Oak Ridge Facilities Update

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Advisory Board on Radiation and Worker Health, 122nd Meeting

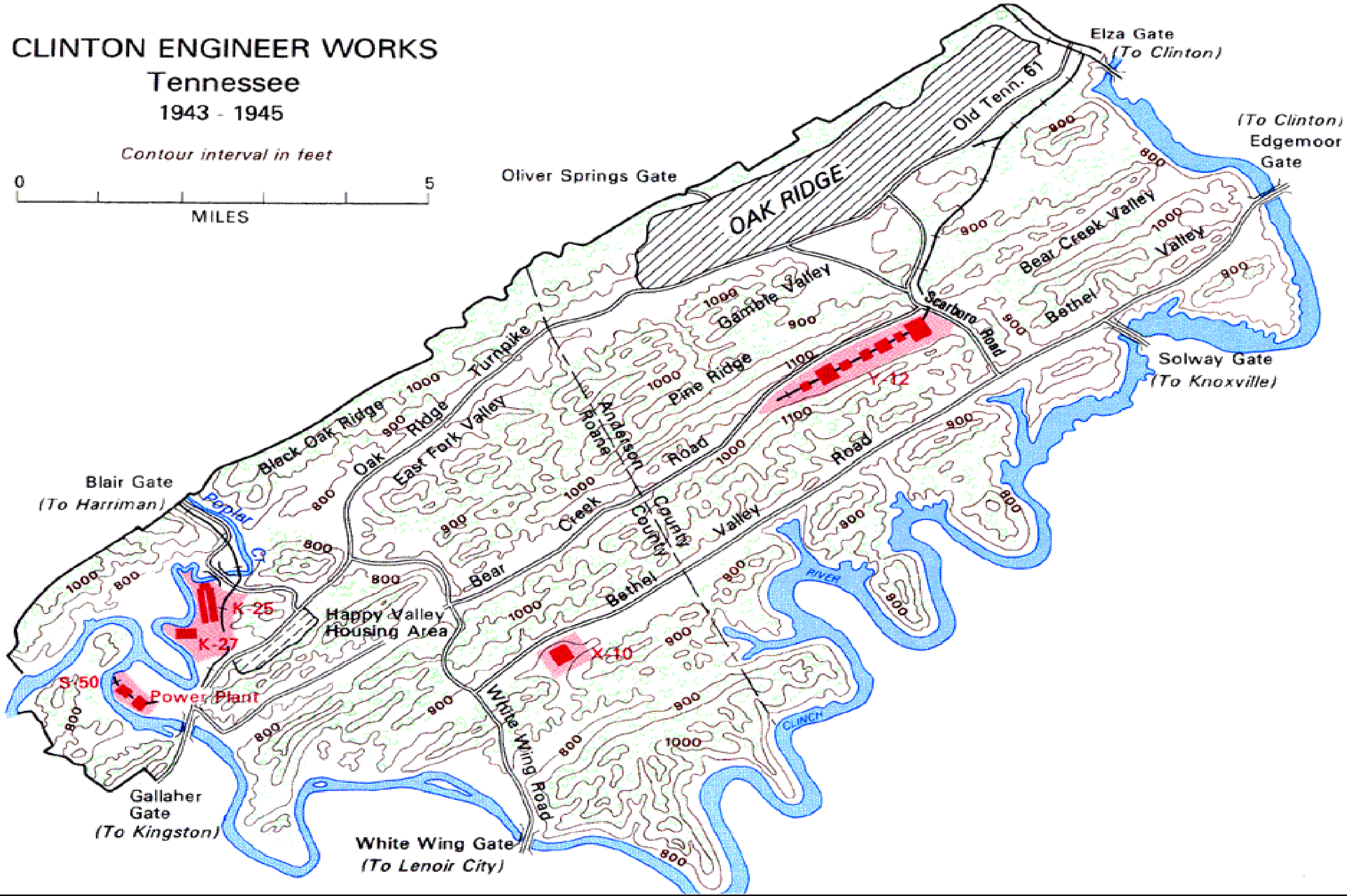
Oak Ridge, TN

April 11, 2018

Oak Ridge EEOICPA Facilities

Facility	Covered Period	SEC period	NOCTS claims (03/16/2018)
ORNL/X-10	1943 - present	1943 - July 31, 1955	3639
Y-12	1942 - present	Mar. 1943 - Dec. 1957	6284
K-25	1943 - 1987, 1988 - present	1943 - Feb.1, 1992	3993
CEW	1943 - 1949	1943 - 1949	64
ORISE	1946 - present	May 15, 1950 - Dec. 31, 1963	101
Oak Ridge Hospital	1943 -1959	May 15, 1950 - Dec. 31, 1959	26
OSTI	1957- present	None	51
S-50	1944 - 1951	July 9, 1944 - Dec. 31, 1951	43

Oak Ridge Facilities - CEW Map



Oak Ridge Facilities - Background

- Clinton Engineer Works (CEW):
  - “Everything inside the fence”
  - 59,000 acre federal government area
  - Exposure potential limited to warehouse area near Elza Gate
  - Evaluation report presented to Board in Feb. 2012, class effective June 10, 2012
  - Infeasibility: Internal and external exposure to U bearing ores

- Oak Ridge Gaseous Diffusion Plant (K-25):
  - Uranium-235 enrichment, processing and recycling
  - SEC was one of the classes that Congress included when the Act was signed

Oak Ridge Facilities – Background cont.

- Oak Ridge Institute for Science and Education (ORISE):
  - Scientific Research Institute operated by ORAU
  - ORINS Cancer Research Hospital was evaluated
  - Evaluation presented to Board in 2006, class effective Dec. 9, 2006
  - Infeasibility: Internal dose from nuclear medicine handling

- Oak Ridge Hospital
  - Community Hospital run by MED/AEC
  - Evaluation presented to Board in 2009, SEC effective Jan. 9, 2010
  - Infeasibility: Internal and external dose from support of nuclear medicine operations

Oak Ridge Facilities – Background cont.

- Office of Scientific and Technical Information (OSTI):
  - Federal Repository for DOE technical reports
