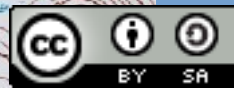
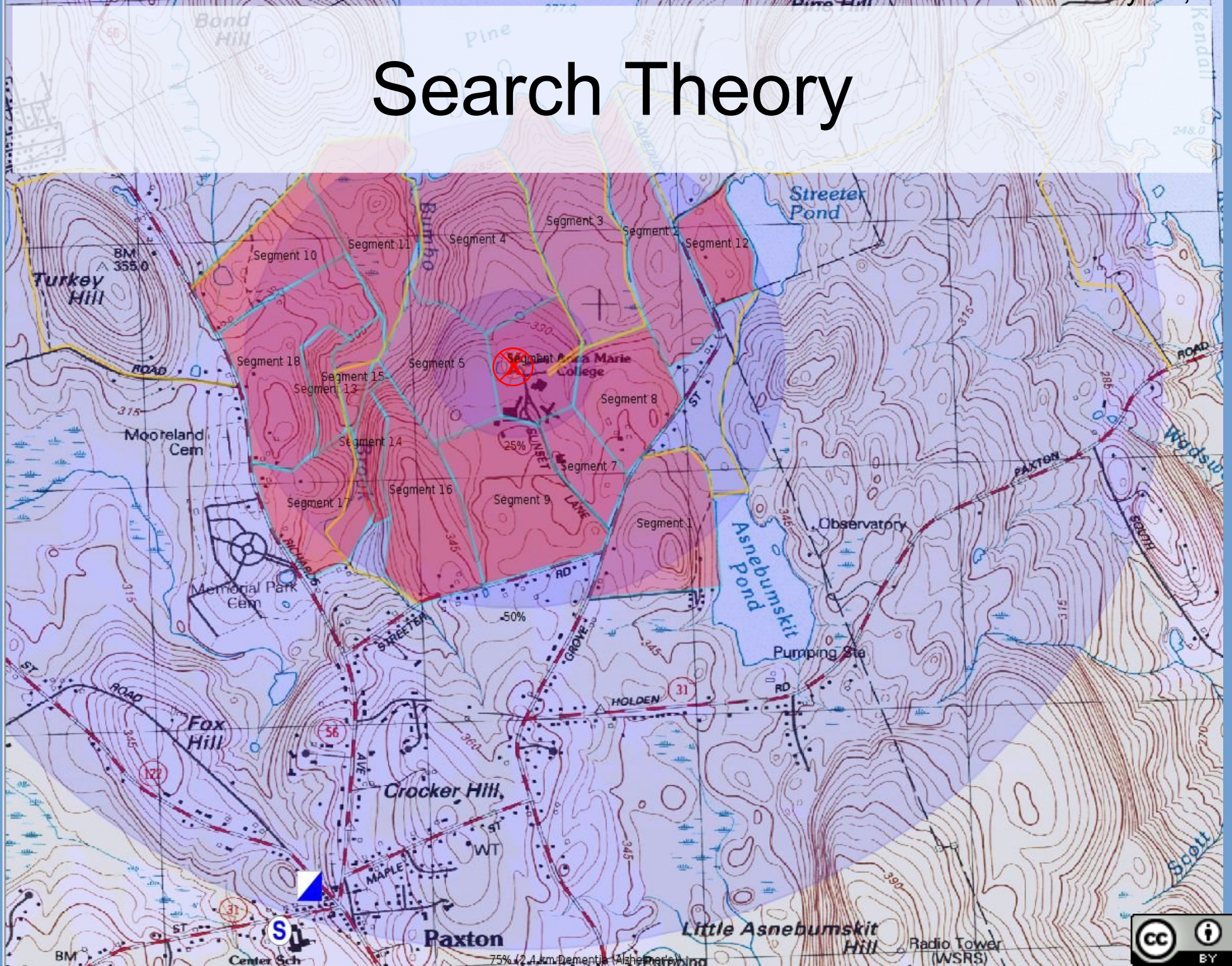
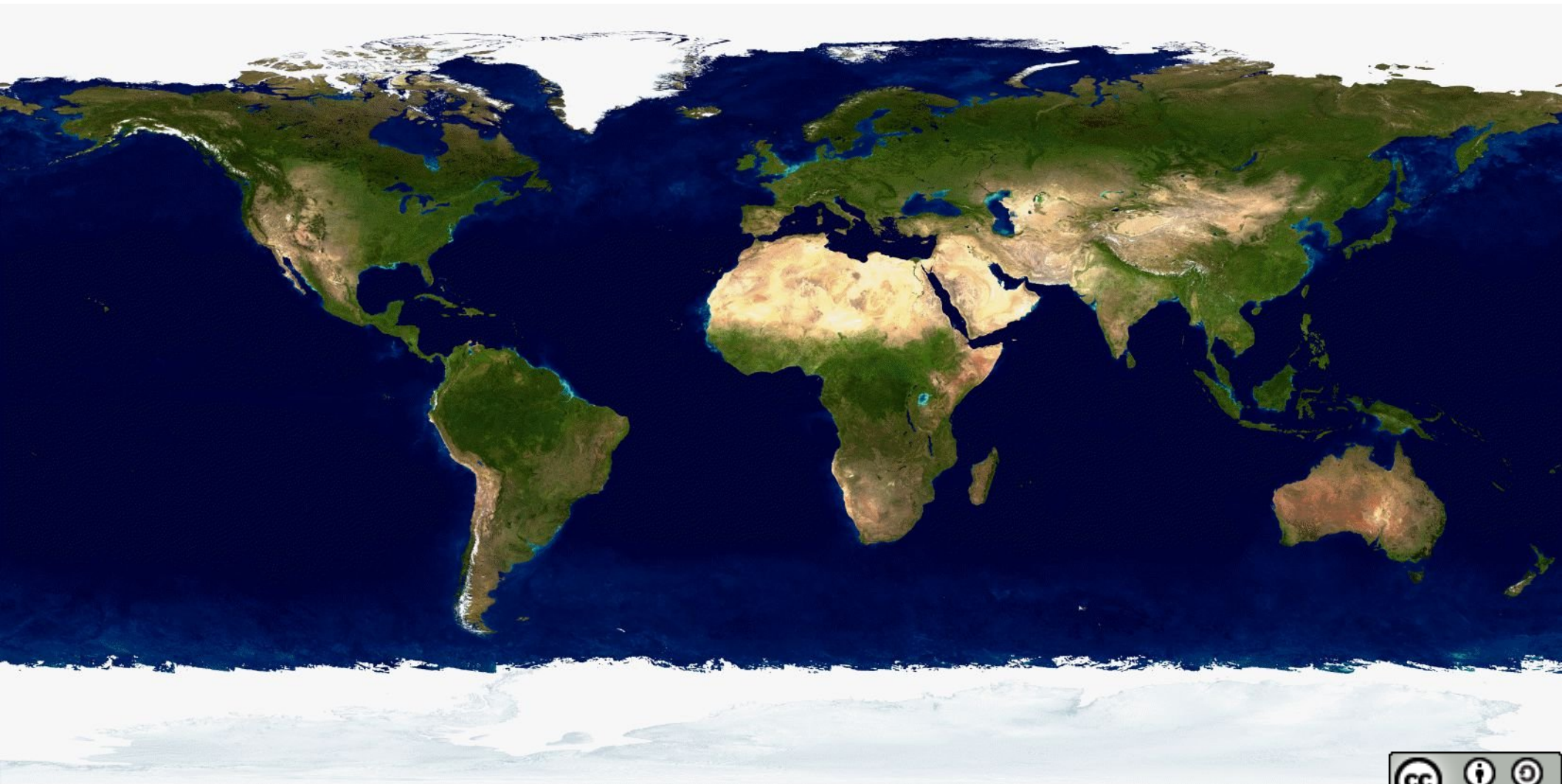


Search Theory

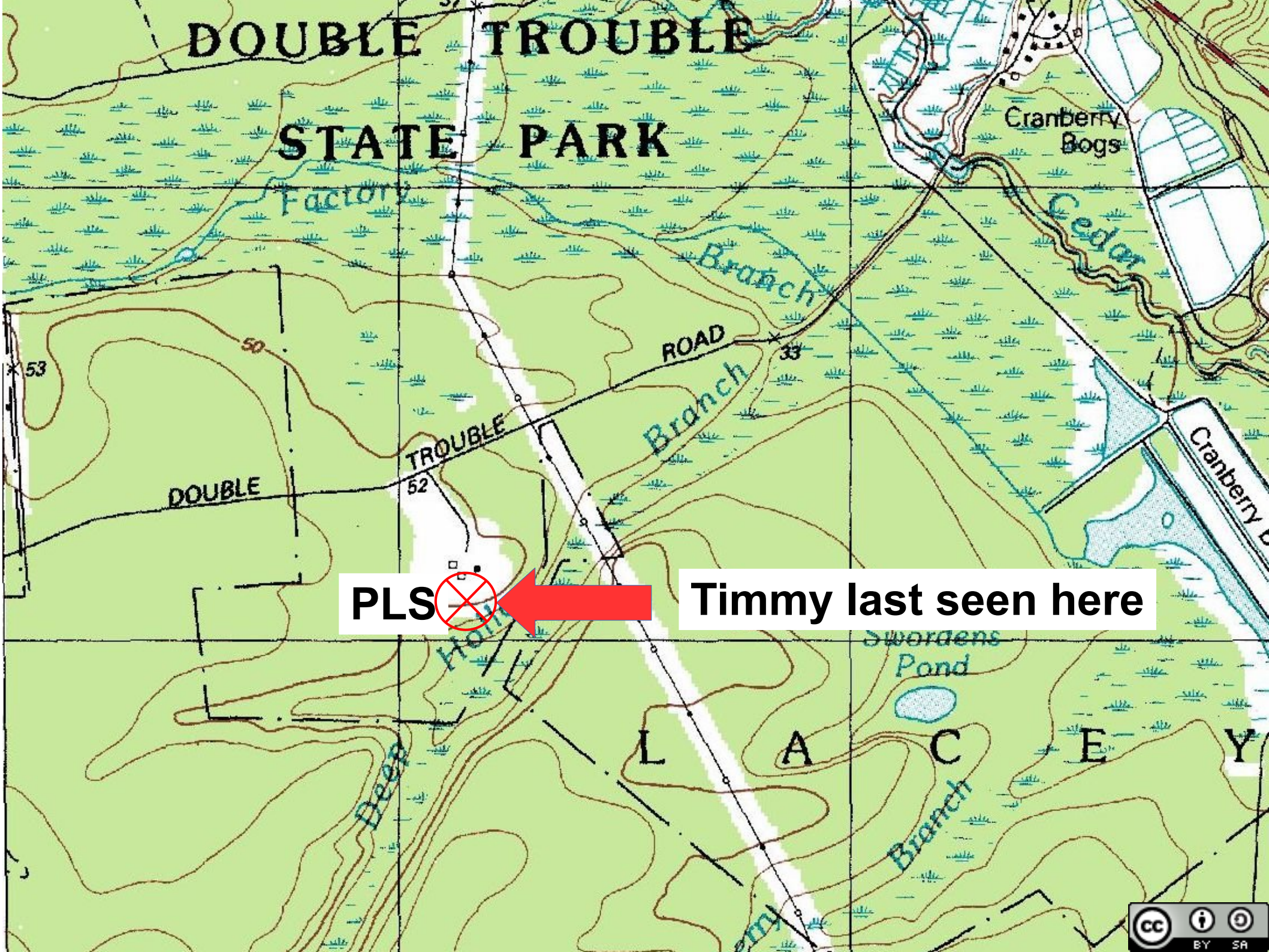


Timmy is Missing



DOUBLE TROUBLE

STATE PARK



Cranberry Bogs

Factory

Branch

Cedar

Branch

Cranberry

DOUBLE

TROUBLE

PLS

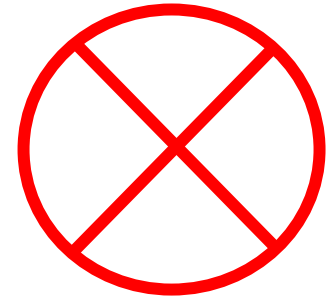


Timmy last seen here

Swordens Pond

L A C E Y

PLS



Point Last Seen

“The boys had been observed in the yard playing with a garden hose between 4:30 and 5:00 PM. Shortly thereafter, they were gone.”

Report of the Review Panel concerning the disappearance and deaths of three young young boys in East Camden June 22-24 2005.

