

IDENTIFYING AND MAPPING TILE DRAINAGE TUTORIAL

WRIGHT COUNTY, IOWA

ABOUT THIS TUTORIAL

In this tutorial, you will learn to do the following:

- Become familiar with imagery collected for mapping tiled fields and the criteria necessary to collect this specialized imagery
- Learn techniques to identify and digitize tile lines using aerial photography and LiDAR hillshade
- Learn how identify and map tile intakes using aerial imagery

BACKGROUND

Approximately 95% of the nearly 4 million acres of wetlands located in Iowa's portion of the Prairie Pothole Region (PPR) are drained and farmed primarily for row crops. Many of these wetland basins are too wet to produce consistent crop yields and too dry to function as normal wetlands. In Iowa, there is little documentation on the location and extent of the privately built tile drainage infrastructure used to remove water from the landscape.

Drained wetlands and farm fields can be observed in high density within the PPR, and are drained by private and/or public drain tiles. The latter are managed by landowners within a county drainage district, which consists of a drainage network of a given area. On the other hand, the private drains are managed by landowners within their fields, and are installed according to the resources and needs of farmers. Despite the broad use of drainage systems in Iowa, there is no local or state agency responsible for recording or reviewing individual drainage plans. For this reason, a property owner can install any number of tiles, as long as their neighbors do not feel prejudiced. Therefore, a record of drainage systems could be a tool to help in dealing with potential conflicts between neighbors.

In addition, it is extremely important when planning the installation of new tiles to know the locations of existing tiles, and determine their compatibility within the field being drained. Therefore, the advantages of recording the positions of the tiles are numerous.

Photo-interpretation of color infrared aerial imagery can be used to map drainage tile patterns revealed after a heavy rainfall event. Previous research in Illinois and Indiana reported that the optimum conditions for aerial flights were 2 to 3 days after a one-inch or greater rainfall in 24 hours. Tile patterns were best viewed with minimal crop residue and before crop canopy, from late April to late May.

However, when these parameters were applied to the heavy clay soils of the PPR, the criteria did not work as hoped. More rainfall was needed to thoroughly saturate the soil profile. Further

investigation revealed that the necessary conditions for successful flights where tiles were completely visible were preceded by 7 to 10-day totals of 4 to 7 inches of rainfall. Less than 4 inches of rainfall only produced partial visibility and more than 7 inches produced too much surface flooding in the lower lying areas. The original criteria of 1" plus rainfall did work in other areas of the state, including the Iowa Erosion Surface and Southern Iowa Drift Plain, where the older, more weathered glacial tills were overlain by thick deposits of windblown silt. These areas have soils that are more similar to the original research areas in Illinois and Indiana.

The imagery collected for the Wright County test area (in the PPR) used in this exercise follows the 10-day, 4" plus criteria. The interpretation procedures are the same for all the areas, but the preparation and planning of aerial flights is much more difficult in areas where the heavier rainfall conditions are required.



Drainage District 160 in Wright County, IA in blue. Tile mains are yellow line features and the exercise mapping area is outlined in red. The imagery is from 2007 CIR.

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UNDERSTANDING THE IMAGERY

This relatively easy example will help familiarize us with the imagery. In this example, there are three dates of imagery that show the presence of tiles: 4/28/1980, 4/29/2007, and 5/31/2013. This exercise will mainly use the two most recent images.

The three images available for this exercise use three different imaging technologies. The 4/28/1980 (**ortho_1980**) image was acquired with color-infrared positive film, digitally scanned, and converted to a digital orthophoto with photogrammetric software. The 4/29/2007 (**ortho_2007**) image was acquired with a four-band, digital frame camera, and the 5/31/2013 (**ortho_2013**) image was acquired with a four-band digital pushbroom scanner. While the pushbroom scanner produced high quality, high-resolution imagery, the contrast differences between the lighter and darker toned soils indicating the presence of tiles are not as distinct as the frame camera or film images. The cause for this contrast difference is unknown.

The presence of tiles are not normally visible unless the soil profile has been thoroughly saturated. After the rainfall ends, the soil profile above the tiles dries out faster than the surrounding areas. Drier soils are lighter in tone, while wetter soils appear darker. This is especially true for color-infrared photography, but it also works for regular color photography.

1. Open the **tilemappingexercise.mxd**.
2. Go to **Bookmarks > Field1**.
3. Examine each year of imagery: **ortho_1980, ortho_2007 and ortho_2013**, look for differences between the different years of imagery. Notice the tile patterns, often seen as areas of light gray in linear patterns. The 2013 image has three band combinations: IR/Green/Blue, RGB and standard CIR. There is nothing particularly special about these band combinations, but sometimes certain features are more visually prominent in one, rather than in one of the other two.

BASIC TILE MAPPING TECHNIQUE

In this tutorial, we are only mapping one set of fields in the NW quarter of a section plus the western half of the next quarter section. This area of interest is in a layer called **Fields_to_Map**, which is a red polygon. This area only has a range of elevation of about 7 meters or 23 feet, which is fairly flat, but it does have distinct lows and highs and therefore we can use it to predict which way the drainage tiles should flow. This may not be 100% accurate - some situations will still be ambiguous - but it provides a good starting point and a useful framework for organizing your work.

The **LiDAR 3 meter ACPF hydro enforced DEM and hillshade** is a layer showing the relief in this area created from LiDAR points. We are using this layer in order to get a sense of the topographic lay of the land, which is not obvious if you were driving by, or just looking at the aerials. The **AreaFlowNet ACPF** is a model of the how water flows across the landscape based on relief. Both of these layers were created with the Agricultural Conservation Practice Framework (ACPF) toolbox (<http://northcentralwater.org/acpf/>). For information and exercises on how those layers were derived, please visit the ACPF toolbox website. The **drainage_district** layer boundary lines were digitized based on paper maps of county drainage districts.

1. After examining the three dates of imagery, turn them off and turn on the **LiDAR 3 meter ACPF DEM and hillshade layer**, the **areafloernet** (stream lines in blue) and the **drainage district boundary** (in dark blue). It should look like **Figure 1A** below.

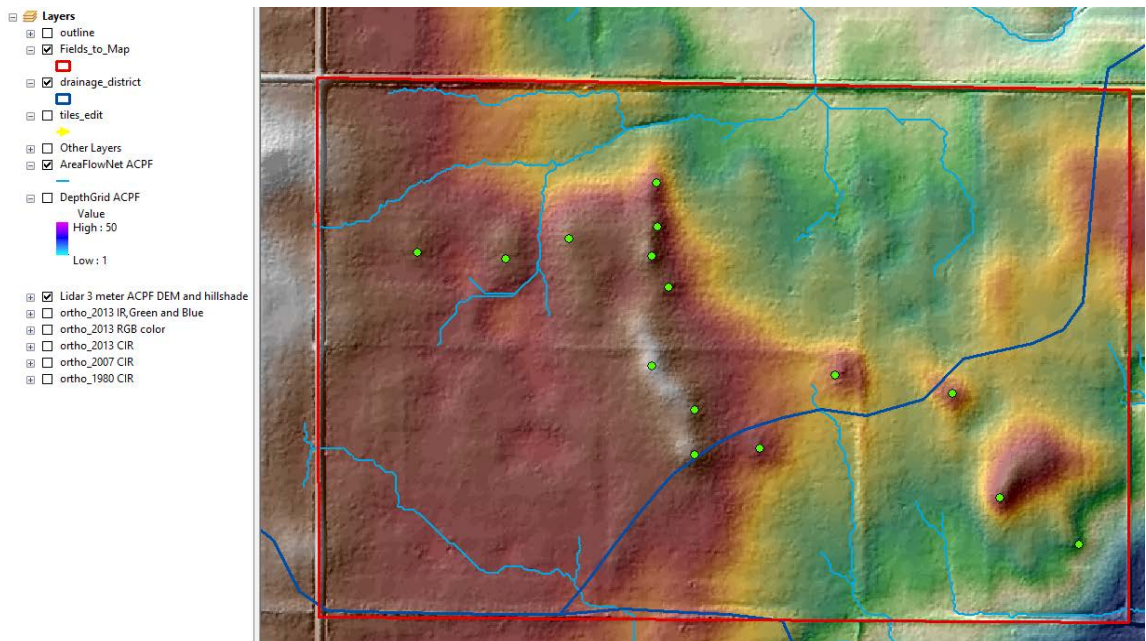


Figure 1A: ACPF hydro enforced DEM and hillshade, stream flow lines (light blue), drainage district boundary lines (dark blue), and topographic “highs” (green dots).

