National Register of Historic Places Continuation Sheet

Name of Property

County and State

Name of multiple property listing (if applicable)

Section number ______ Page ______

SUPPLEMENTARY LISTING RECORD

NRIS Reference Number: 100001460 Date Listed: 8/11/2017

Property Name: Hiwassee Hydroelectric Project (Historic Resources of the TVA Hydroelectric Project)

County: Cherokee State: NC

This property is listed in the National Register of Historic Places in accordance with the attached nomination documentation subject to the following exceptions, exclusions, or amendments, notwithstanding the National Park Service certification included in the nomination documentation.

Signature of the Keeper

8-11-2017
Date of Action

Amended Items in Nomination:

Section 8:

This SLR seeks to clarify the level of significance. The Hiwassee Hydroelectric Project is significant in ENGINEERING at the NATIONAL level. All other areas of significance are at the local and state levels.

MILITARY is hereby deleted as an area of significance. The fact that the industry this project supplied electricity to produced a product that was used for military purposes does not comport with military significance

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The TVA FPO and North Carolina SHPO were notified of this amendment.

DISTRIBUTION:

National Register property file
Nominating Authority (without nomination attachment)

MP-1460

National Register of Historic Places Registration Form

This form is for use in nominating or requesting determinations for individual properties and districts. See instructions in National Register Bulletin, *How to Complete the National Register of Historic Places Registration Form*. If any item does not apply to the property being documented, enter "N/A" for "not applicable." For functions, architectural classification, materials, and areas of significance, enter only categories and subcategories from the instructions.

1. Name of Property

Historic name: Hiwassee Hydroelectric Project
Other names/site number: ______
Name of related multiple property listing:
Historic Resources of the Tennessee Valley Authority Hydroelectric Project
(Enter "N/A" if property is not part of a multiple property listing

2. Location

Street & number: 600 Powerhouse Road
City or town: Murphy State: North Carolina County: Cherokee
Not For Publication: ☐ Vicinity: ☐

3. State/Federal Agency Certification

As the designated authority under the National Historic Preservation Act, as amended,

I hereby certify that this X nomination ___ request for determination of eligibility meets the documentation standards for registering properties in the National Register of Historic Places and meets the procedural and professional requirements set forth in 36 CFR Part 60.

In my opinion, the property X meets ___ does not meet the National Register Criteria. I recommend that this property be considered significant at the following level(s) of significance:

X national **X statewide** **X local**

Applicable National Register Criteria:

X A **___ B** **X C** **___ D**

Patricia B. Ezzell / Sr. Prog. Mgr. + FPO 6-19-17

Signature of certifying official/Title: **Date**

Tennessee Valley Authority

State or Federal agency/bureau or Tribal Government

In my opinion, the property X meets ___ does not meet the National Register criteria.

Kevin Cherry 4/13/2016

Signature of commenting official: **Date**

State Historic Preservation Officer North Carolina Department of Natural and Cultural Resources

Title : **State or Federal agency/bureau or Tribal Government**

4. National Park Service Certification

I hereby certify that this property is:

✓ entered in the National Register

__ determined eligible for the National Register

__ determined not eligible for the National Register

__ removed from the National Register

__ other (explain:) ____________

[signature] 8-11-2017

Signature of the Keeper — Date of Action

5. Classification

Ownership of Property

(Check as many boxes as apply.)

Private:	
Public – Local	
Public – State	
Public – Federal	X

Category of Property

(Check only **one** box.)

Building(s)	
District	X
Site	
Structure	
Object	

Number of Resources within Property
(Do not include previously listed resources in the count)

Contributing	Noncontributing	
2	1	buildings
0	1	sites
3	3	structures
0		objects
5	5	Total

Number of contributing resources previously listed in the National Register ____N/A_____

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6. Function or Use

Historic Functions
(Enter categories from instructions.)
INDUSTRY/PROCESSING/EXTRACTION/ *Energy Facility*
RECREATION AND CULTURE/ *Outdoor Recreation*

Current Functions
(Enter categories from instructions.)
INDUSTRY/PROCESSING/EXTRACTION/ *Energy Facility*
RECREATION AND CULTURE/ *Outdoor Recreation*

7. Description

Architectural Classification
(Enter categories from instructions.)
MODERN MOVEMENT/Streamlined Moderne

Materials: (enter categories from instructions.)
Principal exterior materials of the property: ___Concrete, Steel, Earth, Rock____

Narrative Description
(Describe the historic and current physical appearance and condition of the property. Describe contributing and noncontributing resources if applicable. Begin with **a summary paragraph** that briefly describes the general characteristics of the property, such as its location, type, style, method of construction, setting, size, and significant features. Indicate whether the property has historic integrity.)

Narrative Description

The Hiwassee Hydroelectric Project was constructed from 1936-1940 by the Tennessee Valley Authority (TVA). The primary purpose for construction of the Hiwassee project was for hydroelectric power and flood control. The name Hiwassee comes from the Cherokee word for savanna, or large meadow, which was also given to one of two Cherokee villages along the river.[1] Located in Cherokee County, North Carolina, the Hiwassee Hydroelectric Project straddles the Hiwassee River, which originates in Georgia and flows in a northwest direction through North Carolina and into Tennessee. The Hiwassee Dam impounds Hiwassee Reservoir (also called Hiwassee Lake). The dam has a total capacity of 434,000 acre-feet and a flood-storage capacity of 205,600 acre-feet. Hiwassee Hydroelectric Project has two generator units with a net dependable capacity (the daily average power produced minus the electricity used by the dam itself) of 124 megawatts.[2]

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[1] James Mooney, *Myths of the Cherokee and Sacred Formulas of the Cherokee,* (Nashville, TN.: C and R Elder, 1972), 512.
[2] Tennessee Valley Authority, ñHiwassee Reservoir,ò at webpage http://www.tva.gov/sites/hiwassee.htm accessed August 12, 2015.

INVENTORY

Construction of the Hiwassee Hydroelectric Project began July 15, 1936. The facility was put into operation February 8, 1940. The Hiwassee Hydroelectric Project originally consisted of the dam, powerhouse and control building, and switchyard, which are interconnected and integral to one another (*see Photo 1*). To the south of the dam is a recreational area consisting of picnic tables, campground, a boat ramp, and restrooms. The recreational area was designed in 1940 as part of the TVA mission. The 125-acre nominated area includes all the above structures and buildings, a portion of the Hiwassee Reservoir, and roads that access both the hydroelectric facilities and recreational points of visitation. Hiwassee Dam Access Road enters the property from the west to access the dam, crosses the dam, and continues to the south out of the property boundaries. At that point, it is intersected on the west by Powerhouse Road, which loops around to the north, passed picnic and boat ramp areas before ending below the dam.

1.) Hiwassee Dam, 1940 (Contributing Structure)

The Hiwassee dam (*see Photos 2-5*) is a straight gravity concrete structure 1,287 feet in length.[3] The maximum height of the dam is 307 feet, from the foundation to top of deck. The dam consists of continuous blocks from zero to twenty-seven from the north to south. Blocks zero through eight compose a non-overflow section to the north of the spillway; blocks twenty through twenty-seven compose another non-overflow section, south of the powerhouse intake. The high overflow spillway, 260 feet in length, is located seventy feet to the north of the mid-point of the original riverbed. It has seven (7) radial crest gates measuring twenty-three feet high and thirty-two feet wide. The gates are divided by six-foot-wide concrete piers. The capacity of the spillway is 130,000 cubic feet per second with the reservoir at maximum elevation. The crest is at elevation 1503.5. Additional discharge can be obtained via four (4) steel-lined sluiceways at the base of the spillway. These sluiceways measure 102 inches in diameter. The spillway overflow is contained within training walls at the base of the downstream side of the dam. Energy of discharging water is dissipated in a deep stilling pool above a concrete apron with a weir at the downstream end.[4]

The dam is designed such that each of its blocks is independently stable, without any support from adjacent blocks. The blocks withstand the water pressure, the thrust from spillway piers between the radial gates, and load from the operating bridge on which the 120-gantry crane travels. The downstream face of the dam is on a five-to-one slope, which helps to distribute base pressures. The training walls at the base of the spillway are forty-six feet in height. The south

[3] Commonly, dam design includes a section that permits the overflow of water from the reservoir (the spillway) and other sections that do not allow the passage of water (non-overflow). Together, these sections contribute to the total length of the dam structure that impounds the reservoir. A gravity type dam is one constructed of concrete or stone and uses the sheer weight of the structure to resist the horizontal pressure of the water pushing against it. Gravity dams are designed in sections that are independently stable.

[4] Tennessee Valley Authority, *The Hiwassee Valley Projects, Technical Report No. 5, Volume 1: The Hiwassee Project: A Comprehensive Report on the Planning, Design, Construction, and Initial Operations of the Hiwassee Project*, (Washington, D.C.: United States Government Printing Office, 1946), 31, 37, 41.

wall separates the stilling pool and the powerhouse tailrace, preventing interference during flood discharges.[5]

Atop the dam is a gantry crane for operation of the radial gates and sluiceways. There is a roadway across the top of the dam. It is both a through-traffic road and a maintenance service road for the dam. The roadway accesses isolated farms that would have otherwise required new road construction and a full-width roadway added little cost to the design of the dam, since a roadway was needed for the large gate operation equipment.[6]

2.) Powerhouse, 1940 (Contributing Building)

The powerhouse (*see Photo 6-19*), located on the left (south) bank, is the outdoor type.[7] The powerhouse measures 133 feet wide, 182 feet long, and seventy-six feet high from bedrock to the generator deck. The substructure, below the turbine floor, is of massive reinforced concrete construction. Above this, the superstructure includes the service bay and electrical bay and is constructed of reinforced concrete walls, floor slabs, steel beams, columns, and girders. The powerhouse was designed for two generator units, each served by its own penstock, eighteen feet in diameter. Each penstock is designed for a flow of 4,380 cubic feet per second under a head of 190 feet. The powerhouse was originally installed with one generating unit that consists of a Francis-type turbine rated at 80,000 horsepower at 190-foor head and connected to a vertical-shaft generator rated at 64,000 kilovolt-amperes (57,600 kilovolts) 0.9 power factor, as well as with space for a second, similar unit.[8] The Hiwassee powerhouse was placed into service with one unit operating; the second unit was added in1956. Unit two has been designated with landmark status in the field of mechanical engineering as the first integrated, reversible pump-turbine ever designed and installed.

The powerhouse is a one-story building whose north elevation abuts the dam. Its exterior walls are made of precast blocks or panels that have a textured appearance obtained by using rough-sawed lumber forms, with alternating grain in adjacent blocks. The roof is flat and has metal coping at the roofline. The roof of the powerhouse structure is the generator deck. The use of the outdoor or open-type deck resulted in a savings of $240,000 over the conventional indoor-type powerhouse. Removable steel housing covers each generator. A gantry crane travels on the generator deck parallel to the axis of the dam. The façade (south) contains the main entrance, which is flanked by projecting, wide, concrete pilasters and topped with aluminum lettering spelling out the project name, HIWASSEE. At the east end of the façade are three vented portholes below the roofline. To the west of the main entrance is a shorter one-story wing with a continuous band of fenestration across the façade consisting of alternating three-part, aluminum casement windows and structural glass blocks.

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[5] Ibid., 49-50.
[6] Ibid., 38.
[7] Four of TVAȏs hydroelectric powerhouses (Fort Loudoun, Hiwassee, Watts Bar, and Wheeler) are of the outdoor type, with the tops of the generators extending through the roofline. The units are covered with metal sheathing and are serviced by a gantry crane on the exterior of the powerhouse.
[8] Ibid., 51-52.

The entrance into the powerhouse lobby has original glass and metal doors. The powerhouse lobby interior has plaster wall and ceilings, tile floors, and tile walls. The interior north wall of the lobby has aluminum letting stating, ñ1937- BUILT FOR THE PEOPLE OF THE UNITED STATES OF AMERICA - 1940.ò On the east wall is a viewing window into the control room. The lobby retains original marble water fountains of an elliptical design. Some of the interior walls, as well as the walls of some stairwells, have curved corners.

The womenôs restrooms have tile floors, original tile walls, drop ceiling, and new grey tile wall and shower. The menôs restroom has the original marble partitions. Office spaces have plaster walls and ceilings and new linoleum flooring. Original interior doors are solid metal with a central louvered vent. A conference room has been retro-fitted into the office area with pre-fab partition wall; the room has a carpeted floor, a drop ceiling, and fluorescent light fixtures. On the top floor, there is structural glass block situated between the aluminum windows. The second floor breakroom has linoleum floors and concrete board walls; some spaces have been remodeled with carpet and drop ceilings. The generator room has tile floors and poured concrete and steel structure walls. From this level, the turbine pit is accessed down a short flight of steps.

3. Switchyard and Transmission Lines, 1940 (Contributing Structure)

The switchyard is located on the left bank downstream of the dam. The main generator is connected directly to the low-voltage terminals of the main transformer bank via the oil circuit breaker. The 541-kilovolt switchyard was designed for a future main-and-transfer-bus configuration for ultimate installation of two unites and four transmission lines. All structures are galvanized and fabricated steel. The 154-kilovolt structure was designed for a maximum conductor tension of 6,000 pounds in the 1,400-foot river span and 3,000 pounds for the 400-foot land span. The 44-kilovolt structures were designed for conductor tension of 1,500 pounds, and the 12.5-kilovolt structure, 750 pounds (*see Photos 20 & 21*).[9]

4. Grounds/Picnic Area, ca. 1972 (Non-Contributing Site)

Not original to the reservation, the grounds were developed for public use after the war. These plans were in accordance with TVAôs mission to provide for public visitation to the site. The grounds include sidewalks picnic areas with tables and benches, and boat ramp (*see Photos 22 & 23*).

Maintenance Base - 4 resources (*see Photo 24-26*)

The maintenance base includes four utility buildings/structures:

5. Garage/Shop building ca. 1980 (Non-Contributing Building)

This is a ca. 1980 metal building with a low-pitched gable-front roof of metal has a façade with a large, overhead-tracking, metal door, and a solid metal pedestrian door.

6. Flammable Storage Building ca. 1950 (Contributing Structure)

This is a ca. 1950, two-bay, rectangular building of concrete block with flat roof. The two bays are enclosed with chain-link fence gates for ventilation of the interior; one of the gates is covered

[9] Ibid., 76-77.

with a sheet of solid metal. Next to this structure is an open-air structure covering two large cylindrical tanks and has a gable roof of metal supported by metal posts.

7. Equipment Shed ca. 1980 (Non-Contributing Structure)

This is a ca. 1980 structure with two open-air bays, one enclosed bay of concrete block construction, and one enclosed bay with walls of sheet metal siding, all under a shed roof of metal.

8. Equipment Shed ca. 1980 (Non-Contributing Structure)

This is a ca. 1980 structure with two open-air bays, an enclosed bay of concrete block construction at one end with a large, metal, overhead-tracking door, and a two-bay, open-air lateral addition with a shorter roofline Both sections have shed roofs of metal.

9. Visitor Building, 1955 (Contributing Building)

The visitor building was constructed after the war in 1955. Its exterior walls have brick veneer and vertical wood board siding. The plan is symmetrical with a central breezeway. There are large exposed wood beams supporting the roof, which has wide eaves of wood planking and a hip roof of standing-seam metal (*see Photos 27-29*).

10. Picnic Shelter, 1972 (Non-Contributing Structure)

At the visitor building is a new picnic shelter. This is an open-air structure with five bays divided by wood posts supporting a gabled roof of standing-seam metal on a poured concrete pad (*see Photo 30).*

8. Statement of Significance

Applicable National Register Criteria
(Mark "x" in one or more boxes for the criteria qualifying the property for National Register listing.)

- [X] A. Property is associated with events that have made a significant contribution to the broad patterns of our history.
- [ ] B. Property is associated with the lives of persons significant in our past.
- [X] C. Property embodies the distinctive characteristics of a type, period, or method of construction or represents the work of a master, or possesses high artistic values, or represents a significant and distinguishable entity whose components lack individual distinction.
- [ ] D. Property has yielded, or is likely to yield, information important in prehistory or history.

Criteria Considerations
(Mark ñxò in all the boxes that apply.)

- [ ] A. Owned by a religious institution or used for religious purposes
- [ ] B. Removed from its original location
- [ ] C. A birthplace or grave
- [ ] D. A cemetery
- [ ] E. A reconstructed building, object, or structure
- [ ] F. A commemorative property
- [ ] G. Less than 50 years old or achieving significance within the past 50 years

Areas of Significance
(Enter categories from instructions.)
ARCHITECTURE
ENGINEERING
INDUSTRY
MILITARY
RECREATION

Period of Significance
__1936-1966
____
____

Significant Dates
_1936-1940________
____
____

Significant Person
(Complete only if Criterion B is marked above.)
______N/A_____________
____
____

Cultural Affiliation
______N/A_____________
____
____

Architect/Builder
_Architect:_Tennessee Valley Authority; U.S. Army Corps of Engineers; Wank, Roland; Mock, Rudolph; Bianculli, Mario_________
_Builder:_Tennessee Valley Authority___________
____

Statement of Significance Summary Paragraph (Provide a summary paragraph that includes level of significance, applicable criteria, justification for the period of significance, and any applicable criteria considerations.)

