Elliott Ditch Geomorphic Surface Mapping and Historic Data Review July 6, 2015

Prepared for Alcoa

Prepared by Tetra Tech CES

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APPENDICES

LIST OF ACRONYMS

GPS	Global Positioning System
USEPA	United States Environmental Protection Agency
PCB	Polychlorinated Biphenyl
PPM	parts per million
RTK	Real Time Kinematic
PPB	parts per billion
USGS	United States Geological Survey
DEM	Digital Elevation Model
FEMA	Federal Emergency Management Agency
DEM	Digital Elevation Model
GIS	Geographic Information System
LDB	Left descending bank
RDB	Right descending bank

1.0 OVERVIEW

Tetra Tech performed a geomorphology and depositional pattern assessment of Elliott Ditch (between Alcoa's Outfall 001 and Wea Creek) and the surrounding floodplain in Lafayette, Indiana in 2013 and 2014. Assessment work proceeded, over this period, on an iterative basis. In 2013, preliminary geomorphic surface mapping (desktop) was conducted to evaluate the depositional/erosional pattern in the channel and surrounding floodplain. Field work included a detailed survey of the upstream 0.5 mile of Elliott Ditch and the 100-year floodplain to complete detailed channel profiles. In 2014, the desktop geomorphic surfaces were field confirmed and edited to reflect the field confirmation findings.

This report describes the purpose and tasks, methods, and results of the work completed in 2013 and 2014 by Tetra Tech.

2.0 PURPOSE AND TASKS

2.1 PURPOSE

The purpose of this study was to use geomorphic methods to evaluate the deposition and erosion patterns in Elliott Ditch and the surrounding floodplain. A geomorphology based approach will be implemented to guide an investigation of Elliott Ditch. The objective of this investigation is to support a site conceptual model to understand the distribution of potential PCB impacts in Elliott Ditch and the adjacent floodplain caused by historical releases from Alcoa's storm water outfall. Elliott Ditch is a dynamic fluvial system. A typical grid-based sampling investigation approach often provides results that are difficult to interpret. Fluvial geomorphology provides a framework for sampling and data analysis that incorporates the predictable environmental and fluvial processes ongoing in Elliott Ditch and the surrounding floodplain.

2.1.1 Fluvial Geomorphology and Geomorphic Sampling Approach

Geomorphology is the science of landform evolution. Fluvial geomorphology focuses on river formation, evolution, and function. Fluvial geomorphology can be used to identify, delineate, and remediate impacts in river systems. The science provides an understanding of the depositional and erosional pattern of river systems.

A grid network sampling approach has been used to define sediment and soil sample locations on many sediment projects. The advantage of this approach is that sample locations are readily established by superimposing a grid pattern with predefined transects over a map that includes the area of concern. A significant disadvantage of grid network sampling is the probability that physical conditions influencing spatial distribution of sediment are not considered because rivers are not homogeneous surfaces. The sample density distribution within areas of low potential for impacted sediment is similar to that of areas with high potential for impacted sediment. Therefore, sampling efficiency and data optimization are compromised because grid networks are adapted to conditions with limited spatial variability; which is not typical of a fluvial system.

An environmental investigation based upon geomorphic principles assumes that deposition, erosion, and impacted sediment distribution are not random; rather they are predictable and the result of known physical processes. A geomorphic sampling approach is based on focusing the sampling effort in areas with high potential for impacted sediment. Using geomorphic analysis, the sample location density distribution is based on potential for deposition and spatial variability. This approach is more efficient and it provides more informative data compared to a uniform sample location distribution (grid network). The geomorphic sampling approach is based on selection of sample transects and locations for each geomorphic surface category because each geomorphic surface type represents a specific depositional/erosional environment.

Tetra Tech completed desktop and field activities sufficient to establish a baseline geomorphic conceptual model for Elliott Ditch in 2013 and 2014. The methods and results of the geomorphic analysis of Elliott Ditch are presented in this report. Additionally, a summary of the historic sampling efforts conducted in Elliott Ditch is presented, as well as a brief summary of the geologic history.

2.2 TASKS

The Tetra Tech scope of work included the following tasks:

- Desktop Tasks
  - Background data collection and desktop geomorphic surface mapping
  - Review of historic data
  - Elliott Ditch longitudinal profile
  - Floodplain data collection and review
  - Landowner parcel mapping
  - Survey transect mapping
  - Incorporate historic data analysis, where appropriate, into geomorphic analysis of Elliott Ditch
  - Determine geologic history of Elliott Ditch

- Field Tasks
  - Global positioning survey (GPS)/total station topographic survey data collection
  - Photo log
  - Geomorphic surface mapping field confirmation
  - Top of water and water depth measurement

3.0 METHODS

The methods that were used to complete the tasks listed in Section 2.2 are described below.

3.1 DESKTOP TASKS

3.1.1 Preliminary Geomorphic Surface Mapping

A geomorphic surface is an area formed by similar physical factors related to morphology and time (e.g. elevation, floodplain configuration, and deposition/erosion environment). Fluvial geomorphology provides a basis for supporting the development of depositional or erosional environments, and therefore contaminant distribution, using multiple lines of evidence. Each line of evidence is evaluated independently within a Geographic Information System (GIS) to develop an understanding of its effect on deposition or erosion. Geomorphic surfaces are edited on an iterative basis to incorporate each dataset into the surface mapping process.

The multiple lines of evidence are merged to support geomorphic interpretation and contaminant distribution for a river system. This method provides a means to identify inconsistencies and data gaps that may require additional review or data collection. For Elliott Ditch, the following lines of evidence were available for desktop geomorphic surface mapping:

- Aerial Photographs (recent and historic)
- One foot contour intervals, derived from a ten-meter Digital Elevation Model (DEM)
- Channel longitudinal profile (gradient)
- Surface aspect
- Geomorphic setting
- Water velocity
- Water depth
- Channel width
- Valley width
- Land use
- Anthropogenic impacts (e.g. channel armoring, dams, bridges, dredging, etc.)

The initial geomorphic surfaces developed for Elliott Ditch were based on changes in topography. Aerial photographs and one-foot topographic contours were used to support the development of geomorphic surface boundaries. Several topographic factors were considered when delineating geomorphic surfaces using contours. Elevation changes were identified by tight groupings of contours. Abrupt changes in elevation are indicative of two different geomorphic surface boundaries. The best example for Elliott Ditch elevation change is the steep slope associated with the valley wall between the geomorphic surfaces in the floodplain and the upland area outside of the floodplain. Subtle changes in topography were also used in the delineation. For example, broad surfaces of relatively uniform elevation were delineated as the same surface.

Information related to geologic history and past anthropogenic activities were reviewed to understand past influences on the fluvial process. Historical information was obtained from public records and published literature sources. The historical information was used to relate evolution and formation to past development and constituent release over time. The information discussed in the preliminary geomorphic analysis, including the historical aerial photographs, was used to support the historical analysis. Industrial and urban development, structures (e.g. dams, channel alignment), and watershed condition including land use change from agricultural to industrial were incorporated in the geomorphic surface mapping.

To assist in data analysis and mapping, a milepost system was developed for Elliott Ditch using GIS. The stream channel was digitized using the most recent aerial photos and used as an input for a GIS tool that creates equally spaced points based on a user-defined distance. The distance between mileposts for Elliott Ditch is 0.10 miles (Figure 1, Appendix A).

3.2 FIELD TASKS

Tetra Tech conducted work in 2014 to perform a topographic field survey of the lower reaches of Elliott Ditch. The survey was performed within the Elliott Ditch stream channel and the adjacent Federal Emergency Management Agency (FEMA) mapped 100-year floodplain. The survey was conducted along 66 transects on Elliott Ditch from Alcoa's Outfall 001 to the confluence with Wea Creek, a distance of approximately 4.10 miles (Figure 2, Appendix A). Field work was completed in coordination with TBIRD Design Services Corp., a professionally licensed survey company based in Lafayette, IN. TBIRD provided notification to landowners within the survey area prior to the start of field work.

Tetra Tech conducted the field activities in two mobilizations. In mid-March, the upper 0.5 miles from Outfall 001 to the railroad bridge was surveyed. In mid-November, the remaining 3.6 miles from the railroad bridge to the confluence with Wea Creek were surveyed. The field crew consisted of one TBIRD survey crew chief and one Tetra Tech geomorphologist.

The methods used to conduct the topographic survey are described below.

3.2.1 Topographic Survey Data Collection

Tetra Tech and TBIRD collected topographic survey data to support the geomorphic surface mapping during leaf-off conditions. Collecting surface boundary information during periods of sparse vegetation increases surface boundary visibility in the field.

A Real Time Kinematic Global Positioning System (RTK-GPS) and total station were used to collect topographic survey data in Indiana State Plane West (NAD83 datum) coordinate system.

The linear units were collected in US survey feet and the horizontal and vertical accuracy was set to a tolerance of ten centimeters.

Survey point data was collected at the following locations on each transect:

- Top of the water surface
- Top of sediment surface in the thalweg
- Edges of stream channel
- Top of channel banks
- Edge of escarpments marking the boundaries between stream terraces or floodplain surfaces
- Edge of FEMA mapped 100-year floodplain boundaries
- A location that is approximately half the horizontal distance from the channel banks to the 100-year floodplain boundaries

3.2.2 Geomorphic Surface Mapping Field Confirmation

Desktop geomorphic surface mapping provided a preliminary estimate of the geomorphology of Elliott Ditch. A field assessment of geomorphic surfaces was required to confirm the surface boundaries. The preliminary geomorphic surfaces were mapped from one-foot contours derived from ten meter DEMs. All data derived from secondary sources like DEMs have inherent inaccuracies. Field confirmation of surfaces reduces the errors introduced by the secondary datasets.

Geomorphic surface boundaries were confirmed by evaluating elevation changes at the edges of surfaces (e.g. terrace scarps) observed in the field. Additionally, anthropogenic features were identified or confirmed and incorporated into the geomorphic surface mapping.

A photo log was developed to document the channel morphology and sequence of geomorphic surfaces at each survey transect as well as photograph any significant natural or anthropogenic impacts to stream flow. Site photographs are provided in Appendix B.

4.0 RESULTS

The results of the desktop and field activities completed in 2013 and 2014 are presented below.

4.1 GEOMORPHIC HISTORY OF WABASH RIVER BASIN

Elliott Ditch is located in the Wabash River Basin in Tippecanoe County, IN, and flows west into Wea Creek, a tributary of the Wabash River. The streams of the Wabash River Basin formed in glacial outwash deposited during the Pleistocene epoch. During the Pleistocene, various glaciations leveled plains and filled in valleys, resulting in a gently undulating plain. As glaciers receded, meltwater streams cut drainage ways and stream valleys that drain toward the Wabash River. The streams draining the Wea Plains (which includes Elliott Ditch), were formed after glaciers receded from the area. Generally, the topography of the area is relatively unchanged by stream development since glaciation, as most streams are typically shallow and have gently sloping gradients. Glacial landforms (e.g. kames, eskers, swales, etc.) are plentiful (USDA, 1958).

Review of the aerial photographs provided by Alcoa reveals that Elliott Ditch formed sometime before 1939; the Ditch is clearly visible in the 1939 aerial photo. The 1939 aerial suggests that at least part of Elliott Ditch originated as a naturally formed stream that was later modified by human activity. The stream appears to be free flowing and naturally meandering along the western portion of the stream in 1939. Some channelization may have occurred prior to the photo because the stream channel appears abnormally straight where Elliott Ditch crosses the railway.

