

# Identifying stressors to Aquatic Biota

Sean Regalado



# Goal

To share a methodology we're developing to identify water quality stressors in an automated framework using patterns of **beta diversity** and decades of best professional judgement (BPJ).

# Iterative Approach



# Iterative Approach

Compare sites we know **LITTLE** about (i) to sites we know **A LOT** about (j) using measures of beta diversity.



# Iterative Approach

Compare sites we know **LITTLE** about (i) to sites we know **A LOT** about (j) using measures of beta diversity.

i = 1



# Iterative Approach

Compare sites we know **LITTLE** about (i) to sites we know **A LOT** about (j) using measures of beta diversity.

i = 1



j = 1

# Iterative Approach

Compare sites we know **LITTLE** about (i) to sites we know **A LOT** about (j) using measures of beta diversity.

i = 1



j = 1



*The extent of  
differentiation of  
communities along  
habitat gradients*  
**Whittaker, R.H. 1972**

# Iterative Approach

Compare sites we know **LITTLE** about (i) to sites we know **A LOT** about (j) using measures of beta diversity.



*The extent of  
differentiation of  
communities along  
habitat gradients*  
Whittaker, R.H. 1972

# Iterative Approach

Compare sites we know **LITTLE** about (i) to sites we know **A LOT** about (j) using measures of beta diversity.



*The extent of differentiation of communities along habitat gradients*  
Whittaker, R.H. 1972

# Iterative Approach

Compare sites we know **LITTLE** about (i) to sites we know **A LOT** about (j) using measures of beta diversity.



*The extent of differentiation of communities along habitat gradients*

**Whittaker, R.H. 1972**

*Accounts for total abundance-based dissimilarity between sites, measured as the Bray-Curtis index*  
Baselga (2013)

# Iterative Approach

Compare sites we know **LITTLE** about (i) to sites we know **A LOT** about (j) using measures of beta diversity.



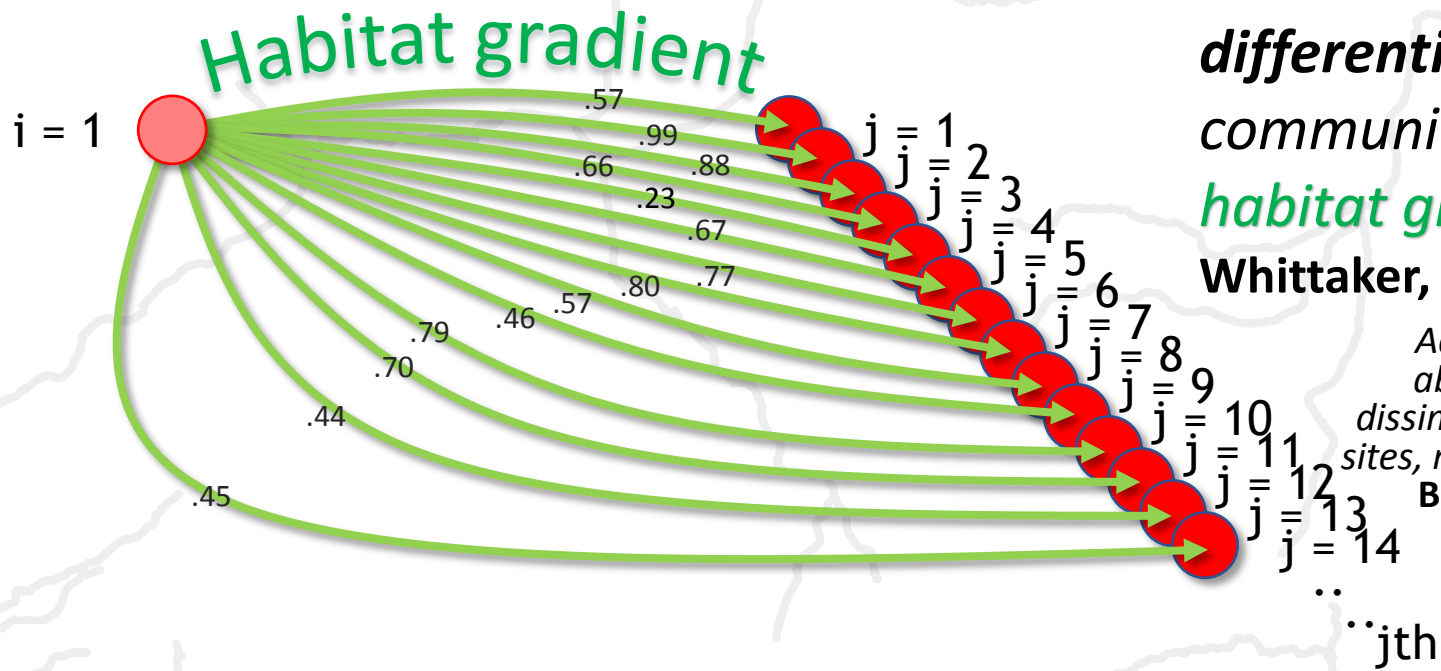
*The extent of differentiation of communities along habitat gradients*

**Whittaker, R.H. 1972**

*Accounts for total abundance-based dissimilarity between sites, measured as the Bray-Curtis index*  
Baselga (2013)

# Iterative Approach

Compare sites we know **LITTLE** about (i) to sites we know **A LOT** about (j) using measures of beta diversity.



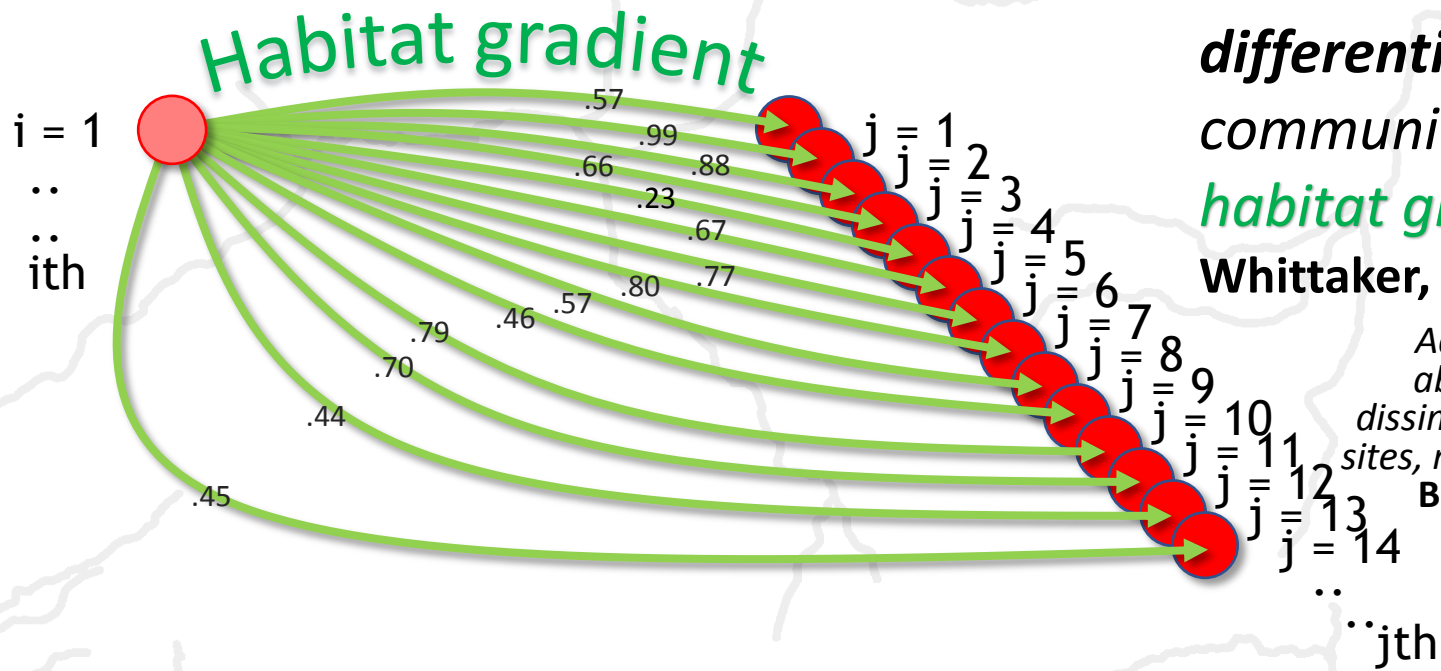
*The extent of differentiation of communities along habitat gradients*  
**Whittaker, R.H. 1972**

*Accounts for total abundance-based dissimilarity between sites, measured as the Bray-Curtis index*  
**Baselga (2013)**



# Iterative Approach

Compare sites we know **LITTLE** about (i) to sites we know **A LOT** about (j) using measures of beta diversity.

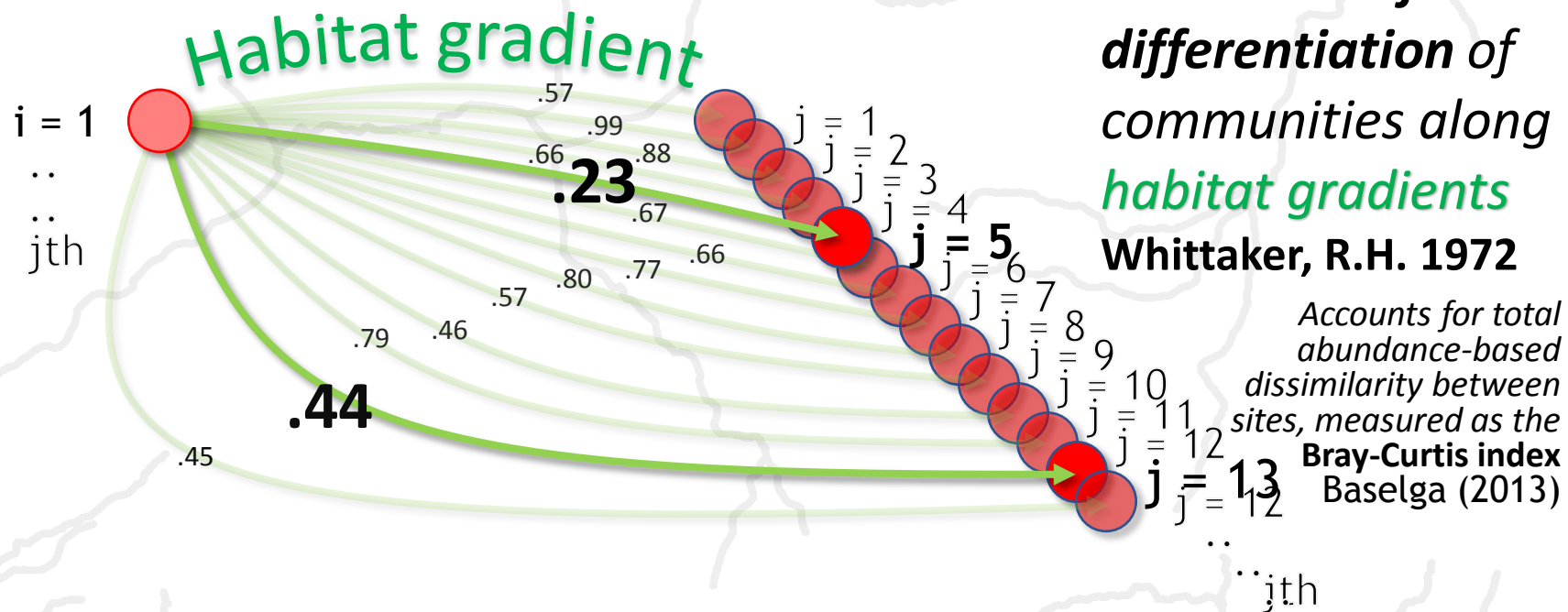


*The extent of differentiation of communities along habitat gradients*  
**Whittaker, R.H. 1972**

*Accounts for total abundance-based dissimilarity between sites, measured as the Bray-Curtis index*  
**Baselga (2013)**

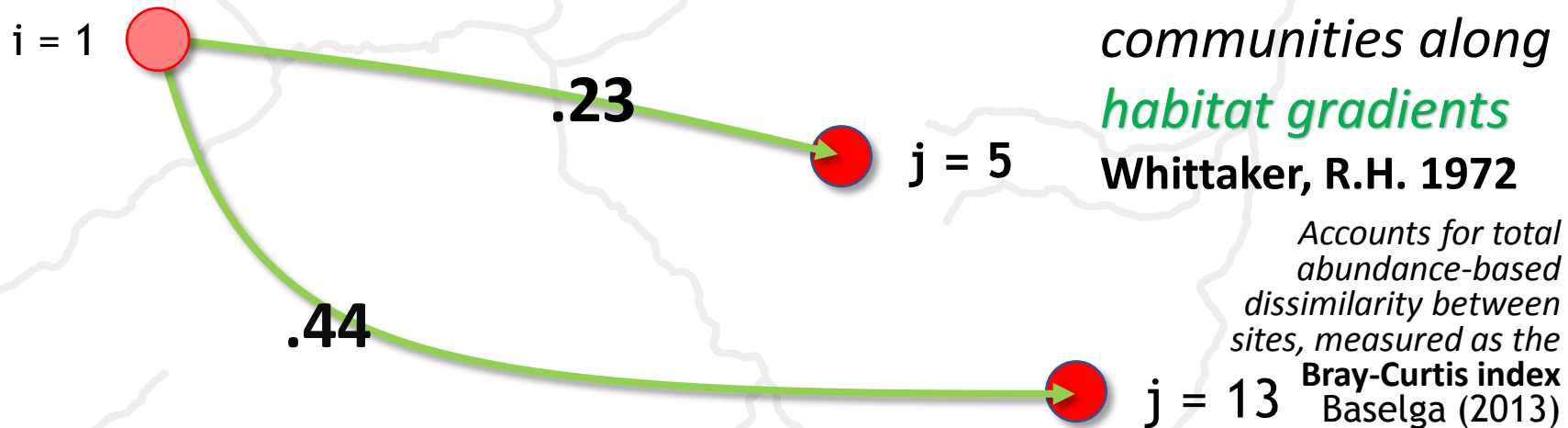
# Iterative Approach

Compare sites we know **LITTLE** about (i) to sites we know **A LOT** about (j) using measures of beta diversity.



