



**GeoMarc<sup>®</sup>**

Digital Watermarking  
for Advanced Geospatial Data Management

ASRC MS and USDA FAS Seminar  
21 October, 2008

**Your Data. Smarter.**

# GeoMarc Technology

- Geospatial Application of Digital Watermarking
  - Imperceptible alteration of imagery pixels to store data
- Redundant algorithm allows retrieval even after many image alterations
  - rotation, scaling, compression, cropping
  - format changes and header loss
  - printing and scanning
- No perceptible effect on image quality or interpretability
- Provides reliable imagery identity and linkage







IMAGE SOURCE: GEOEYE





IMAGE SOURCE: GEOEYE



**Original Image**



**Watermarked Image**





**Original Image**



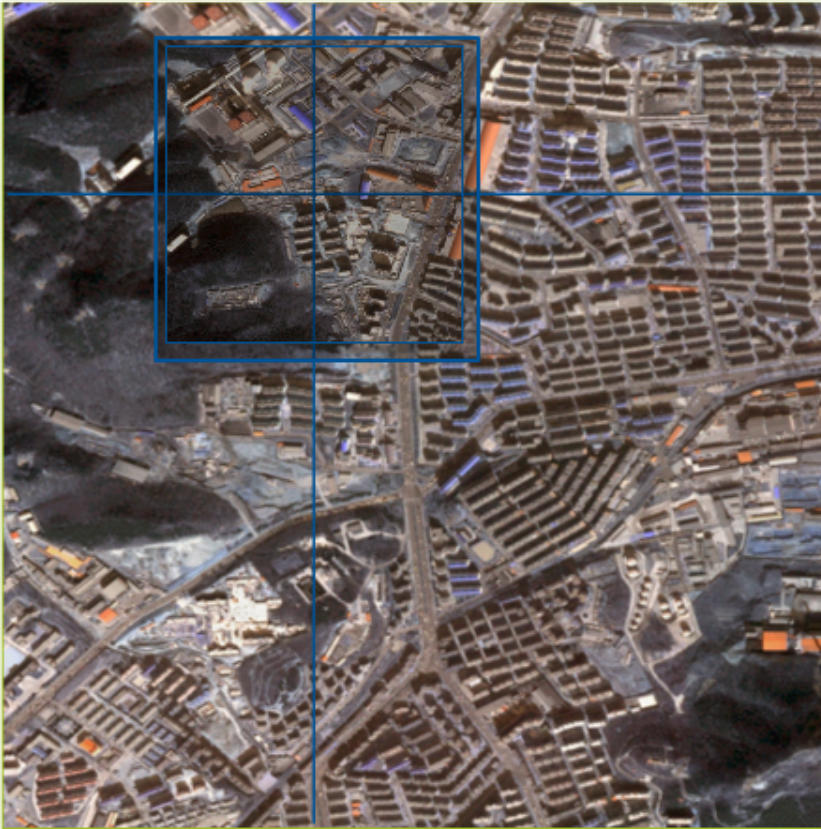
**Watermarked Image**



**Original Image**



**Watermarked Image**



**Original Image**



**Watermarked Image**



**Original Image**



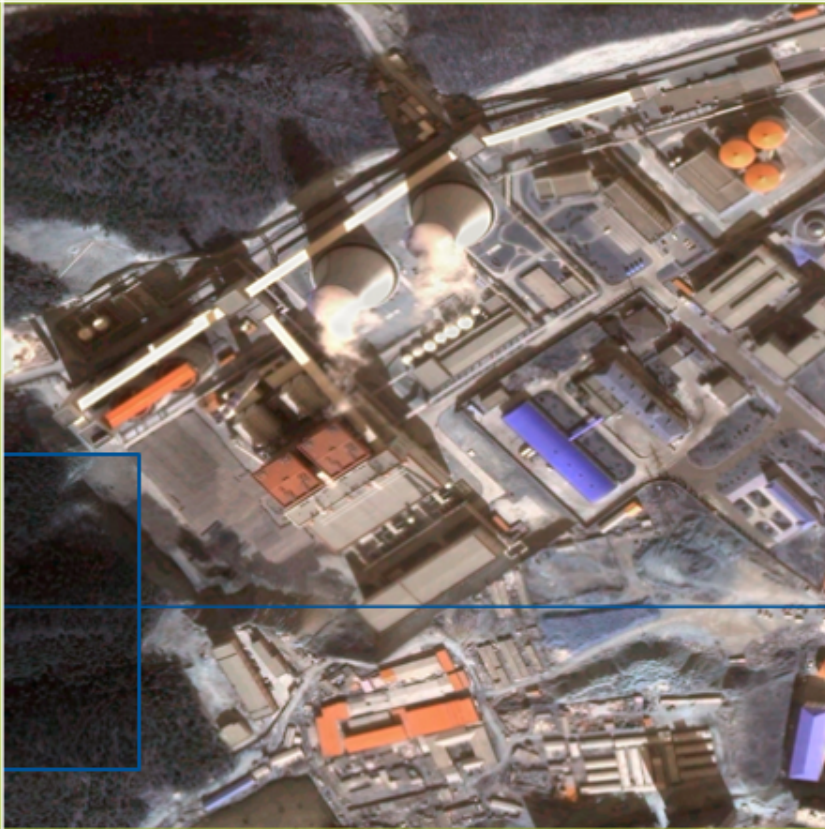
**Watermarked Image**



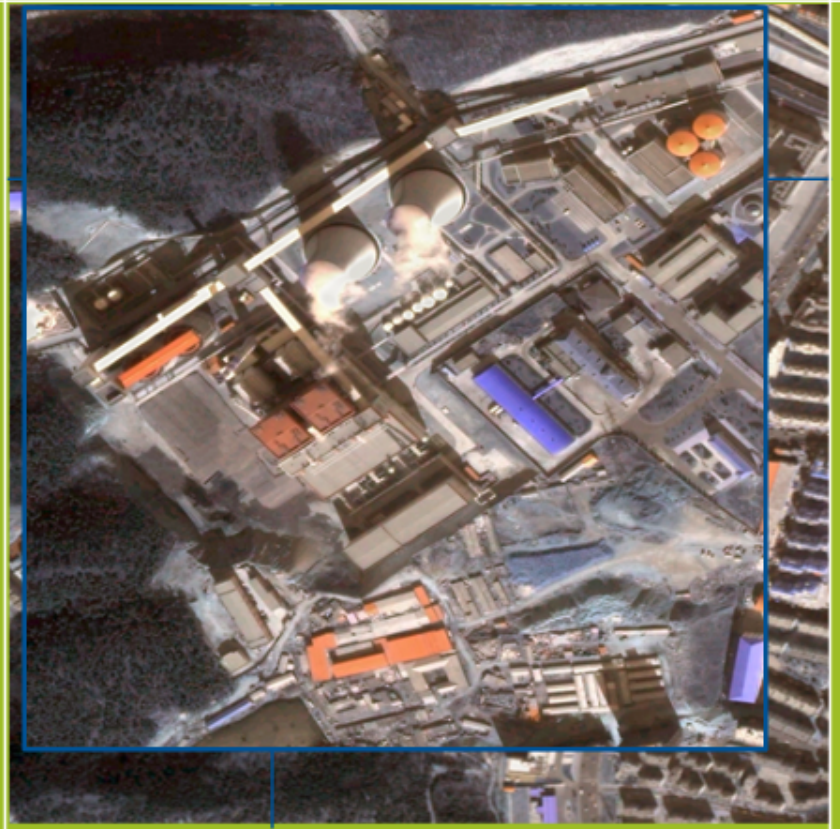
Original Image



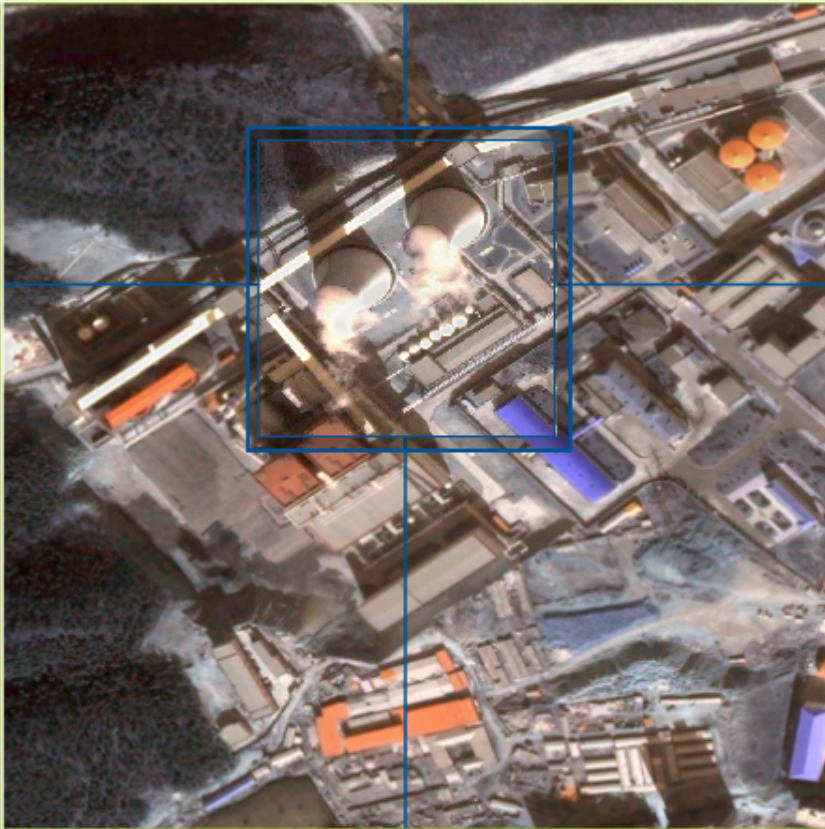
Watermarked Image



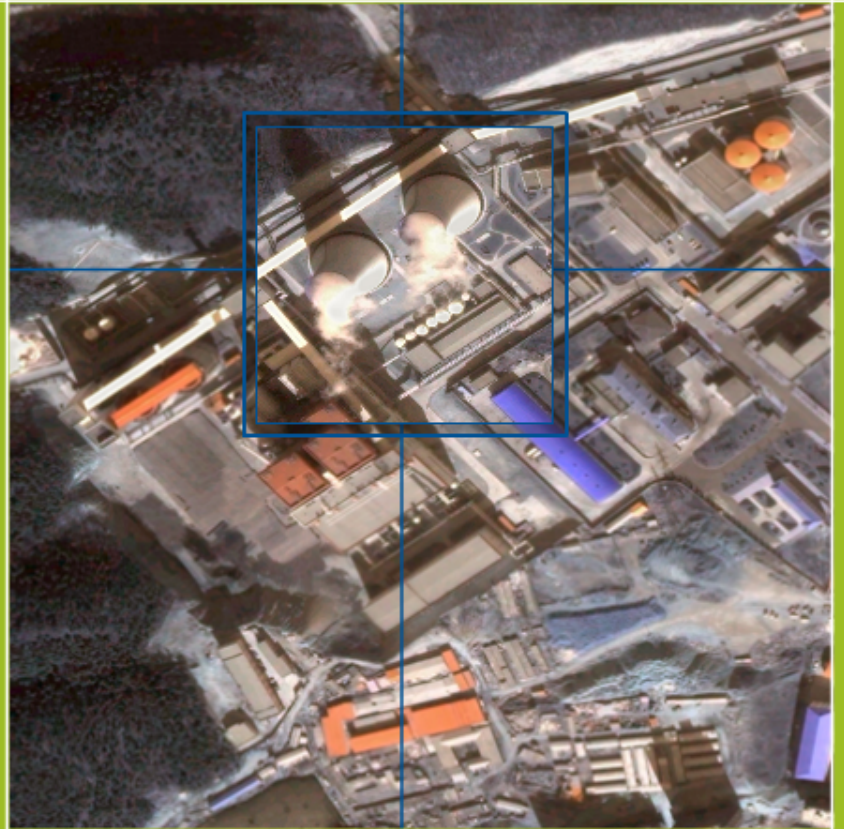
Original Image



Watermarked Image



Original Image



Watermarked Image



Original Image



Watermarked Image



**< H E A D E R >**



```
<source data>  
<# bands> <date of acquisition>  
  
<latitude="x" longitude="y">  
<country CODE "#">  
<sensor="type">  
</source data>
```

< H E A D E R >

```
<source data>  
<# bands> <date of acquisition>  
  
<latitude="x" longitude="y">  
<country CODE "#">  
ne">  
ta>
```

**Static  
Attributes**

< H E A D E R >

```
<source data>  
<# bands> <date of acquisition>  
  
<latitude="x" longitude="y">  
<country CODE "#">  
<name">  
<ta>
```



**Static  
Attributes**

**Dynamic Metadata  
Pointer**

# Workflow – AWiFS Mosaic of Iraq

- Overall Goals
  - Create country-wide orthomosaic with minimal cloud cover
  - Allow imagery users to easily determine source, date and other metadata for any given area of the image
- GeoMarc Solution
  - Define GeoMarc Flags to encode critical desired metadata
  - Use GeoMarc to embed source, date and flags into each original scene before mosaic creation
  - Publish additional related data via a GeoMarc webservice

