OPERATION & MAINTENANCE PLAN

Haggetts Pond Rail Trail
Andover, Massachusetts

August 2024

PREPARED FOR

BSC GROUP

Town of Andover Department of Public Works

Operation & Maintenance Plan

Maintenance: Routine

Routine maintenance is the regular regimen of litter pick-up, trash, and debris removal, weed and dust control, trail sweeping, sign replacement, tree and shrub trimming and other regularly scheduled activities. Routine maintenance also includes minor repairs and replacement such as fixing cracks and potholes or repairing broken boardwalk and/or fencing.

MAINTENANCE RESPONSIBILITY

The enforcement of the Long-Term Operation and Maintenance Plan will be the responsibility of the Owner, the Town of Andover, Massachusetts.

REQUIREMENTS FOR ROUTINE INSPECTIONS AND MAINTENANCE OF THE RAIL TRAIL AND PARKING LOT AREAS

Rail Trail

Trail user safety

Safety is central to all maintenance operations and is the single most important trail maintenance concern. Scheduling and documentation of inspections, the condition of fencing and trail surfaces, proper and adequate signage, and removal of debris is required to ensure user safety.

Trails inspection

Trails inspections are integral to all trail maintenance operations. Inspections will occur monthly from Spring to Fall throughout operation and are to be documented. Any changes made to inspection frequency will be documented and based on site specific conditions.

Trail sweeping

Trail sweeping is one of the most important aspects of trail maintenance, helping ensure trail user safety. Trail sweeping shall be performed by blowing debris such as leaves and pine needles off the trail. This must be done at a minimum twice a year during the Fall and Spring and following any large storm events that cast debris across the trail.

Trash removal

Trash removal from trail corridors is important for both safety and protection of environmentally sensitive areas and includes removing ground debris and emptying trash containers and the dog waste receptacles. Trash removal will occur weekly once the trail is completed, and schedules shall be adjusted based on the use and needs after the first year of use, and may be reduced during the winter months if warranted.

Tree and shrub pruning

Tree and shrub pruning will be performed for the safety of trail users keeping the trail free from low overhanging and encroaching branches.

Pruning - (Annually November) Prune woody vegetation 2-feet back from sides of trail – 12-feet vertical clearance – remove invasive vines.

Trimming of Trees/Limbs - (Annually November) Evaluation/ removal of unhealthy or dead trees and limbs. All trimmed and felled limbs and trees are to remain on site outside the limits of the trail and wetland areas to support habitat value.

Mowing of vegetation

The mowing of vegetation along trail corridors is not needed to maintain the trail shoulders and edges of the parking areas. Mowing/weed whacking shall only occur annually, after October 15th and before April 15th if it is determined that the vegetation is encroaching onto, or over the parking and/or trail. When mowing grasses, keep the grass height to greater than 6 inches. Vegetation shall be checked annually.

Trail edging

Trail edging maintains trail width and improves drainage. Problem areas include trail edges where berms tend to build up, and where uphill slopes erode onto the trails. Removal of this material will allow proper draining of the trail surface, allow the flowing action of the water to clean the trail, and limit standing water on the trail surfaces. Proper drainage of trail surfaces will also limit ice build-up during winter months. Trail edging is to occur annually after October 15th and before April 15th.

Rail Trail and Parking Lot Pavement

Properly constructed asphalt pavement using an appropriate mix design requires minimal maintenance. Providing proper drainage is also a key to reducing maintenance costs. Maintenance is generally divided into two categories: preventative maintenance and corrective maintenance. Preventive maintenance is performed on a regularly scheduled basis to improve the life of the pavement and decrease the rate of deterioration. Corrective maintenance is performed to correct a specific pavement failure or distress area.

The path or trail is to be inspected on an annual basis in the Spring to determine the overall condition of the drainage, asphalt pavement, signage, and vegetation growth.

Drainage areas shall be improved or repaired where problems are noted. Vegetation shall be removed from the pavement and surrounding areas where it will affect use of the trail. Signage must be repaired, replaced, or upgraded.

The asphalt pavement shall be inspected for cracks, raveling, disintegration, and premature signs of failure. Cracks which are wide enough (1/4 inch to 1/2 inch) shall be thoroughly cleaned, dried, and filled with a sealant. The best method is to rout the cracks, clean the crack with compressed air, and pour hot crack filling material into the crack. The crack fill should be left 1/4 inch below the surface of the pavement.

Preventive maintenance includes sealing the surface of the asphalt pavement. Surface seals are used to retard oxidation of the asphalt, restore skid resistance, seal small cracks, provide additional moisture protection to the pavement, and retard raveling of aggregate from the surface. Common surface seals include fog seals, rejuvenators, and slurry seals. The type of seal used will depend on the age and condition of your pavement. In general, a fog seal will improve the moisture resistance of the pavement, reduce future oxidation, and fill small cracks. Regardless of the type of sealing to be performed, an environmentally friendly sealant shall be used, such as BioSealcoat, and approved by the Andover Water Department, and copied to the Andover Conservation Commission, prior to use if it is determined the at the trail would benefit from sealing.

Boardwalk

The boardwalk shall be inspected monthly for the first year, and then every 6 months. Inspection shall include foundations, surface, and structural elements of the boardwalk to ensure safety for all users.

