



# **Geoanalytical Support for EPA's DARTER Application via OGC® Web Processing Services (WPS):**

## **WPS Overview, and Required *Proximity* and *Intersection* Functionality**

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# 1 Geoanalytical Services for Wetlands Jurisdictional Determination and Review

The two geoanalytical functions proposed to support the wetland regulation processes of Jurisdictional Determination and Review are *Intersection* (overlay) and *Proximity* (closeness). The following information expresses our understanding, to date, of the functionality required by EPA analysts regarding these two general spatial operations.

## 1.1 Intersection

Image Matters is developing a Web Processing Service (WPS) that examines polygons for the presence of other features (points, lines, or polylines, or polygons), or portions of other features (lines, polylines, or polygons) contained within the polygon boundary. From our discussions and input from EPA OW staff<sup>1</sup> for wetland jurisdictional determinations (JD), we understand the required overlay questions to be answered in support of JD to be the following:

- *Does this NWI polygon overlap with a NHD stream segment?*

This question can be stated as follows in component spatial operations:

Stated Requirements					
Analysis Case Name	User-Defined Inputs			Functional Operations	Outputs
	Input Features (GML)	Intersect Feature (GML)	Fuzzy / Cluster Tolerance (map units)	Find the geometric intersection of the two feature sets.	
Find all NHD segments that intersect with a NWI polygon	set of NHD stream segments	one NWI polygon	optional	Yes	NHD segment IDs (COM-ID) & possibly GML

<sup>1</sup> Palmer Hough, Rose Kwok, and Brian Topping

## 1.2 Proximity

Image Matters is developing a Web Processing Service (WPS) that analyzes the distances from one set of “input” geospatial features to another set of “proximity” features. From our discussions and input from EPA OW staff for wetland jurisdictional determinations (JD), we understand the required proximity questions to be answered in support of JD to be the following:

- *How far away from this NHD stream segment is the closest NWI polygon?*

*One potential tweak that would help us is being able to answer this slightly revised question:*

- *what are the nearest NHD stream segments to this NWI polygon? (or vice versa) with an overall limit threshold (example: within two miles) but return all answers with actual distances.*

These can be stated as follows in component spatial operations:

Stated Requirements						
Analysis Case Name	User-Defined Inputs			Functional Operations		Outputs
	Input Features (GML)	Proximity Features (GML)	Max Search Distance (map units)	Compute and Return the distance between the two closest points on the input features	Compute and Return the closest points on the input features (IDs and X,Y pairs)	
Find the NWI polygon closest to a NHD segment	one NHD stream segment	set of NWI polygons (polylines)	optional	N/A	Yes (need IDs)	NWI polygon ID (GLOBALID) & possibly GML
Find distance between NHD segment and closest NWI polygon	one NHD stream segment	set of NWI polygons (polylines)	optional	Yes	N/A	Distance value (map units or other distance units)
Find the NHD segment closest to a NWI polygon	one NWI polygon (polylines)	set of NHD stream segments	optional	N/A	Yes (need IDs)	NHD segment ID (COM-ID) & possibly GML
Find distance of NHD segment closest to a NWI polygon	one NWI polygon (polylines)	set of NHD stream segments	optional	Yes	N/A	Distance value (map units or other distance units)

Stated Requirements (continued)						
Analysis Case Name	User-Defined Inputs			Functional Operations		Outputs
	Input Features	Proximity Features	Max Search Distance (map units)	Compute and Return the distance between the two closest points on the input features	Compute and Return the closest points on the input features (IDs and X,Y pairs)	
Find closest NHD segment to specified point(s)	X,Y Coordinate Pair(s)	set of NHD stream segments	optional	N/A	Yes (need IDs)	NHD segment GML and ID (COM-ID)
Find distance between NHD segment and specified point(s)	X,Y Coordinate Pair(s)	set of NHD stream segments	optional	Yes	N/A	Distance value (map units or other distance units)
Find closest NWI polygon to specified point(s)	X,Y Coordinate Pair(s)	set of NWI polygons (polylines)	optional	N/A	Yes (need IDs)	NWI polygon GML and ID (GLOBALID)
Find distance between NWI polygon and specified point(s)	X,Y Coordinate Pair(s)	set of NWI polygons (polylines)	optional	Yes	N/A	Distance value (map units or other distance units)

### 1.3 Service Requirements

What is the number of features, both NWI polygons and NHD segments, used in a typical geoanalysis? (At some point in the discussions with OW, we had mentioned the number “50”.)

