
2015 Wetland Mitigation Report Site 34 – Lower Burning Ground (PICA-002)

Picatinny Arsenal, New Jersey

Prepared for



Prepared by

**EA Engineering, Science, and Technology, Inc., PBC
Contract No. W91ZLK-13-D-0004-0009**

March 2016

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Prepared for

U.S. Army

Prepared by



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Project Manager

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9 March 2016

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March 2016
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TABLE OF CONTENTS

	<u>Page</u>
TABLES	ii
FIGURES	ii
ACRONYMS AND ABBREVIATIONS	iii
1. INTRODUCTION	1
1.1 SITE HISTORY AND BACKGROUND	1
1.2 GOALS AND OBJECTIVES	2
2. WETLAND MITIGATION MONITORING AND ADAPTIVE MANAGEMENT REQUIREMENTS.....	5
2.1 WETLAND MONITORING	5
2.1.1 Wetland Mitigation Area Inspections	5
2.1.2 Methods.....	6
2.1.3 Reporting.....	6
2.2 ADAPTIVE MANAGEMENT.....	6
2.2.1 Methods.....	6
2.2.2 Reporting.....	7
3. 2015 MONITORING RESULTS	12
3.1 QUALITATIVE ASSESSMENT	12
3.2 QUANTITATIVE ASSESSMENT	18
3.2.1 Wetland Mitigation Site #1	20
3.2.2 Wetland Mitigation Site #2.....	21
4. CONCLUSIONS AND RECOMMENDATIONS	24
5. REFERENCES	27

APPENDIX A HERBICIDE APPLICATION LOGS
APPENDIX B ONSITE PHOTOGRAPHS

TABLES

<u>Number</u>	<u>Title</u>
1	Coordinates of Plot Pins and Photograph Locations
2	Observed Species Within PICA Wetland Mitigation Sites 1 and 2
3	2015 Quantitative Vegetation Monitoring Data – Wetland Mitigation Site #1
4	2015 Quantitative Vegetation Monitoring Data – Wetland Mitigation Site #2

FIGURES

<u>Number</u>	<u>Title</u>
1	Picatinny Arsenal General Location
2	Wetland Mitigation Sites
3	Monitoring and Photo Locations Map – Mitigation Site #1
4	Monitoring and Photo Locations Map – Mitigation Site #2
5	USGS Quad Map

ACRONYMS AND ABBREVIATIONS

ARCADIS	ARCADIS U.S., Inc.
Completion Report	Mitigation Construction Completion Report
EA	EA Engineering, Science, and Technology, Inc., PBC
GP-4	General Permit Number 4
LUCs	Land Use Controls
Mitigation Plan	Freshwater Wetland and Riparian Zone Mitigation Plan
N.J.A.C.	New Jersey Administrative Code
NJDEP	New Jersey Department of Environmental Protection
PICA	Picatinny Arsenal

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1. INTRODUCTION

EA Engineering, Science, and Technology, Inc., PBC (EA) has been retained by the United States Army Environmental Command to perform wetland mitigation monitoring associated with previous Installation Restoration Program activities at Picatinny Arsenal (PICA) in Rockaway Township, Morris County, New Jersey (Figure 1). This work is being conducted under a Performance Based Contract that encompasses 84 PICA sites. The full scope of services for this contract is defined in the Contract W91ZLK-13-D-0004 Task Order 0009.

EA has been tasked with monitoring the success of the recently created wetland mitigation as detailed in the Freshwater Wetland and Riparian Zone Mitigation Plan (Mitigation Plan) developed by ARCADIS U.S., Inc. (ARCADIS) in April 2014. The mitigation sites detailed in this report are associated with impacts associated with Site 34 (PICA-002) as described below.

This report presents a summary of the 2015 annual monitoring and maintenance activities conducted to ensure the long-term success of the wetlands mitigation sites conducted as part of the remedial action. The future monitoring and adaptive management requirements associated with the wetland mitigation work are also presented herein.

1.1 SITE HISTORY AND BACKGROUND

Site 34 (PICA-002) is located near the southern boundary of PICA, within the 100-year floodplain of Green Pond Brook (Figure 2). As stated within the Record of Decision (U.S. Army 2005), and as modified in the Explanation of Significant Differences (ARCADIS 2014a), the selected response action for PICA-002 includes the following:

- Installation of an engineered hybrid soil and asphalt cover
- Long-term groundwater and surface water monitoring
- Implementation of Land Use Controls (LUCs).

The selected response action was conducted during 2014 and is documented in the Remedial Action Report (ARCADIS 2014b). LUCs for soil and groundwater are implemented to control current and future activities that could result in unacceptable risk to human health as detailed in the Final Remedial Action Work Plan (ARCADIS 2014c). LUCs for Site 34 will also be documented in the 2015 Land Use Certification report, which is anticipated to be prepared prior to the end of the calendar year.

Wetland mitigation activities were conducted to address adverse impacts to regulated areas under the New Jersey Department of Environmental Protection's (NJDEP's) Freshwater Wetlands Protection Act Rules (New Jersey Administrative Code [N.J.A.C.] 7:7A) and Flood Hazard Area Control Act Rules associated with the remedial actions at the Site.

The wetland mitigation plan developed by ARCADIS in 2014 proposed the use of two mitigation sites within the vicinity of PICA-002 to offset impacts to wetlands and floodplain area. Mitigation Site #1 and Mitigation Site #2 (Figure 2) were proposed as existing wetland areas to be enhanced through the control of invasive plant species, planting of natural vegetation, and the

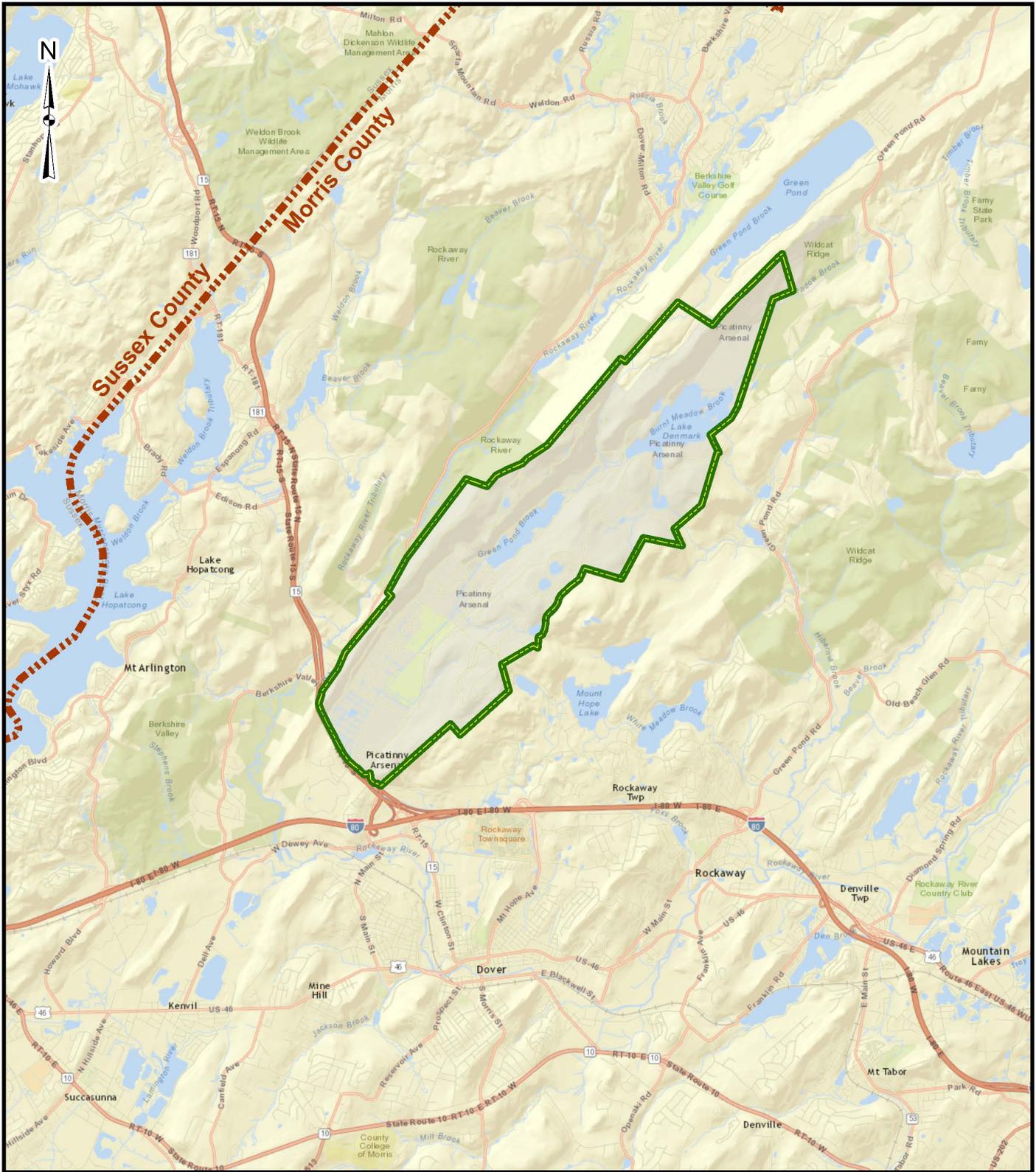
creation of micro-depressions to create habitat diversity. These two mitigation sites were previously identified as being dominated with invasive plant species including common reed (*Phragmites australis*) and reed canary grass (*Phalaris arundinacea*).

