



# Post-Disaster Image Segmentation: Cost-Effective Response Plans

Carlos Govea

Linkedin: carlos-govea-gg

Github: CarlosGG18

# Problem Analysis

- The significant effects of natural disasters on both human lives and economic losses are increasingly evident in recent times.
- Accurate damage assessments make rescue plans more effective
- Post-Disaster images generally come in 3 ways:

## Social Media

- Low quality
- Not Scalable



## Satellite Images

- Expensive
  - Landsat img ~ \$855M
- Captures noise i.e Clouds



## Unmanned Ariel Vehicles(UAV).

- Cost effective
  - RTK Drone image ~ \$30K
- Faster Deployment



# Semantic Segmentation

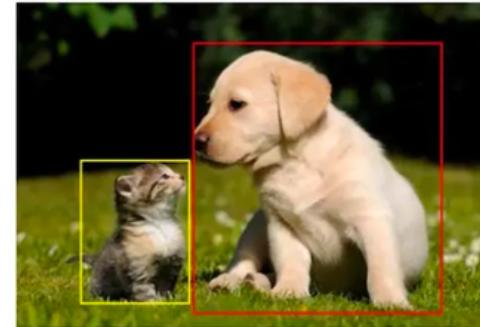
- Deep Learning algorithm that takes in an input image, assign importance to various aspects/objects in the image
- Partitions images into multiple segments of pixels
- Assigns every pixel with class label

Is this a dog?



Image Classification

What is there in image  
and where?



Object Detection

Which pixels belong to  
which object?

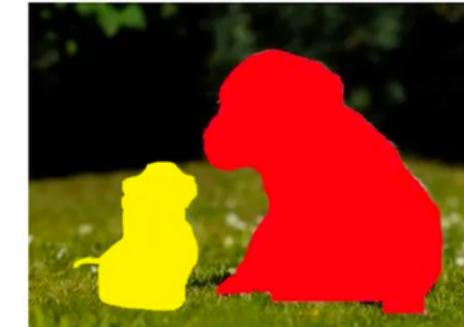


Image Segmentation



Input

segmented

1: Person  
2: Purse  
3: Plants/Grass  
4: Sidewalk  
5: Building/Structures

3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	5	5	5	5	5
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	5	5	5	5
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5	5	3	3	3	3	3	1	1	1	1	1	1	3	3	3	5	5	5	5	5	5	5	5	5	5
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4	4	3	4	1	1	1	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	5	5	5	5
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3	3	3	1	2	2	1	1	1	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4

Semantic Labels

## Dataset and Features

- Post-Hurricane Harvey images in Texas & Louisiana state
- 2,343 images, divided into training (~60%), validation (~20%), and test (~20%)
- 10 Classes: Building Flooded, Building Non Flooded, Road Flooded, Road Non Flooded, Water, Tree, Vehicle, Pool, Grass, Background

