Appendix B – CHEOPS Model Operations Revision Report

Introduction

The Catawba-Wateree CHEOPS (Computer Hydro-Electric Operations and Planning Software) model was developed as a study tool during the Federal Energy Regulatory Commission (FERC) relicensing of Duke Energy's Catawba-Wateree Hydroelectric Project (FERC No. 2232).

CHEOPS utilizes daily flows, plant generating characteristics, and operating criteria of the system to simulate operations, allocate flow releases, and calculate energy production within the system. The model calculates headwater elevation, headlosses, net head, turbine discharge and spill, and power generation. CHEOPS is designed for long-term analysis of the effects of operational and physical changes made to the modeled hydroelectric system.

The model was last updated as part of the original Catawba-Wateree Water Management Group's (CWWMG) Water Supply Management Plan (WSMP) development in 2014. For the Integrated Water Resources Plan (IWRP), updates to the CHEOPS model were necessary, including updates to the model logic, which were identified as part of the previous WSMP Addendum and incorporation of system modifications since 2014. This memo describes modifications made to the CHEOPS model for the Catawba-Wateree River Basin IWRP.

CHEOPS Model Modifications

The following sections detail the modifications made to the CHEOPS model from the previous (2014) update.

Storage Volumes

Reservoir storage volume curves were updated for all developments besides Great Falls and Rocky Creek. The Rhodhiss, Oxford, Lookout Shoals, Cowans Ford, Mountain Island, Wylie, and Fishing Creek developments were all updated using the storage volumes estimated to support modeling using the U.S. Army Corps of Engineers Hydrologic Engineering Center's River Analysis System (HEC-RAS) software for the Fukushima Flood Hazard evaluation of the Catawba Nuclear Station in 2013. Other updates relevant to individual Duke Energy developments on the Catawba-Wateree River are detailed below.

Bridgewater Development

The Lake James storage volume curve was updated by HDR in 2023 with Geographic Information System (GIS) and geometry data, including site survey data, bathymetry survey data, and Light Detection and Ranging (LiDAR) data. These updates incorporated the 2017 North Carolina Emergency Management (NCEM), North Carolina Department of Transportation (NCDOT), and United States Geological Survey (USGS) LiDAR, referred to as the NC Statewide Phase 5 LiDAR, for mapping of the upstream portion of Lake James. These updates determined storage restrictions caused by the Catawba arm of Lake James and the Lineville

arm of Lake James. This study resulted in a smaller total storage volume. The Lake James storage volume curve is provided as Attachment 1.

Wateree Development
The Lake Wateree storage volume curve was updated in 2023 and provided by Duke Energy. The Lake Wateree storage volume curve is provided as Attachment 2.

Spillway Discharge Curves

Spillway discharge curves in the CHEOPS model correlate with those provided in the most recent Standard Technical Information Document (STID) for all developments in the Basin unless noted.

Rhodhiss Development
The Rhodhiss Dam spillway discharge curve was updated in 2023 by HDR to account for increased discharge capacity below the normal pond elevation and flows over the Obermeyer gated section, and to include the 20-foot-wide crest gate trash sluice. The Rhodhiss Dam spillway discharge curve used in the model is provided as Attachment 3.

Wateree Development
The Wateree Dam spillway discharge curve was updated in 2022 by HDR to account for flow over the Obermeyer section and to account for new spillway gates which increased spillway discharge. The Wateree Dam spillway discharge curve used in the model is provided as Attachment 4.

Target Elevations

Target reservoir elevations were modified at the Bridgewater (Lake James), Cowans Ford (Lake Norman), Wylie (Lake Wylie), and Great Falls (Great Falls Reservoir) developments. Bridgewater, Cowans Ford, and Wylie target elevations were increased by 0.5 feet in summer (June, July, and August). These target elevations were increased to improve flood management requirements, which go into effect in 2026 under the Project's FERC license. Updates to the Great Falls/Dearborn development's target elevations are detailed below.

Great Falls/Dearborn Development
The Great Falls / Dearborn development's target reservoir elevations were decreased in order to decrease the minimum flow. Previously, the target elevation for Great Falls Reservoir was set to an elevation of 353.3 feet (National Geodetic Vertical Datum of 1929 [NGVD 29]). The updated target elevations are shown in Table 1.

