CAAS Detector Placement Using MAVRIC

Larry L. Wetzel, PE, B&W, NOG-L
Brandon O'Donnell, B&W,NOG-L
William D. Newmyer, NSA

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Regulatory Requirements

- B&W NOG-L is a NRC Licensed Facility
  - 10 CFR 70.24
  - ANSI/ANS-8.3
  - Regulatory Guide 3.71 Endorses ANSI/ANS-8.3 except for:
    - Requires criticality alarm systems in each area in which special nuclear material is handled, used, or stored
    - Requires monitored area be covered by two criticality detectors
    - Requires monitoring system be capable of detecting a nuclear criticality that produces an absorbed dose in soft tissue of 20 rads of combined neutron and gamma radiation at an unshielded distance of 2 meters from the reacting material within 1 minute.

Analytic Approach

- CIDAS system is a gamma detection system
  - 3 loops of detectors, Blue, White, and Yellow
  - 2 of 3 loops must alarm to activate the system
  - Detectors were spread out, not in triplets
  - Set point was 100 mr/hr
  - Calculations used mean dose rate - $2\sigma > 150$ mr/hr

Source Types

- Operations involve HEU and LEU
- Unencapsulated operations
  - Solids and solutions
  - Various H/X's and solution concentrations
- Clad operations
  - Many product types and designs
- Could we set up source terms that are more realistic than the minimum in the regulation?
  - Yes but there is not sufficient time in this life

Source Types

- B&W makes LWR components
- Most likely criticality scenario will involve moderated configurations
  - Glovebox operations
  - Clad component processing
- Solution processes would involve transfers to unfavorable geometries
- Bare Spheres of HEU metal
  - H/X of 2, 5, 200, 1000

Source Term Development

- Determine the critical spherical radius (CSAS5S)
- Create a fission source (CSAS6)
- Calculate the surface flux energy distribution (n,g)
- Calculate the dose rate at 2 m
  - Use surface flux energy distribution as a point source
- Determine source strength to produce 20 R/hr

