

Nuclear Latency (NL) Dataset
Country Coding Sheets

UNITED STATES OF AMERICA
COW COUNTRY CODE: 2

List of Country's Enrichment and Reprocessing (ENR) Facilities

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Detailed Facility-Specific Information and Sources

1. American Centrifuge Demonstration Facility (Piketon, OH)

- a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Enrichment, centrifuge.

- b. *Facility size (laboratory, pilot, commercial).*

Pilot.

- c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction work began in 2002 and the facility began operation in 2007.¹

- d. *Was the facility developed covertly? If so, identify years that facility was covert.*

No, the facility was publicly announced.

- e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

The United States has had a Voluntary Offer Agreement (VOA) in place with the IAEA since 1980. Like the UK, the United States reportedly includes all civilian plants on its list of facilities eligible for safeguards. However, this plant does not appear on the available lists of US eligible facilities from 2007 to 2013 (available here: <http://www.nrc.gov/about-nrc/ip/intl-safeguards.html>). We therefore do not consider this plant to be under safeguards.

- f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

- g. *Did the facility have a military purpose?*

¹ The start date is from the USEC website, which states that the high efficiency centrifuges and the demonstration facility became operational in August 2007.

No.

- h. Was the facility multinational? If so, identify the other countries that were involved.

No.

- i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No. This facility is described as “the only domestic enrichment facility using US technology.”² The Department of Energy constructed most of the buildings in the 1980’s. The DOE commissioned the plant and the NRC runs the facility.

- j. *Sources:*

International Atomic Energy Agency. “Integrated Nuclear Fuel Cycle Information Systems.” <https://infcis.iaea.org>. Accessed 06/08/2015.

United States Department of Energy, National Nuclear Security Administration, “NPT Compliance.”

<http://nnsa.energy.gov/ourmission/managingthestockpile/nptcompliance>.

Accessed 01/13/2016.

United States Energy Company. “American Centrifuge Demonstration Facility.”

<http://www.usec.com/educational-resources/virtual-tour>.

United States Energy Company. “The American Centrifuge.”

<http://www.usec.com/american-centrifuge>. Accessed 07/13/2015.

United States Energy Company. “The Plant.” <http://www.usec.com/american-centrifuge/what-american-centrifuge/plant>.

Accessed 07/13/2015.

US Nuclear Regulatory Commission. 2009. “US Facilities Eligible for IAEA Safeguards.”

<http://pbadupws.nrc.gov/docs/ML1018/ML101870628.pdf>. Accessed 07/13/2015.

World Information Service on Energy (WISE) Project on Uranium. 2014. “USEC “American Centrifuge Plant” Project in

Piketon, Ohio.” <http://www.wise-uranium.org/epusecc.html>. Accessed

07/13/2015.

—. 2010. “USEC Reports American Centrifuge Progress.” *World Nuclear News*.

² <http://www.usec.com/american-centrifuge>.

http://www.world-nuclear-news.org/NN-USEC_reports_American_Centrifuge_progress-0505104.html. Accessed 0713/2015.

2. American Centrifuge Plant (Piketon, OH)

- a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Enrichment, centrifuge.

- b. *Facility size (laboratory, pilot, commercial).*

Commercial.

- c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

The facility began construction in 2007. Construction was not completed as of January 2013.³

- d. *Was the facility developed covertly? If so, identify years that facility was covert.*

No, the facility was publicly announced.

- e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

This plant does not appear on the available lists of US eligible facilities from 2007 to 2013 (available here: <http://www.nrc.gov/about-nrc/ip/intl-safeguards.html>). We therefore do not consider this plant to be under safeguards.

- f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

- g. *Did the facility have a military purpose?*

No, the facility is for civilian fuel production.

- h. *Was the facility multinational? If so, identify the other countries that were involved.*

The US designed, developed, and built the centrifuge technology.

³ The IAEA lists 2012 as the operational start date. That was the intended date, but it has not been announced that the facility is operating.

- i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No.

- j. *Sources:*

International Atomic Energy Agency. "Integrated Nuclear Fuel Cycle Information Systems." <https://infcis.iaea.org>. Accessed 06/08/2015.

Knapik, Michael and Steven Dolley. 2005 "USEC Centrifuge, Power Situations Rattle Analysts." *Nuclear Fuel*. 30(17): 1.

United States Energy Company. "The American Centrifuge." <http://www.usec.com/american-centrifuge>. Accessed 07/13/2015.

United States Energy Company. "The Plant." <http://www.usec.com/american-centrifuge/what-american-centrifuge/plant>. Accessed 07/13/2015.

—. 2012. "Turning Point for American Centrifuge." *World Nuclear News*. http://www.world-nuclear-news.org/NN-Turning_point_for_American_Centrifuge-1406125.html. Accessed 07/13/2015.

—. "USEC Hopes NRC Will License by Feb. 2004 'American Centrifuge Demonstration Facility.'" *Nuclear Fuel* 28(5): 1.

3. Argonne National Laboratory West

- a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Reprocessing (pyro-metallurgical).

- b. *Facility size (laboratory, pilot, commercial).*

Pilot.

- c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction of the reprocessing facility began in 1950.⁴ The reprocessing facility at Argonne National West operated from 1953 to 1992.⁵

⁴ The 1950 date is from Argonne National Lab document W7500-000-ES-04 page 2-1.

⁵ The operational dates are for the Chemical Reprocessing Plant operating at Argonne and are from the DOE Argonne page. Zentner et al. list operational dates of 1963-1994.

d. *Was the facility developed covertly? If so, identify years that facility was covert.*

Yes, the facility was covertly developed as part of the weapons program.

e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

No, the facility was part of the weapons complex. The United States has not identified such facilities as eligible for safeguards.

f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

g. *Did the facility have a military purpose?*

Yes, the facility was part of the weapons complex.

h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No. The initial investigation was indigenous. Japan invested 30 million into the budget of the pyro-metallurgical reprocessing research in 1990. The investment was important as budget cuts from US DOE threatened reprocessing research at Argonne National Lab. The technology itself was indigenous.

j. *Sources:*

Argonne National Laboratory. "Argonne History- 1940's."
<http://www.anl.gov/photos/argonne-history-1940s>. Accessed 07/13/2015.

Argonne National Laboratory. "Argonne's Nuclear Science and Technology Legacy."
<http://www.ne.anl.gov/About/modern-day-alchemy/>. Accessed 07/13/2015.

Idaho Department of Health and Welfare. 1998. "Final Record of Decisions: Argonne National Laboratory—West."
<http://ar.inel.gov/images/pdf/199812/19981209112526DMG.pdf>. Accessed 07/13/2015.

US Department of Energy. "Argonne National Laboratory—West."

http://www.em.doe.gov/SiteInfo/ArgonneNationalLab_West.aspx?PAGEID=MAIN. Accessed 07/13/2015.

Zentner, M.D., G.L. Coles, and R.J. Talbert. 2005. "Nuclear Proliferation Technology Trends Analysis" Pacific Northwest National Laboratory." Report 14480.

—. 1989. "National Lab Briefs: Argonne Reactor Program Turns to the East." *The Scientist*. <http://www.the-scientist.com/?articles.view/articleNo/10584/title/National-Lab-Briefs/>. Accessed 07/13/2015.

4. Avco-Everett Research Laboratory

a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Enrichment, laser.

b. *Facility size (laboratory, pilot, commercial).*

Laboratory

c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

The construction of the facility probably began in 1969 following an international conference on laser enrichment. We were unable to locate clear construction and operation dates, however. Research conducted in 1971 was made public in 1975. Two scientists from the lab, Levy and Jones, filed a patent in 1970 for laser enrichment, single pass through. The research was sufficiently promising that by 1972 Jersey Nuclear AVCO Isotopes (JNAI) was formed.

In 1981, Lawrence Livermore National Lab selected the AVLIS process over AVCO methods. Scientific work continued until 1984 when Textron Defense System acquired the facility and started to use the lasers for defense purposes. The 1984 date is used for the end of operation date as the lasers were no longer used for enrichment purposes.

d. *Was the facility developed covertly? If so, identify years that facility was covert.*

No, the international community knew about the facility when the initial construction occurred. The nature and specification of the work, however, was kept secret. The US government denied publication to two MIT professors working on the project out of fear that technical information on laser enrichment would benefit other countries' pursuit of the technology. Interestingly, the competition level was so high between

AVCO and Livermore that Joint Committee notes stated the private sector could be more advanced than Livermore, and asked how to justify duplicate spending

- e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

It is unclear whether this plant appeared on the list of eligible facilities per the US VOA with the IAEA.

- f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

- g. *Did the facility have a military purpose?*

No, this facility was commercially owned and operated.

- h. *Was the facility multinational? If so, identify the other countries that were involved.*

No, the facility was indigenously developed by capital flow from Exxon.

- i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No evidence of foreign assistance found. The facility was built with money from the AVCO Corporation with assistance from the USAF. American scientists were employed here.

- j. *Sources:*

Casper, Barry M. 1977. "Laser Enrichment: A New Path to Proliferation?" *Bulletin of the Atomic Scientists*. 33(1): 28-41.

Hafemeister, David W., Editor. 1979. "Laser Enrichment Process Called Proliferation Resistant." In *Physics and Nuclear Arms Today: Readings from Physics Today*. New York City, NY: American Institute of Physics. 199-203.

Kok, Kenneth D., Ed. 2009. *Nuclear Engineering Handbook*. Boca Raton, FL: Taylor & Francis Group. 276.

Overbye, Dennis. 2008. "Arthur R. Kantrowitz, Whose Wide-Ranging Research Had Many Applications, is Dead at 95." *New York Times*.
http://www.nytimes.com/2008/12/09/science/09kantrowitz.html?_r=2&
Accessed 07/13/2015.

Textron Defense Systems. "Company History."

5. Barnwell Reprocessing Facility

- a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Reprocessing.

- b. *Facility size (laboratory, pilot, commercial).*

Commercial.

- c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction of the facility began in 1970. The facility was completed and in an initial test phase in 1977 when US policy on reprocessing changed. The new policy prohibited reprocessing in privately owned facilities. The Barnwell plant, therefore, did not operate for plutonium reprocessing purposes prior to its closure in 1983.⁶

- d. *Was the facility developed covertly? If so, identify years that facility was covert.*

No.

- e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

Because the facility never reprocessed plutonium, it is unlikely that it was listed on the US eligible facility list.

- f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

- g. *Did the facility have a military purpose?*

No, the facility was for commercial industry.

- h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

⁶ The INFCIS states the operational date from 1974-1983. The operational date used is from Zentner et al. who state that “the facility was in the commissioning phase in 1977, when the US policy on reprocessing changed to prohibit reprocessing” (105). The NRC states that the facility did not become operational.

- i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No. The plant was privately owned and constructed with support from the US government. Allied-General Nuclear Services constructed the facility beginning in 1970.

- j. *Sources:*

Andrews, Anthony. 2008. "Nuclear Fuel Reprocessing: US Policy Development." Congressional Research Service. RS22542.
<http://www.fas.org/sgp/crs/nuke/RS22542.pdf>.

Croff, A.G., R.G. Wymer, L.L. Tavlarides, J.H. Flack, H.G.Larson. 2008. "Background, Status, and Issues Related to the Regulation of Advanced Spent Nuclear Fuel Recycle Facilities." US NRC Report NUREG-1909.
<http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1909/sr1909.pdf>.
Accessed 07/13/2015.

International Atomic Energy Agency. "Integrated Nuclear Fuel Cycle Information Systems." <https://infcis.iaea.org>. Accessed 06/08/2015.

Peltier, Robert. 2010. "US Spent Nuclear Fuel Policy: Road to Nowhere." Master Resource Blog. <http://www.masterresource.org/2010/07/spent-nuke-fuel-policy-5/>. Accessed 07/13/2015.

US Nuclear Regulatory Commission. 2009. "US Facilities Eligible for IAEA Safeguards." <http://pbadupws.nrc.gov/docs/ML1018/ML101870628.pdf>. Accessed 07/13/2015.

