Environmental Assessment

Appendix K

Karst

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Approved 9/9/2022

KARST REPORT
SR 11 ROADWAY PROJECT
HARRISON COUNTY, IN

August 8, 2022

Karst Report

Prepared by: Peter Putzier

Des. No.: 2001154

Contract No.: R-42857

Prepared for: INDOT

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Karst Report
State Road 11 Roadway Project
Harrison County, Indiana
DES # 2001154

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Karst Report
State Road 11 Roadway Project
Harrison County, Indiana
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Date of Karst Investigation
February 24, 2021 to May 30, 2021

Location
The SR 11 Roadway Project (The Project) is located between the State Road (SR) 135 and Watson Road junction and the SR 11, Old Highway 337 and Melview Road junction, 4.7 miles north of the existing junction between SR 135 and Old Highway 11 and approximately 10 miles south of Corydon, Indiana along SR 135 (Attachment 1).

- Harrison County, Boone and Heth Townships, Indiana
- Township 5 South, Range 3 East, Sections 11, 12, 13, 14. Township 5 South, Range 4 East Sections 7, 8, 9, 16, 17, 18.
- Mauckport and Laconia 1:24,000 United States Geological Survey (USGS) Quadrangles (Attachments A4 and A5).
- Latitude: 38.083798°; Longitude: -86.110096°

Project Description
The Project (DES # 2001154) involves upgrading county roads, construction of a new terrain roadway, and construction of a bridge crossing Buck Creek.

The Karst Survey area is 5 miles long between SR 135 and the SR 11, Old Highway 337, and Melview Road intersection (Page A2). The Karst Survey area extends north from the intersection of SR 135 and Watson Road approximately 1,800 ft and south approximately 1,460 ft. The Karst Survey area along SR 135 is 300 ft wide south of Watson Road and 500 feet wide north of Watson Road. Along Watson Road and Melview Road the Karst Survey area is approximately 500 feet wide. Near Buck Creek, where approximately 2 miles of new terrain road will be constructed, the Karst Survey area is approximately 2,500 ft wide. East of Buck Creek the Karst Survey area extends north 725 ft from the intersection of SR 337 and SR 11, south from the intersection 820 ft and east-northeast from the intersection 990 ft. The Karst Survey area is 300 ft wide along SR 337. The landscape within and around the Karst Survey area is predominantly composed of rural residential properties, pasture, agricultural fields, mature forest, and floodplain. The karst feature investigation for this project encompassed approximately 820 acres.

Karst Red Flag Investigation and Desktop Review
The Project is located within the south-central portion of the "Indiana Karst Region" as defined in the document, *Protection of Karst Features during Project Development and Construction*, July 15, 2021 (Attachment A2). Graphical Information Systems (GIS) data for caves, sinkholes, sinking stream basins

and springs was examined for the project area (Attachment A3). A Red Flag Investigation and desktop review of the project shows two mapped karst springs along the east side of Buck Creek within the Karst Survey area (Attachment A3). The Karst Survey area is partially within two sinking stream basin polygons, three sinkhole polygons, and two cave entrance density tiles where there are a total of two identified caves. The cave entrance density layer does not give cave names, only that two caves are located within these tiles. Indiana Cave Survey's (ICS) confidential database indicates the presence of twelve caves within approximately one mile of the Karst Survey area. The nearest dye trace in the literature prior to those conducted for this project is located 6.17 miles to the north of the Karst Survey area.[1] The project lies within the south-central portion of the Mitchell Plateau Physiographic region, an area of rolling topography with abundant sinkholes, soil piping, limestone caves, and sinking stream basins. Several large cave systems are in Harrison County. Indiana Caverns, a commercial cave and subset of the larger Binkley Cave System, is 6.5 miles north of the Karst Survey area. Binkley Cave System is the 8th longest mapped cave system in the United States, with over 40 miles of mapped passage. Squire Boon Caverns is another commercial cave system located approximately 1.25 miles south of the Karst Survey area.

The Mauckport and Laconia 1:24,000 USGS Quadrangles are populated with topographically defined sinking stream basins, sinkholes, and springs all on a local sinkhole plain, the central and eastern portion of which is drained by Buck Creek (Attachment A4). The western portion of the Karst Survey area drains through solution widened limestone conduits south and southwest to the Ohio River (Attachment A8). Karst features in and surrounding the Karst Survey area are typical for the southern portion of the Mitchell Plateau Physiographic Division. Beneath the Karst Survey area, bedrock is comprised of Mississippian Age Blue River Group (300 ft thick) and subjacent Sanders Group (150 ft thick) marine carbonate rock formations (limestones). Karst bedrock features in and around the Karst Survey area have an extensive, thick, covering of regolith, heterogeneous, loose rock fragments up to 50 feet thick sitting on top of bedrock, comprised of red, orange, and yellow variegated karst clays. This variegated karst clay regolith fills many of the limestone sinkholes and subterranean limestone conduits in the Karst Survey area. A residuum of less soluble gravels composed of silicious chert nodules and fossil replacements cover the sinkholes locally. These karst sediments are covered by post glacial loess silt deposits. Unconsolidated sediment overlying limestone bedrock is dynamic in its migration into sinkholes and subterranean drainage pathways. The dynamic movement of sediment regulates the infiltration of surface water into the karst voids. The extensive unconsolidated cover alters surface hydrology, but the sinkholes continue to capture surface water, diverting it downward into subterranean karst system drainage pathways. The karst system around the project area may have been relatively stable below the existing roadways over the past several decades; however, the local karst system is known to be dynamic with potentially rapid changes to structural stability and hydrology. Sediment migration through the cave streams over time may result in short or long term flow blockages and cave-ins. Blockages can result in long term ponding of stormwater in sinkholes and related instability to soil parameters. Additional supplemental environmental maps are provided showing Light Detection and Ranging (LiDAR) derived Topography with approximate construction limits (Attachment A10), 2 ft surface contours (Attachment A11), and Historical Aerials (Attachment A7). Karst features

[1] KARST_DYE_LINES_IN: Inferred Connections for Selected Subsurface Dye Traces in Southern Indiana (Indiana Geological Survey, 1:24,000, Line Shapefile)

identified in the field were given IDs with a 4 prefix. Table 1 and Table 2 list the Field identified karst features. Attachment A10 and A11 maps depict the location of Field identified karst features.

Bedrock Geology and Structure

The surface bedrock groups that are mapped within the project area include Blue River Group Limestones, located both east and west of Buck Creek, and Sander's Group Limestones which are exposed in the valley of Buck Creek. The western edge of the Karst Survey area abuts the mapped transition from the Crawford Uplands Physiographic Region in the west to the Mitchell Plateau Physiographic Region. Approximately 7.75 miles east of the Karst Survey area, Borden Group siltstone bedrock is present at the surface near the transition from the Mitchell Plateau Physiographic Region to the Norman Uplands Physiographic Region in the east. The headwaters of Buck Creek originate northeast of the Karst Survey area near the west edge of the Norman Uplands Physiographic Region. Bedrock units in the project area generally dip 35 feet per mile to the southwest (approximately 0.5 degrees) and regional strike is approximately 25 degrees to the west of north (Attachment A6).

Soils

The Soil Survey Geographic (SSURGO) database for Harrison County includes the following mapped soil series within the Karst Survey area (Attachment A9). These soils, deposited on an uneven limestone surface, vary in thickness within the valley of Buck Creek. The valley surface of Buck Creek is underlain with karst fissures and swallets which are often covered by the gravels and finer sediments in the channel. The SSURGO soil types in the project area are:

- **Bedford silt loam (BDoB)**, 2 to 6 percent slopes
- **Brussels-Rock outcrop complex (BvsG)**, 35 to 90 percent slopes
- **Caneyville-Rock outcrop complex (CcaG)**, 25 to 60 percent slopes
- **Crider silt loam (CtaB)**, karst, undulating
- **Crider-Vertrees silt loams (CteC2)**, karst, rolling eroded
- **Elkinsville silt loam (EepA)**, 0 to 2 percent slopes
- **Elkinsville silt loam (EepB2)**, 2 to 6 percent slopes, eroded
- **Elkinsville silt loam (EepC2)**, 6 to 12 percent slopes, eroded
- **Haymond silt loam (HcgAW)**, 0 to 2 percent slopes, occasionally flooded, very brief duration
- **Haymond silt loam (HcpAP)**, depression, 0 to 2 percent slopes, frequently ponded, very brief duration
- **Kintner loam (KunAW)**, 1 to 3 percent slopes, occasionally flooded, very brief duration
- **Knobcreek-Navilleton-Haggatt silt loam (KxoC2)**, karst, rolling, eroded
- **Knobcreek-Haggatt-Caneyville silt loams (KxpD2)**, karst, hilly, eroded
- **Knobcreek-Navilleton-Haggatt complex (KxrC3)**, karst, rolling, severely eroded
- **Knobcreek-Haggat-Caneyville complex (KxsD3)**, karst, hilly, severely eroded
- **Laconia silt loam (LaaA)**, 0 to 1 percent slopes
- **Nolin silt loam (NprAQ)**, 0 to 2 percent slopes, rarely flooded
- **Pekin silt loam (PcrA)**, 0 to 2 percent slopes
- **Vertrees-Crider-Caneyville complex (VcaC3)**, karst, rolling, severely eroded
- **Vertrees-Crider-Caneyville silt loams (VcbD2)**, karst, hilly, eroded

- **Vertress-Haggatt-Caneyville complex (VccD3)**, karst, hilly, severely eroded

Field Reconnaissance
Karst features have been mapped within the Karst Survey area, based on environmental conditions at the time of the Karst Survey. Karst features will be analyzed during the alternatives evaluation to assist in the selection of a recommended preferred alternative.
Onsite karst inspections were completed for the Karst Survey area on multiple days in February, March, April, and May, 2021 by a Lochmueller Group licensed professional geologist. Relevant topographic and drainage observations inside the Karst Survey area are included in the following descriptions. The focus of the field inspection was to identify surface karst features, assess the karst drainage for those features and determine which karst features would be impacted by the project. In addition to the field Karst Survey, the karst evaluation included a dye trace study (Attachment 13), a geophysical survey (Attachment 14 and 15), and geotechnical borings (Attachment 16). The geophysical survey included both Ground Electrical Resistivity (ER) and Electromagnetic Survey (EM) performed by Atlas Technical Consultants, LLC (Atlas). The purpose of the geophysical survey was to locate subterranean voids, provide mapping of the bedrock/regolith contact, and provide hydrologic information. Atlas advanced and logged 27 geotechnical borings. Boring locations were chosen using alternative alignments and information collected from the geophysical survey. A dye trace study was completed by Hydrogeology Inc. based on projected sinkhole infiltration rates, springs listed in this study, and their own field survey of the project area.

Karst features (4-ID#) that were identified during the field investigation are listed in Table 1 and Table 2. Photograph location maps are included in Attachment A12. Table 1 includes the karst feature ID, feature type, the estimated stormwater infiltration rate potential based on the day the feature was surveyed, feature coordinates and photo number. The ground surface is dynamic over time and infiltration rates are subject to change as drainage pathways are plugged with or cleared of sediment. Table 2 includes feature ID, feature type, and a brief feature description.

Table 1. Field Review Karst Features

Observed Feature ID	Feature Type	Stormwater Infiltration Potential	Latitude, Longitude (decimal degrees)	Photo Number(s)
4-0001	Sinkhole	High	38.085477, -86.164681	1
4-0002	Soil Piping	N/A	38.085155, -86.163663	2
4-0003	Sinkhole	Medium	38.084982, -86.162451	3
4-0004	Sinkhole	Low	38.085487, -86.155773	4
4-0005	Sinkhole	Medium	38.084521, -86.155484	5
4-0006	Sinkhole	Medium	38.085334, -86.154608	6
4-0007	Sinkhole	High	38.086059, -86.153203	7
4-0008	Sinkhole	Low	38.085030, -86.151215	8
4-0009	Soil Piping	Medium	38.084520, -86.151104	9
4-0010	Sinkhole	Medium	38.085107, -86.149975	10
4-0011	Other	N/A	38.083576, -86.146405	11
4-0012	Sinkhole	Low	38.084513, -86.145668	12

Observed Feature ID	Feature Type	Stormwater Infiltration Potential	Latitude, Longitude (decimal degrees)	Photo Number(s)
4-0013	Sinkhole	High	38.084377, -86.143191	13
4-0014	Sinkhole	Low	38.084459, -86.141823	14
4-0015	Sinkhole	Low	38.084563, -86.140065	15
4-0016	Sinkhole	Low	38.084160, -86.139724	16
4-0017	Other	N/A	38.084752, -86.117123	17
4-0018	Sinkhole	Medium	38.084632, -86.137036	18
4-0019	Sinkhole	Medium	38.084249, -86.135618	19
4-0020	Sinkhole	Medium	38.084538, -86.135206	20
4-0021	Sinkpoint	High	38.084765, -86.133248	21
4-0022	Sinkhole	Low	38.084604, -86.133038	22
4-0023	Soil Piping	Medium	38.084581, -86.132622	23
4-0024	Spring	Medium	38.085190, -86.129983	24
4-0025	Soil Piping	Medium	38.084288, -86.130153	25
4-0026	Other	N/A	38.084025, -86.129475	26
4-0027	Soil Piping	Medium	38.084355, -86.129092	27
4-0028	Sinkhole	High	38.084265, -86.128503	28
4-0029	Other	N/A	38.084072, -86.128573	29
4-0030	Other	Low	38.084251, -86.127014	30
4-0031	Sinkhole	N/A	38.083763, -86.126153	31
4-0032	Soil Piping	Medium	38.084435, -86.125115	32
4-0033	Soil Piping	Medium	38.082497, -86.122842	33
4-0034	Sinkhole	High	38.082904, -86.121563	34
4-0035	Sinkhole	High	38.084959, -86.118509	35
4-0036	Other	N/A	38.084848, -86.117597	36
4-0037	Other	N/A	38.084786, -86.117334	37
4-0038	Spring	N/A	38.084099, -86.116163	38
4-0039	Soil Piping	High	38.083502, -86.115843	39
4-0040	Soil Piping	High	38.082824, -86.115818	40
4-0041	Soil Piping	Medium	38.080286, -86.116084	41
4-0042	Sinkhole	Medium	38.079851, -86.113817	42
4-0043	Spring	N/A	38.083577, -86.114496	43
4-0044	Other	N/A	38.084799, -86.113250	44
4-0045	Spring	N/A	38.083823, -86.112898	45
4-0046	Spring	N/A	38.083270, -86.112219	46
4-0047	Sinkhole	Low	38.084808, -86.118771	47
4-0048	Other	N/A	38.083681, -86.117757	48
4-0049	Other	N/A	38.084808, -86.119858	49
4-0050	Spring	N/A	38.083387, -86.111791	50
4-0051	Spring	N/A	38.088073, -86.112788	51
4-0052	Spring	N/A	38.087949, -86.111784	52

Observed Feature ID	Feature Type	Stormwater Infiltration Potential	Latitude, Longitude (decimal degrees)	Photo Number(s)
4-0053	Sinkhole	High	38.087288, -86.111268	53
4-0054	Sinkhole	High	38.086737, -86.110049	54
4-0055	Sinkhole	High	38.086593, -86.109965	55
4-0056	Sinkhole	Medium	38.086613, -86.110123	56
4-0057	Sinkhole	High	38.085895, -86.110308	57
4-0058	Sinkhole	High	38.085811, -86.109182	58
4-0059	Sinkhole	High	38.084820, -86.110268	59
4-0060	Sinkhole	High	38.084410, -86.109334	60
4-0061	Spring	N/A	38.083514, -86.111284	61
4-0062	Spring	N/A	38.083096, -86.109081	62
4-0063	Spring	N/A	38.082594, -86.108259	63
4-0064	Other	N/A	38.081982, -86.108610	64
4-0065	Spring	N/A	38.082332, -86.108011	65
4-0066	Other	N/A	38.081404, -86.108494	66
4-0067	Spring	N/A	38.081496, -86.107518	67
4-0068	Other	N/A	38.080164, -86.10870	68
4-0069	Spring	N/A	38.079296, -86.108421	69
4-0070	Other	N/A	38.079119, -86.109626	70
4-0071	Sinkhole	High	38.080311, -86.106387	71
4-0072	Sinkhole	High	38.080767, -86.106027	72
4-0073	Soil Piping	Low	38.081679, -86.105325	73
4-0074	Soil Piping	Medium	38.082246, -86.104735	74
4-0075	Sinkhole	Low	38.082656, -86.105207	75
4-0076	Sinkhole	Low	38.082829, -86.105132	76
4-0077	Sinkhole	Low	38.083232, -86.107496	77
4-0078	Sinkhole	N/A	38.083743, -86.108209	78
4-0079	Sinkhole	Low	38.083683, -86.106997	79
4-0080	Sinkhole	Low	38.084230, -86.107225	80
4-0081	Sinkhole	N/A	38.086508, -86.108407	81
4-0082	Sinkhole	Medium	38.086934, -86.108777	82
4-0083	Sinkhole	High	38.086166, -86.106407	83
4-0084	Sinkpoint	Medium	38.085705, -86.106101	84
4-0085	Sinkhole	Medium	38.084649, -86.105525	85
4-0086	Sinkhole	Medium	38.084285, -86.104742	86
4-0087	Sinkpoint	Medium	38.084938, -86.104286	87
4-0088	Sinkpoint	Medium	38.086100, -86.104472	88
4-0089	Sinkhole	Low	38.085737, -86.103574	89
4-0090	Sinkhole	Medium	38.085871, -86.103252	90
4-0091	Sinkhole	Low	38.083649, -86.104061	91
4-0092	Sinkpoint	Low	38.083752, -86.103621	92

Observed Feature ID	Feature Type	Stormwater Infiltration Potential	Latitude, Longitude (decimal degrees)	Photo Number(s)
4-0093	Sinkhole	Low	38.083423, -86.104049	93
4-0094	Other	Low	38.083921, -86.102728	94
4-0095	Spring	N/A	38.084456, -86.102467	95
4-0096	Spring	N/A	38.084359, -86.102331	96
4-0097	Sinking Stream	Low	38.084092, -86.102162	97
4-0098	Other	N/A	38.082521, -86.102383	98
4-0099	Other	N/A	38.081173, -86.104132	99
4-0100	Soil Piping	Medium	38.081730, -86.100584	100
4-0101	Soil Piping	N/A	38.080958, -86.100166	101
4-0102	Other	N/A	38.081340, -86.099305	102
4-0103	Sinking Stream	High	38.083842, -86.101674	103
4-0104	Sinkpoint	Low	38.083760, -86.101051	104
4-0105	Other	N/A	38.084387, -86.100862	105
4-0106	Other	N/A	38.084605, -86.101067	106
4-0107	Sinkhole	Low	38.086370, -86.102285	107
4-0108	Sinkpoint	N/A	38.086211, -86.100927	108
4-0109	Sinkpoint	Low	38.086137, -86.101206	109
4-0110	Spring	N/A	38.085014, -86.107462	110
4-0111	Soil Piping	N/A	38.085967, -86.101438	111
4-0112	Sinkhole	Medium	38.087010, -86.099777	112
4-0113	Sinkhole	Low	38.086899, -86.098675	113
4-0114	Sinkhole	Low	38.084884, -86.098980	114
4-0115	Other	N/A	38.081314, -86.095882	115
4-0116	Sinkhole	Low	38.083185, -86.092119	116
4-0117	Sinkpoint	Low	38.083922, -86.082339	117
4-0118	Sinkpoint	Low	38.083132, -86.082706	118
4-0119	Other	N/A	38.082192, -86.076215	119
4-0120	Sinking Stream	Low	38.083607, -86.074560	120
4-0121	Sinking Stream	High	38.077552, -86.104696	121
4-0122	Sinkhole	High	38.085344, -86.117524	122
4-0123	Sinkhole	High	38.085053, -86.117388	123
4-0124	Sinking Stream	N/A	38.084960, -86.118136	124
4-0125	Soil Piping	High	38.084844, -86.092210	125
4-0126	Other	N/A	38.081454, -86.111433	126
4-0127	Other	N/A	38.082928, -86.078905	127
4-0128	Sinkhole	Medium	38.083698, -86.165352	128
4-0129	Spring	N/A	38.077955, -86.107884	129
4-0130	Spring	N/A	38.078062, -86.131675	130
4-0131	Sinkhole	Low	38.085233, -86.158168	131
4-0132	Sinkhole	Medium	38.084738, -86.156735	132

Observed Feature ID	Feature Type	Stormwater Infiltration Potential	Latitude, Longitude (decimal degrees)	Photo Number(s)
4-0133	Sinkhole	Low	38.084706, -86.144758	133

Table 2 – Karst Feature Descriptions

Observed Feature ID	Feature Type	Description
4-0001	Sinkhole	Sinkhole drains water from SR 135, active soil piping in sinkhole, culvert conveys water to sinkhole, dye injection point was traced southwest to a spring on the north bank of the Ohio River, an electrical resistivity (ERT) line (STL-A) was conducted at this location
4-0002	Soil Piping	Located on grassy slope in a yard, small active soil piping
4-0003	Sinkhole	Shallow soil depression with soil piping surrounded by growing trees
4-0004	Sinkhole	Ponded sinkhole
4-0005	Sinkhole	Soil depression with large growing trees
4-0006	Sinkhole	Soil piping filled with crushed stone
4-0007	Sinkhole	Soil piping present in sinkhole, thick sapling growth in sinkhole
4-0008	Sinkhole	Storm water ponds in a broad shallow sinkhole depression that is partitioned into a northern and southern half by Watson Road
4-0009	Soil Piping	Soil piping on slope of southern half of the broad shallow sinkhole depression partitioned by Watson Road
4-0010	Sinkhole	Broad shallow soil depression with aggregate stone in center, located in a residential yard
4-0011	Other	Natural gas production well near a large sinkhole, beware of shallow gas pipeline collection network, potential hazards
4-0012	Sinkhole	Soil piping along the edge of a road, thick brush and vegetation, ERT line (STL-D) was conducted at this location
4-0013	Sinkhole	Soil piping in center with growing trees in a broad shallow depression, dye injection point was traced southwest to a spring along the north bank of the Ohio River, ERT line (STL-E) was conducted at this location
4-0014	Sinkhole	Small soil depression, three large trees are growing out of sinkhole
4-0015	Sinkhole	Located along the edge of a road, verbal record that that the sinkhole was recently filled
4-0016	Sinkhole	Ponded soil depression
4-0017	Other	Ephemeral creek with exposed limestone bedrock and visible jointing in creek bed
4-0018	Sinkhole	Stormwater ponds in sinkhole, two small soil pipes observed on southwest side of sinkhole
4-0019	Sinkhole	Broad steep sided soil filling over bedrock valley on the edge of Watson Road
4-0020	Sinkhole	Soil piping in small depression with loose bedrock, in a wooded front yard of a home
4-0021	Sinkpoint	Primary sinkpoint of a larger enclosed valley, sinkpoint drains the field to the north and east, ERT line (STL-F) was conducted near this location
4-0022	Sinkhole	Broad soil depression in a pasture field with one medium sized tree, ERT line (STL-F) was conducted at this location

Observed Feature ID	Feature Type	Description
4-0023	Soil Piping	Small soil depression in a pasture field, ERT line (STL-F) was conducted near this location
4-0024	Spring	Steep sided depression in soil but appears that flow as abandoned a former spring, karst window
4-0025	Soil Piping	Small runoff rill piping down along road embankment
4-0026	Other	Slope has rill cutting from sheetwash in red soils, note gravel residuum of silica from Lost River Chert Bed preserved at the local elevation
4-0027	Soil Piping	Small soil depression in slope of a pasture field
4-0028	Sinkhole	Soil depression abuts road grade with soil piping and receives sheetwash runoff and rills starting in red soils. Vertical corrugated metal pipe (CMP) drains through a 20 ft deep treated sinkhole (according to locals) 4 ft south of Watson Road. Sinkhole is filled with debris to 5 ft below ground surface. Dye injection point traced to 4-0130, ERT line (STL-G) was conducted near this location
4-0029	Other	Erosional gully drains broad pastured slope into the sinkhole with a vertical CMP (4-0028)
4-0030	Other	Broad shallow soil depression adjacent and north of Watson Road. Water collects along the roadside
4-0031	Sinkhole	Broad shallow soil depression with stormwater collection
4-0032	Soil Piping	Broad slope area with depression and gullying that retains stormwater for several days, ERT line (STL-H) was conducted near this location
4-0033	Soil Piping	Soil piping at the bottom of a broad depression, drains the field north, northeast, and east up to Watson Road
4-0034	Sinkhole	Soil depression at base of trees, loose slabs of limestone exposed, ERT line (STL-I) was conducted near this location
4-0035	Sinkhole	Soil depression in drainage axis with open limestone throat, debris in bottom, potential cave entrance
4-0036	Other	Steep dry branch ephemeral stream with exposed limestone, bedrock fractures and infiltration, ERT line (STL-K2) was conducted near this location
4-0037	Other	Steep dry branch with bedrock fractures and infiltration
4-0038	Spring	Emerges from bank of Buck Creek about 7 ft above channel bottom
4-0039	Soil Piping	Multiple large soil pipes approximately 100 feet from the west edge of Buck Creek
4-0040	Soil Piping	Opening in small depression below stubble
4-0041	Soil Piping	Opening in small depression or groundhog burrow
4-0042	Sinkhole	Soil depression with soil piping around trees
4-0043	Spring	Located along east bank of Buck Creek, discharge estimated at 25 gallons per minute (gpm), dye detection point from injection at 4-0059
4-0044	Other	Gulley widening in soil over limestone
4-0045	Spring	Discharges from shallow limestone in drainage gully, flow estimated at 1-3 gpm
4-0046	Spring	Spring on limestone slope flow estimated at 1-3 gpm

