How Ice Age Floods Helped Create the Hanford Nuclear Site

And...
Some Hanford History

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Trinity Explosion
July 16, 1945

Implosion bomb fueled by plutonium from the Hanford site.
Alamogordo Bombing Range NM – Now White Sands Missile Range
Little Boy

- Weight: 9,700 lbs
- Uranium Fuel: approx. 140 lbs;
- Efficiency of weapon: poor
- Approx. 1.38% of the uranium fuel actually fissioned
- Explosive force: 15,000 tons of TNT equivalent
- Use: Dropped on Japanese city of Hiroshima; August 6, 1945

Fat Man

- Weight: 10,800 lbs
- Plutonium Fuel: approx. 13.6 lbs; approx. size of a softball
- Efficiency of weapon: 10 times that of Little Boy
- Approximately 1 kilogram of plutonium fissioned
- Explosive force: 21,000 tons of TNT equivalent
- Use: Dropped on Japanese city of Nagasaki; August 9, 1945
The name “Manhattan” Project was chosen by Groves and Colonel James C. Marshal.

It was named after the city where its headquarters was located - 270 Broadway NY.

The Hanford Site was part of the Manhattan Project.

For over 50 years the site and its activities were largely invisible to the American public and the world.

Groves – “All design and operations were governed by three rules”

1) Safety first against both known and unknown hazards
2) Certainty of operation – every possible chance of failure was guarded against.
3) The utmost saving of time in achieving full production.
The original name for the Hanford site was the “Hanford Engineer Works”.

The sites code name was “Site W”

Hanford was the last site selected for the Manhattan Project.

Initial Construction was – December of 1943 to December 1946

Initial construction force
A few thousand workers in 1943
Peak workforce 45,000 in 1944

Production lasted from 1944 to 1990

World War II Posting Found on a Barrack Wall

- 1,000,000 meal ticket cards on file
- $3,500,000 worth of meal tickets sold in 8 months through payroll deduction (does not include meal tickets sold for cash)
- Menus prepared 60 days in advance
- Eight mess halls, 2700 workers in each hall at each setting, usually three settings per meal
- 3000 pounds of sausage used for one breakfast
- 2500 pounds of pot roast for one meal
- 18,000 pork chops for one meal for one mess hall
- 11,000 pounds of Swiss steak for one meal for all mess halls
- 250,000 pounds of meat used for all mess halls for 1 week
- 15 tons of potatoes for one mess hall each day
- 5000 heads of lettuce for each meal for one mess hall
- 1200 pounds of onions for one meal for one mess hall
- 900 full pies for one meal for one mess hall
- 600 gallons of ice cream a day
- 250 good cows needed to supply the milk for one breakfast
- 1000 pounds of coffee for one day for one mess hall
- 700 cases of Coca-Cola a day
- 2200 loaves of bread used each day for sandwiches, not counting bread on tables
- Three sandwich machines, each making 360 sandwiches an hour
- 272,000 pounds of processed meat, ready for oven or grill used in 1 week
- 4,000,000 lunch boxes sold from July 1943 to October 1944
- 30,000 doughnuts for one day
- An automatic doughnut machine making 18,000 doughnuts per hour
- 6500 eggs used for Sunday breakfast (only time fried eggs could be served because meals were served over a longer period of time)
- 12,000 turkeys for Thanksgiving (22 tons of turkey, 12 tons of ham)

Other information supplied on this sheet indicates:

- Number of employees quartered in barracks: 40,000
- Number of employees quartered in trailer camp: 8,000
- 10,000 newspapers sold each day by recreation halls
- 16,000 packages of cigarettes sold each day
- 12,000 gallons of beer consumed each week (13 carloads)
- 2000 keys for barracks lost each month by employees
The 100 Area – 26-square-mile piece of land along the Columbia River nine water-cooled plutonium reactors constructed between 1943-1963.

The 200 Areas – facilities for chemical processing, plutonium finishing, and defense waste management activities took place.

The 300 Area – facilities for fabricating uranium reactor fuel and research aimed at improving the production process.

