Calculation of Gradient

B-006-OWQ-WAP-XXX-24-T-R2
Technical Standard Operating Procedure (TSOP)
Office: Office of Water Quality
Branch: Watershed Assessment and Planning Branch
Section: All

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Purpose

This technical standard operating procedure (TSOP) provides instructions in using Esri's ArcGIS software to calculate gradients for sampling sites. Gradient for a stream location is the drop in elevation between topographic lines for a minimum of one square mile. Gradient is used in the Qualitative Habitat Evaluation Index (QHEI) and biological indices.

Scope

This TSOP applies to agency staff in the Office of Water Quality (OWQ) Watershed Assessment and Planning Branch (WAPB) who are responsible for calculating gradient and performing quality control (QC) of the measurements.

Authorizing Signatures

I approve and authorize this technical standard operating procedure:

Logan McHenry — 12/18/2024
Logan McHenry, Environmental Manager — Date
Office of Water Quality, Technical and Logistical Services Section

Paula Kaszynski — 12/18/2024
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This TSOP is consistent with agency requirements.

April Fetts — 12/18/2024
Quality Assurance Staff — Date
Office of Program Support

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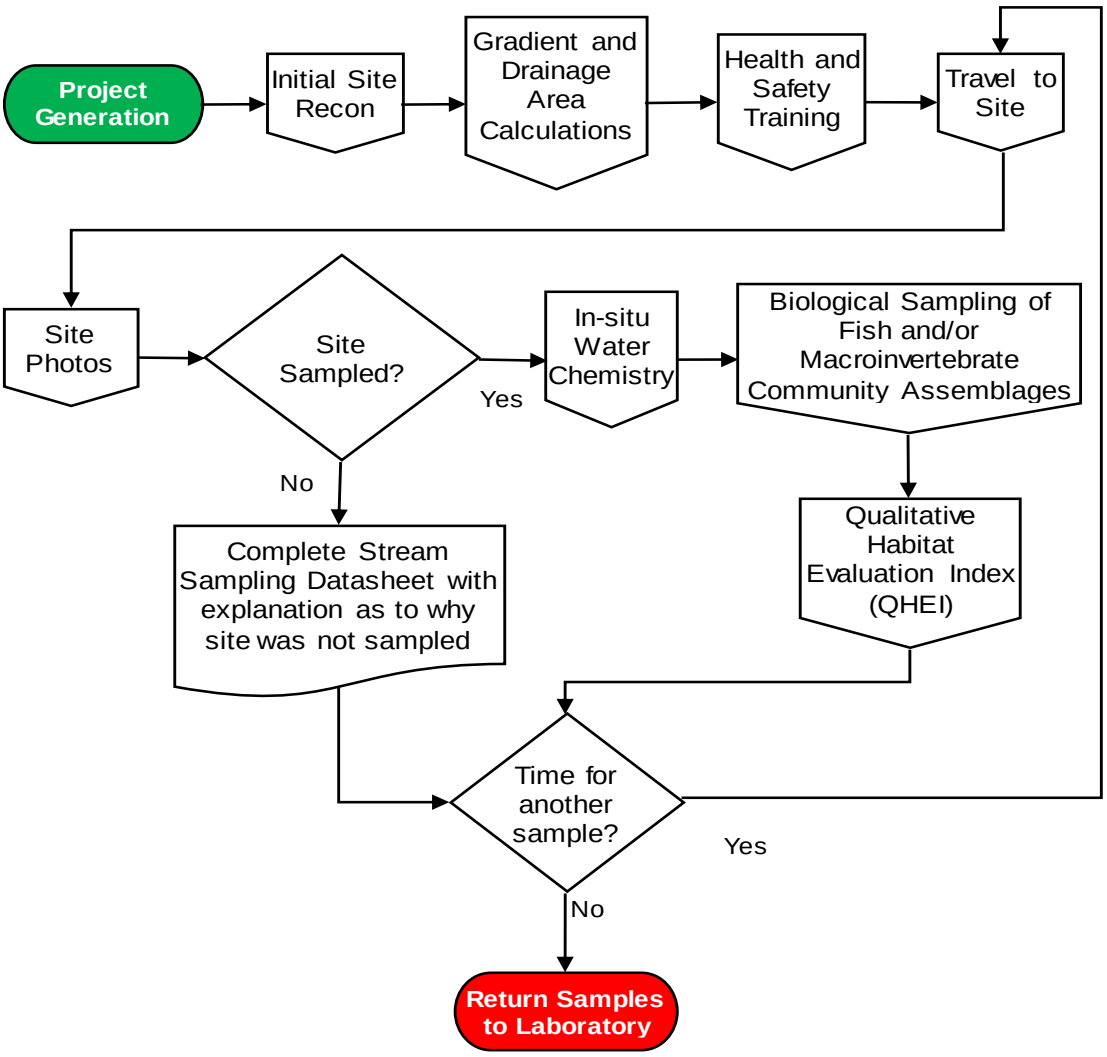
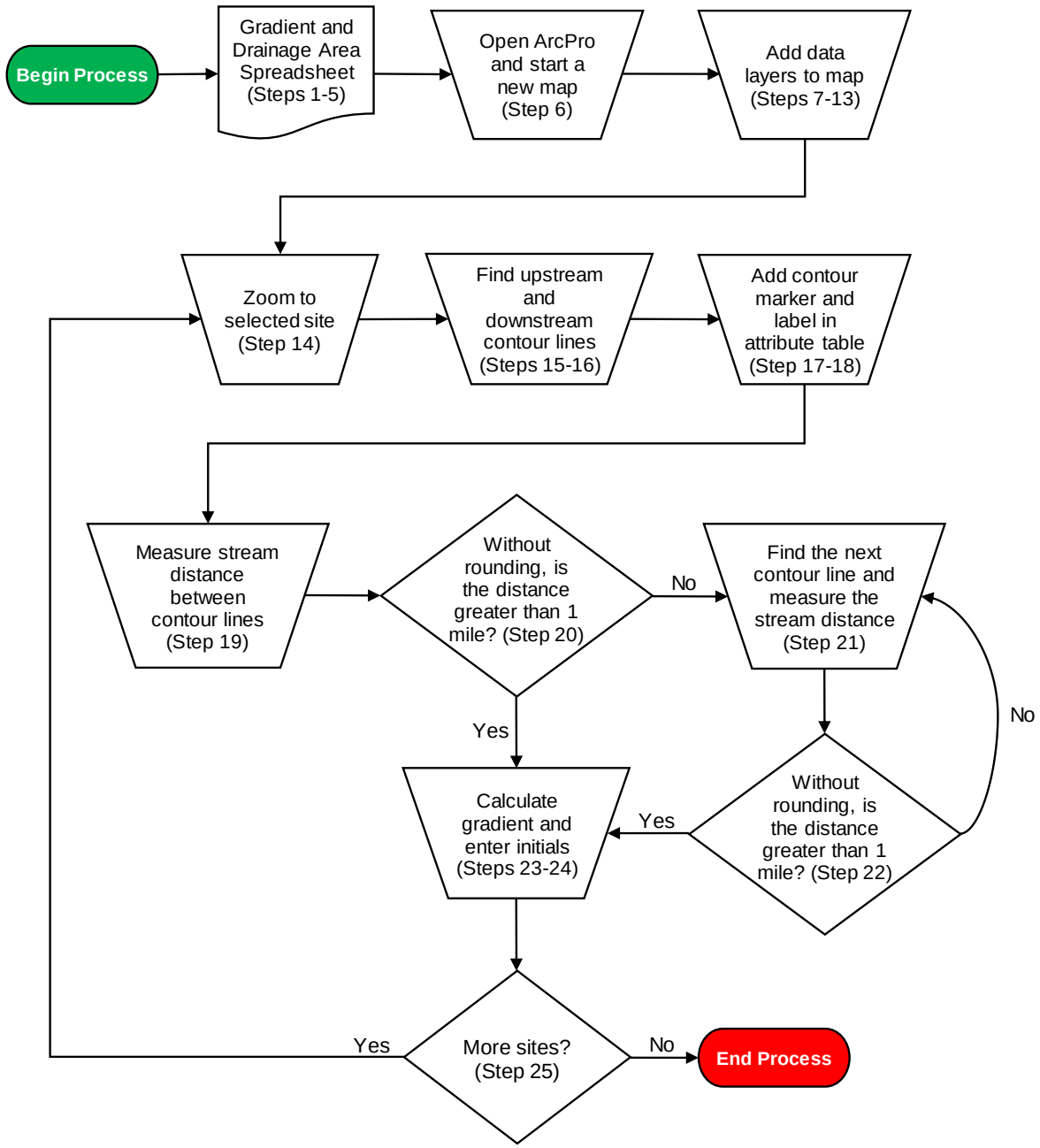
1.0. Overview Flowchart



