Advanced Applications of N-SPECT

Introduction

Exercise 1 *Regional Scale Assessment of Baseline Conditions*

Exercise 2 *Catchment Scale Analysis of Source Areas*

Exercise 3 *Subcatchment Scale Scenario Implementation*

Summary

Estimated Length: Three hours

Introduction

The three exercises included in the following slides are examples of how the Nonpoint-Source Pollution and Erosion Comparison Tool (N-SPECT) can be applied, and how the results from N-SPECT analyses can be used to learn more about the relationships between land cover and water quality. There are many ways an N-SPECT user can use the tool and interpret the results. The method used is entirely dependent upon the question being asked. In order to facilitate flow between the three exercises and to present a methodology that is widely applicable to current landscape issues, this document leads the user through a hierarchical sequence of analyses.

The approach adopted for the following exercises is a contextual, or top-down, interpretation of modeled results. In the first exercise, the user assesses regional characteristics and targets a specific catchment for further examination. In the second exercise, the user analyzes a single catchment and defines unique areas most likely to degrade downstream water quality. The third exercise leads the user through a scenario analysis in which an alternative land cover is assigned to an area of interest. In all cases, N-SPECT results are used in conjunction with other common spatial analysis techniques to increase the value of the modeled information.

Exercise 1 – Regional Scale Assessment of Baseline Conditions

Background

Water quality in fluvial, estuarine, and marine environments is influenced directly by the regional collection of watersheds that contribute runoff to these areas. Given the large extent of such regions, a broad landscape perspective is often necessary when assessing nonpoint source pollution in these water bodies. The main goal is to detect the watershed(s) responsible for contributing the greatest amounts of nonpoint source pollutants and sediments to the nearshore environment. This exercise includes regional data from the Wai’anae area on the west side of O’ahu, Hawai’i.

Objectives

- Gain familiarity with the N-SPECT user interface.
- Learn to visually assess the data output, and enhance map visualizations with simple display adjustments.
- Use standard geographic information system (GIS) techniques to develop additional information.
- Distinguish catchments with potentially degraded water quality.

Steps

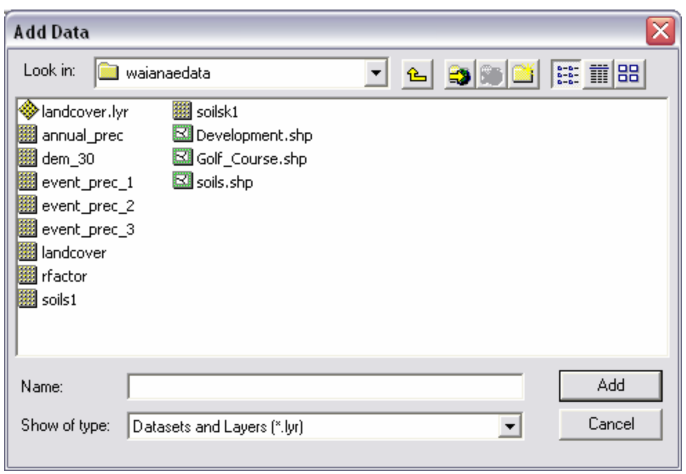
1. Initialize the ArcMap and N-SPECT analysis environments.
2. Run N-SPECT.
3. View the results.
4. Calculate catchment characteristics.
5. Select a target catchment for further analysis.

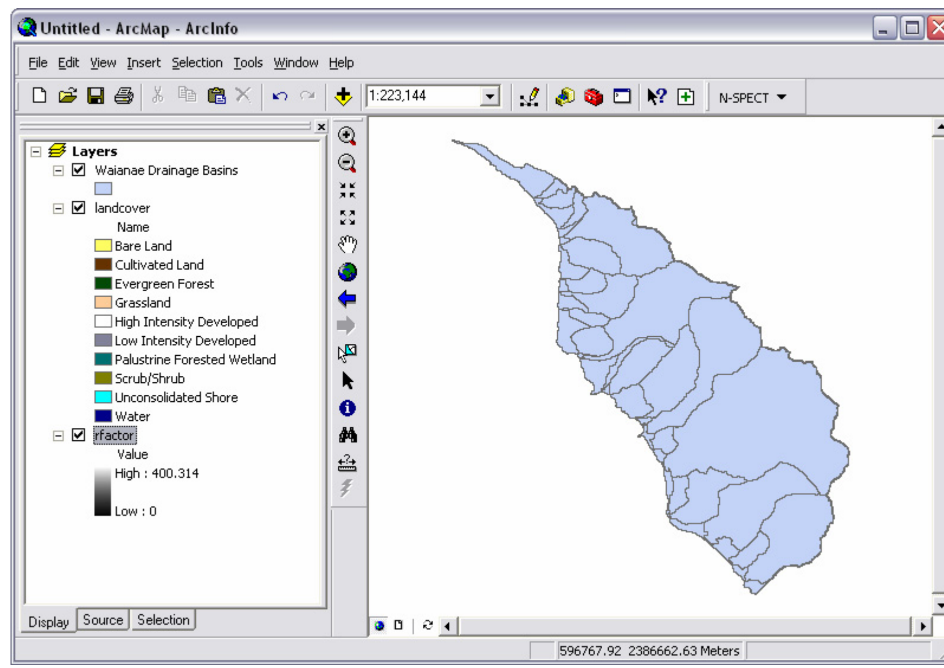
Exercise 1 – Regional Scale Assessment of Baseline Conditions

This exercise demonstrates a basic analysis with N-SPECT, in which the accumulated loads of surface water runoff, pollutants, and sediments are estimated from baseline land cover, topography, soils, and precipitation data. Every N-SPECT analysis follows the same basic procedure outlined here.

Start ArcMap™

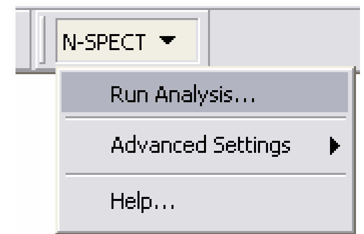
1. Open a new ArcMap™ document.
2. Click the **Add Data** button .
3. Navigate to **C:\NSPECT\waianaedata**.
4. Select the ***rfactor*** grid. This grid represents rainfall and runoff erosivity, and must be added manually.
5. Click **Add**.





Exercise 1 – Regional Scale Assessment of Baseline Conditions

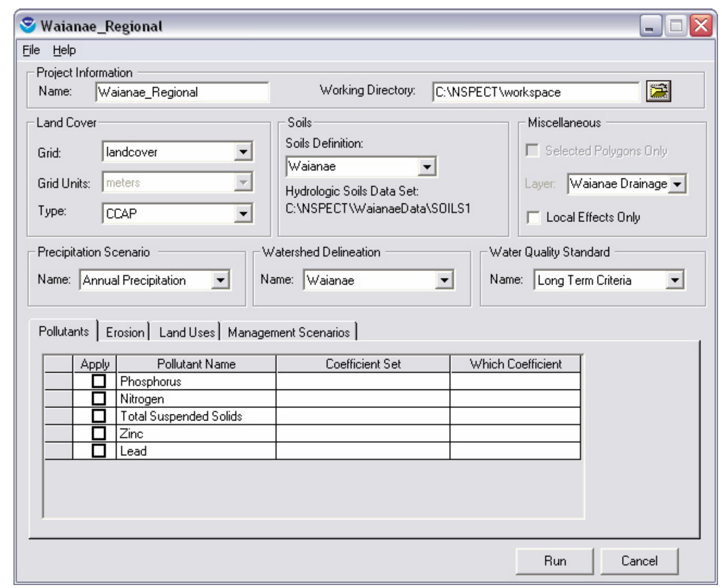
Start N-SPECT



An N-SPECT analysis is set up in the Run Analysis window. The basic project information is defined and the input data sets are selected in the upper panel of the interface. The derived outputs are chosen in the lower panels.

6. Select **Run Analysis** from the N-SPECT drop-down menu.

   Other options, which will not be explored in this document, are under this drop-down menu and lead to the Advanced Settings and the Help documents. Extensive customization settings exist under Advanced Settings, allowing the user to create new watershed delineations and define new soils, precipitation scenarios, pollutants, land cover, and water quality parameters.



Open a Preexisting N-SPECT Project

7. Under File, select **Open Project**. Choose **Waianae.xml**. This file is an N-SPECT project that was previously saved. It contains all of the set up information needed to run an analysis.
8. Click in the **Name** box and rename the project: **Waianae_Regional**.
9. Make sure the working directory is **C:\NSPECT\workspace**.

Exercise 1 – Regional Scale Assessment of Baseline Conditions

Set N-SPECT Inputs

All of the input information should already be entered upon opening the project. However, it is important to check each input name and option box in order to make sure that the analysis will produce the desired outputs.

10. The landcover grid should be **landcover,** and the type should be **CCAP**.
    Any landcover data that is in a grid format can be used by N-SPECT. National Oceanic and Atmospheric Administration (NOAA) Coastal Change and Analysis Program (C-CAP) landcover data products are available for many coastal counties and follow a standard classification scheme which makes these data widely applicable.

11. Select the **Waianae** soils definition.
    Again, any GIS soils data can be used as long as they contain hydrologic soil group and soil erosivity attributes. U.S. Department of Agriculture soil survey geographic database (SSURGO) soil data are available nationally, and are used in this application.

12. Make sure the Local Effects Only option is unchecked.
    This option will be used later, but in brief, it produces outputs that represent the production of materials at each cell.

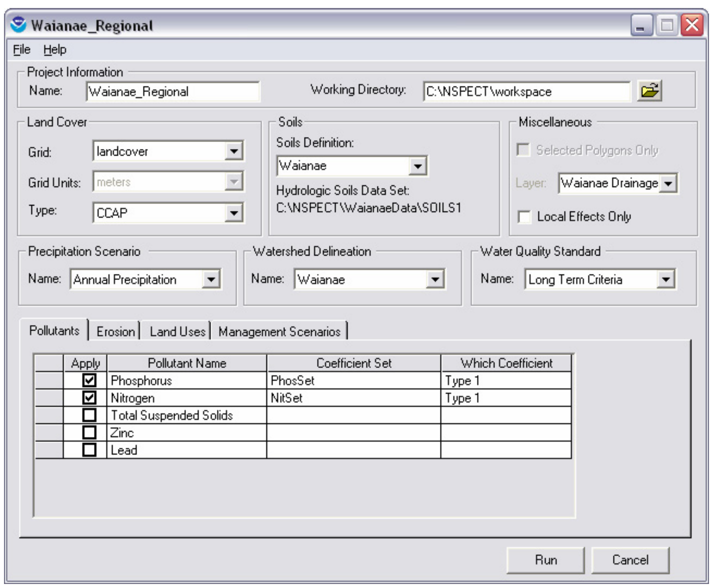
13. Select the **Annual Precipitation** scenario.
14. Select the **Waianae** watershed delineation.
    This field points N-SPECT to a folder of topographic data sets that were derived from USGS 10 meter digital elevation models (DEM).

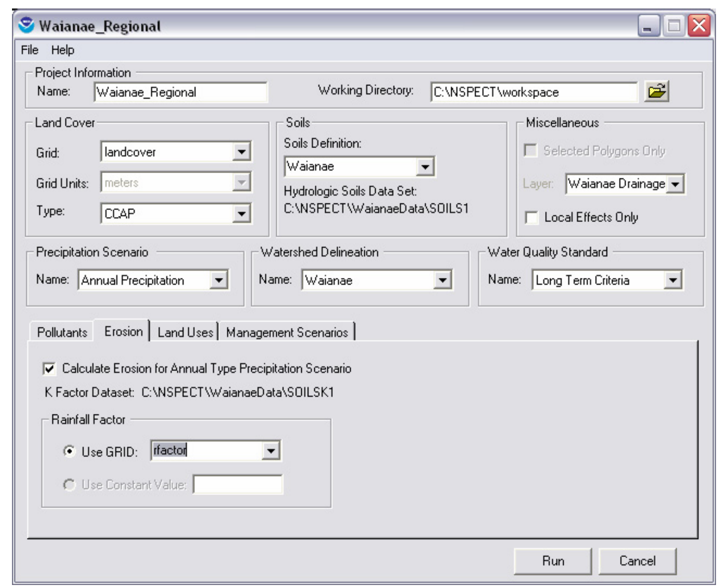
15. Select the **Long Term Criteria** water quality standard.

Exercise 1 – Regional Scale Assessment of Baseline Conditions

Select N-SPECT Outputs

16. Under the **Pollutants** tab, click in the check boxes next to **Phosphorus** and **Nitrogen**.
17. Select **PhosSet** and **NitSet** from the Coefficient Set drop-down menus by clicking in the table. Make sure that the **Type I** coefficient is entered.
18. Under the **Erosion** tab, click in the check box to **Calculate Erosion**.
19. Select the **rfactor** grid from the **Rainfall Factor** drop-down menu.