4.2 GEOMORPHIC SURFACE MAPPING

Geomorphic surface mapping is an iterative, science-based process that uses multiple lines of evidence to assess the erosional/depositional pattern in streams. Flowing bodies of water have specific characteristics resulting from factors that affect flow regime. Channel gradient, width, and geometry, bed texture, water velocity, valley wall width, watershed soil type, and anthropogenic features all affect the flow of the water and the resulting geomorphology. To interpret stream geomorphology as a cohesive system, geomorphologists look at the flow regime factors and organize streams into river reaches and further into geomorphic surfaces for both the in-channel and overbank areas.

For Elliott Ditch, river reaches were developed based on similarities (within a reach) and differences (between reaches), resulting in areas grouped by broad depositional characteristics. The factors used to define the Elliott Ditch reaches were channel gradient, sinuosity, land use, and geomorphic surfaces. The Elliott Ditch reaches are further described in Section 4.3.2.

Overbank geomorphic surfaces were initially based on their spatial and topographic relationships including topography, proximity to the river, and the elevation differences between the surfaces. Aerial photographs were used to determine anthropogenic influences to stream function. Additional anthropogenic impacts (not visible on the aerial photos) and surface soil development were incorporated into surface boundaries during the field confirmation process. Other lines of evidence incorporated during the field process include evidence of high water (e.g. high water marks, sediment deposited over vegetation, etc.), and differences in vegetation cover.

The results of the desktop and field confirmed geomorphic surface mapping are presented below.

4.2.1 Geomorphic Surface Mapping Results

Floodplains are areas of low-lying ground directly adjacent to streams subject to regular flooding. Floodplains typically have relatively young soils formed in river sediments. Based on topography and the relative lack of soil development, the lowest surfaces in the overbank were categorized as floodplain (Figure 3, Appendix A). Approximately 0.2 acres of floodplain were mapped adjacent to Elliott Ditch.

The other surfaces mapped were stream terraces. Stream terraces are the remnants of historic floodplains that existed at a time when a stream was flowing at a higher elevation than present. Streams down cut into sediments and/or bedrock and create new floodplains over time. This process results in a series of stream terraces that reflect the stream's channel at a given point in the history of the stream. These surfaces are denoted by increasing elevations relative to each other. Terraces are typically level, discontinuous surfaces along the sides of the stream valley. Each surface that has the same relative elevation above the stream is given the same designation. In fluvial geomorphology, the terrace 1 (T-1) is the geomorphic surface with an elevation immediately above that of the floodplain. Each surface higher in elevation from the T-1 is sequentially numbered in ascending order (i.e. T-2, T-3, T-4, etc.). The lower numbered terraces are considered to be younger surfaces (i.e. the most recent active floodplain of a stream). The highest numbered terrace is the oldest surface. Within the portion of the Elliott Ditch valley mapped for this task, a total of seven stream terraces were identified.

Below is a summary of the area in square feet (ft^2) and acres of each geomorphic surface mapped within the Elliott Ditch valley from Outfall 001 to the confluence with Wea Creek.

Geomorphic Surface	Area (ft^2)	Acres
Floodplain	10,068	0.2
T-1	194,823	4.5
T-2	3,923,312	90.0
T-3	604,721	13.9
T-4	583,998	13.4
T-5	290,788	6.7
T-6	776,714	17.8
T-7	28,020	0.6
TOTAL	**6,412,444**	**147.1**

The preservation of active floodplain and T-1 surfaces along Elliott Ditch appears to be extremely rare. Combined, they account for less than 5 acres of the 147 acres mapped. The floodplains found along Elliott Ditch appeared to be mainly erosional surfaces based on the abundance of coarse grain material found on this surface with little to no vegetation cover. Often, the floodplains consisted of surfaces of sand and/or gravel. Based on this evidence, the floodplain appears to be inundated by flood waters at a high frequency. Surface soils on the T-

1 were typically loosely consolidated sandy material, suggesting relatively limited soil development. Some patchy vegetation, such as forbs and groundcover, covered the T-1 surface, implying the surface is likely flooded several times per year.

The T-2 surface comprised the largest portion of the surfaces mapped along Elliott Ditch, 90 acres in total. Based on the exposed soils of the T-2 along the stream, soils appeared to be fully developed. Vegetation on the T-2 surface consisted of forbs, shrubs and trees. Flood debris, such as organic detritus and garbage, was often present on the T-2 surface, suggesting that flood waters reach that elevation on occasion.

The remaining stream terrace surfaces comprise about 52 acres. These surfaces all displayed well developed soils and vegetation included groundcover, shrubs and trees, indicating rare inundation by floodwaters.

4.2.2 Geomorphic Interpretation

The overbank depositional pattern for Elliott Ditch is a result of elevation and proximity to the channel. Sediment deposition will decrease as distance from the stream and elevation increase. For example, older terraces like the T-5 will flood less often than the T-2 terrace, because the T-5 is higher in elevation. Higher elevations require larger floods to become inundated and subject to sediment deposition.

The floodplain and younger terraces that are flooded during the one and two year flood events will have the most sediment deposition. The floodplain is not vegetated, suggesting it is inundated regularly. Additionally, the surface soils on the floodplain are typically coarse grained (i.e. sand, gravel, cobbles), suggesting fine-grained materials (silt, clays) have eroded away during high-velocity flood events. In Elliott Ditch, the floodplain is an erosional surface rather than a depositional surface.

The in-channel depositional pattern for Elliott Ditch is characterized by pool and riffle systems common in running water bodies. Streams develop pool and riffle systems based on channel gradient, water velocity, channel width, sinuosity (a stream's tendency to move back and forth across its floodplain, in an s-shaped pattern, over time), and bed type. The pools are deeper areas of the stream that have a reduced water velocity, resulting in a depositional area. The riffles are shallow parts of the stream with steeper gradients and higher water velocities, resulting in erosional areas.

The geomorphic surface mapping completed for Elliott Ditch suggests that Elliott Ditch has eight distinct reaches (erosional/depositional regimes):

- Reach 1: Outfall 001 to just downstream of the railroad bridge (Transects 1-14)
- Reach 2: Transect 14 to the South 18th Street Bridge (Transect 19)

- Reach 3: South 18th Street Bridge to just upstream of the 9th Street Bridge (Transects 19-30)
- Reach 4: South 9th Street Bridge (Transect 30) to Transect 39, located north of Brookside Drive
- Reach 5: Transect 39 to Transect 50 (located downstream of Poland Hill Road)
- Reach 6: Transect 50 to Transect 60 (located just downstream of the Old Romney Road Bridge)
- Reach 7: Transect 60 to Transect 64 (located just upstream of US Highway 231 South Bridge)
- Reach 8: Transect 64 to Transect 66 (Elliott Ditch –Wea Creek confluence)

Reach 1 of Elliott Ditch is characterized by a relatively straight channel, steep valley walls, and no stream terraces (Figure 2, Appendix A). The longitudinal profile (Figure 4, Appendix A) for Segment 1 indicates a relatively shallow gradient (0.4 feet/mile) compared to downstream reaches. While some erosion is occurring along the channel banks and immediately downstream of the outfall, deposition is occurring within the stream in pools in areas of relatively fine-grained sediment. The erosional/depositional areas of Reach 1 are presented in Figure 5 (Appendix A).

Reach 2 of Elliott Ditch is characterized by a straight channel and a steeper channel gradient of approximately 8 feet/mile (Figure 4, Appendix A). The north side of the channel is upland, but the south side has a preserved T-4 terrace adjacent to the ditch. Deposition in this reach may occur on the T-4 terrace after large flood events and locally in-channel associated with pools.

Reach 3 has a relatively straight channel with only minor meandering. The channel banks are steeper than in Reach 2 and the channel gradient is similar (8 feet/mile). Elliott Ditch has a deeply incised channel and steep channel banks in Reach 3. T-6 and T-7 terraces are preserved adjacent to both sides of the ditch. Additionally, a T-5 terrace is present on the north side of the ditch at the downstream end of the reach. Deposition in the overbank is unlikely except for large flood events; in-channel deposition will be limited to the pool areas.

Reach 4 is the first naturally occurring reach of the ditch downstream of Outfall 001, featuring meanders and increased sinuosity compared to upstream reaches. Channel gradient increases to 20 feet/mile. Terraces adjacent to the ditch include T-4 through T-6, indicating steep banks. Deposition in the overbank is still limited to larger flood events.

Reach 5 is similar to Reach 4 in channel gradient and sinuosity; however, Reach 5 has the T-2 through T-4 terraces preserved adjacent to the ditch. The terrace segments are smaller than upstream and their development is more affected by the sinuosity. The terraces on the inside of the meander bends are fairly well preserved, with depositional point bars often found at the apex of the meanders. This reach has more potential for overbank deposition than Reaches 1 – 4 due to the sinuosity of the ditch and the lower elevation terrace development.

Reach 6 is characterized by an increased gradient relative to upstream reaches (28 feet/mile) and an increase in valley wall width. The broader valley allows terrace development and promotes overbank deposition as the ditch meanders over time. The terrace sequence ranges from T-1 to T-6 terraces. The lower terraces are subject to overbank deposition.

Reach 7 has a similar channel gradient to Reach 6 and a broader valley width. Terrace development in Reach 7 is limited to T-1 through T-3. Reach 7 has potential for overbank deposition because the terraces are relatively low in elevation and the valley is wide.

Reach 8 has a similar channel gradient and amount of terrace development as Reach 7. However, several geomorphic and anthropogenic factors result in an erosional environment in Reach 8. Wea Creek has eroded an outside meander upstream of the bridge, moving the confluence with Elliott Ditch east. The channel banks are high, limiting flood waters outside of the channel and increasing erosion potential in-channel. Further, the US 231S Bridge constricts the channel, increasing water velocity and erosion potential during flood events. For example, a historic point bar under and downstream of the US 231S Bridge, predominately composed of sand and cobbles, suggests fine-grained materials have eroded away.

4.2.3 Geomorphic Interpretation of Historic Data

A review of the most recent historic sediment data provides some insights into the geomorphology of Elliott Ditch. The Anchor 2004 and 2010 sample locations ranged from upstream of Outfall 001 (#2) to the Veterans Parkway/Co Road 350 S Bridge (#9) (Anchor, 2013). This discussion is limited to the sampling locations inside the current project area (locations 3-9). Anchor sampling locations are presented on the geomorphic surfaces in Figure 6 (Appendix A). The geomorphic analysis of historic data is summarized below.

4.2.3.1 Sampling in Erosional Areas

Several Anchor sample locations were placed in erosional environments such as the downstream side of bridges and adjacent to Outfall 001:

- Locations 6-9 were placed at bridges
- Location 4-6 placed in dredged portion of Elliott Ditch (1990/1991) and between two bridges
- Location 3 was placed at Outfall 001

The conclusion from the results of these sample events suggests that natural recovery may be occurring; however, variability in PCB concentrations hindered trend observation (Alcoa, 2013). The variability in the data from the same locations between sampling events is the result of the sample location (erosional environments), anthropogenic features, and flood history. The data from the Anchor sampling events support the geomorphic interpretation for Elliott Ditch.

