Maintenance of Low Impact Development Facilities

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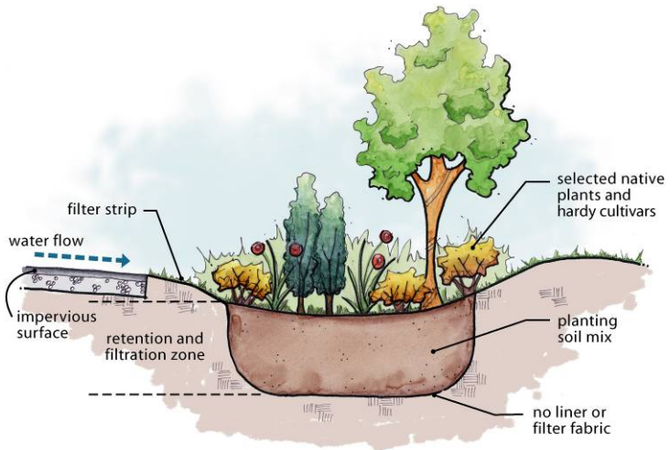

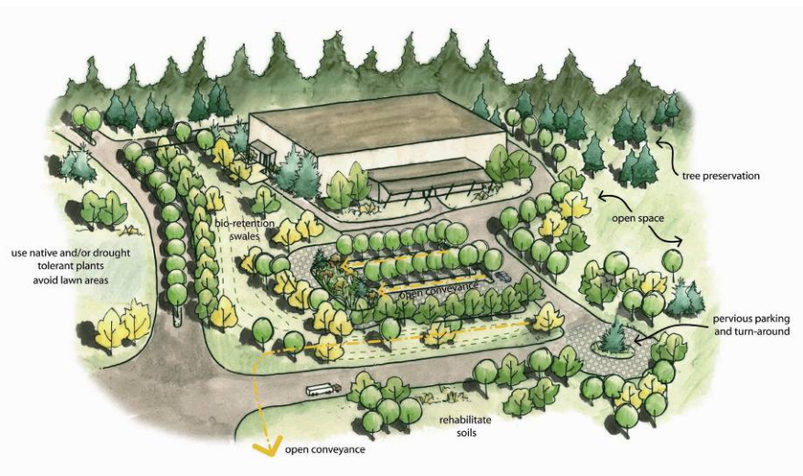

Prepared by:

WASHINGTON STATE UNIVERSITY
PIERCE COUNTY EXTENSION

AHBL

For:

PUGET SOUND ACTION TEAM

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A. Introduction

The maintenance of LID facilities is essential to ensure that designed stormwater management performance and other benefits continue over the full life cycle of the installation. Some of the maintenance agreements and activities associated with LID practices are similar to those performed for conventional stormwater systems; however, the scale, location, and the nature of a LID approach will also require new maintenance strategies.

The following outlines typical maintenance goals and objectives, types of maintenance agreements and training, and provides matrices with maintenance activities and schedules for bioretention areas, amended construction site soils, permeable paving, vegetated roofs, and roof rainwater collection systems.

1. *Goals and Objectives*
   Many maintenance goals of LID facilities will be similar throughout the Puget Sound region. The following provides a standard set of goals that can be added to or modified according to the specific physical settings and needs of a local jurisdiction.

   A) Flow Control and Drainage
   - Maintain pre-development infiltration capacity (reduce total volume of surface flows) and flow attenuation of facility.
   - Maintain pre-development detention capability to reduce peak flows.
   - Safely convey design storm flows.

   B) Water Quality Treatment
   - Maintain pre-development infiltration and detention capability.
   - Preserve soil and plant health and contact of storm flows with those plant soil systems.

   C) Safety and Emergency Vehicle Access
   - Maintain adequate sight distances.
   - Create signage for emergency vehicle access and facilities.
   - Ensure the sufficient carrying capacity for emergency vehicles of any permeable load-bearing surfaces.

   D) Cost Effectiveness
   - Maintain facilities for long-term, high quality performance at a cost that is equal to, or less than, conventional systems.
   - Prevent expensive repair of large scale or catastrophic problems through continued routine procedures.

   E) Aesthetics
   - Develop LID facilities as a landscape amenity as well as a stormwater management system.

   F) Public Health
   - Minimize potential for disease transmission and mosquito breeding by maintaining designed infiltration capacity, storm flow conveyance, ponding depths, and dewatering rates.