The 1100 Area – contained several hazardous wastes landfill sites
Historical Perspective

Selection Criteria

Hanford is located in central Washington State on the shores of the Columbia River – approximate area is 670 square miles.

Area of at least 12 miles by 16 miles.

Remote setting with no population greater than 1,000 within 20 miles - safety & secrecy.

Abundant water supply of at least 25,000 gallons per minute - cool the reactors.

Dependable hydroelectric power source to supply at least 100,000 kilowatts of electricity – Grand Coulee Dam.

Convenient access to railroad and highway facilities.

Relatively flat landscape.

Available concrete aggregate (Sand & Gravel).
Extremely large cracks in the earth’s crust 17.5 million years ago.

Possibly caused by a tectonic hot spot that formed somewhere in northeast Oregon and central Washington.

The hot spot has slowly moved to its current location at Yellowstone park in Wyoming.

Flows are 2 to 3 miles thick.

Many of the lava flows made it from Idaho to the coast of Oregon.

At Pasco Basin it is estimated that the Basalt flows are as much as 15000 feet thick.
• Lake Bonneville - 20,000 sq mi
• Boneville Flood occurred 17,000 ya
• Released nearly 1,000 cubic miles of water
• Volume of this flood was twice as large as the biggest Missoula Flood
• Bonneville Flood occurred over a period of several weeks happened only once
• Slower movement of water 40 to 60 mph
• *Large sand & gravel deposition*
Glacial Lake Missoula in northwestern Montana - Ice dam across the Clark Fork River.

May have contained more water than Lake Erie and Lake Ontario combined.

The entire lake drained in 48 - 72 hours.

Glacial Lake Missoula existed for 2,000 to 2,500 years between 15,300 and 12,700 years ago, creating possibly 100 separate flood events.

Flood waters possibly moved at 10 qmph (80 mph) a rate 10 times of all the rivers that flow on earth.

Water height during floods at Hanford located over 200 miles from the Lake Missoula Dam, estimated at roughly 900 to 1000 feet.
More than 3,000 square miles of land were under water.

- Periods of only two or more weeks
- Lake level of 1,200 feet elevation
- Pasco Richland & Hanford would have been under 800 - 1000 feet of water
- Area of fantastic sediment deposition
The Wallula Gap is the choke point that created Lake Lewis

- Range of basalt hills and ridges
- Created during the Columbia Basalt Group formation 17mya
- Elevations reach 2,000 feet or higher
- *Floodwater may have overtopped high point on right by 80 feet!*
- The only natural outlet for the entire Columbia River Basin
- During the flood event 200 cubic miles of water per day may have accumulated
Imagine
Security and secrecy were hallmarks of the Manhattan Project

1) Many security measures violated individual civil liberties.
2) Workers never knew what they were going to be working on.
3) Plans were viewed in special vaults and by specially selected people.
4) Fewer than one percent of workers were told the true nature of the project.
5) Workers were terminated if too many questions were asked.
6) Counter-espionage agents and undercover agents were everywhere assuming roles that provided them with access to all operating facilities.
Hanford site’s sole purpose was to produce weapons grade plutonium.

The site and its activities have been largely invisible.

Challenge of producing plutonium on a large scale was significant.

Plutonium produced – approximately 55 metric tons.

9 different reactors
6 different separations plants
1 Uranium fuel manufacturing
1 Plutonium production facility

Creating plutonium was a challenge because it is an artificially made element.
For each kilogram (2.2lbs) of Pu made for the U.S. weapons program roughly 1,000 tons of uranium ore was extracted from the ground.

Processed uranium was formed into rods and billets.

Billets measured from 4.5 inches in diameter and 12 to 20 inches in length and weighed a minimum of 125 lbs.

The billets were extruded into rods which were then canned in an aluminum-silicon alloy.

Once canned and tested the uranium fuel rods were shipped off to the on site nuclear reactors to be irradiated.

Aluminum-clad elements contained metallic uranium and measured 1.5 inches in diameter and 8 inches long.
The soul of Pu Production
Reactor Operations...

