Evaluate and Develop Post-Construction Groundcover that Meets Erosion and Sediment Goals and is Beneficial to Pollinators

Prepared by:
Davey Resource Group, Inc.
Ana Burns (Principal Investigator)
Cheryl Daniels (Co-Principal Investigator)

Prepared for:
The Ohio Department of Transportation,
Office of Statewide Planning & Research

Project ID Number: 107320

March 2023

Final Report

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA/OH-2023/04		

4. Title and Subtitle	5. Report Date
Evaluate Replacement of Current Post-Construction Groundcover with Pollinator Beneficial Groundcover	March 2023
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Ana Burns, Cheryl Daniels, Angela Burdell, Corine Peugh, Emily Kocis, Keith Shane, Jesse Smith, Adrienne Watts, Theresa Wolanin	

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Davey Resource Group, Inc. 295 S. Water Street, Suite 300 Kent, OH 44240	
	11. Contract or Grant No.
	32394

12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Ohio Department of Transportation 1980 West Broad Street Columbus, Ohio 43223	Final Report
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

The Ohio Department of Transportation (ODOT) is constantly looking for ways to reduce maintenance costs following construction using native seed mixes while ensuring all Stormwater Pollution Prevention Plan (SWPPP) requirements are met. Davey Resource Group "DRG" was contracted by ODOT to develop seed mixes for various habitats and research appropriate establishment and maintenance processes to help accomplish these goals statewide.

17. Keywords	18. Distribution Statement
native plants, pollinators, right-of-way, seed mixes, native habitat, Monarch butterfly	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classification (of this report)	20. Security Classification (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	178 pages	$774,165.52

Form DOT F 1700.7 (8-72)	**Reproduction of completed pages authorized**

Credits and Acknowledgments

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Davey Resource Group, Inc.

Ana Burns, Cheryl Daniels, Angela Burdell, Emily Kocis, Corine Peugh, Keith Shane, Jesse Smith, Adrienne Watts, Theresa Wolanin

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Prepared in cooperation with the Ohio Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration

Acknowledgments

The authors would like to thank the Technical Advisory Panel at Ohio Department of Transportation, including Joel Hunt, Scott Lucas, Ready Field Solutions (RFS), as well as Gresham Smith (GS) for their valuable input during this project. We would also like to thank the staff at Ohio Department of Transportation County garages in Ashland, Athens, Cuyahoga, Geauga, Montgomery, and Summit who participated in the field research, volunteered staff and equipment, and supported the project's goals.

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Problem Statement

Pollinators are critical to the nation's food production. Due to habitat loss, pollinators such as the monarch butterfly, rusty patched bumblebee, and other native bee species are sharply declining (Vanbergen, 2013). As a result of pollinator populations severely decreasing worldwide, President Obama signed a memorandum: Creating a Federal Strategy to Promote the Health of Honeybees and Other Pollinators. The memorandum called for the establishment of a pollinator task force composed of leaders from the United States Department of Transportation (DOT) as well as leaders from other executive departments and agencies. As part of this memorandum, member agencies are tasked with developing pollinator habitat on their lands. To meet the goals as assigned by the task force, the Ohio Department of Transportation (ODOT) has been working to increase pollinator habitat by converting existing landscaped lands to pollinator habitat with the use of native species through the Ohio Pollinator Habitat Initiative (OPHI). OPHI is dedicated to creating pollinator habitats in highly visible locations. As a part of the initiative to increase native species and take an active role in habitat creation, ODOT joined the Monarch Candidate Conservation Agreement with Assurances (Monarch CCAA). The Monarch CCAA strives to achieve its goal of creating 2.3 million acres of habitat corridors for wildlife, particularly for pollinators, to increase population numbers (Vanbergen, 2013; Cardno, 2020).

To meet the requirements of the pollinator task force's action plan, ODOT wants to know whether seeding with natives is a viable post-construction option. By directly seeding with natives' post-construction rather than converting turfgrass to natives at a later date, ODOT can create pollinator habitat at a much higher rate and do it as part of the post-construction landscaping process rather than altering established landscaping.

ODOT construction plans usually do not call for a specific seed mix to be used post-construction from the mixes listed in Specification 659. The choice of seed mix to use is left to the contractor to select. Although there are a variety of mixes to select from including turfgrass and native mixes, contractors typically select a turfgrass mix for seeding due to the increased cost of native seed mixes and the uncertainty of utilizing native seeds due to establishment timeframes.

In construction departments, there is a lack of knowledge about native seeding, concern about whether native seed mixes can meet the Stormwater Pollution Prevention Plan (SWPPP) requirements within the typical timeline, and whether they can be planted using typical seeding methods. ODOT has learned through the OPHI initiative that native species of grasses and forbs have the ability to provide improved soil stabilization due to their extensive root systems when compared with turfgrass species (Davey, 2016). However, ODOT's current seeding specification does not sufficiently address seeding with natives for construction projects to feel confident in using the native mixes in the specification.

Research Background

DOTs manage 17 million miles of road with approximately 10 million acres of adjoining roadside land (Forman, Sperling, Bissonette, et al., 2003; Wojcik and Buchmann, 2012). With all of this land, DOTs are capable of potentially providing millions of acres of native pollinator habitat. In the state of Ohio, ODOT manages over 50,000 lane miles of highways and 80,000 acres of rights-of-way (ROW) (ODOT, N.D.). The breadth of the potential pollinator habitat is vast in context due to pollinators' ability to survive and reproduce in narrow lands, such as ROWs (Trauth, Aloysius, Brown, 2021).

Given its ability to provide habitat for declining pollinator species, ODOT is seeking to update its post-construction groundcover seeding specification by replacing non-native turfgrass species and invasive crown vetch with native pollinator-friendly grasses, forbs, and legumes.

ODOT contracted Davey Resource Group, Inc. "DRG" to assist in these efforts by evaluating seed mixtures, improving these mixes by adding native plant species when possible, and determining if the seeding method impacted their successful germination. The goals of this project were to improve pollinator habitat in the ROW while reducing mowing and maintenance costs. Phase I identified native plant species that are salt tolerant, prevent erosion, and are capable of thriving in compacted soils. Phase II tested the seed mixes developed during Phase I and assessed pollinator habitat created from native plantings.

Goals and objectives for this study include:

- Identify potential post-construction pollinator-beneficial groundcover that will:
  - Be comparable in cost to existing post-construction groundcover.
  - Meet Ohio EPA 70% coverage seeding requirement.
  - Meet coverage requirement within ODOT's 12-month window.
  - Reduce ODOT's roadside maintenance costs by reducing the need for mowing and herbicide applications.
  - Utilize native forbs and grasses when practical.
  - Ensure all ODOT clear zone requirements are met to ensure public safety.
- Recommend the best methods of planting and maintaining the groundcover to address weed pressure and woody vegetation establishment.
- Recommend environmentally sound materials and procedures that are compliant with EPA rules.

To meet these goals, DRG performed the following tasks in Phase I:

- Performed a literature review regarding installation and establishment of native species appropriate for roadside conditions.
- Interviewed DOTs across the Midwest and adjoining states for their experience and recommendations surrounding the use of natives in the DOT ROW.
- Reviewed Ohio Department of Transportation Construction and Material Specification Item 659 (Specification 659).
- Created an informational matrix of species characteristics found in Specification 659, alternative seed mixes available through regional vendors, and seed mixes developed by DRG.
- Assessed additional native plants that could be successful in roadside ROWs and altered or developed seed mixes to ensure roadside durability.

At the completion of Phase I, DRG reviewed the findings and matrix with the project's Technical Advisory Committee. DRG recommended a path to move forward with the second phase of the project. Phase II tasks included:

- Field testing applicable seed mixes.
  - Set up field tests to replicate post-construction conditions.
  - Assess the vegetation and pollinators that visited the sites.
  - Performing mowing and herbicide maintenance as needed.
- Observe an active construction site to view typical roadside construction practices.
- Create an identification guide to aid in the identification of native grass and forb seedlings used in the field-tested mixes and OPHI plantings.
- Update the Guide for Roadside Integrated Vegetation Management of Prohibited Noxious Weeds in Ohio with new species added to the Ohio Revised Code in 2018.

Research Approach

Phase I

During Phase I, DRG performed a literature review (Appendix A), reviewed current post-construction landscaping specifications of ODOT and neighboring DOTs, interviewed neighboring DOTs to learn from their experiences with native groundcover (Appendix B), and reviewed industry literature on native groundcover. DRG developed a matrix to analyze ODOT's current seed mixes and seed mixes designed by native seed vendors. The seed mixes were categorized by the appropriate ROW zone in which they should be planted. Mix characteristics, tolerances, environmental benefits, procurement, and seeding rates were researched. DRG evaluated individual seeds in the existing mixes and made modifications suitable for roadside conditions to create additional mixes (Appendix C; Appendix D). The IVM seed mix originally had Korean lespedeza (*Kummerowia stipulacea*); this species was replaced with wild lupine (*Lupinus perennis*). The seed mixes that were most suitable for highway conditions were recommended in the final Phase I matrix. During Phase II, the top two seed mixes for each part of the roadside were field tested against ODOT's Class 2 seed mix (Table 1). Native seed mixes included a variety of forbs, graminoids, and legumes.

Table 1. Tested Seed Mix Application Methods

Test Type	Seed Mix Treatments by Seeding Method		
	Drill Seeder	Hand Broadcast	Hydro-mulch
Fenceline	• All Ohio CRP[1, 2] • Class 6	• Class 2	• All Ohio CRP1, 2 • Class 6 • Class 2
Roadside	N/A	• Freedom II[3] • Class 3B • Class 2	• Freedom II[3] • Class 3B • Class 2
Slope	N/A	• Ohio IVM1, 4, 6 • Class 5B • Class 2	• Ohio IVM1, 4, 6 • Class 5B • Class 2
Wet Ditch	N/A	• Wet Ditch/Swale5 • Seasonally Flooded5 • Class 2	• Wet Ditch/Swale5 • Seasonally Flooded5 • Class 2

[1] Pheasants Forever
[2] Conservation Reserve Program
[3] Ohio Prairie Nursery
[4] Korean lespedeza (*Kummerowia stipulacea*) replaced by wild lupine (*Lupinus perennis*)
[5] Seed mix designed by Davey Resource Group, Inc. for this project.
[6] Integrated Vegetation Management

Phase II

Location Selection and Plot Setup

Six ROW test locations spread across six counties in five districts were chosen based upon available areas that fit testing conditions for each test type. Test locations for this project were located along: State Route US-33 in Athens (Athens, D10); Interstate I-71 in Ashland (Ashland, D3); the I-480/I-271 interchange in Warrensville Heights (Cuyahoga, D12); State Route US-422 in Auburn Township (Geauga, D12); exit bowl N235 merging onto I-70 in Park Layne (Montgomery, D7); and I-271 in Macedonia (Summit, D4) (Appendix E).

Across the identified ROW locations, 12 test sites were chosen. The selected locations included test types of Fenceline, Roadside, Slope, and Wet Ditch. The slopes ranged from 31% to 43% grade, or greater than 3:1 to greater than 2:1. Each Fenceline, Roadside, and Slope test site was 1.8 acres and consisted of 18 test plots, each 0.1 acre (4,356 ft^2) in dimension. The Wet Ditch test sites were 0.9 acre with each test plot measuring 0.05 acre (2,178 ft^2) in dimension. Each test site was divided into three replicate blocks.

DRG located sites that were homogeneous and large enough to contain an entire set of plots. Safe access was taken into account to ensure the research team would be able to prepare, complete installation, maintain, and complete surveys as needed. DRG spoke with ODOT staff to ensure sites selected would not be affected by current or future construction projects throughout the life of the study. The research team attempted to select sites that did not contain a majority of fill (in this study, a mix of in-situ soil and broken-down asphalt, concrete, and other road materials or reclaimed mine soils), had a minimal number of rills, and had existing vegetation on site. All ditches included in the study needed to remain partially wet for the majority of the year.

Invasive species percent coverage was determined prior to seeding. Sites were selected in various locations throughout the state to demonstrate the project's goals could be met across the state.

Each replicate block was composed of six test plots and was separated by an untreated buffer region with a minimum size of one plot width. The test plots were seeded with one of three different seed mix treatments designated per test type. Each seed mix was installed using two or three different methods at each test site (Figure 1).

Test Site	Replicate Block 1						Replicate Block 2						Replicate Block 3					
	Plot A	Plot B	Plot C	Plot D	Plot E	Plot F	Plot E	Plot F	Plot C	Plot B	Plot A	Plot D	Plot C	Plot D	Plot F	Plot B	Plot A	Plot E

Figure 1. Sample of test site design. Test sites consisted of three replicate blocks with six plots in each. Each block is a single test type of Wet Ditch, Slope, Roadside, and Fenceline. Letters represent different seed mix and seed installation method combinations, replicated three times within a test type.

Site Preparation and Baseline Evaluations

Baseline quadrat evaluations were conducted after plots were established to record the plant community prior to the start of the experiment in 2019 (Appendix F).

During June and August 2019, prior to seed installation, the research team removed pre-existing herbaceous and woody vegetation. Herbaceous vegetation at all test sites was treated with two applications of non-selective herbicides (glyphosate and isopropylamine salt of imazapyr). Woody species present in Slope 1 and 2 (Ashland) and Fenceline 1 (Ashland) sites were managed with the hack and squirt method; trees were cut and treated with triclopyr, and later removed from the site. The trees were removed by hand, and then hauled off site manually to existing brush piles in the ROW.

Once all vegetation died off, the plots were mowed and pulverized six inches deep to prepare for seeding. The soil was broken up into clumps of two-inch diameter or less. There was no difference in the depth or method of soil pulverization between the turfgrass plots and the native plots. Slope test types were mowed and pulverized in Athens and Ashland only in areas where it was safe to operate equipment per DRG and ODOT standards.

Initial Soil Analysis and Preparation

Soil samples were taken at a depth of 4 to 6 inches at four randomized locations within plots at each test site. Soils were analyzed for nutrients and texture by Spectrum Analytic, Inc. in 2019 (Table 2). The optimal pH and organic matter for each seed mix is represented in Appendix G.

Table 2. Soil Analyses

Year	Laboratory	Location	Test Completed
2019	Spectrum Analytic, Inc.	• Ashland	T1- Basic: pH, organic matter, P, K, Ca, Mg, CEC
		• Athens	
		• Cuyahoga	Texture- Soil Texture (i.e., % sand, silt, and clay)
		• Geauga	
		• Montgomery	
		• Summit	

Soil analysis results showed depleted nutrients in 11 of the 12 test sites, resulting in a prescribed 11-52-0 nitrogen-phosphorus-potassium (N-P-K) dry fertilizer application for site preparation at the sites that showed deficiencies. Fertilizer applications were performed at the sites in Ashland, Athens, Cuyahoga, Geauga, and Summit counties. Fertilizer was applied in a 60/40 methodology; 60% was mixed into the soil via a pulverizer prior to seeding and 40% was applied with seeding.

Slope 1 and 2 (Ashland) test sites received all fertilizer during seeding and not in the 60/40 split application method because the pulverizer could not be used on the slopes at these locations. Turfgrass (Class 2) control plots received the ODOT specification recommended rate of 152.5 pounds of fertilizer per acre, whereas plots seeded with native or alternative mixes received only 130.7 pounds per acre as indicated by the soil analysis results and resulting recommendations for turfgrass and native seeding.

Additional soil amendments were added based on results of the soil testing completed in 2019. As ODOT's seeding contractors typically do not utilize amendments other than lime and fertilizer, DRG and the project's technical advisory committee agreed to only apply additional soil amendments to sites well below minimum thresholds of Specification 659 (Appendix H), where values were determined to be uninhabitable by all vegetation species. Specification 659 requires organic content to be above 4% for seeding. Roadside 1 (Ashland) had an extremely low organic matter content of 1.5%. As such, Verdyol Biotic Earth™ was applied at this site. Verdyol Biotic Earth™ increases soil moisture retention and facilitates soil nutrient cycling and stimulates soil microbial community development in areas with low organic content. Biotic Earth™ Black was applied through a tackifier tank during the seeding process as directed by the soil test and product labels at 3,500 pounds per acre (Appendix I). Recommended soil pH is 5.0 to 8.0 for turfgrass and 5.0 to 7.5 for native grasses and forbs. Soil tests at Wet Ditch 1 (Cuyahoga) and Fenceline 2 (Cuyahoga) were 9.2 and 9.0 pH, respectively. Profile Aqua-pHix™ quickly reduces soil pH to improve plant growth in alkaline soils. Profile Aqua-pHix™ was applied prior to seeding according to label directions at 10 gallons per acre.

Seeding Treatments and Methodology

Nine seed mixes were tested with three mixes for each test type. These consisted of the seed mix typically used post-construction, ODOT Class 2 mix, and two alternative native seed mixes. ODOT Class 2 mix served as the control and was represented in each test type. Native seed mixes were not placed in the clear zone (Roadside test type), as they are incompatible with the clear zone mowing requirement. Rather, turfgrass species were planted in the clear zone as they are capable of being mowed up to 10 times a year with no ill-effects to the plants.

Native species do not germinate well when seeded during the summer as seeds can dry out and they may not have time to complete reproduction to allow for seed dispersal prior to fall senescence; therefore, native species should be seeded in the spring, fall, or winter. Turfgrass does best when seeded from either spring to early summer or late summer to mid-fall. To ensure germination of both turfgrass and native seed mixes and reduce overall mobilization for seeding for the research project, all seed mixes were scheduled for installation in a narrow window during the fall of 2019. Due to soil conditions that were too wet to operate the drill seeder, the Fenceline 2 (Cuyahoga) seed installation was delayed until early 2020 when the ground was firm enough for drill seeder operation.

Seeding rates utilized throughout the study were determined by Specification 659 or licensed native seed vendors, with the exception of Class 5B and Class 6. ODOT specifications require a seeding rate of 24.83 pounds per acre and 73.18 pounds per acre for Class 5B and Class 6, respectively. Seeding rates for native upland seed mixes are recommended at 20 pounds per acre by licensed seed vendors.

The research team seeded Class 5B and Class 6 seed mixes at 20 pounds per acre during the course of this study. Class 2 was seeded at 217.8 pounds per acre, and Class 3B at 101.5 pounds per acre as specified in Specification 659.

The Ohio IVM and Ohio All Conservation Reserve Program (CRP) seed mixes were obtained from Pheasants Forever (PF) and were seeded at 6.964 pounds per acre, and 5.723 pounds per acre, respectively, as indicated by PF. Freedom II mix was obtained from Ohio Prairie Nursery (OPN) and seeded at 220 pounds per acre as stated by the seed vendor. DRG developed the Wet Ditch/Swale mix and the Seasonally Flooded mix and, following input from native seed vendors, seeded at 30 pounds per acre and 20 pounds per acre, respectively.

Across the test sites, three seeding methods were used: hydromulching, drill seeding, and broadcast seeding. DRG tested two seeding methods per seed mixture at all test sites except Fenceline, where all three seeding methods were tested (Appendix J). The resulting establishment of the mixes were compared by seeding method to demonstrate efficacy. The seeding methods utilized were determined based on site characteristics (i.e., drill seeding was only completed in Fenceline locations due to equipment capabilities and safety requirements). Broadcast and drill seeding are common seeding methods used on DOT ROWs that were utilized in this study. Hydroseeding is also a common seeding method used along DOT ROWs but was not utilized due to the logistics of mobilizing staff and equipment for numerous small batches of different seed mix slurries needed at each site. Hydromulching was used as a replacement for this seeding methodology due to the compatibility of the two methods.

Photo 1. RFS applying hydro-mulch at Wet Ditch 1 (Cuyahoga) site.

Additives such as straw, fiber mulch, and tackifier were used depending upon the seeding method. Seeds planted using drill seeding were incorporated into the soil at 0.25-inch depth with no straw or tackifier added. Broadcast seeding methodology included the application of seed followed by straw, then Tornado Tack solution. Hydromulching was performed by broadcasting the seed mix then applying the fiber mulch solution. All tackifier applications were completed by Ready Field Solutions (RFS). All mulching and tackifier measures were completed according to manufacturer specifications, Specification 659, or native seeding standards depending on whether native seed or turfgrass seed mixes were used (Photo 1).

Terminology used in this report is as follows: Infields are part of the Fenceline sites (Zone 4), clear zones and foreslopes are Roadside sites (Zone 2), no-mow slopes and backslopes are Slope sites (Zone 3), and wet ditches and swales are Wet Ditch sites (Zone varies based on distance from road). Seed mixes and seeding methodology by test type are found in Table 1.

Post-Seeding Maintenance

ODOT typically mows four times per year along the clear zone and once per year at all other areas along the ROW as feasible following safety and equipment guidelines.

Per ODOT staff, vegetation height is typically reduced to 3 to 4 inches, which differs from the posted maintenance practices.

Each seeding treatment and test type received appropriate post-seeding maintenance according to native seeding Best Management Practices (BMP) or ODOT county mowing practices (Davey, 2016; Specification 659). The BMPs were followed to ensure the proper growth and reproduction of native seeded species and to provide overwintering habitat for insect species. Included in the maintenance schedule were mowing and application of herbicide.

Mowing

Fenceline

The control plots in the Fenceline sites were mowed in the fall following typical ODOT maintenance practices. During the first and second growing years, mowing was completed on native seed mixes in the Fenceline test plots when vegetation exceeded 18 inches during early spring and again as needed following vegetation evaluations. During the third growing season, an early spring mow back was completed on native seeded Fenceline test plots. Vegetation height was reduced to 6 to 8 inches as recommended by native seeding BMPs.

Roadside

In Roadside plots, mowing was completed throughout all three growing years after seeding to ensure visibility in the clear zone following ODOT's mowing schedule of 4 times per growing season. During all mowing events completed by DRG in the clear zone, vegetation height was reduced to 6 to 8 inches in contrast to ODOT's typical 3 to 4 inches. During unapproved mowing events completed by ODOT contractors, vegetation was mowed to a height of 3 to 4 inches in all plots. Clear zone mowing was completed four times per year at the Roadside test sites.

Slope

Due to the safety risk in operating equipment on a slope, Slope sites were not mowed regularly after seeding. On Slope 1 and 2 (Ashland) sites, sections that were deemed safe for equipment operation were mowed once in the spring of the first growing season following seeding. Vegetation height was reduced to 6 to 8 inches in contrast to ODOT's typical 3 to 4 inches in compliance with native seeding BMPs.

Wet Ditch

The Wet Ditch 3 (Summit) site and the first replication of the Wet Ditch 1 (Cuyahoga) plots were in the clear zone and the first Plots in the clear zone were mowed four times a year to ensure visibility in the clear zone following ODOT's mowing schedule. During all mowing events in the clear zone, vegetation height was reduced to 6 to 8 inches in contrast to ODOT's typical 3 to 4 inches. In the Wet Ditch plots not located near roadsides, the plots were not mowed as they were down a steep slope and would not typically be mowed by ODOT.

Herbicide Application

DRG staff completed herbicide applications on prolific noxious weeds and invasive species following plant or pollinator surveys throughout the entirety of the project. To limit erosion, DRG staff only applied herbicide in instances when the total percent of all groundcover was greater than 50%.

The application methods and herbicides utilized were determined according to the site conditions and targeted species. Herbicides used included selective and nonselective herbicides through broadcast or spot spraying applications as appropriate for the conditions to avoid overspray onto desired species.

Corrective Re-seeding Efforts

Following the first growing season, DRG reviewed the results of the vegetation evaluations and assessed the initial seeding success to ensure plots met the 70% cover requirement. Sites that did not meet 70% vegetative cover included Slope 3 (Athens), Fenceline 2 (Cuyahoga), and Wet Ditch 3 (Summit). Additional soil samples were taken at these sites to determine the soil properties that caused the failure to achieve 70% vegetative coverage.

Since the control mix did not have better vegetative coverage than the native seed mixes at the three sites that did not reach 70% coverage, it was determined with the project's ODOT Technical Advisory Committee that soil amendments prior to reseeding would be needed to achieve better vegetative success than the initial 2019 seeding.

At Fenceline 2 (Cuyahoga), although the composite soil samples did not reveal an extremely low organic matter content and the phosphorus levels were within recommended limits, the vegetation growing showed stunted growth and the plots had a visible distribution of broken asphalt. While topsoil would have helped vegetative success, it was not used due to cost constraints. Instead, Verdyol Biotic Earth™ was selected to increase organic matter along with 11-52-0 (N-P-K) to increase phosphorus levels in order to counteract the high levels of calcium.

At Slope 3 (Athens) soil amendments applied included Profile Aqua-pHix™, Verdyol Biotic Earth™ and 11-52-0 (N-P-K). Profile Aqua-pHix™, a chelated acid, was used to quickly reduce the pH of the soil. According to the label, Profile Aqua-pHix™ also reduces salts in soil and loosens soils to promote root growth. While topsoil would have helped vegetative success, it was not used due to cost constraints. Instead, Verdyol Biotic Earth™ was selected to increase organic matter along with 11-52-0 (N-P-K) to increase phosphorus levels in order to counteract the high levels of calcium. Additionally, straw wattles were installed to divert water coming off the top of the slope to reduce seed being washed downslope.

At Wet Ditch 3 (Summit) soil amendments applied during seeding included Profile Aqua-pHix™, Verdyol Biotic Earth™ and 11-52-0 (N-P-K). Profile Aqua-pHix™, a chelated acid, was used to quickly reduce the pH of the soil. According to the label, Profile Aqua-pHix™ also reduces salts in soil and loosens soils to promote root growth. While topsoil would have helped vegetative success, it was not used due to cost constraints. Instead, Verdyol Biotic Earth™ was selected to increase organic matter along with 11-52-0 (N-P-K) to increase phosphorus levels in order to counteract the high levels of calcium.

Prior to reseeding, existing vegetation on these three test sites was not controlled with the use of herbicides. Each of the plots at the three sites were seeded in October and November 2020 with the same test mixes and methods as had been completed in 2019.

As Wet Ditch 3 (Summit) continued to struggle with achieving vegetative coverage, additional soil tests were performed in 2021 using Cornell lab to test for heavy metals as well as to determine if any of the previous measurements had changed with the addition of the soil amendments (Table 3).

Table 3. 2020 and 2021 Soil Analyses

Year	Laboratory	Location	Test Completed
2020 - July & August	Spectrum Analytic, Inc.	• Athens • Cuyahoga • Summit	T3: T1 test*, T2 test**, Boron, Nitrate Nitrogen, Sodium, and Soluble Salts and Sulfur
2021 - July	Cornell Nutrient Analysis Laboratory	• Cuyahoga • Summit	1060 - Soil Fertility: Al, Ca, Cu, Fe, K, Mg, Mn, Mo, Na, P, S, Zn (ICP); pH; and organic matter
2021-July	Cornell Nutrient Analysis Laboratory	• Summit	1880 - Soluble Salts (conductivity)
			2021- Heavy Metals: Al, As, B, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Ni, P, Pb, S, Se, Sr, Ti, V, Zn
2021-September	Spectrum Analytic, Inc.	• Athens	T1 test*

**Composed of soil pH, buffer pH, organic matter, available phosphorus (Mehlich-3), exchangeable potassium (Mehlich-3), Magnesium (Mehlich-3), Calcium (Mehlich-3), cation exchange capacity, percent base saturation of cation elements*

***Composed of T1 test, iron, manganese, zinc, and copper*

Vegetative Assessment Methods

In 2020, the first growing season after seeding, vegetative assessments were completed six times, once every 30 days. In the following growing seasons, 2021 and 2022, beginning in May, vegetation was assessed three times per year, once approximately every 45 days.

Species identification and assessment of plant growth were completed at random centralized points within each plot. Survey locations were centralized to limit edge effects and minimize confounding variables. Surveys consisted of two 1-meter diameter quadrat samples per plot. A hula hoop was utilized to ensure a 1-meter square area was surveyed (Photo 2). In total, a single site with 18 plots had 36 plot quadrat surveys. Plots were assessed for the total percent of bare ground, found by estimating the percent plant cover.

Photo 2. DRG staff completing vegetation survey in roadside site.

Sites were closely monitored to determine when the 70% plant cover threshold was reached. Plant species found in the sample areas were recorded and measured for plant height, life stage, and approximate percent cover within the sample area. Invasive species present within the entire plot, as well as a visual estimate of invasive coverage in square feet, were recorded. Invasive species were monitored and assessed by DRG staff and scheduled for target herbicide application as needed.

Entomological Assessment Methods

Entomological assessments were completed during all three growing seasons. Assessments were completed two times in 2020 and 2022 and three times in 2021. Entomological assessments were performed when a minimum of 5% of an individual plot's vegetation contained floral resources.

Photo 3. Monarch butterfly resting on swamp milkweed in Cuyahoga Wet Ditch site. Swamp milkweed was included in the Seasonally Flooded mix.

Entomological surveys focused on observations of bee, butterfly, and moth pollinator visitations to floral resources available in each plot, not merely their presence flying through the plots. Butterflies and moths were surveyed for adult and larval (caterpillar) life stages (Photo 3). Surveys consisted of walkthroughs of plots for a 90-minute maximum survey time per site. Identifications were to species level for butterflies, moths, and bees. When an identification required capture and investigation, the survey timer was paused to allow for accurate identification. Since identifications of butterflies, moths, and bees were completed by capture and release methods, species identification that required review under a microscope were identified to the scientific classification of family.

Weather conditions impact pollinators that are observed at a site. For this study, daily temperature, cloud cover, and wind measurements were taken from the Weather Channel phone application. Due to increased wind in the ROW, and the timing of surveys, optimal survey conditions were not always met; sometimes entomological surveys were conducted during weather conditions considered acceptable as listed in Table 4. While the optimal survey conditions provide the best likelihood of ensuring the accuracy and true diversity for a survey location, accepted survey conditions are weather conditions that will support the greatest variety of pollinators at a time.

This approach allowed for the entomological surveys to occur throughout the survey season, although most pollinator surveys were completed during the optimal conditions listed in Table 4.

Table 4: Pollinator Survey Conditions

Accepted Survey Conditions	**Optimal Survey Conditions**
Temperature 50°F -100°F	Temperature 66°F -98°F
Wind less than 13 mph	Wind less than 8 mph
No large raindrops	No precipitation
Survey time between 8 am-3 pm	Less than 75% cloud cover

Table 4. Weather conditions for pollinator assessments that aid in assessing the true diversity and abundance of pollinators likely to be observed.

Research Findings and Conclusions

Soil Analysis and Site Preparation

As initially discussed during the regional DOT interviews and later confirmed during field tests, soil conditions play a critical role in the success of any vegetation. Vegetation success is meeting 70% establishment within 12 months as set forth by ODOT and the Ohio EPA. As part of the site preparation for field testing of the seed mixes, no topsoil or compost was brought in from off-site. As such, Specification 659 did not call for soil testing. However, as was evident in the soil samples taken prior to seeding in 2019, soil conditions were not optimal at many test locations and were outside thresholds compatible with life for species seeded. The nutrient and organic levels found across the sites used in this study indicate that soil health will have to be managed prior to seeding in order to achieve healthy vegetation along ODOT ROWs.

After the first growing season, three sites did not meet the 70% vegetative coverage goal with any of the seed mixes or seeding methods used, including the control seed mix. Of the three sites that required reseeding in 2020 (Slope 3 (Athens), Fenceline 2 (Cuyahoga), Wet Ditch 3 (Summit), the original soil testing completed in 2019 showed high soil pH, low organic matter, low phosphorus, and high calcium.

The additional use of soil amendments was initially discouraged by the Technical Advisory Committee due to contractors not typically applying amendments during post-construction re-vegetation operations. Ultimately, it was agreed upon to take additional soil samples of these sites in 2020 and apply necessary amendments for successful re-seeding growth. Results for Slope 3 (Athens) in the non-vegetated areas found that the pH was above the tolerance limit for any of the seeds in the mixes, the organic matter was very low, and the calcium was extremely high and was likely binding the phosphorus which was extremely low. The Fenceline 2 (Cuyahoga) soil samples found that calcium was very high. The Wet Ditch 3 (Summit) soil samples found that the pH was above the tolerance limit of any of the seeds in the mixes, sodium was extremely high, phosphorus was low, and calcium was high.

These three sites showed the highest values of calcium throughout the study. Currently, Specification 659 does not recommend testing for calcium values in soil, however, high levels of calcium can reduce uptake of other nutrients (particularly phosphorus) or cause a cementation of the soil, preventing water and air movement within the soil and reducing vegetation growth. The discrepancies between the present and optimal values explain the lack of vegetation after the first growing season despite the use of 11-52-0 (N-P-K) at each of these sites and Profile Aqua-pHix™ at Fenceline 2 (Cuyahoga) during initial seeding.

Seeding Methods

All three methods (broadcast seeding, drill seeding, and hydromulching) were effective at the sites for which they were used as all methods were able to achieve 70% vegetative coverage. Hydroseeding/hydromulching and broadcast seeding are compatible with both turfgrass and native species included in this study, while drill seeding is compatible with native species only. The native drill seeder is good at applying seed at a low per acre rate within one inch of the soil surface. It is not practical to use for turfgrass seed mixes that are applied at much higher rates and deeper seeding depths.

Overall, it was found that all seeding methods (drill seeding, broadcast seeding and hydromulching) were equally effective at achieving 70% vegetative cover for fencelines, as there was no statistical significant difference between vegetation establishment of the three seed mixes and each method. Broadcast seeding and hydromulching methods show no significant differences for establishment along roadsides.

When comparing seeding methods between the tested seed mixes for slopes, the only statistically significant difference was with Class 2 Hydro-mulch performing better than Class 5B Broadcast and IVM Broadcast and Hydro-mulched seed mixes. There was no statistically significant difference in vegetative coverage between broadcast seeding and hydromulching along wet ditches (Appendix K).

Seed Mix Performance

The seed mixtures included in this study were tested to determine the most appropriate seed mix for meeting required vegetation establishment goals of 70% coverage within 12 months and reducing overall maintenance costs while promoting a native landscape beneficial to pollinators. Each site utilized the Class 2 turfgrass seed mix as the control; due to this, data regarding this seed mix has been averaged during the analysis so it is not weighted more heavily than the other seed mixes.

A large proportion of the species identified throughout the study were volunteers: native, naturalized, and invasive (Figure 11). Native volunteers included species such as purpletop tridens (*Tridens flavus*), common spikerush (*Eleocharis palustris*), and neckweed (*Veronica peregina*). Common introduced species included naturalized species such as coltsfoot (*Tussilaga farfara*) and grassy tarweed (*Madia gracilis*), and invasive species such as birdfoot trefoil (*Lotus corniculatus*). This indicates a positive correlation between the seed bank and plant species present on site prior to seeding, and the vegetation that will be present after restoration activities have been completed on site.

Each seed mix had specific species that thrived or underperformed. Species that were not found during surveyed were: panicledleaf ticktrefoil (*Desmodium paniculatum*) from the Seasonally Flooded mix, partridge pea (*Cassia fasciculata*) from the Class 5B mix, swamp milkweed (*Asclepias incarnata*) from the IVM mix, common milkweed (*Asclepias syriaca*) from the IVM mix, and wild lupine (*Lupinus perennis*) from the IVM mix. The native planted species with the highest average cover was prairie dock (*Silphium terebinthinaceum*) in the Class 5B mix seeded on the Slope test types. Refer to Table 5 for the top native planted species with the highest average covers.

Table 5. Highest Average Cover of Native Species Planted with Corresponding Seed Mix

Planted Species	Average Cover	Test Type	Seed Mix
Prairie dock (*Silphium terebinthinaceum*)	19.70%	Slope	Class 5B
Stiff goldenrod (*Solidago rigida*)	9.97	Slope	Class 5B
Switchgrass (*Panicum virgatum*)	8.90%	Slope	IVM
Soft rush (*Juncus effusus*)	8.35%	Wet Ditch	Wet Ditch/Swale
Indian grass (*Sorghastrum nutans*)	8.13%	Fenceline	Class 6

All seed mixes were capable of meeting the required 70% vegetation coverage within 12 months. However, the original 2019 seeding at Fenceline 2 (Cuyahoga), Slope 3 (Athens) and Wet Ditch 3 (Summit) sites failed on a full site basis. Of particular interest was that Wet Ditch 3 (Summit) had successful germination in 2020 following the initial seeding, which was subsequently followed by a die-off of nearly 100% of the vegetation on site.

This may have been caused by the high sodium found on site during the 2020 soil sampling efforts, as high levels of salt can be deposited at lower soil layers, killing the roots. High calcium values also contributed to the failure. After reseeding efforts in November of 2020, Fenceline 2 (Cuyahoga), Slope 3 (Athens), and Wet Ditch 3 (Summit) all achieved 70% vegetation coverage. Fenceline 2 (Cuyahoga) met the 70% vegetation coverage goal in the summer of 2021 while Slope 3 (Athens) and Wet Ditch 3 (Summit) met the goal in the summer of 2022 (Appendix L).

Pollinator Performance

It was found throughout the study that when plant species richness or total amount of pollinator friendly plant species increased, that pollinator counts were directly impacted in a positive manner. When the richness of plant species increased, the diversity of pollinators grew and included a larger number of species that specialize in a certain plant species or genus.

Surveys completed during mid-season showed the highest diversity of pollinators. The species on which the highest diversity of pollinators were found were: black-eyed Susan (*Rudbeckia hirta*), oxeye sunflower (*Heliopsis helianthoides*), wild bergamot (*Monarda fistulosa*), red clover (*Trifolium hybridum*), and purple coneflower (*Echinacea purpurea*). This time period also corresponds with the blooming period of the following species that showed the highest pollinator counts: black-eyed Susan (*Rudbeckia hirta*), wild bergamot (*Monarda fistulosa*), oxeye sunflower (*Heliopsis helianthoides*), prairie coneflower (*Ratibida pinnata*), and purple coneflower (*Echinacea purpurea*). See Appendix M for further analysis.

Post-Seeding Maintenance

Sites that are mowed frequently after vegetation establishment will have a reduced forb presence and, in turn, a reduced pollinator presence. This was evidenced in Wet Ditch 1 (Cuyahoga) through the mowing of plots within the clear zone (plots 1—6 in replication 1). The areas that were mowed had a reduced number of flowering forbs, both seeded and volunteer, compared to the unmowed sections. The reduction in flowering species is depicted in Photo 4. Plants that were not mowed were permitted to mature into flowering stages and able to reproduce and spread seed. Being able to complete the reproductive cycle allowed the vegetation to get thicker from one year to the next. It also provided habitat for pollinator species.

Photo 4: The red line indicates where mowing was completed throughout the course of the study. To the left of the red line are Canada goldenrod, New England aster, and salt-march aster. To the right of the line are grasses.

Herbicide applications had varying effects controlling invasive species found on test sites (Appendix N). Even though mowing was not completed on slopes or within wet ditches, the use of targeted herbicide applications to invasive species allowed for the growth of native species. Native species on these sites were still able to reach full maturation, though at a slower pace from competition and reduced light. This indicates that mowing is not the sole maintenance approach for native seedings, and that herbicide application is a viable option.

Costs

Cost comparisons were made between the site preparation, seeding, and maintenance of the turfgrass seed mixes and the native seed mixes as performed in this study. The cost analysis completed is based on the products and equipment used for this study and recommended by DRG. A detailed analysis of cost factors for broadcast seeding, drill seeding, and hydromulching for ODOT implementation can be found in Appendix O. The compared costs are not inclusive of labor, equipment costs, and delivery fees.

A factor that prevents organizations from choosing native plants is that native plant seed mixes typically cost more per pound than turfgrass seed mixes. One reason native seed costs more per pound than turfgrass is that the number of native seeds per pound is substantially higher than the number of seeds per pound of turfgrass. This can be easily seen from the pure live seed rates as provided by a seed vendor. According to Ernst Seed, black-eyed Susan (*Rudbeckia hirta*), a common species used in native seed mixes, has 1,576,000 seeds per pound, whereas tall fescue (*Festuca arundincaea*), a common species used in turfgrass mixes, has 227,000 seeds per pound (https://www.ernstseed.com). Per specification 659, Class 2 turfgrass is seeded at 5 pounds per 1,000 ft.^{2} at a cost of $8.81. Native seed mixes such as the Seasonally Flooded Mix are seeded at 0.459 pounds per 1,000 ft.^{2} at a cost of $16.07. Also, the cost associated with native seed mixes is typically higher than turfgrass mixes due to the limited availability of seed. However, as more organizations adopt native seeding, the increased demand will result in a greater production of native mixes, which will decrease costs in the future (Goldsmith, Flint, and Shaw, 2022). A majority of the cost savings for seeding native species over turfgrass species comes from the costs related to installation and maintenance. The costs associated with soil tests and the soil amendments applied are consistent between the turfgrass and native seed mixes for this study. However, generally turfgrass seedings require more soil nutrients in order to germinate and grow at a site, so overall, the cost of fertilizer should be slightly increased for turfgrass species seedings when compared to native seedings.

Cost factors are not always shared between native and turfgrass seed mixes. Native seed mixes often require the additional seeding of a nurse crop, which aids in plant establishment and is not needed by turfgrass seed mixes. The nurse crop adds $0.62 per 1,000 ft.^{2} for native seed mixes. Inversely, turfgrass mixes require additional watering and greater applications of fertilizer and straw (mulch). The main cost difference for turfgrass is the price of water which must be applied at seeding and once afterwards for germination at a cost of $149.60 per 1,000 ft.^{2}. Also, straw bales are applied at a rate nearly four times higher for turfgrass than for native seed mixes. The total cost differences with both water and straw comes to $169.19 per 1,000 ft.^{2} more for turfgrass seeding. Long-term maintenance costs between native plant and turfgrass seeded areas also differ and are due to the differing frequency of mowing. A typical turfgrass site could be mowed up to 10 times in a year but is usually mowed by ODOT or a contractor four times, for an average cost of $0.81 per 1,000 ft.^{2} per year. Native plant areas require less frequent mowing (once every 1-3 years at established sites) with an average cost of $0.07 to $0.20 per 1000 ft.^{2} per year. To extrapolate, the difference of mowing a native or turfgrass 1,000 ft.^{2} area over 15 years would be between $9.15 and $11.11 per 1,000 ft.^{2}

The total 1-year implementation costs of native or turfgrass Class 2 seed mix are similar. Establishment of turfgrass seed mixes including the soil amendments applied for this study using hydromulching method results in a total cost of $300.95 per 1,000 ft.^{2}. The total cost of year one native seed establishment is $152.46 per 1,000 ft.^{2} for hydroseeding, resulting in a reduced cost for seeding with native plants based on year one establishment. Additionally, long-term maintenance differences can significantly add to cost savings. Ultimately, the establishment and maintenance costs of native plants are lesser than turfgrass species. Native seedings are typically more cost effective, especially long term, than turfgrass seedings. There is a reduced need for fertilization, watering, and mulching for natives. Once established, native seedings require significantly less maintenance compared to turfgrass seedings. The cost per pound of natives is greater, but you use significantly less seed per acre than turf. Usually, the establishment of natives is less expensive, or the price is similar to turfgrass seedings.

In addition to economic benefits, native plants provide ecological benefits through services that are often not valued or are undervalued. Some such benefits are greater soil stabilization, stormwater management, and pollinator habitat that are not included in economic assessments (Davey, 2016; Vanbergen, 2013).

Investing in native seeding methods and mixes not only fulfills the Monarch CCAA and other pollinator initiatives, but also reduces maintenance costs for ODOT staff. As an added benefit to increasing pollinator richness, native vegetation has the ability to improve erosion control through extensive roots when compared to turfgrass species (Davey, 2016). Native plants also have the ability to be more successful than turfgrass species as they are drought tolerant, require less mowing, and according to some research, may have the ability to suppress invasive and woody species (Tilman, 1994). Overall, this study showed that ODOT planting native species can lead to cost reductions, less maintenance, and increased beneficial habitat for pollinators.

Recommendations for Implementation

Overview

The following recommendations are based on site preparation, seeding methodology, seed mixtures, and maintenance requirements of each habitat type. These recommendations are intended to aid in implementation and overcome obstacles to implementation.

Based on the research performed for this study, DRG recommends amending the seed mixes used in Specification 659 for successful installation along the ROW. In addition to updating the seed mixes included in Specification 659, DRG recommends a variety of other updates to the specification. The timeframe for seeding natives is different than turfgrass thus, the language should be updated to account for the appropriate window for seeding natives. The specification should provide information to decrease the soil pH. Since low levels of topsoil were observed at newly seeded construction sites (Appendix P), compost or topsoil placement should be increased by 2 inches to allow for loss from wind and water erosion and allow seeds the chance to germinate. Before applying a seed mix, sites with vegetation would benefit from broadcast herbicide applications to kill invasive and noxious species. These applications will benefit both turfgrass and native mixes by helping them establish with reduced competition. It will also benefit the maintenance performed by roadside operations at the county garages by reducing the amount of maintenance required on site after seeding establishment. Specifically for natives, there are recommendations for mulch, mowing, and fertilizer applications found below in updates to Specification 659.

ODOT staff and contractors are strongly advised to follow all ODOT specifications per recommended updates to Specification 659. This includes soil testing, soil depth and quality, the use of amendments as recommended by soil testing, soil prep (pulverizing, herbicide application), seed mix assignments, and seeding rates. Inspectors will need to verify that all specifications are followed and ensure that the 70% coverage of plants on site are desirable species through identification.

Location Selection

DRG developed a scorecard that will easily allow the identification of high, medium, and low priority sites for native seeding (Appendix Q). Sites receiving a high score have the best likelihood of success and those that receive a low score have the least likelihood of success. If ODOT chooses to transition turfgrass sites to native sites, they should prioritize those that have the best chance of success and are legally able to be grown to the appropriate height. Sites along the clear zone (Roadside site types) are not eligible for native seeding due to the mowing requirements to ensure safety of the traveling public. Ranking criteria for the scorecard were determined based on issues commonly found along roadside revegetation projects. Criteria are as follows:

- Current or historical use of site
- Habitat directly adjacent to site
- Size of potential project (acres)
- Distance to naturalized area (miles)
- Site accessible to mower or herbicide application
- Concern of herbicide drift to non-targeted areas
- Maintenance practices of ODOT and neighbors allow plants to mature.
- Site Soil Properties: salt (<180 mg/kg), no leaching chemicals, 6-8 inches topsoil present, pH 5-8, and 4-20% organic soil content (Spectrum Analytic, Inc. and Specification 659)
- Daily sunlight exposure
- Endangered or vulnerable pollinator species identified within county.
- Time until site reconstruction

Completion of the site selection scorecard and following of the recommendations within will increase the chances of a successful native seeding. The seeding of an area that does not meet these criteria will mean an increased cost to the department for the maintenance of the site. It is recommended that this scorecard be used when considering a location for transition from turfgrass to native seeding or when seeding a site post-construction. If a site is not to be seeded post-construction and has suitable environmental and native plant presence, refer to no-till methods of native seeding in the Statewide Roadside Pollinator Habitat Program Restoration Guidelines and Best Management Practices document (Davey, 2016).

Soil Analysis and Site Preparation

Prior to bidding and construction, all topsoil should be tested to make preliminary determinations for the need for amendments and allow ODOT to have this information factored into the bids. Due to the overall soil analysis results during the field tests, DRG strongly recommends soil testing of all sites and application of soil amendments when seeding both native and turfgrass species. Testing needs to be completed with both on-site topsoil and imported soil to meet ODOT specifications and topsoil depth requirements.

Before soil testing is completed, it is critical to inform the lab as to whether the soil is to be tested in preparation for turfgrass or native seed mixes. Turfgrass and native species require different specifications and nutrient thresholds, resulting in the need for different recommendations from the soil lab. Due to time and funding constraints, contractors or ODOT may push back on soil testing and the use of amendments. As evidenced by the research for this project, both turfgrass and native seed mixes failed to establish without the use of amendments. The suggested changes to Specification 659 detail the requirements for the levels of the various nutrients, pH, organic content, and depth of the topsoil. Inspectors should verify these requirements are met.

Currently, ODOT and contractors fall back on the application of lime if soil testing is not completed per Specification 659.02.B. This is an issue not only for native plants but also turfgrasses. Adding lime to a site with high pH will increase the pH to the point that the soil will not be compatible with vegetation growth. Therefore, DRG advises against the application of lime to sites without testing the soil's pH first. This is a process change that contractors will need to adjust to, but it will allow for better germination and establishment of turfgrass and native seed mixes alike.

Fertilizer and any amendments should be applied per the product's label. The determination of appropriate fertilizers should be finalized only after soil testing has been completed. ODOT and contractors will not be able to fall back on a generic fertilizer recommendation, as each site has varying nutrient needs. The use of fertilizers and amendments may increase costs if the current specifications are not currently being followed for seeding but will benefit both turfgrass and native seed mixes alike.

Through interviews with Maryland State Highway Administration, DRG learned of their success with native seedings and the low occurrence of invasive species in the ROW (Knipe, 2022; Swift, 2022). This was attributed in large part to the DOT's use of furnished topsoil on most construction sites. ODOT should use furnished topsoil for post-construction seeding. Furnished topsoil is topsoil brought into a site rather than taken from the site itself. This topsoil is free of grass, brush, and roots. The topsoil consists of loose, friable, loamy material without a mixture of subsoil or refuse. The use of furnished topsoil will reduce the need for soil amendments, reduce invasive species presence, and improve the growth of desirable species. DRG recommends the inclusion of a qualified vendors list to assist contractors on where to obtain furnished topsoil. Testing of all qualified vendors' furnished topsoil should be completed once per year with additional periodic testing as needed to ensure all ODOT requirements are being met. This process is currently in the Maryland Department of Transportation (MDOT) Qualified Landscaping Soils Procedures List and has a high success rate.

Adequate nutrient levels can be obtained with proper amounts of topsoil and compost placed post-construction, taking soil samples of existing and imported soil regardless of whether the location is to be seeded with native species or turfgrass, and as determined by the soil analysis, through use of appropriate amendments utilized during the seeding process.

Seeding Methodology and Seed Mixes

Seeding Methodology

Seed mixes need to be determined by the landscape architect, or other designer, to ensure the seed mix will be capable of meeting all requirements and goals of the site. Contractors and ODOT staff will need to verify that the methods used for seeding are compatible with native species seedings.

These methods are:

- Drill seeding:
  - Roadsides, Slopes and Wet Ditches are not able to be seeded using drill seeding due to safety or equipment issues that would arise during the process.
  - Native seeds require the use of a native drill which permits proper seeding depth and has measures in place to prevent clogging of the system.
- Broadcast seeding:
  - All habitats tested (Fenceline, Roadside, Slope, and Wet Ditch) are capable of being seeded through this method.
  - For native seedings, straw should be applied at a lower rate than is typical for turfgrass as native species require light to reach the seed in order to allow germination.
    - DRG recommends a total of 1 ton per acre as opposed to the 3 tons per acre currently in practice.
- Hydroseeding or hydromulching:
  - All habitats tested (Fenceline, Roadside, Slope, and Wet Ditch) are capable of being seeded through this method.
  - Avoid using wood fiber mulch during native seed installations.
  - For native seeding, agitate solution twice as long as is typical for turfgrass mixes to allow for proper mixing.

Seed Mixes

The results of this study have determined the most successful seed mixes by seeding methods for each test type. General information is described below as well as recommended seed mix edits.

Table 6. Recommended Seed Mixes by Application Method and Test Type

Test Type	Seed Mix Treatments by Seeding Method		
	Drill Seeder	**Hand Broadcast**	**Hydro-mulch**
Fenceline	• All Ohio CRP • Class 6	• Class 2*	• All Ohio CRP# • Class 6 • Class 2
Roadside	N/A	• Class 2	• Class 2
Slope	N/A	• Class 5B • IVM • Class 2*	• Class 5B# • IVM • Class 2*
Wet Ditch	N/A	• Seasonally Flooded • Wet Ditch/Swale# • Class 2*	• Seasonally Flooded • Wet Ditch/Swale • Class 2

* If site is not suitable for native seeding

\# Most recommended

To transition from the nearly exclusive use of turfgrass for groundcover, it is recommended that ODOT indicate in the construction plans the seed mixes to be used post-construction. Seed mixes should be selected based on the ROW zone, hydrology, and any other limiting factors on site. By designating the seed mix to be used in each section of the ROW in the post-construction design plans, the seed mix selection will not be at the sole discretion of the contractors who usually choose Class 2, a turfgrass mix. When designing the plans, the landscape architect, or ODOT representative, should designate particular seed mixes for different parts of the ROW. For example, plans should indicate a turfgrass mix for the clear zones, and a native mix appropriate for the wet ditches, backslopes, and fencelines or infields of the project area. Designating specific mixes for particular parts of the ROW will alleviate concerns about sight distance by the traveling public as well as ensure the mixes are suitable to the various habitat requirements (slope, wetness). Native seed mixes should not be seeded along the clear zone due to frequent mowing of these areas, which hinders their growth.

A nurse crop should be part of the installation of any native seed mix. The nurse crop will provide quick temporary vegetative coverage while the native species take time to show growth above ground. A nurse crop such as annual rye (*Lolium multiflorum*) or oats (*Avena setiva*) will help achieve 70% coverage within a year and will not reseed and create competition for the native seed mixes. DRG recommends revising the amount of nurse crop required for native seedings. Currently, the amount of nurse crop required in Specification 659 ranges from too low to exceptionally high for various seed mixes. Currently, the Class 6 seed mix calls for 4.79 pounds per acre of cover crop during a spring planting, which will not provide adequate vegetative coverage while awaiting germination of the native species. The 40.1 pounds of cover crop currently called for when seeding Class 5B during the fall will shade out native species and reduce germination of the permanent species. DRG recommends a total of 20 pounds per acre of nurse crop for any native seed mixes.

ODOT should specify which seed formulations are acceptable for each individual DOT project. DRG recommends the use of the appropriate seed mixes in areas where there is topsoil present, seeded using the methods listed above. In areas where there is exposed rock with no topsoil, it is recommended to not use any seed mixes at all, as topsoil and seeds will erode quickly.

Through the research completed for this project, it was determined that the use of crown vetch on 3:1 slopes is not necessary or recommended due to the invasive nature of the species (Invasive Plant Atlas, 2018). Additionally, the crown of the plant flops over and prevents visibility to the erosion that is taking place around the roots. As a replacement on slopes 3:1 or greater, in areas where there is topsoil present, DRG recommends the use of Class 5B or IVM seed mixes.

ODOT currently uses inoculants within their hydroseeding slurries that contain crown vetch. With the removal of crown vetch, the use of inoculants is not needed. Ohio native legumes do not require the use of inoculants for successful establishment, thus reducing overall cost (Fritz, 2022; Riddell, 2022).

During the evaluation of the seed mixes tested, it was found some species did not germinate throughout the duration of the project and should be replaced. In the Seasonally Flooded seed mix, DRG recommends replacing panicledleaf ticktrefoil (*Desmodium paniculatum*) with showy ticktrefoil (*Desmodium canadense*) to maintain the number of leguminous seeds. While partridge pea (*Cassia fasciculata*) did not germinate in areas seeded with the Class 5B seed mix, it did successfully germinate in the IVM seed mix that was utilized in the same habitat type, due to this, DRG does not recommend replacing this species. There are multiple recommended replacements within the IVM seed mix. DRG recommends swamp milkweed (*Asclepias incarnata*) be replaced with additional seed for butterfly milkweed (*Asclepias tuberosa*), as this species germinated and provides the same benefits to pollinators.

Common milkweed (*Asclepias syriaca*) should be replaced with whorled milkweed (*Asclepias verticillata);* this species prefers dry, rocky habitats and is native to Ohio. Wild lupine (*Lupinus perennis*) should be replaced with white wild indigo (*Baptisia alba*); this will maintain the total amount of leguminous seeds in the IVM seed mix (Appendix R).

Timing of Planting

In order for native plant seeds to germinate, seeds require specific moisture and temperature requirements to be met. Native plant species do not germinate well when seeded during the summer, as seeds are prone to drying out during this time of year. Native seeds also require periods for cold stratification for successful germination. Seeding native plant species too early will cause them to sprout and then die off after frost, never to reach full maturation to spread their seed for the next year. Therefore, DRG recommends seeding native species in the late fall or early spring for proper temperature and water requirements to be met for successful germination. Cold season turfgrasses do not require cold stratification and need a higher temperature than native plant species for germination. It is therefore recommended to plant these in spring through early fall.

