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# Searching for Hotspots

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# Report Documentation Page

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# Isn't there an easy formula?

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If we are estimating a mean:

$$n = \frac{(z_{1-\alpha/2})^2 s^2}{d^2} + \frac{1}{2} z_{1-\alpha/2}^2$$

If we are estimating a mean to make a decision:

$$n = \frac{(z_{1-\alpha} + z_{1-\beta})^2 s^2}{d^2} + \frac{1}{2} z_{1-\alpha}^2$$

and using either requires a random sample...

## **...but these are for means (averages)**

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- **The formulae for estimating a mean will not work if the objective is the detection of the presence of a potential "hot-spot".**
- **A different approach is needed, one that uses a grid to locate samples and a threshold value such that above this value implies a hotspot.**
- **The problem becomes:**
  - **How big is the potential hotspot**
  - **How large a mesh-spacing is needed**
  - **What is the chance of missing a hotspot**

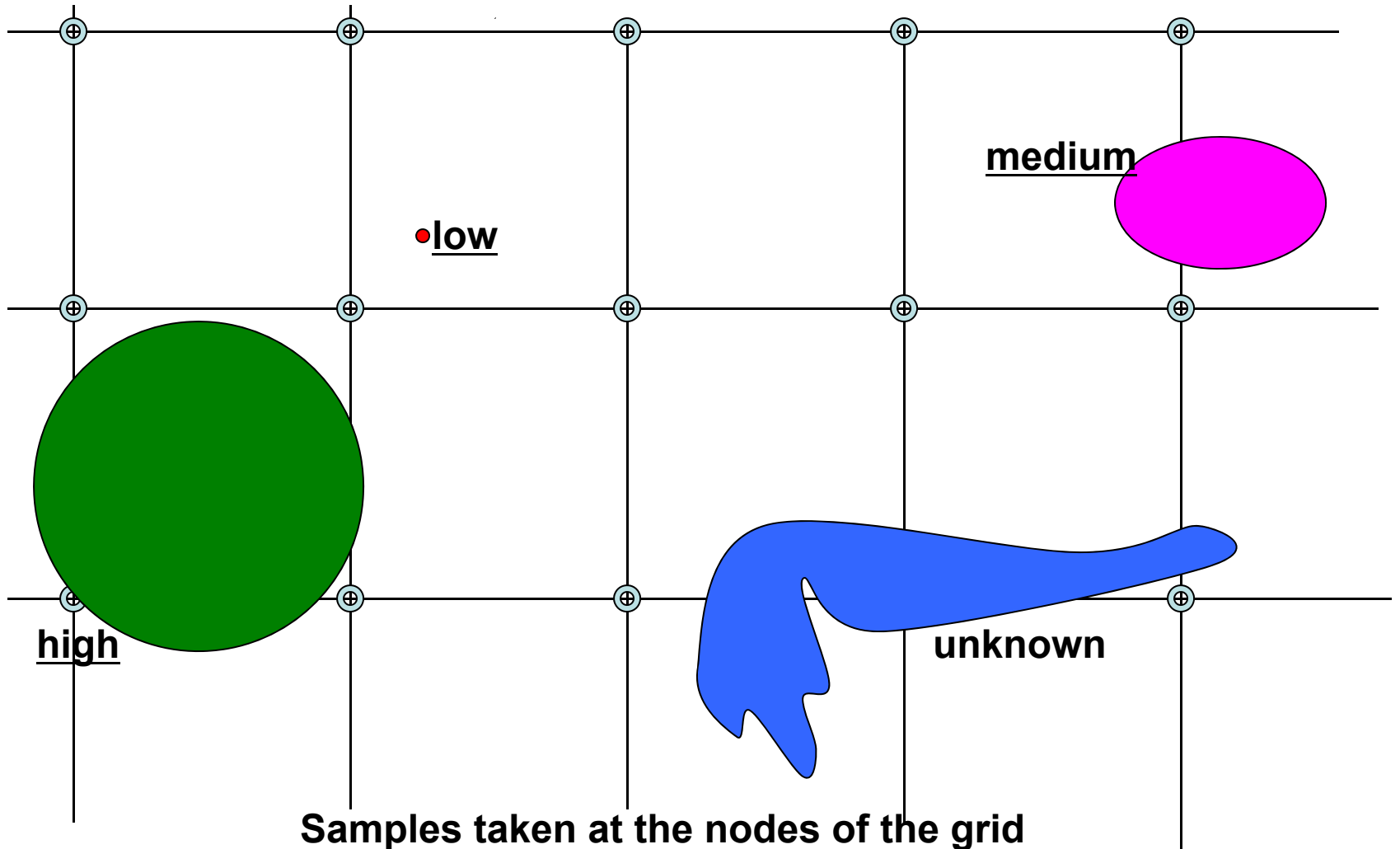
## Specify one of the three

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- **How big is the potential hotspot?**
  - **If hotspot is bigger than the mesh, then 100% chance!**
  - **If very small then very low chance of catching it**
- **How large a mesh-spacing is needed?**
  - **If large spacing used, then high risk of missing hotspot**
  - **If small spacing, then will be collecting many samples**
- **What about the chance of missing a hotspot?**
  - **Depends on how certain do you want to be**
  - **If its important to find then will need many samples**

# Hot-Spot size, grid spacing, and probability of missing

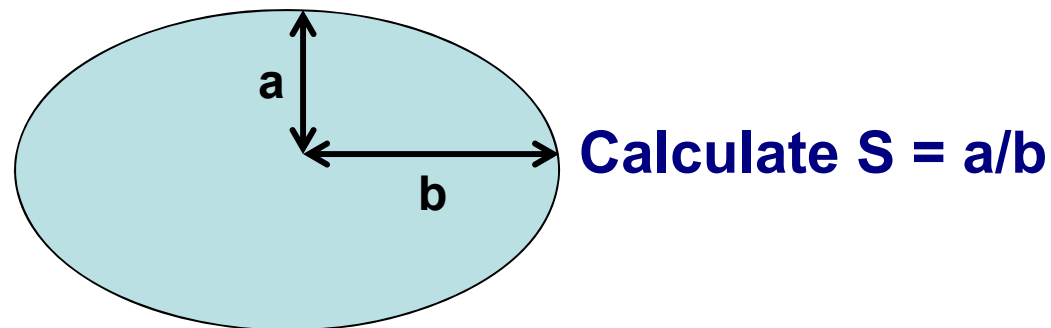
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# How hot-spot sampling works

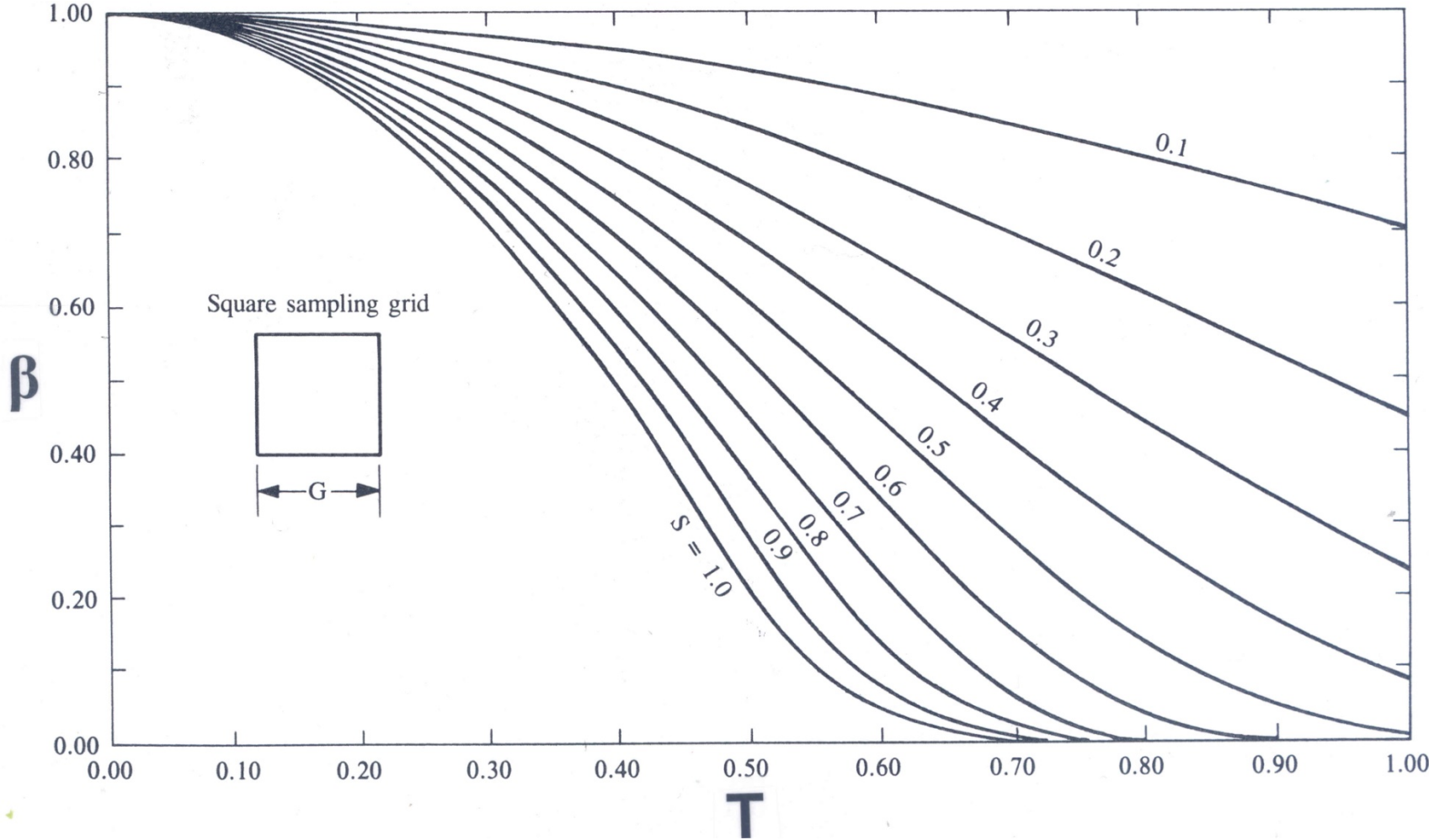
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- You specify the size and decide if it is circular (radius “a”) or elliptical (short arm “a”, longer arm “b”).