DOUBLE TROUBLE

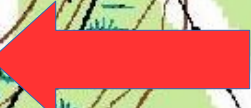
STATE PARK



Timmy's Hat found here by hasty task checking powerline



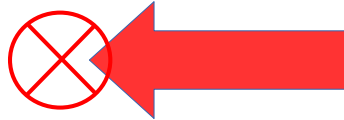
PLS



Timmy last seen here

LKP

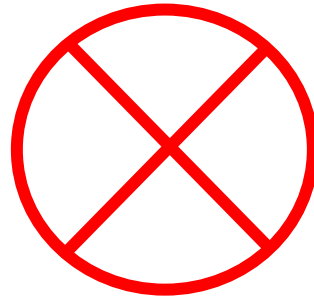
Last Known Point



Timmy's Hat found here.

IPP

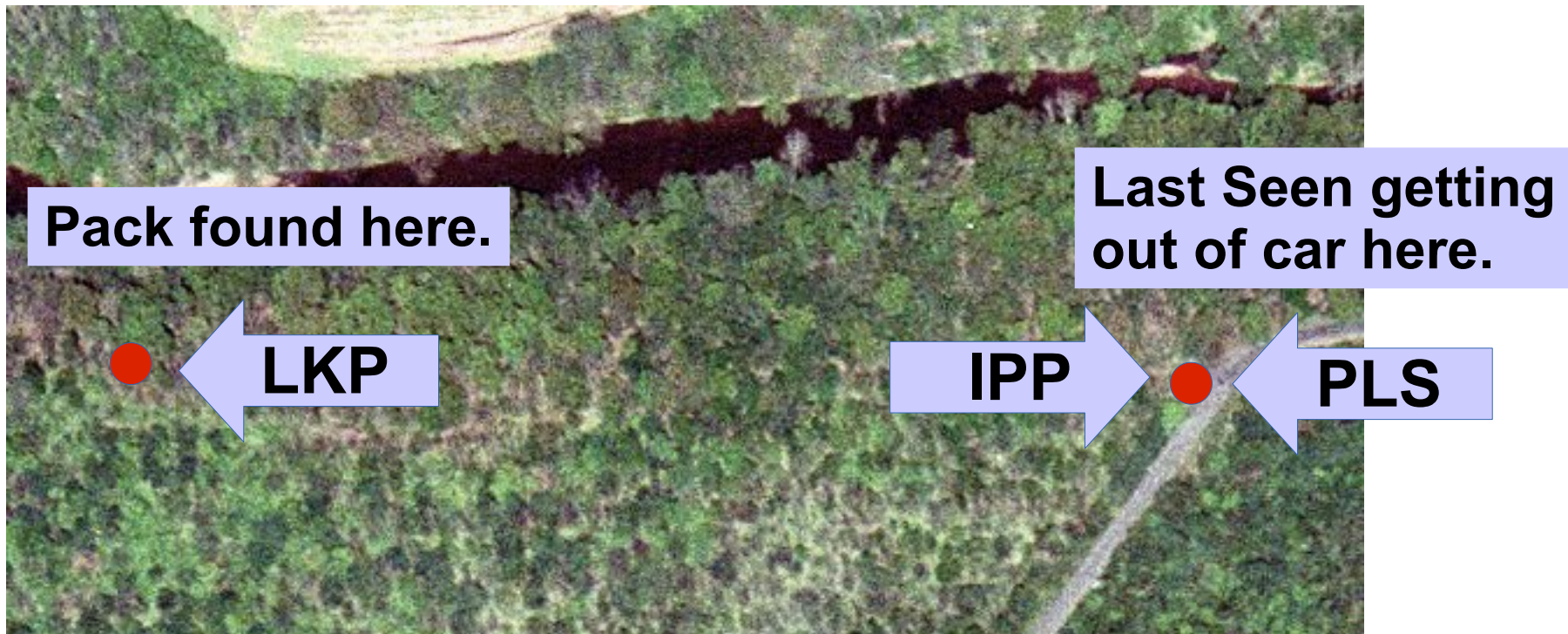
Initial Planning Point



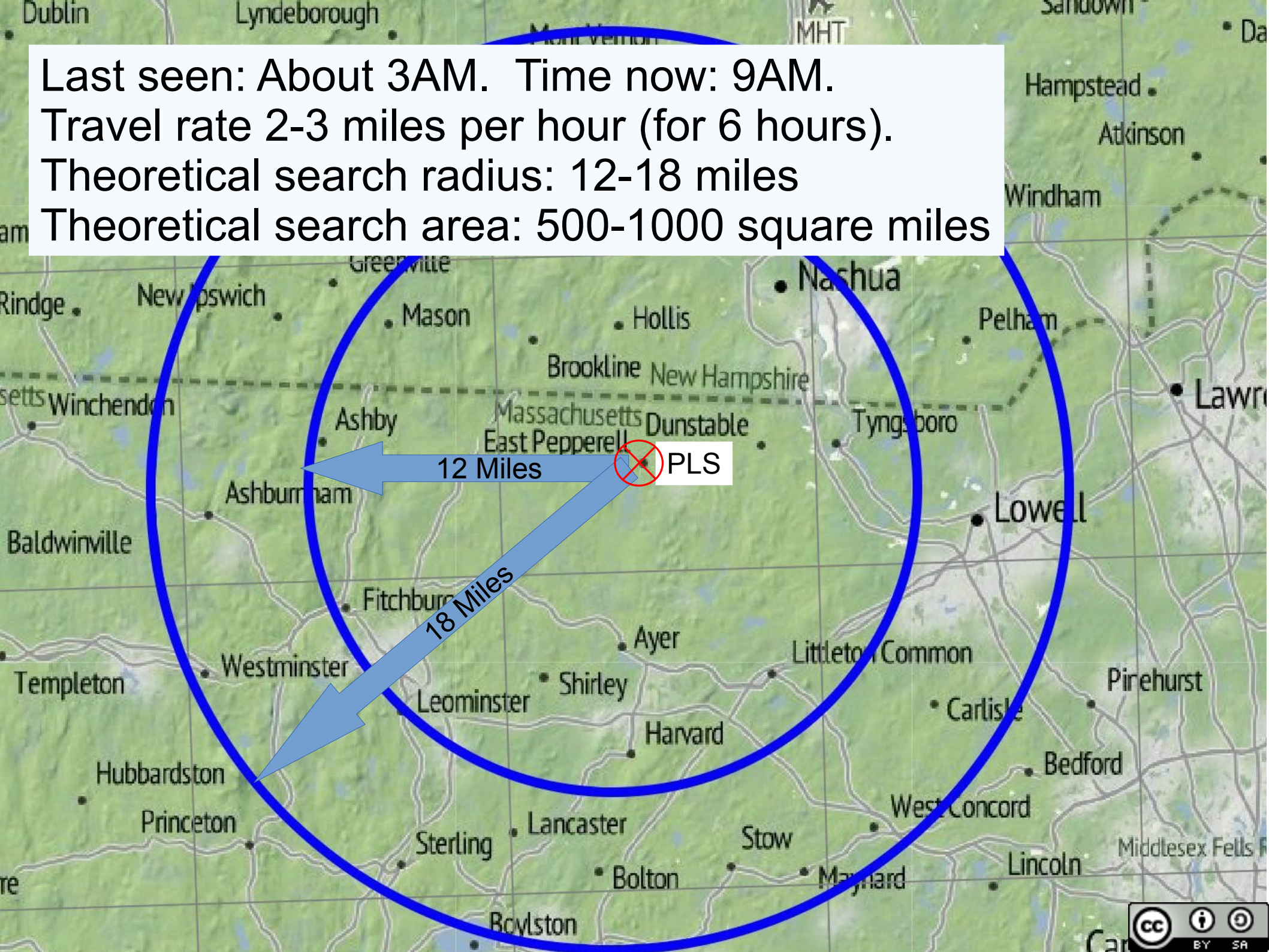
PLS or LKP at the onset of the search.

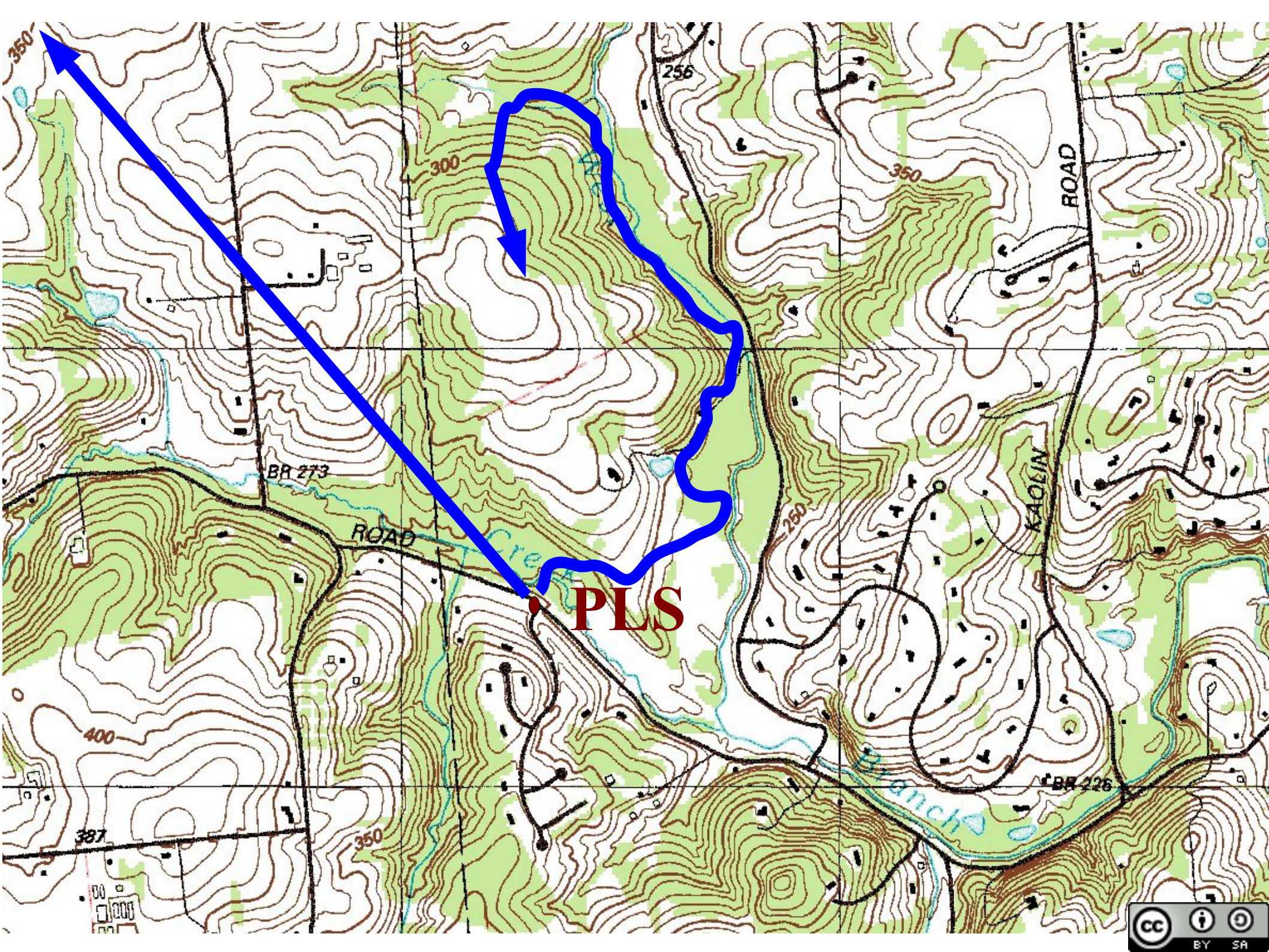
Never Changes

- **PLS:** Point Last Seen
- **LKP:** Last Known Point
- **IPP:** Initial Planning Point