A newly built deck that uses pressurized wood will need time to dry completely before a sealer can be applied. The chemicals used to treat the wood leave moisture behind, and depending on the climate, it can take a few months until it's dry enough to seal. A non-toxic EPA approved formula shall be used to seal the boardwalk deck as needed to protect the decking, such as Garden-Seal, Seal It Green Xtreme Marine, Deck Armor-Total Wood Protection by Seal It Green or equivalent. Any and all sealants shall be approved by the Andover Water Department, and copied to the Andover Conservation Commission, prior to use.

Long-term Management of Open Field Habitats

Two large, open fields are currently maintained on parcels owned by the Andover Water Department and the Andover Conservation Commission. These fields are maintained annually by *ad hoc* management agreements. Trails currently exist along the south edges of both open field areas. The Northern field is approximately 4.5 acres and the Southern field is approximately 2 acres (see included aerial image below).

Locking access gates and post-and-rail fencing with time of year closure signage is proposed at the trail connections with the proposed rail trail to limit public access to these field habitats during ecologically sensitive seasons (before April 15 and after October 15) and for users to remain on the trails.

The annual mowing of these field is to occur after October 15th and before April 15st annually.

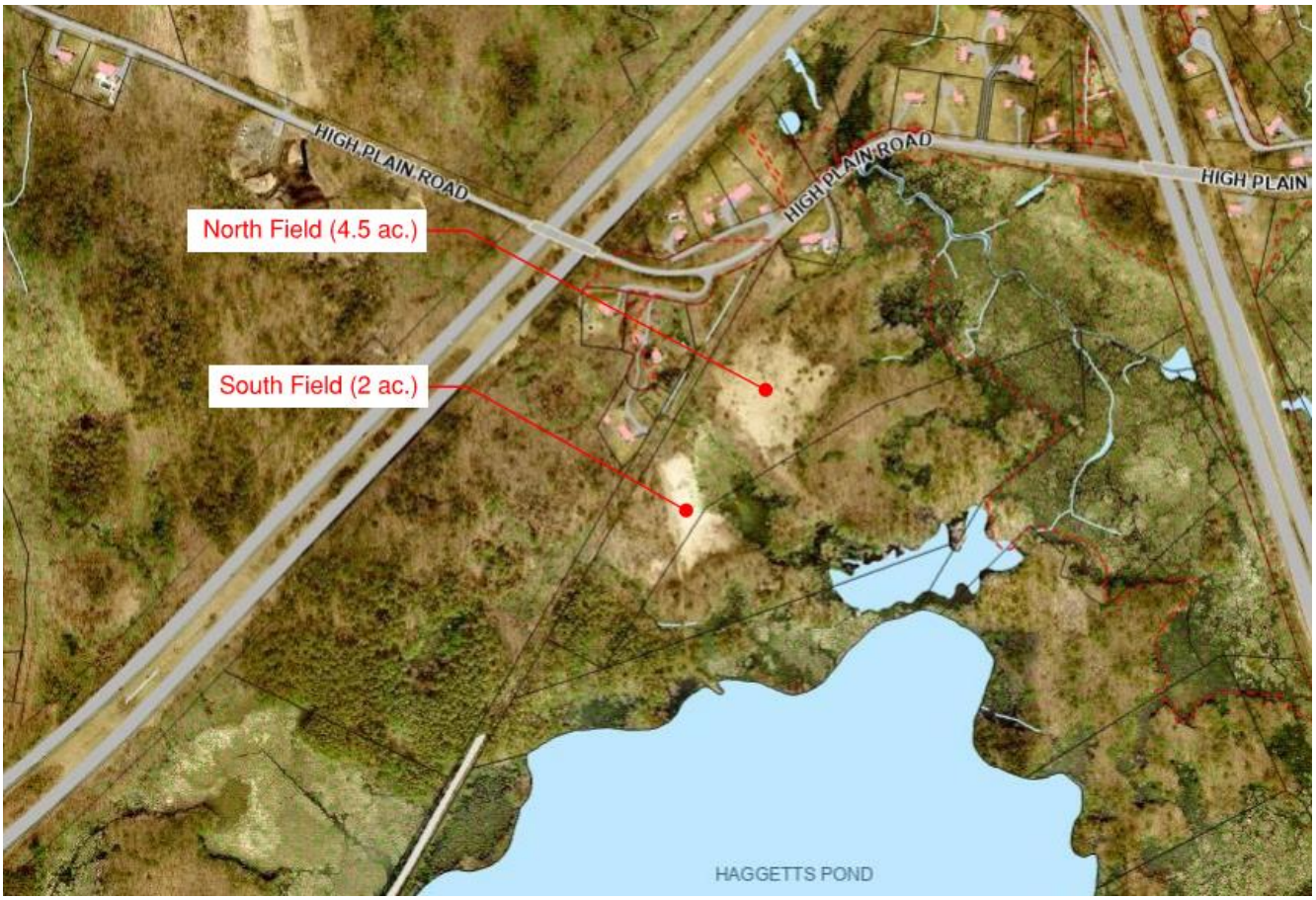


Figure: Protected Field Locations

REQUIREMENTS FOR ROUTINE INSPECTIONS AND MAINTENANCE OF STORMWATER BEST MANAGEMENT PRACTICES

All stormwater Best Management Practices (BMP's) are to be inspected and maintain as follows:

Water Quality Units

Water quality structures will require periodic inspection and cleaning to maintain operation and function. Owners shall have these units inspected on a quarterly basis and after periods of intense precipitation. Inspections of the units can be done by using a clear Plexiglas tube ("sludge judge") to extract a water column sample. When sediment depths exceed 12" then cleaning of the unit is required.