Post-Seeding Maintenance

Native grasses and forbs should be mowed less frequently than turfgrasses in order to promote pollinators and seed head formation. Native plants should be mowed in the early spring to provide overwintering habitat for pollinators, rather than ODOT's typical fall schedule. Plant growth regulator should not be applied to native seedings, as this will stunt the growth of the plants. Broadleaf selective herbicide cannot be utilized in a native seeding that includes flowers, as these chemicals will kill the flowering species. The county maintenance staff will need to be educated on the BMPs for promoting native plant species. Maintenance staff will also need to be updated on where the native flowers and grasses are planted. This information should be tracked in a database, ideally with geospatial data.

DRG has developed a manual and a guide to assist in post-seeding maintenance and plant identification. These are available in printed and electronic format. Creating an application for use on smartphones, field computers, and other electronic devices is recommended to facilitate distribution and encourage greater use of these reference resources.

The guide is an update of the Guide for Roadside Integrated Vegetation Management of Prohibited Noxious Weeds in Ohio. This is a practical field guide for identifying and controlling all of Ohio's prohibited noxious weeds, and select invasive species, including species previously listed as prohibited noxious weeds. There are numerous other invasive and non-native plants that are problematic on the state's ROW, and these should be added to the Guide with the same content and be in the same graphic layout as the current Guide. The manual is the Post-Construction Native Groundcover Seedling Identification Manual. This Manual is designed with dichotomous keys, detailing where certain species can be located, a species index, and alphabetically by species type (grass, flower, etc.). This Manual includes a number of species that are included in seed mixes compatible with roadside conditions. Images are included of various life stages to enable identification throughout the life of the plant. This Manual allows users to identify seeded species that are uncommon, difficult to identify, or commonly found along the ROW. DRG recommends expanding the content of the Manual to include native species that often volunteer along the ROW as opposed to only including seeded species. The information on the additional plants should have the same content and be in the same graphic layout as the current Manual.

Additional resources for species identification can be found in Appendix S.

Obstacles to Implementation

Cultural shifts will be needed to allow for the use of native species along the ROW. Native species will only need to be mowed once every 1—3 years, as opposed to the current mowing routine of once per year. This is to allow native species to reproduce and allow for pollinator habitat. This reduction in maintenance will reduce costs over time allowing ODOT to focus on other projects for the ROW. ODOT staff may push back on this reduced schedule as it is a large proportion of the spring, summer, and fall work. This reduction in maintenance will also have an effect on citizens. Motorists may question why the "weeds" are being allowed to grow to the extent that is visible along the side of the road. The public should be educated as to the changes they will be seeing in the mixes and maintenance of them so they understand why it is being done and can understand it as a positive change to promote habitat. It is recommended that ODOT inform the public through signage, ODOT's website, advertisements, and other forms of communication to counter these thought processes.

Full implementation of the use of native species as opposed to turfgrass species may take years to accomplish. This is due to the increased demand that will be placed on native seed vendors to provide the amount of seed that will be necessary when seeding native species across the state. Another issue that may arise is the cost of native species seed mixtures. Native species tend to be sold at a much higher cost per pound. Part of the reason behind this increased price is that the size of the seeds are smaller, resulting in more seeds per pound. Native species will have a larger lifespan along the side of the road, which will lead to less need for re-seeding.

The timing of seeding may have implications on construction projects where the need to seed temporary cover will increase in volume due to the slower germination of native plants. The use of this temporary cover (nurse crop) will increase pricing but will ultimately prevent erosion and provide vegetative cover.

In addition, the differences in the seeding methodologies and the different seed mixes may impact businesses, local governments, or citizens who are using guidance from ODOT in the seeding of commercial or residential land. ODOT should have documentation describing the reasoning for the change in both the seed mixes and maintenance practices.

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Appendices

Appendix A: Literature Review

Overview

Pollinators have seen declines in population numbers worldwide (Vanbergen, 2013). Responsible for this decline are intensifying land use, introduced plant species, pests, and pathogens (Vanbergen, 2013). One way to help slow the decline of pollinators is to create corridors for these species to utilize, such as ROWs. These ROWs can become important areas of flowering resources and potential habitat for species of concern such as the rusty patched bumblebee and the monarch butterfly. Butterflies (including the monarch butterfly) are pollinators that are highly visible and charismatic species that can gain the public's interest and support. Multiple bee species, including endangered species such as the rusty patched bumblebee, are important pollinators for both wild and crop plants. The reduction of native bees across the globe will lead to food shortages globally. There is a national movement including the *Obama Administration's Presidential Memorandum – Creating a Federal Strategy to Promote the Health of Honeybees and Other Pollinators* and the resulting Pollinator Research Action Plan for DOTs and other ROW managers to enhance pollinator habitat as they are one of the largest landholders in the country. Ohio, with one of the largest interstate systems in the country (ODOT, 2022), is uniquely stationed to work on creating solutions for this issue.

In response to the Obama Administration's Presidential Memorandum and the resulting Pollinator Research Action Plan, ODOT has implemented a variety of proactive strategies that are designed to support an increase to pollinator populations in the state, including converting existing ROW to roadside pollinator habitats. As an advantageous way to meet its goal, ODOT set its sights on using native plants in various habitats throughout the state to help reduce maintenance costs while promoting local pollinators. Since 2013, ODOT has been working towards increasing pollinator habitat along its ROWs through partnerships with the Ohio Department of Natural Resources (ODNR), and Pheasants Forever (PF). These partnerships culminated in the creation of the Ohio Pollinator Habitat Initiative (OPHI) in 2015 (ODOT, N.D.). OPHI is dedicated to creating pollinator habitats in accessible areas to raise awareness of declining pollinator populations. As a part of this initiative to increase native pollinator populations, ODOT joined the Monarch Candidate Conservation Agreement with Assurances (Monarch CCAA).

While the population of pollinator species has sharply declined, national efforts through agreements such as the Monarch CCAA will help increase habitat availability required by these species (Cardno, 2020). The Monarch CCAA strives to achieve its goal by creating habitat corridors for wildlife, particularly for pollinators, to increase population numbers (Vanbergen, 2013; Cardno, 2020). In addition to aiding monarch butterflies, the Monarch CCAA aims to gain public support and encourage further pollinator conservation through the creation of native habitats. This will have an overarching effect on all native pollinator species in the ecosystem, including species currently listed as endangered or threatened.

Pollinators

Pollinator habitat can be established within ROWs. In fact, the use of DOT ROWs provides a significant amount of land that can be converted into pollinator habitat. It has been found that mowing the ROW during the summer reduces pollinator habitat and has a detrimental effect on the pollinator populations (Phillips, Gaston, Bullock, et al., 2019). In addition, pollinator habitat should not be mowed in the fall to ensure overwintering pollinators are not negatively impacted by the removal of vegetation over the course of the winter (Davey, 2016). These mowing restrictions indicate that naturalized land (land designed for wildlife or pollinators) should only be mowed during the spring.

Pollinators require food sources to be available throughout their lifecycle. This means that any seed mix that is designed to help pollinators needs to provide nutrients in spring, summer, and fall. It is recommended that there should be more than three food sources during each season to ensure food availability to a multitude of pollinator species (Dauber, Biesmeijer, Gabriel, et al., 2010; Hopwood, Black, Mäder, et al., 2015; NRCS, 2021). Queen bees will forage for food prior to the development of the hive. This foraging behavior so early in the season requires spring blooming ephemerals. This increases the need for spring blooming species, particularly in early spring (Kudo and Ida, 2013). The diversity of plant species impacts whether generalist or specialist pollinators frequent an area designed to be pollinator habitat.

Pollinators are considered either generalists or specialists. A generalist pollinator is capable of visiting or attracting many different species of plants while a specialist may only be able to visit or attract one plant species or genus (group of plant species) (Motten, 1981). These dynamics require that habitats are represented by diverse communities of plants to support a greater diversity of pollinators. Likewise, the size of a flowering patch and the quality of the floral resources offered can impact pollinators (Dauber, Biesmeijer, Gabriel, et al., 2010).

Seeding Methods

Seeding methodology is different between native and turfgrass species as well as between different types of sites. Post-construction planting methods used depend upon the site condition following construction and include hydromulching/hydroseeding, broadcast seeding, and drill seeding. Native species require a shallower seeding depth (0.25-0.75 inches) than turfgrass species (approximately 1 inch) due to the size of the seeds (Davey, 2016).

Broadcast seeding is typically used in smaller projects, as it can be time consuming to apply. Broadcast seeding may involve replacing the topsoil layer, if there is compacted or clay soil on site, and tilling the top six inches of soil in order to increase seed-soil contact. A cultipacker is then used to lightly press the seed into the soil after it has been placed on the ground (Davey, 2016). This seeding method is effective across various sites, including roadsides, wet ditches, fencelines and slopes.

Drill seeding can be utilized on flat areas and in areas where the soil has not been disturbed. Native seeds require the use of a native drill which has measures in place to prevent clogging of the system and allows for a reduced seeding depth. Some such measures to prevent clogging are multiple seed boxes (2-3). Some of these boxes are designed with agitators to continuously mix the seeds (Davey, 2016). A common drill seeder is a grain or agricultural drill, these drills lack the agitators found in native seed drills. Drills without agitators easily become clogged from native seeds with chaff. Grain drills often seed approximately one inch in depth, which is too deep for many native species, but they work well for large grain seeds.

Drill seeding is not compatible with steep slopes, or wet areas, such as wet ditches, leaving only dry fencelines as applicable locations for this native seeding method. No-till drills are available and allow for seeding to occur without any soil preparation, which can help to reduce erosion. This method is ideal for sites that do not have a lot of invasive pressure as soil preparation is reduced with this method (Davey, 2016). Traditional drills require traditional soil preparation.

Hydroseeding is utilized along slopes and larger bare ground areas; this is one of the more common seeding methods for DOTs. Hydroseeding is effective across various sites, including roadsides, wet ditches, fencelines and slopes. During hydroseeding; seed, water, mulch, fertilizer, tackifier, and any inoculants needed are added into a slurry that is applied to the site at one time.

A similar seeding method to hydroseeding is hydromulching; however, with this method, seed is hand broadcast and then covered by fiber mulch following industry BMPs (Davey, 2016). Hydromulching and hydroseeding can be done interchangeably to achieve the same result. All mulch types currently utilized by ODOT for hydroseeding and hydromulching are acceptable for turfgrass species but need to be adjusted for native species germination with the exception of asphalt emulsion. Application of asphalt emulsion will severely limit the germination of native species. When seeding native species use paper, straw, cotton, bonded fiber matrix (BFM), or flexible growth media mulch. Native species should not be seeded with wood mulch as the fibers destroy the seed casings on native plants, reducing germination. Wood mulch is preferred for turfgrass species due to the reduced cost (Pawelek, Smith, Faulk et al., 2015; OPN, 2022; ODOT, 2019). Tackifier should be applied at no more than 0.5 inch thickness for native species; when seeding turfgrass, this can be one inch thick (Davey, 2016). This is because native species require light to reach the seeds for successful germination.

Inoculants are added into the hydromulching slurry when needed. Species such as crown vetch (*Securigera varia*) have historically been used on ROWs and these species require inoculants. Native legumes do not require inoculants for growth. It has been found that native inoculants enhance growth, but do not improve the rate of survival (Chaudhary, Akland, Johnson, et al., 2019; Maltz and Treseder, 2015). The proper inoculants can be difficult to locate with the use of native plants, as they are not a constant item in construction. In addition, the use of commercial inoculants has been found to provide varying degrees of success, with some commercially available species being detrimental to commonly seeded native species (Duell, Cobb, Wilson, 2022). As such, it is not recommended that inoculants be utilized in native seedings (Riddell, 2022).

Ohio law mandates that permanent soil stabilization shall be applied to disturbed areas within seven days after the final grade is reached on any portion of the site (Legislative Service Commission, 2017; ODOT, 2016). The state of Ohio requires the establishment of 70% permanent herbaceous vegetation coverage within 12 months of completion of the final seeding. If a site does not meet this requirement, the site will be rejected by the inspector and must be re-seeded (ODOT, 2000).

Seed Mixes

Seed mixes utilized by DOTs must be compatible with post-construction establishment methods and maintenance to ensure they will be successful after construction work on the ROW is completed. Currently, ODOT's specifications include mixes with naturalized species, invasive species, and native species for wildlife habitat. Both naturalized and invasive species are commonly referred to as non-native species. The non-native mixes are used more often due to the difference in seed price per pound and the ability of the species to tolerate high salt, high pH, and repeated mowing throughout the year. While these mixes ensure 70% coverage is achieved quickly, they often fail later as the species in these mixes are not regional species and lack key adaptations to Ohio's climate, such as drought and temperature resilience. The roots of these species are much shallower (4-6 inches) than native grasses and forbs which can be up to 96 inches, with most roots being approximately 12 inches deep. This means these non-native mixes provide a much lower soil stabilization benefit than native mixes. This reduced root depth is what leads to the increased maintenance of turfgrass species. Native species will be competitive with naturalized and invasive species, due to them being able to withstand and thrive in localized habitats and conditions that are not compatible with non-native species (Nippert, 2012; Simmons, 2011). Additionally, non-native species are often not compatible with native pollinators and wildlife found within Ohio, limiting their benefits in a habitat.

To account for the slower germination rate of native species, as compared to turfgrass species, seeded nurse crops are utilized. These will provide the necessary vegetation coverage while the native species are germinating (Wilsey, 2014).

Differences between native and non-native plant species are multifaceted and not limited to one aspect. For instance, turfgrass species require watering for germination, they are also removed from their place of origin and offer little or no benefit to wildlife. Native plant species, however, have evolved in the regional climate and have unique adaptations that allow them to thrive within their native range with limited maintenance. Adaptations of native plants that may limit the need for management include drought tolerance, the ability to successfully reproduce, and deep roots that aid in groundwater infiltration (Davey, 2016). These adaptations aid in Stormwater Pollution Prevention Plan (SWPPP) requirements and provide reasoning for the inclusion of native plants for erosion control. In addition, through co-evolution, native pollinators benefit from native plant landscapes with increased floral resources. Through these adaptations, native plant species can lead to reduced costs for seeding and maintenance (Sage and Kubien, 2007; Tillman, 1987 & 2006; Pearcy, Tumosa, Williams, 1981).

Establishment

Turfgrass, commonly used along the ROW, has an establishment period of 6—12 months. Seeded turfgrass species typically have increased early mortality due to the lack of climatic adaptations. This, along with reduced root capacity can leave the ROW susceptible to erosion and noxious weed growth.

Native species establish over a period ranging from 6 months to 3 years, depending on the species. Native seed mixes typically include annual, biennial, and perennial species; the inclusion of annuals and biennials allow for these seed mixes to provide the 70% vegetative coverage required of a revegetation event within the 12-month window required by ODOT and the EPA.

Table 7: Established Timeline for Native Seed Mix

Seed Mix	Turf Grass Mix	Native Seed Mix
0-6 Months	• Permanent species germinating • Volunteer species present	• Cover crop species provide majority of coverage • Permanent species germinating
6-12 species	• Permanent species begin to compete for majority of coverage • Volunteer species present	• Cover crop species dominant • Permanent species germinated • Volunteer species present • Annual flowers growing, blooming and seeding
12-24 months	• Permanent species provide majority of coverage • Seeding established	• Permanent species present • Volunteer species may be dominant • Annual seeded species dominant • Perennial and biennial species present, but not dominant
24-36 months	• Permanent species provide majority of coverage • Seeding established	• Biennial and Annual species dominant • Permanent species dominant • Volunteer species major component
36+ months	• Permanent species provide majority of coverage, seeding established	• Permanent species dominant • Seeding established • Annual and biennial species present in smaller numbers than year 1 and year 2 seeding established. • Volunteer species are present, but numbers are reduced.

This difference in establishment demonstrates a need to rely on temporary cover in native seeded areas to ensure the 70% vegetation cover is achieved within the required time frame. This temporary seeding, alongside the native annual species, reduces the amount of erosion that occurs during the establishment stage and reduces weedy encroachment. Replacement of turfgrass with native species leads to a reduction in weedy species due to regionalization and success of the species over time. More diverse seed mixes further reduce weed encroachment (Simmons, 2011; Tillman, 2006).

Maintenance

Depending on the zone of the roadway, ODOT mows between 1-4 times a year, and up to 10 times in urban clear zones. Turfgrass requires mowing at least once per year to prevent tree and weedy invasion. Many invasive or noxious weeds grow in the turfgrass seedings, increasing maintenance costs due to vegetation control. In addition, areas where seeding previously failed require re-seeding, increasing the cost of maintenance.

Native species should be mowed every 1—3 years in the winter or early spring prior to spring growth, thus decreasing the total mowing required thereby reducing management costs. It is strongly recommended to postpone mowing until the early spring to provide habitat for overwintering pollinators. Supporting the growth of native species will also decrease the amount of herbicide needed. This is due to the dense roots of native species. This reduces the capability of invasives to take root and grow.

Conclusion

While there are differences in the seeding methodology, establishment, and maintenance of native species when compared to turfgrass species; these differences do not place limits on DOTs for utilization. All methods currently employed by ODOT to seed turfgrass are compatible with native species. The establishment timeline for native species follows SWPP requirements as established by the EPA. The maintenance of native plants is reduced when compared to the requirements of turfgrass species but are compatible with the current equipment in use by ODOT.

Appendix B: DOT Surveys

DOT	Specifications? (seed mixes, establishment, maintenance)	Conditional seed mixes?	Percent cover or stabilization	Percent cover timeline	Stabilization responsibility? (for DOT projects > 1-acre disturbance)	Pollinator Program	Up to date?	Pollinator areas inventoried?	Monitored?	Maintained?	Pollinator specific seed mix?	Seed mix pros:	See mix cons:	Seed supplier	Current process pros:	Current process cons:	Recommendations
Ohio	Yes. ODOT Construction and Materials Specifications (Section 659).	Yes. Multiple recommended mixes categorized by habitat type.	70%	Within 6 months (Ohio EPA).	Subcontractor.	Yes, but needs statewide implementation and protocol.	Yes. But policies will be updated with new research.	Some areas inventoried.	Yes.	Yes.	Yes. Certain mixes (4A, 5A, 5B, 6) contain native wildflowers and grasses	Seed mixes tailored for specific areas.	Seed mixes not specifically designed for pollinator habitat.	Varies.	Some pollinator habitat success in District 9.	ODOT looking to apply pollinator mix to all suitable disturbed areas	DRG reviewing protocols to provide recommendations.
Illinois	Yes. IDOT Construction Manual 2018.	Yes.	70%	No.	Subcontractor.	Yes. Focused on monarch butterflies.	Yes. But slow progress.	Some areas inventoried (hard to get funding for mapping).	Some: *Suitability of Roadsides for Habitat Study (FHWA)* - monarch specific study.	Yes, but no guidance. Districts do what they want. DOT policy instituted in May 2018 to cut down on mowing. Trying to switch from broadcast herbicide to spot treatment.	Yes. Monarch and Pollinator Mix.	Mix intentionally targets monarch butterflies and other pollinators.	Monarch mix has too many seeds. More specialized mixes are much costlier. Concerned about lack of local genotypes.	Quail Forever.	Reduced mowing = reduced maintenance costs. Taking policy development slow to do things right.	Biggest challenge is manpower, time, and funding.	Pick native wildflower seed mixes that balance cost and effectiveness. (Mixes can get expensive quick when including certain species.)
Indiana	Yes. INDOT Standard Specifications.	Yes. Seed type chosen by 'zones'. Mostly use R, D, and U seed mixes (these mixes contain standard roadside groundcovers).	70%	No. (Notice of termination provided once 70% is met.)	Subcontractor. (Maintenance department handles post-contract work.)	Yes. But the program has gone stagnant (lack of funding and staffing).	No.	No.	Only mitigation areas are monitored.	Yes. Refer to Maintenance Policy; however, problems with local management and lack of expertise and knowledge. Pollinator areas treated as "hands off" as far as maintenance crews are concerned.	Not actively used. Historically some pollinator mixes were used from the Hoosier Roadside Heritage Program.	Good pollinator mixes with local genotypes from Hoosier Roadside Heritage Program.	Hoosier program and seed plots were maintained by INDOT employees. The program has gone stagnant for lack of interest, advocates, and/or funding.	Cardno and Spence Nurseries.	Plant Growth Layer Specification (spells out soil reqs.) should lead to better establishment.	Leaving planting schedule up to contractor. Lack of staffing and program advocates.	Need permanent staffing structure and program advocates. Soil amendments are potentially more important than seed mix.
Iowa	Yes. Iowa DOT Design Manual.	Yes, but typical (rural, urban, native, salt tolerant, stabilization). Sometimes customize mixes for Final Erosion Control Plans (including pollinator species).	70% (done via a "visual check").	No. Permit requires 70% coverage to discontinue the permit.	Design plans it and contractor installs it. Materials & Construction inspects it to 70% coverage.	Yes. Started in 1990s to revegetate the ROW to natural habitat.	Yes.	Partially: inventory needs updating and digitized to KMZ	Partially: inventoried areas treated as highway assets.	Yes. Maintenance policy included in Design Manual and will also be part of updated State Integrated Roadside Vegetation Management (IRVM).	Yes. Customized mixes are used for specific conditions. Iowa DOT encourages the use of local ecotypes where available.	Customized mixes establish well in targeted areas.	Tried a stabilization mix with natives and got drastically different results dependent on mowing/not mowing.	Varies. Nurseries bid on projects or seed purchases.	Clear guidelines for maintenance. Good establishment with customized seed mixes.	Getting the District to comply with maintenance spraying and reduced mowing in these areas can be difficult. Contract sprayers applying 2-4D to entire ROW and killing established forbs = lower diversity. If topsoil isn't placed, costly to place compost after the fact. Without compost/topsoil, seed doesn't take.	Timing of seeding (and mowing) is crucial. (Don't seed during heat of summer.) Mowing during establishment is for the first 2 growing seasons; when veg reaches 18" in height, vegetation is to be cut to a height of 6" (2-3 mows per growing season).
Michigan	Yes. MDOT Standard Construction Specifications.	Special site-specific recommendations for wildflowers.	90% coverage. Less than 5% weeds.	No. Can sometimes sign off too quickly.	Subcontractor.	No. But Bay and Isabella Counties have piloted sunflower plantings in ROW.	n/a	n/a	n/a	n/a	MDOT has partnered with MSU to develop a native wildflower mix.	n/a	n/a	n/a	n/a	n/a	Need to have inspectors present at seeding to make sure mulch is put down.
Pennsylvania	Yes. Design Manual, Part 2 (Chapters 8 and 13).	Yes. But not generally specified for pollinators. Some projects do include special provisions.	70%	Within 90 days and thru the end of the contract.	Subcontractor.	No. Had wildflower areas previously, but they declined in 1990s.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Ernst (for customized mixes).	n/a	n/a	Use annuals in mixes to hold soil until perennials establish.

Appendix C: Tested Seed Mix Formulas

Class 2 Roadside Mix (ODOT)

217.8 PLS Pounds per Acre			
Scientific Name	**Common Name**	**Percent**	**Bloom Time (Pollinator Friendly Plants Only)**
Poa pratensis	Kentucky Bluegrass	30.00%	N/A
Festuca arundinacea var. KY	Kentucky 31 Fescue	40.00%	N/A
Lolium perenne	Perennial Ryegrass	30.00%	N/A

Class 3B Low Growing Slope Mix (ODOT)

101.5 PLS Pounds per Acre			
Scientific Name	**Common Name**	**Percent**	**Bloom Time (Pollinator Friendly Plants Only)**
Festuca longifolia	Hard Fescue	55.79%	N/A
Festuca rubra	Creeping Red Fescue	34.33%	N/A
Lolium multiflorum	Annual Ryegrass	9.87%	N/A

Class 5B Native Wildflower and Grass Mix (ODOT)

20 PLS Pounds per Acre Native Seed, 30 Pounds per Acre Cover Crop			
Scientific Name	**Common Name**	**Percent**	**Bloom Time (Pollinator Friendly Plants Only)**
Asclepias tuberosa	Butterfly-weed	1.10%	Summer
Aster novae-angliae	New England Aster	1.10%	Fall
Cassia fasciculata	Partridge Pea	1.10%	Summer, Fall
Echinacea purpurea	Purple Coneflower	1.10%	Summer
Eryngium yuccifolium	Rattlesnake Master	1.10%	Summer
Heliopsis helianthoides	Ox-eye Sunflower	1.10%	Summer
Monarda fistulosa	Wild Bergamot	1.10%	Summer
Ratibida pinnata	Greyhead Coneflower	1.10%	Summer
Rudbeckia fulgida	Orange Coneflower	1.10%	Summer
Silphium terebinthinaceum	Prairie Dock	1.10%	Summer, Fall
Silphium trifoliatum	Whorled Rosinweed	1.10%	Summer
Solidago rigida	Stiff Goldenrod	1.10%	Late Summer, Fall
Andropogon gerardii	Big Bluestem	1.10%	N/A
Schizachyrium scoparium	Little Bluestem	1.79%	N/A
Sorghastrum nutans	Indiangrass	2.68%	N/A
Lolium multiflorum	Annual Ryegrass	81.44%	N/A

Class 6 Wildlife Mix (ODOT)

20 PLS Pounds per Acre Native Seed, 30 Pounds per Acre Cover Crop			
Scientific Name	**Common Name**	**Percent**	**Bloom Time (Pollinator Friendly Plants Only)**
Andropogon gerardii	Big Bluestem	3.88%	N/A
Schizachyrium scoparium	Little Bluestem	5.37%	N/A
Sorghastrum nutans	Indiangrass	3.88%	N/A
Heliopsis helianthoides	Ox-eye Sunflower	5.37%	Summer
Silphium terebinthinaceum	Prairie Dock	5.37%	Summer, Fall
Echinacea purpurea	Purple Coneflower	5.37%	Summer
Silphium trifoliatum	Whorled Rosinweed	3.28%	Summer
Helianthus mollis	Downy Sunflower	2.09%	Late Summer, Fall
Aster novae-angliae	New England Aster	2.09%	Fall
Lolium multiflorum	Annual Ryegrass (Spring)	60.00%	N/A

Ohio IVM Mix (PF)

6.964 PLS Pounds per Acre Native Seed, 30 Pounds per Acre Cover Crop			
Scientific Name	**Common Name**	**Percent**	**Bloom Time (Pollinator Friendly Plants Only)**
Andropogon gerardii	Big Bluestem	1.35%	N/A
Sorghastrum nutans	Indiangrass	0.68%	N/A
Schizachyrium scoparium	Little Bluestem	4.06%	N/A
Bouteloua curtipendula	Sideoats Grama	3.38%	N/A
Panicum virgatum	Switchgrass	1.35%	N/A
Trifolium hybridum	Alsike Clover	0.14%	Spring, Summer, Fall
Rudbeckia hirta	Black-eyed Susan	0.28%	Late Spring, Summer
Rudbeckia triloba	Brown-eyed Susan	0.19%	Late Spring, Summer
Asclepias tuberosa	Butterfly Milkweed	0.08%	Late Spring, Summer
Oenothera biennis	Common Evening	0.11%	Summer, Fall
Asclepias syriaca	Common Milkweed	0.08%	Late Spring, Summer
Veronicastrum virginicum	Culvers Root	1.08%	Summer, Early Fall
Silphium perfoliatum	Cup Plant	0.01%	Summer, Early Fall
Heliopsis helianthoides	False or Oxeye Sunflower	0.05%	Summer
Penstemon digitalis	Foxglove Beardstongue	0.54%	Spring, Early Summer
Zizia aurea	Golden Alexander	0.03%	Spring
Ratibida pinnata	Grayhead Coneflower	0.07%	Summer
Verbena stricta	Hoary Vervain	0.07%	Summer
Desmanthus illinoensis	Illinois Bundleflower	1.35%	Spring, Summer, Early Fall
*Lupinus perennis**	Sundial Lupine	0.27%	Spring, Summer
Trifolium repens	White Clover	0.08%	Spring, Summer, Fall
Coreopsis lanceolata	Lanceleaf Coreopsis	1.08%	Spring, Summer
Aster novae-angliae	New England Aster	0.09%	Late Summer, Fall
Cassia fasciculata	Partridge Pea	1.35%	Summer, Fall
Echinacea purpurea	Purple Coneflower	0.54%	Summer
Aster azureus	Smooth Blue Aster	0.04%	Late Summer, Fall
Solidago rigida	Stiff Goldenrod	0.08%	Late Summer, Fall
Asclepias incarnata	Swamp Milkweed	0.08%	Summer, Fall
Pycnanthemum virginianum	Virginia Mountain Mint	0.03%	Summer
Monarda fistulosa	Wild Bergamot	0.14%	Summer
Lolium multiflorum	Annual Ryegrass (Spring)	81.16%	N/A

Ohio All CRP Mix (PF)

5.723 PLS Pounds per Acre Native Seed, 30 Pounds per Acre Cover Crop			
Scientific Name	**Common Name**	**Percent**	**Bloom Time (Pollinator Friendly Plants Only)**
Schizachyrium scoparium	Little Bluestem	4.20%	N/A
Sporobolus cryptandrus	Sand Dropseed	0.14%	N/A
Bouteloua curtipendula	Sideoats Grama	3.50%	N/A
Panicum virgatum	Switchgrass	0.56%	N/A
Rudbeckia hirta	Black-eyed Susan	0.29%	Late Spring, Summer
Rudbeckia triloba	Brown-eyed Susan	0.20%	Late Spring, Summer
Veronicastrum virginicum	Culvers Root	0.00%	Summer, Early Fall
Heliopsis helianthoides	False or Oxeye Sunflower	0.56%	Summer
Ratibida pinnata	Grayhead Coneflower	0.17%	Summer
Desmanthus illinoensis	Illinois Bundleflower	1.40%	Spring, Summer, Early Fall
Coreopsis lanceolata	Lanceleaf Coreopsis	1.12%	Spring, Summer
Aster novae-angliae	New England Aster	0.04%	Late Summer, Fall
Cassia fasciculata	Partridge Pea	1.40%	Summer, Fall
Echinacea purpurea	Purple Coneflower	0.56%	Summer
Solidago rigida	Stiff Goldenrod	0.08%	Late Summer, Fall
Monarda fistulosa	Wild Bergamot	0.14%	Summer
Trifolium hybridum	Alsike Clover	0.14%	Spring, Summer, Fall
Trifolium incarnetum	Crimson Clover	1.12%	Spring, Summer, Fall
Trifolium repens	White Clover	0.14%	Spring, Summer, Fall
Asclepias tuberosa	Butterfly Milkweed	0.08%	Late Spring, Summer
Asclepias syriaca	Common Milkweed	0.08%	Late Spring, Summer
Asclepias incarnata	Swamp Milkweed	0.08%	Summer, Fall
Lolium multiflorum	Annual Ryegrass (Spring)	83.98%	N/A

Freedom II Mix (OPN)

220 PLS Pounds per Acre			
Scientific Name	**Common Name**	**Percent**	**Bloom Time (Pollinator Friendly Plants Only)**
Festuca trachyphylla	hard fescue	25.00%	N/A
Festuca rubra commutata	Chewing's fescue	25.00%	N/A
Lolium multiflorum	annual ryegrass	25.00%	N/A
Festuca ovina	Sheep's fescue	25.00%	N/A

Wet Ditch/Swale Mix (DRG)

30 PLS Pounds per Acre Native Seed, 30 Pounds per Acre Cover Crop			
Scientific Name	**Common Name**	**Percent**	**Bloom Time (Pollinator Friendly Plants Only)**
Elymus riparius	riverbank wildrye	10.0%	N/A
Puccinellia distans	alkaligrass	10.0%	N/A
Agrostis stolonifera	creeping bentgrass	9.0%	N/A
Panicum clandestinum	deertongue	8.5%	N/A
Poa palustris	fowl bluegrass	7.5%	N/A
Carex vulpinoidea	fox sedge	2.5%	N/A
Juncus effusus	soft rush	1.5%	N/A
Carex scoparia	blunt broom sedge	0.5%	N/A
Juncus tenuis	path rush	0.5%	N/A
Lolium multiflorum	Annual Ryegrass (Spring)	50.00%	N/A

Seasonally Flooded Wildlife Mix (DRG)

20 PLS Pounds per Acre Native Seed, 30 Pounds per Acre Cover Crop			
Scientific Name	**Common Name**	**Percent**	**Bloom Time (Pollinator Friendly Plants Only)**
Panicum clandestinum , 'Tioga'	Deertongue, ‘Tioga’	8.8%	N/A
Elymus virginicus , PA Ecotype	Virginia Wildrye, PA Ecotype	8.4%	N/A
Andropogon gerardii , 'Niagara'	Big Bluestem, ‘Niagara’	6.8%	N/A
Echinochloa crusgalli var.	Japanese Millet	6.0%	N/A
Carex vulpinoidea , PA Ecotype	Fox Sedge, PA Ecotype	4.0%	N/A
Panicum virgatum , 'Shawnee'	Switchgrass, ‘Shawnee’	3.2%	N/A
Chamaecrista fasciculata , PA	Partridge Pea, PA Ecotype	1.2%	Summer, Fall
Heliopsis helianthoides , PA Ecotype	Oxeye Sunflower, PA	0.7%	Summer
Desmodium paniculatum , PA	Panicledleaf Ticktrefoil, PA	0.4%	Summer
Eupatorium maculatum , PA Ecotype	Spotted Joe Pye Weed, PA	0.2%	Summer, Early Fall
Juncus tenuis , PA Ecotype	Path Rush, PA Ecotype	0.2%	N/A
Asclepias incarnata , PA Ecotype	Swamp Milkweed, PA	0.1%	Summer, Fall
Lolium multiflorum	Annual Ryegrass (Spring)	60.00%	N/A

Appendix D: Phase I Seed Mix Matrix

Seed Mixes Matrices

CLEAR ZONE/FORESLOPES

		ODOT Current Mixes (659.09)				DRG Seed Mixes
Slope Designation →		3:1 slopes or flatter			Any	Any
Use Designation →		Zones 1-4 (In front of residences/ commercial properties; between curb and sidewalk)	Zones 1-4 (Low-growing/mowed areas)		Zones 1-4	Zones 1-4 (Low-growing/mowed areas/difficult to mow areas)
Category	Attribute	Class 1 Lawn Mixture	Class 2 Roadside Mixture	Class 3B Low Growing Slope Mixture	Class 7 Temporary Erosion Control Mixture	Low Maintenance Freedom Lawn I Mixture
	Use Rating	★★	★★	★★	★½	★★★
Seed Mix Characteristics	Phenology	Cool Season Grasses	Cool Season Grasses	Cool Season Grasses	Cool Season Grass	Cool Season Grasses
	Life Cycle	Annual/Perennial	Perennial	Annual/Perennial	Annual	Annual/Perennial
	Growth Rate	Moderate-Rapid	Moderate-Rapid	Moderate-Rapid	Rapid	Rapid
	Maximum Height (Inches)	18	36	48	30	10
	Root Depth (Inches)	6-30	6-30	10-30	8-30	12
	Soil Type	Loam, Clay	Loam, Clay	Loam, Clay	Sand, Loam, Clay	Loam, Clay
	pH Range	5.5-7.5	5.5-7.5	5.5-7.5	5.0-8.0	5.0 - 8.0
	Germination	Rapid	Rapid	Rapid	Rapid	Rapid
	Bloom Period	May-July	May-July	May-July	April-July	May-July
	Establishment Period	🌱🌱	🌱🌱	🌱🌱	🌱	🌱🌱
	Sunlight Requirement	⛅☀	⛅☀	⛅☀	⛅☀	⛅☀
	Hardiness Zone	5a	5a	5a	5a, 5b, 6a, 6b	5a, 5b, 6a, 6b
	Native Status (* Annual Rye Introduced)	Introduced	Introduced	Introduced	Introduced	Introduced
	Indicator Status	FAC to UPL	FAC to UPL	FAC to UPL	n/a	FACU
Tolerance	Drought Tolerance	🌵🌵🌵	🌵🌵🌵	🌵🌵🌵	🌵🌵	🌵🌵🌵🌵🌵
	Tolerance to Significant Sheet Flow	Tolerant	Tolerant	Tolerant	Moderate Tolerance	Tolerant
	Salt Tolerance	Low-Moderate	Low-Moderate	Low-Moderate	High	Moderate to High
	Tolerance to Disturbance/ Mowing	High	High	High	Moderate	High
	Soil Compaction Tolerance	Moderate-High	Moderate-High	Moderate-High	Moderate-High	Moderate
Environmental Benefits	Attractiveness to Pollinators	Low	Low	Low	Low	Low
	Water Quality Benefits	Low-Moderate	Low-Moderate	Low	Low	Low
	Erosion Control Benefits	🌱🌱	🌱🌱	🌱🌱	🌱	🌱🌱
Cost	Price Per Pound	$2.48	$2.61	$2.94	$0.96	$3.85 (OPN)
	Cost to Seed 1 Acre	**$$$$**	**$$$$**	**$$$**	**$**	**$$$$**
	Mow Cost/Acre/Year	$84.40	$33.76-$84.40 + $423.24-$1,638.80 String Trimming	$40.11	$0.00	$0.00
Seeding Rates	lbs [*of PLS] Per Acre	348.5	304.9	101.5	95.8	*220
	lbs Per 1000 ft^2	8	7	2.33	2.02	5.05
	kg Per 1000 m^2	39.04	34.16	11.37	9.86	24.66

BACKSLOPES

Slope Designation →		ODOT Current Mixes (659.09)						Pheasants/Quail Forever Mixes	DRG Seed Mixes
		3:1 slopes or flatter				2:1 slopes or flatter	Any	2:1 slopes or flatter	Any
Use Designation →		Zones 1-4 (In front of residences/ commercial properties; between curb and sidewalk)	Zones 1-4 (Low-growing/mowed areas)		Zones 2-4 (Shale or rocky slopes)	Zones 3-4 (min-mow areas; non-critical visibility areas)	Zones 1-4	Zones 3-4 (min-mow areas; non-critical visibility areas)	Zones 1-4 (Low-growing/mowed areas/difficult to mow areas)
Category	Attribute	Class 1 Lawn Mixture	Class 2 Roadside Mixture	Class 3B Low Growing Slope Mixture	Class 3C Crown Vetch Mixture	Class 4B Low Growing Native Grass Mixture	Class 7 Temporary Erosion Control Mixture	Ohio Critical Area Mixture	Low Maintenance Freedom Lawn I Mixture
	Use Rating	★★	★★	★★	★★	★★	★½	★★½	★★
Seed Mix Characteristics	**Phenology**	Cool Season Grasses	Cool Season Grasses	Cool Season Grasses	Cool Season Grasses/Legume	Warm-Season/Cool-Season Grasses	Cool Season Grass	Forbs, Warm-Season/Cool-Season Grasses	Cool Season Grasses
	Life Cycle	Annual/ Perennial	Perennial	Annual/Perennial	Annual/Perennial	Annual/Perennial	Annual	Annual/Perennial	Annual/ Perennial
	Growth Rate	Moderate-Rapid	Moderate-Rapid	Moderate-Rapid	Moderate-Rapid	Moderate	Rapid	Rapid	Rapid
	Maximum Height (Inches)	18	36	48	48	48	30	36	10
	Root Depth (Inches)	6-30	6-30	10-30	12-30	12-156	8-30	6-30	12
	Soil Type	Loam, Clay	Loam, Clay	Loam, Clay	Sand, Loam, Clay	Sand, Loam, Clay	Sand, Loam, Clay	Sand, Loam, Clay	Loam, Clay
	pH Range	5.5-7.5	5.5-7.5	5.5-7.5	5.0-7.0	5.0-7.5	5.0-8.0	5.0-7.5	5.0 - 8.0
	Germination	Rapid	Rapid	Rapid	Rapid	Moderate	Rapid	Moderate-Rapid	Rapid
	Bloom Period	May-July	May-July	May-July	May-September	April-September	April-July	May-September	May-July
	Establishment Period	🍃🍃	🍃🍃	🍃🍃	🍃🍃	🍃🍃🍃🍃	🍃	🍃🍃🍃	🍃🍃
	Sunlight Requirement	⛅☀	⛅☀	⛅☀	⛅☀	⛅☀	⛅☀	⛅☀	⛅☀
	Hardiness Zone	5a	5a	5a	5a	5a	5a, 5b, 6a, 6b	5a	5a, 5b, 6a, 6b
	Native Status (* Annual Rye Introduced)	Introduced	Introduced	Introduced	Introduced	Native*	Introduced	Native/Introduced	Introduced
	Indicator Status	FAC to UPL	FAC to UPL	FAC to UPL	FAC to UPL	FAC to UPL	n/a	FAC to UPL	FACU
Tolerance	**Drought Tolerance**	🌵🌵🌵	🌵🌵🌵	🌵🌵🌵	🌵🌵🌵	🌵🌵🌵🌵	🌵🌵	🌵🌵🌵	🌵🌵🌵🌵🌵
	Tolerance to Significant Sheet Flow	Tolerant	Tolerant	Tolerant	Tolerant	Tolerant	Moderate Tolerance	Tolerant	Tolerant
	Salt Tolerance	Low-Moderate	Low-Moderate	Low-Moderate	Low-Moderate	Low-Moderate	High	Low-Moderate	Moderate to High
	Tolerance to Disturbance/ Mowing	High	High	High	High	Moderate	Moderate	Moderate	High
	Soil Compaction Tolerance	Moderate-High	Moderate-High	Moderate-High	Moderate-High	Moderate	Moderate-High	Moderate	Moderate
Environmental Benefits	**Attractiveness to Pollinators**	Low	Low	Low	Moderate	Moderate	Low	Moderate	Low
	Water Quality Benefits	Low-Moderate	Low-Moderate	Low	Moderate	Moderate to High	Low	Moderate to High	Low
	Erosion Control Benefits	🌱🌱	🌱🌱	🌱🌱	🌱🌱	🌱🌱🌱	🌱	🌱🌱🌱	🌱🌱
Cost	**Price Per Pound**	$2.48	$2.61	$2.94	$20.94	$12.35	$0.96	$4.32 (Quail) $5.15 (OPN)	$3.85 (OPN)
	Cost to Seed 1 Acre	**$$$$**	**$$$$**	**$$$**	**$$$$$**	**$$$**	**$**	**$$$**	**$$$$**
	Mow Cost/Acre/Year	$84.40	$33.76-$84.40 + $423.24-$1,638.80 String Trimming	$40.11	$0.00	$33.76	$0.00	$8.44	$8.44
Seeding Rates	**lbs [*of PLS] Per Acre**	348.5	304.9	101.5	130.7	*16.12 (spring); *26.14 (fall)	95.8	*57.85	*220
	lbs Per 1000 ft²	8	7	2.33	3	0.37 (spring); 0.6 (fall)	2.02	1.328	5.05
	kg Per 1000 m²	39.04	34.16	11.37	14.64	1.8 (spring); 2.92 (fall)	9.86	6.483	24.66

INFIELDS - MEADOWS (WET/DRY)

Slope Designation →	ODOT Current Mixes (659.09)											Pheasants/Quail Forever Mixes					DRG Seed Mixes			
	3:1 slopes or flatter					2:1 slopes or flatter					Any	2:1 slopes or flatter					Any			3:1 slopes or flatter
Use Designation →	Zones 1-4 (In front of residences/ commercial properties; between curb and sidewalk)	Zones 1-4 (Low-growing/mowed areas)			Zones 2-4 (Shale or rocky slopes)	Zones 3-4 (min-mow areas; non-critical visibility areas)					Zones 1-4 (temporary or cover crop seeding)	Zones 3-4 (min-mow areas; non-critical visibility areas)					Zones 1-4 (Low-growing/mowed areas/difficult to mow areas)	Zones 1-4 (mowed wet ditches and swales)	Zones 3-4 (min-mow areas; non-critical visibility areas)	
Category / Attribute	Class 1 Lawn Mixture	Class 2 Roadside Mixture	Class 3A Slope Mixtures	Class 3B Low Growing Slope Mixture	Class 3C Crown Vetch Mixture	Class 4A Native Grass Mixture	Class 4B Low Growing Native Grass Mixture	Class 5A Annual and Perennial Wildflower Mixture	Class 5B Native Wildflower and Grass Mixture	Class 6 Wildlife Mixture	Class 7 Temporary Erosion Control Mixture	Ohio Pipeline Mixture	Ohio IVM Mixture	Ohio Critical Area Mixture	Ohio All CRP Mixture	Ohio All CRP Wet Grass Mixture	Low Maintenance Freedom Lawn I Mixture	Wet Ditch/Swale Mixture	Wet Meadow Mixture	Seasonally Flooded Wildlife Mixture
Use Rating	★★	★★	n/a	★★	★★	★★★	★★★	★★★	★★★★	★★★★	★½	★★★	★★★★	★★½	★★★	★★★½	★★	★★★	★★★	★★★½
Seed Mix Characteristics: Phenology	Cool Season Grasses	Cool Season Grasses	n/a	Cool Season Grasses	Cool Season Grasses/ Legume	Warm-Season/Cool-Season Grasses	Warm-Season/Cool-Season Grasses	Forbs	Forbs, Warm-Season/Cool-Season Grasses	Forbs, Warm-Season/Cool-Season Grasses	Cool Season Grass	Forbs, Warm-Season/Cool-Season Grasses	Forbs, Warm-Season Grasses	Forbs, Warm-Season/Cool-Season Grasses	Forbs, Warm-Season Grasses	Forbs, Warm-Season/Cool-Season Grasses	Cool Season Grasses	Warm-Season/Cool-Season Grasses	Forbs, Warm-Season/Cool-Season Grasses	Forbs, Warm-Season/Cool-Season Grasses
Life Cycle	Annual/ Perennial	Perennial	n/a	Annual/ Perennial	Annual/ Perennial	Annual/ Perennial	Annual/ Perennial	Annual/ Perennial	Annual/ Perennial	Annual/ Perennial	Annual	Annual/ Perennial	Annual/ Perennial	Annual/ Perennial	Annual/ Perennial	Annual/ Perennial	Annual/ Perennial	Perennial	Perennial	Annual/ Perennial
Growth Rate	Moderate-Rapid	Moderate-Rapid	n/a	Moderate-Rapid	Moderate-Rapid	Moderate	Moderate	Moderate	Moderate	Moderate	Rapid	Moderate	Moderate	Rapid	Moderate	Moderate	Rapid	Moderate	Moderate to Rapid	Moderate
Maximum Height (Inches)	18	36	n/a	48	48	120	48	78	120	120	30	120	120	36	96	120	10	60	84	84
Root Depth (Inches)	6-30	6-30	n/a	10-30	12-30	12-108	12-156	6-96	6-168	24-168	8-30	6-156	6-168	6-30	6-156	6-156	12	12	10	10
Soil Type	Loam, Clay	Loam, Clay	n/a	Loam, Clay	Sand, Loam, Clay	Sand, Loam, Clay	Sand, Loam, Clay	Sand, Loam, Clay	Sand, Loam, Clay	Sand, Loam, Clay	Sand, Loam, Clay	Sand, Loam, Clay	Sand, Loam, Clay	Sand, Loam, Clay	Sand, Loam, Clay	Sand, Loam, Clay	Loam, Clay	Sand, Loam, Clay	Sand, Loam, Clay	Sand, Loam, Clay
pH Range	5.5-7.5	5.5-7.5	n/a	5.5-7.5	5.0-7.0	5.0-8.0	5.0-7.5	5.0-7.5	5.0-7.5	5.0-7.5	5.0-8.0	5.0-7.5	5.0-7.5	5.0-7.5	5.0-7.5	5.0-7.5	5.0 - 8.0	5.0-7.5	4.5-8.0	4.5-7.5
Germination	Rapid	Rapid	n/a	Rapid	Rapid	Moderate	Moderate	Moderate	Moderate	Moderate	Rapid	Moderate	Moderate	Moderate-Rapid	Moderate	Moderate	Rapid	Rapid	Moderate to Rapid	Moderate
Bloom Period	May-July	May-July	n/a	May-July	May-September	July-September	April-September	April-September	April-September	April-September	April-July	April-September	April-September	May-September	April-September	April-September	May-July	May-September	May-October	May-October
Establishment Period	🌱🌱	🌱🌱	n/a	🌱🌱	🌱🌱	🌱🌱🌱🌱	🌱🌱🌱🌱	🌱🌱🌱🌱	🌱🌱🌱🌱	🌱🌱🌱🌱	🌱	🌱🌱🌱🌱	🌱🌱🌱🌱	🌱🌱🌱	🌱🌱🌱🌱	🌱🌱🌱🌱	🌱🌱	🌱🌱	🌱🌱🌱	🌱🌱🌱
Sunlight Requirement	⛅☀	⛅☀	n/a	⛅☀	⛅☀	⛅☀	⛅☀	⛅☀	⛅☀	⛅☀	⛅☀	⛅☀	⛅☀	⛅☀	⛅☀	⛅☀	⛅☀	⛅☀	⛅☀	⛅☀
Hardiness Zone	5a	5a	n/a	5a	5a	5a, 5b, 6a, 6b	5a	5a, 5b, 6a, 6b	5a, 5b, 6a, 6b	5a, 5b, 6a, 6b	5a, 5b, 6a, 6b	5a	5a	5a	5a	5a	5a, 5b, 6a, 6b	5a, 5b, 6a, 6b	5a, 5b, 6a, 6b	5a, 5b, 6a, 6b
Native Status (* Annual Rye Introduced)	Introduced	Introduced	n/a	Introduced	Introduced	Native*	Native*	Native/ Introduced	Native*	Native*	Introduced	Native/ Introduced	Native/ Introduced	Native/ Introduced	Native/ Introduced	Native/ Introduced	Introduced	Native/ Introduced	Native	Native*
Indicator Status	FAC to UPL	FAC to UPL	n/a	FAC to UPL	FAC to UPL	FAC to UPL	FAC to UPL	FAC to UPL	FAC to UPL	FAC to UPL	n/a	FAC to UPL	FAC to UPL	FAC to UPL	FAC to UPL	FACW to UPL	FACU	FACW to OBL	FACW to OBL	FACW to OBL
Tolerance: Drought Tolerance	🌵🌵🌵½	🌵🌵🌵½	n/a	🌵🌵🌵½	🌵🌵🌵	🌵🌵🌵🌵½	🌵🌵🌵🌵½	🌵🌵🌵🌵½	🌵🌵🌵🌵½	🌵🌵🌵🌵½	🌵🌵	🌵🌵🌵🌵½	🌵🌵🌵🌵½	🌵🌵🌵	🌵🌵🌵🌵½	🌵🌵🌵🌵½	🌵🌵🌵🌵	🌵🌵	🌵🌵	🌵🌵
Tolerance to Significant Sheet Flow	Tolerant	Tolerant	n/a	Tolerant	Tolerant	Tolerant	Tolerant	Tolerant	Tolerant	Tolerant	Moderate Tolerance	Tolerant	Tolerant	Tolerant	Tolerant	Tolerant	Tolerant	Tolerant	Tolerant	Tolerant
Salt Tolerance	Low-Moderate	Low-Moderate	n/a	Low-Moderate	Low-Moderate	Moderate	Low-Moderate	Low-Moderate	Low-Moderate	Low-Moderate	High	Low-Moderate	Low-Moderate	Low-Moderate	Low-Moderate	Low-Moderate	Moderate to High	High	Moderate	Moderate
Tolerance to Disturbance/ Mowing	High	High	n/a	High	High	Moderate	Moderate	Low-Moderate	Low-Moderate	Low-Moderate	Moderate	Low-Moderate	Low-Moderate	Moderate	Low-Moderate	Low-Moderate	High	Moderate	Low	Low
Soil Compaction Tolerance	Moderate-High	Moderate-High	n/a	Moderate-High	Moderate-High	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate-High	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Environmental Benefits: Attractiveness to Pollinators	Low	Low	n/a	Low	Moderate	Moderate	Moderate	High	High	High	Low	High	High	Moderate	High	High	Low	Low	Very High	Moderate to High
Water Quality Benefits	Low-Moderate	Low-Moderate	n/a	Low	Moderate	Moderate to High	Moderate to High	Moderate to High	Moderate to High	Moderate to High	Low	Moderate to High	Moderate to High	Moderate to High	Moderate to High	Moderate to High	Low	Moderate to High	High	Moderate to High
Erosion Control Benefits	🌻🌻½	🌻🌻½	n/a	🌻🌻½	🌻🌻	🌻🌻🌻½	🌻🌻🌻½	🌻🌻½	🌻🌻½	🌻🌻½	🌻	🌻🌻½	🌻🌻½	🌻🌻½	🌻🌻½	🌻🌻½	🌻🌻	🌻🌻½	🌻🌻🌻	🌻🌻½
Cost: Price Per Pound	$2.48	$2.61	n/a	$2.94	$20.94	$8.93	$12.35	$30.75	$52.69	$99.07	$0.96	$38.46 (Quail) $46.10 (OPN)	$35.62 (Quail) $41.65 (OPN)	$4.32 (Quail) $5.15 (OPN)	$34.09 (Quail) $36.75 (OPN)	$28.49 (Quail) $30.95 (OPN)	$3.85 (OPN)	$12.31 (Ernst) $29.00 (OPN)	$58.76 (Ernst)	$12.62 (Ernst) $27.00 (OPN)
Cost to Seed 1 Acre	$$$$	$$$$	n/a	$$$	$$$$$	$$	$$$	$$$	$$$$$	$$$$$	$	$$$	$$$	$$$	$$	$$	$$$$	$$$$	$$$$	$$$$
Mow Cost /Acre/Year	$84.40	$33.76-$84.40 + $423.24-1,638.80 String Trimming	n/a	$40.11	$0.00	$33.76	$33.76	$33.76	$33.76	$8.44	$0.00	$8.44	$8.44	$8.44	$8.44	$8.44	$0.00	$8.44	$8.44	$8.44
Seeding Rates: lbs [*of PLS] Per Acre	348.5	304.9	n/a	101.5	130.7	*22.65 (spring); *25.26 (fall)	*16.12 (spring); *26.14 (fall)	*15.2	*60.9	*58.37 (spring); *68.39 (fall)	95.8	*6.65	*6.964	*57.85	*5.723	*7.023	*220	*20 - 40	*20	*20
lb. Per 1000 ft²	8	7	n/a	2.33	3	0.52 (spring); 0.58 (fall)	0.37 (spring); 0.6 (fall)	0.35	1.398	1.34 (spring); 1.57 (fall)	2.02	0.153	0.160	1.328	0.131	0.161	5.05	0.459 - 0.918	0.459	0.459
kg Per 1000 m²	39.04	34.16	n/a	11.37	14.64	1.41 (spring); 2.53 (fall)	1.8 (spring); 2.92 (fall)	1.71	6.82	6.54 (spring); 7.66 (fall)	9.86	0.747	0.781	6.483	0.64	0.786	24.66	2.241 - 4.482	2.241	2.241