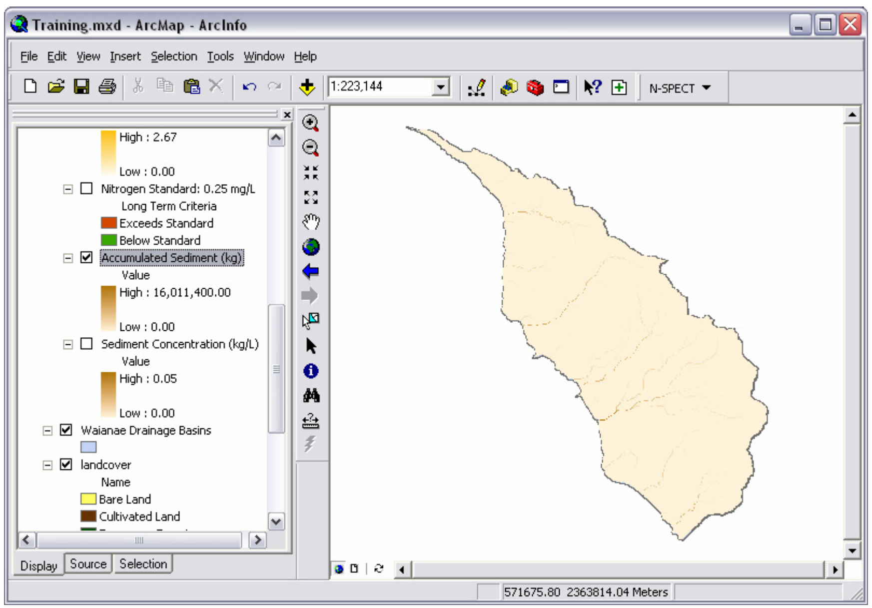


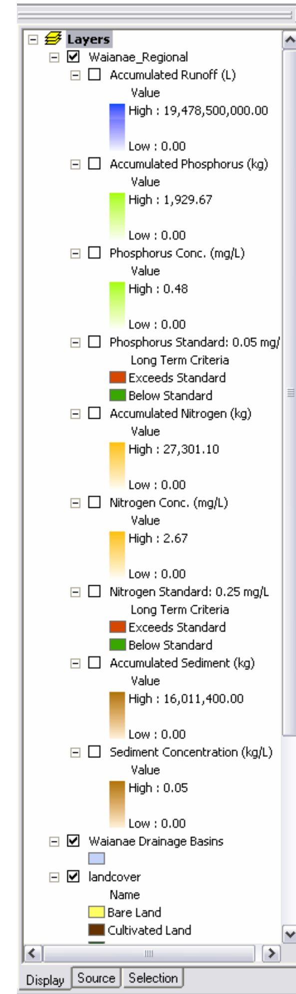
NOTE: The Revised Universal Soil Loss Equation (RUSLE) equation is used to calculate erosion for annual estimates. RUSLE requires an R factor grid as an input to estimate erosion. The Modified Universal Soil Loss Equation (MUSLE), which is used to calculate erosion from a single storm event, does not require an R factor value. Notice how the Erosion tab changes based on the precipitation scenario that is selected (annual or event).

Exercise 1 – Regional Scale Assessment of Baseline Conditions

Run N-SPECT

20. Click **Run** at the bottom of the interface. Answer **Yes**.
21. Click **Save** to save the new N-SPECT project (entitled Waianae_Regional) to the default directory. Once a project is saved it can be opened later and rerun. However, if any settings are changed before a subsequent run, they will be saved automatically and the original settings will be lost.
22. Wait while N-SPECT processes the input data and produces output rasters and metadata (approximately three minutes).

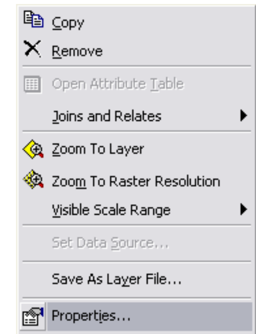




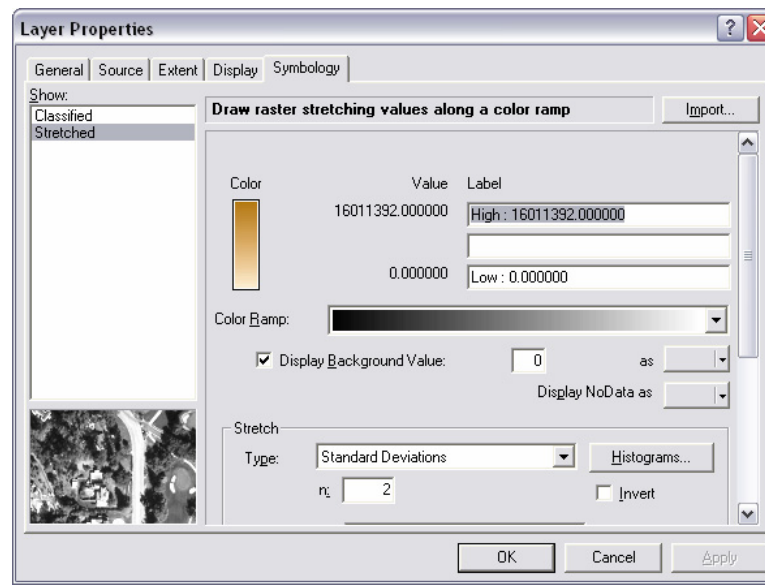
Exercise 1 – Regional Scale Assessment of Baseline Conditions

Adjust the Display Characteristics

Once N-SPECT finishes processing the data, nine new rasters are produced and organized within a group layer named according to the project name, Waianae_Regional. Rasters produced by N-SPECT are displayed using predefined color ramps and a default stretch type of minimum-maximum. Stretch types are useful for highlighting certain cell values, and when used in concert with a descriptive color ramp, can enhance the display of data. The following steps change the appearance of the output data to better enable visualization.



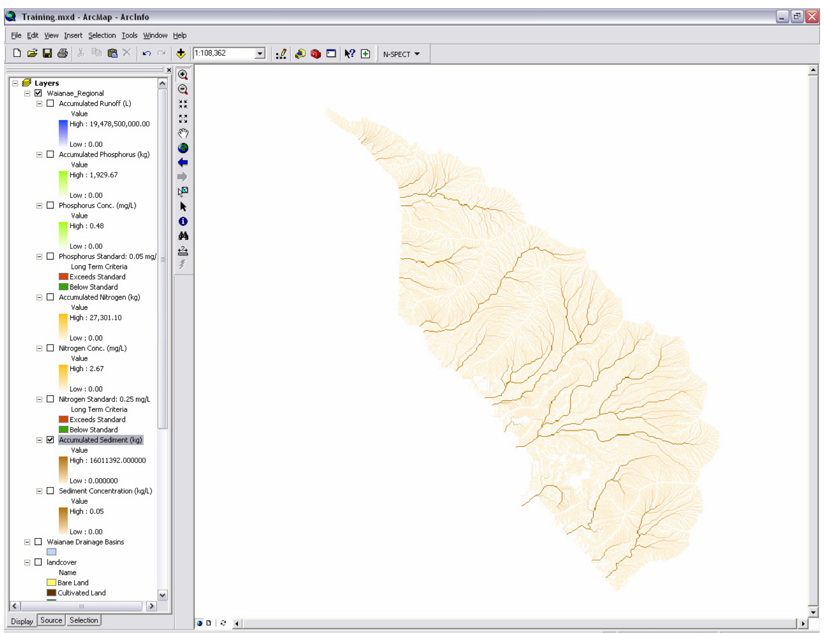
23. Turn off all layers (i.e., make them invisible).
24. Turn on **Accumulated Sediment (kg)** (i.e., make it visible).
25. Right-click on Accumulated Sediment (kg) and then click on **Properties**.
26. Click on the **Symbology** tab.
27. Select **Standard Deviations** from the **Stretch Type** drop-own menu.
28. Place a check mark in the box next to **Display Background Value**. Enabling this option will display just the pixels with values greater than 0.
29. Click **OK**.



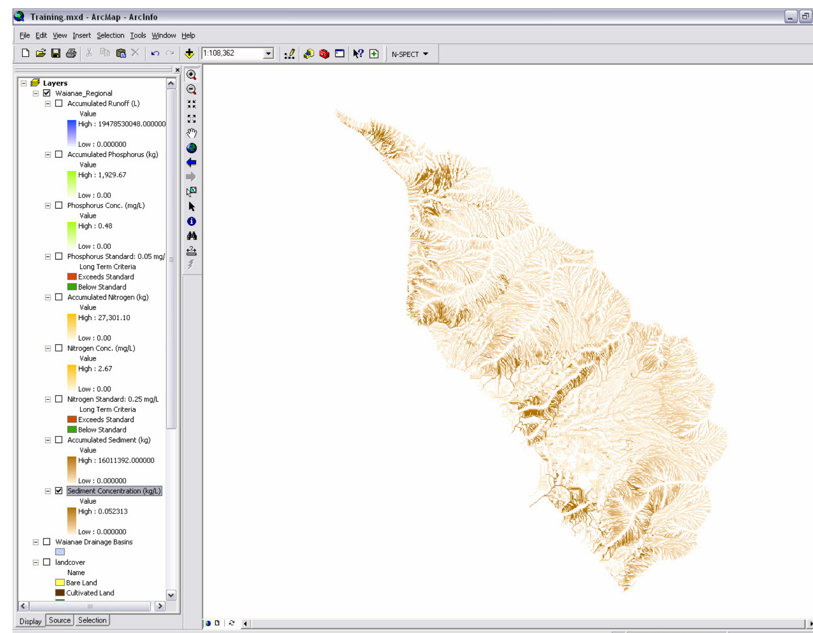
Exercise 1 – Regional Scale Assessment of Baseline Conditions

View the Results

30. Examine the spatial patterns of Accumulated Sediment. Note that the areas with high loads are consistent with the drainage network patterns in the area. Individual pixels can be queried to observe calculated loads.
31. View the other outputs and adjust their display properties to enhance their visualization qualities. Keep in mind that this exercise is meant to assess the relative contributions of sediments and pollutants to the nearshore environment. Try to identify the areas with the greatest contributions.



Accumulated Sediment (kg) with Standard Deviation stretch.



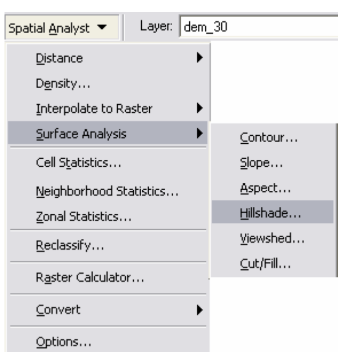
Sediment Concentration (kg/L) with Standard Deviation stretch.

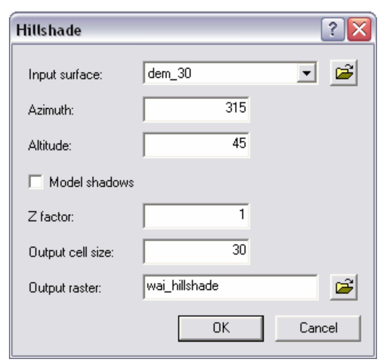
Exercise 1 – Regional Scale Assessment of Baseline Conditions

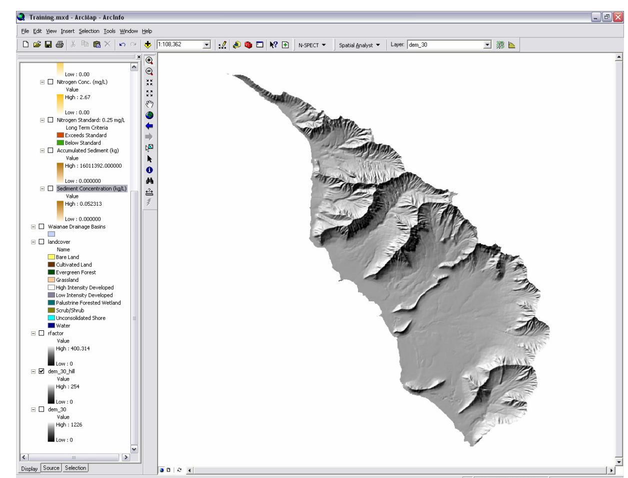
Enhance the Data Display with a Hillshade

While it is possible to infer the locations of drainage divides and stream channels, it is difficult to visualize the topography beneath the output rasters. Creating a sun-illuminated view (i.e., hillshade) of the topography and placing it beneath the N-SPECT data set helps the user to visualize individual watersheds and to better understand the topographic influence on runoff, sediment, and pollutant production patterns across the landscape.

32. Activate the **Spatial Analyst** extension (Tools >> Extensions >> Spatial Analyst). Add the Spatial Analyst toolbar to the menu (View >> Toolbars >> Spatial Analyst).
33. Click the **Spatial Analyst** dropdown menu and open the Spatial Analyst **Options** menu. Set the working directory to **C:\NSPECT\waianaedata\.**
34. Add the **dem_30** grid from the C:\NSPECT\waianaedata directory. This is the topography raster, or DEM.
35. Click on the Spatial Analyst drop-down menu, select **Surface Analysis**, and select **Hillshade**.
36. Choose **dem_30** as the input surface, select a folder for the output raster, and name the new grid: **wai_hillshade**
37. Click OK. The new raster will be added to the table of contents.
38. Leave wai_hillshade at the top of the table of contents.
39. Turn off the **dem_30** layer, if it is visible.





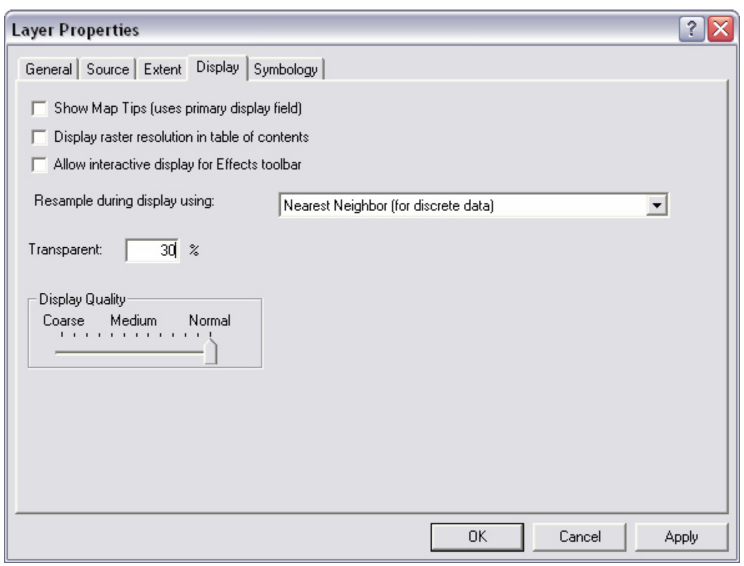


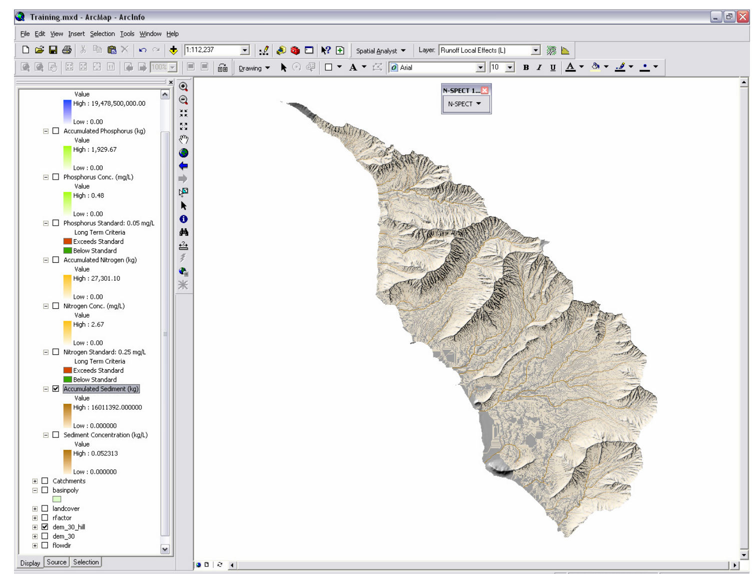
Exercise 1 – Regional Scale Assessment of Baseline Conditions

Enhance the Data Display with a Hillshade

40. Right-click on **wai_hillshade** and click **Properties**.
41. Click the **Display** tab and set the transparency value to **70 percent**. Click **OK**.
42. Make sure the hillshade is above the Accumulated Sediment raster and that both are visible.