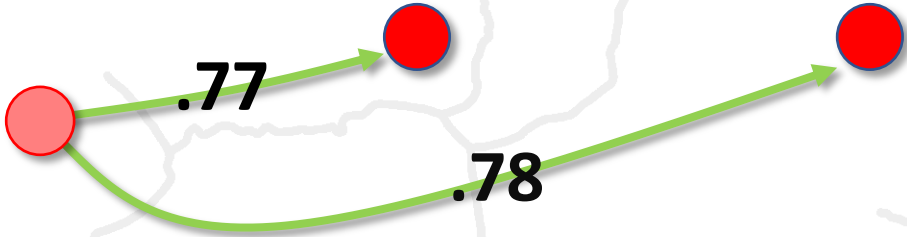
# Iterative Approach

Compare sites we know **LITTLE** about (i) to sites we know **A LOT** about (j) using measures of beta diversity.



South Mtn.  
Branch Trib 7 Jay  
Branch

Dutton  
Brook



Dutton  
Brook

Stressor

South Mtn.  
Branch Trib 7

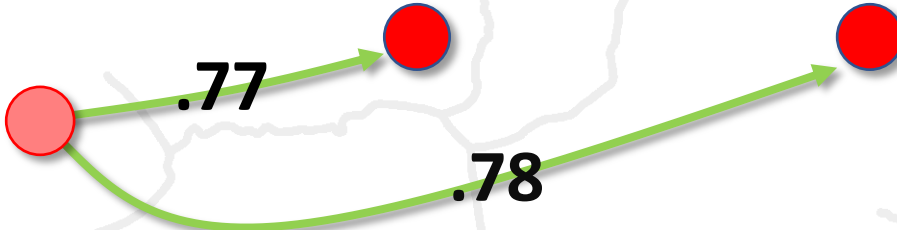
Jay  
Branch

Sediment

Sediment

**.77**

**.78**



Dutton  
Brook

Stressor  
Source

South Mtn.  
Branch Trib 7

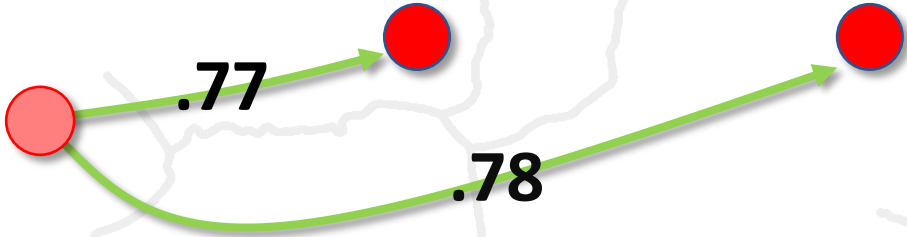
Jay  
Branch

Sediment

Sediment

POTENTIAL  
SEDIMENT  
FROM  
DEVELOPMENT

EROSION  
FROM LAND  
DEVELOPMENT  
ACTIVITIES



Dutton Brook



.77



South Mtn.  
Branch Trib 7

Stressor  
Source

Sediment  
POTENTIAL  
SEDIMENT  
FROM  
DEVELOPMENT

Jay  
Branch

Sediment  
EROSION  
FROM LAND  
DEVELOPMENT  
ACTIVITIES



.78

**Biologist's notes on Dutton Brook**  
*...The percent Oligocheata is very high with 19 percent, 14 percent Lumbricina at large aquatic earth worm type worm, and Lumbriculidae. Typically these animals indicate a sediment problem.*

Potash  
Brook  
Trib 7

Stressor  
Source

Munroe Brook

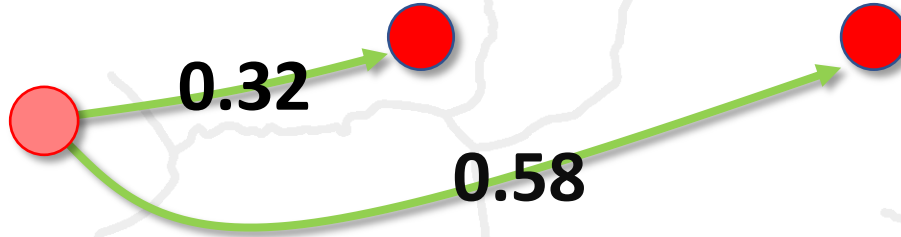
Muddy Brook  
Trib 4

Stormwater

Chloride

STORMWATER  
RUNOFF,  
EROSION, LAND  
DEVELOPMENT

ELEVATED  
INSTREAM  
CHLORIDE  
LEVELS



### Biologist's notes on Potash Brook

*Community however remains very low in richness and EPT taxa present.*



# Method Overview

Link Monitoring Locations to NHDPlus  
REACHCODES

Categorize reaches as (i)s and (j)s

Impose knowledge upon the algorithm

Use beta diversity indices to compare these  
reaches

# Method Overview

## Link Monitoring Locations to NHDPlus REACHCODES

Categorize reaches as (i)s and (j)s

Impose knowledge upon the algorithm

Use beta diversity indices to compare these reaches

# Method Overview

Link Monitoring Locations to NHDPlus  
REACHCODES

**Categorize reaches as (i)s and (j)s**

Impose knowledge upon the algorithm

Use beta diversity indices to compare these  
reaches

# Method Overview

Link Monitoring Locations to NHDPlus  
REACHCODES

Categorize reaches as (i)s and (j)s

**Impose knowledge upon the algorithm**

Use beta diversity indices to compare these  
reaches

# Method Overview

Link Monitoring Locations to NHDPlus  
REACHCODES

Categorize reaches as (i)s and (j)s

Impose knowledge upon the algorithm

**Use beta diversity indices to compare these reaches**

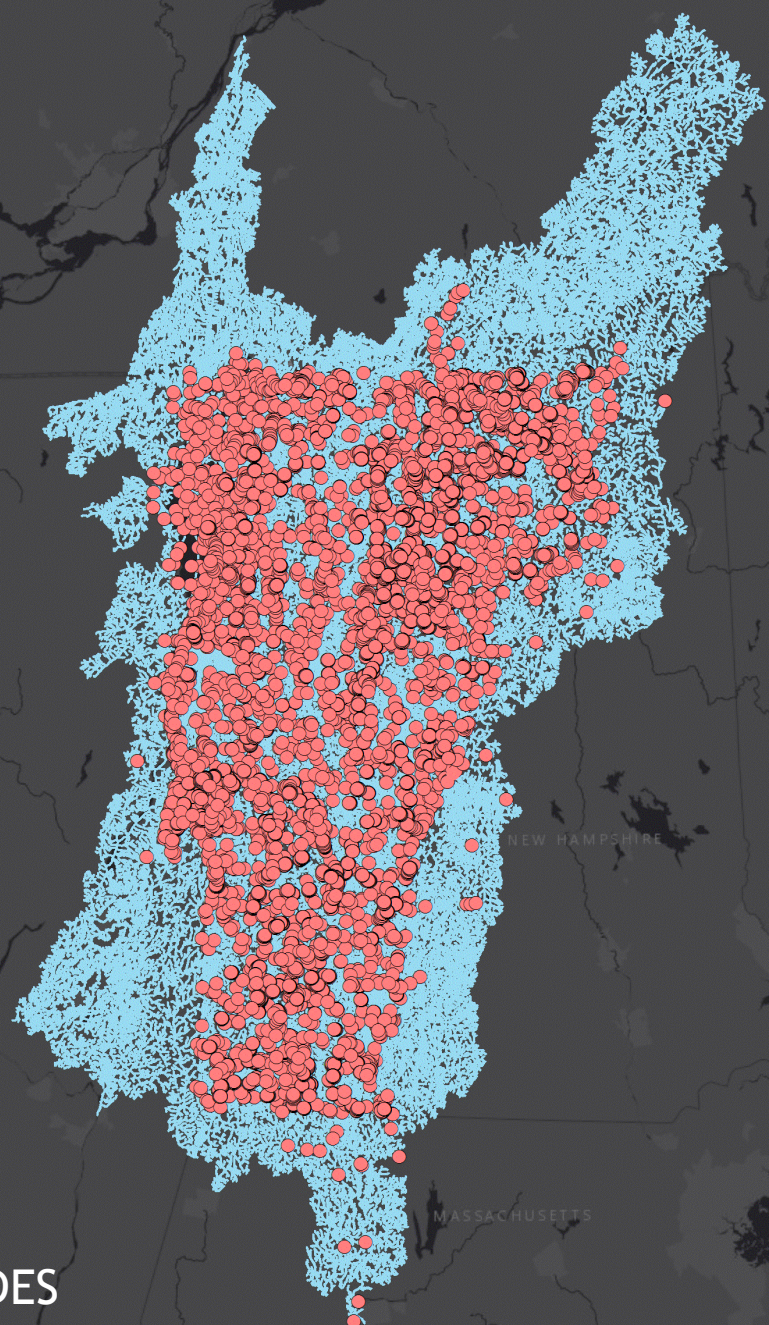
# Link Monitoring Locations to NHDPlus REACHCODES

Remove Reaches that are already on a list.



10,217 unique  
LocationIDs

101719 unique  
REACHCODES



NEW YORK

NEW HAMPSHIRE

MASSACHUSETTS

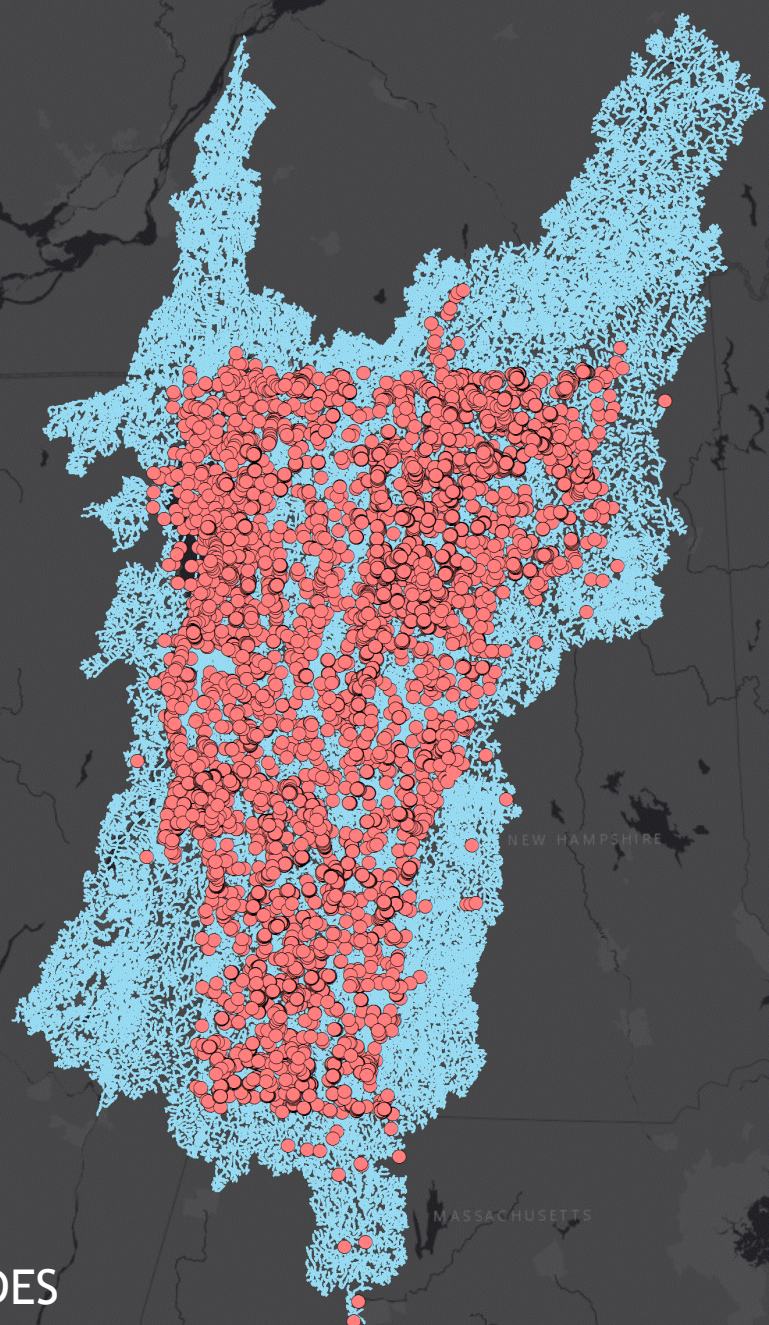
Link Monitoring Locations to NHDPlus REACHCODES