# Sample Flag Definitions

```
- <Flags>
- <GROUP name="Product Level Radiometry" length="3" type="enum">
- <Domain>
  <Flag code="0" value="FLAGS INVALID"/>
  <Flag code="1" value="No Radiometric Correction"/>
  <Flag code="2" value="Top of Atmosphere Reflectance"/>
  <Flag code="3" value="Std. Atmosphere Surface Reflectance"/>
  <Flag code="4" value="Modeled Atmosphere Surface Reflectance"/>
  <Flag code="5" value="Other Radiometry"/>
  <Flag code="6" value="TBD"/>
  <Flag code="7" value="Other"/>
</Domain>
</GROUP>
- <GROUP name="Product Level Geometry" length="3" type="enum">
- <Domain>
  <Flag code="0" value="Raw Data/Un-Rectified"/>
  <Flag code="1" value="Radiometric and Sensor Corrected"/>
  <Flag code="2" value="Geo-Rectified"/>
  <Flag code="3" value="Ortho-Ready"/>
  <Flag code="4" value="Ortho-Rectified"/>
  <Flag code="5" value="Ortho-Reference"/>
  <Flag code="6" value="Ortho-Pro"/>
  <Flag code="7" value="Ortho-Precision"/>
</Domain>
</GROUP>
- <GROUP name="License Type" length="4" type="enum">
- <Domain>
  <Flag code="0" value="Multiple private companies"/>
  <Flag code="1" value="FedCiv Agencies"/>
  <Flag code="2" value="Single Organization"/>
  <Flag code="3" value="DOD/Title 50"/>
  <Flag code="4" value="Military by branch or command"/>
  <Flag code="5" value="State or provincial government"/>
  <Flag code="6" value="Municipal government"/>
  <Flag code="7" value="Multiple NGO and/or NPO"/>
  <Flag code="8" value="All dept. within an educational org"/>
  <Flag code="9" value="Multiple International agencies"/>
  <Flag code="10" value="FedCiv + Tiers"/>
  <Flag code="11" value="Negotiated License/Research/Tech Transfer"/>
  <Flag code="12" value="ClearView"/>
  <Flag code="13" value="NextView"/>
  <Flag code="14" value="Limited Distribution"/>
  <Flag code="15" value="Other"/>
</Domain>
</GROUP>
- <GROUP name="Product Type" length="2" type="enum">
- <Domain>
  <Flag code="0" value="PAN"/>
  <Flag code="1" value="PAN-Sharpened"/>
  <Flag code="2" value="Multi Spectral"/>
  <Flag code="3" value="Other"/>
</Domain>
</GROUP>
```

```
- <GROUP name="Satellite Sensor" length="6" type="enum">
- <Domain>
  <Flag code="0" value="LandSAT 4 TM"/>
  <Flag code="1" value="LandSAT 4 MSS"/>
  <Flag code="2" value="LandSAT 5 TM"/>
  <Flag code="3" value="LandSAT 5 MSS"/>
  <Flag code="4" value="SPOT 1 HRV"/>
  <Flag code="5" value="SPOT 2 HRV"/>
  <Flag code="6" value="SPOT 3 HRV"/>
  <Flag code="7" value="IRS-1C LISS3"/>
  <Flag code="8" value="IRS-1C WiFS"/>
  <Flag code="9" value="IRS-1C PAN"/>
  <Flag code="10" value="IRS-1D LISS3"/>
  <Flag code="11" value="IRS-1D WiFS"/>
  <Flag code="12" value="IRS-1D PAN"/>
  <Flag code="13" value="SPOT 4 HRVIR"/>
  <Flag code="14" value="LandSAT 7 ETM+"/>
  <Flag code="15" value="IKONOS-2"/>
  <Flag code="16" value="TERRA ASTER"/>
  <Flag code="17" value="TERRA MODIS"/>
  <Flag code="18" value="EO-1 ALI"/>
  <Flag code="19" value="EO-1 HYPERION"/>
  <Flag code="20" value="SAC-C"/>
  <Flag code="21" value="EROS-A"/>
  <Flag code="22" value="QuickBird"/>
  <Flag code="23" value="SPOT 5 HRG"/>
  <Flag code="24" value="AQUA MODIS"/>
  <Flag code="25" value="DMC-AISat-1 SLIM6"/>
  <Flag code="26" value="DMC-UK SLIM6"/>
  <Flag code="27" value="DMC-NigeriaSat SLIM6"/>
  <Flag code="28" value="IRS-ResourceSAT-1 LISS4PN"/>
  <Flag code="29" value="IRS-ResourceSAT-1 LISS4MX"/>
  <Flag code="30" value="IRS-ResourceSAT-1 LISS3"/>
  <Flag code="31" value="IRS-ResourceSAT-1 AWiFS"/>
  <Flag code="32" value="CBERS-2 CCD"/>
  <Flag code="33" value="CBERS-2 IR-MSS"/>
  <Flag code="34" value="CBERS-2 WFI"/>
  <Flag code="35" value="FORMOSAT-2"/>
  <Flag code="36" value="IRS-CartoSAT-1"/>
  <Flag code="37" value="Monitor-E PAN"/>
  <Flag code="38" value="Monitor-E MS"/>
  <Flag code="39" value="DMC-Beijing-1 SLIM6"/>
  <Flag code="40" value="DMC-TopSat"/>
  <Flag code="41" value="ALOS AVNIR-2"/>
  <Flag code="42" value="EROS-B"/>
  <Flag code="43" value="Resurs-DK1"/>
  <Flag code="44" value="KOMPSAT-2"/>
  <Flag code="45" value="IRS-CartoSAT-2"/>
  <Flag code="46" value="WorldView 1"/>
  <Flag code="47" value="CBERS-2B HRC"/>
  <Flag code="48" value="CBERS-2B CCD"/>
  <Flag code="49" value="CBERS-2B WET"/>
```

# Sample Flag Definitions

```
- <Flags>
- <GROUP name="Product Level Radiometry" length="3" type="enum">
- <Domain>
  <Flag code="0" value="FLAGS INVALID"/>
  <Flag code="1" value="No Radiometric Correction"/>
  <Flag code="2" value="Top of Atmosphere Reflectance"/>
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  <Flag code="6" value="TBD"/>
  <Flag code="7" value="Other"/>
</Domain>
</GROUP>
```

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- <GROUP name="Satellite Sensor" length="6" type="enum">
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  <Flag code="3" value="LandSAT 5 MSS"/>
  <Flag code="4" value="SPOT 1 HRV"/>
  <Flag code="5" value="SPOT 2 HRV"/>
  <Flag code="6" value="SPOT 3 HRV"/>
  <Flag code="7" value="IRS-1C LISS3"/>
  <Flag code="8" value="IRS-1C WiFS"/>
  <Flag code="9" value="IRS-1C PAN"/>
  <Flag code="10" value="IRS-1D LISS3"/>
```

```
- <GROUP name="Product Level Geometry" length="3" type="enum">
- <Domain>
  <Flag code="0" value="Raw Data/Un-Rectified"/>
  <Flag code="1" value="Radiometric and Sensor Corrected"/>
  <Flag code="2" value="Geo-Rectified"/>
  <Flag code="3" value="Ortho-Ready"/>
  <Flag code="4" value="Ortho-Rectified"/>
  <Flag code="5" value="Ortho-Reference"/>
  <Flag code="6" value="Ortho-Pro"/>
  <Flag code="7" value="Ortho-Precision"/>
</Domain>
</GROUP>
```

```
<Flag code="9" value="Multiple International agencies"/>
<Flag code="10" value="FedCiv + Tiers"/>
<Flag code="11" value="Negotiated License/Research/Tech Transfer"/>
<Flag code="12" value="ClearView"/>
<Flag code="13" value="NextView"/>
<Flag code="14" value="Limited Distribution"/>
<Flag code="15" value="Other"/>
</Domain>
</GROUP>
- <GROUP name="Product Type" length="2" type="enum">
- <Domain>
  <Flag code="0" value="PAN"/>
  <Flag code="1" value="PAN-Sharpened"/>
  <Flag code="2" value="Multi Spectral"/>
  <Flag code="3" value="Other"/>
</Domain>
</GROUP>
```

```
<Flag code="33" value="CBERS-2 IR-MSS"/>
<Flag code="34" value="CBERS-2 WFI"/>
<Flag code="35" value="FORMOSAT-2"/>
<Flag code="36" value="IRS-CartoSAT-1"/>
<Flag code="37" value="Monitor-E PAN"/>
<Flag code="38" value="Monitor-E MS"/>
<Flag code="39" value="DMC-Beijing-1 SLIM6"/>
<Flag code="40" value="DMC-TopSat"/>
<Flag code="41" value="ALOS AVNIR-2"/>
<Flag code="42" value="EROS-B"/>
<Flag code="43" value="Resurs-DK1"/>
<Flag code="44" value="KOMPSAT-2"/>
<Flag code="45" value="IRS-CartoSAT-2"/>
<Flag code="46" value="WorldView 1"/>
<Flag code="47" value="CBERS-2B HRC"/>
<Flag code="48" value="CBERS-2B CCD"/>
<Flag code="49" value="CBERS-2B WET"/>
```

# Sample Flag Definitions

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  <Flag code="6" value="SPOT 3 HRV"/>
  <Flag code="7" value="IRS-1C LISS3"/>
  <Flag code="8" value="IRS-1C WiFS"/>
  <Flag code="9" value="IRS-1C PAN"/>
  <Flag code="10" value="IRS-1D LISS3"/>
  <Flag code="11" value="IRS-1D WiFS"/>
  <Flag code="12" value="IRS-1D PAN"/>
  <Flag code="13" value="SPOT 4 HRVIR"/>
  <Flag code="14" value="LandSAT 7 ETM+"/>
  <Flag code="15" value="IKONOS-2"/>
  <Flag code="16" value="TERRA ASTER"/>
  <Flag code="17" value="TERRA MODIS"/>
  <Flag code="18" value="EO-1 ALI"/>
  <Flag code="19" value="EO-1 HYPERION"/>
  <Flag code="20" value="SAC-C"/>
  <Flag code="21" value="EROS-A"/>
  <Flag code="22" value="QuickBird"/>
  <Flag code="23" value="SPOT 5 HRG"/>
  <Flag code="24" value="AQUA MODIS"/>
  <Flag code="25" value="DMC-AISat-1 SLIM6"/>
  <Flag code="26" value="DMC-UK SLIM6"/>
  <Flag code="27" value="DMC-NigeriaSat SLIM6"/>
  <Flag code="28" value="IRS-ResourceSAT-1 LISS4PN"/>
  <Flag code="29" value="IRS-ResourceSAT-1 LISS4MX"/>
  <Flag code="30" value="IRS-ResourceSAT-1 LISS3"/>
  <Flag code="31" value="IRS-ResourceSAT-1 AWiFS"/>
  <Flag code="32" value="CBERS-2 CCD"/>
  <Flag code="33" value="CBERS-2 IR-MSS"/>
  <Flag code="34" value="CBERS-2 WFI"/>
  <Flag code="35" value="FORMOSAT-2"/>
  <Flag code="36" value="IRS-CartoSAT-1"/>
  <Flag code="37" value="Monitor-E PAN"/>
  <Flag code="38" value="Monitor-E MS"/>
  <Flag code="39" value="DMC-Beijing-1 SLIM6"/>
  <Flag code="40" value="DMC-TopSat"/>
  <Flag code="41" value="ALOS AVNIR-2"/>
  <Flag code="42" value="EROS-B"/>
  <Flag code="43" value="Resurs-DK1"/>
  <Flag code="44" value="KOMPSAT-2"/>
  <Flag code="45" value="IRS-CartoSAT-2"/>
  <Flag code="46" value="WorldView 1"/>
  <Flag code="47" value="CBERS-2B HRC"/>
  <Flag code="48" value="CBERS-2B CCD"/>
  <Flag code="49" value="CBERS-2B WET"/>
```

- Layers
  - Auckland\_Mosaic.tif
    - RGB
      - Red: Band\_1
      - Green: Band\_2
      - Blue: Band\_3





Untitled - ArcMap - ArcView

File Edit View Insert Selection Tools Window Help



GeoMarc 1:17,788 Spatial Analyst Layer:

Scanning ...  
Watermarked  
Auckland\_Mosaic.tif  
Mosaic Region 1  
Non-Watermarked



Display Source Selection GeoMarc



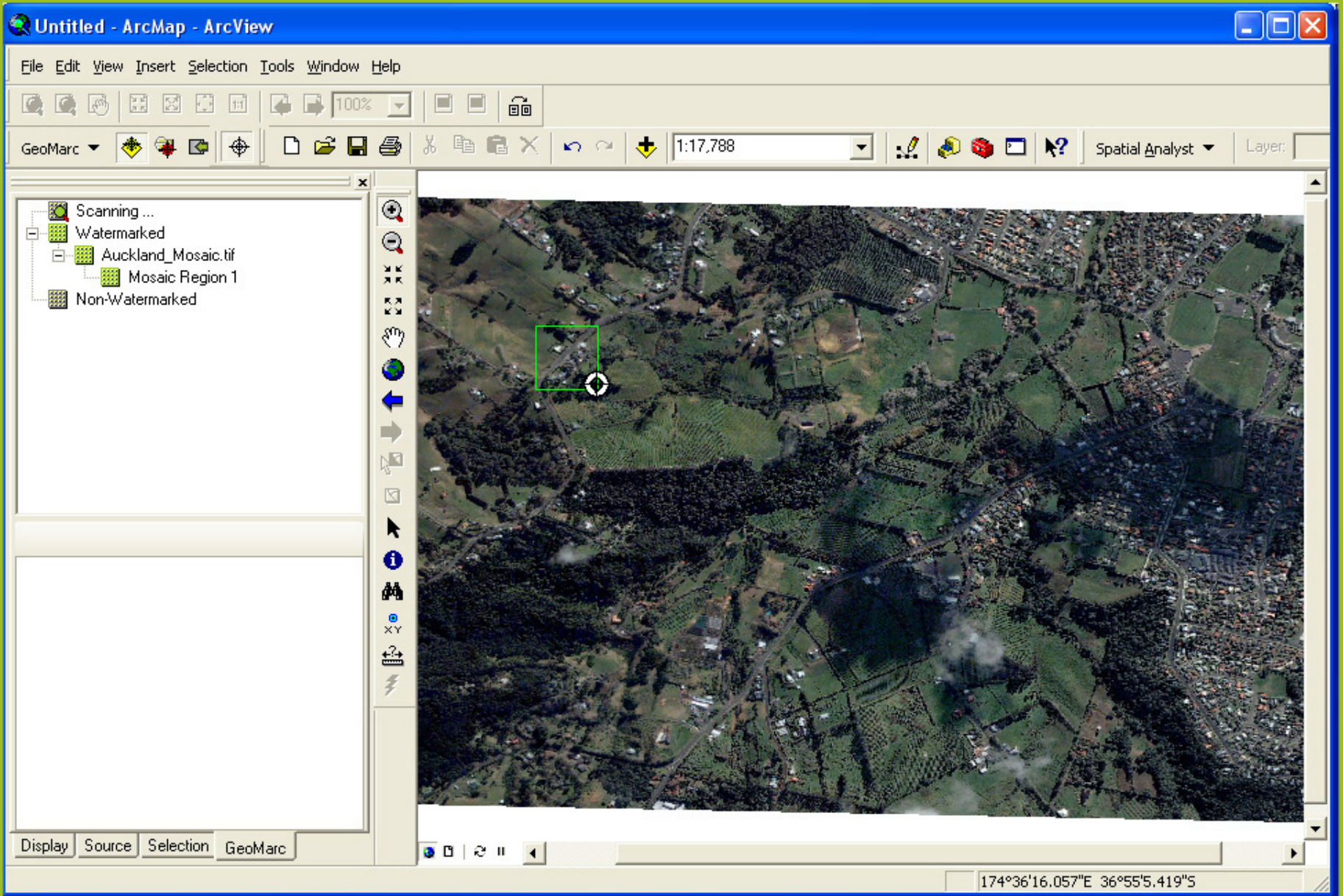
174°36'16.057"E 36°55'5.419"S



Spot Scan Tool

- Scanning ...
- Watermarked
  - Auckland\_Mosaic.tif
    - Mosaic Region 1
  - Non-Watermarked