Table 1. Great Falls/Dearborn Target Elevations

Date	Elevation (feet, NGVD 29)	Elevation (feet, Local Datum, Full Pond = 100 ft
January 1	351.8	96
February 14	351.8	96
February 15	352.8	97
May 15	352.8	97

Date	Elevation (feet, NGVD 29)	Elevation (feet, Local Datum, Full Pond = 100 ft
May 16	351.8	96
December 31	351.8	96

Leakage

Leakage in the model was updated based on information provided by Duke Energy (*Hydrounitassessment.xlsx spreadsheet*). While other developments in the Basin correlated to this data, Rhodhiss, Lookout Shoals, Cowans Ford, Wylie, Fishing Creek, Great Falls, Dearborn, Cedar Creek, and Wateree developments required updating. Updated leakage rates in cubic feet per second (cfs) from individual developments are listed in Table 2.

Table 2. Catawba-Wateree Leakage Rates

Development	Leakage (cfs)
Rhodhiss	45
Lookout Shoals	93
Cowans Ford	120
Wylie	80
Fishing Creek	25
Great Falls	40
Dearborn	30
Cedar Creek	31
Wateree	82.5

Low Inflow Protocol

The previous version of the Low Inflow Protocol (LIP) for the Project was modified to more accurately reflect Duke Energy's system operations during drought to maintain reservoir levels below the full pond elevation during inflow events. These modifications allow reservoirs to fill above their target levels to increase system storage if significant inflow occurs while the system implements the LIP but remains below full pond elevations to reduce spilling potential. The model logic was updated to limit the ceiling (or uppermost elevation) for lake levels when in the LIP based on Table 3.

Table 3: CHEOPS Model Logic Updates Regarding LIP Conditions

Development	LIP Reservoir Level Ceiling – Winter (feet above Normal Target Elevation)	LIP Reservoir Level Ceiling – Summer (feet above Normal Target Elevation)
Bridgewater	+2 feet	+1 foot
Rhodhiss	+1 foot	+1 foot
Oxford	+1 foot	+1 foot
Lookout Shoals	+1 foot	+1 foot
Cowans Ford	+2 feet	+1 foot
Mountain Island	+1 foot	+1 foot

Development	LIP Reservoir Level Ceiling – Winter (feet above Normal Target Elevation)	LIP Reservoir Level Ceiling – Summer (feet above Normal Target Elevation)
Wylie	+1 foot	+1 foot
Fishing Creek	+1 foot	+1 foot
Great Falls	+1 foot	+1 foot
Cedar Creek	+1 foot	+1 foot
Wateree	+2 feet	+1 foot

To incorporate the changes noted above for the updated LIP, there were several changes to the model logic that were required when the LIP stage is greater than or equal to zero:

- Determine maximum desired elevation limit.
    - For developments with 1-foot limit year-round reservoir band, set the maximum elevation limit to 1 foot above target elevation.
    - For other developments, determine time of year (summer, winter, or up ramp, down ramp) and the maximum elevation limit (prorated between winter and summer values during ramping periods) and add to the target elevation.
- Summer and winter periods are set as follows based on the reservoir target elevations (manually estimated from the target curves in the scenario):
    - Bridgewater
        - Summer: May 1 – October 1
        - Winter: November 1 – March 1
    - Cowans Ford
        - Summer: May 1 – October 1
        - Winter: December 1 – March 1
    - Wateree
        - Summer: March 1 – November 1
        - Winter: December 1 – February 1
- Determine reservoir storage at this maximum elevation limit and compare to estimated end of day elevation volume (start of day reservoir volume + [(inflows – LIP required outflows) × converted to volume])
- If estimated elevation volume is greater than the maximum elevation limit volume then increase outflows above LIP/Non-Production License Flows (NPLF) by this volume, converted to a daily average flow rate.
- Outflows up to turbine capacity can be scheduled. If inflows are still too high, then the reservoir may exceed this maximum elevation limit, up to the point of exceeding the spill elevation, at which time spill will be computed.
- Logic may still reduce the plant's outflow to avoid spilling at a downstream plant (if such condition exists).

High Inflow Protocol

The original High Inflow Protocol (HIP) was developed using hydrologic data. With the recent updates, the HIP hydrological data was extended to December 2023.

Recreational Releases

Recreational releases were updated following the Catawba-Wateree Recreation Flow Schedule for the 2023 calendar year as provided by Duke Energy.

Bridgewater Development

The Bridgewater development incorporates recreational releases on holidays and weekends from April through October. Releases also occur on Wednesdays and Thursdays in June and July from 4:30 pm to 6:30 pm. Flows alternate between float angling flows and paddling flows. Float angling flows are estimated at 900 cfs and are released from 8:00 am to 1:00 pm. Paddling flows are estimated at 1,300 cfs and are released from 10:00 am to 3:00 pm.