2.0. Procedure

2.1. Procedural Flowchart



2.2. Procedural Steps

Step 1. A WAPB staff member completes all steps. Query the following site data from the Assessment Information Management System (AIMS) database: Latitude, Longitude, L-Site, Waterbody_Name, Description, Site Number, UTM_EAST, and UTM_NORTH. Save the unaltered queried data using a filename which includes the year and sampling basin, such as 2024UpperWabash_GradientDrainageArea_GIS.
Note: Check with other staff to determine whether this document was previously created, to prevent duplicating an existing file.

Step 2. Create a new Microsoft Excel spreadsheet with the column headers SiteID, Waterbody_Name, L-Site, Site Description, Latitude, Longitude, UTM_EAST, and UTM_NORTH for sites approved through site reconnaissance (Appendix A). Save the file in the project folder on the shared drive using a filename which includes the year and sampling basin, such as 2024 Upper Wabash Gradient and Drainage Area.

Note: The spreadsheet created to record drainage area (mi^2) values is the same spreadsheet used to record gradient values. Check with other staff to determine whether this document was created previously to prevent duplicating an existing file.

Step 3. Add columns for Gradient, Gradient QC1, Gradient QC2, Drainage Area (mi^2), Drainage Area QC1, and Drainage Area QC 2. Directly underneath the list of sites, add a row for Initials/Date. Staff filling in the Gradient and QC columns will initial and date the completed columns in the Initial/Date cell below the last calculation. Each set of columns should include three different initials.

Step 4. In the same spreadsheet, add columns for Site Number, Distance (mi), U/S elevation, D/S elevation, Gradient (ft/mi), and Pattern below the columns created in Step 2 and Step 3. Next, copy and paste the information from the Site Number column created in Step 2 into the Site Number column added in this step (Appendix B).

Note: This step is not necessary to calculate drainage area (mi^2). If a spreadsheet to record drainage area (mi^2) was already created, these columns may need to be added.

Step 5. Copy and paste the columns added in Step 4 next to those same columns. Copy and paste twice, with a single column separating each new set of columns. In the row above the three sets of

columns, label the set of columns Gradient Calculations, Gradient QC1, and Gradient QC2. The sets of columns will be used to help calculate gradients.

Step 6. Open ArcGIS Pro and start a new map.

Step 7. Add USGS National Map base map from the Portal to the map from Step 6. Click Map on the top ribbon menu. Click Add Data. Then go to ArcGIS Enterprise, search for and click on USGS National Map, then click Okay to add the basemap to your project (Figure 1).

Note: You may have to go into the basemap Properties and eliminate the In Beyond visibility scale (Right-click USGS National Map => General)