Zentner, M.D., G.L. Coles, and R.J. Talbert. 2005. "Nuclear Proliferation Technology Trends Analysis." Pacific Northwest National Laboratory. Report 14480.

6. Chemistry and Metallurgy Research (CMR) Facility at Los Alamos

- a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Reprocessing.

- b. *Facility size (laboratory, pilot, commercial).*

Laboratory.

- c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

The CMR facility was completed in 1952. The hot cells were placed in the facility in 1960 and the facility continues to operate.

Beginning in the 2000s, the United States proposed building a new plant – the Chemistry and Metallurgy Research Replacement (CMRR) facility – to replace the aging CMR plant. However, plans for building this facility have been put on hold.

- d. *Was the facility developed covertly? If so, identify years that facility was covert.*

Yes, it was likely covert from 1952 to 1976, following announcements of operations at Los Alamos.

- e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

This facility is part of the weapons complex and therefore probably does not appear on the US list of eligible plants per the VOA with the IAEA. The US excludes all plants located in areas with national security implications, such as the DOE national laboratories (see: <http://www.nrc.gov/about-nrc/ip/intl-safeguards.html>).

- f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

- g. *Did the facility have a military purpose?*

Given the time period and nature of Los Alamos, it is likely this was a military facility.

- h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

- i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No.

- j. *Sources:*

National Nuclear Security Administration. "CMR: Chemistry and Metallurgy Research Facility." Los Alamos National Laboratory.

<http://www.lanl.gov/about/assets/docs/fact-sheets/chemistry-and-metallurgy-research-factsheet.pdf>. Accessed 07/13/2015.

National Nuclear Security Administration. "TA-55 PF-4: LANL Plutonium-Processing Facilities." Los Alamos National Laboratory.
<http://www.lanl.gov/about/assets/docs/fact-sheets/ta-55-factsheet.pdf>. Accessed 07/13/2015.

Nuclear Threat Initiative. 2013. "US Nuclear Lab Ready to Shelve Costly Facility Plan."
<http://www.nti.org/gsn/article/us-nuclear-lab-ready-shelve-costly-facility-plan/>.

Stockton, Peter. 2012. "US Nuclear Weapons Complex: Energy Department Plans to Waste Billions of Dollars on Unneeded Los Alamos Lab Facility." Project on Government Oversight.
<http://www.pogo.org/our-work/reports/2012/nss-nwc-20120118-us-nuclear-weapons-complex.html>. Accessed 07/13/2015.

7. GE Morris

- a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Reprocessing.

- b. *Facility size (laboratory, pilot, commercial).*

Commercial.

- c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction began in 1967 when the facility was authorized. The INFCIS states that the facility operated in 1971 and was shut down in the same year.⁷ This facility was never operational.

- d. *Was the facility developed covertly? If so, identify years that facility was covert.*

No, the facility was developed by General Electric Company and was publicly announced.

- e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

No, the plant pre-dated the US VOA with the IAEA.

⁷ However, Andrews states the facility was not completed.

f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

g. *Did the facility have a military purpose?*

No, the facility is commercial.

h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No. The plant was privately owned and constructed with the support of the US government. The AEC authorized GE to build the plant in 1967.

j. *Sources:*

Andrews, Anthony. 2008. "Nuclear Fuel Reprocessing: US Policy Development." Congressional Research Service. RS22542. <http://www.fas.org/sgp/crs/nuke/RS22542.pdf>. Accessed 07/13/2015. 3.

International Atomic Energy Agency. "Integrated Nuclear Fuel Cycle Information Systems." <https://infcis.iaea.org>. Accessed 06/08/2015.

Peltier, Robert. 2010. "US Spent Nuclear Fuel Policy: Road to Nowhere." Master Resource Blog. <http://www.masterresource.org/2010/07/spent-nuke-fuel-policy-5/>. Accessed 07/13/2015.

US Nuclear Regulatory Commission. 2009. "US Facilities Eligible for IAEA Safeguards." <http://pbadupws.nrc.gov/docs/ML1018/ML101870628.pdf>. Accessed 07/13/2015.

8. Hanford B Plant I

a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Reprocessing (bismuth phosphate).

b. *Facility size (laboratory, pilot, commercial).*

Laboratory.

- c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction of the facility began in 1943.⁸ The facility operated from 1945 to 1952.⁹

- d. *Was the facility developed covertly? If so, identify years that facility was covert.*

Yes, the facility was part of the Manhattan Project. The facility remained covert until 1962 with the release of Hewlett and Anderson (1962), which used previously classified information to detail Manhattan Project programs.

- e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

No.

- f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

- g. *Did the facility have a military purpose?*

Yes, the facility was part of the nuclear weapons program.

- h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

- i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No. However, the Manhattan project did receive considerable assistance from international scientists residing in the US. The plant was based on Fermi's work and was built and operated by DuPont.

- j. *Sources:*

Global Security. "Hanford: Separation Plants."

⁸ Simmons (2000) lists construction beginning in 1943.

⁹ Zentner et al. (2005) list 1952 as the operational end date. Global Security states 1952 as the operational end date. The Department of Energy list 1957 as the end date of operations. The facility was later refurbished to reprocess radioactive material but not to reprocess plutonium. The Department of Ecology in the State of Washington lists 1943-1952 as the operational dates.

<http://www.globalsecurity.org/wmd/facility/hanford-plu.htm>. Accessed 07/13/2015.

Hewlett, Richard and Oscar E. Anderson, Jr. 1962. *The New World, 1939-1946: Volume I: A History of the United States Atomic Energy Commission*. University Park, PA: The Pennsylvania State University Press.

Simmons, F.M. 2000. "Remote Methodology Used at B Plant Hanford to Map High Radiation/Contamination Fields and Document Remaining Hazard." US Department of Energy. HNF-3938-FP. <http://www.osti.gov/bridge/servlets/purl/801106-7ritxp/webviewable/801106.pdf>. Accessed 07/13/2015.

Simpson, Michael and Jack D. Law. 2010. "Nuclear Fuel Reprocessing." Idaho National Laboratory. Report INL/EXT-10-17753. <http://www.inl.gov/technicalpublications/Documents/4460757.pdf>. Accessed 07/13/2015.

US Department of Energy. "B Plant." <http://www.hanford.gov/page.cfm/BPlant>. Accessed 07/13/2015.

US Department of Energy. 2001. "Historic American Engineering Record: B Reactor." Hanford Cultural and Historical Resources Program. http://www.b-reactor.org/HAER_WA-164_B-Reactor.pdf. Accessed 07/13/2015.

Washington State Department of Ecology. "B Plant Complex Closure Unit Group 24 (CUG-24)." http://www.ecy.wa.gov/Programs/NWP/Permitting/HDWP/CU/B_plant.html. Accessed 07/13/2015.

Zentner, M.D., G.L. Coles, and R.J. Talbert. 2005. "Nuclear Proliferation Technology Trends Analysis." Pacific Northwest National Laboratory. Report 14480.

9. Hanford Redox Facility (Plutonium Finishing Plant - Plant Z)

a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Reprocessing (Purex).

b. *Facility size (laboratory, pilot, commercial).*

Pilot.

c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction started in 1949.¹⁰ The facility operated from 1952¹¹ to 1967.¹² The facility used Purex in 1949 and REDOX in 1952 to 1967 in the same facility.

d. *Was the facility developed covertly? If so, identify years that facility was covert.*

It is difficult to identify when the facilities at Hanford became publicly known. The facility was part of the nuclear weapons complex and therefore was probably developed under secrecy.

e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

No.

f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

g. *Did the facility have a military purpose?*

Yes, the facility is part of the weapons complex.

h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No evidence of foreign nuclear assistance found.

j. *Sources:*

Gerber, M.D. and Fluor Daniel Hanford. 1997. "History and Stabilization of the Plutonium Finishing Plant (PFP) Complex, Hanford Site."

http://www.osti.gov/bridge/product.biblio.jsp?osti_id=325360. Accessed 07/13/2015.

¹⁰ Global Security lists 1949 as the start of construction.

¹¹ Zentner et al. state that 1949 was the start of construction while Kennedy and Harvey list 1949 as the completion date. The 1949 date is from the INFICS database. Global Security states the facility did not start operating until 1951. Zentner et al (2005, 88) list 1951. The US DOE states 1952.

¹² The facility closure date listed by Zentner et al. and the Hanford website provides 1967. The IAEA INFICS lists the closure date as 1956.

- Global Security. "Hanford Separation Facilities."
<http://www.globalsecurity.org/wmd/facility/hanford-plu.htm>. Accessed 07/13/2015.
- International Atomic Energy Agency. "Integrated Nuclear Fuel Cycle Information Systems." <https://infcis.iaea.org>. Accessed 06/08/2015.
- Kennedy, E.P. and D.W. Harvey. 2006. "Mitigation of Selected Hanford Site Manhattan Project and Cold War Era Artifacts." Pacific Northwest National Laboratory. http://www.pnl.gov/main/publications/external/technical_reports/pnnl-16056.pdf. Accessed 07/13/2015
- US Department of Energy. "Plutonium Finishing Plant."
<http://www.hanford.gov/page.cfm/PFP>. Accessed 07/13/2015.
- US Department of Energy. "Reduction-Oxidation Plant (Redox)."
<http://www.hanford.gov/page.cfm/REDOX>. Accessed 07/13/2015.
- Zentner, M.D., G.L. Coles, and R.J. Talbert. 2005. "Nuclear Proliferation Technology Trends Analysis." Pacific Northwest National Laboratory. Report 14480.

10. Hanford T Plant Complex (T 224 Facility)

- a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Reprocessing (bismuth-phosphate separation).

- b. *Facility size (laboratory, pilot, commercial)*

Commercial.

- c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction began in 1944 and it operated from 1945-1956. The facility was idle until 1975 when it was modified to serve as storage for plutonium-bearing scraps and liquids. It is not considered a reprocessing facility during the second period.

- d. *Was the facility developed covertly? If so, identify years that facility was covert.*

Yes, the facility was part of the Manhattan project and was covert while it operated during reprocessing efforts. The facility remained covert until 1962 with the release of Hewlett and Anderson (1962), which used previously classified information to detail Manhattan Project programs. Hewlett and Anderson describe the Hanford

facilities but do not detail T244 in particular. This omission is most likely due to the facility's limited importance during the Manhattan project.

- e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

No.

- f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

- g. *Did the facility have a military purpose?*

Yes, the facility produced the plutonium used in the Trinity test and the Nagasaki weapon.

- h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

- i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

The facility was indigenously developed. However, the Manhattan project did receive considerable assistance from international scientists residing in the US.

- j. *Sources:*

Harrison, John. 2008. "Hanford Nuclear Reservation." Northwest Power and Conservation Council. <http://www.nwcouncil.org/history/Hanford.asp>. Accessed 07/13/2015.

Hewlett, Richard and Oscar E. Anderson, Jr. 1962. *The New World, 1939-1946: Volume I: A History of the United States Atomic Energy Commission*. University Park, PA: The Pennsylvania State University Press.

International Atomic Energy Agency. "Integrated Nuclear Fuel Cycle Information Systems." <https://infcis.iaea.org>. Accessed 06/08/2015.

Kennedy, E.P. and D.W. Harvey. 2006. "Mitigation of Selected Hanford Site Manhattan Project and Cold War Era Artifacts." Pacific Northwest National Laboratory. http://www.pnl.gov/main/publications/external/technical_reports/pnnl-16056.pdf. Accessed 07/13/2015

US Department of Energy. "224-T Facility." <http://www.hanford.gov/page.cfm/224-T>. Accessed 07/13/2015.

Zentner, M.D., G.L. Coles, and R.J. Talbert. 2005. "Nuclear Proliferation Technology Trends Analysis." Pacific Northwest National Laboratory. Report 14480.

11. Hanford T Plant Complex (T-Plant)

- a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Reprocessing (bismuth-phosphate separation).

- b. *Facility size (laboratory, pilot, commercial).*

Commercial.