Oxford Development

The Oxford development incorporates recreational releases on holidays and weekends from May through September. Releases also occur on Saturdays in October. The scheduled recreational releases are estimated to be 2,600 cfs.

Wylie Development

The Wylie development incorporates recreational releases on holidays and weekends from April through October. Recreational flows between 3,000 cfs and 4,500 cfs are required between 10:00 am and 4:00 pm. From May 1 to July 15, flows of at least 1,300 cfs are required from 4:00 am to 10:00 am.

Great Falls/Dearborn Development

The Great Falls/Dearborn development incorporates recreational releases on weekends from March through October. Recreational releases include short bypass reach flows and long bypass reach flows. Short bypass reach flows are approximately 2,860 cfs and are released between 10:00 am and 3:00 pm. Long bypass reach flows are approximately 2,940 cfs and are released between 10:00 am and 3:00 pm.

Wateree Development

The Wateree development incorporates recreational releases on weekends and holidays from April through October. Recreational flows of 2,760 cfs are released between 10:00 am and 3:00 pm.

Turbine-Generator Units

Modifications were made to the turbine-generating units at the Rhodhiss, Great Falls, and Rocky Creek developments in accordance with the Hydrounitassessment.xlsx spreadsheet provided by Duke Energy.

Rhodhiss Development

The Rhodhiss powerhouse Unit 3 performance data was updated to match the Unit 2 performance data.