After construction of the wetland mitigation sites a Mitigation Construction Completion Report, dated September 2014 was prepared by ARCADIS to document the “As-Built” conditions of the two wetland mitigation sites.

1.2 GOALS AND OBJECTIVES

Compliance monitoring for a period of 5 years is required pursuant to conditions of N.J.A.C. 7:7A-15. The compliance monitoring is required in order to determine if the performance standards, as defined below, are being met at the conclusion of 5 years. The monitoring activities are designed to evaluate the success of the mitigation project and ensure that the wetlands proposed for enhancement will not require additional management at the conclusion of the 5 year monitoring period. The following performance standards must be met in order to determine that the mitigation project was successful.

- 85 percent vegetative coverage of target species as well as 85% survival rate of planted material.
- Less than 10 percent cover of invasive species.
- Maintenance of the hydrologic regime specified in the mitigation plan.



 Installation Boundary



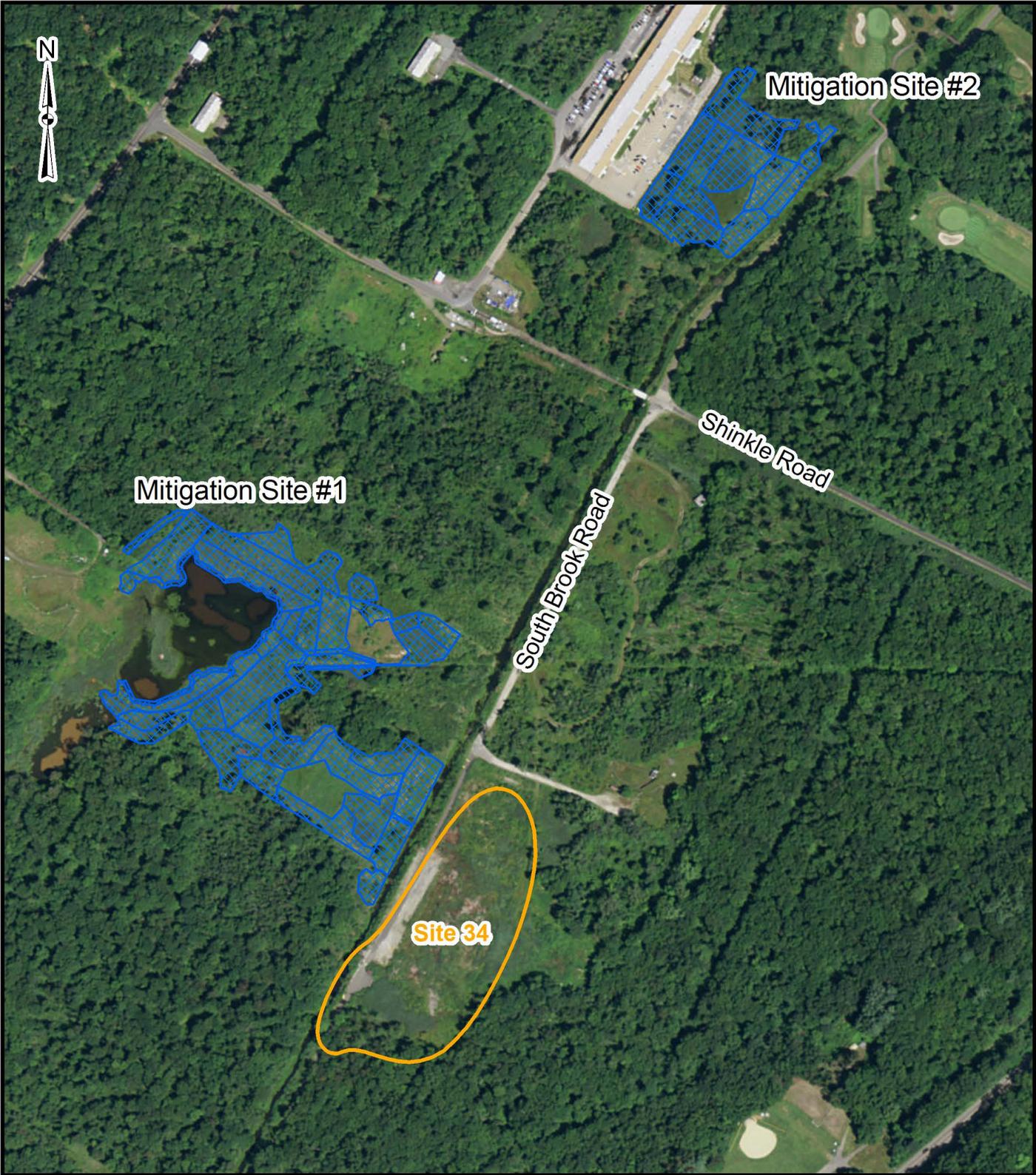
Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013



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 SITE 34 - LOWER BURNING GROUND (PICA-002)
 PICATINNY ARSENAL

Figure 1
 Picatinny Arsenal General Location

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Mitigation Site #2

Mitigation Site #1

Shinkle Road

South Brook Road

Site 34

0 500

Feet



Wetland Mitigation Area



Lower Burning Ground (PICA-002)

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 SITE 34 - LOWER BURNING GROUND (PICA-002)
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Figure 2
 Wetland Mitigation Sites

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2. WETLAND MITIGATION MONITORING AND ADAPTIVE MANAGEMENT REQUIREMENTS

This section presents the monitoring and adaptive management plan for wetland mitigation sites 1 & 2 (Figure 2) associated with Site 34 (PICA-002). In addition, this section also presents the 2015 monitoring and adaptive management activities conducted to date in accordance with the monitoring and adaptive management plan contained herein.

