Description of Completed Project and what was Achieved/Learned

Provide a description of what was learned/achieved through this Tier One Project.

Background:

There are a number of considerations to make when aiming to develop a soil health building plan for farmlands. A primary consideration should be the physical environment of the soil. An ideal mineral soil contains approximately 50% by volume solids (sand, silt, clay particles and organic matter) and 50% void space which houses oxygen and water. When and how we choose to conduct our field operations determines how much stress (compaction) we place on the soil and the soils ability to rebound from this stress. In compacted soils, crops have a difficult time developing extensive root systems which limits their ability to adequately explore the root zone in search of moisture and nutrients needed to achieve optimal yields. This reduced access to moisture and nutrient is further exacerbated by the fact that there is less infiltration of surface water into the soil profile due to the compaction. Not only does this limit yield, but it can dramatically influence field scale hydrologic and sediment transport processes. Increased runoff has a greater ability to detach and entrain topsoil, removing the most valuable asset the farm has. Soil nutrients are often bound to this sediment and once deposited into rivers and lakes, these nutrients (primarily phosphorus) can contribute to rapid growth of aquatic vegetation. Of greatest concern is the summer-time growth of algae and the associated cyanobacteria that can cause human health impacts. Furthermore, increased runoff increases the likelihood of downstream flooding and reduces deep groundwater recharge which threatens municipal and private groundwater drinking supplies. Taking corrective action to improve water quality and quantity is often an expensive option and greater emphasis ought to be placed on limiting the impact at the source, where multiple benefits (farm and environmental) can be achieved.

Study Objective:

This study aimed to achieve the following:

- test the ability of using Normalized Difference Vegetation Index (NDVI) imagery at detecting soil compaction;
- investigate the cause for compaction, and;
- assess the impact the compaction had on corn yields.

Methodology:

This study took place at three Halton Region corn fields. To test for soil type influence, two south Halton (clay sites) and one north Halton (loam site) was used. Two Unmanned Aerial Vehicle (UAV) flights were conducted to obtain the NDVI imagery at each field location. The first flight was conducted on July 25th, 2018 and the second September 11th, 2018. Using the imagery obtained on the first flight, field investigations were conducted and areas of compaction were ground-truthed with the assistance of a penetrometer. Soil samples were collected from more compact and less compact locations for the purposes of textural analysis, and corn plants were dug up for visual observation of their root structure. In-tact soil cores were taken from the more compact and less compact locations and exposed to simulated rainfall to determine if there was a difference in the amount of runoff/infiltration depending on the degree of compaction.

Upon corn harvest, yield maps were produced and this data was correlated to the NDVI imagery to estimate the impact to yield caused by compaction.

Results:

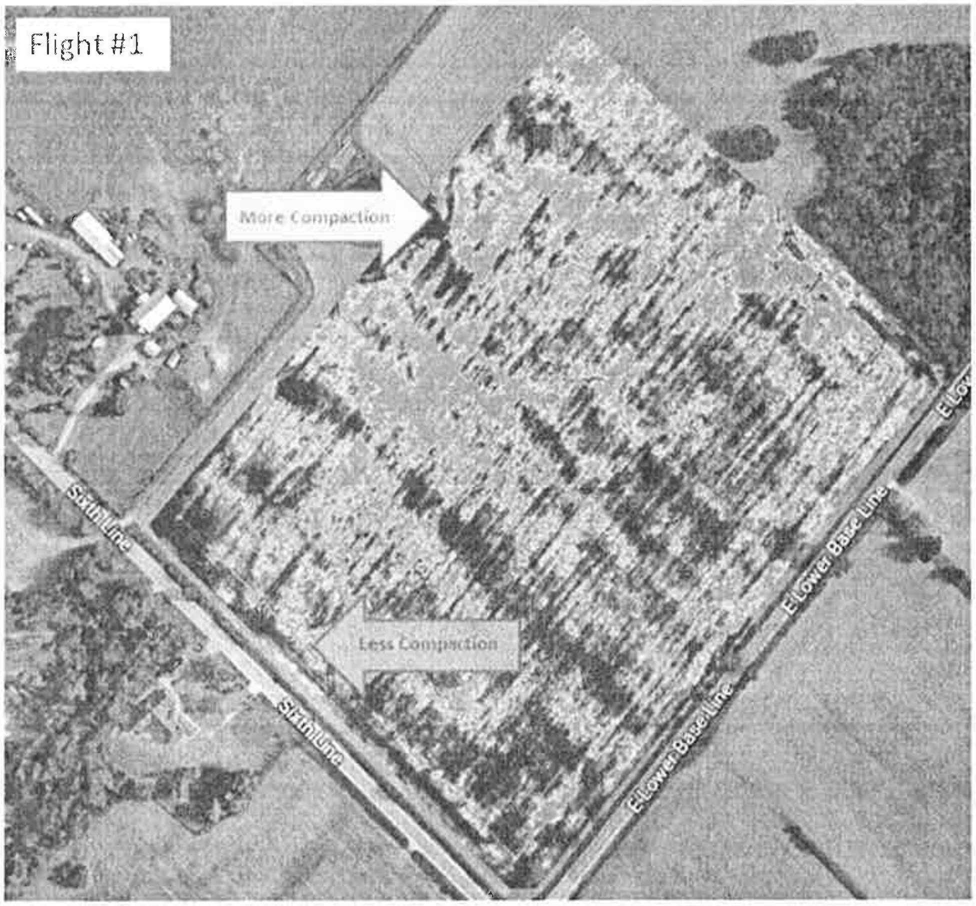
***Site ID:* Site #1**

Site Location: South Halton

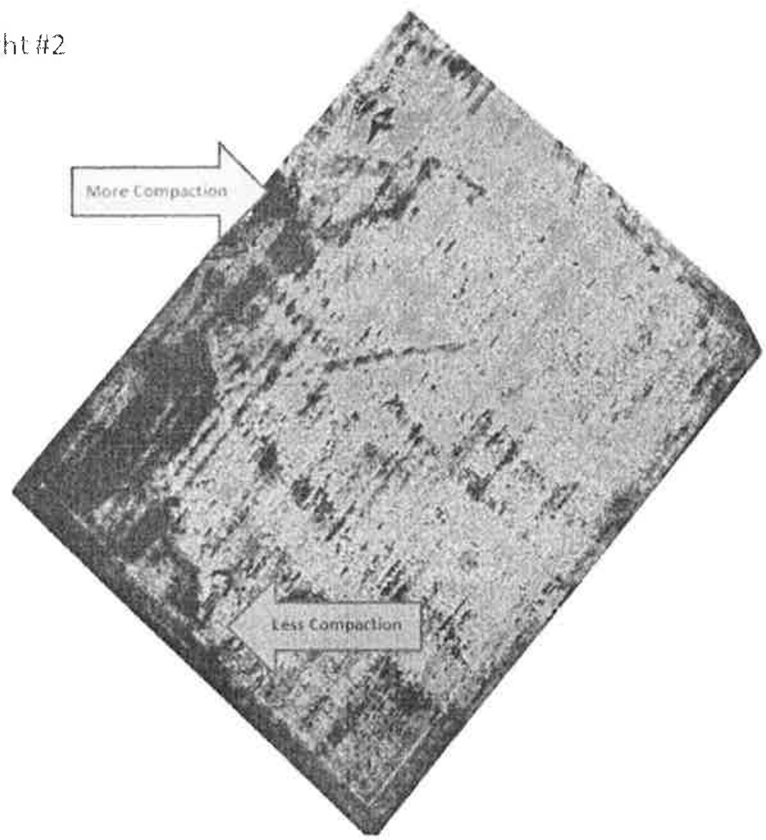
History: No tile drainage, biosolids application in 2017, oat cover crop fall 2017, disked spring 2018, planted corn May 25, no fertilizer after planting

