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Engineers | Planners
in association with
Optimatics

BEND OREGON
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CITY OF BEND

Collection System Master Plan

CITY PROJECT NO. SW12AA

VOLUME 4 OF 6
DECEMBER 2014

VOLUME 1 OF 6

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APPENDIX 3A

Land Use Assumptions in CSMP GIS Database

APPENDIX 3A
LAND USE ASSUMPTIONS IN CSMP GIS DATABASE

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TO: **MSA, LEGAL DEPARTMENT, EIPD**
FROM: **BRIAN RANKIN AND COLLEEN MILLER**
SUBJECT: **LAND USE ASSUMPTIONS IN CSMP GIS DATABASE**
DATE: **12/27/2013**

This memorandum explains the assumptions and process used to inform the hydraulic model used in the 2013 CSMP. It also provides data to be used in subsequent analysis relying on population projections and growth rates. There is a discussion of the assumed calculated population resulting from the GIS analysis and the Coordinated Population Forecast.

The Goal 11 rule requires that improvements and plans for the sewer system be tied to population forecasts in the acknowledged General Plan. Since the approach at the outset was to use the best available information for the short-term analysis, and the project requires a build-out analysis that extends beyond the timeframe of the Coordinated Population Forecast, this memorandum ties these approaches together so the result is legally defensible and technically feasible.

Many of the assumptions used to forecast future development patterns were approved by the Sewer Infrastructure Advisory Group (SIAG) during a February 6, 2013 meeting. Other assumptions and approaches that were not discussed in detail with SIAG are explained in this memorandum.

Summary of Approach
A GIS shapefile was provided to MSA for purposes of estimating future development both in the short term and long term. Assembly of this shapefile involved two different methodologies to account for the higher degree of certainty in the short term (2013-2018), and greater degree of uncertainty in the medium to longer term (2018-2033 assumed build-out). The shapefile combined both of these approaches and time periods so the build-out analysis is consistent throughout the entire planning period.

Short-Term Analysis (December 31, 2013 through December 31, 2017)
Staff first created a GIS database to predict development from 2013 through the end of 2017 in order to determine solutions serving the immediate needs of the wastewater conveyance system. This database was developed with a different, but compatible, approach as the long-term build-out database (December 31, 2018 through December 31, 2033). Since the time period is shorter, specific development proposals could be predicted and used in the modeling effort. The analysis for the long-term period used a different methodology.

All planners from the Community Development Department, Engineering, and GIS staff gathered all available data including information received from recent informal and formal discussions with land use applicants to predict the type and location of future development during the short-term period. Information on the type and intensity of use, as well as the anticipated timing, was then entered into the GIS database to indicate development that was likely to be built in between 2013 and 2017. In addition to these approved, pending, and anticipated development proposals, staff also assumed additional development in years 2013-2017 based on recent absorption rates and the location of recent development in the city's sewer basins. The result was a five year estimate of development that predicts the type and intensity of development for each year during the 2013-2017 time period.

Total developed units in the current UGB were calculated for November 1, 2012 based on GIS data. In addition, developed units were calculated for developments served by the sewer system that are outside the UGB (service through contractual agreements). Estimated units for 2013 through 2017 were based on submitted building permit applications, submitted land use applications, and anticipated land use applications based on discussions with the Planning Division. Additionally, the city examined yearly building permit activity and estimated that 450 units per year would be constructed during 2013-2017. If these 450 units were not already accounted for in the submitted/anticipated applications, the appropriate numbers of additional units were applied to vacant residential lands. These units were also distributed according to sewer basins based on trends of where development was occurring during the 2008-2012 time period. This was done to estimate the location of development, since location of development affects the location of flows, and therefore, the location of needed improvements.

The same methodology for estimating short-term development was used for properties outside the current UGB. This resulted in a small number of new single family homes being constructed on vacant platted lots in Tetherow (4 units in 2013 and 5 units each year in 2014-2017), a church being constructed on a vacant lot on the west edge of the UGB in 2014, and a new 800 student middle school being constructed on a vacant lot on the northwest edge of the UGB in 2017. A more detailed discussion of the inclusion of properties outside the current UGB and their projected land uses can be found later in this document.

The table below summarizes the resulting analysis for the short-term. Total developed units were calculated based on the above GIS analysis. The other statistics apply assumptions discussed later to illustrate the estimated population, but are not part of the GIS database.

Time Period	Total Developed Units	Vacancy Rate	Occupied Units	Persons per Household	Estimated Population
November 1, 2012	36,700	12%	32,296	2.4	77,510
December 31, 2013	37,343	6.4%	34,953	2.4	83,887
December 31, 2014	37,886	6.4%	35,461	2.4	85,106

Time Period	Total Developed Units	Vacancy Rate	Occupied Units	Persons per Household	Estimated Population
December 31, 2015	38,667	6.4%	36,192	2.4	86,860
December 31, 2016	39,116	6.4%	36,612	2.4	87,868
December 31, 2017	39,709	6.4%	37,167	2.4	89,200

Comparison of Short-term Analysis with Coordinated Population Forecast
The following information is presented to determine the relative accuracy of the city's analysis against US Census data and the Coordinated Population Forecast. Caution should be taken to make direct comparisons because of differences between methodologies, definitions, and time periods. For example, there are 1,117 lots outside the city that were included in the CSMP analysis since they are served by the City's sewer system. However, the comparison can demonstrate an approximate level of accuracy and if the city's analysis is within accepted margins of error.

The U.S. Census Bureau's 2012 American Community Survey, 1-Year Estimates, estimated the City of Bend had 34,844 housing units (+/- 1,393 units), 32,379 occupied housing units (margin of error of +/- 1,498 units) with an approximate vacancy rate of 7%. MSA utilized a 12% vacancy rate for 2012, and based on direction from the city, assumed 6.4% going forward based on ACS data. It is important to note that the city's estimate of dwelling units includes nursing homes, assisted living facilities, mobile home parks, and units in condominiums and mixed use housing in commercial areas. The US Census may define and categorize units in a different manner than the City's analysis. The same data source estimated 77,455 persons on Bend in 2012. Based on these statistics, it is fair to say the city's baseline analysis is fairly realistic and accurate for purposes of estimating the total number of dwelling units, occupied units, and persons.

The Coordinated Population Forecast in Bend's General Plan estimates:

- 2010 population of 81,155
- 2015 population of 91,158
- 2020 population of 100,646

The estimates from the CSMP analysis above, estimate a 2015 population of 86,860, which is 4,298 persons less than the estimated population in the 2015 Coordinated Population Forecast. The Coordinated Population Forecast is a 20-year estimate ending in year 2025. This forecast did not anticipate a major downturn in the economy starting in 2006/2007, a downturn which is reflected in the CSMP's GIS analysis.

OAR 660-011-0025(2) requires that "timing provisions for public facility projects shall be consistent with the acknowledged comprehensive plan's projected growth estimates." It is not clear from the OAR the degree of accuracy that is required between the growth estimates and timing of the projects. What is clear from the analysis below is that the city's approach did not rely upon the Coordinated Population Forecast to estimate the short-term improvements, but will use it for purposes of estimating the population between 2017 and 2025, when the Coordinated Population Forecast ends.

Long-term Analysis (December 31, 2018-December 31, 2033)
Building upon the results of the short-term analysis, staff then created additional attributes which provide an estimate of the future build-out of each property in the City's UGB and for developments outside the UGB served by city sewer through contractual agreement. Build-out has been defined as the state where all residential lands categorized as vacant and redevelopable are developed with residential uses, in addition to public schools and parks. The resulting database can then be used as an estimate of the total number of existing and anticipated residential units at this build-out condition. This product was then provided to MSA for use in the hydraulic model and optimization. A similar analysis was done for economic lands, but loading rates were applied by MSA to these lands versus trying to predict employment levels on vacant lands.

Estimated units upon full build-out assumed that all vacant and re-developable residential lands, less the amount needed for schools, parks, rights of way (21% for parcels larger than 1 acre), and physically constrained portions (flood plains and 25%+ slope), would be built to the median density allowed by the zoning district. This assumption of medium density was selected by SIAG compared to selecting a low or higher density assumption.

The table below illustrates all zoning designations, the gross density and net densities currently allowed by code, and the median or medium density assumption used for this analysis.

	Gross Density		Net Density		Median
Zones	**Minimum**	**Maximum**	**Minimum**	**Maximum**	**Used in CSMP**
RL	1.1	2.2	1.4	2.8	**2**
RS	2	7.3	2.5	9.2	**6**
RM	7.3	21.7	9.2	27.5	**18**
RH	21.7	43	27.5	54.4	**41**

The table below illustrates the total number of developed units at build-out including developments outside the UGB served with sewer through contractual agreement The other statistics below result from applying assumptions documented in this memorandum in order to estimate a build-out population.

Time Period	Total Developed Units	Vacancy Rate	Occupied Units	Persons per Household	Estimated Population
December 31, 2018- December 31, 2033	55,044	6.4%	51,522	2.4	123,652

The figures above include the additional units assigned to “Special Areas” (2,200 units) and “Existing and Future Development of Contractually-served Areas Outside of UGB” (1,576 units) described in more detail below.

The Coordinated Population Forecast estimates Bend’s population will be 109,389 persons by 2025. The total estimated build-out population based on the acknowledged General Plan designations and assumptions documented in this memorandum is 123,652 on December 31, 2033.

Assuming Bend’s population is 109,389 in 2025 and then 123,652 in 2033, the annualized rate of growth from 2025 to 2033 is about 1.54 % per year. The annualized rate of growth used by the city in the UGB expansion project which was approved by LCDC was 1.7% per year between 2025 and 2028, yielding a forecast of 115,063 persons. The rate used in the CSMP is consistent with the city’s extension of the Coordinated Forecast, and reflects slower population growth as documented by forecasts of Deschutes County prepared by the Oregon Office of Economic Analysis (OEA). The forecasts developed in January 2013, available on-line at http://www.oregon.gov/DAS/OEA/Pages/demographic.aspx, for Deschutes County (not Bend specific), use the following annualized growth rates:

- 2015-2020: 1.78%
- 2020-2025: 1.7%
- 2025-2030: 1.52%
- 2030-2035: 1.28%

The average of the three rates above between 2020 and 2035 is 1.5%, which is close to the 1.54% annualized growth rate assumed for Bend’s population growth by the CSMP analysis from the end of the Coordinated Population Forecast in 2025 to 2033, the estimated year of build-out for the existing UGB. This demonstrates the CSMP analysis for Bend is consistent with anticipated population growth rates for Deschutes County during the period of time following the Coordinated Population Forecast, as well as the anticipated build-out of uses allowed by the existing General Plan.

Ten Year Population Forecast

The CSMP will develop a 10-year estimate of development and population in order to determine phasing of the wastewater conveyance system.

The 10-year date used in the CSMP will be December 31, 2022.

- The coordinated population forecast is 100,646 in 2020 and 109,389 in 2025.
- A straight line projection between these two population estimates results in an annualized growth rate of approximately 1.69% per year.
- Applying this rate to the 100,646 population in year 2020 results in a year 2022 population of 104,056 persons.

The table below compares the calculated CSMP population estimate as a result of the short and long term build-out analysis, combined with data from the Coordinated Population Forecast. For the years 2020 and 2025, the CSMP population and annualized growth rates in the table below use the Coordinated Population Forecast. These figures are not the result of the GIS analysis, because the GIS analysis only did a short-term and final build-out analysis.

Since the Coordinated Population Forecast ends in 2025, the calculated CSMP population is based on estimated build-out as well as additional population from special areas and developments outside the current UGB served with sewer. As illustrated below, the CSMP annualized growth rates are generally consistent with the Coordinated Population Forecast growth rates with the exception of the time period between 2017 (the end of the short-term period associated with the CSMP) and 2020, where the CSMP estimates must "catch up" with the Coordinated Population Forecast. The Coordinated Population Forecast data is used for intervening years in the CSMP between 2017 and 2033 in order to create alignment of the estimated population. As discussed earlier, the slower rate of population growth from 2025 to 2033 assumed in the CSMP analysis is consistent with the OEA population growth rates for Deschutes County during the same time period.

Year	CSMP Population	CSMP Annualized Growth Rates	Coordinated Population Forecast	Coordinated Forecast Annualized Growth Rates
2010	Not Available		81,155	Start
2011	Not Available			↓
2012	77,510	Start		↓
2013	83,887	↓		↓
2014	85,106	↓		↓
2015	86,860	↓	91,158	2.352
2016	87,868	↓		↓
2017	89,200	2.852		↓
2018		↓		↓
2019		↓		↓
2020	100,646	4.106	100,646	2.000
2021		↓		↓
2022	104,056	1.680		↓
2023		↓		↓
2024		↓		↓
2025	109,389	1.680	109,389	1.680
2026		↓	Not Available	
2027		↓	Not Available	
2028		↓	Not Available	
2029		↓	Not Available	
2030		↓	Not Available	
2031		↓	Not Available	
2032		↓	Not Available	
2033	123,652	1.540	Not Available	

Description of GIS Data and Assumptions

Data Sources and Format

Data sources used in the assembly of the short term and long term (build-out) databases include a November 2012 tax lot GIS shapefile with basic property such as ownership, land values, improvement values and type, and zoning. This data was supplemented by the City's existing buildable lands inventory and current (Nov 2012) building permit to determine the type and extent of existing development on each tax lot.

Major Assumptions
A number of assumptions about the future must be made to complete the analysis. These assumptions are described below.

Future development of land considered developed – The parcel database uses the development status of "Developed" to describe parcels that this analysis assumes will not experience additional development between now and build-out. The development status of "developed" was applied to parcels that were not considered vacant or redevelopable. Generally, these are residential parcels with a structure or other improvements with a value greater than the land and are smaller than a half-acre in size. For non-residential lands like commercial and industrial land, developed are all those lands that are less than a half-acre in size with a structure, or parcels larger than five acres with development that occupies more than a half-acre of the site. Developed lands also include those used for schools, parks, open space, rights or way, or other institutional uses such as utilities.

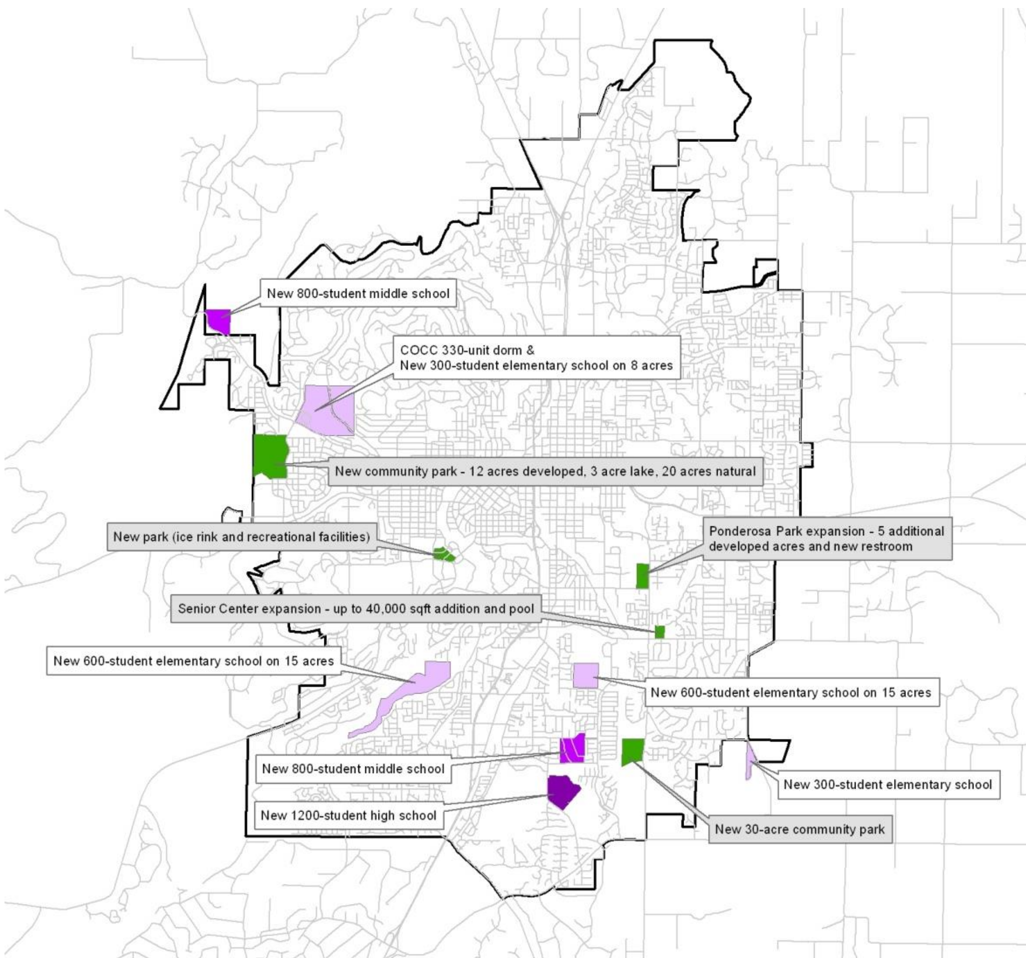
Development on Platted/Approved Lots – There are thousands of platted residential lots that do not have a structure and are vacant. This analysis assumes each of these lots will be developed with a single unit (or the unit that was approved during the land use approval process). This assumes what was approved by the city is constructed, and that single-lots are developed with a single unit. Density assumptions used for vacant acreage (raw acreage) are not applied to these parcels.

Rights-of-way - Generally, parcels that are vacant or redevelopable and that are larger than a certain size were assumed to require additional rights of way. For this analysis these are residentially designated properties over 1 acre in size and non-residentially designated properties over 5 acres in size. This analysis removed 21% of the gross acreage from these parcels when calculating the amount of buildable land to account for future public rights of way that will be removed as part of the typical subdivision process. The 21% figure is from a LCDC-approved analysis associated with the UGB expansion.

Physical Constraints – This analysis assumes that areas of steep slopes or that are within a floodplain will not accommodate additional development. For this analysis, lands with a slope greater than 25% or within a floodplain are considered physically constrained. That acreage was removed from the gross acreage, and a right of way factor was then applied to large properties as described above, to determine the number of buildable acres on vacant and redevelopable lands.

Parks and Schools – Anticipated needs and possible locations of future public schools and public parks were provided by the Bend-La Pine School District and Bend Metro Parks and Recreation. This effectively removed vacant acreage from the inventory and assigned the appropriate park or school facility in the GIS parcel inventory. A list of the anticipated new school and park facilities and a map showing their possible locations is provided below.

New 600-student elementary schools (2)
New 300-student elementary schools (2)
New 800-student middle schools (2)
New 1,200-student high school (1)
New community parks (2)
New ice rink/recreational facility (1)
Existing park expansion (1)
Existing Senior Center expansion (1)



Density by General Plan Designation – To estimate the number of new dwelling units on vacant and redevelopable residential lands, SIAG recommended using the median of allowable residential densities by plan designation and the acknowledged Development Code. Gross densities in the Development Code were converted to net densities, and then the median was calculated as follows:

	Gross Density		Net Density		Median
Zones	Minimum	Maximum	Minimum	Maximum	Used in CSMP
RL	1.1	2.2	1.4	2.8	**2**
RS	2	7.3	2.5	9.2	**6**
RM	7.3	21.7	9.2	27.5	**18**
RH	21.7	43	27.5	54.4	**41**

For vacant and redevelopable residential lands, the median densities listed above were applied to the buildable acres for each property to estimate the number of units on each property at build-out.

Recommended Assumptions for Working with the Parcel Inventory
There are several assumptions that should be considered when working with the parcel inventory that are not included in the GIS database.

Vacancy Rate – To account for residential vacancies (unoccupied units at any given time), staff recommend the use of a 6.4% vacancy rate for years during and after 2013. This statistic is based on the 2000 US Census. Although the 2010 US census estimates the residential vacancy rate in Bend at 12%, staff feels this number does not accurately reflect current/future conditions, but instead reflects a short term condition due to an oversupply of houses during Bend's building boom followed by its housing market crash. The 6.4% vacancy rate is believed to be more realistic of current and future conditions.

People per Household – To estimate the number of people (population) per residential unit, staff recommends using 2.4 persons per household figure. This statistic is based on the 2010 US Census.

Special Areas – There are several areas in the City where the intensity of use may be higher than that which has been projected city-wide. These areas include the Medical District Overlay Zone, Central Area, Old Mill/College Area, and transit corridors.

> Properties in the Medical District Overlay Zone are designated residential; however, it is assumed that vacant lands in this area will be built with nonresidential (medical) uses as allowed under the City's development code. The exception are the 8 vacant lots in platted residential subdivisions, which are anticipated to be built with single family dwellings. The remainder of the vacant lots in the MDOZ were assigned the value "Non Residential Use" for the long-term (build-out) analysis. Additionally, due to the higher sewer flows anticipated with medical-related uses, this area had its unit flow factor peaked by an additional 20% over the standard non-residential rate for the long-term/build-out analysis.
>
> In the Central Area, it is anticipated that there may be about 1,000 additional dwelling units and more intense development/redevelopment

than in other parts of the City. To account for the 1,000 additional dwelling units, 250 units were placed on each of four separate parcels in the Central Area (one parcel for each of the four sewer basins located within the Central Area) for the build-out analysis. The higher intensity land use assumptions due to redevelopment of already developed properties are not reflected within the parcel inventory.

It is anticipated that the OSU-Cascades campus will require some development/redevelopment of lands. Although the specific location of the campus was not known at the time of the analysis, it was anticipated to be located in the general vicinity of the Old Mill District. For the short-term (2013-2017) analysis, a vacant property on Emkay Drive was selected at random to account for campus uses supporting 1,000 new students by 2017. For the long-term/build-out analysis, the unit flow factor was peaked by an additional 20% over the standard non-residential rate to account for the fully built OSU-Cascades campus.

Although not necessarily considered a "Special Area," the City anticipates more intense use of lands around existing transit corridors, including about 1,200 additional dwelling units upon build-out. For the short-term, no intensification of land use for areas near transit corridors was assumed beyond the projections used city-wide. To account for the long-term intensification of land use, the additional dwelling units were placed on six individual parcels – one parcel near each of six major transit corridors. The geographic distribution of these units was estimated as follows:

1) 300 units in the segment of SE 3rd St, south of the Central Area Plan.
2) 300 units in the segment of Highway 20, east of Pilot Butte
3) 100 units on Galveston Ave
4) 200 units on Shevlin Park Rd, just west of College Way
5) 150 units in the segment of NE 3rd St, north of the Central Area Plan
6) 150 units on 27th St south of Highway 20

Septic Areas – The parcel inventory indicates which properties currently have a septic permit through Deschutes County. Of the 38,711 parcels included in the inventory, 3,002 have a septic permit. Similar to the other areas in the city, information was gathered on the anticipated type and intensity of development for the short-term development analysis. For the long-term analysis staff assumed that properties would be developed with the type and intensity of use allowed under the City's development code. The current availability of sewer was not considered in developing the build-out scenario.

Existing and Future Development of Areas Outside of UGB –

For both the short-term and long-term analysis, the parcel inventory includes certain areas outside of the current UGB where the City currently provides, or is anticipated to provide, sewer service. These areas include the Tetherow destination resort, the Inn at Seventh Mountain and Widgi Creek Resort, several individual properties owned by the Bend-La Pine School District, and two properties that are the subject of a pending UGB expansion proposal. In total, there are 452 existing dwelling units on these lands, with a total of 1,576 units anticipated on these lands upon build-out.

Tetherow: The Tetherow destination resort is comprised of 450 parcels, the majority of which are currently vacant. Existing development is limited to a golf course, club house, private roads, and 20 single family dwellings. For the short-term analysis, staff assumed that four parcels will be developed with single family dwellings in 2013 and five parcels will be developed with single family dwellings in each year from 2014 to 2017 (total of 24 new SFDs in short term). For the long-term analysis, land use documents were examined to identify the approved and anticipated future development. Upon full build-out, the Tetherow area will contain a total of 209 single family dwellings, 408 multi-family units, 24 overnight units and a 300-unit hotel. Associated uses also include the existing golf course and club house, a new fitness center, and commercial uses associated with the adjacent hotel.

Inn at Seventh Mountain/Widgi Creek Resort: This area is comprised of 658 parcels, the majority of which are currently developed. Existing development includes a golf course, club house, conference center, private roads and parking/storage, 203 single family dwellings, and 229 condominiums. For the short-term analysis, staff assumed no additional development in this area. For the long-term analysis, staff assumed that 56 additional single family dwellings would be built on the vacant-platted lots that remain.

Bend-La Pine School District Properties: There are three properties owned by the school district that are adjacent to the current UGB and are currently served, or anticipated to be served, by City sewer. These properties include a vacant 32-acre lot on Shevlin Park Road where a new 800-student middle school is anticipated by 2017, a 12-acre lot on 27th Street where a new 300-student elementary school is anticipated in the long-term analysis, and a 62-acre lot developed with an existing middle school (High Desert Middle School).

UGB Expansion/Church: There are two properties owned by the Unitarian Universalist Fellowship of Central Oregon adjacent to the current UGB that are anticipated to be brought into the UGB and developed with a church and parking lot, according to a pending land use application. For the short-term analysis, the church is anticipated to be constructed in 2014. The long-term analysis shows these lots being developed with a church and associated parking area.

MSA

APPENDIX 3B

Developments Outside of the UGB

APPENDIX 3B
DEVELOPMENTS OUTSIDE OF THE URBAN GROWTH BOUNDARY (UGB)

Developments Outside of UGB

The City currently provides sewer services to two areas outside the UGB, Seventh Mountain and Tetherow. Although both are often described as "destination resorts" they were developed at different times under different statutory and regulatory schemes, with different procedures. The City has the legal right to continue to provide sewer service to both areas, including the provision of new sewer connections within each area. Because of the different factual and legal background for each area, they are addressed separately.

Seventh Mountain

The overall Seventh Mountain development from the beginning included two sub-areas, the destination resort area (Inn at the Seventh Mountain/Seventh Mountain Resort) and the "golf village" (Seventh Mountain Golf Village/Widgi Creek). The Seventh Mountain development originally had its own on-site sewer system, but later connected to the City sewer system. The first development was in the 1970s, but the City sewer connection did not occur until the early 1990s. The first development of Seventh Mountain occurred in the 1970s and early 1980s, before the state adopted statutes specifically authorizing and regulating destination resorts. Deschutes County did not adoption maps and regulations implementing the statutory scheme until 1992.

In 1990, by Ordinance No. 90-041, Deschutes County Board of Commissioners approved an exception to Goal 11 allowing the extension of sewer service to Seventh Mountain. The exception applied to the entire area, both the resort and the golf village. The Ordinance included a map of the exception area where city sewer service is allowed. The Ordinance was not appealed, so the exception is considered acknowledged.

The City has entered into several sewer service agreements covering the resort development and the golf village area as authorized by the exception taken in Ordinance No. 90-041. The area has been developed by more than one developer and the City has multiple sewer service agreements, but all City sewer service in the 7^{th} Mountain area is within the exception area adopted by Ordinance No. 90.041, and the agreements are only for service in the exception area.

Tetherow

Tetherow was developed after Deschutes County adopted maps and regulations implementing the statutory provisions regarding destination resorts. Acknowledged County and City comprehensive plans and implementing regulations either allow or require City sewer service to destination resorts in the City's Urban Reserve area. Furthermore, state statutes and regulations authorize the provision of municipal sewer service to destination resorts without an exception. See memorandum dated December 23, 2013. Because the sewer service to Tetherow is to a destination resort, the City can provide sewer service to Tetherow, both to existing development and to new development that is part of the destination resort.

TO: CITY COUNCIL

FROM: GARY FIRESTONE, ASSISTANT CITY ATTORNEY

SUBJECT: SEWER SERVICE TO TETHEROW DESTINATION RESORT

DATE: DECEMBER 23, 2013

Background

Legal Background – State of Oregon

Oregon's statewide planning program relies on a division of land into urban land and rural land. Urban land is defined as land inside an urban growth boundary. Rural land is defined as land outside of an urban growth boundary that is:

(a) Non-urban agricultural, forest or open space,

(b) Suitable for sparse settlement, small farms or acreage homesites with no or minimal public services, and not suitable, necessary or intended for urban use, or

(c) In an unincorporated community. (Oregon Statewide Land Use Planning Goals and Guidelines – Definitions.)

In 1987, the legislature adopted a policy of promoting Oregon as a vacation destination and encouraging tourism as a valuable segment of Oregon's economy. ORS 197.440(1). The legislature also identified a need to provide year-round destination resorts in rural areas. ORS 197.440(2)-(3). The legislature provided that "a comprehensive plan may provide for the siting of a destination resort on rural lands without taking an exception to statewide planning goals relating to agricultural lands, forestlands, public facilities and services or urbanization. ORS 197.450. Because a destination resort may be sited on rural lands without an exception to Goals 11 and 14, urban services may be provided to a destination resort without taking an exception to Goals 11 and 14. Destination resorts must be "self-contained development," which requires that water and sewer facilities must be either on-site facilities or "existing public sewer or water service as long as all costs related to service extension and any capacity increases are borne by the development." ORS 197.435(6)

Goal 8 provides: "Comprehensive plans may provide for the siting of destination resorts on rural lands subject to the provisions of state law, including ORS 197.435 to 197.467, this and other Statewide Planning Goals, and without an exception to Goals 3, 4 11 and 14." Goal 8, like ORS 197.450, allows urban services to be provided to destination resorts without an exception to Goals 11 and 14.

Furthermore, Goal 8 provides that large destination resorts must be at least 160 acres in size and must maintain 50 percent of the site as permanent open space. This is not an urban level of development. Goal 8 repeats the statutory definition of self-contained development that allows service to be provided by "existing public sewer or water service as long as all costs related to service extension and any capacity increases are borne by the development."

Legal Background – Deschutes County

The County implemented Goal 8 and the destination resort statutes by adopting ordinances that amended the County's Comprehensive Plan to include a destination resort siting map and a Destination Resort chapter (Chapter 23.84) in its Comprehensive Plan. A copy of Deschutes County's acknowledged Destination Resort map is attached as Exhibit A, and a copy of the acknowledged Chapter 23.84 is attached as Exhibit B. Section 23.84.010, which is part of the Comprehensive Plan, provides in relevant part:

> Since 1979 destination resorts have increased in importance to the economy of Deschutes County. In 1989, recognizing the importance of tourism to the economy of the State of Oregon, the state legislature and the Land Conservation and Development Commission ("LCDC") took steps to make it easier to establish destination resorts on rural lands in the state. Statewide Planning Goal 8, the recreation goal, was amended to specify a process for locating destination resorts on rural land without taking an exception to Goals 3, 4, 11 and 14, which govern development on rural resource lands. This was followed by legislation incorporating Goal 8 into Oregon's land use statutes. **By these actions, the State of Oregon recognized destination resorts as a legitimate rural land use**. Under these changes, destination resorts may be sited in EFU zones where they weren't allowed before. (*Emphasis added*).

In January 1999, the Deschutes County Board of Commissioners adopted Ordinance 99-001 that amends Title 19 of the Deschutes County Code to include a new chapter 19.106 Destination Resorts "to establish an approval process for siting destination resorts under LCDC Goal 8 and the Bend Urban Area General Plan on lands identified in the Bend Urban Area General Plan map as eligible for destination resort siting." This new chapter mirrored the County's existing land use regulations for development of destination resorts under Chapter 18.113 of the Deschutes County Zoning Ordinance, Destination Resorts. The process for siting a destination resort includes (1) approval of a conceptual master plan for the resort and (2) approval of a final master plan for the resort. Destination resorts are a conditional use in areas designated as urban area reserve area under the General Plan. Deschutes County Code 19.106.040.A. Destination resorts may use municipal sewer services, but must have a sewer service agreement with the City of Bend. DCC 19.106.050.B.11.d. These county code provisions are acknowledged.

Legal Background – City of Bend

Because the City, pursuant to an intergovernmental agreement with Deschutes County, has jurisdiction over areas designated as urban reserves, the City also adopted provisions related to destination resorts. Destination resorts are a permitted secondary use in mapped areas in the Urban Area Reserve (UAR-10) zone. Bend Area General Plan Table 5-7. The acknowledged Bend Area General Plan also includes a map of areas eligible for destination resort siting. Bend Area General Plan Figure 5-22. The acknowledged Bend Area General Plan also contains the following Housing and Residential Lands policies relating to destination resorts:

> 50. Destination resorts, as defined by state law, shall only be allowed in areas designated for such use as shown on the adopted destination resort map. An exception to statewide goals relating to agricultural lands, forestlands, public facilities and services or urbanization is not needed for development of a destination resort on the eligible lands in the urban area.
>
> 51. A destination resort within the Urban Area Reserve shall be served by municipal water and sewer service or an approved community water and sewer service for domestic use. (BAGP at 5-29.)

The Bend Area General Plan provides for the siting of destination resorts and includes a map (Figure 22) that identifies lands eligible for siting of a destination resort. Most of the lands mapped as eligible are also designated urban area reserve on the Plan Map west of Bend. Chapter 5 of the Bend Area General Plan includes policies for mapping eligible lands and developing destination resorts on eligible lands. Figure 5-22 was amended in 2003 as part of periodic review.

These acknowledged plan provisions provide that an exception to the public facilities and services and urbanization goals is not needed to develop destination resorts on eligible lands in the urban reserve area, and expressly authorize destination resorts in the urban area reserve to be serviced by municipal water and sewer service.

The Tetherow Destination Resort is within the Urban Area Reserve and within an area mapped as eligible for destination resorts under Figure 5-22 of the Bend Area General Plan. Both the City and the County have adopted ordinances that identify the lands on which Tetherow was developed as eligible for the siting of a Goal 8 destination resort. The City and County plans and implementing regulations, including the requirement that destination resorts must have City sewer service, are consistent with Goal 8, and, because they have been acknowledged, have been determined to be consistent with Goals 11 and 14.

Legal Background – Urban Area Reserve Exception

The urban reserve area, shown on Figure 1-1 of the Bend Area General Plan, has an acknowledged exception to Goals 3 and 4. The Tetherow Destination Resort is within the urban reserve area.

Factual Background – Land Use Process for Tetherow Destination Resort, Agreement with City.

Deschutes County approved a destination resort conceptual master plan for the Tetherow Destination Resort in January, 2005. Condition of Approval # 2 provided: "The applicant shall submit a signed formal agreement with the City of Bend for connection to the City of Bend sewer treatment plant. A copy of the signed contract with the City of Bend shall be submitted with the Final Master Plan application." That decision was not appealed.

The City then entered into the Water and Sewer Service Agreement covering the Tetherow Destination Resort. A copy of that agreement is attached as Exhibit C. That agreement provides that the City will provide sewer service to serve the development approved by the County.

The County then approved the final master plan for the Tetherow Destination Resort on September 29, 2005. The approval documents states that the applicant submitted the utility service agreement with the City. The County's final decision approving the Final Master Plan was not challenged. A copy of the County's decisions are attached as Exhibits D (Conceptual Master Plan approval) and E (Final Master Plan approval).

ANALYSIS

1. <u>Destination resort use is allowed without an exception to Goals 11 and 14</u>
Both the applicable statute and Goal 8 provide that destination resorts may be sited on rural lands without an exception to Goals 2, 3, 11 and 14. ORS 197.440; Statewide Land Use Planning Goal 8. Goal 8 provides "Comprehensive plans may provide for the siting of destination resorts on rural lands subject to the provisions of state law, including ORS 197.435 to 197.467, this, and other Statewide Planning Goals, and without an exception to Goals 3, 4, 11 or 14." There would have been no need to include a reference to Goals 11 and 14 if the legislature and LCDC had not intended to allow municipal utilities to be provided to destination resorts.

Both the applicable statute and applicable goal provisions expressly state that a destination resort's water and sewer needs may be provided from "existing public sewer or water service as long as all costs related to service extension and any capacity increases are borne by the development." ORS 197.435(6); Goal 8.

ORS 197.445(1) provides that destination resorts must be at least 160 acres in size[1] and ORS 197.445(2) requires that at least half the site must be permanent open space (not counting streets and parking as open space). Development of that size and composition does not result in urban levels of development.

[1] The statute provides for smaller sized destination resorts within 2 miles of the ocean shoreline, but that exception is not applicable here.

ORS 197.445(5) provides that commercial uses are limited to types and levels necessary to meet the needs of visitors to the resort and prohibits industrial development. Again, this shows that a destination resort is not an urban use; otherwise the commercial use would not be so restricted.

ORS 197.450 provides that a comprehensive plan may provide for the siting of destination resorts on rural lands without taking an exception to statewide planning goals relating to agricultural lands, forestlands, **public facilities and services** or **urbanization**. (*Emphasis added.*)

The acknowledged County Comprehensive Plan refers to destination resorts as a legitimate rural land use. Deschutes County Comprehensive Plan Section 23.84.010. The County has an entire chapter in its acknowledged development code that provides for the siting of destination resorts. The County does not regulate land uses within cities. The County and City have coordinated land use planning for destination resorts in the "Urban Reserve" area outside the UGB, so that their plans and code provisions are consistent.

The City and County, before the statutes governing urban reserves, created an "Urban Area Reserve" that was outside the UGB as an area that could provide for an expanded UGB at some future time. Exceptions to Goals 3 and 4 were adopted for that land. Because of the anticipation of potential future inclusion in the UGB, these rural lands were addressed in the Bend Area General Plan. Policy 50 in the Housing and Residential Lands chapter for the BAGP provides in part that destination resorts may be developed without an exception to statewide goals relating to agricultural lands, forestlands or urbanization.

2. No exception is needed to provide water to destination resorts.

As discussed above, relevant statutes and statewide land use planning goals specifically provide that no exception to the public facilities and services or urbanization goals is needed for a destination resort.

Deschutes County Code Section 19.106.070.O requires destinations resorts to be served with either on-site water and sewer or "by municipal sewer and water as allowed by the Bend Urban Area General Plan."

The acknowledged Bend Area General Plan contains, in the housing and residential land chapter, the following policy:

> 51. A destination resort within the Urban Area Reserve shall be served by municipal water and sewer service or an approved community water and sewer service for domestic use.

These plan and code provisions have been acknowledged. Because they have been acknowledged to be in compliance with the goals and the time for any appeal of the acknowledged decisions is passed, an attempt to challenge an action consistent with these provisions on the grounds that it is inconsistent with a statewide land use planning goal must fail.

The County approved the Tetherow resort in 2005 and accepted the utility service agreement at that time. In making its final land use decision on the development and provision of sewer to Tetherow, the County properly relied on its own acknowledged code in approving the development and provision of service to Tetherow. That decision was not appealed and is no longer subject to appeal. An exception to the statewide planning goals is not needed in a quasi-judicial action when the action is in compliance with acknowledged plan and implementing regulations, which are deemed to be in compliance with the goals. Nothing in any applicable statute, goal or regulation requires a goal exception to comply with a final, unchallenged land use decision.

The land use decision to provide sewer service to Tetherow was an unchallenged decision by the County in 2005 based on acknowledged plan and code provisions.

4. Not providing service would violate Bend General Plan, which was acknowledged by LCDC (not just deemed acknowledged) as being in compliance with goals

Policy 51 of the Bend Area General Plan requires that destination resorts be served by municipal water and sewer or an approved community water and sewer service. Not allowing municipal sewer service would violate that section because municipal sewer service is being provided and no community water and sewer service has been approved.

5. Not planning for and continuing to provide sewer service to Tetherow would be an unconstitutional impairment of contract

Both the federal and state constitutions prohibit the impairment of contracts. Or Const Art I, Section 21; US Const Art I, Section 10. “Impairment” of contract occurs when a law passed by a government entity prohibits that government entity from fulfilling its obligations under a valid contract. The City entered into valid contracts to provide sewer service to the Tetherow Destination Resort. A public facilities plan is an ancillary document to a comprehensive plan, and a comprehensive plan has legal effect. The City of Bend cannot adopt a public facilities plan that precludes it from complying with its valid contractual obligation to provide sewer service to Tetherow.

6. Even if the City’s legal analysis is incorrect, the City initially provided water service to Tetherow after being informed by DLCD representatives that the City could provide sewer service to destination resorts without an exception, and DLCD did not appeal the County decisions authorizing and requiring City sewer service to Tetherow.

MSA

APPENDIX 4A

Design Storm Considerations

Tab 4A

MSA

Design Storm Considerations for the City of Bend Sewer Collection System

DRAFT TECHNICAL MEMORANDUM
DESIGN STORM CONSIDERATIONS FOR THE CITY OF BEND SEWER COLLECTION SYSTEM

DATE: 9-20-2007

PROJECT: City of Bend, Oregon Sewer Collection System Model and Capital Improvements Program

TO: Victoria Wodrich, City of Bend, Oregon; Walt West, Oregon Department of Environmental Quality

FROM: Shad Roundy, PE
Murray, Smith & Associates, Inc.

REVIEW: David Stangel, PE
Murray, Smith & Associates, Inc.

RE: Design Storm Consideration for the City of Bend Sewer Collection System

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Purpose

The purpose of this technical memorandum is to briefly discuss some considerations for the City of Bend Sewer Collection System design storm. The design storm will be used in modeling system-wide improvements for several planning horizons including: the existing condition, 2030 build-out, and full build-out.

Oregon Department of Environmental Quality Design Storm Requirement

The Oregon Department of Environmental Quality (DEQ) has the following requirements for design storm events when designing collection systems (Oregon Administrative Rule 340-041-0009 items 6 and 7):

> (6) Sewer Overflows in winter: Domestic waste collection and treatment facilities are prohibited from discharging raw sewage to waters of the State during the period of November 1 through May 21, except during a storm event greater than the one-in-five-year, 24-hour duration storm**.**
>
> (7) Sewer Overflows in summer: Domestic waste collection and treatment facilities are prohibited from discharging raw sewage to waters of the State during the period of May 22 through October 31, except during a storm event greater than the one-in-ten-year, 24-hour duration storm.

Based on the above requirements either the 5-year, 24 hour storm event or the 10-year, 24 hour storm event should be used as the design storm. Whichever storm causes a greater impact to the system should be chosen when sizing improvements.

Total Storm Depth

The total storm depths from the NOAA Atlas II precipitation maps are 1.9 inches and 2.1 inches for the 5-year, 24 hour and 10-year, 24 hour storm events respectively. An additional storm frequency analysis was completed to validate the NOAA Atlas II precipitation maps using the Bend airport precipitation gauge data for the period of record (1949-2006). The resulting storm depths for the frequency analysis are shown in Table 1.

The maximum 24 hour storm event for each year during the period of record was used to estimate the storm frequency. Because the maximum precipitation events typically occur during the winter months in the City of Bend, the total storm depths presented in the frequency analysis are representative of winter-time precipitation. The runoff characteristics of a winter-time event are different than a summer time event since much of the winter-time precipitation occurs as snowfall.

The frequency analysis does not account for variation in intensity or rainfall distribution by season. To understand storm depths during the spring and summer months, the frequency analysis was repeated considering precipitation from April through September only. The resulting spring/summer storm depths are also shown in Table 1.

Table 1
Storm Frequency Analysis, City of Bend, Oregon

Source	5-year 24 hour Storm Depth (inches)	10-year 24 hour Storm Depth (inches)
NOAA Atlas II	1.9	2.1
Bend, Airport Period of Record (1948-2007), results typical of winter months	1.8	2.5
Bend, Airport Period of Record April-September (1948-2007), results typical of spring/summer months	1.0	1.2

Storm Distribution

The Oregon DEQ requirements do not specify a required storm distribution. Applicable storm distributions for Oregon are SCS Type IA for longer duration, lower intensity storms typical of winter and spring-time rain events and SCS Type II for shorter duration, higher intensity storms typical of summer-time localized thunder showers. The Bend, Oregon hourly precipitation record at the airport gauge (1949-2006) was reviewed for the period of record to determine an appropriate storm distribution. All storms with 24 hour cumulative precipitation greater than 1.8 inches were reviewed for months from October through March. All storms with 24 hour cumulative precipitation greater than 1.2 inches were reviewed for months from April through September. The precipitation data collected with temporary rain gauges throughout the City in May and June of 2007 was also reviewed. Three representative storm events were selected to assist in selecting an appropriate storm distribution. These three storms are described below:

1. A storm occurring in January 1980 with a total storm depth of 2.0 inches over 24 hours. This storm was selected to represent the DEQ requirement for a 5-year, 24 hour winter-time storm event. The actual storm distribution is compared to theoretical SCS Type IA and Type II storm distributions in Figure 1. The January 1980 storm event resembles the SCS Type IA storm distribution with a more intense peak.

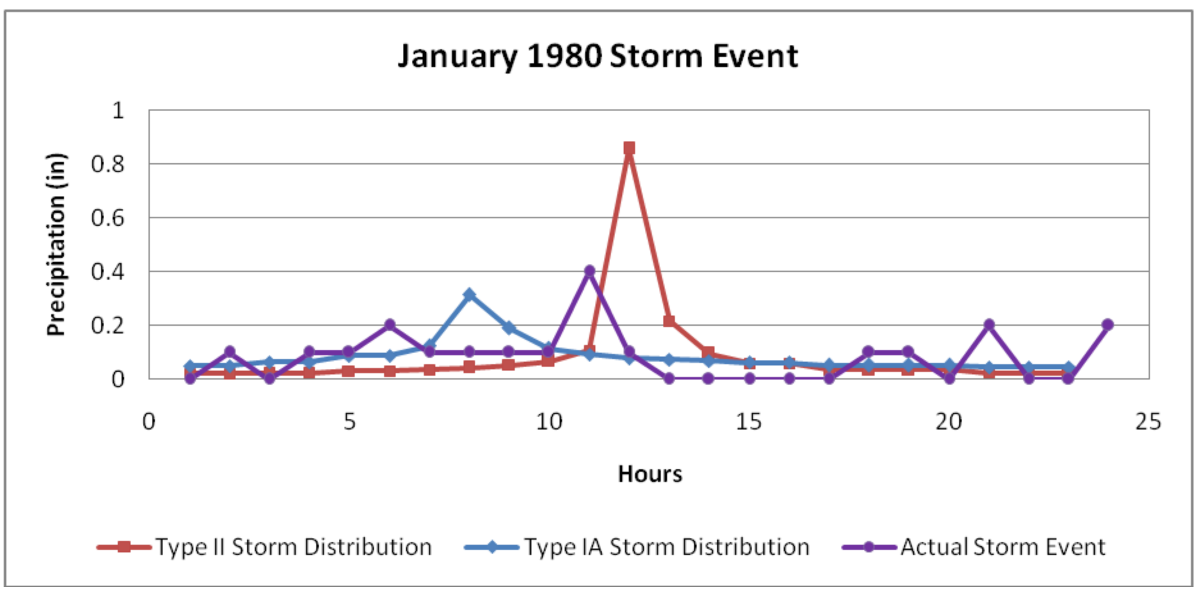


Figure 1: January Storm Event (2.0 inches) with SCS Type IA and Type II Theoretical Storm Distributions

2. A storm occurring in June 1965 with a total storm depth of 1.47 inches over 24 hours. This storm was selected to represent the DEQ requirement for a 10-year, 24 hour summer-time storm event. The actual storm distribution is compared to theoretical SCS Type IA and Type II storm distributions in Figure 2. The June 1965 storm event resembles both distribution types with the peak rainfall occurring somewhere between the two.

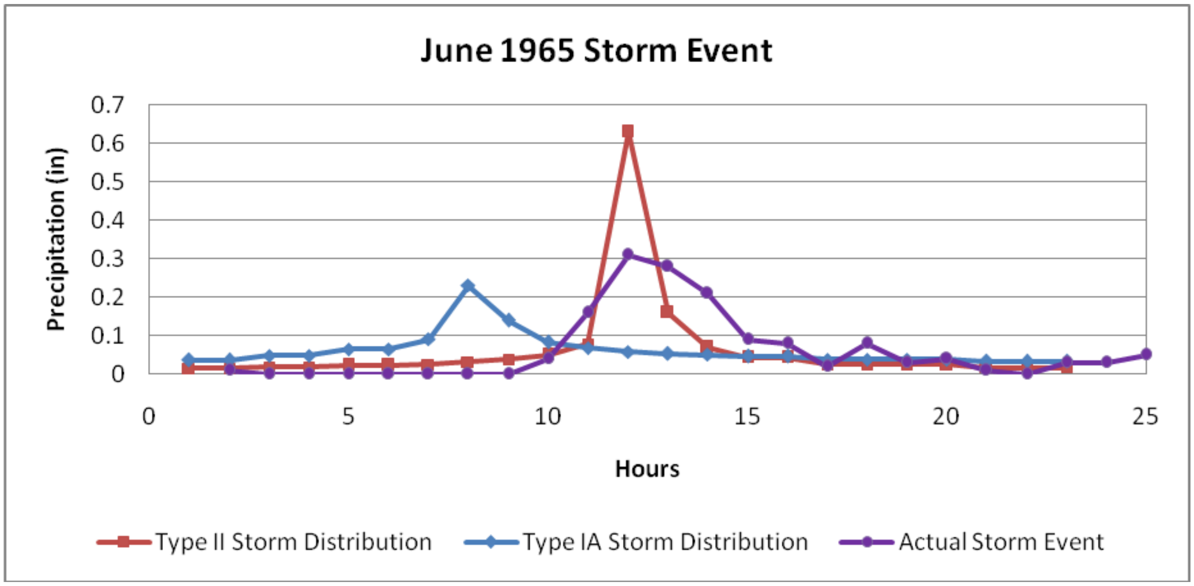


Figure 2: June 1965 Storm Event (1.47 inches) with SCS Type IA and Type II Theoretical Storm Distributions

3. A storm occurring in June 2007 and recorded at a temporary precipitation gauge in the City of Bend with a total storm depth of 1.4 inches over 24 hours. This storm was selected to represent a high intensity summer-time thunderstorm. The actual storm distribution is compared to theoretical SCS Type IA and Type II storm distributions in Figure 3. The June 2007 storm event resembles the Type II storm distribution.

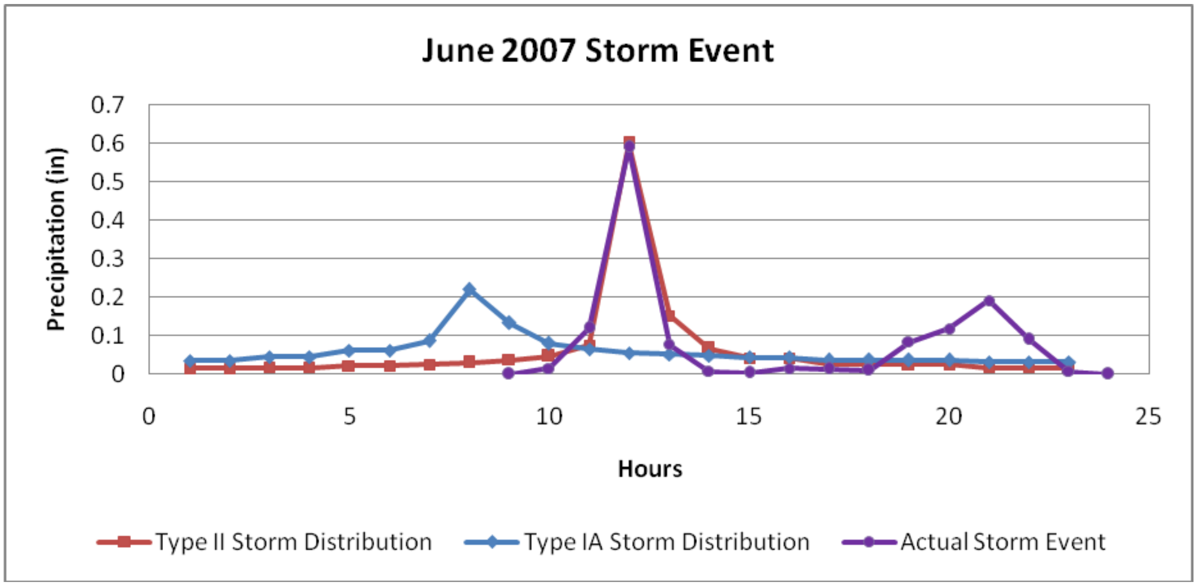


Figure 3: June 2007 Storm Event (1.4 inches) with SCS Type IA and Type II Theoretical Storm Distributions

The storm event example in Bend from June 2007 indicates that the SCS Type II distribution is more appropriate for a summer-time storm event; while the storm event example from January 1980 indicates that the SCS Type IA distribution is more appropriate for a winter-time storm event. The June 1965 storm event example indicates that there are a number of summer-time storm events that fall somewhere between the two distributions with the SCS Type II distribution being more conservative.

Infrastructure sizing in a sewer collection system are more sensitive to storm distribution and peak intensity than to total storm depth. For example, flooding may occur in a 1.2 inch, high intensity, summer-time thunderstorm and may not occur in a 2.1 inch, uniform intensity, winter-time storm. This concept is presented in two model profile results shown in Figures 4 and 5. Figure 4 shows model results with a 2.1 inch 24 hour storm event using a Type IA storm distribution. Figure 5 shows model results with a 1.2 inch 24 hour storm event using a Type II storm distribution. The Type II storm distribution results in a higher peak intensity, greater flow depths, and more substantial surcharging. Based on these results, the Type II storm distribution is recommended to model collection system deficiencies and improvements.

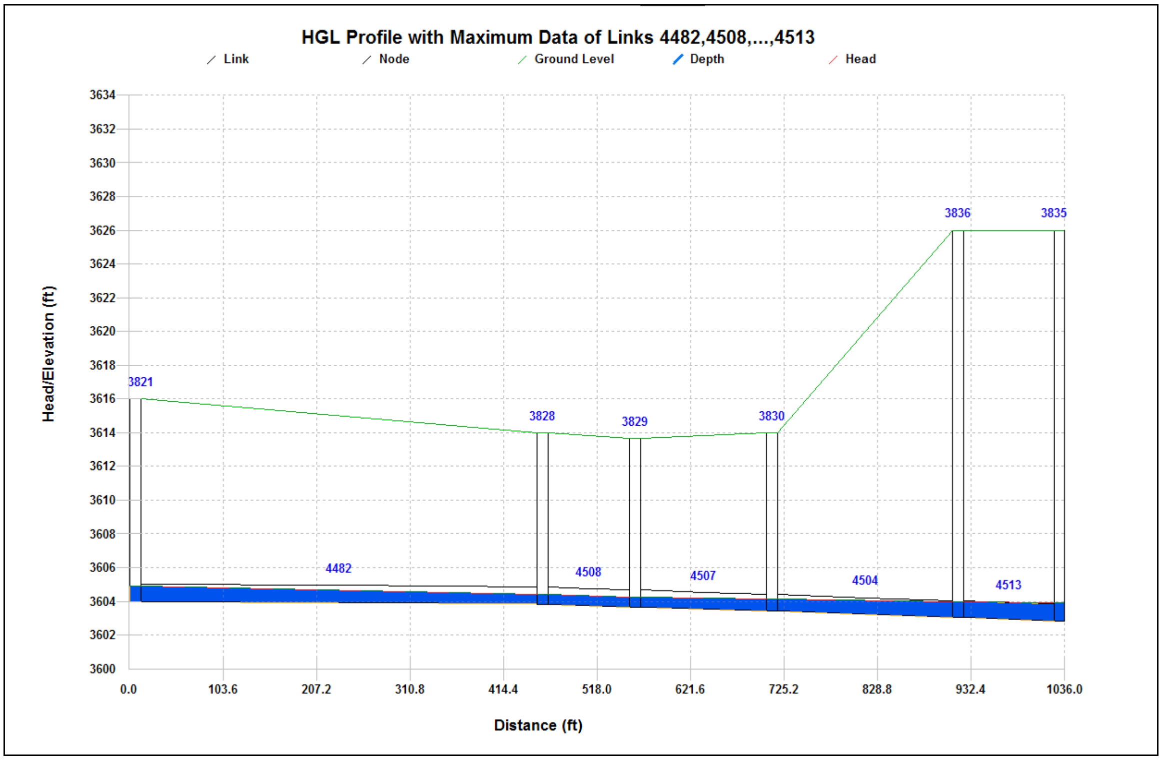


Figure 4: Model Results for Type IA Distribution, 2.1 inch 24 hour Storm Event

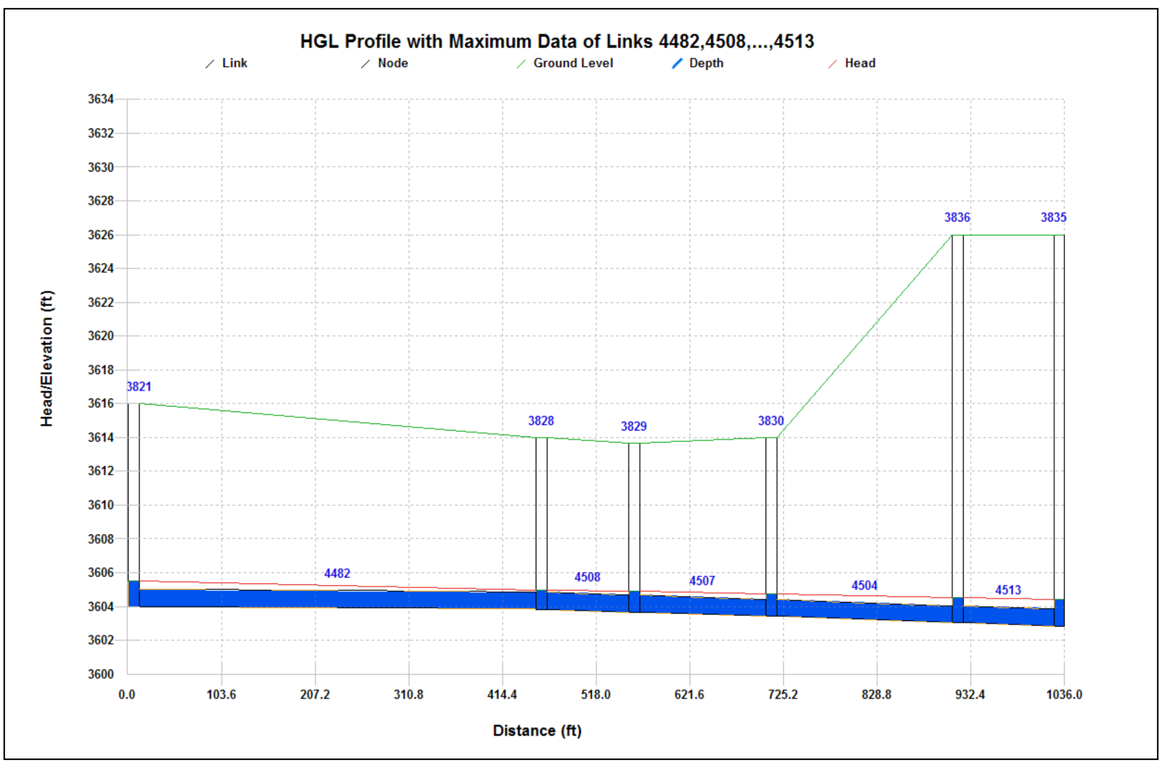


Figure 5: Model Results for Type II Distribution, 1.2 inch 24 hour Storm Event

Selecting the Design Storm Depth

Another method for determining adequate design storm depth is to review the number of times a peak hour storm depth is exceeded over the precipitation gauge period of record. The hourly storm depths selected for this analysis were derived from the peak hour of the SCS Type II distribution. With the SCS Type II distribution, approximately 50% of the design storm depth falls during the peak hour. Four design storms were analyzed. The design storms are described and the results of the analysis are shown in Table 2. Note that the hourly occurrence intervals reported are "on-average." Multiple hourly occurrences may in actuality have occurred within the same day during one large storm event.

Table 2
Hourly Storm Depth Occurence, City of Bend, Oregon

Storm Description	Total Storm Depth (inches)	Peak Hour Depth (inches)	Number of Hours Peak Hour Depth Equaled or Exceeded During Period of Record (1949-2006)	Number of Hours Peak Hour Depth Equaled or Exceeded During Period of Record (summer-time)	On Average Occurrence (summer-time)	Number of Hours Peak Hour Depth Equaled or Exceeded During Period of Record (winter-time)	On Average Occurrence (winter-time)
10-year, 24 hour Storm (NOAA Atlas II)	2.1	0.9	6	2	1 hour every 29 years	4	1 hour every 14.5 years
5-year, 24 hour Storm (NOAA Atlas II)	1.9	0.81	7	2	1 hour every 29 years	5	1 hour every 11.6 years
June 1965 Actual Storm Depth at Bend Airport	1.47	0.63	13	4	1 hour every 14.5 years	9	1 hour every 6.4 years
10-year, 24 hour Storm, April-Sept precip data at Bend Airport	1.2	0.51	21	8	1 hour every 7.3 years	13	1 hour every 4.5 years

The challenge in sewer collection system master planning is to meet the DEQ standard for overall storm depth and frequency, while not over-sizing improvements. Over-sized improvements are costly and may not meet the minimum velocity requirements for scour and prevention of sediment build-up.

Based on the analysis shown in Table 2 using the SCS Type II distribution, the NOAA Atlas II storm depths (1.9 inches and 2.1 inches) appear overly conservative. When considering winter-time months, peak hour storm depths are equaled or exceeded only 4 and 5 times over 58+ years (on average 1 hour every 11.6 – 14.5 years). When considering the same peak hour storm depths during a summer-time storm, the results are even more conservative with depths being equaled or exceeded only 2 times over 58+ years (on average 1 hour every 29 years).

A more appropriate storm event would fall somewhere between the 10-year, 24 hour April-Sept storm (1.2 inches) and the June 1965 storm (1.47 inches). The peak hour depths are equaled or exceeded 9 and 13 times over 58+ years during the winter-time (on average 1 hour every 4.5 and 6.4 years) and 4 and 8 times over 58+ years during the summer-time (on average 1 hour every 7.3 and 14.5 years) for the two storms respectively. A 1.3 inch design storm depth can be interpolated from the two winter storm depths at a 5-year interval. A 1.3 inch design storm depth can also be interpolated from the two summer time storm depths at a 10-year interval.

Based on the two interpolated numbers, the minimum design storm recommendation is 1.3 inches with an SCS Type II distribution. This means that the peak hour storm depths derived from the recommended storm depth and distribution will be exceeded less than once every 5 years during the winter on average and less than once every 10 years during the summer on average.

Another verification of the recommended design storm is to equate the peak intensity of the 1.3 inch SCS Type II distribution summer-time storm (peak intensity = 0.4 in/hr) with the peak intensity of a 2.6 inch SCS Type IA distribution winter-time storm (peak intensity = 0.40 in/hr). In both cases the total design storm depths at their respective distributions satisfy the storm frequency analysis shown in Table 1 and meet the DEQ requirement (summer-time storm depth, 10-year, 24 hour event 1.3 inches > 1.2 inches; winter-time storm depth, 5-year, 24 hour event 2.6 inches > 1.8 inches).

APPENDIX 4B

Model Calibrations

APPENDIX 4B
MODEL CALIBRATION

Introduction

This appendix summarizes the methodology and results for the calibration of the updated hydraulic model, which predicted the system response under dry and wet weather conditions to determine deficiencies in the system.

The City of Bend's (City) updated hydraulic model includes nearly all gravity pipes in the system (down to 4 inches in diameter) totaling 347 miles. The updated network in the model reflects recent development and other improvements, and is consistent with the City's Geographical Information System (GIS) sewer database. Over the past few years, the City's GIS department has made a significant effort to collect survey elevations at all manholes in the system. Manhole and pipe invert elevations were updated using as-built information. The City contains 438 pumping systems; 71 were included in the model. Many of the pumping systems are individual residential units that were not modeled. Modeled lift stations consist primarily of regional stations that collect sewage from a sewer basin or sub-basin and are City owned and operated.

In contrast, the previous hydraulic model developed for the 2007 CSMP, contains pipes greater than or equal to10 inches in diameter, with some 8-inch piping totaling 104 miles of pipeline. Twenty-seven (27) lift stations were included in the previous model.

The hydraulic model was updated by MSA in InfoSWMM by Innovyze. InfoSWMM is a fully ArcGIS-integrated, hydrologic and hydraulic simulation software program for the effective management of urban stormwater and wastewater collection systems. InfoSWMM integrates EPASWMM Version 5 with ArcGIS.

To complete the update process of the hydraulic model, the dry weather loads, diurnal curves, and wet weather parameters described in Section 3-Wastewater Flow Projections were assigned to the corresponding model manholes.

Model Calibration

Calibration is the process of adjusting a model's hydraulic and hydrologic parameters until a reasonable representation of the wastewater flows throughout the system has been obtained. Flow rates measured at each flow monitoring location are compared to model flow rates for an extended period of time (typically at least 24 hours) for both a dry weather period, including weekdays and weekend days, and a wet weather period. The results are compared with field measurements to determine the model's level of accuracy.

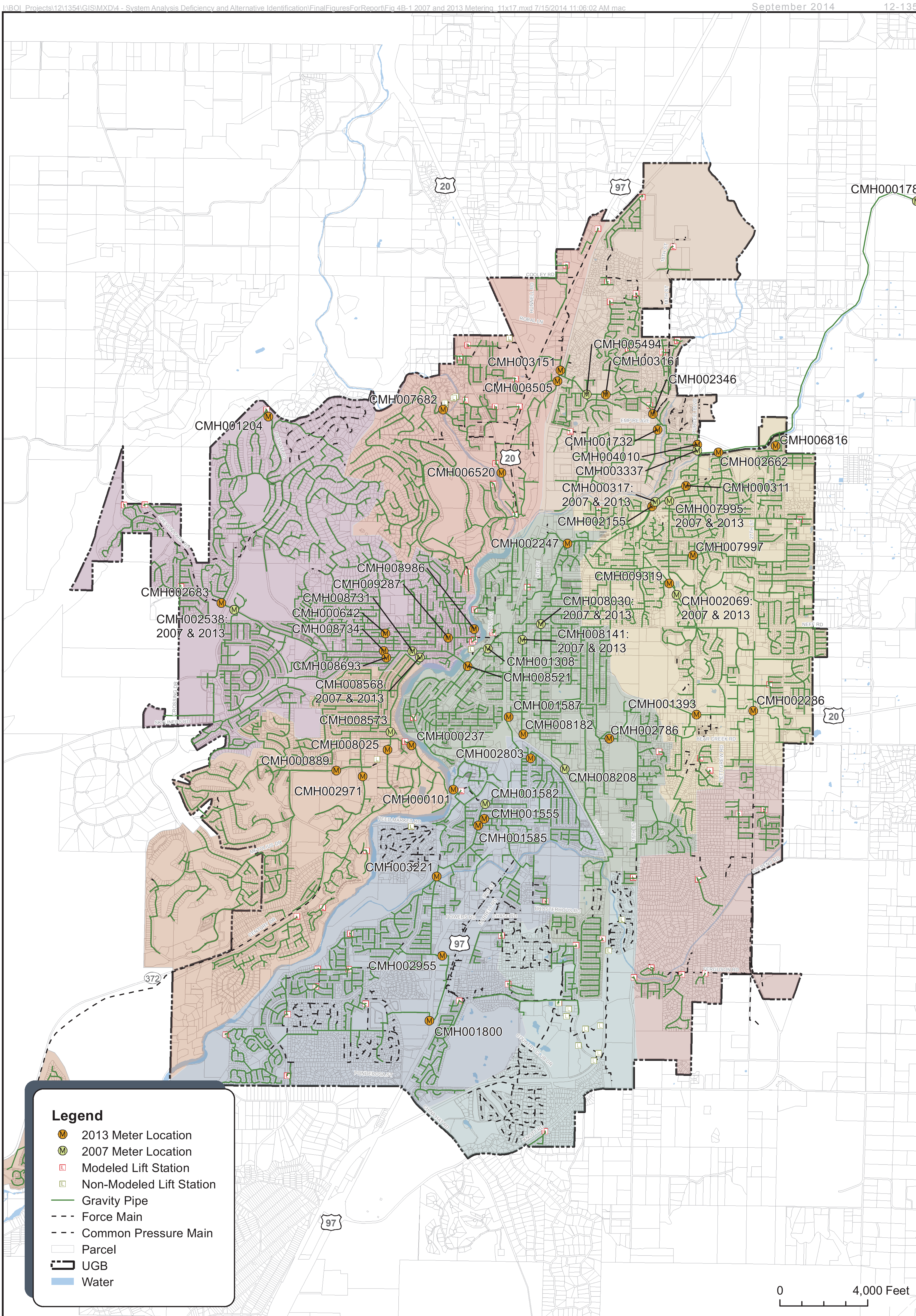
The model was calibrated until the relative error of less than 20% or an absolute error of less than 50 gpm was obtained for volume and peak flow. The results were also reviewed visually to assess the range of flows during the analysis period. The simulated variation in flow during the day reasonably represents measured flow at all collection system monitoring locations. The large number of flow monitoring locations (47) and the overall system coverage (98%), paired with the level of calibration, indicate a high confidence level for the dry weather model calibration.

Calibration Methodology

A different methodology was used to calibrate each component of the wastewater flow: dry weather flow (base wastewater flow and groundwater infiltration) and RDII (rainfall-dependent infiltration and inflow) flow:

- The dry weather component was calibrated using the flow monitoring data recorded in March – April, 2013 at 47 locations that cover 98% of the service area. Flow monitoring data collected in 2011 at 33 locations was also used to supplement and or confirm the 2013 data where required. The model was calibrated for dry weather flow conditions with adjustments to loading and diurnal patterns until field and model flows match.
- The model was calibrated for wet weather conditions with adjustments to wet weather hydrographs and RDII sewersheds (wet weather impact areas) until field and model flows match during a rain event. The wet weather component was calibrated using the flow monitoring data measured in May-June 2007, due to the absence of storms during the 2011 and 2013 data collection periods. This 2007 flow monitoring effort included 9 rain gages and flow meters at 15 locations. Historical records at the WRF show minimal change in the overall average flows in the 2007-2013 period. There was also relatively little overall development and expansion of the system during 2007-2013, allowing for the measured data to be considered generally representative of the 2013 system response. Results of the wet weather calibration were verified using rainfall and flow measured at the WRF during the storm event of January 18, 2012. The calibration and verification process was complemented with a sensitivity analysis that resulted in two sets of wet weather parameters: Mid-R and High-R. These sets were then applied to the design storm to generate two different potential wet weather responses (Mid-R and High-R), and the system was evaluated to obtain a range of deficiencies. For exhaustive background and detail, see Appendix 4D—Flow Monitoring for flow monitoring and temporary flow monitoring reports created by ADS Environmental Services (2011 and 2013, respectively), and an inflow and infiltration analysis report created by V&A Consulting Engineers, Inc. in 2007.

Figure 4B-1 shows the location of the 2007 and 2013 flow monitors. The results and details of the calibration process and the results described herein.



MSA
Murray, Smith & Associates, Inc.

City of Bend
Collection System Master Plan

Figure 4B-1
2007 - 2013 Flow Meter

N
W E
S

Dry Weather Calibration

The hydraulic model utilizes two parameters to represent the dry weather wastewater flow at a specific loading point: a daily average dry weather flow and a unit diurnal pattern. The diurnal pattern describes the fluctuation of the loading during a typical 24-hour period. For the City's sewer system, these parameters were estimated from flow monitoring data and then adjusted until an acceptable system response during dry conditions was obtained. The calibration procedure was as follows:

1. ***Determination of contributing manholes to each flow monitoring location:*** The parameters inferred from flow monitoring data were assigned to all manholes in the discrete contributing area of each meter location. This was done for the locations in the 2013 flow monitoring program.

2. ***Development of diurnal patterns:*** Dry weather flow data was processed to develop a curve that represents a typical hourly distribution for weekdays and weekend days. This appendix shows the calculated diurnal patterns for the 47 flow monitoring locations, obtained from the 2013 flow measured data. The pattern developed for a flow monitor location was assigned to all the manholes in the flow monitoring contributing area. A typical diurnal curve is presented in Figure 4B-2. The observed diurnal pattern also reflects a lift station or a large user contributing to the area. In those cases, the measured flow was separated into two hydrographs and a diurnal pattern for the flow without the lift station or large user influence was developed.

3. ***Estimation of initial average dry weather contribution in each manhole:*** The initial existing average contribution was estimated using the parcels and land use information (BLI Database), based on a calculated (*Buildable Land Inventory and Property use Assumptions: Existing and Planning Flow Summary Technical Memorandum*, (MSA, June 4, 2013) included as Appendix 4-C) a per-capita contribution of 67 gallon per capita per day (gpcpd). The parcel information also contains a parcel development status; therefore, vacant or currently undeveloped parcels were not included in the initial contribution estimates. The contribution from a specific parcel was assigned to the closest manhole that serves that portion of the City. The initial model input was designated as the total contribution per manhole.

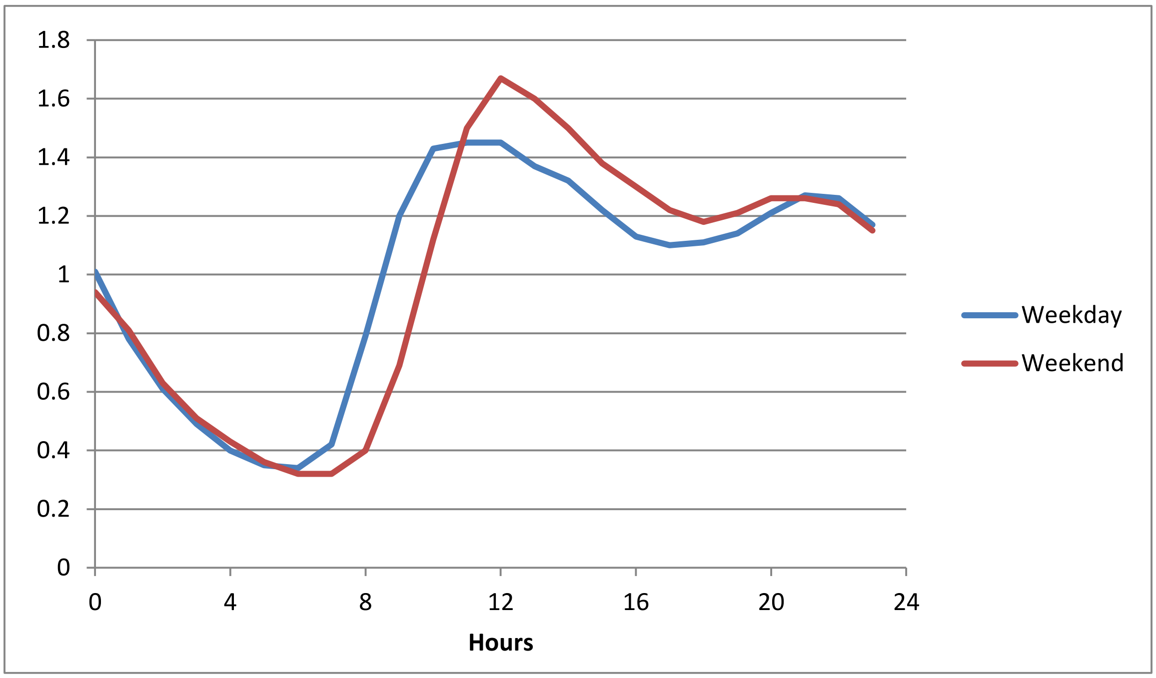
4. ***Adjustment of average base wastewater flow:*** The average contribution at each manhole in the flow monitor contributing area was adjusted to match the total average measured flow. The adjustment factor was applied to all the manholes in a particular flow monitoring basin.

5. ***Adjustment of operation controls at lift stations:*** During the dry weather calibration process, the operational cycles of upstream lift stations were also adjusted to match the measured data, adjusting the start/stop levels for each pump.

The measuring interval and quality of the field measured data reflected the effect of the lift stations upstream of the flow meter.

6. ***Verification of calibration parameters:*** Dry weather flows were further verified using 2007 dry weather measured data. This was an important baseline check since the 2007 data was utilized for the wet weather calibration. Once the hydraulic model results were adequately representing the dry weather flow measured during the 2013 flow monitoring period, the model results were also compared to the dry weather measured during the 2007 flow monitoring period, to verify the calibration. A small increase in flow at the WRF (based on influent flow measurements) was observed between 2007 and 2013 (see Section 3—Wastewater Flow Projections, Figure 3-3).

Figure 4B-2
Typical Diurnal Curve in the System



Dry Weather Flow Calibration and Verification Results

The results of the dry weather calibration are summarized in Table 4B-1. This appendix shows the measured and modeled flow in each flow monitoring location (2013). Figure 4B-3 shows the model results and flow monitoring data just upstream of the WRF.

The model was calibrated until a relative error of less than 20% or an absolute error of less than 50 gpm was obtained, for peak flow. The model results were compared to two different sets of field measured data (a Friday and a Saturday) to estimate the accuracy of the modeling results. The results were also inspected visually to assess the range of flows during the analysis period. A reasonable representation of the variation in flow during the day is observed at all flow monitoring locations. The number of flow meters (47) and the system coverage (98%), pared with the level of calibration, indicate a high confidence level for the dry weather model calibration.

The average peak flow and volume is predicted at the flow monitor just upstream of the WRF (flow meter location CMH000178) within 6% of the measured data for both calibration sets. For flow meters CMH000101, CMH000642, CMH001800, CMH002683, CMH003505, CMH006816, CMH008986, and CMH009287, the peak flow relative error is more than 20% but the absolute error is less than 50 gpm. In all these meters except CMH002683, the relative error for average flow and volume is below 20%. For meter CMH002683 (downstream of Aubrey Glen Lift Station), the peak flow and volume error is below 25% and the average flow error is below 50gpm.

As noted, the dry weather calibration was further verified comparing the model results to a dry weather period using the 2007 field data. The results of the dry weather verification are summarized in Table 4B-2. This appendix shows the measured flow (2007) and model results at those flow monitoring locations. Figure 4B-4 shows the verification results at the WRF. The model results have an average volumetric peak flow error of 16% overall in the system. At the WRF, the field data is over-predicting the peak flow by 15% and under-predicting the volume by 1%. The model results did not represent the 2007 field measured data well, with volume errors greater than 20% at meters CMH007995, CMH08208, CMH001582 and CMH002538. A potential reason for this discrepancy may include upstream changes in sewer infrastructure, including changes in the diversion upstream of meter 14. The model parameters were not adjusted further to match the 2007 meter data, since the 2013 data was more comprehensive and was similar in most locations.

Table 4B-1
Dry Weather Calibration Results

Flow Meter	Model Average (gpm)	Measured Average (gpm)	Average Error %	Average Absolute Error (gpm)	Modeled Peak Flow	Measured Peak Flow Day 1	Measured Peak Flow Day 2	% Error Day 1	% Error Day 2	Combined Peak Error %	Peak Flow error %	Peak Flow error %	Modeled Volume (gal)	Measured Volume Day 1 (gal)	Measured Volume Day 2 (gal)	% Error Day 1	% Error Day 2	Combined Volume error %	Calibration Level	Comments
CMH000101	21	25	**-15%**	(4)	36	50	58	-28%	-37%	**-33%**	14	22	31,221	33,475	32,312	-7%	-3%	**-5%**	high	low flow
CMH000178	4,150	4,395	**-6%**	(245)	7251	7343	7127	-1%	2%	**0%**	91	(124)	5,994,567	5,944,976	5,846,851	1%	3%	**2%**	high	line to WWTP
CMH000237	24	20	**19%**	4	217	191		14%		**14%**	(27)		38,043	47,750	13,576	-20%		**-20%**	medium	Deschutes Brewery/Higher Volume because of 1hr curve time step
CMH000311	3,299	3,732	**-12%**	(433)	5814	5731	5938	1%	-2%	**0%**	(83)	124	4,772,917	5,034,253	5,011,843	-5%	-5%	**-5%**	high	
CMH000317	2,262	2,518	**-10%**	(256)	3933	4065	3852	-3%	2%	**-1%**	133	(80)	3,271,707	3,358,836	3,225,361	-3%	1%	**-1%**	high	
CMH000642	17	14	**23%**	3	33	37	87	-12%	-62%	**-37%**	4	54	24,937	21,608	37,628	15%	-34%	**-9%**	high	
CMH000889	77	78	**-1%**	(0)	142	144	166	-2%	-14%	**-8%**	2	24	111,998	98,312	114,590	14%	-2%	**6%**	high	
CMH001204	71	70	**1%**	1	114	125	143	-9%	-20%	**-14%**	11	29	103,036	90,795	114,315	13%	-10%	**2%**	high	
CMH001393	39	50	**-21%**	(11)	144	159	166	-9%	-13%	**-11%**	15	21	56,895	58,406	61,180	-3%	-7%	**-5%**	high	
CMH001555	87	103	**-15%**	(16)	220	259	206	-15%	7%	**-4%**	39	(14)	126,409	129,211	123,221	-2%	3%	**0%**	high	
CMH001585	559	578	**-3%**	(19)	1119	1442	1111	-22%	1%	**-11%**	323	(8)	811,520	728,825	703,957	11%	15%	**13%**	high	
CMH001587	762	839	**-9%**	(77)	1550	1501	1459	3%	6%	**5%**	(49)	(90)	1,102,778	1,099,913	1,080,608	0%	2%	**1%**	high	
CMH001732	54	43	**26%**	11	171	139	149	23%	15%	**19%**	(32)	(22)	78,846	78,076	69,177	1%	14%	**7%**	high	absolute error < 50gpm
CMH001800	176	197	**-11%**	(21)	427	531	502	-20%	-15%	**-17%**	105	75	254,860	248,460	257,554	3%	-1%	**1%**	high	
CMH002069	515	575	**-11%**	(61)	985	1150	1230	-14%	-20%	**-17%**	165	244	746,664	769,519	812,599	-3%	-8%	**-6%**	high	
CMH002155	38	42	**-9%**	(4)	128	140	175	-8%	-26%	**-17%**	11	46	55,772	52,916	55,066	5%	1%	**3%**	high	
CMH002247	45	60	**-26%**	(16)	128	118	100	9%	28%	**18%**	(10)	(28)	64,321	83,413	79,843	-23%	-19%	**-21%**	medium	absolute error < 50gpm
CMH002286	96	133	**-28%**	(37)	302	314	295	-4%	3%	**-1%**	12	(8)	139,263	178,790	157,797	-22%	-12%	**-17%**	high	
CMH002346	347	359	**-3%**	(11)	790	766	833	3%	-5%	**-1%**	(25)	42	501,837	457,310	447,150	10%	12%	**11%**	high	
CMH002538	88	86	**3%**	2	496	405	440	22%	13%	**18%**	(91)	(56)	127,038	102,156	180,764	24%	-30%	**-3%**	medium	
CMH002662	120	146	**-18%**	(27)	256	300	280	-15%	-9%	**-12%**	45	24	174,728	190,950	185,419	-8%	-6%	**-7%**	high	
CMH002683	69	98	**-30%**	(29)	340	285	280	19%	22%	**20%**	(55)	(60)	99,338	134,460	126,002	-26%	-21%	**-24%**	medium	
CMH002786	107	112	**-4%**	(5)	194	219	232	-12%	-16%	**-14%**	26	38	155,692	146,704	148,614	6%	5%	**5%**	high	
CMH002803	70	75	**-7%**	(5)	118	139	145	-15%	-19%	**-17%**	21	27	102,036	98,176	95,815	4%	6%	**5%**	high	
CMH002955	374	414	**-10%**	(40)	898	1001	785	-10%	14%	**2%**	103	(112)	543,327	533,212	529,488	2%	3%	**2%**	high	
CMH002971	35	36	**-3%**	(1)	54	69	64	-21%	-16%	**-18%**	14	10	50,288	46,802	39,323	7%	28%	**18%**	medium	absolute error < 50gpm
CMH003151	121	126	**-4%**	(5)	385	449	404	-14%	-5%	**-9%**	64	19	174,045	158,561	136,044	10%	28%	**19%**	medium	low flow
CMH003161	279	248	**13%**	31	660	590	562	12%	18%	**15%**	(70)	(98)	402,169	307,557	365,536	31%	10%	**20%**	high	
CMH003221	510	560	**-9%**	(50)	1080	1187	1110	-9%	-3%	**-6%**	107	30	741,447	712,506	721,843	4%	3%	**3%**	high	
CMH003505	108	131	**-17%**	(23)	295	253	240	17%	23%	**20%**	(42)	(56)	156,064	160,846	154,728	-3%	1%	**-1%**	high	
CMH004010	563	570	**-1%**	(8)	1162	1046	1036	11%	12%	**12%**	(116)	(126)	812,068	751,349	734,610	8%	11%	**9%**	high	
CMH006520	174	197	**-12%**	(23)	319	325	332	-2%	-4%	**-3%**	5	12	252,936	245,939	239,988	3%	5%	**4%**	high	
CMH006816	16	17	**-10%**	(2)	33	48	41	-32%	-21%	**-27%**	15	9	23,032	23,726	22,923	-3%	0%	**-1%**	high	low flow
CMH007683	23	24	**-7%**	(2)	44	69	52	-36%	-15%	**-25%**	25	8	33,189	31,871	29,062	4%	14%	**9%**	high	
CMH007995	892	987	**-10%**	(95)	1618	1406	1538	15%	5%	**10%**	(213)	(80)	1,292,634	1,320,467	1,310,203	-2%	-1%	**-2%**	high	
CMH007997	181	194	**-7%**	(14)	306	322	353	-5%	-13%	**-9%**	16	48	262,298	249,342	286,123	5%	-8%	**-2%**	high	
CMH008025	108	121	**-11%**	(13)	269	279	318	-4%	-16%	**-10%**	11	49	156,077	166,610	156,641	-6%	0%	**-3%**	medium	absolute error < 50gpm
CMH008030	287	304	**-5%**	(17)	478	497	512	-4%	-7%	**-5%**	18	33	417,174	406,511	418,636	3%	0%	**1%**	high	
CMH008141	973	1,070	**-9%**	(97)	1814	1943	1755	-7%	3%	**-2%**	129	(58)	1,404,972	1,408,300	1,378,015	0%	2%	**1%**	high	
CMH008182	68	84	**-20%**	(17)	242	257	238	-6%	2%	**-2%**	14	(5)	98,021	117,662	116,947	-17%	-16%	**-16%**	medium	absolute error < 50gpm
CMH008521	193	217	**-11%**	(24)	303	328	327	-8%	-7%	**-7%**	25	23	279,474	291,467	281,391	-4%	-1%	**-2%**	high	
CMH008568	376	408	**-8%**	(32)	744	734	833	1%	-11%	**-5%**	(11)	89	544,897	558,451	574,340	-2%	-5%	**-4%**	high	
CMH008693	42	49	**-13%**	(6)	88	106	91	-17%	-4%	**-11%**	19	3	61,571	60,680	49,621	1%	24%	**13%**	medium	absolute error < 50gpm
CMH008734	154	172	**-11%**	(18)	610	588	564	4%	8%	**6%**	(22)	(46)	223,287	24,245	217,901	0%	2%	**1%**	high	
CMH008986	31	38	**-17%**	(7)	65	79	85	-18%	-24%	**-21%**	14	20	45,614	46,027	46,663	-1%	-2%	**-2%**	high	
CMH009287	36	37	**-4%**	(1)	62	85	86	-27%	-28%	**-28%**	23	24	51,994	48,996	53,691	6%	-3%	**1%**	medium	absolute error < 50gpm
CMH009319	72	87	**-17%**	(15)	141	165	170	-15%	-17%	**-16%**	24	29	105,205	106,874	101,038	-2%	4%	**1%**	medium	

Figure 4B-3
Model Results and Flow Monitoring Data Upstream of the WRF (2013)

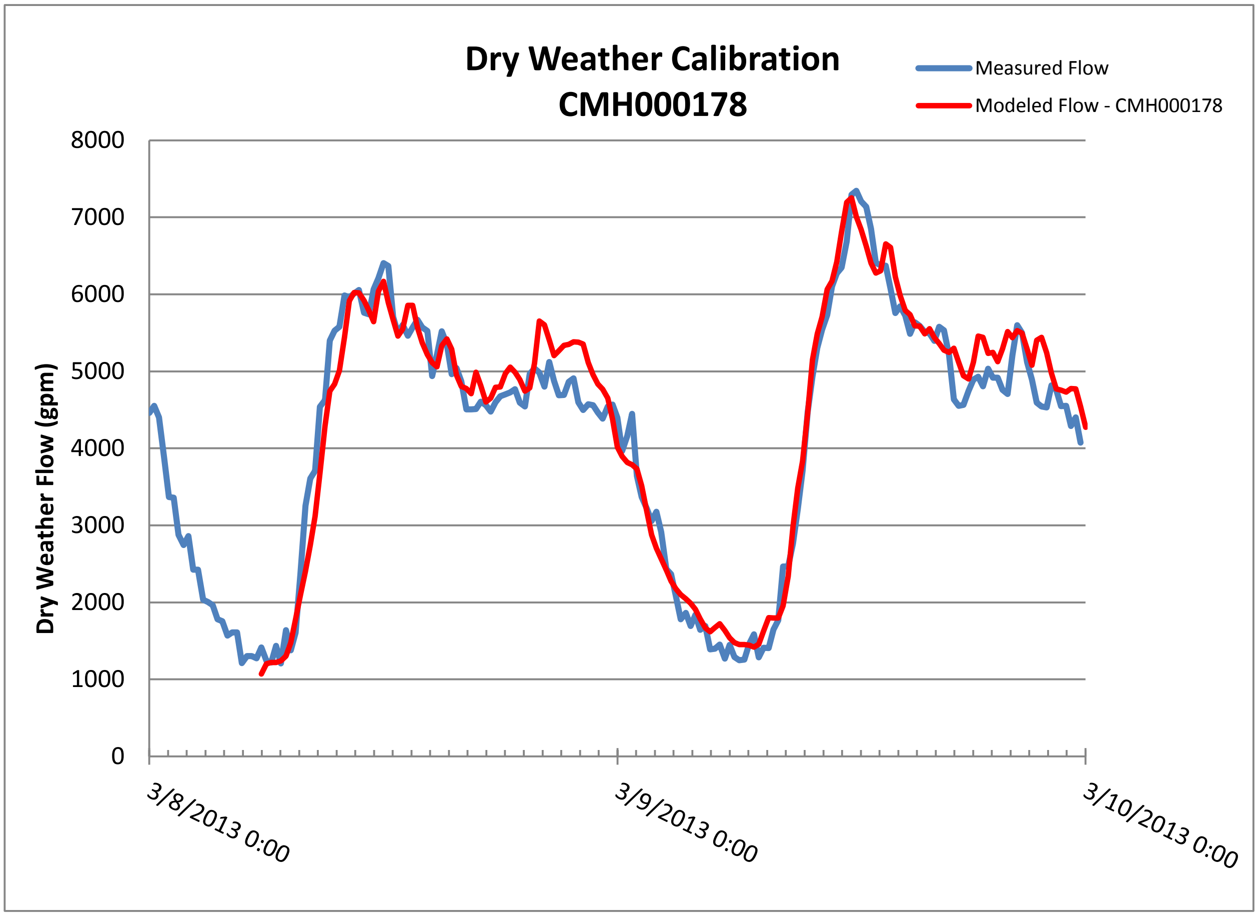
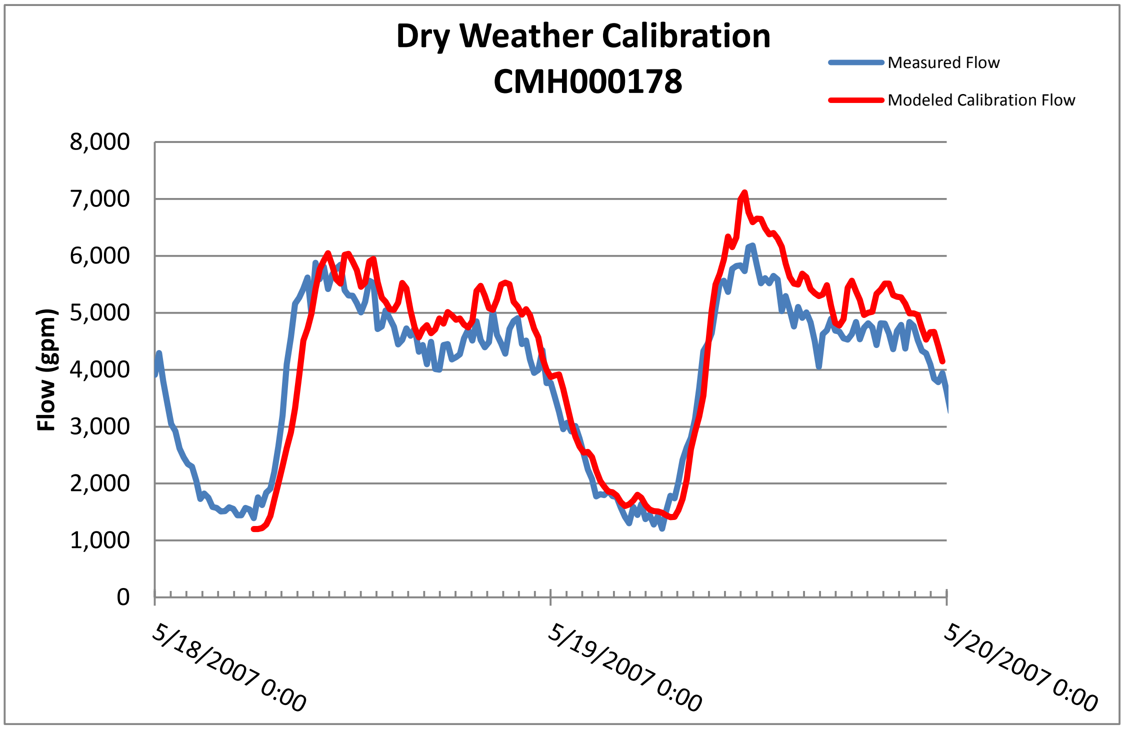


Table 4B-2
Dry Weather Verification Results (2007)

Site	Modeled Peak Flow	Measured Peak Flow	Absolute Error	% Error	Modeled Volume	Measured Volume	% Error	Comments
1	7114	6182	-932	-15%	11241154	11183259	1%	Upstream of WRF
2	1568	1099	-469	-43%	2514878	1969819	28%	Difference due to changes in system configuration
3	3849	4069	219	5%	6168917	7103972	-13%	
4	991	806	-186	-23%	1456963	1291340	13%	
5	480	449	-31	-7%	817223	711146	15%	
6	1701	1872	171	9%	2677630	2876917	-7%	
7	209	162	-48	-29%	786525	235369	234%	Low absolute error
8	1240	915	-325	-36%	1819978	1293219	41%	Difference due to changes in system configuration
9	598	651	53	8%	763274	819493	-7%	
10	301	324	23	7%	537781	589600	-9%	
11	729	791	62	8%	1054664	1143056	-8%	
12	658	808	151	19%	664874	835457	-20%	
13	490	276	-215	-78%	286273	289352	-1%	
14	591	753	162	22%	687989	1123733	-39%	Difference due to changes in system configuration
15	1164	967	-197	-20%	1614809	1493135	8%	

Figure 4B-4
Model Results and Flow Monitoring Data Upstream of the WRF (2007)



Dry Weather Flow Calibration Limitations

The flow measured at a monitoring location shows the hydraulic conditions at one specific point in the system; this point is used to interpret the hydraulic conditions occurring upstream in the system, where the contribution is discrete and by gravity. All the flow monitors were installed downstream of lift stations. For the sections of the system upstream of a lift station, the dry and wet parameters were assumed to be consistent with the others in the flow monitoring basin. Flow monitors installed downstream of lift stations normally can be used to determine the lift station operation but not the diurnal variations upstream of the wet well. In this system, some of the flow monitors were downstream of common force mains (serving more than one lift station); in this case, the flow monitoring data could not be used to determine the lift station cycles or operation point.

Wet Weather Calibration

To simulate the wet weather component, the hydraulic model uses a set of hydrologic parameters for each flow monitoring basin, rainfall information, and the estimated area of contribution for each manhole. This information was estimated using the following sources:

- 2007 monitoring data (rainfall and flow)
- Historical rainfall records
- Historical influent flow at WRF

- Influent flow at WRF, January 18, 2012
- Pipe length upstream of manhole

To develop the wet weather parameters for the Bend system, the meter data collected during the 2007 calibration effort was used, due to the absence of storms during the metering period in 2011 and 2013. A storm event caused a significant response at the WRF on January 18, 2012; however, it was only metered at that location. The flow measured at the plant was used to validate the wet weather parameters. These parameters were then applied to a design storm to compute the corresponding expected design hydrographs.

Wet Weather Parameters

The RTK (described later in this appendix) curve-fitting method was used to simulate the RDII flow. This method assumes that the RDII in a sewer responding to rainfall can be quantified and characterized using three triangular hydrographs that relate RDII to unit precipitation volume, specified time duration, and sewershed characteristics for short-, medium- and long-term response. R is the fraction of rainfall volume entering the sewer system as RDII during and immediately after the rainfall event, T is the time to peak, and K is the ratio of the time of recession to T. To determine the initial RTK parameters for each basin, a Sanitary Sewer Overflow Analysis and Planning (SSOAP) model was developed. SSOAP is an industry-standard tool developed by EPA. Using this tool, the superimposed triangular hydrographs were visually compared to the wet portion of the flow at each flow monitoring location. The SSOAP tool was used to estimate an RTK hydrograph based on area and pipe length. The SSOAP parameters were transferred to InfoSWMM and then adjusted until an acceptable wet response was obtained.

The RTK parameters are applied to the sewershed contributing to each manhole in the system. The assumption is that the RDII is proportional to the pipe length. In the City model, the sewersheds are defined by placing a 20-foot buffer around all system pipes. The sewershed areas are assigned to model nodes using the upstream manhole.

Rainfall Data and Storm Events

The available rainfall/flow data presented challenges to interpretation due to the small number of significant storms measured during the 2011 and 2013 monitoring periods. The City has not deployed permanent flow meters outside the WRF. The largest storm event during the two-month flow monitoring period in 2007 occurred on June 4 and can be described as a summer thunderstorm with high-intensity rain during the peak hour of the storm. The largest response observed at the WRF since 2007 resulted from a storm event on January 18, 2012. The wet weather parameters were validated using this event.

Unfortunately, this event was only measured at the WRF. It should also be noted that the climate conditions preceding the January 18, 2012 winter storm were below freezing, with some snow still on the ground. The January 2012 storm was also a longer, lower intensity storm, compared to a more typical summer storm. Figure 4B-5 shows the rainfall distribution for both the calibration (June 4, 2007) and the verification storm (January 18, 2012). The characteristics of the available measured storms since 2007 events are presented in Table 4B-3.

Figure 4B-5
Rainfall Distribution During the Calibration and Verification Storms

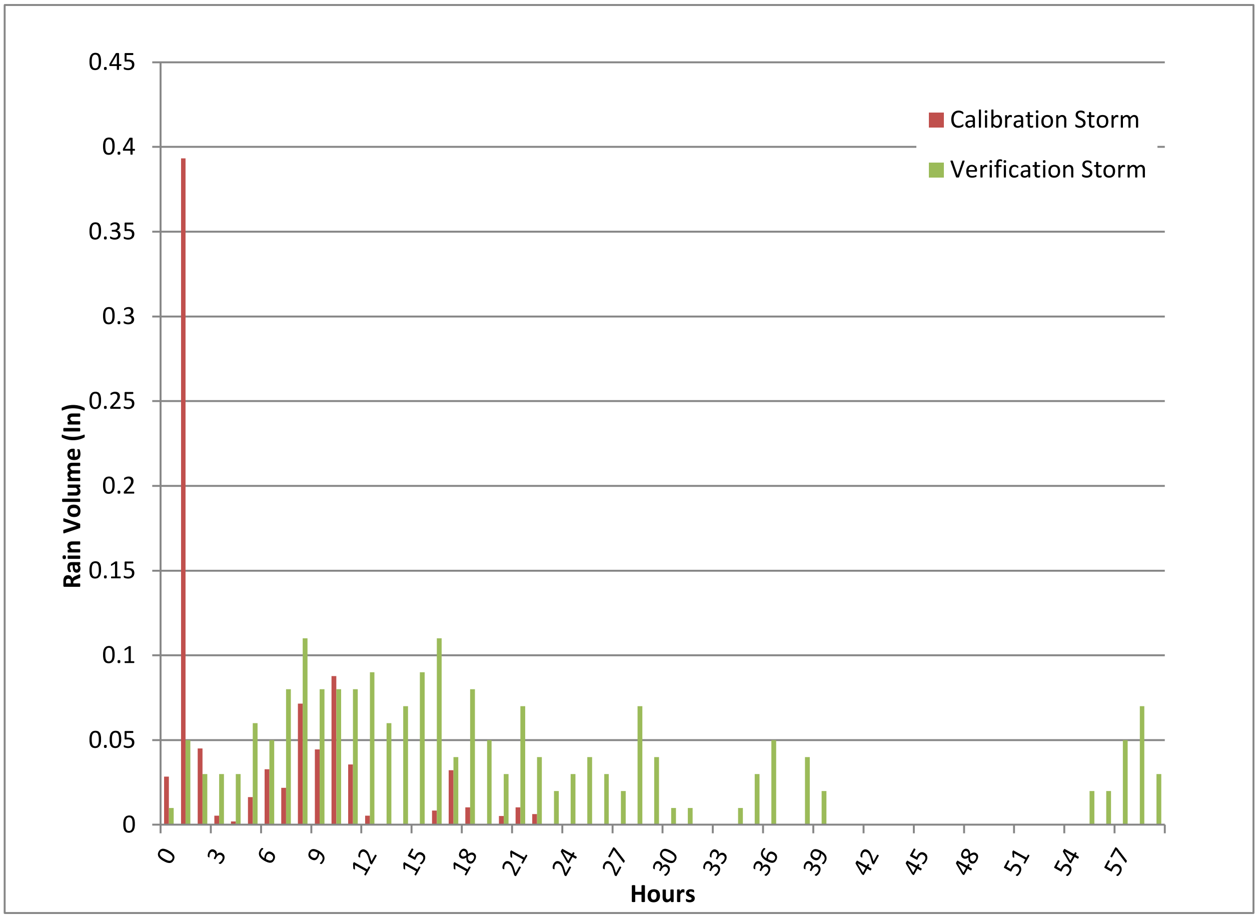


Table 4B-3
Runoff Coefficient Results

Storm Event	Date	Peak Rain (in/hr)	Peak Wet Flow at WRF (gpm)	Total Volume (in)	Duration (hr)	Runoff Coefficient
Storm 1[1]	6/1/2007	0.2	1,041	0.2	3	0.6%
Storm 2[1]	6/4/2007	0.4	1,550	0.9	8	0.4%
Storm 3[2]	1/18/2012	0.1	3,200	1.7	32	3.5%
Storm 4	10/24/2010	0.11	700	0.7	15	0.7%
Storm 5	1/24/2012	0.12	2,776	0.46	9	2.6%
Storm 6	3/29/2012	0.12	1,388	0.37	8	1.3%

[1] *Measured during the 2007 Flow Measuring Program*
[2] *Largest storm event response observed at WRF since 2007*

Runoff Coefficient Analysis

To characterize the wet weather flow in the Bend sewer system, a runoff coefficient analysis was performed. The runoff coefficient defines the relationship between the peak RDII flow and the rainfall intensity. Ideally, a system would exhibit a relatively consistent trend and a runoff coefficient that describes the hydraulic response for wet weather can be estimated. However due to the antecedent conditions at the time of rainfall, variations in the RDII response between storms can and often do occur. For the available storm events, there was no consistency observed in the rain intensity/peak wet flow ratio. Figure 4B-6 shows the relationship between peak RDII flow and rainfall peak intensity.

Due to the different relationship between peak RDII flow and the rainfall intensity for those events measured, as well as the limitations of the available rainfall data, it was not possible to select one wet weather response to represent the system. Considering the available data, three sets of RTK parameters were selected to perform a sensitivity analysis of the system response during a design storm:

- The first set, Low-Runoff (Low-R) Coefficient, generates a system response similar to the response observed during the calibration storm on June 4, 2007.

- The second, High-Runoff (High-R) Coefficient, generates a system response comparable to the one observed during the verification storm on January 18, 2012.

- The third, Mid-Runoff (Mid-R) Coefficient, generates an intermediate response with a peak flow within 20% of both the calibration and the verification storms.

Figure 4B-7 shows the measured and calculated inflow at the WRF, using High- and Mid-R Coefficient RTKs.

The Low-R Coefficient RTKs are based on flow and rainfall measured throughout the system. The High-R Coefficient RTKs present a response of higher risk, indicating the possibility of a higher runoff coefficient for this system, but are based on only one measured point in the system (at the WRF). The hydraulic model was calibrated with the Low-R Coefficient RTK. The High- and Mid-R Coefficient RTK sets were adjusted proportionally for each basin to the Low set, to retain the spatial distribution of wet weather flows.

Based on the indication of a faster response during a winter storm, the Low-R Coefficients (developed for the summer period) are not recommended for use as the wet weather parameters of the City's system. The High-R Coefficient response was measured in one spatial location, and the flow measured indicates the possibility of a faster response that should be taken into account when planning for future conditions. The Mid-R Coefficient set represents a middle point that takes in account the limitations of both sets of data. For master planning purposes, the system was analyzed for both the Mid- and High-R Coefficient RTKs. The deficiencies and required improvements for both potential types of response during the design storm were later compared to determine the effect in improvement size and cost. The

Mid-R Coefficient RTK parameters for each of the system basins are presented in Table 4B-4. The High-R Coefficient RTK parameters are presented in Table 4B-5.

Figure 4B-6
Runoff Coefficient Analysis

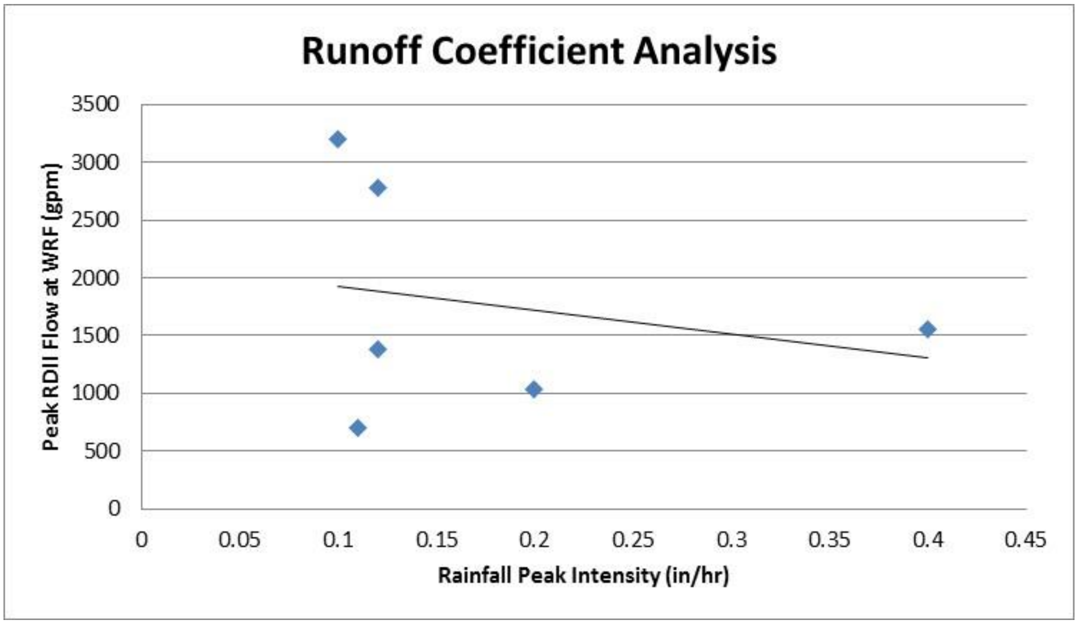


Figure 4B-7
High- and Mid-R Coefficient Results

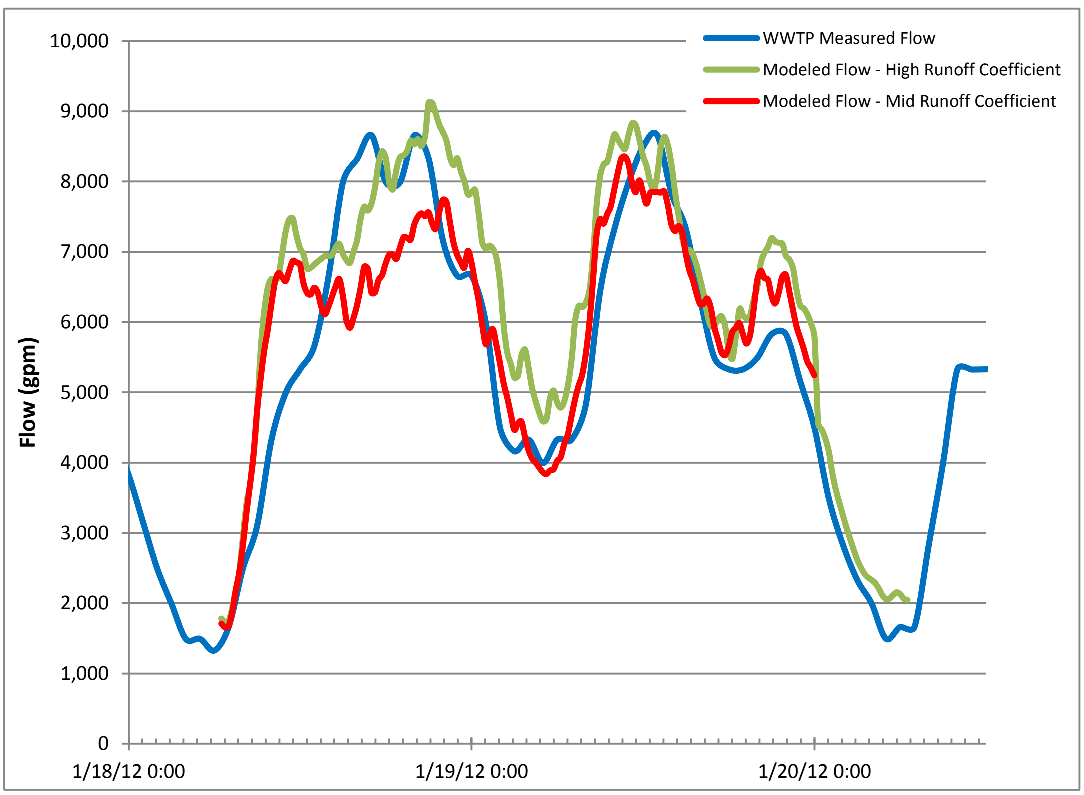


Table 4B-4
Mid-R Coefficient RTKs

Unit Hydrograph Group ID	R1	T1	K1	R2	T2	K2
HYDRO-1	0.044	1	2	0.023	6	3
HYDRO-2	0.010	1.5	2	0.023	6	3
HYDRO-3	0.023	1	2	0.023	6	3
HYDRO-4	0.003	0.5	1	0.023	6	3
HYDRO-5	0.039	0.5	1	0.023	6	3
HYDRO-6	0.037	0.5	1	0.023	6	3
HYDRO-7	0.041	0.5	1	0.023	6	3
HYDRO-8	0.047	0.5	1	0.023	6	3
HYDRO-9	0.003	1	2	0.023	6	3
HYDRO-10	0.044	0.5	1	0.023	6	3
HYDRO-11	0.011	0.5	2	0.023	6	3
HYDRO-12	0.006	0.5	1	0.023	6	3
HYDRO-13	0.010	0.5	1	0.023	6	3
HYDRO-14	0.002	0.5	1	0.023	6	3
HYDRO-15	0.022	0.5	1	0.023	6	3

Table 4B-5
High-R Coefficient RTKs

Unit Hydrograph Group ID	R1	T1	K1	R2	T2	K2
HYDRO-1	0.079	1	2	0.023	6	3
HYDRO-2	0.018	1.5	2	0.023	6	3
HYDRO-3	0.041	1	2	0.023	6	3
HYDRO-4	0.006	0.5	1	0.023	6	3
HYDRO-5	0.069	0.5	1	0.023	6	3
HYDRO-6	0.068	0.5	1	0.023	6	3
HYDRO-7	0.073	0.5	1	0.023	6	3
HYDRO-8	0.086	0.5	1	0.023	6	3
HYDRO-9	0.006	1	2	0.023	6	3
HYDRO-10	0.079	0.5	1	0.023	6	3
HYDRO-11	0.02	0.5	2	0.023	6	3
HYDRO-12	0.01	0.5	1	0.023	6	3
HYDRO-13	0.018	0.5	1	0.023	6	3
HYDRO-14	0.004	0.5	1	0.023	6	3
HYDRO-15	0.04	0.5	1	0.023	6	3

Synthetic Unit Hydrograph Method

The RTK curve-fitting method was used to simulate the RDII flow. This method assumes that the RDII in a sewer responding to rainfall can be quantified and characterized using three triangular hydrographs that relate RDII to unit precipitation volume, specified time duration, and sewer shed characteristics for short-, medium-, and long-term response: R is the fraction of rainfall volume entering the sewer system as RDII during and immediately after the rainfall event; T is the time to peak; and K is the ratio of the time of recession to T. For the City's system, two hydrographs were used (short- and medium-term response). Table 4B-6 shows the Mid-R Coefficient Response RTK parameters for the flow monitoring basins. Table 4B-7 shows the High-R Coefficient Response RTK parameters.

Table 4B-6
Mid-R Coefficient Response

RTK Parameters for Flow Monitoring Basins	R1	T1	K1	R2	T2	K2
1	0.044	1	2	0.023	6	3
2	0.01	1.5	2	0.023	6	3
3	0.023	1	2	0.023	6	3
4	0.003	0.5	1	0.023	6	3
5	0.039	0.5	1	0.023	6	3
6	0.037	0.5	1	0.023	6	3
7	0.041	0.5	1	0.023	6	3
8	0.047	0.5	1	0.023	6	3
9	0.003	1	2	0.023	6	3
10	0.044	0.5	1	0.023	6	3
11	0.011	0.5	2	0.023	6	3
12	0.006	0.5	1	0.023	6	3
13	0.01	0.5	1	0.023	6	3
14	0.002	0.5	1	0.023	6	3
15	0.022	0.5	1	0.023	6	3

Table 4B-7
High-R Coefficient Response
RTK Parameters for Flow Monitoring Basins

Basin	R1	T1	K1	R2	T2	K2
1	0.079	1	2	0.023	6	3
2	0.018	1.5	2	0.023	6	3
3	0.041	1	2	0.023	6	3
4	0.006	0.5	1	0.023	6	3
5	0.069	0.5	1	0.023	6	3
6	0.068	0.5	1	0.023	6	3
7	0.073	0.5	1	0.023	6	3
8	0.086	0.5	1	0.023	6	3
9	0.006	1	2	0.023	6	3
10	0.079	0.5	1	0.023	6	3
11	0.02	0.5	2	0.023	6	3
12	0.01	0.5	1	0.023	6	3
13	0.018	0.5	1	0.023	6	3
14	0.004	0.5	1	0.023	6	3
15	0.04	0.5	1	0.023	6	3

Wet Weather Calibration Results

The hydraulic model was calibrated initially using the 2007 flow monitoring data. When comparing measured data with model results, the wet weather parameters indicate that the City's collection system is primarily impacted by inflow during a wet weather event with minimal infiltration. The R parameter for the unit hydrograph provides a measure of the total volume of inflow that enters the collection system by sub-basin; system R values range from 0.2% to 5%. The contributing area was assumed to be a 20-foot buffer around each pipe in the system. The comparison of measured and modeled flows, along with precipitation for the WRF, are presented in Figure 4B-9. The comparison of measured and modeled flows, along with precipitation for all basins, are presented in this appendix.

The model results follow the hydrograph shapes observed in the measured data for most of the flow monitoring locations. The differences observed between the modeled data and the measured wet weather data (basins 2, 7, 8, and 14) were consistent with the differences observed between the modeled data and the measured data for the 2007 dry weather calibration period. The modeled response was 23% higher at the WRF when compared to measured calibrated data. A comparison of modeled versus measured flows in each basin can be seen in Table 4B-8.

The initial calibration wet weather factors correspond to the Low-R Coefficient Response, and were adjusted to represent the verification storm (January 18, 2012), generating the High-R Coefficient Response. The medium-level response between the calibration and verification, where the wet weather parameters overpredict the flow during the calibration storm but under-predict the inflow at the WRF during the verification storm, is the Mid-R Coefficient Response.

Design Storm

Based on the recommendations of the technical memorandum Design Storm Considerations for the City of Bend Sewer Collection System (presented in Appendix 4A), the design storm for the sewer collection system is the 10-year frequency, 24-hour duration storm with the Natural Resource Conservation Service (NRCS) Type II (thunderstorm-type event) rainfall distribution. The total rainfall depth for the design storm is 1.3 inches. A 10-year frequency design storm has a 10% chance of occurring in any given year. Figure 4B-8 shows the design storm rainfall distribution.

Figure 4B-8
City of Bend Sewer System Design Storm

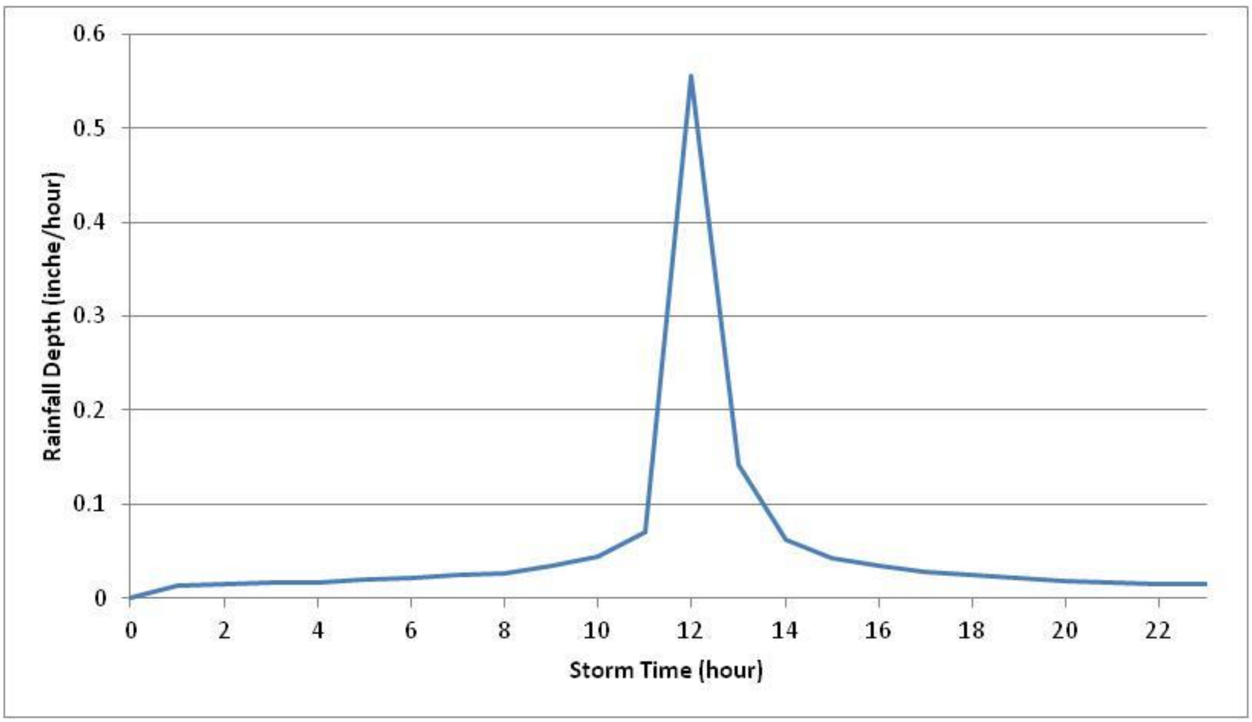


Figure 4B-9
Calibration Results Upstream of the WRF

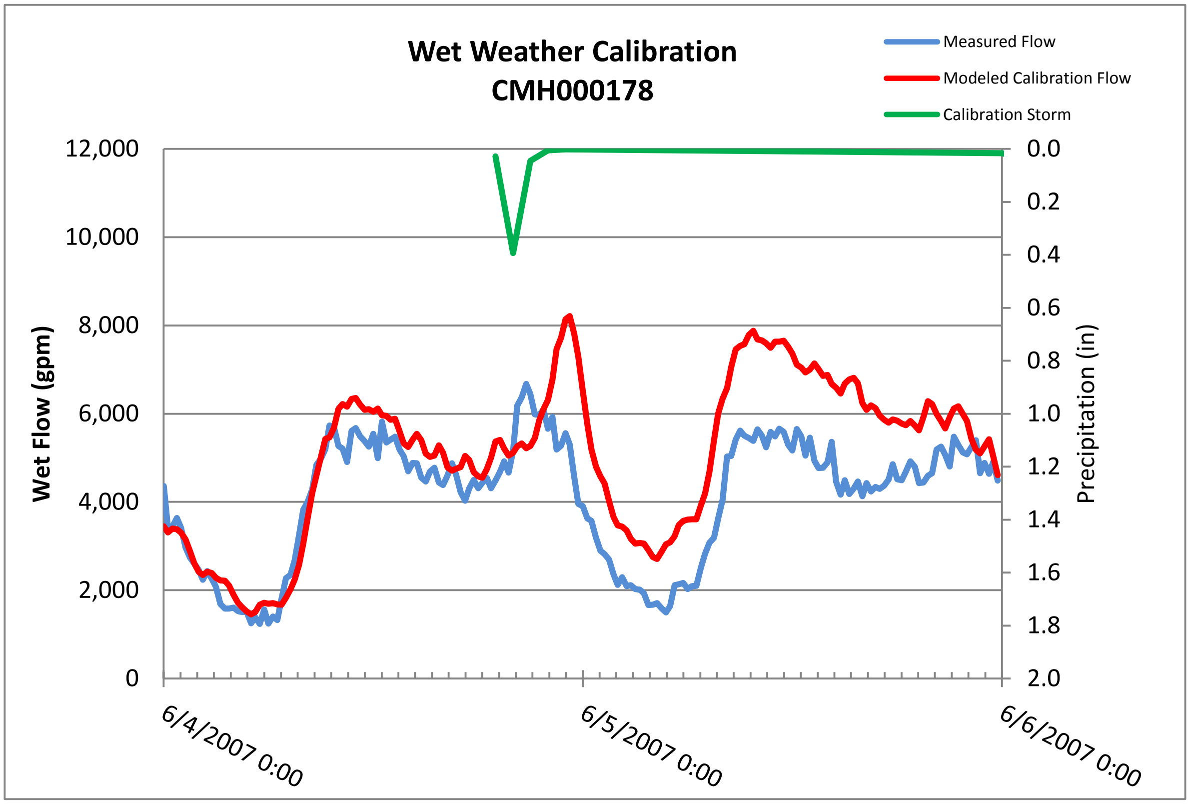


Table 4B-8
Modeled vs. Measured Flow for Each Basin

Site	Modeled Peak Flow (gpm)	Measured Peak Flow (gpm)	% Error	Modeled Volume	Measured Volume	% Error
1	8,209	6,675	-23	14,443,841	11,806,699	22
2	1,650	1,164	-42	2,829,914	2,037,775	39
3	5,212	4,302	-21	8,221,709	7,635,221	8
4	996	761	-31	1,632,250	1,279,197	28
5	747	809	8	985,700	873,981	13
6	2,334	1,962	-19	3,393,010	2,882,053	18
7	288	162	-77	822,382	210,928	290
8	1,456	885	-65	2,266,545	1,261,534	80
9	785	704	-12	1,053,381	1,027,021	3
10	678	549	-24	691,485	634,578	9
11	998	1,002	0	1,424,763	1,449,633	-2
12	818	1,026	20	935,275	962,294	-3
13	509	612	17	399,388	426,844	-6
14	684	669	-2	880,647	1,127,349	-22
15	1,290	1,266	-2	2,033,392	1,537,121	32

Wet Weather Flow Calibration Conclusions

The primary challenge with the wet weather calibration of the City's model was the lack of significant storm events during the 2011 or 2013 monitoring periods. Therefore, the distribution of wet weather RDII throughout the system was based on 2007 monitoring data, adding a level of uncertainty derived from the changes in the system connectivity, loading, and condition of the system. The City is in the process of implementing a long-term flow monitoring program that will begin in October 2013 and run through June 2014 that will be conducted at 15 locations. Depending on the rainfall events that occur during the monitoring period, the calibration and subsequent modeled rainfall response may be refined, particularly in relation to whether the Mid-R or High-R response is more appropriate for use in future planning scenarios. This appendix shows the measured and modeled flow in each flow monitoring location for both the 2007 and 2013 calibrations.

For this CSMP, and in lieu of additional wet weather flow monitoring data, it is recommended that the City proceed with analyzing the difference in capital improvements required to address both the Mid-R and High-R design flow responses under both existing and future conditions. It is also recommended that the City evaluate the system response, not only for the summer design storm described in Section 4 of this master plan, but also for a winter design storm. The design storm per the hydraulic criteria is a 10-year-frequency, 24-hour-duration storm with the Natural Resource Conservation Service (NRCS) Type II (summer thunderstorm-type event) rainfall distribution. The winter storm recommended for this sensitivity analysis is a 5-year-frequency, 24-hour-duration storm with an NRCS Type 1A distribution, with a lower peak but higher volume.

Future RDII

The wet weather parameters (RTKs) developed from the available flow monitoring data represent the hydraulics of the existing system, and reflect the general condition and age of the pipe and manhole infrastructure. For future areas where new infrastructures will be required, these parameters are not applicable; therefore, the wet weather contribution was calculated following the City of Bend Design Standards (Section 4.2.4, Version 07/01/2011):

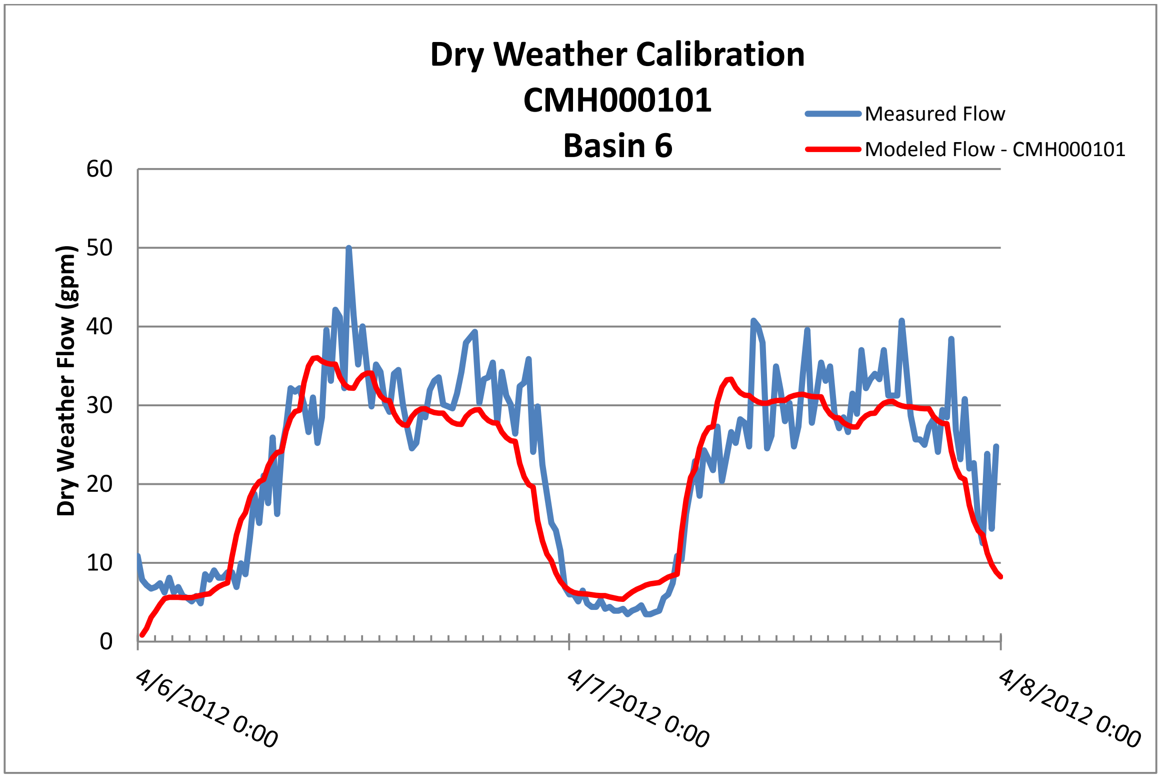
Sanitary sewage design flows are calculated by applying a peaking factor to the average daily flow. This is done by accumulating flows from the upper reaches of the system and multiplying the accumulated average daily flow at specific nodes.

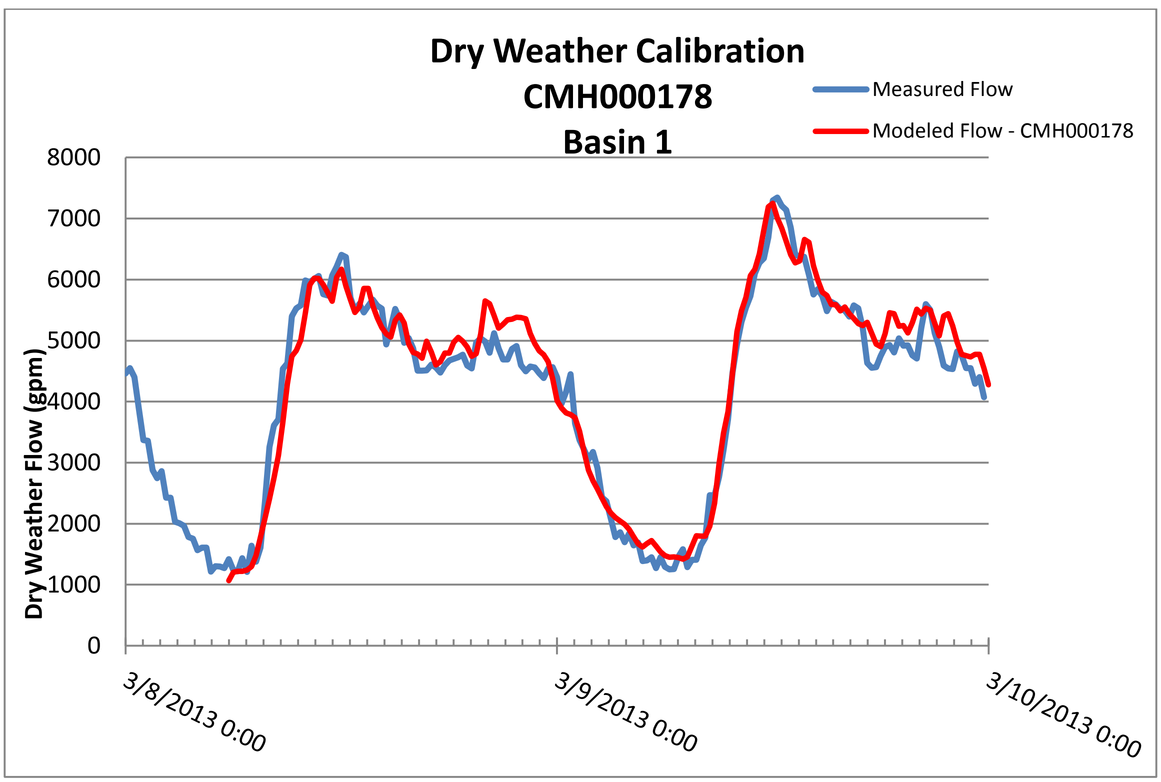
Apply the following peaking factors to obtain the design peak flow at that point:

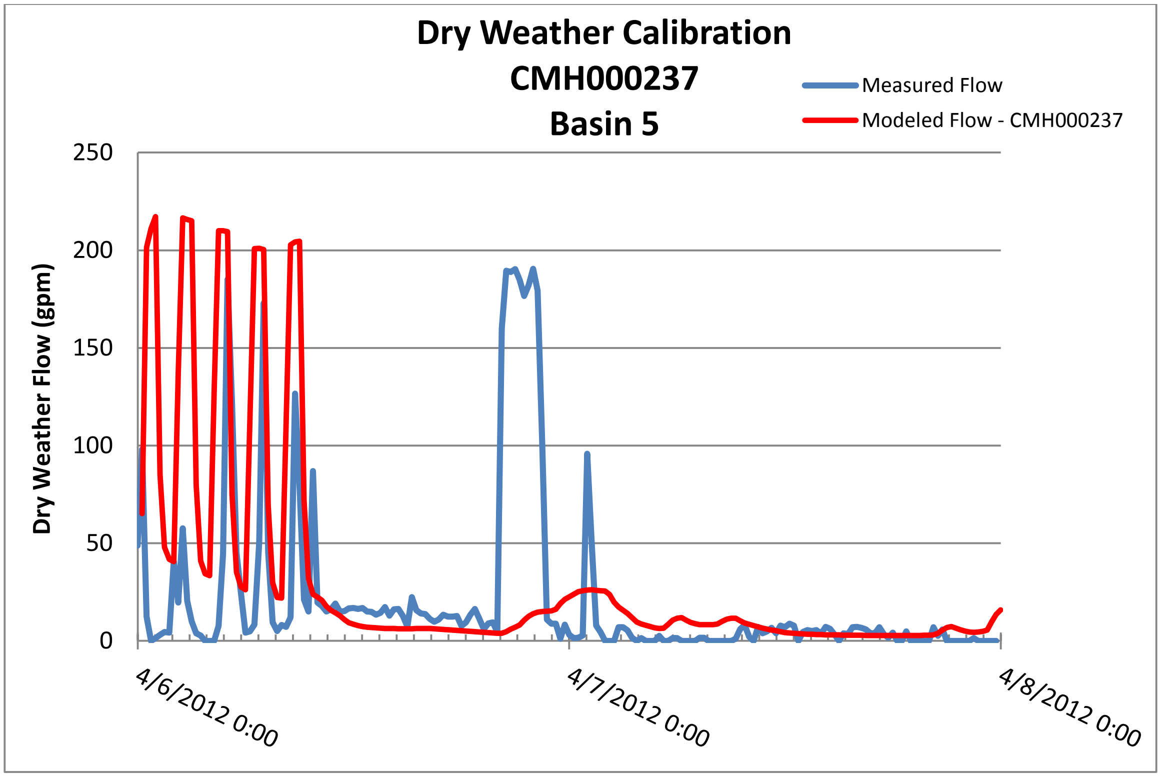
- *Average domestic flows below 1.0 mgd, P.F. = 3.0*
- *Average domestic flows from 1.0 to 2.5 mgd, P.F. = 2.5*
- *Average domestic flows from 2.5 to 5.0 mgd, P.F. = 2.25*
- *Average domestic flows greater than 5.0 mgd, P.F. = 2.0*

The existing total peak flow to average daily flow ratio is 3.2. The factor to calculate RDII for future conditions is expected to be lower than the existing calculated peaking factor, which includes the effect of aging and condition issues in the system.

