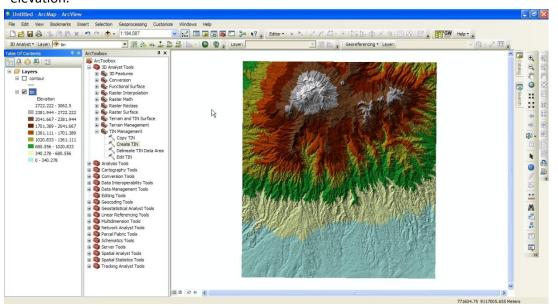
16) After "contour" layer is chosen, on column "height\_field", choose Elevation, and on "tag\_field" column, choose <None>. Click OK button.

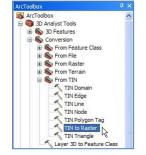
Create TIN Dutput TIN K:\SABO IV\Data source f patial Reference (optional WGS_1984_UTM_Zone_4 nput Feature Class (option	9S	ün			Create TIN Output TIN K:\SABO IV\Data source Spatial Reference (option: WGS_1984_UTM_Zone_' Input Feature Class (optic	49S	ata\tin			
in_feature_class	height_field       Shape.Z                      Shape. M       Elevation	SF_type hardline	tag_field <none></none>	+ * *	in_feature_class	height_field Elevation	SF_type hardline	tag_field <none> <none> FID Elevation</none></none>	~	+ × ↑ +
Constrained Delaunay (	optional)				Constrained Delaunay					

17) The process of TIN making will take some time. Various process of ArcGIS can be seen based on indicator that appear on bottom right corner of ArcMap workspace like as figure below.
...Create TIN...Creat ③ 796151.139

18) Here is a view of the resulting TIN. The colors shown are a representation of the range of elevation.



Digital Elevation Model (DEM) is a digital data describing the geometry of the earth's surface. This data was obtained through the processing of TIN data.
 On ArcToolbox window, click symbol + on 3D Analyst Tools → Conversion → From TIN, double click TIN to Raster. Next will appear TIN to Raster window.



20) On Input TIN combo box, choose "tin" layer.

1	IN to Raster	
•	put TIN	
	OK Cancel Environments Sh	ow Help >>

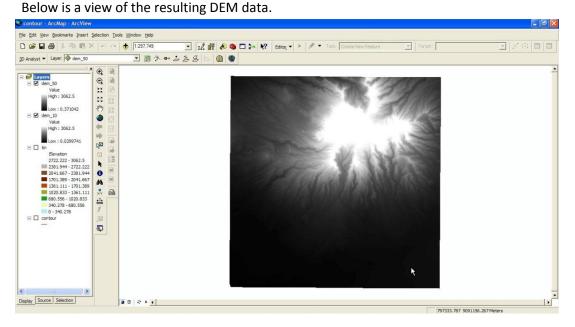
21) On Output Raster text box, click 🖻 button. Next will appear Output Raster window. Save the file into the folder: Data source for training/02 Contour data. On the Name text box, write "dem\_50". Click Save button.

Output Ra	ister	×
Look in:	🖆 02 Contour data 🛛 🕑 🚖 🏠 🗔 🏢 🔹 😂 🗳	٩
		-
Name:	dem_50 Save	
Save as typ	e: Raster datasets Cancel	5

22) On Output Data Type text box, choose FLOAT; on Method text box, choose LINEAR; on Sampling Distance text box, choose/write CELLSIZE 50. Click OK button on TIN to Raster window.

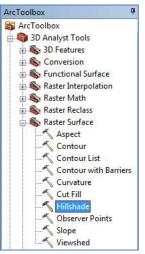
Input TIN	
tin	I 🗃
Output Raster	
K: \SABO IV\Training SOURCE\Data sourve for training	\02 Contour data\dem_50
Output Data Type (optional)	
FLOAT	~
Method (optional)	
LINEAR	~
Sampling Distance (optional)	174
CELLSIZE 50	*
Z Factor (optional)	
	1

23) We need two DEM with different pixel size that are 50m and 10m. Therefore, do the procedures refer to steps 19 – 22, but change the value of Sampling Distance become CELLSIZE 10, and then give the name as "dem\_10".
Below is a view of the resulting DEM data



## Step 2. Making hillshade view

1) To making hillshade vies, on Arc Toolbox window, click symbol + on 3D Analyst Tools  $\rightarrow$  Raster Surface, and then double click Hillshade.



