# Tritium Deposition Analysis at Harris Nuclear Plant

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# Harris Nuclear Plant

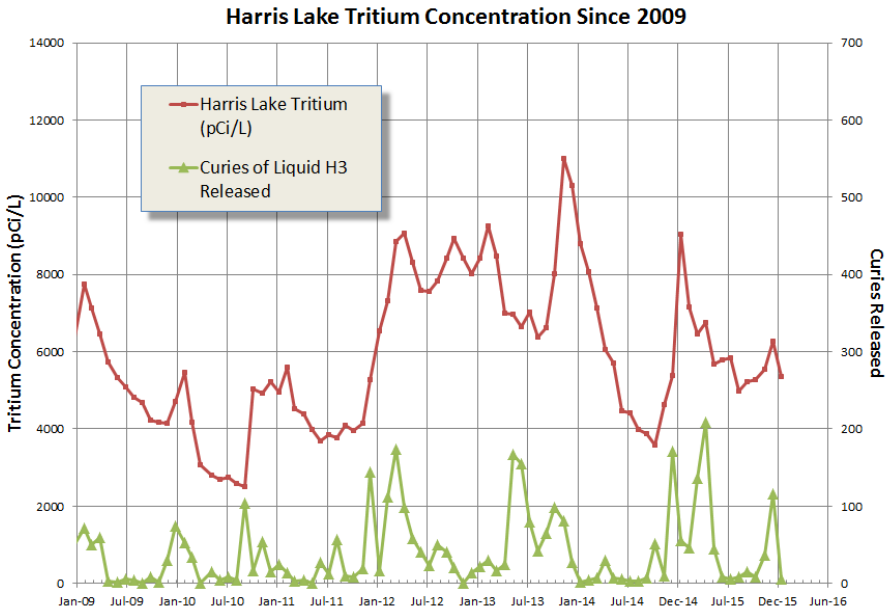
- Harris Nuclear Plant is a single unit PWR in New Hill, NC
- The plant is located in the middle of a ~11,000 acre site– 4,200 acres (6.5 miles$^2$) of which is occupied by Harris Lake.
- Cooling is provided by a Cooling Tower and all releases are discharged to the lake via the Cooling Tower Blowdown Line.

# Harris Lake

- Man-made reservoir with an average depth of 15 feet and is surrounded by woods
- Permitted release point for all plant discharges (radioactive, NPDES, Cooling, etc)
- The lake is fed by a couple of minor creeks and surface runoff.
- The main dam will allow water to overflow via the spillway into Buckhorn Creek
- The lake only flows over the spillway when there is sufficient rain (typically spring months)

# Tritium Concentration

- Harris Lake tritium concentration depends upon the concentration of tritium in a release tank, lake elevation, and rainfall.
- Site releases about 800 Ci of tritium to the lake each year
- From 2009 to 2015 lake tritium concentration ranged from 2,500 – 11,000 pCi/L (2015 average = 6,170 pCi/L)
- Lake evaporation releases about 125 Curies of tritium into the atmosphere each year.