File Edit View Insert Selection Tools Window Help

100%

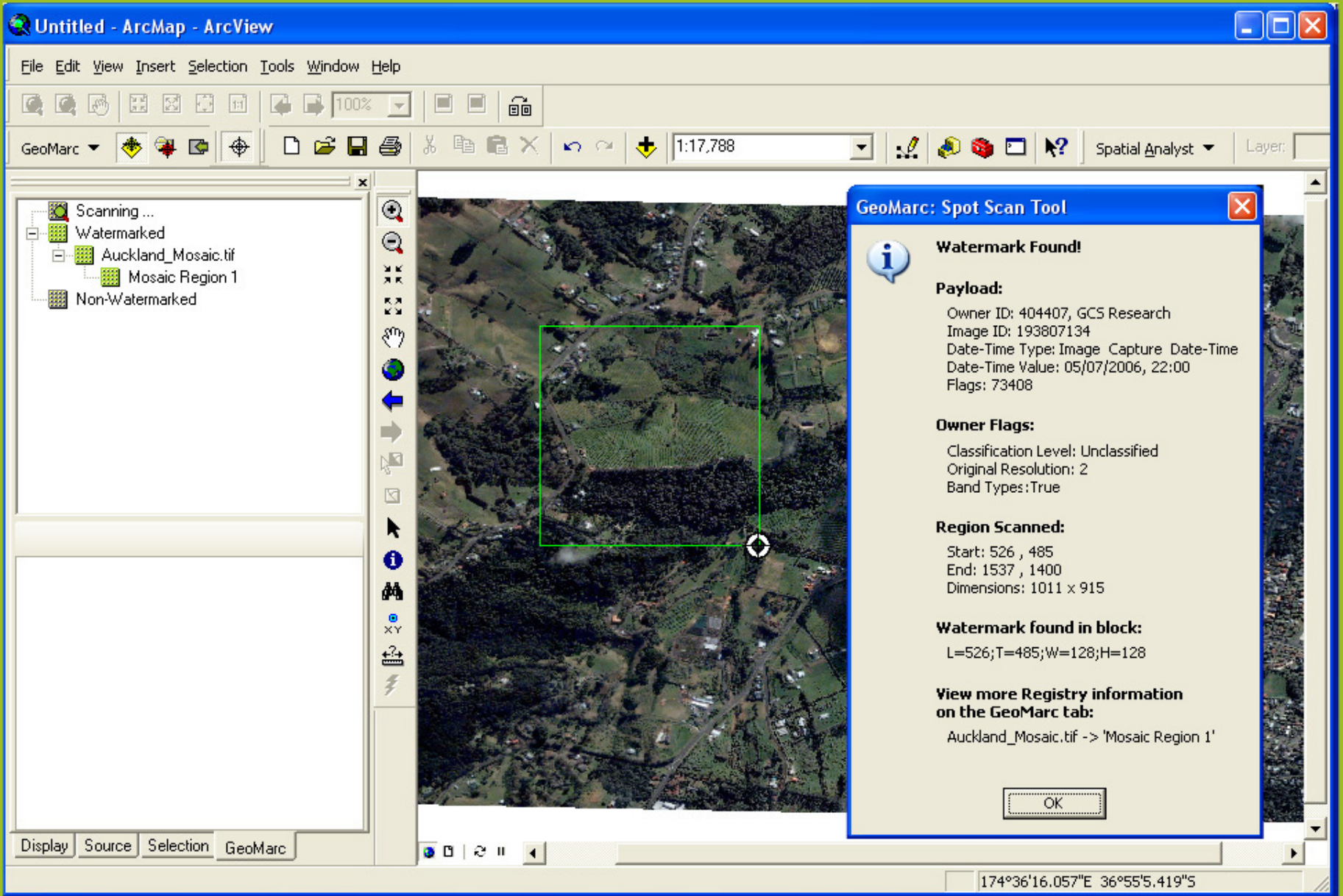
GeoMarc 1:17,788 Spatial Analyst Layer:

- Scanning ...
- Watermarked
  - Auckland\_Mosaic.tif
    - Mosaic Region 1
- Non-Watermarked



Display Source Selection GeoMarc

174°36'16.057"E 36°55'5.419"S



**GeoMarc: Spot Scan Tool**

**Watermark Found!**

**Payload:**  
Owner ID: 404407, GCS Research  
Image ID: 193807134  
Date-Time Type: Image Capture Date-Time  
Date-Time Value: 05/07/2006, 22:00  
Flags: 73408

**Owner Flags:**  
Classification Level: Unclassified  
Original Resolution: 2  
Band Types: True

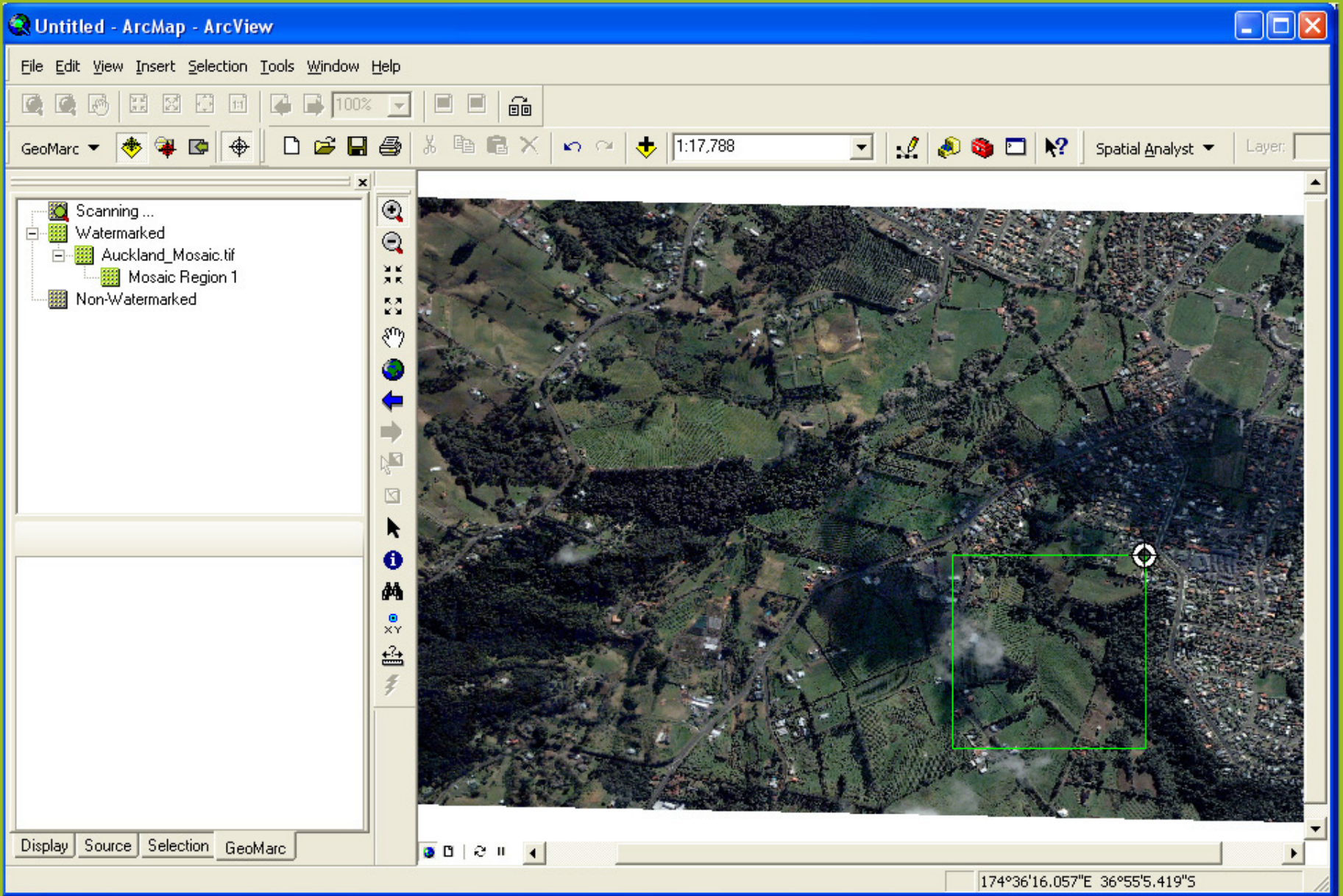
**Region Scanned:**  
Start: 526 , 485  
End: 1537 , 1400  
Dimensions: 1011 x 915

**Watermark found in block:**  
L=526;T=485;W=128;H=128

**View more Registry information on the GeoMarc tab:**  
Auckland\_Mosaic.tif -> 'Mosaic Region 1'

OK

174°36'16.057"E 36°55'5.419"S



File Edit View Insert Selection Tools Window Help

100%

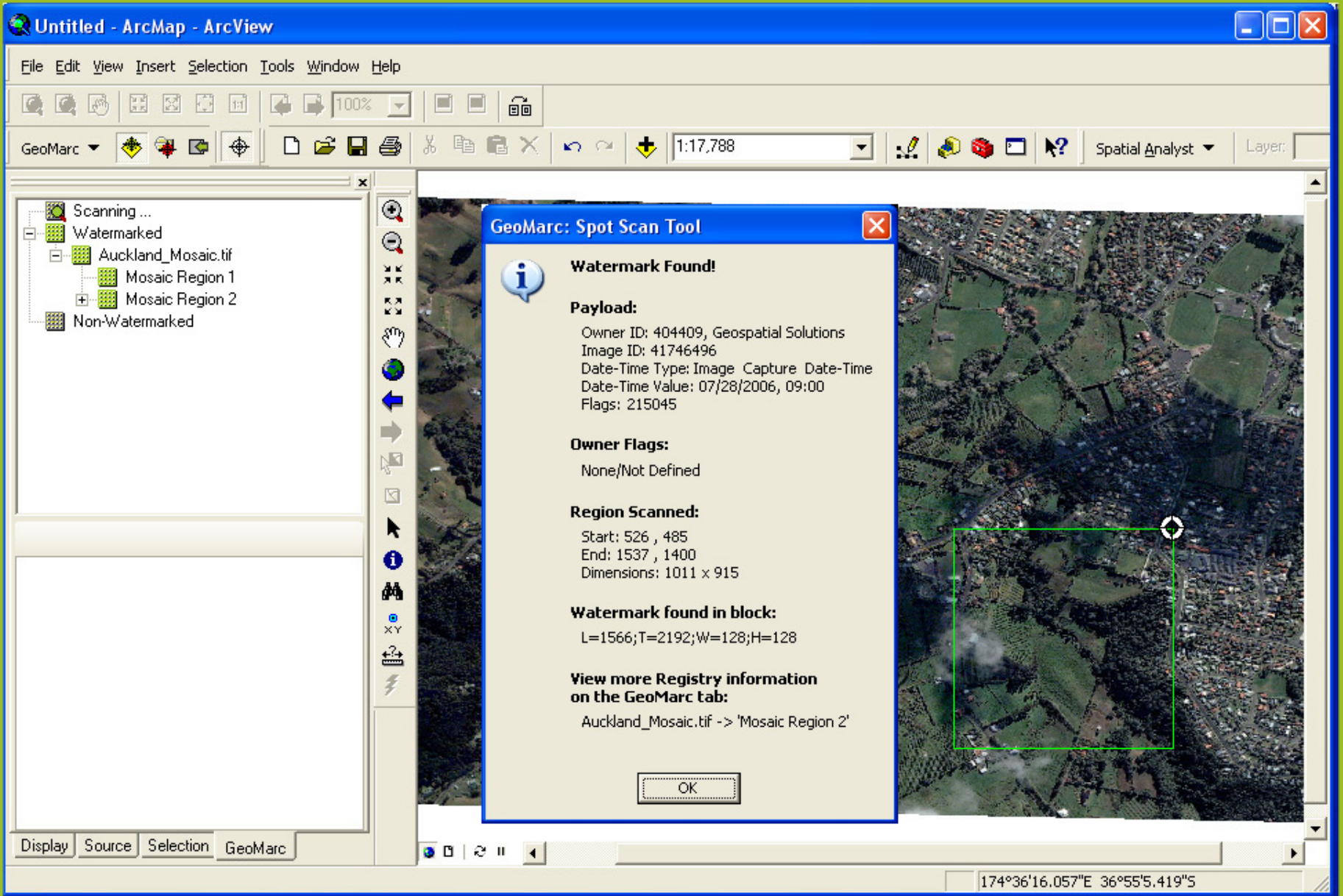
GeoMarc 1:17,788 Spatial Analyst Layer:

- Scanning ...
- Watermarked
  - Auckland\_Mosaic.tif
    - Mosaic Region 1
- Non-Watermarked



Display Source Selection GeoMarc

174°36'16.057"E 36°55'5.419"S



GeoMarc: Spot Scan Tool



**Watermark Found!**

**Payload:**

Owner ID: 404409, Geospatial Solutions  
Image ID: 41746496  
Date-Time Type: Image Capture Date-Time  
Date-Time Value: 07/28/2006, 09:00  
Flags: 215045

**Owner Flags:**

None/Not Defined

**Region Scanned:**

Start: 526 , 485  
End: 1537 , 1400  
Dimensions: 1011 x 915

**Watermark found in block:**

L=1566;T=2192;W=128;H=128

**View more Registry information on the GeoMarc tab:**

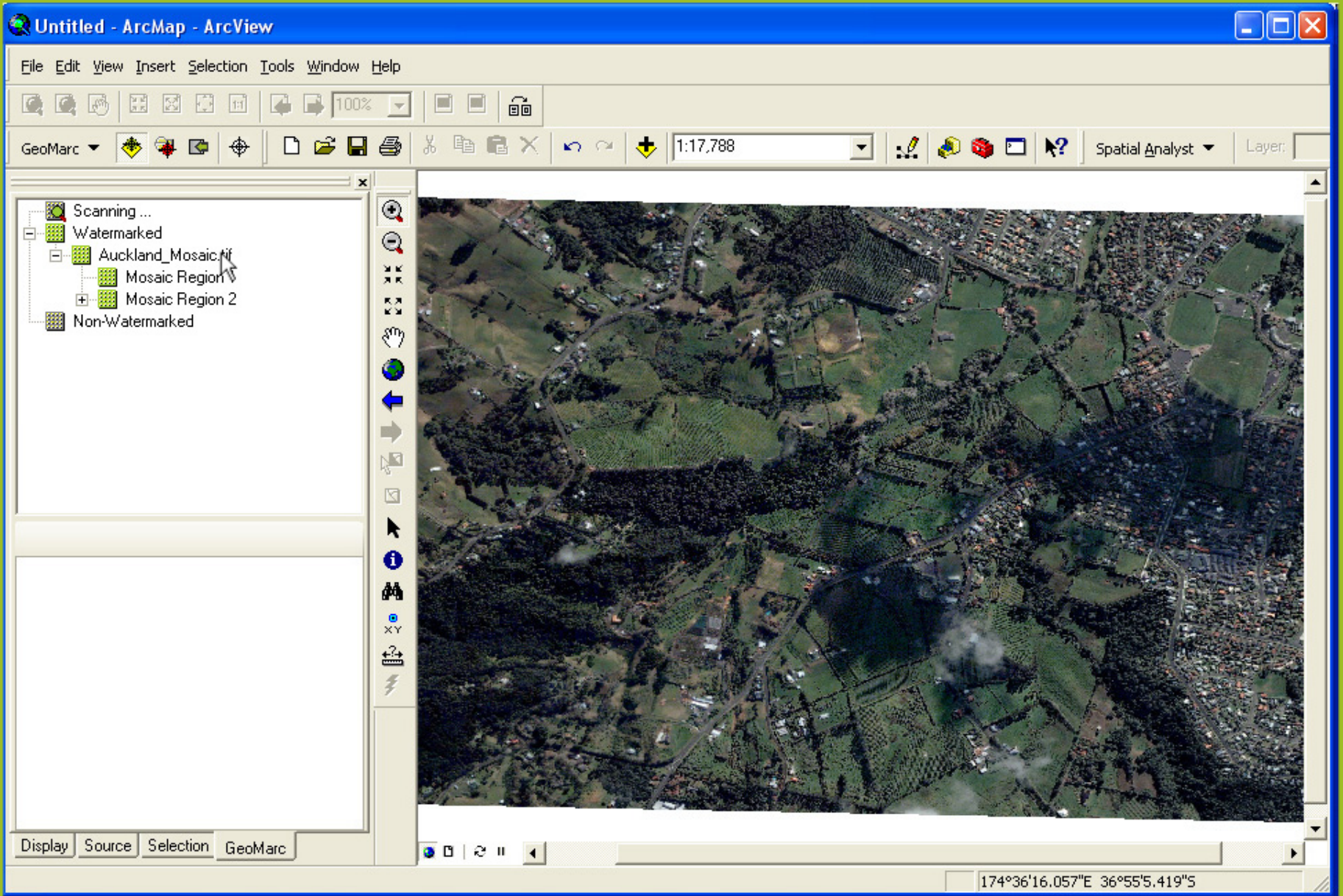
Auckland\_Mosaic.tif -> 'Mosaic Region 2'