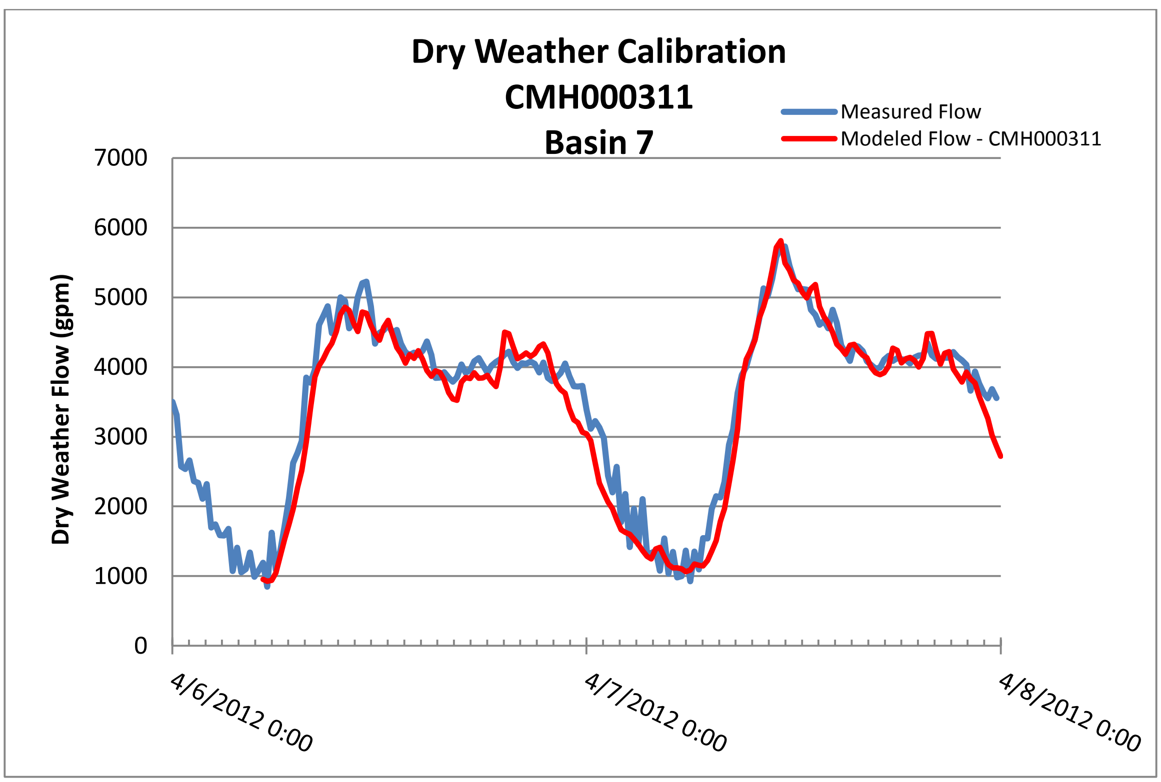
Dry Weather Flow Calibration Results (2013)

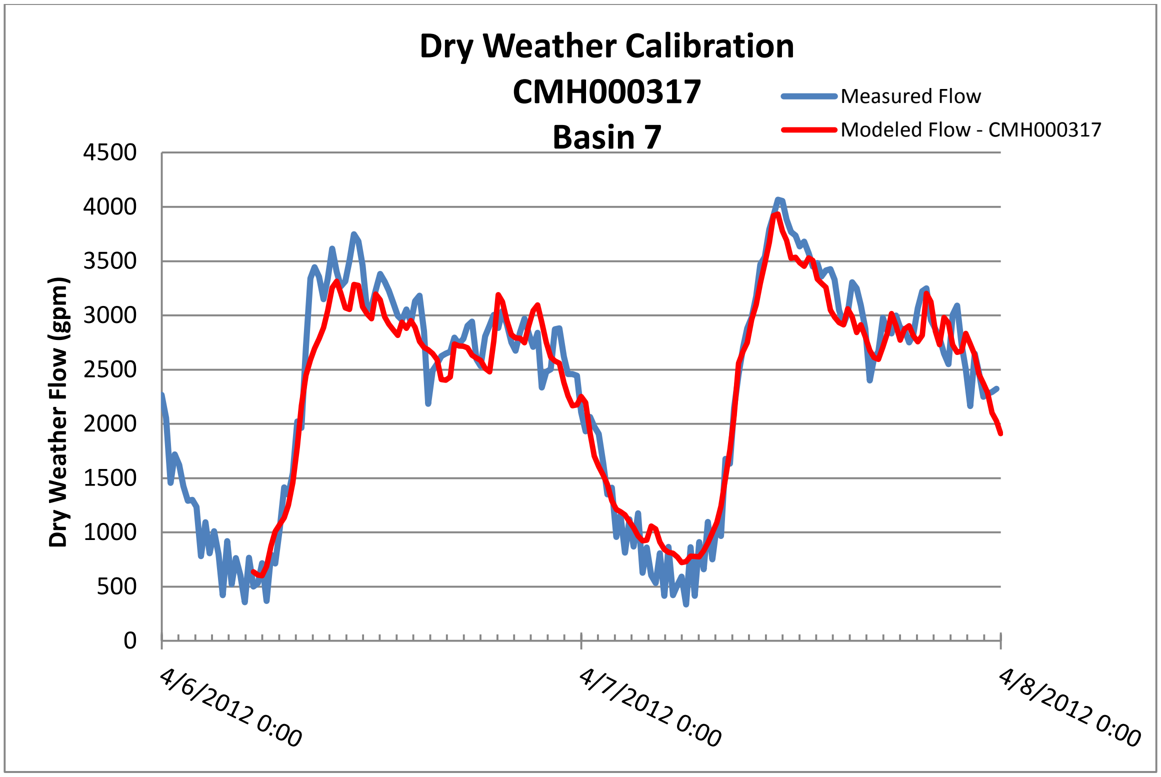






*Located Downstream of Deschutes Brewery

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CMH000317
Basin 7
Measured Flow
Modeled Flow - CMH000317
Dry Weather Flow (gpm)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
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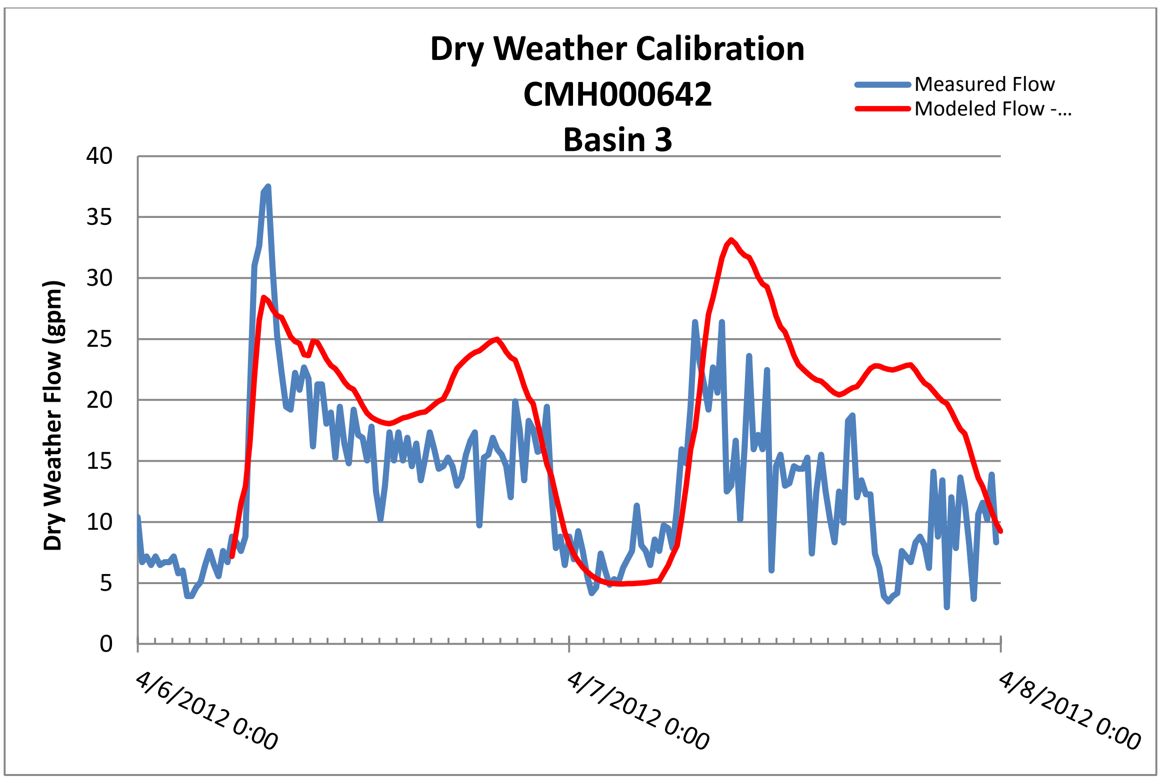
4/7/2012 0:00
4/8/2012 0:00


Dry Weather Calibration
CMH000642
Basin 3
Measured Flow
Modeled Flow -...
Dry Weather Flow (gpm)
40
35
30
25
20
15
10
5
0
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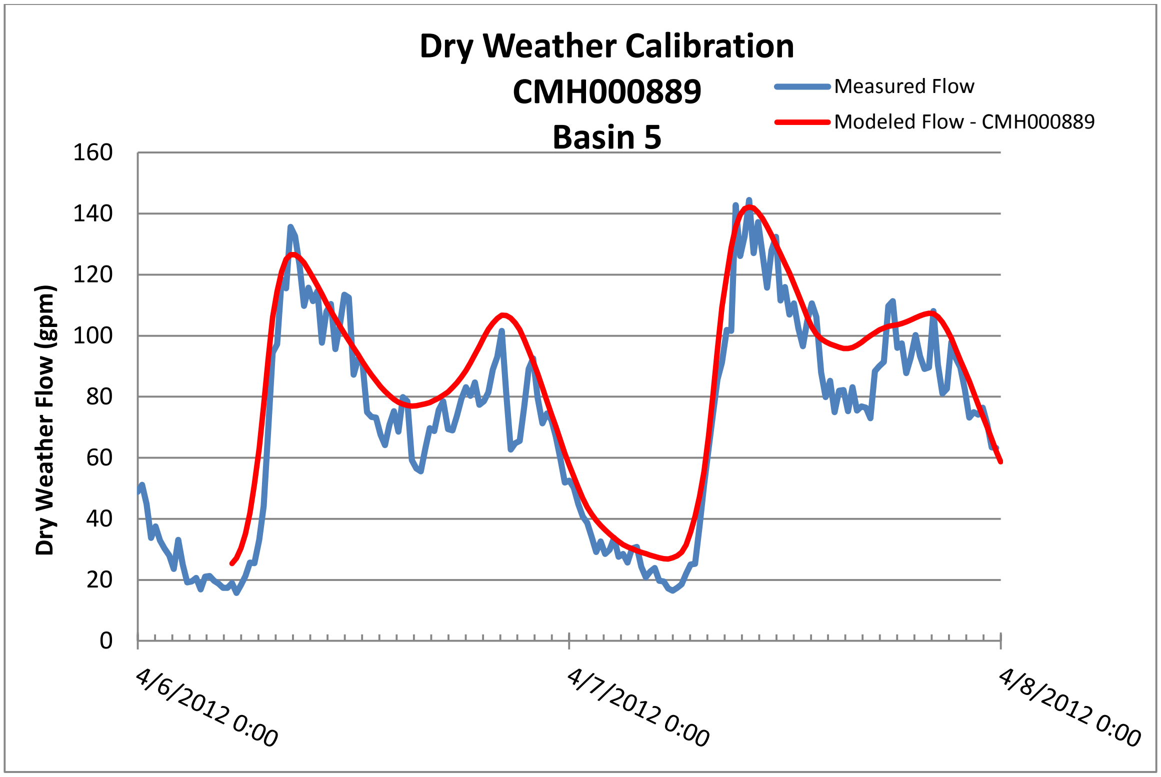
4/7/2012 0:00
4/8/2012 0:00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CMH000889
Basin 5
Measured Flow
Modeled Flow - CMH000889
Dry Weather Flow (gpm)
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140
120
100
80
60
40
20
0
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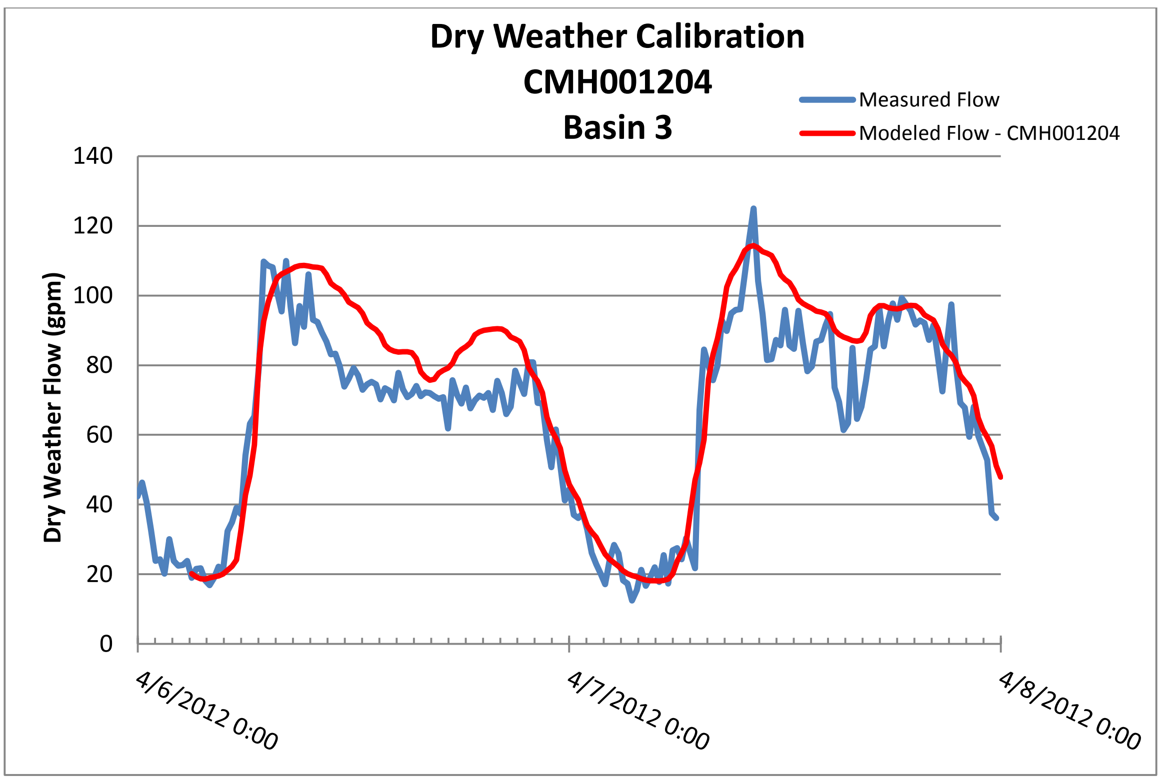
4/7/2012 0:00
4/8/2012 0:00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Basin 3
Measured Flow
Modeled Flow - CMH001204
Dry Weather Flow (gpm)
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100
80
60
40
20
0
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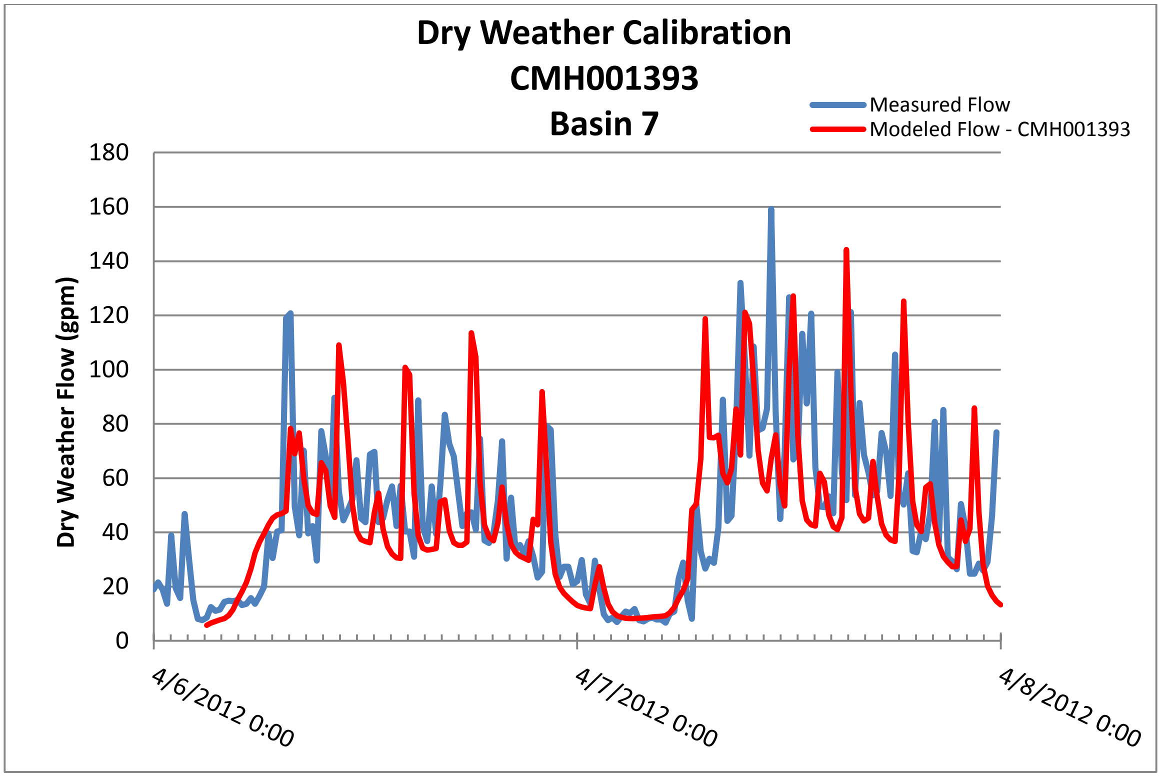
4/7/2012 0:00
4/8/2012 0:00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CMH001393
Basin 7
Measured Flow
Modeled Flow - CMH001393
Dry Weather Flow (gpm)
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140
120
100
80
60
40
20
0
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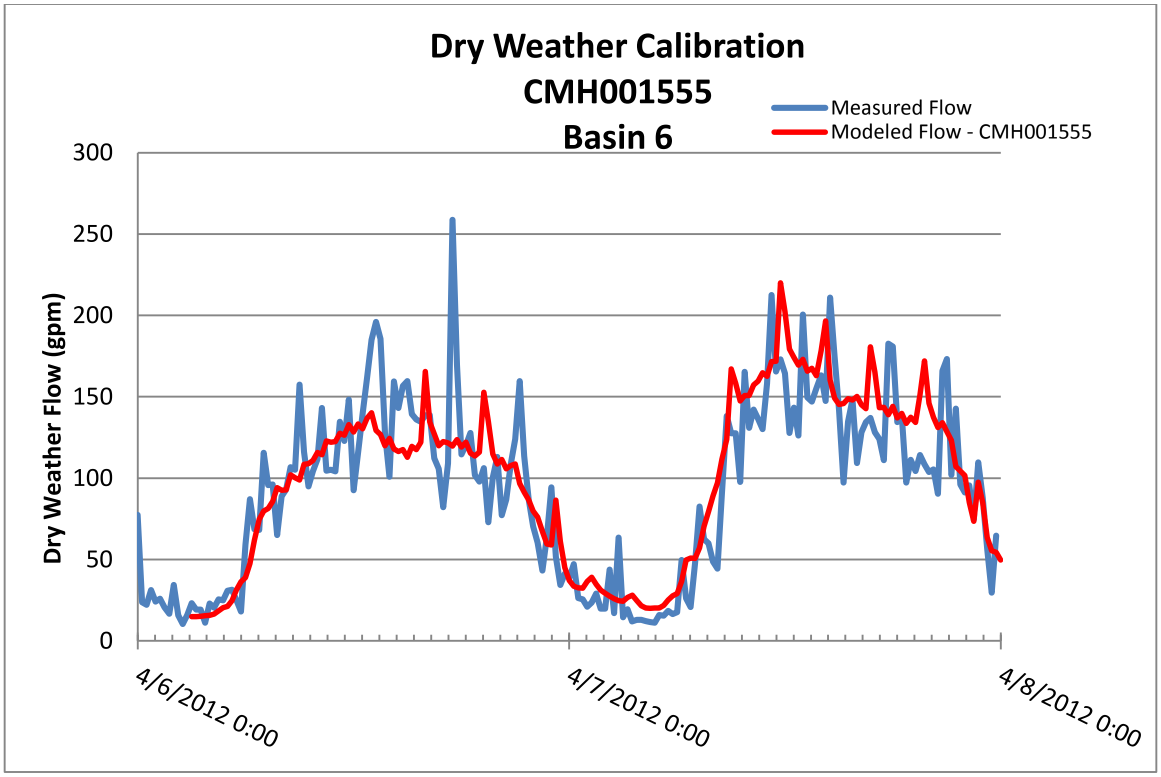
4/7/2012 0:00
4/8/2012 0:00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CMH001555
Basin 6
Measured Flow
Modeled Flow - CMH001555
Dry Weather Flow (gpm)
300
250
200
150
100
50
0
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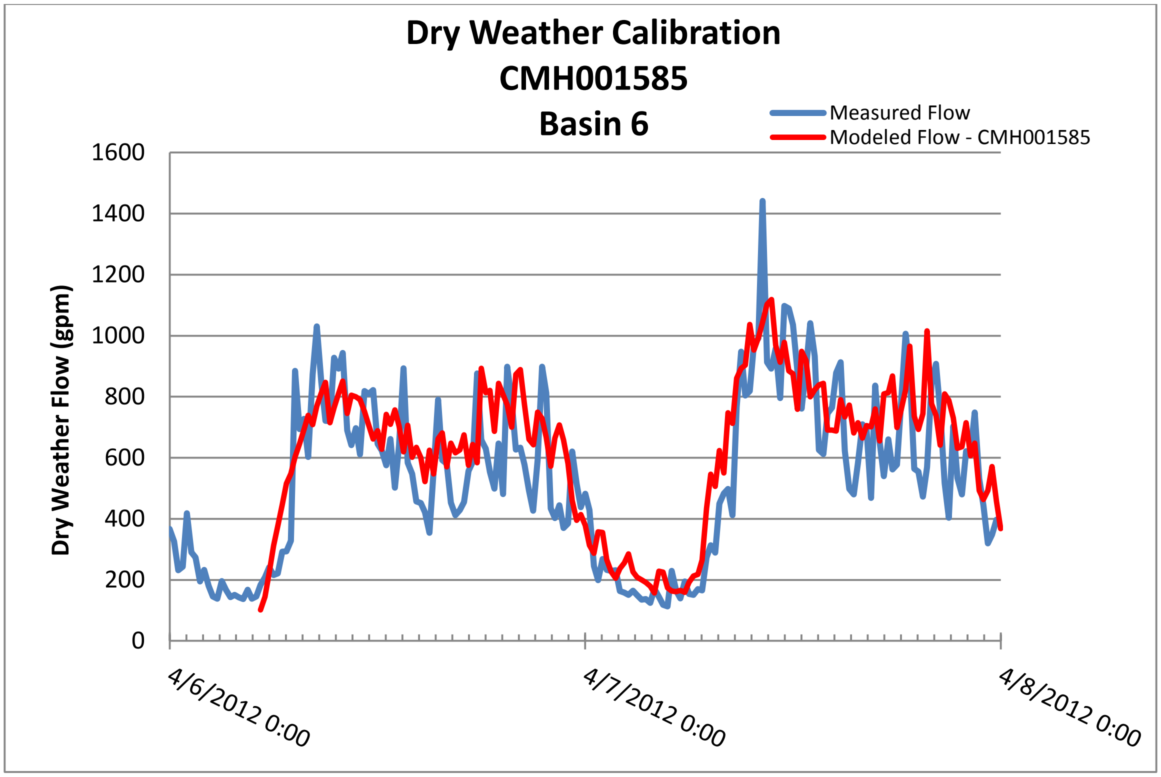
4/7/2012 0:00
4/8/2012 0:00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CMH001585
Basin 6
Measured Flow
Modeled Flow - CMH001585
Dry Weather Flow (gpm)
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1400
1200
1000
800
600
400
200
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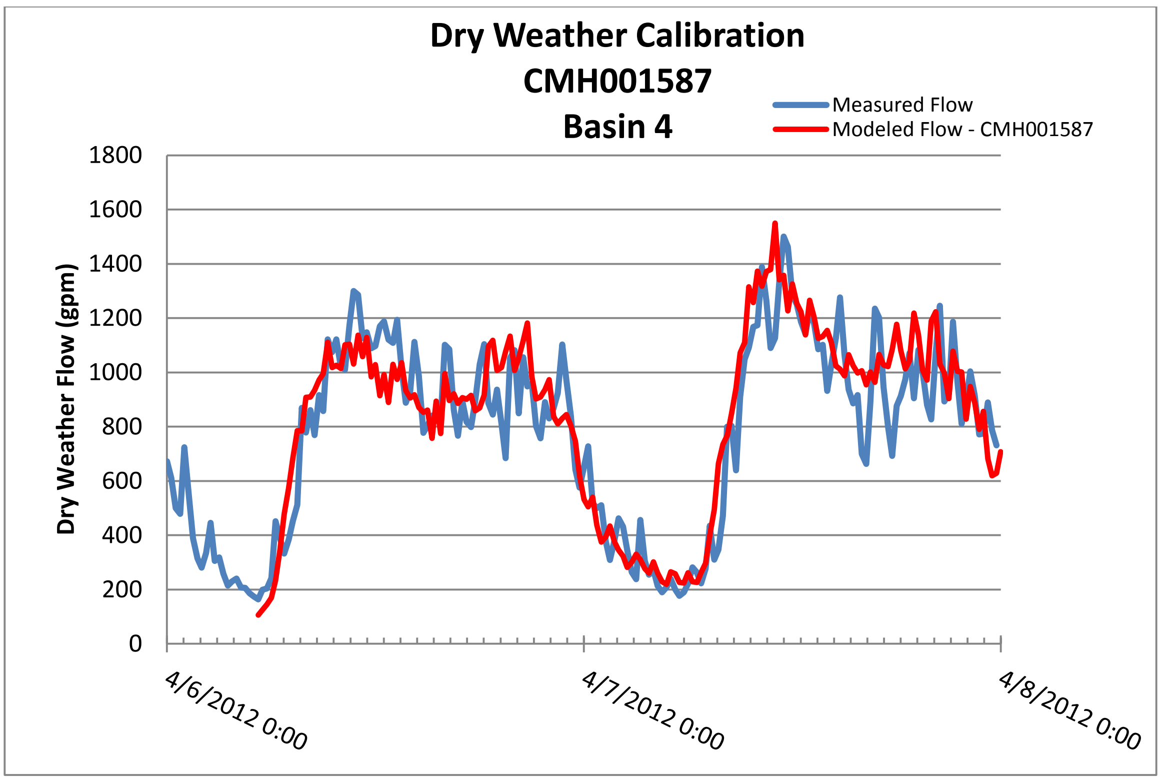
4/7/2012 0:00
4/8/2012 0:00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CMH001587
Basin 4
Measured Flow
Modeled Flow - CMH001587
Dry Weather Flow (gpm)
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1600
1400
1200
1000
800
600
400
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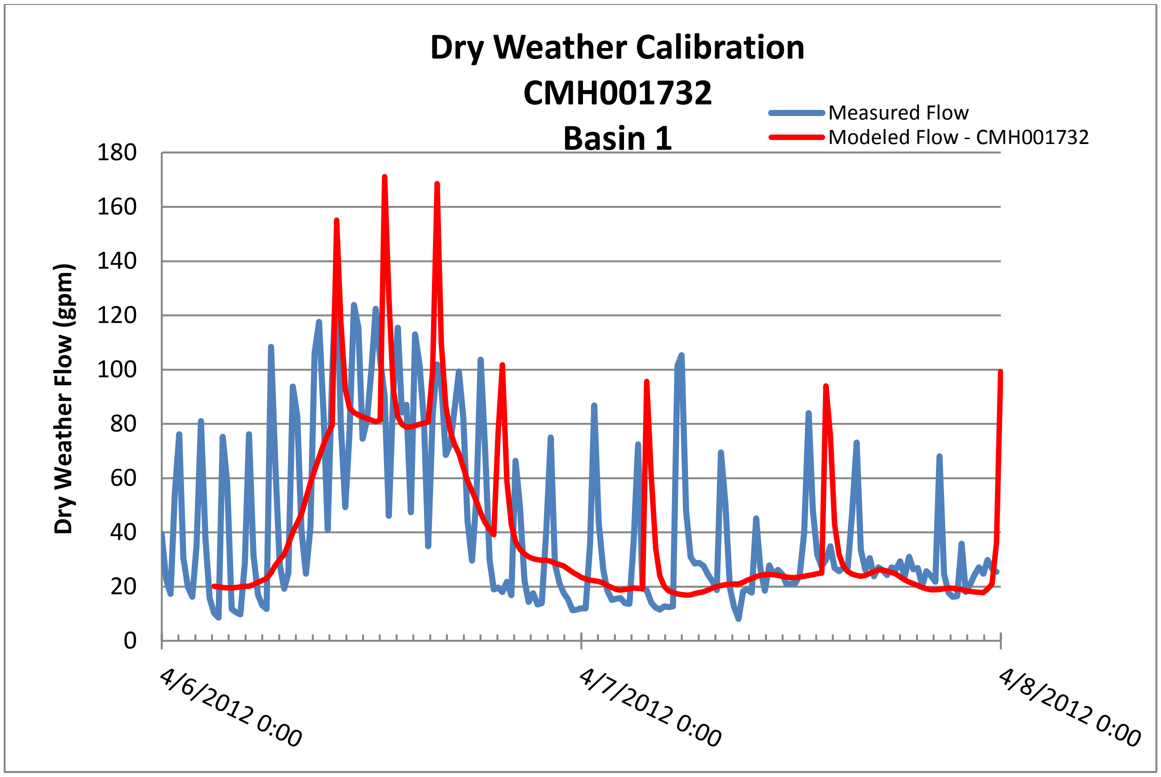
4/7/2012 0:00
4/8/2012 0:00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Basin 1
Measured Flow
Modeled Flow - CMH001732
Dry Weather Flow (gpm)
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160
140
120
100
80
60
40
20
0
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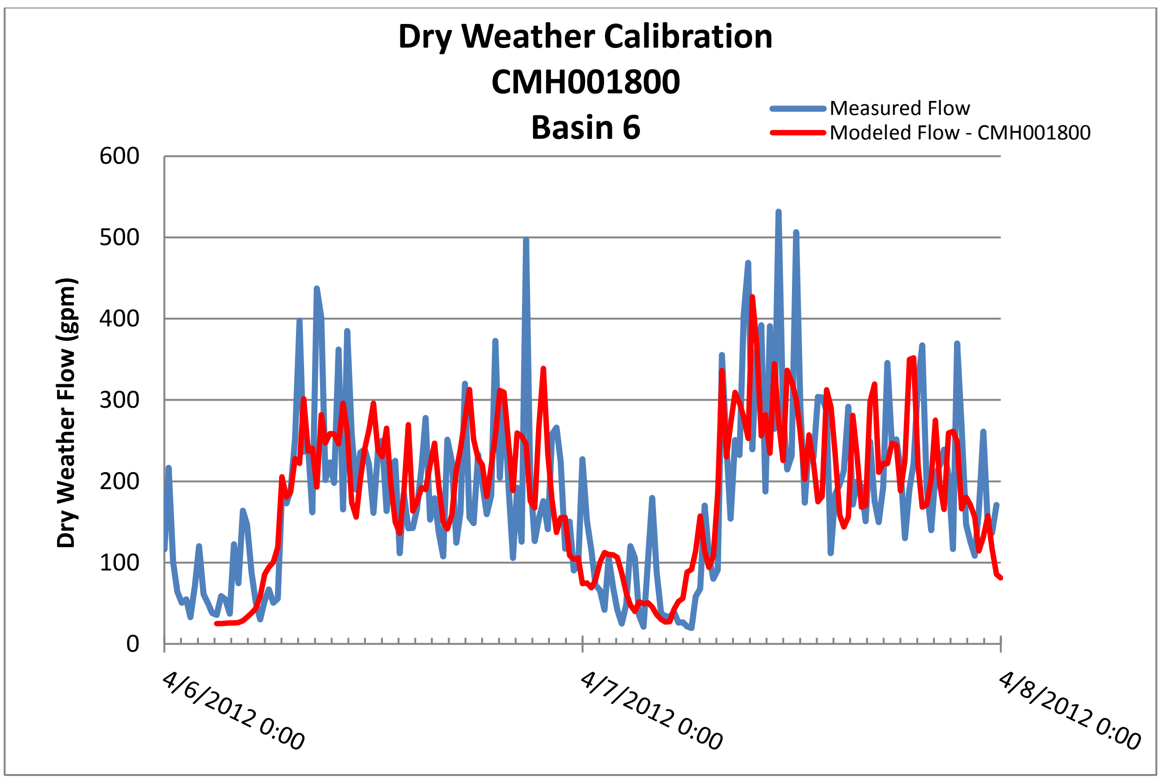
4/7/2012 0:00
4/8/2012 0:00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Basin 6
Measured Flow
Modeled Flow - CMH001800
Dry Weather Flow (gpm)
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500
400
300
200
100
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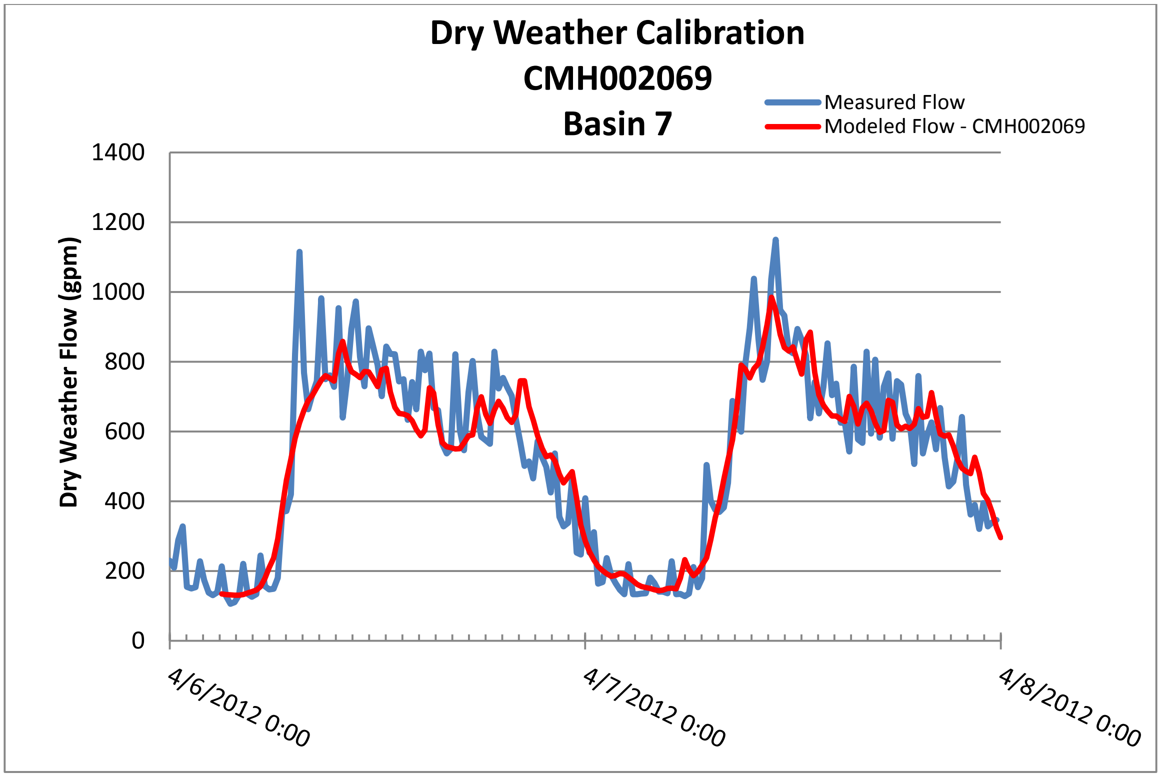
4/8/2012 0:00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CMH002069
Basin 7
Measured Flow
Modeled Flow - CMH002069
Dry Weather Flow (gpm)
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1200
1000
800
600
400
200
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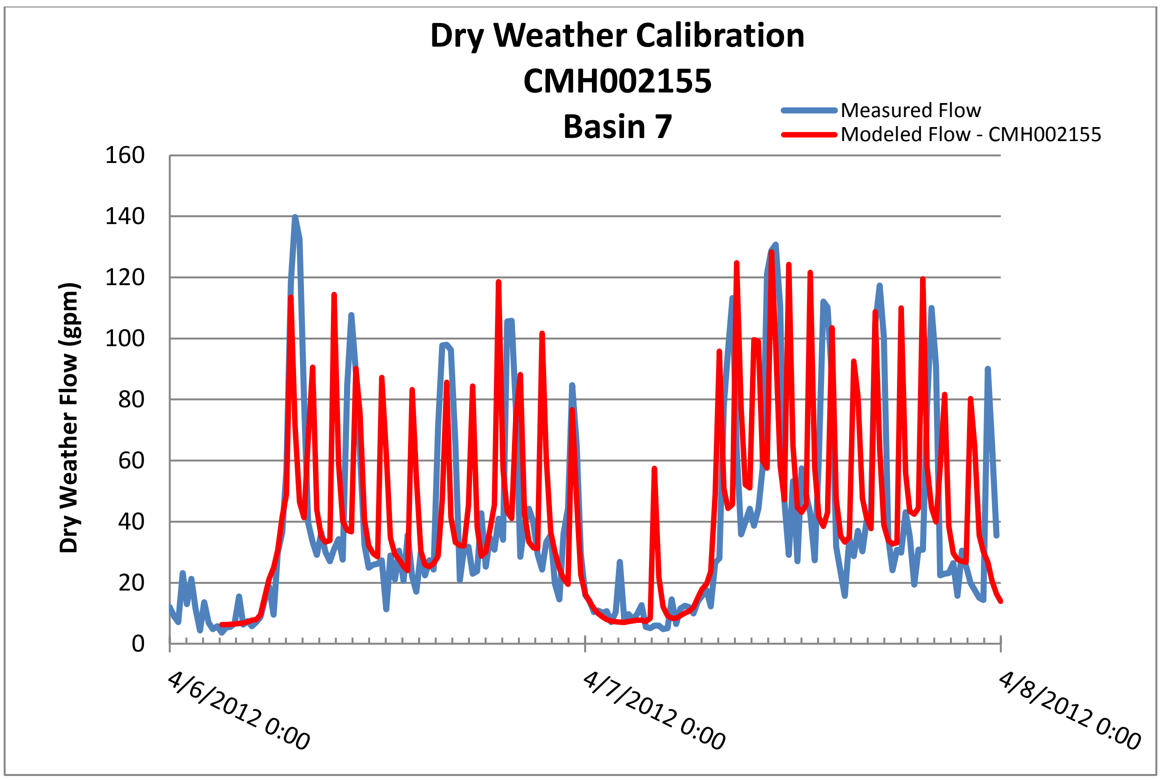
4/7/2012 0:00
4/8/2012 0:00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Basin 7
Measured Flow
Modeled Flow - CMH002155
Dry Weather Flow (gpm)
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100
80
60
40
20
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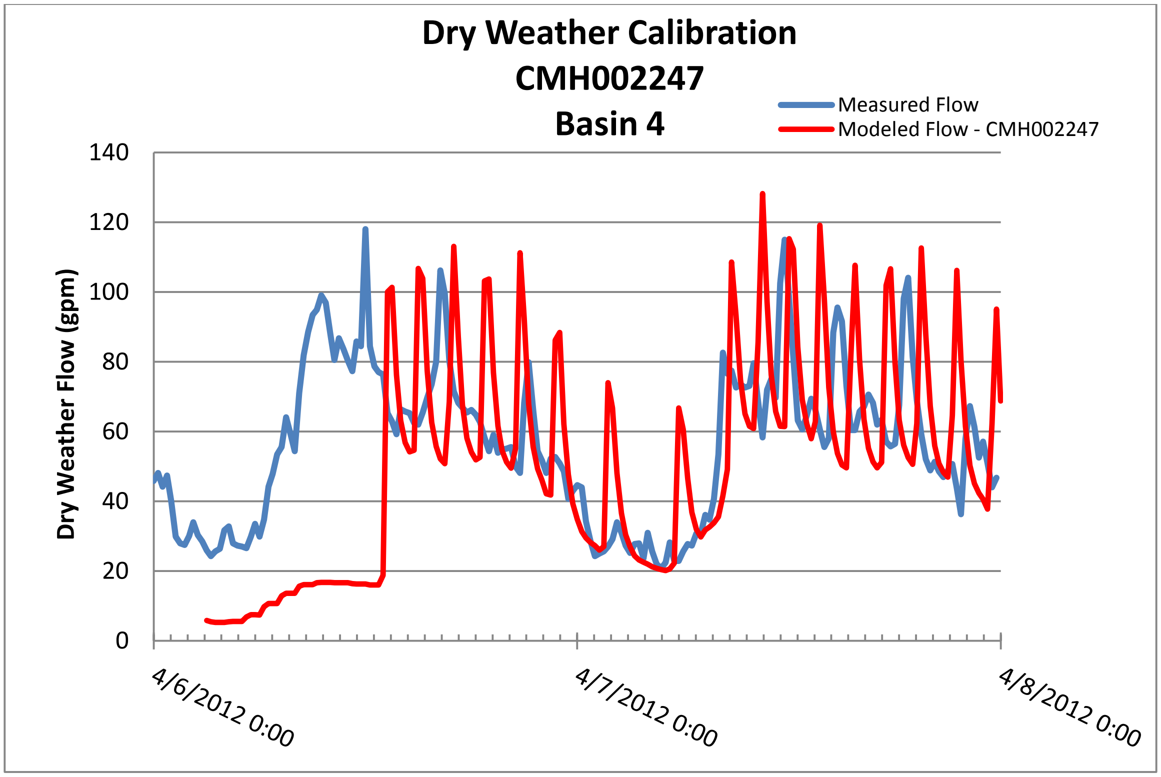
4/8/2012 0:00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CMH002247
Basin 4
Measured Flow
Modeled Flow - CMH002247
Dry Weather Flow (gpm)
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120
100
80
60
40
20
0
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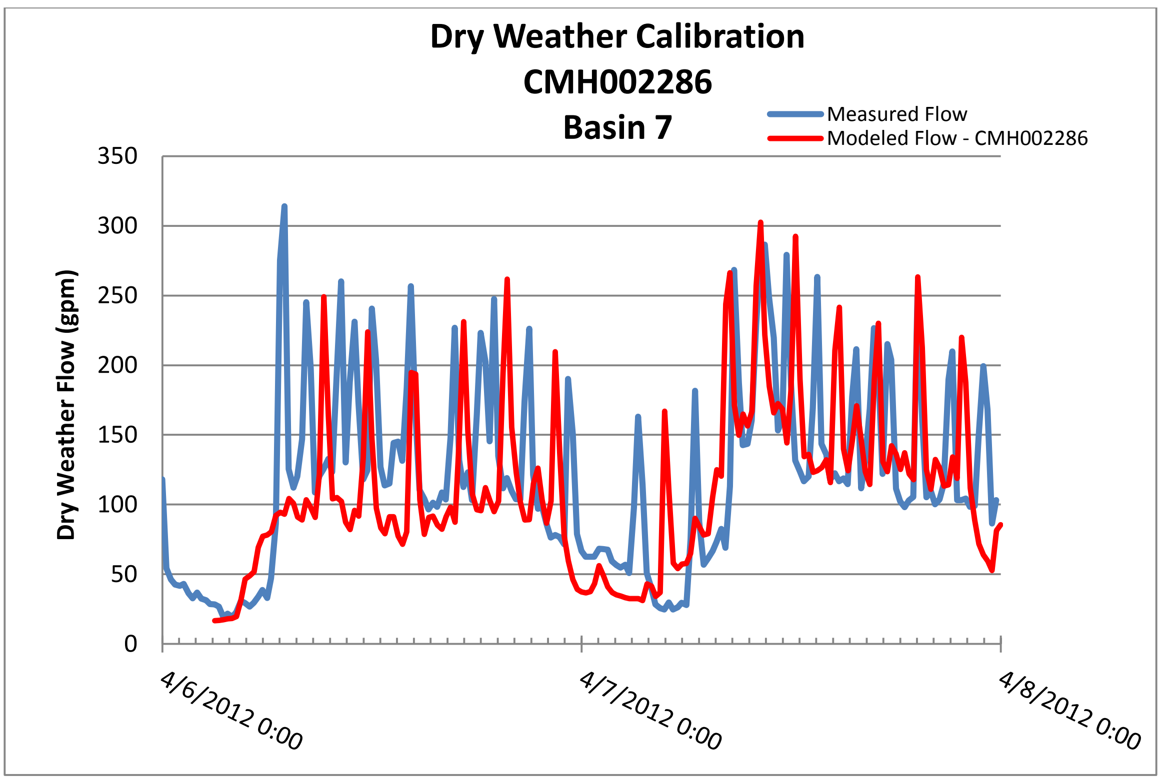
4/7/2012 0:00
4/8/2012 0:00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CMH002286
Basin 7
Measured Flow
Modeled Flow - CMH002286
Dry Weather Flow (gpm)
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250
200
150
100
50
0
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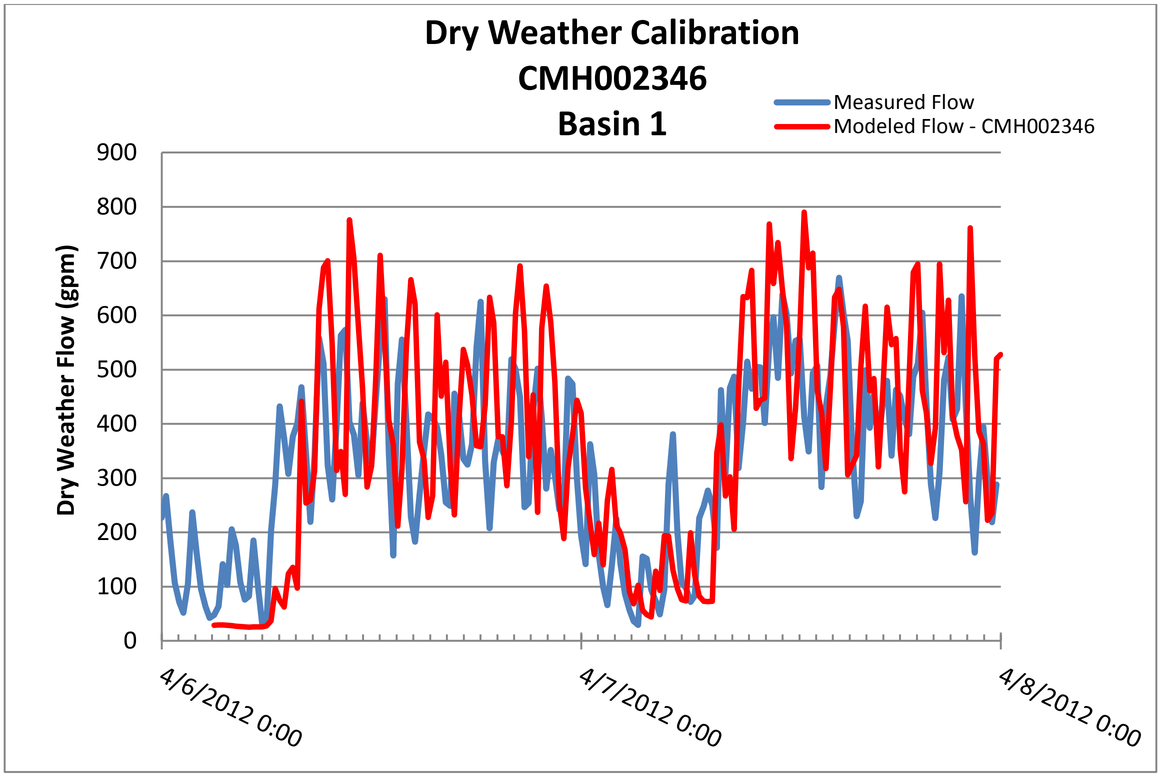
4/7/2012 0:00
4/8/2012 0:00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CMH002346
Basin 1
Measured Flow
Modeled Flow - CMH002346
Dry Weather Flow (gpm)
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700
600
500
400
300
200
100
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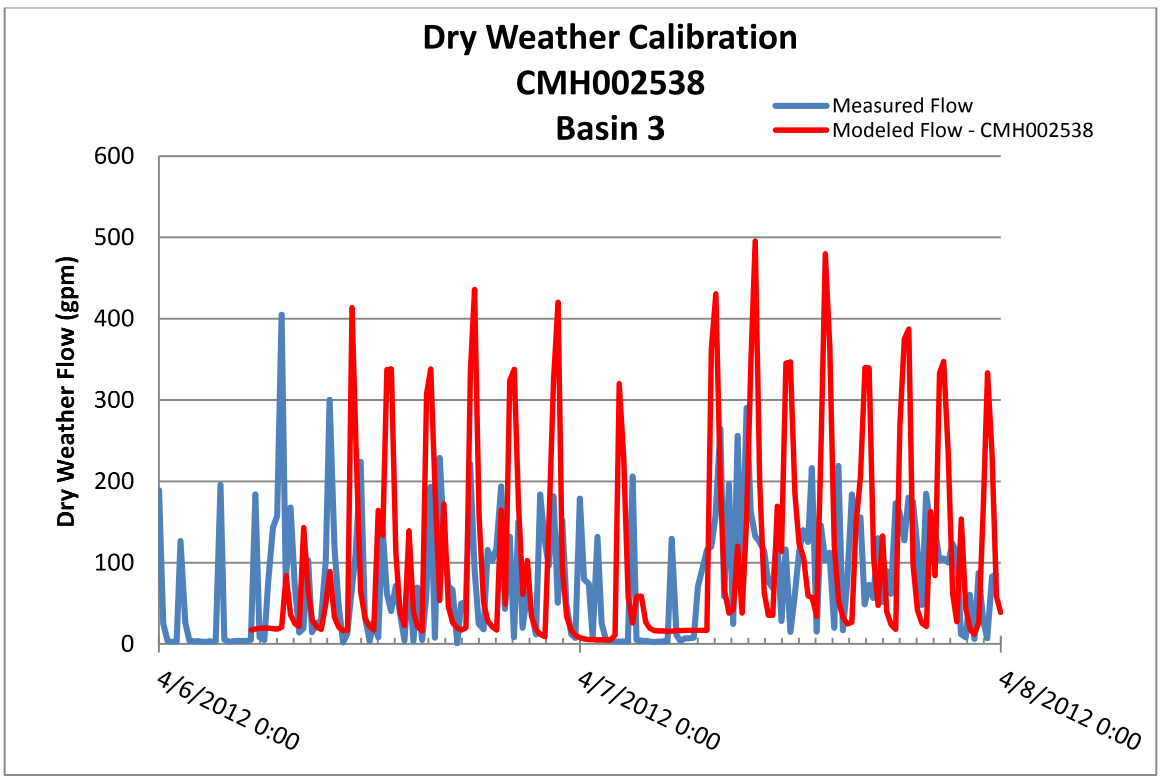
4/7/2012 0:00
4/8/2012 0:00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CMH002538
Basin 3
Measured Flow
Modeled Flow - CMH002538
Dry Weather Flow (gpm)
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400
300
200
100
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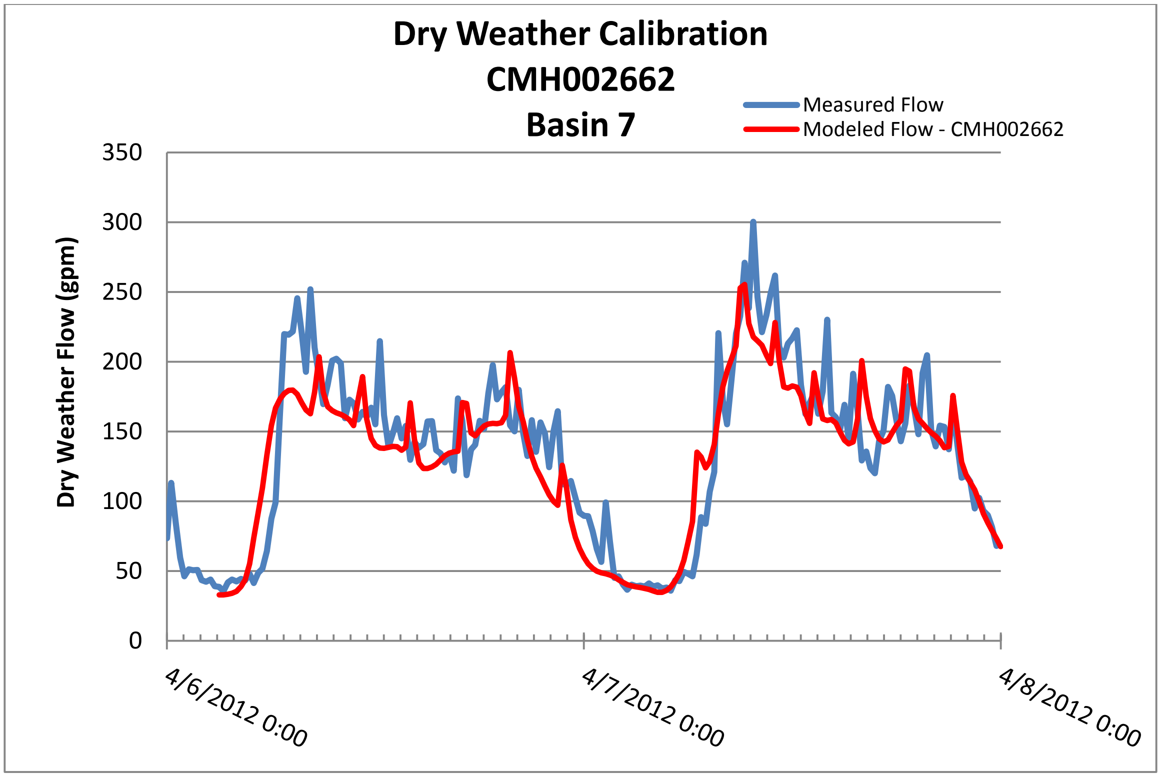
4/8/2012 0:00



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CMH002662
Basin 7
Measured Flow
Modeled Flow - CMH002662
Dry Weather Flow (gpm)
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200
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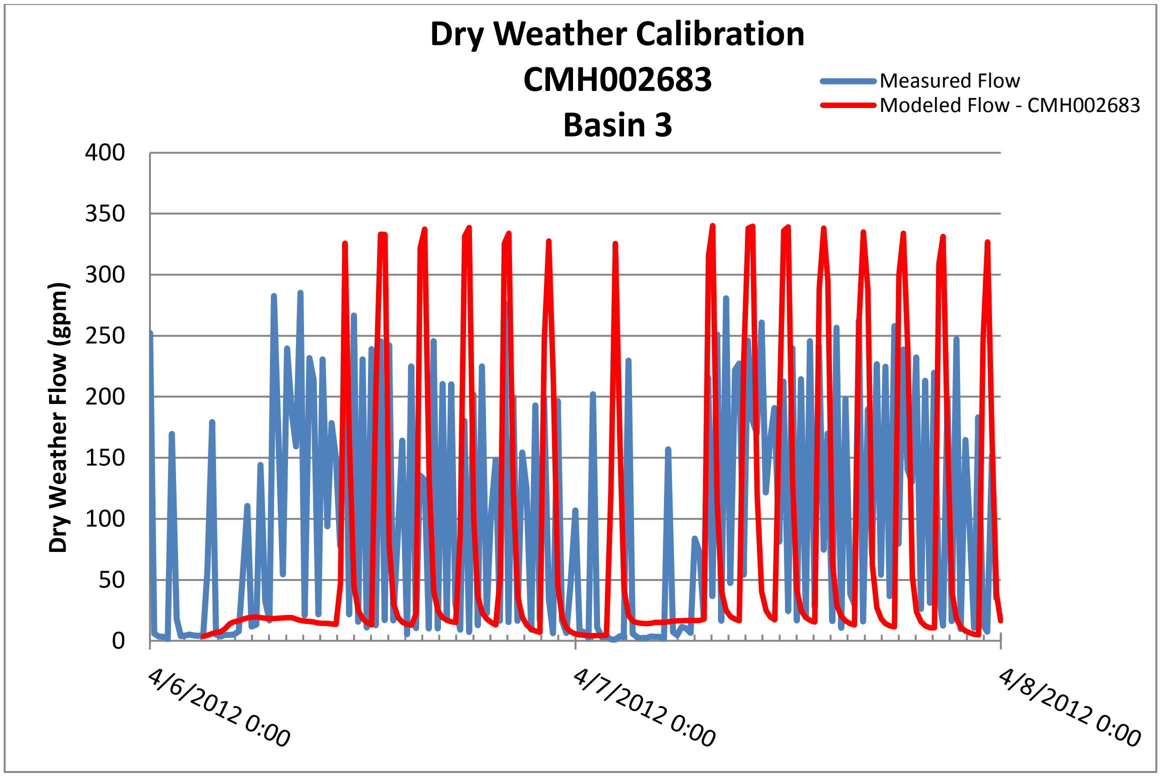
4/8/2012 0:00



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CMH002683
Basin 3
Measured Flow
Modeled Flow - CMH002683
Dry Weather Flow (gpm)
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300
250
200
150
100
50
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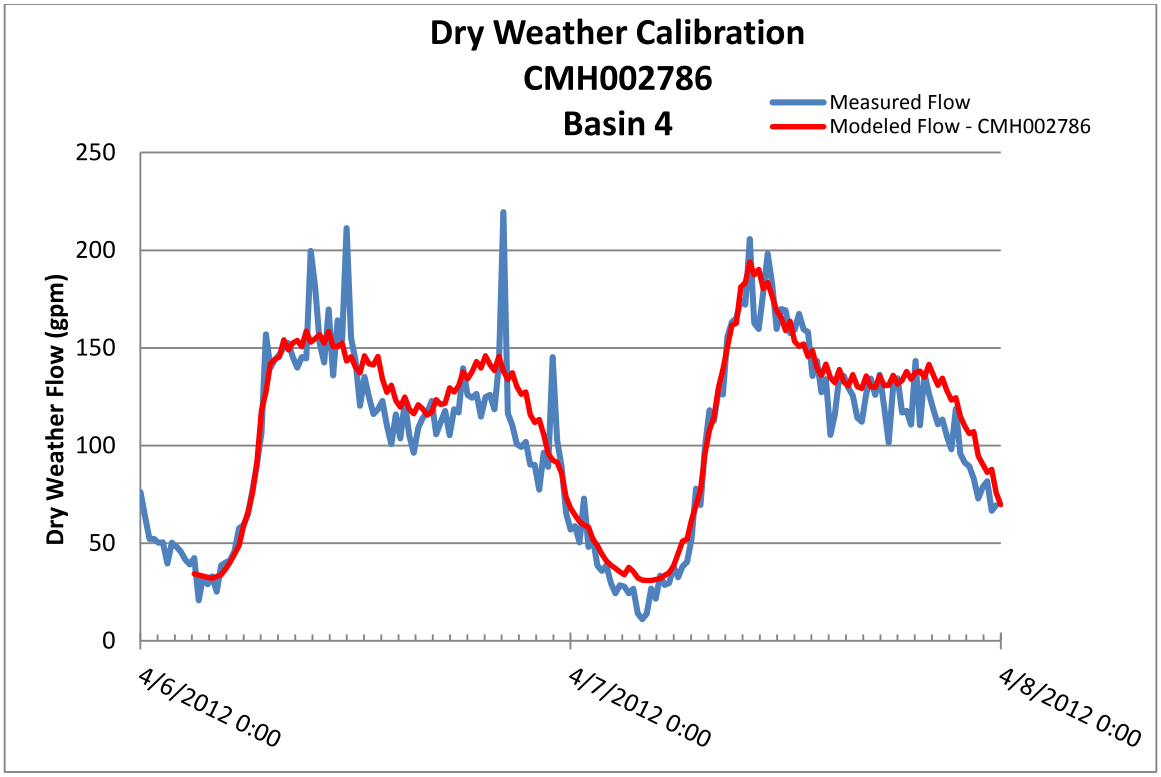
4/7/2012 0:00
4/8/2012 0:00


Dry Weather Calibration
CMH002786
Basin 4
Measured Flow
Modeled Flow - CMH002786
Dry Weather Flow (gpm)
250
200
150
100
50
0
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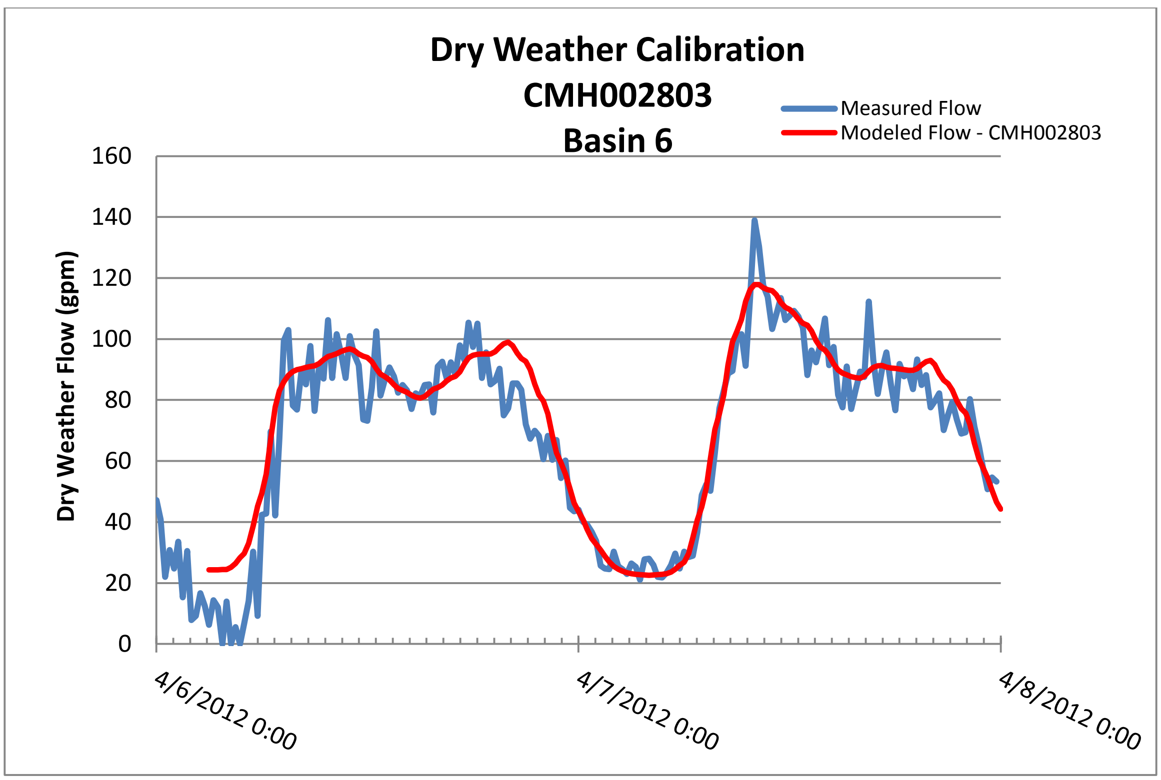
4/7/2012 0:00
4/8/2012 0:00


Dry Weather Calibration
CMH002803
Basin 6
Measured Flow
Modeled Flow - CMH002803
Dry Weather Flow (gpm)
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140
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100
80
60
40
20
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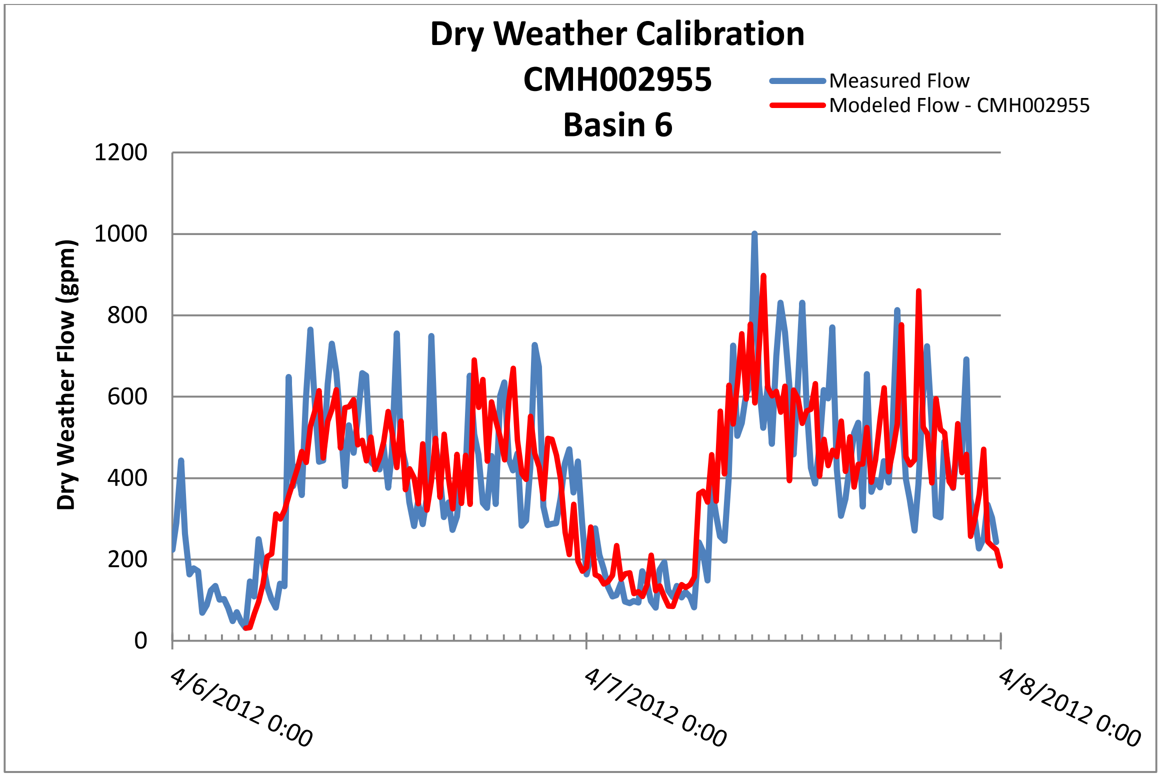
4/7/2012 0:00
4/8/2012 0:00


Dry Weather Calibration
CMH002955
Basin 6
Measured Flow
Modeled Flow - CMH002955
Dry Weather Flow (gpm)
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800
600
400
200
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4/7/2012 0:00
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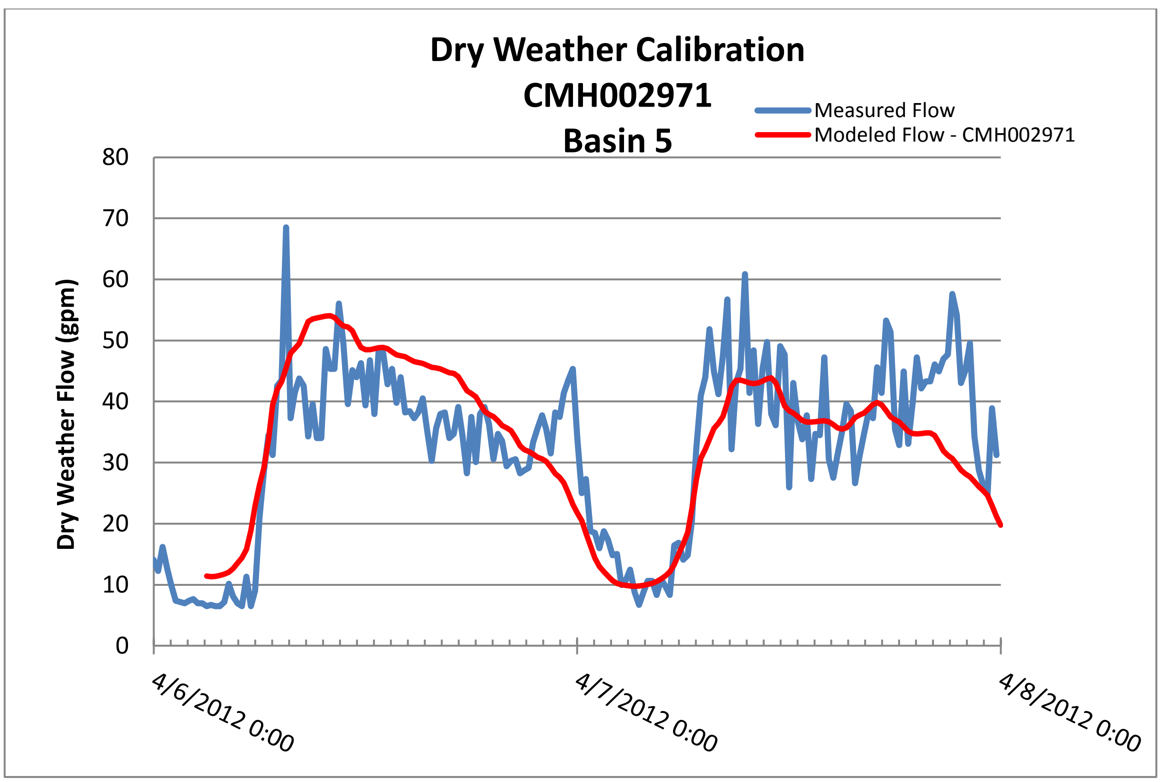
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CMH002971
Basin 5
Measured Flow
Modeled Flow - CMH002971
Dry Weather Flow (gpm)
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50
40
30
20
10
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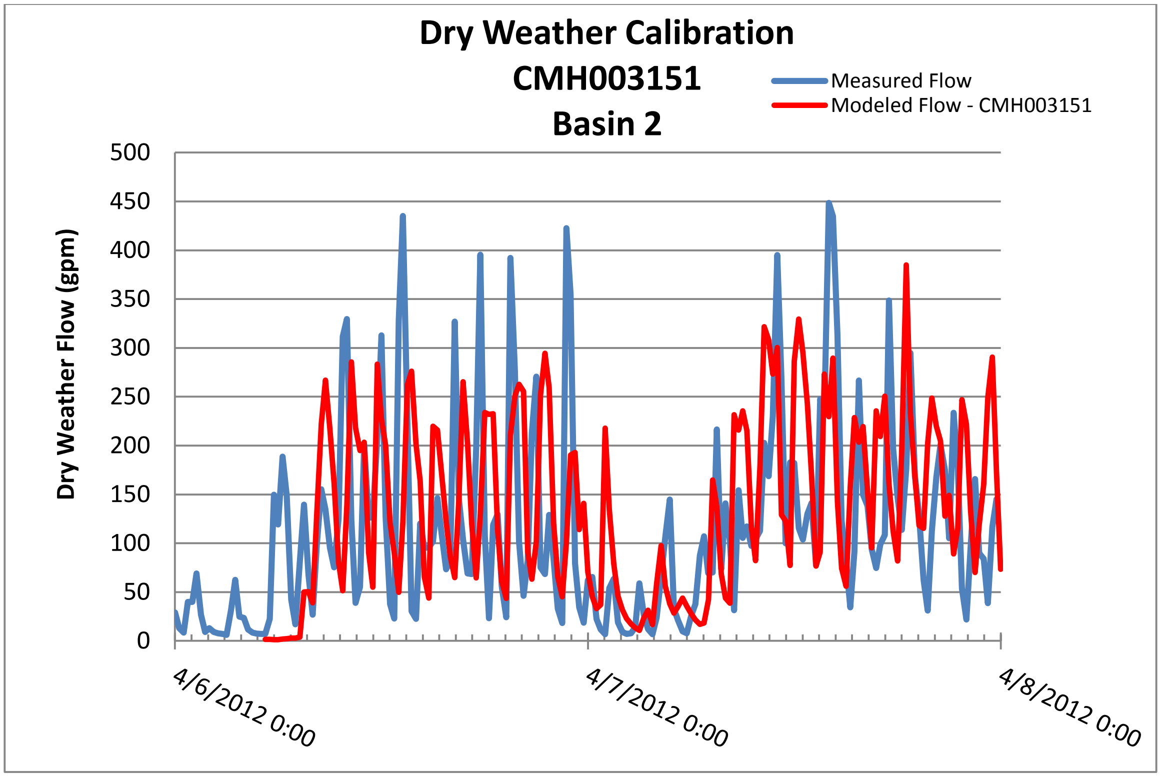
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CMH003151
Basin 2
Measured Flow
Modeled Flow - CMH003151
Dry Weather Flow (gpm)
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100
50
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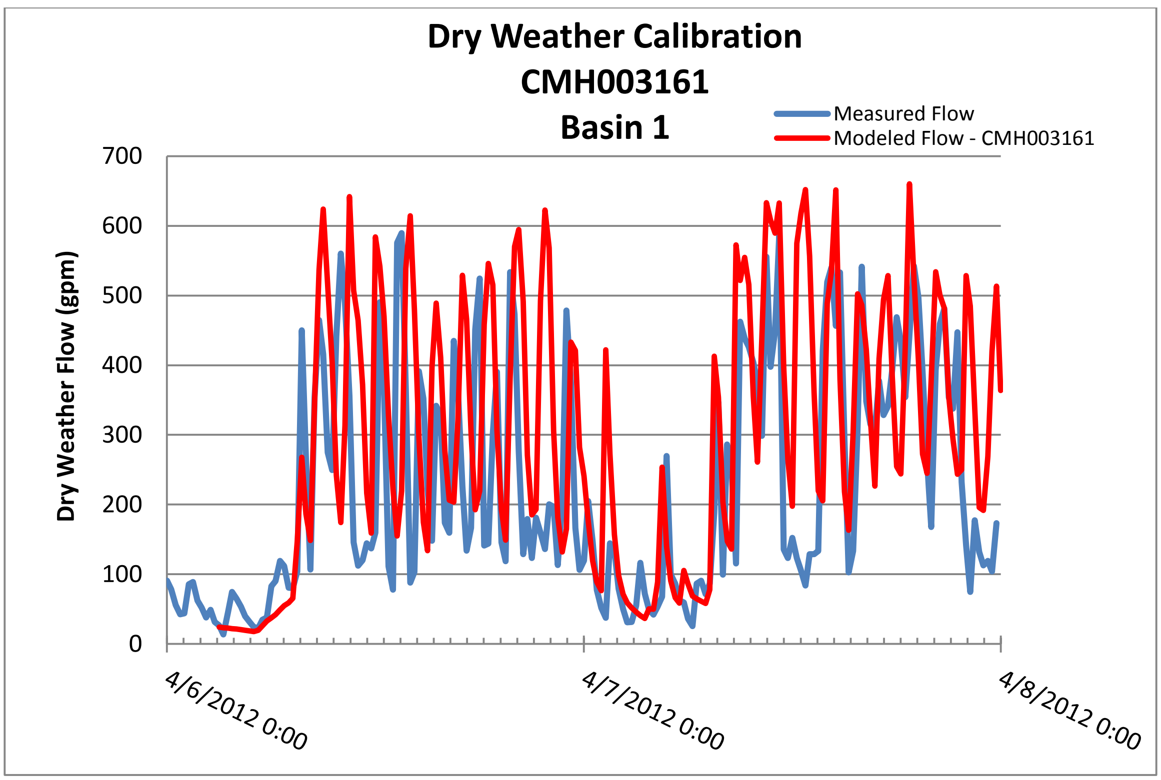
4/7/2012 0:00
4/8/2012 0:00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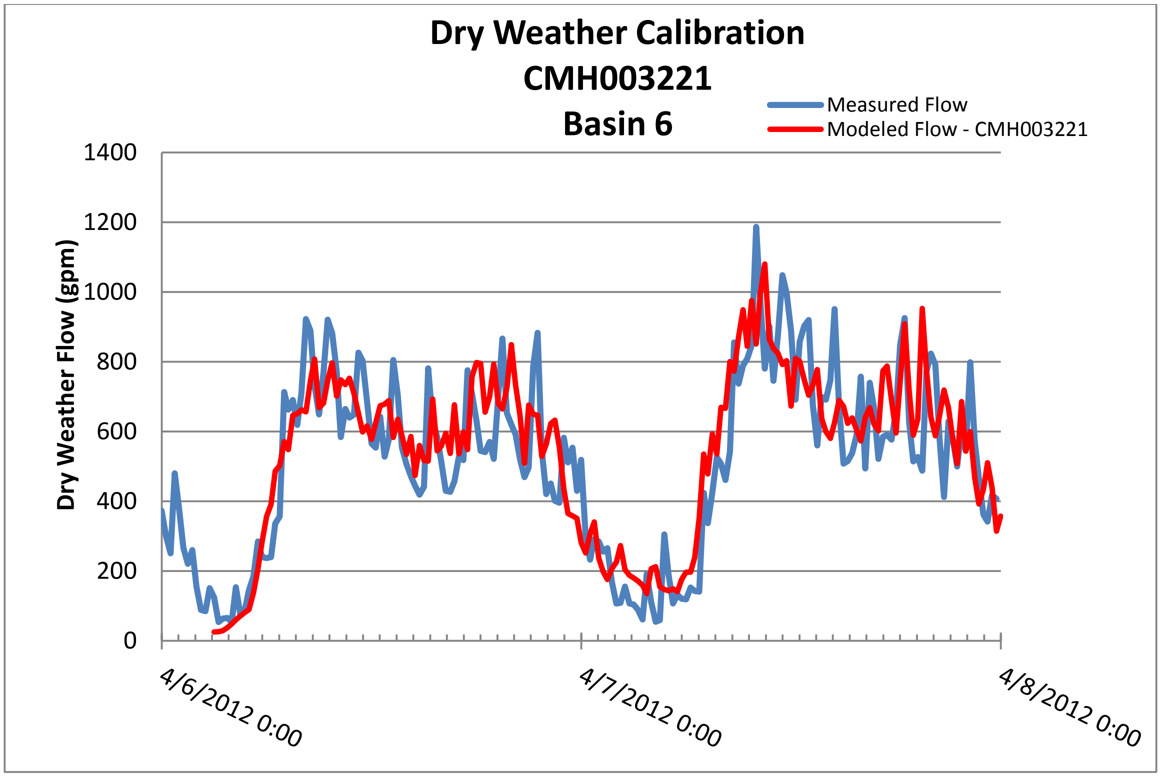
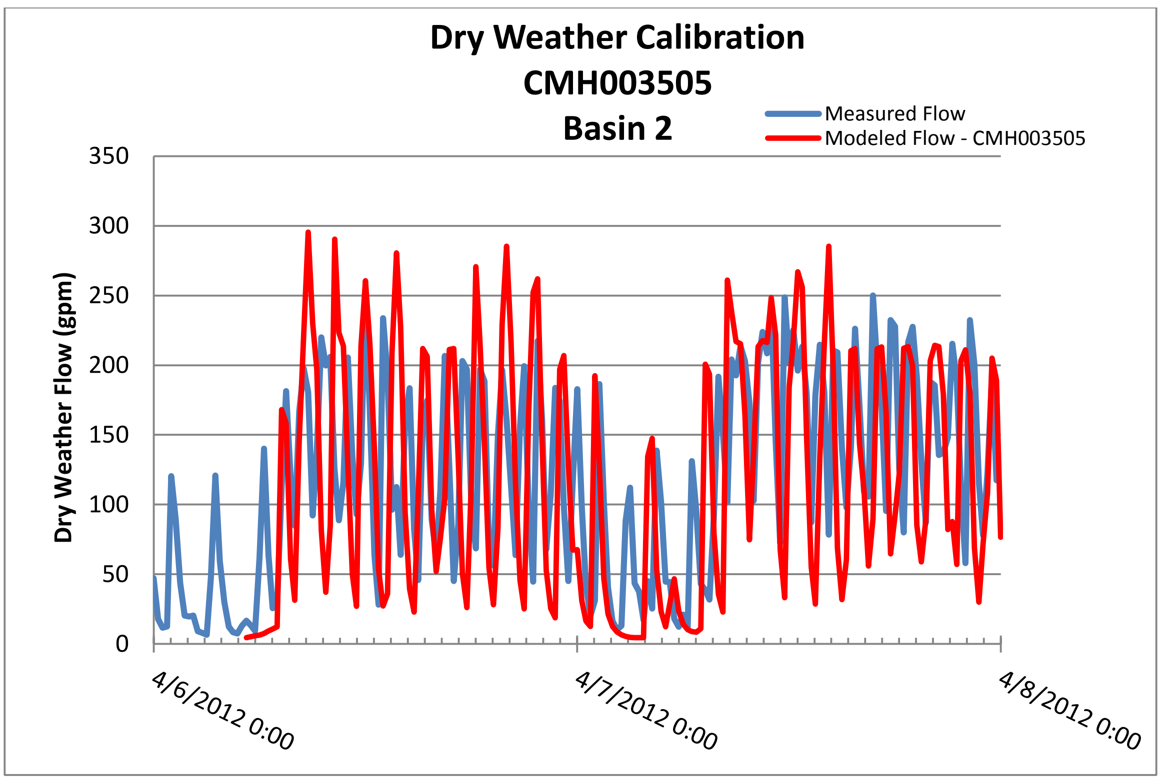
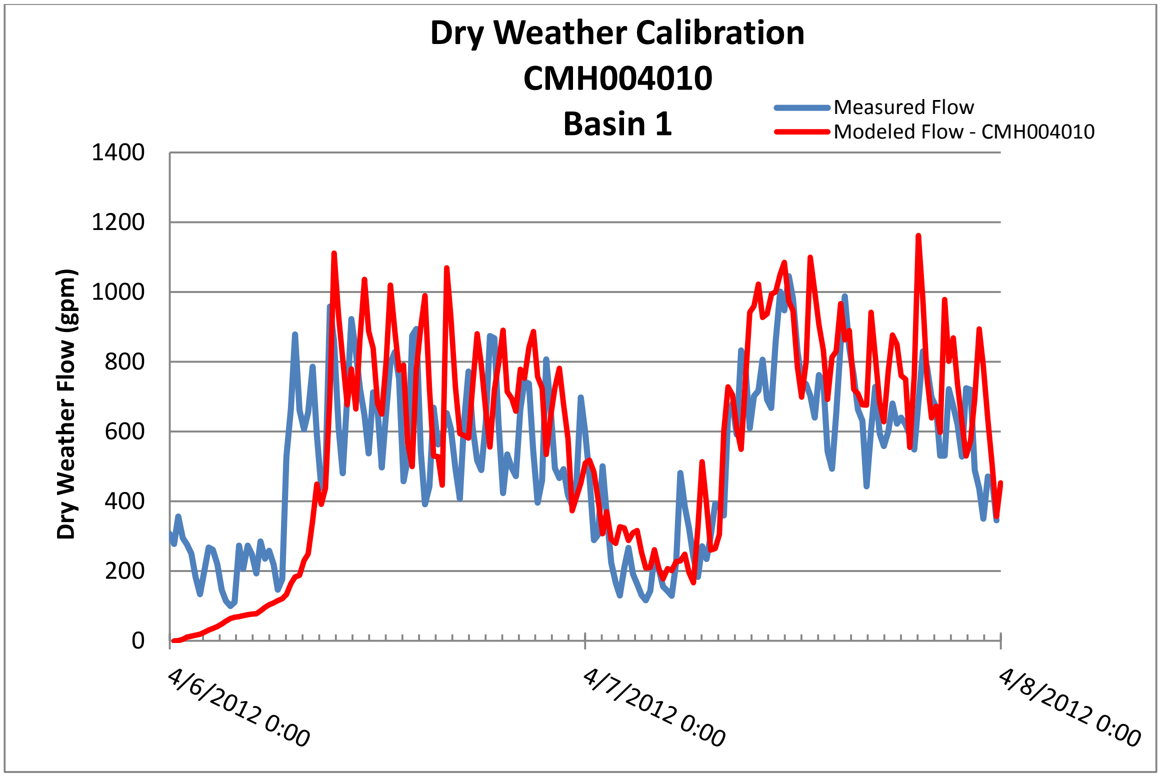
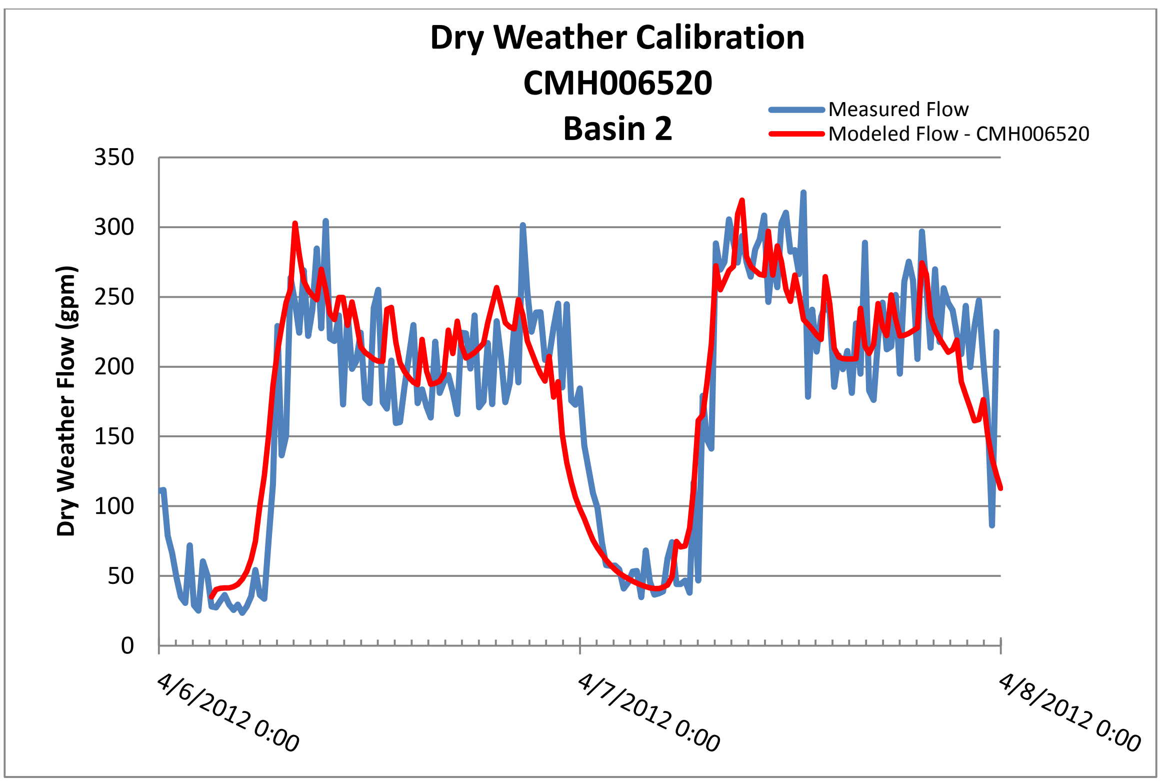
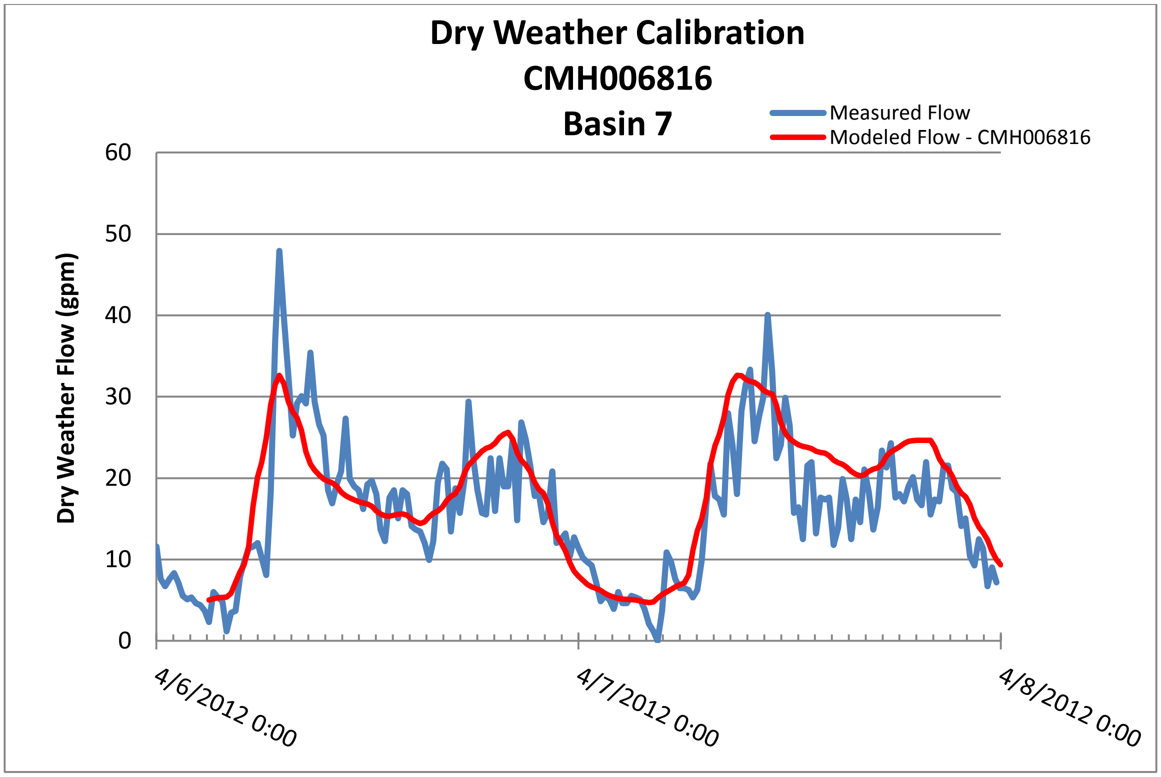
CMH003161
Basin 1
Measured Flow
Modeled Flow - CMH003161
Dry Weather Flow (gpm)
700
600
500
400
300
200
100
0
4/6/2012 0:00
4/7/2012 0:00
4/8/2012 0:00

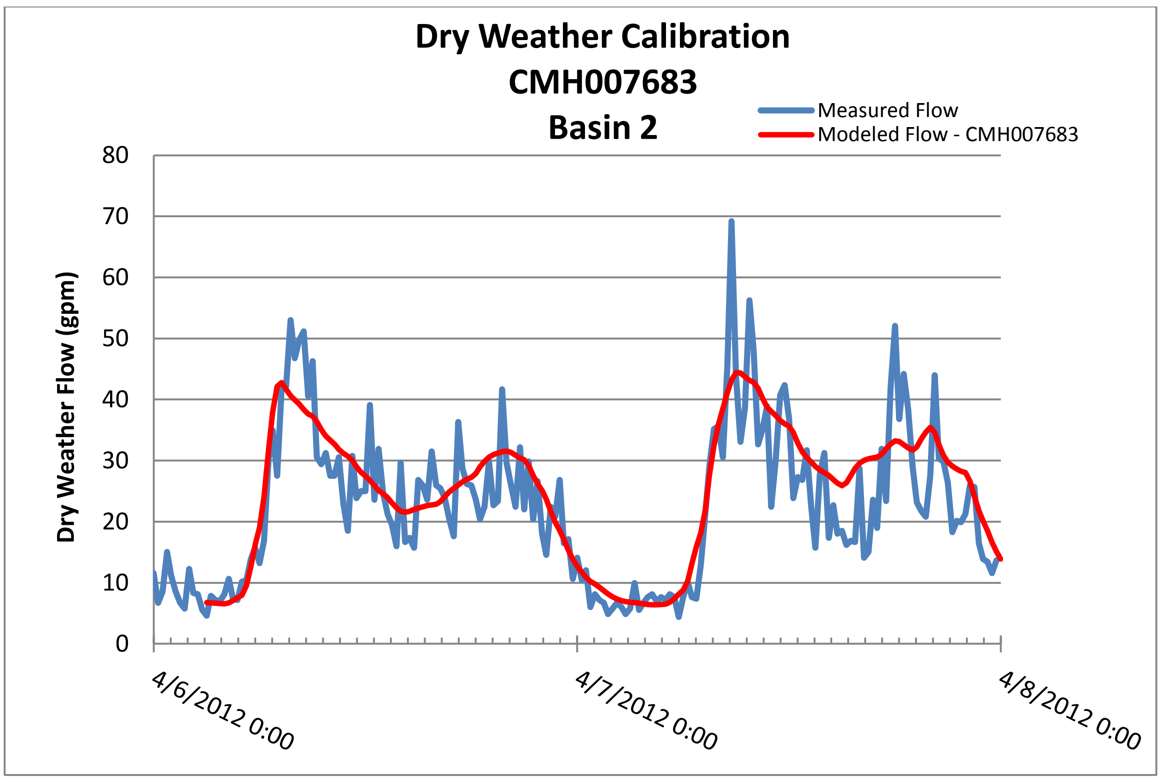

Dry Weather Calibration
CMH003221
Basin 6
Measured Flow
Modeled Flow - CMH003221
Dry Weather Flow (gpm)
1400
1200
1000
800
600
400
200
0
4/6/2012 0:00
4/7/2012 0:00
4/8/2012 0:00

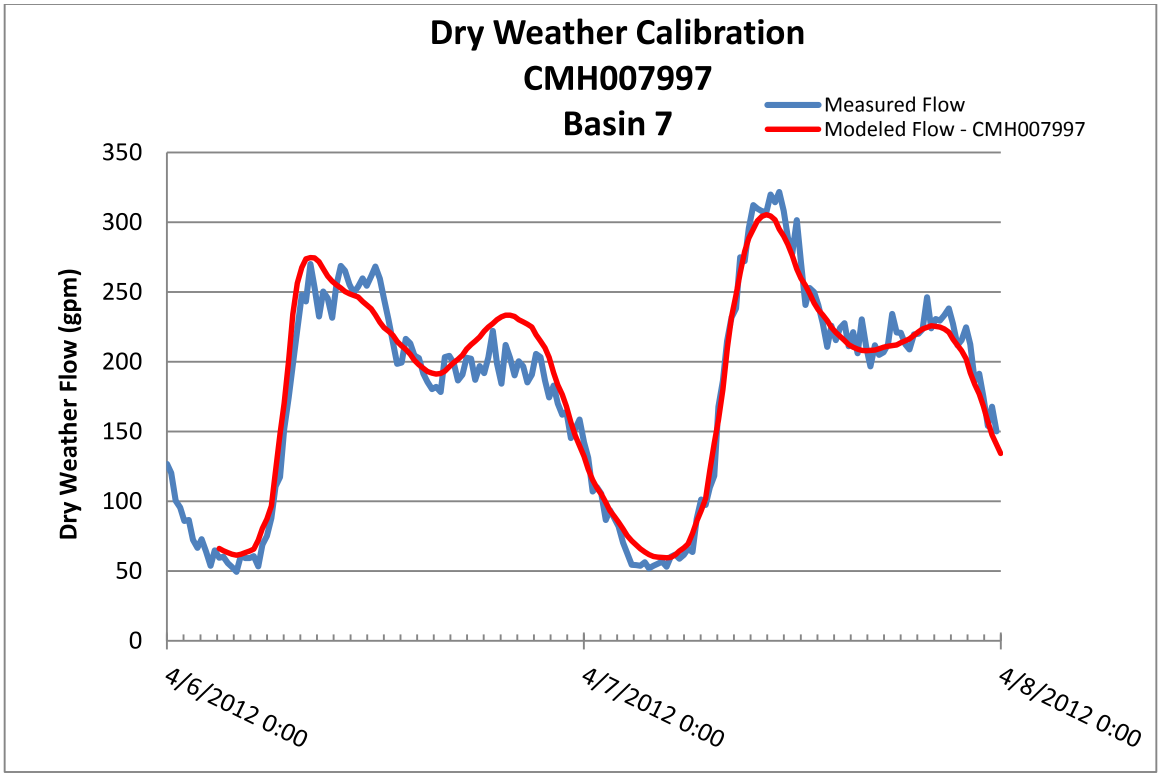

Dry Weather Calibration
CMH003505
Basin 2
Measured Flow
Modeled Flow - CMH003505
Dry Weather Flow (gpm)
350
300
250
200
150
100
50
0
4/6/2012 0:00
4/7/2012 0:00
4/8/2012 0:00

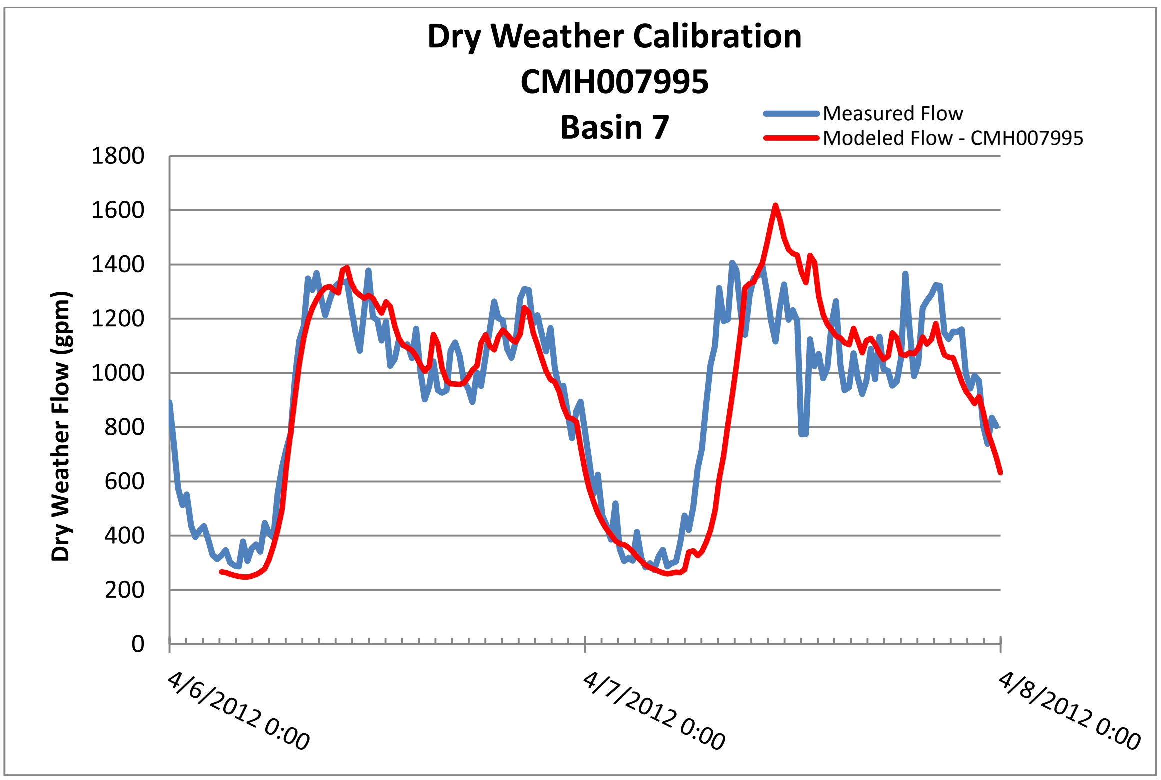

Dry Weather Calibration
CMH004010
Basin 1
Measured Flow
Modeled Flow - CMH004010
Dry Weather Flow (gpm)
1400
1200
1000
800
600
400
200
0
4/6/2012 0:00
4/7/2012 0:00
4/8/2012 0:00

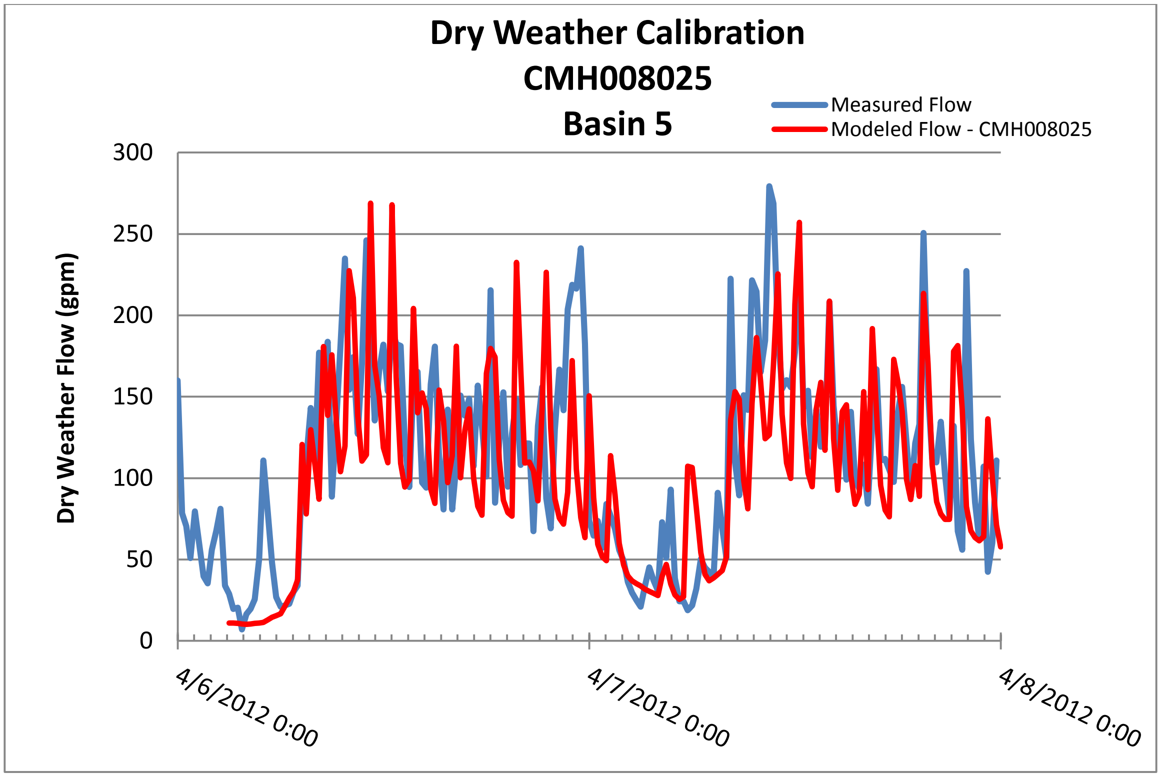

Dry Weather Calibration
CMH006520
Basin 2
Measured Flow
Modeled Flow - CMH006520
Dry Weather Flow (gpm)
350
300
250
200
150
100
50
0
4/6/2012 0:00
4/7/2012 0:00
4/8/2012 0:00

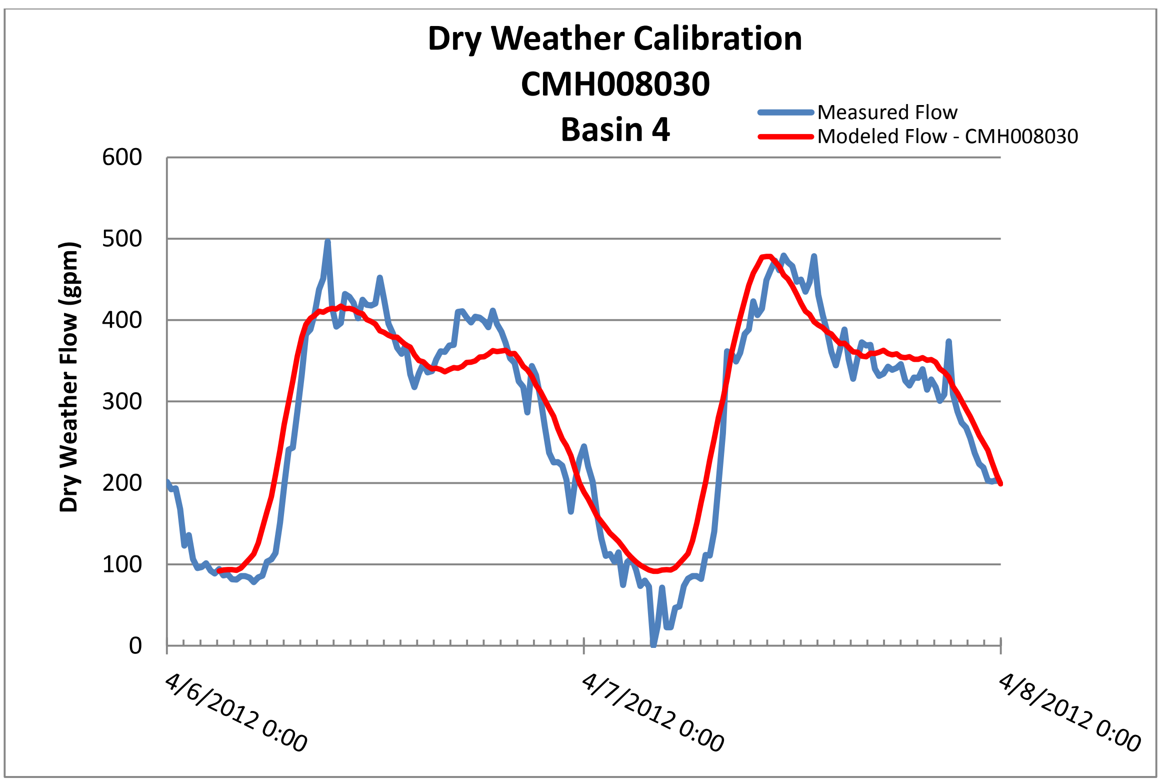

Dry Weather Calibration
CMH006816
Basin 7
Measured Flow
Modeled Flow - CMH006816
Dry Weather Flow (gpm)
60
50
40
30
20
10
0
4/6/2012 0:00
4/7/2012 0:00
4/8/2012 0:00

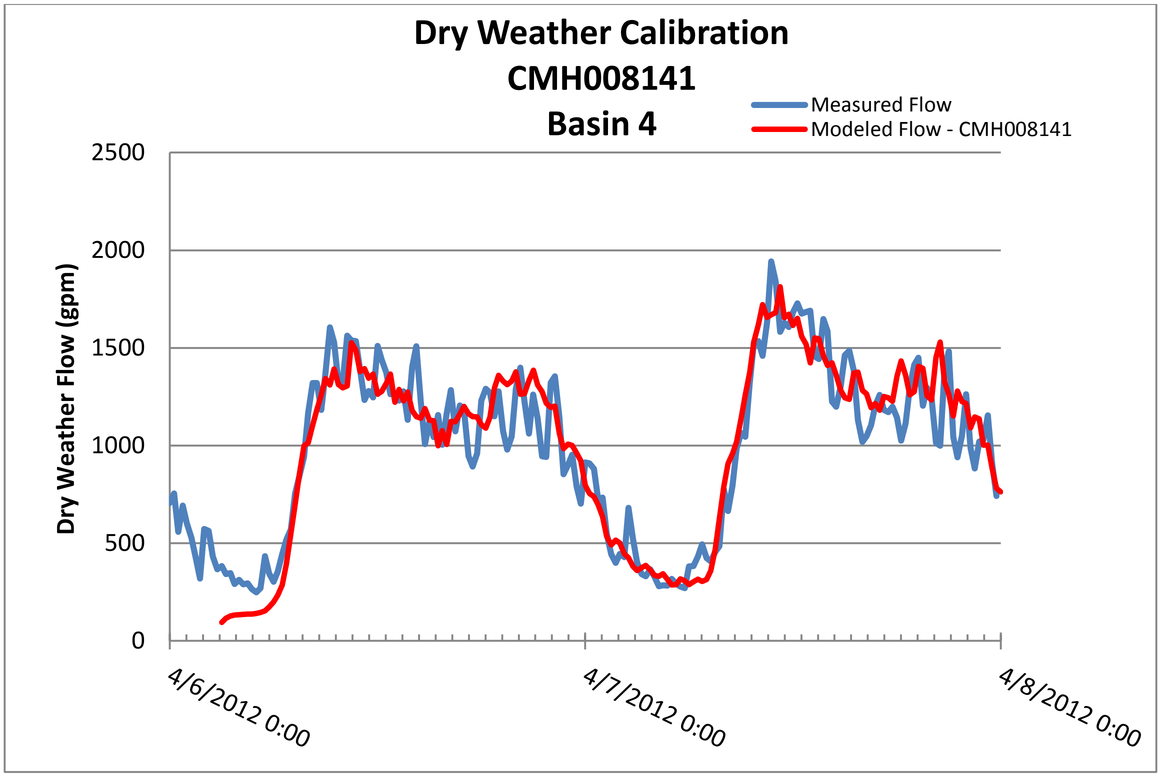

Dry Weather Calibration
CMH007683
Basin 2
Measured Flow
Modeled Flow - CMH007683
Dry Weather Flow (gpm)
80
70
60
50
40
30
20
10
0
4/6/2012 0:00
4/7/2012 0:00
4/8/2012 0:00

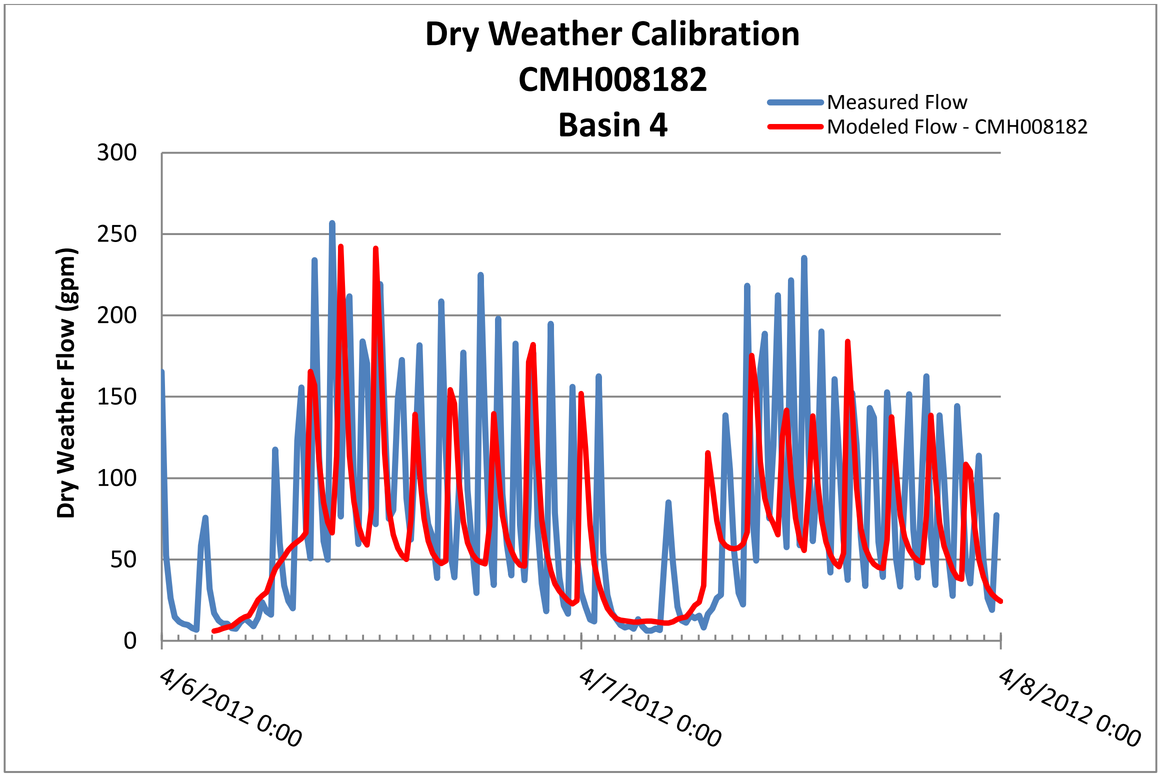

Dry Weather Calibration
CMH007997
Basin 7
Measured Flow
Modeled Flow - CMH007997
350
300
250
200
150
100
50
0
Dry Weather Flow (gpm)
4/6/2012 0:00
4/7/2012 0:00
4/8/2012 0:00

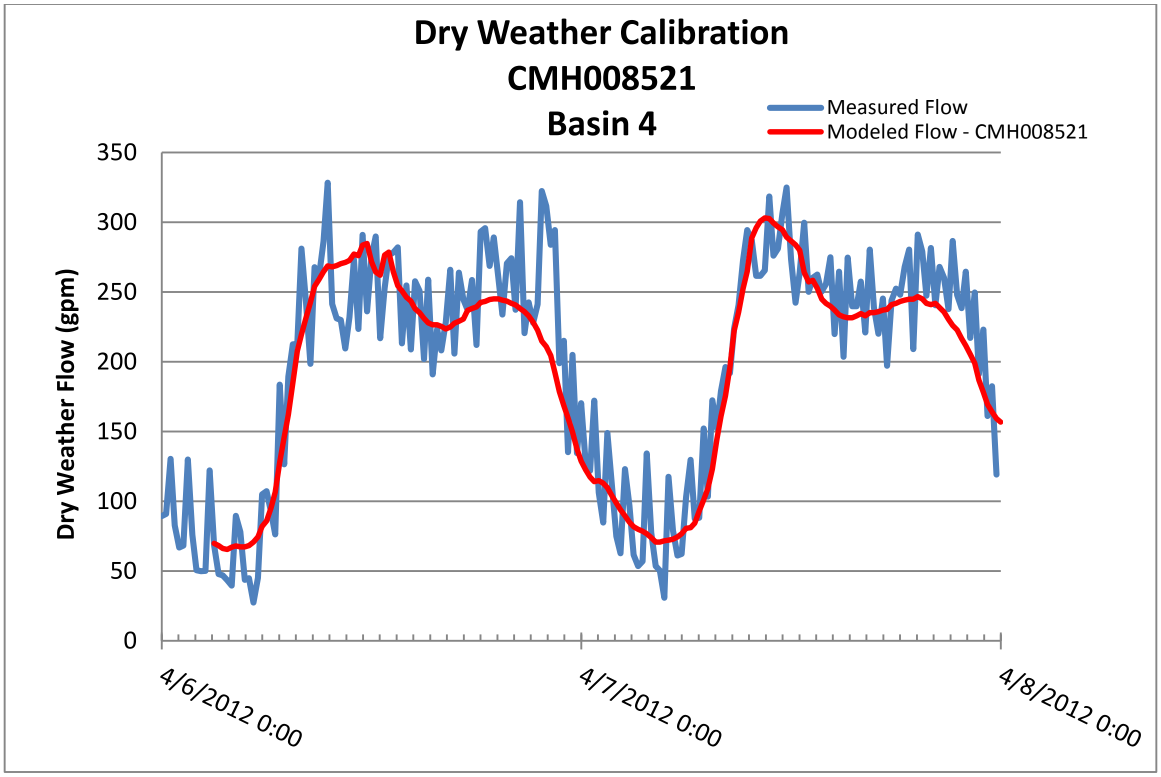

Dry Weather Calibration
CMH007995
Basin 7
Measured Flow
Modeled Flow - CMH007995
1800
1600
1400
1200
1000
800
600
400
200
0
Dry Weather Flow (gpm)
4/6/2012 0:00
4/7/2012 0:00
4/8/2012 0:00

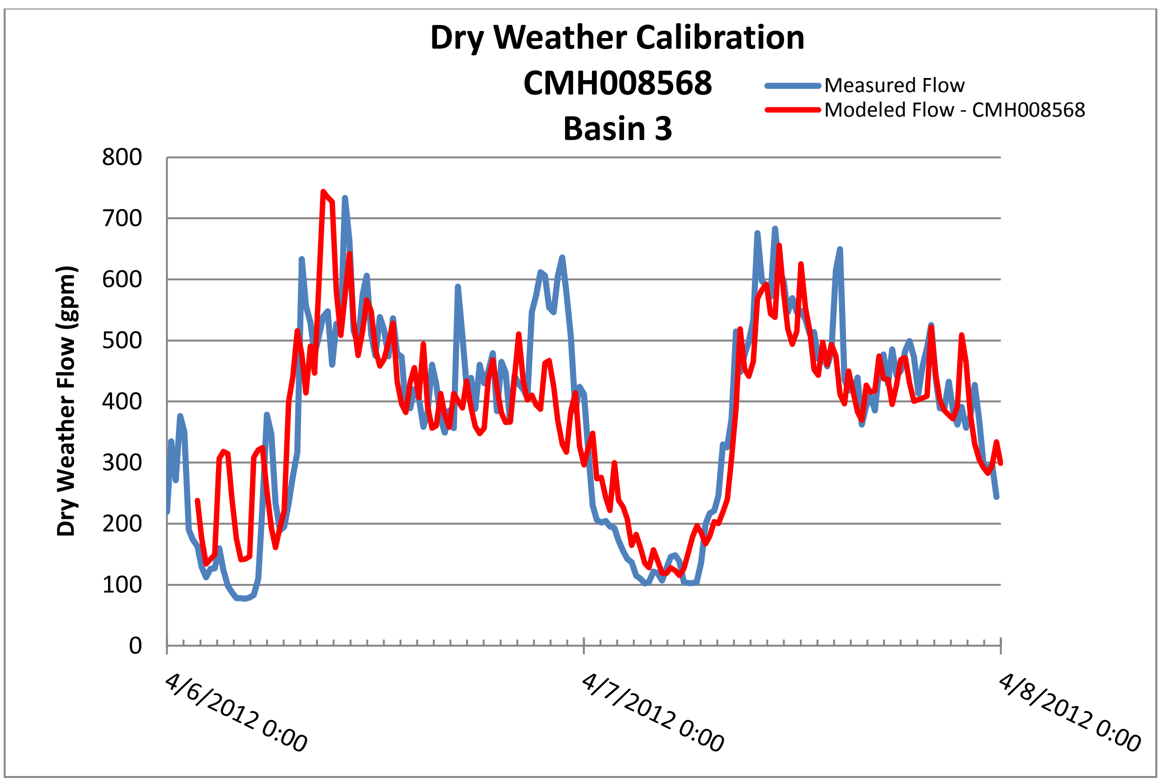

Dry Weather Calibration
CMH008025
Basin 5
Measured Flow
Modeled Flow - CMH008025
Dry Weather Flow (gpm)
300
250
200
150
100
50
0
4/6/2012 0:00
4/7/2012 0:00
4/8/2012 0:00

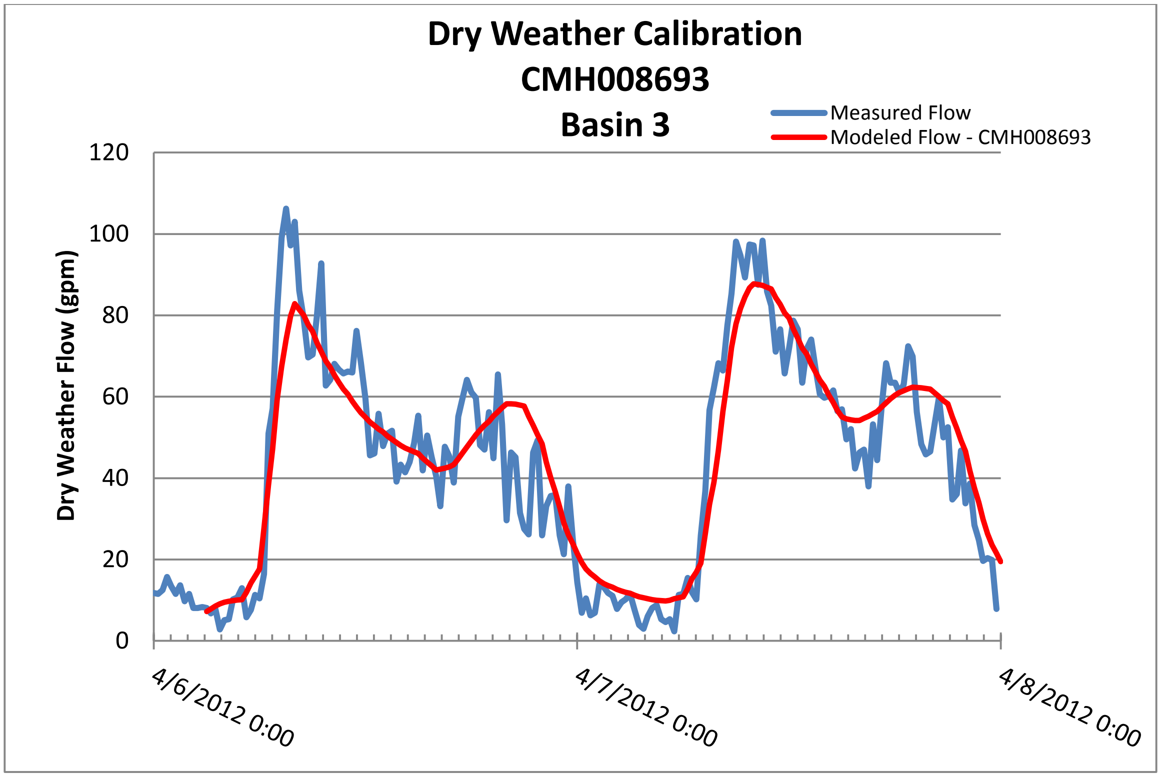

Dry Weather Calibration
CMH008030
Basin 4
Measured Flow
Modeled Flow - CMH008030
Dry Weather Flow (gpm)
600
500
400
300
200
100
0
4/6/2012 0:00
4/7/2012 0:00
4/8/2012 0:00

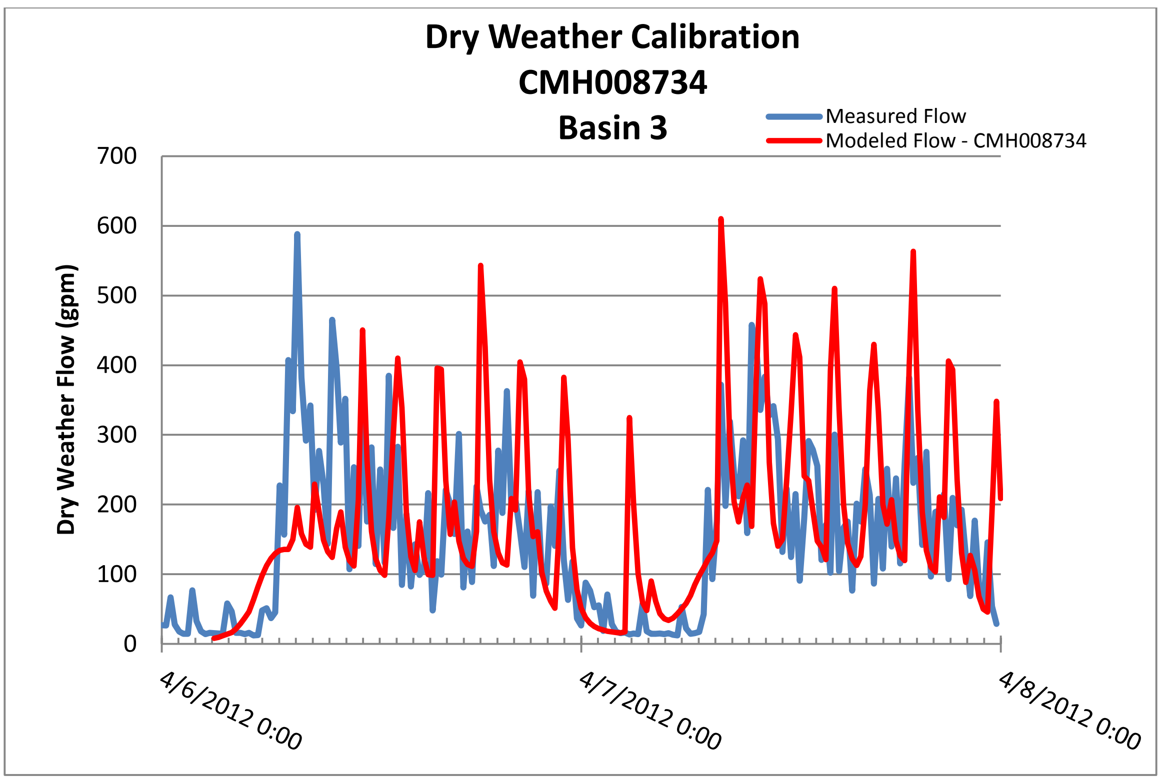

Dry Weather Calibration
CMH008141
Basin 4
Measured Flow
Modeled Flow - CMH008141
Dry Weather Flow (gpm)
2500
2000
1500
1000
500
0
4/6/2012 0:00
4/7/2012 0:00
4/8/2012 0:00

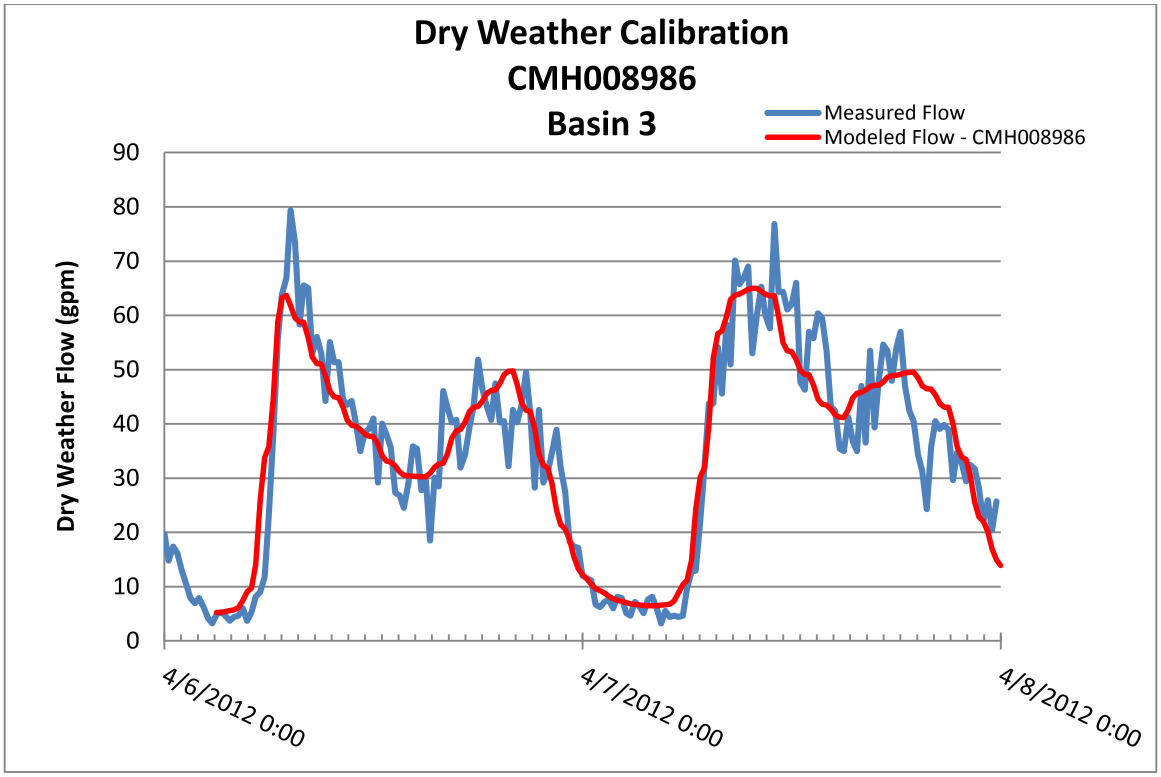

Dry Weather Calibration
CMH008182
Basin 4
Measured Flow
Modeled Flow - CMH008182
Dry Weather Flow (gpm)
300
250
200
150
100
50
0
4/6/2012 0:00
4/7/2012 0:00
4/8/2012 0:00

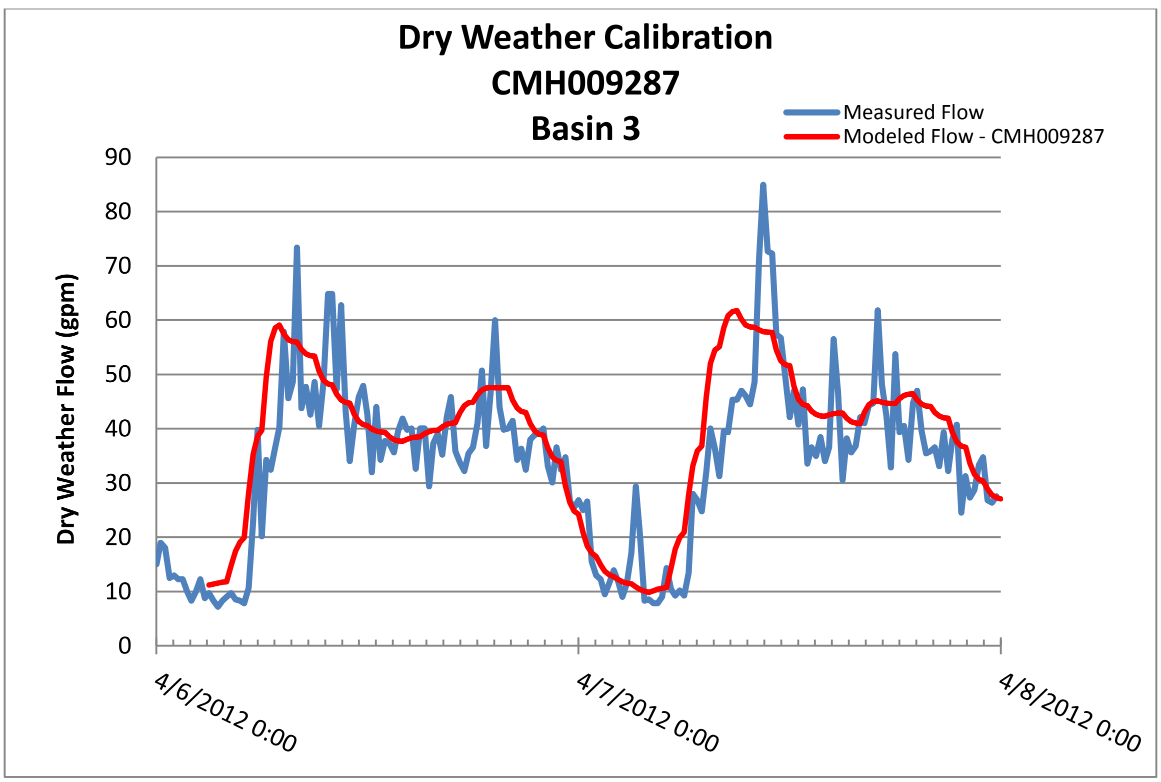

Dry Weather Calibration
CMH008521
Basin 4
Measured Flow
Modeled Flow - CMH008521
Dry Weather Flow (gpm)
350
300
250
200
150
100
50
0
4/6/2012 0:00
4/7/2012 0:00
4/8/2012 0:00

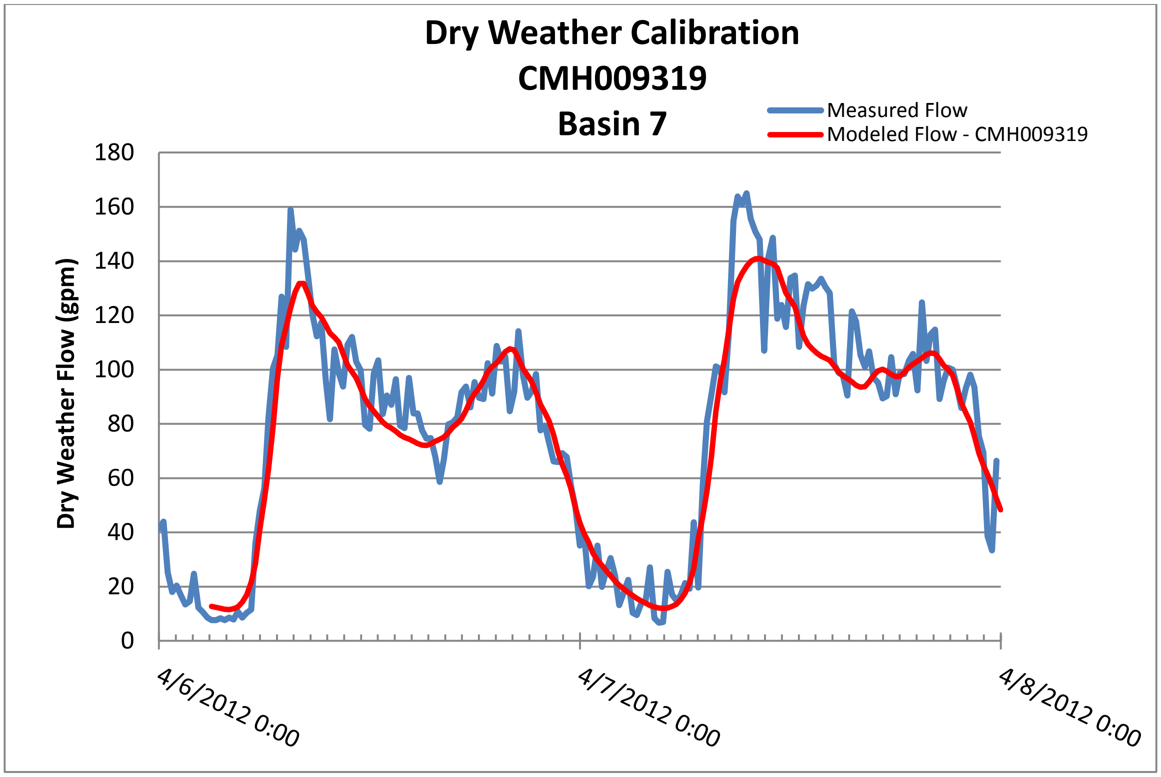

Dry Weather Calibration
CMH008568
Basin 3
Measured Flow
Modeled Flow - CMH008568
Dry Weather Flow (gpm)
800
700
600
500
400
300
200
100
0
4/6/2012 0:00
4/7/2012 0:00
4/8/2012 0:00


Dry Weather Calibration
CMH008693
Basin 3
Measured Flow
Modeled Flow - CMH008693
Dry Weather Flow (gpm)
0
20
40
60
80
100
120
4/6/2012 0:00
4/7/2012 0:00
4/8/2012 0:00

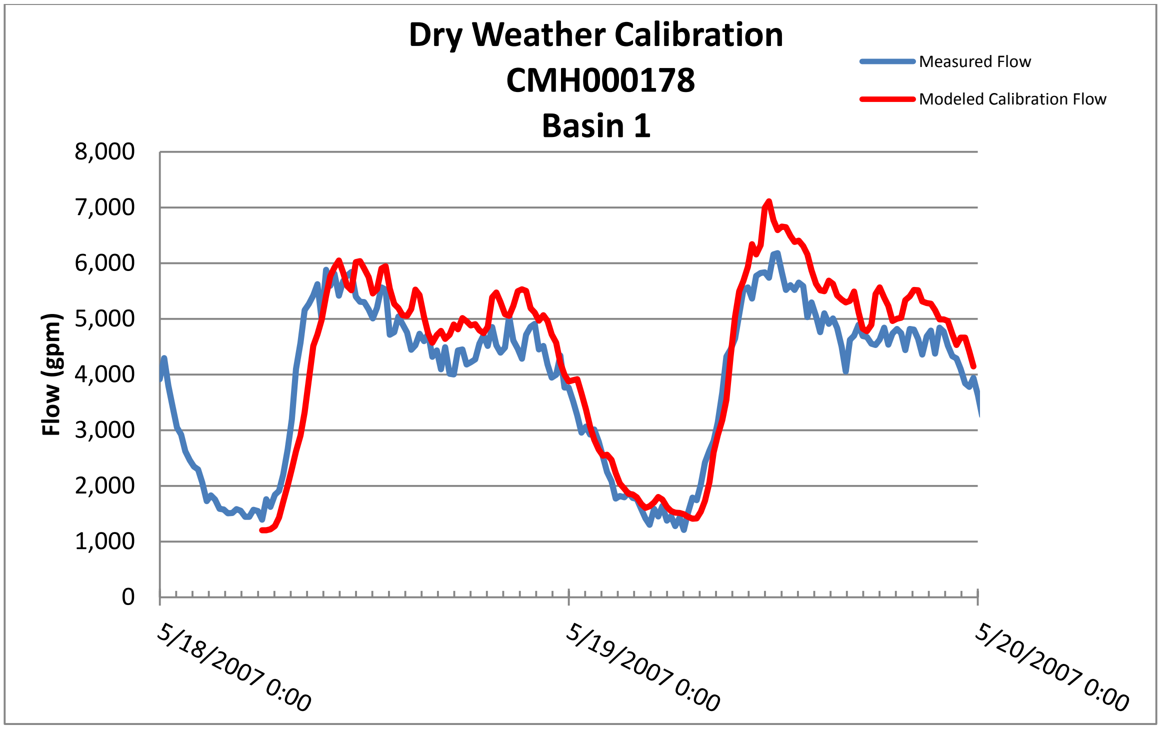

Dry Weather Calibration
CMH008734
Basin 3
Measured Flow
Modeled Flow - CMH008734
Dry Weather Flow (gpm)
0
100
200
300
400
500
600
700
4/6/2012 0:00
4/7/2012 0:00
4/8/2012 0:00

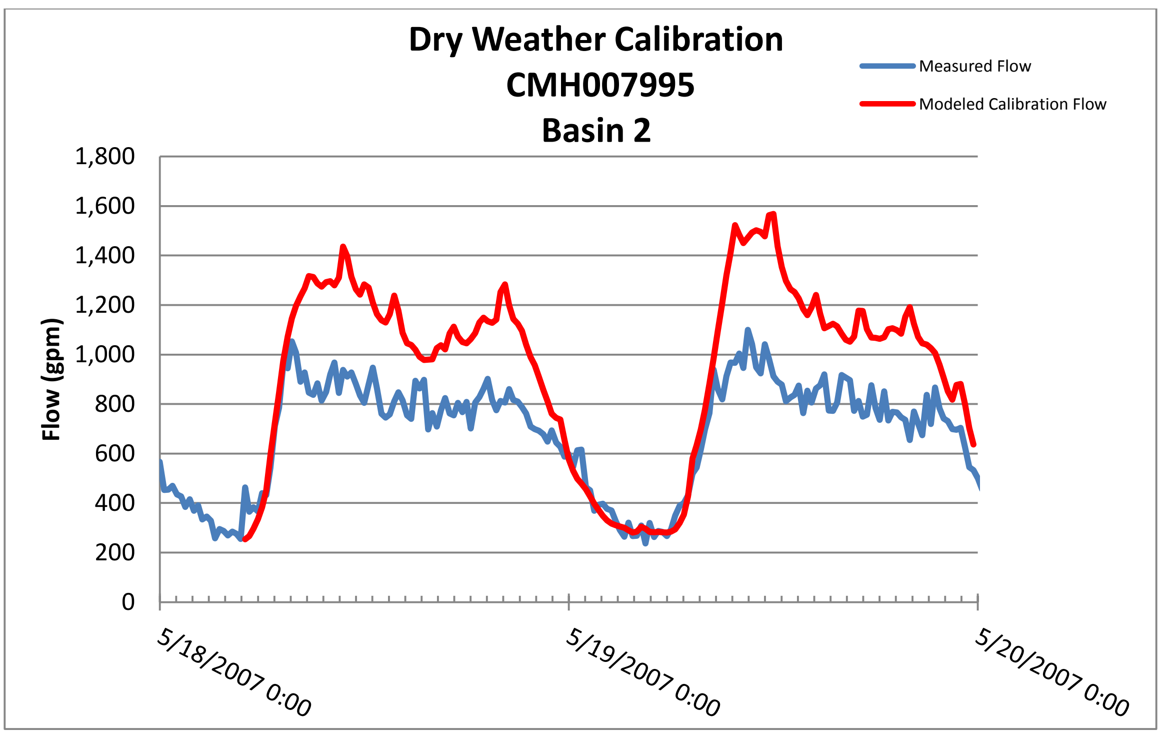

Dry Weather Calibration
CMH008986
Basin 3
Measured Flow
Modeled Flow - CMH008986
Dry Weather Flow (gpm)
90
80
70
60
50
40
30
20
10
0
4/6/2012 0:00
4/7/2012 0:00
4/8/2012 0:00

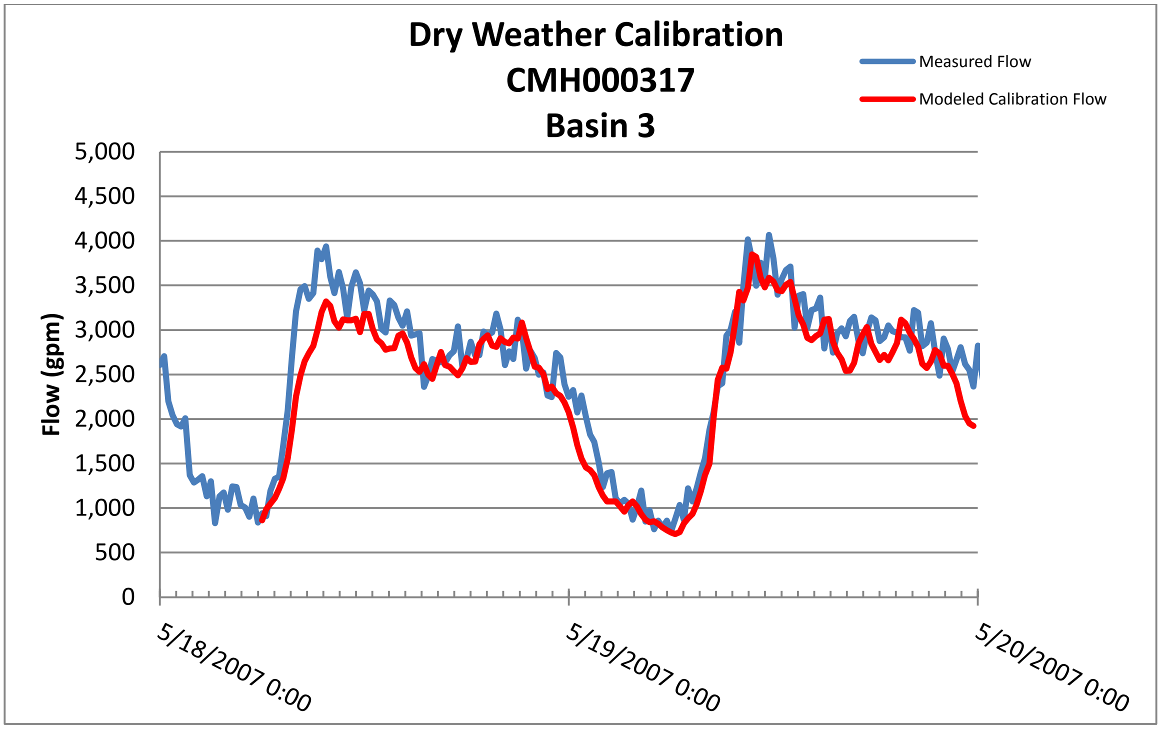

Dry Weather Calibration
CMH009287
Basin 3
Measured Flow
Modeled Flow - CMH009287
Dry Weather Flow (gpm)
90
80
70
60
50
40
30
20
10
0
4/6/2012 0:00
4/7/2012 0:00
4/8/2012 0:00

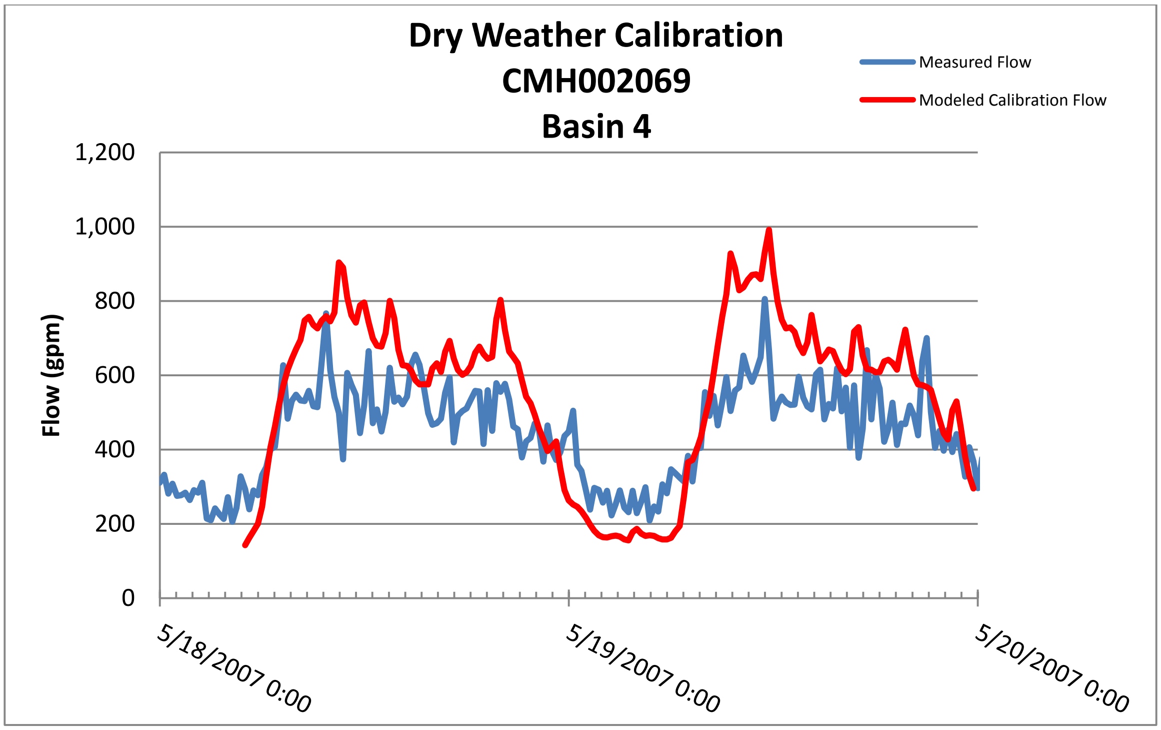

Dry Weather Calibration
CMH009319
Basin 7
Measured Flow
Modeled Flow - CMH009319
Dry Weather Flow (gpm)
0
20
40
60
80
100
120
140
160
180
4/6/2012 0:00
4/7/2012 0:00
4/8/2012 0:00

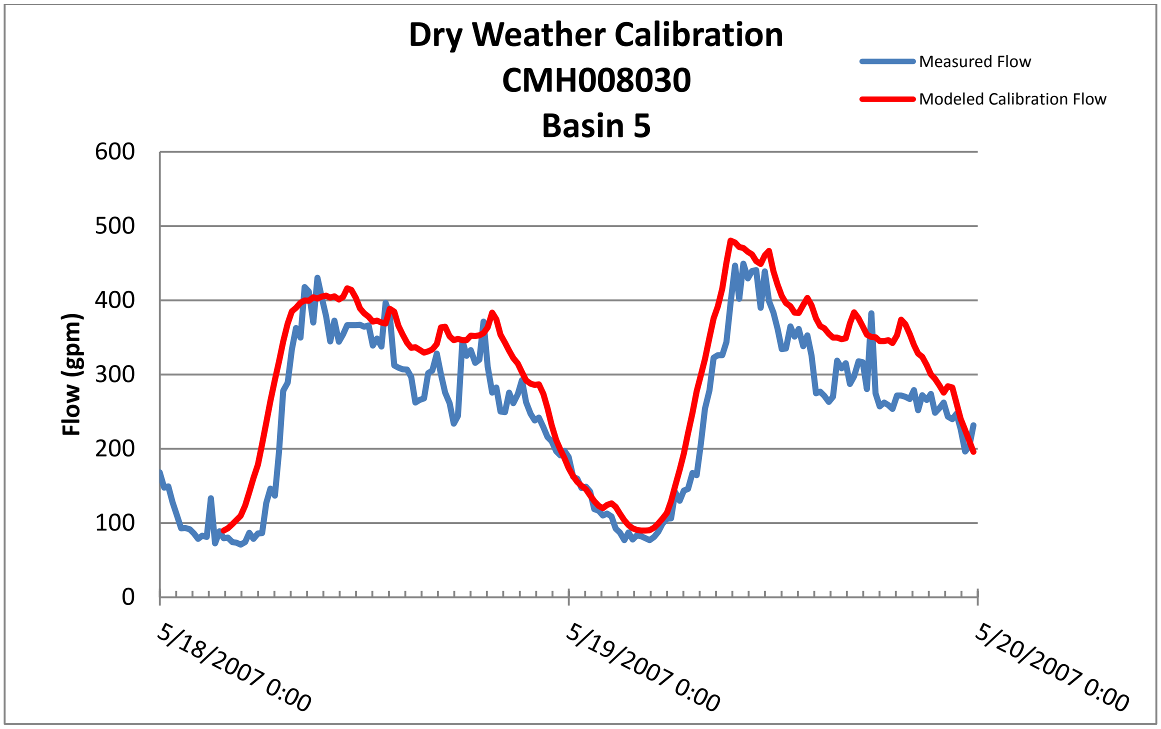
Dry Weather Flow Calibration Results (2007)

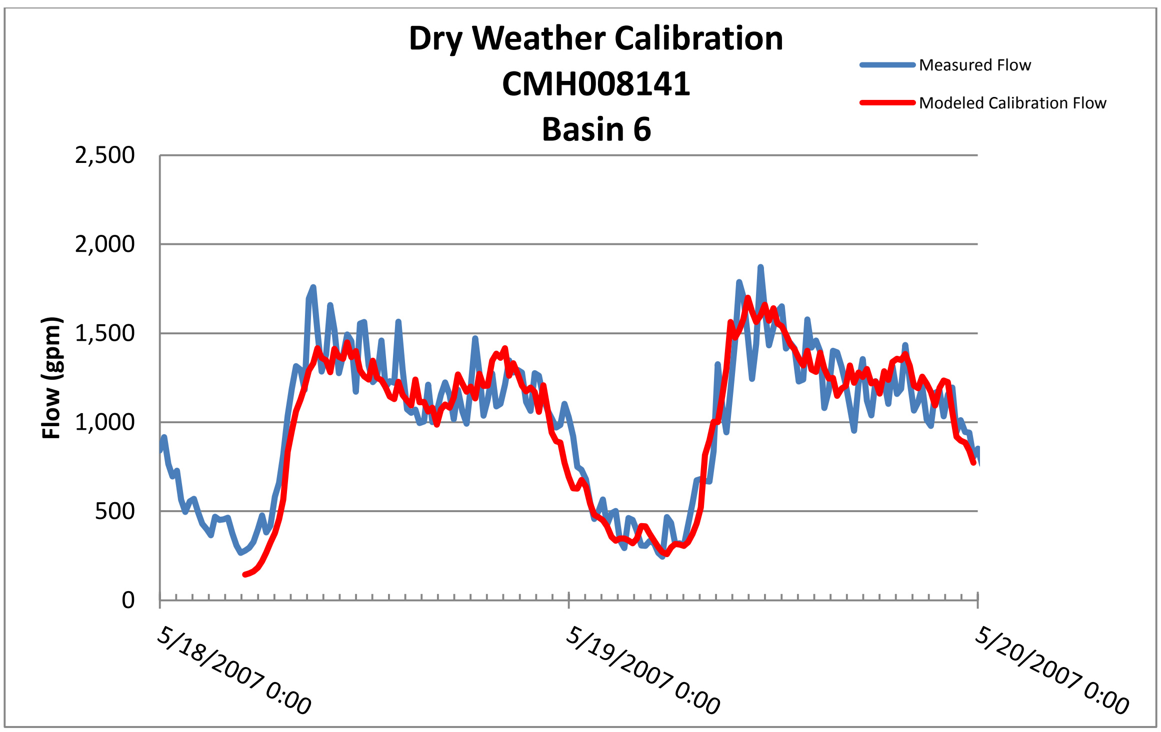


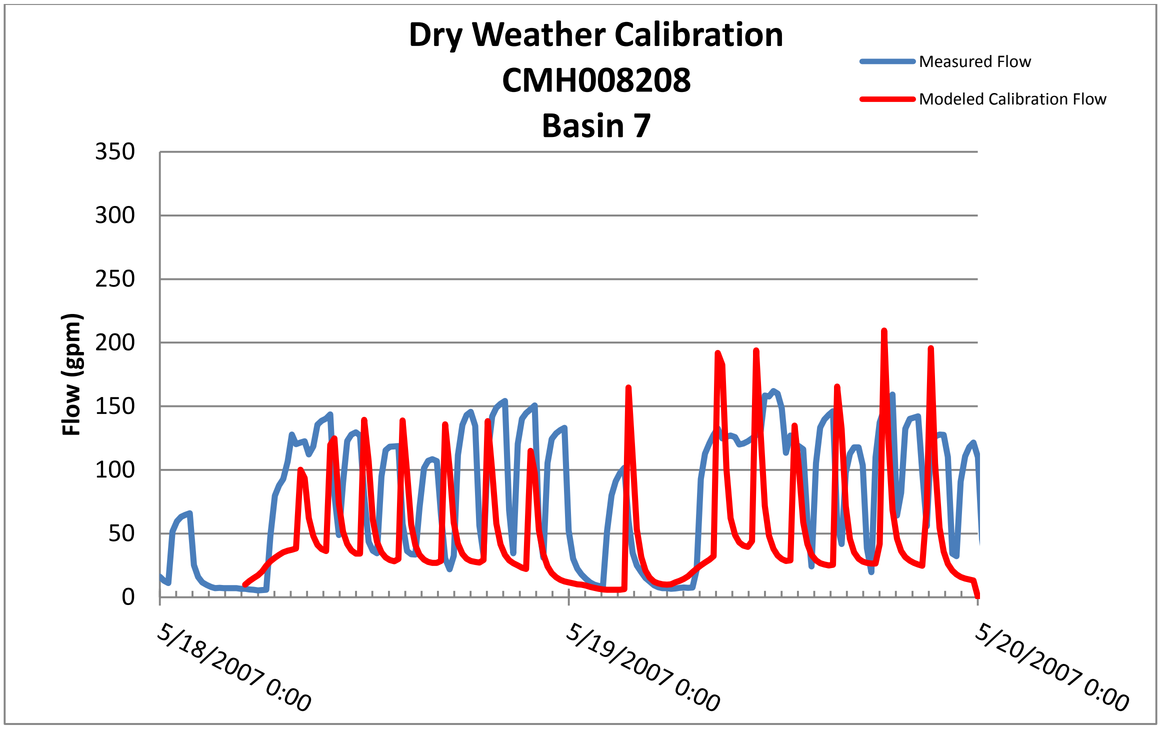


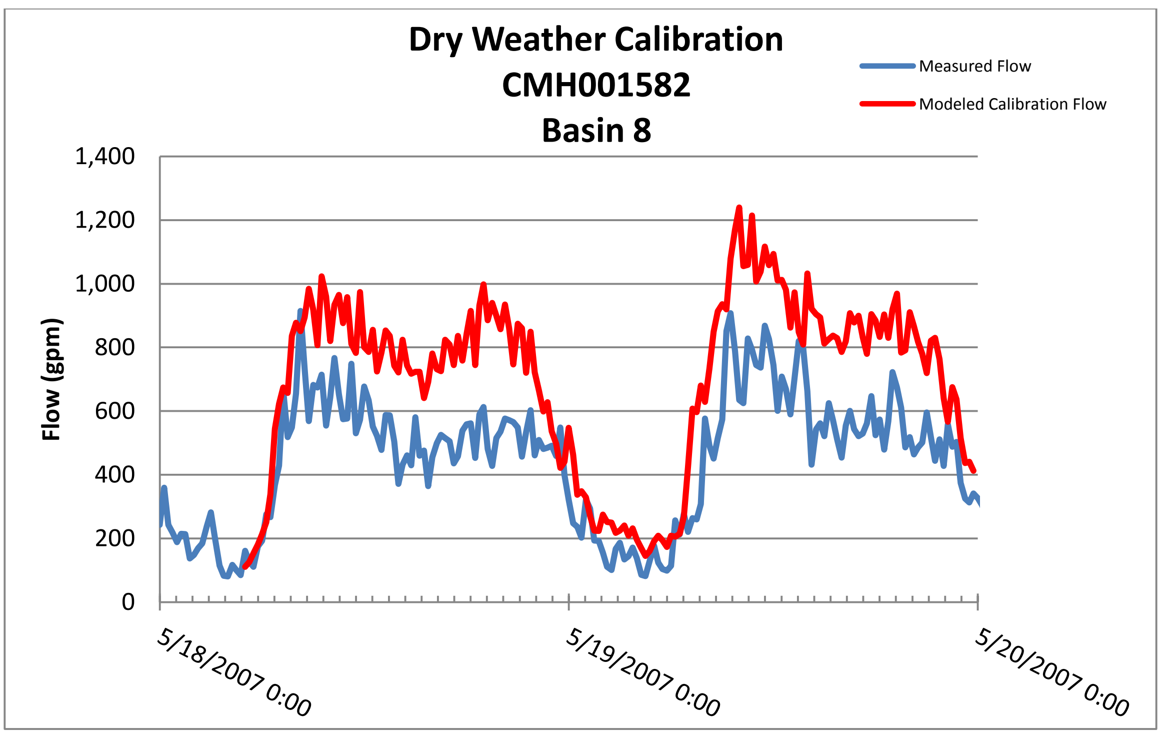

Dry Weather Calibration
CMH000317
Basin 3
Measured Flow
Modeled Calibration Flow
Flow (gpm)
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
5/18/2007 0:00
5/19/2007 0:00
5/20/2007 0:00