- c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction began in 1943¹³ and the facility operated from 1945¹⁴ to 1956.

- d. *Was the facility developed covertly? If so, identify years that facility was covert.*

Yes, the facility was part of the Manhattan project and was covert during the entire period. The facility remained covert until 1962 with the release of Hewlett and Anderson (1962), which used previously classified information to detail Manhattan Project programs. Hewlett and Anderson describe the Hanford facilities but do not detail individual facilities within the Hanford complex. They do discuss specifics of operations at the facility.

- e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

No.

- f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

- g. *Did the facility have a military purpose?*

¹³ Zentner et al. (2005) provide the construction start date. The IAEA date for closure is 1956. The 1952 ending date is from the PNNL report

¹⁴ The construction and operational dates are from DOE Hanford website. IAEA provide the closure date. The IAEA lists 1956 as the end of operation date.

Yes, the facility produced the plutonium used in the Trinity test and the Nagasaki weapon. The facility was designed to chemically separate plutonium from spent fuel rods. Today the facility processes and packages waste.

h. Was the facility multinational? If so, identify the other countries that were involved.

No.

i. Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.

The facility was indigenously developed. However, the Manhattan project did receive considerable assistance from international scientists residing in the US.

j. Sources:

Harrison, John. 2008. "Hanford Nuclear Reservation." Northwest Power and Conservation Council. <http://www.nwcouncil.org/history/Hanford.asp>. Accessed 07/13/2015.

Hewlett, Richard and Oscar E. Anderson, Jr. 1962. *The New World, 1939-1946: Volume I: A History of the United States Atomic Energy Commission*. University Park, PA: The Pennsylvania State University Press.

International Atomic Energy Agency. "Integrated Nuclear Fuel Cycle Information Systems." <https://infcis.iaea.org>. Accessed 06/08/2015.

Kennedy, E.P. and D.W. Harvey. 2006. "Mitigation of Selected Hanford Site Manhattan Project and Cold War Era Artifacts." Pacific Northwest National Laboratory. http://www.pnl.gov/main/publications/external/technical_reports/pnnl-16056.pdf. Accessed 07/13/2015

Zentner, M.D., G.L. Coles, and R.J. Talbert. 2005. "Nuclear Proliferation Technology Trends Analysis." Pacific Northwest National Laboratory. Report 14480.

US. Department of Energy. "T Plant." <http://www.hanford.gov/page.cfm/TPlant>. Accessed 07/13/2015.

12. Hanford-B Plant II (PUREX Plant)

a. ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).

Reprocessing (Purex).

- b. *Facility size (laboratory, pilot, commercial).*

Laboratory.

- c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction began in 1953 and the facility operated from 1956-1972 and 1983-1988.¹⁵ The facility was deactivated and restarted in 1983 before being shut down in 1988.

- d. *Was the facility developed covertly? If so, identify years that facility was covert.*

Yes, the specific operations at the Hanford site are difficult to separate based on when the facilities are publicly known. However, the nuclear weapons complex remained covert during the period.

- e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

No, given the national security implications of the Hanford site.

- f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

- g. *Did the facility have a military purpose?*

Yes, the facility is located within the military complex.

- h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

- i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No.

- j. *Sources:*

¹⁵ The operational dates are from INFCIS while Zentner et al. (2005) provide the construction start year. Zentner et al. also states the closure date of 1988 with deactivation activities ending in 1997. INFCIS says operation ended in 1989. PNL and Global Security state a final closure date of 1990.

International Atomic Energy Agency. "Integrated Nuclear Fuel Cycle Information Systems." <https://infcis.iaea.org>. Accessed 06/08/2015.

US Department of Energy. "Plutonium Uranium Extraction Plant (PUREX)." <http://www.hanford.gov/page.cfm/PUREX>.

Zentner, M.D., G.L. Coles, and R.J. Talbert. 2005. "Nuclear Proliferation Technology Trends Analysis." Pacific Northwest National Laboratory. Report 14480.

13. Knolls Atomic Power Laboratory

a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Reprocessing (PUREX).

b. *Facility size (laboratory, pilot, commercial).*

Laboratory.

c. *Is the facility under construction or in operation? List the start and end year for construction and operation.*

Construction of the facility began in 1950¹⁶ and was completed in 1950. The facility operated from 1950 to 1954 when the technology was moved to the Savannah River F Canyon facility.¹⁷

d. *Was the facility developed covertly? If so, identify years that facility was covert.*

Yes, the facility was covertly developed and operated.

e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

No, IAEA safeguards were not available during operation.

f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

g. *Did the facility have a military purpose?*

¹⁶ The construction date is based on information in Zentner et al. The experiments were utilizing equipment and technologies in the lab for a new technique. The buildings themselves were built in 1948.

¹⁷ Atomic Traveller claims the facility was placed on standby in 1953.

Yes, the facility was part of the weapons complex. The reprocessing work was moved to Savannah River F Canyon in 1954 after demonstration of the technology.

h. Was the facility multinational? If so, identify the other countries that were involved.

No.

i. Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.

No indication of foreign nuclear assistance. GE both built and operated the plant and the PUREX process was developed at the GE laboratory in the 1950's.

j. Sources:

Simpson, Michael and Jack D. Law. 2010. "Nuclear Fuel Reprocessing." Idaho National Laboratory. Report INL/EXT-10-17753.
<http://www.inl.gov/technicalpublications/Documents/4460757.pdf>. Accessed 07/13/2015.

Zentner, M.D., G.L. Coles, and R.J. Talbert. 2005. "Nuclear Proliferation Technology Trends Analysis." Pacific Northwest National Laboratory. Report 14480.

—. "Knolls Atomic Power Laboratory." Atomic Traveler.
<http://www.atomictraveler.com/knolls.pdf>. Accessed 11/15/2015.

14. Idaho Spent Fuel Reprocessing Facility

a. ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).

Reprocessing (Purex).¹⁸

b. Facility size (laboratory, pilot, commercial).

Commercial.

c. Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.

Construction of the facility began in 1950. The facility operated from 1959 to 1992.¹⁹

d. Was the facility developed covertly? If so, identify years that facility was covert.

¹⁸ Zentner et al. describe the activities as a modification to the Redox process.

¹⁹ The operational dates are from INFCIS and Zentner et al. support the closure dates. The construction date is from Pace, Braun, and Gilbert.

Yes, it is likely the facility was covertly developed. Westinghouse/Idaho Nuclear Company operated the facility.

- e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

The Idaho Spent Fuel facility is listed as an eligible facility for the application of safeguards by the IAEA.

- f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

- g. *Did the facility have a military purpose?*

Yes, the facility was part of the nuclear weapons complex.

- h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

- i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No. The plant was run through Idaho National Laboratory. The Bechtel Corporation was the construction contractor and the American Cyanamid Company was the operating contractor. Phillips Petroleum took over as the operating contractor in 1953. Scientists from ORNL designed much of the equipment at the plant.

- j. *Sources:*

International Atomic Energy Agency. "Integrated Nuclear Fuel Cycle Information Systems." <https://infcis.iaea.org>. Accessed 06/08/2015.

Paul Menser. "Cleaning House and Charting a Future at INL." *Post Register*. <http://www.postregister.com/articles/2013/08/27/site-impact>. Accessed 07/13/2015.

Pace, Brenda, Julie Braun, and Hollie Gilbert. 2006. "Idaho National Laboratory Fuel Reprocessing Complex Historic American Engineering Record Report-ID-3-H." <http://www.inl.gov/technicalpublications/Documents/4460713.pdf>. Accessed 07/13/2015. 20.

Todd, Terry. 2008. "Spent Fuel Reprocessing." Idaho National Laboratory.

http://www.ne.doe.gov/pdfFiles/NRCseminarreprocessing_Terry_Todd.pdf.
Accessed 07/13/2015.

US Nuclear Regulatory Commission. 2014. "Idaho National Laboratory Disposal Facility for Waste Incidental to Reprocessing." <http://www.nrc.gov/waste/incidental-waste/wir-process/wir-locations/wir-inl.html#history>. Accessed 07/13/2015.

US Nuclear Regulatory Commission. 2009. "US Facilities Eligible for IAEA Safeguards." <http://pbadupws.nrc.gov/docs/ML1018/ML101870628.pdf>. Accessed 07/13/2015.

15. Isotope Technologies

- a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Enrichment, laser (CRILSA).

- b. *Facility size (laboratory, pilot, commercial).*

Laboratory.

- c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

The company started to develop the technology in August 1990.²⁰ Eventually, the company partnered with Cameco and the work was transferred in 1990 to Canada. The Canadian entry accounts for the work done from 1990 to 1993.

- d. *Was the facility developed covertly? If so, identify years that facility was covert.*

No, public announcements concerning the company's progress were made throughout the development process.

- e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

We were unable to verify whether this facility appeared on the list of eligible plants per the US VOA with the IAEA.

- f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

²⁰ Eerkins patented the technology in the late 1970s.

g. *Did the facility have a military purpose?*

No, a commercial company hoping to draw investment for laser technology developed the facility.

h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No. This was originally a US-based technology patented by Dr. Jeff Eerkins. In 1990 it became a joint venture with Cameco. In 1990 the equipment was transferred to Canada. Within the US though, it appears this was an indigenous facility.

j. *Sources:*

Knapik, Michael and Eric Lindeman. 1990. "Isotope Technologies Soon to Announce Partners in CRISLA Enrichment Project." *Nuclear Fuel*. 15(16): 1.

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—. 1990. "Change—A Watchword for the Nuclear Fuel Cycle Industry in the '90s." *Nuclear Fuel* 15(7): 7.

—. 1990. "Cameco, Argra to 'Rebirth' CRISLA Process in Saskatoon." *Nuclear Fuel* 15(18): 2.

16. Lawrence Livermore ALVIS Laboratory

a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Enrichment, laser (AVLIS).

b. *Facility size (laboratory, pilot, commercial).*

Laboratory.

c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction of the facility began in 1984 and the facility operated from 1991 to 1999.²¹

d. *Was the facility developed covertly? If so, identify years that facility was covert.*

No, despite being part of the nuclear weapons complex the experiments were widely known by the public. Several news articles were found detailing the experiments from the program's inception.

e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

No, given the national security implications of the Livermore site.

f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

g. *Did the facility have a military purpose?*

The laboratory has stated that the research on laser enrichment was intended to provide US Enrichment Corp. (USEC) with a commercially viable laser enrichment option.

h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No evidence of foreign assistance found. The AVLIS technology is run through the US Enrichment Corporation.

j. *Sources:*

Dizard III, Wilson. 1997. "Lawmakers Press for USEC Sale; ALVIS, SILEX Project Proceed." *Nuclear Fuel*. 22(12): 3.

International Atomic Energy Agency. "Integrated Nuclear Fuel Cycle Information Systems." <https://infcis.iaea.org>. Accessed 06/08/2015.

Knapik, Michael. 1983. "House Panel Moves to Slow GCEP in Favor of Advanced

²¹ The construction date is from Zentner et al., which list dates of the research program. Exact identification of when the laboratory where the experiments were conducted was not identified. The operational dates are from INFCIS.

Technologies. *Nuclear Fuel*. 8(7): 6.

Thurston, Charles. 1985. "AVLIS Program to Gear Up to Full-Scale 1-Million SWU/YR by 1988." *Nuclear Fuel*. 10(15): 3.

US Department of Energy. "AVLIS Team Puts Enrichment Technology Through its Paces." Lawrence Livermore National Laboratory. <https://www.llnl.gov/str/News1296.html>. Accessed 07/13/2015.

US Department of Energy. "Laser Technology Follows in Lawrence's Footsteps." Lawrence Livermore National Laboratory. <https://str.llnl.gov/str/Hargrove.html>. Accessed 07/13/2015.

Zentner, M.D., G.L. Coles, and R.J. Talbert. 2005. "Nuclear Proliferation Technology Trends Analysis." Pacific Northwest National Laboratory. Report 14480.