- You decide how much risk you are willing to take on missing hitting the hot-spot (the risk, probability “ $\beta$ ”).
- You use “ $\beta$ ” and “S” with the following nomogram to find T, then the Grid mesh size,  $G = b/T$ .

# Hot-spot nomogram



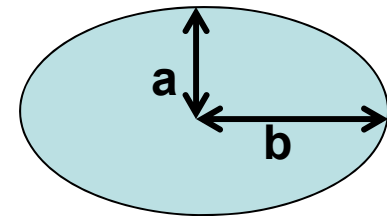
# Example: Hot-spot grid size calculation

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*4 acre abandoned property thought to have dispensed pesticides from a single location over 10 years ago. No information on probable location of filling area. 4 acres = roughly 4 football fields.*

- You specify the size and shape:

**Elliptical,  $a=20\text{ft}$ ,  $b=40\text{ft}$**



- You decide risk of missing hitting hot-spot:

**No more than a 10% chance ( $\beta = 0.10$ )**

- Calculate  $S = a/b$ :  **$S = 20/40 = 0.50$**

- Use “ $\beta$ ” and “ $S$ ” with the nomogram to find

**T:  $T = 0.82$**

- Grid mesh size  $G = b/T$ :  **$G = 40/0.82 = 48.8 \text{ ft}$**

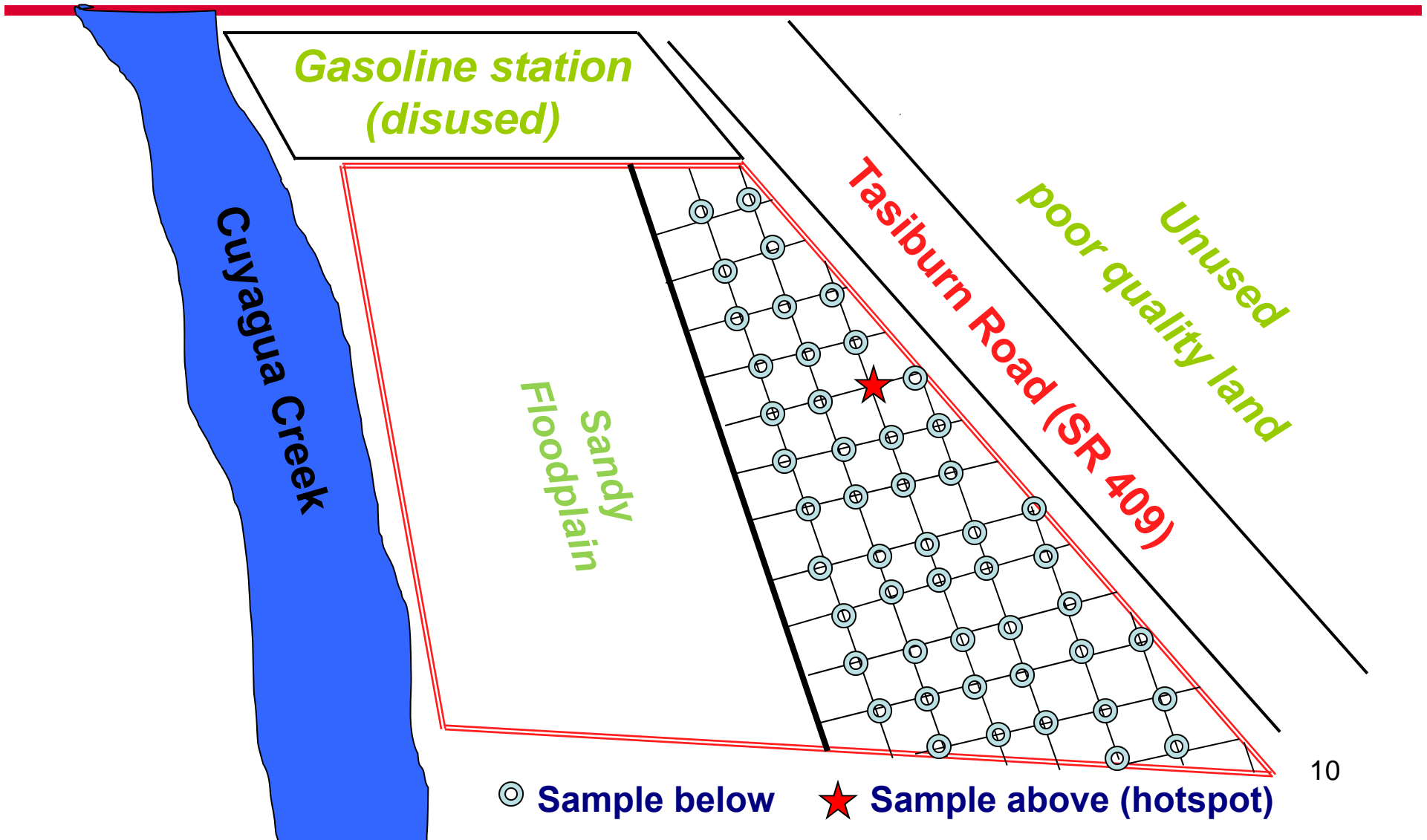
## Hot spot sampling (cont)

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- Now asking a field crew to create a grid with a mesh size 48.8ft (48ft 9½in) is very difficult.
- Working backwards from the nomogram:
  - If 50ft mesh selected then  $\beta = 0.17$  (17%)
  - If 45ft mesh selected then  $\beta = 0.08$  ( 8%)
- Original requirement was  $\beta$  not to exceed 10% so a choice has to be made:

Select 50ft mesh with higher chance of missing hotspot  
or select 45ft mesh but take more samples?

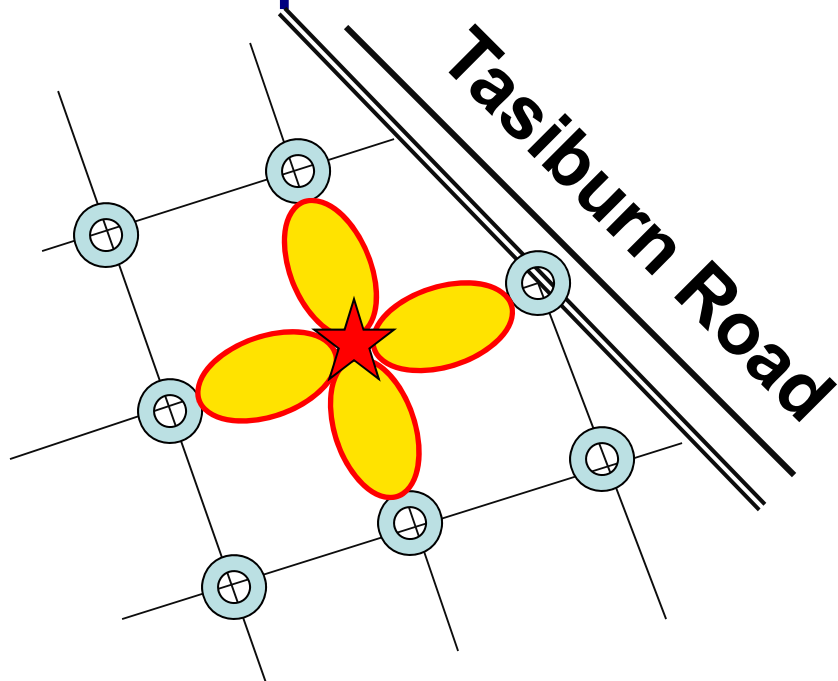
# Samples results compared to a threshold