10,217 unique  
LocationIDs



101719 unique  
REACHCODES



Link Monitoring Locations to NHDPlus REACHCODES



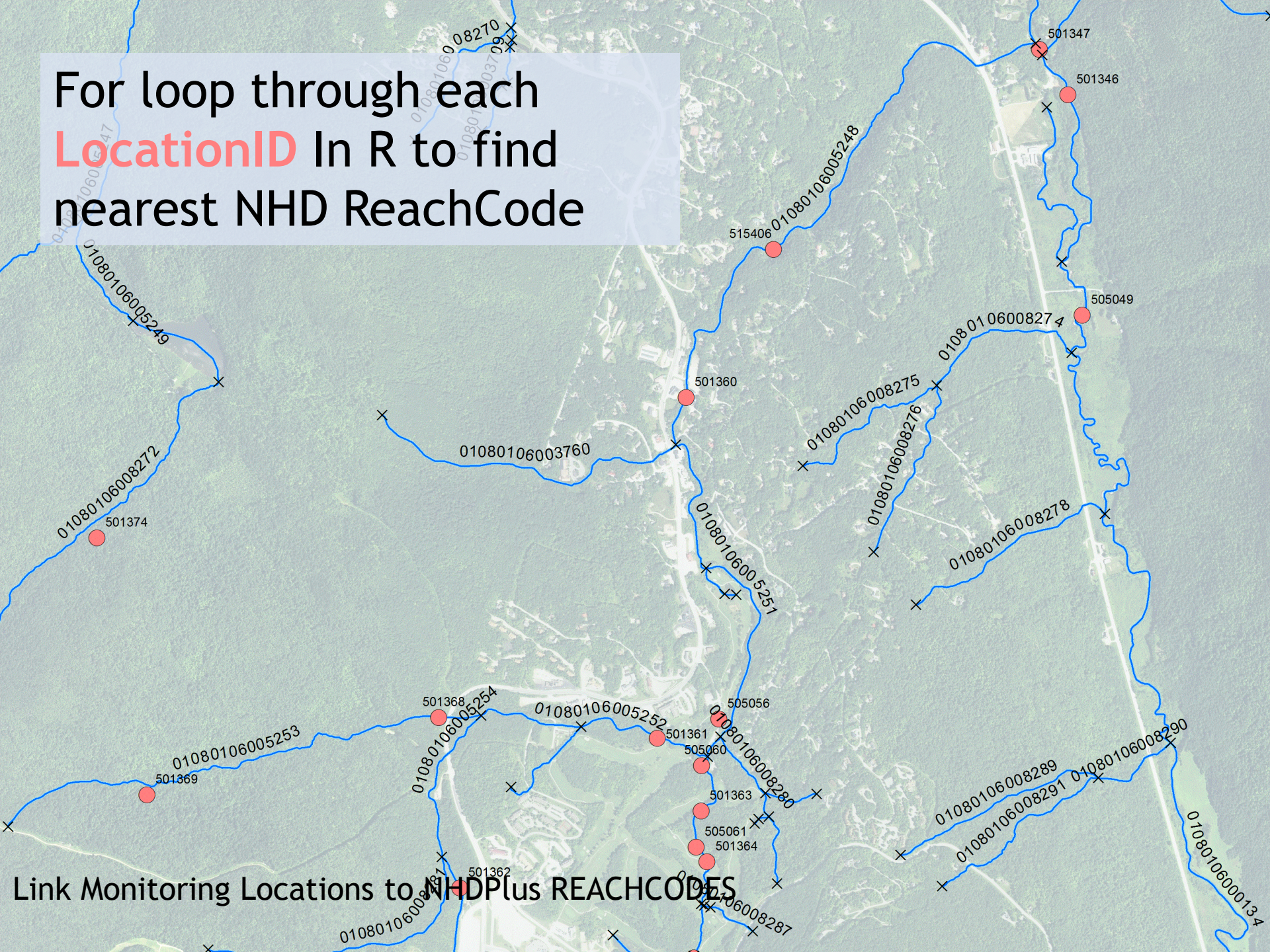
# For loop through each **LocationID** In R to find nearest NHD ReachCode

```
for (i in 1:nrow(Sites)){
  tryCatch({
    pts<-Sites[i,] #subset site
    pts_list <- gWithinDistance(pts, Lines,byid=TRUE, dist=100) #find all sites within 1000m
    pts_list<-data.frame(pts_list) #convert site matrix to dataframe
    pts_list$REACHCODE<-row.names(pts_list) #add row names (site IDs) to a field
    pts_list<-pts_list[which(pts_list[,1]==TRUE),] #subset nearest lines
    near_reaches<-pts_list$REACHCODE #create a vector of line IDs (RIDs)
    res.mat<-gDistance(pts,Lines[match(near_reaches, Lines@data$RID),], byid=TRUE)
    res.mat<-data.frame(res.mat) #convert results matrix to dataframe
    res.mat$VRAMRID<-colnames(res.mat) #add column name (point id) to all values of an ID field
    res.mat$LINESID<-rownames(res.mat) #add row names (Line IDs (RIDs)) to a LINE id field
    rownames(res.mat)<-NULL
    colnames(res.mat)[1]<-"Distance"
    #res.mat1<-res.mat
    res.mat1<-rbind(res.mat1, res.mat)
  }, error=function(e){})
}
```

Link Monitoring Locations to NHDplus REACHCODES



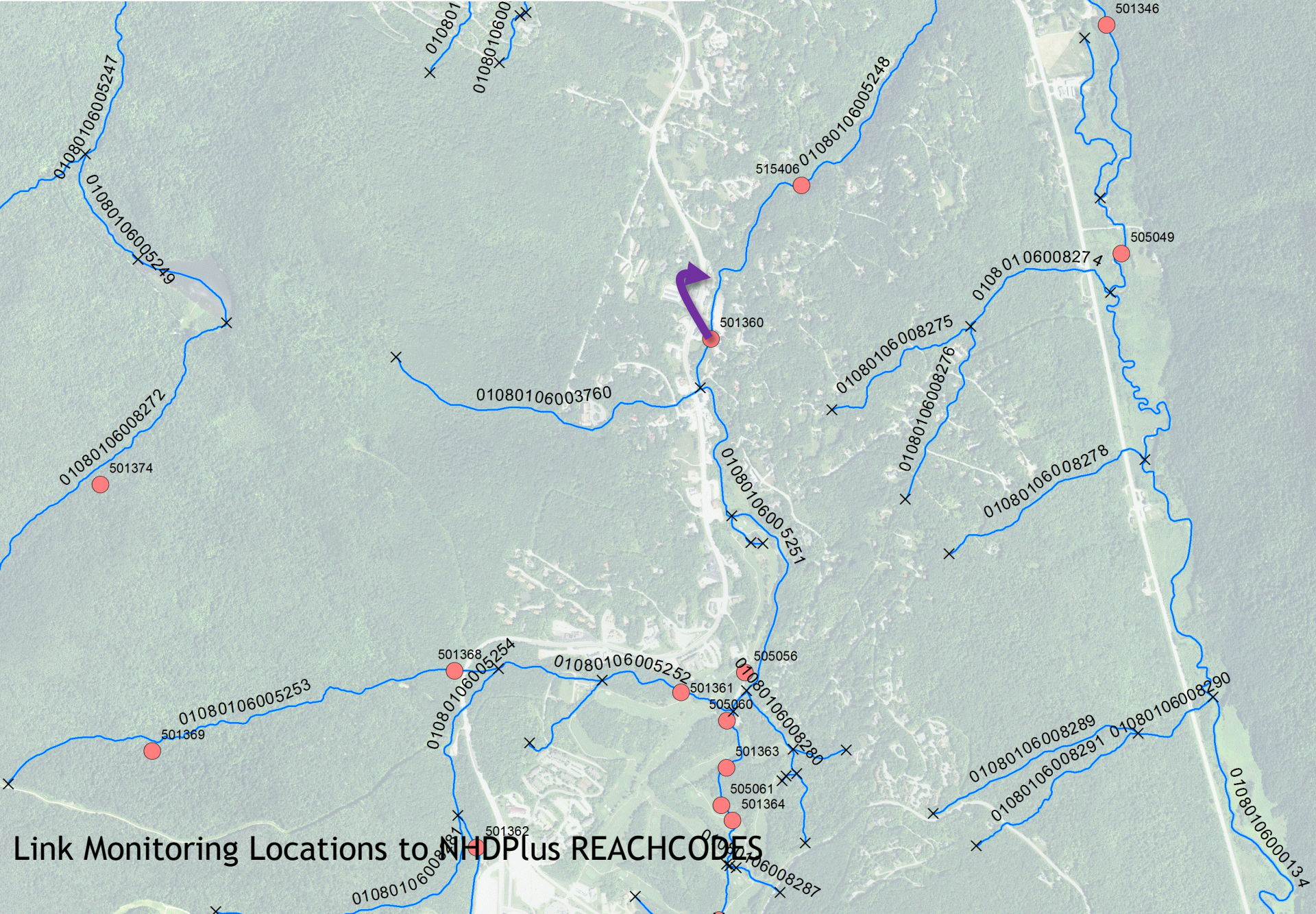
For loop through each **LocationID** In R to find nearest NHD ReachCode



Link Monitoring Locations to NHDplus REACHCODES



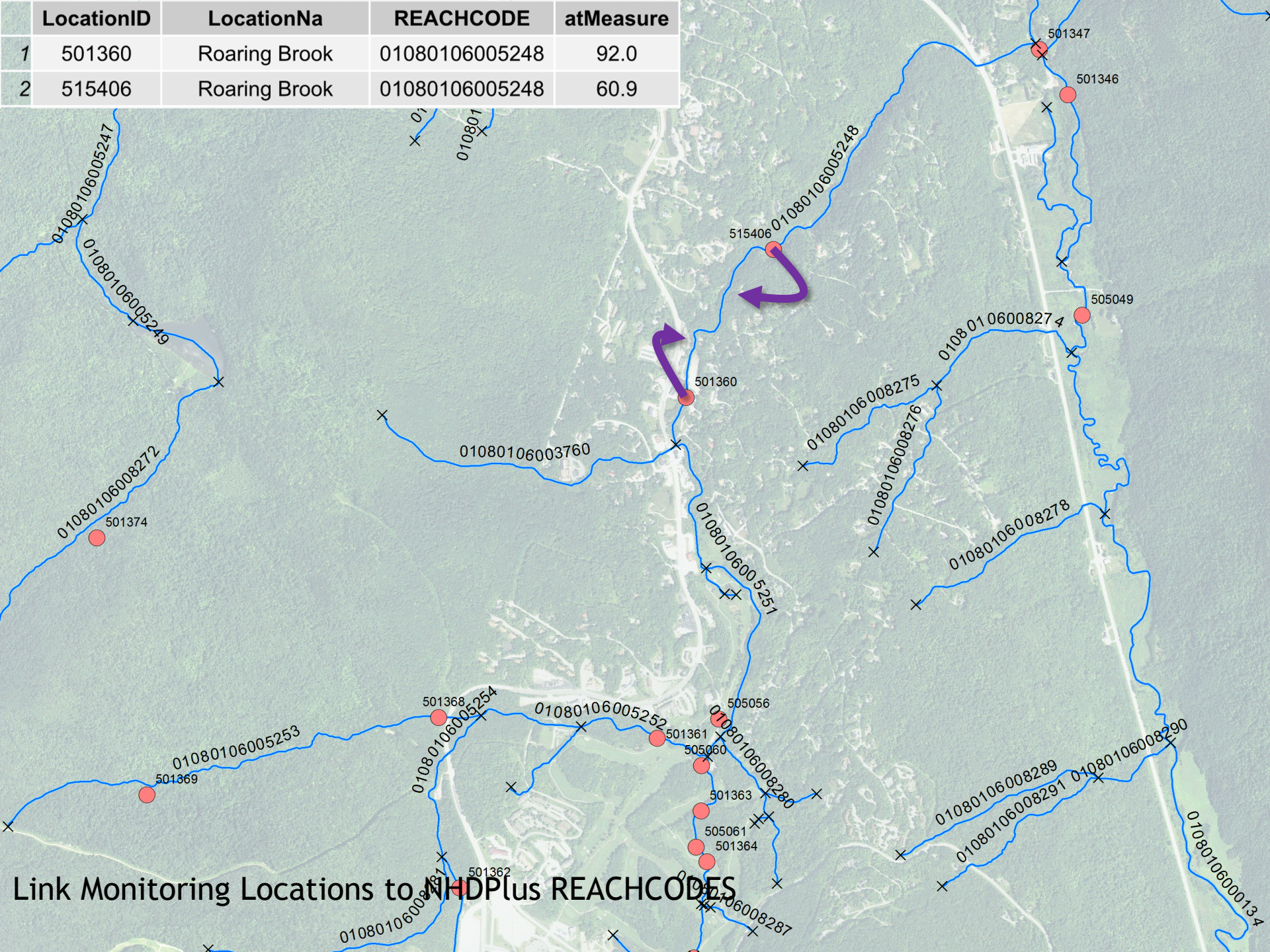
	LocationID	LocationNa	REACHCODE	atMeasure
1	501360	Roaring Brook	01080106005248	92.0



Link Monitoring Locations to NHDPlus REACHCODES



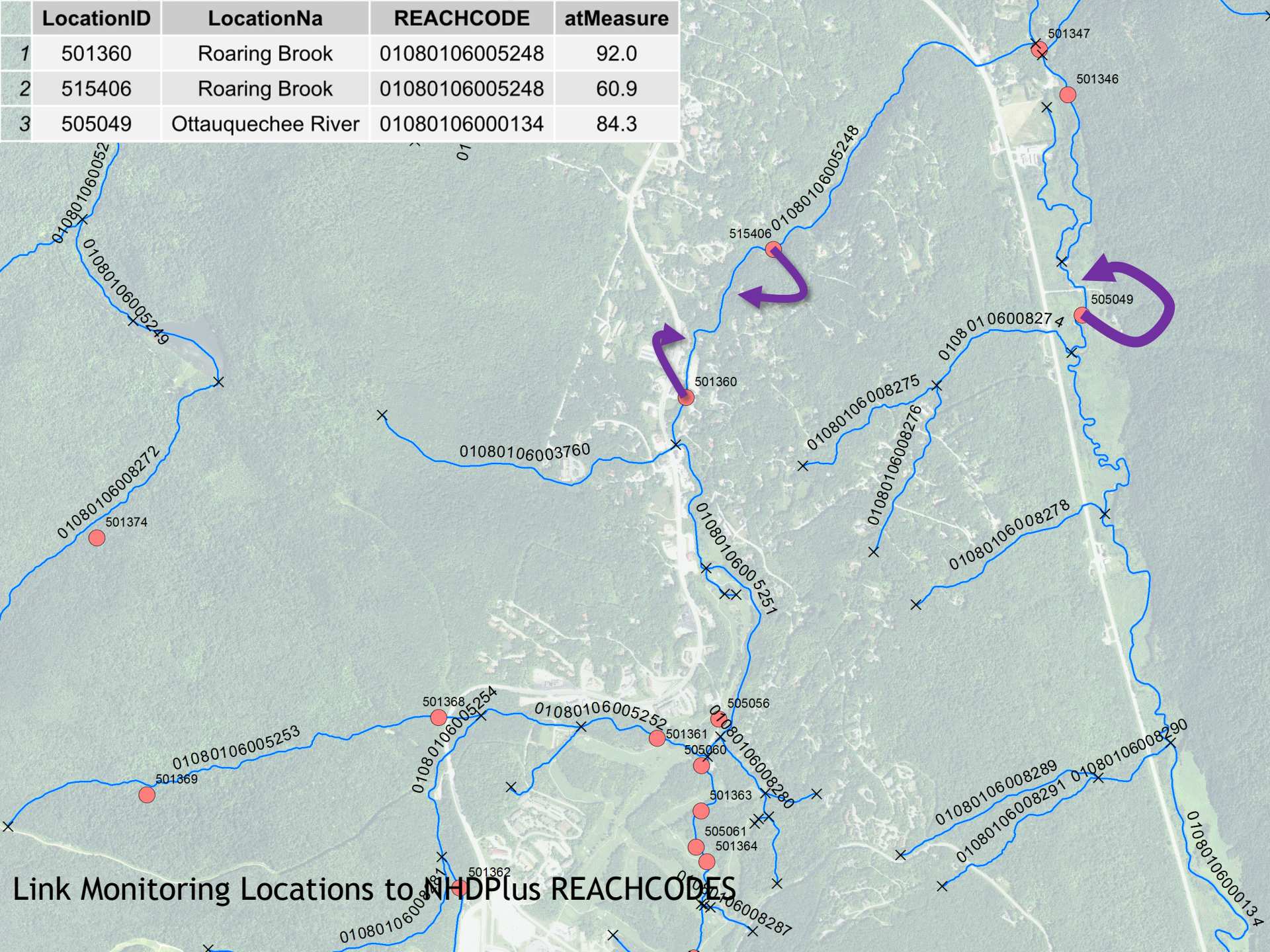
	LocationID	LocationNa	REACHCODE	atMeasure
1	501360	Roaring Brook	01080106005248	92.0
2	515406	Roaring Brook	01080106005248	60.9