Wetland mitigation as-built conditions are documented in the Mitigation Construction Completion Report (Completion Report), submitted as a part of the Remedial Action Report (ARCADIS 2014b). The monitoring activities conducted to date and the future monitoring and adaptive management strategy are consistent with the approved Mitigation Plan, and conditions of the approved NJDEP Freshwater Wetlands General Permit Number 4 (GP-4), Flood Hazard Individual Permit with hardship exception Flood Hazard Verification and Water Quality Certification for Access File No.: 1435-06-0006.2 Activity No.: FHA130001 and FWW130001, as stated in the 13 June 2014 letter from NJDEP and the subsequent letter from Mr. Ted Gabel (of PICA) dated 20 August 2014.

2.1 WETLAND MONITORING

This subsection discusses the inspection requirements, methodology, and reporting requirements associated with wetland mitigation area monitoring.

2.1.1 Wetland Mitigation Area Inspections

Consistent with the approved NJDEP permit conditions, compliance monitoring is required for a 5-year period at both mitigation sites. A minimum of two site visits throughout the growing season are required to effectively monitor the mitigation areas. Monitoring events will include:

- Early summer, in approximately June of each year: A qualitative event intended to monitor the condition of planted stock and determine growth and/or establishment of invasive species of concern.
- Late summer/early fall, in approximately August of each year: A quantitative site visit to provide specific data necessary to provide adaptive management recommendations.

Based upon 2014 site observations, an additional qualitative site visit in July for at least the first few years was recommended. The objective of this site visit would be to determine the extent of purple loosestrife (*Lythrum salicaria*) across the site. Depending upon seasonal climate, the first site visit may be too early to detect the full extent of purple loosestrife. This July visit will provide a more effective evaluation of this invasive species, and provide the flexibility to implement a mid-season herbicide application.

2.1.2 Methods

Required compliance monitoring methods are summarized in the approved Mitigation Plan and include two monitoring events as described in Section 2.1.1, which included a qualitative survey of the two mitigation sites in the early summer and a quantitative survey in the fall of each year. No permanent vegetation or photograph locations were established in 2014; therefore, these locations were established during the quantitative monitoring effort conducted in October 2015. The plot sample and photographic locations were located based on the proposed mitigation plans and included the placement of a metal rebar pin at the center of the sample plot. Each sample plot pin and photograph location was GPS located with sub-meter accuracy and is included on Figures 3 and 4 for future sampling events. GPS coordinates are provided on Table 1.

2.1.3 Reporting

A monitoring report summarizing results of the fall site visit, as well as relevant site observations and implemented adaptive management actions, is required by the end of the year in each of the five years (2015-2019). Note that 2014 Completion Report should provide a baseline with which to compare future monitoring results. This Report includes the results of the 2015 monitoring effort and serves as the Year 1 report.

2.2 ADAPTIVE MANAGEMENT

Adaptive management strategies are required to ensure the success of the mitigation sites. The adaptive management will be determined and directed by the two monitoring site visits noted above in Section 2.1.1. The amount of time required to implement adaptive management strategies will be dependent upon site conditions. The primary management action anticipated to be needed in each of the five years is exotic/invasive species control and supplemental planting of native vegetation, the need for which will be determined based on each year's monitoring results. Adaptive management will be required throughout the monitoring period if results indicate that the Sites are not meeting the required performance standards and cannot be self-corrected through natural succession.

Additional enhancement planting may be required if fall monitoring data demonstrate a stem density significantly less than that of the as-built densities (85% survival) or if the vegetative coverage is below 85%.

2.2.1 Methods

Control of exotic/invasive plant species will primarily rely on herbicide application over the 5 years of compliance monitoring. Consistent with the approach implemented in 2014 during the establishment of the mitigation sites, glyphosate (i.e., Rodeo) was selected to treat the above mentioned species and is approved for use in wetlands. Future application of glyphosate should be accomplished by backpack sprayers or wicking. This minimizes exposure to surrounding native vegetation. All work must be conducted by a New Jersey certified pesticide applicator.

2.2.2 Reporting

To support reporting requirements specific to PICA, as well as for the State of New Jersey, a brief description of adaptive management actions will be included in the annual monitoring report, including the herbicide application logs (Appendix A). The Application Logs shall include (1) selected herbicide, (2) time of application, (3) acreage of application, (4) targeted species, and (5) amount of herbicide applied.

Table 1 Coordinates of Plot Pins and Photograph Locations

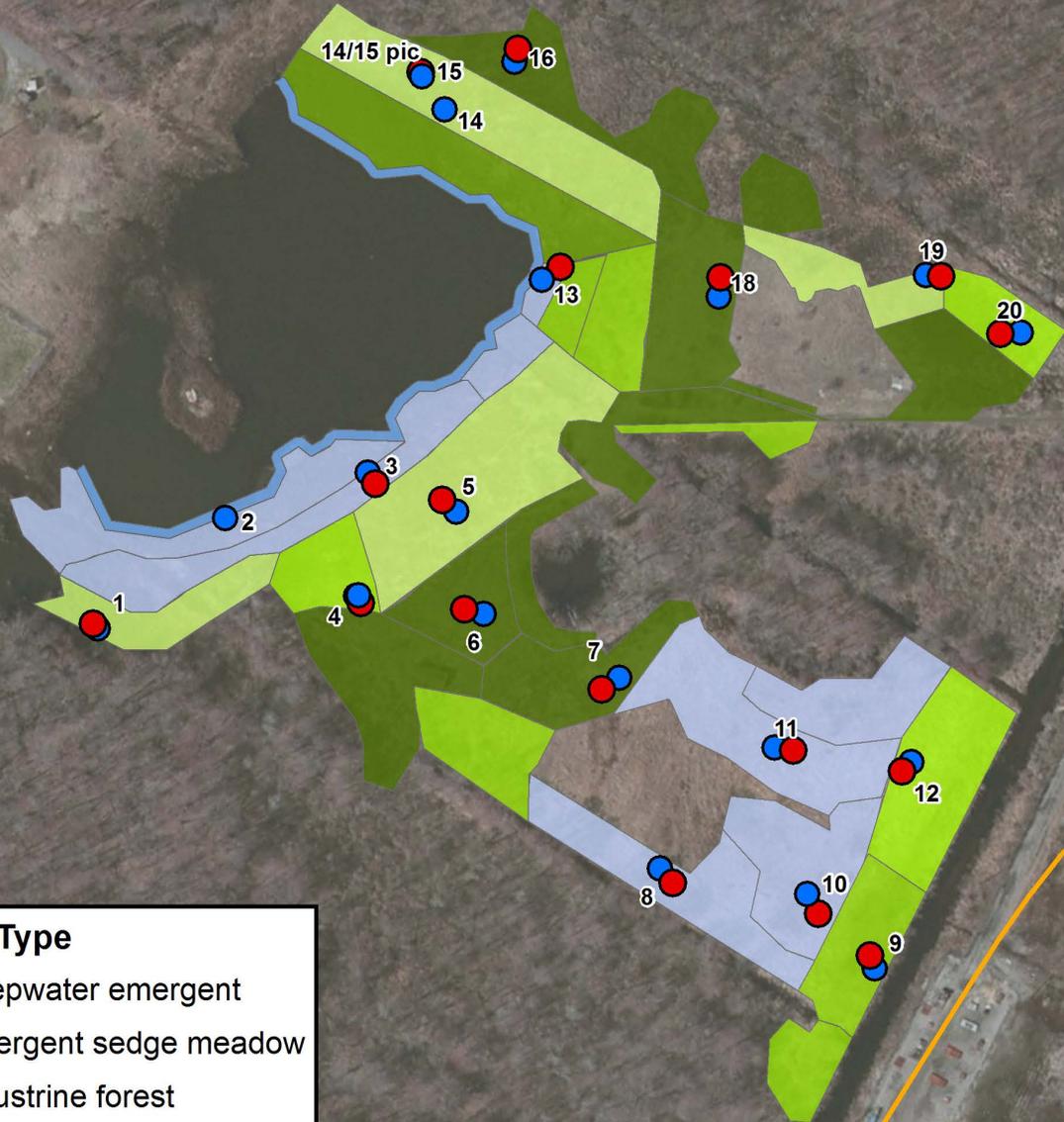
Location	X-Coordinate	Y-Coordinate
Wetland Mitigation Site #1		
1 - Monitoring Location	468752.98	761791.92
1 - Photo Location	468748.12	761796.82
2 - Monitoring Location	468881.07	761903.34
3 - Monitoring Location	469023.88	761948.60
3 - Photo Location	469031.75	761937.81
4 - Monitoring Location	469012.57	761825.14
4 - Photo Location	469017.16	761817.63
5 - Monitoring Location	469113.10	761909.40
5 - Photo Location	469098.83	761921.15
6 - Monitoring Location	469140.18	761806.87
6 - Photo Location	469120.86	761811.72
7 - Monitoring Location	469276.35	761742.24
7 - Photo Location	469258.95	761730.56
8 - Monitoring Location	469317.33	761550.52
8 - Photo Location	469330.11	761536.11
9 - Monitoring Location	469533.13	761450.27
9 - Photo Location	469528.52	761463.03
10 - Monitoring Location	469465.44	761524.88
10 - Photo Location	469476.55	761505.18
11 - Monitoring Location	469432.58	761672.38
11 - Photo Location	469451.23	761669.54
12 - Monitoring Location	469570.18	761657.80
12 - Photo Location	469560.50	761648.36
13 - Monitoring Location	469199.08	762142.58
13 - Photo Location	469217.72	762155.90
14 - Monitoring Location	469101.06	762313.82
14/15 - Photo Location	469077.20	762351.42
15 - Monitoring Location	469078.42	762347.24
16 - Monitoring Location	469171.06	762362.12
16 - Photo Location	469174.84	762374.86
18 - Monitoring Location	469376.60	762126.13
18 - Photo Location	469378.34	762145.16
19 - Monitoring Location	469584.52	762147.77