Maintenance of these units shall be done by a vacuum truck that will remove the water, sediment, debris, floating hydrocarbons and other materials in unit. The proper cleaning and disposal of the removed materials and liquid must be followed.

Inlet and outlet pipes must be checked for any obstructions and if any obstructions are found, they must be removed. Structural parts of the unit will be repaired as needed.

Existing and Proposed Catch Basins

Regular maintenance is essential. Deep sump catch basins remain effective at removing pollutants only if they are cleaned out frequently. Inspect or clean deep sump basins at least four times per year and at the end of the foliage and snow removal seasons. Sediments must also be removed at a minimum of two times per year or whenever the depth of the deposits in the catch basin sump is greater than or equal to one half the depth form the bottom of the invert of the lowest pipe in the basin.

Pipe Outlet Protection

The outlet protection shall be checked at least twice a year and after every major storm. If the riprap has been displaced, undermined, or damaged, it must be repaired immediately. The channel immediately below the outlet will be checked to see that erosion is not occurring. The downstream channel must be kept clear of obstructions such as fallen trees, debris, and sediment that could change flow patterns and/or tailwater depths on the pipes. Repairs must be carried out immediately to avoid additional damage to the outlet protection apron.

Rain Garden Areas

Premature failure of rain garden areas is a significant issue caused by lack of regular maintenance. Rain garden areas require careful attention while plants are being established and seasonal landscaping maintenance thereafter.

Inspect pretreatment devices and rain gardens at least for times a year, and after major storm events for sediment build-up, structural damage, and standing water.

Repair eroded areas as needed. Re-mulch void areas as needed (determined during inspections). Remove litter and debris monthly. Treat diseased vegetation as needed. Remove and replace dead vegetation twice per year (spring and fall).

Remove invasive species as needed to prevent these species from spreading into the rain garden area. Upon failure, excavate rain garden, scarify bottom and sides, replace filter fabric and soil, replant, and mulch. A summary of maintenance activities can be found on the following table:

Rain Garden Maintenance Schedule

Activity	**Time of Year**	**Frequency**
Inspect & remove trash	Year-round	Monthly
Mulch	Spring	Annually
Remove dead vegetation	Fall or Spring	Annually
Replace dead vegetation	Spring	Annually
Prune	Spring or Fall	Annually
Replace entire media & all vegetation	Late Spring/early Summer	*as needed

Because the soil medium filters contaminants from runoff, the cation exchange capacity of the soil media will eventually be exhausted. When the cation exchange capacity of the soil media decreases, change the soil media to prevent contaminants from migrating to the groundwater. Using small shrubs and plants instead of larger trees will make it easier to replace the media with clean material when needed.

Plant maintenance is critical. Concentrated salts in roadway runoff may kill plants, necessitating removal of dead vegetation each spring and replanting. The operation and maintenance plan must include measures to make sure the plants are maintained.

Infiltration Trench

Perform preventive maintenance at least twice a year. Remove accumulated sediment, trash, debris, leaves and any clippings from mowing/wed whacking. Remove tree seedlings, before they become firmly established. Inspect the infiltration trench after the first several rainfall events, after all major storms, and on regularly scheduled dates every six months. If there is ponded water at the surface of the trench, it is likely that the trench surface is clogged. To address surface clogging, remove and replace the first layer of stone aggregate and the filter fabric. If water is ponded inside the trench, it may indicate that the bottom of the trench has failed. To rehabilitate a failed trench, all accumulated sediment must be stripped from the bottom, the bottom of the trench must be scarified and tilled to induce infiltration, and all of the stone aggregate and filter fabric or media must be removed and replaced.

Subsurface Infiltration Chamber Systems

Subsurface Infiltration Chamber Systems perform an important role, as they provide 80% TSS removal at the end of the treatment train system. Maintenance is required for the proper operation of the Subsurface Infiltration Systems. The use of pretreatment BMPs such as deep-sump hooded catch basins and water quality units will minimize failure and maintenance requirements.

After construction, the infiltration system shall be inspected monthly and after every major storm for the first few months to ensure proper stabilization. Water levels in the access ports should be recorded over several days to check the drainage of the systems. A logbook shall be kept showing the depth of water in the systems at each observation in order to determine the rate at which the system dewaters after runoff producing storm events. Once the performance characteristics of the system have been verified, the monitoring schedule can be reduced to a biannual basis, unless the performance data suggests that a more frequent schedule is required.

Preventive maintenance on the systems should be performed at least twice a year, and sediment should be removed from any and all pretreatment and collection structures. Sediment should be removed when deposits approach within six inches of the invert heights of connecting pipes, or in sumped inlet structures.

The system is designed with access covers such that a vacuum truck tube that can be used to remove sediment.

SNOW DISPOSAL AND PLOWING PLANS

Snow removal and disposal is not anticipated for the proposed trail. Any snow removal in the proposed parking areas will not plow snow into rain gardens or sensitive resource areas.

OPERATION AND MAINTENANCE BUDGET

The Town of Andover DPW intends to maintain and perform routine inspections and maintenance of the trail, parking areas and stormwater BMPs. The Town has the necessary staff and equipment to perform the routine maintenance required, other then the cleaning of the catch basins and water quality units. These will require a vacuum truck to remove the collected sediments and liquid in the structure sumps. The following are estimates of the Andover DPW time commitments and costs.