# Conclusions from the example

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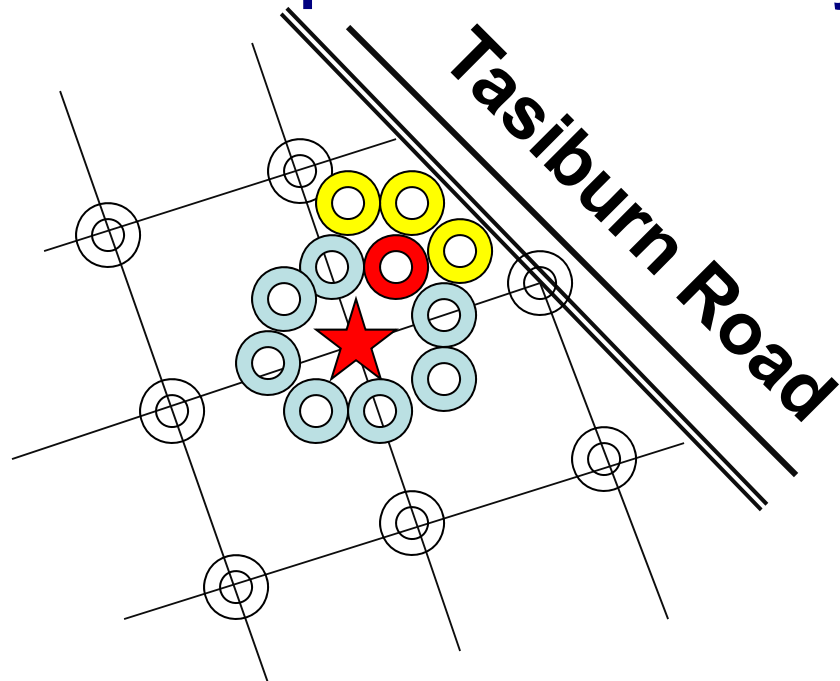
- Using a 50ft grid mesh we covered the site with 50 samples taken at the nodules of the grid
- 1 sample was above the threshold thus implying the potential existence of a hotspot



# Further sampling to determine the extent of the hotspot

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- Using the position of the as the central location, further samples are taken around this position
- This is repeated until the boundaries of the hotspot are sufficiently delineated



- ★ Hotspot
- Sample above threshold
- Sample below threshold
- Potential further samples

# Hot Spot Sampling: **Pro**

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- **Very effective in finding hot spots of a specified size and shape**
- **Able to control the probability of missing a hot-spot of a given size**
- **Indirectly delineates the size and shape of the hot-spot**
- **Results can be used to guide further investigation**




## Hot Spot Sampling: **Con**

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- **Need to know what size and shape the potential hot-spot should be**
- **Need to decide the chance of missing a hot-spot of a certain size**
- **Could be expensive as you need to take samples from all over the grid**

# What can we infer (qualitatively)?

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- Samples taken across the entire grid revealed a hot-spot, indicated by a red star 
- After identification of the hot spot, 8 extra samples were taken around the hot-spot but off the grid (recall initial samples were from the nodes of the grid mesh)
- 7 of the extra samples were considered “not hot”  , but 1 sample could be considered “hot”  , further samples could delineate the extent of the hotspot
- The hotspot is in the form of a plume stretching from Tasiburn Road roughly 60 ft into the field

# Can we increase the quantitative information using extra samples?

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- **No.** The new data is not random (like the original data) but deliberately selected as there was a hot-spot guiding them. You can't just add them together and expect the inferences (probabilities) to come out right.
- **Yes.** However, it is not straight-forward. This kind of sampling is known as Adaptive Cluster Sampling and you have to use special formulae to adjust for the fact you're using non-random samples.