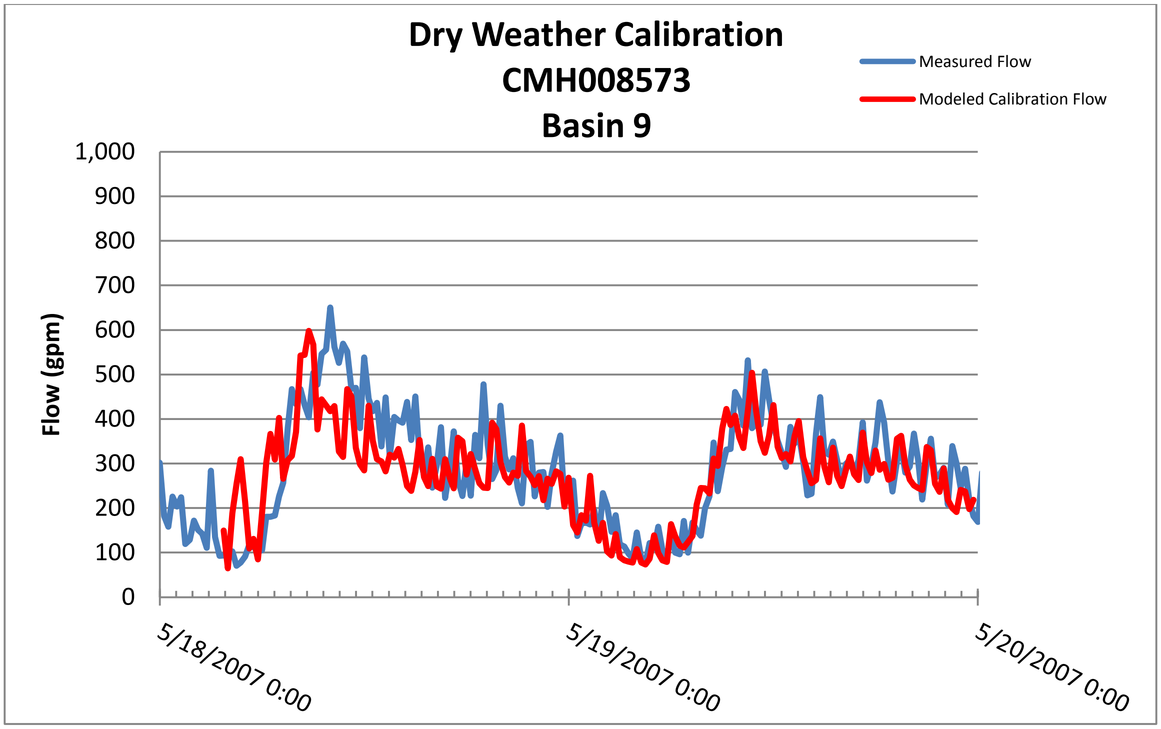

Dry Weather Calibration
CMH002069
Basin 4
Measured Flow
Modeled Calibration Flow
Flow (gpm)
1,200
1,000
800
600
400
200
0
5/18/2007 0:00
5/19/2007 0:00
5/20/2007 0:00

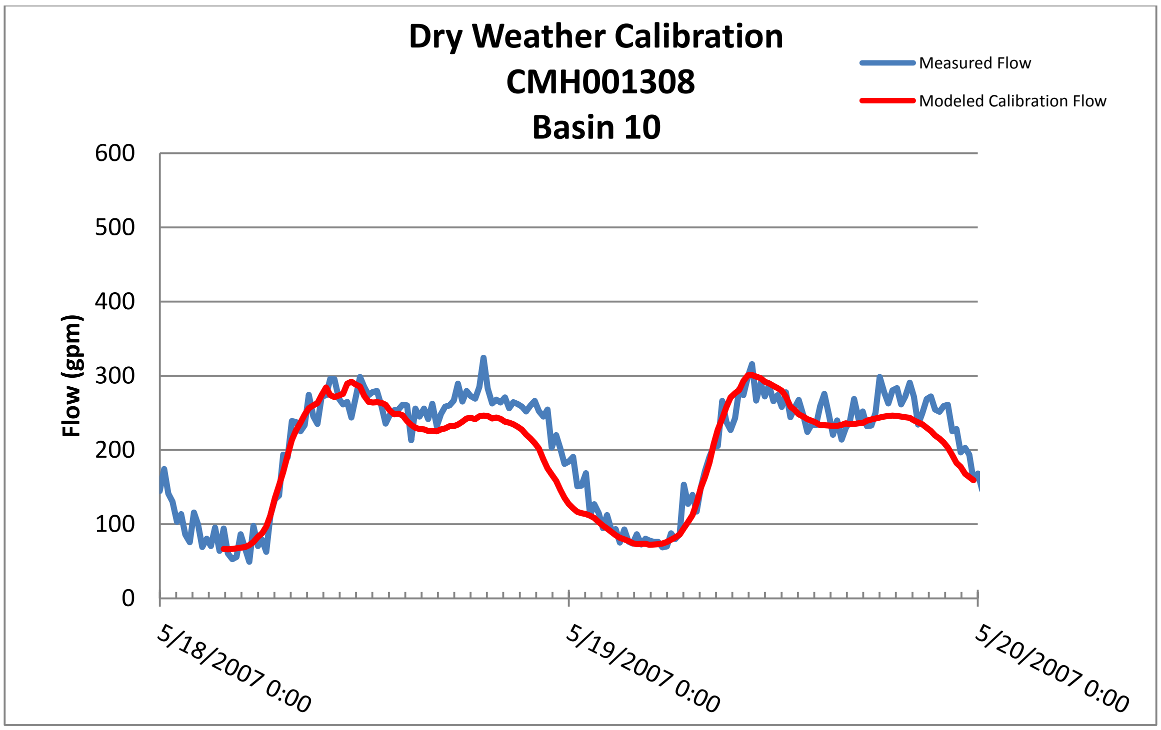

Dry Weather Calibration
CMH008030
Basin 5
Measured Flow
Modeled Calibration Flow
Flow (gpm)
600
500
400
300
200
100
0
5/18/2007 0:00
5/19/2007 0:00
5/20/2007 0:00

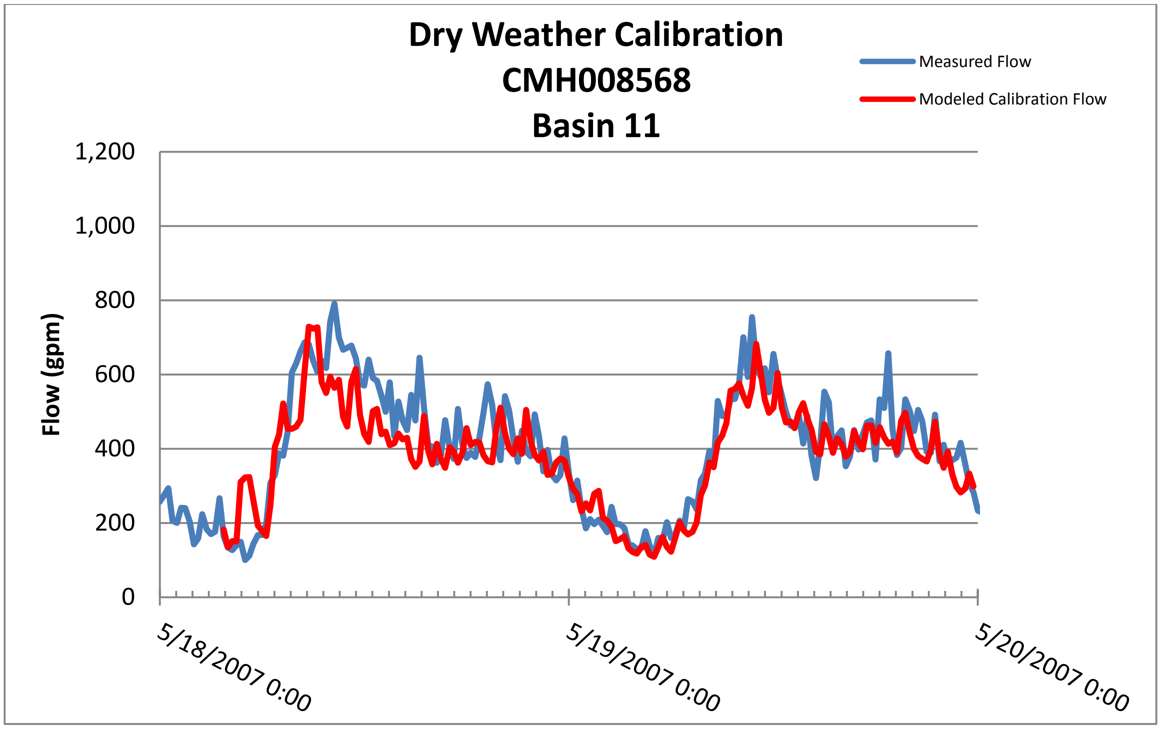

Dry Weather Calibration
CMH008141
Basin 6
Measured Flow
Modeled Calibration Flow
Flow (gpm)
2,500
2,000
1,500
1,000
500
0
5/18/2007 0:00
5/19/2007 0:00
5/20/2007 0:00

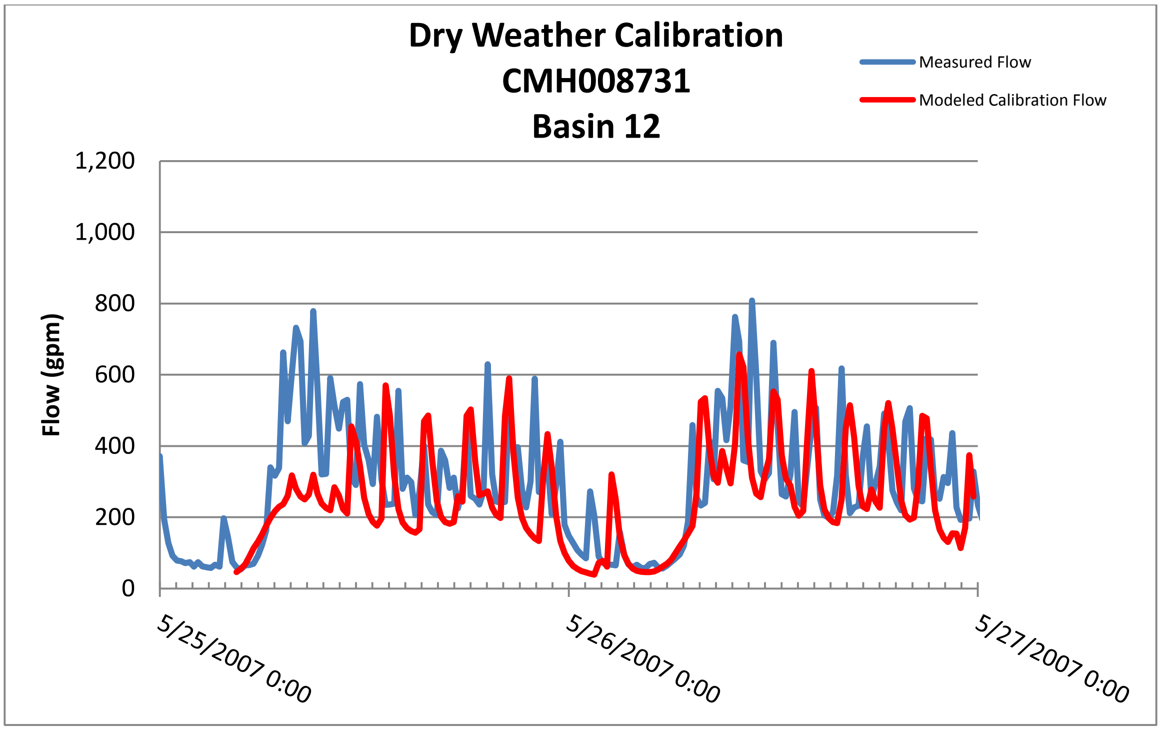

Dry Weather Calibration
CMH008208
Basin 7
Measured Flow
Modeled Calibration Flow
Flow (gpm)
350
300
250
200
150
100
50
0
5/18/2007 0:00
5/19/2007 0:00
5/20/2007 0:00

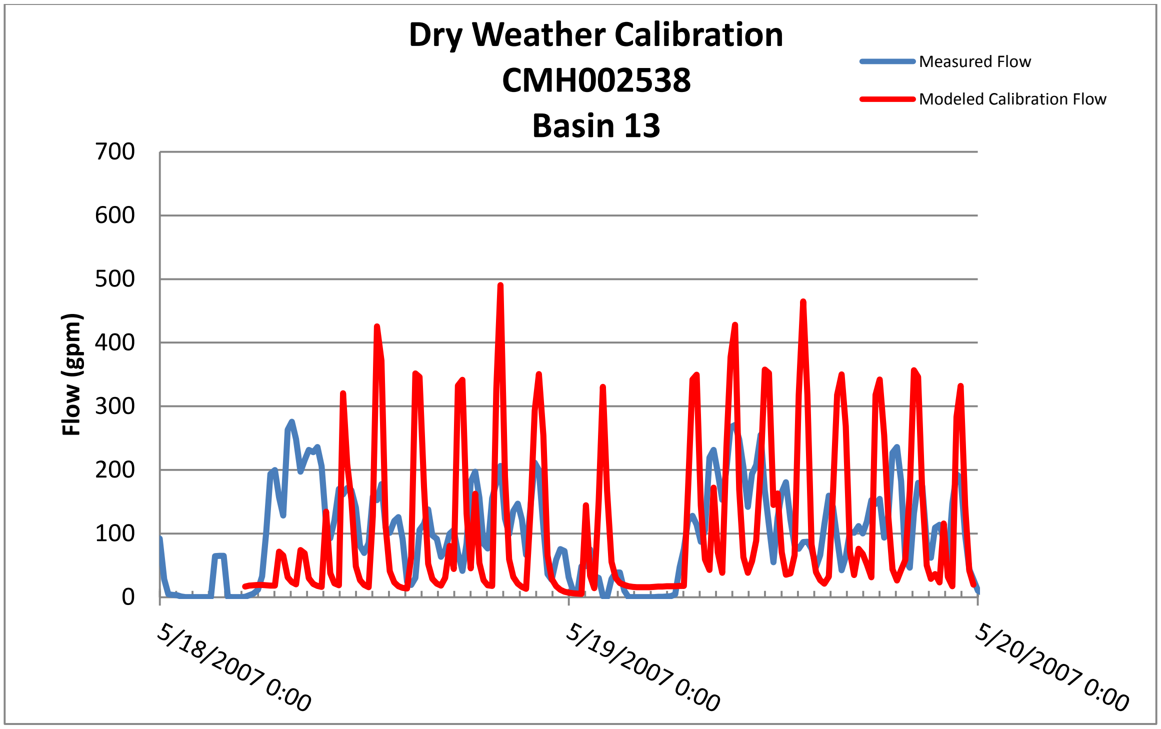

Dry Weather Calibration
CMH001582
Basin 8
Measured Flow
Modeled Calibration Flow
Flow (gpm)
1,400
1,200
1,000
800
600
400
200
0
5/18/2007 0:00
5/19/2007 0:00
5/20/2007 0:00

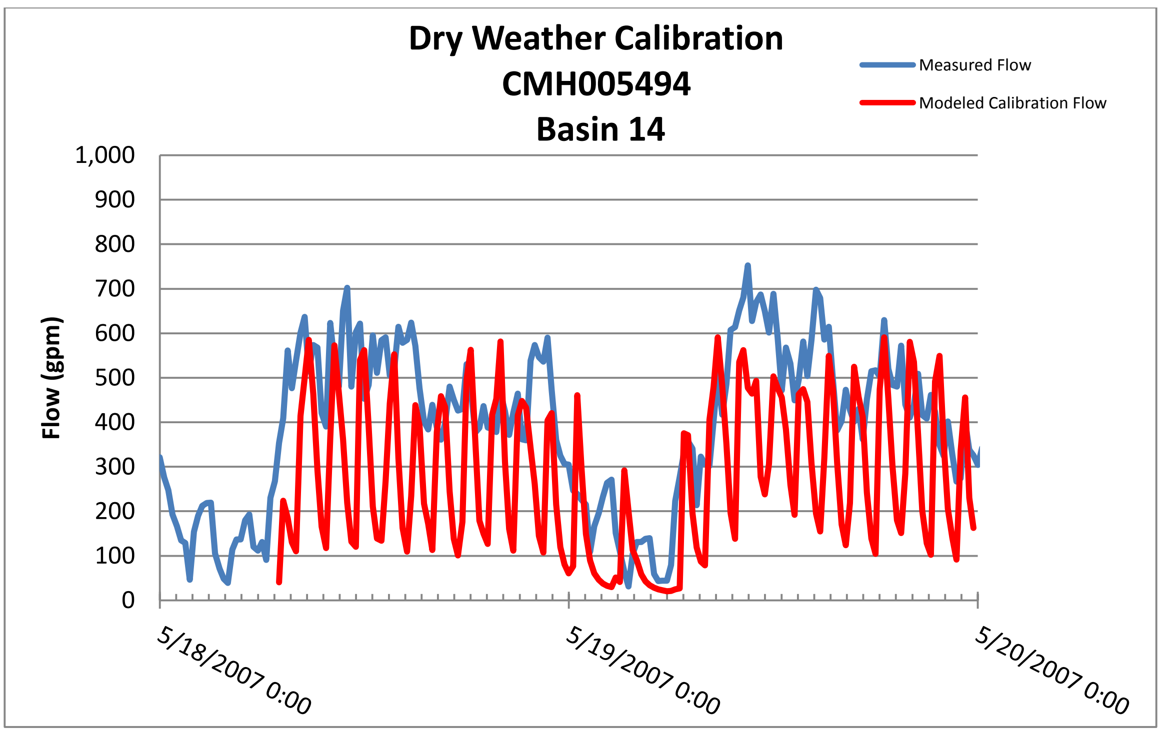

Dry Weather Calibration
CMH008573
Basin 9
Measured Flow
Modeled Calibration Flow
Flow (gpm)
1,000
900
800
700
600
500
400
300
200
100
0
5/18/2007 0:00
5/19/2007 0:00
5/20/2007 0:00

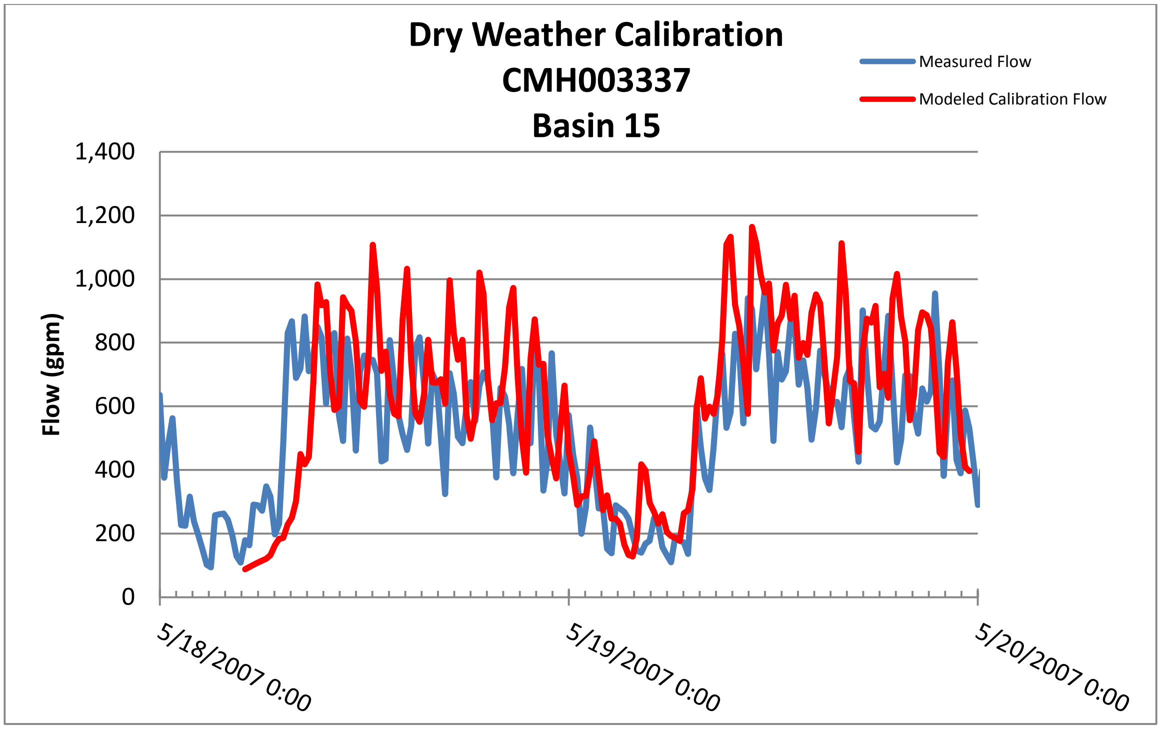

Dry Weather Calibration
CMH001308
Basin 10
Measured Flow
Modeled Calibration Flow
Flow (gpm)
600
500
400
300
200
100
0
5/18/2007 0:00
5/19/2007 0:00
5/20/2007 0:00


Dry Weather Calibration
CMH008568
Basin 11
Measured Flow
Modeled Calibration Flow
Flow (gpm)
1,200
1,000
800
600
400
200
0
5/18/2007 0:00
5/19/2007 0:00
5/20/2007 0:00

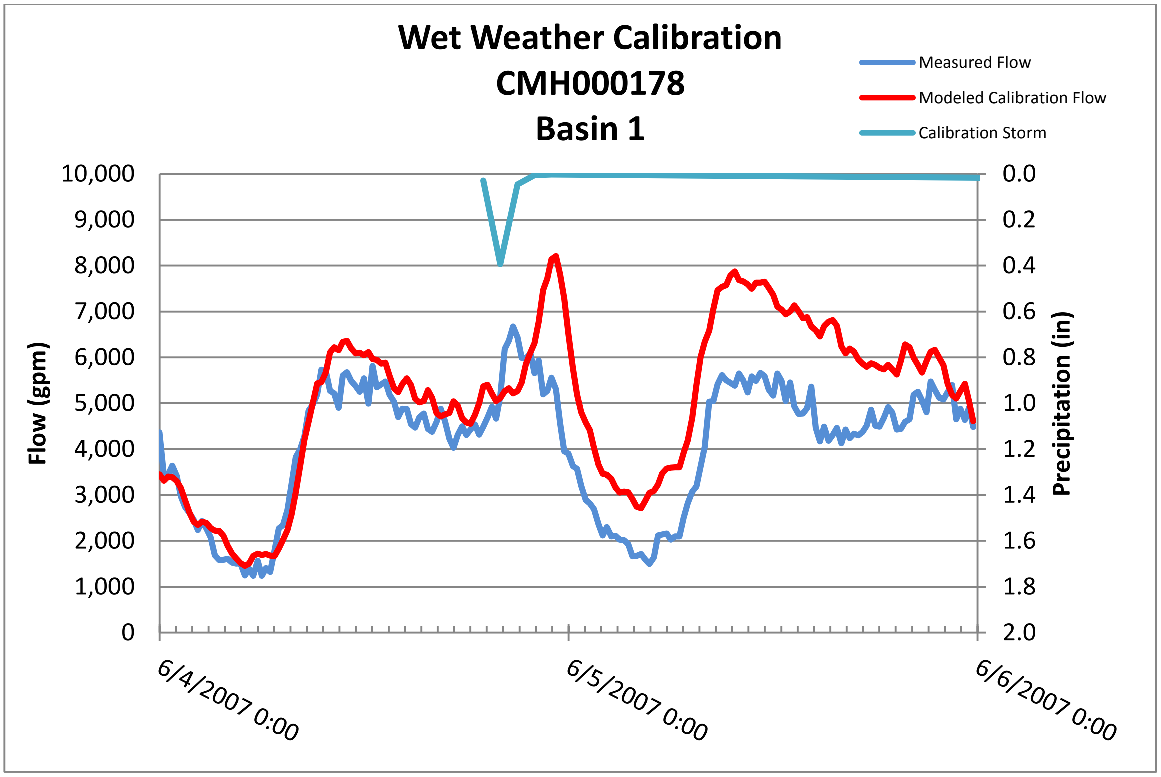

Dry Weather Calibration
CMH008731
Basin 12
Measured Flow
Modeled Calibration Flow
Flow (gpm)
1,200
1,000
800
600
400
200
0
5/25/2007 0:00
5/26/2007 0:00
5/27/2007 0:00

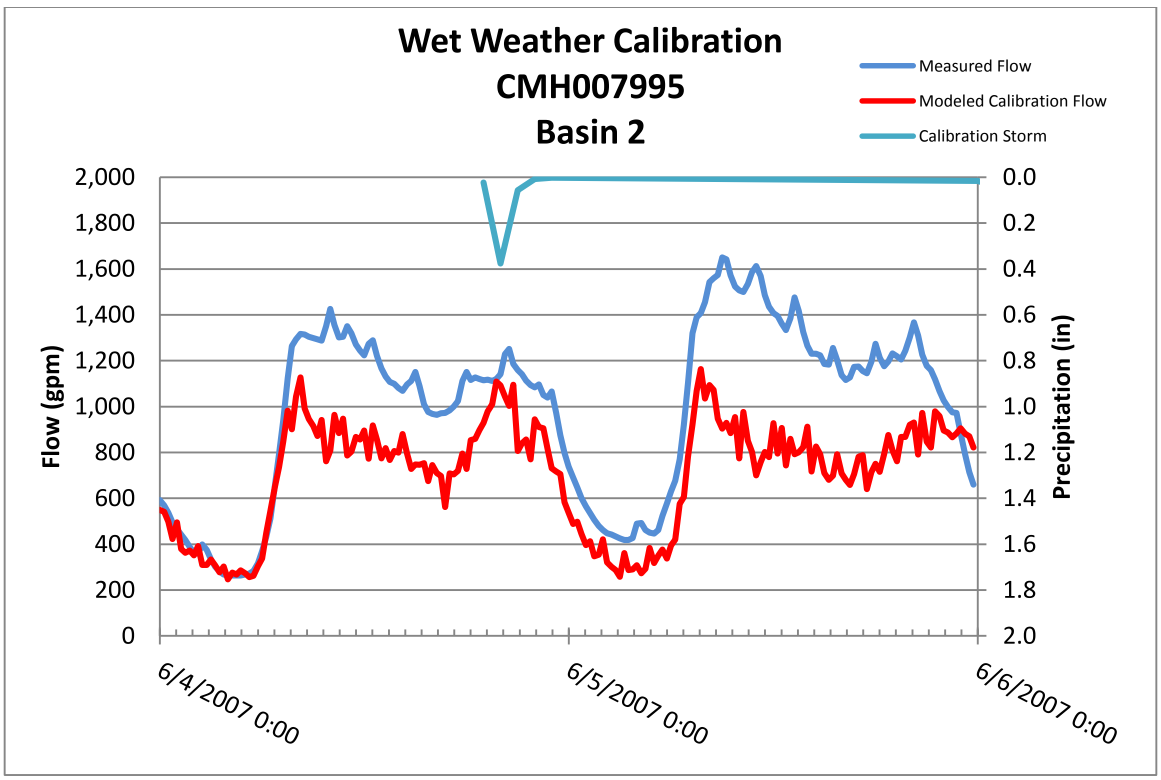

Dry Weather Calibration
CMH002538
Basin 13
Measured Flow
Modeled Calibration Flow
Flow (gpm)
700
600
500
400
300
200
100
0
5/18/2007 0:00
5/19/2007 0:00
5/20/2007 0:00

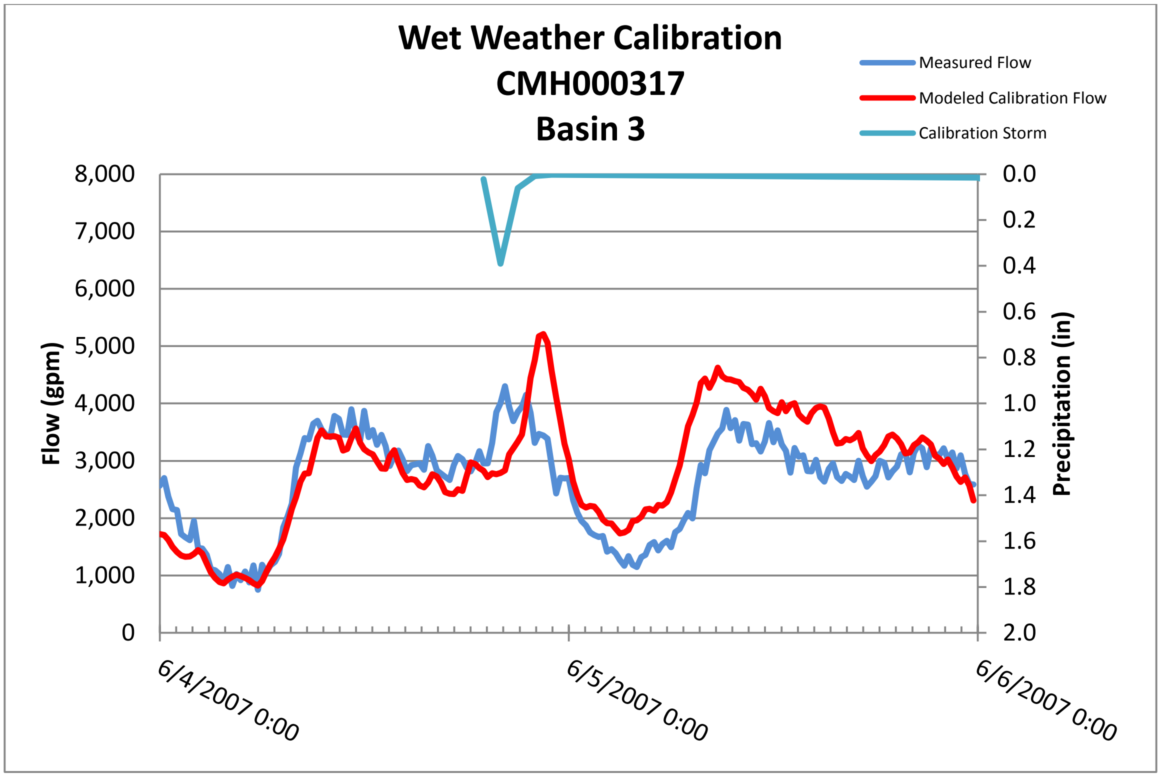

Dry Weather Calibration
CMH005494
Basin 14
Measured Flow
Modeled Calibration Flow
Flow (gpm)
1,000
900
800
700
600
500
400
300
200
100
0
5/18/2007 0:00
5/19/2007 0:00
5/20/2007 0:00

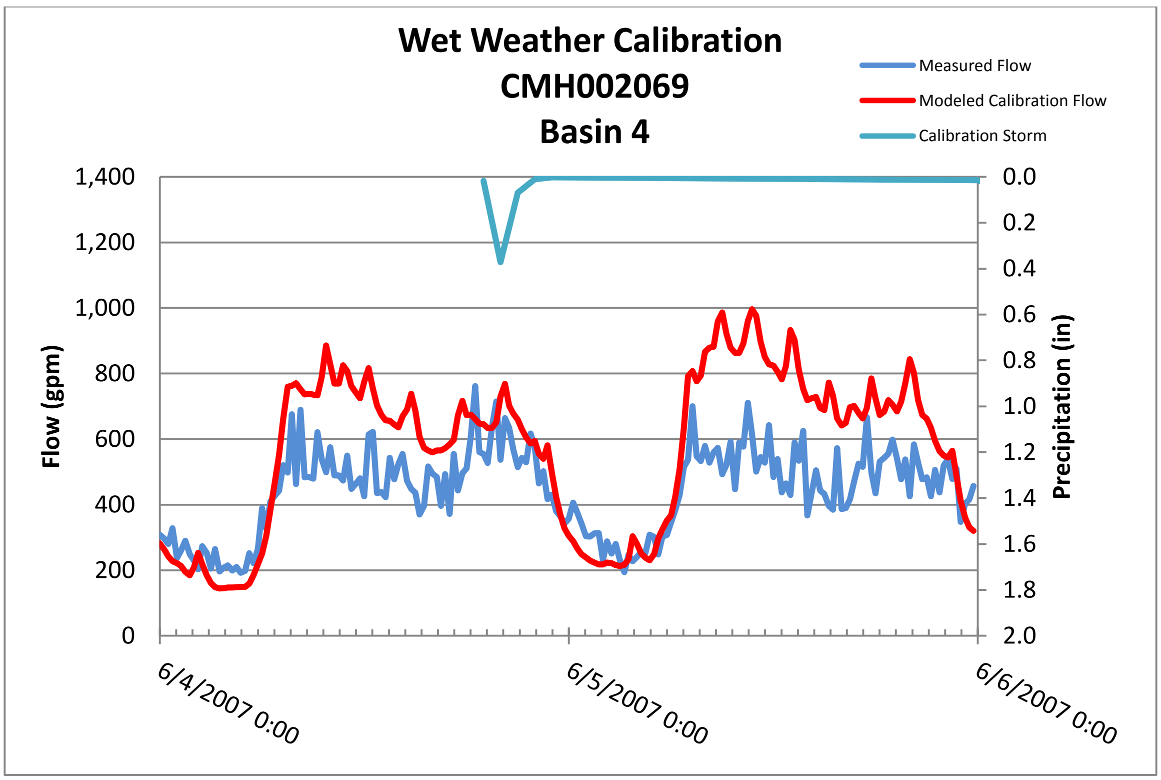

Dry Weather Calibration
CMH003337
Basin 15
Measured Flow
Modeled Calibration Flow
Flow (gpm)
1,400
1,200
1,000
800
600
400
200
0
5/18/2007 0:00
5/19/2007 0:00
5/20/2007 0:00

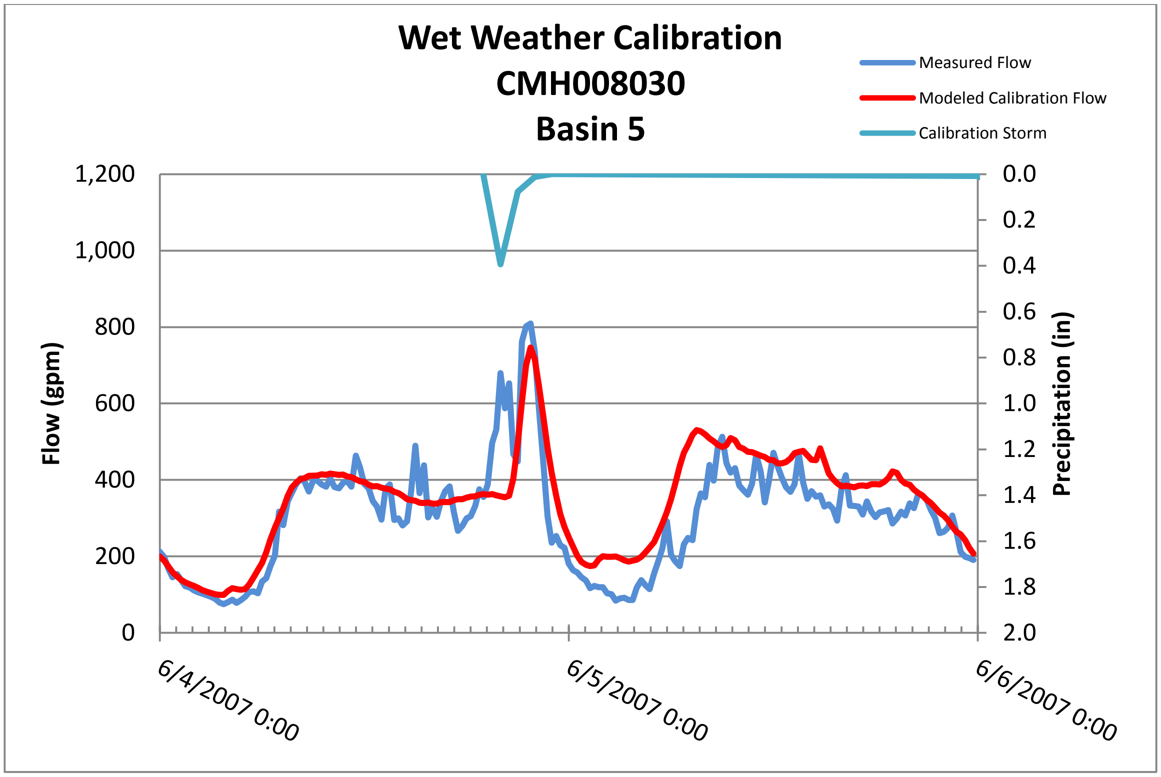
Wet Weather Flow Calibration Results (2007)

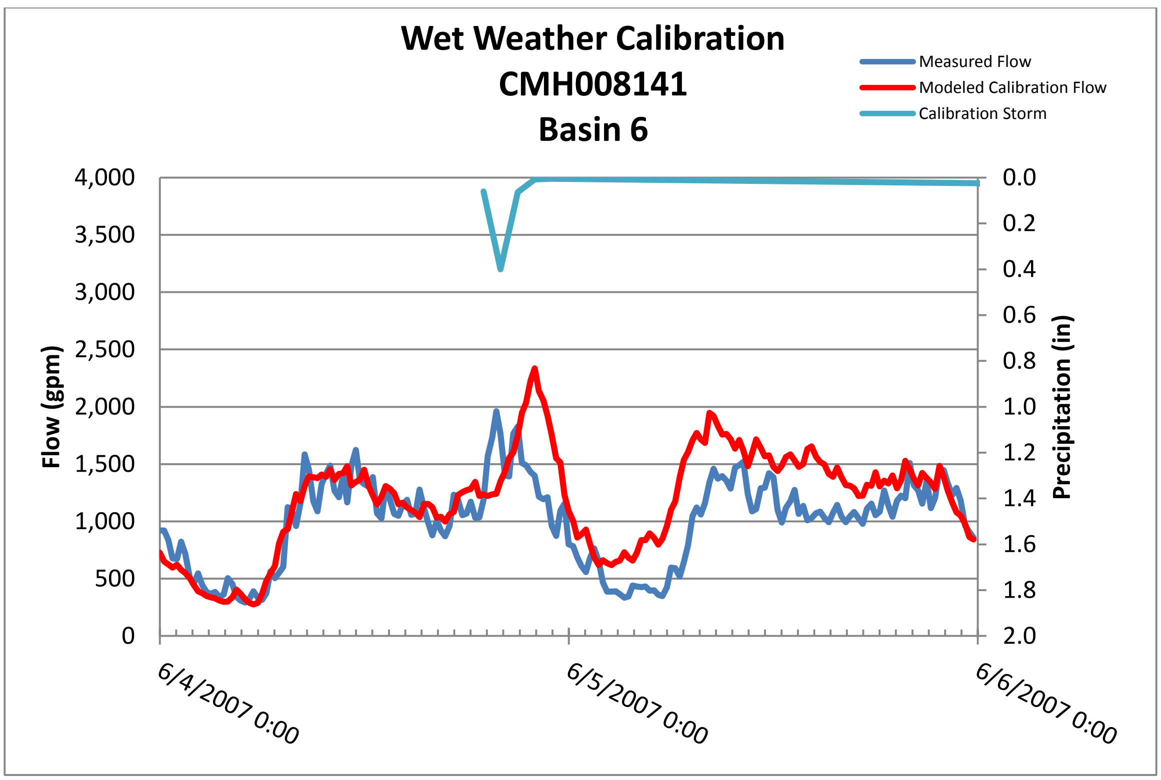


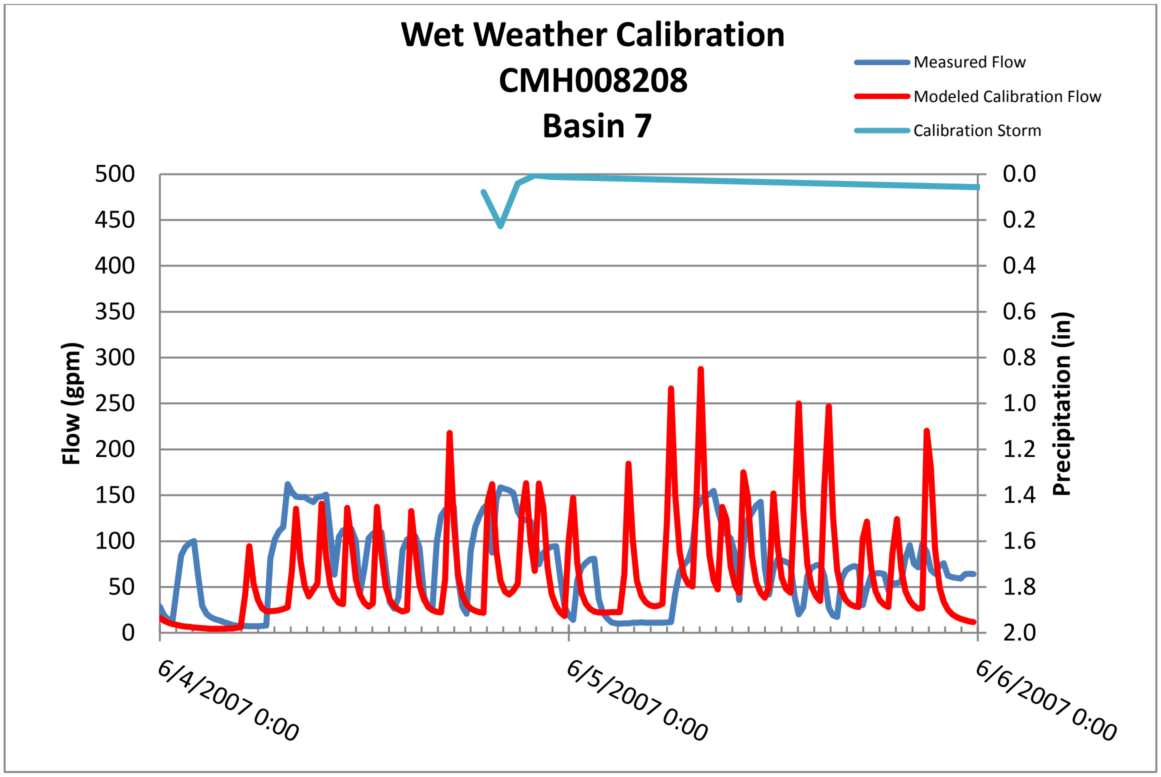


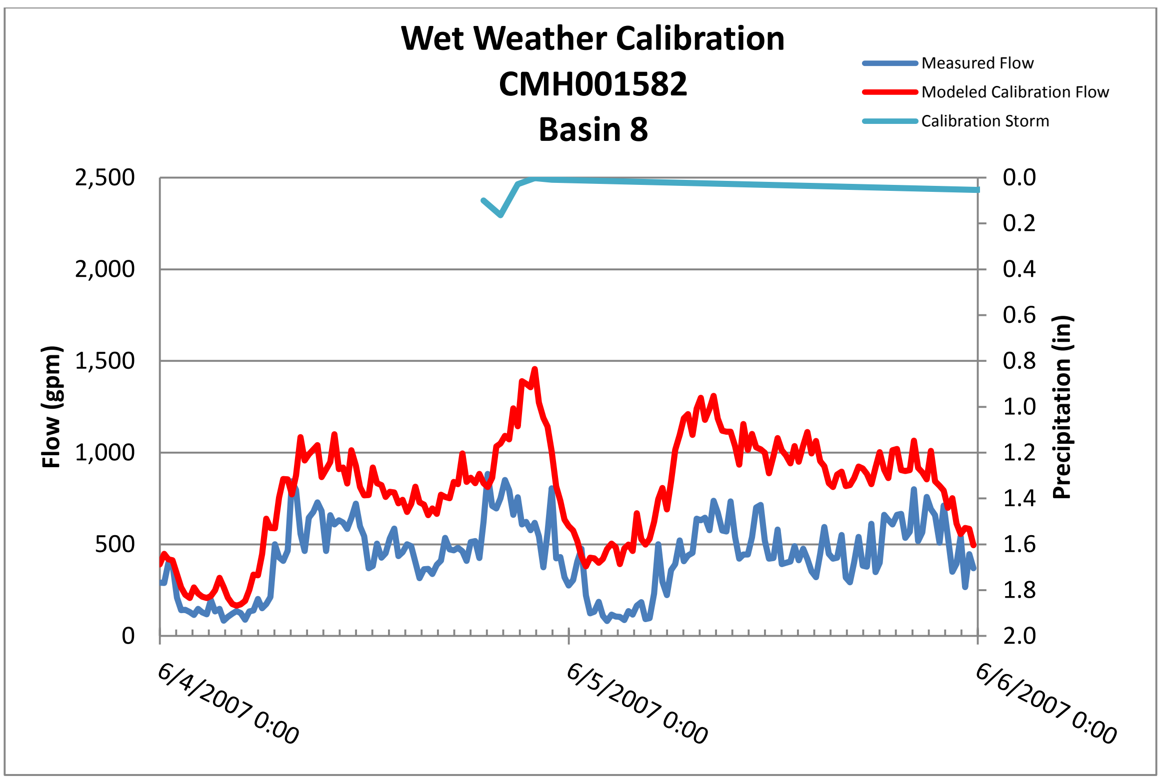

Wet Weather Calibration
CMH000317
Basin 3
Measured Flow
Modeled Calibration Flow
Calibration Storm
Flow (gpm)
Precipitation (in)
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
6/4/2007 0:00
6/5/2007 0:00
6/6/2007 0:00


Wet Weather Calibration
CMH002069
Basin 4
Measured Flow
Modeled Calibration Flow
Calibration Storm
Flow (gpm)
Precipitation (in)
1,400
1,200
1,000
800
600
400
200
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
6/4/2007 0:00
6/5/2007 0:00
6/6/2007 0:00


Wet Weather Calibration
CMH008030
Basin 5
Measured Flow
Modeled Calibration Flow
Calibration Storm
Flow (gpm)
Precipitation (in)
1,200
1,000
800
600
400
200
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
6/4/2007 0:00
6/5/2007 0:00
6/6/2007 0:00


Wet Weather Calibration
CMH008141
Basin 6
Measured Flow
Modeled Calibration Flow
Calibration Storm
Flow (gpm)
Precipitation (in)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
6/4/2007 0:00
6/5/2007 0:00
6/6/2007 0:00


Wet Weather Calibration
CMH008208
Basin 7
Measured Flow
Modeled Calibration Flow
Calibration Storm
Flow (gpm)
Precipitation (in)
500
450
400
350
300
250
200
150
100
50
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
6/4/2007 0:00
6/5/2007 0:00
6/6/2007 0:00


Wet Weather Calibration
CMH001582
Basin 8
Measured Flow
Modeled Calibration Flow
Calibration Storm
Flow (gpm)
Precipitation (in)
2,500
2,000
1,500
1,000
500
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
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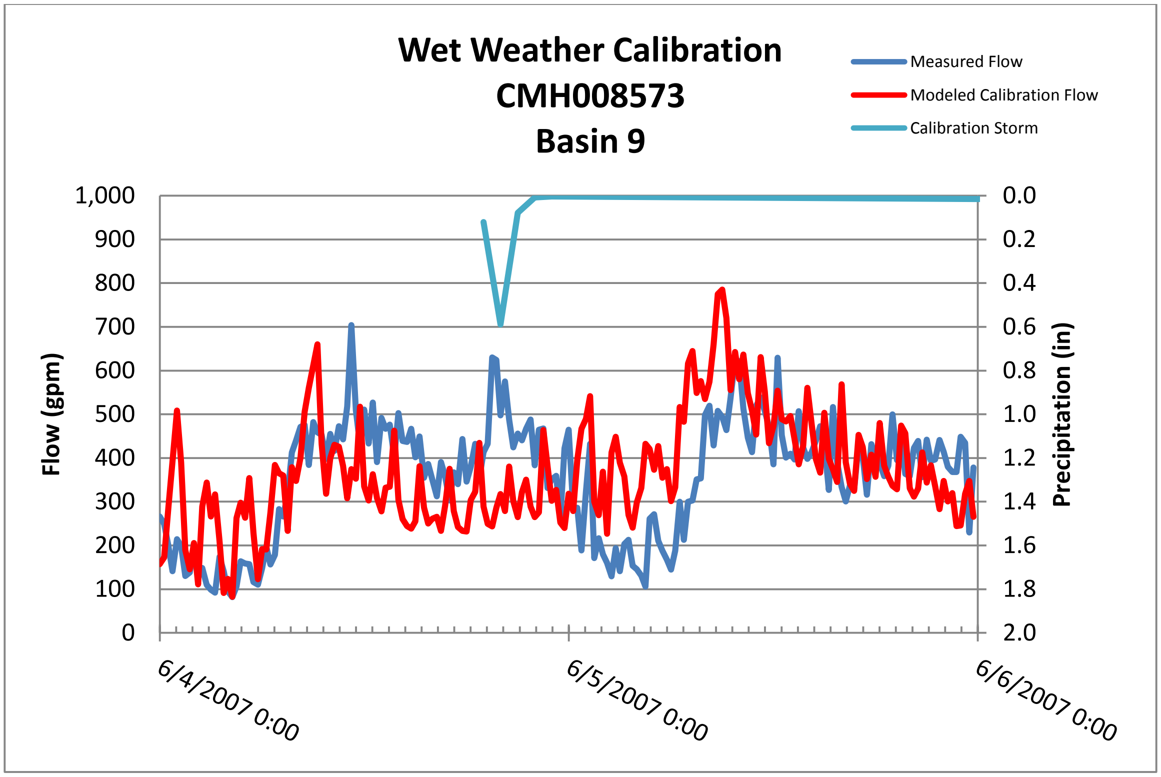
Wet Weather Calibration
CMH008573
Basin 9
Measured Flow
Modeled Calibration Flow
Calibration Storm
Flow (gpm)
Precipitation (in)
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900
800
700
600
500
400
300
200
100
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
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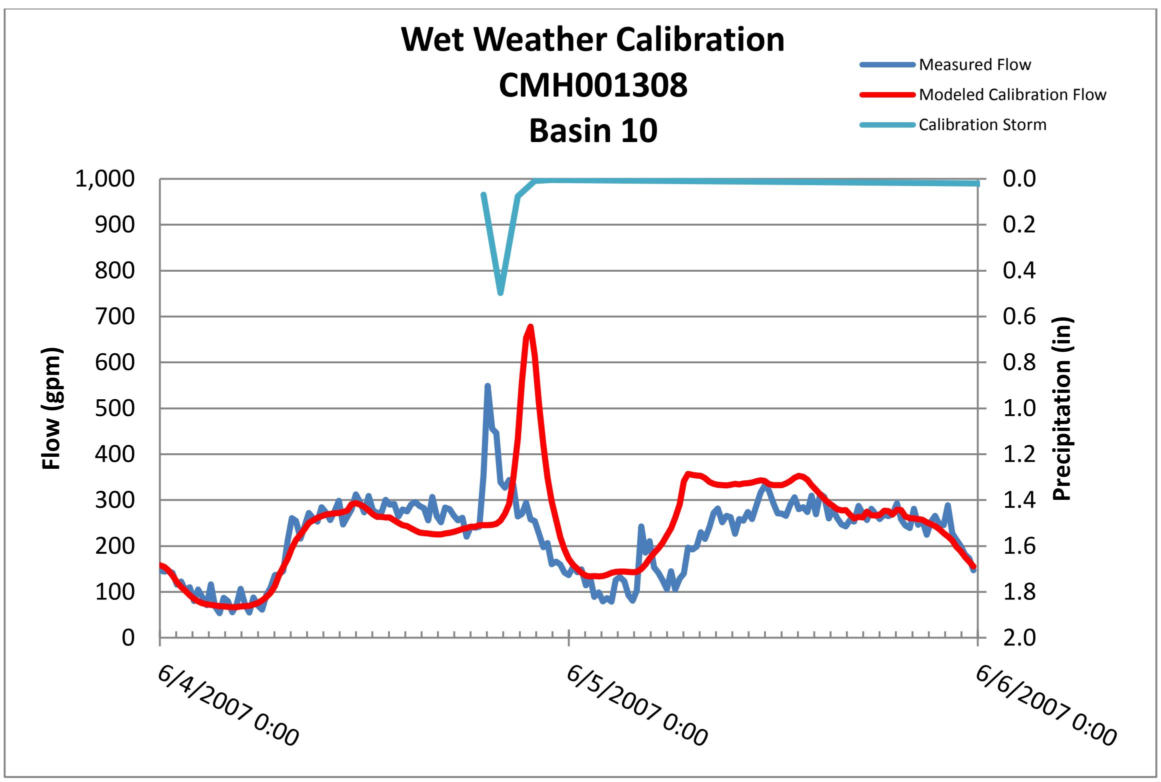
6/5/2007 0:00
6/6/2007 0:00


Wet Weather Calibration
CMH001308
Basin 10
Measured Flow
Modeled Calibration Flow
Calibration Storm
Flow (gpm)
Precipitation (in)
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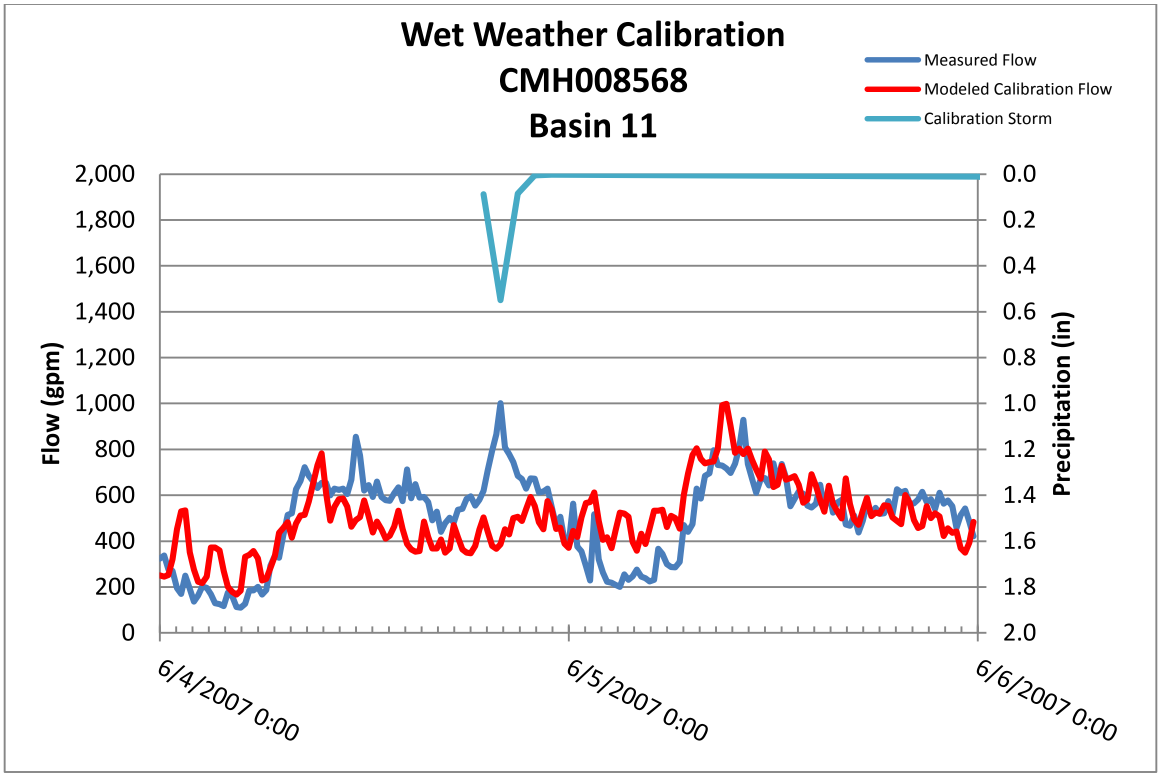
900
800
700
600
500
400
300
200
100
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
6/4/2007 0:00
6/5/2007 0:00
6/6/2007 0:00


Wet Weather Calibration
CMH008568
Basin 11
Measured Flow
Modeled Calibration Flow
Calibration Storm
Flow (gpm)
Precipitation (in)
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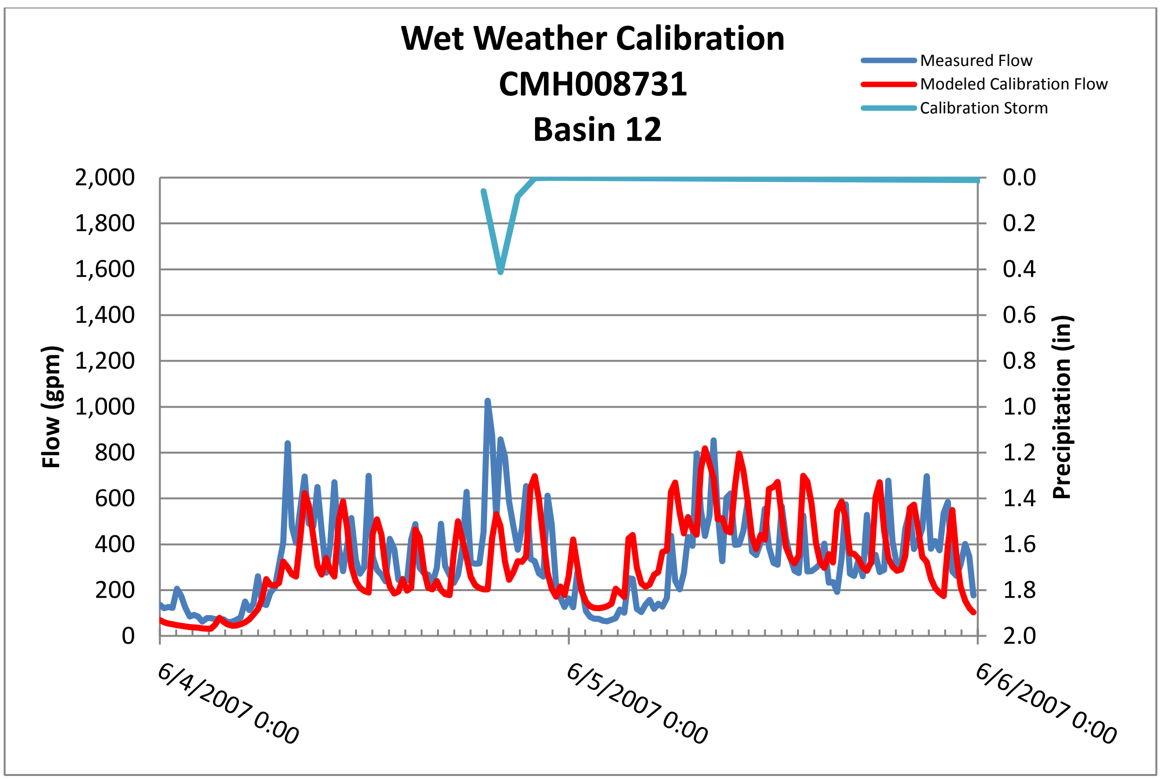
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
6/4/2007 0:00
6/5/2007 0:00
6/6/2007 0:00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CMH008731
Basin 12
Measured Flow
Modeled Calibration Flow
Calibration Storm
Flow (gpm)
Precipitation (in)
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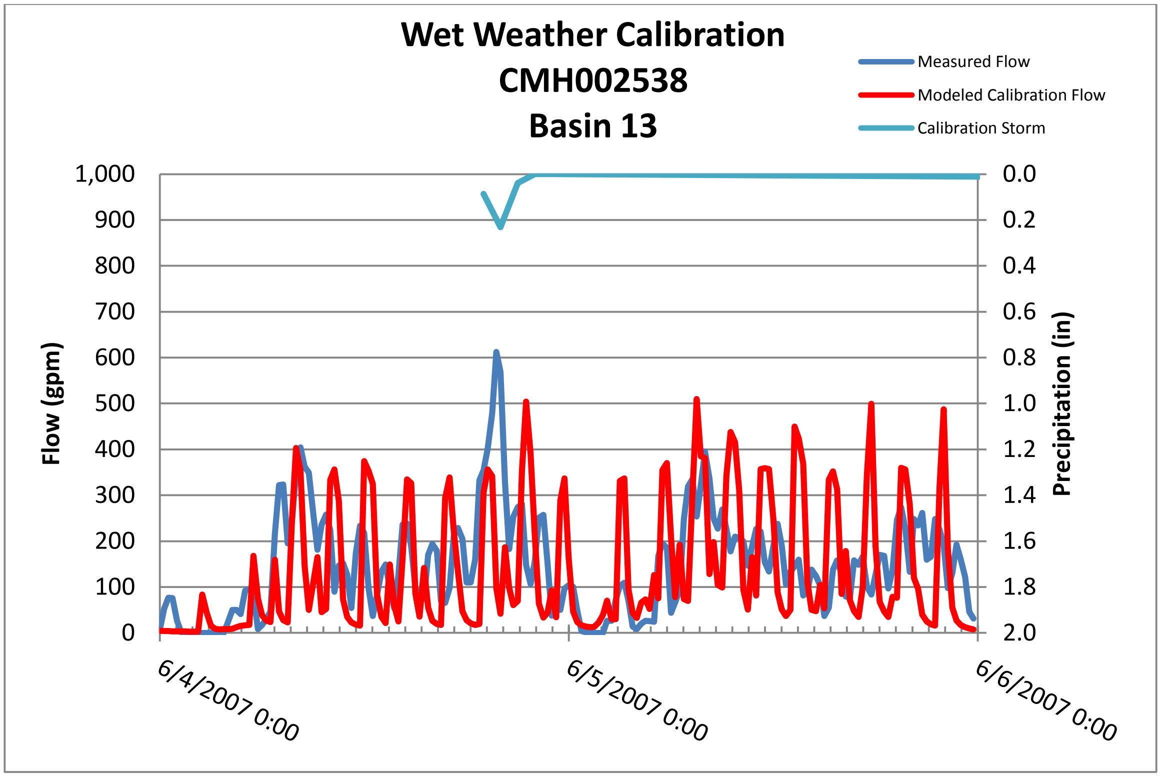
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
6/4/2007 0:00
6/5/2007 0:00
6/6/2007 0:00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CMH002538
Basin 13
Measured Flow
Modeled Calibration Flow
Calibration Storm
Flow (gpm)
Precipitation (in)
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900
800
700
600
500
400
300
200
100
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
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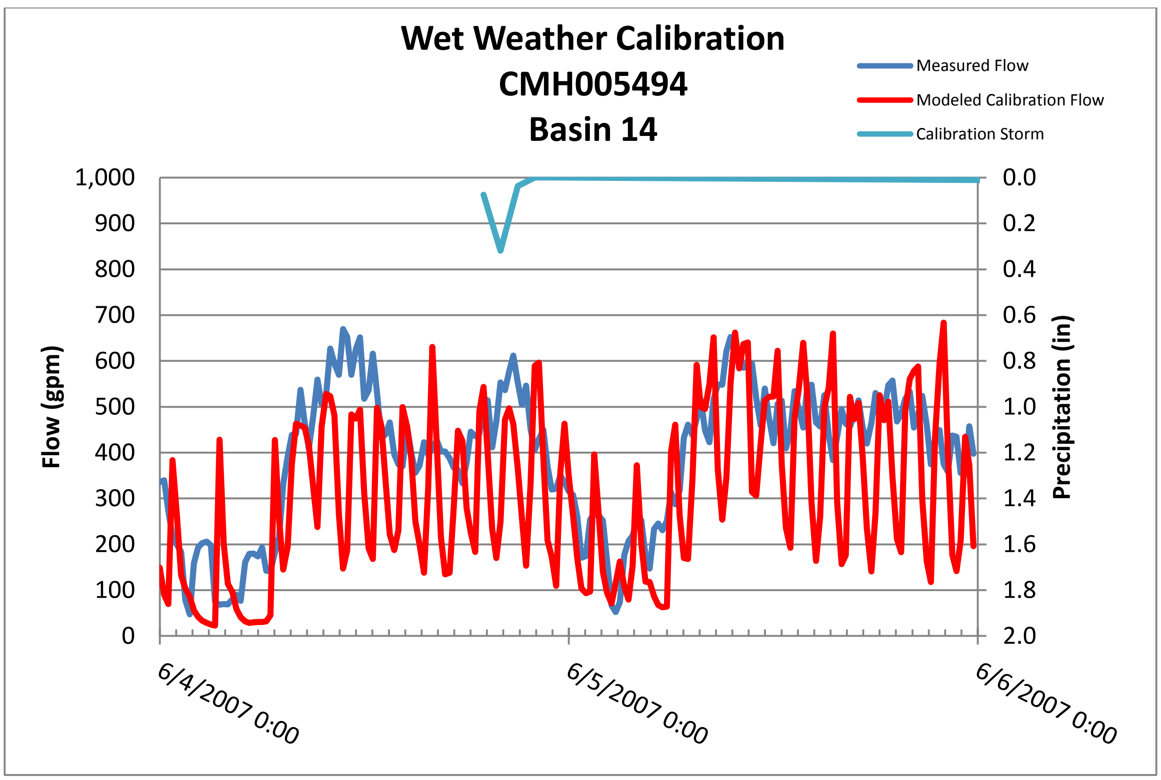
6/5/2007 0:00
6/6/2007 0:00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CMH005494
Basin 14
Measured Flow
Modeled Calibration Flow
Calibration Storm
Flow (gpm)
Precipitation (in)
1,000
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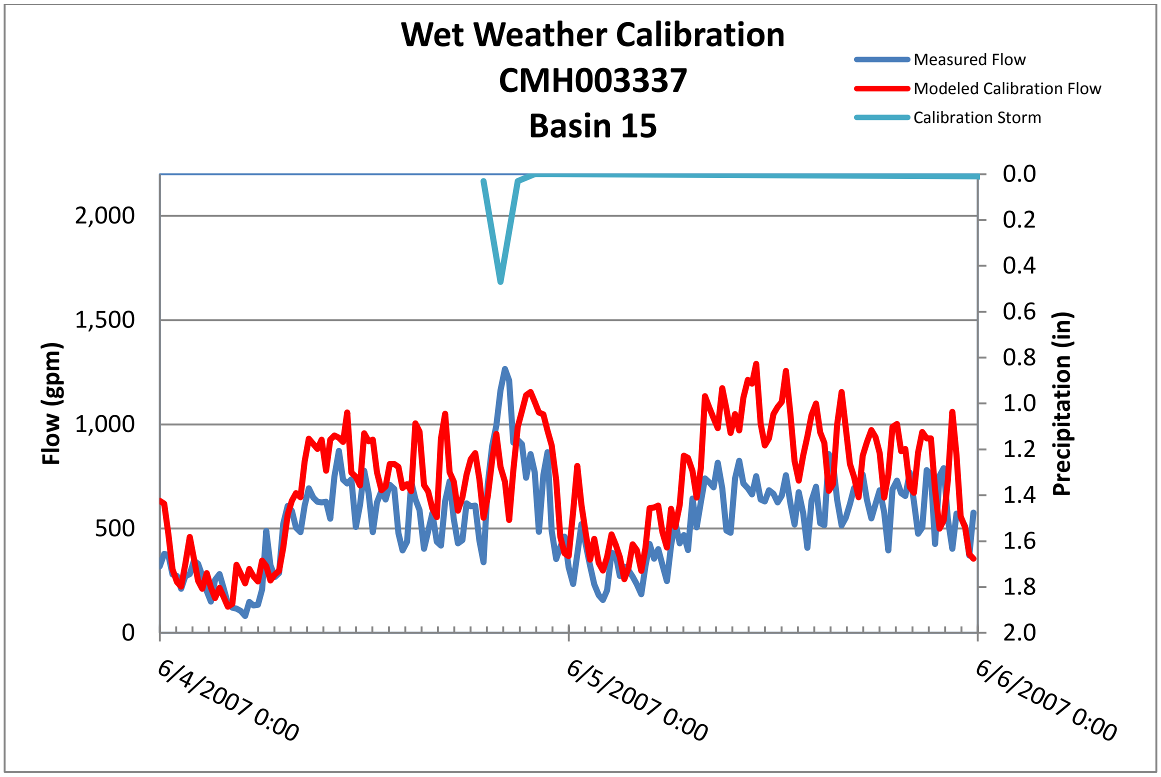
800
700
600
500
400
300
200
100
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
6/4/2007 0:00
6/5/2007 0:00
6/6/2007 0:00


Wet Weather Calibration
CMH003337
Basin 15
Measured Flow
Modeled Calibration Flow
Calibration Storm
Flow (gpm)
Precipitation (in)
2,000
1,500
1,000
500
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
6/4/2007 0:00
6/5/2007 0:00
6/6/2007 0:00

APPENDIX 4C

Lift Station Duty Point Analysis

APPENDIX 4C
LIFT STATION DUTY POINT ANALYSIS

This appendix presents the Lift Station Duty Point Analysis for the City of Bend (City) Collection System Master Plan (CSMP) update. The objective of this appendix is to document the capacity of each existing lift station compared to the service area peak wet weather flow response for existing and future planning horizons.

Firm capacity was evaluated for each lift station by plotting pump curve and system curves to determine if the duty point, intersection of the curves satisfied existing and future loading estimates. Firm capacity is defined as the pumping capacity with the largest pump out of service. System curves were developed based on both existing piping and any modified and/or improved piping configurations expected to occur as a result of future CIP projects. If the firm pumping capacity (duty point associated with the lift station firm capacity) was less than the existing, 10- or 20-year wastewater flow rates as determined in the sewer model, then the lift station was flagged as deficient during the respective timeframe. Section 4—System Analysis describes Mid-R and High-R conditions included in this appendix. However, only the results of analysis under the Mid-R conditions were used to create the CIP. Figure 4C-1 provides an example of a firm capacity evaluation. In this example, the lift station is assumed deficient within 11 to 20 years.

Due to the hydraulic complexity of the common pressure mains in the collection system where multiple lifts stations discharge into one force main, a detailed review of each lift station and common pressure main system was completed. Analysis of common pressure main configurations took into account flow from multiple lift stations and the associated pumping head experienced at each lift station. The lift stations in the common pressure systems have been assessed for two pumping conditions: the first with one lift station operating, and the second with all lift stations operating simultaneously, contributing to the common pressure main. By using these two conditions, the best-case and worst-case flow conveyance scenario for each lift station was investigated.

The results of the analysis presented in Table 4C-1 include Mid R Single Lift Station Operating, Mid R All Lift Station Operating, High R Single Lift Station Operating, High R All Lift Stations Operating, and CIP Mid R configurations. Duty point graphs associated with these configurations are attached to appendix. Not all City-owned lift stations in the collection system were modeled. Lift stations not modeled are characterized by small service areas and limited upstream gravity sewer, and are not expected to experience significant changes in flow during the planning horizon, because the service areas are fully or almost fully developed.

For lift stations pumping into a common pressure main, the City selected a flexible approach to address lift station deficiency and defer hydraulic improvement projects to a time period between the best case Single Lift Station Operating and worst case All Lift Stations Operating deficiency horizons. The City is aware of the increased risk of sanitary sewer overflows indicated by longer station run times; however, the Operation and Maintenance Department has protocols in place to mitigate reoccurring long run time occurrences and potential overflow conditions. This scenario is noted in Table 4C-1 under the CIP column as “Allowed to Defer.”

The solution to an apparent hydraulic deficiency at a lift station may not necessarily be an upsize or upgrade of lift station pumps. Modifying the force main or common pressure main systems, may be an improvement option because this affects the pump analysis by shifting the system curve and potentially improving pump station performance. In the CIP, further described in Section 7, there are multiple instances where lift stations will be decommissioned in the future and will no longer convey flow to a common pressure main system. This will decrease the required pumping head in the system and potentially increase the pumping capacity of the remaining lift station(s). Increasing the diameter of a force main can also decrease the headloss in the force main and increase the pumping capacity of the existing pumps. When a force main or common pressure main system is modified in the CIP, it is noted as “Modified Piping” in the CIP column in Table 4C-1. If the CIP is not implemented as described in Section 7, the associated lift stations may become deficient earlier than indicated by the final results of this analysis.

Figure 4C-1
Duty Point Analysis Results

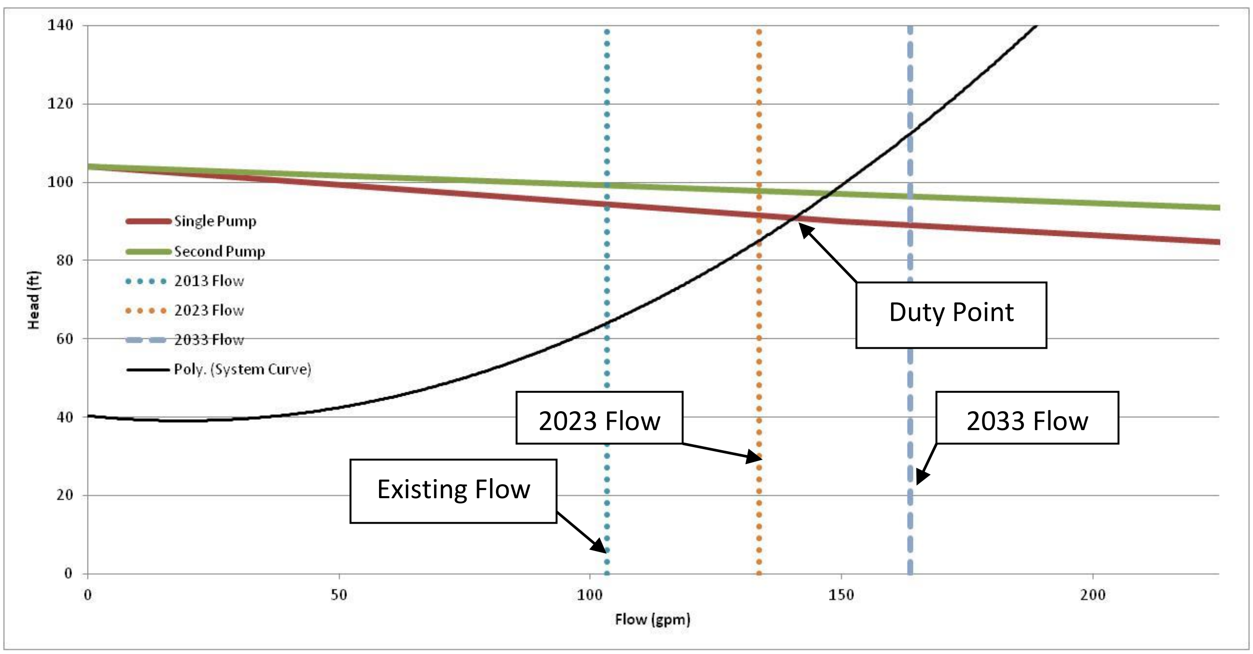


Table 4C-1
Duty Point Analysis Results

Lift Station	Lift Station Group	Deficiency Horizon				
		Single Lift Station Operating Mid-R[4]	All Lift Stations Operating Mid-R[4]	Single Lift Station Operating High-R	All Lift Stations Operating High-R	CIP Mid-R
Camden Park	Southeast Group	Beyond 20 years	Existing	Beyond 20 years	1 to 5 years	6 to 10 years, Allowed to Defer
Darnell Estates	Southeast Group	Beyond 20 years	11 to 20 years	Beyond 20 years	11 to 20 years	11 to 20 years
Desert Skies	Southeast Group	6 to 10 years	6 to 10 years	6 to 10 years	6 to 10 years	6 to 10 years
Ridgewater #1	Southeast Group	Beyond 20 years	Existing	Beyond 20 years	Existing	6 to 10 years, Allowed to Defer
Ridgewater #2	Southeast Group	11 to 20 years	6 to 10 years	11 to 20 years	1 to 5 years	6 to 10 years
Shadow Glen	Southeast Group	11 to 20 years	6 to 10 years	11 to 20 years	1 to 5 years	6 to 10 years
Murphy	Murphy Group	1 to 5 years	Existing	Existing	Existing	1 to 5 years, Allowed to Defer
South Village	Murphy Group	11 to 20 years	Existing	Existing	Existing	6 to 10 years, Allowed to Defer
Sun Meadow	Murphy Group	Beyond 20 years	Existing	Beyond 20 years	Existing	6 to 10 years, Allowed to Defer
Canal View	Northeast Group	Existing	Existing	Existing	Existing	Existing, Modified Piping
Juniper Ridge	Northeast Group	11 to 20 years	6 to 10 years	11 to 20 years	6 to 10 years	11 to 20 years, Allowed to Defer
North Pointe	Northeast Group	11 to 20 years	6 to 10 years	11 to 20 years	1 to 5 years	11 to 20 years, Allowed to Defer
North Wind	Northeast Group	Beyond 20 years	6 to 10 years	Beyond 20 years	1 to 5 years	11 to 20 years, Allowed to Defer

Lift Station	Lift Station Group	Deficiency Horizon				
		Single Lift Station Operating Mid-R[4]	All Lift Stations Operating Mid-R[4]	Single Lift Station Operating High-R	All Lift Stations Operating High-R	CIP Mid-R
Phoenix	Northeast Group	Beyond 20 years	1 to 5 years	Beyond 20 years	Existing	11 to 20 years, Allowed to Defer
Quail Crossing	Northeast Group	Beyond 20 years	1 to 5 years	Beyond 20 years	Existing	6 to 10 years, Allowed to Defer
Highland	Far North Group	Beyond 20 years	11 to 20 years	Beyond 20 years	11 to 20 years	11 to 20 years
Holiday Inn	Far North Group	Beyond 20 years	Beyond 20 years	Beyond 20 years	Beyond 20 years	Beyond 20 years
Deschutes Business[1]	North Area Group	Beyond 20 years	Existing	Beyond 20 years	Existing	Beyond 20 years, Allowed to Defer, Modified Piping
Enchant on Deschutes	North Area Group	Beyond 20 years	1 to 5 years	Beyond 20 years	1 to 5 years	Beyond 20 years, Modified Piping
Empire Estates	North Area Group	Beyond 20 years	6 to 10 years	Beyond 20 years	1 to 5 years	Beyond 20 years, Modified Piping
Glen Vista	North Area Group	Beyond 20 years	Beyond 20 years	Beyond 20 years	Beyond 20 years	Beyond 20 years, Modified Piping
Riverhouse[2]	North Area Group	Beyond 20 years	Existing	Beyond 20 years	Existing	Beyond 20 years, Allowed to Defer, Modified Piping
Sawyer Park	North Area Group	1 to 5 years	1 to 5 years	1 to 5 years	Existing	11 to 20 years, Modified Piping
Service Station[1]	North Area Group	Beyond 20 years	Existing	Beyond 20 years	Existing	Beyond 20 years, Allowed to Defer, Modified Piping
Rim Rock Riders	North Area Group	Beyond 20 years	11 to 20 years	Beyond 20 years	Beyond 20 years	Beyond 20 years, Modified Piping

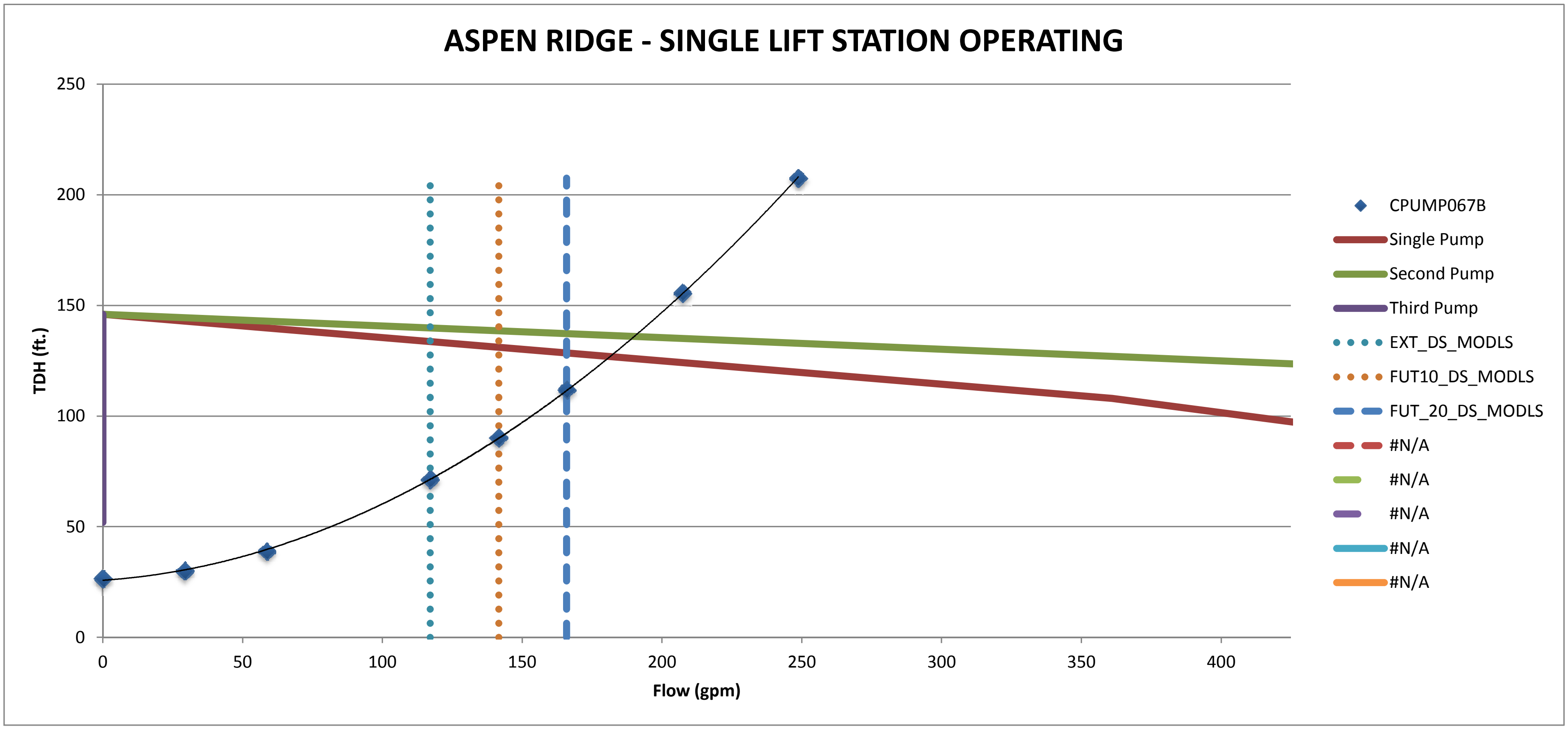
Lift Station	Lift Station Group	Deficiency Horizon				
		Single Lift Station Operating Mid-R[4]	All Lift Stations Operating Mid-R[4]	Single Lift Station Operating High-R	All Lift Stations Operating High-R	CIP Mid-R
Wyndemere[1]	North Area Group	Beyond 20 years	Existing	Beyond 20 years	Existing	Beyond 20 years, Allowed to Defer, Modified Piping
Renaissance	West Group	Beyond 20 years	11 to 20 year	Beyond 20 years	6 to 10 year	11 to 20 year
Shevlin Commons	West Group	Beyond 20 years	11 to 20 year	11 to 20 year	6 to 10 year	11 to 20 year
Shevlin Meadows	West Group	Beyond 20 years	11 to 20 year	6 to 10 year	1 to 5 year	11 to 20 year
Hollow Pines #1	Hollow Pines Group	Beyond 20 years	Beyond 20 years	Beyond 20 years	Beyond 20 years	Beyond 20 years
Hollow Pines #2	Hollow Pines Group	Beyond 20 years	Beyond 20 years	Beyond 20 years	Beyond 20 years	Beyond 20 years
Aspen Ridge	Southwest Group	Beyond 20 years	Existing	Existing	Existing	6 to 10 year, Allowed to Defer
River Canyon #1	Southwest Group	Beyond 20 years	Beyond 20 years	Beyond 20 years	Existing	Beyond 20 years
River Canyon #2	Southwest Group	Existing	Existing	Existing	Existing	Existing
Sunrise #1	Far Southwest Group	Beyond 20 years	Beyond 20 years	Beyond 20 years	Beyond 20 years	Beyond 20 years
Widgi Creek	Far Southwest Group	Beyond 20 years	Beyond 20 years	Beyond 20 years	Beyond 20 years	Beyond 20 years
Awbrey Glen	-	Beyond 20 years	NA	6 to 10 year	NA	Beyond 20 years
Bachelor Village	-	Beyond 20 years	NA	Beyond 20 years	NA	Beyond 20 years

Lift Station	Lift Station Group	Deficiency Horizon				
		Single Lift Station Operating Mid-R[4]	All Lift Stations Operating Mid-R[4]	Single Lift Station Operating High-R	All Lift Stations Operating High-R	CIP Mid-R
Blue Ridge	-	Beyond 20 years	NA	Beyond 20 years	NA	Beyond 20 years
Boyd Acres	-	1 to 5 years	NA	Existing	NA	1 to 5 years
Crown Villa #1	-	Not Modeled	NA	Not Modeled	NA	Not Modeled
Crown Villa #2	-	Not Modeled	NA	Not Modeled	NA	Not Modeled
Deschutes River Crossing	-	Beyond 20 years	NA	Beyond 20 years	NA	Beyond 20 years
Drake	-	Beyond 20 years	NA	Existing	NA	Beyond 20 years
Empire	-	Beyond 20 years	NA	Beyond 20 years	NA	Beyond 20 years
Empire Village	-	Beyond 20 years	NA	Beyond 20 years	NA	Beyond 20 years
Forum	-	Beyond 20 years	NA	Beyond 20 years	NA	Beyond 20 years
Foxborough	-	Beyond 20 years	NA	Existing	NA	Beyond 20 years
Glenshire	-	Beyond 20 years	NA	11 to 20 years	NA	Beyond 20 years
Linster	-	Beyond 20 years	NA	Beyond 20 years	NA	Beyond 20 years
Main Fire Station	-	Not Modeled	NA	Not Modeled	NA	Not Modeled
Majestic	-	Beyond 20 years	NA	Beyond 20 years	NA	Beyond 20 years
North Fire Station	-	Not Modeled	NA	Not Modeled	NA	Not Modeled
Nottingham #1	-	Not Modeled	NA	Not Modeled	NA	Not Modeled

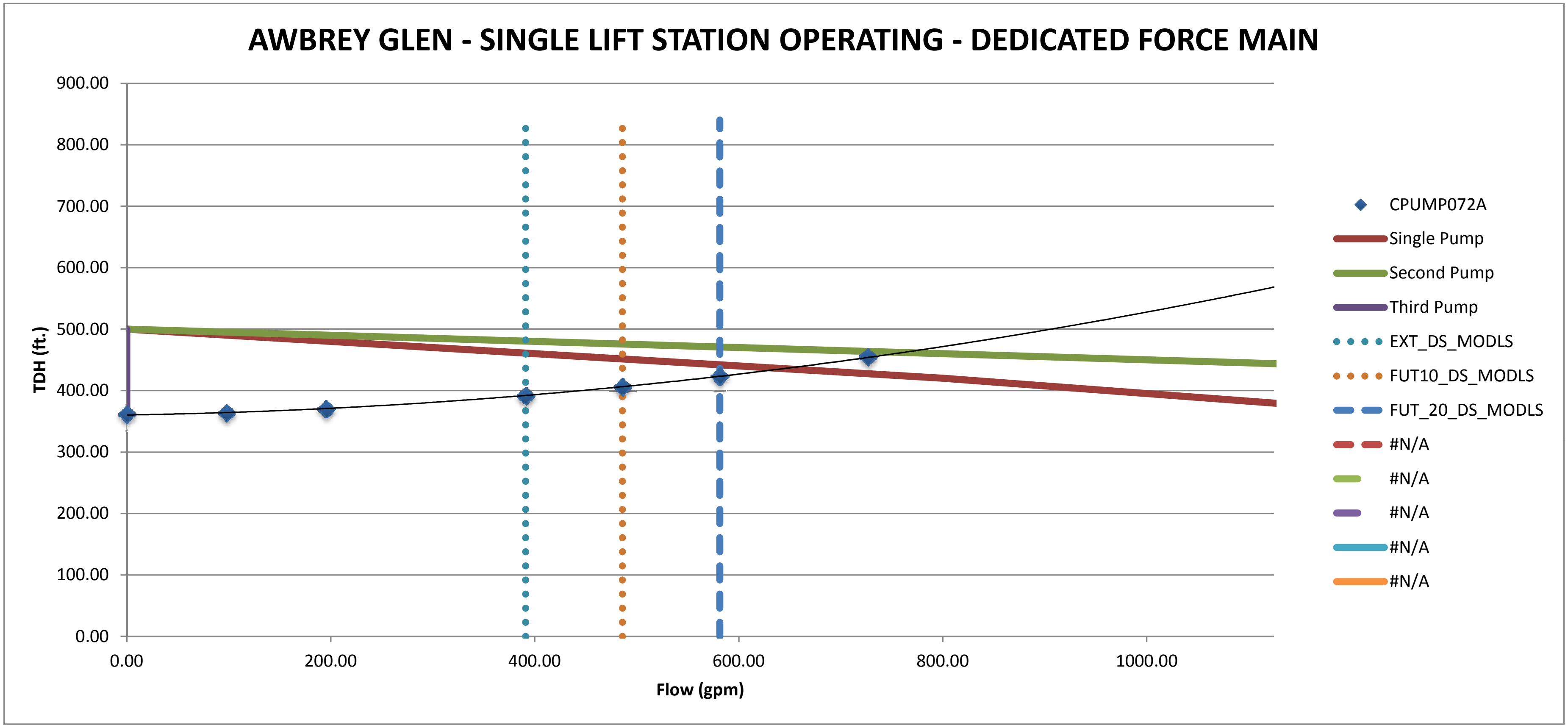
Lift Station	Lift Station Group	Deficiency Horizon				
		Single Lift Station Operating Mid-R[4]	All Lift Stations Operating Mid-R[4]	Single Lift Station Operating High-R	All Lift Stations Operating High-R	CIP Mid-R
Nottingham #2	-	Not Modeled	NA	Not Modeled	NA	Not Modeled
Old Mill	-	6 to 10 year	NA	Existing	NA	6 to 10 year
Orion Greens	-	Beyond 20 years	NA	Beyond 20 years	NA	Beyond 20 years
Pacific	-	Not Modeled	NA	Not Modeled	NA	Not Modeled
Pheasant Run	-	11 to 20 year	NA	Existing	NA	11 to 20 year
Pine Ridge	-	Beyond 20 years	NA	Existing	NA	Beyond 20 years
Pioneer	-	Beyond 20 years	NA	Beyond 20 years	NA	Beyond 20 years
Poplar Park	-	Beyond 20 years	NA	Beyond 20 years	NA	Beyond 20 years
Quail Ridge #1	-	Not Modeled	NA	Not Modeled	NA	Not Modeled
Quail Ridge #2	-	Not Modeled	NA	Not Modeled	NA	Not Modeled
Renwick	-	Beyond 20 years	NA	Beyond 20 years	NA	Beyond 20 years
Rimrock #1	-	Not Modeled	NA	Not Modeled	NA	Not Modeled
Rimrock #2	-	Not Modeled	NA	Not Modeled	NA	Not Modeled
Rimrock #4	-	Not Modeled	NA	Not Modeled	NA	Not Modeled
Rimrock #5	-	Not Modeled	NA	Not Modeled	NA	Not Modeled
River Rim	-	Existing	NA	Existing	NA	Existing
Rivers Edge	-	Beyond 20 years	NA	Beyond 20 years	NA	Beyond 20 years
Riviera	-	Not Modeled	NA	Not Modeled	NA	Not Modeled
Shevlin[3]	-	Beyond 20 years	NA	Beyond 20 years	NA	1 to 5 year

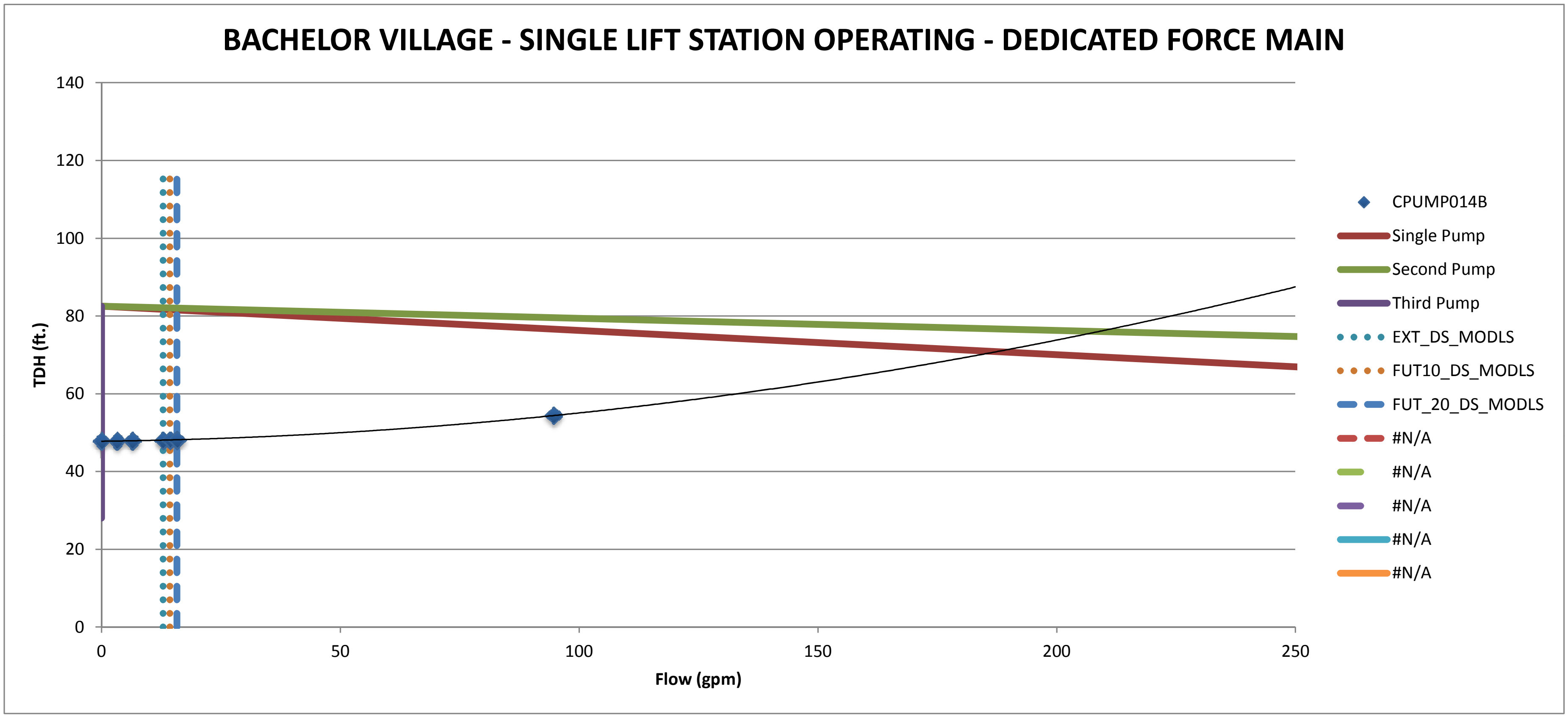
Lift Station	Lift Station Group	Deficiency Horizon				
		Single Lift Station Operating Mid-R[4]	All Lift Stations Operating Mid-R[4]	Single Lift Station Operating High-R	All Lift Stations Operating High-R	CIP Mid-R
Simplicity	-	Beyond 20 years	NA	Beyond 20 years	NA	Beyond 20 years
Stone Haven	-	Beyond 20 years	NA	Beyond 20 years	NA	Beyond 20 years
Summit Park	-	Beyond 20 years	NA	Beyond 20 years	NA	Beyond 20 years
The Pines #5	-	Not Modeled	NA	Not Modeled	NA	Not Modeled
The Pines #6	-	Not Modeled	NA	Not Modeled	NA	Not Modeled
The Pines #7	-	Not Modeled	NA	Not Modeled	NA	Not Modeled
The Shire	-	Beyond 20 years	NA	11 to 20 years	NA	Beyond 20 years
Touchmark	-	Beyond 20 years	NA	Beyond 20 years	NA	Beyond 20 years
Tri Peaks	-	1 to 5 year	NA	1 to 5 years	NA	1 to 5 years
Tumalo Heights	-	Beyond 20 years	NA	Beyond 20 years	NA	Beyond 20 years
Underwood	-	Beyond 20 years	NA	Beyond 20 years	NA	Beyond 20 years
West Side	-	Beyond 20 years	NA	11 to 20 years	NA	Beyond 20 years
Wood River Village	-	Not Modeled	NA	Not Modeled	NA	Not Modeled

[1] *Lift station hydraulic capacity upgrade was deferred and future common pressure main modifications remove the need for an upgrade at the lift station.*
[2] *Riverhouse Lift Station is not hydraulically deficient after modified common pressure main system. However, it is severely oversized and a project to decrease the capacity is recommended.*
[3] *While Shevlin Lift Station does not appear to be deficient hydraulically, flows from Deschutes Brewery are released over a short period and result in a deficiency only mitigated by wet well storage. The lift station is considered an existing deficiency for the CIP.*
[4] *Mid-R was used to define the deficiencies and associated improvements identified in the overall CSMP.*

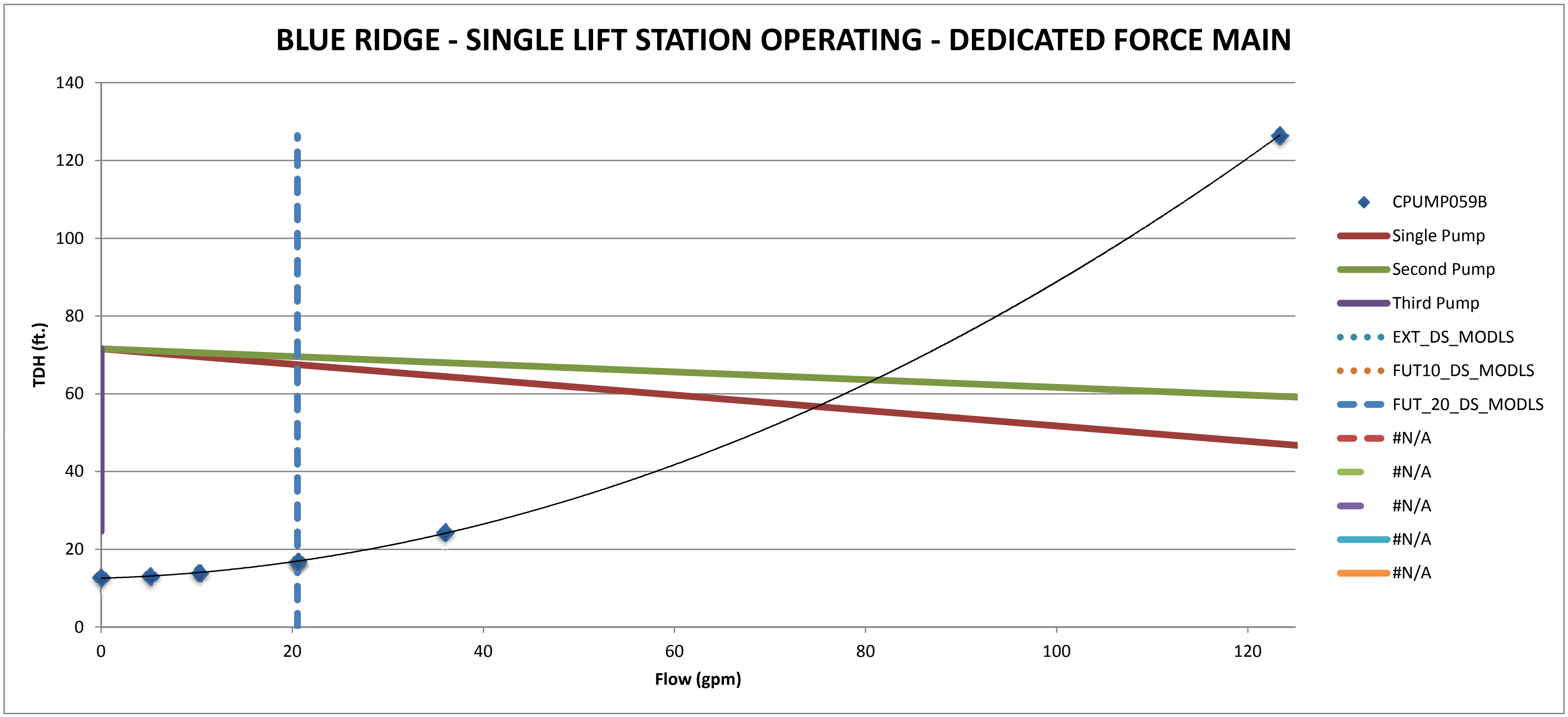


ASPEN RIDGE - SINGLE LIFT STATION OPERATING
250
200
150
100
50
0
TDH (ft.)
0
50
100
150
200
250
300
350
400
Flow (gpm)
CPUMP067B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

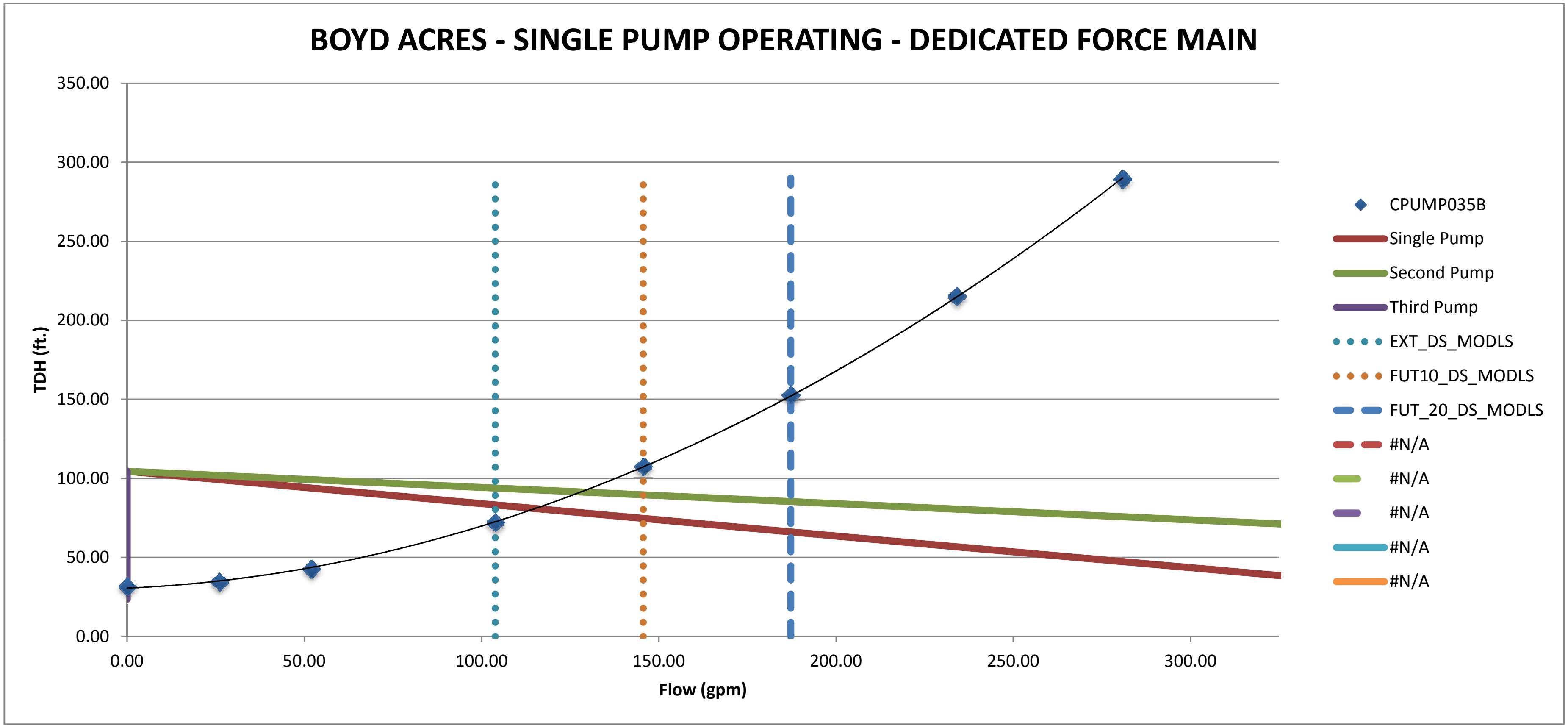

AWBREY GLEN - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
TDH (ft.)
0.00
200.00
400.00
600.00
800.00
1000.00
Flow (gpm)
CPUMP072A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A



BACHELOR VILLAGE - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
140
120
100
80
60
40
20
0
TDH (ft.)
0
50
100
150
200
250
Flow (gpm)
CPUMP014B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A



BLUE RIDGE - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
140
120
100
80
60
40
20
0
0
20
40
60
80
100
120
Flow (gpm)
CPUMP059B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A



BOYD ACRES - SINGLE PUMP OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
0.00
50.00
100.00
150.00
200.00
250.00
300.00
Flow (gpm)
CPUMP035B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
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FUT_20_DS_MODLS
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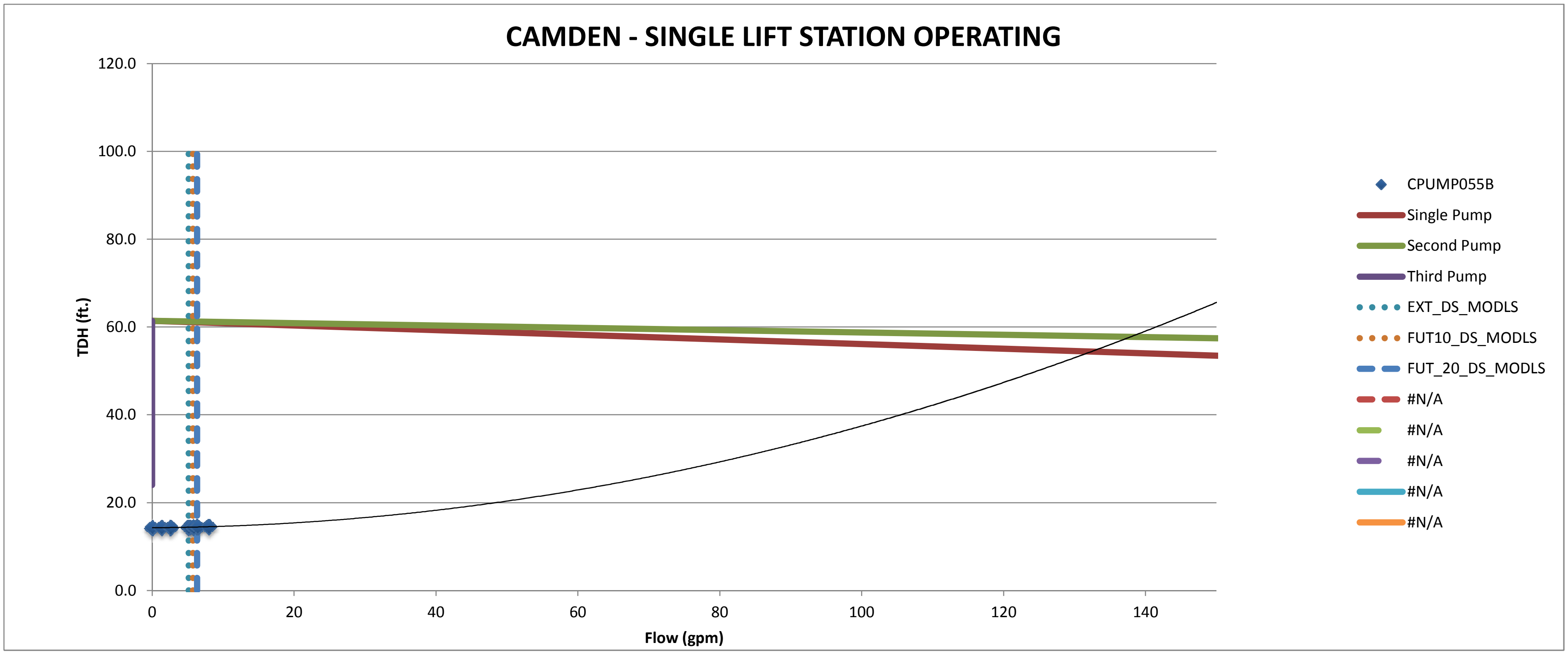
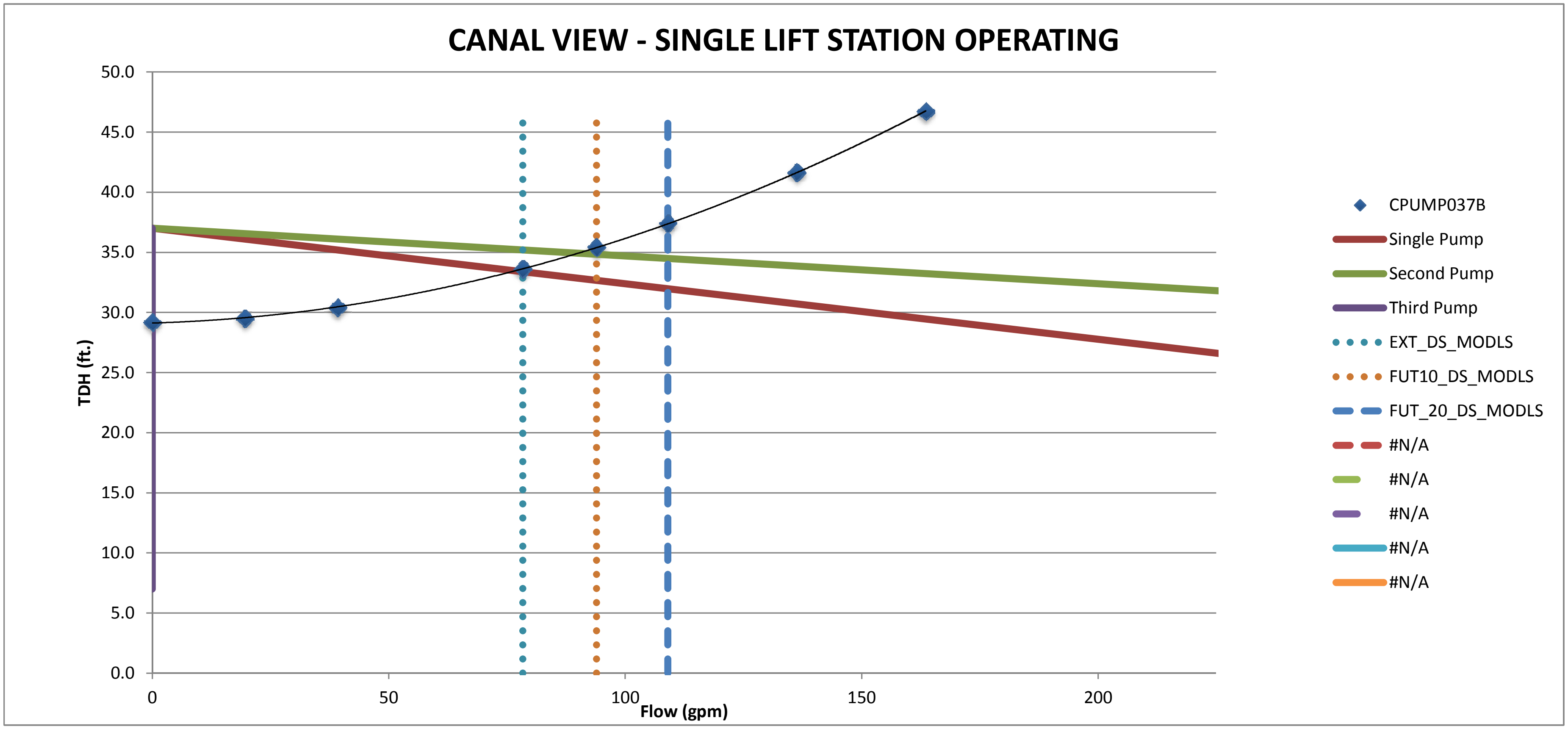
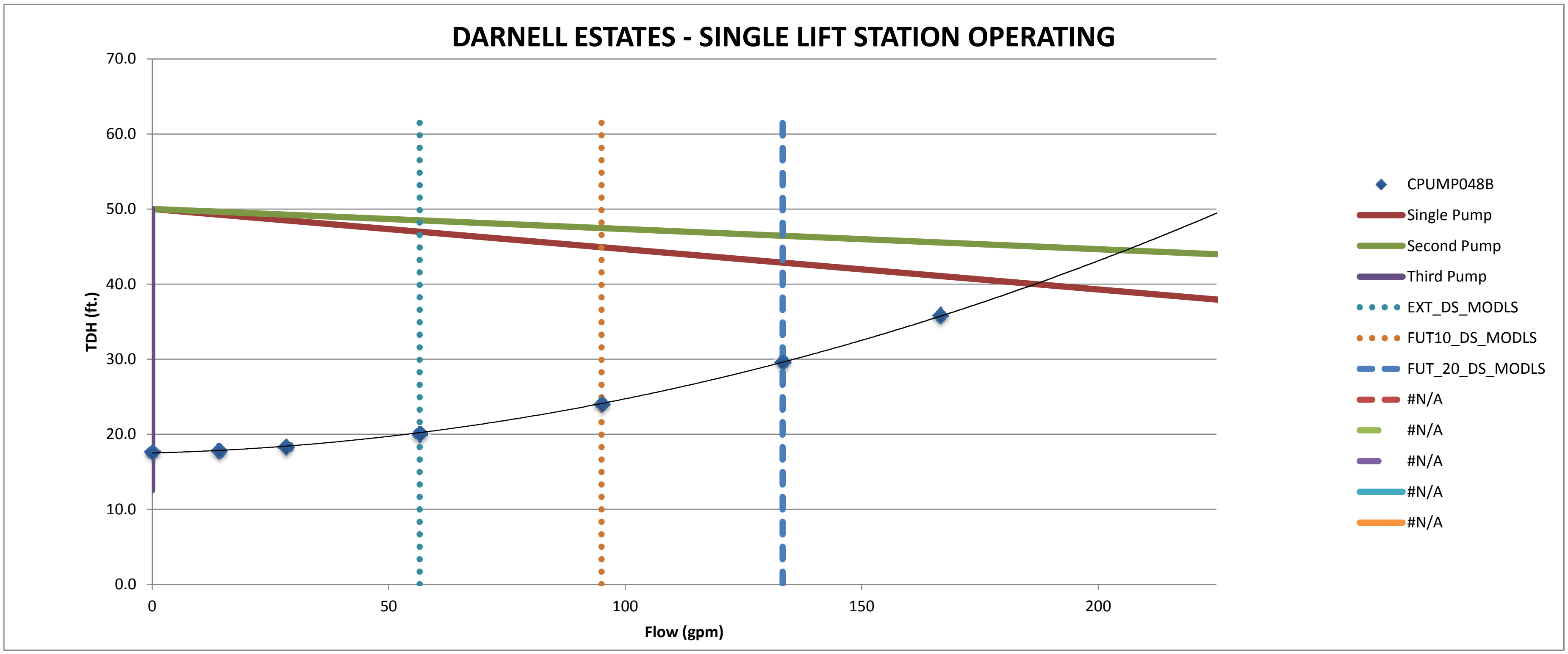
#N/A
#N/A
#N/A

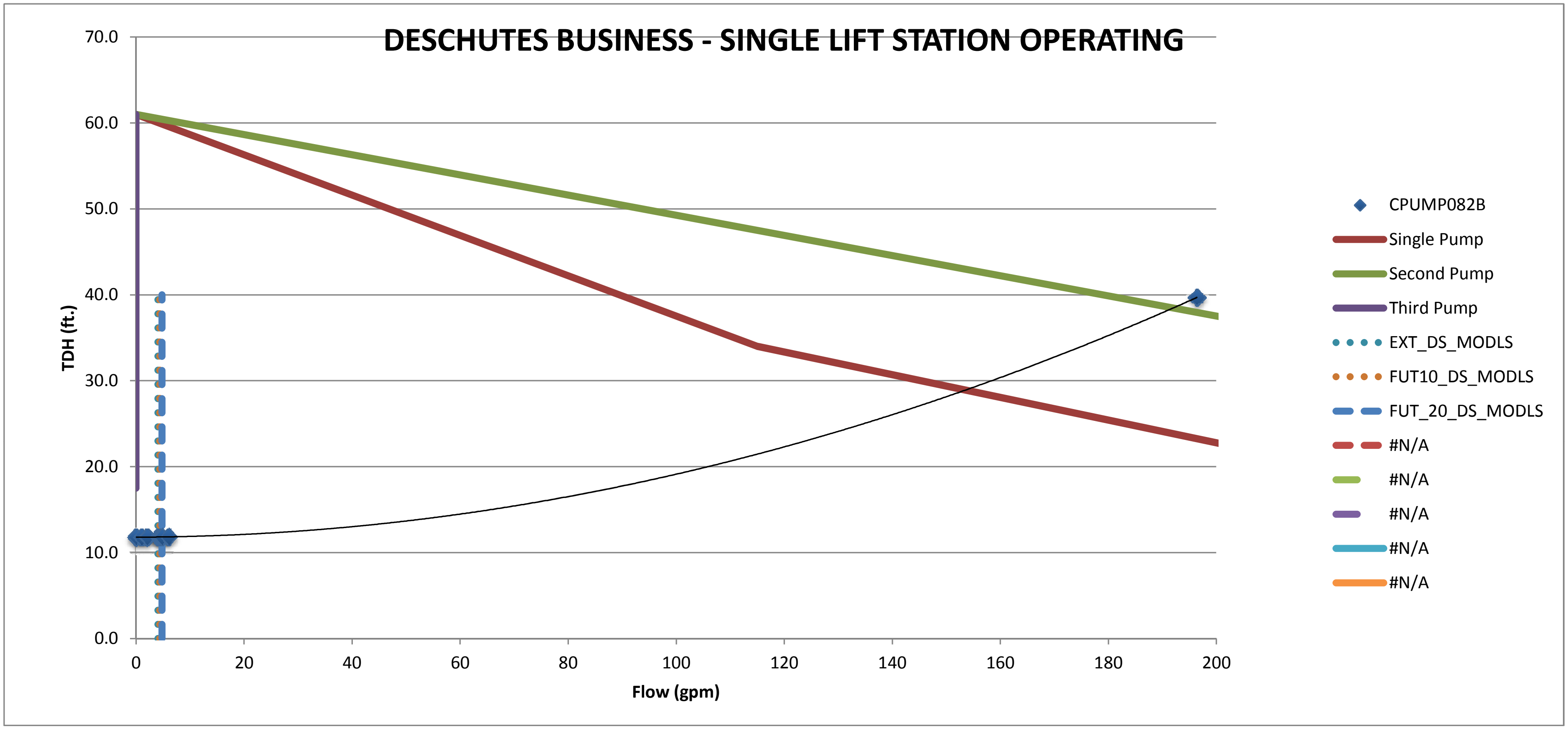


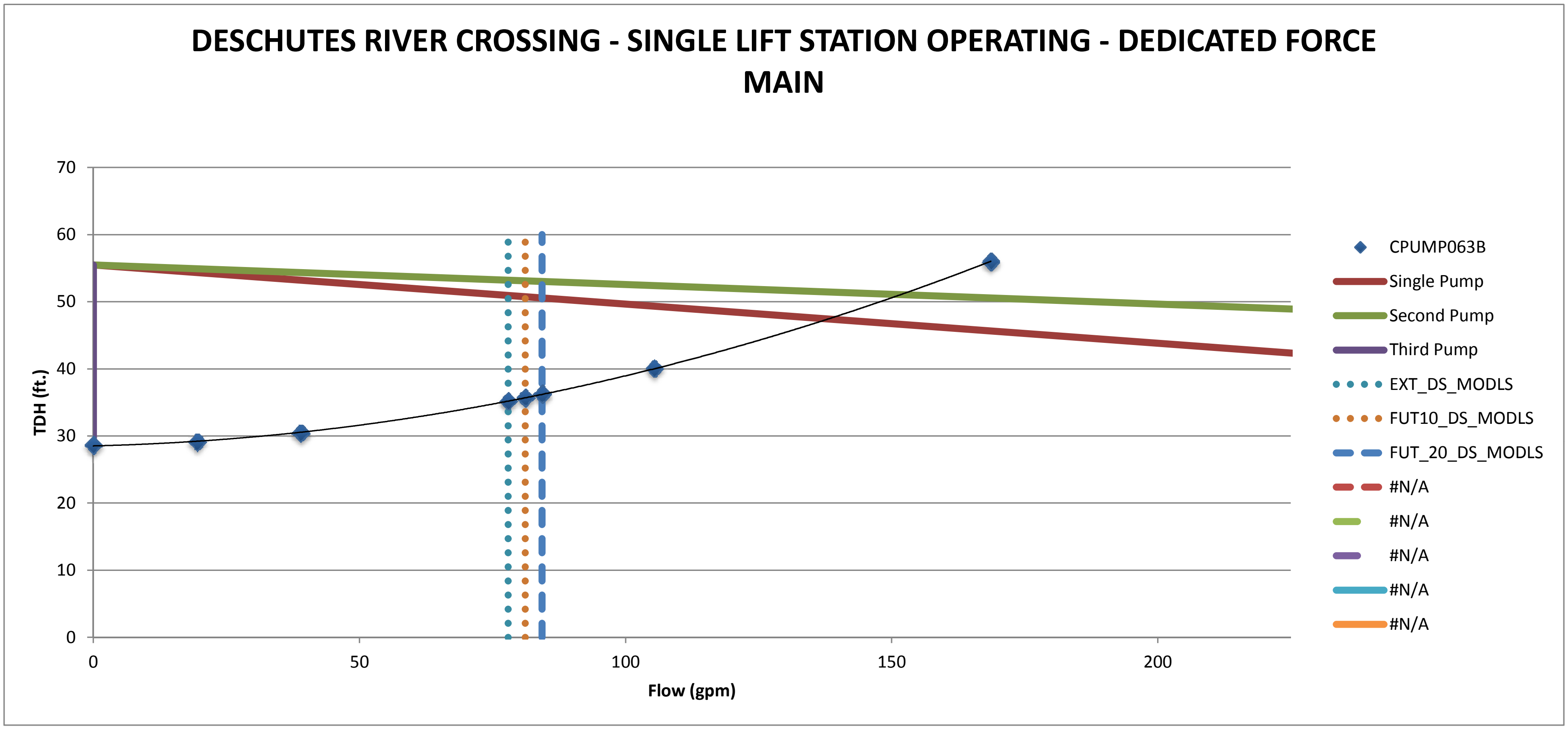
CAMDEN - SINGLE LIFT STATION OPERATING
TDH (ft.)
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0
20
40
60
80
100
120
140
Flow (gpm)
CPUMP055B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A


CANAL VIEW - SINGLE LIFT STATION OPERATING
TDH (ft.)
Flow (gpm)
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
50
100
150
200
CPUMP037B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

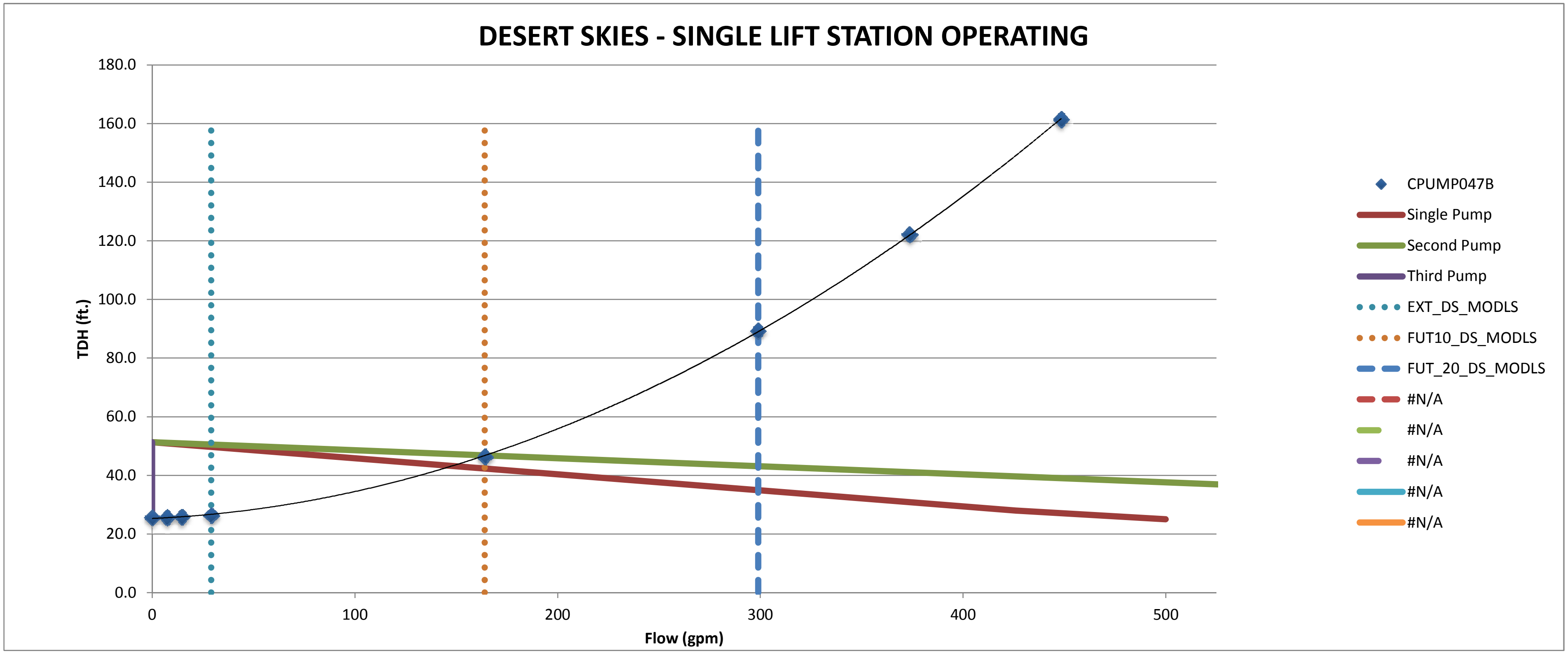


DARNELL ESTATES - SINGLE LIFT STATION OPERATING
TDH (ft.)
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
50
100
150
200
Flow (gpm)
CPUMP048B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

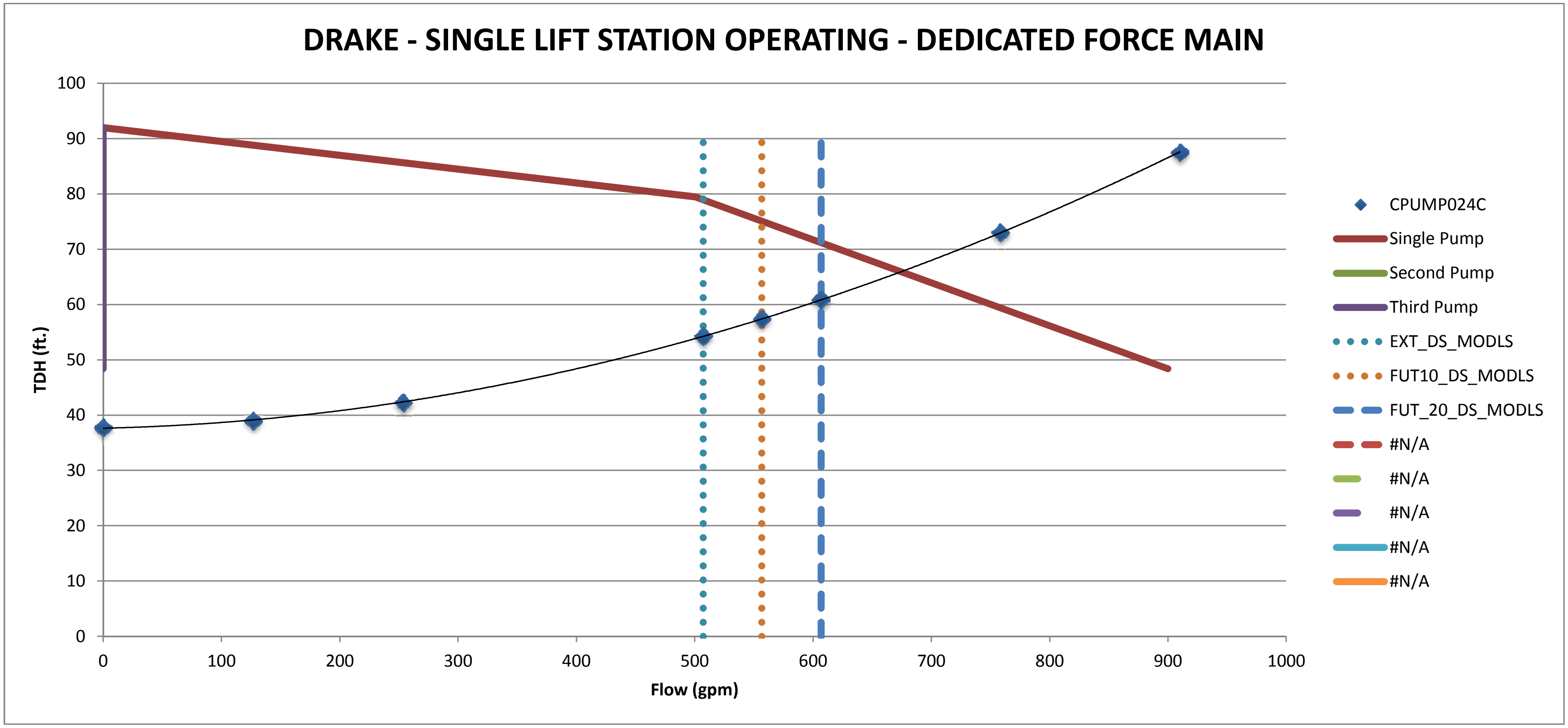

DESCHUTES BUSINESS - SINGLE LIFT STATION OPERATING
TDH (ft.)
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
20
40
60
80
100
120
140
160
180
200
Flow (gpm)
CPUMP082B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

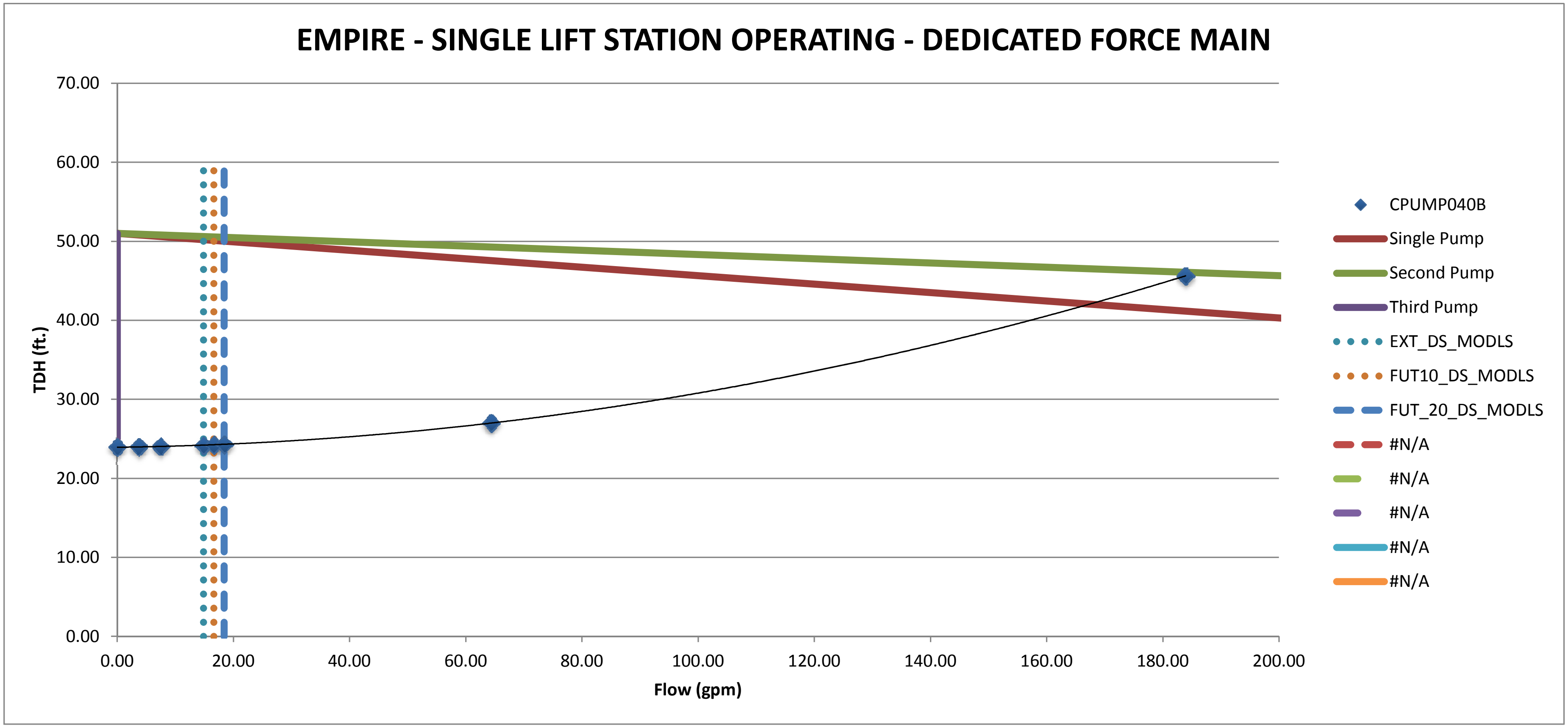


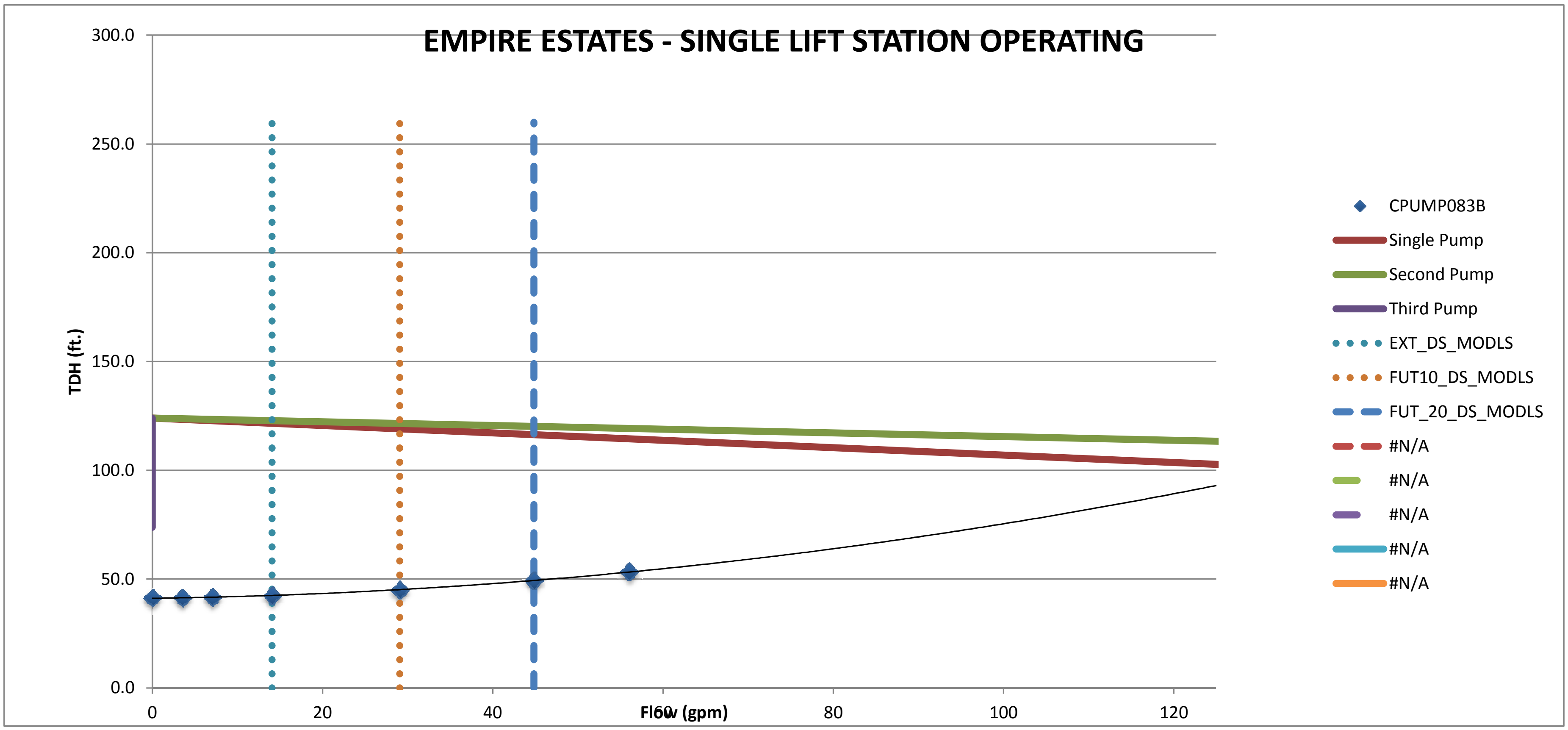
DESCHUTES RIVER CROSSING - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
70
60
50
40
30
20
10
0
TDH (ft.)
0
50
100
150
200
Flow (gpm)
CPUMP063B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

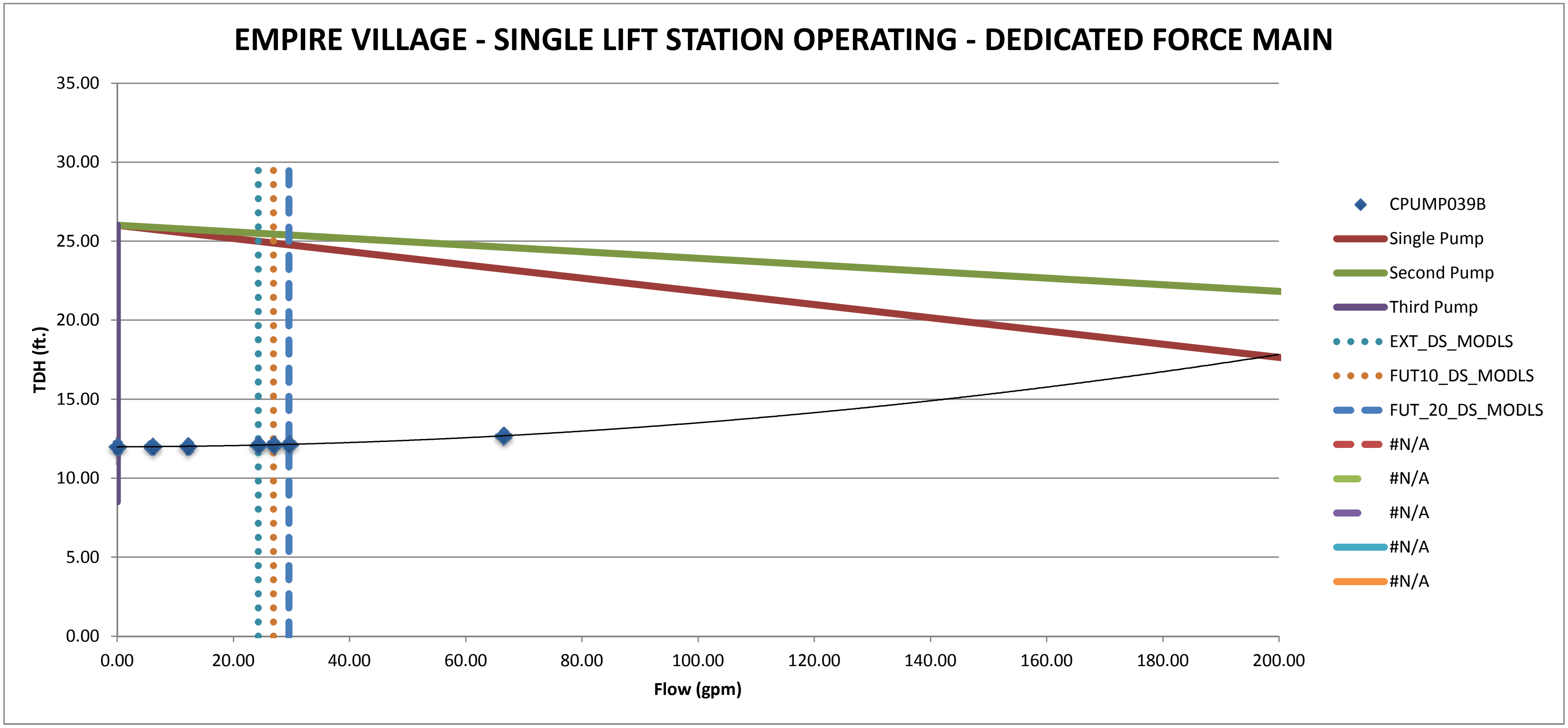


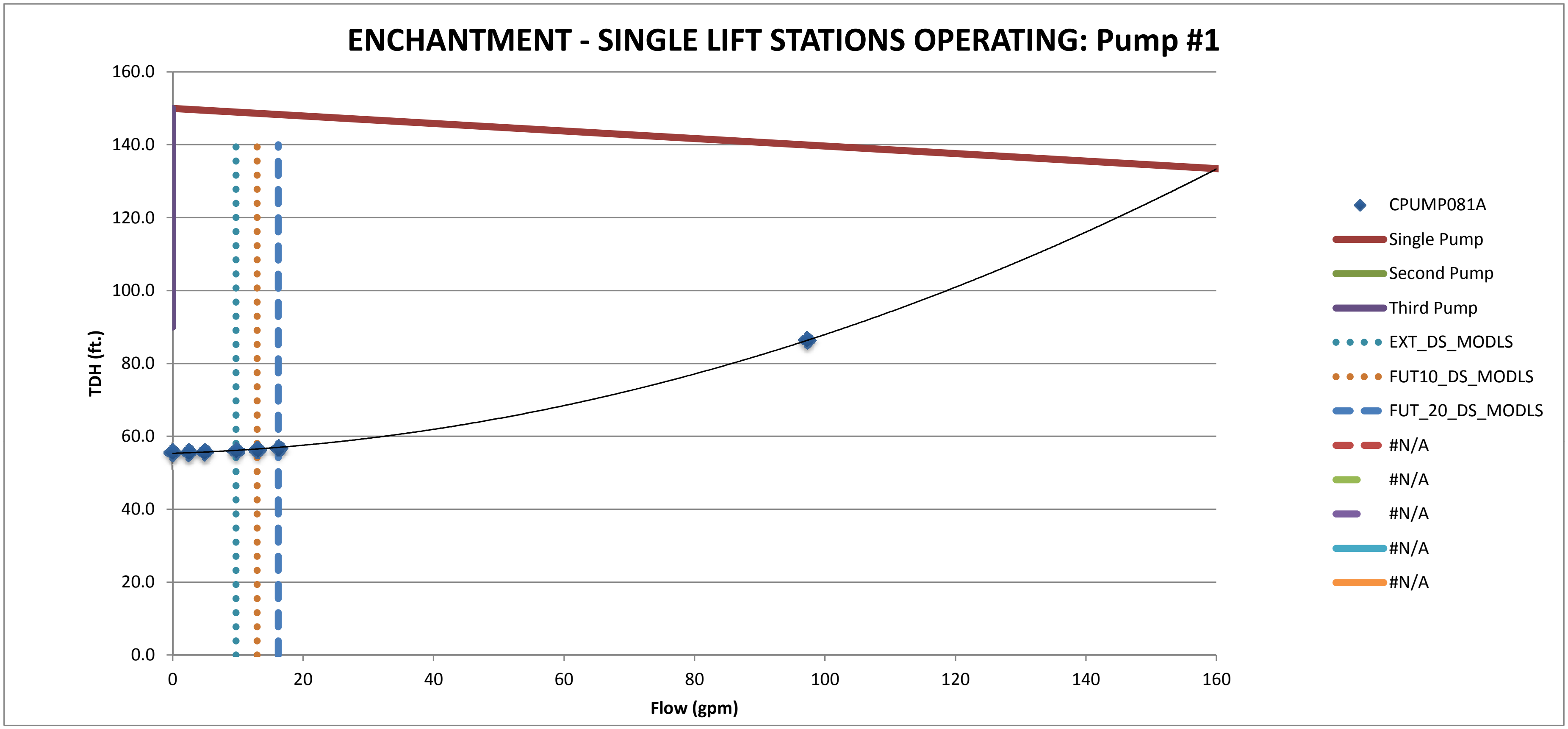
DESERT SKIES - SINGLE LIFT STATION OPERATING
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
TDH (ft.)
0
100
200
300
400
500
Flow (gpm)
CPUMP047B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