Source Placement

- Point sources on the outside of the reacting material

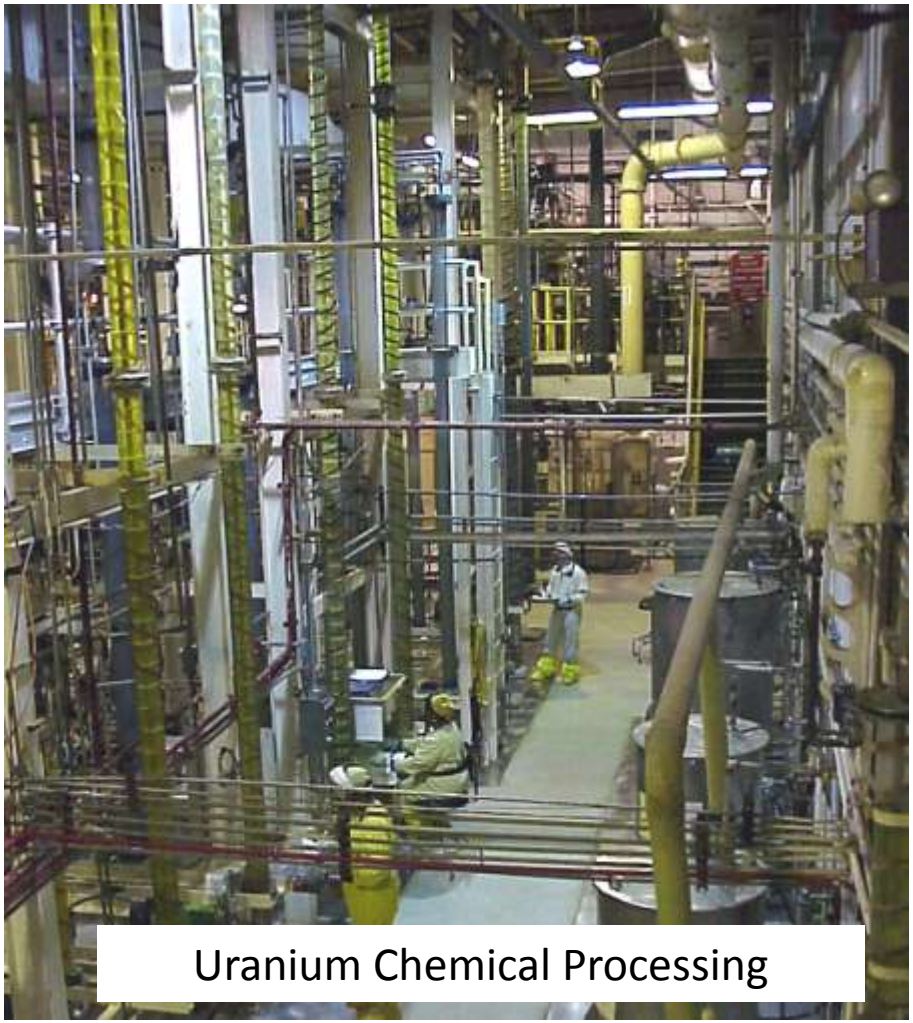
  OR

- At the center but without the reacting material present
- Locations chosen based on where material is expected.
  - Fuel assemblies are not expected to be under a desk.
  - In unclad areas, more locations are possible
  - In solution areas, most anywhere is fair game
- Bottom line – **Professional Judgment** was used.

Model Development

Research Test Reactor (RTR) Machine Shop

Model Development



Uranium Chemical Processing

Model Development

- Model size required automation
  - Microsoft Excel with VBA embedded programs
    - Master Sheet (Case Identification)
    - Input Sheet (Identifies what sheet is used for which part of the input file)
      - Materials
      - Equipment and Walls
      - Bay Configurations
      - Final Layout
      - Arrays
      - Sources and Detectors
    - Results Sheets