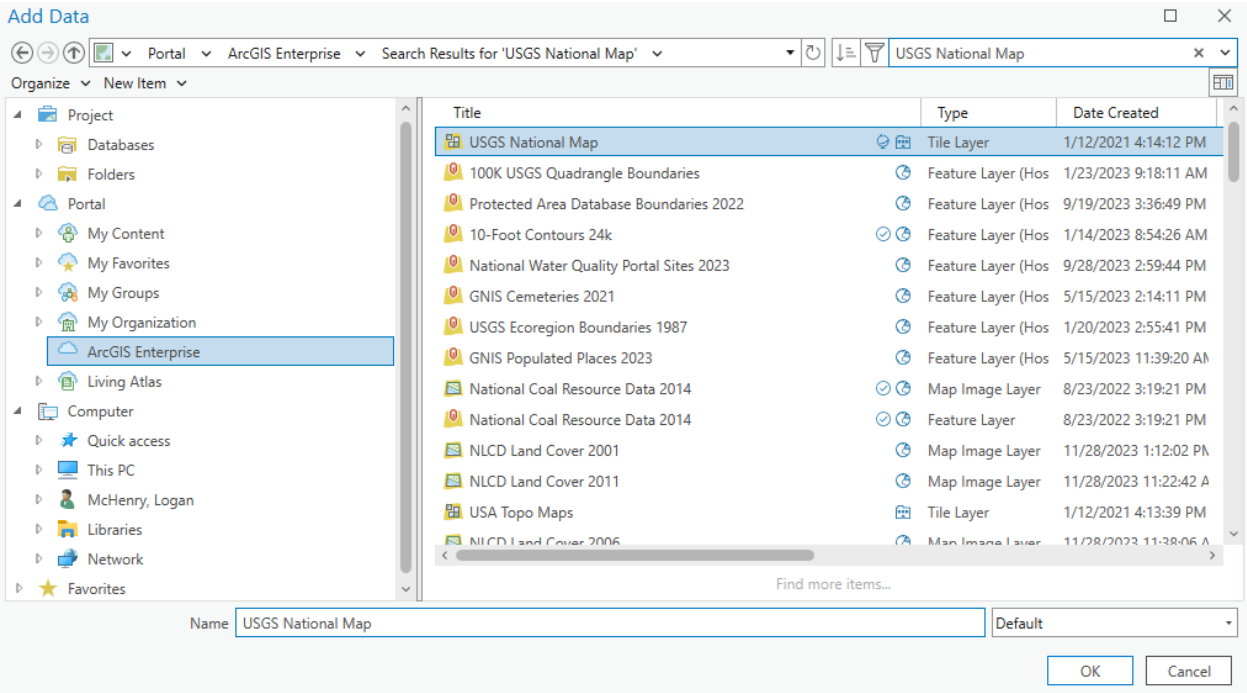


Figure 1

Step 8. Add a folder connection to the project folder on the shared drive.

In the Catalog pane, go to the Computer tab. Find the appropriate folder under the Shared (S) drive. Right-click on the folder and select + Add To Project. The project folder location will now appear in the Catalog menu, on the Project tab, under Folders (Figure 2).

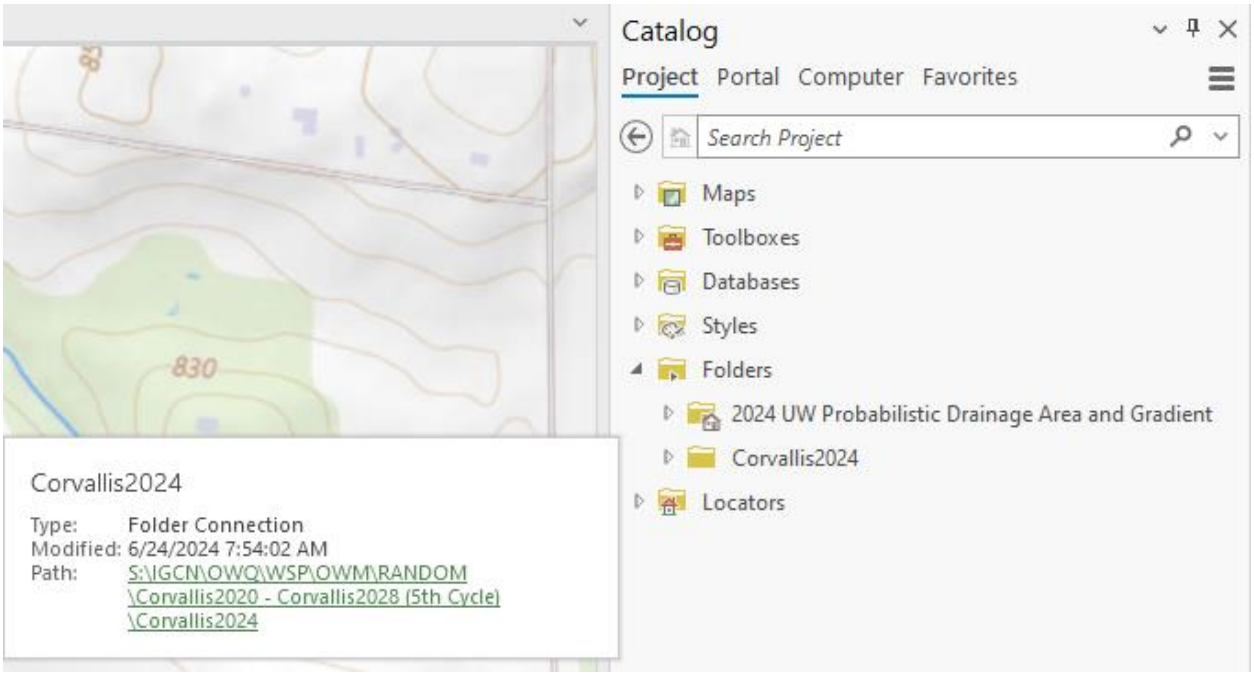


Figure 2

Step 9. Add the sites layer to the map by selecting the spreadsheet created in Step 1. Right click the spreadsheet and click Add To Current Map. Right click the standalone table in the Contents pane and click Display XY Data, which displays the sites as points. In the Display XY Data window, specify Easting for the X Field and Northing for the Y Field. Make sure the NAD 1983 UTM Zone 16N coordinate system has been assigned. When finished, click OK. The point feature class should automatically apply to your map and be saved in your project geodatabase. Next, find the new file in the project database. Right click the layer and click Rename. Rename the new shapefile using a filename which includes the year and sampling basin, such as 2024UpperWabash_ApprovedSites.

Notes: Check with other staff to determine whether this layer was previously created to prevent recreating an existing file.

Step 10. Two additional layers which can be added – a hydrography layer, such as Reach Index 2019 or NHD HighRes Flowline, and a layer displaying contour lines in vector form, USGS Topo (Figure 3) or 10-Foot Contours 24k from the Portal. These layers use digital line graphs (DLGs) to represent contour lines, which are created from downloading, projecting, and combining several data sets from the United States Geological Survey (USGS). This is helpful in areas where contour lines are not easily distinguishable nor labeled with elevation values, because using

the Identify tool on vector data pulls up the attribute information associated with a feature.

Note: Filenames may have changed from the time this TSOP was written.

