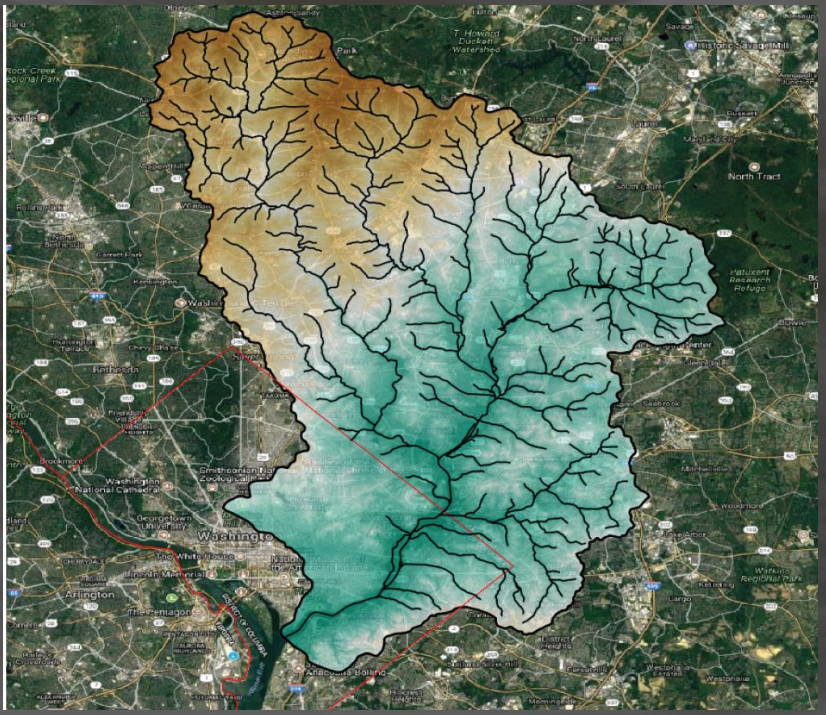
Micro and Macroplastics in Metro DC

THE CATHOLIC UNIVERSITY OF AMERICA

Dr. Jason H Davison, Assistant Professor

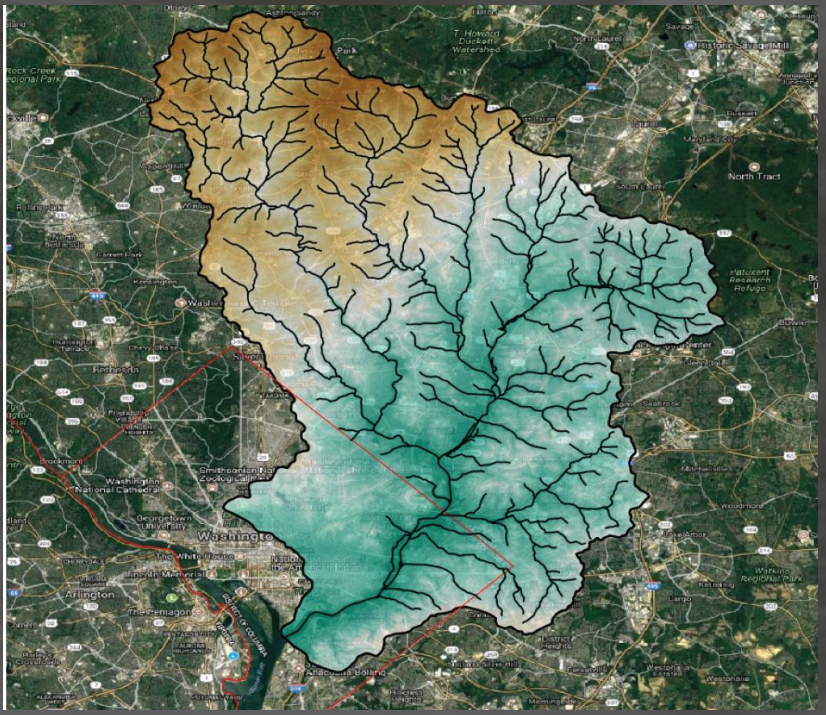
AnthroHydro Research Group
RAISE Director
School of Engineering

Anacostia Watershed



- Urban Watershed
  - 460 km^2
  - 14 km long
  - 1 million residents
- Head waters originate in Maryland (Montgomery and Prince George's County)

Anacostia Watershed

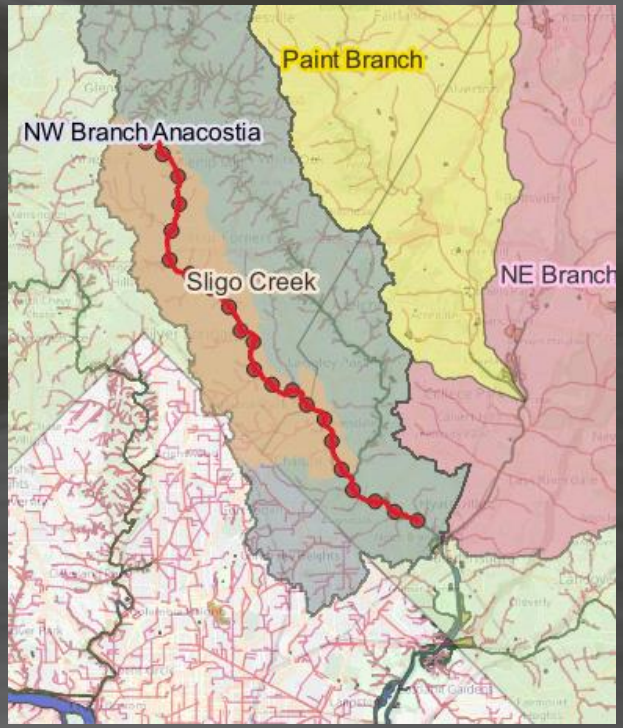


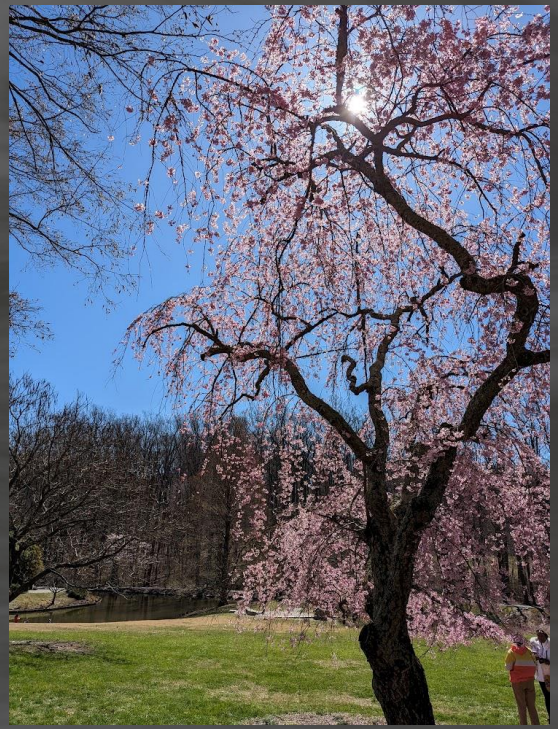
THE CAT

AnthroHydro

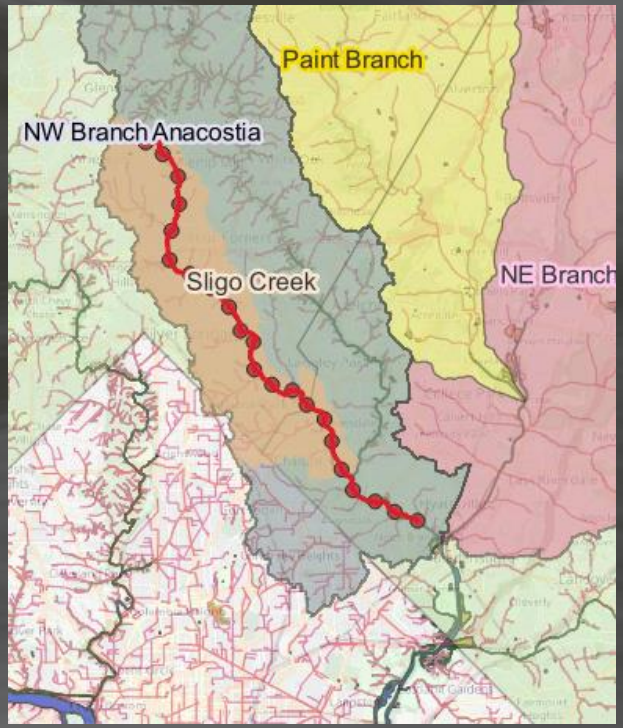
FIELD & LAB

Field Campaign



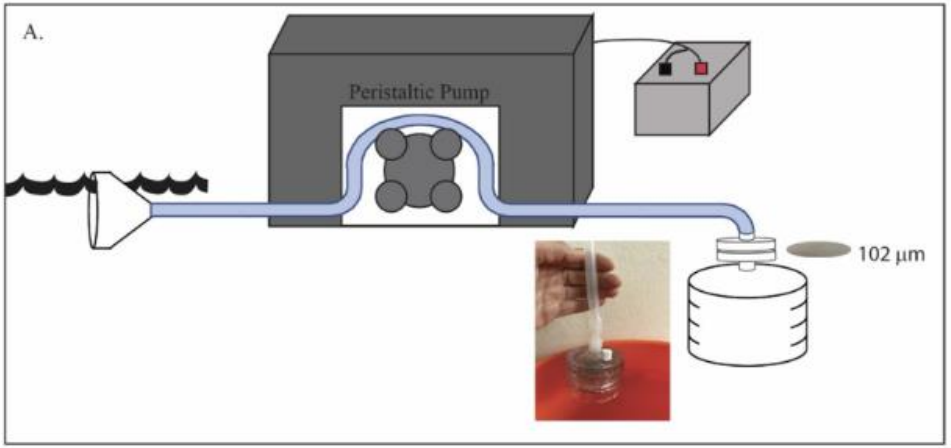


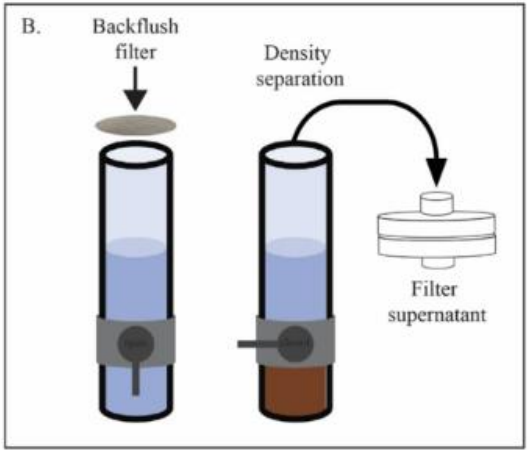
Field Campaign

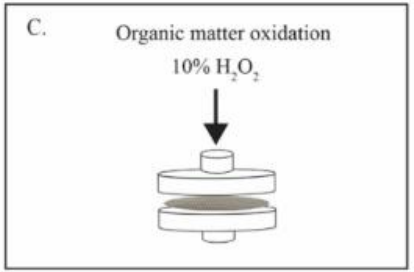


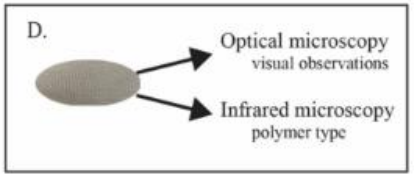
- 20 Samples in Sligo Creek
  - 0.5 Mile Sampling
- 100% Carbon Neutral Sampling
- Sampling methods from:
  Harrold and Arienzo et al. 2022, ES&T

A Peristaltic Pump and Filter-Based Method for Aqueous Microplastic Sampling and Analysis