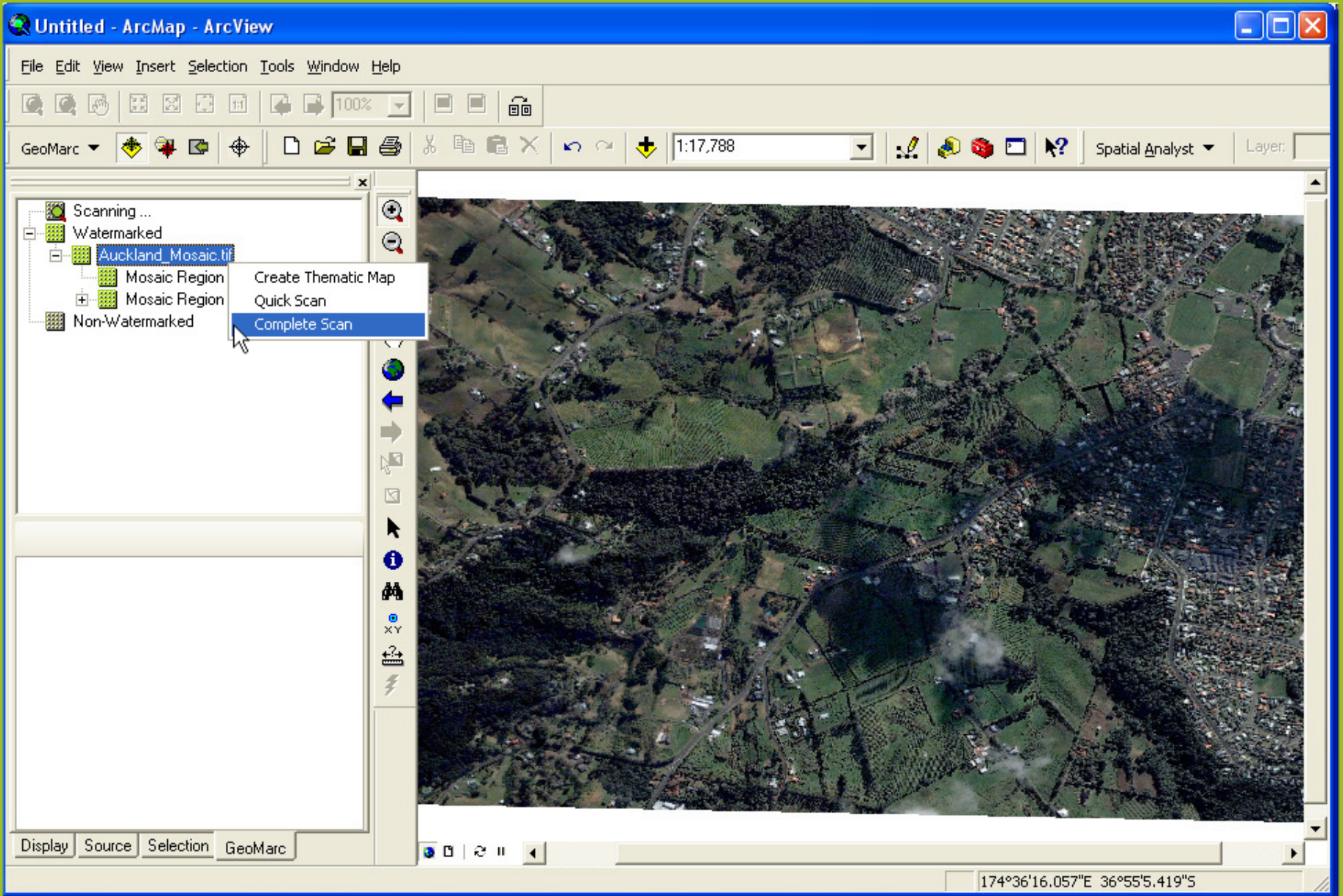
OK

- Scanning ...
- Watermarked
  - Auckland\_Mosaic.tif
    - Mosaic Region 1
    - Mosaic Region 2
  - Non-Watermarked