Images

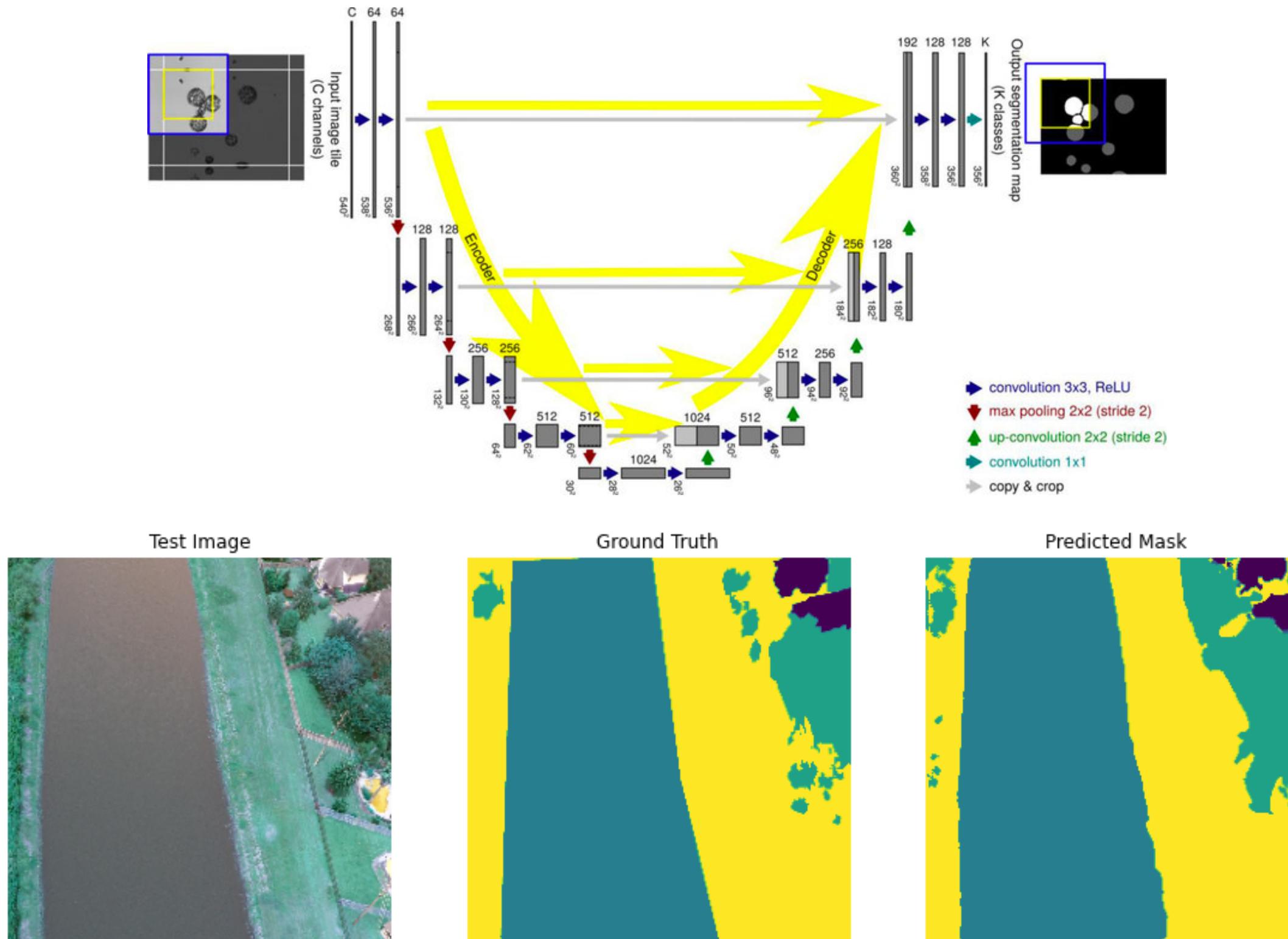


Ground Truth/ Mask



