

The Genesis of the Savannah River Site Key Decisions, 1950

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Abstract

Key decisions that shaped the future of the Savannah River Site were made by members of the U.S. Atomic Energy Commission (AEC), the General Advisory Committee, and management of E. I. du Pont de Nemours and Company (Du Pont) during 1950. These decisions included:

- Defining the scope of the facility
- Selecting Du Pont as the prime contractor for design, construction, and operation
- Establishing appropriate AEC and Du Pont organizations to manage the project
- Choosing the location in South Carolina
- Defining the unique provisions of the Du Pont contract
- Agreeing on primary design criteria for the various site processes

The chronology of these decisions is summarized in Figure 1.

The decisions were made very rapidly by a small number of experienced and qualified people. The decisions were made boldly; many were based on data that were incomplete at the time. The effectiveness of the decisions was validated by the subsequent contribution of the Savannah River Site to ending the Cold War.

Background

The unexpected test of the first Soviet atomic bomb on August 27, 1949, shocked the U.S. nuclear establishment that believed it was several years ahead of the Soviets. "We will stop glorifying our past," said Eugene Wigner, and the race was on.

Atomic Energy Commission Chairman David Lilienthal sent a letter to President Harry Truman in November proposing the development of a "super" bomb. The commission concluded that, with a minimum of three years of development, "there is a better than even chance it can be made to work." On January 31, 1950, President Truman announced he had directed the AEC to continue work on all forms of nuclear activity, including the "hydrogen or

fusion" bomb. The Commission and Department of Defense recommended a program for quantity production of materials for thermonuclear weapons, which was approved by President Truman on June 8.

As late as September 29, 1950, well after the program had been launched, minutes of the Atomic Energy Commission indicated that it was "impossible at this time to make a final determination of the feasibility of the tritium bomb." This uncertainty was not erased until the Greenhouse test series in April and May of 1951 demonstrated thermonuclear principles. Thus, the decision to proceed with the project was a huge leap of faith and evidence of the perceived urgency.

Key Decisions

The Contractor

Du Pont was the leading candidate for the proposed project from the moment the concept was developed. Du Pont participation in the atomic energy program began in 1942 when Crawford Greenewalt was reassigned from his position as Technical Director of Grasselli Chemical Department to provide liaison with the atomic scientists working in the "Metallurgical Laboratory" at the University of Chicago, which was directed by Arthur Compton. The renowned physicist, Enrico Fermi, designed the world's first nuclear reactor at the Met Lab. On December 2, 1942, Greenewalt was present at the first self-sustaining chain reaction of the atomic "pile" under the stadium grandstand.

Greenewalt subsequently became Technical Director at Hanford when Du Pont was requested to design, build, and operate that plant. Greenewalt and Du Pont Chief Engineer Granville Read were cited by General Leslie Groves, who directed the Army's Manhattan Engineering District, as the two men "without whom we could not have completed Hanford." The ultimate accolade from the atomic scientists came in 1946 when Fermi asked Greenewalt to quit Du Pont and devote his life to pure research.

The company had continued to take an active interest in atomic energy after turning over operation of the Hanford Plant to General Electric in October 1946. Hood Worthington was one of the first members of the General Advisory Committee serving from 1946 to 1948 under Chairman J. Robert Oppenheimer. The Committee was formed to provide advice from experienced nuclear physicists to the AEC. Greenewalt and Donald Carpenter, vice president of Du Pont's Remington Arms subsidiary, were appointed to advisory boards in 1947 and 1948. In 1948, Du Pont was asked to study "all chemical activities bearing on the manufacture of plutonium" and make recommendations to

the government. Du Pont performed this study at no cost to the government and continued to review Hanford operations and perform other studies requested by the AEC. Liaison offices were established at Hanford, Argonne National Laboratory, and Chalk River, Canada. These projects involved many Du Pont engineers and managers, including Monty Evans, Bill Mackey, Lombard Squires, Milton Wahl, Don Miller, and others who went on to lead the Du Pont Atomic Energy Division in the 1950s and beyond.