DRI
Desert Research Institute

THE CATHOLIC UNIVERSITY OF AMERICA

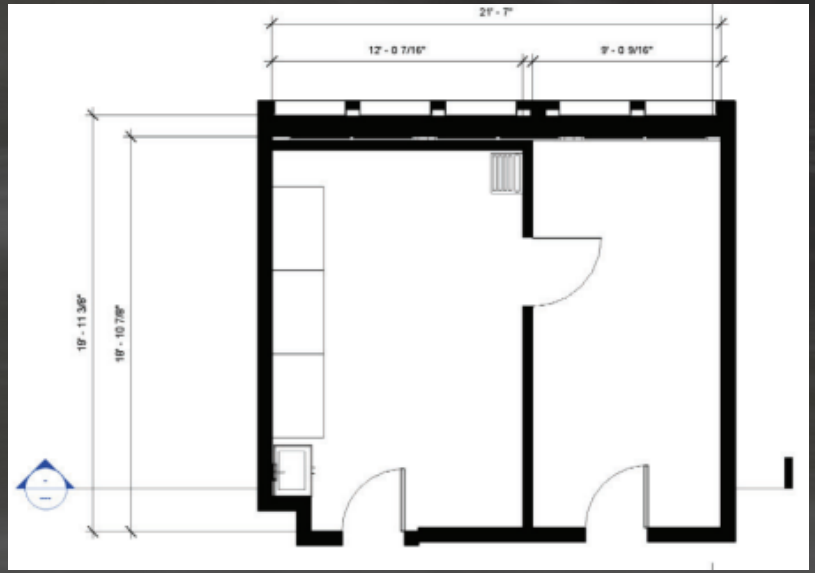
ThroHydro

Sligo Creek Field Sampling

Bike Field Work

Clean Room Development

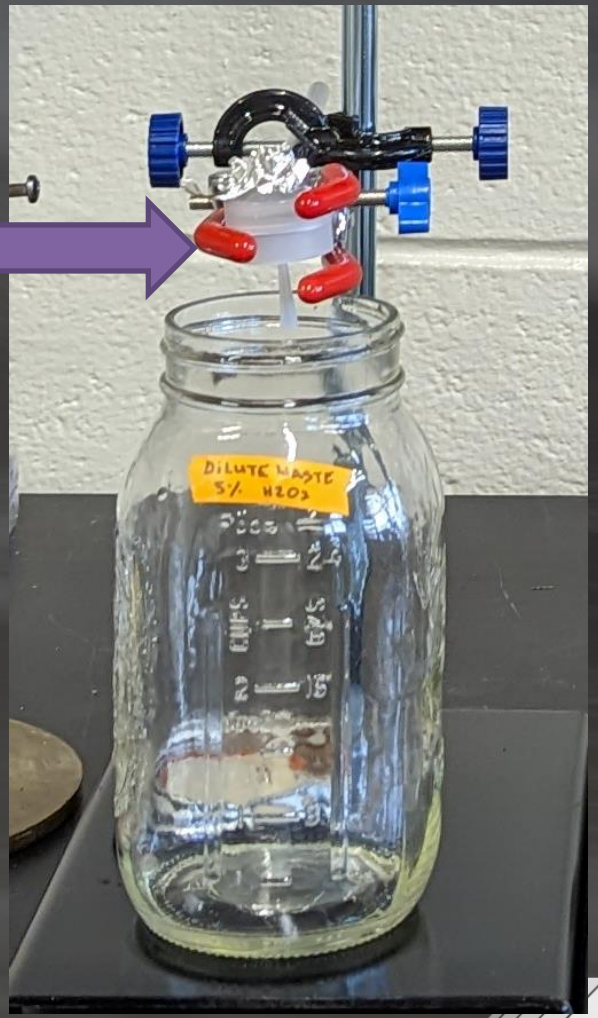
- Civil and Environmental Engineering Senior Design Team
- 2 Semester project
- Design Fall Semester
- Build Spring Semester

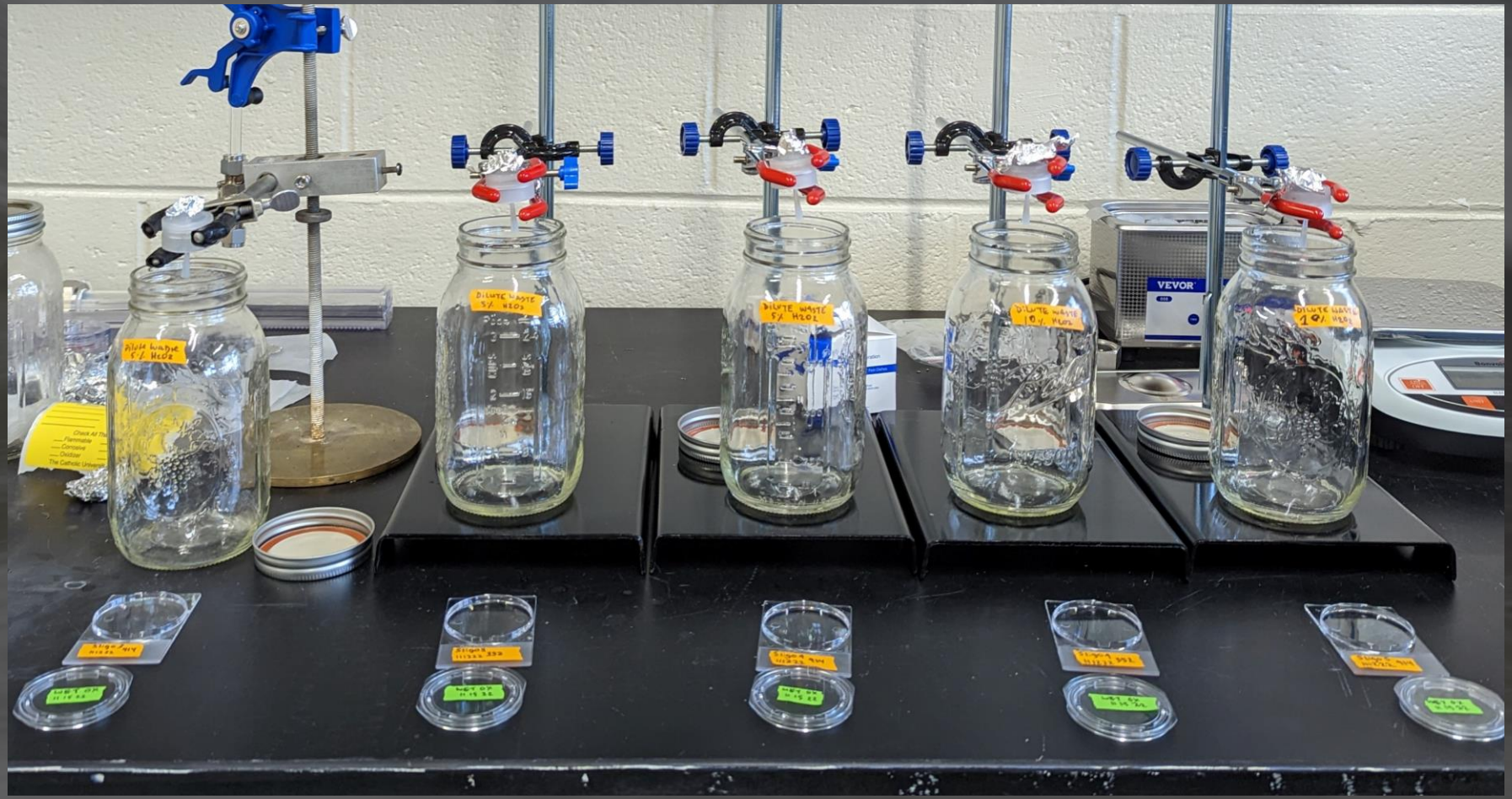


Clean Room

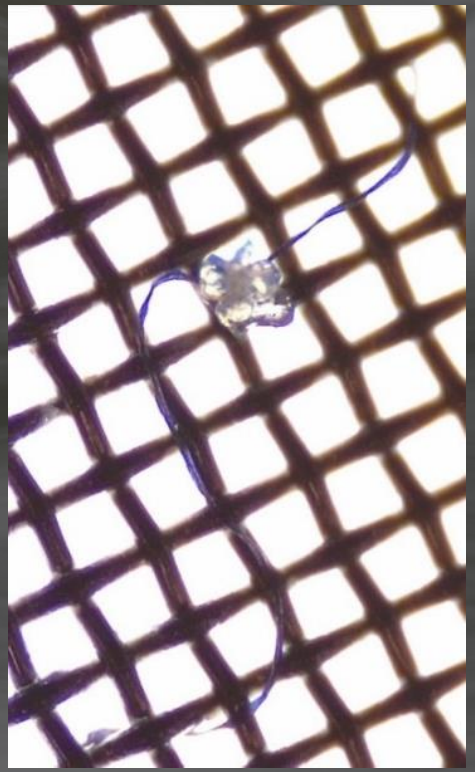
- Clean room to fix leaky air system
  - 1960's era building
- Include filtration system
- Small project budget ~ $5,000

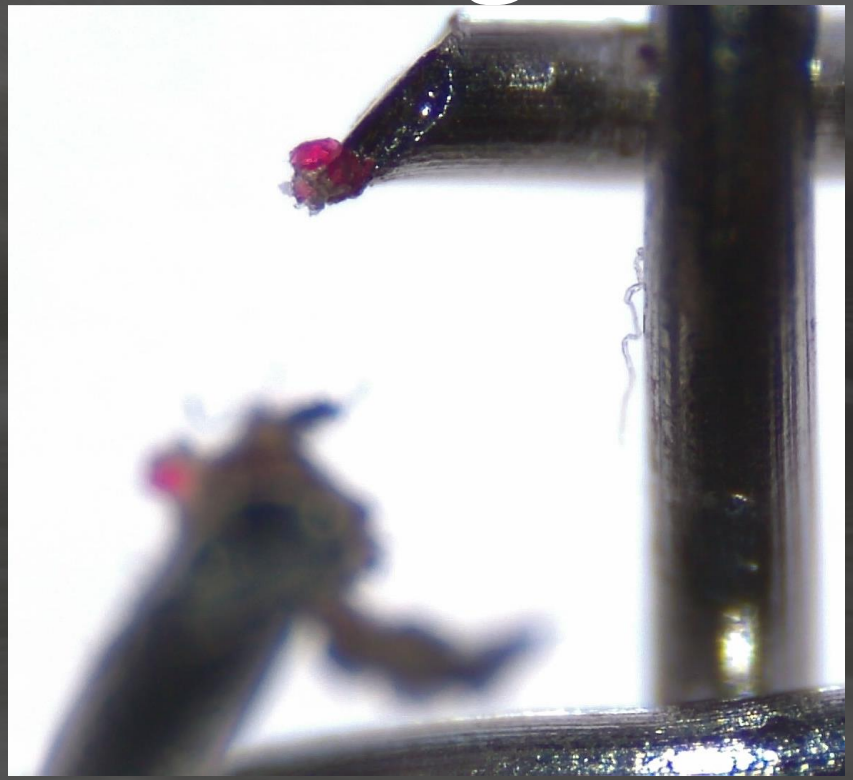
- 10% H_2O_2 12 hours
- Dry at room temperature 12 hours




