Using Animation & Static Maps to Capture the Dynamic Phenomenon of Flooding on Farm fields
When flood waters inundate farm fields, situations are created where nutrients & sediment from floodplain soils are transported into rivers and streams. There needs to be a balance between using highly productive floodplain soils for crop production & avoiding nutrient / sediment loss in areas regularly inundated with floodwaters.
Lake Champlain is in Trouble

Curbing Nutrient Pollution

Lake Champlain Is a Mess; Now Who's Going to Clean It Up?
Over the decades there have been many serious flood events in Vermont - *extreme weather events are occurring with more frequency*

We need to **manage risk** – we need to find ways to reduce sediment & nutrient loss from agricultural soils **in the floodplain**
On the Federal level, USDA has a system to evaluate farm fields in terms of erosion risk (sheet & rill erosion) -- taking into account such things as slope length, steepness, soil type, etc.

Fields with high erosion risk are labeled Highly Erodible Land (HEL)

To minimize erosion risk practices such as crop rotation & growing cover crops are required on HEL fields

This assessment system always rates flat Floodplain Soils as Non-HEL
The erosion risk on floodplains is caused by different factors that are *not* evaluated under the current risk assessment system (HEL) for farm fields.

**What are the erosion risks in the Floodplain?**

- Inundation risk
- Avulsion risk & Scouring risk

During floods, fast moving water will cut new channels in the floodplain (these can be permanent).
Scouring - Just how much material is being lost? On one farm – close to 100 truck loads of topsoil lost in one storm.

In 2000, USDA FSA helped with the cost of filling in gullies and scour holes - with 1266 yards of fill (90, 14 yard truck loads of fill).

In 2002, same thing - this time “65, 14 yard truck loads of sand”.

Scouring risk is different from Inundation risk.
Erosion on **uplands vs alluvial soils** – amount of sediment lost is staggeringly different

<table>
<thead>
<tr>
<th>Upland soil</th>
<th>Allowable soil loss</th>
<th>4-5 tons/acre per year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \frac{1}{2} ) a dump truck load</td>
<td></td>
</tr>
</tbody>
</table>

(14 yards = 20 tons)

The **HEL rating** system has a “tolerable soil loss” amount

**Alluvial Soil that has scouring** - Soil Loss from *one* floodplain field after *one* storm event!!! 90 dump truck loads

There are **no systems** in place to evaluate and monitor soil loss in **floodplains** (or sediment accumulation)
Adaptation – this farmer has changed management on these fields & put permanent vegetation in those areas that flood constantly (the flood chute)
VT Agency of Agriculture has drafted & passed new rules in order to more *strictly regulate farming practices on floodplains* -- to help curb nutrient pollution

The Basic idea:

- **is to ensure cover crops** are used on flood plains (to lessen sediment loss)

  &

- **shorten the widow of time** when **manure** can be spread be spread on floodplains (to encourage plant uptake of nutrients from manure application while it is still the growing season)

- spreading is banned from Oct16 to April 14th – on the FP

*Cover crops* provide *vegetative cover* once the corn has been harvested which protects the soil over the winter from erosion & from spring flooding (to some degree)
FREQUENTLY FLOODED FIELDS

**DEFINITION. WHY IN RAPS?**

1st Draft Oct 2015

- Based on farmer feedback that this term was "too broad" and requesting a more discreet definition, we shifted to:

**Final Rule December 2016**

(c) Annual croplands subject to flooding from adjacent surface waters are required to be planted to cover crops. Broadcast seeding must be completed by September 15th of each year. Seed established with drill seeders or otherwise incorporated shall be completed by October 1st of each year.

(d) Annual croplands subject to frequent flooding from adjacent surface waters, as described in the USDA Soil Survey Flooding Frequency Class, shall be required to be planted to cover crops. Broadcast seeding must be completed by October 1 of each year. Seed planted with drill seeders or otherwise incorporated shall be completed by October 15 of each year. The Secretary may, on a case-by-case
Why use USDA / NRCS Frequently Flooded Soils?

It is the only “flooding data” that we have in Vermont that is **Statewide**

Unfortunately, these maps are being used **beyond** the intended scale (1:20,000 scale of mapping – often enlarged to 1:5,000 farm field scale)

In the Champlain Valley the soil maps are from 1940s, 1950s era – much has changed. Flood plains are dynamic – soils & topography in this setting do change over time.

Why not use **lidar**?

That is the plan, in time, once we have statewide coverage.
Using **lidar** (but not taking into account the *change in elevation of the surface of the river* as it flows through this map extent)

**NRCS Soil Maps**

How can the flooding regime change from frequent to occasional all on the same plane?

Note how the creek has changed course since soil mapping was done.
Comparison of both – lidar “flooded to a contour” & Soil maps

2011 fairly big flood but not unusual – occurs quite often in past 30 years

Would be good to have information on this particular event – 2 year flood, 5 year flood???
Trying different Symbology for colorizing the DEM – various attempts
Helpful to see old oxbows
The flood waters appear to come up the river – a little weird...