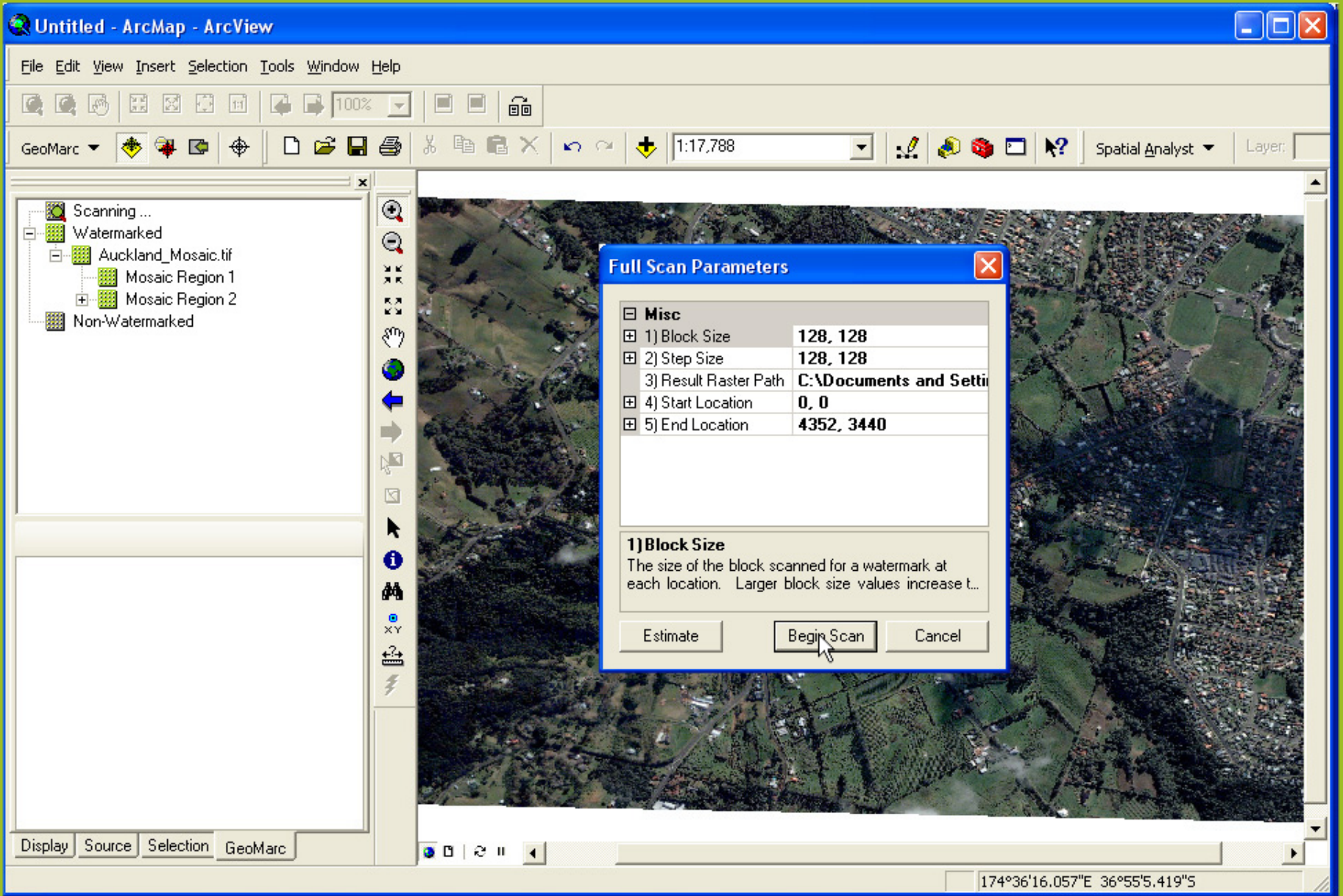
Display Source Selection GeoMarc

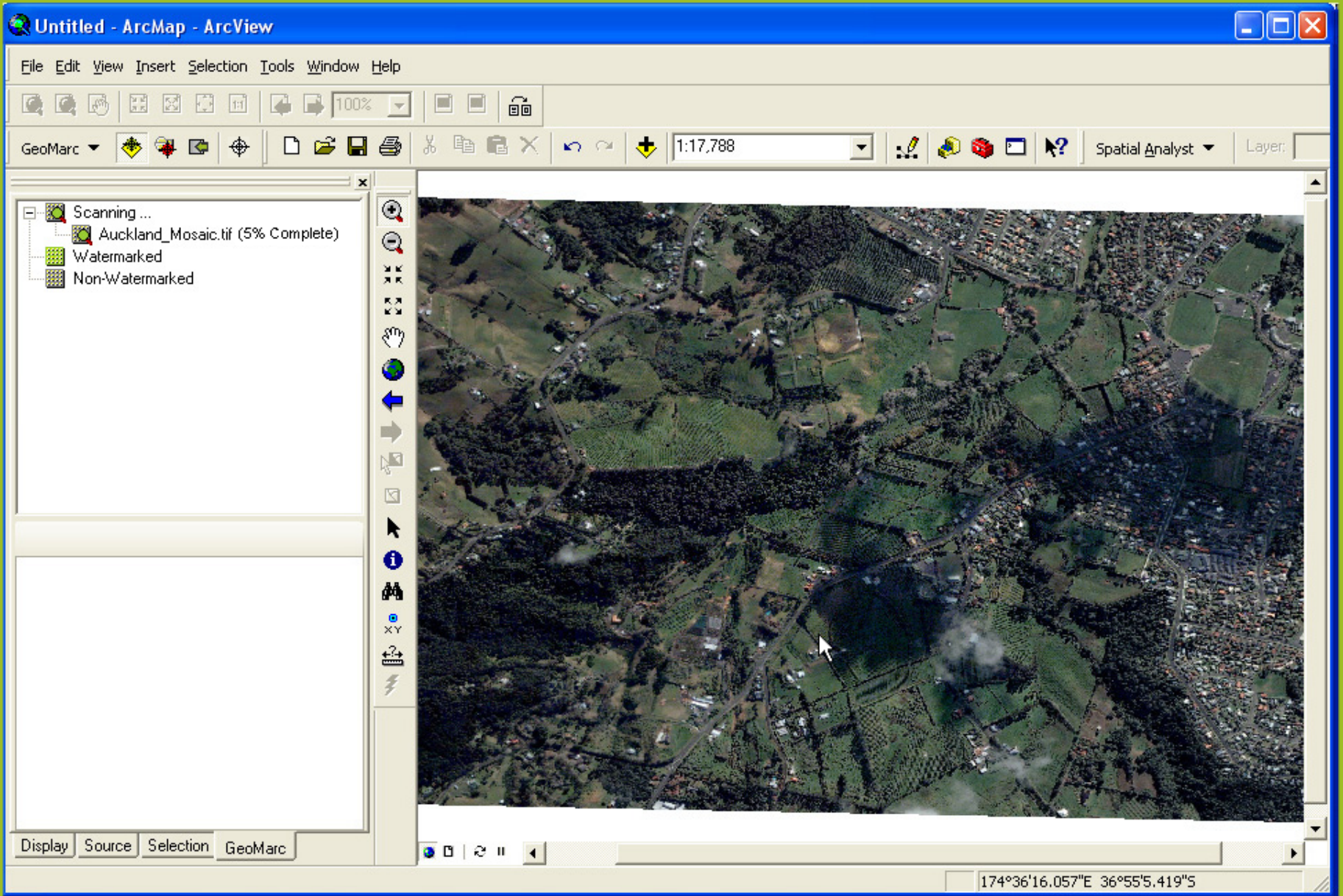
174°36'16.057"E 36°55'5.419"S

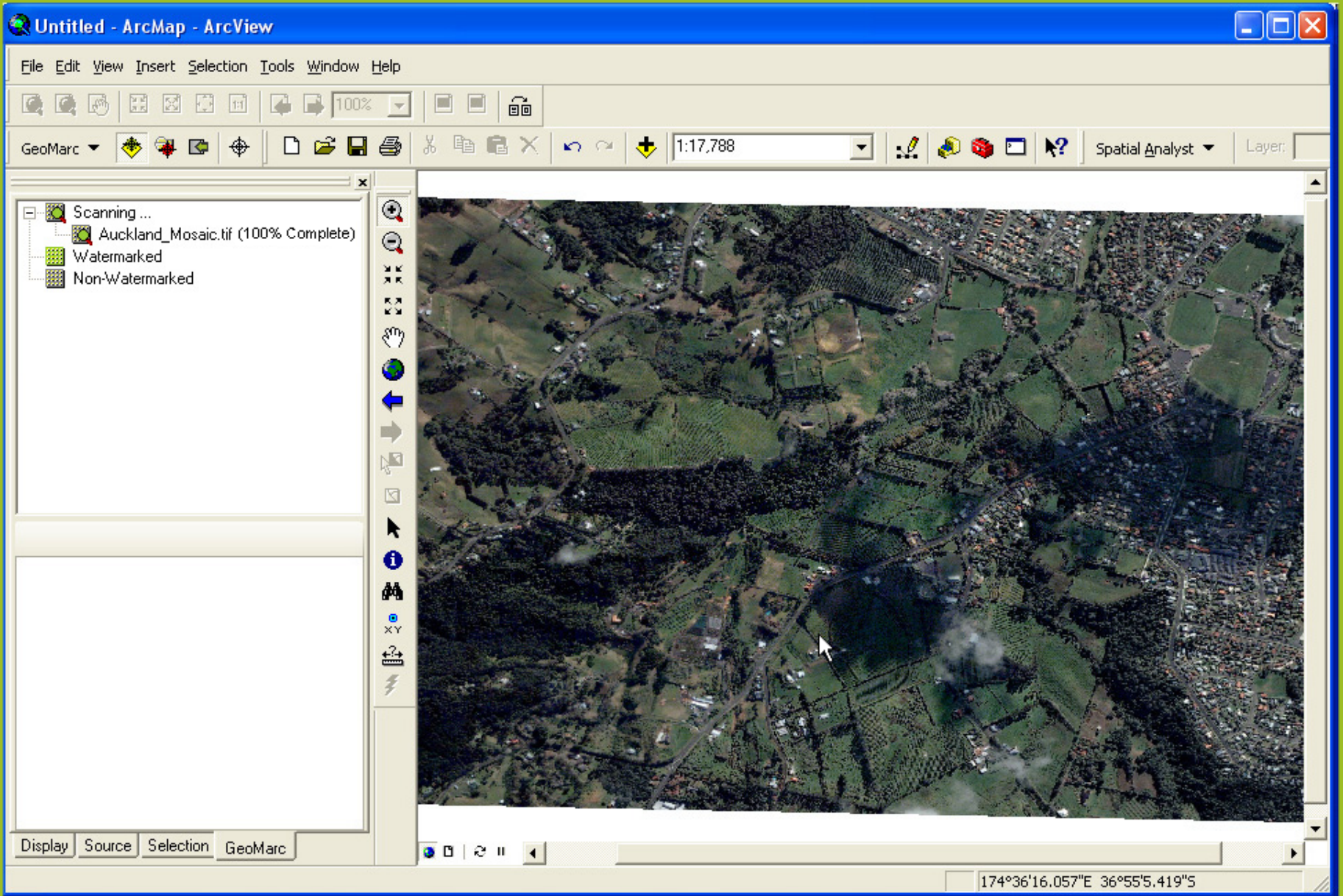


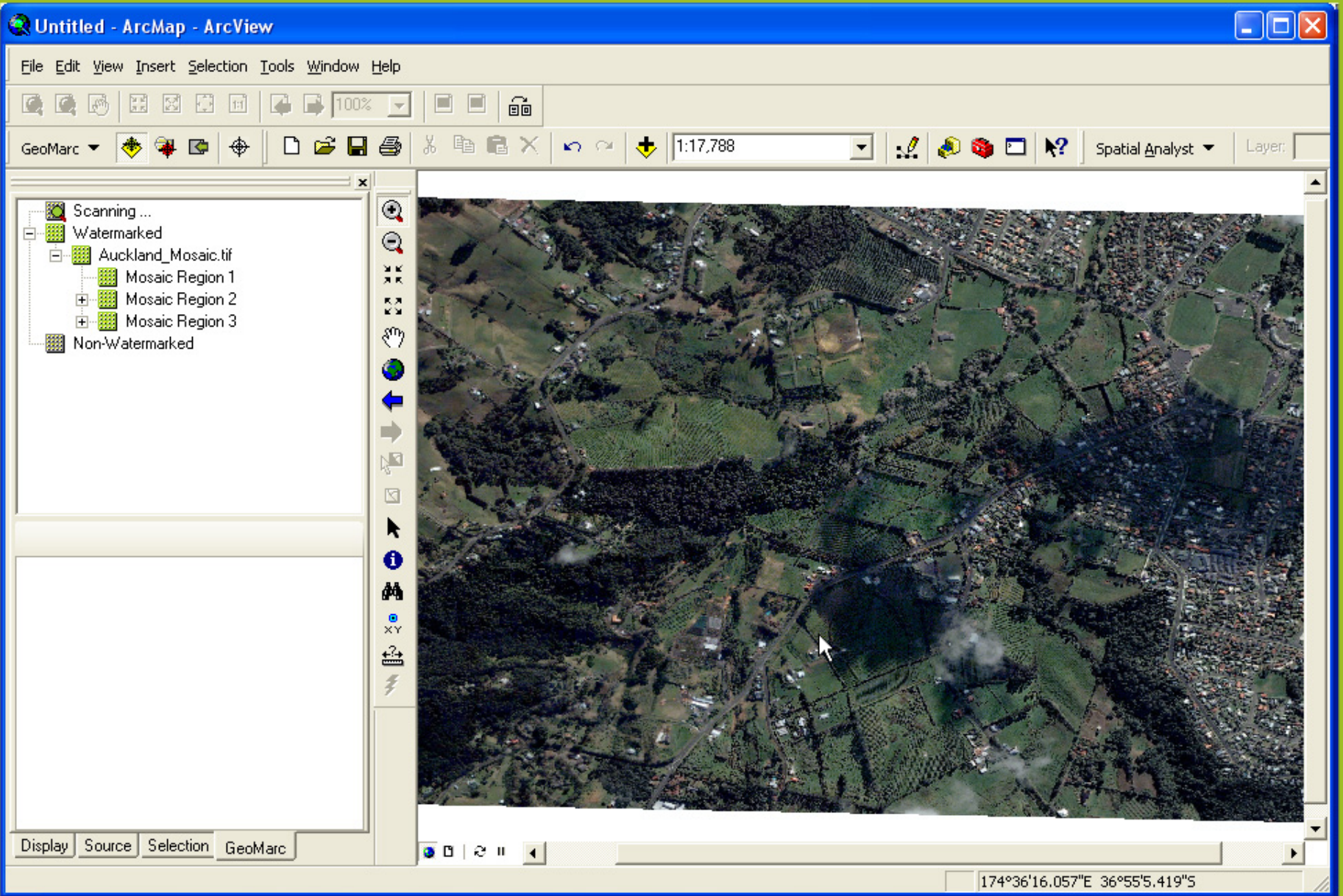










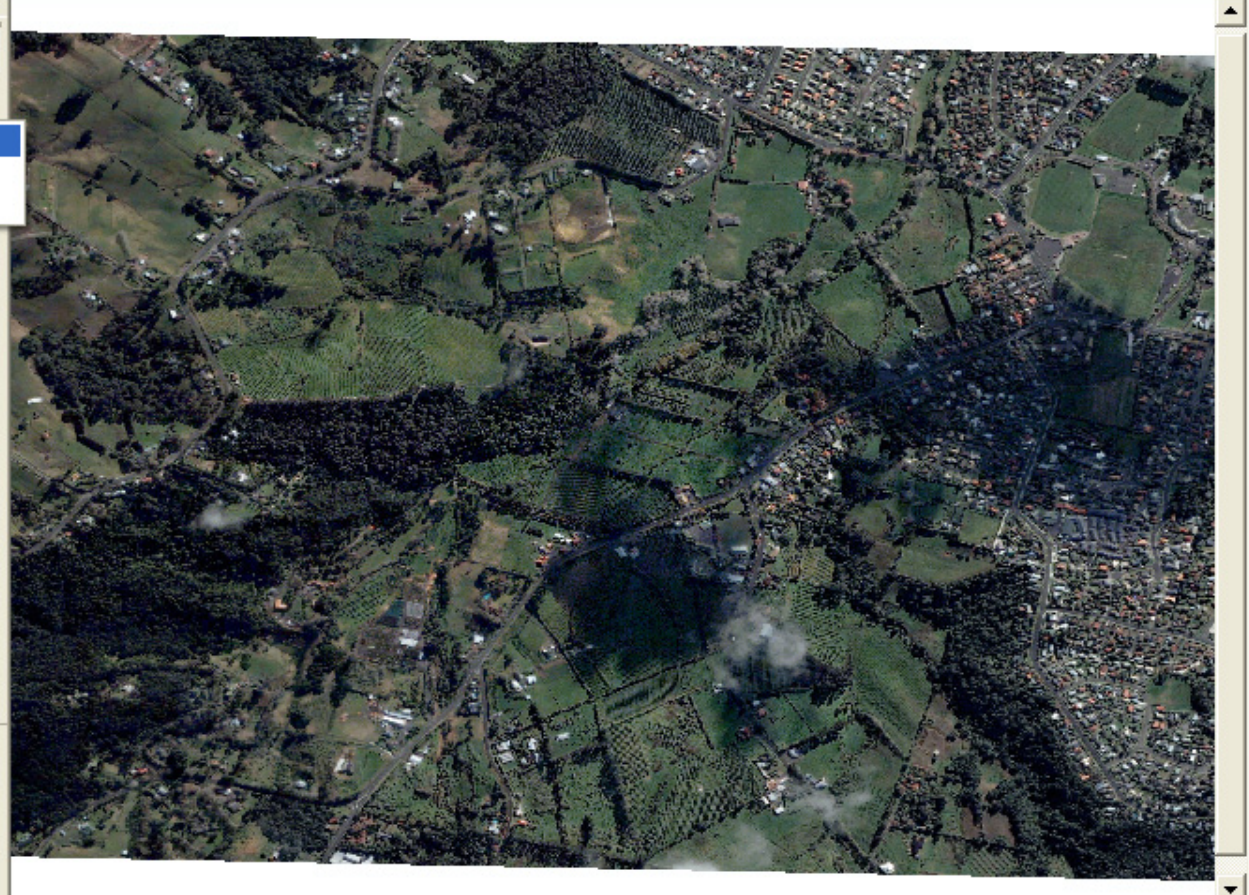


Scanning ...  
Watermarked  
Auckland\_Mosaic.tif  
Mosaic Region  
Mosaic Region  
Mosaic Region  
Non-Watermarked

Create Thematic Map  
Quick Scan  
Complete Scan

Payload Registry

<b>Misc</b>	
RegionId	1
<b>PayLoad Information</b>	
Owner:	GCS-Research
Date-Time Type:	Image_Capture_DateTime
<b>Owner Flags:</b>	
classification	<b>Not classified in regis</b>
license	<b>DOD/Title 50</b>
band types	<b>true</b>
original product	<b>2</b>
Image ID:	193807134
Date-Time Stamp:	5/17/2006 10:00:00 PM



Scanning ...

- Watermarked
  - Auckland\_Mosaic.tif
    - Mosaic Region 1
    - Mosaic Region 2
    - Mosaic Region 3
  - Non-Watermarked

Payload Registry

Misc

RegionId: 1

PayLoad Information

Owner: GCS-Research

Date-Time Type: Image\_Capture\_DateTime

Owner Flags:





- classification: **Not classified in regis**
- license: **DOD/Title 50**
- band types: **true**
- original product: 2
- Image ID: 193807134
- Date-Time Stamp: 5/17/2006 10:00:00 PM

### Thematic Display Options

Layer Name: Payload Map

Mosaic Region  
Owner/Source  
Unique Date-Time

Options

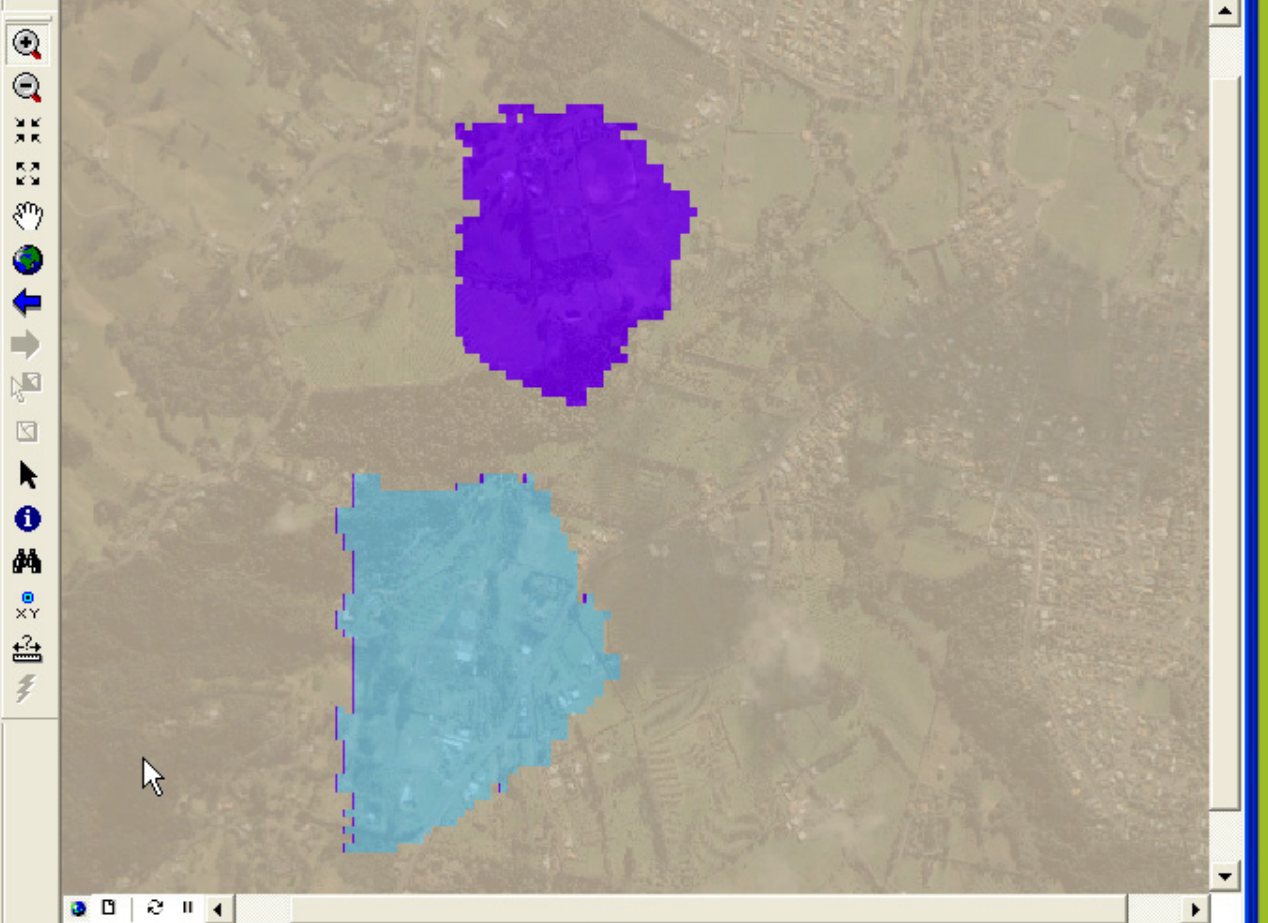
Color	Value	Label
	-1	Watermark Not Found
	1	Mosaic Region 1
	2	Mosaic Region 2
	3	Mosaic Region 3