NO-MOW SLOPES

		ODOT Current Mixes (659.09)					Pheasants/Quail Forever Mixes			DRG Seed Mixes
Slope Designation →		2:1 slopes or flatter					2:1 slopes or flatter			Any
Use Designation →		Zones 3-4 (min-mow areas; non-critical visibility areas)					Zones 3-4 (min-mow areas; non-critical visibility areas)			Zones 1-4 (Low-growing/mowed areas/difficult to mow areas)
Category	Attribute	Class 4A Native Grass Mixture	Class 4B Low Growing Native Grass Mixture	Class 5A Annual and Perennial Wildflower Mixture	Class 5B Native Wildflower and Grass Mixture	Class 6 Wildlife Mixture	Ohio IVM Mixture	Ohio Critical Area Mixture	Ohio All CRP Mixture	Low Maintenance Freedom Lawn I Mixture
	Use Rating	★★★	★★★	★★★	★★★★	★★★★	★★★★	★★½	★★★	★★★★
Seed Mix Characteristics	Phenology	Warm-Season/Cool-Season Grasses	Warm-Season/Cool-Season Grasses	Forbs	Forbs, Warm-Season/Cool-Season Grasses	Forbs, Warm-Season/Cool-Season Grasses	Forbs, Warm-Season Grasses	Forbs, Warm-Season/Cool-Season Grasses	Forbs, Warm-Season Grasses	Cool Season Grasses
	Life Cycle	Annual/Perennial	Annual/Perennial	Annual/Perennial	Annual/Perennial	Annual/Perennial	Annual/Perennial	Annual/Perennial	Annual/Perennial	Annual/Perennial
	Growth Rate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Rapid	Moderate	Rapid
	Maximum Height (Inches)	120	48	78	120	120	120	36	96	10
	Root Depth (Inches)	12-108	12-156	6-96	6-168	24-168	6-168	6-30	6-156	12
	Soil Type	Sand, Loam, Clay	Sand, Loam, Clay	Sand, Loam, Clay	Sand, Loam, Clay	Sand, Loam, Clay	Sand, Loam, Clay	Sand, Loam, Clay	Sand, Loam, Clay	Loam, Clay
	pH Range	5.0-8.0	5.0-7.5	5.0-7.5	5.0-7.5	5.0-7.5	5.0-7.5	5.0-7.5	5.0-7.5	5.0 - 8.0
	Germination	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate-Rapid	Moderate	Rapid
	Bloom Period	July-September	April-September	April-September	April-September	April-September	April-September	May-September	April-September	May-July
	Establishment Period	🍃🍃🍃🍃	🍃🍃🍃🍃	🍃🍃🍃🍃🍃	🍃🍃🍃🍃	🍃🍃🍃🍃	🍃🍃🍃🍃	🍃🍃🍃	🍃🍃🍃🍃	🍃🍃
	Sunlight Requirement	☀☀	☀☀	☀☀	☀☀	☀☀	☀☀	☀☀	☀☀	☀☀
	Hardiness Zone	5a, 5b, 6a, 6b	5a	5a, 5b, 6a, 6b	5a, 5b, 6a, 6b	5a, 5b, 6a, 6b	5a	5a	5a	5a, 5b, 6a, 6b
	Native Status (* Annual Rye Introduced)	Native*	Native*	Native/Introduced	Native*	Native*	Native/Introduced	Native/Introduced	Native/Introduced	Introduced
	Indicator Status	FAC to UPL	FAC to UPL	FAC to UPL	FAC to UPL	FAC to UPL	FAC to UPL	FAC to UPL	FAC to UPL	FACU
Tolerance	Drought Tolerance	🌵🌵🌵🌵	🌵🌵🌵🌵	🌵🌵🌵🌵	🌵🌵🌵🌵	🌵🌵🌵🌵	🌵🌵🌵🌵	🌵🌵🌵	🌵🌵🌵🌵	🌵🌵🌵🌵
	Tolerance to Significant Sheet Flow	Tolerant	Tolerant	Tolerant	Tolerant	Tolerant	Tolerant	Tolerant	Tolerant	Tolerant
	Salt Tolerance	Moderate	Low-Moderate	Low-Moderate	Low-Moderate	Low-Moderate	Low-Moderate	Low-Moderate	Low-Moderate	Moderate to High
	Tolerance to Disturbance/ Mowing	Moderate	Moderate	Low-Moderate	Low-Moderate	Low-Moderate	Low-Moderate	Moderate	Low-Moderate	High
	Soil Compaction Tolerance	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Environmental Benefits	Attractiveness to Pollinators	Moderate	Moderate	High	High	High	High	Moderate	High	Low
	Water Quality Benefits	Moderate to High	Moderate to High	Moderate to High	Moderate to High	Moderate to High	Moderate to High	Moderate to High	Moderate to High	Low
	Erosion Control Benefits	🌾🌾🌾	🌾🌾🌾	🌾🌾🌾	🌾🌾🌾	🌾🌾🌾	🌾🌾🌾	🌾🌾🌾	🌾🌾🌾	🌾🌾
Cost	Price Per Pound	$8.93	$12.35	$30.75	$52.69	$99.07	$35.62 (Quail) $41.65 (OPN)	$4.32 (Quail) $5.15 (OPN)	$34.09 (Quail) $36.75 (OPN)	$3.85 (OPN)
	Cost to Seed 1 Acre	$$	$$$	$$$	$$$$$	$$$$$	$$$	$$$	$$	$$$$
	Mow Cost/Acre/Year	$33.76	$33.76	$33.76	$33.76	$8.44	$8.44	$8.44	$8.44	$0.00
Seeding Rates	lbs [*of PLS] Per Acre	*22.65 (spring); *25.26 (fall)	*16.12 (spring); *26.14 (fall)	*15.2	*60.9	*58.37 (spring); *68.39 (fall)	*6.964	*57.85	*5.723	*220
	lbs Per 1000 ft²	0.52 (spring); 0.58 (fall)	0.37 (spring); 0.6 (fall)	0.35	1.398	1.34 (spring); 1.57 (fall)	0.160	1.328	0.131	5.05
	kg Per 1000 m²	1.41 (spring); 2.53 (fall)	1.8 (spring); 2.92 (fall)	1.71	6.82	6.54 (spring); 7.66 (fall)	0.781	6.483	0.64	24.66

WET DITCHES/SWALES				
Slope Designation →		DRG Seed Mixes		
		Any		3:1 slopes or flatter
Use Designation →		Zones 1-4 (mowed wet ditches and swales)	Zones 3-4 (min-mow areas; non-critical visibility areas)	
Category	Attribute	Wet Ditch/Swale Mixture	Wet Meadow Mixture	Seasonally Flooded Wildlife Mixture
	Use Rating	★★★★	★★★½	★★★½
Seed Mix Characteristics	Phenology	Warm-Season/Cool-Season Grasses	Forbs, Warm-Season/Cool-Season Grasses	Forbs, Warm-Season/Cool-Season Grasses
	Life Cycle	Perennial	Perennial	Annual/Perennial
	Growth Rate	Moderate	Moderate to Rapid	Moderate
	Maximum Height (Inches)	60	84	84
	Root Depth (Inches)	12	10	10
	Soil Type	Sand, Loam, Clay	Sand, Loam, Clay	Sand, Loam, Clay
	pH Range	5.0-7.5	4.5-8.0	4.5-7.5
	Germination	Rapid	Moderate to Rapid	Moderate
	Bloom Period	May-September	May-October	May-October
	Establishment Period	🍃🍃	🍃🍃🍃	🍃🍃🍃
	Sunlight Requirement	⛅☀	⛅☀	⛅☀
	Hardiness Zone	5a, 5b, 6a, 6b	5a, 5b, 6a, 6b	5a, 5b, 6a, 6b
	Native Status (* Annual Rye Introduced)	Native/Introduced	Native	Native*
	Indicator Status	FACW to OBL	FACW to OBL	FACW to OBL
Tolerance	Drought Tolerance	🌵🌵	🌵🌵	🌵🌵
	Tolerance to Significant Sheet Flow	Tolerant	Tolerant	Tolerant
	Salt Tolerance	High	Moderate	Moderate
	Tolerance to Disturbance/ Mowing	Moderate	Low	Low
	Soil Compaction Tolerance	Moderate	Moderate	Moderate
Environmental Benefits	Attractiveness to Pollinators	Low	Very High	Moderate to High
	Water Quality Benefits	Moderate to High	High	Moderate to High
	Erosion Control Benefits	🌻🌻🌻½	🌻🌻🌻	🌻🌻🌻½
Cost	Price Per Pound	$12.31 (Ernst) $29.00 (Ohio Prairie Nursery)	$58.76 (Ernst)	$12.62 (Ernst) $27.00 (Ohio Prairie Nursery)
	Cost to Seed 1 Acre	**$$$$**	**$$$$**	**$$$$**
	Mow Cost/Acre/Year	$8.44	$8.44	$8.44
Seeding Rates	lbs [*of PLS] Per Acre	*20 - 40	*20	*20
	lbs Per 1000 ft^2	0.459 - 0.918	0.459	0.459
	kg Per 1000 m^2	2.241 - 4.482	2.241	2.241

Matrix Notes
All seed mixes in the matrices (current ODOT mixes and recommended alternatives) have moderate or high winter hardiness. In the winter, all the groundcover species are dormant and winter hardiness is not a factor. Hardiness zone speaks to the applicability of the seed mix to the region. All seed mixes in the matrices are either available or routinely available according to USDA definitions.
Zone One: Vegetation Free Zone This zone is the shoulder area. This area is kept free of all vegetation to:

- Allow for surface drainage
- Provide visibility and maintenance of roadside hardware
- Prevent pavement breakups by invasive plants
- Provide sight distance for passing, stopping, and at intersections

Zone Two: Operational Zone This zone is also called the safety recovery zone; it begins where Zone One ends. Zone Two widths can vary depending on the width of the right-of-way but is typically 30 feet along interstate and divided highway. This area is managed to:

- Provide for a clearly visible area for vehicle recovery
- Provide sight distance for stopping on curves and at intersections
- Maintain visible and clear ditches
- Eliminate hazardous trees and tree canopy shading pavement
- Control weeds
- Prevent erosion
- Accommodate underground utilities
- Enhance visual quality

Zone Three: Transition Zone This zone requires selective vegetation management. It is far enough away from the travel lanes so that tall trees will not fall onto the road. Management of this zone may also:

- Promote low maintenance plant communities
- Blend and/or screen adjacent surroundings
- Control noxious weeds
- Prevent erosion
- Maintain and enhance visual quality
- Preserve wetlands and wildlife habitat
- Accommodate utilities
- Preserve or conserve native plants and wildflowers

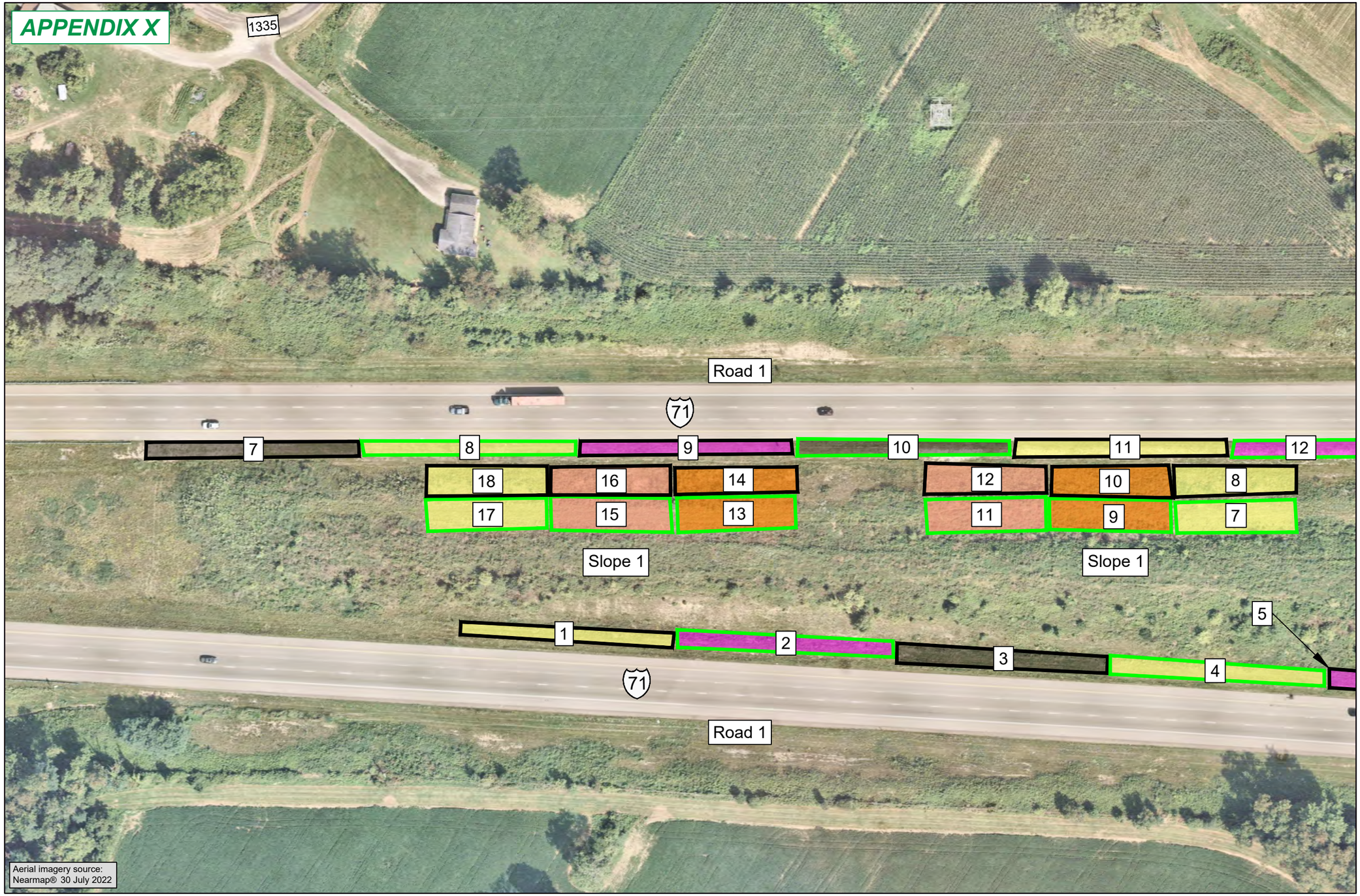
Zone Four: Undisturbed Zone In this zone vegetation management can be dictated by surrounding property, such as farmland or wood lots. Manage Zone Four to ensure that the vegetation present is not detrimental to neighboring land use.

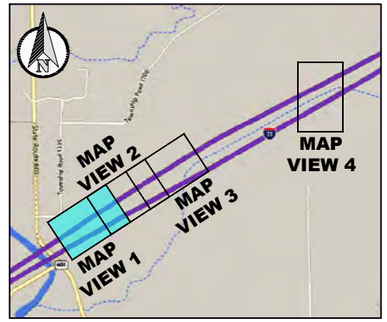
Legend												
Use Rating		**Cost**		**Drought Tolerance**		**Erosion Control Benefits**		**Sunlight Requirement**		**Establishment Period**		
Very Low	★	< $200.09	**$**	Very Low	🌵	Low	🌱	Full Sun	☀	< 6 months	🍃	
Low	★★	$200.10 to $249.91	**$$**	Low	🌵🌵	Moderate	🌱🌱	Part Sun	⛅	6 months to 1 year	🍃🍃	
Moderate	★★★	$249.92 to $467.40	**$$$**	Moderate	🌵🌵🌵	High	🌱🌱🌱	Shade	☁	1 to 2 years	🍃🍃🍃	
High	★★★★	$467.41 to $1175.20	**$$$$**	High	🌵🌵🌵🌵					2-3 Years	🍃🍃🍃🍃	
Very High	★★★★★	> $1175.20	**$$$$$**	Very High	🌵🌵🌵🌵🌵					3+ Years	🍃🍃🍃🍃🍃	

Appendix E: Location of Test Sites on County and Highway Map


Lake Erie
FULTON
LUCAS
OTTAWA
SANDUSKY
ERIE
LORAIN
CUYAHOGA
LAKE
GEAUGA
HENRY
WOOD
SENECA
HURON
MEDINA
SUMMIT
PORTAGE
PUTNAM
HANCOCK
WYANDOT
CRAWFORD
RICHLAND
ASHLAND
WAYNE
STARK
ALLEN
HARDIN
AUGLAIZE
MARION
HOLMES
CARROLL
MORROW
TUSCARAWAS
SHELBY
LOGAN
UNION
DELAWARE
KNOX
COSHOCTON
HARRISON
CHAMPAIGN
MIAMI
LICKING
GUERNSEY
MUSKINGUM
BELMONT
CLARK
MADISON
FRANKLIN
NOBLE
MONTGOMERY
FAIRFIELD
PERRY
MONROE
GREENE
FAYETTE
PICKAWAY
MORGAN
HOCKING
WARREN
CLINTON
ROSS
WASHINGTON
ATHENS
VINTON
MEIGS
JACKSON
Legend
= Ashland County Test Site Location
= Athens County Test Site Location
= Cuyahoga County Test Site Location
= Geauga County Test Site Location
= Montgomery County Test Site Location
= Summit County Test Site Location
N
15 7.5 0 15 30
Miles
Site Location: Ohio Department of Transportation
Groundcover Research Test Sites
Ashland, Athens, Cuyahoga, Geauga,
Montgomery and Summit Counties, Ohio
Source: Esri
Redlands, California

APPENDIX X





The information presented is not a survey or engineering product, and should not be used for any purpose provided by applicable law or regulation that requires a surveying or engineering license.

Legend

- = Broadcast
- = Hydro
- = Drill
- = Freedom
- = Class 3B
- = Class 6
- = CRP
- = ODOT Rural
- = IVM
- = Class 5B

GRAPHIC SCALE

0 100 200

(IN FEET)

MAPPED BY: DAVEY Resource Group

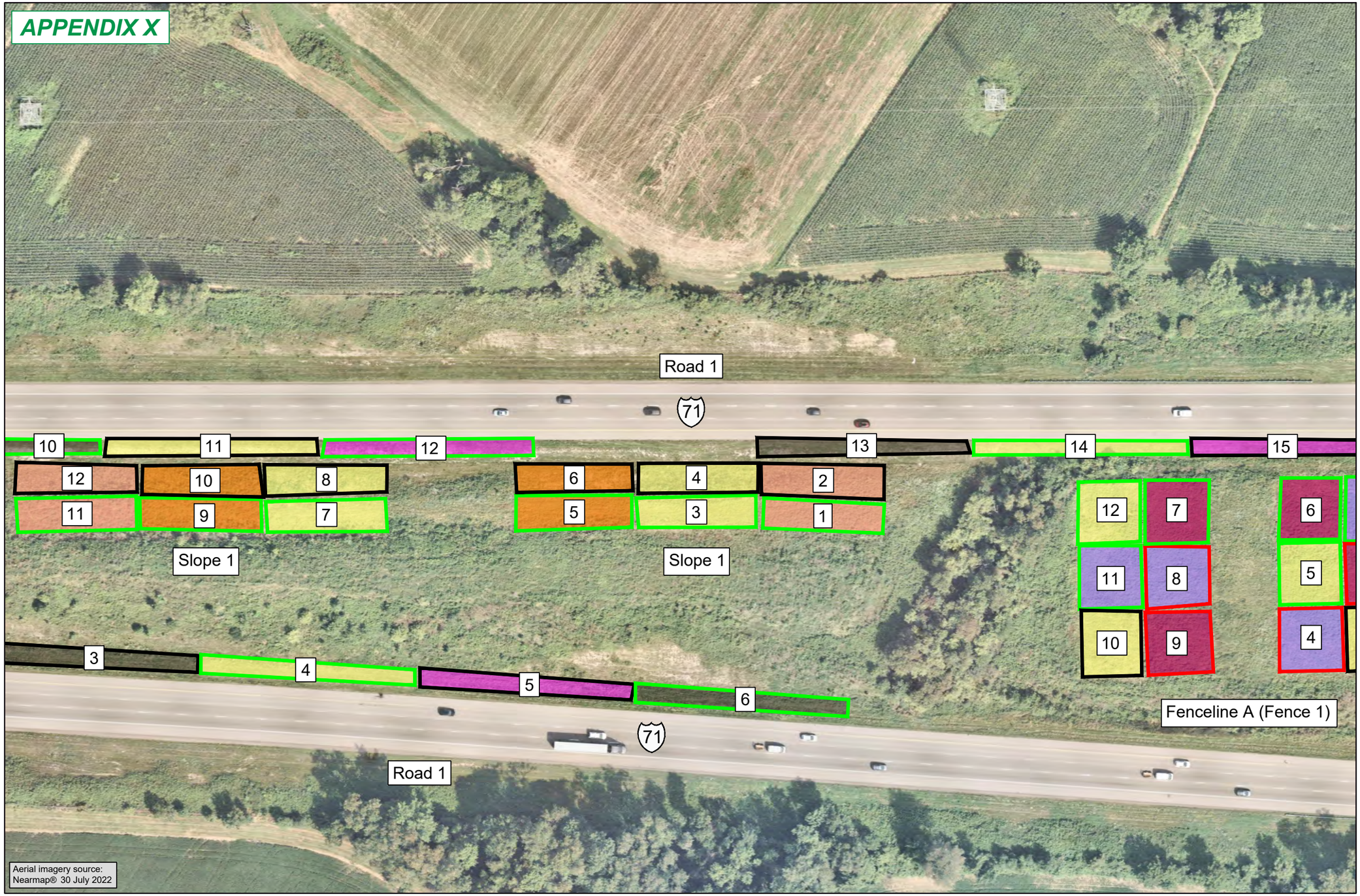
MAPPED FOR: Ohio Department of Transportation

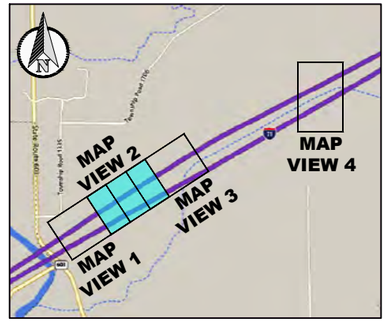
Ashland County
Groundcover Research Test Site
I-71
Mifflin Township, Ashland County, Ohio

Maps generated
28 October 2022

Map View **1** of **4**

APPENDIX X





The information presented is not a survey or engineering product, and should not be used for any purpose provided by applicable law or regulation that requires a surveying or engineering license.

Legend

- = Broadcast
- = Hydro
- = Drill
- = Freedom
- = Class 3B
- = Class 6
- = CRP
- = ODOT Rural
- = IVM
- = Class 5B

GRAPHIC SCALE

0 100 200

(IN FEET)

MAPPED BY: DAVEY Resource Group

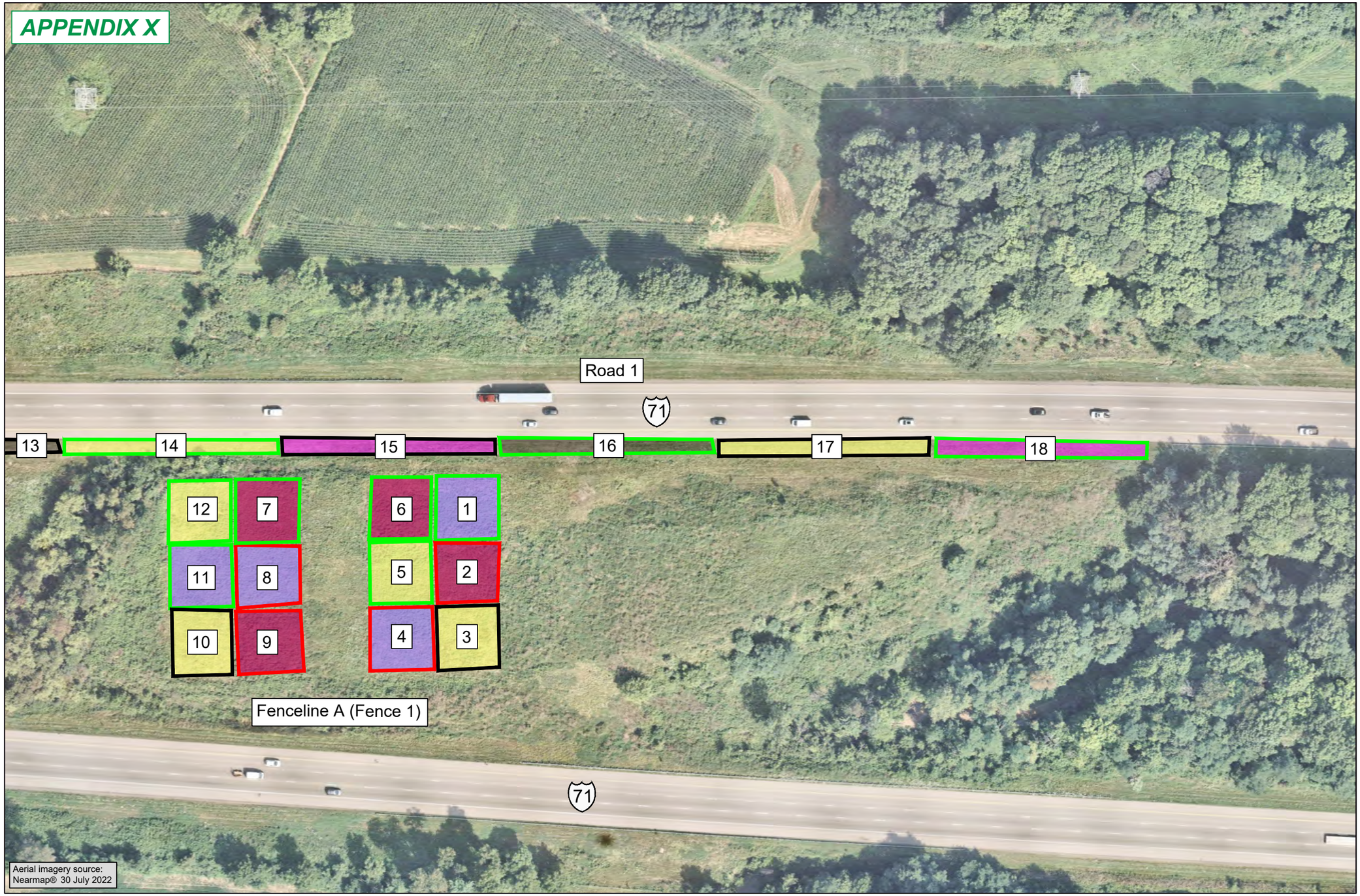
MAPPED FOR: Ohio Department of Transportation

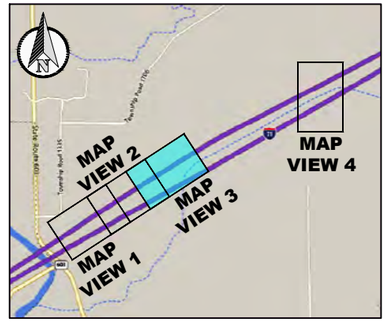
Ashland County
Groundcover Research Test Site
I-71
Mifflin Township, Ashland County, Ohio

Maps generated
28 October 2022

Map View 2 of 4

APPENDIX X





The information presented is not a survey or engineering product, and should not be used for any purpose provided by applicable law or regulation that requires a surveying or engineering license.

Legend

- = Broadcast
- = Hydro
- = Drill
- = Freedom
- = Class 3B
- = Class 6
- = CRP
- = ODOT Rural
- = IVM
- = Class 5B

GRAPHIC SCALE

0 100 200

(IN FEET)

MAPPED BY: DAVEY Resource Group

MAPPED FOR: Ohio Department of Transportation

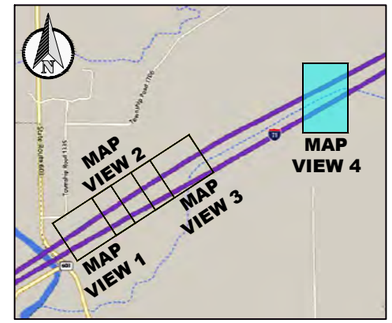
Ashland County
Groundcover Research Test Site
I-71
Mifflin Township, Ashland County, Ohio

Maps generated
28 October 2022

Map View 3 of 4

APPENDIX X

Aerial imagery source:
Nearmap® 30 July 2022



The information presented is not a survey or engineering product, and should not be used for any purpose provided by applicable law or regulation that requires a surveying or engineering license.

Legend

- = Broadcast
- = Hydro
- = Drill
- = Class 6
- = CRP
- = ODOT Rural
- = IVM
- = Class 5B

N

GRAPHIC SCALE

0 100 200

(IN FEET)

MAPPED BY:
DAVEY Resource Group

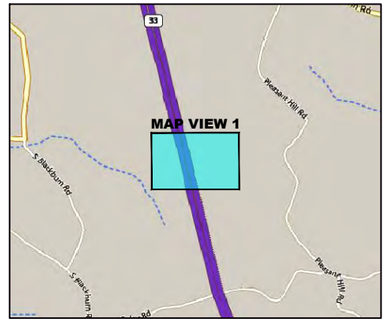
MAPPED FOR:
Ohio Department of Transportation

Ashland County
Groundcover Research Test Site
I-71
Mifflin Township, Ashland County, Ohio

Maps generated
28 October 2022

Map View **4** of **4**

APPENDIX X



The information presented is not a survey or engineering product, and should not be used for any purpose provided by applicable law or regulation that requires a surveying or engineering license.

Legend

- = Broadcast
- = Hydro
- = IVM
- = Class 5B
- = ODOT Rural

N

GRAPHIC SCALE

0 100 200

(IN FEET)

MAPPED BY:
DAVEY Resource Group

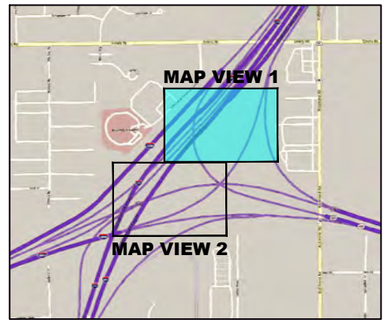
MAPPED FOR:
Ohio Department of Transportation

Athens County
Groundcover Research Test Site
US 33
Alexander and Athens Townships
Athens County, Ohio

Map generated
25 October 2022

Map View **1** of **1**

APPENDIX X



The information presented is not a survey or engineering product, and should not be used for any purpose provided by applicable law or regulation that requires a surveying or engineering license.

Legend

- = Broadcast
- = Hydro
- = Drill
- = CRP
- = Class 6
- = ODOT Rural
- = SF
- = WD/S

GRAPHIC SCALE

0 100 200

(IN FEET)

MAPPED BY: DAVEY Resource Group

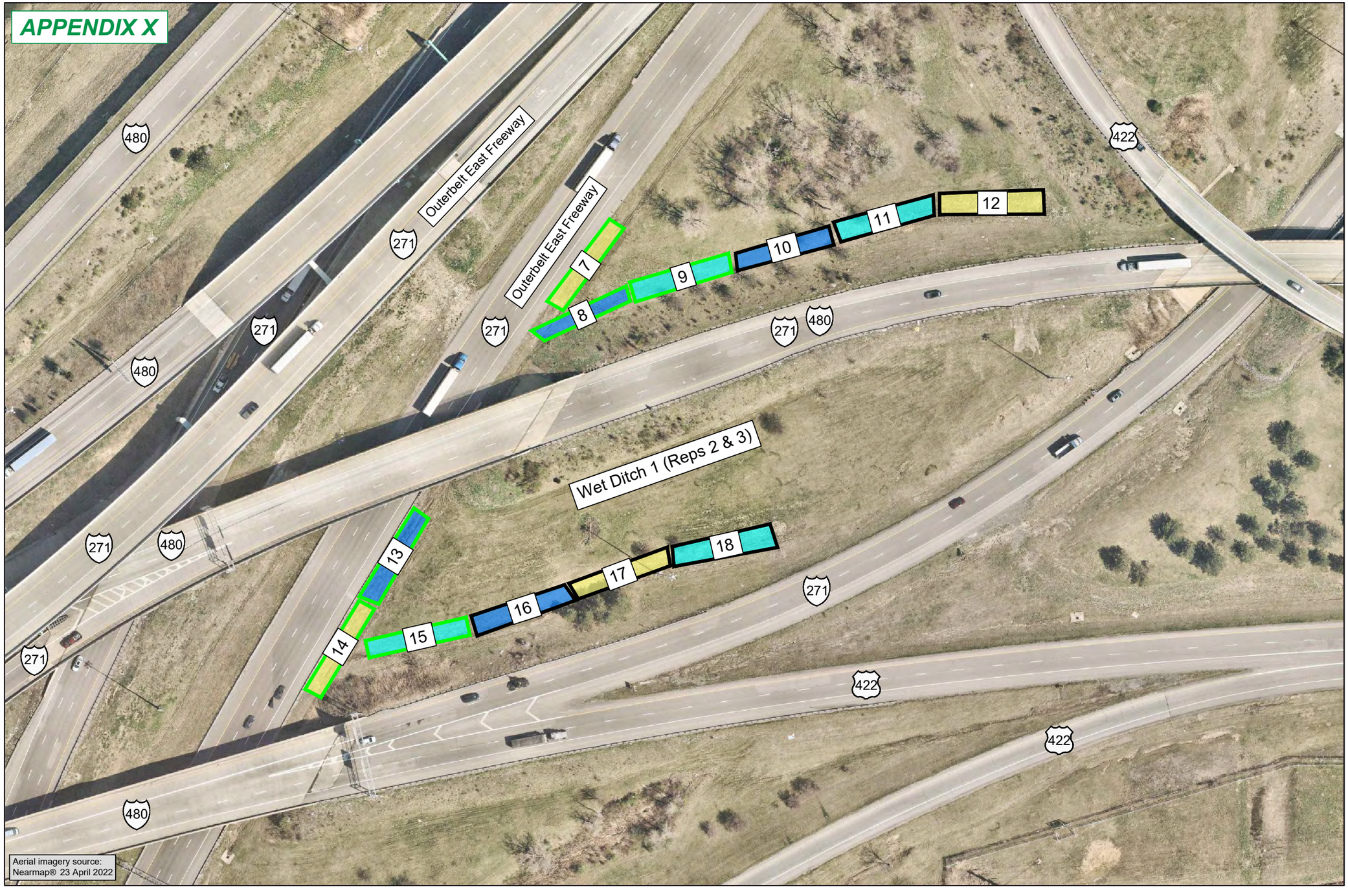
MAPPED FOR: Ohio Department of Transportation

Cuyahoga County
Groundcover Research Test Site
I-271
Warrensville Heights
Cuyahoga County, Ohio

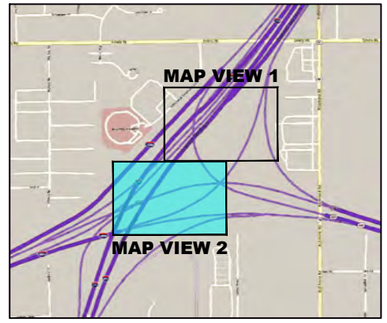
Maps generated
27 October 2022

Map View **1** of **2**

APPENDIX X



Aerial imagery source:
Nearmap® 23 April 2022



The information presented is not a survey or engineering product, and should not be used for any purpose provided by applicable law or regulation that requires a surveying or engineering license.

Legend

- = Broadcast
- = Hydro
- = ODOT Rural
- = SF
- = WD/S

N

GRAPHIC SCALE

0 100 200

(IN FEET)

MAPPED BY: DAVEY Resource Group

MAPPED FOR: Ohio Department of Transportation

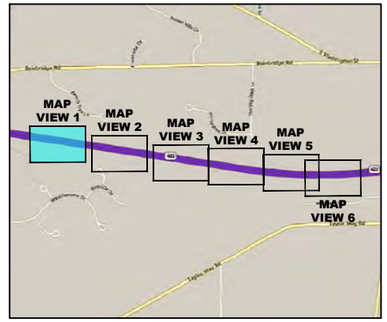
Cuyahoga County
Groundcover Research Test Site
I-271
Warrensville Heights
Cuyahoga County, Ohio

Maps generated
27 October 2022

Map View **2** of **2**

APPENDIX X

Aerial imagery source:
Nearmap® 23 April 2022



The information presented is not a survey or engineering product, and should not be used for any purpose provided by applicable law or regulation that requires a surveying or engineering license.

Legend

- = Broadcast
- = Hydro
- = Drill
- = Freedom
- = ODOT Slope
- = Class 3B
- = ODOT Rural
- = SF
- = WD/S

N

GRAPHIC SCALE

0 100 200

(IN FEET)

MAPPED BY:
DAVEY Resource Group

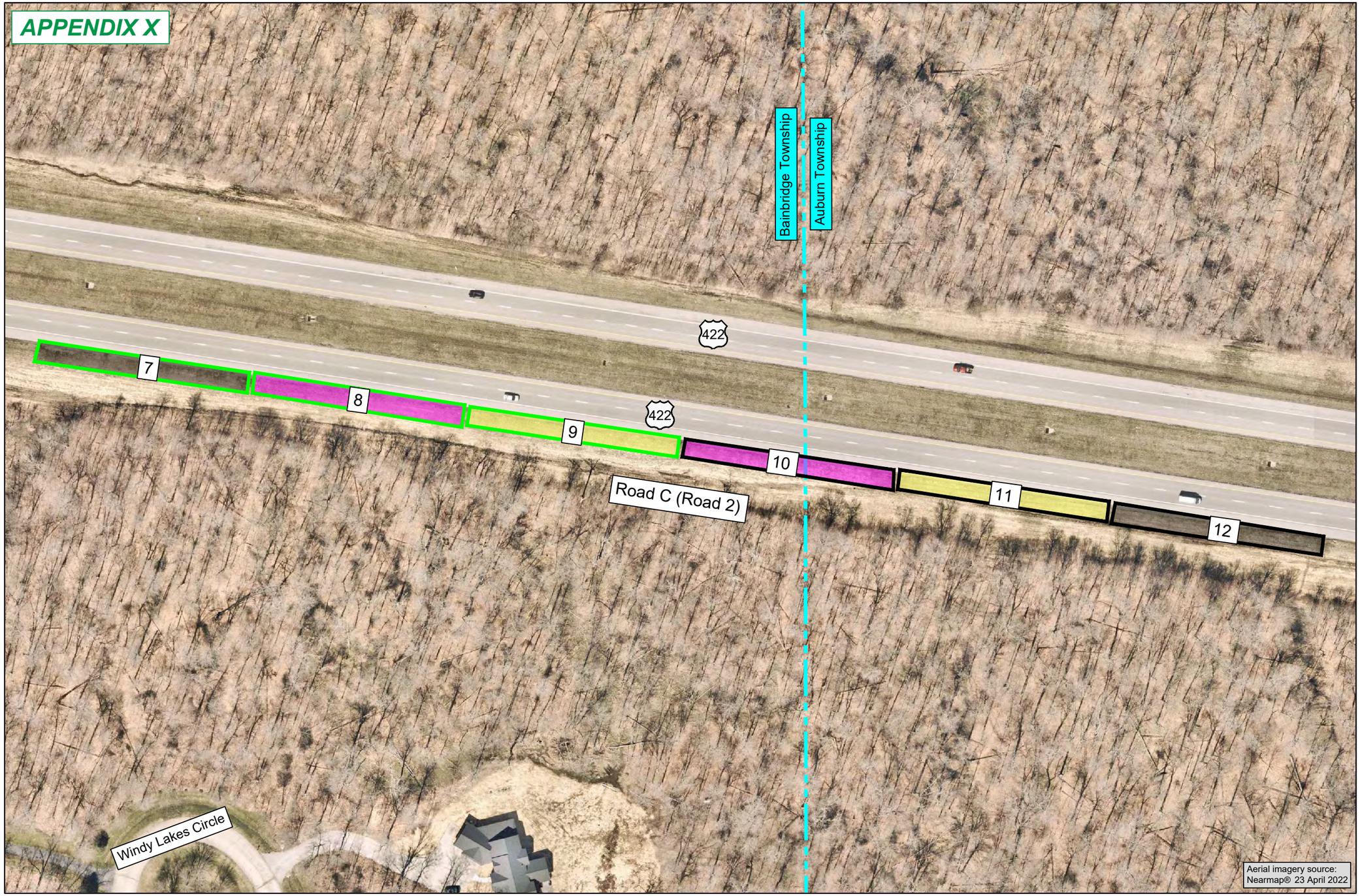
MAPPED FOR:
Ohio Department of Transportation

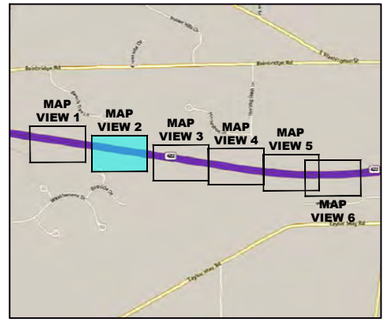
Geauga County
Groundcover Research Test Site
US 422
Auburn and Bainbridge Townships
Geauga County, Ohio

Maps generated
28 October 2022

Map View **1** of **6**

APPENDIX X





The information presented is not a survey or engineering product, and should not be used for any purpose provided by applicable law or regulation that requires a surveying or engineering license.

Legend

- = Broadcast
- = Hydro
- = Drill
- = Freedom
- = ODOT Slope
- = Class 3B
- = ODOT Rural
- = SF
- = WD/S

GRAPHIC SCALE

0 100 200

(IN FEET)

MAPPED BY: DAVEY Resource Group

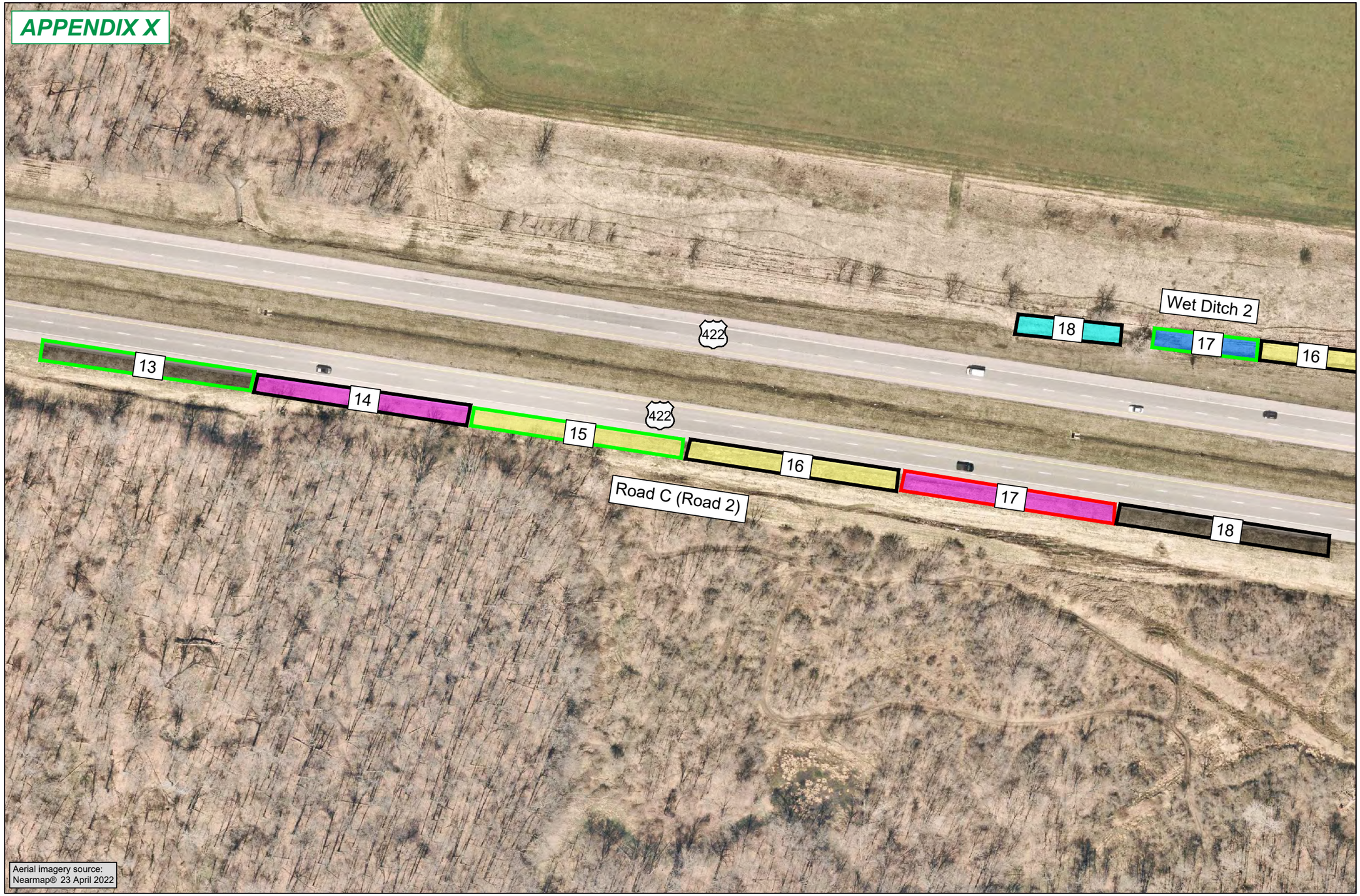
MAPPED FOR: Ohio Department of Transportation

Geauga County
Groundcover Research Test Site
US 422
Auburn and Bainbridge Townships
Geauga County, Ohio

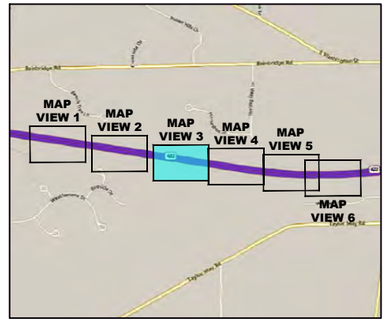
Maps generated
28 October 2022

Map View **2** of **6**

APPENDIX X



Aerial imagery source:
Nearmap® 23 April 2022



The information presented is not a survey or engineering product, and should not be used for any purpose provided by applicable law or regulation that requires a surveying or engineering license.

Legend

- = Broadcast
- = Hydro
- = Drill
- = Freedom
- = ODOT Slope
- = Class 3B
- = ODOT Rural
- = SF
- = WD/S

N

GRAPHIC SCALE

0 100 200

(IN FEET)

MAPPED BY: DAVEY Resource Group

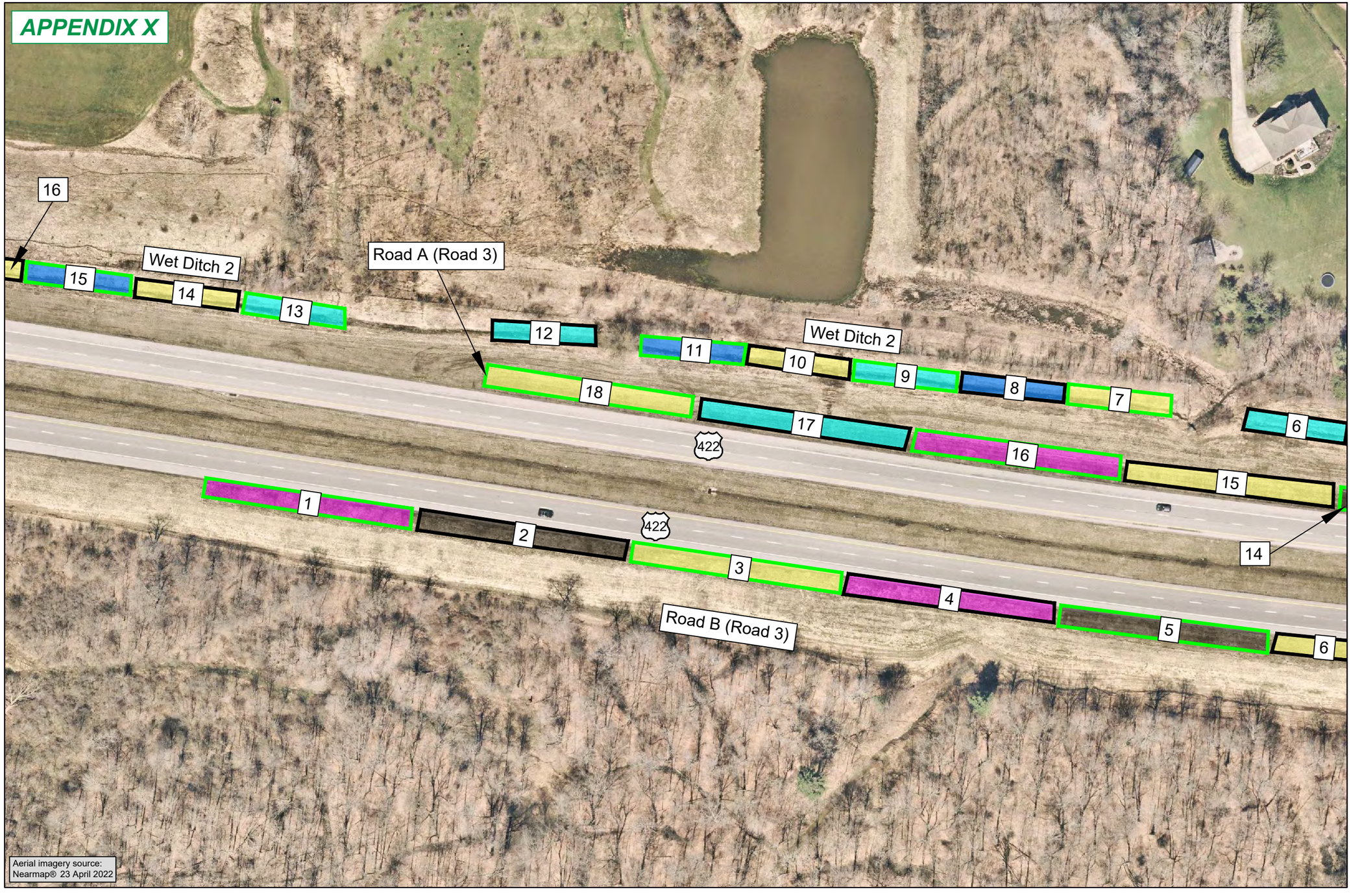
MAPPED FOR: **Ohio Department of Transportation**

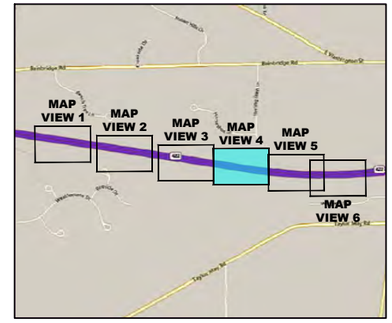
Geauga County
Groundcover Research Test Site
US 422
Auburn and Bainbridge Townships
Geauga County, Ohio

Maps generated
28 October 2022

Map View **3** of **6**

APPENDIX X





The information presented is not a survey or engineering product, and should not be used for any purpose provided by applicable law or regulation that requires a surveying or engineering license.

Legend

- = Broadcast
- = Hydro
- = Drill
- = Freedom
- = ODOT Slope
- = Class 3B
- = ODOT Rural
- = SF
- = WD/S

N

GRAPHIC SCALE

0 100 200

(IN FEET)

MAPPED BY: DAVEY Resource Group

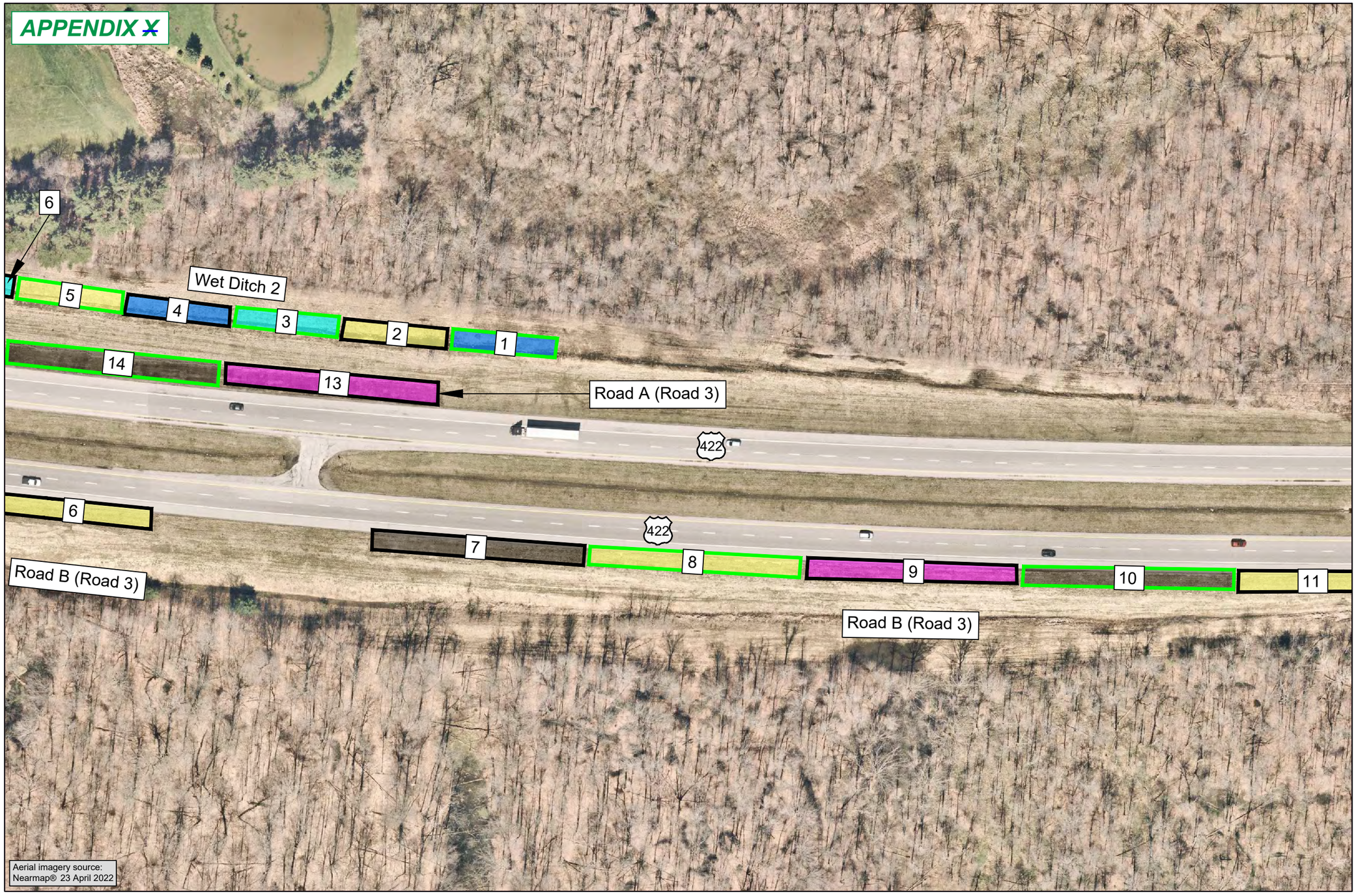
MAPPED FOR: Ohio Department of Transportation

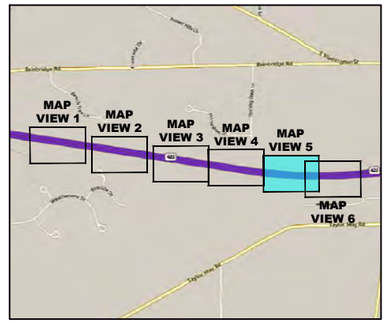
Geauga County
Groundcover Research Test Site
US 422
Auburn and Bainbridge Townships
Geauga County, Ohio

Maps generated
28 October 2022

Map View **4** of **6**

APPENDIX ~~X~~





The information presented is not a survey or engineering product, and should not be used for any purpose provided by applicable law or regulation that requires a surveying or engineering license.