  - No SEC class (Petition submitted in 2009 did not qualify for evaluation)
  - Facility not associated with radiological work
- Oak Ridge Liquid Thermal Diffusion Plant (S-50):
  - U enrichment facility adjacent to K-25 during wartime
  - Later work on Nuclear Energy for the Propulsion of Aircraft (NEPA)
  - Evaluation presented to Board in 2006, SEC effective Dec. 9, 2006
  - Infeasibility: Internal and external exposure to U and unknown radionuclides

Oak Ridge Facilities - Current Effort

- Oak Ridge National Laboratory (ORNL/X-10):
  - Current SEC period: June 17, 1943 through July 31, 1955
  - Current SEC infeasibility based on internal exposure to U, MFP and Th

- Y-12:
  - Addressing period after current SEC period ending Dec. 1957
  - SEC infeasibility based on internal exposure to thorium and cyclotron produced radionuclides
  - Potential Pu-241 infeasibility from calutron operations at Y-12 (by ORNL)
  - Evaluation of thorium exposures: thorium air and in-vivo data assessment

ORNL - SEC-00189

- SEC-00189 petition was evaluated in 2011-2012
  - Exotic radionuclides (reserved in prior SEC evaluation)
  - ORAUT-RPRT-0090 sent to ABRWH and ORNL WG

Internal Sources	Year												
	43	44	45	46	47	48	49	50	51	52	53	54	55
Plutonium		Air	Bio	Air	Bioassay								
Uranium	No Data						Bioassay						
Thorium		Air Data				No Data							
Fission Products		No Data						Bioassay					
Exotic Radionuclides	*Reserved for a joint ORNL (X-10) and Y-12 evaluation*												

ORNL - History

Graphite Reactor

- Graphite Reactor used for initial Pu production
- DOE civilian nuclear power program
    - Total of 7 critical test facilities and reactors
- Nuclear Fuel Reprocessing R&D
    - Dissolving of irradiated fuel and separation of Pu and U
- Isotope production
    - Production and sale of isotopes for research and medical uses
    - Reactor Produced
    - Some produced at Y-12 using calutrons
    - Separation, packing and shipping facilities

ORNL - History - cont.