2) Next will appear Hillshade window. On Input raster combo box, choose "dem\_10" layer.



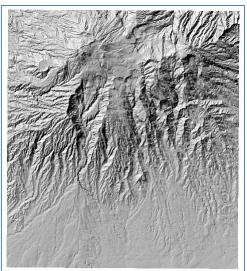
3) On Output raster text box, click is symbol, save the file into folder: Data source for training/02 Contour data. On Name text box, write "hillshade\_10". Click Save button.

Output raste	r 🔀
Look in:	02 Contour data 💽 🐁 🯠 🕼 👬 🕇 😂 ն ն
Name: Save as type:	hilshade_10

4) Click OK button on Hillshade window.

nput raster	
dem_10	⊥ 🖻
utput raster	
/\# Training SOURCE #\new results\02 Conto	ur data (hillshade_10 🔂
zimuth (optional)	
	315
ltitude (optional)	
	45
Model shadows (optional) factor (optional)	
	1

5) The hillshade view is as below.



### Step 3. Making slope data

1) To make slope data, on Arc Toolbox window, click symbol + on 3D Analyst Tools  $\rightarrow$  Raster Surface, and then double click Slope. Next will appear Slope window.

ArcToolbox	<b>P</b>	
🚳 ArcToolbox		
3D Analyst Tools 3D Features	* Slope	
Sonversion     Surface	Input raster	
<ul> <li>Sector State State</li> <li>Sector State</li> <l< td=""><td>Output raster</td><td> <b>≝</b></td></l<></ul>	Output raster	<b>≝</b>
Kaster Reclass     Kaster Surface	Output measurement (optional)	
Aspect	Z factor (optional)	1
Contour List Contour with Barriers Curvature Cut Fill Hillshade Observer Points	L	×
Slope Viewshed	OK Cancel	Environments Show Help >>

2) On Input surface combo box, choose "dem\_10" layer.

*\ Slope	
Input raster  I	
	Help >>

3) On Output raster text box, click 🖻 symbol, save the file into folder: Data source for training/02 Contour data. On Name text box, write "slope\_10". Click Save button.

Output raste	r								×
.ook in: 🛛 🚞	02 Contour data	~	仓 🟠	1	•	21	2	ŭ	6
iiii dem_10 dem_50 iiii hillshade_10	i								
Name:	slope_10					] (	Si	ave	
Save as type:	Raster datasets				~		Ca	ncel	

4) Make sure the Output measurement combo box choose DEGREE. Click OK button on Slope window.

Input raster	
dem_10	- 🖻
Output raster	
O IV\# Training SOURCE #\new results\02 Contour data\slope	_10 🔁
Output measurement (optional)	
DEGREE	~
Z factor (optional)	
	1

5) Do steps 1 – 4 above to obtain slope data from processing dem\_50 data (pixel size 50m). Give the file name with "slope\_50".

## Step 4. <u>Making flow direction data</u>

 The first step in hydrology analysis is making flow direction data. On Arc Toolbox window, click symbol + on Spatial Analyst Tools → Hydrology, double click Flow Direction. Next will appear Flow Direction window.

Source Conditional     Source Conditional     Source Conditional	* Flow Direction	
Distance		
Extraction	Input surface raster	
🕀 🎭 Generalization	JI Output flow direction raster	- 🖻
💿 🗞 Groundwater	Output now direction raster	
🖨 🌑 Hydrology		B
Basin	Force all edge cells to flow outward (optional)	
Fill	Output drop racter (optional)	
	Output drop raster (optional)	-
Flow Accumulation	Output drop raster (optional)	
Flow Accumulation	Output drop raster (optional)	
Flow Accumulation	Output drop raster (optional)	
Flow Accumulation	Output drop raster (optional)	
Flow Accumulation	Output drop raster (optional)	_ d

2) On Input surface raster combo box, choose "dem\_10" layer.

* Flow Direction	
Input surface raster      slope_10     slope_50     hilshade_10     dem_10     dem_50     k	e) e)
	Help >>

3) On Output flow direction raster combo box, click est symbol, save the file into folder: Data source for training/02 Contour data. On Name text box, write "flowdir\_10". Click Save button.

output flo	w direction raster				
ook in:	🛅 02 Contour data	*	仓值	• 8	1 🛍 🍯 🍫
iiii dem_10 dem_50 iiii hillshade_ slope_10 iiii slope_50					
Name:	flowdir_10				Save
Save as type	Raster datasets			 ~	Cancel

4) On Flow Direction window, click OK button.

