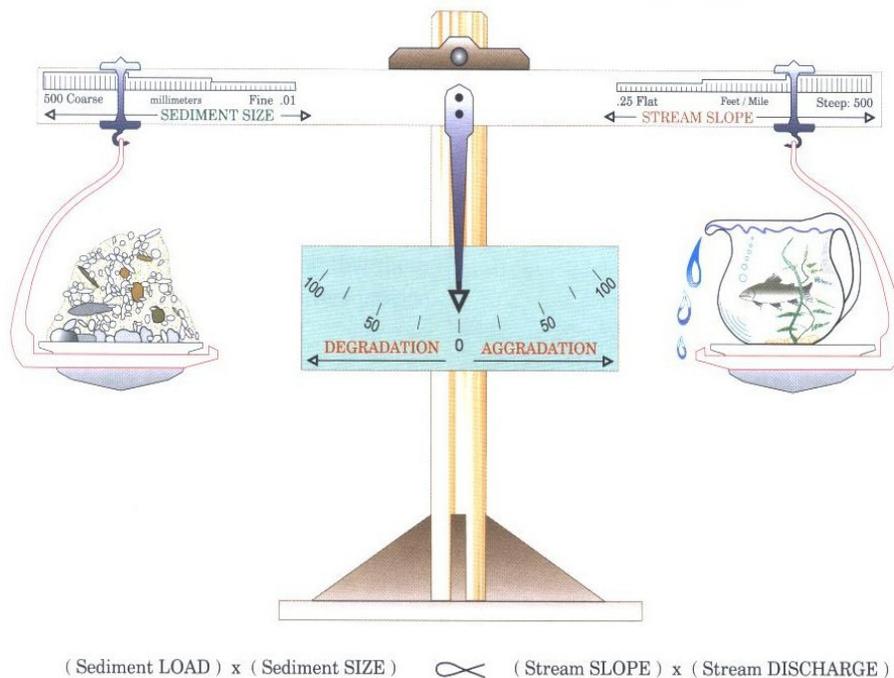


**Assessing Channel Erosion in Arcade Creek  
Sacramento County, California  
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Project Summary

Accelerated stream channel erosion is a major natural resource issue in the United States and around the world. Next to agriculture, urban landscape conversion is responsible for more miles of sediment impaired streams than any other landuse (USEPA 2006). Sediment impairment negatively affects the stream biota and also can lead to increased flooding and water treatment costs. Urbanization changes the hydrologic regime and the balance in sediment supply, transport, and deposition (Figure 1).