17. Los Alamos Laboratory Laser Enrichment Facility

a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Enrichment, laser (MLIS).

b. *Facility size (laboratory, pilot, commercial).*

Laboratory.

c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction of the facility began around 1970.²² The facility first produced measureable quantities of enriched uranium in 1971. The facility was phased out in 1981 when AVLIS showed more promise. It is coded as officially ending in 1982 based on Serrato.

d. *Was the facility developed covertly? If so, identify years that facility was covert.*

Yes, Casper states that the experiments at all three national labs involving laser technology were conducted in secret. The facility can be considered covert from 1971 to 1976 as experiments were made public in 1976. For example, C. Paul Robinson

²² The 1970 date is an estimate based on when an international conference occurred that spurred US investment in laser technology. In 1969, the idea of laser enrichment spread from Israel and France to the US where both private and government organizations initiated research programs. Zentner et al. state that laser enrichment first occurred in the US at Los Alamos Laboratory.

and Reed J. Jensen delivered presentations on their experiments at the American Physical Society meeting in February 1976.

- e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

We do not consider this plant to be eligible for safeguards given the national security implications of Los Alamos.

- f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

- g. *Did the facility have a military purpose?*

The technology appears to have been developed primarily for commercial purposes. All ENR technologies, however, have dual-use applications and could be used to produce fissile material for bombs. We code this plant as “civilian” given the apparent motives for developing the technology.

- h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

- i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No evidence of foreign assistance found. It was Los Alamos scientists who conceived of MLIS in 1971, so it is unlikely assistance was found externally.

- j. *Sources:*

Casper, Barry M. 1977. “Laser Enrichment: A New Path to Proliferation?” *Bulletin of the Atomic Scientists*. 33(1): 28-41.

Global Security. “Laser Isotope Separation Uranium Enrichment.”
<http://www.globalsecurity.org/wmd/intro/u-laser.htm>. Accessed 07/13/2015.

Kok, Kenneth D. Editor. 2009. *Nuclear Engineering Handbook*. Boca Raton, FL: Taylor & Francis Group. 276.

Serrato, Ruben M. 2010. “Laser Isotope Separation and the Future of Nuclear Proliferation.”

US Nuclear Regulatory Commission. 2009. "US Facilities Eligible for IAEA Safeguards." <http://pbadupws.nrc.gov/docs/ML1018/ML101870628.pdf>. Accessed 07/13/2015.

Zentner, M.D., G.L. Coles, and R.J. Talbert. 2005. "Nuclear Proliferation Technology Trends Analysis." Pacific Northwest National Laboratory. Report 14480.

18. Los Alamos Plutonium Facility (TA-55)

a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Reprocessing.

b. *Facility size (laboratory, pilot, commercial).*

Commercial.

c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction began in 1973. The facility has operated continuously since April 1978.

d. *Was the facility developed covertly? If so, identify years that facility was covert.*

No.

e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

We do not consider this plant to be eligible for safeguards given the national security implications of Los Alamos.

f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

g. *Did the facility have a military purpose?*

The facility serves a wide range of national security-related objectives.

h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

- i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

We found no evidence of foreign assistance.

- j. *Sources:*

International Atomic Energy Agency. "Integrated Nuclear Fuel Cycle Information Systems." <https://infcis.iaea.org>. Accessed 06/08/2015.

National Nuclear Security Administration. "TA-55 PF-4: LANL Plutonium-Processing Facilities." Los Alamos National Laboratory. http://www.lanl.gov/about/_assets/docs/fact-sheets/ta-55-factsheet.pdf. Accessed 07/13/2015.

National Nuclear Security Administration. "Los Alamos National Laboratory." Surplus Plutonium Disposition Supplemental Environmental Impact Statement. <http://nnsa.energy.gov/sites/default/files/nnsa/01-12-inlinefiles/LANL%20Factsheet%20Draft%209.pdf>. Accessed 12/01/2015.

Nuclear Threat Initiative. 2012. "Budget Forced Delay of Los Alamos Plutonium Lab: DOE Secretary." www.nti.org/gsn/article/budget-forced-delay-los-alamos-plutonium-lab-doe-chief/. Accessed 07/13/2015.

19. Oak Ridge Demonstration Facility (Manufacturing Demonstration Facility)

- a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Reprocessing (Purex).

- b. *Facility size (laboratory, pilot, commercial).*

Pilot.

- c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction of the facility is estimated to have started in 1949.²³ The facility operated from 1950 to 1953.²⁴

²³ The estimated construction date is based on when the PUREX process was first discovered in 1949. Work developing the technology occurred at ORNL and Knolls Atomic Laboratory prior to the plutonium production facility in Savannah River becoming operational.

²⁴ The operational dates are provided by Zentner et al. (2005).

d. *Was the facility developed covertly? If so, identify years that facility was covert.*

Yes, the facility was part of the weapons complex and is considered covert.

e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

No.

f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

g. *Did the facility have a military purpose?*

Yes, the facility was part of the weapons complex. It was designed to produce plutonium for bombs.

h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

We found no evidence of foreign assistance.

j. *Sources:*

Jubin, Robert. "Spent Fuel Reprocessing." Oak Ridge National Laboratory.

http://www.cresp.org/NuclearChemCourse/monographs/07_Jubin_Introduction%20to%20Nuclear%20Fuel%20Cycle%20Separations%20-%20Final%20rev%202_3_2_09.pdf. Accessed 07/13/2015.

Zentner, M.D., G.L. Coles, and R.J. Talbert. 2005. "Nuclear Proliferation Technology Trends Analysis." Pacific Northwest National Laboratory. Report 14480.

20. Oak Ridge K-25 Plant

a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Enrichment, gaseous diffusion.

b. *Facility size (laboratory, pilot, commercial).*

Commercial.²⁵

- c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction started in 1943.²⁶ The facility operated from 1945 to 1985.²⁷

- d. *Was the facility developed covertly? If so, identify years that facility was covert.*

Yes, the facility was part of the Manhattan project. The facility remained covert until 1962 with the release of Hewlett and Anderson (1962), which used previously classified information to detail Manhattan Project programs. The authors provide detailed description of K-25 complex.

- e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

No, the facility is not eligible for safeguards.

- f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

- g. *Did the facility have a military purpose?*

Yes, the facility was designed to produce HEU and LEU as stock feed for other enrichment facilities at Oak Ridge. Small quantities of enriched uranium were available as of 1945 but significant quantities of HEU were not produced until 1947.

- h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

- i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No. The facility was designed and built by the Kellex Corporation.

- j. *Sources:*

²⁵ There were up to six buildings built in the K-25 complex.

²⁶ Zentner et al. state 1943 as the construction date.

²⁷ The 1985 end of operation is from the IAEA INFCIS. The *Oak Ridge Today* newspaper states the facility was completely closed by 1987. The 1987 date probably refers to the complete closure of the facility compared to the end of operation. K-25 was originally taken out of service in 1964 but the two southern units on the East Wing were used until 1984 (DOE 2010).

Atomic Heritage Foundation. "K-25 Plant." Manhattan Project Heritage Preservation Association Inc. <http://www.mphpa.org/classic/HISTORY/H-06b3.htm>.

Atomic Heritage Foundation. "Oak Ridge, TN." <http://www.atomicheritage.org/location/oak-ridge-tn>. Accessed 07/13/2015.

Hewlett, Richard and Oscar E. Anderson, Jr. 1962. *The New World, 1939-1946: Volume I: A History of the United States Atomic Energy Commission*. University Park, PA: The Pennsylvania State University Press.

Huotari, John. 2012. "Community Celebrates K-25 Historic Preservation Agreement." *Oak Ridge Today*. <http://oakridgetoday.com/2012/08/10/community-celebrates-k-25-historic-preservation-agreement/>. Accessed 07/13/2015.

International Atomic Energy Agency. "Integrated Nuclear Fuel Cycle Information Systems." <https://infcis.iaea.org>. Accessed 06/08/2015.

National Park Service. 2012. "Secretary of the Interior Report to The Advisory Council on the Historic Perseveration." http://www.nps.gov/nr/publications/guidance/K25_Section_213_Final_Report_3_23_12.pdf.

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US Department of Energy. 2010. "K-25, K-1065, and K-1313-F Building Tour." <http://www.oakridge.doe.gov/External/LinkClick.aspx?fileticket=EXZs7BHzLys%3D&tabid=644&mid=1848>. Accessed 07/13/2015.

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—. "Manhattan Project Signature Facilities: K-25 Gaseous Diffusion Processing Building." Atomic Archive. http://www.atomicarchive.com/History/sites/K_25.shtml. Accessed 07/13/2015.

21. Oak Ridge K-27 Plant

a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Enrichment, gaseous diffusion.

b. *Facility size (laboratory, pilot, commercial).*

Commercial.

c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction started in 1945 (Hewlett and Anderson 1962).²⁸ The facility operated from 1945 to 1964, following a Presidential order to shut down the facility.

d. *Was the facility developed covertly? If so, identify years that facility was covert.*

Yes, the facility was part of the Manhattan project. The facility remained covert until 1962 with the release of Hewlett and Anderson (1962), which used previously classified information to detail Manhattan Project programs. They provide details on K-27

e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

No, the facility was not under IAEA safeguards as it is not eligible for safeguards.

f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

g. *Did the facility have a military purpose?*

Yes, the facility was designed to produce HEU and LEU as stock feed for other enrichment facilities at Oak Ridge. Small quantities of enriched uranium were available as of 1945 but significant quantities of HEU were not produced until 1947.

h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No. The facility was designed and built by the Kellex Corporation, a domestic company.

²⁸ Zentner states 1943 as the construction date. Hewlett and Anderson state March 31, 1945 as the day Groves gave the order to start construction.

j. Sources:

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- Oak Ridge National Laboratory. 2002. "Chapter 1: Wartime Laboratory." *Review*. 25(3/4). <http://web.ornl.gov/info/ornlreview/rev25-34/chapter1.shtml>. Accessed 07/13/2015.
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- Zentner, M.D., G.L. Coles, and R.J. Talbert. 2005. "Nuclear Proliferation Technology Trends Analysis." Pacific Northwest National Laboratory. Report 14480.
- . "Manhattan Project Signature Facilities: K-25 Gaseous Diffusion Processing Building." Atomic Archive. http://www.atomicarchive.com/History/sites/K_25.shtml. Accessed 07/13/2015.
- . "K-27 Building D&D Project." DOE Oak Ridge Environmental Management Program. <http://www.oakridge.doe.gov/External/LinkClick.aspx?fileticket=bybEsVfkaDY%3D&tabid=658&mid=1846>. Accessed 11/16/2015.

22. Oak Ridge K-29 Plant

- a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Enrichment, gaseous diffusion.

- b. *Facility size (laboratory, pilot, commercial).*

Commercial.

- c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction start year could not be identified. The facility operated from 1951 to 1985 when all diffusion activity ceased.

- d. *Was the facility developed covertly? If so, identify years that facility was covert.*

Yes, the facility became publicly available in 1985 as no additional information suggesting an earlier release of information date was found.

- e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

No, the facility was not under IAEA safeguards as it is not eligible for safeguards.

- f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

- g. *Did the facility have a military purpose?*

Yes, the facility was designed to produce HEU and LEU as stock feed for other enrichment facilities at Oak Ridge. Small quantities of enriched uranium were available as of 1945 but significant quantities of HEU were not produced until 1947.

- h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

- i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No. The facility was designed and built by the Kellex Corporation.

j. Sources:

Atomic Heritage Foundation. "K-25 Plant." Manhattan Project Heritage Preservation Association Inc. <http://www.mphpa.org/classic/HISTORY/H-06b3.htm>.

Atomic Heritage Foundation. "Oak Ridge, TN." <http://www.atomicheritage.org/location/oak-ridge-tn>. Accessed 07/13/2015.

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US Department of Energy. 2010. "K-25, K-1065, and K-1313-F Building Tour." <http://www.oakridge.doe.gov/External/LinkClick.aspx?fileticket=EXZs7BHzLys%3D&tabid=644&mid=1848>. Accessed 07/13/2015.

