White Pine Springs
Evaluation of Fish, Macroinvertebrates, and Aquatic Habitat Resulting from an Increase in Groundwater Withdrawal

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1.0 INTRODUCTION

Nestlé Waters North America Inc. (NWNA) pumps water from Well PW-101 for bottled water production. The production well is located approximately three miles northwest of the City of Evart in Section 20 of Osceola Township, Michigan (T18N, R8W; Figure 1-1). NWNA has requested an increase from the baseline withdrawal rate of 150 gallons per minute to 400 gpm. NWNA has previously registered the 400 gpm withdrawal rate with the Michigan Department of Environmental Quality (MDEQ) under Part 327 of the Natural Resources and Environmental Protection Act.

NWNA is submitting an application under Section 17(3) of the Safe Drinking Water Act for approval of the requested increase in withdrawal rate. The Section 17(3) application contains a description of the prevailing environmental, hydrological and hydrogeological conditions, and an evaluation of the predicted effects of the intended increase in withdrawal.

The purpose of this report is to describe the predicted effects of the increased withdrawal on fish, aquatic macroinvertebrates, and stream habitat in the vicinity of PW-101. The project vicinity for this report includes seven stream sample stations, which are distributed among Twin and Chippewa Creeks and are represented within Figure 1-2. Advanced Ecological Management, LLC (AEM) staff have conducted aquatic surveys of Twin and Chippewa Creeks in the vicinity of PW-101 since 2003. AEM's description of the predicted effects of the increased withdrawal on fish, aquatic macroinvertebrates, and stream habitat is based on previous survey data collected by AEM staff, and information presented by S.S. Papadopulos & Associates, Inc. (2016) related to changes in stream flow and water temperature as a result of the increased withdrawal rate.

2.0 STUDY AREA

The groundwater withdrawal well PW-101 is located near the headwaters of Twin Creek and Chippewa Creek in Osceola County, MI. The watersheds of Twin Creek and Chippewa Creek are contiguous near the well location, and drain a mixture of agricultural and forested watersheds (GVSU, 2001). Much of the agricultural land in the immediate vicinity of the well is managed as hay or pasture land.

Twin Creek

Twin Creek flows southeast through the City of Evart and empties into the Muskegon River approximately three miles downstream from the well location (Figure 1-1). Twin Creek is designated as a coldwater trout

stream by the Michigan Department of Natural Resources (MDNR, 2003). In the general vicinity of the well location, the stream is bordered by a forested and scrub/shrub wetland riparian area dominated by wetland woody plant species such as northern white cedar (*Thuja occidentalis*) and speckled alder (*Alnus rugosa*), and herbaceous plants, such as tussock sedge (*Carex stricta*) and sensitive fern (*Onoclea sensibilis*). The stream channel is generally well-defined, with some braided portions located throughout the watershed. There are several small impoundments located in the upper reach (north of Station SF1) of the Twin Creek system and one small impoundment located mid-system, immediately north of 7 Mile Road (Figures 1-1 and 1-2).

Chippewa Creek

Chippewa Creek flows southeast and empties into the Muskegon River approximately one mile northeast of the City of Evart (Figure 1-1). Chippewa Creek is designated as a coldwater trout stream by the Michigan Department of Natural Resources (MDNR, 2003). Similar to Twin Creek, the channel of Chippewa Creek is well-defined and the creek flows through a predominantly forested watershed. A small portion of the headwaters of Chippewa Creek is impounded, forming a series of water bodies known as Decker Ponds that are primarily used for recreational purposes as part of Spring Hill, a non-profit camp.

3.0 AQUATIC COMMUNITY DESCRIPTION

The aquatic community in the vicinity of PW-101 has been well studied for approximately 13 years. NWNA has commissioned aquatic studies in 2003, annually from 2006 through 2013, and once every other year since 2013 as part of a process of investigating and monitoring the aquatic system in the vicinity of PW-101 (Figure 1-1; AEM 2008-2015; NES, 2003; KME, 2006). The aquatic surveys have typically been conducted mid to late-July each year.

3.1 Survey Methods

Aquatic surveys have been conducted to evaluate fish and macroinvertebrate communities, and habitat conditions within four sample stations located in Twin Creek (Stations SF1, SF5, SF5-6, and SF9) and three sample stations located in Chippewa Creek (Stations SG5, SF8, and SF16), Osceola County, MI (Figure 1-2).