Link Monitoring Locations to NHDPlus REACHCODES



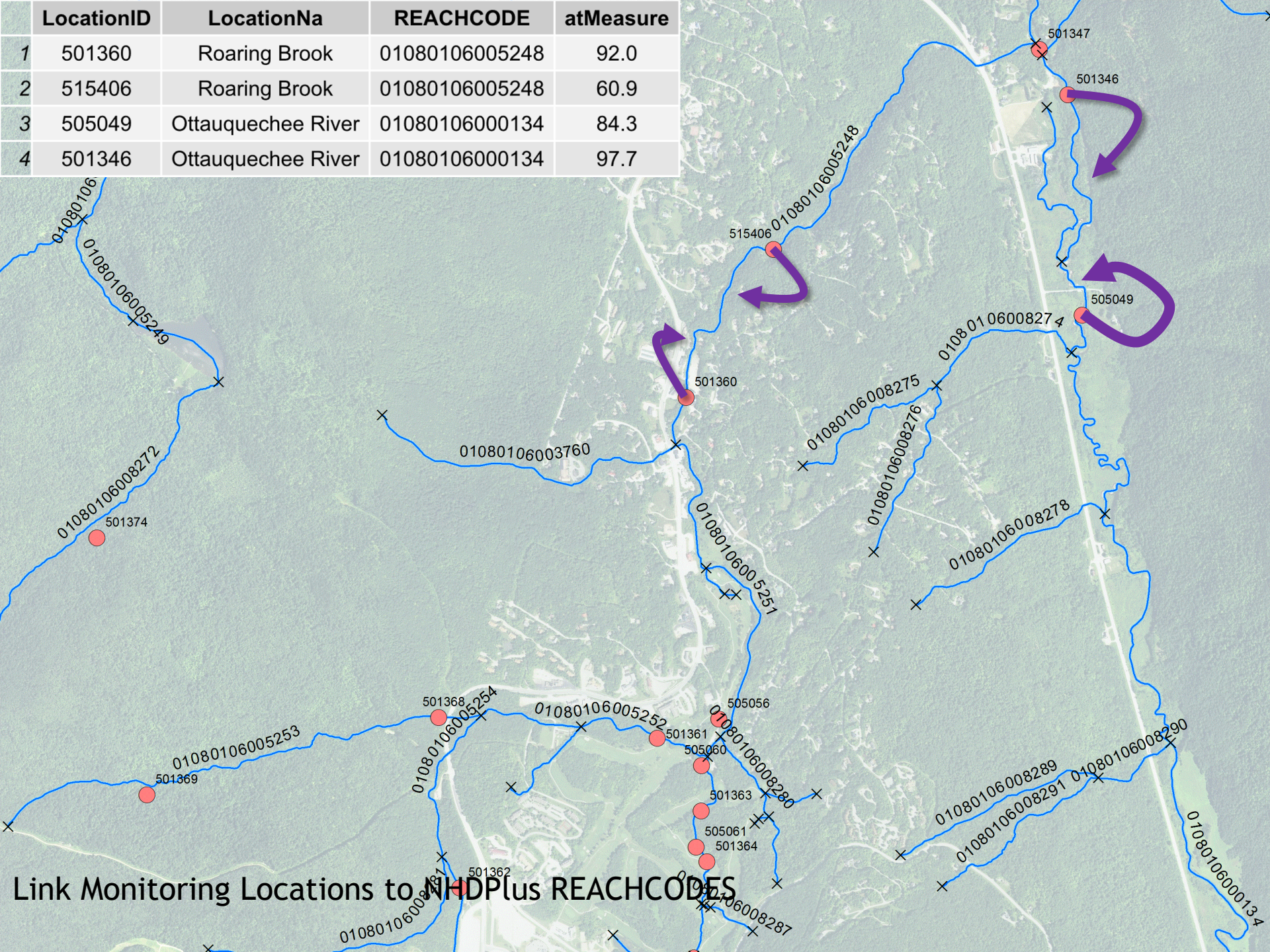
	LocationID	LocationNa	REACHCODE	atMeasure
1	501360	Roaring Brook	01080106005248	92.0
2	515406	Roaring Brook	01080106005248	60.9
3	505049	Ottauquechee River	01080106000134	84.3



Link Monitoring Locations to NHDPplus REACHCODES



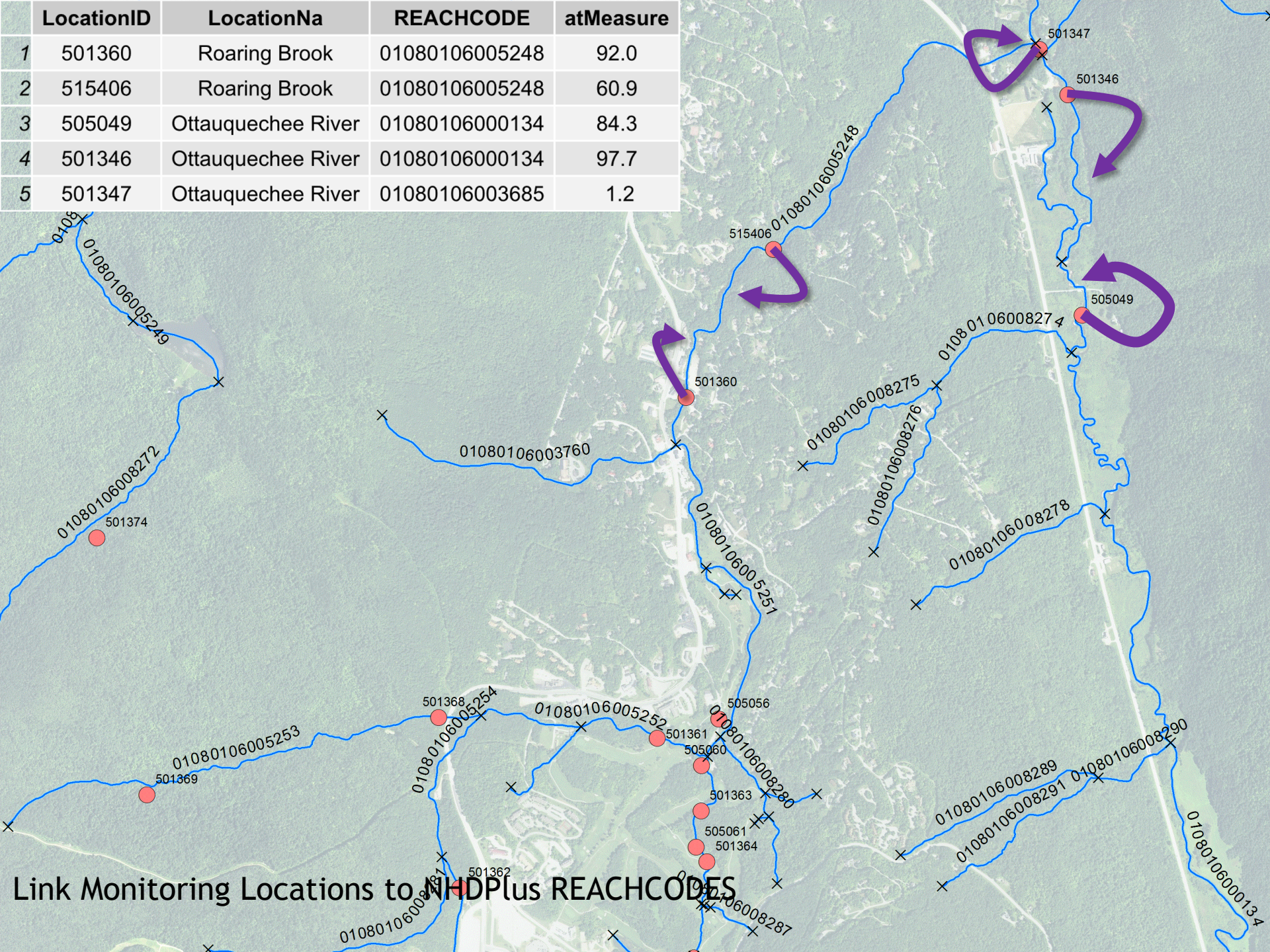
	LocationID	LocationNa	REACHCODE	atMeasure
1	501360	Roaring Brook	01080106005248	92.0
2	515406	Roaring Brook	01080106005248	60.9
3	505049	Ottauquechee River	01080106000134	84.3
4	501346	Ottauquechee River	01080106000134	97.7



Link Monitoring Locations to NHDPplus REACHCODES



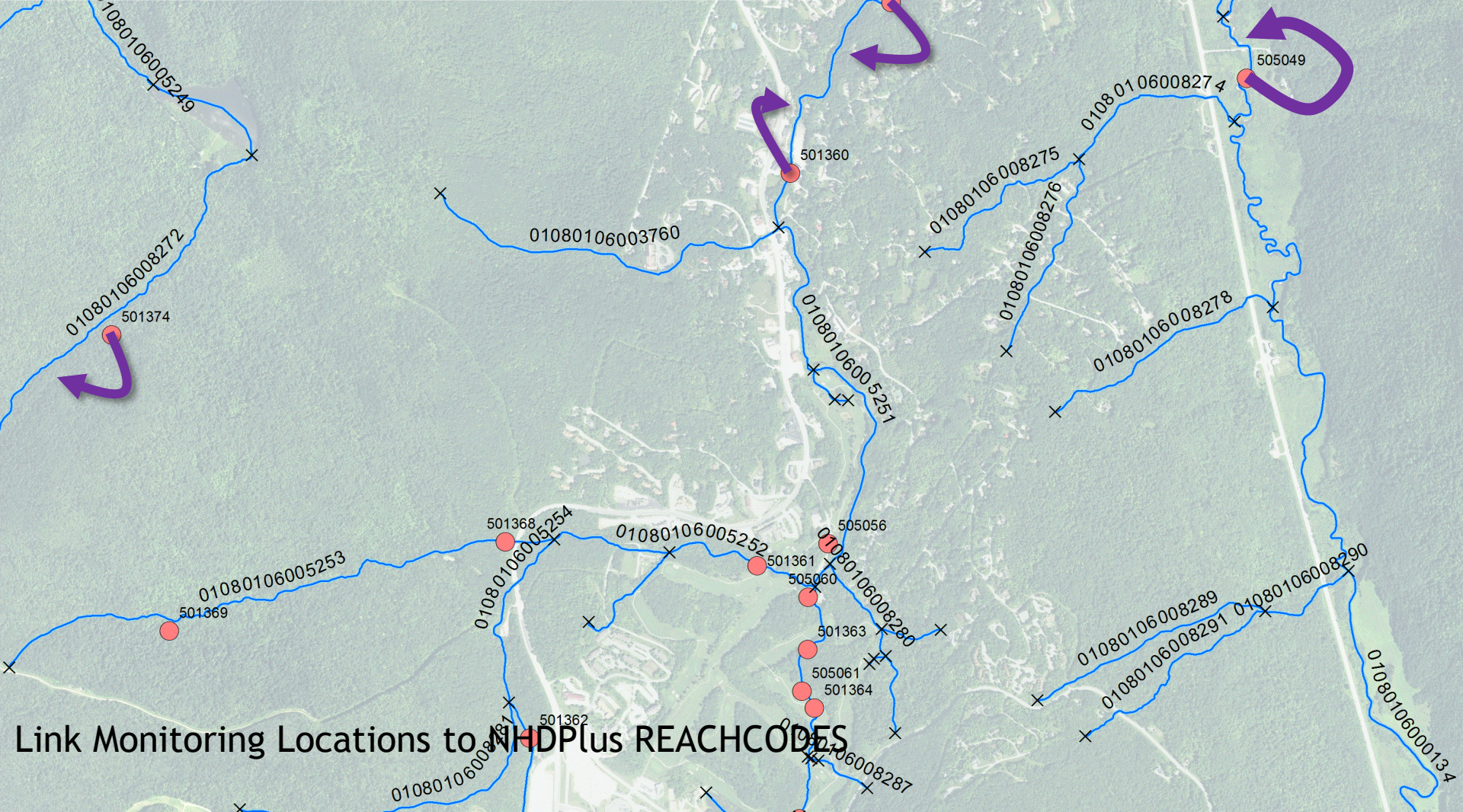
	LocationID	LocationNa	REACHCODE	atMeasure
1	501360	Roaring Brook	01080106005248	92.0
2	515406	Roaring Brook	01080106005248	60.9
3	505049	Ottauquechee River	01080106000134	84.3
4	501346	Ottauquechee River	01080106000134	97.7
5	501347	Ottauquechee River	01080106003685	1.2