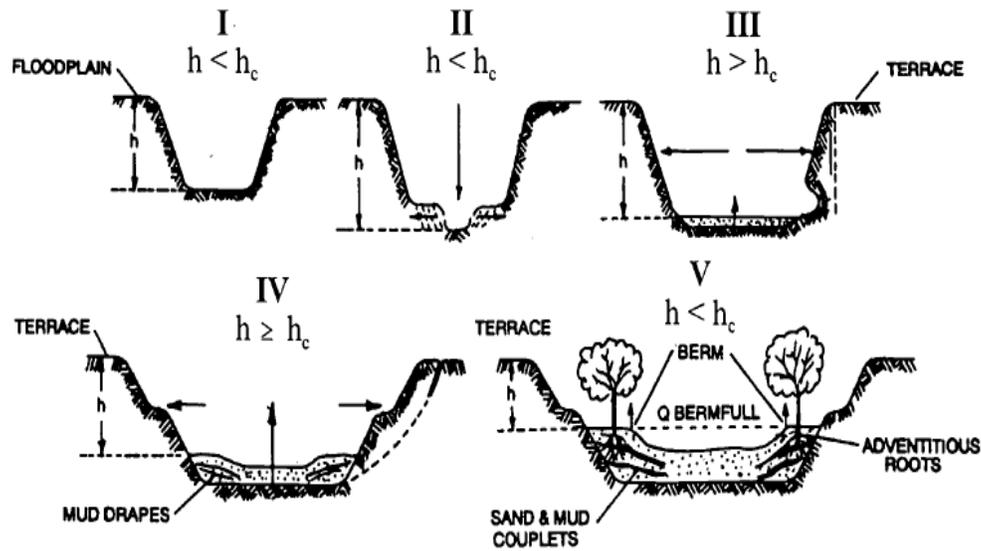
Figure I – Lane’s Balance



*After Lane (1955) as cited in Rosgen (1996)*

Streams generally respond to these changes by progressing through a stepwise process of downcutting, widening, bank sloughing, and ultimate detachment from the existing floodplain (Figure 2). Because larger flows cannot reach the floodplain, the higher energy is confined to within the channel and leads to further channel erosion.

Figure 2 – Channel Evolution Model



From Schumm 1984

Identifying these erosive areas is often a challenging task and usually results in many hours of office preparation and field work. Remote sensing technology offers a way to make a “first tier” cut at identifying erosive areas and prioritizing areas for further ground truthing, thus saving considerable time and effort and making resources available for covering more area in a given period of time. The purpose of this project was to evaluate the use of high resolution digital orthoimagery within a reach of Arcade Creek, Sacramento County (Figure 3) to identify areas where accelerated erosion is occurring.

### Methodology

I obtained 1:500,000 high resolution digital orthoimagery from the USGS Earth Explorer website (<http://edscns17.cr.usgs.gov/NewEarthExplorer>) for the area of interest (Figure 3). I chose this area because it represented a highly-urbanized watershed with suitable access to field verify channel erosion areas. I chose the February 2006 image to minimize the influence of tree canopy.

I performed the following tasks on the imagery using the Image Processing functions in ArcGIS 10:

- ◆ Conducted isocluster unsupervised classifications on the image using 4, 5, 7, 10, 20, and 30 classifications.
- ◆ Conducted field reconnaissance at known channel erosion sites
- ◆ Created training sites on the 5 and 30 class unsupervised images based on verification with the base image and field reconnaissance.
- ◆ Conducted supervised classifications using the signature files from the training sites and the Maximum Likelihood Estimator function.

Figure 3 – Arcade Creek near Del Paso Park, Sacramento County



## Results and Discussion

Images were generated for all isocluster unsupervised classifications. Figure 4 shows the image from the four class isocluster unsupervised classification. Table 1 shows the channel stability index rating calculated for the area between the two training sites in Figure 5. Photo 1 was taken looking west and Photo 2 was taken looking east. The channel stability index rating of 27 indicates severe instability (Simon and Downs 1995) and the photos indicate severe incision and bank erosion. Figure 5 also shows the image generated from the Maximum Likelihood Estimator used on the five class unsupervised image. Note that the spectral signatures for the pavement on the bridge and the channel erosion site are the same, suggesting that not enough classes were used in the unsupervised classification.

Table 2 shows the channel stability index rating calculated for the area between the two training sites in Figure 6. Photos 3 and 4 were taken looking south from the north training site. The channel stability index rating of 30 indicates severe instability and the photos indicate severe incision, scouring, deposition and bank erosion.

Figure 7 shows the image generated from the Maximum Likelihood Estimator used on the 30 class unsupervised image. The training sites were located on channel erosion areas. Note that the spectral signatures for the pavement on the bridge and the channel erosion site are not the same. However, there are very few pixels located on the erosion areas. This suggests that the image resolution may not be adequate to distinguish areas of exposed soil that are indicative of channel erosion. The same pattern is shown in Figure 8.