With those layers turned on, we see seven places where the blue streamlines cross the field boundaries. Five of these points are exits and two are entry points, so we must make sure to map the upstream tile lines for those two entry points, even if they are outside the dark blue drainage district polygon. Notice the “uplands” are fairly flat with some undulations and closed depressions. The stream delineation algorithm within the ACPF filled these depressions to overflowing in order to see where they would flow given enough rainfall.

2. **Notice the green dots.** These indicate topographic “highs” a few feet above the surrounding terrain. This is important to note because these high areas dry out sooner than the low lying areas and appear lighter in tone than the low lying wet areas. The light toned high spots can be confused with light toned tiles or make their shapes appear elongated or more connected. Try to keep this in mind while interpreting the lighter toned tile lines.
3. Turn on **DepthGrid ACPF** to see these depressional areas (**Figure 1B**).

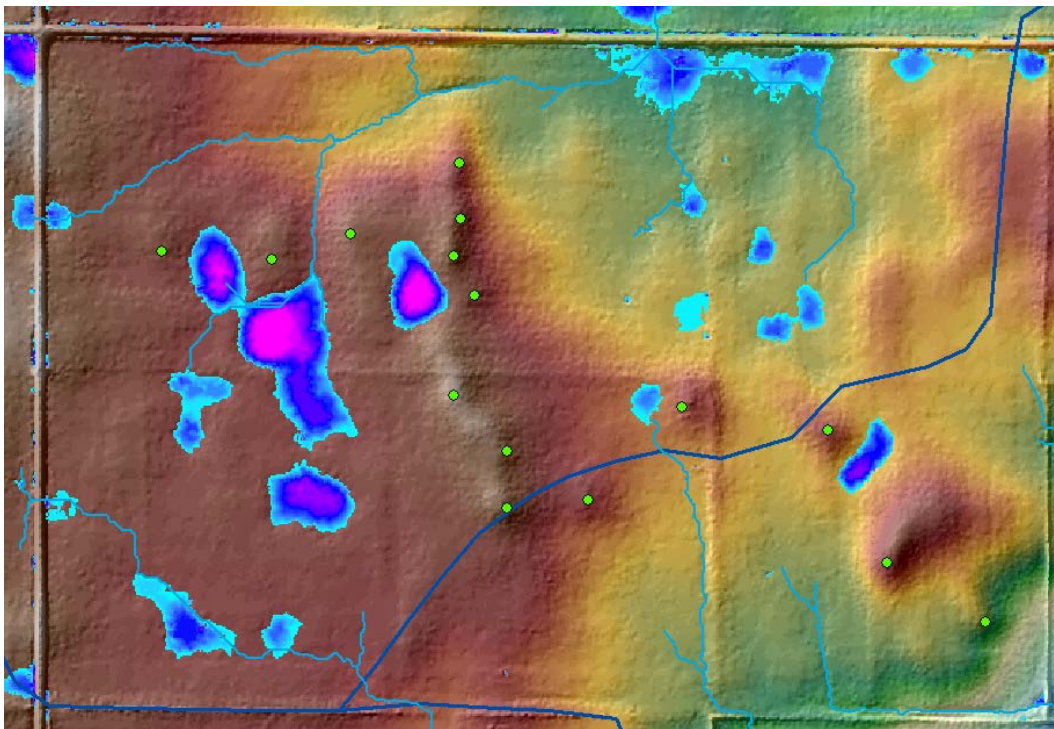


Figure 1B: With DepthGrid from the ACPF turned on.

4. Turn off the **DEM/hillshade layer** and turn on the **ortho2007 CIR image**. This is a color-infrared image so vegetation is pink or red and non-vegetation is gray, blue or white. Water is black. All the fields are bluish-green or gray in this image, no pink vegetation, indicating the barren fields of spring. Notice the lighter toned linear features - these

features are areas drained by tiles underground. Notice the green dots again; the round areas of slightly higher elevation are also lighter toned indicating drier soils. These can be confused with the tiles or mask them. Dark tones represent wetness and you can see a number of small circular pond like features. These are the “prairie pothole” wetlands of the Des Moines Lobe landscape and almost all of them are drained by tiles and used for cropland (**Figure 2**). There are other linear patterns on the imagery that can be confused with the tiles. We will discuss those as we go.

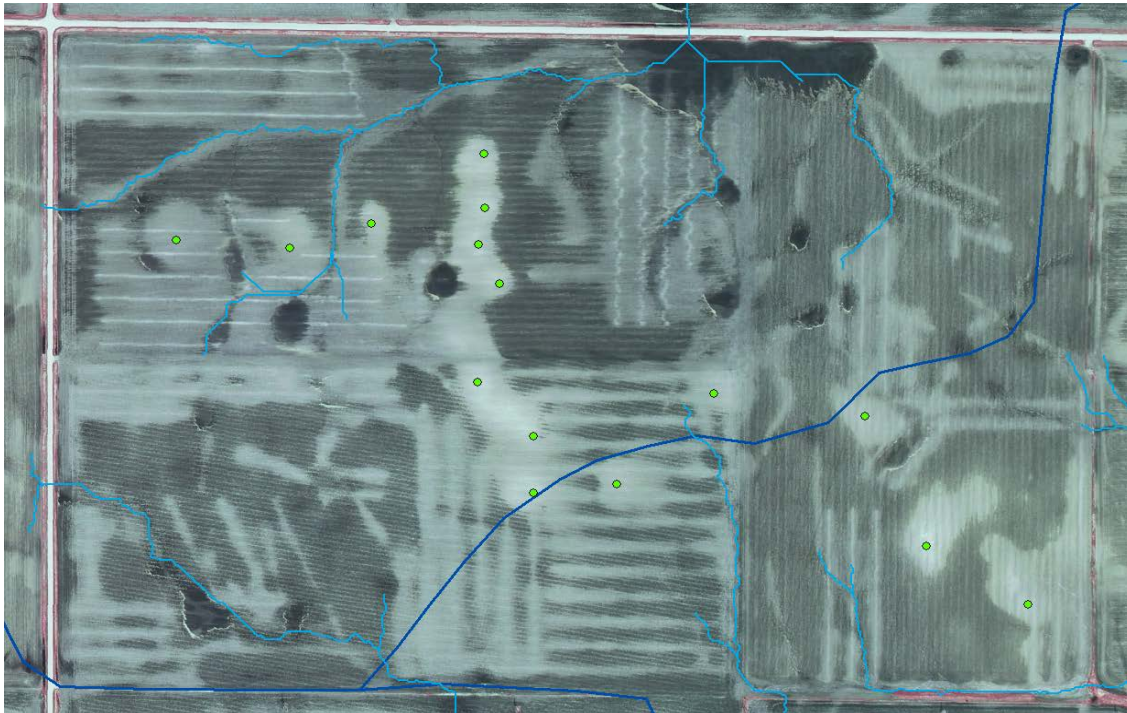


Figure 2: Ortho_2007 CIR image clearly shows the light toned tiles and green dot uplands.

5. Start in the upper left corner, turn off the **areafloernet** and turn on **tiles_edit** layer, and right click, go to **edit features/start editing**. Make sure the **Create Features** window is visible, click on **tiles_edit** so **Construction tools/line** shows up at the bottom of the window (**Figure 3**).

Notice in the Create Features window that the tile line feature has a yellow arrow symbol. The arrow indicates the direction of flow and we will try as best we can to determine flow direction from the drainage patterns. This is only a best guess. We will start by digitizing the main tiles first, which are easier to tell their flow directions since they often follow in the direction of the surface drainage. We will click a vertex at each tile intersection so the line digitizing has something easy to snap to; make sure to turn on snapping for this dataset.