Observed Feature ID	Feature Type	Description
4-0047	Sinkhole	Shallow soil depression
4-0048	Other	Manmade pond, collects drainage from valley slopes to the west
4-0049	Other	Manmade pond, collects drainage from valley slopes to the west
4-0050	Springs	Multiple springs outcropping in line along rock outcrop along river bluff
4-0051	Spring	Spring emerging into dry creek bed, flow estimate 15 gpm
4-0052	Spring	Spring forms small rivulet that sinks 50 ft downslope, flow estimated at 5 gpm
4-0053	Sinkhole	High infiltration rate and active soil loss
4-0054	Sinkhole	Steep walls on south and west, short sinking stream channel within sinkhole
4-0055	Sinkhole	Soil depression, short dry sinking stream basin within sinkhole
4-0056	Sinkhole	Sinkpoint in broad shallow soil depression
4-0057	Sinkhole	Steep soil depression into limestone
4-0058	Sinkhole	Broad shallow channel area with sinkpoint
4-0059	Sinkhole	Shallow soil depression with trash in sinkpoint, dye injection point traced to 4-0043, ERT line (STL-N) was conducted near this location
4-0060	Sinkhole	Steep sided sinkhole in forest, Limestone exposed
4-0061	Springs	Multiple spring seeps along bedrock outcrop on Buck Creek bluff, Seepage along micrite finely crystalline granular texture bed
4-0062	Spring	Outflow current below rock ledge in limestone
4-0063	Spring	Seepage out from top of tan stained area in gully
4-0064	Other	Cliff exposure of “shingle joints” in dolostone on west bank of Buck Creek
4-0065	Spring	Dry spring at top of gully, dye detection point from dye injection at 4-0111
4-0066	Other	Exposure of “shingle joints” in dolostone west bank of Buck Creek
4-0067	Spring	Spring, discharge estimated at 1-3 gpm from spring in gully on east bank of Buck Creek
4-0068	Other	Overbank high water slough with possible sinkpoint
4-0069	Spring	Two or three gullies with possible spring outlets and intermittent flow
4-0070	Other	Rock scarp and gully to right, south, and above Buck Creek channel
4-0071	Sinkhole	Steep sided soil depression with rock throat in upper 1/3r’d St. Louis Limestone, ERT line (STL-O) was conducted near this location
4-0072	Sinkhole	Soil depression in cultivated field, ERT line (STL-O) was conducted near this location
4-0073	Soil Piping	Isolated soil piping in agricultural field east of Buck Creek
4-0074	Soil Piping	Soil collapse column with steep sides
4-0075	Sinkhole	Soil depression, no soil piping visible
4-0076	Sinkhole	Shallow soil depression
4-0077	Sinkhole	Broad linear soil depression or swale
4-0078	Sinkhole	Compound sinkpoints in curvilinear soil depression
4-0079	Sinkhole	Soil depression
4-0080	Sinkhole	Broad flat bottomed soil depression with saplings and leaf litter at the bottom

Observed Feature ID	Feature Type	Description
4-0081	Sinkhole	Catastrophic and active soil pipe 10 ft by 20 ft, 15 ft deep. Hazardous to people, mammals, or equipment. Will either collapse deeper or shallow out and get broader
4-0082	Sinkhole	Small soil depression with piping, note tires and sticks in the sinkhole
4-0083	Sinkhole	Steep sided depression in soil with piping, a sinkpoint for a broad shallow soil depression, drains the field to north and northeast
4-0084	Sinkpoint	Small soil depression in a larger sinkhole
4-0085	Sinkhole	Sinkpoint in soil in area of slope trellis drainage
4-0086	Sinkhole	Linear soil depression axis ending at a sinkpoint
4-0087	Sinkpoint	Sinkpoint of broader soil depression
4-0088	Sinkpoint	Sinkpoint in broader axial soil depression
4-0089	Sinkhole	Shallow soil depression
4-0090	Sinkhole	Small soil depression
4-0091	Sinkhole	Broad shallow soil depression, possible sinkpoints
4-0092	Sinkpoint	In axial soil depression/channel
4-0093	Sinkhole	Potential sinkpoint in broad shallow depression axis
4-0094	Other	Stormwater ponding in depressional soil swale
4-0095	Spring	Seepage from soil
4-0096	Spring	Seepage into small pond at source of short sinking stream
4-0097	Sinking Stream	Low infiltration rate, 150 ft long gully with sinkpoints in soil
4-0098	Other	Broad shallow flat wetland with stormwater ponding/detention
4-0099	Other	Bare flat summit area exposing karst residuum of cherty gravel from Lost River Chert Bed
4-0100	Soil Piping	Individual soil pipe in field
4-0101	Soil Piping	Piping near field drain in place of agricultural ditch
4-0102	Other	Soil piping suspect related to underground piping
4-0103	Sinking Stream	Sinkpoint in soil at end of channel axis
4-0104	Sinkpoint	Broad flat shallow depression > 1 acre stormwater detention with multiple sinkpoints in soil
4-0105	Other	North edge of broad low depression for which -0104 is the primary sinkpoint
4-0106	Other	Channel heads at a col then to south of Colombo sinkhole pond
4-0107	Sinkhole	Small soil depression on wooded slope
4-0108	Sinkpoint	Broad shallow soil depression in drainage axis, drains large surrounding area including double pond north of gravel road and also slope from south
4-0109	Sinkpoint	Small soil depression
4-0110	Spring	Clear seepage from soil at head of very small channel
4-0111	Soil Piping	Multiple sinkpoints withs curvy channels draining field to the north, dye injection point traced to 4-0065
4-0112	Sinkhole	Sinkhole pond that drains south to woods, Infiltration down into limestone
4-0113	Sinkhole	Sinkhole pond with infiltration down into limestone

Observed Feature ID	Feature Type	Description
4-0114	Sinkhole	Low infiltration rate, sinkpoint in soil at low end of a small capture area
4-0115	Other	Concrete precast box culvert and riprap apron under field lane, access for gas well installation/maintenance
4-0116	Sinkhole	Depression in soil with small trees
4-0117	Sinkpoint	Small soil depression on edge of wooded area downslope from field
4-0118	Sinkpoint	Sinkpoint in soil in drainage axis
4-0119	Other	Culvert with soil piping below in draining gully, well vegetated, has rip rap energy choke
4-0120	Sinking Stream	Sinking stream axis water detention during low flow conditions
4-0121	Sinking Stream	Multiple sinkpoints along end reaches of sinking stream, dye traced to stream fed by spring 4-0129
4-0122	Sinkhole	Sinkhole on edge of bluff, approximately 100 feet west of Buck Creek, filled with woody debris
4-0123	Sinkhole	Sinkhole on edge of bluff, approximately 100 feet west of Buck Creek
4-0124	Sinking Stream	Dry sinking stream that emerges several hundred feet east of sinkpoint
4-0125	Soil Piping	Soil Piping and sinkpoint along swale that drains to UNT 10 to Buck Creek
4-0126	Other	Limestone bluff on west bank of Buck Creek
4-0127	Other	Culvert carrying UNT 11 to Buck Creek beneath Melview Road
4-0128	Sinkhole	Medium infiltration rate, located in yard behind home
4-0129	Spring	Dye detection point for dye injection 4-0121
4-0130	Sinkhole	Medium infiltration rate, sinkhole south of Watson Rd. in a lawn
4-0131	Sinkhole	Low infiltration rate, Watson Rd crosses the south side of the bowl-shaped sinkhole, no visible soil piping
4-0132	Sinkhole	Medium infiltration rate, large (400 ft diameter) bowl-shaped sinkhole, south of and adjacent to Watson Rd, no ponding observed.
4-0133	Sinkhole	Low infiltration rate, filled sinkhole pond, north of and adjacent to Watson Rd

Karst Feature Impact Comparison

Three alternatives are under consideration for final design. Potential impacts to the karst system from each alternative are compared by tallying field survey identified (4-ID#, Table 3) surface karst features within 20 feet of the construction limit. The number of field identified karst features, separated by type, within 20 feet of the construction limit for each alternative are tallied in Table 3 and listed in Table 4. Karst features and drainage are complex and do not always have a clear surface expression; therefore, each of the alternatives will have “unknown” karst features identified during construction. Although Table 3 is not an exhaustive count of karst features, it is a good approximation of the degree of karst impact that will be caused by each alternative. Table 4 lists the identification number of the karst features tallied in Table 3.

Table 3 – Field Identified Karst Feature Alternative Comparison

Karst Feature Type	Alternative 1	Alternative 2	Alternative 3
Sinkholes	17	16	12
Soil Piping	3	6	4
Sinking Stream	3	2	2
Sinkpoint	N/A	2	N/A
Spring	N/A	1	N/A
Other	4	1	5
Total	27	28	23

Table 4 - Field Identified Karst Feature Impact Comparison

Alternative 1		Alternative 2		Alternative 3	
ID	Category	ID	Category	ID	Category
4-0004	Sinkhole	4-0004	Sinkhole	4-0004	Sinkhole
4-0008	Sinkhole	4-0008	Sinkhole	4-0008	Sinkhole
4-0010	Sinkhole	4-0010	Sinkhole	4-0010	Sinkhole
4-0015	Sinkhole	4-0015	Sinkhole	4-0015	Sinkhole
4-0018	Sinkhole	4-0018	Sinkhole	4-0018	Sinkhole
4-0020	Sinkhole	4-0020	Sinkhole	4-0119	Other
4-0022	Sinkhole	4-0022	Sinkhole	4-0020	Sinkhole
4-0023	Soil Piping	4-0023	Soil Piping	4-0022	Sinkhole
4-0025	Soil Piping	4-0025	Soil Piping	4-0023	Soil Piping
4-0027	Soil Piping	4-0027	Soil Piping	4-0025	Soil Piping
4-0028	Sinkhole	4-0028	Sinkhole	4-0027	Soil Piping
4-0029	Other	4-0032	Soil Piping	4-0028	Sinkhole
4-0030	Other	4-0039	Soil Piping	4-0032	Soil Piping
4-0034	Sinkhole	4-0040	Soil Piping	4-0072	Sinkhole
4-0035	Sinkhole	4-0045	Spring	4-0099	Other
4-0047	Sinkhole	4-0060	Sinkhole	4-0102	Other
4-0049	Other	4-0079	Sinkhole	4-0115	Other
4-0081	Sinkhole	4-0091	Sinkhole	4-0120	Sinking Stream
4-0113	Sinkhole	4-0093	Sinkhole	4-0121	Sinking Stream
4-0119	Other	4-0116	Sinkhole	4-0127	Other
4-0120	Sinking Stream	4-0118	Sinkpoint	4-0131	Sinkhole
4-0121	Sinking Stream	4-0119	Other	4-0132	Sinkhole
4-0123	Sinkhole	4-0120	Sinking Stream	4-0133	Sinkhole

Alternative 1		Alternative 2		Alternative 3	
4-0124	Sinking Stream	4-0121	Sinking Stream		
4-0131	Sinkhole	4-0127	Other		
4-0132	Sinkhole	4-0131	Sinkhole		
4-0133	Sinkhole	4-0132	Sinkhole		
		4-0133	Sinkhole		

Report of Geophysical Investigation

Geophysical evaluation reports were completed for the project area on June 3, 2021 by Atlas (Attachment A14 and A15). Geophysical investigations included an electromagnetic conductivity investigation (EM) and electrical resistivity investigation (ER). The EM investigation of twelve locations took place from March 8 through 11, 2021. The EM investigation assisted in the determination of the placement of the electrical resistivity tomography (ERT) traverses. The ER investigation consisting of 16 ERT traverses took place on April 19 through 23, April 26 through 28, May 5 through 7, and May 10 to 11 of 2021. Geophysical investigation locations were selected to provide information about subsurface karst conditions within the three alternatives for the SR 11 Roadway Project.

Electromagnetic conductivity creates slices of resistivity/conductivity measurements at three depth ranges; 7.2 ft below ground surface (bgs), 13.8 ft bgs, and 22 ft bgs. These layers of resistivity measurements provide insight into the characteristics of the subsurface that impact electromagnetic properties. Soil type and depth, bedrock type and depth, and water content are three variables that can impact EM measurements and be interpreted from EM layers.

Sixteen ERT traverses were completed in the Karst Survey area. The ER investigation was designed to identify subsurface anomalies and potential voids. Resistivity profiles show a diverse geometry of resistivity values in the soil, loose bedrock floaters, solid bedrock, and open and closed karst voids in the limestone. The variation in resistivity is primarily related to soil type and depth, bedrock type and depth, and water content which is dependent on soil and bedrock characteristics and surface topography. The resistivity profiles indicate a complex bedrock surface. The sediment filled sinkholes and buried limestone voids identified in the resistivity profiles will require further evaluation for construction methods and potential karst features evaluation through additional geotechnical borings.

Geotechnical Borings Investigation

A geotechnical engineering investigation for the SR 11 Roadway Project was prepared by Atlas (Attachment A16) based on geotechnical borings along the alternatives. Geotechnical boring (borings/boreholes) locations were selected to further investigate subsurface features identified during the ER and EM surveys. Twenty-seven borings were completed. Boring logs frequently indicate the presence of small to medium sized voids (voids < 3 feet). These voids showed that they are occasionally sediment filled. The frequency of limestone voids noted in borings is pronounced on the bluff west of Buck Creek (TB-03, B-07, B-08, B-09). During boring advancement, drilling water drained out of boreholes, which demonstrates that the bedrock subsurface is permeated with karst drainage pathways. The depth to bedrock identified in the borings is variable (0 to >50 feet), often changing over short horizontal distances (e.g. B-01A, B-01 and TB-4, TB-4A, B-07). Water levels in three borings located within 800 feet of each other on the top of the west bluff of Buck Creek measured after allowing 9-10 days equilibrate, were between 8 and 53 feet bgs (TB-4, B-08, B-15A). The highly variable depth to water highlight the heterogeneity of subsurface drainage conditions in the Karst Survey area.

Dye Trace Investigation

The SR 11 Roadway Project Dye Trace Study (Attachment A13) by Hydrogeology Inc. selected six karst features from those listed in Table 1 (4-0121, 4-0001, 4-0013, 4-0111, 4-0028, and 4-0059) for fluorescent dye injection. Injection points were selected based on supposed high infiltration potential and spread out to provide a general picture of groundwater flow patterns across the Karst Survey area. Dye injected into 4-0121, 4-0111, 4-0028, and 4-0059 were traced to four limestone springs along Buck Creek (Attachment A10). Dye injected into 4-0001 and 4-0013 were traced to a small stream near its confluence with the Ohio River (Attachment A10, page a31). These dye traces show that there is at least one groundwater flow divide in the Karst Survey area located between karst features 4-0013 and 4-0029. The groundwater divide separates water flowing southwest to the Ohio from water flowing south-southwest or east to Buck Creek. The limestone bedrock interval through which the dye passes is St. Louis Limestone within the Blue River Group. This interval includes crystalline and micritic lithologies in bedded layers. The lower part is mostly micrite, a more brittle and fractured rock susceptible to forming many interconnected and diffuse karst flowpaths. This is evident in the map of Binkleys Cave to the north. The more complex flowpaths allow for interconnection of flowpaths during high flow conditions, a factor in evaluating potential impacts to groundwater and karst species. Approximate groundwater flow velocities were calculated using the distance from injection to detection point and the time between injection and dye detection (Attachment A13). Groundwater flow velocities were determined to be between 500 ft/day and 4,000 ft/day.

Proposed Activities and Direct Impacts

Construction of the proposed SR 11 Roadway Project between SR 135 and SR 337 on one of the three alternatives will have environmental karst impacts as well as karst related stability and storm flooding hazards. A No-Build option would also have karst impacts and stability/storm flooding impacts related to the maintenance of existing roadways in the future.

Based on the Karst Agreement and expected Agency coordination/consultation, there is a preference for construction in the Indiana Karst Area to perpetuate existing drainage and karst flow paths with avoidance of karst features to minimize impacts. Where construction occurs over or through a karst feature, alternate drainage is sometimes a preferrable method of minimizing karst impacts and protecting structural conditions below the roadway, where sinkhole treatments are implemented. The karst plateau geology and overlying loess plain cover will be a factor in excavation of the karst features for treatments. The width of existing Watson Road and proximity of residences and structures pose a limitation on excavation of karst features. Observation of surface karst features and bedrock exposures during the Karst Survey along with the resistivity studies and geotechnical borings indicate a concern for sinkhole treatments. Typically, for a sinkhole treatment to succeed, the excavation must be sufficiently deep to find a solid rock boundary 360 degrees around the interior otherwise the treatment may not be stable. Excavation requirements along Watson Road may require digging up to 45 feet or more below the surface with excavations requiring lateral "laybacks" for safety that would exceed the existing right-of-way geometry.

The karst voids along Watson Road, the steep cliffs along Buck Creek, and the broad karst plain east of Buck Creek are less likely to provide habitat for cave obligate species, but have hydrological continuity to springs along the channel of Buck Creek where cave crayfish, blind cave fish, and cave invertebrates may be present. Cave/spring openings (entrances) that were identified in the karst study area generally do not fit criteria for hibernacula for the Indiana Bat or the Northern-Long Eared bat.

Recommendations

The Karst Survey with documented karst features indicates that there is potential for direct impacts to the karst system within the Karst Survey area and along subsurface drainage pathways between the Karst Survey area, Buck Creek, and the Ohio River. This system includes previous records of the federally endangered Indiana bat (*Myotis sodalis)* and other karst related species.

Based on the identified karst features and system, drainage modification associated with the project should be minimized and drainage controls should be incorporated to address water quantity and quality discharged from the roadway to the swallet locations. This should include impermiable liners to limit infiltration in areas planned for stormwater detention or low gradient ditches that could experience ponding. The *Protection of Karst Featured during Project Development and Construction* (Ecology and Waterway Permitting Office; Environmental Service Division; July 15, 2021) document indicates that where possible, surface water draining to karst inlets should be perpetuated unless alternative drainage is approved with Agency coordination. The thick sediment cover of soils and loess should be evaluated to determine adequate stabilization methods around sinkhole treatments.

Soil covered or otherwise unknown karst features in bedrock may be found during construction with possible direct impacts to the underlying karst system. In the event a bedrock void, karst flowpath, bat, cave fish, or troglobitic species is encountered during construction, work within 100 feet of the feature should be stopped. The feature should be protected from sediment runoff. The project engineer and karst qualified geologist should be contacted immediately to determine if additional karst investigations are needed and to address the stipulations of the Karst Agreement.

Key Karst Terms

Definitions are taken from *Protection of Karst Features During Project Development and Construction* for those terms defined in that document.

Sinkhole – A basin or funnel-shaped hollow in limestone, ranging in diameter from a few feet to up to 300 feet and in depth from a few to several hundred feet.

Spring – Any natural discharge of water from a rock or soil onto the surface of the land or into a body of surface water.

Seep – An area, generally small, where water percolates slowly to the land surface through small openings of a porous material.

Sinking Stream (losing stream) – A surface-flowing stream that disappears underground. In this report sinking streams included ephemeral and intermittent streams that may not have been flowing at the time of karst inspection but show clear signs of sinking (sudden loss of channel and/or clear sinkpoints).

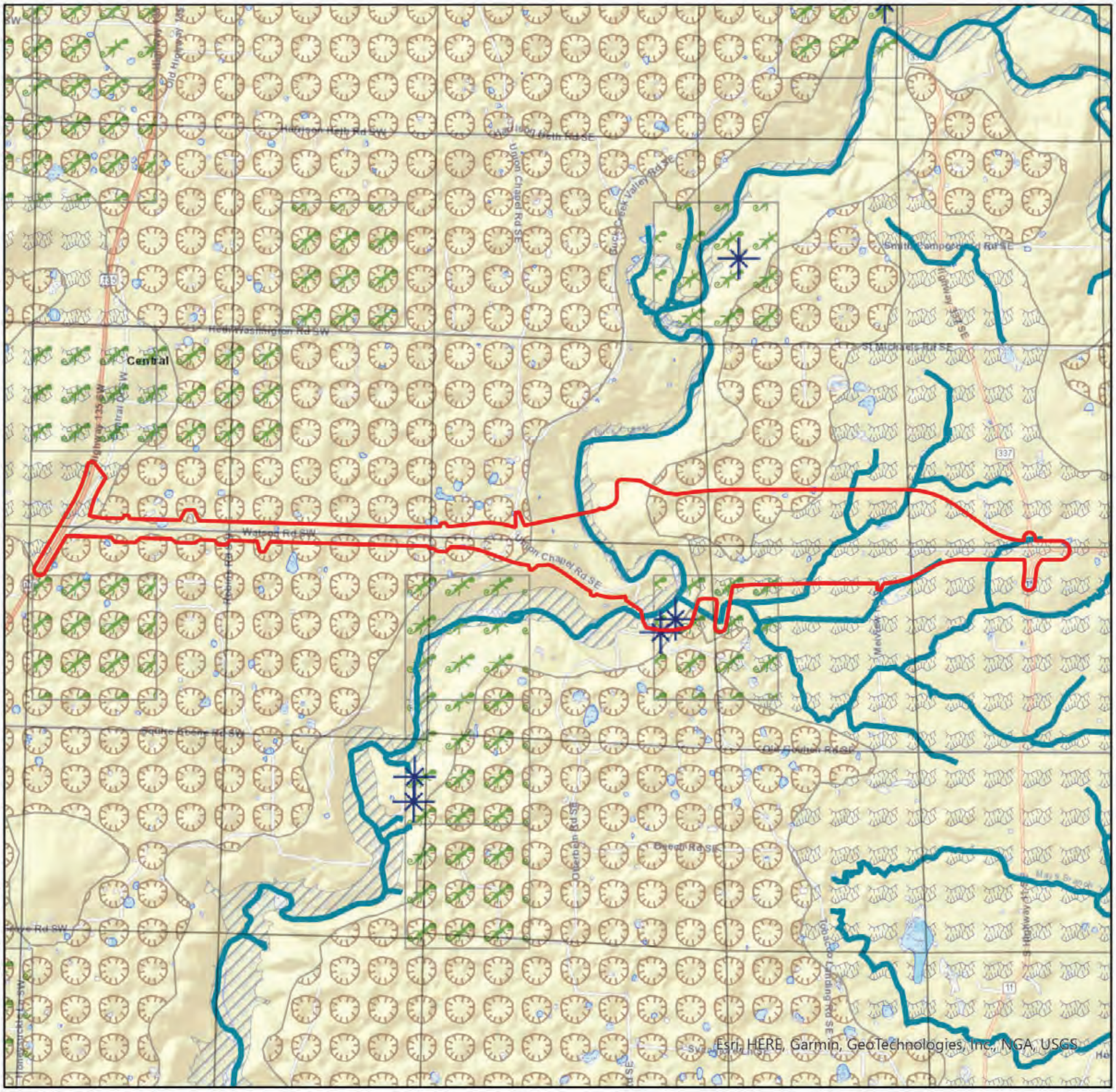
Sinkpoint – Location where water sinks into the ground, often at the end of a drainage feature that is not classified as a stream. In this report, sinkpoints typically drain portions of broad basins. Often sinkpoints are marked by the accumulation of logs/sticks and organic debris (that may obscure soil piping) over the point where water sinks into the ground.

Soil Piping – A location where water sinking into the subsurface through soil, erodes overlying cohesive clay soil creating a hollow pipe shaped void into the ground. Soil pipes can occur at the bottom of sinkholes, in large basins, or in flat topography.