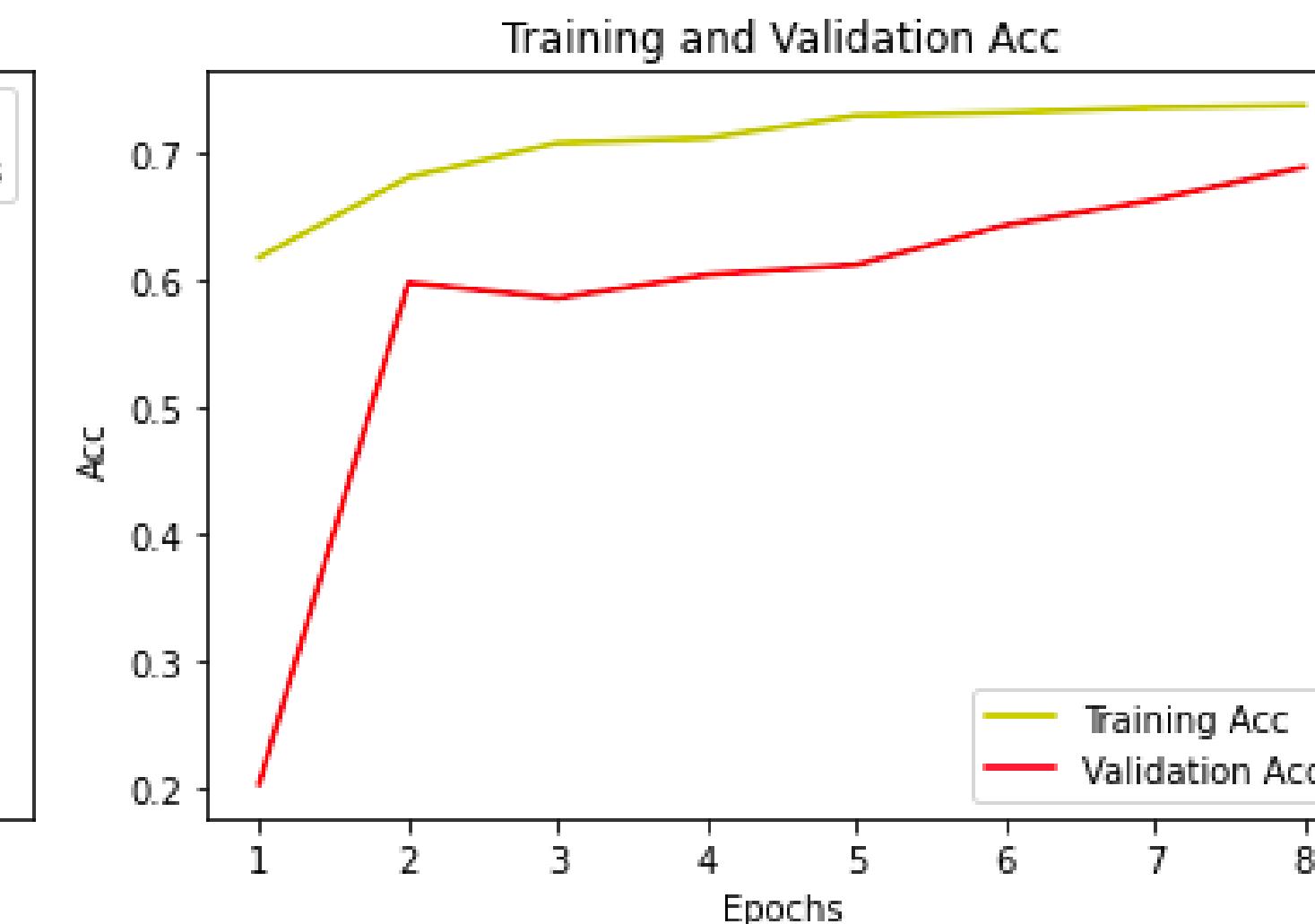
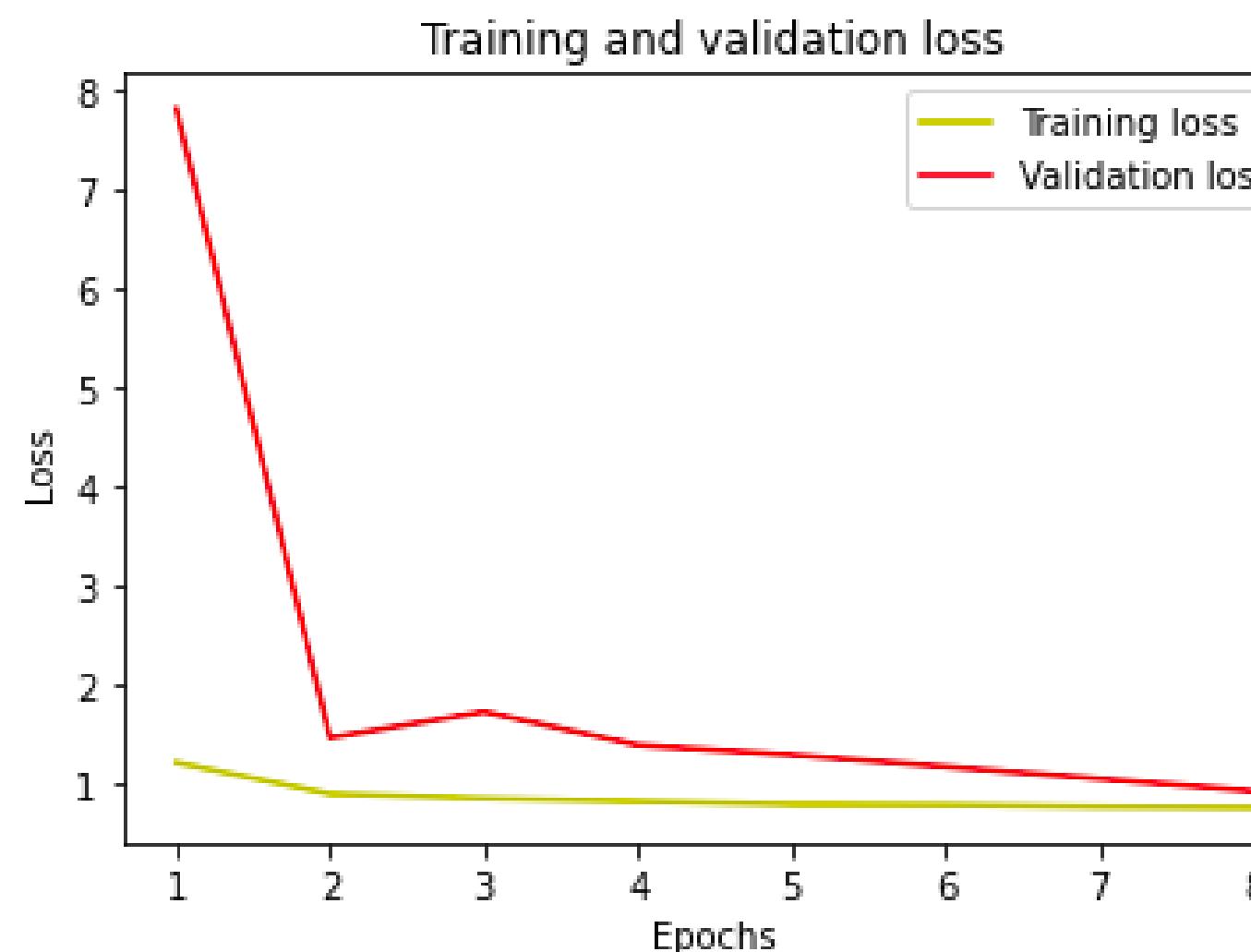
# Unet Model