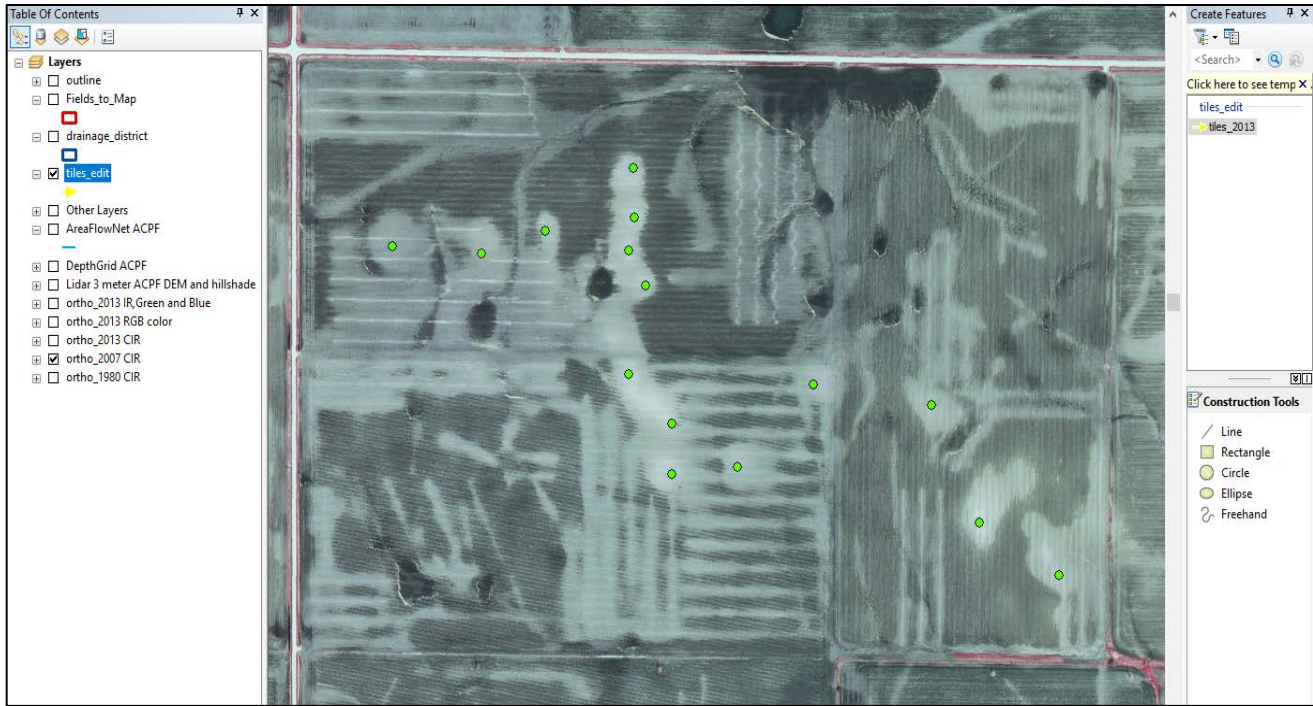


Figure 3: Screenshot showing editing mode with the Create Features window.

6. **Start digitizing** the tile line that runs diagonally from the upper left corner of the area of interest to the right top center by the road where it exits. Put the **end point** in the middle of road; this will leave a good starting point for future additions. See Figure 4. You can check this with the **LiDAR DEM and Hillshade** layer and the **DepthGrid**. These layers will show the lowest spot on the landscape south of the road; this is the likely spot for a tile line to exit the field.

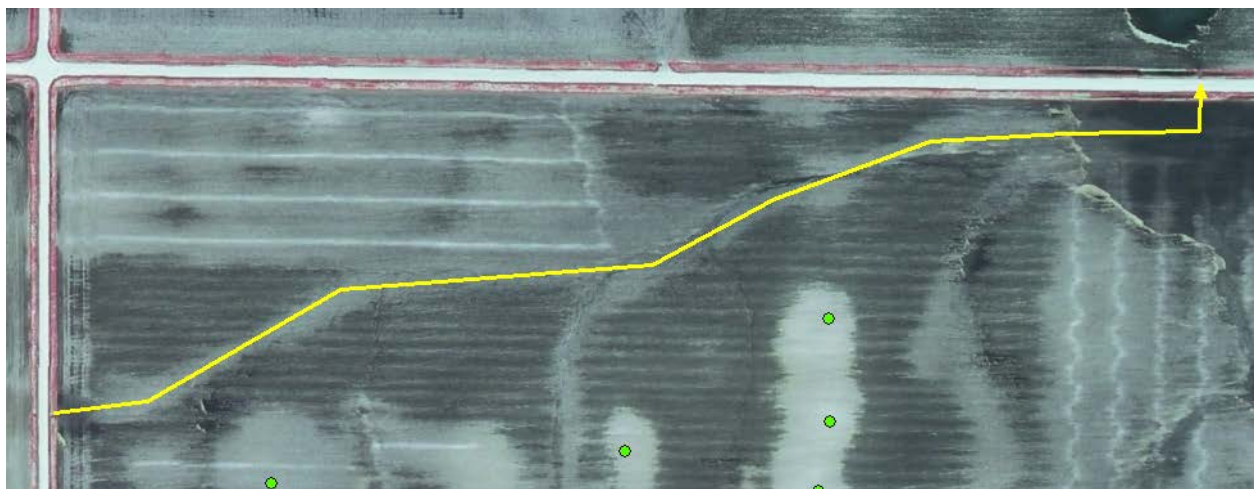


Figure 4: Upper left corner of mapping area, digitized the main tile line that follows the stream drainage. It outlets at the low point along the highway at the top of the area.

Notice the thin horizontal light lines stretching all the way across the entire field. They are likely tillage artifacts, slight higher mounds of drier soils or crop residues left on fields. Because they are so regular and even, they should be ignored. The way to distinguish them from the more irregular tile lines is their total coverage of the field and they parallel the edges of the field (usually). Some light toned features are also at the edges of fields. These are curved shapes and indicate where the field equipment turned around.

7. Next, **digitize the upper left set of tiles**. They are the series of four strong gray lines. **Starting at the top left, add a single line across the top, add a vertex to bend, continue vertex at each intersection and snap to the main line.**
8. **Add the next three lines and snap to the vertex.** Ignore the small thin, evenly spaced lines, which are tillage artifacts. The digitized tiles in the upper left part of the field are shown here in the **Figure 5**.