Location	X-Coordinate	Y-Coordinate
19 - Photo Location	469599.77	762146.23
20 - Monitoring Location	469679.92	762089.42
20 - Photo Location	469659.26	762088.63
Wetland Mitigation Site #2		
21 - Monitoring Location	470377.26	763291.32
21 - Photo Location	470352.56	763316.09
22 - Monitoring Location	470603.19	763309.84
22 - Photo Location	470602.64	763334.99
23 - Monitoring Location	470622.15	763441.18
23 - Photo Location	470610.11	763423.13
24 - Monitoring Location	470777.53	763497.59
24 - Photo Location	470766.11	763511.73
25 - Monitoring Location	470570.21	763508.40
25 - Photo Location	470591.56	763525.63
26 - Monitoring Location	470517.94	763536.79
26 - Photo Location	470517.25	763551.82
27 - Monitoring Location	470514.97	763577.00
27 - Photo Location	470505.17	763562.97

Note: Coordinates provided in NAD83 State Plane NJ



Mitigation Site #1



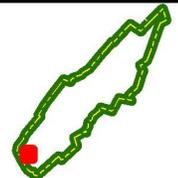
Wetland Type

-  Deepwater emergent
-  Emergent sedge meadow
-  Palustrine forest
-  Scrub-shrub #1
-  Scrub-shrub #2
-  Scrub-shrub #3
-  Scrub-shrub #4

-  Photo Location
-  Monitoring Location
-  Lower Burning Ground (PICA-002)



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



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SITE 34 - LOWER BURNING GROUND (PICA-002)
PICATINNY ARSENAL

Figure 3
Monitoring and Photo Locations
Mitigation Site #1

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Mitigation Site #2

Wetland Type

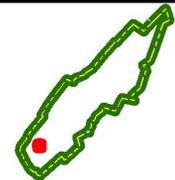
-  Deepwater emergent
-  Emergent sedge meadow
-  Palustrine forest
-  Scrub-shrub #1
-  Scrub-shrub #2
-  Scrub-shrub #3
-  Scrub-shrub #4

-  Photo Location
-  Monitoring Location
-  Lower Burning Ground (PICA-002)

0 150

Feet

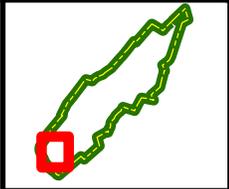
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



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SITE 34 - LOWER BURNING GROUND (PICA-002)
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Figure 4
Monitoring and Photo Locations
Mitigation Site #2

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 Wetland Mitigation Area



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 SITE 34 - LOWER BURNING GROUND (PICA-002)
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Figure 5
 USGS Quad Map

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3. 2015 MONITORING RESULTS

3.1 QUALITATIVE ASSESSMENT

A qualitative assessment was performed during late August 2015¹ to identify the location and extent of invasive species throughout the two mitigation sites. During this qualitative assessment, stands of invasive species were identified with survey flagging for herbicide application.

Relative to the extent of invasive species, the two initial species of concerns (i.e., common reed and reed canary grass) were commonly observed in both mitigation areas during the 2015 qualitative assessment. In addition to these species, two additional invasive species (Bush Honeysuckle and Purple Loosestrife) were identified within both mitigation sites and were targeted for herbicide treatment. As the two mitigation sites were treated for invasive species both prior to restoration activities and after the sites were planted, a reduction in the coverage of invasive species was expected and observed throughout both sites. With the exception of common reed, the invasive coverage appeared to be sporadic and limited to small pockets or individual stems and did not include large monotypic stands. Common reed was identified throughout Mitigation Site #1 in larger stands, including larger monotypic stands greater than 500 square feet along the western portion of the mitigation site, within the emergent sedge meadow area (Figure 3). A large monotypic stand of common reed is present throughout the open water area to the northwest of the mitigation site and provides an existing seed source that is currently not being treated as part of the mitigation adaptive management. Given the aggressiveness of this species, it is anticipated that control activities will be required throughout the entire monitoring period and may require adaptive management outside of the current mitigation site. Significant stands of common reed, although not monotypic were also identified in areas of Mitigation Site #2 (Figure 4). During the 2015 qualitative assessment, common reed was predominantly identified along the western boundary of the mitigation site along the edge of the existing parking lot, as well as within the vicinity of monitoring location #21.

In addition to the identification and location of invasive plant species, the qualitative assessment also noted significant herbaceous plant establishment (i.e., ground cover) throughout each of the mitigation sites and the majority of the sites were vegetated with little bare ground. Although there appeared to be a low success rate of the planted nursery stock from the as-built plans, the majority of the site was successfully vegetated with the specified applied seed mix, as well as significant natural recruitment from surrounding plant communities. No tree protection devices were observed around the nursery stock and deer herbivory was noted throughout each of the sites. A complete list of species observed across the two mitigation sites over the monitoring period is included in Table 2 of this report.

Although an herbicide application was completed in July 2014, the qualitative assessment noted additional need for herbicide application, which was conducted in late August 2015. The herbicide application logs are provided in Appendix A.

¹ The early summer (June) qualitative assessment was not performed due to gap in Government contractors.