- Unique use of skip connections, allows information from the encoder (feature extractor) passed directly to corresponding layers in the decoder
- Pixel accuracy: The fraction of pixels that are classified correctly



# U-Net Loss/Accuracy

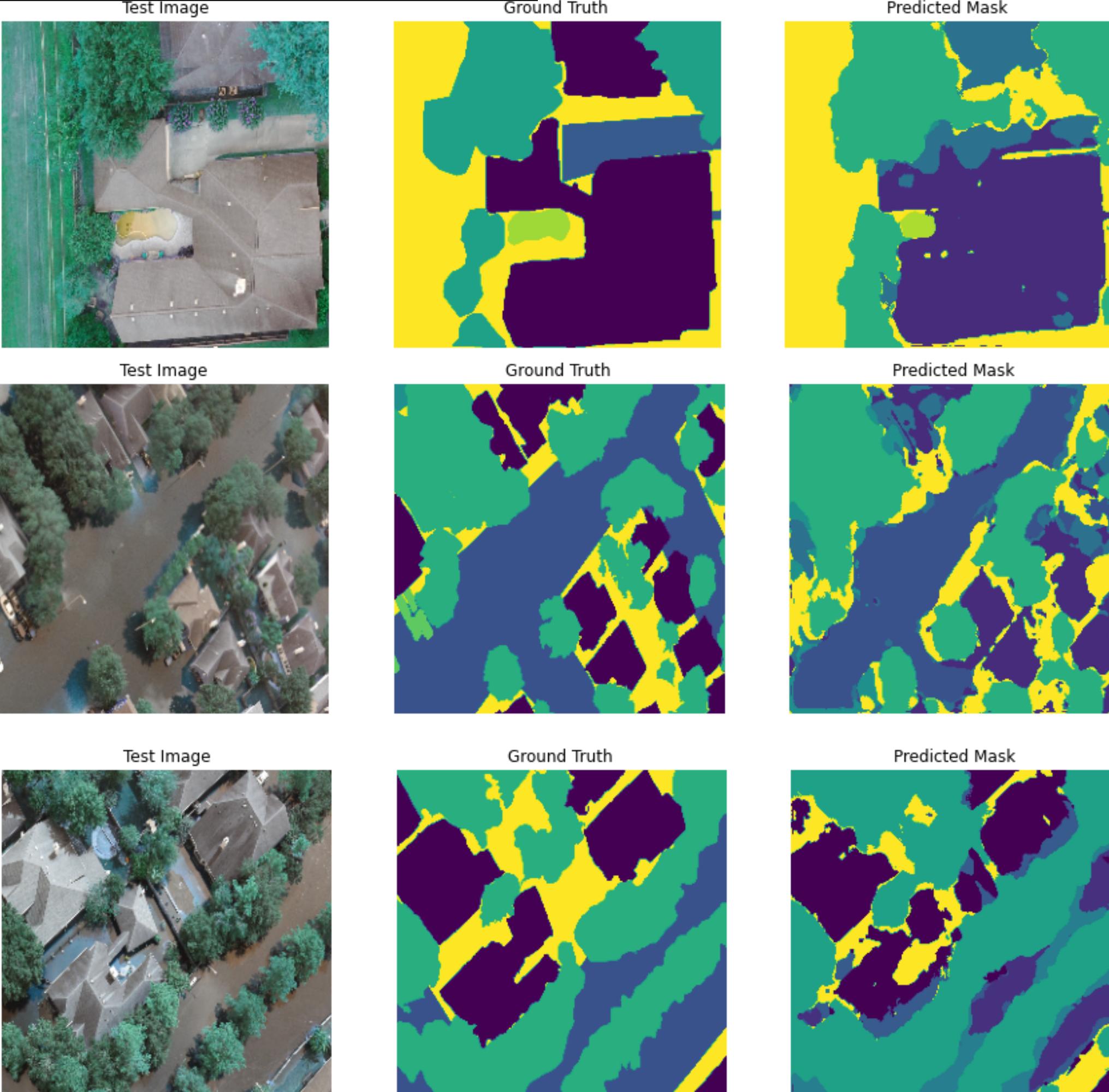
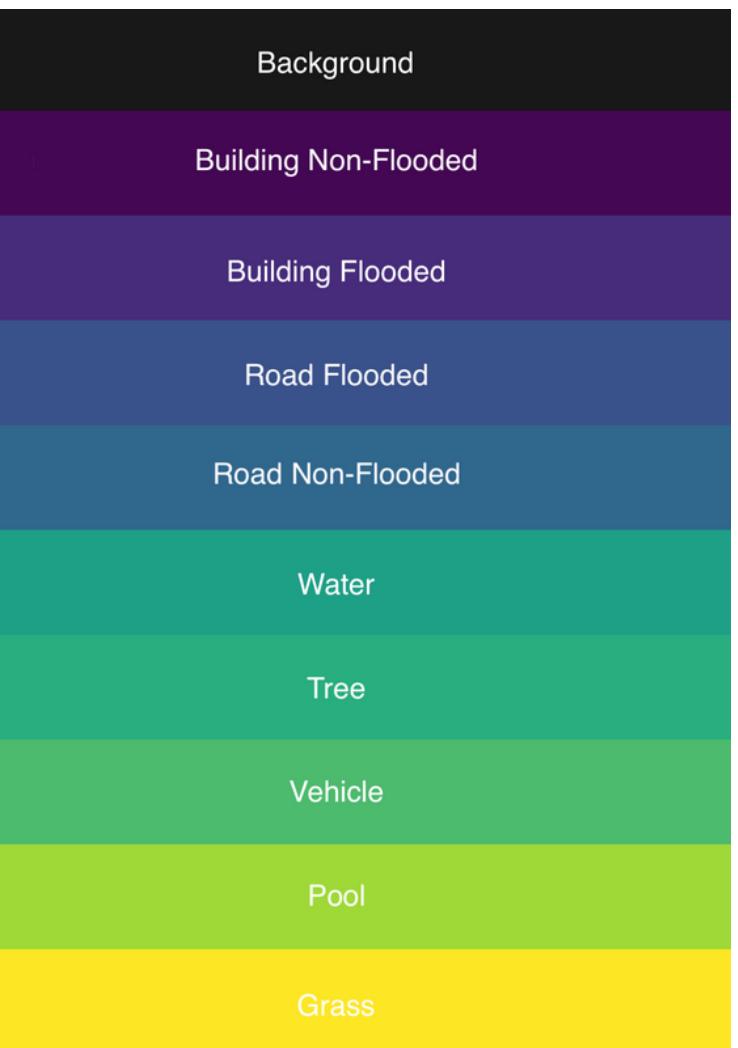
- Loss Function: Sparse Categorical Cross-entropy for multi-class classification
- Evaluation Metric: Sparse Categorical Accuracy
  - Pixel accuracy on correctly classified pixels



