



September 28, 2007

TO: Associate Administrator for Program Analysis and Evaluation
Associate Administrator for Institutions and Management
Director, Glenn Research Center

FROM: Assistant Inspector General for Auditing

SUBJECT: Final Memorandum on the Audit of Requirements for Testing Facilities at Plum Brook Station (Report No. IG-07-033; Assignment No. A-06-002-00)

We are providing this final report on our audit of NASA's requirements for the testing facilities at Plum Brook Station, Sandusky, Ohio, for your information and use. Our objective was to determine whether NASA had a requirement for those testing facilities. We initiated this assignment because the Real Property Mission Analysis Team produced a draft report on June 14, 2005, which recommended that NASA assess closing Plum Brook Station and disposing of the property because "there are no prospects to improve the utilization of Plum Brook Station's facilities. . . . There is minimal workload at Plum Brook and no evident prospect for increasing that workload." See Enclosure 1 for details on the audit scope and methodology.

NASA expends approximately \$10.4 million annually to retain testing and storage facilities at Plum Brook Station, including the following five testing facilities, which are composed of 42 structures:

- Space Power Facility (SPF)—A facility with the world's largest space environment simulation chamber. This facility is active.
- Spacecraft Propulsion Research Facility (B-2)—A facility for full-scale, thermal vacuum, high-altitude rocket engine and launch vehicle rocket propulsion testing. This facility is active. NASA spent about \$10 million during fiscal year (FY) 2007 to update the B-2 control room.
- Cryogenic Components Laboratory (CCL) Facility—A facility for research, development, and qualification of cryogenic materials, components, and systems. The facility is not physically complete. The estimated completion date is January 2008.
- Cryogenic Propellant Tank Facility (K-Site)—A facility for multipurpose cryogenic and space simulation. In April 2007, the Assistant Administrator for Infrastructure and Administration directed Glenn Research Center (Glenn) to

completely abandon¹ the K-Site by the end of FY 2007 and either reassign or release the associated support staff because NASA had determined that there was no customer base for the foreseeable future for that facility.

- Hypersonic Tunnel Facility—A facility for testing at Mach 5, 6, and 7 with non-vitiated (clean air) flow. This facility has been mothballed.²

Results

NASA has identified requirements for the SPF, the B-2, and the CCL facility in support of the Constellation Program. In addition, the Constellation Program Test and Verification Office continues to analyze whether additional tests can be done in those facilities.

When we initiated this assignment, the Crew Exploration Vehicle (CEV) Project Office at Johnson Space Center had not yet solidified its testing requirements. However, the CEV Project Office subsequently made plans to use the SPF and the B-2 at Plum Brook Station to conduct testing for the Constellation Program. Specifically, the SPF is scheduled to be used by the Johnson CEV Project Office to conduct environmental testing, and the Constellation Program Test and Verification Office Director stated that the CEV Project Office plans to use the B-2 to conduct stage testing. In addition, the Constellation Program Test and Verification Office continues to analyze whether additional tests can be done in those facilities.

In July 2007, NASA also identified a requirement for the CCL facility. We reported in our “Final Memorandum on Observations on the Review and Approval of Glenn Research Center’s Relocation of the Cryogenic Components Laboratory Facility” (IG-07-027, September 28, 2007), that, when design and construction of the CCL facility began, NASA did not have a valid operational requirement for the facility and, according to Space Act Agreement 10, paragraph III.B.18, the CCL facility was to be put in a standby³ status once completed. However, on July 24, 2007, the Project Manager, Purge and Hazardous Gas Project, in the Launch Systems Project Office at Glenn, provided an “intent to test” memorandum. That memorandum states that the project manager intends

¹ Abandoned: a facility for which there are no plans for future reactivation. All utilities have been secured and disconnected at the first service equipment location outside the facility, the facility has been secured to prevent the pilfering of economically salvageable materials, and all personal property and controlled equipment has been removed and accounted for.

² Mothballed: a facility that has been deactivated and appropriate maintenance measures have been taken to prevent deterioration of its vital or essential systems or placed in protective storage. Total time to deactivate and then to reactivate the facility, including the mothballed period, is expected to exceed 12 months. Utility systems and collateral equipment have been shut down and properly prepared for long term inactivation without significant deterioration and facility interior has appropriate environmental control to prevent significant deterioration. In addition, the facility exterior is inspected on a planned basis and work is accomplished as required to maintain the integrity of the exterior from the elements.