3.1.1 Fish Collection

Fish collections have been conducted by wading using a backpack electroshocker. A single upstream pass was conducted to evaluate fish community composition and relative abundance throughout each sample station. As part of the enumeration process, the species, length, weight, and number of fish captured were recorded. Fish were returned alive to the system following collection and identification. Fish were identified to species using various taxonomic references (Bailey et al., 2003; Coon, 2001; Becker, 1983).

3.1.2 Macroinvertebrate Collection

Upon completion of fish sampling, aquatic macroinvertebrates, including mussels and decapods (crayfish), were collected within each station using D-framed kick nets (Merritt et al., 1996). Stations were sampled for 30 minutes using two kick nets (total sample time = 1 hour/station) and samples were collected in all habitat types within each station to characterize the macroinvertebrate community. Collected specimens were stored in 250 ml plastic wide-mouth jars containing 70% ethanol, and were identified using various taxonomic references (Bright, 2015; Merritt et al., 2008; Pennak, 1990).

3.1.3 Habitat and Water Quality Evaluations

General stream characteristics including woody and herbaceous vegetation, abundance of woody debris, stream habitat type, and substrate have been observed in each station. Stream flow has been measured during each aquatic survey using a Marsh McBirney Flo-mate 2000® (Buchanan and Somers, 1969). Water temperature, dissolved oxygen, pH, and conductivity have been measured at the lower, middle, and upper extent of each sample station using a Yellow Springs Instrument Model YSI Professional Plus water quality meter. Photographs have been collected at downstream and upstream extents of each station to illustrate the conditions during each sampling event.

Additional water temperature data have been continually collected at one-hour intervals from three HOBO® Water Temp Pro V2 - Model U22-001 HOBO data loggers. One data logger has been located in middle reach of Station SF1, another data logger has been located approximately 30 feet downstream from the confluence of Stations SF5 and SF5-6, and a third data logger has been located in the downstream extent of Station SF9 (Figure 1-2).

Two additional water HOBO data loggers were installed in SF8 and SF8-1 in the tributaries of Chippewa Creek in June 2015. Both additional data loggers were installed at the downstream extend of each sample station and continually record water temperature at one-hour intervals.

3.2 Fish Community Description

Twin Creek and Chippewa Creek are characterized as trout streams based on the fish present in the stations that have been monitored by AEM personnel (Table 1). A total of nine species have been observed in the Twin Creek stations, with both brown trout (*Salmo trutta*) and brook trout (*Salvelinus fontinalis*) found in some of the stations surveyed by AEM. Station 1 has been characterized by a variety of coldwater species, with blacknose dace (*Rhinichthys atratulus*) observed the most frequently among all surveys, followed by creek chubs (*Semotilus atromaculatus*) and brown trout (Table 1). Stations SF5 and SF5-6 are located in a northern white cedar swamp and contain a fish community characterized by a predominance of juvenile brook trout and mottled sculpins (*Cottus bairdii*).

Station SF9 is downstream-most station of the Twin Creek stations (Figure 1-2). Brook trout and brown trout have been frequently observed in Station SF9 during all surveys conducted by AEM. Station SF9 had the greatest diversity of fish among all stations surveyed by AEM (Table 1).

A total of six species have been observed in the Chippewa Creek stations, and creek chubs, mottled sculpin and brown trout have been the most frequently observed species in Station SF16 of Chippewa Creek. (Table 1). No fish have been collected by AEM during the aquatic surveys in Stations SG5 and SF8 of Chippewa Creek. Stations SG5 and SF8 are located upstream of a shallow pond and 100th Avenue (Figure 1-2), which may leave the stations isolated and inaccessible to fish.

3.3 Macroinvertebrate Community Description

A total of 5,078 macroinvertebrates have been collected among all stations surveyed by AEM in Twin Creek and Chippewa Creek since 2003. The greatest diversity of macroinvertebrates has been observed in Station SF9 of Twin Creek with a total of at least 42 taxa that have been observed. The lowest diversity has been observed Stations SG5 where there were at least eight observed taxa, and SF8 where there were at least 12 observed taxa (Table 2).

Amphipods (Amphipoda, scuds) have been the most frequently collected macroinvertebrate in most of the stations, except for Station SF5-6 of Twin Creek and Station SF16 of Chippewa Creek (Table 2). Megalopterans (alderflies, Sialidae), Chironomids (midges), and Ephemperopterans (mayflies) and have consistently been the most frequently collected macroinvertebrates in Station SF5-6 of Twin Creek (Table 2). Mayflies and Trichopterans (caddisflies) have been the most frequently collected macroinvertebrates from Station SF16 of Chippewa Creek (Table 2). Species diversity and the characteristic macroinvertebrate community has remained consistent for all years in stations that have been repeatedly surveyed by AEM (all stations have been repeatedly surveyed except Stations SG5 and SF8 of Chippewa Creek, which were first surveyed for macroinvertebrates in 2015).