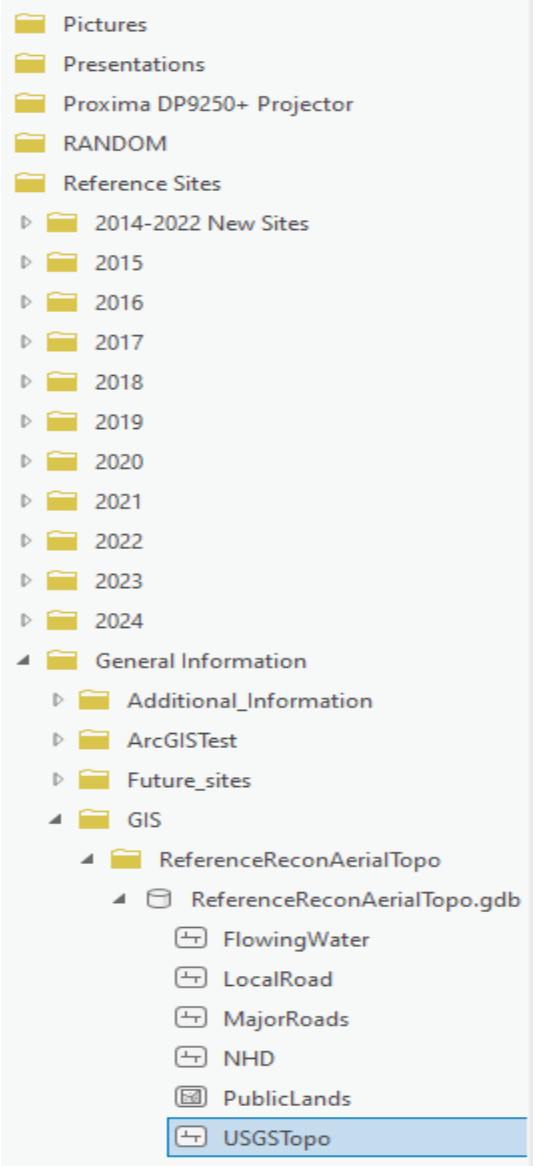


Figure 3

Step 11. Add a new Feature Class to the file geodatabase. Do this by right clicking the file geodatabase in the Catalog, clicking New, and then clicking Feature Class. This Feature Class will be used to add markers next to each contour used to calculate gradient. Name the new Feature Class using a filename which includes your initials and description, such as ABC_Contours. For Type select Point Features from the dropdown menu (Figure 4).

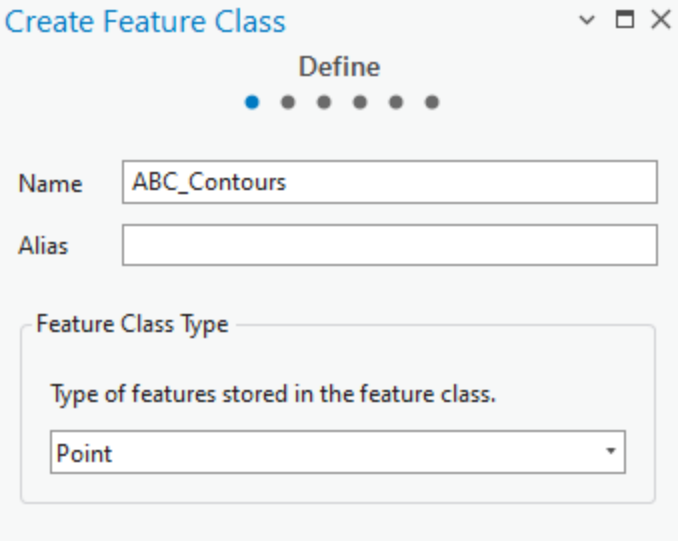


Figure 4

Step 12. Click Next. In the Field Name column type Label in the cell underneath SHAPE. In the Data Type column select Text from the drop-down menu (Figure 5). Click Next. Make sure the NAD 1983 UTM Zone 16N coordinate system has been assigned. Click Next three times. Click Finish.

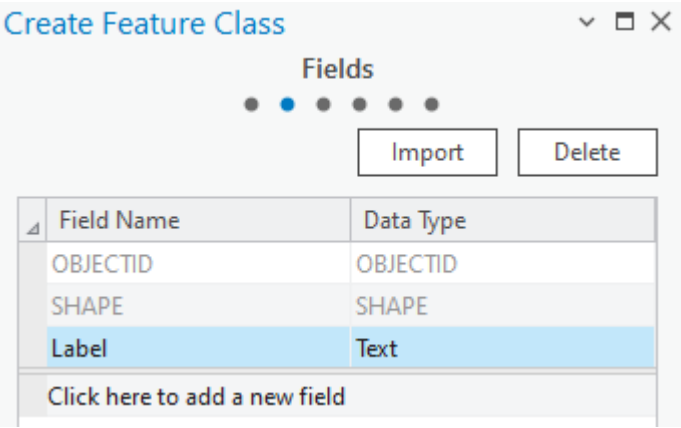


Figure 5

Step 13. Save the map document using a filename which includes the year and sampling basin, such as '2019 Ohio River Basin Gradient Calculations Map' so recreation of the map is not required if gradient calculations are not completed in one sitting.

Step 14. Open the attribute table of the sites layer and select a site; this will highlight the site's row in the table. Then use the 

button at the top of the attribute table window to navigate to the selected site.

Step 15. Use the scroll wheel on the mouse or the Zoom In button on the toolbar to get a closer look at the contour lines, which are shown

in purple on the USGS Topo layer. Pan for the contour line upstream and downstream of the site that fully crosses through the stream. For tributaries which join a larger stream, continue to look for the downstream contour line on the larger stream.

Step 16. Determine the contour interval. Contour lines are usually 10-foot intervals, but some areas are flat, like the Kankakee watershed, which may have 5-foot intervals. If utilizing the USGS Topo layer, use the Explore tool to help with contour intervals.

Step 17. At each contour line used to calculate gradient, add a contour marker. To add a contour marker, click the Edit toolbar. Then click the Create button  in the Features Group. The Create Features pane will appear. Select the Feature Class created in Steps 11-12. Click on the contour line on the map to place the contour marker.