³ Standby: a facility that is temporarily not in use and appropriate maintenance measures have been taken to maintain its vital or essential operating systems in a state of readiness or availability for future use. Total time to deactivate and then to reactivate the facility, including the standby period, is expected to be less than 12 months.

to conduct developmental testing of the Crew Launch Vehicle Upper Stage purge system and hazardous gas detection system starting in January 2008 for 6 months.

NASA does not have any requirements for the other two testing facilities at Plum Brook Station. The Hypersonic Tunnel Facility has been mothballed. The K-Site is being abandoned by the end of FY 2007. We have determined that NASA's decision to mothball the Hypersonic Tunnel Facility and to abandon the K-Site is appropriate and is in accordance with NASA Procedural Requirements (NPR) 8800.15A, "Real Estate Management Program Implementation Manual," September 1, 1998, paragraphs 3.9.4 and 3.9.5.

Glenn maintains 217 other structures at Plum Brook Station, including storage igloos and warehouses; old test facilities, shops, and laboratories; support facilities; and a nuclear reactor complex. Of the 217 structures, 149 structures (68.7 percent) are in active status and not scheduled to close and 68 (31.3 percent) are planned to be demolished, abandoned, or closed. NASA is in the process of decommissioning and demolishing the nuclear reactor complex. Decommissioning and demolition is planned to be completed in FY 2011. We did not audit the requirements for those 217 other structures; we focused on the requirements for the testing facilities.

Given the status of NASA's plans for the testing facilities at Plum Brook Station, we did not make any recommendations and, therefore, management comments were not required. We did, however, provide management a draft of this report for review and comment. Management chose not to provide comments.

Background

As of June 27, 2007, Plum Brook Station consisted of approximately 6,755 acres of Government-controlled land and 259 structures, as follows (see Enclosure 2 for details):

- 42 structures are part of the 5 testing facilities.
- 115 are warehouses or storage igloos for records and spare parts.
- 40 are old test facilities used in the 1950s and 1960s, shops, laboratories, and fuel storage and gas handling facilities.
- 39 are power-related and support facilities.
- 23 are part of the nuclear reactor complex that NASA is in the process of decommissioning and demolishing, which is planned to be completed in FY 2011.

Between FY 2000 and FY 2007, Plum Brook Station testing facilities generated a total of \$13.8 million in revenue from NASA, Federal, and non-Federal customers. The following table shows the status of and the revenue generated by each facility.

Plum Brook Testing Facilities		
<u>Facility Name</u>	<u>Status/Last Used to Support NASA Missions</u>	<u>Revenue Generated since FY 2000 (in thousands)</u>
SPF	Active/October 2005	\$8,134
B-2	Active/August 2002	1,529
CCL facility	Under construction	0
K-Site	Being abandoned in FY 2007	2,817
Hypersonic Tunnel Facility	Mothballed in FY 2006	1,346
Total		\$13,826

Two NASA projects and nine non-NASA organizations lease facilities on Plum Brook Station, which generated revenue of \$251,836 during FY 2007. Specifically, the Environmental Protection Agency, U.S. Department of Agriculture, the U.S. Geological Survey, the Federal Bureau of Investigations, the Ohio Air National Guard, SprintCom (for a cell tower), the U.S. Coast Guard, and the Department of Interior lease office space or land from Glenn at Plum Brook Station. In addition, NASA has 16 leases for buffer land outside the fence with local farmers, companies, and the Erie County Conservation League which generated revenue of \$100,800 during FY 2007. Also, about 1,500 acres are habitats for 16 threatened and endangered species, with 8 Species Management Areas.

CEV Project Office Will Use Testing Facilities

NASA is planning to use the testing facilities at Plum Brook Station to conduct testing for the CEV. Specifically, the Johnson CEV Project Office is planning to use the SPF to conduct environmental testing; the Constellation Program Test and Verification Office is planning to conduct stage testing in the B-2; and the Launch Systems Project Office at Glenn plans to conduct purge system and hazardous gas detection system testing in the CCL facility.

SPF. The SPF is in active status. NASA used the SPF for a total of 36 months since FY 2000, generating \$5.1 million in revenue for Plum Brook Station. The Marshall Space Flight Center last used the facility for solar sail tests during December 2004 through October 2005. Non-NASA organizations used the SPF for 31 months since FY 2000, generating \$3 million in revenue. According to the "Crew Exploration Vehicle (CEV) Propulsion Plan - Volume 1 Development Appendix C: Crew Exploration Vehicle Propulsion Test Facility Assessment" (CEV Propulsion Plan), March 24, 2006, the SPF is fully operational for thermal vacuum testing.