The super-imposed display now contains information allowing the user to visualize the distribution of sediment loads within individual catchments. The stream channels which are the natural conduits of sediment have the highest values, while the contributing areas have the lowest values. However, due to the large data range and the limited symbology, it is difficult to detect the catchments that contribute the most sediment to the nearshore environment. To better accomplish this, the following steps will help stratify the catchments using different catchment characteristics.

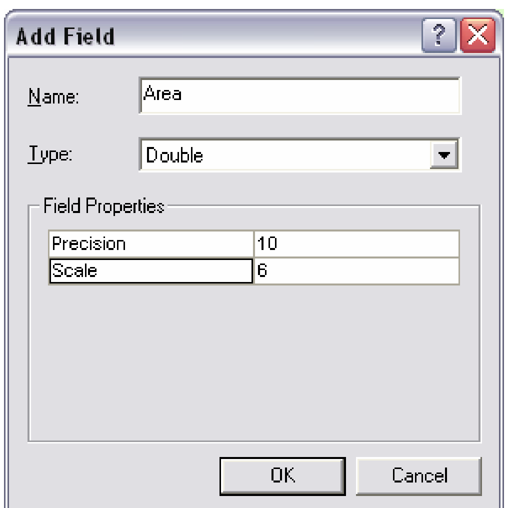




Exercise 1 – Regional Scale Assessment of Baseline Conditions

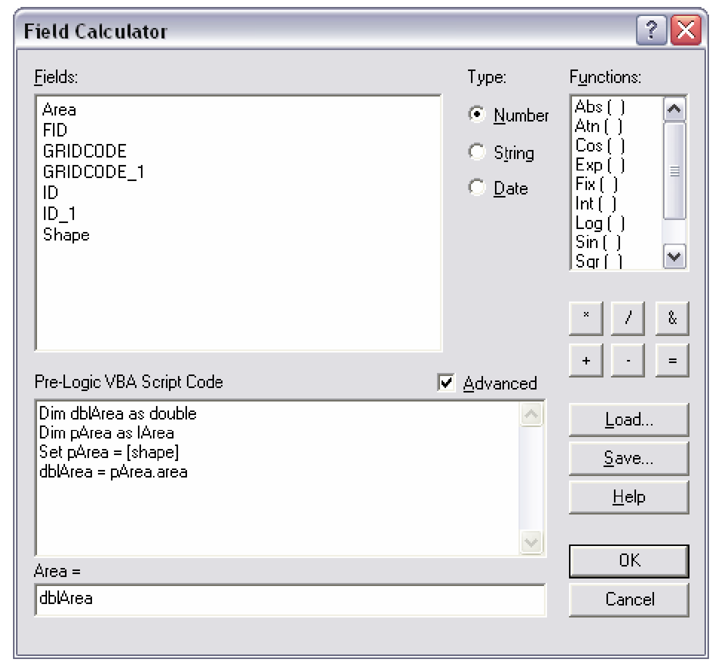
Calculate Catchment Characteristics

43. Open the attribute table of Waianae Drainage Basins.
44. Click the **Options** button and select **Add Field**.
45. Enter the following values: name = **Area**, type = **double**, precision = **10**, and scale = **6**. Click **OK**.
46. With the attribute table open, right-click on the field header **"Area"** and select **Calculate Values**.
47. Check the **Advanced** box to and enter the arguments as shown below. Click **OK**.
48. The new field is populated with values for area in square meters for each basin.




```
Dim dblArea as Double
Dim pArea as IArea
Set pArea = [shape]
dblArea = pArea.area
```

```
dblArea
```



Exercise 1 – Regional Scale Assessment of Baseline Conditions

Calculate Catchment Characteristics

49. Repeat steps 42-47 to create and populate two more fields named **Perimeter** and **Bas_Shape**.
50. Enter the following expression to calculate perimeter:

```
Dim dblPerimeter as Double
Dim pCurve as ICurve
Set pCurve = [shape]
dblPerimeter = pCurve.Length
```

```
dblPerimeter
```

51. Use the following equation for basin shape:

    [Perimeter] / Sqr([Area])

    Note: do not enter this function in the Pre-Logic VBA Script Code box – uncheck the **Advanced box.

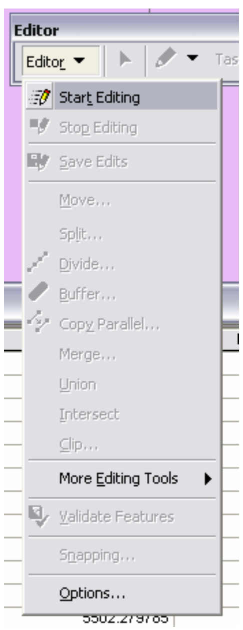
Basin shape influences the time of concentration and magnitude of peak discharge for precipitation events.
The values produced with this calculation are unitless ratios between the basin perimeter and area. Lower values represent more compact basins and higher values represent more elongated basins. Elongated basins exhibit more sustained runoff hydrographs than rounder basins, resulting in a steady input to coastal waters.

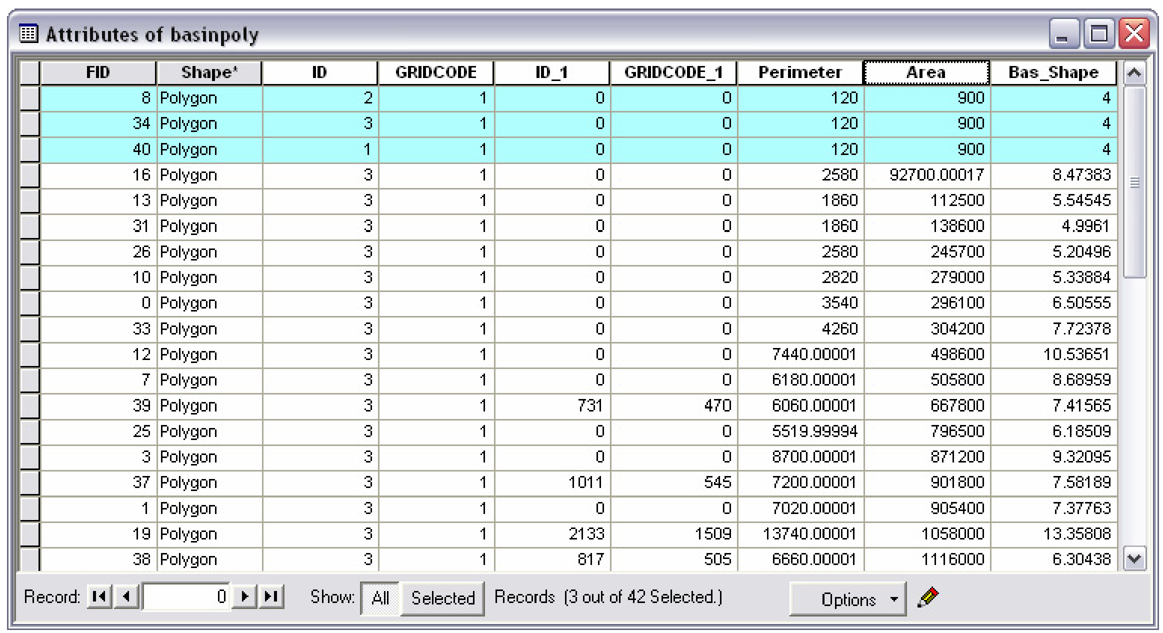
Exercise 1 – Regional Scale Assessment of Baseline Conditions

Edit Waianae Drainage Basins

Several one-cell polygons were created in the Waianae Drainage Basins shapefile during the watershed delineation process. They must be removed so they will not skew the statistically based map displays created in the next steps.

52. Activate the **Editor** tool bar by clicking the icon. Click the Editor drop down menu and click **Start Editing**. (If asked, select the directory containing **Waianae Drainage Basins** and click **OK**.)
53. Open the attribute table for Waianae Drainage Basins. Select the records for which **Area equals 900**, and hit the delete key.
54. Click the Editor drop down menu and click **Stop Editing**. Save the edits.




Attributes of basinpoly

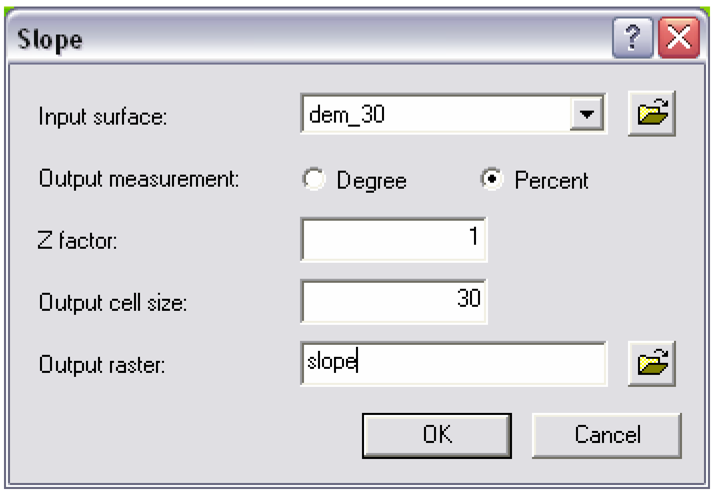
FID	Shape*	ID	GRIDCODE	ID_1	GRIDCODE_1	Perimeter	Area	Bas_Shape
8	Polygon	2	1	0	0	120	900	4
34	Polygon	3	1	0	0	120	900	4
40	Polygon	1	1	0	0	120	900	4
16	Polygon	3	1	0	0	2580	92700.00017	8.47383
13	Polygon	3	1	0	0	1860	112500	5.54545
31	Polygon	3	1	0	0	1860	138600	4.9961
26	Polygon	3	1	0	0	2580	245700	5.20496
10	Polygon	3	1	0	0	2820	279000	5.33884
0	Polygon	3	1	0	0	3540	296100	6.50555
33	Polygon	3	1	0	0	4260	304200	7.72378
12	Polygon	3	1	0	0	7440.00001	498600	10.53651
7	Polygon	3	1	0	0	6180.00001	505800	8.68959
39	Polygon	3	1	731	470	6060.00001	667800	7.41565
25	Polygon	3	1	0	0	5519.99994	796500	6.18509
3	Polygon	3	1	0	0	8700.00001	871200	9.32095
37	Polygon	3	1	1011	545	7200.00001	901800	7.58189
1	Polygon	3	1	0	0	7020.00001	905400	7.37763
19	Polygon	3	1	2133	1509	13740.00001	1058000	13.35808
38	Polygon	3	1	817	505	6660.00001	1116000	6.30438

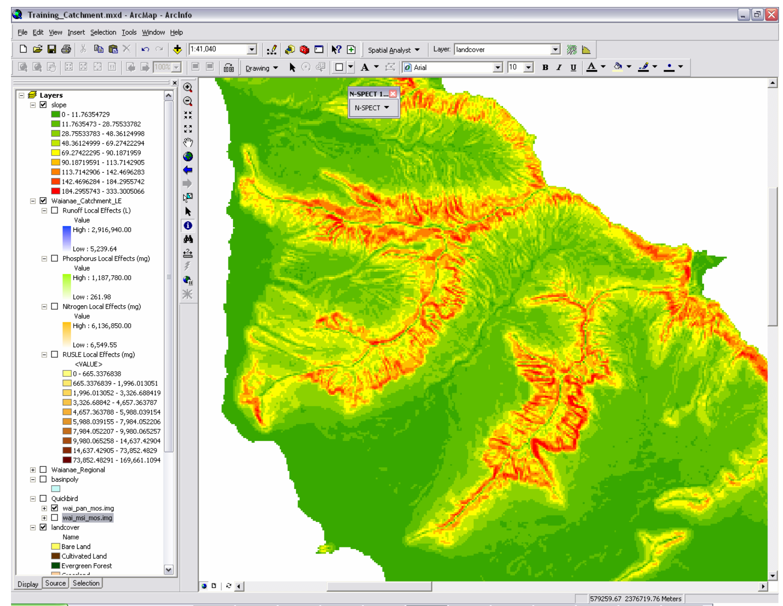
Record: 0 Show: All Selected Records (3 out of 42 Selected.) Options

Exercise 1 – Regional Scale Assessment of Baseline Conditions

Calculate Catchment Characteristics

55. Select **Surface Analysis** from the Spatial Analyst drop-down menu and click **Slope**.
56. Choose **dem_30** as the input surface, **percent** as the output measure, and name the output grid **slope**. Click **OK**.