Link Monitoring Locations to NHDPplus REACHCODES



	LocationID	LocationNa	REACHCODE	atMeasure
1	501360	Roaring Brook	01080106005248	92.0
2	515406	Roaring Brook	01080106005248	60.9
3	505049	Ottauquechee River	01080106000134	84.3
4	501346	Ottauquechee River	01080106000134	97.7
5	501347	Ottauquechee River	01080106003685	1.2
6	501374	Pico Pond Inlet	01080106008272	51.9

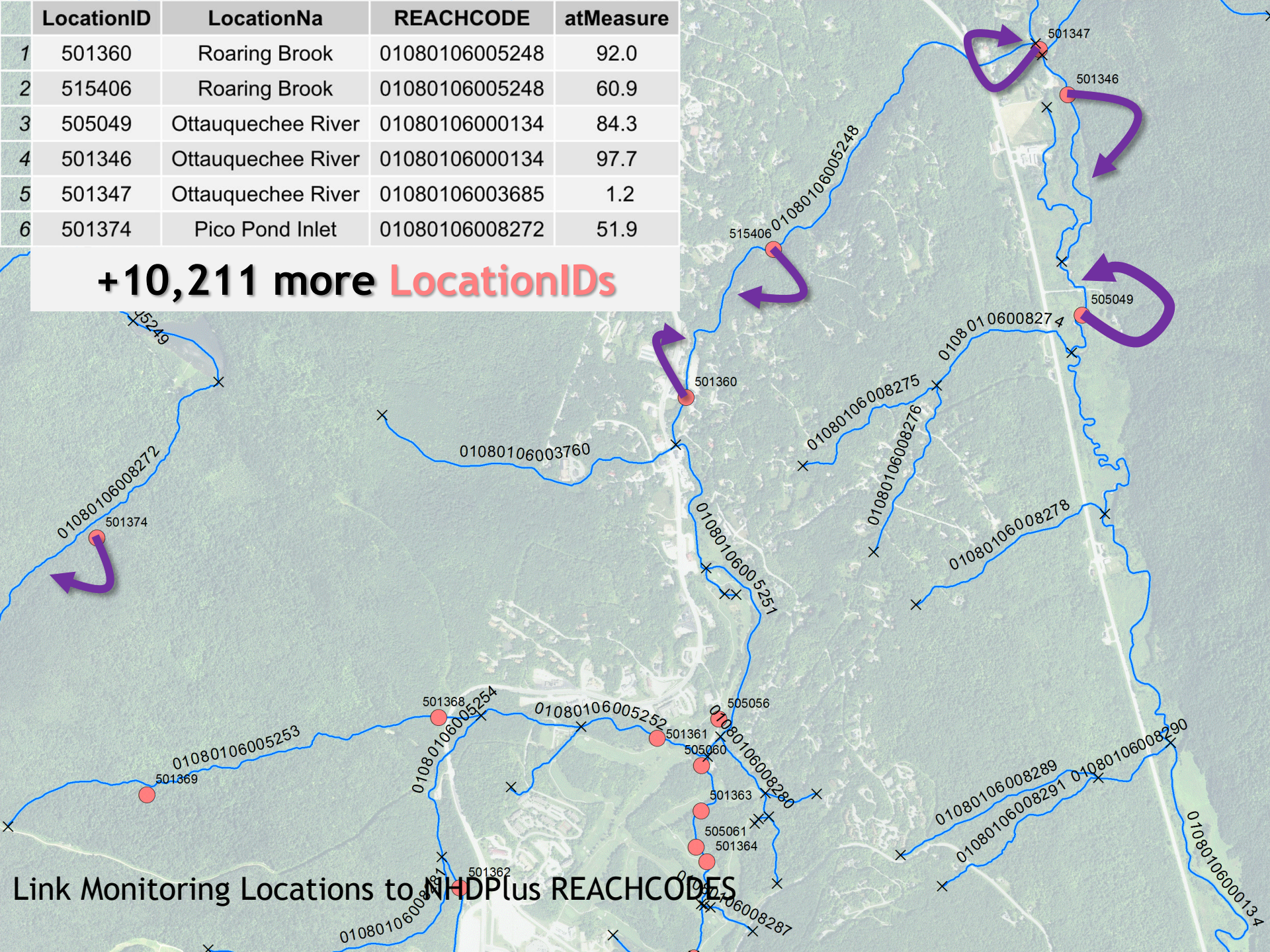


Link Monitoring Locations to NHDPplus REACHCODES



	LocationID	LocationNa	REACHCODE	atMeasure
1	501360	Roaring Brook	01080106005248	92.0
2	515406	Roaring Brook	01080106005248	60.9
3	505049	Ottauquechee River	01080106000134	84.3
4	501346	Ottauquechee River	01080106000134	97.7
5	501347	Ottauquechee River	01080106003685	1.2
6	501374	Pico Pond Inlet	01080106008272	51.9

**+10,211 more LocationIDs**



Link Monitoring Locations to NHDPplus REACHCODES

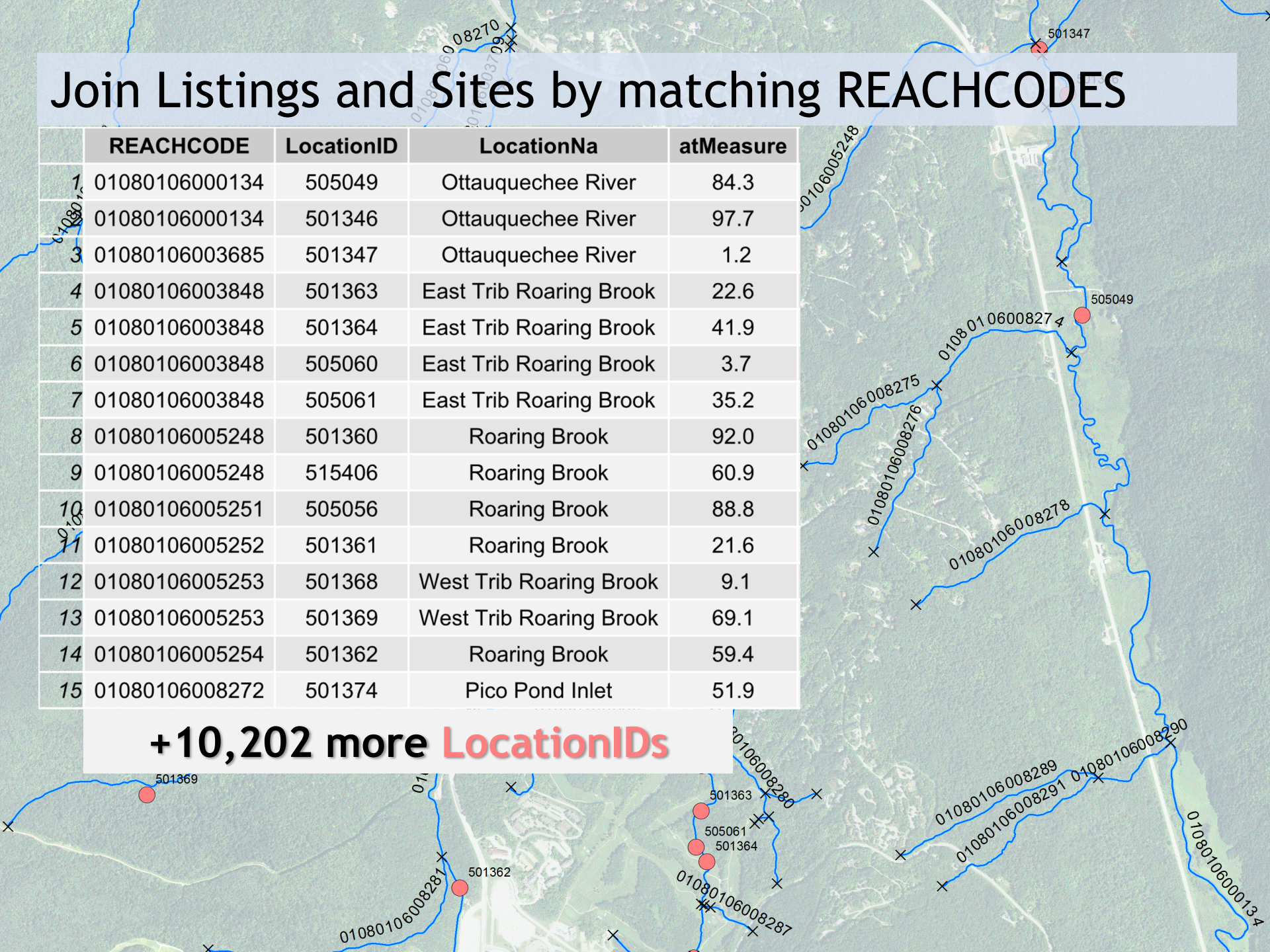


Categorize reaches as (j)s

# Join Listings and Sites by matching REACHCODES

	REACHCODE	LocationID	LocationNa	atMeasure
1	01080106000134	505049	Ottauquechee River	84.3
2	01080106000134	501346	Ottauquechee River	97.7
3	01080106003685	501347	Ottauquechee River	1.2
4	01080106003848	501363	East Trib Roaring Brook	22.6
5	01080106003848	501364	East Trib Roaring Brook	41.9
6	01080106003848	505060	East Trib Roaring Brook	3.7
7	01080106003848	505061	East Trib Roaring Brook	35.2
8	01080106005248	501360	Roaring Brook	92.0
9	01080106005248	515406	Roaring Brook	60.9
10	01080106005251	505056	Roaring Brook	88.8
11	01080106005252	501361	Roaring Brook	21.6
12	01080106005253	501368	West Trib Roaring Brook	9.1
13	01080106005253	501369	West Trib Roaring Brook	69.1
14	01080106005254	501362	Roaring Brook	59.4
15	01080106008272	501374	Pico Pond Inlet	51.9

**+10,202 more LocationIDs**

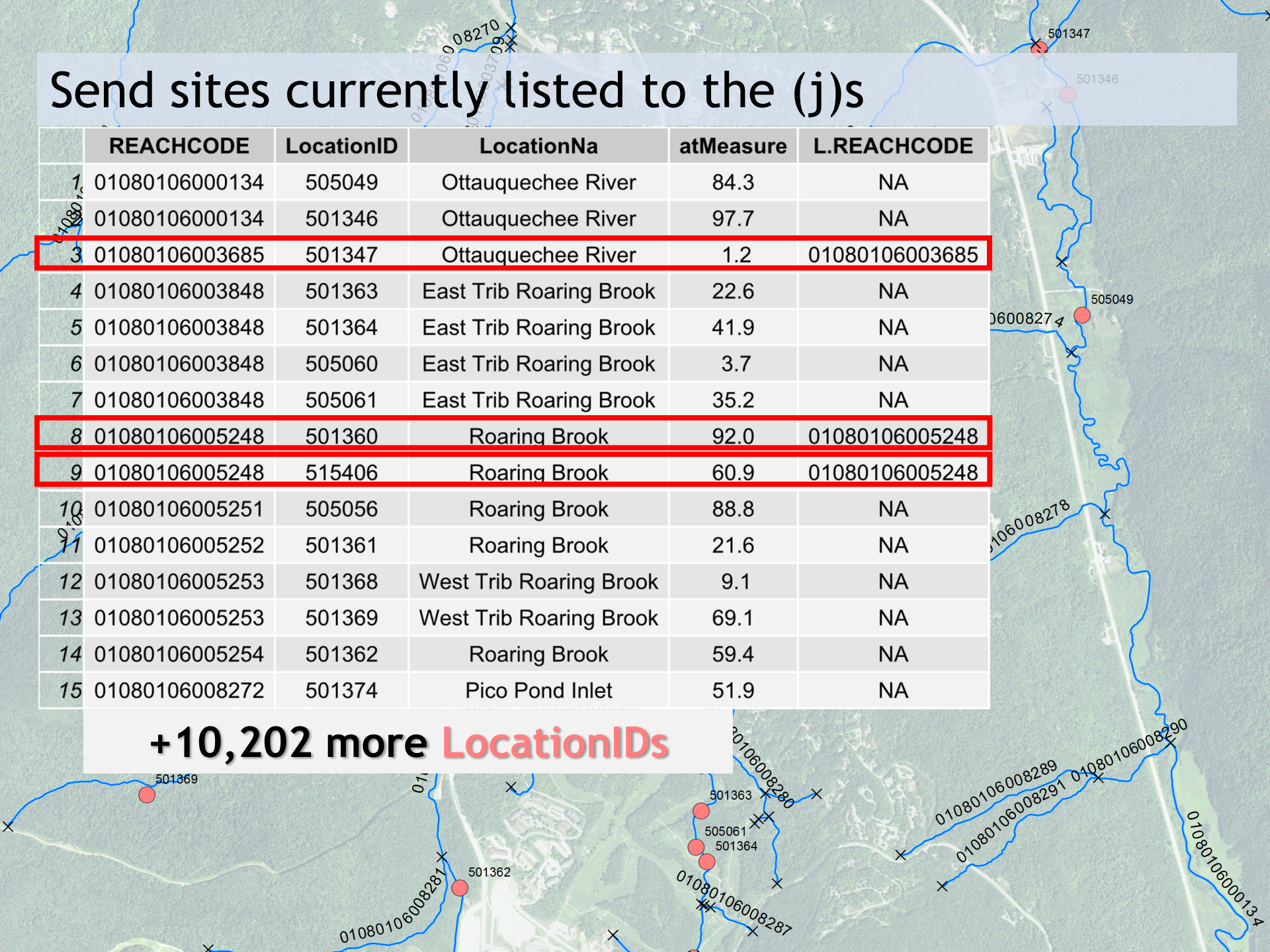




# Send sites currently listed to the (j)s

	REACHCODE	LocationID	LocationNa	atMeasure	L.REACHCODE
1	01080106000134	505049	Ottauquechee River	84.3	NA
2	01080106000134	501346	Ottauquechee River	97.7	NA
3	01080106003685	501347	Ottauquechee River	1.2	01080106003685
4	01080106003848	501363	East Trib Roaring Brook	22.6	NA
5	01080106003848	501364	East Trib Roaring Brook	41.9	NA
6	01080106003848	505060	East Trib Roaring Brook	3.7	NA
7	01080106003848	505061	East Trib Roaring Brook	35.2	NA
8	01080106005248	501360	Roaring Brook	92.0	01080106005248
9	01080106005248	515406	Roaring Brook	60.9	01080106005248
10	01080106005251	505056	Roaring Brook	88.8	NA
11	01080106005252	501361	Roaring Brook	21.6	NA
12	01080106005253	501368	West Trib Roaring Brook	9.1	NA
13	01080106005253	501369	West Trib Roaring Brook	69.1	NA
14	01080106005254	501362	Roaring Brook	59.4	NA
15	01080106008272	501374	Pico Pond Inlet	51.9	NA