# Cooling Tower

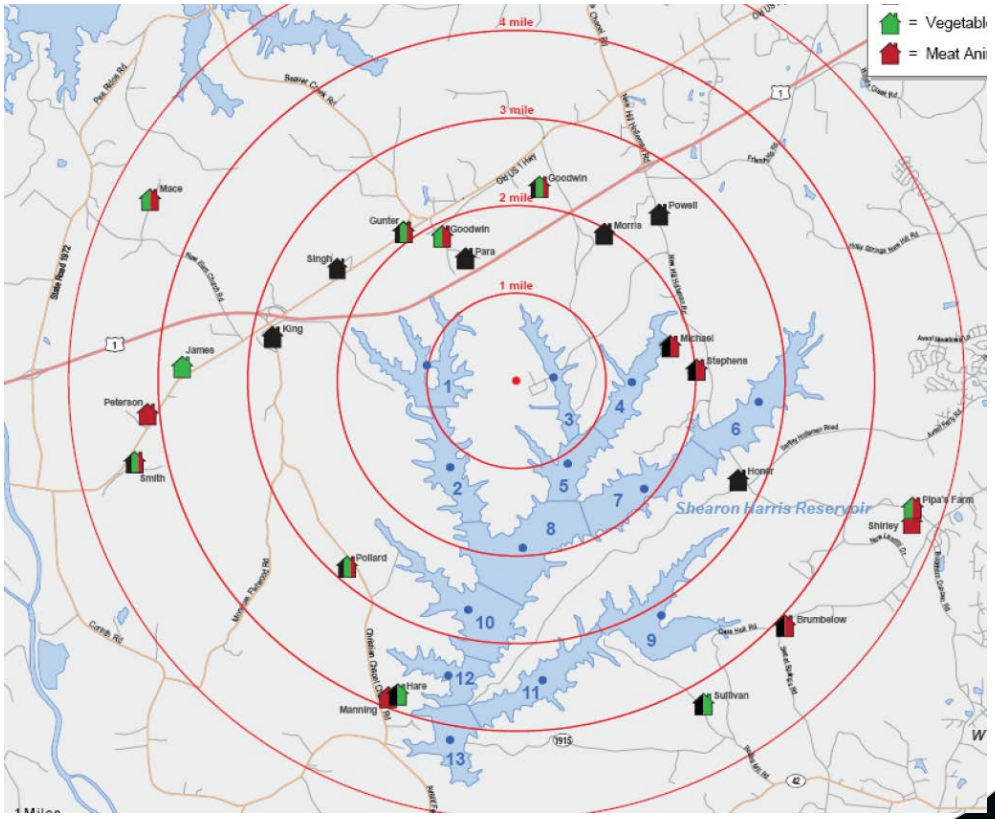
- Site cooling is through a 523 foot (160 meter) Cooling Tower
- Make up to the cooling system is provided by Harris Lake
- Approximately 10,000 gallons/min is released to the atmosphere
- The Cooling Tower plume discharges about 100 Ci of tritium into the atmosphere annually

# Gaseous Release Stacks

- Harris Nuclear has 4 gaseous release stacks (Plant Vent, Stack 3, Stack 5, and Stack 5a).
- Plant Vent Stack discharges about 98% of the gaseous tritium.
- About 135 Ci of tritium via Plant Vent Stack
- The Plant Vent Stack is 41.45 m tall.

# Sources of Tritium into the Atmosphere

- The dose from the gaseous stacks is calculated in accordance to regulations
- In addition, the inhalation dose from the Cooling Tower and evaporation of Harris Lake is reported annually
- Concern that the atmospheric deposition of the tritium potentially contaminates the groundwater which could be ingested by a member of the public



# Tritium Ground Deposition at Harris

- Hirsh Shah – Murray and Trettel modeled atmospheric deposition using 2013 tritium release data and 2013 meteorology data
- Amount of deposition is based upon the rate of rainfall and the number of hours rainfall occured
- Model based upon the vapor washout model which assumes 100% of tritium is removed from the atmosphere when rainfall is >30 mm/hr. The removal rates diminish at lower rainfall rate based on a logarithmic expression.
- Assumes that the tritium will be deposited to the ground within one hour of release
- See EPRI Technical Report 1021183 “Atmospheric Deposition of Tritium at Nuclear Power Plants”

# 2013 Data

| Source | Tritium Released (Ci) |
|---|---|
| Harris Lake Evaporation | 151.86 |
| Cooling Tower Plume | 126.10 |
| Plant Vent Stack | 138.58 |
| Total | 416.54 Ci |