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23. Oak Ridge K-31 Plant

a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Enrichment, gaseous diffusion.

b. *Facility size (laboratory, pilot, commercial).*

Commercial.

c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction took place in 1952. It was operational from 1952 to 1985 when all diffusion activity ceased (National Park Service).

d. *Was the facility developed covertly? If so, identify years that facility was covert.*

Yes, the facility is coded as coming into the public knowledge in 1985 as no additional information suggesting an earlier release of information date was found.

e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

No, the facility was not under IAEA safeguards as it is not eligible for safeguards.

f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

g. *Did the facility have a military purpose?*

Yes, the facility was designed to produce HEU and LEU as stock feed for other enrichment facilities at Oak Ridge. Small quantities of enriched uranium were available as of 1945 but significant quantities of HEU were not produced until 1947.

h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No. The facility was designed and built by the Kellex Corporation.

j. *Sources:*

Atomic Heritage Foundation. "K-25 Plant." Manhattan Project Heritage Preservation Association Inc. <http://www.mphpa.org/classic/HISTORY/H-06b3.htm>.

Atomic Heritage Foundation. "Oak Ridge, TN." <http://www.atomicheritage.org/location/oak-ridge-tn>. Accessed 07/13/2015.

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Huotari, John. 2012. "Community Celebrates K-25 Historic Preservation Agreement." *Oak Ridge Today*. <http://oakridgetoday.com/2012/08/10/community-celebrates-k-25-historic-preservation-agreement/>. Accessed 07/13/2015.

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National Park Service. 2012. "Secretary of the Interior Report to The Advisory Council on the Historic Perseveration." http://www.nps.gov/nr/publications/guidance/K25_Section_213_Final_Report_3_23_12.pdf.

Oak Ridge National Laboratory. 2002. "Chapter 1: Wartime Laboratory." *Review*. 25(3/4). <http://web.ornl.gov/info/ornlreview/rev25-34/chapter1.shtml>. Accessed 07/13/2015.

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24. Oak Ridge K-33 Plant

- a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Enrichment, gaseous diffusion.

- b. *Facility size (laboratory, pilot, commercial).*

Commercial.

- c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction occurred in 1954. The facility operated from 1954 to 1985 when all diffusion activity ceased (National Park Service).

- d. *Was the facility developed covertly? If so, identify years that facility was covert.*

Yes, the facility became public knowledge in 1985 as no additional information suggesting an earlier release of information date was found.

- e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

No, the facility was not under IAEA safeguards as it is not eligible for safeguards.

- f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

- g. *Did the facility have a military purpose?*

Yes, the facility was designed to produce HEU and LEU as stock feed for other enrichment facilities at Oak Ridge. Small quantities of enriched uranium were available as of 1945 but significant quantities of HEU were not produced until 1947.

- h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

- i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No. The facility was designed and built by the Kellex Corporation.

- j. *Sources:*

Atomic Heritage Foundation. "K-25 Plant." Manhattan Project Heritage Preservation Association Inc. <http://www.mphpa.org/classic/HISTORY/H-06b3.htm>.

Atomic Heritage Foundation. "Oak Ridge, TN." <http://www.atomicheritage.org/location/oak-ridge-tn>. Accessed 07/13/2015.

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International Atomic Energy Agency. "Integrated Nuclear Fuel Cycle Information Systems." <https://infcis.iaea.org>. Accessed 06/08/2015.

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25. Oak Ridge Thorex Reprocessing

- a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Reprocessing (Thorex).

- b. *Facility size (laboratory, pilot, commercial).*

Pilot.

- c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction started in approximately 1950.²⁹ The facility operated from 1954 to 1958.³⁰

- d. *Was the facility developed covertly? If so, identify years that facility was covert.*

Yes, identification of specific facilities at Oak Ridge is difficult but no evidence was found suggesting there were public announcements, nor that the general public had access to information on the facility.

- e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

No, the facility was not eligible for safeguards.

- f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

- g. *Did the facility have a military purpose?*

Yes, the facility was part of the US nuclear weapons program and was used for reprocessing thorium.

- h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

- i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

²⁹ Yarbrow (1957) does not list a construction start date. Rather, the book provides the technical capabilities of the facility in detail. The 1950 date is the year that the thorium based reactor came online at Oak Ridge and is used as the start year.

³⁰ The operational dates are from Zentner et al. (2005).

No evidence of foreign assistance was found.

j. Sources:

Oak Ridge National Laboratory. 2002. "Chapter. 4: Olympian Feats." *Review*. 25(3/4). <http://web.ornl.gov/info/ornlreview/rev25-34/chapter4.shtml>. Accessed 03/17/2015.

Sailing, James, Y.S. Tang, and Audeen W. Fentiman. 2001. *Radioactive Waste Management*. 3rd Edition. CRC Press. 111.

Yarbro, O.O. 1957. "A Criticality Study of the Thorex Pilot Plant." Oak Ridge National Laboratory. Report ORNL-2332.

Zentner, M.D., G.L. Coles, and R.J. Talbert. 2005. "Nuclear Proliferation Technology Trends Analysis." Pacific Northwest National Laboratory. Report 14480. 105.

26. Oak Ridge X-10 (Clinton Laboratories)

a. ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).

Reprocessing (bismuth-phosphate process). The facility included the reactor, chemical separation and support facilities.

b. Facility size (laboratory, pilot, commercial).

Laboratory.

c. Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.

Construction of the facility began in 1943.³¹ The facility began operations in 1943 and ended in 1945.

d. Was the facility developed covertly? If so, identify years that facility was covert.

Yes, the facility was part of the Manhattan project. The facility remained covert until 1962 with the release of Hewlett and Anderson (1962), which used previously classified information to detail Manhattan Project programs.

e. Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.

³¹ The construction start date is from the Manhattan Project Heritage Preservation Association website. The end of reprocessing operations in 1945 is from Zentner (2005).

No.

- f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

- g. *Did the facility have a military purpose?*

Yes, the facility was a laboratory reprocessing facility for the Manhattan project. The facility only produced 326.4 grams of plutonium.

- h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

- i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No. The construction was initiated by DuPont.

- j. *Sources:*

Hewlett, Richard and Oscar E. Anderson, Jr. 1962. *The New World, 1939-1946: Volume I: A History of the United States Atomic Energy Commission*. University Park, PA: The Pennsylvania State University Press.

Atomic Heritage Foundation. "Clinton Engineer Works (Oak Ridge) X-10 Graphite Reactor." Manhattan Project Preservation Association, Inc. <http://www.mphpa.org/classic/HISTORY/H-06b4.htm>. Accessed 07/13/2015.

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Zentner, M.D., G.L. Coles, and R.J. Talbert. 2005. "Nuclear Proliferation Technology Trends Analysis." Pacific Northwest National Laboratory. Report 14480.

27. Oak Ridge Y-12 Plant

- a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Enrichment, EMIS.

- b. *Facility size (laboratory, pilot, commercial).*

Commercial.

- c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction of the facility began in February 1943. The facility started operations in November of 1943 and ended in September 1945,³² with the exception of Building 9731 and Beta 3. The DOE states 1946 as the end of enrichment operations. 1946 is the end of operations date used.

- d. *Was the facility developed covertly? If so, identify years that facility was covert.*

Yes, the facility was covert during the entire war period from early work at the facility. The facility remained covert until 1962 with the release of Hewlett and Anderson (1962), which used previously classified information to detail Manhattan Project programs.³³

- e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

No, the facility was not eligible for IAEA safeguards nor was it placed on the eligibility list.

- f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

- g. *Did the facility have a military purpose?*

Yes, the facility was the source of enriched uranium for the Manhattan project. HEU for the uranium bomb, Little Boy, was produced at this facility.

- h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

³² The initial Alpha calutrons were taken off line on September 4, 1945. K25 and S50 were producing higher levels of enriched uranium so the Army opted to pursue those facilities. Additionally the draw down after the war significantly decreased the workforce at Y-12. (DOE). The IAEA uses 1986 as the end of operation, but that is probably due to some other usage of the building not related to enrichment.

³³ DOE provide 1949 as the year the "Secret City's" gates were opened:
<http://www.y12.doe.gov/about/history/highlights.php>.

- i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No. The electromagnetic method for separating uranium was developed at UC Berkeley. Stone & Webster were in charge of design and construction for the facility. Experimental data was used from Lawrence's laboratory and the Tennessee Eastman Company was the plant operator. Westinghouse, Allis-Chalmers, and Chapman Valves provided equipment for the plant, and GE provided electrical equipment.

- j. *Sources:*

Atomic Heritage Foundation. "Oak Ridge, TN."

<http://www.atomicheritage.org/location/oak-ridge-tn>. Accessed 07/13/2015.

Consolidated Nuclear Security, LLC. "More Radical Changes at Y-12." National Security Complex. <http://www.y12.doe.gov/library/pdf/about/history/08-04-03.pdf>.

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28. Paducah Gaseous Diffusion

- a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Enrichment, gaseous diffusion.

- b. *Facility size (laboratory, pilot, commercial).*

Commercial.

- c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction began in 1950.³⁴ The facility began operation in 1952.³⁵ The electricity contract for the plant expired in May 2012³⁶ and the facility shutdown in 2013. The facility is coded as continuing for the current edition through 2012. Laughter lists the facility as still operating.

- d. *Was the facility developed covertly? If so, identify years that facility was covert.*

The facility was probably not covertly developed. Martin Marietta Energy Systems operated the plant from 1984 to 1995, when Martin Marietta merged with Lockheed.

- e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

Yes, the facility is eligible for voluntary safeguards. It appears on the November 2009 list of eligible facilities per the US VOA with the IAEA (see: <http://pbadupws.nrc.gov/docs/ML1018/ML101870628.pdf>).

- f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

- g. *Did the facility have a military purpose?*

Yes, the facility initially produced commercial fuel and material for the nuclear weapons program. The focus on commercial enrichment occurred in the mid-1960. From the mid-1960s the facility produced fuel for commercial reactors and navy ships. By the 1990s, the plant was primarily enriching for commercial reactors.

- h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

- i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No. The plant opened in 1954 and was operated by the USAEC. The plant is still owned by the Energy Department and is the only American-owned uranium enrichment facility in the US.

³⁴ Zentner et al. list the construction date as 1950.

³⁵ USEC states that the first production cells went online in 1952 and this is used as the start of operations. INFCIS states 1954 as the date when construction was completed finished.

³⁶ The start operation dates are from Zentner et al. Conley (2012) discusses the continued operation of the facility.

j. Sources:

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29. Philadelphia Navy Yard

- a. ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Enrichment, liquid thermal diffusion.

- b. Facility size (laboratory, pilot, commercial).*

Laboratory (100 column).

- c. Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction began in 1943. If the facility actually operated it was shut down in 1944 to focus on the construction of the S-50 plant at Oak Ridge. (This facility was

completely closed by 1945 because the enrichment equipment had already been shipped to Oak Ridge). The facility was operated by the Union Carbide Company.

d. *Was the facility developed covertly? If so, identify years that facility was covert.*

Yes, the Navy funded original experimental research, outside the Army's budget for the Manhattan Project. The facility and operation of Abelson's equipment were considered top secret during the operational period. The facility remained covert until 1962 with the release of Hewlett and Anderson (1962), which used previously classified information to detail Manhattan Project programs. Hewlett and Anderson detail Oppenheimer's reception of thermal diffusion results from the lab.

e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

No, the facility was not eligible for IAEA safeguards.

f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

g. *Did the facility have a military purpose?*

Yes, the facility was developed to provide enriched feedstock for the other two enrichment facilities at Oak Ridge. The technology was originally not pursued due to perceptions of the feasibility of EMIS and diffusion. However, Abelson's 1944 experiments success at the Philadelphia Navy Yard prompted inclusion of the technology at Oak Ridge.

h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No.

j. *Sources:*

Atomic Heritage Foundation. "S-50 Plant." The Manhattan Project Heritage Preservation Association Inc. <http://www.mphpa.org/classic/HISTORY/H-06b5.htm>. Accessed 07/13/2015.