3.4 Aquatic Habitat Description

Station SF 1

The stream channel in Station SF1 has remained partially shaded by a woody canopy predominantly located in the upstream extent (Photographs 1 and 2). Wetland vegetation along the stream channel has included reed canarygrass (*Phalaris arundinacea*), sensitive fern (*Onoclea sensibilis*), and tussock sedge (*Carex stricta*). Undercut banks were observed and woody debris has been present throughout Station SF1. Stream habitat consisted of a mix of small pools and runs, and the substrate was predominately sand, with small patches of gravel.

The average width of Station SF1 among years 2008 through 2015 (stream dimension data was not recorded prior to 2008) was 6.1 feet (sample size, *n* = 21) and the average depth was 0.5 feet (*n* = 63, Table 3). Station SF1 had the highest average water temperature among all Twin Creek stations and all water temperature measurements that were collected using the YSI Professional Plus meter at the time of the survey (Table 3).

Station SF 5

The stream channel in Station SF5 has been partially shaded by a woody canopy that is predominantly comprised of northern white cedar and eastern hemlock (*Tsuga Canadensis*, Photographs 3 and 4). The wetland vegetation along the stream channel has included tussock sedge, sensitive fern, horsetail (*Equisetum arvense*), and lowbush blueberry (*Vaccinium angustifolium*). Woody debris was abundant throughout the station. A mix of small pools, undercut banks, and woody debris provide the predominant

in-stream habitat. The substrate in Station SF5 was predominately sand, with silt and organic matter present along the margins and in the stream channel.

The average width of Station SF5 among years 2008 through 2015 was 5.3 feet (sample size, *n* = 21) and was the smallest among the Twin Creek stations (Table 3). The average depth was 0.3 feet (*n* = 63) and Station SF5 had the lowest average water temperature among all Twin Creek stations (Table 3).

Station SF 5-6

Station SF5-6 is located on a small tributary approximately 50 feet downstream of Station SF5 (Figure 1-2). Similar to Station SF5, the stream channel in Station SF5-6 has been partially shaded by a riparian canopy, although more dead standing white cedar is present in the riparian zone of Station SF5-6 than in Station SF5 (Photographs 5 and 6). Wetland vegetation along the stream channel in Station SF5-6 has appeared to be more abundant than Station SF5. Woody debris, root wads, and undercut banks have provided in-stream habitat throughout the stream channel. The substrate in Station SF5-6 has remained predominately silt and organic matter.

The average width of Station SF5-6 among years 2008 through 2015 was 6.1 feet (sample size, *n* = 21; Table 3). The average depth was 0.3 feet (*n* = 63) and Station SF5-6 had the second lowest average water temperature among all Twin Creek stations (Table 3).

Station SF 9

The stream channel in Station SF9 has remained heavily shaded by a woody canopy (Photographs 7 and 8) that is predominately speckled alder. Wetland vegetation along the stream channel has been predominately tussock sedge. A mix of pools, undercut banks, and woody debris provide the predominant in-stream habitat. The substrate in Station SF9 has remained predominately sand, with silt and organic matter present along the margins and in the stream channel in the upstream portion of the station, with small gravel present in the center of the channel in the downstream extent of the station.

The average width of Station SF9 among years 2008 through 2015 was 14.1 feet (sample size, *n* = 21) and was the widest of all Twin Creek stations (Table 3). The average depth was 1.0 feet (*n* = 63) and was the

deepest among all stations surveyed by AEM (Table 3). The average water temperature among was second highest among all Twin Creek stations.

Station SG5

The majority of Station SG5 flows through a wet meadow with a small portion of the upstream extent shaded by a mature wood canopy (Photographs 10 and 11). Most of the stream channel in Station SF8-1 was well connected to the floodplain and has stable streambanks with well-developed vegetation. Woody debris is present throughout most of the station and undercut banks are prevalent throughout the downstream portion of the station. The substrate was predominately comprised of silt and organic matter with small patches of sand and gravel, which were primarily located in the upstream extent of the station.

The average width of Station SG5 was 1.4 feet (*n* = 3) and the average depth was 0.2 feet (*n* = 9). The average water temperature as measured with the YSI Professional Plus was 11.8°C (*n* = 3; Table 3).