VEVOR

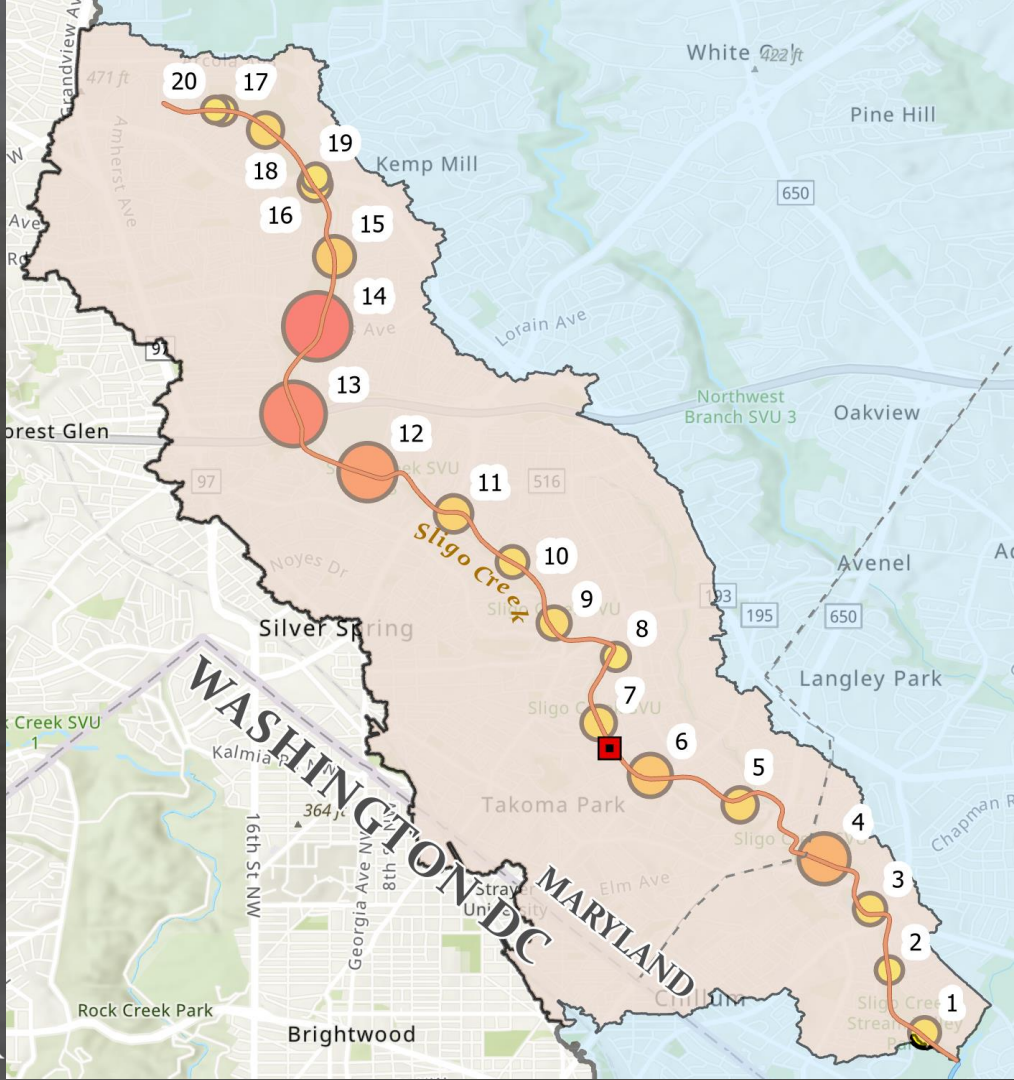
Microplastic Images





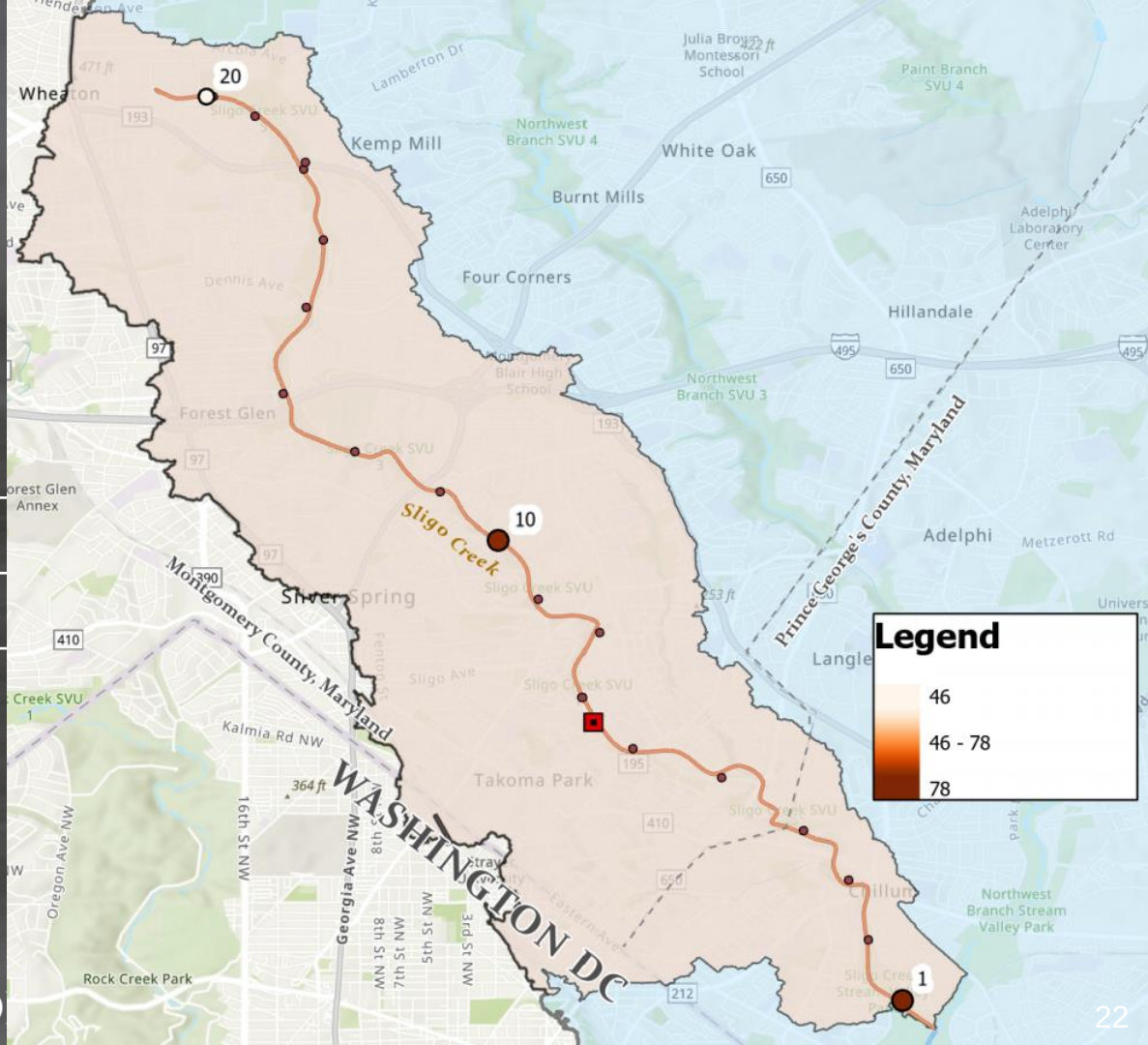
Optical Analysis

Site ID	914 µm Filter Counts	352 µm Filter Counts	Total Counts
1	52	229	281
2	28	186	214
3	63	242	305
4	106	658	764
5	48	311	359
6	5	503	548
7	20	335	355
8	16	208	224
9	16	310	326
10	25	273	298
11	50	356	406
12	11	987	998
13	19	1,208	1,227
14	48	1,323	1,371
15	35	459	494
16	48	277	325
17	41	200	241
18	6	354	360
19	29	201	230
20	15	192	207