Gosling, F.G. 1999. "The Manhattan Project: Making the Bomb." US Department of Energy.

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http://www.osti.gov/manhattan-project-history/Events/1942-1944_ur/navy_ltd.htm. Accessed 07/13/2015.

30. Portsmouth Gas Centrifuge Facility, Piketon Ohio

a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Enrichment, centrifuge.

b. *Facility size (laboratory, pilot, commercial).*

Commercial.

c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction started in the early 1980s but was not completed. The project was terminated in 1985.³⁷

d. *Was the facility developed covertly? If so, identify years that facility was covert.*

No, the facility was not developed covertly.

e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

Yes, the facility was listed on the voluntary list in 1983. Inspections occurred between 1983 and 1985. In July 1985 the DOE terminated the gas centrifuge project and the location was removed from the eligibility list.

³⁷ The construction dates are from the DOE website on the facility. Global Security states the facility may have started construction in 1977. 1980 is used as the construction start year.

f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

g. *Did the facility have a military purpose?*

No.

h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No.

j. Sources:

Global Security. "Portsmouth Gaseous Diffusion Plant (Centrifuge Discussion)." http://www.globalsecurity.org/wmd/facility/portsmouth_oh.htm. Accessed 07/13/2015.

International Atomic Energy Agency. "Integrated Nuclear Fuel Cycle Information Systems." <https://infcis.iaea.org>. Accessed 06/08/2015.

US Department of Energy. "Gas Centrifuge Enrichment Plant." http://www.pppo.energy.gov/Gas_Centrifuge_Enrichment_Plant.html.

US Department of State. 1977/1980. "Agreement Between The United States of America and The International Atomic Energy Agency for the Application of Safeguards in the United States (and Protocol Thereto)." Bureau of International Security and Nonproliferation. <http://www.state.gov/t/isn/5209.htm>. Accessed 07/13/2015.

Waters, Dean. 2003. "The American Gas Centrifuge Past, Present, and Future." SPLG Workshop. <http://www.osti.gov/energycitations/servlets/purl/912770-dBuasR/912770.PDF>. Accessed 07/13/2015.

Zentner, M.D., G.L. Coles, and R.J. Talbert. 2005. "Nuclear Proliferation Technology Trends Analysis." Pacific Northwest National Laboratory. Report 14480. 32.

31. Portsmouth Diffusion Plant (A-Plant)

- a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Enrichment, diffusion.

- b. *Facility size (laboratory, pilot, commercial).*

Commercial.

- c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction started in 1952. The facility operated from 1956³⁸ to 2001.

- d. *Was the facility developed covertly? If so, identify years that facility was covert.*

The facility was built using Peter Kiewitt Sons of Nebraska as the primary contractor. It is possible that the facility was covertly developed and operated between around 1952 and around 1965. DOE sources provide information that was publicly available during this time.

- e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

The facility was included on the US list of eligible facilities per the VOA with the IAEA beginning in 1996, after the plant transitioned to civilian applications.

- f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

- g. *Did the facility have a military purpose?*

Yes, the facility was initially part of the weapons complex. There is disagreement about when the facility switched from military to civilian purposes. Zentner et al. (2005) state the 1960's as when the switch occurred. The DOE (2001, 50) states 1991 as end of HEU production. HEU can be produced for non-weapon purposes. However, the US was also phasing out HEU based research reactors.

- h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

³⁸ The USEC lists 1956 as the construction completion date as the entire complex was completed at that time. However, USEC also lists 1954 as the first production cells going online. Since Zentner et al and IAEA list 1956, this is taken as the start of operations.

- i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No. The plant was constructed by the USAEC. Construction began in 1952 through the construction contractor of Peter Kiewit Sons of Nebraska.

- j. *Sources:*

Centrus. "Portsmouth Gaseous Diffusion Plant." <http://www.usec.com/gaseous-diffusion/portsmouth-gdp>. Accessed 07/13/2015.

Global Security. "Portsmouth Gaseous Diffusion Plant." http://www.globalsecurity.org/wmd/facility/portsmouth_oh.htm. Accessed 07/13/2015.

Gordon, DM, et. al. 1998. "IAEA Verification Experiment at the Portsmouth Gaseous Diffusion Plant." Paper presented at the annual meeting of the Institute for Nuclear Materials Management. https://inis.iaea.org/search/search.aspx?orig_q=RN:29064168.

Portsmouth Gaseous Diffusion Plant. "Virtual Museum." <http://www.portsvirtualmuseum.org/history-uranium-enrichment.htm>

US Department of Energy. "Portsmouth Plant History." http://www.pppo.energy.gov/port_history.html. Accessed 07/13/2015.

US Department of Energy. 2001. *Highly Enriched Uranium: Striking A Balance: A Historical Report on the United States Highly Enriched Uranium Production, Acquisition, and Utilization Activities from 1945 Through September 30, 1996*. National Nuclear Security Administration, Office of the Deputy Administrator for Defense Programs. <http://fissilematerials.org/library/doe01.pdf>. Accessed 07/23/2015.

Zentner, M.D., G.L. Coles, and R.J. Talbert. 2005. "Nuclear Proliferation Technology Trends Analysis." Pacific Northwest National Laboratory. Report 14480.

32. Savannah River F Canyon

- a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Reprocessing (Purex).

- b. *Facility size (laboratory, pilot, commercial).*

Commercial.

- c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction began in 1950.³⁹ The facility began operation in 1954 and was temporarily suspended from 1992 to 1995. The facility continued to operate after 1995. The F Canyon and FB line completed stabilization operations until 2004 and the FB line processed legacy nuclear material. The facility is considered closed as of 2004.⁴⁰

- d. *Was the facility developed covertly? If so, identify years that facility was covert.*

It seems likely, but we do not have clear evidence one way or the other. We code it as covert based on circumstantial evidence.

- e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

This plant was not eligible for safeguards given the national security implications of the Savannah River site.

- f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

- g. *Did the facility have a military purpose?*

Yes, the facility was part of the weapons complex, though commercial reprocessing could also have been performed.

- h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

- i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No. The DuPont Company was selected to build the facility given their experience with the Hanford site in Washington State.

- j. *Sources:*

³⁹ Fernandez provides the precise construction year and the early 1950's has been confirmed by other sources.

⁴⁰ The end operation dates are from the Fact List in the reference section. The DOE provides the end of operation date. We code end of stabilization operations in 2002 as the end of operations.

Fernandez, LeVerne. "Savannah River Site Canyons—Nimble Behemoths of the Atomic Age." WSRC-MS-2000-00061.

http://www.c-n-t-a.com/srs50_files/133fernandez.pdf. Accessed 07/13/2015.

US Department of Energy. 2008. "Facts: About the Savannah River Site."

<http://www.srs.gov/general/news/factsheets/fc.pdf>. Accessed 07/13/2015.

US Department of Energy. 2010. "Recovery Act Enables F-Canyon Drum Remediation to Restart." <http://www.srs.gov/recovery/recovery-act-enables-f-canyon-drum-remediation-to-restart>.

US Department of Energy. "Savannah River Site. <http://energy.gov/em/savannah-river-site>.

Accessed 07/13/2015.

Zentner, M.D., G.L. Coles, and R.J. Talbert. 2005. "Nuclear Proliferation Technology Trends Analysis." Pacific Northwest National Laboratory. Report 14480. 105.

33. Savannah River H Canyon

a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Reprocessing (Purex).

b. *Facility size (laboratory, pilot, commercial).*

Commercial.

c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction of the facility began in 1950. The facility began operation in 1955 and operated until 1992. It restarted operations in 1995 and continues to the present in a limited manner.⁴¹

d. *Was the facility developed covertly? If so, identify years that facility was covert.*

It seems likely, but we do not have clear evidence one way or the other. We code it as covert based on circumstantial evidence.

e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

⁴¹ Dates are from Zentner et al (2005). Zentner et al. provide two operational start dates and list 2002 as the operational end date. However, DOE documents and other sources state that the H Canyon continued to reprocess plutonium as recently as 2011 (Podvig 2011, Woods 2009).

This plant was not eligible for safeguards given the national security implications of the Savannah River site. The facility does not appear on the August 2012 list of eligible facilities licensed by the NRC (available here: <http://pbadupws.nrc.gov/docs/ML1317/ML13177A355.pdf>).

f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

g. *Did the facility have a military purpose?*

Yes.

h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

Found no evidence of foreign assistance.

j. *Sources:*

Hiruo, Elaine. 1992. "DOE Says It Will Scrap HEU Reprocessing, Stockpile Can Meet Need for Decades." *Nuclear Fuel*. 17(10): 12.

Podvig, Pavel. 2011. "H-Canyon to Produce MOX Feed From Excess Weapon Plutonium." International Panel on Fissile Materials. http://fissilematerials.org/blog/2011/11/h-canyon_to_produce_mox_f.html. Accessed 07/13/2015.

US Department of Energy. 2008. "Facts: About the Savannah River Site." <http://www.srs.gov/general/news/factsheets/fc.pdf>. Accessed 07/13/2015.

US Department of Energy. "Savannah River Site. <http://energy.gov/em/savannah-river-site>. Accessed 07/13/2015.

Woods, Randy. 2009. "DOE Processing New Batch of PU; EIS Not Completed." *Nuclear Fuel*. 34(22): 7.

Zentner, M.D., G.L. Coles, and R.J. Talbert. 2005. "Nuclear Proliferation Technology Trends Analysis." Pacific Northwest National Laboratory. Report 14480. 105.

- . “H Area Nuclear Materials Disposition.” SRS.
<http://www.srs.gov/general/programs/harea/>. Accessed 11/16/2015.

34. Union Carbide Centrifuge Development at Oak Ridge National Laboratory

- a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Enrichment, centrifuge.

- b. *Facility size (laboratory, pilot, commercial).*

Laboratory.

- c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Work on centrifuge development began in 1960 in here and at a second site run by AirResearch Manufacturing Company in Torrance, CA (facility #35 below below).⁴² Three centrifuge designs were developed: Set I, Set II, and Set III. The United States built a pilot plant to demonstrate the feasibility of this technology in 1978 (facility #36 below). We assume that lab-based work on the Set designs ended in this year.

- d. *Was the facility developed covertly? If so, identify years that facility was covert.*

It is likely the facility was initially developed covertly, despite general recognition of research on centrifuges by the US.

- e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

IAEA safeguards did not cover the facility.

- f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

- g. *Did the facility have a military purpose?*

Centrifuge research became part of the US weapons program after Washington discovered that the Soviet Union was pursuing centrifuge enrichment in 1958. The US effort to develop centrifuge technology was also partially in response to DOE

⁴² The Oak Ridge National Laboratory Review states that the first cascade of 35 centrifuges was completed in 1961. See http://www.ornl.gov/info/ornlreview/v37_1_04/article_04.shtml. Kemp states that reliability testing of Set I centrifuges occurred from 1972-1977.

expectations that demand for nuclear power would increase substantially in the 1970s. The DOE wanted to replace the aging gaseous diffusion facility at Portsmouth to supply enriched uranium to the market.

h. Was the facility multinational? If so, identify the other countries that were involved.

No.

i. Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.

No evidence of foreign assistance found.

j. Sources:

Kemp, R. Scott. 2009. "Gas Centrifuge Theory and Development: A Review of US Programs." *Science and Global Security*. 17: 1-19.

Zentner, M.D., G.L. Coles, and R.J. Talbert. 2005. "Nuclear Proliferation Technology Trends Analysis." Pacific Northwest National Laboratory. Report 14480. 32.

35. AirResearch Manufacturing Company Centrifuge Development

a. ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).

Enrichment, centrifuge.

b. Facility size (laboratory, pilot, commercial).

Laboratory.

c. Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.

The development and testing of Set centrifuges occurred at this site from around 1960 to 1978.

d. Was the facility developed covertly? If so, identify years that facility was covert.

Probably.

e. Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.