Step 18. In the attribute table, label the contour markers created in Step 16 with a name which includes the Site Number, contour location in relation to site (upstream (US) or downstream (DS)), and contour line elevation. For example, the second contour marker downstream of site 9 could be labeled 9 DS 700.

Note: The attribute table for the feature class created in Steps 11-12 may not be open. To open the attribute table, right click the name of the contour marker feature class in the Contents pane. Then click Attribute Table.

Step 19. Zoom in to an extent where tracing along the stream is easily performed. Use the Measure tool to quantify the stream length (**not straight-line distance**) between the two contour lines in miles. Left click once to start and use as many points as deemed necessary to trace the stream from the first contour line upstream of the site to the first contour line downstream of the site. Double click to end the line. The distance will be displayed in the Measure Distance window.

Note: Make sure the units are in miles. It will most likely default to metric.

Step 20. Without rounding, is the distance greater than one mile?
If yes, proceed to Step 23.
If no, continue to Step 21.

Step 21. Follow the pattern of 1 upstream then 1 downstream; 2 upstream then 1 downstream; 2 upstream then 2 downstream; 3 upstream then 2 downstream; 3 upstream then 3 downstream; etc. For example, if the distance from one contour line upstream of the

site to one contour line downstream of the site is already measured, find the next contour line upstream of the site and measure the distance from two contour lines upstream of the site to one contour line downstream of the site. Always measure to the next contour line upstream before measuring to the next contour line downstream. The only exception to this rule is when the flowline ends upstream, then measure from one contour line upstream of the site to two contour lines downstream of the site, or more if necessary.

Step 22. Without rounding, is the distance greater than one mile?
If yes, proceed to Step 23.
If no, return to Step 21 and continue to the next part of the pattern.

Step 23. Enter the stream length, upstream elevation, downstream elevation, and pattern in the appropriate column. Calculate gradient as the change in elevation of the contour lines in feet (also known as the contour interval) divided by the distance in stream miles. The units for gradient are feet per mile. Enter this number into the spreadsheet cell corresponding to the site number and round to three decimal places.

Note: An example is shown in Appendix B.

Step 24. Repeat Steps 14 through 23 for the remaining sites. Once gradient calculations are completed, see Section 7.0 QA/QC procedures listed in of this TSOP to complete the spreadsheet.

Step 25. Enter your initials and the date the gradient calculations were completed in the appropriate ‘Completed by’ row at the bottom of data entry table. Individuals who perform QC1 and QC2 should also enter their initials and the date. QC2 is only necessary in gradient calculations if the one who entered and the one who performed QC1 do not meet an agreement on the calculations.

2.3. Related Technical Issues

A. Health and Safety Warnings
Not applicable. This TSOP does not involve travel or field work. All steps are to be completed in an office setting at a computer workstation.

B. Cautions:
1. Be sure to save often to avoid loss of work.
2. Enter initials in the appropriate column after calculations are completed.

3. To ensure the proper contour intervals are used, always check the contour intervals (5-foot or 10-foot) for the area's gradient being calculated.
4. Make sure the unit of distance is in miles when using the Measure tool.
5. Use as many points as necessary to capture the turns and bends of a stream to obtain a fairly accurate distance.
6. Follow the methodology discussed in Steps 20 through 23. Going further upstream before proceeding downstream matters because the upstream environment influences the site while the downstream does not.
7. Only perform gradient calculations on sites with confirmed coordinates. Latitude and longitude can change following GPS verification and can result in incorrect gradient calculations.

C. Interferences
Not applicable.

D. Calibration
Not applicable.

E. Troubleshooting
1. If data connections are not currently established to the correct servers on the computer used, visit Indiana Department of Environmental Management (IDEM) GIS Resources for setup instructions.
2. If the Measure Tool is unavailable for selection, the units may be unknown. Right click on the Map header in the Contents pane and select Properties. This will open the Data Frame Properties window. In the General Tab, ensure Units have been assigned and if not, use the Map Units and Display Units dropdown menus to select the appropriate units. This should enable the Measure Tool.
3. If uncertain about the calculated gradient value, visually compare with the spacing of the contour lines. A larger value represents a steep slope, which means contour lines are closer together. A smaller value represents a gentle slope, which means contour lines are further apart. Recalculate gradient if needed.
4. If on Step 22 and looking to measure to the next contour line upstream but the tributary ends, move to the next part of the pattern. Measure the distance from one contour line upstream of the site to two contour lines downstream of the site.
5. If looking for a contour line downstream of a site and the tributary flows into a larger stream, continue to look for the downstream contour line on the larger stream.

6. When looking for a contour upstream, choose an upstream contour on the stream being assessed. For example, if looking for an upstream contour on the Wabash River and a contour appears on a tributary entering the river, continue following the river segment in search of an upstream contour and not the contour on the tributary. An exception to this is if two streams form to make one larger stream (i.e. Big Blue River and Sugar Creek form Driftwood River), then follow the larger tributary to next upstream contour.
7. For further assistance, seek help from experienced full-time WAPB staff.

3.0. Roles

3.1. Responsibilities

A. WAPB staff member
   1. Reviews and follows this TSOP.
   2. Prepares the Gradient and Drainage Area Spreadsheet.
   3. For Gradient QC Round 2 assigned staff, will discuss value discrepancies with staff who performed calculations and finalize which gradient calculations to enter in AIMS.

3.2. Training requirements

A. Microsoft Excel
   1. WAPB staff member

B. Esri ArcGIS Pro
   1. WAPB staff member

C. AIMS database management
   1. WAPB staff member

4.0. Required Forms, Equipment, or Software List

4.1. Forms

A. Gradient and Drainage Area Spreadsheet

4.2. Equipment

A. Computer workstation

4.3. Software

A. Internet capabilities
B. Microsoft Excel
C. Esri ArcGIS Pro
D. AIMS database

5.0. Records Management

Information recorded in each Gradient and Drainage Area Spreadsheet is entered into the AIMS database. The Gradient and Drainage Area Spreadsheet is stored electronically in the project folder on the shared drive.

6.0. Definitions

6.1. “Agency staff” – Any employee or representative of Indiana Department of Environmental Management (IDEM) including regular employees, temporary employees, contractors, and interns.