Table 1 – Channel Stability Index between Training Sites in Figure 5

<b>Channel Stability Index Rating<sup>1</sup></b>						<b>Score</b>
<b>1. Primary bed material</b>						
	Bedrock	Boulder/Cobble	Gravel	Sand	Silt Clay	
	0	1	2	3	4	3
<b>2. Bed/bank protection</b>						
	Yes	No	(with)	1 bank protected	2 banks	
	0	1		2	3	1
<b>3. Degree of incision</b> (Relative ele. Of "normal" low water; floodplain/terraces @ 100%)						
	0-10%	11-25%	26-50%	51-75%	76-100%	
	4	3	2	1	0	4
<b>4. Degree of constriction</b> (Relative decrease in top-bank width from up to downstream)						
	0-10%	11-25%	26-50%	51-75%	76-100%	
	0	1	2	3	4	1
<b>5. Streambank erosion</b> (Each Bank)						
	None	Fluvial	Mass Wasting	(failures)		
Left	0	1	2			1
Right	0	1	2			1
<b>6. Streambank instability</b> (Percent of each bank failing)						
	0-10%	11-25%	26-50%	51-75%	76-100%	
Left	0	0.5	1	1.5	2	1.5
Right	0	0.5	1	1.5	2	1.5
<b>7. Established riparian woody-vegetative cover</b> (Each bank)						
	0-10%	11-25%	26-50%	51-75%	76-100%	
Left	2	1.5	1	0.5	0	0.5
Right	2	1.5	1	0.5	0	0.5
<b>8. Occurrence of bank accretion</b> (Percent of each bank with fluvial deposition)						
	0-10%	11-25%	26-50%	51-75%	76-100%	
Left	2	1.5	1	0.5	0	0.5
Right	2	1.5	1	0.5	0	0.5
<b>9. Stage of channel evolution</b>						
I	II	III	IV	V	VI	
0	1	2	4	3	1.5	4
<b>10. Composition of adjacent side slope</b>						
	N/A	Bedrock	Boulders	Gravel-SP	Fines	
Left	0	0.5	1	1.5	2	2
Right	0	0.5	1	1.5	2	2
<b>11. Percent of slope (length) contributing sediment</b>						
	0-10%	11-25%	26-50%	51-75%	76-100%	
Left	0	0.5	1	1.5	2	0
Right	0	0.5	1	1.5	2	0
<b>12. Severity of side-slope erosion</b>						
	None	Low	Moderate	High		
Left	0	0.5	1.5	2		1.5
Right	0	0.5	1.5	2		1.5
					<b>Total Score =</b>	<b>27</b>

<sup>1</sup> The length of stream channel to be analyzed depends on the width and length of the channel. Data shall be collected at two sites at each transect within a distance of 30 bankfull channel widths. The sites shall be located in portions of the channel reach with relatively uniform width and gradient. For example, a 20 foot-wide channel would require data from at least two sites within a 600 foot distance. If sections of channel within the 30 bankfull width distance are immediately upstream or downstream of steps, culverts, grade controls, tributary junctions, or other features and structures that significantly affect the shape and behavior of the channel, a distance of longer than 30 bankfull widths must be analyzed. A total score of 10 or less indicates a stable channel; scores of 20 or more are indicative of severe instability.