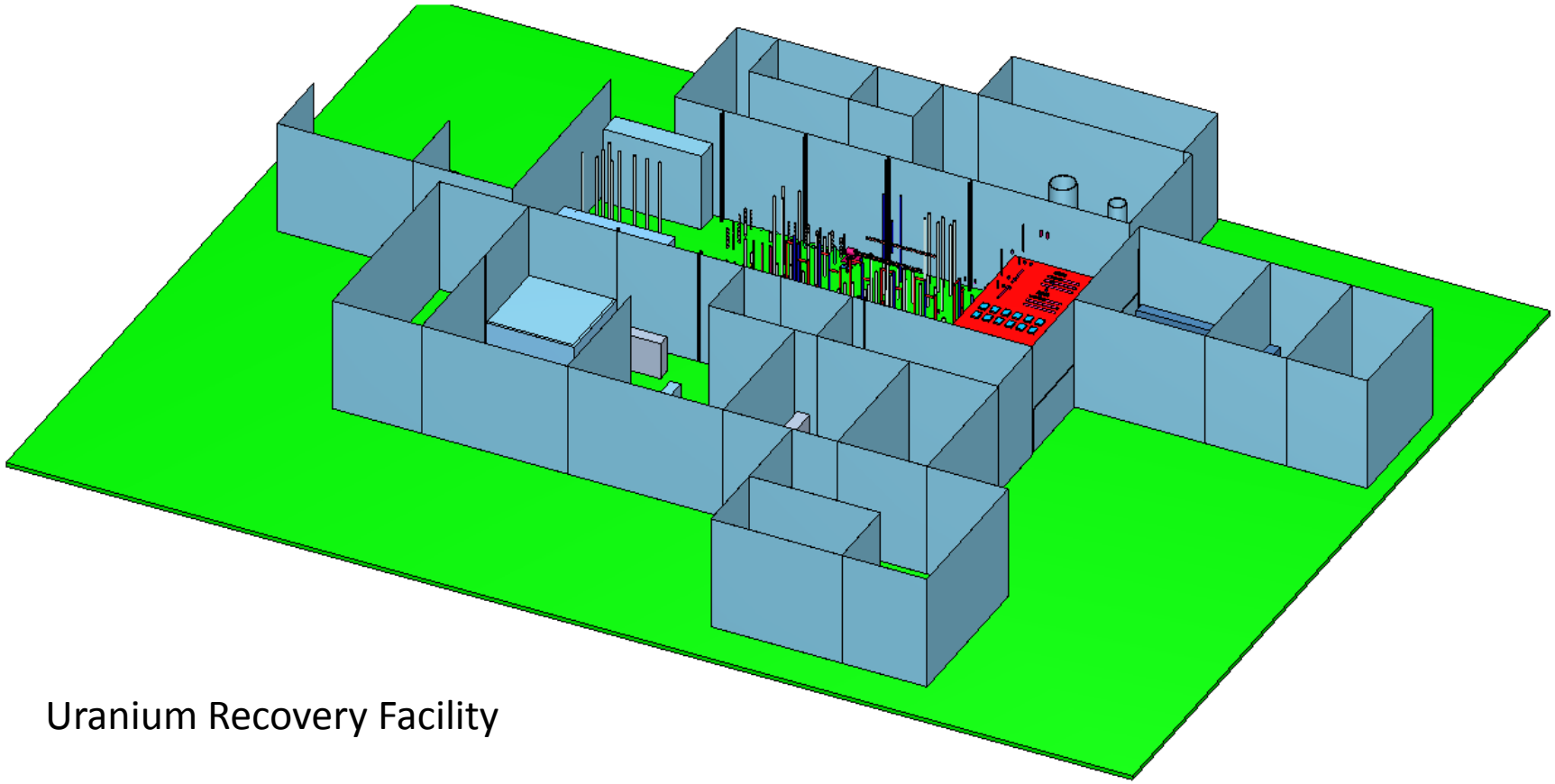
Model Development

- Equipment and Walls
  - Geometry and Media
  - Material ID brought in via lookup
- Bay Configuration
  - Insert equipment and wall as holes or as geometry
  - Equipment and walls brought in via lookup
  - Translations and media built via VBA program
- Final Layout