Preparers

Lochmueller Group, Inc. Staff	Position	Contributing Effort
Garre Conner	Licensed Professional Geologist	Field Data Collection Report Preparation
Jeremy Kieffner	Environmental Department Manager	Report Preparation
Peter Putzier	Environmental Specialist	Field Data Collection Mapping and Report Preparation

Attachments

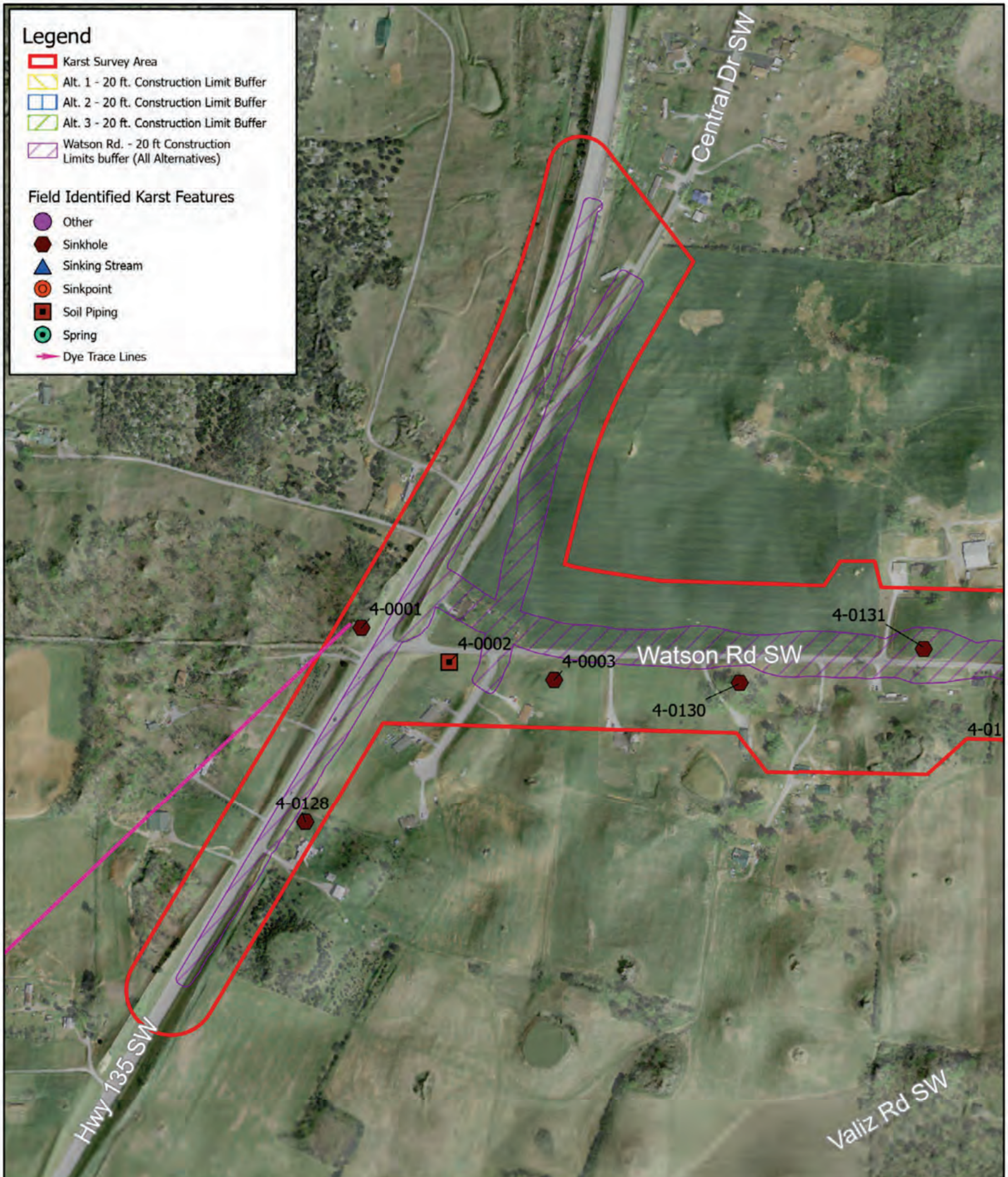


Sources:
Non Orthophotography
Data - Obtained from the State of Indiana Geographical Information Office Library
Orthophotography - Obtained from Indiana Map Framework Data (www.indianamap.org)
Map Projection: UTM Zone 16 N **Map Datum:** NAD83

This map is intended to serve as an aid in graphic representation only. This information is not warranted for accuracy or other purposes.

Legend			
Karst Survey Area		Cave Entrance Density	
Karst Spring		Sinkhole Area	
Wetlands		Sinking-Stream Basin	
River		Floodplain - DFIRM	
Lake			

LOCHMUELLER GROUP 6200 Vogel Road Evansville, Indiana 47715 PHONE: 812.479.6200 TOLL FREE: 800.423.7411	**A3 - Karst & Water Resources Map** **Des. No. 2001154** **Karst Report**	Township: Harrison County: Boone & Heth State: Indiana
	0 0.5 1 Miles N	SR-11 Extension New Roadway Construction SR-135 to SR 11, SR 337, Melview Rd. Jct. Created: 7/26/2022, P.Putzier



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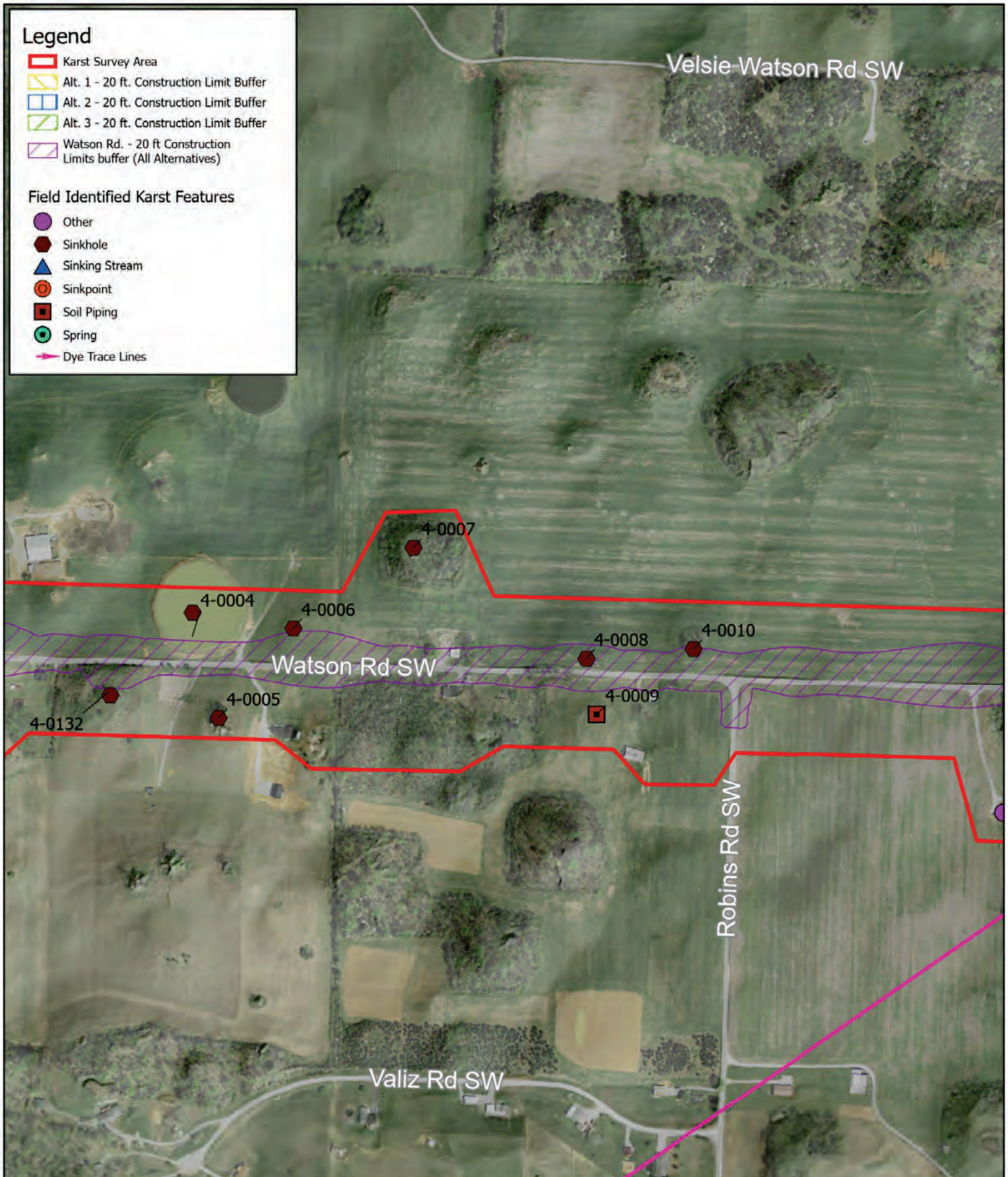
A10 - Karst Features & Dye Trace - 1

Des. No. 2001154
Karst Report

Township: Boone & Heth
County: Harrison
State: Indiana

0 350 700 Feet N

SR-11 Extension New Roadway Construction
SR 135 to SR 11, SR 337, Melview Rd. Jct.
Created:7/26/2022, P. Putzier



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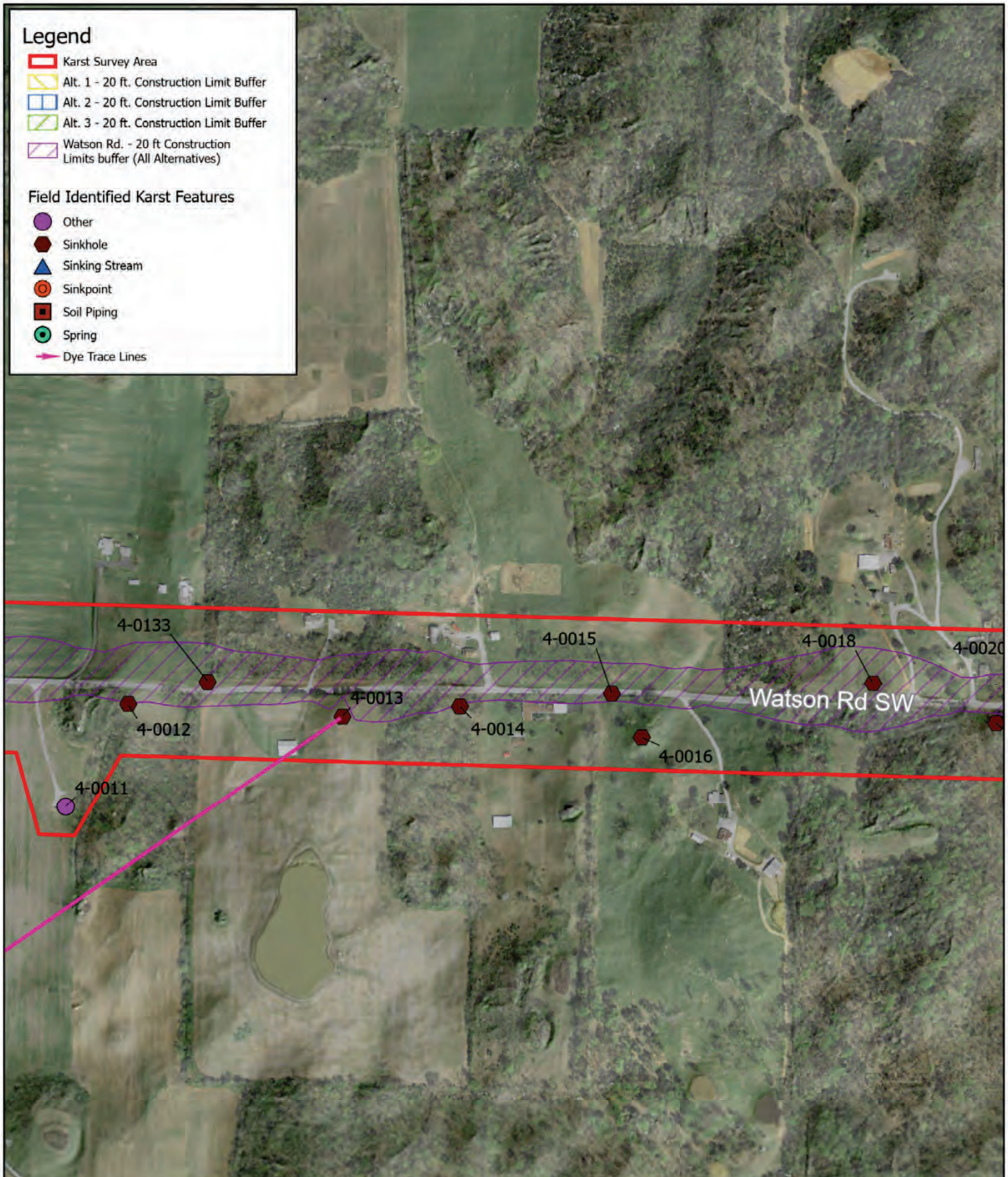
A10 - Karst Features & Dye Trace - 2
Des. No. 2001154
Karst Report

Township: Boone & Heth
County: Harrison
State: Indiana

0 350 700 Feet
N

SR-11 Extension New Roadway Construction
SR 135 to SR 11, SR 337, Melview Rd. Jct.
Created:7/26/2022, P. Putzier



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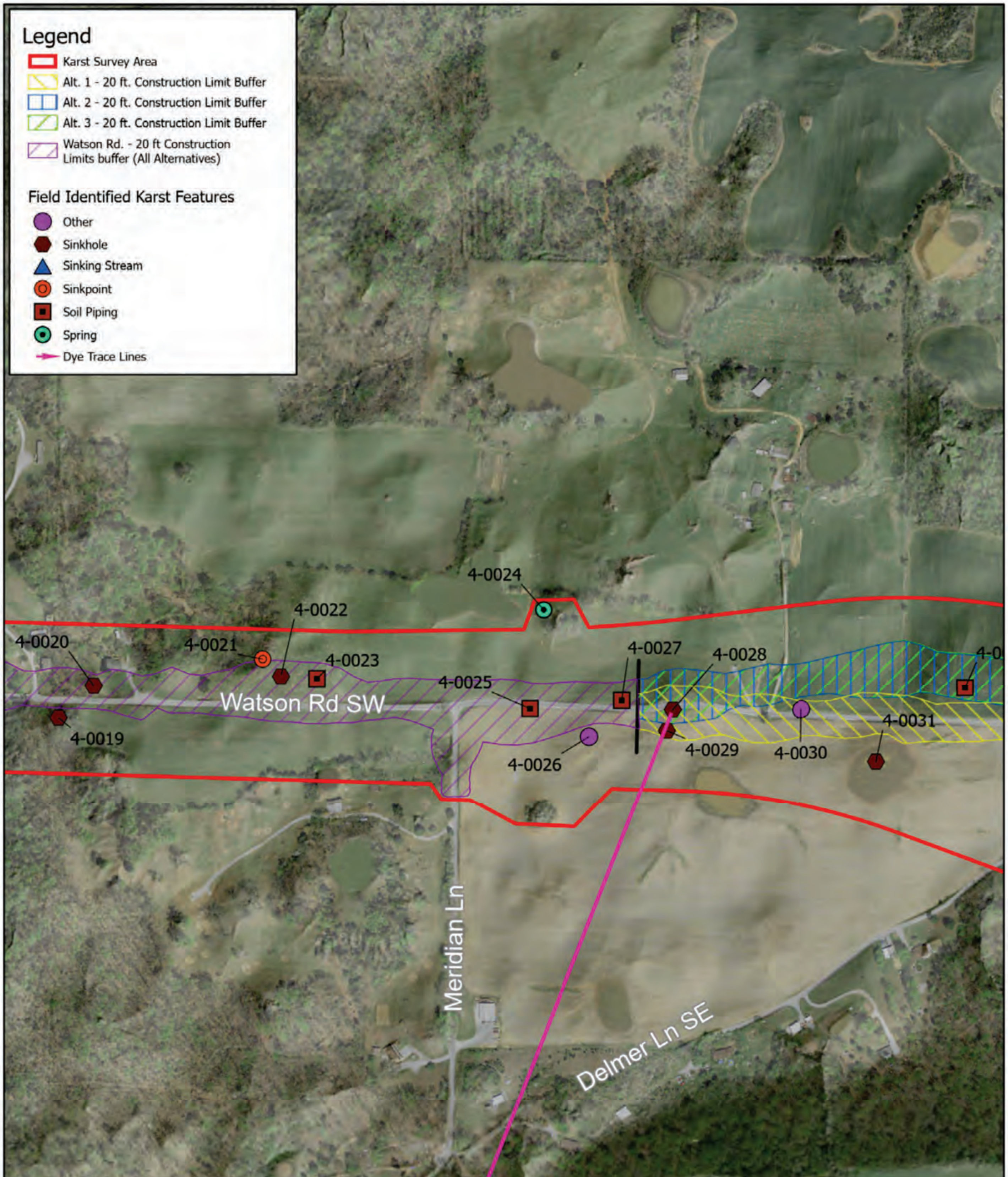
A10 - Karst Features & Dye Trace - 3

Des. No. 2001154
Karst Report

Township: Boone & Heth
County: Harrison
State: Indiana

0 350 700 Feet

SR-11 Extension New Roadway Construction
SR 135 to SR 11, SR 337, Melview Rd. Jct.
Created:7/26/2022, P. Putzier



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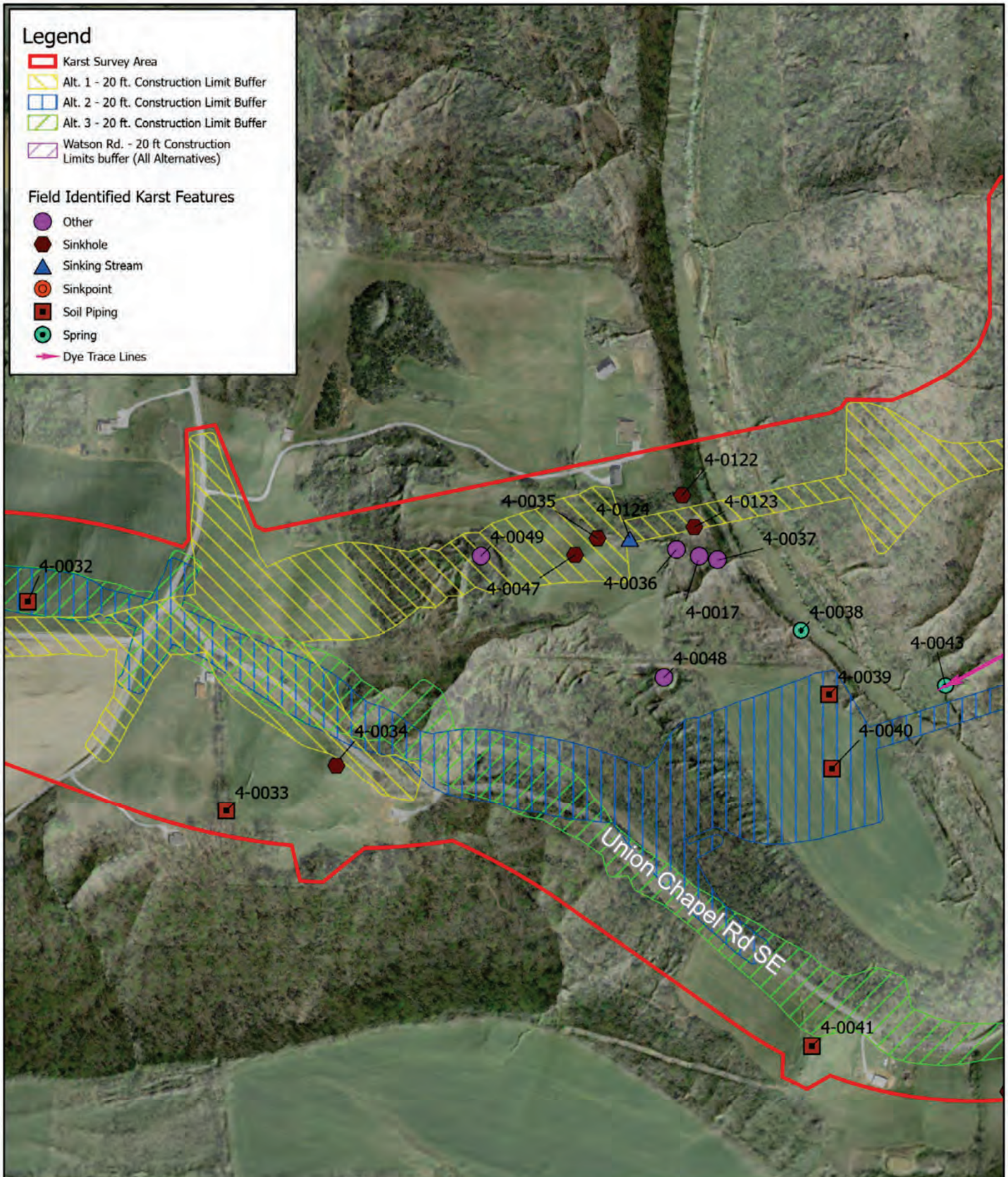
A10 - Karst Features & Dye Trace - 4

Des. No. 2001154
Karst Report

Township: Boone & Heth
County: Harrison
State: Indiana

0 350 700 Feet
N

SR-11 Extension New Roadway Construction
SR 135 to SR 11, SR 337, Melview Rd. Jct.
Created:7/26/2022, P. Putzier



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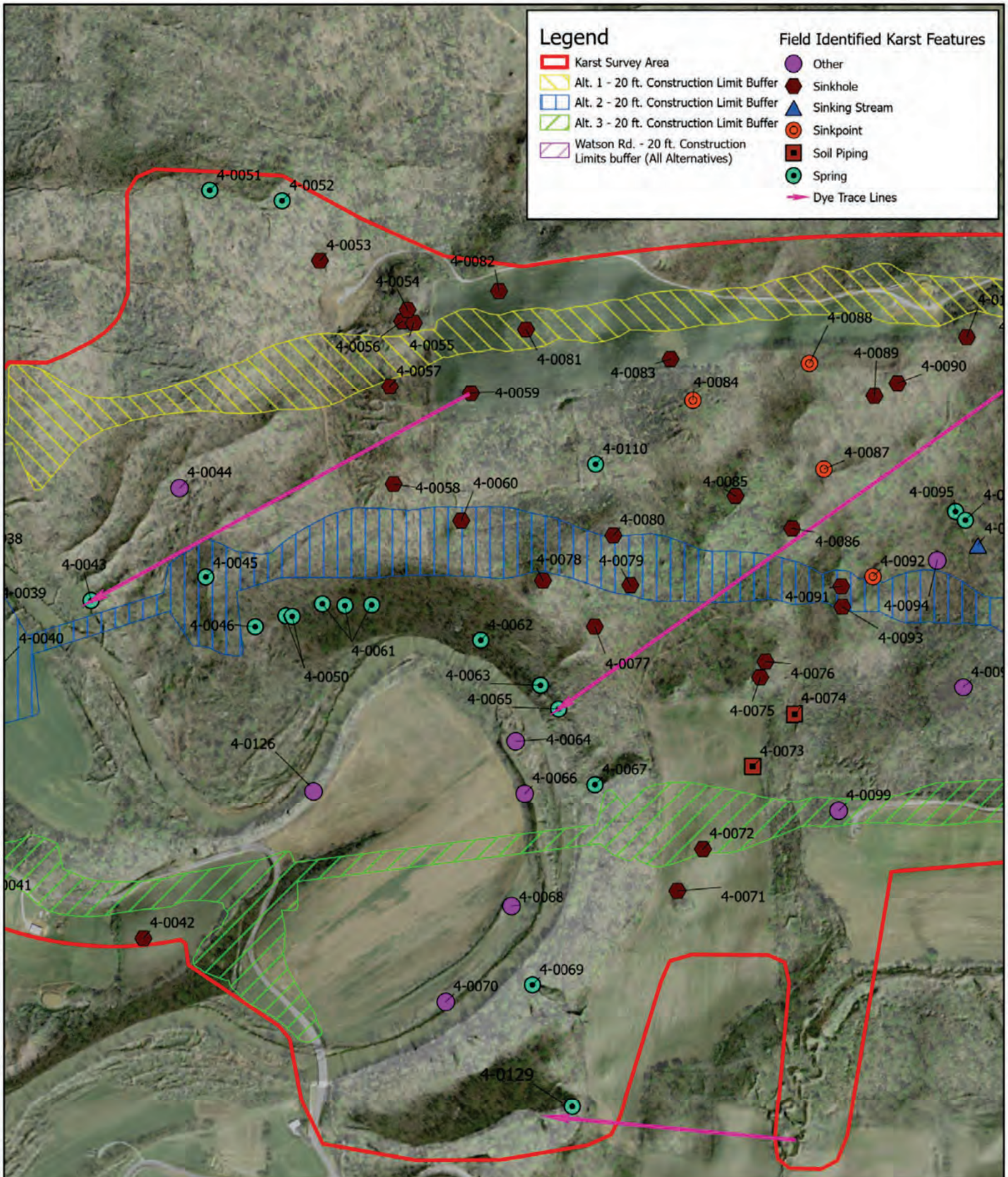
A10 - Karst Features & Dye Trace - 5
Des. No. 2001154
Karst Report

Township: Boone & Heth
County: Harrison
State: Indiana

SR-11 Extension New Roadway Construction
SR 135 to SR 11, SR 337, Melview Rd. Jct.
Created:7/26/2022, P. Putzier