Estimated Town of Andover DPW Time Commitment

Inspection/Maintenance	Frequency			Annual Commitment	
Trail Inspection	Monthly	2	hrs	24	hrs
Boardwalk Inspection	Monthly	1	hr	12	hrs
Haggetts Parking Inspection	Monthly	1	hr	12	hrs
High Plain Parking Inspection	Monthly	1	hr	12	hrs
Existing Culverts Inspection	Monthly	2	hr	24	hrs
Stormwater BMP Inspections	Quarterly	8	hrs	32	hrs
Trail Sweeping	Twice Year	8	hrs	16	hrs
Trash Pickup	Weekly	2	hrs	104	hrs
Estimated Trail Side Maintenance	Annually	8	hrs	8	hrs
		Total Annual Estimated Hrs		**132**	**hrs**

Estimated Town of Andover Cleaning Cost

Stormwater BMP	Maintenance Schedule	Cost per Cleaning	Annual Cost
EX CB-1	Fall/Spring	$300	$600
PR CB-1	Fall/Spring	$300	$600
WQU-1	Fall/Spring	$300	$600
WQU-2	Fall/Spring	$300	$600
WQU-3	Fall/Spring	$300	$600
WQU-4	Fall/Spring	$300	$600
WQU-5	Fall/Spring	$300	$600
	Total Annual Estimated Cost		**$4,200**

POST CONSTRUCTION PHASE INSPECTION SCHEDULE AND EVALUATION CHECKLIST

INSPECTION DATE	STRUCTURE	INSPECTION FREQUENCY REQUIREMENTS	COMMENTS	RECOMMENDATION
	Trail	Monthly to Twice a Year and After Major Storm Events		
	Parking Areas	Twice a Year and After Major Storm Events		
	Trash & Dog Waste Receptacles	Weekly		
	Rain Garden	Monthly to Annually		
	Existing and Proposed Catch Basins	Quarterly and/or seasonally		
	Water Quality Units	Quarterly and After Major Storm Events		
	Subsurface Infiltration/Detention System	Twice a Year and After Major Storm Events		
	Infiltration Trenches	Twice a Year and After Major Storm Events		
	Pipe Outlets (Ex. Culverts, Proposed Flared-End	Twice a Year and After Major Storm Events		

POST CONSTRUCTION PHASE INSPECTION SCHEDULE AND EVALUATION STRUCTURE CHECKLIST

(see attached Operations & Maintenance Inspection Key for locations)

INSPECTION DATE	STRUCTURE	COMMENTS	RECOMMENDATION
	EX CB-1		
	PR CB-1		
	EX CULVERT-1		
	EX CULVERT-2		
	EX CULVERT-3		
	EX CULVERT-4		
	EX CULVERT-5		
	EX CULVERT-6		
	EX CULVERT-7		
	INFILTRATION TRENCH-1		
	INFILTRATION TRENCH-2		
	WATER QUALITY UNIT-1		
	WATER QUALITY UNIT-2		
	WATER QUALITY UNIT-3		

	WATER QUALITY UNIT-4		

All structures shall be inspected twice a year and/or after major storm events, unless otherwise specified.

POST CONSTRUCTION PHASE INSPECTION SCHEDULE AND EVALUATION STRUCTURE CHECKLIST

(see attached Operations & Maintenance Inspection Key for locations)

INSPECTION DATE	STRUCTURE	COMMENTS	RECOMMENDATION
	WATER QUALITY UNIT-5		
	AREA DRAIN-1		
	FLARED-END SECTION-1		
	FLARED-END SECTION-2		
	FLARED-END SECTION-3		
	FLARED-END SECTION-4		
	FLARED-END SECTION-5		
	FLARED-END SECTION-6		
	RAIN GARDEN #1		
	RAIN GARDEN #2		
	SUBSURFACE INFILTRATION SYSTEM - 1		
	SUBSURFACE INFILTRATION SYSTEM - 2		
	DISSIPATION BOWL -1 (PIPE OUTLET)		

All structures shall be inspected twice a year and/or after major storm events, unless otherwise specified.

References

Jed Wagner
Maintenance Checklist for Greenways and Urban Trails
Denver Parks and Recreation Department

Eric West, PE
Technical Aspects of Asphalt Trail Design
American Trails

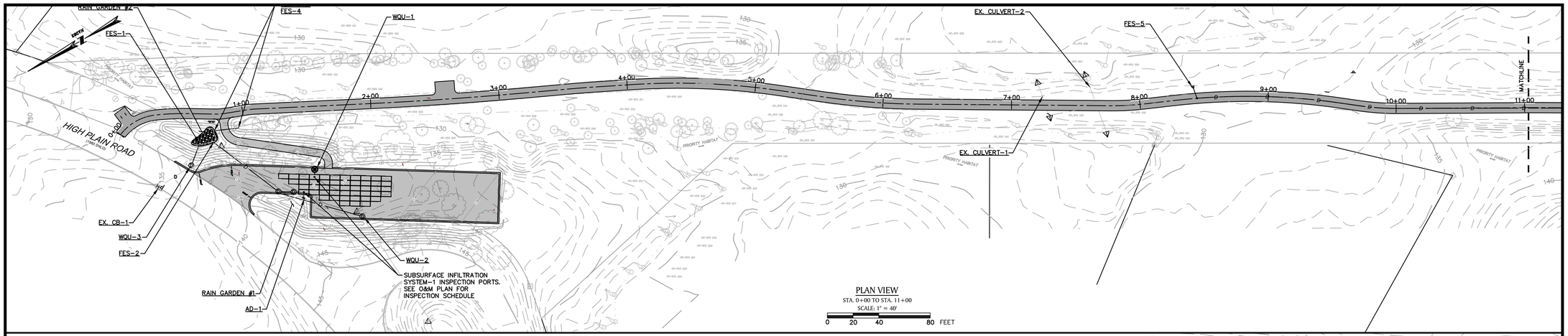
From Feasibility Study for Various Rails to Trails Projects
Trail Operation and Maintenance Requirements
American Trails