Ground-Truthing Observations: More Compact Site: 300PSI @1"depth, 400PSI@2"depth
Less Compact Site: 300PSI @9"depth, 400PSI@14"depth

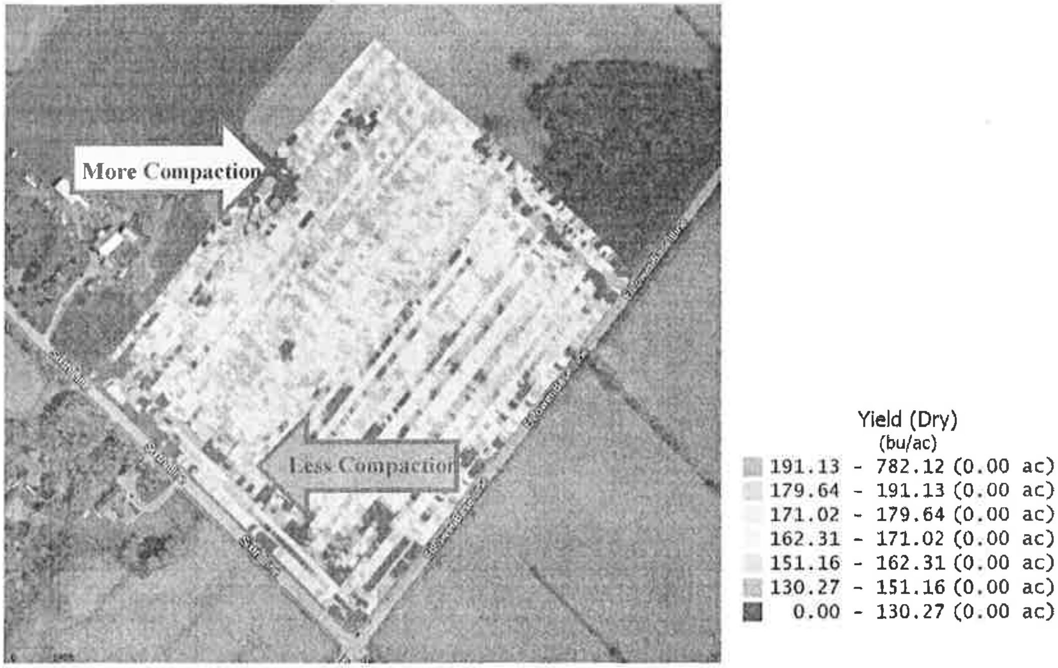
Soil Textural Analysis: More Compact Site: 36.4% clay, 47.1% silt, 16.5% sand – silty clay loam
Less Compact Site: 30.6% clay, 47.5% silt, 21.9% sand – clay loam


Flight #1
More Compaction
Less Compaction
Sixth Line
Sixth Line
E Lower Base Line
E Lower Base Line