Preliminary negotiations with Du Pont were initiated as early as April 1950. Crawford Greenewalt had become president of Du Pont in 1948. Greenewalt was confident of Du Pont's ability to undertake the project because of the background of Hanford experience and demonstrated technical competence. The commission shared this confidence. The AEC considered briefly Union Carbide, Monsanto, Dow Chemical, and American Cyanamid for the project but concluded that Du Pont had unique qualifications and experience.

In a meeting on May 12, 1950, with Carleton Shugg, former AEC manager at Hanford, and Carroll L. Wilson, one of the original commissioners, Greenewalt insisted that a letter from President Truman endorsing the urgency of the project would be required to obtain Du Pont's participation and that Du Pont wanted full responsibility for the project, including design, construction, and operation. Greenewalt said the company would make no commitment until its engineers reviewed the AEC plans and evaluated the chances of completing the project on schedule.

In May 1950, Du Pont was asked informally to review technical aspects of the new project. This request was formalized June 12 when Acting AEC Chairman Sumner Pike requested Du Pont to review technical aspects of a new atomic energy production center for the purpose of considering a contract with the AEC for all phases of the work, including the site survey.

Curtis Nelson was appointed manager of the new AEC operations office for the tritium production project in June 1950. Like Greenewalt, Nelson was a veteran of the atomic energy business. He had broad construction experience and had been a colonel in the Manhattan Engineer District. After Hanford, he served as the AEC liaison officer at the Canadian Chalk River site where he became familiar with Canadian heavy-water reactor technology. (The 40 MW Canadian NRX reactor, fueled with natural uranium, moderated with heavy water, and cooled with light water, had been taken critical in 1947.) Nelson's deputy manager was Robert C. Blair.

After considerable discussion within AEC, Chairman Gordon Dean wrote President Truman on July 21 recommending that the president write to Greenewalt asking Du Pont to proceed with the project. President Truman wrote the letter on July 25.

Du Pont promptly formalized their commitment to the project by establishing the Atomic Energy Division (AED) within the Explosives Department. The AED management team was listed on the August 1, 1950, organization chart (see Table 1).

This organization was supplemented in a letter from Monty Evans to Curtis Nelson, AEC Operation Manager, on August 9. Additional assignments were V. R. Thayer, J. C. Woodhouse, D. F. Babcock, and C. W. J. Wende to the Research (Technical) Division and W. H. Holstein and J. B. Tinker to the Production (Manufacturing) Division.

AEC announced on August 2, 1950, that Du Pont had been selected as the contractor for design, construction, and operation of new production facilities to be built at a site yet to be determined. A letter contract was issued October 17 with an effective date of August 1. On the same day, Greenewalt wrote to President Truman to inform him of the contract and to assure him that Du Pont would "as always, put forth its best efforts."

The management teams brought to the new project by the Atomic Energy Commission and the Du Pont Company were experienced and well qualified to lead the new enterprise.

Site Scope

The initial budget proposal sent by President Truman to Congress in July 1950 was for two heavy-water reactors at the facility. In August, AEC told Du Pont that the Site should include five heavy-water reactors on normal (natural) uranium, a facility for Purex separation (Building 221), a fabrication facility for plutonium shapes (Building 235), a tritium separation plant (Building 232), and capability for irradiation of bismuth, if required.

The scope of work was modified in December 1950 to include addition of a second separation area with a future separation area (200-X) under consideration. In January 1951, the decision was made to build a heavy-water plant at Savannah River to supplement the Dana Plant. Du Pont recommended to AEC that the bulk of the electric power needed for SRP be generated on site in small, dispersed plants. In November

Table 1. AED Management Team, August 1, 1950

Assistant General Manager	– R. M. Evans
Administrative Assistant	– D. F. O'Connor
Atomic Energy Division Manager	– B. H. Mackey
Manufacturing Division, Director of Manufacture	– W. C. Kay
Control Division Manager	– F. M. Burns, Jr.
Technical Division Manager	– L. Squires
Assistant Manager	– J. E. Cole
Assistant Manager	– H. Worthington

1951, AEC eliminated funds for U-233 separation; plutonium production in all five reactors was recommended with excess reactivity applied to tritium production.

A power-producing heavy-water reactor was considered in initial planning. This concept was relegated to second priority at Argonne National Laboratory in February 1951 because of concerns that it might interfere with design of the production reactors. The sixth reactor was dropped from the budget in November 1952.