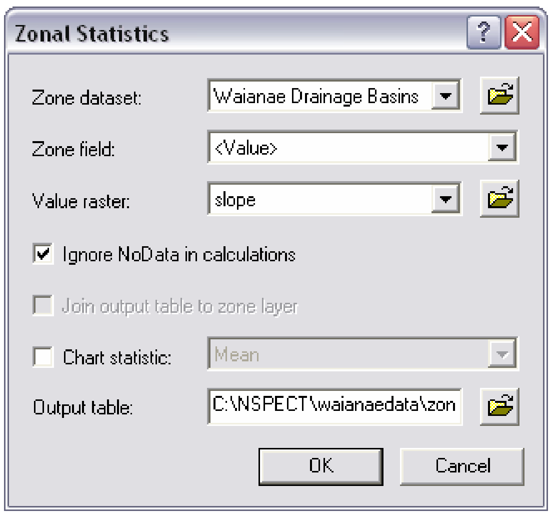
Slope is a particularly useful variable for learning more about potential sediment source areas. Average slope values for an assortment of catchments helps rank the catchments in terms of relative production and delivery potential.

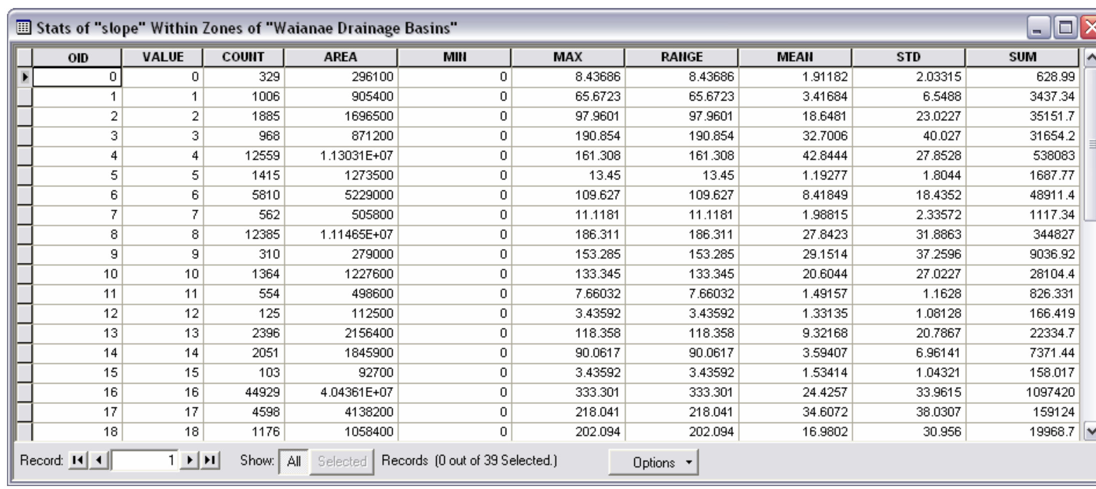
Exercise 1 – Regional Scale Assessment of Baseline Conditions

Extract Catchment Specific Slope Values

The next few steps focus on sediment loads. Sediment is the primary landscape component that impacts the coastal environment in this area of O'ahu. These following methods can also be applied to other pollutants of interest.

57. Click the Spatial Analyst dropdown menu and select **Zonal Statistics**.
58. The Zone Dataset should be **Waianae Drainage Basins**, the Zone Field should be **<Value>**, and the Value Raster should be **slope**.
59. Save the output file as **Zonal_Regional_Slope.dbf**.





Stats of "slope" Within Zones of "Waianae Drainage Basins"

OID	VALUE	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM
0	0	329	296100	0	8.43686	8.43686	1.91182	2.03315	628.99
1	1	1006	905400	0	65.6723	65.6723	3.41684	6.5488	3437.34
2	2	1885	1696500	0	97.9601	97.9601	18.6481	23.0227	35151.7
3	3	968	871200	0	190.854	190.854	32.7006	40.027	31654.2
4	4	12559	1.13031E+07	0	161.308	161.308	42.8444	27.8528	538083
5	5	1415	1273500	0	13.45	13.45	1.19277	1.8044	1687.77
6	6	5810	5229000	0	109.627	109.627	8.41849	18.4352	48911.4
7	7	562	505800	0	11.1181	11.1181	1.98815	2.33572	1117.34
8	8	12385	1.11465E+07	0	186.311	186.311	27.8423	31.8863	344827
9	9	310	279000	0	153.285	153.285	29.1514	37.2596	9036.92
10	10	1364	1227600	0	133.345	133.345	20.6044	27.0227	28104.4
11	11	554	498600	0	7.66032	7.66032	1.49157	1.1628	826.331
12	12	125	112500	0	3.43592	3.43592	1.33135	1.08128	166.419
13	13	2396	2156400	0	118.358	118.358	9.32168	20.7867	22334.7
14	14	2051	1845900	0	90.0617	90.0617	3.59407	6.96141	7371.44
15	15	103	92700	0	3.43592	3.43592	1.53414	1.04321	158.017
16	16	44929	4.04361E+07	0	333.301	333.301	24.4257	33.9615	1097420
17	17	4598	4138200	0	218.041	218.041	34.6072	38.0307	159124
18	18	1176	1058400	0	202.094	202.094	16.9802	30.956	19968.7

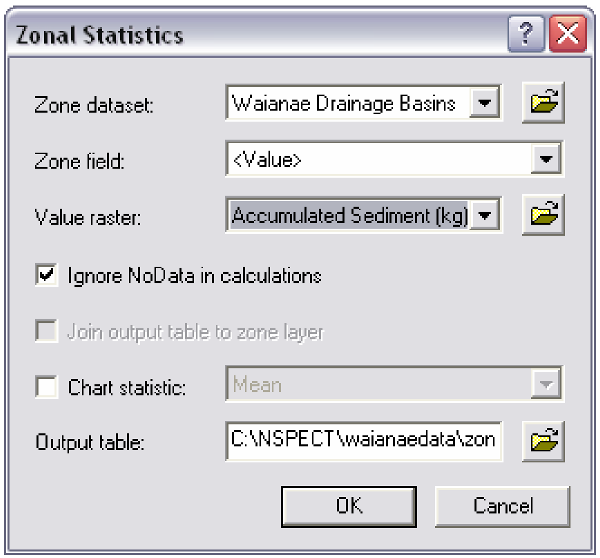
Record: 1 Show: All Selected Records (0 out of 39 Selected.) Options

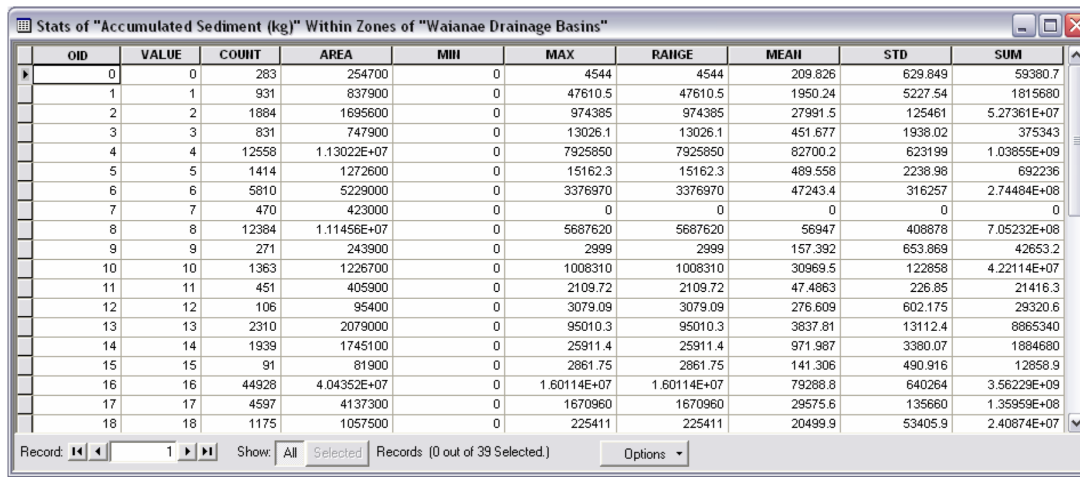
The *Zonal Statistics* tool summarizes raster values that fall within the zones represented by another raster layer or polygon shapefile. The Waianae Drainage Basins data layer can be used to summarize raster values for each unique catchment, or zone. Statistical values for each zone are saved in a table which can be joined to the original shapefile.

Exercise 1 – Regional Scale Assessment of Baseline Conditions

Extract Catchment Specific Sediment Contributions

60. Click the Spatial Analyst dropdown menu and select **Zonal Statistics**.
61. The zone dataset should be **Waianae Drainage Basins**, the zone field should be **<Value>**, and the value raster should be **Accumulated Sediment (kg)**.
62. Save the output file as **Zonal_Regional_Accum_Sed.dbf**.




Stats of "Accumulated Sediment (kg)" Within Zones of "Waianae Drainage Basins"

OID	VALUE	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM
0	0	283	254700	0	4544	4544	209.826	629.849	59380.7
1	1	931	837900	0	47610.5	47610.5	1950.24	5227.54	1815680
2	2	1884	1695600	0	974385	974385	27991.5	125461	5.27361E+07
3	3	831	747900	0	13026.1	13026.1	451.677	1938.02	375343
4	4	12558	1.13022E+07	0	7925850	7925850	82700.2	623199	1.03855E+09
5	5	1414	1272600	0	15162.3	15162.3	489.558	2238.98	692236
6	6	5810	5229000	0	3376970	3376970	47243.4	316257	2.74484E+08
7	7	470	423000	0	0	0	0	0	0
8	8	12384	1.11456E+07	0	5687620	5687620	56947	408878	7.05232E+08
9	9	271	243900	0	2999	2999	157.392	653.869	42653.2
10	10	1363	1226700	0	1008310	1008310	30969.5	122858	4.22114E+07
11	11	451	405900	0	2109.72	2109.72	47.4863	226.85	21416.3
12	12	106	95400	0	3079.09	3079.09	276.609	602.175	29320.6
13	13	2310	2079000	0	95010.3	95010.3	3837.81	13112.4	8865340
14	14	1939	1745100	0	25911.4	25911.4	971.987	3380.07	1884680
15	15	91	81900	0	2861.75	2861.75	141.306	490.916	12858.9
16	16	44928	4.04352E+07	0	1.60114E+07	1.60114E+07	79288.8	640264	3.56229E+09
17	17	4597	4137300	0	1670960	1670960	29575.6	135660	1.35959E+08
18	18	1175	1057500	0	225411	225411	20499.9	53405.9	2.40874E+07

Record: 1 Show: All Selected Records (0 out of 39 Selected.) Options

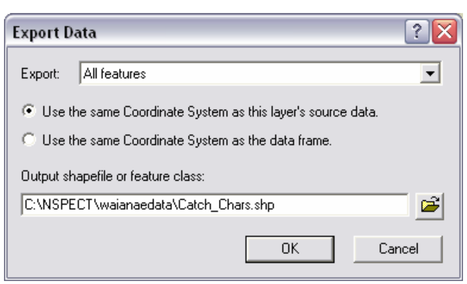
The *Zonal Statistics* tool has now been used to summarize the slope and accumulated sediment raster values for each catchment in the Waianae. These tables will now be joined to Waianae Drainage Basins, and the statistical values will be used in a quantity based symbology scheme.

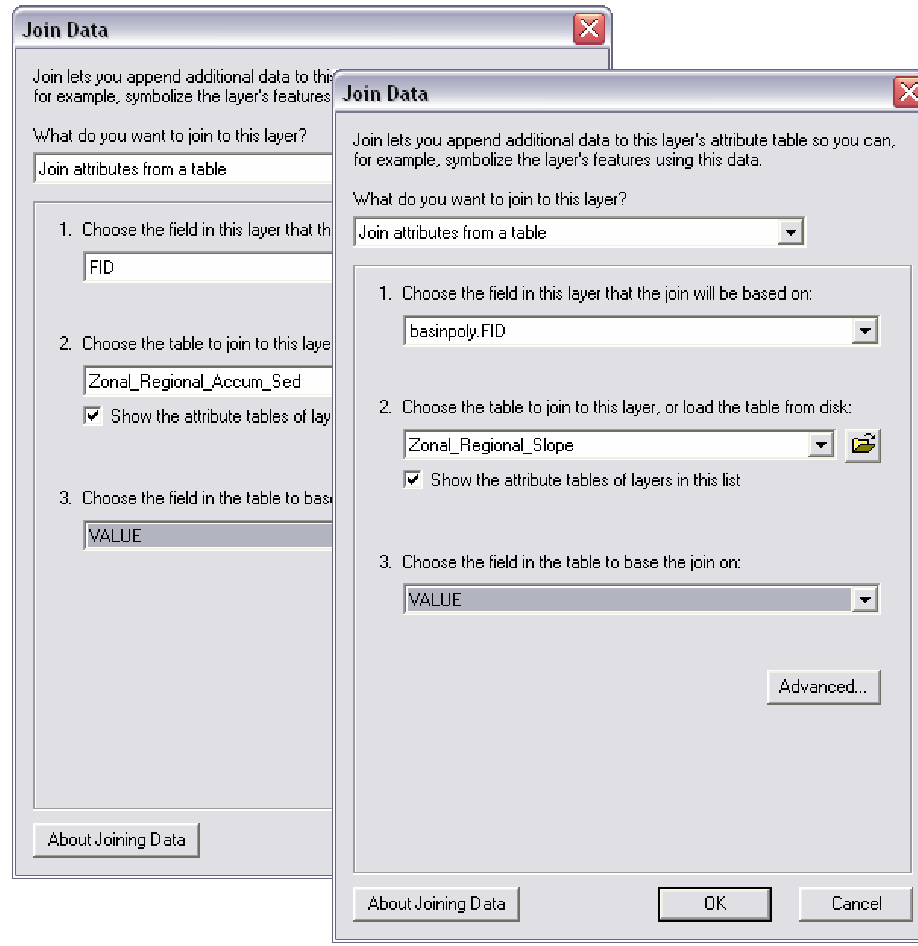
Exercise 1 – Regional Scale Assessment of Baseline Conditions

Join Tables to Shapefile

Now join the two new tables to the drainage basins.