The CEV Project Office at Johnson Space Center is planning to use the SPF for CEV testing. The Johnson CEV Project Office had planned to perform integrated environmental testing at Johnson Chamber A. However, in July 2006, the NASA Administrator decided that the James Webb Space Telescope (JWST) would get priority in Johnson Chamber A. As a result, the Johnson CEV Project Office asked for alternative proposals from the Centers and from contractors because of Chamber A schedule conflicts between CEV and JWST. In response to requirements provided by the Constellation Program Test and Verification Office, the Glenn Programs and Projects

Directorate provided a “round 2” proposal, “Space Power Facility Proposal,” December 15, 2006, to conduct thermal vacuum testing, reverberant acoustic testing, random vibration testing, and electromagnetic interference/electromagnetic compatibility testing at the SPF. As part of that proposal, Glenn proposed constructing a new random/modal vibration facility and a new acoustic vibration facility within the main building of the SPF to meet the statement of work requirements of the Johnson CEV Project Office, at a cost of \$57.3 million.

Once the Johnson CEV Project Office agreed to use the Plum Brook Station SPF, that office’s staff worked with Glenn to prepare a statement of work to be sent to prospective contractors for the construction of the new test facilities specified in Glenn’s round 2 proposal. The draft statement of work revision A, “Vibro-Acoustic Test Capability at Plum Brook Station Space Power Facility (SPF), Building No. 1411,” March 14, 2007, states that the construction needs to be complete and the facility operational by December 1, 2008.

The Agency Operating Plan⁴ submitted on March 15, 2007, notified Congress that NASA planned to provide funding so that the SPF can be prepared for CEV environmental testing.

B-2. The B-2 is in active status. The B-2 is a thermal vacuum chamber designed to conduct stage testing with engine restart; that is, the B-2 can simulate space-like conditions for an extended period of time while allowing the engines on the stage test article to be started, stopped, and restarted. NASA has not used the B-2 in support of a NASA mission since August 2002. NASA projects used the B-2 for a total of 17 months since FY 2000, generating \$726,000 in revenue for Plum Brook Station. The Jet Propulsion Laboratory last used the facility for the Mars Exploration Rover Cold Inflation test, September 2001 through August 2002. Non-NASA organizations used the B-2 for 11 months since FY 2000, generating \$803,000 in revenue.

According to the CEV Propulsion Plan, the B-2 is not in good condition. Specifically, the primary propellant systems and support fluids systems have not been used recently, have gone out of certification, have had little or no maintenance, and are likely in need of end-to-end refurbishment (to include detecting and replacing dead wiring, stuck valving, and compromised piping). The refrigeration system is non-functional and not cost-effective to repair. The operational status of the electrical systems, data systems, and steam lines is not known. Building systems (instrument air, cooling water, etc.) work, but they are not highly reliable and are in marginal repair.

The Upper Stage Engine Project Office at Marshall Space Flight Center had planned to use the B-2 for upper stage (J-2X) engine testing—which the B-2 was not designed for—and issued Technical Task Agreement CLV-J2X-06-004 on October 24, 2006, to Glenn. The Task Agreement directed Glenn to start work on refurbishment and modernization of the B-2. The Task Agreement’s total value was \$171 million through FY 2011, with

⁴ The Agency Operating Plan details the specific amount of appropriated funds that will be spent in the fiscal year to fulfill NASA’s missions and the specific purposes for which the funds will be used.

\$31.8 million to be spent during FY 2007 on designs and plans. After assessing the condition and capabilities of the B-2, the Upper Stage Engine Project Office determined that it was not suitable for J-2X engine testing. The Administrator approved construction of a new engine test stand at Stennis Space Center on May 1, 2007. However, the Upper Stage Engine Project Office authorized the use of \$10 million of Task Agreement funding during FY 2007 to modernize the B-2 control room, which had its original 1960s control systems and no modern automation, such as high-speed or modern data acquisition systems.

The Director, Constellation Program Test and Verification Office, stated that the Constellation Program would fund the refurbishment of the B-2 because it is needed for stage testing. The Director stated that because NASA decided not to close Plum Brook Station, spending \$75 million to \$100 million to refurbish the B-2 so that it can be used for its originally designed purpose—stage testing—was the best option. Stage testing may start in FY 2012. The Director also stated that his office is analyzing the Plum Brook Station testing facilities to determine what additional testing can be done in the B-2 and the SPF.