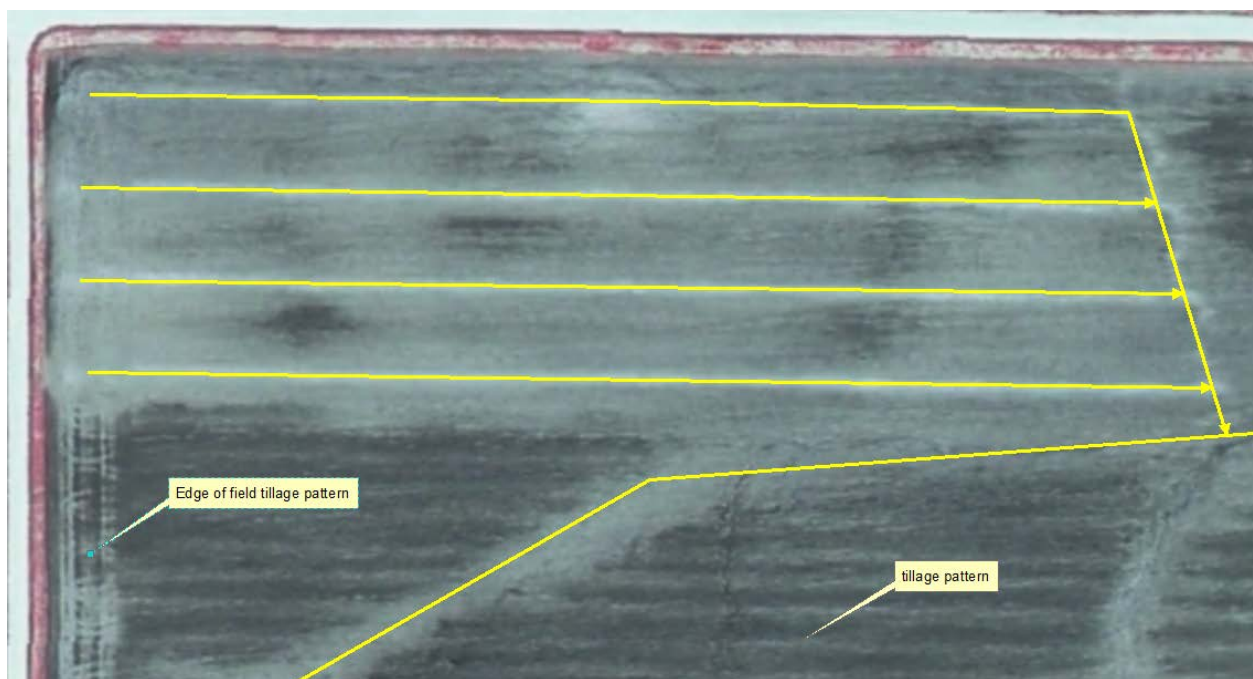


Figure 5: Digitized tiles lines along with examples of tillage artifacts and edge of field tillage patterns.

9. Now move right to **digitize the right side of the field**. Look for the light gray lines. Start with the pothole just to the left of the field boundary, indicated by the pink vegetation along the fence line. Here we are assuming the tiles drain toward the main outlet to the west, so we connect to the line to the low point that was previously digitized. It could have easily flowed to the east, but we are making a judgement call here and will not cross the major field boundary, which might also indicate an ownership boundary, see **Figure 6**.
10. **Start by digitizing the line on the far right side of the area of interest, turn left at top, and connect to the low point outlet.** Check other dates of imagery as you add the other lines. Notice the pink vegetation along the fence line at the right of the figure. We

assume this is maybe a property boundary so the tiles drain to the west instead of the east.



Figure 6: Digitized tile lines in the NE area of interest.

ADVANCED TECHNIQUE ONE: USING HISTORIC IMAGERY TO SIMPLIFY THE IMAGE

Things are beginning to get trickier, so we will use our first advanced technique: using the oldest image in the set. Many of the tile lines are overlaid by newer installations. Using the older imagery helps clear up where some of the older tile lines were installed and helps make sense of the patterns found on later imagery.

11. **Turn on** the 1980s imagery, **ortho_1980_CIR**, as seen in **Figure 7**. There are fewer tile lines present in the older imagery. The tile lines are very wide and fuzzy looking, but some of them persist on the later imagery. Some disappear completely on the later imagery.

Normally, it would be very unusual to have three different sets of imagery to look at, especially over a 33-year range. Here though, we can contrast and compare and look for features persistent through time. Then when you run into a more normal situation with perhaps only one set of imagery showing tiles, you can try and tease out something usable based on your experiences in this exercise.

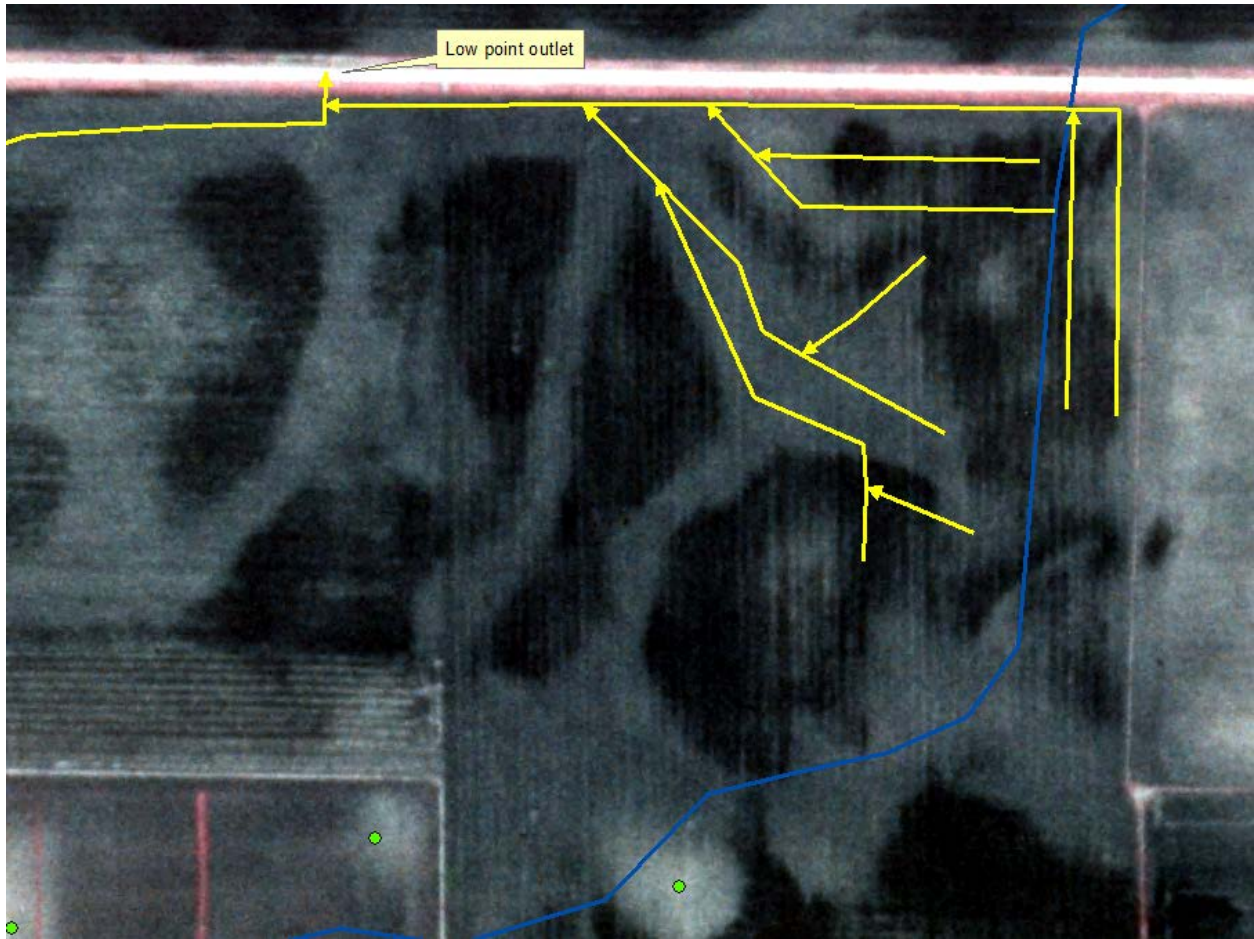


Figure 7: Using historic imagery ortho_1980 CIR can reveal tile line pathways. (Notice the straighter gray lines that run towards the digitized areas.)

12. **Begin digitizing the tile lines that are revealed in the 1980s imagery.** Start drawing a tile line and switch between the three imagery dates to see if there are any changes in the tile line. In particular, on the left side, there is an area that appears to have tile drainage in the 1980 image, but nothing shows up in the subsequent images (**Figure 8**).



Figure 8: Digitized tile lines using ortho_1980 CIR to find older, irregular tile lines. Notice area on left with lighter tone, a possible tile line, but it does not show up on later imagery, either the 2007 or 2013.

Having digitized some of the older tile lines, we now have a clearer picture of what is underneath. We can add more detail from the two later images (Figure 9).

13. **Use the 2007 and 2013 to continue digitizing tile lines.** Notice the parallel tile patterns visible in the later images. They seem to lie on top of the older irregular patterns. Interestingly, the older tiles continue to function as evidenced by the continued visibility of the drying patterns.