LOCHMUELLER GROUP 6200 Vogel Road Evansville, Indiana 47715 PHONE: 812.479.6200 TOLL FREE: 800.423.7411	**A10 - Karst Features & Dye Trace - 6** **Des. No. 2001154** **Karst Report**	Township: Boone & Heth County: Harrison State: Indiana
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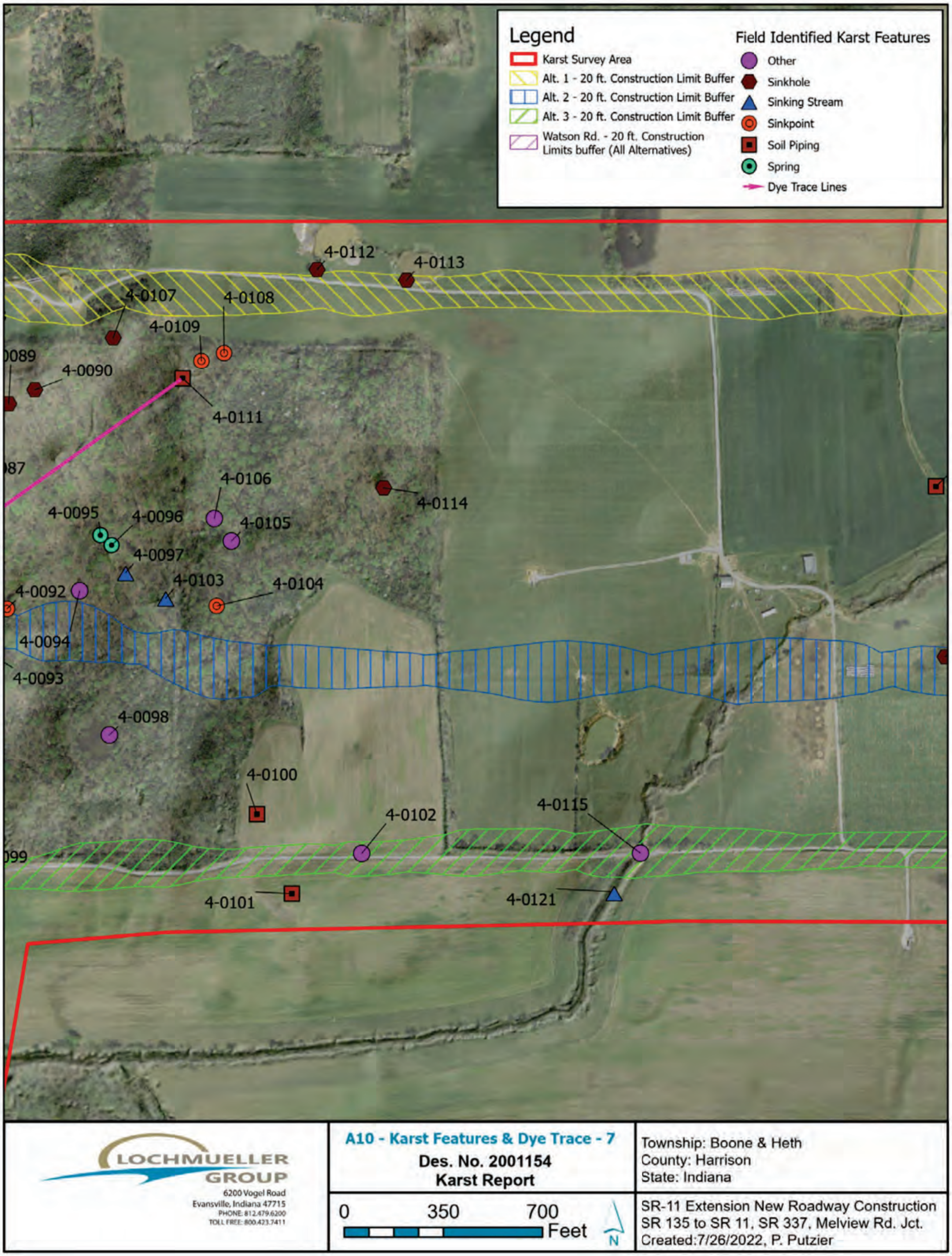
Legend
Karst Survey Area
Alt. 1 - 20 ft. Construction Limit Buffer
Alt. 2 - 20 ft. Construction Limit Buffer
Alt. 3 - 20 ft. Construction Limit Buffer
Watson Rd. - 20 ft. Construction Limits buffer (All Alternatives)
Field Identified Karst Features
Other
Sinkhole
Sinking Stream
Sinkpoint
Soil Piping
Spring
Dye Trace Lines
4-0112
4-0113
4-0107
4-0108
4-0109
4-0090
4-0111
4-0106
4-0114
4-0095
4-0096
4-0105
4-0097
4-0092
4-0103
4-0104
4-0094
4-0093
4-0098
4-0100
4-0102
4-0115
4-0101
4-0121
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A10 - Karst Features & Dye Trace - 7
Des. No. 2001154
Karst Report
Township: Boone & Heth
County: Harrison
State: Indiana
0
350
700
Feet
N
SR-11 Extension New Roadway Construction
SR 135 to SR 11, SR 337, Melview Rd. Jct.
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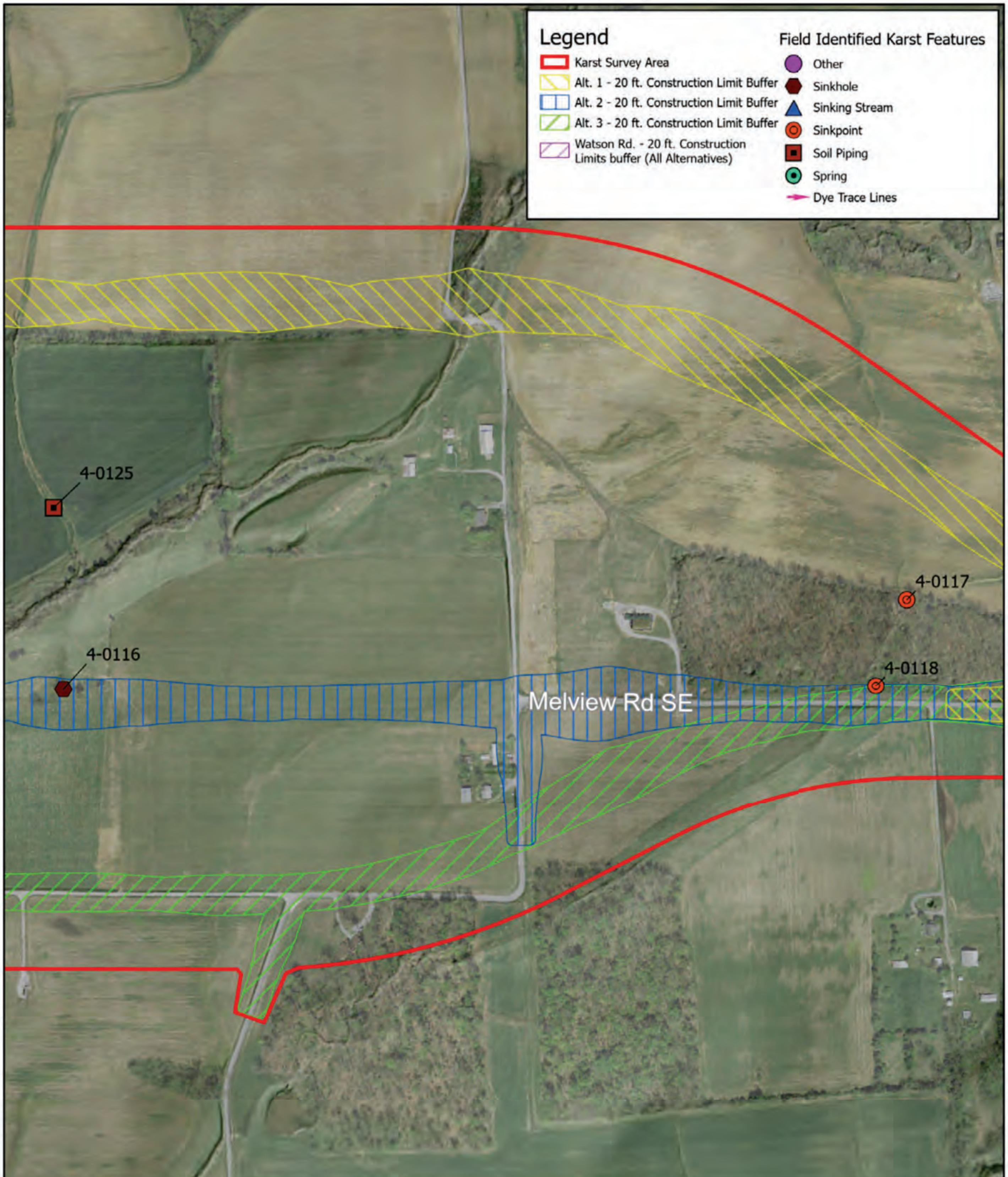

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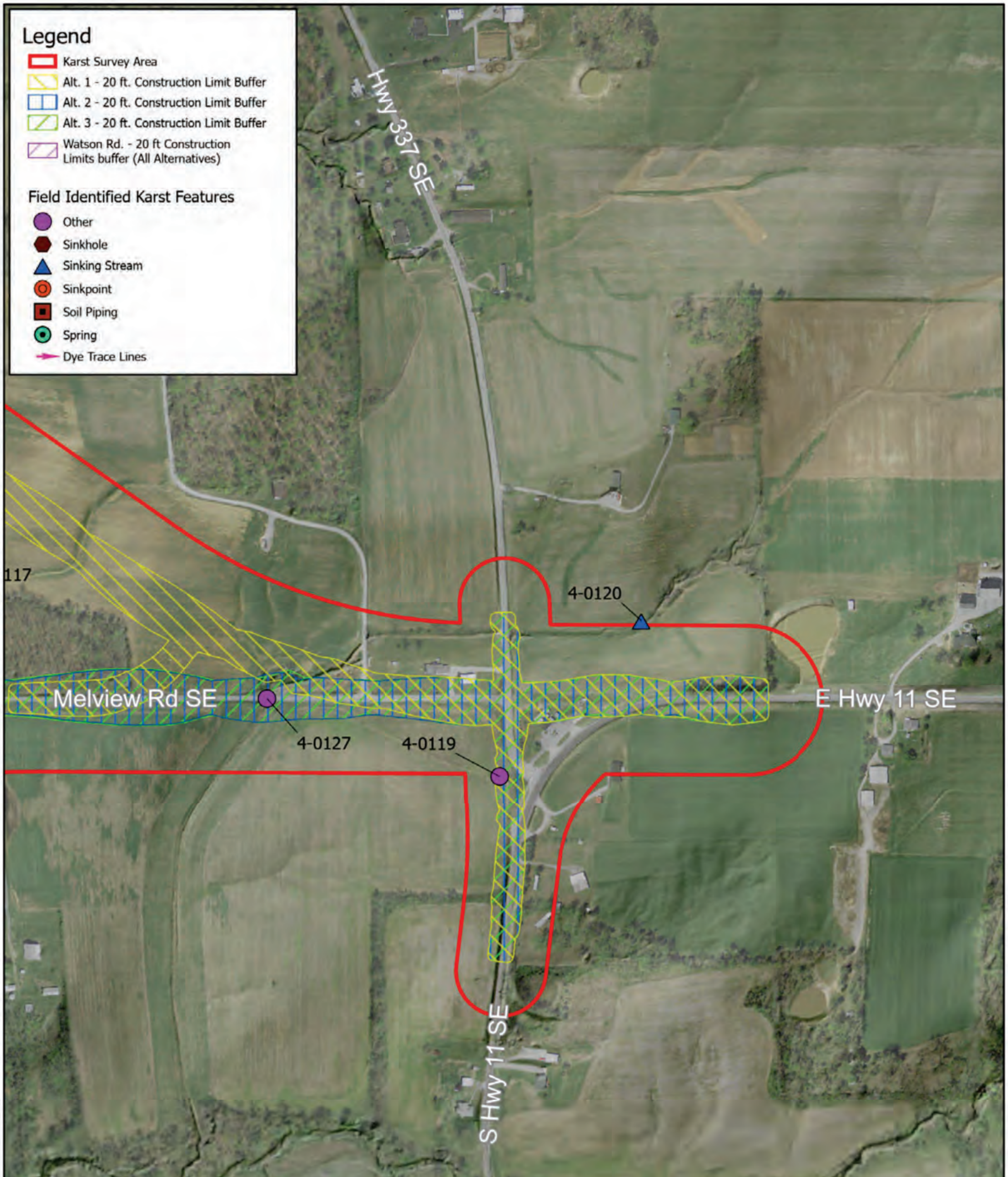
A10 - Karst Features & Dye Trace - 8
Des. No. 2001154
Karst Report

Township: Boone & Heth
County: Harrison
State: Indiana

0 350 700 Feet
N

SR-11 Extension New Roadway Construction
SR 135 to SR 11, SR 337, Melview Rd. Jct.
Created:7/26/2022, P. Putzier



LOCHMUELLER GROUP
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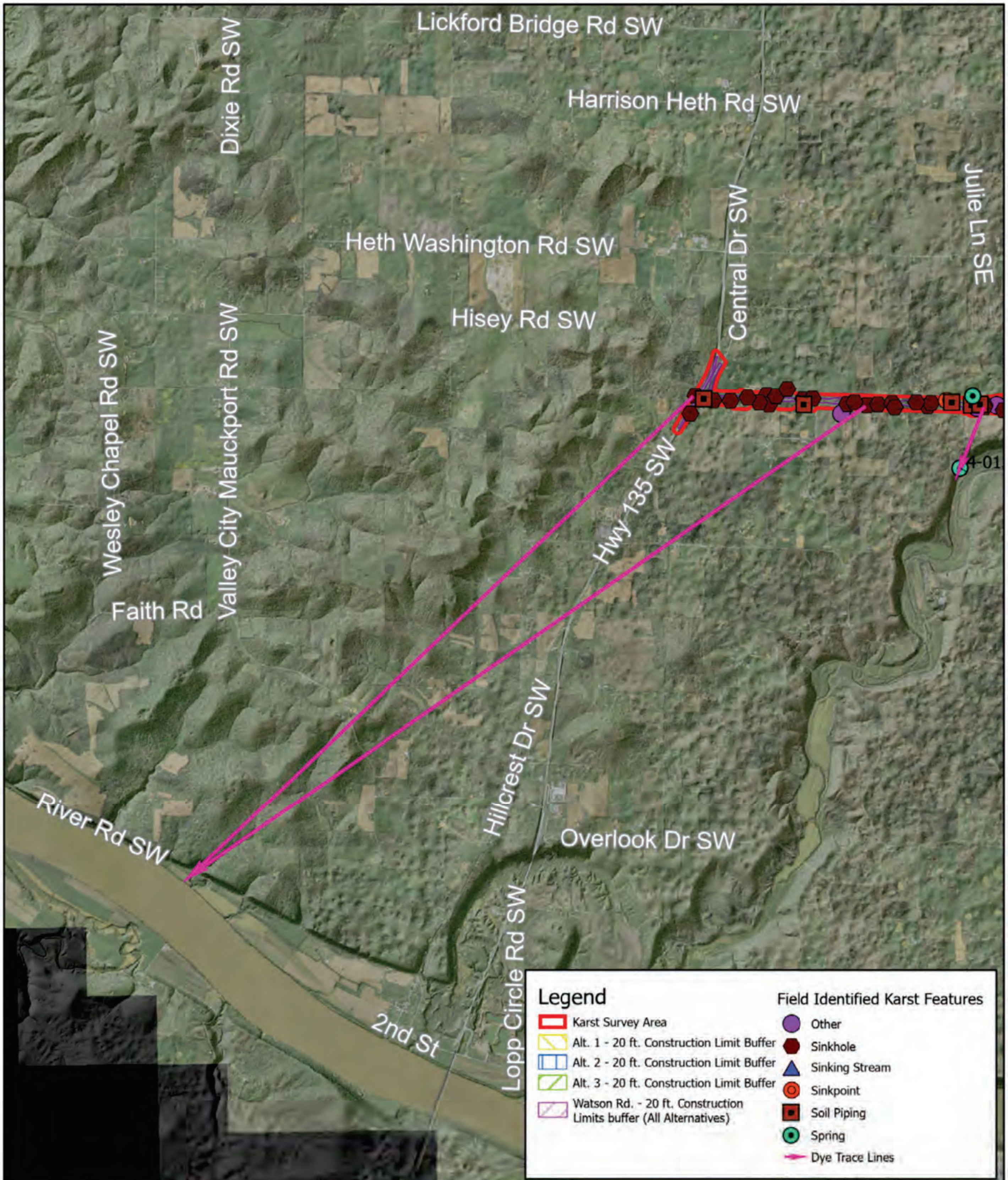
A10 - Karst Features & Dye Trace - 9
Des. No. 2001154
Karst Report

Township: Boone & Heth
County: Harrison
State: Indiana

0 350 700 Feet
N

SR-11 Extension New Roadway Construction
SR 135 to SR 11, SR 337, Melview Rd. Jct.
Created:7/26/2022, P. Putzier



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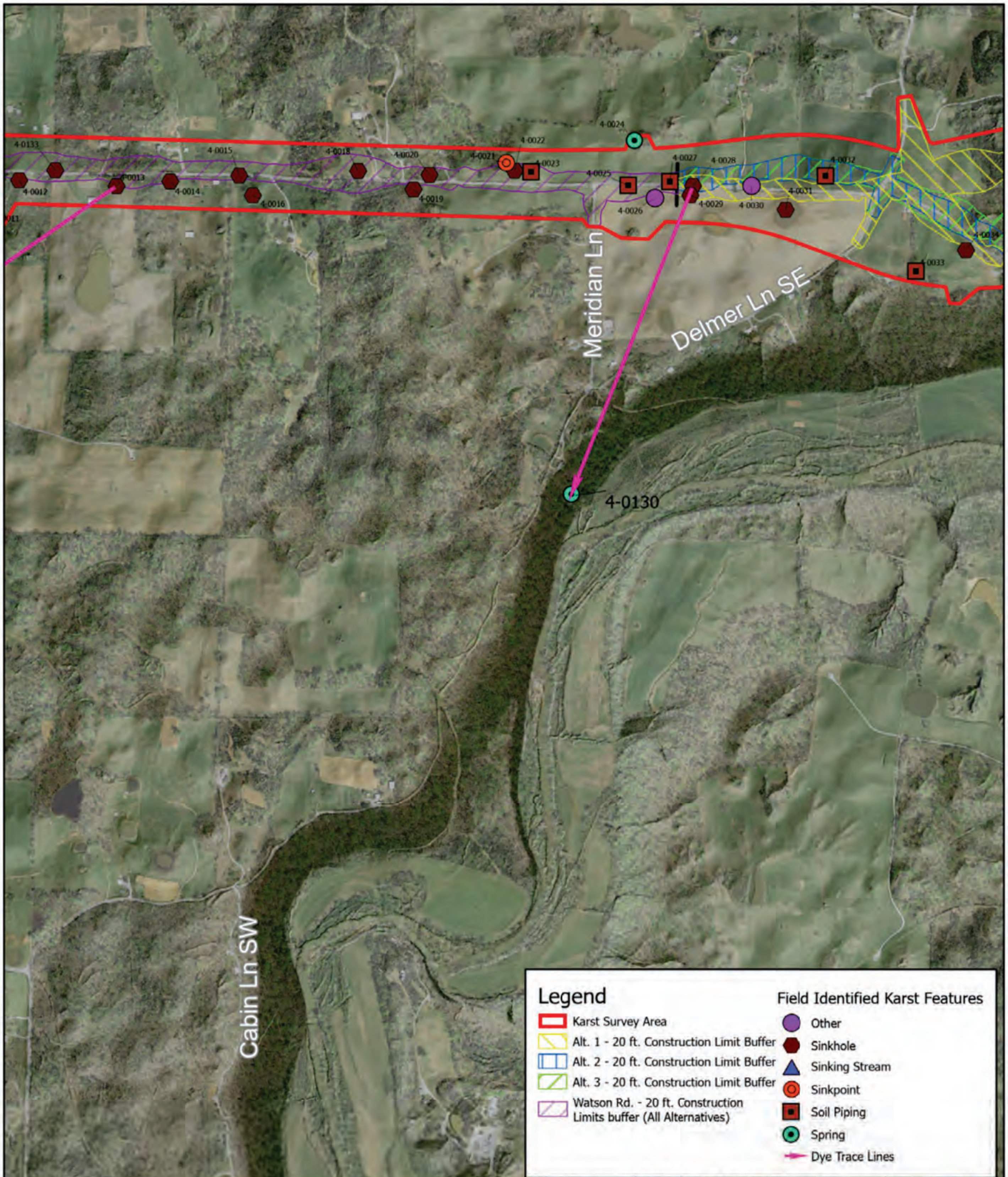
A10 - Karst Features & Dye Trace -10
Des. No. 2001154
Karst Report

0 3,000 6,000 Feet
N

Township: Boone & Heth
County: Harrison
State: Indiana

SR-11 Extension New Roadway Construction
SR 135 to SR 11, SR 337, Melview Rd. Jct.
Created:7/26/2022, P. Putzier



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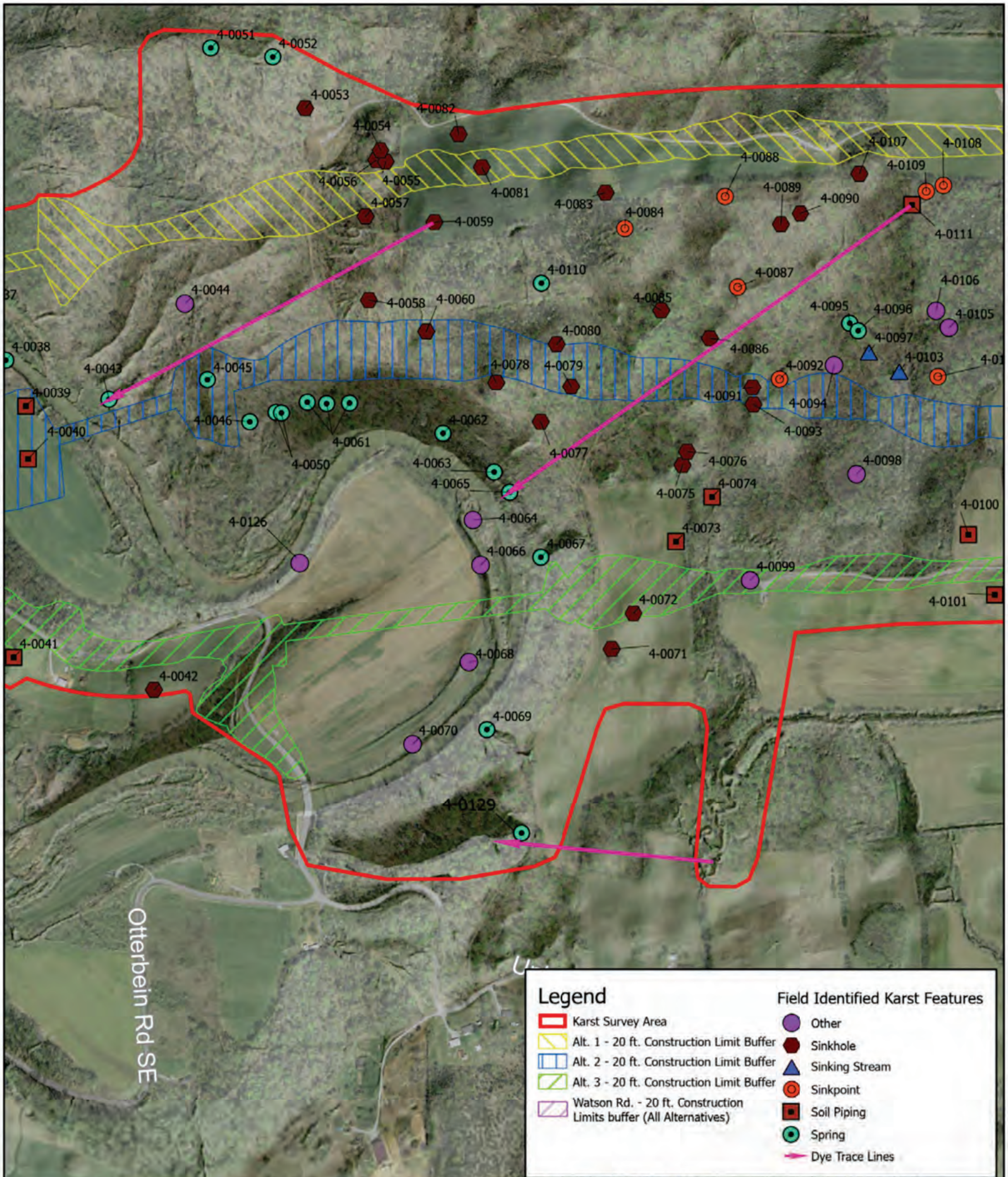
A10 - Karst Features & Dye Trace -11

Des. No. 2001154

Karst Report

Township: Boone & Heth
County: Harrison
State: Indiana

SR-11 Extension New Roadway Construction
SR 135 to SR 11, SR 337, Melview Rd. Jct.
Created:7/26/2022, P. Putzier



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A10 - Karst Features & Dye Trace -12

Des. No. 2001154

Karst Report

Township: Boone & Heth
County: Harrison
State: Indiana

SR-11 Extension New Roadway Construction
SR 135 to SR 11, SR 337, Melview Rd. Jct.
Created:7/26/2022, P. Putzier

SR 11 Roadway Project
Water Quality Monitoring Plan
Des. No. 2001154
April, 2023

Introduction

The SR 11 Roadway Project (The Project) (Des. No. 2001154) involves upgrading county roads, construction of a new terrain roadway, and construction of a bridge crossing Buck Creek in Harrison County Indiana. The Project is located within karst terrain and therefore will follow the stipulations outlined in Indiana Department of Transportation (INDOT), Ecology and Waterway Permitting Office (EWPO), Environmental Services Division's document titled *Protection of Karst Features during Project Development and Construction* (Karst Guidance)[1]. A full karst investigation for The Project took place from February 24, 2021 to May 30, 2021 and a Karst Report detailing the investigation was approved on September 9, 2022. The Karst Report was provided to the Karst Consulting Agencies (U.S. Fish and Wildlife Service (USFWS), Indiana Department of Environmental Management Groundwater Section (IDEM Groundwater Section), Department of Natural resources Division of Fish and Wildlife (DNR DFW) and Indiana Geological and Water Survey (IGWS) and the Environmental Protection Agency (EPA)) as part of karst agency coordination.

In their response to coordination, the IDEM Groundwater Section – Drinking Water Branch stated:

> *Sampling of springs and seeps in the area is needed to show road construction is not affecting water quality. Sampling of springs needs to include samples collected under base flow conditions (less than 0.75 inches of rain has fallen over the previous 24 hours) and storm flow conditions (more than 0.75 inches of rain has fallen over the previous 24 hours).*

This Water Quality Monitoring Plan fulfills section II.D.8 (Page 13) of the Karst Guidance which states:

> *A water quality sampling plan should only be developed when requested by the agencies during coordination. The purpose of the plan is to document the project water quality sampling program.*

Water Quality Sampling Locations

Appendix A contains a table of water quality sampling locations. Appendix B contains maps showing the locations of the water quality sampling points. Water quality sampling will be conducted at 10 selected locations in Harrison County including 8 springs and 2 stream crossings. The selected locations are based on three criteria:

1) Proximity to the Project Area

2) Dye Connectivity (DC) to preferred alignment established through dye tracing;

3) Inferred Connectivity (IC) to the preferred alignment based on nearby dye traces, topography, and hydrogeology of the area.