63. Right-click the Waianae Drainage Basins layer, highlight **Joins and Relates**, and click **Join**.
64. Enter the information as shown to the right for **Zonal_Regional_Accum_Sed**. Click **OK**. Answer **Yes** to index if asked.
63. Repeat the join process for **Zonal_Regional_Slope**. Note that the field name in option 1 will be different now. Choose **basinpoly.FID**.
64. Export this joined data by right-clicking Waianae Drainage Basins, selecting **Data**, clicking **Export Data**, and saving it as a new shapefile called **Catchment_Chars.shp**. Answer **Yes** to add to viewer.





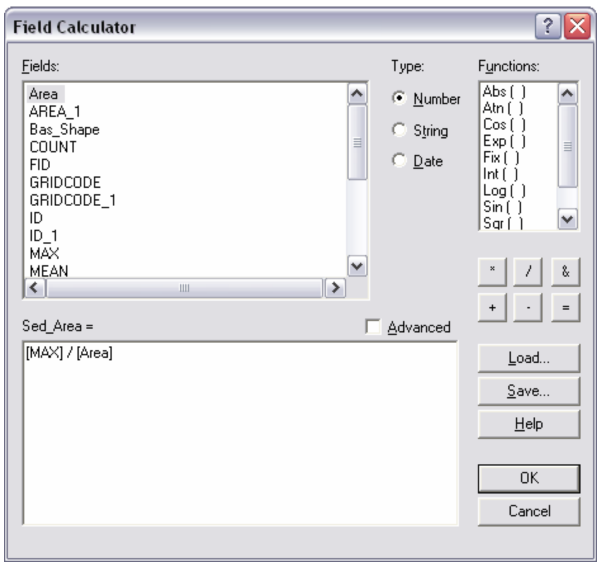
Exercise 1 – Regional Scale Assessment of Baseline Conditions

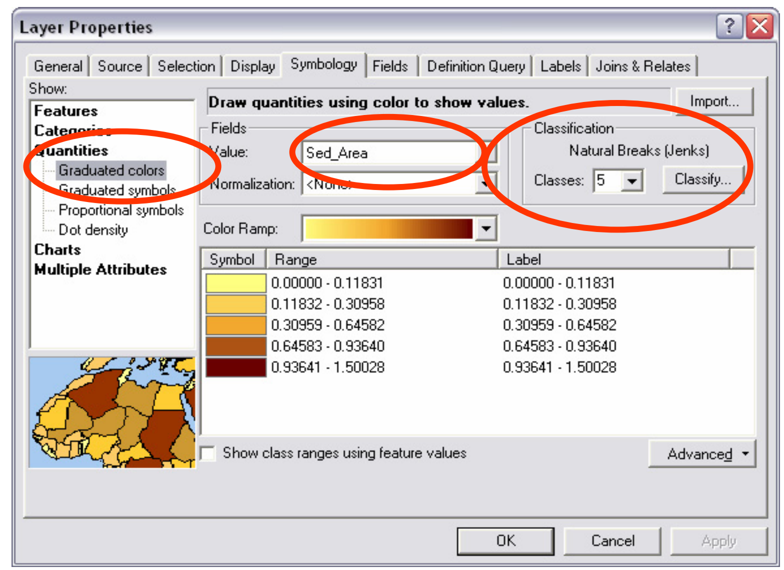
Calculate Area-Weighted Sediment Contributions

67. Open the attribute table for **Catchment_Chars** and add a new field called **Sed_Area** as type double.
68. Use the field calculator again to populate the new field with area-weighted values of total sediment production.

[MAX] / [Area] ***Note: there are multiple fields with "Area" and "Max" in their names. Be careful.**

69. Display **Catchment_Chars** using a graduated color quantity symbology for **Sed_Area**.





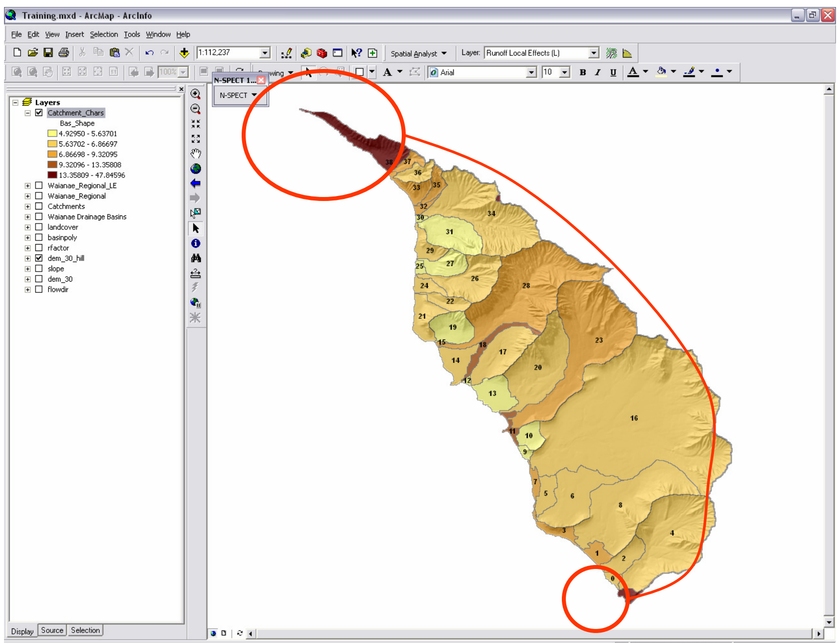
Area weighted map displays are useful for visualizing the relative contribution of sediment without the influence of catchment area. This technique is one way the user can begin to see differences between independent catchments.

Exercise 1 – Regional Scale Assessment of Baseline Conditions

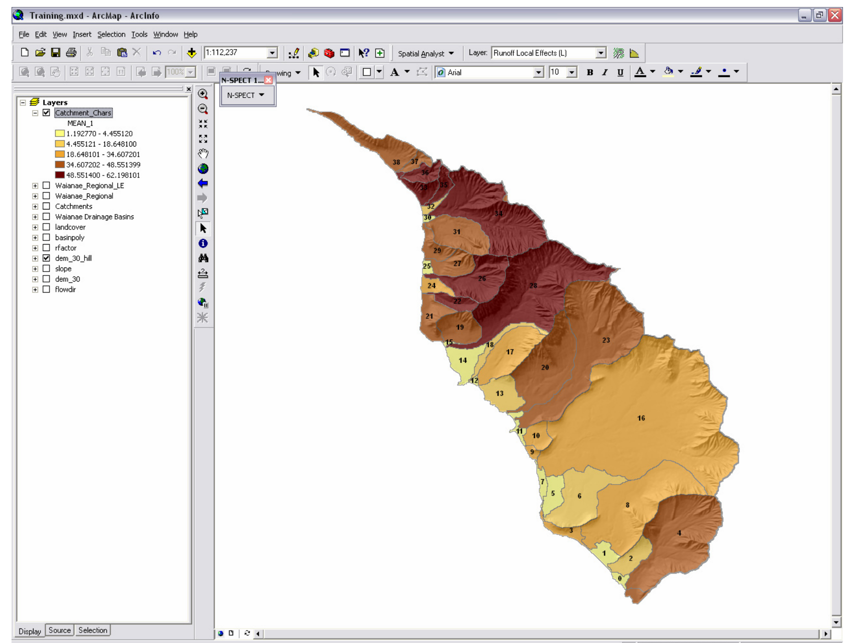
Catchment Characteristics

The new shapefile, **Catchment_Chars**, now contains information describing basin shape and slope for each catchment. These indices are important geomorphic variables that relate to watershed processes and can be used to help characterize catchments based on their response to rainfall.

**Note that the southernmost catchment appears to have a very high shape value. This is because it is actually connected to the northernmost catchment by a very long, linear connection along the ridge line (this is an error).



Catchment Shape (Bas_Shape)

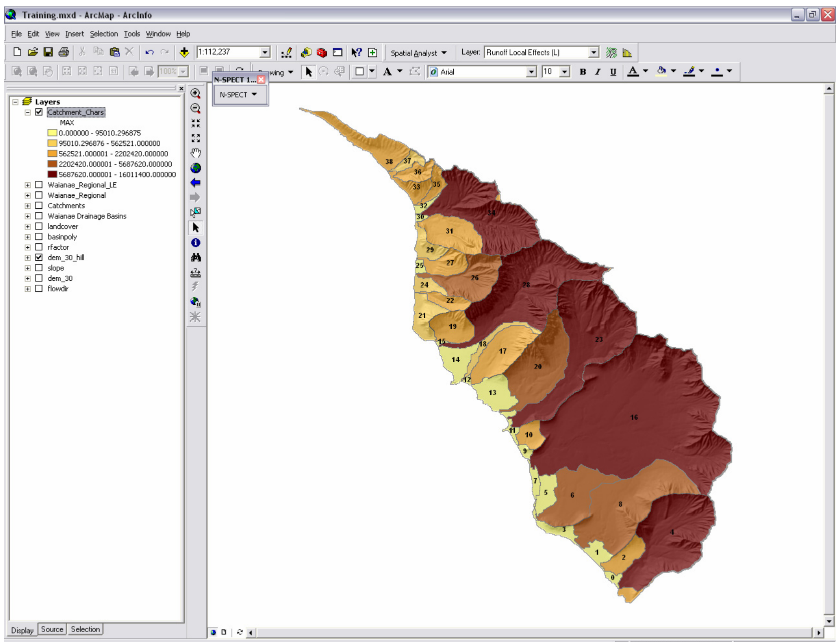


Average Slope (MEAN_1)

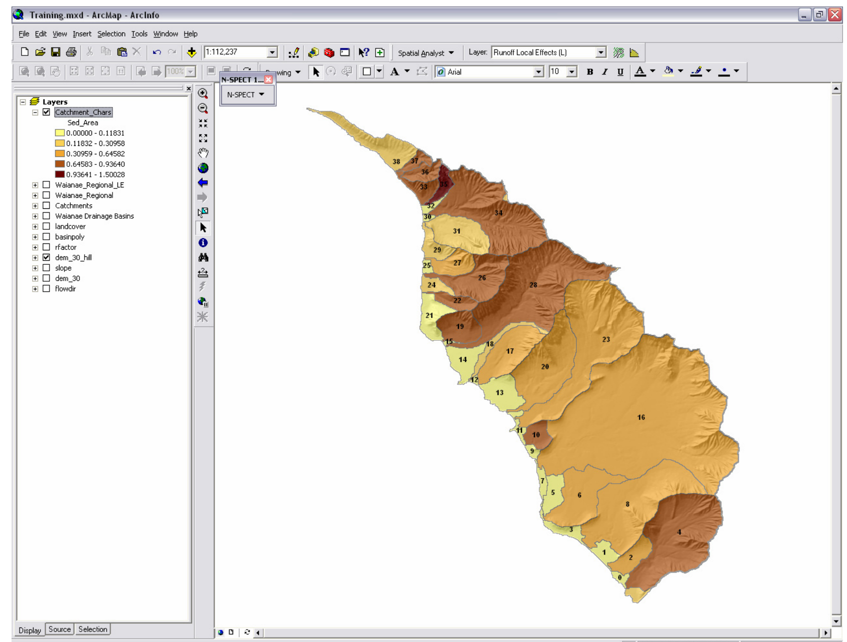
Exercise 1 – Regional Scale Assessment of Baseline Conditions

Catchment Characteristics

Catchment_Chars also contains information describing accumulated sediment loads for each catchment. These variables can be displayed a variety of ways.



Maximum Sediment Output (MAX)



Area-Weighted Sediment (Sed_Area)

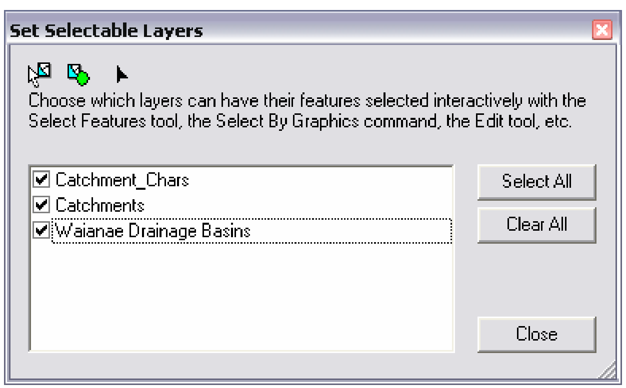
The user can apply these simple landscape characterizations, in addition to others, to help understand the topographic and geomorphic influences on natural watershed processes that interact in concert and affect water quality.

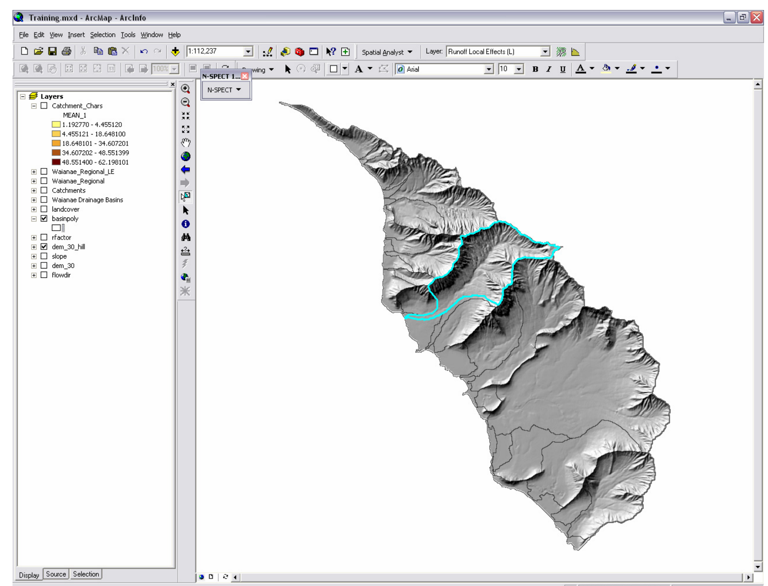
Exercise 1 – Regional Scale Assessment of Baseline Conditions

Select a Target Catchment for Catchment Scale Analysis

Several catchments that produce relatively high amounts of sediment have elongated shapes and have high mean slope values. This indicates that they may be the sources of sustained sediment inputs to the nearshore environment and should be looked at more closely. The next two exercises look at one catchment in particular.