There's the dry looking area marked on Figure 9 near the top middle - there may be another tile there, or two, but nothing distinctly linear stands out. The other tiles on the bottom of the figure will be dealt with later since they drain to the south and east.



Figure 9: Additional tile lines digitized using the 2007 and 2013 images.

14. **Move down to the lower left corner of the area of interest.** This area will require a little more guesswork. First, notice the very prominent tillage pattern is at a slight angle to the field boundaries now. This may be caused by fall harvesting or spring tillage. If you look closely at the dark potholes, one can see lighter lines running across and connecting to the lighter toned tile features outside the pothole. They crisscross more and make interpretation less sure. It is becoming more and more subjective at this point.
15. **Begin digitizing this section. Use 2007 and 2013 images to find and connect the obvious lines as you did earlier. Then use your best interpretation to connect the tile lines to the southern outlet.** Figure 10 shows one interpretation. Some of the lines draining the potholes zigzag back and forth. It is possible these lines drain to the north and the connecting lines are just coincidental overlays.

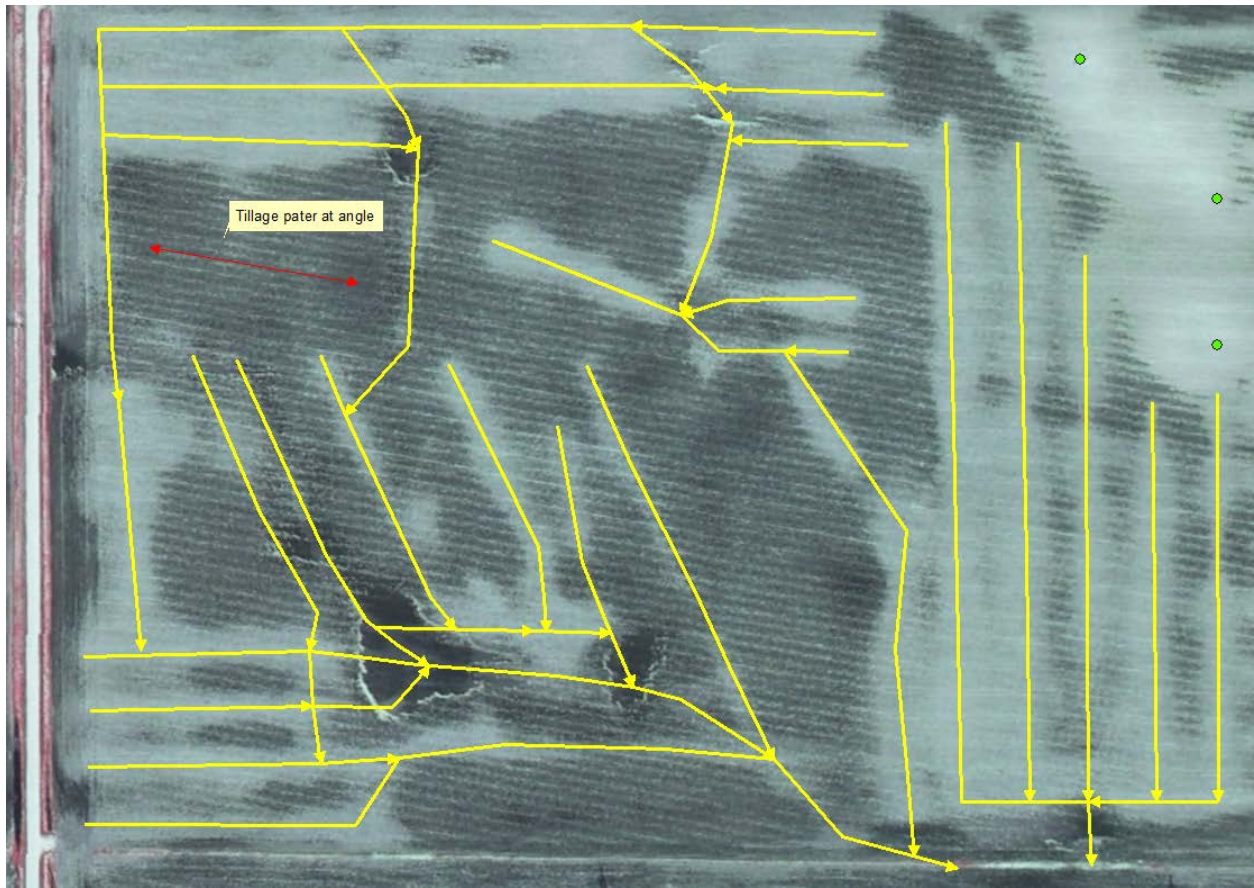


Figure 10: Digitized SW area of interest. Please note this is only one interpretation. Yours could be equally valid.

16. **Take a rest.** Three more areas to digitize; for each of these we have to decide which direction is the likely outlet.

ADVANCED TECHNIQUE TWO: USING TOPOGRAPHY AS AN INTERPRETATION TOOL

17. **Move to the next area of interest, to the east (right) of the last assignment.** Look at the image. Does the tile set drain to the bottom/southeast or does it flow northeast? Without looking at the topography (**Figure 11**), it looks like it could go either way.

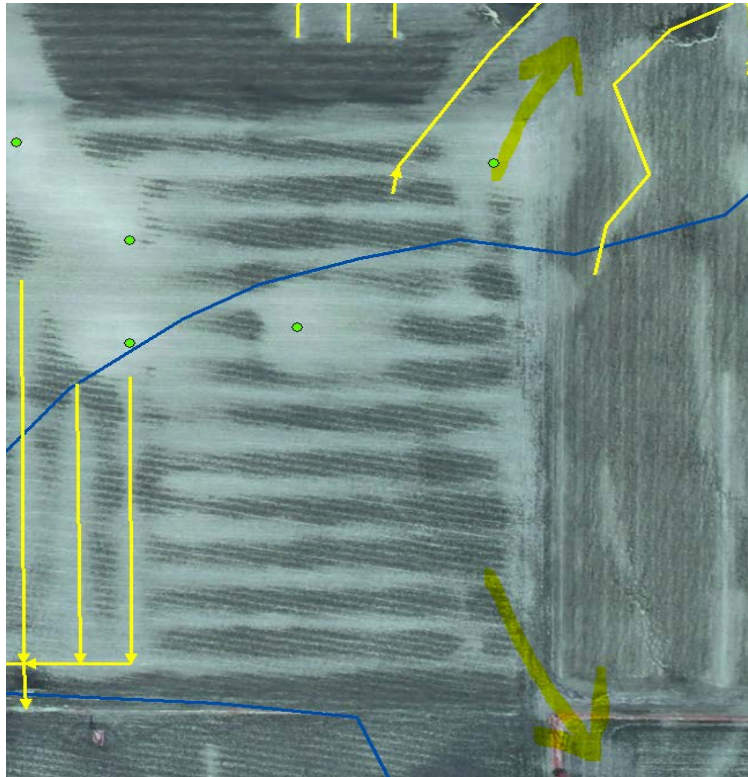


Figure 11: Possible tile flow exits from the field as indicated by light yellow magic marker arrows, without looking at topography.

18. **Turn on the LiDAR 3 meter ACPF DEM and hillshade layer again.** Notice how most of the land slopes to the southeast. The land is flat and it could flow to the northeast. However, the drainage contractor would have to dig an extra two meters deeper at the top of the hill to get all the flow going to the northeast. It seems simpler to send that drainage to the southeast (**Figure 12**). Notice that at least two of the previously digitized tile lines drain to the northeast outlet.



Figure 12: Two sets of parallel pattern drainage tile sets. Based on topography, the set on the right probably drains to the SE outlet, and not to the NE.

19. Now move to the **SE corner of the area of interest.**

20. Finish **digitizing** this section.



Figure 13: Digitized tile lines in SE corner of area of interest.

21. Use Figure 13 to check your work. Notice the tile on the right field boundary was broken into a north-draining piece and a south draining piece, which is another interpretation based on the ortho_2013 IR, Green and Blue image.

Finally, the last area!

