contamination. The goal of this study is to help water suppliers, local officials, residents and consumers to learn more about source water protection. Because water quality is directly related to land use activities, everyone living or working in the source protection area has a role to play in keeping local water supplies safe.

Susceptibility To Contamination		
√ Low	Moderate	High

Note: A low rating does **NOT** mean that the source is free from contamination risk. Without sufficient protection, **ANY** water supply can become contaminated.

POLLUTION RISKS:

- High-intensity land uses, including institutional and recreational, are densely clustered near the well.
- A road is located near the wells, increasing the risk of hazardous material spills and road salt contamination.
- An underground storage tank is located inside the source protection area.

PROTECTION OPPORTUNITIES:

- The majority of the source protection area consists of undeveloped forestland.
- The town can implement land use controls and programs to protect this source protection area from high-intensity development.
- The town and supplier can encourage institutions to use best management practices in handling potential contaminants.
- Residents can follow the guidelines on the back to reduce the impact of household contaminants.

Source Water

The focus of these assessments is on public drinking water supply "source" areas—the *wellhead protection area* that recharges a well or the *watershed* that drains to a surface water reservoir. Source water is untreated water from streams, lakes, reservoirs, or underground aquifers that is used to supply drinking water.

Source Water Assessments were conducted by the R.I. Department of Health in collaboration with the University of Rhode Island Cooperative Extension (URI CE) under the Rhode Island Source Water Assessment Program. This is part of a national initiative, established under the 1996 Amendments to the Federal Safe Drinking Water Act (SDWA), to foster more comprehensive protection of drinking water supplies at the local, state, and national levels.

Table 1. High-intensity land uses identified within the source water protection area that have the potential to contaminate drinking water.

Land Use Category	Associated Contaminants[1]	% of Protection Area
% Residential	Nutrients, Pathogens, VOCs, SOCs	1.8%
% Commercial, Industrial, Institutional	VOCs, SOCs, Solvents, Inorganics	2.9%
% Intensive Agriculture	Nutrients, Pathogens, VOCs, SOCs	0.0%

[1]Potential contaminants include nutrients (nitrates and phosphorus from fertilizers and human and animal waste); pathogens (bacteria, viruses, and other microorganisms that can cause disease); volatile organic compounds (VOCs) found in fuels and solvents; synthetic organic compounds (SOCs), such as pesticides and plastics; and inorganics, including metals and other substances that can harm human health in high concentrations.

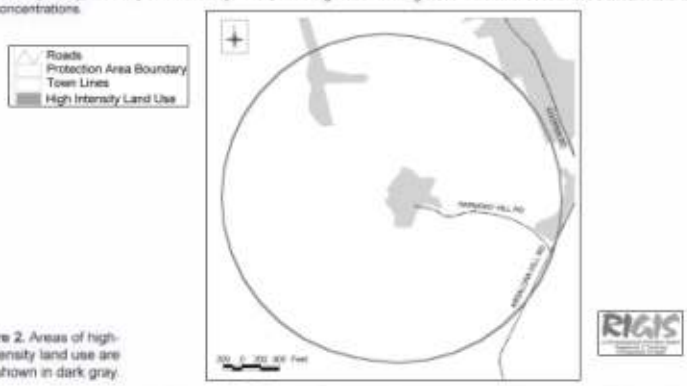

Figure 2. Areas of high-intensity land use are shown in dark gray.

What You Can Do To Protect Water Quality

Public Water Suppliers:
- Implement all recommendations in the latest Sanitary Survey.
- Protect undeveloped land within the wellhead or watershed protection area. Work with municipal boards and government as needed to implement land use protection measures and education programs.
- Post signs alerting public to Wellhead or Watershed Protection Area.
- Inspect water supply and protection area regularly for potential pollution sources.

Municipal Boards and Government:
- Develop a groundwater protection plan and ordinance and supporting protective zoning regulations, such as limits of paved surface areas within new developments.
- Incorporate groundwater and source water protection goals into the Comprehensive Plan.
- Implement on-site wastewater management or sewer maintenance plans and ordinances.
- Develop programs for land acquisition, conservation easements, or other critical lands protection.
- Adopt a stormwater management plan and ordinance.
- Establish a community education and outreach program that promotes residential pollution prevention and best management practices for the Public Works Department.