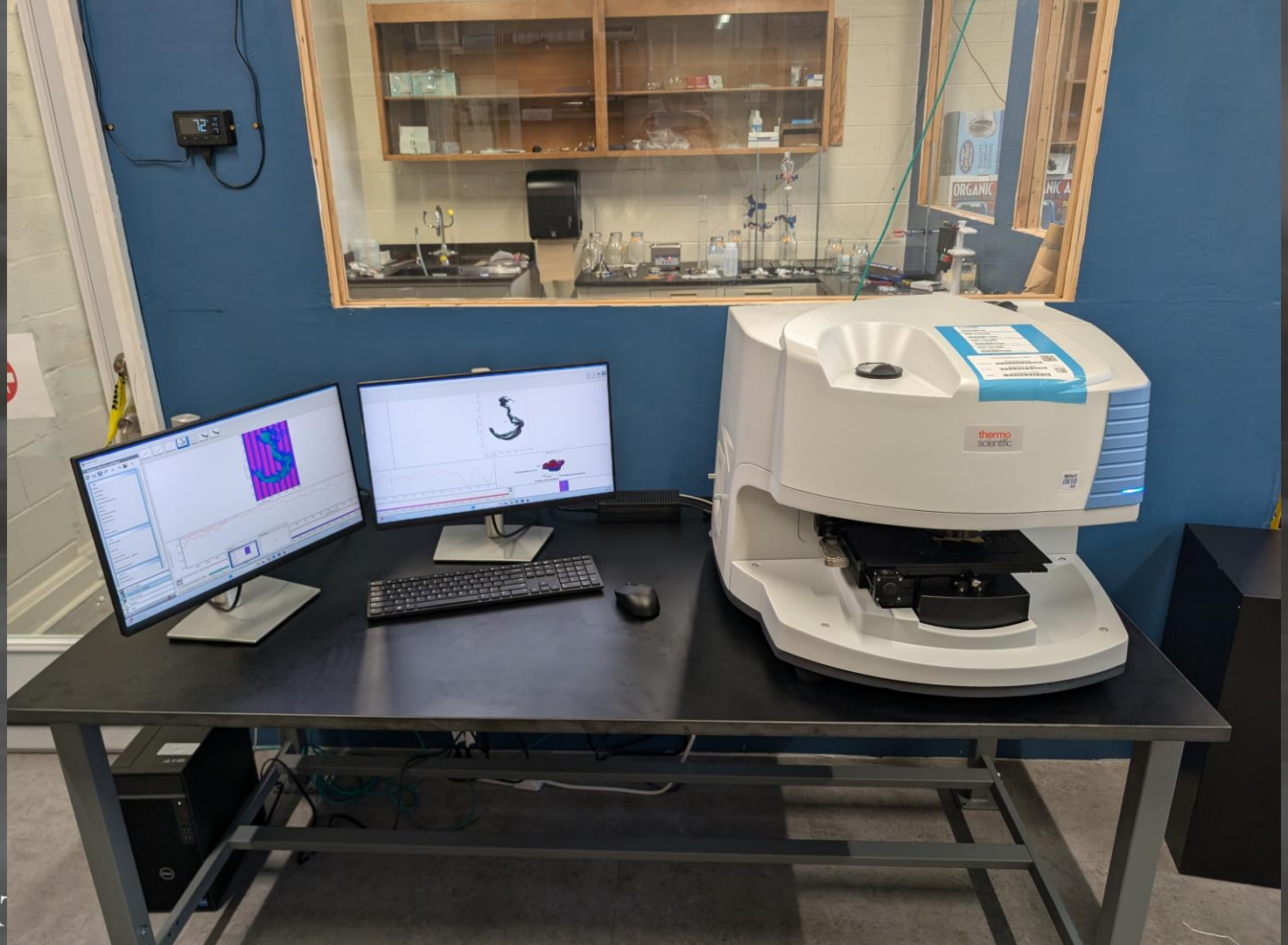


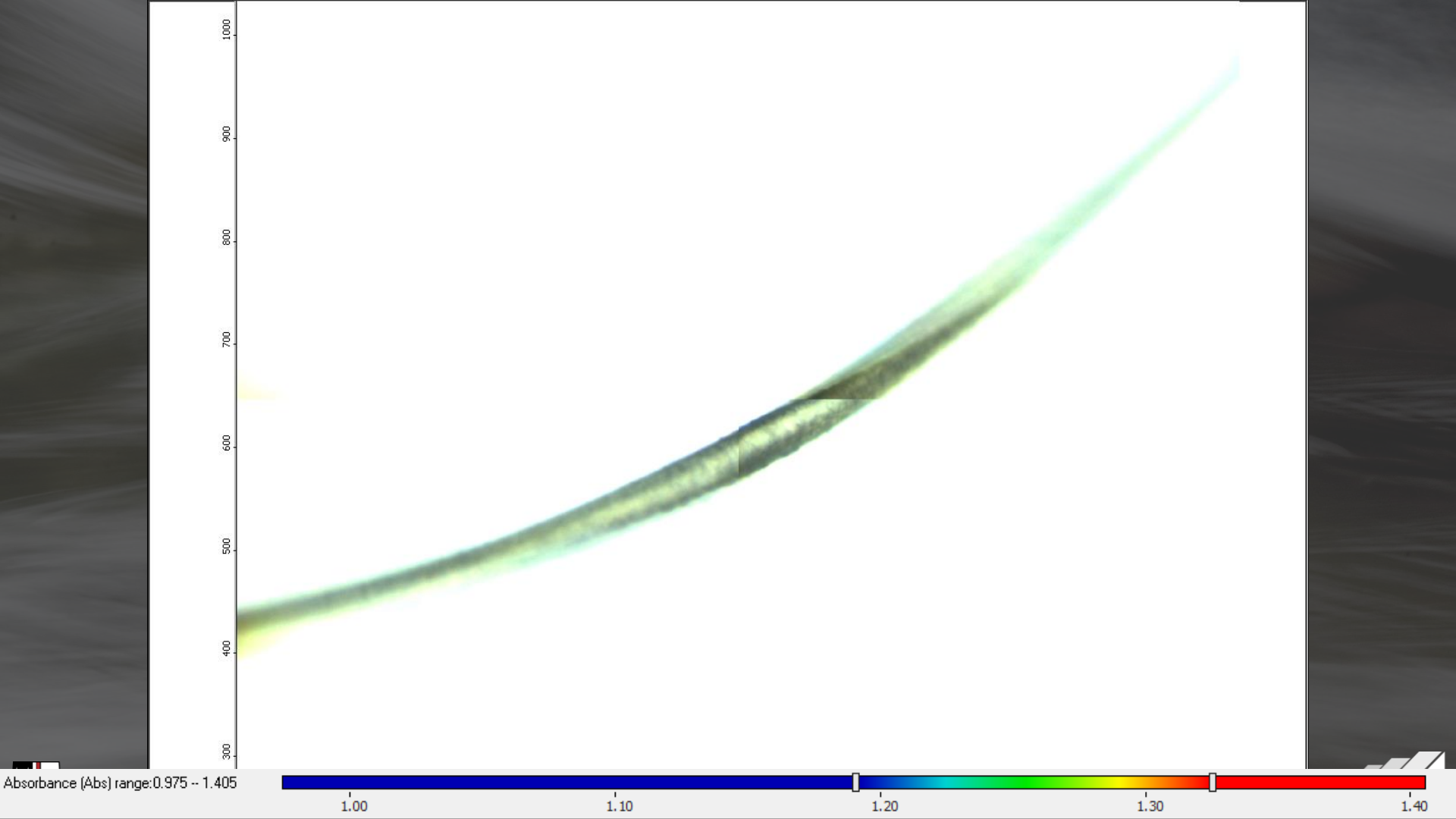
µFTIR Analysis

Site	352 µm	914 µm	Total
20	173	11	184
10	369	25	394
1	56	528	584



μFTIR

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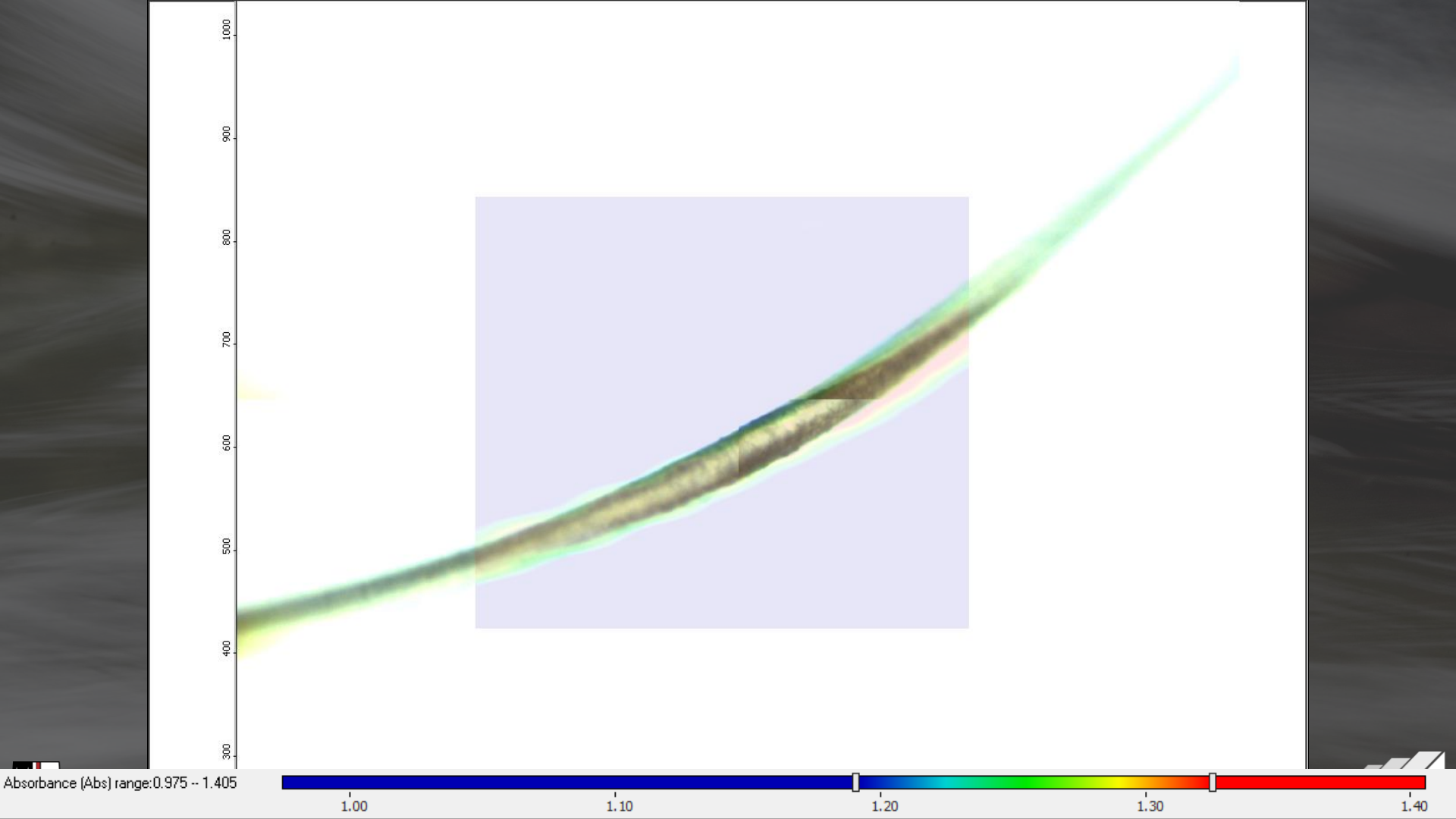
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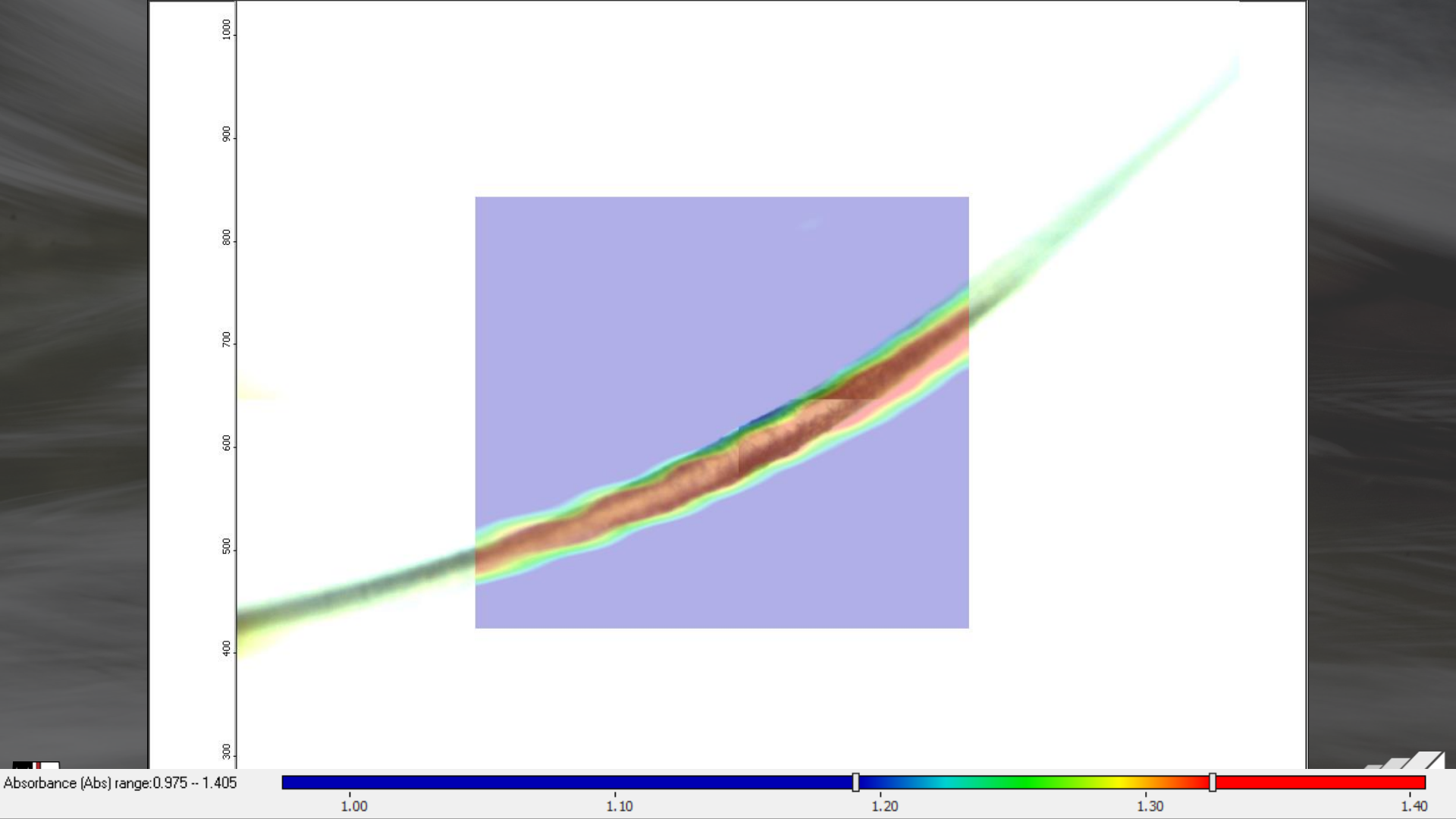
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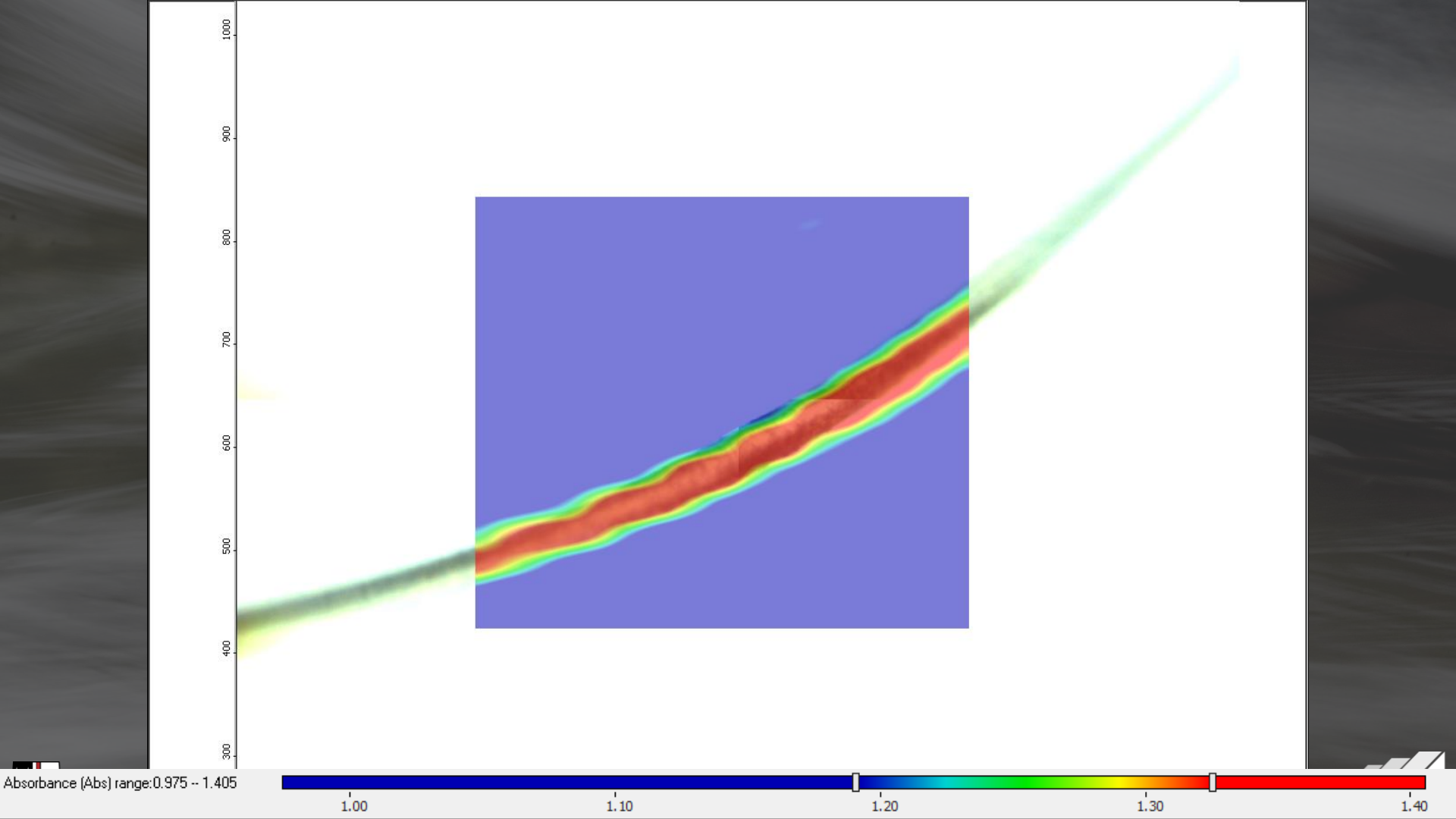
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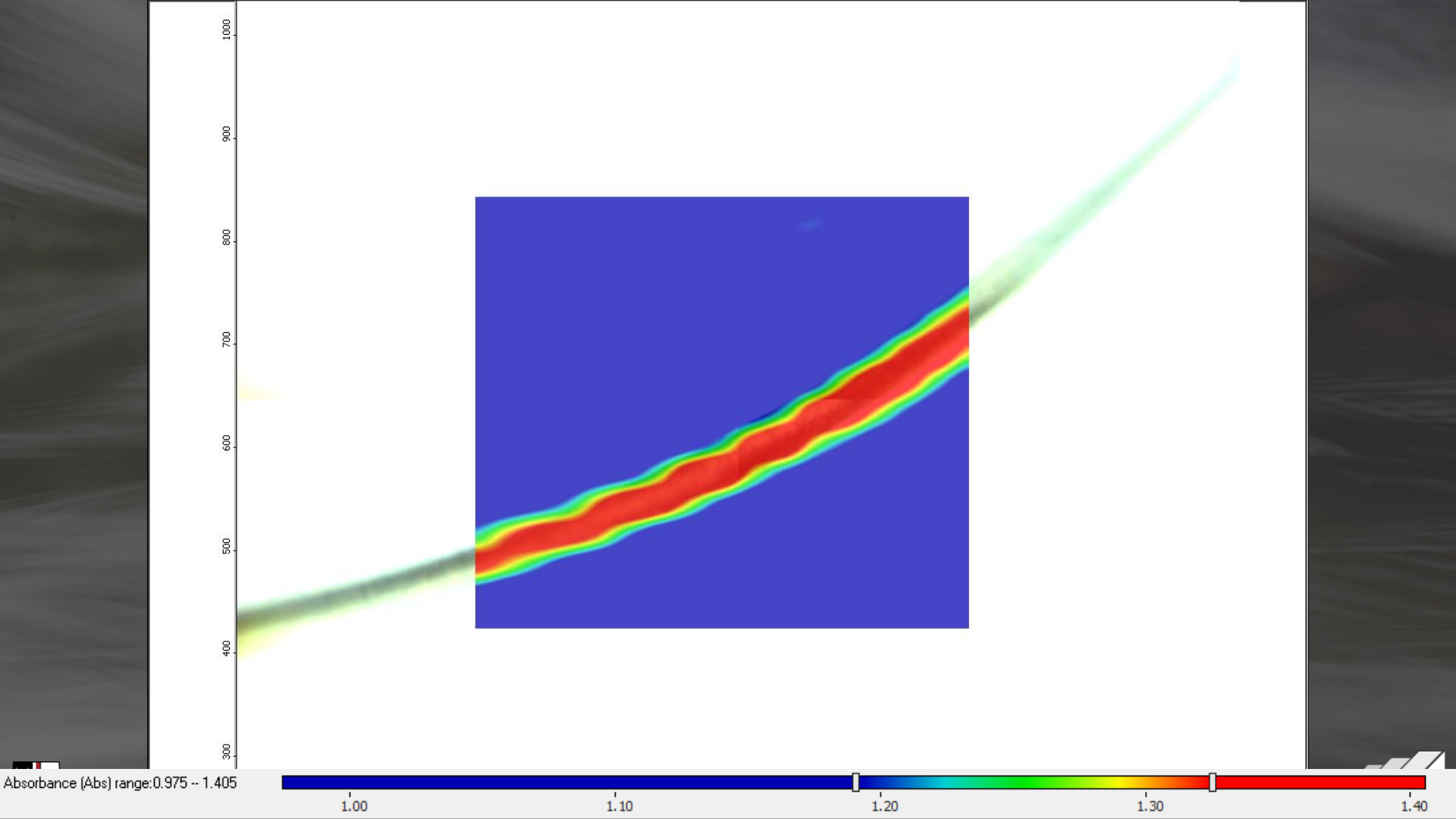
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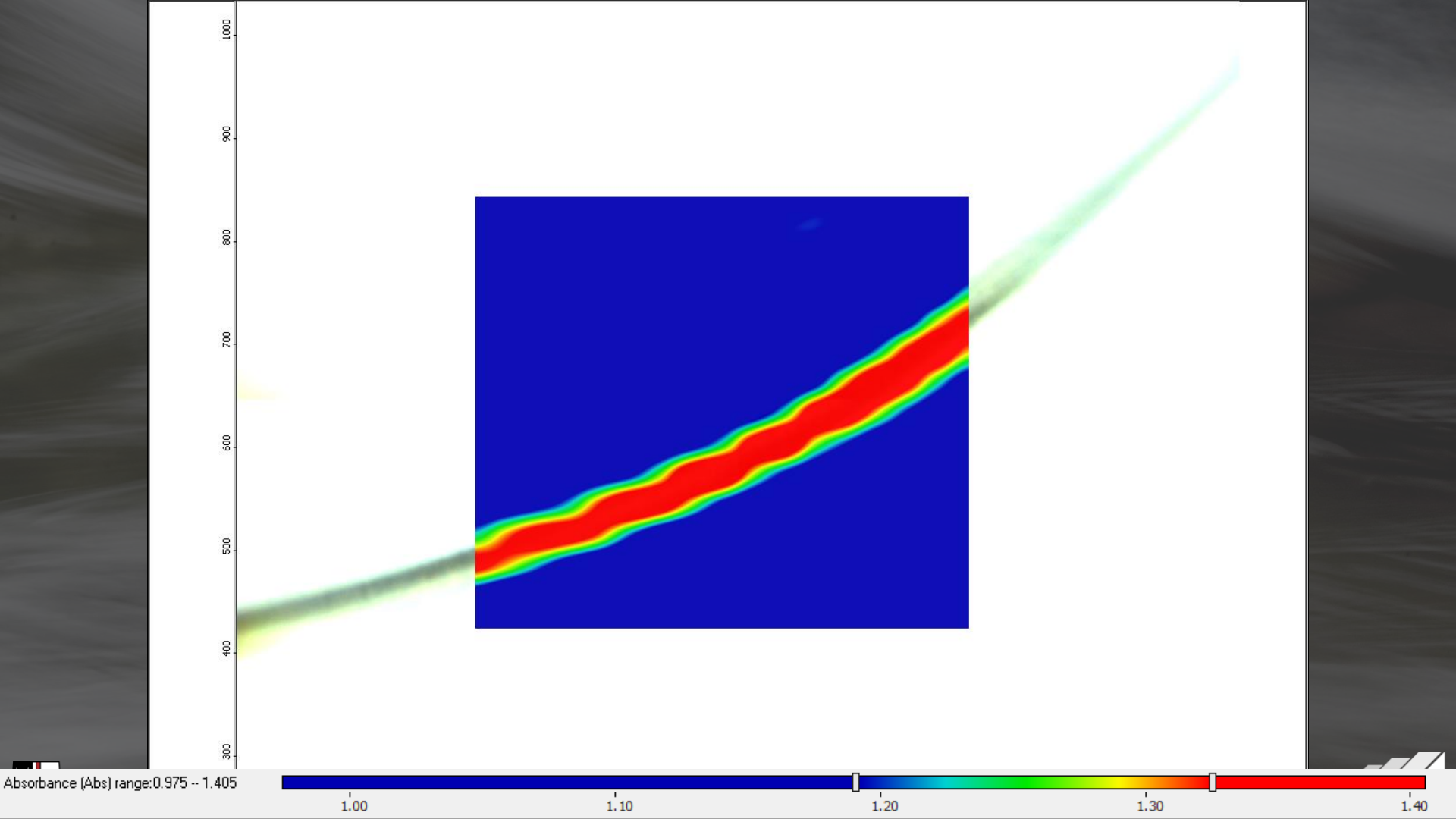
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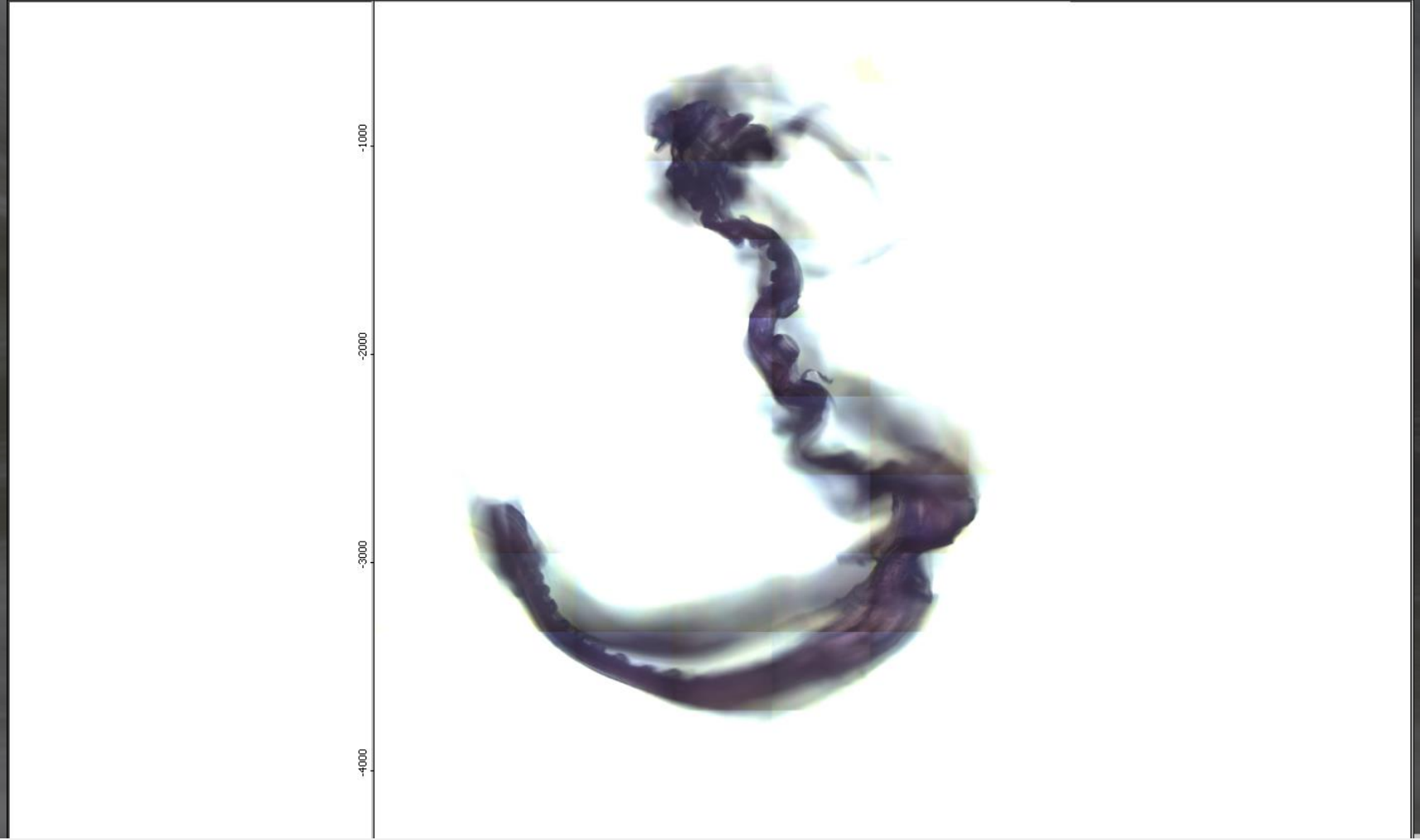