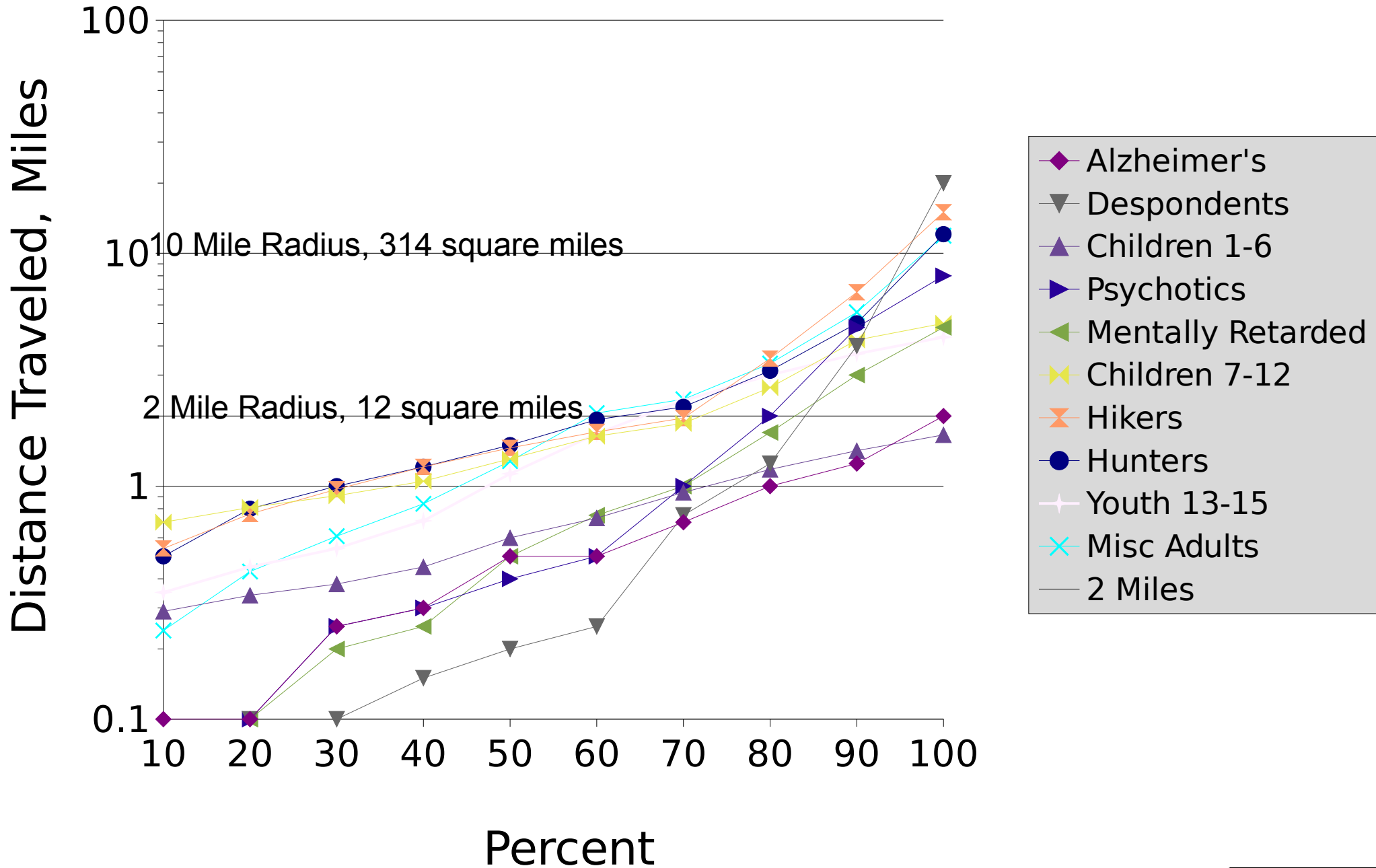
Last seen: About 3AM. Time now: 9AM.
Travel rate 2-3 miles per hour (for 6 hours).
Theoretical search radius: 12-18 miles
Theoretical search area: 500-1000 square miles





PLS

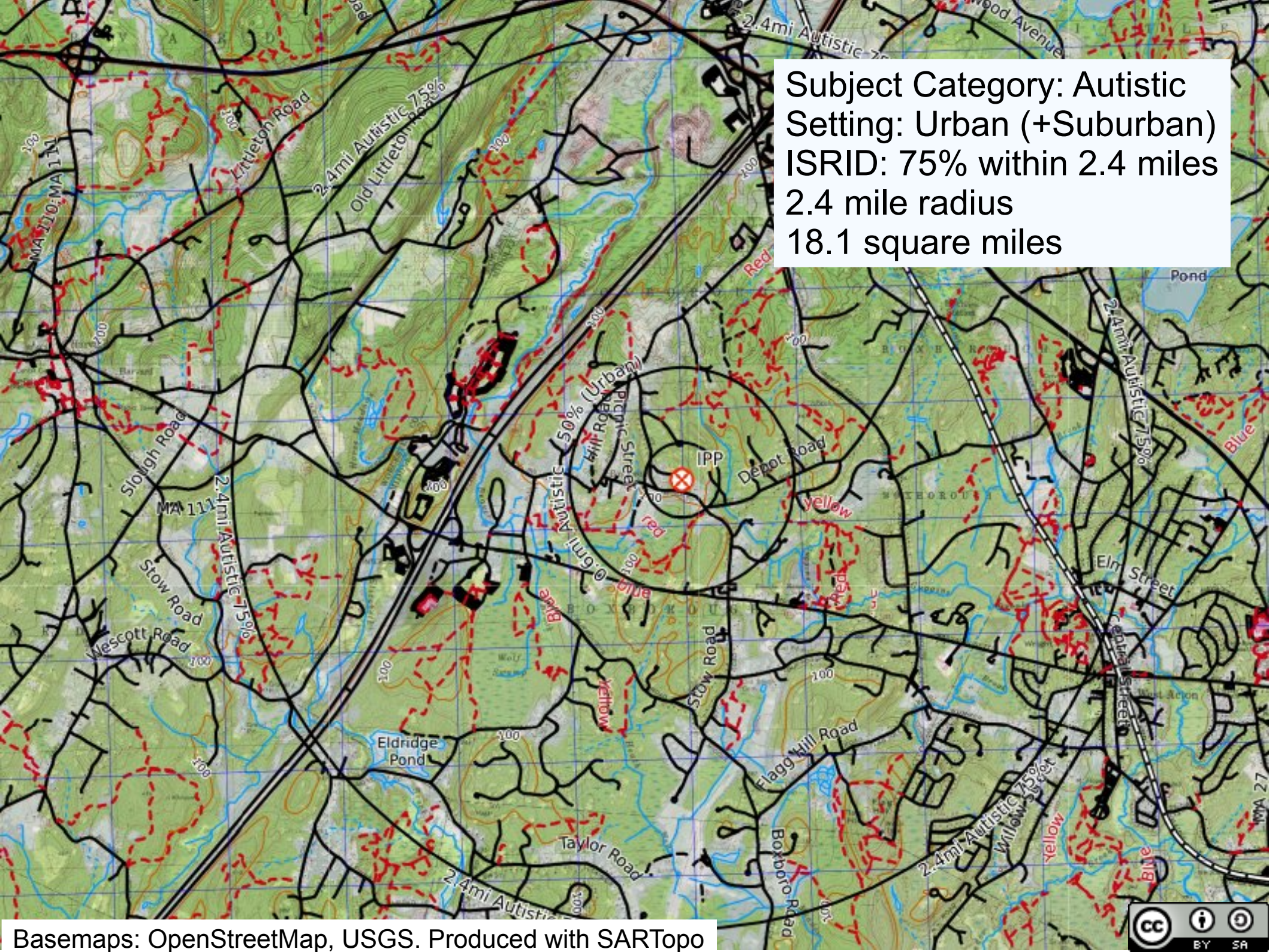
Lost Person Behavior



Data from ISRID (Koester, 2008)



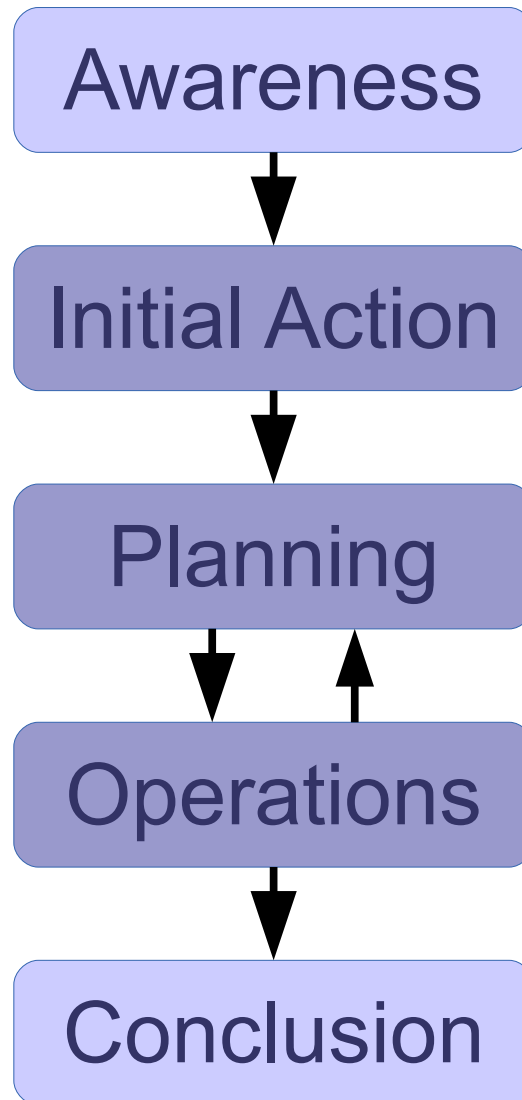
Subject Category: Autistic
Setting: Urban (+Suburban)
ISRID: 75% within 2.4 miles
2.4 mile radius
18.1 square miles



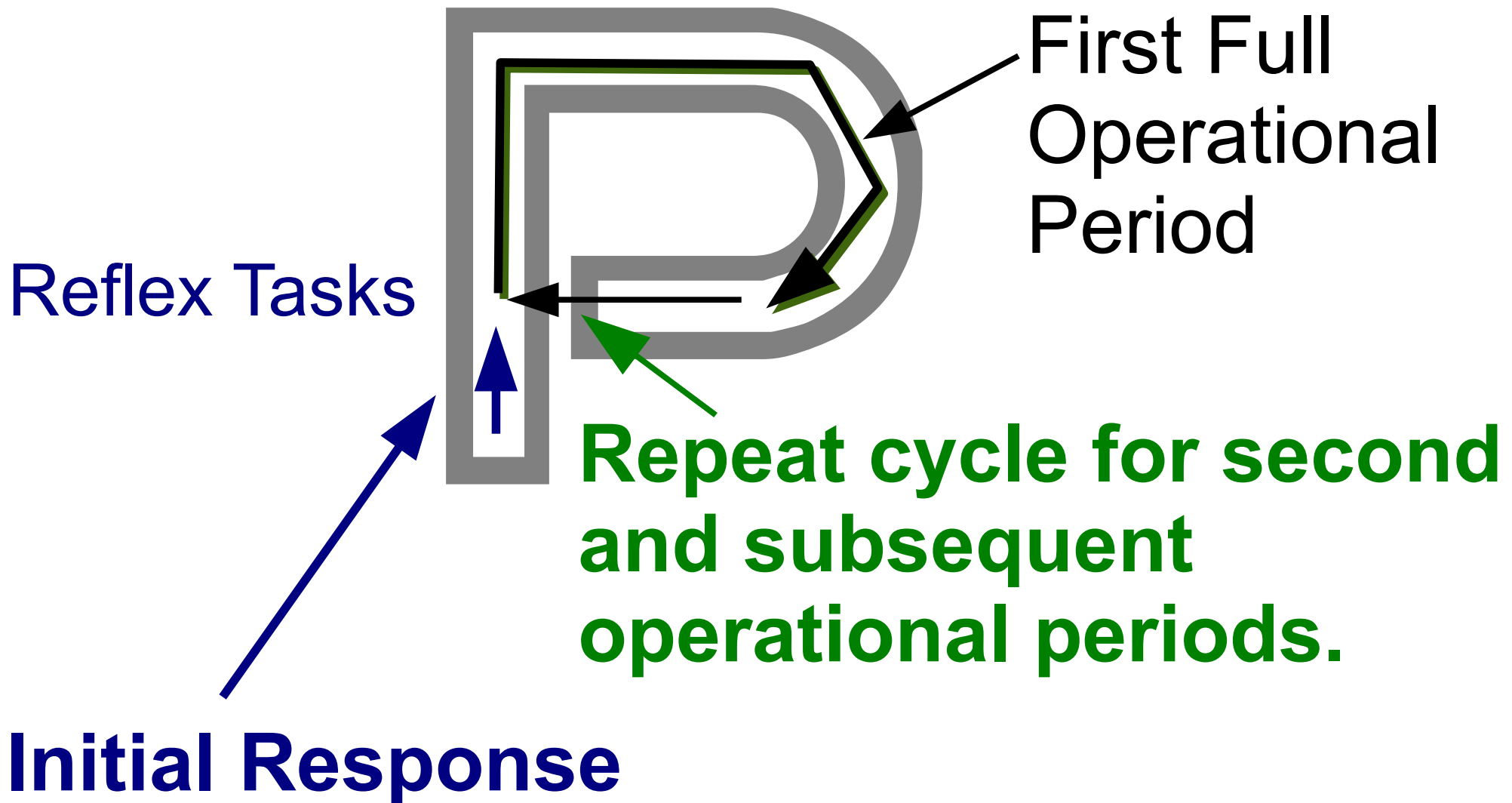
Search Areas

- Theoretical
 - travel speed times time missing
- Statistical
 - how far do 75% or 95% of people in this missing person category travel?
- Deductive
 - Statistical, modified by terrain analysis.