*HP: Average is probably 5 but can range up to the hundreds when looking at a large relevant reach with many wetlands and tributary networks. 50 would probably cover our needs.*

*PS: The numbers would depend on the geographic scope of analysis and purpose of the analysis, and could go well into the 100's (such as the number of wetland polygons in a watershed).*

*RK: This is a tricky question to answer, but I can't foresee there being many instances where the number of features would exceed 50, unless a particular stream reach was extremely long. As mentioned above, this could potentially mean that there will be instances where the numbers would go into the 100s, though 50 will likely cover most of our needs.*

What is the typical spatial extent (e.g., 1 square mile, 40 acres, etc) of an area within which features would be analyzed?

*PH: Analyzing between wetlands and NHD segments would typically occur within 10-20 square miles for large relevant reaches (averaging much smaller ~5). Downstream analysis within the NHD could extend for many miles - in arid areas up to and more than 100 miles.*

*PS: I agree the spatial extent can be quite large but is nested, a smaller one near the site when looking at the stream reach and a larger extent when mapping the connection to the TNW. The typical spatial extent could be 1 square mile around the relevant reach up, to 10-20 square miles mapping to RPW's and way larger (or longer) when mapping to the TNW.*

*RK: This is a tricky question to answer, because this is dependent on the size of the aquatic resource that is being analyzed. If the stream reach is over a mile long, the area of analysis would need to include the entire reach. If we're looking at wetlands adjacent to that stream reach, we would want to evaluate all wetlands adjacent to the reach, and there is no set distance from a stream that a wetland has to be to be considered adjacent.*

What is an acceptable duration of processing for geoanalysis, e.g., the amount time that you have to wait for an answer to your query?

*PH: Anything more than a minute for a single query (that would have to be repeated in multiple ways) would be tough.*

*PS: I agree instant is best, but for extensive geo-processing several minutes is OK.*

*RK: Of course, the quicker the better, as I think field staff are always antsy and short on time. I've run queries before that take hours to run, and that is not reasonable for our purposes. A few minutes max, due to short time and short attention spans, is my recommendation.*

In our proposal to FGDC, we estimated the level of use of the geoanalysis tools as follows: "Every year 60,000 - 90,000 Section 404 wetland permits are processed. Of those, only about 10% require analysis, and use of the proposed SOA solution. This works out to 30 per working day per agency, spread among the ~110 ACE analysts and ~45 EPA analysts distributed nationwide." Is this estimated level of use accurate?

*PH: Add an order of magnitude to the number of ACE analysts (~1000) and then also note that this would probably be used several times for each assessment - but the range of 100 times a working day sounds correct.*

*RK: I agree that it might be used several times for each assessment, so the range of 100 times or less might be correct.*

What projection or coordinate system will DARTER use in its mapping component?

*BC: If possible use a projected coordinate system because the measurement tools work better when the units are feet or meters*



Will you be accessing contextual layers (e.g., political boundaries, transportation, orthoimagery) via WMS for the mapping component?

BC: YES

## 2 OGC® Web Processing Service (WPS) Interface Standard: an overview

No longer are costly GIS applications required to perform geospatial processing, nor are these confined to a desktop. The advent of the *Geospatial Web* has made it possible to perform “spatial operations” – that functionality that defines a GIS from other RDBMSs – through thin clients while largely keeping I/O and processing complexity transparent with respect to the end user. In the Geospatial Web user community, an interface standard has been developed to ensure interoperability of, and thus facilitating reuse of, web services that perform geoanalysis: the OGC® Web Processing Service (WPS).

In our Category 2 CAP grant, aimed at providing geoanalytical capabilities via the Web for wetlands JD, we will provide services that are compliant to the WPS standard. We will be developing a particular “application profile” for this generic service specification.