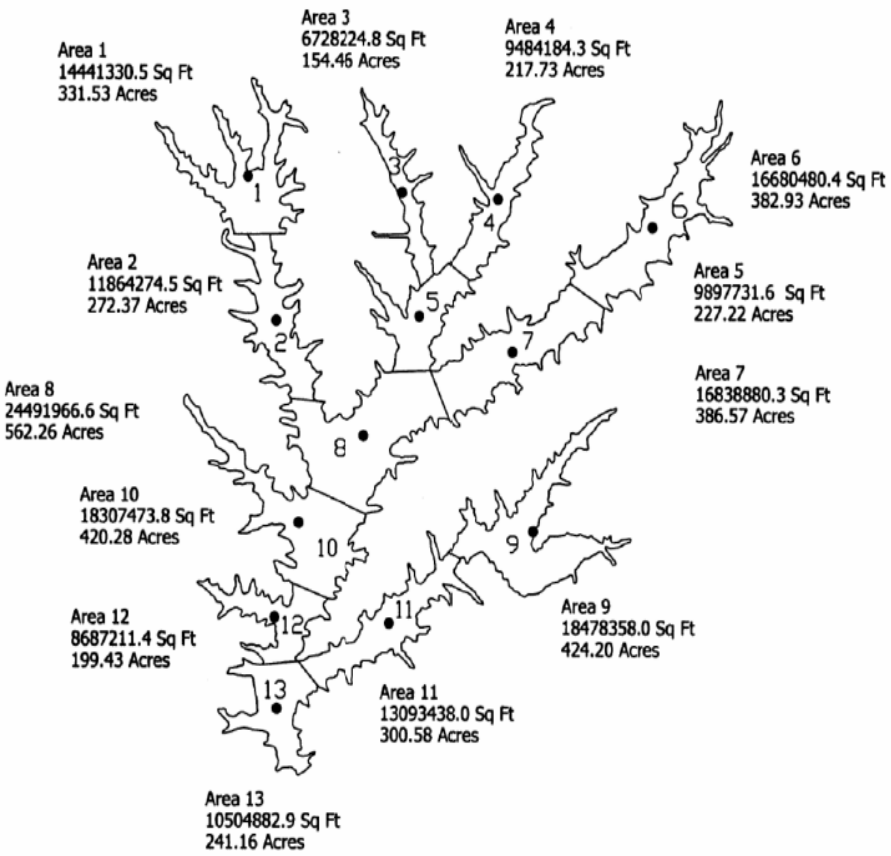
| National Weather Service Data | |
|---|---|
| Total Rainfall | 1264.16 mm |
| Rainfall Hours | 570 hours |
| Av 10 m Wind Speed | 6.88 miles/hr |
| Av 45 m Wind Speed | 8.53 miles/hr |
| Av 160 m Wind Speed | 11.0 miles/hr |
| Highest Rainfall Rate | 52.83 mm/hr |
| Lowest Rainfall Rate | 0.3 mm/hr |
| Average Rainfall Rate (RR) | 2.22 mm/hr |
| Average Tritium Removal during rainfall hours | 17.1% |

$$Avg\ Tritium\ removal\ rate\ \% = 10^{(0.67699(Log\ RR)\ +1)}$$

$$= 17.1\%$$

# Division of Harris Lake

- Due to the uneven shape and large surface area, Harris Lake was divided into 13 sections
- Area and center point of each sector was determined using Auto-CAD.
- This was done to determine the impact of each lake section



# Tritium Deposition By Source

| Source | Tritium Released (Ci) | Tritium Deposition (Ci/yr) |
|---|---|---|
| Total Harris Lake Evaporation | 151.86 | 1.746 |
| Section 1 | 12.22 | 0.136 |
| Section 2 | 10.04 | 0.111 |
| Section 3 | 5.69 | 0.063 |
| Section 4 | 8.02 | 0.089 |
| Section 5 | 8.37 | 0.093 |
| Section 6 | 14.11 | 0.156 |
| Section 7 | 14.25 | 0.158 |
| Section 8 | 20.72 | 0.230 |
| Section 9 | 15.63 | 0.173 |
| Section 10 | 15.49 | 0.172 |
| Section 11 | 11.08 | 0.123 |
| Section 12 | 7.35 | 0.082 |
| Section 13 | 8.89 | 0.098 |
| Cooling Tower Plume | 126.10 | 1.395 |
| Plant Vent Stack | 138.58 | 1.542 |
| Total | 416.54 | 4.683 |

- 17.1% of the tritium released is washed out by rainfall
- In 2013 there was 570 hours of rainfall
- Evaporation is considered to occur uniformly across the lake

$$Section\ 1 \ = 12.22\ \frac{Ci}{yr} \times 17.1\% \times \frac{570\ hour\ rainfall}{24\ hr \times 365\ day}$$
$$= 0.136\ Ci/yr$$

# Calculation of Annual Tritium Deposition

- Tritium washout occurs within 1 hour release from source
- D/Q computed using XOQDOQ
- Tritium from Harris Lake is considered 13 separate tritium sources
  - Average 10 m wind speed  was 6.88 mph
  - Tritium will deposit in a circle 6.88 miles (10 mile radius XOQDOQ)
- Cooling Tower
  - Average 160 m wind speed was 11 mph
  - Tritium will deposit in a circle 11 miles (20 mile radius XOQDOQ)
- Plant Vent Stack
  - Average 45 m wind speed was 8.53 mph
  - Tritium will deposit in a circle 8.53 miles (10 mile radius XOQDOQ)