Legend

- = Broadcast
- = Hydro
- = Drill
- = Freedom
- = ODOT Slope
- = Class 3B
- = ODOT Rural
- = SF
- = WD/S

N

GRAPHIC SCALE

0 100 200

(IN FEET)

MAPPED BY: DAVEY Resource Group

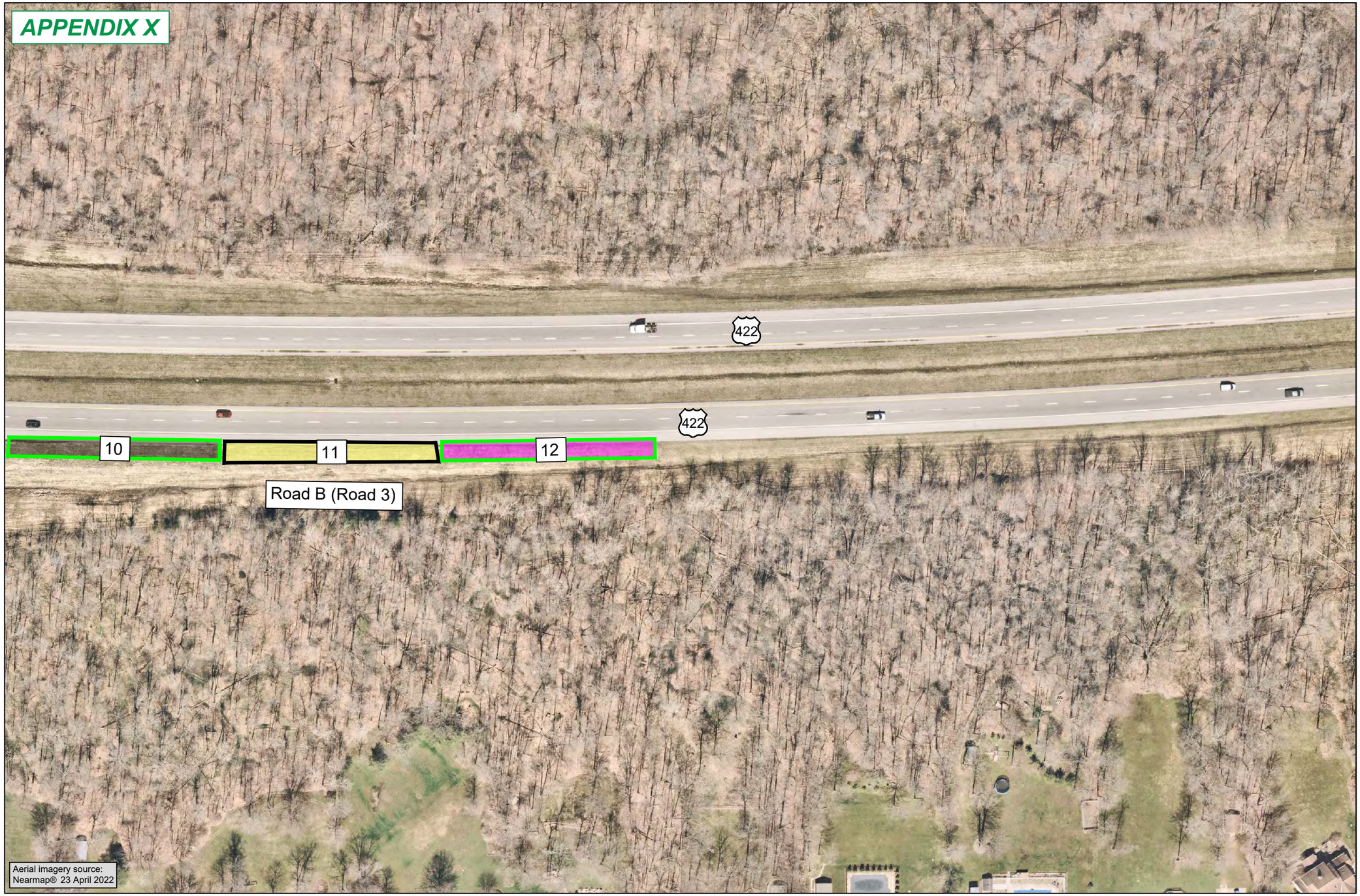
MAPPED FOR: **Ohio Department of Transportation**

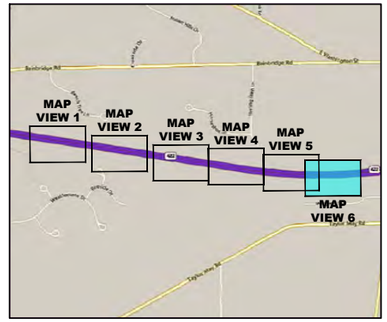
Geauga County
Groundcover Research Test Site
US 422
Auburn and Bainbridge Townships
Geauga County, Ohio

Maps generated
28 October 2022

Map View **5** of **6**

APPENDIX X





The information presented is not a survey or engineering product, and should not be used for any purpose provided by applicable law or regulation that requires a surveying or engineering license.

Legend

- = Broadcast
- = Hydro
- = Drill
- = Freedom
- = ODOT Slope
- = Class 3B
- = ODOT Rural
- = SF
- = WD/S

N

GRAPHIC SCALE

0 100 200

(IN FEET)

MAPPED BY: DAVEY Resource Group

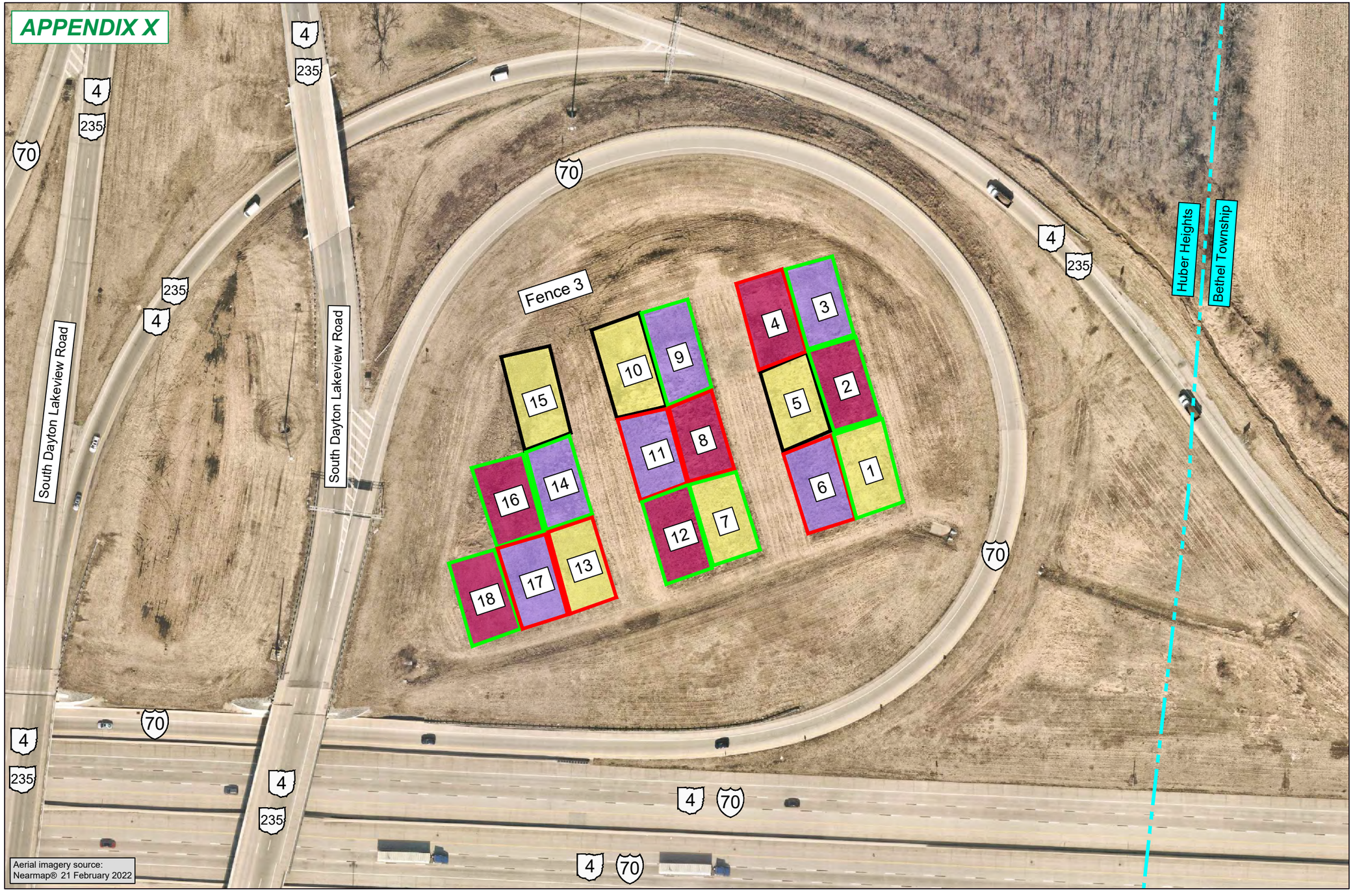
MAPPED FOR: **Ohio Department of Transportation**

Geauga County
Groundcover Research Test Site
US 422
Auburn and Bainbridge Townships
Geauga County, Ohio

Maps generated
28 October 2022

Map View **6** of **6**

APPENDIX X



The information presented is not a survey or engineering product, and should not be used for any purpose provided by applicable law or regulation that requires a surveying or engineering license.

Legend

- = Broadcast
- = Hydro
- = Drill
- = CRP
- = Class 6
- = ODOT Rural

N

GRAPHIC SCALE

0 100 200

(IN FEET)

MAPPED BY:
DAVEY Resource Group

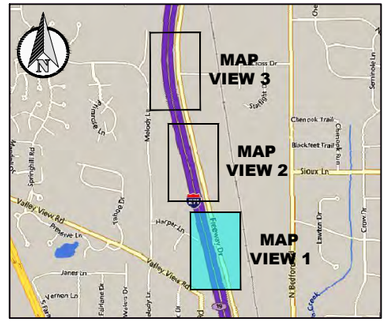
MAPPED FOR:
Ohio Department of Transportation

Montgomery County
Groundcover Research Test Site
I-70 and State Routes 4 and 235
Huber Heights, Montgomery County, Ohio

Map generated
25 October 2022

Map View 1 of 1

APPENDIX X



The information presented is not a survey or engineering product, and should not be used for any purpose provided by applicable law or regulation that requires a surveying or engineering license.

Legend

- = Broadcast
- = Hydro
- = ODOT Rural
- = SF
- = WD/S

GRAPHIC SCALE

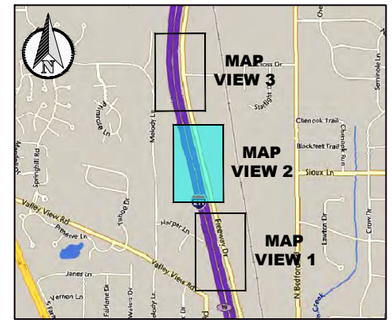
0 100 200

(IN FEET)

MAPPED BY:	MAPPED FOR:			
DAVEY Resource Group	**Ohio Department of Transportation**	**Summit County Groundcover Research Test Site** I-271 Macedonia, Summit County, Ohio	Maps generated 27 October 2022	Map View **1** of **3**

APPENDIX X

Aerial imagery source:
Nearmap® 23 April 2022



The information presented is not a survey or engineering product, and should not be used for any purpose provided by applicable law or regulation that requires a surveying or engineering license.

Legend

- = Broadcast
- = Hydro
- = ODOT Rural
- = SF
- = WD/S

GRAPHIC SCALE

0 100 200

(IN FEET)

MAPPED BY: DAVEY Resource Group

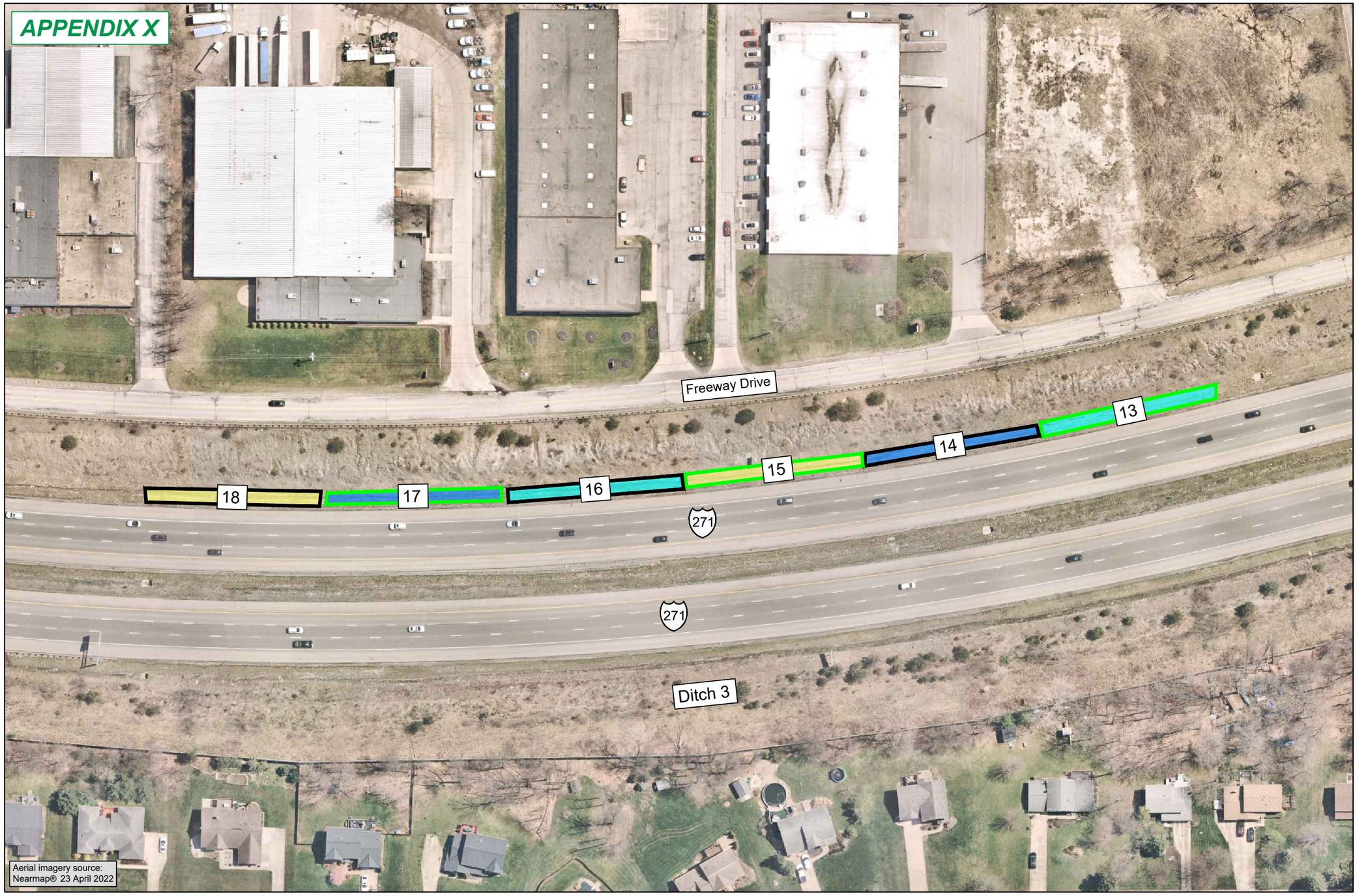
MAPPED FOR: Ohio Department of Transportation

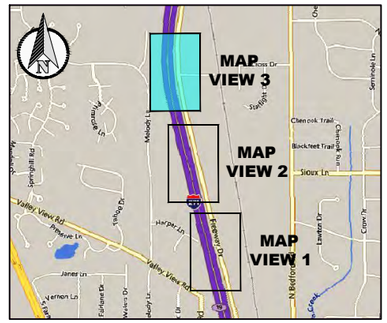
Summit County
Groundcover Research Test Site
I-271
Macedonia, Summit County, Ohio

Maps generated
27 October 2022

Map View **2** of **3**

APPENDIX X





The information presented is not a survey or engineering product, and should not be used for any purpose provided by applicable law or regulation that requires a surveying or engineering license.

Legend

- = Broadcast
- = Hydro
- = ODOT Rural
- = SF
- = WD/S

GRAPHIC SCALE

0 100 200

(IN FEET)

MAPPED BY: DAVEY Resource Group

MAPPED FOR: Ohio Department of Transportation

Summit County
Groundcover Research Test Site
I-271
Macedonia, Summit County, Ohio

Maps generated
27 October 2022

Map View 3 of 3

Appendix F: Site Visit Dates

Site Information			
Site	**District**	**County**	**Location**
Fence line 1A	District 03	Ashland	I-71_N_mm179_median
Fence line 1B	District 03	Ashland	I-71_S_mm180
Fence line 2	District 12	Cuyahoga	I-271_N_mm27.6
Fence line 3	District 07	Montgomery	I-70_W_rampN235
Roadside (R1 eval 1)	District 03	Ashland	I-71_N_mm179_median
Roadside (R1 (eval 2-3)	District 03	Ashland	1-71 S-bound median
Roadside 2A	District 12	Geauga	US-422_W_mm26.4
Roadside 3B	District 12	Geauga	US-422_E_mm26.0
Roadside 3C	District 12	Geauga	US-422_W_mm26.4
Slope 1A	District 03	Ashland	I-71_N_mm179_median
Slope 2B	District 03	Ashland	I-71_N_mm179.8
Slope 2C	District 03	Ashland	I-71_S_mm180
Slope 3	District 10	Athens	OH-33_W_ after bridge
Wet Ditch 1 (Rep 1)	District 12	Cuyahoga	I-271_N_mm27.6
Wet Ditch 1 (Rep 2)	District 12	Cuyahoga	1-271_N_mm27.4
Wet Ditch 1 (Rep 3)	District 12	Cuyahoga	I-271_N_mm27.4
Wet Ditch 2	District 12	Geauga	US-422_W_mm26.4
Wet Ditch 3	District 04	Summit	I-271_N_mm19.6

Project Initiation								
2019								
Site	Plot Identified & Marked	GPS	Plot Pictures (Individual)	Soil Testing	Baseline Evaluation for Diversity	Prep Herbicide #1	Prep Herbicide #2	Seeded
Fence line 1A	1 May 19	1 May 19	26 Aug 19	28 May 19	28 May 19	14 Jun 19	28 Aug 19	11 Nov 19
Fence line 1B	13 May 19	13 May 19	26 Aug 19	30 May 19	30 May 19	12 Jun 19	30 Aug 19	21 Nov 19
Fence line 2	15 May 19	15 May 19	6 Sep 19	18 Jun 19	19 Jun 19	19 Jun 19	6 Sep 19	9 Dec 19/20 Feb 20
Fence line 3	28 Apr 19	28 Apr 19	7 Aug 19	3 Jun 19	3 Jun 19	3 Jun 19/4 Jun 19	7 Aug 19	5 Dec 19
Roadside (R1 eval 1)	8 May 19	8 May 19	26 Aug 19	6 Jun 19	6 Jun 19	7 Jun 19	30 Aug 19	20 Nov 19
Roadside (R1 (eval 2-3)	9 May 19	9 May 19	26 Aug 19	5 Jun 19	5 Jun 19	7 Jun 19	30 Aug 19	20 Nov 19
Roadside 2A	16 May 19	16 May 19	22 Aug 19	25 Jun 19	24 Jun 19	26 Jun 19	23 Aug 19	4 Nov 19
Roadside 3B	16 May 19	16 May 19	16 Aug 19	25 Jun 19	24 Jun 19	26 Jun 19	16 Aug 19	6 Nov 19
Roadside 3C	16 May 19	16 May 19	16 Aug 19	24 Jun 19	25 Jun 19	26 Jun 19	16 Aug 19	6 Nov 19
Slope 1A	8 May 19	8 May 19	20 Aug 19	6 Jun 19/13 Jun 19	6 Jun 19/13 Jun 19	14 Jun 19	21 Aug 19	19 Nov 19
Slope 2B	10 May 19	10 May 19	26 Aug 19	13 Jun 19	13 Jun 19	14 Jun 19	28 Aug 19	19 Nov 19
Slope 2C	10 May 19	10 May 19	26 Aug 19	30 May 19	30 May 19	12 Jun 19	30 Aug 19	19 Nov 19
Slope 3	30 Apr 19	30 Apr 19	8 Aug 19	4 Jun 19	4 Jun 19	4 Jun 19/11 Jun 19	8 Aug 19	14 Nov 19
Wet Ditch 1 (Rep 1)	15 May 19	15 May 19	23 Aug 19	20 Jun 19	20 Jun 19	27 Jun 19	23 Aug 19	30 Oct 19
Wet Ditch 1 (Rep 2)	15 May 19	15 May 19	23 Aug 19	20 Jun 19	20 Jun 19	27 Jun 19	23 Aug 19	30 Oct 19
Wet Ditch 1 (Rep 3)	17 May 19	17 May 19	23 Aug 19	20 Jun 19	20 Jun 19	27 Jun 19	23 Aug 19	30 Oct 19
Wet Ditch 2	16 May 19	16 May 19	22 Aug 19	25 Jun 19	25 Jun 19	25 Jun 19	23 Aug 19	1 Nov 19
Wet Ditch 3	2 May 19	2 May 19	9 Aug 19	17 Jun 19	17 Jun 19	19 Jun 19	9 Aug 19	15 Nov 19

Groundcover Evaluations

	2020						2021			2022		
Site	Eval 1	Eval 2	Eval 3	Eval 4	Eval 5	Eval 6	Eval 1	Eval 2	Eval 3	Eval 1	Eval 2	Eval 3
Fence line 1A	9 Apr 20	1 Jun 20	29 Jun 20	28 Jul 20	26 Aug 20	21-Sep-20	11-May-21	15-Jul-21	1-Sep-21	20-May-22	28-Jul-22	13-Sept-22
Fence line 1B	9 Apr 20	3 Jun 20	29 Jun 20	27 Jul 20	25 Aug 20	21-Sep-20	10-May-21	19-Jul-21	1-Sep-21	19-May-22	27-Jul-22	12-Sept-22
Fence line 2	10 Apr 20	21 May 20	25 Jun 20	21 Jul 20	21 Aug 20	17-Sep-20	14-May-21	9-Jul-21	27-Aug-21	12-May-22	19-Jul-22	07-Sept-22
Fence line 3	7 Apr 20	15 May 20	15 Jun 20	16 Jul 20	17 Aug 20	14-Sep-20	17-May-21/18-May-21	6-Jul-21	23-Aug-21	23-May-22	12-Jul-22	01-Sept-22
Roadside (R1 eval 1)	9 Apr 20	3 Jun 20	30 Jun 20	28 Jul 20	26 Aug 20	22-Sep-20	11-May-21	20-Jul-21	2-Sep-21	25-May-22	29-Jul-22	13-Sept-22
Roadside (R1 (eval 2-3)	9 Apr 20	3 Jun 20	1 Jul 20	29 Jul 20	26 Aug 20	22-Sep-20	12-May-21	20-Jul-21	2-Sep-21	27-May-22	29-Jul-22	14-Sept-22
Roadside 2A	14 Apr 20	26 May 20	26 Jun 20	24 Jul 20	24 Aug 20	17-Sep-20	20-May-21	14-Jul-21	31-Aug-21	18-May-22	22-Jul-22	08-Sept-22
Roadside 3B	10 Apr 20	22 May 20	25 Jun 20	23 Jul 20	24 Aug 20	18-Sep-20	20-May-21	14-Jul-21	30-Aug-21	17-May-22	22-Jul-22	08-Sept-22
Roadside 3C	10 Apr 20	18 May 20	26 Jun 20	23 Jul 20	24 Aug 20	18-Sep-20	20-May-21	14-Jul-21	30-Aug-21	17-May-22	22-Jul-22	08-Sept-22
Slope 1A	9 Apr 20	19 May 20	30 Jun 20	28 Jul 20	26 Aug 20	22-Sep-20	12-May-21	20-Jul-21	2-Sep-21	25-May-22	28-Jul-22	12-Sept-22
Slope 2B	8 Apr 20	5 Jun 20	1 Jul 20	29 Jul 20	27 Aug 20	23-Sep-20	12-May-21	20-Jul-21	3-Sep-21	27-May-22	29-Jul-22	13-Sept-22
Slope 2C	9 Apr 20	5 Jun 20	29 Jun 20	27 Jul 20	25 Aug 20	21-Sep-20	10-May-21	19-Jul-21	1-Sep-21	20-May-22	27-Jul-22	14-Sept-22
Slope 3	8 Apr 20	14 May 20	16 Jun 20	17 Jul 20	18 Aug 20	15-Sep-20	19-May-21	7-Jul-21	24-Aug-21	24-May-22	11-Jul-22	02-Sept-22
Wet Ditch 1 (Rep 1)	10 Apr 20	27 May 20	24 Jun 20	21 Jul 20	20 Aug 20	16-Sep-20	13-May-21	9-Jul-21	30-Aug-21	13-May-22	20-Jul-22	07-Sept-22
Wet Ditch 1 (Rep 2)	10 Apr 20	27 May 20	25 Jun 20	21 Jul 20	20 Aug 20	17-Sep-20	13-May-21	9-Jul-21	30-Aug-21	13-May-22	20-Jul-22	07-Sept-22
Wet Ditch 1 (Rep 3)	10 Apr 20	27 May 20	25 Jun 20	21 Jul 20	20 Aug 20	17-Sep-20	14-May-21	9-Jul-21	30-Aug-21	13-May-22	21-Jul-22	07-Sept-22
Wet Ditch 2	14 Apr 20	26 May 20	26 Jun 20	24 Jul 20	21 Aug 20	18-Sep-20	21-May-21	15-Jul-21	31-Aug-21	19-May-22	25-Jul-22	09-Sept-22
Wet Ditch 3	10 Apr 20	28 May 20	24 Jun 20	20 Jul 20	19 Aug 20	16-Sep-20	13-May-21	8-Jul-21/13-Jul-21	26-Aug-21	11-May-22	13-Jul-22	06-Sept-22

Insect Evaluations

	2020		2021			2022	
Site	Eval 1	Eval 2	Eval 1	Eval 2	Eval 3	Eval 1	Eval 2
Fence line 1A	28-Jul-20	21-Sep-20	10-May-21	19-Jul-21	2-Sep-21	25-May-22	28-Jul-22
Fence line 1B	27-Jul-20	23-Sep-20	10-May-21	19-Jul-21	1-Sep-21	19-May-22	28-Jul-22
Fence line 2	20-Jul-20	17-Sep-20	13 May 21	13 July 21	26-Aug-21/27 Aug 21	No resources	19 July 22
Fence line 3	16-Jul-20	14-Sep-20	18-May-21	6-Jul-21	23-Aug-21	23-May-22	12-Jul-22
Slope 1A	28-Jul-20	21-Sep-20	11-May-21	15-Jul-21	1-Sep-21	25-May-22	28-Jul-22
Slope 2B	29-Jul-20	23-Sep-20	12-May-21	20-Jul-21	3-Sep-21	27-May-22	29-Jul-22
Slope 2C	27-Jul-20	21-Sep-20	10-May-21	19-Jul-21	1-Sep-21	19-May-22	28-Jul-22
Slope 3	17-Jul-20	15-Sep-20	19-May-21	7-Jul-21	24-Aug-21	24-May-22	11-Jul-22
Wet Ditch 1 (Rep 1)	21-Jul-20	17-Sep-20	13 May 21	13 July 21	27 Aug 21/30 Aug 21	No resources	20 July 22
Wet Ditch 1 (Rep 2)	21-Jul-20	17-Sep-20	13 May 21	13 July 21	27 Aug 21/30 Aug 21	No resources	20 July 22
Wet Ditch 1 (Rep 3)	21-Jul-20	17-Sep-20	13 May 21	13 July 21	27 Aug 21/30 Aug 21	No resources	20 July 22
Wet Ditch 2	24-Jul-20	17-Sep-20	20-May-21	14-Jul-21	31-Aug-21	17-May-22	22-Jul-22
Wet Ditch 3	20-Jul-20	16-Sep-20	13-May-21	8 Jul 21/13-Jul-21	26-Aug-21	No resources	13-Jul-22

Reseeding		
	2020	
Site	2020 Reseeding	2020 Tackifier
Fence line 2	23 Oct 20 (drill); 5 Nov 20	10 Nov 20
Slope 3	16-Nov-20	23-Nov-20
Wet Ditch 3	5-Nov-20	10-Nov-20

Soil Tests			
	2019	2020	2021
Site	Test #1 (all sites)	Test #2 (poor sites)	Test #3 (re-test poor sites)
Fence line 1A	28 May 19	N/A	N/A
Fence line 1B	30 May 19	N/A	N/A
Fence line 2	18 Jun 19	21 Aug 20	13 Jul 21
Fence line 3	3 Jun 19	N/A	N/A
Roadside (R1 eval 1)	6 Jun 19	N/A	N/A
Roadside (R1 (eval 2-3)	5 Jun 19	N/A	N/A
Roadside 2A	25 Jun 19	N/A	N/A
Roadside 3B	25 Jun 19	N/A	N/A
Roadside 3C	24 Jun 19	N/A	N/A
Slope 1A	6 Jun 19/13 Jun 19	N/A	N/A
Slope 2B	13 Jun 19	N/A	N/A
Slope 2C	30 May 19	N/A	N/A
Slope 3	4 Jun 19	30 Jul 20	10 Sep 21
Wet Ditch 1 (Rep 1)	20 Jun 19	N/A	N/A
Wet Ditch 1 (Rep 2)	20 Jun 19	N/A	N/A
Wet Ditch 1 (Rep 3)	20 Jun 19	N/A	N/A
Wet Ditch 2	25 Jun 19	N/A	N/A
Wet Ditch 3	17 Jun 19	30 Jul 20	8 Jul 21

Post-Seeding IVC									
	2020				2021			2022	
Site	IVC #1	IVC #2	IVC #3	IVC #4	IVC #1	IVC #2	IVC #3	IVC #1	IVC #2
Fence line 1A	5 Feb 20 Spot-spray	N/A	8 Jun 20 Spot-spray	8 Aug 20 Spot-spray	10 Mar 21 Spot-spray	N/A	22 Jul 21 Spot-spray	7 Apr 22 Spot-spray	23 Jun 22 Spot-spray
Fence line 1B	5 Feb 20 Spot-spray	N/A	8 Jun 20 Spot-spray	30 Jul 20 Spot-spray	10 Mar 21 Spot-spray	N/A	N/A	7 Apr 22 Spot-spray	13 Jun 22 Spot-spray
Fence line 2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Fence line 3	N/A	N/A	N/A	N/A	N/A	5/18/2021 Spot-spray	7 Jul 21 Spot-spray	N/A	N/A
Roadside (R1 eval 1)	N/A	N/A	8 Jun 20 Spot-spray	8 Aug 20 Spot-spray	N/A	N/A	26 Jul 21 Broadcast Spray	N/A	8 Jun 22 Broadcast Spray
Roadside (R1 (eval 2-3)	N/A	N/A	8 Jun 20 Spot-spray	N/A	N/A	N/A	26 Jul 21 Broadcast Spray	N/A	8 Jun 22 Broadcast Spray
Roadside 2A	9 Jun 20 Spot-spray	4 Aug 20 Spot-spray	N/A	N/A	N/A	5/21/2021 Broadcast Spray	27 Jul 21 Broadcast Spray	N/A	9 Jun 22 Broadcast Spray
Roadside 3B	9 Jun 20 Spot-spray	31 Jul 20 Spot-spray	N/A	N/A	N/A	5/21/2021 Broadcast Spray	23 Jul 21 Broadcast Spray	N/A	9 Jun 22 Broadcast Spray
Roadside 3C	9 Jun 20 Spot-spray	31 Jul 20 Spot-spray	N/A	N/A	N/A	5/21/2021 Broadcast Spray	23 Jul 21 Broadcast Spray	N/A	9 Jun 22 Broadcast Spray
Slope 1A	12 Feb 20 Spot-spray	9 Mar 20 Spot-spray	8 Jun 20 Spot-spray	1 Nov 21 Spot-spray	10 Mar 21 Spot-spray	N/A	N/A	7 Apr 22 Spot-spray	24 Jun 22 Spot-spray
Slope 2B	12 Feb 20 Spot-spray	N/A	8 Jun 20 Spot-spray	N/A	10 Mar 21 Spot-spray	N/A	21 Jul 21 Spot-spray	7 Apr 22 Spot-spray	N/A
Slope 2C	5 Feb 20 Spot-spray	N/A	8 Jun 20 Spot-spray	30 Jul 20 Spot-spray	10 Mar 21 Spot-spray	N/A	N/A	7 Apr 22 Spot-spray	13 Jun 22 Spot-spray
Slope 3	N/A	N/A	N/A	N/A	N/A	5/19/2021 Spot-spray	N/A	N/A	N/A
Wet Ditch 1 (Rep 1)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Wet Ditch 1 (Rep 2)	N/A	N/A	N/A	N/A	N/A	N/A	27 Jul 21 Spot-spray	N/A	N/A
Wet Ditch 1 (Rep 3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Wet Ditch 2	24 Jul 20 Spot-spray	4 Aug 20 Spot-spray	N/A	N/A	N/A	5/21/2021 Spot-spray	27 Jul 21 Spot-spray	N/A	N/A
Wet Ditch 3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Appendix G: Soil Analysis

Throughout the course of the study, soil analyses were completed as needed, with an initial analysis in 2019 prior to soil preparation. The optimal levels are shown below with dashed lines for the recommended levels for each of the soil components. The optimal levels for each site were determined by the lab for the individual habitat types.

Per Spectrum Analytic, Inc. labs, all sites in the study were either on the upper range of the allowable pH for the site, or higher than the recommended pH, with an average pH of 7.98 (Figure 2).

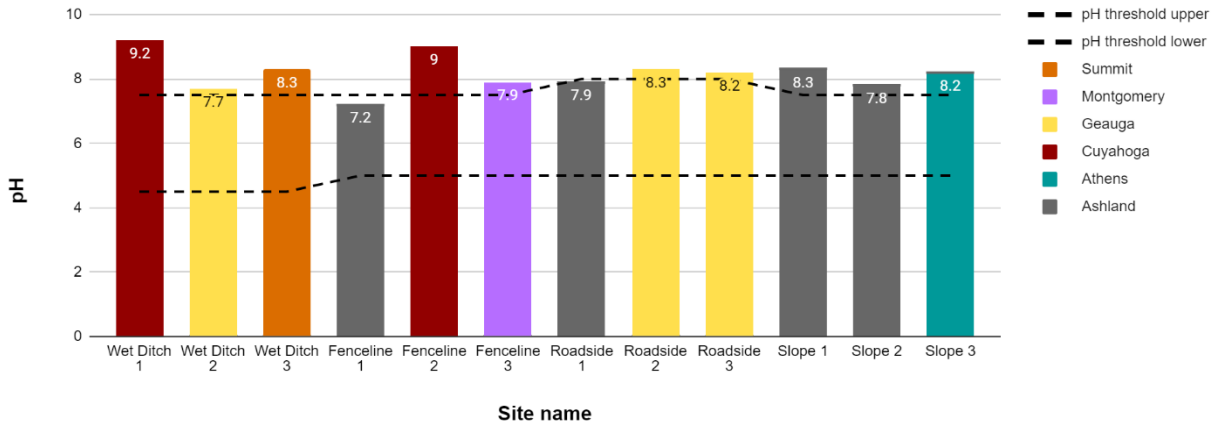


Figure 2. 2019 soil pH data for each test site. Columns are labeled by county.

According to ODOT specifications, the minimum organic content level for seeding is 4%. With the exception of Fenceline 1 (Ashland) and Wet Ditch 2 (Geauga), all sites fell below this threshold during the initial soil test (Figure 3).

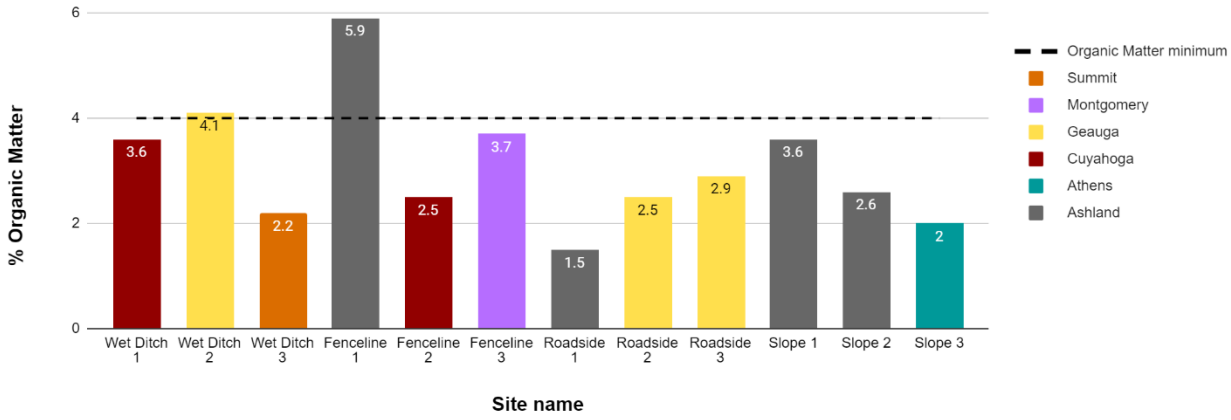


Figure 3. 2019 soil percent organic matter data for each test site. Columns are labeled by county.

Testing was conducted to determine the appropriate fertilizer formulations and applications. With the exception of Fenceline 3 (Montgomery) all of the sites utilized during this study were below the optimal level of Phosphorus (Figure 4).

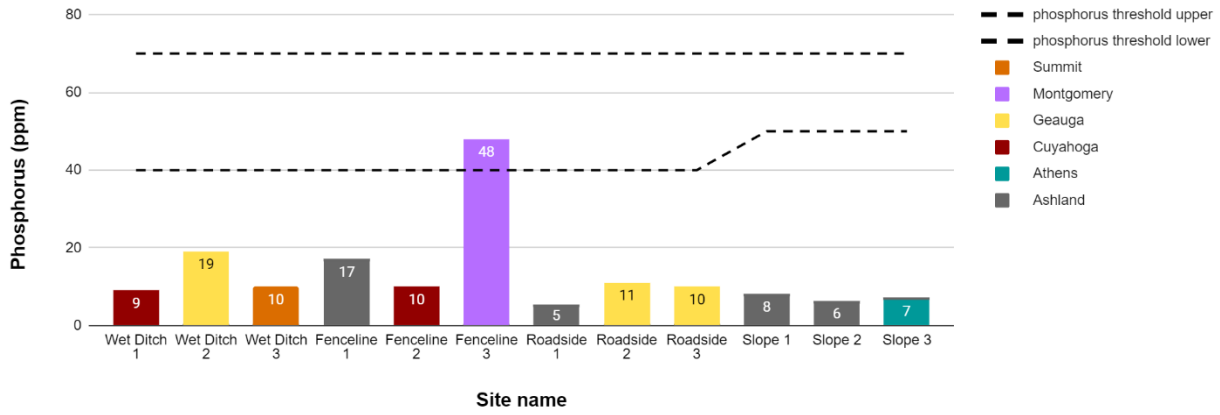


Figure 4. 2019 soil phosphorus (ppm; mg/m^3) content for each test site. Columns are labeled by county.

Following the failure of Fenceline 2 (Cuyahoga), Slope 3 (Athens), and Wet Ditch 3 (Summit) testing was conducted to assess the sodium content of the soil to determine why certain sites were not showing the required vegetation growth. The data collected from Wet Ditch 3 (Summit) showed an extremely high sodium content that would prevent vegetation growth (Figure 5).

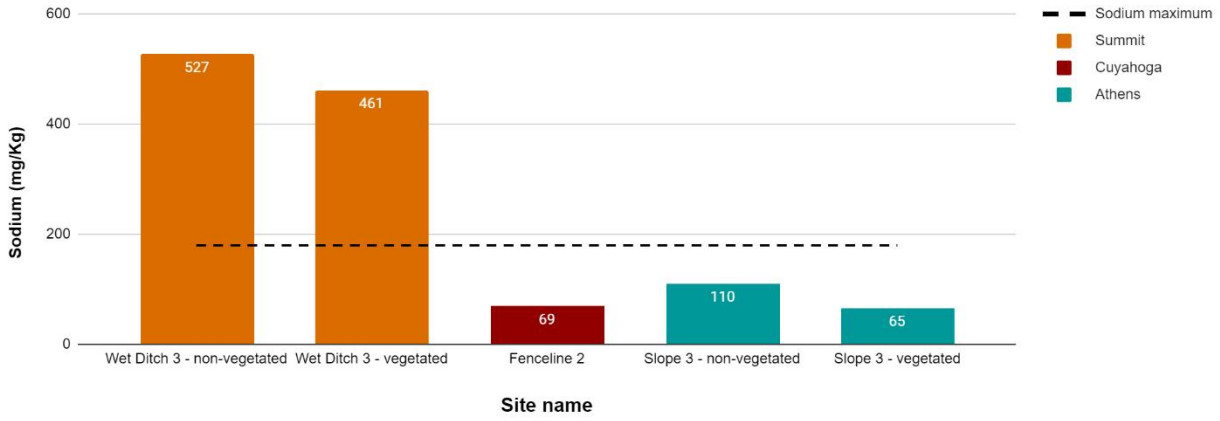


Figure 5. 2020 soil sodium (mg/Kg) content for re-seeded test sites. Columns are labeled by county.

Following the failure of Fenceline 2 (Cuyahoga), Slope 3 (Athens), and Wet Ditch 3 (Summit) testing was conducted to assess the calcium content of the soil to determine why certain sites were not showing the required vegetation growth. The data collected from all three sites showed an extremely high sodium content that would prevent vegetation growth (Figure 6). The level of calcium shown below would increase the probability of cementation of the soil which would reduce air and water flow in the soil, increase the amount of salt in the soil, and decrease the availability of phosphorus to vegetation due to binding of calcium to phosphorus.

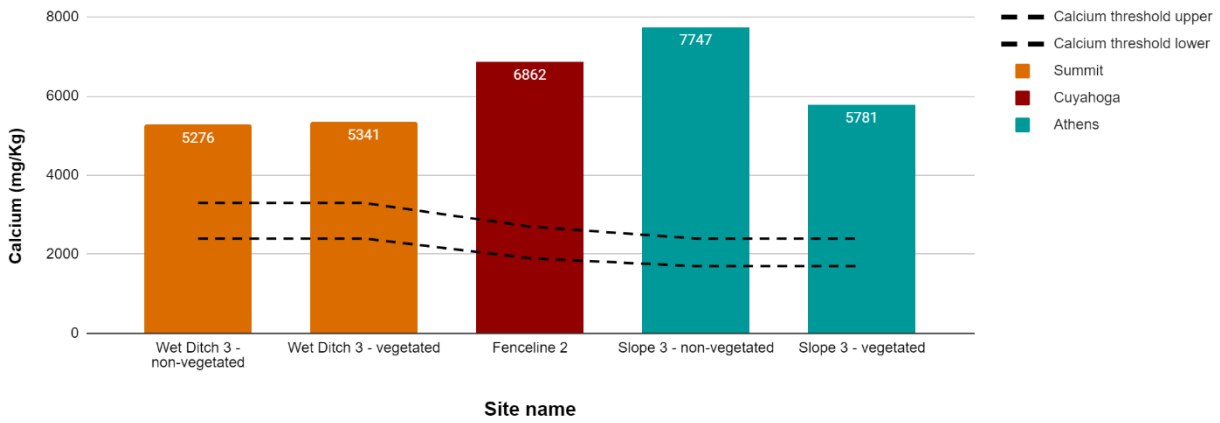


Figure 6. 2020 soil calcium (mg/Kg) content for re-seeded test sites. Columns are labeled by county.

2019 Soil Sample Results/Spectrum Analytic/Turf and Ornamental Soil Analysis								
Lab no	**Sample ID**	**Date tested**	**Sample no**	**Soil pH (Optimal: Fenceline-5.0-7.5, Roadside-5.0-8.0, Slope-5.0-7.5, Wet Ditch-4.5-7.5)**	**Texture**	**Phosphorus m3-ppm (Optimal: Fenceline-40-70, Roadside-40-70, Slope-50-70, Wet Ditch-40-70) [1]**	**Calcium m3-ppm (Optimal: Fenceline-1900-2700, Roadside-2200-3100, Slope-1700-2400, Wet Ditch-2400-3300)**	**Organic Matter (ODOT Minimum 4%)**
C10436	Summit Wet Ditch	7/15/19	S19-1120-1	8.3	Clay loam	10**	6236	2.2
C10437	Ashland Slope B&C	7/15/19	S19-1121-2	7.8	Clay loam	6**	2423	2.6
C10438	Geauga Road A&B	7/15/19	S19-1122-3	8.2	Clay loam	10**	3337	2.9
C10439	Montgomery Fence	7/15/19	S19-1123-4	7.9	Loam	48	2755	3.7
C10440	Ashland Fence A &B	7/15/19	S19-1123-5	7.2	Sandy loam	17**	2388	5.9
C10442	Ashland Road	7/15/19	S19-1123-6	7.9	Sandy clay loam	5**	6190	1.5***
C10443	Cuyahoga Wet Ditch	7/15/19	S19-1126-7	9.2*	Sandy clay loam	9**	5053	3.6
C10444	Ashland Slope A	7/15/19	S19-1127-8	8.3	Sandy clay loam	8**	2852	3.6
C10445	Cuyahoga Fence	7/15/19	S19-1128-9	9*	Sandy clay loam	10**	6490	2.5
C10446	Geauga Road C	7/15/19	S19-1129-10	8.3	Sandy clay loam	11**	3626	2.5
C10447	Athens Slope	7/15/19	S19-1130-11	8.2	Clay	7**	6624	2
C10448	Geauga Wet Ditch	7/15/19	S19-1131-12	7.7	Sandy clay loam	19**	2111	4.1

*AquapHix applied via tackifier tank mix during seeding

**60% Phosphorus to be applied ahead of power rake and 40% mixed with seed

***Biotic earth applied via tackifier tank mix during seeding

2020 Soil Sample Results/Spectrum Anayltic/Turf and Ornamental Soil Analysis									
Sample ID	**Date tested**	**Sample no**	**Soil pH (Optimal: Fenceline-5.0-7.5, Roadside-5.0-8.0, Slope-5.0-7.5, Wet Ditch-4.5-7.5)**	**Texture**	**Phosphorus m3-ppm (Optimal: Fenceline-40-70, Roadside-40-70, Slope-50-70, Wet Ditch-40-70) [1]**	**Calcium m3-ppm (Optimal: Fenceline-1900-2700, Roadside-2200-3100, Slope-1700-2400, Wet Ditch-2400-3300)**	**Sodium (Optimal: <180 mg/Kg)**	**Soluble Salt (Optimal 0-1.4 mmhos/cm)**	**Organic Matter (ODOT Minimum 4%)**
Summit Wet Ditch Vegetated	7/30/20	1196	8.4	Sandy Clay Loam	13	5341	461	0.22	2.9
Summit Wet Ditch Non-Vegetated	7/30/20	1198	8.2*	Sandy Clay Loam	18**	5276	527	0.37	2.3***
Cuyahoga Fenceline	8/21/20	1376	7.9	Clay Loam	41**	6862	69	0.33	3.1***
Athens Slope Vegetated	7/30/20	1196	7.9	Clay Loam	31	5781	65	0.14	3
Athens Slope Non-Vegetated	7/30/20	1198	8*	Clay	8**	7747	110	0.14	1.5***

*AquapHix applied via tackifier tank mix during seeding

**60% Phosphorus to be applied ahead of power rake and 40% mixed with seed

***Biotic earth applied via tackifier tank mix during seeding

2021 Soil Sample Results;Cornell Nutrient Analysis Laboratory/Modified Morgan and Soluble Salts; Spectrum Analytic/ Turf and Ornamental Soil Analysis									
Lab no	**Sample ID**	**Date tested**	**Sample no**	**Soil pH (Optimal: Fenceline-5.0-7.5, Roadside-5.0-8.0, Slope-5.0-7.5, Wet Ditch-4.5-7.5)**	**Texture**	**Phosphorus m3-ppm (Optimal: Fenceline-40-70, Roadside-40-70, Slope-50-70, Wet Ditch-40-70) [1]**	**Calcium m3-ppm (Optimal: Fenceline-1900-2700, Roadside-2200-3100, Slope-1700-2400, Wet Ditch-2400-3300)**	**Organic Matter (ODOT Minimum 4%)**	**Soluble Salt (Optimal 0-1.4 mmhos/cm)**
FN29027	Summit Wet Ditch	7/8/21	1	8.14	Sand, loam, clay	0.99	14778	3.56	0.748
FN29027	Summit Wet Ditch	7/8/21	2	8.09	Sand, loam, clay	1.4	31912	2.61	0.703
FN29027	Summit Wet Ditch	7/8/21	3	7.59	Sand, loam, clay	2	37005	2.77	0.803
FN29114	Summit Wet Ditch	10/19/21	Rep 2	--	Sand, loam, clay	--	--	--	1.045
FN29114	Summit Wet Ditch	10/19/21	Rep 3	--	Sand, loam, clay	--	--	--	0.499
FN29114	Summit Wet Ditch	10/19/21	Rep 1	--	Sand, loam, clay	--	--	--	0.59
FN29028	Cuyahoga Fence	7/13/21	4	8	Sand, loam, clay	0.98	28517	3.4	--
FN29028	Cuyahoga Fence	7/13/21	5	4.97	Sand, loam, clay	0.64	39217	3.05	--
FN29028	Cuyahoga Fence	7/13/21	6	5.31	Sand, loam, clay	2.21	86946	3.6	--
K06040	Athens Slope 3 Rep 2	9/23/21	1487	7.7	Clay, loam	15 (m3-ppm)	6842	1.8	--
K09042	Athens Slope 3 Rep 3	9/23/21	1488	8	Sand, loam, clay	7 (m3-ppm)	6982	1.7	--

Appendix H: Recommended Language Updates to Specification 659

ITEM 659 SEEDING AND MULCHING

659.01 Description
659.02 Testing of Soil or Topsoil
659.03 Lime
659.04 Commercial Fertilizer
659.05 Topsoil
659.06 Compost
659.07 Seeds
659.08 Turfgrass
659.09 Native Grasses and Wildflowers
659.10 Site Preparation
659.11 Placing Topsoil
659.12 Seeding Methods
659.13 Mulching Operation
659.14 Straw Mulch
659.15 Wood Fiber Mulch
659.16 Compost Mulch
659.17 Erosion Matting
659.18 Watering
659.19 Maintenance
659.20 Mowing
659.21 Repair Seeding and Mulching
659.22 Inter-Seeding
659.23 Fertilization: 2nd Application
659.24 Performances
659.25 Method of Measurement
659.26 Basis of Payment

659.01 Description. This work consists of placing topsoil, preparing the seed bed, and placing and incorporating seed, agricultural lime, commercial fertilizer, and placing mulching material used to achieve NPDES final stabilization.

Perform this work in areas shown on the plans for seeding and mulching.

Perform seeding and mulching after completing all work in the area and within 7 days of obtaining final grade. If it is anticipated that future work may disturb an area, place temporary NPDES compliant Best Management Practices as needed until final stabilization measures under this item can be installed. If the Contractor disturbs a final area, then the Contractor shall restore this area. With the Engineer's approval, the Contractor may apply permanent turfgrass seed between October 30 and March 1, and permanent native seed between October 15 and May 15 on projects started and completed within the same calendar year.

Use all excavation material in the work. Alternatively legally use, recycle, or dispose of all excavated materials according to 105.16 and 105.17.

659.02 Testing of Soil or Topsoil. Perform a Soil Analysis Test of the soil or topsoil using the following sampling frequency to determine the lime or chelated, buffered acid required:

A. When an area is near final grade, perform Standard Soil Analysis Test to measure the soil acidity or alkalinity (pH) if no topsoil is to be placed. This testing

will determine the soil requirements for lime to raise the pH or chelated, buffered acid to lower the pH. If the soil requirements are different than the standard lime mixture ratio application rates, then the standard application rate shall be adjusted up or down such that the soil requirements are met. If liquid lime is used, then use the following application table to achieve a pH between 5.0-8.0 for turfgrass seedings or 5.0-7.5 for native seedings. Calculate the difference between the soil pH and the lowest recommended pH for the seeding.

pH Difference		0.25	0.50	0.75	1.0
Application rate in gals/ac (L/ha)		2.5 (4)	5 (8)	10 (15)	20 (30)

Example: Soil Analysis Test pH=4.5 required pH=5.0 difference= 0.5 required application rate is 5 gals/ac (8L/ha)

Only use liquid lime on the QPL list. Provide the Engineer with the liquid lime manufacturers written application rate. The Engineer will only accept printed application rates.

Apply a chelated, buffered acid product as directed on the label to lower the pH. to the appropriate level, 5.0-8.0 for turfgrass and 5.0-7.5 for native seedings. Provide the product label to the Engineer for approval prior to use.

There will be no change in the mixture ratio. The soil sampling frequency is one sample every 10 acres (4.0 ha) per project side or one sample per project side whichever is greater. A sample consists of 15 soil cores in a random pattern spaced at a minimum of 500 feet (153 m) apart. Sample any change in soil. Soil changes can be seen as color and/or texture changes.

B. If placing topsoil, perform the Standard Soil Analysis Test from topsoil stockpiles to measure the topsoil acidity or alkalinity (pH). This testing will determine the soil requirements for lime or chelated, buffered acid. If the topsoil requirements are different than the standard lime or chelated, buffered acid mixture ratio application rates, then the standard application rate shall be adjusted up or down such that the topsoil requirements are met.

If liquid lime is used, then use the following application table to achieve a pH between 5.0-8.0 for turfgrass seeding or 5.5-7.5 for native grass seeding. Calculate the difference between the soil pH and the lowest recommended pH for use of lime.

pH Difference	0.25	0.50	0.75	1.0
Application rate in gals/ac (L/ha)	2.5 (4)	5 (8)	10 (15)	20 (30)

Example: Soil Analysis Test pH=4.5 required pH=5.0 difference= 0.5 required application rate is 5 gals/ac (8L/ha)

Only use liquid lime on the QPL list. Provide the Engineer with the liquid lime manufacturers written application rate. The Engineer will only accept printed application rates.

Apply chelated, buffered acid to lower the pH of the soil. Follow the product label to achieve a pH between 5.0-8.0 for turfgrass seeding or 5.5-7.5 for native grass and forb seedling. Provide the chelated, buffered acid product label to the Engineer for approval prior to use.

There will be no change in the mixture ratio. The soil sampling frequency is one sample every 10,000 cubic yards (7600 m^3) of a topsoil stockpile, or at least two samples per stockpile, whichever is greater. Test each stockpile. A sample consists of 15 soil cores in a random pattern spaced evenly throughout the stockpile.

Mix the 15 cores from each sample and then remove 1 pint (0.5 L) for testing.

The Ohio County Extension offices can provide the Contractor with a soil sample kit and testing laboratory locations.

The Department will review the sample test results and approve application rates for the standard mixture ratios provided by the Contractor.

When a specified Soil Analysis Test is not stated in the plans, default to the minimum soil testing requirements in 659.02 A and 659.02 B.

659.03 Lime. Obtain granular or liquid lime from an agricultural lime dealer or manufacturer whose brands are grades registered or licensed by the State of Ohio, Department of Agriculture. The granular or liquid lime standard grade is Ag-ground 90+. Ag-ground 90+ is defined as agricultural ground limestone, having a total neutralizing power (TNP) of 90 percent or more, at least 40 percent passing a No. 100 (150 □m) sieve and 95 percent passing a No. 8 (2.36 mm) sieve. Test granular or liquid lime according to Supplement 1007. Apply the granular or liquid lime standard grade Ag-ground 90+ at the standard application rate of 92 pounds per 1000 square feet (2 tons per acre) [0.45 kg/m^2 (9 metric tons/ha)].

The Contractor may provide other lime grade materials. The lime grade materials provided will meet Table 7-10 “Equivalent Amounts of Liming Materials” found in Bulletin 472, *Ohio Agronomy Guide*, published by the Cooperative Extension Service, The Ohio State University. Based on the type of lime grade material provided, determine the increase or decrease in the standard application rate from Table 7-10 “Equivalent Amounts of Liming Materials” found in Bulletin 472, “Ohio Agronomy Guide”, published by the Cooperative Extension Service, The Ohio State University.

If using liquid lime, apply liquid lime at a rate of 5 gals/acre (8 L/ha) unless otherwise required per the soil or topsoil Soil Analysis Test. Provide the Engineer with the liquid lime manufacturers written application rate. The Engineer will only accept printed application rates. Only use liquid lime on the QPL list.

The lime required will be such that a growing environment with a pH of 5.0-8.0 for a turfgrass seeding or 5.5-7.5 for a native seeding can be reached. The application rate of the standard grade lime Ag-ground 90+ will be adjusted up or down to achieve this condition and reported to the Department for approval. No lime is required for the soil or topsoil if the test shows a slightly acidic condition.