Flow Direction	
Input surface raster	<u>^</u>
dem_10	- 🖻
Output flow direction raster	
IV\# Training SOURCE #\new results\02 Contour data\flowdir_	10 🔁
	2
OK Cancel Environments Sh	now Help >>

Do steps 1 – 4 above to obtain flow direction data from processing dem\_50 data (pixel size 50m). Give the file name with "flowdir\_50".

6) Here is a view of flow direction data.

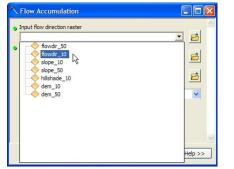


## Step 5. <u>Making flow accumulation data</u>

1) The next step is making flow accumulation data. Click Flow Accumulation on Hydrology toolbox. Next will appear Flow Accumulation window.

🗐 🧠 Spatial Analyst Tools		
🕀 🇞 Conditional		
🕀 🇞 Density		
🗉 🚳 Distance		
Extraction	K Flow Accumulation	
🗉 🗞 Generalization		~
🗊 🗞 Groundwater	Input flow direction raster	
Hydrology	Output accumulation raster	
Basin	output accumulation naster	2
	Input weight raster (optional)	
S Flow Accumulation	v	0
Flow Direction	Output data type (optional)	
	FLOAT	~
Sink		
Snap Pour Point	R	
Stream Link	n,	
Stream Order		~
Stream to Feature		
Watershed	OK Cancel Environments Show F	telp >>

2) On Input flow direction raster combo box, choose "flowdir\_10" layer.



3) On Output accumulation flow raster text box, click 🖻 symbol, save the file into folder: Data source for training/02 Contour data. On text box Name, write "flowacc\_10". Click Save button.

Output a	accur	nulation raster							
Look in:		02 Contour data	~	仓	1	•	1	20	
dem_: dem_5 flowdii flowdii hillsha iiii slope_ iiii slope_	50 r_10 r_50 de_10 _10								
Name:		flowacc_10						Save	
Save as t	ype:	Raster datasets				~		Cano	el

4) On Flow Accumulation window, click OK button.

Flow Accumulation		L	
Input flow direction raster			-
flowdir_10		•	B
Output accumulation raster			
[V\# Training SOURCE #\new resu	ts\02 Contour dat	a\flowacc_1d	1
Input weight raster (optional)			
		•	0
Output data type (optional)			
FLOAT			~
OK Cancel	Environments	s Show H	ielp >>

- 5) Do steps 1 4 above to obtain flow accumulation data from processing slope\_50 data (pixel size 50m). Give the file name with "flowacc\_50".
- 6) Here is a view of flow accumulation data.



7) To save the workspace, click Save 🖬 button on Standard toolbar, or press Ctrl+S button on computer keyboard. Save the MXD file into folder: Data source for training\02 Contour data, give the name file "contour", and then click Save button.

# I.3. Georeferencing geological map and digitations geological elements

## Step 1. <u>Georeferencing geological map</u>

- 1) Open/run ArcMap, choose Blank Map.
- 2) To set the projection and coordinate system of ArcMap workspace, right click Layers in Table of Contents and then click Properties. Next will appear Data Frame Properties window.
- 3) Click Coordinate System tab.

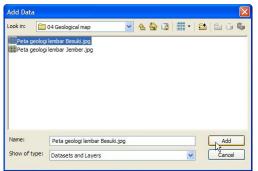
eature Cache Annotation Grou	ps	Extent Indicators	Fran	me	Size	and Position
General Data Frame	Co	ordinate System	Illu	minati	on	Grids
Current coordinate system:		G				
No projection			<u> </u>		Cle	ar
Select a coordinate system:		×	9	Tra	nsform	nations
Favorites					Modi	
			l		Impo	rt
			(		Ne	w <del>-</del>
			1	Ad	ld To F	avorites
				Remo	ve Fro	m Favorites

4) On part Select a coordinate system, click symbol + on Predefined  $\rightarrow$  Geographic Coordinate System  $\rightarrow$  World, and choose WGS 1984. Click OK button on Data Frame Properties window.