Station SF 8

The upstream portion of stream channel in Station SF8 has been shaded by a mature wood canopy predominantly located in the upstream extent, and flowed through a wet meadow and scrub/shrub wetland near the downstream extent of the station (Photographs 11 and 12). The upstream half of the station is the highest gradient of any of the stream that were surveyed for this report and the stream channel is incised (down cut) into the slope such that the stream channel has a narrow flood plain. The downstream half of the station is well connected to the floodplain and has stable streambanks with well-developed vegetation. Woody debris is present throughout most of the station and undercut banks are prevalent throughout the downstream portion of the station. The substrate was predominately comprised of sand with small patches of gravel.

The average width of Station SF8 was 2.0 feet (*n* = 3) and the average depth was 0.2 feet (*n* = 9). The average water temperature as measured with the YSI Professional Plus was 10.5°C (*n* = 3) and was the lowest among all stations (Table 3).

Station SF 16

The stream channel in Station SF16 has remained shaded by a woody canopy comprised of speckled alder and trembling aspen (*Populus tremuloides*; Photographs 13 and 14). A mix of shallow pools, limited

undercut banks, and scattered small woody debris have been observed throughout Station SF16. The substrate in Station SF16 has remained predominately sand with small patches of gravel and cobble, with silt and organic matter present along the margins and in the stream channel.

The average width of Station SF16 was 12.3 feet (*n* = 21) and average depth was 0.5 feet (*n* = 63), which was the widest and deepest among all Chippewa Creek stations (Table 3). The average water temperature as measured with the YSI Professional Plus was 19.6°C (*n* = 21) and was the second warmest among all stations (Table 3).

4.0 PREDICTED EFFECTS ON THE AQUATIC COMMUNITY

The increased pumping rate from 150 gpm to 400 gpm for a total increase of 250 gpm will result in a loss of 250 gpm of groundwater that is currently distributed among the streams and wetlands in the project vicinity. Changes in streamflow, stream surface water level, and water temperature were predicted based on a variety of watershed characteristics, including an evaluation of streamflow data, groundwater elevation, stream temperature, and surficial geology (S.S. Papadopulos & Associates, Inc., 2016). The average annual total reduction in discharge is expected to be approximately 127 gpm in Twin Creek and approximately 90 gpm in Chippewa Creek, which amounts to an average decrease of less than four percent of the base flow in both systems (S.S. Papadopulos & Associates, Inc., 2016).

4.1 Fish

The withdrawal of groundwater could result in an increase in summer stream temperature and a decrease in winter stream temperature (Risley et al. 2010). The greatest predicted change in summer water temperature in any of the stations surveyed by AEM is expected to occur in Stations SF5 and SF5-6, and is expected to increase less than 0.2°C (Figure 1-2; S.S. Papadopulos & Associates, Inc., 2016). The greatest expected change in winter water temperature from the groundwater withdrawal is expected to be less than the expected change in the summer (Charles Andrews, S.S. Papadopulos & Associates, personal communication, May 27, 2016).

Brook trout (*Salvelinus fontinalis*), and mottled sculpin (*Cottus bairdii*) are the species of fish that are typically collected from Stations SF5 and SF5-6. The average summer water temperature for the months of July and August from 2013 through 2015 was 11.3°C (Table 1). A maximum increase of 0.2°C would not change or significantly affect the characteristic fish community. Brook trout are considered a coldwater fish species and are known to prefer water temperatures from 9.8 to 17.9°C (Brown, 1974).

The fish community of Station SF1 is characterized by a predominance of blacknose dace (*Rhinichthys atratulus*), creek chubs (*Semotilus atromaculatus*), one to two brown trout (*Salmo trutta*) and an occasional brook trout. The summer water temperature ranges from 14.1°C to 24.8°C, with an average of 18.7°C from 2013 through 2015. The predicted increase in water temperature is expected to be less than the increase that would be expected in the vicinity of Stations SF5 and SF5-6. Brown trout are known to prefer water temperatures in the range of 6.7°C to 19.0°C, and can tolerate water temperature ranging from 0°C to 27°C (Raleigh et al., 1986). Therefore, the predicted increase in water temperature is not expected to change or significantly affect the characteristic fish community, or the aquatic habitat.

The fish community of Station SF9 is characterized as a coldwater trout community with a predominance of brown trout, brook trout, mottled sculpin, and blacknose dace. Station SF9 is located downstream of the greatest expected change in water temperature and the expected change in water temperature within the vicinity of Station SF9 is not expected to change or significantly affect the characteristic fish community, or the aquatic habitat.