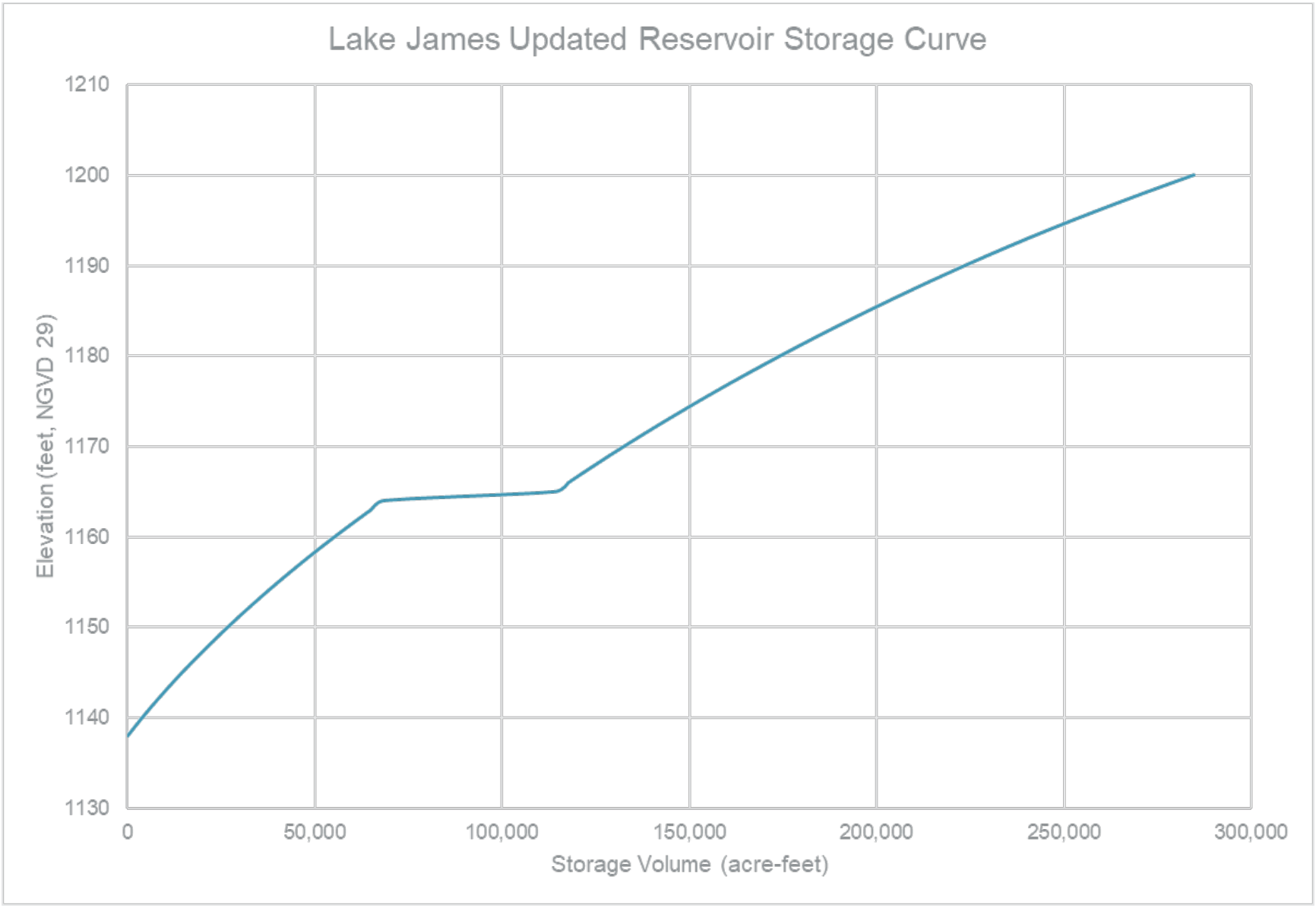
Great Falls/Dearborn Development

All units at the Great Falls/Dearborn development were taken offline to represent current operations.

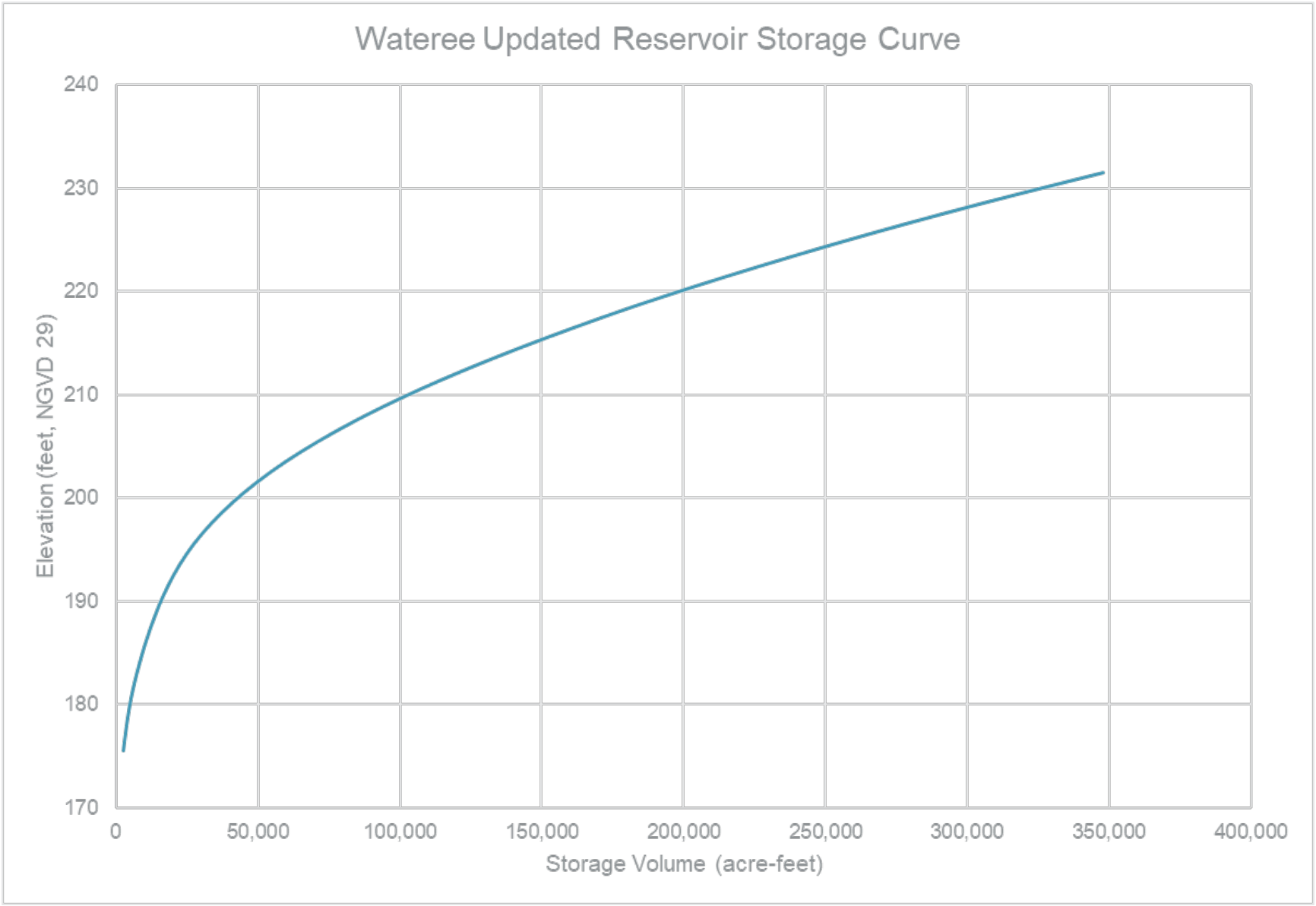
Rocky Creek/Cedar Creek Development
All units at the Rocky Creek development were taken offline to represent current operations.