ature Cache Annotation Groups Exten	t Indicators Frame	Size and Position	Feature Cache Annotation Gr	oups Extent Indicators	Frame	Size and Positi
General Data Frame Coordinate			General Data Frame	Coordinate System	Illuminatio	
urrent coordinate system:			Current coordinate system:			
GCS_WGS_1984 Datum: D_WGS_1984	<u>^</u>	Clear	GCS_WGS_1984 Datum: D_WGS_1984		<u> </u>	Clear
elect a coordinate system:	∑ Tra	nsformations	Select a coordinate system:	5		nsformations
Pavorites     Prodefined     P		Modify Import New  td To Favorites ve From Favorites		2 TBE	Ad	Modify Import New d To Favorites

At this time, ArcMap workspace has had projection system of WGS 1984 and LatLon coordinate system.

5) Click Add Data 💁 button. Enter into folder: Data source for training\04 Geological map, choose file "Peta geologi lembar Besuki.jpg", and then click Add button.



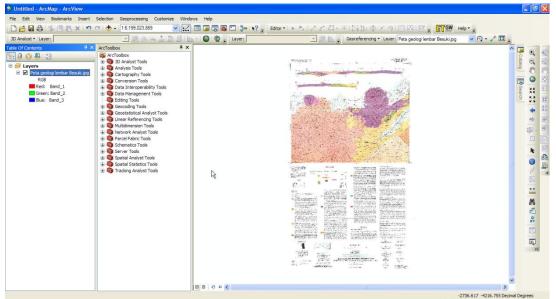
6) If data that will be inserted into the ArcMap workspace is a raster data, there will be a confirmation whether we want to create a "pyramid" for this data. Making pyramid is useful to smoothen the process of data loading and zooming. Click the Yes button.

This raster data so rarying resolution:		s not have py	ramids. Pyra	mids allow f	or rapid display a
		d building may uld you like to			
	***	did you inte to	Create pyr	annua :	
Help		Yes		No	Cancel

7) Raster file that we will enter, not yet have a geospatial reference, so there will appear a message like below. Click OK button.

The following data sources you added nformation. This data can be drawn in	
Peta geologi lembar Besuki jpg	

8) The following is a geological map that are inserted.



9) Because the geological map has not georeferenced yet, so for georeferencing purpose we need Georeferencing toolbar. Right click on any empty space on ArcMap workspace and then click Georeferencing.



10) Next, will appear Georeferencing toolbar as below. Place the toolbar on the upper side of ArcMap workspace.



11) On Georeferencing toolbar, make sure that file that is chosen on Layer combo box is the data that will be georeferenced. This should be considerable concern if there are several image layers on the Table of Contents. On this step, layer that should be chosen is "Peta geologi lembar Besuki" layer.

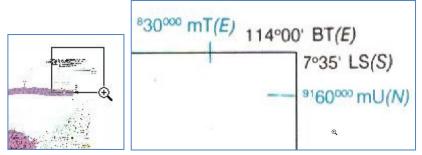
<u>G</u> eoreferencing $ imes$	Layer:	Peta geologi lembar Besuki jpg 🔀	$\odot$	•	*	:::	
--------------------------------	--------	----------------------------------	---------	---	---	-----	--

12) To choose georeference method, click Georeferencing button, and click Auto Adjust.



13) To make this geological map become georeferenced, we will make actual coordinate of fourframe corner of the geological map.

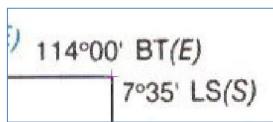
Click Zoom In button on Tools toolbar, and then zoom the upper right corner of geological map frame until the corner can be seen clearly.



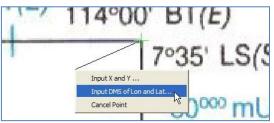
14) To start georeferencing process, click Add Control Points button on Georeferencing toolbar.

Georeferencing 🔻	Layer:	Peta geologi lembar Besuki jpg 💌 🕠 💌	+	
				S Add Control Point

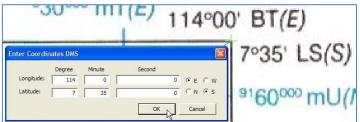
15) Point the + cursor, as precise as possible to upper right corner of geological map frame, and then click one time.