70. Make Waianae Drainage Basins a selectable layer (Menu Bar: Selection >> Set Selectable Layers >> Waianae Drainage Basins).
71. Choose the **Feature Select** tool  and select the **Makaha drainage basin** (see below for appropriate basin).
72. Save the ArcMap project with a name of your choice.





Exercise 2 – Catchment Scale Analysis of Source Areas

Makaha Valley

Makaha Valley encompasses approximately 1,800 acres of land between the Makua Valley and the Wai'anae Valley on the leeward coast of O'ahu, Hawai'i. Together, the Makaha Valley and the town of Makaha are home to approximately 9,000 people. A variety of land uses are found in the valley, including residential areas, two 18-hole golf courses (the 300-acre Makaha Resort Golf club and the Makaha Valley Country Club), a condominium and hotel development, some agriculture, and bare land. Along the coast, Makaha Beach Park provides a place for community gatherings, recreational activities, and fishing.

Exercise 2 – Catchment Scale Analysis of Source Areas

Background

Catchment scale processes have been shown to be important influences on stream and nearshore water quality. Examining the sources of pollutants and sediment within catchments allows people to design effective strategies to manage water quality. This exercise follows a simple spatial analysis methodology to target high sediment-producing areas within Makaha Valley.

Objectives

- Use the Local Effects option of N-SPECT to calculate source specific loads.
- Stratify high-contributing areas by subwatershed.
- Compare the strengths of spatially lumped and spatially distributed information.

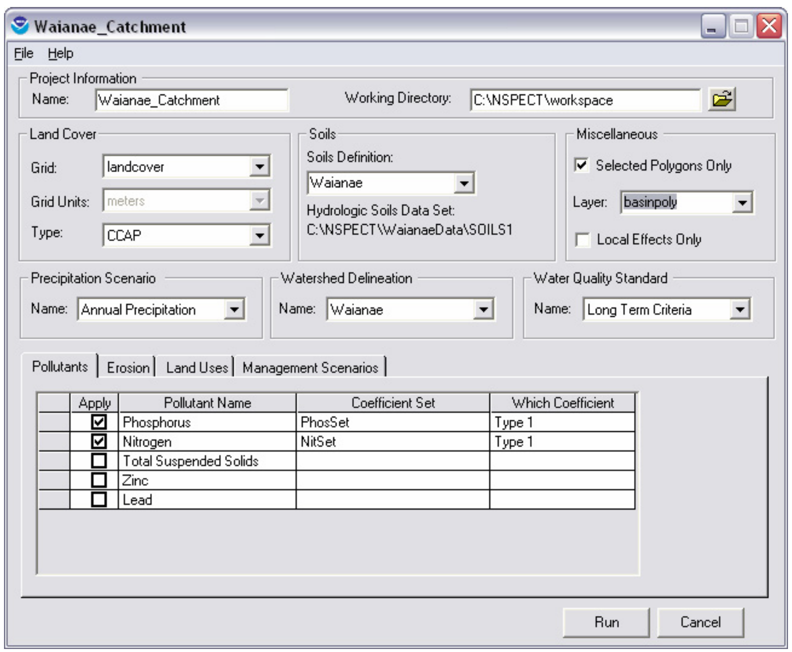
Steps

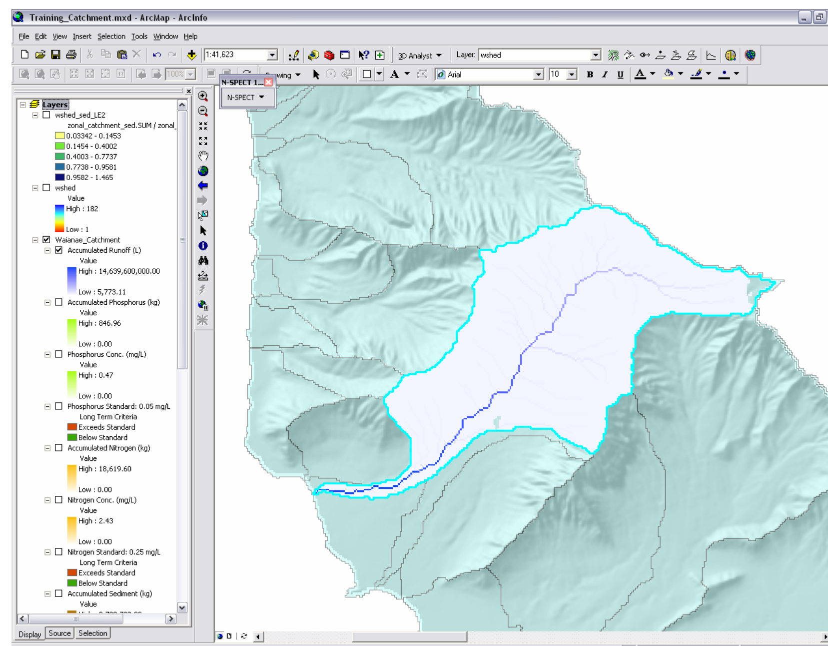
1. Run N-SPECT on a catchment level (extracting Accumulated and Local Effects).
2. Calculate relative loads for each subwatershed.
3. Calculate slope.
4. Query pixels based on a combination of slope and sediment output values.

Exercise 2 – Catchment Scale Analysis of Source Areas

Run N-SPECT for Accumulated Results

1. Using the previously saved ArcMap project, use the **select features tool** to select the **Makaha Valley** catchment.
2. Select **Run Analysis** from the NSPECT drop-down menu.
3. Open the NSPECT project named **Waianae_Regional**. Delete the extra drainage layer from the viewer.
4. Change the name to **Waianae_Catchment**, and click in the box for **Selected Polygons Only** under the Miscellaneous section. Make sure the drainage basins shapefile is the listed layer.
5. Run the analysis.

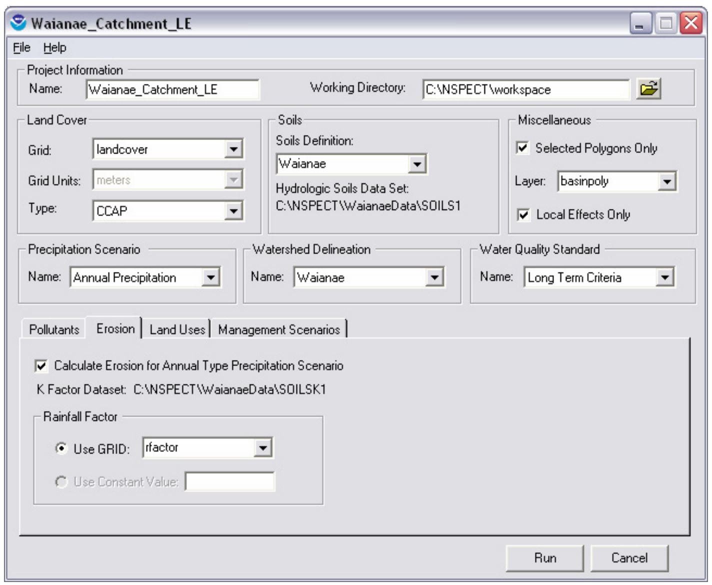


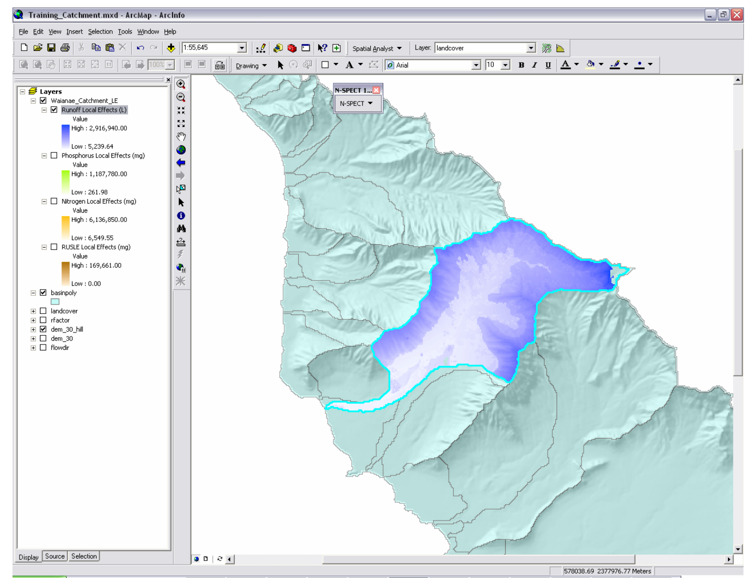


Exercise 2 – Catchment Scale Analysis of Source Areas

Run N-SPECT for Local Effects

6. Open the N-SPECT project named **Waianae_Catchment**. Delete the extra drainage layer from the viewer.
7. Change the name to **Waianae_Catchment_LE**, and click in the box for **Local Effects Only** under the Miscellaneous section.
8. Run the analysis.



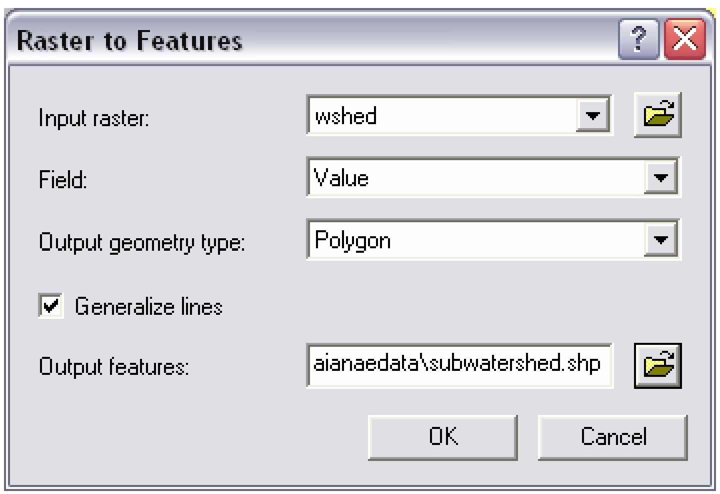


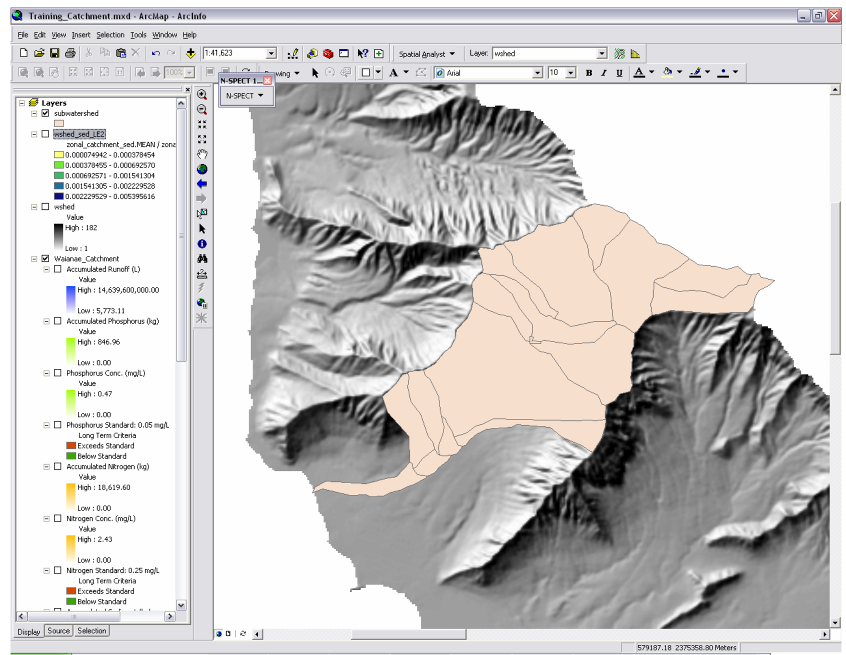
When the *Local Effects* option is activated, N-SPECT produces raster data outputs that describe just the runoff volume (L) and pollutant and sediment loads (mg) produced within each cell of the input data. Neither concentration data nor accumulated loads are calculated because upslope contributions are not considered.

Exercise 2 – Catchment Scale Analysis of Source Areas

Convert Subwatersheds to Features

9. Add the grid named **wshed** from the **C:\NSPECT\wsdelin\Waianae** folder.
10. Open the **Spatial Analyst Options** menu and set the analysis mask to **Runoff Local Effects (L)**.
11. Use the Spatial Analyst function, **Convert** >> **raster to features**, to create a polygon shapefile called **Subwatershed** (Spatial Analyst >> Convert >> Raster to Features).