The Hiwassee Hydroelectric Project meets National Register criteria A and C for its historical and architectural significance as an integral part of the Tennessee Valley Authority Hydroelectric Project. The Hiwassee Hydroelectric Project is significant in the expansion of energy for World War II manufacturing and improvement of quality of life through transmission of electricity, control of seasonal flooding, and creation of public recreational facilities. The Hiwassee Hydroelectric Project was one of twenty-five (25) dam sites constructed by the Tennessee Valley Authority (TVA) for the purpose of generating electrical power from, improving navigation of, and controlling seasonal flooding of the river system of the region. The main objective of the 1933 Tennessee Valley Authority Act was the creation of a continuously navigable nine-foot channel from the mouth of the Tennessee River to Knoxville, as well as flood control, power generation, and public benefits. The Hiwassee Hydroelectric Project was TVAȏs second completed tributary storage dam, contributing to the integrated TVA system. It was TVAõs the sixth major construction project and the fourth for which TVAõs staff prepared plans.

The Multiple Property Documentation Form, ñHistorical Resources of the Tennessee Valley Authority Hydroelectric Project, 1933-1979ò identifies the property types of powerhouses, dams, navigational locks and lock control buildings, visitor buildings, recreational buildings, maintenance buildings, and other buildings and structures specifically associated with TVAõs missions of hydroelectric power, flood control, navigation, improvement of quality of life, and recreation. These common property types can be found at the majority of the TVAõs hydroelectric facilities. This collection of identifiable and consistent property types essential to TVAõs multi-faceted mission are associated with important developments in the areas of agriculture, architecture, conservation, engineering, industry, military, and recreation, social history, and/or transportation. At Hiwasee, the specific property types within the proposed boundary convey significance of the project specifically to architecture, engineering, industry, military, and recreation.

For architecture, the Hiwassee project is significant for its Streamlined Moderne style, embodying the TVAõs mission of progress in its economy of adornment, as well as the industry of the machine age. The projectõs significance in engineering is reflected in TVAõs overall plan for an integrated system of river management through site-specific designs tested on scaled models. The significance of the Hiwassee project in industry and military is seen through the supplying of electricity to ALCOA for war-related manufacturing. The Hiwassee project is significant in recreation because of the extensive outdoor opportunities it fostered.

Under criterion C, the Hiwassee Hydroelectric Project is a notable example of the Streamlined Moderne style of the twentieth century. This style is expressed in the design of the dam and the interior and exterior of the powerhouse. Few changes have occurred to the exterior of these structures, and they retain integrity of their original design. The Hiwassee Hydroelectric Project meets the registration requirements set forth in the Multiple Property Documentation Form, Historical Resources of the Tennessee Valley Authority Hydroelectric Project. While the MPDFõs period of significance spans to 1979, in order to include all of the TVAõs hydroelectric and dam projects on the main river and its tributaries, the period of significance for the individual nomination of the Hiwassee project stops at fifty years ago, to include the largest number of historic resources that have been added since 1940.

Narrative Statement of Significance (Provide at least **one** paragraph for each area of significance.)

TVA was created under President Rooseveltõs New Deal program as part of his ñFirst One Hundred Days.ò Roosevelt envisioned ña corporation clothed with the power of government but possessed of the flexibility and initiative of a private enterprise.ò To this end, Congress passed the TVA Act on May 18, 1933.[10] The multi-purpose legislation sought to improve navigation and

[10] ñHistory of the Tennessee Valley Authority,ò at website http://www.policyalmanac.org/economic/archive/tva_history.shtml accessed April 16, 2015.

flood control of the Tennessee River, spur agricultural and industrial development in the Tennessee Valley, and provide for national defense via government facilities in the proximity of Muscle Shoals, Alabama (Sec. 1). The act authorized the TVA Corporation to acquire real estate for the construction of dams, reservoirs, power houses, transmission lines, or navigations projects at any point along the Tennessee River and its tributaries (Sec. 4i).[11]

Congress authorized the Hiwassee Project on August 12, 1935, and TVA followed suit on January 10, 1936. Construction began July 15, 1936. The dam was closed and the reservoir began filling on February 8, 1940. The projectôs first generator was placed in service on May 21, 1940, and construction was completed in December of the same year.[12] The approval for the Hiwassee project actually came before TVA presented its unified development plan to Congress on March 31, 1936. This report recommended the construction of nine main-river dams and three or more tributary storage dams, specially emphasizing the contributions of the latter to flood control and reservoir levels needed to maintain a navigable channel on the Tennessee River. The report named Norris, Fontana, and Fowler Bend, later re-named the Hiwassee project for the river on which it would located. The Hiwassee River was flood prone, causing extensive damage 112 miles downstream at Chattanooga. Thus, management of the Hiwassee River was critical to prevention of financial losses in this major city.[13]

The Hiwassee project required the purchase of approximately 25,000 acres of land in Cherokee County, displacing 261 families. TVA visited 185 families to obtain basic demographic data to aid in their relocation. TVA also was responsible for grave relocation, investigating twenty-two cemeteries with 1,245 graves in the reservoir area. While just three of the cemeteries would be flooded, impoundment would cut off access to ten other sites. A total of 462 graves were relocated, while 109 remained in place, by the wishes of family. TVA performed the work to the standard of the North Carolina State Board of Health[14]

The Hiwassee project entailed the relocation and construction of approximately twelve miles of access highway, three miles of state highways, and seven miles of non-state highways, as well as almost two miles of city streets and three miles of tertiary roads. In the re-building of affected roads, TVA agreed to upgrade and improve the relocated sections to modern standards, with better alignment and greater width. Adjustments were also required for 1.65 miles of Louisville and Nashville rail lines, including an eighty-two-foot bridge. A total of eight bridges totaling 975 feet were also built.[15] The road and bridge improvements provided short-term employment and contributed to an upgrade in local infrastructure, benefitting commerce and quality of life for area residents.

Total land costs for the project amounted to $1,233,071, which included acquisition by fee or condemnation proceedings, flowage easements, and highway relocation. Direct construction

[11] Tennessee Valley Authority Act of 1933, at website http://www.policyalmanac.org/economic/archive/tva_history.shtml, accessed April 16, 2015.
[12] Tennessee Valley Authority, *The Hiwassee Project*, 12.
[13] Ibid., 1-2.
[14] Ibid., 248.
[15] Ibid., 242.

costs, such as labor, materials, equipment, transportation, totaled $10,764,624. Indirect construction costs, including accounting, timekeeping, office supplies, and police service, came to $1,997,834. Design and engineering expenditures, which included salaries and expenses of executive engineers, technicians, and inspectors, amounted to $1,291,728. These amounts plus other categorized costs brought the total project to $16,844,042.[16]

After World War II the planned recreational facilities were finally completed and included a campground, picnic area, and boat launch ramp along the west shore of the lake and east of the dam. A maintenance area was also built to provide upkeep and regular maintenance for the facility and grounds.

Since its construction, the powerhouse has not been significantly altered and retains its original exterior and interior design and detailing. Of particular note is the intact original lobby with its tile floors, walls, and glass and aluminum finishes.

SIGNIFICANCE IN ARCHITECTURE

TVAφs hydroelectric projects were designed to embody its mission for social progress. The goals and achievements of these projects - power production, navigation, flood control, malaria prevention, reforestation, and erosion control ï reached across the Valley region penetrating Americaφs social and economic strata. Architect Roland Wank impressed upon a receptive board of directors that government projects were beholden to their real stockholders, the American taxpayers, and should be open for public viewing. Further, Wank stated that the design of powerhouses should both welcome the public and convey strength in purpose. Thus, TVA powerhouses were designed as massive monoliths with visitor reception areas.[17] A prominently displayed message in every TVA powerhouse would emphasize the project as ñBuilt for the People of the United States of America.ò

The pre-World War II TVA projects exemplify the Streamlined Moderne style, a late version of the Art Deco style popular during this period. Streamlined Moderne was an expression of progress, a particularly important underpinning of the New Deal agenda. Stylistic elements that manifested this ideology include the use of geometric shapes, basic and pure in form, sleek and shiny materials evoking machinery and movement, and restrained décor suggesting an economical design ethic. Streamlined Moderne architecture often emphasized curved forms and horizontal lines, sometime including nautical motifs.

The design of the Hiwassee dam and powerhouse reflects the ñmodernismò that the TVA architects and engineers strived for in the 1930s and early 1940s. The dam was built utilizing the most advanced methods of its time, and the powerhouse was built with Streamlined Moderne characteristics on both its exterior and interior. The Hiwassee powerhouse lobby retains original glazed tiles surfaces, sleek, aluminum handrails, marble water fountains and restroom partitions,

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[16] Ibid., 263-64.

[17] North Callahan, *TVA ï Bridge Over Troubled Waters: A History of the Tennessee Valley Authority*, (Cranbury, NJ: A. S. Barnes and Co., Inc., 1980), 33; and Erwin C. Hargrove, *Pioneers of Myth: The Leadership of the Tennessee Valley Authority, 1933-1990*, (Princeton, NJ: Princeton University Press, 1994), 30-33.

glass and aluminum doors to the exterior, and interior doors of metal with narrow rectangular, louvered insets. These elements express the sleek minimalism of the Streamlined Moderne architectural style.

On the exterior, the powerhouseȇs block form is modern in its utilitarian simplicity. The concrete wall surface is broken into regular blocks with deep seams and given a textured effect from board forms. The treatment emphasizes the rectangular form in its repetition and breaks the massive wall into smaller units on a human scale.

The dam itself embodies progress, in its engineering and its design. Its massive scale represents the immensity of the project, spatially and philosophically. The architectural design of the dam employs smooth surfaces of concrete.

SIGNIFICANCE IN ENGINEERING

The Hiwassee Hydroelectric Project is an integral part of the overall engineering design of the TVA system. Located on the Hiwassee River, the Hiwassee damȇs release provides power to the Apalachia Hydroelectric Project 9.8 miles downstream. Above the Hiwassee dam, the Hiwassee Reservoir forks at the confluence of the Hiwassee and Nottely Rivers. The Hiwassee Hydroelectric Project is provided release from both the Chatuge Dam (Hiwassee River) and the Nottely Dam (Nottely River).

In designing the Hiwassee Dam, TVA conducted model studies at its Norris laboratory to determine the proper design of the spillway apron and the type and location of sluices. Use of a model allowed for study and solution of many engineering problems specific to the site that could not be solved simply mathematically. The Hiwassee model was built on a scale of 1:55.

The spillway model included small, steel shapes covered with sheet metal. A non-overflow section including the powerhouse tailrace was constructed of wood, and a glass panel was installed in place of the right training wall to view the flow of water from the spillway to a point 500 feet below the axis of the dam. Various designs evaluated the effect of erosion produced in a bed of gravel passing through two mesh screens. Researchers were specifically studying whether to install at Hiwassee the Grand Coulee- or Norris-type apron. The Grand Coulee design was a curved bucket. In Hiwassee model tests, six different designs were conducted at discharges of 50,000, 100,000, and 150,000 cubic feet per second; with bucket elevation ranging from 1120 to 1266; and bucket radii from thirty-five to fifty feet. In all combinations, this design proved unsatisfactory: without the bucket being excavated to an excessive depth, this apron type resulted in surging, high velocities below the spillway, and severe erosion downstream.

Some thirty designs were tested using the Norris-type apron, which dissipates energy through the use of a hydraulic jump. These tests were conducted simulating four elevations between 1239.75 and 1258. The distance from the crest to the end of the apron ranged from 330 to 482 feet. In general, these results were more satisfactory than those with the Grand Coulee type apron, in that there was less turbulence below the spillway. At low flows, there was very little erosion, but with higher discharged, erosion effects were severe. Once a satisfactory combination of these factors was achieved, more tests were conducted with the inclusion of four sluices. Maximum discharge through the sluices was 5,000 cubic feet per second. Horizontal sluices proved unsatisfactory; inclined sluices performed well alone and when combined with spillway discharges. The final apron design had a bucket at elevation 1,249 with an end sill located 420 feet below the crest line of the dam. This design resulted in little scour. When fewer than six spillway gates were operating, the best results were obtained when one or more of the center gates was closed unless the sluices were in operation. Also, if the sluice gates were in operation, it was undesirable to discharge through fewer than three spillway gates.[18]

In 1956, TVA installed Unit 2 in the Hiwassee powerhouse. It was the first integrated, reversible pump-turbine ever designed and installed in the country. TVAøs 1956 annual report described the unit:

> ñOperated as a generator, the unit has a capacity of 59,500 kilowatts [when] it is operated as a conventional generatoré .In reverse operation, however, the generator operates as a motor of 102,000 horsepower, turning the turbine which then acts as a pump. As a pump, the unit takes water from the reservoir of Appalachia [sic] Damé and pumps it back up into the Hiwassee Reservoir. In a test operation, the unit pumped 4,000 cubic feet per second against a head of 238 feeté .This operation helps to maintain the head of water for power generation at the project and provides additional water to be run through the Hiwassee turbines.ò[19]

The unit was designated with landmark status in the field of mechanical engineering in 1981.

SIGNIFICANCE IN INDUSTRY

Once placed into operation, the power from Hiwassee Dam was transmitted to ALCOAøs plants at Alcoa, Tennessee, to assist in war-time production. The opening of TVAøs Hiwassee Hydroelectric Project contributed to Alcoa Inc.øs 600 percent production increase and $300 million expansion for war-related manufacturing.[20] The dam was finished in 1940 and by June of 1943 was turning out nearly 277,000 kilowatts of power. Most of that electricity went to the aluminum factories in Alcoa. Following World War II, the majority of Hiwasseeô power continued to be utilized by ALCOA.

SIGNIFICANCE IN MILITARY

The Hiwassee Hydroelectric Project was completed in 1940, and much of its electricity went to industries essential to the military during World War II. The Hiwassee switchyard distributed 154-kilovolt current to the Apalachia facility and to ALCOA.[21] At the nationøs peak of war-time

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[18] Tennessee Valley Authority, *The Hiwassee Project*, 323-27.
[19] Edward A. Ackerman, and George O.G. Lof, *Technology in American Water Development – 2nd ed.*, (NYC: Earthscan, 2011), 250.
[20] City of Alcoa, ñAlcoa Inc. Needed Electricity,ò at webpage http://www.cityofalcoa-tn.gov/content/view/full/817 accessed April 14, 2016.
[21] Tennessee Valley Authority, *The Hiwassee Project,* 8.

activity in 1942, the TVA had completed or was in the process of building twelve hydroelectric facilities. Of the 12 billion kilowatt hours of energy produced among the TVA system, 66% was devoted to the war effort.[22]

SIGNIFICANCE IN RECREATION

Following World War II, as middle class American households gained wealth and indoor electricity, a by-product was outdoor leisure time. The TVAõs contribution to recreational activities is noteworthy. The agencyõs hydroelectric projectsô reservoirs attracted outdoor enthusiasts who enjoyed fishing, boating, camping, and hiking in the environs the TVA helped create, re-forest, and conserve.

The mountain setting of Hiwassee Reservoir is idyllic, yet its isolated location and lack of major access roads restricted its potential development as a recreational center. Additionally, Hiwassee Reservoir is subject to a maximum fluctuation of eleven feet in water level. These factors informed TVAõs preliminary studies for recreation planning at the site. TVA planned the grounds of the Hiwassee project site to include landscaping and minimal visitor facilities knowing that visitation would be limited until region growth occurred. Accommodations included parking above and below the dam, a reception lobby within the powerhouse, and a Visitor Building on the right bank above the dam. Records indicate that 29,000 visited the Hiwassee dam in 1939 (while that same year, 800,000 visited Norris and more than 100,000 visited Guntersville, Wilson, and Chickamauga each).[23]

TVA provided planning assistance to the city of Murphy, North Carolina, in recreational development. There were plans for several public recreation areas on TVA shores of Hiwassee Reservoir. Plans included a municipal park with tennis courts, picnic areas, badminton and shuffleboard courts, and parking space. Another project was a public boat dock on U.S. Forest Service-managed land. A small dam would be built on Persimmon Creek, an arm of Hiwassee Reservoir, in order to establish a seventy-acre recreational lake with a constant water level. TVA and the Forest Service would work in cooperation to maintain the Persimmon Creek project as a combination recreational-biological readjustment development for swimming, boating, and raising fish, including small- and large-mouth bass and wall-eyed pike for release into the main reservoir.[24]

[22] Ezzell, ñTennessee Valley Authority in Alabama (TVA).ò
[23] Ibid., 259-60.
[24] Ibid.