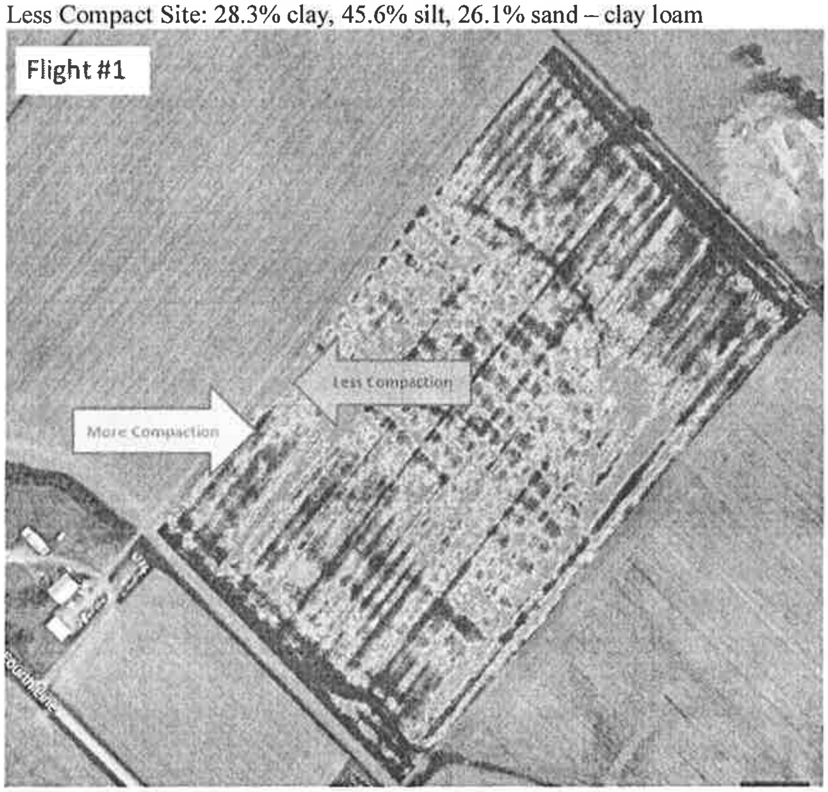
Flight #2


More Compaction
Less Compaction

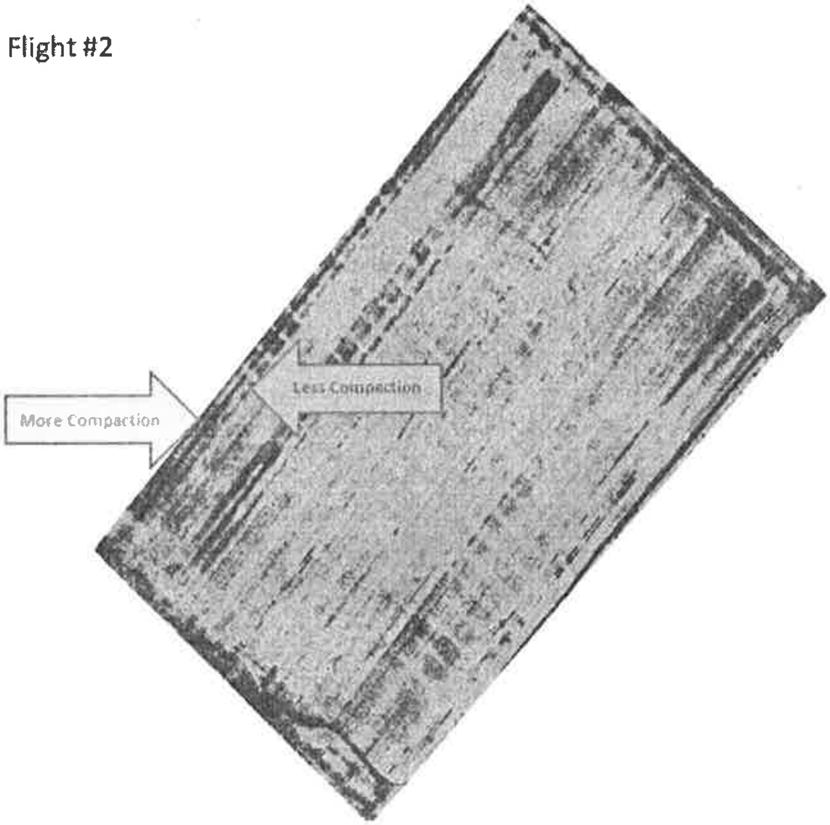
Yield Data



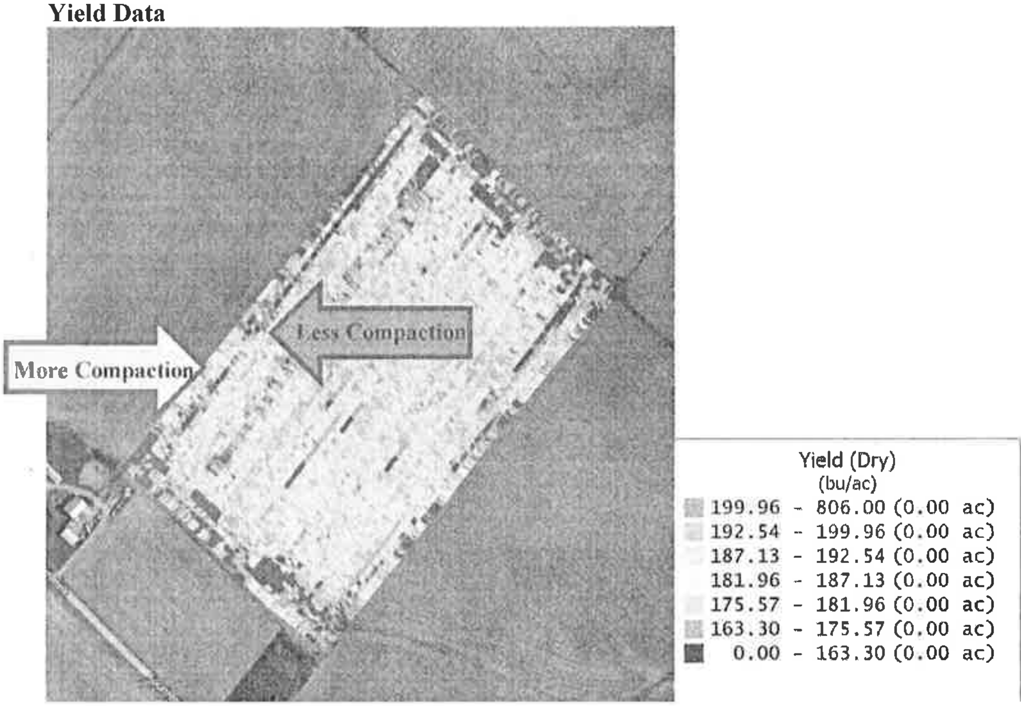
***Site ID:* Site #2**
Site Location: South Halton
History: Corn planted approx. May 27th
Ground-Truthing Observations: More Compact Site: 300PSI @1/2"depth, 400PSI@4"depth
Less Compact Site: 300PSI @6"depth, 400PSI@13"depth
Soil Textural Analysis: More Compact Site: 34.3% clay, 46.6% silt, 19.1% sand – silty clay loam
Less Compact Site: 28.3% clay, 45.6% silt, 26.1% sand – clay loam