Create Map Cancel

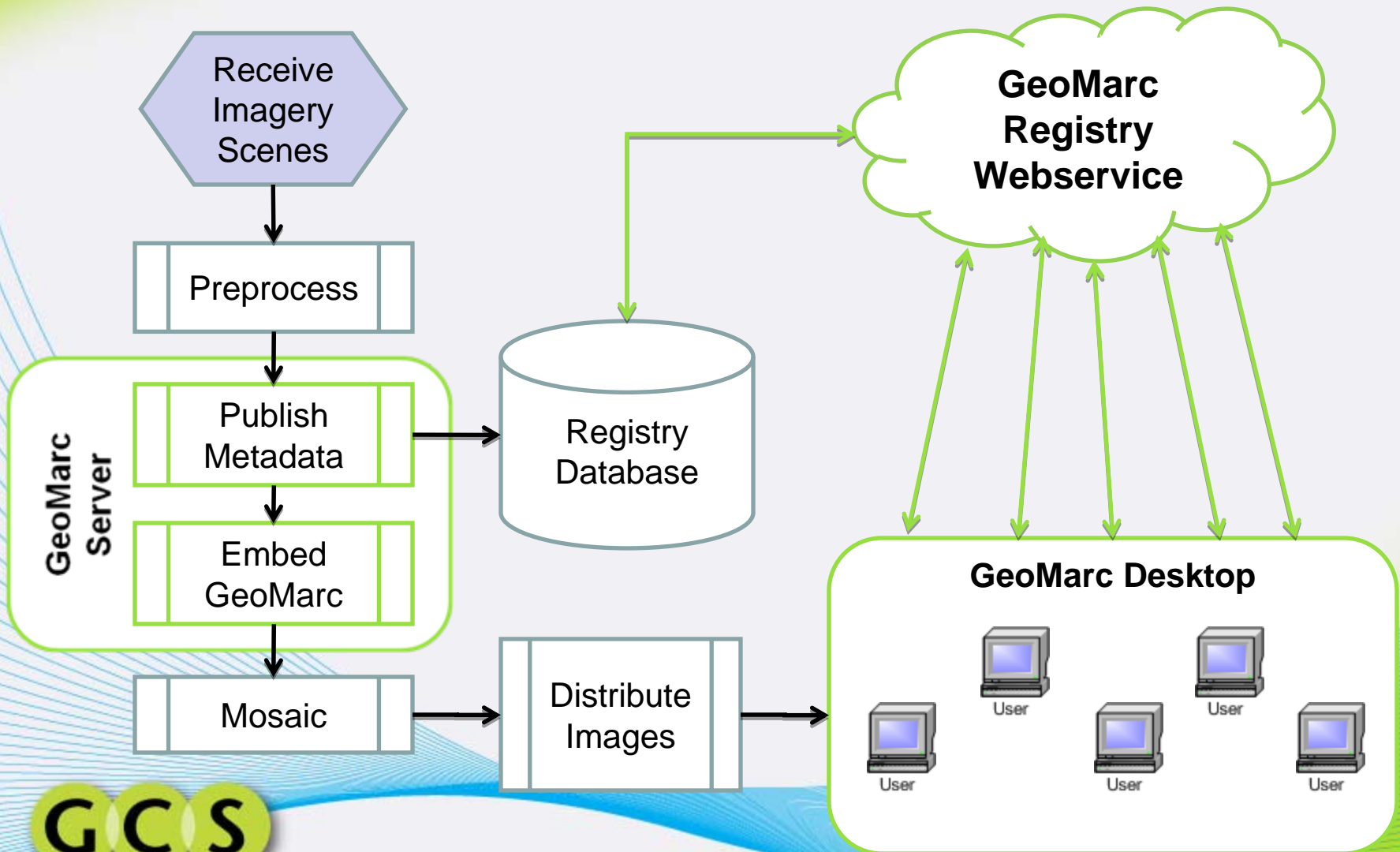


**Layers**

- Payload Map
  - Mosaic Region 1
  - Mosaic Region 2
  - Mosaic Region 3
- Auckland\_Mosaic.tif
  - RGB
    - Red: Band\_1
    - Green: Band\_2
    - Blue: Band\_3

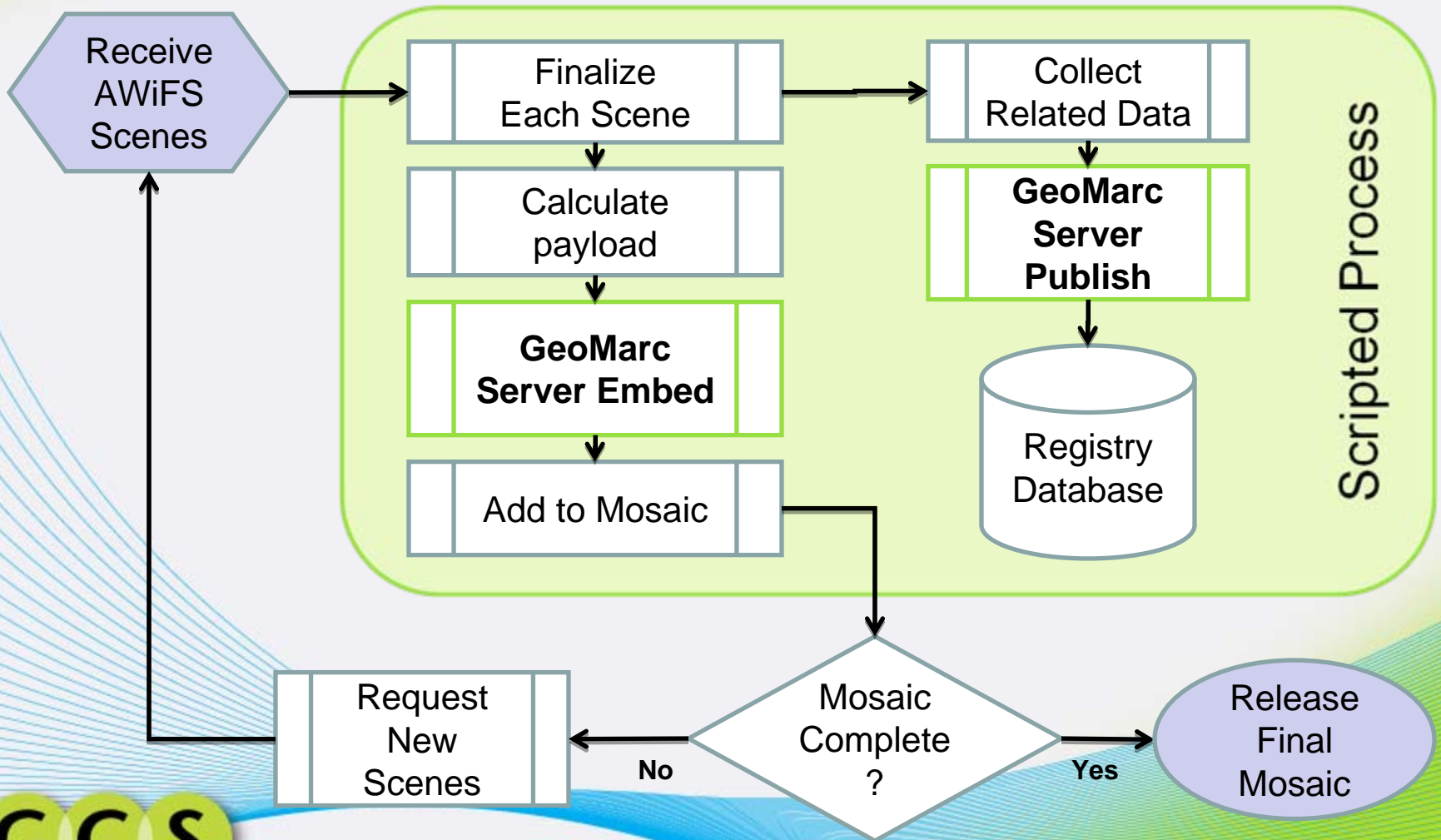


# Workflow – Overview

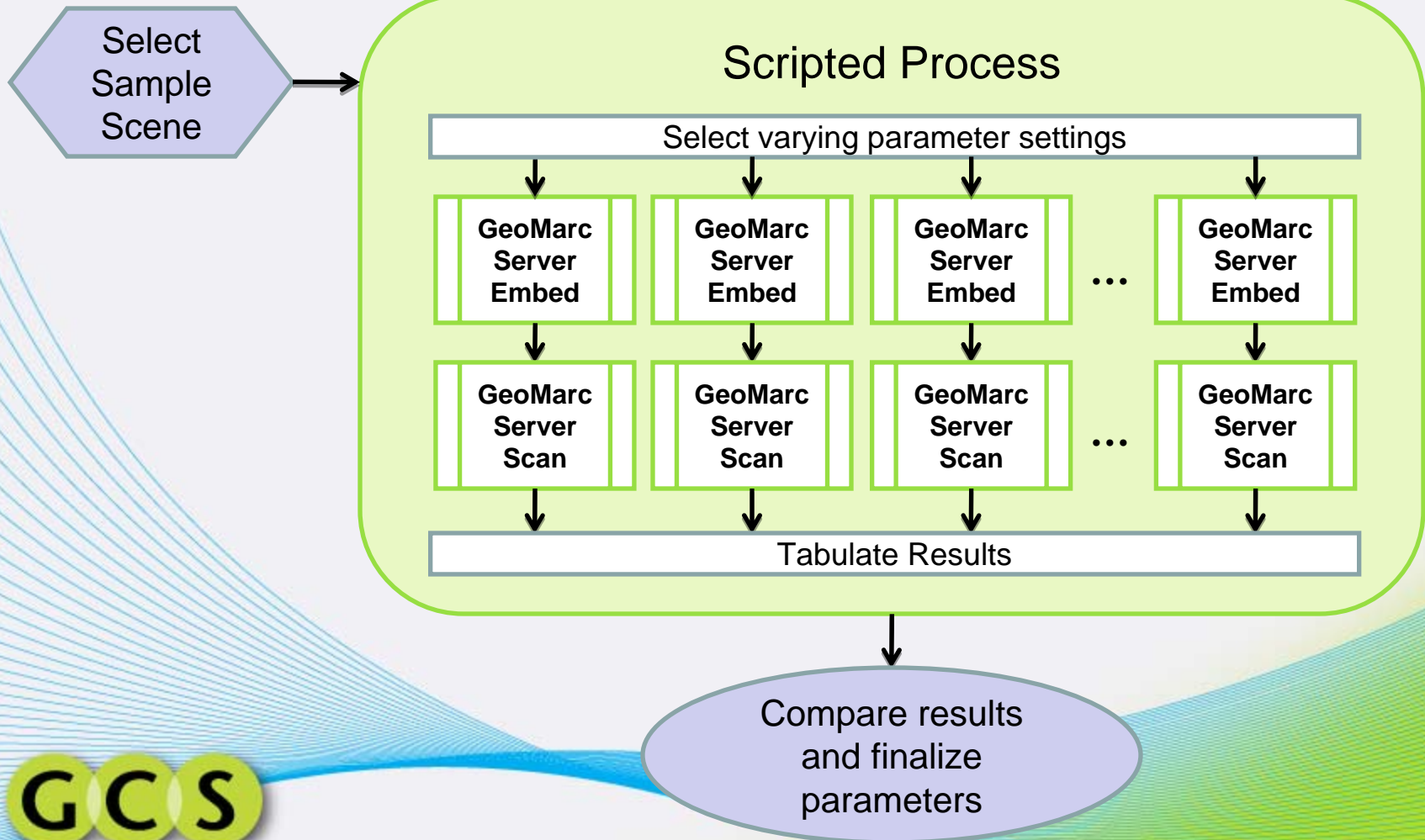




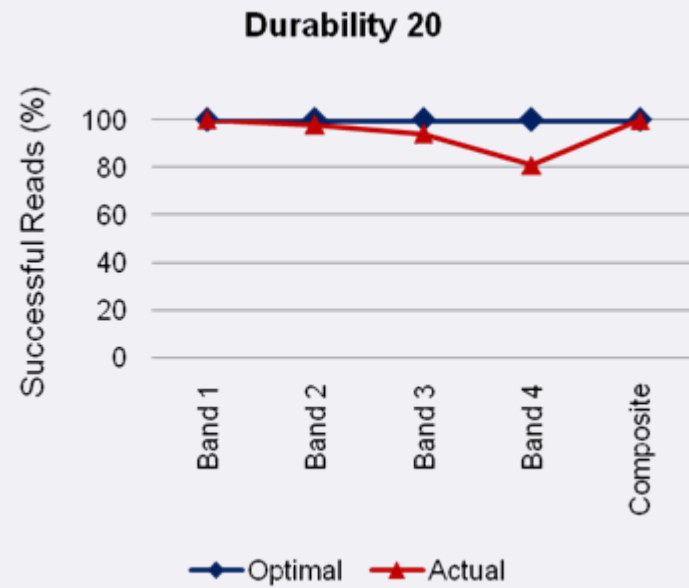
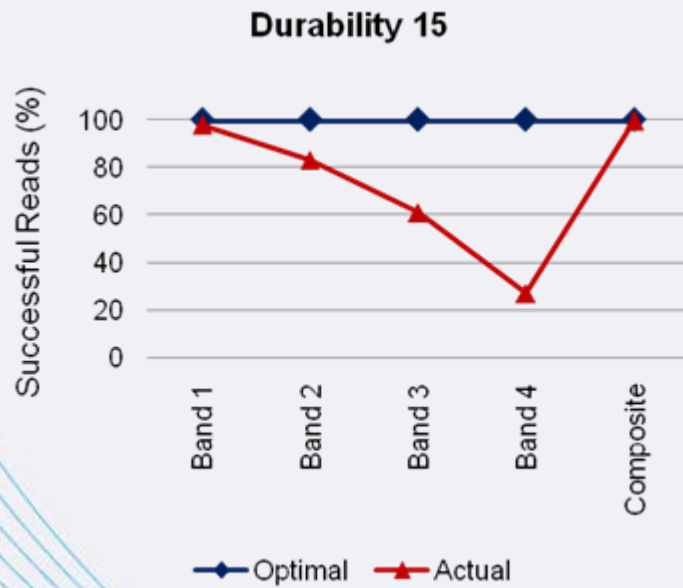
# Workflow – GeoMarc Server