CCL Facility. As of June 27, 2007, the CCL facility was not physically complete and Glenn planned to put the CCL facility into standby status. The predecessor facility had not been used since FY 1994. However, in July 2007, Glenn determined that the CCL facility would be used in support of the Constellation Program. Specifically, on July 24, 2007, the Project Manager, Purge and Hazardous Gas Project, in the Launch Systems Project Office at Glenn, provided an “intent to test” memorandum. That memorandum states that the project manager intends to conduct developmental testing of the Crew Launch Vehicle Upper Stage purge system and hazardous gas detection system starting in January 2008 for 6 months.

Memorandum IG-07-027 addresses construction of the CCL facility, stating that, as of June 27, 2007, Glenn had no plans to use the new CCL facility once it was operational and did not have a valid operational requirement when Glenn entered into the agreement with the City of Cleveland for the construction of the CCL facility at Plum Brook Station. The Glenn Chief Counsel stated that identifying a mission requirement before constructing the CCL facility was not Glenn’s primary consideration. Instead, the primary consideration was whether NASA could reasonably expect to need the capability of the CCL facility at any point in the future. According to the Glenn Chief Counsel, since Glenn officials could not determine that NASA would never need the CCL facility, they decided that the CCL facility should be constructed.

Memorandum IG-07-027 on the CCL facility did not include any recommendations concerning identifying an operational requirement for the facility because the time for that had passed. However, we did recommend that the CCL facility be inspected to determine the extent of work needed to complete it and that a cost estimate and plan of action for completing the CCL facility be prepared. In addition, we recommended that Glenn prepare a functional requirement statement for any future facility projects. Management concurred with the recommendations.

K-Site. The K-Site was put into standby status in November 2005. According to the CEV Propulsion Plan, many systems at the K-Site are non-functional, the facility structure has severely deteriorated, and operation of the chamber at high vacuum levels has not been achieved. In addition, the control room is antiquated and nearly uninhabitable, and the structure has severe water problems. In an April 3, 2007, memorandum, "Disposition of the Plum Brook Station Cryogenic Tank Facility (K-Site)," the Assistant Administrator for Infrastructure and Administration directed that all buildings at the K-Site be abandoned by the end of FY 2007, stating that "[t]he primary reason for this decision is the lack of any customer base for the foreseeable future for these facilities." The Assistant Administrator directed that all support staff associated with the K-Site be reassigned or released.

Hypersonic Tunnel Facility. NASA determined that it does not have a current or future mission need for the Hypersonic Tunnel Facility. In an August 3, 2006, memorandum, the Associate Administrator for the Aeronautics Research Mission Directorate (ARMD) and the Assistant Administrator for Infrastructure and Administration informed the Glenn Director that ARMD had determined that there was no foreseeable requirement for the facility and that no resources should be spent on it, except to mothball it. NASA and the Department of Defense determined that other facilities, at the Arnold Engineering Development Center and Langley Research Center, will meet their needs.

We appreciate the courtesies and cooperation provided to the staff during this audit. If you have questions, or would like to discuss this matter further, please contact Ms. Catherine M. Schneider, Financial and Institutional Management Director, at 202-358-3789 (e-mail: catherine.schneider@nasa.gov).



Evelyn R. Klemstine

cc:

Deputy Administrator
 Associate Administrator
 Associate Deputy Administrator
 Associate Administrator, Exploration Systems Mission Directorate
 Assistant Administrator for Infrastructure and Administration
 Director, Facilities Engineering and Real Property Division
 Director, Constellation Program Office, Johnson Space Center
 Director, Constellation Program Test and Verification Office, Johnson Space Center
 Manager, Exploration Launch Office, Marshall Space Flight Center
 Manager, CEV Project Office, Johnson Space Center
 Chief Counsel, Glenn
 Director, Plum Brook Station

Scope and Methodology

We performed this audit from November 2005 through May 2006 and from December 2006 through September 2007. We delayed the audit while the CEV Project Office solidified its requirements. We performed this audit in accordance with generally accepted government auditing standards except for the evidence standard. Specifically, we did not validate the information in the study by the Systems Engineering and Institutional Transitions Team (the SEITT Study); the estimated costs to refurbish and modernize the SPF and the B-2; or the estimated costs to construct new facilities.

To assess the condition of the facilities at Plum Brook Station, we reviewed

- “Crew Exploration Vehicle (CEV) Propulsion Plan - Volume 1 Development Appendix C: Crew Exploration Vehicle Propulsion Test Facility Assessment” (Propulsion Plan), March 24, 2006, prepared by the Glenn CEV Project Office;
- the scope of work for Technical Task Agreement CLV-J2X-06-004, October 24, 2006; and
- the Plum Brook Station master building listing as of June 27, 2007.

In addition, we interviewed Plum Brook Station personnel and physically toured the Plum Brook Station facilities.