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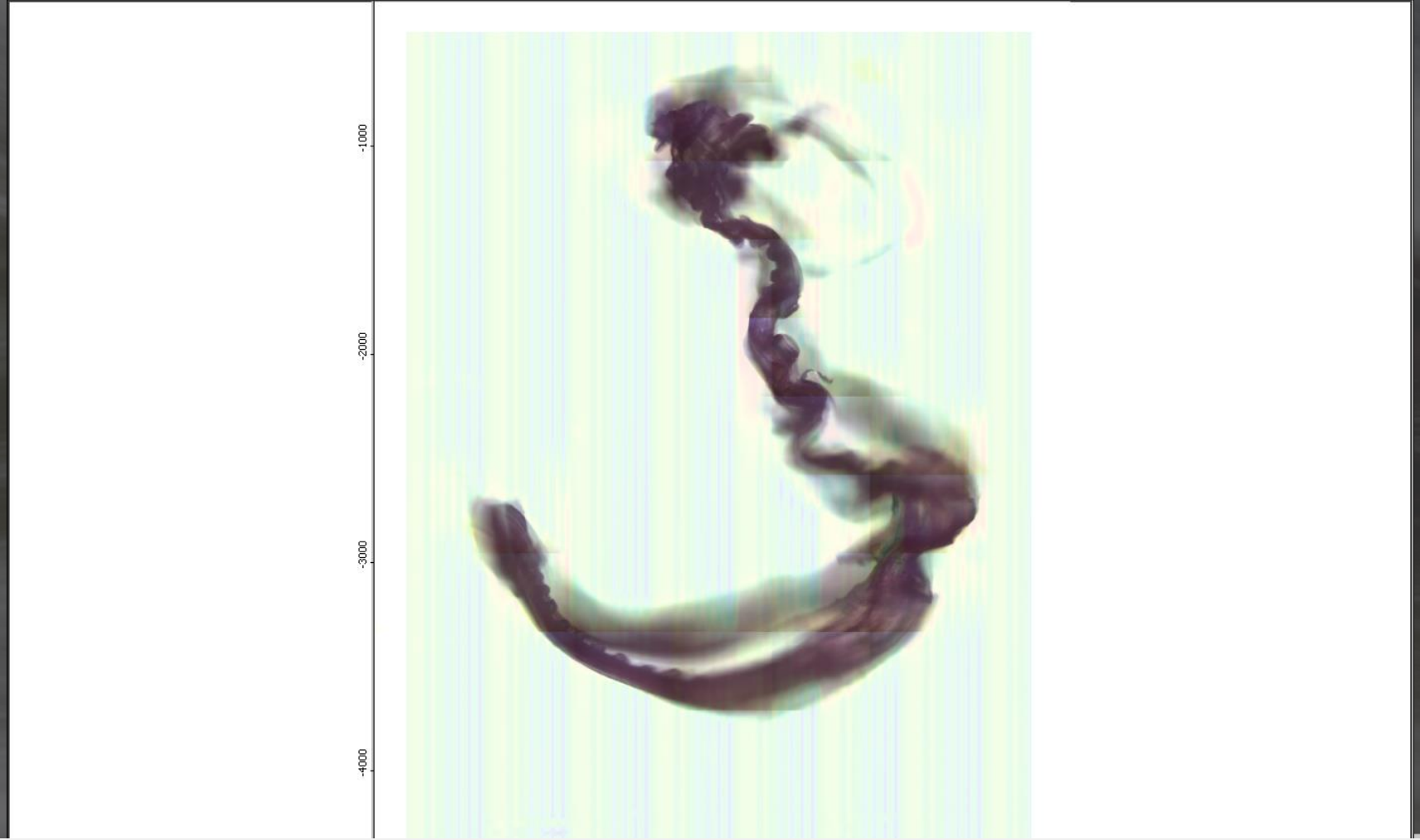