659.04 Commercial Fertilizer. Obtain commercial fertilizer from a dealer or manufacturer whose brands are grades registered or licensed by the State of Ohio, Department of Agriculture.

Commercial fertilizer may be dry or liquid. Apply standard commercial fertilizer

10-20-10 evenly over the surface at a standard dry application rate of 20 pounds per 1000 square feet (0.1 kg/m^2) for turfgrass seeding. Testing of the soil for nutrients will be required for any seeding of native species. This testing will be completed on both furnished topsoil and soil salvaged from on site. The need for fertilizer will be determined from soil testing. Furnish liquid application rates for approval by the Department.

The Contractor may provide other commercial fertilizer mixture ratios, however, for turfgrass, ensure that the ratio meets or exceeds the standard commercial fertilizer ratio of 10- 20-10 by providing an application rate specific for that ratio. The Department will approve this application rate that is specific to that ratio provided by the Contractor.

For areas of inter-seeding, apply commercial fertilizer 12-12-12 over the affected area at the above rate for turfgrass. Do not apply commercial fertilizer to areas of inter-seeding of native species unless otherwise directed by soil testing.

For commercial fertilizer second application on turfgrass, the method, mixture, and rate is broadcast 12-12-12 evenly over the surface without incorporation into the soil at a rate of 10 pounds per 1000 square feet (0.05 kg/m^2).

659.05 Topsoil. If placing topsoil as specified in the plan, then stockpile off project site topsoil for testing and/or stockpile stripped topsoil from the project for testing. Perform the Soil Analysis Test from these stockpiles to determine the percent of organic matter present. The topsoil shall contain between 4 percent and 20 percent organic matter as determined by loss on ignition of samples oven dried to constant weight at 212° F (100° C) and consist of fertile, loose, friable, and loamy material that contains humus material. For topsoil to be considered loamy, ensure that the fraction passing the No. 10 (200) sieve does not contain more than 40 percent clay. Test topsoil according to AASHTO T 267. All topsoil shall meet the requirements for nutrients and pH according to 659.02, 659.03, and 659.04.

The Department will review the sample test results and approve the stockpiles for use. Stockpiles outside the above limits will not be used.

Stripped topsoil from the R/W limits will be from the upper most layers of the excavation areas. Remove all heavy grass, weeds, and other vegetation before stripping topsoil from the excavation areas.

A mixture of 1 part compost and 2 parts topsoil will be treated as topsoil.

659.06 Compost. Acceptable compost shall include Ohio EPA rated Class IV compost, EQS biosolids compost, or a Department approved equal. Furnish compost with a nitrogen content of 1.4 percent or above. Obtain compost from an Ohio EPA approved facility. Before delivering compost, provide the Engineer with the facility name and location.

659.07 Seeds. Furnish grass seed from a grass seed dealer or grower whose brands are grades registered or licensed by the State of Ohio, Department of Agriculture or from the approved list of grass seed dealers or growers on file with Department. Furnish the kind and type of grass seed required that meets current specifications on file with the Department as to percentage purity, percentage weed seed, and percentage germination.

659.08 Turfgrass. Turfgrass germination rate specifications are shown

below in Table 659.07-1 to provide an understanding of the specifications on file with the Department along with information to understand what is required.

TABLE 659.08-1 GERMINATION RATES

Species	Minimum Percent	High Quality Percent
Kentucky Bluegrass	80	85
Fine Fescue	85	90
Perennial Ryegrass	85	90
Annual Ryegrass	85	90
Tall Fescue	85	90
Creeping Red Fescue	85	90

If high quality is not shown on the plans, then the minimum germination rate is required.

Mark the test date on seed bags. Furnish seeds as separate species and cultivars, packaged together or bagged separately, and labeled, tagged, or marked according to ORC 907.03. Sow seeds within 9 months of the testing date. The Department reserves the right to test, reject, or approve all seed after delivery.

Use cool season turfgrass Classes 1 and 2, as listed in Table 659.10-1 composed of no less than two and no more than four cultivars of the same species. Sixty days before seeding, provide a written description for the Class 1, and 2 mixtures showing the percentage by weight (mass) of each kind of seed for the Engineer's approval.

Include the following with the description:

A. Name and location of the seed supplier.

B. Origin and date of harvest of each kind of seed.

C. A statement of the purity and germination of each seed.

D. Testing date for each seed.

E. How and when seeds were mixed.

659.09 Native Grasses and Wildflowers. Table 659.10-1 lists the seed quantities by weight per area. Do not seed species on rock due to the lack of erosion in these areas, and the incompatibility of root systems and rock. Use Classes 5 6, CRP, IVM, Wet Ditch/Swale, and Seasonally Flooded in the amounts of pure live seed (PLS) for each species listed. If seed tests show that the seed has an actual pure live seed (PLS) yield less than the intended yield, adjust the specified quantity to provide the intended PLS yields.

For Classes, 5 6, CRP, IVM, Wet Ditch/Swale, and Seasonally Flooded mixtures, provide seed specifically grown for the Ohio climate.

Sixty days before seeding, provide a written description for the Classes, 5, 6, CRP, IVM, Wet Ditch/Swale, and Seasonally Flooded mixtures showing the percentage by weight (mass) of each kind of seed for the Engineer's approval.

Include the following with the description:

A. Name and location of the seed supplier.

B. Origin and date of harvest of each kind of seed.

C. A statement of the purity and germination of each seed.

D. Testing date for each seed.

E. How and when seeds were mixed.

TABLE 659.09-1 GRASS AND WILDFLOWER SEED MIXES

Class	Mix Type Seeds	Weight per Area lb 1000 ft^2	 kg 1000 m^2
1	Lawn Mixture Use for areas in front of residences, commercial properties, etc. between curb and sidewalk with slopes 3:1 or flatter.		
	Kentucky Bluegrass (Poa pratensis)	3	14.64
	Creeping Red Fescue (Festuca rubra)	3	14.64
	Annual Ryegrass (Lolium multiflorum)	2	9.76
	Perennial Ryegrass, turfgrass type (Lolium perenne)	2	9.76
2	Roadside Mixture		
	Kentucky Bluegrass (Poa pratensis)	1.5	7.32
	Kentucky 31 Fescue (Festuca arundinacea var. KY 31)	2	9.76
	Perennial Ryegrass (Lolium perenne)	1.5	7.32
	Slope Mixtures Use for slopes up to 3:1		
5B	Native Wildflower and Grass Mixture Use for slopes greater than 2:1 and greater than 3:1 and seeding for wildlife habitat mitigation.		
	Native Wildflower Mixture Do not exceed 10% by weight PLS of any one of the following species:	0.0559	0.2732
	Butterfly-weed (Asclepias tuberosa)		
	New England Aster (Aster novae-angliae)		
	Partridge Pea (Cassia fasciculata)		
	Purple Coneflower (Echinacea purpurea)		
	Rattlesnake Master (Eryngium yuccifolium)		
	Ox-eye Sunflower (Heliopsis helianthoides)		
	Wild Bergamot (Monarda fistulosa)	0.0093	0.0455
	Greyhead Coneflower (Ratibida pinnata)	0.0093	0.0455
	Orange Coneflower (Rudbeckia fulgida)	0.0093	0.0455
	Prairie Dock (Silphium terebinthinaceum)	0.0093	0.0455
	Whorled Rosinweed (Silphium trifoliatum)	0.0093	0.0455
	Stiff Goldenrod (Solidago rigida)	0.0093	0.0455
	Grass Mixture		
	Big Bluestem (Andropogon gerardii)	0.0093	0.0455
	Little Bluestem (Schizachyrium scoparium)	0.0151	0.0737
	Indiangrass (Sorghastrum nutans)	0.0227	0.1107
	Annual Ryegrass (Lolium multiflorum)	0.6887	3.3625

Class	Mix Type Seeds	Weight per Area lb 1000 ft^2	 kg 1000 m^2
IVM	IVM Use for slopes greater than 2:1 and greater than 3:1 and seeding for wildlife habitat mitigation		
	Big Bluestem (Andropogon gerardii)	0.0115	0.0560
	Indiangrass (Sorghastrum nutans)	0.0057	0.0280
	Little Bluestem (Schizachyrium scoparium)	0.0344	0.1681
	Sideoats Grama (Bouteloua curtipendula)	0.0287	0.1401
	Switchgrass (Panicum virgatum)	0.0115	0.0560
	Alsike Clover (Trifolium hybridum)	0.0012	0.0056
	Black-eyed Susan (Rudbeckia hirta)	0.0024	0.0118
	Brown-eyed Susan (Rudbeckia triloba)	0.0016	0.0079
	Butterfly Milkweed (Asclepias tuberosa)	0.0014	0.0067
	Common Evening Primrose (Oenothera biennis)	0.0009	0.0044
	Whorled Milkweed (Asclepias verticillate)	0.0007	0.0034
	Culvers Root (Veronicastrum virginicum)	0.0092	0.0448
	Cup Plant (Silphium perfoliatum)	0.00005	0.0002
	False or Oxeye Sunflower (Heliopsis helianthoides)	0.0005	0.0023
	Foxglove Beardtongue (Penstemon digitalis)	0.0046	0.0224
	Golden Alexander (Zizia aurea)	0.0002	0.0011
	Grayhead Coneflower (Ratibida pinnata)	0.0006	0.0028
	Hoary Vervain (Verbena stricta)	0.0006	0.0028
	Illinois Bundleflower (Desmanthus illinoensis)	0.0115	0.0560
	Wild White Indigo (Baptisia alba)	0.0023	0.0112
	White Clover (Trifolium repens)	0.0007	0.0034
	Lanceleaf Coreopsis (Coreopsis lanceolata)	0.0092	0.0448
	New England Aster (Aster novae-angliae)	0.0007	0.0036
	Partridge Pea (Cassia fasciculata)	0.0115	0.0560
	Purple Coneflower (Echinacea purpurea)	0.0046	0.0224
	Smooth Blue Aster (Aster azureus)	0.0004	0.0017
	Stiff Goldenrod (Solidago rigida)	0.0007	0.0034
	Virginia Mountain Mint (Pycnanthemum virginianum)	0.0002	0.0011
	Wild Bergamot (Monarda fistulosa)	0.0012	0.0056
	Annual Ryegrass (Lolium multiflorum)	0.6887	3.3625
6	Wildlife Mixture Use for slopes flatter than 2:1 and seeding for wildlife habitat mitigation.		
	Big Bluestem (Andropogon gerardii)	0.0445	0.2175
	Little Bluestem (Schizachyrium scoparium)	0.0617	0.3010
	Indiangrass (Sorghastrum nutans)	0.0445	0.2175
	Ox-eye Sunflower (Heliopsis helianthoides)	0.0617	0.3010
	Prairie Dock (Silphium terebinthinaceum)	0.0617	0.3010

Class	Mix Type Seeds	Weight per Area lb 1000 ft^2	 kg 1000 m^2
	Purple Coneflower (Echinacea purpurea)	0.0617	0.3010
	Whorled Rosinweed (Silphium trifoliatum)	0.0377	0.1840
	Downy Sunflower (Helianthus mollis)	0.0240	0.1171
	New England Aster (Aster novae-angliae)	0.0240	0.1171
	Annual Ryegrass (Lolium multiflorum) spring	0.6887	3.3625
7	Temporary Erosion Control Mixture		
	Annual Ryegrass (Lolium multiflorum)	2.02	9.86
	Fawn Tall Fescue (Festuca arundinacea)	3.0	14.64
CRP	CRP use for slopes under 2:1 and seeding for wildlife habitat mitigation.		
	Little Bluestem (Schizachyrium scoparium)	0.0344	0.1681
	Sand Dropseed (Sporobolus cryptandrus)	0.0011	0.0056
	Sideoats Grama (Bouteloua curtipendula)	0.0287	0.1401
	Switchgrass (Panicum virgatum)	0.005	0.0224
	Black-eyed Susan (Rudbeckia hirta)	0.002	0.0117
	Brown-eyed Susan (Rudbeckia triloba)	0.002	0.0078
	Culvers Root (Veronicastrum virginicum)	0.00004	0.0002
	False or Oxeye Sunflower (Heliopsis helianthoides)	0.0046	0.0224
	Grayhead Coneflower (Ratibida pinnata)	0.0014	0.0067
	Illinois Bundleflower (Desmanthus illinoensis)	0.0115	0.0561
	Lanceleaf Coreopsis (Coreopsis lanceolata)	0.0092	0.0448
	New England Aster (Aster novae-angliae)	0.0004	0.0018
	Partridge Pea (Cassia fasciculata)	0.0115	0.0561
	Purple Coneflower (Echinacea purpurea)	0.0046	0.0224
	Stiff Goldenrod (Solidago rigida)	0.0007	0.0033
	Wild Bergamot (Monarda fistulosa)	0.0011	0.0056
	Alsike Clover (Trifolium hybridum)	0.0011	0.0056
	Crimson Clover (Trifolium incarnatum)	0.0092	0.0448
	White Clover (Trifolium repens)	0.0011	0.0056
	Butterfly Milkweed (Asclepias tuberosa)	0.0007	0.0033
	Common Milkweed (Asclepias syriaca)	0.0007	0.0033
	Swamp Milkweed (Asclepias incarnata)	0.0007	0.0033
	Annual Ryegrass (Lolium multiflorum)	0.6887	3.3625
Wet Ditch/Swale	Wet Ditch/Swale use for slopes under 2:1 and seeding for wildlife habitat mitigation		
	Riverbank Wildrye (Elymus riparius)	0.1377	0.6725
	Alkaligrass (Puccinellia distans)	0.1377	0.6725
	Creeping Bentgrass (Agrostis stolonifera)	0.1240	0.6053
	Deertongue (Panicum clandestinum)	0.1171	0.5716
	Fowl Bluegrass (Poa palustris)	0.1033	0.5044
	Fox Sedge (Carex vulpinoidea)	0.0344	0.1681

	Soft Rush (Juncus effusus)	0.0207		0.1009
	Blunt Broom Sedge (Carex scoparia)	0.0069		0.0336
	Path Rush (Juncus tenuis)	0.0069		0.0336
	Annual Ryegrass (Lolium multiflorum)	0.6887		3.3625
Seasonally Flooded	Seasonally Flooded use for slopes under 2:1 and seeding for wildlife habitat mitigation			
	Deertongue, ‘Tioga’ (Panicum clandestinum , 'Tioga')	0.1010		0.4932
	Virginia Wildrye, PA Ecotype (Elymus virginicus , PA Ecotype)	0.0964		0.4708
	Big Bluestem, ‘Niagara’ (Andropogon gerardii , 'Niagara')	0.0781		0.3811
	Japanese Millet (Echinochloa crusgalli var. frumentacea)	0.0689		0.3363
	Fox Sedge, PA Ecotype (Carex vulpinoidea , PA Ecotype)	0.0459		0.2242
	Switchgrass. ‘Shawnee’ (Panicum virgatum , 'Shawnee')	0.0367		0.1793
	Partridge Pea, PA Ecotype (Chamaecrista fasciculata , PA Ecotype*)	0.0184		0.0897
	Showy Ticktrefoil (Desmodium canadense)	0.0046		0.0224
	Oxeye Sunflower, PA Ecotype (Heliopsis helianthoides , PA Ecotype)	0.0078		0.0381
	Spotted Joe Pye Weed, PA Ecotype (Eupatorium maculatum , PA Ecotype)	0.0023		0.0112
	Path Rush, PA Ecotype (Juncus tenuis , PA Ecotype)	0.0023		0.0112
	Swamp Milkweed, PA Ecotype (Asclepias incarnata , PA Ecotype)	0.0014		0.0067
	Annual Ryegrass (Lolium multiflorum)	0.6887		3.3625

659.10 Site Preparation. Before placing topsoil or seed, remove rock or other foreign material of 3 inches (75 mm) or greater in any dimension, from all areas except as listed below.

A. Remove stones 1-inch (25 mm) or greater in any dimension from all seed areas from in front of residences, commercial properties, etc.; between curb and sidewalks; or as shown on the plans.

B. Remove nothing in shale cuts but allow the shale to deteriorate to a soil type surface before seeding or placing topsoil.

C. For native seedings, treat any existing vegetation on the site that is to be seeded with herbicide before soil preparation to reduce any invasive vegetation. Follow the herbicide label to determine herbicide persistence in soil and the recommended waiting period between herbicide application and seeding.

Apply compost into the soil or topsoil separately to a depth of 6 to 8 inches (100 to 200 mm). Incorporate the commercial fertilizer, granular lime, chelated, buffered acid, or other soil amendments either separately or together, into the soil or topsoil to a depth of 2 to 4 inches (50 to 100 mm). Do not mix liquid lime or liquid chelated, buffered acid into the soil or topsoil. Only apply liquid lime or liquid chelated, buffered acid to the top of the soil or topsoil. Furnish a smooth surface for the seed or topsoil by tracking with a dozer or by other methods. If the site is inaccessible to a dozer and other methods do not provide results equivalent to hand raking, hand rake these areas. Ensure that the surface is uniform, free of gullies, rivulets, crusting, and caking. Finely grade the surface for seed or topsoil for slopes 4:1 or flatter, and grade all other slopes. Rake or open the surface with dozer cleats or otherwise loosen the surface of these areas to a depth of 1 inch (25 mm) immediately before covering with topsoil. Remove raked up material from the area.

659.11 Placing Topsoil. Place topsoil in loose lifts that construct a 6-8-inch (100 mm) compacted depth. The surface of the topsoil shall be such that the final grade as shown on the cross-sections is met. Use the following methods or combination of any of the methods to produce the required space to place the topsoil:

A. The 203 Items can be cut or placed to the final grade, which will match the plan quantities for Items 203, and then remove a 6ch (100 mm) thickness for the topsoil to be placed.

B. The 203 Items can be cut or placed to a 6-8-inch (100 mm) height below the final grade to allow for topsoil placement. There will be no change from the plan quantities in the 203 Items for this method.

Track the area with a dozer to compact and provide good contact between the topsoil and the surface.

The Contractor may place topsoil by using pneumatic, or hydraulic methods. If using pneumatic or hydraulic methods to place the topsoil for turfgrass seeding, the Contractor may place the top 1-inch (25 mm) with a mix of seed, commercial fertilizer, lime, chelated, buffered acid, and other soils amendments. This mixture will be 1 part compost and 2 parts topsoil. Do not apply mulch to this surface. The compost is the mulch.

659.12 Seeding Methods. Apply seed to prepared areas. If the prepared areas to be seeded become compacted before seeding, loosen the surface using disks, rakes, or other methods.

Thoroughly mix all seed, and evenly sow the seed over the prepared areas at the required rates. Do not sow seed during high winds. For slopes subject to windy conditions, seed using hydraulic methods only. Operate equipment in a manner to ensure complete coverage of the entire area to be seeded.

If broadcast seeding, seed Classes 1, and 2 , between August 15 to October 30. If necessary to seed Classes 1 or 2, , between March 1 and August 15, increase the seeding rates by 5 percent.

Between March 1 and October 30, the Contractor may use hydro seeding, which applies the mulch, seed, water, and commercial fertilizer in the same operation, for Classes 1, 2, , and 7.

Between October 30 and March 1, apply temporary seed according to Item SS832. With the Engineer's approval, the Contractor may apply permanent seed between October 30 and March 1 on projects started and completed within the same calendar year.

Seed before or concurrently with all required erosion control items.

Wildflower Classes 5, 6, CRP, IVM, Wet Ditch/Swale, and Seasonally Flooded mixtures seed from October 15 to November 15 and March 15 to May 15. If approved by the Engineer, frost seeding can occur between November 15 to March 15 .

Seed native grasses and wildflowers in Classes 5, 6, CRP, IVM, Wet Ditch/Swale, and Seasonally Flooded mixtures with a rangeland type, slit seeder or native seed drill. Seed native species with no less than two passes in perpendicular passes and by equally splitting the seed application rate to each pass.

When hydroseeding, use paper, straw, cotton, bonded fiber matrix (BFM), or flexible growth media mulch. The flexible growth media mulch and BFM shall be pourable mulch consisting of corn and paper. All mulch shall be applied at a low rate per manufacturers guidelines when seeding native species. Native species should be no more than ½ inch from surface. Hydroseed only with the engineer's approval. Do not use wood mulch, or products containing wood when seeding native seeds.

If broadcast seeding, perform the following, immediately after sowing, to provide good seed-soil contact:

A. For flat surfaces, lightly rake, cultipack, or roll.

B. Apply straw as specified in 659.15.

659.13 Mulching Operation. Mulch materials consist of straw, compost, or wood fiber for 3:1 or flatter slopes. The Contractor may specify which mulch to use if it is not shown on the plans. Use mulch that is reasonably free of weed seed, foreign materials, or other materials that would prohibit seed germination. Reference 659.13 for acceptable mulch materials for native seedings. Do not mulch during high winds. For slopes subject to windy conditions mulch using hydraulic methods only. Within 24 hours after seeding an area, evenly place mulch. Immediately replace mulch that becomes displaced.

659.14 Straw Mulch. Straw mulch consists of straw. Evenly place straw mulch over all seeded areas at the following rates:

Seeding Period	Rate
From March 15 to October 30	Class 1, 2, and 7: 2 tons per acre (0.5 metric ton/1000 m^2) Classes, 5 6, CRP, IVM, Wet Ditch/Swale, and Seasonally Flooded mixtures: 1 ton per acre (0.25 metric ton/1000 m^2)
From October 31 to March 14	Class 1, 2, and 7: (3 tons per acre (0.7 metric ton/1000 m^2) Classes, 5 6, CRP, IVM, Wet Ditch/Swale, and Seasonally Flooded mixtures: 2 tons per acre (0.5 metric ton/1000 m^2)

Keep straw mulching materials in place by applying tackifiers according to the manufacturer's recommendations. Apply an additional application at a rate of 30 gallons per ton (125 L/metric ton) of straw mulch to shoulder areas, starting at the berm edge and extending out for a distance of 10 feet (3 m). Use an emulsion that is nontoxic to plants and prepared in a manner that will not change during transportation or storage.

659.15 Wood Fiber Mulch. Wood fiber mulch consists of pure wood fibers manufactured expressly from clean wood chips. Ensure that the chips do not contain lead paint, varnish, printing ink, and petroleum-based compounds. Do not use wood fiber mulch manufactured from recycled materials of unknown origin such as sawdust, paper, cardboard, or residue from chlorine-bleached pulp and paper mills.

Wood fiber mulch is to be used solely for Class 1, 2, , and 7. For Classes, 5 6, CRP, IVM, Wet Ditch/Swale, and Seasonally Flooded mixtures refer to 659.13 for acceptable mulch types and depth.

Ensure that the wood fiber mulch maintains uniform suspension in water under agitation and blends with grass seed, commercial fertilizer, and other additives to form a homogeneous slurry. Use manufacturer-approved tackifiers.

Using standard hydraulic mulching equipment, evenly apply the slurry over the soil surface in a one-step operation. Apply slurry from March 1 to October 30 at the following rates:

Surface	Rate
Slopes 3:1 or flatter	46 pounds per 1000 square feet (225 kg/1000 m^2)

659.16 Compost Mulch. The Contractor may provide compost applied to a minimum depth of ¼-inch (6 mm) over the prepared seed areas. The Contractor may also mix the grass seed with the compost and using pneumatic equipment, place this mixture to a minimum depth of ¼-inch (6 mm) over the prepared seed areas. If seeding native species, do not exceed ½-inch (12 mm) in depth.

659.17 Erosion Matting. In lieu of hydromulching or hydroseeding on slopes 3:1 or greater, broadcast seed as specified in Table 659.10 and then apply erosion matting. Apply erosion matting following manufacturers specifications.

659.18 Watering. Thoroughly water all permanent seeded areas (Classes 1 to 6) after the seed has germinated. Apply a total rate of 300 gallons per 1000 square feet (12.2 m^3/1000 m^2) in at least 2 applications spread over 7 days. Apply the water using a hydro-seeder or a water tank under pressure with a nozzle that produces a spray that will not dislodge the mulch material.

Perform a secondary water application between 7 and 10 days after the primary applications. If 1/2-inch (13 mm) or greater of rainfall has occurred within the first 7-day period, the Contractor may delay or omit the secondary application, depending on weather conditions.

659.19 Maintenance. Maintain all seeded and mulched areas until final inspection. Repair damaged areas to the original condition and grade.

659.20 Mowing. The Engineer may require mowing before permanent seeding and during the growing season following permanent seeding. The Engineer will notify the Contractor of when to begin each mowing. Use suitable mowing equipment of the rotary, flail, disk, or sickle type. Use handheld equipment where inaccessible by larger equipment. Do not bunch or windrow mowed vegetation. Mow Classes 1 and 2, to a final cutting height of no less than 6 inches (150 mm). If necessary to achieve the cutting height, make more than one pass with the mower. When seeding Classes, 5, 6, CRP, IVM, Wet Ditch/Swale, and Seasonally Flooded mixtures, mow three times during the initial growing season. When vegetation is 18-24 inches tall, mow back to 6-8 inches.

659.21 Repair Seeding and Mulching. Repair all damage or erosion of the seeded and mulched areas before the completion of the project.

Rework or reshape slopes, and bring in additional material, as necessary, using whatever equipment is necessary to restore slopes to grade. Seed and mulch repaired areas according to this specification. As an alternative, the Contractor may apply compost to repair areas as specified in Item 659.

659.22 Inter-Seeding. Inter-seeding is seeding existing thin and spotty growing grass using a slit or drill type seeder. Perform inter-seeding only from March 15 to May 15 and from September 1 to October 15 for Class 1, 2 and 7; inter-seed March 15 to May 15 or October 15 to November 15 for Classes, 5 6, CRP, IVM, Wet Ditch/Swale, and Seasonally Flooded mixtures. If necessary to achieve good seed-soil contact, mow before seeding according to Item 65.

For seeding steep slopes or inaccessible areas, the Contractor may use broadcast or hydraulic seeding methods. Broadcast commercial fertilizer over affected areas as specified in Item 659. Water affected areas at the rate specified in 659 to aid in seed-soil contact.

659.23 Fertilization: 2nd Application. Once all repair seeding and mulching, and inter-seeding is complete and no earlier than 3 months after seeding, perform a Soil Analysis Test if shown on the plans to determine the need for a second application of commercial fertilizer for Class 1, and 2. Do not apply the second application of commercial fertilizer unless the grass has germinated. Broadcast commercial fertilizer of 12-12-12 evenly over the surface without incorporation at a rate of 10 pounds per 1000 square feet (0.05 kg/m^2). Do not apply fertilizer to Classes, 5 6, CRP, IVM, Wet Ditch/Swale, and Seasonally Flooded mixtures as this will encourage weed growth.

659.24 Performance. The Department will inspect all seeded areas no earlier than 6 months and no later than 12 months after final seeding. For any area identified without a uniform density of at least 70 percent grass cover, repair seeding and mulching as specified in 659 or perform inter-seeding as specified in 659.22, and fertilize as specified in this subsection.

Also repair seeding and mulching or perform inter-seeding, and fertilize seeded areas damaged by traffic or erosion, due to no fault or negligence of the Contractor.

659.25 Method of Measurement. The Department will measure Soil Analysis Test by the number of tests submitted to the Engineer.

The Department will measure the compacted topsoil by the number of cubic yards (cubic meters).

The Department will measure Commercial Fertilizer by the number of tons (kilograms) of each quantity of furnished, spread, and incorporated into the soil or topsoil. This measure will be converted to the standard application rate for the standard mixture ratio.

The Department will measure lime, liquid lime, or chelated, buffered acid by the number of acres (ha) furnished, spread, and incorporated into the soil or topsoil. The measure will be converted to the standard application rate for the standard mixture ratio.

The Department will measure Seeding and Mulching by the number of square yards (square meters).

The Department will measure Repair Seeding and Mulching by the number of square yards (square meters) of damaged or eroded areas reshaped, seeded, and mulched. If compost is substituted for mulch to repair areas, the Department will include such work under Repair Seeding and Mulching.

The Department will measure Water by the number of M gallons or 1000-gallon units (cubic meters) applied. The Department will measure water in tanks, tank wagons, or trucks of predetermined capacity, or by means of meters of a type satisfactory to the Engineer and furnished and installed by the Contractor at expense to the Department, or determined by weight conversion.

The Department will measure Inter-Seeding by the number of square yards (square meters) of the seeded area.

The Department will measure mowing by the number of M square feet (square meters) satisfactorily mowed.

If seeded areas are damaged by traffic or erosion, due to no fault or negligence of the Contractor, the Department will measure for such work and mobilization by Supplemental Agreement.

The Department will not measure for repairs to seeding and mulching if damage or erosion of the areas occurs as a result of fault or negligence of the Contractor.

659.26 Basis of Payment.

The Department will pay the plan quantity for compacted topsoil. The Department will not adjust topsoil quantities when the volume between two consecutive cross-sections differs by less than 5 percent from the plan quantity, unless the difference between the actual quantity and plan quantity is greater than 1000 cubic yards (1000 m³). For quantity differences greater than 5 percent or greater than 1000 cubic yards (1000 m³), submit supporting documentation to the Engineer.

The Department will pay the plan quantity for Seeding and Mulching. The Department will not adjust Seeding and Mulching quantities when the area between two consecutive cross-sections differs by less than 5 percent from the plan quantity, unless the difference between the actual quantity and plan quantity is greater than 20,000 square yards (20,000 m²) for all Seeding and Mulching pay items, combined.

For quantity differences greater than 5 percent or greater than 20,000 square yards (20,000 m²), submit supporting documentation to the Engineer.

The Department will pay for accepted quantities at the contract prices as follows (M=1000):

Item	Unit	Description
659	Each	Soil Analysis Test
659	Cubic Yard (Cubic Meter)	Topsoil
659	Ton (Kilogram)	Commercial Fertilizer
659	Acres (ha)	Lime
659	Acres (ha)	Chelated, buffered acid
659	Square Yard (Square Meter)	Seeding and Mulching
659	Square Yard (Square Meter)	Seeding and Mulching for Wildlife
659	Square Yard	Seeding and Mulching Class ____ (Square Meter)
659	Square Yard (Square Meter)	Repair Seeding and Mulching
659	M Gallons (Cubic Meters)	Water
659	Square Yard (Square Meter)	Inter-Seeding
659	M Square Feet (Square Meter)	Mowing

ITEM 660 SODDING

660.01 Description
660.02 Materials
660.03 Lifting Sod
660.04 Preparation of Areas to be Sodded
660.05 Placing Sod on Slopes 3 to 1 or Flatter
660.06 Placing Sod on Slopes Steeper Than 3 to 1 But Flatter Than 2 to 1
660.07 Placing Sod in Ditches
660.08 Placing Reinforced Sod On Slopes 2 to 1 or Steeper
660.09 Watering
660.10 Method of Measurement
660.11 Basis of Payment

660.01 Description. This work consists of furnishing, hauling, excavating for and preparing the bed, and placing sod.

660.02 Materials. Furnish sod consisting of well-rooted Kentucky Blue Grass (Poa pratensis) or Canadian Blue Grass (Poa compressa) containing a growth of not more than 30 percent of other grasses and clovers, and free from all noxious weeds such as wild mustard, thistles, quack grass, and Johnson grass, and reasonably free from dandelions and crab grass.

Appendix I: Product Labels

ProPlus®

Aqua-pHix™ Spray Formula

• Quickly decreases pH of soil solution • Unlocks calcium and nutrients in soil for better plant uptake • Flushes unwanted salts and bicarbonate • Improves water penetration • Non-corrosive formula is ideal for spray application

DIRECTIONS FOR USE

Have water pH and mineral content analyses conducted by a reputable lab. Use rate chart below to calculate appropriate application rate. Apply and immediately irrigate to field capacity to flush salts. May be applied monthly or as necessary to maintain desired salt and bicarbonate levels. Allow newly seeded areas to establish prior to applying Aqua-pHix. Do not tank mix with pesticides, fertilizers and/or JumpStart™. Aqua-pHix will not harm sprayer parts including copper, brass and aluminum except where zinc is present.

TYPICAL APPLICATION RATES*

Minimum dilution rate 25 parts water: 1 part Aqua-pHix

50 Bicarbonate ppm	1 gal/acre
100 Bicarbonate ppm	2 gal/acre
200 Bicarbonate ppm	4 gal/acre
300 Bicarbonate ppm	6 gal/acre
400 Bicarbonate ppm	8 gal/acre
450 Bicarbonate ppm	9 gal/acre

*Based on irrigation water hardness. Apply 1-9 gal in 50-450 gal of water per acre for optimal dilution of 50 parts water:1 part Aqua-pHix.

PHYSICAL CHARACTERISTICS

Dispersibility	Water
pH	< 1
Freezing Stability	Store above 0°F

Active Ingredients: 10% Hydrochloric Acid, 10% Phosphoric Acid, 1% Oxalic Acid, 1% Citric Acid, 78% Water

Profile warrants that this product consists of the ingredients specified and is reasonably fit for the purposes referred to in the directions. Profile makes no other express or implied warranty. In no case shall Profile or seller be liable for consequential, special or indirect damages resulting from the use or handling of this product, and no claim of any kind shall be greater in amount than the purchase price of the product.

CAUTION: Keep out of reach of children. Harmful if swallowed. Avoid inhalation, eye contact or ingestion. Prolonged or repeated contact with skin may cause irritation. Wash thoroughly after handling. Non-corrosive.

PROFILE Products LLC
750 Lake Cook Road • Suite 440 • Buffalo Grove, IL 60089 • (800) 207-6457 • www.profileproducts.com

NET CONTENTS 2.5 GAL (9.46 L) • NET WEIGHT 22 LB (10 KG)

Specification Sheet

Verdyol Biotic Earth Black

Product Description:

Verdyol Biotic Earth Black is specifically designed to assist in the creation of a suitable growth medium for establishing vegetation over poor and deficient soil. It is also designed to speed up the vegetation establishment and full expression, as well as increases the survivability of vegetation where used. This product is designed for hydraulic application, but dry application (hand spreading) is also acceptable.

For Use on Sites Where:

- Soil tests show less than 5% organic material
- Where topsoil intended for revegetation has been stockpiled for extended periods or is of less than ideal quality
- As a replacement for compost or other soil improvement methods
- Steep slopes or other site conditions make installation of topsoil or compost difficult
- Where fast establishment of vegetation is required

Please note: Verdyol Biotic Earth Black is a soil improvement product so an adequate and separate erosion control product (RECP, TRM, or Hydraulic) is recommended for site protection.

Performance Properties			
Vegetation Establishment and Germination Improvement	ASTM D7322*	%	1502%
Average Plant Height	ASTM D7322*	%	308%
Plant Mass per Area	ASTM D7322*	%	419%
Material and Environmental Properties			
Organic Material	ASTM D586	%	>95
Water Holding Capacity	ASTM D7367	%	1020%
pH	Saturated Media Extract Method	n/a	6 +/- 1
C:N Ratio	Independent laboratory	n/a	35:1 (+/- 10)
Natural Material Color (Dye Free)	Observed	n/a	Dark Brown/ Black
Moisture Content	Independent laboratory	%	30.50%
Acute Toxicity	EPA TM 2002.0	na	100% Non Toxic
Foreign Seed Content	Viability Analysis	%	0%
Product Composition			
Professional Grade Peat Moss		%	57%
Thermally and Mechanically Processed Straw and Flexible Flax Fiber		%	40%
Trace Minerals, Plant Based Biodegradeable co-polymer, sugars, starches, proteins, and 16 amno acids (including folic acid, vitamin A, and tricontanol growth stimulants/ regulators)		%	2%
Multiple Species of Both Mycorrhizae and Beneficial Bacteria		%	1%
Material Viability			
Biotic Earth moisture content ensures microbial viability in excess of 75% for two years from date of manufacture.			
Packaging Properties			
Bag Weight	Scale	kg (lb.)	22.7 (50)
Bags per Pallet	Observed	#	42
UV and weather resistant bags. Pallets are weather proof stretch wrapped with a UV resistant pallet cover. Dates on manufacture listed per bag			
*percentages are the average of 7, 14, and 21 day results of ASTM D7322			
To the best of our knowledge the information contained herein is accurate. However, ECBVerdyol cannot assume any liability whatsoever for the accuracy or completeness thereof.			

BIOTIC EARTH INSTALLATION AND MIXING GUIDE

A mechanically agitated hydroseeder is recommended for the most effective application of Biotic Earth Black BSA. Read, understand, and follow all instructions and safety requirements for the hydroseeding equipment and materials.

Depending on site-specific conditions, and for the most effective application and performance, use a two-step, multidirectional application process to maximize performance and reduce the potential for shadowing. Please contact ECBVerdyol for site-specific recommendations. Standard application rates for most sites consists of applying 3500 pounds of Biotic Earth Black BSA per acre.

MIXING

1. Fill hydroseeder tank with water to a level where the paddles are ¼ covered and may be activated.
2. Activate the mechanical agitation system.
3. Prime pump and any discharge hoses before adding any amendments, soil stabilizer/tackifier, or Biotic Earth.
4. Add the appropriate amount and type of Tackifier as recommended for the site-specific application. Allow Tackifier and water to mix for 5 minutes prior to adding Biotic Earth.
5. Suggested mixing ratio is 1-50lb. bale Biotic Earth with 40 gallons of water.
6. Continue filling tank with water to approximately ¾ full and begin adding bags of Biotic Earth.
7. All quantity of Biotic Earth should be added before the water level reaches 85% of the tank's capacity.
8. Add seed and/or other amendments to slurry as required.
9. Completely fill tank with water and allow slurry to mix for a minimum of 5 minutes or until all Biotic Earth is mixed into a consistent slurry.

APPLICATION

1. Prior to application and mixing of the mulch it is recommended that the site be measured and marked to verify area to ensure appropriate seed, amendment, and Biotic Earth application rates.
2. Bring hydroseeder to appropriate operating speed and agitator speed for slurry application.
3. Apply in a consistent and even manner across soil surface.
4. Apply from opposite directions, if possible, to ensure the highest level of coverage, effectiveness, and performance.
5. If you need to stop spraying at anytime, close the spray nozzle at the end of the hose to avoid water draining from the hose. If you are using a tower applicator, stop normally and upon restart remove the spray tip, discharge a small amount of Biotic Earth, replace the tip and return to applying the product.

CLEANING AND STORAGE

Clean equipment per the equipment manufacturer's recommendations.
Store all Verdyol Biotic Earth materials in a cool dry place away from open flames.

ECBVERDYOL

BIOTIC EARTH TANKLOAD GUIDE

Biotic Earth™ Tankload Application:
40 gallons of water for every 50 lb bag,
applied at 3,500 lbs/AC in all conditions.

TANK SIZE	NUMBER OF BAGS LOADED PER TANKLOAD	TOTAL LBS OF BIOTIC EARTH PER TANKLOAD	TANKLOADS REQUIRED PER ACRE, REGARDLESS OF SLOPE OR ORGANIC MATTER CONTENT
250	6	300	11.6
500	12	600	5.8
750	28	900	3.8
1,000	25	1,250	2.8
1,500	37	1,850	1.9
2,500	62	3,100	1.1
3,000	75	3,750	0.9
3,500	87	4,350	0.8
4,000	100	5,000	0.7

Biotic Earth: more bags per tank, lower per-acre application rate, easier application rate to calculate, and fewer tank loads required per acre!
Other Products: fewer bags per tank, more difficult to calculate. (Due to variable application rate. Requires more tankloads and product per acre.)

11-52-0 *MONOAMMONIUM PHOSPHATE*

LESCO® ELITE® PROFESSIONAL STARTER FERTILIZER

For use in Rotary Spreaders Only

50 lb COVERS 26,000 sq ft SGN 100

DIRECTIONS FOR USE: This LESCO product is a professional quality turf fertilizer for use on fairways, tees, and other turf. The best results with this product are obtained when it is applied to dry turf and actively growing grass. Water into the turf soon after application. Avoid mowing immediately following application to prevent pick-up.

For best results, sweep or blow the fertilizer off walks and painted surfaces following application to avoid discoloration.

Do not apply near water, storm drains or drainage ditches. Do not apply if heavy rain is expected. Apply this product only to your lawn and sweep any product that lands on the driveway, sidewalk or street, back onto your lawn.

For use as a phosphorus supplement on existing lawns to correct a soil deficiency or as a starter fertilizer in lawn establishment.

According to state law in Maryland, this product may not be applied at an application rate of more than 0.7 lbs. Nitrogen per 1,000 sq. ft.

For additional LESCO, Inc. product assistance call 1-800 347-4272.

COVERAGE: 50 pounds of LESCO 11-52-0 Fertilizer covers approximately 26,000 sq ft at the application rate of one pound of phosphate (2.0 pounds of fertilizer) per 1,000 sq ft.

GUARANTEED ANALYSIS

TOTAL NITROGEN (N).....11.00%
11.00% Ammoniacal Nitrogen
AVAILABLE PHOSPHATE (P_2O_5).....52.00%

DERIVED FROM: Monoammonium Phosphate.

ROTARY SPREADER SETTINGS: Apply LESCO Fertilizers and Combination Products only with a rotary spreader. The following rotary spreader settings are approximate for the application rates of one pound of phosphate per 1,000 square feet. You may need to adjust the setting depending on walking speed, spreader condition and product. An extended Spreader Setting listing can be found at www.lesco.com.

ROTARY SPREADER	SETTINGS 0.5 lb	1.0 lb
LESCO Calibration Gauge	#7	#9
PermaGreen	#7	#9
Cyclone® or Spyker®	2¼	2¾
LESCO Pendulum	-	13
Lely®	-	2½ II

This fertilizer contains phosphorus and may not be used on turf in the state of Maryland or Virginia except when 1) Providing nutrients to specific soils and target vegetation as determined to be necessary in accordance with a soil test that was conducted by a laboratory identified under § 8-803.7 of the Agriculture Article, Annotated Code of Maryland, performed no more than 3 years before the application; 2) Establishing vegetation for the first time, such as after land disturbance, provided the application is conducted in accordance with the recommended application rates established by the State; or 3) Reestablishing or repairing a turf area

WARNING

Harmful if inhaled. Eye and skin irritant. Avoid breathing dust. Avoid contact with skin, eyes, or clothing. Wash thoroughly with soap and water after handling.

CONDITION OF SALE AND LIMITATION OF WARRANTY AND LIABILITY

NOTICE: Read the entire Directions for Use and Conditions of Sale and Limitation of Warranty and Liability before buying or using this product. If the terms are not acceptable, return the product at once, unopened, and the purchase price will be refunded.

The Directions for Use of this product must be followed carefully and completely. It is impossible to eliminate all risks inherently associated with the use of this product. Buyer and/or User assume all risks of ineffectiveness or other unintended consequences or damages that may result from conditions outside or beyond the control of LESCO, Inc. including but not limited to such factors as manner of use or application, weather or weather conditions outside the range considered normal at the application site or for the time period in which the product is applied, the, presence of other materials, incompatible products, or other influencing factors which are beyond the control of LESCO, Inc.. All such risks shall be assumed by Buyer and/or User, and Buyer and/or User agrees to hold LESCO, Inc. harmless for any claims relating to such factors.

LESCO, Inc. warrants that this product conforms to the chemical description on the label and is reasonably fit for the purposes stated in the Directions for Use, subject to the inherent risks referred to above, when used in accordance with the Directions for Use under normal use conditions. This warranty does not extend to the use of this product contrary to label instructions, or under abnormal conditions or under conditions not reasonably foreseeable to or beyond the control of LESCO, Inc. and Buyer and/or User assume the risk of any such use.

LESCO, INC. MAKES NO WARRANTIES OF MERCHANTABILITY OR OF FITNESS FOR A PARTICULAR PURPOSE NOR ANY OTHER EXPRESS OR IMPLIED WARRANTY EXCEPT AS STATED ABOVE.

THE EXCLUSIVE REMEDY OF THE BUYER AND/OR USER AND THE EXCLUSIVE LIABILITY OF LESCO, INC. FOR ANY AND ALL CLAIMS, LOSSES, INJURIES OR DAMAGES (INCLUDING CLAIMS BASED ON BREACH OF WARRANTY, CONTRACT, NEGLIGENCE, TORT, STRICT LIABILITY OR OTHERWISE) RESULTING FROM THE USE OR HANDLING OF THIS PRODUCT, SHALL BE THE RETURN OF THE PURCHASE PRICE OF THE PRODUCT OR, AT THE ELECTION OF LESCO, INC. REPLACEMENT OF THE PRODUCT, OR IF NOT ACQUIRED BY PURCHASE, REPLACEMENT OF SUCH QUANTITY. IN NO EVENT SHALL LESCO, Inc., BE LIABLE FOR ANY INCIDENTAL, CONSEQUENTIAL OR SPECIAL DAMAGES.

LESCO, Inc. offers this product, and Buyer and/or User accepts it, subject to the foregoing Conditions of Sale and Limitation of Warranty and Liability, which may not be modified except by written agreement signed by a duly authorized representative of LESCO, Inc.

Information concerning the raw materials composing this product can be obtained by writing to: LESCO, Inc., Attn: RA Dept, 1385 East 36th Street, Cleveland, Ohio 44114-4114, referring to the item number found on this bag.

Information regarding the contents and levels of metals in this product is available on the Internet at http://www.aapfco.org/metals.htm.

N:\Regulatory\WP\Regul Private\MstrLbl_ERIEVIEW ADDRESS\Landscape Style Master Lbls\Fertilizer Labels
Rev. 11/15/17 VT

510412
PP

F1560

Net Weight 50 lb (22.7 kg)

Manufactured for: **LESCO, Inc.**
1385 East 36th Street
Cleveland, OH 44114-4114

Tornado Tack

ST-1000

WOOD CELLULOSE TACKING AGENT FOR OVERSPRAYING AND TACKING STRAW

INSTALLATION GUIDELINES

Straw Tacking:

Mix Tornado Tack™ ST-1000 at a rate of 65-70 pounds (29-32 kg) per 100 gallons (379 L) of water in hydroseeding tank. Confirm loading rates with equipment manufacturer.

APPLICATION RATE GUIDELINES

Hay and Straw Mulch Binder: 500 lb/acre (560 kg/ha)

Strictly comply with equipment manufacturer's installation instructions and recommendations. Use approved hydro-spraying machines with fan-type nozzle (50-degree tip is preferred for maximum fiber distribution and coverage).

PRODUCT COMPOSITION

NON PLANT FOOD INGREDIENTS

Wood Cellulose Fiber	95%	Crimped, Man-Made Biodegradable Interlocking Fibers	1%
Organic Biopolymers	3%	Porous Ceramic Particles	1%

Profile®

Solutions for your Environment™

NET WEIGHT 50 LB (22.7 KG)

MADE IN U.S.A.

WARRANTY

PROFILE PRODUCTS LLC ("Profile") represents and warrants that its products are manufactured in accordance with the product's specifications and that its products, at the time of delivery to the purchaser, shall be free from all material defects. In the event of a breach of the foregoing warranty, Profile's sole obligation shall be, at its option, to refund the purchase price or to provide products which conform to this warranty, so long as any deficiencies are reported to Profile within thirty (30) days after discovery thereof, but in no event later than one (1) year after the date of manufacture. ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, BY LAW OR OTHERWISE, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, ARE DISCLAIMED. FURTHER, IT IS UNDERSTOOD AND AGREED THAT PROFILE'S LIABILITY SHALL NOT EXCEED THE RETURN OF THE AMOUNT OF THE PURCHASE PRICE PAID BY PURCHASER AND UNDER NO CIRCUMSTANCES SHALL PROFILE BE LIABLE FOR SPECIAL, INDIRECT, INCIDENTAL, CONSEQUENTIAL OR PUNITIVE DAMAGES. Products for which a warranty claim is made are to be returned transportation prepaid to Profile's factory. Any use not in accordance with product directions and precautionary statements, and any modifications or additives to the products, or any adulteration, dilution or alteration by the purchaser shall void this warranty. No employee or representative of Profile is authorized to change this warranty in any way or to grant any other warranty.

Appendix J: Tested Seed Mix Application Methods

Table 8: Tested Seed Mix Application Methods

Site Name	District	County	Test Type	Drill Seeder	Broadcast	Hydromulch
Fenceline 1	3	Ashland	Fenceline	• All Ohio CRP • Class 6	• Class 2	• All Ohio CRP • Class 6 • Class 2
Fenceline 2	12	Cuyahoga	Fenceline	• All Ohio CRP • Class 6	• Class 2	• All Ohio CRP • Class 6 • Class 2
Fenceline 3	7	Montgomery	Fenceline	• All Ohio CRP • Class 6	• Class 2	• All Ohio CRP • Class 6 • Class 2
Roadside 1	3	Ashland	Roadside	• N/A	• Freedom II • Class 3B • Class 2	• Freedom II • Class 3B • Class 2
Roadside 2	12	Geauga	Roadside	• N/A	• Freedom II • Class 3B • Class 2	• Freedom II • Class 3B • Class 2
Roadside 3	12	Geauga	Roadside	• N/A	• Freedom II • Class 3B • Class 2	• Freedom II • Class 3B • Class 2
Slope 1	3	Ashland	Slope 43%	• N/A	• Ohio IVM • Class 5B • Class 2	• Ohio IVM • Class 5B • Class 2
Slope 2	3	Ashland	Slope 31%, 39%	• N/A	• Ohio IVM • Class 5B • Class 2	• Ohio IVM • Class 5B • Class 2
Slope 3	10	Athens	Slope 35%	• N/A	• Ohio IVM • Class 5B • Class 2	• Ohio IVM • Class 5B • Class 2
Wet Ditch 1	12	Cuyahoga	Wet Ditch	• N/A	• Wet Ditch/Swale • Seasonally Flooded • Class 2	• Wet Ditch/Swale • Seasonally Flooded • Class 2
Wet Ditch 3	4	Summit	Wet Ditch	• N/A	• Wet Ditch/Swale • Seasonally Flooded • Class 2	• Wet Ditch/Swale • Seasonally Flooded • Class 2

Appendix K: Seed Mix, Methodology, and Seed Installation Timing

Seed Installation Timing

During the seeding process in 2019, each seed installation was timed to determine which seeding methodology was the fastest to complete. The seeding methodology with the fastest time was hydromulching, and broadcast seeding was the slowest method tested in the study (Figure 7, Figure 8, Figure 9, Figure 10). All results for the Fenceline test types had statistically significant differences for average seed application time between broadcast and drill seeding (Tukey test; p-value = 0.0006), broadcast seeding and hydromulching (Tukey test; p-value < 0.0001), and drill seeding and hydromulching (Tukey test; p-value = 0.0006) application methods. Roadside test types showed a statistically significant difference for average seed application time between broadcast seeding and hydromulching application methods (Tukey test; p-value < 0.0001). Slope test types showed a statistically significant difference for average seed application time between broadcast seeding and hydromulching application methods (Tukey test; p-value < 0.0001). Wet Ditch test types showed a statistically significant difference for average seed application time between broadcast seeding and hydromulching application methods (Tukey test; p-value < 0.0001).

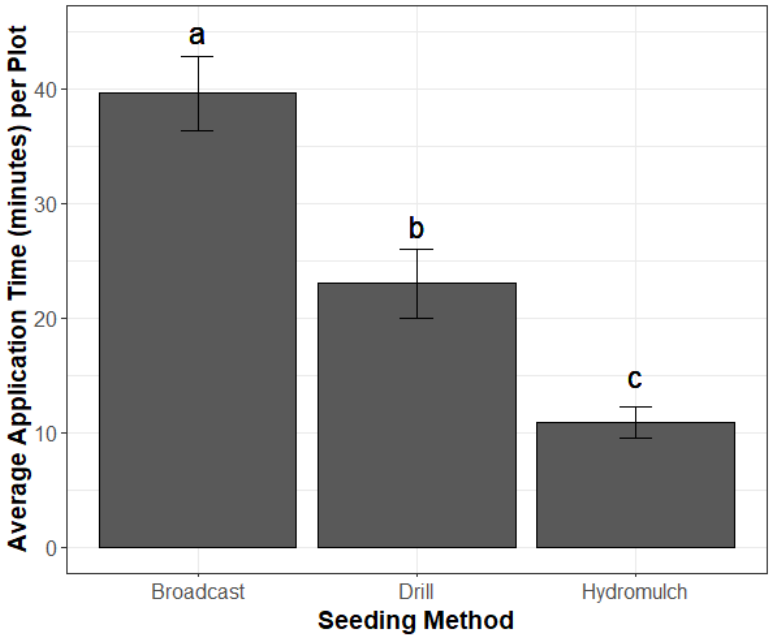


Figure 7. Average seed application time (minutes) per plot for each seeding method for Fenceline sites. Bars sharing a common letter are not significantly different. Error lines are standard errors around the mean values.

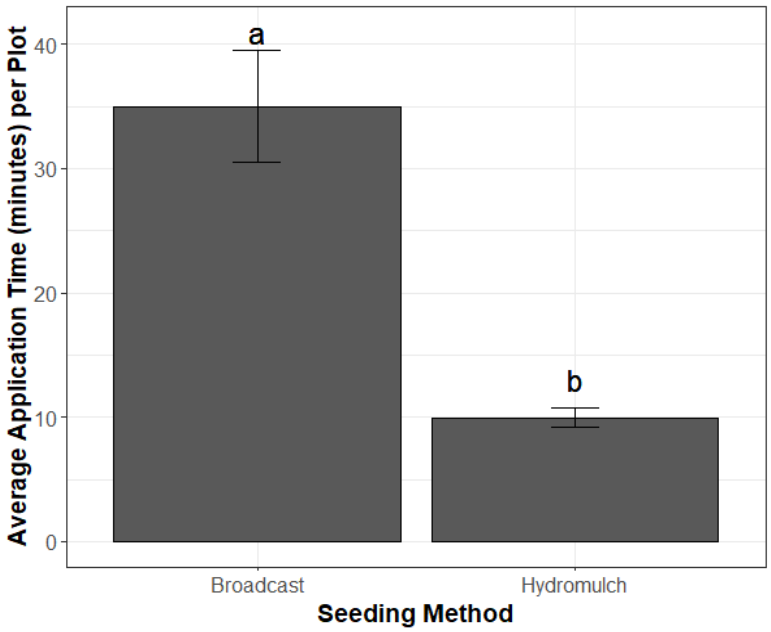


Figure 8. Average seed application time (minutes) per plot for each seeding method for Roadside sites. Bars sharing a common letter are not significantly different. Error lines are standard errors around the mean values.

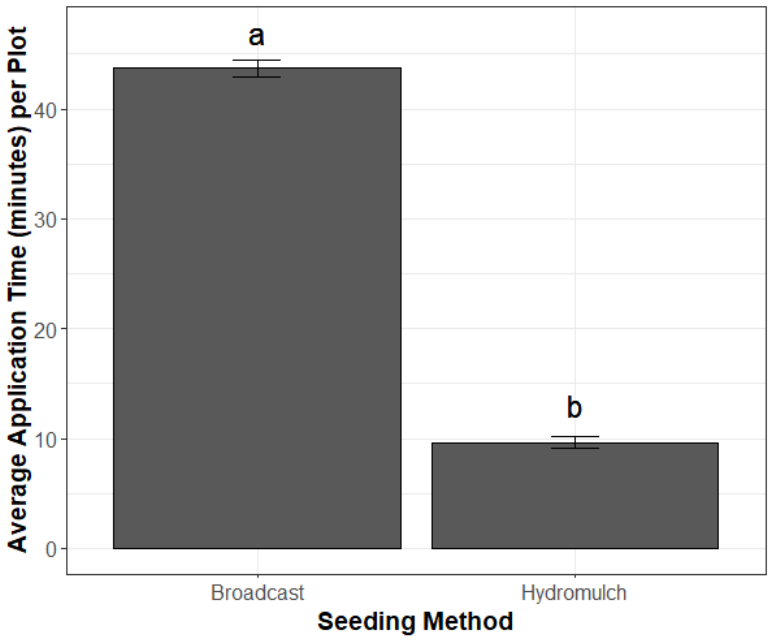


Figure 9. Average seed application time (minutes) per plot for each seeding method for Slope sites. Bars sharing a common letter are not significantly different. Error lines are standard errors around the mean values.