Residents:
- Inspect septic systems annually and pump as needed.
- Replace/repair cesspools and failing septic systems.
- Reduce fertilizer and pesticide use.
- Reduce stormwater runoff by limiting paved surface areas and maintaining good vegetative cover.
- Pick up after your pets.
- Properly use, store, and dispose of hazardous products.
- Properly maintain motor vehicles and fuel storage tanks. Consider replacing underground storage tanks with properly contained above-ground tanks.
- Check all municipal laws that may apply.

Farmers and Landowners: *Develop conservation plans on agricultural and forest lands that:*
- Reduce soil erosion, sediment, and stormwater runoff.
- Address proper nutrient, manure, pest, and irrigation water management.
- Address proper fuel storage and equipment maintenance.
- Conserve water, improve soil health, and protect surrounding natural resources.
- Check all federal and state laws that apply.

Commercial and Industrial Businesses: *Adhere to all laws, regulations, and recommended practices for:*
- Hazardous waste management.
- Above- and underground storage tanks.
- Wastewater discharge.
- Floor drains.
- Proper training for all employees.

For More Information

R.I. Department of Health, Office of Drinking Water Quality, (401) 222-6867, www.healthri.org/environment/dwq/Home.htm
URI CE Home*A*Syst Program (401) 874-5398, www.uri.edu/ce/wq
URI CE Nonpoint Education for Municipal Officials (401) 874-2138, www.uri.edu/ce/wq
Local Municipal Boards and Government, contact town/city hall
R.I. DEM Office of Water Resources (401) 222-4700, www.state.ri.us/DEM/programs/benviron/water/index.htm
USDA Natural Resources Conservation Service and Conservation District Offices, (401) 828-1300, www.ri.nrcs.usda.gov

University of Rhode Island

Report templates produced by Rhode Island Sea Grant (2003).

Appendix C: Lower-Maintenance Tree Species

Pawpaw

From *Edible Forest Gardens*, Volume I:

> *p. 309 – Pawpaw – Asimina triloba*
> *Hardiness zone 5b, full sun to part shade, suckering tree, 20-35 ft. x 20-35 ft., edible fruit*
>
> *This underutilized native is a relative of the luscious tropical fruit cherimoya. The pawpaw is an understory tree in native forests with black walnut, pecan, canebrake bamboo, and other useful species. It forms long-lived thickets; it is conceivable that a single individual could live for thousands of years by sending up new shoots to replace the old. Pawpaw fruits are large, with creamy white or yellow flesh that you eat with a spoon. The flavor is like a mix of avocado and pear, sometimes described as vanilla custard with hints of banana, mango, and papaya. The trees can fruit well even in partial shade. Pawpaws are a great choice for forest gardens – not only do they have few pest problems, their foliage can function as an insecticide! Active efforts are under way to select and breed improved pawpaws. Plant at least two for pollination.*

Persimmon

From *Edible Forest Gardens*, Volume I:

> *p. 310-311 – Persimmons – Diospyros SPP.*
>
> > *Asian Persimmon – Diospyros kaki*
> > *Hardiness zone 7 (some to 6), full sun, standard (single trunk) tree, 25-40 ft x. 25-40 ft., edible fruit*
> >
> > *American Persimmon – Diospyrus virginiana*
> > *Hardiness zone 5, full sun, suckering tree, 50-75 ft. x 50-75 ft., edible fruit*
> >
> > *Hybrid Persimmon*
> > *Hardiness zone 5 or 6, full sun, may sucker, height variable, edible fruit*
>
> *The Asian or kaki persimmon is one of the most popular fruits in the world, having been cultivated for untold centuries. However, few in the United States have ever eaten one. A fully ripe Asian persimmon is as luscious and sweet as anything you can imagine, with the consistency of an overripe tomato. In contrast, the unripe fruit of most varieties tastes unbelievably horrible – metallic, chalky, and bitter. Unfortunately, most cultivars of this fruit are hardy only to zone 7, though a few varieties are hardy to zone 6. Most varieties need a male pollinator, although some are self-pollinating.*
>
> *Luckily, the native American persimmon is hardy into zone 5, and perhaps even farther north. People consider this fruit tree a weed through much of its range in the Southeast and Midwest. It grows well in poor, sandy, acid soils and is an early midsuccession species. The fruits are smaller than those of the Asian species, up to medium plum size, but extremely delicious when ripe (unripe fruits, like the kaki, taste terrible). The fruit of many varieties partially dry on the*