6.2. “Assessment Information Management System database (AIMS database)” – Indiana Department of Environmental Management (IDEM) database containing information related to water chemistry; aquatic habitat; macroinvertebrate, fish, and algae communities; fish tissue analyses; sediments; and *E. coli* bacteria data collected by agency staff from watershed sampling events.

6.3. “Attribute” – Nonspatial information about a geographic feature in GIS, usually stored in a table and linked to the feature by a unique identifier. For example, attributes of a river might include its name, length, and sediment load at a gauging station.

6.4. “Contour interval” – The difference in elevation between adjacent contour lines.

6.5. “Contour line” – A line on a map which connects points of equal elevation based on a vertical datum, usually sea level.

6.6. “Data connection” – In Catalog, a mechanism used to access remote file systems and shared databases.

6.7. “Digital line graphs (DLGs)” – Digital vector representations of cartographic information derived from USGS maps and related sources.

6.8. “Elevation” – The vertical distance of a point or object above or below a reference surface or datum (generally mean sea level).

6.9. “Gradient” – The ratio of drop in elevation of a stream per unit of horizontal distance.

6.10. “Hydrography” – The measurement and description of water features and related land areas for the purposes of safe navigation.

6.11. “L-Site” – A unique site ID generated by the AIMS database for each sampling site, and linked with location information (stream name, description, latitude, longitude, county, HUC12, HUC14, etc.,).

6.12. “Quality control” – The overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify they meet the stated requirements established by the customer; operational techniques and activities used to fulfill requirements for quality. In other words, QC involves measuring the "thing produced" against a standard to ensure the product’s quality meets the identified need.

6.13. “Raster data model” – A representation of the world as a surface divided into a regular grid of cells. Raster models are useful for storing data which varies continuously, as in an aerial photography, satellite image, a surface of chemical concentrations, or an elevation surface.

6.14. “Reconnaissance” – Obtaining information about a site through visual observations and investigating routes to safely access the site, as well as gathering property owner information and access permission.
6.15. “Site number” – The designated program area specific numeral given to an environmental location of interest.
6.16. “Technical standard operating procedure (TSOP)” – A standard operating procedure involving environmental data generation, manipulation, or compilation of an analytical process.
6.17. “Tributary” – A smaller river or stream which flows into a larger river or stream. Usually, a number of smaller tributaries merge to form a river.
6.18. “Vector data model” – A representation of the world using points, lines, and polygons. Vector models are useful for storing data which has discrete boundaries, such as country borders, land parcels, and streets.

7.0. Quality Assurance and Quality Control

New WAPB staff should review this TSOP prior to calculating gradients. Before entering data into the AIMS database, perform quality checks. Assign a WAPB staff member to perform Gradient QC Round 1 by going through Steps 3 to 24 of Section 2.2. After QC Round 1 has been completed, calculate the relative percent difference (RPD) between the first and second calculation. The RPD between the first and second calculation should be less than or equal to 10%. RPD is calculated as follows:

$$\mathrm{RPD} = \left(\frac{|\mathrm{S}-\mathrm{D}|}{(\mathrm{S}+\mathrm{D})/2}\right) \mathrm{x}\ 100$$

Where:
S = the first calculation
D = the second calculation

If the RPD is greater than 10%, a third WAPB staff member experienced in determining gradient with Esri ArcGIS Pro performs Gradient QC Round 2 by going through Steps 3 to 24 of Section 2.2. Once the RPD calculation between two staff is less than or equal to 10%, average the two calculations for entry into AIMS. If the RPD between all three measurements is >10%, the staff will discuss the measurements to determine the possible reasons for the discrepancies and agree on a final gradient value.

When all discrepancies are resolved and gradient values are finalized, enter the data into the AIMS database. Following data entry, perform two rounds of quality control on the database entries to ensure proper reflection of the Gradient and Drainage Area Spreadsheet. As necessary, perform additional rounds of quality control. When quality control on the database entries is complete, the data is available for use in other work products.