No, the facility was not under IAEA safeguards.

f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

g. *Did the facility have a military purpose?*

This facility seems to have military applications, at least in part, although none of the sources we consulted make this claim explicitly.

h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No evidence of foreign assistance found.

j. *Sources:*

Kemp, R. Scott. 2009. "Gas Centrifuge Theory and Development: A Review of US Programs." *Science and Global Security*. 17:1-19.

Zentner, M.D., G.L. Coles, and R.J. Talbert. 2005. "Nuclear Proliferation Technology Trends Analysis." Pacific Northwest National Laboratory. Report 14480. 32.

36. Pilot Centrifuge Plant at Oak Ridge National Laboratory

a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing.)*

Enrichment, centrifuge.

b. *Facility size (laboratory, pilot, commercial).*

Pilot.

c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

The United States built this facility in 1978. It is unclear when it ceased operations; we code 1985 as the end year since this is when the government ended the centrifuge program.

- d. *Was the facility developed covertly? If so, identify years that facility was covert.*

It is likely that the facility was initially developed covertly, despite general recognition of research on centrifuges by the US.

- e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

No.

- f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

- g. *Did the facility have a military purpose?*

This facility seems to have military applications, at least in part, although none of the sources we consulted make this claim explicitly.

- h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

- i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No evidence of foreign assistance found.

- j. *Sources:*

Kemp, R. Scott. 2009. "Gas Centrifuge Theory and Development: A Review of US Programs." *Science and Global Security*. 17: 1-19.

Zentner, M.D., G.L. Coles, and R.J. Talbert. 2005. "Nuclear Proliferation Technology Trends Analysis." Pacific Northwest National Laboratory. Report 14480. 32.

37. SILEX Plant, Wilmington

- a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Enrichment, laser (SILEX).

- b. *Facility size (laboratory, pilot, commercial).*

Commercial.

- c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction of the facility began in 2007 and it became operational in 2009.⁴³

- d. *Was the facility developed covertly? If so, identify years that facility was covert.*

No, the facility is for commercial production and has had numerous public reviews and announcements.

- e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

The enrichment and testing areas are not eligible for safeguards, but the LWR fuel and scrap recovery are safeguarded.

- f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

- g. *Did the facility have a military purpose?*

No, the facility is for commercial fuel production.

- h. *Was the facility multinational? If so, identify the other countries that were involved.*

Yes, the original technology for the SILEX laser is based on research conducted in Australia. The Australian company Silex System was bought out by GE. The Global Laser Enrichment company is a business venture by GE Hitachi (Japan), and Cameco (USA).

- i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

Yes. In May 2000 an Agreement for Cooperation was signed between the US and Australia allowing for the commercial deployment of the Australian SILEX technology in the U.S. In 2001 both governments officially classified the technology. In 2006 SILEX signed the Technology Commercialization and License Agreement with the American firm GE. Since 2008 Global Laser Enrichment, a subsidiary of GE has managed the US project ((51%), Hitachi (21%), and Cameco (24%)). The Silex plant is a joint effort between GE and Hitachi, and the technology is Australian in origin.

⁴³ Zentner et al. (2005) provide the construction and operation dates.

j. Sources:

- Laughter, M.D. 2009. "Profile of World Uranium Enrichment Programs—2009." Oak Ridge National Laboratory
- Loche, Gabriele. 2012. "Is A Step Towards Laser Enrichment a Step Back for Nuclear Non-Proliferation?" VERTIC. <http://www.vertic.org/pages/posts/is-a-step-towards-laser-enrichment-a-step-back-for-nuclear-non-proliferation-234.php>. Accessed 07/13/2015.
- Logan, David. 2013. "Is America About to Launch a New Wave of Nuclear Proliferation?" *The National Interest*. <http://nationalinterest.org/commentary/america-about-launch-new-wave-nuclear-proliferation-9611>. Accessed 07/13/2015.
- McGoldrick, Fred. 2011. "Limiting Transfers of Enrichment and Reprocessing Technology: Issues, Constraints, Options." The Belfer Center. <http://belfercenter.ksg.harvard.edu/files/MTA-NSG-report-color.pdf>. Accessed 07/13/2015. 9.
- Silex. "Silex Systems Third Generation Laser-Based Uranium Enrichment Technology." <http://www.silex.com.au/businesses/silex>. Accessed 07/13/2015.
- US Nuclear Regulatory Commission. 2009. "US Facilities Eligible for IAEA Safeguards." <http://pbadupws.nrc.gov/docs/ML1018/ML101870628.pdf>. Accessed 07/13/2015.
- World Information Service on Energy (WISE) Project on Uranium. "GE-Hitachi Laser Isotope Separation Enrichment Demonstration Facility Project in Wilmington (North Carolina)." <http://www.wise-uranium.org/epusa.html#GESILEXDEMOWILM>. Accessed 07/13/2015.
- Zentner, M.D., G.L. Coles, and R.J. Talbert. 2005. "Nuclear Proliferation Technology Trends Analysis." Pacific Northwest National Laboratory. Report 14480.

38. Silex Test Loop, Global Laser Enrichment (GLE) in Wilmington

- a. ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Enrichment, laser (SILEX).

- b. Facility size (laboratory, pilot, commercial).*

Pilot.

- c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction started in 2008 after the NRC finalized the process in May of 2008. The facility started bench-scale testing in 2009 and is consider operational from that point forward.⁴⁴ Full start up is expected in 2013.

- d. *Was the facility developed covertly? If so, identify years that facility was covert.*

No.

- e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

The enrichment and testing areas are not eligible for safeguards, but the LWR fuel and scrap recovery are safeguarded.

- f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

- g. *Did the facility have a military purpose?*

No, the facility is a commercial fuel production facility.

- h. *Was the facility multinational? If so, identify the other countries that were involved.*

Yes, the facility is multinational and includes the US, Japan, Canada, and Australia.

- i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

Yes. In May 2000 an Agreement for Cooperation was signed between the US and Australia allowing for the commercial deployment of the Australian SILEX technology in the US. In 2001 both governments officially classified the technology. In 2006 SILEX signed the Technology Commercialization and License Agreement with the American firm GE. Since 2008 Global Laser Enrichment, a subsidiary of GE has managed the US project ((51%), Hitachi (21%), and Cameco (24%)). The Silex plant is a joint effort between GE and Hitachi, and the technology is Australian in origin.

- j. *Sources:*

Brumm, Jim. 2010. "Global Laser Enrichment to Build Commercial Uranium Enrichment

⁴⁴ The dates are from the NRC facility website.

Facility at Castle Hayne Plant.” *Start News Online*.
<http://www.starnewsonline.com/article/20100415/ARTICLES/100419797>.
Accessed 07/13/2015.

Homer, Daniel. 2006. “GE, SILEX Gets US OK to Proceed with Enrichment Technology Deal.” *Nuclear Fuel*. 31(21): 9.

Laughter, M.D. 2009. “Profile of World Uranium Enrichment Programs—2009.” Oak Ridge National Laboratory.

Loche, Gabriele. 2012. “Is A Step Towards Laser Enrichment a Step Back for Nuclear Non-Proliferation?” VERTIC. <http://www.vertic.org/pages/posts/is-a-step-towards-laser-enrichment-a-step-back-for-nuclear-non-proliferation-234.php>.
Accessed 07/13/2015.

Logan, David. 2013. “Is America About to Launch a New Wave of Nuclear Proliferation?” *The National Interest*.
<http://nationalinterest.org/commentary/america-about-launch-new-wave-nuclear-proliferation-9611>. Accessed 07/13/2015.

McGoldrick, Fred. 2011. “Limiting Transfers of Enrichment and Reprocessing Technology: Issues, Constraints, Options.” The Belfer Center.
<http://belfercenter.ksg.harvard.edu/files/MTA-NSG-report-color.pdf>. Accessed 07/13/2015. 9.

Silex. “Silex Systems Third Generation Laser-Based Uranium Enrichment Technology.”
<http://www.silex.com.au/businesses/silex>. Accessed 07/13/2015.

US Nuclear Regulatory Commission. “GE Laser Enrichment Facility Licensing.”
<http://www.nrc.gov/materials/fuel-cycle-fac/laser.html>. Accessed 07/13/2015.

US Nuclear Regulatory Commission. 2009. “US Facilities Eligible for IAEA Safeguards.” <http://pbadupws.nrc.gov/docs/ML1018/ML101870628.pdf>.
Accessed 07/13/2015.

Zentner, M.D., G.L. Coles, and R.J. Talbert. 2005. “Nuclear Proliferation Technology Trends Analysis.” Pacific Northwest National Laboratory. Report 14480.

—. 2010. “Initial Success from SILEX Test Loop.” *World Nuclear News*.
http://www.world-nuclear-news.org/NN-Initial_success_from_SILEX_test_loop-1204104.html. Accessed 07/13/2015.

39. Special Metallurgical Facility, Miamisburg (Mound Lab)

a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Reprocessing.

- b. *Facility size (laboratory, pilot, commercial).*

Commercial.

- c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction occurred around 1956.⁴⁵ The facility operated from 1960 to 1968.

- d. *Was the facility developed covertly? If so, identify years that facility was covert.*

The initial work was done in secret. The facility complex continued to be part of the DOD research program on polonium.

- e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

No.

- f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

- g. *Did the facility have a military purpose?*

Yes, the initial work at the location contributed to the Manhattan Project by focusing on polonium. This facility was part of the weapons program.

- h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

- i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No evidence of foreign nuclear assistance found.

- j. *Sources:*

Alliance for Nuclear Accountability. "Mound Facility."

⁴⁵ The 1956 date is an approximation from the Historic American Building Survey HABS OH-2470 (6). The document outlines construction at the Mound complex in Miamisburg.

<http://ananuclear.org/Portals/0/documents/water%20report/waterreportmound.pdf>.
Accessed 07/13/2015.

International Atomic Energy Agency. "Integrated Nuclear Fuel Cycle Information Systems." <https://infcis.iaea.org>. Accessed 06/08/2015.

US Department of Energy. 2004. "Miamisburg Closure Project Building Data Package." Environmental Restoration Program.
http://www.lm.doe.gov/cercla/documents/mound_docs/AR/Revised%203001XX-XXXX-0406170010.pdf. Accessed 07/13/2015.

US Department of Energy. "Mound Facility HABS No. Oh-2470." Historic American Building Survey."
<http://memory.loc.gov/pnp/habshaer/oh/oh1900/oh1908/data/oh1908data.pdf>.

40. S-50 Plant at Oak Ridge Tennessee

a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Enrichment, liquid thermal diffusion.

b. *Facility size (laboratory, pilot, commercial).*

Pilot.

c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction began in 1944. The facility became partially operational in September 1944. The facility became completely operational in March 1945. The facility was operated by the Union Carbide Company. The facility was shut down at the latest in 1946 and all the buildings were destroyed.⁴⁶

d. *Was the facility developed covertly? If so, identify years that facility was covert.*

Yes, the facility became part of the Manhattan Project and was built adjacent to the K-25 facility. The Navy funded the original experimental research outside the Army's budget for the Manhattan Project. The facility remained covert until 1962 with the release of Hewlett and Anderson (1962), which used previously classified information to detail Manhattan Project programs.

e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

⁴⁶ The end of operation date is from the ATSDR report (1).

No, the facility was not eligible for IAEA safeguards.

f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

g. *Did the facility have a military purpose?*

Yes, the facility was developed to provide enriched feedstock for the other two enrichment facilities at Oak Ridge. The technology was originally not pursued due to perceptions on the feasibility of EMIS and diffusion. However, Abelson's 1944 experiments success at the Philadelphia Navy Yard prompted inclusion of the technology at Oak Ridge.

h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No. H.K. Ferguson Company, an engineering firm from Cleveland built the plant after 21 firms turned down the assignment.

j. *Sources:*

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41. Urenco USA Eunice, New Mexico (National Enrichment Facility (ENF))

a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Enrichment, centrifuge.

b. *Facility size (laboratory, pilot, commercial).*

Commercial.

c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction of the facility began in 2006 and it became operational in 2010.⁴⁷

d. *Was the facility developed covertly? If so, identify years that facility was covert.*

No, the facility provides commercial fuel.

e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

The facility appears on the August 2012 list of facilities eligible for IAEA safeguards licensed by the NRC (available here:

<http://pbadupws.nrc.gov/docs/ML1317/ML13177A355.pdf>).

f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

g. *Did the facility have a military purpose?*

No, the facility is only for commercial purposes.