  - Global unit with bays inserted as holes from Bay Configuration sheet

Model Development

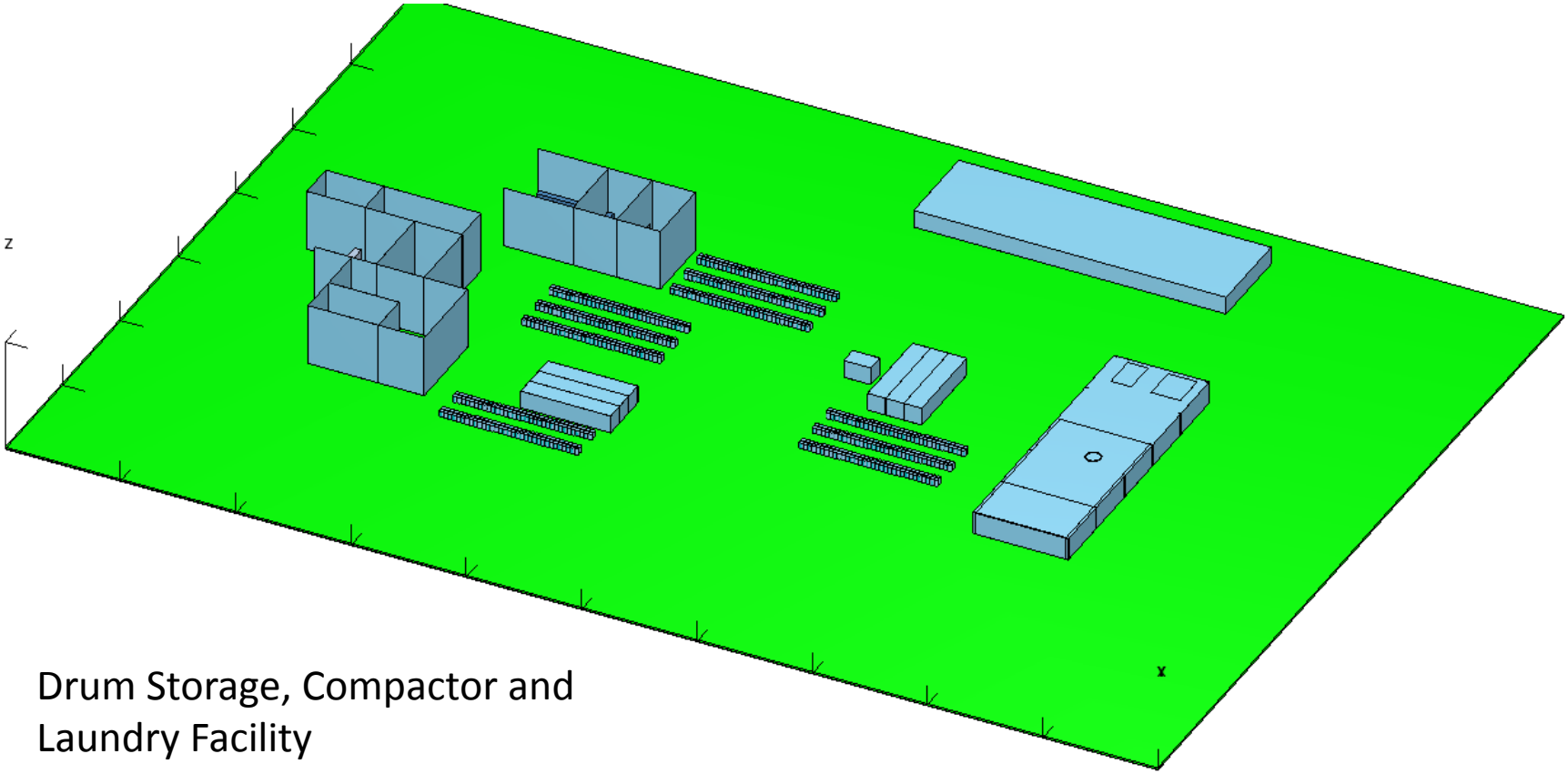
- Source Data
  - Each of the source terms with strengths and energy distributions as available
- Sources and Detectors
  - The specified source is pulled in via lookup function
  - MeshTally built based on area of the model being run