tree and will remain on the branches until December. This is a species only recently brought into cultivation – many of the best cultivars, like the famed 'Early Golden', are actually individuals that were selected from the wild for their superior flavor. We believe that these native, delicious, low-maintenance fruits are one of the very best choices for the edible forest garden. You will need a male persimmon for every eight or so females. The cultivars 'Szukis' is self-pollinating. Note that the two species will not pollinate each other.

After many attempts, breeders have recently developed hybrid persimmons. They seem to combine the best of both worlds, retaining the hardiness of American persimmons while increasing fruit size. Some hybrids are naturally dwarfed.

Pear

From *Edible Forest Gardens*, Volume I:

p. 312-313 – Pear (Pyrus SPP.)

Asian Pear – Pyrus bretschneideris
Hardiness zone 4, full sun, standard (single trunk) tree, 25-30 ft. x 25 ft., edible fruit

European Pear – Pyrus communis
Hardiness zone 3 or 4, full sun, standard (single trunk) tree, 8-40 ft. x 10-25 ft. (depending on rootstock), edible fruit

Pears are one of the best fruits we can grow in the forest garden. In most of the eastern forest region, apples have intense pressure from pests and diseases. Pears, in contrast, are far easier and more rewarding to grow in a low-maintenance regime. Although they do not store as well as apples, pears are certainly among the world's finest fruits. Their flavor ranges from melting, buttery European pear cultivar like 'Seckel' to crisp, juicy, applelike Asian pears like '20th Century'. One disease problem is worth noting: fireblight is a very serious problem that can quickly decimate susceptible trees. Obtain fireblight-resistant varieties as insurance. Even if the disease has not yet reached your area, it is moving across the region and may well arrive within the lifetime of your trees. Pears are available in full, dwarf, and semidwarf sizes. There are also enormous pear varieties available that yield small, hard fruits used to make a pear cider, known as 'perry.' Plant at least two pears for pollination. Not all varieties within a species will pollinate each other, and some – but not all – Asian and European pears will pollinate each other. See a nursery catalog for details.

Hardy Kiwifruit

From *Edible Forest Gardens*, Volume I:

p. 313-314 – Hardy Kiwifruit (Actinidia SPP.)

Hardy Kiwifruit – Actinidia arguta
Hardiness zone 4, full sun, climber, 20-100 ft., edible fruit

Super-Hardy Kiwifruit – Actinidia kolomikta

Hardiness zone 3, full sun, climber, 20-100 ft., edible fruit

Purple Hardy Kiwifruit – Actinidia purpurea
Hardiness zone 4, full sun, climber, 20-100 ft., edible fruit

Hardy kiwifruits are among the most promising low-maintenance fruits for our climate. These woody vines are in the same genus as the kiwifruit you buy in the supermarket but yield smaller fruit (about the size of a large grape) that have smooth skin instead of fuzz and taste much sweeter. A fresh hardy kiwi off the vine is one of the world's finest fruits.

