SOIL CLAY CONTENT INFORMATION PER FIELD - GIS ANALYSIS

Whittaker Farm for SmartRice program certification

Report prepared by Landviser LLC for RiceTec Inc

Our Approach:

We would characterize Client's land resources (soil maps, available geology information, elevation, satellite imagery, outlining existing structures) and combine that with detail SUBSURFACE IMAGING – utilizing state-of-art technologies developed by us and our Partners. Depending on the project Landviser can go beyond just obtaining existent geological and soil maps from USDA/NRCS and satellite imagery as some land accessors do. In additional to that information, we can deploy field crew equipped with the whole range of geophysical instruments for complete subsurface imaging of soil horizons or geological layers on your site – as deep as 1200 ft – if needed!
To learn more about our company Products and Services, visit https://landviser.com/

Landviser LLC is authorized representative of the manufacturers of geophysical instruments and GIS- geophysical-geological software (ESRI and Bentley-Seequent) and has deep understanding of all modern Geo-Technologies and applications.

Sincerely Yours, *Dr. Larisa Golovko, CEO of Landviser (info@landviser.net)*

Contents

INPUTS

FARM DATA

We were provided two Excel files with Latitude-Longitude of the field center for the fields participating in SmartRice branded grain production (2020-2021 and 2022). This dataset is a subset of the fields and farms enrolled in multi-year sustainable rice production program "SmartRice" pioneered by RiceTec in 2015. Landviser has also worked on the SmartRice project with RiceTec Inc in 2020-202 compiling and analyzing geospatial data of all farmers and consultants enrolled in the program.

SOIL INFORMATION DATA SOURCES

There are several soil datasets available from USDA/NRCS, the most detailed is SSURGO. However, since Whittaker farm is split between four counties in AR, we also explored the possibility to use a state-aggregated dataset STATSGO2. The brief description of the dataset features, spatial resolution and

SSURGO

The most detailed SSURGO soil database (META data description webpage https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=nrcs142p2_053631). All documentation on the database was downloaded, organized in private GitHub repo for SmartRice Project and delivered to RiceTec Inc via secure Landviser's Client Support Portal.

The spatial and tabular information is available per county and needs to be accessed separately per each county if a farm split between counties (as was the case with Whittaker farm).

The SSURGO standard encompasses both tabular and spatial data. SSURGO spatial data duplicates the original soil survey maps. This level of mapping is designed for use by landowners and townships and for county-based natural resource planning and management. The original mapping scales generally ranged from 1:12,000 to 1:63,360. The original maps from soil survey manuscripts were recompiled to scales of 1:12,000 or 1:24,000 for digitizing into the SSURGO format. SSURGO is the most detailed level of soil mapping published by the National Cooperative Soil Survey.

STATSGO2

STATSGO is a generalization of SSURGO database with the same table structure but less detail spatial coverage in map units. However, it is conveniently available to download for the whole state or US. Yet, those generalizations were compiled in 2016 and the updates are not often.

The Digital General Soil Map of the United States or STATSGO2 is a broad-based inventory of soils and non-soil areas that occur in a repeatable pattern on the landscape and that can be cartographically shown at the scale mapped of 1:250,000 in the continental U.S., Hawaii, Puerto Rico, and the Virgin Islands and 1:1,000,000 in Alaska. The level of mapping is designed for broad planning and management uses covering state, regional, and multi-state areas. The U.S. General Soil Map is comprised of general soil association units and is maintained and distributed as a spatial and tabular dataset.

The U.S. General Soil Map was developed by the National Cooperative Soil Survey and supersedes the State Soil Geographic (STATSGO) dataset.

Soil Data Delivery Format

Spatial data are available in ESRI® shapefile format. Spatial reference is decimal degrees, World Geodetic System 1984 (WGS84). Tabular data are available as ASCII text files (.txt). Fields are pipe delimited, and text is double-quote delimited. A Microsoft® Access® template database is available for use with the tabular data.

SSURGO/STATSGO2 Structural Metadata and Documentation

Soil Data Citation

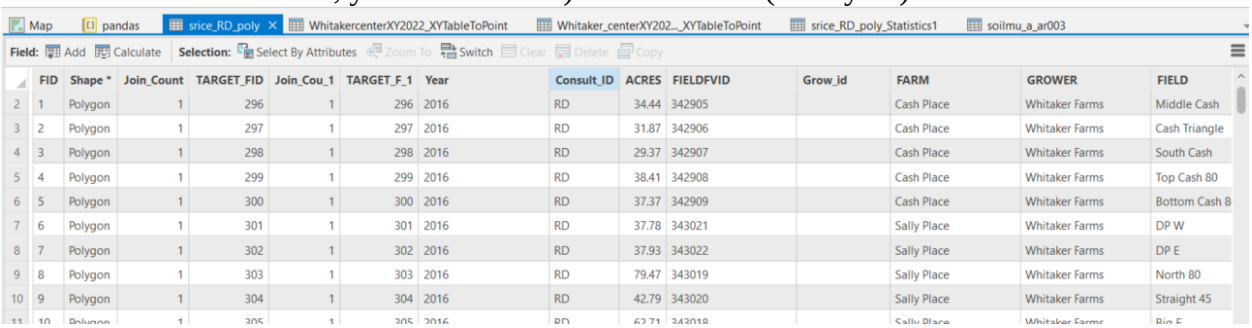
Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at http://websoilsurvey.nrcs.usda.gov/ .
Accessed [06/25/2022].

METODOLOGY

Prepare Farm Data

1. Create unique Field ID for fields provided – two datasets:
   - 2020-2021 (167 records)
   - 2022 (163 records)

   - clean data (check for duplicates, empty fields, etc – Python Pandas).
   - Import into ArcGIS and create two POINT shapefiles from the tables for spatial joint with field outlines shapefiles (when importing/converting to point map layer – make sure that extra empty features are not created – sometimes for data coming from Excel->CSV->ArcMap empty fields are mistaken as features).
2. Create Unique Shapefiles dataset for fields outlines (SmartRice GIS program data – from Robb Dedman Consultant, years 2015-2021) – 599 records (field-year)



	FID	Shape *	Join_Count	TARGET_FID	Join_Cou_1	TARGET_F_1	Year	Consult_ID	ACRES	FIELDFVID	Grow_id	FARM	GROWER	FIELD
2	1	Polygon	1	296	1	296	2016	RD	34.44	342905		Cash Place	Whitaker Farms	Middle Cash
3	2	Polygon	1	297	1	297	2016	RD	31.87	342906		Cash Place	Whitaker Farms	Cash Triangle
4	3	Polygon	1	298	1	298	2016	RD	29.37	342907		Cash Place	Whitaker Farms	South Cash
5	4	Polygon	1	299	1	299	2016	RD	38.41	342908		Cash Place	Whitaker Farms	Top Cash 80
6	5	Polygon	1	300	1	300	2016	RD	37.37	342909		Cash Place	Whitaker Farms	Bottom Cash 8
7	6	Polygon	1	301	1	301	2016	RD	37.78	343021		Sally Place	Whitaker Farms	DP W
8	7	Polygon	1	302	1	302	2016	RD	37.93	343022		Sally Place	Whitaker Farms	DP E
9	8	Polygon	1	303	1	303	2016	RD	79.47	343019		Sally Place	Whitaker Farms	North 80
10	9	Polygon	1	304	1	304	2016	RD	42.79	343020		Sally Place	Whitaker Farms	Straight 45