Facilities were added to and deleted from the scope of the site almost continuously as designs were firmed and requirements changed. This flexibility and adaptability became one of the principal attributes of the Site and allowed it to adjust to many changing missions through its first five decades of operation.

Site Selection

In June 1950, the Atomic Energy Commission asked Du Pont to locate a suitable tract of land for a plant to manufacture radioactive products. Originally, the study was to be limited to the "First Defense Zone," an area of the southeastern U.S. judged to be least susceptible to missile or sabotage attack from the Soviet Union. Basic site requirements were defined by Du Pont and agreed to by AEC:

- Manufacturing Area—Six reactor plant locations and one test location will be spaced approximately two miles apart and no closer than two miles to any other plant. Five separations plant locations will be approximately one mile apart.
- Site Area—The site area will include a 5.5-to-6-mile-wide zone outside the critical manufacturing area. All inhabitants or personnel not connected with the plant will be evacuated from the total site area.
- Supporting Population—The edge of the manufacturing area will be between 20.5 and 40 air miles to the edge of a center of population with at least 25,000 people.

- Isolation—Distances from the manufacturing area and maximum community populations shall be:

Distance (miles)	Maximum Population (persons)
5.5-10.5	500
10.5-15.5	5,000
15.5-20.5	10,000

- Water—Adequate water will provide cooling for six reactors without damage to other presently established users:

	Cooling Water (cubic feet/second)	
	Once-Through	Cooling Tower
Withdrawal for plant	600	180
Consumption	50	65

- Electric Power—Uninterrupted supply of 125,000 KW
- Railroad—Site must be accessible.
- Highways—Site must be accessible.
- Meteorology—No absolute limits but a favorable site would have prevailing wind velocities above 3 miles per hour directed away from centers of population closer than 20 miles. Climate should be as favorable as possible for plant construction and operation.
- Geology—The geological substructure and overburden should be stable with a low earthquake record and probability.
- Construction and Operating Costs—The Site should have characteristics that assure economy consistent with other requirements for satisfactory operation.

Eighty-four specific sites were identified in the First Defense Zone. Onsite inspections were performed by AEC, Corps of Engineers, and Du Pont representatives at 5 of the 17 most favorable locations. The study was subsequently extended to the Second Defense Zone, which included most of the northeastern, central, and southwestern U.S. to include sites with lower water temperatures and humidity. Six sites in

this zone were visited, and the potential sites were reduced to four, two each from the two defense zones:

- Site Number 5—Aiken and Barnwell Counties in South Carolina, on the Savannah River, 20 air miles southeast of Augusta, Georgia, and 15 air miles south of Aiken, South Carolina
- Site Number 125—Fannin and Lamar Counties in Texas and Bryan and Choctaw Counties in Oklahoma on the Red River, 15 air miles east of Bonham, Texas, and 76 air miles northeast of Dallas, Texas
- Site Number 59—Crawford and Clark Counties in Illinois and Sullivan County in Indiana, on the Wabash River, 20 air miles southeast of Terre Haute, Indiana
- Site Number 205—Bayfield and Douglas Counties in Indiana, on the shore of Lake Superior, 26 air miles southeast of Duluth, Minnesota

Public Law Number 843 was passed in September 1950 to authorize AEC to acquire land for a plant to manufacture radioactive products. On November 10, Du Pont recommended selection of the Savannah River Site to the Site Review Committee, consisting of five members of leading engineering firms selected by AEC. Critical criteria were seclusion and an adjoining labor market; the dissolved mineral content of the Red River in Texas and construction difficulties in the northern part of the country also contributed. The committee, the Department of Defense, and the AEC concurred unanimously. The commission officially designated the Site as "The Savannah River Plant," and the Corps of Engineers was authorized to acquire approximately 240,000 acres. The public announcement of the Savannah River Plant was made November 28.

The commission expressed concern over the original plan, which included the sites of the towns of Dunbarton, Ellenton, Jackson, and Snelling within the plant's boundaries. By year's end, the project boundary line was changed to

exclude Snelling and Jackson. The layout provided space for five reactors with two additional sites available. The first property was transferred December 29, 1950, and all SRP land, including 6,000 acres around Lower Three Runs Creek, was acquired by June 30, 1952.