   G) Community Participation
   - Provide educational materials to homeowners and commercial property owners explaining the benefits, function, and importance of community participation for the long-term performance of LID facilities.

2. *Support Strategies*
Effective measures to support and ensure quality maintenance of LID facilities include education, incentives, and regulations. In order to provide the most effective maintenance programs, a variety of strategies should be selected from the list below.

A) Education
- Simple, concise messages delivered throughout the project life cycle.
- Brochures explaining the functions, benefits, and responsibilities of facilities at transfer of deed.
- Information bulletins over public access channels.
- Community volunteers providing informal workshops.
- Ongoing involvement of developer with community groups.
- Training programs for those maintaining the systems.

B) Incentives
- Reduce stormwater utility fees for individual homeowners or commercial properties.
- Provide support for property owners with technical advice and materials, such as mulch and plants.
- Provide awards and recognition to innovative developers and communities that build and properly maintain LID facilities.

C) Regulations
- Require maintenance plans and agreements prior to project approvals. (These would include a list of all proposed facilities, facility locations, a schedule of maintenance procedures, monitoring requirements, if any, and an agreement that all subject properties are collectively liable for the ongoing maintenance of the facilities.)
- Mandate jurisdictional maintenance and additional taxes for funding.
- Require fines for corrective actions.
- State that maintenance responsibilities and liabilities are shared by all property owners for projects with facilities designed to serve multiple properties or owned and/or maintained collectively.
- Require deed restrictions or covenants conveyed with deed for the full life cycle of all project types.

3. *Maintenance Responsibilities*
Low Impact Development facilities range in size and complexity. Accordingly, entities responsible for maintenance should be appropriately matched to the tasks required to ensure long-term performance. An individual homeowner may be able to reasonably maintain a rain garden, permeable driveway, or other small facility; however, larger facilities are often maintained through private parties, shared maintenance agreements or the presiding jurisdiction. In addition, the use and ownership of properties can often help dictate the most appropriate means of facility maintenance. Below are some general guidelines for the three primary categories of Maintenance Responsibilities.

A) Property Owners

- Are usually responsible for small facilities located on an individual property.
- Require basic knowledge and understanding of how the system functions.
- Jurisdiction(s) can improve system function over time by offering basic training to property owners.
- Should know when to seek and where to find technical assistance and any additional information.
- Requirements for maintenance should be conveyed with deed.
- Failure to properly maintain LID facilities may result in jurisdictional liens.

B) Private Parties

- Handle the widest range of LID projects in size and scope.
- Handle most commercial or multi-family properties. Copies of agreement may be required prior to project approval.
- Unique maintenance agreements should be developed based on the scale, use, and characteristics of the site and conservation areas, as well as level of expertise of the property owner and the responsible jurisdiction.
- Maintenance agreements can be between a variety of parties, such as individual homeowners, property owner associations, or even jurisdictions.
- Outside groups responsible for maintenance should be trained in the design, function, benefits, and maintenance of LID facilities.
- Recognize that integrated LID management practices require more frequent inspection than conventional facilities.
- Third-party maintainers should provide documentation to the property owners of the type of maintenance performed, a certificate of function, and any non-routine maintenance needs requiring specialized corrective actions.
- Jurisdictions may choose to provide an educational course for prospective maintenance parties and a list of approved or recommended parties.

C) Jurisdictions

- Will handle most public LID infrastructure.
- Should be prepared to handle non-routine maintenance issues for a variety of facilities.
- Maintain primarily large facilities, except for those requiring corrective action.
- Private LID facilities requiring corrective action may require a jurisdiction to hire a private party or use their own staff to complete the work. Property owners should be billed for these expenses.

4. *Inspections*

Regular and appropriately timed inspections are necessary for the proper operation of LID facilities over the full life cycle of the installation. Inspectors should be trained in the design and proper function and appearance of LID practices. Inspections should be seasonally timed in order to have early detection, repair and efficiency. These inspections should include the following: During Fall to clear debris and organic material from structures and prepare for impending storms; early winter storm events to confirm proper flow control operation and to identify any erosion problems; before major horticultural cycles (i.e., prior to weed varieties dispersing seeds); and any other regularly scheduled maintenance activities. To ensure continuity and to better identify trends in the function of facilities, the same individual(s) should inspect the same drainage area. Finally, LID facilities are integrated into the development landscape and willing homeowners can provide frequent inspection and identification of basic problems with minimal training.