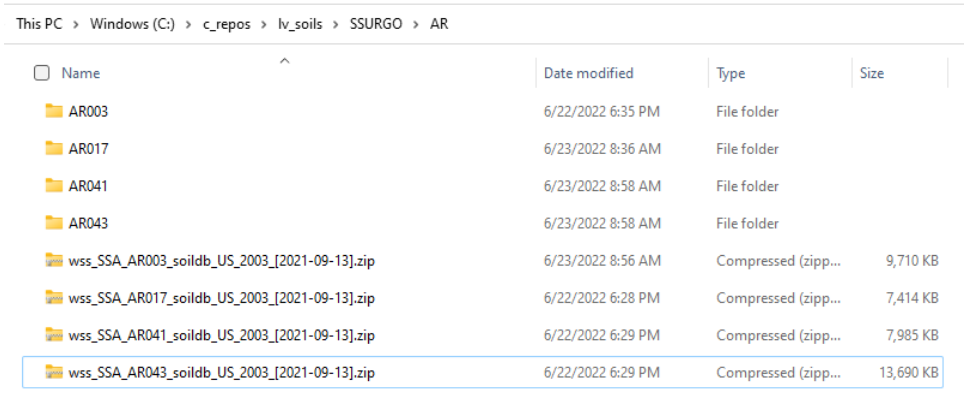
which only has 170 unique fields (if using FVID). Perform Dissolve per unique fields and calculate Average of the field acres and Center X/Y coordinates. That dissolve resulted in 233 unique polygons (some duplicates of field ID due to changes in field name (as named by Farmer) over the years).

Download Soil Data from NRCS (SSURGO)

Whittaker farm is spread across four counties in Arkansas.

	OBJECTID *	NAME	FREQUENCY
1	1	Ashley County	122
2	2	Chicot County	71
3	3	Desha County	348
4	4	Drew County	58
	Click to add new row.		

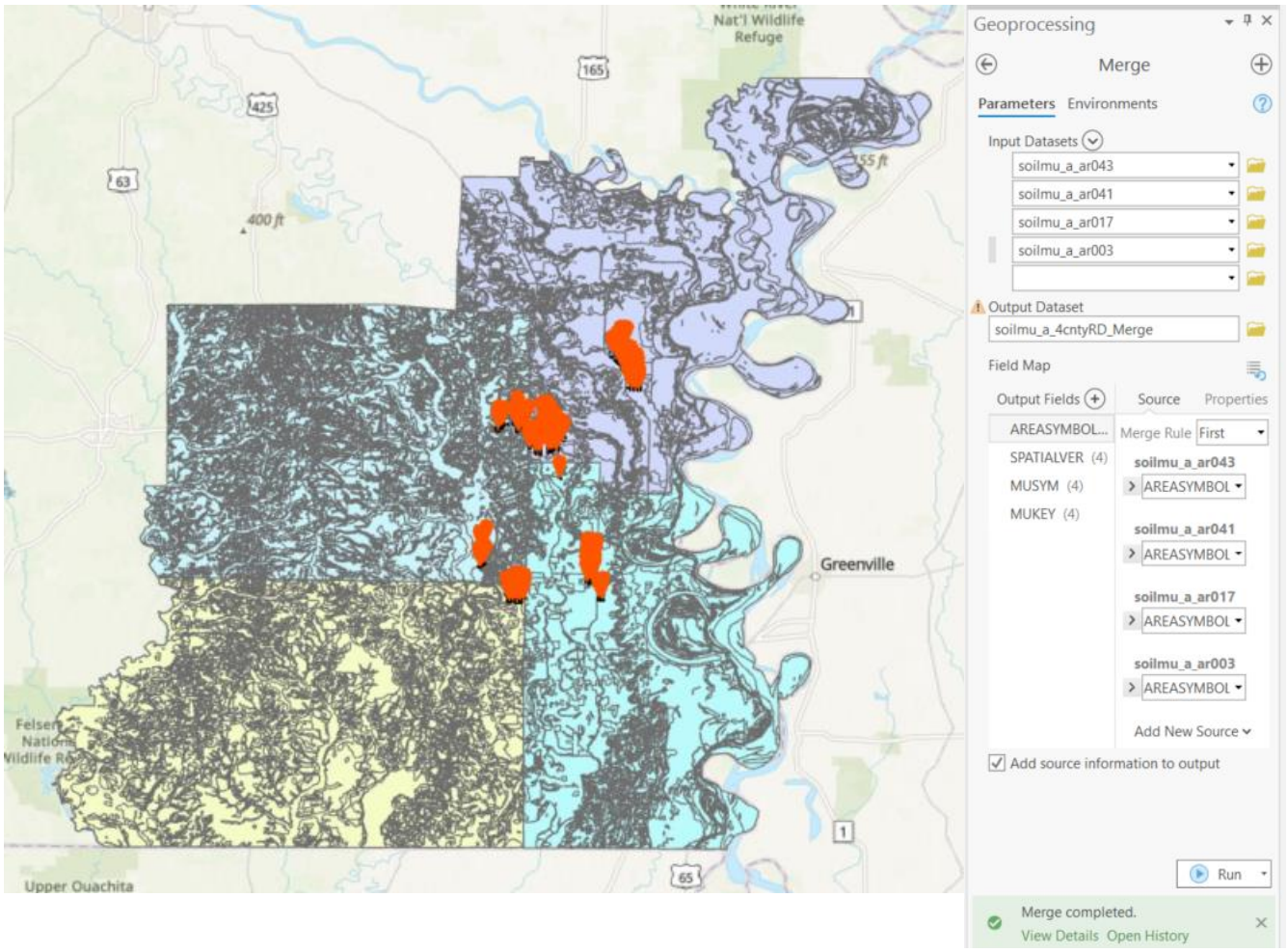
3. The SSURGO soil datasets (zipped spatial and tabular) were downloaded for each county (SSURGO soil survey area) from https://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx
4. Soil data pre-processing:
   - Creating local data repo and unzipping spatial and tabular data per county in organized manner.