Table 2 Observed Species Within PICA Wetland Mitigation Sites 1 and 2

Scientific Name	Common Name	Stratum	Observed in 2014 by Arcadis	Observed in 2015 by EA	Planted or Seeded? (Y or N)	Invasive or Species of Concern? (Y or N)
<i>Nuphar advena</i>	Yellow Pond-Lily	A	X	X	N	N
<i>Nymphaea odorata</i>	Fragrant Water Lily	A	X	X	Y	N
<i>Nymphoides cordata</i>	Little Floatingheart	A	X		N	N
<i>Pontederia cordata</i>	Pickeralweed	A	X	X	Y	N
<i>Acalypha rhomboidea</i>	Common Three-Seed-Mercury	H	X		N	N
<i>Achillea millefolium</i>	Common Yarrow	H	X	X	N	N
<i>Acorus americanus</i>	Sweet Flag	H	X	X	Y	N
<i>Agalinis tenuifolia</i>	Slender-Leaf False Foxglove	H	X		N	N
<i>Alisma subcordatum</i>	American Water-Plantain	H	X		N	N
<i>Ambrosia artemisiifolia</i>	Annual Ragweed	H	X	X	N	N
<i>Apocynum androsaemifolium</i>	Spreading Dogbane	H	X		N	N
<i>Apocynum cannabinum</i>	Indian Hemp	H		X	N	N
<i>Arctium minus</i>	Lesser Burrdock	H	X		N	N
<i>Artemisia vulgaris</i>	Common Wormwood	H	X	X	N	Y
<i>Asarum canadense</i>	Canadian Wild Ginger	H	X		N	N
<i>Asclepias incarnata</i>	Swamp Milkweed	H	X	X	Y	N
<i>Asclepias syriaca</i>	Common Milkweed	H	X	X	N	N
<i>Aster puniceus</i>	Swamp Aster	H		X	Y	N
<i>Athyrium angustum</i>	Northern Lady Fern	H	X	X	N	N
<i>Baptisia australis</i>	Blue Wild Indigo	H	X		N	N
<i>Bidens aristosa</i>	Bearded Beggarticks	H	X	X	N	N
<i>Bidens cernua</i>	Nodding Burr-Marigold	H	X	X	N	N
<i>Bidens frondosa</i>	Devil's-Pitchfork	H	X		N	N
<i>Bidens laevis</i>	Smooth Beggarticks	H	X		N	N
<i>Bidens tripartita</i>	Three-Lobe Beggarticks	H	X		N	N
<i>Boehmeria cylindrica</i>	Small-Spike False Nettle	H	X	X	N	N
<i>Brassica sp.</i>	Unidentified Mustard	H	X		N	N
<i>Carex lupulina</i>	Hop Sedge	H		X	Y	N
<i>Carex lurida</i>	Shallow Sedge	H	X	X	Y	N
<i>Carex scoparia</i>	Broom Sedge	H	X	X	Y	N
<i>Carex stipata</i>	Awl-Fruited Sedge	H	X	X	Y	N

Scientific Name	Common Name	Stratum	Observed in 2014 by Arcadis	Observed in 2015 by EA	Planted or Seeded? (Y or N)	Invasive or Species of Concern? (Y or N)
<i>Carex stricta</i>	Tussock Sedge	H	X	X	Y	N
<i>Celastrus orbiculatus</i>	Asian Bittersweet	H	X		N	Y
<i>Centaurea jacea</i>	Brown-Ray Knapweed	H	X	X	N	N
<i>Chenopodium album</i>	Lamb's-Quarters	H	X		N	N
<i>Cirsium vulgare</i>	Bull Thistle	H	X	X	N	Y
<i>crownvetch</i>	Securigera sp.	H	X	X	N	N
<i>Cyperus esculentus</i>	Yellow Nutsedge	H	X	X	N	N
<i>Daucus carota</i>	Queen Anne's-Lace	H	X	X	N	N
<i>Dianthus armeria</i>	Deptford Pink	H	X	X	N	N
<i>Dichanthelium clandestinum</i>	Deer-Tongue Rosette Grass	H	X	X	N	N
<i>Doellingeria umbellata</i>	Parasol White-Top	H	X		N	N
<i>Dulichium arundinaceum</i>	Three-Way Sedge	H	X		N	N
<i>Echinochloa crus-galli</i>	Large Barnyard Grass	H	X	X	N	N
<i>Eleocharis palustris</i>	Common Spike-Rush	H	X	X	N	N
<i>Elymus virginicus</i>	Virginia Wild Rye	H	X	X	Y	N
<i>Epilobium ciliatum</i>	Fringed Willowherb	H	X		N	N
<i>Equisetum arvense</i>	Field Horsetail	H	X	X	N	N
<i>Erigeron annuus</i>	Eastern Daisy Fleabane	H	X	X	N	N
<i>Erigeron strigosus</i>	Prairie Fleabane	H	X		N	N
<i>Eupatorium perfoliatum</i>	Boneset	H	X	X	Y	N
<i>Euthamia graminifolia</i>	Flat-Top Goldentop	H	X	X	N	N
<i>Galium asprellum</i>	Rough Bedstraw	H	X	X	N	N
<i>Hypericum mutilum</i>	Dwarf St. John's-Wort	H	X		N	N
<i>Hypericum perforatum</i>	Common St. John's-Wort	H	X	X	N	N
<i>Impatiens capensis</i>	Spotted Touch-Me-Not	H	X		N	N
<i>Iris versicolor</i>	Harlequin blueflag iris	H	X	X	Y	N
<i>Juncus acuminatus</i>	Knotty-Leaf Rush	H	X		N	N
<i>Juncus effusus</i>	Common rush	H	X	X	Y	N
<i>Lactuca canadensis</i>	Canadian Blue Lettuce	H	X		N	Y
<i>Lepidium sp.</i>	Field Pepperweed	H	X		N	N
<i>Lolium perenne</i>	Perennial Rye Grass	H	X	X	N	N
<i>Ludwigia alternifolia</i>	Seedbox	H	X	X	N	N
<i>Lycopus americanus</i>	Cut-Leaf Water-Horehound	H	X		N	N

Scientific Name	Common Name	Stratum	Observed in 2014 by Arcadis	Observed in 2015 by EA	Planted or Seeded? (Y or N)	Invasive or Species of Concern? (Y or N)
<i>Lythrum salicaria</i>	Purple Loosestrife	H	X	X	N	Y
<i>Medicago lupulina</i>	Black Medick	H	X		N	N
<i>Microstegium vimineum</i>	Japanese Stilt Grass	H	X		N	Y
<i>Monarda sp.</i>	Osewgo Tea	H	X		N	N
<i>Oenothera perennis</i>	Small Evening-Primrose	H	X		N	N
<i>Onoclea sensibilis</i>	Sensitive Fern	H	X	X	N	N
<i>Osmundastrum cinnamomeum</i>	Cinnamon Fern	H	X		N	N
<i>Oxalis stricta</i>	Upright Yellow Wood-Sorrel	H	X		N	N
<i>Panicum rigidum</i>	Redtop Panicum	H	X	X	Y	N
<i>Panicum virgatum</i>	Wand Panic Grass	H	X		N	N
<i>Parthenocissus quinquefolia</i>	Virginia-Creeper	H	X		N	N
<i>Peltandra sagittifolia</i>	White Arrow-Arum	H	X		N	N
<i>Peltandra virginica</i>	Green Arrow-Arum	H		X	N	N
<i>Persicaria hydropiper</i>	Mild Water-Pepper	H	X		N	N
<i>Persicaria maculosa</i>	Spotted Lady's-Thumb	H	X	X	N	N
<i>Persicaria sagittata</i>	Arrow-Leaf Tearthumb	H	X	X	N	N
<i>Phalaris arundinacea</i>	Reed Canary Grass	H	X	X	N	Y
<i>Phragmites australis</i>	Common Reed	H	X	X	N	Y
<i>Phytolacca americana</i>	American Pokeweed	H	X		N	N
<i>Plantago lanceolata</i>	English Plantain	H	X	X	N	N
<i>Plantago major</i>	Great Plantain	H	X		N	N
<i>Polygonum pensylvanicum</i>	Pennsylvania Smartweed	H	X	X	N	N
<i>Polygonum scandens</i>	Climbing False Buckwheat	H	X		N	N
<i>Portulaca oleracea</i>	Little-Hogweed	H	X		N	N
<i>Potentilla indica</i>	Indian-Strawberry	H	X		N	N
<i>Potentilla norvegica</i>	Norwegian Cinquefoil	H	X		N	N
<i>Prunella vulgaris</i>	Common Selfheal	H	X		N	N
<i>Pseudognaphalium obtusifolium</i>	Sweet Everlasting	H	X		N	N
<i>Rumex crispus</i>	Curly Dock	H	X	X	N	Y
<i>Sagittaria latifolia</i>	Common Arrowhead	H	X	X	Y	N
<i>Schoenoplectus acutus</i>	Hardstem Bulrush	H	X		Y	N