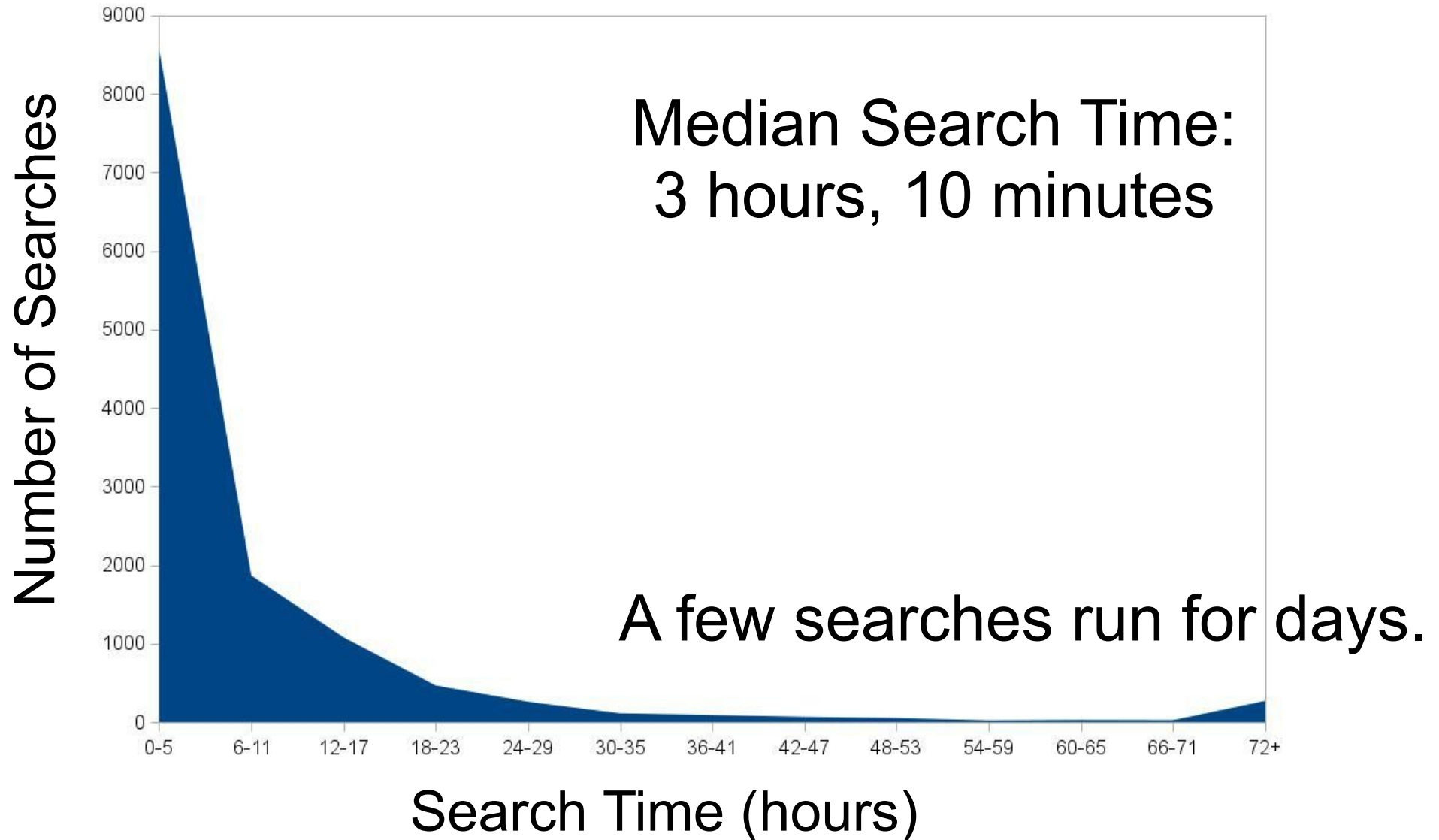
IAMSAR Manual: SAR Stages



The ICS Planning P



Half of all searches are over in 3 hours



Search Crucials

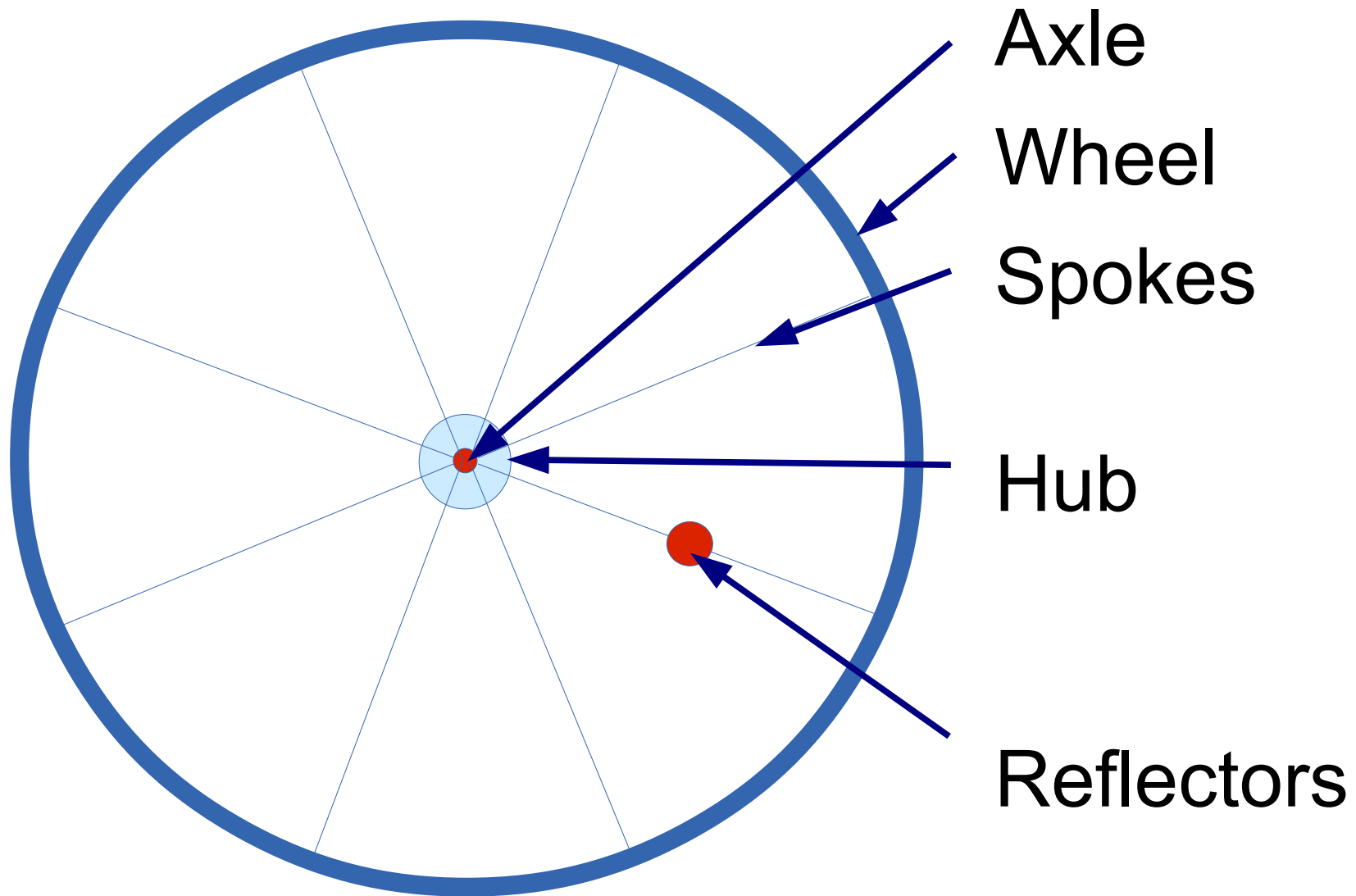
- **Search is an Emergency**
- **Search is a classic mystery**
- **Search for clues not just the subject**
- **Know if the subject leaves the search area**
- **Close grid search as a last resort**
- **Manage by objectives**
- **Search management is information management**

Initial Actions

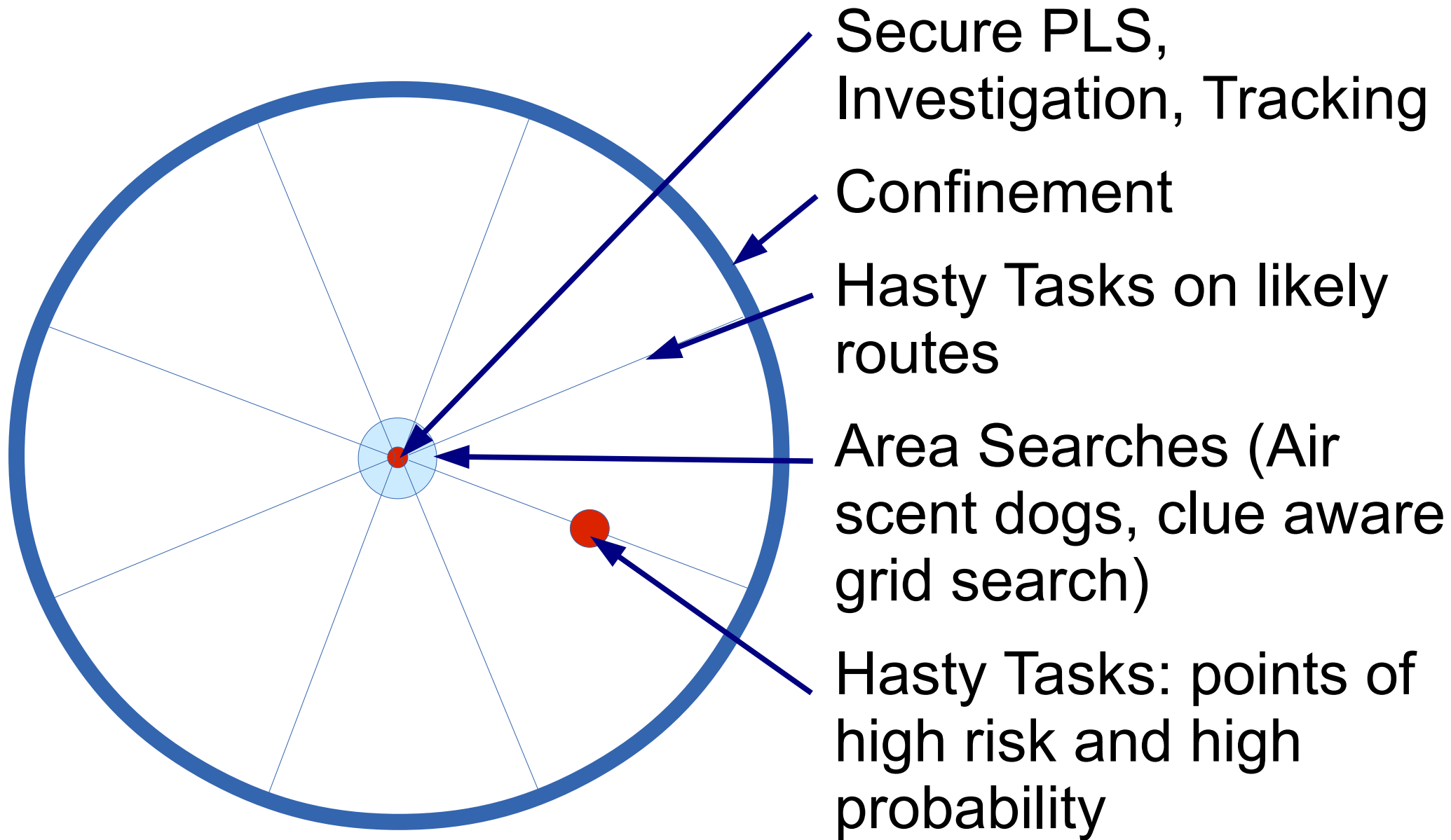
- Classic mystery → Investigate
- Subject in search area → Confinement
- Emergency → Hasty Tasks
 - Areas of high risk
 - Areas of high probability
- Clues and the subject → Get Help
 - Protect Clues
 - Secure the PLS
 - Scent Articles
 - Tracks