# Unet Predictions

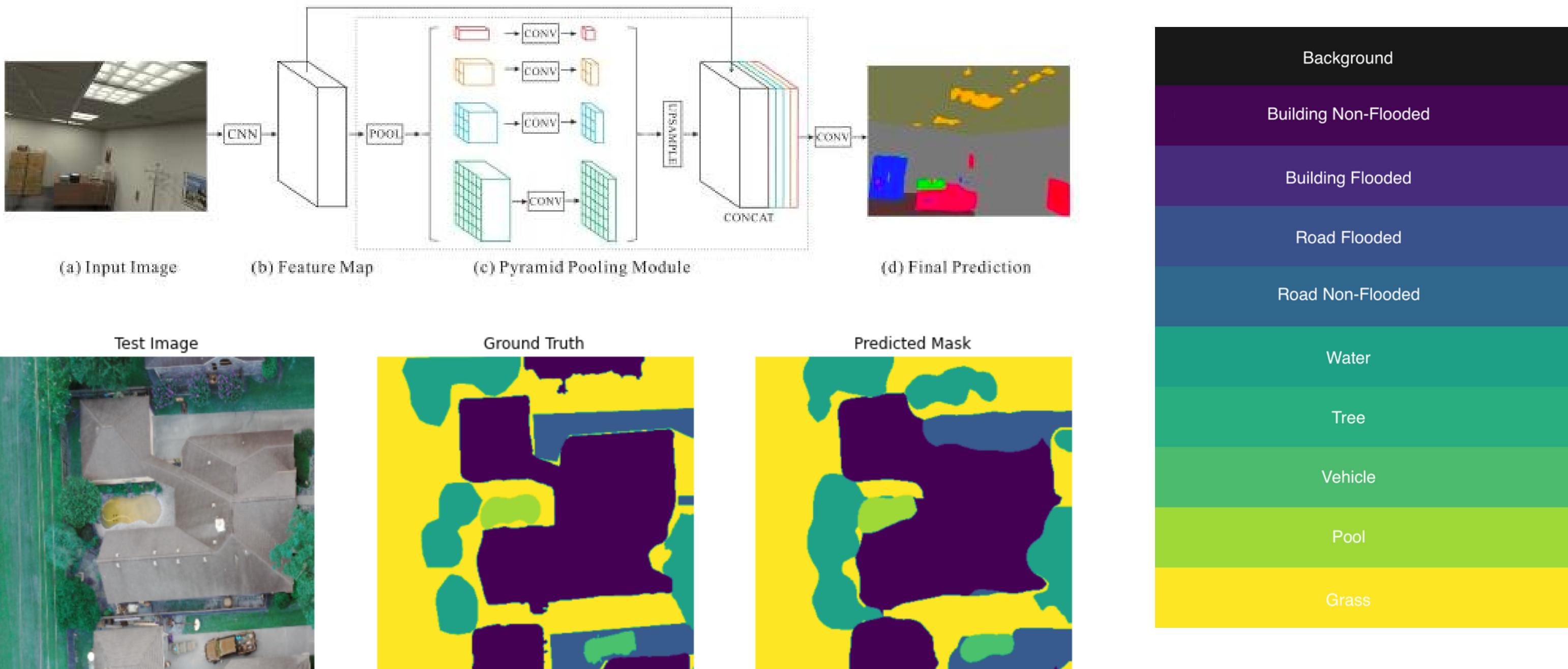
## Tuned U-Net

- Test Pixel Accuracy  
~70%
- Trouble distinguishing flooded building v non flooded
- Correctly classifies flooded Roads