Stations SF8 and SG5 are located in the headwaters of Chippewa Creek and are also located upstream of a series of ponds on Spring Hill Camp property. Although the average summer temperature of both sample stations are cold enough to support trout species (Table 1), no fish have been observed in Stations SF8 and SG5 during previous surveys by AEM personnel.

4.2 Aquatic macroinvertebrates

The characteristic aquatic macroinvertebrate communities are not expected to change as a result of the increased withdrawal. The predicted change in water temperature is small and is not expected to significantly affect the macroinvertebrate community composition of Twin Creek or Chippewa Creek.

4.3 Aquatic Habitat

A reduction in the stream flow of Twin Creek and Chippewa Creek is expected to result in a decrease in average width and an increase in the average depth over time (S.S. Papadopulos & Associates, Inc., 2016). Although there is an expected change in stream morphology as a result in the increased withdrawal, the morphological change to Twin Creek and Chippewa Creek is expected to be extremely small. Water level changes are expected to be less than 0.01 feet throughout the project vicinity (Charles Andrews, S.S. Papadopulos & Associates, personal communication, May 27, 2016).

5.0 SUMMARY

Twin Creek and Chippewa Creek have been functioning as coldwater trout streams with characteristic fish communities that have remained consistent since AEM personnel began monitoring them in 2003. Similarly, the macroinvertebrate communities have remained consistent in community composition and relative abundance since they have been monitored by AEM. The aquatic habitat has also remained stable among all years monitored by AEM personnel.

The increased groundwater withdrawal rate from 150 gpm to 400 gpm will result in a reduction in streamflow, a warming of stream temperature, and a narrowing and deepening of the stream channel in the project vicinity. However, all of these impacts to the stream habitat, fish, and macroinvertebrates will be small and will not significantly affect the characteristic fish and macroinvertebrate communities, or the aquatic habitat. The average water temperature is expected to increase in the summer months less than 0.2°C in all locations within the project vicinity, and the average stream elevation is expected to decrease less 0.01 feet in all locations within the project vicinity. The magnitude of the predicted changes will be significantly less than the daily variation of stream depth, or stream temperature within Twin Creek or Chippewa Creek.

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TABLES

Table 1. Fish species collected from Twin Creek and Chippewa Creek from 2003 through 2015.

		Twin Creek				Chippewa Creek		
Common name	**Scientific Name**	**SF1**	**SF5**	**SF5-6**	**SF9**	**SG5**	**SF8**	**SF16**
American brook lamprey	*Lampetra appendix*	6	2		1			1
Blacknose dace	*Rhinichthys atratulus*	99			47			2
Brook trout	*Salvelinus fontinalis*	2	43	15	29			
Brown trout	*Salmo trutta*	12			46			21
Central mudminnow	*Umbra limi*				4			
Creek chub	*Semotilus atromaculatus*	19		1	4			179
Mottled sculpin	*Cottus bairdii*	6	33	8	19			29
Pumpkinseed sunfish	*Lepomis gibbosus*				2			
White sucker	*Catostomus commersonii*	1			4			3
	Total Count of Species	**145**	**78**	**24**	**156**	**0**	**0**	**235**

Table 2. Aquatic macroinvertebrates collected from Twin Creek and Chippewa Creek from 2003 through 2015.

		Twin Creek				Chippewa Creek		
Order	**Family**	**SF1**	**SF5**	**SF5-6**	**SF9**	**SG5**	**SF8**	**SF16**
Amphipoda	Gammaridae	577	992	13	730	181	209	11
Amphipoda	Hyalellidae			2	17			66
Architaenioglossa	Viviparidae			4				
Basommatophora	Physidae		1	5	3			7
Basommatophora	Planorbidae	1	2		3			1
Coleoptera	Elmidae	35			25			32
Coleoptera	Gyrinidae	3	5		4			1
Coleoptera	Hydrophilidae	1	1		6			
Coleoptera	Scirtidae			1				
Coleoptera	Dytiscidae		2	4	1	1	3	
Coleoptera	Haliplidae				1			
Decapoda	Cambaridae	10			2			39
Diptera	Athericidae	1	1		3			
Diptera	Chironomidae	28	24	148	64	1	10	72
Diptera	Dixidae			11	1			
Diptera	Ptychopteridae		6					
Diptera	Simuliidae	14		2	5		5	4
Diptera	Tabanidae	2	3		6			1
Diptera	Tipulidae		4	1	2		1	
Diptera	Stratiomyidae		1					
Diptera	Ceratopogonidae		1	1				
Diptera	Empididae		1					
Diptera	Pelecorhynchidae						1	
Ephemeroptera	Baetidae	13	3	5	70		5	2
Ephemeroptera	Ephemeridae	11	5	90	17			6
Ephemeroptera	Heptageniidae	23			8			102
Ephemeroptera	Leptophlebiidae		2	28	15			4
Ephemeroptera	Letohyphidae	2			13			2
Hemiptera	Gelastrocoridae			1				
Hemiptera	Gerridae	11	8	12	20			14
Hemiptera	Notonectidae				1			
Hemiptera	Saldidae	2						2
Hemiptera	Veliidae	3	3	13	3			16
Hemiptera	Corixidae		1	1	6			
Megaloptera	Corydalidae	21			14			13
Megaloptera	Sialidae	2	8	155	17			46
Oligochaeta	Lumbriculidae	4	2		3			
Plecoptera	Leuctridae		7	27				
Plecoptera	Nemouridae		2	6			4	1
Plecoptera	Perlidae	34			1			
Plecoptera	Philopotamidae							2