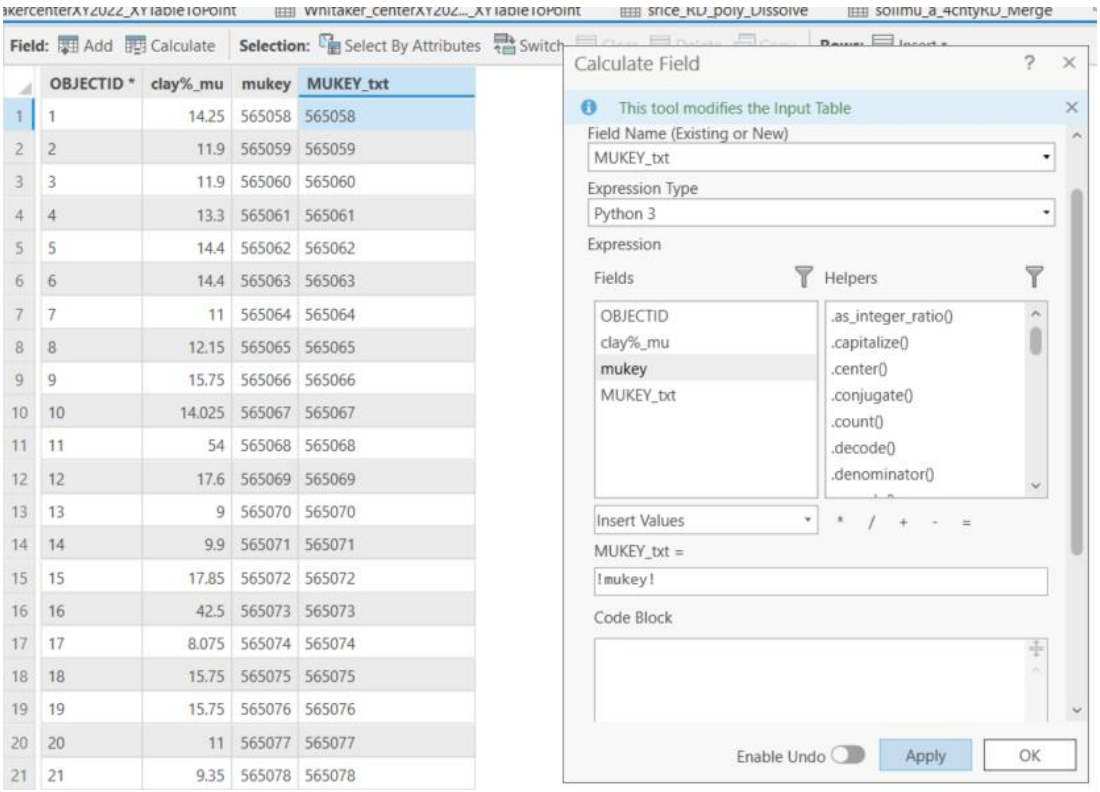
- the shapefiles of soil map units (four separate counties) plotted in ArcGIS
- the tabular data were imported into MS Access as described in SSURGO database manual to verify if the required clay percentage of the soil map units is available and how to summarize those for the Whittaker fields

SSURGO Spatial data – ArcGIS Pro

The spatial outlines of soil map units per each county was merged in one shapefile outline to prepare for cutting per Whitaker farm fields.



The resultant shapefile table was joined with the total clay content percentage (by mukey) derived from SSURGO Tabular data as described below. First the mukey datatype had to correspond with SHAPEFILE (i.e. TXT), therefore we needed to import CSV file to geodatabase and recalculate new index.



SSURGO Tabular data – Python scripting

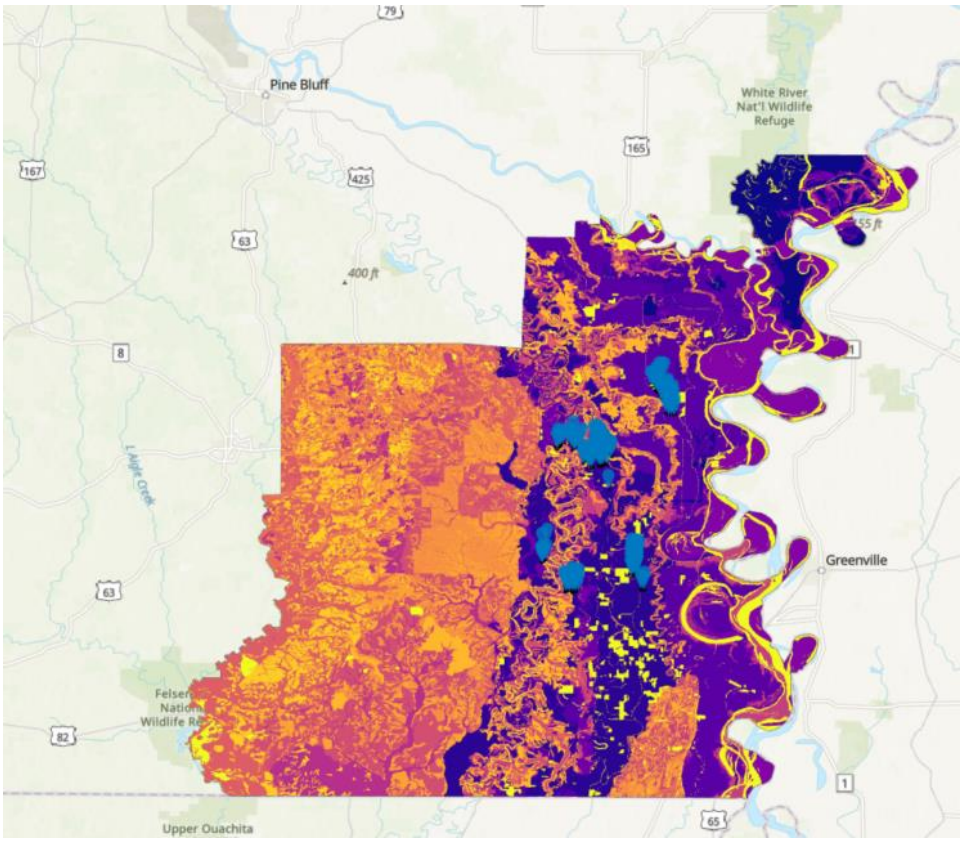
To process the tabular data and calculate weighted average the Python script was written (PDF of the Jupyter notebook of the procedure is included as deliverable, Python code available upon request). Steps for each county:

1. Load soil horizon data per soil component.
2. Extract percent of total clay content per topsoil horizon (A) for each soil component (cokey).
3. Calculate weighted average of the clay content per map unit (mukey) based on the percent of each soil component included in the map unit.
4. Merge all four counties together and output combined CSV mukey | clay%.

SSURGO – join Spatial and Tabular data

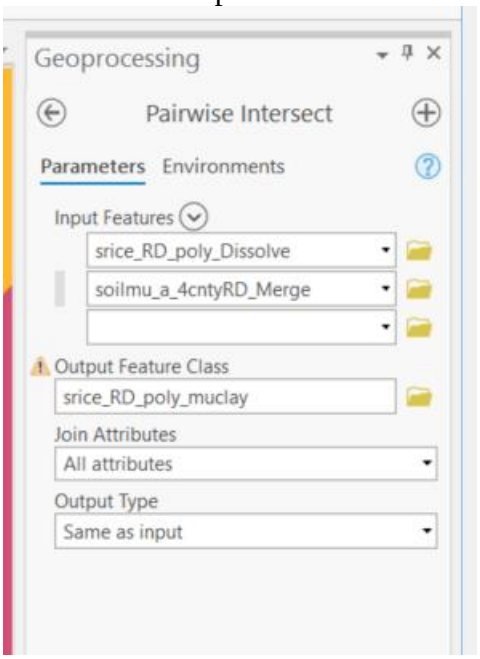
The map of the clay content of the whole area was derived by joining spatial shapefiles of the counties together with the complete % clay in the topsoil recalculated from tabular SSURGO data.