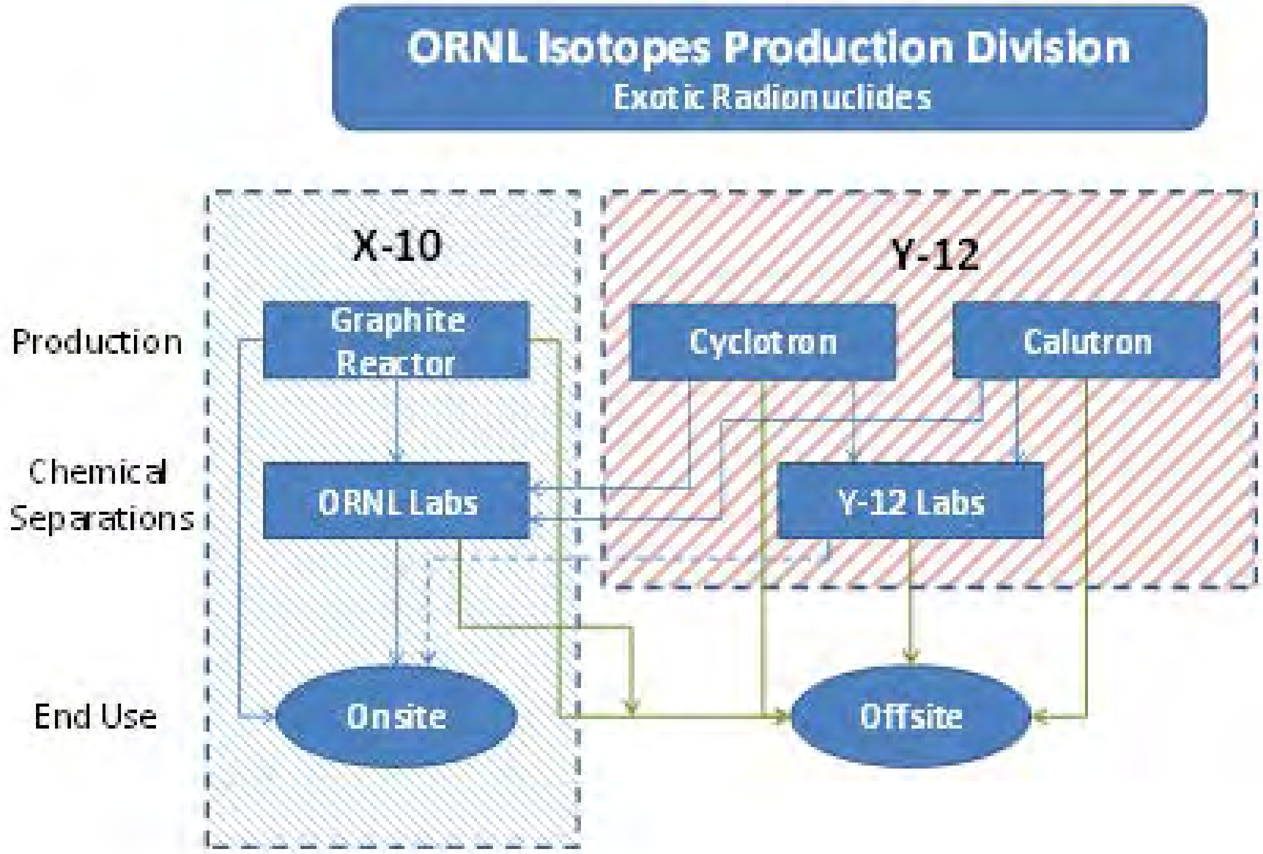
- Fusion Energy Programs
- Conservation/Renewable Energy
- Fossil Energy Programs
- Basic Physical Sciences Research
- Biomedical and Environmental Programs
- Waste Management
- Space and Defense Technologies
- AI
- Parallel Computing
- Education