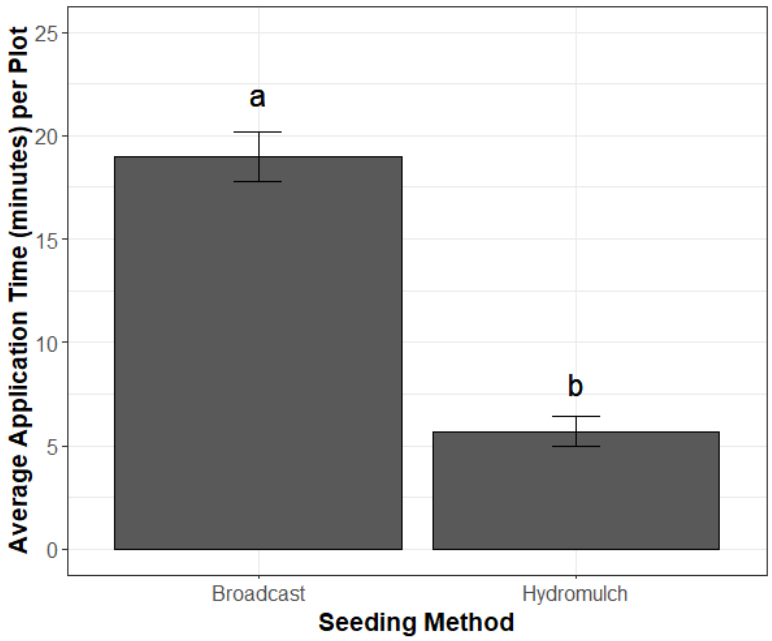


Figure 10. Average seed application time (minutes) per plot for each seeding method for Wet Ditch sites. Bars sharing a common letter are not significantly different. Error lines are standard errors around the mean values.

The results of the seeding methodology timing indicate that hydromulching is a quick seeding methodology that can be utilized across all site types.

Seed Mix and Methodology

The chart below details the average seeded and volunteer vegetation coverage across all site types by the end of year 3. Class 2 seed mix had higher percent coverage in Roadside, Slope and Wet Ditch site types, and lower percent coverage in Fenceline site types. The seed bank had a heavy impact on the germinated species, as indicated in the chart below (Figure 11).

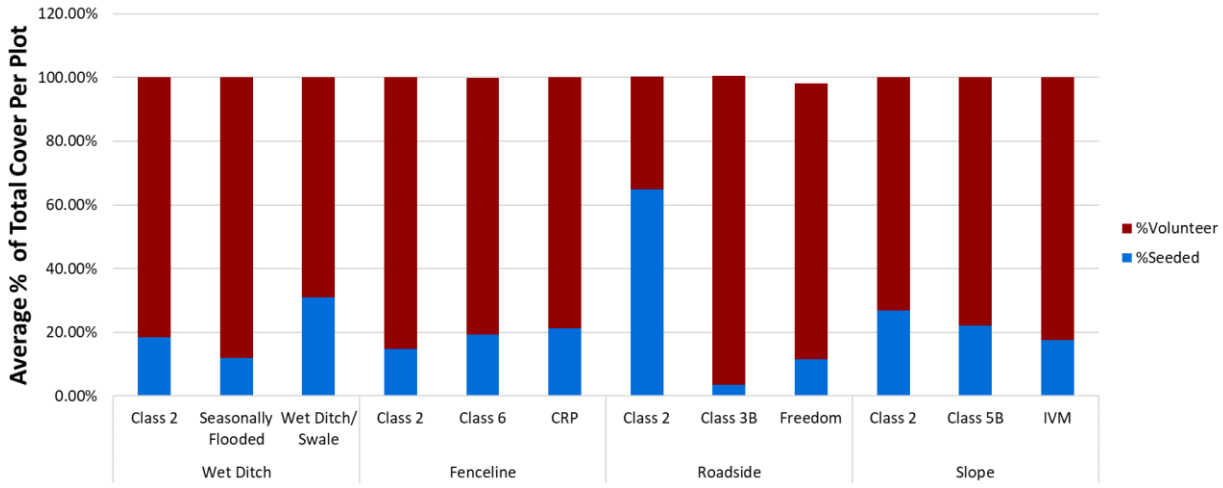


Figure 11. Average percent of total plant coverage per plot for seeded and volunteer species for each seed mix and test type for the final evaluation of 2022.

Fenceline

The Fenceline type tests were seeded with Class 2 (ODOT, control), Class 6 (ODOT), and CRP (Pheasants Forever) seed mixes. The last two seed mixes are composed primarily of native species, with Class 2 being turfgrass. The plots included in this site type were seeded using broadcast (Class 2), drill seeding (Class 6 and CRP), and hydromulching (Class 2, Class 6, CRP) methods. The resulting input from the seedbank led to a large proportion of seeded and volunteer native species present in the Fenceline plots (Figure 12). There was no statistical significance between the application methods or seed mixes in regards to native species percent cover.

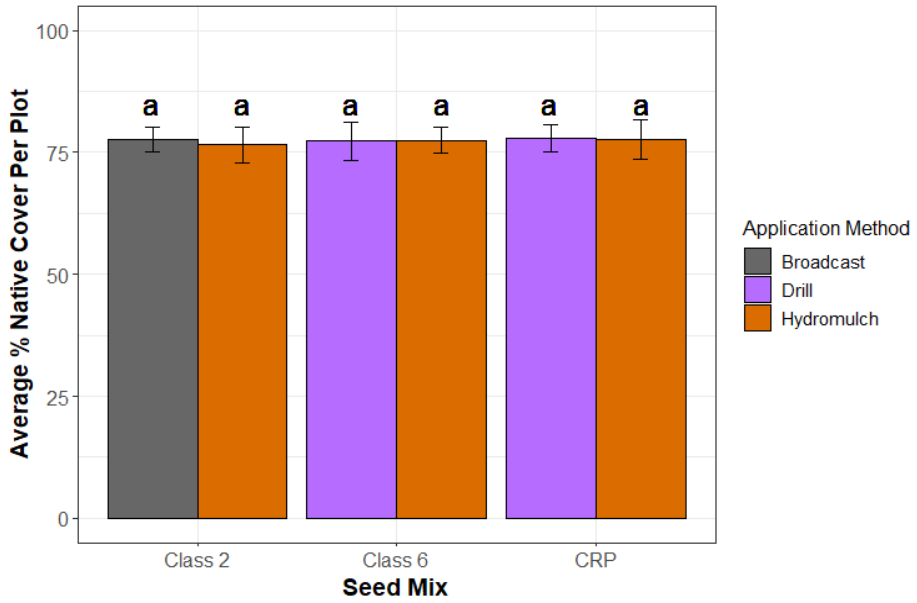


Figure 12. Average percent native plant coverage (within total plant coverage) per plot for each seed mix and application method for Fenceline sites across all 2020-2022 sampling dates. Bars sharing a common letter are not significantly different.

All of the seeding methods and seed mixes demonstrated a similar germination rate for Fenceline site types (Figure 13). There was an increase (not statistically significant) in percent cover on sites that were hydro-mulched with the CRP seed mix or broadcast seeded with the Class 2 seed mix.

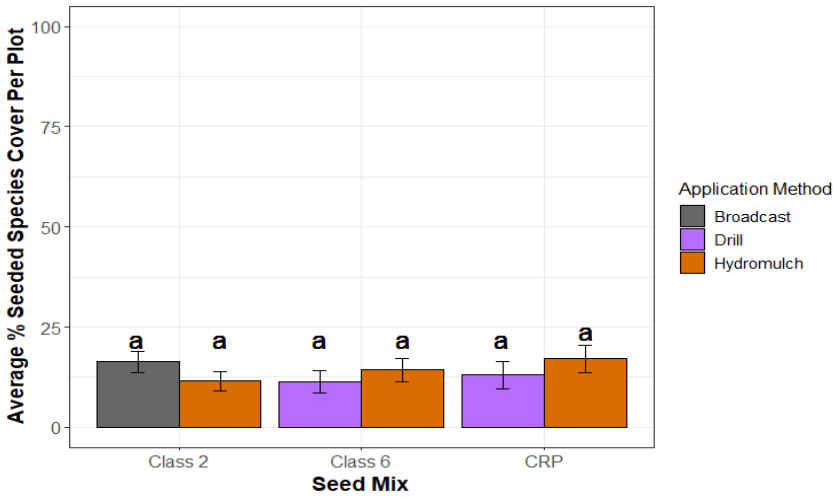


Figure 13. Average percent seeded species cover per plot (within total plant coverage) for each seed mix and application method for Fenceline sites across all 2020-2022 sampling dates. Bars sharing a common letter are not significantly different.

Roadside

The Roadside type tests were seeded with the Class 2 seed mix (ODOT, control), Class 3B seed mix (ODOT), and Freedom mix (OPN). Each of these seed mixes were turfgrass. The plots included in this site type were seeded using broadcast and hydromulching methods. The resulting input from the seedbank led to a large proportion of native species present in the Roadside plots, with a large proportion of these species being volunteer species (Figure 14). There was no statistical significance between the application methods or seed mixes in regards to native species percent cover.

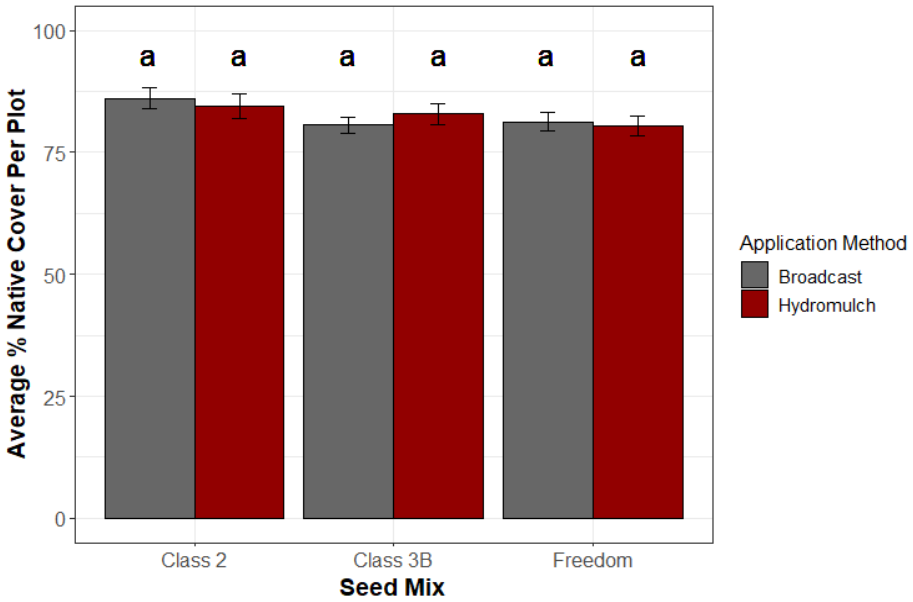


Figure 14. Average percent native plant coverage (within total plant coverage) per plot for each seed mix and application method for Roadside sites across all 2020-2022 sampling dates. Bars sharing a common letter are not significantly different.

There were no significant differences in application methods within the seed mixes for percent seeded species cover (Figure 15). However, there was a significant difference (p-value <0.0001) between the Class 2 seeded species percent cover when compared to the seeded species presence of the plants seeded in the Class 3B and Freedom seed mixes. The data indicates that Class 2 seed mix is a better fit along roadsides within the DOT ROW. Due to the nature of the habitat, and the species included in the seed mixes, the possibility of misidentification of *Festuca* species is possible, and may have skewed the results of Class 3B and Freedom seed mixes.

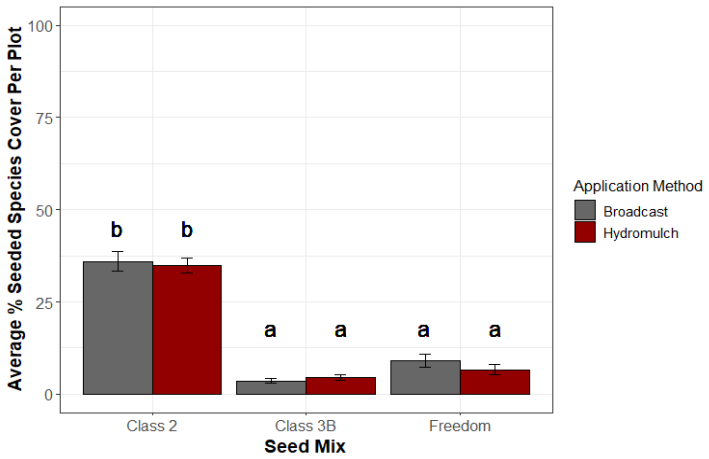


Figure 15. Average percent seeded species cover per plot (within total plant coverage) for each seed mix and application method for Roadside sites across all 2020-2022 sampling dates. Bars sharing a common letter are not significantly different.

Slope

The Slope type tests were seeded with Class 2 (ODOT, control), Class 5B (ODOT), and IVM (Pheasants Forever) seed mixes. The last two seed mixes are composed primarily of native species, with Class 2 being turfgrass. The plots included in this site type were seeded using broadcast and hydromulching methods. The resulting input from the seedbank led to a large proportion of seeded and volunteer native species present in the Slope plots (Figure 16). There was no statistical significance between the application methods or seed mixes in regards to native species percent cover.

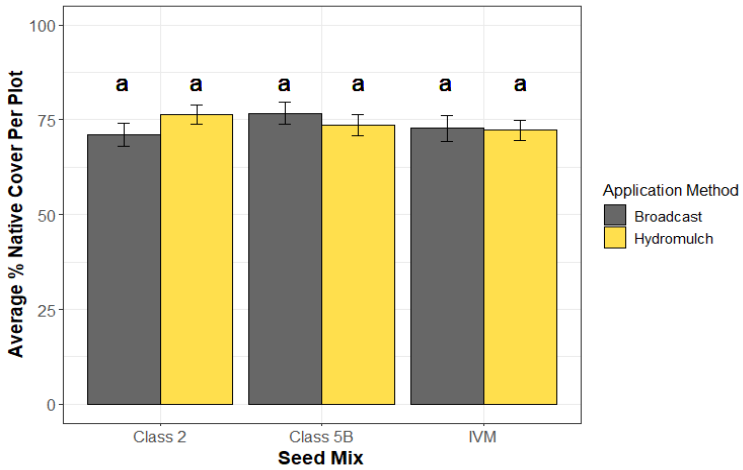


Figure 16. Average percent native plant coverage (within total plant coverage) per plot for each seed mix and application method for Slope sites across all 2020-2022 sampling dates. Bars sharing a common letter are not significantly different.

The statistical significance between IVM (broadcast and hydro-mulch) and Class 2 (hydro-mulch) seed mixes for percent seeded species cover indicates that Class 2 (hydro-mulch) would yield greater seeded species cover on average compared to the IVM (broadcast and hydro-mulch) seed mix. There is no statistically significant difference between seeding methodologies within seed mixes, however, there is a significant statistical difference between Class 2 (hydro-mulch) and Class 5B (broadcast) seed mixes (Figure 17).

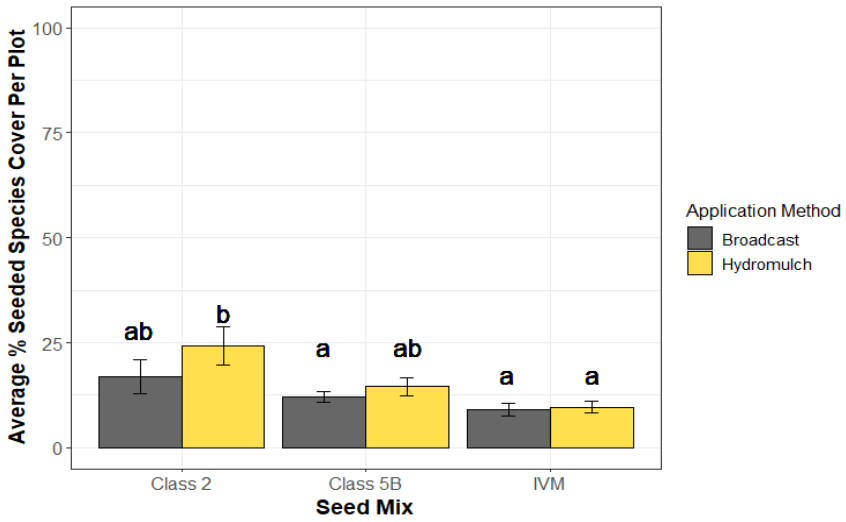


Figure 17. Average percent seeded species cover per plot (within total plant coverage) for each seed mix and application method for Slope sites across all 2020-2022 sampling dates. Bars sharing a common letter are not significantly different.

Wet Ditch

Wet Ditch site types were seeded with Class 2 (ODOT, control), Seasonally Flooded (DRG), and Wet Ditch/Swale seed mixes (DRG). The plots included in this site type were seeded using broadcast and hydromulching methods. There was no statistical significance between the application methods or seed mixes in regards to native species percent cover (Figure 18).

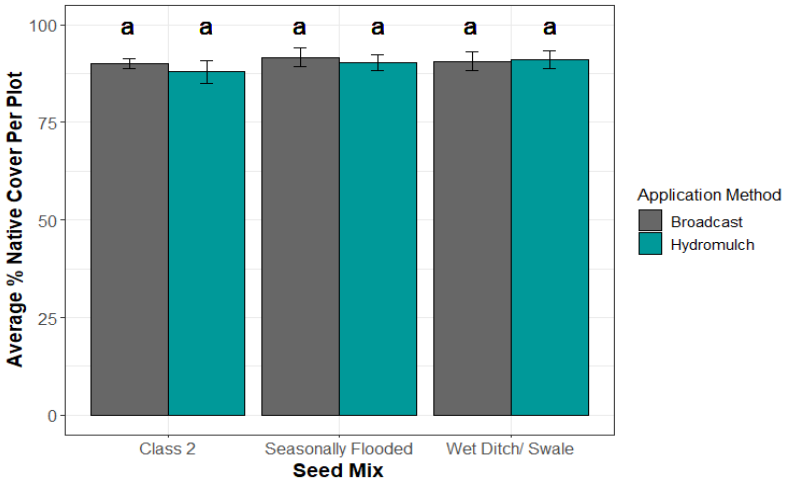


Figure 18. Average percent native plant coverage (within total plant coverage) per plot for each seed mix and application method for Wet Ditch sites across all 2020-2022 sampling dates. Bars sharing a common letter are not significantly different.

All of the seeding methods and seed mixes demonstrated a similar germination rate for Wet Ditch site types. There was an increase (not statistically significant) in germination on sites that were broadcast seeded with the Wet Ditch/Swale seed mix (Figure 19). The results of the seed mixes and methodologies used during this study indicate that broadcast seeding and hydromulching of Class 2, Seasonally Flooded and Wet Ditch/Swale seed mixes will allow for similar results during post-construction seeding. This is due to the slight (not statistically significant) increase in seeded species found in the Wet Ditch/Swale seed mix. In addition, while not statistically significant, the Seasonally Flooded seed mix showed a reduced growth when compared to Class 2 and Wet Ditch/Swale seed mixes.

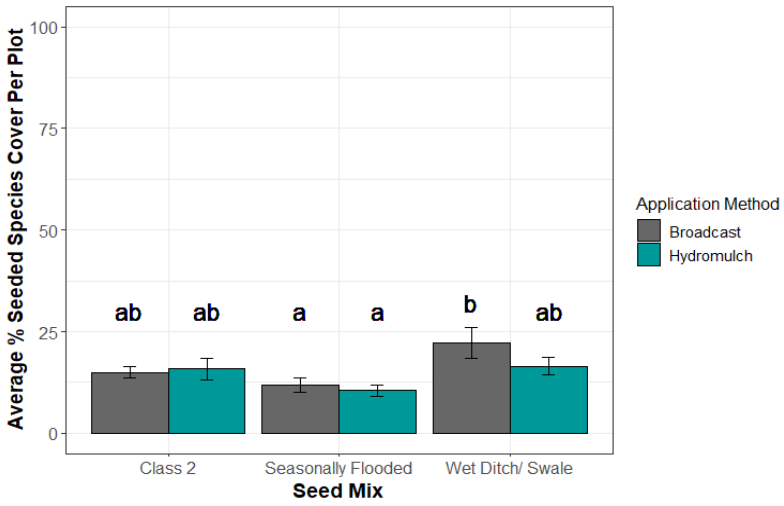


Figure 19. Average percent seeded species cover per plot (within total plant coverage) for each seed mix and application method for Wet Ditch sites across all 2020-2022 sampling dates. Bars sharing a common letter are not significantly different.

Appendix L: Vegetation Timeline

Seeding Establishment (70% goal)

All sites met the required 70% vegetation coverage by the end of the first year with the exception of Wet Ditch 3 (Summit), Fenceline 2 (Cuyahoga), and Slope 3 (Athens). Comparing the time frame when 70% coverage was reached, native seed mixes and Class 2 (turfgrass control mix) had similar results. Turfgrass species (cool-season grasses) are capable of growing in early spring as opposed to native grasses (typically warm-season) and flowers that begin growing in the late spring. During establishment periods this difference between the growing seasons will be more noticeable, as seen below.

Fenceline

Fenceline 1 (Ashland) reached 70% vegetation coverage during the first year. The final survey of 2022 illustrates all plots with a greater ground cover percent than the baseline assessment in 2019 (Figure 42).

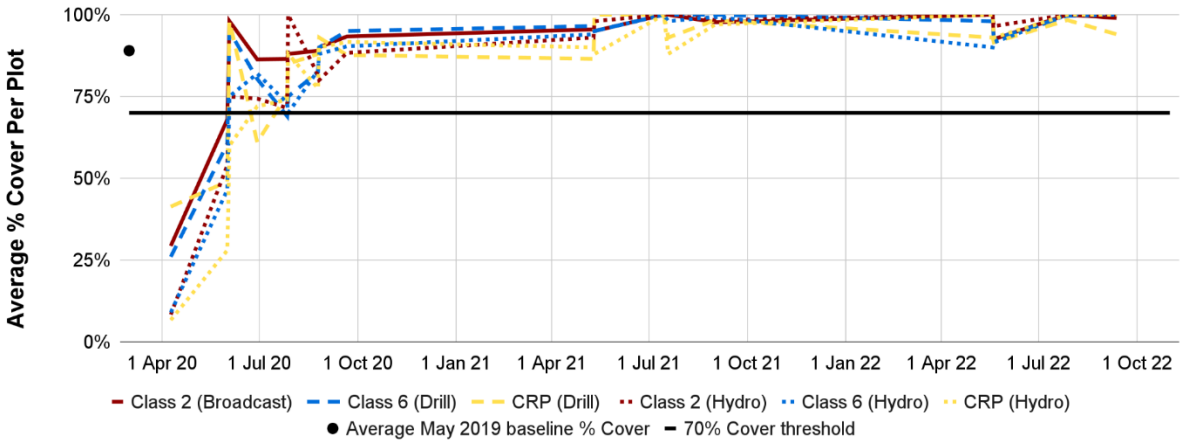


Figure 42. Average percent cover per plot by date for plots of each seed mix and application method for Fenceline 1 (Ashland). The average 2019 baseline percent cover across all Fenceline 1 (Ashland) plots is given at the start of the x-axis.

Fenceline 2 (Cuyahoga) was re-seeded in November 2020 due to the required 70% coverage not being met after 1 year. During re-seeding efforts, additional 11-52-0 fertilizer, Verdyol Biotic Earth™ and Profile Aqua-pHix™ were applied as directed by labels. Following re-seeding efforts in November 2020, vegetation coverage increased and met the goals of 70% coverage across the site during the summer of 2021. The final survey of 2022 illustrates all plots with a greater ground cover percent than the baseline assessment in 2019 (Figure 43).

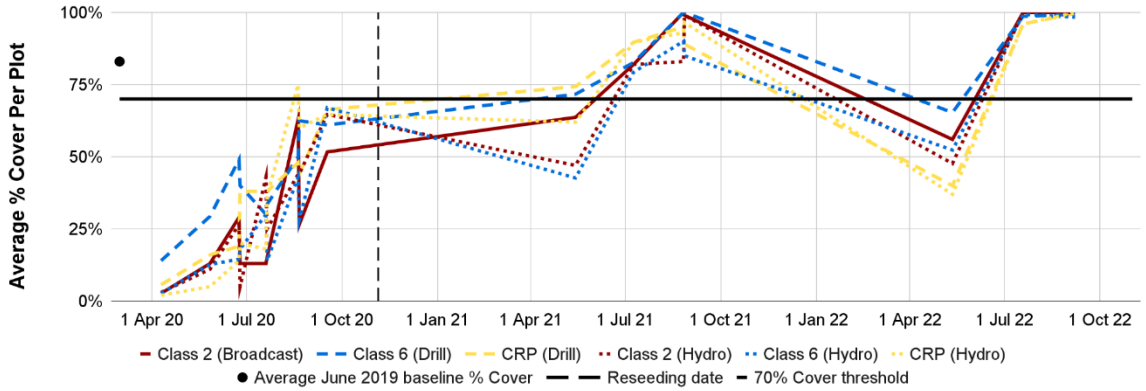


Figure 43. Average percent cover per plot by date for plots of each seed mix and application method for Fenceline 2 (Cuyahoga). The average 2019 baseline percent cover across all Fenceline 2 (Cuyahoga) plots is given at the start of the x-axis.

Fenceline 3 (Montgomery) reached 70% vegetation coverage during the first year. The final survey of 2022 illustrates all plots with an equal ground cover percent compared to the baseline assessment in 2019 (Figure 44).

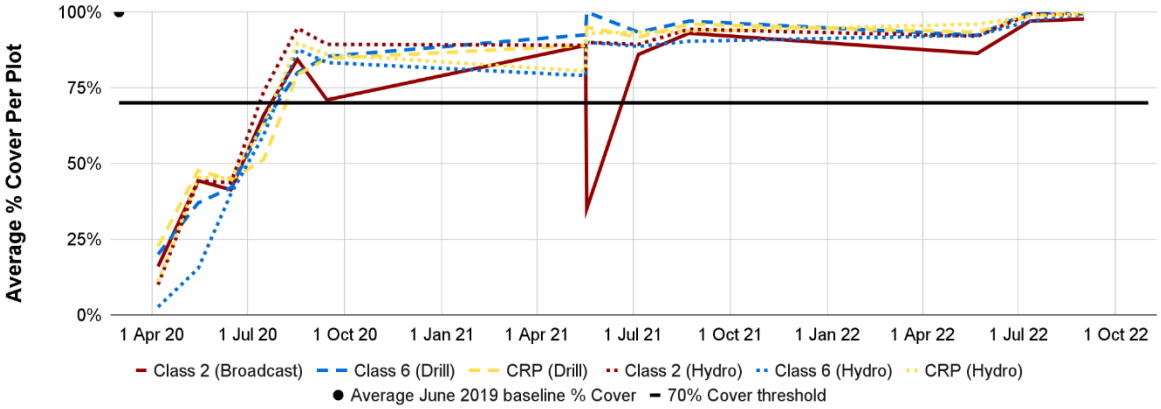


Figure 44. Average percent cover per plot by date for plots of each seed mix and application method for Fenceline 3 (Montgomery). The average 2019 baseline percent cover across all Fenceline 3 (Montgomery) plots is given at the start of the x-axis.

Roadside

Roadside 1 (Ashland) reached 70% throughout the site during the first year. The final survey of 2022 illustrates all plots with a greater ground cover percent than the baseline assessment in 2019, with the exception of the Class 3B hydro-mulched plots.

The Class 3B hydro-mulched plots provided the least amount of coverage at the site, however the coverage was still above the 70% coverage requirement (Figure 45).

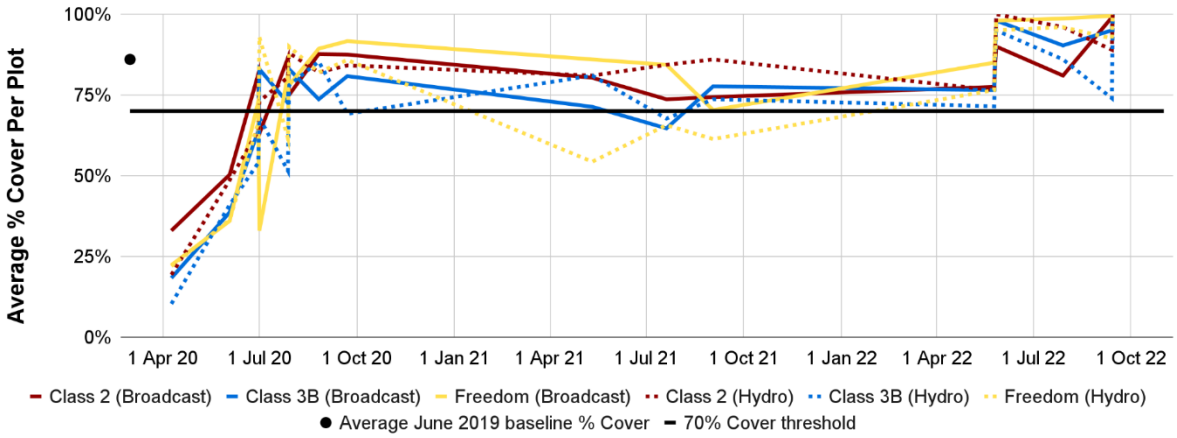


Figure 45. Average percent cover per plot by date for plots of each seed mix and application method for Roadside 1 (Ashland). The average 2019 baseline percent cover across all Roadside 1 (Ashland) plots is given at the start of the x-axis.

Roadside 2 (Geauga) reached 70% across the site overall during the first year. The Class 3B mix that was broadcast seeded provided the least amount of coverage across the site. The final survey of 2022 illustrates all plots with a greater ground cover percent than the baseline assessment in 2019 (Figure 46).

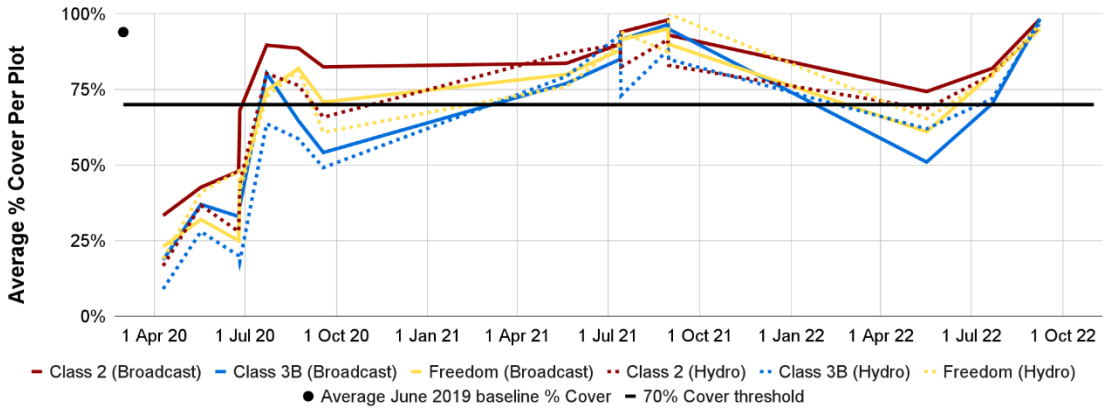


Figure 46. Average percent cover per plot by date for plots of each seed mix and application method for Roadside 2 (Geauga). The average 2019 baseline percent cover across all Roadside 2 (Geauga) plots is given at the start of the x-axis.

Roadside 3 (Geauga) reached 70% across the site overall during the first year, with the Class 3B mix that was hydro-mulched provided the least amount of coverage across the site.

The final survey of 2022 illustrates all plots with a similar ground cover percentage compared to the baseline assessment in 2019 (Figure 47).

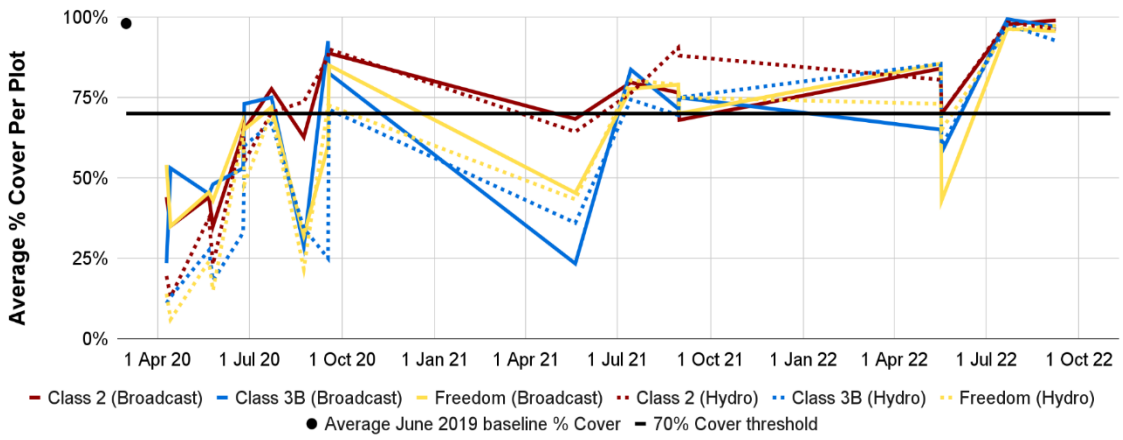


Figure 47. Average percent cover per plot by date for plots of each seed mix and application method for Roadside 3 (Geauga). The average 2019 baseline percent cover across all Roadside 3 (Geauga) plots is given at the start of the x-axis.

Slope

Slope 1 (Ashland) reached 70% across the site overall during the first year. The final survey of 2022 illustrates all plots with a greater ground cover percent than the baseline assessment in 2019. There was a slight reduction in vegetation coverage in the spring of each growing season that was especially evident with the native seedings. This quickly corrected itself, and acceptable coverage was reached by the summer of each growing year (Figure 48).

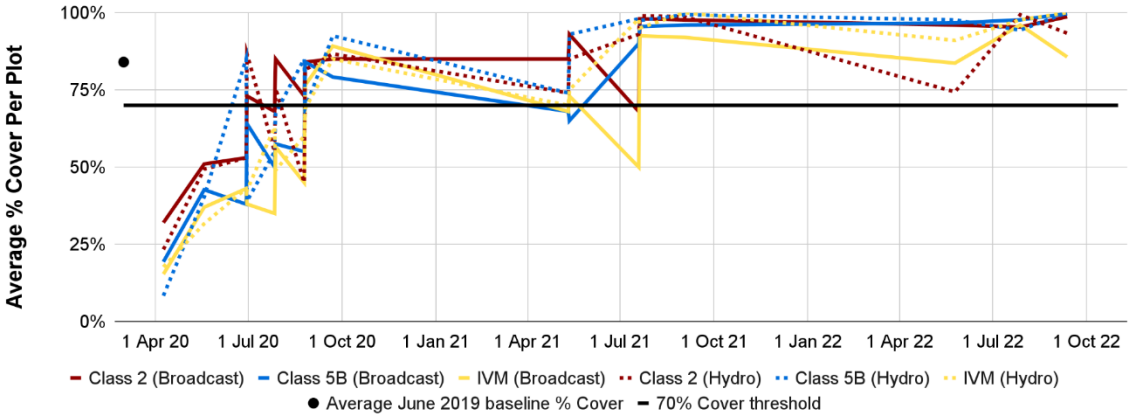


Figure 48. Average percent cover per plot by date for plots of each seed mix and application method for Slope 1 (Ashland). The average 2019 baseline percent cover across all Slope 1 (Ashland) plots is given at the start of the x-axis.

Slope 2 (Ashland) reached 70% across the site overall during the first year. The final survey of 2022 illustrates all plots with a greater ground cover percent than the baseline assessment in 2019 (Figure 49).

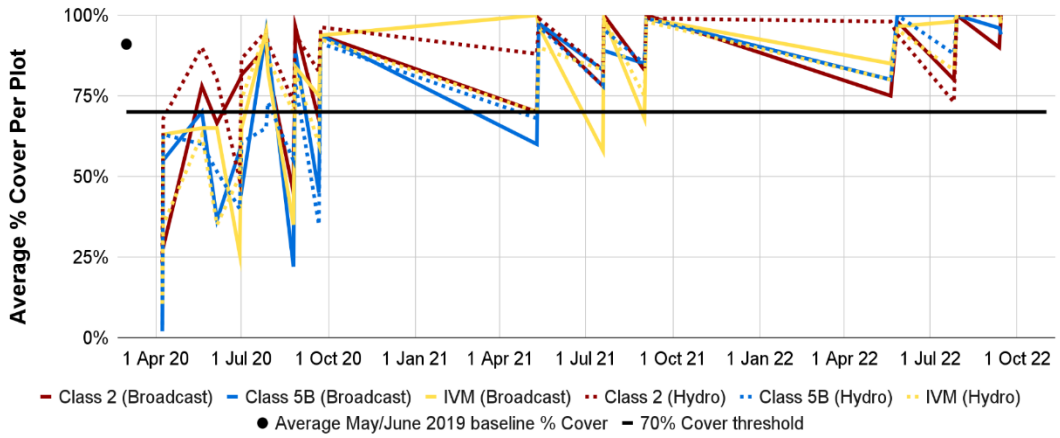


Figure 49. Average percent cover per plot by date for plots of each seed mix and application method for Slope 2 (Ashland). The average 2019 baseline percent cover across all Slope 2 (Ashland) plots is given at the start of the x-axis.

Slope 3 (Athens) was re-seeded in November 2020 due to the required 70% coverage not being met after 1 year. Following re-seeding efforts in November 2020, vegetation coverage increased and met the 70% coverage requirements across the site. This site had a majority of annual species during the first 2 years, followed by an explosion of perennial growth during the third and final evaluation year. The final survey of 2022 illustrates plots seeded with Class 2 and Class 5B using the hydromulching seeding method with a greater ground cover percent than the baseline assessment in 2019 (Figure 50).

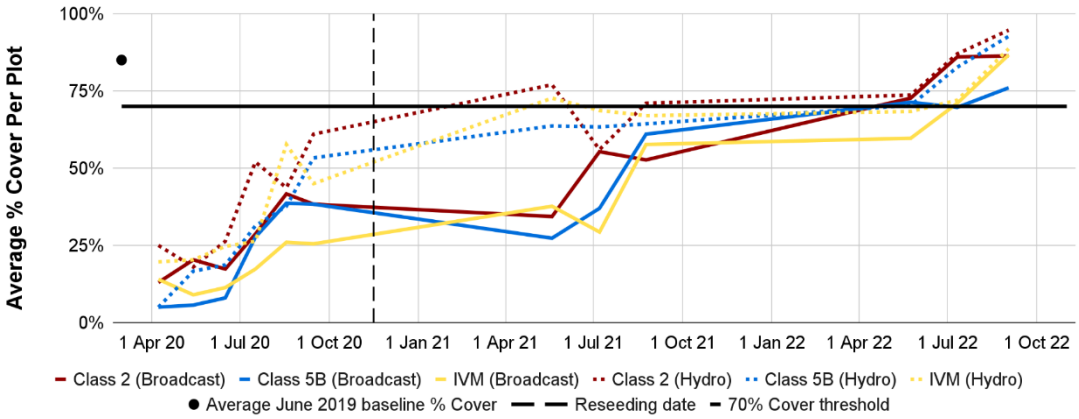


Figure 50. Average percent cover per plot by date for plots of each seed mix and application method for Slope 3 (Athens). The average 2019 baseline percent cover across all Slope 3 (Athens) plots is given at the start of the x-axis.

Wet Ditch

Wet Ditch 1 (Cuyahoga) reached 70% across the site overall during the first year. The Seasonally Flooded mix provided the least amount of coverage across the site. At the end of the project, all plots demonstrated a higher percent coverage than the average baseline percent coverage in 2019.

There was a reduction in vegetation coverage in the spring of each growing season that was especially evident with the native seedings. This quickly corrected itself, and acceptable coverage was reached by the summer of each growing year (Figure 51).

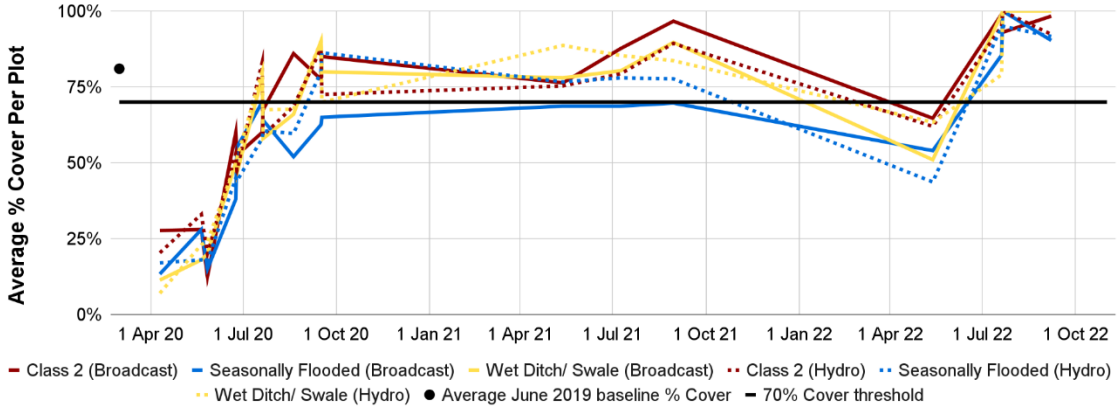


Figure 51. Average percent cover per plot by date for plots of each seed mix and application method for Wet Ditch 1 (Cuyahoga). The average 2019 baseline percent cover across all Wet Ditch 1 (Cuyahoga) plots is given at the start of the x-axis.

Wet Ditch 2 (Geauga) reached 70% across the site overall during the first year. At the end of the project, all plots met or exceeded the average baseline percent coverage from 2019. There was reduction in vegetation coverage in the spring of each growing season. This quickly corrected itself, and acceptable coverage was reached by the summer of each growing year (Figure 52).

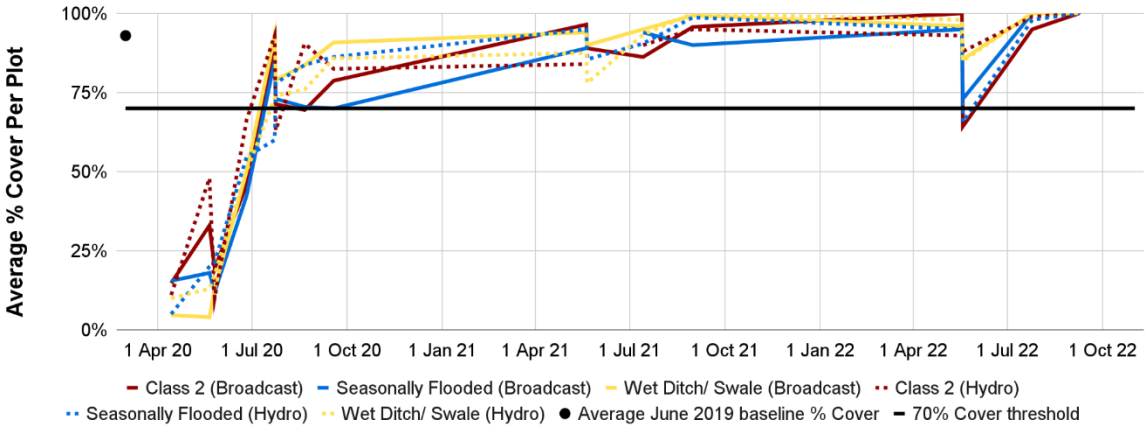


Figure 52. Average percent cover per plot by date for plots of each seed mix and application method for Wet Ditch 2 (Geauga). The average 2019 baseline percent cover across all Wet Ditch 2 (Geauga) plots is given at the start of the x-axis.

Wet Ditch 3 (Summit) was re-seeded in November 2020 due to the required 70% coverage not being met after 1 year. Soil analysis completed throughout the course of this project revealed soil insufficiencies. During re-seeding efforts additional 11-52-0 fertilizer, Verdyol Biotic Earth™ and Profile Aqua-pHix™ were applied as directed by labels. Following re-seeding efforts, vegetation coverage increased and met the goals of 70% coverage across the site during the summer of 2022. As seen in Figure 42 there was a reduction in vegetation coverage each spring as a result of the vegetation being primarily composed of native species that die back each fall.

During the course of the 2022 surveys, perennial vegetation became more prominent. This increase in perennial cover will ensure 70% vegetative cover during the following spring (Figure 53). At the end of the study, all plots exceeded the percent coverage found during the baseline survey. The baseline vegetation percent coverage fell below the 70% threshold prior to site disturbance.

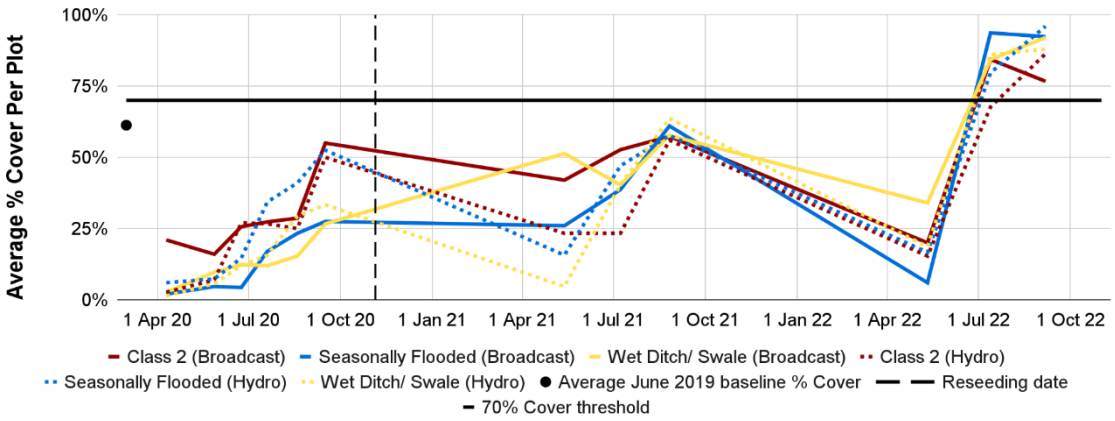


Figure 53. Average percent cover per plot by date for plots of each seed mix and application method for Wet Ditch 3 (Summit). The average 2019 baseline percent cover across all Wet Ditch 3 (Summit) plots is given at the start of the x-axis.

Appendix M: Pollinator Analysis

Pollinators Compared to Seed Mixes

The graphs depicted below show correlation between an increase in pollinator species richness when plant species richness increases, regardless of the seed mix utilized. This indicates that a seed mix with a large number of species will be indicative of a larger diversity of visiting pollinator species. The data represented within this report indicates that a diverse seed mix composed primarily of flowering native species will allow for the greatest diversity of native pollinators. Figure 20 shows the correlation between plant species diversity and pollinator diversity, while Figure 21 shows the correlation between native plant species and pollinator diversity.

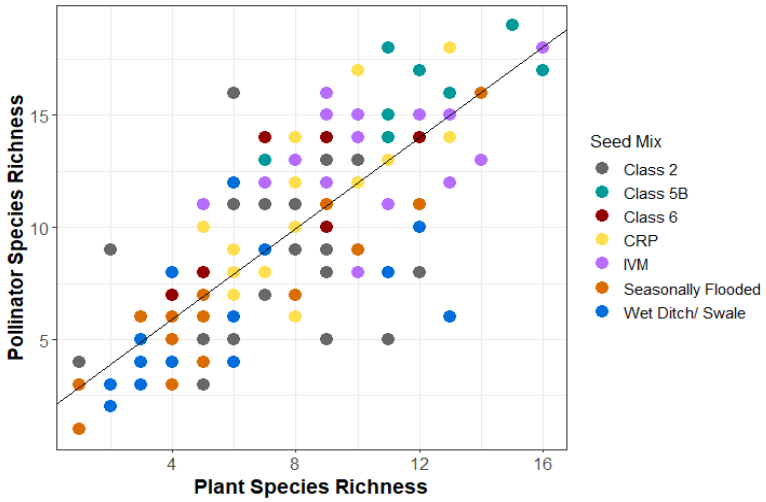


Figure 20. Active pollinator species richness vs plant species richness of host plants (all plants) for plots of each seed mix. The black line is a linear regression fitted to the data and was statistically significant (p-value = <0.0001; R2 = 0.62).

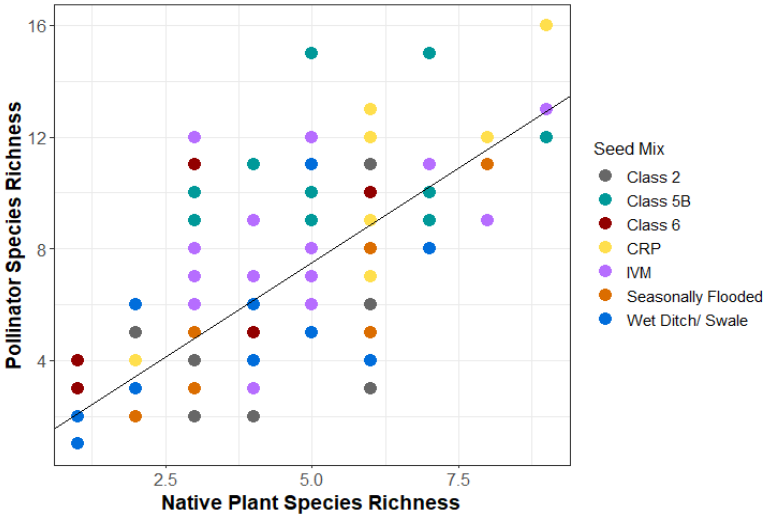


Figure 21. Active pollinator species richness vs plant species richness of host plants (native plants only) for plots of each seed mix. The black line is a linear regression fitted to the data and was statistically significant (p-value = < 0.0001; R2 = 0.61).

The ability of certain plant species to attract more pollinators may be due to the location of the plant, the abundance of the plant species, pollen and nectar amount and quality, or the plant attracting generalist pollinators. This study observed that a select number of plant species attract a greater abundance and diversity of pollinators, largely due to these factors (Figure 22, Figure 23).

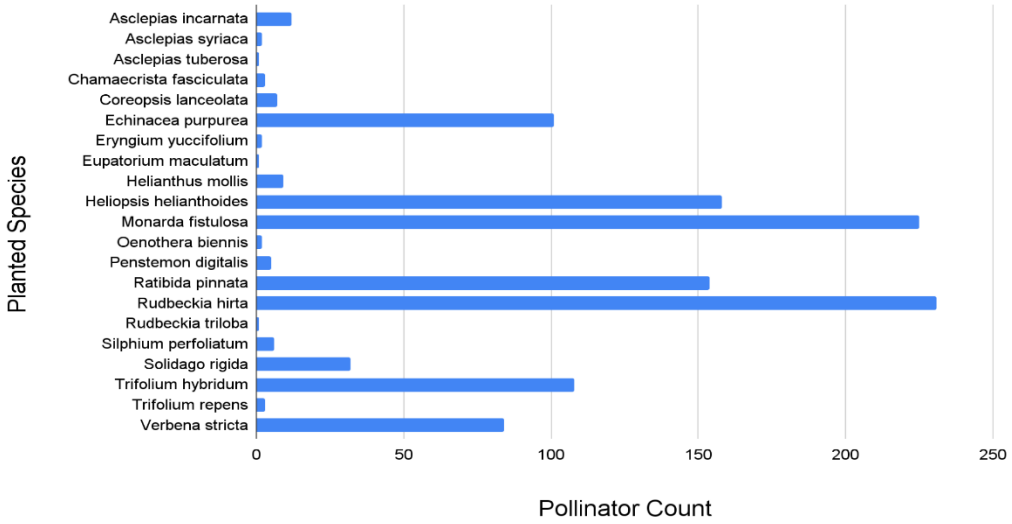


Figure 22. Total counts of pollinators found on planted species throughout all 2020-2022 sampling dates.

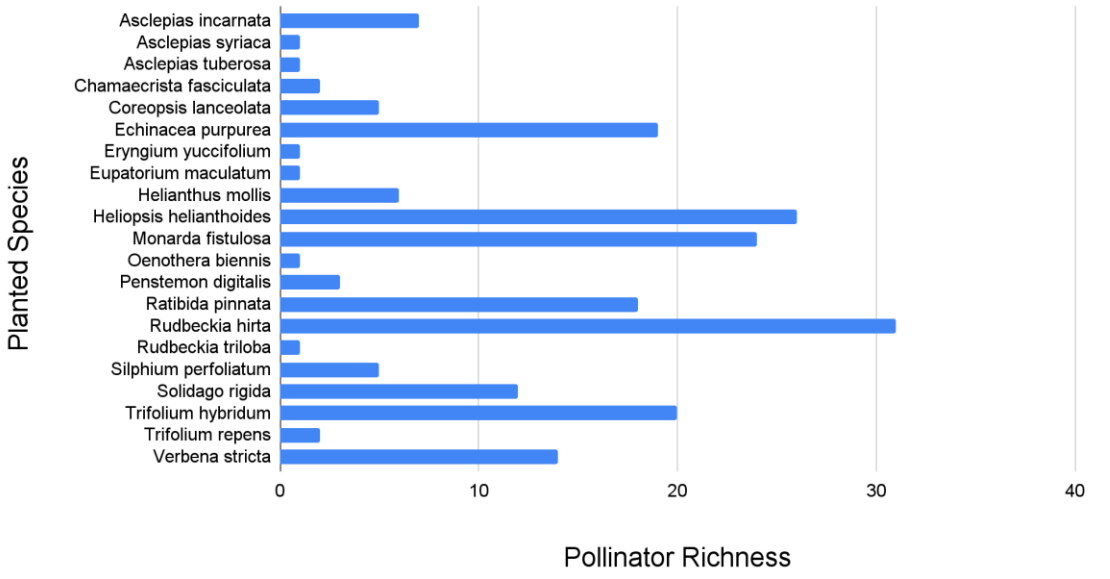


Figure 23. Overall pollinator species richness found on planted species throughout all 2020-2022 sampling dates.

Fenceline

The Fenceline test types were seeded with Class 2 (ODOT, control), Class 6 (ODOT), and CRP (Pheasants Forever) seed mixes. There was a statistically significant difference for the average pollinator-friendly cover between Class 2 and CRP seed mix plots (Tukey test; p-value = 0.006) (Figure 24). Class 2 mix contained introduced turfgrass while the CRP mix contained pollinator-friendly plants. The native pollinator-friendly plants that were found in the Class 2 mix plots were the result of plants that were already in the seed bank, while the CRP plots pollinator-friendly plants were from the seed mix as well as the seed bank. This resulted in a higher percentage of pollinator-friendly plants in the CRP plots.

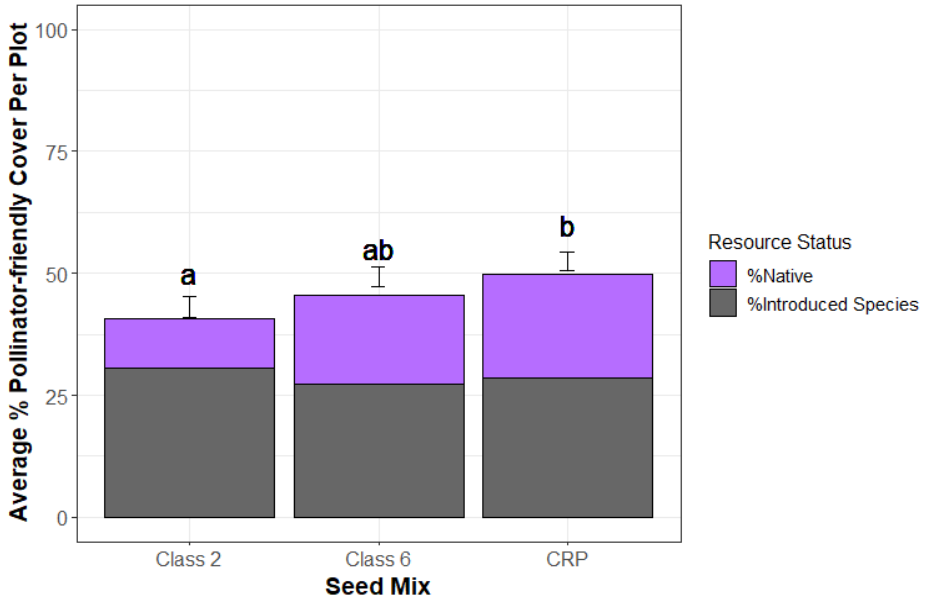


Figure 24. Average percent pollinator-friendly plant coverage (within total plant coverage) per plot for each seed mix for Fenceline sites across all 2020-2022 sampling dates. The percent pollinator-friendly coverage is broken out between native and introduced species coverage. Note that error bars and statistical tests for differences were run on the total percent pollinator coverage only, not on the resource status. Bars sharing a common letter are not significantly different.