SUMMARY

By 1951, the TVA hydroelectric program had resulted in construction of eighteen (18) dams: seven (7) on the Tennessee River and eleven (11) on tributaries. The projects on the main river are: Kentucky, Pickwick Landing, Wheeler, Guntersville, Chickamauga, Watts Bar, and Fort Loudon. Those on tributaries are: Apalachia, Hiwassee, Chatuge, Ocoee No. 3, Nottely, Norris, Fontana, Douglas, Cherokee, South Holston, and Watauga. Total costs for the eighteen dams were more than $600 million.[25]

The Hiwassee Hydroelectric Project was one of twenty-five (25) constructed by the Tennessee Valley Authority (TVA) for the purpose of generating electrical power from, improving navigation of, and controlling seasonal flooding of the river system of the region. The project brought construction jobs and later electricity to the rural area. The Hiwassee Hydroelectric Project brought new opportunities to and spurred economic development in the surrounding counties. The Hiwassee facility is an important component in the vast TVA system of flood control and power generating, as well as contributing to management of river navigation.

The Hiwassee Hydroelectric Project retains much of its integrity from its original design in the 1930s and later improvements in following decades. The dam and powerhouse control building have not been significantly altered, and the control building displays its original Streamlined Moderne design in its exterior and interior detailing. The project continues to be an integral part of the TVA system. The Hiwassee Hydroelectric Project meets the registration requirements set forth in the Multiple Property Documentation Form, ñHistorical Resources of the Tennessee Valley Authority Hydroelectric Project,ò and this MPDF contains additional contextual information concerning TVA and its hydroelectric system.

[25] Tennessee Valley Authority, *Design of TVA Projects Technical Report No. 24, Vol. 1*, (Washington D.C.: Government Printing Office, 1952), 1.

9. Major Bibliographical References

Bibliography (Cite the books, articles, and other sources used in preparing this form.)

Ackerman, Edward A., and George O.G. Lof, *Technology in American Water Development – 2nd ed*. NYC: Earthscan, 2011.

Callahan, North. *TVA ï Bridge Over Troubled Waters: A History of the Tennessee Valley Authority*. Cranbury, NJ: A. S. Barnes and Co., Inc., 1980.

ñEconomic Development.ò At webpage http://www.tva.com/econdev/index.htm. Accessed May 5, 2015.

Ezzell, Patricia Bernard.ñTennessee Valley Authority in Alabama (TVA).ò At webpage http://www.encyclopediaofalabama.org/article/h-2380. Accessed April 22, 2015.

Hargrove, Erwin C. *Prisoners of Myth: The Leadership of the Tennessee Valley Authority, 1933-1990*. Princeton, NJ: Princeton University Press, 1994.

ñHistory of the Tennessee Valley Authority.ò At website http://www.policyalmanac.org/economic/archive/tva_history.shtml. Accessed April 16, 2015.

James Mooney. *Myths of the Cherokee and Sacred Formulas of the Cherokee.* Nashville, TN.: C and R Elder, 1972.

Tennessee Valley Authority, ñHiwassee Reservoir,ò at webpage http://www.tva.gov/sites/hiwassee.htm accessed August 12, 2015.

Tennessee Valley Authority. *The Hiwassee Valley Projects, Technical Report No. 5, Volume 1: The Hiwassee Project: A Comprehensive Report on the Planning, Design, Construction, and Initial Operations of the Hiwassee Project*. Washington, D.C.: United States Government Printing Office, 1946.

Tennessee Valley Authority Act of 1933. At website http://www.policyalmanac.org/economic/archive/tva_history.shtml. Accessed April 16, 2015.

Tennessee Valley Authority. *Design of TVA Projects Technical Report No. 24, Vol. 1*. Washington D.C.: Government Printing Office, 1952.

________. ñNorris Reservoir.ò At webpage http://www.tva.com/sites/norris.htm accessed August 5, 2015.

Previous documentation on file (NPS):

____ preliminary determination of individual listing (36 CFR 67) has been requested
____ previously listed in the National Register
____ previously determined eligible by the National Register
____ designated a National Historic Landmark
____ recorded by Historic American Buildings Survey #____________
____ recorded by Historic American Engineering Record # __________
____ recorded by Historic American Landscape Survey # ___________

Primary location of additional data:

____ State Historic Preservation Office
____ Other State agency
_X_ Federal agency
____ Local government
____ University
____ Other
Name of repository: __Tennessee Valley Authority, Knoxville, Tennessee___

Historic Resources Survey Number (if assigned): CE0118, CE0119_______

10. Geographical Data

Acreage of Property _125 _acres_____________

Use either the UTM system or latitude/longitude coordinates

Latitude/Longitude Coordinates (decimal degrees)
Datum if other than WGS84:__________
(enter coordinates to 6 decimal places)

1. Latitude: Longitude:

2. Latitude: Longitude:

3. Latitude: Longitude:

4. Latitude: Longitude:

Or
UTM References
Datum (indicated on USGS map):

☐ NAD 1927 or ☐ NAD 1983

1. Zone: 16 Easting: 756617 Northing: 3893017

2. Zone: 16 Easting: 757413 Northing: 3893526

3. Zone: 16 Easting: 756866 Northing: 3892716

4. Zone:16 Easting: 756606 Northing: 3893813

Verbal Boundary Description (Describe the boundaries of the property.)

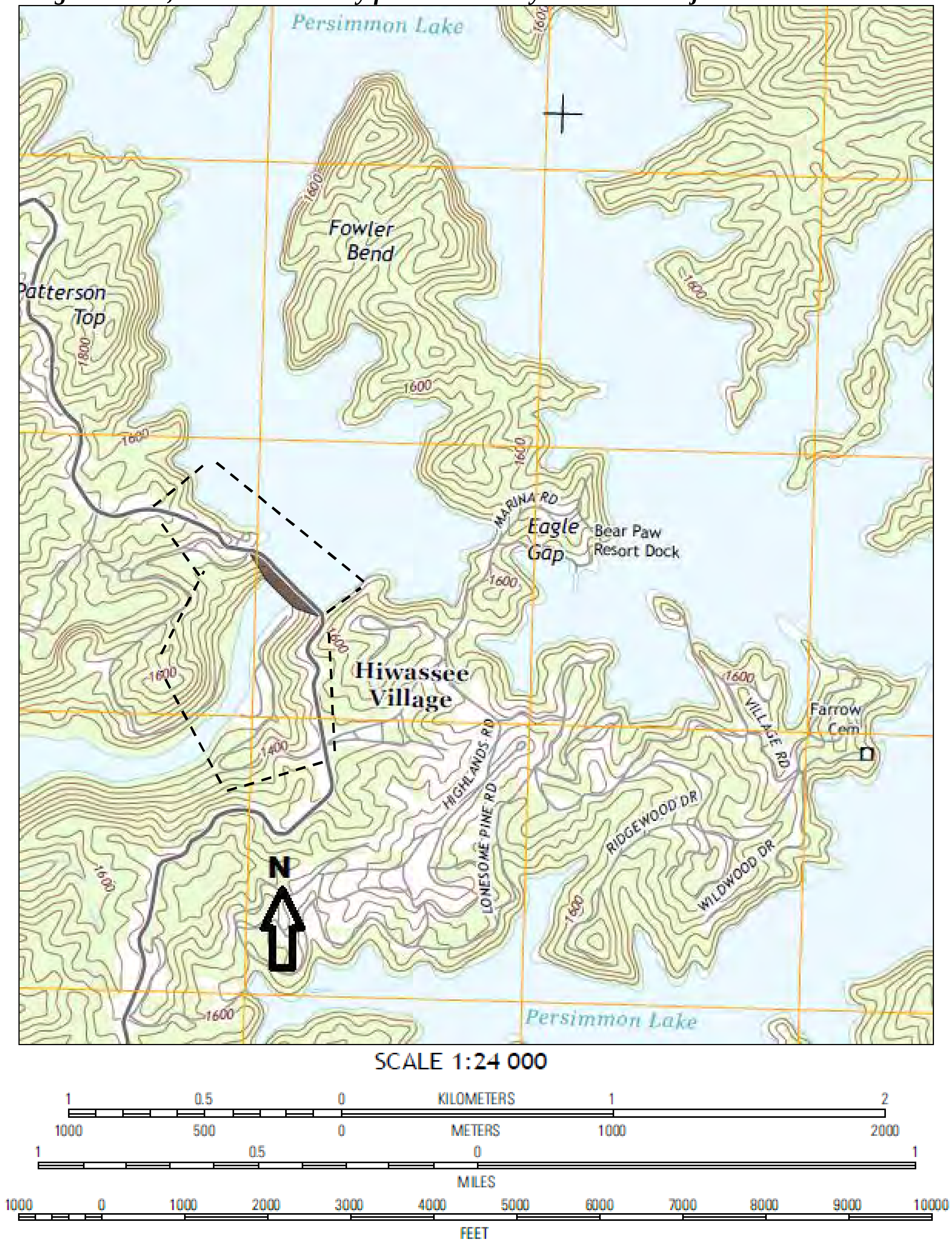
The boundary for the Hiwassee Hydroelectric Project is depicted as a dashed line on the accompanying US Quad map and site plan map. The boundary includes property to encompass the adjacent recreational facilities as well as the immediate environs of the dam and powerhouse.

Boundary Justification (Explain why the boundaries were selected.)

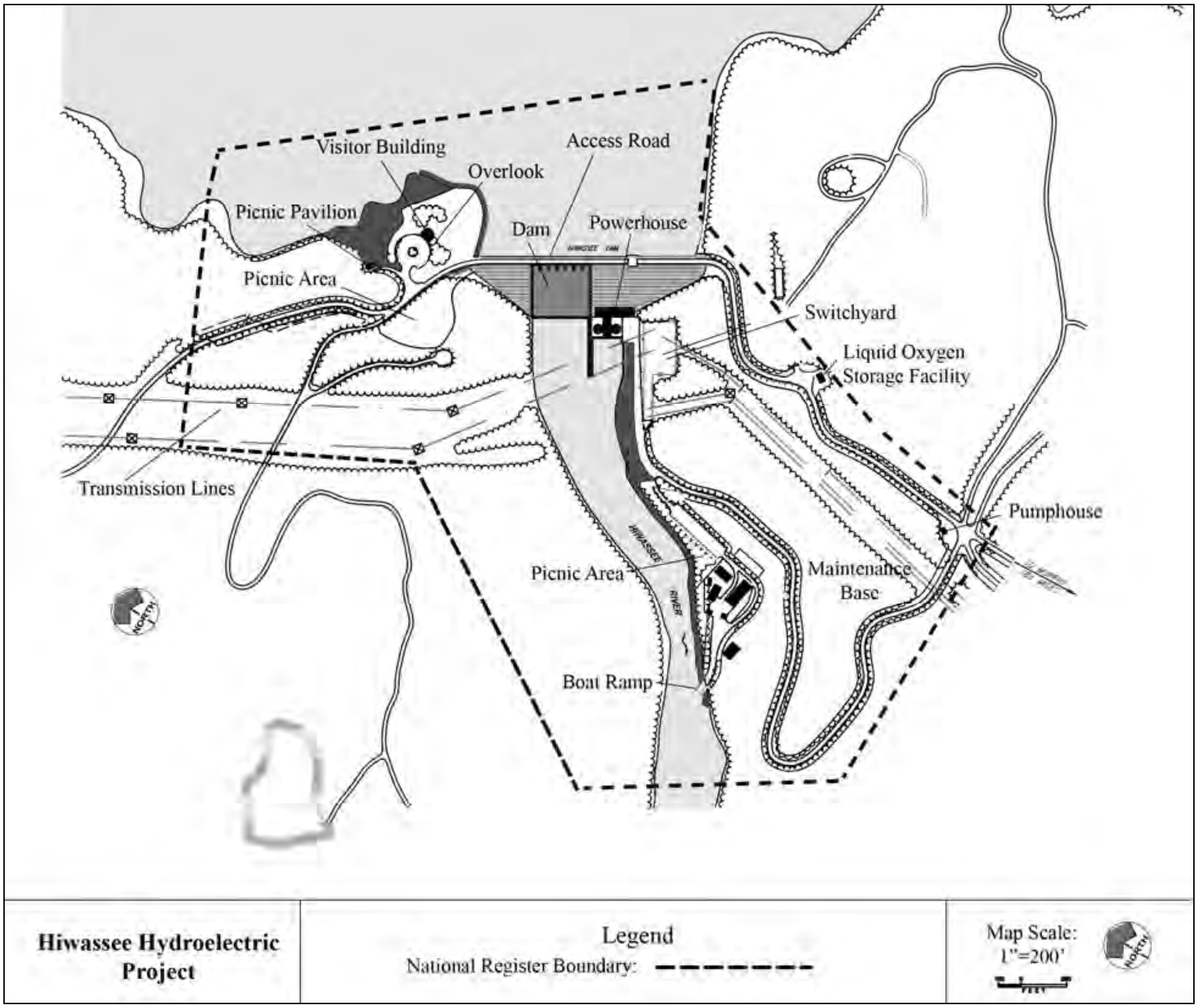
The boundary includes all facilities necessary for the operation of the hydroelectric project and/or associated with the mission of TVA, which includes power generation, navigation, and public recreation. The boundary omits other TVA lands not directly associated with hydroelectric production.

Unaka Quad, USGS Topo Revision 2013 with Hiwassee HydroelectricProject

Enlarged section, with NR boundary for Hiwassee Hydroelectric Project



Site plan and National Register boundary for Hiwassee Hydroelectric Project



11. Form Prepared By

name/title: _ Rebecca Hightower/Andra Kowalczyk Martens/Phil Thomason ___________
organization: __Thomason and Associates
street & number: __P.O. Box 121225
city or town: __Nashville___________ state: _Tennessee____ zip code:_37212____
e-mail__Thomason@bellsouth.net
telephone:__615-385-4960
date: _April 22, 2016

Additional Documentation

Submit the following items with the completed form:

- **Maps:** A **USGS map** or equivalent (7.5 or 15 minute series) indicating the property's location.

- **Sketch map** for historic districts and properties having large acreage or numerous resources. Key all photographs to this map.

- **Additional items:** (Check with the SHPO, TPO, or FPO for any additional items.)

Photographs

Submit clear and descriptive photographs. The size of each image must be 1600x1200 pixels (minimum), 3000x2000 preferred, at 300 ppi (pixels per inch) or larger. Key all photographs to the sketch map. Each photograph must be numbered and that number must correspond to the photograph number on the photo log. For simplicity, the name of the photographer, photo date, etc. may be listed once on the photograph log and doesnðt need to be labeled on every photograph.

Photo Log

Name of Property: Hiwassee Hydroelectric Project

City or Vicinity: Murphy

County: Cherokee State: NC

Photographer: Thomason and Associates

Date Photographed: June 24, 2015

Description of Photograph(s) and number, include description of view indicating direction of camera:

1 of 30 - General View of Hiwassee Dam, looking east.

2 of 30 - Hiwassee Dam, looking northeast.

3 of 30 - Hiwassee Dam, looking southwest.

4 of 30 - North side of Hiwassee Dam, looking southeast.

5 of 30 - Roadway on top of Hiwassee Dam, looking northwest.

6 of 30 - Powerhouse exterior, south entrance, looking north.

7 of 30 - Powerhouse exterior, south elevation, looking northeast.

8 of 30 - Powerhouse exterior, Gantry Crane, looking west.

9 of 30 - Powerhouse exterior, east elevation, looking west.

10 of 30 - Powerhouse exterior, west elevation, looking east.

11 of 30 - Powerhouse exterior, south elevation, looking north.

12 of 30 - Powerhouse interior, lobby north elevation.

13 of 30 - Powerhouse interior, lobby southeast elevation.

14 of 30 - Powerhouse interior, lobby stairwell.

15 of 30 - Powerhouse interior, restroom.

16 of 30 - Powerhouse interior, office corridor.

17 of 30 - Powerhouse interior, break room.

18 of 30 - Powerhouse interior, generator governor cabinet.

19 of 30 - Powerhouse interior, generator ground floor.

20 of 30 ï Switchyard, looking southeast.

21 of 30 ï Transmission Lines, looking northwest.

22 of 30 - Picnic Area, looking north.

23 of 30 - Picnic Area, looking southeast.

24 of 30 - Maintenance Base, equipment shed and garage, looking north.