There are several locations where roadway runoff currently discharges directly to a karst feature. Baseline (pre-construction), during construction, and post-construction water quality sampling are proposed to determine if current and future roadway discharge has an impact on water quality, as well determine the nature of any impacts.

Water Quality Sampling Analytical

The SR 11 Water Quality Monitoring Plan draws on experience from other road construction projects through karst terrain in Indiana. Appendix C includes two lists of parameters; one list for baseline analysis, and one list for analysis of samples collected during construction and post construction. Observation of what analytes were and were not detected in previous road construction water quality monitoring programs has resulted in a refined list of recommended analysis for detecting changes in water quality resulting from road construction. The recommended analysis for baseline sampling is broader (includes more analytes) to capture background water quality conditions and rule out potential causal connection to the new construction. Analytical results of the baseline sampling may result in new recommendations for during-construction and post-construction water quality sampling. Any recommendations for altering the sampling plan would be coordinated with the Karst Consulting Agencies. If samplings results suggest that the roadway is impacting water quality, additional parameters and sampling events can be included to quantify the impact.

Water Quality Sampling Schedule

INDOT, or its representative, will conduct water quality sampling in three (3) phases at each of the 10 sampling locations identified in Appendix A. In total, 4-5 years of semi-annual sampling (depending on the duration of construction) consisting of a total of 8-10 sampling events will occur as described below:

a. Phase 1: Baseline Sampling: Baseline sampling will consist of one year of semi-annual sampling (total of two samples) one or two years prior to the beginning of construction. One base flow (less than 0.75 inches of rain has fallen over the previous 24 hours) and one storm flow (more than 0.75 inches of rain has fallen over the previous 24 hours) sample will be collected at each sampling location. The results of the baseline sampling will be provided to the IDNR, IDEM, USFWS and IGWS after both baseline sampling events are complete in an annual report.
b. Phase 2: Sampling During Construction: The selected locations will be sampled during construction. Samples will be collected semi-annually for the duration of construction and include one base flow and one storm flow sample per year of construction. Construction is anticipated to last one to two years. The results of the sampling will be provided to the IDNR, IDEM, USFWS and IGWS after each sampling event.
c. Phase 3: Sampling Post Construction: Water quality sampling of the selected springs will consist of two years of sampling (total of four sampling events) following completion of construction. Samples will be collected semi-annually the first year after construction is complete and the third year after construction is completed. One base flow and one storm flow sample will be collected each year. The results of the sampling will be provided to the INDR, IDEM, USFWS and IGWS in annual reports.

Water Quality Sampling Methodology
Surface water samples will be collected using direct fill methods. Ideal conditions will allow the sample to be collected directly from the water source utilizing laboratory certified, clean, unpreserved sample media (e.g., a 1- liter amber glass container), and a disposable, laboratory grade dip-cup or re-usable stainless steel dip-cup for filling preserved sample containers. Where flow conditions are not ideal, alternative sample methods may need to be used. If alternative methods are necessary, the sample quality and collection methodologies will remain consistent with the industry standard. Surface water sample collection will be completed in accordance with the IDEM field procedure manual. Upon collection of surface water samples, they will be transported/shipped utilizing appropriate chain-of-custody documentation and procedures.

In addition to those parameters listed in Appendix C for laboratory analysis, field parameters including temperature, acidity (pH), oxidation/reduction potential (ORP), turbidity (NTU), dissolved oxygen (DO), and conductivity will also be collected using a multi-parameter meter (e.g., Horiba U-50 or similar) at the sampling location. The flow rate will be estimated based on visual observations.

Water Quality Documentation
Prior to construction, a single baseline water quality report will be provided to the Karst Consulting Agencies including water quality data collected in two sampling events prior to the beginning of construction activities. During construction, short reports containing the water quality analytical data will be provided to the Karst Consulting Agencies after each sampling event. After construction, annual water quality reports will be provided to the Karst Consulting Agencies summarizing field activities and including all water quality data collected that year.

Karst Feature Treatment Inspection
Karst feature treatments within the right-of-way in the project area including but not limited to aggregate caps, concrete/impervious caps, spring capture boxes, lined ditches, and lined basins will be inspected during post construction water quality monitoring events for proper functioning.

Water Quality Remediation
The water quality sampling results will be compared to Indiana's Water Quality Standards for aquatic life and drinking water. These standards are from Indiana Administrative Code (327 IAC 2-1-6, Table 6-1). If the water quality sampling results exceed the standards, INDOT will assess whether this is likely due to construction or other outside factors. Baseline sampling results and other activities within the potential spring recharge area will be included in the assessment. If deemed necessary, in consultation the Karst Consulting Agencies and based on baseline sampling results, water quality sampling will be conducted at the inputs of karst features to identify the contaminant source. If the water quality monitoring results suggest that the standards are exceeded because of The Project, remediation measures will be developed in coordination with the Karst Consulting Agencies.

Appendices

Appendix A – Water Quality Sampling Locations Table

Appendix B – Maps (General Location Map and Water Quality Sampling Location Map)

Appendix C – Water Quality Sampling Parameters (Pre-Construction, During & Post Construction)

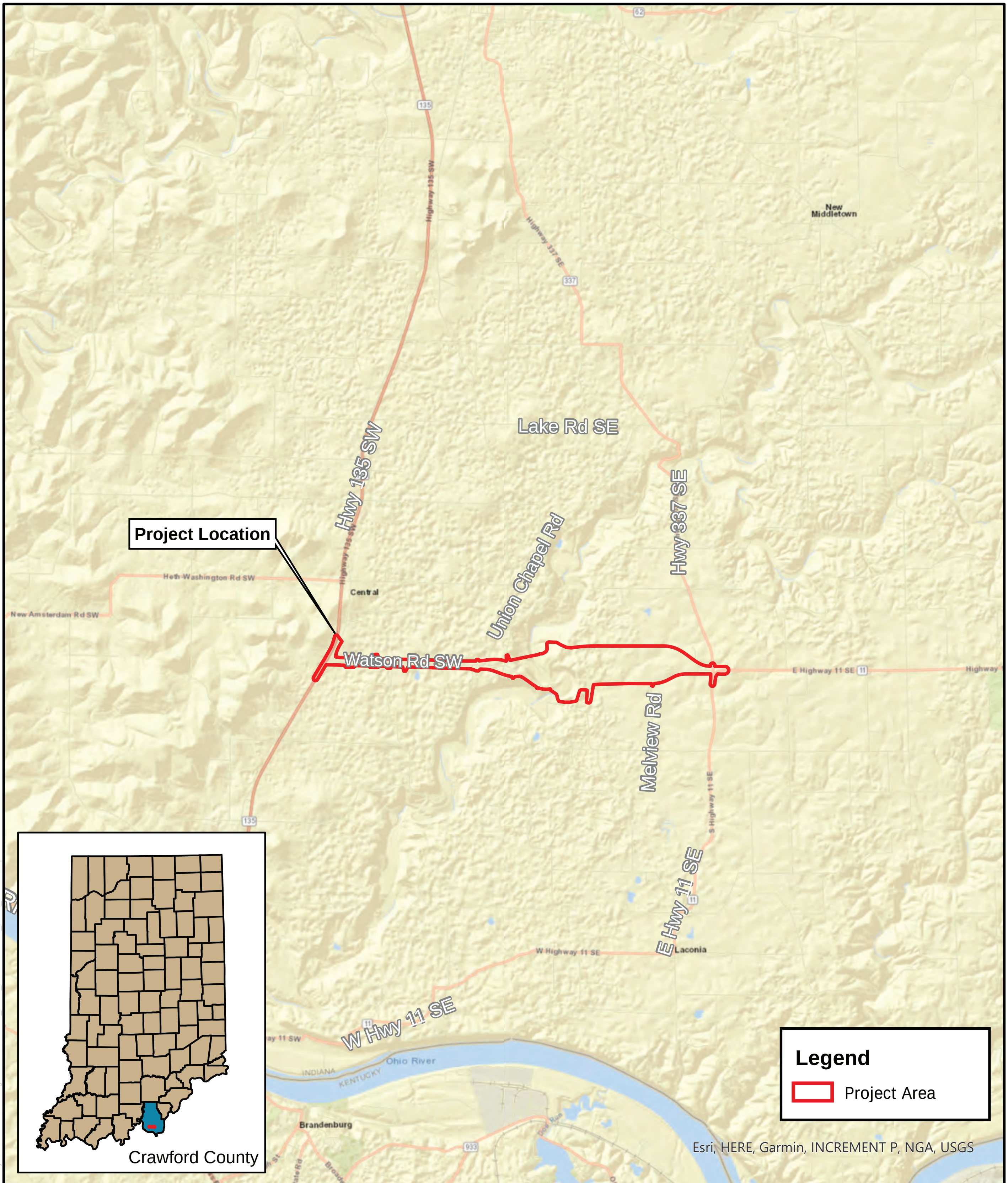
References

1. Indiana Department of Transportation Ecology and Waterway Permitting Environmental Services Division, "Protection of Karst Features during Project Development and Construction" July 15, 2021

Appendix A
Water Quality Sampling Locations

Feature ID / Dye Trace Report ID	Location	Reason For Sampling	Latitude / Longitude	Notes
4-0129 / SP-6	Head of the spring fed valley east of Buck Creek and north of Union Chapel Road. 992 feet northwest of the intersection between Otterbein Road SE and Union Chapel Road SE	DC	38.077955/ -86.107884	Stream / Spring
4-0133 / SP-1	1.7 miles west of Mauckport, IN on River Road Southwest, South of the Road	DC	38.037724/ -86.226442	Spring
4-0130	795 feet south of the intersection of Meridian Lane and Delmer Lane SE	DC	38.07807/ -86.13168	Spring
4-0067	Left bank of Buck Creek	IC	38.081496/ -86.107518	Spring
4-0065	Left bank of Buck Creek	IC	38.082332/ -86.108011	Spring
4-0134 / SP-32	530 feet east of the intersection of N Ridge Road SW and Cabin Lane SW	IC	38.070297/ -86.138498	Spring
4-0135 / SP-28	525 feet south of Pleasant Grove Road SW, 0.4 mile west of intersection with Squire Boone Road SW	IC	38.060634/ -86.153134	Spring
4-0136 / SC-18	Union Chapel Road SE crossing of Buck Creek	IC	38.078404/ -86.111347	Stream Crossing
4-0137 / Squire Boone Caverns	Creek emerging from Squire Boone Caves, 1,850 feet west of theSquire Boon Road bridge over Buck Creek and 80 feet south of the road	AI	38.063891/ -86.133899	Spring
4-0138 / SC-34	Squire Boone Road SW crossing of Buck Creek	IC	38.062953/ -86.136144	Stream Crossing

AI = Area of Importance
DC = Dye Connectivity
IC = Inferred Connectivity



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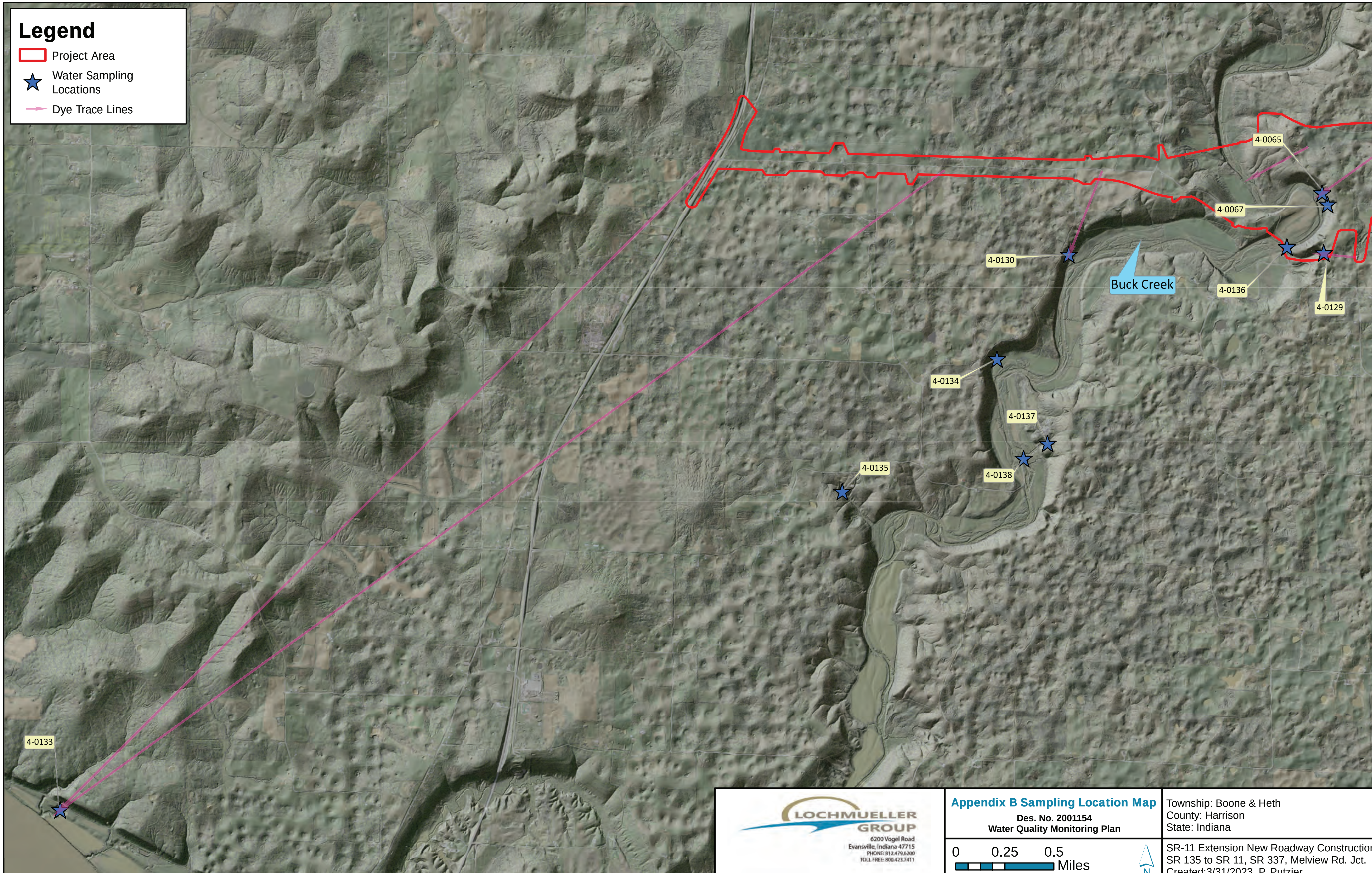
TOLL FREE: 800.423.7411

Appendix B - Project Location Map
Des. No. 2001154
Water Quality Monitoring Plan

Township: Boone & Heth
Counties: Harrison
State: Indiana

0 1 2 Miles
N

SR-11 Extension New Roadway Construction
SR-135 to SR-11, SR337, Melview Rd. Jct.
Created:3/31/2023, P. Putzier


Legend
Project Area
Water Sampling Locations
Dye Trace Lines
4-0065
4-0067
4-0130
Buck Creek
4-0136
4-0129
4-0134
4-0137
4-0135
4-0138
4-0133
LOCHMUELLER GROUP
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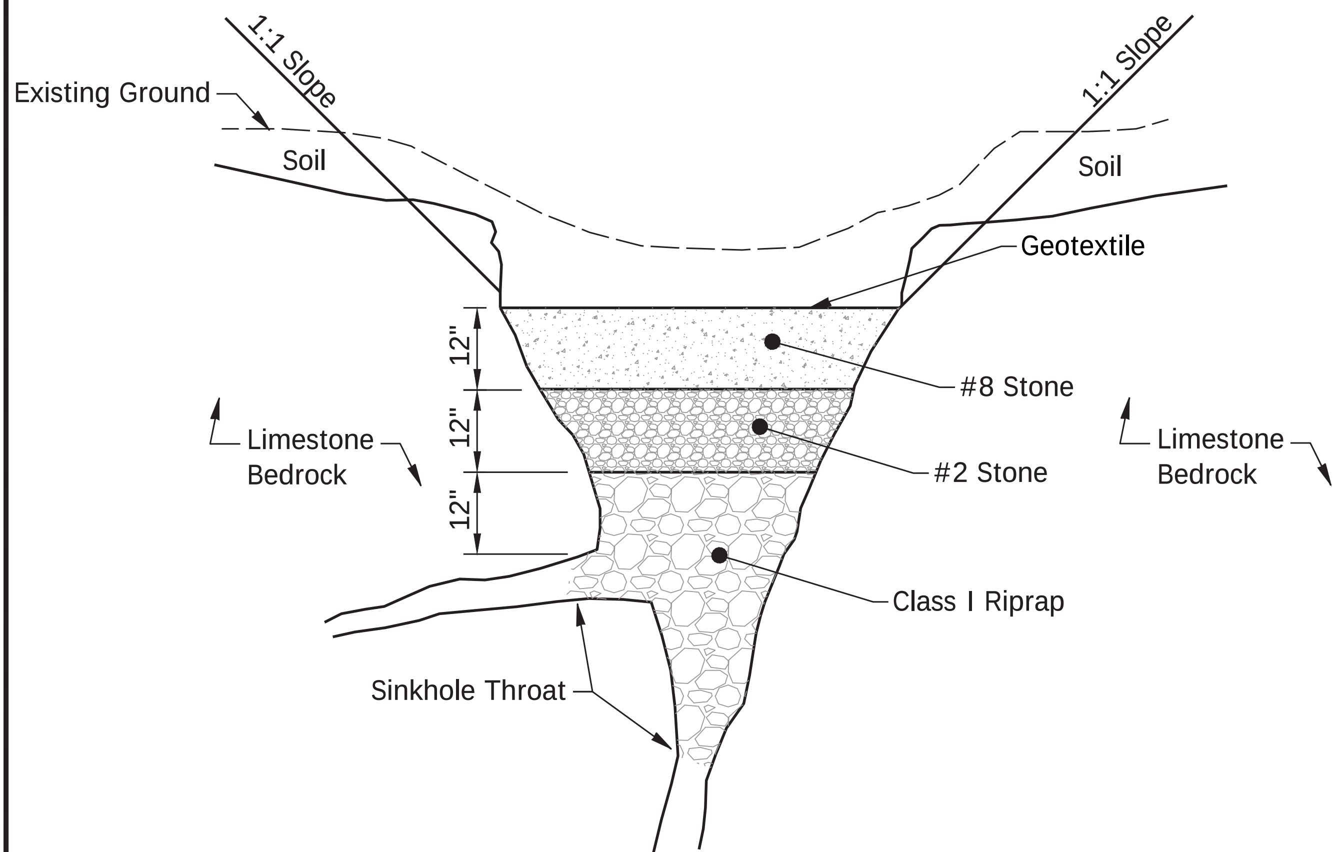
Evansville, Indiana 47715
PHONE: 812.479.6200
TOLL FREE: 800.423.7411
Appendix B Sampling Location Map
Des. No. 2001154
Water Quality Monitoring Plan
0 0.25 0.5
Miles
N
Township: Boone & Heth
County: Harrison
State: Indiana
SR-11 Extension New Roadway Construction
SR 135 to SR 11, SR 337, Melview Rd. Jct.
Created:3/31/2023, P. Putzier

Appendix C
Water Quality Sampling Parameters

Water Quality Sampling Parameters - Pre-Construction	
Laboratory Method - Name	**Analytes**
EPA 300.0	Bromide, Chloride, Fluoride, and Sulfate
200.7	Metals Analysis: Calcium, Iron, Magnesium, Total Hardness
200.8	Metals Analysis (ICP/MS): Aluminum, Antimony, Arsenic, Barium, Berylium, Boron, Cadmium, Chromium, Cobalt, Copper, Lead, Manganese, Molybdenum, Nickel, Selenium, Silver, Thallium, Vanadium, Zinc
SM 9223B	Total Coliform & e.Coli
2540D	Total Suspended Solids
2540C	Total Dissolved Solids
EPA Method 1664A	Oil & Greese
EPA 525.3	SVOCs
EPA 524.2	VOCs
EPA 350.1	Nitrogen Amomonia
EPA 508.1	Pesticides / PCBS
EPA 515.3	Chloridinated Herbicides (Synthetic Organic Compounds)
EPA 547	Glyphosate

Water Quality Sampling Parameters - During and Post Construction	
Laboratory Method - Name	**Analytes**
EPA 300.0	Bromide, Chloride, Fluoride, and Sulfate
200.7 - Metals Analysis	Calcium, Iron, Magnesium, Total Hardness
200.8 - Metals Analysis (ICP/MS)	Aluminum, Antimony, Arsenic, Barium, Berylium, Boron, Cadmium, Chromium, Cobalt, Copper, Lead, Manganese, Molybdenum, Nickel, Selenium, Silver, Thallium, Vanadium, Zinc
SM 9223B - Total Coliform & e.Coli	E.coli
2540D Solids	Total Suspended Solids
2540C solids	Total Dissolved Solids
EPA Method 1664A	Oil & Greese

Field Parameters - Pre, During, Post Construction
Temperature
Acidity (pH)
oxygen reduction potential (ORP)
Turbidity (NTU)
Dissolved Oxygen (DO)
Conductivity
Estimated flow rate



TYPICAL AGGREGATE CAP SINKHOLE TREATMENT

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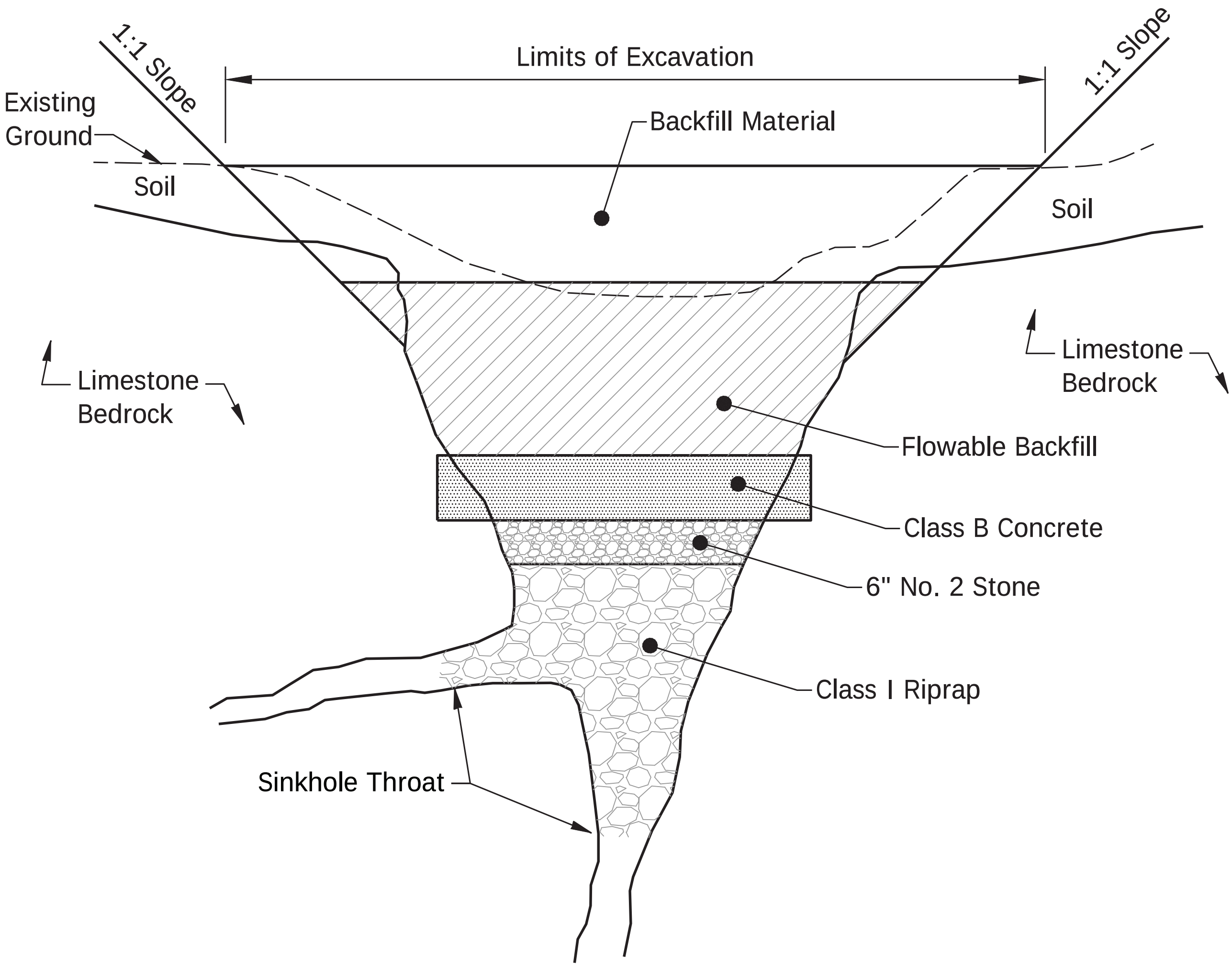
LOCHMUELLER GROUP 6200 Vogel Road Evansville, Indiana 47715 Phone: 812.479.6200 Toll Free: 800.423.7411	DRAWN BY: R.A.P. CHECKED BY: P.P. LOCATION Harrison County, Indiana	DATE: 03/24/23 SCALE: Not To Scale	SR 11 ROADWAY PROJECT	DES. NO. 2001154 SHEET NO. 1 OF 3