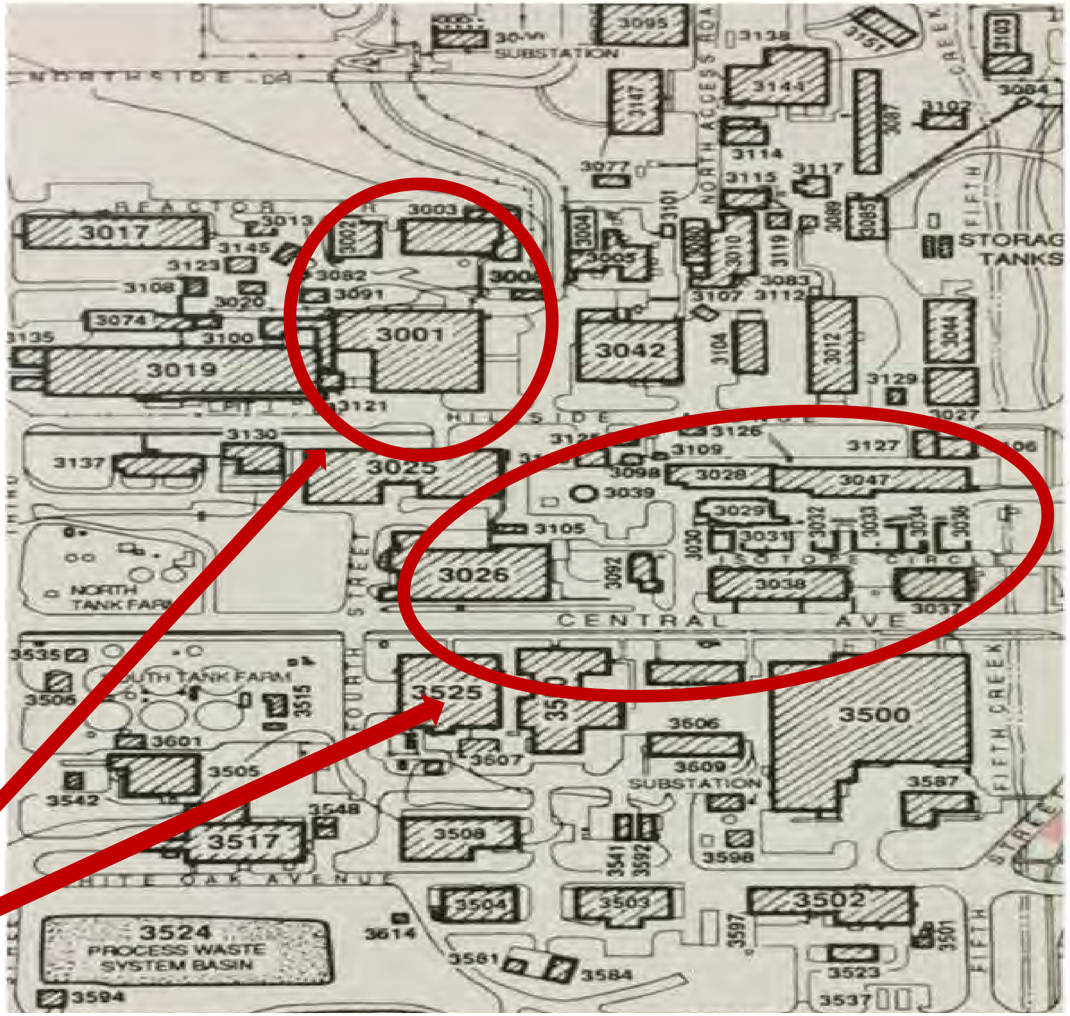
Early medical isotope production

ORNL - History - cont.