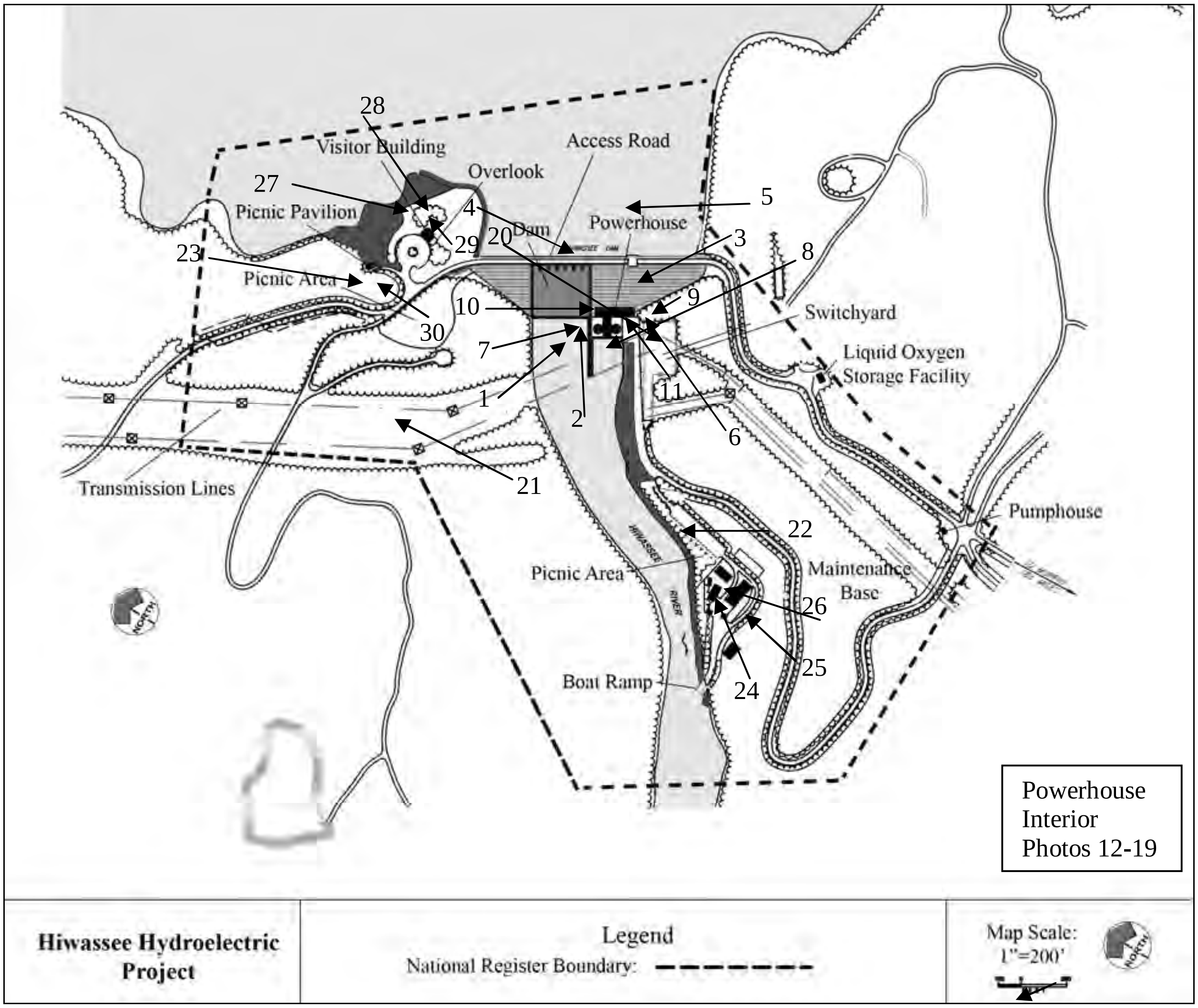
25 of 30 - Maintenance Base, main building, looking north.

26 of 30 - Maintenance Base, pesticide storage building, looking north.

27 of 30 - Visitor Building, looking east.

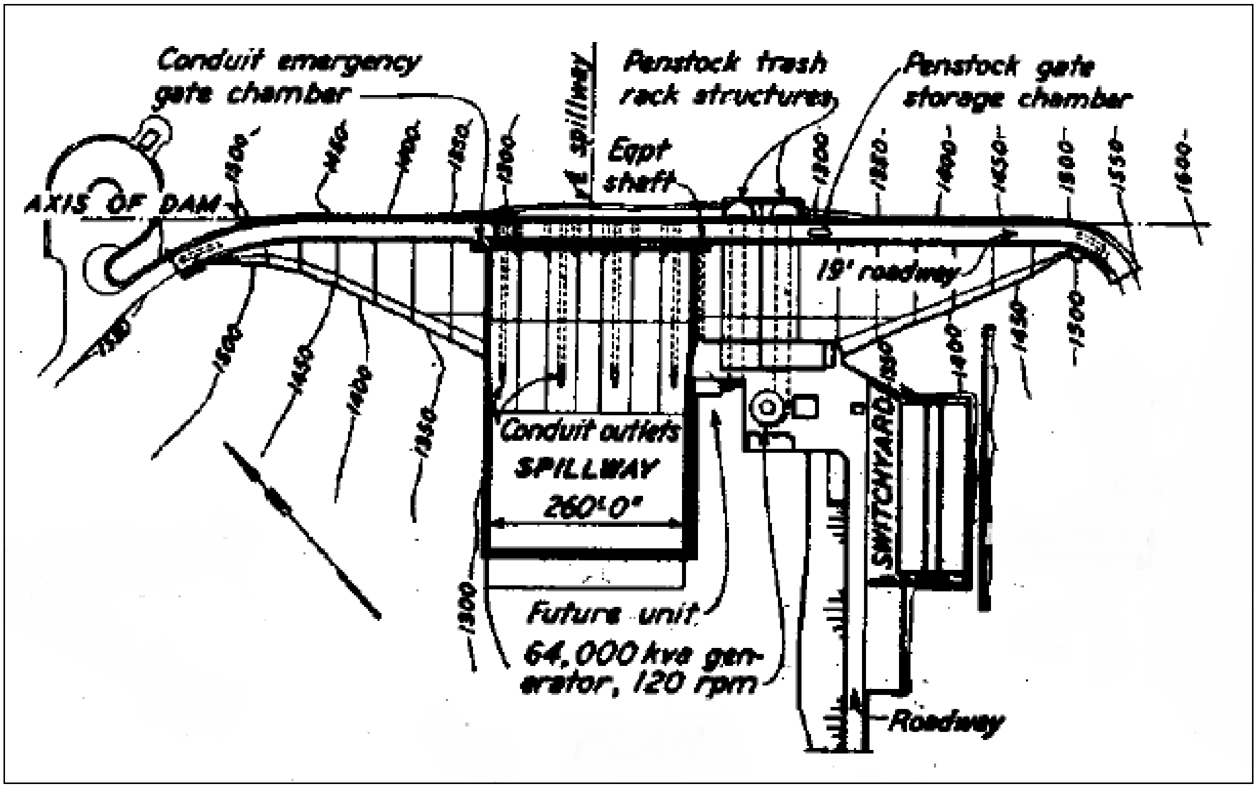
28 of 30 - Visitor Building, looking south.

Photo Key Map:

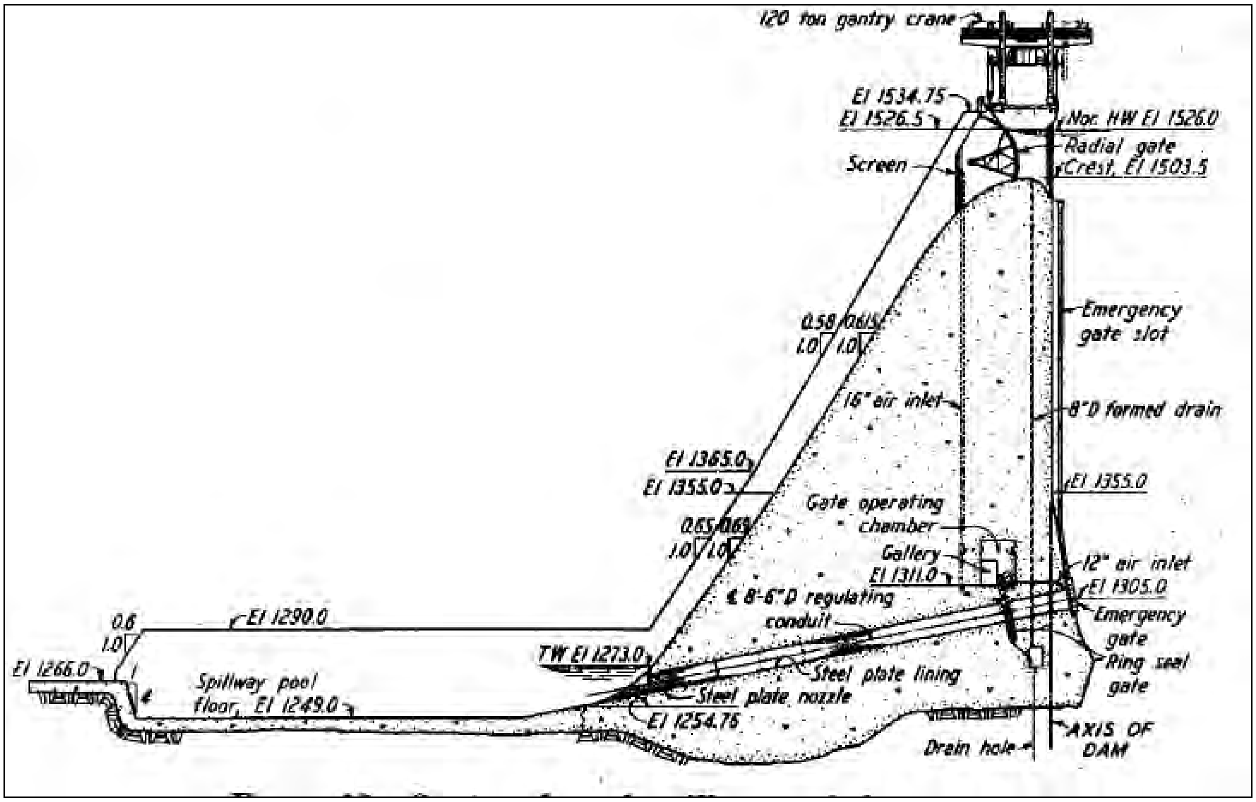


Site Plans

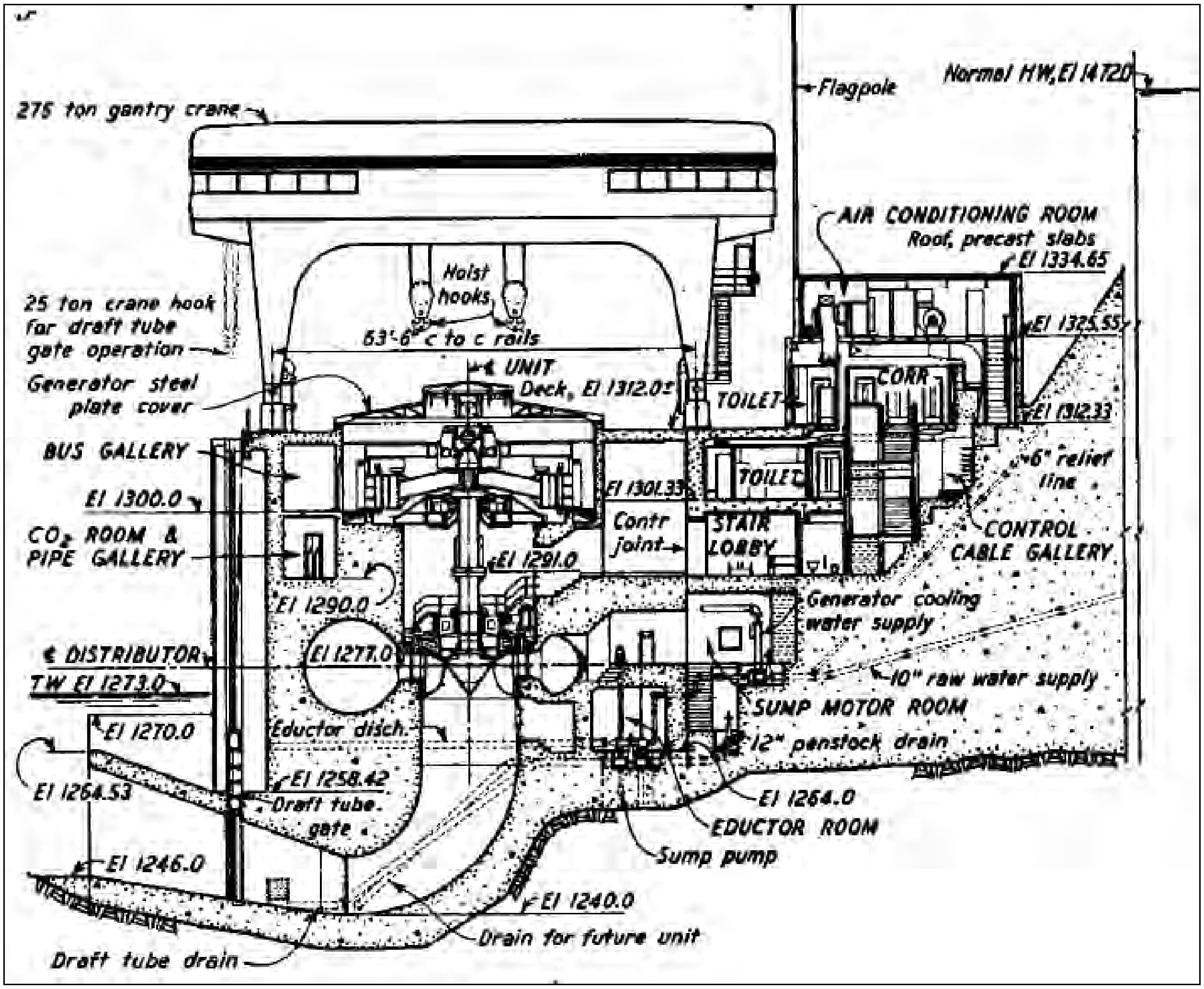
Plan of Hiwassee Hydroelectric Project.



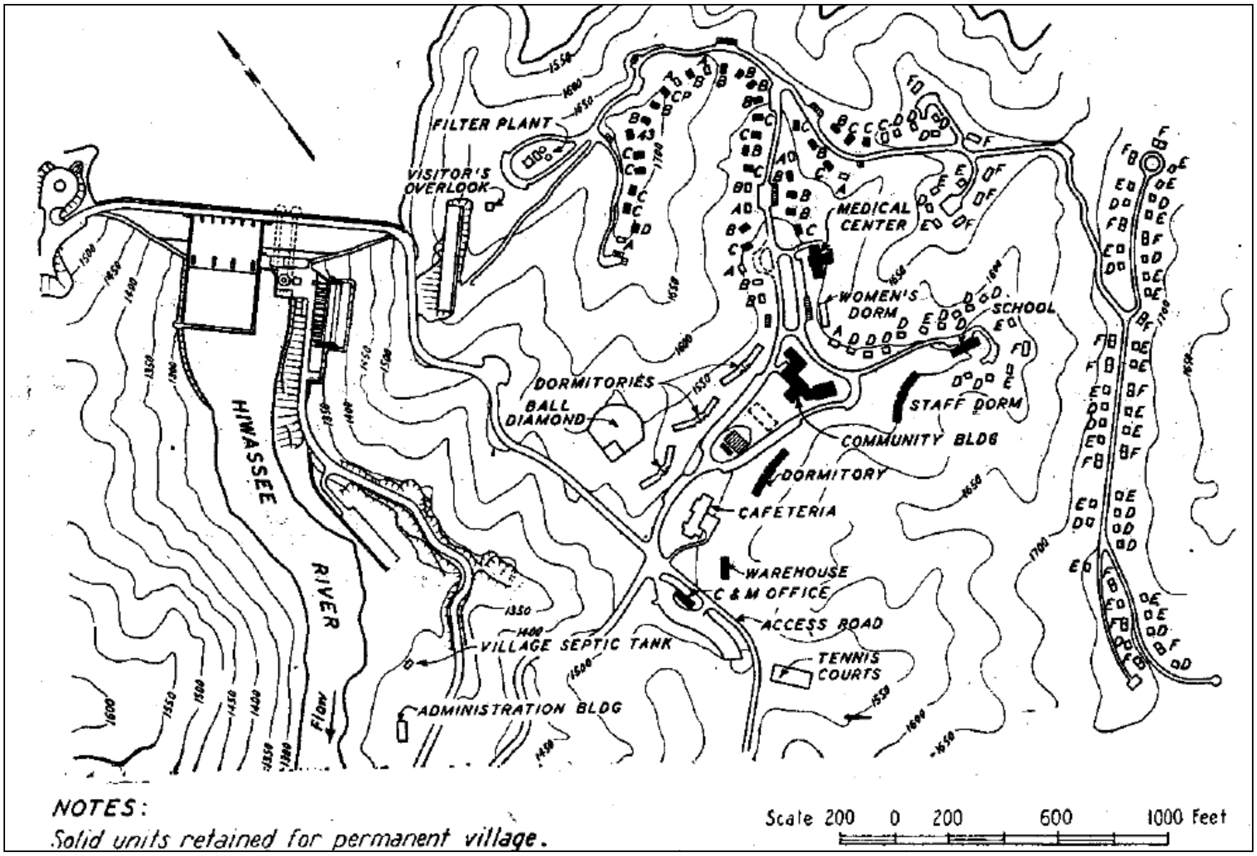
Section through spillway and sluiceway



Transverse section through the powerhouse



Plan of Hiwassee Village



Property Owner:

(This information will not be submitted to the National Park Service, but will remain on file at the Tennessee Historical Commission)

Name: Tennessee Valley Authority ï Pat Ezzell

Street & Number: 400 West Summit Hill Drive 460WT7D-K Telephone: 865-632-6461

City or Town: Knoxville State/Zip: TN 37902

Paperwork Reduction Act Statement: This information is being collected for applications to the National Register of Historic Places to nominate properties for listing or determine eligibility for listing, to list properties, and to amend existing listings. Response to this request is required to obtain a benefit in accordance with the National Historic Preservation Act, as amended (16 U.S.C.460 et seq.).