B. Bioretention Maintenance Schedule

Bioretention areas require annual plant, soil, and mulch layer maintenance to ensure optimum infiltration, storage and pollutant removal capabilities. The majority of routine maintenance procedures are typical landscape care activities and can be performed by various entities including individual homeowners.

Routine

Activity	Objective	Schedule	Notes
Watering: Maintain drip irrigation system without breaks or blockages. Hand water as needed for specific plants.	Establish vegetation with a minimum 80% survival rate.	Twice annually (May and July) or as indicated by plant health.	Plants should be selected to be drought tolerant and not require watering after establishment (2-3 years). Watering may be required during prolonged dry periods after plants are established.
Clean curb cuts: Remove any accumulation of debris from gutter and entrance to bioretention area.	Maintain proper flow of stormwater from paved/impervious areas to bioretention facility.	Twice annually (October and January)	
Remove and/or prune vegetation	Maintain adequate plant coverage and plant health. Reduce shading of under-story if species require sun. Maintain soil health and infiltration capability. Maintain clearances from utilities and sight distances.	Once or twice annually.	Depending on aesthetic requirements, occasional pruning and removing dead plant material may be necessary.
Weeding: Remove undesired vegetation by hand.	Reduce competition for desired vegetation. Improve aesthetics.	Prior to major weed species disbursing seeds (usually twice annually)	Periodic weeding is necessary until plants are established. The weeding schedule should become less frequent if the appropriate plant species and planting density have been used and, as a result, undesirable plants excluded.
Mulching: Replace or add mulch with hand tools to a depth of 2-3 inches.	Replenish organic material in soil, reduce erosion, prolong good soil moisture level, and filter pollutants.	Once annually or every two years.	Consider replacing mulch annually in bioretention facilities where high pollutant loading is likely (e.g. contributing areas that include quick marts). Use compost in the bottom of the facility and wood chips on side slopes and rim (above typical water levels).
Trash removal	Maintain aesthetics and prevent clogging of infrastructure.	Twice annually.	
Maintain access to infrastructure: Clear vegetation within 1 foot of inlets and out falls, maintain access pathways.	Prevent clogging of infrastructure and maintain sight lines and access for inspections.	Once annually.	

Bioretention Maintenance Schedule (cont.)

Non routine

Activity	Objective	Schedule	Notes
Erosion control: Replace soil, plant material, and/or mulch layer in areas if erosion has occurred.	Reduce sediment transport and clogging of infrastructure. Maintain desired plant survival and appearance of facilities.	Determined by inspection.	Properly designed facilities with appropriate flow velocities should not have erosion problems except perhaps in extreme events. If erosion problems persist, the following should be reassessed: (1) flow volumes from contributing areas and bioretention cell sizing; (2) flow velocities and gradients within the cell; and (3) flow dissipation and erosion protection strategies in the pretreatment area and flow entrance.
Sediment removal: Shovel or rake out sediment within vegetated areas. Vactor catch basins or other sediment structures.	Reduce sediment transport and clogging of infrastructure. Maintain desired plant survival and appearance of facilities. Maintain proper elevations and ponding depths.	Determined by inspection.	If sediment is deposited in the bioretention area, immediately determine the source within the contributing area and stabilize.
Clean under-drains: Jet clean or rotary cut debris/roots from under-drains.	Maintain proper subsurface drainage, ponding depths, and dewatering rates.	Determined by inspection of clean-outs.	
Clean intersection of pavement and vegetation: Remove excess vegetation with a line trimmer, vacuum sweeper, rake or shovel.	Prevent accumulation of vegetation at pavement edge and maintain proper sheet flow of stormwater from paved/impervious areas to bioretention facility.	Determined by inspection.	Bioretention facilities should be designed with a proper elevation drop from pavement to vegetated area to prevent blockage of storm flows by vegetation into infiltration area.
Replace vegetation: Reseed or replant bare spots or poor performing plants.	Maintain dense vegetation cover to prevent erosion, encourage infiltration and exclude unwanted weed species.	Determined by inspection.	If specific plants have a high mortality rate, assess the cause and replace with appropriate species.
Replace soil: Remove vegetation (save as much plant material as possible for replanting) and excavated soil with backhoe, excavator or, if small facility, by hand.	Maintain infiltration, soil fertility, and pollutant removal capability.	Determined by inspection (visual, infiltration, pollutant, and soil fertility tests).	Soil mixes for bioretention facilities are designed to maintain long-term fertility and pollutant processing capability. Estimates from metal attenuation research suggest that metal accumulation should not present an environmental concern for at least 20 years in bioretention systems. Replacing mulch in bioretention facilities where heavy metal and hydrocarbon deposition is likely provides an additional level of protection for prolonged performance.
Rebuild or reinforce structures: Various activities to maintain walls, intake and outfall pads, weirs, and other hardscape elements.	Maintain proper drainage, and aesthetics and prevent erosion.	Determined by inspection.	
Re-grade or re-contour side slopes: Maintain proper slope with hand tools, back hoe or excavator, replant exposed areas.	Prevent erosion where side slopes have been disturbed by foot or auto traffic intrusion.	Determined by inspection.	