There were not any statistically significant differences across application methods for average percent pollinator-friendly cover on the Fenceline test types (Tukey tests; p-values > 0.05). There was a slight (not statistically significant) difference between the hydromulching method as compared to the broadcast and drill seeding methods (Figure 25).

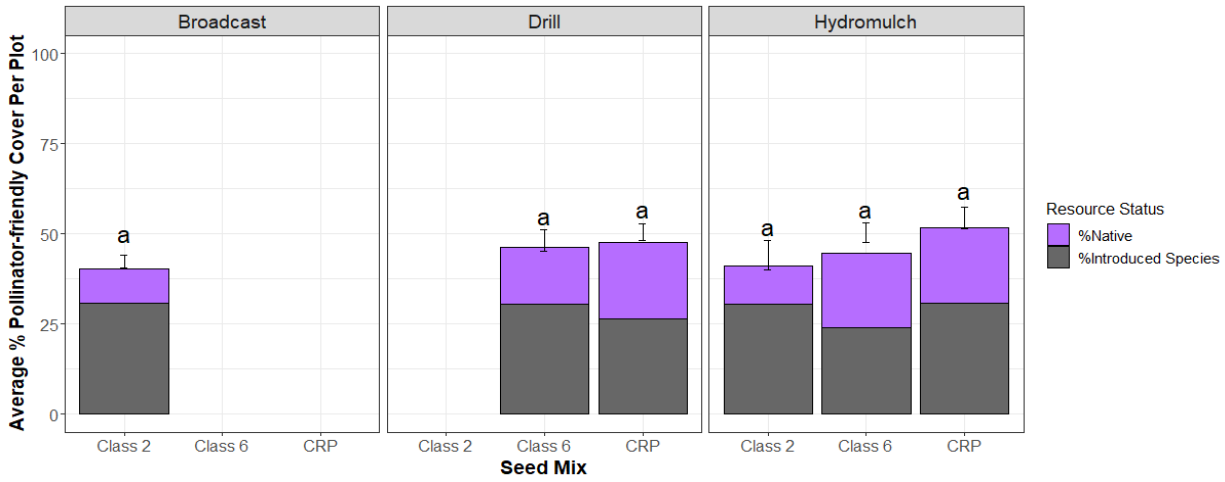


Figure 25. Average percent pollinator-friendly plant coverage (within total plant coverage) per plot for each seed mix and application method for Fenceline sites across all 2020-2022 sampling dates. The percent pollinator-friendly coverage is broken out between native and introduced species coverage. Note that error bars and statistical tests for differences were run on the total percent pollinator coverage only, not on the resource native status. Bars sharing a common letter are not significantly different.

There were not statistically significant differences across seed mixes and resource native status for average daily per plot pollinator counts nor for seed mixes and average daily per plot active pollinator species richness (Tukey test; p-value > 0.05) (Figure 26, Figure 27).

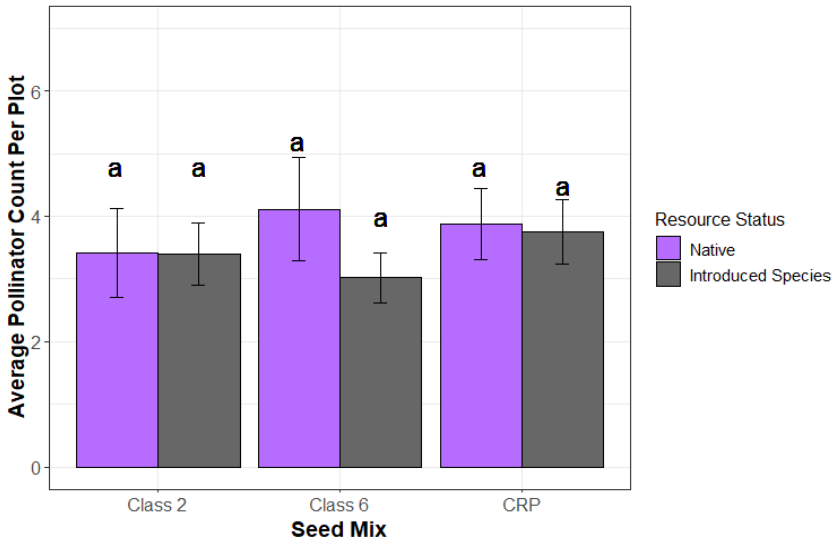


Figure 26. Average daily per plot active pollinator counts on native and introduced species host plants across plots of each seed mix for Fenceline sites across all 2020-2022 sampling dates. Bars sharing a common letter are not significantly different.

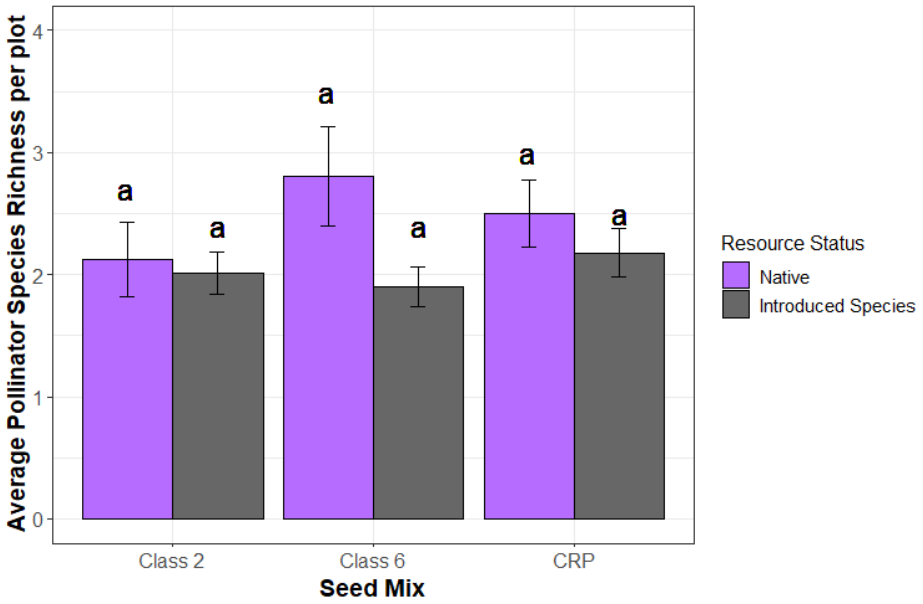


Figure 27. Average daily per plot active pollinator species richness on native and introduced species host plants across plots of each seed mix for Fenceline sites across all 2020-2022 sampling dates. Bars sharing a common letter are not significantly different.

Slope

The Slope test type plots were seeded with Class 2 (ODOT, control), Class 5B (ODOT), and IVM (Pheasants Forever) seed mixes. The native pollinator-friendly plants that were found in the Class 2 mix plots were the result of plants that were already in the seed bank, while the Class 5B and IVM seed mix plots pollinator-friendly plants were from the seed bank as well as the seed mix. This resulted in a higher percentage of pollinator-friendly plants in the Class 5B and IVM seed mix plots (Figure 28). Due to these results, it is recommended to use Class 5B seed mix for Slope test type plots.

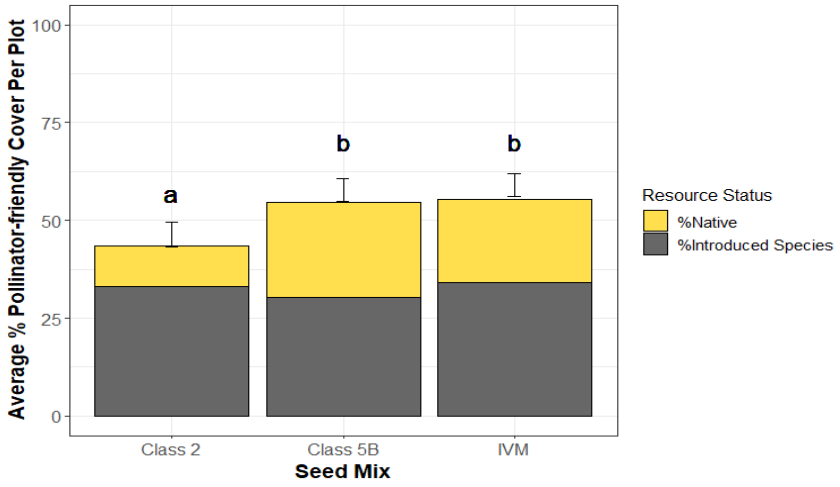


Figure 28. Average percent pollinator-friendly plant coverage (within total plant coverage) per plot for each seed mix for Slope sites across all 2020-2022 sampling dates. The percent pollinator-friendly coverage is broken out between native and introduced species coverage. Note that error bars and statistical tests for differences were run on the total percent pollinator coverage only, not on the resource status. Bars sharing a common letter are not significantly different.

For the seeding application methods, the difference in average percent of pollinator-friendly cover between Class 2 hydromulching and Class 5B hydromulching (Tukey test; p-value = 0.015), and between Class 2 hydromulching and both IVM broadcast and hydromulching (Tukey tests; p-values = 0.016 and 0.037, respectively) were statistically significant (Figure 29).

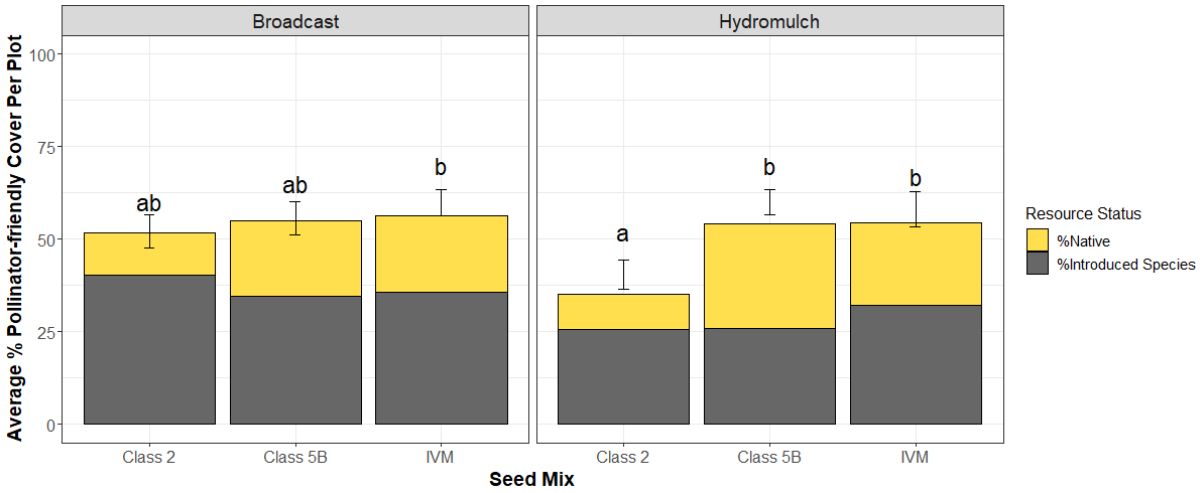


Figure 29. Average percent pollinator-friendly plant coverage (within total plant coverage) per plot for each seed mix and application method for Slope sites across all 2020-2022 sampling dates. The percent pollinator-friendly coverage is broken out between native and introduced species coverage. Note that error bars and statistical tests for differences were run on the total percent pollinator coverage only, not on the resource native status. Bars sharing a common letter are not significantly different.

There were statistically significant differences for average daily per plot pollinator counts between Class 2 - introduced plant species and Class 2 and IVM - native plant species (Tukey tests; p-values = 0.0001 and 0.015, respectively); and between Class 2 - native plant species and Class 5B and IVM - introduced species (Tukey tests; p-values = 0.025 and 0.002, respectively) (Figure 30). All pollinator-friendly species identified within the Class 2 seed mix were volunteers, whereas the pollinator-friendly species for Class 5B and IVM were both volunteer and seeded species.

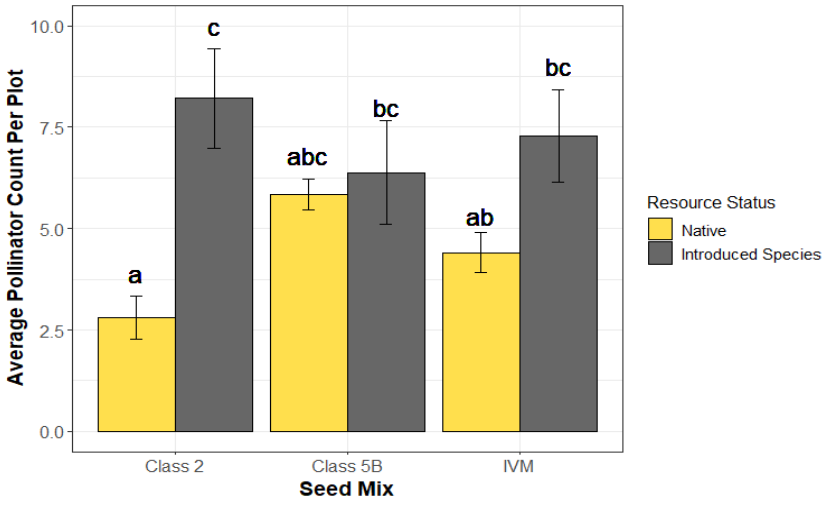


Figure 30. Average daily per plot active pollinator counts on native and introduced species host plants across plots of each seed mix for Slope sites across all 2020-2022 sampling dates. Bars sharing a common letter are not significantly different.

There were statistically significant differences for average daily per plot pollinator species richness between Class 2 - native plant species and Class 2 - introduced species (Tukey test; p-value = 0.044); between Class 2 - native plant species and Class 5B - native plant species (Tukey test; p-value = 0.001); and between Class 2 - native plant species and IVM - native plant species (Tukey test; p-value = 0.011) (Figure 31). All pollinator-friendly species for Class 2 were volunteers, whereas the pollinator-friendly species for Class 5B and IVM were both volunteer and seeded species. Less diverse areas, such as the Class 2 seed mix plots, are not able to support as many species of pollinators as diverse areas. The average pollinator count per plot on native resources in Class 5B and IVM seed mix plots show statistical significance as compared to Class 2 seed mix plots. Supporting the use of native seed mixes over Class 2 seed mix.

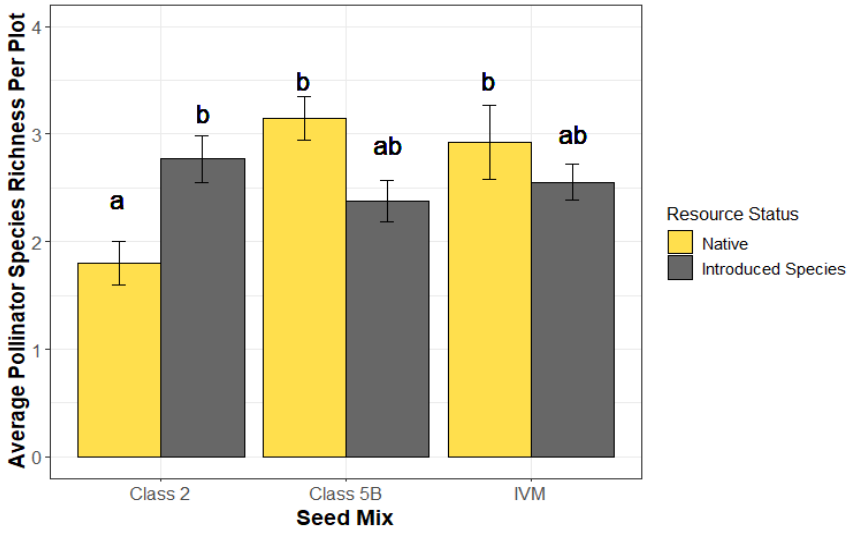


Figure 31. Average daily per plot active pollinator species richness on native and introduced species host plants across plots of each seed mix for Slope sites across all 2020-2022 sampling dates. Bars sharing a common letter are not significantly different.

Wet Ditch

Wet Ditch site types were seeded with Class 2 (ODOT, control), Seasonally Flooded (DRG), and Wet Ditch/Swale seed mixes (DRG). The last two seed mixes are composed primarily of native species, with Class 2 being introduced turfgrass. The percentage of native pollinator-friendly plants that were found in the Class 2 mix plots were the result of plants that were already in the seed bank. There were not any statistically significant differences across seed mixes for the average percent of pollinator-friendly cover (Tukey test; p-value > 0.05) (Figure 32, on the next page).

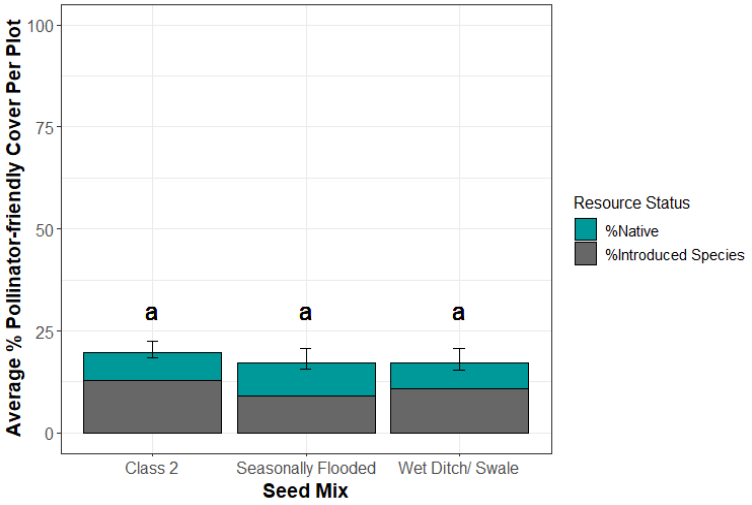


Figure 32. Average percent pollinator-friendly plant coverage (within total plant coverage) per plot for each seed mix for Wet Ditch sites across all 2020-2022 sampling dates. The percent pollinator-friendly coverage is broken out between native and introduced species coverage. Note that error bars and statistical tests for differences were run on the total percent pollinator coverage only, not on the resource status. Bars sharing a common letter are not significantly different.

There were no statistically significant differences across seed mixes and application methods for the average percent of pollinator-friendly cover per plot (Tukey test; p-value > 0.05) (Figure 33).

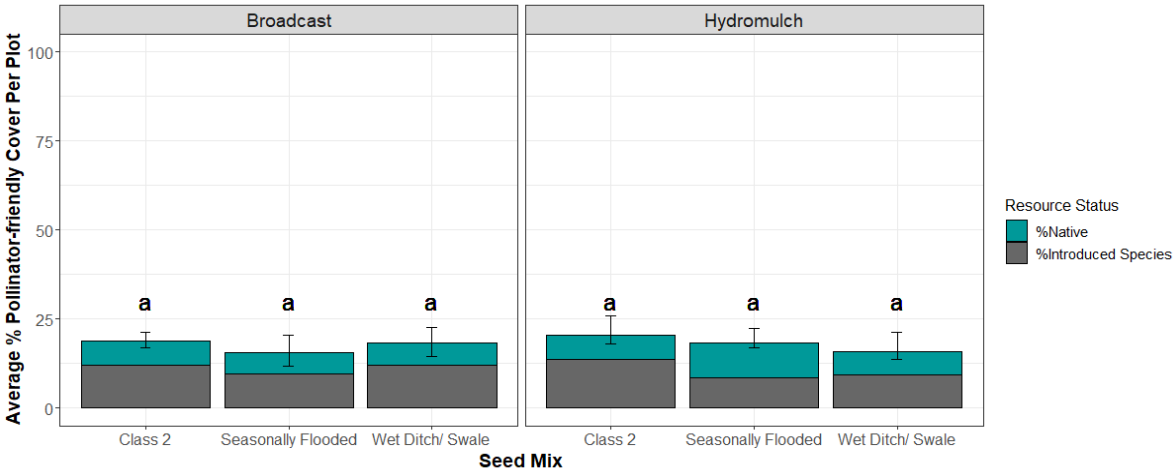


Figure 33. Average percent pollinator-friendly plant coverage (within total plant coverage) per plot for each seed mix and application method for Wet Ditch sites across all 2020-2022 sampling dates. The percent pollinator-friendly coverage is broken out between native and introduced species coverage. Note that error bars and statistical tests for differences were run on the total percent pollinator coverage only, not on the resource native status. Bars sharing a common letter are not significantly different.

There were no statistically significant differences across seed mixes and resource native status for average daily per plot pollinator counts (Tukey test; p-value > 0.05) (Figure 34).

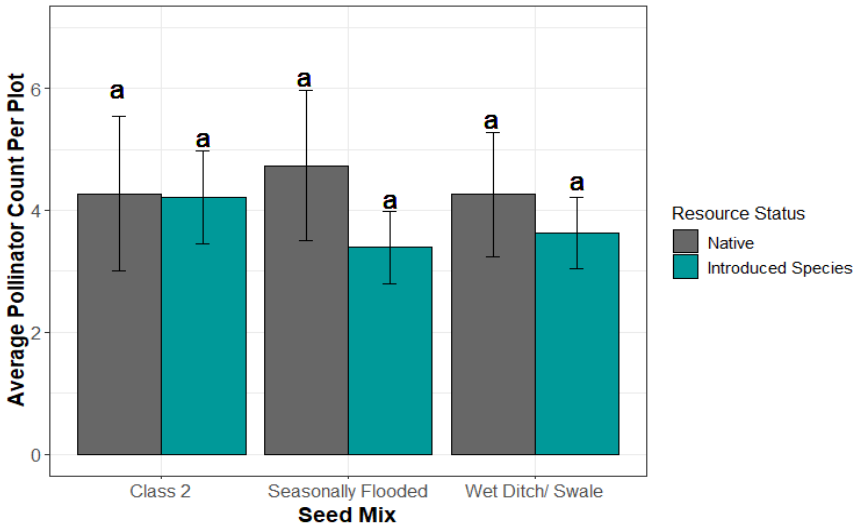


Figure 34. Average daily per plot active pollinator counts on native and introduced species host plants across plots of each seed mix for Wet Ditch sites across all 2020-2022 sampling dates. Bars sharing a common letter are not significantly different.

There were not statistically significant differences across seed mixes and resource native status for average daily pollinator species richness per plot (Tukey test; p-value > 0.05) (Figure 35).

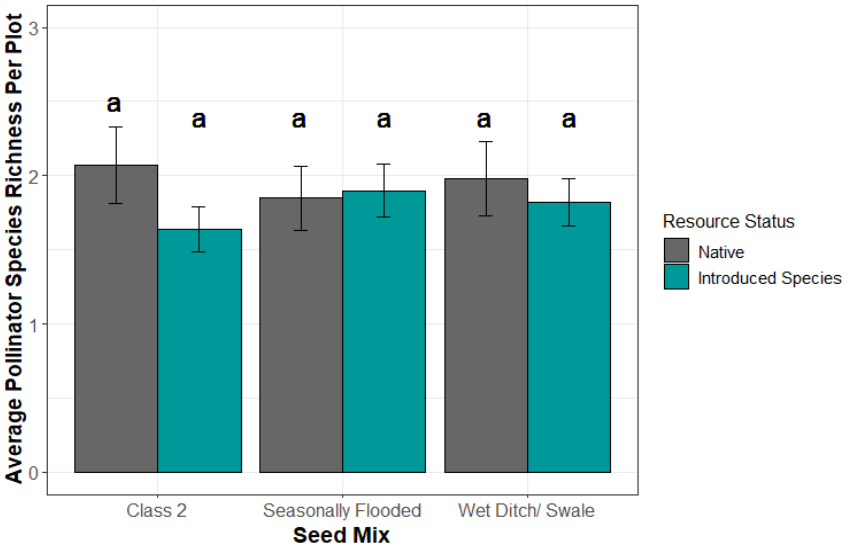


Figure 35. Average daily per plot active pollinator species richness for plots of each seed mix for Wet Ditch sites across all 2020-2022 sampling dates. Bars sharing a common letter are not significantly different.

Pollinators During Different Seasons

Throughout the project, DRG staff recognized differences in the responses of pollinators throughout the growing season. Early-season evaluations occurred in May 2021 and 2022; mid-season evaluations occurred in July 2020, 2021, and 2022; and late-season evaluations occurred in August and September 2020 and 2021.

Upon further investigation, it was determined that mid- season surveys consistently showed a larger pollinator count, particularly when compared to early- season surveys.

Fenceline

There was a statistically significant difference for average daily pollinator count between Class 6 mid-season evaluations and Class 2, Class 6 and CRP early-season evaluations (Tukey tests; p-values = 0.019, 0.001, and 0.011, respectively); there was also a statistically significant difference between Class 6 mid-season evaluations and Class 2 late-season evaluations (Tukey test; p-values = 0.001); between CRP mid-season evaluations and Class 2, Class 6, and CRP early-season evaluations (Tukey tests; p-values = 0.001, <0.0001, and 0.0004, respectively); and lastly there was a statistically significant difference between CRP mid-season evaluations and Class 2, Class 6, and CRP late-season evaluations (Tukey tests; p-values = <0.0001, 0.004, and 0.01, respectively). This information shows that pollinators were more active during the mid-season evaluation when compared to the early or late-seasons (Figure 36).

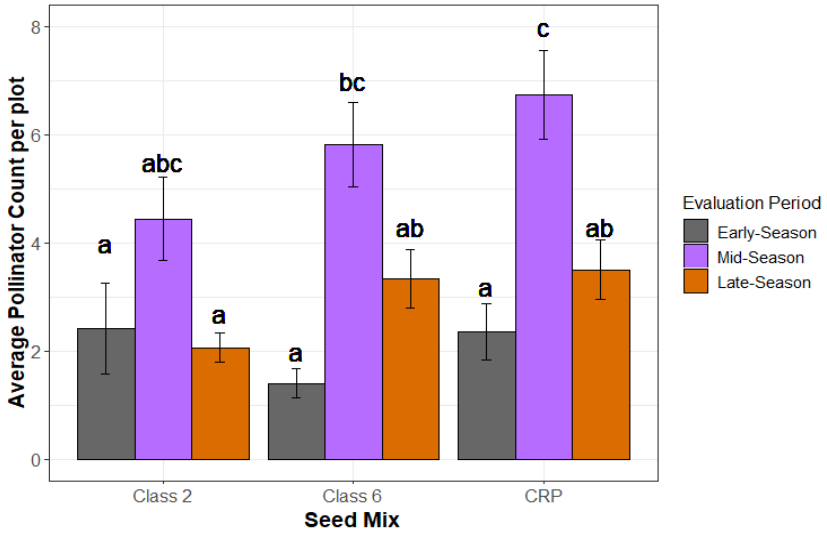


Figure 36. Average daily per plot active pollinator counts for plots of each seed mix and evaluation period for Fenceline sites across all 2020-2022 sampling dates. Bars sharing a common letter are not significantly different.

Within the Fenceline sites across the 2020-2022 sampling dates, there is no statistically significant difference between the average percent of blooming vegetation and seed mix or evaluation period.

There is no difference in percent of blooming vegetation over the evaluation periods regardless of seed mix (Figure 37).

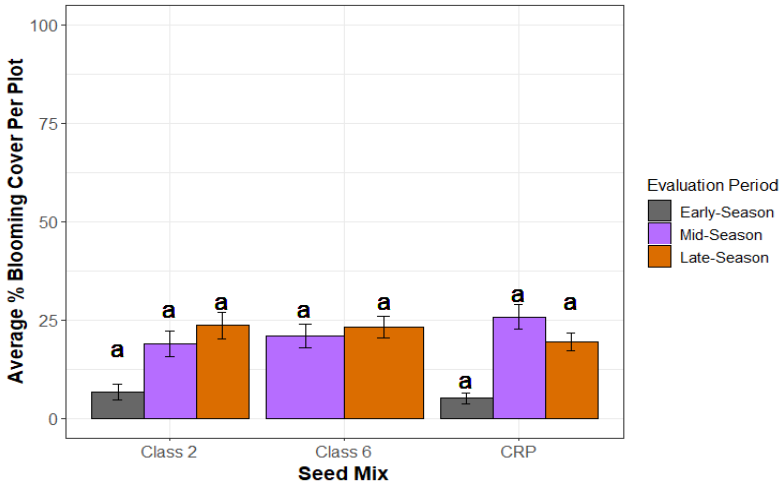


Figure 37. Average percent blooming pollinator-friendly plant coverage per plot for each seed mix and evaluation period for Fenceline sites across all 2020-2022 sampling dates. Bars sharing a common letter are not significantly different.

Slope

There were statistically significant differences for average daily pollinator count between: Class 2 mid-season and Class 2, Class 5B, and IVM for early and late-season evaluations (Tukey tests: p-values = <0.0001, <0.0001, <0.0001, 0.0005, 0.0012, 0.0077, respectively); and between Class 5B mid-season and Class 2, Class 5B, and IVM for early and late-season evaluations (Tukey tests: p-values = <0.0001, <0.0001, <0.0001, <0.0001, 0.0002, 0.0017, respectively). This information shows that pollinators were more active during the mid-season evaluation when compared to the early or late-season (Figure 38).

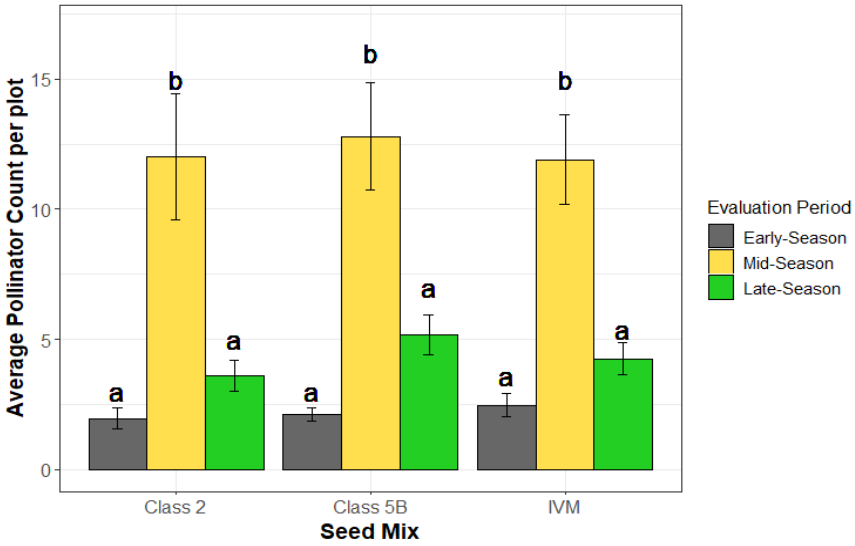


Figure 38. Average daily per plot active pollinator counts for plots of each seed mix and evaluation period for Slope sites across all 2020-2022 sampling dates. Bars sharing a common letter are not significantly different.

Within the Slope sites across the 2020-2022 sampling dates, there is no significant difference of average percent of blooming vegetation between seed mix or evaluation period (Tukey test; p-value > 0.05). There is no difference in percent of blooming vegetation over the evaluation periods regardless of seed mix (Figure 39).

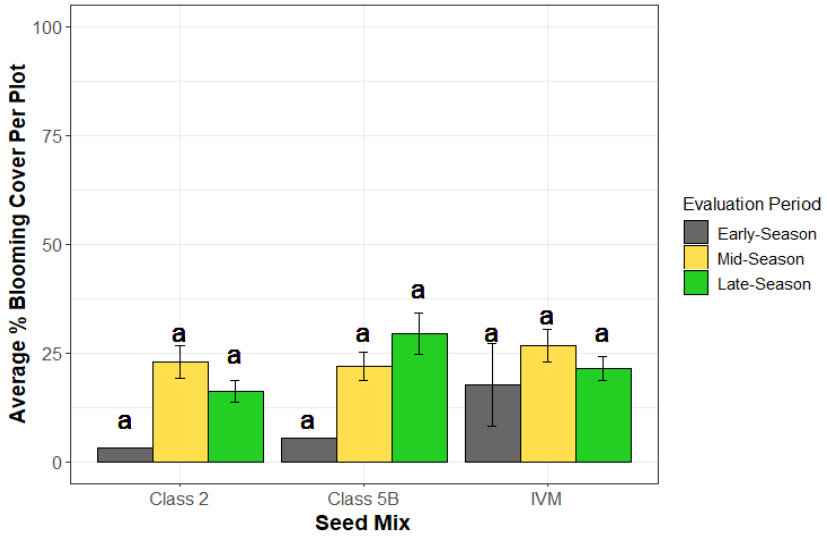


Figure 39. Average percent blooming pollinator-friendly plant coverage per plot for each seed mix and evaluation period for Slope sites across all 2020-2022 sampling dates. Bars sharing a common letter are not significantly different.

Wet Ditch

There were no statistically significant differences across seed mixes and evaluation periods for average daily per plot pollinator counts (Tukey test; p-value > 0.05) (Figure 40).

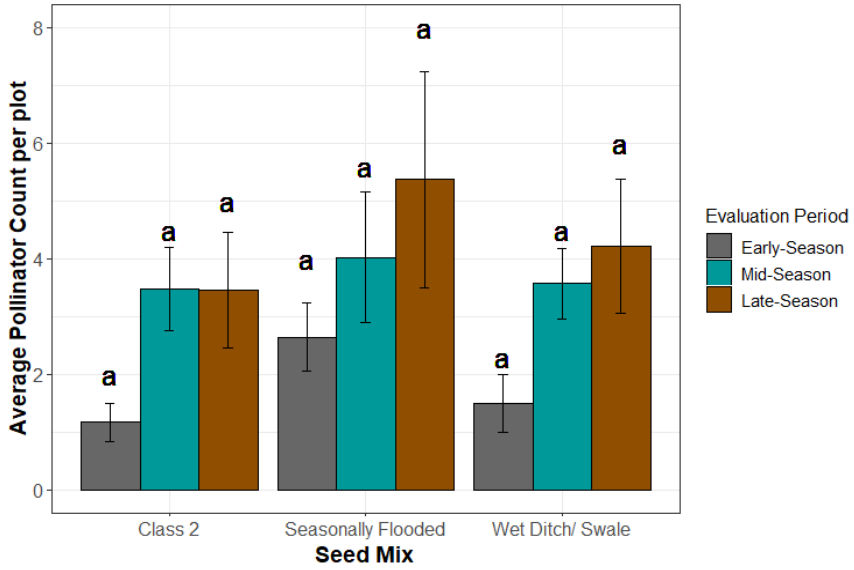


Figure 40. Average daily per plot active pollinator counts for plots of each seed mix and evaluation period for Wet Ditch sites across all 2020-2022 sampling dates. Bars sharing a common letter are not significantly different.

Within the Wet Ditch sites across the 2020-2022 sampling dates, there is no significant difference of average percent of blooming vegetation between seed mix or evaluation period (Tukey test; p-value > 0.05). There is no difference in percent of blooming vegetation over the evaluation periods regardless of seed mix (Figure 41).

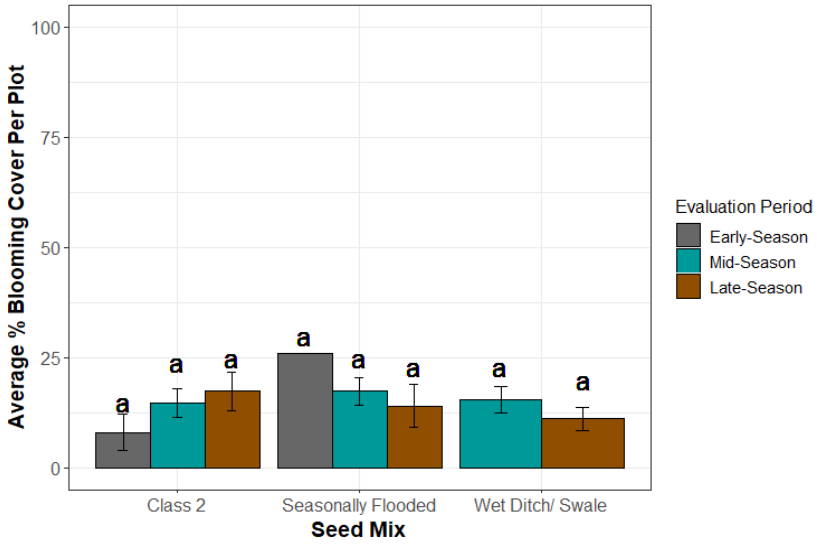


Figure 41. Average percent blooming pollinator-friendly plant coverage per plot for each seed mix and evaluation period for Wet Ditch sites across all 2020-2022 sampling dates. Bars sharing a common letter are not significantly different.

For the Fenceline and Slope test type plots, there was a significant difference between the mid-season evaluation periods as compared to the early and late-season evaluations for all seed mix types for pollinator counts. For the Wet Ditch test type plots, all three seed mixes tested (Class 2, Seasonally Flooded, and Wet Ditch/Swale) show no significant difference between the late-season evaluation period as compared to the early and mid-season evaluation periods. The Class 2 seed mix had an insignificant difference between the mid-season evaluation as compared to the early and late-season evaluation periods for Fenceline and Wet Ditch test types and a significant difference between mid, early, and late season pollinator counts for Slope test types.

Evaluations of the average percent cover of blooming vegetation over the course of a season are not significant for the test types of Fenceline, Slope, and Wet Ditch. These results show that regardless of the seed mixture and evaluation time period, the amount of flower resources is consistent.

Appendix N: Response to Herbicide Applications

Throughout the study, DRG staff completed IVC on areas of the test sites that had a large amount of non-native invasive species. As such, each site listed below had a different herbicide treatment plan targeting different species. During this study, only species within the plots were treated with herbicide, this enabled encroachment from the surrounding area.

Fenceline 1A and 1B (Ashland)

The species controlled for this test type site were poison hemlock (*Conium maculatum)*, birdfoot trefoil (*Lotus corniculatus*), and crown vetch (*Securigera vera*). Fenceline sites were spot treated with herbicide using backpack sprayers. Poison hemlock (*Conium maculatum*) was very susceptible to the herbicide treatments; the amount found at this site significantly declined after the fourth (1A) and sixth (1B) IVC treatment. Due to study restrictions and the resilient nature of the plant, the amount of birdfoot trefoil (*Lotus corniculatus*) varied throughout the study. Birdfoot trefoil (*Lotus corniculatus*) also was not controlled by mowing, as the plant was usually growing lower than what the mower deck is adjusted to. This species also seeds multiple times throughout the year, making it difficult to find an ideal time to apply herbicide. Thus, resulting in an increase of this species even after herbicide applications. The percent cover of crown vetch (*Securigera vera*)*'s* did increase over the course of the study. It is suspected that this is due to the fact that this species was once planted on this slope per ODOT's Class 3C seed mix designed for slopes. This increases the percent coverage of crown vetch (*Securigera vera*) in the seed bank in the test plots as well as the surrounding areas, making it more difficult to control (Figure 54, Figure 55). Fenceline 1A and Fenceline 1B are separated out in this section due to the differences in the invasive species that required different treatment between Fenceline 1A and Fenceline 1B.

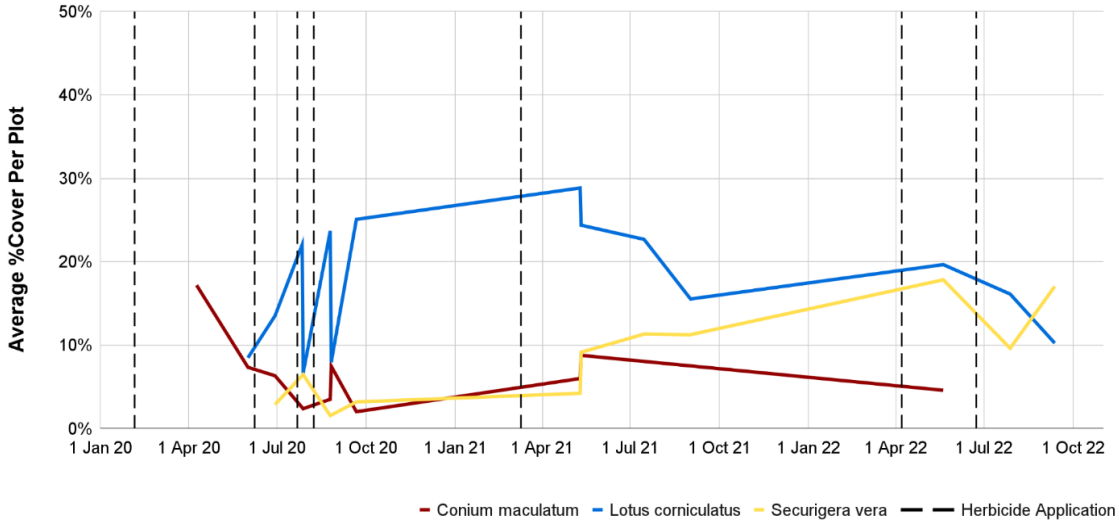


Figure 54. Average percent cover per plot by date for common invasive species found at Fenceline 1A (Ashland).

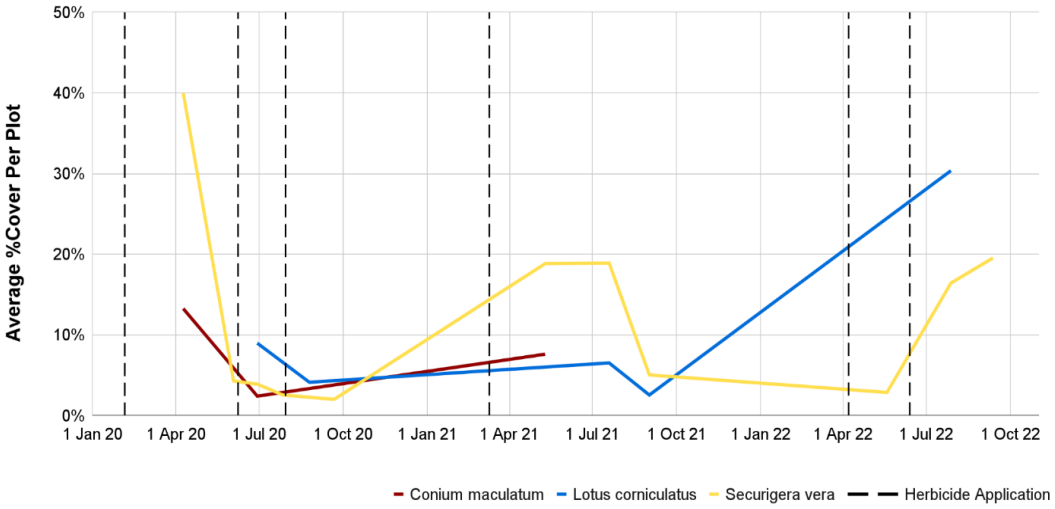


Figure 55. Average percent cover per plot by date for common invasive species found at Fenceline 1B (Ashland).

Roadside 1 (Ashland)

The species controlled for this test type site were poison hemlock (*Conium maculatum*), birdfoot trefoil (*Lotus corniculatus*), and crown vetch (*Securigera vera*). Roadside 1 (Ashland) was broadcast treated with herbicide using a power sprayer attached to the back of a truck. Poison hemlock (*Conium maculatum*) was very susceptible to the herbicide treatments, the amount found on this test type significantly declined after the first IVC treatment. Due to study restrictions and the resilient nature of the plant, the amount of birdfoot trefoil (*Lotus corniculatus*) varied throughout the study. Birdfoot trefoil (*Lotus corniculatus*) was not controlled by mowing, as the plant is usually growing lower than what the mower deck is adjusted to. This species also seeds multiple times throughout the year, making it difficult to find an ideal time to apply herbicide. Thus, resulting in an increase of this species even after herbicide applications.

Securigera vera was not very prominent throughout the site and it was also very susceptible to the herbicide treatments. The amount found at this site decreased after the second herbicide application (Figure 56).

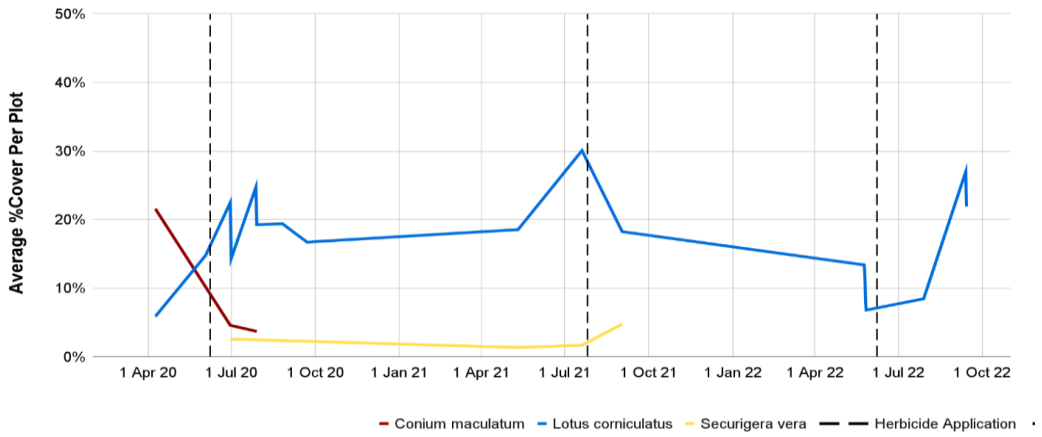


Figure 56. Average percent cover per plot by date for common invasive species found at Roadside 1 (Ashland).

Roadside 2 and 3 (Geauga)

The species controlled for this test type site was birdfoot trefoil (*Lotus corniculatus)*. Roadsides 2 and 3 (Geauga) were broadcast treated with herbicide using a power sprayer attached to the back of a truck. Due to study restrictions and the resilient nature of the plant, the amount of birdfoot trefoil (*Lotus corniculatus)* varied throughout the study. Birdfoot trefoil (*Lotus corniculatus)* also was not controlled by mowing, as the plant is usually growing lower than what the mower deck is adjusted to. This species also seeds multiple times throughout the year, making it difficult to find an ideal time to apply herbicide. Thus, resulting in an increase of this species, even after herbicide applications (Figure 57, Figure 58).

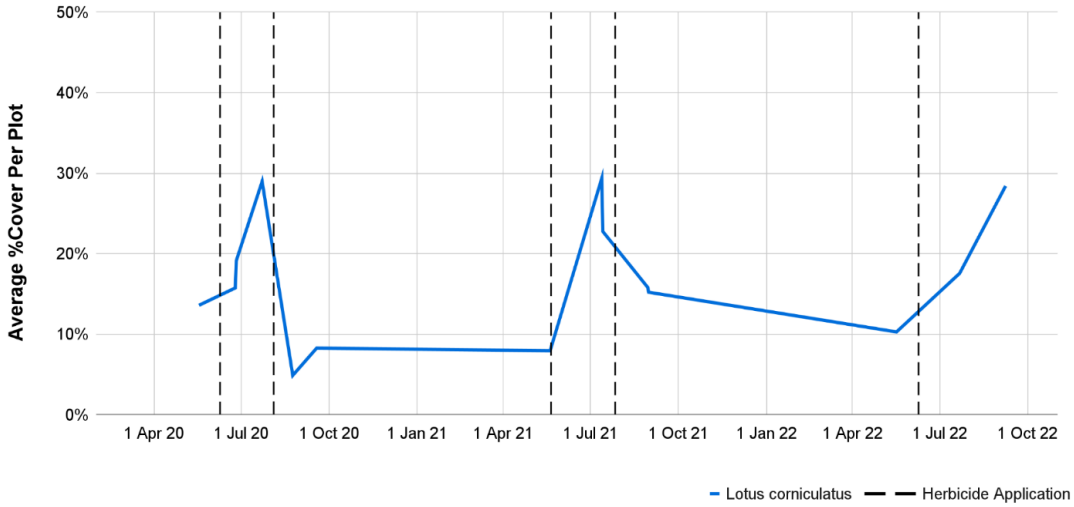


Figure 57. Average percent cover per plot by date for common invasive species found at Roadside 2 (Geauga).

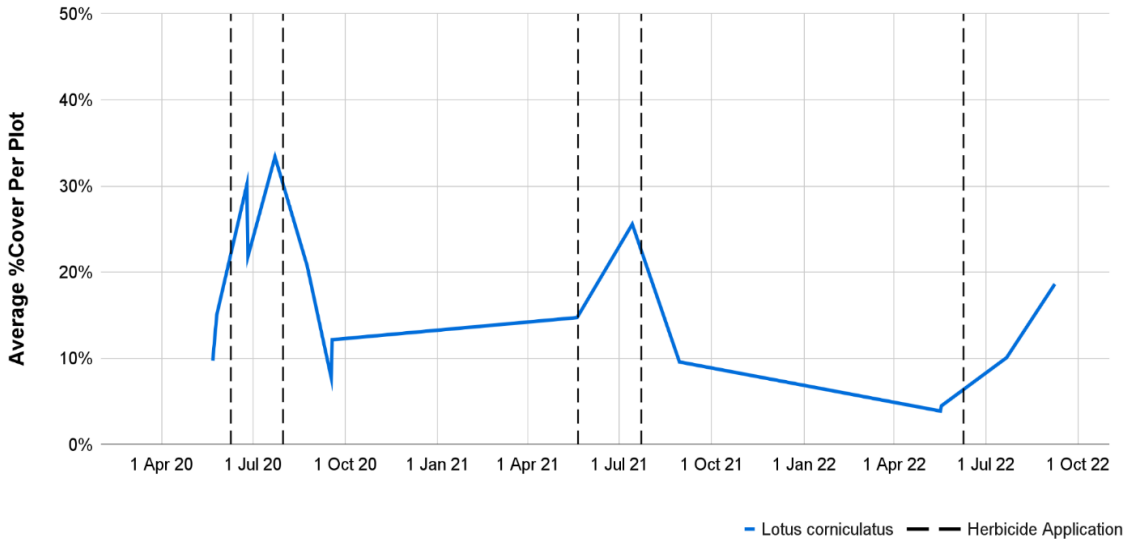


Figure 58. Average percent cover per plot by date for common invasive species found at Roadside 3 (Geauga).

Slope 1 (Ashland)

The species controlled in this test type site was poison hemlock (*Conium maculatum*). Fenceline sites were spot treated with herbicide using backpack sprayers. The presence of this species significantly decreased over the course of this study, especially after the third application of herbicide (Figure 59).

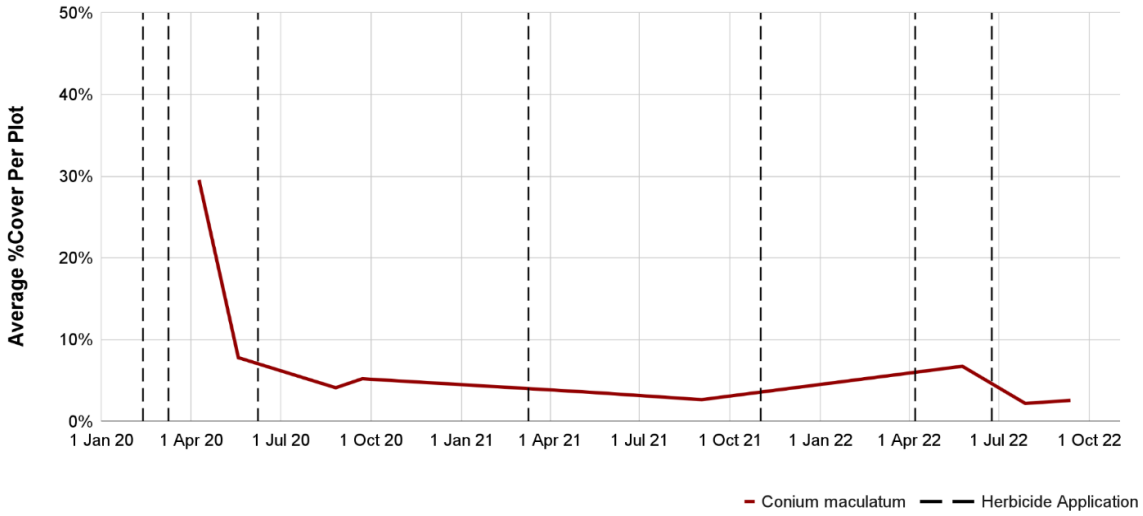


Figure 59. Average percent cover per plot by date for common invasive species found at Slope 1 (Ashland).

Appendix O: Cost Analysis

The following is a comparison of seeding costs for native and turfgrass seed mixes. Costs are based on values from this study. Costs for the recommendations made throughout this report by DRG are outlined below. The cost of the all-native seed mixes tested in this study ranges between $5.39-$86.78, with an average of $30.60/1,000 ft.^{2} area. All values listed below are based on average prices at the time of seeding in 2019.

Table 9 compares broadcast seeding costs for native and turfgrass seedings. Costs include Profile Aqua-pHix™ and Verdyol Biotic Earth™ as they were used at some sites based on soil conditions. ODOT seeding specifications were followed for fertilizer, lime, straw application, and watering during site preparation and seeding. Seeding rates and seed cost values are averages of seed mixes used for hydroseeding throughout this study. This table represents the costs of seeding and is not inclusive of labor, equipment costs, and delivery fees. As illustrated in the table below, the cost of broadcasting native seed is $149.22 less expensive than seeding with turfgrass.

Table 9. Site Preparation and Broadcast Seeding Cost Factors for This Study

Cost Factors	**Turfgrass Seed Mixes**	**Native Seed Mixes**
Broadcast Non-Selective Herbicide/1,000 ft.^{2} *	$0.00	$8.00
Soil Test	$9.00	$9.00
Fertilizer (N-P-K) lbs./1,000 ft.^{2} (as needed)	4.0 lbs.	3.4 lbs.
Fertilizer (N-P-K) cost/1,000 ft.^{2} (as needed)	$1.30	$1.11
Lime/1000 ft.^{2} (as needed)	N/A	N/A
Profile Aqua-pHix™ gal/1,000 ft.^{2} (as needed)	0.23 gal	0.23 gal
Profile Aqua-pHix™ cost/1,000 ft.^{2} (as needed)	$16.79	$16.79
Verdyol Biotic Earth™ lbs./1,000 ft.^{2} (as needed)	56.24 lbs.	56.24 lbs.
Verdyol Biotic Earth™ cost/1,000 ft.^{2} (as needed)	$72.31	$72.31
Average Seeding lbs./1,000 ft.^{2}	4.128 lbs.	0.44
Average Seed cost/1,000 ft.^{2}	$11.31	$22.85
Nurse Crop lbs./1,000 ft.^{2}	0.00 lbs.	0.689 lbs.
Nurse Seed cost/1,000 ft.^{2}	$0.00	$0.62
Straw Application lbs./1,000 ft.^{2}	137.7	36.2
Straw cost/1,000 ft.^{2}	$26.56	$6.97
Tackifier cost/1,000 ft.^{2}	$6.77	$6.77
Watering cost/1,000 ft.^{2}	$149.60	$0.00
Site Prep and Seeding Total	**$293.66**	**$144.43**

*Price listed for herbicide mix only. Does not include the price of water.

Table 10 represents drill seeding costs for native seedings only as it is impractical to use a native drill seeder with turfgrass seed mixes. Costs include Profile Aqua-pHix™ and Verdyol Biotic Earth™ as they were used at some sites based on soil conditions. All ODOT seeding specifications were followed for fertilizer, and lime during site preparation and seeding. This table represents the average costs of seeding with the seed mixes tested with a drill seeder during this study. This table is not inclusive of labor, equipment costs, and delivery fees. As illustrated in the table below, the average cost of drill native seed is $154.40.