The increased gradient downstream, the historic point bar consisting of cobbles and gravel, and the amount of debris moving in the channel suggests high velocity water flow during flood events. The presence of several bridges will exacerbate natural flood processes ongoing in the channel. The dynamic nature of deposition and erosion at bridges requires a review of the flood history to understand whether the bridge area is in a low flow depositional mode or a post flood event erosion mode.

The overall distribution of geomorphic surfaces identified within the Elliott Ditch valley is displayed in Figure 3, Appendix A: Geomorphic Surface Map.

4.2.4 Example Sampling Locations

Example sampling locations were developed for Elliott Ditch based on the geomorphic surface mapping. Locations were placed to maximize sampling in depositional areas, with some locations placed to verify the absence of impacts (erosional areas).

The fate and transport characteristics of PCBs is important when determining the depositional pattern. The PCBs attach to silt and clay sediment particles and are transported as a silt and clay (soft sediment). The deposition areas for silt and clay need to have little to no water velocity to allow time for the silt and clay particles to settle out of the water column. These soft sediment depositional areas are the areas identified in the geomorphology approach.

The sample locations are divided into groups of transects with one location in-channel and one or two adjacent locations overbank, based on the stream morphology (Figure 5, Appendix A). The following summarizes the sample location rationale:

- Sample Transect 1 is placed along anthropogenic bank armoring. Areas upstream of bank armoring may be depositional because they are wider and thus have slower water velocities. The overbank locations will determine if spoils from past dredging activity are present along the top of the channel banks. The left-descending bank (LDB) of this section of Elliott Ditch has a fairly continuous levee that appears to be man-made. No levee is present on the right-descending bank (RDB); the sample location on the RDB will verify the absence of a man-made feature.
- Sample Transect 2 is located at a slight meander bend. The in-channel proposed sample location is on the inside of the meander bend (depositional surface). The overbank location is on the inside meander bend of the stable upland surface. This location is assumed to be relatively untouched by stream erosion and therefore, a good sample location.
- Sample Transect 3 is located near the upstream end of a depositional area (implied by a fine-grained sediment bed type). The overbank samples are located on upland surfaces with slightly different elevations. The LDB is slightly higher due to the presence of the levee. The RDB side is about 0.5 foot lower in elevation. If flooding reached the top of

the channel banks, the flood waters would naturally flow (and deposit sediment) towards the RDB.

- Sample Transect 4 is located just downstream of the depositional area. The in-channel sample here would confirm the absence of sediment deposition. The overbank sample locations on the RDB and LDB here are lower relative to the channel banks upstream, perhaps due to the anthropogenic impact of the railroad bridge.

5.0 SUMMARY

Elliott Ditch is a unique water body because the combination of natural stream evolution and anthropogenic activities have altered natural depositional/erosional processes. Typically, stream gradient decreases downstream as the channel erodes toward local base level. However, the gradient in Elliott Ditch increases downstream. Anthropogenic features such as the additional water from storm water outfalls and dredging downstream of Outfall 001, combined with glacial deposits that feature a significant amount of cobbles that armor the channel bed have resulted in a unique geomorphic environment in Elliott Ditch.

The geomorphic surface mapping suggest Elliott Ditch is regularly affected by high water velocities that limit sediment deposition in-channel. The majority of the overbank deposition is present on the lower terraces, T-1, T-2, and T-3. Large flood events could deposit sediment on the higher terraces. The primary area of overbank deposition is in the downstream reaches where the low terraces are present and the valley walls are wider.

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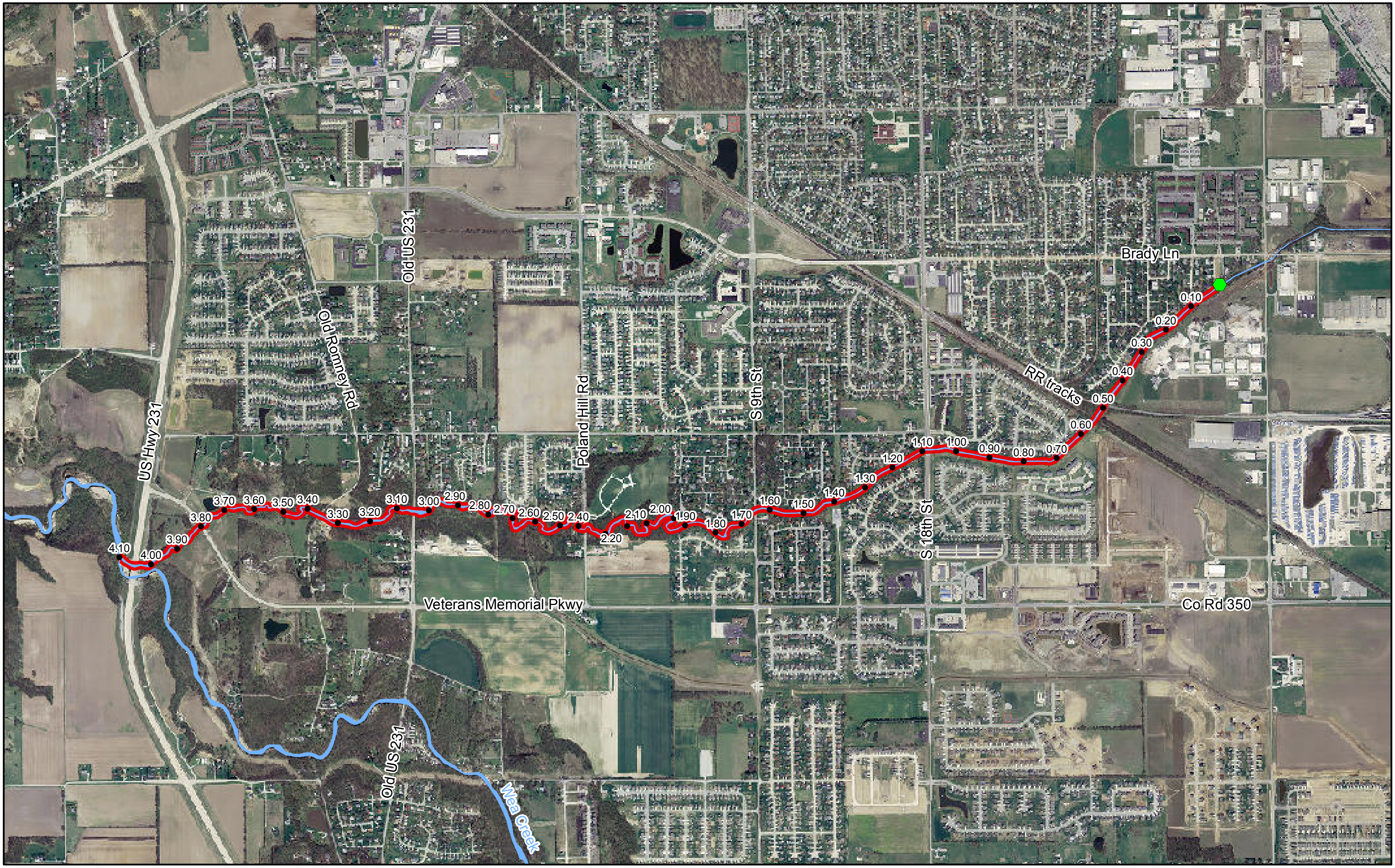
Appendix A

Figure 1

Overview – Elliott Ditch



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OVERVIEW - Elliott Ditch

- Outfall 001
- Milepost
- Survey Area

Drawn By: MEB
Date Created: 6/17/2013
Last Revised: 12/31/2014
Approved By: DBR
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File Path: F:\Alcoa Elliott Ditch\GIS\AlcoaElliottDitch.mxd

N 0 1,000 2,000 Feet
SCALE = 1:24,000

Appendix A

Figure 2

Stream Reaches and Survey Transects

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STREAM REACHES & SURVEY TRANSECTS - Elliott Ditch

		Stream Reach		
Outfall 001		Reach 1	Reach 3	Reach 6
Milepost		Reach 2	Reach 4	Reach 7
Transect			Reach 5	Reach 8

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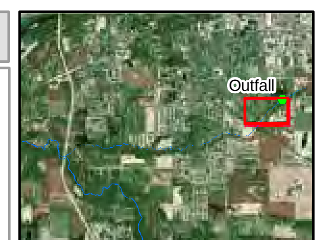

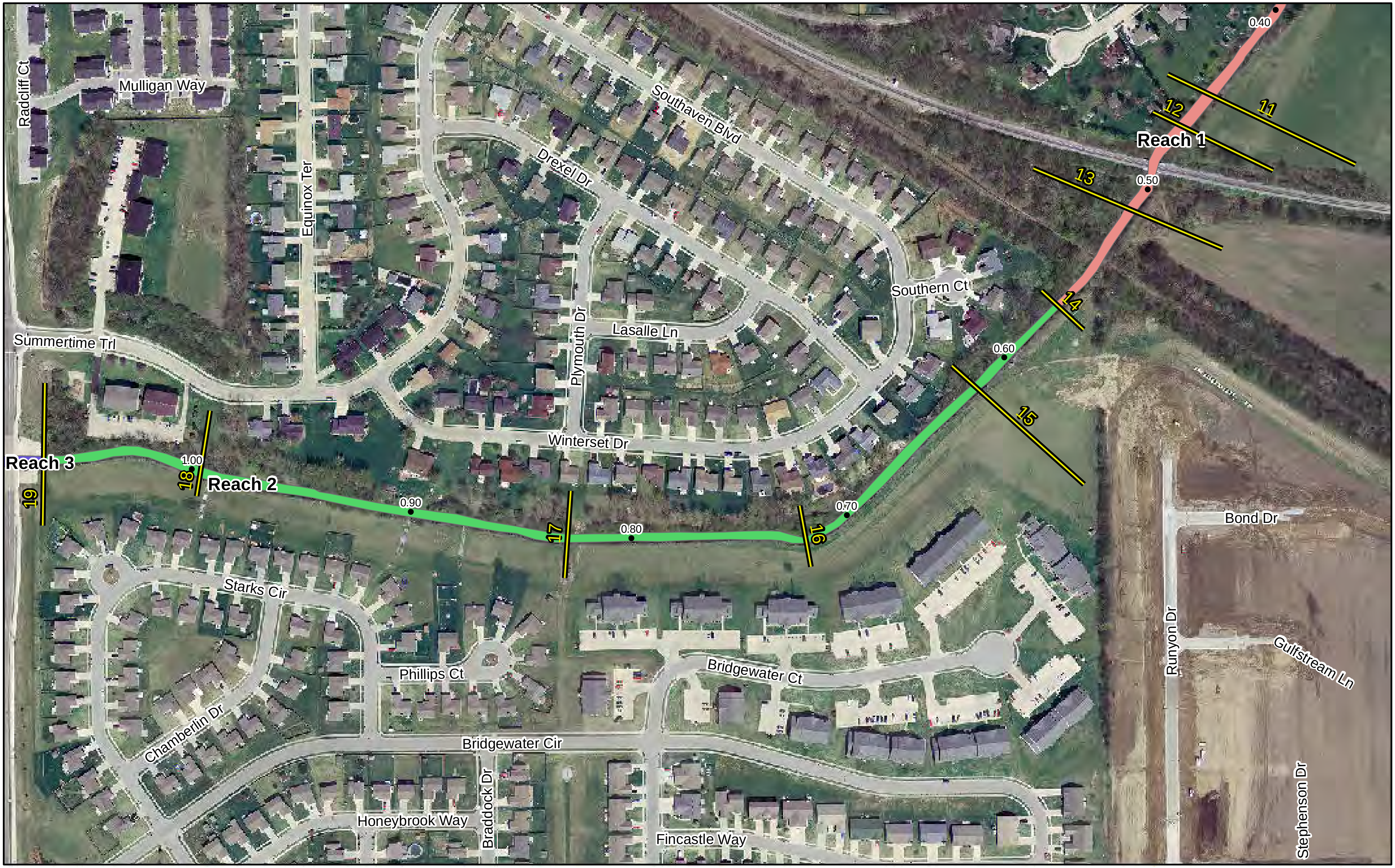

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STREAM REACHES & SURVEY TRANSECTS - Elliott Ditch