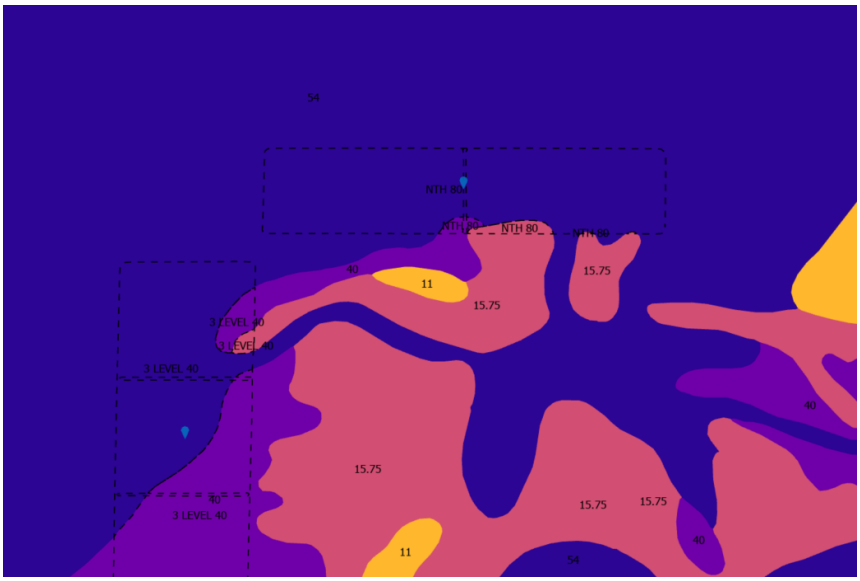
The whole area clay content map.



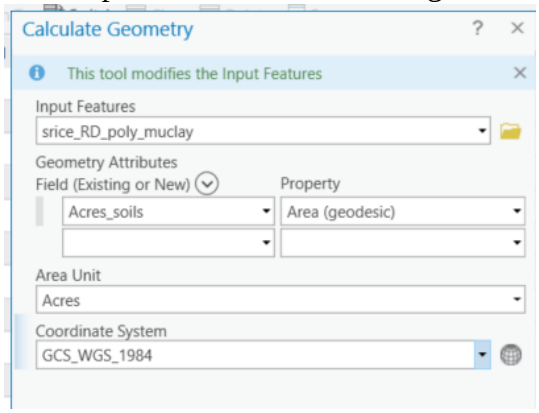
Intersect Soil Clay Map with Field Outlines

1. From the unique field outlines and soil map units (mukey) from SSURGO we performed spatial intersection and calculated number of acres in each field corresponding to MUKEY. Some fields completely correspond to one soil type while other can be equally covered by two or more soil types. Therefore, the number of unique polygons increased from 233 to 403. Number on the map shows clay % for the soil map unit.

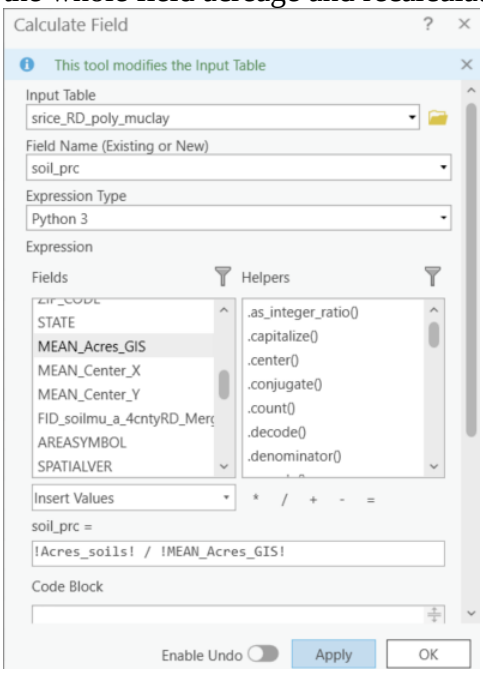


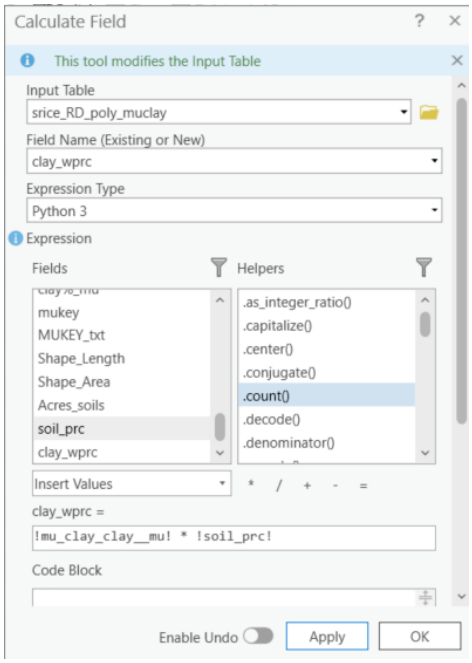


2. After spatial intersect of soil map units and field outline the acreage of each unique polygon (soil type within field) was computed in ArcGIS Pro using Geometric Calculator.