# Tritium Deposition Contours

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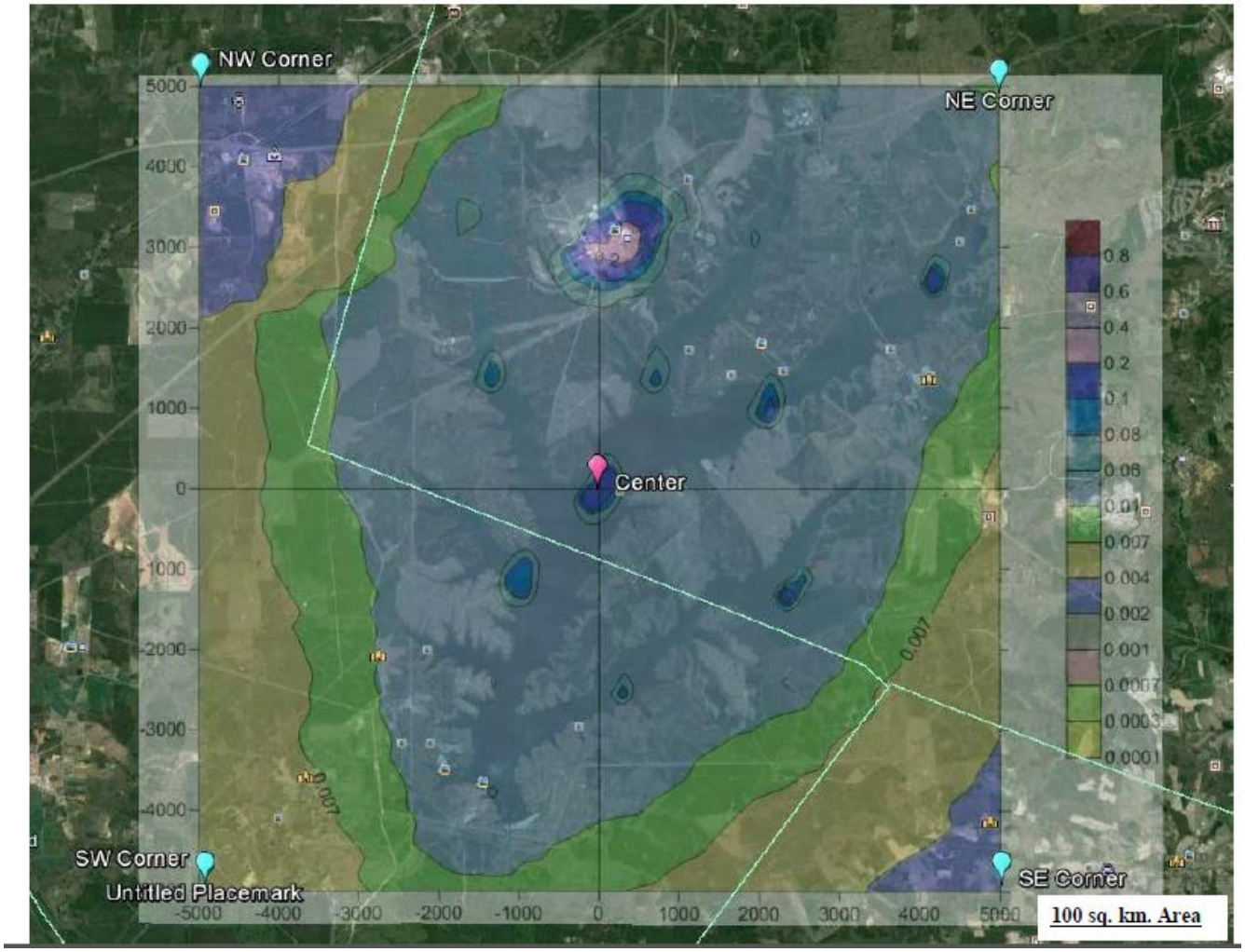