Scientific Name	Common Name	Stratum	Observed in 2014 by Arcadis	Observed in 2015 by EA	Planted or Seeded? (Y or N)	Invasive or Species of Concern? (Y or N)
<i>Schoenoplectus pungens</i>	Common Three Square	H	X	X	Y	N
<i>Schoenoplectus tabernaemontani</i>	Softstem Bulrush	H	X	X	Y	N
<i>Scirpus atrovirens</i>	Dark Green Bulrush	H		X	Y	N
<i>Scirpus cyperinus</i>	Woolgrass	H	X	X	Y	N
<i>Setaria verticillata</i>	Rough Bristle Grass	H	X		N	N
<i>Solidago gigantea</i>	Late Goldenrod	H	X		N	N
<i>Solidago lancifolia</i>	Lance-Leaf Goldenrod	H	X		N	N
<i>Solidago patula</i>	Rough-Leaf Goldenrod	H	X	X	N	N
<i>Solidago rugosa</i>	Wrinkle-Leaf Goldenrod	H	X	X	N	N
<i>Sorghastrum nutans</i>	Yellow Indian Grass	H	X	X	Y	N
<i>Sparganium americanum</i>	American Burr-Reed	H	X	X	Y	N
<i>Symphyotrichum novae-angliae</i>	New England American-Aster	H	X	X	N	N
<i>Taraxacum officinale</i>	Common Dandelion	H	X		N	N
<i>Trichostema dichotomum</i>	Forked Bluecurls	H	X		N	N
<i>Trifolium hybridum</i>	Alsike Clover	H	X		N	N
<i>Trifolium pratense</i>	Red Clover	H	X		N	N
<i>Typha latifolia</i>	Broad-Leaf Cat-Tail	H	X		N	Y
<i>Urtica dioica</i>	Stinging Nettle	H	X		N	N
<i>Verbascum thapsus</i>	Great Mullein	H	X		N	N
<i>Verbena hastata</i>	Blue Vervain	H	X	X	Y	N
<i>Vernonia noveboracensis</i>	New York Ironweed	H	X		N	N
<i>Toxicodendron radicans</i>	Eastern Poison Ivy	H/V	X		N	N
<i>Cephalanthus occidentalis</i>	Button Bush	S	X	X	Y	N
<i>Clethra alnifolia</i>	Sweet Pepperbush	S	X	X	Y	N
<i>Cornus amomum</i>	Silky Dogwood	S	X		Y	N
<i>Cornus sericea</i>	Red Osier Dogwood	S	X	X	Y	N
<i>Ilex verticillata</i>	Common Winterberry	S	X	X	Y	N
<i>Lindera benzoin</i>	Northern Spicebush	S	X	X	Y	N
<i>Lonicera sp.</i>	Bush Honeysuckle	S		X	N	Y
<i>Rhododendron viscosum</i>	Swamp Azalea	S	X		Y	N
<i>Rosa palustris</i>	Swamp Rose	S	X		Y	N
<i>Sambucus canadensis</i>	Common Elderberry	S	X	X	Y	N

Scientific Name	Common Name	Stratum	Observed in 2014 by Arcadis	Observed in 2015 by EA	Planted or Seeded? (Y or N)	Invasive or Species of Concern? (Y or N)
<i>Spirea tomentosa</i>	Steeplebush	S	X	X	Y	N
<i>Vaccinium corymbosum</i>	Highbush Blueberry	S	X	X	Y	N
<i>Viburnum dentatum</i>	Arrowwood	S	X	X	Y	N
<i>Alnus serrulata</i>	Smooth Alder	S	X	X	Y	N
<i>Amelanchier canadensis</i>	Shadbush	S	X		Y	N
<i>Acer rubrum</i>	Red Maple	T	X	X	Y	N
<i>Acer saccharinum</i>	Silver Maple	T	X	X	Y	N
<i>Betula nigra</i>	River Birch	T	X	X	Y	N
<i>Betula papyrifera</i>	Paper Birch	T	X		Y	N
<i>Elaeagnus umbellata</i>	Autumn Olive	T	X		N	Y
<i>Liquidambar styraciflua</i>	Sweetgum	T	X	X	Y	N
<i>Liriodendron tulipifera</i>	Tulip Poplar	T	X		Y	N
<i>Nyssa sylvatica</i>	Black Gum	T	X	X	Y	N
<i>Populus deltoides</i>	Eastern Cottonwood	T	X	X	N	N
<i>Populus tremuloides</i>	Trembling Aspen	T	X		N	N
<i>Prunus serotina</i>	Black Cherry	T	X		N	N
<i>Quercus bicolor</i>	Swamp White Oak	T	X	X	Y	N
<i>Quercus paultris</i>	Pin Oak	T	X	X	Y	N
<i>Salix nigra</i>	Black Willow	T/S	X	X	N	N
<i>Salix scouleriana</i>	Scouler's Willow	T/S	X		N	N
<i>Cuscuta sp.</i>	Dodder	V	X		N	N
<i>Ipomoea cairica</i>	Mile-a-Minute-Vine	V	X		N	Y
<i>Lonicera japonica</i>	Japanese Honeysuckle	V	X		N	Y
<i>Rubus idaeus</i>	Common Red Raspberry	V	X	X	N	N
<i>Rubus phoenicolasius</i>	Wine Raspberry	V	X		N	Y
<i>Rubus pubescens</i>	Dwarf Red Raspberry	V	X		N	N
<i>Vitis labrusca</i>	Fox Grape	V	X	X	N	N

A = Aquatic

H = Herbaceous

N = No

S = Shrub

T = Tree

V = Vine

Y = Yes

3.2 QUANTITATIVE ASSESSMENT

A quantitative assessment for 2015 was conducted on 13 October 2015 in order to quantify the success of the wetland mitigation sites. The quantitative assessment included the establishment of 26 monitoring locations which included a 1/10th acre sampling plot for woody material (shrubs and trees) and two herbaceous sampling quadrants of 2-square meters each within the large plot. Within each sampling plot the following information was collected:

- Wetland mitigation type
- Total percent vegetative cover (percent herbaceous cover and percent woody material cover)
- Percent invasive species cover
- Number of woody plants observed
- Invasive species and native species identified
- Condition of planted material
- Wetland hydrology indicators
- Wildlife observation.

A summary of the quantitative assessment results are provided in Sections 3.2.1 and 3.2.2 and information for individual sample plots is provided in Table 3 and Table 4. Onsite photographs of each sampling plot are included within Appendix B.