Estimated Burden Statement: Public reporting burden for this form is estimated to average 100 hours per response including time for reviewing instructions, gathering and maintaining data, and completing and reviewing the form. Direct comments regarding this burden estimate or any aspect of this form to the Office of Planning and Performance Management. U.S. Dept. of the Interior, 1849 C. Street, NW, Washington, DC.


HIWASSEE


TVA
Hiwassee Dam
ESKOLA ROOFING.COM


EL. 1312
WARNING


NOTICE


1937 BUILT FOR THE PEOPLE OF THE UNITED STATES 1940
NO EXIT

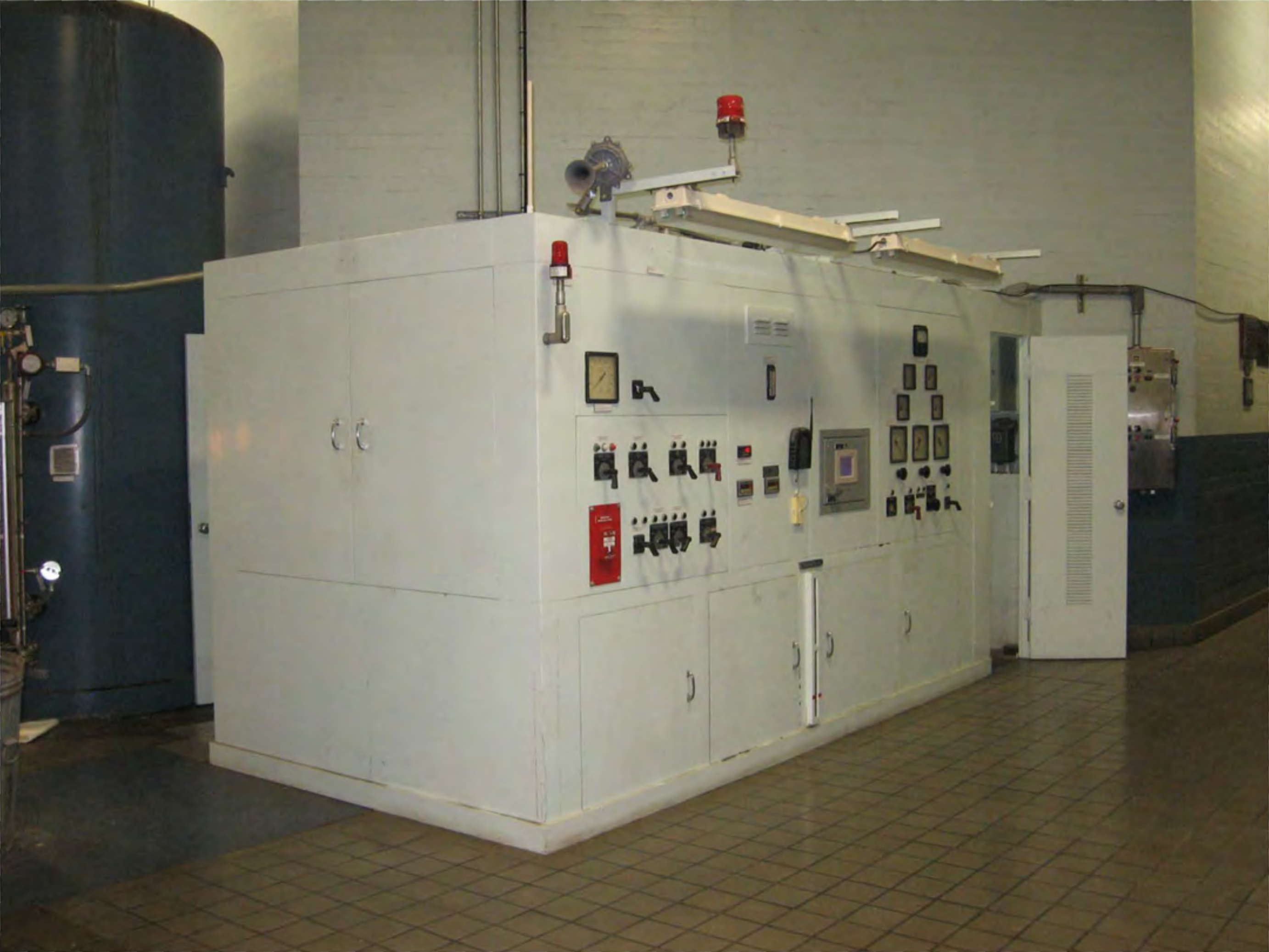

EXIT


WORK
THE PROMISE
WE MAKE TO
EACH OTHER
SAFE


FIRE
EXTINGUISHER


EXIT


EXIT




DANGER
STOP
JLG


NOTICE
TVA
Facilities
Maintenance Base
TVA
PESTICIDE
STORAGE AREA


Welcome


CAT

National Register of Historic Places
Memo to File

Correspondence

The Correspondence consists of communications from (and possibly to) the nominating authority, notes from the staff of the National Register of Historic Places, and/or other material the National Register of Historic Places received associated with the property.
Correspondence may also include information from other sources, drafts of the nomination, letters of support or objection, memorandums, and ephemera which document the efforts to recognize the property.

UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

NATIONAL REGISTER OF HISTORIC PLACES
EVALUATION/RETURN SHEET

Requested Action:	Nomination
Property Name:	Hiwassee Hydroelectric Project
Multiple Name:	Tennessee Valley Authority Hydroelectric System, 1933-1979 MPS
State & County:	NORTH CAROLINA, Cherokee

Date Received:	Date of Pending List:	Date of 16th Day:	Date of 45th Day:	Date of Weekly List:
6/30/2017	7/27/2017	8/11/2017	8/14/2017	

Reference number:	MP100001460
Nominator:	State

Reason For Review:

__ Appeal	__ PDIL	__ Text/Data Issue
__ SHPO Request	__ Landscape	__ Photo
__ Waiver	X National	__ Map/Boundary
__ Resubmission	__ Mobile Resource	__ Period
__ Other	__ TCP	__ Less than 50 years
	__ CLG	

X Accept ____ Return ____ Reject **8/11/2017** Date

Abstract/Summary Comments:	Meets registration requirements of MPS. National significance for ENGINEERING only; not significant militarily
Recommendation/ Criteria	Accept / A & C

Reviewer Jim Gabbert Discipline Historian

Telephone (202)354-2275 Date

DOCUMENTATION: see attached comments : No see attached SLR : **Yes**

If a nomination is returned to the nomination authority, the nomination is no longer under consideration by the National Park Service.

Thomason&Associates
preservation planners

June 21, 2017

Paul Loether
National Register of Historic Places, Keeper
Mail Stop 7228
1849 C Street NW
Washington, D. C. 20240

Dear Mr. Loether,

The Tennessee Valley Authority (TVA) contracted with Thomason and Associates, Preservation Planners to complete nominations to the National Register of Historic Places (NRHP) for twenty-five of its hydroelectric projects. Three nominations - for the Norris, Guntersville, and Wheeler Hydroelectric Projects - were previously submitted, resulting in listing in the NRHP in 2016. The TVA proposes the nomination of the remaining twenty-two hydroelectric projects. The enclosed disks contain the true and correct copies of the nominations of:

Georgia: the Nottely Hydroelectric Project;
Kentucky: the Kentucky Hydroelectric Project;
North Carolina: the Apalachia, Chatuge, Fontana, and Hiwassee Hydroelectric Projects; and
Tennessee: the Boone, Cherokee, Chickamauga, Douglas, Fort Loudoun, Fort Patrick Henry, Melton Hill, Nickajack, Normandy, Ocoee No. 3, Pickwick Landing, South Holston, Tellico, Tims Ford, Watts Bar, and Watauga Hydroelectric Projects.

The overall context for these nominations, the MPDF "Historic Resources of the Tennessee Valley Authority Hydroelectric System, 1933-1979" was approved by your office on March 12, 2016. The enclosed nominations have been reviewed by TVA as well as the respective State Review Boards and enclosed are the twenty-two physical signed copies of the signature pages of each nomination. All local governments have been notified of the intent to list these hydroelectric projects in the National Register.

We are pleased to submit these nominations to you which recognize the diverse history and contributions made by the Tennessee Valley Authority to our nation.

Please contact me if any additional information is needed.

Sincerely,

Philip Thomason
Principal

cc. Pat Ezell, Senior Program Manager, TVA

Enc/

TVA

Tennessee Valley Authority, 400 West Summit Hill Drive, Knoxville, TN 37902

August 9, 2017

Mr. Paul Loether
National Register of Historic Places, Keeper
Mail Stop 7228
1849 C Street NW
Washington, D. C. 20240

Dear Mr. Loether,

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- North Carolina: the Apalachia, Chatuge, Fontana, and Hiwassee Hydroelectric Projects; and
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Please contact me if any additional information is needed.

Sincerely,

Pat Bernard Ezzell

Patricia Bernard Ezzell
Federal Preservation Officer
Communications

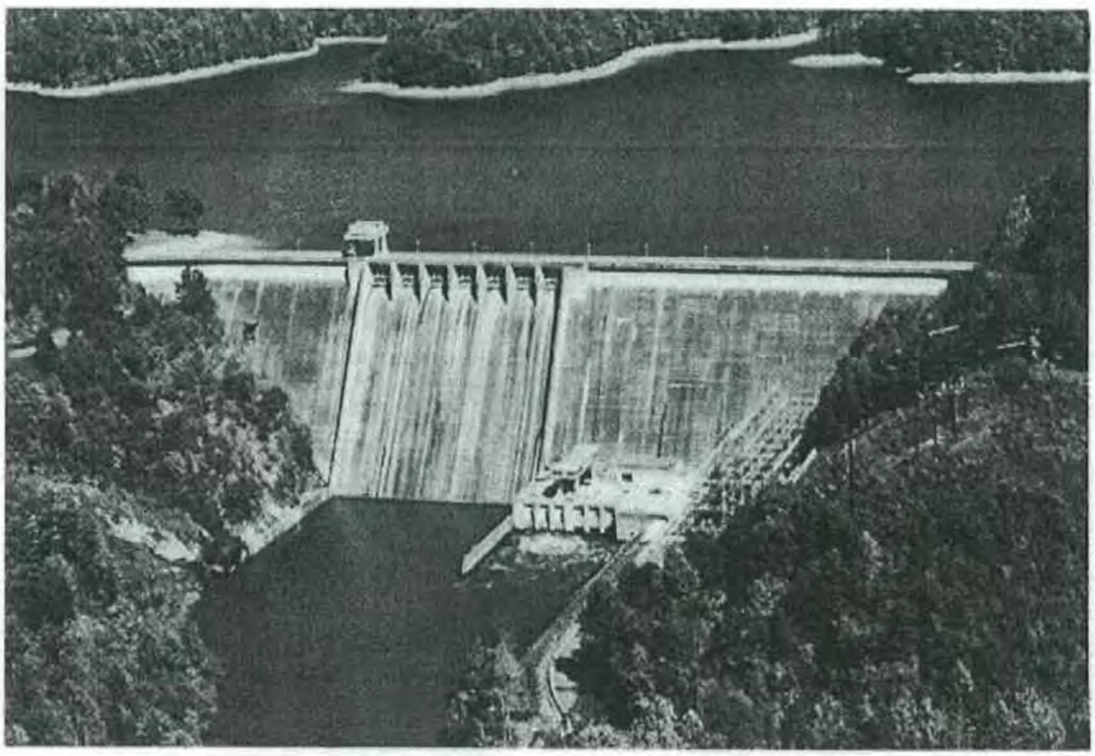
Enclosures

Added to file 8.11.2017 JG.

TVA
Tennessee Valley Authority

HIWASSEE DAM UNIT 2 REVERSIBLE PUMP-TURBINE (1956)

A National Historic Mechanical Engineering Landmark



July 14, 1981
Murphy, North Carolina

ACKNOWLEDGEMENTS

The East Tennessee Section of the American Society of Mechanical Engineers gratefully acknowledges the efforts of those who helped organize the landmark dedication of the Hiwassee unit 2.

The American Society of Mechanical Engineers

Dr. Robert Gaither, *President*
Robert Vogler, *Vice President, Region IV*
J. Karl Johnson, *immediate past Vice President, Region IV*
Sylvan J. Cromer, *History & Heritage, Region IV*
Earl Madison, *Field Service Director*

ASME National History & Heritage Committee

Prof. J. J. Ermenc, *Chairman*
R. Carson Dalzell, *Secretary*
R. S. Hartenberg
J. Paul Hartman
R. Vogel, *Smithsonian Institution*

ASME East Tennessee Section

Charles Chandley, *Chairman*
Mancil Milligan, *Vice Chairman*
Larry Boyd, *Treasurer*
Steve Doak, *Secretary*
Guy Arnold

Allis-Chalmers Corporation

James M. Patterson, *Manager, Marketing Services Hydro-Turbine Division*
Lloyd Zellner, *Public Relations*

Siemens-Allis, Inc.

Paul Rieland, *Large Rotating Apparatus Division*

NATIONAL HISTORIC MECHANICAL ENGINEERING LANDMARK
Hiwassee Unit 2 Reversible Pump-Turbine
1956

This integration of pump and turbine was the first of many to be installed in power plant systems in the United States; it was the largest and most powerful in the world.

As a "pump storage" unit in the Tennessee Valley Authority's system it offered significant economies in the generation of electrical energy.

The unit was designed by engineers of the Tennessee Valley Authority and the Allis-Chalmers Company. It was built by Allis-Chalmers Company.

The Hiwassee unit 2 is the 61st landmark designated by the American Society of Mechanical Engineers. For a complete listing of landmarks, please contact the Public Information Department, ASME, 345 E. 47th St., New York, NY 10017.

HIWASSEE POWER PLANT BACKGROUND

The Hiwassee dam and power plant on the Hiwassee River near Murphy, North Carolina, was built by TVA between 1936 to 1940 as a flood control and electrical generating facility. The initial power installation consisted of a single conventional Francis turbine driving a generator with a rating of 57,600 kW, placed in service in May 1940. Space was provided in the powerhouse for later installation of a second unit.

When studies were begun for the installation of a second generating unit in the late 1940's, a reversible pump-turbine was considered. Installation of a pump-turbine was selected to provide additional generating capacity during periods of system daily peak loads, especially during the months of January through March which at that time corresponded to TVA's seasonal peak period. Apalachia Reservoir, immediately downstream from Hiwassee, provided sufficient storage for approximately 27 hours of pumping with the pump-turbine. The pump-turbine selected has a generator rating of 59,500 kW and a pump capacity of 3900 cfs at 205-foot total head (102,000 hp).

The pump-turbine unit was installed and placed in operation in May 1956 after extensive commissioning tests. Performance tests for both pumping and generating operation were made in April 1957, using the Allen salt-velocity method for measuring discharge, and again in March 1958, utilizing Apalachia reservoir for volumetric flow measurement. These tests showed that both the turbine guaranteed efficiency of 88.4 percent and pump guaranteed efficiency of 90.0 percent were met or exceeded.

HISTORICAL SIGNIFICANCE

Hiwassee unit 2 was the first reversible pump-turbine installed in this country solely for the purpose of storing electrical energy in a pumped storage plant. An earlier pump-turbine, installed in 1954 at the Flatiron Power and Pumping Plant in Colorado, was used primarily for irrigation rather than electrical energy storage. It was much smaller than the Hiwassee pump-turbine and had a somewhat specialized design, providing no control of turbine power output.

Pumped storage plants had been in use for electrical energy storage in Europe for some years prior to operation of Hiwassee unit 2. But these plants employed either completely separate motor-driven pumps and turbine-generators or a pump, a turbine, and a generator/motor all on a single shaft. They did not use reversible pump-turbines which are now standard for pumped storage plants.

Finally, there were a few instances of pumps being retrofitted for reverse operation as turbines prior to the introduction of reversible pump-turbines. These machines were designed as pumps and had less-than-optimum performance when operated as turbines.