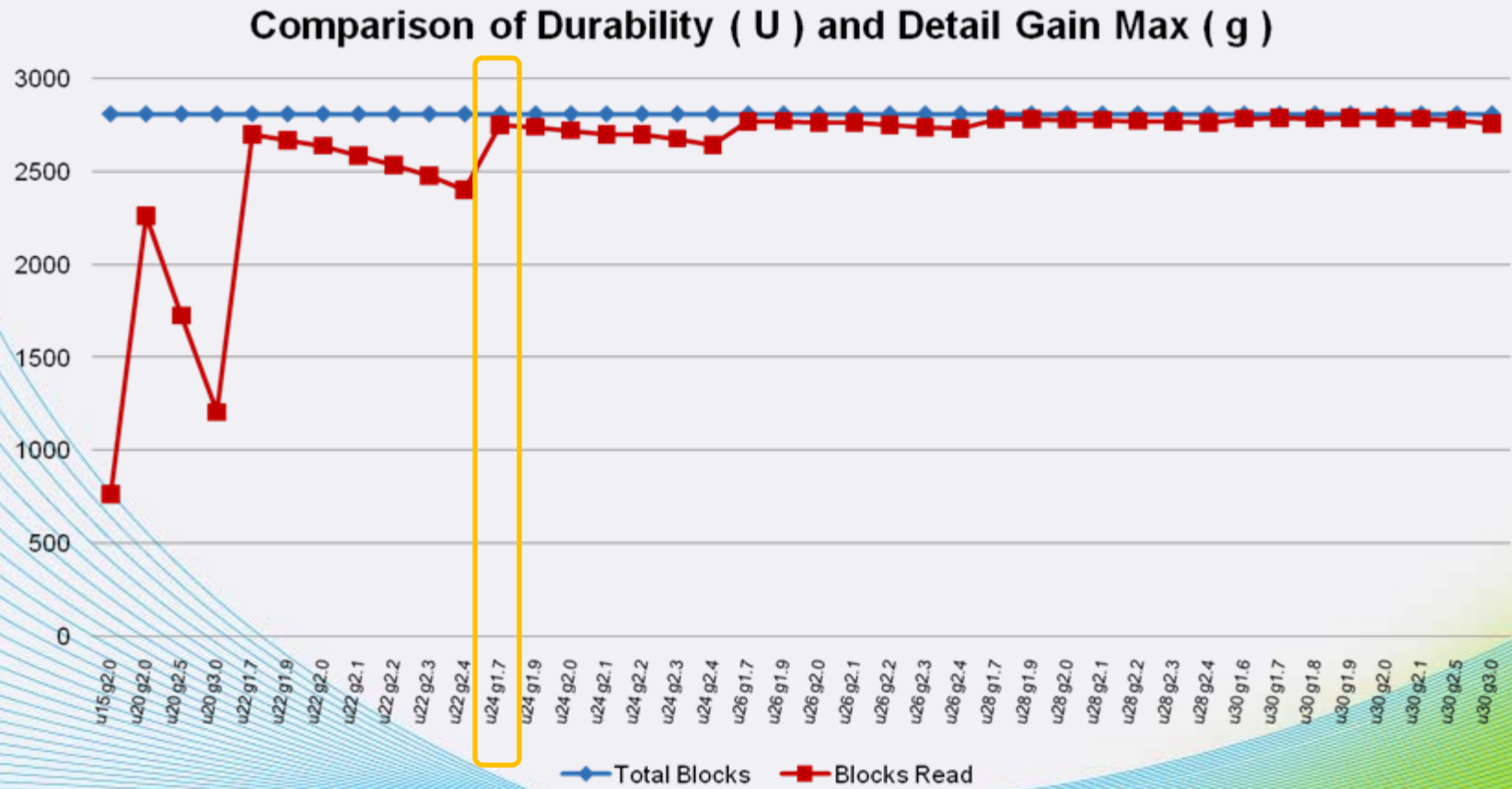
# Workflow – Embed Tuning



# Embed Tuning Sample Results



# Embed Tuning Sample Results

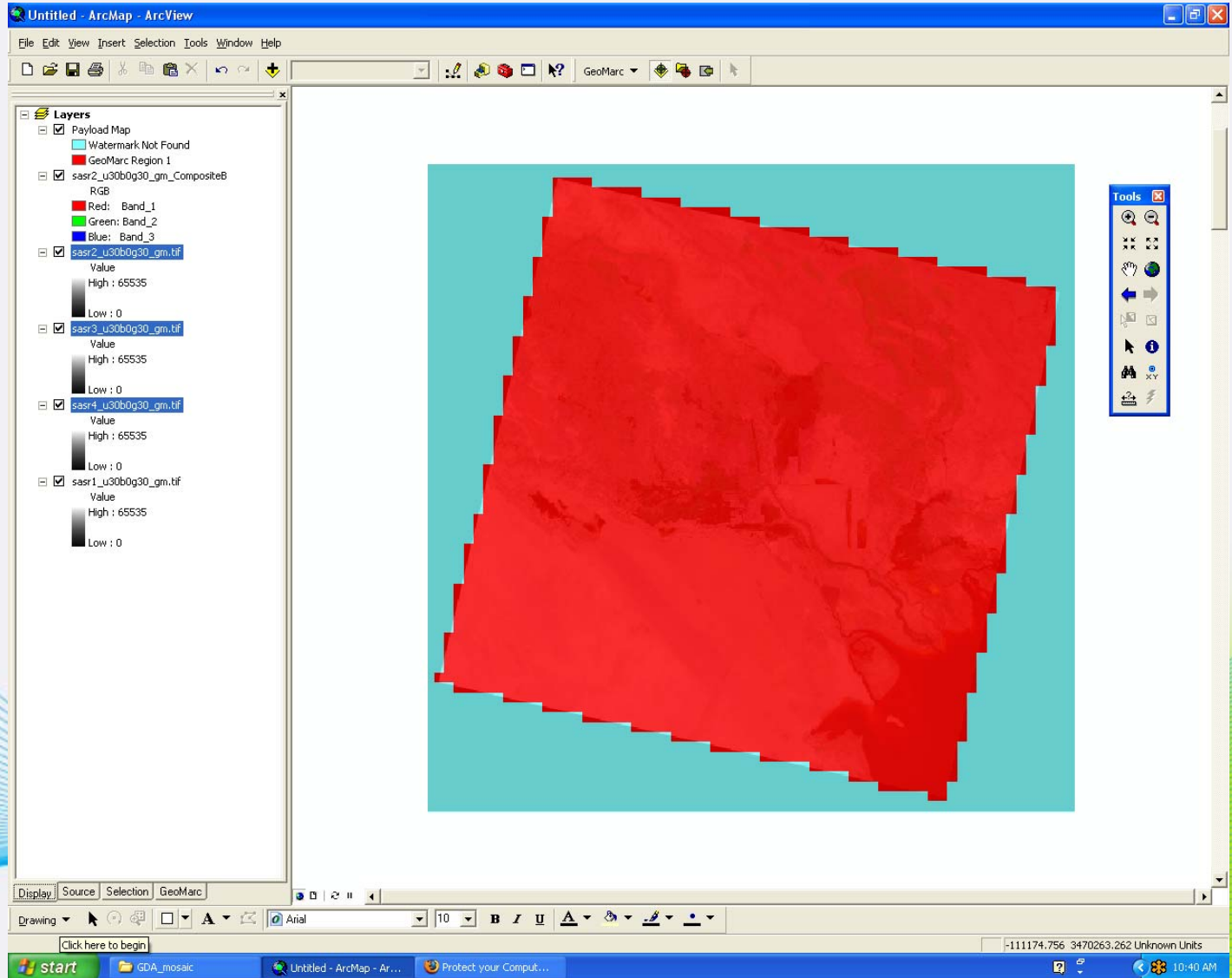


# AWiFS Test Sample

The screenshot displays the ArcMap interface with a satellite image of a region. The metadata table is as follows:

Payload Registry	
<b>PayLoad Information</b>	
Owner	510010
Date-Time Type:	Image_Capture_DateTime
Owner Flags:	
Image ID:	9
Date-Time Stamp:	4/3/2008 12:00:00 AM
<b>Raw Payload:</b>	
Owner Id	510010
Owner Flags	117407
Image Id	9
Date-Time Value	948936
Date-Time Type	0

# Thematic GeoMarc Overlay

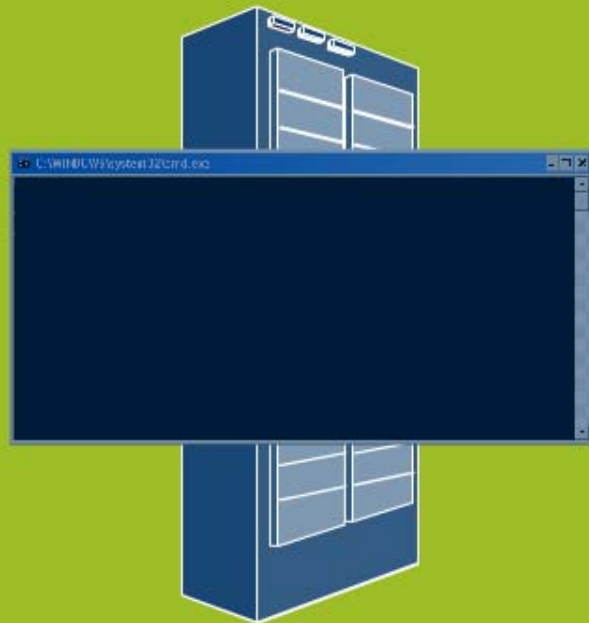














```
C:\WINDOWS\system32\cmd.exe

Completed Watermark

11/26/2007 6:33:25 PM

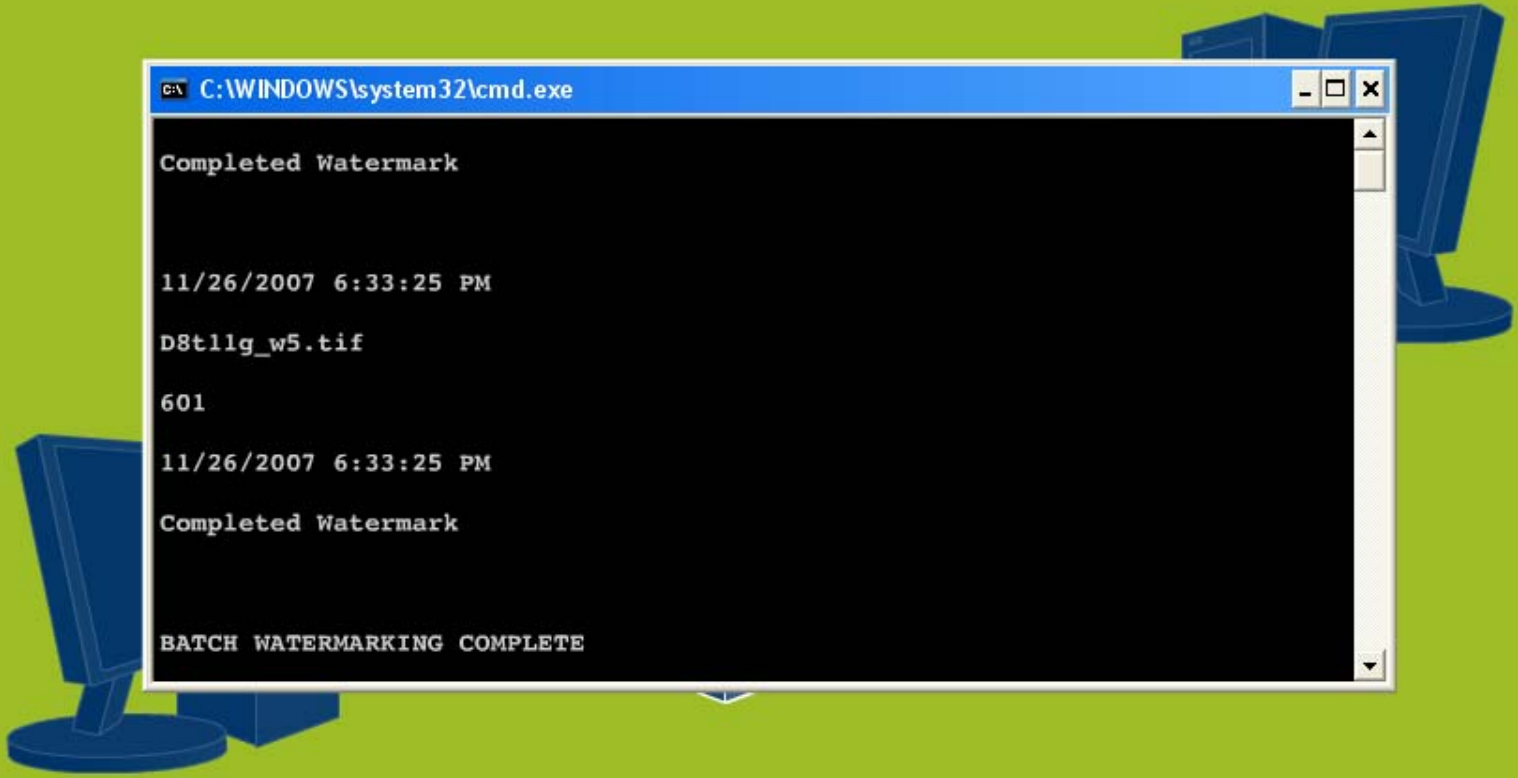
D8t11g_w5.tif

601

11/26/2007 6:33:25 PM

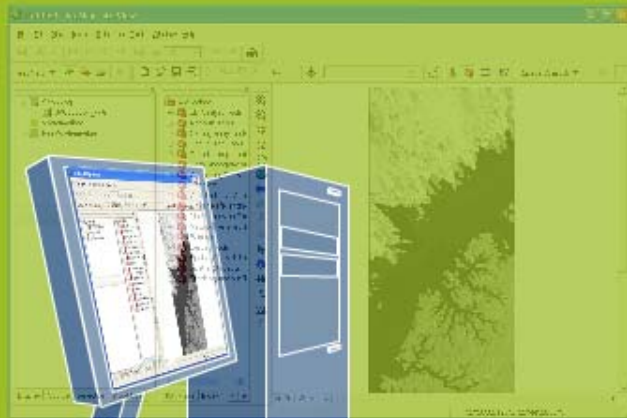
Completed Watermark

BATCH WATERMARKING COMPLETE
```











Scanning ...

- Watermarked
  - 3V050505P\_w.tif
    - Mosaic Region 1
- Non-Watermarked

Add Link

Registry

**Misc**

RegionId	1
----------	---

**PayLoad Information**

Owner	GCS-Research
Date-Time Type	Embed_DateTime

**Owner Flags:**

classification	unclass
license	N/A
band types	pan
original prod	TBD
Image ID:	100333173
Date-Time Star	1/16/2008 4:00:00 F

**Raw Payload:**

Owner Id	404407
Owner Flags	0
Image Id	100333173

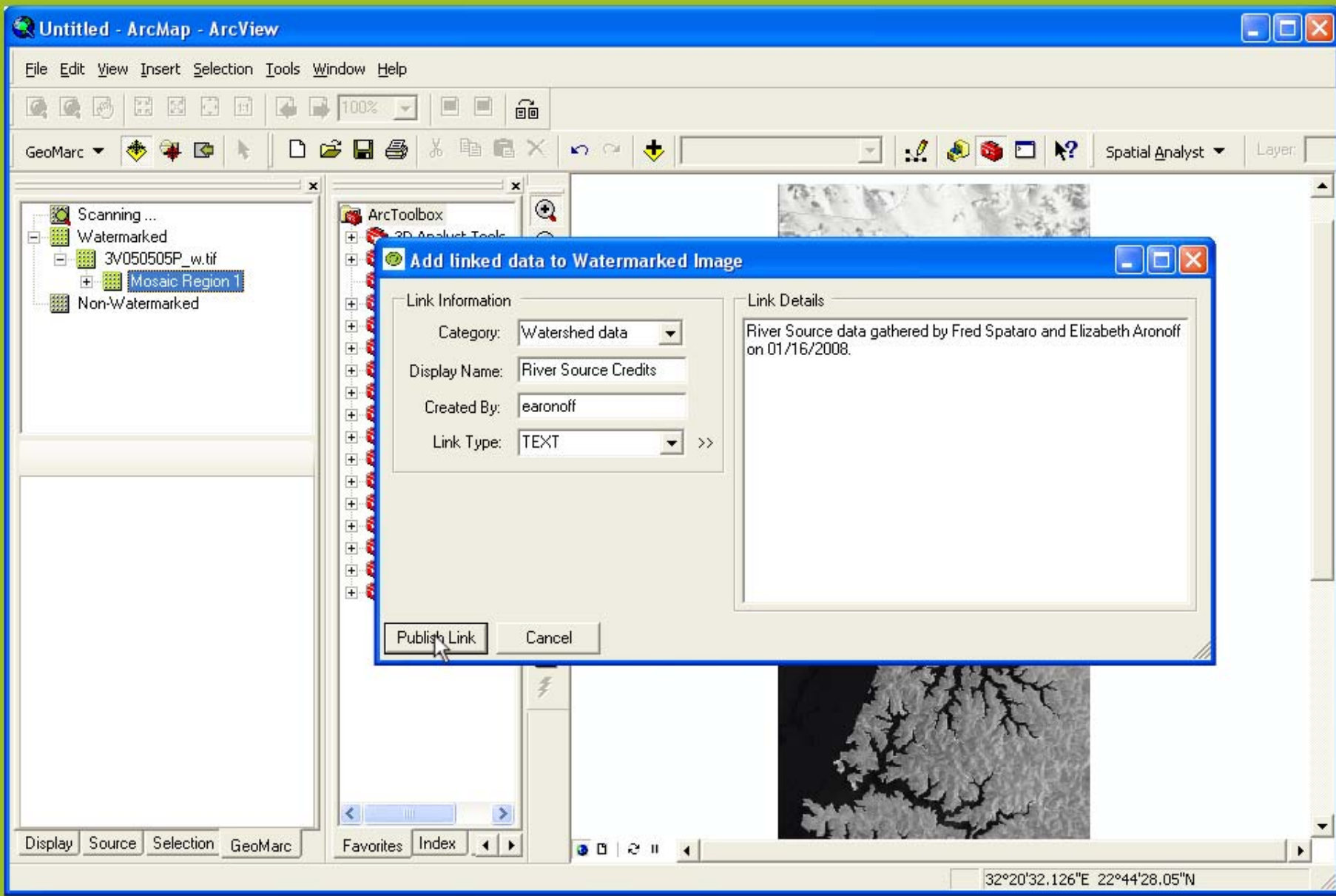
ArcToolbox

- 3D Analyst Tools
- Analysis Tools
- Cartography Tools
- Conversion Tools
- Data Interoperabi
- Data Management
- Geocoding Tools
- GeoMarc
- Geostatistical Ana
- Linear Referencin
- Multidimension To
- Network Analyst T
- Samples
- Server Tools
- Spatial Analyst To
- Spatial Statistics T
- Tracking Analyst T



Display Source Selection GeoMarc

Favorites Index



**Add linked data to Watermarked Image**

Link Information

Category: Watershed data

Display Name: River Source Credits

Created By: earonoff

Link Type: TEXT >>

Link Details

River Source data gathered by Fred Spataro and Elizabeth Aronoff on 01/16/2008.