8.0. References

8.1. USGS

A. Digital Line Graphs (DLGs)
B. Topographic Map Symbols
C. Water Science Glossary of Terms

8.2. Other Guidance

A. Esri GIS Dictionary

9.0. Appendices

Appendix A – Example of a Gradient and Drainage Area Spreadsheet

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	SiteID	WATERBODY_NAME	L-Site	Site Description	Latitude	Longitude	UTM_EAST	UTM_NORTH	Gradient	Gradient QC1	Gradient QC2	*RPD of Calculation and QC1	*RPD of Calculation and QC2	*RPD of QC1 and QC2	Average Gradient	Drainage Area (sq. mi)	Drainage Area QC1	Drainage Area QC2
2	*INRB19-002*	*Silver Creek*	*OSK-08-0014*	*Gutford Road*	*38.31291184*	*-85.7935054*	*EXAMPLE*	*EXAMPLE*	*5.666*	*5.672*	*5.657*	0.113	*0.156*	*0.270*	*5.665*			
3	INRB24-001	Tippecanoe River	WTI-06-0020	Pulaski	41.0794	-86.5832	535037.17	4547655.81	1.462	0.000	0.000	200.000	n/a	n/a	0.731			
4	INRB24-003	Flat Creek	WUW-11-0013	Wells	40.8822	-85.3134	642091.08	4527040.39	6.803	0.000	0.000	200.000	n/a	n/a	3.401			
5	INRB24-004	Salamonie River	WSA-03-0009	Wells	40.6343	-85.3689	637938.97	4499423.59	2.326	0.000	0.000	200.000	n/a	n/a	1.163			
6	INRB24-009	Tippecanoe River	WTI-02-0075	Kosciusko	41.2735	-85.8641	595162.01	4569681.95	5.181	0.000	0.000	200.000	n/a	n/a	2.591			
7	INRB24-011	Wheeler Creek	WAE-04-0012	Wabash	41.0439	-85.7169	607816.48	4544429.74	4.000	0.000	0.000	200.000	n/a	n/a	2.000			
8	INRB24-017	Little Indian Creek	WTI-08-0007	Cass	40.8799	-86.5619	536911.64	4525529.78	2.451	0.000	0.000	200.000	n/a	n/a	1.225			
9	INRB24-018	Bachelor Run	WDE-05-0013	Carroll	40.5551	-86.5239	540316.57	4489491.64	4.367	0.000	0.000	200.000	n/a	n/a	2.183			
10	INRB24-019	Lagro Creek	WUW-14-0029	Wabash	40.8848	-85.6936	610131.65	4526637.31	14.925	0.000	0.000	200.000	n/a	n/a	7.463			
11	INRB24-020	Mississinewa River	WMI-05-0026	Grant	40.5565	-85.6469	614441.49	4490101.81	1.389	0.000	0.000	200.000	n/a	n/a	0.694			
12	INRB24-021	Weesau Creek	WAE-06-0005	Miami	40.9156	-86.1270	573515.56	4529753.87	18.182	0.000	0.000	200.000	n/a	n/a	9.091			
13	INRB24-025	Tippecanoe River	WTI-06-0021	Fulton	41.1321	-86.3937	550893.15	4553568.51	0.813	0.000	0.000	200.000	n/a	n/a	0.407			
14	INRB24-027	Squaw Creek	WUW-10-0012	Allen	41.0446	-85.3216	641069.50	4545071.59	22.727	0.000	0.000	200.000	n/a	n/a	11.364			
15	INRB24-029	Lauramie Creek	WAW-03-0043	Tippecanoe	40.2889	-86.7574	520621.60	4459849.84	11.561	0.000	0.000	200.000	n/a	n/a	5.780			
16	INRB24-034	Kokomo Creek	WAW-01-0004	Howard	40.4478	-86.0451	580975.44	4477888.99	3.774	0.000	0.000	200.000	n/a	n/a	1.887			
17	INRB24-037	Eel River	WAE-06-0006	Miami	40.8561	-86.0036	584014.08	4523288.76	2.179	0.000	0.000	200.000	n/a	n/a	1.089			
18	INRB24-038	Wildcat Creek	WAW-04-0007	Carroll	40.4864	-86.4012	550732.31	4481898.31	3.759	0.000	0.000	200.000	n/a	n/a	1.880			
19	INRB24-040	Grant Creek	WMI-06-0011	Wabash	40.6724	-85.7223	607926.43	4503179.42	17.544	0.000	0.000	200.000	n/a	n/a	8.772			
20	INRB24-046	Tributary of Wabash River	WDE-01-0009	Cass	40.7204	-86.3983	550824.21	4507887.03	27.211	0.000	0.000	200.000	n/a	n/a	13.605			
21	INRB24-048	Bear Creek	WUW-04-0006	Jay	40.5134	-84.9721	671806.19	4486709.50	5.236	0.000	0.000	200.000	n/a	n/a	2.618			
22	INRB24-051	Majenica Creek	WSA-04-0019	Huntington	40.7682	-85.5393	623274.71	4514049.00	5.917	0.000	0.000	200.000	n/a	n/a	2.959			
23	INRB24-057	Tributary of Wildcat Creek	WAW-04-0006	Tippecanoe	40.4543	-86.7707	519441.21	4478223.17	51.724	0.000	0.000	200.000	n/a	n/a	25.862			
24	INRB24-058	South Fork Deer Creek	WDE-04-0007	Cass	40.5984	-86.2205	565481.28	4494875.86	5.208	0.000	0.000	200.000	n/a	n/a	2.604			
25	INRB24-059	Wabash River	WUW-08-0007	Wells	40.7624	-85.1892	652841.43	4513969.91	0.654	0.000	0.000	200.000	n/a	n/a	0.327			
26	INRB24-060	Halfway Creek	WMI-02-0026	Jay	40.3378	-85.1497	656916.41	4466907.69	7.813	0.000	0.000	200.000	n/a	n/a	3.906			
27	INRB24-062	Clear Creek	WUW-12-0003	Huntington	40.9615	-85.5199	624562.23	4535543.65	4.975	0.000	0.000	200.000	n/a	n/a	2.488			
28	INRB24-065	East Branch Twelve Mile Creek	WAE-07-0006	Cass	40.8492	-86.1841	568772.91	4522349.16	8.000	0.000	0.000	200.000	n/a	n/a	4.000			
29	INRB24-068	Mill Creek	WUW-14-0032	Wabash	40.7408	-85.8755	594936.30	4510585.66	28.302	0.000	0.000	200.000	n/a	n/a	14.151			
30	INRB24-069	Hog Run	WAW-02-0003	Clinton	40.3775	-86.6837	526812.14	4469697.41	23.810	0.000	0.000	200.000	n/a	n/a	11.905			
31	INRB24-074	Talbert Ditch	WAW-03-0040	Clinton	40.2959	-86.3985	551111.97	4460780.49	6.579	0.000	0.000	200.000	n/a	n/a	3.289			
32	INRB24-081	Aberger Ditch	WAE-05-0041	Miami	40.9567	-86.0112	583254.05	4534441.46	22.222	0.000	0.000	200.000	n/a	n/a	11.111			
33	INRB24-083	Loon Creek	WUW-13-0015	Huntington	40.8499	-85.5811	619603.80	4523055.84	7.937	0.000	0.000	200.000	n/a	n/a	3.968			
34	INRB24-092	Tributary of Rees Creek	WMI-04-0021	Delaware	40.3400	-85.3394	641039.07	4466802.62	19.048	0.000	0.000	200.000	n/a	n/a	9.524			
35	INRB24-094	Little Deer Creek	WUW-15-0013	Cass	40.7128	-86.2053	567125.24	4507183.60	14.925	0.000	0.000	200.000	n/a	n/a	7.463			
36	INRB24-099	Salamonie River	WSA-04-0020	Huntington	40.7438	-85.5272	624405.58	4511387.20	3.745	0.000	0.000	200.000	n/a	n/a	1.873			
37	INRB24-101	Minnow Ditch	WTI-05-0027	Fulton	41.0733	-86.2274	564898.82	4547178.25	4.762	0.000	0.000	200.000	n/a	n/a	2.381			
38	INRB24-102	Middle Fork Wildcat Creek	WAW-02-0005	Carroll	40.4430	-86.5032	542159.71	4477058.96	5.155	0.000	0.000	200.000	n/a	n/a	2.577			
39	INRB24-105	Wildcat Creek	WAW-04-0010	Tippecanoe	40.4307	-86.8148	515684.05	4475660.30	4.032	0.000	0.000	200.000	n/a	n/a	2.016			
40	INRB24-107	Johnson Ditch	WUW-09-0008	Wells	40.9181	-85.2881	644161.09	4531055.96	9.259	0.000	0.000	200.000	n/a	n/a	4.630			
41	INRB24-108	Mississinewa River	WMI-02-0029	Delaware	40.2888	-85.2235	651011.56	4461349.64	3.534	0.000	0.000	200.000	n/a	n/a	1.767			
42	INRB24-111	Richland Creek	WSA-04-0024	Huntington	40.7038	-85.5688	620900.76	4506871.41	8.696	0.000	0.000	200.000	n/a	n/a	4.348			
43	INRB24-112	Stony Creek	WUW-01-0001	Jay	40.3989	-84.8106	685791.92	4474292.36	10.050	0.000	0.000	200.000	n/a	n/a	5.025			
44	INRB24-113	Big Monon Ditch	WTI-10-0014	White	40.8680	-86.7791	518630.34	4524119.57	0.583	0.000	0.000	200.000	n/a	n/a	0.291			
45	INRB24-117	Mud Branch	WAE-07-0007	Cass	40.8158	-86.2523	563047.53	4518567.48	25.862	0.000	0.000	200.000	n/a	n/a	12.931			
46	INRB24-119	Simonton Creek	WAE-04-0016	Whitley	41.0049	-85.6814	610890.79	4540136.14	11.765	0.000	0.000	200.000	n/a	n/a	5.882			
47	INRB24-121	Tippecanoe River	WTI-03-0021	Kosciusko	41.2470	-85.9123	591142.31	4566722.82	2.278	0.000	0.000	200.000	n/a	n/a	1.139			
48	INRB24-122	Tributary of Wabash River	WUW-16-0005	Miami	40.7340	-86.0316	581781.39	4509672.89	34.188	0.000	0.000	200.000	n/a	n/a	17.094			
49	INRB24-124	Mississinewa River	WMI-04-0022	Delaware	40.2743	-85.2956	644931.50	4459584.68	3.003	0.000	0.000	200.000	n/a	n/a	1.502			
50	INRB24-126	Sugar Creek	WUW-15-0016	Miami	40.5845	-85.9396	589743.08	4493160.36	6.098	0.000	0.000	200.000	n/a	n/a	3.049			
51	INRB24-128	Salamonie River	WSA-02-0009	Blackford	40.5246	-85.2054	651977.76	4487513.33	2.024	0.000	0.000	200.000	n/a	n/a	1.012			
52	INRB24-129	Big Monon Ditch	WTI-10-0015	Pulaski	41.0777	-86.7973	517031.52	4547381.17	2.857	0.000	0.000	200.000	n/a	n/a	1.429			
53	Initials/date-->											*Calculation uses whole number.						