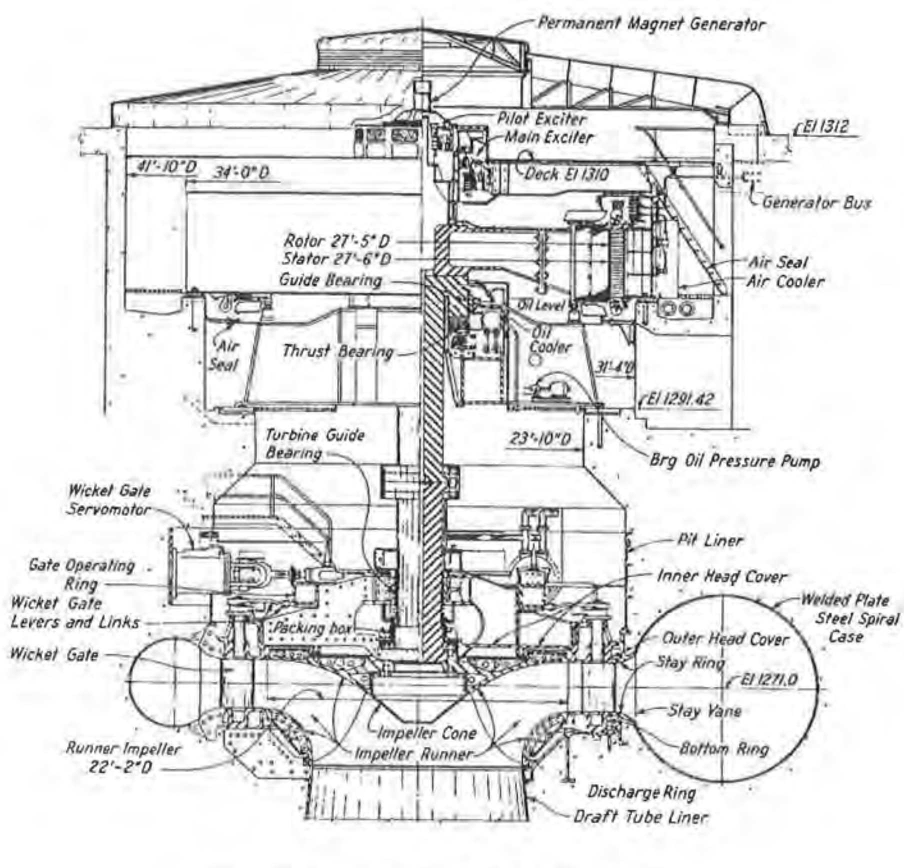
UNIQUE FEATURES

The Hiwassee pump-turbine was the first reversible pump-turbine built and installed in this country using wicket gates for control of turbine output power and improved pump efficiency. The unit also was much larger and more powerful than any reversible pump-turbine in service in the world at the time it went into operation. The rated turbine power output of 80,000 hp was over four times greater than the next largest pump-turbine, installed at the Pederia power plant in Brazil in 1953.

With a diameter of 266 inches, the impeller/runner was the largest water wheel in the world for either a pump-turbine or conventional Francis turbine at the time it was built. The impeller was so large that it had to be shipped in three sections and assembled at the power plant site. Operating as a pump, it had more than three times the capacity of each pump serving the Grand Coulee irrigation project, which then had the world's largest pumps.

CONTRIBUTION TOWARD DEVELOPMENT OF THE NATION

The Hiwassee pump-turbine demonstrated to electric power companies worldwide that reversible pump-turbines could be used in a pumped storage plant to efficiently and economically store electrical energy during periods of low demand to meet peak load demands. Prior to the installation of Hiwassee unit 2, pumped storage plants used separate pumps and conventional turbines for storage and generation. But the size and reversible nature of the Hiwassee unit served as a prototype for design and construction of subsequent pumped storage plants. The 59.5-MW capacity far exceeded the 25-MW ceiling predicted when reversible units were first studied. Larger units meant that pumped storage could better fulfill its promising role in meeting peak demand. The compact physical arrangement also improved opportunities to build pumped storage. Today, reversible pump-turbines have almost completely supplanted the use of separate pumps and turbines in these facilities.



Cross Section of Hiwassee Unit 2 Pump-Turbine

Allis-Chalmers Awarded Contract to Build World's Largest Electric Motor and Reversible Pump-Turbine

Unit Will Serve as Heart Of Pump Storage Project At TVA's Hiwassee Dam

Contracts for the largest electric motor and reversible pump-turbine ever built have been awarded to the Allis-Chalmers Manufacturing Company, according to an announcement by R. M. Casper, manager of the firm's Power department.

The equipment will be the heart of a pump-storage project at Hiwassee Dam in southwestern North Carolina on the Tennessee Valley Authority's power network and is scheduled for completion late in 1955.

Serves Two Purposes

In this installation a single hydraulic machine will operate in one direction as a turbine and in the reverse direction as a pump. A direct-connected electrical machine will serve as a motor for pump operation and as a generator for turbine operation.

When in service, water from the Hiwassee reservoir, driving the unit as a turbine-generator, will add needed energy to the TVA system in peak demand periods. During off-peak periods, when surplus power is available from other plants, the unit will operate as a motor-driven pump to lift water back into the reservoir. It will act, in other words, as a huge storage battery for storing energy.

The project has many unusual aspects. The reversible pump-turbine will utilize the largest Francis type runner ever built. As a turbine it will have a maximum rating of 120,000 horsepower. When motor driven, the unit will have a pumping capacity of 3.3 billion gallons of water per day, or nearly three times as much as New York City requires.

The pump has more than three times the capacity of each of those serving the Grand Coulee irrigation project, which are presently the world's largest.

Motor Rated 102,000 hp

The electrical motor-generator is equally imposing. As a motor it will be the world's largest, rated 102,000 horsepower 106 revolutions per minute. It is approximately 50 percent larger than the motors driving the Grand Coulee pumps. As a generator it is rated 70,000 kva, 13,800 volts.

In a normal cycle of operation, the pump will begin lifting water from Apalachia lake into Hiwassee lake under a head of 135 feet at 5200 cubic feet per second. By the time the upper reservoir is filled, the head will increase to 254.5 feet. The rated pumping capacity will be 3900 cubic feet per second against a 205-ft head.

At the beginning of operation as a turbine, the unit will generate 120,000 horsepower and drop to 36,000 horsepower as the reservoir approaches the low point. Guaranteed efficiencies are 90 percent as a pump and 89.5 percent as a turbine.

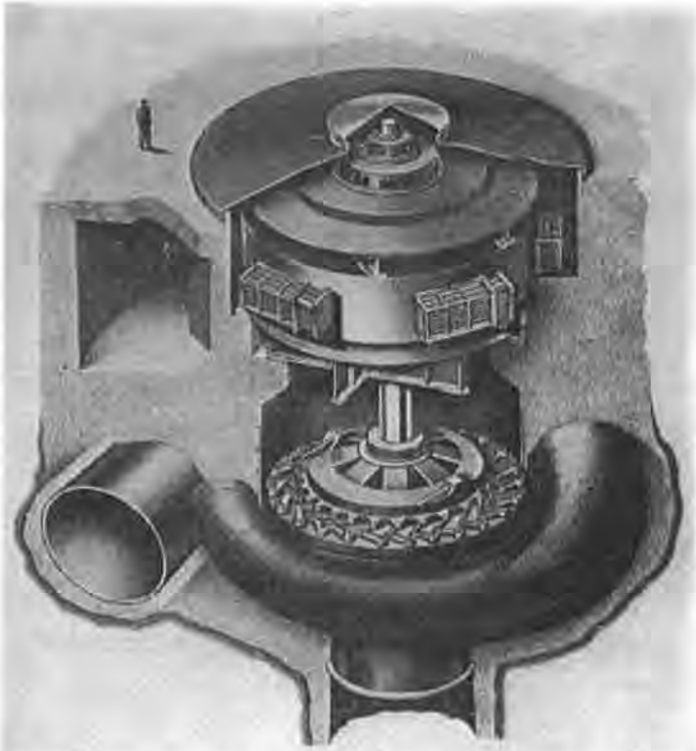
The application of this type of unit is economically feasible and profitable because off-peak power for pumping will cost less and improve the load factor on the system, while the power generated for peak loads will bring in more revenue.

Model tests, standard practice with all new turbine designs, will be made within the next few months at the company's hydraulic laboratory where they will be witnessed and approved by TVA engineers.

A-C is Pioneer of Unit

Allis-Chalmers has pioneered the development of the reversible pump-turbine. In June, 1950, the company conducted a conference on pump-turbines at its West Allis Works which was widely attended by hydraulic and power company engineers. Models of pump-turbines were demonstrated at this conference. Following it, the company obtained contracts for three 19,000-hp reversible pump-turbines for the Sao Paulo Light & Power Company Ltd. in Brazil. These units are now under construction at the Canadian Allis-Chalmers plant in Montreal.

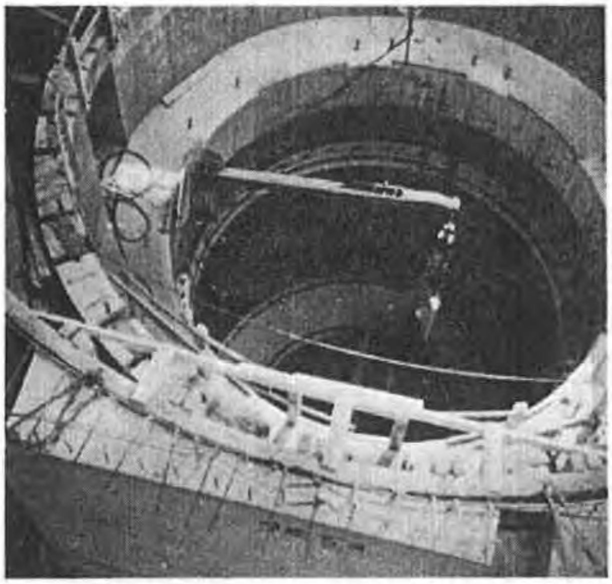
Allis-Chalmers is also building a 12,000-hp reversible pump-turbine for the Flatiron power and pumping plant in Colorado for the Bureau of Reclamation. This unit is under construction at the West Allis Works and is a new development in that it will be run at two speeds. It will have a synchronous generator-motor which will run at 257 rpm as a generator when driven by the turbine and at 300 rpm as a motor when pumping.



This is an artist's drawing of the largest electric motor and reversible pump-turbine ever built. The equipment, which is being built by Allis-Chalmers, will be the heart of a pump-storage project at Hiwassee Dam in southwestern North Carolina on the TVA's power network. It is scheduled for completion in 1955.

Reprint from A-C Sales News, November, 1952

Installing World's Largest Pump-Turbine

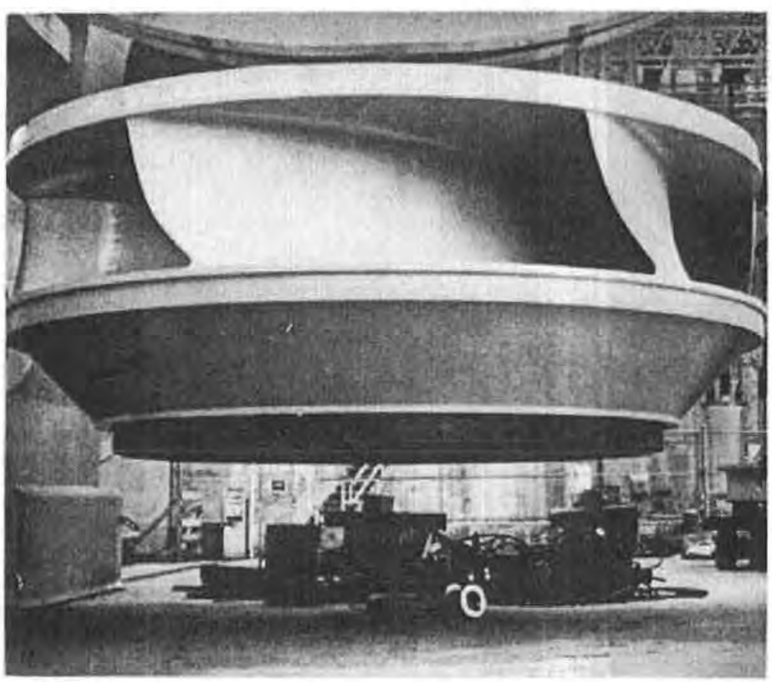


ONE OF 20 wicket gates which will control flow of water from the welded joint scroll case into the runner-impeller is being lowered into place. (FIGURE 3)

by **R. M. LEWIS**
and
R. S. DOMINICK
Service Section
Allis-Chalmers Mfg. Co.

ERECTION of the world's largest reversible pump-turbine at Hiwassee Dam in southwestern North Carolina began when the inlet pipe connection to the original penstock was positioned for welding in November 1954, about 15 years after the first unit went into service at this 307-ft high concrete gravity dam.

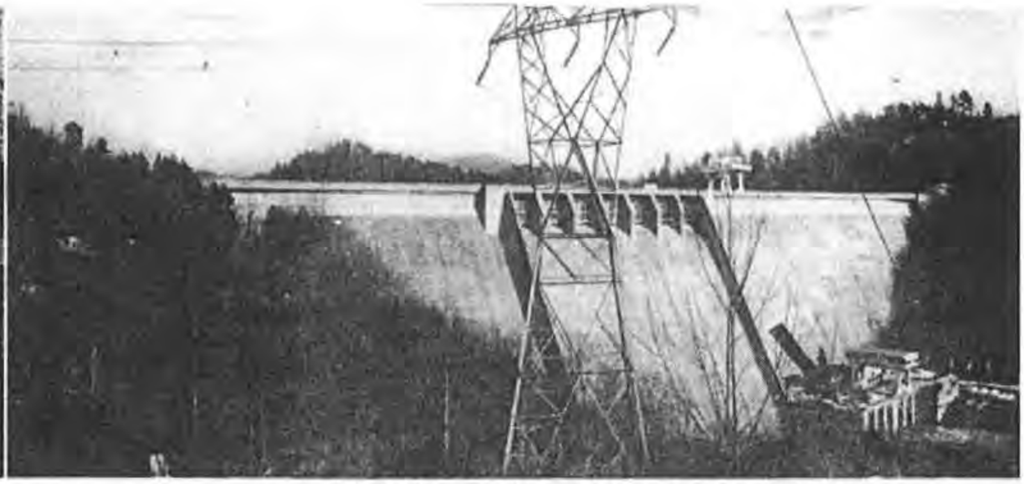
When originally constructed, the dam was built with an open bay adjacent to the 57,600-kw initial turbine-generator. Although this bay was designed to accommodate a unit that would duplicate the first, increasing need for



WHEN WEAR RINGS were fitted onto this 266-inch diameter three-piece runner, strip heaters were used to expand the rings, water spray to contract the runner for the shrink-fit. (FIGURE 4)

FROM THE 18-FOOT diameter penstock, water will fill the scroll case, surround the stay ring and wicket gates. (FIGURE 5)

LOW WATER in Hiwassee Lake during months of high system load will be alleviated by the pump-turbine. **(FIG. 1)**



INSTALLED at the Apalachia Lake side of the powerhouse (see arrow), the pump-turbine unit will lift 3900 cfs of water into Hiwassee Lake or generate 80,000 hp. **(FIGURE 2)**

system peaking capacity during the intervening years made it economically attractive for the Tennessee Valley Authority to install a reversible pump-turbine.*

Vital to any pump-turbine installation is a suction pool or downstream reservoir of sufficient size to permit a pumping cycle. At Hiwassee Dam, the suction pool is Apalachia Lake, with its 58,570 acre-feet of water. Formed by Apalachia Dam, nearly 10 miles downstream on the Hiwassee River, and backing up to Hiwassee Dam, this lake provides controlled storage for 8700 acre-feet of usable water.†

During periods of peak power demand, the pump-turbine will function as a conventional turbine-generator, adding 59,500 kw of rated capacity to the system. During hours of low power demand, especially throughout the season of minimum rainfall, surplus power from the TVA system will be fed into the generator/motor. As a motor-driven pump, rotating in the opposite direction, the unit is rated to pump 3900 cfs from Apalachia Lake back into Hiwassee Lake against a 250-ft head.

In this way, surplus electric power will be stored as additional water in Hiwassee Lake for reuse during the next peak-load period.

As is the case with almost all large, modern hydraulic installations, size restrictions were imposed by shipping limitations. Clearances along rail right-of-ways from Milwaukee to Turtletown, Tenn., required that the scroll case, the stay ring, and even the Francis-type runner of the pump-turbine be shipped in sections. At Turtletown, parts were transferred to low-bed tractor trailers and hauled the remaining twelve miles to the Hiwassee Dam powerhouse. Generator/motor parts were also shipped in sections: the stator in three sections, wound except for a few coils at each parting, and the fabricated rotor spider in three sections. Laminations were stacked and pole faces were attached to the rotor as a part of field assembly.

In 1955 on April 20th scroll case welding was finished and hydrostatic tests were made. Second-stage concreting was started in May, and 82 percent completed by July, when the cofferdam was removed and generator rotor stacking begun.

In February of 1956 erection of the pump-turbine and generator/motor was completed. Electrical and hydraulic tests on the world's largest motor and world's largest pump-turbine were then begun.