Publish Link Cancel

32°20'32.126"E 22°44'28.05"N





Scanning ...

- Watermarked
  - 3V050505P\_w.tif
    - Mosaic Region 1
      - Watershed data
        - River Source Credits**
- Non-Watermarked

**Link Information**

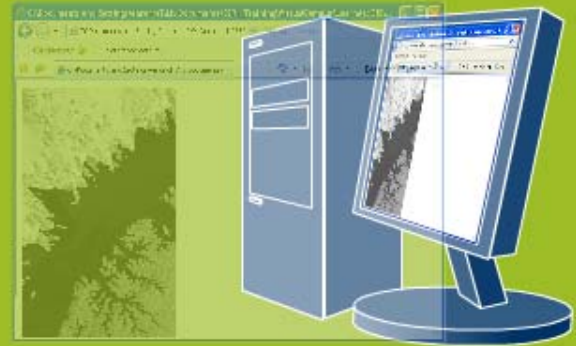
Modifier	earonoff
Image_ID	100333173
Image_OwnerID	404407
Created	1/16/2008 4:47 PM
Category	<b>Watershed data</b>
Modified	1/16/2008 4:47 PM
LinkName	<b>River Source Credits</b>
Data Type	TEXT
Creator	earonoff

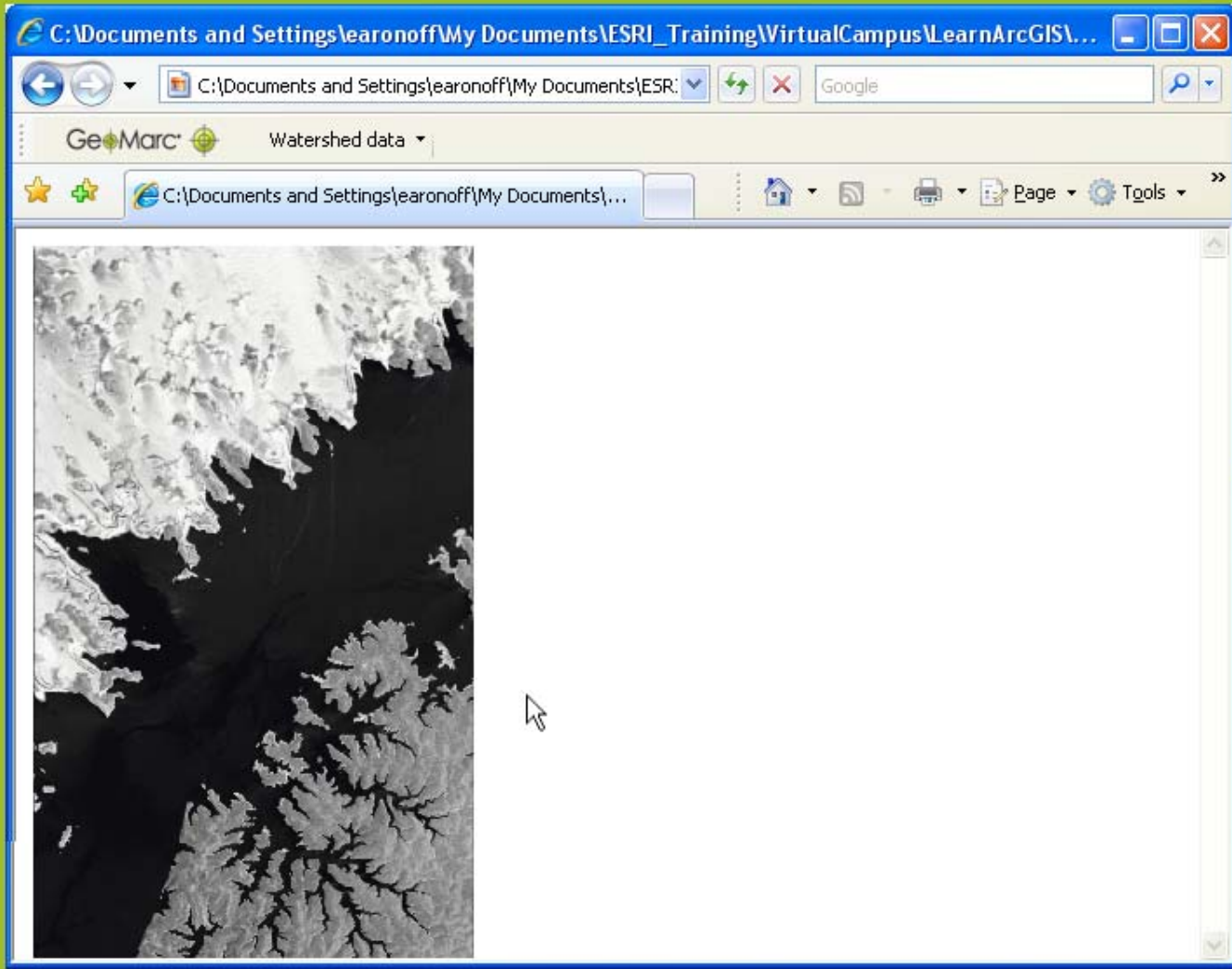
ArcToolbox

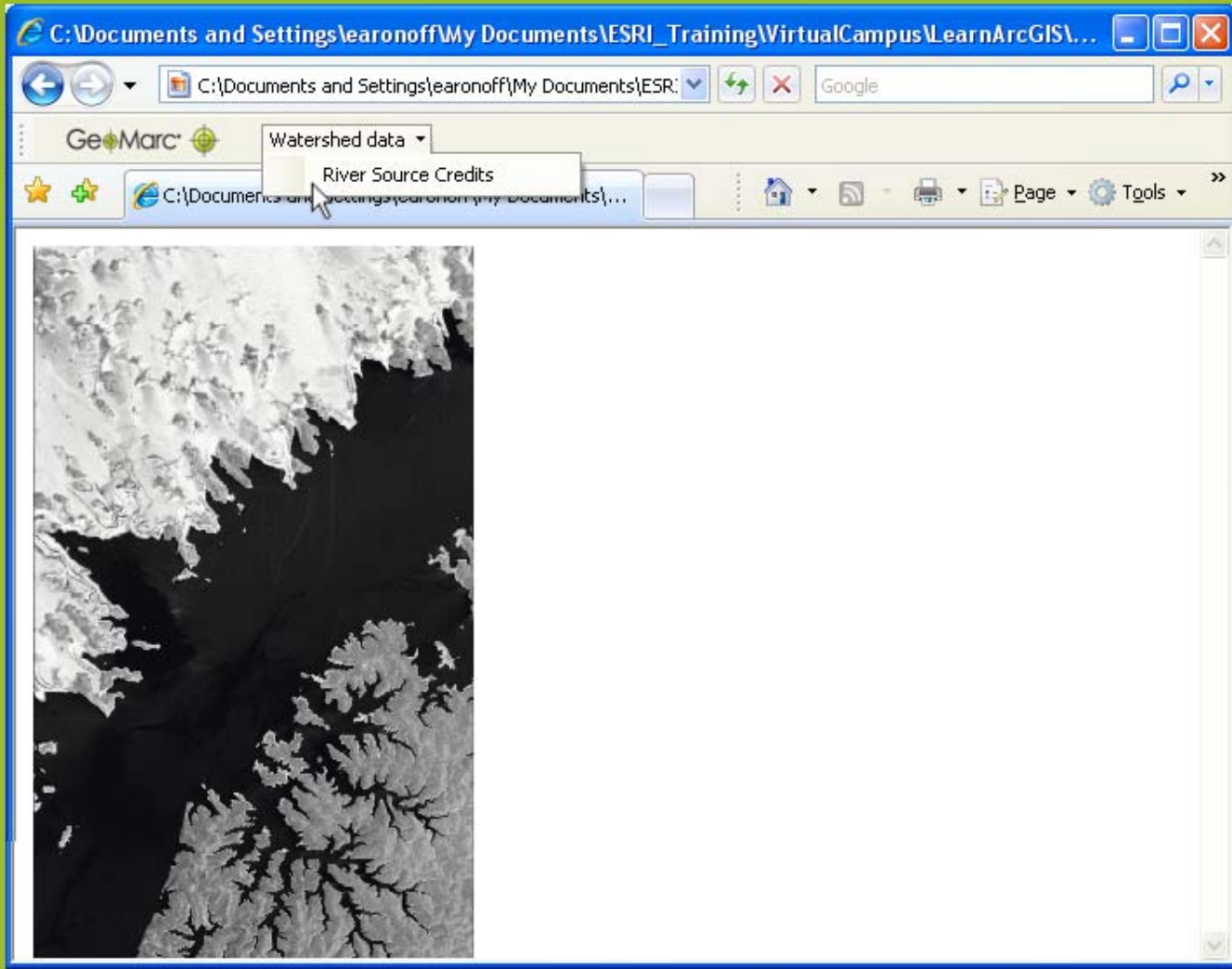
- 3D Analyst Tools
- Analysis Tools
- Cartography Tools
- Conversion Tools
- Data Interoperabi
- Data Management
- Geocoding Tools
- GeoMarc
- Geostatistical Ana
- Linear Referencin
- Multidimension To
- Network Analyst T
- Samples
- Server Tools
- Spatial Analyst To
- Spatial Statistics T
- Tracking Analyst T

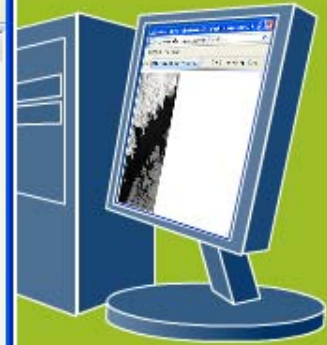
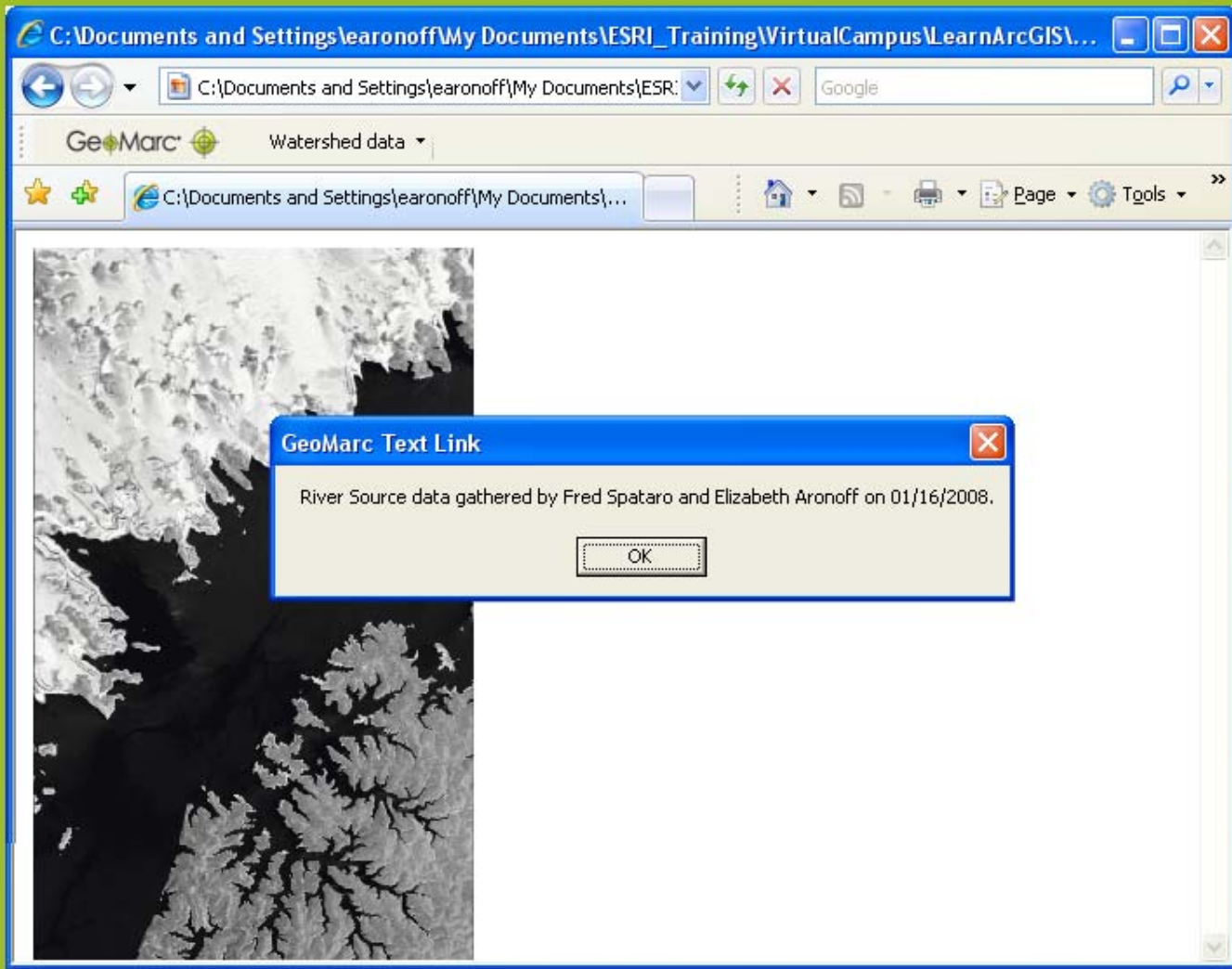
Display Source Selection GeoMarc Favorites Index













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