The total impact of the land acquisition included:

- 1,500 people
- 1,706 tracts of land
- 200,742 acres
- 165 cemeteries containing 6,000 graves; 124 cemeteries with 4,980 graves were removed and reburied.

The Contract

Du Pont had negotiated a unique relationship with the Army Manhattan Engineering District for their work at Hanford. Notable features of the contract were:

- Du Pont received a fee of only one dollar for what became a half-billion dollar project.
- Du Pont continued to apply corporate pay scales rather than government pay scales to employees who were transferred or hired for the project. This permitted Du Pont to assign its best people without sacrifice because corporate pay scales were 150%-250% higher than government or university pay scales for equivalent work.
- The government reimbursed Du Pont for all costs and losses incurred as a result of the work.
- The government took possession of all products. This was important to Du Pont because most of the products were dangerously radioactive.
- Du Pont retained the option of leaving the enterprise nine months after the war ended. This option was invoked in October 1946, 11 months after the Japanese surrender was signed.

Crawford Greenewalt took a firm position on the proposed contract for the new production facility, insisting that it be modeled on the Hanford relationship. There was some reluctance within AEC to follow the Hanford model, but Du Pont stood firm. Greenewalt explained the Du Pont position to the Joint Committee on Atomic Energy on August 4, 1950. He pointed out that Du Pont did not seek the assignment and would undertake it only because of a clear need on behalf of national security, as demonstrated by the July 25 letter from President Truman. He described the decision to do the work for no fee as resulting from two considerations: (1) the experience that Du Pont brought to the job had been gained at government expense, and (2) Du Pont felt that “. . .we simply cannot be in a position of making money out of an engine of war that is as horrible as this one is likely to be.” The Du Pont president told senators and congressmen that Du Pont expected to be reimbursed by the government for all reasonable costs. He said general overhead costs would be held as low as possible, as was the case in normal commercial practice.

Greenewalt devoted most of his presentation to a discussion of the importance of paying employees in accordance with normal Du Pont compensation practices. He said Du Pont intended to staff the plant with “our very best people” and that they would be compensated on the same terms as they would have been had they remained in commercial activities. Greenewalt ended his discussion by stating that Du Pont had concluded that the elements of the project appeared to be perfectly feasible.

Despite some continued resistance within the commission, Gordon Dean wrote President Truman on September 27 requesting the president to “authorize AEC to proceed with a contract with Du Pont that would be similar to the Hanford job.” Letter Contract AT(07-2) was issued to Du Pont on October 17 with an effective date of August 1. The contract contained all of Greenewalt’s key requirements.

The contract allowed Du Pont the freedom to recruit competitively and carry out the project in accordance with established corporate practices. In today’s legalistic environment, it is hard to imagine that a major corporation would perform work for the government for six months with only a “handshake agreement” rather than a binding legal contract.

Process Designs

Reactor

In February 1950, the Joint Committee on Atomic Energy (JCAE) discussed four alternatives for producing tritium:

- Load the H Reactor at Hanford with enriched uranium.
- Build six materials testing reactors (MTRs). The MTR at Idaho Falls was a 40 MW reactor with enriched fuel, cooled and moderated by light water, was about to be built, and would be taken critical in 1952.
- Use a large linear accelerator being studied currently at Berkeley Radiation Laboratory.
- Continue design work on a large heavy-water-moderated reactor similar to the NRX, which had been in operation at Chalk River, Canada, since 1947.

The JCAE concluded that the last alternative seemed to be efficient and realizable and an ad hoc AEC committee, chaired by George Weil, recommended that the heavy-water reactors be built to produce materials for thermonuclear weapons. On July 20, Du Pont concurred in the selection.

Eugene Wigner, the Nobel-prize-winning theoretical physicist had proposed light-water cooling for the Hanford reactors and advocated heavy-water moderation in the early 1940s. The basic concept for a reactor cooled and moderated with heavy water had been developed by the prolific Walter Zinn at Argonne National Laboratory (ANL). Zinn worked closely with the Canadians, who had heavy-water operating experience with their NRX plant. Argonne

expanded its heavy-water reactor program rapidly during 1950 to develop experimental data on reactor physics and engineering. Much of the work focused on the metallurgy of reactor materials.