Table 2 (Continued). Aquatic macroinvertebrates collected from Twin Creek and Chippewa Creek from 2003 through 2015.

		Twin Creek				Chippewa Creek		
Order	**Family**	**SF1**	**SF5**	**SF5-6**	**SF9**	**SG5**	**SF8**	**SF16**
Pulmonata	Physidae	1	1	7				7
Trichoptera	Brachycentridae		1		10			
Trichoptera	Hydropsychidae	59			11			90
Trichoptera	Lepidostomatidae	1	7	11	12			
Trichoptera	Limnephilidae	4	31	30	4	2	8	7
Trichoptera	Philopotamidae	44	3		20			6
Trichoptera	Polycentropodidae				2			1
Trichoptera	Molannidae		1		2			1
Trichoptera	Leptoceridae							2
Trichoptera	Uenoidae							1
Trichoptera	Rhyacophilidae				1			
Trichoptera	Arctopsychidae					2	4	
Veneroida	Sphaeridae	1	2	3	8			13
Odonata	Aeshnidae	40			10			9
Odonata	Calopterygidae	73			50			65
Odonata	Cordulegasteridae	22	7	4	4		1	1
Odonata	Coenagrionidae	3						2
Odonata	Gomphidae	1						7
Hygrophila	Lymnaeidae			6				
Collembola			1					
Limnophila	Lymnaeidae		2	6	1			
Rhynchobdellida	Glossiphoniidae							2
Trombidiformes	Hydrachnidiae						1	
	Total	**1,047**	**1,141**	**597**	**1,196**	**187**	**252**	**658**

Table 3. Stream dimensions and water temperature measured at the time of the survey from 2008 through 2015.

Sample Station	Average width in feet (*n*)	Average depth in feet (*n*)	Average water temperature in °C (*n*)
SF1 (Twin Creek)	6.1 (21)	0.5 (63)	19.7 (21)
SF5 (Twin Creek)	5.3 (21)	0.3 (63)	11.5 (21)
SF5-6 (Twin Creek)	6.1 (21)	0.3 (63)	11.8 (21)
SF9 (Twin Creek)	14.1 (21)	1.0 (63)	15.7 (21)
SG5 (Chippewa Creek)	1.4 (3)	0.2 (9)	11.8 (3)
SF8 (Chippewa Creek)	2.0 (3)	0.2 (9)	10.5 (3)
SF16 (Chippewa Creek)	12.3 (21)	0.5 (63)	19.6 (21)