• Between 1943 and 1987 nine graphite-moderated, water-cooled, plutonium production reactors were constructed.

• Aluminum-clad fuel elements were loaded into the reactors and irritated via uranium reactor cores.

• Graphite was used as a moderator to slow down neutrons so they can be captured by uranium atoms in the fuel elements.
- Uranium-238 metal fuel slugs were inserted into the font face of a graphite cube.

- Boron rods were moved in or out to absorb neutrons to slow or shut down the reaction.

- Water from the Columbia river was circulated through the reactor to carry away heat produced during fission.

- Irritated elements were extracted from the reactors and cooled in holding tanks for weeks.
• Between 1943 and 1956 six different chemical separations plants were constructed

• Awesome canyon-like structures

• 800 feet long

• 65 feet wide

• 80 feet high

• Containing forty process pools.
Irritated elements were loaded into shielded cask cars and shipped 10 miles from reactors to chemical separations plants via above ground and underground railroads.

The irritated elements were off loaded on one side of the plant into dissolver tanks/cells. Each tank consisted of three buckets of fuel elements and weighed 3 tons.

The elements were dissolved with an agent such as sodium hydroxide, nitric acid and other chemicals and turned into a uranium slurry.

Chemical separations process and then slurry - precipitated and centrifuged to create plutonium semi-solids such as plutonium nitrate paste.

Plutonium nitrate paste was shipped to the plutonium finishing plant for final processing –
From 1944 to 1994 the United States produced 103.4 metric tons of plutonium 67.4 MT at Hanford, and 36.1 at Savannah River.
<table>
<thead>
<tr>
<th>Type</th>
<th>Volume</th>
<th>Curies</th>
</tr>
</thead>
<tbody>
<tr>
<td>*Tank Waste</td>
<td>54 Million Gal</td>
<td>200 Million</td>
</tr>
<tr>
<td>Soil &amp; Ground water</td>
<td>40 Billion ft³</td>
<td>1 Million</td>
</tr>
<tr>
<td>Solid Waste</td>
<td>25 Million ft³</td>
<td>6 Million</td>
</tr>
<tr>
<td>Facilities</td>
<td>175 Million ft³</td>
<td>10 Million</td>
</tr>
<tr>
<td>Nuclear Material</td>
<td>25,000 ft³</td>
<td>200 Million</td>
</tr>
</tbody>
</table>

*High Level liquid waste was generated at approximately 10,000 gallons per a ton of irradiated fuel processed during WW II -
Starting in 1945, 149 single-shell tanks were built - 94 million gallons of storage capacity.

Tanks size ranged from 55,000 to 1 millions gallons.

1968 – 1986, 28 newer double-shell tanks were constructed - 31 million gallons of capacity.

Total of 18 Tank Farms, On The Hanford Site.
Sixty-Seven Of The Single Shell Tanks Have, Or Are Suspected To Have, Leaked 1 million gallons of Waste Into The Vadose Zone

Single-shell tanks (SSTs) built between 1943 and 1964
Solution

Retrieve the waste and transfer it into more secure DSTs for temporary storage before final treatment.

Double-shell tanks constructed in 1970s
Challenge

- Removing tank waste is extremely difficult.
- Retrieval Methods differ based on tank integrity.
- If structurally sound, waste can be retrieved using high pressure jets and pumps.
- If integrity is questionable more expensive vacuum retrieval systems may be required.
- May be necessary to add solution to mix tank constituents.
- All methods of removal could potentially create new leaks or re-invigorate old leaks.
In 2000 Pacific Northwest National Laboratory established the Vadose Zone Transport Field Studies to examine potential technologies.

Two key parameters: technologies utilize existing infrastructure and be noninvasive.

Geophysical methods based on direct current electrical resistivity, were better suited for monitoring.
The Monitoring Program Takes Advantage Of Changes In Contact Resistance That Will Occur If Conductive Tank Liquid Leaks Into The Soil.
Long-Term Monitoring

• A complete data set contains a data sequence where each electrode acts as both a transmitter and a receiver.