⁴⁷ The construction and operational dates are from Urenco USA.

h. *Was the facility multinational? If so, identify the other countries that were involved.*

Yes, the facility is owned and operated by Urenco.

i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

Yes. In 2006 the NRC issued a license to Urenco to build the enrichment plant. Urenco is co-owned by BNFL, the Dutch Government, and German utility firms. Though the plant was constructed and is operated by Louisiana Energy Services, the site is fully owned and operated by Urenco (with the exception of the centrifuge assembly, which is co-run with AREVA), and the technology is Urenco technology. The technology is “black-boxed,” meaning “no sensitive nuclear technology or restricted data is transferred to the US” (McGoldrick 2011).

j. *Sources:*

International Atomic Energy Agency. “Integrated Nuclear Fuel Cycle Information Systems.” <https://infcis.iaea.org>. Accessed 06/08/2015.

McGoldrick, Fred. 2011. “Limiting Transfers of Enrichment and Reprocessing Technology. The Belfer School. <http://belfercenter.ksg.harvard.edu/files/MTA-NSG-report-color.pdf>. Accessed 07/13/2015. 9.

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Urenco. 2010. “URENCO USA: Building and Operating URENCO USA.” <http://www.urenco.com/content/323/urenco-inaugurates-uranium-enrichment-facility-in-eunice-new-mexico.aspx>.

Wald, Matthew L. 2006. “Uranium Enrichment Project Gets License.” *New York Times*, <http://www.nytimes.com/2006/06/24/us/24nuke.html>. Accessed 07/13/2015.

42. University of Virginia, Centrifuge Testing Facility

a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Enrichment, centrifuge.

b. *Facility size (laboratory, pilot, commercial).*

Laboratory.

- c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction of the facility began in 1939.⁴⁸ The centrifuges operated between 1941 and January 1944.⁴⁹ Earlier centrifuge development, including working prototypes, did not introduce material into the facility.

- d. *Was the facility developed covertly? If so, identify years that facility was covert.*

Yes, the facility was developed covertly. The facility was part of the Manhattan project. The entire duration of the project was secret. The facility remained covert until 1962 with the release of Hewlett and Anderson (1962), which used previously classified information to detail Manhattan Project programs.

- e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

No, the facility was not eligible for safeguards.

- f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

- g. *Did the facility have a military purpose?*

Yes, the facility was designed to test theories of centrifuge separation. Two centrifuge designs were developed at the university. The first, called “short bowl” was 42 inches long and had an inside diameter of 7.2 inches. The second, called “long bowl” was 11 feet 4 inches long and an inside diameter of 7.2 inches. The centrifuges were driven by a steam turbine. Short Bowl ran for 93 days while the Long Bowl failed during testing. The separating capacity was 1 SWU/year. All gas centrifuge research was suspended in January 1944 in favor of gaseous diffusion and calutron separation.

- h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

⁴⁸ Experimentation on centrifuge technology continued until the demonstration of nuclear fission by neutron occurred in 1939. Waters states, “it became clear to many that because of the huge release of energy through fission that a bomb might be created using the uranium 235 isotope”(4). 1939 is the start date used for the facility. 1934 is the date when Dr. Jesse Beams first demonstrated that centrifuge technology could separate chlorine isotopes, which demonstrated the feasibility of centrifuge technology.

⁴⁹ Waters does not identify an exact time for the 93-day enrichment testing. However, PNNL states that the US first enriched uranium at the University of Virginia in 1941. The end date of January 1944 is the end date for the research. It is probable that centrifuge enrichment occurred in 1941.

- i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No. In 1934 Jesse Beams had the idea to thermally isolate the centrifuge rotor. Beams was in charge of the design team at UVA for centrifuges at the beginning of the Manhattan Project. Westinghouse was in charge of building the first production machines at Standard Oil Development Company in New Jersey.

- j. *Sources:*

Hewlett, Richard and Oscar E. Anderson, Jr. 1962. *The New World, 1939-1946: Volume I: A History of the United States Atomic Energy Commission*. University Park, PA: The Pennsylvania State University Press.

Kemp, R. Scott. 2009. "Gas Centrifuge Theory and Development: A Review of US Programs." *Science and Global Security*. 17: 1-19.

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Zentner, M.D., G.L. Coles, and R.J. Talbert. 2005. "Nuclear Proliferation Technology Trends Analysis." Pacific Northwest National Laboratory. Report 14480. 32.

43. Westinghouse Research Laboratory/Standard Oil Development Company

- a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Enrichment, (ionic) centrifuge.

- b. *Facility size (laboratory, pilot, commercial).*

Laboratory.

- c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction of the facility began in 1942.⁵⁰ The facility operated from August 1943 to December 1943. The program was terminated in either late December 1943 or early January 1944 as the US shifted focus to gaseous diffusion technologies.

⁵⁰ The 1942 date is from the Stempfley (2009) SEC Petition Evaluation Report. He states, "all Atomic Weapons Employer employees who worked on the developed of the ionic centrifuge at the Westinghouse Atomic Power Development Plant in East Pittsburgh, Pennsylvania, from 13, 1942 through December 31, 1944" had the same classification level"(1).

d. *Was the facility developed covertly? If so, identify years that facility was covert.*

Yes, the facility was developed covertly. The facility remained covert from 1943 to 1944.

e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

No, the facility did not have IAEA safeguards, as it was not eligible for safeguards.

f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

g. *Did the facility have a military purpose?*

Yes, the facilities were part of the Manhattan project and were an extension of the research occurring at the University of Virginia. The Westinghouse Research Laboratory was “charged with building the first production machines, and testing was done at the Standard Oil Development Company in Bayway, New Jersey” (Kemp 2009, 2). The facility operated from August to December of 1943. Following the crash of the cascades due to an oil leak, the program was shut down in favor of gaseous diffusion.

h. *Was the facility multinational? If so, identify the other countries that were involved.*

No.

i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No evidence of foreign nuclear assistance found. The facility was built and operated by Westinghouse.

j. *Sources:*

Kemp, R. Scott. 2009. “Gas Centrifuge Theory and Development: A Review of US Programs.” *Science and Global Security*. 17: 1-19.

Reed, Cameron B. 2009. “Centrifugation During the Manhattan Project.” *Physics in Perspective*.
http://download.springer.com/static/pdf/408/art%253A10.1007%252Fs00016-009-0429-3.pdf?auth66=1406752547_8ba52565681772b1489e42f4f16da372&ext=.pdf

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Westinghouse. "History."
http://www.westinghousenuclear.com/our_company/Research_&Technology/history_research_technology.shtm.

44. West Valley Reprocessing Facility

- a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Reprocessing (LWR spent fuel).

- b. *Facility size (laboratory, pilot, commercial).*

Commercial.

- c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction started in 1966 and the facility operated from 1966 to 1972.⁵¹

- d. *Was the facility developed covertly? If so, identify years that facility was covert.*

No, the Nuclear Fuel Service Inc. commercially operated the facility.

- e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

No.

- f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No.

- g. *Did the facility have a military purpose?*

No.

- h. *Was the facility multinational? If so, identify the other countries that were involved.*

⁵¹ Zentner et al. provide the construction and operation dates.

No.

- i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

No. The facility was privately owned and constructed with support from the US government. The AEC granted the license in 1966.

- j. *Sources:*

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<http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1909/sr1909.pdf>

International Atomic Energy Agency. "Integrated Nuclear Fuel Cycle Information Systems." <https://infcis.iaea.org>. Accessed 06/08/2015.

Peltier, Robert. 2010. "US Spent Nuclear Fuel Policy: Road to Nowhere." Master Resource. <http://www.masterresource.org/2010/07/spent-nuke-fuel-policy-5/>.

Union of Concerned Scientists. "A Brief History of Reprocessing and Cleanup in West Valley, NY." http://www.ucsusa.org/assets/documents/nuclear_power/west-valley-fact-sheet-final.pdf

Zentner, M.D., G.L. Coles, and R.J. Talbert. 2005. "Nuclear Proliferation Technology Trends Analysis." Pacific Northwest National Laboratory. Report 14480.

Additional Facilities:

Eagle Rock Enrichment Facility

- a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Enrichment, centrifuge.

b. *Facility size (laboratory, pilot, commercial).*

Commercial.

c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

Construction on this plant had yet to begin at the time our data collection effort ended.

d. *Was the facility developed covertly? If so, identify years that facility was covert.*

No, the facility has been publicly announced and licensed.

e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*

Yes, the facility was part of the arrangement with Areva and it will be under IAEA safeguards. The enrichment technology will remain a black box.

f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

No, there are no regional agreements that cover US facilities.

g. *Did the facility have a military purpose?*

No, the facility is for commercial fuel production.

h. *Was the facility multinational? If so, identify the other countries that were involved.*

Yes, the facility is owned by Areva.

i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*

Yes. Areva (France) was very involved with the facility. On December 30, 2008 Areva Enrichment Services, LLC submitted an application to the US NRC to construct and operate a gas centrifuge uranium enrichment plant. The plant is being built with Urenco (UK, Germany, Netherlands) technology, though the technology is being transferred in such a way that restricts the transfer of classified technology to the US.

j. *Sources:*

- Areva. "Eagle Rock Enrichment Plant." <http://www.aveva.com/EN/operations-779/the-eagle-rock-project-construction-of-an-enrichment-plant-in-the-united-states.html>. Accessed 07/13/2015.
- Areva. "Eagle Rock Enrichment Facility." <http://us.aveva.com/EN/home-203/eagle-rock-enrichment-facility.html>. Accessed 07/13/2015.
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- World Information Service on Energy (WISE) Project on Uranium. 2014. "Eagle Rock Enrichment Plant." Areva. <http://www.wise-uranium.org/epusarc.html>. Accessed 07/13/2015.

Claiborne Enrichment Center (LICENSED DENIED)

- a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Enrichment, centrifuge.

- b. *Facility size (laboratory, pilot, commercial).*

Commercial.

- c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

The facility has been deferred. The NRC Atomic Safety and Licensing Board issued the verdict of license denied.

- d. *Was the facility developed covertly? If so, identify years that facility was covert.*

- e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*
- f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*
- g. *Did the facility have a military purpose?*
- h. *Was the facility multinational? If so, identify the other countries that were involved.*
- i. *Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*
- j. *Sources:*

World Information Service on Energy (WISE) Project on Uranium. "LES Claiborne Enrichment Plant Project." <http://www.wise-uranium.org/epl.html#LES>. Accessed 07/13/2015.

Zentner, M.D., G.L. Coles, and R.J. Talbert. 2005. "Nuclear Proliferation Technology Trends Analysis." Pacific Northwest National Laboratory. Report 14480.

Oak Ridge Reprocessing (No details on construction found)

- a. *ENR type (diffusion, centrifuge, EMIS, chemical and ion exchange, aerodynamic isotope separation, reprocessing).*

Reprocessing.
- b. *Facility size (laboratory, pilot, commercial).*

Commercial.
- c. *Is the facility under construction or in operation? If under construction, list the construction years. If in operation, list the years of operation.*

The facility was cancelled. The operator was Martin Marrietta
- d. *Was the facility developed covertly? If so, identify years that facility was covert.*
- e. *Was the facility placed under IAEA safeguards? If so, identify the years that the facility was safeguarded.*
- f. *Was the facility placed under regional safeguards? If so, identify the years that the facility was under regional safeguards.*

- g. Did the facility have a military purpose?*
- h. Was the facility multinational? If so, identify the other countries that were involved.*
- i. Was the facility built with foreign assistance? If so, list the supplier(s) and what they provided.*
- j. Sources:*

International Atomic Energy Agency. "Integrated Nuclear Fuel Cycle Information Systems." <https://infcis.iaea.org>. Accessed 06/08/2015.