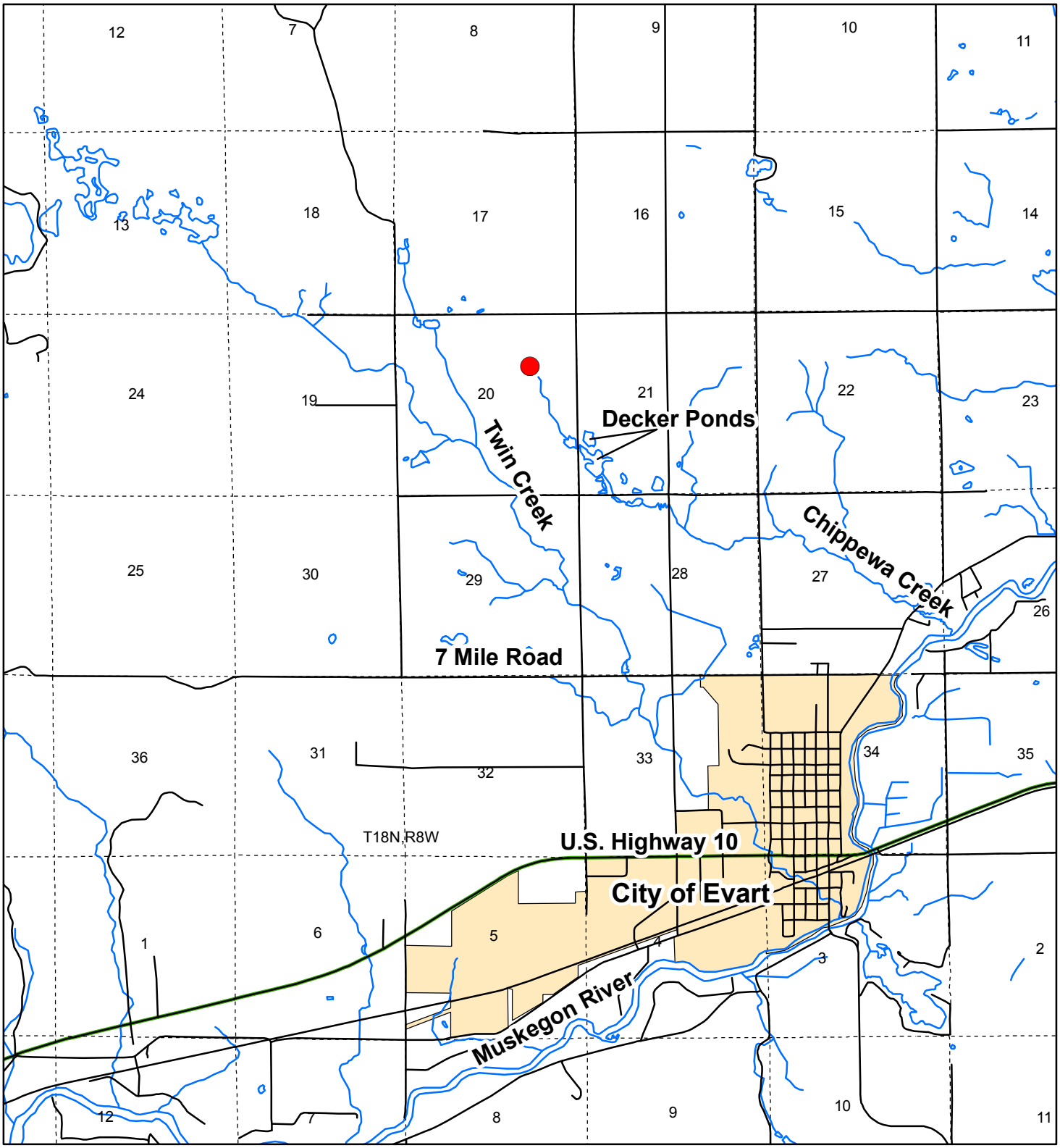
n – sample size

Table 4. Daily water temperature summary for the months of July and August 2013 through 2015 as recorded by HOBO® Water Temp Pro V2.

Sample Station	Minimum Temperature (°C)	Maximum Temperature (°C)	Average Temperature (°C)
SF1 (Twin Creek)	14.1	24.8	18.7
SF 5-5-6 (Twin Creek)	8.6	17.9	11.3
SF 9 (Twin Creek)	11.8	24.9	17.3
SF8 (Chippewa Creek)*	8.8	13.2	10.6
SG 5 (Chippewa Creek)*	9.6	15.6	12.2