Appendix B – Example of a Gradient and Drainage Area Spreadsheet

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
54																				
55																				
56	**Gradient**	**Calculations**						**Gradient QC**							**Gradient QC 2**					
57	**Site Number**	**Distance (mi)**	**U/S elevation**	**D/S elevation**	**Gradient (ft/mi)**	**Pattern**		**Site Number**	**Distance (mi)**	**U/S elevation**	**D/S elevation**	**Gradient (ft/mi)**	**Pattern**		**Site Number**	**Distance (mi)**	**U/S elevation**	**D/S elevation**	**Gradient (ft/mi)**	**Pattern**
58	**EXAMPLE**	1.432	470	450	13.96648045	2u/1d		~~EXAMPLE~~	~~2.440~~	~~470~~	~~450~~	~~8.196721311~~	~~1u/2d~~		*EXAMPLE*	*1.412*	*470*	*450*	*14.16747657*	*2u/1d*
59	INRB19-002							INRB19-002							INRB19-002					
60	INRB19-003							INRB19-003							INRB19-003					
61	INRB19-005							INRB19-005							INRB19-005					
62	INRB19-006							INRB19-006							INRB19-006					
63	INRB19-007							INRB19-007							INRB19-007					
64	INRB19-008							INRB19-008							INRB19-008					
65	INRB19-009							INRB19-009							INRB19-009					
66	INRB19-011							INRB19-011							INRB19-011					
67	INRB19-013							INRB19-013							INRB19-013					
68	INRB19-014							INRB19-014							INRB19-014					
69	INRB19-016							INRB19-016							INRB19-016					
70	INRB19-017							INRB19-017							INRB19-017					
71	INRB19-018							INRB19-018							INRB19-018					
72	INRB19-019							INRB19-019							INRB19-019					
73	INRB19-020							INRB19-020							INRB19-020					
74	INRB19-021							INRB19-021							INRB19-021					
75	INRB19-022							INRB19-022							INRB19-022					
76	INRB19-023							INRB19-023							INRB19-023					
77	INRB19-027							INRB19-027							INRB19-027					
78	INRB19-028							INRB19-028							INRB19-028					
79	INRB19-030							INRB19-030							INRB19-030					
80	INRB19-032							INRB19-032							INRB19-032					
81	INRB19-033							INRB19-033							INRB19-033					
82	INRB19-034							INRB19-034							INRB19-034					
83	INRB19-036							INRB19-036							INRB19-036					
84	INRB19-037							INRB19-037							INRB19-037					
85	INRB19-038							INRB19-038							INRB19-038					
86	INRB19-041							INRB19-041							INRB19-041					
87	INRB19-042							INRB19-042							INRB19-042					
88	INRB19-044							INRB19-044							INRB19-044					
89	INRB19-045							INRB19-045							INRB19-045					
90	INRB19-046							INRB19-046							INRB19-046					
91	INRB19-047							INRB19-047							INRB19-047					
92	INRB19-049							INRB19-049							INRB19-049					
93	INRB19-050							INRB19-050							INRB19-050					
94	INRB19-051							INRB19-051							INRB19-051					
95	INRB19-052							INRB19-052							INRB19-052					
96	INRB19-053							INRB19-053							INRB19-053					
97	INRB19-054							INRB19-054							INRB19-054					
98	INRB19-055							INRB19-055							INRB19-055					
99	INRB19-058							INRB19-058							INRB19-058					
100	INRB19-059							INRB19-059							INRB19-059					
101	INRB19-063							INRB19-063							INRB19-063					
102	INRB19-064							INRB19-064							INRB19-064					
103	INRB19-067							INRB19-067							INRB19-067					