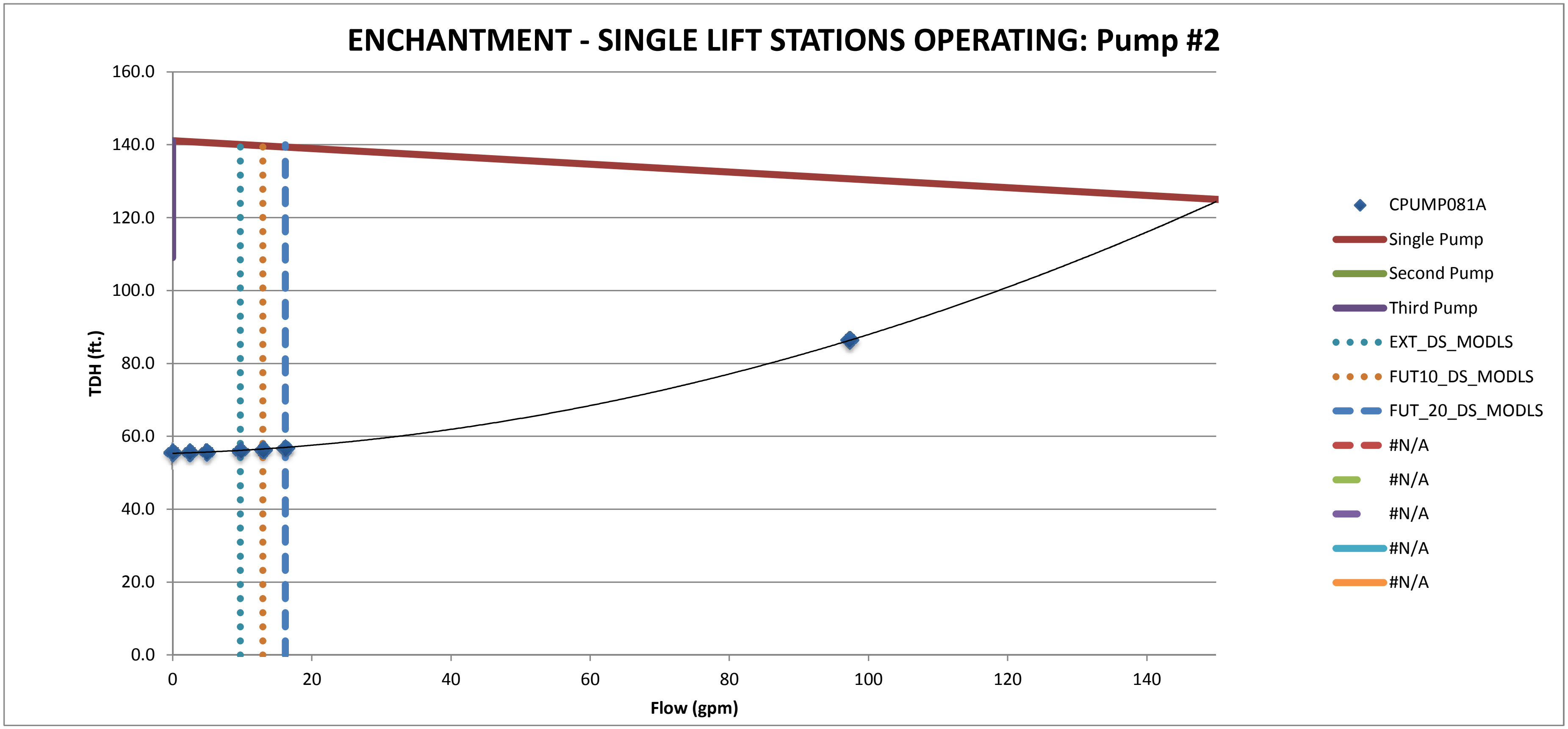

DRAKE - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
100
90
80
70
60
50
40
30
20
10
0
TDH (ft.)
0
100
200
300
400
500
600
700
800
900
1000
Flow (gpm)
CPUMP024C
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

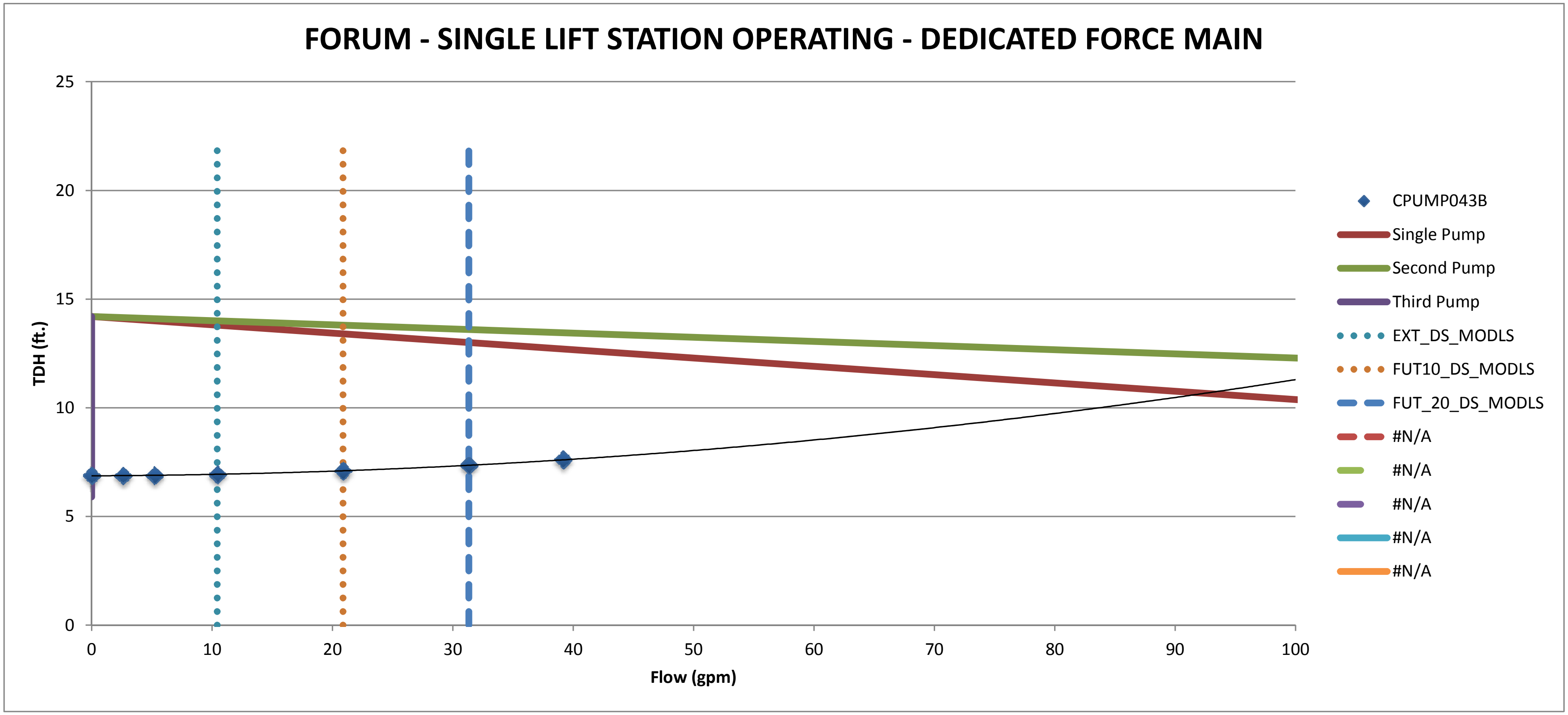

EMPIRE - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
Flow (gpm)
CPUMP040B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

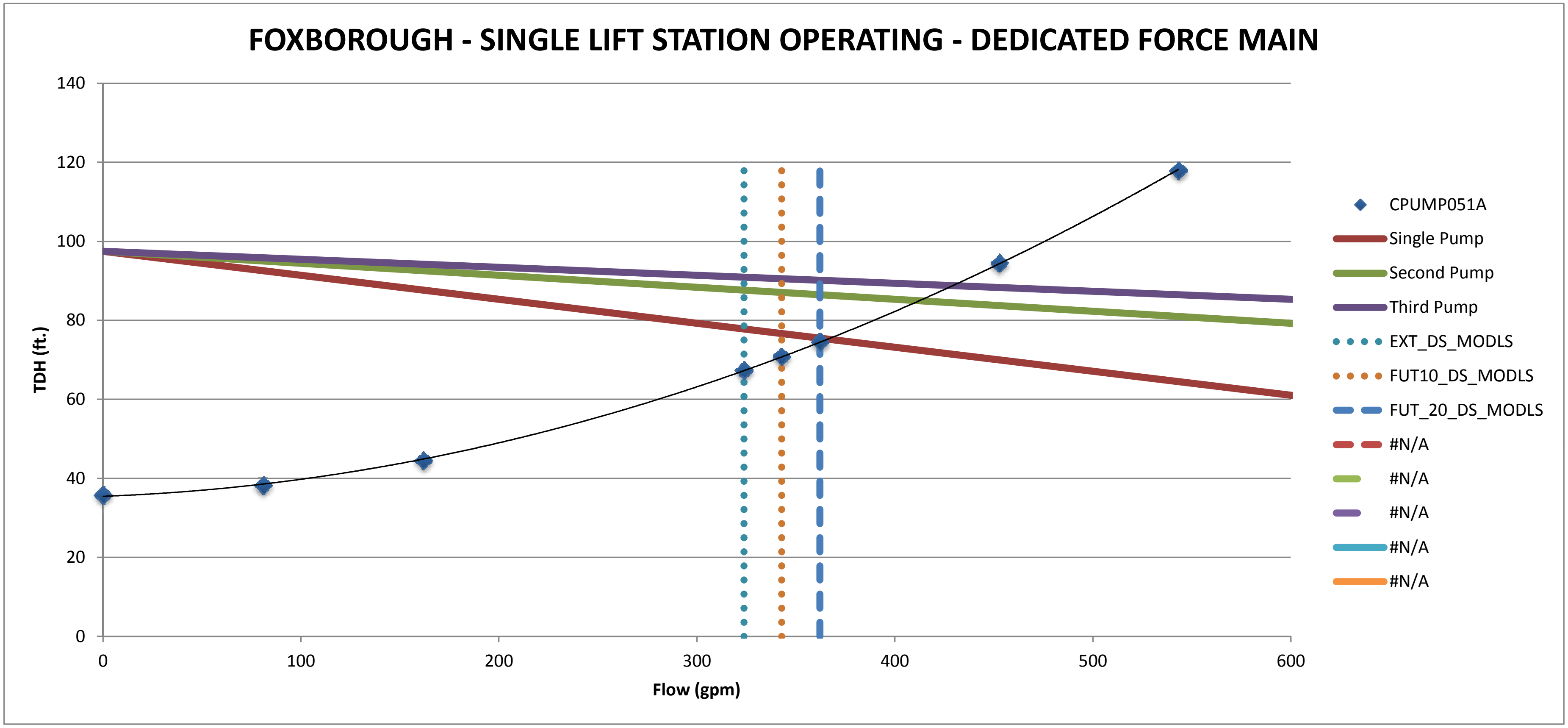

EMPIRE ESTATES - SINGLE LIFT STATION OPERATING
TDH (ft.)
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0
20
40
60
80
100
120
Flow (gpm)
CPUMP083B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A


EMPIRE VILLAGE - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
TDH (ft.)
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
Flow (gpm)
CPUMP039B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

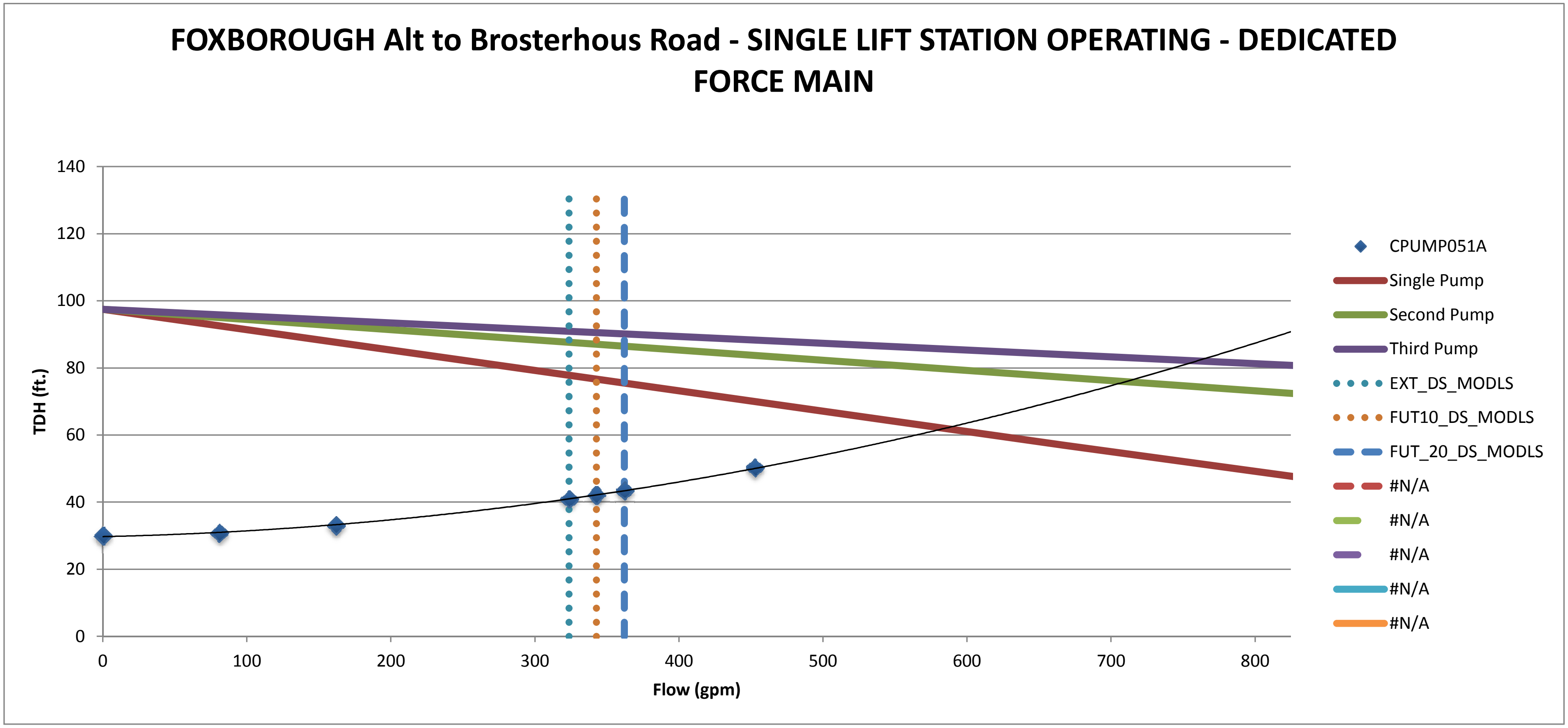

ENCHANTMENT - SINGLE LIFT STATIONS OPERATING: Pump #1
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
TDH (ft.)
0
20
40
60
80
100
120
140
160
Flow (gpm)
CPUMP081A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A


ENCHANTMENT - SINGLE LIFT STATIONS OPERATING: Pump #2
TDH (ft.)
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0
20
40
60
80
100
120
140
Flow (gpm)
CPUMP081A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

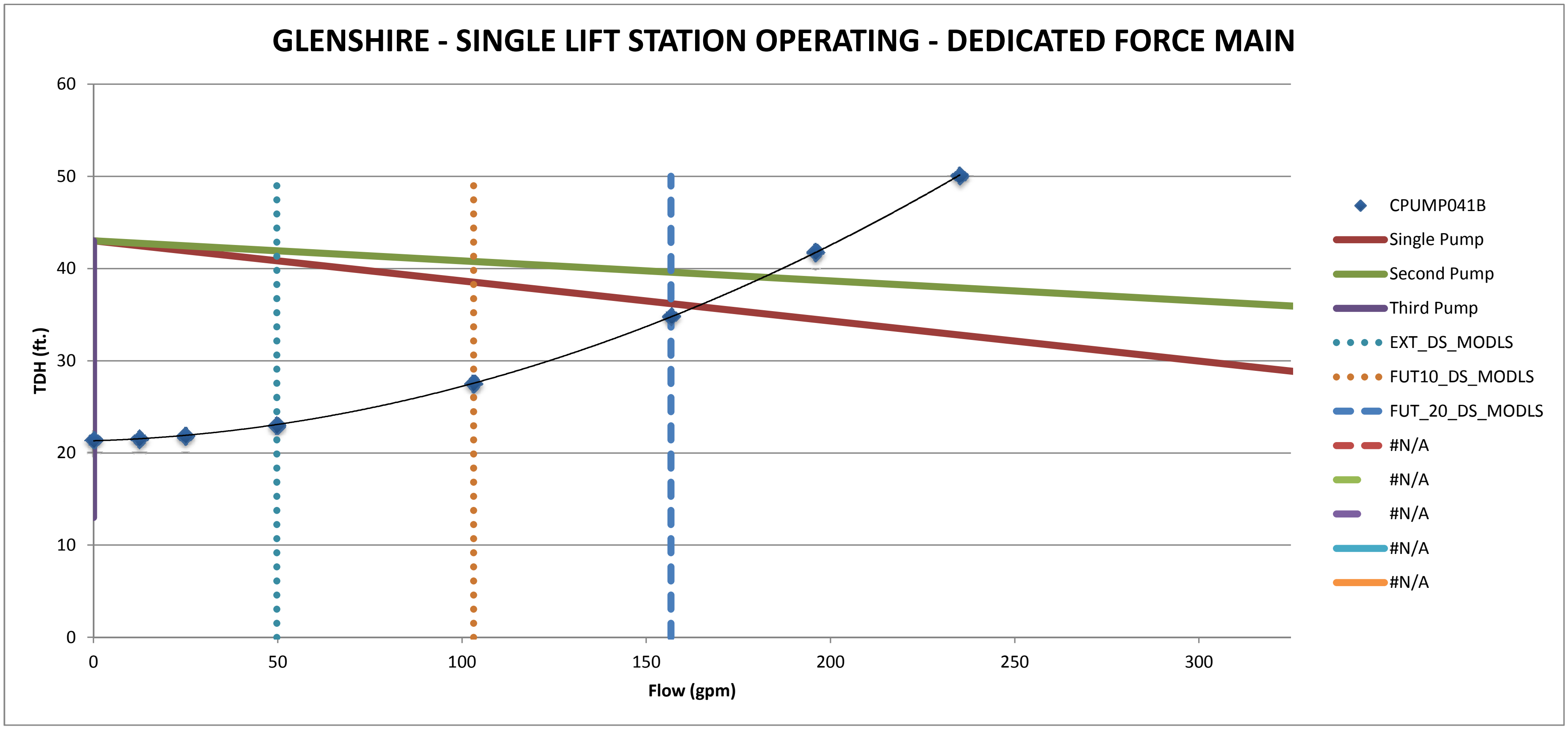

FORUM - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
Flow (gpm)
0
5
10
15
20
25
0
10
20
30
40
50
60
70
80
90
100
CPUMP043B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

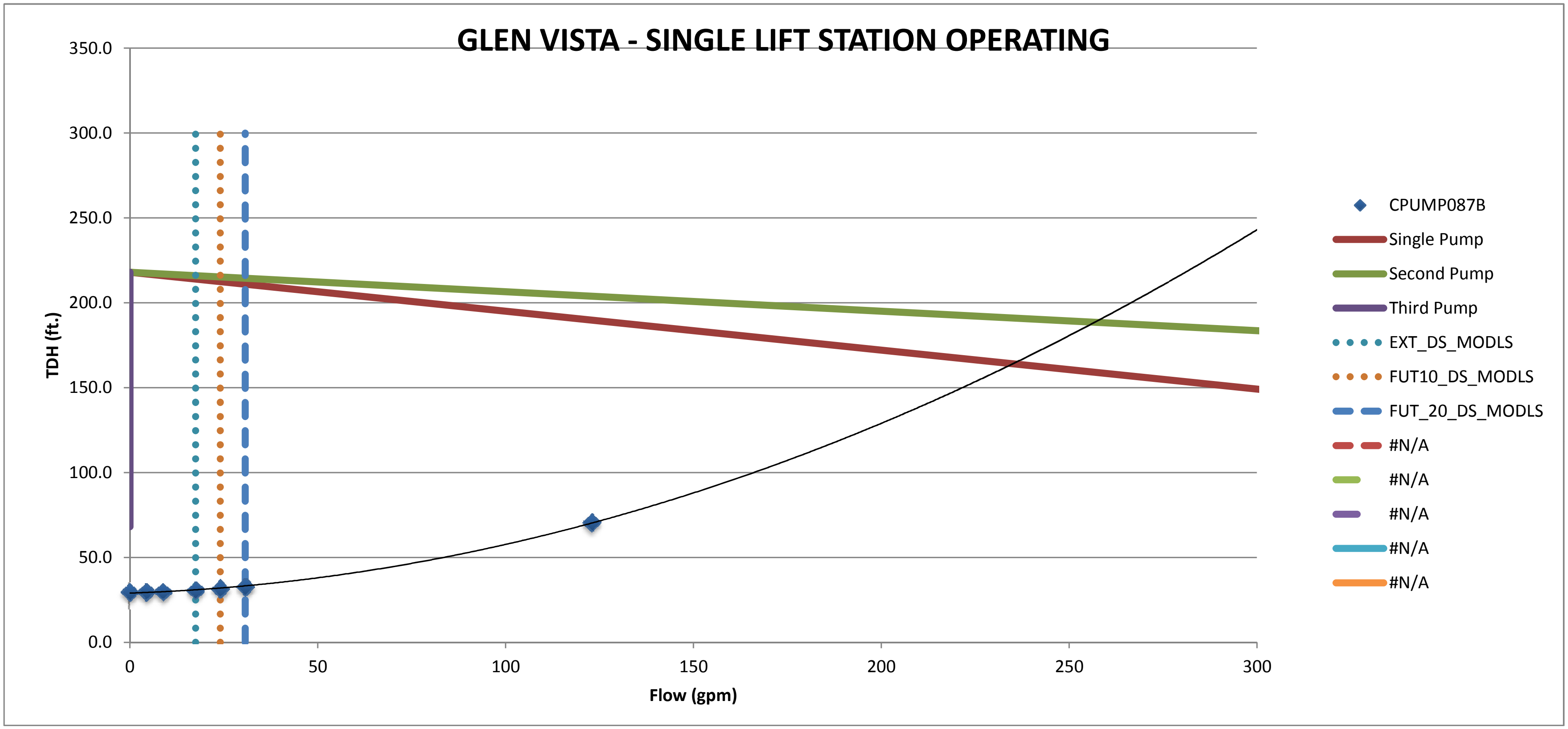


FOXBOROUGH - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
140
120
100
80
60
40
20
0
TDH (ft.)
0
100
200
300
400
500
600
Flow (gpm)
CPUMP051A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

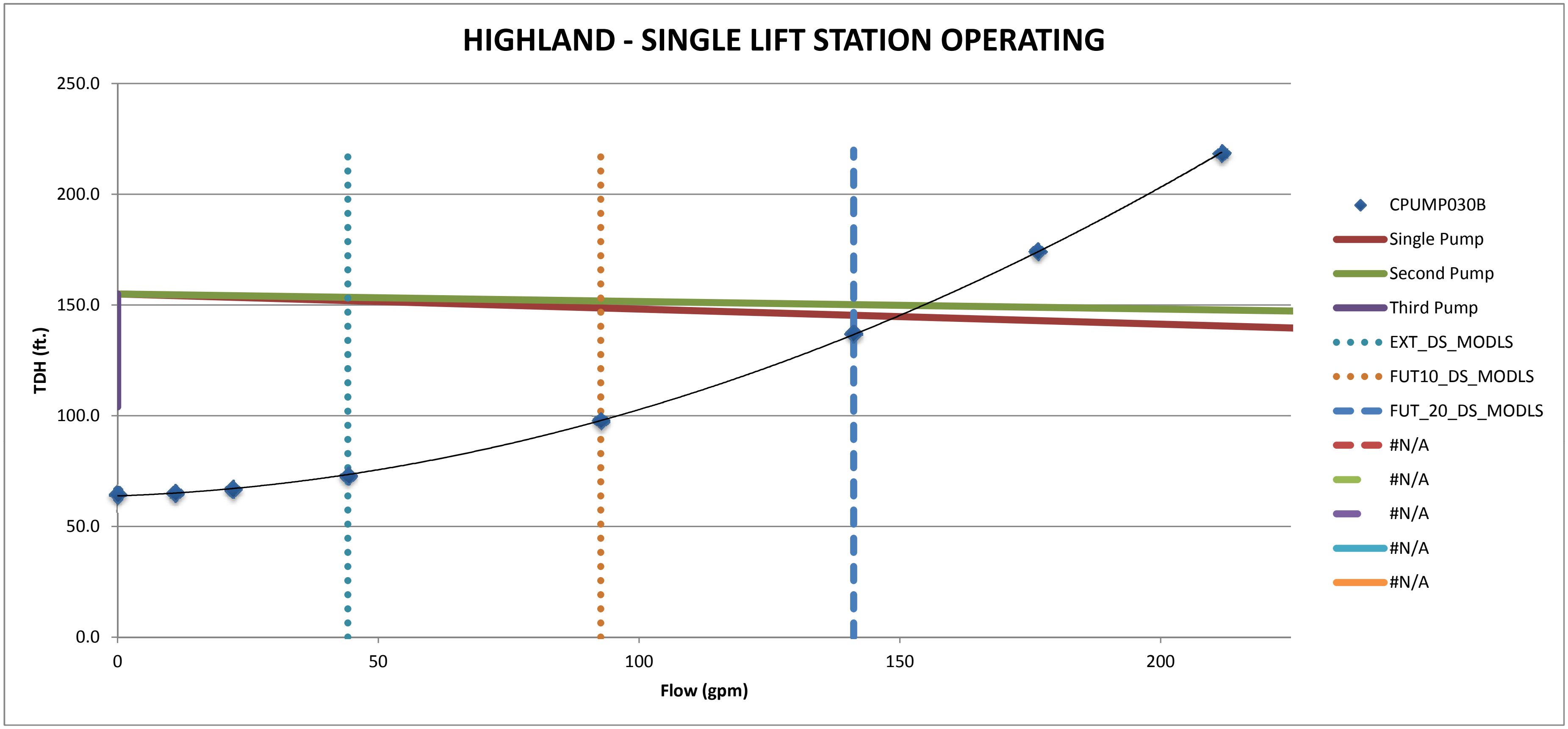


FOXBOROUGH Alt to Brosterhous Road - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
140
120
100
80
60
40
20
0
TDH (ft.)
0
100
200
300
400
500
600
700
800
Flow (gpm)
CPUMP051A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

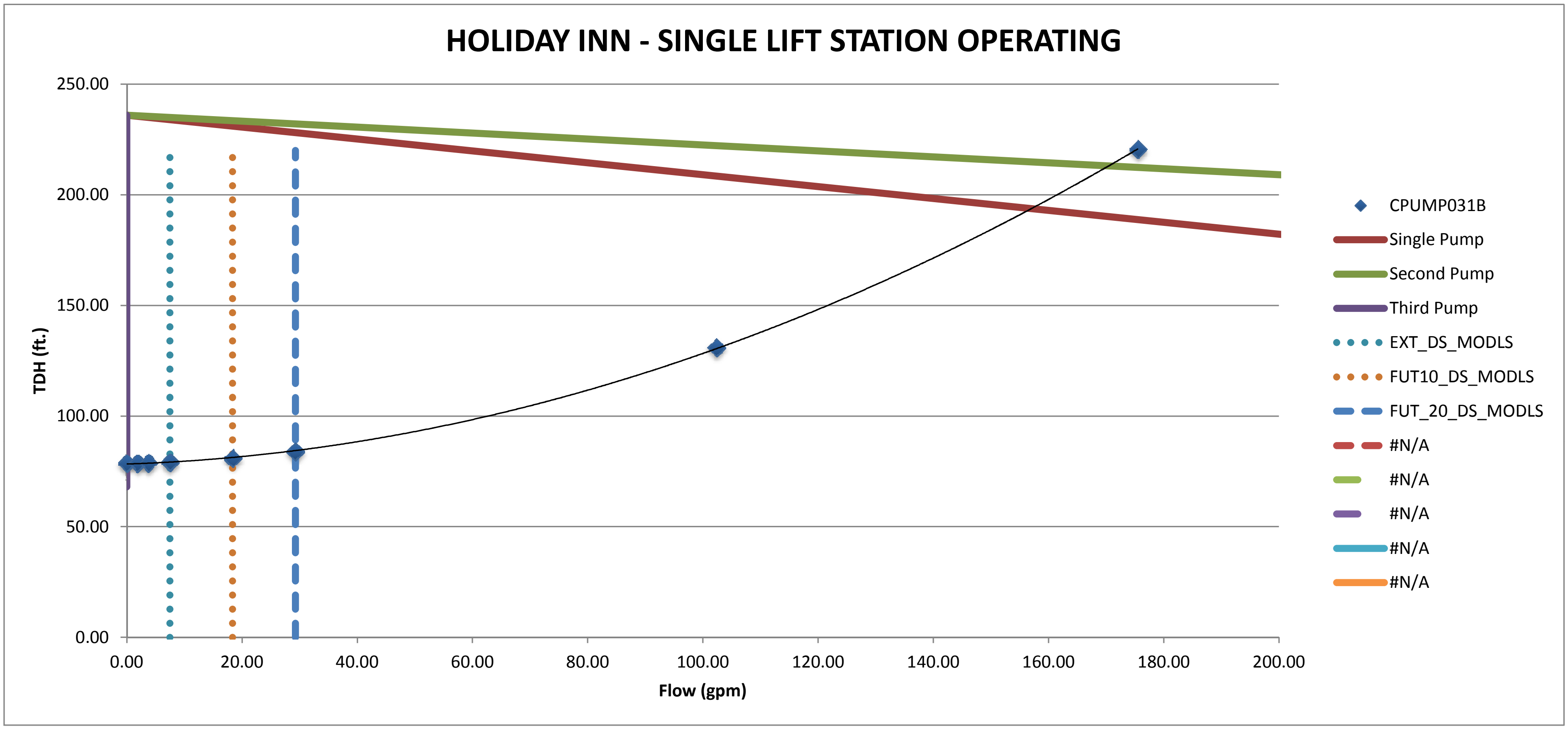

GLENSHIRE - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
60
50
40
30
20
10
0
TDH (ft.)
0
50
100
150
200
250
300
Flow (gpm)
CPUMP041B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A



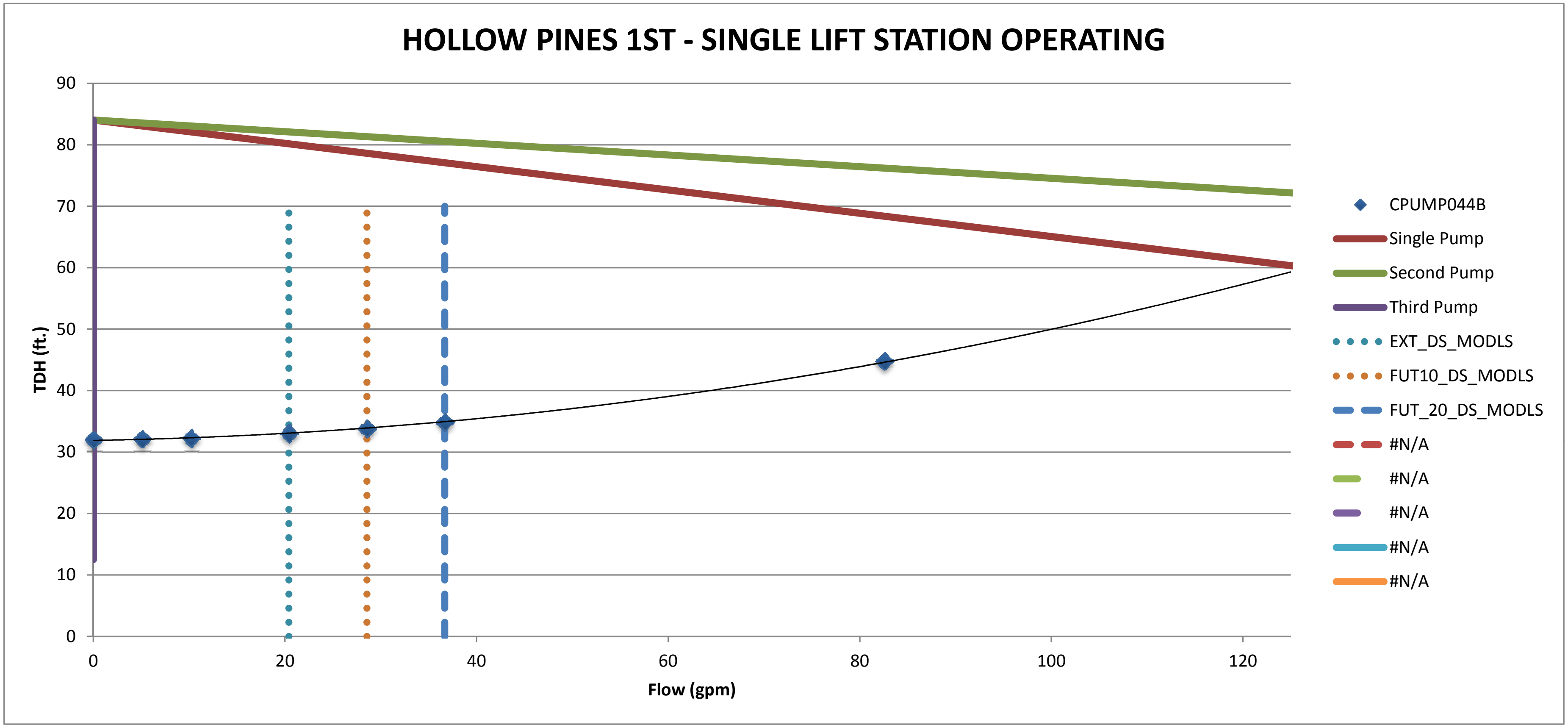
GLEN VISTA - SINGLE LIFT STATION OPERATING
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
TDH (ft.)
0
50
100
150
200
250
300
Flow (gpm)
CPUMP087B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

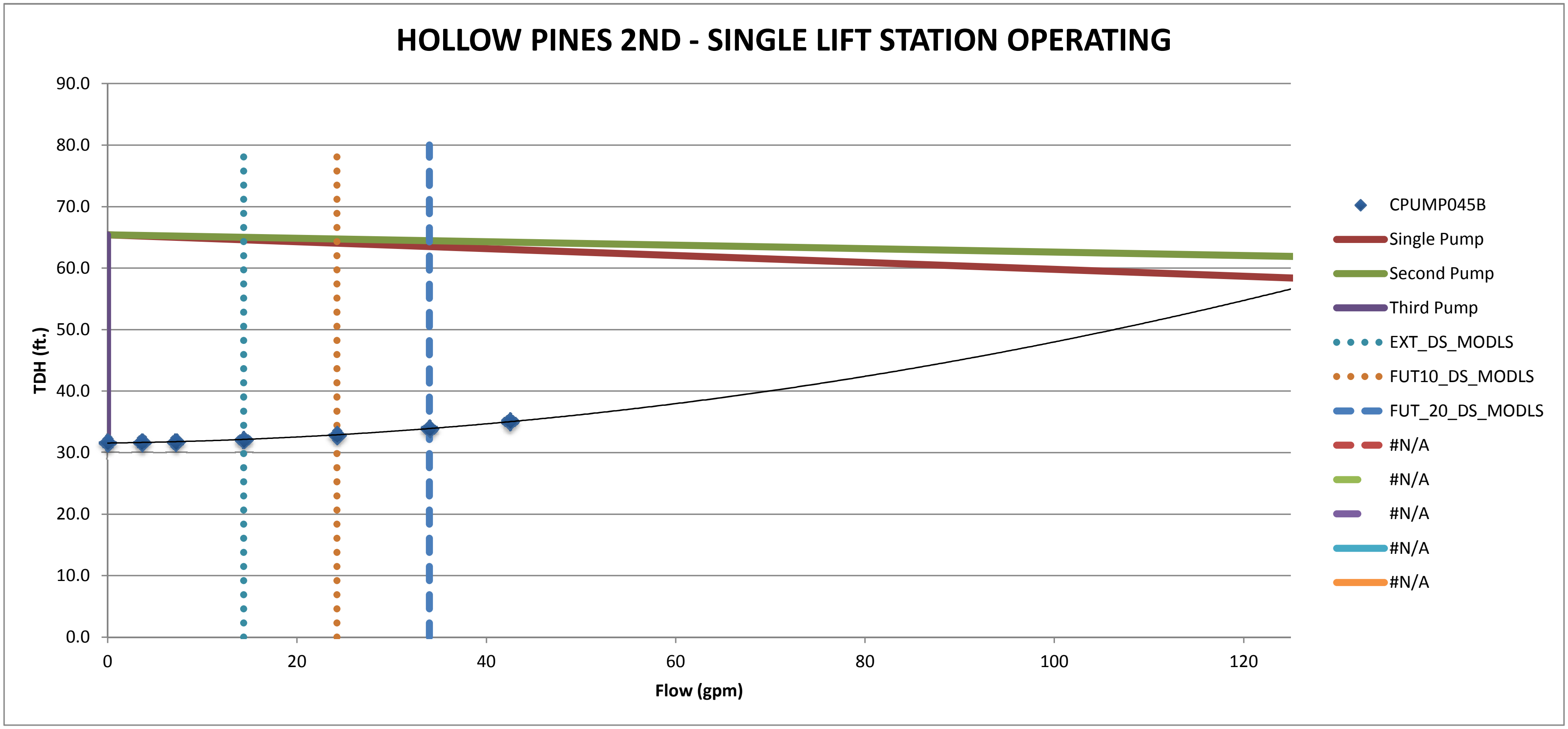


HIGHLAND - SINGLE LIFT STATION OPERATING
250.0
200.0
150.0
100.0
50.0
0.0
TDH (ft.)
0
50
100
150
200
Flow (gpm)
CPUMP030B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

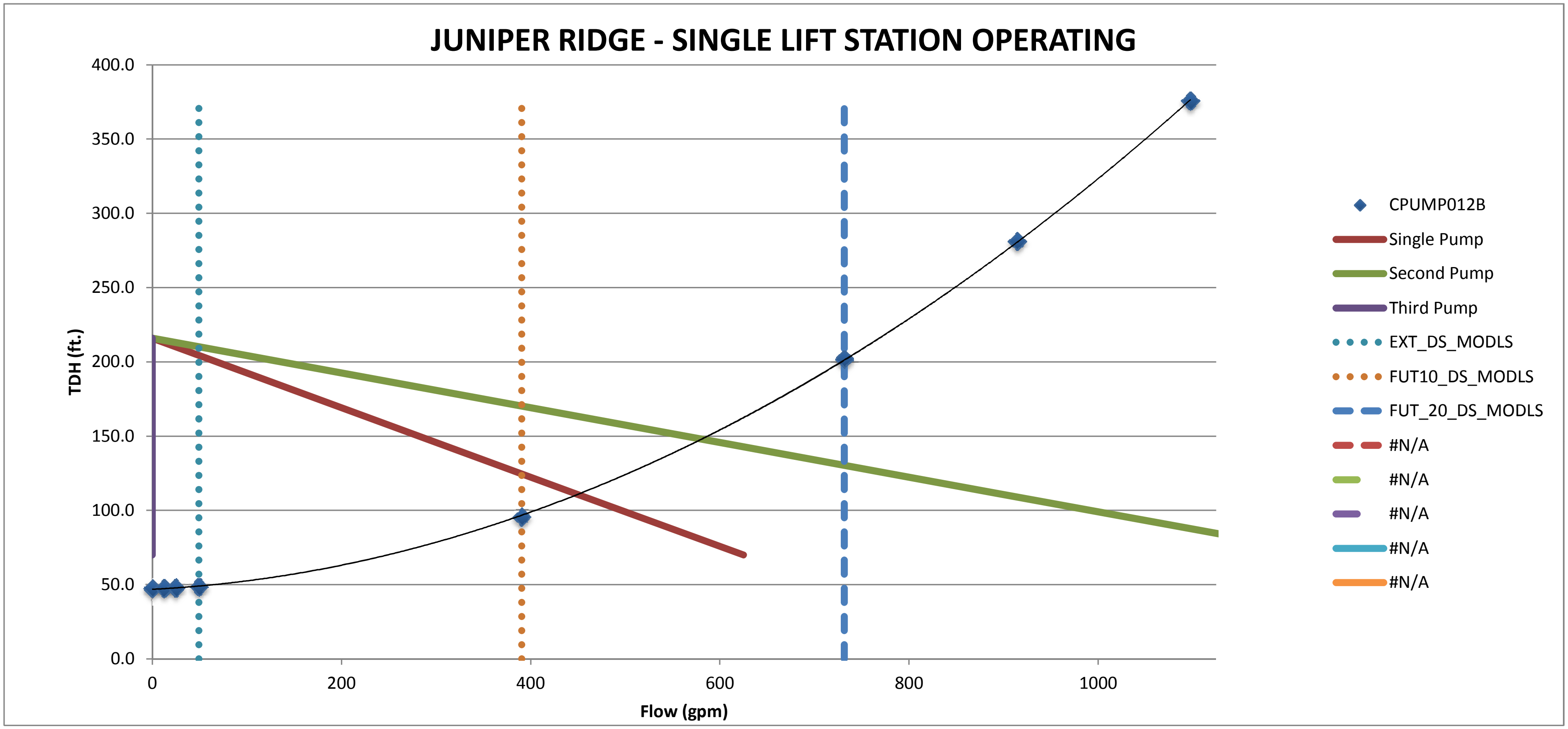


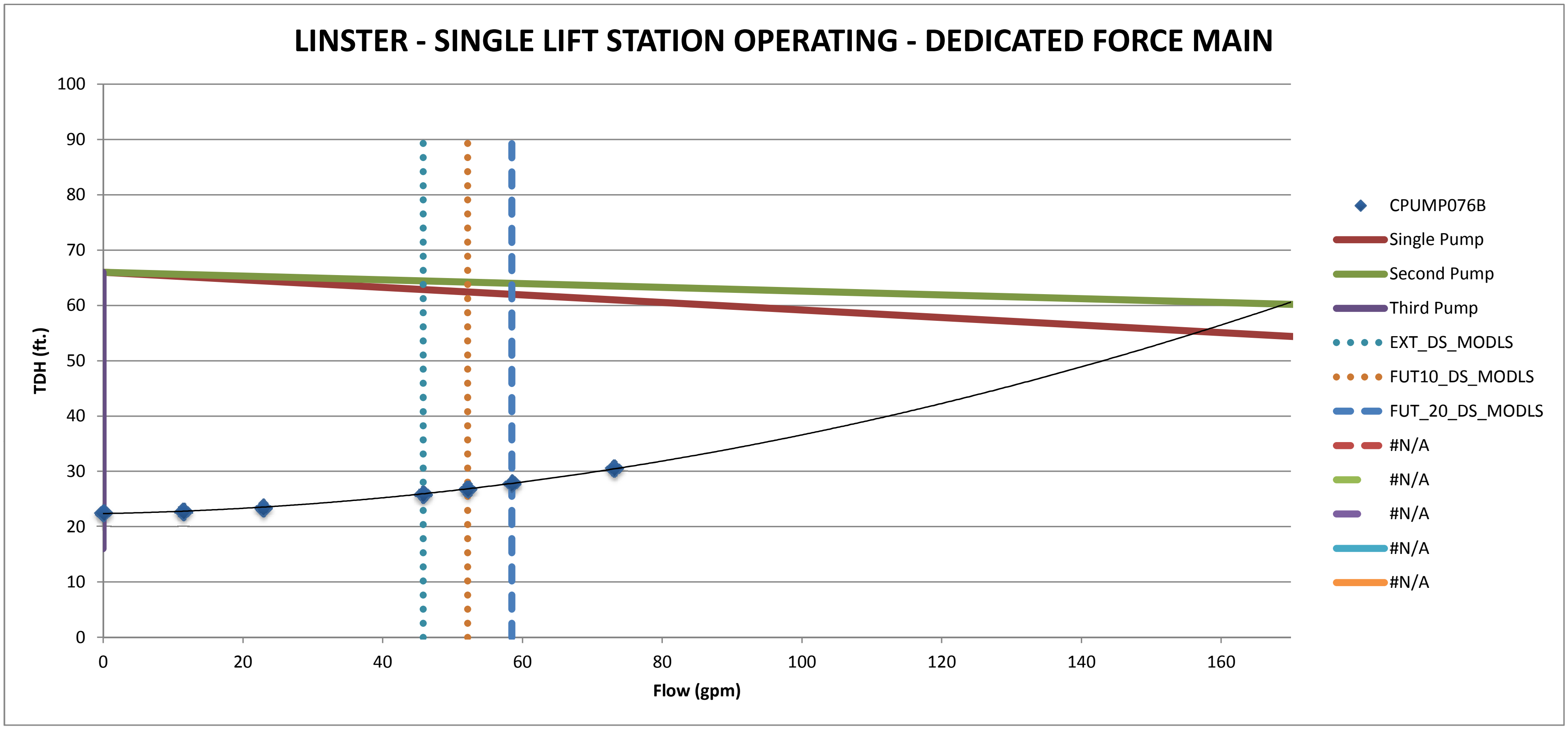
HOLIDAY INN - SINGLE LIFT STATION OPERATING
250.00
200.00
150.00
100.00
50.00
0.00
TDH (ft.)
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
Flow (gpm)
CPUMP031B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A


HOLLOW PINES 1ST - SINGLE LIFT STATION OPERATING
TDH (ft.)
Flow (gpm)
0
10
20
30
40
50
60
70
80
90
0
20
40
60
80
100
120
CPUMP044B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

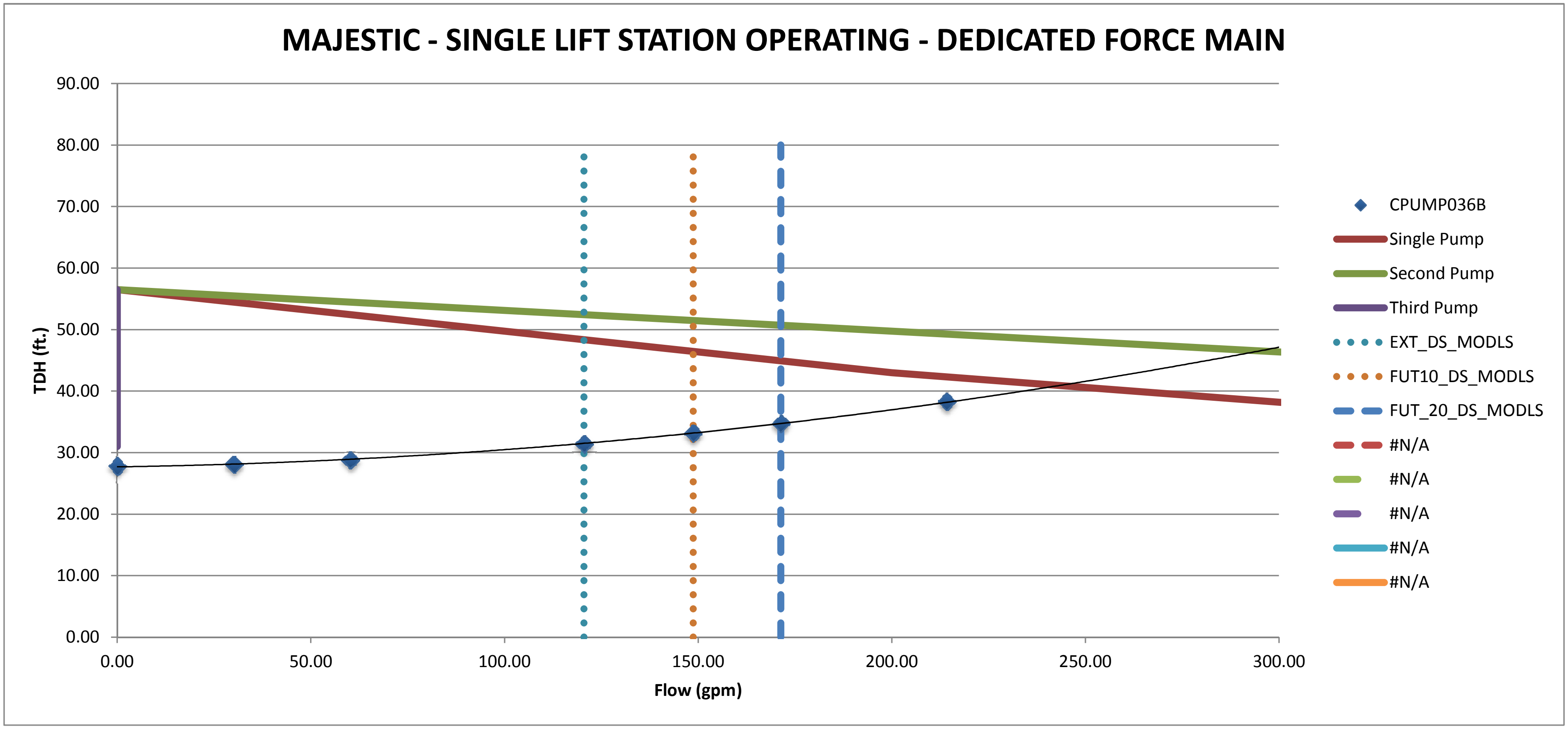


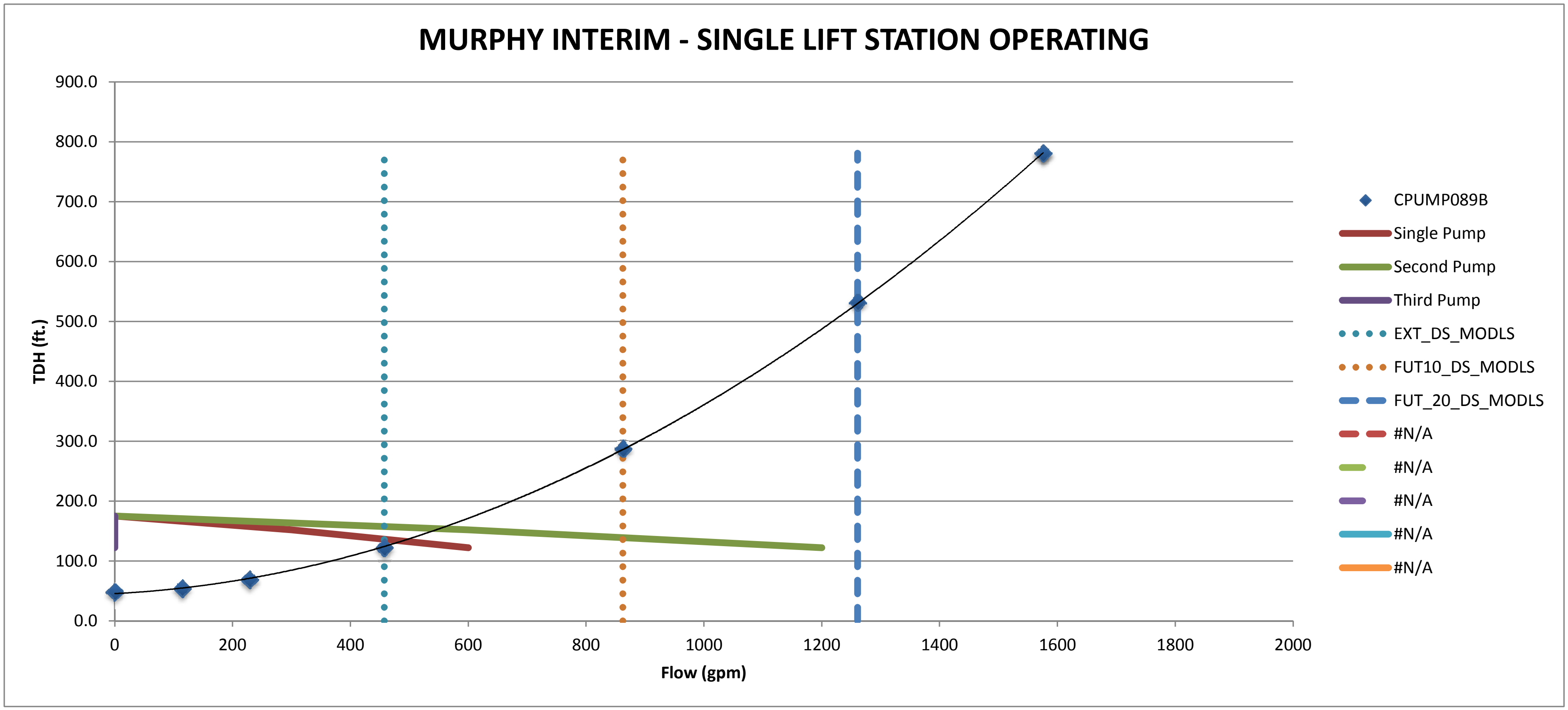
HOLLOW PINES 2ND - SINGLE LIFT STATION OPERATING
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
TDH (ft.)
0
20
40
60
80
100
120
Flow (gpm)
CPUMP045B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A


JUNIPER RIDGE - SINGLE LIFT STATION OPERATING
TDH (ft.)
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0
200
400
600
800
1000
Flow (gpm)
CPUMP012B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

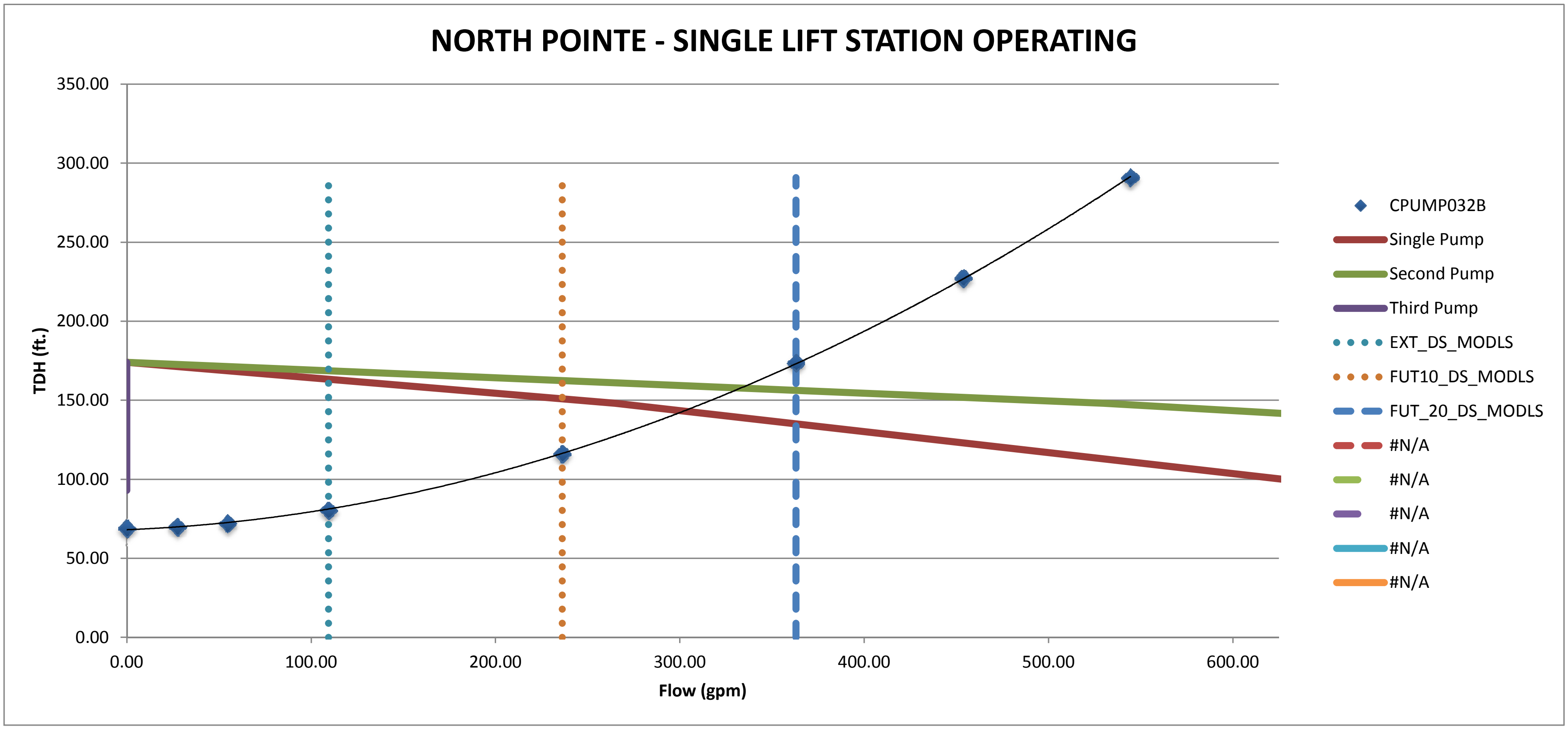


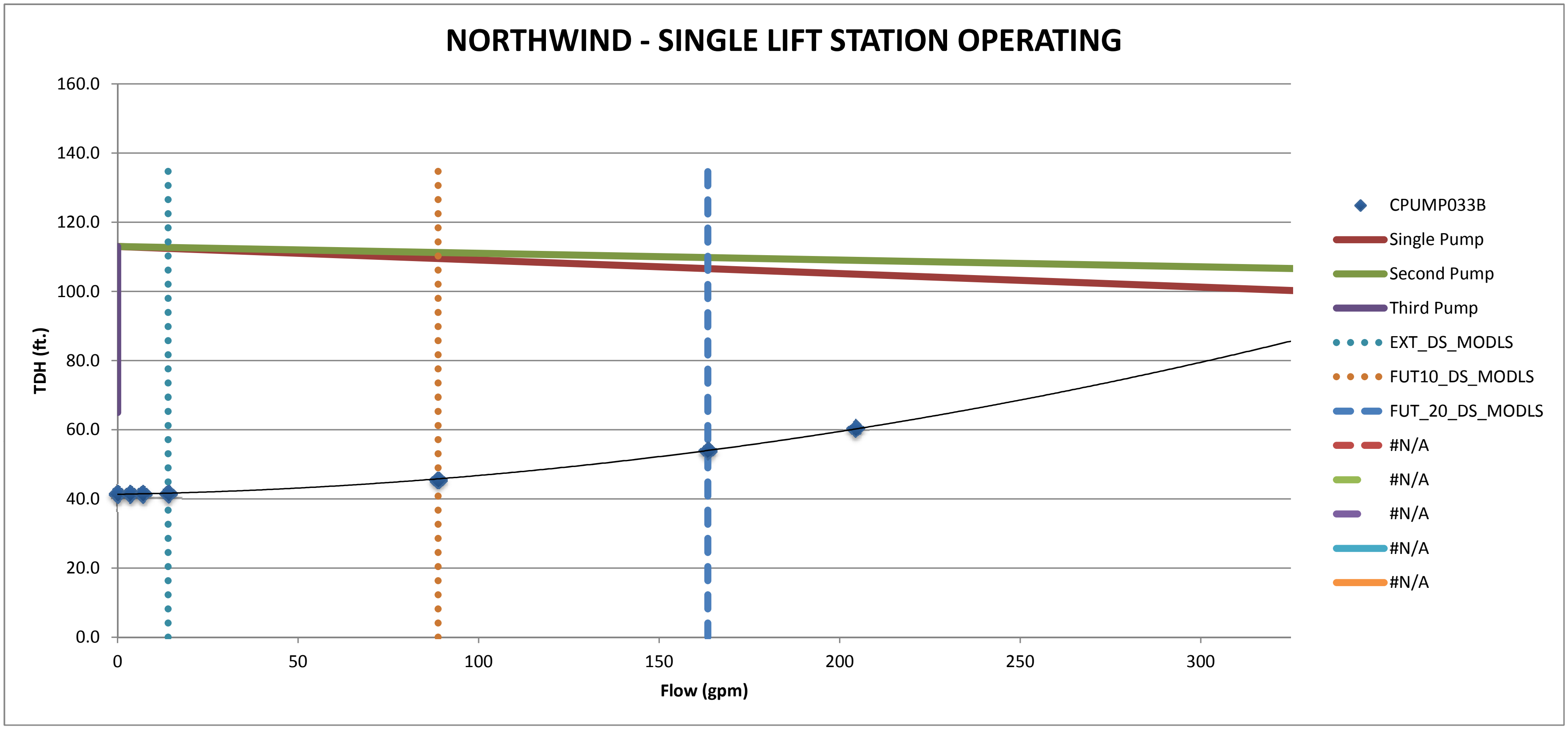
LINSTER - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
Flow (gpm)
0
10
20
30
40
50
60
70
80
90
100
0
20
40
60
80
100
120
140
160
CPUMP076B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

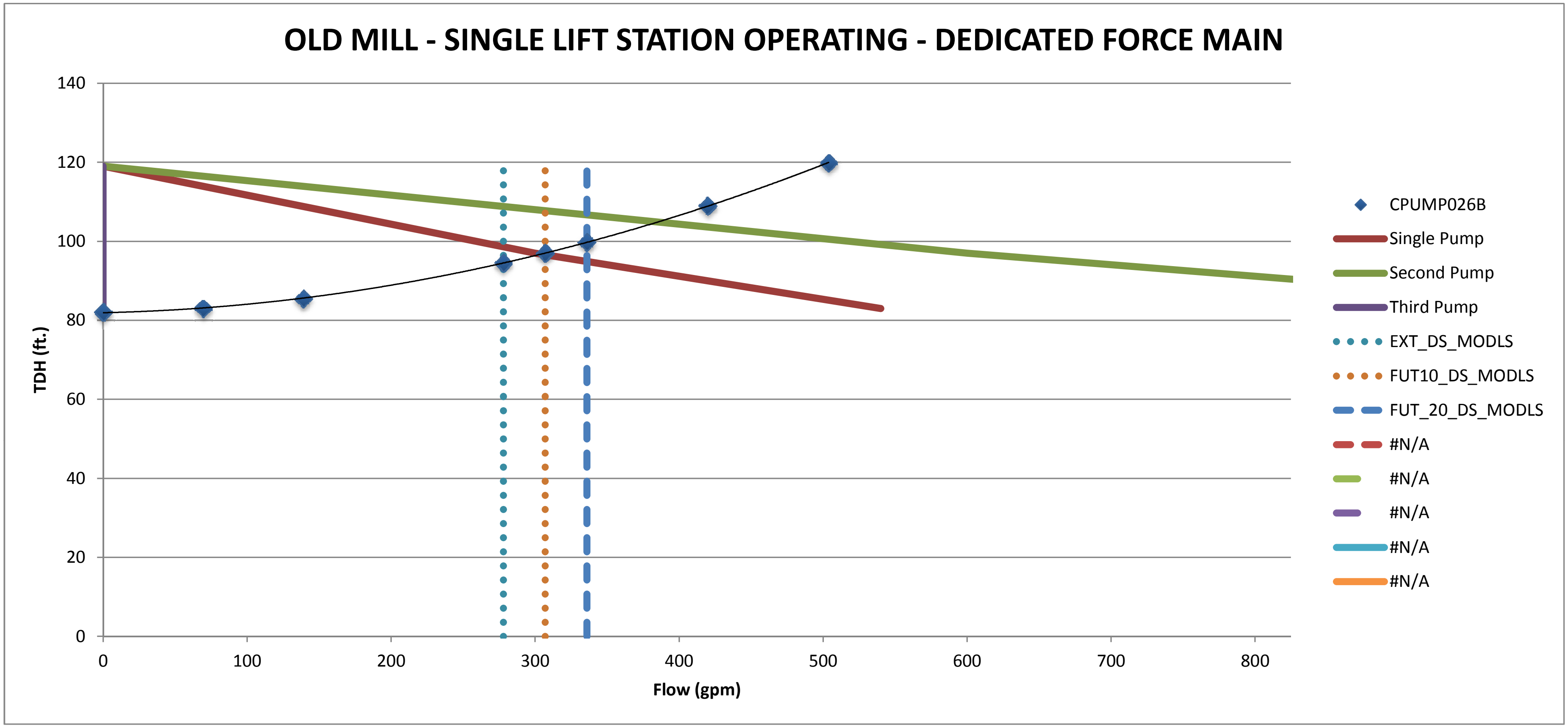

MAJESTIC - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0.00
50.00
100.00
150.00
200.00
250.00
300.00
Flow (gpm)
CPUMP036B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A



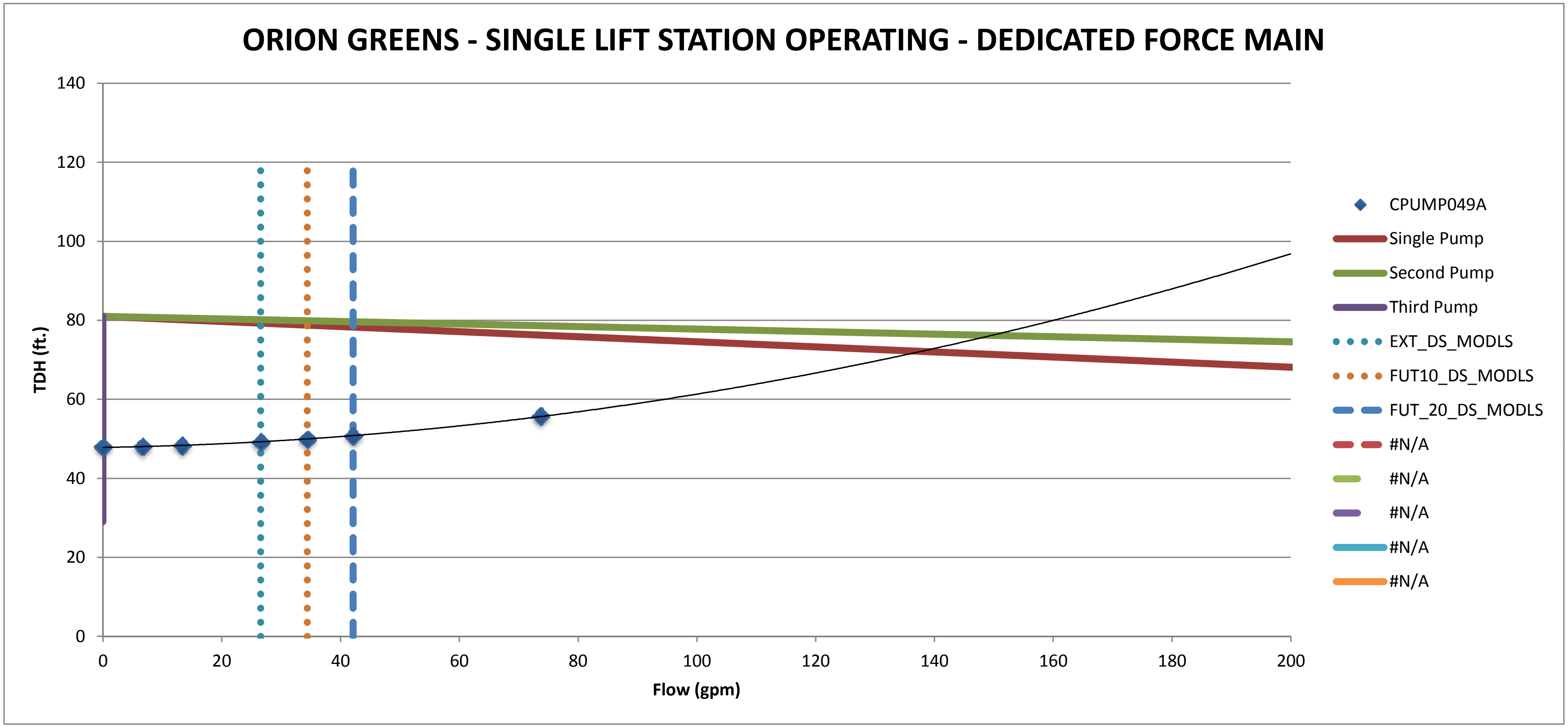
MURPHY INTERIM - SINGLE LIFT STATION OPERATING
900.0
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
TDH (ft.)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Flow (gpm)
CPUMP089B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

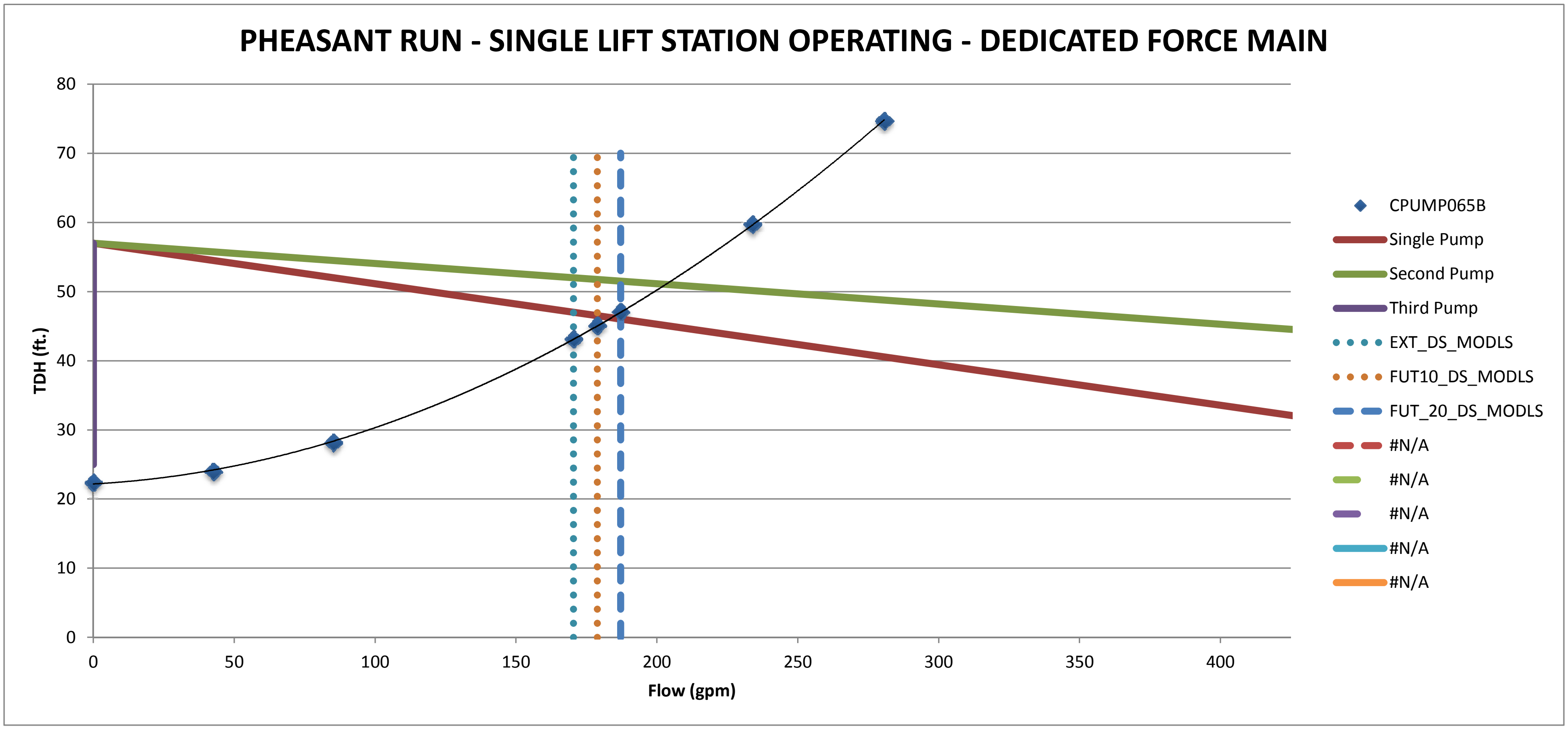

NORTH POINTE - SINGLE LIFT STATION OPERATING
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
TDH (ft.)
0.00
100.00
200.00
300.00
400.00
500.00
600.00
Flow (gpm)
CPUMP032B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A


NORTHWIND - SINGLE LIFT STATION OPERATING
TDH (ft.)
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0
50
100
150
200
250
300
Flow (gpm)
CPUMP033B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

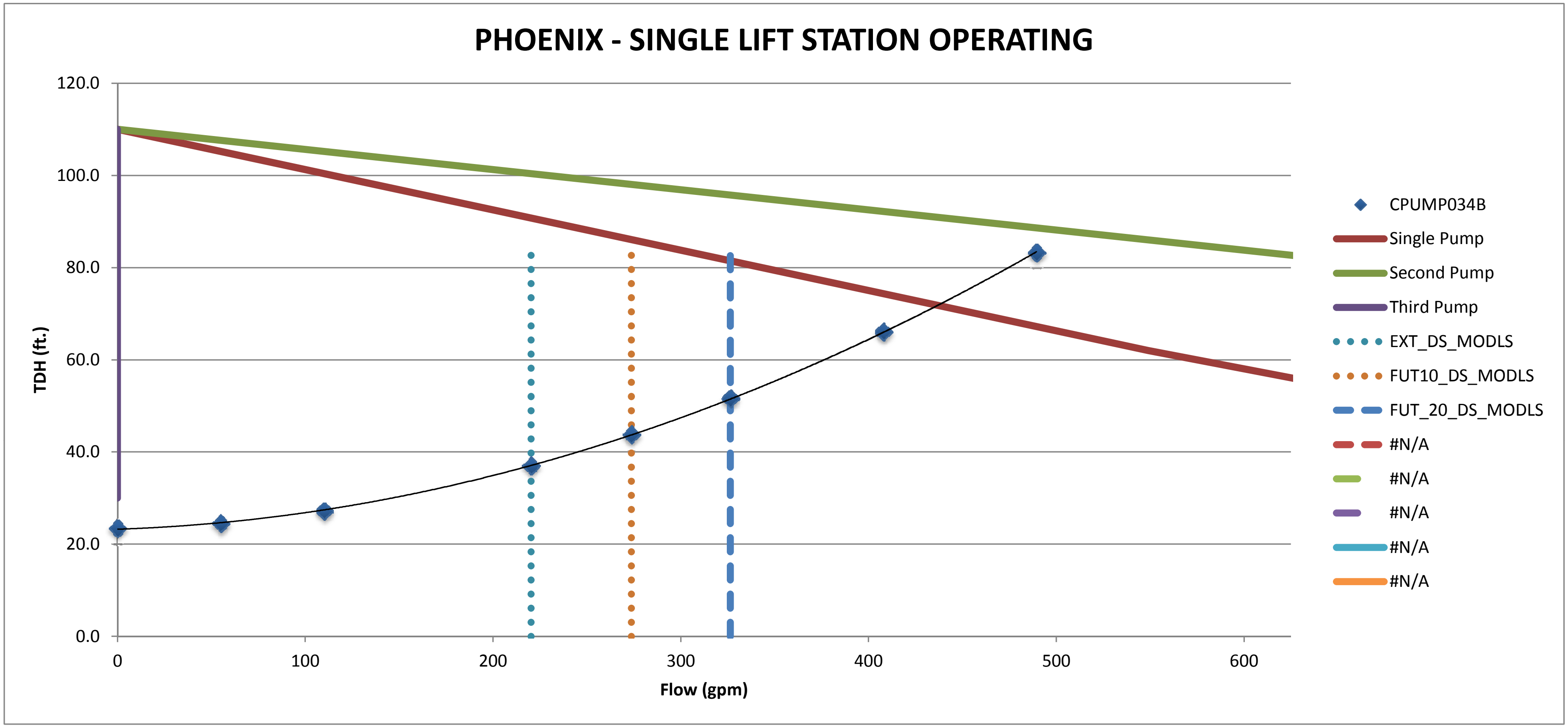


OLD MILL - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
0
20
40
60
80
100
120
140
Flow (gpm)
0
100
200
300
400
500
600
700
800
CPUMP026B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

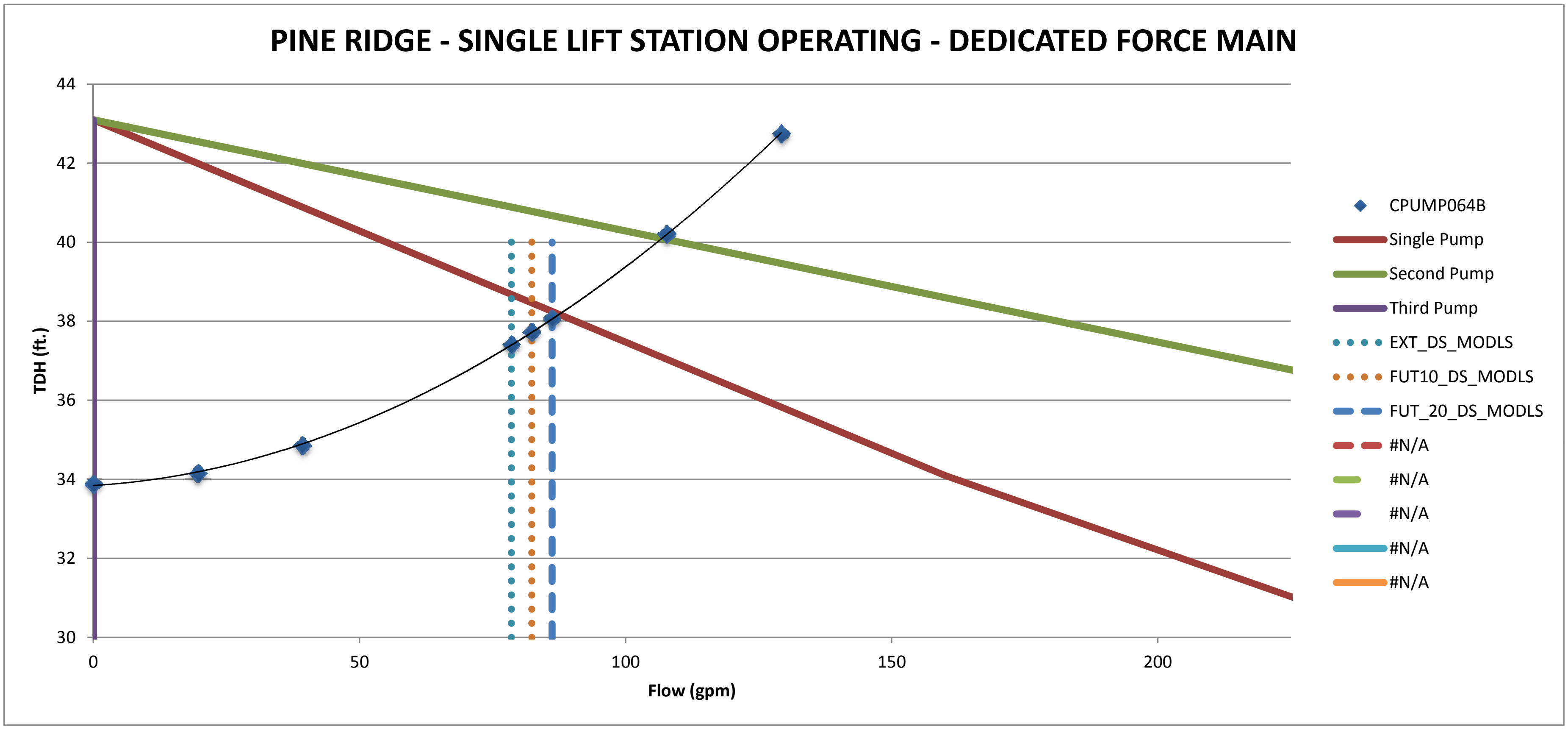

ORION GREENS - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
Flow (gpm)
0
20
40
60
80
100
120
140
160
180
200
CPUMP049A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A



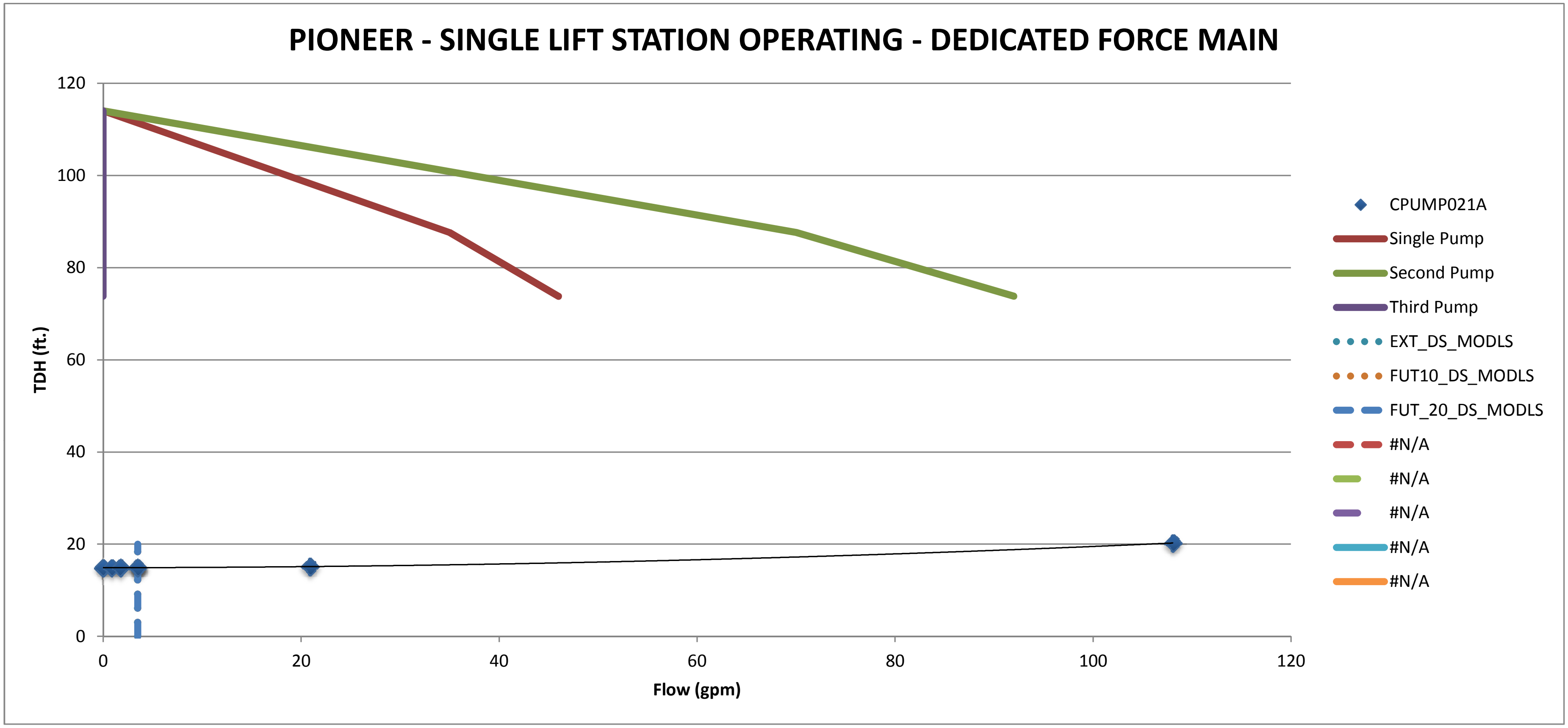
PHEASANT RUN - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
80
70
60
50
40
30
20
10
0
0
50
100
150
200
250
300
350
400
Flow (gpm)
CPUMP065B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

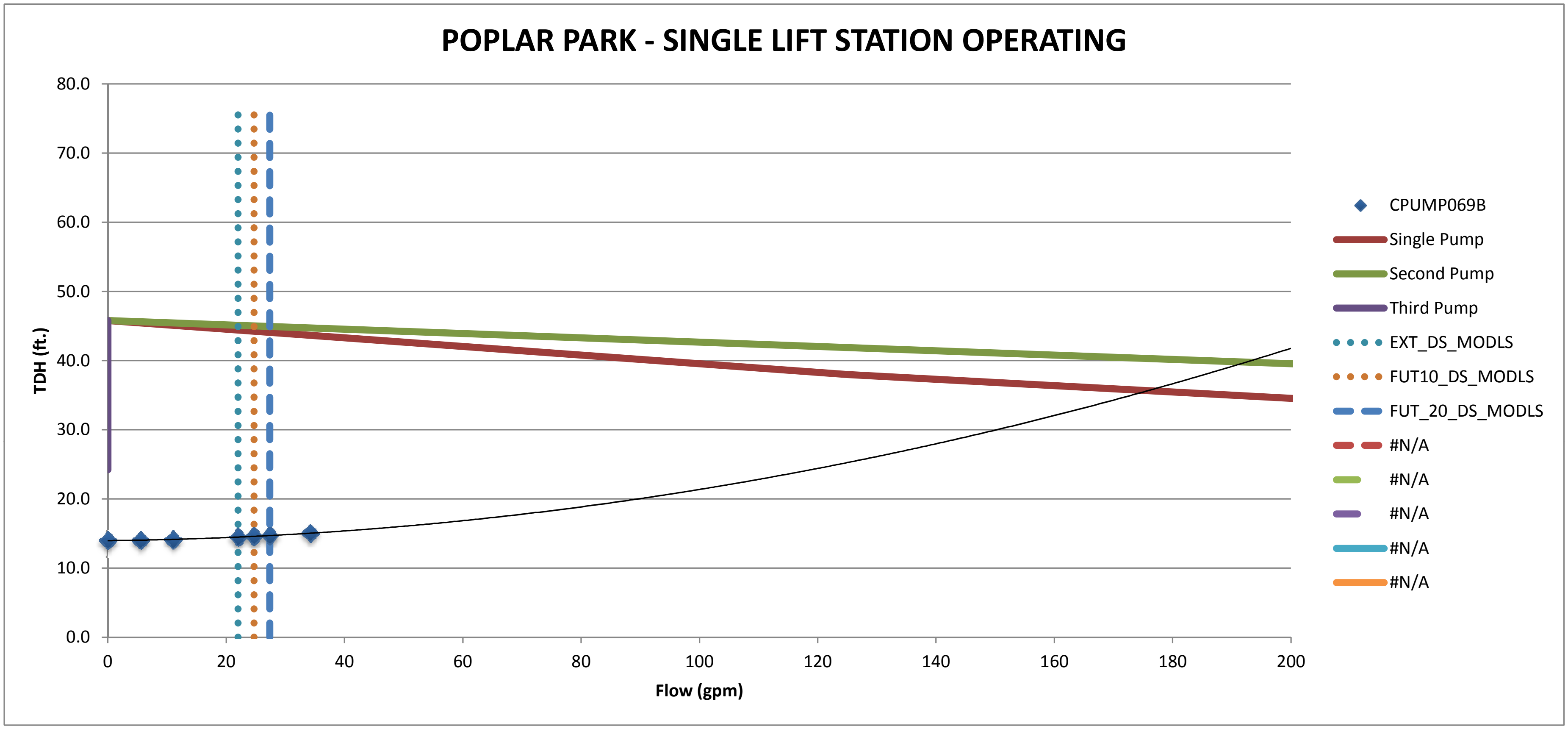


PHOENIX - SINGLE LIFT STATION OPERATING
120.0
100.0
80.0
60.0
40.0
20.0
0.0
TDH (ft.)
0
100
200
300
400
500
600
Flow (gpm)
CPUMP034B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

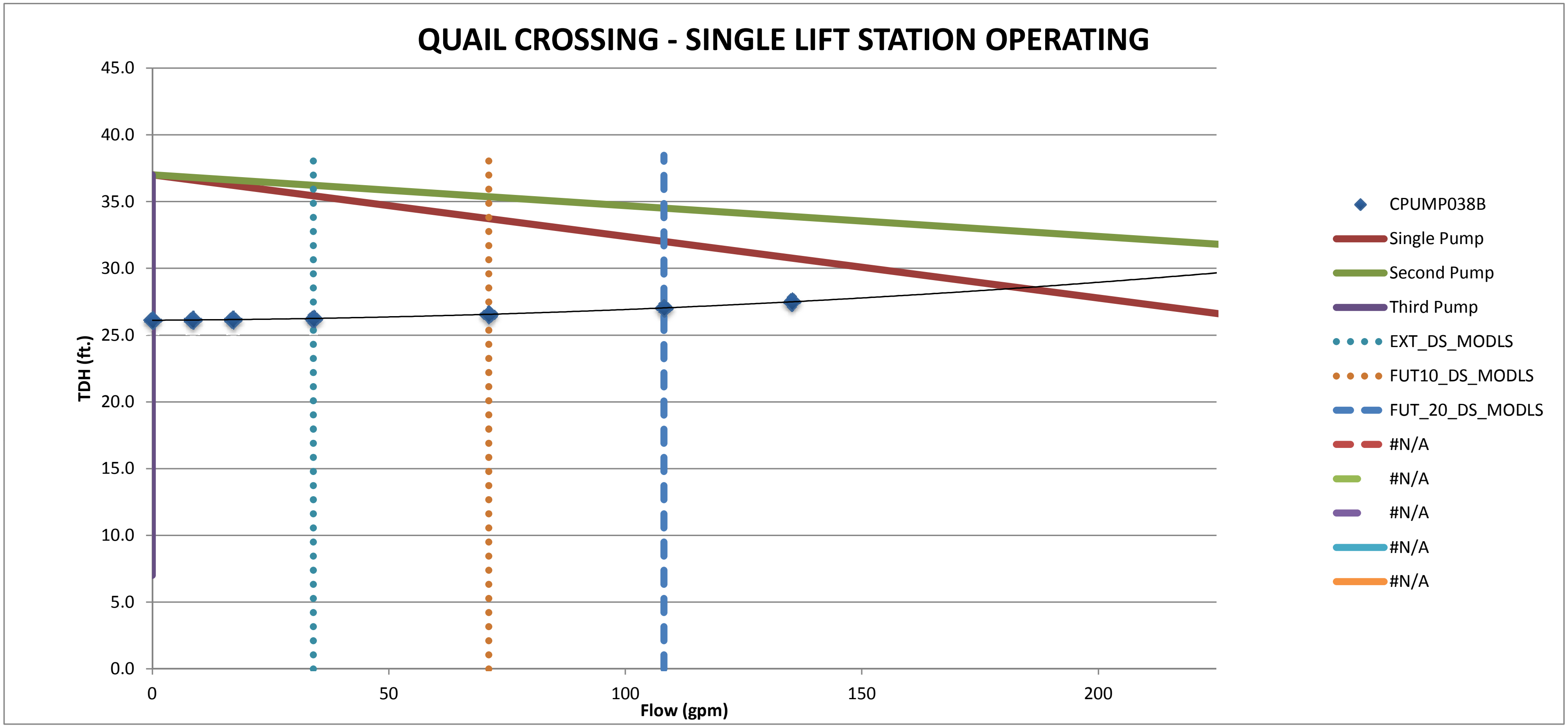


PINE RIDGE - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
44
42
40
38
36
34
32
30
0
50
100
150
200
Flow (gpm)
CPUMP064B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

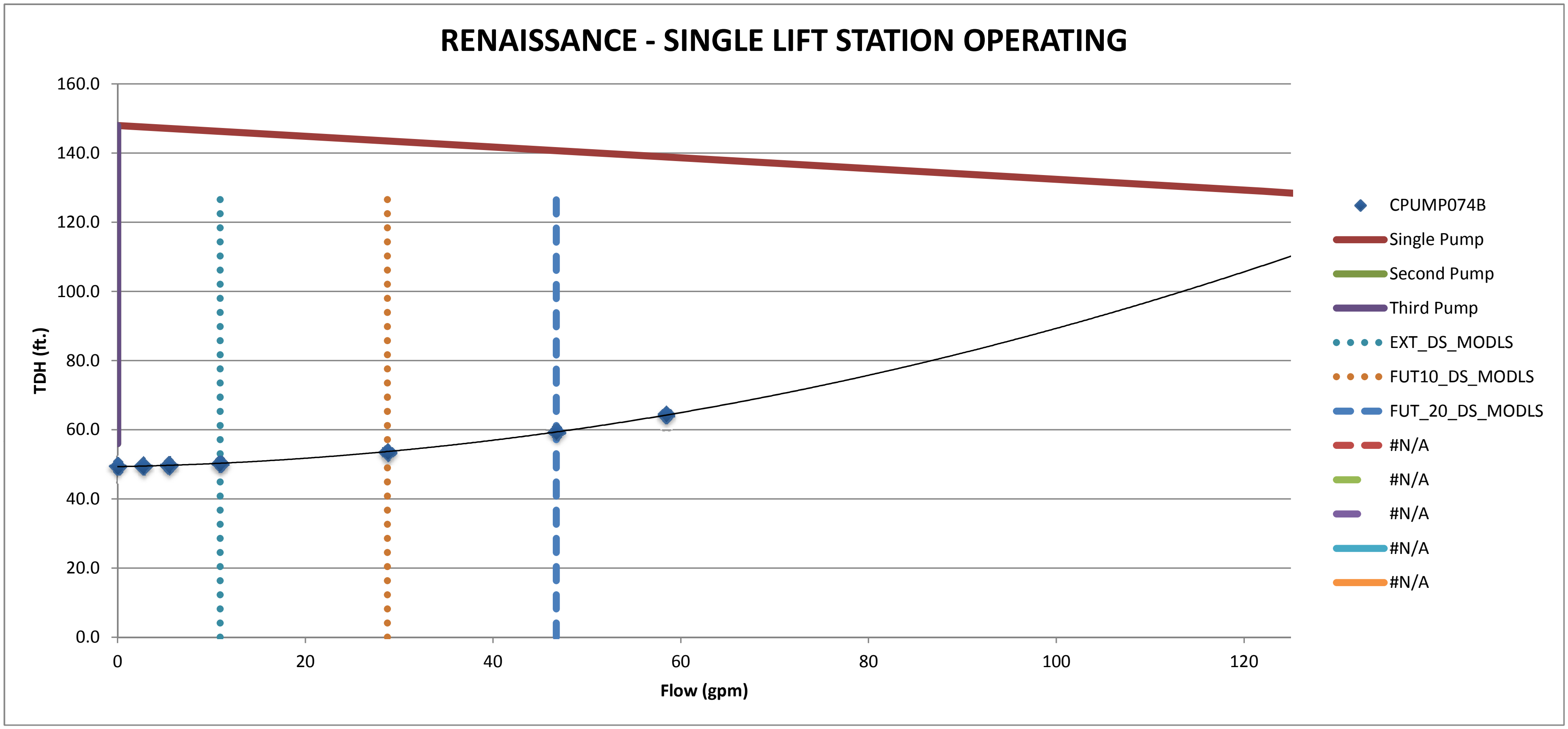

PIONEER - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
120
100
80
60
40
20
0
TDH (ft.)
0
20
40
60
80
100
120
Flow (gpm)
CPUMP021A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

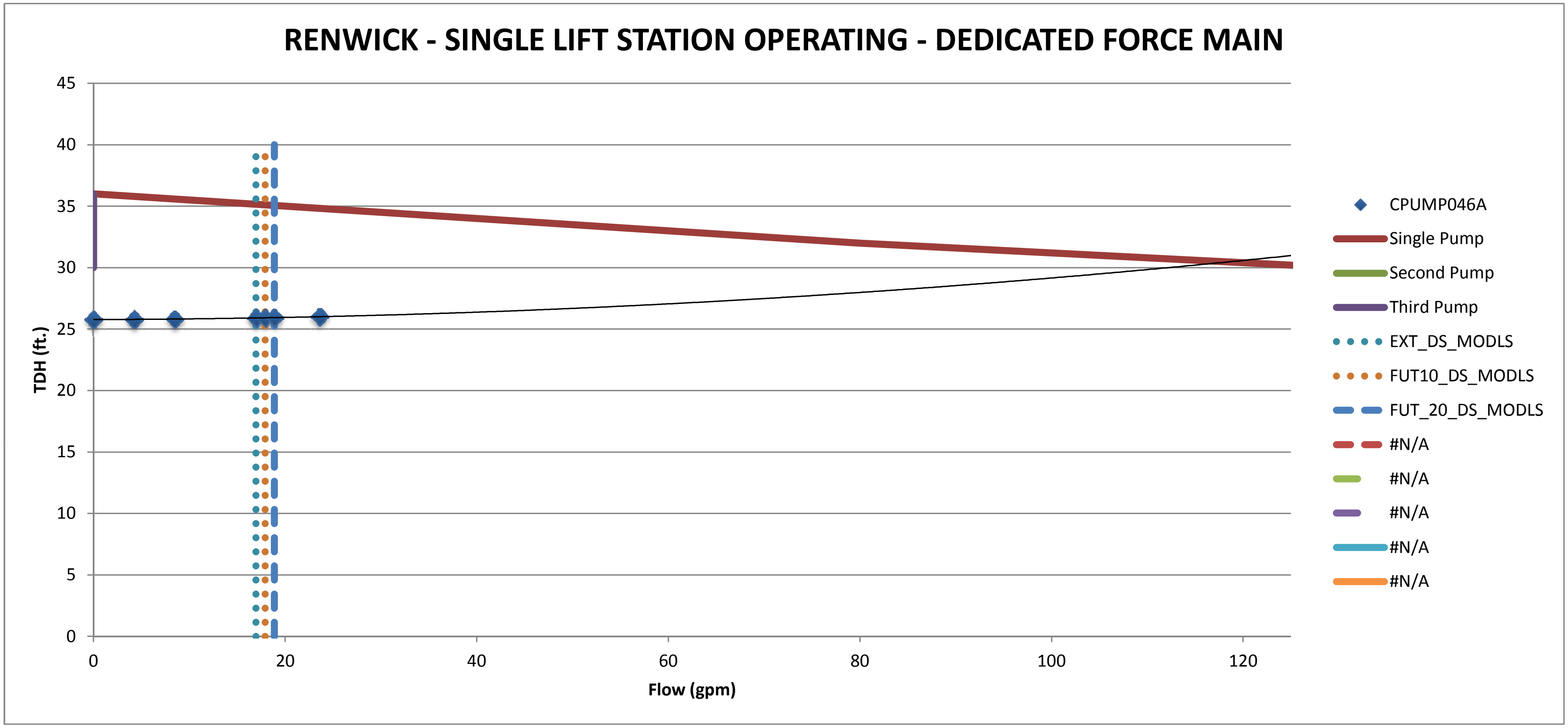


POPLAR PARK - SINGLE LIFT STATION OPERATING
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
TDH (ft.)
0
20
40
60
80
100
120
140
160
180
200
Flow (gpm)
CPUMP069B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

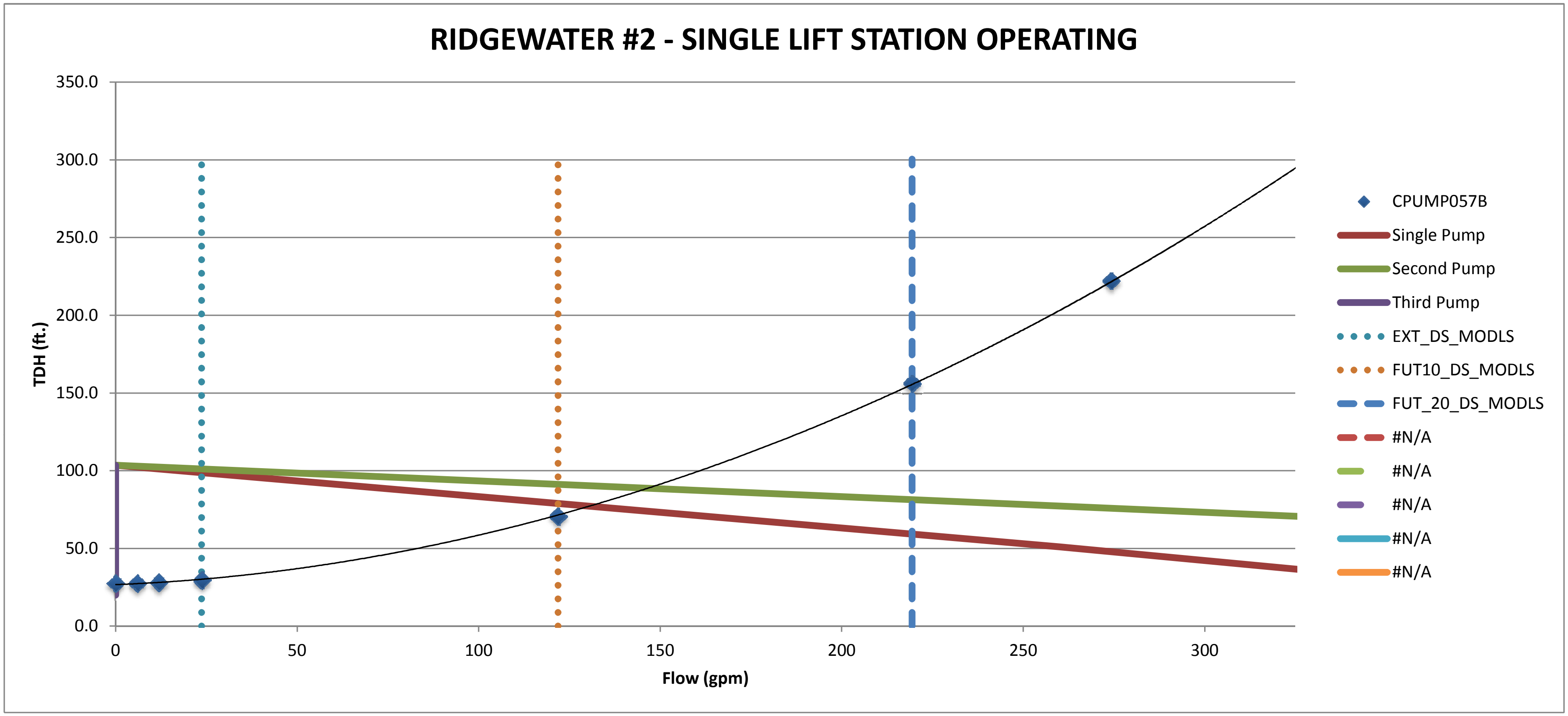


QUAIL CROSSING - SINGLE LIFT STATION OPERATING
TDH (ft.)
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
50
100
150
200
Flow (gpm)
CPUMP038B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

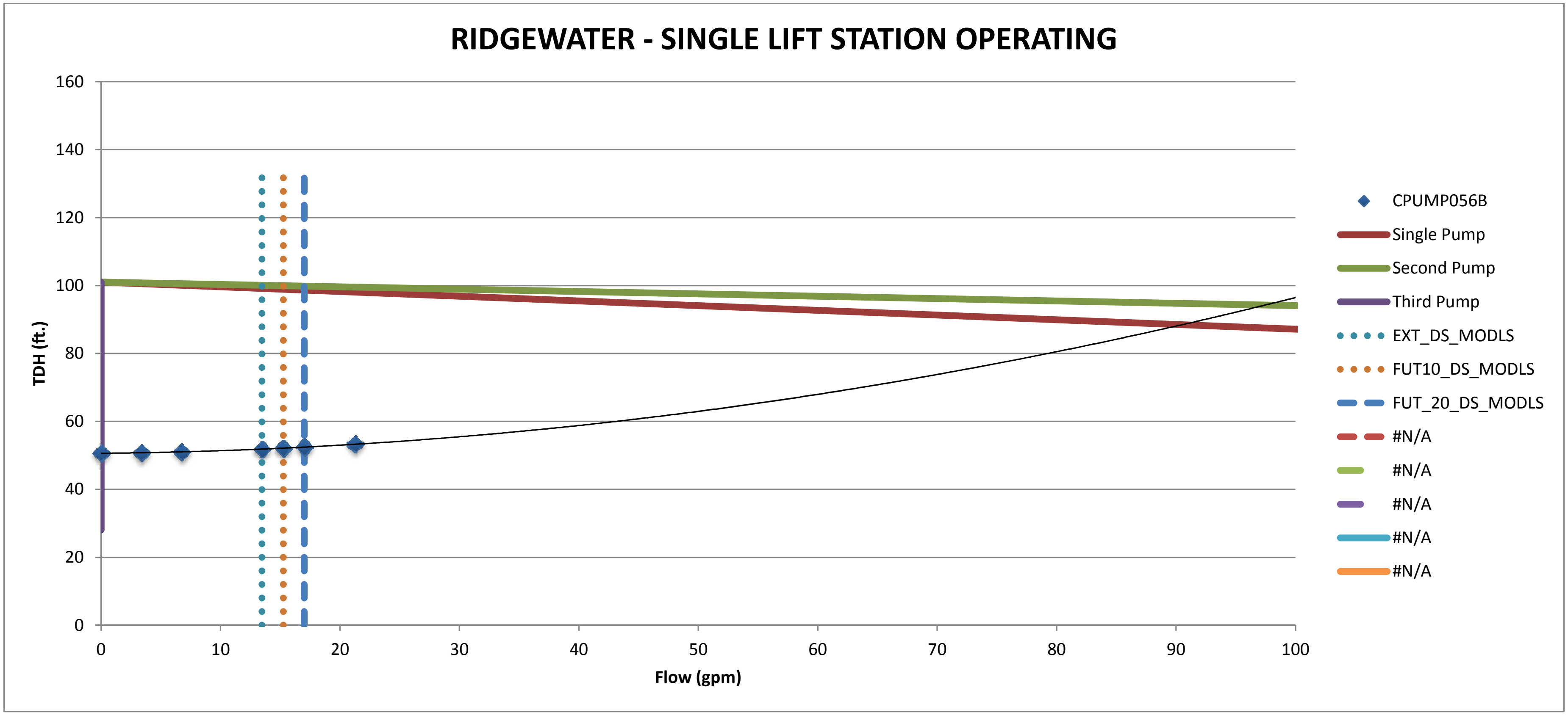

RENAISSANCE - SINGLE LIFT STATION OPERATING
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
TDH (ft.)
0
20
40
60
80
100
120
Flow (gpm)
CPUMP074B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A



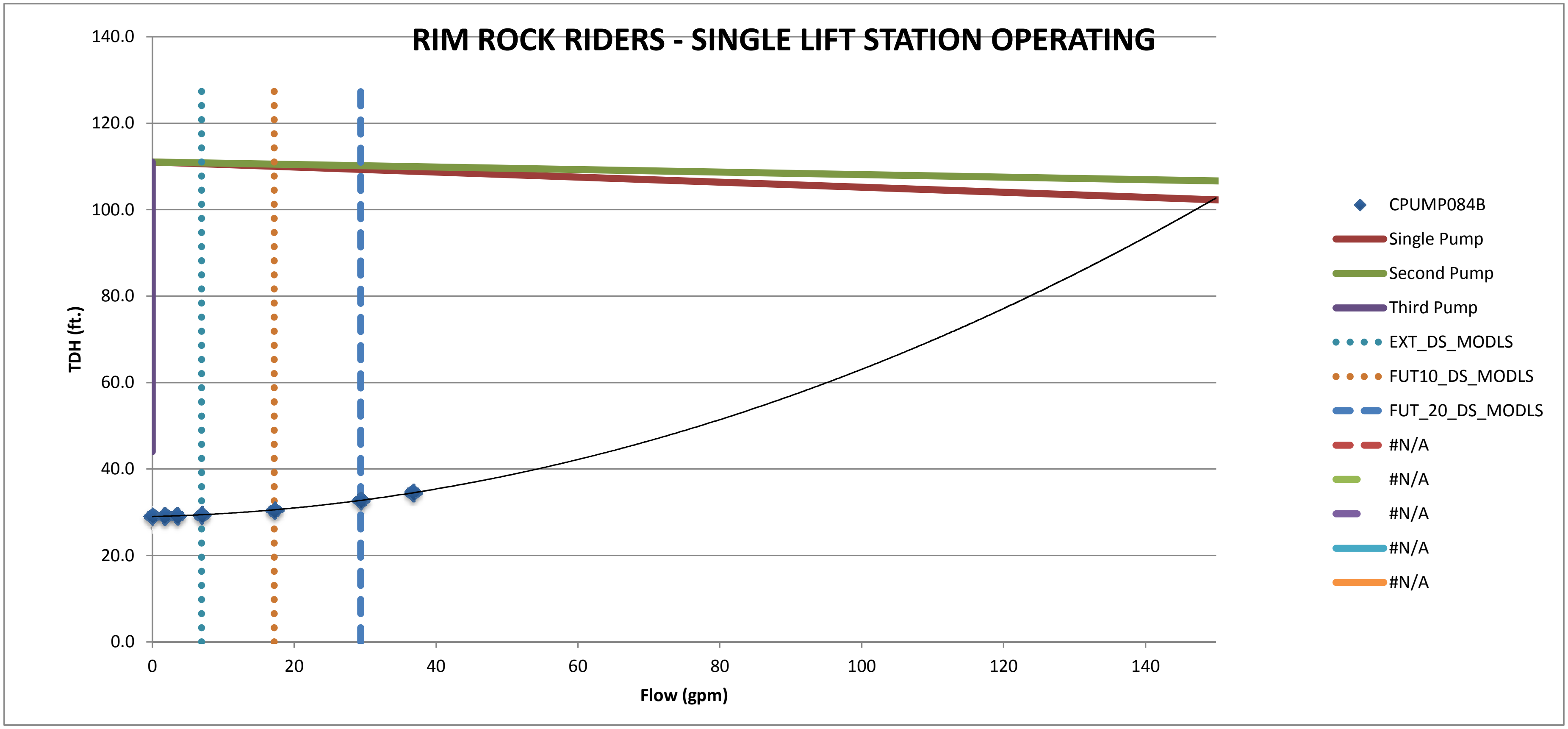
RENWICK - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
45
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
120
Flow (gpm)
CPUMP046A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A



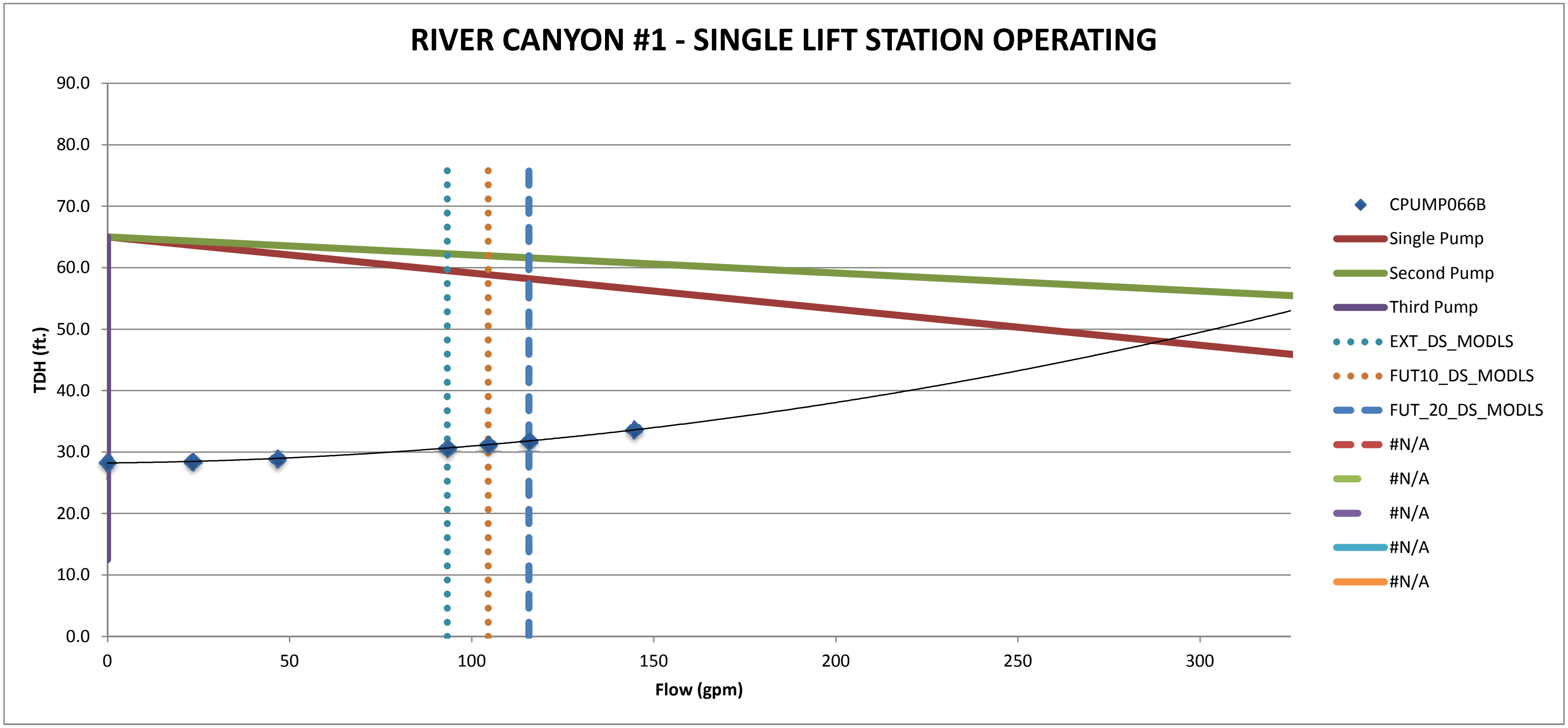
RIDGEWATER #2 - SINGLE LIFT STATION OPERATING
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
TDH (ft.)
0
50
100
150
200
250
300
Flow (gpm)
CPUMP057B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A



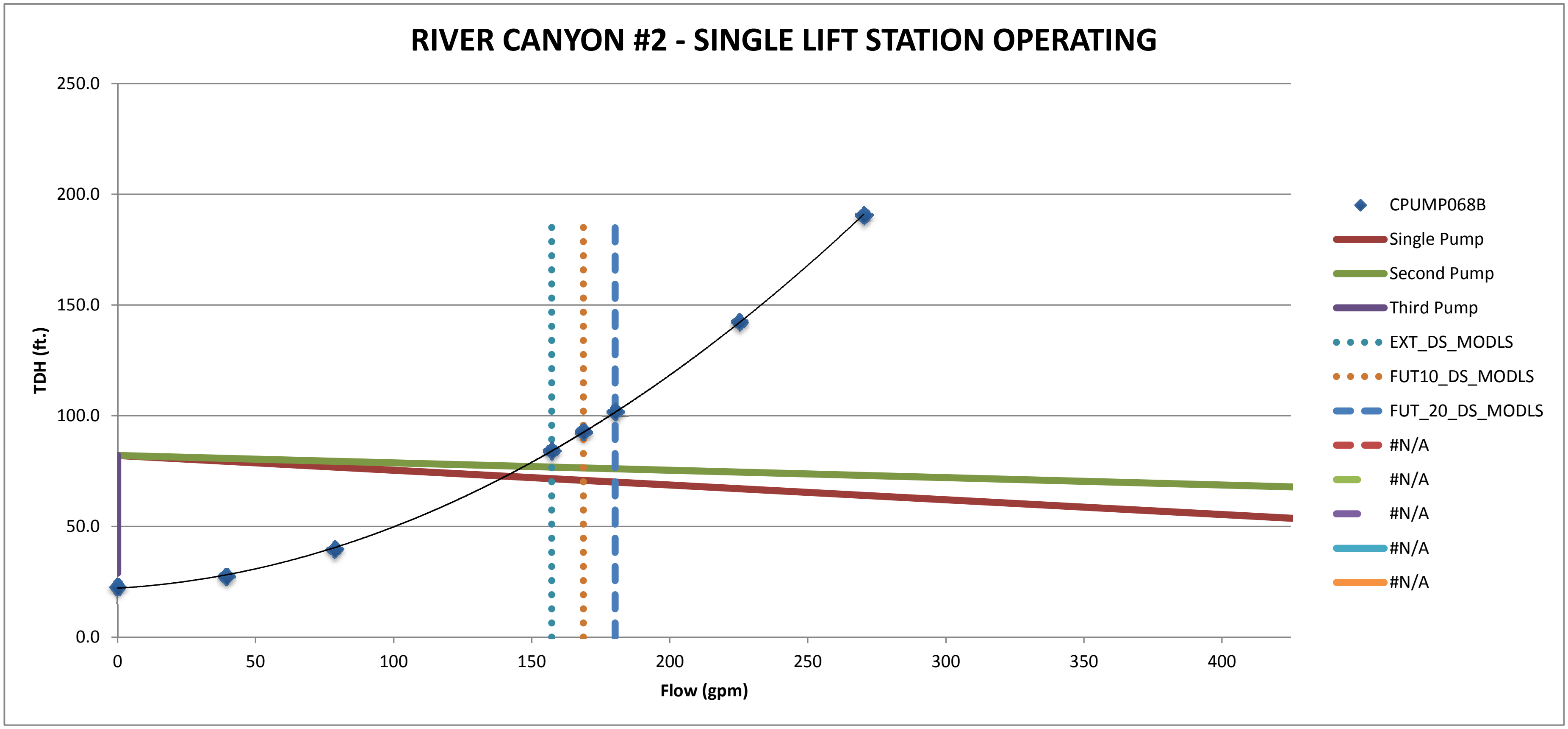
RIDGEWATER - SINGLE LIFT STATION OPERATING
160
140
120
100
80
60
40
20
0
TDH (ft.)
0
10
20
30
40
50
60
70
80
90
100
Flow (gpm)
CPUMP056B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A



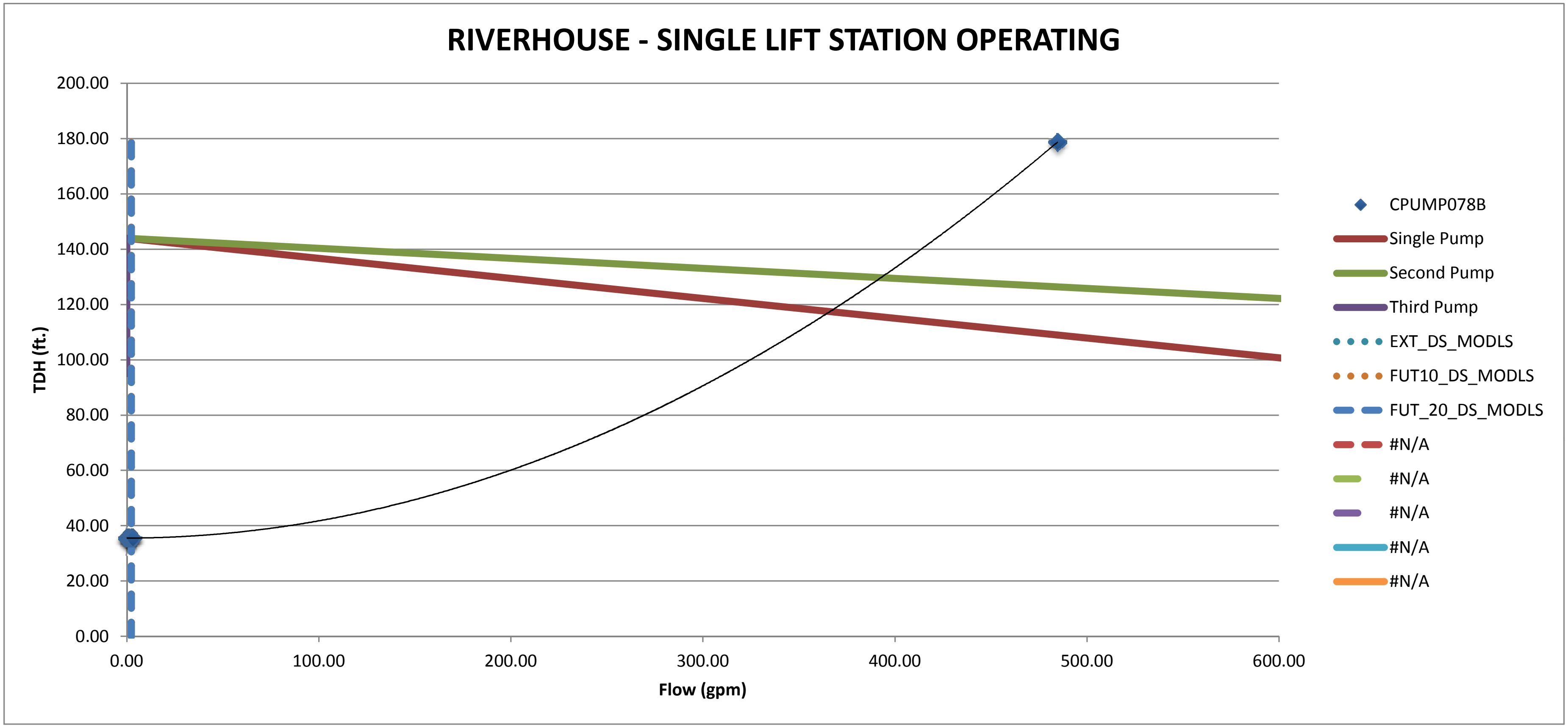
RIM ROCK RIDERS - SINGLE LIFT STATION OPERATING
TDH (ft.)
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0
20
40
60
80
100
120
140
Flow (gpm)
CPUMP084B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A



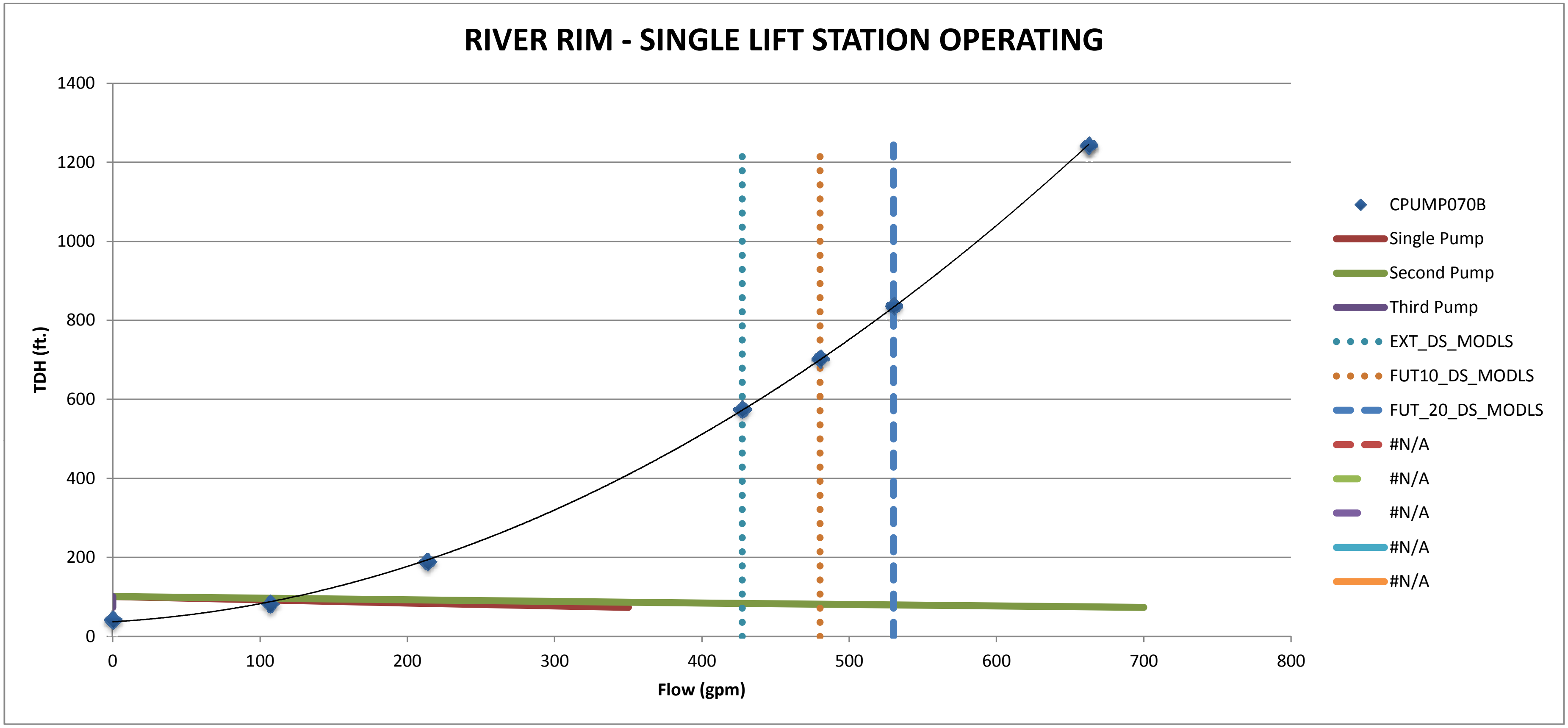
RIVER CANYON #1 - SINGLE LIFT STATION OPERATING
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
TDH (ft.)
0
50
100
150
200
250
300
Flow (gpm)
CPUMP066B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A



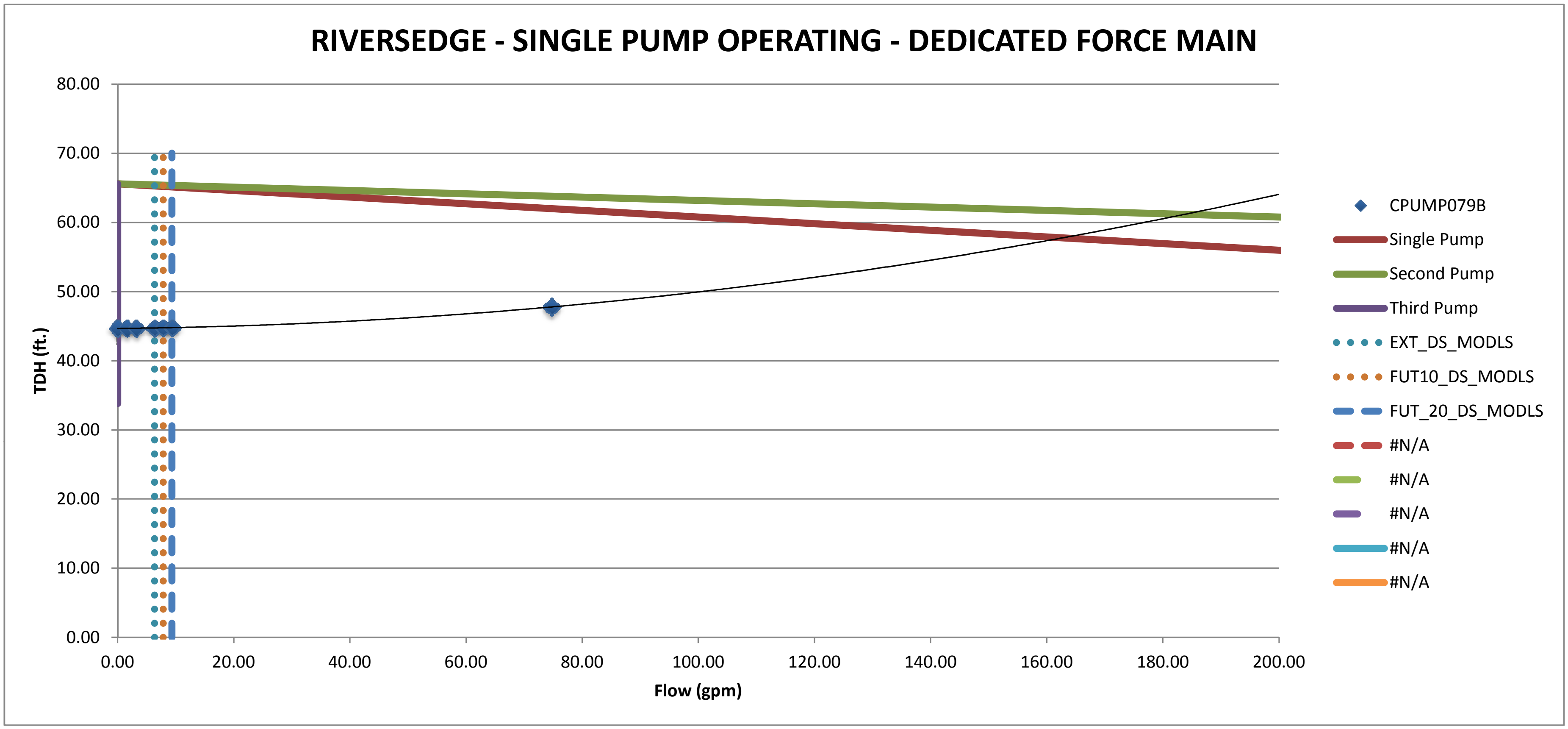
RIVER CANYON #2 - SINGLE LIFT STATION OPERATING
TDH (ft.)
250.0
200.0
150.0
100.0
50.0
0.0
0
50
100
150
200
250
300
350
400
Flow (gpm)
CPUMP068B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

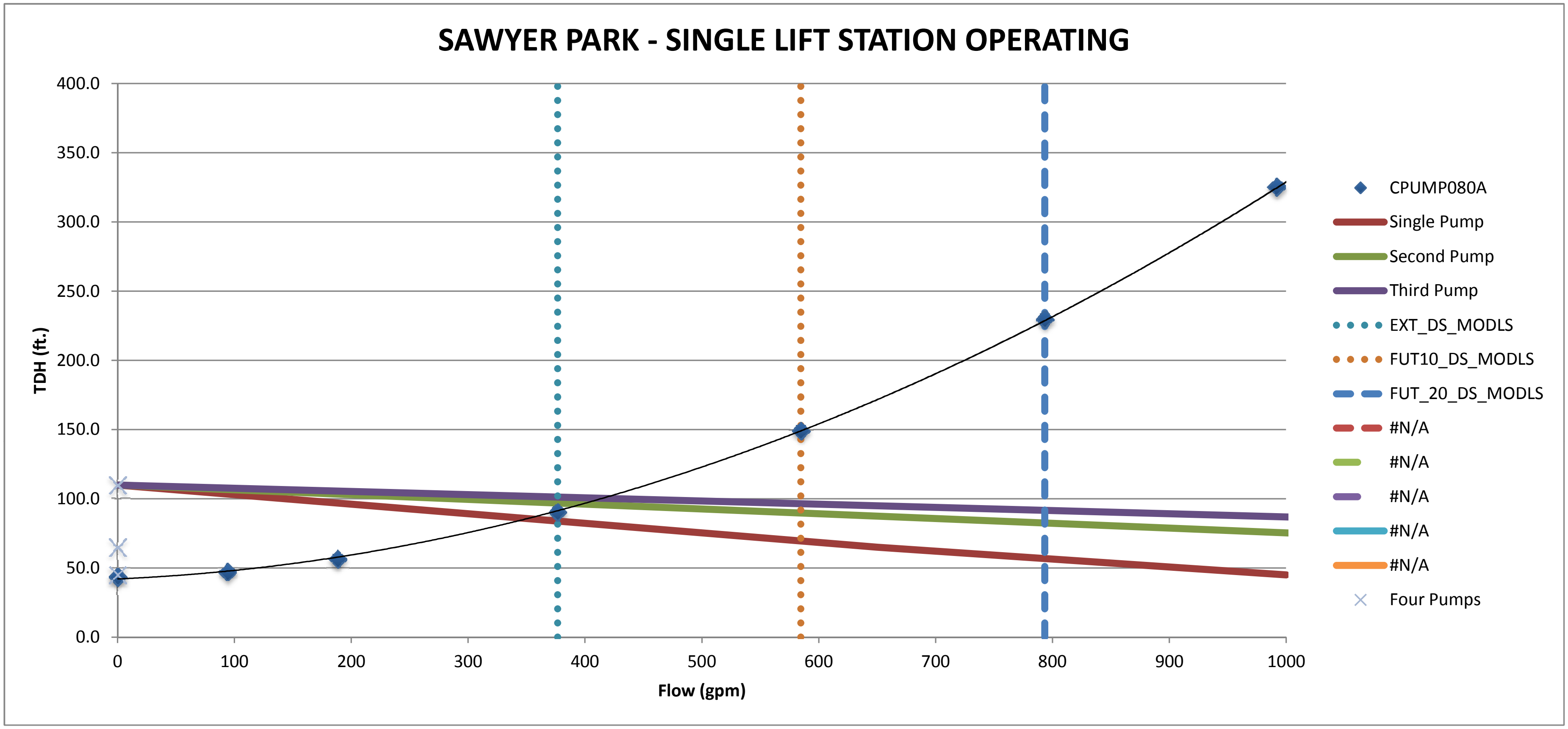


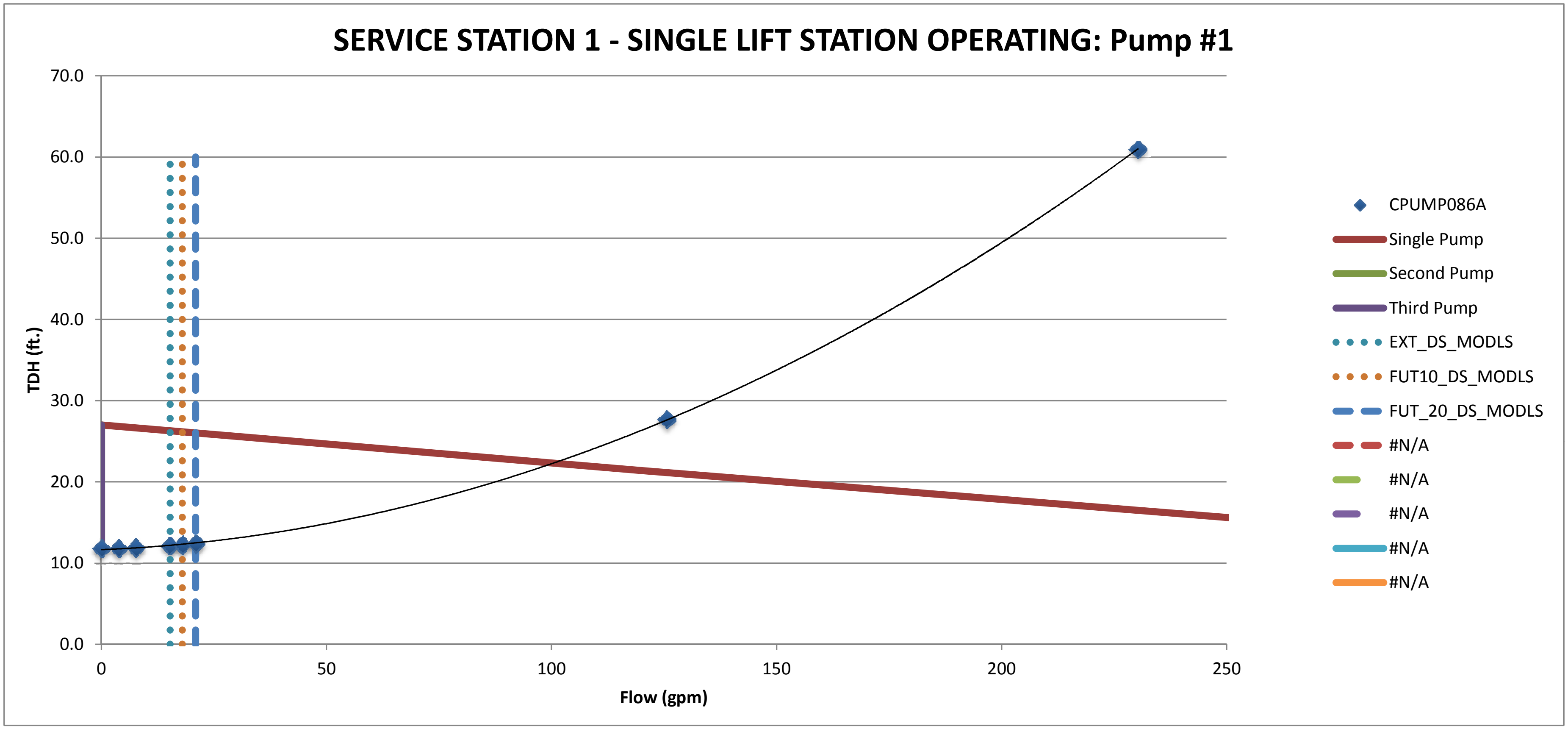
RIVERHOUSE - SINGLE LIFT STATION OPERATING
TDH (ft.)
200.00
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0.00
100.00
200.00
300.00
400.00
500.00
600.00
Flow (gpm)
CPUMP078B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A



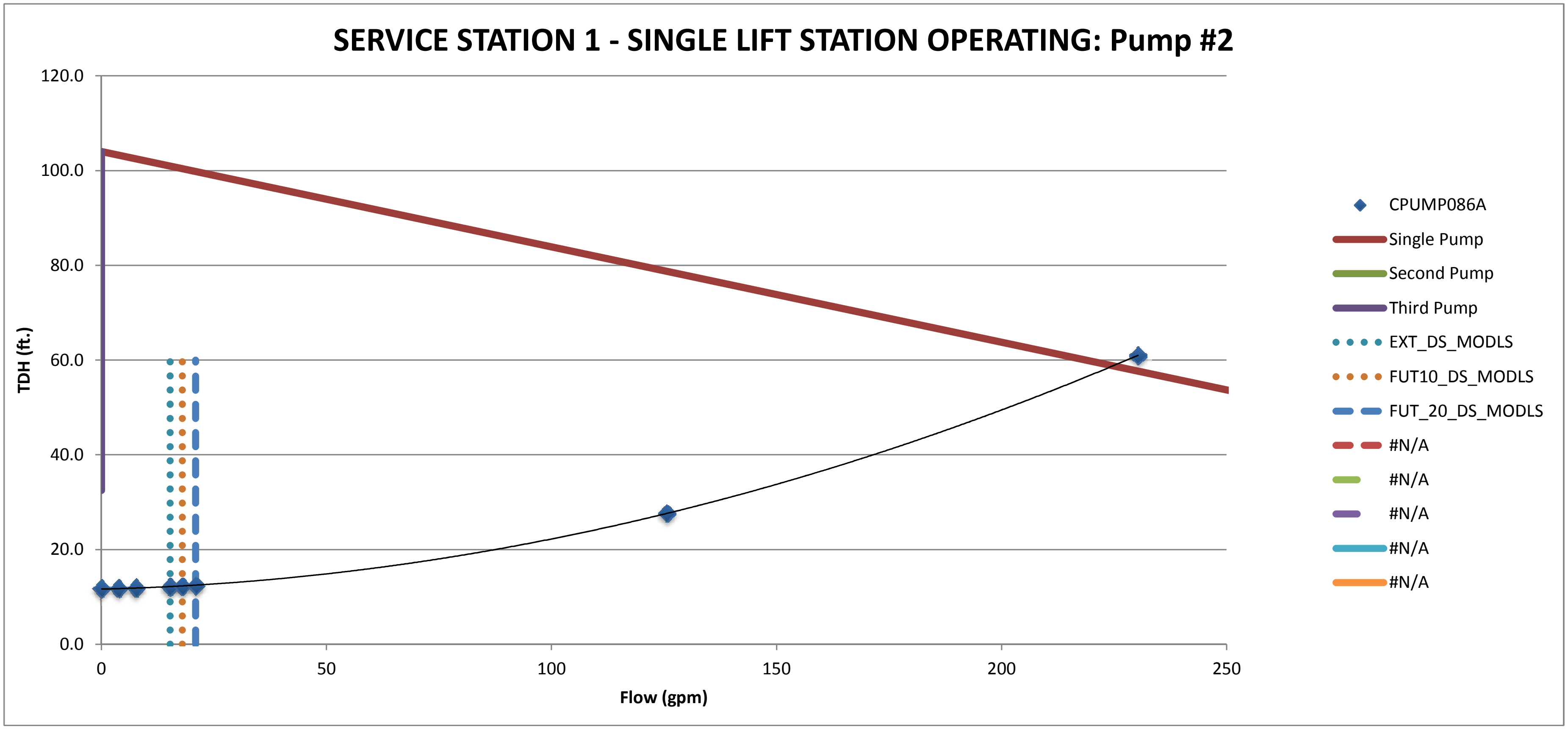
RIVER RIM - SINGLE LIFT STATION OPERATING
1400
1200
1000
800
600
400
200
0
TDH (ft.)
0
100
200
300
400
500
600
700
800
Flow (gpm)
CPUMP070B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

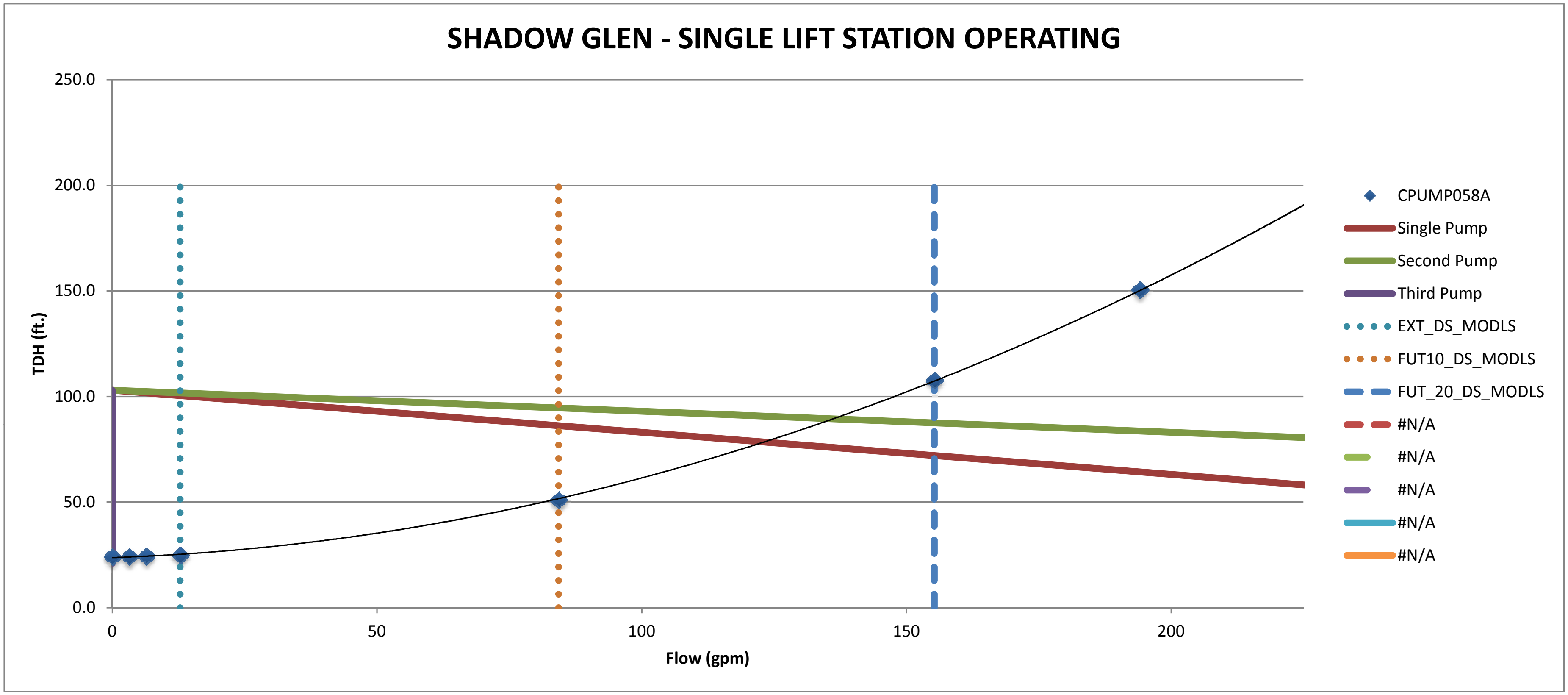

RIVERSEDGE - SINGLE PUMP OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
Flow (gpm)
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
CPUMP079B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