* "Pump-Turbines . . . 1954 Progress Report," Frank E. Jaski, "Generator-Motor Units for Reversible Pump-Turbines," H. H. Roth, both in 4th Quarter, 1954 Allis-Chalmers *Electrical Review;* and "Pump-Turbine Addition at TVA Hiwassee Hydro Plant," L. R. Sellers and J. E. Kirkland, Jr., March 1956 *Electrical Engineering.*

† One acre-foot equals 43,560 cubic feet.

BEFORE LIFTING the rotor from the erection bay, the keyway through which the world's largest motor will drive the pump shaft was expanded 0.018 inch by heating. **(FIGURE 6)**

READY FOR INSTALLATION, the 330-inch diameter rotor will be lowered into the 331-inch diameter stator, the expanded keyway mated to the key. **(FIGURE 7)**

CRUSHING STICKS of ¼-inch plywood, held in the ½-inch air gap between the stator and rotor pole faces, assured proper centering of the rotor as it was lowered. **(FIGURE 8)**

HIWASSEE PROJECT

SUMMARY OF PRINCIPAL FEATURES
January 1978

LOCATION

On Hiwassee River at river mile 75.8; in Cherokee County, North Carolina; 13.6 miles upstream from Apalachia Station on Louisville and Nashville Railroad; 20 miles downstream from Murphy, North Carolina; 60 air miles south of Knoxville, Tennessee; 60 air miles east of Chattanooga, Tennessee; 100 air miles north of Atlanta, Georgia.

CHRONOLOGY

Authorized by TVA
  Board of Directors. . . . . January 10, 1936
Preliminary construction, including
  access, started. . . . . July 15, 1936
Stripping of south
  abutment started. . . . . November 21, 1936
First cofferdam started. . . . . July 13, 1937
First concrete placed . . . . April 20, 1938
Reservoir clearance started . . . . October 24, 1938
Last (third) cofferdam unwatered. . . . . . January 3, 1939
River flow diverted through sluiceways . . . April 22, 1939
Reservoir clearance completed. . . . . . December 12, 1939
Concreting by mixer
  plant completed . . . . January 31, 1940
Dam closure (ring seal gates closed). . . . . February 8, 1940
Unit 1 in commercial operation . . . . May 21, 1940
Unit 2 authorized by TVA
  Board of Directors. . . . . September 25, 1951
Unit 2 construction began. . . . . January 4, 1954
Unit 2 in commercial operation . . . . May 24, 1956

PROJECT COST

Initial project, including 1 unit.	$ 16,844,042
Addition of unit 2.	6,356,211
Total, including switchyard	$ 23,200,253

STREAMFLOW

Drainage area at dam:
  Total. . . . . 968 sq. miles
  Uncontrolled (below Chatuge
  and Nottely Dams) . . . . 565 sq. miles
Gaging station discharge records (for
  complete records see Data Services
  Branch files):
  At Hiwassee Dam, September 1934 to
    September 1943; drainage area. . . . . . 968 sq. miles
  Below Apalachia Dam, North Carolina,
    June 1941 to April 1946;
    drainage area . . . . 1,018 sq. miles
  Near Apalachia, Tennessee, January 1914
    to December 1922; drainage area . . . . . 1,038 sq. miles
  Near McFarland, Tennessee, October 1942
    to date; drainage area. . . . . 1,136 sq. miles
Gaging station discharge records (cont.)
  At Reliance, Tennessee, August 1900 to
    December 1913; February 1919 to
    September 1926; drainage area. . . . . . . 1,181 sq. miles
  Near Reliance, Tennessee, October 1926
    to September 1948; drainage area. . . . 1,223 sq. miles
Maximum known flood at dam site,
  natural (1898) . . . . 80,000 cfs
Average unregulated flow at dam site,
  estimated (1901-1969) . . . . 2,040 cfs
Minimum daily natural flow at dam site
  (1925), approx. . . . . 145 cfs

RESERVOIR

Counties affected: State of North Carolina. . . . . Cherokee
Reservoir land at June 30, 1976:
  Fee simple. . . . . 5,834 ac.
  Easements . . . . 31 ac.
  Total. . . . . 5,865 ac.
Operating levels at dam:
  Maximum used for design (153,000 cfs). . . . . . el. 1532
  Top of gates (area 6,230 ac.) . . . . el. 1526.5
  Normal maximum pool (area 6,090 ac.). . . . . . el. 1524.5
  Normal minimum pool (area 2,180 ac.) . . . . el. 1450
Backwater, length at top of gates level. . . . . 22.2 miles
Shoreline, length at top of gates level:
  Main shore. . . . . 161 miles
  Islands. . . . . 2 miles
  Total. . . . . 163 miles
Original river area (to el. 1526 crossing). . . . . . . 1,000 ac.
Storage (flat pool assumption):
  Total volume:
    At top of gates (el. 1526.5). . . . . 434,000 ac.-ft
    At normal maximum
      pool (el. 1524.5). 422,000 ac.-ft
    At normal minimum pool (el. 1450) 128,000 ac.-ft
  Reservation for flood control on:
    January 1 to January 27
      (el. 1526.5-1465) . . . . 270,100 ac.-ft
    March 15 (el. 1526.5-1482). . . . . 216,100 ac.-ft
  Useful controlled storage
    (el. 1526.5-1450) . . . . 306,000 ac.-ft

TAILWATER

Maximum used for design (130,000 cfs). . . . . . . el. 1302.0
Maximum known flood (1936) . . . . el. 1286.0
Full plant operation (2 units). . . . . el. 1276.2
One unit operating at best efficiency. . . . . el. 1275.8
Minimum level . . . . el. 1272.0

HEAD (Gross)

Maximum static (el. 1526.5-1272) . . . . 254.5 ft
Normal maximum operating
  (el. 1524.5-1272.5) . . . . 252.0 ft

HEAD (Gross) (Cont.)

Average operating . . . . . 213.0 ft
Minimum operating (el. 1415-1278) . . . . . 137.0 ft

RESERVOIR ADJUSTMENTS

Clearing below el. 1528 . . . . . 3,270 ac.
Wiring down below el. 1410 . . . . . 569 ac.
Drainage of isolated pools. . . . . 395 cu. yd
Highways:
- Access. . . . . 11.7 miles
- State. . . . . 3.4 miles
- County . . . . . 8.8 miles
- Tertiary . . . . . 3.1 miles
- Total . . . . . 27.0 miles

Railroads . . . . . 1.7 miles
Bridges (highway 11, railroad 3). . . . . 14 bridges
Concrete box culverts. 40
Families relocated. 261
Graves. . . . . 571 agreements; 475 removals
Utilities adjusted or constructed. . . . . 3.0 miles

DAM

Material and type . . . . . Concrete gravity nonoverflow dam and spillway
Lengths:
- Nonoverflow dam . . . . . 1,027 ft
- Spillway . . . . . 260 ft
- Cutoff wall, right (north) bank. . . . . 89 ft
- Total. . . . . 1,376 ft

Maximum height, foundation to deck level. . . . . 307 ft
Maximum width at base:
- Spillway section only. . . . . 240 ft
- Including apron. . . . . 493 ft

Deck level . . . . . el. 1537.5
Outlet facilities:
- Spillway clear opening (7 openings at 32 ft) . . . . . 224 ft
- Spillway crest level . . . . . el. 1503.5
- Crest gates . . . . . 7 radial gates, 32 ft wide, 23 ft high, separated by 6-ft-thick piers
- Traveling crane . . . . . One 120-ton gantry
- Traveling hoist . . . . . One 40-ton hoist
- Sluices. . . . . Four 102-in.-dia. steel-lined outlets with nozzle at outlet end
- Centerline sluice inlet. . . . . el. 1305.0
- Sluice control:
  - Regulating gates . . . . . 4 ring seal gates, screw hoist operated
  - Emergency gate. . . . . 1 roller train lift gate on face of dam, operated by gantry

Spillway discharge capacity:
- HW el. 1532.0. . . . . 130,000 cfs
- HW el. 1526.5 (top of gates) . . . . . 90,000 cfs

Sluice discharge capacity:
- HW el. 1532.0. . . . . 23,000 cfs
- HW el. 1526.5. . . . . 22,000 cfs

Highway . . . . . 19 ft wide on dam
Foundation . . . . . Rock (graywacke)

POWER FACILITIES

INTAKES

Number. 2
Gates . . . . . Two 19-ft-wide by 26-ft-high structural steel gates with roller trains
Hoists . . . . . Two 60-ton fixed hoists under roadway in dam
Trashrack structure . . . . . 2 reinforced concrete semi-circular towers
Steel trashracks. . . . . 160 sections, 2 ft 7 in. wide by 11 ft 3-1/2 in. high
Gross area at racks (per unit). . . . . 3,050 sq. ft

PENSTOCKS

Number. 2
Type . . . . . Riveted steel 3/4 in. to 1-3/8 in. thick
Diameter . . . . . 18 ft
Length . . . . . 217 ft 5 in. for unit 1; 189 ft 9-1/2 in. for unit 2
Air vents . . . . . One 30-in.-dia. for each penstock

POWERHOUSE

Generating capacity, 2-unit total . . . . . 117,100 kW
Type of construction . . . . . Outdoor; reinforced concrete and structural steel
Principal outside dimensions, including service bay . . . . . 190 ft long by 89.5 ft wide by 76 ft high
Service bay . . . . . 54.5 ft by 122 ft
Draft tubes:
- Type . . . . . Elbow, 3 openings
- Horizontal length (centerline of turbine to downstream face) . . . . . 57.0 ft
- Vertical distance from distributor centerline to draft tube floor:
  - Unit 1. . . . . 37.0 ft
  - Unit 2 . . . . . 32.5ft
- Net area at outlet opening:
  - Unit 1 . . . . . 661 sq. ft
  - Unit 2 . . . . . 1,048 sq. ft
- Trashrack at pump unit (unit 2) . . . . . Gross area 1,641 sq. ft; net area 1,321 sq. ft
- Gates . . . . . 1 set of 3 slide gates, 15 ft 4 in. wide by 13 ft high
- Gate hoist . . . . . 25-ton auxiliary hoist on powerhouse gantry

Erecting crane. . . . . 275-ton gantry with two 137-1/2-ton main hooks and two 25-ton auxiliary hoists

HYDRAULIC TURBINE (Unit 1)

Number 1
Manufacturer . . . . . Newport News Shipbuilding and Dry Dock Co.

SUMMARY OF PRINCIPAL FEATURES

HYDRAULIC TURBINE (Unit 1) (Cont.)

Type	Vertical Francis
Rated capacity	80,000 hp at 190-ft net head
Rated speed	120 r/min
Maximum runaway speed	235 r/min
Specific speed at rating	48
Value of sigma at rating	0.141
Diameter of runner, intake	161 in.
Diameter of runner, discharge	165.187 in.
Centerline to bottom of runner	55.375 in.
Centerline to top of runner	21 in.
Diameter of guide vane circle	189 in.
Diameter of lower pit	19.6 ft
Spacing of turbines, center to center of units	62.08 ft
Governors	Woodward, cabinet actuator type
Weight of rotating parts	Approx. 142,000 lb

PUMP-TURBINE (Unit 2)

Number	1
Manufacturer	Allis-Chalmers Manufacturing Co.

	As Turbine	As Pump
Type	Vertical Francis	Centrifugal
Rated horsepower	80,000	102,000
Rated head	190 ft net	205 ft net
Rated discharge	4,180 cfs	3,900 cfs
Rated speed	105.9 r/min	105.9 r/min
Maximum runaway speed	161 r/min	121 r/min
Direction of rotation	Clockwise	Counterclockwise
Specific speed at rating	42.1	121
Value of sigma at rating	0.202	0.185

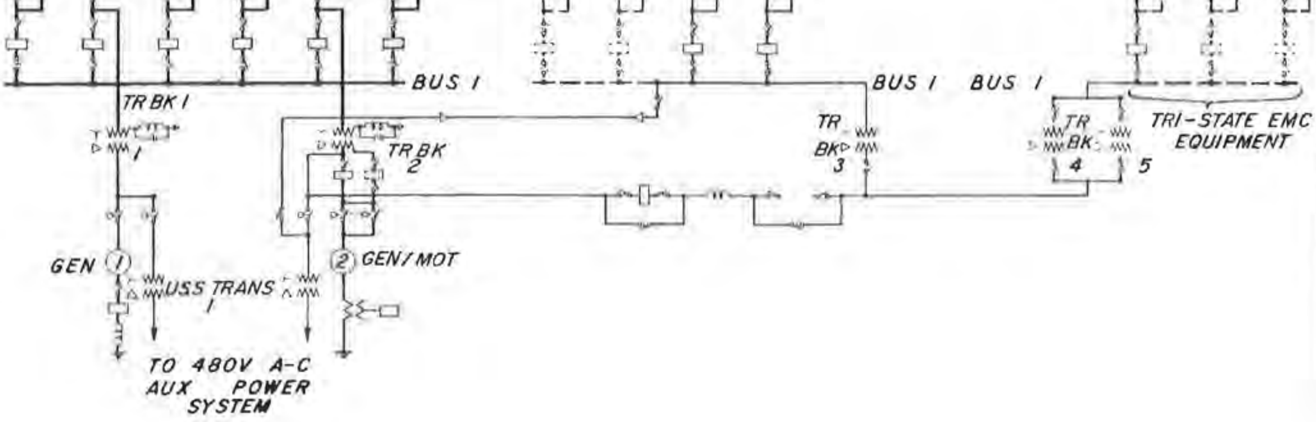
Diameter of runner, intake	266 in.
Diameter of runner, discharge	182 in.
Centerline to bottom of runner	69 in.
Centerline to top of runner	23 in.
Diameter of guide vane circle	312 in.
Diameter of lower pit	30.0 ft
Spacing of turbines, center to center of units	62.08 ft
Governors	Woodward, cabinet actuator type
Weight of rotating parts	Approx. 335,000 lb

GENERATORS

Unit 1 Generator

Manufacturer	Westinghouse Electric Corp.
Type	Enclosed, water-cooled, vertical-shaft; vertical cylindrical concrete wall of housing, and removable weather cover, furnished by TVA
Rating	64,000 kVA, 57,600 kW, 2864 A, 60 degrees C rise, 0.9 pf, 13.8 kV, 3 ph, 60 Hz
Capacity	73,600 kVA, 66,240 kW, 3086 A, 80 degrees C rise

SINGLE LINE DIAGRAM OF MAIN CONNECTIONS



GENERATORS (Cont.)

Efficiency (tested):
At rated kVA, 1.0 pf . . . . 98.34 percent
At 75% kVA, 0.9 pf. . . . . 97.79 percent
Flywheel effect:
Calculated . . . . .60,300,000 $lb\text{-}ft^2$
Tested. .62,900,000 $lb\text{-}ft^2$
Thrust bearing . . . . Kingsbury type, dia. 76 in., max. load 540 tons
Neutral reactor. . . . . .0.97 ohm, 6000 A, 1 min
Exciters:
Main . . . . 275 kW, 250 V
Pilot . . . . 10 kW, 250 V
Weight of heaviest crane lift, rotor . . . . .243 tons
Diameter over air housing, less trim. . . . . .454 in.
Top of pilot exciter:
Above stator soleplates. . . . . .153.75 in.
Above turbine floor. . . . . .273.75 in.

Unit 2 Generator-Motor

Manufacturer . . . . Allis-Chalmers Manufacturing Co.
Type. . . . . Enclosed, water-cooled, vertical-shaft; vertical cylindrical concrete wall of housing, and removable weather cover, furnished by TVA
Rating as generator . . . . . 70,000 kVA, 59,500 kW, 2929 A, 60 degrees C rise, 0.85 pf lag, 13.8 kV, 3 ph, 60 Hz
Capacity as generator. . . . . 80,500 kVA, 68,425 kW, 3368 A, 80 degrees C rise
Rating as motor . . . . 102,000 hp, 80 degrees C rise, 0.95 pf lead, 13.5 kV
Efficiency (guaranteed):
As generator:
At 70,000 kVA, 1.0 pf . . . . 97.7 percent
At 52,500 kVA, 0.85 pf lag. . . . . 96.9 percent
As motor:
At 102,000 hp, 1.0 pf . . . . 97.6 percent
At 88,700 hp, 0.95 of lead . . . . 97.4 percent
Flywheel effect. . . . . .82,818,700 $lb\text{-}ft^2$
Thrust bearing . . . . Kingsbury, dia. 87 in., max. load 683 tons
Neutral transformer . . . . 75 kVA, 14.4 kV-240 V, 1 ph
Exciters:
Main . . . . .350 kW, 250 V
Pilot . . . . 20 kW, 250 V

Unit 2 Generator-Motor (Cont.)
Weight of heaviest crane lift, rotor . . . . 365.8 tons
Diameter inside air housing . . . . 514 in.
Top of pilot exciter:
Above stator soleplates. . . . . 166 in.
Above generator floor . . . . 154 in.