**+10,202 more LocationIDs**





# Send sites currently listed to the (j)s

	REACHCODE	LocationID	LocationNa	atMeasure	L.REACHCODE
1	01080106000134	505049	Ottauquechee River	84.3	NA
2	01080106000134	501346	Ottauquechee River	97.7	NA
3	01080106003685	501347	Ottauquechee River	1.2	01080106003685
4	01080106003848	501363	East Trib Roaring Brook	22.6	NA
5	01080106003848	501364	East Trib Roaring Brook	41.9	NA
6	01080106003848	505060	East Trib Roaring Brook	3.7	NA
7	01080106003848	505061	East Trib Roaring Brook	35.2	NA
8	01080106005248	501360	Roaring Brook	92.0	01080106005248
9	01080106005248	515406	Roaring Brook	60.9	01080106005248
10	01080106005251	505056	Roaring Brook	88.8	NA
11	01080106005252	501361	Roaring Brook	21.6	NA
12	01080106005253	501368	West Trib Roaring Brook	9.1	NA
13	01080106005253	501369	West Trib Roaring Brook	69.1	NA
14	01080106005254	501362	Roaring Brook	59.4	NA
15	01080106008272	501374	Pico Pond Inlet	51.9	NA

+10,202 more **LocationIDs**

LISTING

100

REACH

0



# Send sites currently listed to the (j)s

	REACHCODE	LocationID	LocationNa	atMeasure	L.REACHCODE	FMeasure	TMeasure
1	01080106000134	505049	Ottauquechee River	84.3	NA	NA	NA
2	01080106000134	501346	Ottauquechee River	97.7	NA	NA	NA
3	01080106003685	501347	Ottauquechee River	1.2	01080106003685	0	100
4	01080106003848	501363	East Trib Roaring Brook	22.6	NA	NA	NA
5	01080106003848	501364	East Trib Roaring Brook	41.9	NA	NA	NA
6	01080106003848	505060	East Trib Roaring Brook	3.7	NA	NA	NA
7	01080106003848	505061	East Trib Roaring Brook	35.2	NA	NA	NA
8	01080106005248	501360	Roaring Brook	92.0	01080106005248	59.1	70.9
9	01080106005248	515406	Roaring Brook	60.9	01080106005248	59.1	70.9
10	01080106005251	505056	Roaring Brook	88.8	NA	NA	NA
11	01080106005252	501361	Roaring Brook	21.6	NA	NA	NA
12	01080106005253	501368	West Trib Roaring Brook	9.1	NA	NA	NA
13	01080106005253	501369	West Trib Roaring Brook	69.1	NA	NA	NA
14	01080106005254	501362	Roaring Brook	59.4	NA	NA	NA
15	01080106008272	501374	Pico Pond Inlet	51.9	NA	NA	NA

**+10,202 more LocationIDs**





# Send sites currently listed to the (j)s

	REACHCODE	LocationID	LocationNa	atMeasure	L.REACHCODE	FMeasure	TMeasure
1	01080106000134	505049	Ottauquechee River	84.3	NA	NA	NA
2	01080106000134	501346	Ottauquechee River	97.7	NA	NA	NA
3	01080106003685	501347	Ottauquechee River	1.2	01080106003685	0	100
4	01080106003848	501363	East Trib Roaring Brook	22.6	NA	NA	NA
5	01080106003848	501364	East Trib Roaring Brook	41.9	NA	NA	NA
6	01080106003848	505060	East Trib Roaring Brook	3.7	NA	NA	NA
7	01080106003848	505061	East Trib Roaring Brook	35.2	NA	NA	NA
8	01080106005248	501360	Roaring Brook	92.0	01080106005248	59.1	70.9
9	01080106005248	515406	Roaring Brook	60.9	01080106005248	59.1	70.9
10	01080106005251	505056	Roaring Brook	88.8	NA	NA	NA
11	01080106005252	501361	Roaring Brook	21.6	NA	NA	NA
12	01080106005253	501368	West Trib Roaring Brook	9.1	NA	NA	NA
13	01080106005253	501369	West Trib Roaring Brook	69.1	NA	NA	NA
14	01080106005254	501362	Roaring Brook	59.4	NA	NA	NA
15	01080106008272	501374	Pico Pond Inlet	51.9	NA	NA	NA

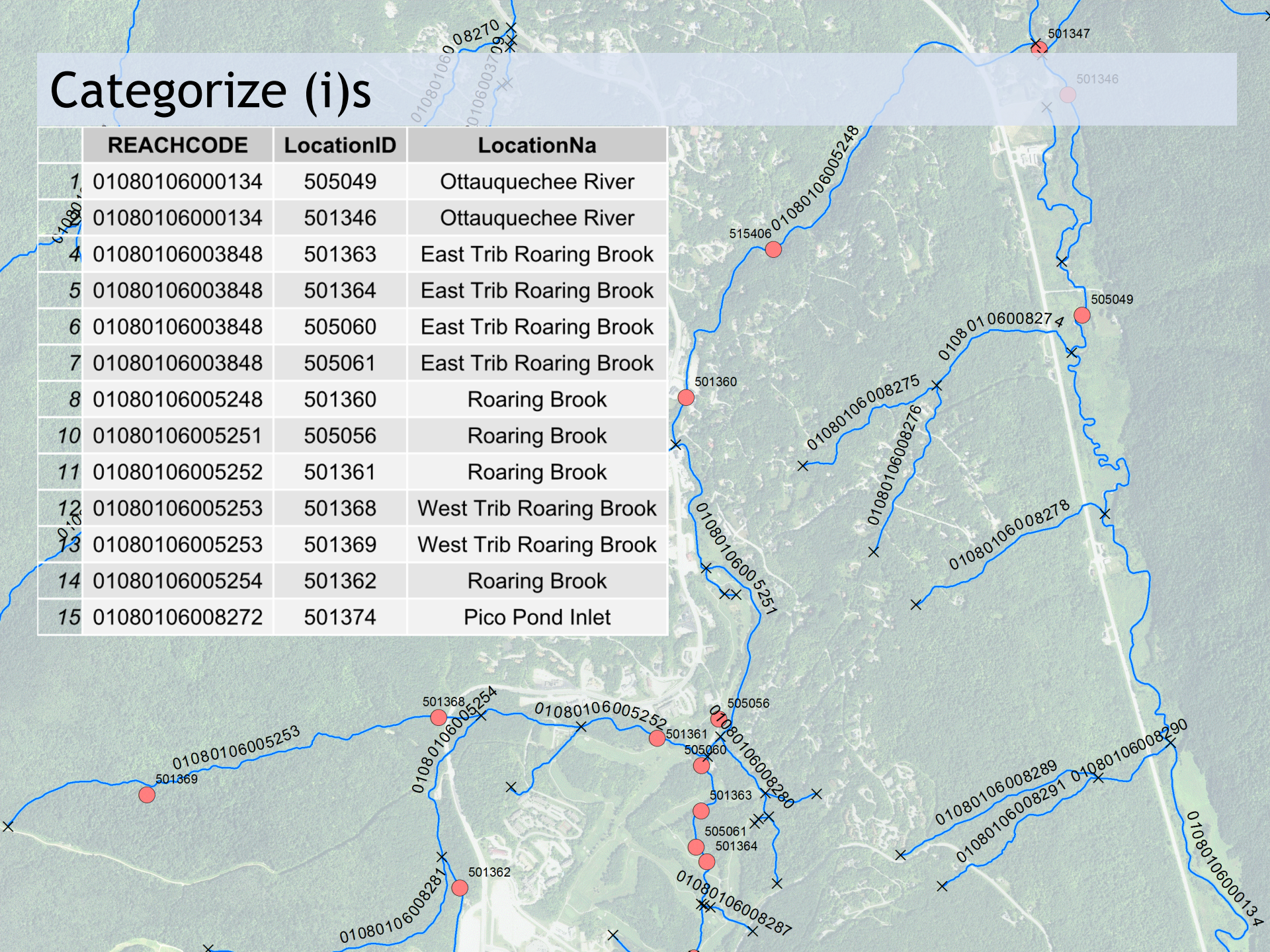
+10,202 more **LocationIDs**

(j)s



# Categorize (i)s

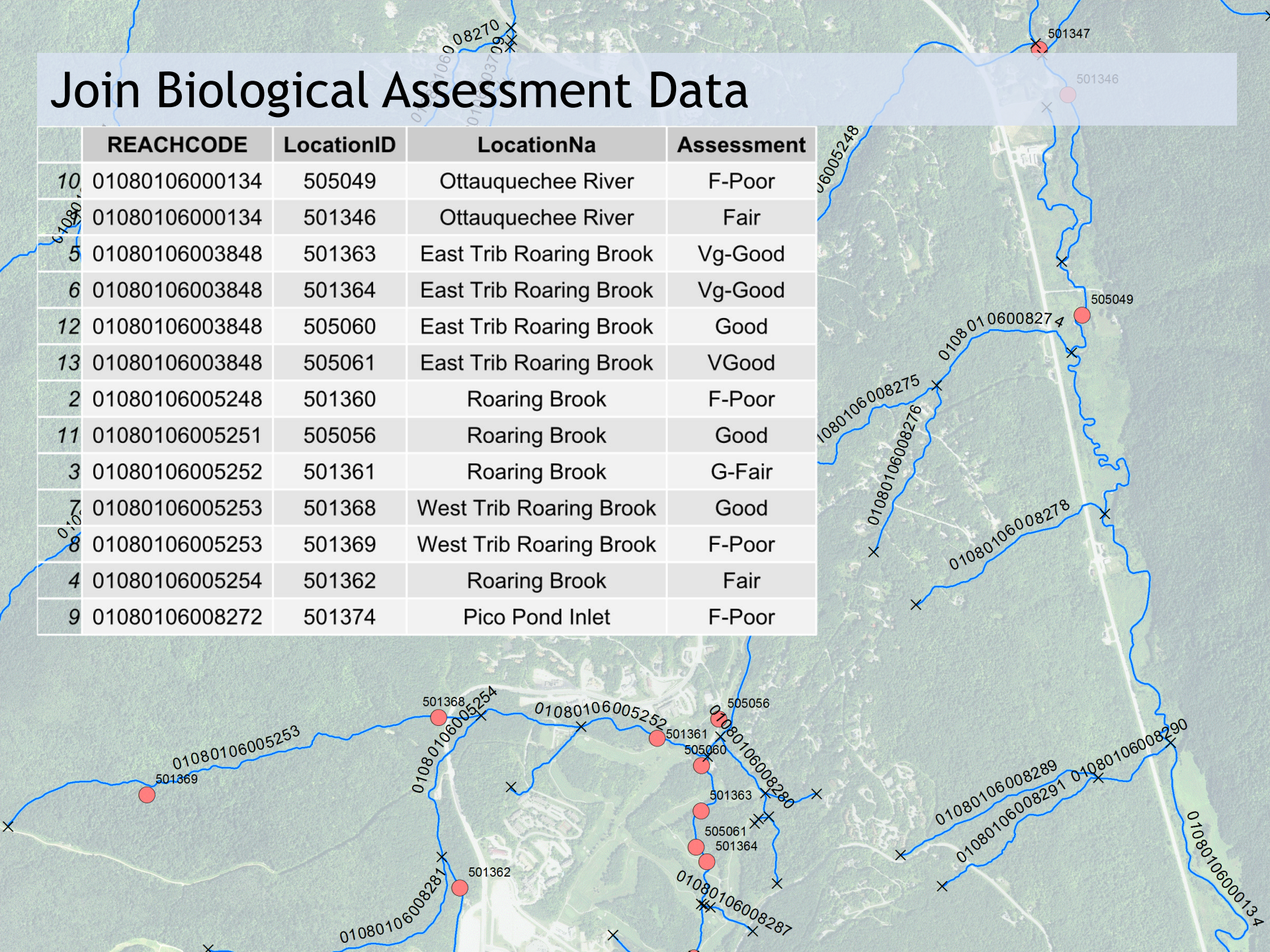
	REACHCODE	LocationID	LocationNa
1	01080106000134	505049	Ottauquechee River
2	01080106000134	501346	Ottauquechee River
4	01080106003848	501363	East Trib Roaring Brook
5	01080106003848	501364	East Trib Roaring Brook
6	01080106003848	505060	East Trib Roaring Brook
7	01080106003848	505061	East Trib Roaring Brook
8	01080106005248	501360	Roaring Brook
10	01080106005251	505056	Roaring Brook
11	01080106005252	501361	Roaring Brook
12	01080106005253	501368	West Trib Roaring Brook
13	01080106005253	501369	West Trib Roaring Brook
14	01080106005254	501362	Roaring Brook
15	01080106008272	501374	Pico Pond Inlet