MassDEP
Mass Stormwater Handbook
MassDEP

Attachements

Operations & Maintenance Inspections Key Plan, Sheets OM-100 & OM-101

Mowing Advisory Guidelines in Rare Turtle Habitat: Pastures, Successional Fields and Hayfields, by The Natural Heritage and Endangered Species Program, Massachusetts Division of Fisheries and Wildlife.



PLAN VIEW
STA. 0+00 TO STA. 11+00
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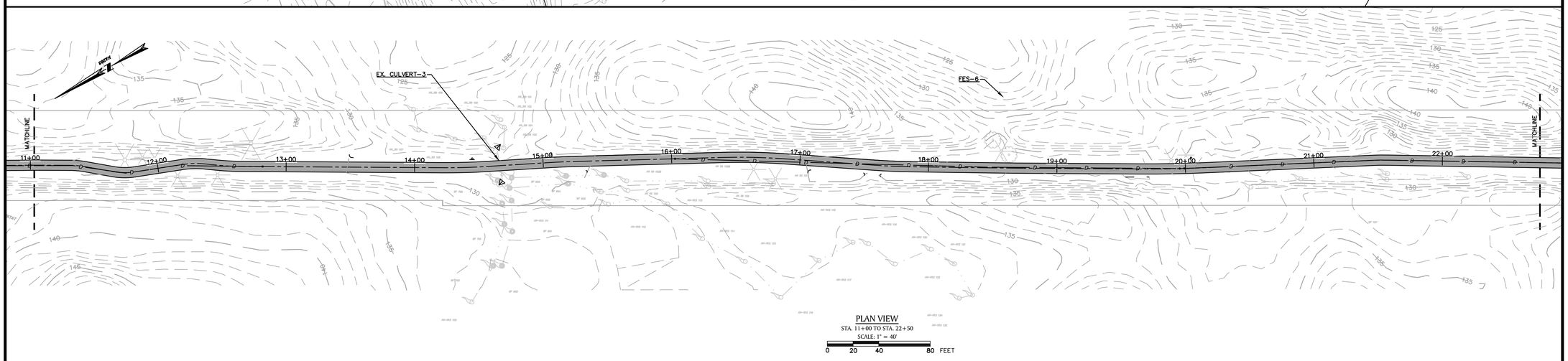
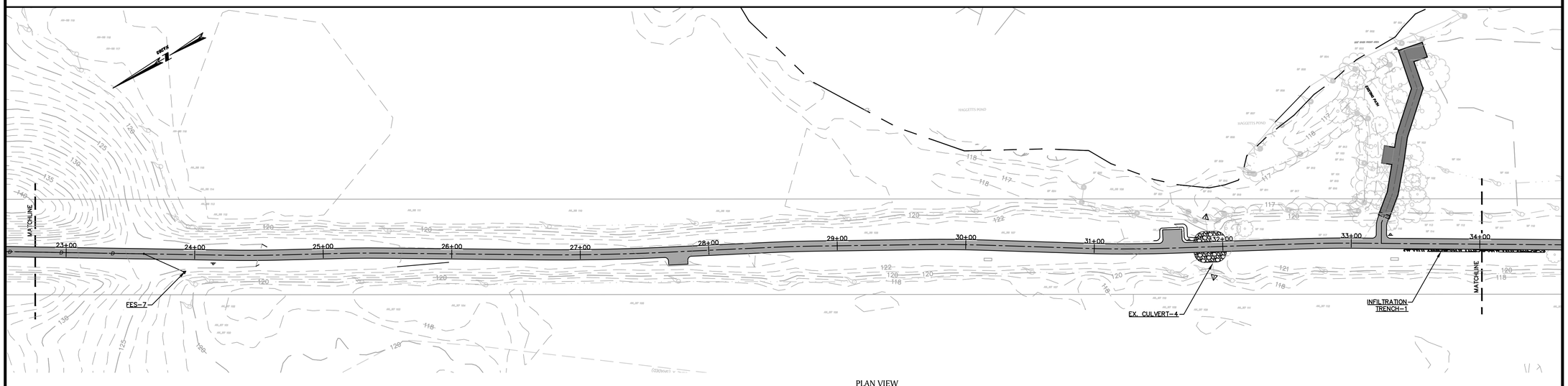


PLAN VIEW
STA. 11+00 TO STA. 22+50
SCALE: 1" = 40'
0 20 40 80 FEET



PLAN VIEW
STA. 22+50 TO STA. 34+00
SCALE: 1" = 40'
0 20 40 80 FEET

ISSUED FOR PERMITTING
NOT FOR CONSTRUCTION

TOWN OF ANDOVER
INCORPORATED MAY 6, 1646
MASSACHUSETTS

PROFESSIONAL ENGINEER DATE

HAGGETTS POND RAIL TRAIL

IN

ANDOVER, MASSACHUSETTS

OPERATIONS & MAINTENANCE INSPECTION KEY

NOVEMBER 7, 2023

REVISIONS:

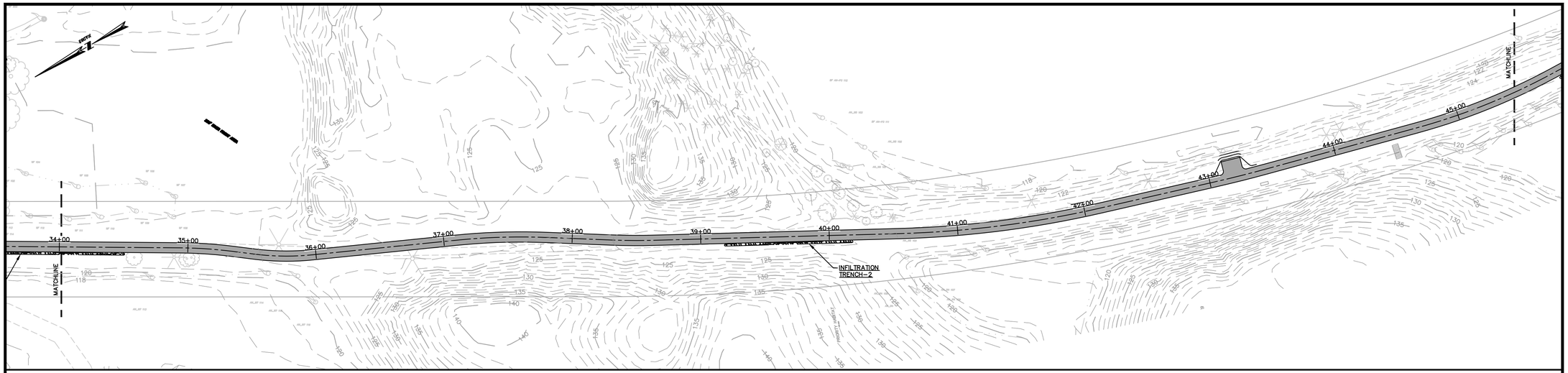
NO.	DATE	DESCRIPTION
1	12/21/23	REDUCED ENV. IMPACTS
2	4/16/24	PEER REVIEW COMMENTS

PREPARED FOR:
TOWN OF ANDOVER
36 BARTLET STREET
ANDOVER, MA, 01810

BSC GROUP
300 Brickstone Square, Suite 203
Andover, Massachusetts
01810
617 896 4300

SCALE: 1" = 40'
0 10 20 40 FEET

FILE: P:\8998501\C_D
DWG.:
JOB. NO: 8-9985.01
SHEET OM-100



PLAN VIEW
STA. 34+00 TO STA. 45+50
SCALE: 1" = 40'
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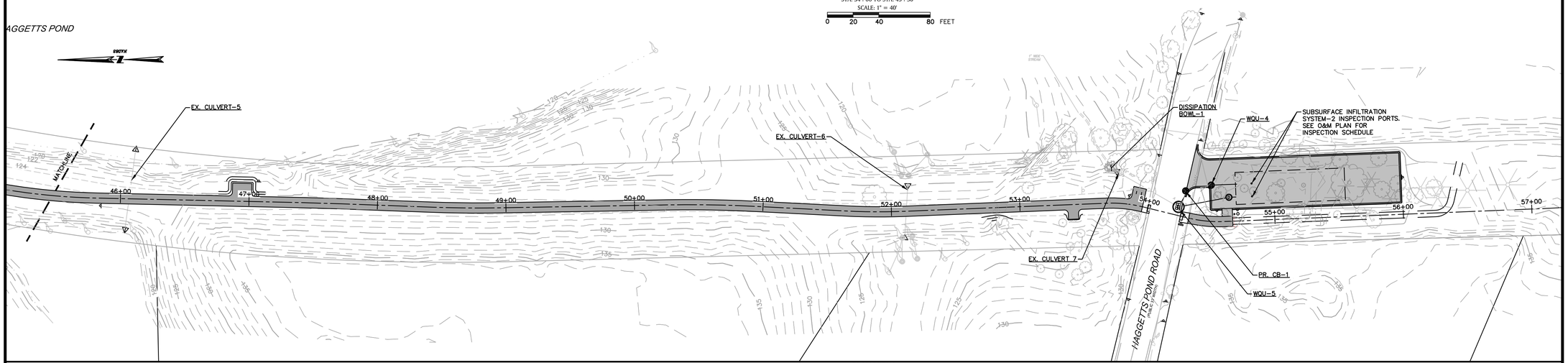

PLAN VIEW
STA. 45+50 TO STA. 57+00
SCALE: 1" = 40'
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OPERATIONS AND MAINTENANCE NOTES:

1. ALL EXISTING CATCH BASINS IN THE AREA TO BE CLEANED, PROTECTED, AND MAINTAINED THROUGHOUT CONSTRUCTION
2. ALL EXISTING CULVERTS IN THE AREA TO BE CLEANED, PROTECTED, AND MAINTAINED THROUGHOUT CONSTRUCTION.
3. ANY EXISTING DRAINAGE STRUCTURE TO BE MODIFIED SHALL BE PROTECTED AND MAINTAINED AS TYPICAL FOR THAT STRUCTURE THROUGHOUT CONSTRUCTION. ONLY FOLLOWING MODIFICATIONS SHALL THE STRUCTURE BE INSPECTED AND MAINTAINED AS SPECIFIED BY THE OPERATIONS AND MAINTENANCE PLAN.
4. ALL CATCH BASINS, AREA DRAINS, WATER QUALITY UNITS, AND OUTLET PIPES SHALL BE INSPECTED AT LEAST TWICE A YEAR AND FOLLOWING ANY MAJOR STORMS, IN ACCORDANCE TO THE OPERATIONS AND MAINTENANCE PLAN.
5. REFER TO THE OPERATIONS AND MAINTENANCE PLAN FOR HAGGETTS POND RAIL TRAIL FOR INSPECTION SCHEDULE, MAINTENANCE DETAILS, AND OTHER INFORMATION.