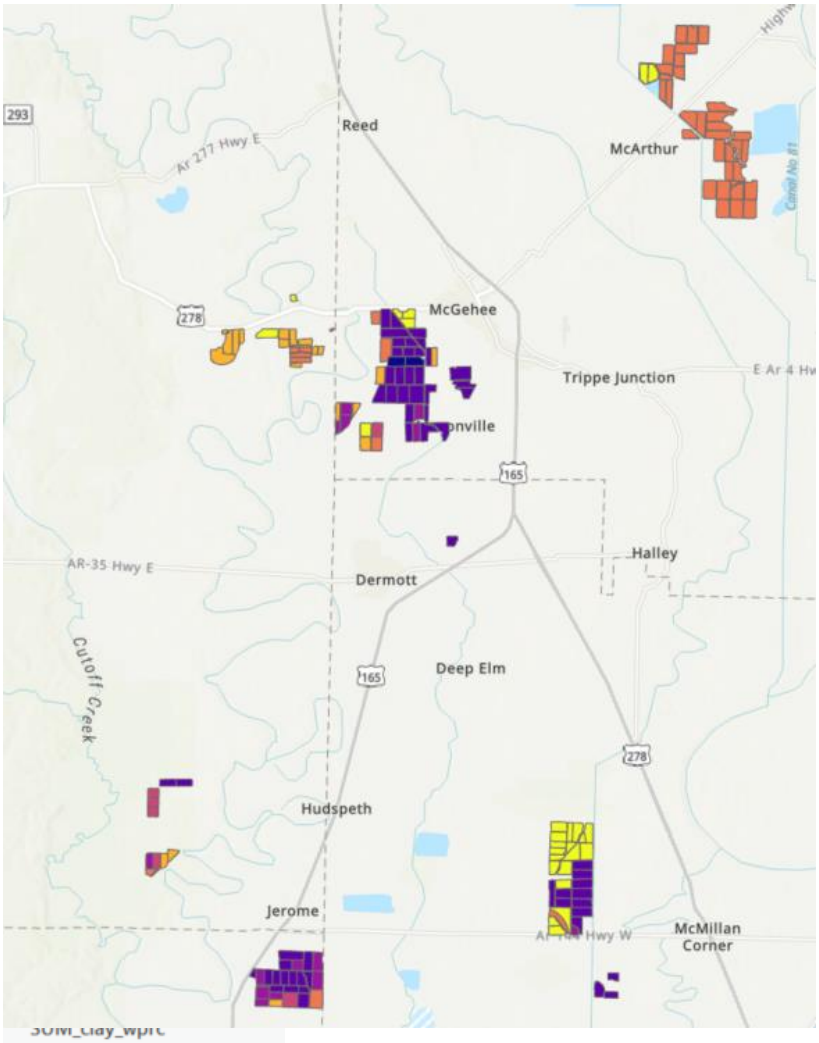


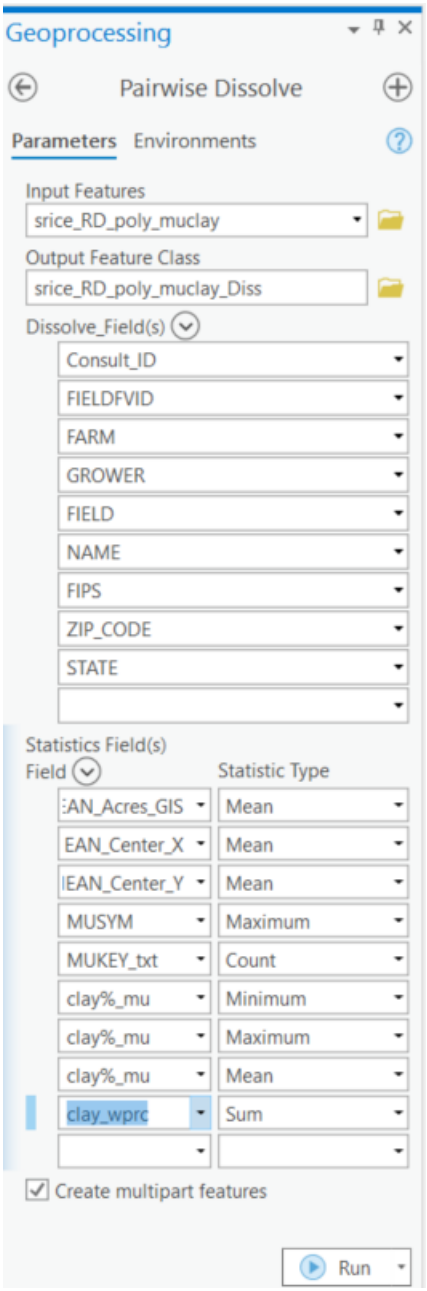
3. Then, we calculated the % of the field occupied by certain soil type from that acreage and the whole field acreage and recalculated weighted clay content % per part of the field.





4. Finally, another dissolve was done to summarize weighted clay content % and soil type info per whole rice field in the program. We are back to 233 unique polygons (fields) – the statistics for the clay content per field was calculated – in some cases a field can occupy as many as 6 soil types. Below is an example of how clay content can vary per field, pulling just value per center point for the field can be very wrong, as well as using just average value from all soil types (not weighted).
5. **Note:** very low clay % values on some fields can be due to the fact that SSURGO map refer to some rice fields as WATER and do not provide soil information (clay content equals 0, etc). Those records were manually QC after merging back with SmartRice production data to Excel files and reviewing records in ArcGIS Pro.



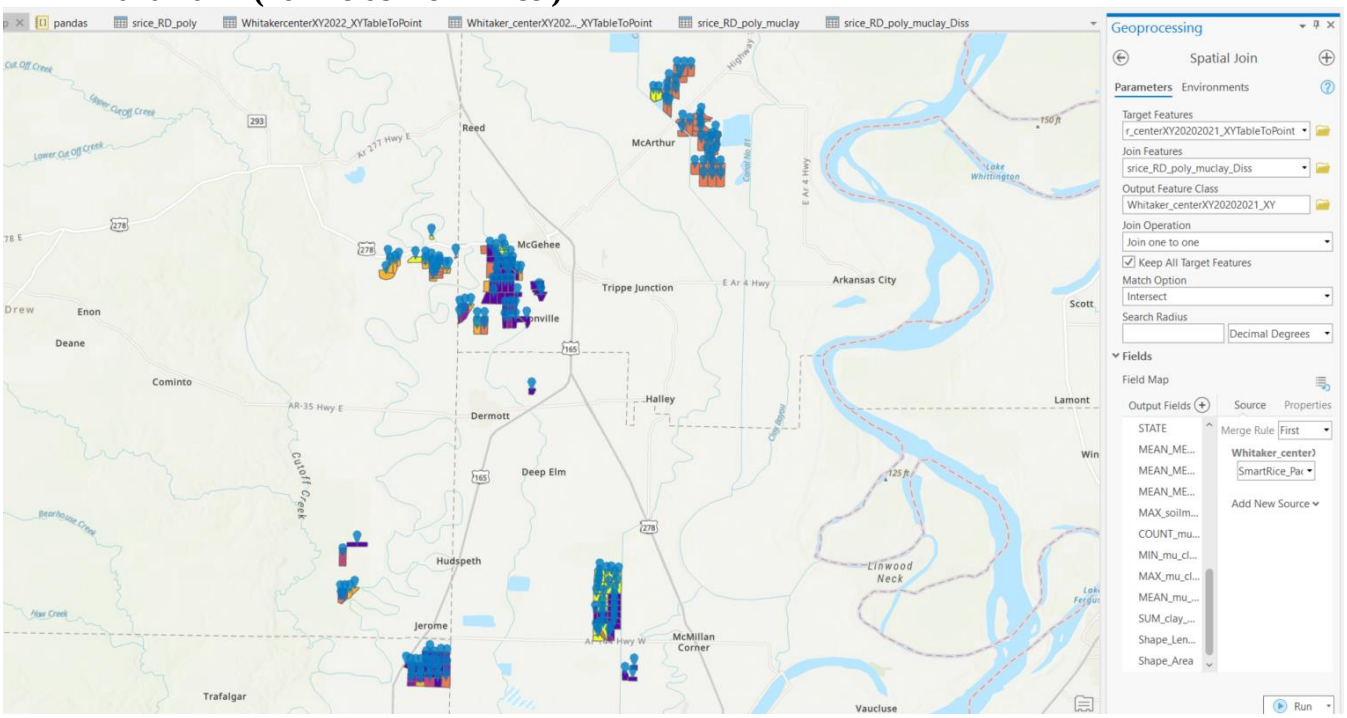


MUSYM	COUNT_mu_clay_MUKEY_txt	clay%_mu	clay%_mu	MEAN_mu_clay_clay__mu	SUM_clay_wprc
RbB	6	11	40	23.391667	14.331083
RbB	3	11	15.75	14.166667	13.102951
RbB	5	11	40	24.92	15.772873
RbB	3	11	40	22.25	15.088423
RbB	2	15.75	40	27.875	24.914723

QC: Link Field Clay back to SmartRice Program data

Verify and merge Excel tables of the points with existing SmartRice unique field outlines – ArcGIS Pro Spatial Join - Intersect.