• Milepost

Transect

Stream Reach

Reach 1
Reach 2
Reach 3
Reach 4
Reach 5
Reach 6
Reach 7
Reach 8

Drawn By: MEB
Date Created: 6/17/2013
Last Revised: 12/30/2014
Approved By: DBR
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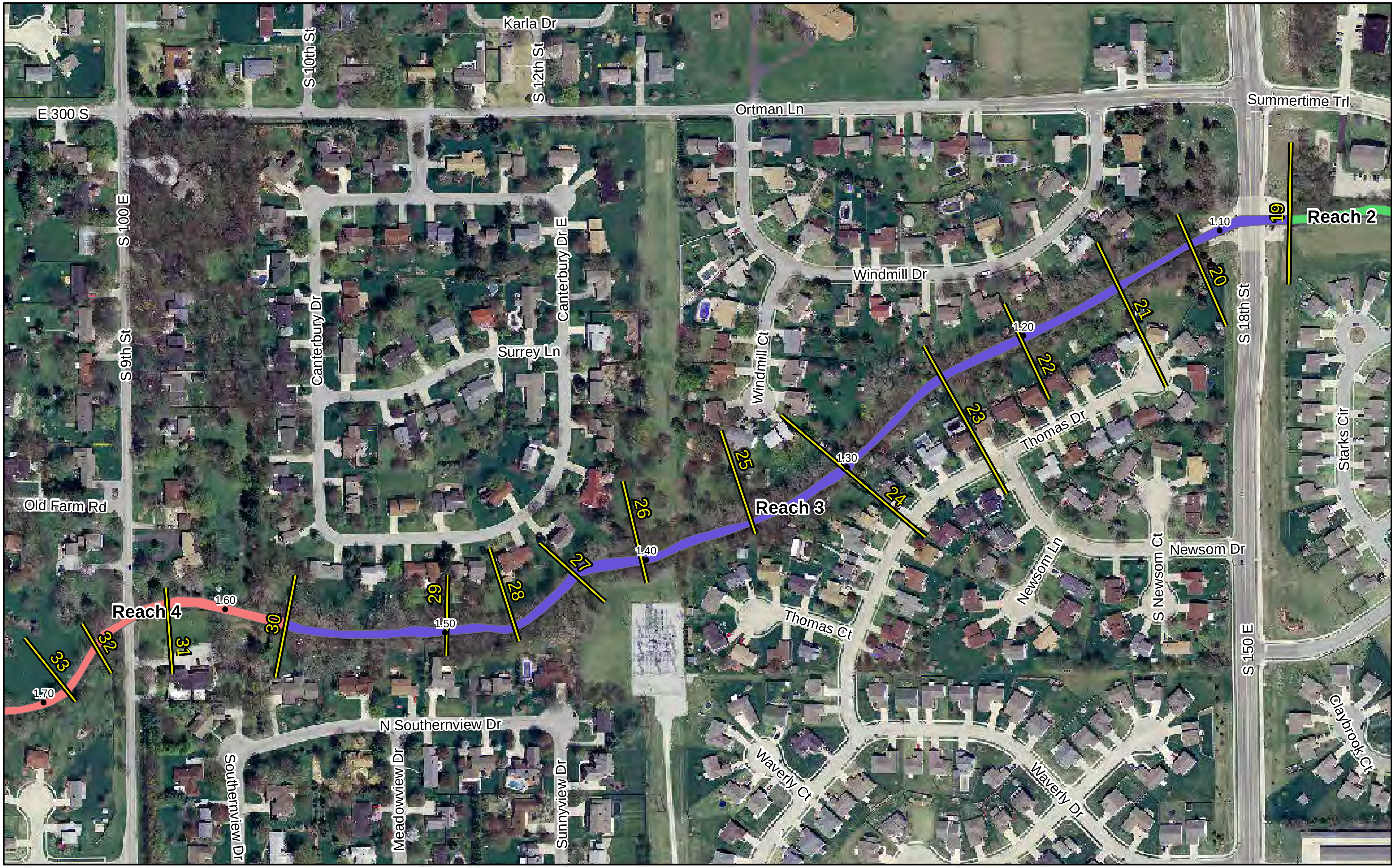

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STREAM REACHES & SURVEY TRANSECTS - Elliott Ditch

• Milepost

Transect

Stream Reach

Reach 1
Reach 2
Reach 3
Reach 4
Reach 5
Reach 6
Reach 7
Reach 8

Drawn By: MEB
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Last Revised: 12/30/2014
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SCALE = 1:3,690

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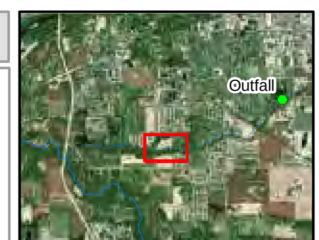
Fax: (920) 457-2357

STREAM REACHES & SURVEY TRANSECTS - Elliott Ditch

Milepost	**Stream Reach**	Reach 3	Reach 6
Transect	Reach 1	Reach 4	Reach 7
	Reach 2	Reach 5	Reach 8

N 0 150 300 Feet
SCALE = 1:3,690



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STREAM REACHES & SURVEY TRANSECTS - Elliott Ditch

• Milepost

Transect

Stream Reach

Reach 1
Reach 2
Reach 3
Reach 4
Reach 5
Reach 6
Reach 7
Reach 8

N 0 150 300 Feet

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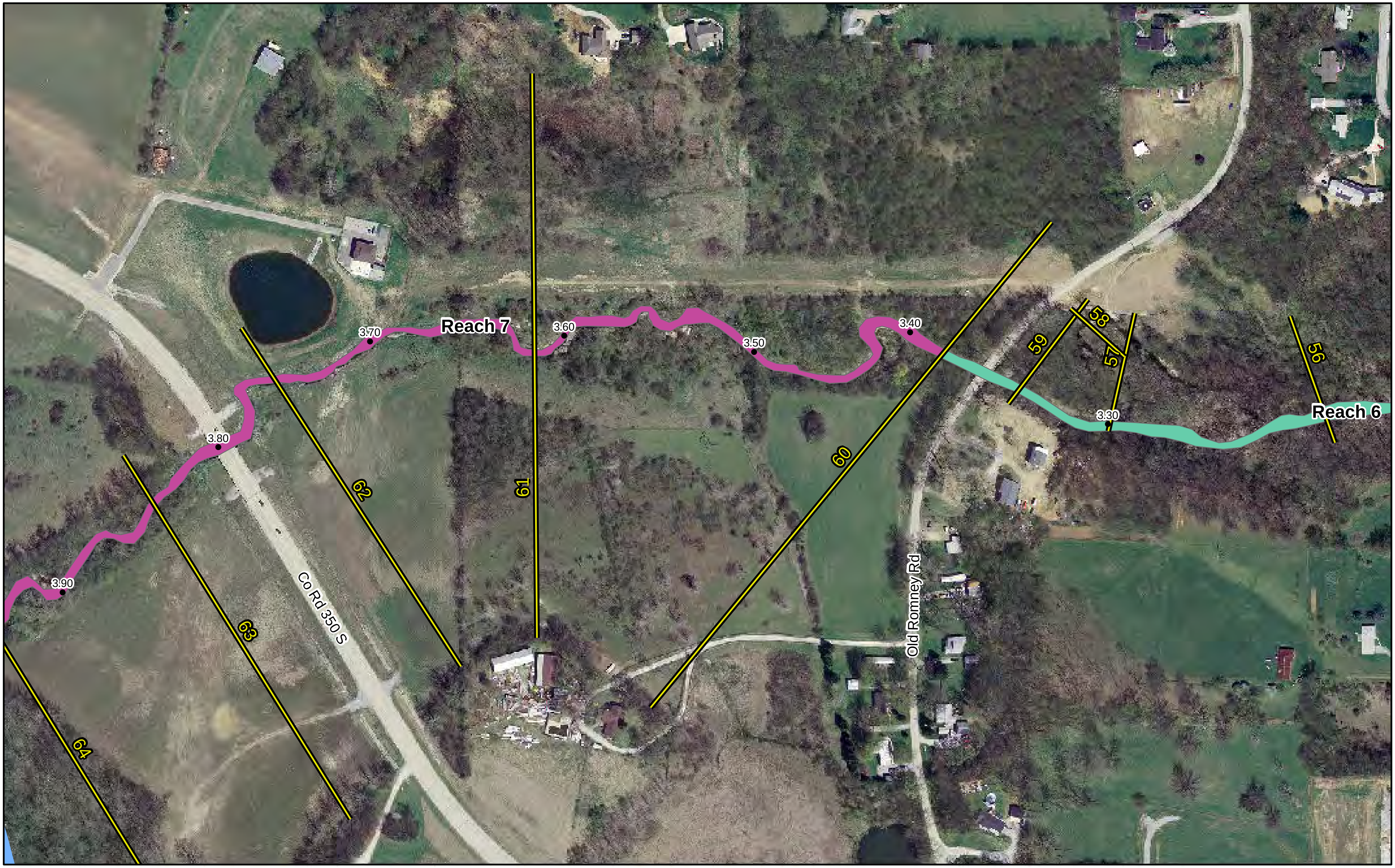

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STREAM REACHES & SURVEY TRANSECTS - Elliott Ditch