ISSUED FOR PERMITTING
NOT FOR CONSTRUCTION

TOWN OF ANDOVER
INCORPORATED MAY 6, 1646
MASSACHUSETTS

PROFESSIONAL ENGINEER DATE

HAGGETTS POND RAIL TRAIL

IN

ANDOVER, MASSACHUSETTS

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SCALE: 1" = 40'
0 20 40 80 FEET

FILE: P:\8998501\C_D
DWG.:
JOB. NO: 8-9985.01
SHEET OM-101

MOWING ADVISORY GUIDELINES IN RARE TURTLE HABITAT: PASTURES, SUCCESSIONAL FIELDS, AND HAYFIELDS

by
The Natural Heritage and Endangered Species Program
Massachusetts Division of Fisheries and Wildlife

Grasslands, shrublands, pastures and hayfields are important habitats for turtles, particularly the Wood Turtle and Eastern Box Turtle. Turtles require sparsely vegetated areas with some bare soil for nesting and many prefer early successional areas as feeding areas during the late spring and summer months. The natural succession of grasslands, shrublands, old pastures, and fields reduces the availability of these critical habitat types forcing turtles to travel longer distances to find similar habitat elsewhere. As the travel distance increase so does the likelihood that they will cross roads putting them at risk of being hit and killed by cars. Therefore, the maintenance of these habitat types is important and often requires periodic mowing, although other methods of control are possible (e.g. prescribed burns, grazing). Mowing during the spring and summer months can also cause significant turtle mortality; up to 10% of a western Massachusetts population of Wood Turtles (Jones 2007). In fact, researchers in rural areas are finding that the percent of mortality due to mowing and agricultural machinery is much higher than the mortality rate due to roads.

The following guidelines are intended to avoid or minimize any detrimental effect of habitat management on Wood Turtle or Box Turtle populations. These measures will likely also benefit other turtle species, such as the Stinkpot and Spotted Turtle. Native plant communities and all native species, particularly MESA-listed species, should be considered when developing management plans for conservation lands. These guidelines provide a suite of options, each of which we believe will help reduce turtle mortality. We recognize that all options will not be appropriate for every circumstance and that land managers may need to modify these guidelines to manage sites to accommodate the needs of other species.

For more information about Wood Turtles and Box Turtles and the types of habitat they use, see the NHESP Fact Sheets:
Wood Turtle http://www.mass.gov/eea/docs/dfg/nhesp/species-and-conservation/nhfacts/glyptemys-insculpta.pdf
E. Box Turtle http://www.mass.gov/eea/docs/dfg/nhesp/species-and-conservation/nhfacts/terrapene-carolina.pdf

An information request form can be submitted to the NHESP for private persons interested in finding out if they have state-listed turtle species on their property; the form may be found at http://www.mass.gov/eea/docs/dfg/nhesp/regulatory-review/inforequform-elect.pdf

For more information on management of these habitats, land managers can refer to the recently released *Managing Grasslands, Shrublands, and Young Forest Habitats for Wildlife: a Guide for the Northeast* available for download at: http://www.wildlife.state.nh.us/habitat/management-guide.html

For more information about Habitat Management for Amphibians and Reptiles see the *Habitat Management guidelines for Amphibians and Reptiles of the Northeastern United States* available for order at http://northeastparc.org/habitat-management-guidelines/

Areas Managed as Turtle Habitat: Lands where the primary objective is turtle habitat (such as nature preserves, wildlife refuges or private lands where the landowners wish to optimize turtle habitat and abundance).

1) ***Timing*** - **The best solution** is to avoiding mowing during the peak time when turtles are using fields.

Peak Time for Field Use by Turtles
May 15th – September 15th

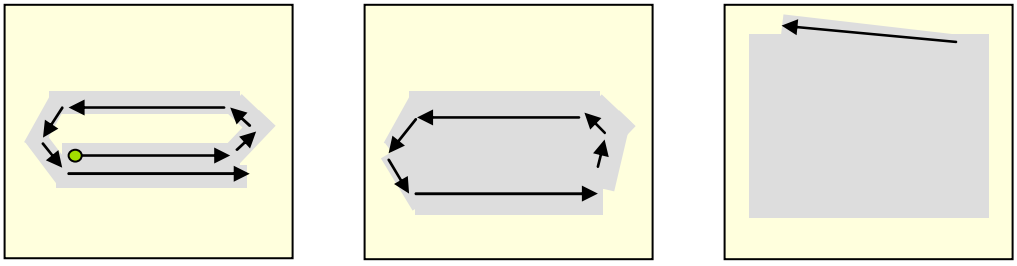
2) *Mowing Rotation* – Mowing to maintain field habitat for conservation reasons should only require multi-year rotations (e.g. mowing once every 2-3 years)*. If mowing is combined with another maintenance method such as chemical control** of invading woody plants, mowing during the turtle active season may not be necessary. If periodic mowing is the sole method used for maintenance, woody plant cover on the site will likely increase over the long-term, and mowing during the active season will be necessary to inhibit woody plant invasion. In some years, very frequent mowing may be required to reduce woody plant abundance. If this repeated mowing treatment is required in a given year, vegetation should be mowed frequently enough that it does not provide habitat for turtles in that year, provided that turtle habitat is present adjacent or nearby to mitigate the temporary loss of use of the site

3) *Percent Mowed* - For sites with > 10 acres of grassland/fields it is recommended that no more than 25%-50% be mowed in any given year. For example, when possible mowing that occurs during the active season should be limited to approximately 25% and areas mowed during the inactive season approximately 50%.