Reflex actions: Koester's Bicycle Wheel

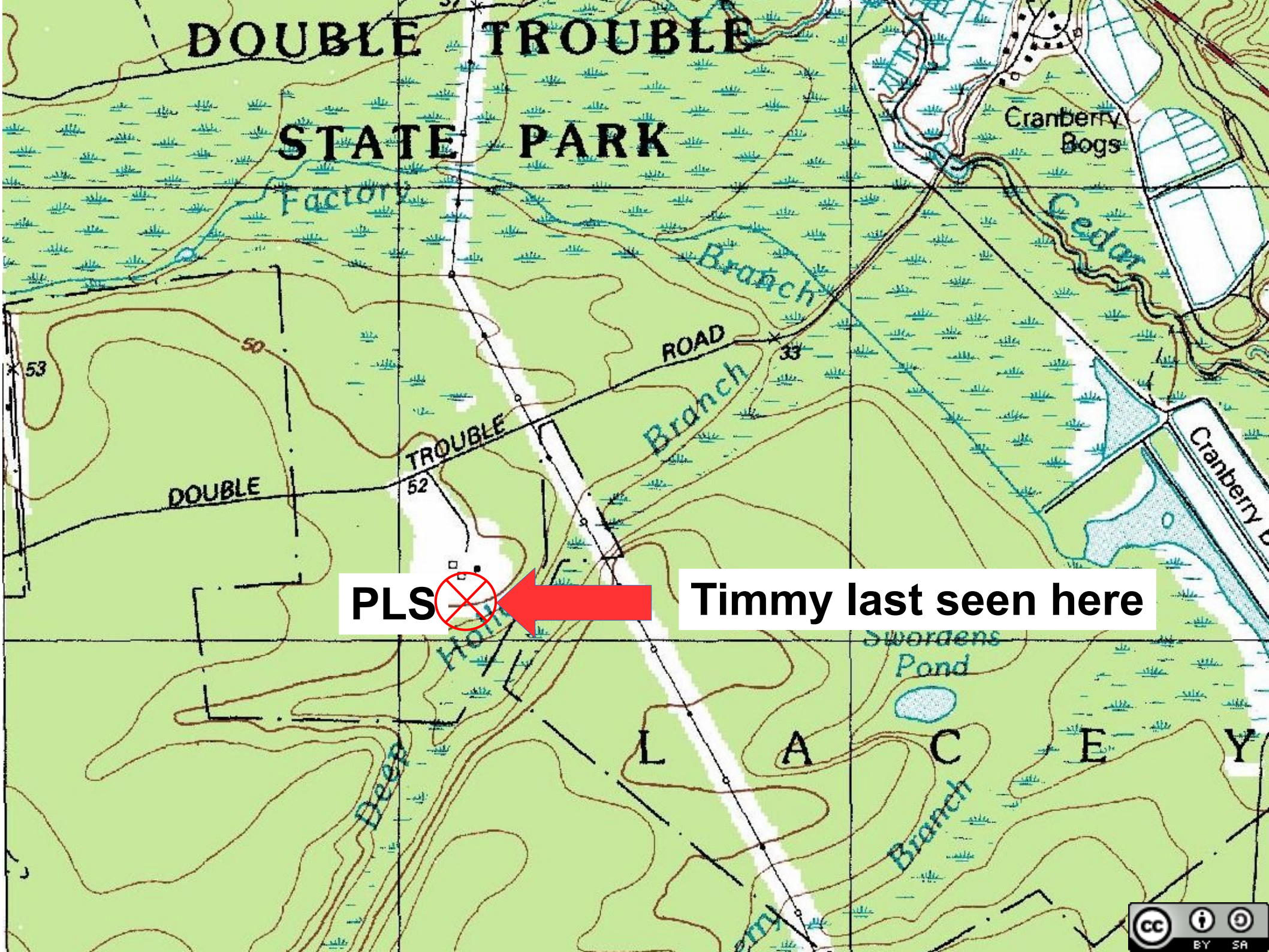


Reflex actions: Koester's Bicycle Wheel

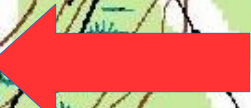


DOUBLE TROUBLE

STATE PARK



PLS



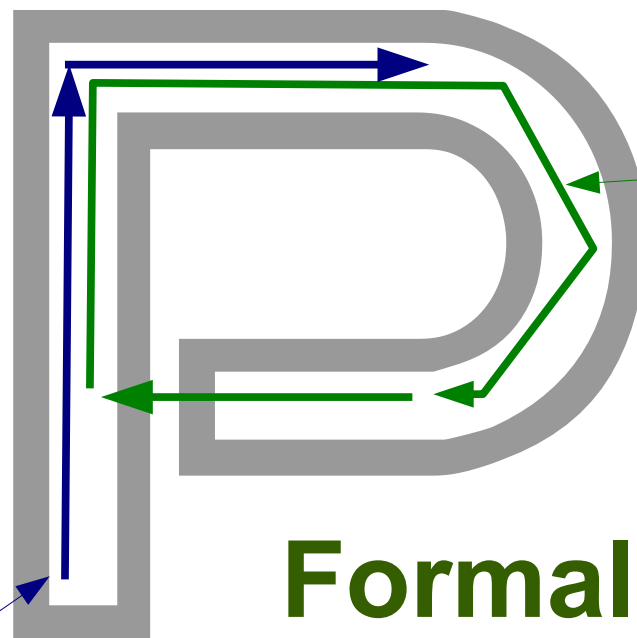
Timmy last seen here

The ICS Planning P

Continue Reflex Tasks
As Overhead Team
Scales up and Plans

Reflex Actions

Koester's
Bicycle Wheel



**First Full
Operational
Period**

Formal Search Theory

Initial Response




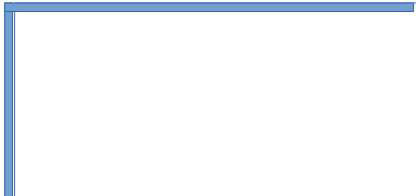
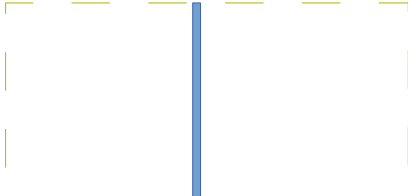
50% of searches are over in the first three hours.

DOUBLE TROUBLE

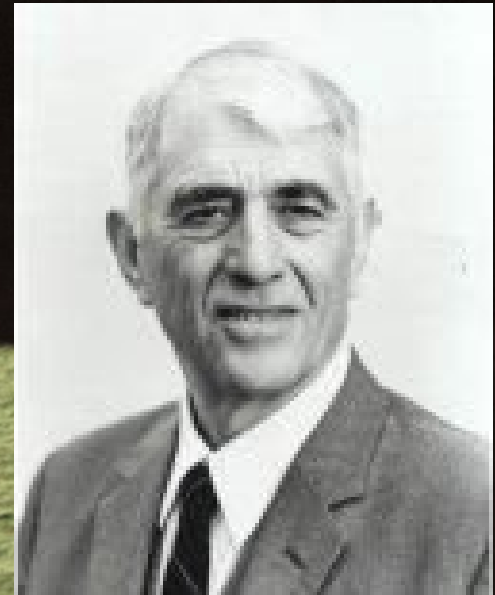
How do I allocate scarce resources to find the missing person in the least amount of time?

- (1) Put resources in the places the subject probably is.
- (2) If you don't find the subject, the probability drops everywhere you looked and increases everywhere else.
- (3) Repeat.

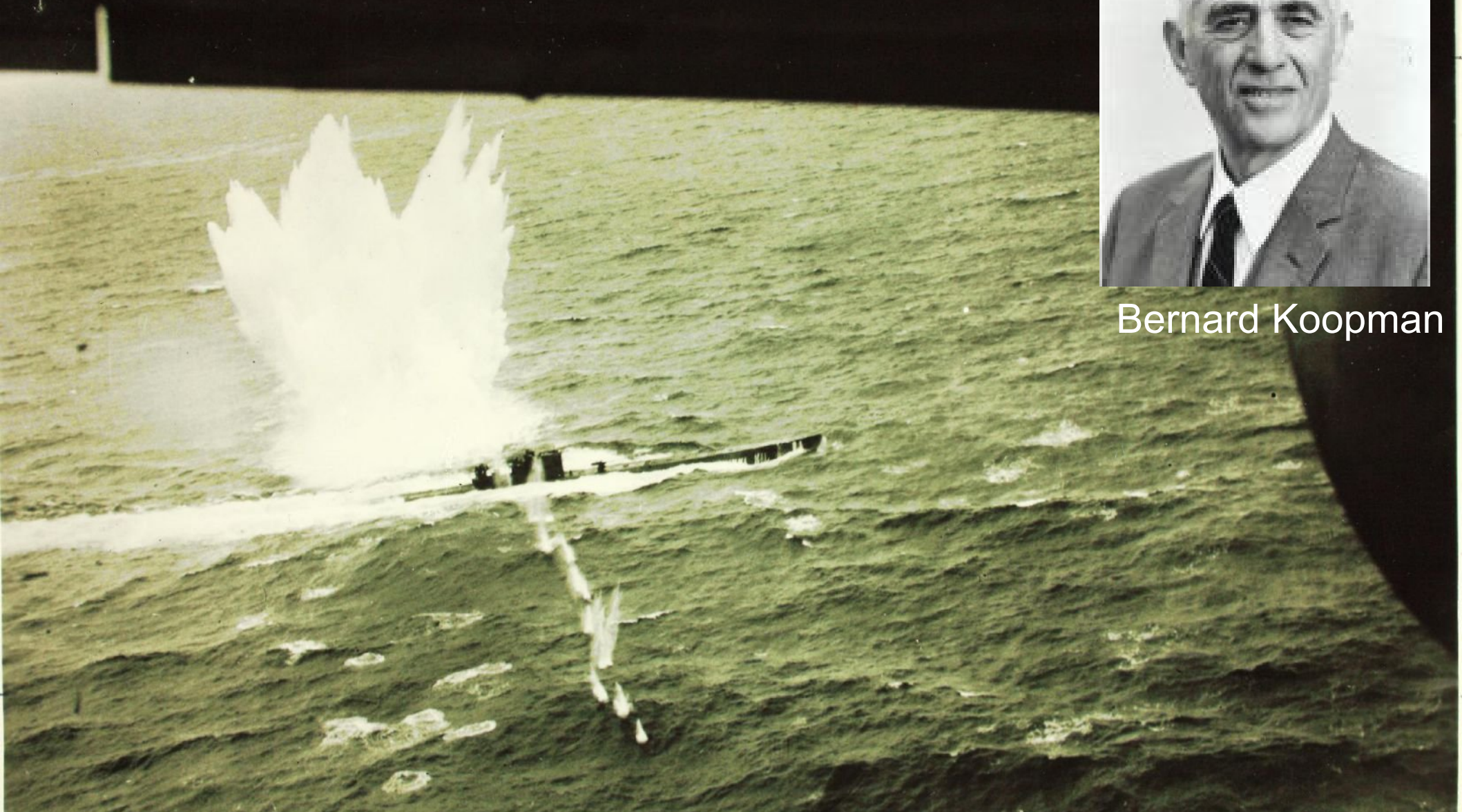
Routes and Areas

- Route Search 
- Area Search
 - Segment 
 - Corridor 
- Boundary Search
 - Containment 
 - Binary Search 

Formal Search Theory



Bernard Koopman



Sinking of German U-Boat, Courtesy of San Diego Air and Space Museum Archives.
No known copyright restrictions

POA: Probability of Area

- The estimated probability that the missing subject is inside some search segment.
- POA is estimated by experienced search managers combining models of where the subject may have gone.

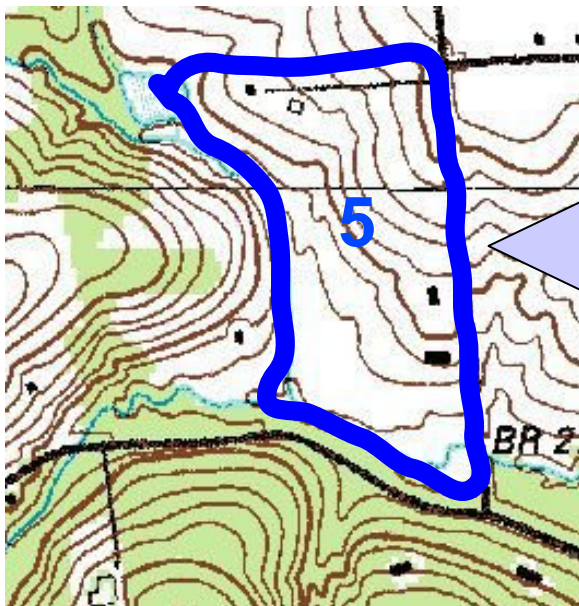


POAs shift over the course of a search as segments are searched.