Flight #2

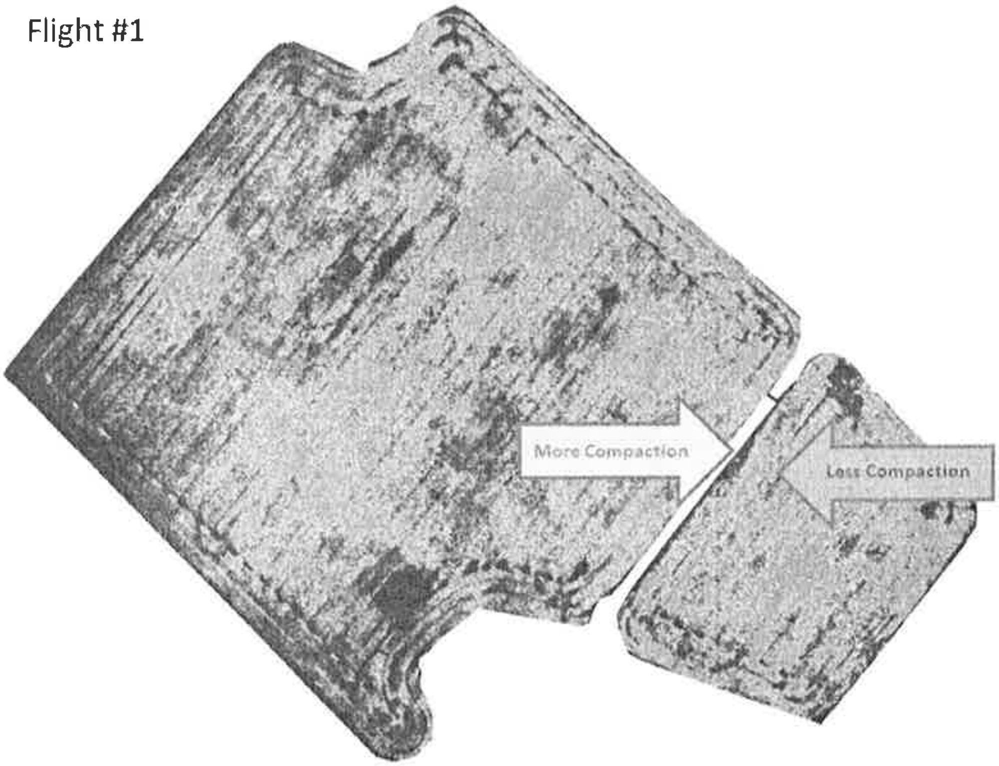


Yield Data

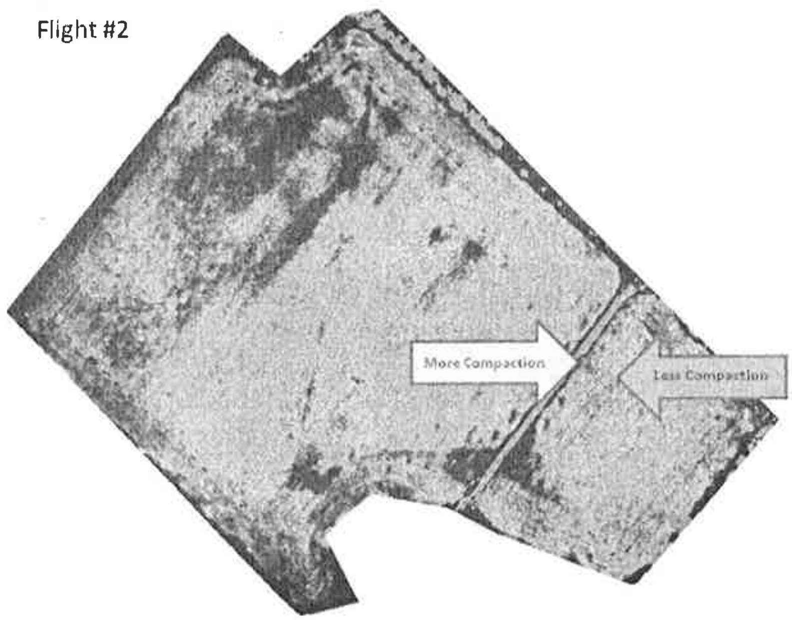


Site ID: **Site #3**
Site Location: North Halton
History: Some random tile drainage, biosolids/compost application in 2017, oat/pea cover crop fall 2017, corn planted May 29th
Ground-Truthing Observations: More Compact Site: 300PSI @1"depth, 400PSI@2"depth
Less Compact Site: 300PSI @9"depth, 400PSI@14"depth
Soil Textural Analysis: More Compact Site: 24.8% clay, 46.7% silt, 28.5% sand – loam
Less Compact Site: 23.3% clay, 47.3% silt, 29.4% sand - loam