Hardy kiwifruits are native to forest edges in eastern Asia. These species can take a few years to establish. They are vulnerable to late frosts when young. Once they are up and running they become highly productive. Under ideal conditions, they can produce up to 100 pounds of fruit per vine annually. Hardy kiwifruit vines are vigorous sprawlers; you should not let them grow on trees about whose form you care. Capable of growing to great heights, they are best grown on large, established trees or kept well maintained on a trellis. Although trellising requires more work (building the trellis, intensive annual pruning), it is the best way to maximize yields. Ripe fruit falling from tall trees is still perfectly edible, but it will not store very well. Because of their high vitamin C content, carefully harvested fruit can last for weeks in a simple box or bucket in your cellar. Male and female flowers grow on separate plants. You need to have one male for every eight or so females to set fruit. The cultivar 'Issai' is self-pollinating but not reliably hardy in zone 5 or even zone 6.

Hardy kiwifruit is the most commonly grown hardy Actinidia, with green grape-size fruit. Super-hardy kiwifruit is significantly hardier, with smaller but still delicious fruits. Purple hardy kiwifruit is essentially a purple-skinned A. arguta.

Appendix D: Excerpt from *Edible Rhody: Celebrating the Content of Rhode Island, Season by Season*, Fall 2010 Issue

FROM THE EARTH

The Pawpaw

Locally Grown Taste of the Tropics Regaining 'Pawpawlarity'

Story and Photos by Aaron Kagan

What if there were a tropical fruit that didn't have to be flown in from Mexico? A fruit that could be grown locally yet tasted like the love child of a mango and a banana? Though it may seem too good to be true, such a thing exists, and it's called a pawpaw.

The pawpaw is the largest fruit native to the United States (and nowhere else) but it just so happens to look and taste as tropical as if it plopped out of the bonnet ofMiss Chiquita Banana. The combination of its place of origin and exotic flavor have earned the pawpaw the nickname of "Indiana Banana" in some parts of the United States but luckily for Rhode Island locavores, the only pawpaw orchard in New England can be found within our foodshed.

Pawpaws are most commonly eaten fresh soon after their harvest in the fall but their creamy pulp is also frozen or used in baking, ice cream, custard, preserves and even beer and wine. The bunch that I acquired from Rocky Point Farm onWarwick Neck was simply too good not to devour immediately.

As soon as the pawpaws entered my kitchen, their musky perfume filled the room. I slit the belly of one of the splotchy, oval fruits and dipped a spoon into its flesh. When it hit my tongue, a cascade of flavors flooded through my mind. Pineapple... melon... vanilla!

Trying to describe the taste of a pawpaw is a brow-furrowing experience. They are often explained by a cocktail of fruits, such as those I've just mentioned, plus passionfruit, papaya, pear and guava. A pawpaw really only tastes like one thing, and that's a pawpaw. The luscious texture, which falls somewhere between avocado and banana, is closer to flan than fruit. It simply must be tasted to believe that such a thing could grow so far from the equator.

If you've never had a pawpaw you need go no further than the Pawtuxet Village Farmers Market in Cranston. Many experience their first taste of the fruit there thanks to the annual Pumpkin & Pawpaw Festival hosted by market manager Steven Stycos.

"At the market we cut pieces and let people taste them," says Rocky Point pawpaw farmer Mark Garrison (shown left). "The first expression is puzzlement, then they say, 'Oh! That's good!' Or a reluctant 'OK,'" notes the farmer, who owns 40 acres of pawpaw and blueberry bushes just a stone's throw from Narragansett Bay.

Garrison noted that the pawpaw's distinctive flavor often divides first-time tasters into "love it" or "hate it" camps but as a lover, I simply cannot fathom the misguided reaction that happens in the mouths of the haters. I truly have never tasted a more delicious fruit than the pawpaws grown at Rocky Point.

Today few have heard of it beyond the lyrics of the song "Way Down Yonder in the Pawpaw Patch," though the fruit used to enjoy what plant geneticist and pawpaw expert Neal Peterson calls "pawpawlarity."

Europeans first encountered pawpaws in 1541 during the Hernando de Soto expedition, and they were commonly eaten by Native Americans throughout the fruit's extensive range (as far south as Florida, as far north as Canada). Lewis and Clark intended to survive on nothing but pawpaws and "a buiskit" per person during 150 miles of their epic voyage, and even the founding fathers were fans of the fruit.