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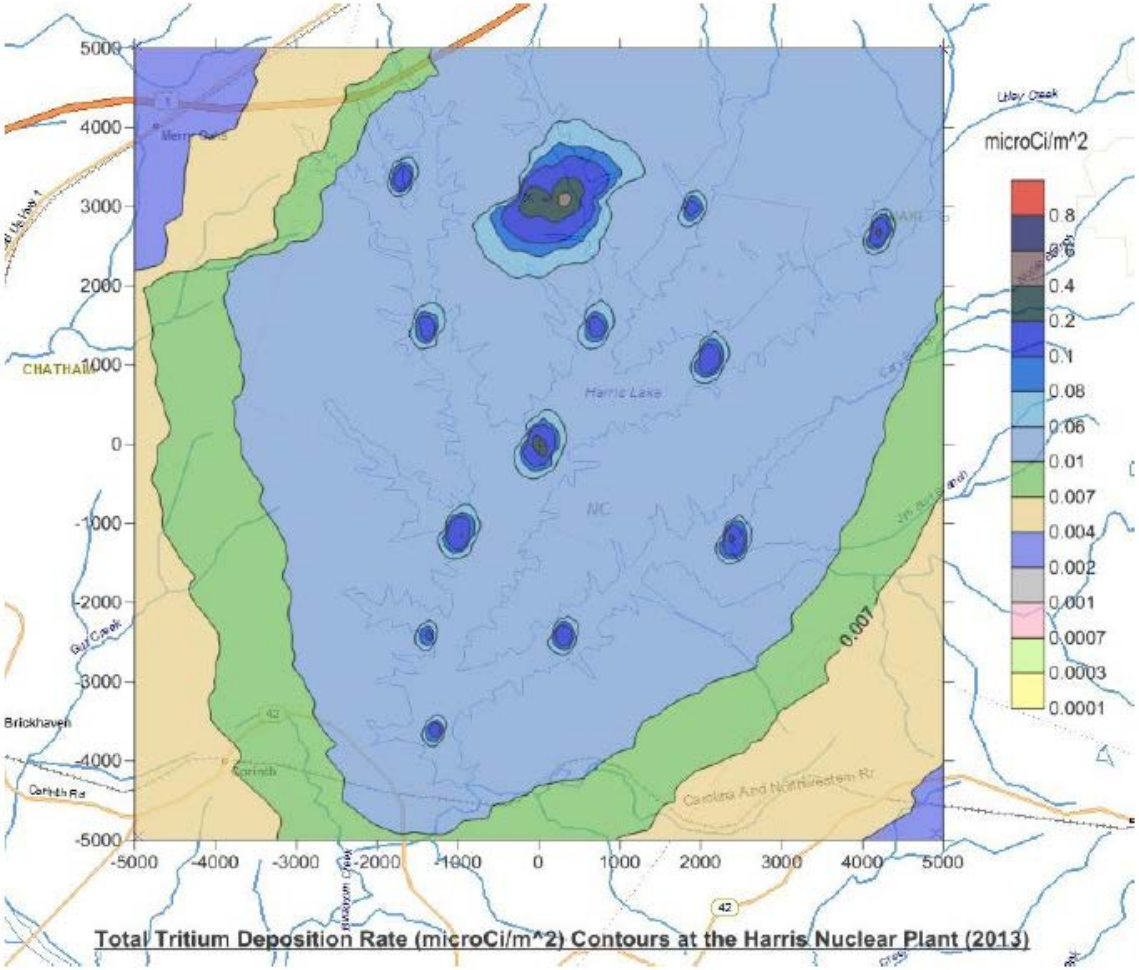


- Harris Lake Tritium washout occurs mostly directly over the lake, so it is not a significant concern