### 2.1 The WPS Standard

- <http://www.opengeospatial.org/standards/wps>
- Adopted February 22, 2008
- Presentation on the latest revisions to the WPS spec, with some useful diagrams and models:  
<http://468041.g.portal.aau.dk/GetAsset.action?contentId=1931343&assetId=2295555>

### 2.2 WPS Description and Characteristics

There is a good summary of the utility and strengths of the WPS spec, in the following message [<http://52north.org/pipermail/geoprocessingservices/2006-June/000004.html>] from Peter Schut, Director of Geomatics, Agriculture and Agri-Food Canada, who has stood up what appears to be the first major implementation of WPS in a production system:

- WPS specifies a standard way to describe a process, including the input and output identifiers, titles, abstracts and keywords, including appropriate length and content for these elements.
- WPS specifies a standard way to call for the execution of a process, and pass it the input parameters it requires, either via the URL (*GET*) or via XML (*POST*).
- WPS specifies a standard way to identify different kinds of process inputs and outputs - literal, complex, and bounding box.
- WPS specifies a standard way to describe literal inputs (based on OWS Common).

- WPS specifies a standard way to encode complex inputs (such as GML, shapefiles, or images), thus allowing these inputs to be passed as part of the execute query (*GET* or *POST*).
- WPS specifies a standard way to reference complex inputs that are available on-line, as well as to identify different kinds of formats and encoding that can be handled by the service.
- WPS specifies a standard way to describe bounding box inputs (based on OWS Common/GML).
- WPS specifies a standard way to request a direct response to a process execution request, so that the output is returned without any XML wrapper (e.g. a GIF file).
- WPS specifies how to request storage of the outputs of a process so that they can be retrieved at some later time.
- WPS specifies a standard way to determine the status of a long-running process.
- WPS specifies under what conditions to create an execution status document, and what that document must contain. (It contains the inputs and outputs or references to them, the execution status, and any processing errors encountered.)
- WPS specifies how to request and customize specific outputs in terms of their descriptive information and formats/encodings.
- WPS identifies a standard and extensible set of errors and their encoding in XML.
- WPS specifies a standard way to uniquely identify a geospatial process using a URN naming convention.
- WPS specifies a way to determine that a process actually conforms to a specific WPS application profile identified by an OGC URN. (Essentially, the *DescribeProcess* response has to be identical to the reference application profile if the process is conformant.)
- WPS will specify how to use SOAP and/or WSDL in concert with WPS.

While there is some overlap in functionality between WPS and SOAP/WSDL, quite clearly WPS provides a much greater degree of standardization than just using WSDL (with or without SOAP). Both WSDL and WPS *GetCapabilities* / *DescribeProcess* can describe a service interface, but in addition WPS forces the Execute request and response to follow a very similar pattern and syntax. This standardization in turn means that it is relatively easy to re-use code and create interoperable services, to the point that it is possible to create a generic WPS server. In such a generic server, implementing a new process can be as simple as writing the code for the spatial operation, and configuring the WPS server with the text that describes the operation and its inputs/outputs as well as the mechanism to call the operation.

## 2.3 Architectural Approaches and Application Profiles

- The Ag Canada implementation:  
<http://www.gmldays.com/gml2005/presentations/OGCWebProcessingService,%20Xiaoyuan%20Geng.pdf>
- The INSPIRE (European Community's SDI) architectural approach:  
[http://www.plan.aau.dk/~enc/AGILE2007/PDF/151\\_PDF.pdf](http://www.plan.aau.dk/~enc/AGILE2007/PDF/151_PDF.pdf)
- WPS employed in OWS-4:  
<http://geobrain.laits.gmu.edu/doc/ows4Demo/introduction.pdf>

## 3 High-Level Architecture for WPS that support JD through DARTER

The following diagram (see next page) represents our current deployment model for the WPS and supporting Web Feature Services (WFS). Several notes about the diagram are worth mentioning:

- Communications are bi-directional (not represented here by arrows).
- Linkage between DARTER and the Corps' OMBIL Regulatory Module (ORM) system is represented, although the direct relevance to the WPS is unknown at this time.
- The National Wetlands Inventory (NWI) WFS could be stood up on either the database managed by FWS (at USGS CAPP facility) or that at EPA (at NCC at the RTP).
- Clients other than DARTER could utilize the geoanalytical services, as EPA sees fit.