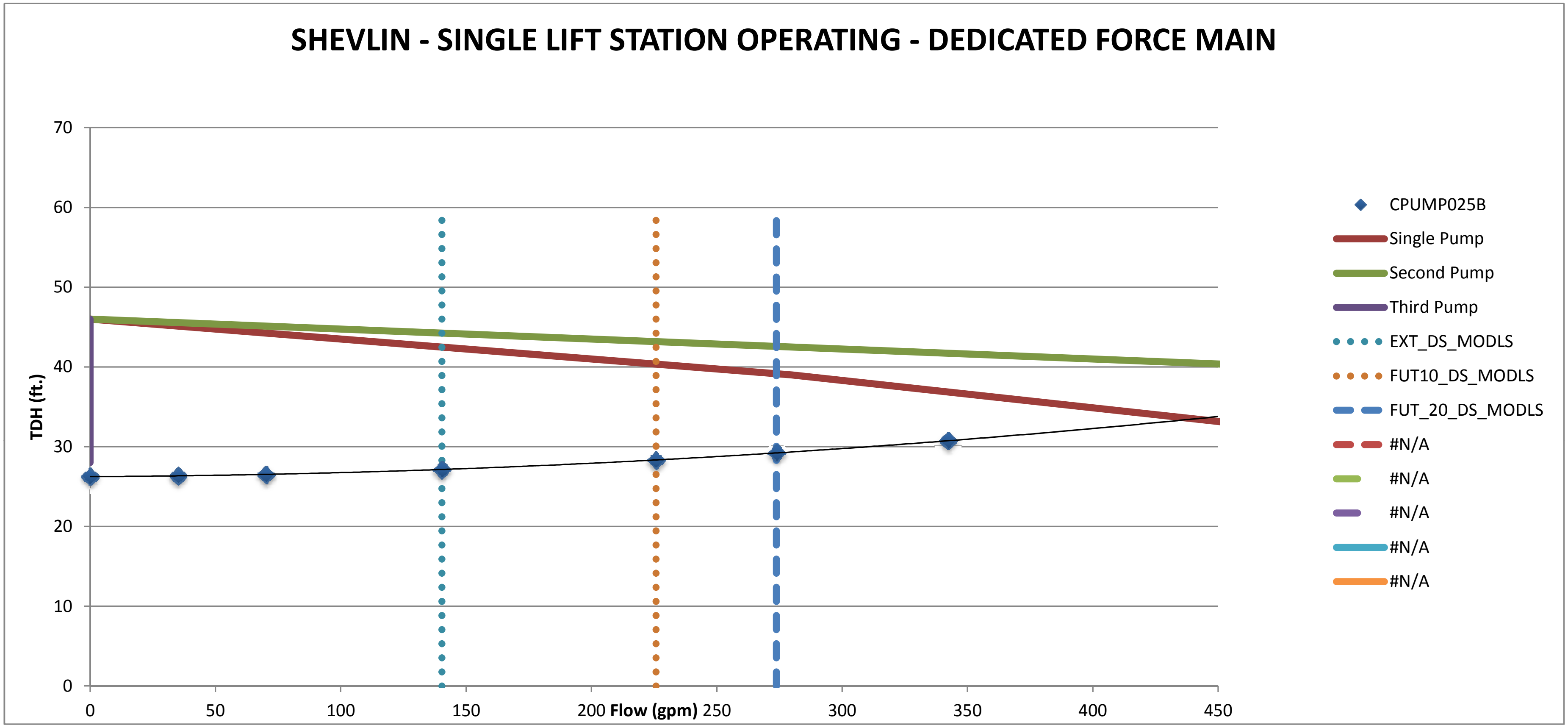

SAWYER PARK - SINGLE LIFT STATION OPERATING
TDH (ft.)
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0
100
200
300
400
500
600
700
800
900
1000
Flow (gpm)
CPUMP080A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A
Four Pumps

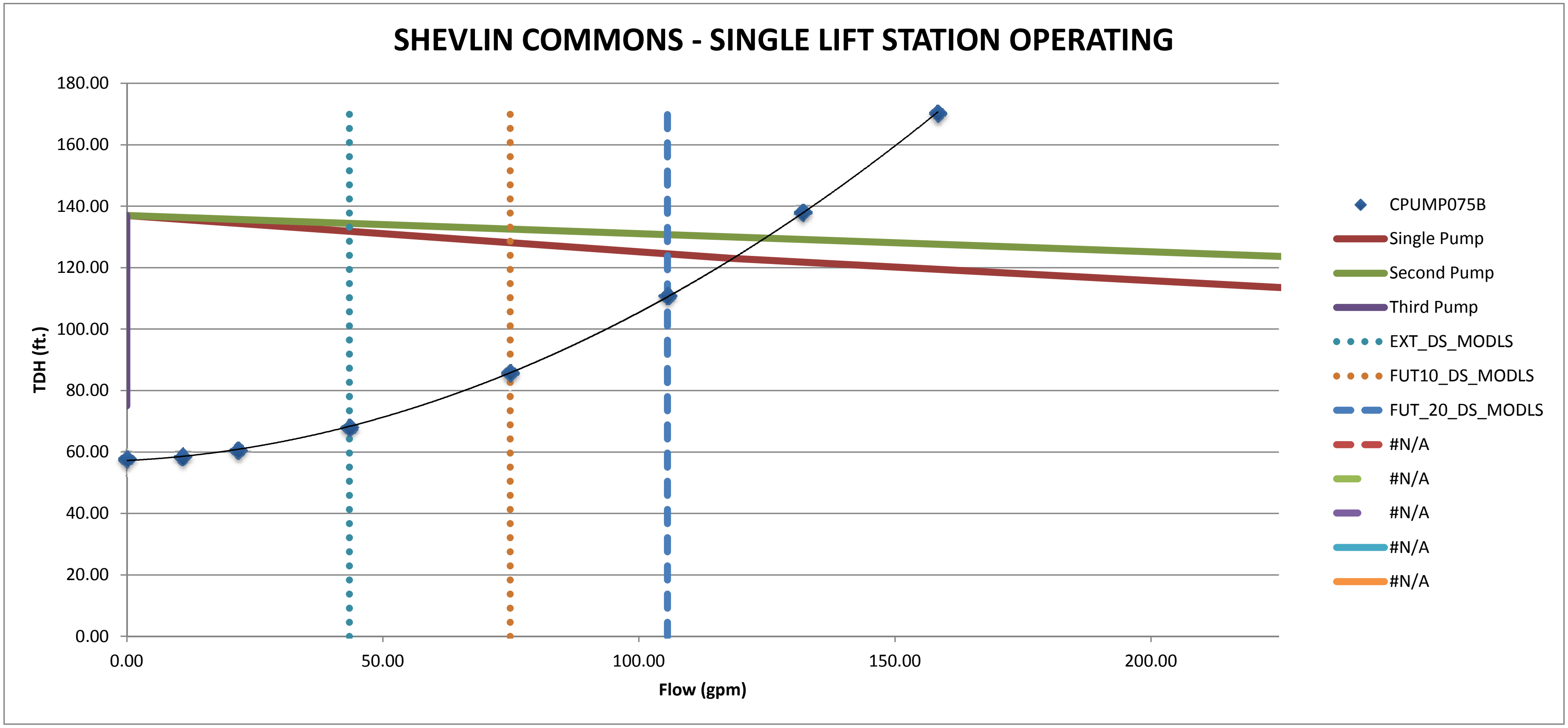


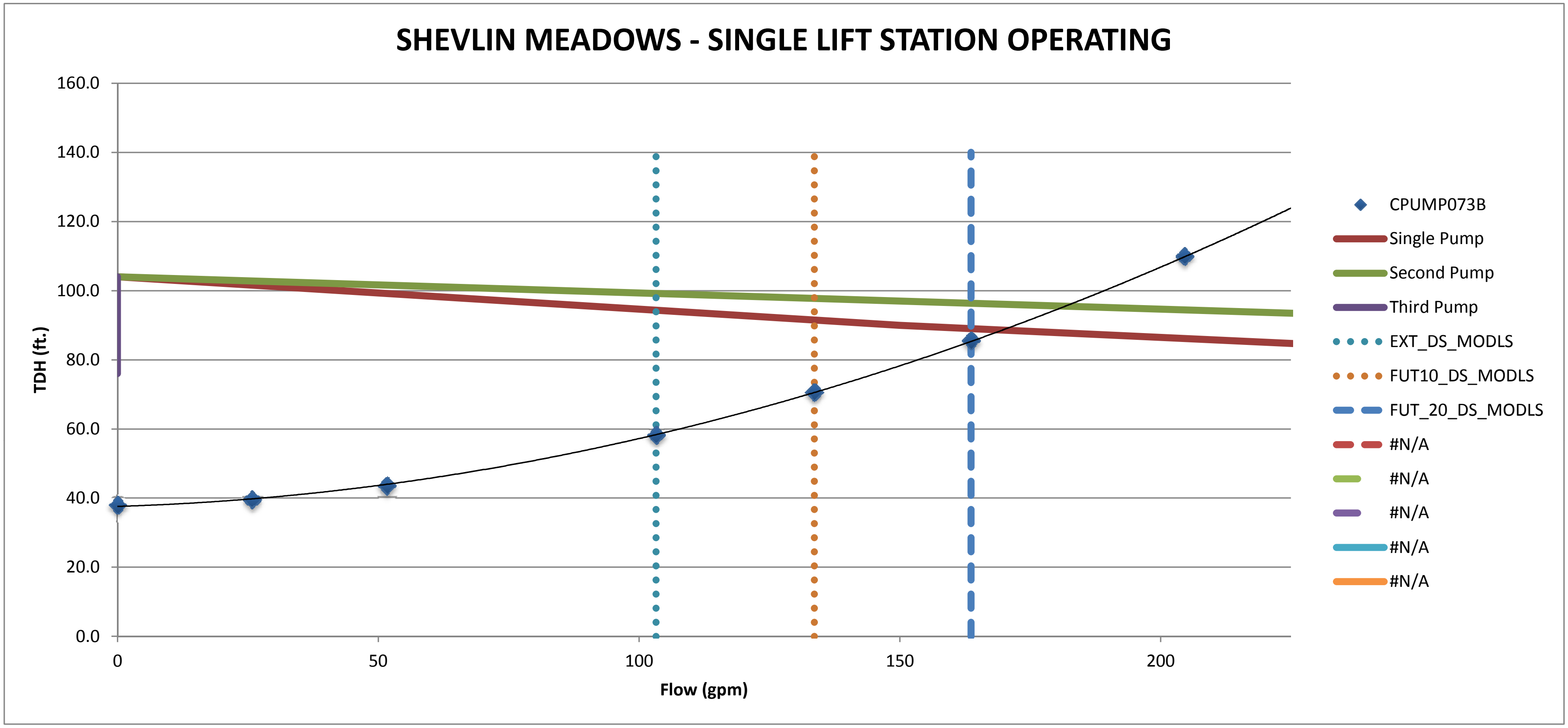
SERVICE STATION 1 - SINGLE LIFT STATION OPERATING: Pump #1
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
TDH (ft.)
0
50
100
150
200
250
Flow (gpm)
CPUMP086A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

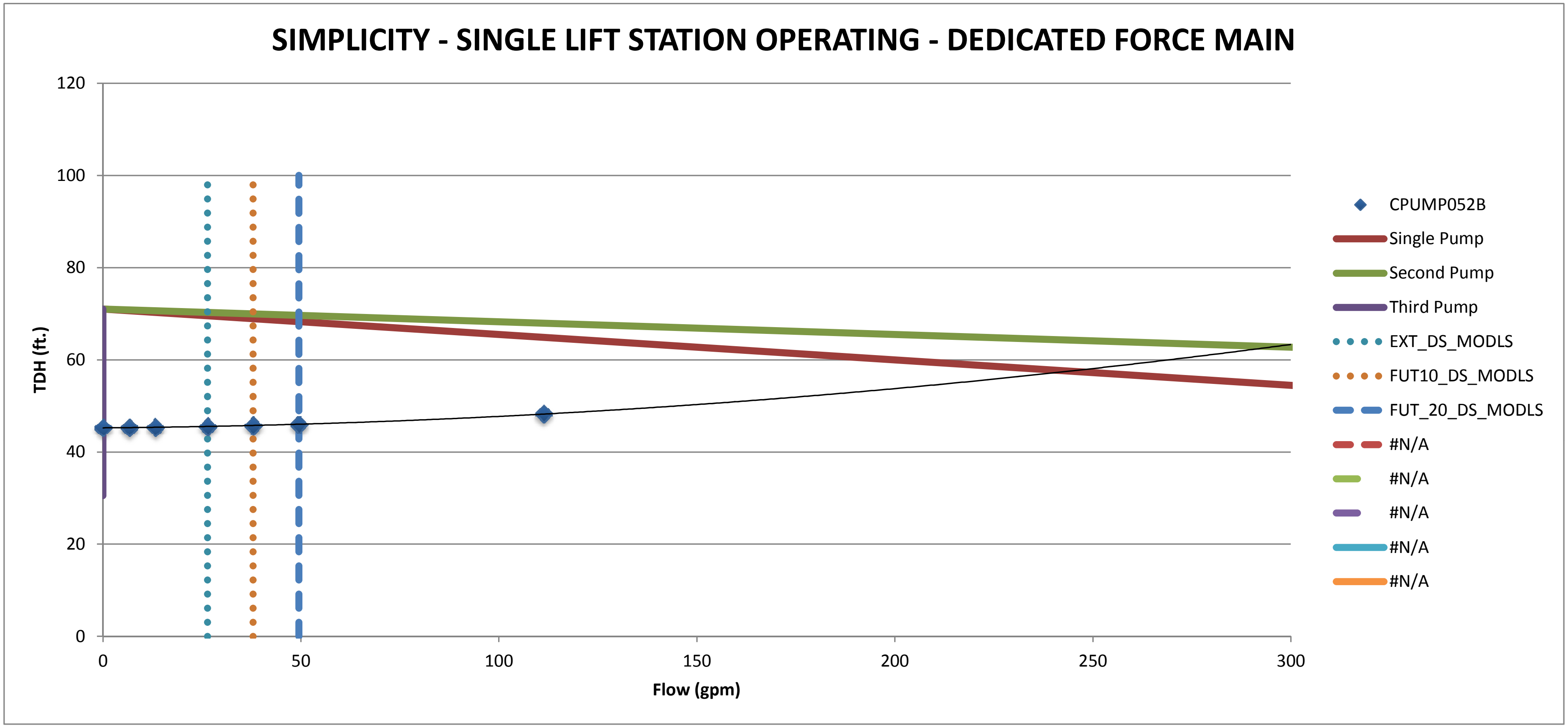

SERVICE STATION 1 - SINGLE LIFT STATION OPERATING: Pump #2
120.0
100.0
80.0
60.0
40.0
20.0
0.0
TDH (ft.)
0
50
100
150
200
250
Flow (gpm)
CPUMP086A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A


SHADOW GLEN - SINGLE LIFT STATION OPERATING
250.0
200.0
150.0
100.0
50.0
0.0
TDH (ft.)
0
50
100
150
200
Flow (gpm)
CPUMP058A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

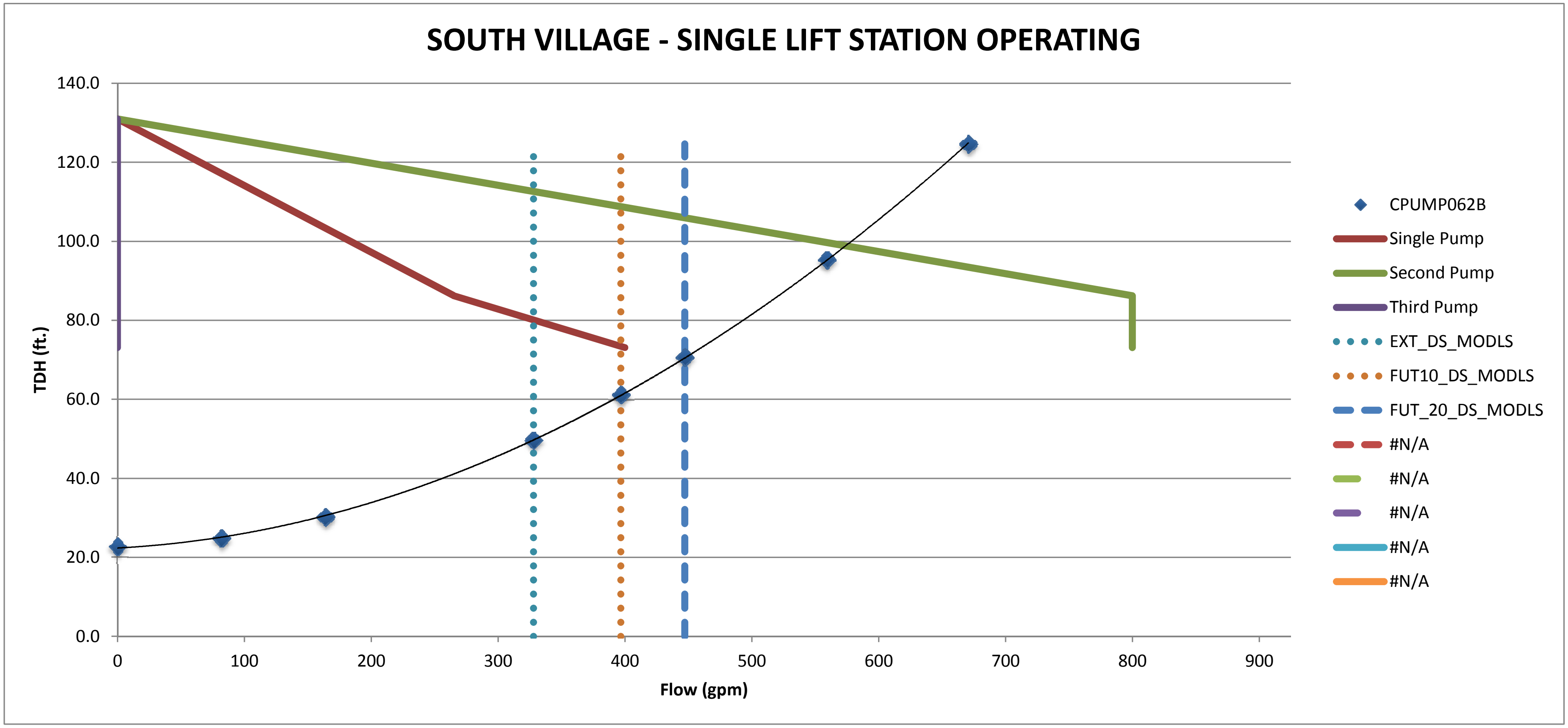

SHEVLIN - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
Flow (gpm)
0
10
20
30
40
50
60
70
0
50
100
150
200
250
300
350
400
450
CPUMP025B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A


SHEVLIN COMMONS - SINGLE LIFT STATION OPERATING
TDH (ft.)
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0.00
50.00
100.00
150.00
200.00
Flow (gpm)
CPUMP075B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

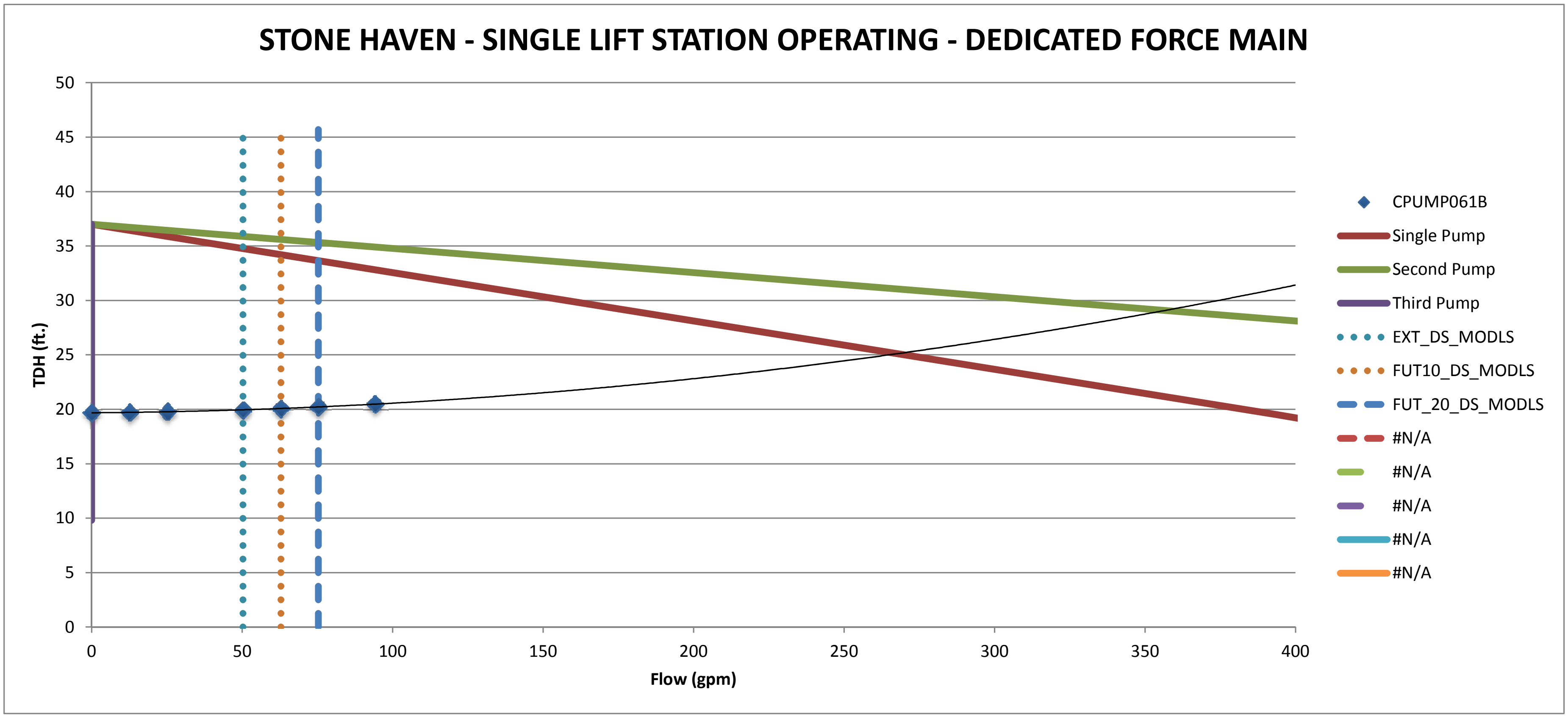

SHEVLIN MEADOWS - SINGLE LIFT STATION OPERATING
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
TDH (ft.)
0
50
100
150
200
Flow (gpm)
CPUMP073B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A



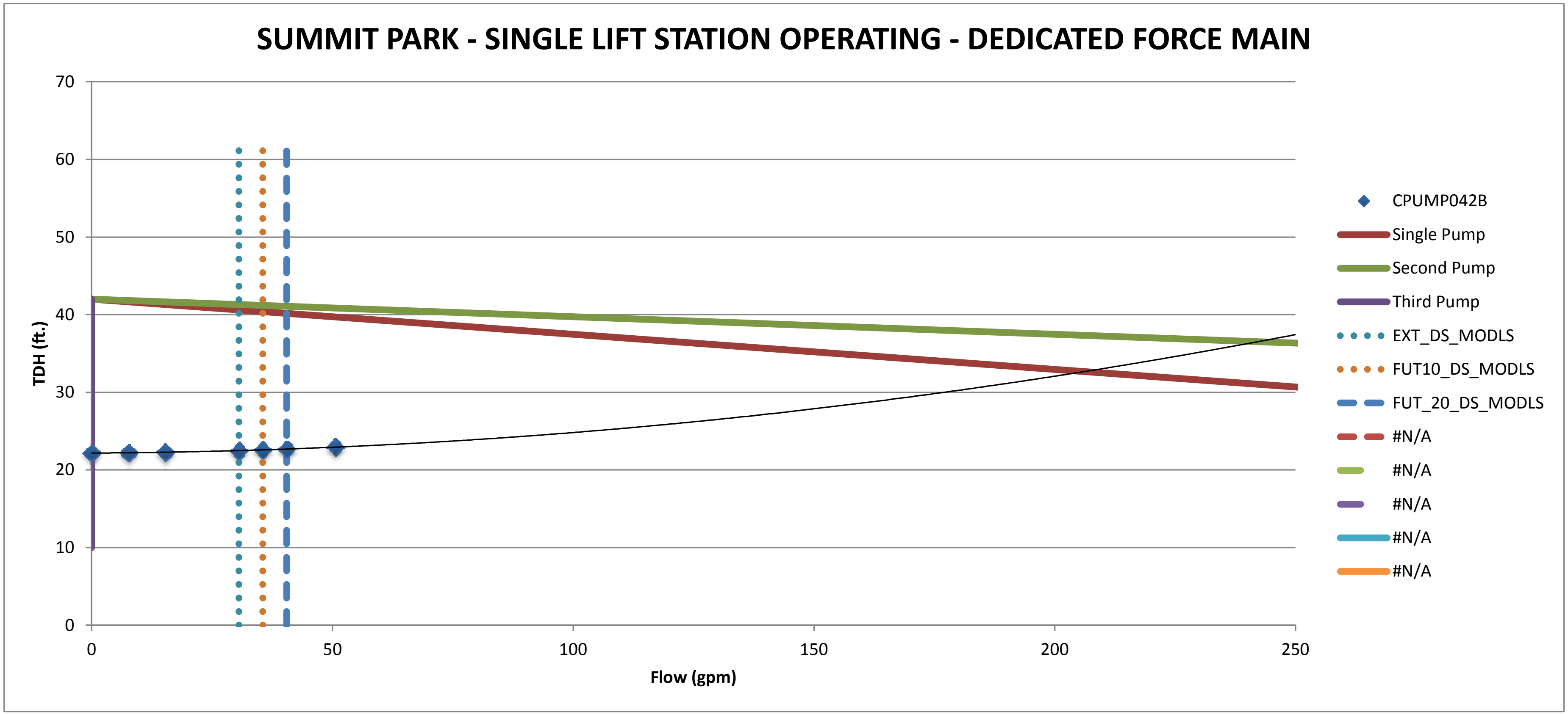
SIMPLICITY - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
Flow (gpm)
0
20
40
60
80
100
120
0
50
100
150
200
250
300
CPUMP052B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

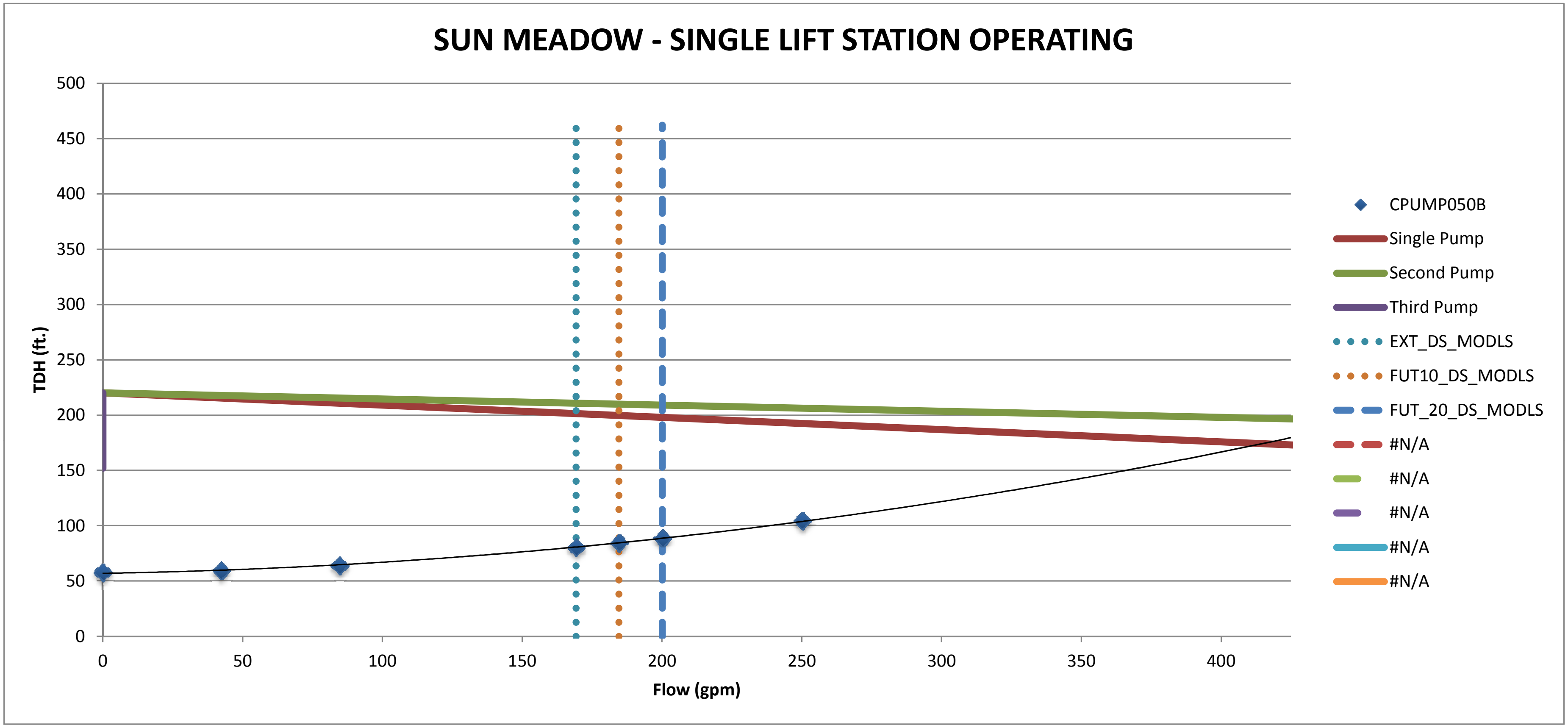


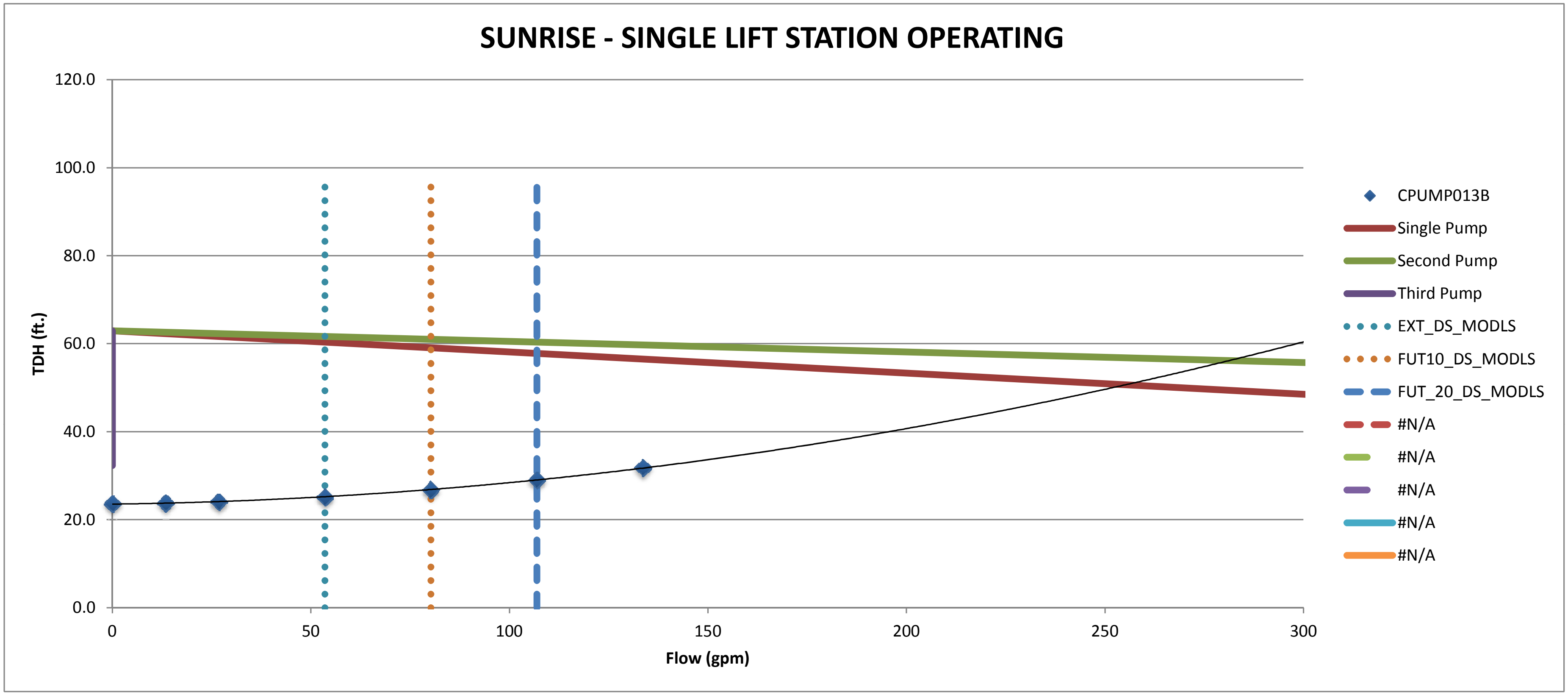
SOUTH VILLAGE - SINGLE LIFT STATION OPERATING
TDH (ft.)
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0
100
200
300
400
500
600
700
800
900
Flow (gpm)
CPUMP062B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A



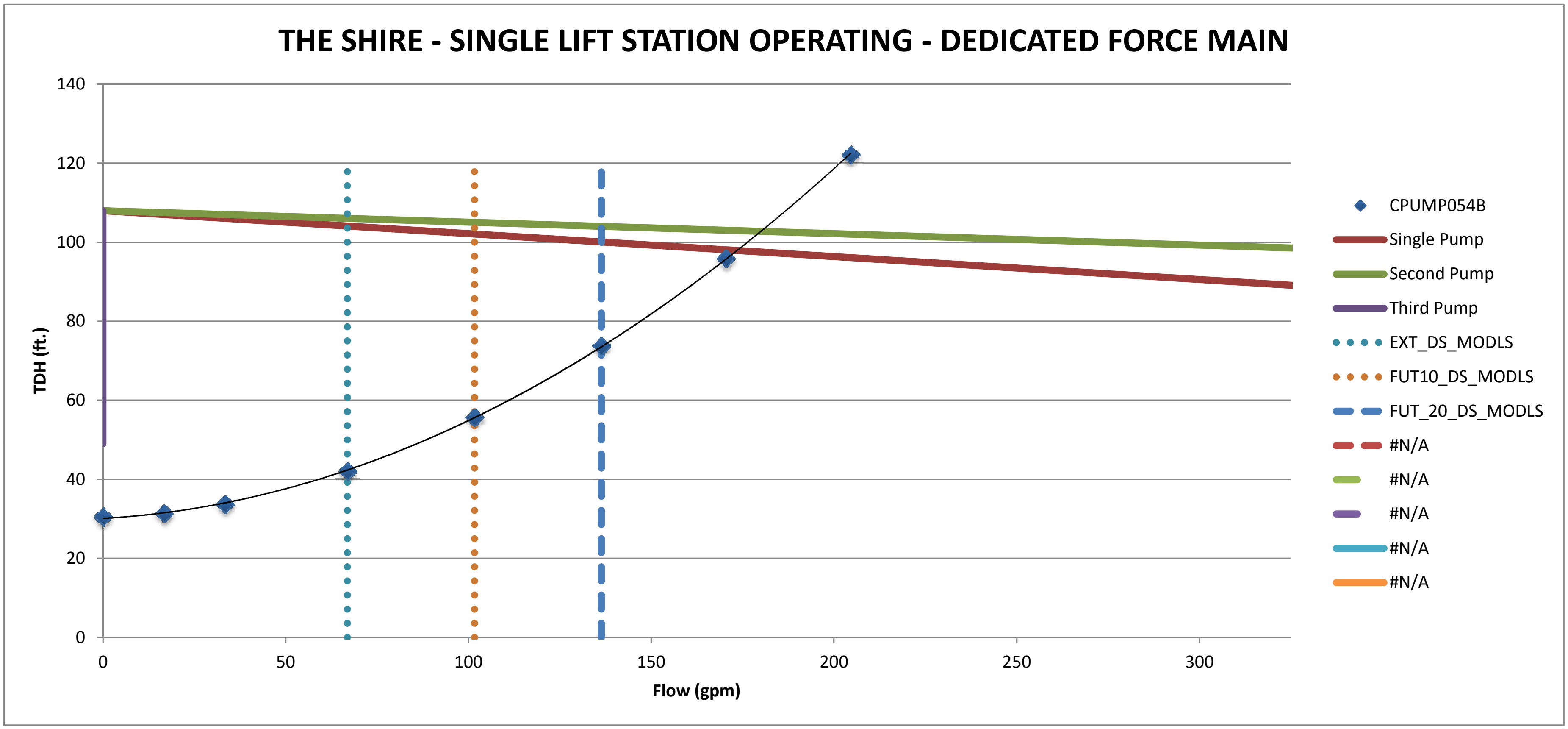
STONE HAVEN - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
50
45
40
35
30
25
20
15
10
5
0
0
50
100
150
200
250
300
350
400
Flow (gpm)
CPUMP061B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

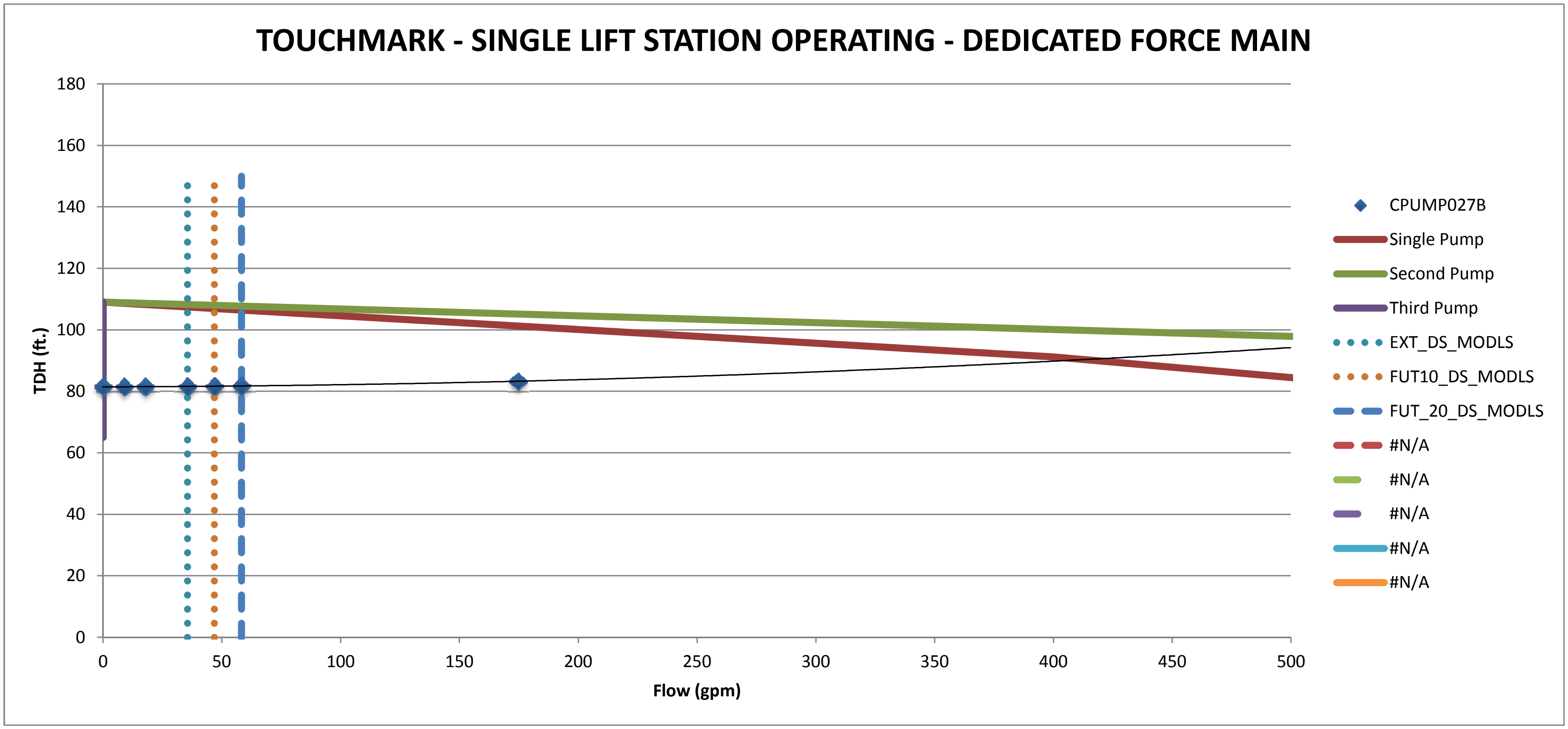

SUMMIT PARK - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
70
60
50
40
30
20
10
0
0
50
100
150
200
250
Flow (gpm)
CPUMP042B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

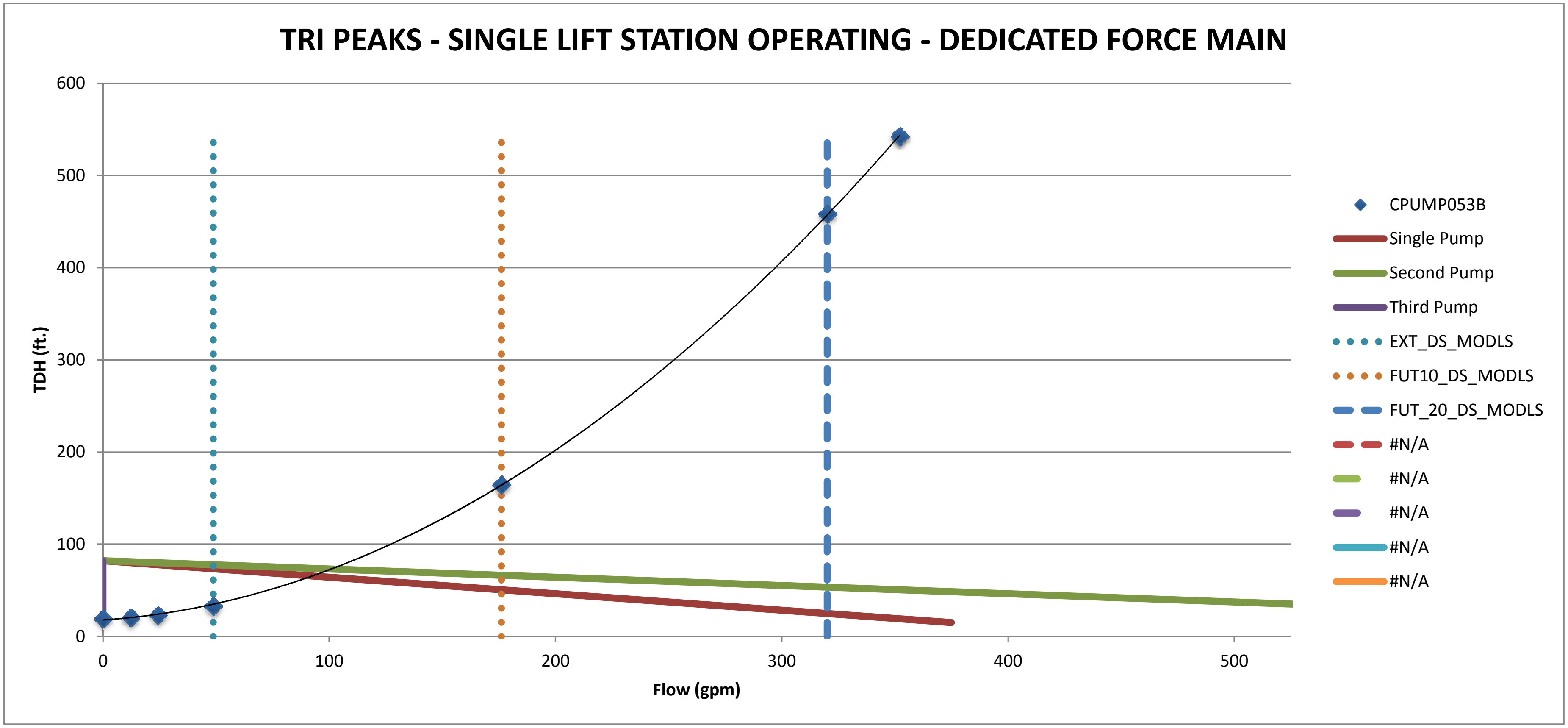

SUN MEADOW - SINGLE LIFT STATION OPERATING
TDH (ft.)
500
450
400
350
300
250
200
150
100
50
0
0
50
100
150
200
250
300
350
400
Flow (gpm)
CPUMP050B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A



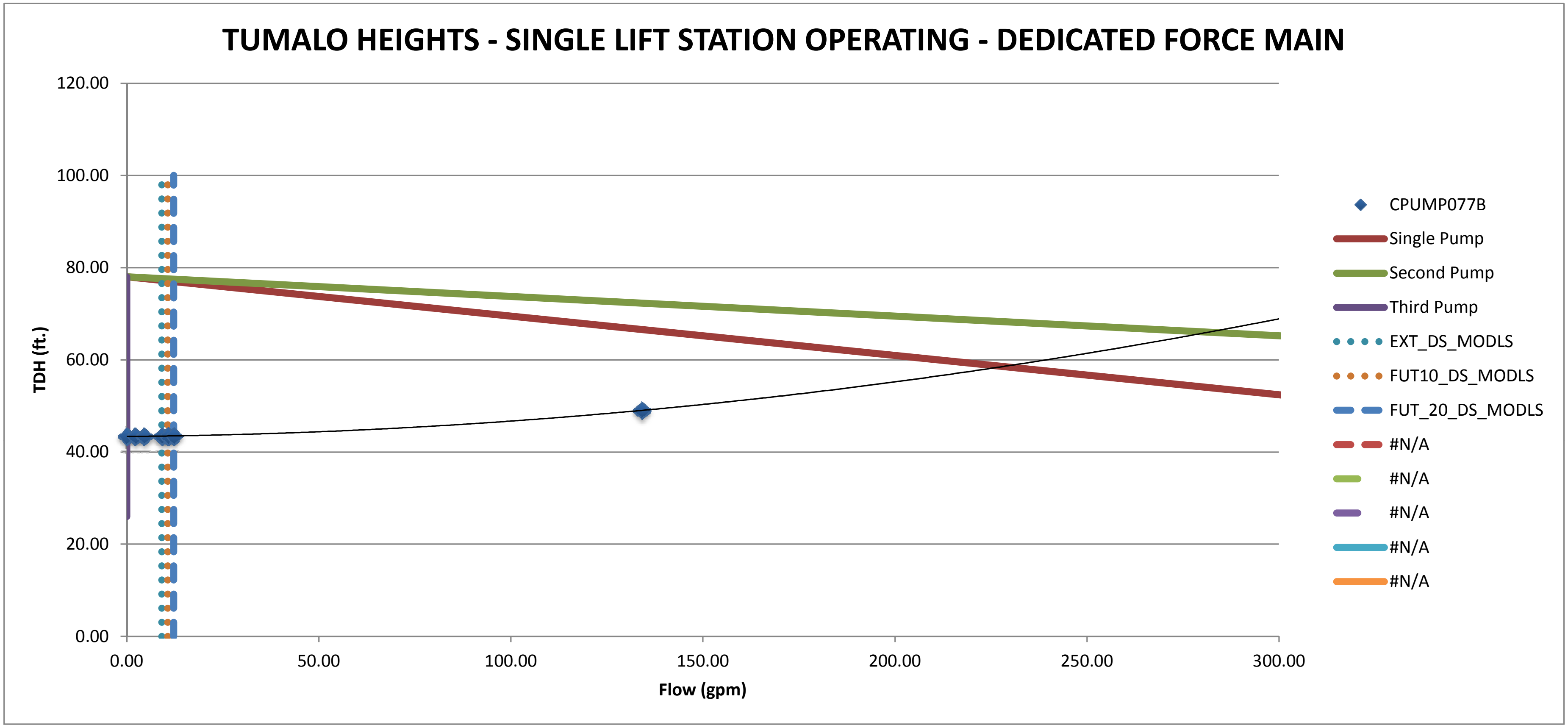
SUNRISE - SINGLE LIFT STATION OPERATING
120.0
100.0
80.0
60.0
40.0
20.0
0.0
TDH (ft.)
0
50
100
150
200
250
300
Flow (gpm)
CPUMP013B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

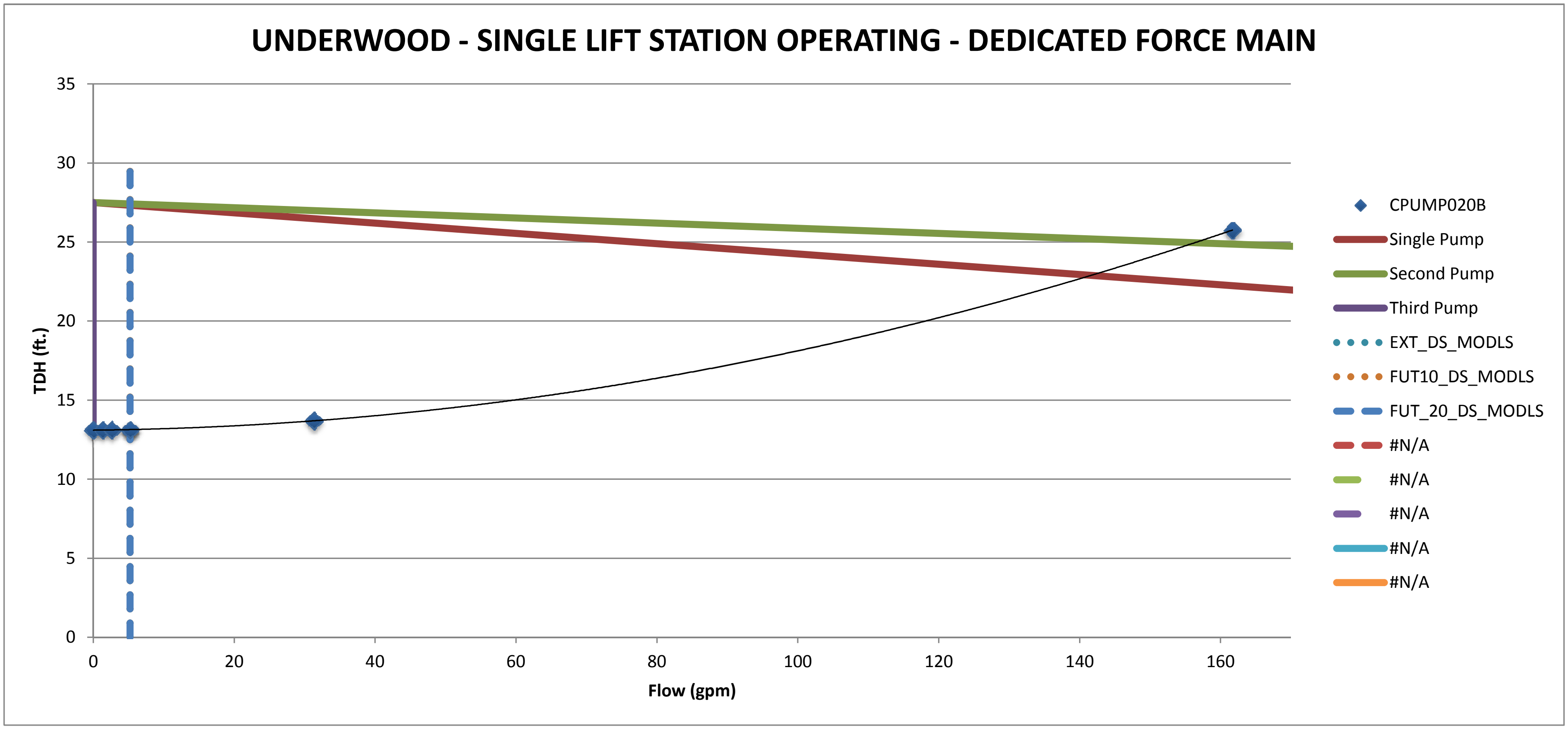

THE SHIRE - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
Flow (gpm)
0
20
40
60
80
100
120
140
0
50
100
150
200
250
300
CPUMP054B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A


TOUCHMARK - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
Flow (gpm)
0
20
40
60
80
100
120
140
160
180
0
50
100
150
200
250
300
350
400
450
500
CPUMP027B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

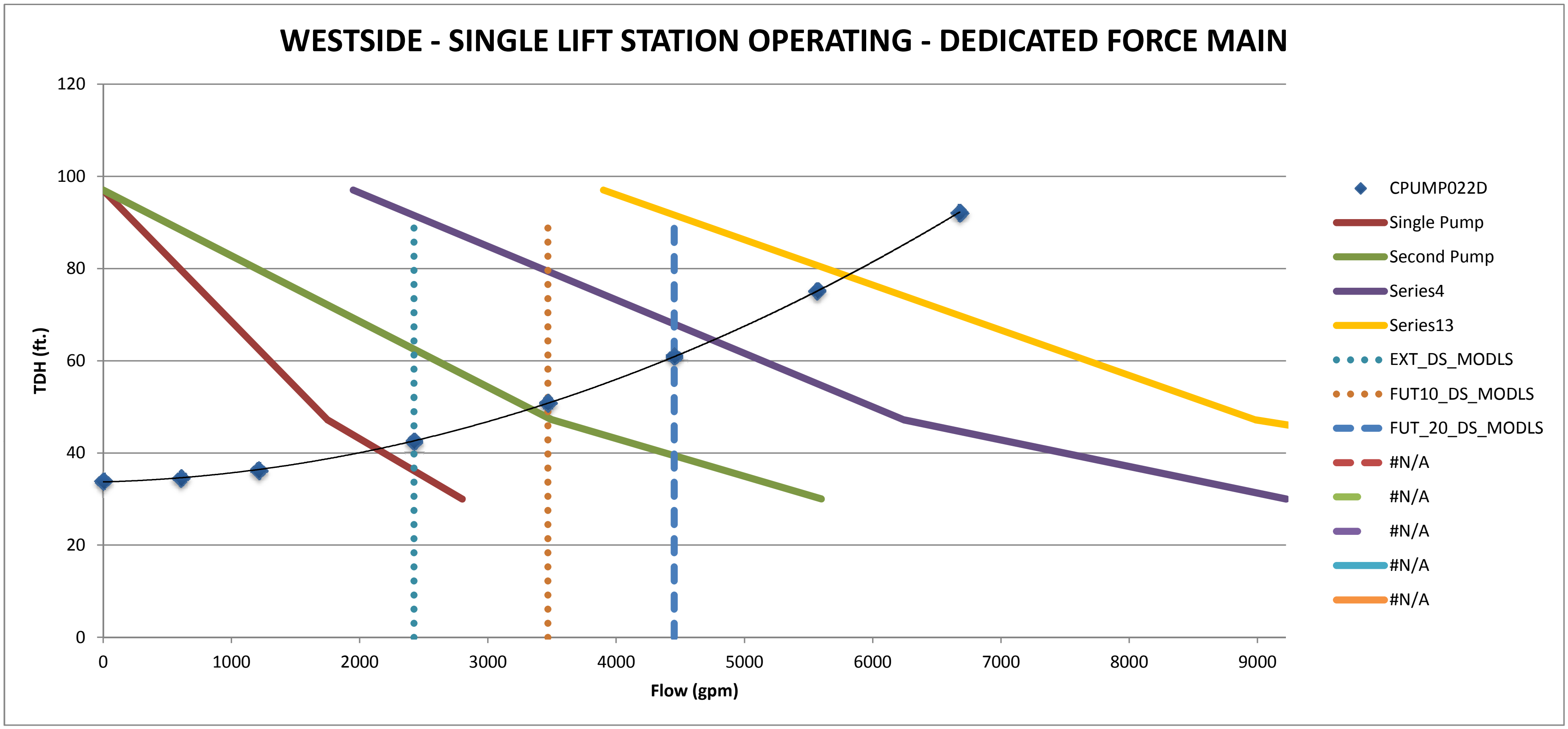


TRI PEAKS - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
600
500
400
300
200
100
0
TDH (ft.)
0
100
200
300
400
500
Flow (gpm)
CPUMP053B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

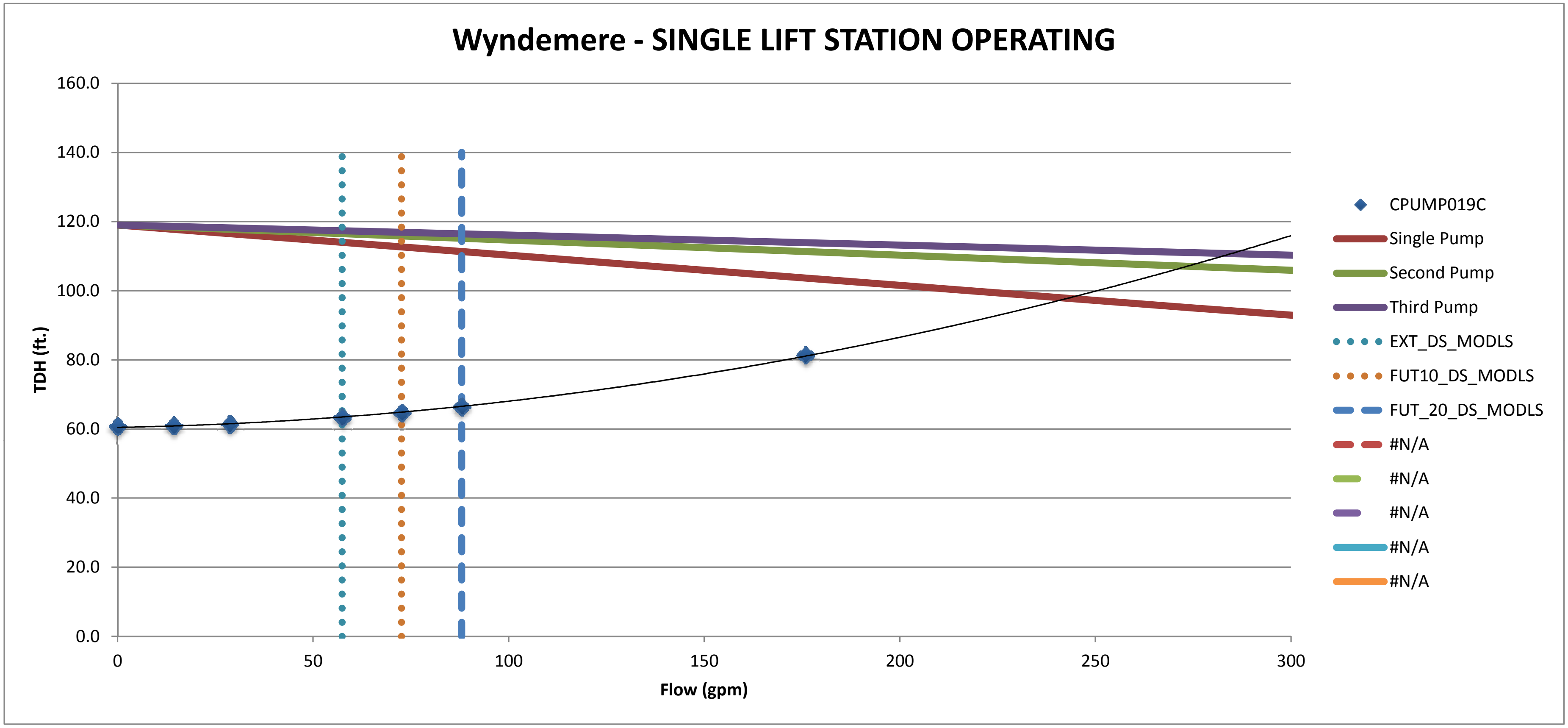

TUMALO HEIGHTS - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
120.00
100.00
80.00
60.00
40.00
20.00
0.00
TDH (ft.)
0.00
50.00
100.00
150.00
200.00
250.00
300.00
Flow (gpm)
CPUMP077B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A



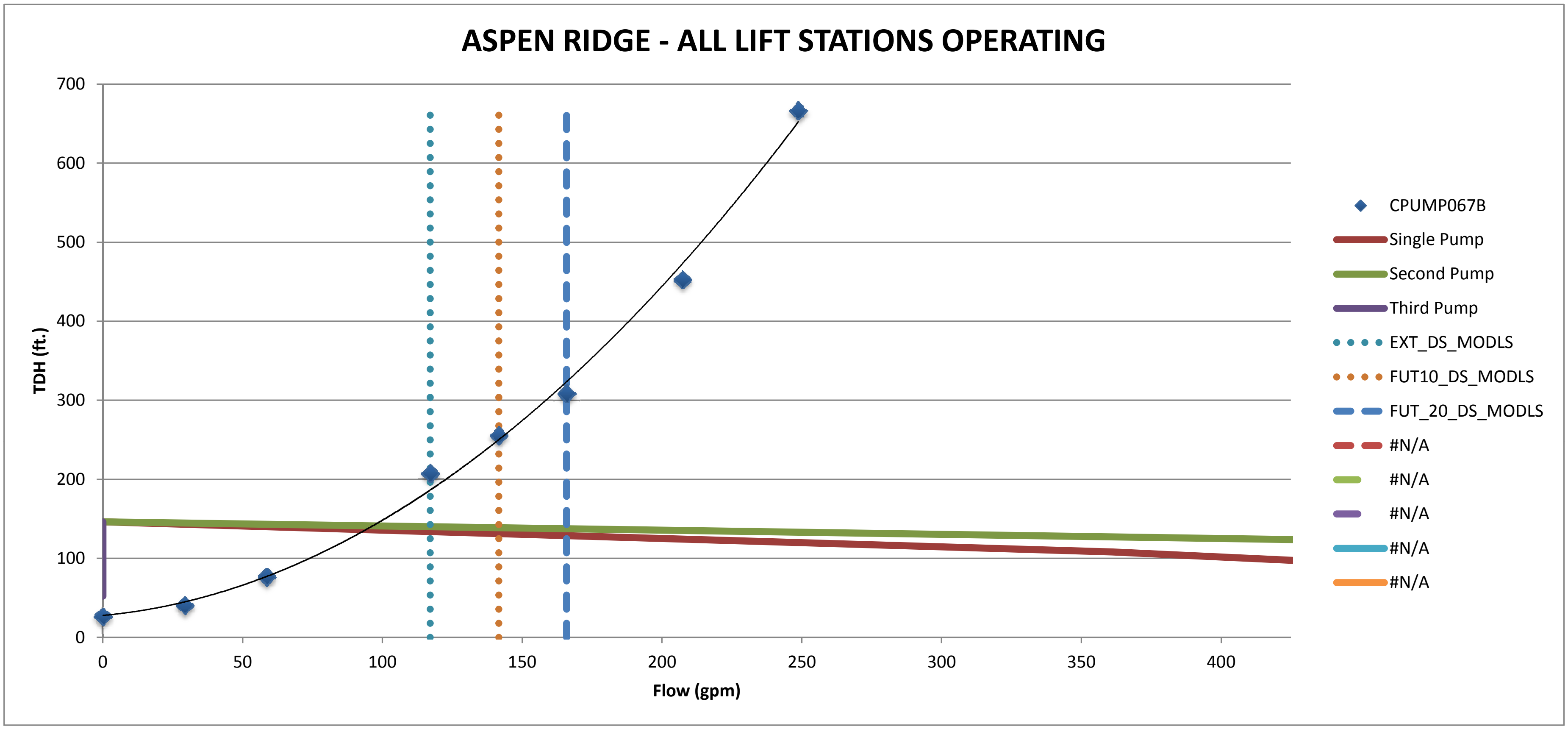
UNDERWOOD - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
35
30
25
20
15
10
5
0
TDH (ft.)
0
20
40
60
80
100
120
140
160
Flow (gpm)
CPUMP020B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

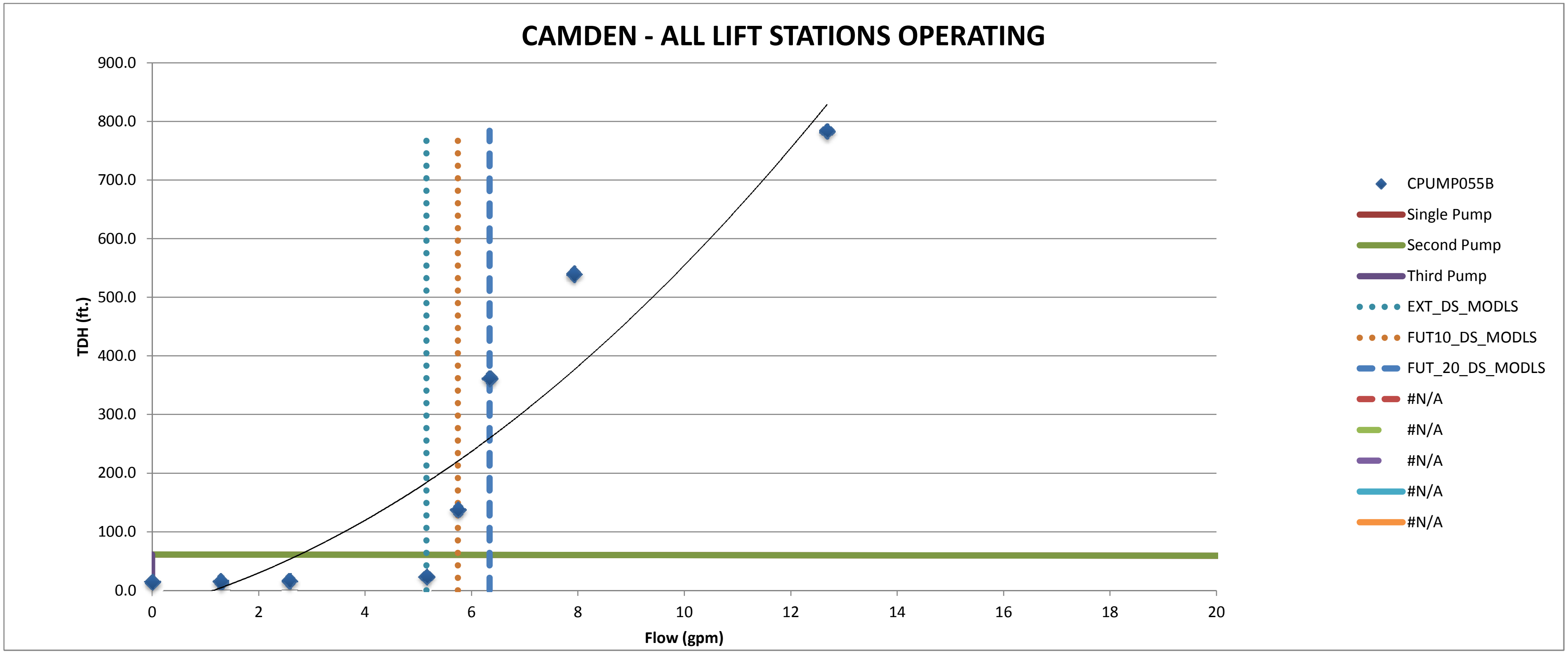

WESTSIDE - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
Flow (gpm)
0
20
40
60
80
100
120
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
CPUMP022D
Single Pump
Second Pump
Series4
Series13
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

WIDGI CREEK - SINGLE LIFT STATION OPERATING
160
140
120
100
80
60
40
20
0
TDH (ft.)
0
50
100
150
200
Flow (gpm)
CPUMP071B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

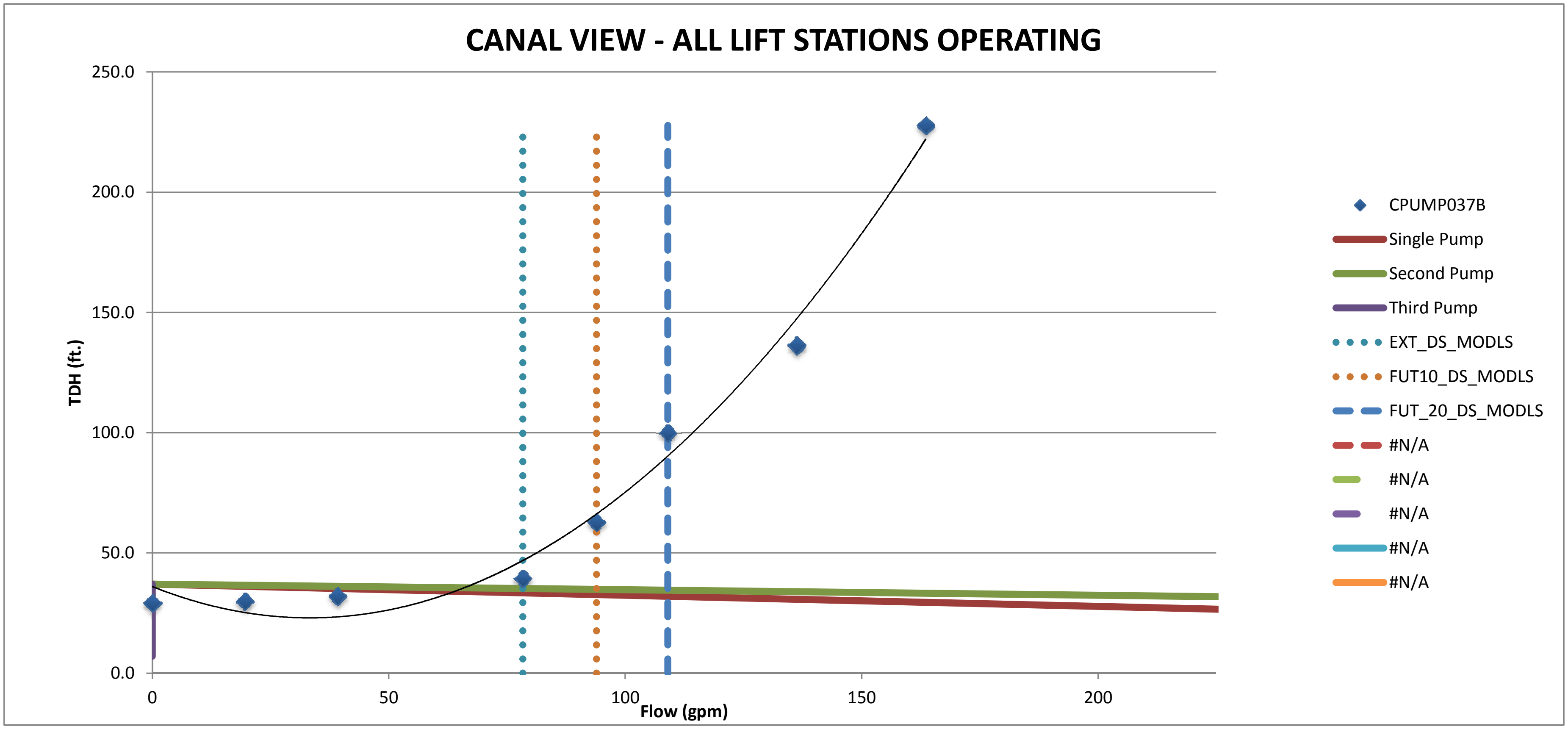


Wyndemere - SINGLE LIFT STATION OPERATING
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
TDH (ft.)
0
50
100
150
200
250
300
Flow (gpm)
CPUMP019C
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

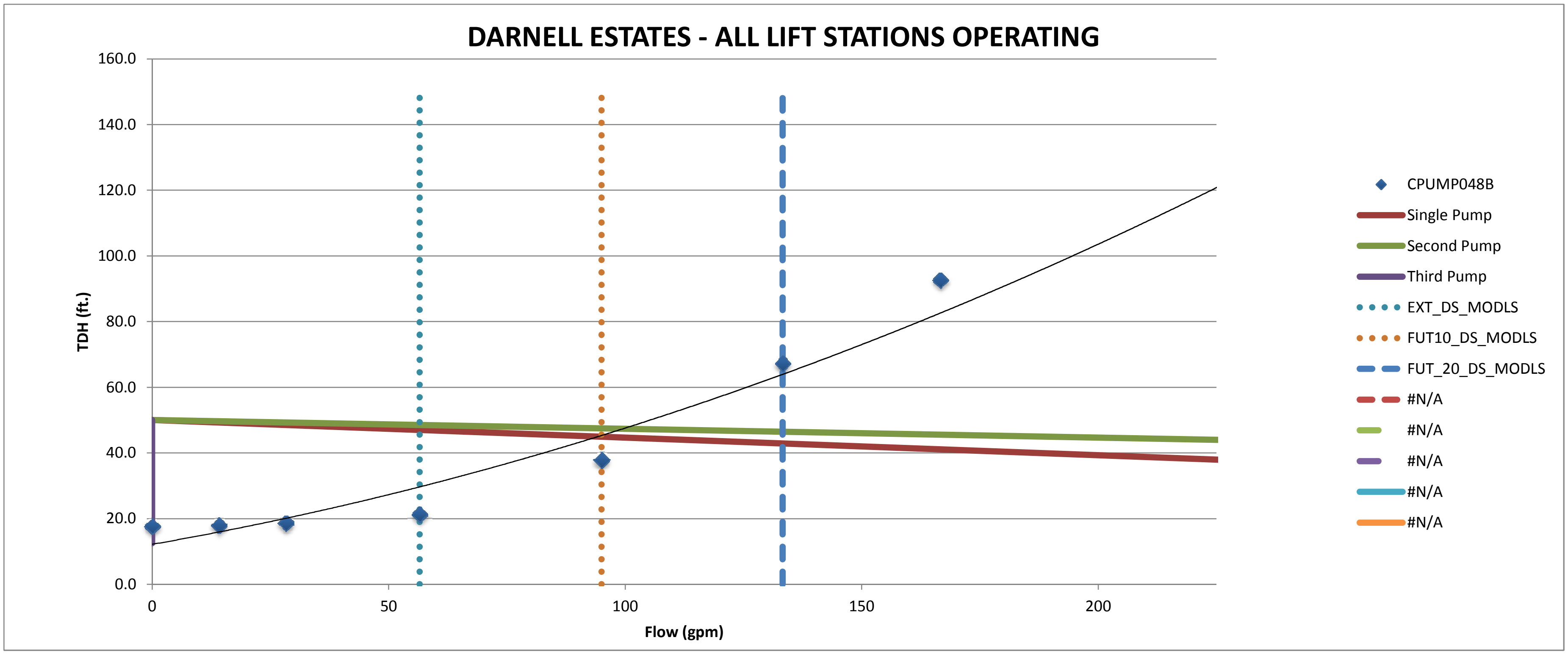

ASPEN RIDGE - ALL LIFT STATIONS OPERATING
TDH (ft.)
700
600
500
400
300
200
100
0
0
50
100
150
200
250
300
350
400
Flow (gpm)
CPUMP067B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

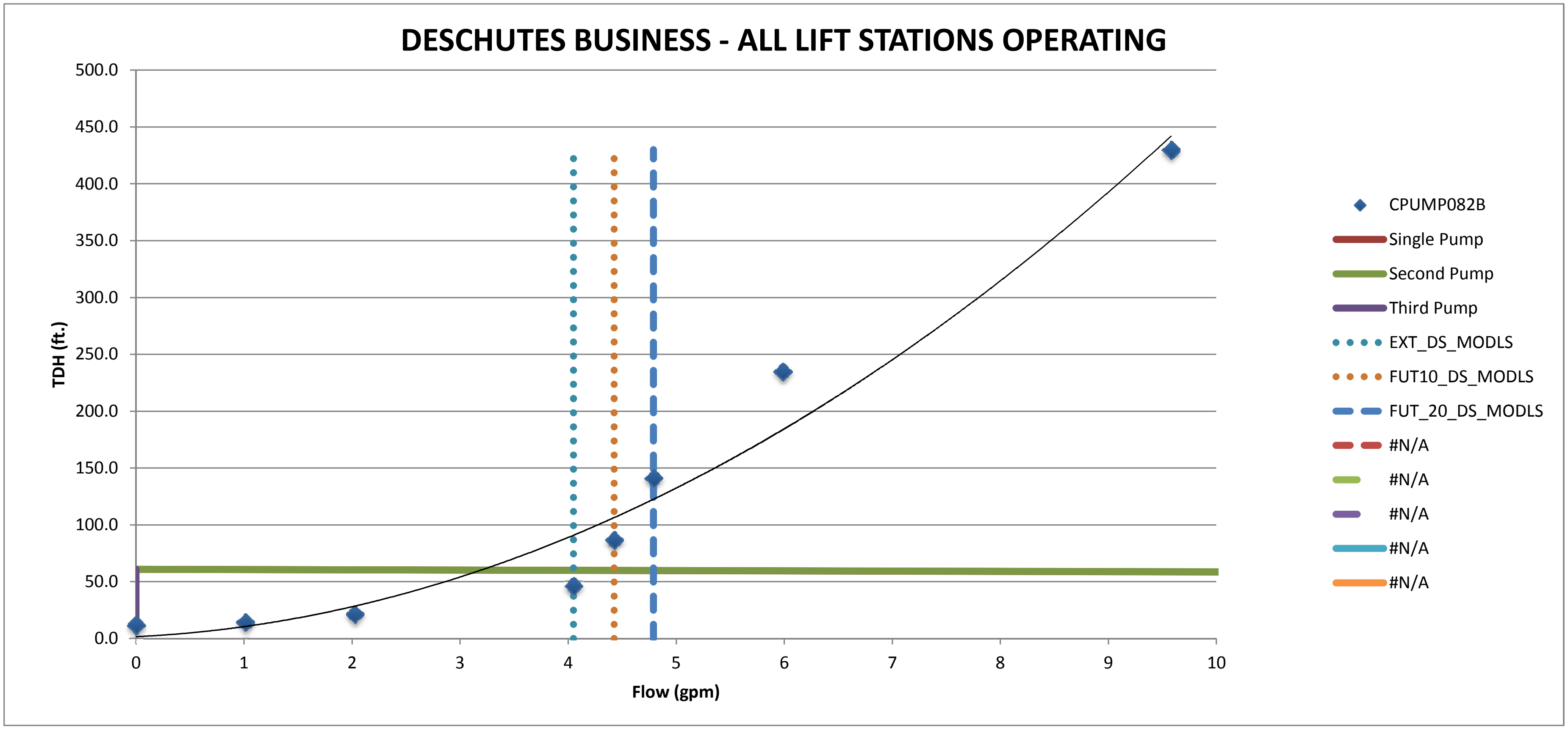


CAMDEN - ALL LIFT STATIONS OPERATING
900.0
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
TDH (ft.)
0
2
4
6
8
10
12
14
16
18
20
Flow (gpm)
CPUMP055B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

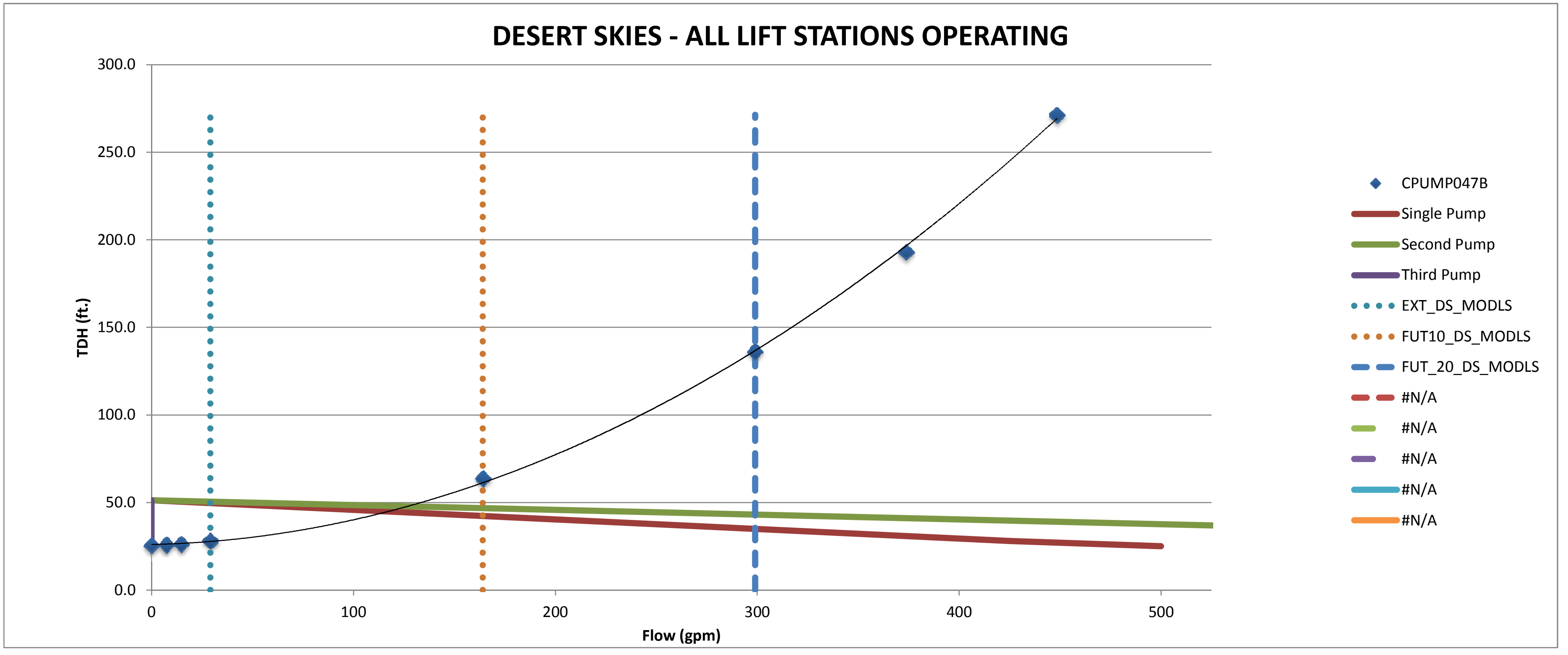


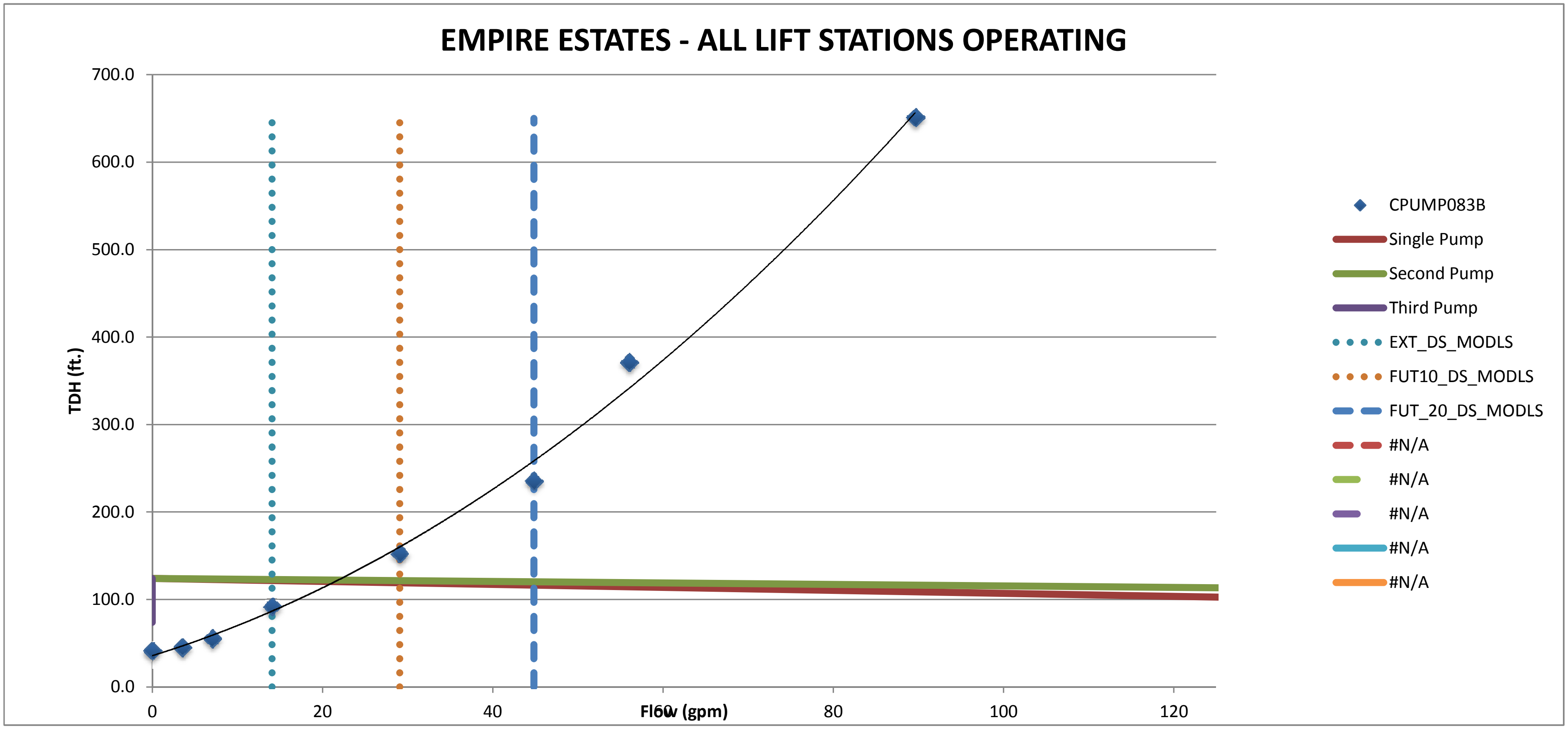
CANAL VIEW - ALL LIFT STATIONS OPERATING
250.0
200.0
150.0
100.0
50.0
0.0
TDH (ft.)
0
50
100
150
200
Flow (gpm)
CPUMP037B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A


DARNELL ESTATES - ALL LIFT STATIONS OPERATING
TDH (ft.)
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0
50
100
150
200
Flow (gpm)
CPUMP048B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

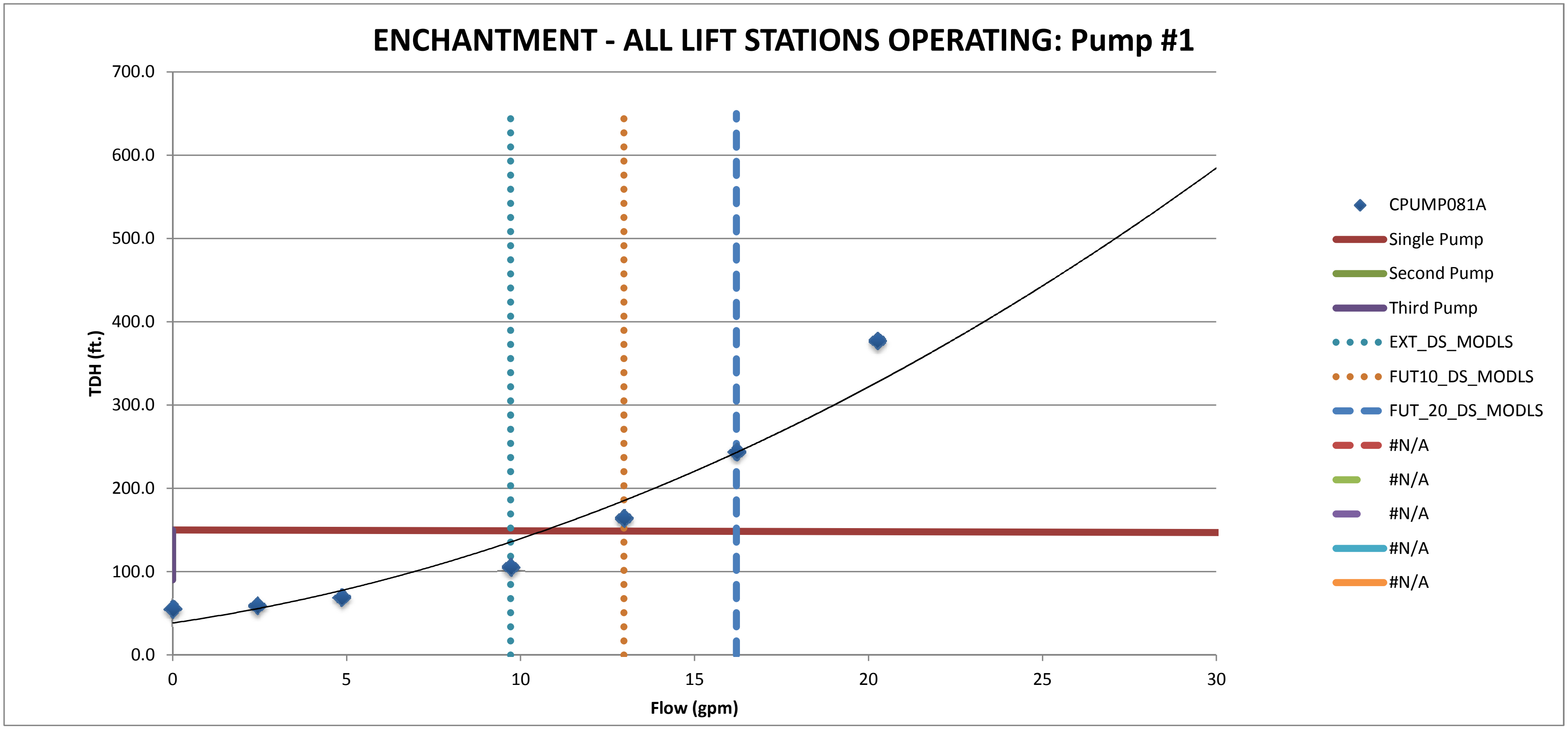


DESCHUTES BUSINESS - ALL LIFT STATIONS OPERATING
TDH (ft.)
500.0
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0
1
2
3
4
5
6
7
8
9
10
Flow (gpm)
CPUMP082B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

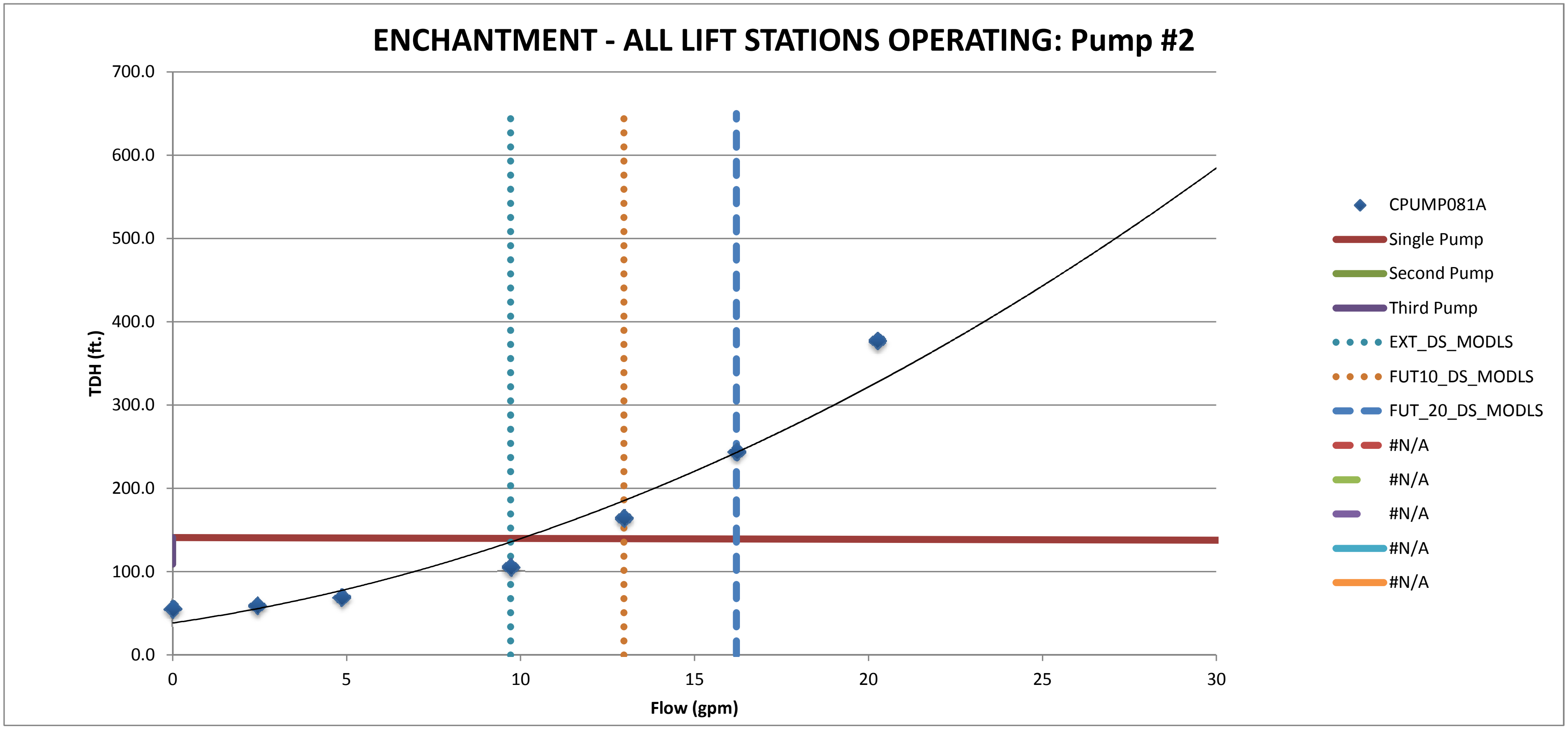

DESERT SKIES - ALL LIFT STATIONS OPERATING
300.0
250.0
200.0
150.0
100.0
50.0
0.0
TDH (ft.)
0
100
200
300
400
500
Flow (gpm)
CPUMP047B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

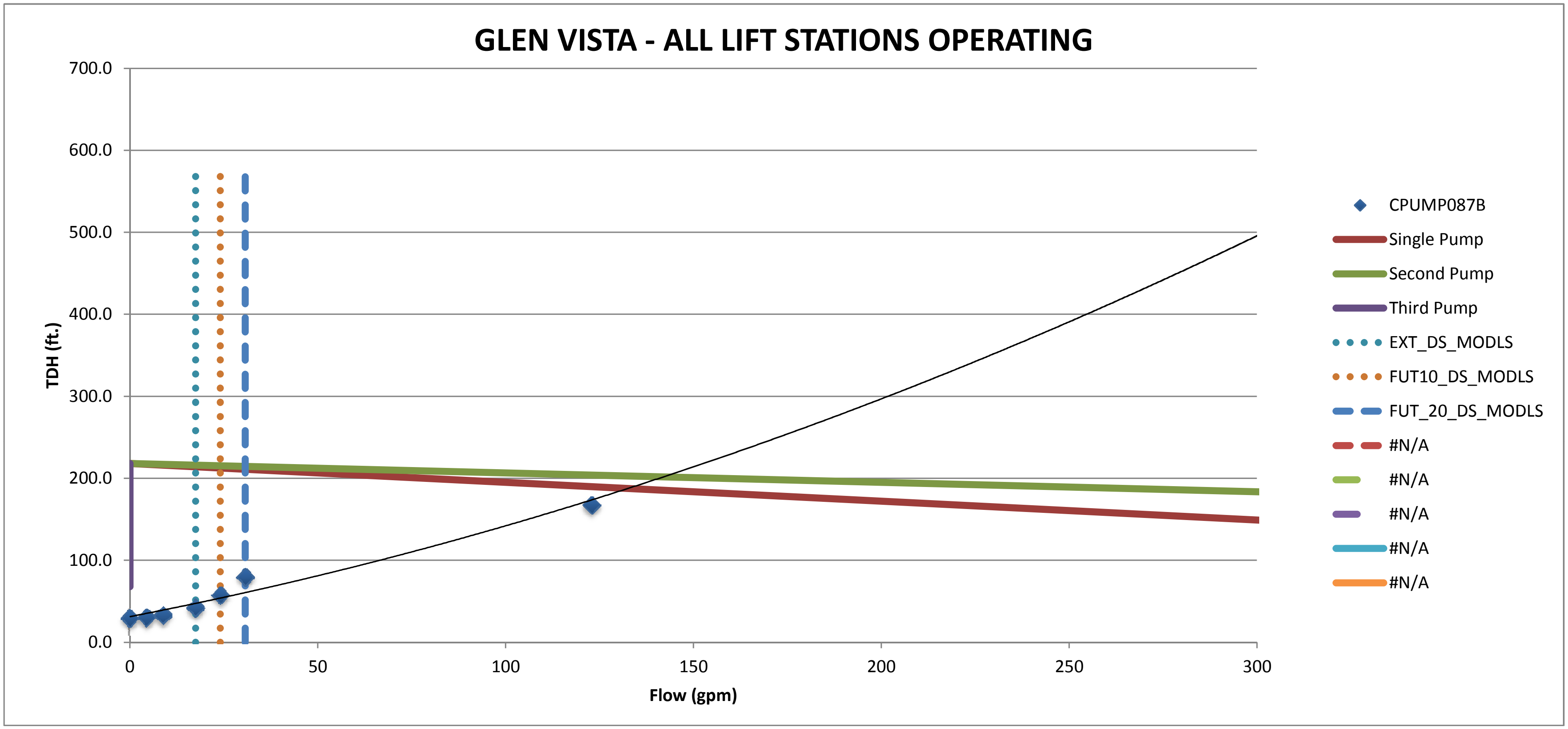


EMPIRE ESTATES - ALL LIFT STATIONS OPERATING
TDH (ft.)
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
0
20
40
60
80
100
120
Flow (gpm)
CPUMP083B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

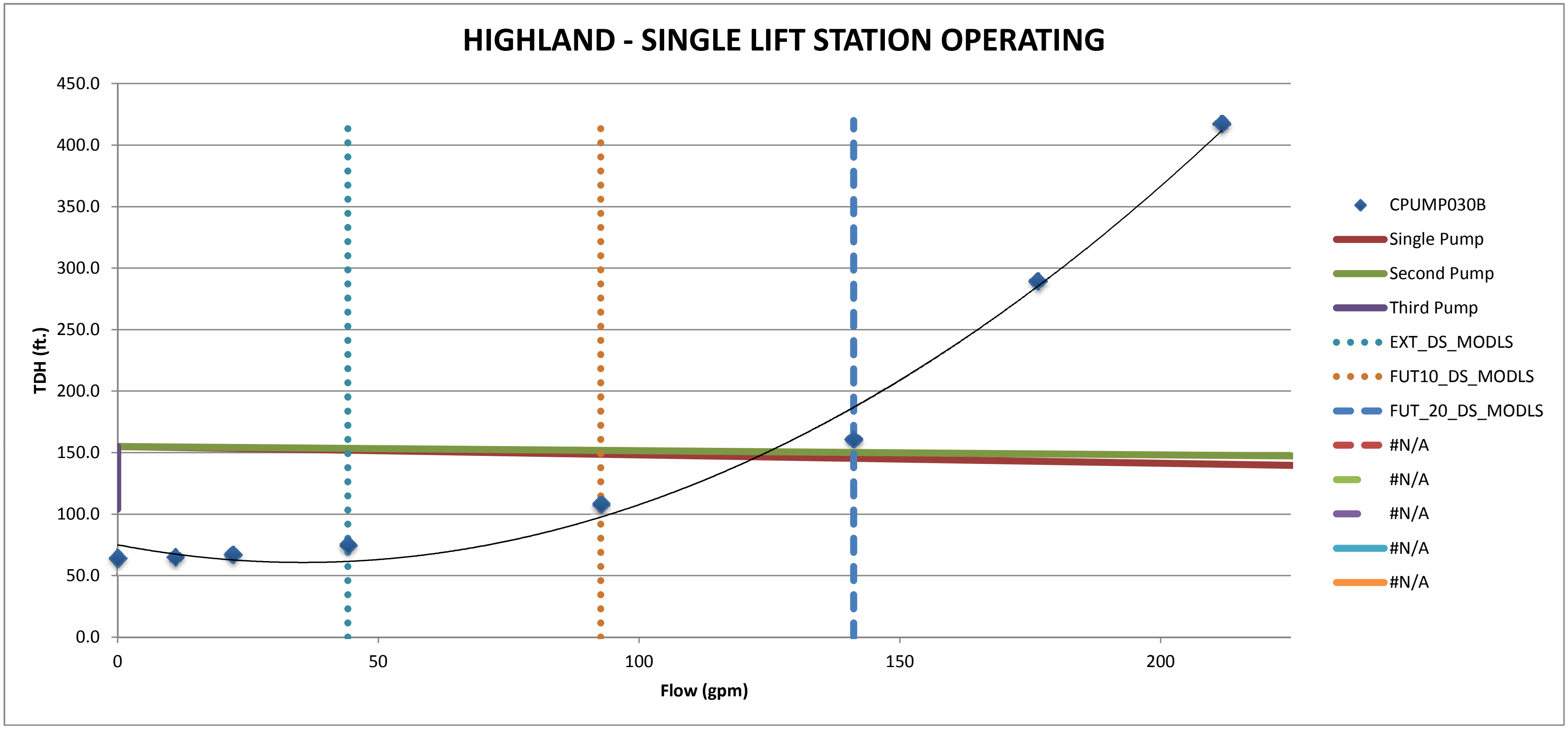


ENCHANTMENT - ALL LIFT STATIONS OPERATING: Pump #1
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
TDH (ft.)
0
5
10
15
20
25
30
Flow (gpm)
CPUMP081A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

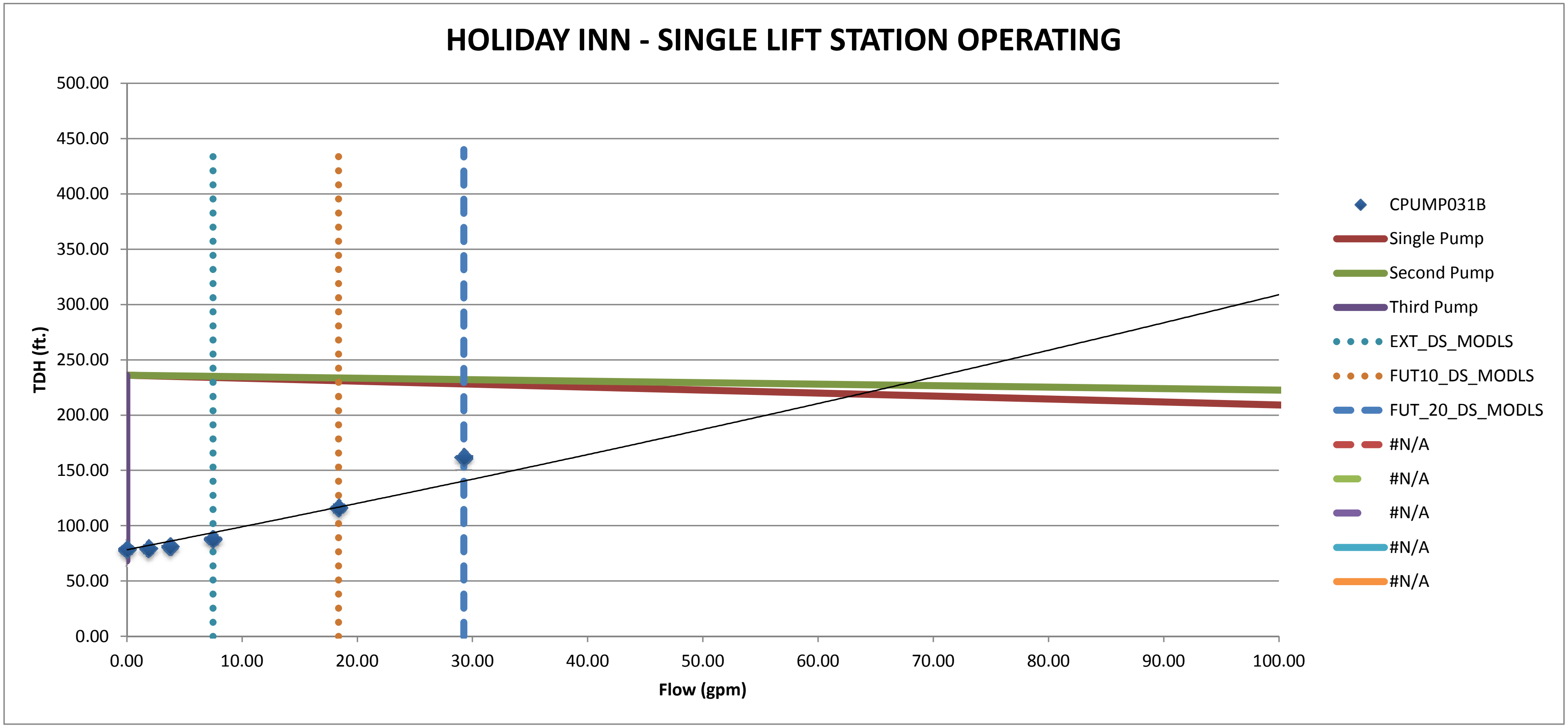

ENCHANTMENT - ALL LIFT STATIONS OPERATING: Pump #2
TDH (ft.)
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
0
5
10
15
20
25
30
Flow (gpm)
CPUMP081A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

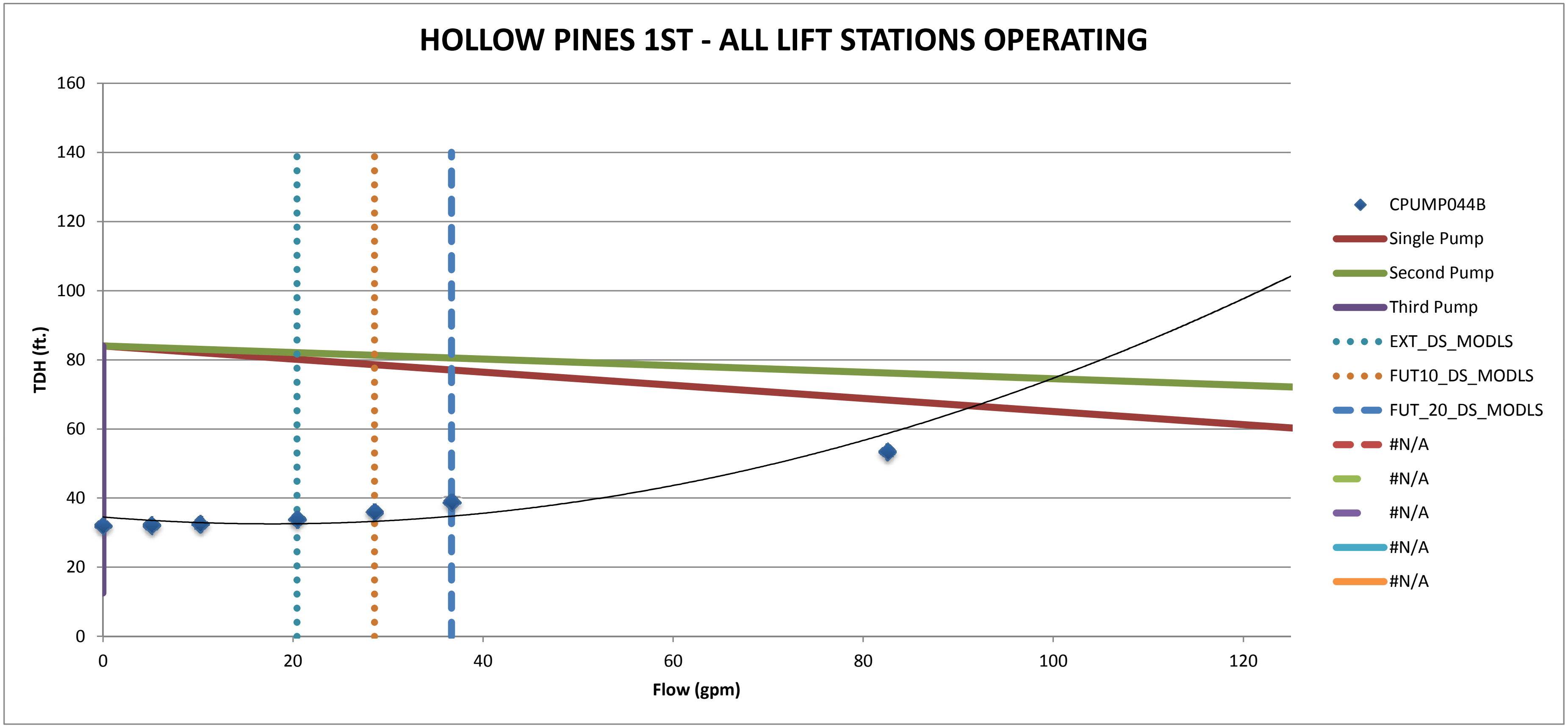


GLEN VISTA - ALL LIFT STATIONS OPERATING
TDH (ft.)
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
0
50
100
150
200
250
300
Flow (gpm)
CPUMP087B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

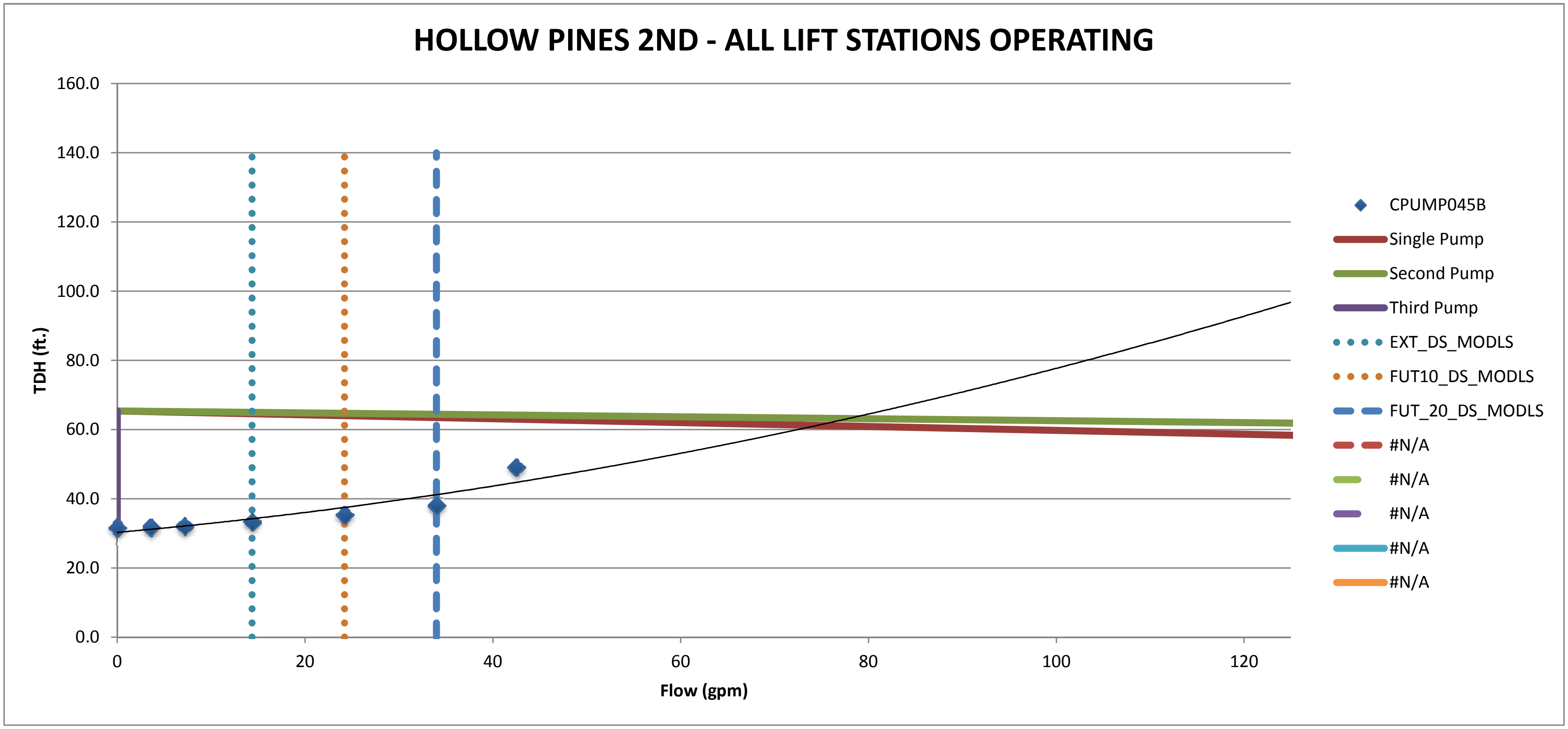


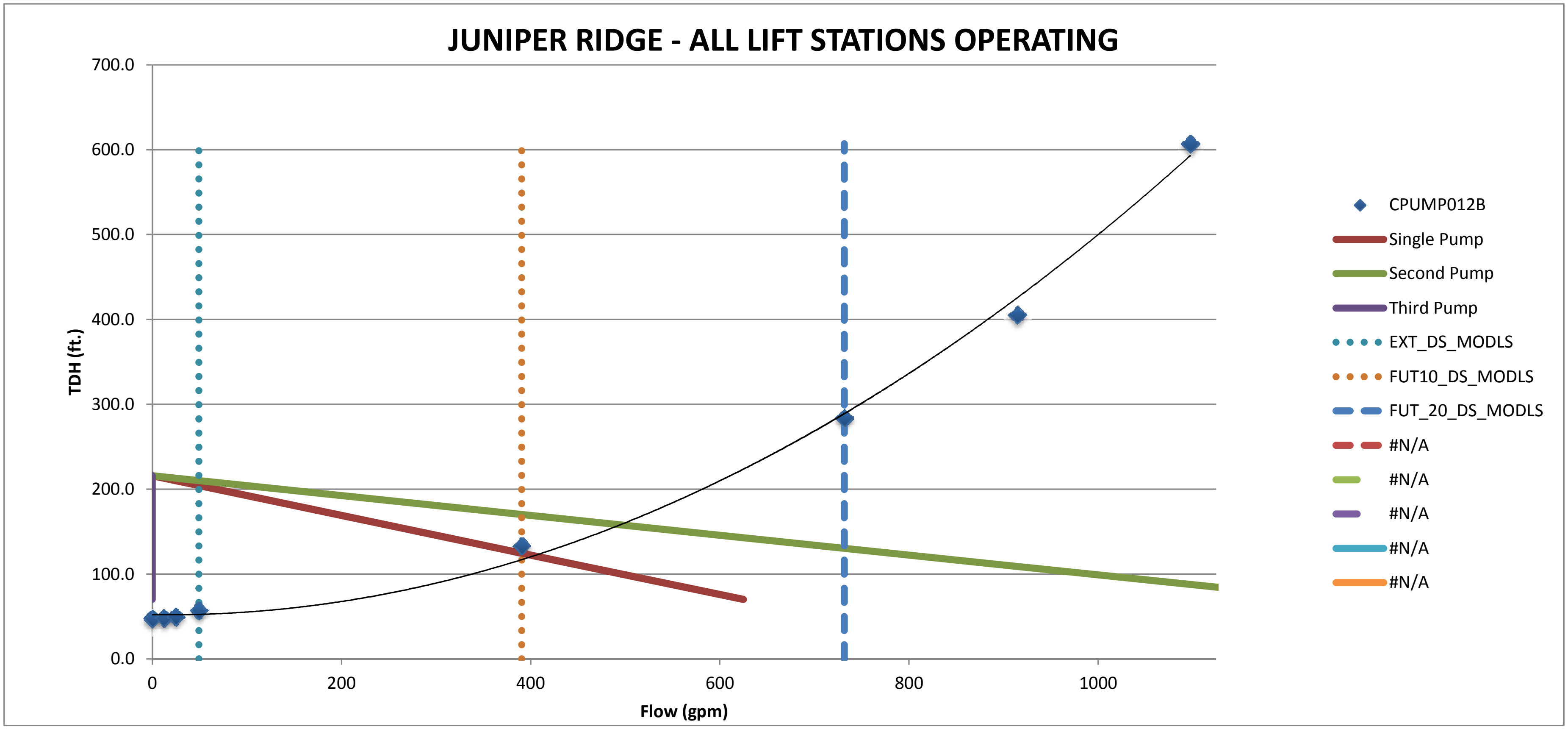
HIGHLAND - SINGLE LIFT STATION OPERATING
TDH (ft.)
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0
50
100
150
200
Flow (gpm)
CPUMP030B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A


HOLIDAY INN - SINGLE LIFT STATION OPERATING
TDH (ft.)
500.00
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
Flow (gpm)
CPUMP031B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

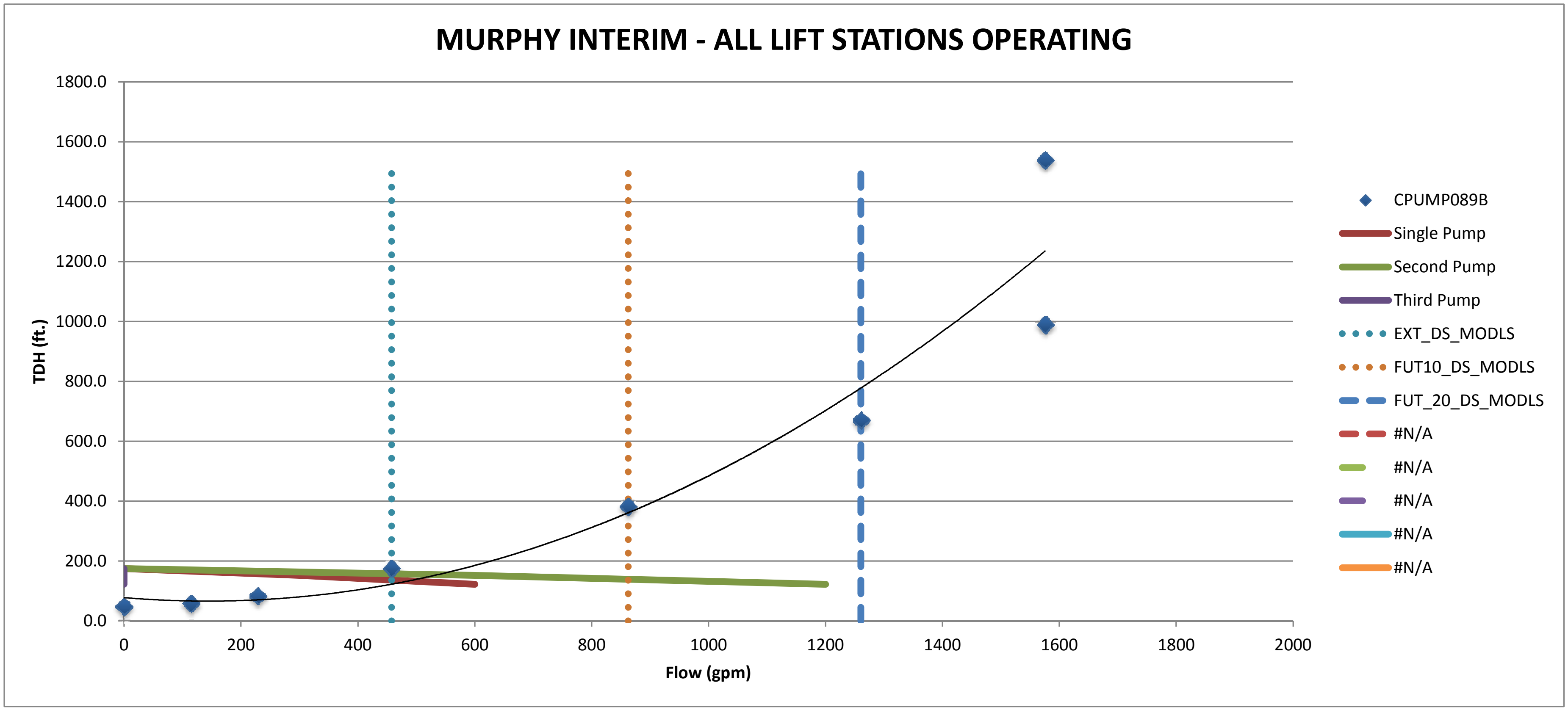


HOLLOW PINES 1ST - ALL LIFT STATIONS OPERATING
TDH (ft.)
160
140
120
100
80
60
40
20
0
0
20
40
60
80
100
120
Flow (gpm)
CPUMP044B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

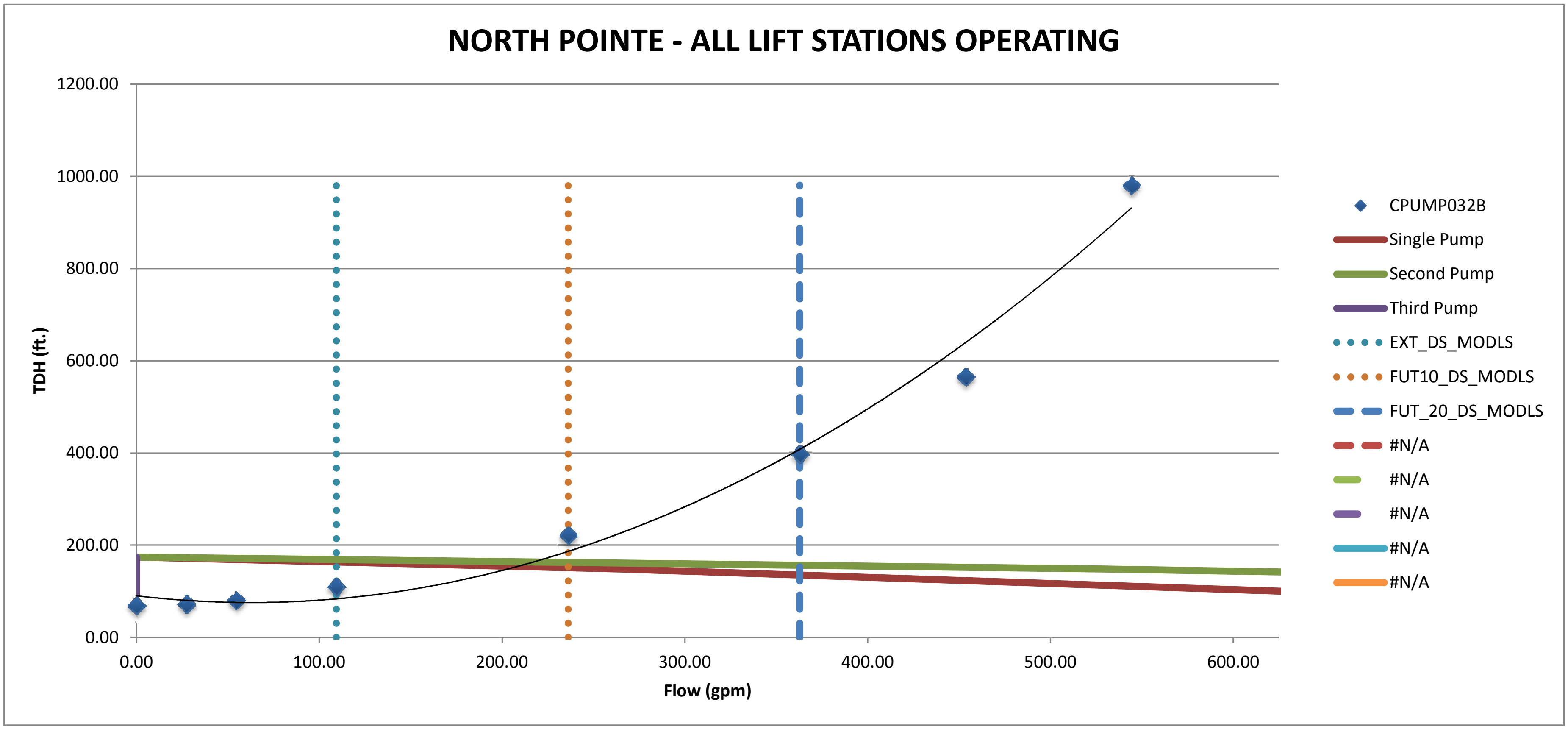

HOLLOW PINES 2ND - ALL LIFT STATIONS OPERATING
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
TDH (ft.)
0
20
40
60
80
100
120
Flow (gpm)
CPUMP045B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A



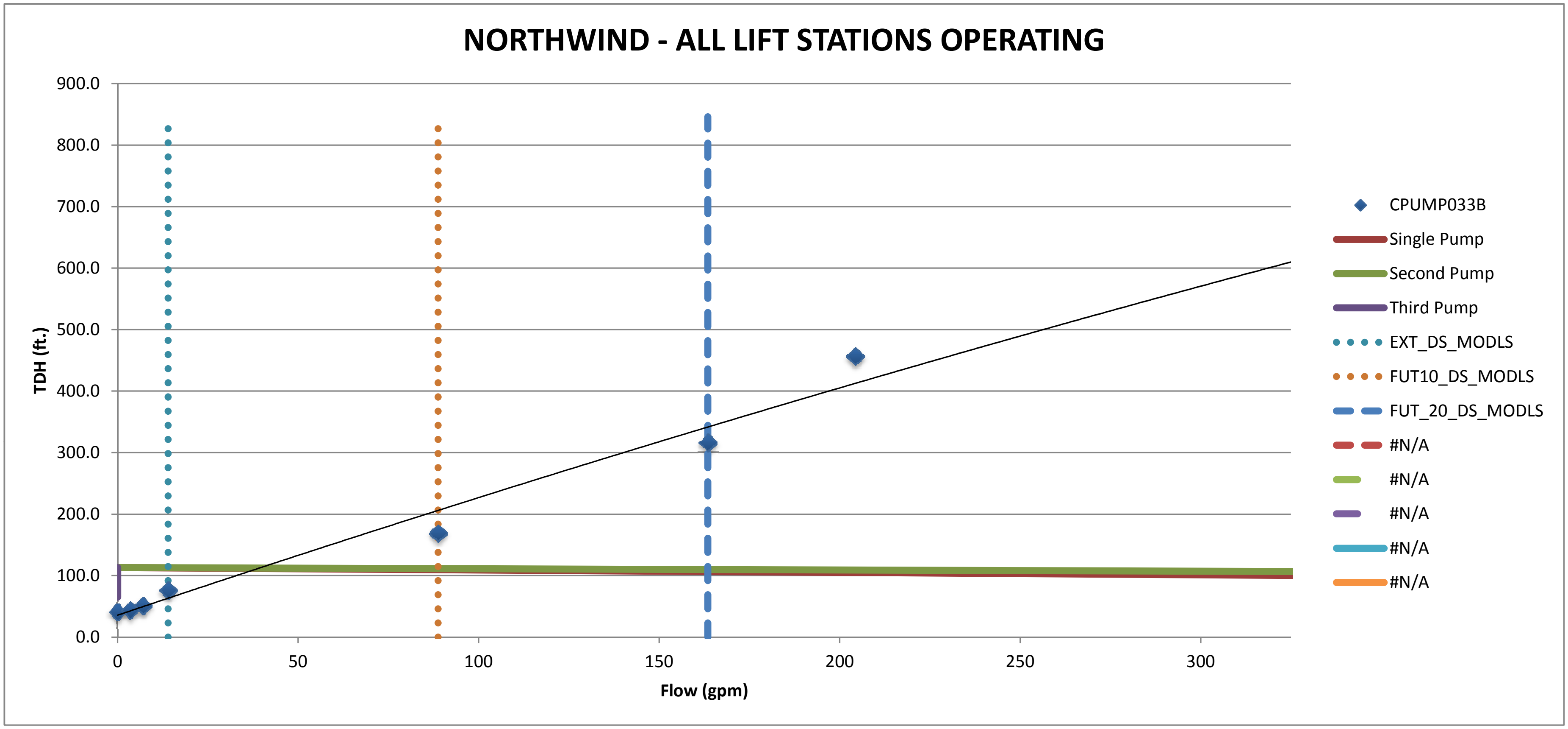
JUNIPER RIDGE - ALL LIFT STATIONS OPERATING
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
TDH (ft.)
0
200
400
600
800
1000
Flow (gpm)
CPUMP012B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

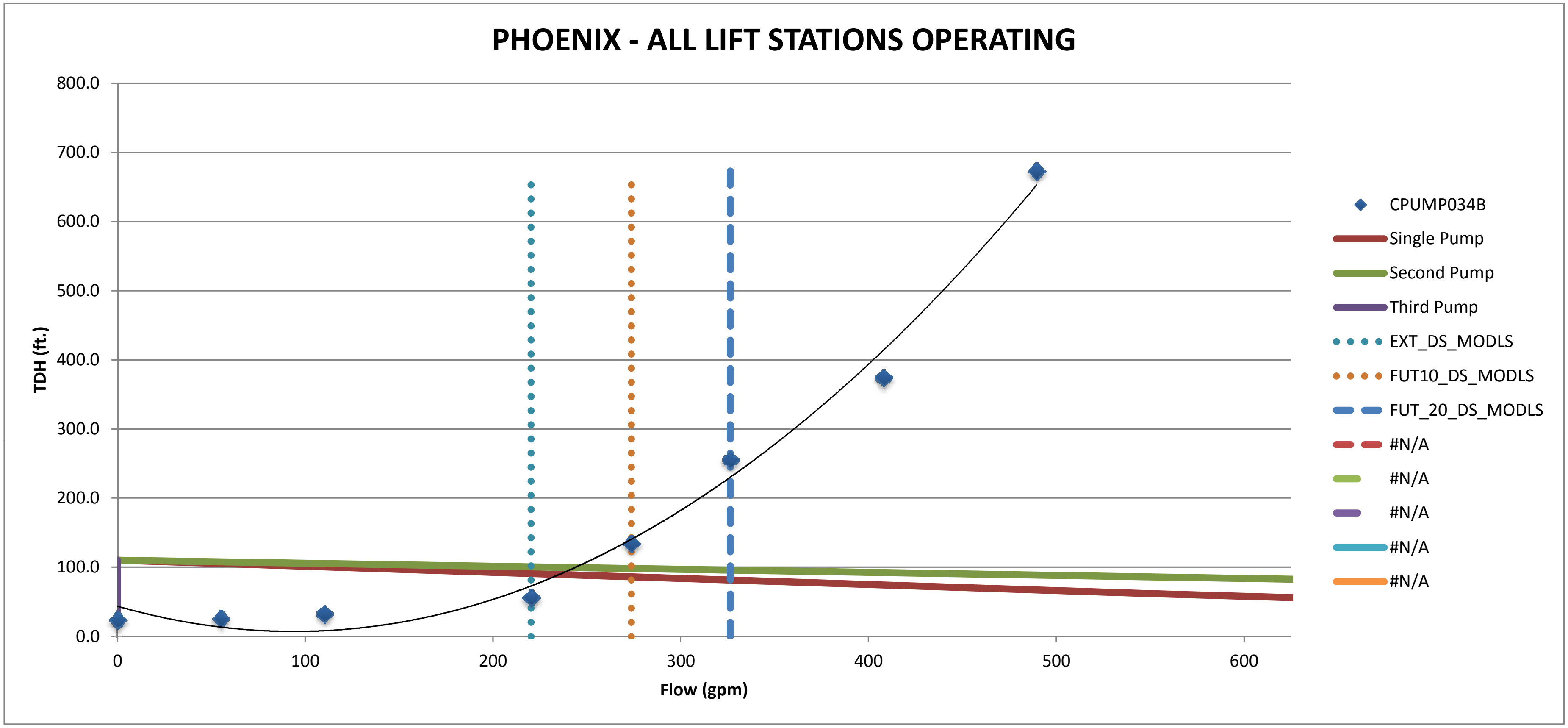


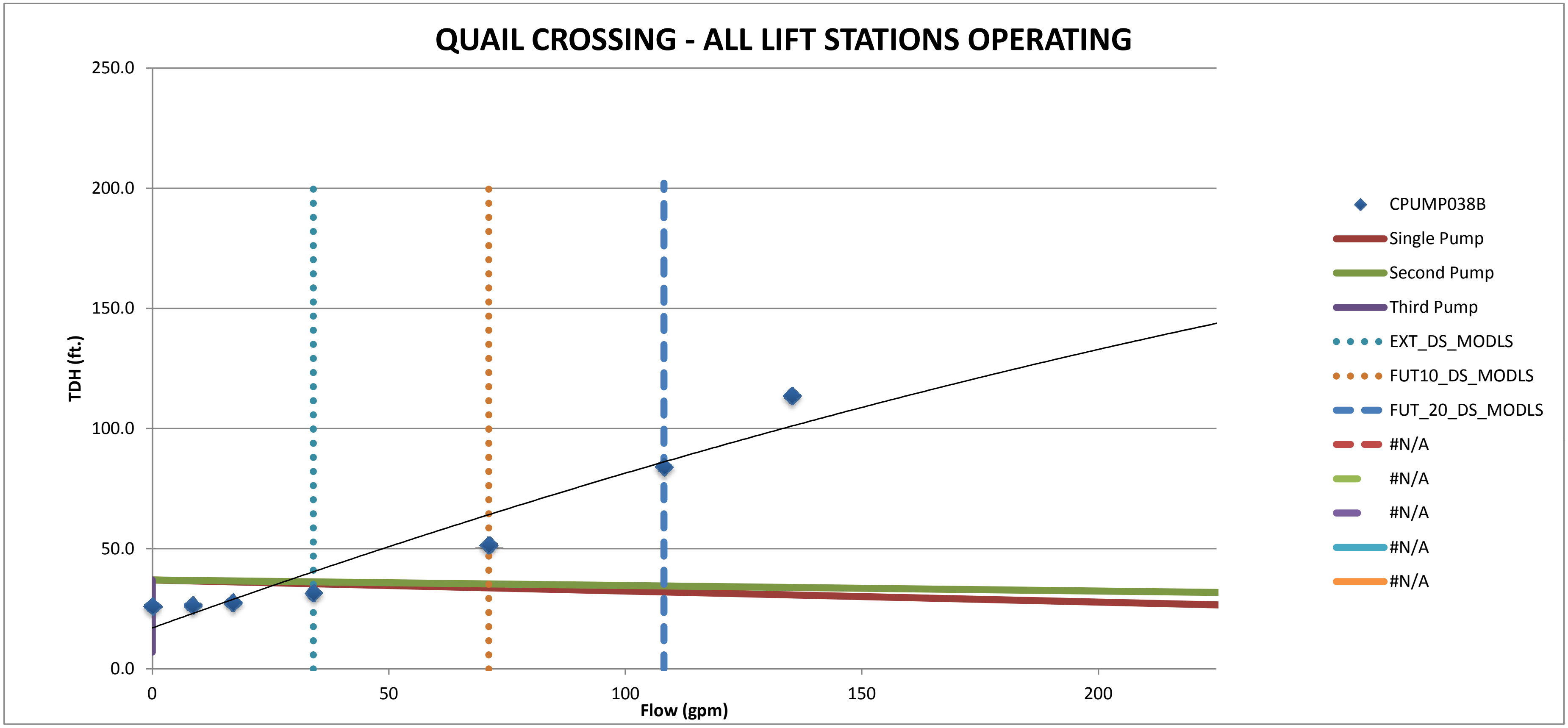
MURPHY INTERIM - ALL LIFT STATIONS OPERATING
TDH (ft.)
1800.0
1600.0
1400.0
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Flow (gpm)
CPUMP089B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A



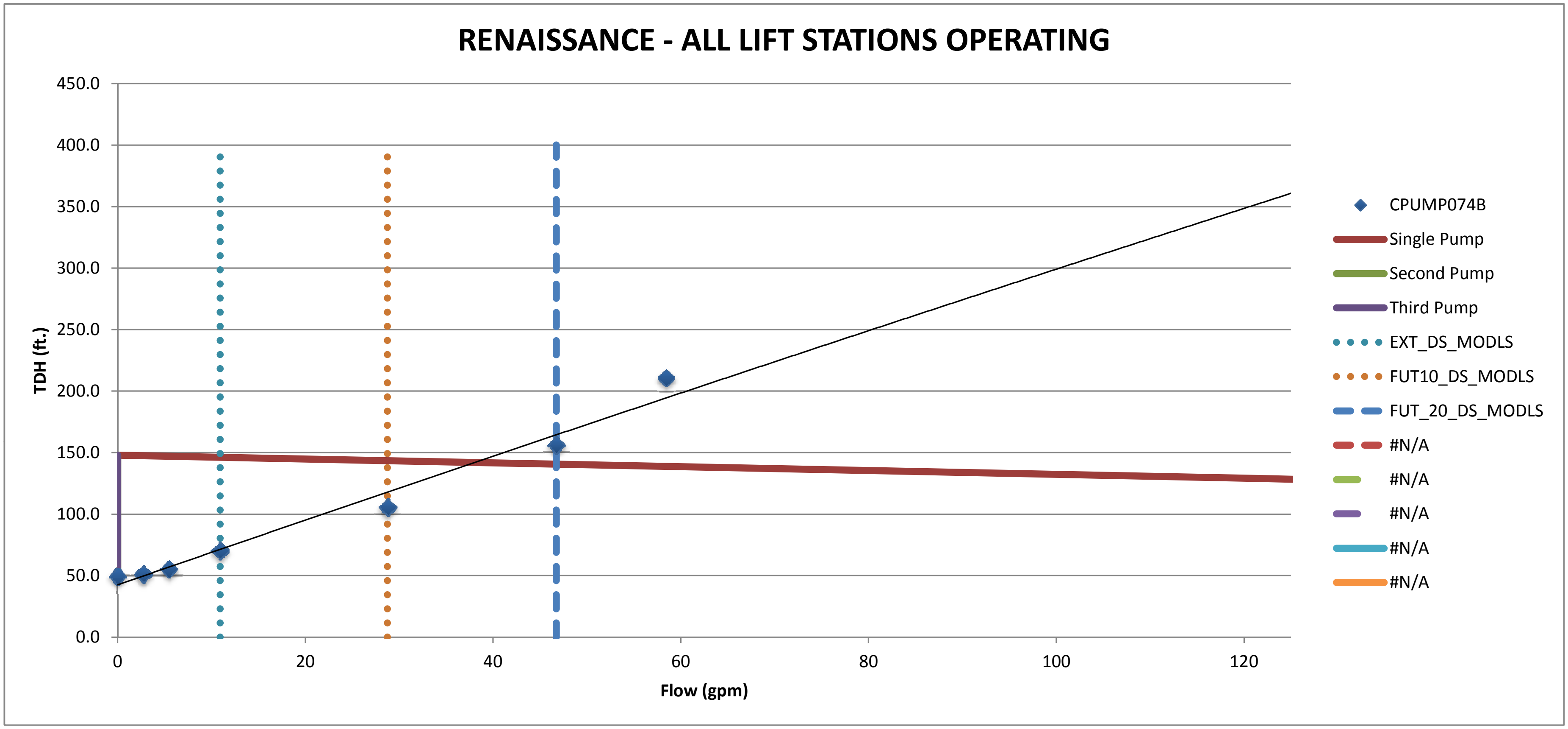
NORTH POINTE - ALL LIFT STATIONS OPERATING
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
TDH (ft.)
0.00
100.00
200.00
300.00
400.00
500.00
600.00
Flow (gpm)
CPUMP032B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

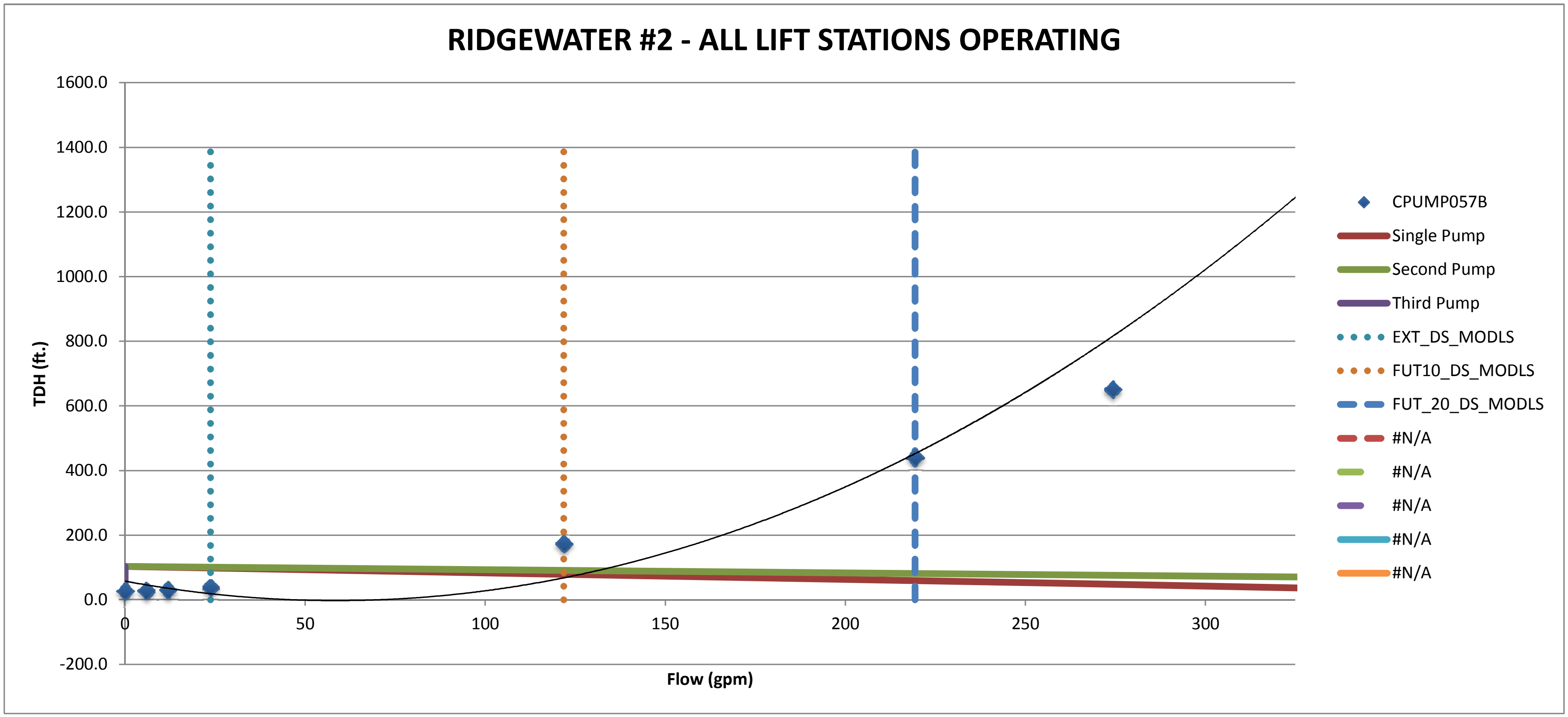

NORTHWIND - ALL LIFT STATIONS OPERATING
900.0
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
TDH (ft.)
0
50
100
150
200
250
300
Flow (gpm)
CPUMP033B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A


PHOENIX - ALL LIFT STATIONS OPERATING
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
TDH (ft.)
0
100
200
300
400
500
600
Flow (gpm)
CPUMP034B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

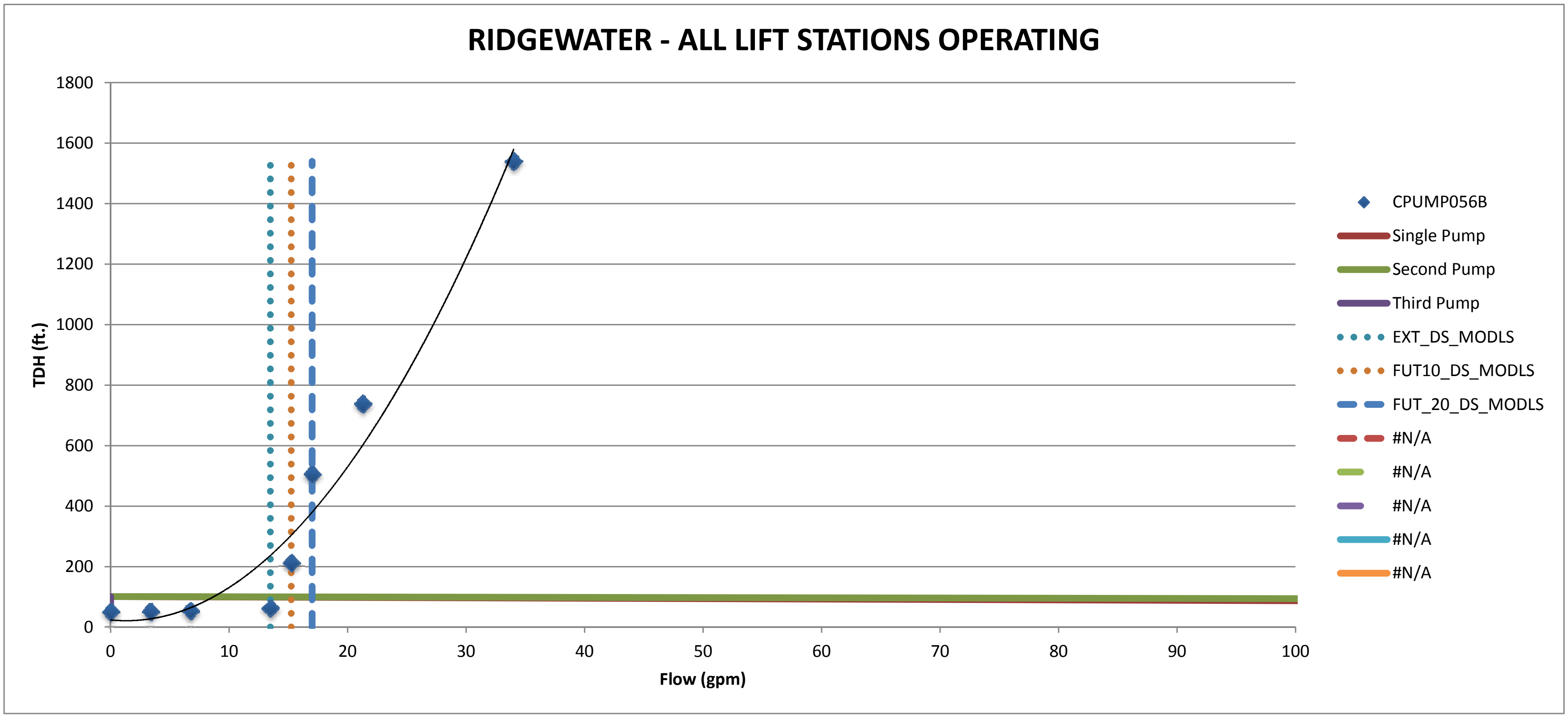


QUAIL CROSSING - ALL LIFT STATIONS OPERATING
250.0
200.0
150.0
100.0
50.0
0.0
TDH (ft.)
0
50
100
150
200
Flow (gpm)
CPUMP038B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