Aerial view of ORNL Campus, undated

ORNL - Isotope Production





Graphite Reactor
Isotope Circle

ORNL - Isotope Production at Y-12

Beta calutron at Y-12

- Calutrons no longer in use for U separation
- Beta calutrons used for Pu separations, starting 1952
- Separations in gloveboxes
- Building 9204-3
- Eight calutrons for various isotope separations, 1962-1972

ORNL - Bioassay Data

- ORNL bioassay data base: 104,947 results (1949-1988)
  - 94,988 results from 7564 individuals for 1955-1988
  - 62 different analytes and code “000” for non-standard method
  - Data base is known to be incomplete (not inaccurate though)
  - Gross beta missing from 1955-1959

- NOCTS bioassay data: 20,374 results (1955-1988)
  - Bioassay data extracted for potential coworker approach
  - NOCTS/ORNL sample ratio average is 1.13

ORNL - Bioassay Data - cont.

- In-vivo data (whole body counts) for gamma emitters:
  - Personnel counting started in June 1960, slow ramp up and program optimization
  - Routine operations starting in 1963 (baseline and recurring counts of potentially exposed persons.
  - System capacity of over 100 persons per month
  - Selection on 5 part criteria based on exposure potential by area HP
  - Baseline/termination, quarterly, semiannual counts

ORNL Radioisotope Inventory List

- Isotope Shipping and sales reports
- Operational and technical reports series
- Logbooks
- ORNL and Y-12 related holdings in the SRDB (over 15,000)
- Does not include service irradiations unless target rupture observed
- Table 6.3 in ORAUT-RPRT-0090: **213 isotope inventory list**
  - Hydrogen – 3: 1955-1957, 1959-1988
  - Beryllium – 7: 1955, 1957-1959, 1962, 1964, 1969
  - …
  - Fermium-255: 1984, 1988
  - Fermium-257: 1968-1977, 1980, 1984, 1986, 1988

ORNL - Capability Analysis

- Compare annual production history of 213 nuclides to available bioassay methods for each year
- Characteristic radionuclide emission (type and energy)
- Analytical method sensitivity (chemical specificity)
- Did not reconcile quantity of radionuclide with frequency of monitoring method
- Once adequate method was indicated it was assumed to be available in following years
- Gap is defined as no monitoring results for other years of interest

ORNL - Capability Analysis - Table Excerpt

Nuclide	Bioassay method code[b]	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69
Technetium-99	000(Tc-99); 006; 013/GB0;GB0;	G	G	G	N	G	G	G	G	G	G	G	G	Y	G	G
Technetium-99m	SC	N	N	N	N	N	N	N	N	N	N	N	G	N	G	N
Ruthenium-97	013/GB0	N	N	N	N	G	G	N	G	N	N	N	N	N	N	N
Ruthenium-103	000(Ru-103); SC[c]	R	R	R	N	R	R	R	G	G	G	G	G	G	G	G
Ruthenium-105	013/GB0	N	G	N	N	N	N	N	N	N	N	N	N	N	N	N
Ruthenium-106	000(Ru-106); 013/GB0; RU6	G	G	G	N	G	G	G	G	G	G	G	G	G	G	G
Rhodium-102	013/GB0	N	N	N	G	N	N	N	N	N	N	N	N	N	N	N
Palladium-103	(c)	N	N	N	N	N	N	N	R	N	R	N	N	N	N	N
Palladium-109	013/GB0	N	N	G	N	G	G	G	G	G	G	G	G	Y	G	G
Silver-110m	013/GB0;018;SC	G	G	G	N	G	G	G	G	G	G	G	G	N	N	N
Silver-111	013/GB0	N	G	G	N	G	G	G	G	G	G	G	G	Y	G	G
Cadmium-109	000(Cd-109)[c]	N	N	R	R	N	R	R	N	R	R	R	R	N	N	N
Cadmium-115	013/GB0	G	G	N	N	N	G	N	G	G	G	G	G	N	N	N
Cadmium-115m	013/GB0	G	G	N	N	N	G	G	G	G	G	G	G	N	N	N
Indium-111	SC	N	N	N	N	N	N	N	N	N	N	N	N	N	N	G
Indium-114	013/GB0	G	G	G	N	G	G	G	G	G	G	G	G	Y	G	G

- N: No radionuclide present in specified year
- Y: Nuclide present, bioassay method present, no sample recorded
- R: Nuclide present, no method identified, further analysis needed
- G: Nuclide present, bioassay method available, sample results available