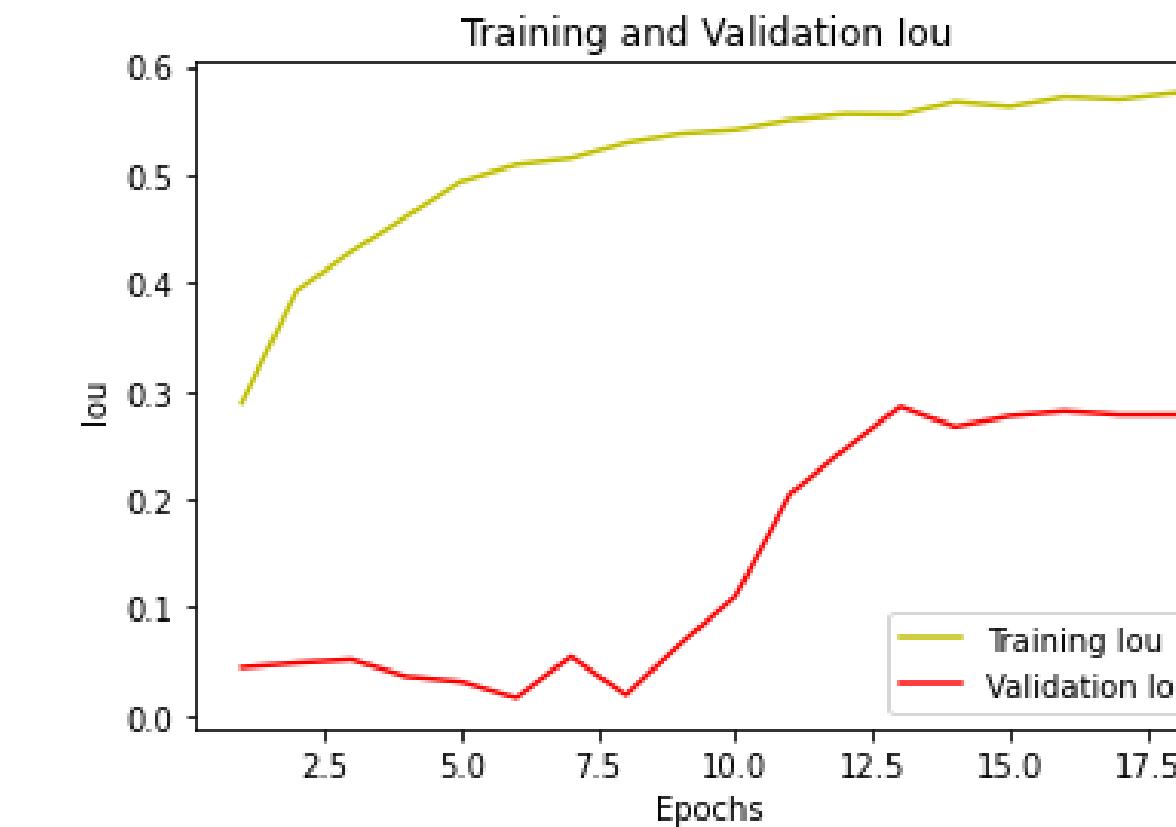
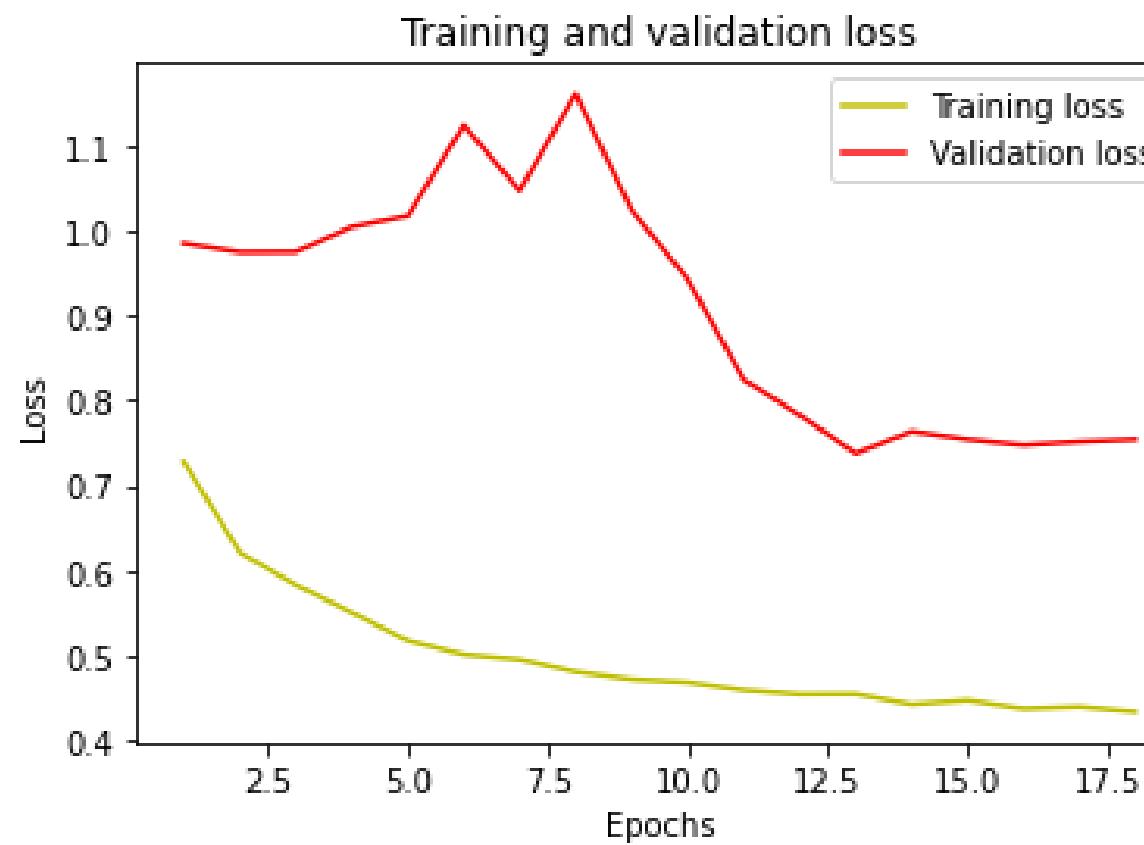
# Pyramid Scene Parsing Network(PSPNET)

- Pyramid pooling module to extract features at different scales and then concat them together to produce more robust representation of the input image.
- Pools feature maps at different scales for multi-scale context information