TRANSMISSION PLANT

Step-up transformers:
1 bank of 3 single-phase, 2-winding transformers, bank 1; bank rated 13.2-161 kV, 56,250 kVA self-cooled, 75,000 kVA forced-air-cooled; Moloney
1 bank of 3 single-phase, 2-winding transformers, bank 2; bank rated 6.6/13.2-161 kV, 114,000 kVA forced-oil-air-cooled; 13.2-kV winding tapped at 6.6 kV for starting pump-turbine unit 2; General Electric
Intersystem transformers:
1 3-phase, 2-winding transformer, bank 3; rated 13.2-7.2/12.47 kV, 1500 kVA self-cooled; Westinghouse
161-kV circuit breakers:
3 1200-A, 2,500,000-kVA, 8/60-Hz, sol, Westinghouse
4 1200-A, 3,500,000-kVA, 5/20-Hz, pneu, Westinghouse
14.4-kV circuit breakers:
2 600-A, 50,000-kVA sol, General Electric
Structures:
6 161-kV switchyard bays, 36 ft wide
2 delta bus and transformer structures
1 26-kV future transformer bay, 22 ft wide
2 26-kV transformer bays, 18 ft wide
5 12-kV switchyard bays, 11 ft wide

ELECTRIC CONTROLS

From control room in powerhouse:
Hiwassee generator No. 1 and generator-motor No. 2, transformers, switchyard, sources of auxiliary power, station auxiliaries, and starting of turbine No. 1 and pump-turbine No. 2 by direct control.
Chatuge hydro plant and switchyard by frequency-shift powerline carrier.
Nottely hydro plant and switchyard by frequency-shift powerline carrier.
Murphy primary substation by frequency-shift powerline carrier.
Apalachia hydro plant and switchyard by frequency-shift powerline carrier.

CONSTRUCTION DATA

PERSONNEL

	Dam and Reservoir Construction	Dam Construction Only	Unit 2 Addition
Peak employed	1,600	1,200	128
Total man-hours	7,682,640	5,424,683	468,114
Number of injuries	205	141	6
Days lost	16,509	15,589	2,749
Fatalities	2	2	0
Accident frequency	26.7	26.0	12.82
Accident severity	2,149	2,874	5,873

HOUSING FACILITIES
(Initial Project)

Semipermanent houses built 42
Low-cost houses built 73
Dormitories built:
Staff (48 capacity) .1
Men (416 total capacity) 4
Women (32 capacity) 1

Public buildings constructed included a cafeteria (240 seats), hospital (17 beds), community and recreation building, school, gas station, and observation building.

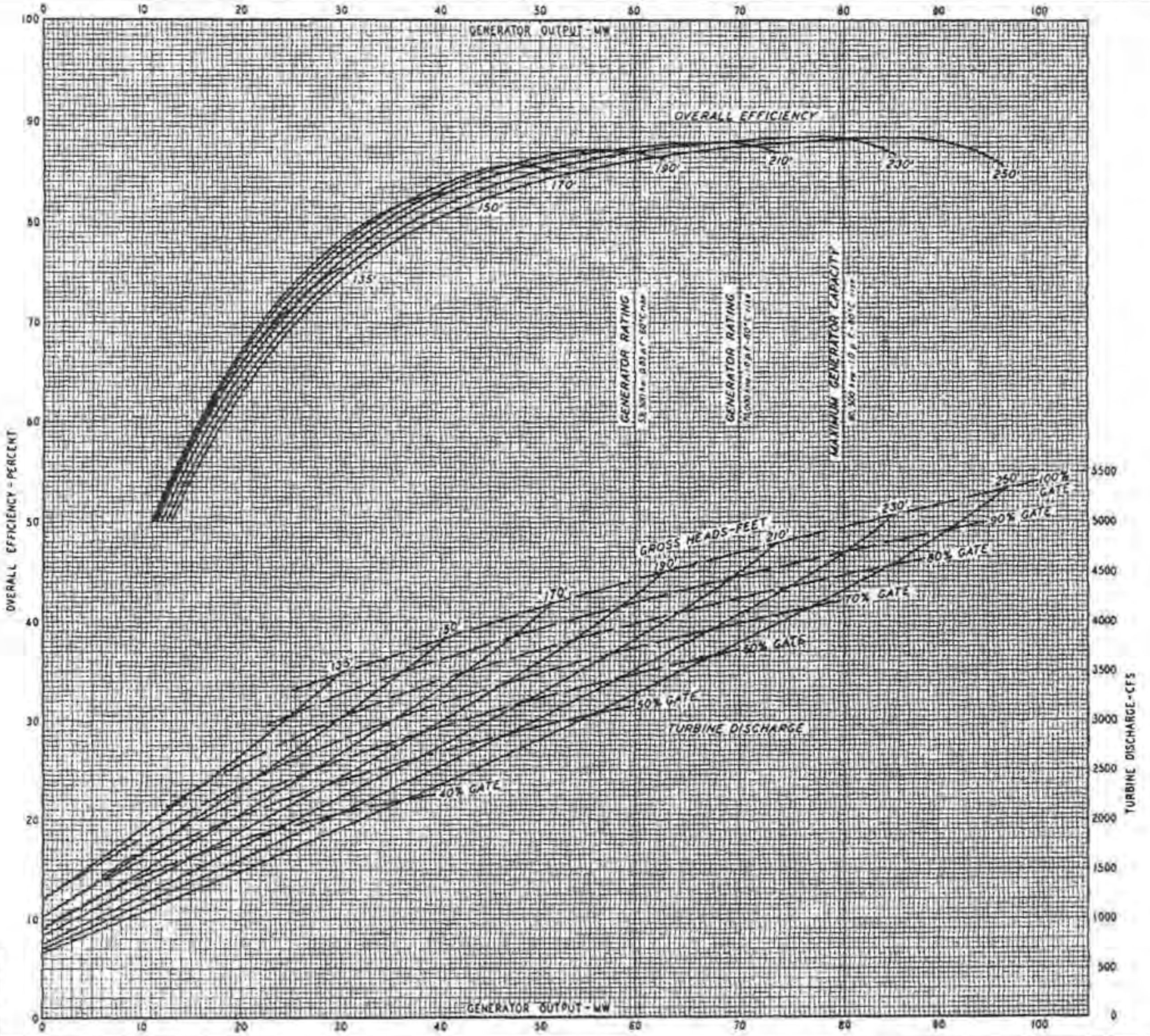
QUANTITIES

	Initial Project	Unit 2 Addition
Dam and power facilities:		
Earth excavation	64,700 cu. yd	-
Rock excavation	294,500 cu. yd	125 cu. yd
Unclassified excavation	19,500 cu. yd	-
Concrete	792,956 cu. yd	7,830 cu. yd
Structural steel	535 tons	23 tons
Reinforcing steel	1,972 tons	156 tons
Highway and railroad:		
Excavation	960,000 cu. yd	-

NOTE

Elevations are based on the U.S.C. & G.S. 1929 Preliminary Adjustment to which the dam is built. To correct to U.S.C. & G.S. 1936 Supplementary Adjustment, subtract 0.62 ft.

TENNESSEE VALLEY AUTHORITY
MAPS AND SURVEYS BRANCH
HIWASSEE RESERVOIR
VICINITY MAP
SCALE OF MILES
0 1 2 3 4
JANUARY 1972
84°10'
84°00'
35°10'
35°00'
CHEROKEE NATIONAL FOREST
TENN
N C
MONROE CO
CHEROKEE CO
GRAHAM CO
CHEROKEE CO
NANTAHALA NATIONAL FOREST
Tellico River
Creek
Shoal Creek
North
JOE BROWN HIGHWAY
Unaka
Beaverdam
Violet
Grandview
Dog Creek
Owl Creek
Hanging
Ogreeta
HIWASSEE DAM
HIWASSEE RIVER
TRANS LINE
Vests
Tomotla
Valley River
SOU
MURPHY
HIWASSEE
RIVER
Beaverdam Creek
Friendship
Creek
PERSIMMON DAM
Lake Cherokee
Persimmon
RIVER
L & N HWY
NOTTELY
Kinsey
APPALACHIAN
Ranger
NAT FOR BDY
Martin Creek
Martin Creek
TRANS LINE
NOTTELY RIVER
Davidsonville
Culberson
N C
GA
CHEROKEE CO
FANNIN CO
UNION CO
Moccasin Cr
L & N
McCullough
Ivy Log
N



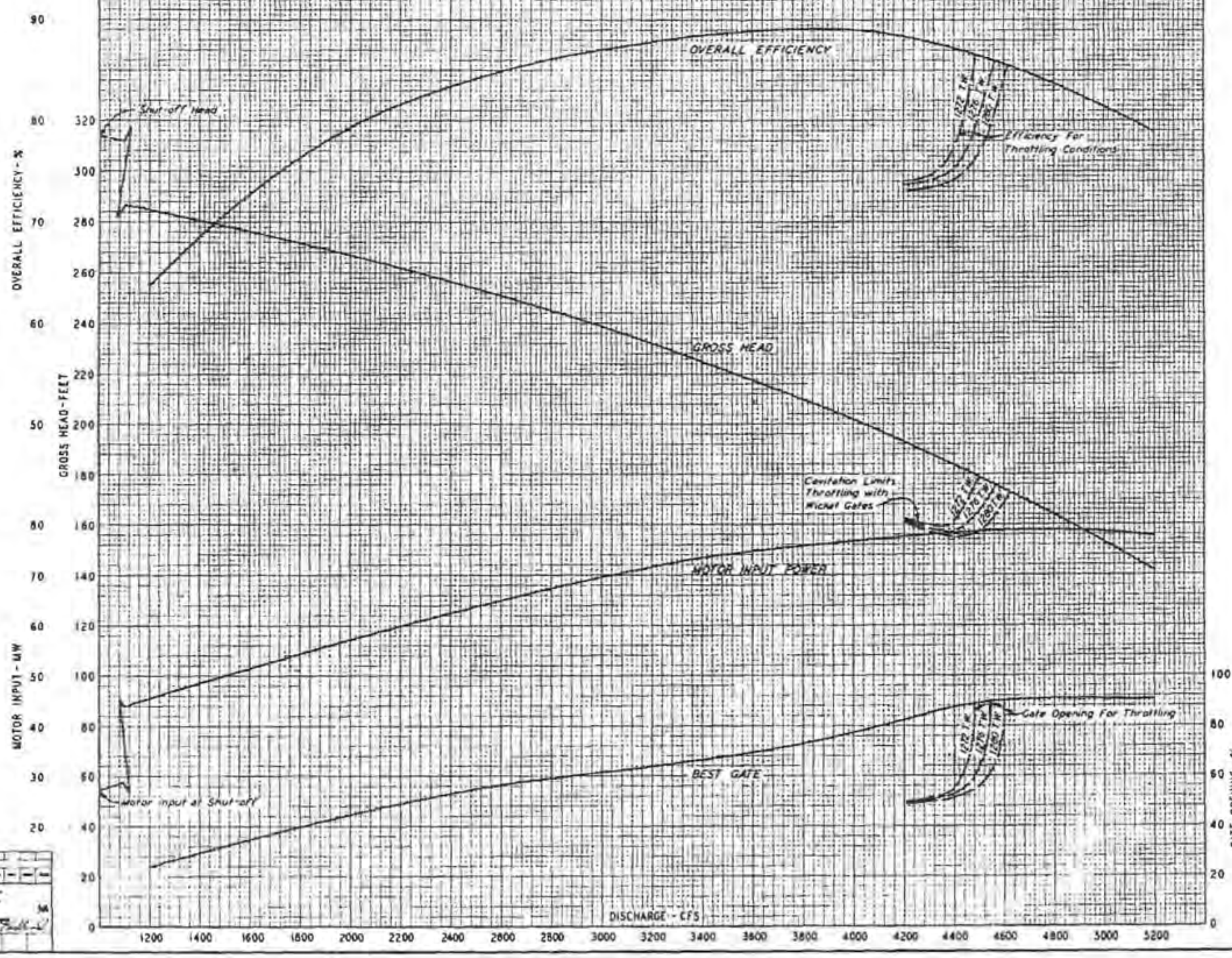
The curve is based on model test No. 39112 of the Allis-Chalmers Co. and is modified in accordance with the self-velocity test conducted on this unit on 4-2-57 at approximately 155-foot gross head. Generator test efficiencies and measured penstock losses were used in the computations.

POWERHOUSE
UNIT 2

OPERATING CHARACTERISTICS OF PUMP-TURBINE UNIT GENERATING

HIWASSEE PROJECT
TENNESSEE VALLEY AUTHORITY

KNOXVILLE | 4-10-58 | 47 K 2864



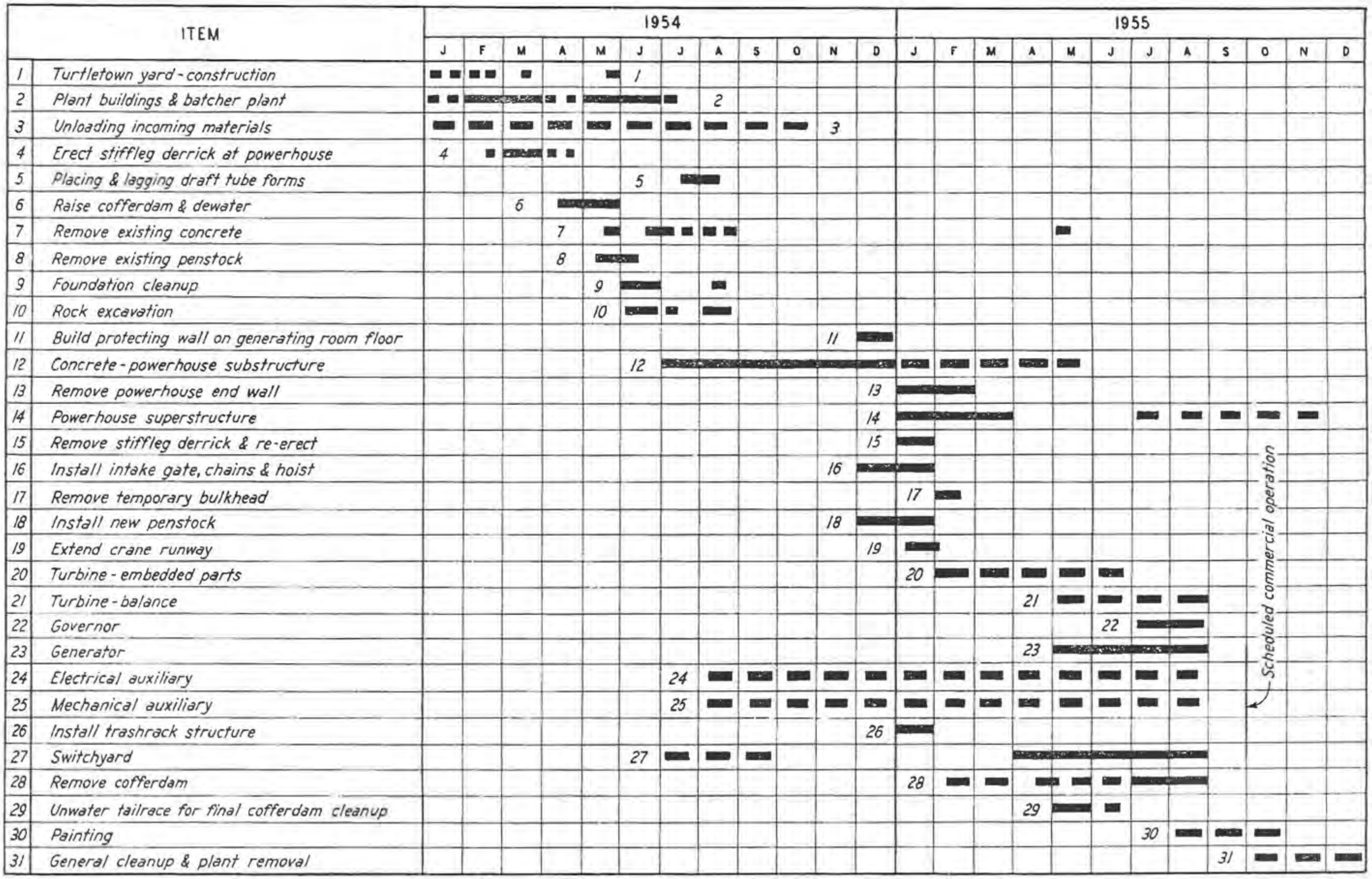
This curve is based on model test No. [illegible] of the Allis-Chalmers Co. and is modified in accordance with certain data from the test conducted on this unit on [illegible] at approximately 185 foot head. Generator test efficiencies and measured penstock losses were used in the computations.

POWERHOUSE
UNIT 2

OPERATING CHARACTERISTICS OF PUMP-TURBINE UNIT PUMPING

HIWASSEE PROJECT
TENNESSEE VALLEY AUTHORITY

KNOXVILLE | 4-17-56 | 47K2565



CONSTRUCTION SCHEDULE-UNIT 2