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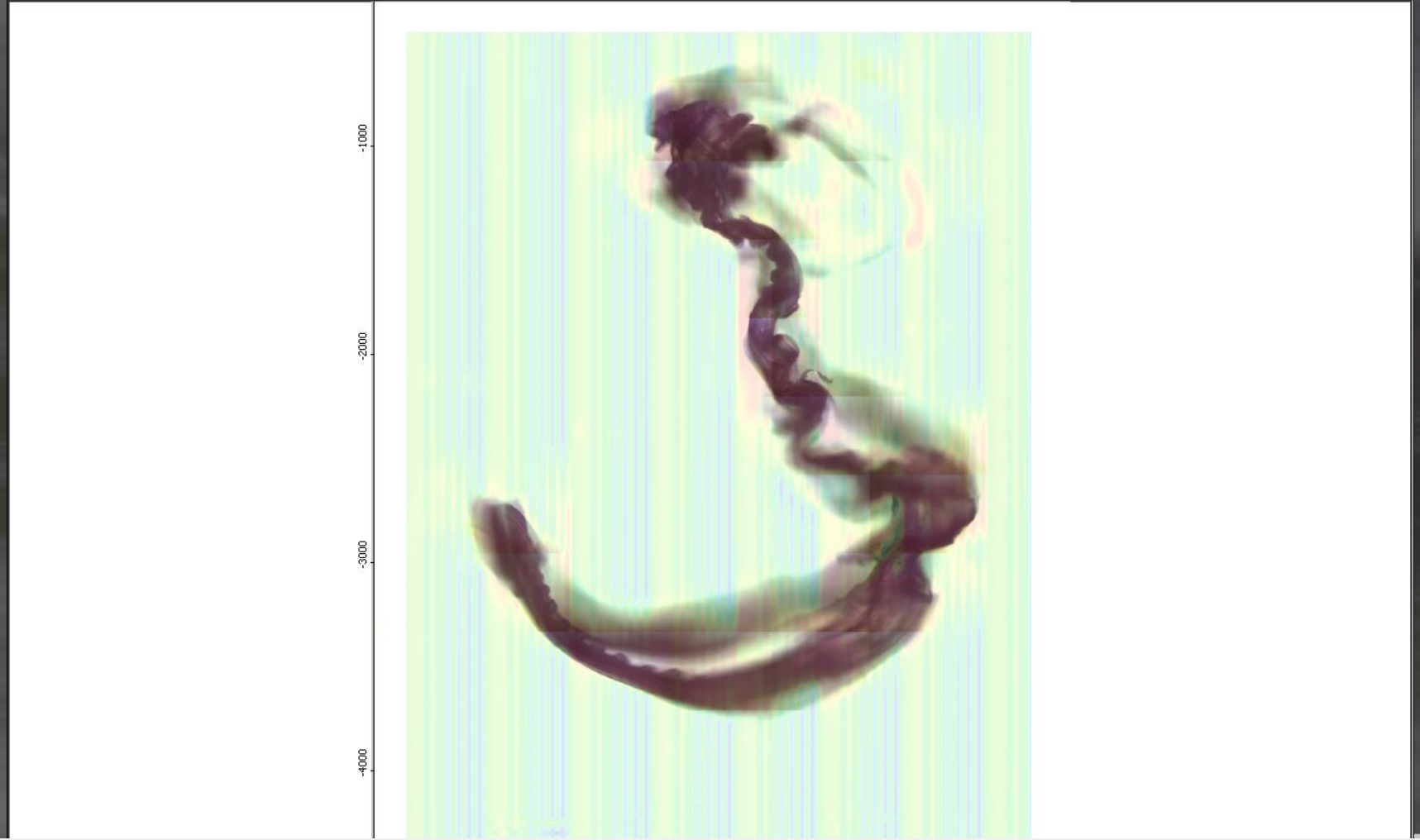