2020-2021 (167 fields from Excel)

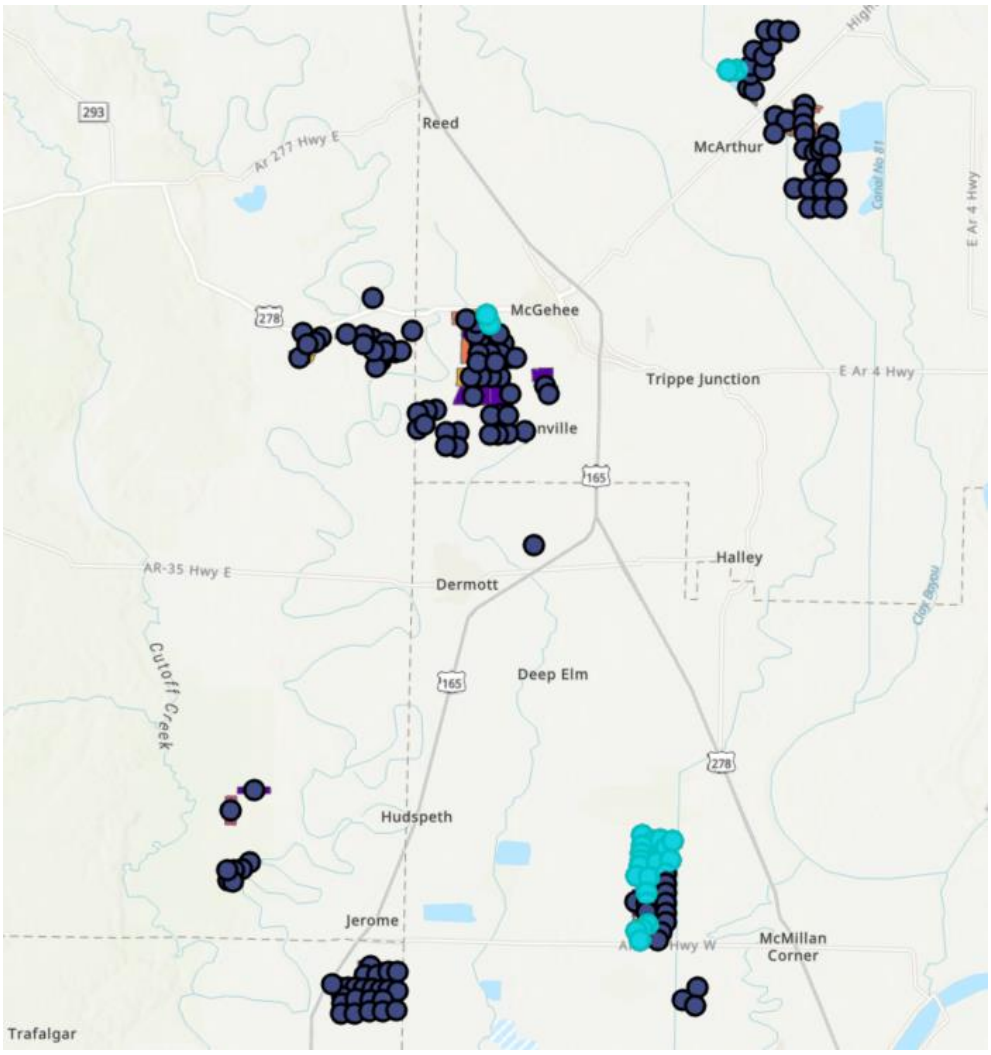


Three fields from 2020-21 missed Center Lat-Long – were removed from final joint.

Count	TARGET_FID	SmartRice Packaging	Farm Name	Farmer Field Name	Batc...	GIS...	FSA Farm...	FSA Tract Number	FSA Field Number	Latitude	Longitude	Consult_ID
0	66	<Null>	Catholic	6 West	<Null>	140.06	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>
0	73	<Null>	Cut Off	#4	<Null>	34.66	2362	4741	<Null>	<Null>	<Null>	<Null>
0	94	<Null>	Gumridge	GR 5	<Null>	7.09	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>
1	4	<Null>	Beouf River	Beouf River 4	BR 1	58.44	1825	2044	7	33.428009	-91.359867	RD
1	5	<Null>	Beouf River	Beouf River 5	BR 1	17.62	1825	2044	9	33.425185	-91.357815	RD

21 fields – corresponded to the WATER on SSURGO maps – resulted in very low clay content %. Those fields are highlighted on the map below.

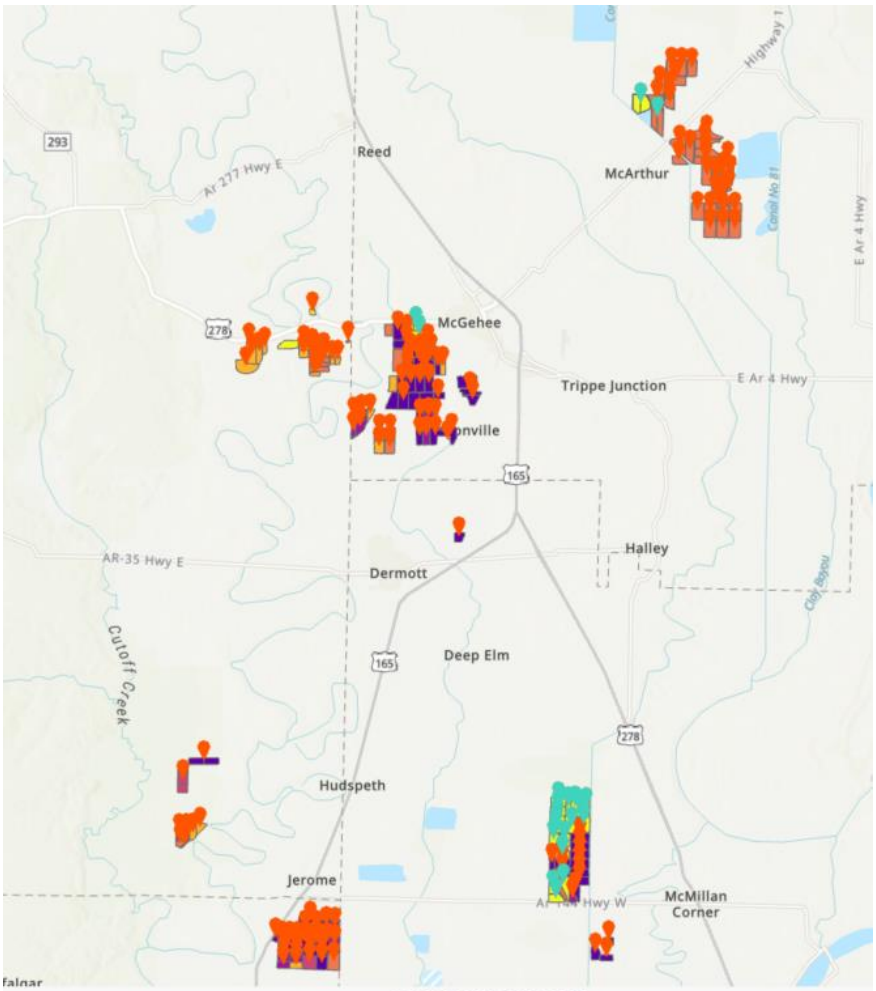
Those fields were manually edited with the clay values provided by the farmer in 2022.



2022

Same three fields have been missing Center Lat/Long as in 2020-21 – removed for now.

The fields with very low total clay content % were manually edited **SUM_claycontent** as from 2022 Farmer supplied data on Total Clay content. Those fields are highlighted in light Teal markers on the map.