Model Development



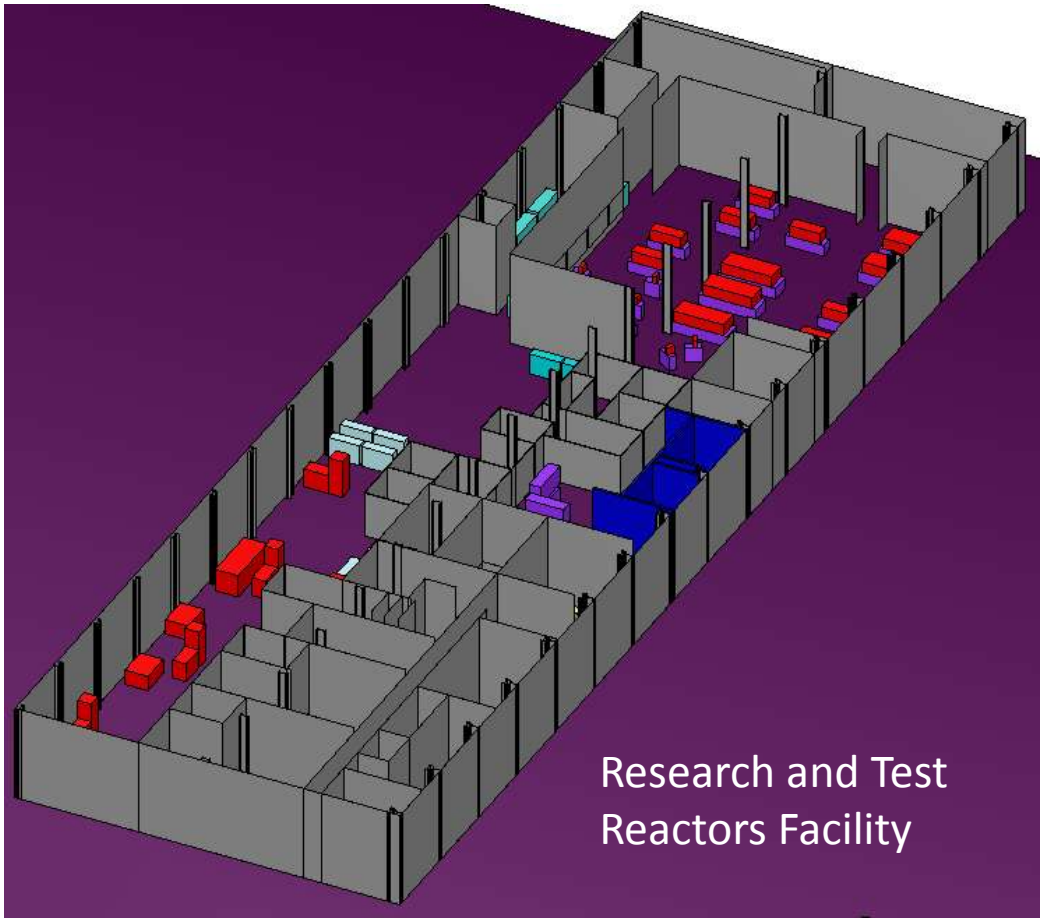
Uranium Recovery Facility

Model Development



Drum Storage, Compactor and Laundry Facility

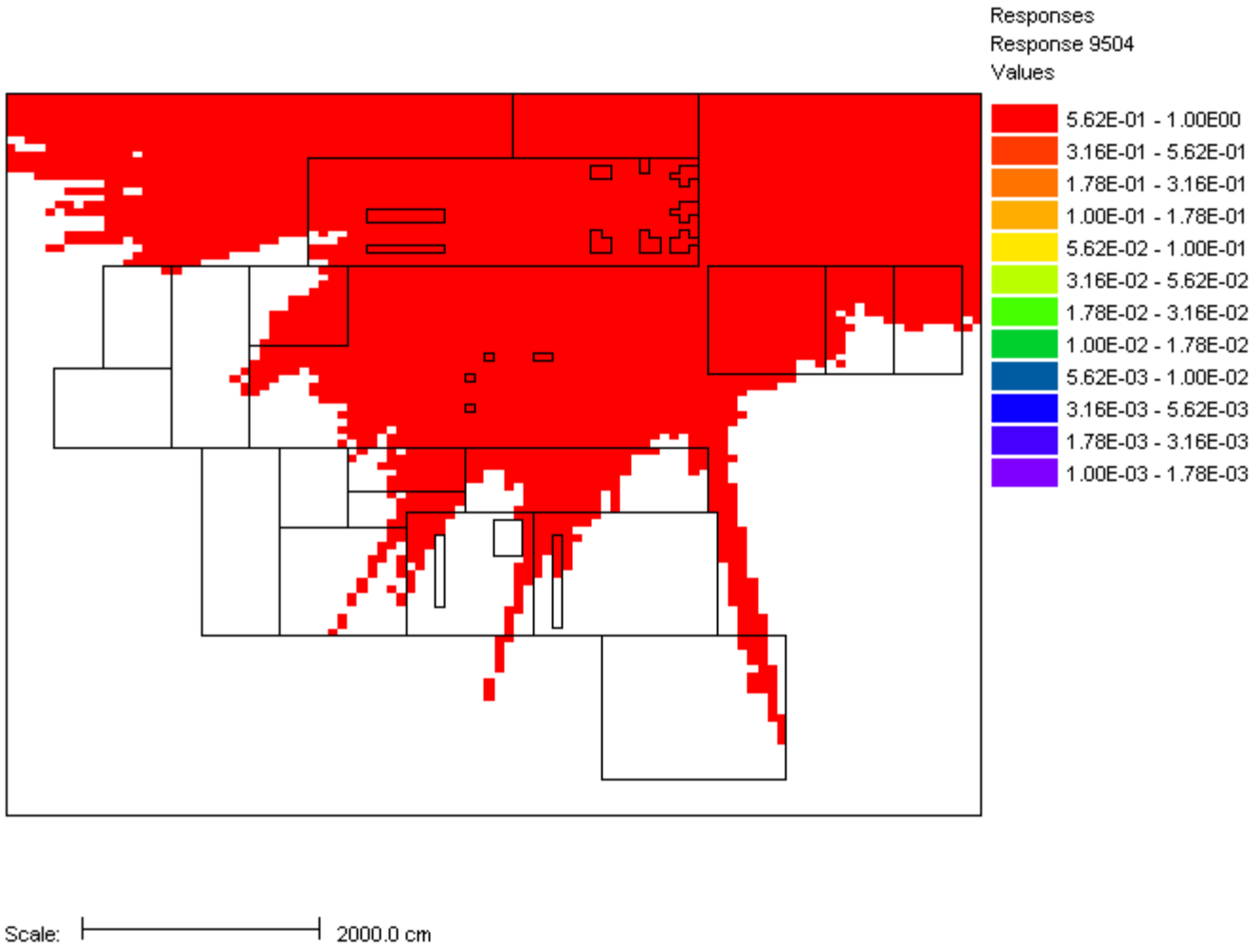
Model Development



Calculational Tools

- SCALE 6.1
  - CSAS5S, CSAS6 with CE-V7
  - MAVRIC with 27 n/19 g groups
    - Analog only
    - FW-CADIS
  - Henderson Dose Conversion Factors (1977)
  - Dose maps
    - MAVRIC generated (neutron and gamma flux and dose)
    - “response” map for gamma dose rate only
    - “above” map for dose rates >150 mr/hr
    - “boolean” map for regions where dose rate is above 150 mr/hr