TYPICAL SINKHOLE TREATMENT CONCRETE CAP

LOCHMUELLER GROUP 6200 Vogel Road Evansville, Indiana 47715 Phone: 812.479.6200 Toll Free: 800.423.7411	DRAWN BY: R.A.P. CHECKED BY: P.P.	DATE: 03/24/23 SCALE: Not To Scale	SR 11 ROADWAY PROJECT	DES. NO. 2001154
	LOCHMUELLER GROUP PROJECT NO. Harrison County, Indiana			SHEET NO. 2 OF 3

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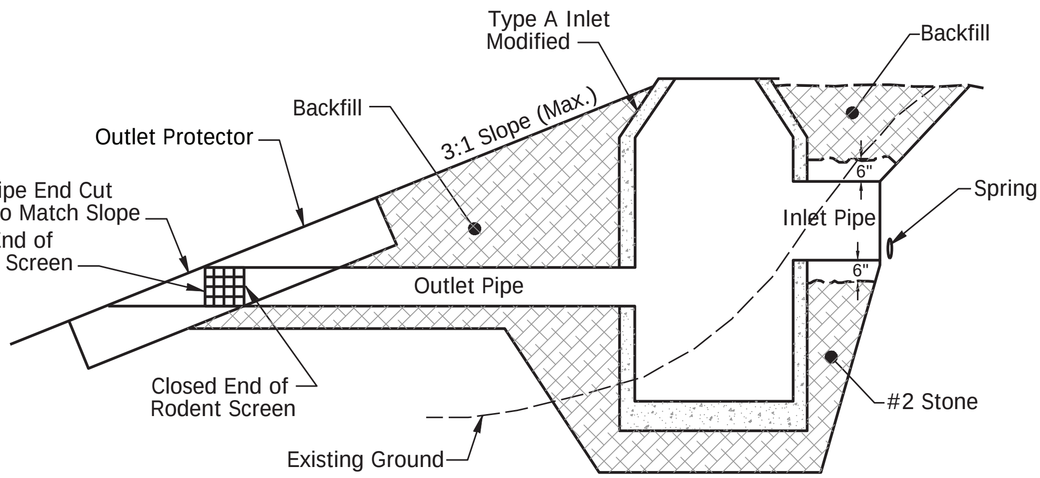


TYPICAL SPRING BOX IN FILL SECTION DETAIL

Date: Mar 24, 2023, 8:40am User Name: rap
File: S:\Projects\110-0114\Design\Segment6\Road\CAD\Misc DWG\SEG6\DT_Sink Hole Cap.dwg

LOCHMUELLER GROUP 6200 Vogel Road Evansville, Indiana 47715 Phone: 812.479.6200 Toll Free: 800.423.7411	DRAWN BY: R.A.P. CHECKED BY: P.P.	DATE: 03/24/23 SCALE: Not To Scale	SR 11 ROADWAY PROJECT	DES. NO. 2001154 SHEET NO. 3 OF 3
	LOCHMUELLER GROUP PROJECT NO. Harrison County, Indiana			

Environmental Assessment

Appendix L

Noise Analysis

Nick Batta

From:	Passmore, Andrew D <APassmore@indot.IN.gov>
Sent:	Thursday, May 11, 2023 3:42 PM
To:	Jeremy Kieffner; Nick Batta
Cc:	Dominick Romano; Bales, Ronald; Foheybreting, Nicole K; Passmore, Andrew D; Rhoads, Matthew
Subject:	Des 2001154 SR 11 Noise Analysis Approval

Jeremy and Nick,

A traffic noise analysis report was completed by CMT in April 2023 to evaluate potential traffic noise impacts for the proposed SR 11 Roadway project in Harrison County, Indiana. Traffic noise was evaluated at all receptors within 500 feet of edge of pavement within the study area. Traffic noise levels were evaluated for the existing (2026) and projected (2046) traffic volumes for the build alternative.

This report evaluated potential noise impacts for the proposed improvements in compliance with the Federal Highway Administration's (FHWA) Procedures for Abatement of Highway Traffic Noise and Construction Noise as presented in the Code of Federal Regulations, Title 23 Part 772 (23 CFR 772) and the Indiana Department of Transportation (INDOT) *Traffic Noise Analysis Procedure* (2022).

Predicted design year (2046) noise levels would not approach or exceed the Noise Abatement Criteria (NAC) at any receptors resulting in no need to evaluate noise abatement.

Based on the studies thus far accomplished, the State of Indiana has not identified any impacted receptors. As a result, noise abatement was not evaluated. A re-evaluation of the noise analysis will occur during final design. If during final design it has been determined that conditions have changed such that noise impacts are identified, noise abatement will be evaluated at that time to determine if it is feasible and reasonable.

This email will serve as INDOT's approval of the traffic noise analysis report for the proposed SR 11 Roadway project (Des. No. 2001154).

Drew Passmore
NEPA Review Team Lead
Environmental Services Division
Indiana Department of Transportation
100 N Senate Ave N758-ES
Indianapolis, IN 46204
Phone: (317) 439-7500
Email: apassmore@indot.in.gov

NOISE ANALYSIS REPORT

SR 11 ROADWAY PROJECT

DES. NO. 2001154
HARRISON COUNTY, INDIANA

PREPARED FOR:

INDIANA DEPARTMENT OF TRANSPORTATION

PREPARED BY:

CRAWFORD, MURPHY & TILLY, INC. (CMT)

TABLE OF CONTENTS

APPENDICES

Select Figures have been removed to avoid duplication and reduce file size.

Appendices B & C have been removed to reduce file size.

PROJECT INFORMATION

The State Road (SR) 11 Roadway Project is located between the SR 135 and Watson Road junction in the west and the SR 11 and Melview Road/Old Highway (Hwy) 337 junction in the east, 4.7 miles north of the existing junction between SR 135 and SR 11 and approximately ten miles south of Corydon, Indiana along SR 135. Specifically, the project is located in Sections 11, 12, 13, and 14, Township 5 South, Range 3 East in Heth Township and Sections 7 and 18, Township 5 South, Range 4 East in Boone Township as depicted on the Mauckport, Indiana USGS 7.5-minute topographic quadrangle, as well as Sections 7, 8, 9, 16, 17, and 18, Township 5 South, Range 4 East in Boone Township as depicted on the Laconia, Indiana USGS 7.5-minute topographic quadrangle. A project location map and the USGS topographic map are located in Appendix A.

Within the study area, Watson Road is functionally classified as a rural major collector and Melview Road is functionally classified as a local road. The typical cross section of Watson and Melview Roads consists of two 9- to 10-foot travel lanes (one lane in each direction) with no shoulder or median. The portion of the study area that will have the new road constructed currently consists of agricultural fields, forests, and streams, with scattered residences throughout the area. Please see Appendix A for maps and photographs of the proposed study area.

The preferred alternative will involve upgrading existing county roads and building a road on new alignment to create a new east-west SR 11 connection across Buck Creek. The project proposes the construction of a new bridge across Buck Creek and installation of additional culverts spanning smaller streams. The exact size of these new structures is not yet known. The project is a Type I project under 23 CFR 772.5 because it involves the construction of a highway on new location.

The need for the SR 11 Roadway project is to provide a safe east-west route connecting SR 11 to SR 135 in southern Harrison County. The existing roadway network does not meet current design standards and has several locations with high crash rates. The existing roadways are narrow with little to no shoulders and have substandard horizontal and vertical curves. In addition, the Old Hwy 11 roadway alignment east of SR 135 is located in the Ohio River floodplain and floods when the Ohio River reaches high flood levels, resulting in safety concerns and access limitations. The purpose of the SR 11 Roadway project is to provide a safe roadway that meets current INDOT design standards to increase the safety for the citizens traveling in southern Harrison County.

TRAFFIC NOISE ANALYSIS BACKGROUND INFORMATION AND REGULATIONS

Noise is generally defined as unwanted sound. Its loudness is measured in terms of sound pressure levels expressed in decibels (dB) and is composed of a wide range of frequencies. The decibel scale is logarithmic and expresses the ratio of the sound pressure unit being measured to a standard reference level. Most sounds occurring in the environment do not consist of a single frequency, but rather a broad band of differing frequencies. Frequencies are measured in hertz (Hz), which is the number of cycles per second. The human ear is typically capable of hearing frequencies from approximately 20 to 20,000 Hz and is less sensitive to higher and lower frequencies than mid-range frequencies. To compensate for low-end and high-end frequency insensitivity and to render noise levels readings more relevant to human experience, an "A-weighting" scale is used to approximate the response of the human ear. The A-weighted decibel (dB(A)) unit emphasizes measurement of perceptible sound energy and factors out the frequencies not perceptible to humans.

The dB(A) unit may indicate the level of environmental noise at an instant in time, but community noise levels vary continuously. Most environmental noise includes a composite of noise from different sources, creating a relatively steady background noise in which no particular source is identifiable. To describe the time-varying character of traffic noise, the equivalent hourly sound level Leq(h), is commonly used. Leq(h) is defined as the equivalent steady-state sound level over a one-hour period which contains the same acoustic energy as the time-varying sound level during the same period. Noise levels referred to in this report are stated as hourly-equivalent sound pressure levels Leq(h) expressed in units of dB(A).

As decibels are logarithmic units, sound levels cannot be added by ordinary arithmetic means. The following general relationships provide a basic understanding of sound generation and propagation:

- The noise level from a line source, such as moving traffic on a road, will decrease approximately 3 dB(A) with every doubling of distance from the source.
- Research has indicated that a difference of 10 dB(A) is perceived as twice as loud (or half as loud) to the human ear.
- Typically, the human ear can barely perceive a 3 dB(A) change in loudness.

FEDERAL REGULATIONS

The Federal Aid Highway Act of 1970 required the Federal Highway Administration (FHWA) to develop noise standards and abatement requirements for highway traffic noise. These standards are contained in Title 23, Code of Federal Regulations (CFR), Part 772, Procedures for Abatement of Highway Traffic Noise and Construction Noise. This regulation applies to highway construction projects where a state department of transportation has requested Federal funding for participation in the project. 23 CFR 772 provides procedures for preparing operational and construction noise studies and evaluating noise abatement considered for federal and federal-aid highway projects. The regulations do not mandate that the abatement criteria be met in all situations, but rather require that reasonable and feasible efforts be made to provide noise mitigation when the abatement criteria are approached or exceeded. Per 23 CFR 772.3, all highway projects that are developed in conformance with this regulation are deemed to be in conformance with FHWA noise standards.

FHWA has developed three “project types” to assess noise analysis applicability. Federal regulations only apply to Type I and Type II projects. Type III projects are ones that do not meet the definition of a Type I or Type II project and do not require a noise analysis. This project is a Type I project under 23 CFR 772.5 because it involves the construction of a highway on a new location. Therefore, a traffic noise analysis is required for the full project limits. The FHWA regulations establish Noise Abatement Criteria (NAC) activity categories based on land use to assess potential traffic noise impacts as defined in 23 CFR 772. The FHWA NAC and description of activity categories are shown in Table 1. Traffic noise impacts occur when predicted design year noise levels under the build scenario approach, meet or exceed the NAC, or if there are substantial increases in traffic noise over existing conditions, independent of the NAC.

The FHWA NAC are used to identify locations where traffic noise impacts occur. The NAC are not used as goals for noise attenuation design criteria or design targets. FHWA requires use of FHWA Traffic Noise Model (TNM) 2.5 or 3.0 to determine current and future traffic noise levels created by a proposed project; TNM 2.5 has been used to perform this noise analysis. FHWA has deferred to the State agencies to define the noise level that "approaches" the NAC and to define a substantial increase in traffic noise levels.

TABLE 1: FHWA NOISE ABATEMENT CRITERIA (NAC) ACTIVITY CATEGORIES

Activity Category	Leq (1 hour)	Description of Activity Category
A	57 dB(A) (exterior)	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B	67 dB(A) (exterior)	Residential.
C	67 dB(A) (exterior)	Active sport areas, amphitheaters, auditoriums, campgrounds, cemeteries, day care centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreation areas, Section 4(f) sites, schools, television studios, trails and trail crossings.
D	52 dB(A) (interior)	Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, schools and television studios.
E	72 dB(A) (exterior)	Hotels, motels, offices, restaurants/bars, and other developed lands, properties or activities not included in A-D or F.
F	-	Agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical) and warehousing.
G	-	Undeveloped lands that are not permitted.

Source: 23 CFR 772, Table 1

If one or both of these conditions (noise level approaching the NAC or substantial increase in noise level) are met as a result of the proposed project, 23 CFR 772 requires that noise abatement measures must be considered. Noise abatement measures may include the following:

- Noise barrier construction: Noise barriers reduce noise by blocking the path of sound between the source of the noise and the receiver. To be effective, a noise barrier should be located adjacent to either the noise source or the receiver. There must be a long, continuous break of the line-of-sight from the highway to the receiver.

- Traffic management measures: These may include restrictions on speed, restrictions on traffic volumes, restricted access for certain motor vehicle types, and restricted times of travel.
- Alteration of horizontal and vertical alignments: Alignment of the road refers to the physical layout and location of the highway. A highway's noise impacts may be altered by shifting it in the horizontal or vertical direction.
- Noise insulation of public use or non-profit institution structures: For buildings listed under Category D in Table 1, insulation may be considered as a noise mitigation strategy; this strategy is not available to other types of noise-sensitive development.
- Acquisition of real property: In this case, the DOT acquires, or acquires interest in, primarily undeveloped property near the roadway that is the noise source, to preempt its future development with noise-sensitive uses.

STATE POLICY

FHWA requires that all states have an approved policy to identify and address highway traffic noise impacts. The Indiana Department of Transportation (INDOT) Traffic Noise Analysis Procedure, effective January 1, 2023, was developed to implement the requirements of 23 CFR Part 772 and the noise-related requirements of the National Environmental Policy Act (NEPA) of 1969. The structure of the policy focuses on the following principal elements:

- Identification of noise sensitive areas and receptors.
- Determination of existing noise levels.
- Prediction of future noise levels.
- Identification of traffic noise impacts.
- Identification and consideration of noise abatement measures.
- Coordination with local government officials.
- Consideration of construction noise.

FHWA requires use of FHWA TNM to determine current and future traffic noise levels created by a proposed project and has deferred to the State agencies to define the noise level that "approaches" the NAC and to define a substantial increase in traffic noise levels.

INDOT defines noise impacts as modeled traffic-generated noise levels that are predicted to come within 1 dB(A) of, meet, or exceed the NAC for the appropriate activity category or that increase by 15 dB(A) or more over the existing traffic-generated noise levels.

INDOT requires that noise barriers achieve a 5 dB(A) reduction at a majority (greater than 50%) of the impacted receptors. If a barrier cannot achieve this acoustic goal, abatement is considered not to be acoustically feasible. INDOT also requires noise abatement measures to be based on sound engineering practices and standards and requires that any measures be evaluated at the optimum location. In situations where engineering considerations make noise barriers not feasible, the noise analysis will explicitly state the reasons.

INDOT's goal for substantial noise reduction is to provide at least a 7.0 dB(A) reduction for benefited first row receptors in the design year. However, conflicts with adjacent lands may make it impossible to achieve substantial noise reduction at all benefited first row receptors. Therefore, the noise reduction design goal for Indiana is 7dB(A) for a majority (greater than 50%) of the benefited first row receptors.

To determine reasonable barrier cost, the required barrier area (in square feet) per benefited receptor (those who would receive a reduction of at least 5 dB(A)) must be less than or equal to the allowable barrier area per benefited receptor for that noise abatement location. The allowable maximum square footage per benefited receptor in Indiana is 1,000 square feet per benefited receptor or less if a majority of the nearby receptors in a given common noise environment were not constructed prior to the roadway. If a majority of the nearby receptors in a common noise environment were constructed prior to the roadway being constructed, the allowable maximum square footage per benefited receptor is 1,250 square feet per benefited receptor or less. The INDOT noise specialist provides the current average cost per square foot for project planning purposes to determine the overall cost of the noise barrier.

Placing noise barriers on structures creates additional challenges, since reinforcement of the structure may be necessary to support the increased load or Zone of Intrusion (ZOI) concerns. In these situations, other options should be assessed to determine whether the maximum square footage of abatement can be provided without requiring complicated and expensive structural modifications. These could include lighter-weight barriers, shorter barriers, or other considerations. Any variations will be evaluated in coordination between the FHWA division office and INDOT's Divisions of Structural Services, Environmental Services and Construction Management.

The objectives of this noise study are to:

- Identify noise sensitive land uses within the traffic noise analysis area.
- Characterize the existing noise environment through field noise measurement at representative noise receptor sites.
- Validate the computer model using traffic data collected during the field measurement period.
- Use TNM to predict the existing year and design year traffic noise levels at noise receptor sites using INDOT certified traffic volumes.
- Identify impacted receptor sites and use TNM to determine if noise abatement measures are reasonable and feasible.

EXISTING CONDITIONS AND MODELED NOISE ENVIRONMENT

The project area includes six intersections along Watson Road east of SR 135. From west to east, these intersections are Central Drive, Asher Court, Robins Road, Meridian Lane, Delmer Lane, and Union Chapel Road. Both Central Drive and Asher Court have very low traffic and were omitted from the TNM model. The project area ties into Melview Road at the east end of the project area. Melview Road ends at Old Highway 337, which ends at the existing SR 11 approximately 300 feet south of Melview Road.

The terrain in the project area is very irregular in nature, with multiple grade changes including Buck Creek and a floodplain. There is an approximate 265-foot grade change from the highest to the lowest point in the project area. West of SR 135 is a ridge rising 50 feet above the level of SR 135. Between SR 135 and the intersection of Watson Road and Union Chapel Road, numerous hillocks and small, scattered ponds dominate the landscape. There is a pond on the north side of Watson Road, between SR 135 and Robins Road. East of its intersection with Watson Road, Union Chapel Road descends along a steep grade over approximately 180 feet in elevation down the west slope of the Buck Creek valley to the creek's floodplain, which is approximately 1,000 feet wide at the location of the proposed SR 11 crossing. The eastern wall of the Buck Creek valley is a bluff rising 190 feet above the floodplain. East of the bluff, the land rises more gently and steadily through the topographic high at the east end of the project area at SR 11.

The noise study area was drawn to incorporate all areas within 500 feet perpendicular to the existing and proposed project alignment. Land uses in the noise study area include residential, agricultural, and undeveloped properties. The NAC Land Use Activity Categories map in Appendix A shows the classification of properties in the noise study area with respect to the FHWA NAC Activity Categories. Noise sensitive uses are shown on the Noise Sensitive Areas and Measurement Points exhibit in Appendix A.

TNM MODELED OBJECTS

The Existing model includes sensitive receivers, applicable roadways and sufficient terrain to represent local conditions. The No Build model for design year 2046 retains the same features, while the 2046 Build model incorporates roadway and surface contour changes proposed for the project. A 2046 Undeveloped model evaluates an array of receivers to develop noise level contours for currently undeveloped lands. Specific features of the input files are as follows:

Validation, 2026 Existing and 2046 No Build models

- On SR 135, one travel lane was modeled in each direction of travel and the paved shoulders on both sides of the roadway were included with no traffic assignments.
- Terrain lines were modeled where necessary to represent the changing grades.

2046 Build model

- On new SR 11, one travel lane was modeled in each direction of travel and the paved shoulders on both sides of the roadway were included with no traffic assignments.
- A new bridge across Buck Creek was modeled as on structure.
- Terrain lines on each side of SR 11 establish ground level at each side of the bridge.
- East and west of the bridge respectively, the terrain lines extend away from the roadway to represent the bottom of the roadway embankment slope.

2046 Undeveloped model

- The 2046 Build model was used as a base.
- An array of evenly spaced receptors was added to each undeveloped area to assist in developing contour lines representing the Category B/C and Category E (66 and 71

dB(A), respectively) NACs and likely impacted areas. The existing receptors were removed to simplify calculations.

TRAFFIC VOLUMES AND SPEED

The 2026 Existing TNM model predicted traffic noise levels for the current roadway configuration based on 2017 traffic volumes provided by the INDOT Traffic Count Database System (TCDS) and supplemented by turning movement counts conducted by Quality Counts, LLC in 2021. The 2046 Build TNM model predicted traffic noise levels for the proposed roadway configuration in the design year. Traffic for the Existing, No Build and Build years assumes a compound growth of 0.25% year over year above the 2017 volumes. The growth rate was approved by the INDOT Traffic Statistics group. The vehicle fleet mix on roadways modeled in the TNM was also based on data from information provided by Quality Counts, LLC. All traffic volumes used in this traffic noise analysis are expected to produce LOS C or better.

Based on field observations, traffic speeds on Union Chapel Road (North of Watson Road/New SR 11), Melview Road, Robins Road, Meridian Road and Delmer Roads reflect the estimated speeds of 40 mph, as these roads do not have posted speed limits. A traffic speed of 50 mph was estimated on Watson Road and 30 mph was estimated for Union Chapel Road (South of Watson Road/New SR 11) as they do not have a posted speed limit. Posted speeds are 40 mph for Old Highway 337, 45 mph for Existing/Old SR 11 and 55 mph for SR 135.

Upon completion of the project the roads in the noise study area will all have posted speed limits. Posted speeds will be 45 mph for New SR 11, 40 mph for Union Chapel Road north of New SR 11 and 30 mph for Union Chapel Road south of New SR 11 and 40 mph for Melview Road, Meridian Road and Delmer Road. These future posted speeds were utilized in the 2046 Build and 2046 Undeveloped models. The existing posted speeds for Old Highway 337, Existing/Old SR 11 and SR 135 remain unchanged in the future condition, and therefore are unchanged in the 2046 Build and 2046 Undeveloped models.

NOISE MEASUREMENTS AND MODEL VALIDATION

FIELD NOISE MEASUREMENTS

CMT collected field noise measurements on October 11, 2022. Noise measurement locations including TNM receivers are shown on the Noise Impacts exhibit in Appendix A. In general, noise measurement locations are those proposed in the noise measurement plan approved by INDOT on September 16, 2022. There was only one deviation from the measurement plan. Noise Measurement Point (NMP) B, which was proposed to be in the front yard of a residence closest to Watson Road (Receiver 21 in the TNM models), was relocated to an open area southwest of the Watson Road and Robins Road intersection due to the unsafe and possibly abandoned nature of the residence. The relocated NMP was offset the same distance from the road as TNM Receiver 20. As stated in the measurement plan, two of the NMP locations (NMP E and NMP F) were established to measure the ambient noise levels near the proposed SR 11 and do not correspond to existing noise sensitive receptors.

TRAFFIC NOISE MODEL RESULTS AND IMPACT ASSESSMENT

Once the models were determined valid, TNM was used to predict existing and future traffic noise impacts at noise sensitive land uses throughout the analysis area. Based on field observations, all noise sensitive receptors in the project area are residential, with a NAC of 67 dB(A). NMP E and NMP F are vacant properties that were added to represent potential noise sensitive uses in areas of the new roadway.

The 2026 Existing and 2046 No Build TNM models predicted traffic noise levels for the current roadway configuration and the 2046 Build TNM model predicted traffic noise levels for the proposed roadway configuration in the design year. The model results were evaluated to assess whether the proposed project results in noise levels that meet one or both of the traffic noise impact criteria described in the "State Policy" section on page 4.

Table 3 provides the TNM results for the project area receptors. There are no receptors that are predicted to experience traffic noise levels that approach, meet or exceed the NAC. Similarly, there are no receptors for which the design year "build" condition results in noise levels of at least 15 dB(A) over the existing condition (a substantial increase). Therefore, no traffic noise impacts were identified. The receptors that experience a decrease in the "build" condition are either farther from the new SR 11 or the elevation of the new SR 11 is lower than the existing roads.