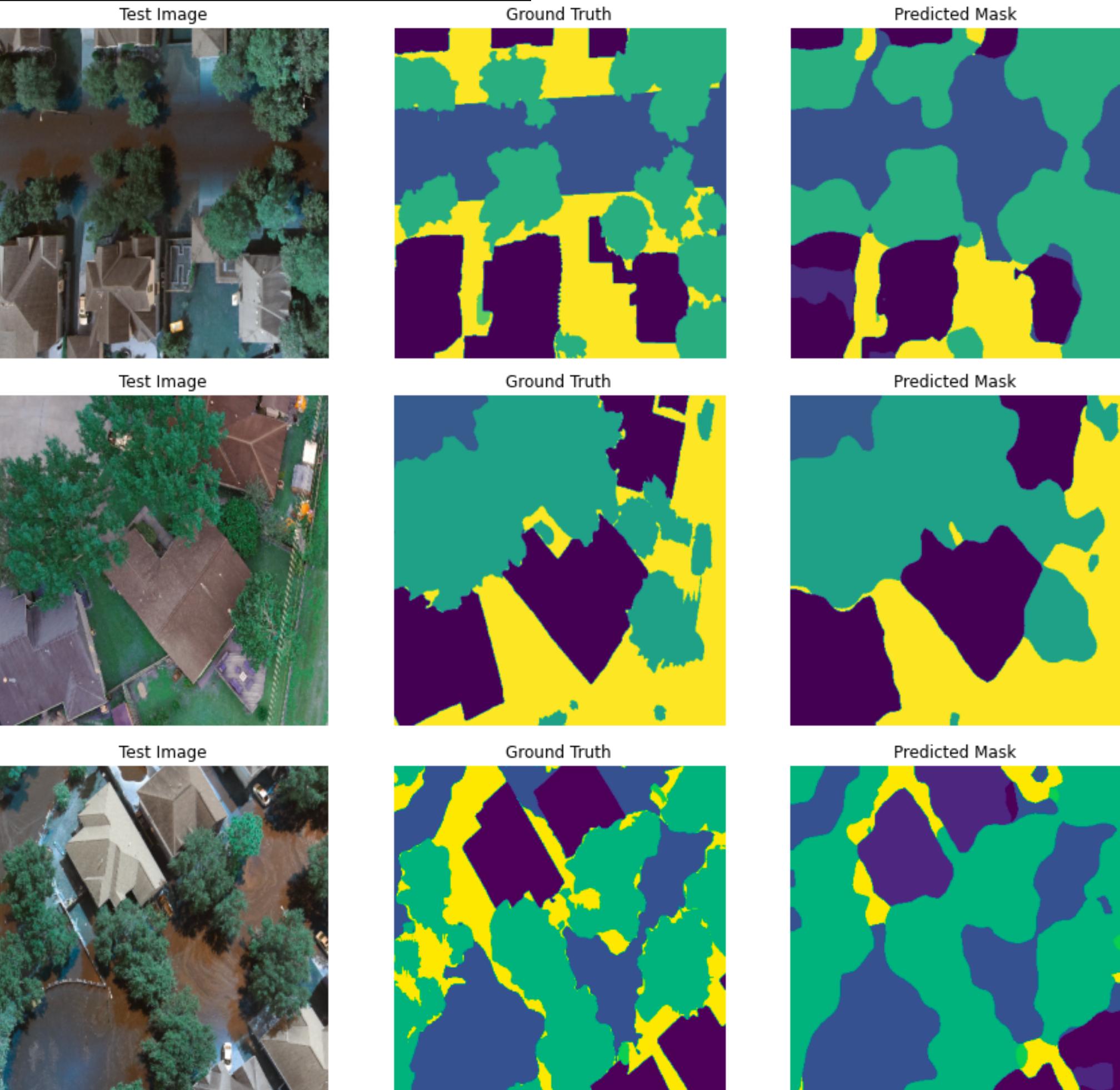
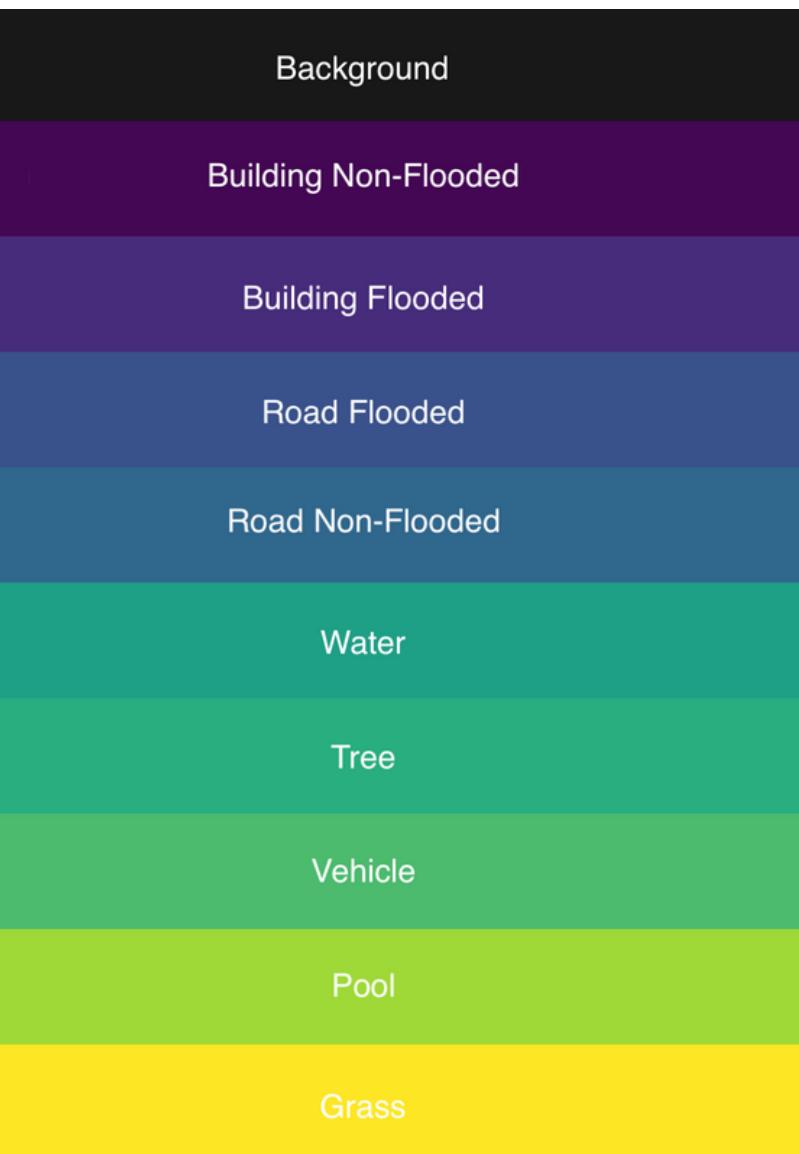
# Train-Val Loss/IoU