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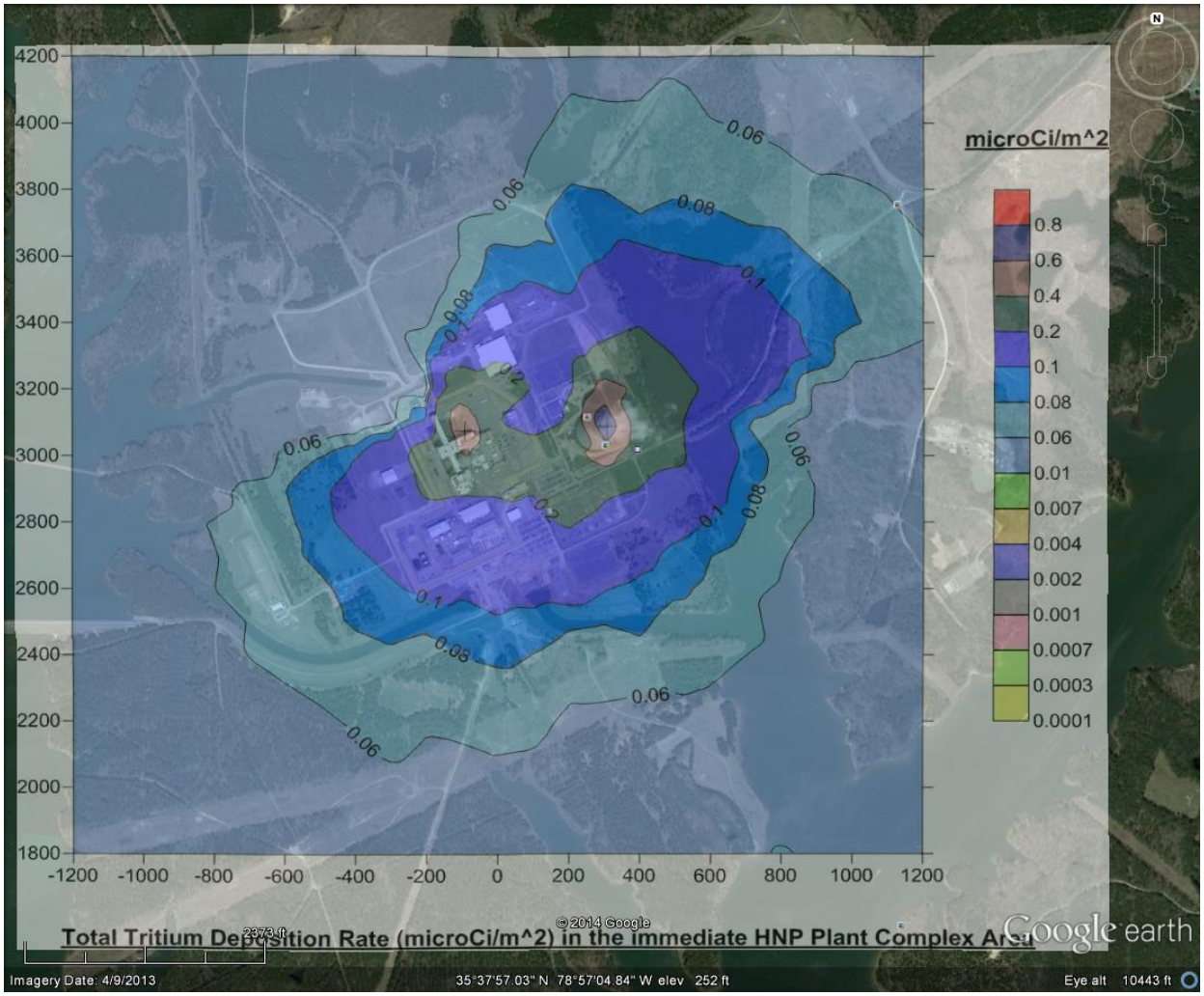
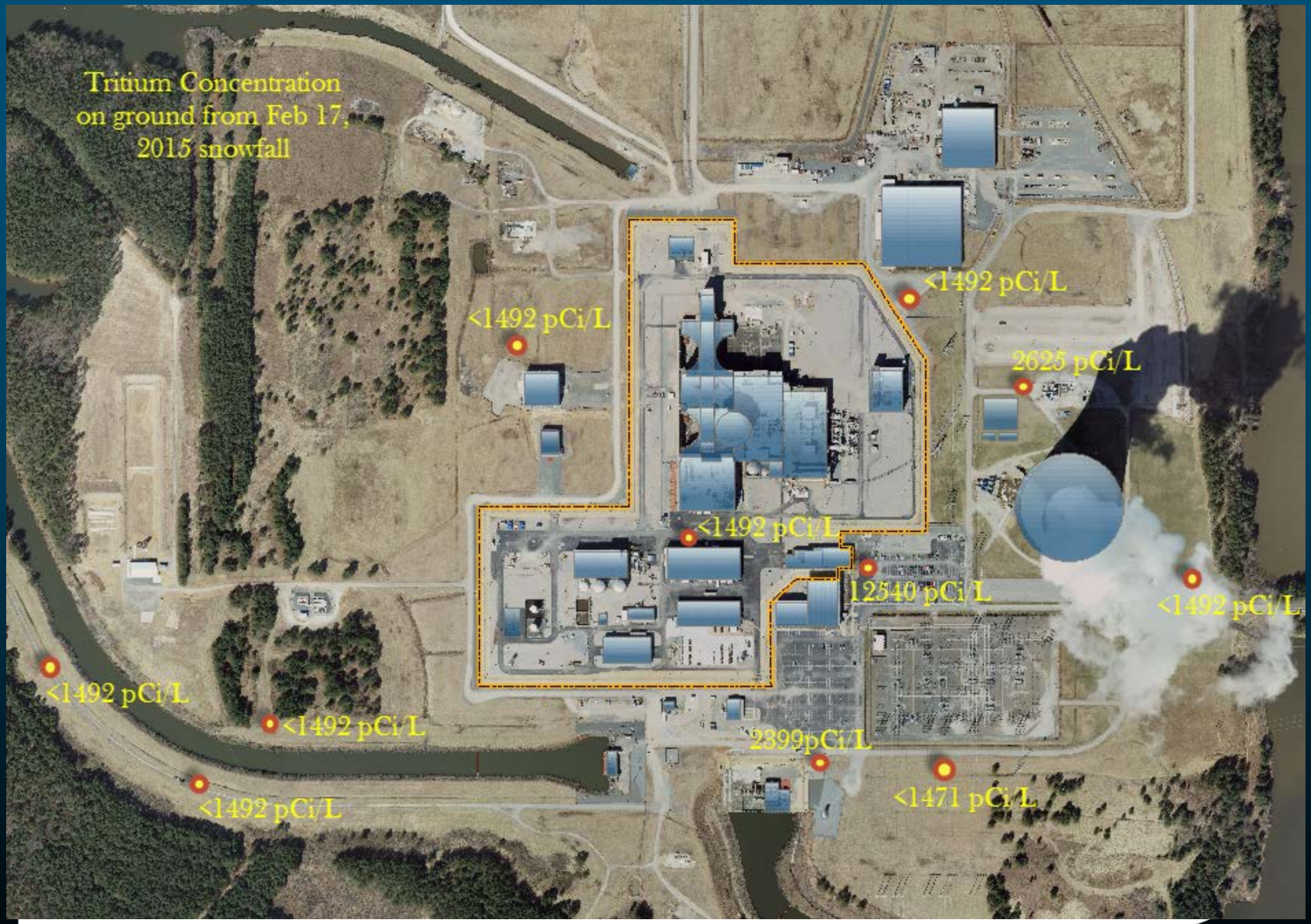