POD: Probability of Detection

- Apply some sensor to some search segment
- POD is the probability that the sensor will detect the subject, if the subject is in the segment.

The sensor (task force) estimates its POD for the segment.

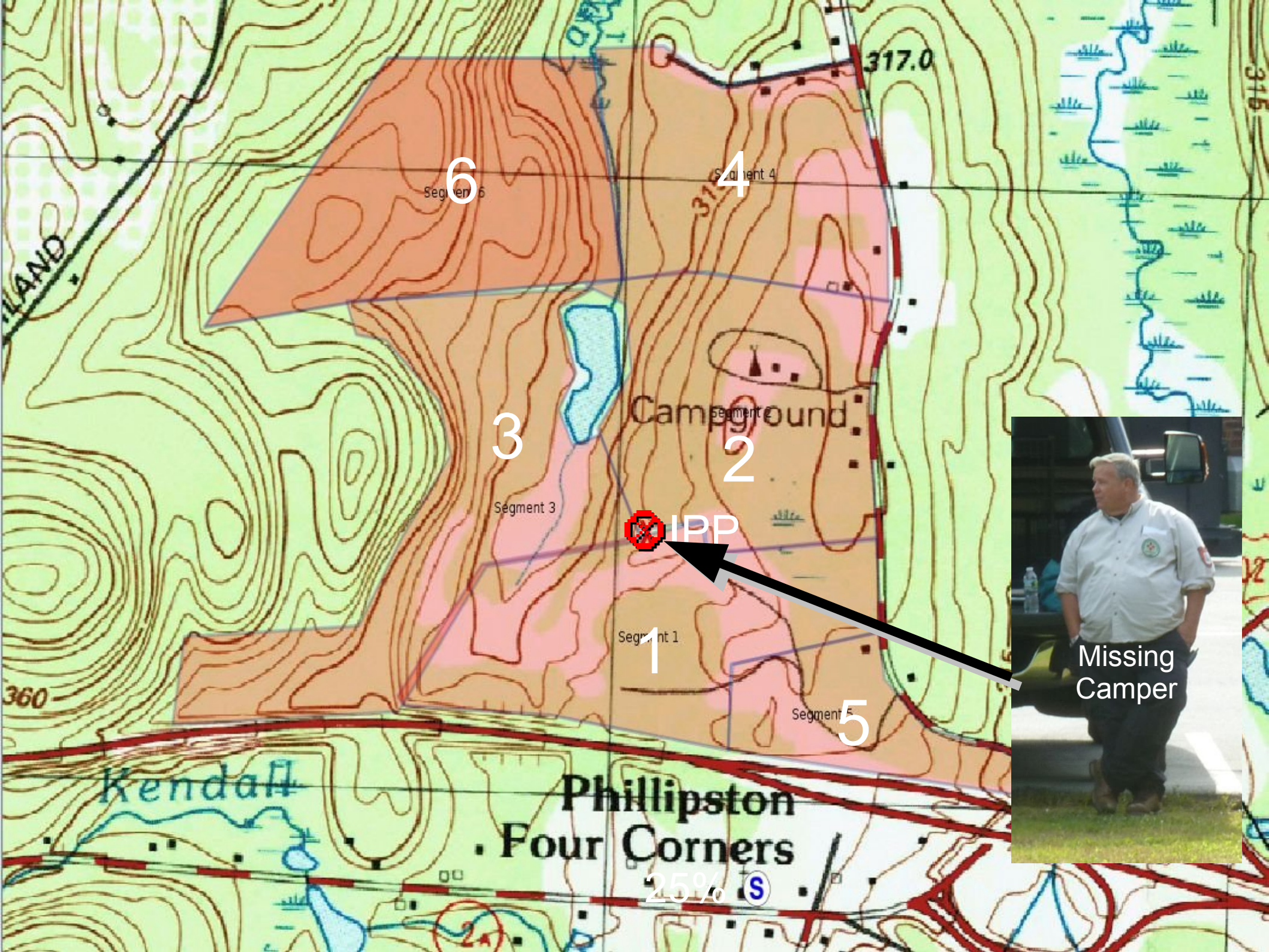


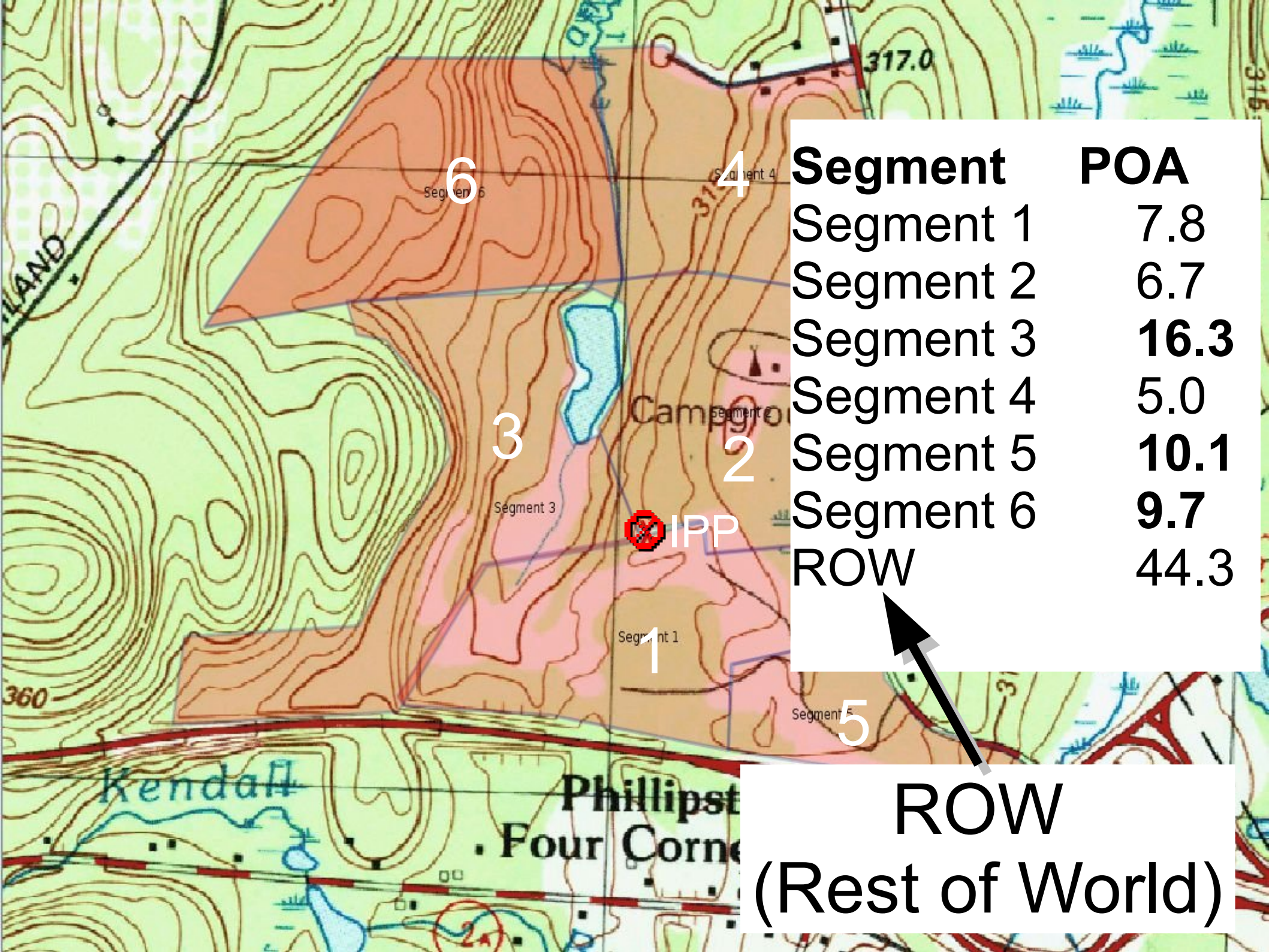
POS: Probability of Success

- Probability of finding the subject in a particular search. Estimator of search effectiveness.
- $POS = POA \times POD$
- Implication: given some resources, search the segments with the highest Probability of Area to get the highest Probability of Success.
- Implication: Searching more area (more total POA) at a lower POD will yield a higher POS than searching less area more thoroughly

Formal Search Theory is about Allocation of Search Effort (Manage By Objectives)

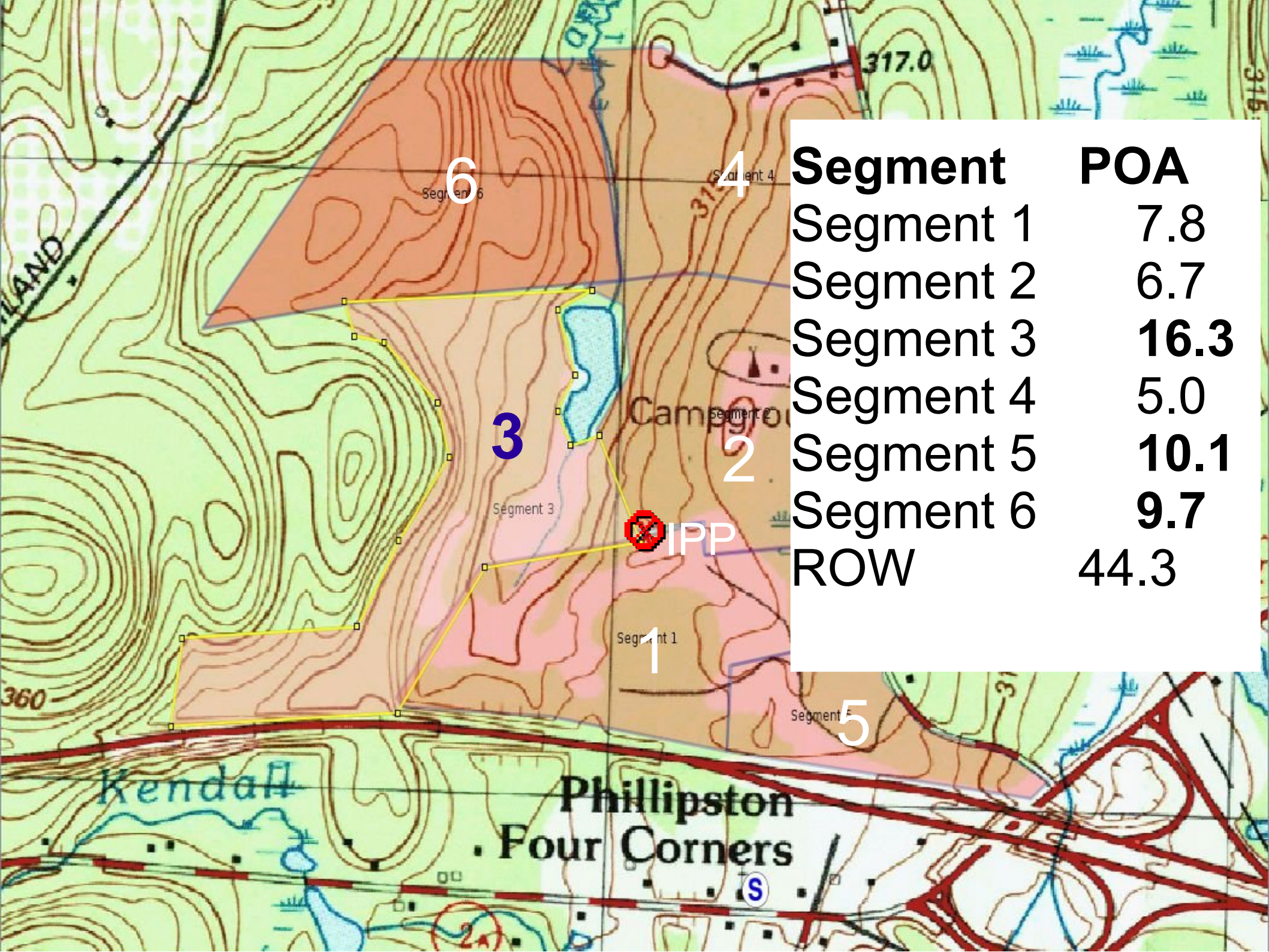
“For a given amount of available effort,
there is an optimal effort allocation
among the search segments that will
produce the maximum OPOS [Overall
Probability of Success]”