# Join Biological Assessment Data

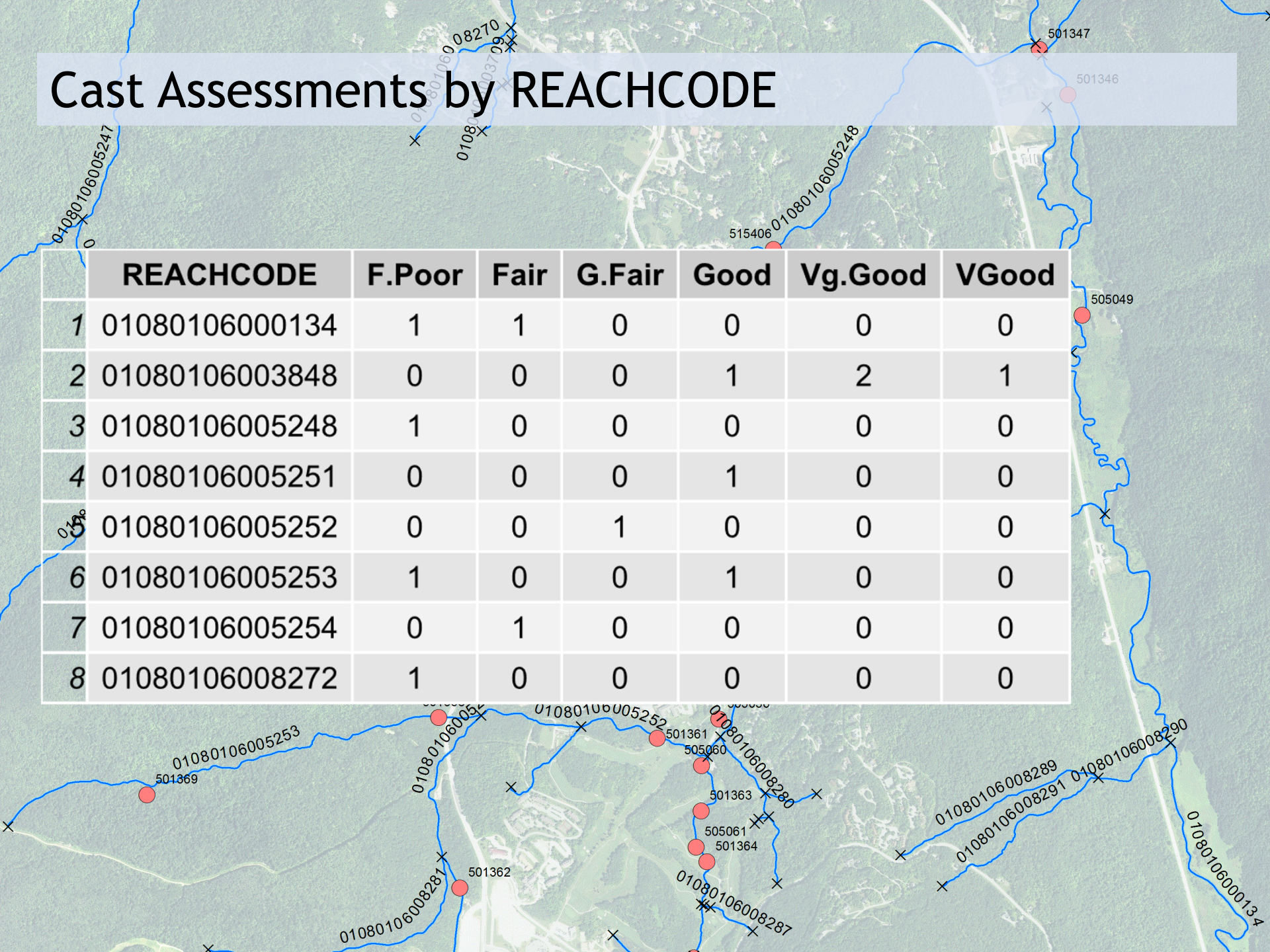
	REACHCODE	LocationID	LocationNa	Assessment
10	01080106000134	505049	Ottauquechee River	F-Poor
8	01080106000134	501346	Ottauquechee River	Fair
5	01080106003848	501363	East Trib Roaring Brook	Vg-Good
6	01080106003848	501364	East Trib Roaring Brook	Vg-Good
12	01080106003848	505060	East Trib Roaring Brook	Good
13	01080106003848	505061	East Trib Roaring Brook	VGood
2	01080106005248	501360	Roaring Brook	F-Poor
11	01080106005251	505056	Roaring Brook	Good
3	01080106005252	501361	Roaring Brook	G-Fair
7	01080106005253	501368	West Trib Roaring Brook	Good
8	01080106005253	501369	West Trib Roaring Brook	F-Poor
4	01080106005254	501362	Roaring Brook	Fair
9	01080106008272	501374	Pico Pond Inlet	F-Poor





# Cast Assessments by REACHCODE

	REACHCODE	F.Poor	Fair	G.Fair	Good	Vg.Good	VGood
1	01080106000134	1	1	0	0	0	0
2	01080106003848	0	0	0	1	2	1
3	01080106005248	1	0	0	0	0	0
4	01080106005251	0	0	0	1	0	0
5	01080106005252	0	0	1	0	0	0
6	01080106005253	1	0	0	1	0	0
7	01080106005254	0	1	0	0	0	0
8	01080106008272	1	0	0	0	0	0





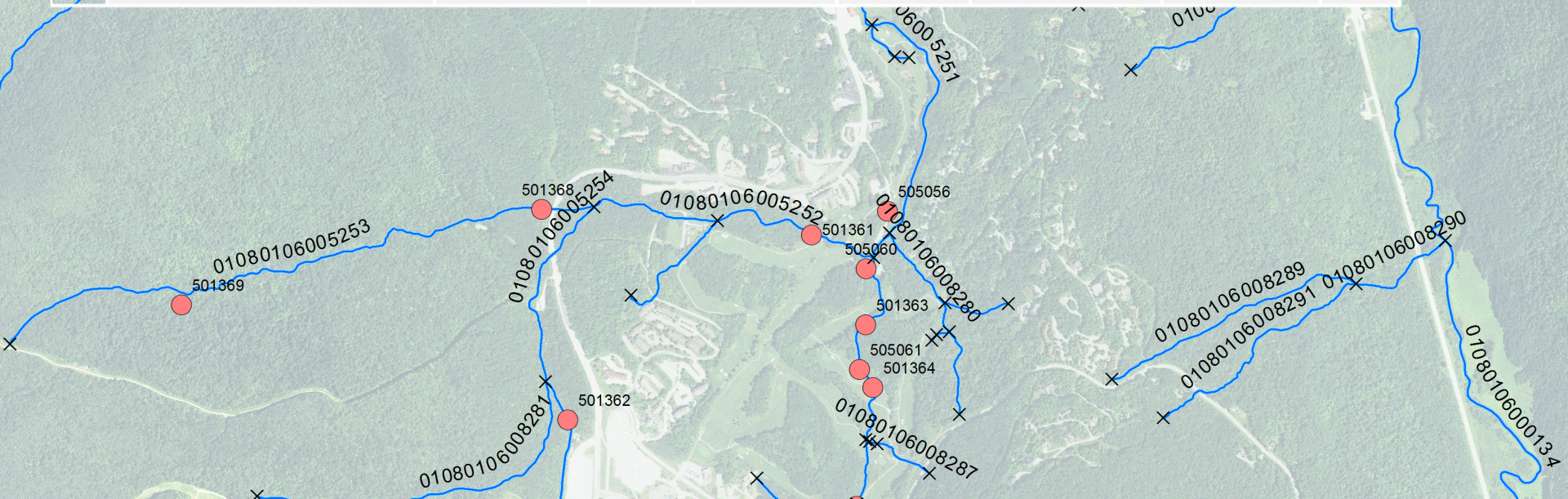
# Delete REACHCODES where $>3/4$ are Passing

	REACHCODE	F.Poor	Fair	G.Fair	Good	Vg.Good	VGood	b3
1	01080106000134	1	1	0	0	0	0	1
2	01080106003848	0	0	0	1	2	1	0
3	01080106005248	1	0	0	0	0	0	1
4	01080106005251	0	0	0	1	0	0	0
5	01080106005252	0	0	1	0	0	0	0
6	01080106005253	1	0	0	1	0	0	1
7	01080106005254	0	1	0	0	0	0	1
8	01080106008272	1	0	0	0	0	0	1



# Delete REACHCODES where $>3/4$ are Passing

	REACHCODE	F.Poor	Fair	G.Fair	Good	Vg.Good	VGood	b3
1	01080106000134	1	1	0	0	0	0	1
3	01080106005248	1	0	0	0	0	0	1
6	01080106005253	1	0	0	1	0	0	1
7	01080106005254	0	1	0	0	0	0	1
8	01080106008272	1	0	0	0	0	0	1

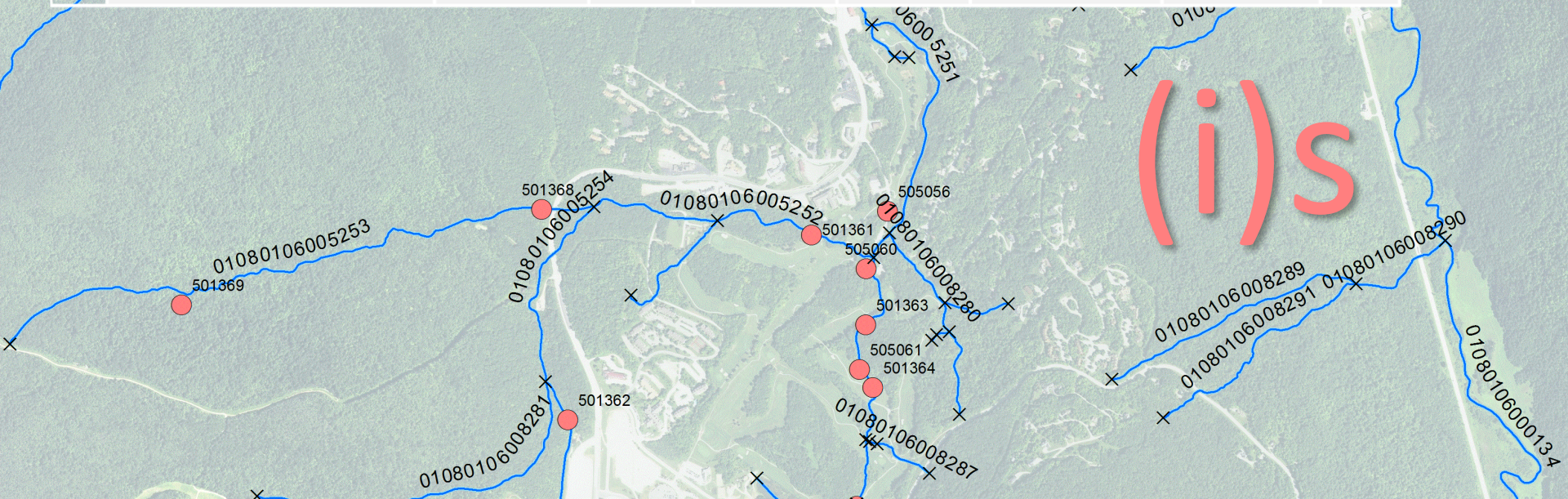




# Delete REACHCODES where $>3/4$ are Passing

	REACHCODE	F.Poor	Fair	G.Fair	Good	Vg.Good	VGood	b3
1	01080106000134	1	1	0	0	0	0	1
3	01080106005248	1	0	0	0	0	0	1
6	01080106005253	1	0	0	1	0	0	1
7	01080106005254	0	1	0	0	0	0	1
8	01080106008272	1	0	0	0	0	0	1