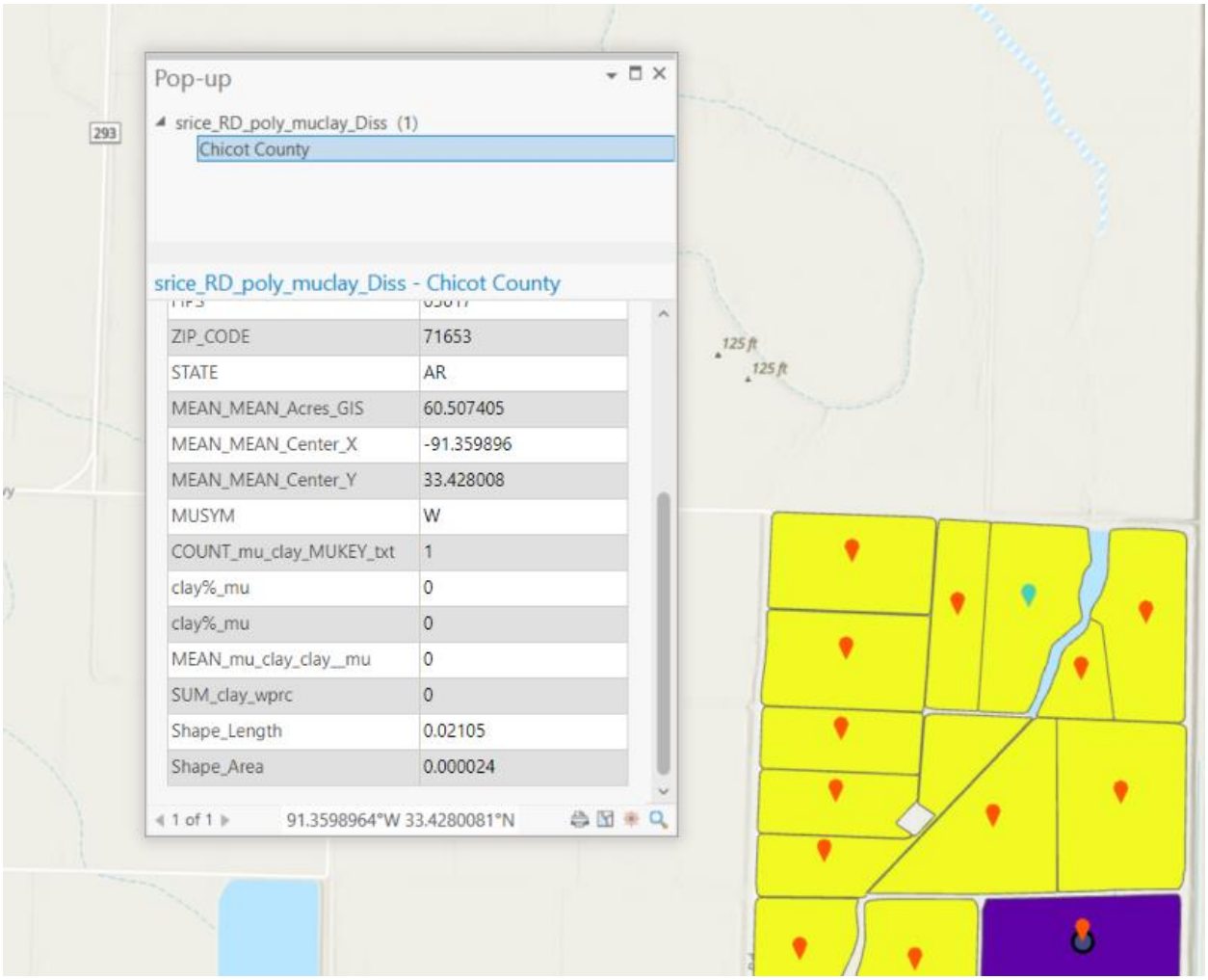
91.6520122°W 33.6928614°N

Map | pandas | srice_RD_poly | WhitakercenterXY2022_XYTableToPoint | srice_RD_poly_muclay_Diss | Whitaker_centerXY20202021_clay | WhitakercenterXY2022_clay

Field: Add Calculate | Selection: Select By Attributes Zoom To Switch Clear Delete Copy

	STATE	MEAN_MEAN_Acres_GIS	MEAN_MEAN_Center_X	MEAN_MEAN_Center_Y	MUSYM	COUNT_mu_clay_MUKEY_txt	clay%_mu	clay%_mu	MEAN_mu_clay_clay__mu	SUM_clay_wprc
1	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	43.17
2	AR	60.507405	-91.359896	33.428008	W	1	0	0	0	45
3	AR	18.57617	-91.357805	33.425167	W	1	0	0	0	45
4	AR	59.866828	-91.355294	33.427367	W	1	0	0	0	45
5	AR	72.655953	-91.361279	33.419366	W	1	0	0	0	45
6	AR	39.168758	-91.362634	33.427708	W	2	0	54	27	45
7	AR	59.851238	-91.330907	33.719867	W	2	0	44.25	22.125	45
8	AR	65.235803	-91.364337	33.413831	W	2	0	54	27	45
9	AR	52.477945	-91.367849	33.389763	W	3	0	54	22.958333	45
10	AR	61.648635	-91.366786	33.429758	W	2	0	54	27	45
11	AR	57.668061	-91.365498	33.419903	W	2	0	54	27	45
12	AR	61.016394	-91.367015	33.425936	W	2	0	54	27	45
13	AR	30.928319	-91.369091	33.393181	W	2	0	54	27	40
14	AR	84.530815	-91.356264	33.420294	W	2	0	54	27	45
15	AR	38.847863	-91.3672	33.422825	W	2	0	54	27	45
16	AR	37.990076	-91.367449	33.420373	W	2	0	54	27	45
17	AR	47.530304	-91.368845	33.414213	W	2	0	54	27	45
18	AR	54.501454	-91.365131	33.407677	W	2	0	54	27	45
19	AR	86.329832	-91.364718	33.395626	W	3	0	54	31.333333	45
20	AR	44.638204	-91.424826	33.623819	W	4	0	54	19.8625	18
21	AR	38.449144	-91.424482	33.627123	W	3	0	14.45	8.483333	35
22	AR	14.22604	-91.469133	33.633328	RbB	3	11	15.75	14.166667	13.102951
23	AR	56.653212	-91.441333	33.582649	Pe	2	11	54	32.5	13.64958
24	AR	30.62049	-91.464455	33.616479	RbB	3	11	40	22.25	15.088423

See the screenshot below of the process of identifying missing Total Clay records in tables and spatially.