22. Begin by examining the area with both 2007 and 2013 imagery. It looks like it could flow either to the south or to the north as shown in the Figure 14A. There is clearly a path visible to the north on the 2007 image, but less so on the 2013 date. Figure 14B is one way to interpret it - mostly based on the 2007 image, but used the 2013 image to verify.

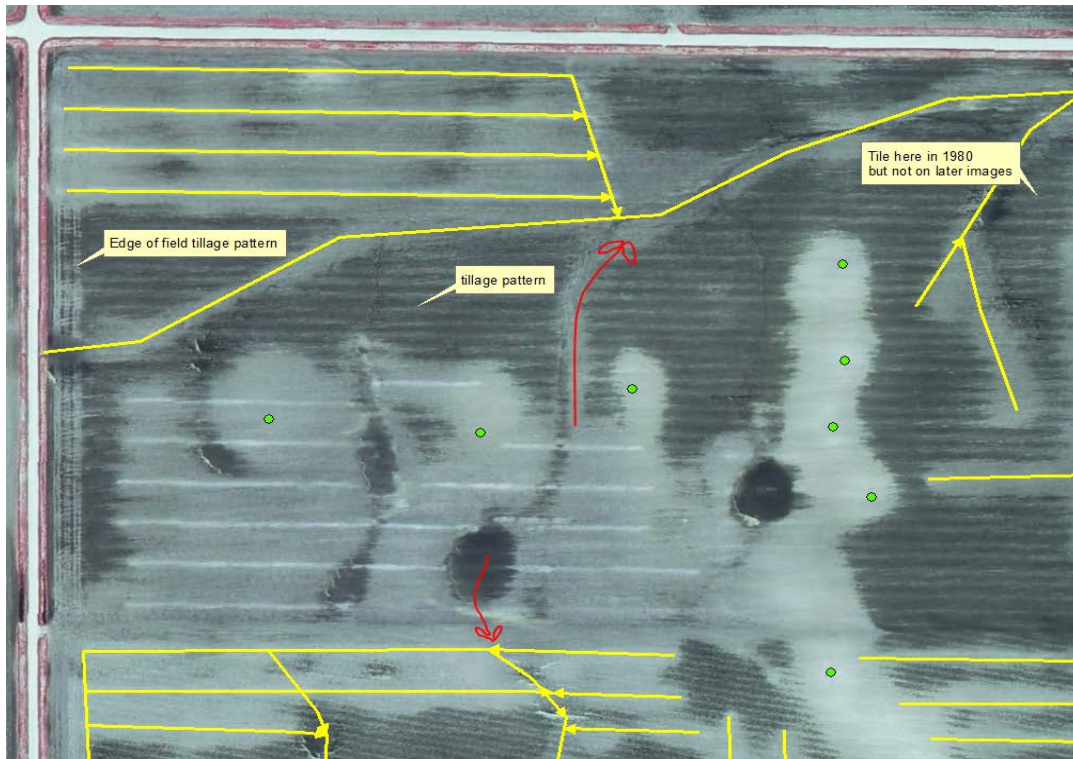


Figure 14A: This image shows two choices of where to drain the tile flow in red.

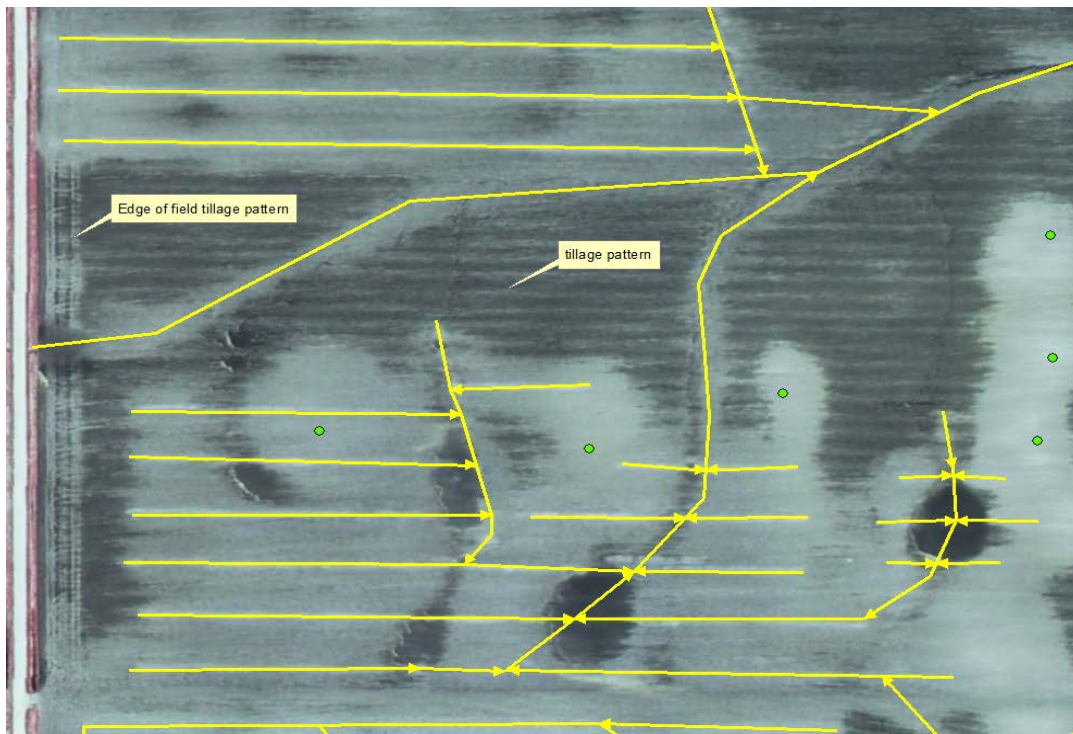


Figure 14B: This image shows an example of how to digitize this area. In this interpretation, the northerly path was chosen though some of the potholes do drain to the south first, run into a collector, and then run east to north outlet tile.

Here is the completed interpretation for this first exercise (**Figure 15A**) using the **ortho2013 IRGB** image as a backdrop. There is a bothersome lighter toned area from **Figure 9** (red line), but that was not included in the final version. Now compare to **Figure 15B**, with the **DEM and Hillshade** as the background and the pothole **Depthgrids**. The field has been thoroughly evaluated and all probable tile lines are digitized.