(i)s





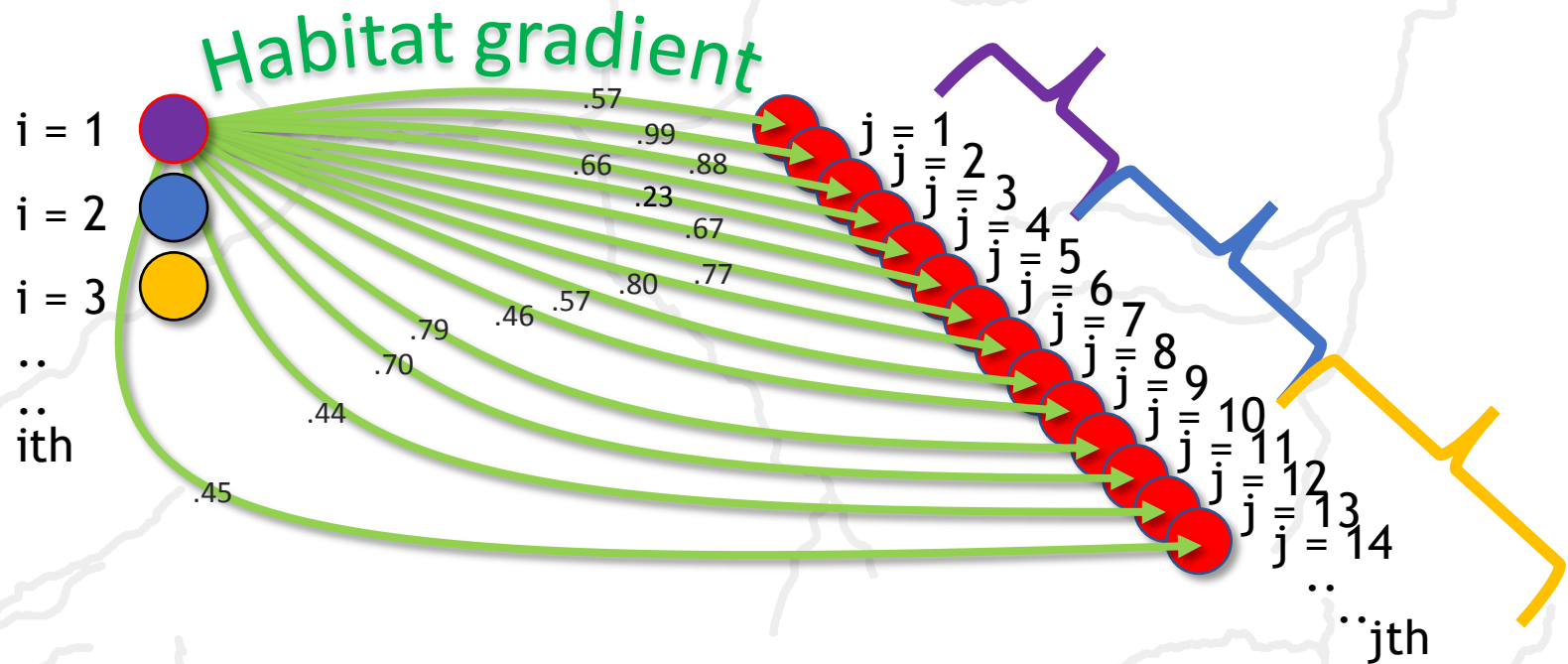






Impose upon the algorithm

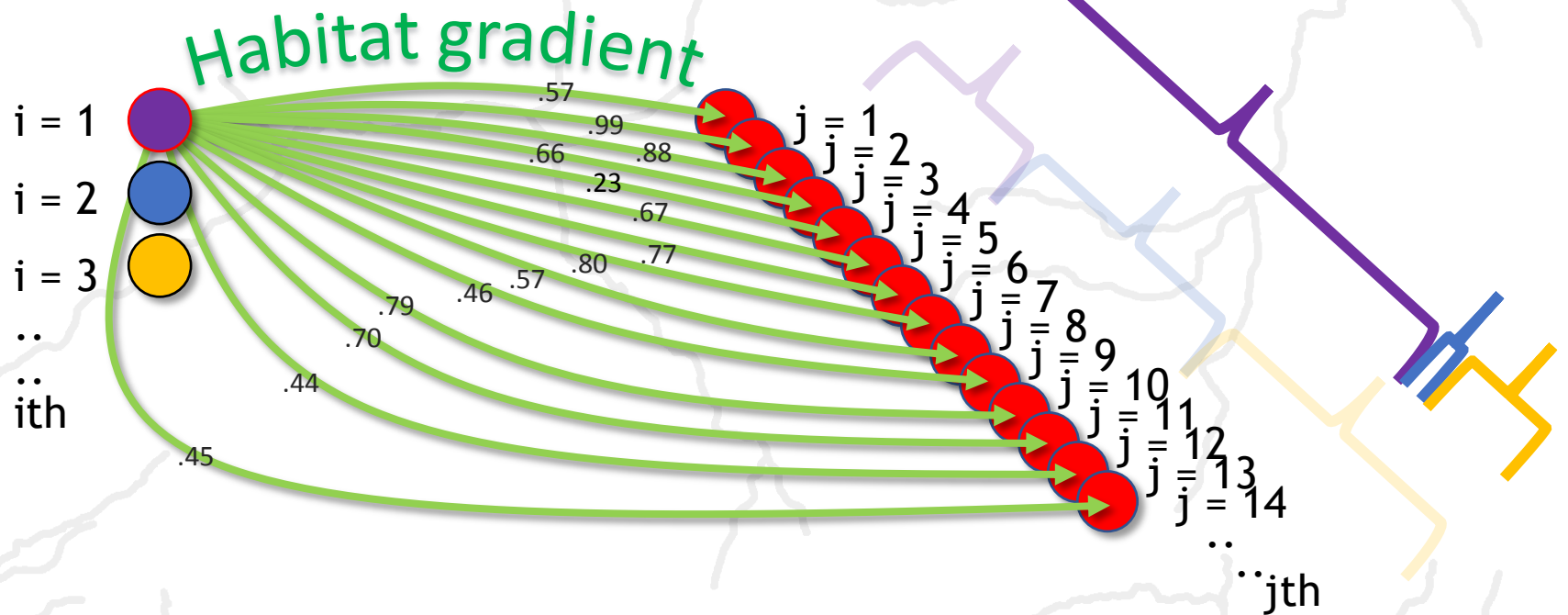
# Stream Size



Impose upon the algorithm

Stream Size

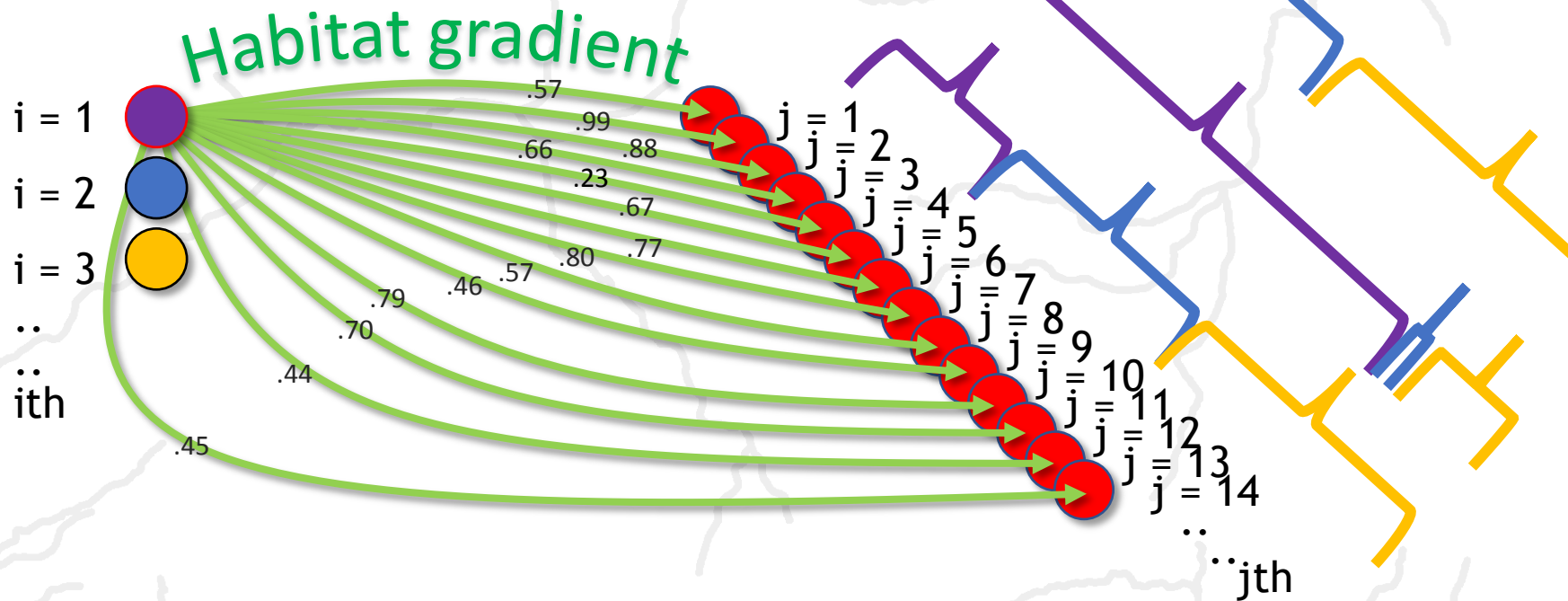
# Sampling Method





Impose upon the algorithm

# Stream Size Sampling Method Eco region



# How to scale



## How to scale

**X, Y Coordinates of Sites**

**X, Y Coordinates of a listing's  
Outlet & Inlet**

**And Bug/Fish counts for each  
sample at each site.**

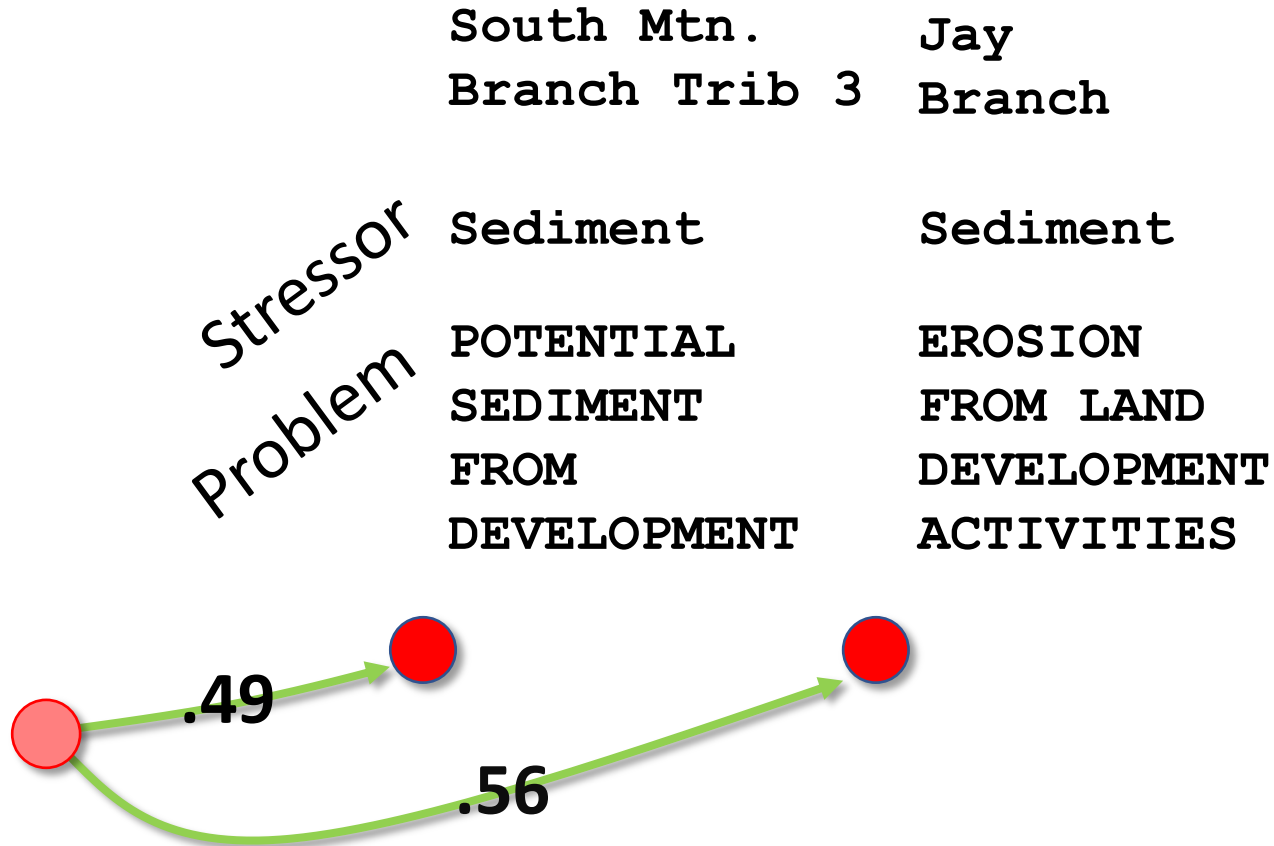


# Identifying stressors to Aquatic Biota

Sean Regalado



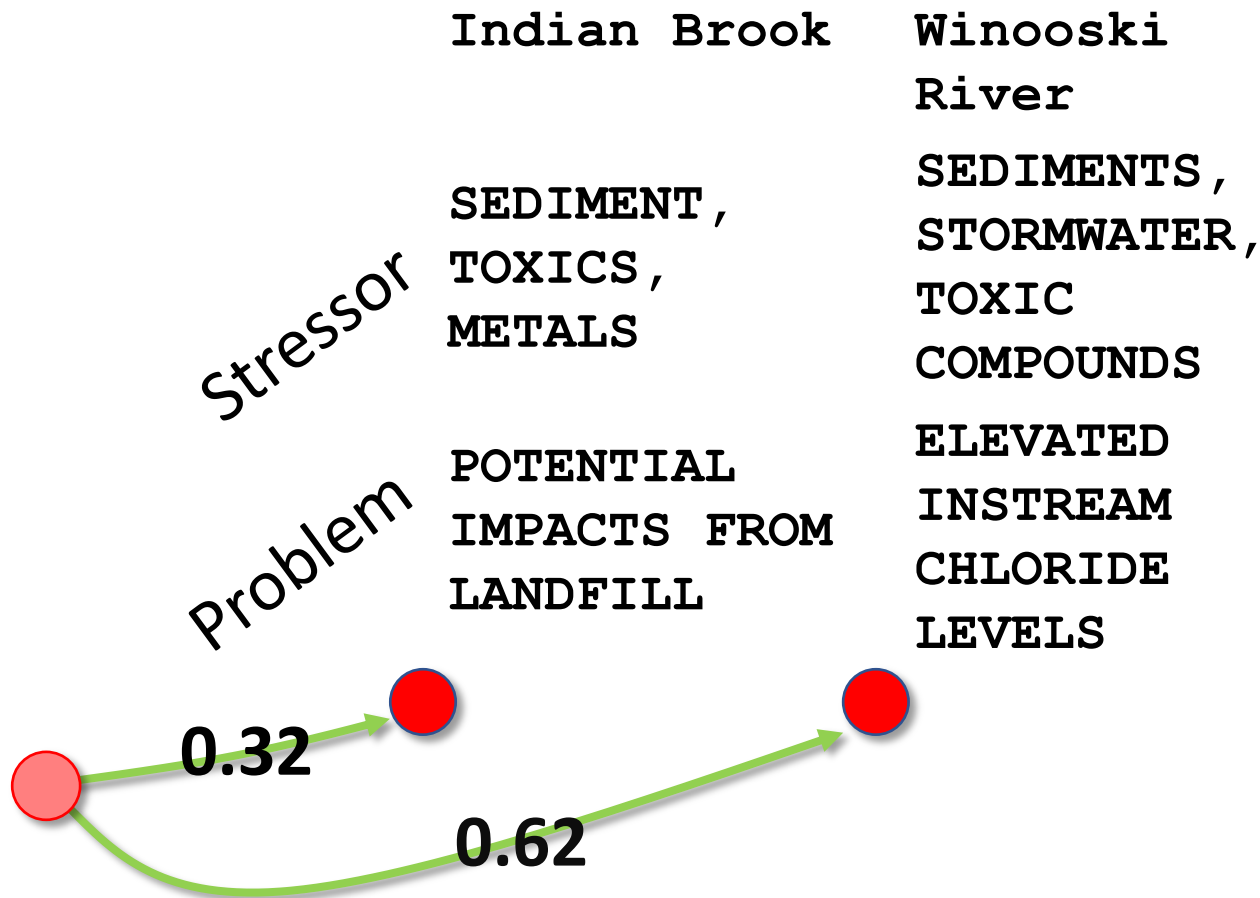
Annis  
Brook



## Biologist's notes on Annis Brook

*...Moss is the most significant periphyton with good cover. This is likely one reason for high percent of *Olumnus laticulus**

Lemon  
Fair  
Trib 7



### Biologist's notes Lemon Fair Trib

*...The dominant taxa show *H. betteni* and *Chuematopsyche* as the dominant taxa. Only two dominant taxa are WQ sensitive.*