To determine whether the Constellation Program had established testing requirements, we interviewed personnel in the Constellation Program Test and Verification Office at Johnson; the Propulsion Test Integration Group at Stennis; the Glenn CEV Project Office; the Core Stage Office and the First Stage Office at Marshall Space Flight Center; and the Shared Capabilities Asset Division at NASA Headquarters. In addition, we reviewed the “SSC [Stennis Space Center] Altitude Test Facility Trade Study,” December 5, 2006.

To determine whether other NASA programs had requirements for the SPF and the B-2, we reviewed the Final Report, “Agency Verification Testing Strategies and Issues Study,” issued by the Office of Program Analysis and Evaluation in December 2006.

To evaluate the cost-effectiveness of various alternatives, we reviewed the

- “SSC [Stennis Space Center] Altitude Test Facility Trade Study,” December 5, 2006, which contains cost estimates for the modification of test stands or construction of the A-X Stand at Stennis;
- SEITT Study, which contains cost estimates for annual operating costs of Plum Brook Station and the estimated replacement cost of the B-2;

- Real Property Mission Analysis Team's draft report dated June 14, 2005, which contained estimated cost savings that could be achieved by closing Plum Brook Station (a final report was not issued);
- Technical Task Agreement CLV-J2X-06-004, October 24, 2006, which contains cost estimates for refurbishment of the B-2; and
- Office of Program Analysis and Evaluation Final Report, "Agency Verification Testing Strategies and Issues Study," December 2006, which contains the estimated replacement cost of the SPF and the estimated cost to construct a runway at Plum Brook Station.

In addition, we interviewed the Element Manager for the Upper Stage Engine in the Core Stage Office, the Chairman of the Propulsion Test Integration Group, and the Deputy Director of Projects at Stennis. We also considered management comments provided in response to our draft memorandum on the CCL facility.

The documentation that we reviewed was dated from May 1997 through August 2007. We did not use computer-processed data to perform this audit.

Prior Coverage

During the last 5 years, the NASA Office of Inspector General issued two reports of particular relevance to the subject of this report. Unrestricted reports can be accessed over the Internet at <http://www.hq.nasa.gov/office/org.hq/audits/reports/FY07/index.html>.

"Final Memorandum on Observations on the Review and Approval of Glenn Research Center's Relocation of the Cryogenic Components Laboratory Facility" (Report No. IG-07-027, September 28, 2007)

"Final Memorandum on Observations on the Review and Approval of Glenn Research Center's Relocation of the Altitude Combustion Stand Facility" (ML-07-001, November 2, 2006). The Addendum to that memorandum is also available over the Internet.

Plum Brook Station Facilities and Structures

<u>Type of Structure</u>	<u>Number of Structures</u>	<u>Description</u>
SPF	12	A facility with the world's largest space environment simulation chamber, measuring 100 feet in diameter and 122 feet high. The facility was designed and constructed to test both nuclear and non-nuclear space hardware in a simulated low Earth orbit environment. The SPF is not considered a rocket propulsion asset and has no hot-fire capability.
B-2	14	A high-altitude test facility capable of full-scale rocket engine and launch vehicle system-level tests. The B-2 supports thermal vacuum simulation and engine firing. The engine or vehicle can be exposed for indefinite periods to low ambient pressures, low background temperatures, and dynamic solar heating, simulating the environment the hardware will encounter during orbital or interplanetary travel.
Hypersonic Tunnel Facility	6	Mothballed - A facility for testing at Mach 5, 6, and 7 with non-vitiated (clean air) flow.
K-Site	4	Abandoned - Part of the Cryogenic Complex, the K-Site consists of four structures for multipurpose cryogenic and space simulation.
CCL Facility	6	Part of the Cryogenic Complex, the CCL facility is for research, development, and qualification of cryogenic materials, components, and systems. The facility is under construction and will be put in a standby status once completed.
Reactor Buildings	23	To be demolished.
Storage Igloos	99	Constructed in 1942 and 1943 - used for Plum Brook Station and Glenn storage. Some are locked because they are unsafe, health hazards, or structurally unsound.
Other Test Facilities	21	Test sites used in the 1950s and 1960s.
Shops, Laboratories, Fuel Storage, and Gas Handling	19	Includes carpentry, maintenance, and garages.
Warehouses	16	Some warehouse space is used for storage and some space is rented out; other warehouses are locked due to safety concerns.
Power-Related Facilities	28	Electrical, water, sewer, gas.
Other	11	Includes infrastructure such as fences, gates, incinerator, monuments, open storage, parking, railroads, recreation buildings, roads, and the telephone system.
Total	259	