C. Compost Amended Construction Site Soil Maintenance Schedule

Compost amendments enhance the water storage and pollutant filtering capability of disturbed soils and improve plant performance on construction sites.

Routine

Activity	Objective	Schedule	Notes
Add compost of mulch: Spread material by hand to minimize damage to plant material.	Maintain organic matter content of soil, optimize soil moisture retention, prevent erosion, and enhance plant growth and survivability.	Once every one or two years.	Compost amended landscapes are stormwater management facilities and pesticide inputs should be eliminated or used only in unusual circumstances. Landscape management personnel should be trained to adjust chemical applications accordingly.

D. Permeable Paving Maintenance Schedule

The following matrices provide general maintenance recommendations applicable to all permeable paving and specific procedures for asphalt, concrete, Eco-Stone pavers, and Gravelpave2.

Routine

Activity	Objective	Schedule	Notes
All permeable paving surfaces			
Erosion and sediment control: Mulch and/or plant all exposed soils that may erode to paving installation.	Minimize sediment inputs to pavement, reduce clogging and maintain infiltration of pavement.	Once annually.	Erosion control is critical for long-term performance of permeable paving.
Permeable asphalt or concrete			
Clean permeable paving installation: Use street cleaning equipment with suction, sweeping and suction or high-pressure wash and suction.	Maintain infiltration capability.	Once or twice every year.	Street cleaning equipment using high-pressure wash with suction provides the best results for improving infiltration rates. Sweeping with suction provides adequate results and sweeping alone is minimally effective. Hand held pressure washers are effective for cleaning void spaces and appropriate for smaller areas such as sidewalks.
Remove snow: Use conventional snow removal techniques.	Maintain access.	Determined by inspection/snow depth.	
Eco-Stone pavers			
Clean permeable paving installation: Use street cleaning equipment with sweeping and suction when surface **and** debris are dry.	Maintain infiltration capability.	Once annually.	Washing should not be used to remove debris and sediment in the openings between the pavers. Vacuum settings may have to be adjusted to prevent excess uptake of aggregate from paver openings or joints.
Remove snow: Use snow plow with skids or rollers to slightly raise blade above pavers.	Maintain access.	Determined by inspection/snow depth.	The structure of the top edge of the paver blocks reduces chipping from snowplows. For additional protection, skids or rollers on the corner of plow blades are recommended.
All permeable paving surfaces			
Backfill utility cuts: Use same aggregate base as under permeable paving.	Maintain conveyance of stormwater through base and prevent migration of fines from standard base aggregate to the more open graded permeable paving base material.	Determined by inspection.	Small utility cuts can be repaired with permeable top course or with conventional asphalt or concrete if small batches of permeable material are not available or are too expensive.
Replace permeable paving material	Maintain infiltration and stormwater storage capability.	Determined by inspection.	If facility is designed, installed and maintained properly permeable paving should last as long as conventional paving.

Permeable Paving Maintenance Schedule (cont.)