ORNL - Further Evaluation Needed

- 34 Radionuclides need additional research
- 6 are iodines, DR method suggested in Appendix C (more later)
- 28 have short half-lives (22 < 1 year) and decay by EC or IT
- Estimated intake of 1×10^{-5} of listed inventory quantity for each
- Compared to action levels of workplace monitoring
- Calculated 50yr committed organ dose to the highest organ
- Postulate that dosimetrically significant intake was not likely

Nuclide	Max. (mCi/yr)	Organ	Dose (mrem)
Be-7	340	ET	5
Ca-41	501	BS	46
Cr-51	46,225	ET	428
Mn-54	115	ET	31
Fe-55	620	Spleen	172
Co-57	175	Lungs	24
Ga-67	120	ET	8
Se-75	2,160	Kidneys	599
Sr-85	142	ET	29
Sr-87m	84	ET	2
Mb-93	n/a	BS	n/a
Ru-103	1020	Lungs	566
Pa-103	n/a	ET	n/a
Cd-109	64	Kidneys	545

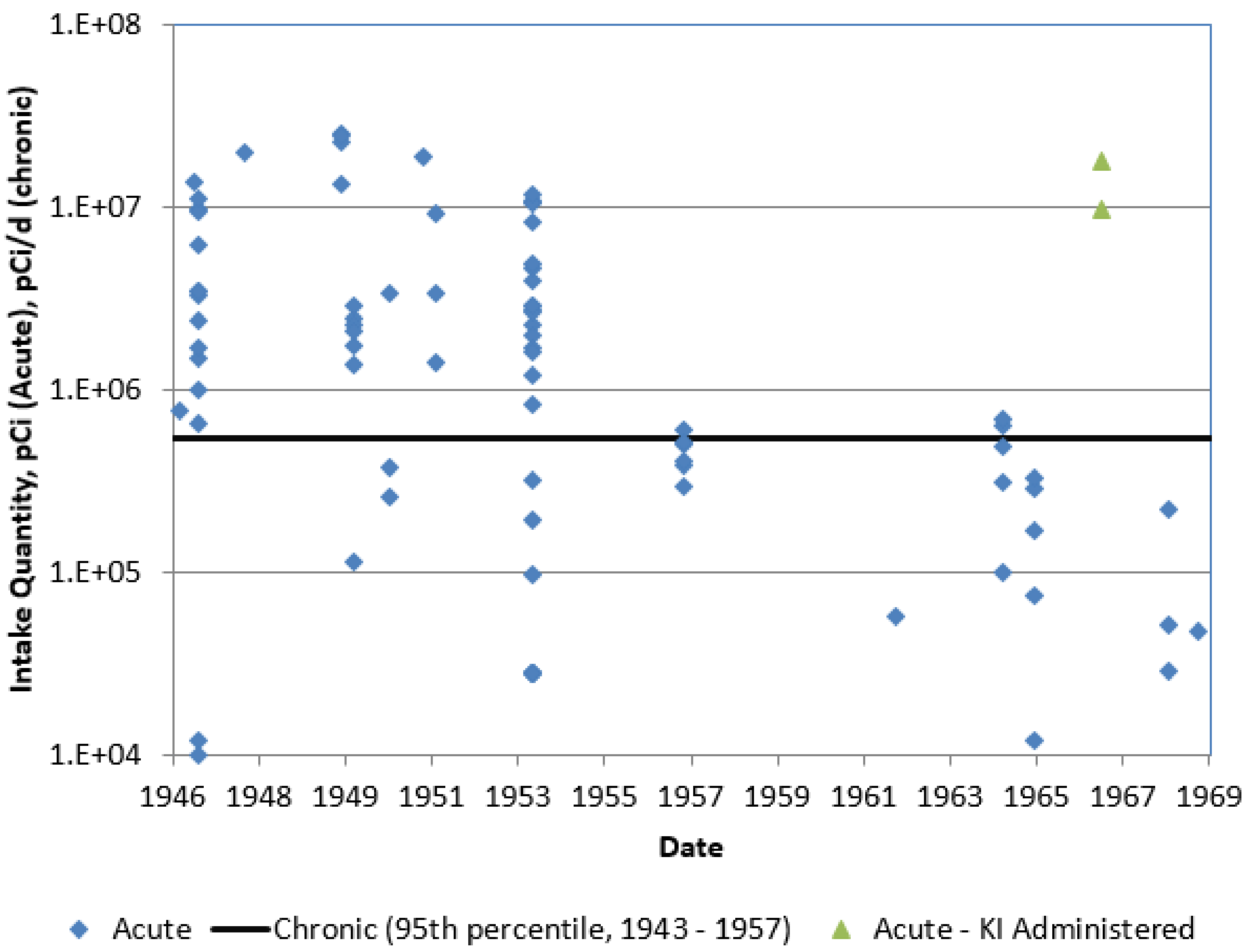
Nuclide	Max. (mCi/yr)	Organ	Dose (mrem)
Sn-113	610	Lungs	293
Sn-119m	3,598	Lungs	1464
Te-121	13	ET	3
Cs-131	25	BS	1
Ba-133	80	BS	28
Ce-139	n/a	Lungs	n/a
Pm-145	32	BS	49
Tb-156	n/a	ET	n/a
Dy-156	60	BS	6
W-181	18	ET	0.3
Os-185	n/a	ET	n/a
Au-195	5.6	Lungs	2
Hg-197	542	Lungs	722
Bi-206	n/a	ET	n/a