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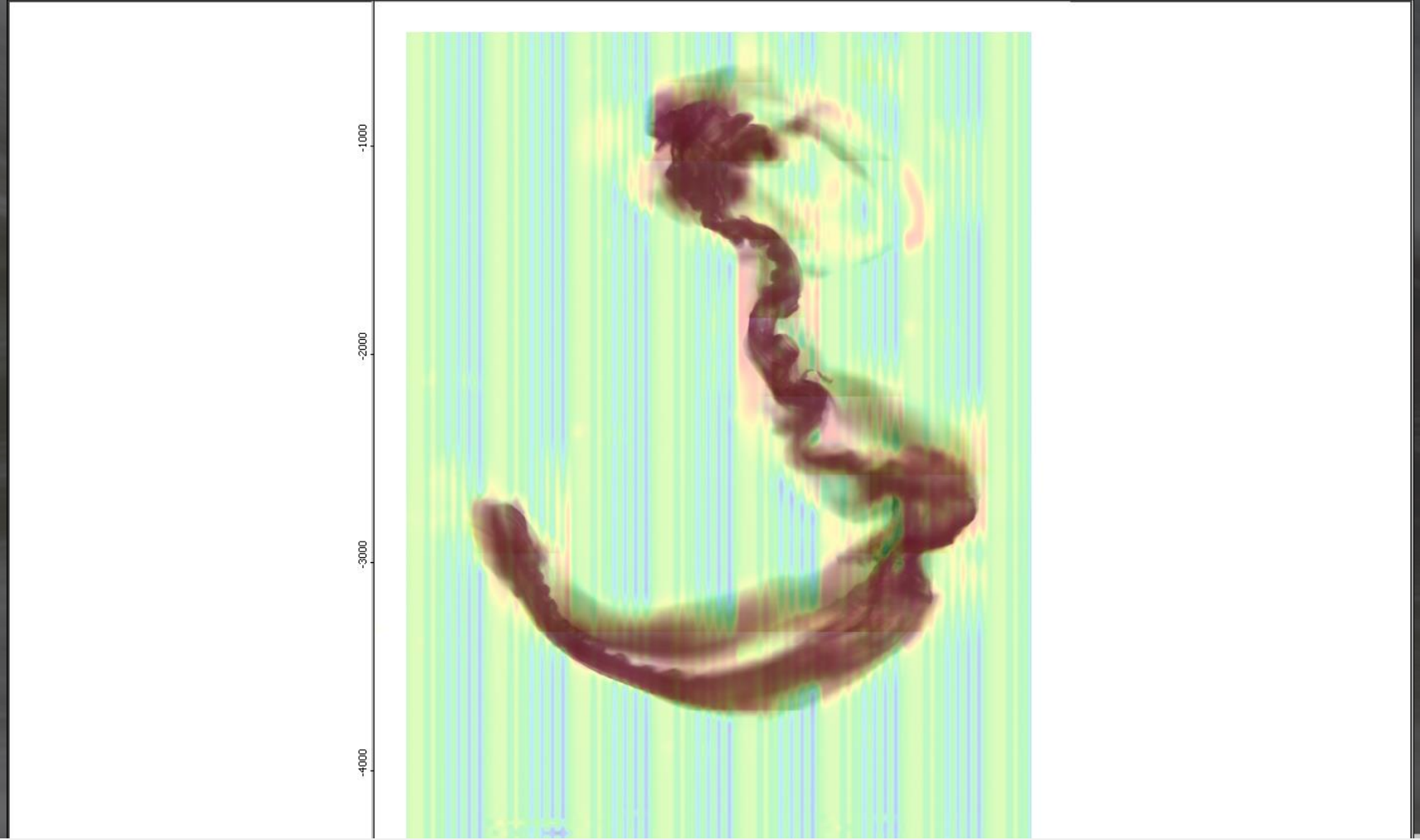
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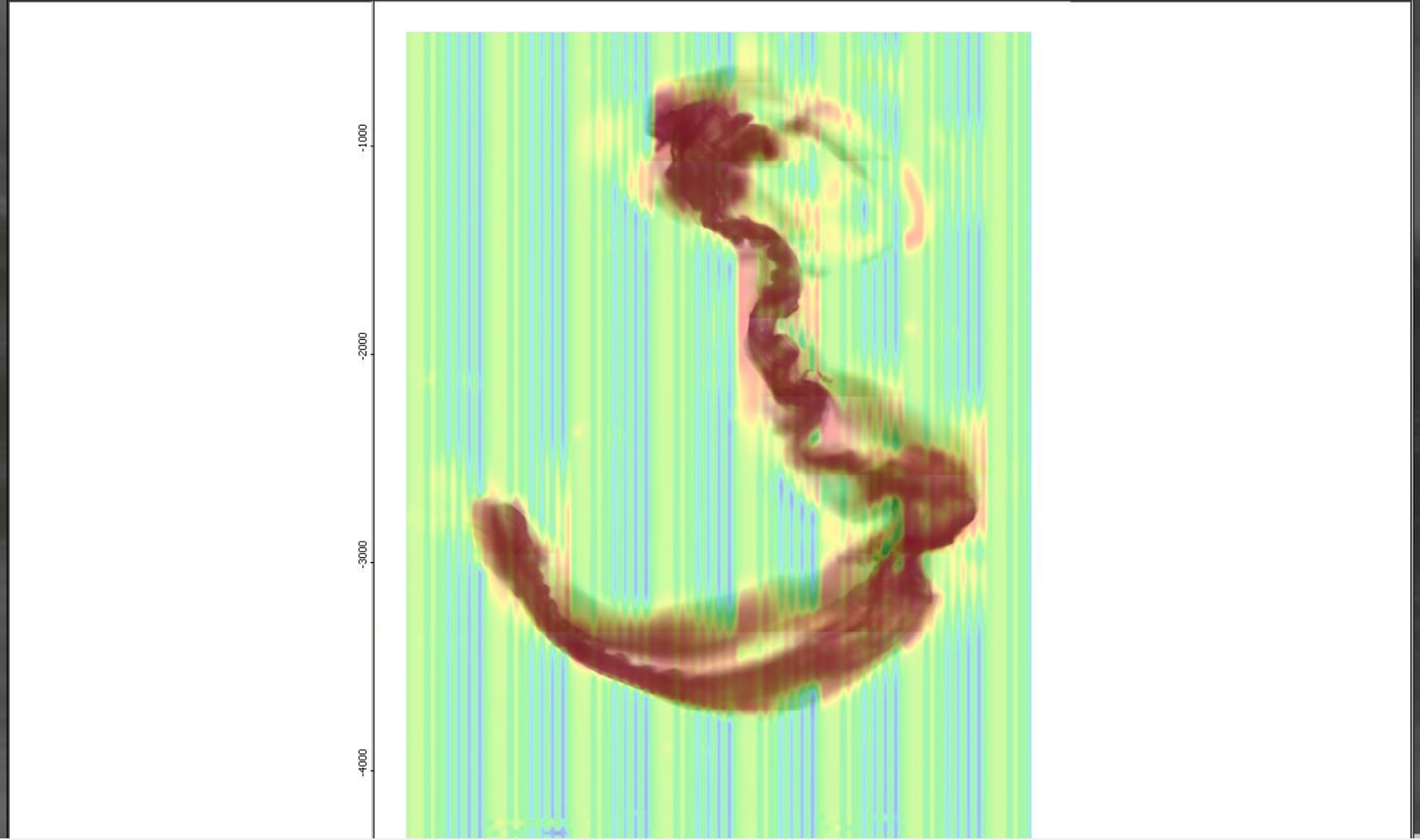
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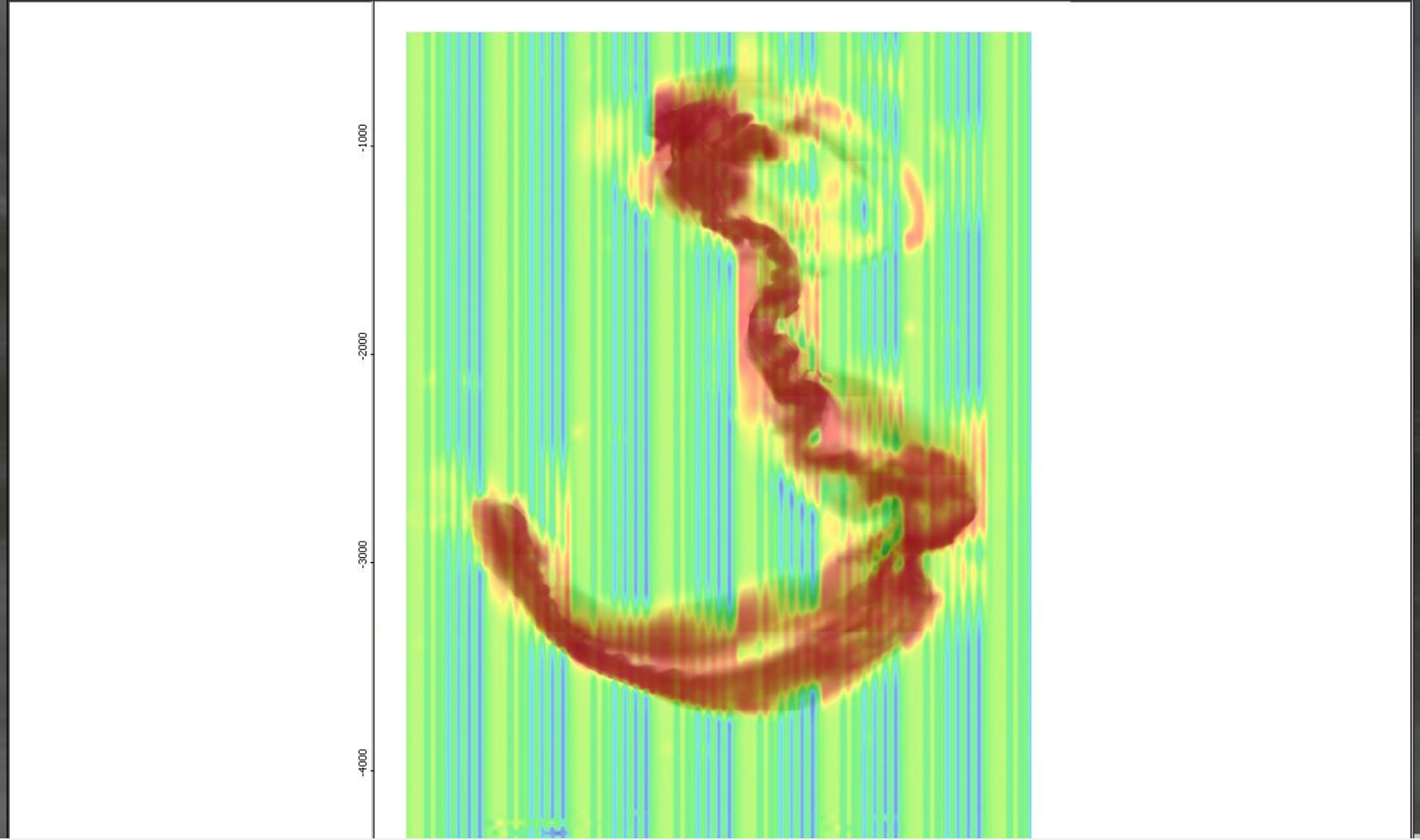
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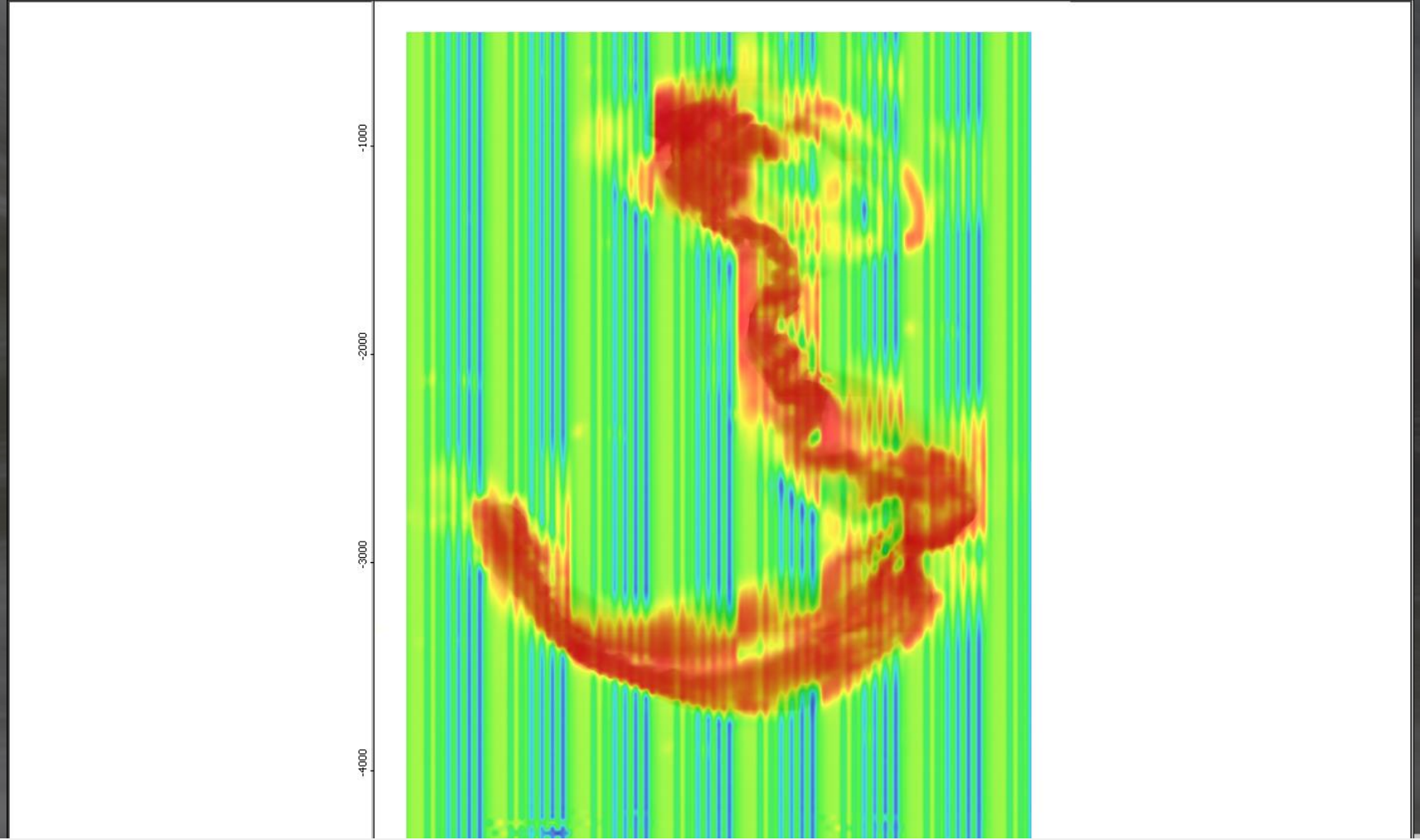
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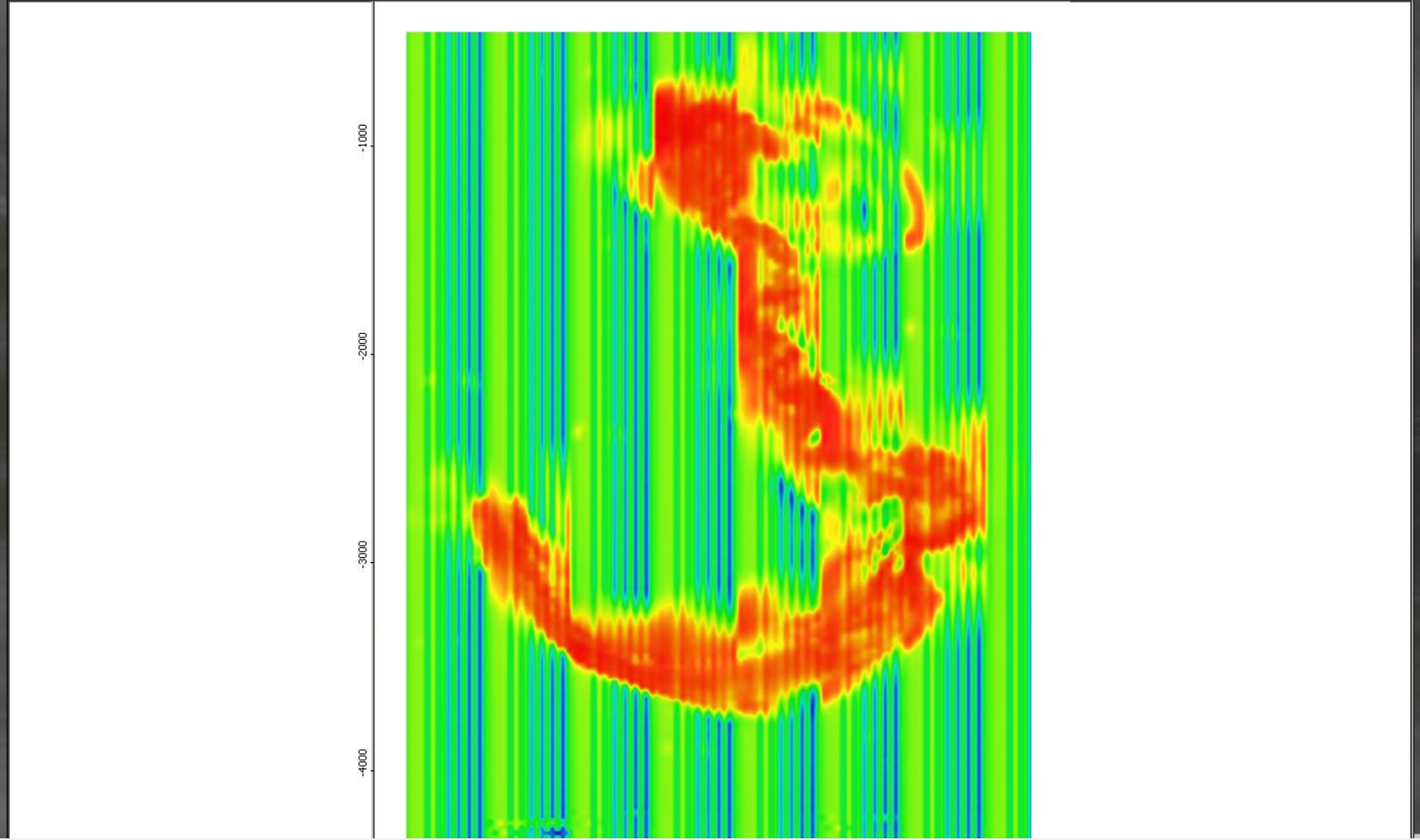
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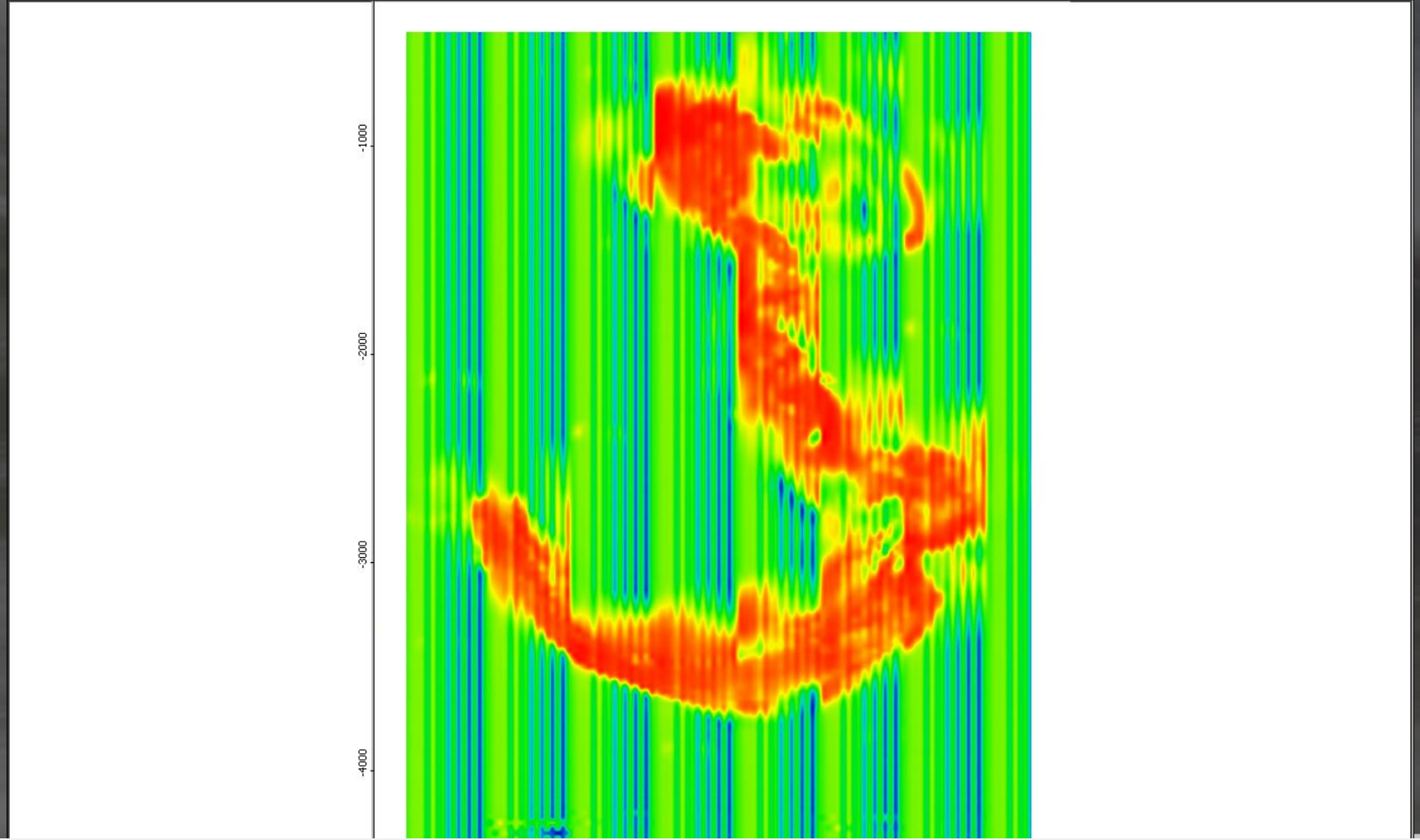