Loadshape

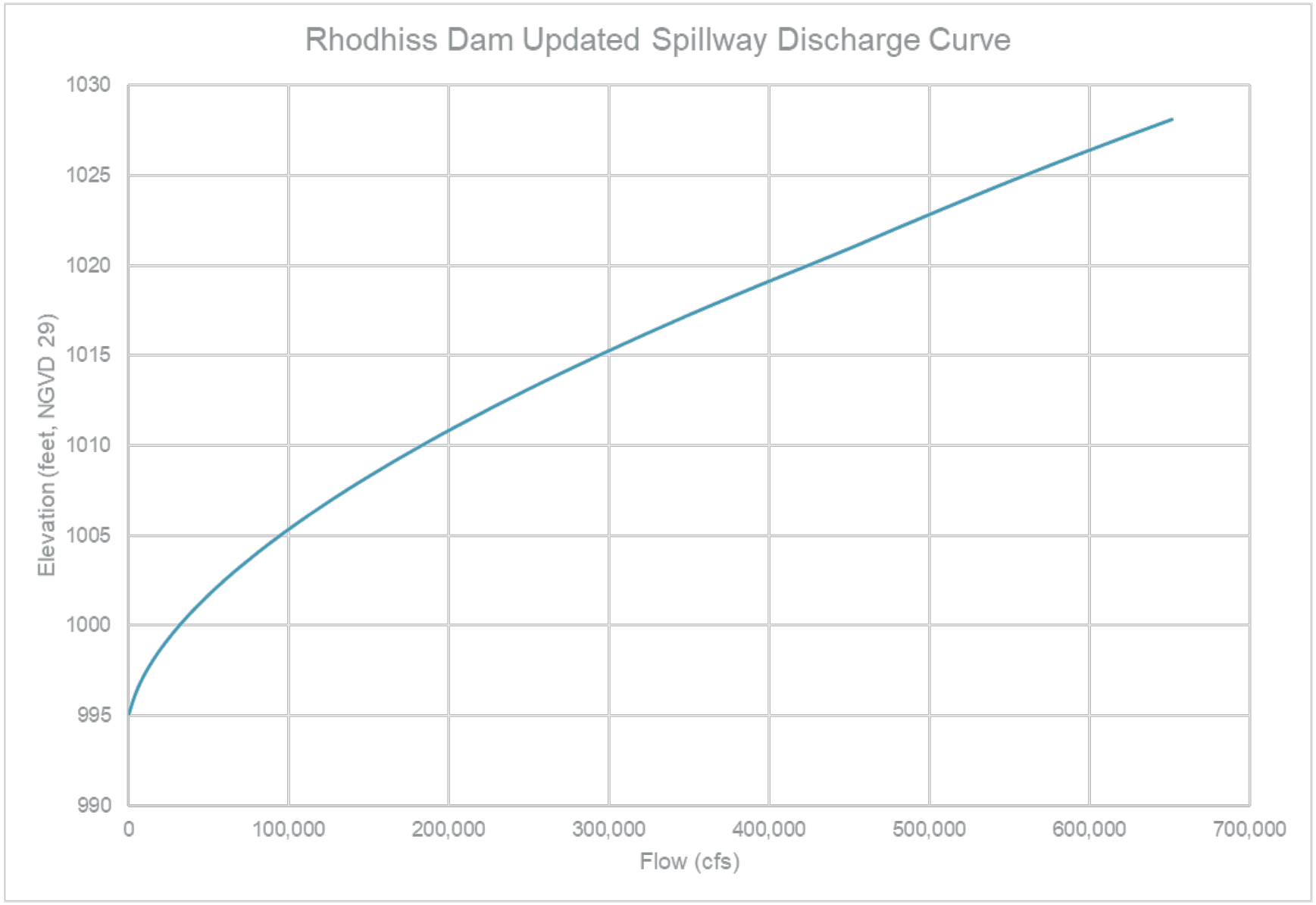
A generalized loadshape was provided by Duke Energy in April 2023 and compared against the loadshape used in the previous version of the model. It was confirmed the loadshape in the model corresponded to the loadshape provided by Duke Energy and was therefore left unchanged.