16) After the + cursor becomes green and attached on the upper right corner of geological map frame, right click on any space. There will appear an option to input the coordinate. Choose Input DMS of Lon and Lat.



17) On Enter Coordinates DMS window, write on the text box the value of Longitude and Latitude according to lat long value of the geological map frame. Click OK button.



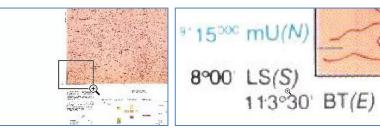
Because the georeferencing method that we choose is Auto Adjust, so after we press OK button, on Enter Coordinates DMS window, the geological map will move according the actual position of the upper right corner of geological map frame.

18) Right click "Peta geologi lembar Besuki" layer, then click Zoom To Layer. At this time, the ArcMap workspace will show "Peta geologi lembar Besuki" layer as a whole.

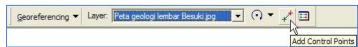


19) When finished setting the actual coordinates of the upper right corner, next we set the actual coordinates of the lower left corner of the geological map. The procedure according to the step 1:13 - 1:17 above.

Click the Zoom In button on the toolbar Tools, and then zoom the lower left corner of the frame until the corner of the geological map is clearly visible.



20) Click the Add Control Points button on the Georeferencing toolbar.



21) Move + cursor as precisely as possible with the lower left corner of the geological map frame, then left click one time.



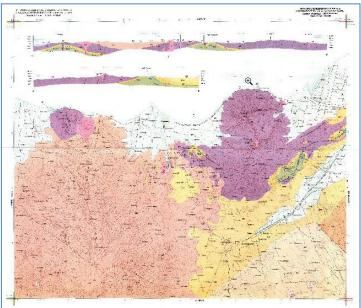
22) Once the green + cursor attached to the frame corner of geological map, right click in any place. There will appear an option to enter the coordinate. Select Input DMS of Lon and Lat.



23) On Enter Coordinates DMS window, fill in the fields of Latitude and Longitude, according to latitude and longitude value of frame corner of the geological map. Then click OK button.



24) Repeat the procedure according with Stage 1:13 – 1:17 or Stage 1:18 – 1:23 for upper left corner and bottom right corner of geological maps frame. The figure below shows the four corners of the geological map frame that has set the actual coordinates.



25) To see the error rate of coordinates setting, click 🔲 button on Georeferencing toolbar to bring up Link Table window. Column "Residual" shows the error values contained in each frame corner. We can see the total Root Mean Square (RMS) error on the lower right corner. All units of this value is in degrees.

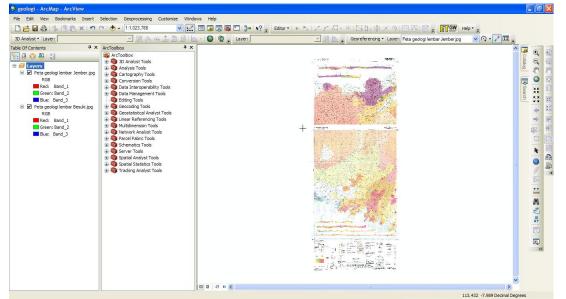
Click OK button to continue.

	Link	X Source	Y Source	X Map	Ү Мар	Residual
3 175,906123 -310.020539 113.500000 -7.583333 0.00055 4 4529,925399 -3928.832733 114.000000 -8.000000 0.00055		4526.877078	-279.910613	114.000000	-7.583333	0.00055
4 4529.925399 -3928.832733 114.000000 -8.000000 0.00055	2	191.960819	-3944.804427	113.500000	-8.000000	0.00055
		175.906123	-310.020539	113.500000	-7.583333	0.00055
	4	4529.925399	-3928.832733	114.000000	-8.000000	0.00055
	<					

26) To set the final stage georeference, click Georeferencing button, then click Update Georeferencing. Once this button is pressed, all the red/green + on the four-frame corner, geological map will disappear.

	Geo	referenc	ing 🔻	Layer:	Peta	
		Update	Geore	ferencing		
1		Rectify				
		Elt To D	isplay			
1.5		Flip or E	otate		•	
		Transfo	rmatio	n	•	
and a	~	Auto Ad	ljust			
531		Update	<u>D</u> isplay	<i>i</i>		
-		Delete	<u>C</u> ontrol	Points		
-		Reset T	ransfo	rmation		

- 27) In total there are four geological maps that should be georeferenced. Therefore do the georeference procedure according with step 1.5 Phase 1:17.
- 28) The following is a view of two geological map after going through stages of georeferenced.