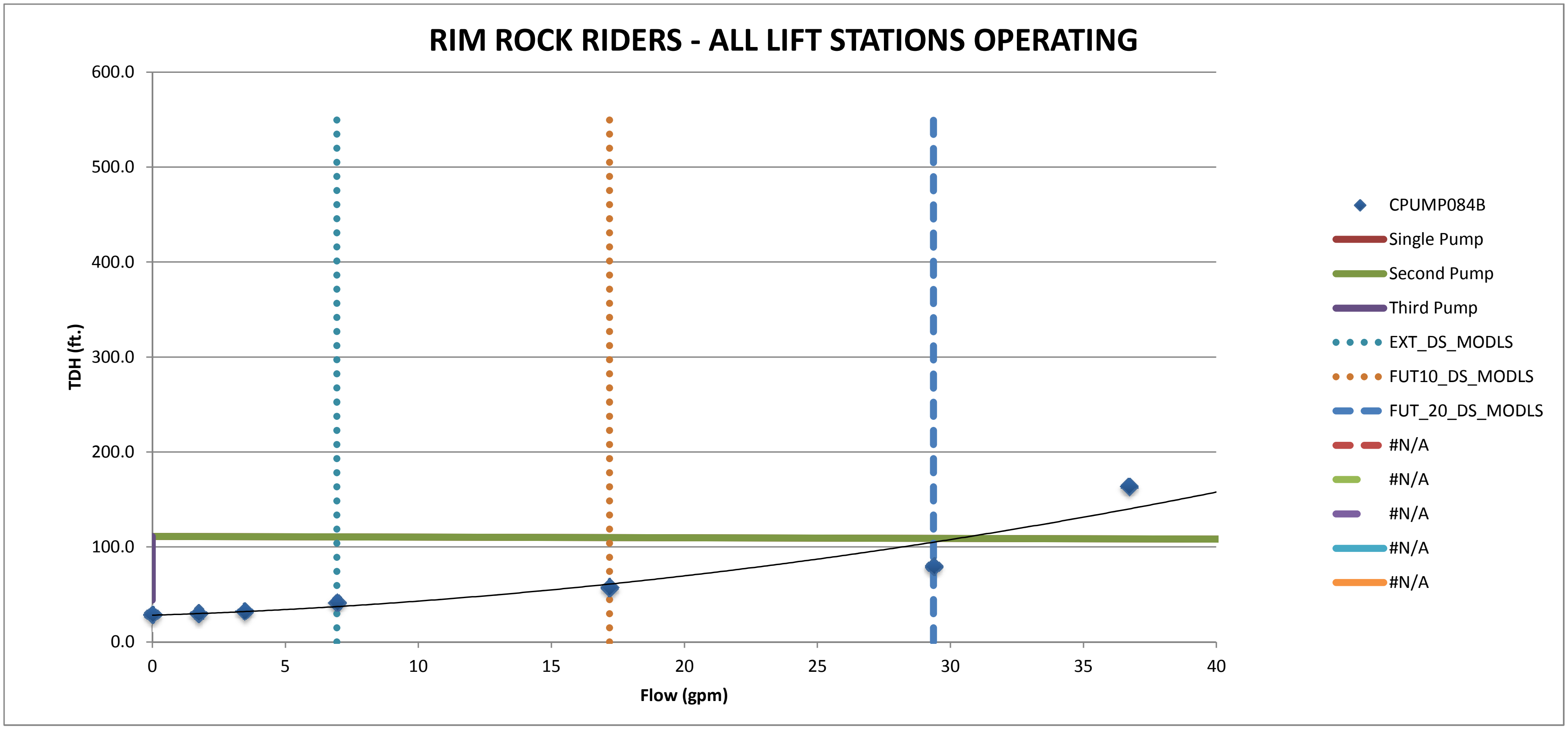

RENAISSANCE - ALL LIFT STATIONS OPERATING
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
TDH (ft.)
0
20
40
60
80
100
120
Flow (gpm)
CPUMP074B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A



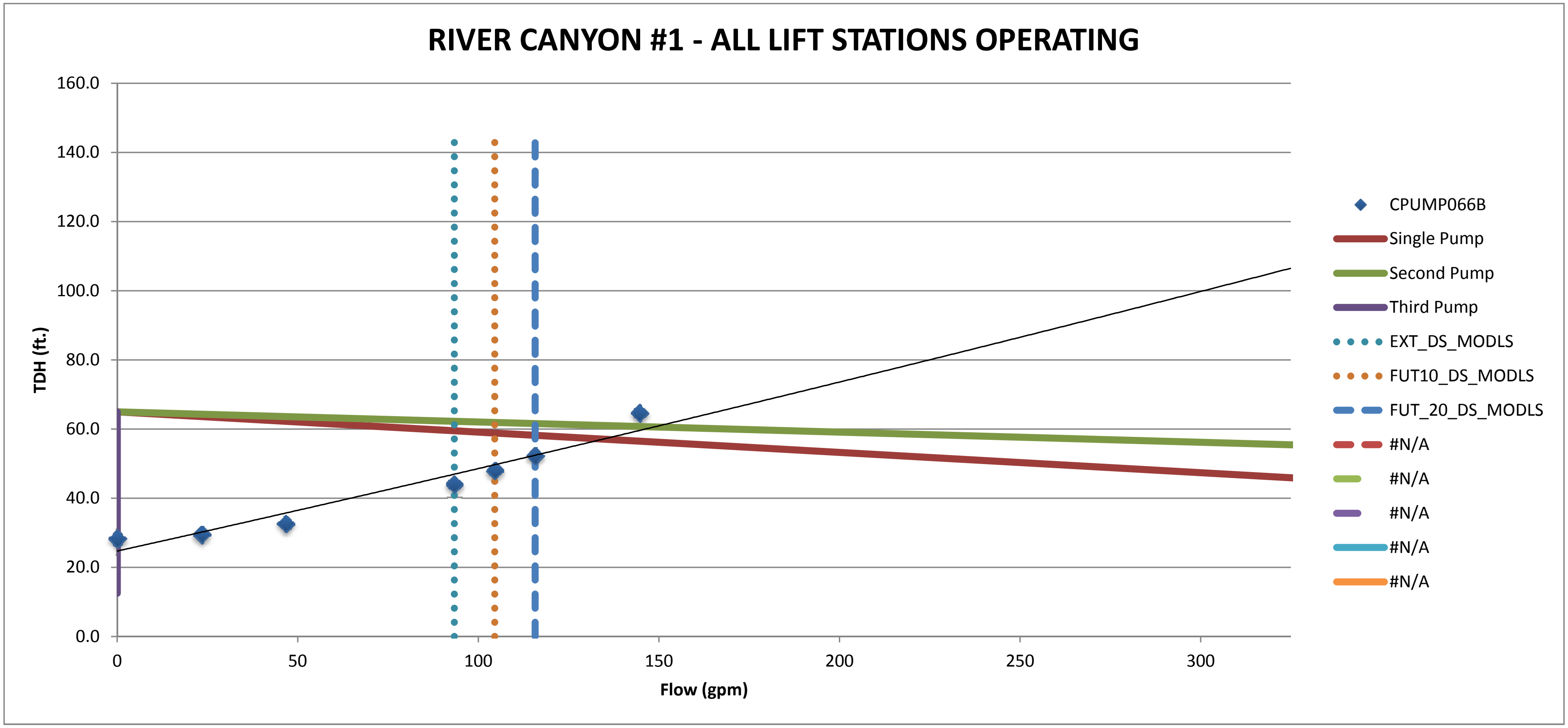
RIDGEWATER #2 - ALL LIFT STATIONS OPERATING
1600.0
1400.0
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
-200.0
TDH (ft.)
0
50
100
150
200
250
300
Flow (gpm)
CPUMP057B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

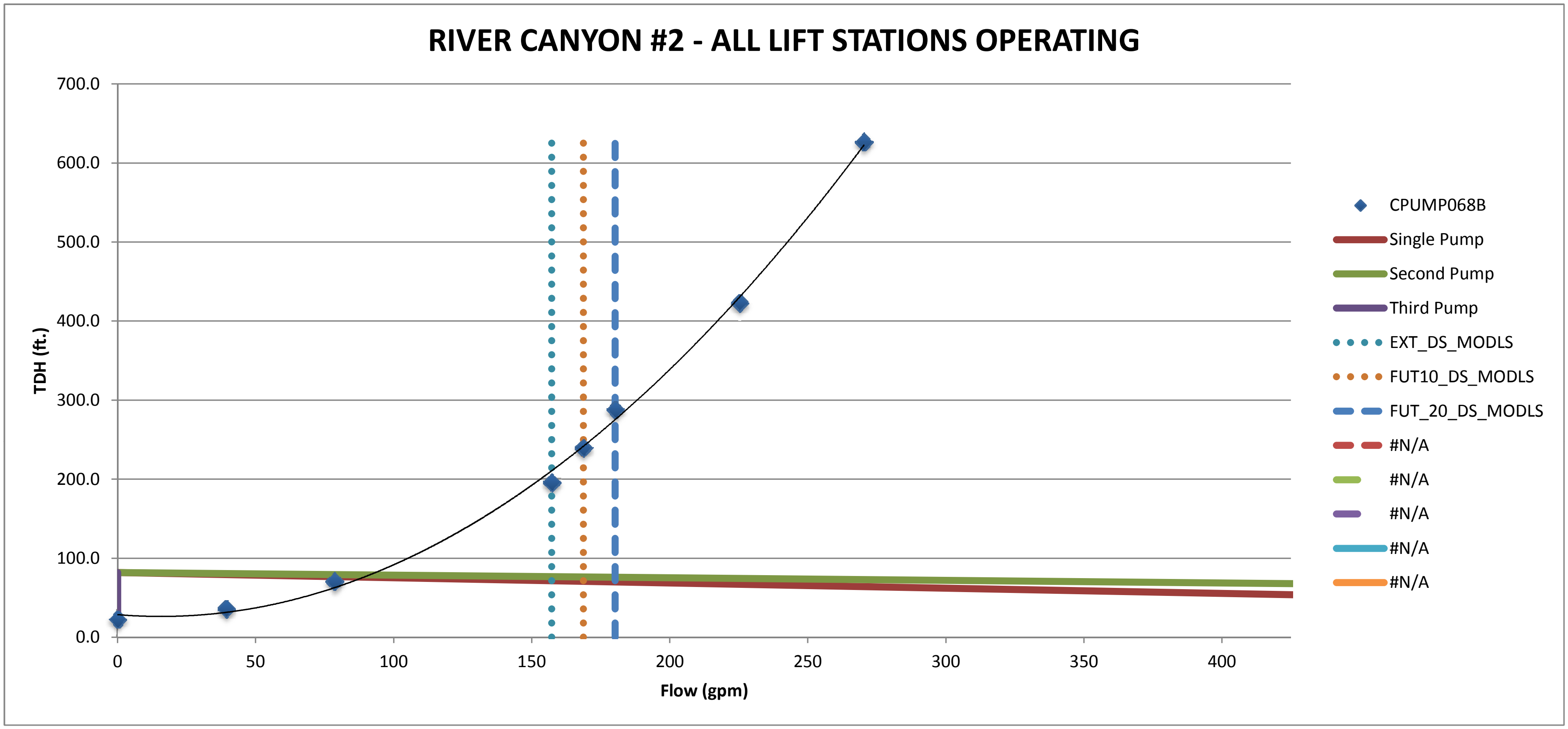


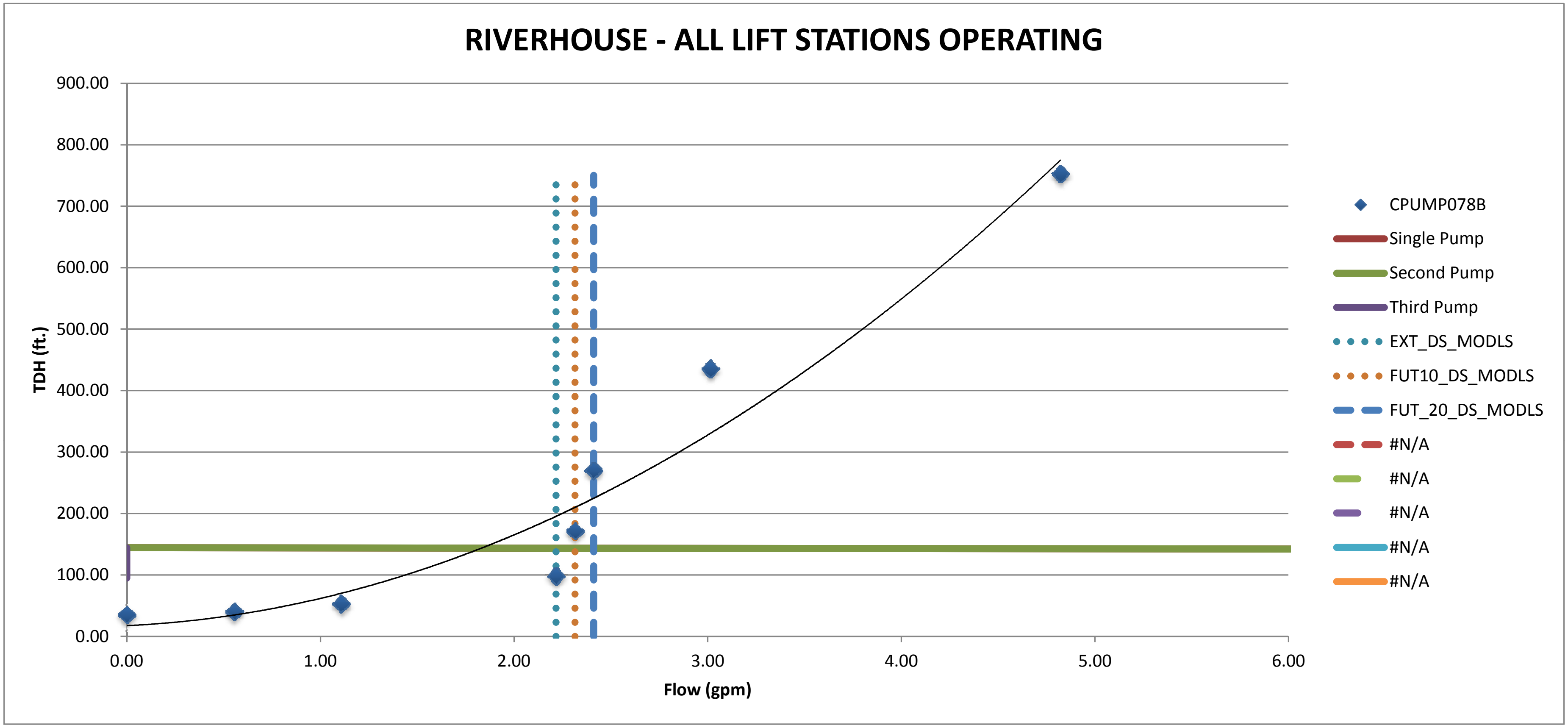
RIDGEWATER - ALL LIFT STATIONS OPERATING
1800
1600
1400
1200
1000
800
600
400
200
0
TDH (ft.)
0
10
20
30
40
50
60
70
80
90
100
Flow (gpm)
CPUMP056B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

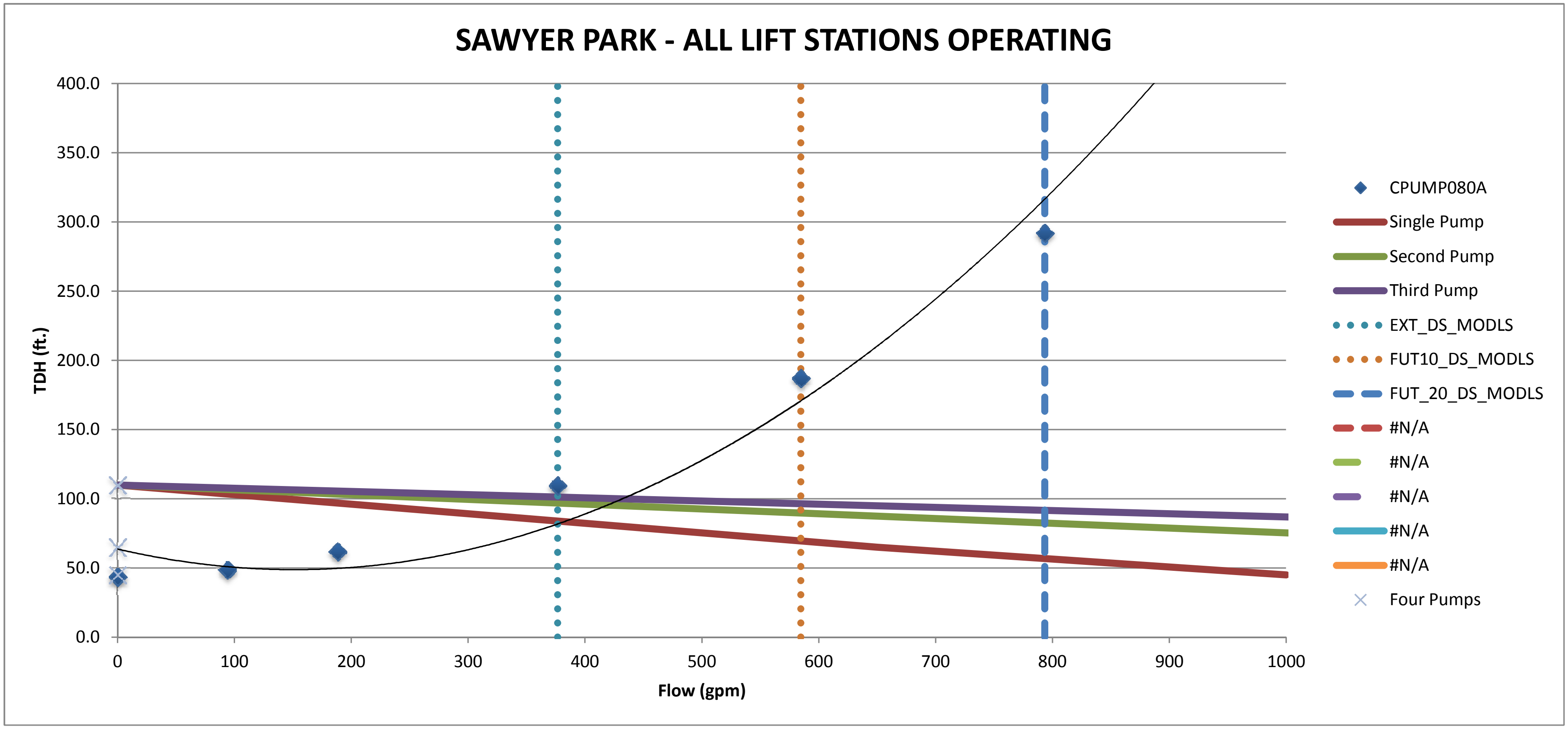


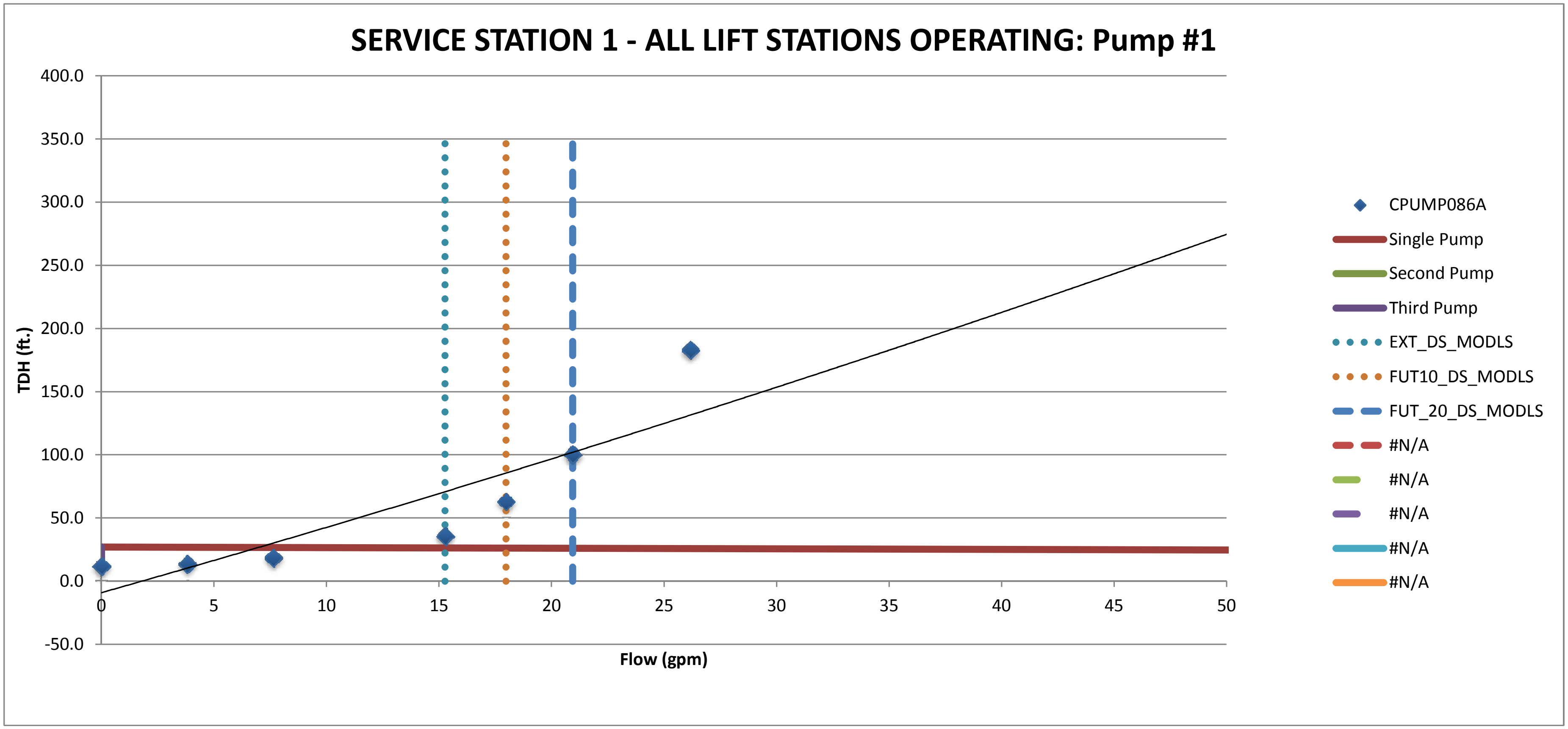
RIM ROCK RIDERS - ALL LIFT STATIONS OPERATING
TDH (ft.)
600.0
500.0
400.0
300.0
200.0
100.0
0.0
0
5
10
15
20
25
30
35
40
Flow (gpm)
CPUMP084B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

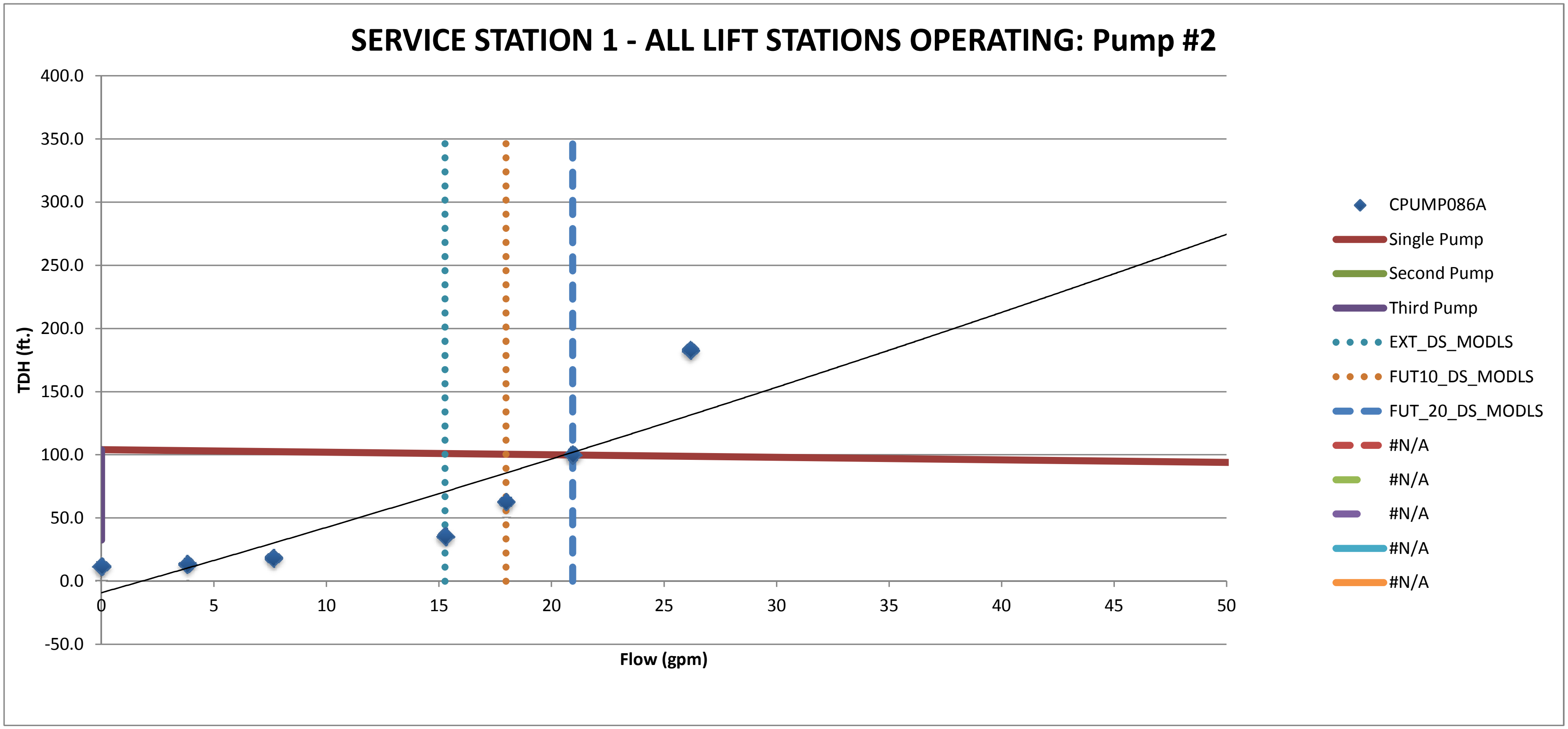

RIVER CANYON #1 - ALL LIFT STATIONS OPERATING
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
TDH (ft.)
0
50
100
150
200
250
300
Flow (gpm)
CPUMP066B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A


RIVER CANYON #2 - ALL LIFT STATIONS OPERATING
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
TDH (ft.)
0
50
100
150
200
250
300
350
400
Flow (gpm)
CPUMP068B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

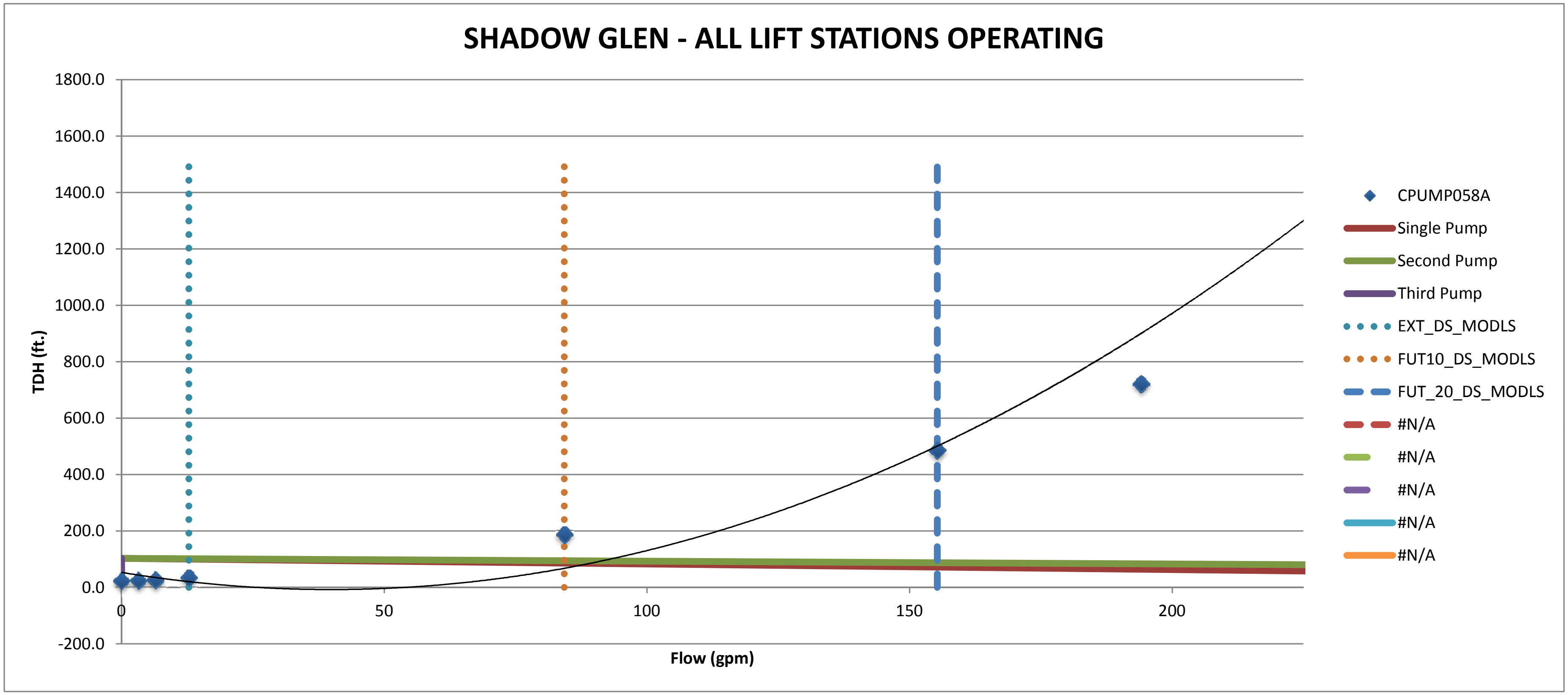

RIVERHOUSE - ALL LIFT STATIONS OPERATING
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
TDH (ft.)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
Flow (gpm)
CPUMP078B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A


SAWYER PARK - ALL LIFT STATIONS OPERATING
TDH (ft.)
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0
100
200
300
400
500
600
700
800
900
1000
Flow (gpm)
CPUMP080A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A
Four Pumps

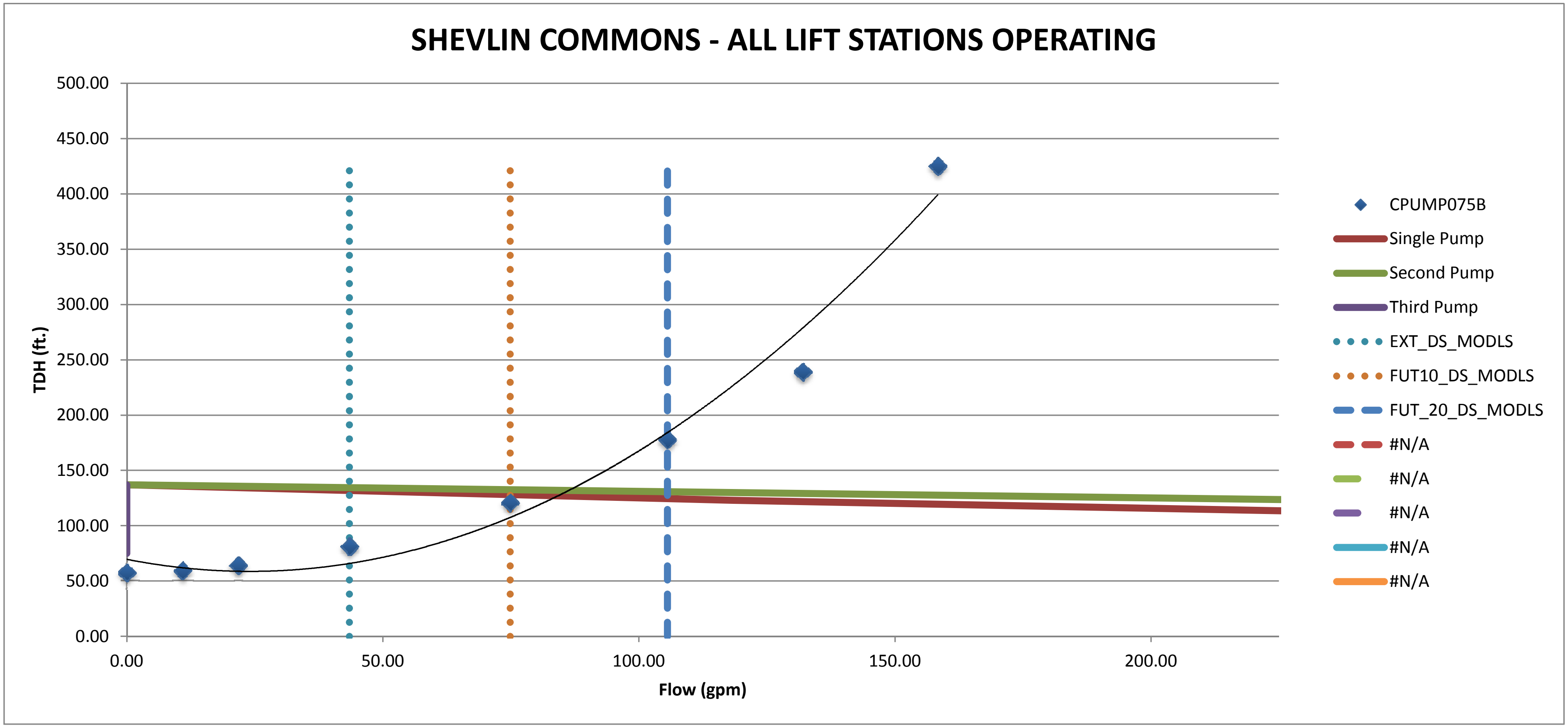

SERVICE STATION 1 - ALL LIFT STATIONS OPERATING: Pump #1
TDH (ft.)
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
-50.0
0
5
10
15
20
25
30
35
40
45
50
Flow (gpm)
CPUMP086A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

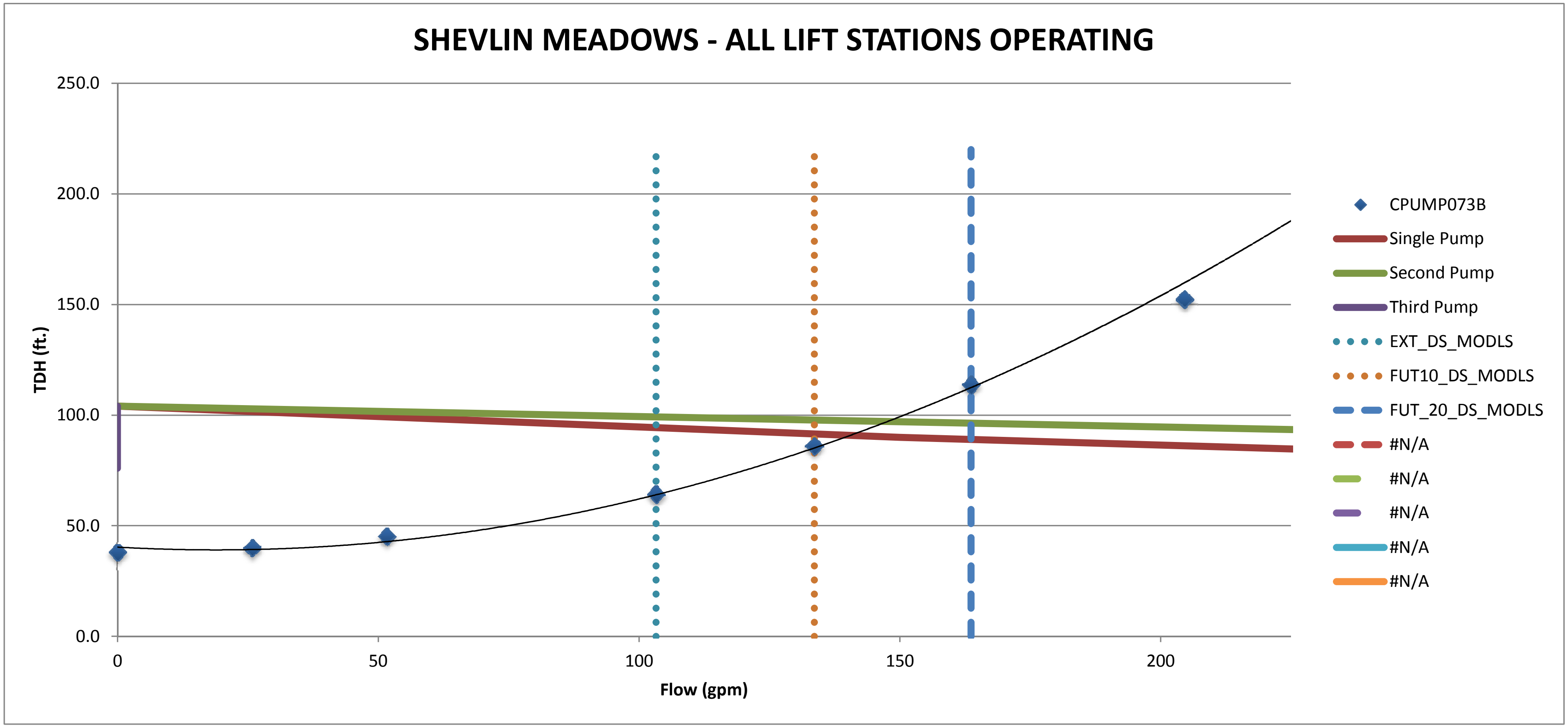


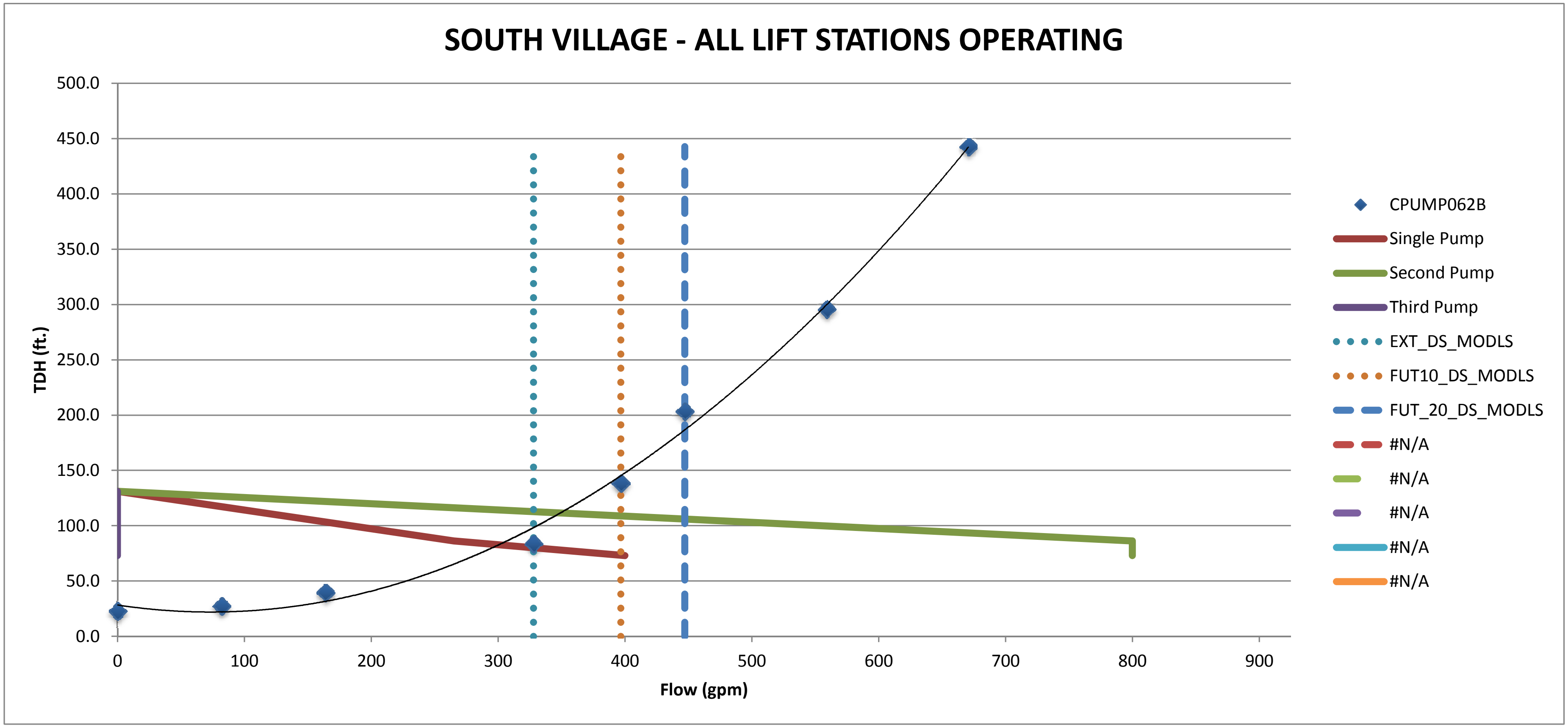
SERVICE STATION 1 - ALL LIFT STATIONS OPERATING: Pump #2
TDH (ft.)
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
-50.0
0
5
10
15
20
25
30
35
40
45
50
Flow (gpm)
CPUMP086A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

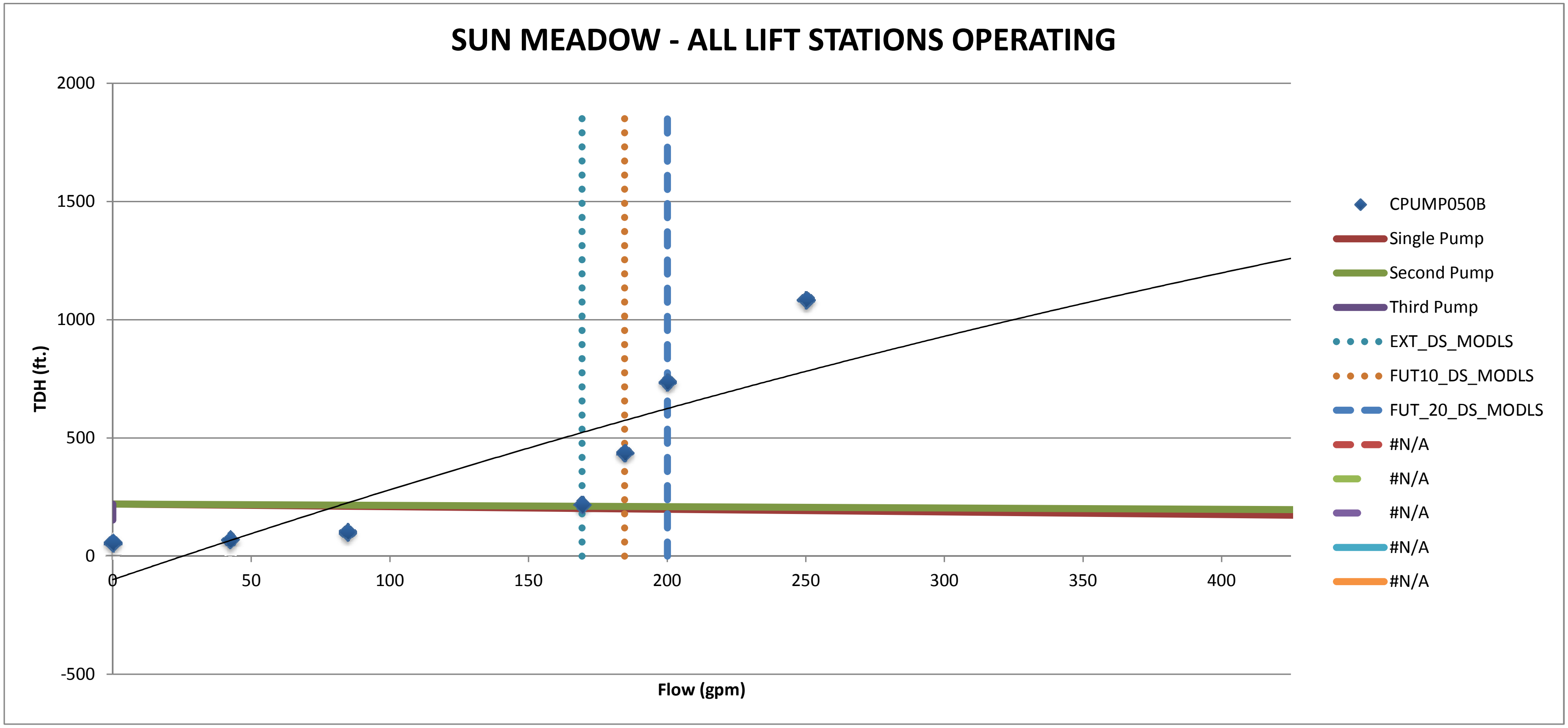


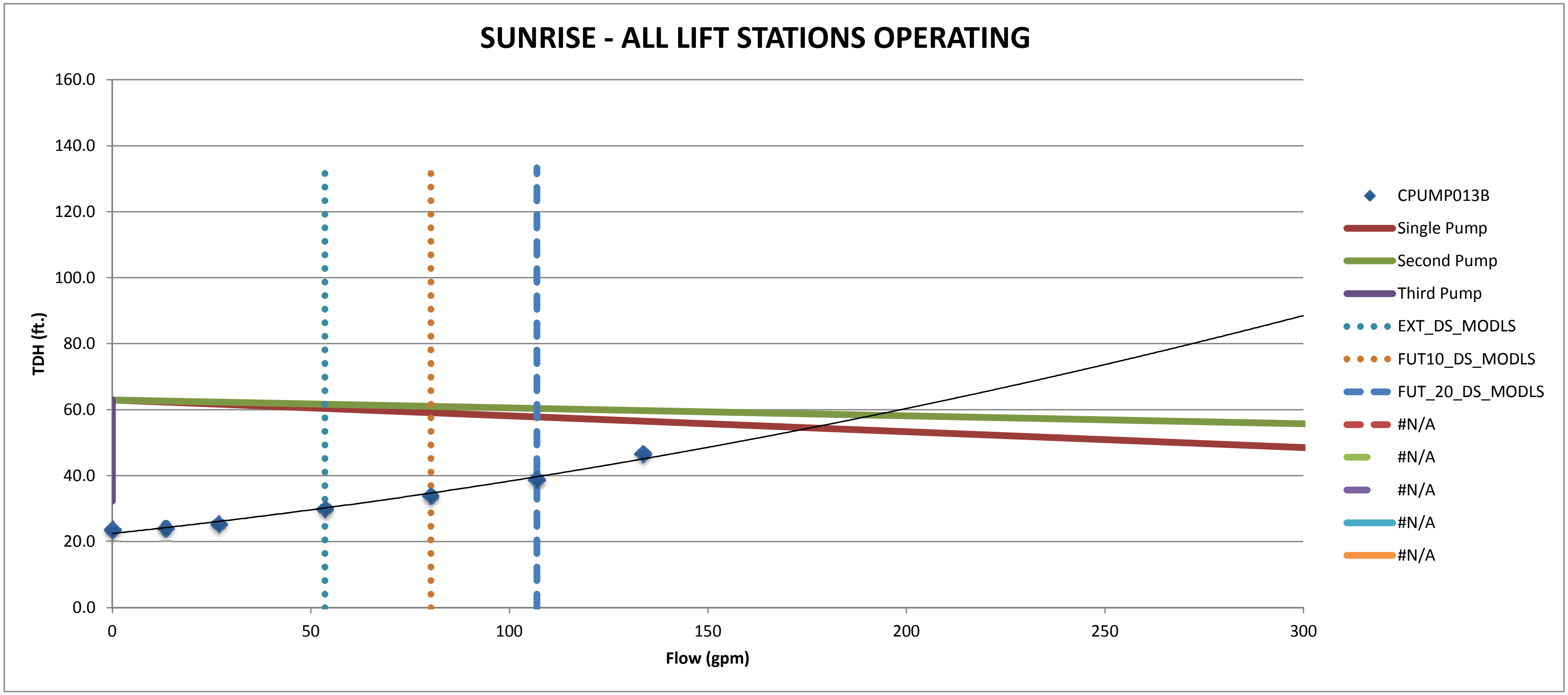
SHADOW GLEN - ALL LIFT STATIONS OPERATING
TDH (ft.)
1800.0
1600.0
1400.0
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
-200.0
0
50
100
150
200
Flow (gpm)
CPUMP058A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

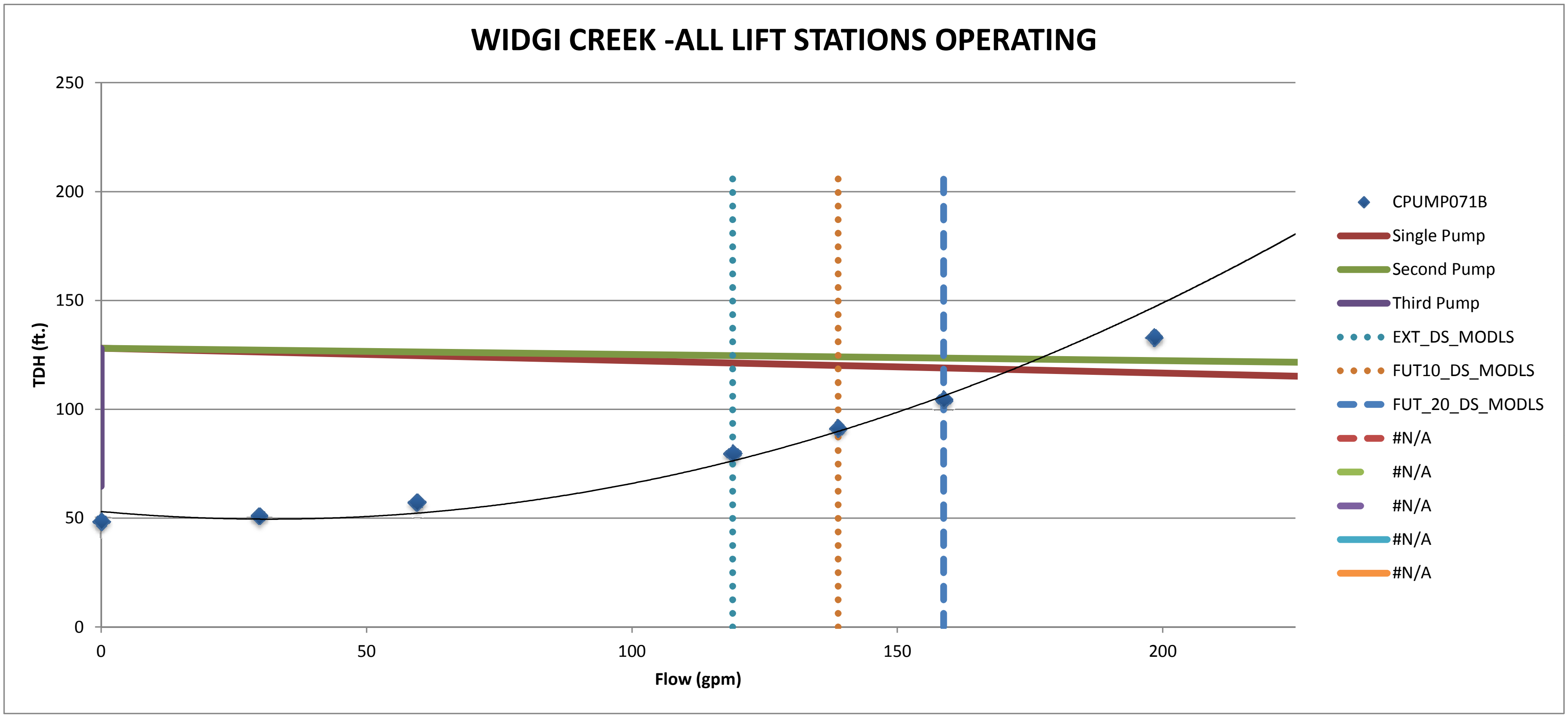

SHEVLIN COMMONS - ALL LIFT STATIONS OPERATING
TDH (ft.)
500.00
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
0.00
50.00
100.00
150.00
200.00
Flow (gpm)
CPUMP075B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

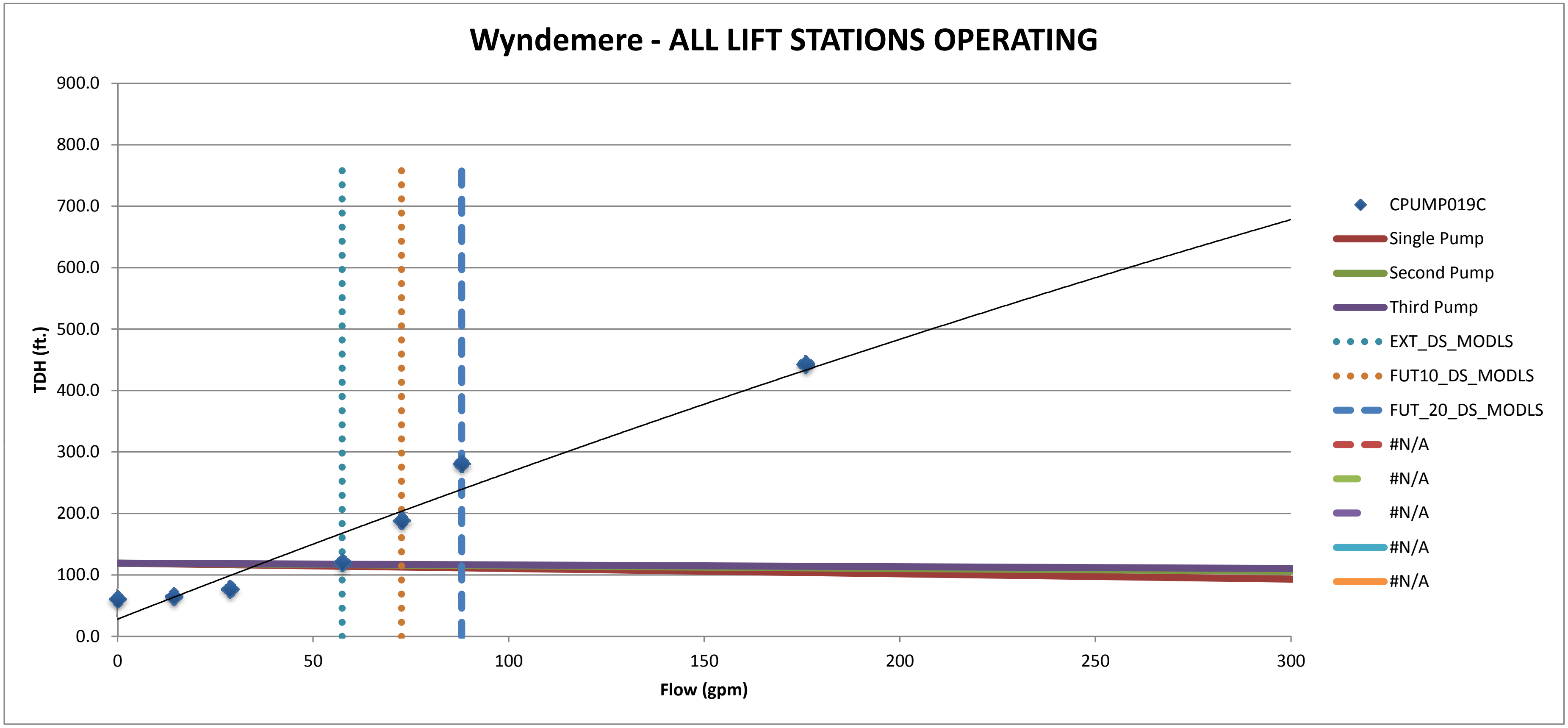

SHEVLIN MEADOWS - ALL LIFT STATIONS OPERATING
250.0
200.0
150.0
100.0
50.0
0.0
TDH (ft.)
0
50
100
150
200
Flow (gpm)
CPUMP073B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

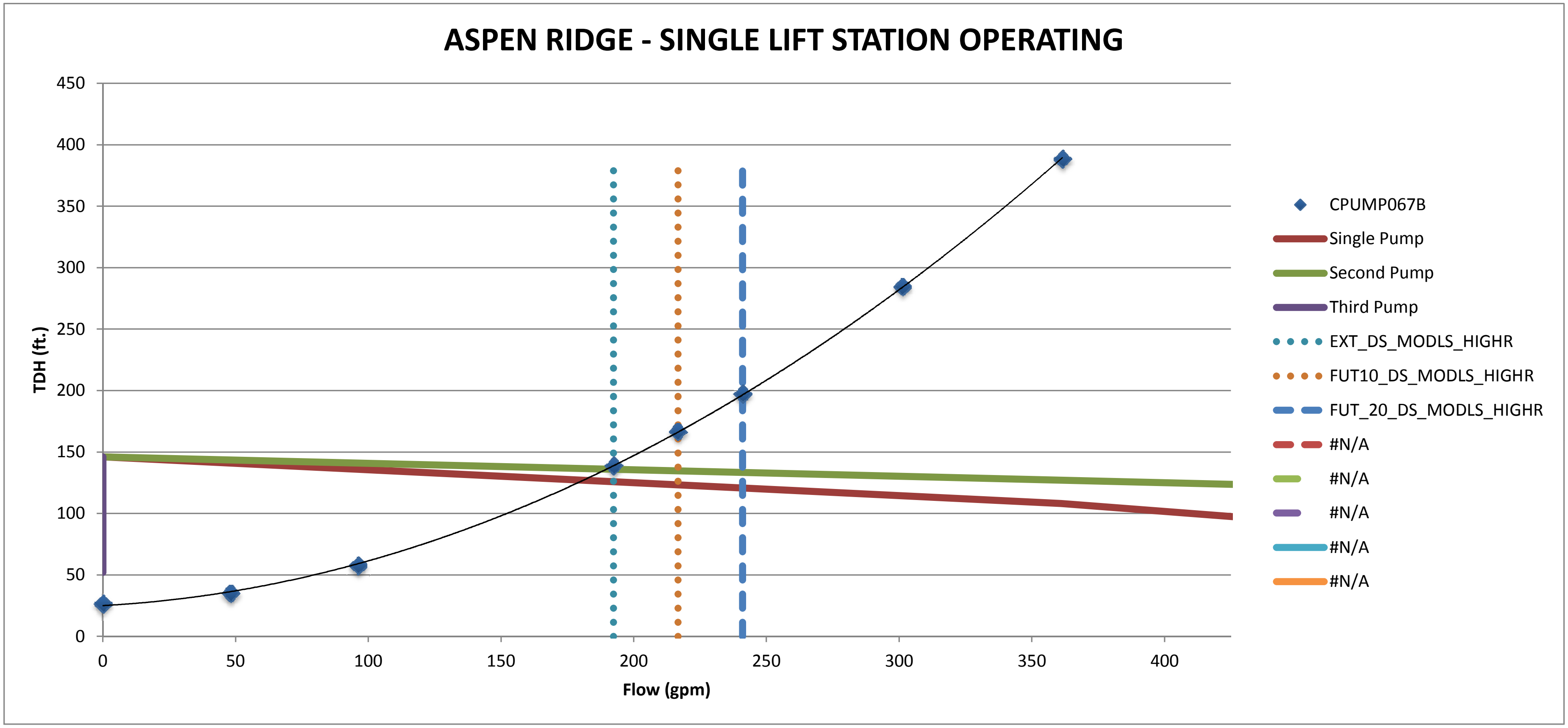

SOUTH VILLAGE - ALL LIFT STATIONS OPERATING
TDH (ft.)
500.0
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0
100
200
300
400
500
600
700
800
900
Flow (gpm)
CPUMP062B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

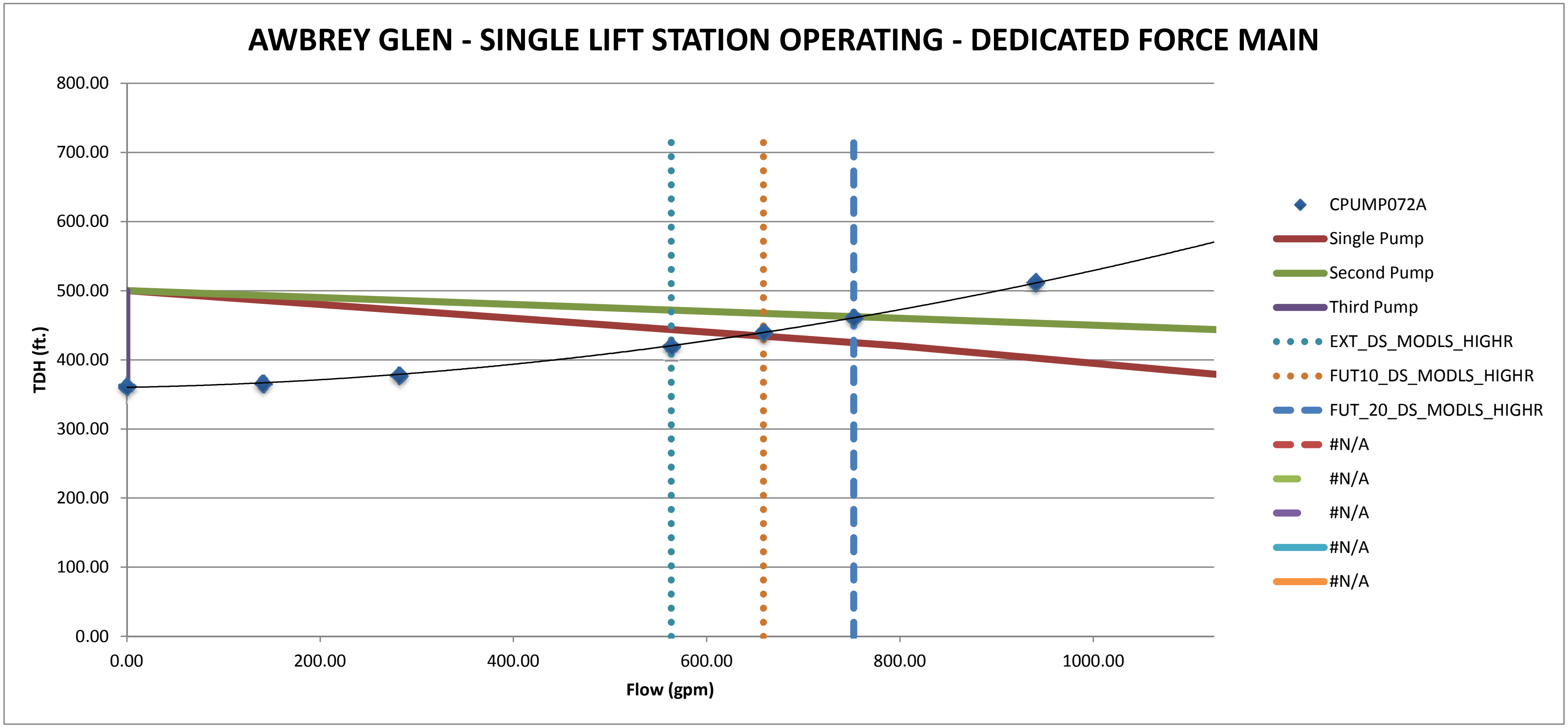

SUN MEADOW - ALL LIFT STATIONS OPERATING
TDH (ft.)
2000
1500
1000
500
0
-500
0
50
100
150
200
250
300
350
400
Flow (gpm)
CPUMP050B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A


SUNRISE - ALL LIFT STATIONS OPERATING
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
TDH (ft.)
0
50
100
150
200
250
300
Flow (gpm)
CPUMP013B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

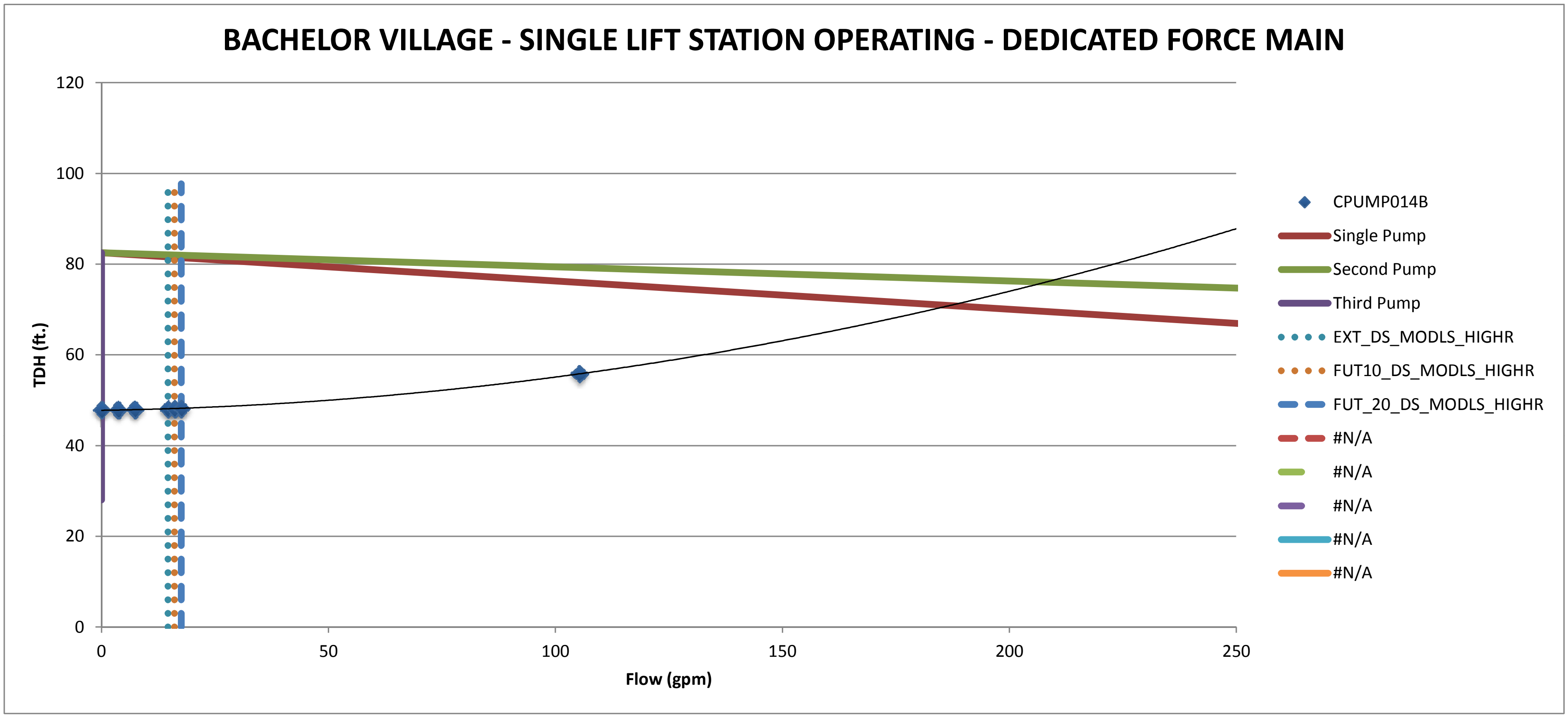

WIDGI CREEK -ALL LIFT STATIONS OPERATING
TDH (ft.)
Flow (gpm)
0
50
100
150
200
250
0
50
100
150
200
CPUMP071B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

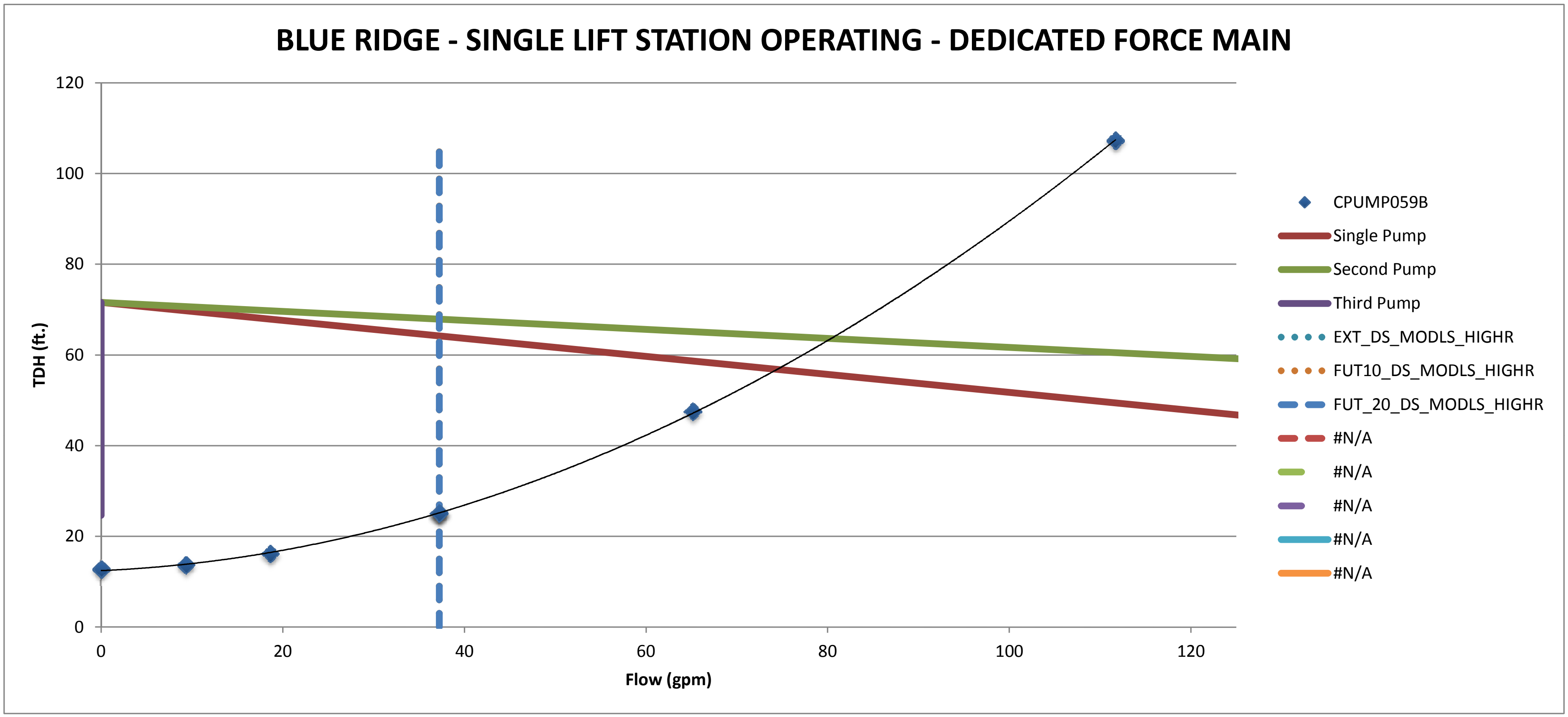

Wyndemere - ALL LIFT STATIONS OPERATING
900.0
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
TDH (ft.)
0
50
100
150
200
250
300
Flow (gpm)
CPUMP019C
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A


ASPEN RIDGE - SINGLE LIFT STATION OPERATING
TDH (ft.)
Flow (gpm)
0
50
100
150
200
250
300
350
400
450
CPUMP067B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

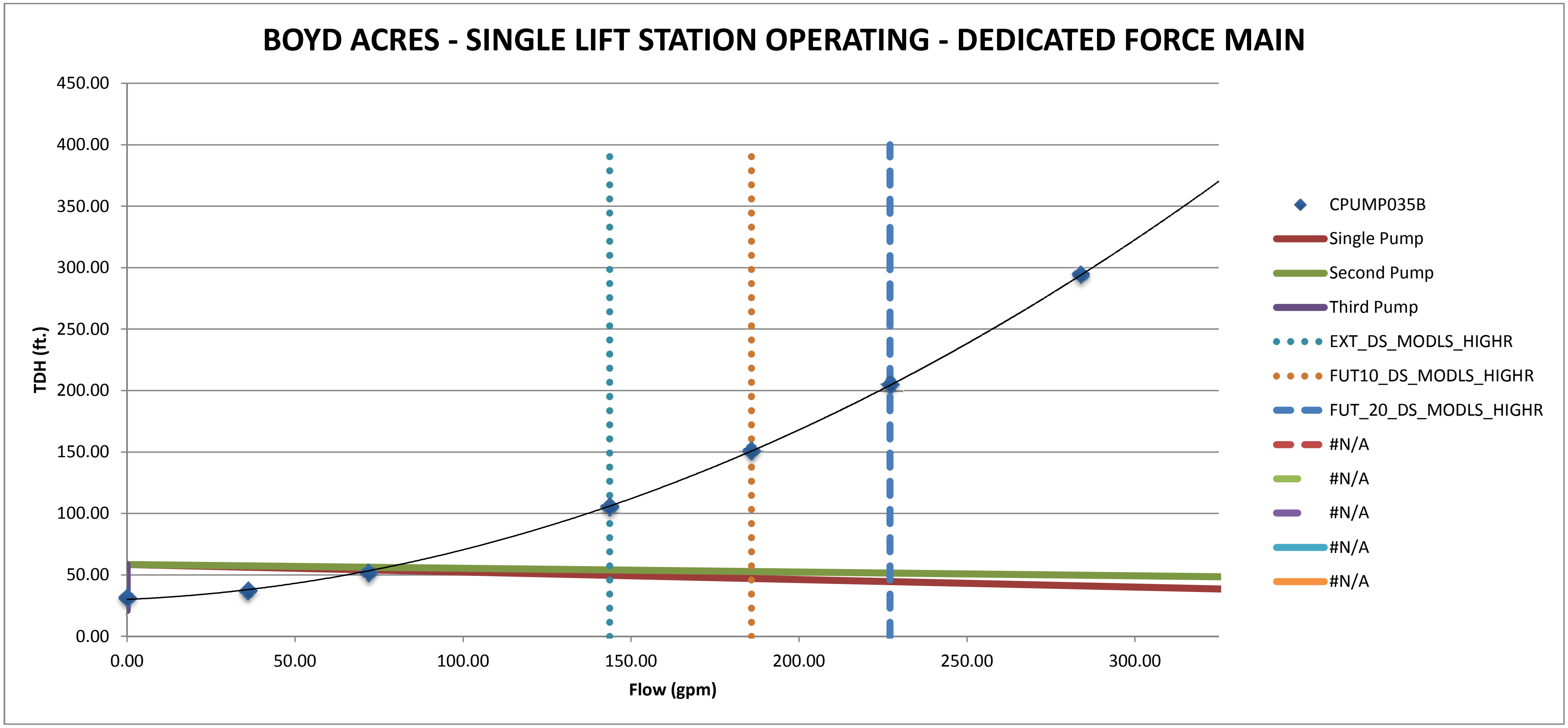


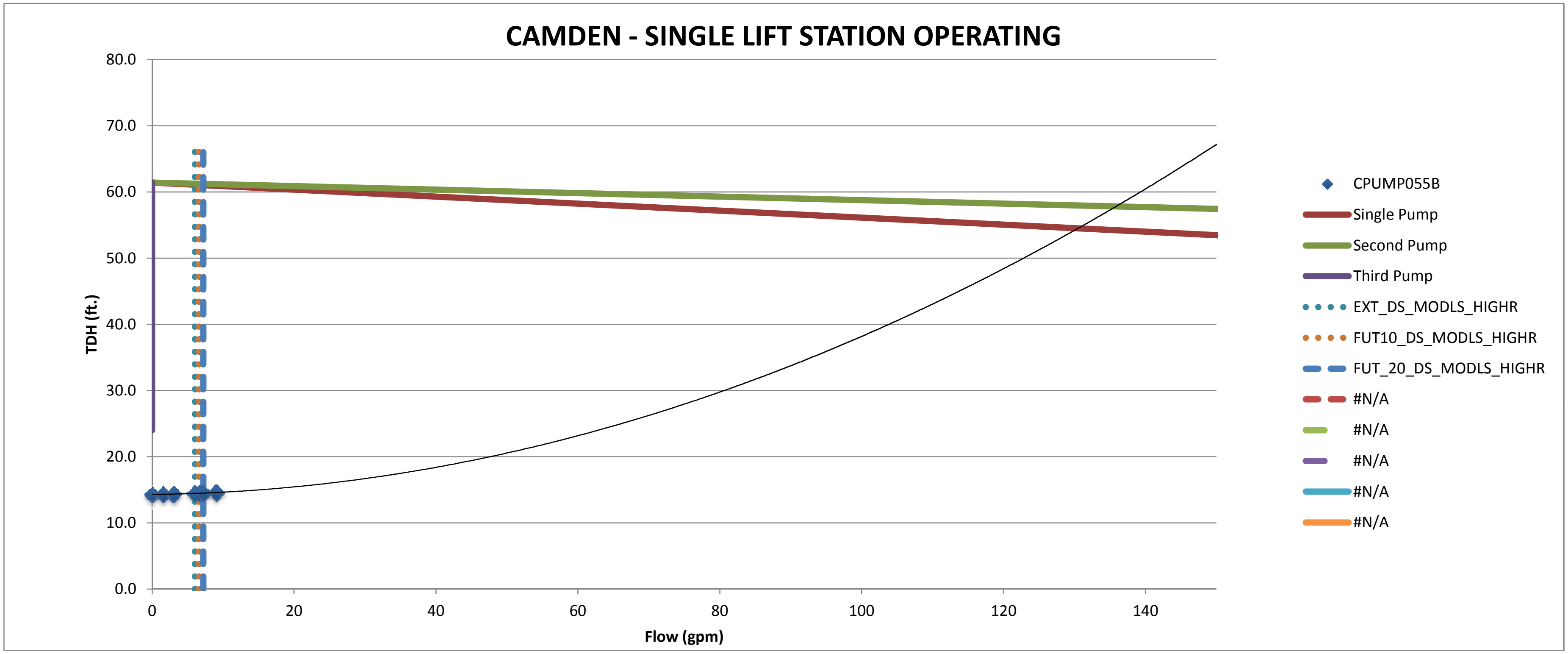
AWBREY GLEN - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
0.00
200.00
400.00
600.00
800.00
1000.00
Flow (gpm)
CPUMP072A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A


BACHELOR VILLAGE - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
120
100
80
60
40
20
0
0
50
100
150
200
250
Flow (gpm)
CPUMP014B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

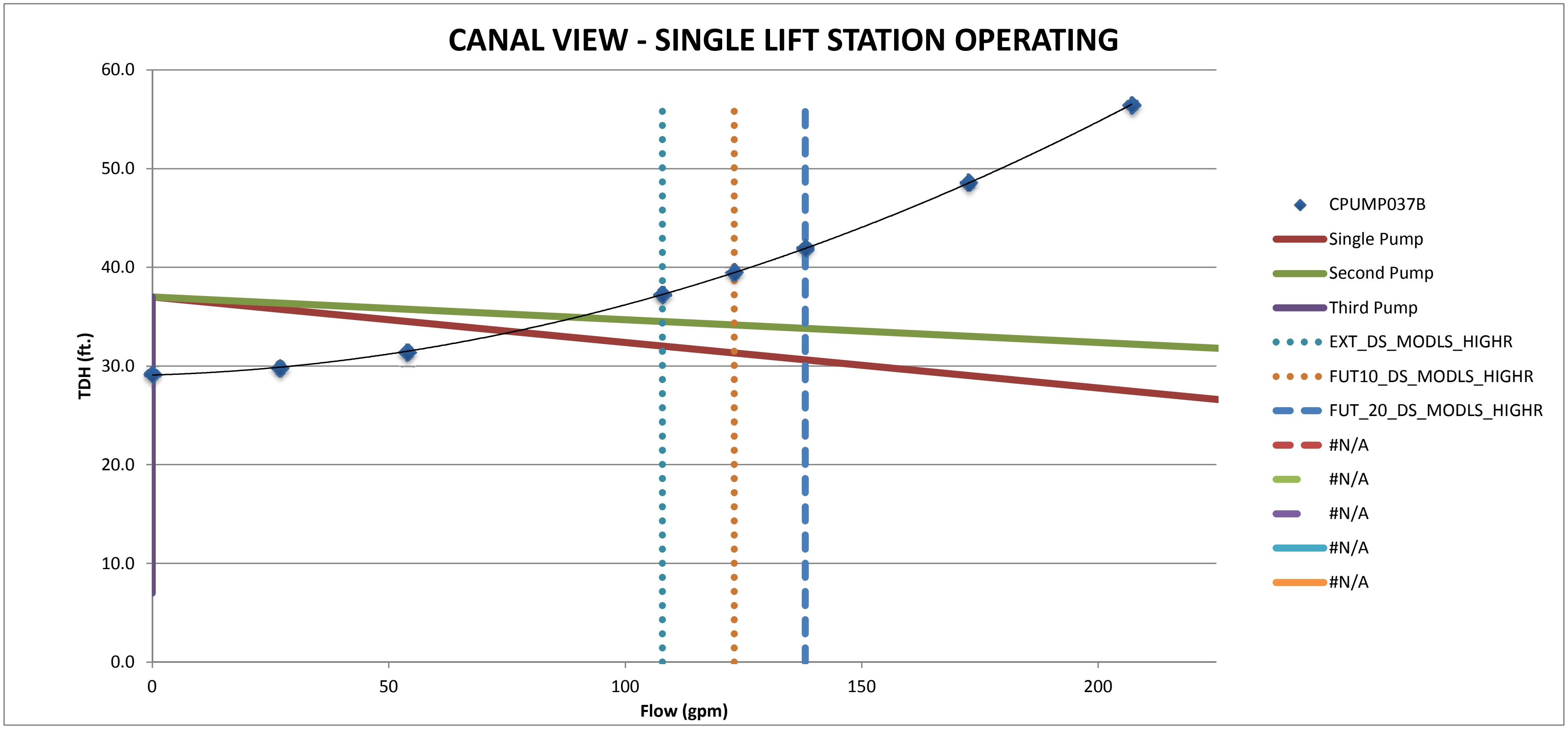


BLUE RIDGE - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
Flow (gpm)
0
20
40
60
80
100
120
CPUMP059B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

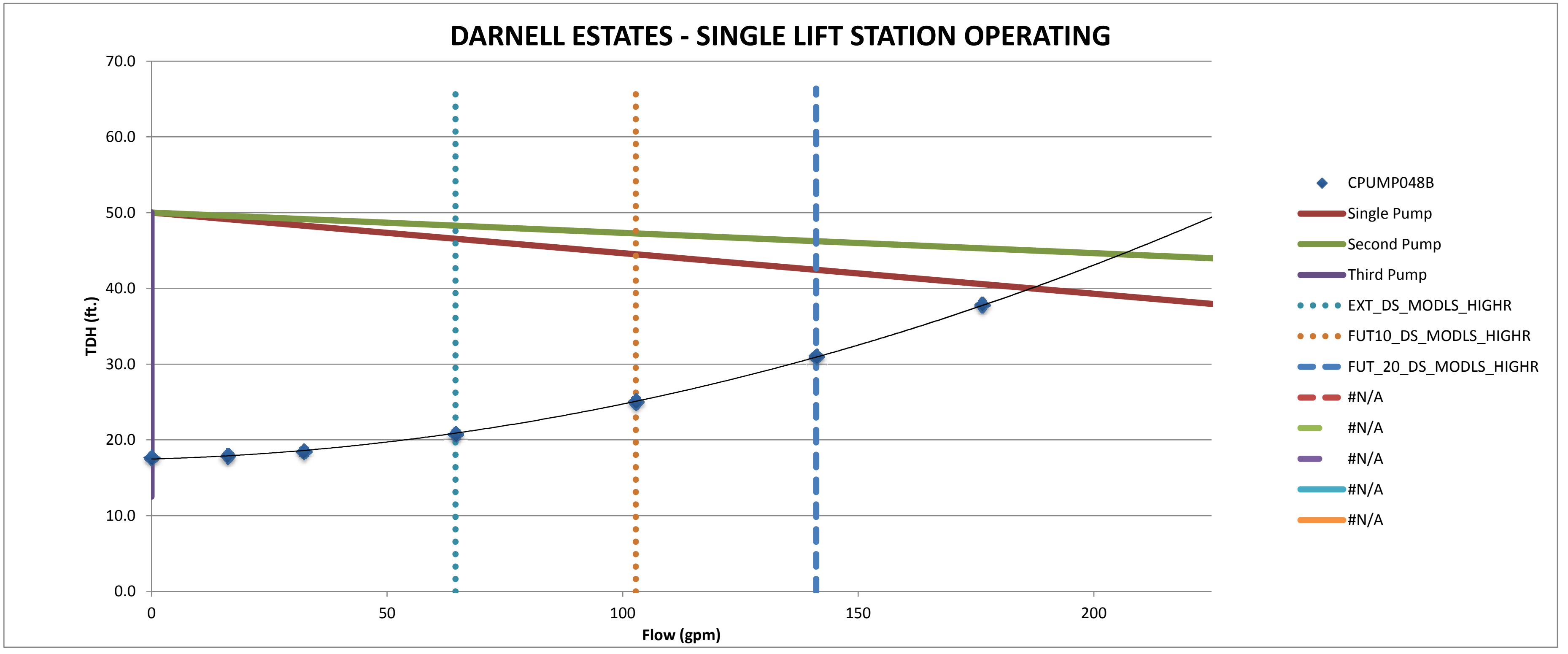

BOYD ACRES - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
TDH (ft.)
0.00
50.00
100.00
150.00
200.00
250.00
300.00
Flow (gpm)
CPUMP035B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A



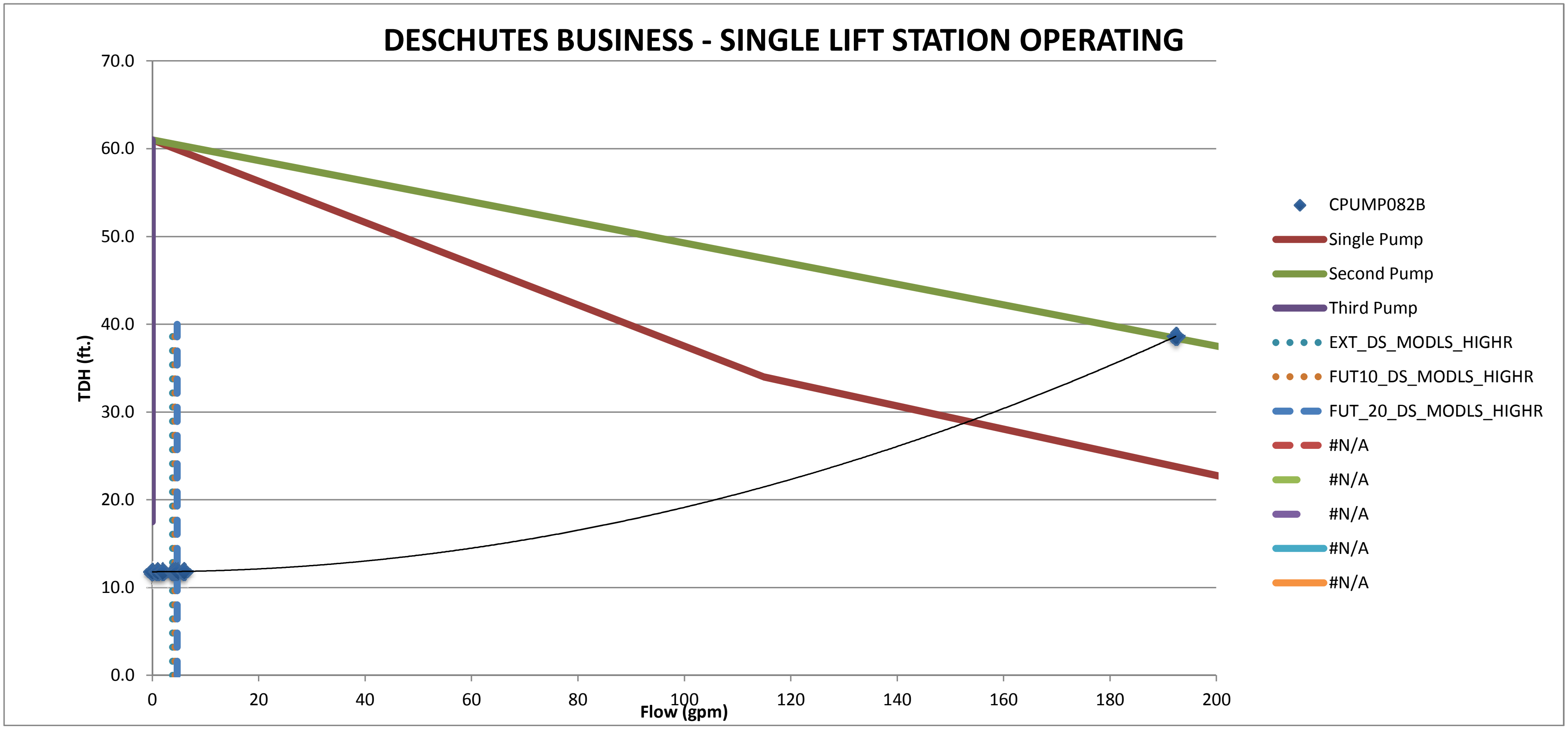
CAMDEN - SINGLE LIFT STATION OPERATING
TDH (ft.)
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
20
40
60
80
100
120
140
Flow (gpm)
CPUMP055B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

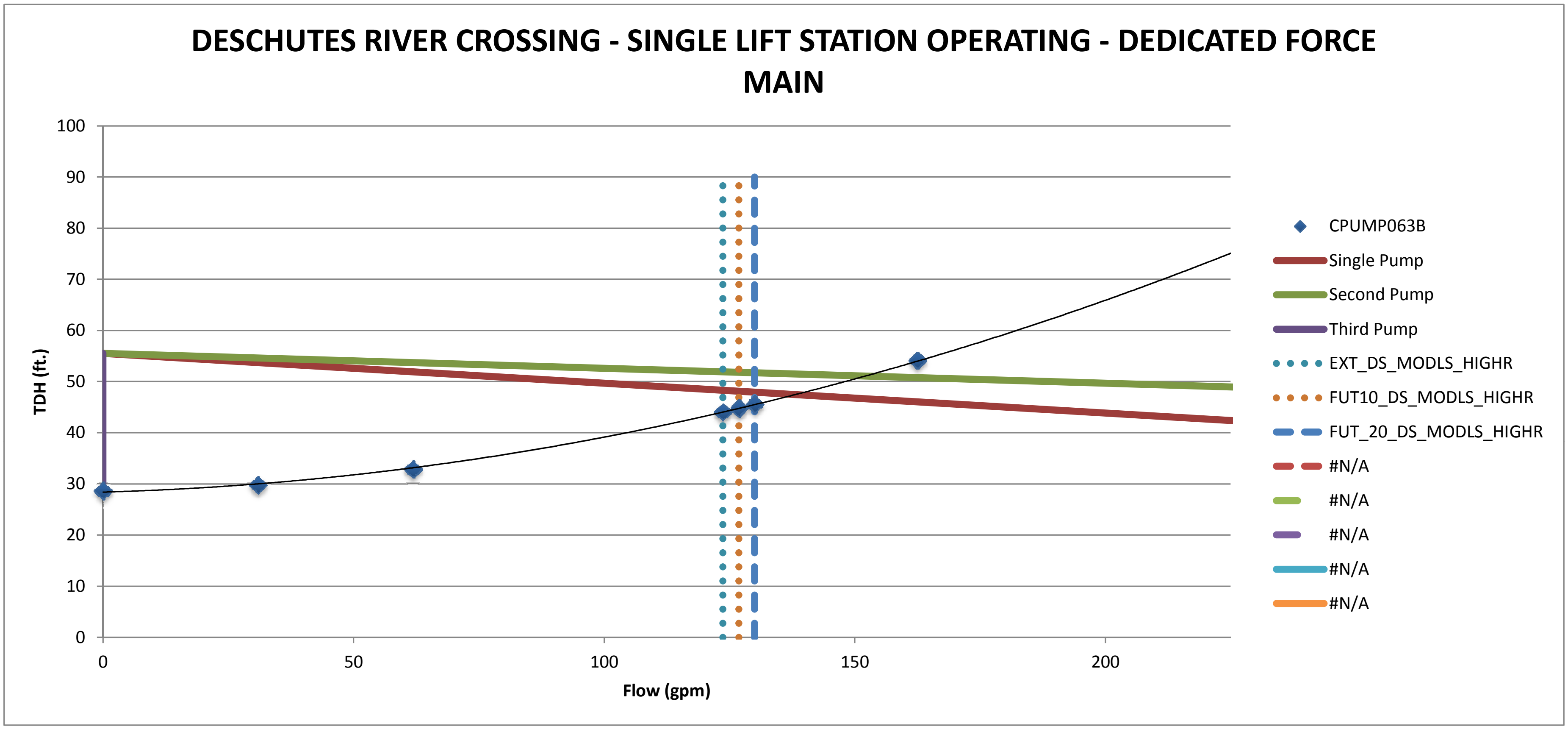


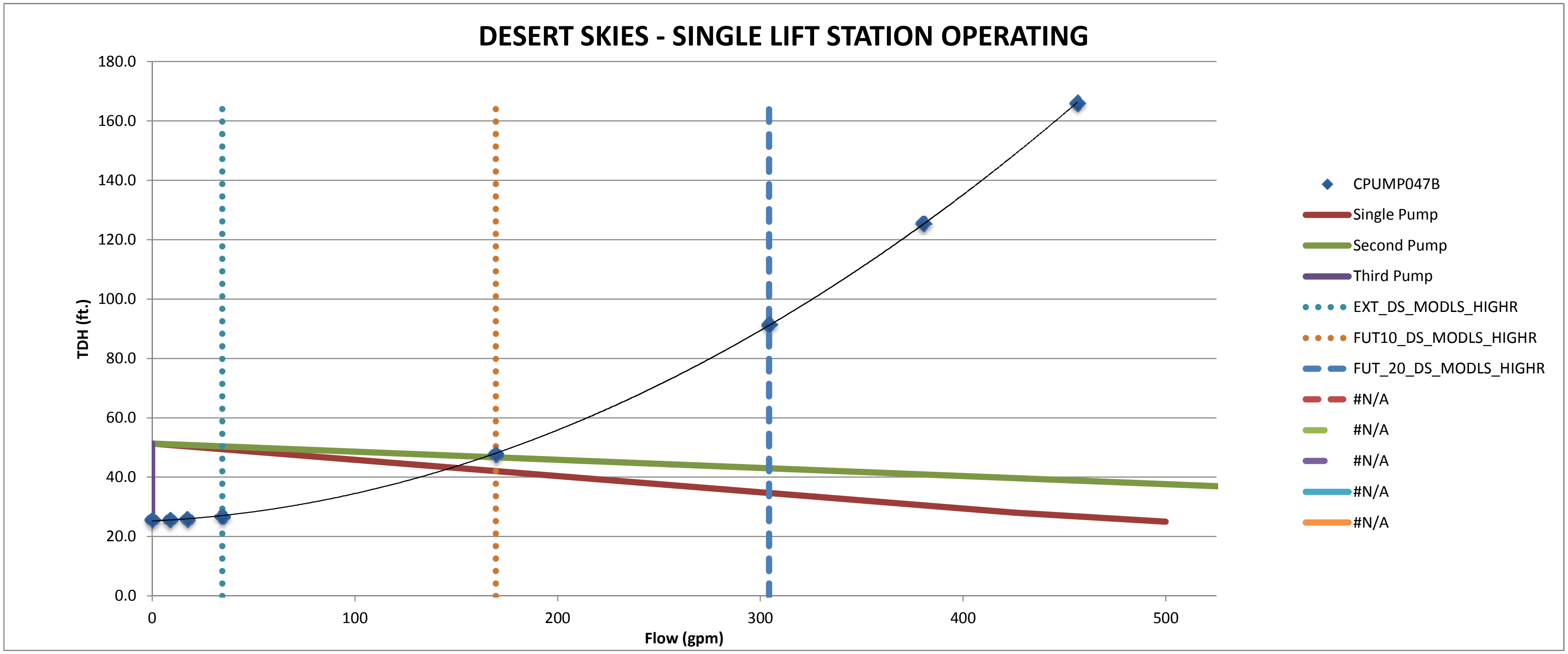
CANAL VIEW - SINGLE LIFT STATION OPERATING
60.0
50.0
40.0
30.0
20.0
10.0
0.0
TDH (ft.)
0
50
100
150
200
Flow (gpm)
CPUMP037B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

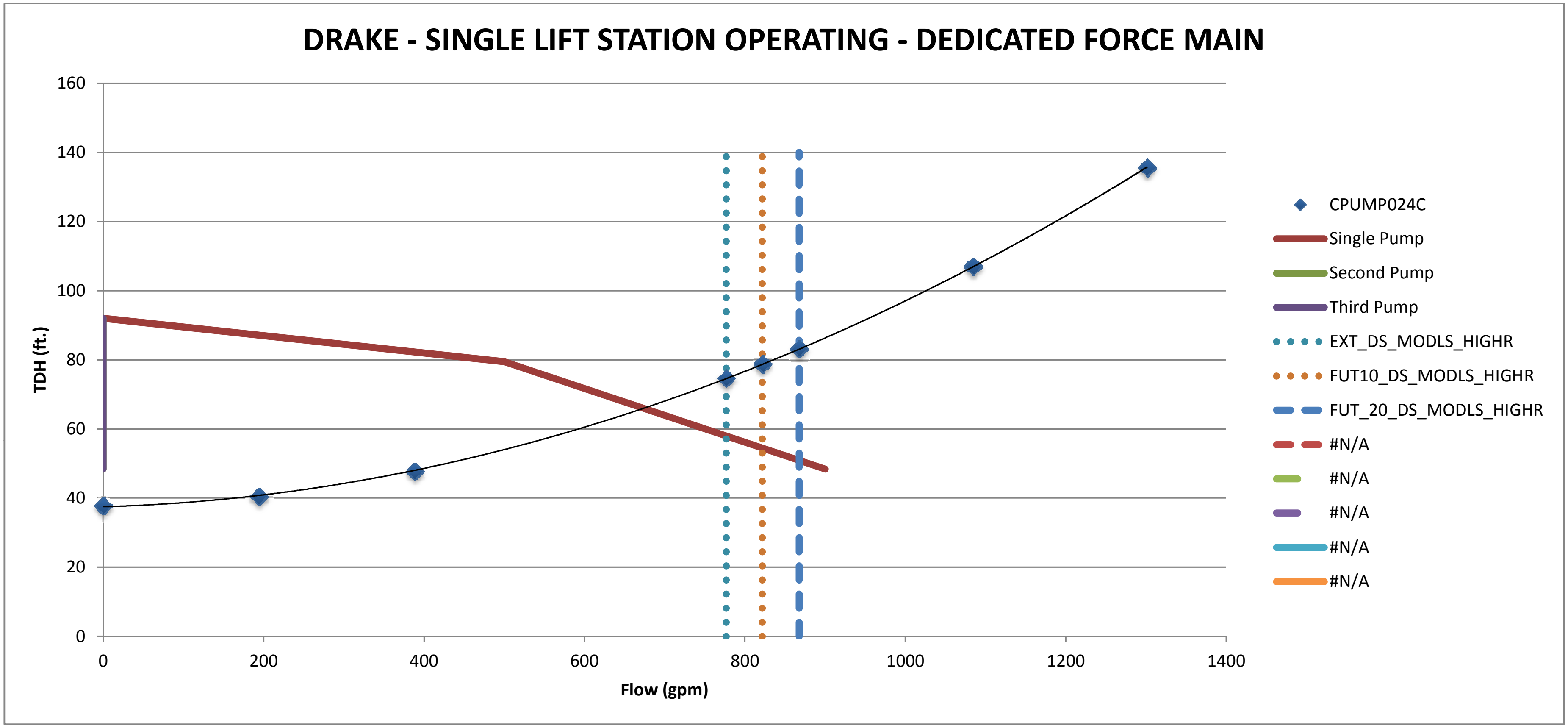


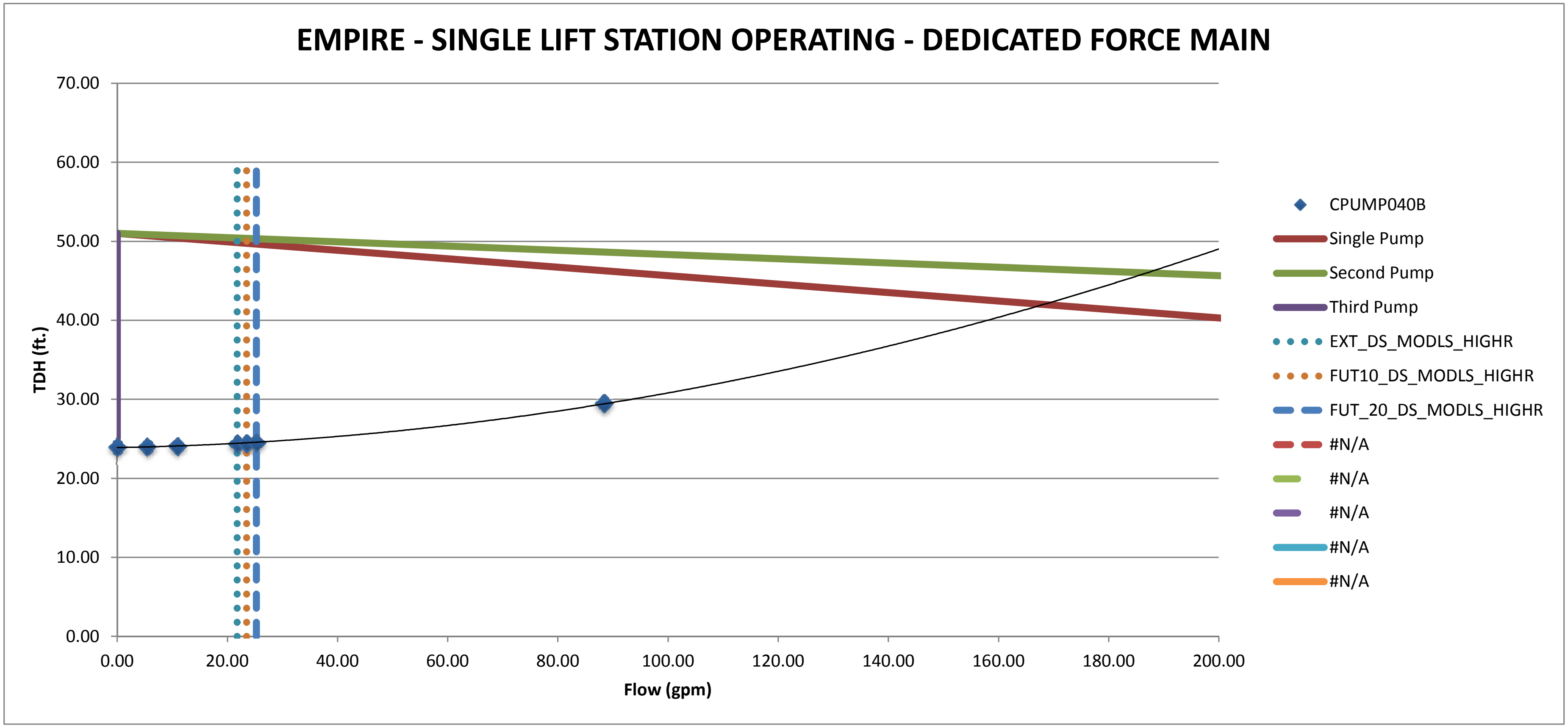
DARNELL ESTATES - SINGLE LIFT STATION OPERATING
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
TDH (ft.)
0
50
100
150
200
Flow (gpm)
CPUMP048B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A


DESCHUTES BUSINESS - SINGLE LIFT STATION OPERATING
TDH (ft.)
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
20
40
60
80
100
120
140
160
180
200
Flow (gpm)
CPUMP082B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

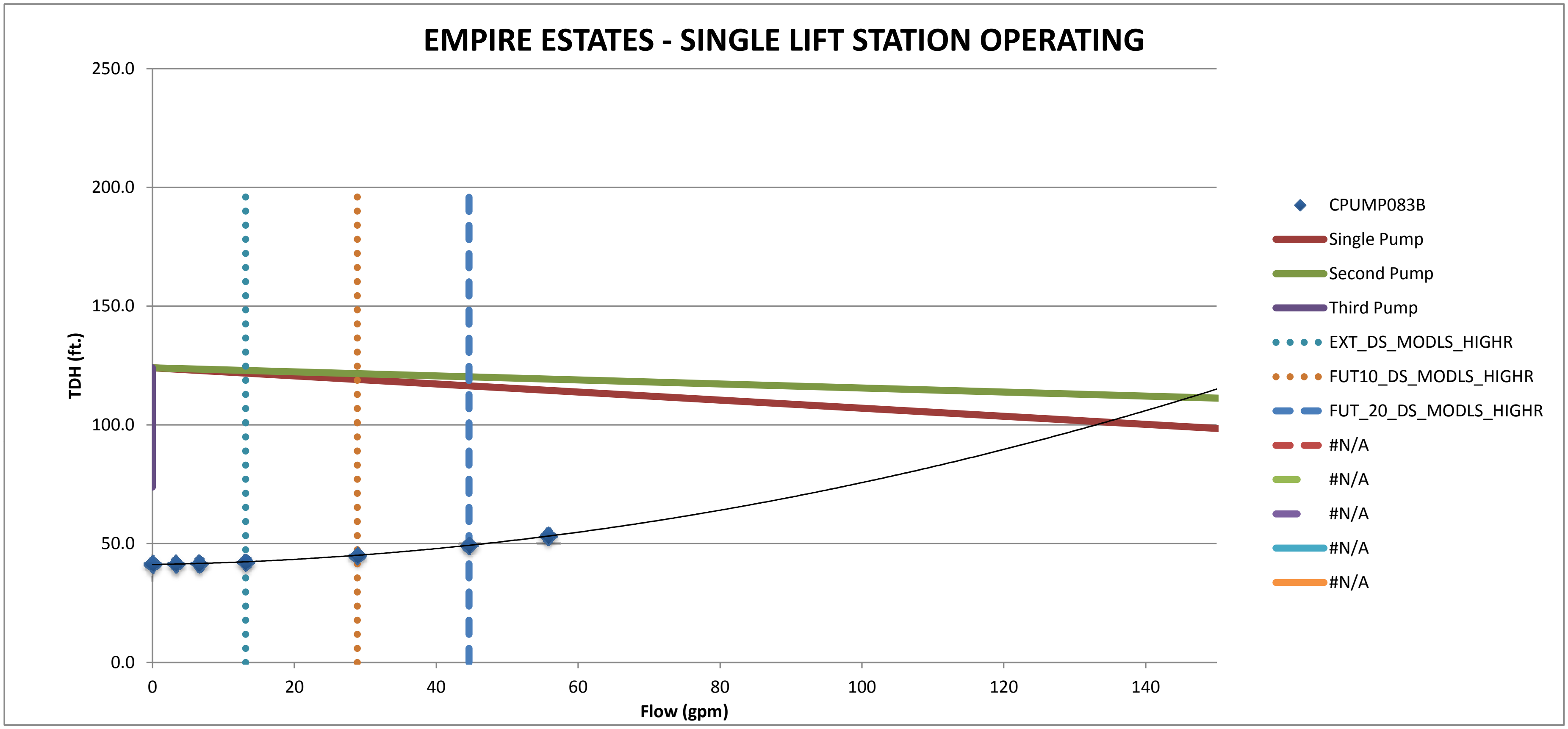

DESCHUTES RIVER CROSSING - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
Flow (gpm)
0
10
20
30
40
50
60
70
80
90
100
0
50
100
150
200
CPUMP063B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

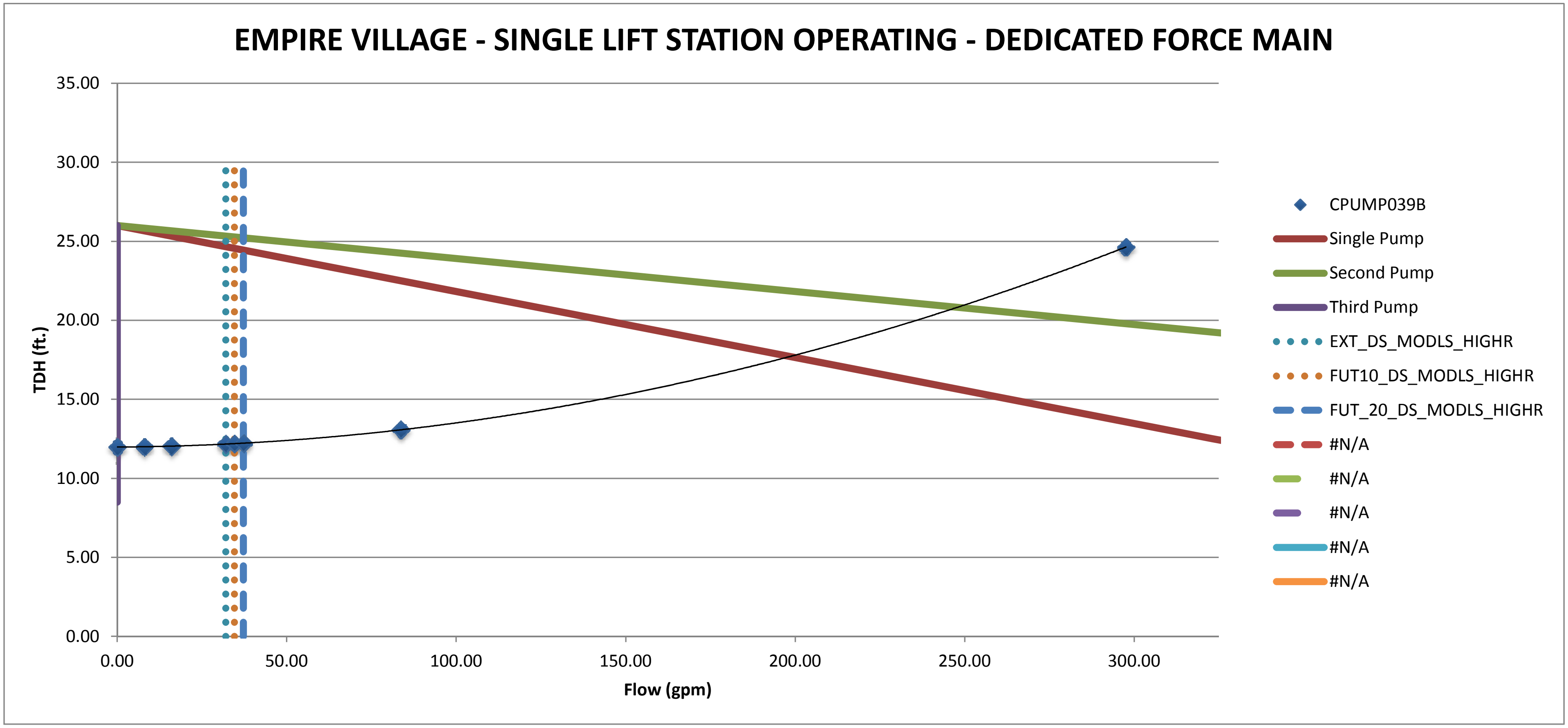

DESERT SKIES - SINGLE LIFT STATION OPERATING
TDH (ft.)
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0
100
200
300
400
500
Flow (gpm)
CPUMP047B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A


DRAKE - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
Flow (gpm)
160
140
120
100
80
60
40
20
0
0
200
400
600
800
1000
1200
1400
CPUMP024C
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

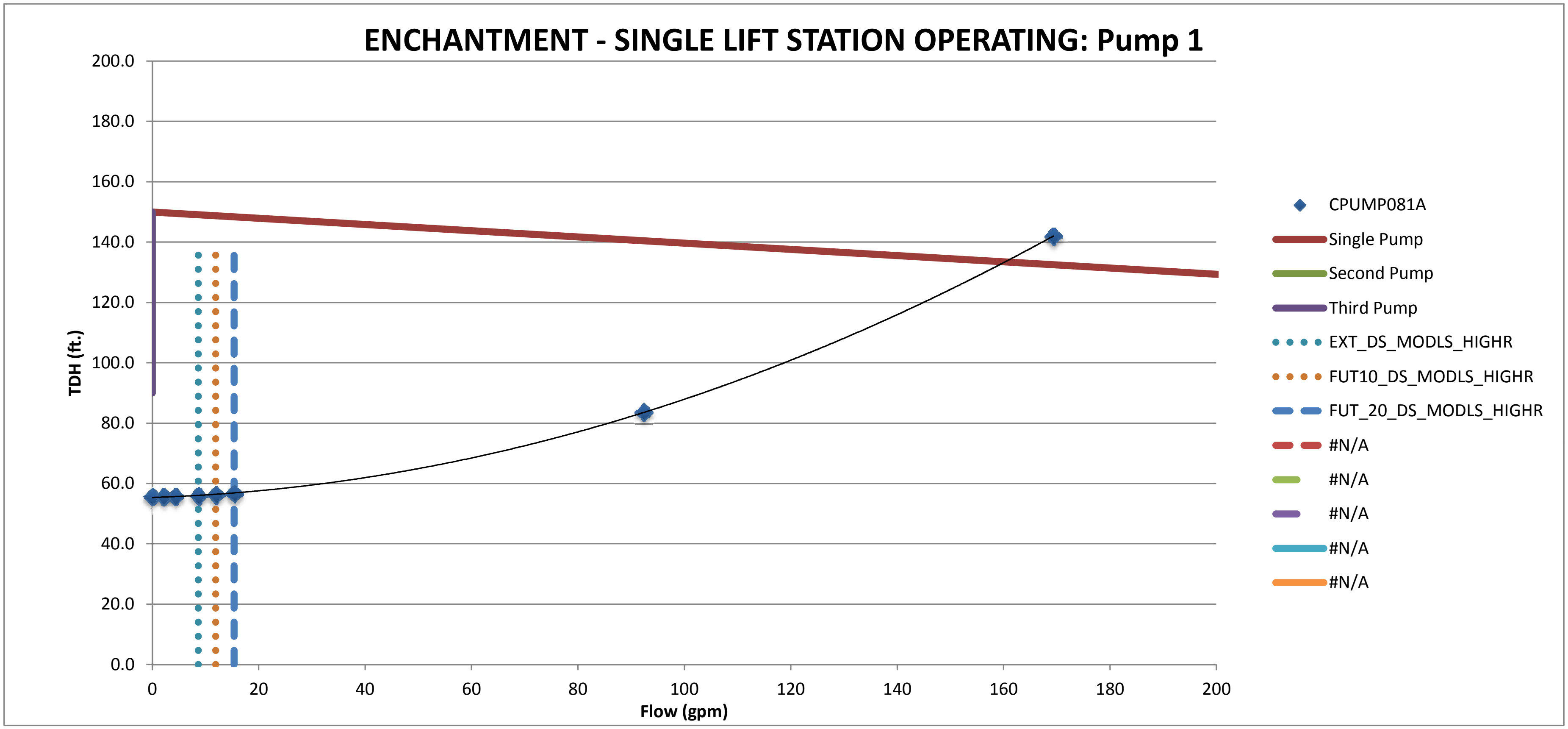


EMPIRE - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
Flow (gpm)
CPUMP040B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

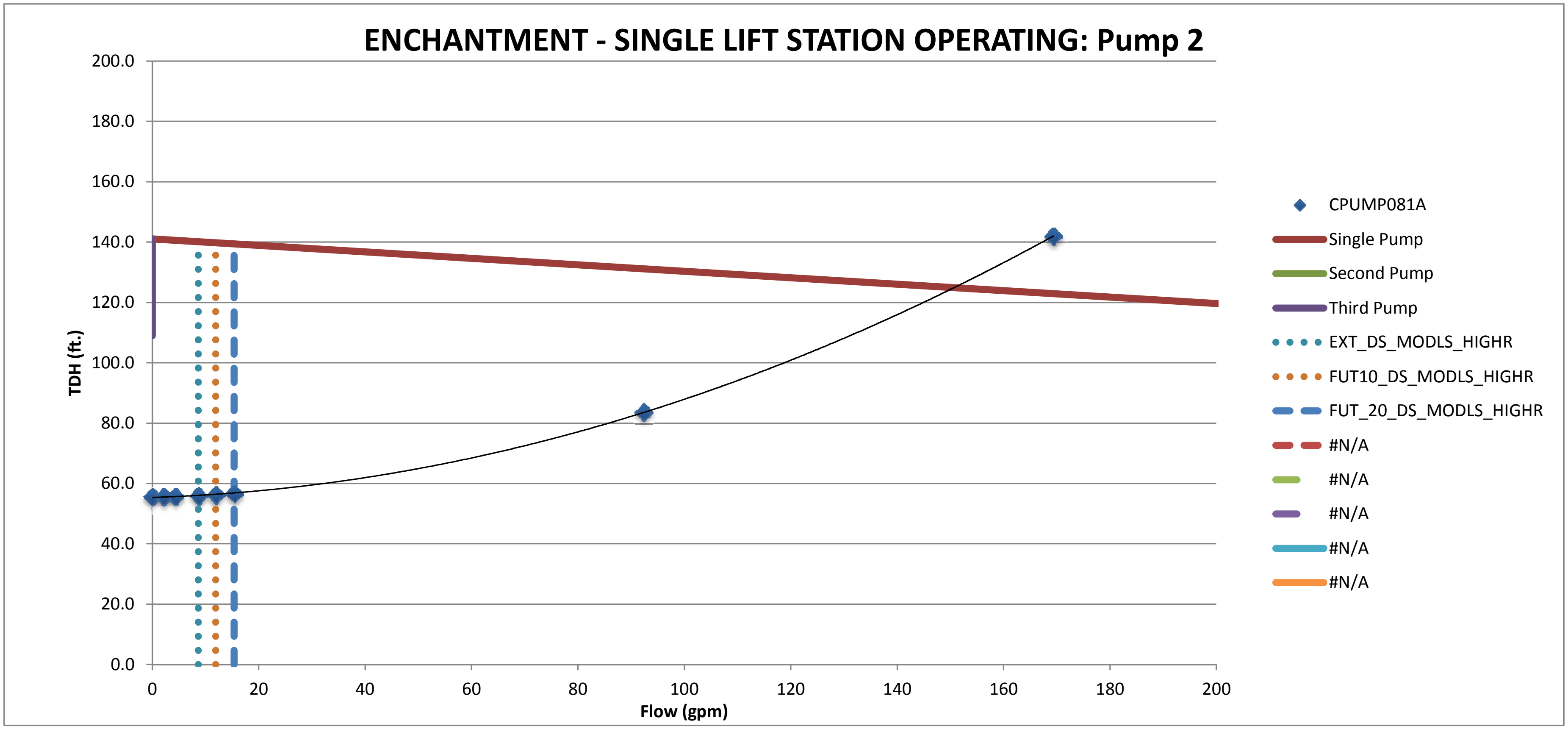

EMPIRE ESTATES - SINGLE LIFT STATION OPERATING
TDH (ft.)
250.0
200.0
150.0
100.0
50.0
0.0
0
20
40
60
80
100
120
140
Flow (gpm)
CPUMP083B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A



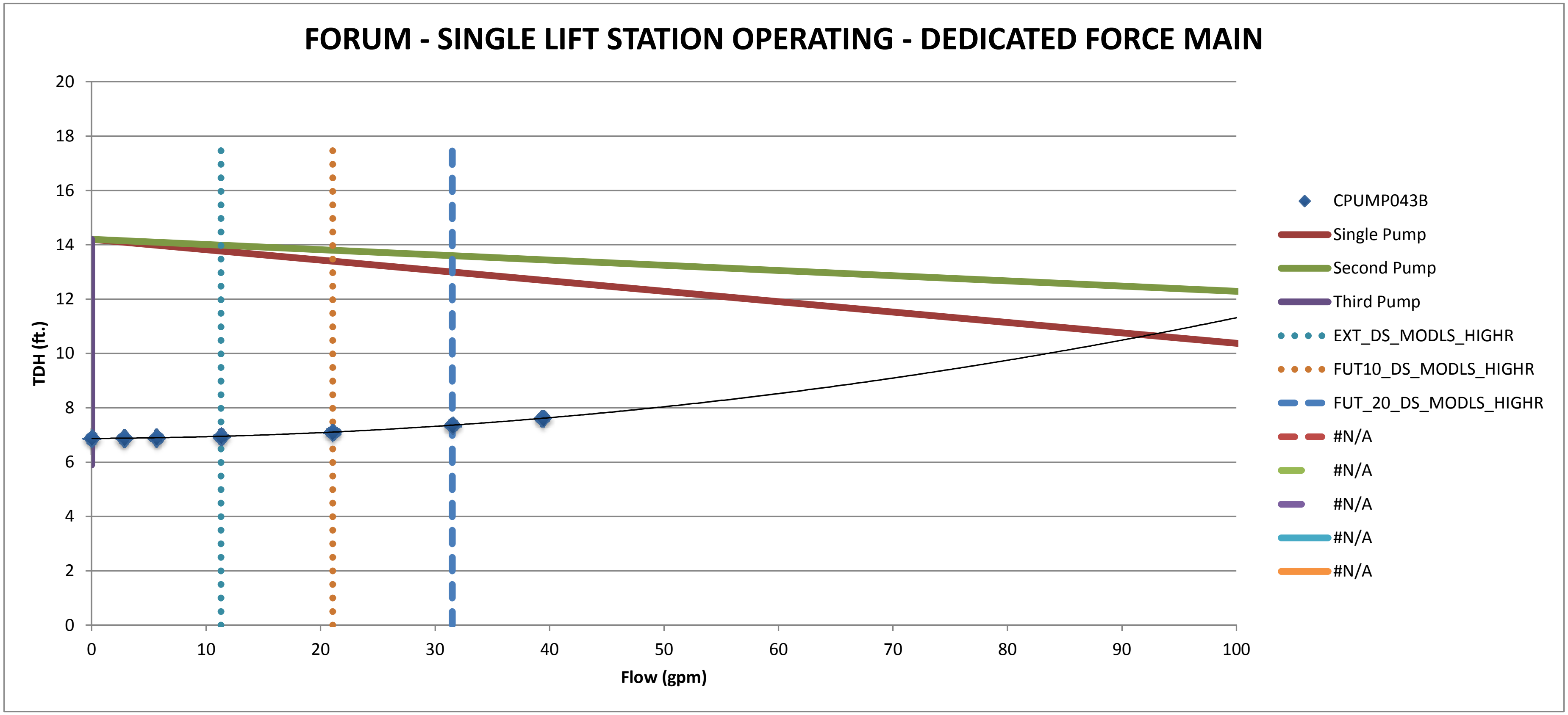
EMPIRE VILLAGE - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
TDH (ft.)
0.00
50.00
100.00
150.00
200.00
250.00
300.00
Flow (gpm)
CPUMP039B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A



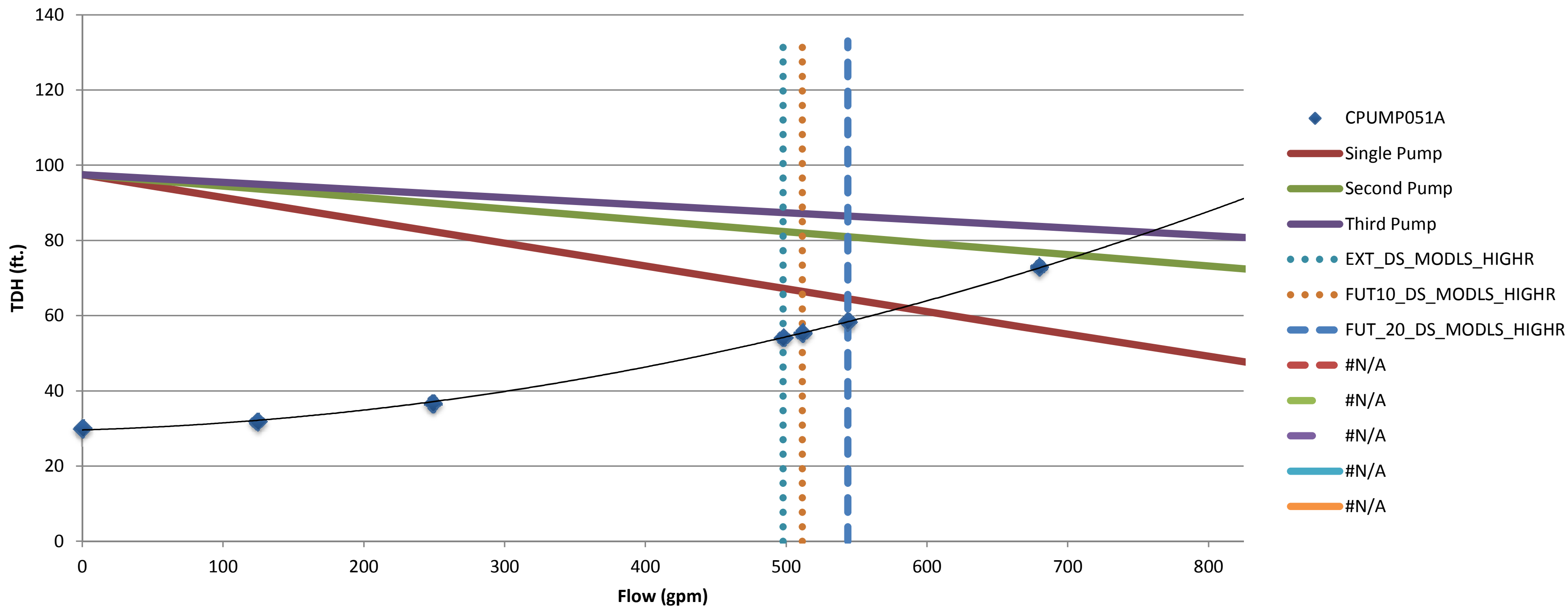
ENCHANTMENT - SINGLE LIFT STATION OPERATING: Pump 1
TDH (ft.)
200.0
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0
20
40
60
80
100
120
140
160
180
200
Flow (gpm)
CPUMP081A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

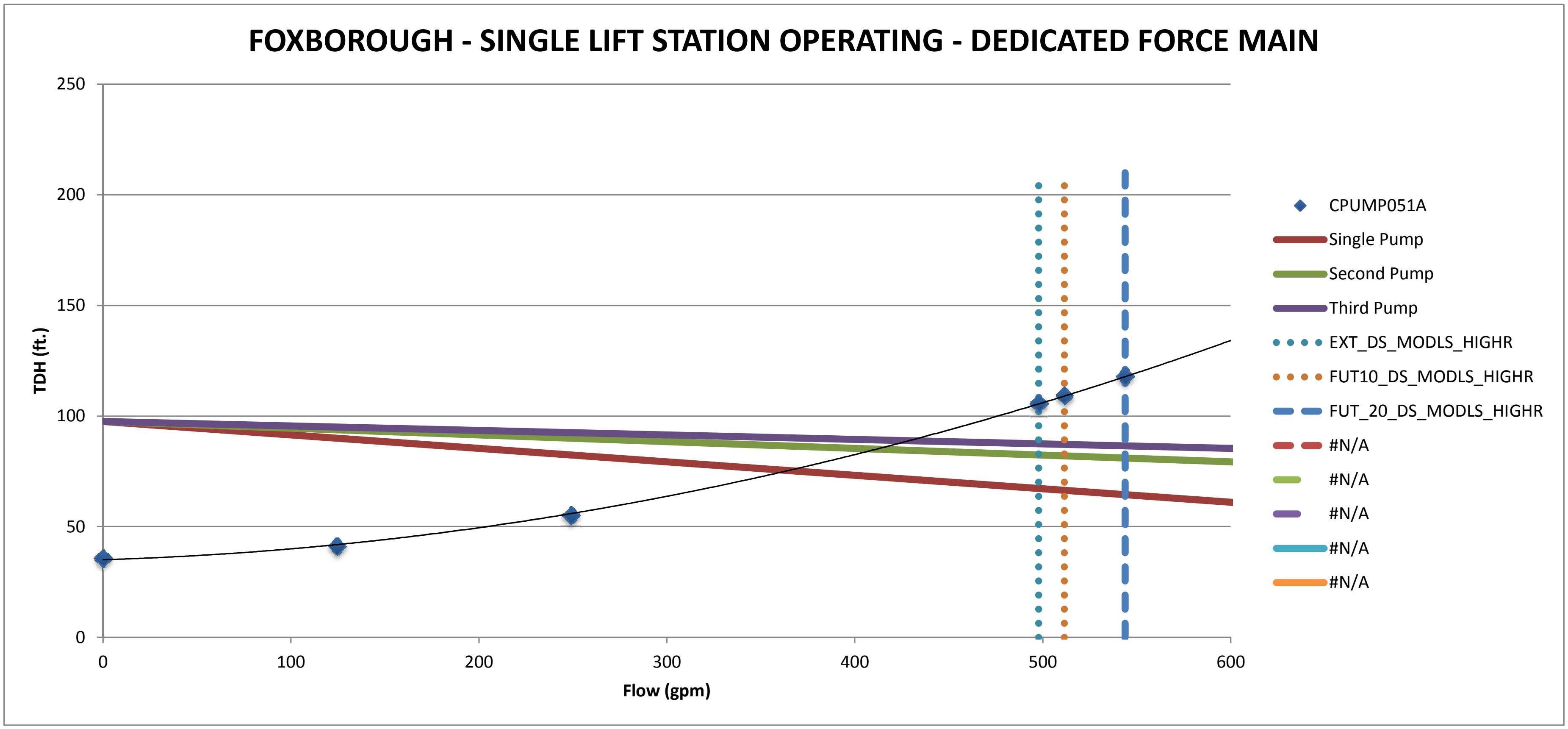


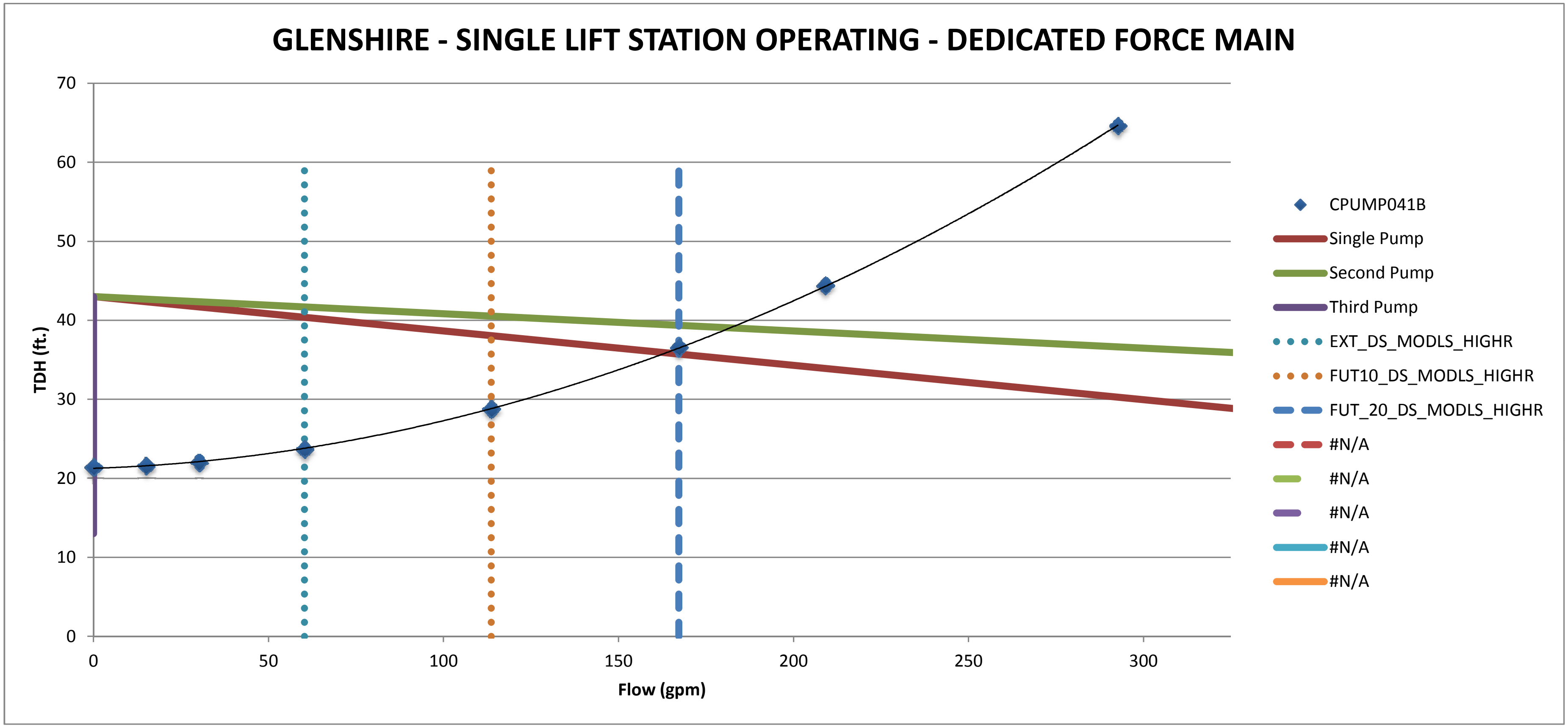
ENCHANTMENT - SINGLE LIFT STATION OPERATING: Pump 2
TDH (ft.)
200.0
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0
20
40
60
80
100
120
140
160
180
200
Flow (gpm)
CPUMP081A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

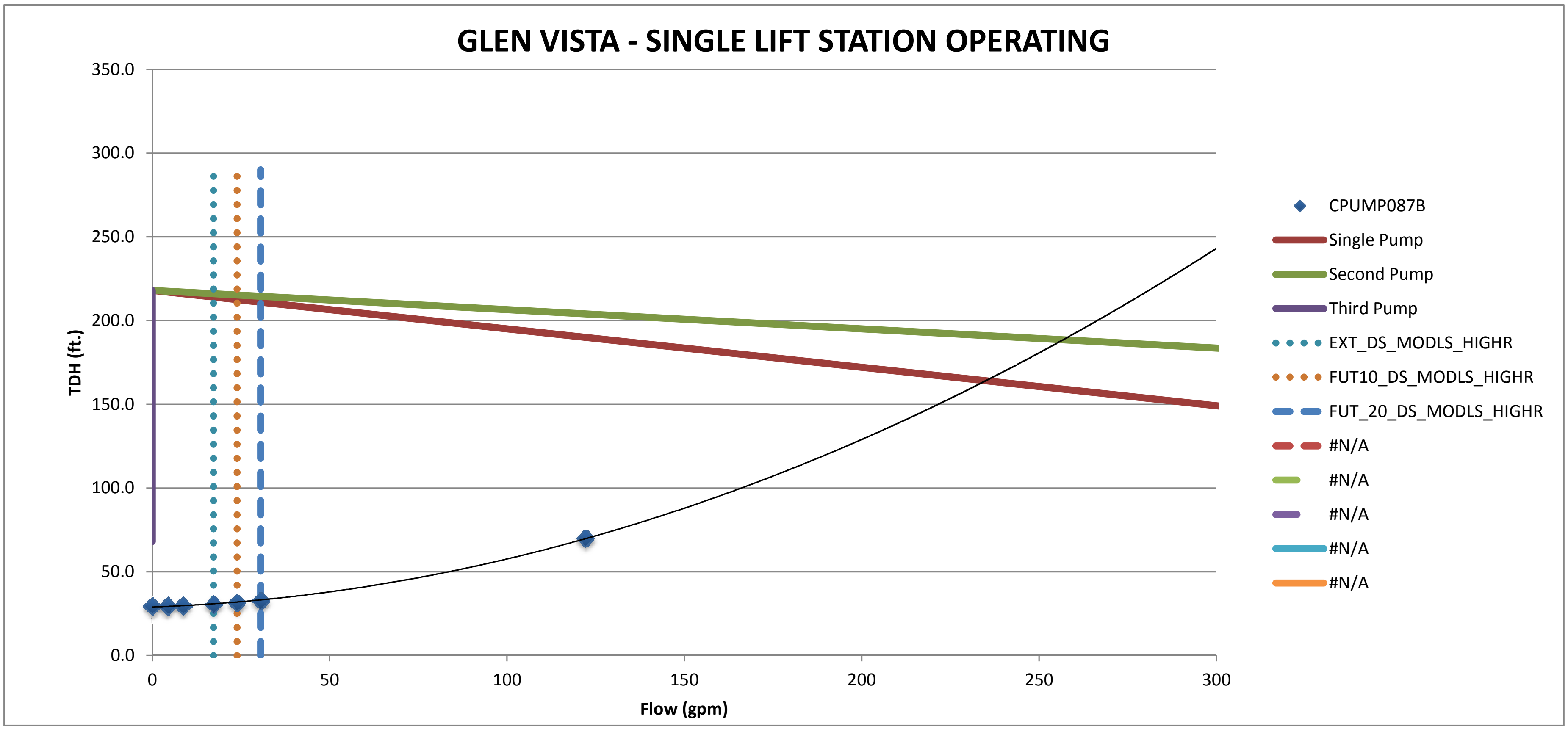

FORUM - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
Flow (gpm)
0
2
4
6
8
10
12
14
16
18
20
0
10
20
30
40
50
60
70
80
90
100
CPUMP043B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

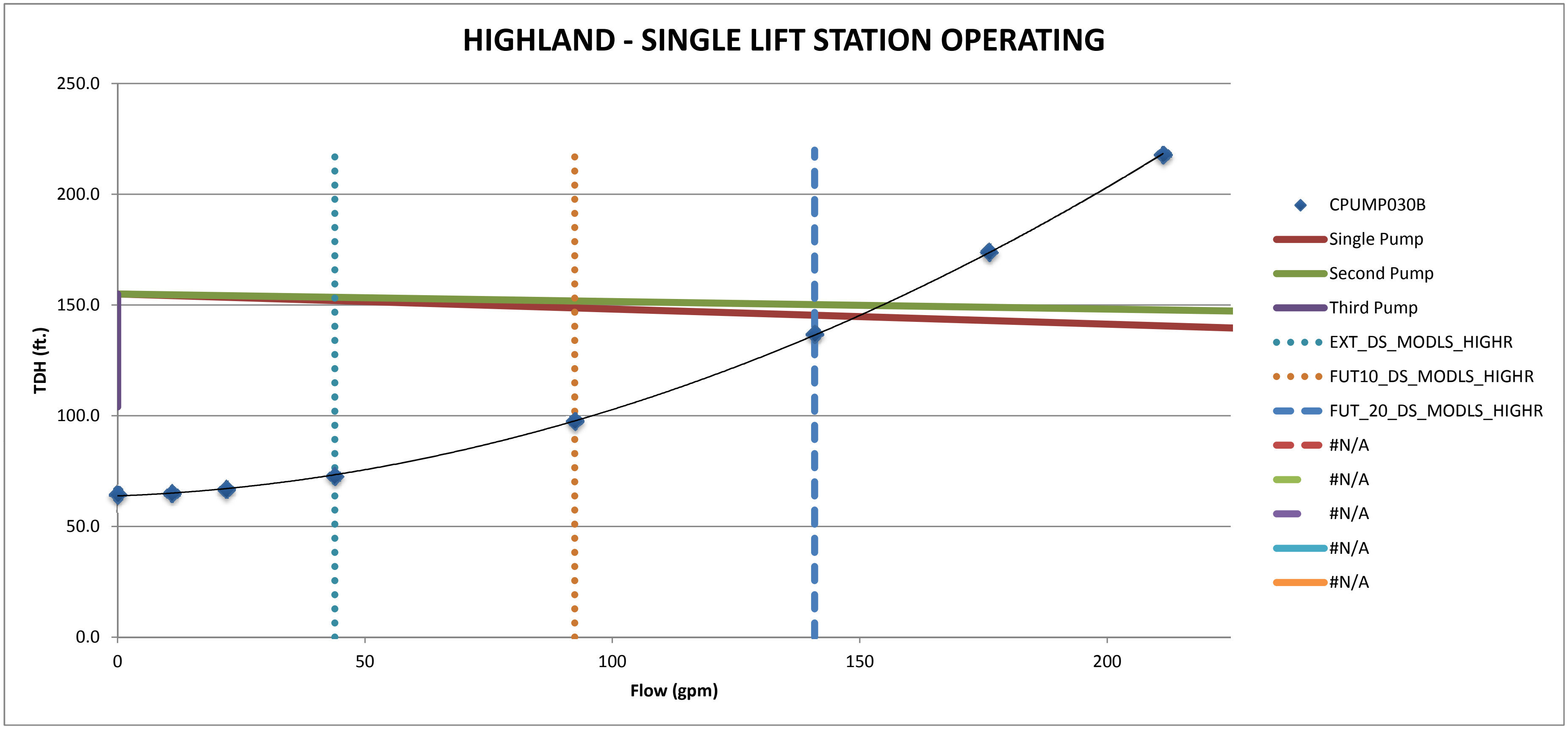
FOXBOROUGH Alt to Brosterhous Road - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN