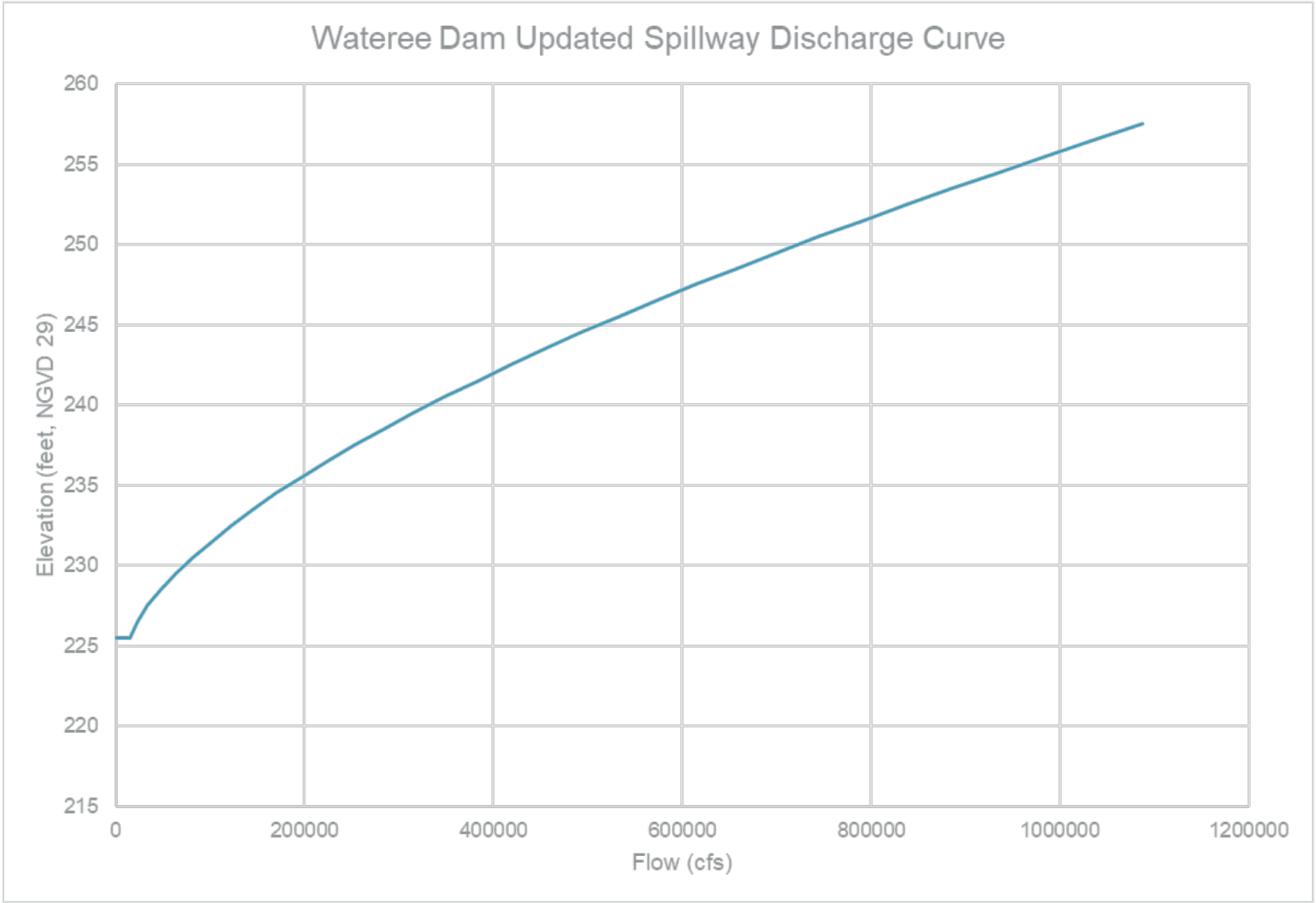
Attachment 1. Lake James Updated Storage Volume Curve



Attachment 2. Lake Wateree Updated Storage Volume Curve



Attachment 3. Rhodhiss Dam Updated Spillway Discharge Curve



Attachment 4. Wateree Dam Updated Spillway Discharge Curve