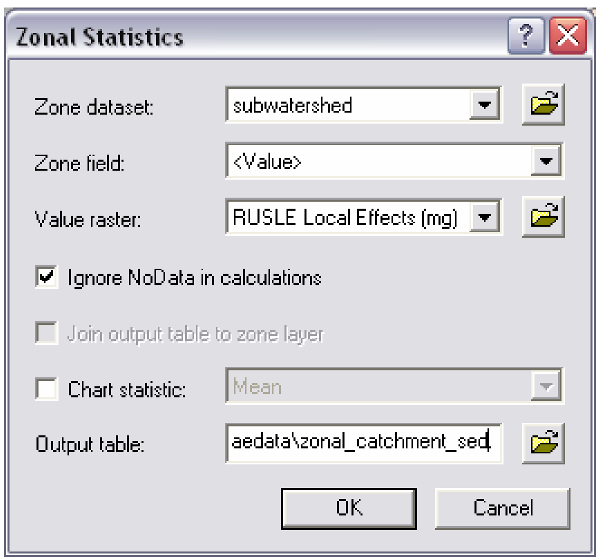


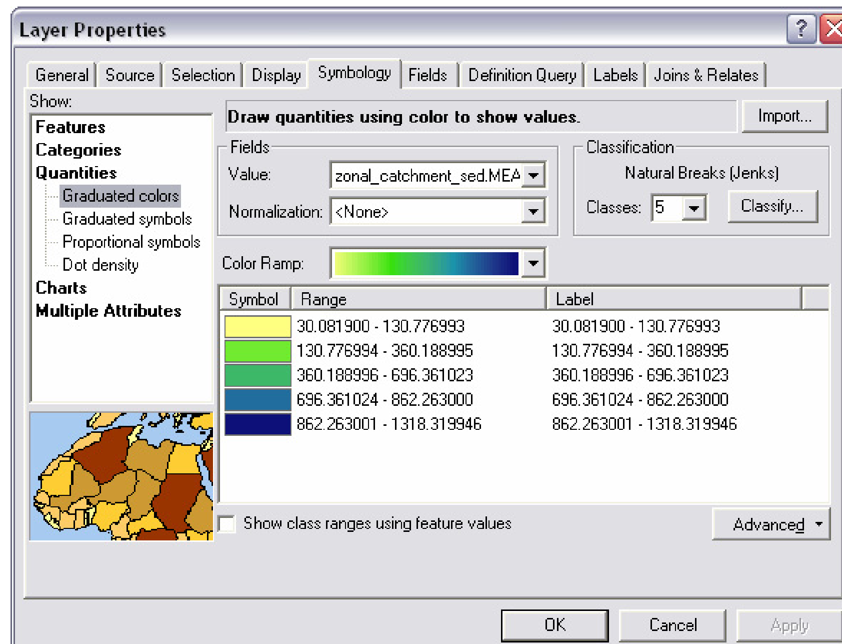


Exercise 2 – Catchment Scale Analysis of Source Areas

Characterize Subwatershed Sediment Loads

12. Use the **zonal statistics** function to extract information from **RUSLE Local Effects (mg)** and have it summarized by subwatershed. This time, check the **Join output table to zone layer** to automate the join procedure. If the option is not available, you will have to follow the join procedure outlined in exercise 1 (steps 63-66), using the fields **Gridcode** (in the subwatershed shapefile) and **Value** (in the zonal_catchment_sed table) to create the join.
13. Change the **symbology** to show the mean value of sediment produced for each subcatchment, as shown below.

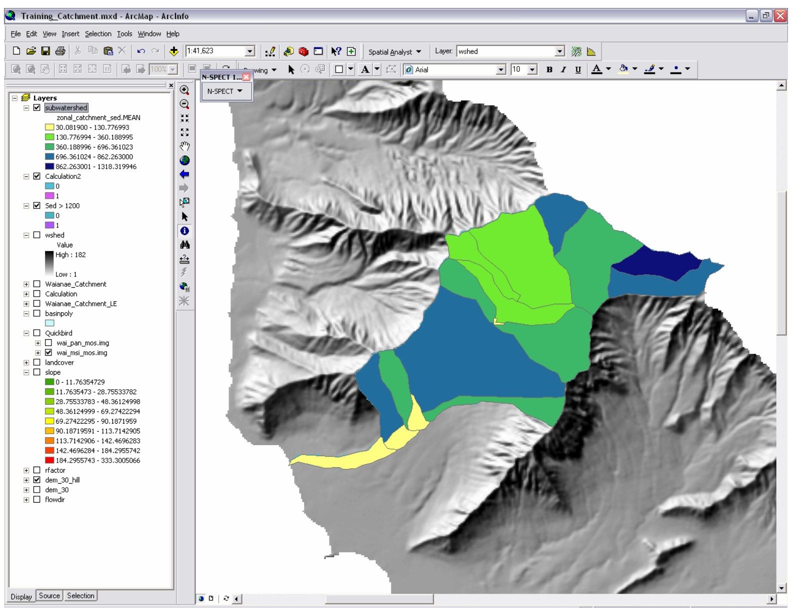




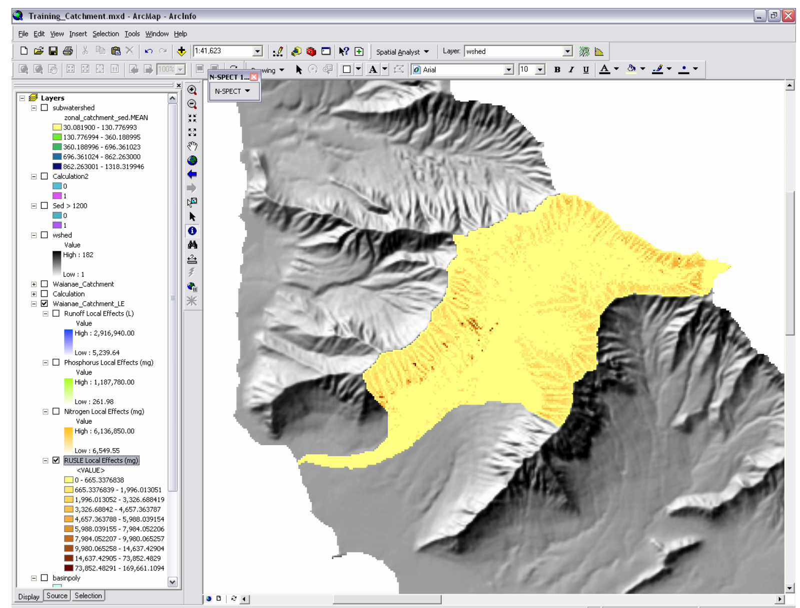
Exercise 2 – Catchment Scale Analysis of Source Areas

Evaluate Visualizations

The image below shows the display as it should appear for average sediment production for each subcatchment (Figure A). Summarizing the sediment output information by an area is useful for compartmentalizing the contributions to total output, but this technique does not display the information in a spatially distributed fashion. Thus, observing raster information at the catchment scale may prove to be more useful for this application. For instance, the raster data show a strong pattern of high sediment production around the edges of the catchment where slopes are quite steep, and small areas with high contributions are noticeable (Figure B). The lumped data do not show this spatial distribution as effectively and do not allow the user to pinpoint certain features of interest.



A. Sediment production lumped by subcatchment.



B. Sediment production distributed across landscape.

Exercise 2 – Catchment Scale Analysis of Source Areas

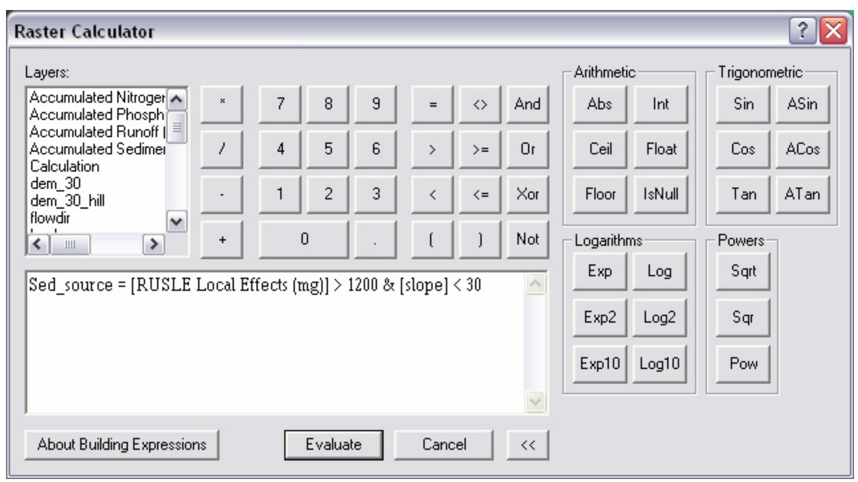
Filter by Sediment and Slope

The following steps are a simple way to extract spatially distributed information from multiple data sets. Slope and the local sediment output layers will be used to pinpoint areas that are accessible and produce high amounts of sediment.

14. Using the **Raster Calculator** (Spatial Analyst >> Raster Calculator), enter the following expression:

    Sed_source = [RUSLE Local Effects (mg)] > 1200 & [slope] < 30

    This produces a new binary grid, **Sed_source**, that codes the pixels that satisfy the above argument with the value of 1. All other pixels are coded with 0. The values used in the expression were decided upon as follows: 1200 mg is equivalent to the mean sediment production within the valley plus one standard deviation, and 30 percent is approximately a 16 degree slope which is easily traversable.

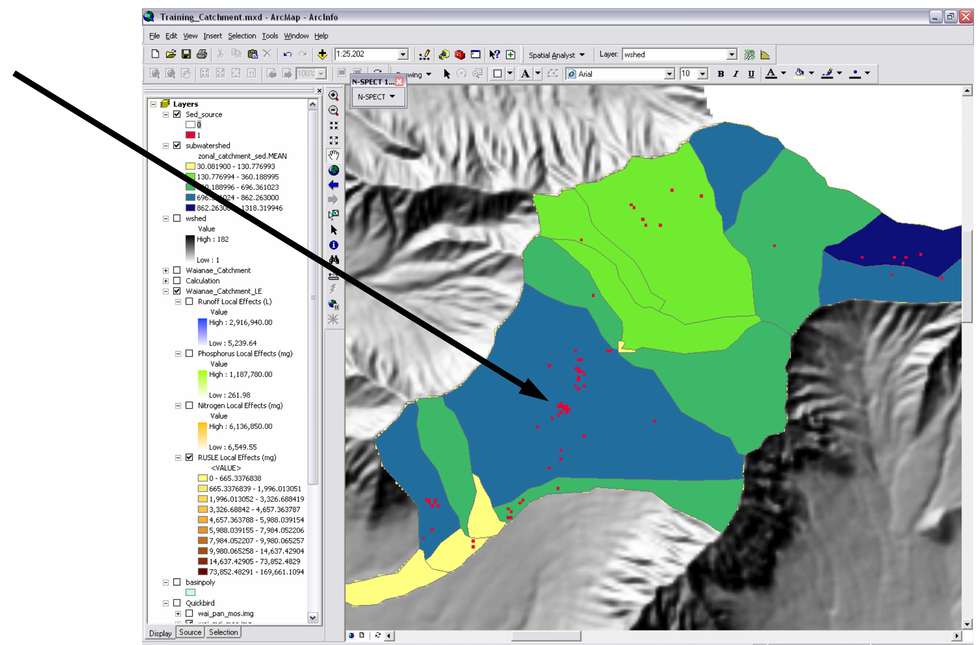


Exercise 2 – Catchment Scale Analysis of Source Areas

Display Sediment Source Areas

15. The new grid, **Sed_source**, can now be overlaid on the **subwatershed** shapefile.
16. In the table of contents, under Sed_source, click on the symbol adjacent to the value 0. A color selector box will appear. Select **Properties** and check **Color is Null**. Click **OK**.
17. **Save** the ArcMap project with the same name!

Now, the eye is drawn toward the middle of the largest polygon where an area of high sediment production most likely exists. Field surveys at this location would allow managers to determine if a sediment control project would improve downstream water quality.



Exercise 3 – Subcatchment Scale Scenario Implementation

Background

Actual hands-on watershed management activities occur at a local level. Often times, it is important to understand the consequences of modifying land cover types. In other instances, people may want to infer what conditions were like under prior management. This type of historic analysis is useful when trying to understand changes in trends.

This exercise illustrates the utility of N-SPECT's management scenario functionality. A shapefile representing an area of alternative land cover (agriculture) is used to modify an area presently covered by scrub/shrub and forest. The new analysis with a land-cover scenario is run and the results are compared to the baseline results.

Objectives

- Learn how to use the scenario option.
- Discern subwatershed scale differences in sediment outputs with different land covers.

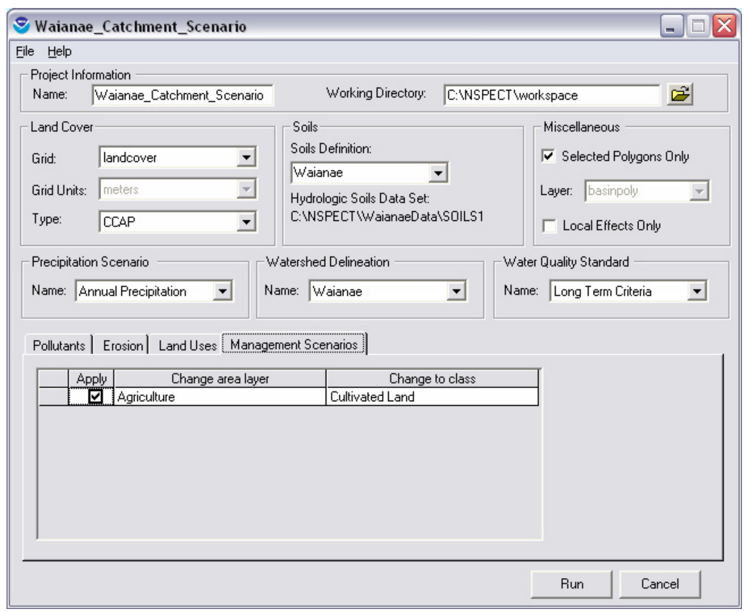
Steps

1. Run N-SPECT on a catchment level with the implementation of an alternative land use scenario.
2. Develop percent change data for accumulated sediment.
3. Evaluate the potential degree of change from historic conditions to present conditions.

Exercise 3 – Subcatchment Scale Scenario Implementation

Define a New Scenario and Run N-SPECT

1. Using the previously saved ArcMap project, add the shapefile named **Agriculture** from the **waianaedata** folder.
2. Make sure that **Makaha Valley** is still selected (see Exercise 2, step 1).
3. Select **Run Analysis** from the NSPECT drop-down menu.
4. Open the NSPECT project named **Waianae_Catchment**.
5. Change the name to **Waianae_Catchment_Scenario**. Make sure that the **Selected Polygons Only** option is still checked, and that the layer is **Waianae Drainage Basins** (or basinpoly).
6. Click the **Management Scenarios** tab. Select **Agriculture** under the **Change area layer** field, select **Cultivated Land** under the **Change to class** field, and check the **Apply** box.
7. Run N-SPECT.