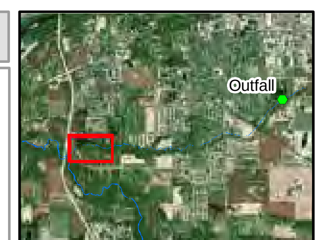
- Milepost
- Transect

Stream Reach

- Reach 1
- Reach 2
- Reach 3
- Reach 4
- Reach 5
- Reach 6
- Reach 7
- Reach 8

N 0 150 300 Feet

SCALE = 1:3,690



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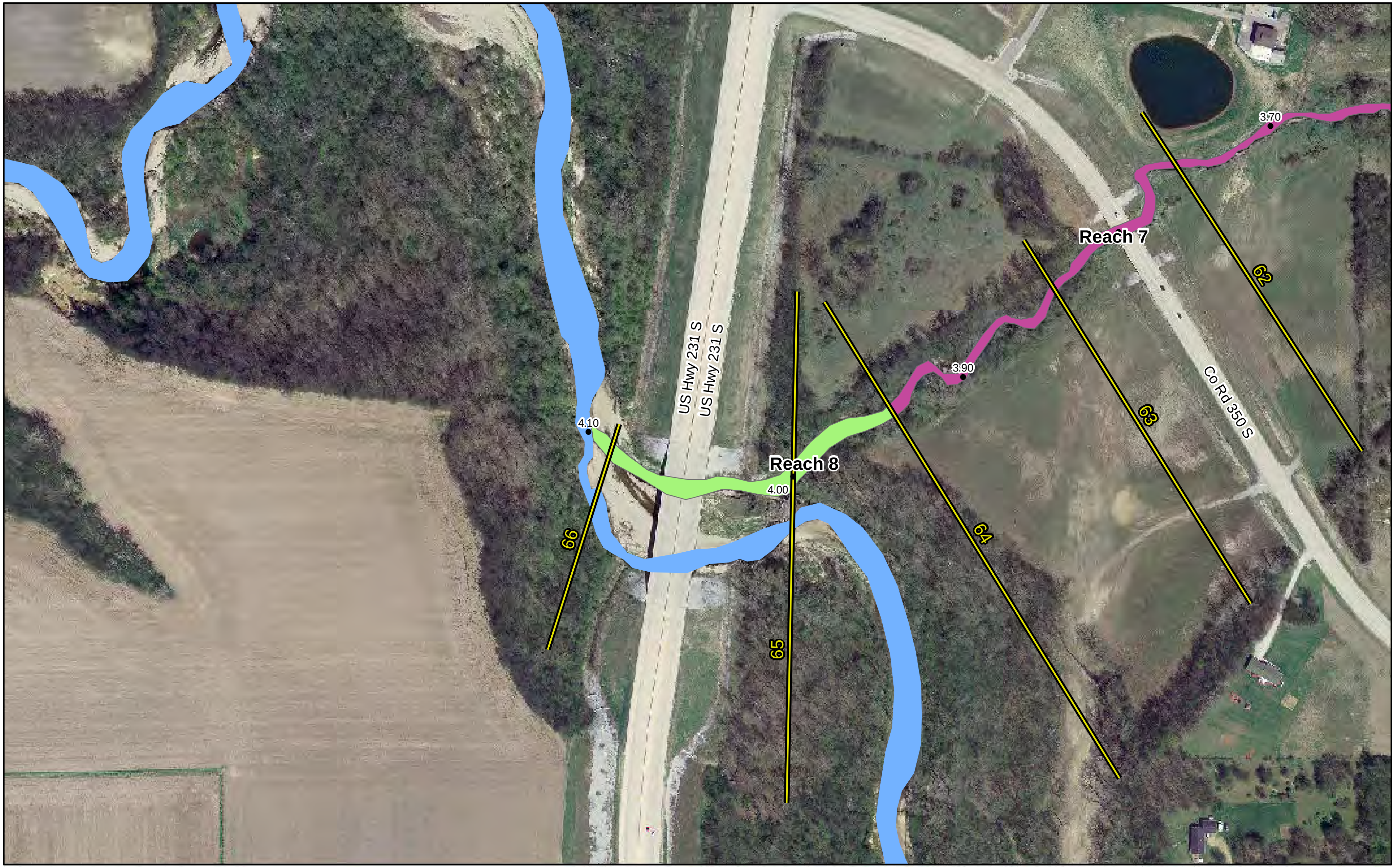

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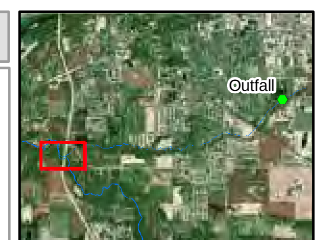
STREAM REACHES & SURVEY TRANSECTS - Elliott Ditch

• Milepost
Transect

Stream Reach
Reach 1
Reach 2
Reach 3
Reach 4
Reach 5
Reach 6
Reach 7
Reach 8



Appendix A

Figure 3

Geomorphic Surfaces

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GEOMORPHIC SURFACES - Elliott Ditch

Outfall 001
Milepost
Geomorphic Surface Boundary

Geomorphic Surface

stream	T-1	T-5	depression
floodplain	T-2	T-6	oxbow
	T-3	T-7	anthropogenic
	T-4		upland

Drawn By: MEB
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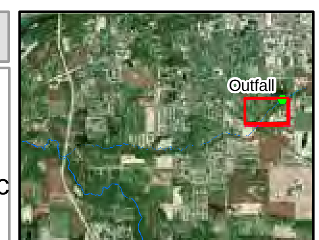

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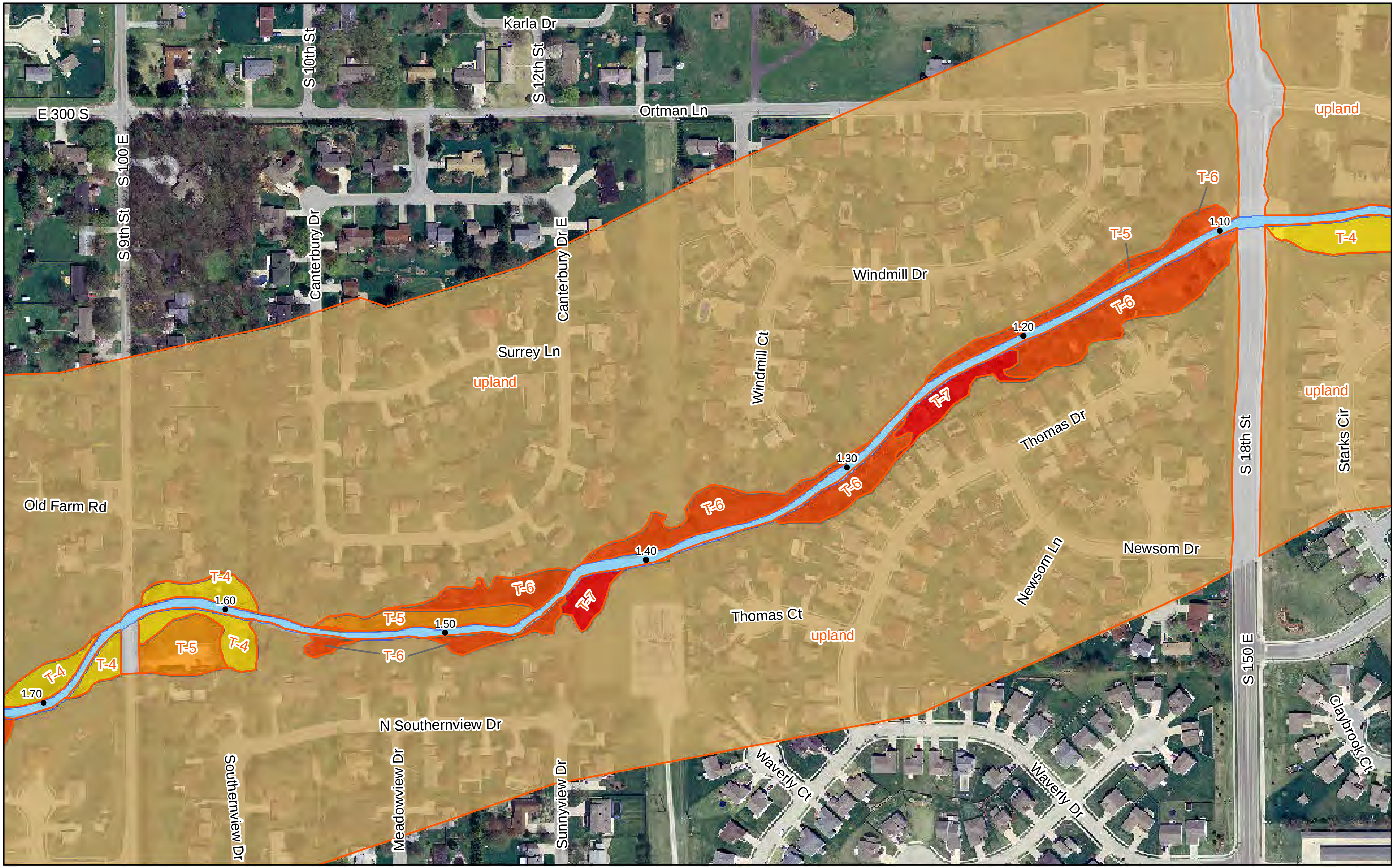
N 0 150 300 Feet
SCALE = 1:3,690

GEOMORPHIC SURFACES - Elliott Ditch

• Milepost
Geomorphic Surface Boundary

Geomorphic Surface
stream
floodplain
T-1
T-2
T-3
T-4
T-5
T-6
T-7
depression
oxbow
anthropogenic
upland



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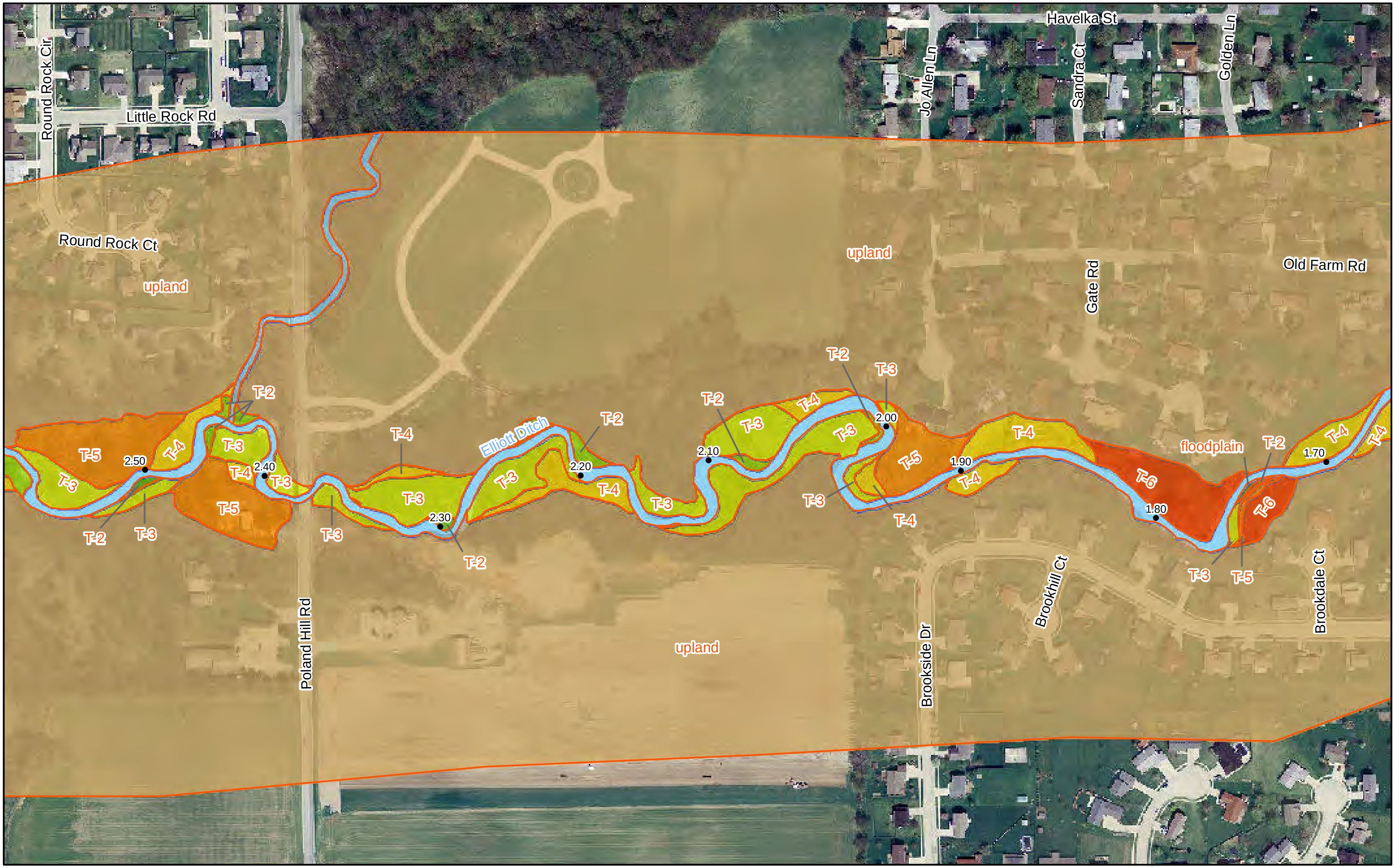
GEOMORPHIC SURFACES - Elliott Ditch