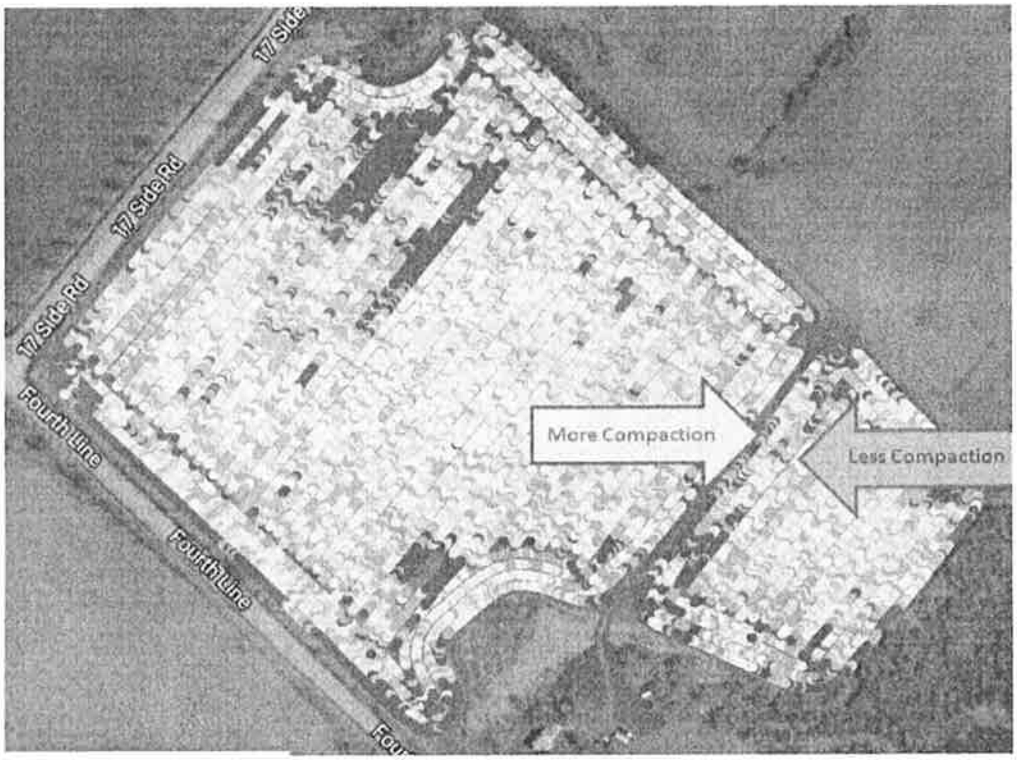
Flight #1



Flight #2



Yield Data



Avg. Yield : 179.93 bu/ac

(bu/ac)

204.84 - 449.38 (11.74 ac)
196.22 - 204.84 (12.11 ac)
189.37 - 196.22 (12.13 ac)
182.26 - 189.37 (12.16 ac)
172.72 - 182.26 (12.12 ac)
152.23 - 172.72 (12.05 ac)
20.11 - 152.23 (11.24 ac)

NDVI and Yield Correlation:

- Flight #1 = 0.478
- Flight #2 = 0.590

Root Growth and Water Infiltration/Runoff:

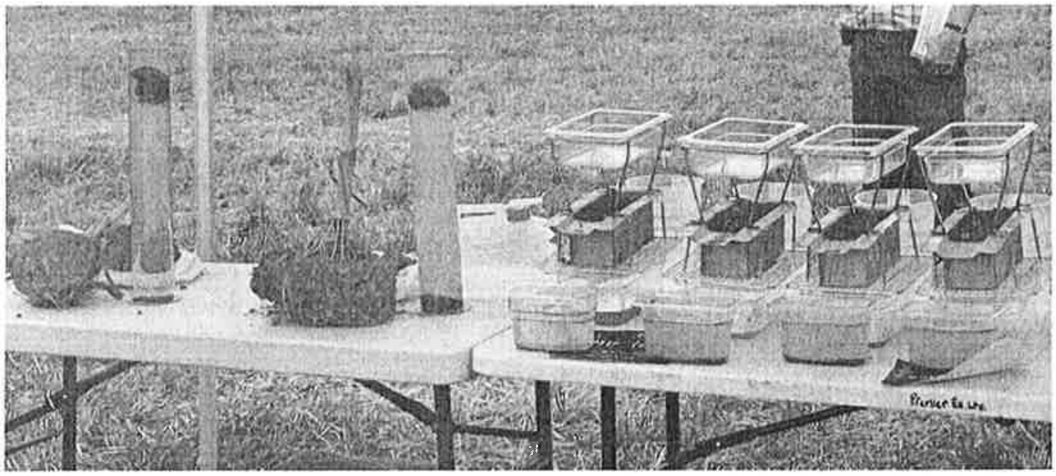
Roots of the growing corn crop from Site #3 (North-Halton, Loam Soil) were dug during July. Two root balls were dug; one from the more compact location and another from the less compact location. The root ball from the more compact location was noticeable smaller, showing early signs of crop growth impairement and likely yield loss. On the left side of the photograph below the root balls are shown.