- Highest deposition is predicted to be in the area between the Plant Vent Stack and Cooling Tower

# Snowfall Results

- Feb 17 2015, HNP had several inches of heavy snowfall.
- 250 ml (approximately 1 $m^2$) snowfall samples were collected at several locations around the plant site
- Analyzed for tritium and results compared to model
- Except for the snow in the middle of the protected area, all of the snow had been undisturbed


Tritium Concentration
on ground from Feb 17,
2015 snowfall
<1492 pCi/L
<1492 pCi/L
2625 pCi/L
<1492 pCi/L
12540 pCi/L
<1492 pCi/L
<1492 pCi/L
<1492 pCi/L
<1492 pCi/L
2399pCi/L
<1471 pCi/L

# Model vs Snow Event

| Location | Model ($uCi/m^2$) | Actual (pCi/L) |
|---|---|---|
| GW57 | 0.088 | <1492 |
| GW59 | 0.049 | <1492 |
| GW68 | 0.040 | <1492 |
| GW69 | 0.192 | 2625 |
| GW72 | 0.183 | 2399 |
| GW75 | 0.288 | 12540 |
| GW76 | 0.211 | <1492 |

- In general, the model did fairly well predicting the locations of elevated tritium
- The model predicted that GW76 should be higher. The difference could be that the snow in this area was plowed and the sample was obtained from snow pile
- This was from a single snow event
- Future samples (snow and rain) are planned (waiting for another blizzard or hurricane!)

# Conclusion

- Atmospheric deposition from tritium was modeled for Harris Nuclear Plant
- Site has several tritium release points (13 lake sections, Cooling Tower, and Plant Vent Stack)
- Calculation assumed 17.1% of gaseous tritium is washed out
- Harris Lake washout occurs directly over the lake
- Cooling Tower and Plant Vent Stack washout occurs near the Cooling Tower area
- No evidence that deposition occurs on a neighbor's property
- Snowfall study showed similar results to model

# Acknowledgement


- Hirsh Shah – Murray and Trettel

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- EPRI Technical Report “Atmospheric Deposition of Tritium at Nuclear Power Plants” 1021183