• Milepost

Geomorphic Surface Boundary

Geomorphic Surface

stream	T-1	T-5	depression
floodplain	T-2	T-6	oxbow
	T-3	T-7	anthropogenic
	T-4		upland



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GEOMORPHIC SURFACES - Elliott Ditch

• Milepost

Geomorphic Surface Boundary

Geomorphic Surface

- stream
- floodplain
- T-1
- T-2
- T-3
- T-4
- T-5
- T-6
- T-7
- depression
- oxbow
- anthropogenic
- upland

N 0 150 300 Feet

SCALE = 1:3,690

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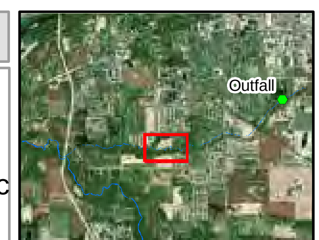

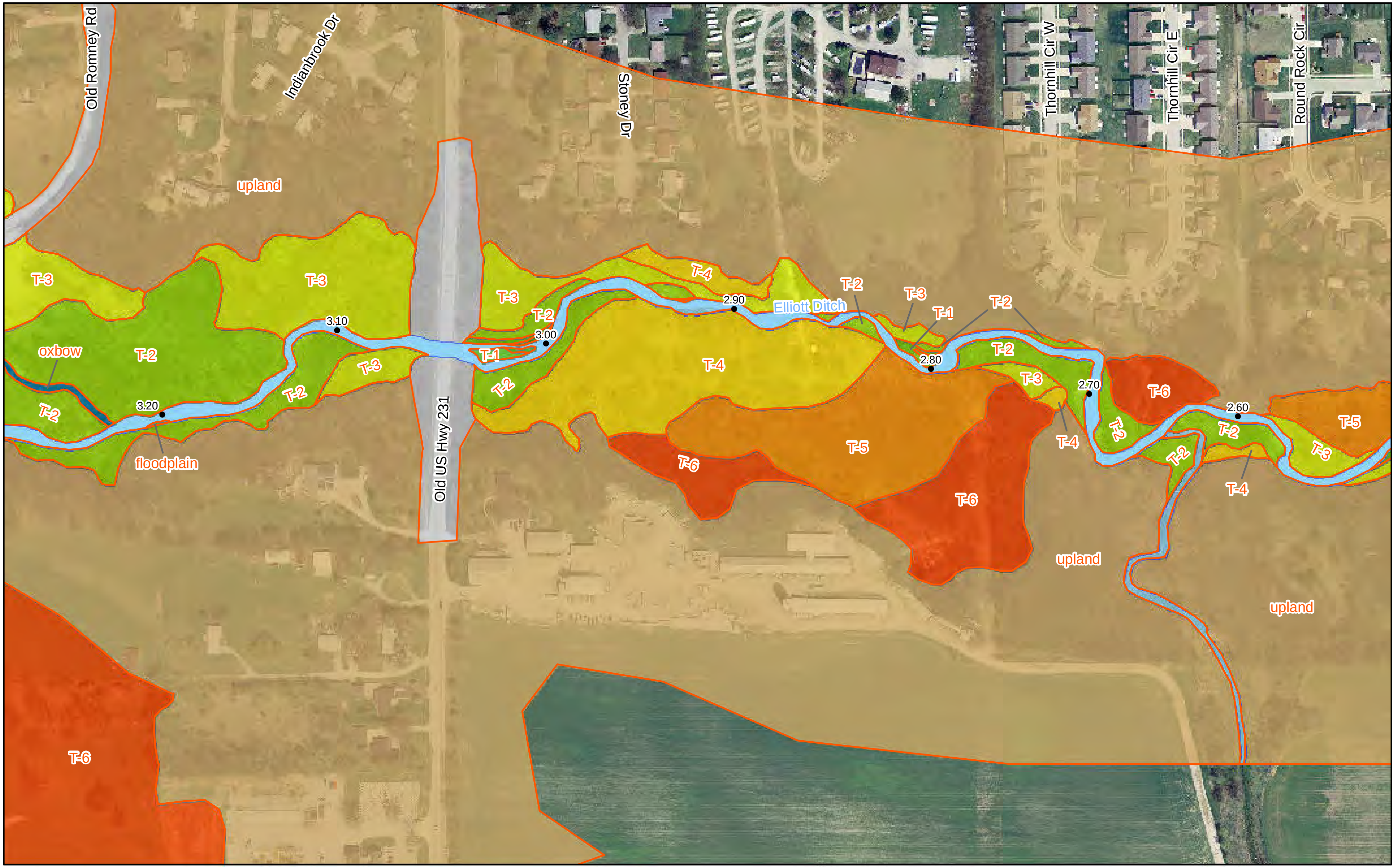

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N 0 150 300 Feet
SCALE = 1:3,690

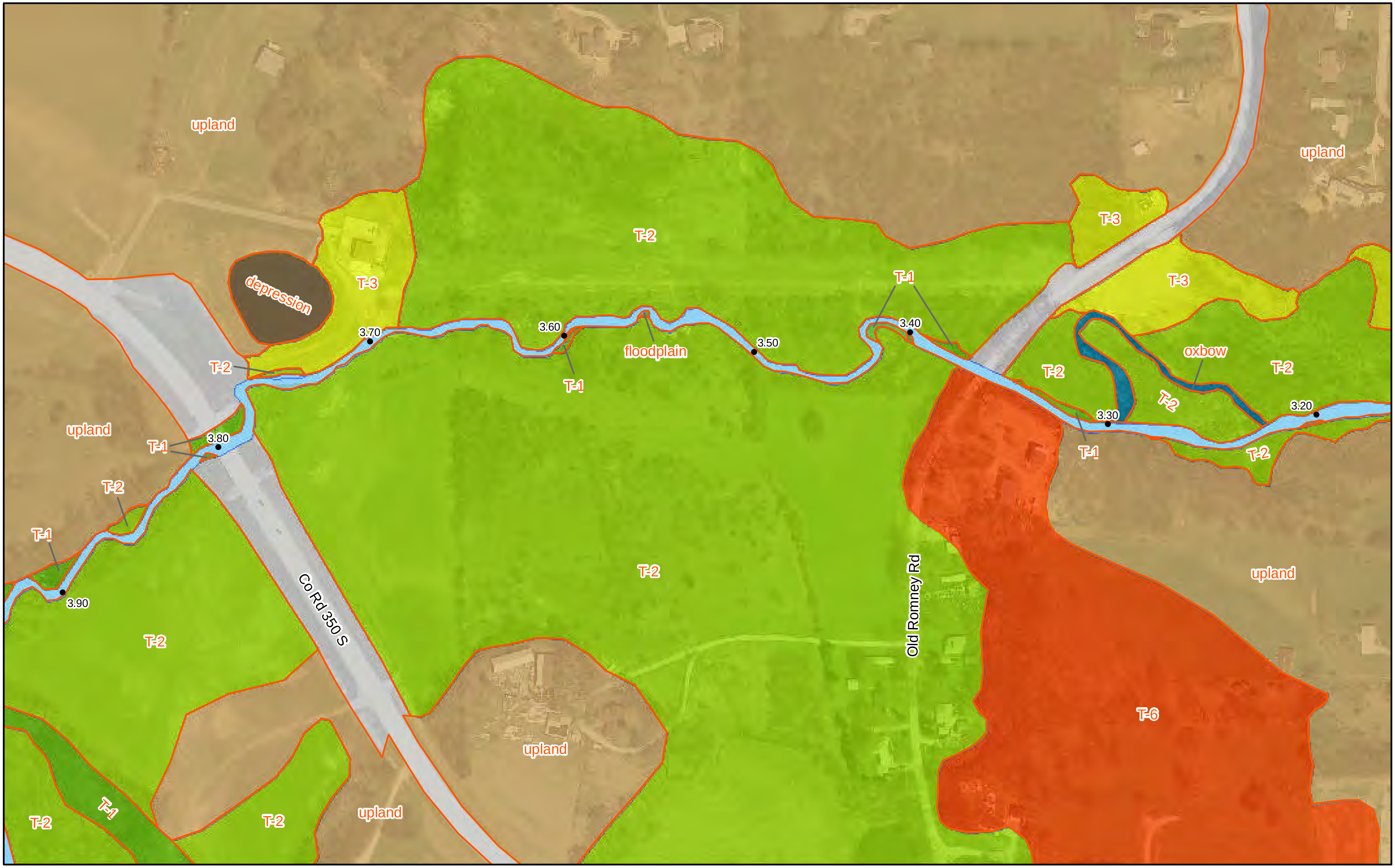
GEOMORPHIC SURFACES - Elliott Ditch

• Milepost
Geomorphic Surface Boundary

Geomorphic Surface

stream	T-1	T-5
floodplain	T-2	T-6
	T-3	T-7
	T-4	

depression
oxbow
anthropogenic
upland



GEOMORPHIC SURFACES - Elliott Ditch

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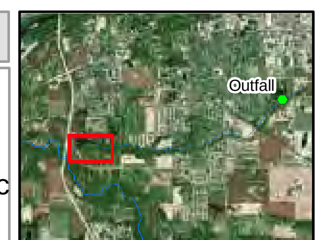
N 0 150 300 Feet
SCALE = 1:3,690

• Milepost
Geomorphic Surface Boundary

Geomorphic Surface
stream
floodplain
T-1
T-2
T-3
T-4
T-5
T-6
T-7
depression
oxbow
anthropogenic
upland



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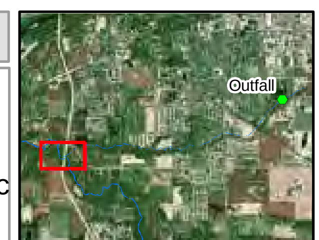
SCALE = 1:3,690