Figure 4 – Four class isocluster unsupervised classification image

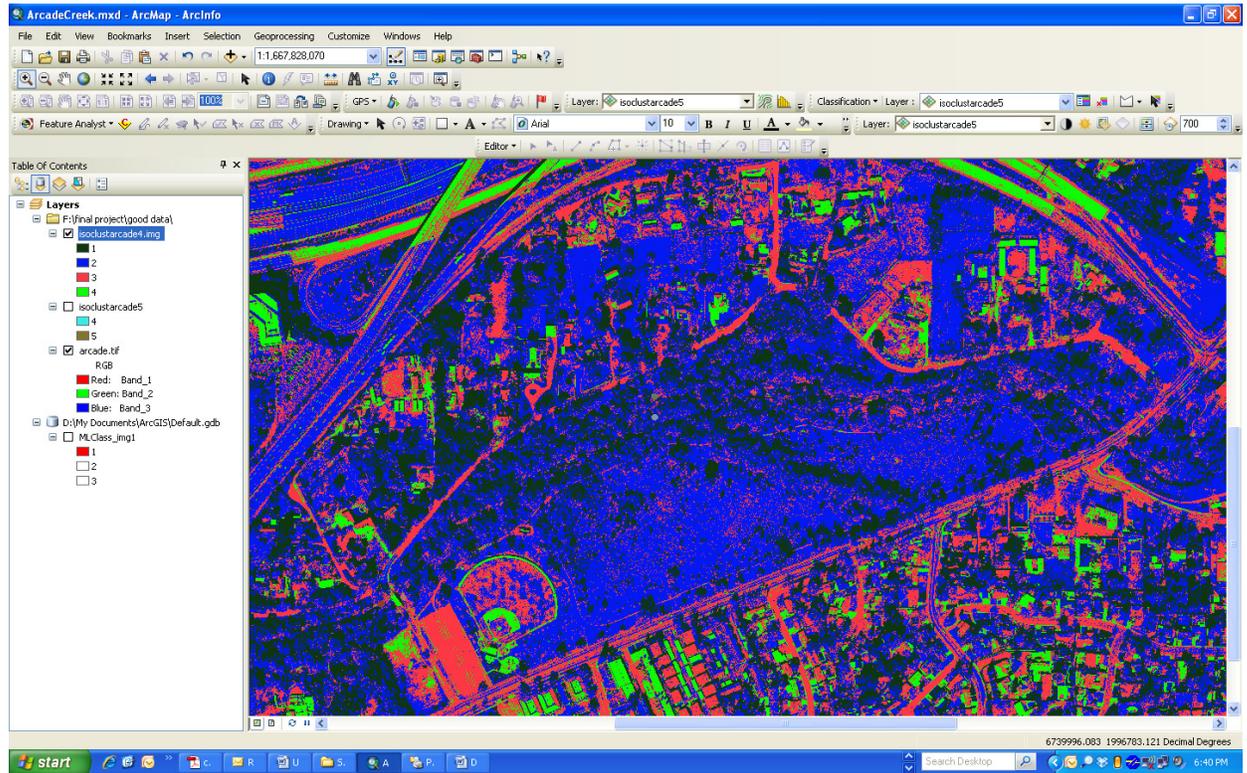


Figure 5 – Training sets and five class supervised classification image (1)