Table 3 2015 Quantitative Vegetation Monitoring Data – Wetland Mitigation Site #1

Sample Plot Number	Wetland Type	Percent Vegetation Cover	Number of Woody Stems in 1/10 acre plot	Percent Invasive Cover	Invasive Species Identified	Dominant Plants Species Observed
1	Scrub shrub	95	0	85	<i>Phragmites australis</i>	<i>Scirpus atrovirens</i>
2	Emergent	90	0	5	<i>Phragmites australis</i>	<i>Scirpus atrovirens</i> , <i>Schoenoplectus pungens</i> ,
3	Emergent	90	0	35	<i>Phragmites australis</i>	<i>Juncus effuses</i> , <i>Carex stricta</i> , <i>Acorus americanus</i> , <i>Carex lurida</i>
4	Scrub shrub	95	6	10	<i>Phragmites australis</i>	<i>Betula nigra</i> , <i>Ilex verticillata</i> , <i>Apocynum cannabinum</i> , <i>Verbena hastata</i>
5	Scrub shrub	80	4	35	<i>Phragmites australis</i> , <i>Lythrum salicaria</i>	<i>Aster puniceus</i> , <i>Asclepias incarnata</i>

Sample Plot Number	Wetland Type	Percent Vegetation Cover	Number of Woody Stems in 1/10 acre plot	Percent Invasive Cover	Invasive Species Identified	Dominant Plants Species Observed
6	Forested	100	9	40	<i>Phragmites australis</i>	<i>Alnus serrulata, Solidago patula, Viburnum dentatum</i>
7	Forested	100	4	30	<i>Phragmites australis,</i>	<i>Asclepias incarnata, Euthamia graminifolia</i>
8	Emergent	85	7	0	N/A	<i>Alnus serrulata, Ilex verticillata</i>
9	Scrub shrub	95	13	15	<i>Phalaris arundinacea</i>	<i>Acer rubrum, Asclepias incarnata, Populus deltoides</i>
10	Emergent	100	0	10	<i>Phragmites australis,</i>	<i>Scirpus atrovirens, Scirpus cyperinus</i>
11	Emergent	100	9	35	<i>Phalaris arundinacea</i>	<i>Salix nigra, Alnus serrulata</i>
12	Scrub shrub	100	3	45	<i>Phalaris arundinacea</i>	<i>Betula nigra</i>
13	Emergent	85	0	15	<i>Phragmites australis</i>	<i>Scirpus atrovirens, Acorus americanus</i>
14	Scrub shrub	90	35	10	<i>Phalaris arundinacea</i>	<i>Salix nigra, Ilex verticillata, Cephalanthus occidentalis</i>
15	Scrub shrub	100	9	20	<i>Phragmites australis,</i>	<i>Salix nigra, Quercus bicolor</i>
16	Forested	100	17	5	<i>Phragmites australis</i>	<i>Carex lurida, Acer rubrum, Quercus bicolor, Alnus serrulata, Ilex verticillata</i>
17	N/A	N/A	N/A	N/A	N/A	N/A
18	Forested	100	4	10	<i>Phragmites australis</i>	<i>Betula nigra, Liquidambar styraciflua</i>
19	Scrub shrub	100	13	15	<i>Phragmites australis</i>	<i>Verbena hastate, Acer rubrum, Quercus bicolor</i>
20	Scrub shrub	100	14	20	<i>Phragmites australis, , Phalaris arundinacea</i>	<i>Cornus sericea, Cephalanthus occidentalis</i>
AVGERAGE		95.0%	7.7	23.2%		

N/A = Not applicable. During the 2015 assessment the proposed location for plot #17 included the forested edge of the existing forest and did not appear to have any planted material within the area.

Wildlife Observations:

Red winged black bird
White tailed deer
Red tailed hawk
Canada geese
Grey catbird

Hydrology:

Drainage patters throughout
Oxidized rhyzospheres throughout
Saturated soil in micro-depressions
Inundation along deepwater edge habitat

Table 4 2015 Quantitative Vegetation Monitoring Data – Wetland Mitigation Site #2

Sample Plot Number	Wetland Type	Percent Vegetation Cover	Number of Woody Stems in 1/10 acre plot	Percent Invasive Cover	Invasive Species Identified	Dominant Plants Species Observed
21	Forested	90	38	10	<i>Phalaris arundinacea</i>	<i>Juncus effuses</i> , <i>Scirpus cyperinus</i> , <i>Salix nigra</i> , <i>Vaccinium corymbosum</i> , <i>Acer rubrum</i> , <i>Betula nigra</i>
22	Scrub shrub	100	15	20	<i>Phalaris arundinacea</i> ,	<i>Cephalanthus occidentalis</i> , <i>Quercus bicolor</i> , <i>Liquidambar styraciflua</i>
23	Scrub shrub	90	11	15	<i>Phalaris arundinacea</i> ,	<i>Vaccinium corymbosum</i> , <i>Betula nigra</i> , <i>Aster puniceus</i>
24	Forested	85	25	5	<i>Lonicera japonica</i>	<i>Clethra alnifolia</i> , <i>Salix nigra</i>
25	Emergent	90	0	15	<i>Phalaris arundinacea</i>	<i>Carex lupulina</i> , <i>Carex lurida</i> , <i>Solidago patula</i>
26	Emergent	90	39	10	<i>Phalaris arundinacea</i>	<i>Cornus sericea</i> , <i>Alnus serrulata</i> , <i>Viburnum dentatum</i> , <i>Ilex verticallata</i>
27	Scrub shrub	90	14	5	<i>Phalaris arundinacea</i>	<i>Acer rubrum</i> , <i>Liquidambar styraciflua</i> , <i>Scirpus cyperinus</i>
AVGERAGE		90.7%	20.3	11.4%		
Wildlife Observations:					Hydrology:	
Red winged black bird					Drainage patters throughout	
White tailed deer					Oxidized rhyzospheres throughout	
					Saturated soil in micro-depressions	
					Water stained plant material throughout	

Similar results for the complete list of plant species were observed from the 2014 vegetative assessment of plant species identified within the two mitigation sites. It is apparent that a large number of the observed species are established from natural recruitment from the existing seed bank in the soil and surrounding plant community as were not identified as planted or seeded material in the 2014 ARCADIS Report. Six different invasive or exotic species of concern were also identified, across the two sites and based on the plot data above exceed the 10% coverage for the success criteria within both Mitigation Site #1 and #2..

3.2.1 Wetland Mitigation Site #1

Wetland Mitigation Site #1 included a total of 19 monitoring locations (1-20 excluding #17). Although 20 monitoring locations were proposed within the mitigation plan, sample point #17 was not established during the 2015 assessment. During the 2015 assessment the proposed location for plot #17 included the forested edge of the existing forest and did not appear to have any planted material within the area. This location included 100 percent vegetation coverage and included larger trees and shrubs consisting of black willow (*Salix nigra*), and red maple (*Acer rubrum*).

In general, Wetland Mitigation Site #1 appears to have sufficient vegetation cover throughout the site with an average of 95 percent cover based on the monitoring plot locations. However invasive species were identified within all 19 sample plots with 12 of the 19 plots having an invasive cover over 10 percent (averaging 23 percent vegetation cover of invasive species). Although common reed (*Phragmites australis*) is commonly found throughout the mitigation site and was identified as the primary species of concern for the mitigation plan, it was not the only dominant and evident invasive species of concern found throughout the mitigation site. Reed canary grass (*Phalaris arundinacea*) was also observed as dominant species in multiple sampling locations (5 of 19). In general the invasive species appear to be affecting the success of the planted woody species.