Absorbance (Abs) range:0.975 -- 1.405

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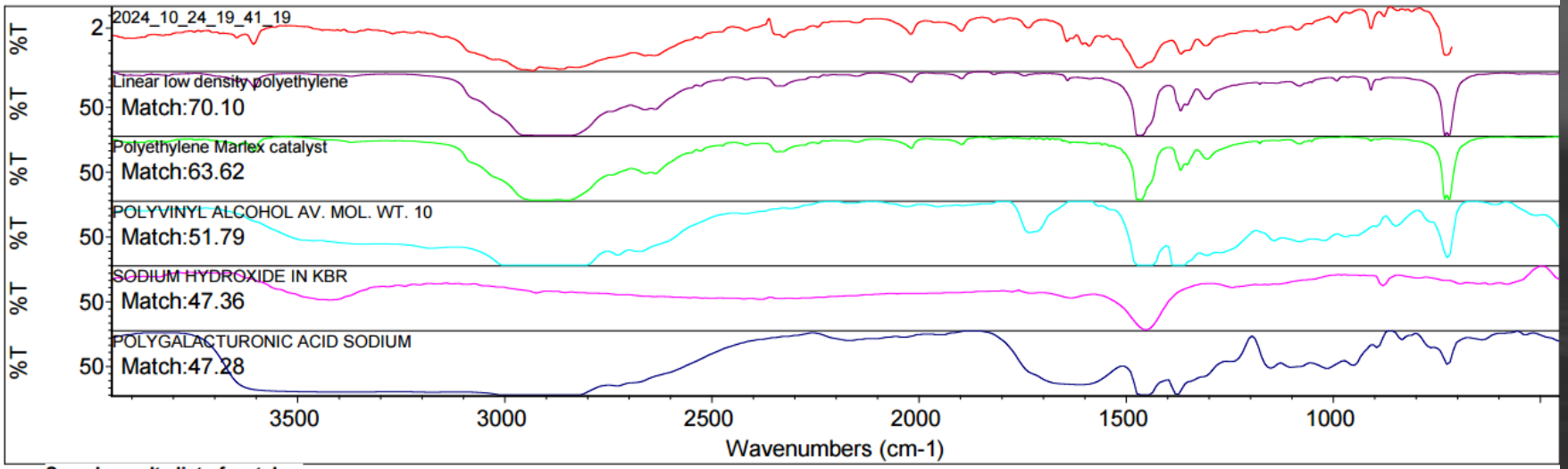
Search results for: 2024_10_24_19_41_19
Date: Fri Oct 25 13:05:00 2024 (GMT-07:00)
Search algorithm: Correlation
Regions searched: 3301.66-748.26

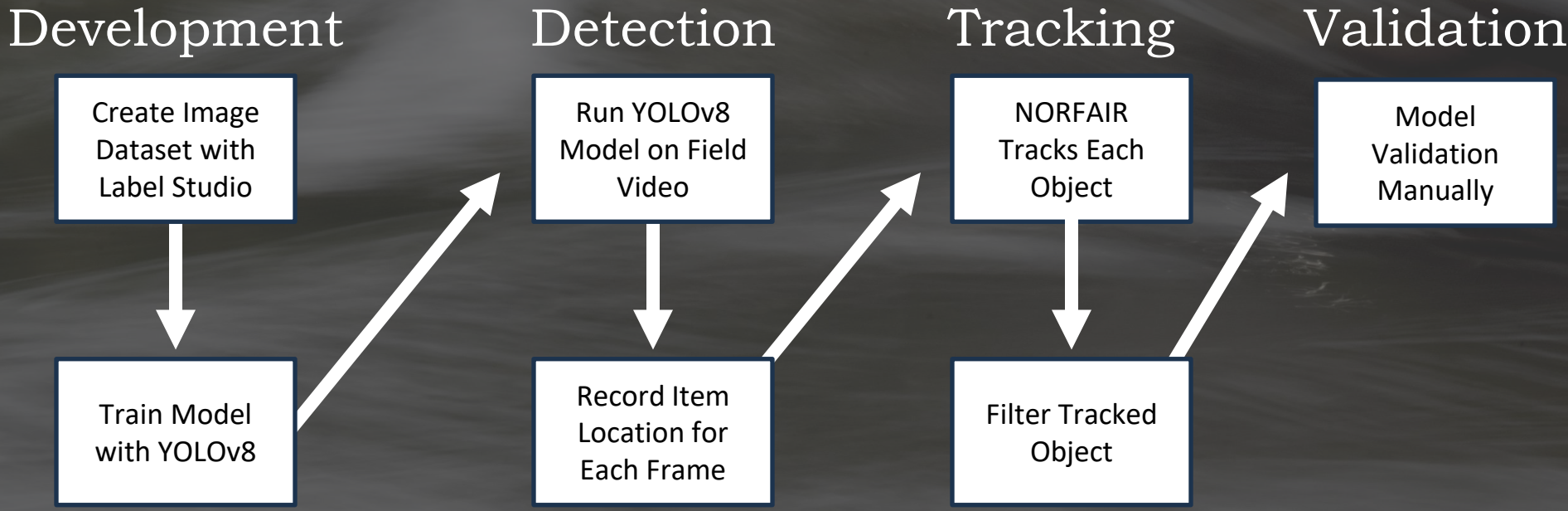


Search results list of matches

	Index	Match	Compound Name	Library Name
1	735	70.10	Linear low density polyethylene	HR Nicolet Sampler Library
2	736	63.62	Polyethylene Marlex catalyst	HR Nicolet Sampler Library
3	63	51.79	POLYVINYL ALCOHOL AV. MOL. WT. 10	Sigma Biological Sample Library
4	129	47.36	SODIUM HYDROXIDE IN KBR	Georgia State Crime Lab Sample Library
5	39	47.28	POLYGALACTURONIC ACID SODIUM	Sigma Biological Sample Library
6	88	46.82	CHOLESTEROL SIGMA GRADE	Sigma Biological Sample Library
7	2	45.61	1-HEXENE, 99%	Aldrich Condensed Phase Sample Library
8	30	44.61	SORBITAN MONOSTEARATE	Sigma Biological Sample Library
9	77	44.03	DEOXYRIBONUCLEIC ACID TYPE I SODI	Sigma Biological Sample Library
10	75	42.39	1,3-DIARACHIDIN (C20:0)	Sigma Biological Sample Library

BOTELL.AI

Framework


Development
Create Image Dataset with Label Studio
Train Model with YOLOv8
Detection
Run YOLOv8 Model on Field Video
Record Item Location for Each Frame
Tracking
NORFAIR Tracks Each Object
Filter Tracked Object
Validation
Model Validation Manually

botell.ai

LOAD Video
LOAD YOLOv8 model with pre-trained weights

LOOP through video frames:
  Apply motion-based background subtraction
  Run object detection
  Reduce confidence for objects in static areas
  FOR each detected object:
    Update tracker with current frame's detections
    IF object is already tracked:
      Append new detection (x, y coordinates, frame #)
    ELSE:
      Initialize new object tracking

POST-PROCESS the tracked objects:
  FOR each tracked object:
    Calculate object's screen time and movement
    IF the object meets time and distance criteria:
      Count as a detected bottle

RETURN bottles tracked, error rate, and metrics

Runs in Anaconda with cmd line

Anaconda Prompt

```
(base) C:\Users\davis\Downloads\costiabottles-main\costiabottles-main>python bottledetector.py -h

usage: bottledetector.py [-h] [-s] [-n NUMBOTTLES] [-f FRAMESKIP] [-t MINTIME] [-d MINFRAMEDIST] [-c CONF] [-o OUTPUT]
                         path

positional arguments:
  path                  the file path to the video that is to be processed

options:
  -h, --help            show this help message and exit
  -s, --show            if this is specified, the model will show the video as it is processed
  -n NUMBOTTLES, --numbottles NUMBOTTLES
                        the number of bottles that appear in the video; if this is specified, error will be calculated
  -f FRAMESKIP, --frameskip FRAMESKIP
                        the n for which every nth frame will be read from the video
  -t MINTIME, --mintime MINTIME
                        the minimum number of seconds a bottle must be on screen for it to be counted
  -d MINFRAMEDIST, --minframedist MINFRAMEDIST
                        a float between 0.0 and 1.0 representing the fraction of the screen the bottle must travel
                        horizontally to be counted
  -c CONF, --conf CONF  confidence threshold the model should use
  -o OUTPUT, --output OUTPUT
                        the name of the .txt the tool should write metrics to

(base) C:\Users\davis\Downloads\costiabottles-main\costiabottles-main>
```

- Model runs slowly on laptops
  - 1 to 3 FPS
- Best with advanced NVidia graphics card
  - 60+ FPS on our Lab GPU
- We are building an HPC cluster to process 10+ videos simultaneously

	Actual	True Positives	False Negatives	False Positives	Recall
Bridge (optimal angle)	38	36	2	0	0.947
Bridge (sub-optimal angle)	38	12	26	0	0.316
Weir (optimal angle)	52	51	1	0	0.981
Weir (sub-optimal angle)	52	37	15	0	0.712
Sideview	7	7	0	0	1.0
Drone	7	7	0	1	1.0

Link to GitHub
botell.ai

Acknowledgements Students

Funded Undergraduate Students

- Connor Quinn
- Jordan Pulley
- Daniel Zhao
- Isabel Kessler
- Justin Pulley
- Elizabeth Caufield
- Clarisse Dapul
- Eilis McCormick
- Kait Caple
- Bella Bernard
- Rhea Roxy
- Anastasia Rao
- Henry Ogden
- Wesley Garnes
- Meg Metzger
- Blaise Trapani
- Ellen O'Brien
- Rhea Roxy
- Elizabeth Staten
- Alaina Smith

Funded Graduate Students

- Grace Pooley
- Alanso Johnson
- Vincente Johnson
- Isabella Freemont
- Maggie Bubel
- Emily Bowman
- Amelia Baldo
- Olivia Rees

Alumni

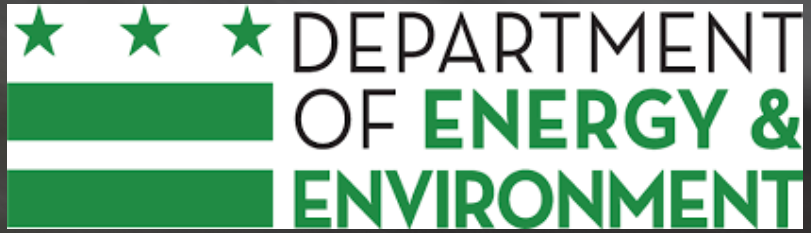
- Mitch Bundschuh (2022, B.S.)
- Thomas Macyko (2022, B.S.)
- Jason Martinez (2022, B.S.)
- Kimberly McGroary (2022, B.S.)

Acknowledgements Funders

Department of Environment and Energy

Office of Naval Research

Chesapeake Bay Trust and Montgomery County



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@jasonhdavison
-instagram