TABLE 3: NOISE MODEL RESULTS AND IMPACT ASSESSMENT

Receptor	Number of Dwelling Units (DUs)	NAC with INDOT Approach Criterion (dB(A))	2026 Existing Traffic Noise (dB(A))	2046 Build Predicted Traffic Noise (dB(A))	Increase/ Decrease (dB(A))	# DUs Impacted	2046 No Build Predicted Traffic Noise (dB(A))
1-NMP A: 7755 Hwy 135 SW, Corydon, IN	1	66	57.5	57.7	0.2	0	57.7
2: 8027 Hwy 135 SW, Mauckport, IN	1	66	47.7	48.1	0.4	0	48.0
3: 8067 Hwy 135 SW, Mauckport, IN	1	66	48.2	48.7	0.5	0	48.4
4: 8113 Hwy 135 SW, Mauckport, IN	1	66	53.2	53.9	0.7	0	53.4
5: 7775 Central Dr. SW, Central, IN	1	66	59.3	60.3	1.0	0	59.5

Receptor	Number of Dwelling Units (DUs)	NAC with INDOT Approach Criterion (dB(A))	2026 Existing Traffic Noise (dB(A))	2046 Build Predicted Traffic Noise (dB(A))	Increase/ Decrease (dB(A))	# DUs Impacted	2046 No Build Predicted Traffic Noise (dB(A))
6: 7656 Central Dr. SW, Central, IN	1	66	51.2	52.0	0.8	0	51.4
7: 7970 Central Dr. SW, Central, IN	1	66	60.3	60.1	-0.2	0	60.6
8: 8065 Asher Ct. SW, Corydon, IN	1	66	57.4	57.0	-0.4	0	57.7
9: 8123 Asher Ct. SW, Corydon, IN	1	66	60.0	60.4	0.4	0	60.3
10: 8120 Hwy 135 SW, Mauckport, IN	1	66	62.4	62.8	0.4	0	62.6
11: 8158 Asher Ct. SW Corydon, IN	1	66	51.2	51.4	0.2	0	51.4
12: 8148 Asher Ct. SW, Corydon, IN	1	66	49.8	49.7	-0.1	0	50.1
13: 8060 Asher Ct. SW, Corydon, IN	1	66	49.8	48.9	-0.9	0	50.1
14: 8056 Asher Ct., Corydon, IN	1	66	53.7	52.0	-1.7	0	54.0
15: 1633 Watson Rd. SW, Corydon, IN	1	66	50.1	48.8	-1.3	0	50.4
16: 1615 Watson Rd. SW, Corydon, IN	1	66	51.4	49.6	-1.8	0	51.7
17: 1495 Watson Rd. SW, Corydon, IN	1	66	55.1	52.5	-2.6	0	55.3
18: 1500 Watson Rd. SW, Corydon, IN	1	66	48.9	47.4	-1.5	0	49.2
19: 1435 Watson Rd. SW, Corydon, IN	1	66	63.4	58.2	-5.2	0	63.6

Receptor	Number of Dwelling Units (DUs)	NAC with INDOT Approach Criterion (dB(A))	2026 Existing Traffic Noise (dB(A))	2046 Build Predicted Traffic Noise (dB(A))	Increase/ Decrease (dB(A))	# DUs Impacted	2046 No Build Predicted Traffic Noise (dB(A))
20: 1313 Watson Rd. SW, Corydon, IN	1	66	51.9	49.9	-2.0	0	52.1
21: 1185 Watson Rd. SW, Corydon, IN	1	66	59.6	57.9	-1.7	0	59.8
22: 1180 Watson Rd. SW, Corydon, IN	1	66	50.5	50.5	0.0	0	50.8
23-NMP B: 1145 Watson Rd. SW, Corydon, IN	1	66	51.3	50.7	-0.6	0	51.6
24: 1006 Watson Rd. SW, Corydon, IN	1	66	47.5	46.7	-0.8	0	47.8
25: 820 Watson Rd. SW, Corydon, IN	1	66	45.2	44.1	-1.1	0	45.5
26: 669 Watson Rd. SW, Corydon, IN	1	66	47.5	45.1	-2.4	0	47.8
27: 670 Watson Rd. SW, Corydon, IN	1	66	50.9	52.4	1.5	0	51.1
28: 600 Watson Rd. SW, Corydon, IN	1	66	56.0	59.1	3.1	0	56.3
29: 535 Watson Rd. SW, Corydon, IN	1	66	62.2	58.5	-3.7	0	62.5
30: 451 Watson Rd. SW, Corydon, IN	1	66	47.9	46.0	-1.9	0	48.2
31: 310 Watson Rd. SW, Corydon, IN	1	66	47.8	46.6	-1.2	0	48.1
32-NMP C: 210 Watson Rd. SW, Corydon, IN	1	66	56.2	59.1	2.9	0	56.5
33-NMP D: 8003 Union Chapel Rd., Laconia, IN	1	66	47.7	52.7	5.0	0	47.9

Receptor	Number of Dwelling Units (DUs)	NAC with INDOT Approach Criterion (dB(A))	2026 Existing Traffic Noise (dB(A))	2046 Build Predicted Traffic Noise (dB(A))	Increase/ Decrease (dB(A))	# DUs Impacted	2046 No Build Predicted Traffic Noise (dB(A))
36-NMP G: 1865 Melview Rd. SE, Laconia, IN	1	66	40.0[1]	51.2	11.2	0	40.3
37: 2000 Melview Rd. SE, Laconia, IN	1	66	46.1	46.4	0.3	0	46.3
38-NMP H: 7985 Old Hwy 337 SE, Laconia, IN	1	66	49.8	57.7	7.9	0	50.3
39: 8030 Old Hwy 337 SE, Laconia, IN	1	66	57.3	56.5	-0.8	0	57.8
40: 8032 S Old Hwy 11 SE, Laconia, IN	1	66	55.4	50.5	-4.9	0	55.8
41-NMP I: 8120 S Old Hwy 11 SE, Laconia, IN	1	66	57.6	50.3	-7.3	0	57.8

[1] The modeled existing level was used in preference to the field measurement due to the non-traffic-noise influence of the rustling corn on the field measurement that is not present year-round.

CONSIDERATION OF ABATEMENT

Because no traffic noise impacts were identified, no abatement measures were considered.

CONSTRUCTION NOISE

Noise from construction activities will add to the average noise level during the construction phase of the project. However, construction activities will be temporary. All activities are expected to occur during normal daytime waking hours, avoiding the annoyance or disruption of sleep that may be caused by nighttime operations.

Noise may also be generated by increases in heavy truck traffic to and from the project area. This increase in noise is also expected to be confined to daytime hours.

Increases in the average noise level due to construction are temporary, but measures should be taken to minimize the impact of additional noise. Recommended standard measures include:

- Limit operation of heavy equipment and other noisy procedures to daylight hours whenever possible.
- Install and maintain effective mufflers on equipment.

- Locate equipment and vehicle staging areas as far from noise sensitive areas as practicable.
- Limit unnecessary idling of equipment.

In all cases, construction operations will adhere to local construction noise ordinances.

COORDINATION WITH LOCAL GOVERNMENT OFFICIALS

Because TNM 2.5's contour module, which produces sound level contours for undeveloped areas to assist in community planning, does not function with modern computer operating systems, "dummy" receivers were used to evaluate the distance from SR 11, SR 135 and Melview Road within currently undeveloped NAC Category G areas at which the NAC for various types of land uses would be exceeded. The results indicate that a level of 66 dB(A), INDOT's NAC for Activity Category B (residential land uses) and Category C (uses that include active sports areas, day care centers, and recreational area) would not extend beyond the right-of-way for the proposed roadway. Additionally, the results indicate that a level of 71 dB(A), INDOT's NAC for Activity Category E (uses that include hotels, motels, offices, restaurants/bars, and other developed lands, properties or activities not included in A-D or F) would not extend beyond the right-of-way for the proposed roadway.

Upon completion of the environmental document for this project, the environmental document preparer will provide this noise study to the Harrison County Planning Commission. INDOT understands that it is in a unique position to provide outreach to local government and county planning units. INDOT also understands that it is the local or county government that has the power to regulate land development. INDOT is willing to help the local government by providing expert guidance on noise-related issues. This can include recommendations on setbacks, how to interpret noise studies that have been provided for FHWA projects, and other general noise concerns so that noise impacts are minimized for areas that are being developed.

CONCLUSIONS AND RECOMMENDATIONS

The SR 11 Roadway Project is located between the SR 135 and Watson Road junction in the west and the SR 11 and Melview Road/Old Highway 337 junction in the east, 4.7 miles north of the existing junction between SR 135 and SR 11 and approximately 10 miles south of Corydon, Indiana along SR 135. The project will involve upgrading existing county roads and building a road on new alignment to create a new east-west SR 11 connection across Buck Creek. The project proposes the construction of a new bridge across Buck Creek. The project is a Type I project under 23 CFR 772.5 because it involves the construction of roadway (SR 11) on new alignment.

A total of 39 noise-sensitive receptors along existing local roadways and two agricultural properties located within the new alignment were evaluated for noise impacts as part of this study. The noise-sensitive receptors were all residences.

Based on the studies completed to date, the State of Indiana has identified no impacted receptors. As a result, noise abatement was not evaluated. This noise analysis was based on preliminary design criteria. A reevaluation of the noise analysis will occur during final design. If during final design it has been determined that conditions have changed and noise impacts are identified, noise abatement will be evaluated at that time as to whether it is feasible and reasonable.

REFERENCES

Federal Aid Highway Act of 1970. United States Congress. August 13, 1973.

Code of Federal Regulations, Title 23, Chapter I, Subchapter H, Part 772, Procedures For Abatement Of Highway Traffic Noise And Construction Noise. 2010.

Indiana Department of Transportation (INDOT) Traffic Noise Analysis Procedure. Effective January 1, 2023.

National Environmental Policy Act (NEPA) of 1969. United States Congress. January 1, 1970.

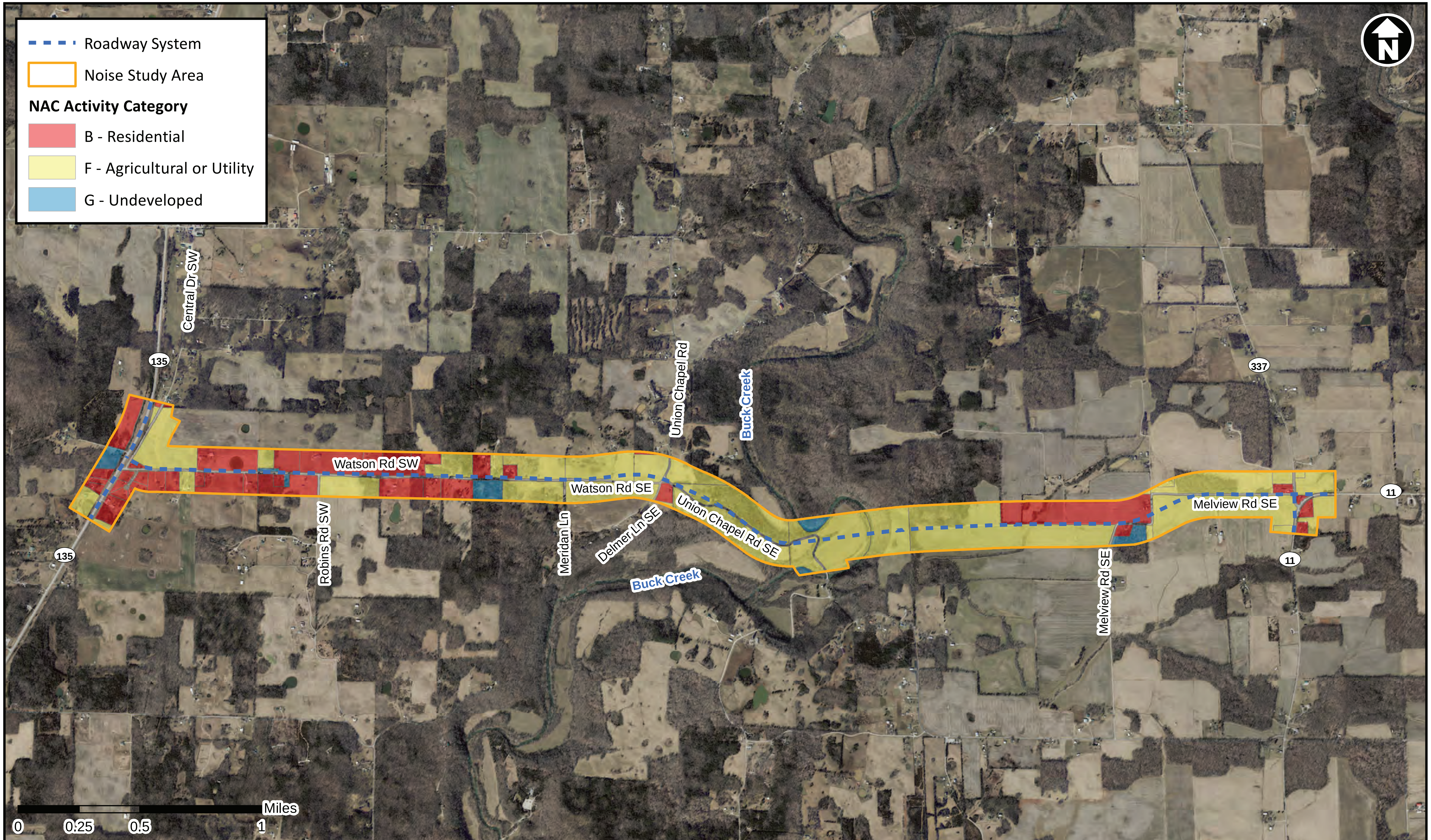
INDOT Traffic Count Database System (TCDS). https://indot.public.ms2soft.com/tcds/tsearch.asp?loc=Indot&mod=tcds&local_id=100700.

Quality Counts, LLC. https://www.qualitycounts.net/.

SR 11 Roadway Noise

APPENDIX A: FIGURES

Note: Select Figures have been removed to avoid duplication and reduce file size.



SR 11 Roadway Project (Des No 2001154)

NAC LAND USE ACTIVITY CATEGORIES

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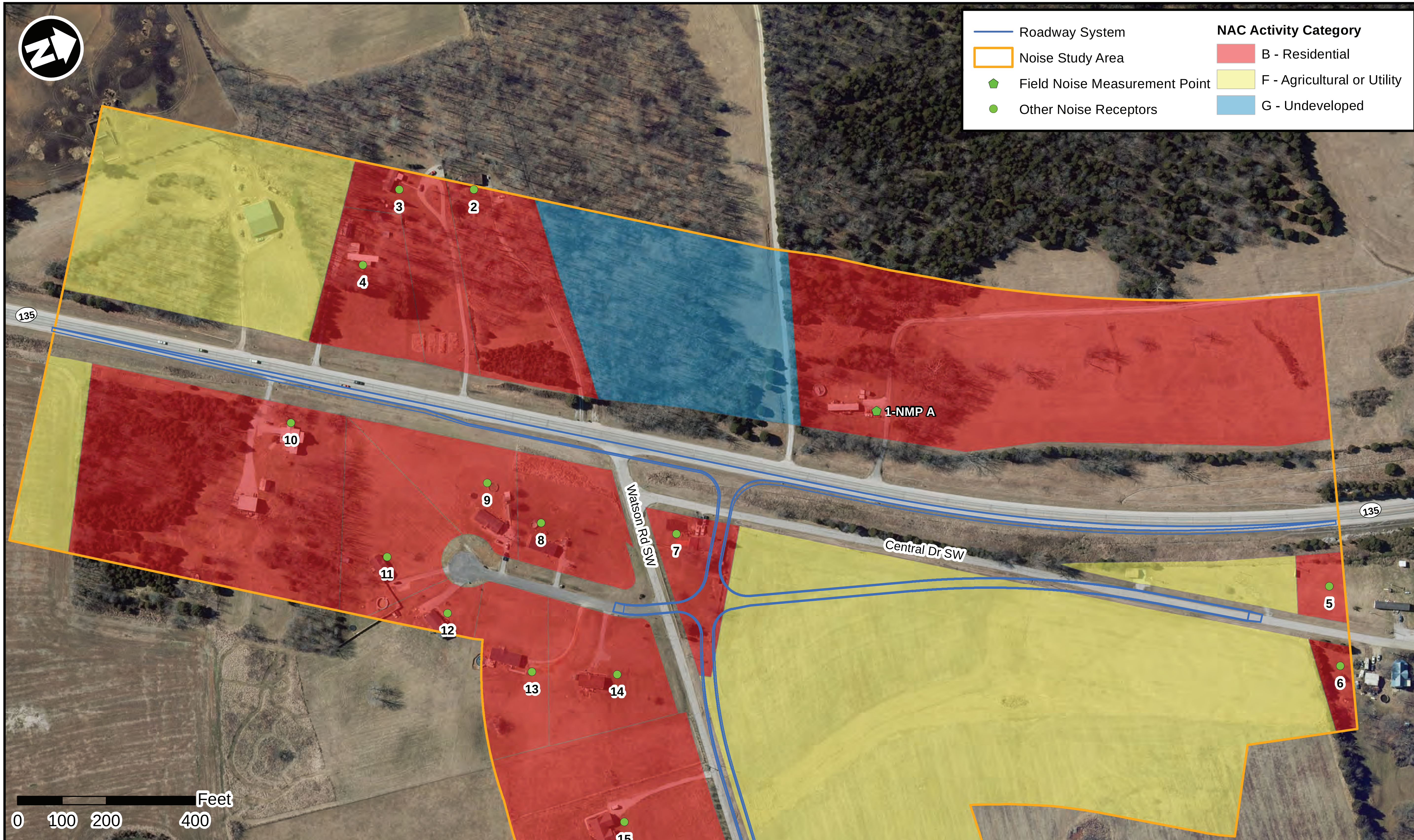

SR 11 Roadway Project (Des No 2001154)

NMP DETAILS

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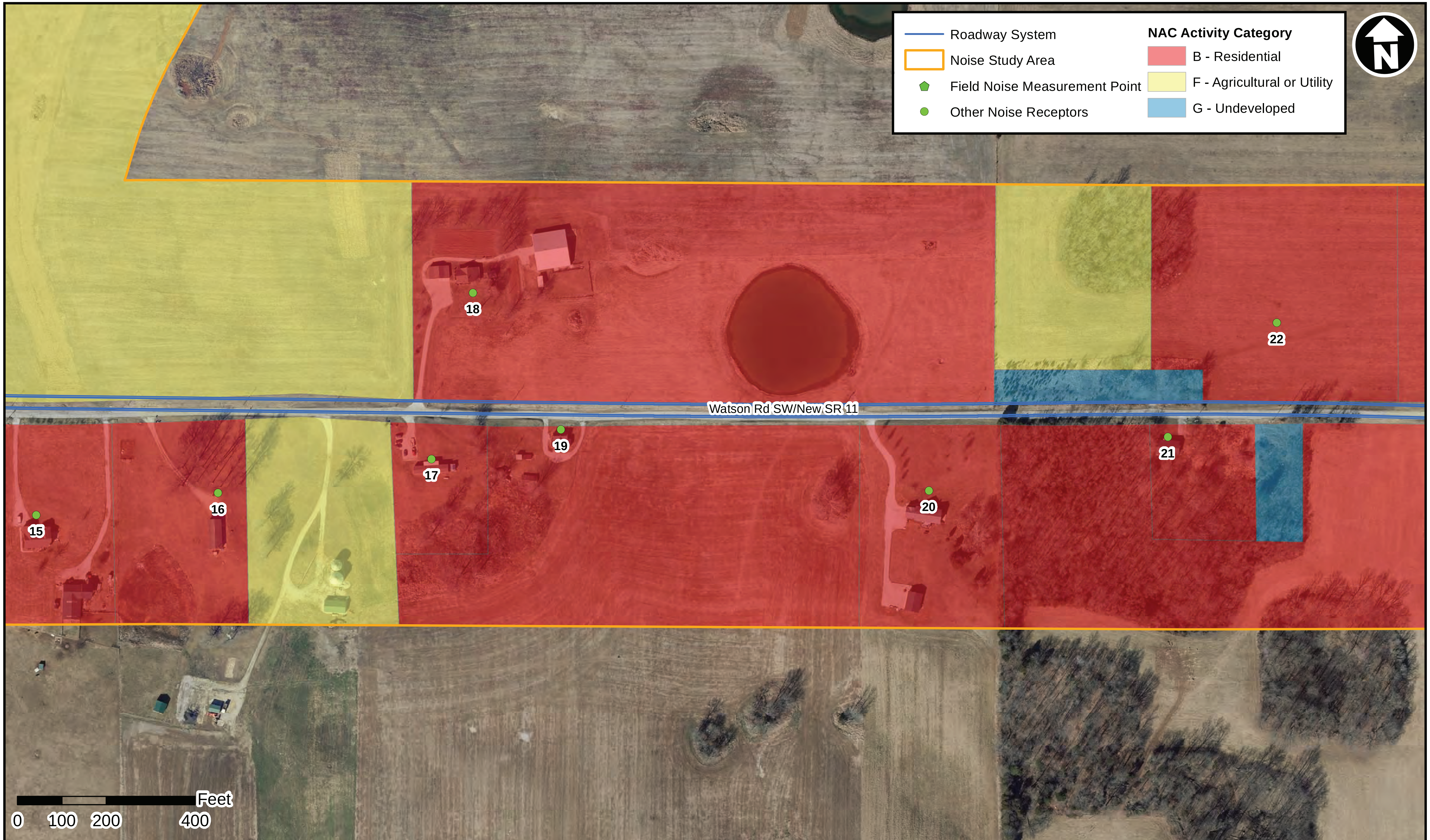

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NMP DETAILS

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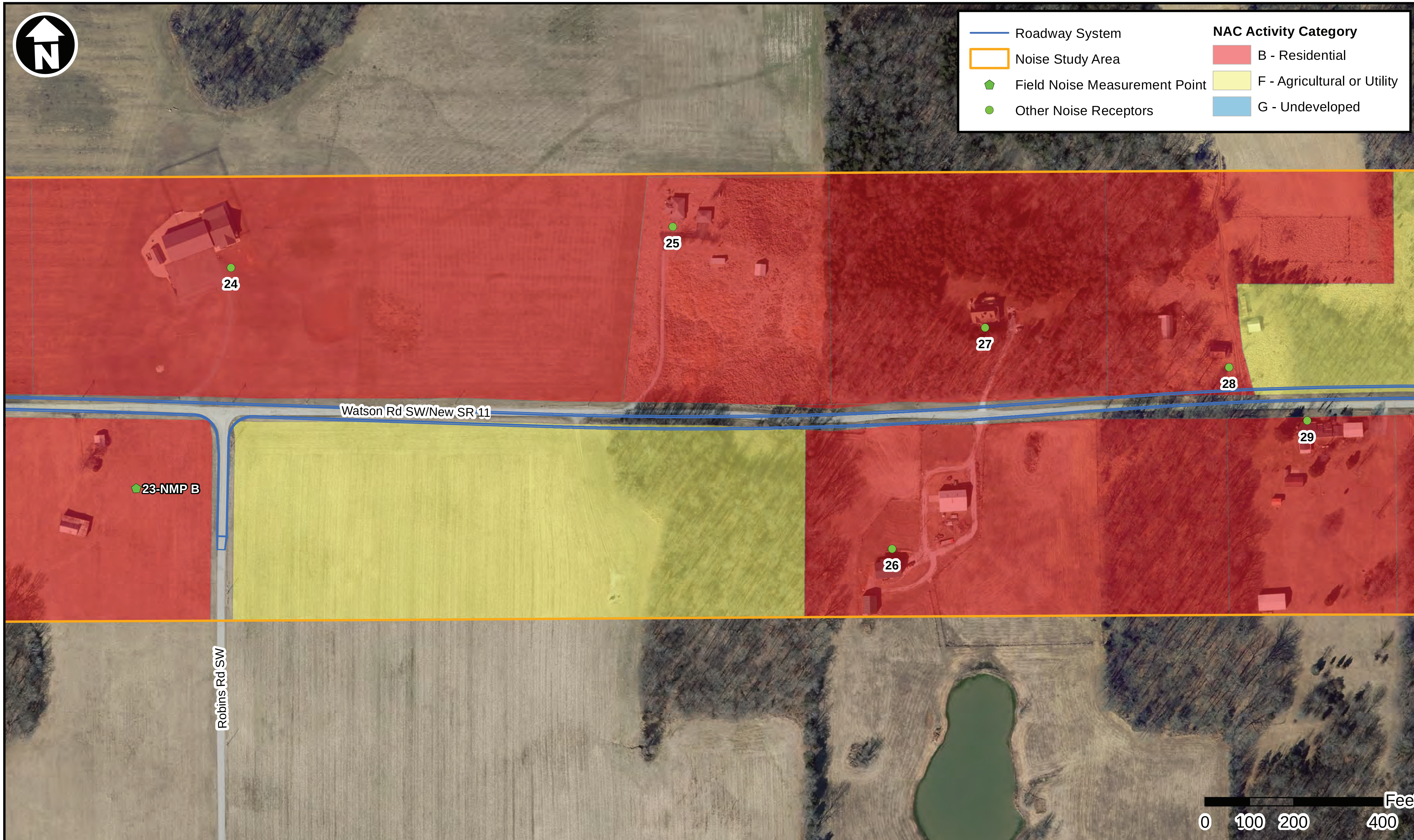