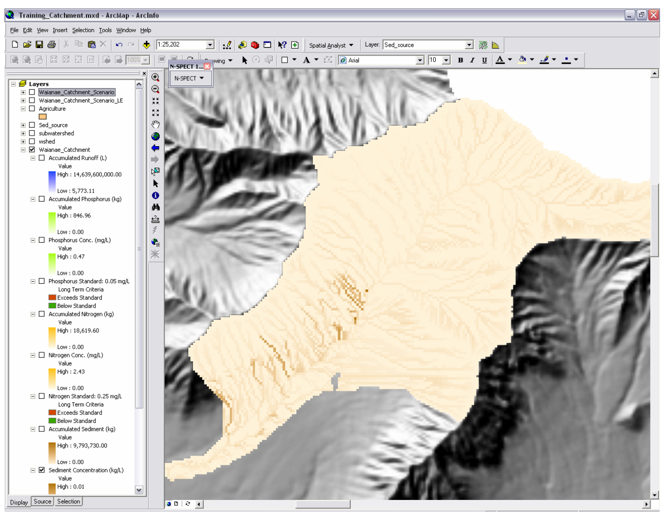


Exercise 3 – Subcatchment Scale Scenario Implementation

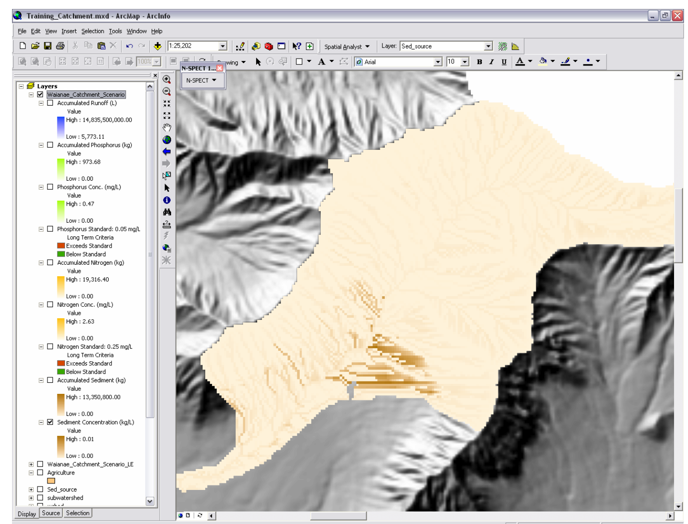
Evaluate Differences

There are several different ways to assess differences between the unchanged and changed analyses. Visual inspection of sediment concentration grids reveals distinct differences in the area where land cover was changed from a scrub/shrub and forest mixture to cultivated land. The following steps will focus on a percent change analysis of accumulated sediment.

Since this is a historic analysis, or a look back in time, the expression used to compare the two accumulated sediment grids assumes that Acc Sed Scenario (kg) is the state from which the water quality conditions have changed. Therefore, the percent change produced is in reference to the state of the water quality when the agricultural operation existed. All other land cover is held constant, and is assumed to have been invariant through time.



Sediment concentration without change.



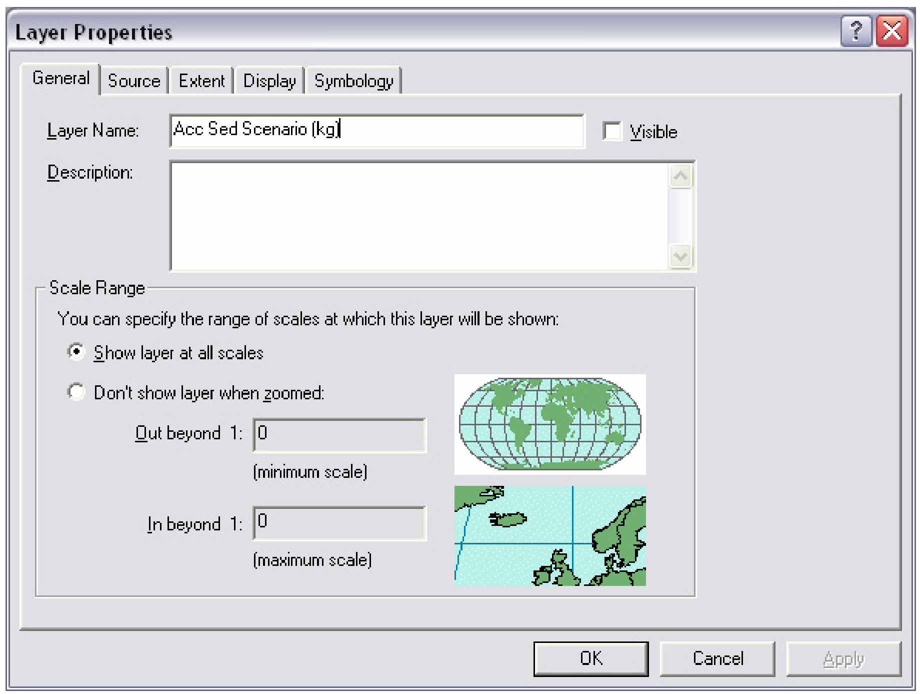
Sediment concentration with scenario implementation.

Exercise 3 – Subcatchment Scale Scenario Implementation

Prepare Grids for Comparison

The grids displayed in the Raster Calculator are listed by the name used in the ArcMap table of contents. N-SPECT groups grids based upon the name of the analysis used to produce them. Therefore, to compare two grids with the same name, the names have to be changed. This can be done in the **Layer Properties** under the **General** tab.

8. Change the name of the accumulated sediment grid in the **Waianae_Catchment_Scenario** group layer to **Acc Sed Scenario (kg)** (right-click on the data layer and select Properties).



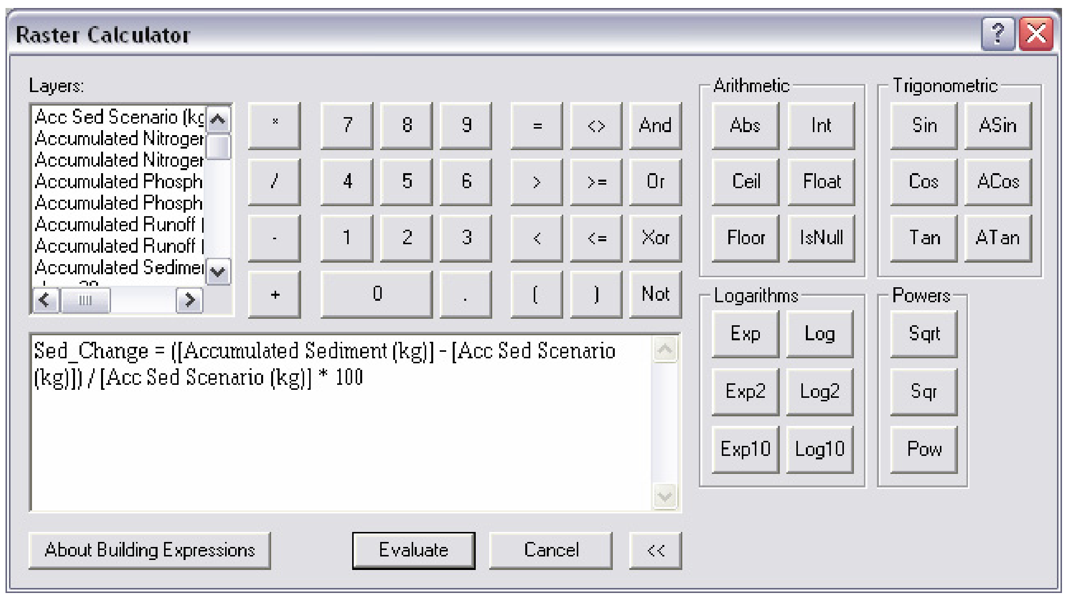
Exercise 3 – Subcatchment Scale Scenario Implementation

Compare Results

The Raster Calculator is a very useful tool for comparing two different grids. Simple functions can be written to extract various descriptions of change between baseline and alternative N-SPECT outputs. The following expression calculates the percent change of accumulated sediment in Makaha Valley. Areas not hydrologically connected to the land use scenario should exhibit 0 percent change.

9. In the Raster Calculator, enter the following expression:

Sed_Change = 100 * ([Accumulated Sediment (kg)] - [Acc Sed Scenario (kg)]) / [Acc Sed Scenario (kg)]

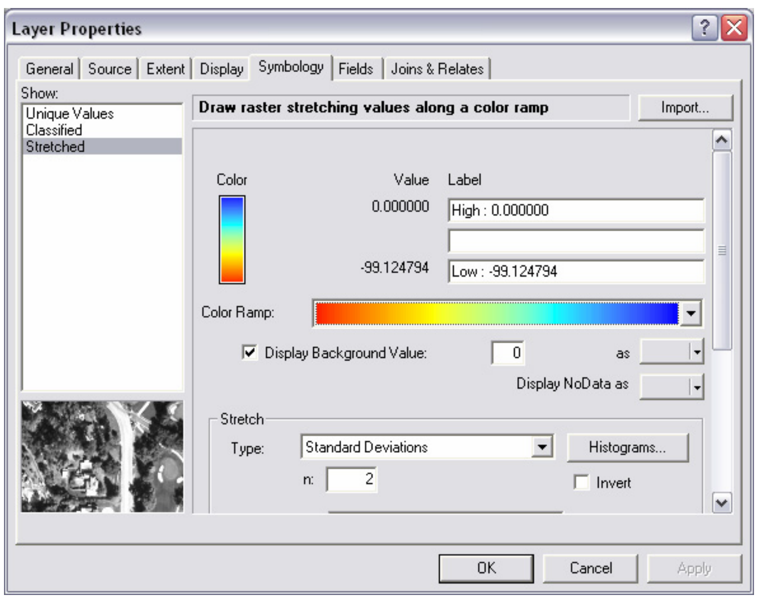


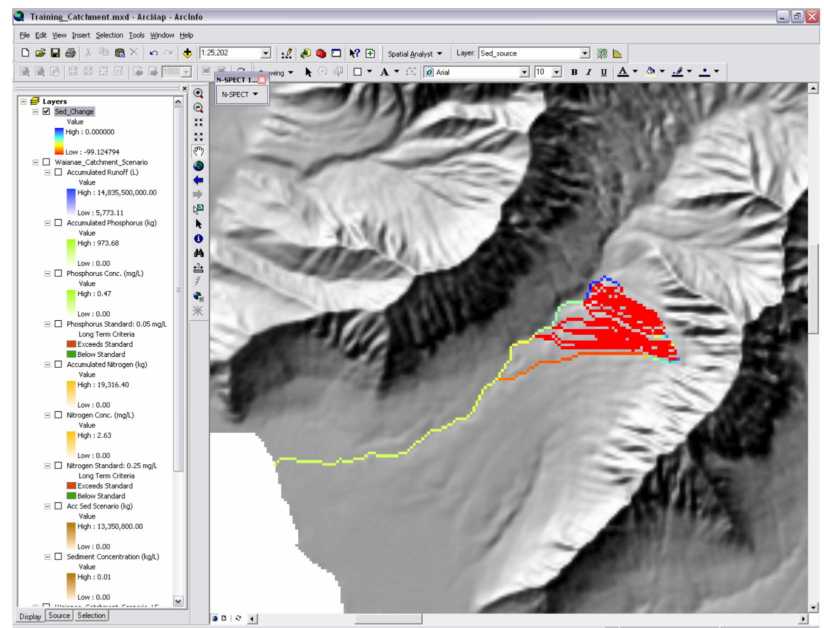
Exercise 3 – Subcatchment Scale Scenario Implementation

Compare Results

10. The display can be adjusted (to eliminate all pixels that didn't experience change) by opening the symbology tab in the layer properties and selecting **Display Background Value** of **0** as **No Color**.
11. A different color ramp can also be selected to help separate magnitudes of change.

The resulting display contains negative values, which represents a net decrease in accumulated sediment load from a time when the back of the valley was agriculture to the current state in which it is a mixture of scrub/shrub and forest. In reality, the conversion from agricultural to natural land covers progresses through time and this analysis simply portrays two possible snapshots in time.





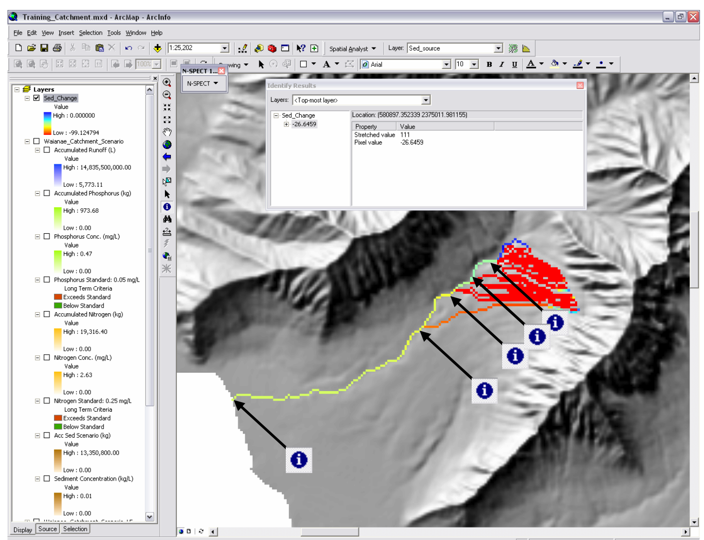
Exercise 3 – Subcatchment Scale Scenario Implementation

Compare Results

The net effects of small scale land cover changes vary throughout the landscape. Note how the percent change values are very high in the near vicinity of the land cover change, and are lower in the main stream channel. This highlights the dilution effects of upstream waters and contributing sediment loads.

12. The Identify Tool  can be used to query individual cells. Use it to observe the dilution effects at various points throughout the landscape, from the stream mouth to the land cover change area.

The change detected at the mouth of the stream is lower (in magnitude) than the change detected where the runoff from the land cover change area enters the stream. The cells along the main stream channel downstream of each "tributary" show slight increases in the magnitude of change due to the hillslope contributions delivered by those tributaries.



Summary

When combined with various data sources and local knowledge, the data produced by N-SPECT can be used quite effectively for regional, catchment, and subcatchment scale water quality assessments. In addition, scenario analyses allow potential land use and land cover changes to be modeled. These exercises introduced the user to the basic functions within N-SPECT and introduced standard GIS methods that are useful for displaying and analyzing data.

However, there are aspects of the natural environment that N-SPECT does not model!

Stochastic sediment inputs (landslides)

Stream diversions

Ground water inputs

Photos courtesy of U.S. Geological Survey