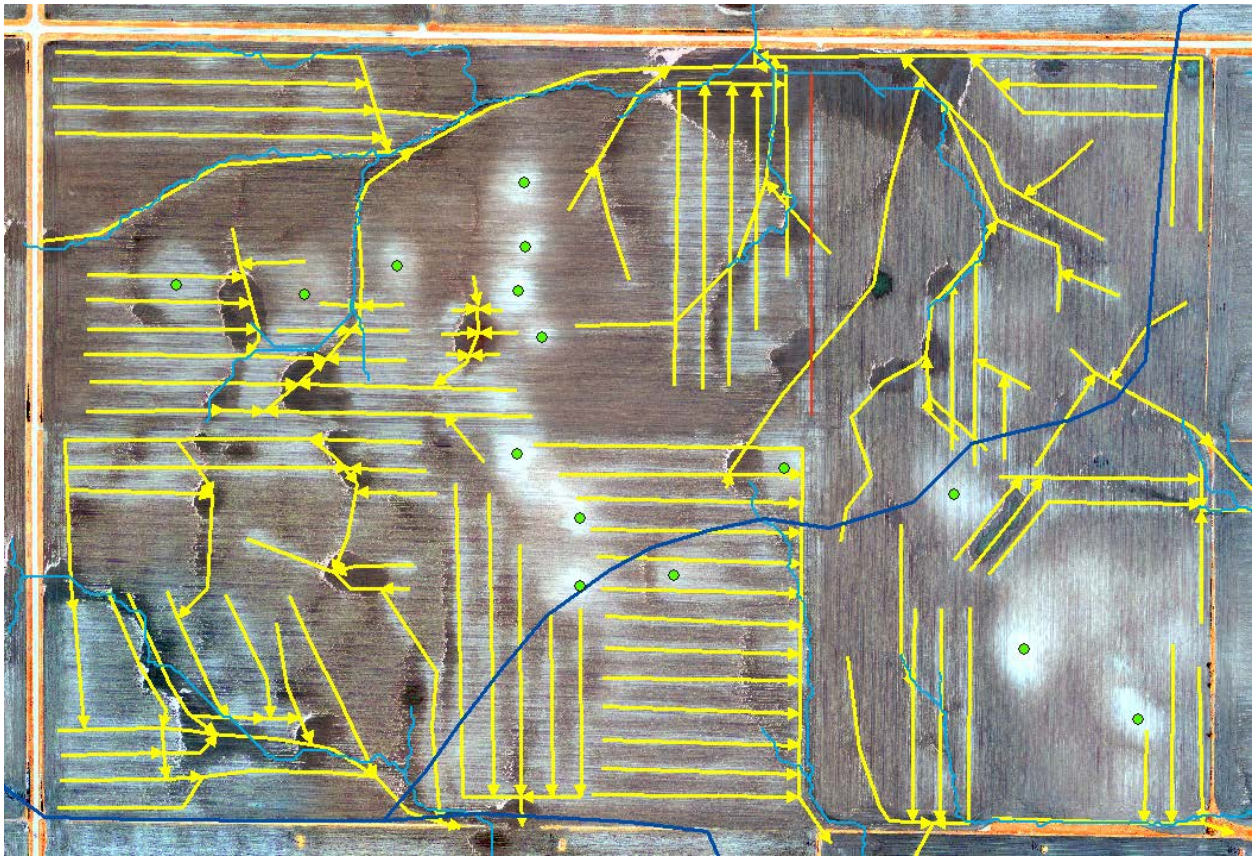


Figure 15A: Final map of tile lines. Ortho 2013 background (IR, Green, Blue bands). Green dots are topographic highs.

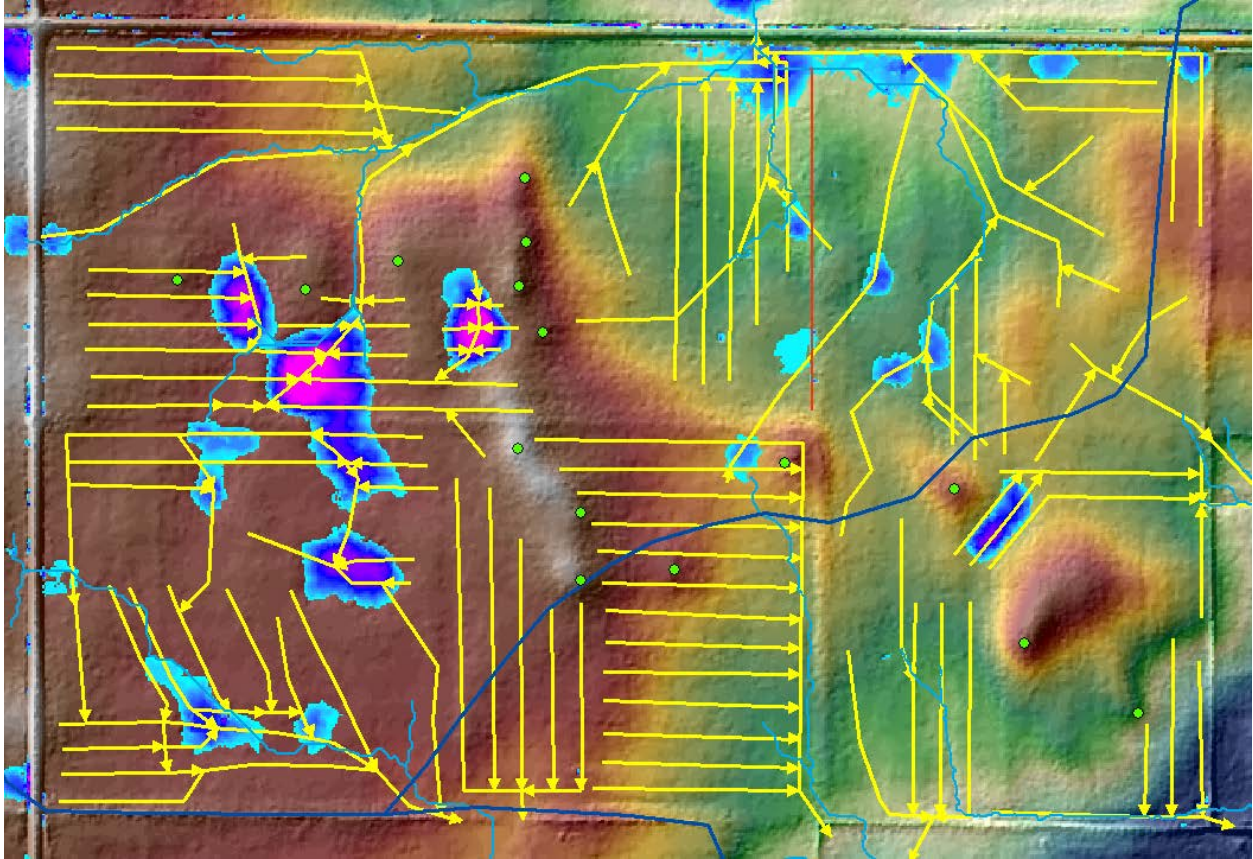


Figure 15B: Final map of tile lines. ACPF hydro enforced DEM and hillshade, stream network, and pothole depression depths.

General tile mapping principles:

- Early on, identify the high and dry topographic spots. Those will cause confusion later on so mark them with a graphic symbol.
- Identify tillage and harvesting patterns in fields. Try to ignore those when mapping tiles. They are closely spaced and sometimes make circular patterns at the field edges where the tractor turns around.
- Find the main channel(s) first; they should follow the major drainage paths if present.
- Do easy, obvious areas first. The “high” flat areas are tougher to interpret flow directions.
- Use the topographic layers (DEM and hillshade) to make educated guesses as to where the tile flow goes.
- A depth grid of depressions identifies obvious targets of tile installation.
- If you are lucky to have more than one date of imagery showing tiles, older dates generally have less detail and can be used to sort out earlier tile installations.
- Keep in mind, some tiles may be plugged or cut and stop functioning and thus not drain water in the overhead soil profile. These places will not be visible on the imagery.

PART TWO: MAPPING THE TILE INTAKES

This section will focus on understanding how to identify tile inlets from the imagery based on key features. Tile inlets are pipes that are above ground that help collect water from the surface of the field. **Figure 16A** is a ground photo of a tile inlet, an orange upright intake pipe with holes to allow water to flow in and leave debris behind. **Figure 16B** shows what the red-orange pipe looks like on the ortho2013 IRGB image.



Figure 16A: Photo of red-orange tile intake pipe, from a car, taken 6/7/2013. The tile intake is about 3 or 4 feet tall and 6-8 inches wide.