Table 10. Site Preparation and Drill Seeding Cost Factors for This Study

Cost Factors	Native Seed Mixes
Broadcast Non-Selective Herbicide/1,000 ft.^{2}*	$8.00
Soil Test	$9.00
Fertilizer (N-P-K) lbs./1,000 ft.^{2} (as needed)	3.4 lbs.
Fertilizer (N-P-K) cost/1,000 ft.^{2} (as needed)	$1.11
Lime/1,000 ft.^{2} (as needed)	N/A
Profile Aqua-pHix™ cost/1000 ft.^{2} (as needed)	$16.79
Profile Aqua-pHix™ gal/1,000 ft.^{2} (as needed)	0.23 gal
Verdyol Biotic Earth™ cost/1,000 ft.^{2} (as needed)	$72.31
Verdyol Biotic Earth™ lbs./1,000 ft.^{2} (as needed)	56.24 lbs.
Average Seeding lbs./1,000 ft.^{2}	0.295 lbs.
Average Seed cost/1,000 ft.^{2}	$46.08
Nurse Crop lbs./1,000 ft.^{2}	0.689 lbs.
Nurse Seed cost/1,000 ft.^{2}	$0.62
Straw Application lbs./1,000 ft.^{2}	0.0 lbs.
Straw cost/1,000 ft.^{2}	$0.00
Tackifier cost/1,000 ft.^{2}	$0.00
Watering cost/1,000 ft.^{2}	$0.00
Site Prep and Seeding Total	**$154.40**

*Price listed for herbicide mix only. Does not include the price of water.

Table 11. compares hydroseeding costs for native and turfgrass seedings. Costs include Profile Aqua-pHix™ and Verdyol Biotic Earth™ as they were used at some sites based on to soil conditions ODOT seeding specifications were followed for fertilizer, lime, straw application, and watering during site preparation and seeding. Seeding rates and seed cost values are averages of seed mixes used for hydroseeding throughout this study. This table represents the costs of seeding and is not inclusive of labor, equipment costs, and delivery fees. As illustrated in the table below, the average cost of hydroseeding native seed is $148.45 less expensive than seeding with turfgrass.

Table 11. Site Preparation and Hydroseeding Cost Factors for This Study

Cost Factors	**Turfgrass Seed Mixes**	**Native Seed Mixes**
Broadcast Non-Selective Herbicide/1,000 ft.^{2} *	$0.00	$8.00
Soil Test	$9.00	$9.00
Fertilizer (N-P-K) lbs./1,000 ft.^{2} (as needed)	4.0 lbs.	3.4 lbs.
Fertilizer (N-P-K) cost/1,000 ft.^{2} (as needed)	$1.30	$1.11
Lime/1,000 ft.^{2} (as needed)	N/A	N/A
Profile Aqua-pHix™ Cost/1,000 ft.^{2} (as needed)	$16.79	$16.79
Profile Aqua-pHix™ gal/1,000 ft.^{2} (as needed)	0.23 gal	0.23 gal
Verdyol Biotic Earth™ Cost/1,000 ft.^{2} (as needed)	$72.31	$72.31
Verdyol Biotic Earth™ lbs./1,000 ft.^{2} (as needed)	56.24 lbs.	56.24 lbs.
Average Seeding lbs./1,000 ft.^{2}	4.128 lbs.	0.392 lbs.
Average Seed Cost/1,000 ft.^{2}	$11.31	$22.85
Nurse Crop lbs./1,000 ft.^{2}	0.0 lbs.	0.689 lbs.
Nurse Seed Cost/1,000 ft.^{2}	$0.00	$0.62
Fiber Mulch Application/1,000 ft.^{2} (Fenceline and Roadside)	34.4 lbs.	34.4 lbs.
Fiber Mulch Application/1,000 ft.^{2} (Slope and Wet Ditch)	45.9 lbs.	45.9 lbs.
Fiber Mulch Cost/1,000 ft.^{2} (Fenceline and Roadside)	$12.05	$12.05
Fiber Mulch Cost/1,000 ft.^{2} (Slope and Wet Ditch)	$16.07	$16.07
Watering Cost/1,000 ft.^{2}	$149.60	$0.00
Site Prep and Seeding Total (Fenceline and Roadside)	**$298.94**	**$150.49**
Site Prep and Seeding Total (Slope and Wet Ditch)	**$302.95**	**$154.50**

*Price listed for herbicide mix only. Does not include the price of water.

Appendix P: Construction Site Observations and Engineer Interviews

The information provided in this section is a combination of notes and responses to questions. This information informed the research team of practices used in ODOT post-construction seeding methods by contractors leading to the recommendations provided by DRG. Active construction site meetings were completed in 2019 with visits in 2021.

Below are observations of various construction sites across Ohio.

Topsoil

Consistent with Specification 659, soil tests for pH and particle size are only completed for imported soil (brought in from offsite). Topsoil may be brought in from other projects or purchased but it is stockpiled and reused whenever possible. Soil amendments (other than lime) are typically not utilized. Lime may be applied to raise the pH of sites despite sites having high pH. During site visits, topsoil was found to be less than required by Specification 659 only a couple of months after seeding. At one completed construction site, topsoil was 2-3 inches deep in most locations but as low as 0.25 inches in some locations. Inspectors indicated sites will be graded and rocks 3 inches or greater in diameter are to be removed. This was found to be inconsistent with road fill that was found at test sites and was discussed with other ODOT personnel as a common practice.

Seeding

Typically, ODOT's design plans do not indicate a permanent seed mix to be used by the contractor. When the seed mix is not indicated, Class 2 seed mix is typically selected and applied by the contractor, Class 1 is applied in residential areas. Seeded sites often have added straw and tackifiers. Hydroseeding is the most commonly used seeding method by contractors. This makes sense as hydroseeding is the most efficient method to install turfgrass seed mixes.

Inspections

Site inspectors look for green growth, not growth of seeded species. Noxious and invasive weeds often cannot be identified by the inspectors and are included in their vegetation coverage evaluations. Areas that do not meet 70% groundcover by green vegetation within 12 months are required to be reseeded. Contractors are responsible for the costs of reseeding.

Plants and Seeding

During site visits, construction sites were found to consist of non-native or invasive grass species such as Johnson Grass. Common volunteer flowering forb species that were present on sites included milkweed species (*Asclepias sp.*), dogbane species (*Apocynum sp.)*, Canada thistle (*Cirsium arvense*), poison ivy (*Toxicodendron radicans*), red clover (*Trifolium pratense*), morning glory (*Ipomoea sp.)*, and dock species (*Rumex sp*). Vine species were found creeping up and spreading near barriers.

Erosion Prevention

After repeated failures at a few sites where turfgrass seeding was not effective, tied concrete block matting was installed as a permanent management tool to combat erosion caused by drainage issues when construction timelines are tight or run over. Mat Type C erosion control is a better option if the contractor is able to apply it prior to soil loss caused by heavy waterflow.

Herbicide

Limited herbicide applications were performed prior to construction, typically those applications target only berms and guardrails.

Road Construction

Typically, sub-base layers of limestone are added during road construction as a stabilization method prior to paving. Dust from this limestone often drifts during construction and lands in natural areas along the roadsides. This limestone raises pH in the soil prior to the intentional addition of lime as an amendment before seeding. Lime raises calcium levels in the roadsides binding phosphorus and reducing its availability to plants and preventing the leaching of salt and causes cementation of the soil reducing water and air movement to plant roots.

Appendix Q: Scorecard to Identify Potential Roadway Sites for Native Restoration to Benefit Pollinators

Scorecard to Identify Potential Roadway Sites for Native Restoration to Benefit Pollinators

Site Name: _____ **County/Route/Section:** _____
District: _____ **Nearest Intersection:** _____ **Mile Point:** _____
Reviewer Name: _____ **Date:** _____ **GPS Collected:** Y N
Site Type: Foreslope Backslope Ditch Fenceline **Soil Sample Collected:** Y N **Photos Collected:** Y N

1. Current or historical use of site (choose the highest percent cover):

☐ Used for fill, paved, invasive cover >50% or bare ground >50%	0 pts.
☐ Invasive cover 25-50% or bare ground 25-50%	15 pts.
☐ Invasive cover 15-25% or bare ground 5-25%	20 pts.
☐ Invasive cover <15% or bare ground 0-5%	25 pts.

Total Points

2. Habitat directly adjacent to site (choose 1 with highest point value):

☐ Invasive cover >50%	0 pts.
☐ Invasive cover 25-50%	3 pts.
☐ Invasive cover 15-25%	7 pts.
☐ Invasive cover <15%	10 pts.

Total Points

3. Size of potential project (acres):

☐ 0.01 - 0.5 acre	1 pts.
☐ 0.5 - 1.0 acre	3 pts.
☐ 1.0 + acres	5 pts.

Total Points

4. Distance to naturalized area (miles):

☐ 1+	0 pts.
☐ 0.5-1	3 pts.
☐ 0-0.5	5 pts.

Total Points

5. Site accessible to mower or herbicide application:

☐ No access	0 pts.
☐ Herbicide only	5 pts.
☐ Mowing & herbicide	10 pts.

Total Points

Total 1-5
(Minimum score of 35 to continue)

6. Concern of herbicide drift to non-targeted areas:

☐ Yes	0 pts.
☐ No	5 pts.

Total Points

7. Maintenance practices of ODOT and neighbors amenable to full maturation of plants on site:

☐ No	0 pts.
☐ Yes	5 pts.

Total Points

8. Daily summer sunlight exposure:

☐ 0-3 hours of sun	1 pts.
☐ 3-5 hours of sun	3 pts.
☐ 6+ hours of sun	5 pts.

Total Points

9. Site Soil Properties: salt (<180 mg/kg), no leaching chemicals, 6" topsoil present, 4-20% organic content, pH 5-8:

☐ Low (0-1 goals met)	0 pts.
☐ Medium (2-3 goals met)	10 pts.
☐ High (4+ goals met)	20 pts.

Total Points

10. Endangered or vulnerable pollinator species identified within county:

☐ No	0 pts.
☐ Yes	5 pts.

Total Points

11. Time until site reconstruction:

☐ 1-5 years	0 pts.
☐ 6-10 years	2 pts.
☐ 11-15 years	4 pts.
☐ No plans being considered	5 pts.

Total Points

Grand Total

Score ratings: Low priority (0-50 points); medium priority (51-75 points); high priority (76-100 points)

Introduction

The Scorecard to Identify Potential Roadway Sites for Native Restoration to Benefit Pollinators (scorecard) is intended to provide a method to determine priority levels for native seeding along ROWs to provide habitat for pollinators. Using the scorecard, sites being considered for native seeding should be assessed through the questions in the scorecard to rate the site and determine whether native seeding would be likely to succeed. Sites are individually evaluated by examining 11 criteria. Ranking criteria were determined based on issues commonly found along roadside revegetation projects. When completing the scorecard, an intermediate score of 35 out of 55 points is required to move forward with the remaining questions. Sites that reach 35 points or higher qualify for further site assessment and investment of time and resources, including soil testing. Scores are dependent upon responses and will range from 0-100 points. The scorecard will easily identify high (76-100), medium (51-75), and low (0-50) priority sites for native seeding. Sites that receive a high score have a greater likelihood of success compared to sites with lower scores. Ultimately, assessment with the scorecard aids in understanding the likelihood of site seeding success leading to healthy pollinator habitats but does not account for every variable which could limit success. A copy of the Site Assessment Scorecard can be found at the end of this Appendix including the instructions.

Scorecard Results and Discussion

Following the creation of the scorecard, the research team used the scorecard at nine sites chosen for this study in order to test the scorecard's accuracy. These were the Fenceline, Slope, and Wet Ditch test type sites. Roadside test types were excluded from this analysis due to the lack of pollinator-friendly habitat seeded along these sites. Due to the scorecards being created after the seed installation at the test locations, not all soil parameters on the scorecard were tested in 2019 before site development occurred. The parameters not tested include salt, any leaching chemicals at the site, and topsoil depth. However, the research team had included a majority of site characteristics found on the scorecard when selecting sites in 2019. Zero points were allocated for any site variable required for the scorecard that was not able to be obtained post-site establishment for the tested sites.

The average scorecard result of the sites tested is a medium ranking value of 64 out of 100 total points. The average for all sites at the intermediate decision point is 39.8 out of 55 points. These results signify that passing the 35 out of 55-point requirement was a possibility on sites that had been managed by ODOT as turfgrass. Similar site types showed differing results based on individual site characteristics. Fenceline test locations had the highest average total score of 75.3 out of 100 points. Wet Ditch test locations averaged 64.3 out of 100 points. Lastly, Slope locations averaged 52.3 out of 100 points. The trends observed here could aid in ODOT's initial site selection by focusing on Fenceline sites. The patterns observed for the total points are reflected in the intermediate decision point in the assessment. The Fenceline and Wet Ditch test types' of intermediate average well exceeds the 35-point minimum, whereas the Slope test types average 30.3 out of 55 points. This result depicts that Slope types may take additional effort for site success. However, other factors may need to be considered when assessing a site that is not included as a part of the scorecard.

Scorecard Conclusions

Some site properties are imperative to seeding success but not all secondary characteristics are represented in the scorecard, such as proximity to a roadway, slope aspect from the road (foreslope or backslope), and shape of the site. Soil properties are an important component of seeding success and increased pressure from road salt and heavy metals at sites can lead to a decreased seeding success and require additional maintenance. Proper soil health increases seeding success while limiting invasive species' presence. Site types such as Slopes or Fencelines are typically larger, and the sizes of these sites can localize site improvement efforts and potentially limit invasive plant pressure.

Overall, the scorecard assessment is a viable means of predicting seeding success. After reviewing the scorecards completed for this study, it was found that sites that scored as high priority or in the upper portion of medium priority (60+ points) were successful. The sites that scored in the lower half of medium priority or in low priority struggled with obtaining 70% vegetative coverage during the first year of growth (Table12). Site characteristics such as existing groundcover and adjacent vegetation cover are important factors to consider. With proper maintenance, sites with 25-50% initial invasive cover can achieve native plant coverage of 75% or greater. Ultimately, the final result of a site is dependent upon site preparation and management. Ensuring site soil properties meet requirements for native plants and limiting invasive plant pressure benefits the establishment of pollinator site improvement projects. Larger sites and sites located near an existing natural area improve pollinator connectivity and offer a greater abundance of floral resources. If these factors are taken into account when planning seeding sites, there will be an increase in the presence of pollinators along land managed by ODOT.

Table 12. Scorecard Results

Site Name	Intermediary Score	Final Score	12-month 70% Vegetation Coverage Success
Fenceline 1 (Ashland)	47	79	Succeeded
Fenceline 2 (Cuyahoga)	38	60	Failed
Fenceline 3 (Montgomery)	55	87	Succeeded
Slope 1 (Ashland)	33	55	Succeeded
Slope 2 (Ashland)	33	55	Succeeded
Slope 3 (Athens)	25	47	Failed
Wet Ditch 1 (Cuyahoga)	46	63	Succeeded
Wet Ditch 2 (Geauga)	43	75	Succeeded
Wet Ditch 3 (Summit)	38	55	Failed

Scorecard to Identify Potential Roadway Sites for Native Restoration to Benefit Pollinators

Directions

This evaluation form is intended to provide a method to determine priority levels for native seeding along Right-of-Ways (ROW) in the state of Ohio. Evaluate each site individually using the criteria listed.

Mark only one score for each criteria
Responses to questions 1-5 must total a minimum 35 of 55 points to complete the assessment
Score ratings: Low priority (0-50 points); medium priority (51-75 points); high priority (76-100 points)

Site Requirements

- A minimum of 30' (9.14 meters) from the road
- No scheduled construction for 5 years
- Regrading occurs only at 4+ year intervals
- Sites must require an ODOT specified seed mix

Descriptions and explanations of criteria:

1. **Current or historical use of site:** impacts the performance and longevity of native seeded areas. Sites with a large percentage of bare soil suggests there is compacted soil. Compacted soils will reduce germination of any species seeded. A high percentage of invasive species present prior to construction/seeding increases the likelihood of invasive species returning to the site. Sites with abundant invasive species reduces the germination, growth, and likely success of the seeded species. When comparing invasive cover to bare ground, use the highest percent cover to determine where the area will score (i.e., high bare ground but low invasive, use the high bare ground percentage).
2. **Habitat directly adjacent to site (choose 1 with highest point value):** Habitat adjacent to a site impacts the pollinators that could visit. Habitats with less invasive species prior to construction decrease invasion into the site, increasing seeding success. Use the habitat with the highest point value for the scorecard.
3. **Size of potential project (acres):** Utilizing larger sites localizes work efforts for a planting. Per the NRCS, a minimum of a 30 ft (9.14m) wide and a half acre or greater size planting is optimal to provide healthy pollinator habitat.
4. **Distance to naturalized area (miles):** Pollinators generally do not travel long distances. Having multiple sites close to each other increases the likelihood that the pollinator habitat will be utilized.
5. **Site accessible to mower or herbicide application:** The ability to manage a site with herbicide and mowing can help decrease the number of invasive plants that reside in the ROW. Increasing the success of seeding.
6. **Concern of herbicide drift to non-targeted areas:** Herbicide drift concerns include agricultural areas and residential areas where the application of herbicide can have a negative impact to neighboring properties or from neighboring properties to the pollinator seeding.
7. **Maintenance practices of ODOT and neighbors amenable to full maturation of plants on site:** There is no concern with seed maturation, or plant encroachment onto neighboring land.
8. **Daily sunlight exposure:** The species included in many pollinator seed mixes require an abundance of sunlight. Increased sunlight will result in greater seeded species success.
9. **Site Soil Properties: salt (<180 mg/kg), no leaching chemicals, 6" topsoil present, 4-20% organic content, pH 5-8:** Soil testing must be completed to determine the current conditions of the site. While native species can grow in habitats with conditions outside of the ranges listed, choosing a site outside of the ranges will reduce seeding success.
10. **Endangered or vulnerable pollinator species identified within the county:** Increasing pollinator habitat in an area that has an endangered pollinator species will benefit that species.
11. **Time until site reconstruction:** Native plants take between 1-5 years to fully establish at a site. The longer a site can grow without construction, the greater the return on investment is.

Scorecard to Identify Potential Roadway Sites for Native Restoration to Benefit Pollinators

Site Name: _____ Fence 1 Ashland _____ **County/Route/Section:** _____ I-71_____
District: _____3_____ **Nearest Intersection:** _____603_____ **Mile Point:** _____180_____
Reviewer Name: _____DRG_____ **Date:** _____ **GPS Collected:** Y N
Site Type: Foreslope Backslope Ditch Fenceline **Soil Sample Collected:** Y N **Photos Collected:** Y N

1. Current or historical use of site (choose highest percent cover):

☐ Used for fill, paved, invasive cover >50% or bare ground >50%	0 pts.
☐ Invasive cover 25-50% or bare ground 25-50%	15 pts.
■ Invasive cover 15-25% or bare ground 5-25%	20 pts.
☐ Invasive cover <15% or bare ground 0-5%	25 pts.

Total Points: 20

2. Habitat directly adjacent to site (choose 1 with highest point value):

☐ Invasive cover >50%	0 pts.
☐ Invasive cover 25-50%	3 pts.
■ Invasive cover 15-25%	7 pts.
☐ Invasive cover <15%	10 pts.

Total Points: 7

3. Size of potential project (acres):

☐ 0.01 - 0.5 acre	1 pts.
☐ 0.5 - 1.0 acre	3 pts.
■ 1.0 + acres	5 pts.

Total Points: 5

4. Distance to naturalized area (miles):

☐ 1+	0 pts.
☐ 0.5-1	3 pts.
■ 0-0.5	5 pts.

Total Points: 5

5. Site accessible to mower or herbicide application:

☐ No access	0 pts.
☐ Herbicide only	5 pts.
■ Mowing & herbicide	10 pts.

Total Points: 10

Total 1-5
(Minimum score 35 to continue): 47

6. Concern of herbicide drift to non-targeted areas:

☐ Yes	0 pts.
■ No	5 pts.

Total Points: 5

7. Maintenance practices of ODOT and neighbors amenable to full maturation of plants on site:

☐ No	0 pts.
■ Yes	5 pts.

Total Points: 5

8. Daily summer sunlight exposure:

☐ 0-3 hours of sun	1 pts.
☐ 3-5 hours of sun	3 pts.
■ 6+ hours of sun	5 pts.

Total Points: 5

9. Site Soil Properties: salt (<180 mg/kg), no leaching chemicals, 6" topsoil present, 4-20% organic content, pH 5-8:

☐ Low (0-1 goals met)	0 pts.
■ Medium (2-3 goals met)	10 pts.
☐ High (4+ goals met)	20 pts.

Total Points: 10

10. Endangered or vulnerable pollinator species identified within county:

☐ No	0 pts.
■ Yes	5 pts.

Total Points: 5

11. Time until site reconstruction:

☐ 1-5 years	0 pts.
■ 6-10 years	2 pts.
☐ 11-15 years	4 pts.
☐ No plans being considered	5 pts.

Total Points: 2

Grand Total: 79

Score ratings: Low priority (0-50 points); medium priority (51-75 points); high priority (76-100 points)

Scorecard to Identify Potential Roadway Sites for Native Restoration to Benefit Pollinators

Site Name: _____ Fence 2 Cuyahoga _____ **County/Route/Section:** _____ I-271_____
District: ___12____ **Nearest Intersection:** _____480_____ **Mile Point:** _____27_____
Reviewer Name: _____DRG_____ **Date:** _____ **GPS Collected:** Y N
Site Type: Foreslope Backslope Ditch Fenceline **Soil Sample Collected:** Y N **Photos Collected:** Y N

1. Current or historical use of site (choose highest percent cover):

☐ Used for fill, paved, invasive cover >50% or bare ground >50%	0 pts.
■ Invasive cover 25-50% or bare ground 25-50%	15 pts.
☐ Invasive cover 15-25% or bare ground 5-25%	20 pts.
☐ Invasive cover <15% or bare ground 0-5%	25 pts.

Total Points: 15

2. Habitat directly adjacent to site (choose 1 with highest point value):

☐ Invasive cover >50%	0 pts.
■ Invasive cover 25-50%	3 pts.
☐ Invasive cover 15-25%	7 pts.
☐ Invasive cover <15%	10 pts.

Total Points: 3

3. Size of potential project (acres):

☐ 0.01 - 0.5 acre	1 pts.
☐ 0.5 - 1.0 acre	3 pts.
■ 1.0 + acres	5 pts.

Total Points: 5

4. Distance to naturalized area (miles):

☐ 1+	0 pts.
☐ 0.5-1	3 pts.
■ 0-0.5	5 pts.

Total Points: 5

5. Site accessible to mower or herbicide application:

☐ No access	0 pts.
☐ Herbicide only	5 pts.
■ Mowing & herbicide	10 pts.

Total Points: 10

6. Concern of herbicide drift to non-targeted areas:

☐ Yes	0 pts.
■ No	5 pts.

Total Points: 5

7. Maintenance practices of ODOT and neighbors amenable to full maturation of plants on site:

☐ No	0 pts.
■ Yes	5 pts.

Total Points: 5

8. Daily summer sunlight exposure:

☐ 0-3 hours of sun	1 pts.
☐ 3-5 hours of sun	3 pts.
■ 6+ hours of sun	5 pts.

Total Points: 5

9. Site Soil Properties: salt (<180 mg/kg), no leaching chemicals, 6" topsoil present, 4-20% organic content, pH 5-8:

■ Low (0-1 goals met)	0 pts.
☐ Medium (2-3 goals met)	10 pts.
☐ High (4+ goals met)	20 pts.

Total Points: 0

10. Endangered or vulnerable pollinator species identified within county:

☐ No	0 pts.
■ Yes	5 pts.

Total Points: 5

11. Time until site reconstruction:

☐ 1-5 years	0 pts.
■ 6-10 years	2 pts.
☐ 11-15 years	4 pts.
☐ No plans being considered	5 pts.

Total Points: 2

Total 1-5
(Minimum score 35 to continue): 38

Grand Total: 60

Score ratings: Low priority (0-50 points); medium priority (51-75 points); high priority (76-100 points)

Scorecard to Identify Potential Roadway Sites for Native Restoration to Benefit Pollinators

Site Name: _____ Fence 3 Montgomery _____ **County/Route/Section:** _____ I-70_____
District: _____7_____ **Nearest Intersection:** _____235 W_____ **Mile Point:** _____41_____
Reviewer Name: _____DRG_____ **Date:** _____ **GPS Collected:** Y N
Site Type: Foreslope Backslope Ditch Fenceline **Soil Sample Collected:** Y N **Photos Collected:** Y N

1. Current or historical use of site (choose lowest applicable point value):

☐ Used for fill, paved, invasive cover >50% or bare ground >50%	0 pts.
☐ Invasive cover 25-50% or bare ground 25-50%	15 pts.
☐ Invasive cover 15-25% or bare ground 5-25%	20 pts.
■ Invasive cover <15% or bare ground 0-5%	25 pts.

Total Points: 25

2. Habitat directly adjacent to site (choose 1 with highest point value):

☐ Invasive cover >50%	0 pts.
☐ Invasive cover 25-50%	3 pts.
☐ Invasive cover 15-25%	7 pts.
■ Invasive cover <15%	10 pts.

Total Points: 10

3. Size of potential project (acres):

☐ 0.01 - 0.5 acre	1 pts.
☐ 0.5 - 1.0 acre	3 pts.
■ 1.0 + acres	5 pts.

Total Points: 5

4. Distance to naturalized area (miles):

☐ 1+	0 pts.
☐ 0.5-1	3 pts.
■ 0-0.5	5 pts.

Total Points: 5

5. Site accessible to mower or herbicide application:

☐ No access	0 pts.
☐ Herbicide only	5 pts.
■ Mowing & herbicide	10 pts.

Total Points: 10

55

Total 1-5
(Minimum score 35 to continue)

6. Concern of herbicide drift to non-targeted areas:

☐ Yes	0 pts.
■ No	5 pts.

Total Points: 5

7. Maintenance practices of ODOT and neighbors amenable to full maturation of plants on site:

☐ No	0 pts.
■ Yes	5 pts.

Total Points: 5

8. Daily summer sunlight exposure:

☐ 0-3 hours of sun	1 pts.
☐ 3-5 hours of sun	3 pts.
■ 6+ hours of sun	5 pts.

Total Points: 5

9. Site Soil Properties: salt (<180 mg/kg), no leaching chemicals, 6" topsoil present, 4-20% organic content, pH 5-8:

☐ Low (0-1 goals met)	0 pts.
■ Medium (2-3 goals met)	10 pts.
☐ High (4+ goals met)	20 pts.

Total Points: 10

10. Endangered or vulnerable pollinator species identified within county:

☐ No	0 pts.
■ Yes	5 pts.

Total Points: 5

11. Time until site reconstruction:

☐ 1-5 years	0 pts.
■ 6-10 years	2 pts.
☐ 11-15 years	4 pts.
☐ No plans being considered	5 pts.

Total Points: 2

Grand Total 87

Score ratings: Low priority (0-50 points); medium priority (51-75 points); high priority (76-100 points)

Scorecard to Identify Potential Roadway Sites for Native Restoration to Benefit Pollinators

Site Name: _____Slope 1 Ashland_____ **County/Route/Section:** _____ I-71_____
District: ___3____ **Nearest Intersection:** _____603_____ **Mile Point:** _____179_____
Reviewer Name: _____DRG_____ **Date:** _____ **GPS Collected:** Y N
Site Type: Foreslope **Backslope** Ditch Fenceline **Soil Sample Collected:** Y N **Photos Collected:** Y N

1. Current or historical use of site (choose the highest percent cover):

☐ Used for fill, paved, invasive cover >50% or bare ground >50%	0 pts.
■ Invasive cover 25-50% or bare ground 25-50%	15 pts.
☐ Invasive cover 15-25% or bare ground 5-25%	20 pts.
☐ Invasive cover <15% or bare ground 0-5%	25 pts.

Total Points: 15

2. Habitat directly adjacent to site (choose 1 with highest point value):

☐ Invasive cover >50%	0 pts.
■ Invasive cover 25-50%	3 pts.
☐ Invasive cover 15-25%	7 pts.
☐ Invasive cover <15%	10 pts.

Total Points: 3

3. Size of potential project (acres):

☐ 0.01 - 0.5 acre	1 pts.
☐ 0.5 - 1.0 acre	3 pts.
■ 1.0 + acres	5 pts.

Total Points: 5

4. Distance to naturalized area (miles):

☐ 1+	0 pts.
☐ 0.5-1	3 pts.
■ 0-0.5	5 pts.

Total Points: 5

5. Site accessible to mower or herbicide application:

☐ No access	0 pts.
■ Herbicide only	5 pts.
☐ Mowing & herbicide	10 pts.

Total Points: 5

Total 1-5
(Minimum score 35 to continue): 33

6. Concern of herbicide drift to non-targeted areas:

☐ Yes	0 pts.
■ No	5 pts.

Total Points: 5

7. Maintenance practices of ODOT and neighbors amenable to full maturation of plants on site:

☐ No	0 pts.
■ Yes	5 pts.

Total Points: 5

8. Daily summer sunlight exposure:

☐ 0-3 hours of sun	1 pts.
☐ 3-5 hours of sun	3 pts.
■ 6+ hours of sun	5 pts.

Total Points: 5

9. Site Soil Properties: salt (<180 mg/kg), no leaching chemicals, 6" topsoil present, 4-20% organic content, pH 5-8:

■ Low (0-1 goals met)	0 pts.
☐ Medium (2-3 goals met)	10 pts.
☐ High (4+ goals met)	20 pts.

Total Points: 0

10. Endangered or vulnerable pollinator species identified within county:

☐ No	0 pts.
■ Yes	5 pts.

Total Points: 5

11. Time until site reconstruction:

☐ 1-5 years	0 pts.
■ 6-10 years	2 pts.
☐ 11-15 years	4 pts.
☐ No plans being considered	5 pts.

Total Points: 2

Grand Total: 55

Score ratings: Low priority (0-50 points); medium priority (51-75 points); high priority (76-100 points)

Scorecard to Identify Potential Roadway Sites for Native Restoration to Benefit Pollinators

Site Name: _____Slope 2 Ashland_____ **County/Route/Section:** _____ I-71_____
District: _____3____ **Nearest Intersection:** _____603_____ **Mile Point:** _____180_____
Reviewer Name: _____DRG_____ **Date:** _____ **GPS Collected:** Y N
Site Type: Foreslope **Backslope** Ditch Fenceline **Soil Sample Collected:** Y N **Photos Collected:** Y N

1. Current or historical use of site (choose the highest percent cover):

☐ Used for fill, paved, invasive cover >50% or bare ground >50%	0 pts.
■ Invasive cover 25-50% or bare ground 25-50%	15 pts.
☐ Invasive cover 15-25% or bare ground 5-25%	20 pts.
☐ Invasive cover <15% or bare ground 0-5%	25 pts.

Total Points: 15

2. Habitat directly adjacent to site (choose 1 with highest point value):

☐ Invasive cover >50%	0 pts.
■ Invasive cover 25-50%	3 pts.
☐ Invasive cover 15-25%	7 pts.
☐ Invasive cover <15%	10 pts.

Total Points: 3

3. Size of potential project (acres):

☐ 0.01 - 0.5 acre	1 pts.
☐ 0.5 - 1.0 acre	3 pts.
■ 1.0 + acres	5 pts.

Total Points: 5

4. Distance to naturalized area (miles):

☐ 1+	0 pts.
☐ 0.5-1	3 pts.
■ 0-0.5	5 pts.

Total Points: 5

5. Site accessible to mower or herbicide application:

☐ No access	0 pts.
■ Herbicide only	5 pts.
☐ Mowing & herbicide	10 pts.

Total Points: 5

Total 1-5
(Minimum score 35 to continue): 33

6. Concern of herbicide drift to non-targeted areas:

☐ Yes	0 pts.
■ No	5 pts.

Total Points: 5

7. Maintenance practices of ODOT and neighbors amenable to full maturation of plants on site:

☐ No	0 pts.
■ Yes	5 pts.

Total Points: 5

8. Daily summer sunlight exposure:

☐ 0-3 hours of sun	1 pts.
☐ 3-5 hours of sun	3 pts.
■ 6+ hours of sun	5 pts.

Total Points: 5

9. Site Soil Properties: salt (<180 mg/kg), no leaching chemicals, 6" topsoil present, 4-20% organic content, pH 5-8:

■ Low (0-1 goals met)	0 pts.
☐ Medium (2-3 goals met)	10 pts.
☐ High (4+ goals met)	20 pts.

Total Points: 0

10. Endangered or vulnerable pollinator species identified within county:

☐ No	0 pts.
■ Yes	5 pts.

Total Points: 5

11. Time until site reconstruction:

☐ 1-5 years	0 pts.
■ 6-10 years	2 pts.
☐ 11-15 years	4 pts.
☐ No plans being considered	5 pts.

Total Points: 2

Grand Total: 55

Score ratings: Low priority (0-50 points); medium priority (51-75 points); high priority (76-100 points)

Scorecard to Identify Potential Roadway Sites for Native Restoration to Benefit Pollinators

Site Name: _____Slope 3 Athens_____ **County/Route/Section:** _____Rt. 33_____
District: ___10___ **Nearest Intersection:** _____Oxley Rd_____ **Mile Point:** _____N/A_____
Reviewer Name: _____DRG_____ **Date:** _____ **GPS Collected:** Y N
Site Type: Foreslope Backslope Ditch Fenceline **Soil Sample Collected:** Y N **Photos Collected:** Y N

1. Current or historical use of site (choose the highest percent cover):

■ Used for fill, paved, invasive cover >50% or bare ground >50%	0 pts.
☐ Invasive cover 25-50% or bare ground 25-50%	15 pts.
☐ Invasive cover 15-25% or bare ground 5-25%	20 pts.
☐ Invasive cover <15% or bare ground 0-5%	25 pts.

Total Points: 0

2. Habitat directly adjacent to site (choose 1 with highest point value):

☐ Invasive cover >50%	0 pts.
☐ Invasive cover 25-50%	3 pts.
☐ Invasive cover 15-25%	7 pts.
■ Invasive cover <15%	10 pts.

Total Points: 10

3. Size of potential project (acres):

☐ 0.01 - 0.5 acre	1 pts.
☐ 0.5 - 1.0 acre	3 pts.
■ 1.0 + acres	5 pts.

Total Points: 5

4. Distance to naturalized area (miles):

☐ 1+	0 pts.
☐ 0.5-1	3 pts.
■ 0-0.5	5 pts.

Total Points: 5

5. Site accessible to mower or herbicide application:

☐ No access	0 pts.
■ Herbicide only	5 pts.
☐ Mowing & herbicide	10 pts.

Total Points: 5

25

Total 1-5
(Minimum score 35 to continue)

6. Concern of herbicide drift to non-targeted areas:

☐ Yes	0 pts.
■ No	5 pts.

Total Points: 5

7. Maintenance practices of ODOT and neighbors amenable to full maturation of plants on site:

☐ No	0 pts.
■ Yes	5 pts.

Total Points: 5

8. Daily summer sunlight exposure:

☐ 0-3 hours of sun	1 pts.
☐ 3-5 hours of sun	3 pts.
■ 6+ hours of sun	5 pts.

Total Points: 5

9. Site Soil Properties: salt (<180 mg/kg), no leaching chemicals, 6" topsoil present, 4-20% organic content, pH 5-8:

■ Low (0-1 goals met)	0 pts.
☐ Medium (2-3 goals met)	10 pts.
☐ High (4+ goals met)	20 pts.

Total Points: 0

10. Endangered or vulnerable pollinator species identified within county:

☐ No	0 pts.
■ Yes	5 pts.

Total Points: 5

11. Time until site reconstruction:

☐ 1-5 years	0 pts.
■ 6-10 years	2 pts.
☐ 11-15 years	4 pts.
☐ No plans being considered	5 pts.

Total Points: 2

Grand Total 47

Score ratings: Low priority (0-50 points); medium priority (51-75 points); high priority (76-100 points)

Scorecard to Identify Potential Roadway Sites for Native Restoration to Benefit Pollinators

Site Name: _____Wet Ditch 1 Cuyahoga_____ **County/Route/Section:** _____271_____
District: ___12____ **Nearest Intersection:** _____480_____ **Mile Point:** _____27_____
Reviewer Name: _____DRG_____ **Date:** _____ **GPS Collected:** Y N
Site Type: Foreslope Backslope Ditch Fenceline **Soil Sample Collected:** Y N **Photos Collected:** Y N

1. Current or historical use of site (choose the highest percent cover):

☐ Used for fill, paved, invasive cover >50% or bare ground >50%	0 pts.
☐ Invasive cover 25-50% or bare ground 25-50%	15 pts.
■ Invasive cover 15-25% or bare ground 5-25%	20 pts.
☐ Invasive cover <15% or bare ground 0-5%	25 pts.

Total Points: 20

2. Habitat directly adjacent to site (choose 1 with highest point value):

☐ Invasive cover >50%	0 pts.
☐ Invasive cover 25-50%	3 pts.
☐ Invasive cover 15-25%	7 pts.
■ Invasive cover <15%	10 pts.

Total Points: 10

3. Size of potential project (acres):

☐ 0.01 - 0.5 acre	1 pts.
■ 0.5 - 1.0 acre	3 pts.
☐ 1.0 + acres	5 pts.

Total Points: 3

4. Distance to naturalized area (miles):

☐ 1+	0 pts.
☐ 0.5-1	3 pts.
■ 0-0.5	5 pts.

Total Points: 5

5. Site accessible to mower or herbicide application:

☐ No access	0 pts.
■ Herbicide only	5 pts.
☐ Mowing & herbicide	10 pts.

Total Points: 5

6. Concern of herbicide drift to non-targeted areas:

☐ Yes	0 pts.
■ No	5 pts.

Total Points: 5

7. Maintenance practices of ODOT and neighbors amenable to full maturation of plants on site:

■ No	0 pts.
☐ Yes	5 pts.

Total Points: 0

8. Daily summer sunlight exposure:

☐ 0-3 hours of sun	1 pts.
☐ 3-5 hours of sun	3 pts.
■ 6+ hours of sun	5 pts.

Total Points: 5

9. Site Soil Properties: salt (<180 mg/kg), no leaching chemicals, 6" topsoil present, 4-20% organic content, pH 5-8:

■ Low (0-1 goals met)	0 pts.
☐ Medium (2-3 goals met)	10 pts.
☐ High (4+ goals met)	20 pts.

Total Points: 0

10. Endangered or vulnerable pollinator species identified within county:

☐ No	0 pts.
■ Yes	5 pts.

Total Points: 5

11. Time until site reconstruction:

☐ 1-5 years	0 pts.
■ 6-10 years	2 pts.
☐ 11-15 years	4 pts.
☐ No plans being considered	5 pts.

Total Points: 2

Total 1-5
(Minimum score 35 to continue): 46

Grand Total: 63

Score ratings: Low priority (0-50 points); medium priority (51-75 points); high priority (76-100 points)

Scorecard to Identify Potential Roadway Sites for Native Restoration to Benefit Pollinators

Site Name: _____Wet Ditch 2 Geauga_____ **County/Route/Section:** _____422_____
District: _____12___ **Nearest Intersection:** _____Munn Rd_____ **Mile Point:** _____N/A_____
Reviewer Name: _____DRG_____ **Date:** _____ **GPS Collected:** Y N
Site Type: Foreslope Backslope Ditch Fenceline **Soil Sample Collected:** Y N **Photos Collected:** Y N

1. Current or historical use of site (choose the highest percent cover):

☐ Used for fill, paved, invasive cover >50% or bare ground >50%	0 pts.
☐ Invasive cover 25-50% or bare ground 25-50%	15 pts.
■ Invasive cover 15-25% or bare ground 5-25%	20 pts.
☐ Invasive cover <15% or bare ground 0-5%	25 pts.

Total Points: 20

2. Habitat directly adjacent to site (choose 1 with highest point value):

☐ Invasive cover >50%	0 pts.
☐ Invasive cover 25-50%	3 pts.
☐ Invasive cover 15-25%	7 pts.
■ Invasive cover <15%	10 pts.

Total Points: 10

3. Size of potential project (acres):

☐ 0.01 - 0.5 acre	1 pts.
■ 0.5 - 1.0 acre	3 pts.
☐ 1.0 + acres	5 pts.

Total Points: 3

4. Distance to naturalized area (miles):

☐ 1+	0 pts.
☐ 0.5-1	3 pts.
■ 0-0.5	5 pts.

Total Points: 5

5. Site accessible to mower or herbicide application:

☐ No access	0 pts.
■ Herbicide only	5 pts.
☐ Mowing & herbicide	10 pts.

Total Points: 5

6. Concern of herbicide drift to non-targeted areas:

☐ Yes	0 pts.
■ No	5 pts.

Total Points: 5

7. Maintenance practices of ODOT and neighbors amenable to full maturation of plants on site:

☐ No	0 pts.
■ Yes	5 pts.

Total Points: 5

8. Daily summer sunlight exposure:

☐ 0-3 hours of sun	1 pts.
☐ 3-5 hours of sun	3 pts.
■ 6+ hours of sun	5 pts.

Total Points: 5

9. Site Soil Properties: salt (<180 mg/kg), no leaching chemicals, 6" topsoil present, 4-20% organic content, pH 5-8:

☐ Low (0-1 goals met)	0 pts.
■ Medium (2-3 goals met)	10 pts.
☐ High (4+ goals met)	20 pts.

Total Points: 10

10. Endangered or vulnerable pollinator species identified within county:

☐ No	0 pts.
■ Yes	5 pts.

Total Points: 5

11. Time until site reconstruction:

☐ 1-5 years	0 pts.
■ 6-10 years	2 pts.
☐ 11-15 years	4 pts.
☐ No plans being considered	5 pts.

Total Points: 2

Total 1-5
(Minimum score 35 to continue): 43

Grand Total: 75

Score ratings: Low priority (0-50 points); medium priority (51-75 points); high priority (76-100 points)

Scorecard to Identify Potential Roadway Sites for Native Restoration to Benefit Pollinators

Site Name: _____Wet Ditch 3 Summit_____ **County/Route/Section:** _____ I-271_____
District: _____4___ **Nearest Intersection:** __Exit 21 Broadview Ave__ **Mile Point:** _____20_____
Reviewer Name: _____DRG_____ **Date:** _____ **GPS Collected:** Y N
Site Type: Foreslope Backslope Ditch Fenceline **Soil Sample Collected:** Y N **Photos Collected:** Y N

1. Current or historical use of site (choose the highest percent cover):

☐ Used for fill, paved, invasive cover >50% or bare ground >50%	0 pts.
■ Invasive cover 25-50% or bare ground 25-50%	15 pts.
☐ Invasive cover 15-25% or bare ground 5-25%	20 pts.
☐ Invasive cover <15% or bare ground 0-5%	25 pts.

Total Points: 15

2. Habitat directly adjacent to site (choose 1 with highest point value):

☐ Invasive cover >50%	0 pts.
☐ Invasive cover 25-50%	3 pts.
☐ Invasive cover 15-25%	7 pts.
■ Invasive cover <15%	10 pts.

Total Points: 10

3. Size of potential project (acres):

☐ 0.01 - 0.5 acre	1 pts.
■ 0.5 - 1.0 acre	3 pts.
☐ 1.0 + acres	5 pts.

Total Points: 3

4. Distance to naturalized area (miles):

☐ 1+	0 pts.
☐ 0.5-1	3 pts.
■ 0-0.5	5 pts.

Total Points: 5

5. Site accessible to mower or herbicide application:

☐ No access	0 pts.
■ Herbicide only	5 pts.
☐ Mowing & herbicide	10 pts.

Total Points: 5

Total 1-5
(Minimum score 35 to continue): 38

6. Concern of herbicide drift to non-targeted areas:

☐ Yes	0 pts.
■ No	5 pts.

Total Points: 5

7. Maintenance practices of ODOT and neighbors amenable to full maturation of plants on site:

■ No	0 pts.
☐ Yes	5 pts.

Total Points: 0

8. Daily summer sunlight exposure:

☐ 0-3 hours of sun	1 pts.
☐ 3-5 hours of sun	3 pts.
■ 6+ hours of sun	5 pts.

Total Points: 5

9. Site Soil Properties: salt (<180 mg/kg), no leaching chemicals, 6" topsoil present, 4-20% organic content, pH 5-8:

■ Low (0-1 goals met)	0 pts.
☐ Medium (2-3 goals met)	10 pts.
☐ High (4+ goals met)	20 pts.

Total Points: 0

10. Endangered or vulnerable pollinator species identified within county:

☐ No	0 pts.
■ Yes	5 pts.

Total Points: 5

11. Time until site reconstruction:

☐ 1-5 years	0 pts.
■ 6-10 years	2 pts.
☐ 11-15 years	4 pts.
☐ No plans being considered	5 pts.

Total Points: 2

Grand Total: 55

Score ratings: Low priority (0-50 points); medium priority (51-75 points); high priority (76-100 points)

Appendix R: Recommended Seed Mix Formulas

Class 2 Roadside Mix (ODOT)

217.8 PLS Pounds per Acre			
Scientific Name	Common Name	Percent	Bloom Time (Pollinator
Poa pratensis	Kentucky Bluegrass	30.00%	N/A
Festuca arundinacea var. KY 31	Kentucky 31 Fescue	40.00%	N/A
Lolium perenne	Perennial Ryegrass	30.00%	N/A

Class 5B Native Wildflower and Grass Mix (ODOT)

20 PLS Pounds per Acre Native Seed, 30 Pounds per Acre Cover Crop			
Scientific Name	Common Name	Percent	Bloom Time (Pollinator Friendly Plants Only)
Asclepias tuberosa	Butterfly-weed	1.10%	Summer
Aster novae-angliae	New England Aster	1.10%	Fall
Cassia fasciculata	Partridge Pea	1.10%	Summer, Fall
Echinacea purpurea	Purple Coneflower	1.10%	Summer
Eryngium yuccifolium	Rattlesnake Master	1.10%	Summer
Heliopsis helianthoides	Ox-eye Sunflower	1.10%	Summer
Monarda fistulosa	Wild Bergamot	1.10%	Summer
Ratibida pinnata	Greyhead Coneflower	1.10%	Summer
Rudbeckia fulgida	Orange Coneflower	1.10%	Summer
Silphium terebinthinaceum	Prairie Dock	1.10%	Summer, Fall
Silphium trifoliatum	Whorled Rosinweed	1.10%	Summer
Solidago rigida	Stiff Goldenrod	1.10%	Late Summer, Fall
Andropogon gerardii	Big Bluestem	1.10%	N/A
Schizachyrium scoparium	Little Bluestem	1.79%	N/A
Sorghastrum nutans	Indiangrass	2.68%	N/A
Lolium multiflorum	Annual Ryegrass	81.44%	N/A

Class 6 Wildlife Mix (ODOT)

20 PLS Pounds per Acre Native Seed, 30 Pounds per Acre Cover Crop			
Scientific Name	Common Name	Percent	Bloom Time (Pollinator
Andropogon gerardii	Big Bluestem	4.01%	N/A
Schizachyrium scoparium	Little Bluestem	5.55%	N/A
Sorghastrum nutans	Indiangrass	4.01%	N/A
Heliopsis helianthoides	Ox-eye Sunflower	5.55%	Summer
Silphium terebinthinaceum	Prairie Dock	5.55%	Summer, Fall
Echinacea purpurea	Purple Coneflower	5.55%	Summer
Silphium trifoliatum	Whorled Rosinweed	3.39%	Summer
Helianthus mollis	Downy Sunflower	2.16%	Late Summer, Fall
Aster novae-angliae	New England Aster	2.16%	Fall
Lolium multiflorum	Annual Ryegrass	62.04%	N/A

Ohio IVM Mix (PF)

6.964 PLS Pounds per Acre Native Seed, 30 Pounds per Acre Cover Crop			
Scientific Name	Common Name	Percent	Bloom Time (Pollinator
Andropogon gerardii	Big Bluestem	1.35%	N/A
Sorghastrum nutans	Indiangrass	0.68%	N/A
Schizachyrium scoparium	Little Bluestem	4.06%	N/A
Bouteloua curtipendula	Sideoats Grama	3.38%	N/A
Panicum virgatum	Switchgrass	1.35%	N/A
Trifolium hybridum	Alsike Clover	0.14%	Spring, Summer, Fall
Rudbeckia hirta	Black-eyed Susan	0.28%	Late Spring, Summer
Rudbeckia triloba	Brown-eyed Susan	0.19%	Late Spring, Summer
*Asclepias tuberosa**	Butterfly Milkweed	0.16%	Late Spring, Summer
Oenothera biennis	Common Evening	0.11%	Summer, Fall
*Asclepias verticillata**	Whorled Milkweed	0.08%	Late Spring, Summer
Veronicastrum virginicum	Culvers Root	1.08%	Summer, Early Fall
Silphium perfoliatum	Cup Plant	0.01%	Summer, Early Fall
Heliopsis helianthoides	False or Oxeye Sunflower	0.05%	Summer
Penstemon digitalis	Foxglove Beardstongue	0.54%	Spring, Early Summer
Zizia aurea	Golden Alexander	0.03%	Spring
Ratibida pinnata	Grayhead Coneflower	0.07%	Summer
Verbena stricta	Hoary Vervain	0.07%	Summer
Desmanthus illinoensis	Illinois Bundleflower	1.35%	Spring, Summer, Early Fall
*Baptisia alba**	Wild White Indigo	0.27%	Spring, Summer
Trifolium repens	White Clover	0.08%	Spring, Summer, Fall
Coreopsis lanceolata	Lanceleaf Coreopsis	1.08%	Spring, Summer
Aster novae-angliae	New England Aster	0.09%	Late Summer, Fall
Cassia fasciculata	Partridge Pea	1.35%	Summer, Fall
Echinacea purpurea	Purple Coneflower	0.54%	Summer
Aster azureus	Smooth Blue Aster	0.04%	Late Summer, Fall
Solidago rigida	Stiff Goldenrod	0.08%	Late Summer, Fall
Pycnanthemum virginianum	Virginia Mountain Mint	0.03%	Summer
Monarda fistulosa	Wild Bergamot	0.14%	Summer
Lolium multiflorum	Annual Ryegrass	81.16%	N/A

Ohio All CRP Mix (PF)

5.723 PLS Pounds per Acre Native Seed, 30 Pounds per Acre Cover Crop			
Scientific Name	Common Name	Percent	Bloom Time (Pollinator
Schizachyrium scoparium	Little Bluestem	4.20%	N/A
Sporobolus cryptandrus	Sand Dropseed	0.14%	N/A
Bouteloua curtipendula	Sideoats Grama	3.50%	N/A
Panicum virgatum	Switchgrass	0.56%	N/A
Rudbeckia hirta	Black-eyed Susan	0.29%	Late Spring, Summer
Rudbeckia triloba	Brown-eyed Susan	0.20%	Late Spring, Summer
Veronicastrum virginicum	Culvers Root	0.00%	Summer, Early Fall
Heliopsis helianthoides	False or Oxeye Sunflower	0.56%	Summer
Ratibida pinnata	Grayhead Coneflower	0.17%	Summer
Desmanthus illinoensis	Illinois Bundleflower	1.40%	Spring, Summer, Early Fall
Coreopsis lanceolata	Lanceleaf Coreopsis	1.12%	Spring, Summer
Aster novae-angliae	New England Aster	0.04%	Late Summer, Fall
Cassia fasciculata	Partridge Pea	1.40%	Summer, Fall
Echinacea purpurea	Purple Coneflower	0.56%	Summer
Solidago rigida	Stiff Goldenrod	0.08%	Late Summer, Fall
Monarda fistulosa	Wild Bergamot	0.14%	Summer
Trifolium hybridum	Alsike Clover	0.14%	Spring, Summer, Fall
Trifolium incarnetum	Crimson Clover	1.12%	Spring, Summer, Fall
Trifolium repens	White Clover	0.14%	Spring, Summer, Fall
Asclepias tuberosa	Butterfly Milkweed	0.08%	Late Spring, Summer
Asclepias syriaca	Common Milkweed	0.08%	Late Spring, Summer
Asclepias incarnata	Swamp Milkweed	0.08%	Summer, Fall
Lolium multiflorum	Annual Ryegrass	83.98%	N/A

Wet Ditch/Swale Mix (DRG)

30 PLS Pounds per Acre Native Seed, 30 Pounds per Acre Cover Crop			
Scientific Name	Common Name	Percent	Bloom Time (Pollinator
Elymus riparius	Riverbank Wildrye	10.00%	N/A
Puccinellia distans	Alkaligrass	10.00%	N/A
Agrostis stolonifera	Creeping Bentgrass	9.00%	N/A
Panicum clandestinum	Deertongue	8.50%	N/A
Poa palustris	Fowl Bluegrass	7.50%	N/A
Carex vulpinoidea	Fox Sedge	2.50%	N/A
Juncus effusus	Soft Rush	1.50%	N/A
Carex scoparia	Blunt Broom Sedge	0.50%	N/A
Juncus tenuis	Path Rush	0.50%	N/A
Lolium multiflorum	Annual Ryegrass	50.00%	N/A

Seasonally Flooded Wildlife Mix (DRG)

20 PLS Pounds per Acre Native Seed, 30 Pounds per Acre Cover Crop			
Scientific Name	Common Name	Percent	Bloom Time (Pollinator
Panicum clandestinum , 'Tioga'	Deertongue, ‘Tioga’	8.8000%	N/A
Elymus virginicus , PA Ecotype	Virginia Wildrye, PA Ecotype	8.4000%	N/A
Andropogon gerardii , 'Niagara'	Big Bluestem, ‘Niagara’	6.8000%	N/A
Echinochloa crusgalli var. frumentacea	Japanese Millet	6.0000%	N/A
Carex vulpinoidea , PA Ecotype	Fox Sedge, PA Ecotype	4.0000%	N/A
Panicum virgatum , 'Shawnee'	Switchgrass, ‘Shawnee’	3.2000%	N/A
Chamaecrista fasciculata , PA Ecotype*	Partridge Pea, PA Ecotype	1.6000%	Summer, Fall
Desmodium paniculatum , PA Ecotype	Panicledleaf Ticktrefoil, PA Ecotype	0.4000%	Summer
Heliopsis helianthoides , PA Ecotype	Oxeye Sunflower, PA Ecotype	0.6800%	Summer
Eupatorium maculatum , PA Ecotype	Spotted Joe Pye Weed, PA Ecotype	0.2000%	Summer, Early Fall
Juncus tenuis , PA Ecotype	Path Rush, PA Ecotype	0.2000%	N/A
Asclepias incarnata , PA Ecotype	Swamp Milkweed, PA Ecotype	0.1200%	Summer, Fall
Lolium multiflorum	Annual Ryegrass	60.0000%	N/A

*Species substituted from tested mixes due to lack of germination

Appendix S: Additional Resources for Plant Identification

For more information on plant identification and native seeding initiatives:

- Ohio Department of Natural Resources Rare and endangered plant species: https://ohiodnr.gov/wps/portal/gov/odnr/discover-and-learn/plants-trees/rare-plants
- Pollinators and Roadsides: Best Management Practices for Managers and Decision Makers https://rosap.ntl.bts.gov/view/dot/55914/dot_55914_DS1.pdf
- University of Michigan LSA Herbarium: https://michiganflora.net/home.aspx
- Illinois Wildflowers: https://www.illinoiswildflowers.info/
- Minnesota Wildflowers: https://www.minnesotawildflowers.info/
- Seek by iNaturalist: https://www.inaturalist.org/pages/seek_app
- Leaf snap: https://leafsnap.app/
- Google lens: https://lens.google/Picture this: https://www.picturethisai.com/

For more information on the benefits of native restoration and information on statewide and nationwide initiatives please refer to the resources listed below:

- Ohio Department of Transportation Statewide Roadside Pollinator Habitat Program Restoration Guidelines and Best Management Practices. https://rosap.ntl.bts.gov/view/dot/55914/dot_55914_DS1.pdf
- Monarch Joint Venture Partnering to Conserve the Monarch Butterfly Migration Department of Transportation: https://monarchjointventure.org/get-involved/i-am-a/department-of-transportation
- Ohio Department of Transportation Pollinator Habitat Program: https://www.transportation.ohio.gov/wps/portal/gov/odot/programs/polliantor-habitat-program/welcome