29) Save the ArcMap work in the folder: Data source for training\04 Geological map, with the name "Geologi.mxd".

### Step 2. Digitize geological element

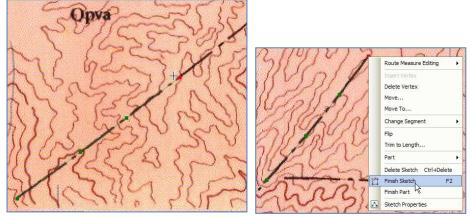
- There are two types of geological elements that will be digitized from geological map. Those element are lineament and fault. The procedure that will be used is refer to Chapter I.1 Step 2 which is procedure to make data if past landslide data.
- 2) By using Catalog that is on the right ArcMap workspace, make a new shapefile with the name of "lineament", feature type: polyline, and coordinate system "WGS\_1984\_UTM\_Zone\_49S".
- 3) On Editor toolbar, click Editor button and click Start Editing.
- 4) Next will appear Start Editing window that give information that the coordinate system of lineament (UTM 49) is different with the coordinate system of ArcMap workspace (lat-long). This is no problem because both still in the same projection system (WGS 84). Click Continue button to continue.

) ke		
	lurusan	Spatial reference does not match data frame.

5) On Create Features window, click lineament; and on Construction Tools window, click Line.

	- ×
Construction Tools	
/ Line fbs	
Rectangle	
O Circle	
O Ellipse	
2 Freehand	

- 6) Zoom-in in such a way the geological map so the objects on the map such as lineament and fault can be seen clearly.
- 7) Find the lineament object, and begin the digitization process by following the lineament object. After completion of the digitized object, press F2 key.



Find another lineament object on the study area, and start again the digitations process.

- 8) Once all the lineament objects of the study area has been completed digitized, on Editor toolbar, click Editor button, click Save edits, and click Stop Editing.
- 9) According to the geological map, the areas covered in the study area does not have fault data, so the fault data can be skipped.
- 10) For the purposes of this training, we use the file "kelurusan ref.shp" contained in the folder: Ref.
- 11) Save the ArcMap workspace into folders: Data source for training\04 Geological map. Give it the name "Geologi.mxd".

# I.4. Making basin, Catchment area and sub-area

Catchment area is an area of land, which is a unity with the river and its tributaries, which serve to accommodate, store, and stream water originating from rainfall to the lake or the sea naturally, where the boundary on land is topographical separators and the boundary at sea until the waters are still affected land activities.

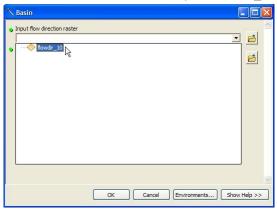
Basin or micro-watershed is a hollow in the landscape where the water flows in a ditch. Catchment area is an amalgamation from several basin.

#### Step 1. Making basin data

- 1) Open/run ArcMap, choose Blank Map.
- 2) Enter "flowdir\_10" data from the folder: Data source for training/02 Contour data.
- 3) On Arc Toolbox window, click + symbol on Spatial Analyst Tools → Hydrology, then double click Basin. Next will appear Basin window.

	🔨 Basin 🗼	
	<ul> <li>Input flow direction raster</li> </ul>	A
	) Output raster	<b>≥</b>
Hydrology		
Sink		
		Cancel Environments   Show Help >>
		Cancer Convoluments Show Help >>

4) On combo box Input flow direction raster, choose layer "flowdir\_10".



5) On text box Output raster, click 🖾 symbol, save the file into the folder: Data source for training/02 Contour data. On text box Name, fill in with the name of "basin". Click Save button.

Output raster 🛛 🛛 🕹								
.ook in:  🚞	02 Contour data	~	仓 🟠		•	8	<b>C U</b>	6,
## dem_10 ## dem_50 ## flowacc_10 ## flowacc_50 ## flowdir_10 ## flowdir_50 ## illishade_10 ## illishade_50 ## slope_10								
Name:	basin				7		Save	
Save as type:	Raster datasets				~	1 1	Cancel	