GEOMORPHIC SURFACES - Elliott Ditch

- Milepost
- Geomorphic Surface Boundary

Geomorphic Surface

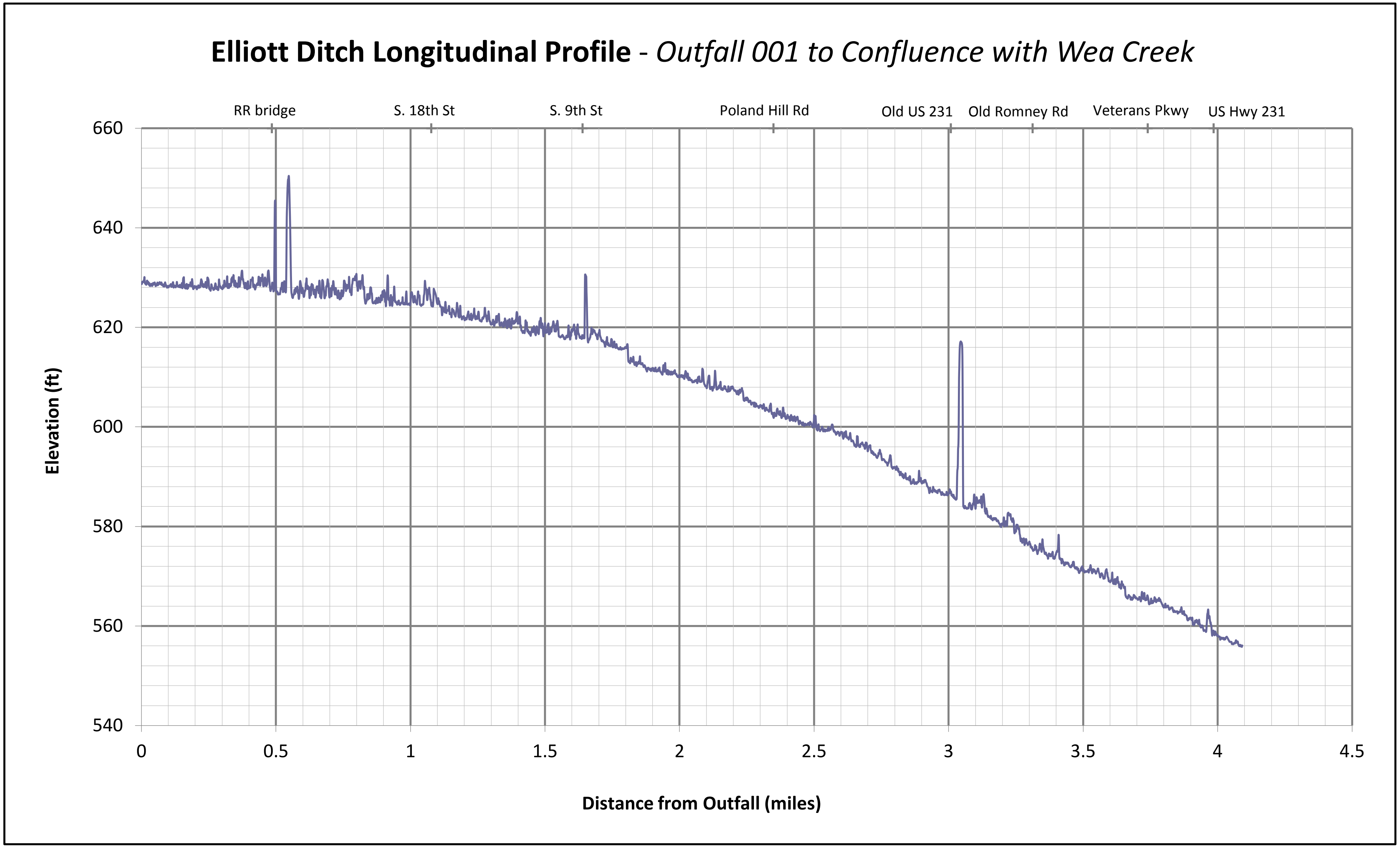
stream	T-1	T-5	depression
floodplain	T-2	T-6	oxbow
	T-3	T-7	anthropogenic
	T-4		upland



Appendix A

Figure 4

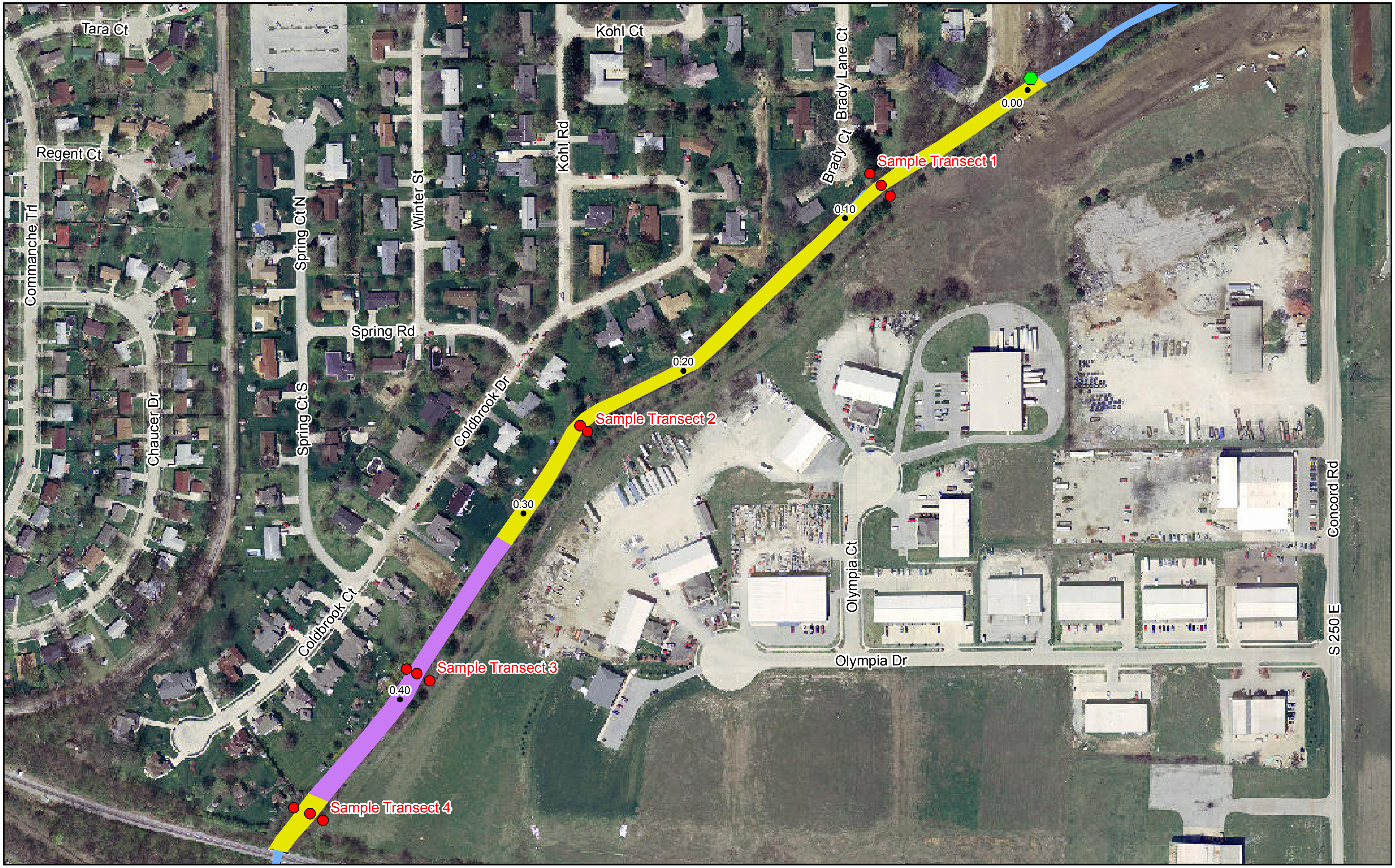
Longitudinal Profile


Elliott Ditch Longitudinal Profile - Outfall 001 to Confluence with Wea Creek
RR bridge
S. 18th St
S. 9th St
Poland Hill Rd
Old US 231
Old Romney Rd
Veterans Pkwy
US Hwy 231
Elevation (ft)
660
640
620
600
580
560
540
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
Distance from Outfall (miles)

Appendix A

Figure 5

Example Proposed Sample Locations and Erosion/Deposition Surfaces



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PROPOSED SAMPLE LOCATIONS & EROSION/DEPOSITION SURFACES - Elliott Ditch

- Outfall 001
- Milepost
- Proposed Sample Location
- Deposition Surface
- Erosion Surface

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Appendix A

Figure 6

Anchor Sample Stations and Geomorphic Surfaces

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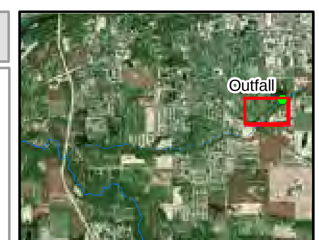
ANCHOR SAMPLE STATIONS & GEOMORPHIC SURFACES - Elliott Ditch

- Outfall 001
- Anchor Sample Station (approx. location)
- Milepost
- Geomorphic Surface Boundary

Geomorphic Surface

stream	T-1	T-5	depression
floodplain	T-2	T-6	oxbow
	T-3	T-7	anthropogenic
	T-4		upland

N 0 150 300 Feet
SCALE = 1:3,690



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ANCHOR SAMPLE STATIONS & GEOMORPHIC SURFACES - Elliott Ditch

Anchor Sample Station (approx. location)
Milepost
Geomorphic Surface Boundary

Geomorphic Surface
stream
floodplain
T-1
T-2
T-3
T-4
T-5
T-6
T-7
depression
oxbow
anthropogenic
upland

Drawn By: MEB
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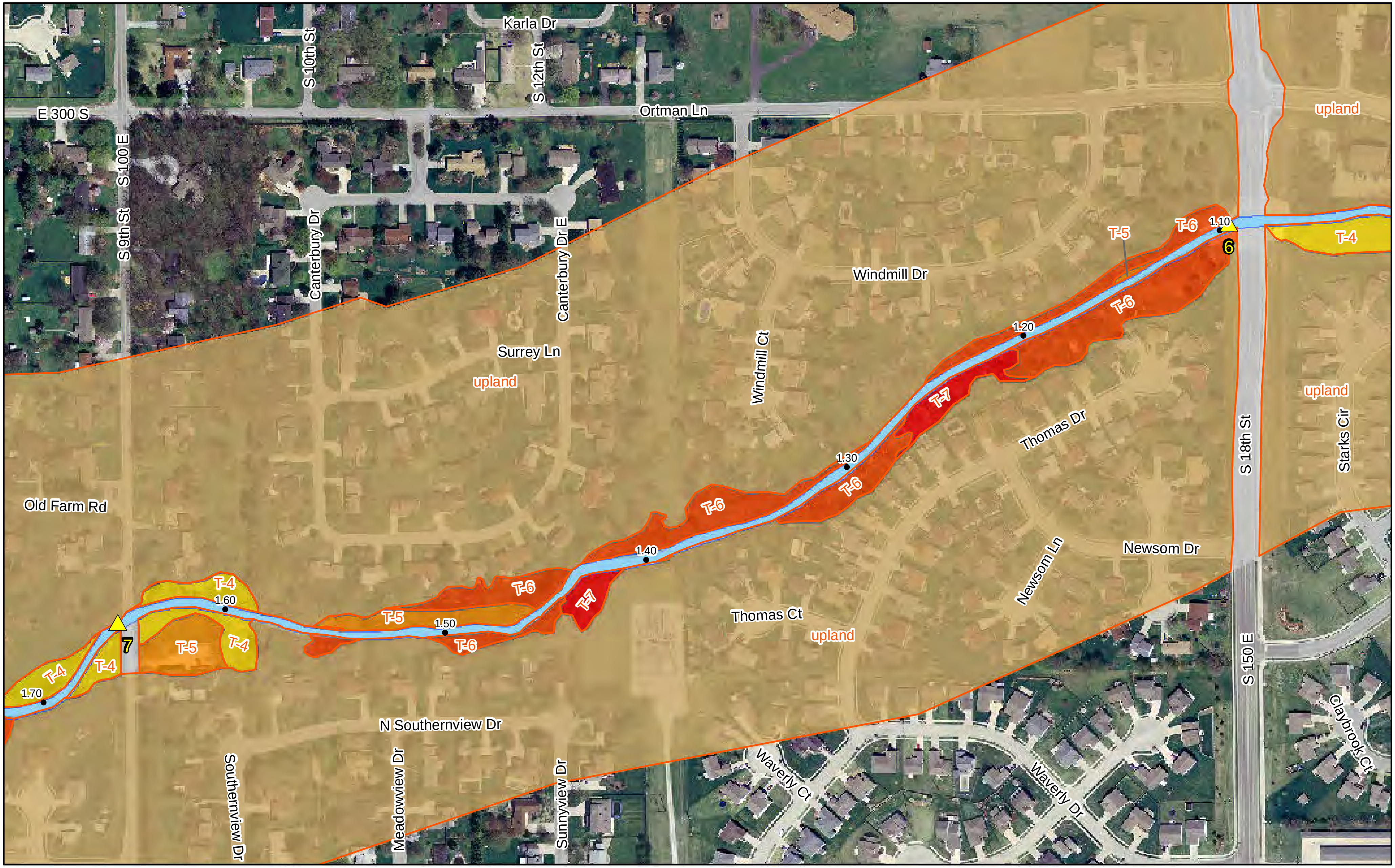