More compact and less compact soil aggregates from this same site were subjected to a soil aggregate stability test by placing them in a wire cage and submersing them in a graduated cylinder full of water. As seen in the photo below, the aggregate from the more compact site held together better than the less compact site. This is not the expected result, but it is believed that if this experiment was allowed to continue for a longer duration of time that once the more compact aggregate became fully saturated, it would have likely dissolved quicker than the less compact site. The aggregate from the less compact site would be unlikely to change over a longer timeframe.

The right-hand side of the photo below shows the rainfall simulator experiment, which was run using Site #3 (Loam Soil) and Site #1 (Clay Soil). Less compact and more compact soil samples were taken from each site. No observable difference in the amount of runoff vs. infiltration or the clarity of the water was observed for the clay soils of Site #1. However, there was an observable difference in runoff vs. infiltration volumes and water clarity for the loam soils of Site #3. The less compact soils infiltrated more water (and generated less runoff) then the compacted location and the runoff water had much less sediment in it.

Loam Soil — Loam Soil — Clay Soil

More Compact — Less Compact — LC — MC — LC — MC



Outreach/Communications:

A field day event was held August 23, 2018in conjunction with the Halton Region Plowing Match. At this event, the corn root balls, aggregate stability and rainfall simulation was conducted and Ontario Ministry of Agriculture, Food and Rural Affairs conducted soil compaction testing of various pieces of farm machinery/equipment and tire configurations. Positive comments were provided by the members in attendance and they saw value in better understanding how to setup their equipment to reduce compaction.
A presentation was delivered to the membership on January 15, 2019 at the Halton Soil and Crop Improvement Association Annual General Meeting. During this presentation the results of this study were presented and group discussion was had about how to reduce the likelihood of causing compaction and if you have it, what can you do to reduce it. All attendees were sent home with a copy of the presentation for later reference.

Conclusions:

With the increasing use of UAVs in agriculture, it is becoming quicker and easier to collect high resolution data from the field. In this study UAVs were used to collect NDVI imagery twice during the corn growing season. Upon harvest, NDVI imagery was correlated with Yield. This represented a moderate to strong correlation and therefore it is safe to say that in-season crop health status is a good predictor of final yield. Furthermore, the NDVI imagery assisted our ground-truthing efforts to find locations of compaction. It should be noted that compaction isn't the only determinate responsible for crop health and therefore, NDVI images need to be interpreted with caution and the value of ground truthing zones of suspected compaction cannot be understated.
It is widely believed that soil texture is an important determinant when considering how prone to compaction a field might be. We don't disagree with this statement, but this study uncovered that clay soils and loam soils can be compacted to the same degree without careful management. This emphasizes the importance of communicating with growers the need to be concerned about compaction regardless of your soil texture.
The zones of more compaction identified in the three study fields on average yielded less than the less compacted zones. This demonstrates that compaction causes yield loss and that growers ought to be concerned about the long-term consequences of compaction from a production point of view.
To further quantify compaction caused yield reduction this study should be expanded upon in future years to more thoroughly assess field level compaction. On-the-go instruments/sensors should be utilized to efficiently obtain and process the collected data. In addition, the effectiveness of various compaction abatement management practices (deep tillage, cover cropping) should be investigated.

Attendance at Event: 60

☐ **If project was a one-year in field trial, Please attach the completed OMAFRA Report Form**

Name of OMAFRA Contact Person:
(where applicable) ______________________