GeorgeWashington repeatedly mentions pawpaws in his diary (Friday, November 18, 1785: "Sent to Mr. Digges for Papaw Bushes to replace the dead ones in my Shrubberies.") and while abroad, Thomas Jefferson wrote to a friend in Philadelphia asking for pawpaw seeds in order to give them away in Paris.

Despite its history, the pawpaw was dubbed the "most neglected American fruit" by the New York Times in 1922, and it remains so today. On-line, references to pawpaw are dwarfed by mentions of Martha Stewart's (former) dog, named Paw Paw. I visited Rocky Point Farm on a gray day in October, when Garrison's verdant orchard looked positively out of place. Cartoonish clusters of the oblong fruits jutted out from between dark green leaves. Occasionally, one fell with a thud.

The ground was littered with windfall and with the large, toffeecolored seeds of last year's bounty. Garrison reached up and snapped off a cluster to let me get a closer look, the same bunch that I would later eat.While inhaling their funky scent, I noticed that Garrison also grows apples. In fact, his two orchards nearly touch.

"Of course if they go the way of the apple, they'll look better but they'll be sprayed," said Garrison, referring to the somewhat homely appearance of the bunch that I was holding. "Thud," went a pawpaw.

Given its uniquely North American range, large size and scrumptious flavor, one would think that the pawpaw could have become the preeminent national fruit. Yet it never joined the ranks of the Concord grape, blueberry and cranberry, the only native fruits to reach high levels of commercial productivity.

When I asked Peterson, who Garrison refers to as "the guru," about why the pawpaw failed to beat the apple as "the" American fruit, he suggested its thin skin and tendency to bruise and therefore difficulty to ship. Peterson sees our underdeveloped relationship with the pawpaw as indicative of a larger trend. "It's very telling about the changes American society has undergone in the past 100 years," he says.

Despite its newfound followers, the pawpaw is listed as "ecologically imperiled" by the Brooklyn Botanical Garden. Or to be more accurate, "The pawpaw is not an endangered species but the folks knowledgeable about the pawpaw are," says Peterson.

Yet pawpaw fans are loyal and growing in number. The pawpaw has enjoyed a resurgence since being "boarded" on Slow Food International's Ark of Taste and included in the affiliated project known as RAFT (Renewing America's Food Traditions), both of which promote what they call the "save it by eating it" paradigm. There are bumper stickers that read "I'm Pro Pawpaw and I Vote," and last year's slogan at the increasingly popular annual pawpaw festival in Albany, Ohio, was "Pawpaws to the People." Orchards that sell pawpaws on-line are unable to meet rising demand, all of which suggests that the once and future fruit is closer to a comeback than ever before.

The pawpaw could very well become mascot for the American local foods movement, a rallying point for both growers and consumers seeking to reconstruct our forgotten national food identity. Nothing better embodies our terroir than this truly American fruit found nowhere else on earth and so deeply embedded in our national history. Certainly not the apple, which, like Borat, is from Kazakhstan.

As we pay closer attention to where our food comes from, why not look a little further back? Even hardcore farm-to-table restaurants like the flagship Chez Panisse are cooking with crops that originated on other continents. In the quest for authenticity, shouldn't an indigenous plant that our first president grew score higher than, say, a cauliflower?

As Peterson said, much has changed in the past 100 years but as the local foods movement has shown, our relationship with what we eat continues to evolve into something more sustainable, delicious and distinctive. I for one hope that evolution will include more and more farms like Rocky Point taking up the cause of our patron fruit and planting pawpaw.

I'm sure you'd agree—just taste one for yourself. eR

Aaron Kagan is a freelance food writer, photographer and cook recently relocated to Western Massachusetts. His work regularly appears in the Boston Globe's Wednesday food section and on his blog at teaandfood.com.

For more information visit www.rockypointblueberries.com

...or try a pawpaw at:

Pawtuxet Pumpkin & Pawpaw Festival

Saturday, Oct. 16, 9am–noon

Pawtuxet Village Farmers' Market, 60 Rhodes Place, Cranston