Non-routine

Activity	Objective	Schedule	Notes
Eco-Stone pavers			
Replace aggregate in paver cells: Remove aggregate with suction equipment.	Maintain infiltration capacity.	Determined by inspection.	Clogging is usually an issue in the upper most few centimeters of aggregate. Check infiltration at various depths in the aggregate profile to determine excavation depth.
Utility maintenance: Remove pavers individually by hand and replaced when utility work is complete.	Repair utilities, maintain structural integrity of pavement.	When maintaining utilities.	Pavers can be removed individually and replaced when utility work is complete.
Replace broken pavers: Remove individual pavers by hand and replace.	Maintain structural integrity of pavement.	Determined by inspection.	
Gravelpave2			
Clean permeable paving installation: Use vacuum trucks for stormwater collection basins to remove and replace top course aggregate if clogged with sediment or contaminated.	Restore infiltration capability.	Determined by inspection.	Permeable gravel paving systems have a very high void to surface coverage ratio. System failure due to clogging is unlikely except in unusual circumstances.
Replenish aggregate material: Spread gravel with rake	Maintain structural integrity.	Determined by inspection.	Gravel level should be maintained at the same level as the plastic rings or above the top of rings. In high traffic areas, such as aisle ways, entrances or exits, gravel may become compacted or transported.
Remove and replace grid segments: Remove pins, pry up grid segments, replace gravel.	Maintain structural integrity.	Determined by inspection.	Replace grid segments where three or more adjacent rings are broken or damaged. Potholes should be remedied in the same way; the base course should be brought to the proper grade and compaction before replacing grid.
Remove snow: Use snow plow with skids or rollers to slightly raise blade above gravel surface.	Avoid concentrated sedimentation accumulation.	Determined by inspection/snow depth.	Elevating blades at least one (1) inch above the aggregate surface prevents loss of top course aggregate and damage to plastic grid.
Grasspave[2]			
Aeration: (see note)			**Do not Aerate Grasspave2 installations.** Aeration equipment will damage the structure of Grasspave2 and could prevent its long term function. Soil compaction and poor water penetration can be the result of soil types or local conditions and should be treated accordingly.
Replace Grasspave[2] installation: Place units over porous gravel base, fill with grass.	Restore system capability.	Determined by Inspection.	Do not place any form of topsoil between sandy gravel base and Grasspave[2] units.

Invasive or nuisance plants: Remove manually and without herbicide applications.	Promote selected plant growth and survival, maintain aesthetics.	Twice annually.	At a minimum, schedule weeding with inspections to coincide with important horticultural cycles (e.g., prior to major weed varieties dispersing seeds).
Fertilization: If necessary apply by hand (see note).	Plant growth and survival.	Determined by inspection.	Installations should be designed to not require fertilization after plant establishment. If fertilization is necessary during plant establishment or for plant health and survivability after establishment, use an encapsulated, slow release fertilizer (excessive fertilization can contribute to increased nutrient loads in the stormwater system and receiving waters).
Irrigate: Use subsurface or drip irrigation.		Determined by inspection and only when absolutely necessary for plant survival.	Surface irrigation systems can promote weed establishment, root development near the drier surface layer of the soil substrate, and increase plant dependence on irrigation. Accordingly, subsurface irrigation methods are preferred. If surface irrigation is the only method available, use drip irrigation to deliver water to the base of the plant.
Remove snow: Use snow plow with skids or rollers to slightly raise blade above gravel surface.	Avoid concentrated sedimentation accumulation.	Determined by inspection/snow depth.	Elevating blades at least one (1) inch above the aggregate surface prevents loss of top course aggregate and damage to plastic grid.

E. Vegetated Roof Maintenance Schedule

Proper maintenance and operation are essential to ensure that designed performance and benefits continue over the full life cycle of the installation. Each roof garden installation will have specific design, operation and maintenance guidelines provided by the manufacturer and installer. The following guidelines are for extensive roof systems and provide a general set of standards for prolonged roof garden performance.

General maintenance guidelines

- All facility components, including structural components, waterproofing, drainage layers, soil substrate, vegetation, and drains should be inspected for proper operation throughout the life of the roof garden.
- Drain inlets should provide unrestricted stormwater flow from the drainage layer to the roof drain system unless the assembly is specifically designed to impound water as part of an irrigation or stormwater management program.
- The property owner should provide the maintenance and operation plan and inspection schedule.
- Written guidance and/or training for operating and maintaining roof gardens should be provided along with the operation and maintenance agreement to all property owners and tenants.
- All elements of an extensive roof installation should be inspected twice annually.
- The facility owner should keep a maintenance log recording inspection dates, observations, and activities.
- Inspections should be scheduled to coincide with maintenance operations and with important horticultural cycles (e.g., prior to major weed varieties dispersing seeds).