4) *Mower Style* – If mowing on a multi-year rotation, avoid flail mower heads with guide bars that ride along the ground. Sickle-bar mowers will likely have the least impact if mowing grassland and fields every 1-5 years. In areas with more woody vegetation >1-2" diameter a Brontosaurus-style mower will likely have the least impact on turtles.

5) *Mowing Height* – If mowing during the active season is necessary, retention of mowing stubble to 7 or even 12 inches will reduce mortality, reduce blade wear, and will leave important cover for animals.

6) *Directionality* - If mowing during the active season is necessary, start mowing from the center of the field and use a back-and-forth approach, or large circular pattern, to avoid concentrating fleeing animals where they may be killed or stranded. In addition, leave an unmowed 30 ft strip around the perimeter of the field and mow this area last. Most turtles are found in these areas and this provides time for them to react to the mowing activity and move out of the area (see diagram below).



There are three exceptions to this general rule. The first is when a stream is near the field; in these cases it is best to start mowing the side furthest from the streams edge first and work your way towards the stream. The second exception is when the field is bordered by woodland, start mowing the sections of the field furthest from the woods and mow towards the woods. The third exception is when the field is bordered by a road; In this case start mowing the section next to the road first and work your way across the field.

7) *Mower Speed* – Mowing in low gear or at slow speeds will allow turtles to react and move out of the field.

8) *Unmowed Edge* - Leaving an unmowed field edge in high turtle use areas until after September 15th. Eastern box turtles are usually along field edges adjacent to forest and wood turtle are often in field edges closest to nearby streams.

*We recognize that this mowing rotation may be beyond the capacity of the mowing equipment to which a land manager has access. Grant programs are available that may assist in providing funds to assist in hiring a contractor with appropriate mowing equipment, including the NRCS WHIP Program (http://www.nrcs.usda.gov/Programs/whip/) and MassWildlife LIP Program (http://www.mass.gov/eea/agencies/dfg/dfw/wildlife-habitat-conservation/habitat-grant.html). However, these programs are often temporary and intended to recover the capacity of the landowner to manage the property on their own.

** In some cases herbicide applications may be the best alternative to control woody plants and avoid impacts to turtles. Make sure that you read and follow all state and federal regulations. Use the minimum amount and least toxic herbicide possible for desired outcome. Spot application to individual woody plants is preferred. Most of the herbicides used today are amino acid inhibitors acting on amino acids found only in plants. These prevent the plant from performing metabolically.

Land with Multiple Uses: Land where turtles and turtle habitat management is secondary to other management objectives (such as sportsmen's clubs, farmland, recreational areas, etc).

1) *Mower Style* – If mowing on a multi-year rotation, avoid flail mower heads with guide bars that ride along the ground. Sickle-bar mowers will likely have the least impact if mowing grassland and fields every 1-5 years. In areas with more woody vegetation >1-2" diameter a Brontosaurus-style mower will likely have the least impact on turtles.

2) *Blade Height* - Elevating the mowing deck height to 7 or even 12 inches (particularly during the 1st haying of the season) will reduce mortality and will leave important cover for animals. Shorter cuts during late summer second hay harvests are less likely to impact turtles.

*Note: It is actually economically wise to mow fields using higher blade heights. The lower portions of the stem have relatively low nutritional value, it reduces blade wear, increases soil moisture retention which can increase yield of the second harvest, and reduces soil erosion (*Saumure 2006*).*

3) *Directionality* - If mowing during the active season is necessary, start mowing from the center of the field and use a back-and-forth approach, or large circular pattern, to avoid concentrating fleeing animals where they may be killed or stranded. In addition, leave an unmowed 10m strip around the perimeter of the field and mow this area last (see diagram in #5 above). Most turtles are found in these areas and this provides time for them to react to the mowing activity and move out of the area.

There are three exceptions to this rule. The first is when a stream is within 100 m; in these cases it is best to start mowing the side furthest from the streams edge first and work your way towards the stream. The second exception is when the field is bordered by woodland, start mowing the sections of the field furthest from the woods and mow towards the woods. The third exception is when the field is bordered by a road; In this case start mowing the section next to the road first and work your way across the field.

4) *Mower Speed* – Mowing in low gear or at slow speeds will allow turtles to react and move out of the field.

5) *Unmowed Edge* - Leaving an unmowed field edge in high turtle use areas until after September 15th. Eastern box turtles are usually along field edges adjacent to forest and wood turtle are often in field edges closest to nearby streams.

Research Needs:

1) Behavior Data – We need data on the behavioral responses of turtles in reaction to mowers.
2) Blade Height Tests During Actual Field Mowing Events – We need to do tests on the blade height in fields as they are actually being mowed as part of regular maintenance at various sites.
3) The optimum mowing rotation for turtle habitat management.

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