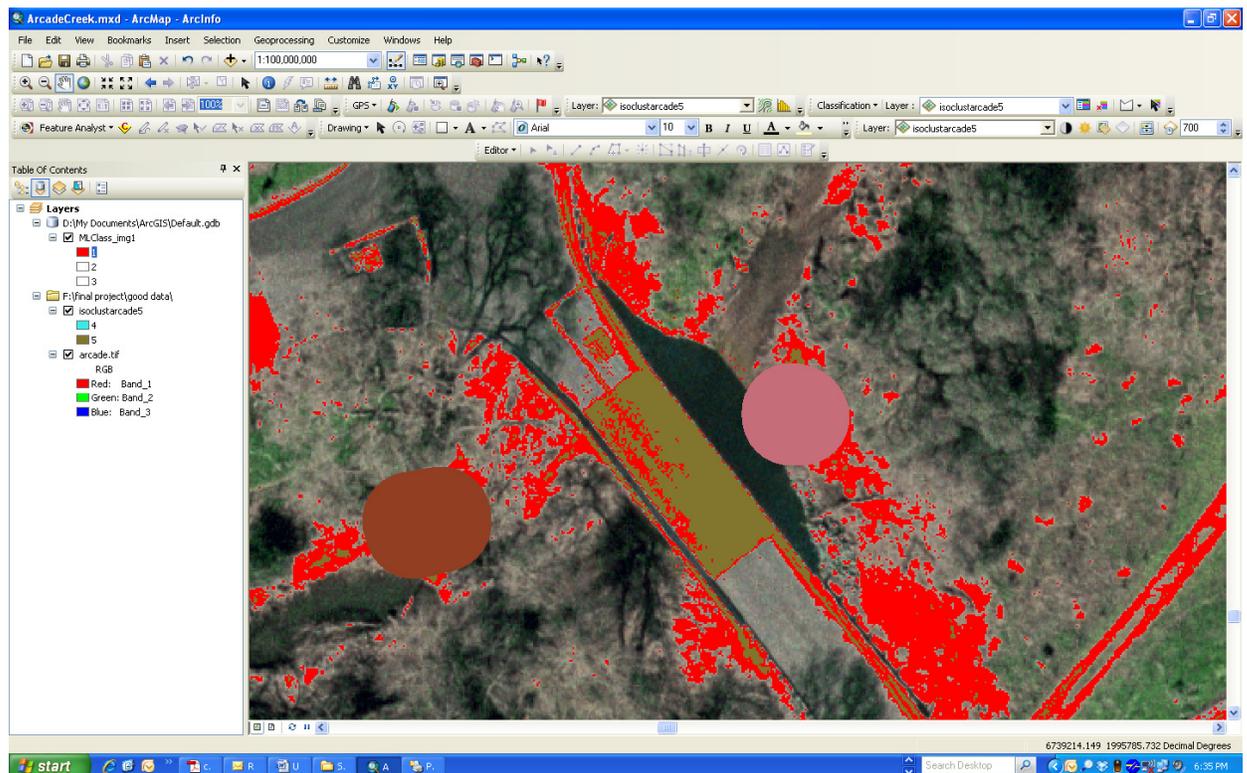


Table 2 – Channel Stability Index between Training Sites in Figure 6

<b>Channel Stability Index Rating<sup>1</sup></b>						<b>Score</b>
<b>1. Primary bed material</b>						
	Bedrock	Boulder/Cobble	Gravel	Sand	Silt Clay	
	0	1	2	3	4	3
<b>2. Bed/bank protection</b>						
	Yes	No	(with)	1 bank protected	2 banks	
	0	1		2	3	1
<b>3. Degree of incision</b> (Relative ele. Of "normal" low water; floodplain/terraces @ 100%)						
	0-10%	11-25%	26-50%	51-75%	76-100%	
	4	3	2	1	0	4
<b>4. Degree of constriction</b> (Relative decrease in top-bank width from up to downstream)						
	0-10%	11-25%	26-50%	51-75%	76-100%	
	0	1	2	3	4	2
<b>5. Streambank erosion</b> (Each Bank)						
	None	Fluvial	Mass Wasting	(failures)		
Left	0	1	2			1
Right	0	1	2			1
<b>6. Streambank instability</b> (Percent of each bank failing)						
	0-10%	11-25%	26-50%	51-75%	76-100%	
Left	0	0.5	1	1.5	2	1.5
Right	0	0.5	1	1.5	2	1.5
<b>7. Established riparian woody-vegetative cover</b> (Each bank)						
	0-10%	11-25%	26-50%	51-75%	76-100%	
Left	2	1.5	1	0.5	0	0.5
Right	2	1.5	1	0.5	0	0.5
<b>8. Occurrence of bank accretion</b> (Percent of each bank with fluvial deposition)						
	0-10%	11-25%	26-50%	51-75%	76-100%	
Left	2	1.5	1	0.5	0	0.5
Right	2	1.5	1	0.5	0	0.5
<b>9. Stage of channel evolution</b>						
I	II	III	IV	V	VI	
0	1	2	4	3	1.5	4
<b>10. Composition of adjacent side slope</b>						
	N/A	Bedrock	Boulders	Gravel-SP	Fines	
Left	0	0.5	1	1.5	2	2
Right	0	0.5	1	1.5	2	2
<b>11. Percent of slope (length) contributing sediment</b>						
	0-10%	11-25%	26-50%	51-75%	76-100%	
Left	0	0.5	1	1.5	2	0.5
Right	0	0.5	1	1.5	2	0.5
<b>12. Severity of side-slope erosion</b>						
	None	Low	Moderate	High		
Left	0	0.5	1.5	2		2
Right	0	0.5	1.5	2		2
<b>Total Score =</b>						<b>30</b>