• Each data set is composed of:
  - Contact resistance - Transmitting current - Received voltage
  - Apparent resistivity - Estimate of measurement error - Self potential.

• Each data type, depending on the electrode, provides critical information on resistivity changes occurring around the tank.

• As the data are acquired and processed, each electrode pair is graphed and trends are evaluated for leaks.
Long-Term Monitoring

A - Disconnected Cable
B - Cathodic Protection Off
C - Faulty Connection to Well
D - Rain Event
E - Seasonal Change
F - Diurnal Change
G - Cathodic Protection On
Horizontal Slice of High Resolution Resistivity Data

$Z = 32 \text{ m}$
NO SAFETY KNOW PAIN
KNOW SAFETY NO PAIN
CAUTION

CONTAMINATION AREA

Entry Requirements:
- Personnel Dosimeter (TLD)
- Radiological Work Permit (RWPT)

RADIOLOGICAL BUFFER AREA

Entry Requirements:
- Personnel Dosimeter (TLD)
- Radiological Worker 1 Training (if unescorted)
- Exit Survey
CAUTION
CONTAINS
PCBs
(Polychlorinated Biphenyls)

A toxic environmental contaminant requiring special handling and disposal in accordance with U.S. Environmental Protection Agency Regulations 40 CFR 761. For disposal information contact the nearest U.S. EPA Office.

In case of accident or spill call toll-free the U.S. Coast Guard National Response Center 800-424-8802.

Hanford Patrol 811 or 373-3800 Utility Dispatch 373-2320 or 373-2321
CAUTION

UNDERGROUND RADIOACTIVE MATERIAL AREA

Prior to excavating, contact radiological control organization.
CAUTION

FIXED CONTAMINATION AREA

FCA W-13-055

Contact Radiological Control Organization Before Disturbing Surfaces
DANGER

HIGH RADIATION AREA

Entry Requirements:
- Personnel Dosimeter (P/D)
- Supplemental Dosimeter
- Radiological Work Permit (RW/PP)
CAUTION

RADIATIONAL BUFFER AREA
Entry Requirements:
- Personnel Dosimeter
- Radiological Worker 1 Training (if unescorted)
- Exit Survey

CAUTION

FIXED CONTAMINATION AREA
W-12-031
CONTACT RADIOLOGICAL CONTROL ORGANIZATION BEFORE DISTURBING SURFACES

CAUTION

RADIATION AREA
and RADIOACTIVE MATERIAL AREA
Entry Requirements:
- Personnel Dosimeter (TLD)
- Radiological Work Permit (RWP)

CAUTION

INTERNALLY CONTAMINATED SYSTEMS LOCATED WITHIN
CONTACT RADIOLOGICAL CONTROL PRIOR TO WORKING ON SYSTEM

CAUTION

UNDERGROUND RADIOACTIVE MATERIAL AREA
Prior to Excavating Contact Radiological Control Organization

RMA-115
WARNING

VAPOR CONTROL ZONE

ENTRY REQUIREMENTS:
1.) Supplied Air - or
2.) In Accordance with Tank Vapor Information Sheet. (TVIS)

CONTACT SHIFT OPERATIONS for SPECIFIC INSTRUCTIONS
WFO: 373-2689 CP: 372-2806
A minimum hand and foot survey is REQUIRED for exit from the Radiological Buffer Area.

1. Verify the instrument is in service and set to the x1 scale. Ensure the Beta–gamma background is (150 cpm). Ensure the audio output can be heard.

2. Frisk hands before handling probe.

3. Hold the probe 6 mm (1/4 inch) from the surface being surveyed for radioactive contamination.

4. Move the probe slowly over the surface of the area being surveyed, approximately 2 inches per second.
CAUTION

CONTAMINATION AREA

Entry Requirements:

- Personnel Dosimeter/TLQ
- Radiological Work Permit (RWQ)

[Image of a warning sign and a yellow barrel in a snowy area]