Based on the approved Completion Report provided by ARCADIS which documents the as-built conditions, Wetland Mitigation Site #1 was planted with a total of 7,208 woody species over 8.8 acres. Based on this information in the Completion Report it was determined that on average across the mitigation site the wetland was planted with a density of 961 stems per acre (Table 3 of the Approved Completion Report). The Completion Report does not identify the number of woody stems per wetland type and therefore the 2015 monitoring data could not be compared to the baseline for each wetland type, rather the planting densities were averaged across the entire wetland site. The monitoring plot data included four sample plots within forested wetlands and an average of 8.5 live woody stems were observed throughout the plot, which would total 85 stems per acre, while the scrub shrub wetlands averaged 107 stems per acre. During the 2015 monitoring event woody material was also identified within the emergent wetland zones at an average density of 27 stems per acre. On average the entire wetland site averaged a woody stem density of 77 stems per acre compared to the 961 stems per acre documented in the completion report.

Natural revegetation and succession was observed through the recruitment and establishment of woody species seedlings throughout all of the monitoring location. Natural seedlings that appear to be establishing successfully throughout the mitigation site include red maple and sweetgum (*Liquidambar styraciflua*). These two species are pioneer species and typically the first to establish within similar areas such as Mitigation Site #1 but may not continue to successfully establish throughout the site if invasive species control is not successful. Details on plant coverage, species, and invasive species for each monitoring location are provided in Table 3.

3.2.2 Wetland Mitigation Site #2

Wetland Mitigation Site #2 included a total of 7 monitoring locations (21-27). In general Wetland Mitigation Site #2 appears to have sufficient vegetation cover throughout the site with an average of 90 percent cover based on the monitoring plot locations. However invasive species were identified within all 7 sample plots and an average of 11 percent vegetation cover consists of invasive species, with 3 of the 7 plots having an invasive cover over 10 percent. Although common reed is commonly found throughout the mitigation site in small pockets it was not identified in any of the actual monitoring locations throughout the mitigation site. Reed canary grass were observed as the dominant species in all but one of the sampling locations (monitoring location #24). In general the invasive species appear to be directly affecting the success of the planted woody species.

Similar to Mitigation Site #1, the as-builts for this mitigation site are inconsistent with the field observations. Based on the Approved Completion Report, Wetland Site #2 was planted with a total of 2,501 woody species over 3.2 acres. Based on this information in the Completion Report it was determined that on average across the mitigation site the wetland was planted with a density of 782 stems per acre (Table 7 of the Approved Completion Report). The Completion Report does not identify the number of woody stems per wetland type and therefore the 2015 monitoring data could not be compared to the baseline for each wetland type, rather the planting densities were averaged across the entire wetland site. The monitoring plot data included two sample plots within forested wetlands and an average of 31.5 live woody stems were observed throughout the plot, which would total 315 stems per acre, while the scrub shrub wetlands averaged 133 stems per acre. During the 2015 monitoring event woody material was also identified within the emergent wetland zones at an average density of 195 stems per acre which is a greater density of woody material than in the scrub shrub wetland areas. On average the entire wetland site averaged a woody stem density of 203 stems per acre compared to the 782 stems per acre documented in the completion report. In general, the woody stem plant material within Mitigation Site #2 appear to be doing better than the areas in Mitigation Site #1, most likely due to the lack of common reed throughout the site.

Natural revegetation and succession was observed through the recruitment and establishment of woody species seedlings throughout all of the monitoring locations. Natural seedlings that appear to be establishing successfully throughout the mitigation site include red maple and sweetgum, similar to the establishment in Mitigation Site #1. Details on plant coverage, species, and invasive species for each monitoring location are provided in Table 4.

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4. CONCLUSIONS AND RECOMMENDATIONS

Based on the 2015 qualitative and quantitative assessments it is evident that both Wetland Mitigation Sites #1 and #2 have a percent invasive species cover over the 10 percent requirement for the established performance standard for the mitigation sites. During the 2015 monitoring effort Mitigation Site #1 has an invasive cover of 23 percent while Mitigation Site #2 has an invasive cover of 11 percent. Although the mitigation sites both have a vegetative cover over 85 percent across each site, this coverage includes invasive species coverage. On average across the site Mitigation Site #1 has a vegetative cover of 72 percent excluding the invasive coverage and Wetland Mitigation Site #2 has a vegetative cover of 79 percent excluding the invasive species. Therefore both of the mitigation sites are below the performance standard of 85 percent vegetative cover for targeted species (non-invasive). Compared to the Approved Completion Report, both wetland sites have a woody stem density below 85 percent of the planted material. Finally, wetland hydrology was typically observed across the two mitigation sites in the form of drainage patterns, oxidized rhizospheres, water-stained plant material and the FAC-neutral test. Therefore the two mitigation sites are only currently meeting one of the three performance standards outlined in the Mitigation Plan as discussed in Section 1.2 of this report.

As this is only the first year monitoring assessment and the performance standards must be met by the end of the five year monitoring period, the mitigation sites should continue to be controlled for invasive species similar to what has been conducted in 2014 and 2015. The treatment of common reed throughout both sites appears to be successful in the areas of treatment and should continue across both sites and should also focus on the reed canary grass found throughout both sites. At this time, natural recruitment of native woody species is evident and should continue to be monitored in 2016 to determine if the woody plant densities increase across the monitoring locations. If the results from the 2016 monitoring do not show an increase in native plant coverage and woody plant densities then additional planting may be required to increase the plant densities. If additional planting is determined to be required based on future monitoring, the proposed planting may require additional practices and maintenance to ensure the survival of newly planted material. Additional practices may include, use of mulch pits, pre-emergent herbicide application, tree protection devices, maintenance of herbaceous material around planted material, etc.

Additionally the Approved Mitigation Plan developed by ARCADIS and approved by NJDEP proposed stem densities exceeding 800 stems per acre throughout all of the plant communities which according to ARCADIS exceeded the typical target density of 450 stems per acre in order to deal with potential mortality concerns of planted stock associated with invasive species competition and deer browsing. As noted sections 3.2.1 and 3.2.2 the Completion Report documents woody stem densities of 961 stems per acre in Mitigation Site #1 and 782 stems per acre in Mitigation Site #2. These woody stem densities exceed typical target densities commonly proposed for wetland mitigation which based on professional experience, standard practices typically range between 350 to 450 stems per acre. If additional planting of woody stems is deemed to be required based on future monitoring results, it is recommended that the target plant density be reduced from the densities in the completion report to the target density of 450 stems per acre.

At this time EA recommends an additional year of monitoring during 2016 to further document plant coverage, provide for a year to year comparison and determine a trend for both wetland mitigation sites. After the 2016 monitoring effort adaptive management practices will be re-assessed to determine the appropriate path forward in an effort to meet the success criteria by the completion of the 5 year monitoring effort.

5. REFERENCES

ARCADIS U.S., Inc. (ARCADIS). 2014a. *Explanation of Significant Differences for Site 34 (PICA-002) Lower Burning Ground*. U.S. Army Garrison Picatinny Arsenal, New Jersey, April.

ARCADIS. 2014b. *Remedial Action Report, Site 34 (PICA-002) Lower Burning Ground*. U.S. Army Garrison Picatinny Arsenal, New Jersey. November.

ARCADIS. 2014c. *Final Remedial Action Work Plan*. U.S. Army Garrison Picatinny Arsenal, New Jersey. April.

United States Department of the Army (U.S. Army). 2005. *Picatinny Record of Decision, Site 34 – The Burning Ground*. January. Final.