The AEC initially established an objective of approximately 1800 MW of total reactor capacity as necessary to produce the quantities of tritium thought to be required. They decided subsequently that the Savannah River reactors should be scaled at 300 MW. Thus, six reactors were proposed originally, and the original site layout included six reactor plants. The August 1950 scope of work called for five reactors.

Du Pont proceeded rapidly with detailed design of the reactors. The design team placed "a large premium on flexibility in the ultimate design." This flexibility was required because of AEC uncertainty as to the relative quantities of plutonium and tritium that were required. In January 1951, Du Pont reported that the reactor design could incorporate flexibility "without loss" for either plutonium or tritium production.

Du Pont arranged with ANL to place young engineers for training and work in physics, chemistry, engineering, and metallurgy at Argonne. Milton H. Wahl, who later was appointed director of the Savannah River Laboratory, led the Du Pont Argonne group. By August 1951, 66 Du Pont employees were working at ANL.

The emphasis on reactor flexibility produced versatile machines capable of operating at powers almost an order of magnitude higher than the design basis and producing isotopes not yet discovered in 1950.

Separations

Substantial work on processes for separating desired isotopes from irradiated reactor components had been conducted at Hanford, Oak Ridge National Laboratory (ORNL), and Knolls Atomic Power Laboratory (KAPL). The original

separations plants built at Hanford used a bismuth-phosphate co-precipitation process that was capable of recovering plutonium but not the large quantities of uranium that went into the waste tanks with highly radioactive wastes. The inefficiency of this process was well understood at the time, but the Army pressed for the simple process because of the wartime urgency. Recovery of the uranium became essential later because of dwindling supplies.

After the war, Hanford worked on the Redox solvent extraction process. In 1948, AEC requested Du Pont to collect information related to recycling uranium and handling fission products and wastes. This endeavor was led by Monty Evans, who later became the first assistant manager of Du Pont's Explosives Department with responsibility for the Atomic Energy Division. Du Pont recommended development of Redox, but work at Hanford proceeded slowly, and the Hanford Redox plant did not start up until August 1951.

Meanwhile, ORNL and KAPL had developed an alternative solvent extraction process known as "Purex" that used a less flammable solvent and produced a substantially smaller volume of liquid wastes. Although Purex was not as well developed as Redox; it had been tested thoroughly on a laboratory scale by the time Du Pont assumed the contract for the new facility. Du Pont immediately dismissed several other separations processes as being unable to assure "a reasonable chance of operating successfully." The selection of the Purex process over the Redox process was recommended in a letter from F. S. Chambers to Lombard Squires, dated September 27, 1950. A large Du Pont group was established at ORNL under Luther Peery and Bob Martens; a smaller group was installed at KAPL.

The Purex process worked well at Savannah River, and Purex variations are the international standard for production and power reactor fuels.

Heavy Water

Heavy-water-cooled and -moderated reactors required a large amount of heavy water, typically 250 tons per reactor. The total world supply of heavy water in 1950 was less than 50 tons. Production of a large volume of heavy water was a major challenge in the early stage of the project and was expected to be on the critical path. Three processes were available for heavy-water production:

- Distillation and catalytic exchange of light water
- Low-temperature distillation of liquid hydrogen
- Gaseous hydrogen sulfide/liquid water dual-temperature exchange

The distillation process had been used by Du Pont during the Manhattan Project to produce about 30 tons of heavy water. However, this process was prohibitively expensive for the large volumes needed for the new reactors.

After the war, AEC asked Hydrocarbon Research, Inc., to design a plant based on the hydrogen distillation process. Despite concerns about the hazards of handling hydrogen gas and operating difficulties with the low-temperature process, the commission approved construction of a pilot plant on March 1, 1950.

Early work on the dual-temperature process had been done under Harold Urey at Columbia University. The process used hydrogen sulfide gas, which was very toxic, in pairs of alternately placed hot and cold mixing towers. Scaling up the process from the laboratory bench to production presented engineering difficulties, but the AEC contracted with the Girdler Corporation to use some of the existing facilities at the Wabash River Ordnance Works near Dana, Indiana, and to build a pilot plant. Inclusion of heavy-water production in the pending Du Pont assignment was considered by the AEC in May 1950.