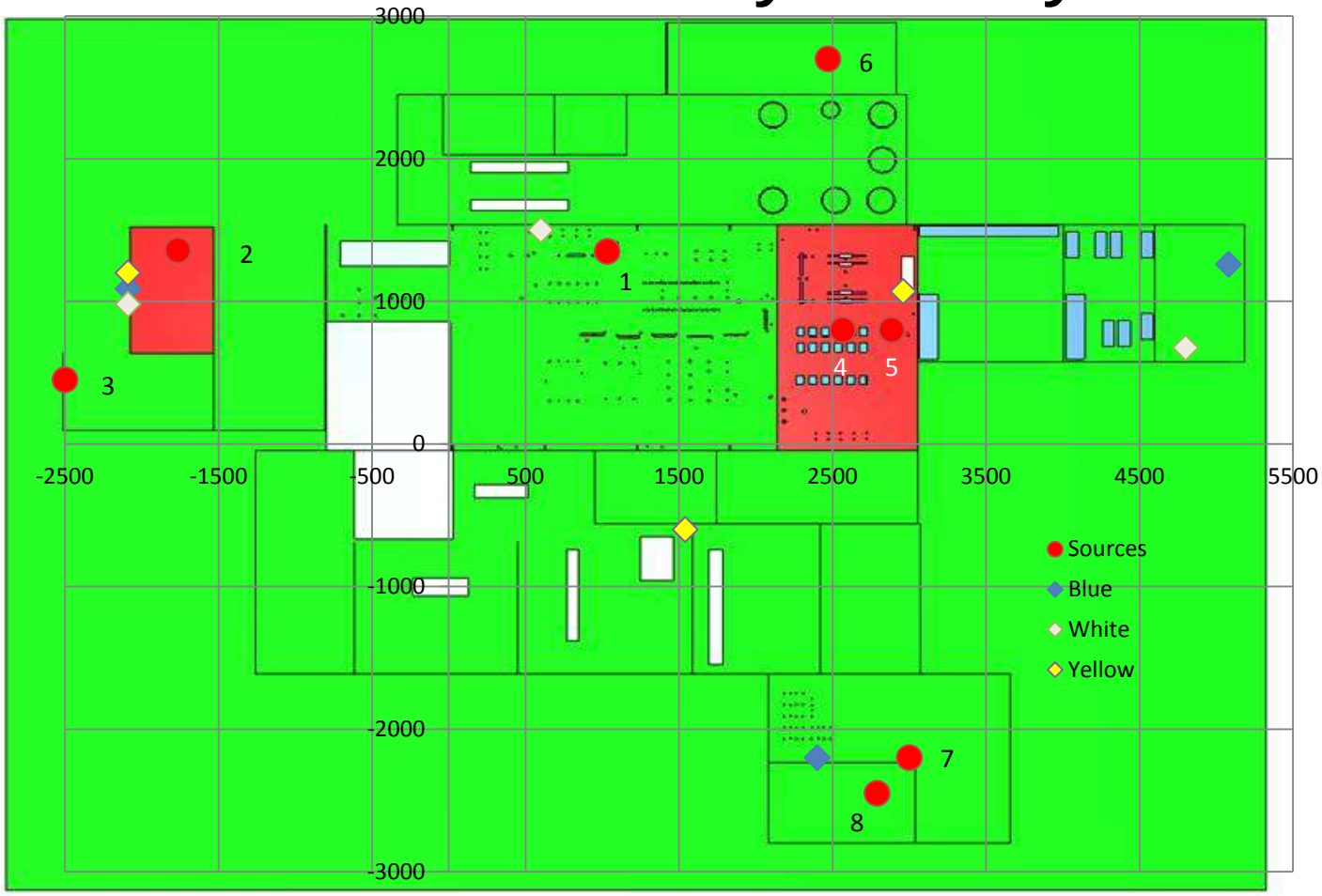
Dose Rate Maps



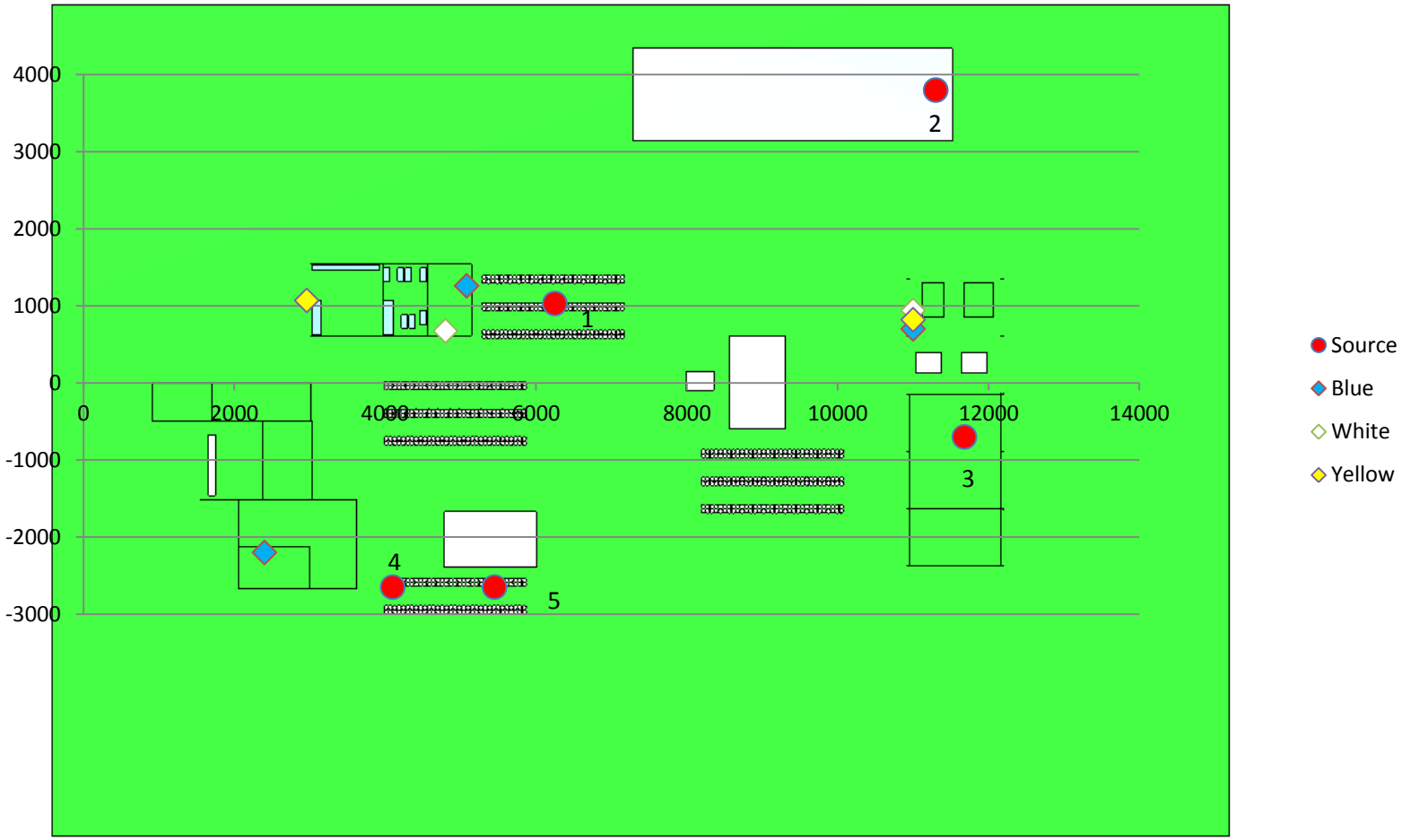
Where to Put the Detectors???

- Auxiliary routines query the dose rate map files
  - MTPULL – extracts data based on x, y, z coordinates
- Data pulled from “above” and “boolean” map files
- Imported into Excel via VBA routine
- Tested to ensure each source point is covered by a detector of each loop
- Modify locations as needed to meet acceptance criteria

Uranium Recovery Facility



"Field"



Summary

- 168 detectors for the new system
- More than the existing system
  - Primarily due to the alarm set point
  - Secondarily three loops must cover all locations
- 2 man-years of effort
- 3875 hours of computer time for cases used in the final report

Questions?