Animation of the flood

3D can be helpful

I’ll play the actual animation at the end – in case it doesn’t work
How does the animated Flood Simulation work? A bit of cursory how-to

A “water layer” is added below the DEM & is pulled through the DEM to give the illusion of flooding
Another toolbar I had never used, until this situation – the Animation toolbar
Hit create button

Check those are set correctly!
Then, set the Z translation for the “Layer Keyframes” that makes the river rise.

Next, save the animation.
Is this my invention?
Absolutely Not!

YouTube -- Instructions - complete with zippy music

OMG!!! Really bad flood in this scenario

https://www.youtube.com/watch?v=DV4QqJNljuo

HOW TO CREATE A FLOOD SIMULATION IN ARCGIS 10.4.1

Many thanks to ArcGIS Tips!!!
For making this video
What is the practical use of flood animations?

Up until now, there were few restrictions placed on farming floodplains. With new more restrictive required practices – some farmers need/want exemptions & variances to the rules.

As demonstrated earlier, the USDA/NRCS maps can be inaccurate. There are indeed **many valid situations** where farmers need the NRCS mapping to be reevaluated & reclassified to better fit the current day floodplain topography and flooding regimes.

However, a few claims of **“this field never floods”** that don’t match reality. Showing the animation **allows discussion** and points out those areas that are at the lowest elevations and most prone to flooding.

Imagery is a great source of information – what date? How big of a flood?
USDA / NRCS frequently flooded soils -- before Interstate existed & state highway was a dirt road

Be cognizant that the minimum size map unit for NRCS soil mapping is **3 acres** -- a lot of detail is washed out!

The **dynamic floodplain** is no longer the same as it was in 1940 or 1950 -- re-evaluation of where flooding occurs is needed

**Flood animation** – a screen capture - more nuanced & realistic picture of areas that flood using current topography from lidar
Useful maps when having discussions with farmers - to arrive a mutually agreed delineation of what floods “frequently”

Draping imagery & showing nutrient levels in fields
red = excessive levels

Note the sediment in the water at the time this image was taken

What is a reasonable end-point for Z value? What is the reference point?

Changing the color ramp was helpful to show more clearly those low elevation flood-prone areas (providing the river is not too incised)
Floods do not fill up to a contour on the landscape to a **set contour level** – the drop in elevation of the river’s surface needs to be taken into account.
To really accurately show flooding -- a model like HEC-RAS should be employed which incorporates channel geometry.
A better way—relative elevation—takes into account the drop in elevation of the river surface.

The color scale on this map goes from 5 feet below the surface of the river water level (purple color) to 26 feet above the water surface (brown color) - - Relative elevations.

The purplish areas flood most frequently

Dots show the actual, current day river surface

An example of lidar from Washington state

Image from the paper:
A methodology for Delineating Planning Level Channel Migration Zones
July 2014
Publication no. 14-06-025
Another consideration ... Definition of “frequently flooded” according to NRCS

Frequency is expressed as none, very rare, rare, occasional, frequent, and very frequent – are the NRCS categories

**Frequent** means flooding is likely to occur often, under normal weather conditions, the chance of flooding is more than 50 percent in any year but is less than 50 percent in all months in any year.

**VT Agency of Agriculture** is using a slight variation on the definition:

**Frequent** is a > 50% of a flood in a given year which essentially is a 2 year flood event (a different shade of meaning - recurrence interval – not a definite thing – a probability)

What about climate change? Increasing rainfall amounts affects the statistics
The bottom line – you need a **reference point**

Does the river really have **access to the floodplain**?

Yes, lower elevations will, at some point, fill up with water but how radical of an event does it take for water to spread over the landscape and leave the river banks?

**Flood simulation provides useful graphics** but not a definite map of what will flood

Many VT rivers are *so incised* it takes a huge event for flooding to occur
In summary – Flood animations

What are the advantages:

• Fairly easy to create
• Shows flooding is dynamic
• Can look at a “Noah’s Ark” type situation
• A useful conversation starter – not necessarily suitable for a regulatory GIS layer

What are the shortcomings to flood animation?

• Only suitable for small area of extent
• Fills to a contour
• If large elevation change along the river in the area of interest, it does not work
• If the lidar was captured at a time of high water levels – gives an exaggerated view of flooding
• Need knowledge of the area – high water marks for a 2 year event – guess work to set Z values
Why not eliminate farming on floodplains?
This is the most productive land in VT & much better than siting houses on floodplains.

What is the best use?
Would like to hear from others how you have depicted flooding using GIS methodologies or HEC-RAS

Floodplains serve a useful purpose and we need to protect them

Please contact me if you have questions or need more details

Also, if you have any of your own methodologies that you would be willing to share

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Extra slides
NRCS Frequently flooded soils

Animation – floodwater in pink