Du Pont initially had concerns about heavy-water production based on their experience with the distillation process. Further studies convinced them that the dual-temperature process was the best option because of its cost benefits. Greenewalt recommended dual temperature to the commission on July 20, 1950. Du Pont was authorized to deal directly with Girdler and proceed with construction of a heavy-water plant on September 29. They recommended building six production units at the Site in addition to the Girdler pilot plant.

In recognition of the importance of the Wabash operation, the commission renamed the heavy water portion as the Dana Plant and established an area office, reporting to Curtis Nelson, in October 1950. The Dana pilot plant completed its first test run October 26. Many potential operating problems were solved there, and the nucleus of the Savannah River heavy-water operating staff was trained there. In January 1951, Du Pont was authorized to build Savannah River heavy-water production lines similar to those at Dana.

Despite initial concerns, 250 tons of heavy water had been produced before the first reactor (R) was completed.

Appreciation

The authors searched primary and secondary references for information on the formative decisions related to the Savannah River Site. The references were selected from materials collected by Mary Beth Reed, Steve Gaither, and Mark Swanson of New South Associates as part of the Site History Project under U.S. Department of Energy Cooperative Agreement DE-FC09-97SR18903. The draft of this paper was reviewed and suggestions made by several former Site employees.

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Biographies

J. Walter Joseph

Mr. Joseph graduated from North Carolina State in 1950 with a BE in Mechanical Engineering. After serving in the Army during the Korean conflict, he joined the staff of the Department of Engineering Research at Penn State and received his MS in Mechanical Engineering in 1954.

He worked for Du Pont and Westinghouse at the Savannah River Site from 1954 to 1993. He started in the Pile Engineering Division of the Savannah River Laboratory, where he conducted research in reactor heat transfer and hydraulics, stress analysis, and effects of irradiation on structural materials. In 1965, he transferred to the Savannah River Plant where he held a variety of technical and management positions in several departments, including Reactor Technology, Equipment Engineering, Traffic and Transportation, L Startup Project Team, and Site Quality.

He currently is founder and principal consultant of Quality Partners, providing training and consulting on Total Quality processes.

C. J. Banick

Mr. Banick earned his MS degree in Physical Chemistry from Georgia Tech. He currently is serving as WSRC's liaison to the SRS History Project. Previous experience at the Savannah River Plant and Laboratory included (1) assistance to plant startup and trouble shooting chemical problems associated with production reactors, (2) analytical chemistry support of operating and R&D efforts (principally by non-routine analytical methods development) in fields of reactor productivity, raw materials, fuel reprocessing, isotopic power sources, environmental monitoring, and characterization of special reactor irradiations, (3) writing, editing, producing, and distributing technical documents, (4) as classification officer, responsibility for approval processing of technical documents prior to public release, (5) as patent liaison, assisting DOE patent counsel in identification and prosecution of patentable inventions, (6) initial involvement in technology transfer activities, and (7) coordination of information exchange between WSRC and the Defense Nuclear Facilities Safety Board.

Figure 1. The Genesis of the Savannah River Site

	Oct.	
1949	Nov.	◀ AEC letter to President Truman proposes development of “super bomb”.
	Dec.	
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	Jan.	
	Feb.	◀ President Truman directs AEC to work on “hydrogen or fusion” bomb.
	Mar.	◀ AEC recommends heavy-water reactors for new plant.
	Apr.	◀ AEC initiates preliminary negotiations with Du Pont.
	May	
1950	Jun.	◀ Du Pont asked to locate a suitable site.
	Jul.	◀ Du Pont recommends dual-temperature heavy water production.
	Aug.	◀ Scope of project defined to include five reactors. ◀ AEC announces selection of Du Pont as contractor.
	Sep.	
	Oct.	◀ Du Pont recommends Purex separations process.
	Nov.	◀ AEC letter contract issued to Du Pont.
	Dec.	◀ Public announcement of Savannah River Site is made.
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	Jan.	
	Feb.	◀ Official start of construction.
1951	Mar.	