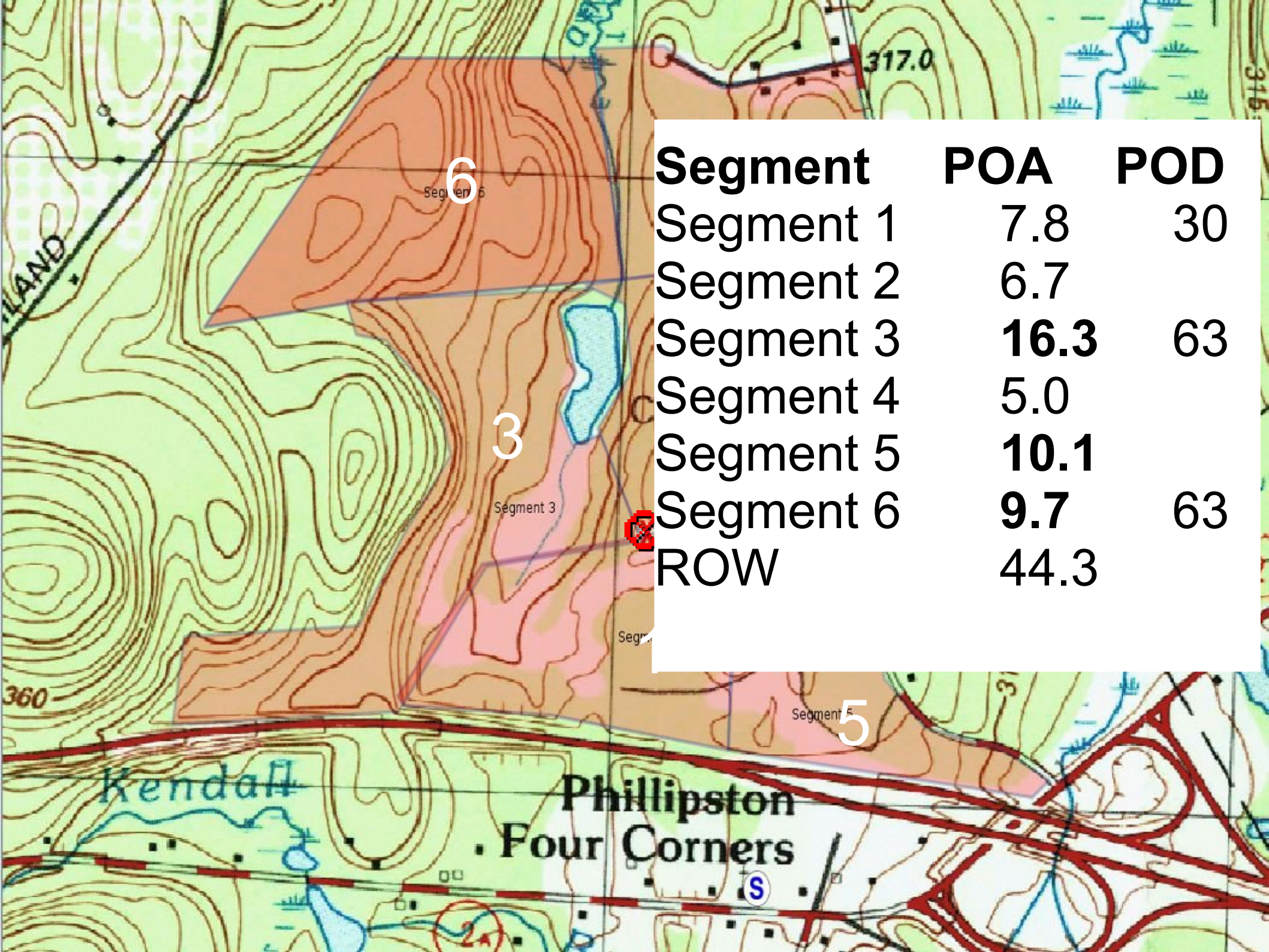


Segment	POA
Segment 1	7.8
Segment 2	6.7
Segment 3	16.3
Segment 4	5.0
Segment 5	10.1
Segment 6	9.7
ROW	44.3

ROW
(Rest of World)



Segment	POA
Segment 1	7.8
Segment 2	6.7
Segment 3	16.3
Segment 4	5.0
Segment 5	10.1
Segment 6	9.7
ROW	44.3



Segment	POA	POD
Segment 1	7.8	30
Segment 2	6.7	
Segment 3	16.3	63
Segment 4	5.0	
Segment 5	10.1	
Segment 6	9.7	63
ROW	44.3	

6

3

5

Phillipston
Four Corners

2.1

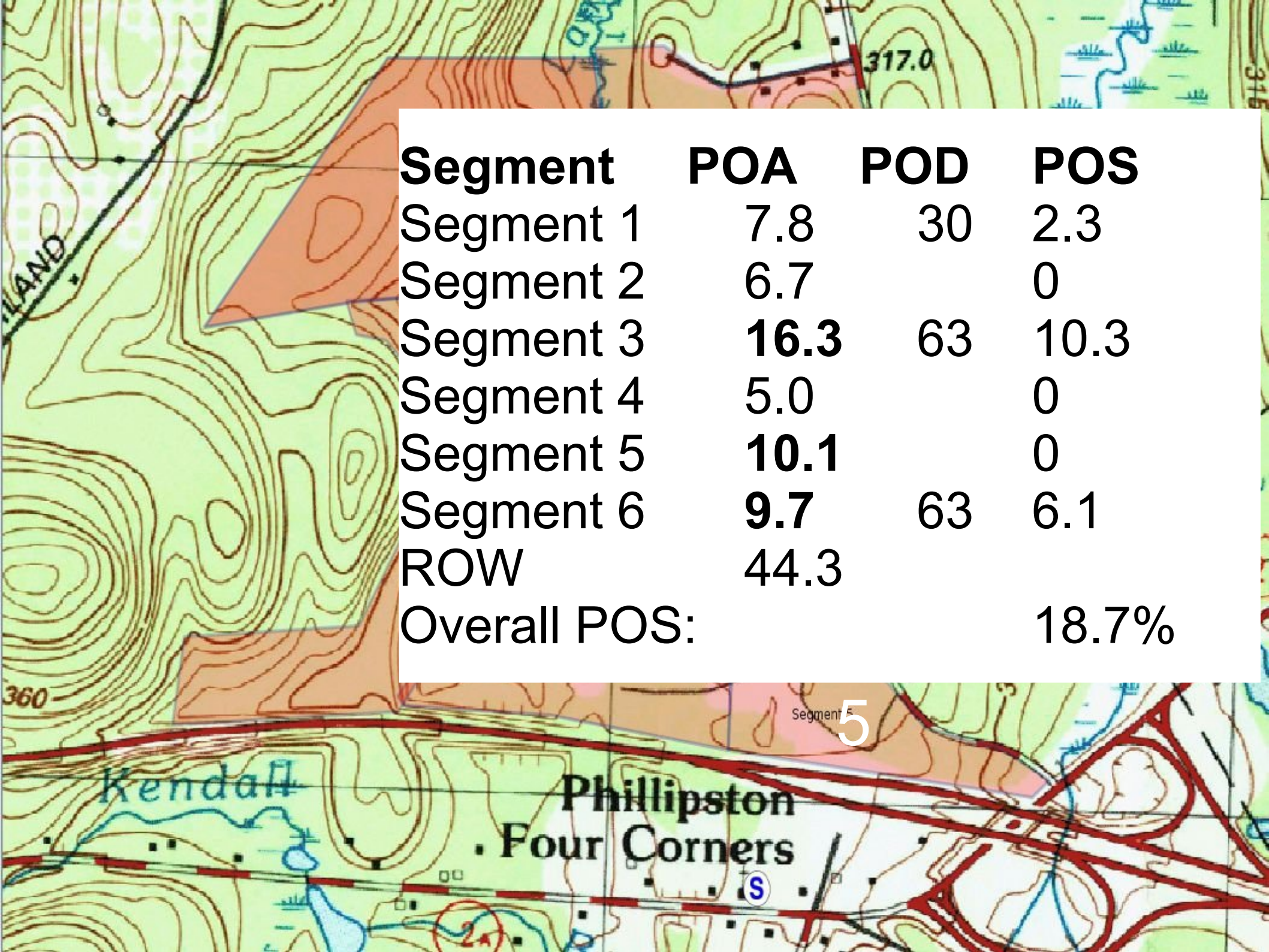
317.0

LAND

360

Kendall

S



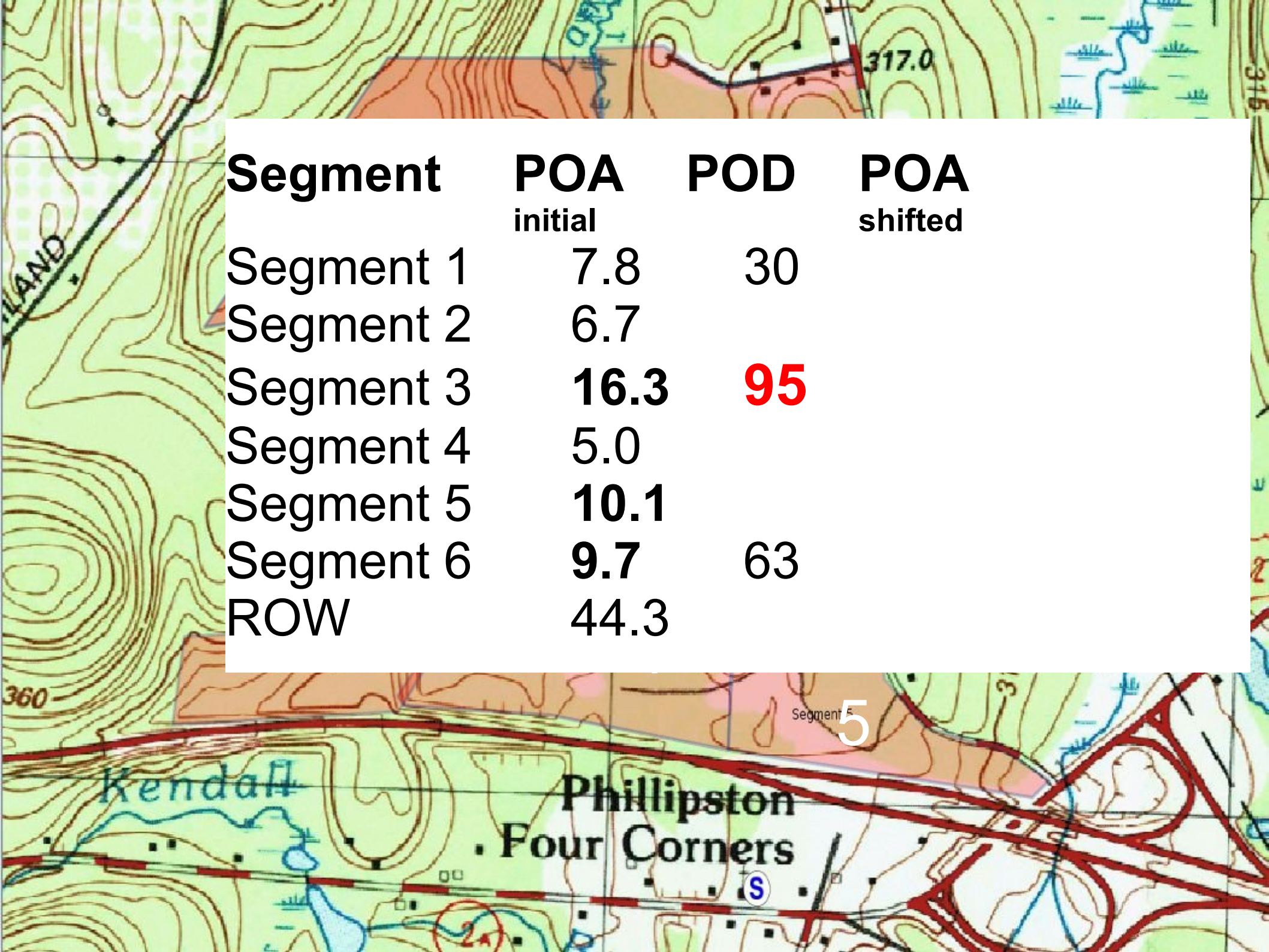
Segment	POA	POD	POS
Segment 1	7.8	30	2.3
Segment 2	6.7	0	0
Segment 3	16.3	63	10.3
Segment 4	5.0	0	0
Segment 5	10.1	0	0
Segment 6	9.7	63	6.1
ROW	44.3		
Overall POS:			18.7%