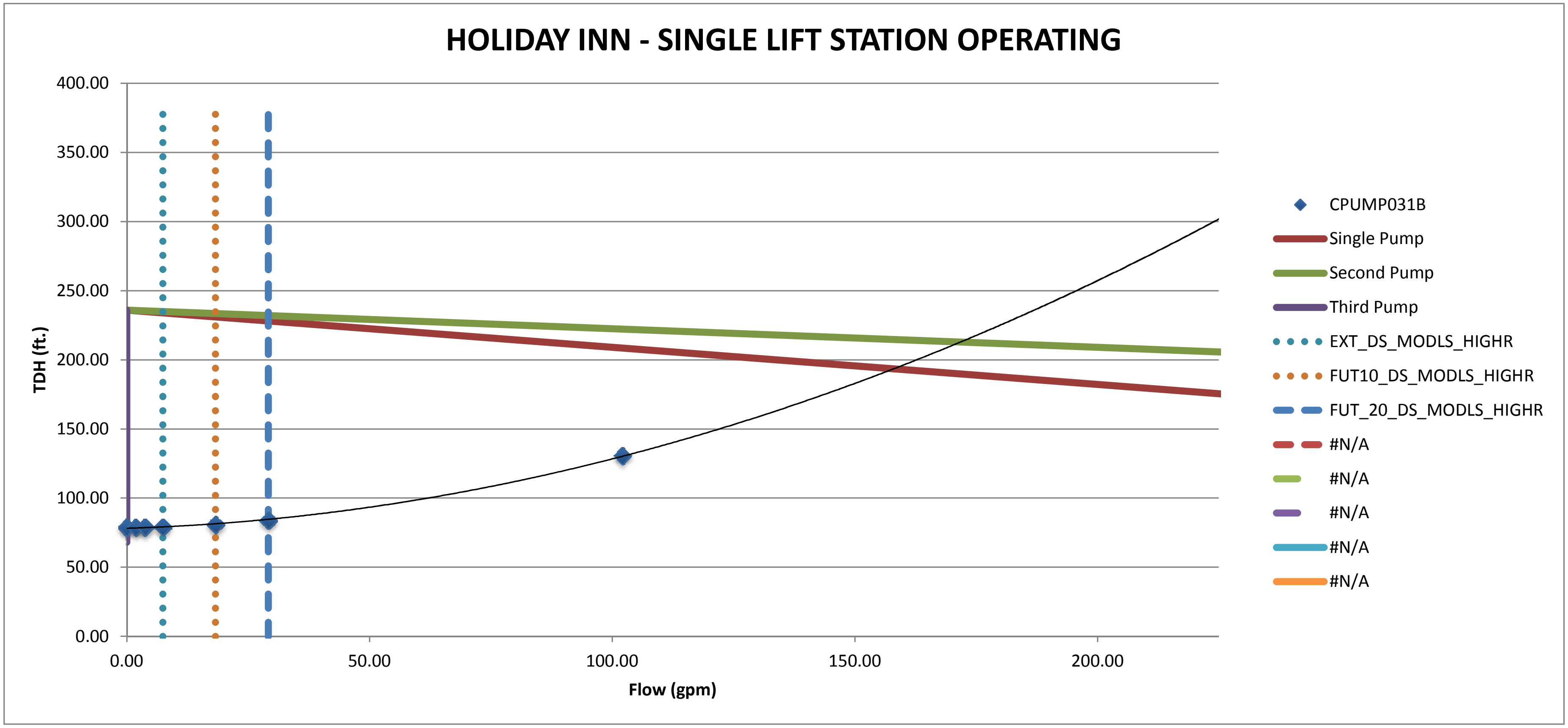


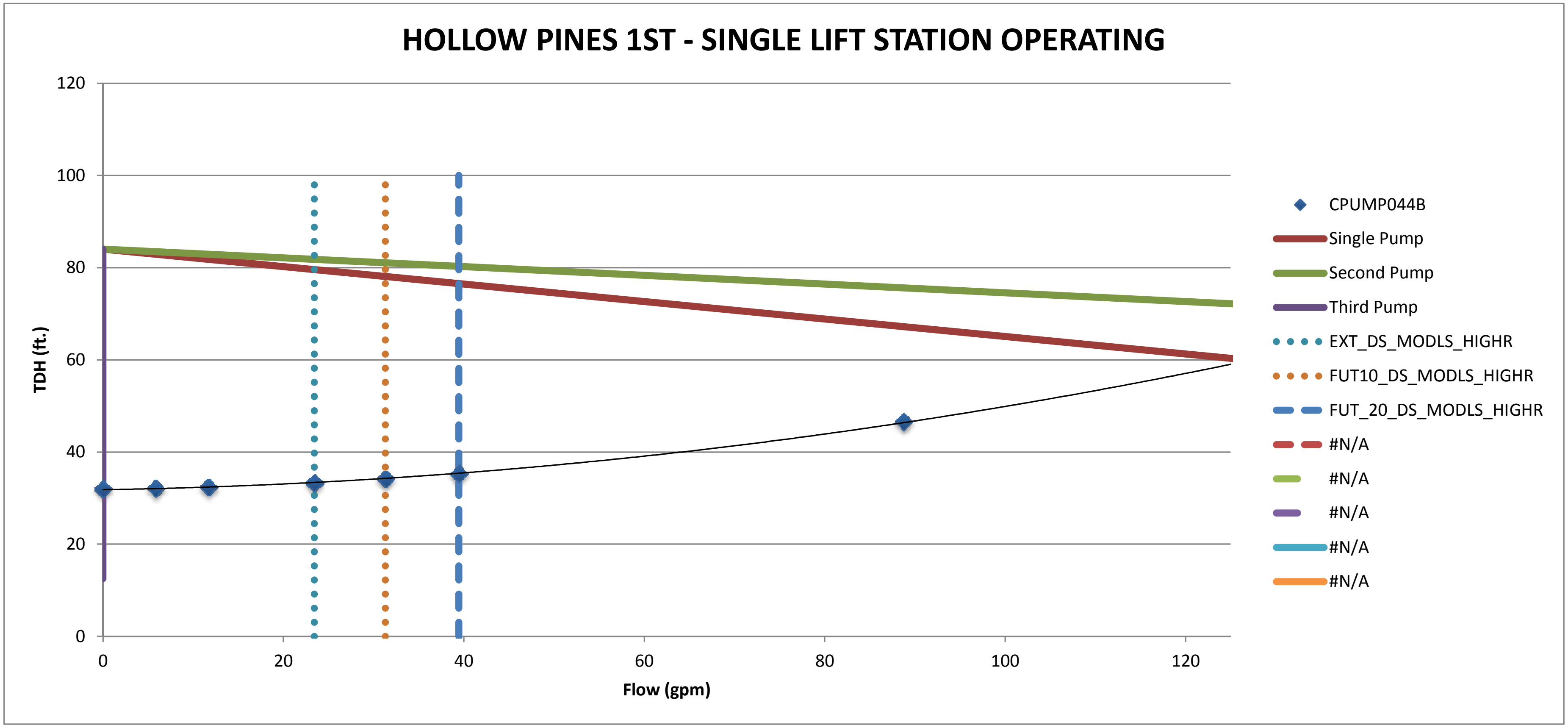

FOXBOROUGH - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
250
200
150
100
50
0
0
100
200
300
400
500
600
Flow (gpm)
CPUMP051A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

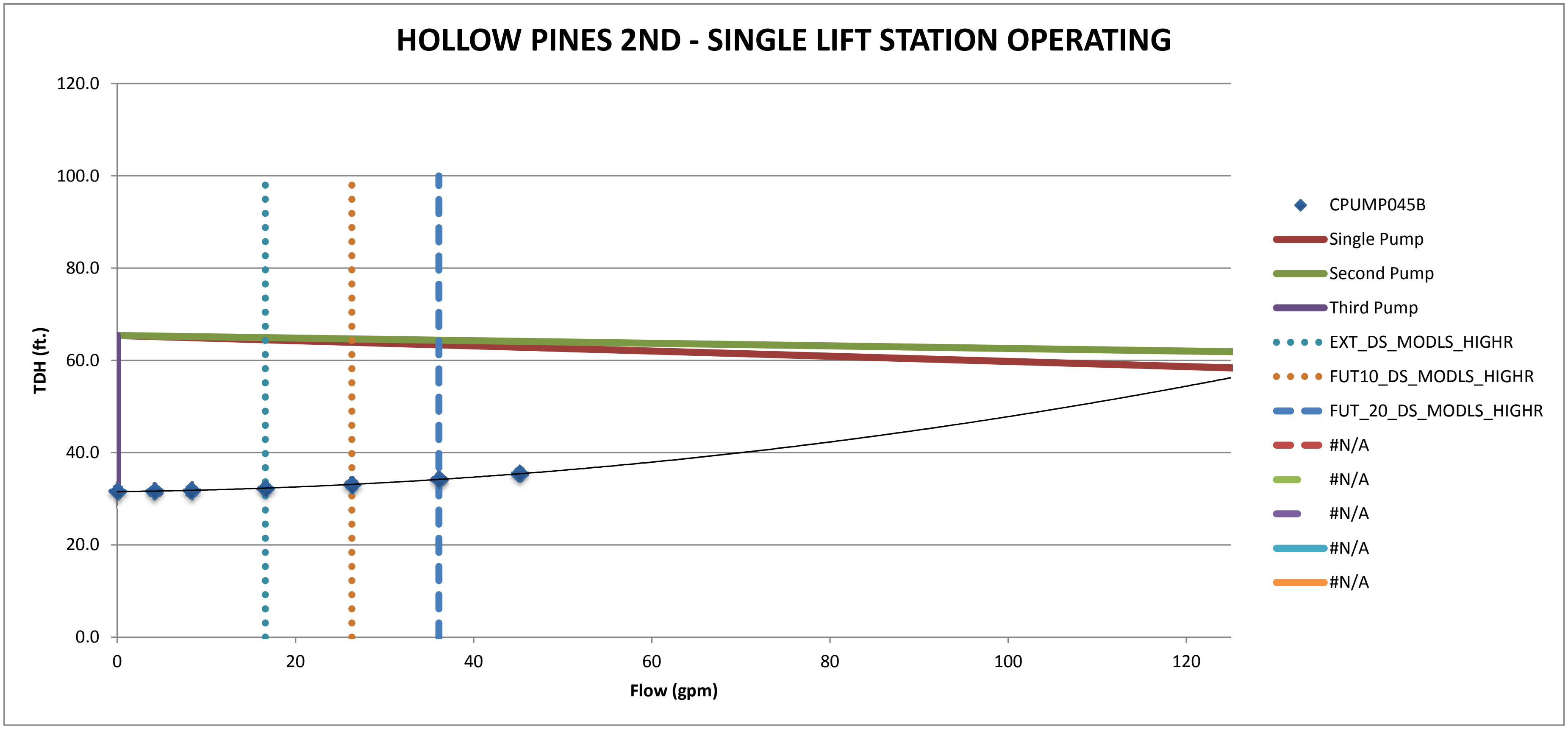

GLENSHIRE - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
Flow (gpm)
0
10
20
30
40
50
60
70
0
50
100
150
200
250
300
CPUMP041B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

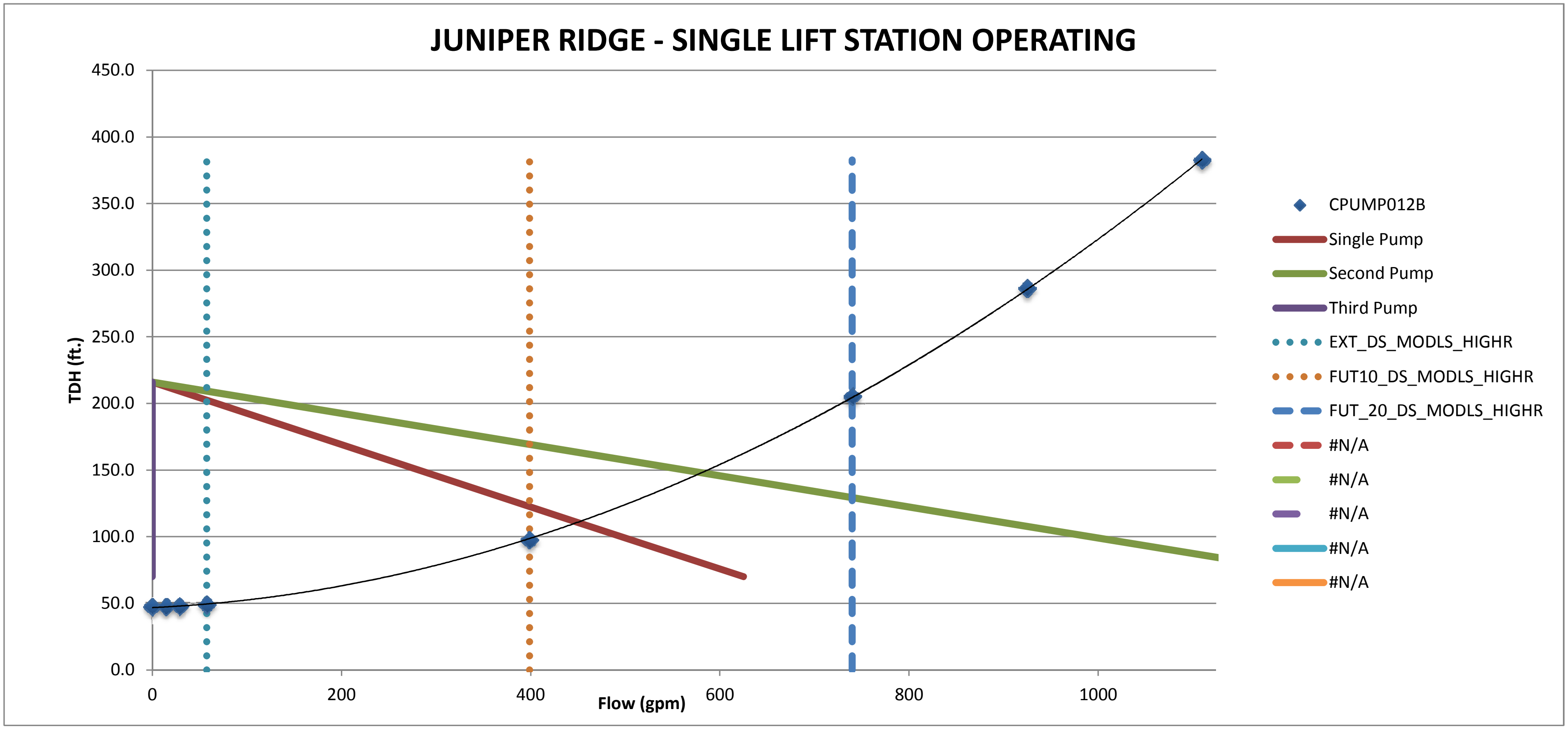

GLEN VISTA - SINGLE LIFT STATION OPERATING
TDH (ft.)
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0
50
100
150
200
250
300
Flow (gpm)
CPUMP087B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A


HIGHLAND - SINGLE LIFT STATION OPERATING
TDH (ft.)
250.0
200.0
150.0
100.0
50.0
0.0
0
50
100
150
200
Flow (gpm)
CPUMP030B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

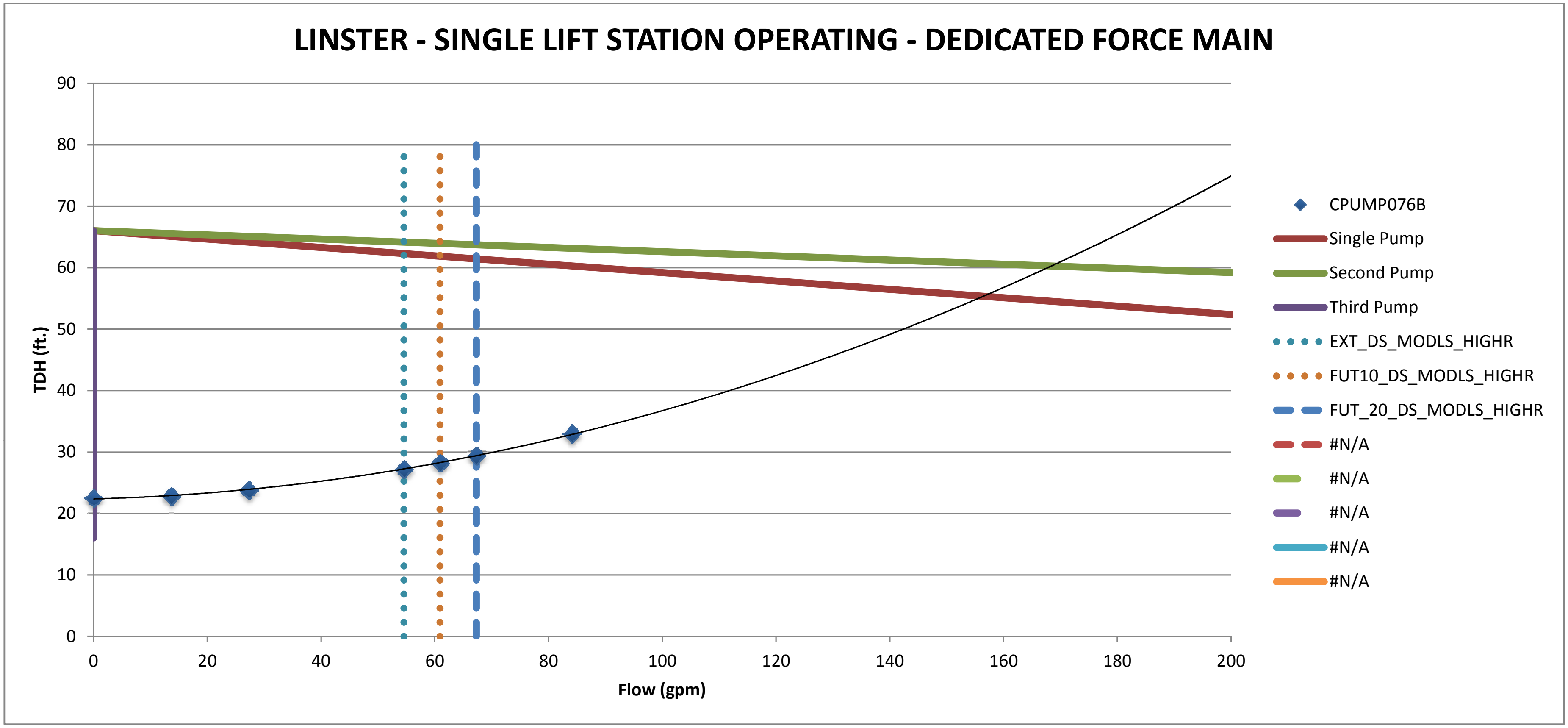

HOLIDAY INN - SINGLE LIFT STATION OPERATING
TDH (ft.)
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
0.00
50.00
100.00
150.00
200.00
Flow (gpm)
CPUMP031B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

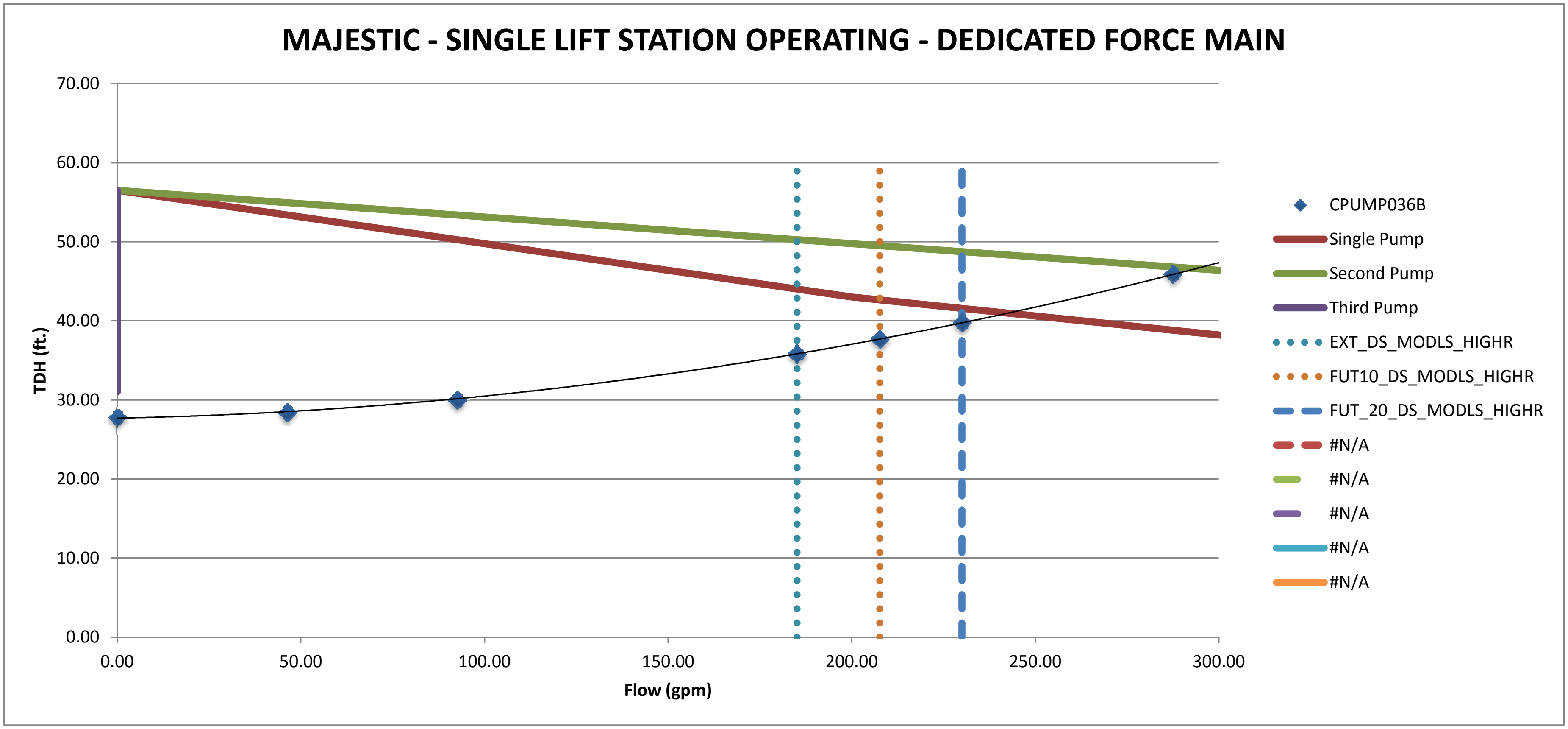

HOLLOW PINES 1ST - SINGLE LIFT STATION OPERATING
TDH (ft.)
Flow (gpm)
0
20
40
60
80
100
120
CPUMP044B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

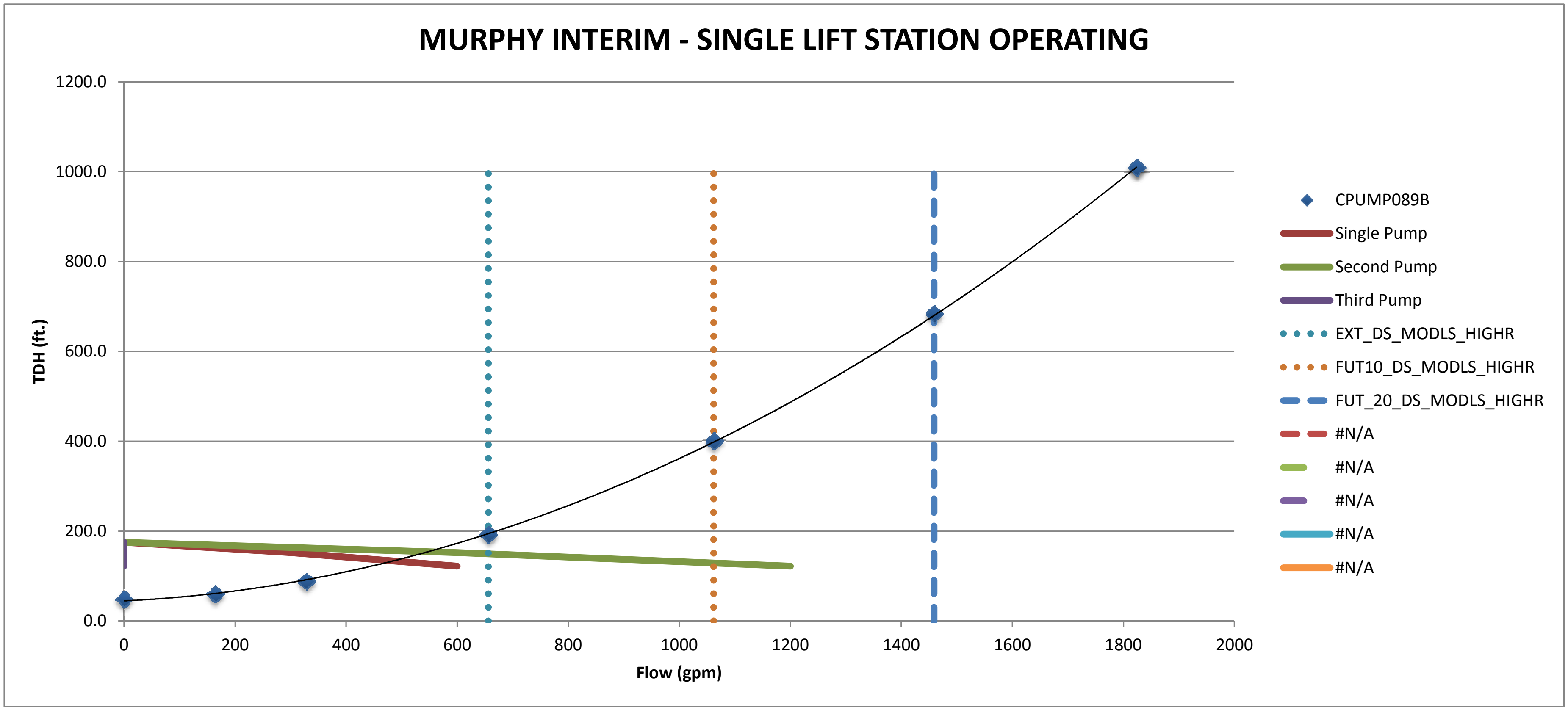

HOLLOW PINES 2ND - SINGLE LIFT STATION OPERATING
120.0
100.0
80.0
60.0
40.0
20.0
0.0
TDH (ft.)
0
20
40
60
80
100
120
Flow (gpm)
CPUMP045B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

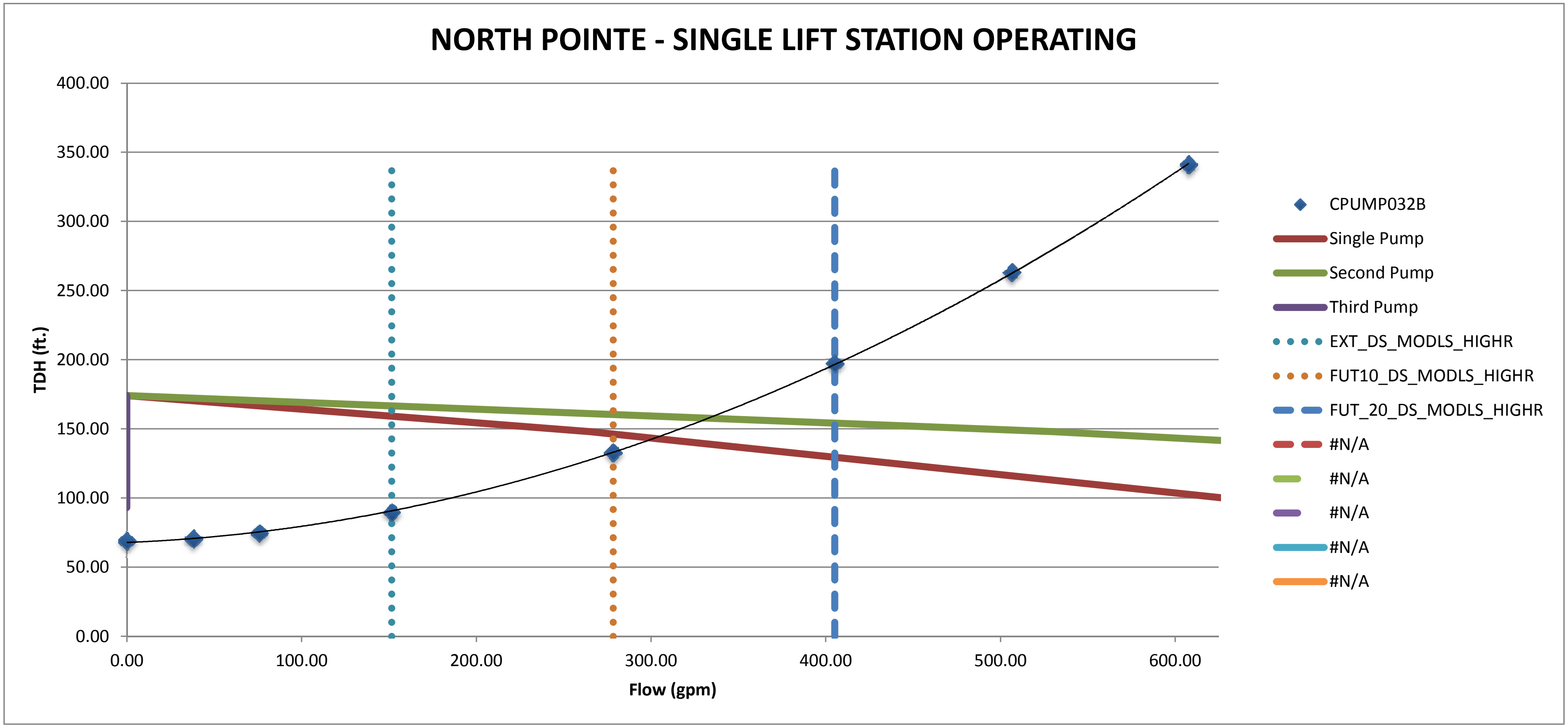


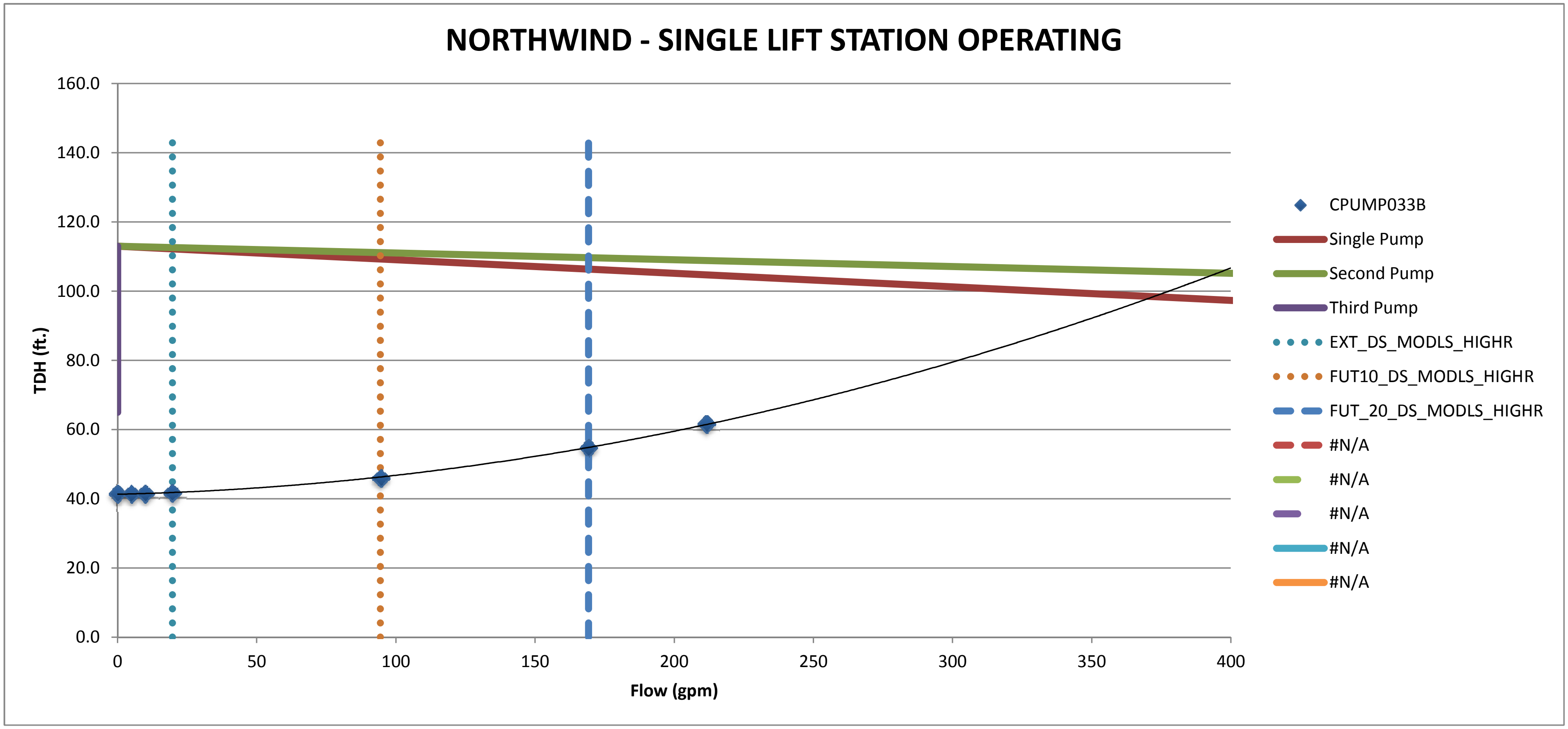
JUNIPER RIDGE - SINGLE LIFT STATION OPERATING
TDH (ft.)
Flow (gpm)
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0
200
400
600
800
1000
CPUMP012B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A


LINSTER - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
Flow (gpm)
0
10
20
30
40
50
60
70
80
90
0
20
40
60
80
100
120
140
160
180
200
CPUMP076B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

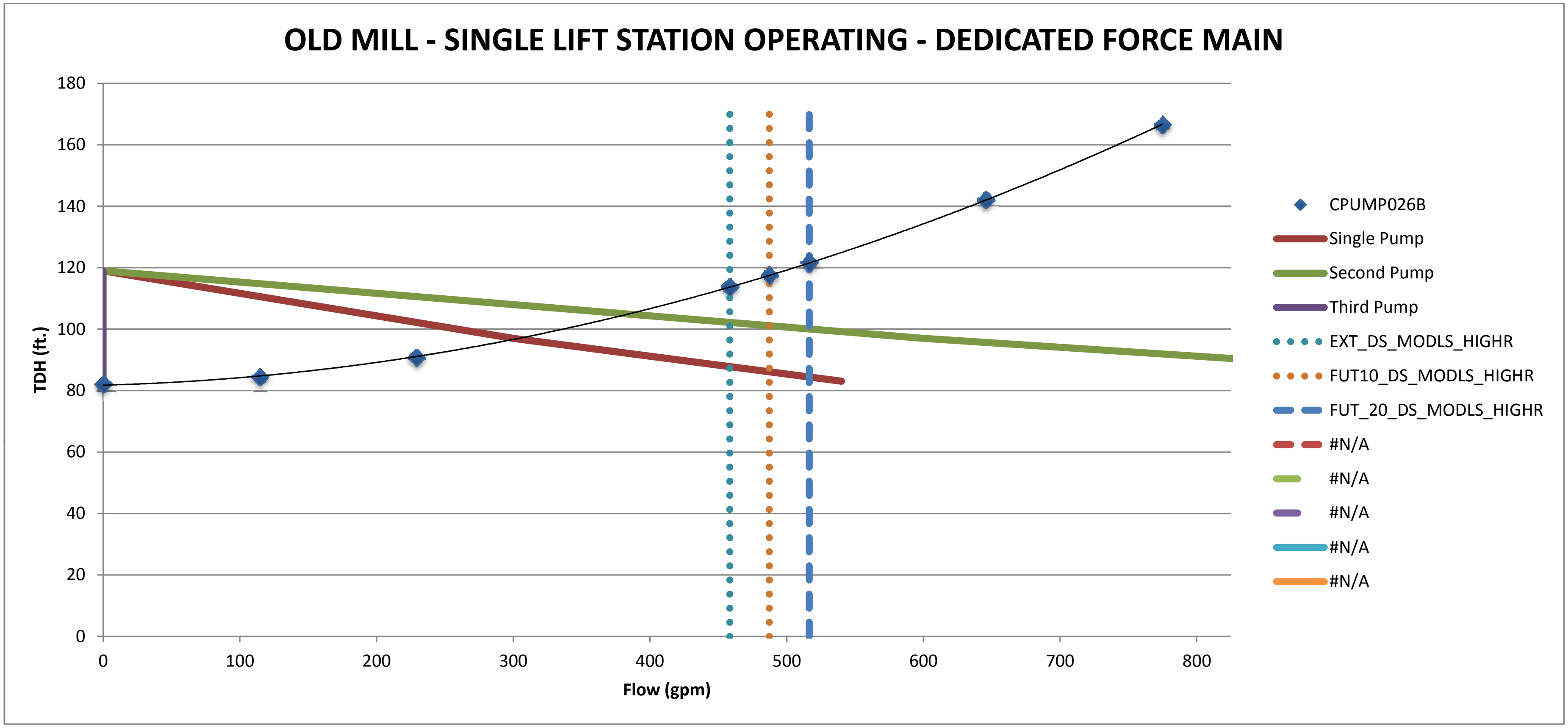

MAJESTIC - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0.00
50.00
100.00
150.00
200.00
250.00
300.00
Flow (gpm)
CPUMP036B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A


MURPHY INTERIM - SINGLE LIFT STATION OPERATING
TDH (ft.)
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Flow (gpm)
CPUMP089B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

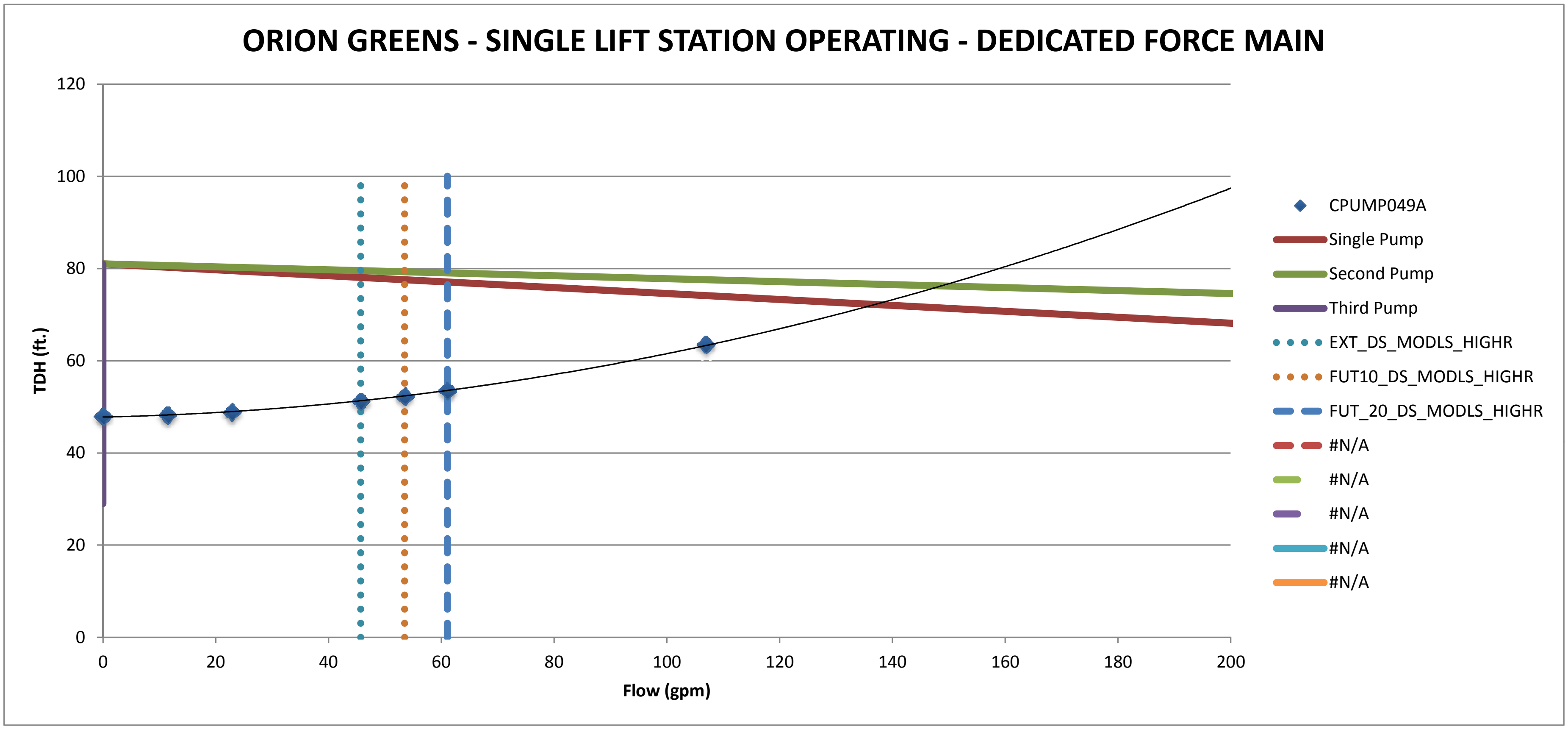

NORTH POINTE - SINGLE LIFT STATION OPERATING
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
TDH (ft.)
0.00
100.00
200.00
300.00
400.00
500.00
600.00
Flow (gpm)
CPUMP032B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A



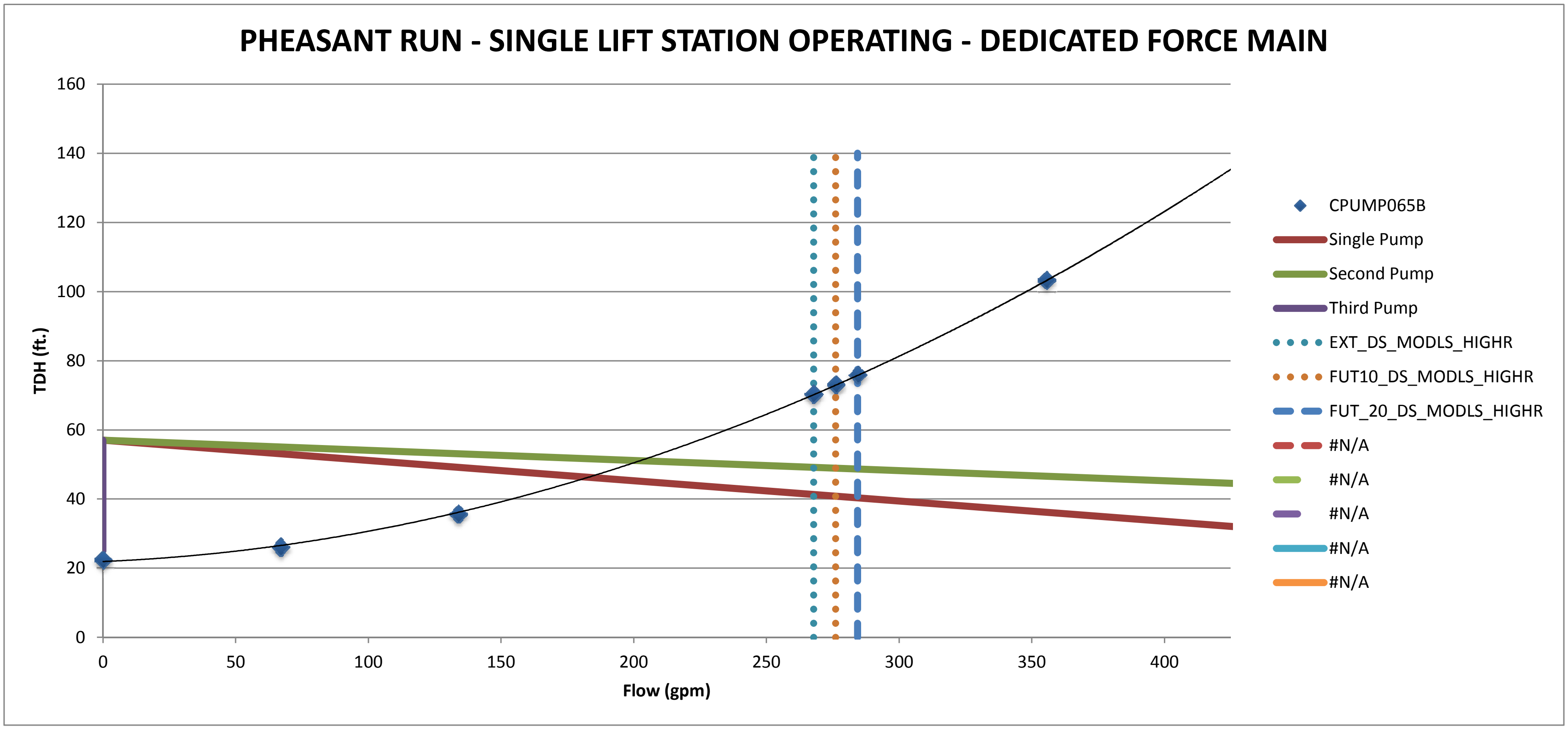
NORTHWIND - SINGLE LIFT STATION OPERATING
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
TDH (ft.)
0
50
100
150
200
250
300
350
400
Flow (gpm)
CPUMP033B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A



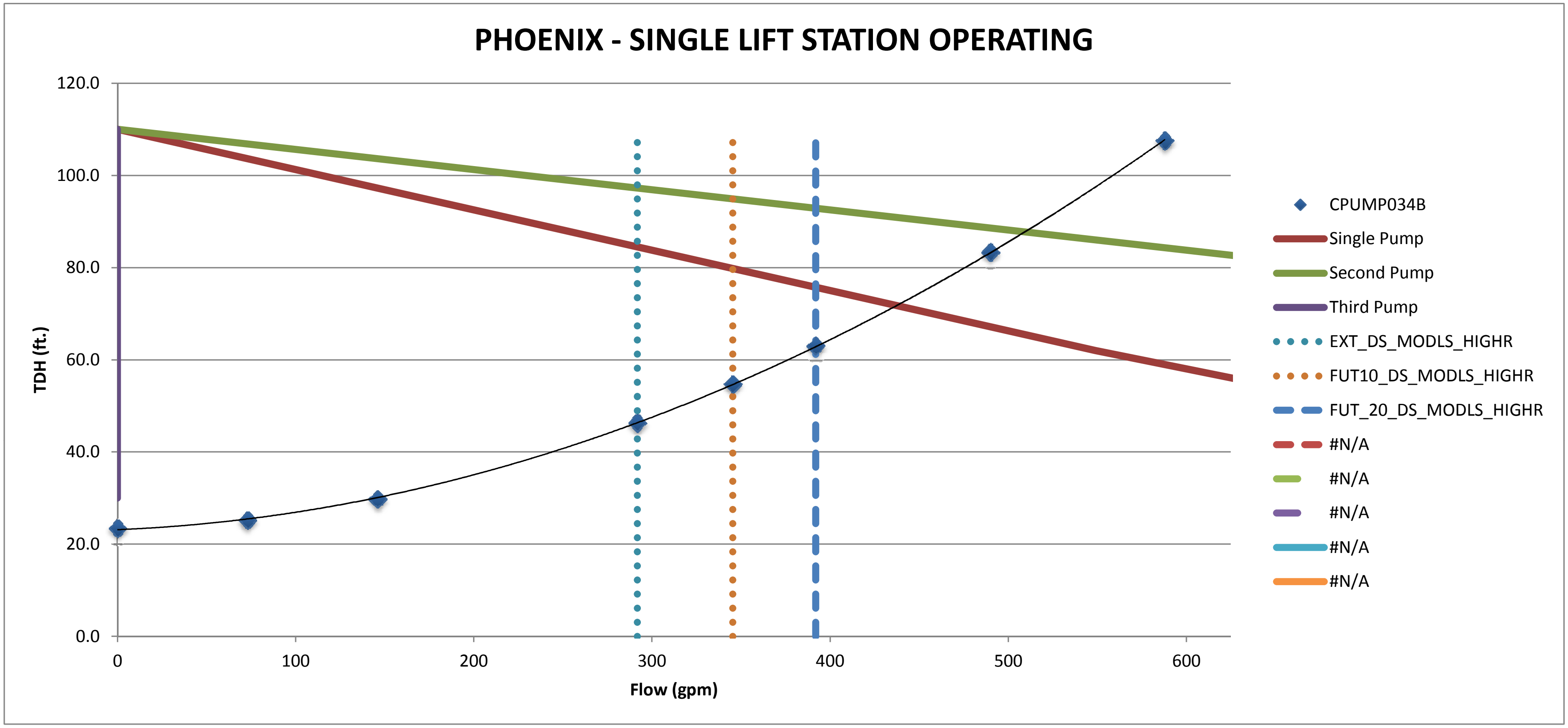
OLD MILL - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
Flow (gpm)
0
20
40
60
80
100
120
140
160
180
0
100
200
300
400
500
600
700
800
CPUMP026B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

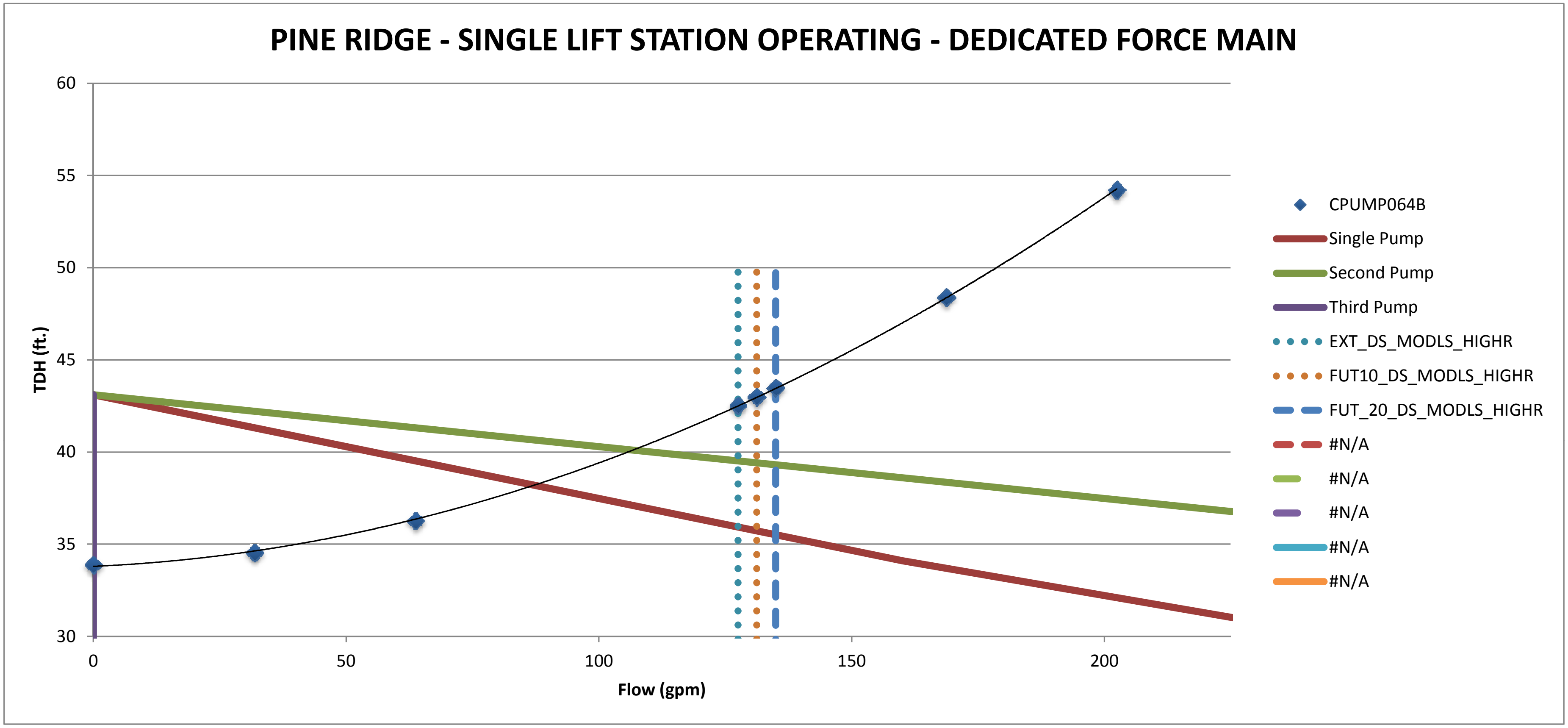


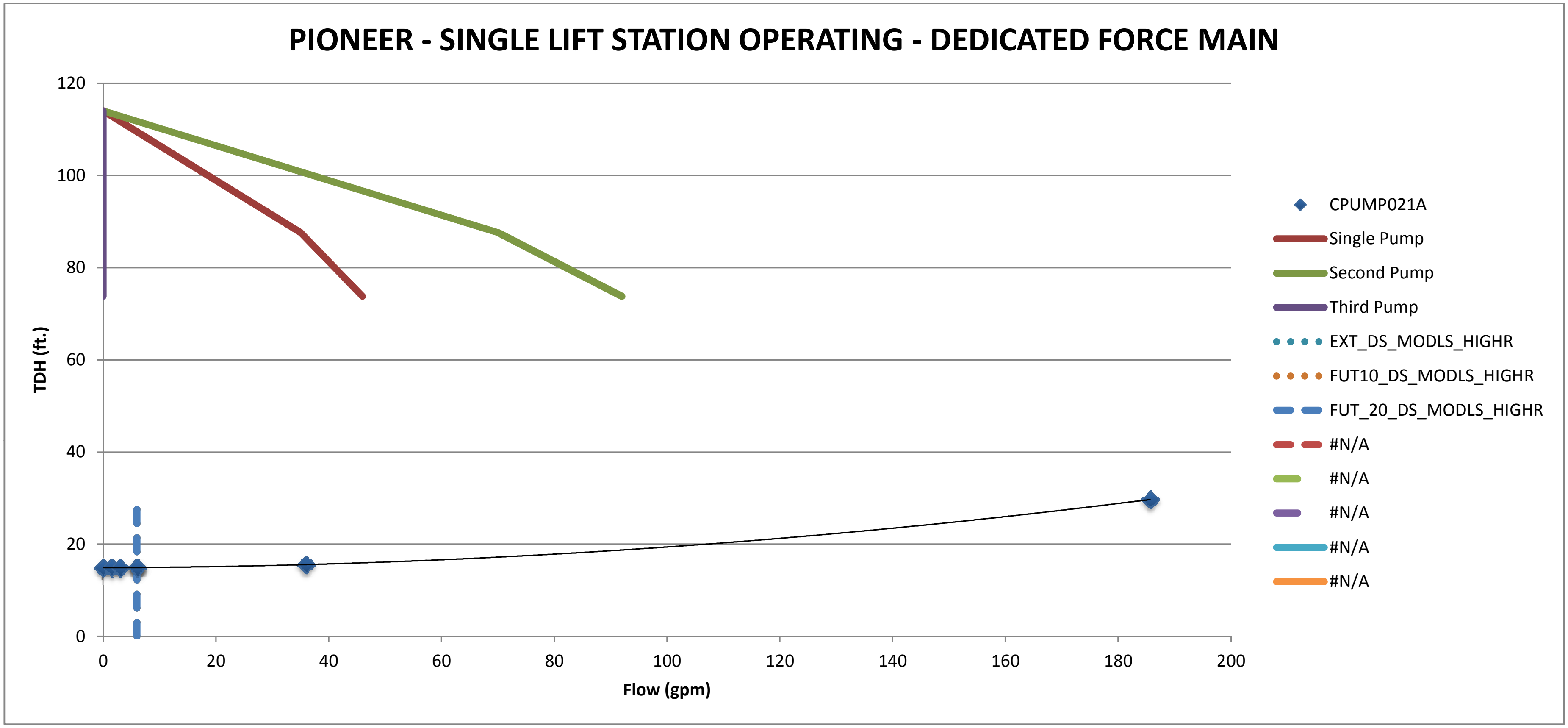
ORION GREENS - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
Flow (gpm)
0
20
40
60
80
100
120
0
20
40
60
80
100
120
140
160
180
200
CPUMP049A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A



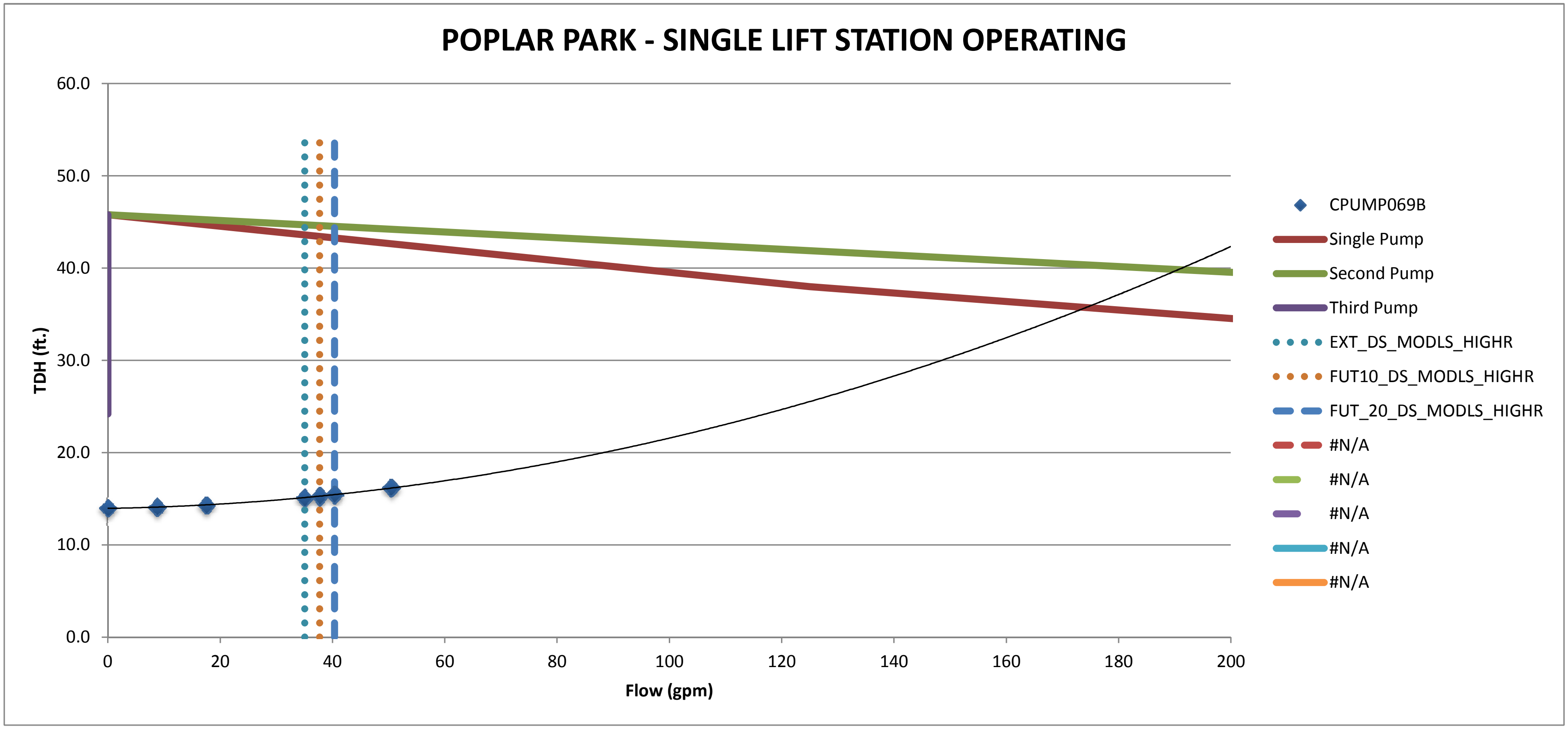
PHEASANT RUN - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
160
140
120
100
80
60
40
20
0
0
50
100
150
200
250
300
350
400
Flow (gpm)
CPUMP065B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

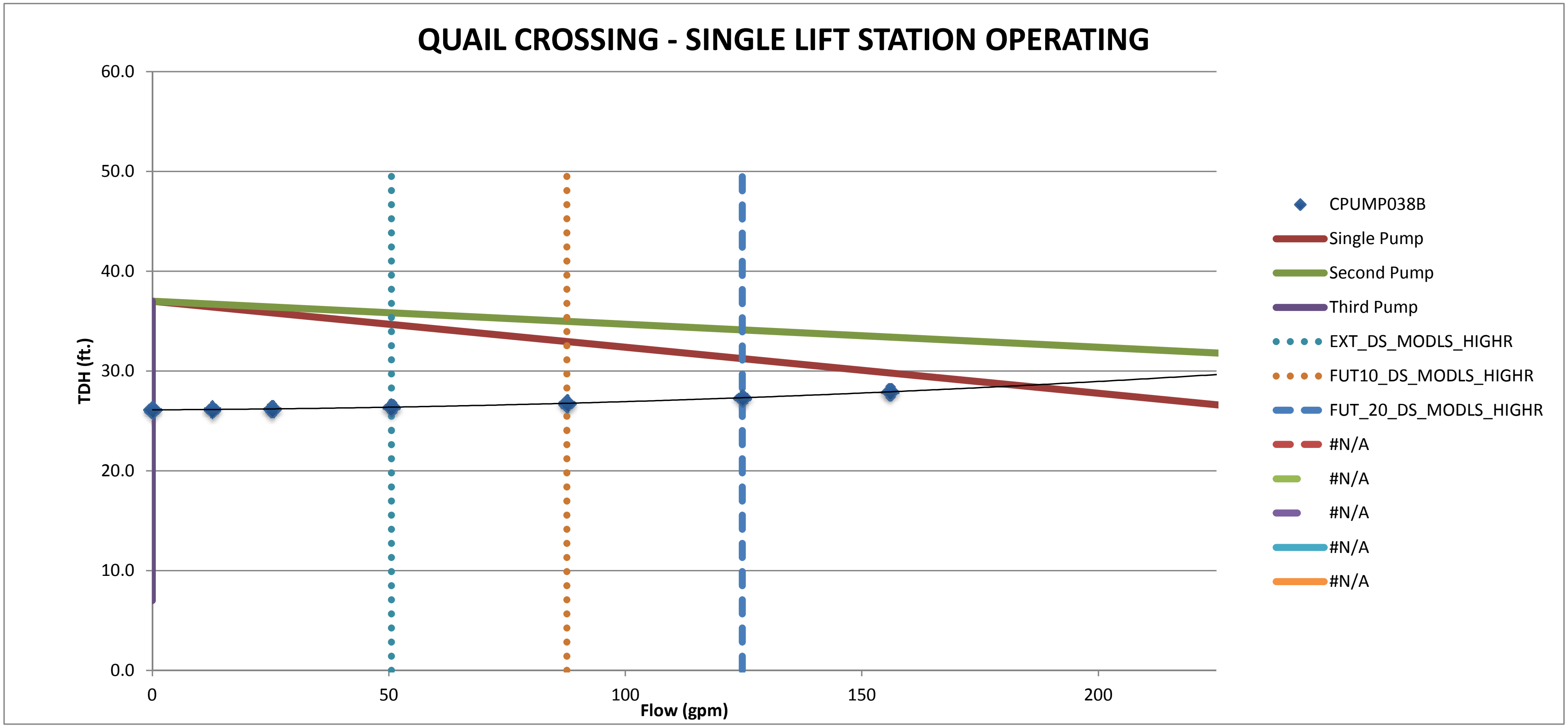

PHOENIX - SINGLE LIFT STATION OPERATING
120.0
100.0
80.0
60.0
40.0
20.0
0.0
TDH (ft.)
0
100
200
300
400
500
600
Flow (gpm)
CPUMP034B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

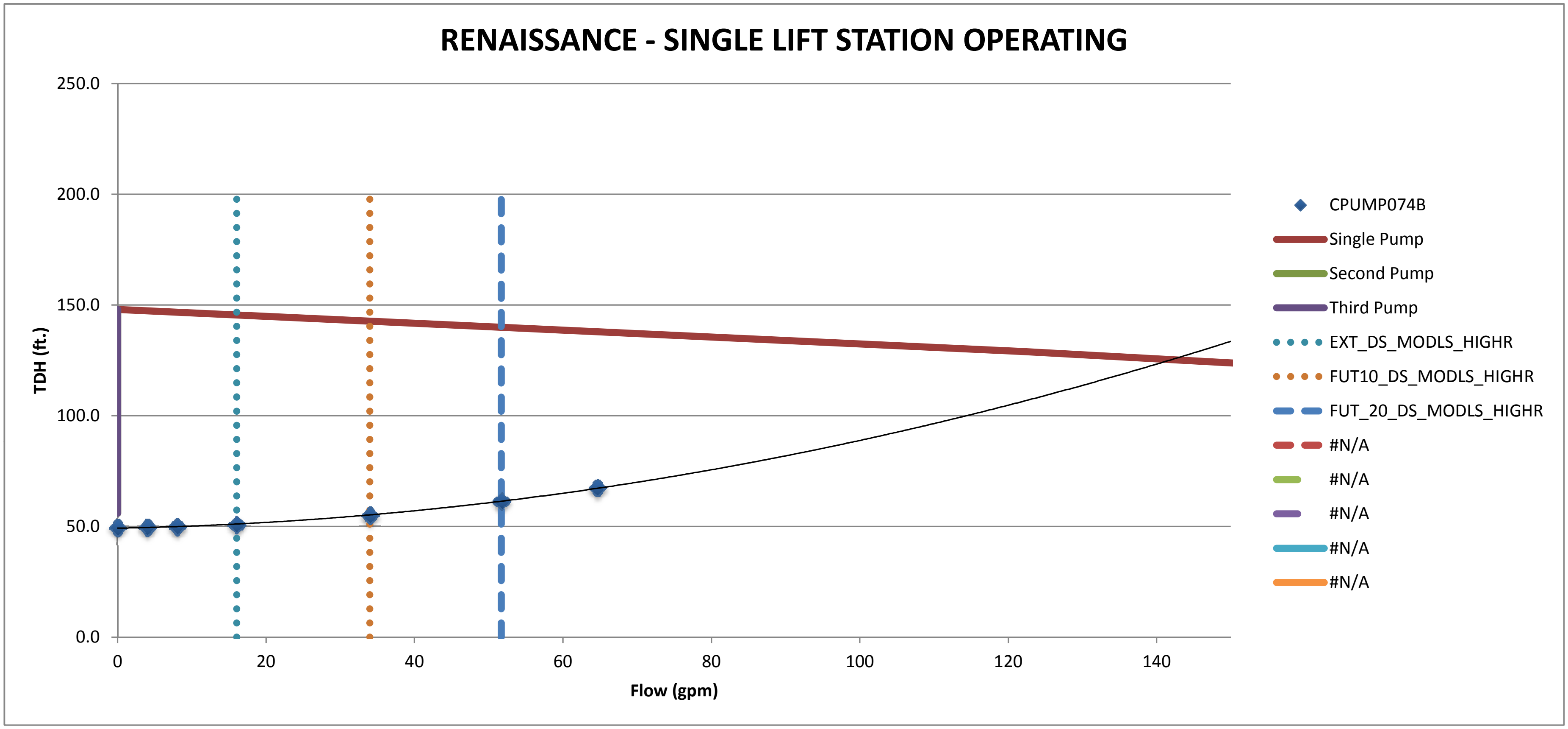

PINE RIDGE - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
60
55
50
45
40
35
30
0
50
100
150
200
Flow (gpm)
CPUMP064B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A



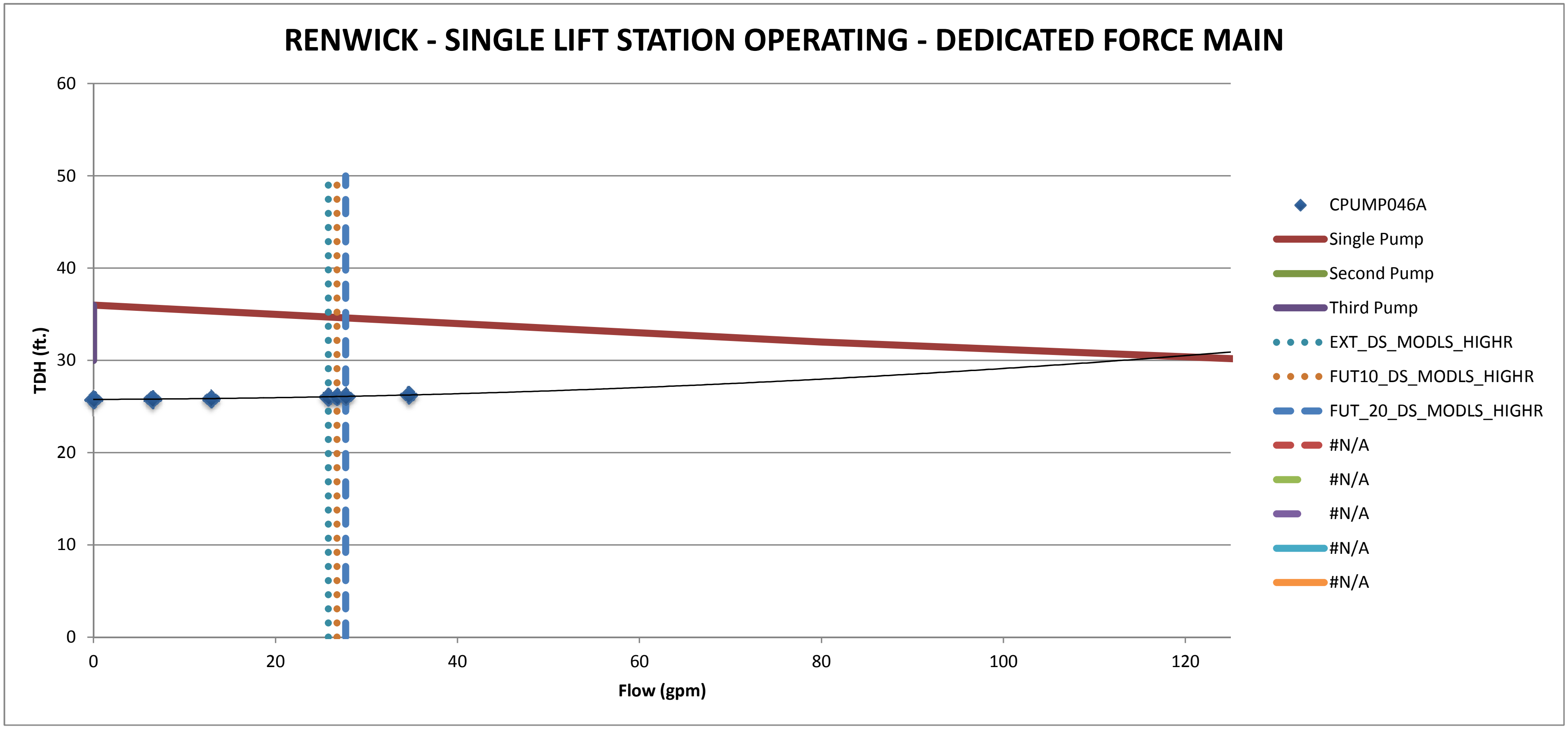
PIONEER - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
120
100
80
60
40
20
0
TDH (ft.)
0
20
40
60
80
100
120
140
160
180
200
Flow (gpm)
CPUMP021A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A


POPLAR PARK - SINGLE LIFT STATION OPERATING
TDH (ft.)
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
20
40
60
80
100
120
140
160
180
200
Flow (gpm)
CPUMP069B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

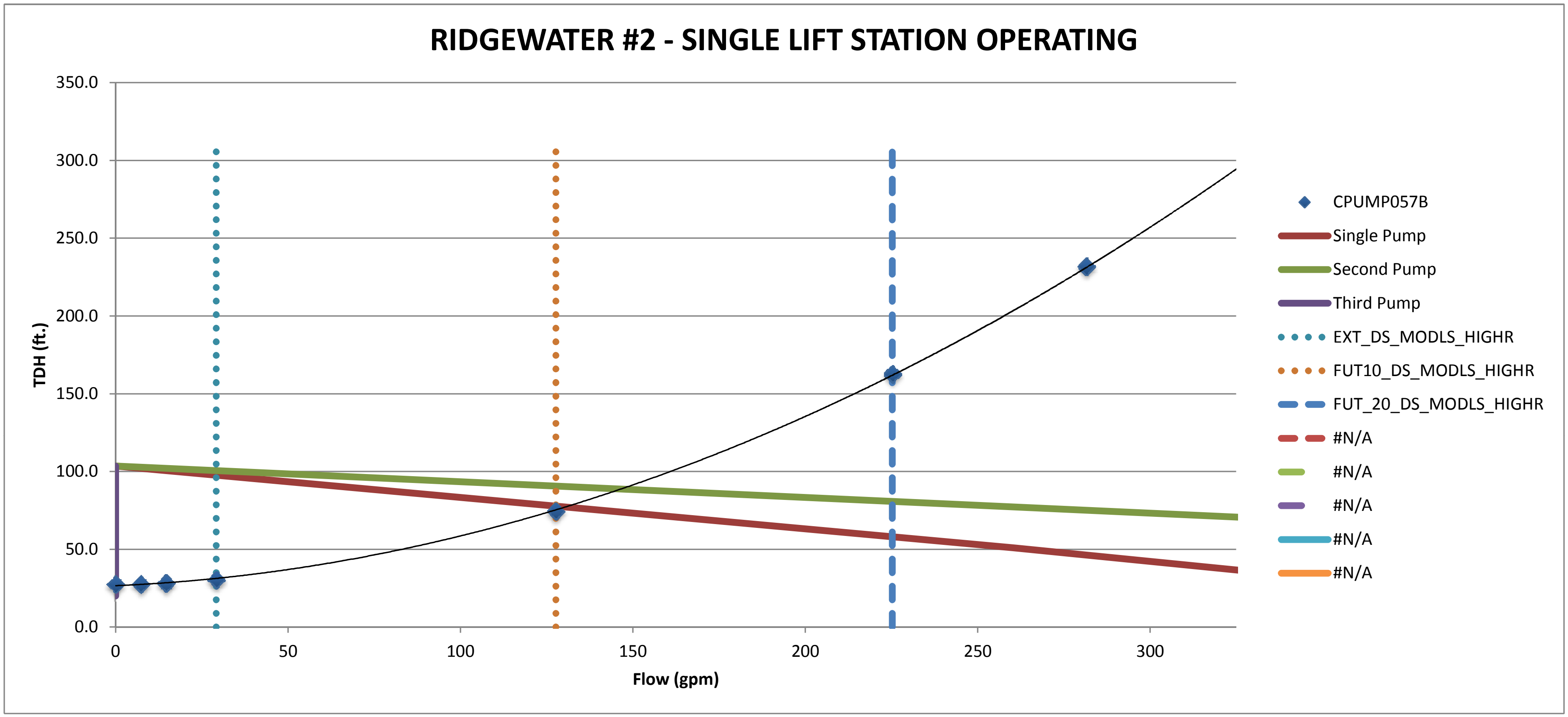

QUAIL CROSSING - SINGLE LIFT STATION OPERATING
60.0
50.0
40.0
30.0
20.0
10.0
0.0
TDH (ft.)
0
50
100
150
200
Flow (gpm)
CPUMP038B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

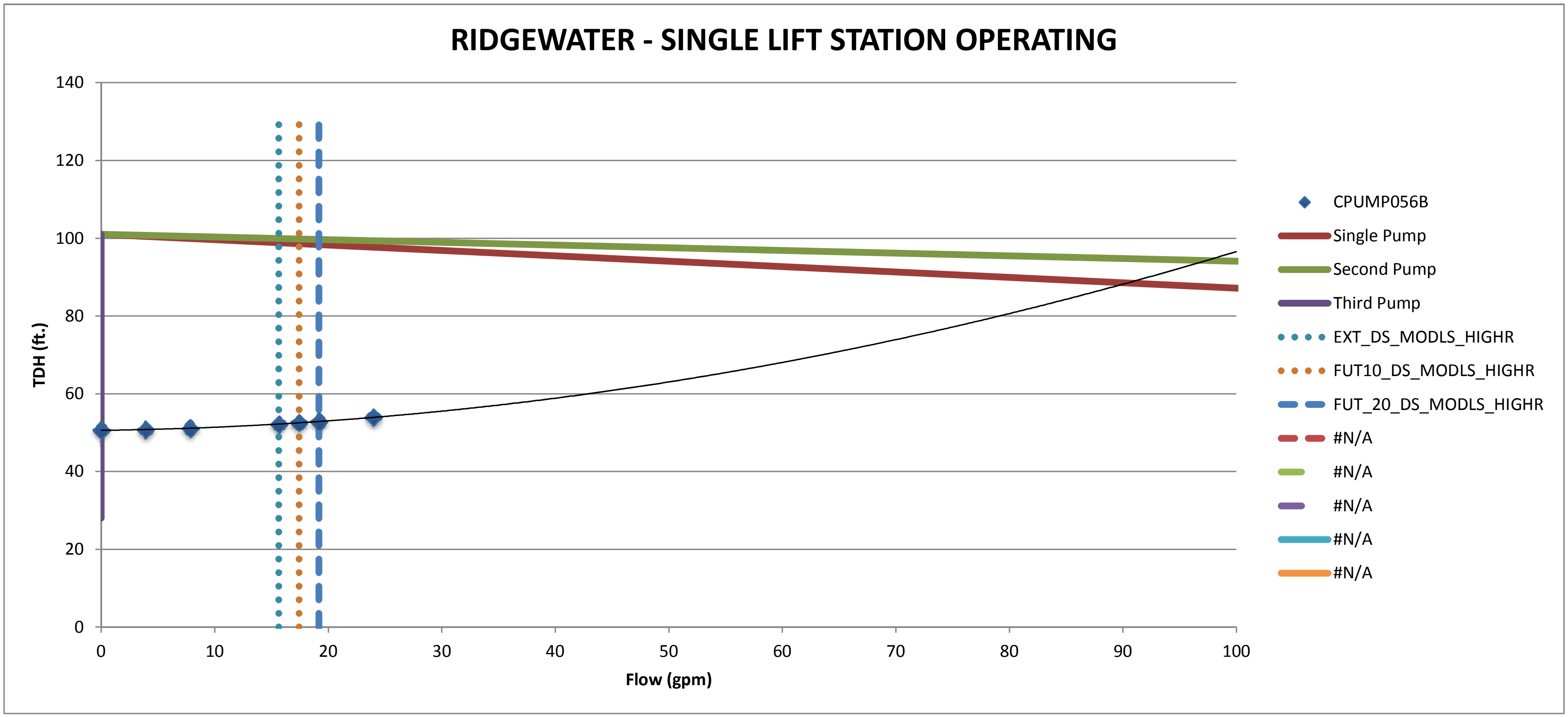


RENAISSANCE - SINGLE LIFT STATION OPERATING
250.0
200.0
150.0
100.0
50.0
0.0
TDH (ft.)
0
20
40
60
80
100
120
140
Flow (gpm)
CPUMP074B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

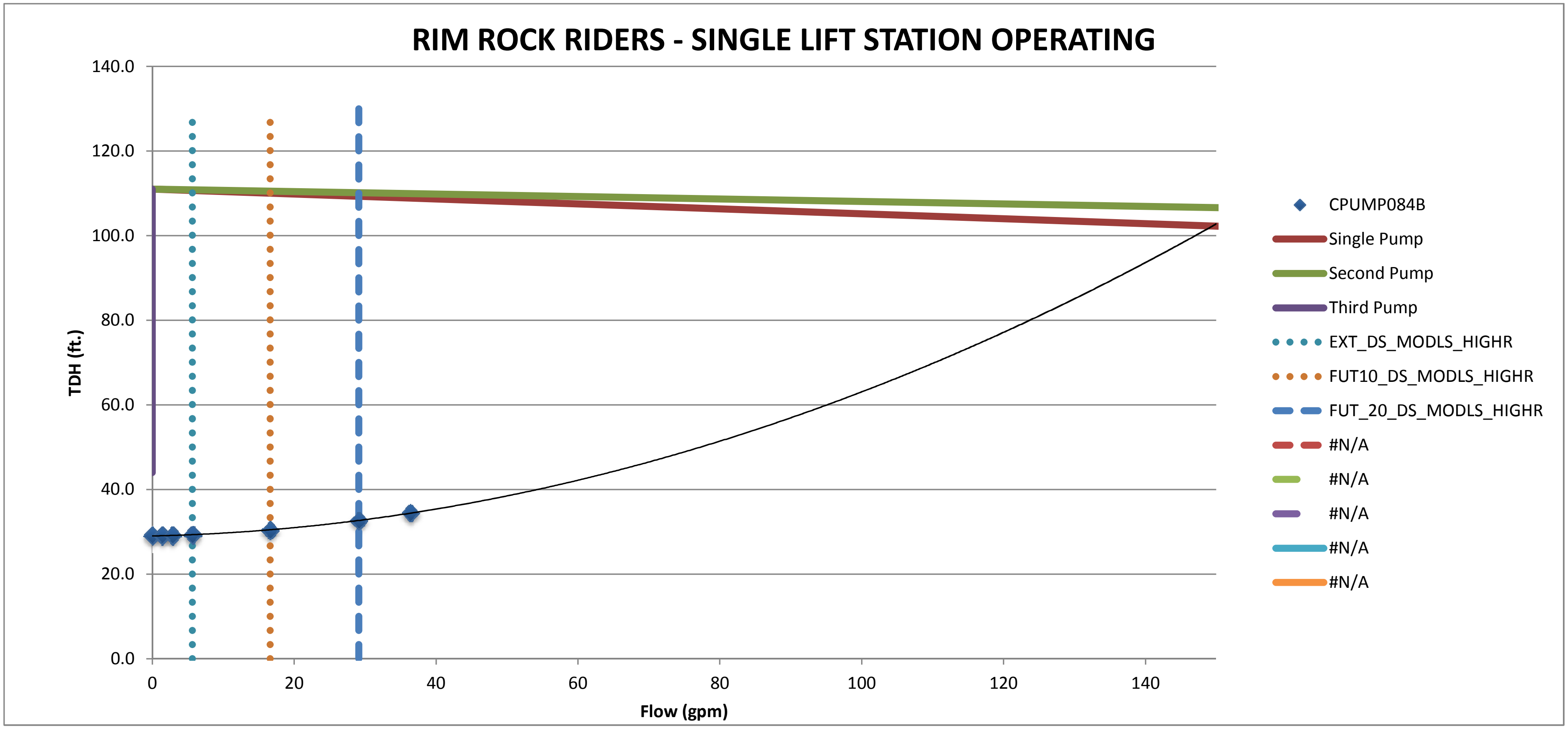


RENWICK - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
60
50
40
30
20
10
0
TDH (ft.)
0
20
40
60
80
100
120
Flow (gpm)
CPUMP046A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

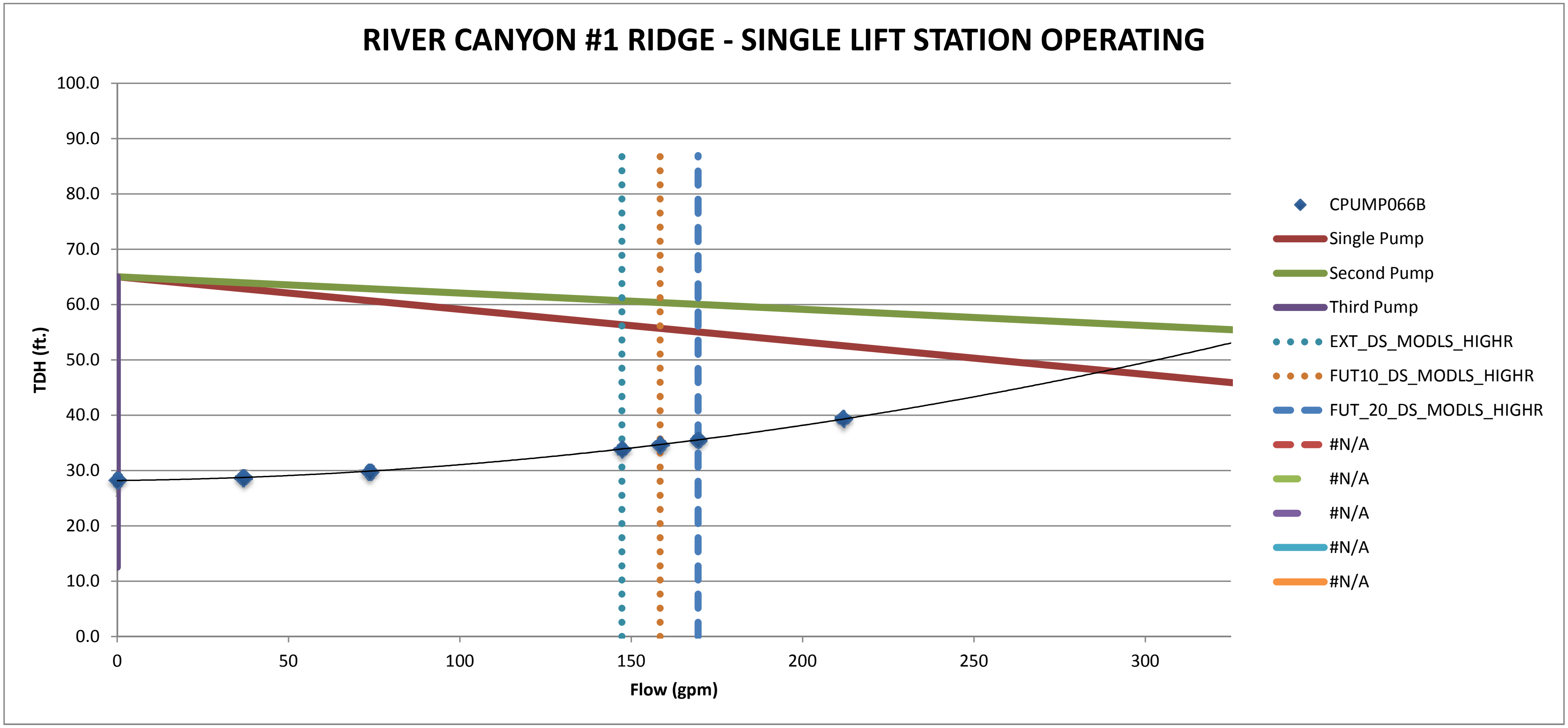

RIDGEWATER #2 - SINGLE LIFT STATION OPERATING
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
TDH (ft.)
0
50
100
150
200
250
300
Flow (gpm)
CPUMP057B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

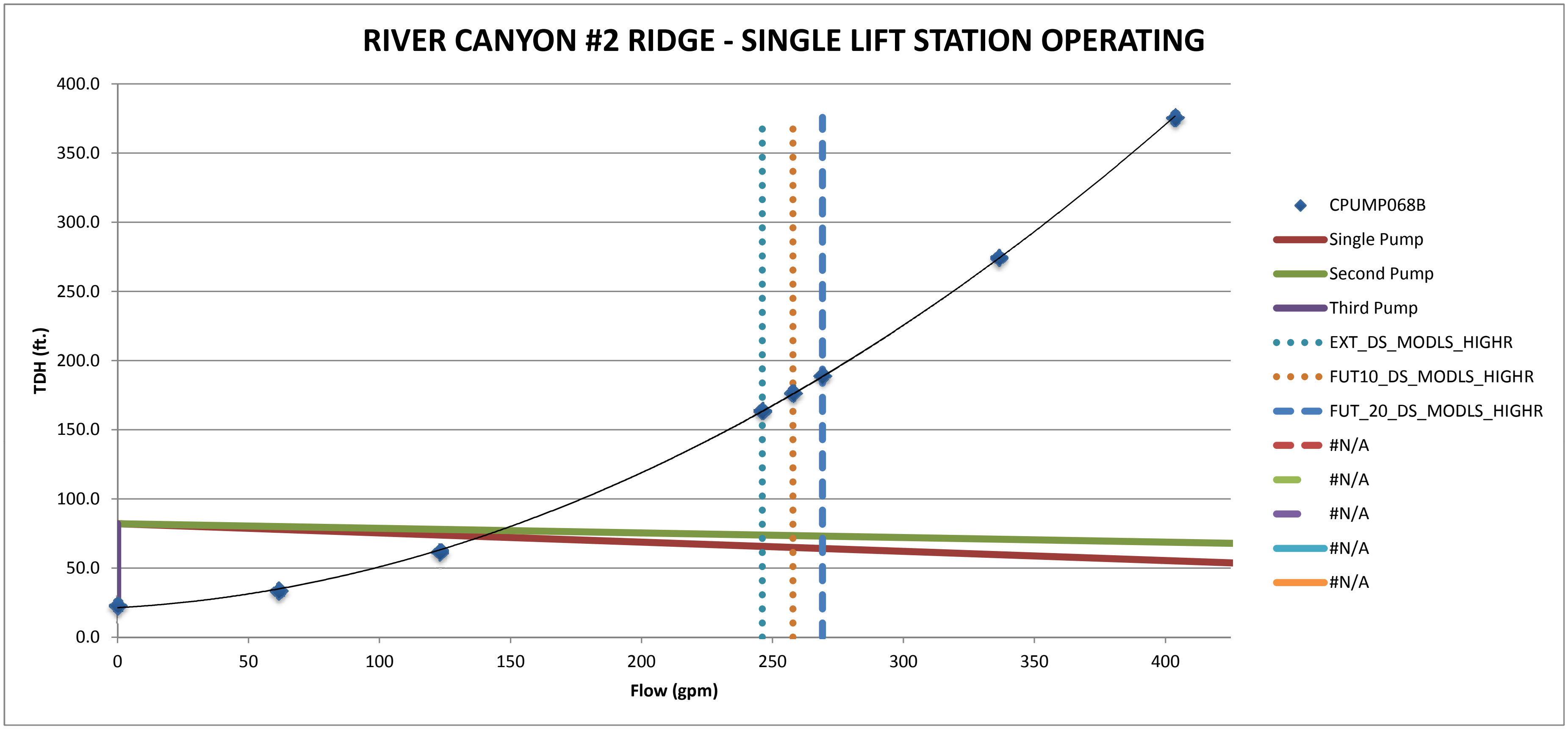


RIDGEWATER - SINGLE LIFT STATION OPERATING
TDH (ft.)
Flow (gpm)
0
20
40
60
80
100
120
140
0
10
20
30
40
50
60
70
80
90
100
CPUMP056B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

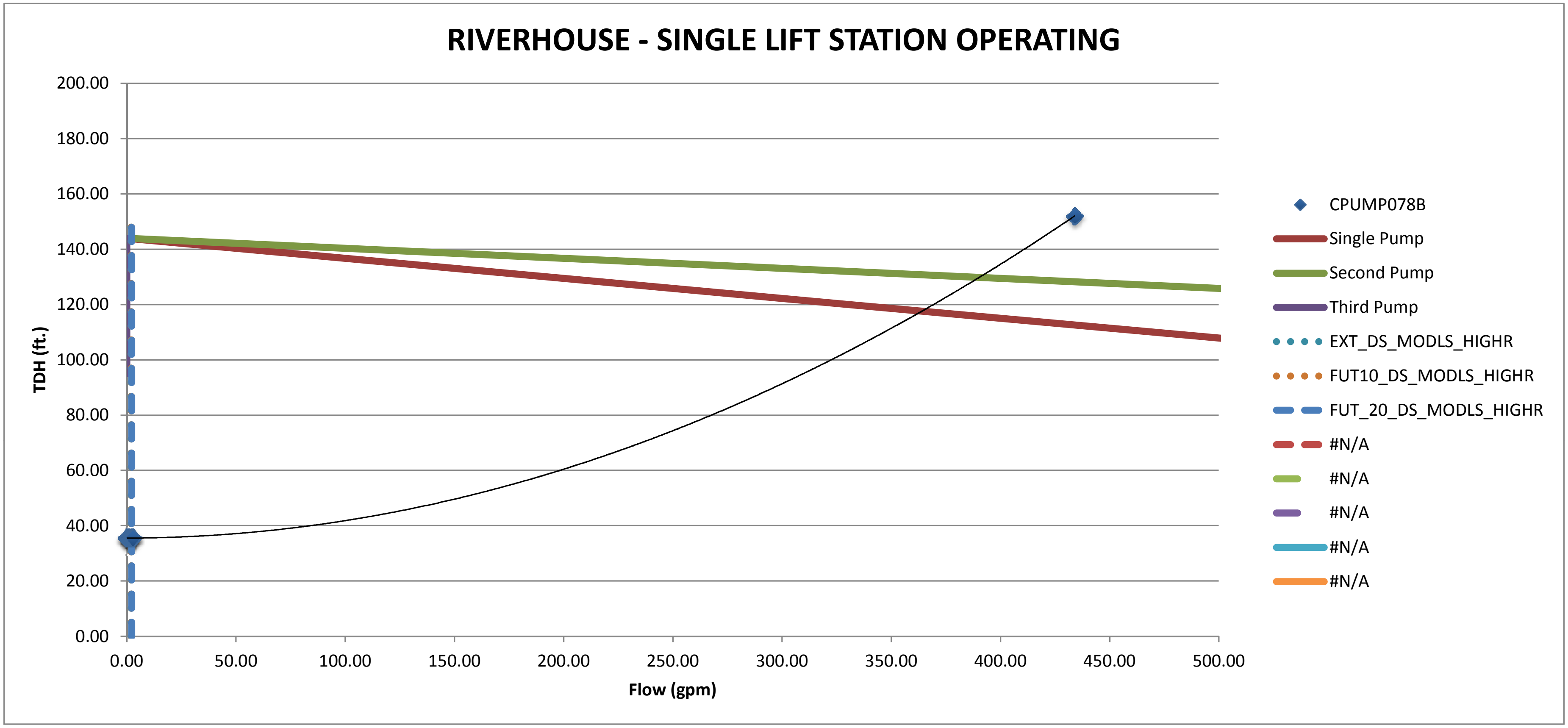


RIM ROCK RIDERS - SINGLE LIFT STATION OPERATING
TDH (ft.)
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0
20
40
60
80
100
120
140
Flow (gpm)
CPUMP084B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

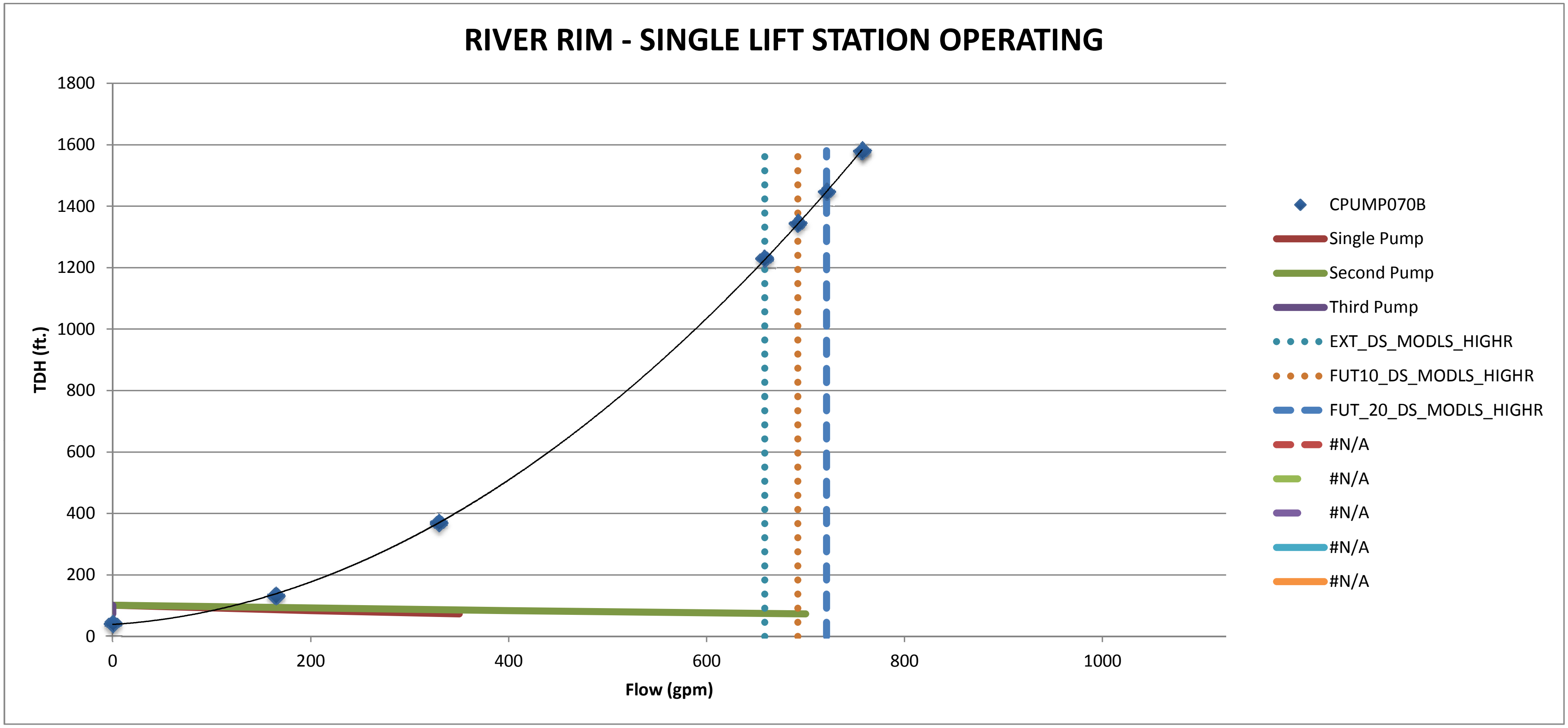

RIVER CANYON #1 RIDGE - SINGLE LIFT STATION OPERATING
TDH (ft.)
Flow (gpm)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
50
100
150
200
250
300
CPUMP066B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A



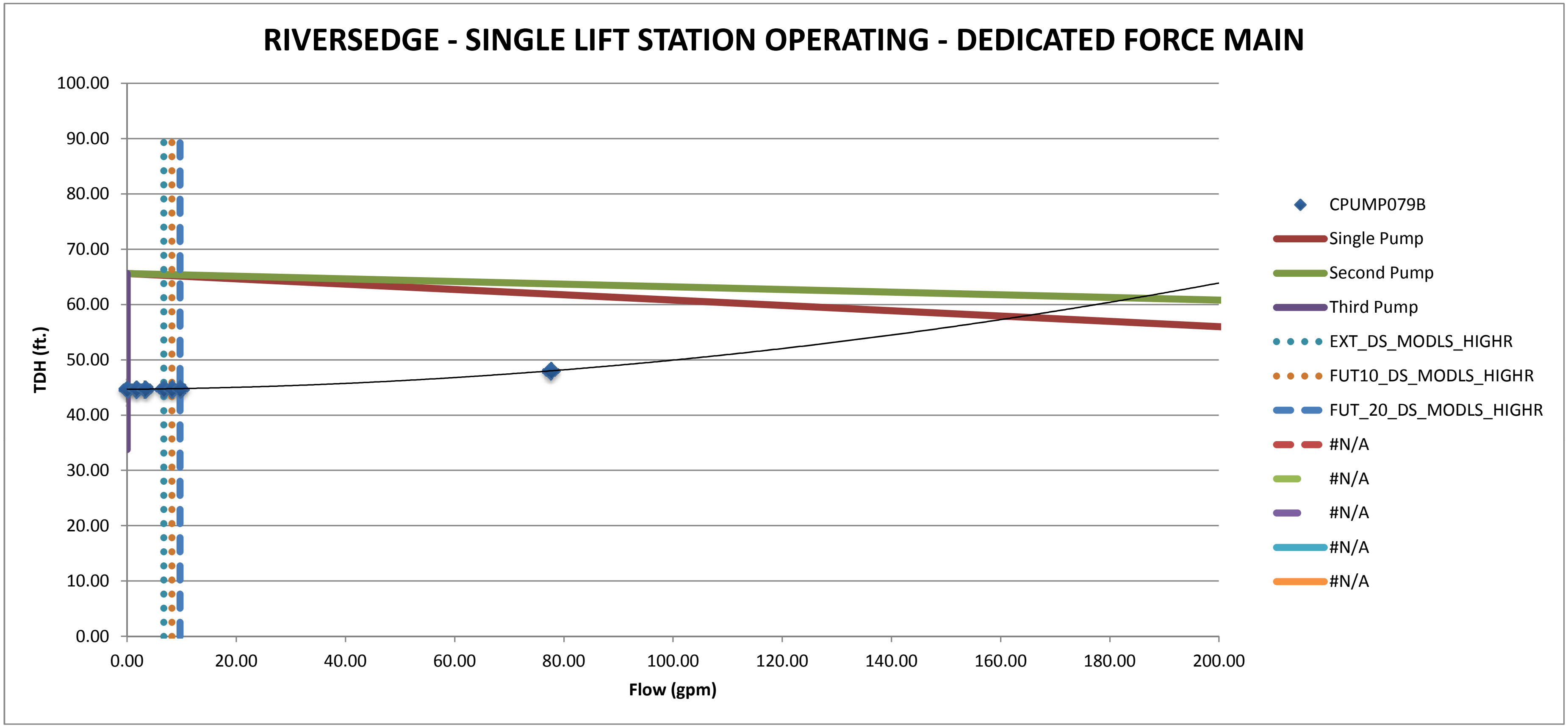
RIVER CANYON #2 RIDGE - SINGLE LIFT STATION OPERATING
TDH (ft.)
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0
50
100
150
200
250
300
350
400
Flow (gpm)
CPUMP068B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

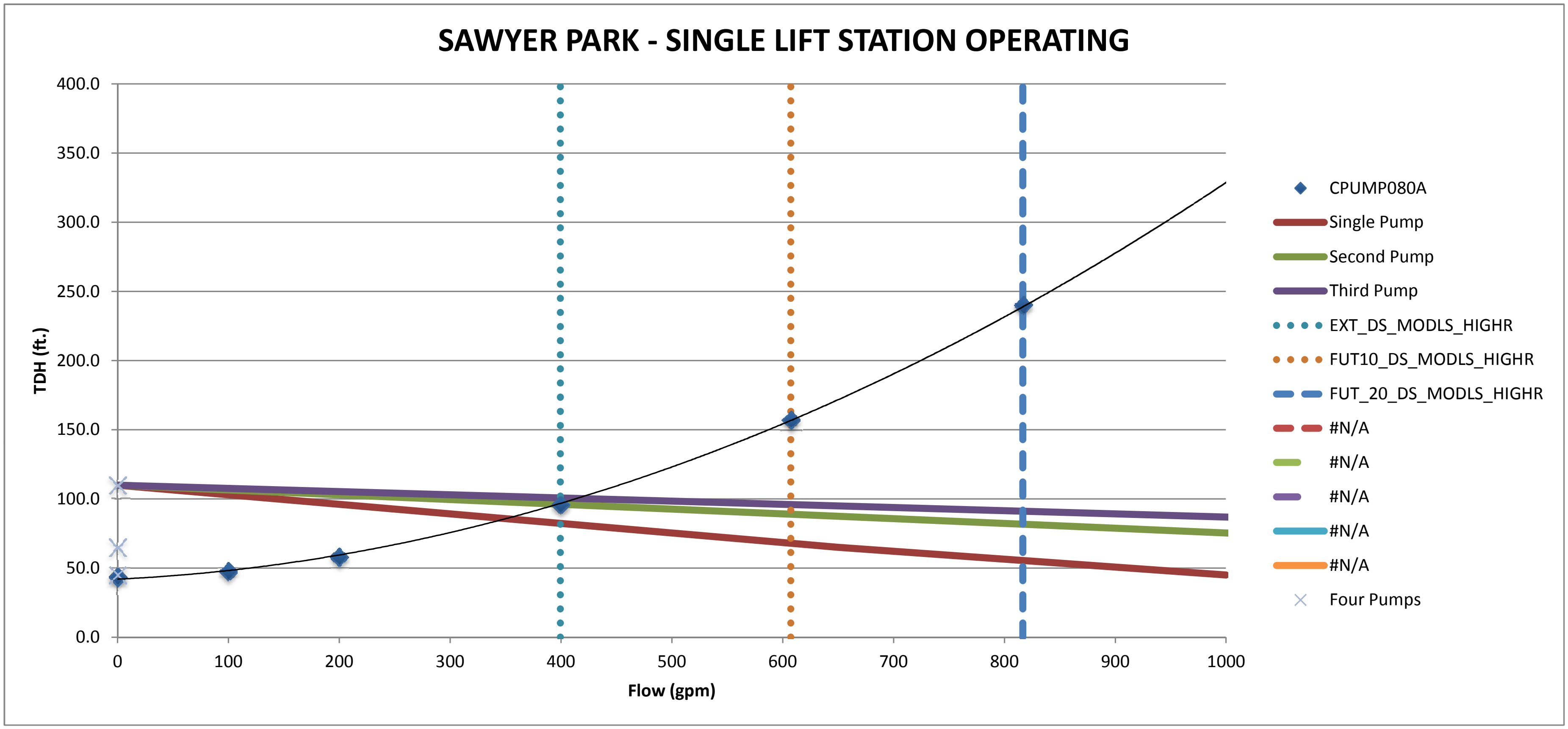


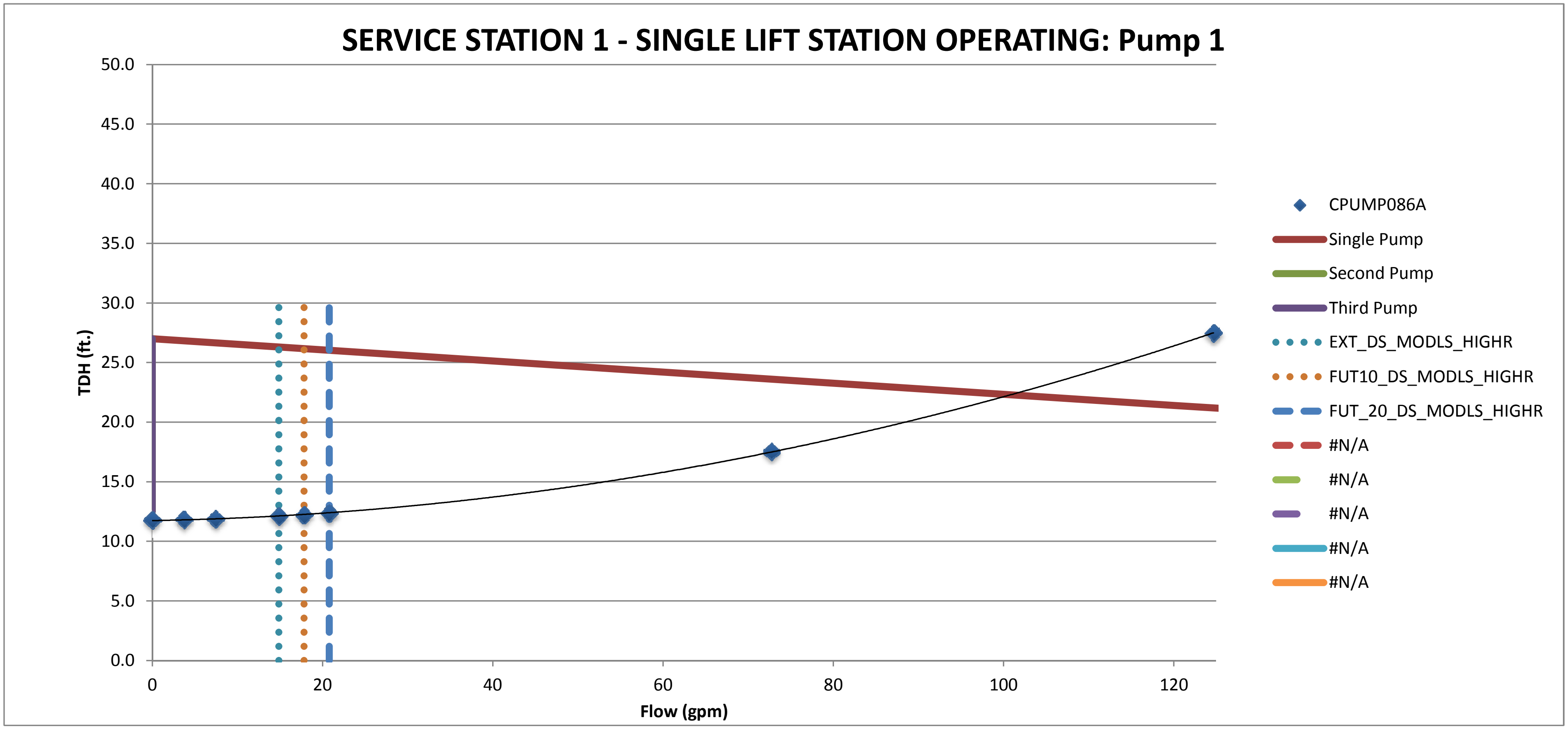
RIVERHOUSE - SINGLE LIFT STATION OPERATING
TDH (ft.)
200.00
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0.00
50.00
100.00
150.00
200.00
250.00
300.00
350.00
400.00
450.00
500.00
Flow (gpm)
CPUMP078B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A



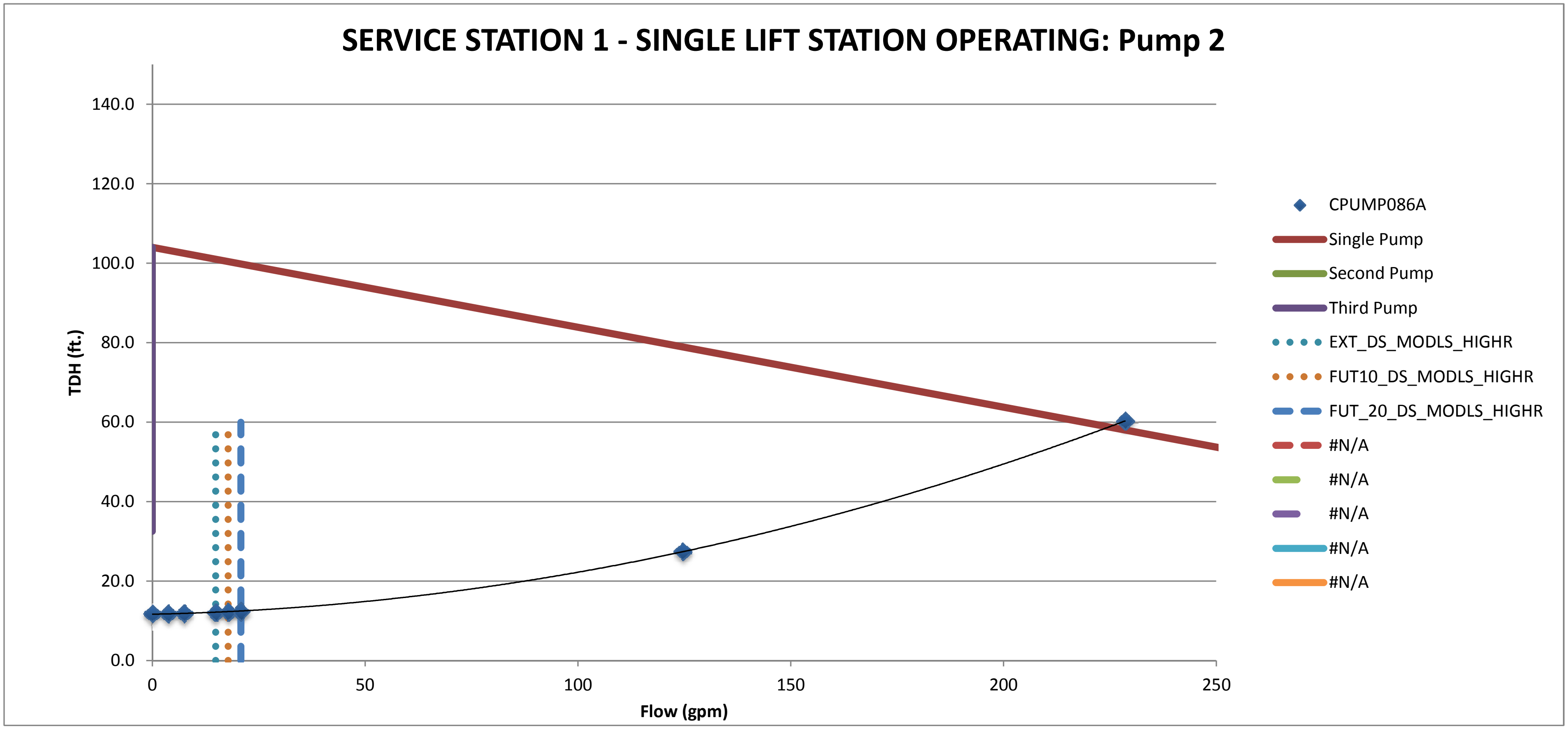
RIVER RIM - SINGLE LIFT STATION OPERATING
TDH (ft.)
1800
1600
1400
1200
1000
800
600
400
200
0
0
200
400
600
800
1000
Flow (gpm)
CPUMP070B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

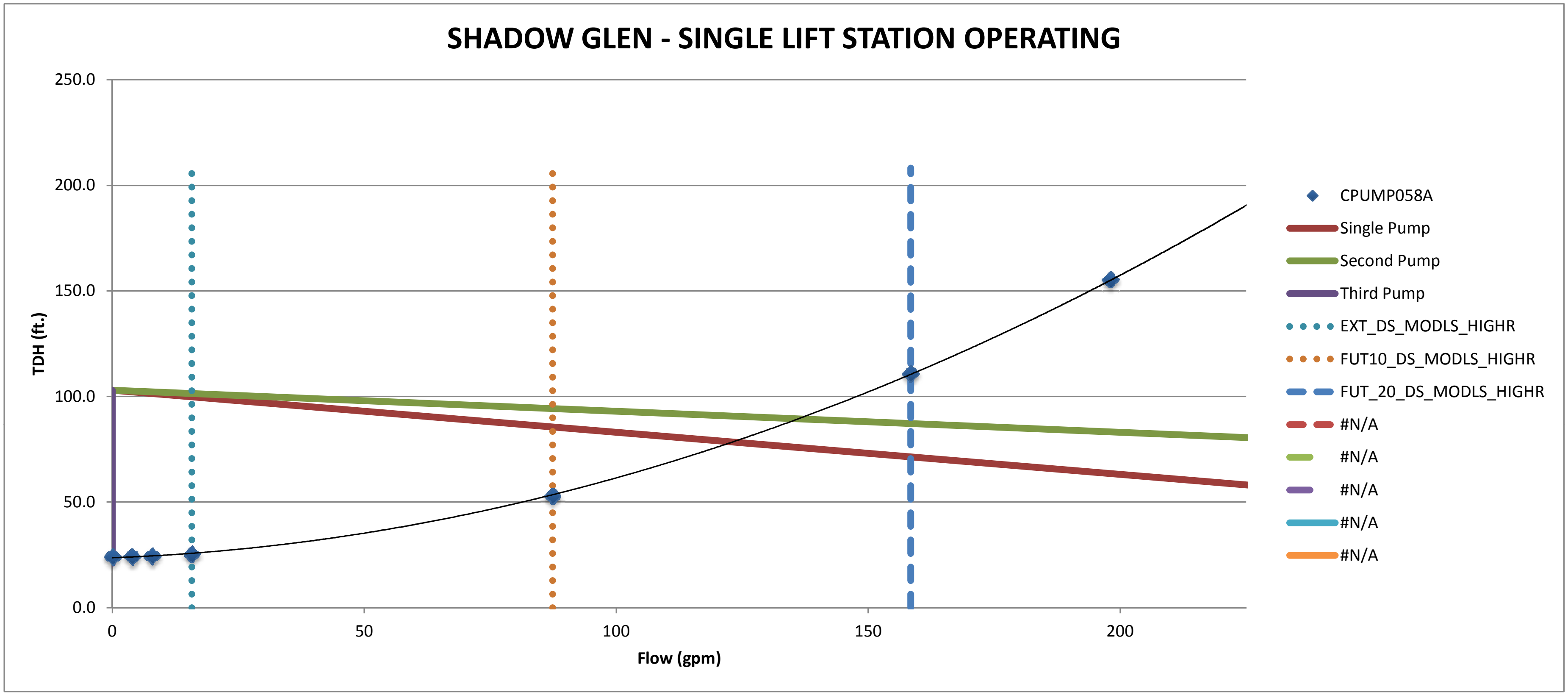

RIVERSEDGE - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
Flow (gpm)
CPUMP079B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A


SAWYER PARK - SINGLE LIFT STATION OPERATING
TDH (ft.)
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0
100
200
300
400
500
600
700
800
900
1000
Flow (gpm)
CPUMP080A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A
Four Pumps

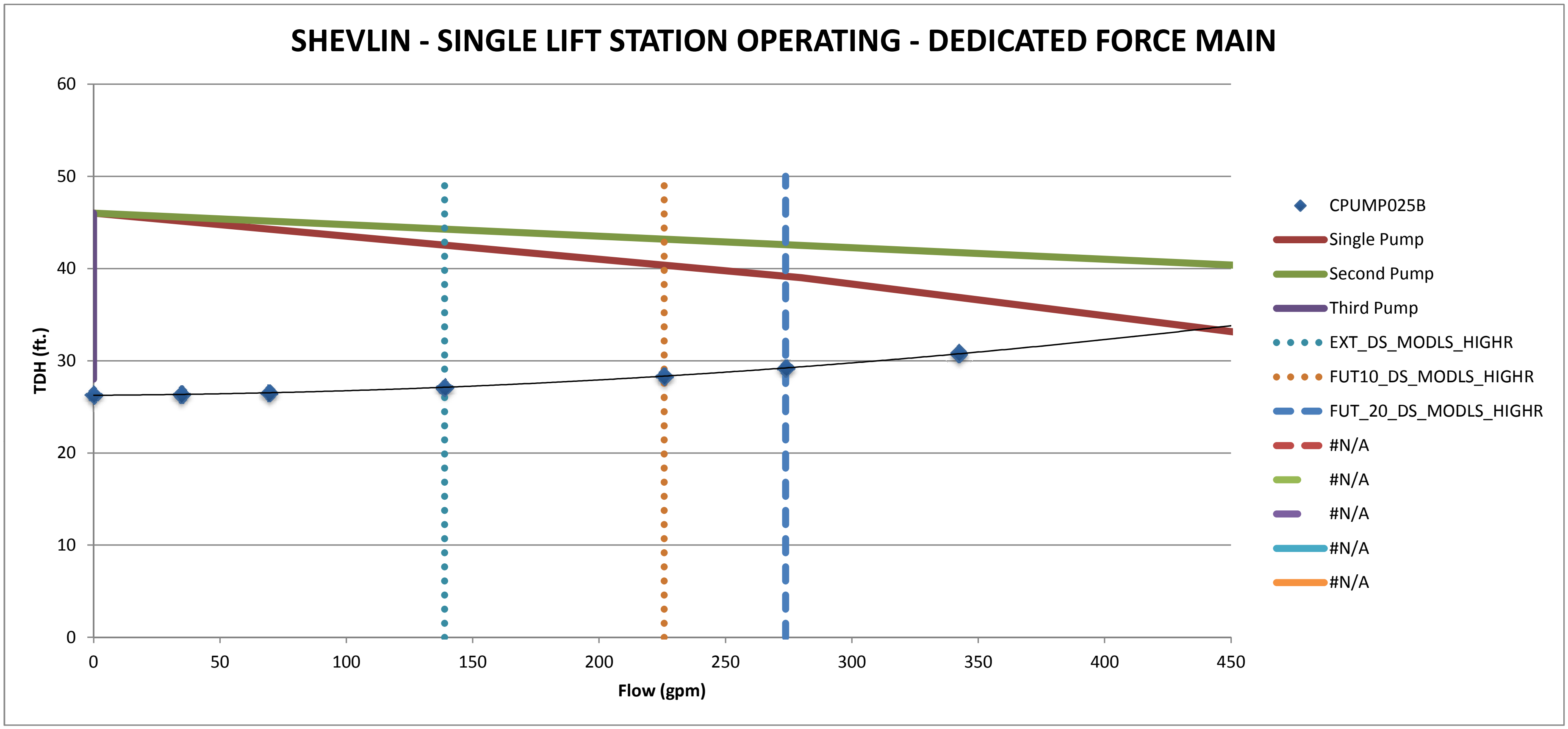


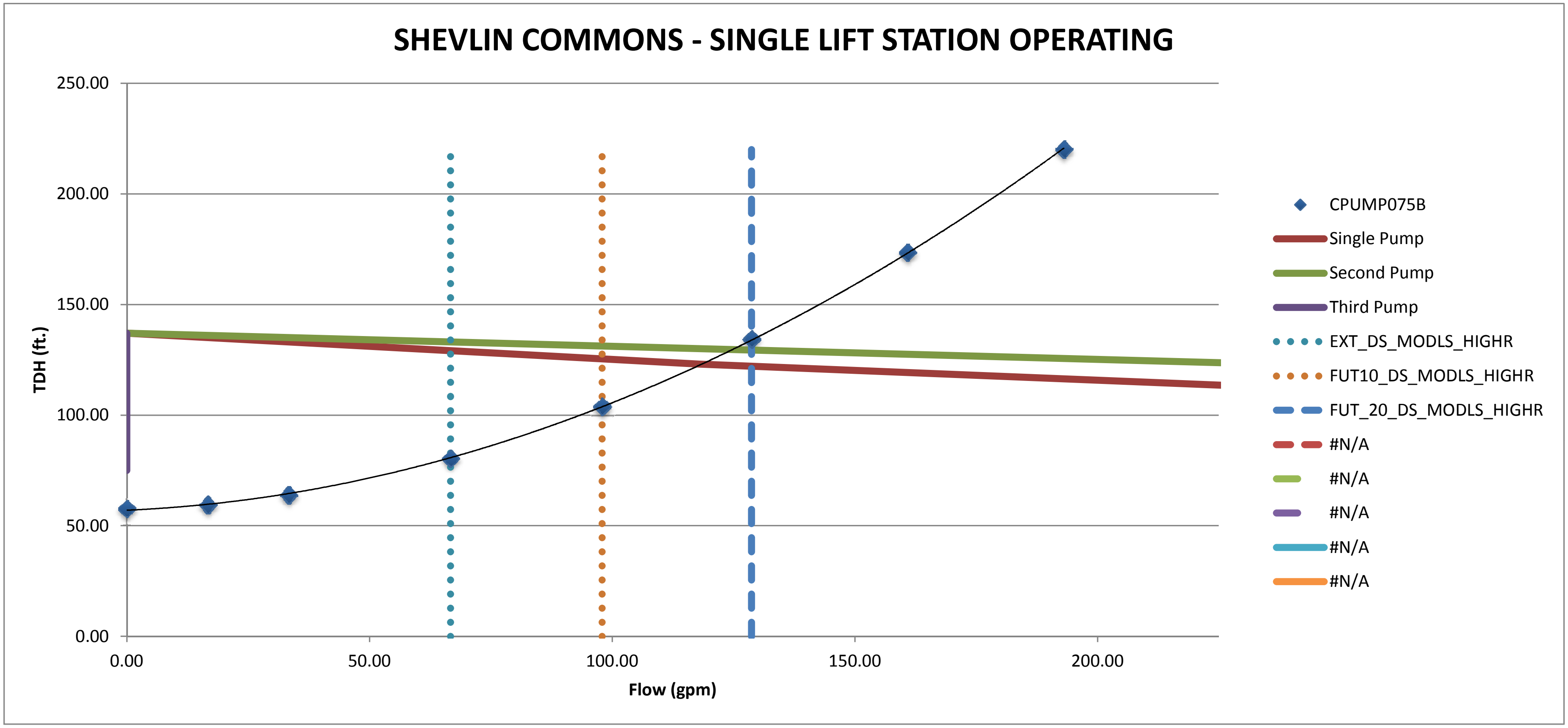
SERVICE STATION 1 - SINGLE LIFT STATION OPERATING: Pump 1
TDH (ft.)
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
20
40
60
80
100
120
Flow (gpm)
CPUMP086A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

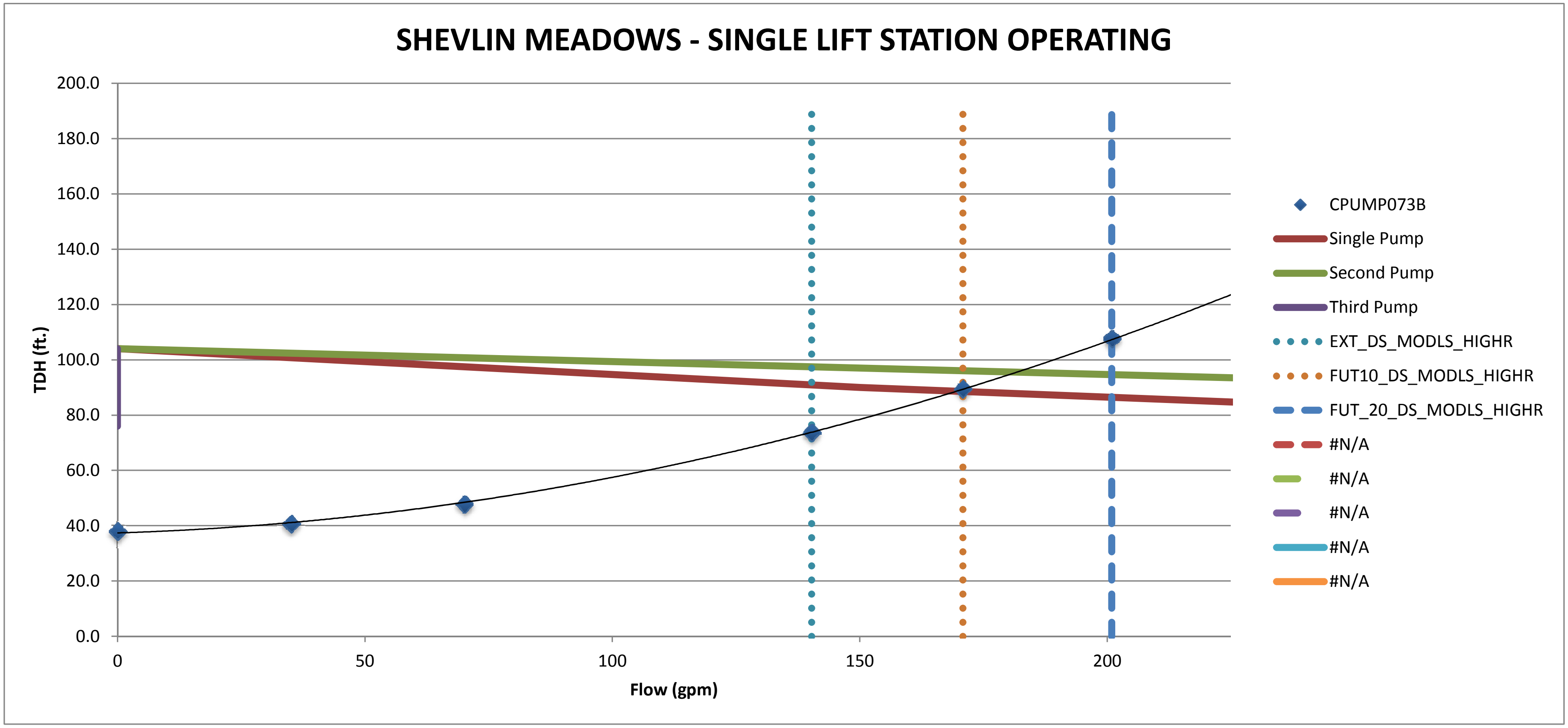

SERVICE STATION 1 - SINGLE LIFT STATION OPERATING: Pump 2
TDH (ft.)
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0
50
100
150
200
250
Flow (gpm)
CPUMP086A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

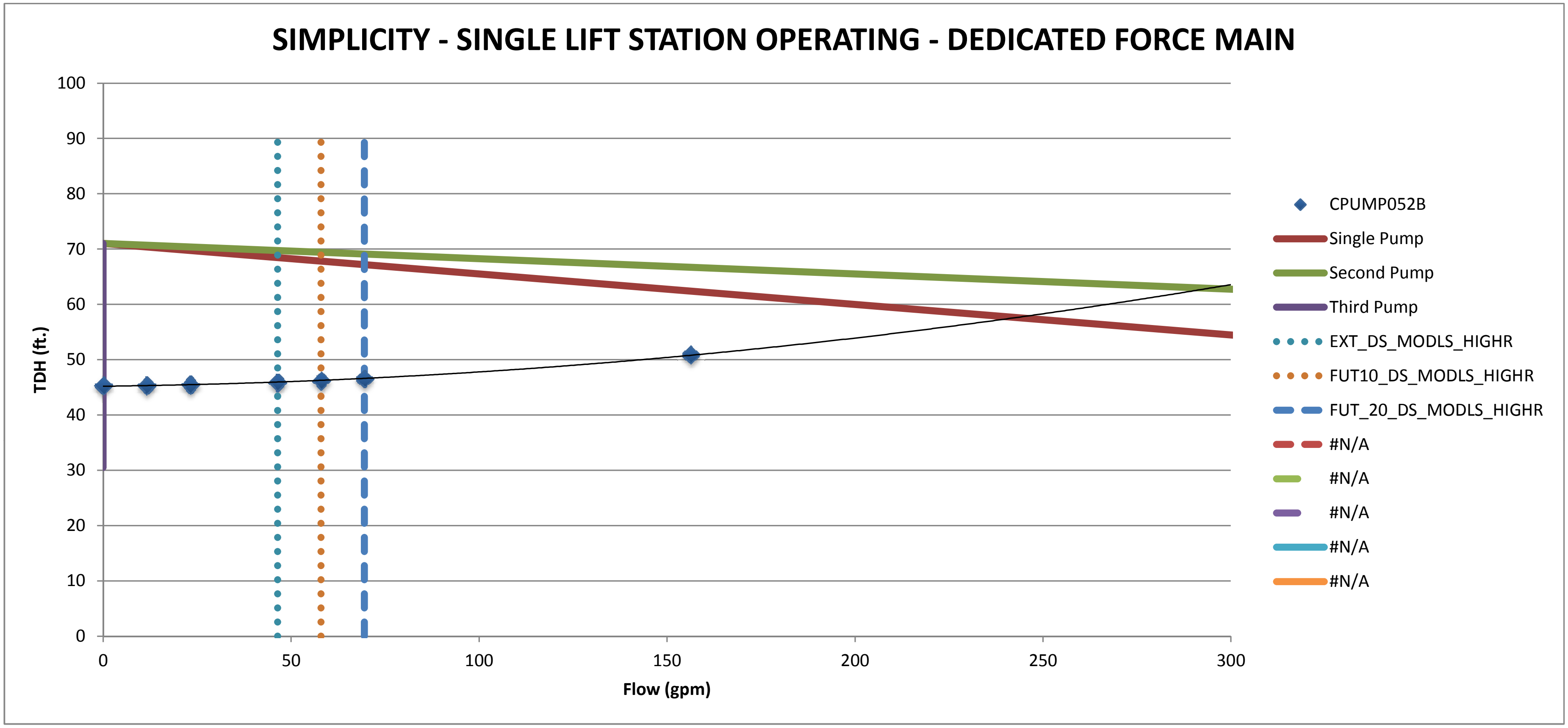


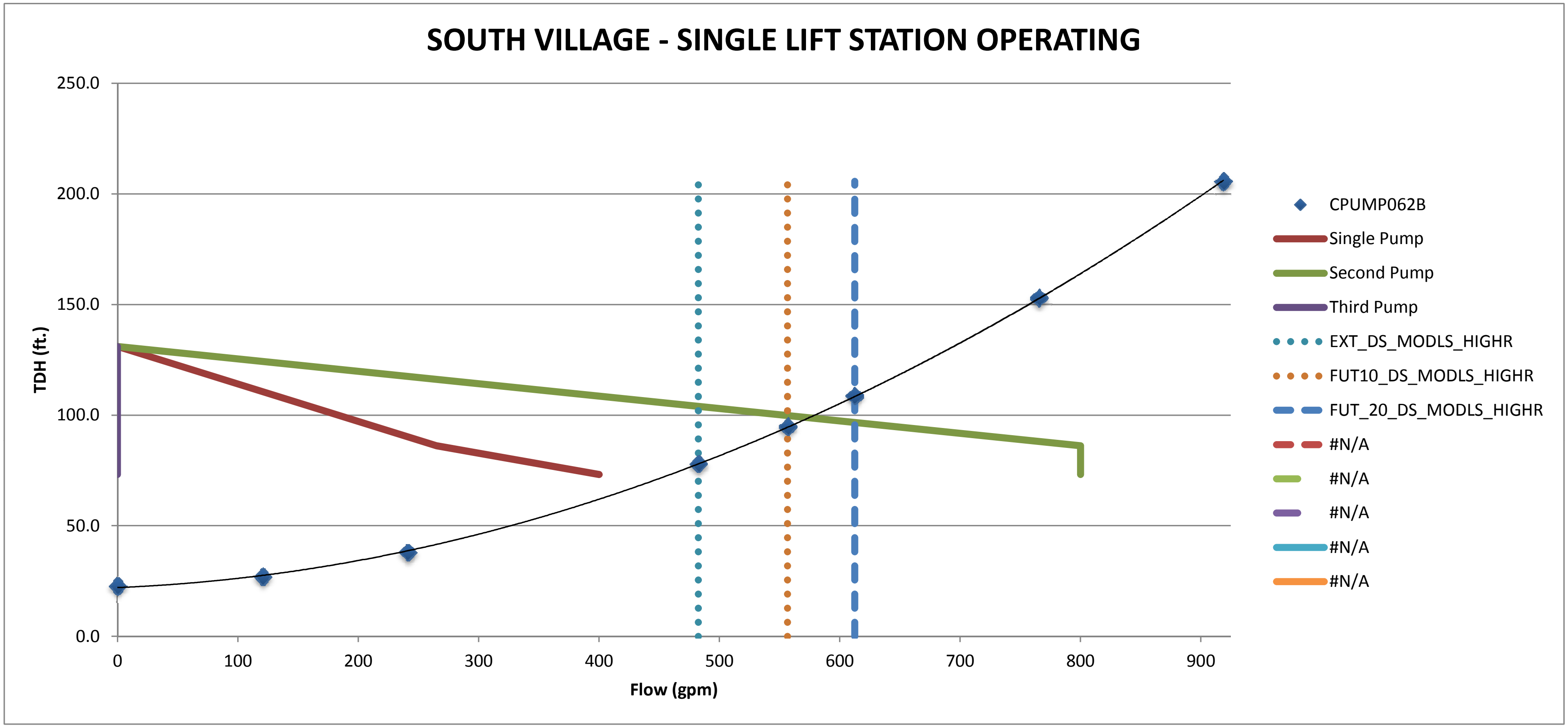
SHADOW GLEN - SINGLE LIFT STATION OPERATING
250.0
200.0
150.0
100.0
50.0
0.0
TDH (ft.)
0
50
100
150
200
Flow (gpm)
CPUMP058A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

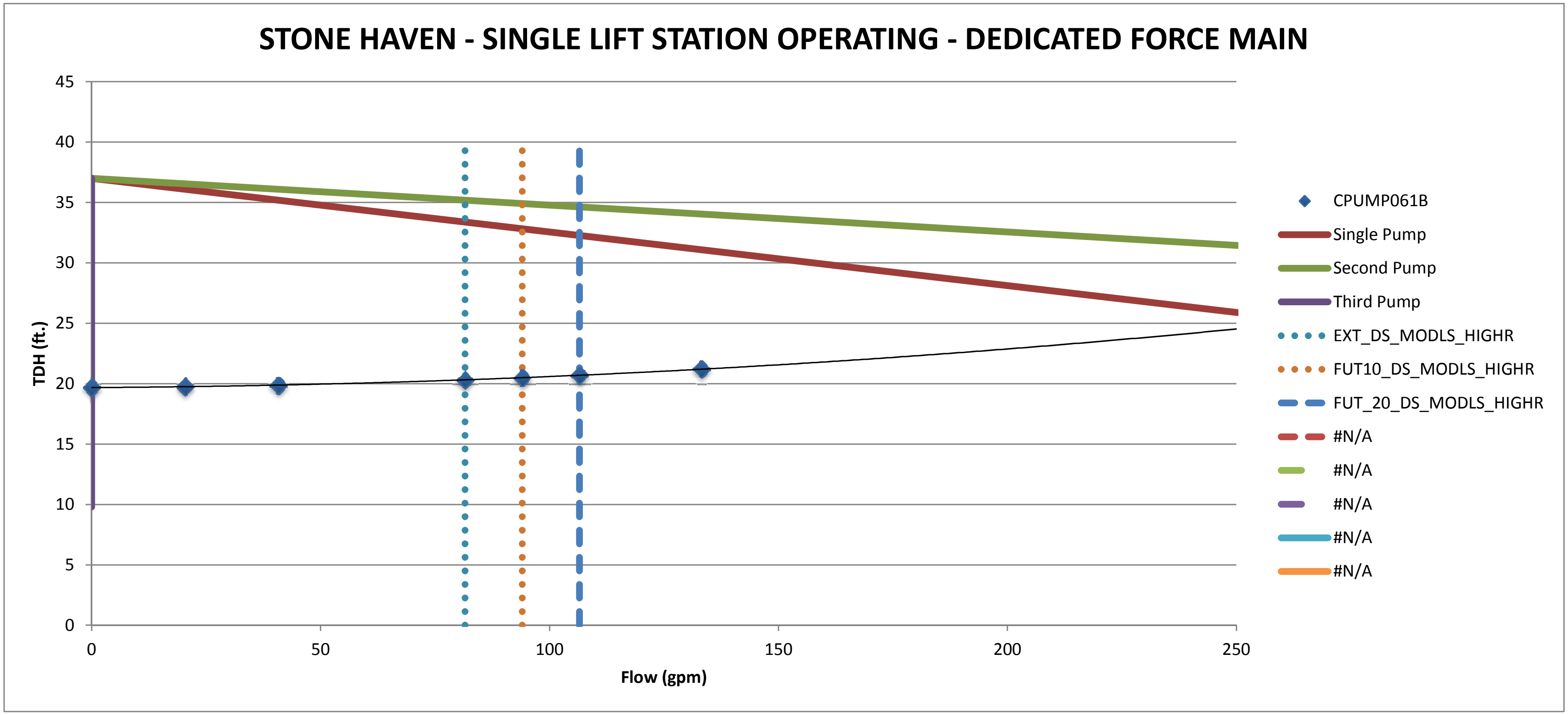

SHEVLIN - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
60
50
40
30
20
10
0
TDH (ft.)
0
50
100
150
200
250
300
350
400
450
Flow (gpm)
CPUMP025B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

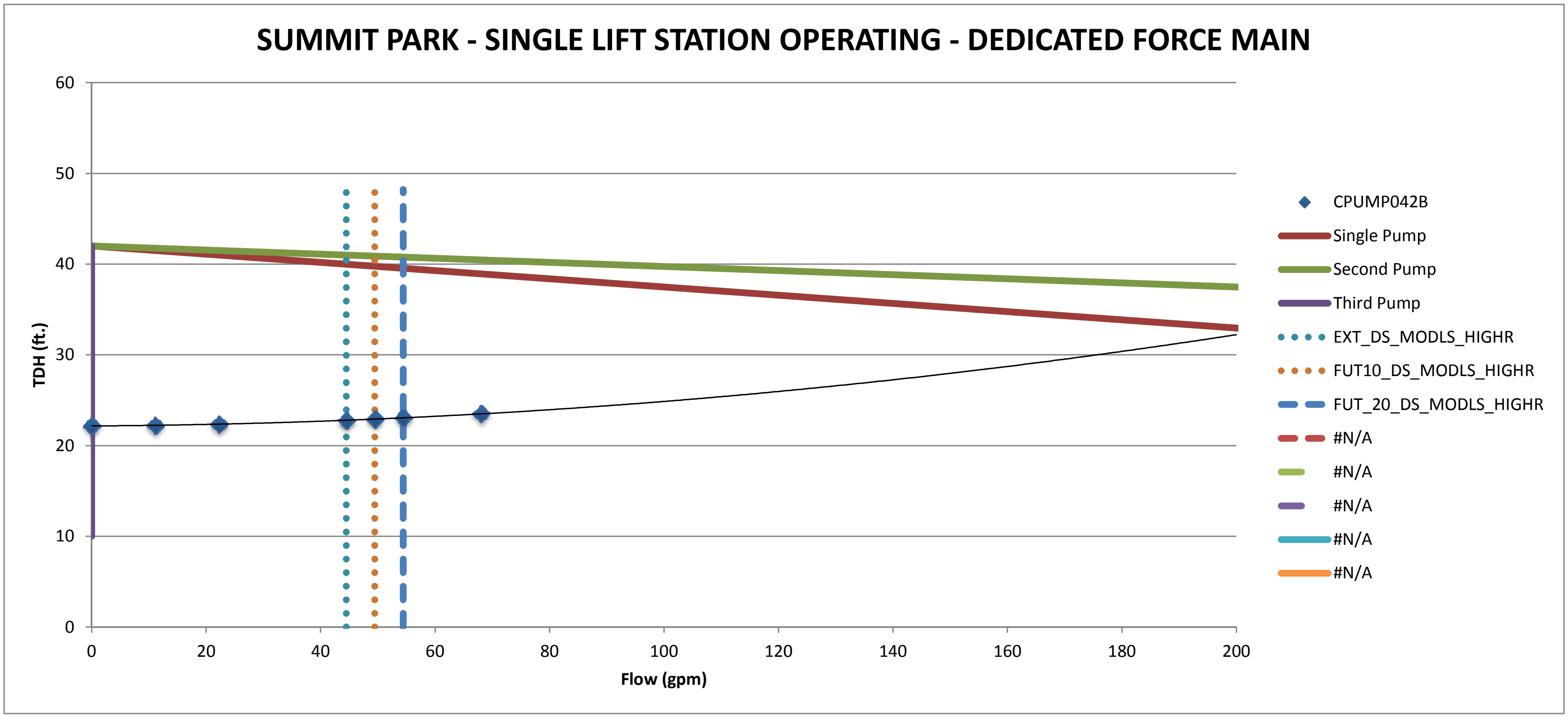

SHEVLIN COMMONS - SINGLE LIFT STATION OPERATING
250.00
200.00
150.00
100.00
50.00
0.00
TDH (ft.)
0.00
50.00
100.00
150.00
200.00
Flow (gpm)
CPUMP075B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A


SHEVLIN MEADOWS - SINGLE LIFT STATION OPERATING
TDH (ft.)
200.0
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0
50
100
150
200
Flow (gpm)
CPUMP073B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

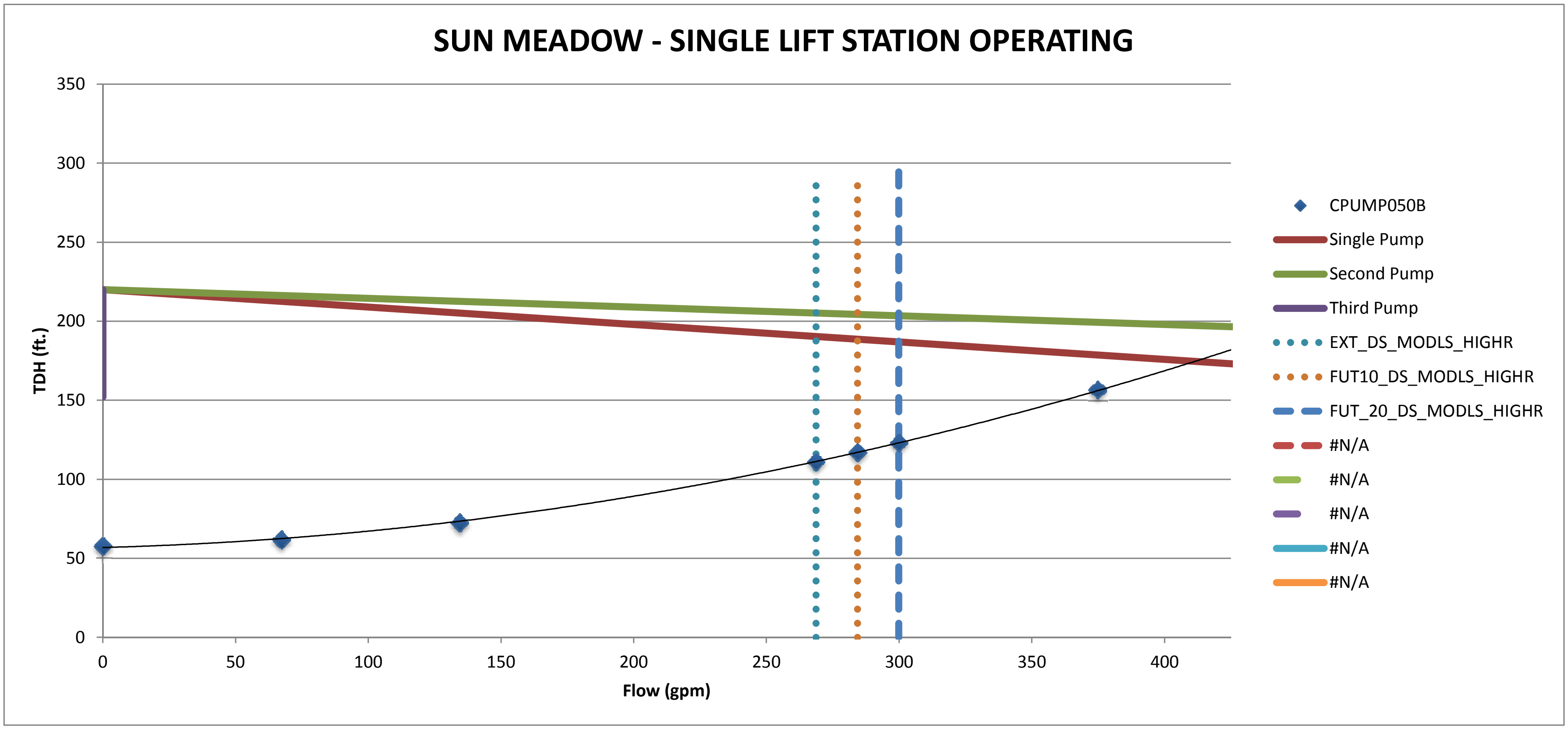

SIMPLICITY - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
100
90
80
70
60
50
40
30
20
10
0
0
50
100
150
200
250
300
Flow (gpm)
CPUMP052B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A


SOUTH VILLAGE - SINGLE LIFT STATION OPERATING
250.0
200.0
150.0
100.0
50.0
0.0
TDH (ft.)
0
100
200
300
400
500
600
700
800
900
Flow (gpm)
CPUMP062B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