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NMP DETAILS

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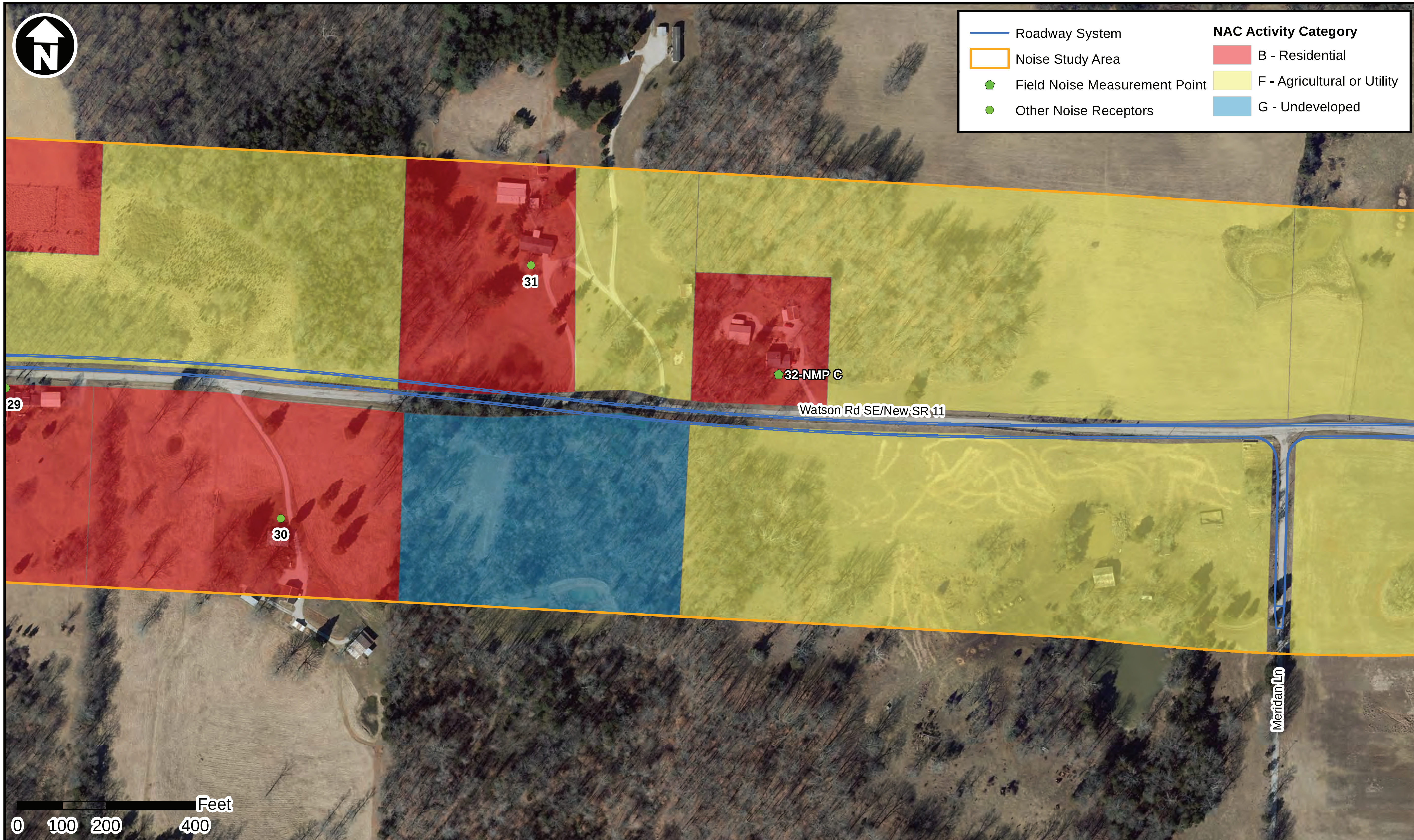

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NMP DETAILS

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NMP DETAILS

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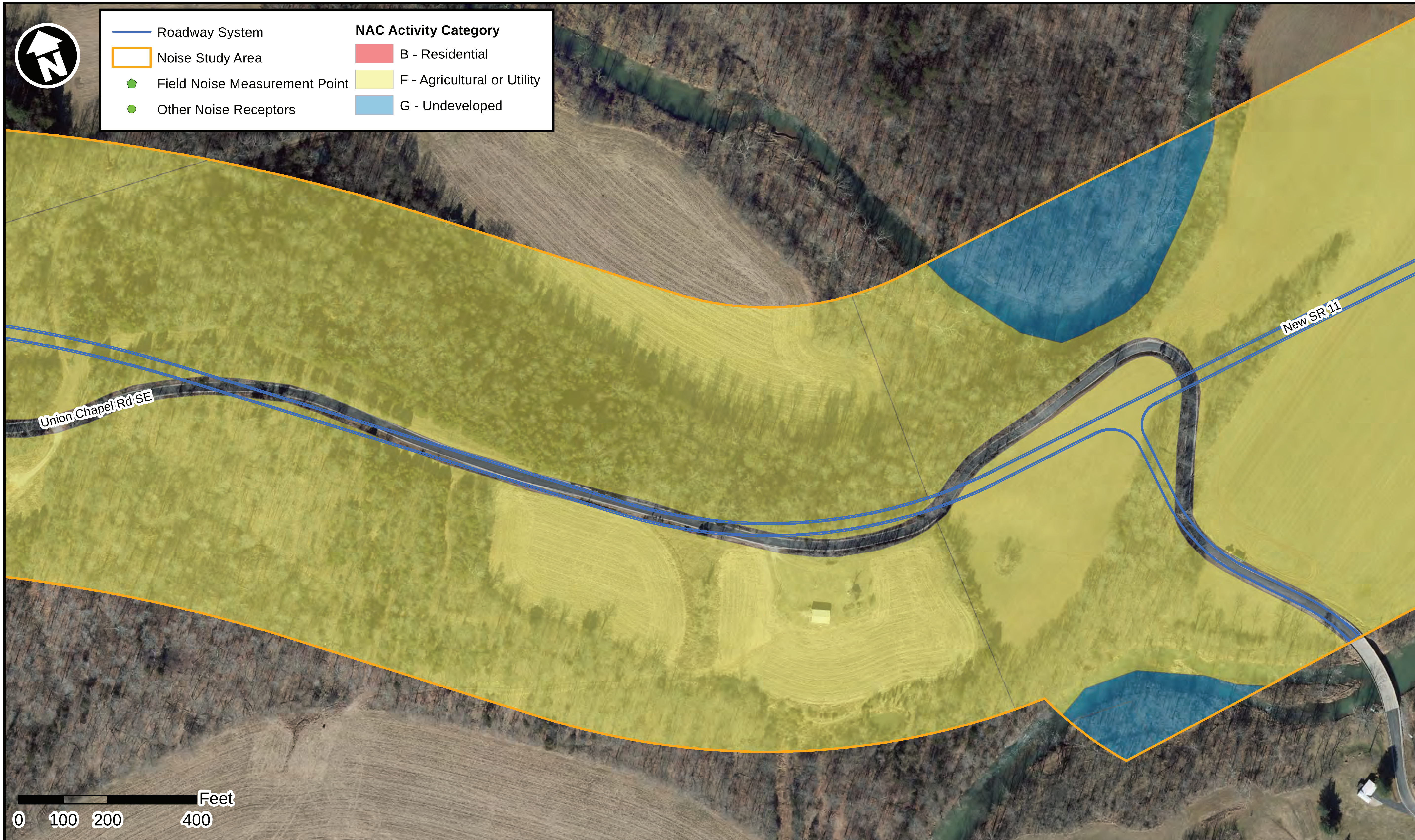

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NMP DETAILS

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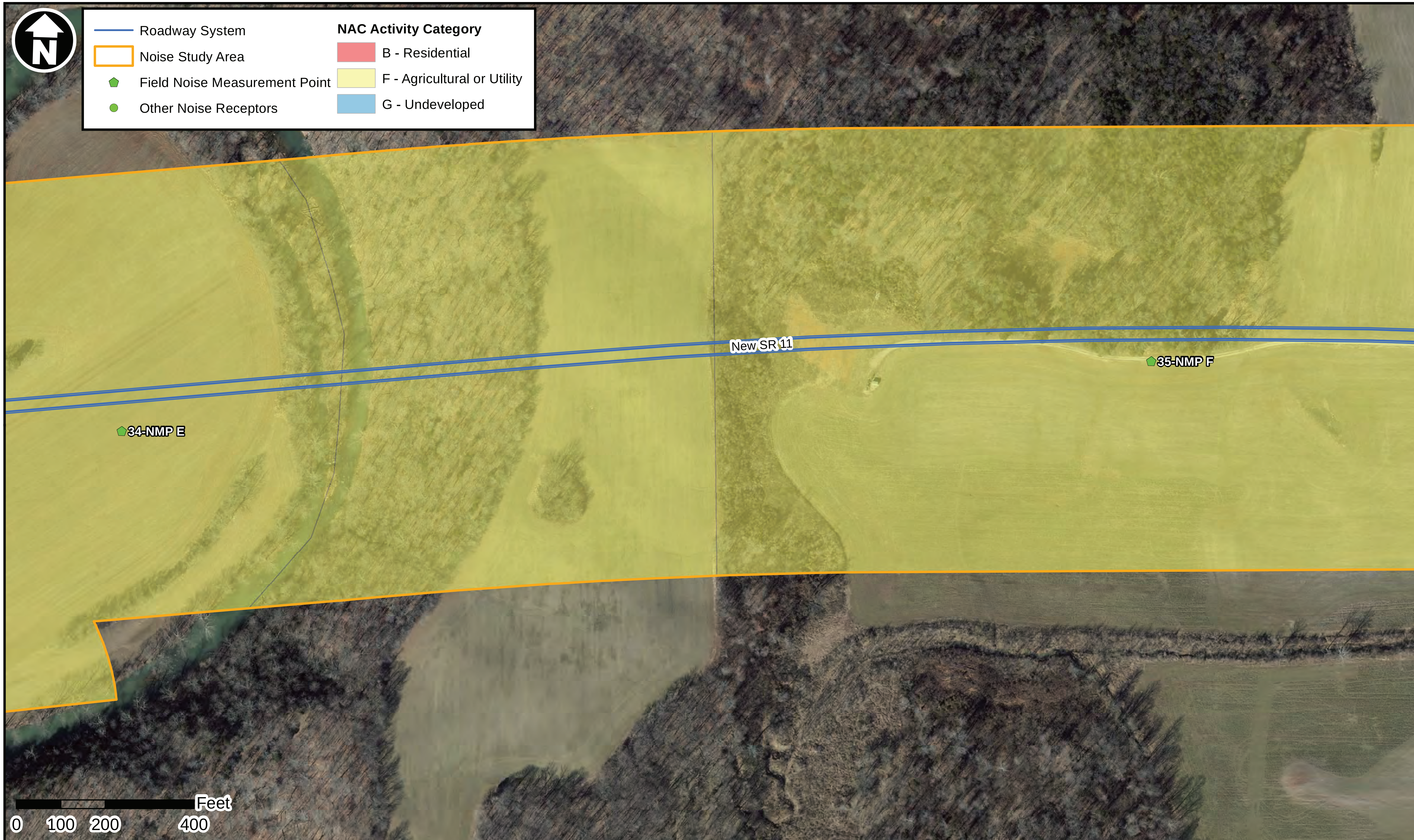

SR 11 Roadway Project (Des No 2001154)

NMP DETAILS

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NMP DETAILS

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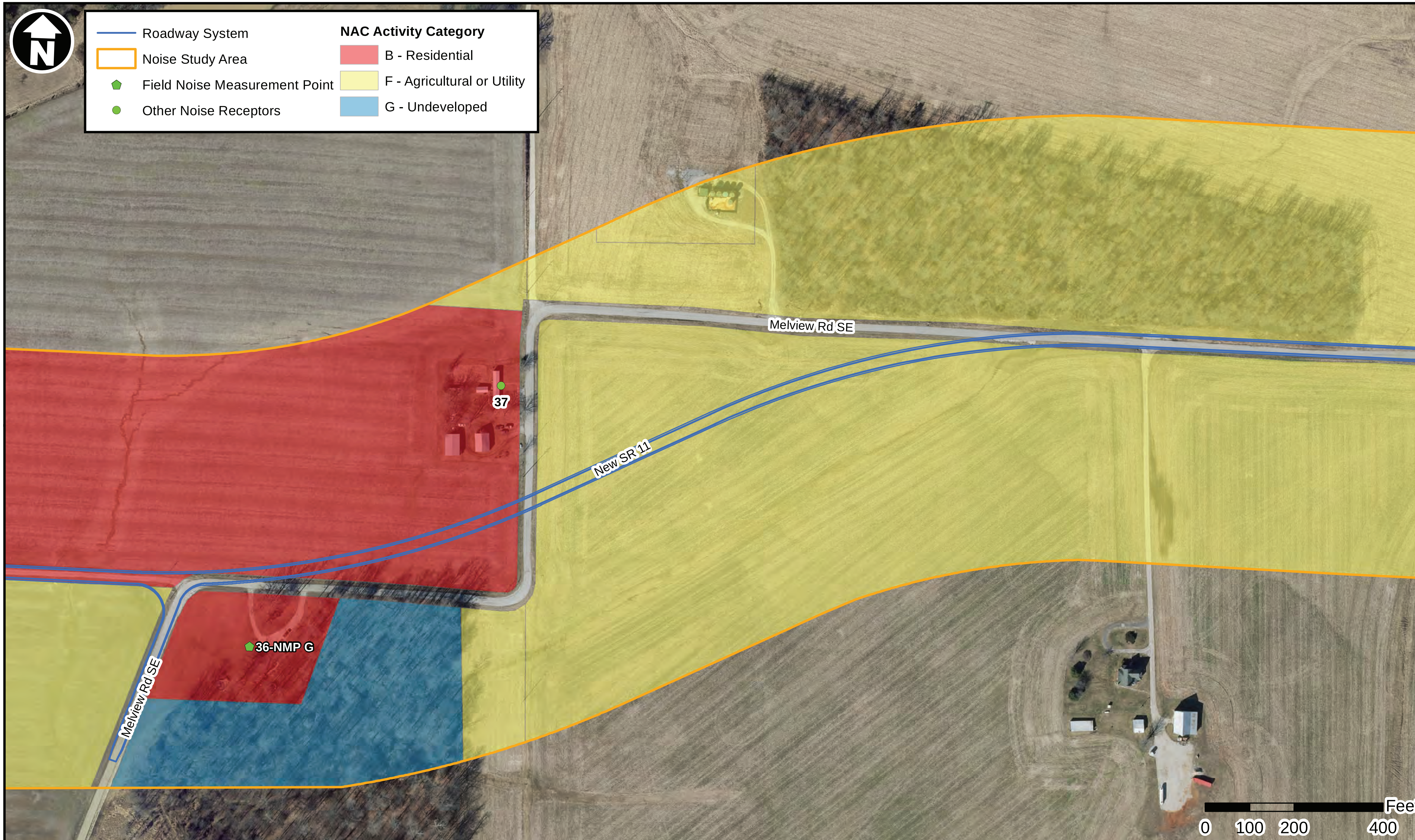

SR 11 Roadway Project (Des No 2001154)

NMP DETAILS

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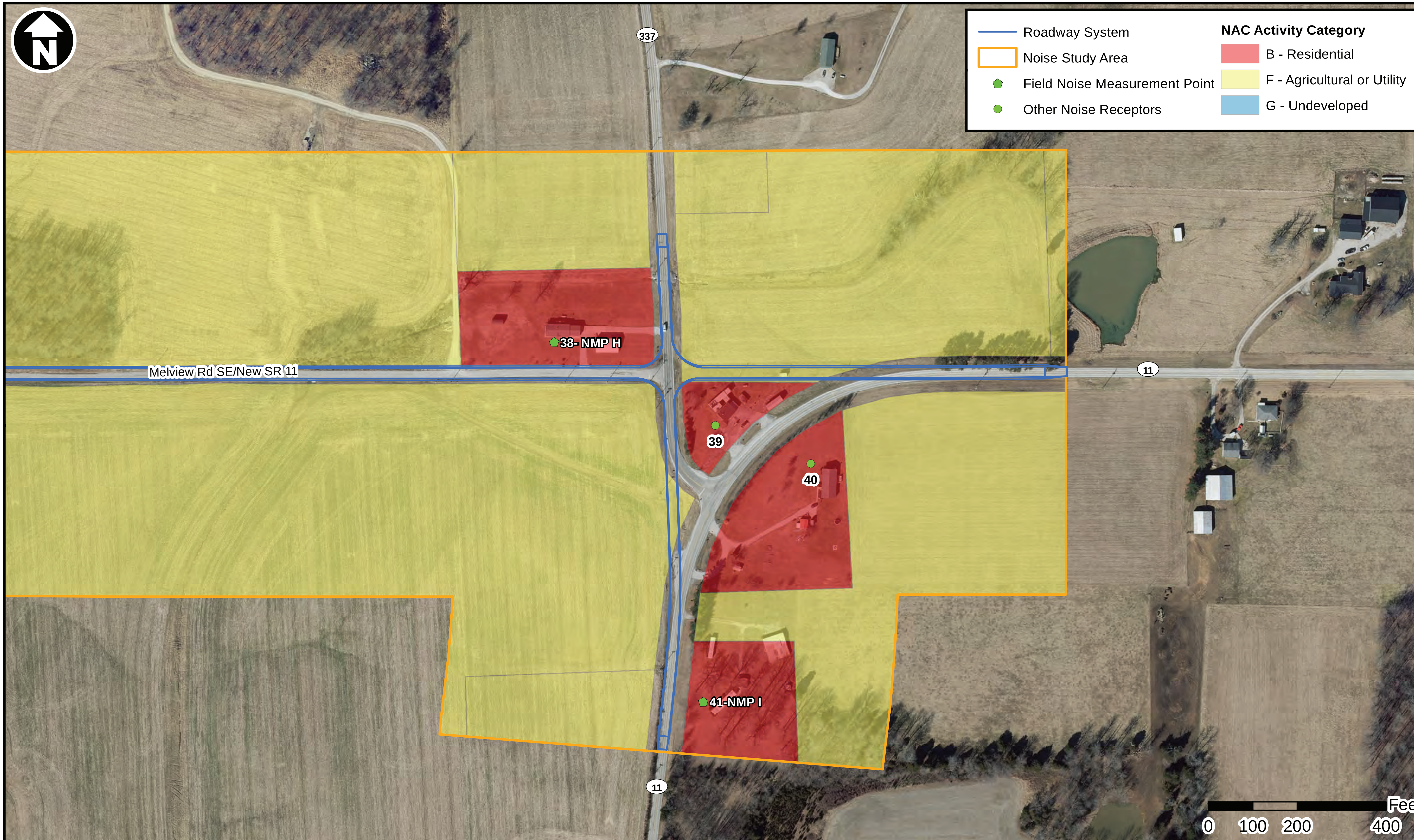

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NMP DETAILS

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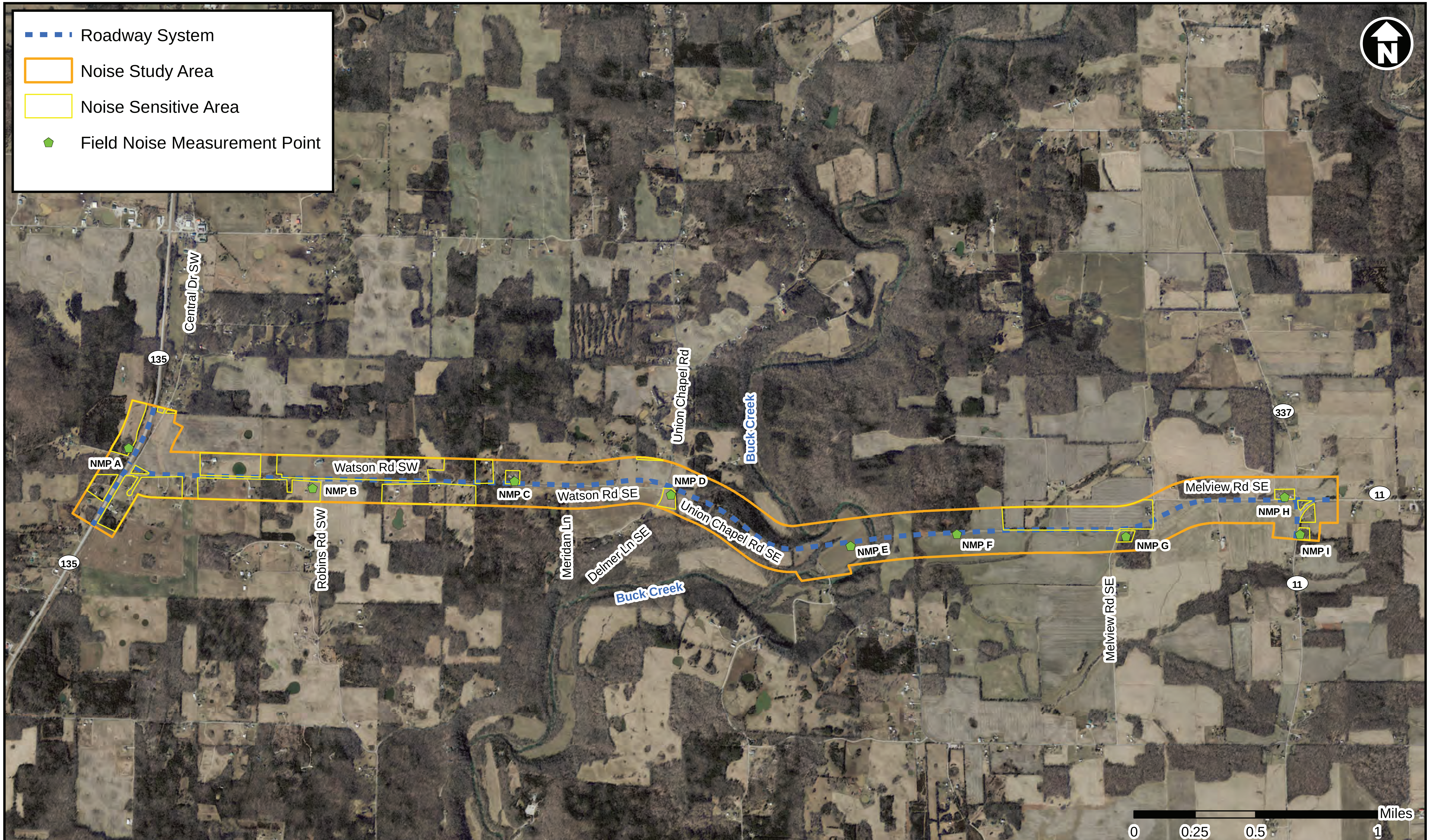

SR 11 Roadway Project (Des No 2001154)

NOISE SENSITIVE AREAS AND NOISE MEASUREMENT POINTS

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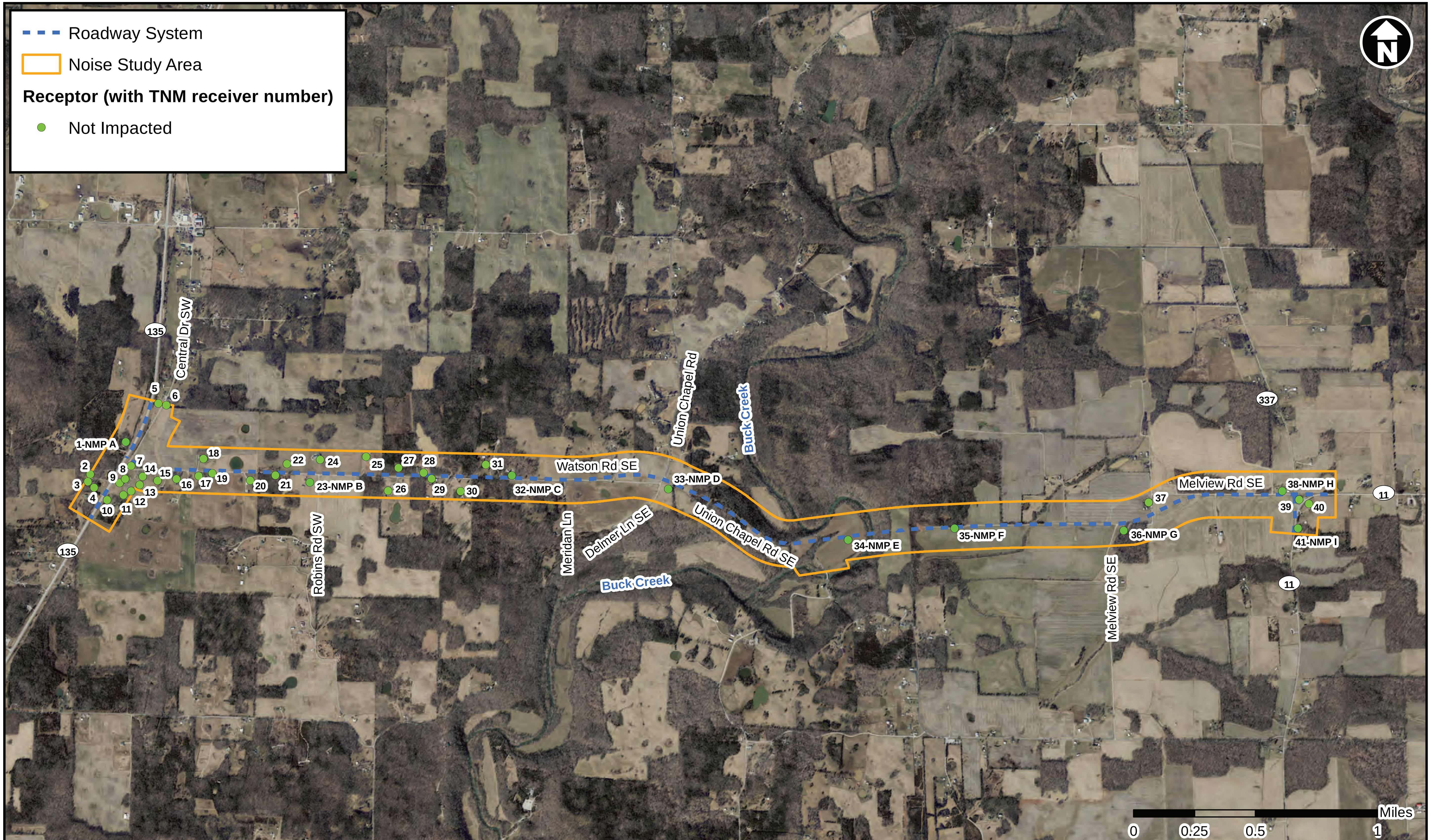

SR 11 Roadway Project (Des No 2001154)

NOISE IMPACTS OVERALL

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SR 11 Roadway Noise

APPENDIX B: FIELD DATA

Note: Appendix has been removed to reduce file size.

SR 11 Roadway Noise

APPENDIX C: TNM MODEL OUTPUT

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