Segment	POA initial	POD	POA shifted
Segment 1	7.8	30	6.7
Segment 2	6.7		8.2
Segment 3	16.3	63	7.4
Segment 4	5.0		6.2
Segment 5	10.1		12.4
Segment 6	9.7	63	4.4
ROW	44.3		54.6

Segment 5

Kendall

Phillipston
Four Corners

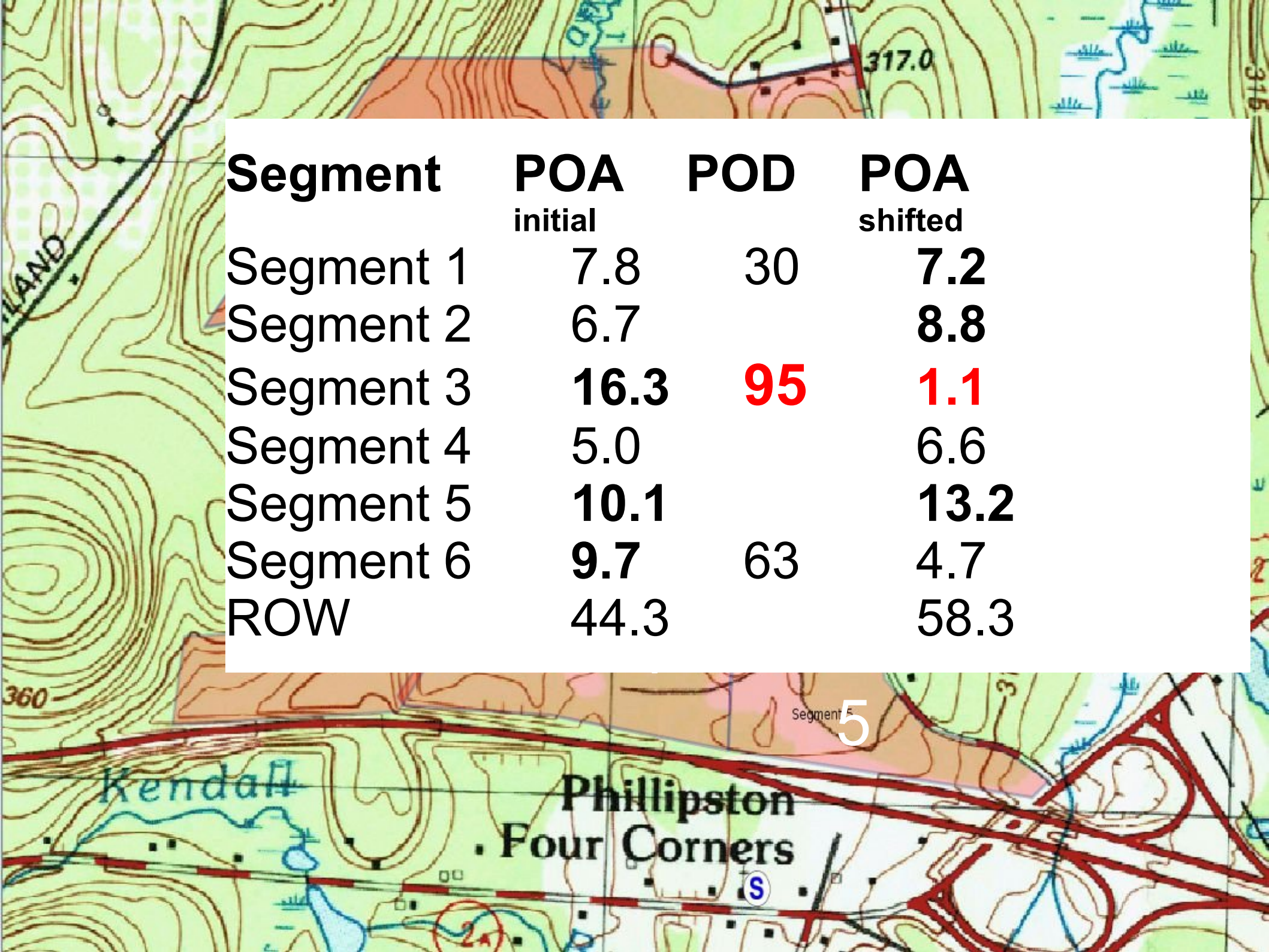


Segment	POA initial	POD	POA shifted
Segment 1	7.8	30	
Segment 2	6.7		
Segment 3	16.3	95	
Segment 4	5.0		
Segment 5	10.1		
Segment 6	9.7	63	
ROW	44.3		

Segment 5

Kendall

Phillipston
Four Corners

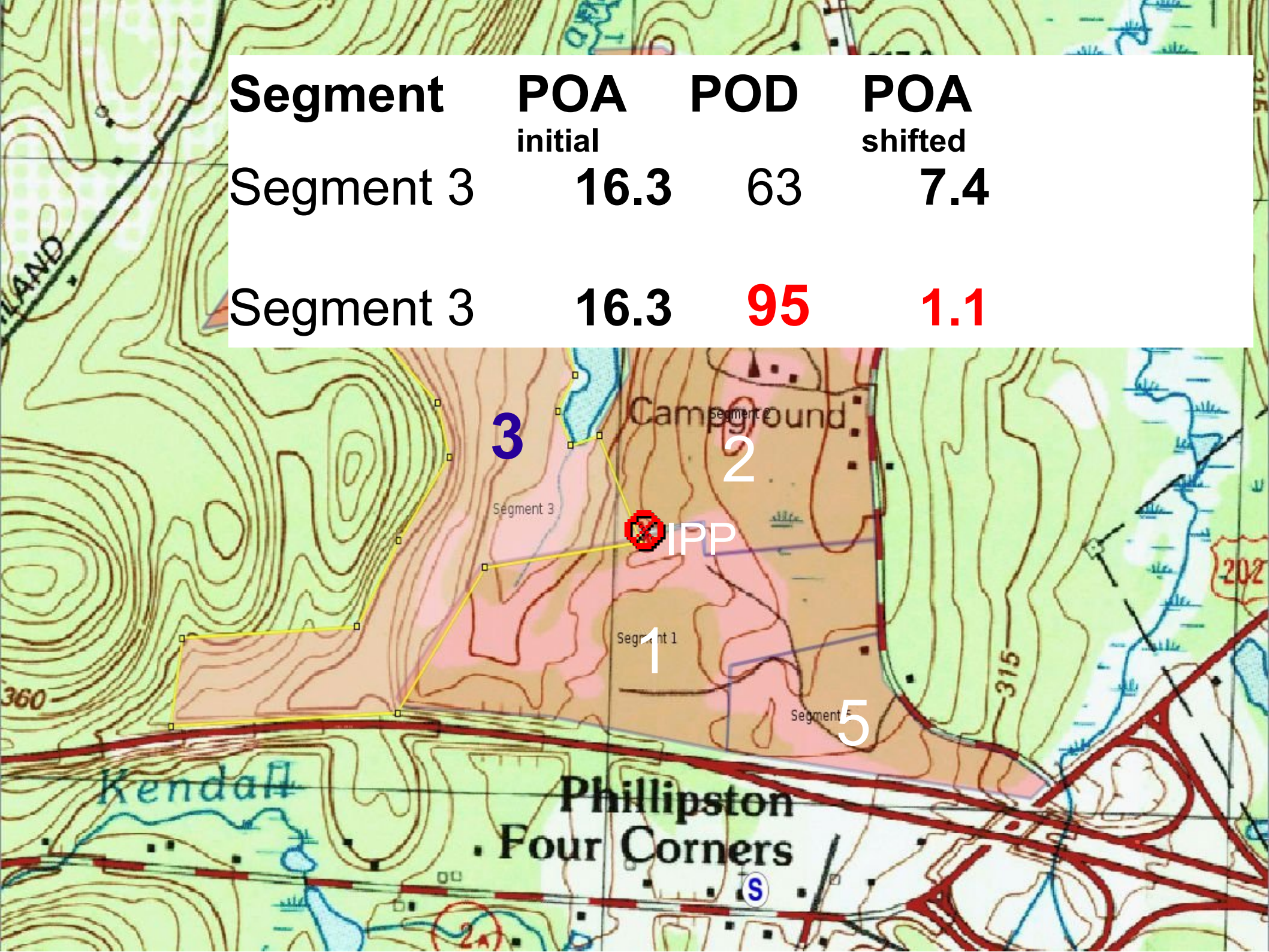


Segment	POA initial	POD	POA shifted
Segment 1	7.8	30	7.2
Segment 2	6.7		8.8
Segment 3	16.3	95	1.1
Segment 4	5.0		6.6
Segment 5	10.1		13.2
Segment 6	9.7	63	4.7
ROW	44.3		58.3

Segment 5

Phillipston
Four Corners

Segment	POA initial	POD	POA shifted
Segment 3	16.3	63	7.4
Segment 3	16.3	95	1.1



Excessively High POD reports Kill

Unless all Resources are reporting POD in a uniform way, the adjusted POAs that drive resource allocation are meaningless.

Learning More:

- NEWSAR POD/Canine POD course
- NEWSAR CASIE course
- NEWSAR Modern Search Management course
- NASAR Managing the Lost Person Incident

Search Crucials

- **Search is an Emergency**
- **Search is a classic mystery**
- **Search for clues not just the subject**
- **Know if the subject leaves the search area**
- **Close grid search as a last resort**
- **Manage by objectives**
- **Search management is information management**

Tactics

- Direct/(Active)

Go find the subject.

- Type I search
(hasty/route search)
- Type II to Type IV
area search (human,
canine, equine)
- Aerial search

- Indirect/(Passive)

Make the subject
come to you/refine
where to look

- Investigation
- Containment
- Attraction
 - Sound
 - Lights
- “Limited Continuing Search”

An Indirect Tactic: Investigation



An Investigation Tool: Lost Person Questionnaire

Thumbnails

1

2

3

4

Some Missing Person Interview Questions

Identify yourself. Explain the purpose of the interview (to find the missing person)

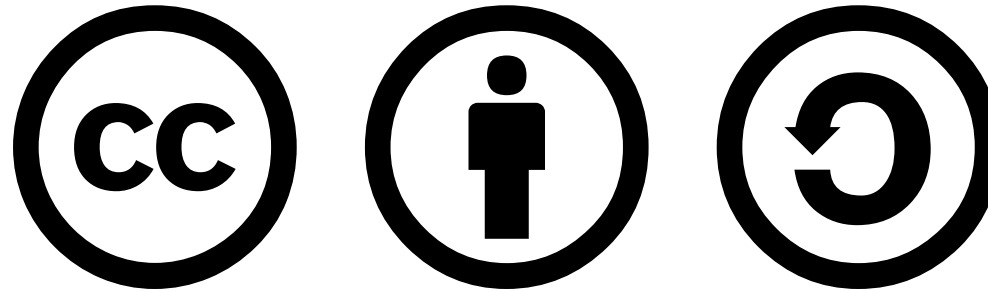
About the interview:
Name of the person being interviewed:
Relationship of the person being interviewed with the missing person:
Names of the people conducting the interview: 1) 2)
Place of the interview:
Time of the interview:
Other people present:

About the missing person [SUBJECT]:
Name, Age, Male/Female
What does SUBJECT look like?
Follow up: height, weight, build, hair color, hair length and style, complexion, facial hair, glasses, general appearance, distinguishing marks, tattoos, glasses, shoe size.
Do you have any pictures of SUBJECT?
What was SUBJECT wearing on their feet? Follow up: type, brand, style, size, tread.
Who else might be with SUBJECT? Follow up: Names, contacts.

Last Seen
Where was SUBJECT last seen?
When was SUBJECT last seen?
Who saw SUBJECT leave?
Who saw SUBJECT last? Follow up: Contact: name, location, phone.
Which way was SUBJECT going when last seen?
What reason might SUBJECT have had for leaving?
What did SUBJECT say they were going to do?

Describe the clothing SUBJECT has on. Follow up: Colors, Styles, Make.
Describe any other clothing SUBJECT might have taken with them.
Follow up: Hat, shirt, outwear (sweater, jacket), foul weather gear, rain gear, gloves, mittens, sunglasses.
Did SUBJECT take any money with them?
Did SUBJECT take anything else with them?
What was SUBJECT doing when they went missing?
What sort of equipment did SUBJECT have when they went missing?
Does subject have a vehicle? Follow up: Color, model, year. Where is it?
Does subject have a bike? Follow up: Color, type, year. Where is it?
If SUBJECT's vehicle/bike broke down, what would he/she do?

How did you find out that SUBJECT was missing?
What have you done to find SUBJECT?
Describe the events of the last few hours.
Describe the events of the last few days



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