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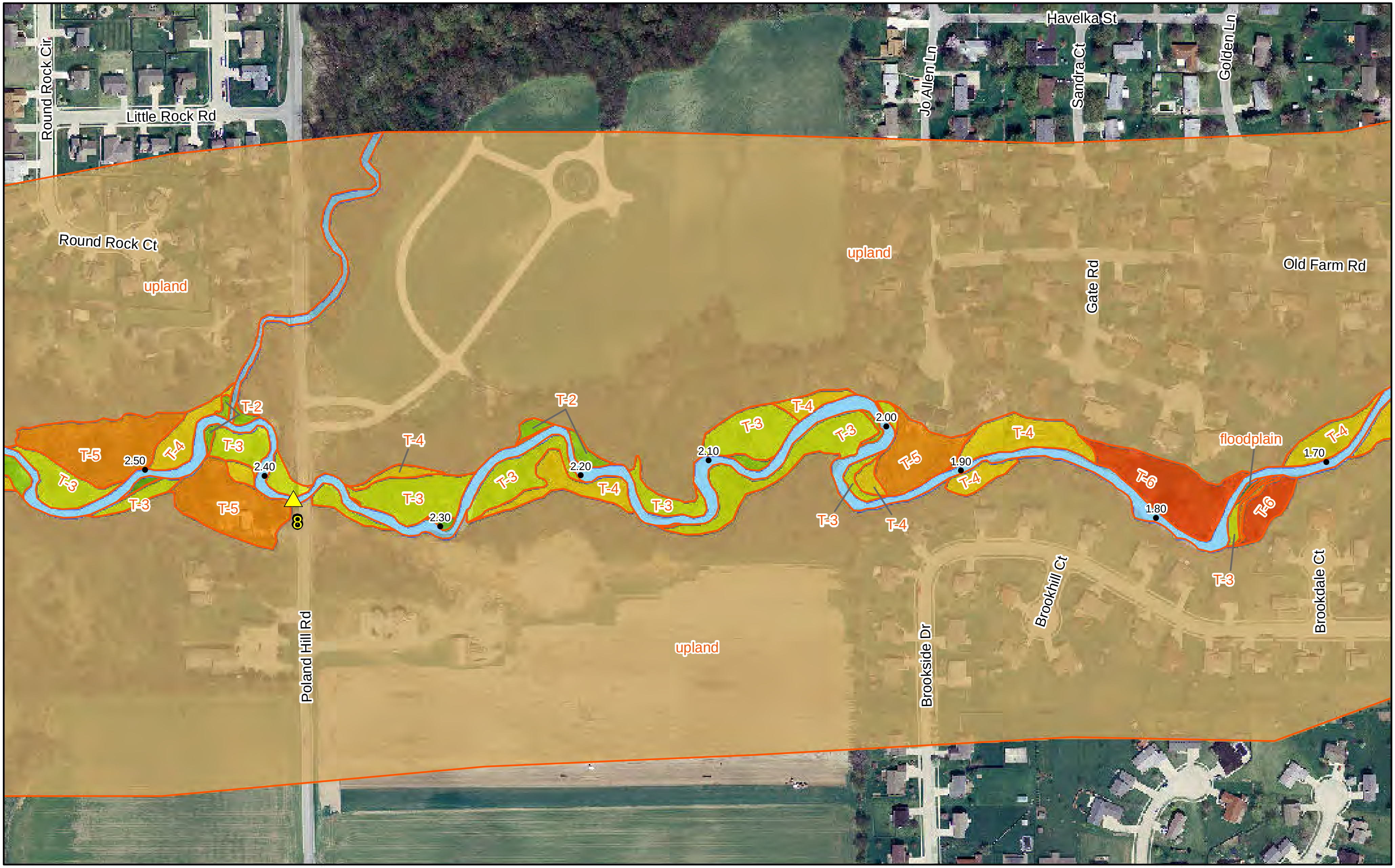
ANCHOR SAMPLE STATIONS & GEOMORPHIC SURFACES - Elliott Ditch

Anchor Sample Station (approx. location)
Milepost
Geomorphic Surface Boundary

Geomorphic Surface

stream
floodplain
T-1
T-2
T-3
T-4
T-5
T-6
T-7
depression
oxbow
anthropogenic
upland



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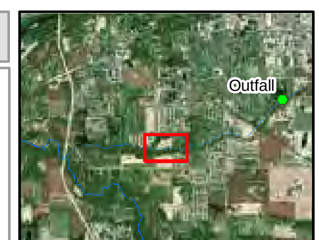
ANCHOR SAMPLE STATIONS & GEOMORPHIC SURFACES - Elliott Ditch

Anchor Sample Station (approx. location)
Milepost
Geomorphic Surface Boundary

Geomorphic Surface

stream
floodplain
T-1
T-2
T-3
T-4
T-5
T-6
T-7
depression
oxbow
anthropogenic
upland



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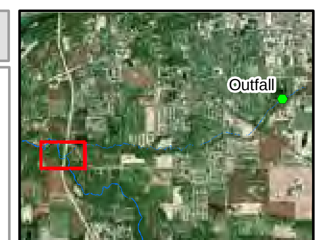
SCALE = 1:3,690

ANCHOR SAMPLE STATIONS & GEOMORPHIC SURFACES - Elliott Ditch

Anchor Sample Station (approx. location)
Milepost
Geomorphic Surface Boundary

Geomorphic Surface
stream
floodplain
T-1
T-2
T-3
T-4
T-5
T-6
T-7
depression
oxbow
anthropogenic
upland



Appendix B

Photographs

Photo 1: Two outfall culverts on RDB. These outfalls are located on transect 1 at Outfall 001.

Photo 2: Looking upstream from transect 12. Bank height on LDB (right side of photo) is ~ 10 feet. Top of the bank on LDB is the upland.

Photo 3: Looking upstream at active railroad bridge between transects 12 and 13. Stream bed consists of sand, gravel and cobbles. Poured concrete floor under bridge arches is completely exposed on RDB side bridge arch.

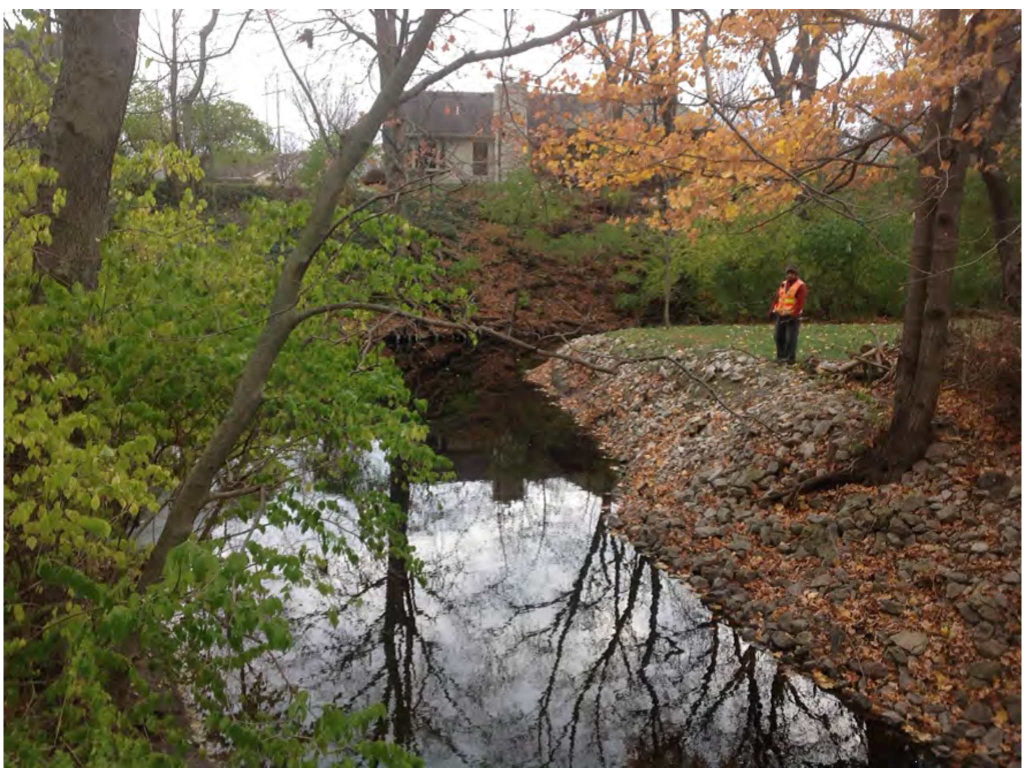


Photo 4: Looking downstream at transect 35. Person is standing on T-6. House in background is sitting on the upland.

Photo 5: Looking at LDB on transect 48. The bare sand in the foreground is the floodplain surface. The T-1 surface is covered with forbs and has flood debris (garbage) and leaf litter. The T-2 surface is in background and is covered by trees and shrubs.

Photo 6: Looking at upstream side of meander bend near transect 60. The cobble surface is the floodplain. A small T-1 is visible where the clump of brown vegetation is located. The T-2 surface is marked by the trees and shrubs on the left of the photo.

Photo 7: Looking at RDB near transect 62. ATV is parked on T-3 surface. The brown vegetation marks the T-2 surface and the T-1 surface is marked by the green vegetation by the edge of the channel.

Photo 8: Looking downstream near transect 39. Point bar in foreground has T-1 (bare gravel & leaf litter), T-2 (single tree), T-3 (exposed tree roots). Flood debris (garbage) is visible on the T-2 surface on the right of the photo. The house is sitting on the upland surface.

Photo 9: Looking at LDB near transect 25. Gravel surface in foreground is the floodplain. The trampoline is on the T-6 and the houses are located on the upland surface.

Photo 10: Looking upstream near transect 65. The sand and gravel surface in the middle of the photo is the floodplain. The T-1 is located on the right of the photo at one end of the protruding log. The T-2 is covered by trees and shrubs on both sides of the channel.

Photo 11: Old wooden bridge pylons and debris under the 9th Street Bridge.