Routine

Activity	Objective	Schedule	Notes
Structural & drainage components			
Clear inlet pipes: Remove soil substrate, vegetation or other debris.	Maintain free drainage of inlet pipes.	Twice annually.	
Inspect drain pipe: Check for cracks settling and proper alignment, and correct and re-compact soils or fill material surrounding pipe, if necessary	Maintain free drainage of inlet pipes.	Twice annually.	
Inspect fire ventilation points for proper operation	Fire and safety.	Twice annually.	
Maintain egress and ingress: Clear routes of obstructions and maintained to design standards	Fire and safety.	Twice annually.	
Insects (see note)			Roof garden design should provide drainage rates that do not allow pooling of water for periods that promote insect larvae development. If standing water is present for extended periods correct drainage problem. Chemical sprays should not be used.

Vegetated Roof Maintenance Schedule (cont.)

Prevent release of contaminants: Identify activities (mechanical systems maintenance, pet access, etc.) that can potentially release pollutants to the roof garden and establish agreements to prevent release.	Water quality protection.	During construction of roof and then as determined by inspection.	Any cause of pollutant release should be corrected as soon as identified and the pollutant removed.
Vegetation and growth medium			
Invasive or nuisance plants: Remove manually and without herbicide applications.	Promote selected plant growth and survival, maintain aesthetics.	Twice annually.	At a minimum, schedule weeding with inspections to coincide with important horticultural cycles (e.g., prior to major weed varieties dispersing seeds).
Removing and replacing dead material: See note.	See note.	Once annually.	Normally, dead plant material will be recycled on the roof; however specific plants or aesthetic considerations may warrant removing and replacing dead material (see manufacturer's recommendations).
Fertilization: If necessary apply by hand (see note).	Plant growth and survival.	Determined by inspection.	Extensive roof gardens should be designed to not require fertilization after plant establishment. If fertilization is necessary during plant establishment or for plant health and survivability after establishment, use an encapsulated, slow release fertilizer (excessive fertilization can contribute to increased nutrient loads in the stormwater system and receiving waters).
Mulching: (see note)			Avoid application of mulch on extensive roof gardens. Mulch should be used only in unusual situations and according to the roof garden provider guidelines. In conventional landscaping mulch enhances moisture retention; however, moisture control on a vegetated roof should be through proper soil/growth media design. Mulch will also increase establishment of weeds.
Irrigate: Use subsurface or drip irrigation.		Determined by inspection and only when absolutely necessary for plant survival.	Surface irrigation systems on extensive roof gardens can promote weed establishment, root development near the drier surface layer of the soil substrate, and increase plant dependence on irrigation. Accordingly, subsurface irrigation methods are preferred. If surface irrigation is the only method available, use drip irrigation to deliver water to the base of the plant.

F. Roof Rainwater Collection System Maintenance Schedule

Maintenance requirements for rainwater collection systems include typical household and system specific procedures. All controls, overflows and cleanouts should be readily accessible and alerts for system problems should be easily visible and audible. The following procedures are operation and maintenance requirements recorded with the deed of homes using roof water harvesting systems in San Juan County, Washington.

Routine

Activity	Objective	Schedule	Notes
Remove debris from roof: Sweep, rake or use leaf blower.	Prevent debris from entering collection and filter system.	Determined by inspection.	
Clean gutters: By hand or use leaf blower.	Prevent debris from entering collection and filter system.	Determined by inspection (generally September, November, January and April). The most critical cleaning is in mid- to late-Spring to flush the pollen deposits from surrounding trees.	Covers for gutters may be appropriate for specific locations, but can make regular cleaning more difficult and will not prevent pollen from entering filter system.
Clean downspout basket screens: Remove debris from screens at top of downspout.	Prevent debris from entering collection and filter system, and clogging of system.	Same as gutters.	
Clean pre-filters	Prevent debris from entering collection and filter system, and clogging of system.	Monthly	
Clean storage tanks of debris: Drain tank and remove debris from bottom of tank.	Prevent contamination.	Determined by inspection.	
Clean particle filters	Prevent contamination.	6 months or determined by pressure drop in system.	
Clean and replace UV filters	Prevent contamination.	Clean every 6 months and replace bulb every 12 months or according to manufacturer's recommendation.	
Chlorinate storage tank: Chlorinate to 0.2ppm-0.5ppm (1/4 cup of household bleach (5.25%) at the rate of 1 cup of bleach to 1000 gallons of stored water)	Prevent contamination.	Quarterly	
Flush household taps: Remove carbon filter and flush until chlorine odor is noticed at taps. Chlorinated water should be left standing in the piping for 30 minutes. Replace the carbon filter.	Prevent contamination.	When storage tanks are cleaned.	