<sup>1</sup> The length of stream channel to be analyzed depends on the width and length of the channel. Data shall be collected at two sites at each transect within a distance of 30 bankfull channel widths. The sites shall be located in portions of the channel reach with relatively uniform width and gradient. For example, a 20 foot-wide channel would require data from at least two sites within a 600 foot distance. If sections of channel within the 30 bankfull width distance are immediately upstream or downstream of steps, culverts, grade controls, tributary junctions, or other features and structures that significantly affect the shape and behavior of the channel, a distance of longer than 30 bankfull widths must be analyzed. A total score of 10 or less indicates a stable channel; scores of 20 or more are indicative of severe instability.

Figure 6 – Training sets and five class supervised classification image (2)

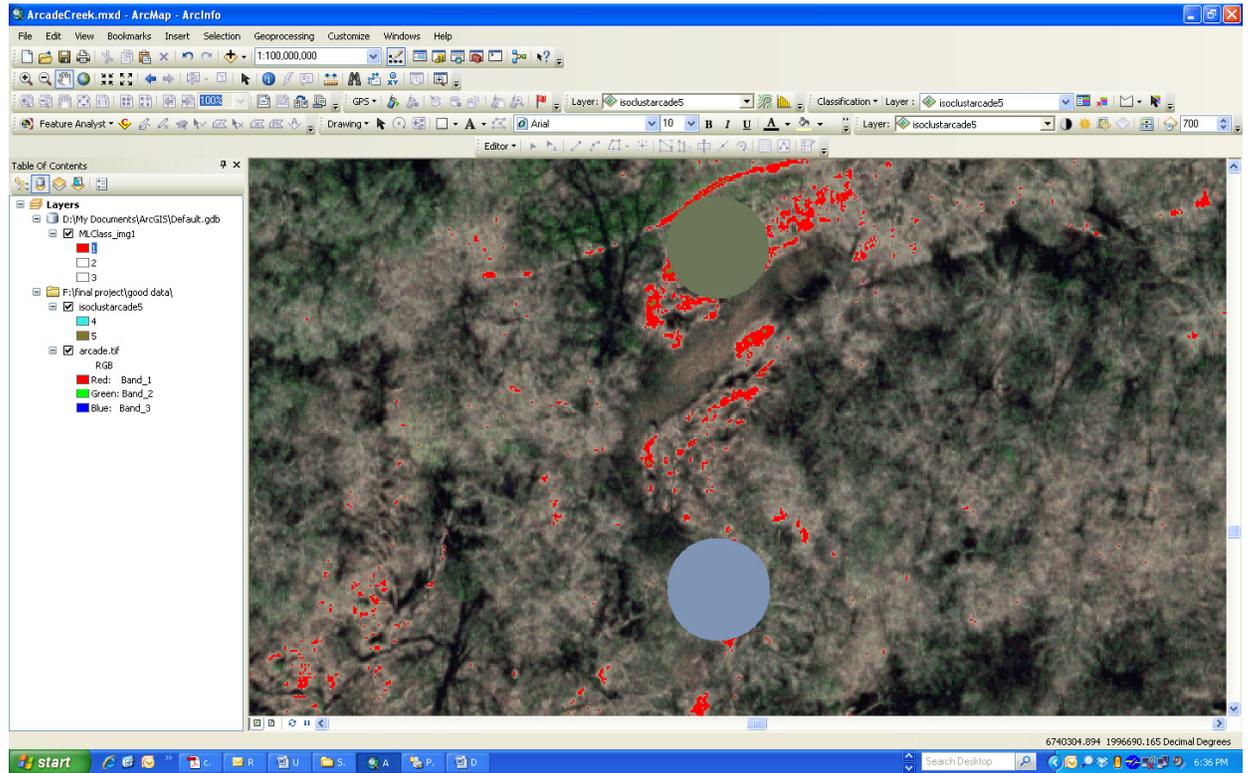


Figure 7 – Training sets and 30 class supervised classification image

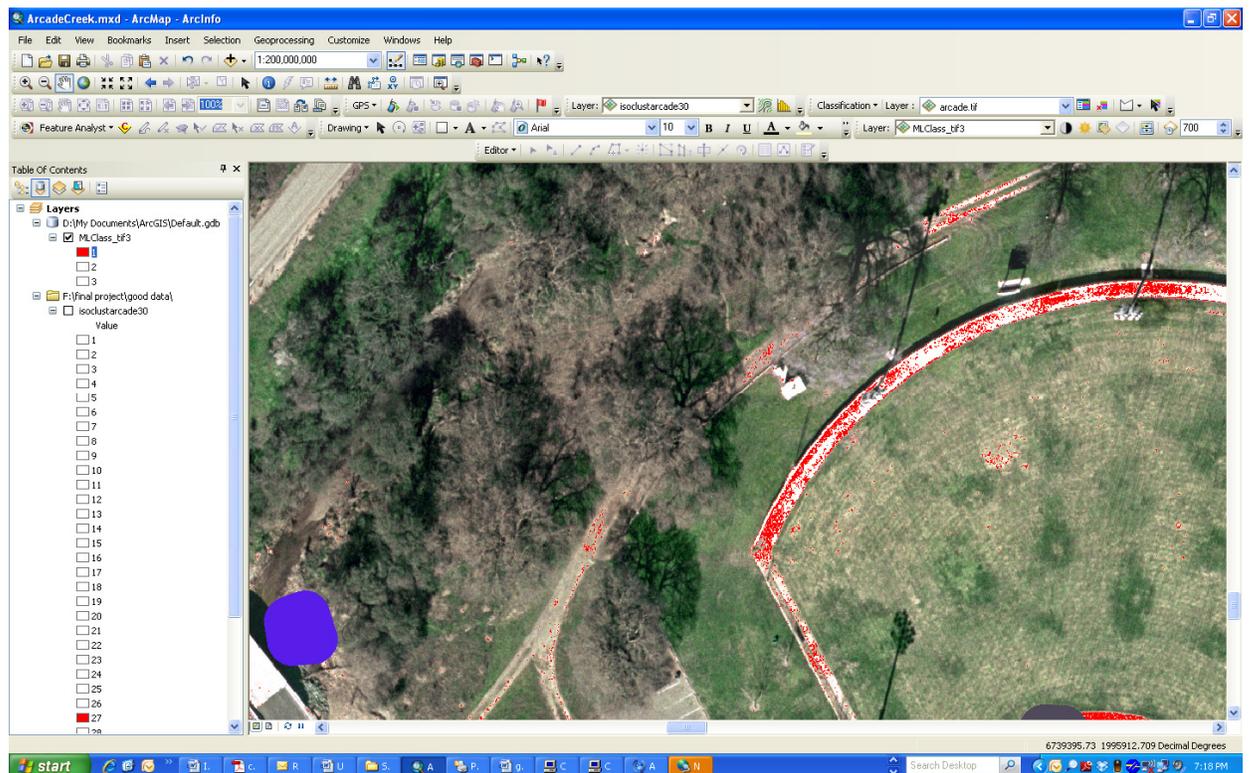
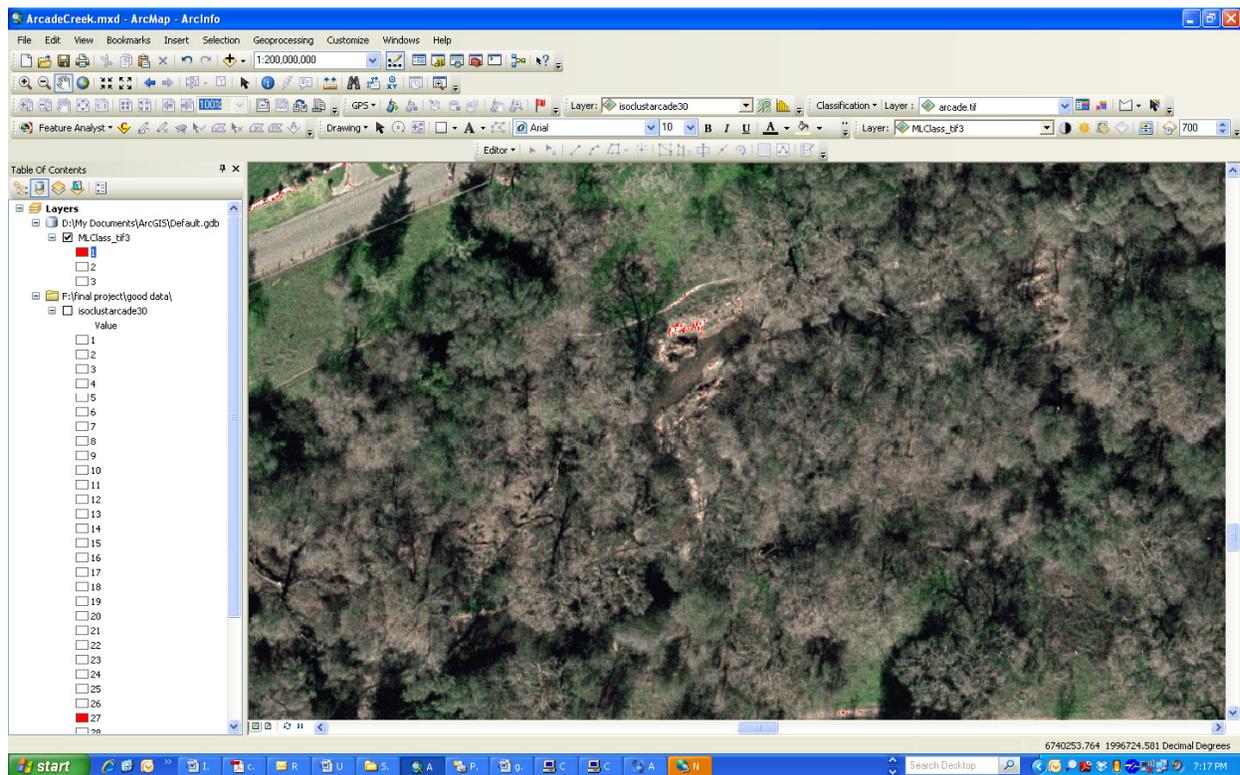


Figure 8 - 30 class supervised classification image



## Conclusions

The project showed that the imagery represents areas where channel erosion is occurring but the spectral signatures for the erosion areas were not as strong and distinctive as I would have expected. I learned that it takes a good deal of trial and error to determine the optimum number of classes to use. In order for this to be a truly effective tool for channel erosion detection, one must use the highest resolution imagery possible in order to create stronger spectral signatures. If I had used a higher resolution, I believe I would have seen a much more definitive spectral signature that could have lead to a clearer identification of channel erosion areas in the Arcade Creek watershed. Now that I know how to perform unsupervised and supervised classifications, I feel comfortable performing this analysis on higher resolution imagery.

## References

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Photo 1 – Looking west from Training Sites in Figure 5



Photo – Looking east from Training Sites in Figure 5



Photo 3 – Looking south from Training Sites in Figure 6



Photo 4 - Looking south from Training Sites in Figure 6