- Loss Function: Categorical Focal Jaccard loss
  - How well model is able to classify different categories
- Evaluation Metric: Intersection Over Union ~ Ratio of overlap between pixel prediction matching the ground truth pixels



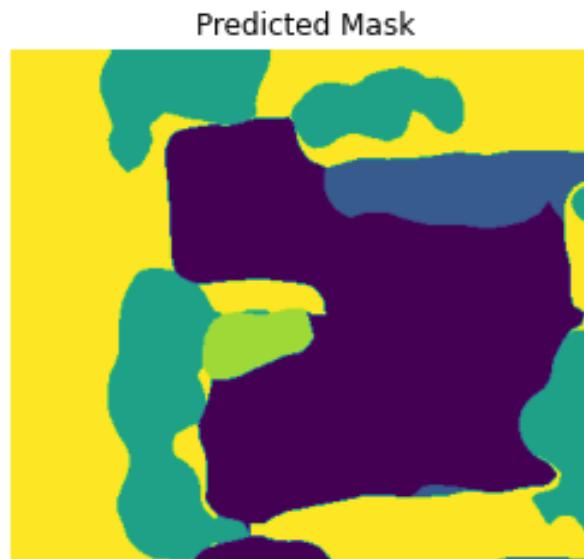
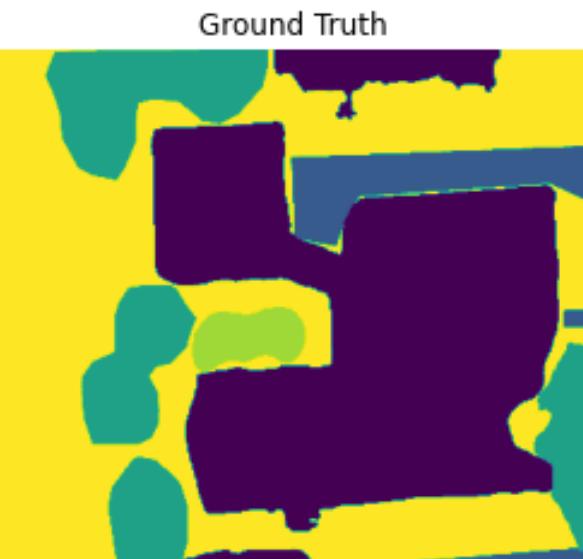
# PSPNet Predictions

- Test IoU ~ 30%
- Classifies smaller objects correctly like cars and pools
- Although not as precise still captures flooded areas

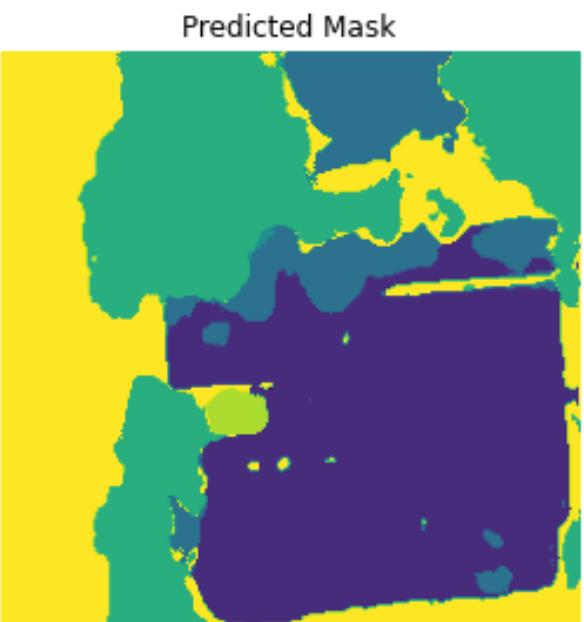
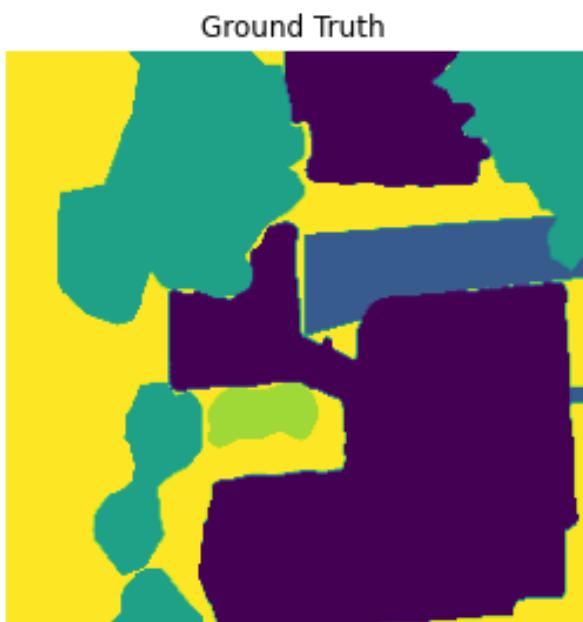


# Model Comparison

- Both models correctly classify Flooded Roads
- PSPNet:
  - Better to classify smaller objects like cars/pools with more precise outline
  - Requires more training data than U-Net
  - Pyramid Pooling requires more computational power



- U-Net:
  - Provides clear-cut segmentation through cluttered imaged
  - Quicker training
  - Overall better performance metric



## Conclusion + Future Work

- **Images make natural disaster damage assessments quicker and effective**
- **PSPNet captures smaller objects due to its focus on spatial details but Unet has greater accuracy**
- **Build PSPNet architecture from scratch and use pre-trained backbones**
- **Experiment with learning rate scheduler and deeper networks**

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