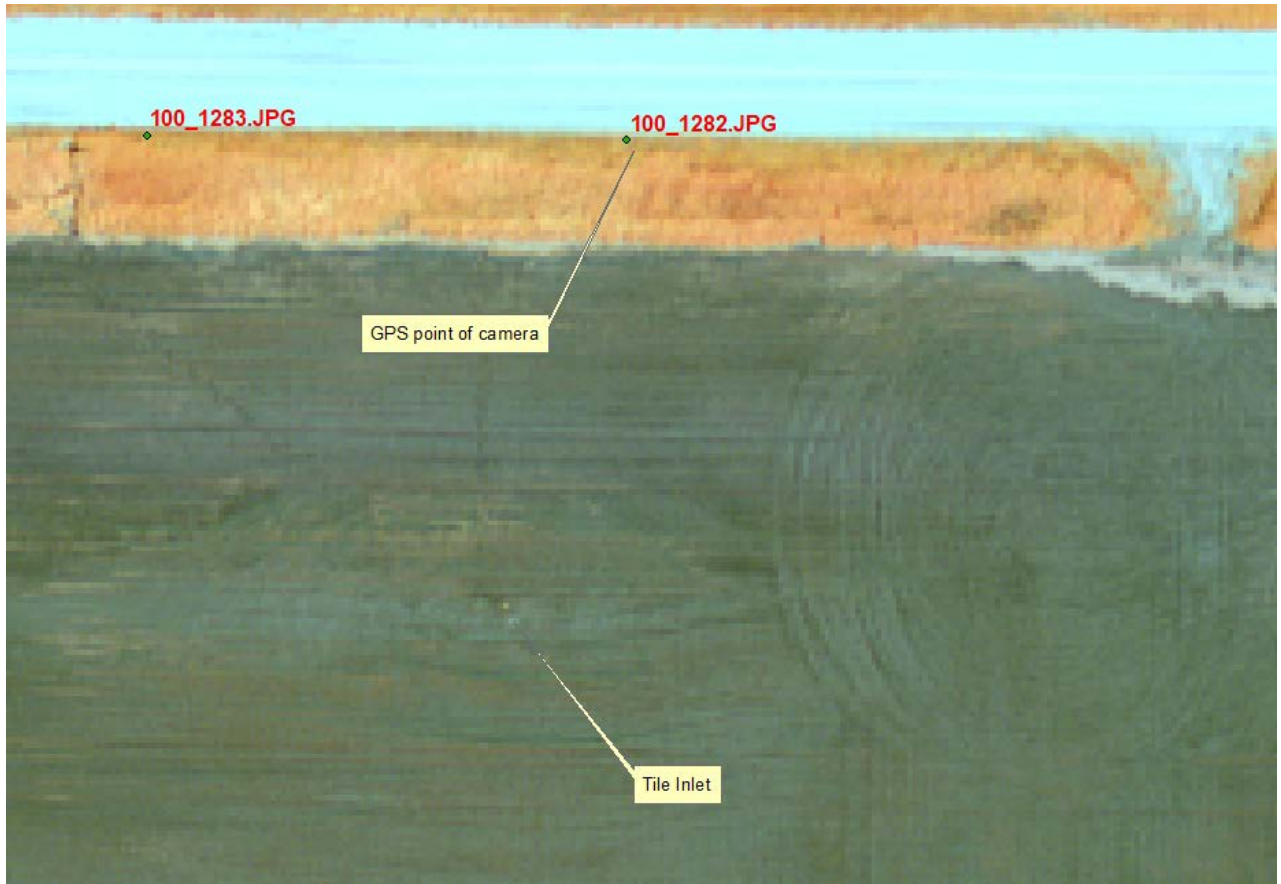


Figure 16B: Ortho2013 IRGB, taken 5/31/2013, eight days prior to the ground photo in Figure 16A. The circular pattern to the right is tractor tracks made when the field equipment enters from the road just above.



Figure 16C: Close up of the tile inlet in Figures 16A and B. Notice the red-orange color in this Ortho2013 Natural Color image and the dark shadow behind and to the left of the two red/orange pixels. The resolution of the orthophoto is 1-foot, which seems to be the minimum for these features to show up. They blend in on lower resolution images like 1-meter NAIP photos.

1. Turn on the **Ortho2013 RGB image**.
2. Go to **Bookmarks > Tile Inlet 2**. It should look like Figure 17.
3. Turn on the **DepthGrid**. Notice that this area is a pothole. Tile inlets are often found in low-lying areas of a field. There are light-toned tile drainage patterns here, but they are hard to see at this scale and using the pushbroom sensor (they do show up on the Ortho2007 image). **Find the light dot** in the middle of dark wet pothole (red arrow in center).
4. **Observe** that the tillage or harvest patterns run east-west. Also, **notice** that the tractor pattern goes around it to avoid running the tile inlet over (curved red arrow around the inlet).

5. **Identify** the light brown deposits around the top and left edge of the pothole. When the pothole was filled with water, it did not drain immediately through the inlet. The water stood for a couple days allowing enough time for the crop residues to float to the surface and be blown to "shore" by the wind (a SE wind in this case). Here, as the water receded, it left the crop residue "beach".

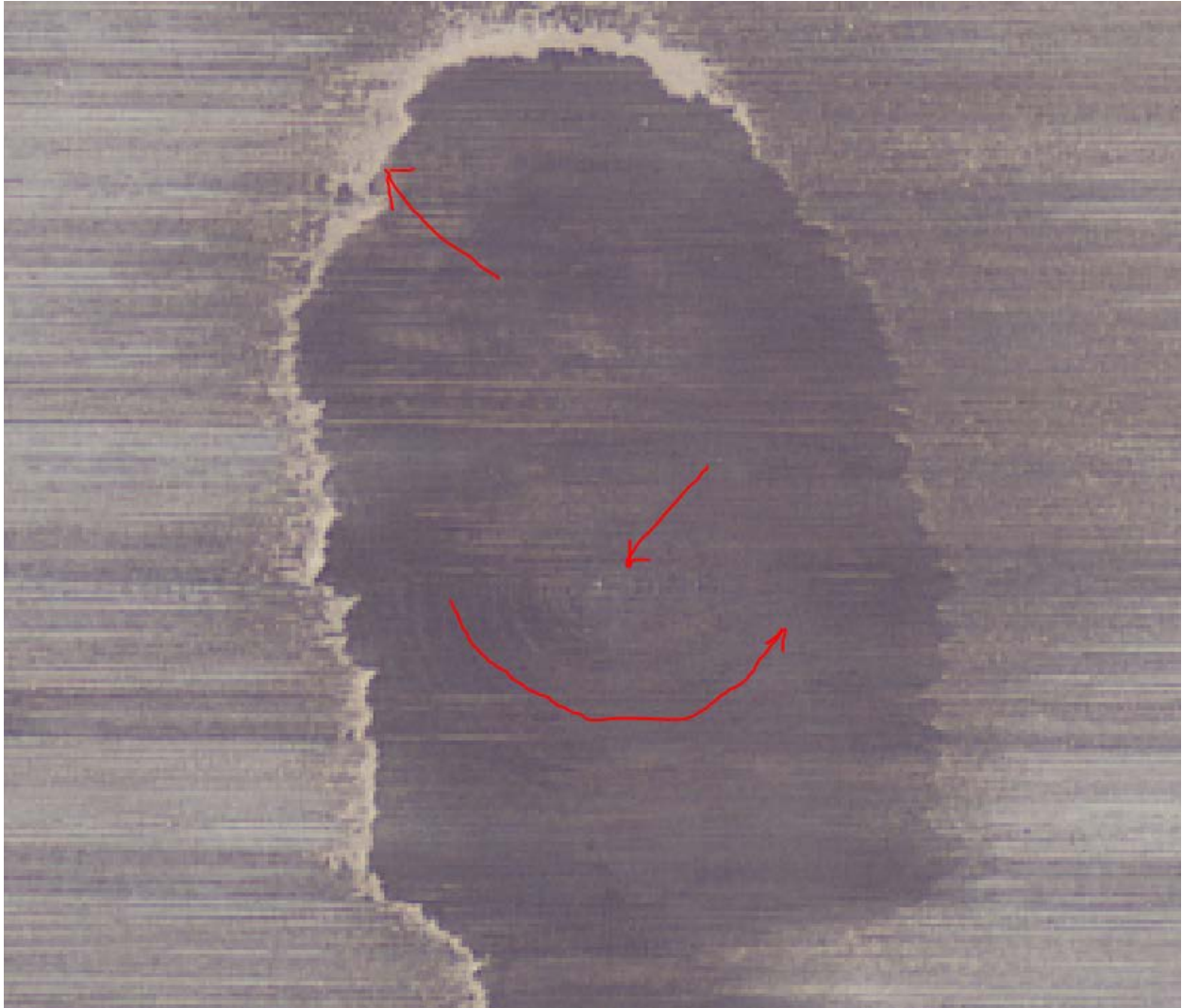


Figure 17: Tile intake in the middle of a cropped wetland or pothole depression.

6. There is at least one more readily identifiable inlet in the middle of one of the other potholes. See if you can find it, then check your result by going to bookmark **Tile Inlet 3**.