ORNL - Iodine Production

- Iodine produced for commercial applications since 1946
- Since 1958 through separation from reactor fuel
- Production (1946-1964) ranged from 1.3 to 3600 Ci/yr
- Limited personnel monitoring data during that time
- Thyroid monitoring took place 1944 – 1954
- Workplace controls were available
- Separations in 3026D and 3028, but exposure possible wherever reactor fuel was processed
- Whole body counting for iodine started in 1961

ORNL - Iodine

- Chronic 95th percentile intake derived from 1943-1957 data: 5.4×10^5 pCi/d
- Bounds acute intakes in post-1955 period
- Assign intake to unmonitored workers from 1955 to onset of WBC for iodine



Y-12 - History

- First Era (1942-1946): U isotope separation
  - Calutrons for Uranium enrichment
- Second Era (1947-1992): Cold war nuclear weapons components manufacturing
  - Produce and test key components of nuclear weapons
  - Stockpiling HEU
  - Technology development for new weapons designs
- Third Era (post 1992): Multiple new missions
  - Storing HEU
  - Continued weapons part production on smaller scale
  - D&D
  - Environmental and waste management

Y-12 History - Thorium

- Thorium processing operations started in early 1960's
- Thorium electrodes were arc melted
- Metal from meltings was pressed, rolled and machined
- Radium and progeny volatilized during process
- Process controls, air sampling, and in-vivo counting
- Detailed process information is classified
- Thorium processing end date is being researched
- In-vivo and air data for DR is being assessed

Y-12 - History

Aerial Photograph of Y-12 Campus, undated

Y-12 - Issue with In-vivo and Air Data

- In-vivo:
  - Thorium results are reported in units of mg of Th
  - Need calibration and count/channel data to potentially assess intakes from in-vivo results
  - Thorium chain disequilibrium is an issue

- Air data:
  - GA, BZ and operational data available, majority is GA
  - Y-12 Thorium air sample data base has issues with data pedigree and completeness
  - BZ and operational samples not sufficient for intake approach for all years

Path Forward - ORNL and Y-12

- No obvious ORNL internal DR infeasibility determined
  - Continued evaluation of internal data issues
- ORAUT-RPRT-0090 was delivered to ORNL WG
  - To be discussed in detail in WG meeting
- Potential Pu-241infeasibility: ORNL process at Y-12
  - SEC evaluation for Y-12 moving forward
- Thorium DR feasibility evaluation
  - Continued data capture to collect more information on Th operations
  - Potential Th infeasibility would be an SEC issue