*Survey data only for 2015

FIGURES



Base map and aerial imagery obtained from Michigan Geographic Data Library

Legend

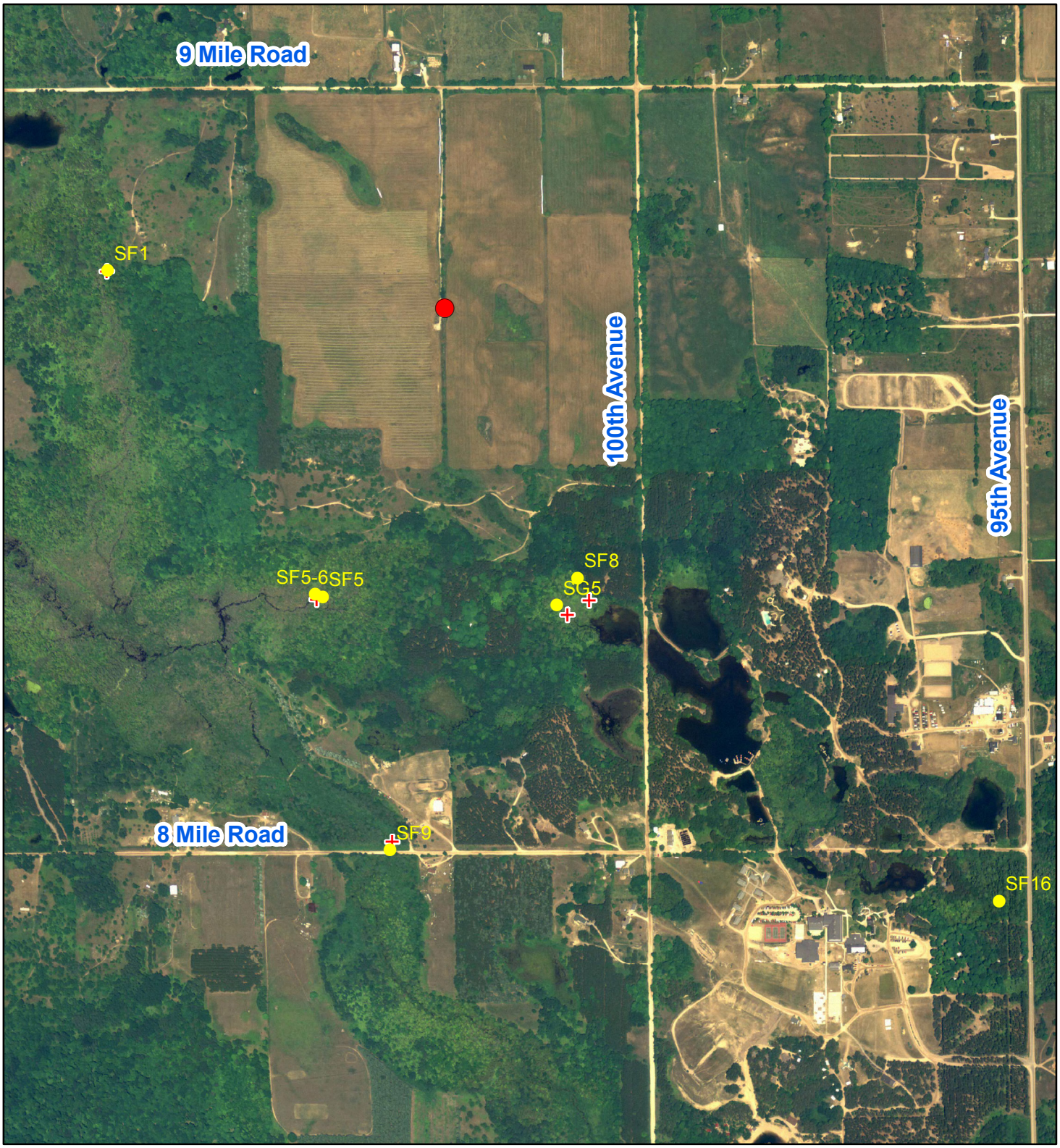
- Approximate Location of Well
- City Limits

N

0 0.25 0.5 1 1.5 2 Miles

AeM ADVANCED ECOLOGICAL MANAGEMENT

PROJECT	NWNA White Pine Springs
TITLE	Project Vicinity
FIGURE	1-1



Base map and aerial imagery obtained from Michigan Geographic Data Library

Legend

- Sample Station Locations
- Approximate Location of Well
- \+ Water Temperature Monitor Locations

N

Feet
0 250 500 1,000 1,500 2,000

AEM ADVANCED ECOLOGICAL MANAGEMENT

PROJECT	NWNA White Pine Springs
TITLE	Sample Station Locations
FIGURE	1-2

PHOTOGRAPHS

Photograph 1. Station SF 1 – Downstream Extent View Northeast.

Photograph 2. Station SF 1 – Upstream Extent View South.

Photograph 3. Station SF 5 – Downstream Extent View East.

Photograph 4. Station SF 5 – Upstream Extent View Southwest.

Photograph 5. Station SF 5-6 – Downstream Extent View Northeast.

Photograph 6. Station SF 5-6 – Upstream Extent View Southwest.

Photograph 7. Station SF 9 – Downstream Extent View Northeast.

Photograph 8. Station SF 9 – Upstream Extent View Southwest.

Photograph 10. Station SG5 – Downstream Extent View West.

Photograph 11. Station SG5 – Upstream Extent View East.

Photograph 11. Station SF 8 – Downstream Extent View Northwest.

Photograph 12. Station SF 8 – Upstream Extent View South.

Photograph 13. Station SF 16 – Downstream Extent View North.

Photograph 14. Station SF 16 – Upstream Extent View South.