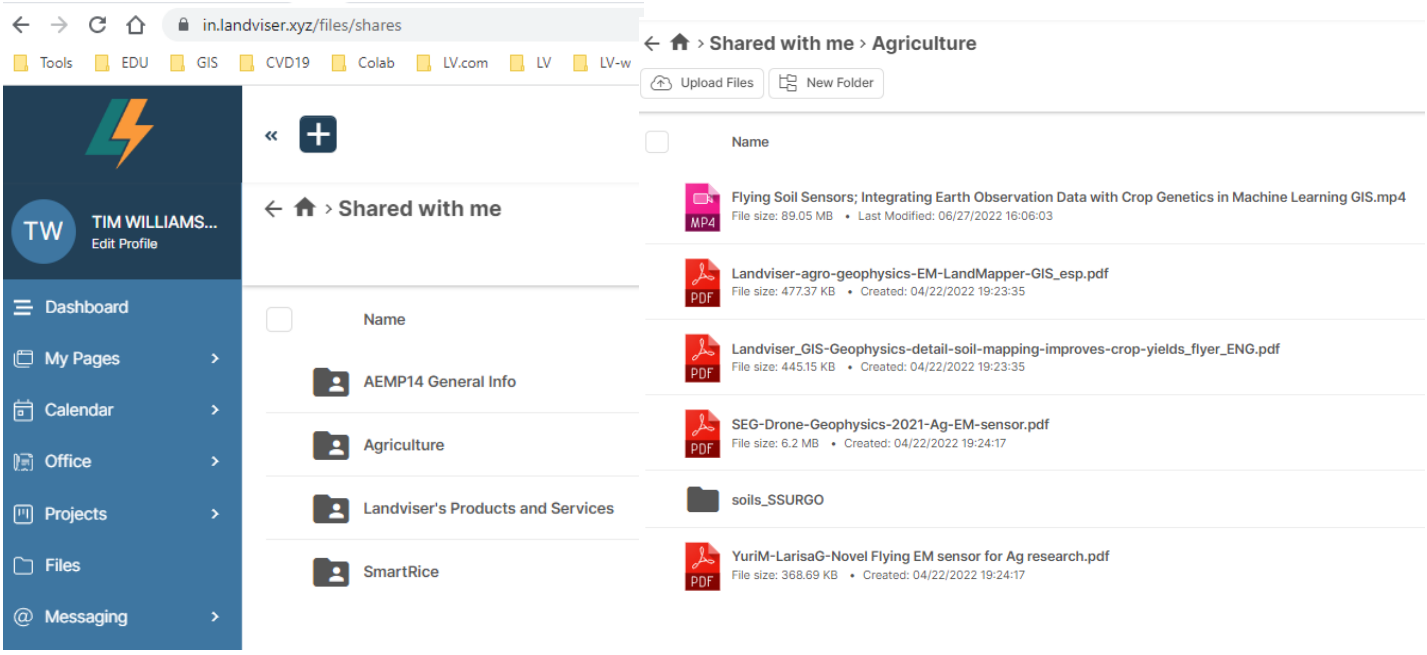


DELIVERED DATA on Landviser's Client Portal

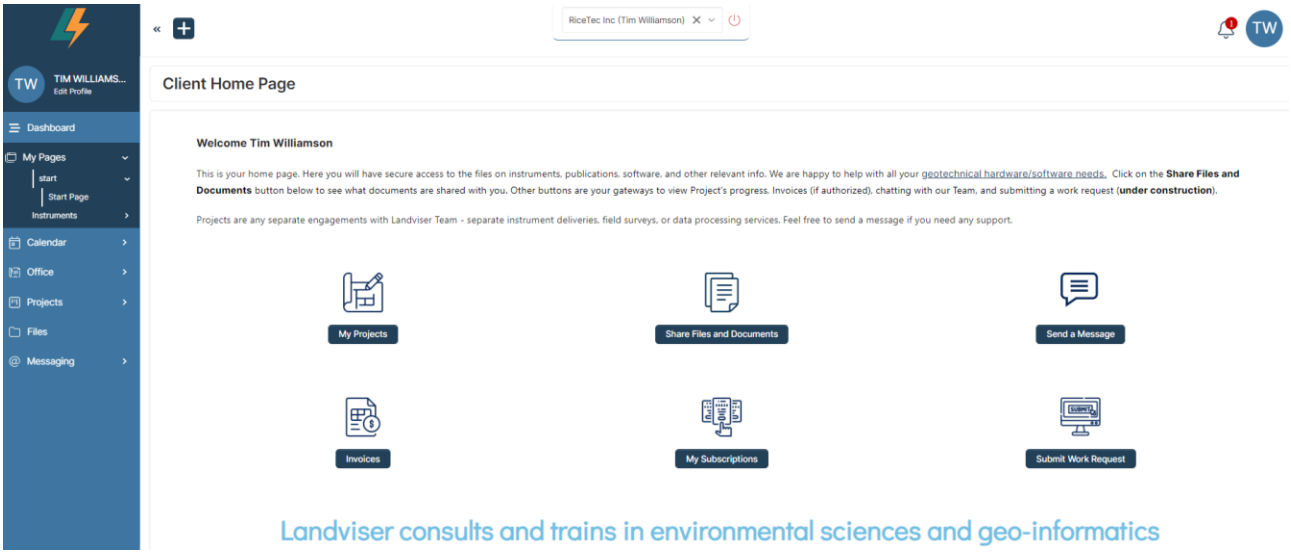
The final delivery is this report and three CSV files:

1. 2020-21 program fields with Clay/Soil info linked
2. 2022 program fields with Clay/Soil info linked
3. All Whittaker SmartRice fields 2016-2021 (Rob Dedman consultant) with Clay/Soil and county/zip code info linked
4. Zipped shapefiles of the #3
5.

Report PDF and CSV were emailed and all datasets, Python script, and references on soil data source (**Agriculture/soils_SSURGO**) are provided on Landviser's GeoTech Client Portal (**SmartRice/Whitaker_Audit**) in respective subfolders.



RiceTec's personnel and consultants of SmartRice Program can access data/reports at any time through their individual secure logins they created before. When you login, click on **Shared Files and Documents**.



If you are not yet a member of Landviser Client Portal, please, signup at https://in.landviser.xyz - make sure to check your email (including Junk/Spam folder) and click on the link to activate account.

THANK YOU

We would like to thank RiceTec Inc, for the opportunity to work together on the SmartRice project!

We are looking forward to continuing working with RiceTec and various crop consultants. We can provide GIS mapping and analytics, obtain and summarize soil, weather, and satellite information from public sources, securely merge it with proprietary company crop growth information, develop BI models, dashboards and geodata collection apps.

We are confident that we can meet the challenges ahead and deliver on our promises.

If you have questions about this report, please, contact Larisa Golovko by email info@landviser.net or phone **281-942-8850**.

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We are Enlightening Research (SM) @ our **Geo Support App:** *SIGN UP to* download manuals, publications, software, or schedule a video chat with me

Qualifications

Landviser LLC is continually proven to be an industry leader for high quality/guaranteed geotechnical equipment, software, and services in the following ways:

- Landviser is Business Partner of ESRI – the leader in geographical software and GIS analytics - and utilizes ESRI interactive mapping platform for all projects, has trained personnel skilled in geophysical subsurface survey processing and GIS (geographical information systems) portal development.
- Landviser is also value-added worldwide reseller of several geophysical and geological software of Seequent, Aarhus Geosoftware, GeoTomo Software and develops analytical models using open-source tools (Python and web development).
- Landviser has invented and brought to international market a LandMapper - hand-held soil resistivity, conductivity and self-potential meter. We are also a value-added supplier of high-quality geophysical surveying instruments of SiberGeo, KB Electrometry, and TerraZond (SibER subsurface imager, EMI scanners AEMP-14 and Geovizer, 3D GPR – Ground Penetrating Radar) and high-accuracy RTK GPS units.

Landviser LLC has recently certified by SBA as WOSB – Women Owned Small Business.