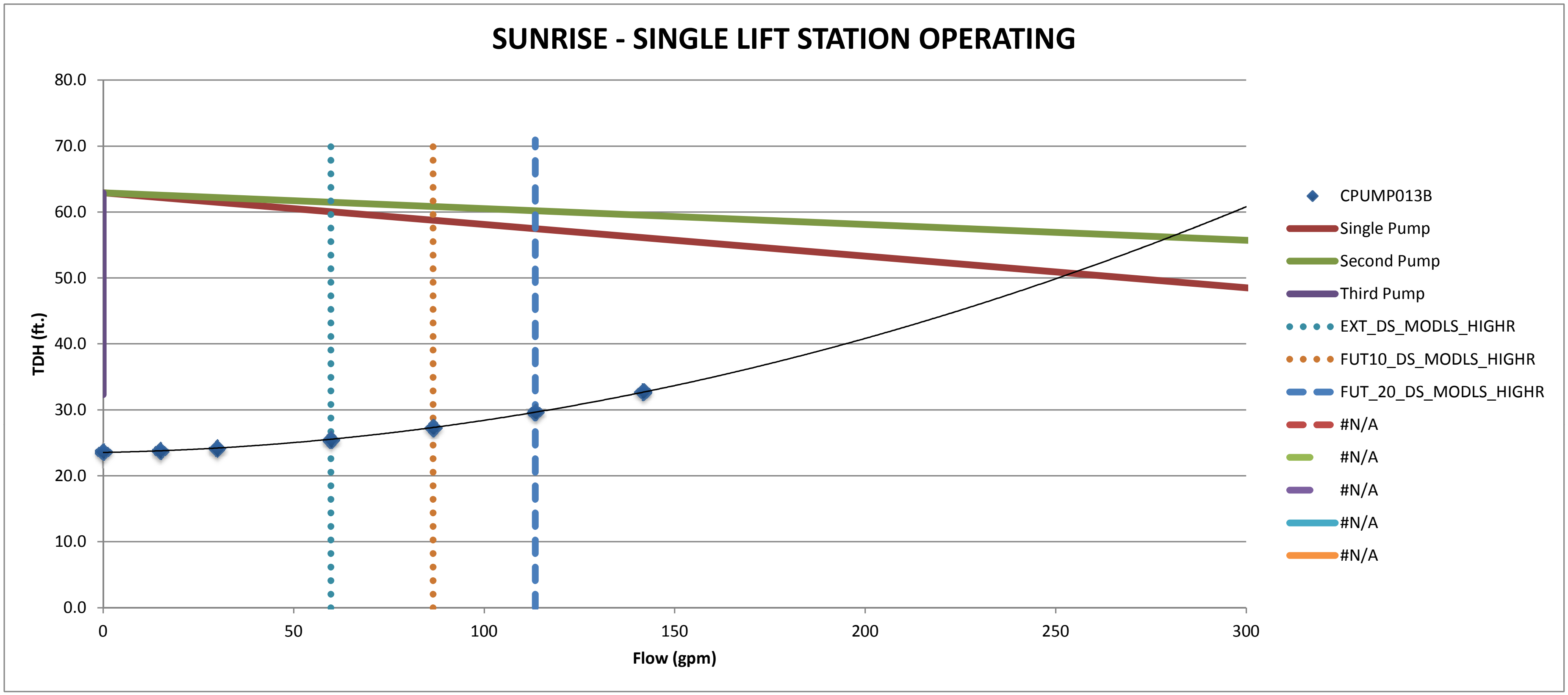

STONE HAVEN - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
45
40
35
30
25
20
15
10
5
0
TDH (ft.)
0
50
100
150
200
250
Flow (gpm)
CPUMP061B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

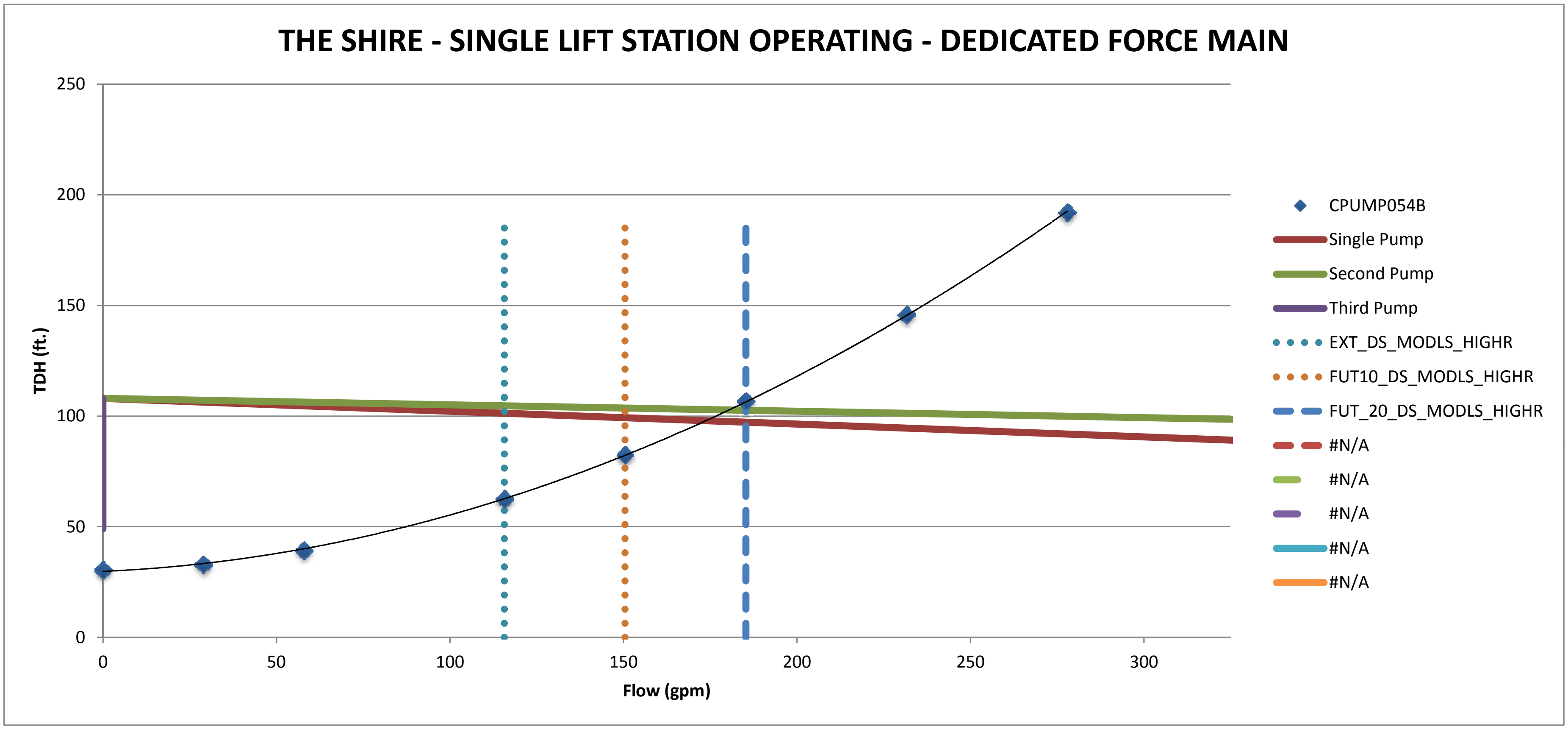


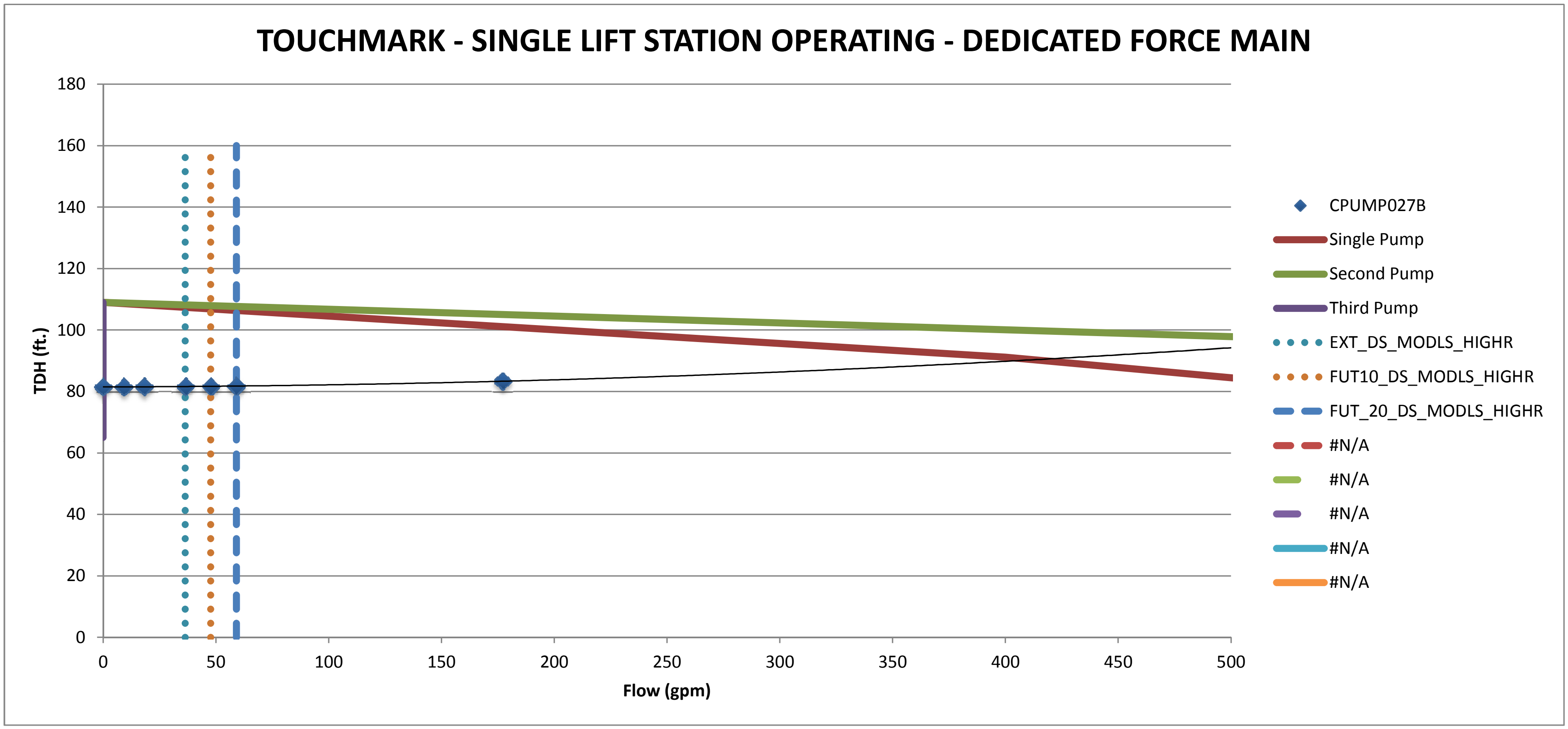
SUMMIT PARK - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
Flow (gpm)
0
10
20
30
40
50
60
0
20
40
60
80
100
120
140
160
180
200
CPUMP042B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

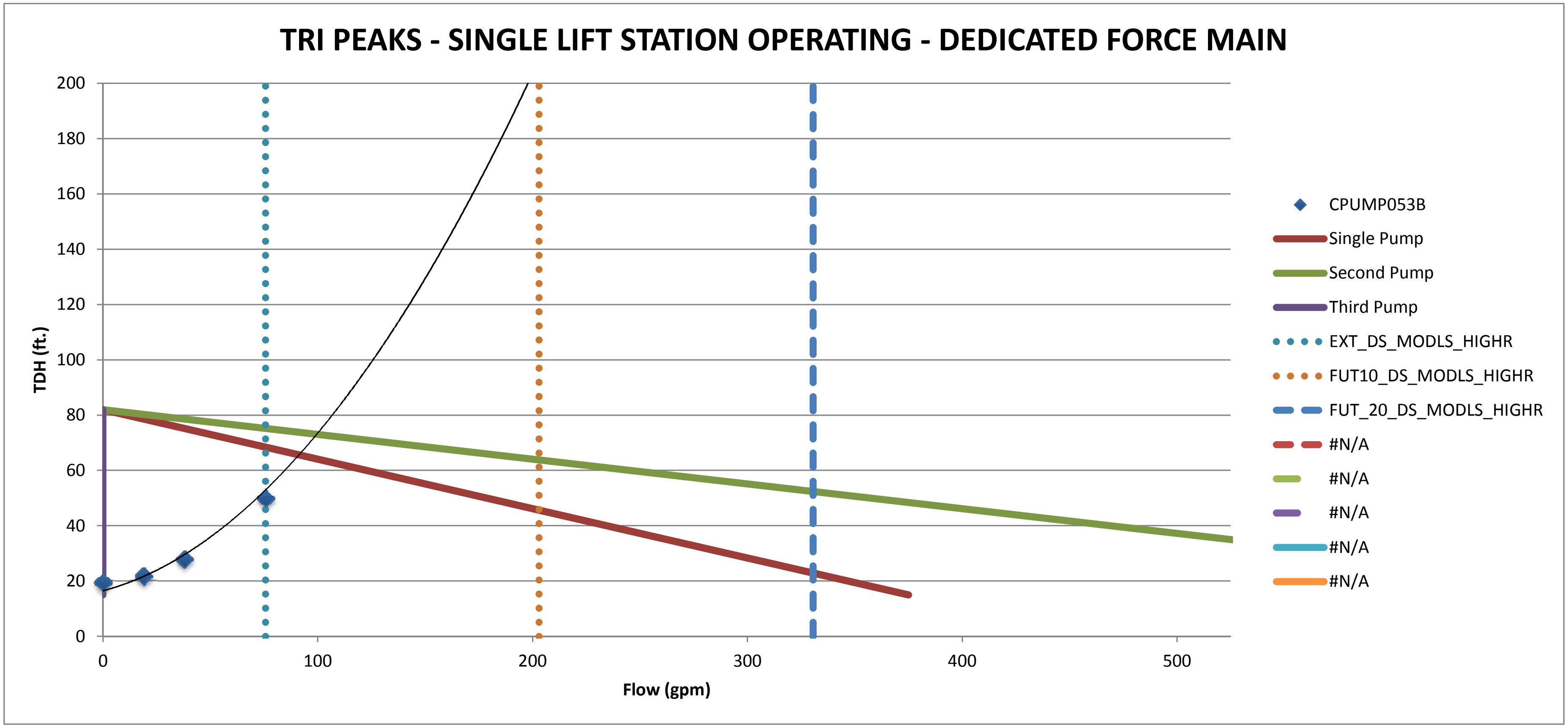


SUN MEADOW - SINGLE LIFT STATION OPERATING
350
300
250
200
150
100
50
0
TDH (ft.)
0
50
100
150
200
250
300
350
400
Flow (gpm)
CPUMP050B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

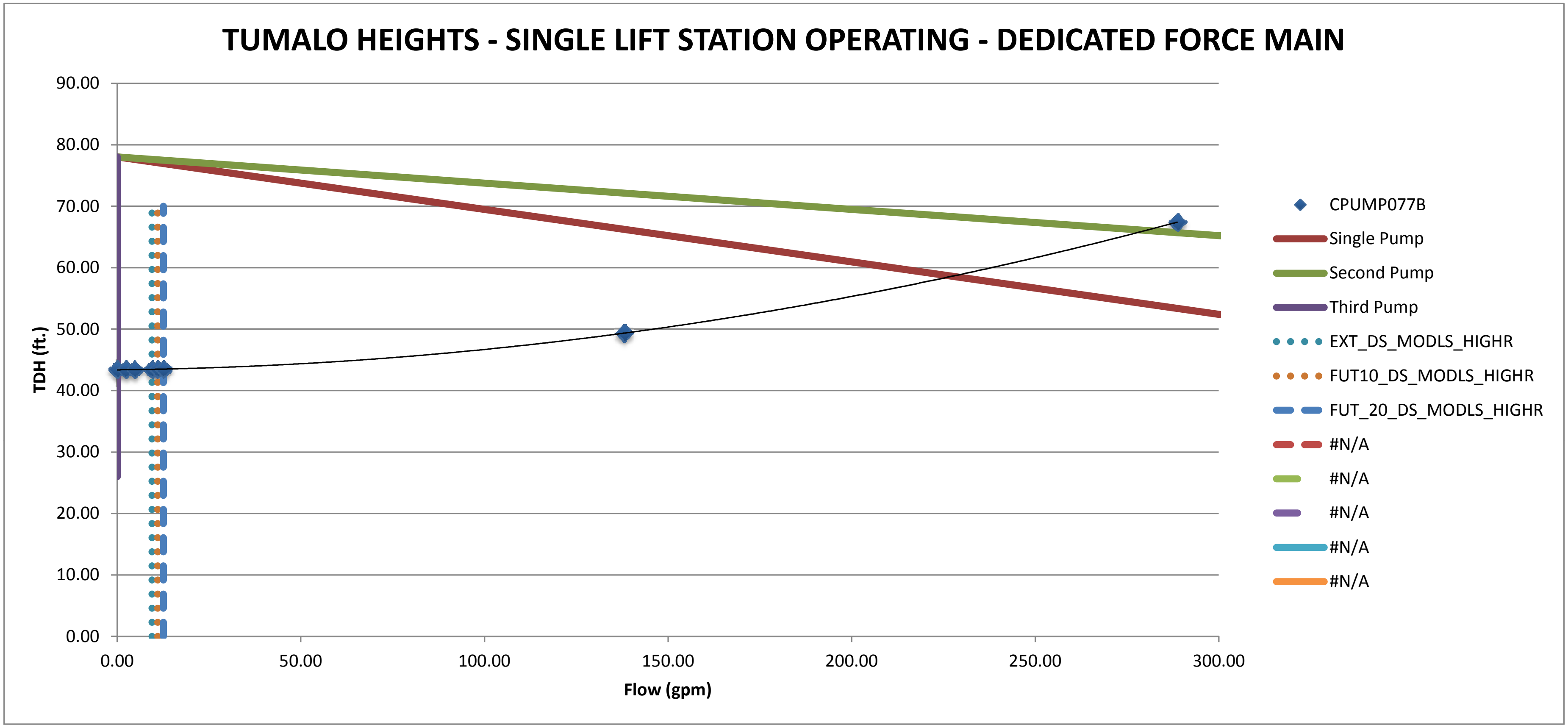

SUNRISE - SINGLE LIFT STATION OPERATING
TDH (ft.)
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
50
100
150
200
250
300
Flow (gpm)
CPUMP013B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A


THE SHIRE - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
Flow (gpm)
0
50
100
150
200
250
300
CPUMP054B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

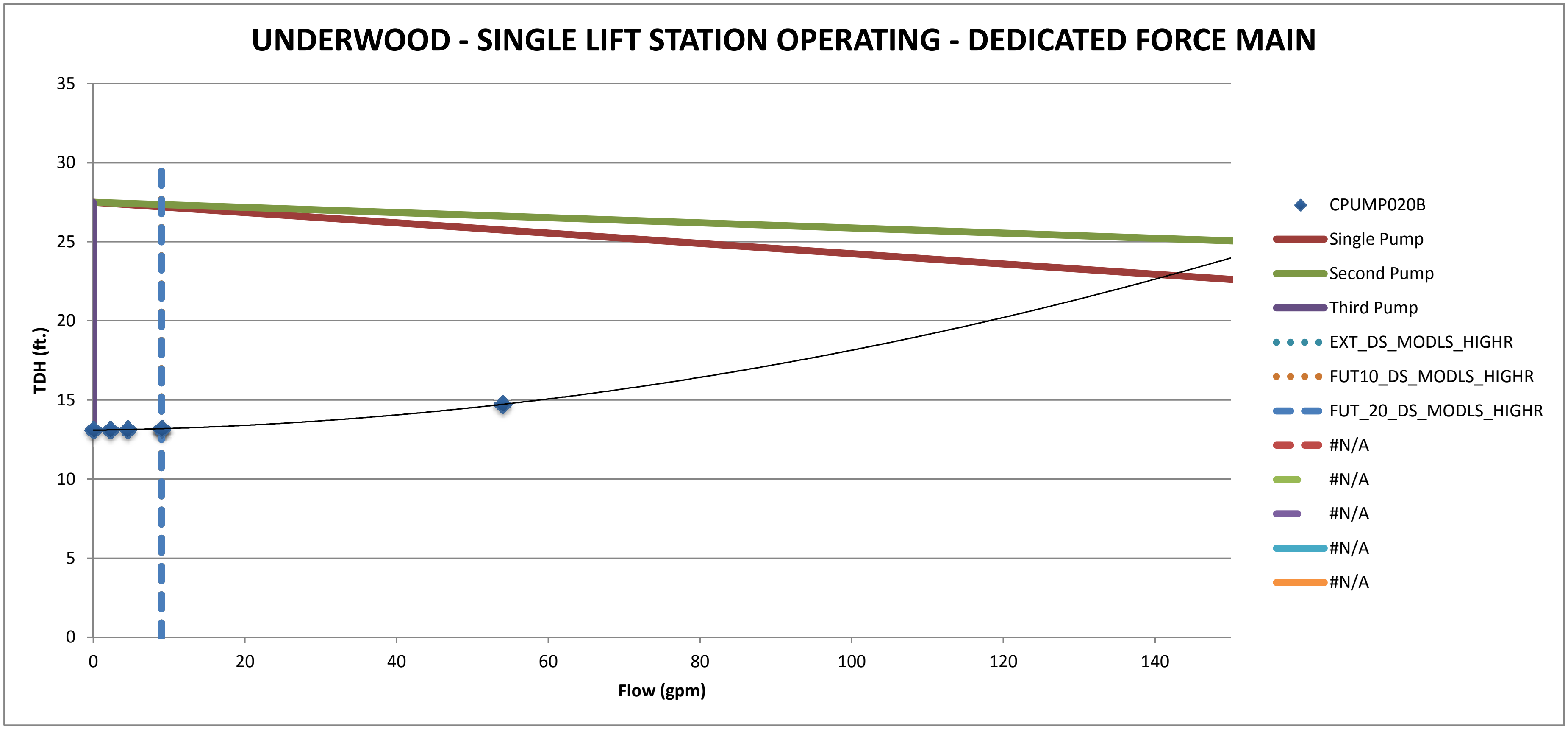

TOUCHMARK - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
Flow (gpm)
0
20
40
60
80
100
120
140
160
180
0
50
100
150
200
250
300
350
400
450
500
CPUMP027B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

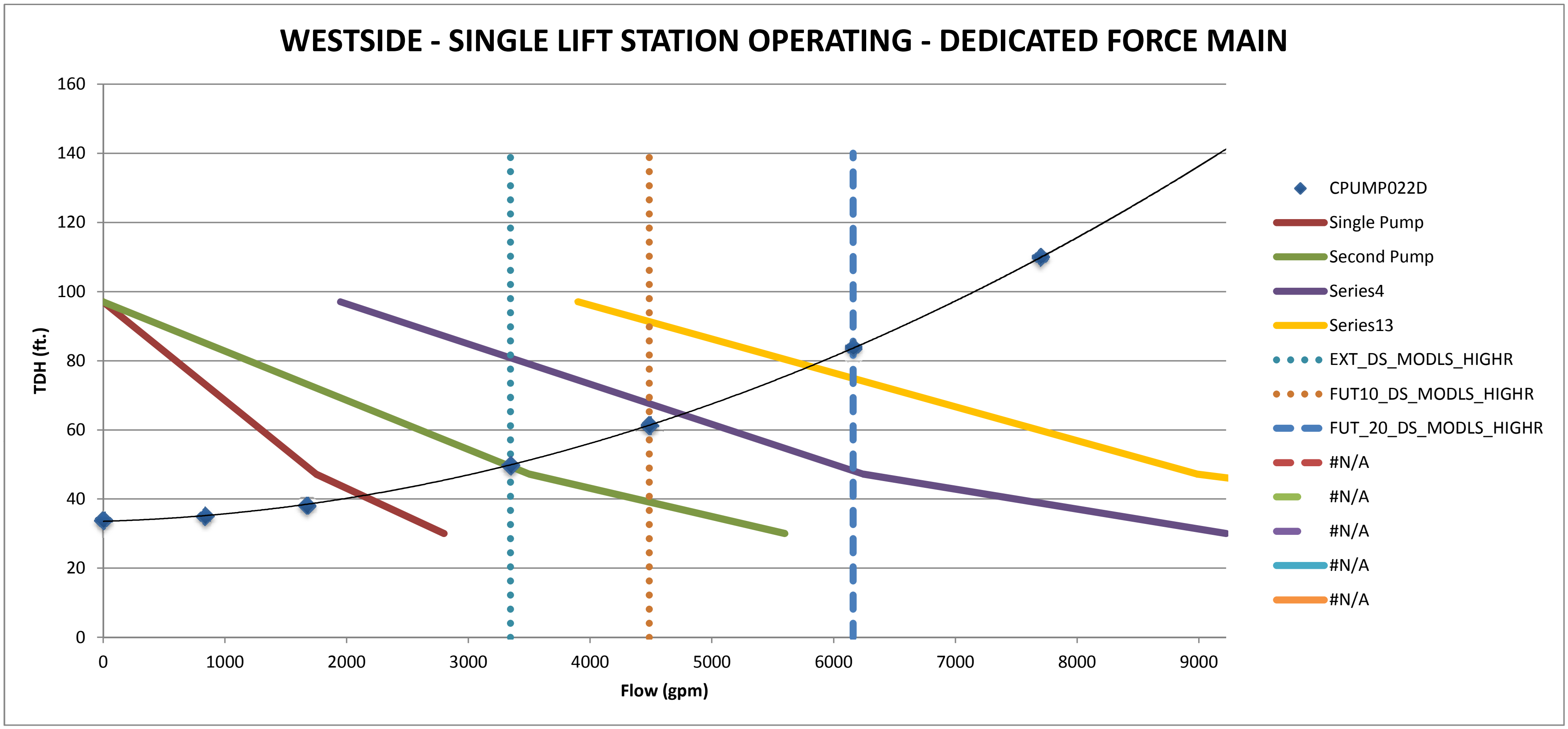


TRI PEAKS - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
200
180
160
140
120
100
80
60
40
20
0
0
100
200
300
400
500
Flow (gpm)
CPUMP053B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A



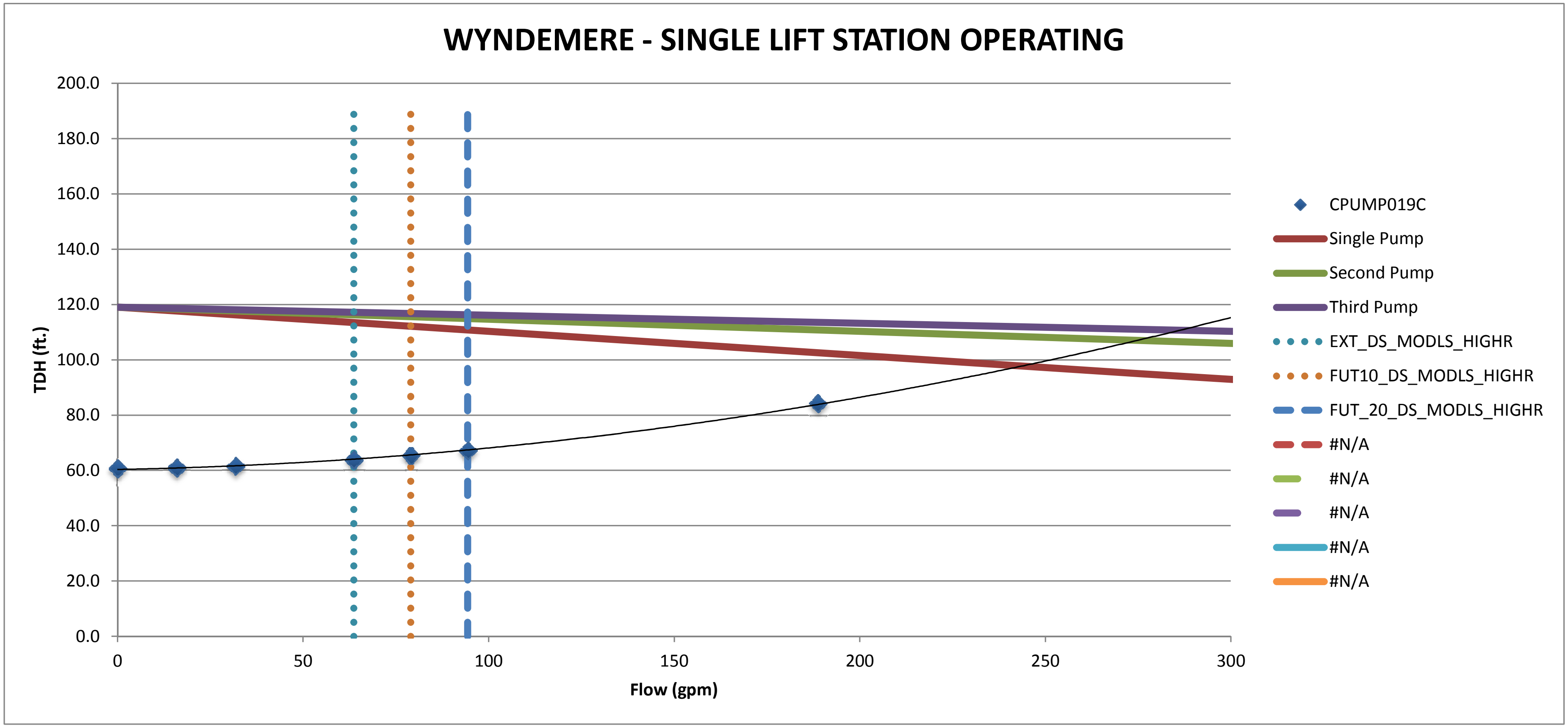
TUMALO HEIGHTS - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0.00
50.00
100.00
150.00
200.00
250.00
300.00
Flow (gpm)
CPUMP077B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

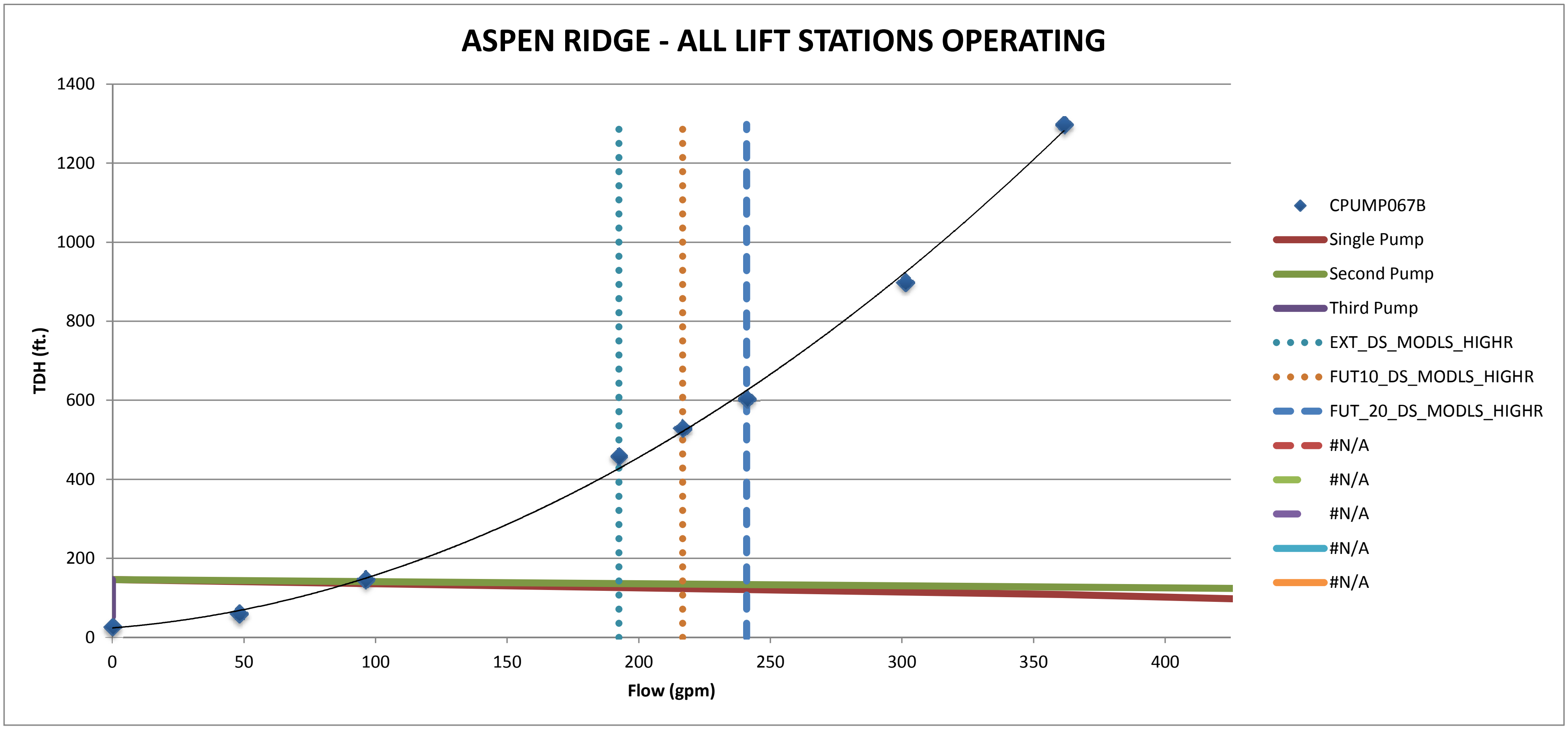

UNDERWOOD - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
TDH (ft.)
35
30
25
20
15
10
5
0
0
20
40
60
80
100
120
140
Flow (gpm)
CPUMP020B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

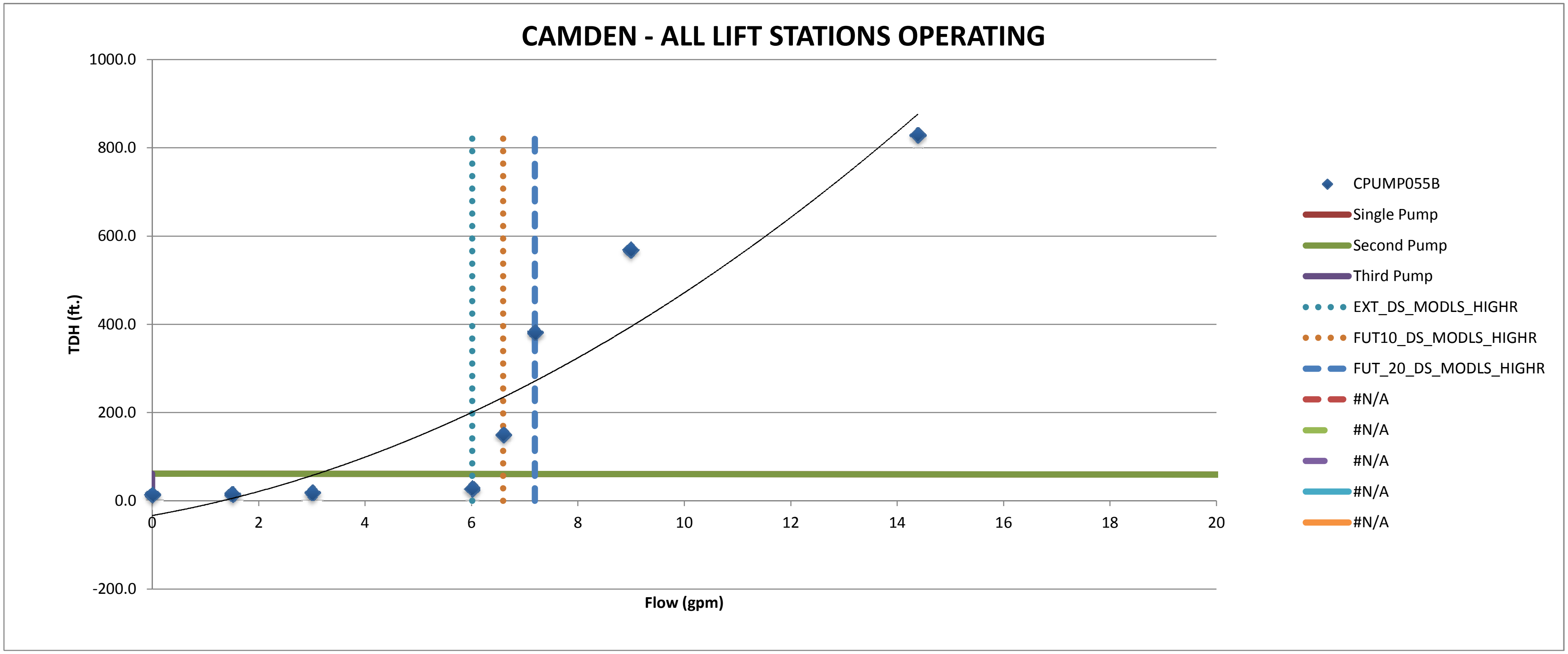


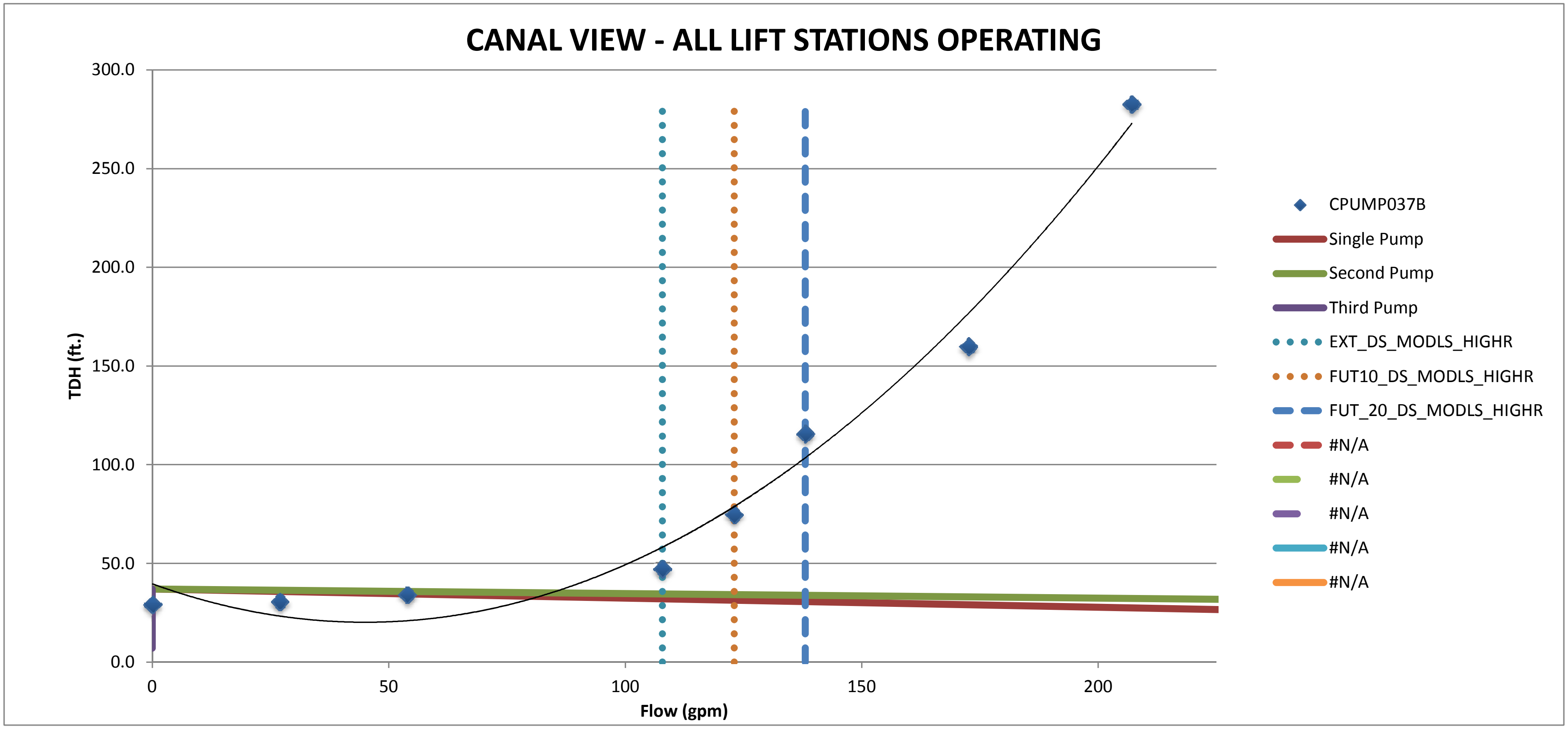
WESTSIDE - SINGLE LIFT STATION OPERATING - DEDICATED FORCE MAIN
160
140
120
100
80
60
40
20
0
TDH (ft.)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
Flow (gpm)
CPUMP022D
Single Pump
Second Pump
Series4
Series13
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

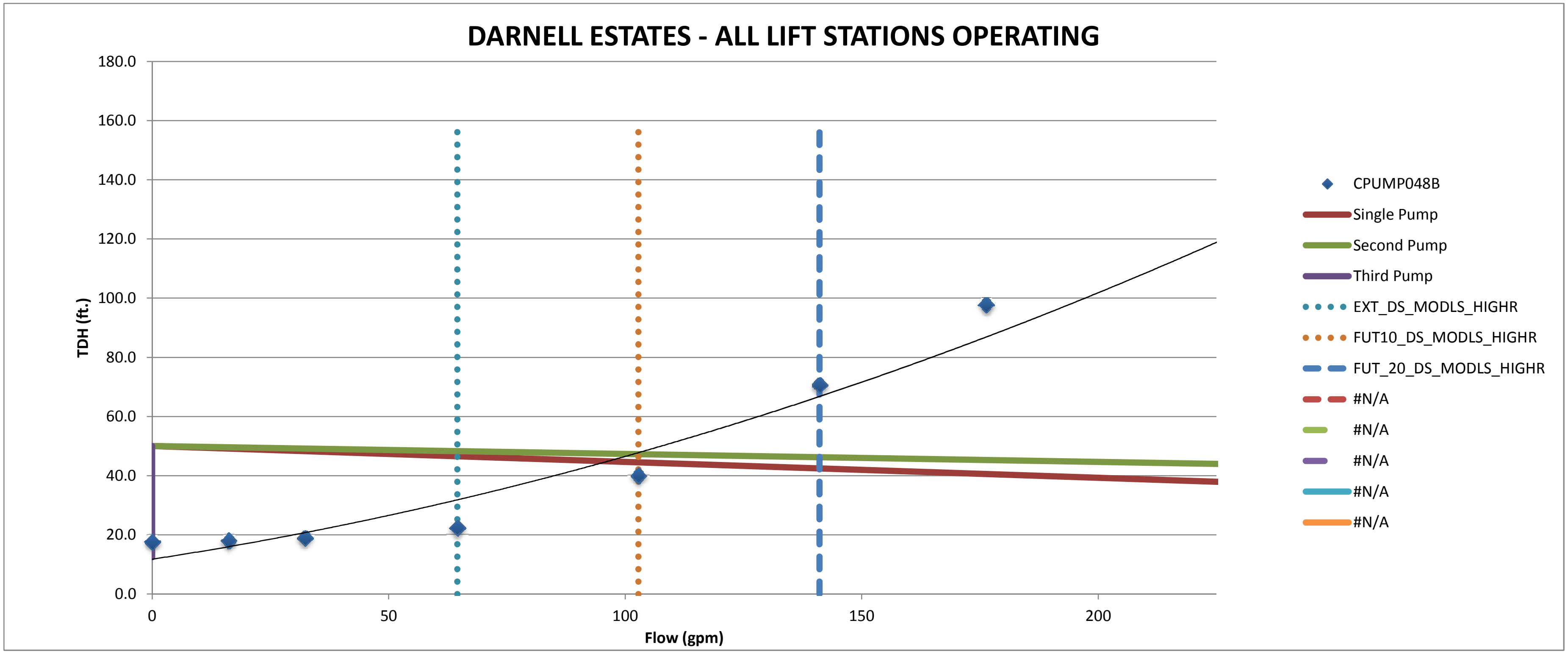

WIDGI CREEK - SINGLE LIFT STATION OPERATING
TDH (ft.)
180
160
140
120
100
80
60
40
20
0
0
50
100
150
200
Flow (gpm)
CPUMP071B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A


WYNDEMERE - SINGLE LIFT STATION OPERATING
200.0
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
TDH (ft.)
0
50
100
150
200
250
300
Flow (gpm)
CPUMP019C
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

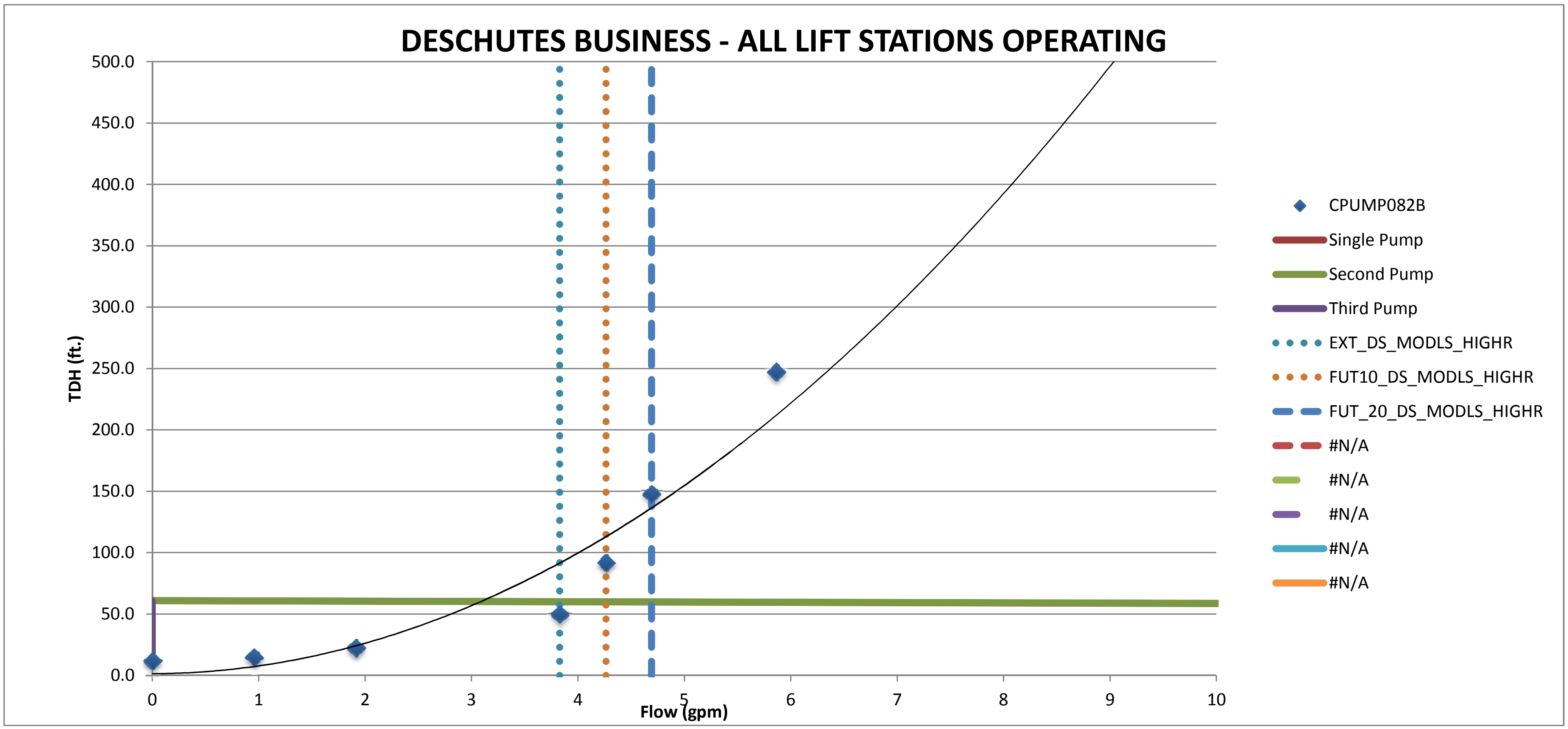

ASPEN RIDGE - ALL LIFT STATIONS OPERATING
TDH (ft.)
1400
1200
1000
800
600
400
200
0
0
50
100
150
200
250
300
350
400
Flow (gpm)
CPUMP067B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

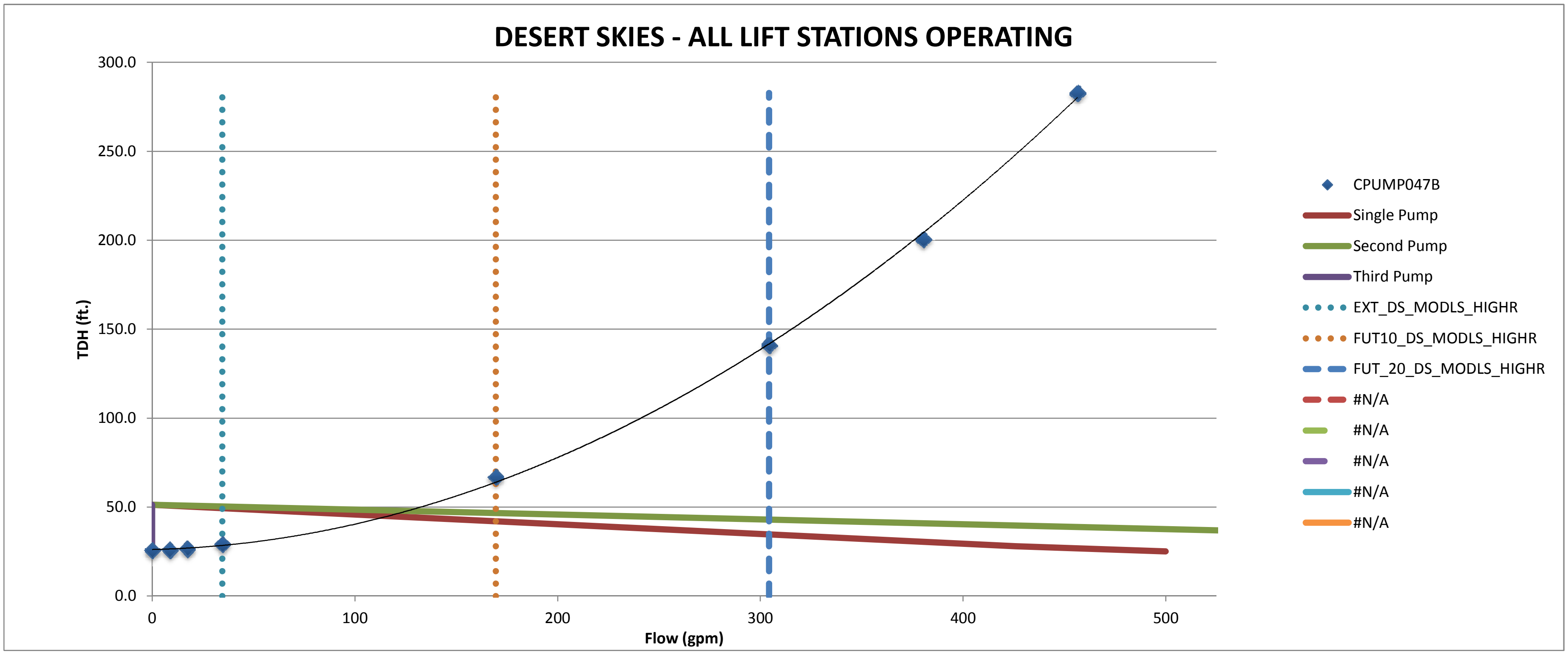

CAMDEN - ALL LIFT STATIONS OPERATING
TDH (ft.)
Flow (gpm)
1000.0
800.0
600.0
400.0
200.0
0.0
-200.0
0
2
4
6
8
10
12
14
16
18
20
CPUMP055B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A


CANAL VIEW - ALL LIFT STATIONS OPERATING
300.0
250.0
200.0
150.0
100.0
50.0
0.0
TDH (ft.)
0
50
100
150
200
Flow (gpm)
CPUMP037B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

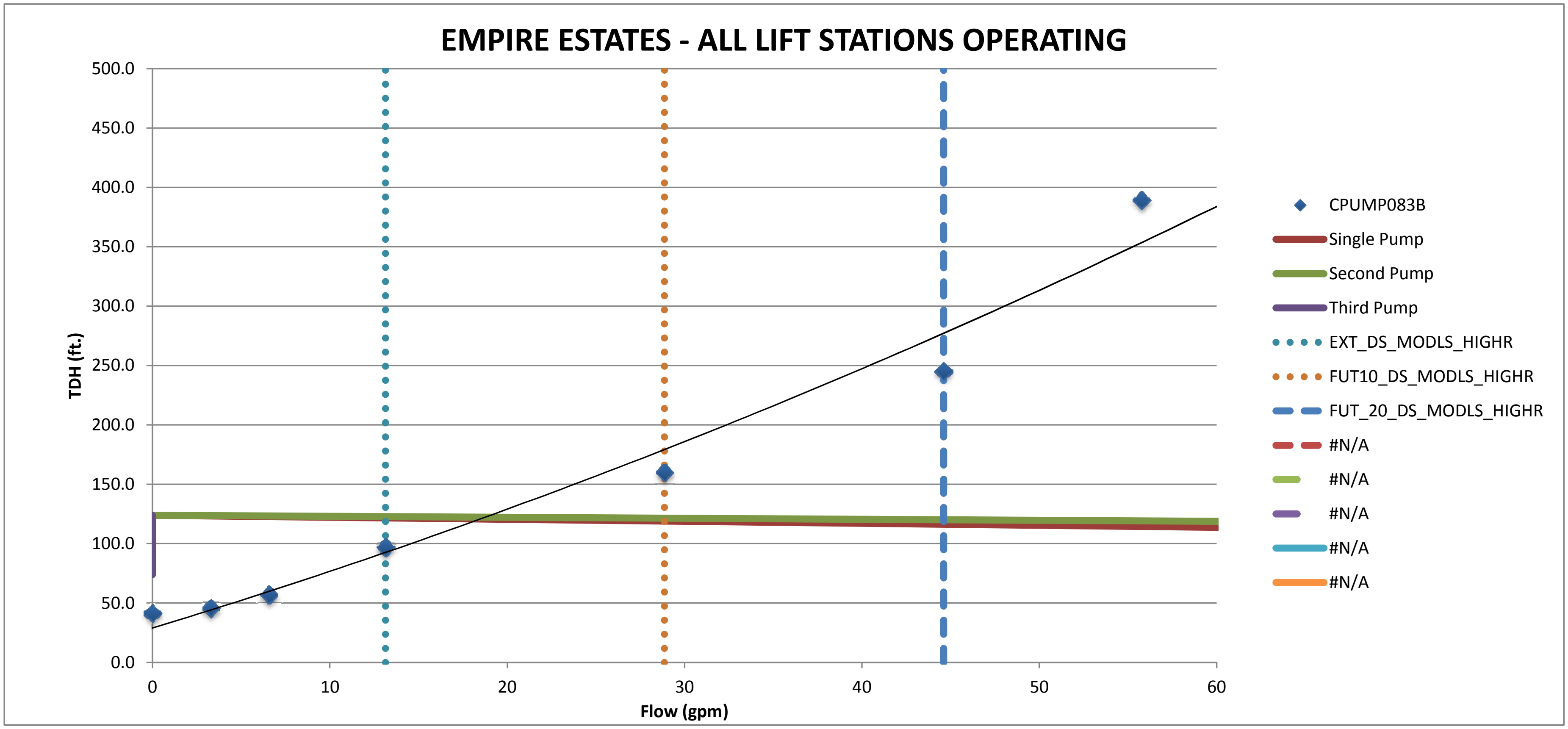


DARNELL ESTATES - ALL LIFT STATIONS OPERATING
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
TDH (ft.)
0
50
100
150
200
Flow (gpm)
CPUMP048B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

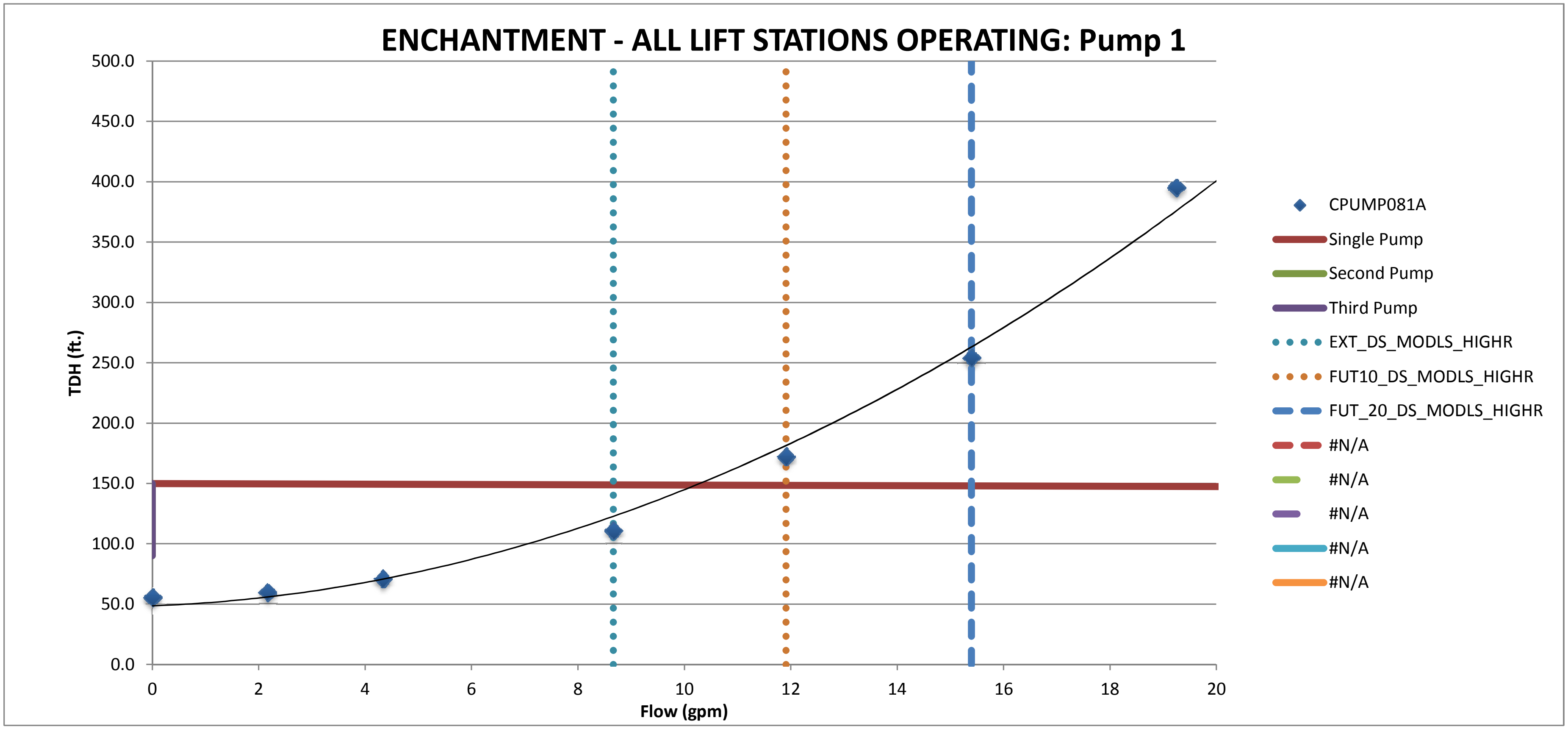

DESCHUTES BUSINESS - ALL LIFT STATIONS OPERATING
TDH (ft.)
500.0
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0
1
2
3
4
5
6
7
8
9
10
Flow (gpm)
CPUMP082B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

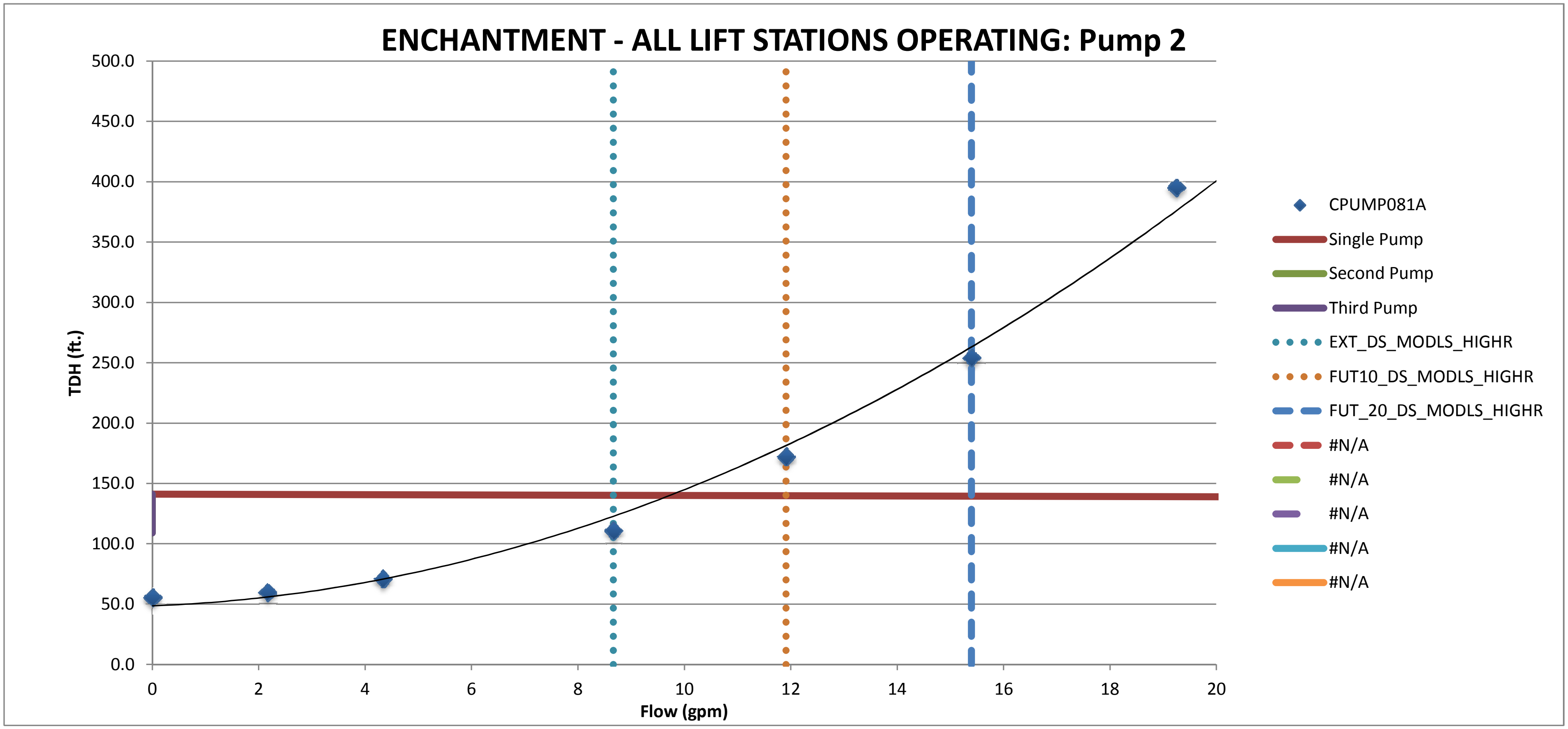


DESERT SKIES - ALL LIFT STATIONS OPERATING
TDH (ft.)
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0
100
200
300
400
500
Flow (gpm)
CPUMP047B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

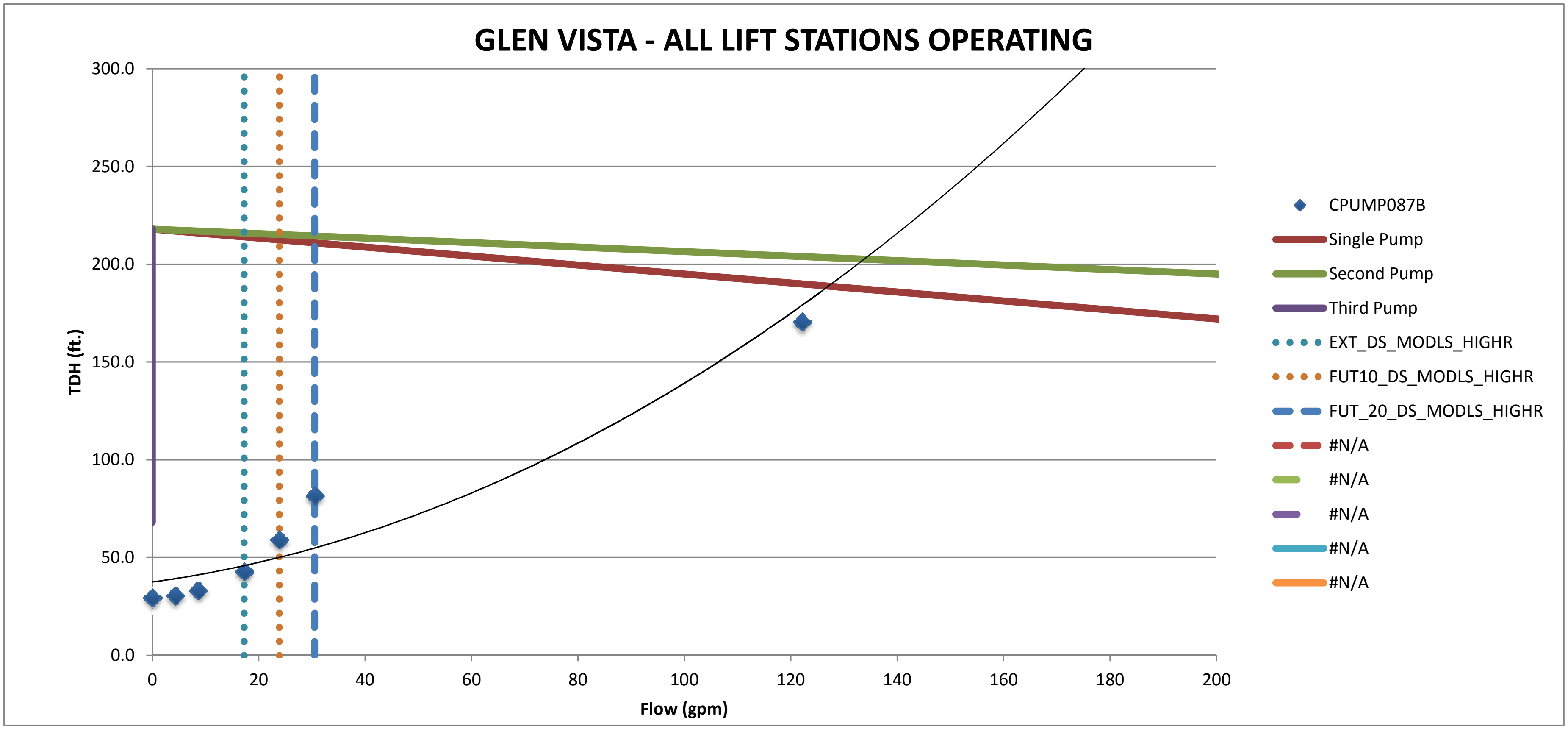


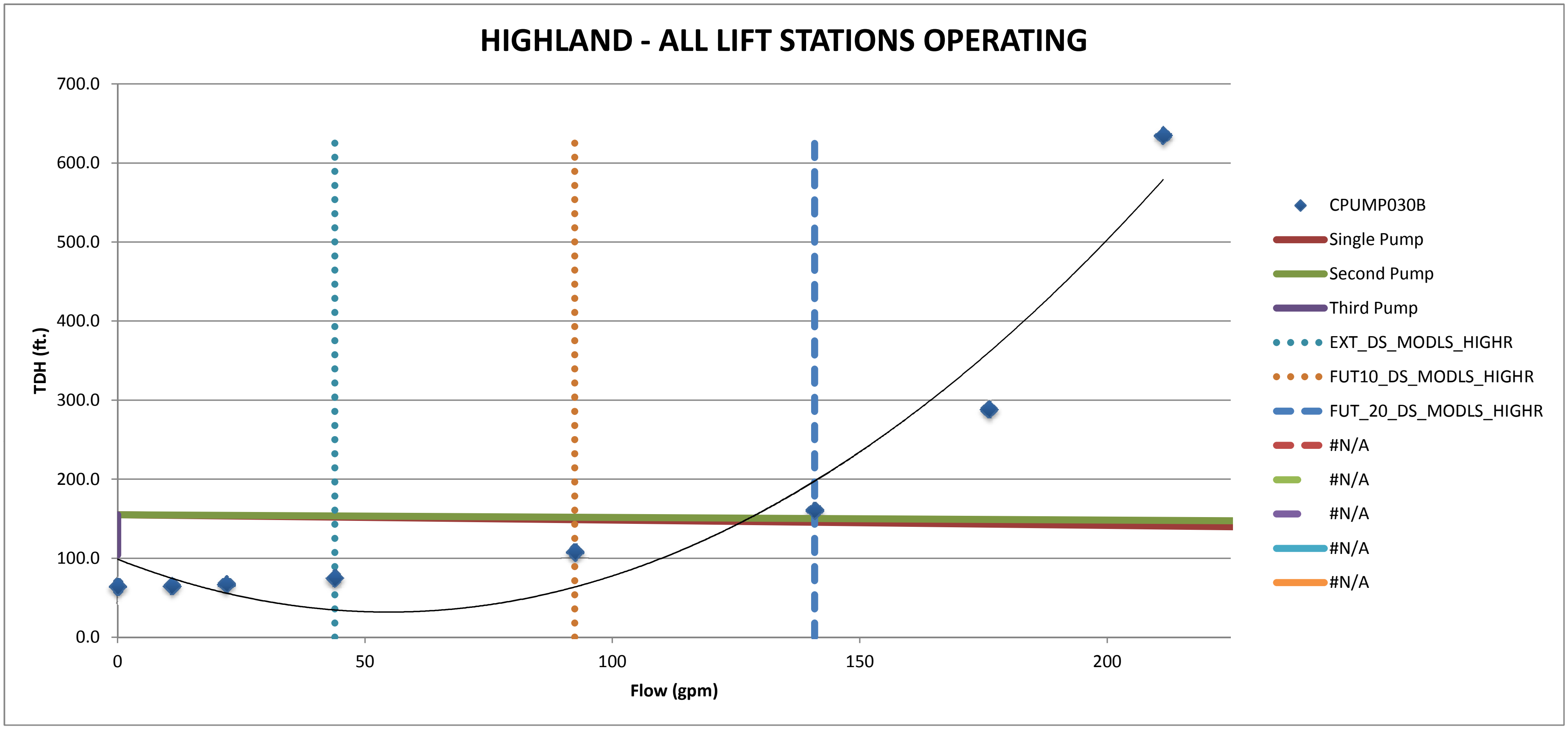
EMPIRE ESTATES - ALL LIFT STATIONS OPERATING
TDH (ft.)
500.0
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0
10
20
30
40
50
60
Flow (gpm)
CPUMP083B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A


ENCHANTMENT - ALL LIFT STATIONS OPERATING: Pump 1
TDH (ft.)
500.0
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0
2
4
6
8
10
12
14
16
18
20
Flow (gpm)
CPUMP081A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

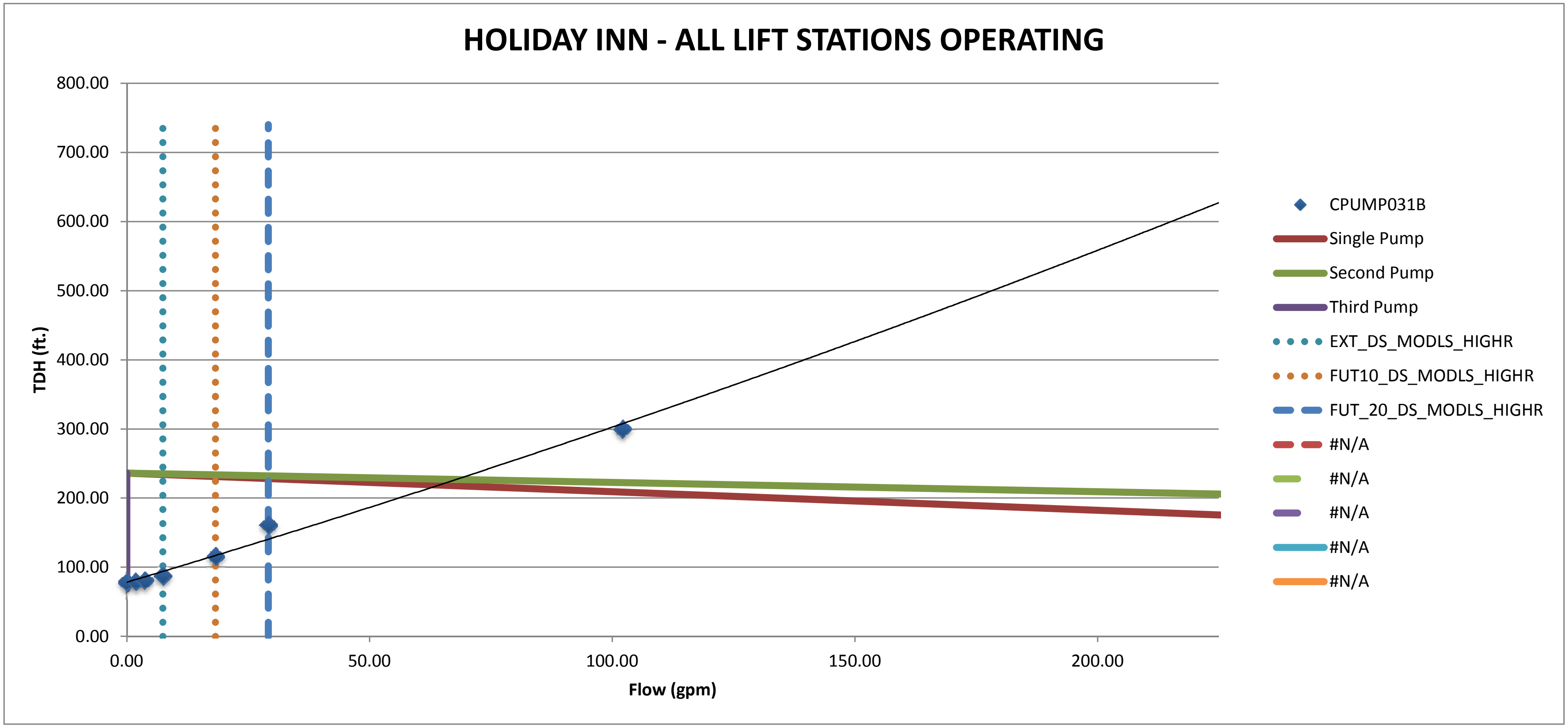


ENCHANTMENT - ALL LIFT STATIONS OPERATING: Pump 2
TDH (ft.)
500.0
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0
2
4
6
8
10
12
14
16
18
20
Flow (gpm)
CPUMP081A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

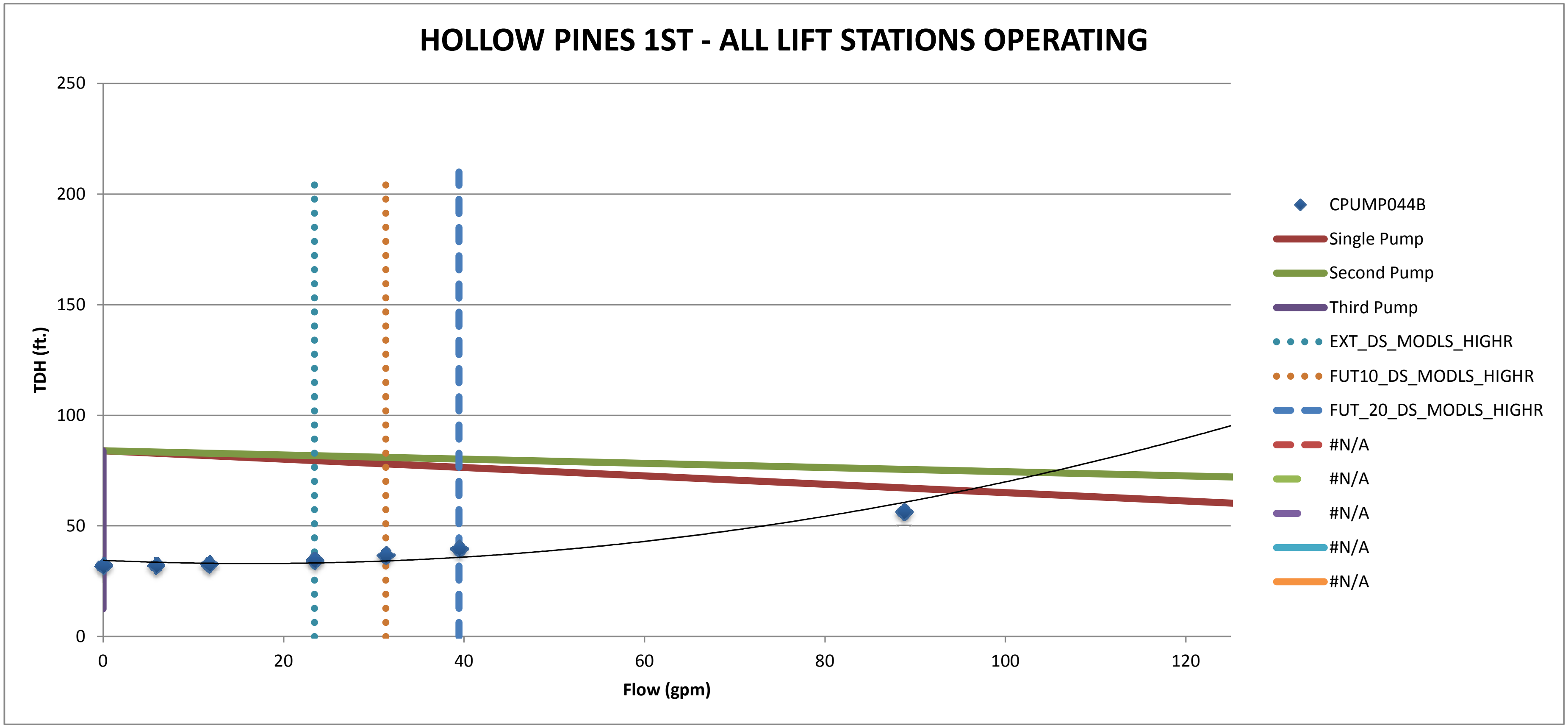

GLEN VISTA - ALL LIFT STATIONS OPERATING
300.0
250.0
200.0
150.0
100.0
50.0
0.0
TDH (ft.)
0
20
40
60
80
100
120
140
160
180
200
Flow (gpm)
CPUMP087B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

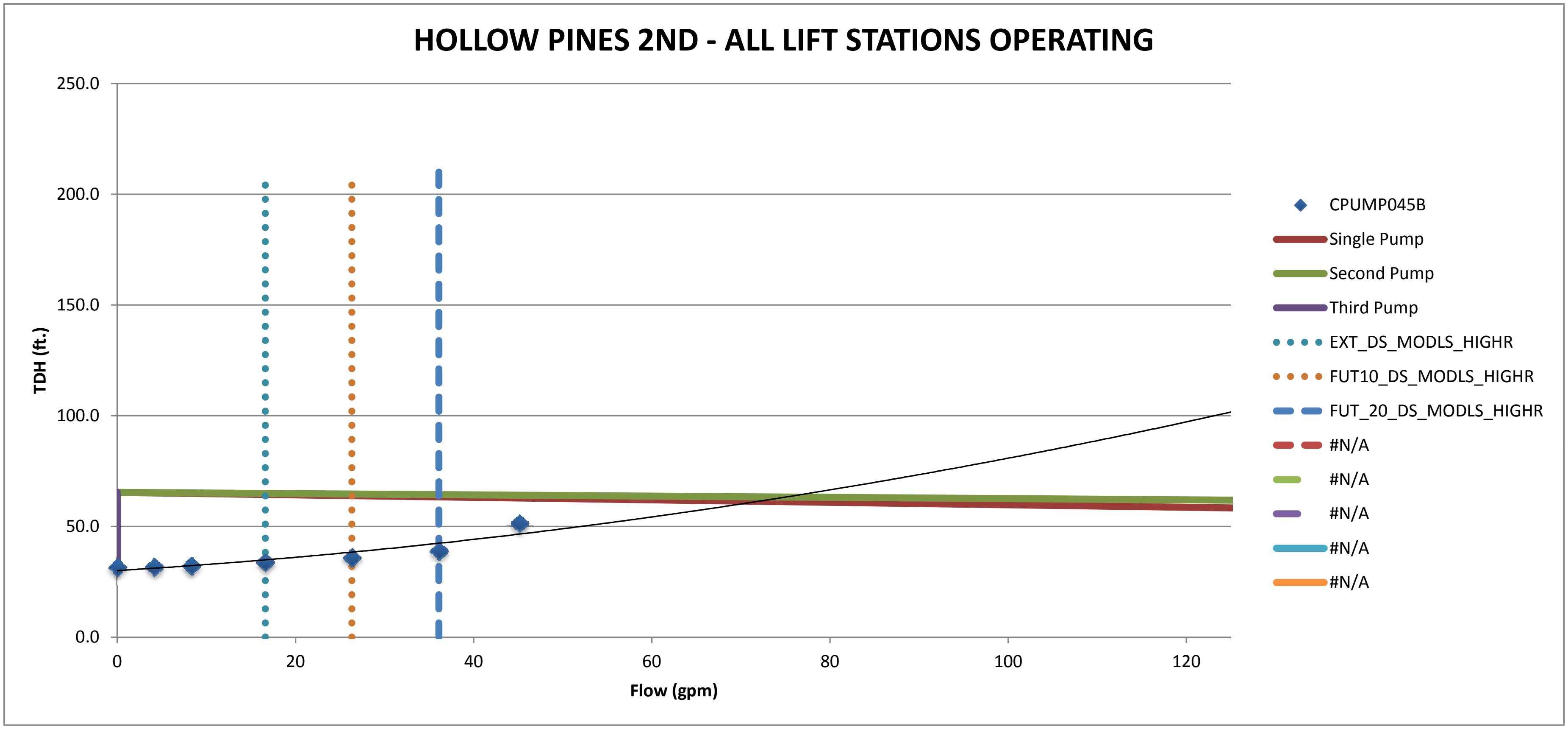


HIGHLAND - ALL LIFT STATIONS OPERATING
TDH (ft.)
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
0
50
100
150
200
Flow (gpm)
CPUMP030B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

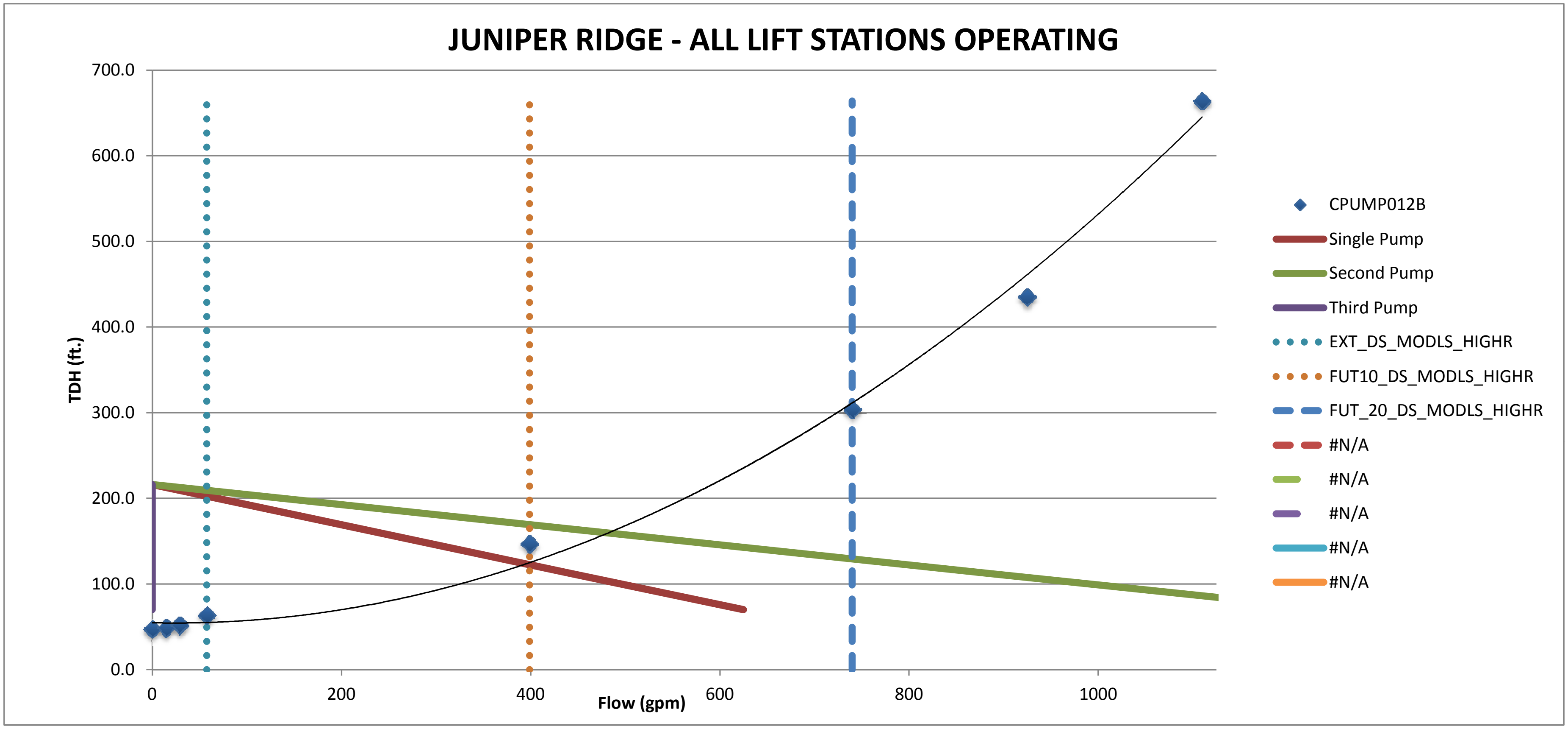


HOLIDAY INN - ALL LIFT STATIONS OPERATING
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
TDH (ft.)
0.00
50.00
100.00
150.00
200.00
Flow (gpm)
CPUMP031B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

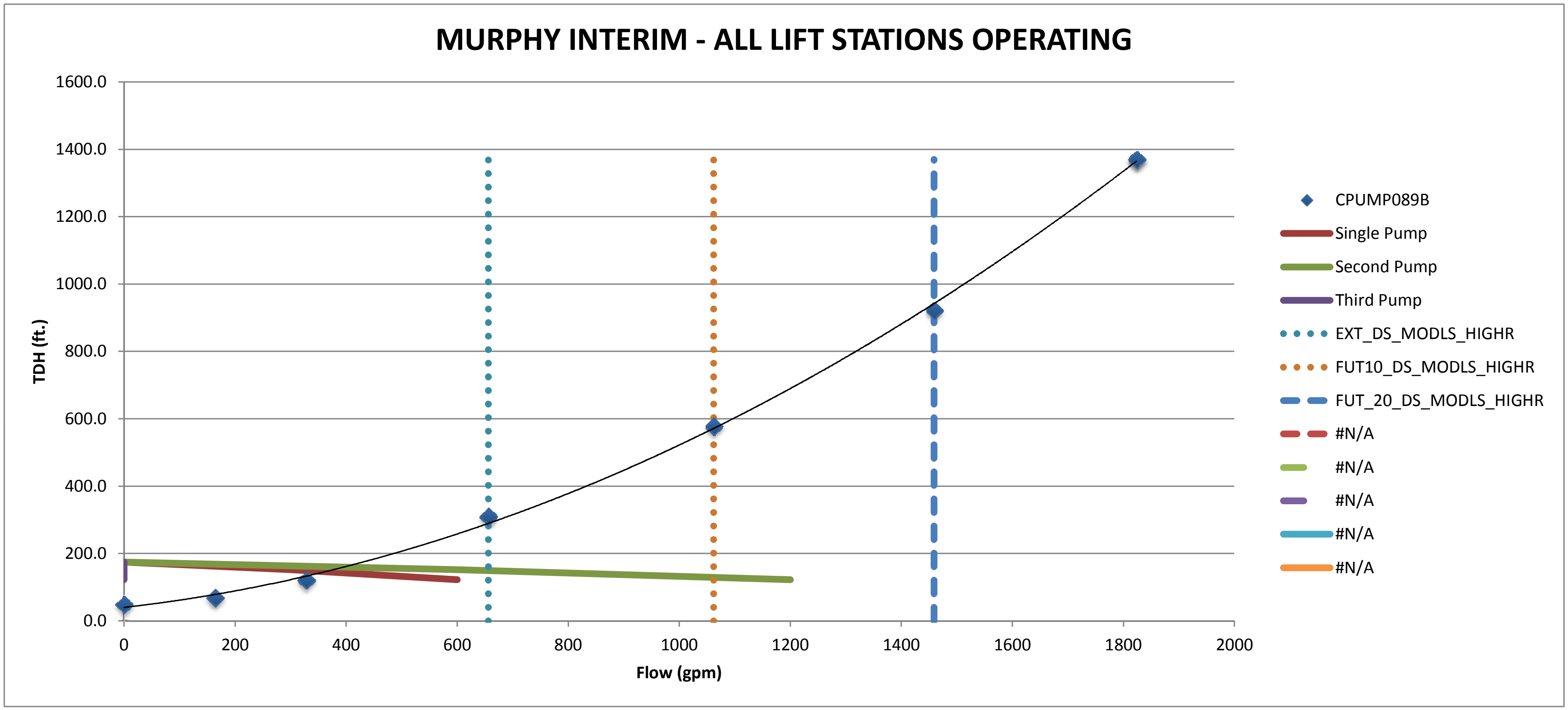

HOLLOW PINES 1ST - ALL LIFT STATIONS OPERATING
TDH (ft.)
250
200
150
100
50
0
0
20
40
60
80
100
120
Flow (gpm)
CPUMP044B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A



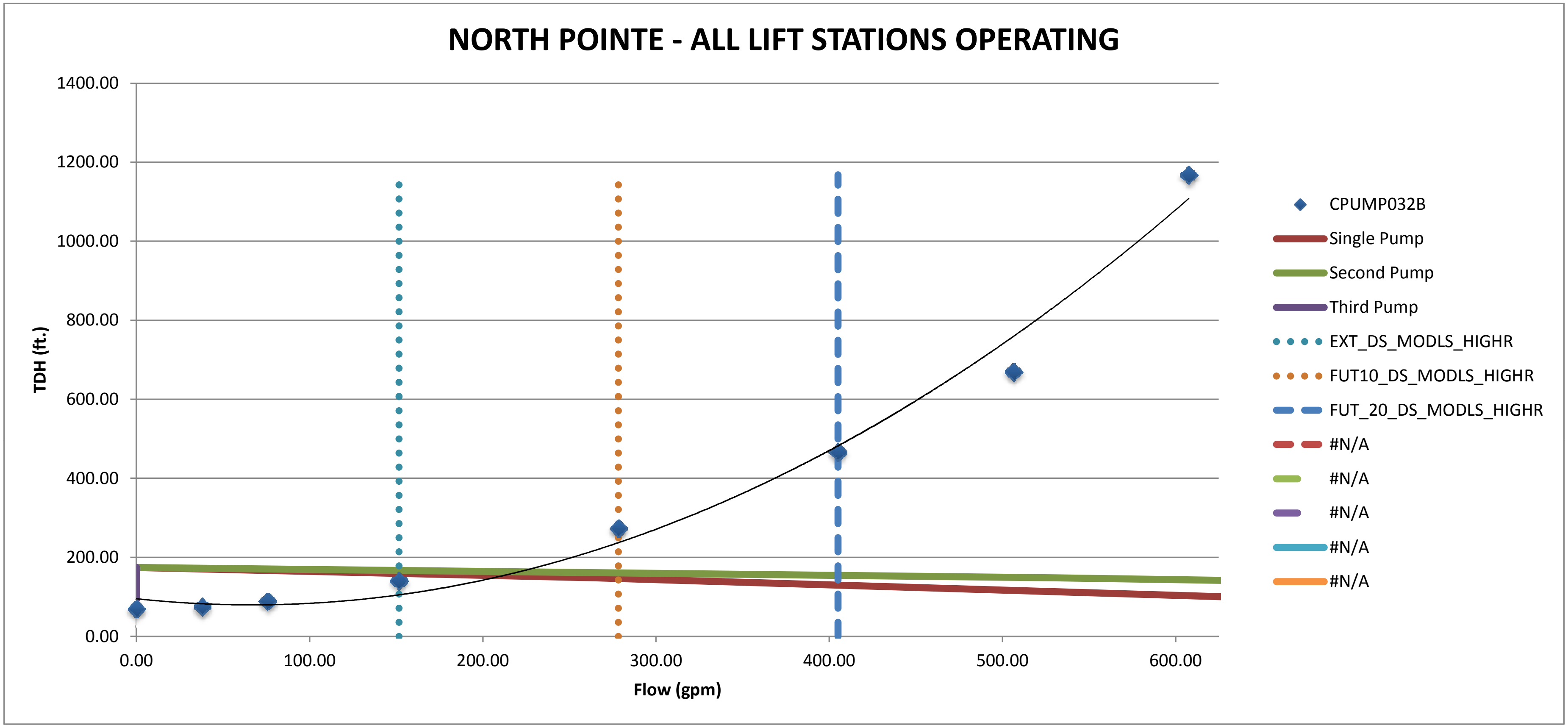
HOLLOW PINES 2ND - ALL LIFT STATIONS OPERATING
250.0
200.0
150.0
100.0
50.0
0.0
TDH (ft.)
0
20
40
60
80
100
120
Flow (gpm)
CPUMP045B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

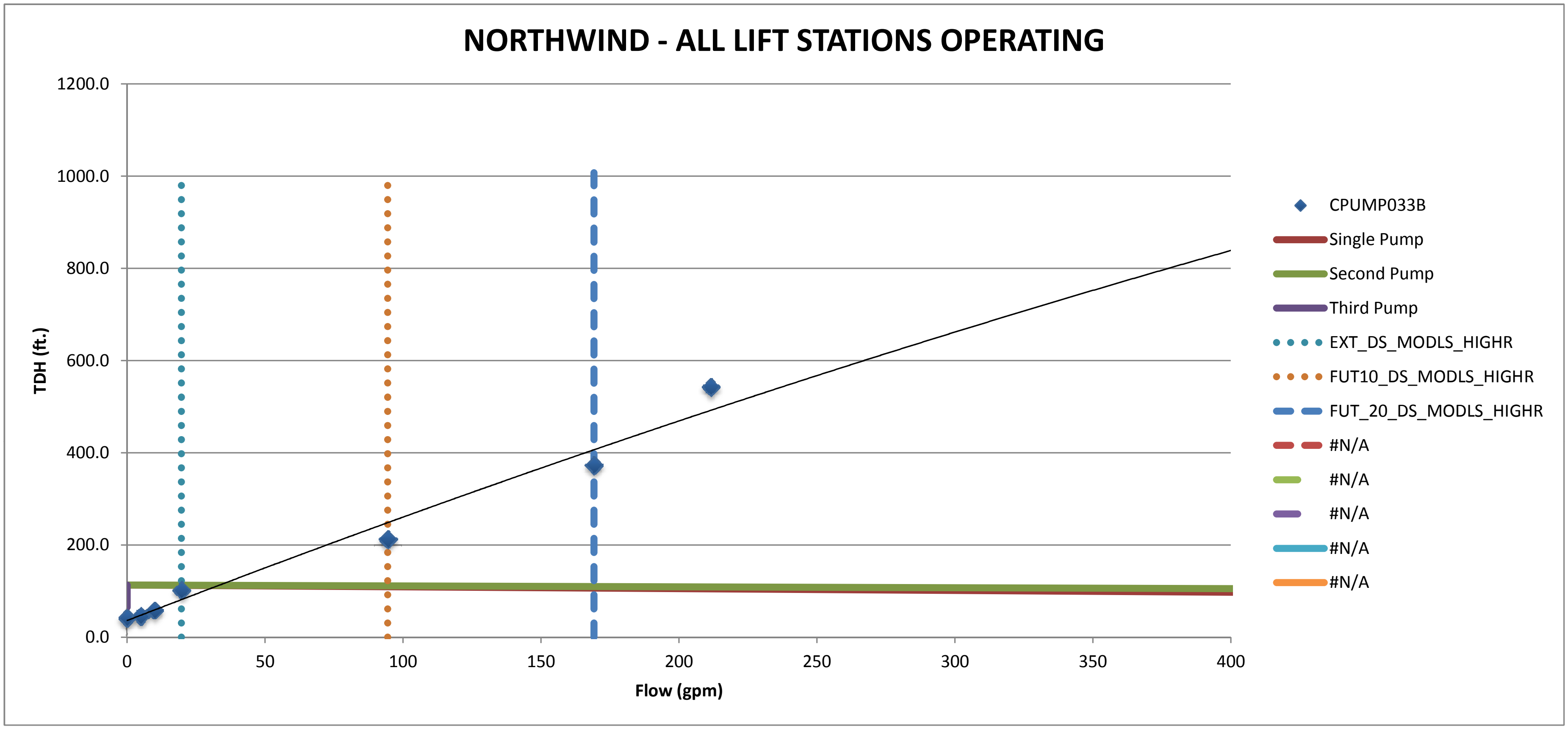


JUNIPER RIDGE - ALL LIFT STATIONS OPERATING
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
TDH (ft.)
0
200
400
600
800
1000
Flow (gpm)
CPUMP012B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

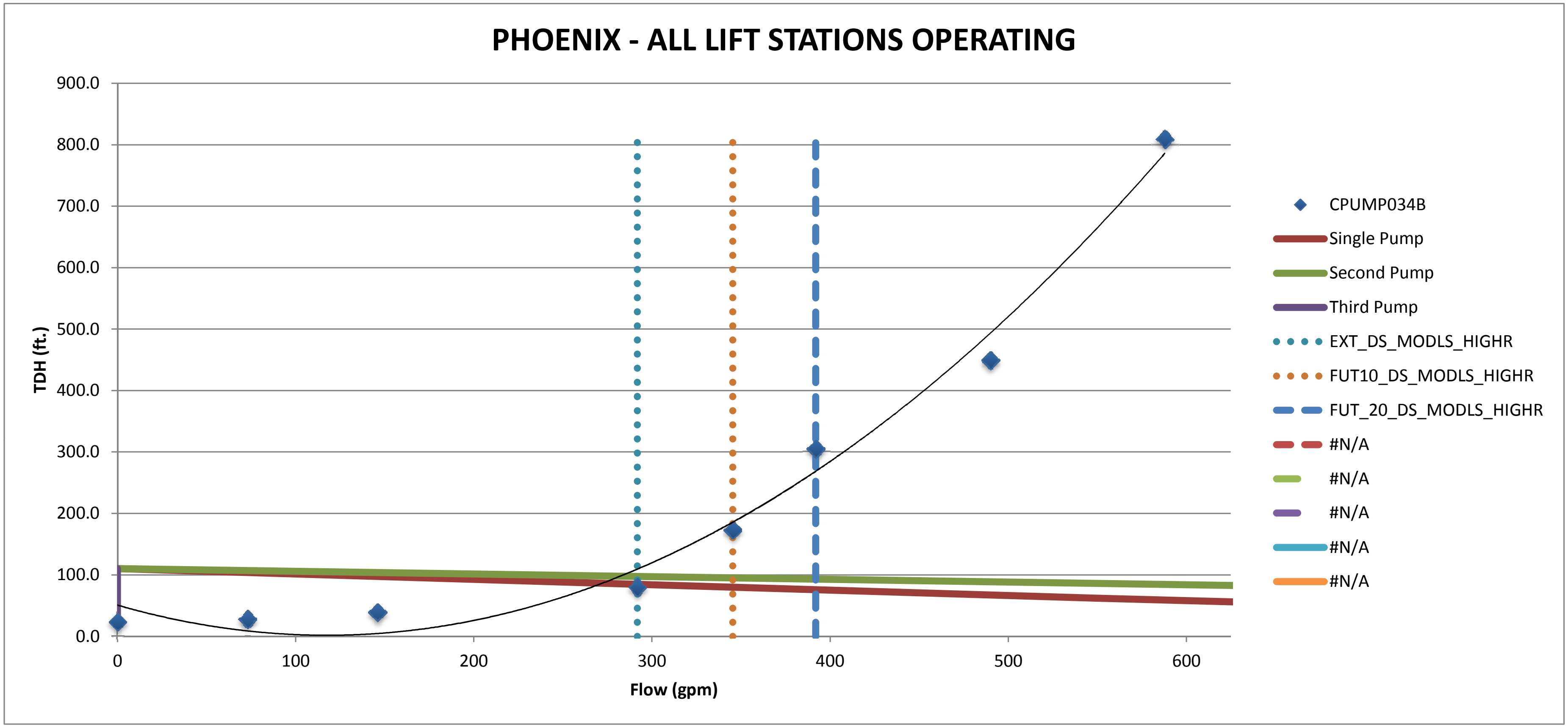


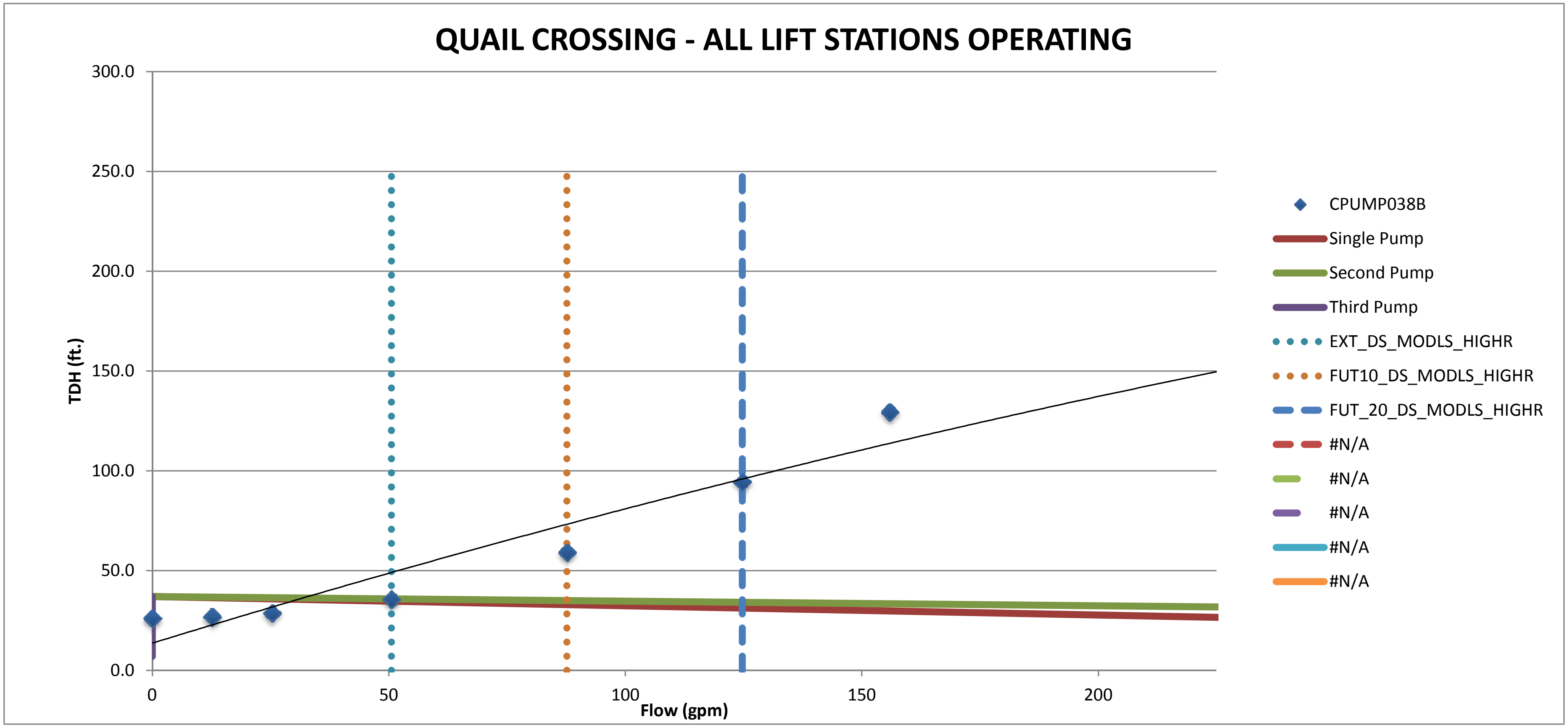
MURPHY INTERIM - ALL LIFT STATIONS OPERATING
1600.0
1400.0
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
TDH (ft.)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Flow (gpm)
CPUMP089B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A


NORTH POINTE - ALL LIFT STATIONS OPERATING
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
TDH (ft.)
0.00
100.00
200.00
300.00
400.00
500.00
600.00
Flow (gpm)
CPUMP032B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

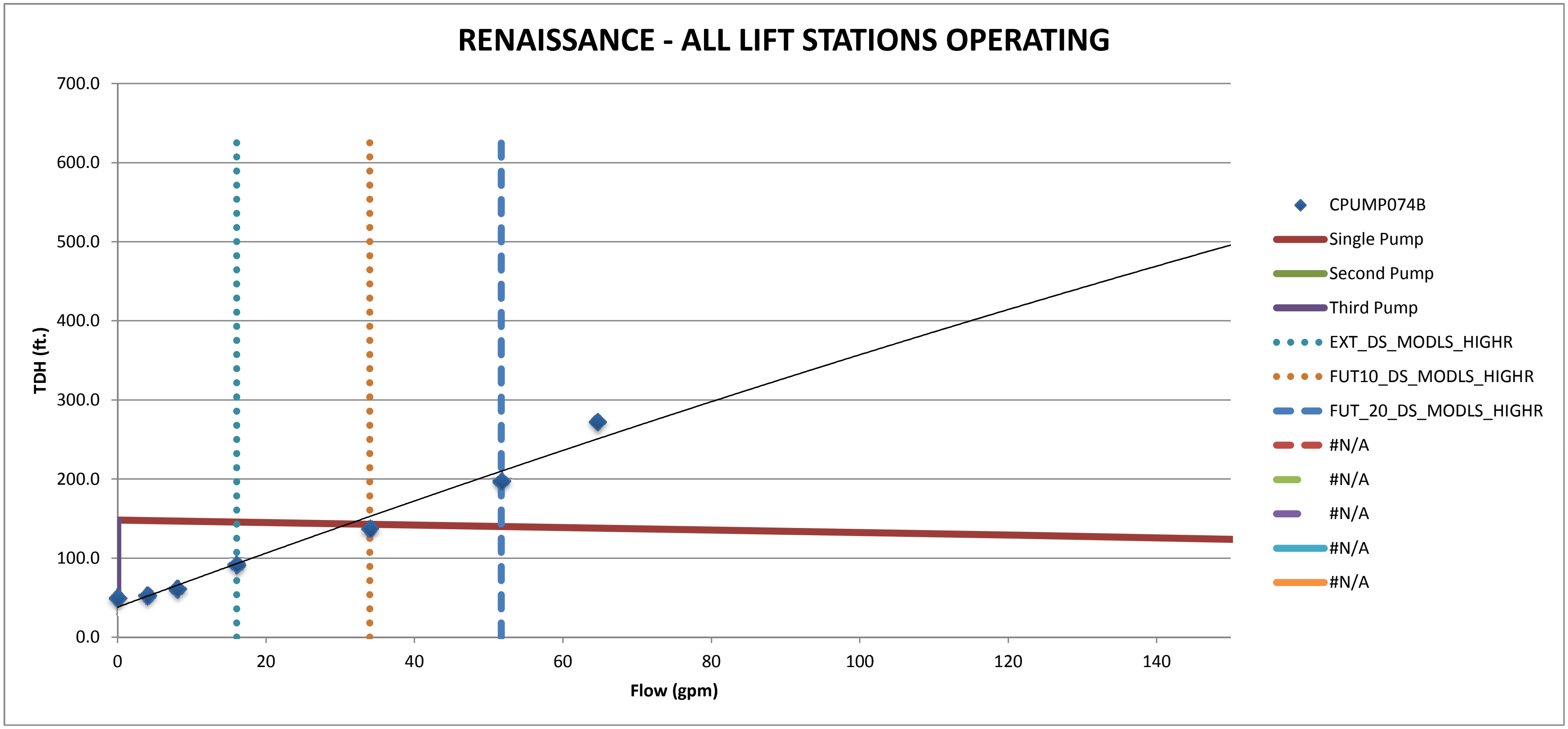


NORTHWIND - ALL LIFT STATIONS OPERATING
TDH (ft.)
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
0
50
100
150
200
250
300
350
400
Flow (gpm)
CPUMP033B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

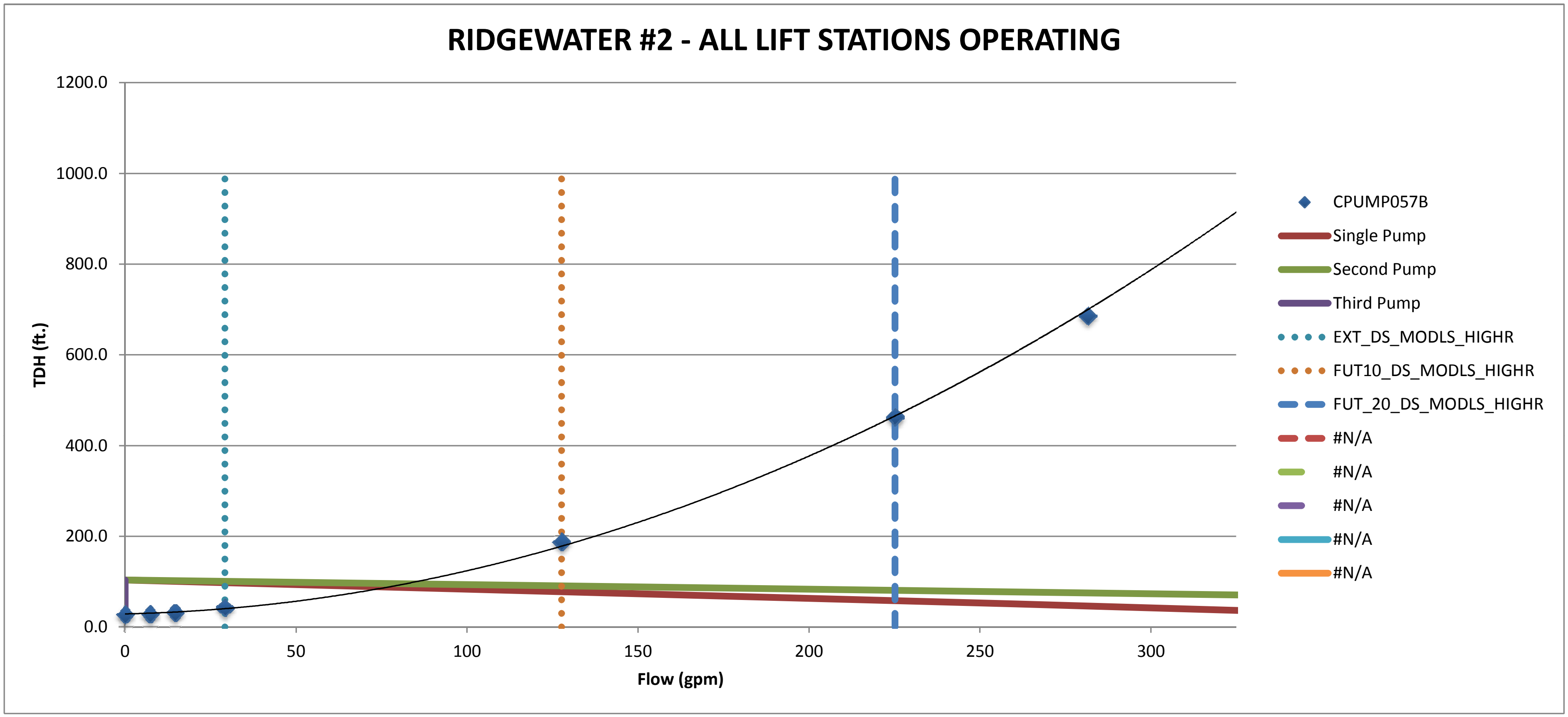

PHOENIX - ALL LIFT STATIONS OPERATING
900.0
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
TDH (ft.)
0
100
200
300
400
500
600
Flow (gpm)
CPUMP034B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

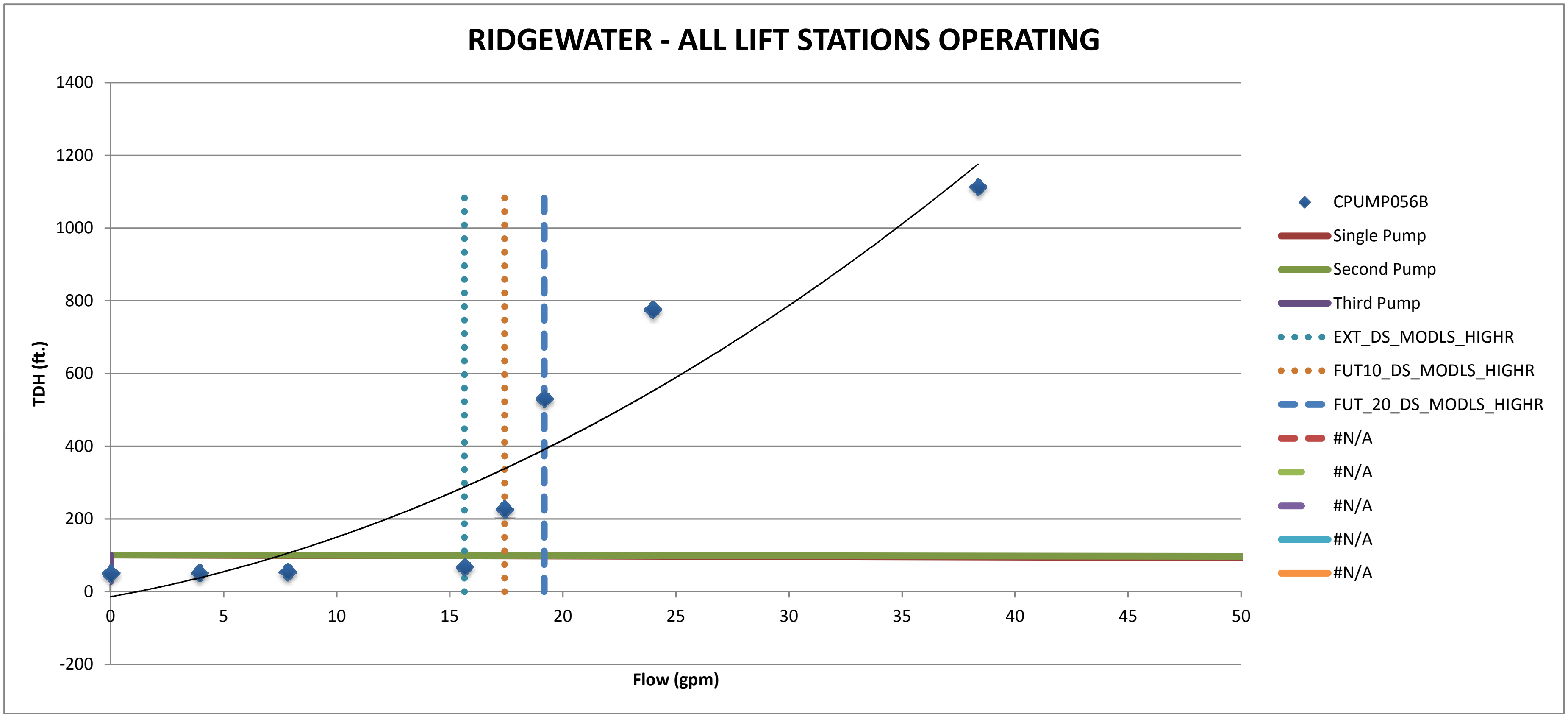


QUAIL CROSSING - ALL LIFT STATIONS OPERATING
TDH (ft.)
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0
50
100
150
200
Flow (gpm)
CPUMP038B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

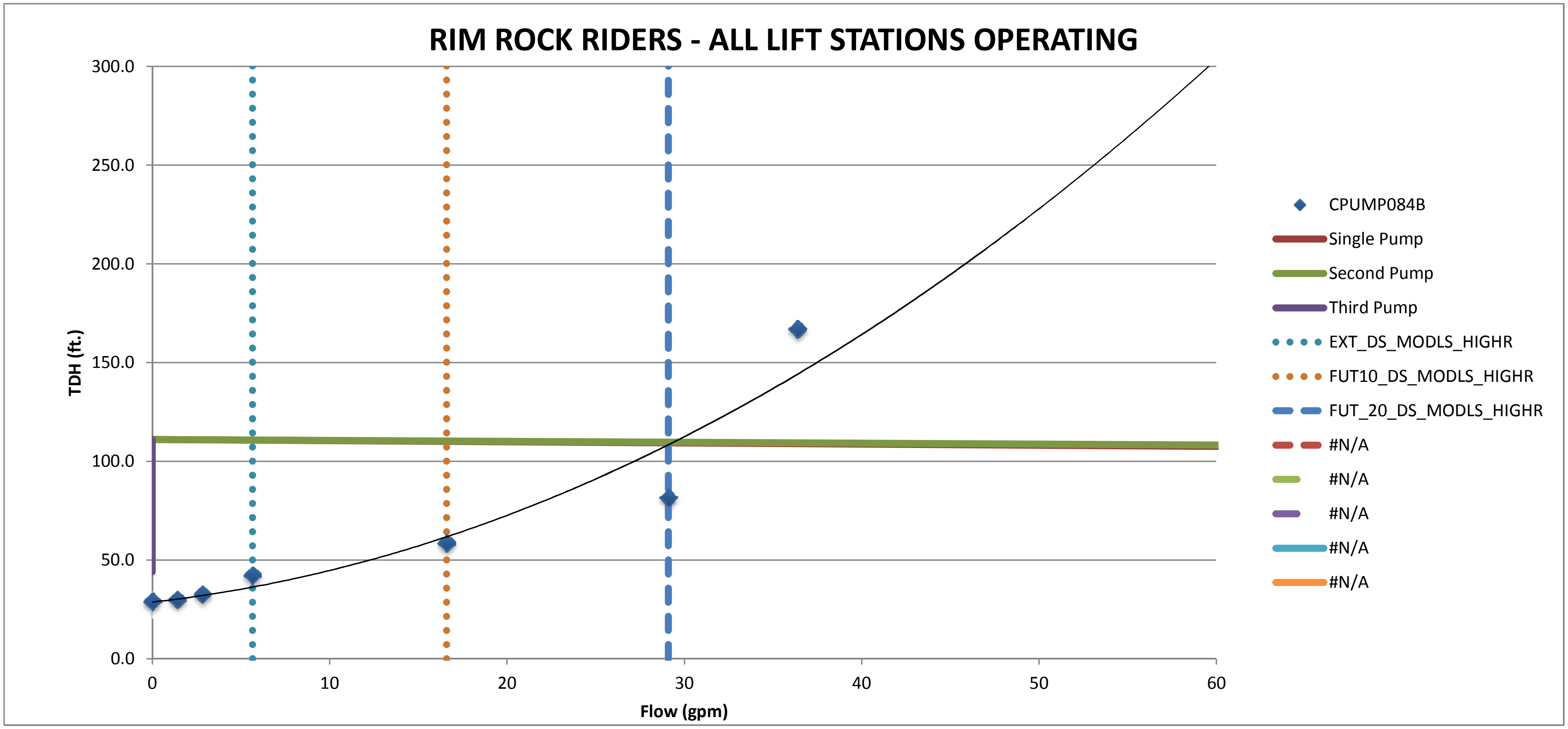


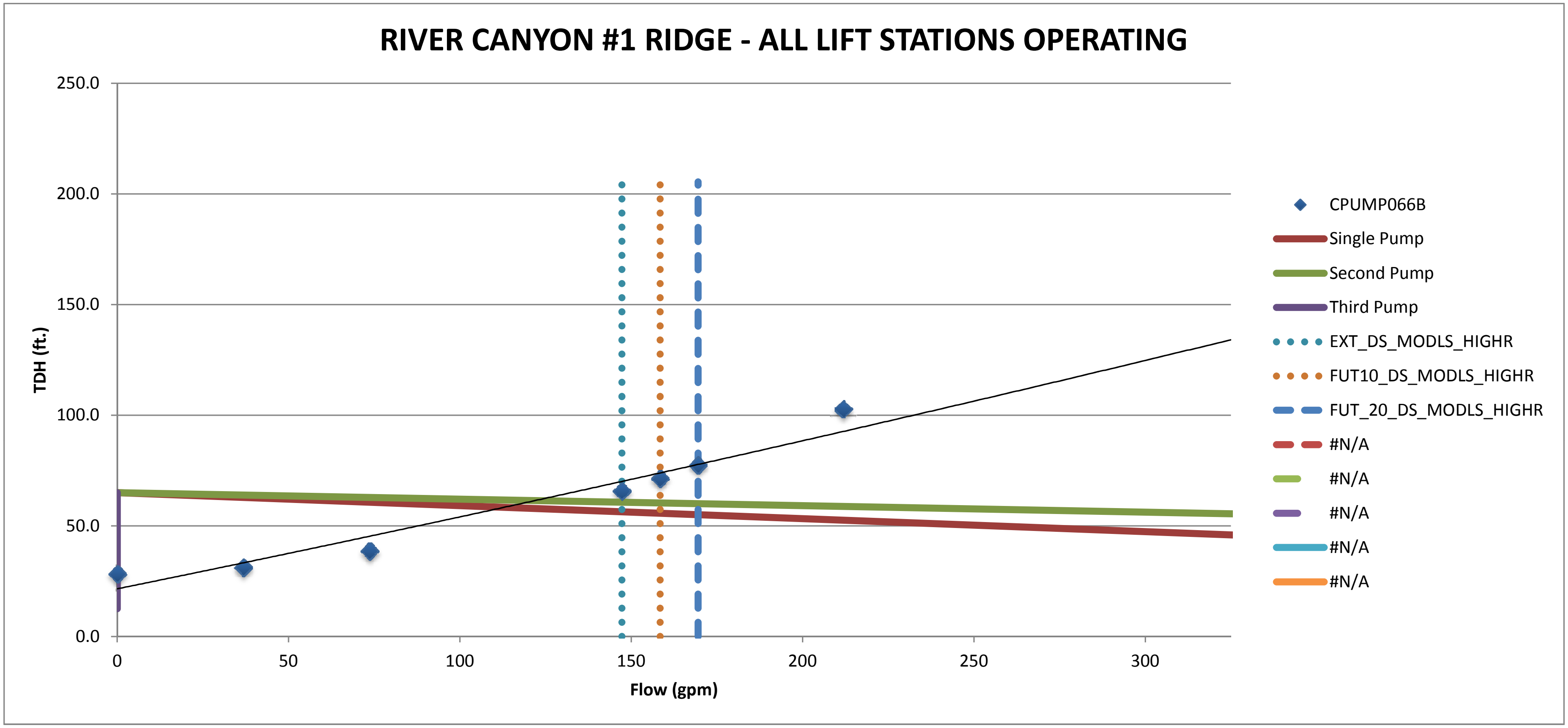
RENAISSANCE - ALL LIFT STATIONS OPERATING
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
TDH (ft.)
0
20
40
60
80
100
120
140
Flow (gpm)
CPUMP074B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A


RIDGEWATER #2 - ALL LIFT STATIONS OPERATING
TDH (ft.)
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
0
50
100
150
200
250
300
Flow (gpm)
CPUMP057B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

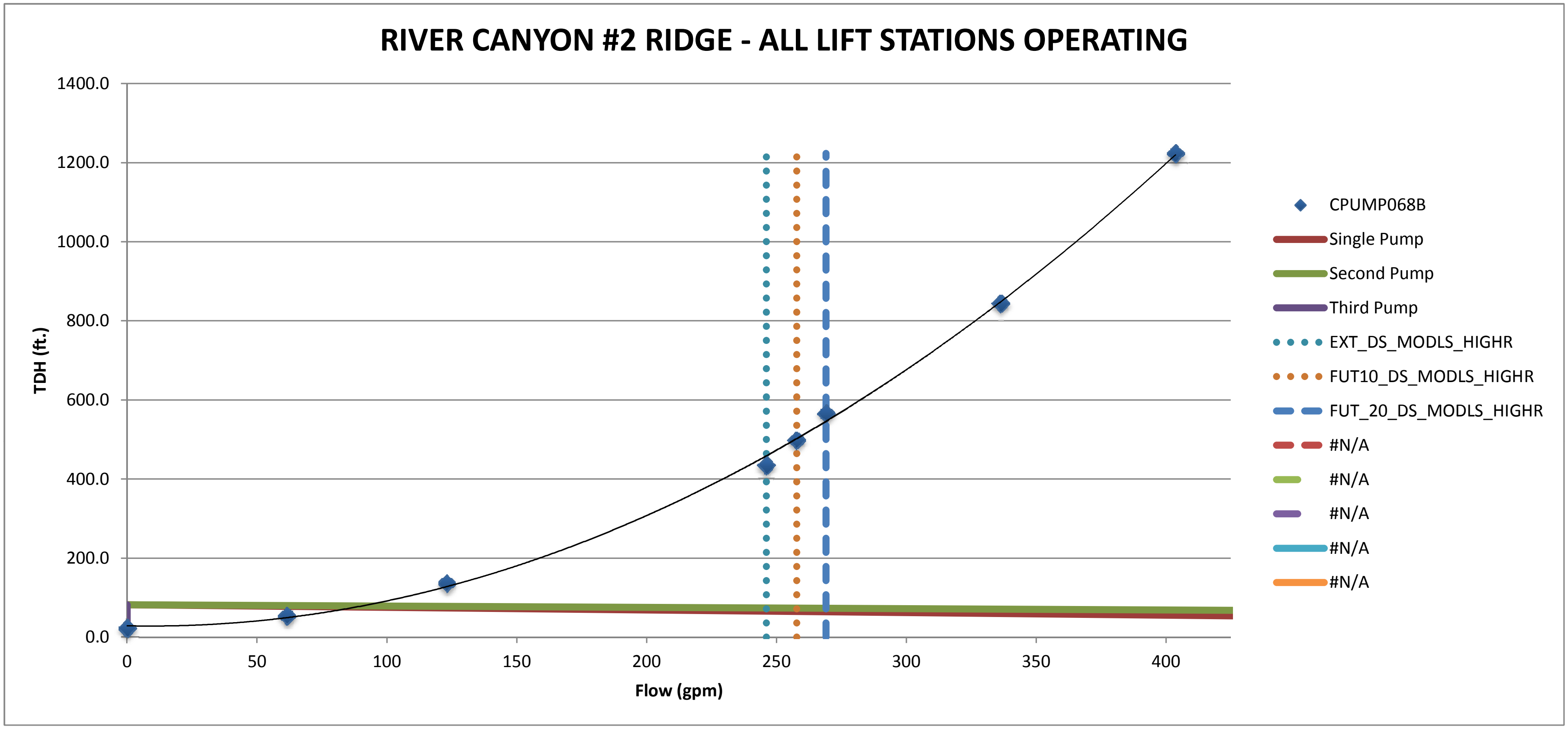


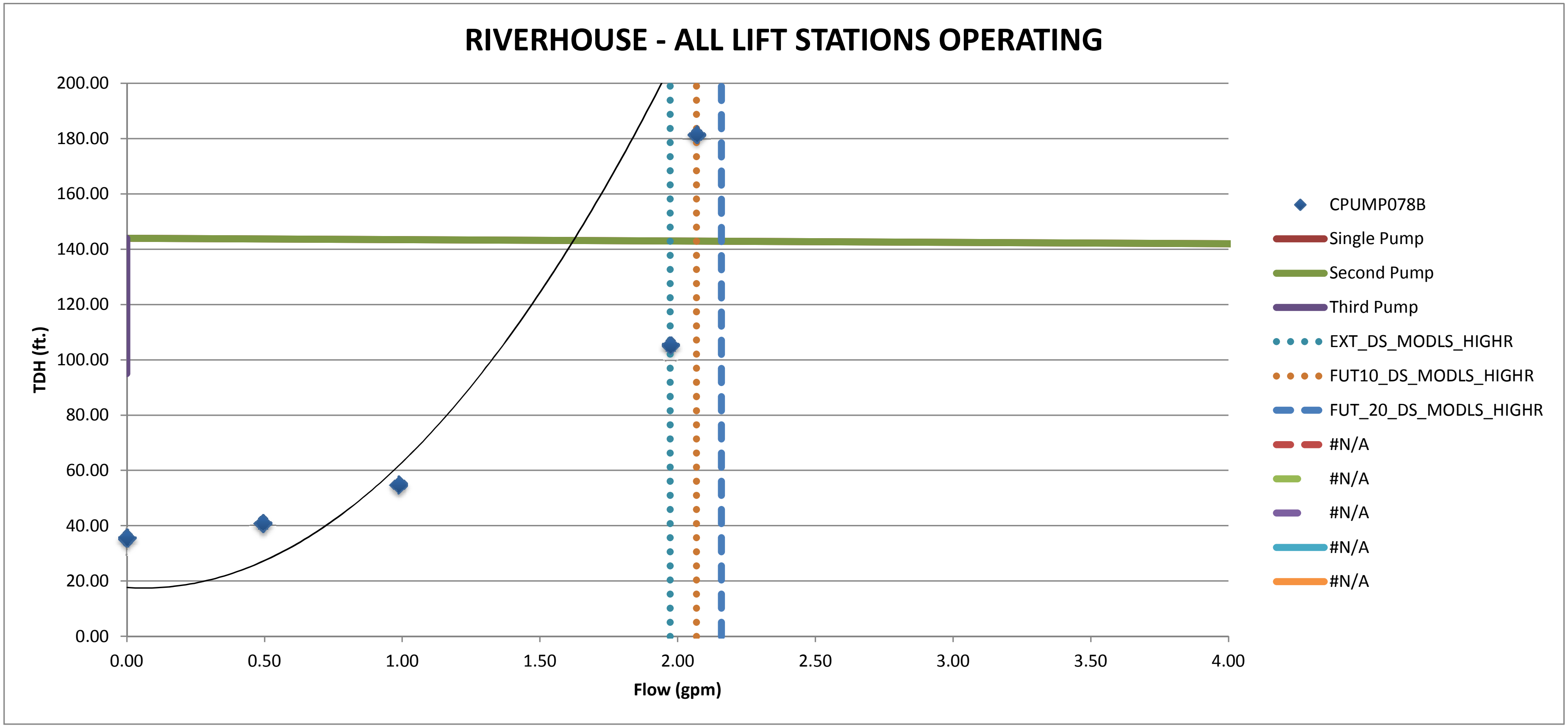
RIDGEWATER - ALL LIFT STATIONS OPERATING
1400
1200
1000
800
600
400
200
0
-200
TDH (ft.)
0
5
10
15
20
25
30
35
40
45
50
Flow (gpm)
CPUMP056B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A


RIM ROCK RIDERS - ALL LIFT STATIONS OPERATING
300.0
250.0
200.0
150.0
100.0
50.0
0.0
TDH (ft.)
0
10
20
30
40
50
60
Flow (gpm)
CPUMP084B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

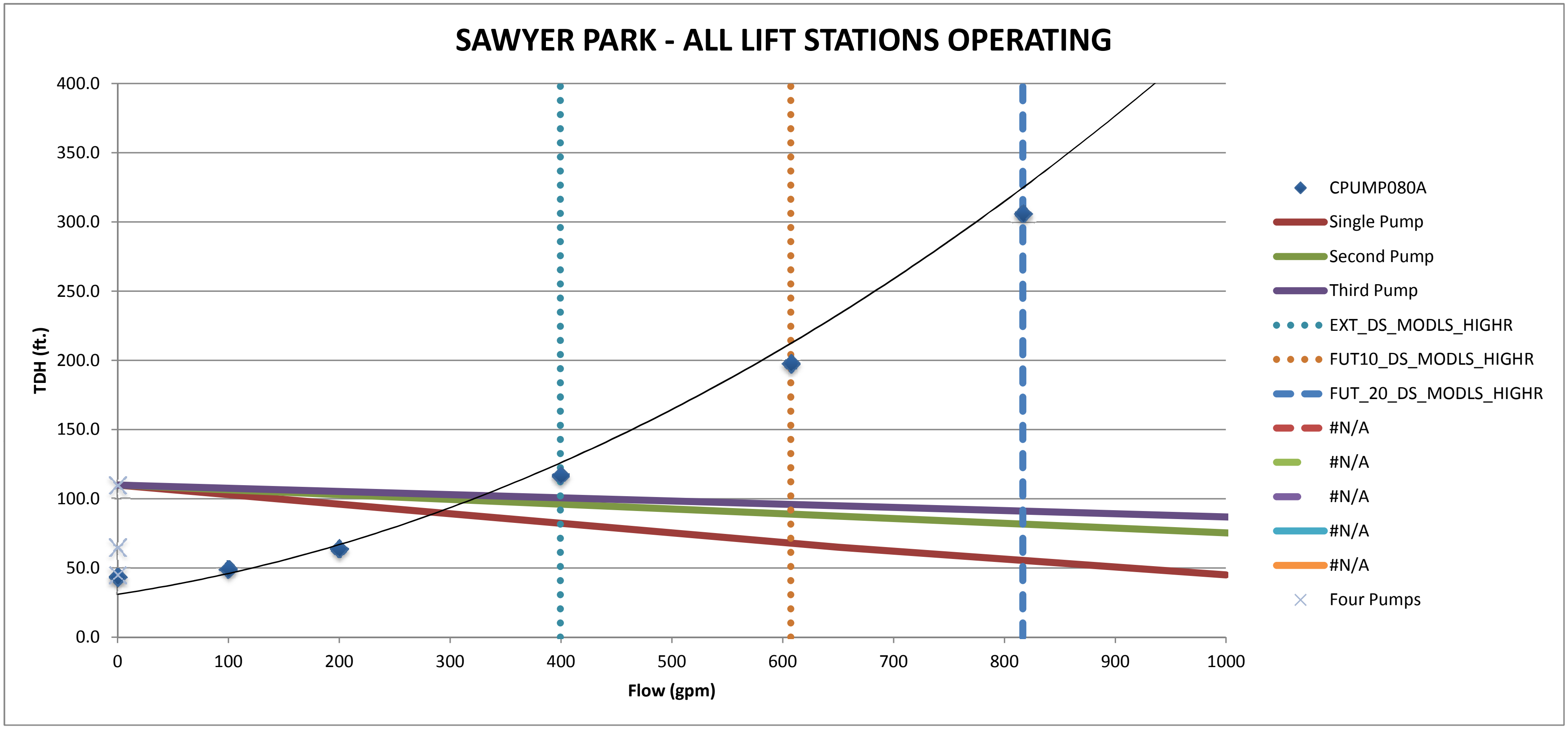


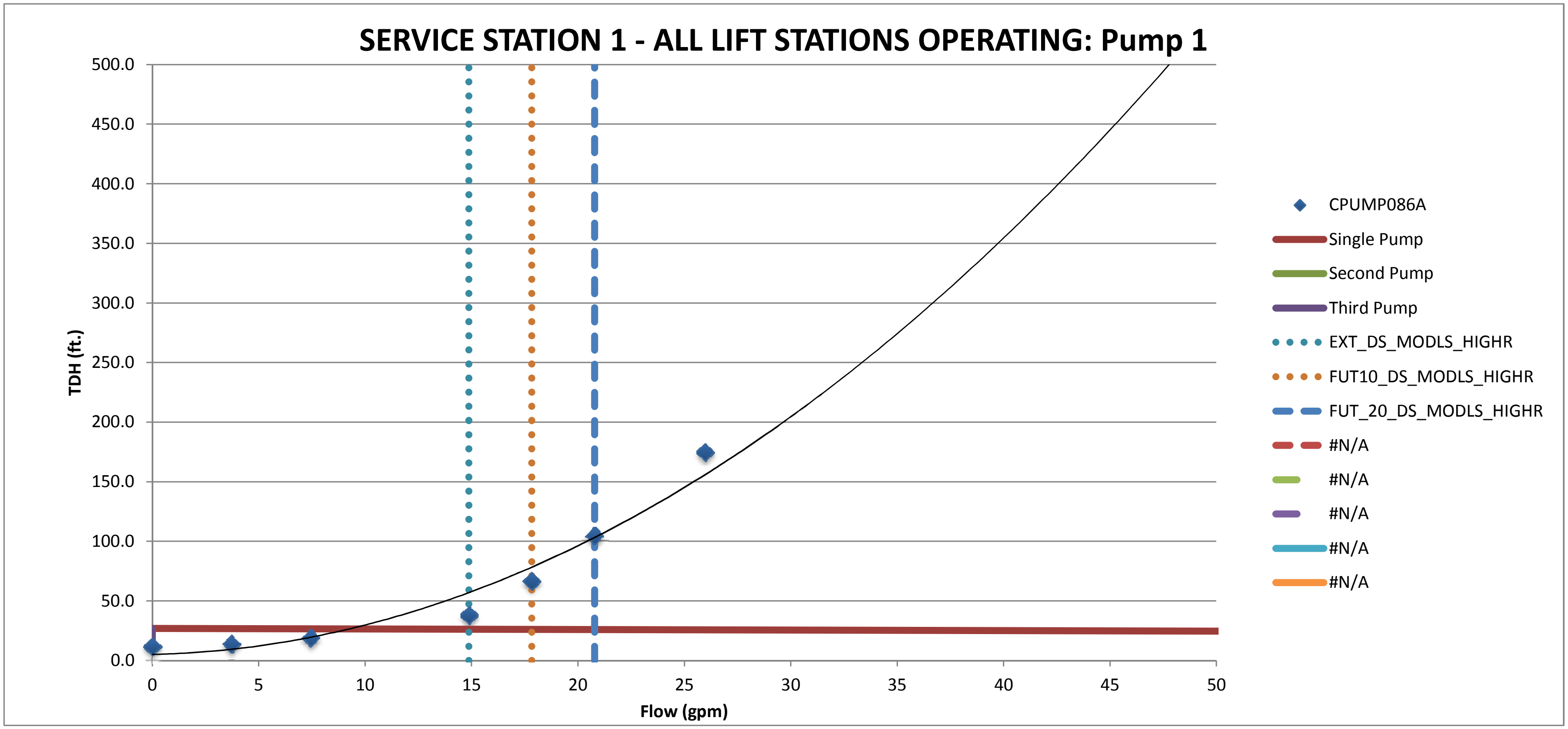
RIVER CANYON #1 RIDGE - ALL LIFT STATIONS OPERATING
TDH (ft.)
250.0
200.0
150.0
100.0
50.0
0.0
0
50
100
150
200
250
300
Flow (gpm)
CPUMP066B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A


RIVER CANYON #2 RIDGE - ALL LIFT STATIONS OPERATING
1400.0
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
TDH (ft.)
0
50
100
150
200
250
300
350
400
Flow (gpm)
CPUMP068B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

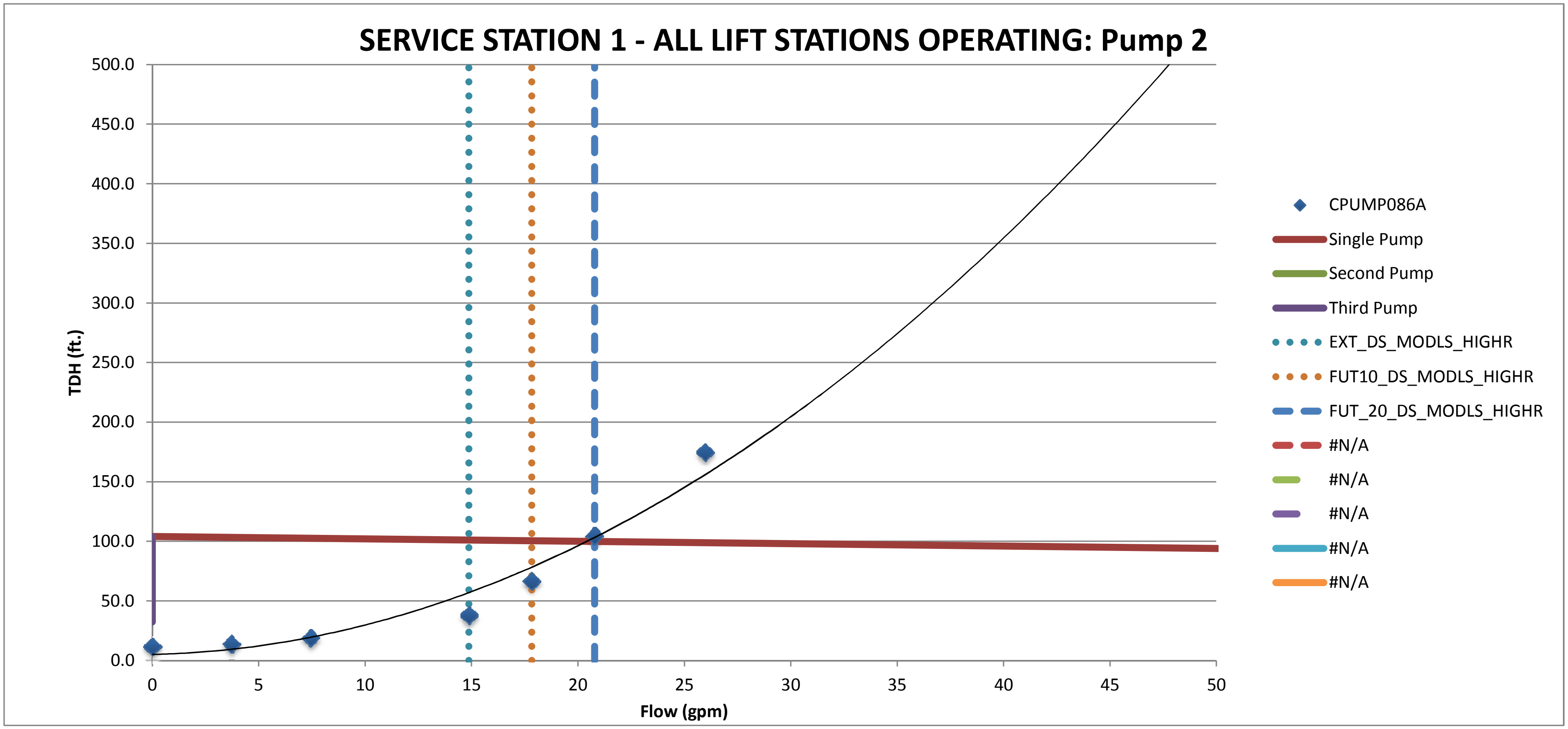


RIVERHOUSE - ALL LIFT STATIONS OPERATING
TDH (ft.)
200.00
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Flow (gpm)
CPUMP078B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

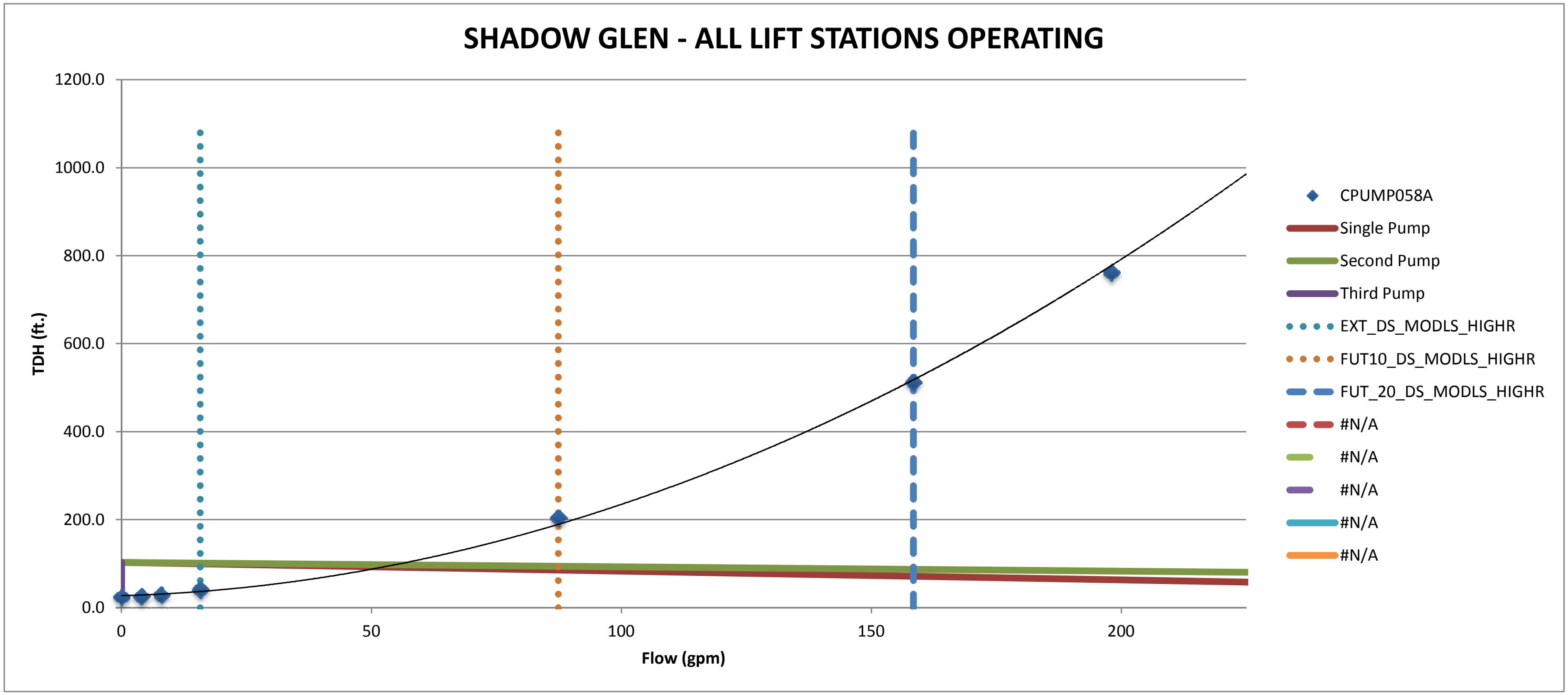

SAWYER PARK - ALL LIFT STATIONS OPERATING
TDH (ft.)
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0
100
200
300
400
500
600
700
800
900
1000
Flow (gpm)
CPUMP080A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A
Four Pumps

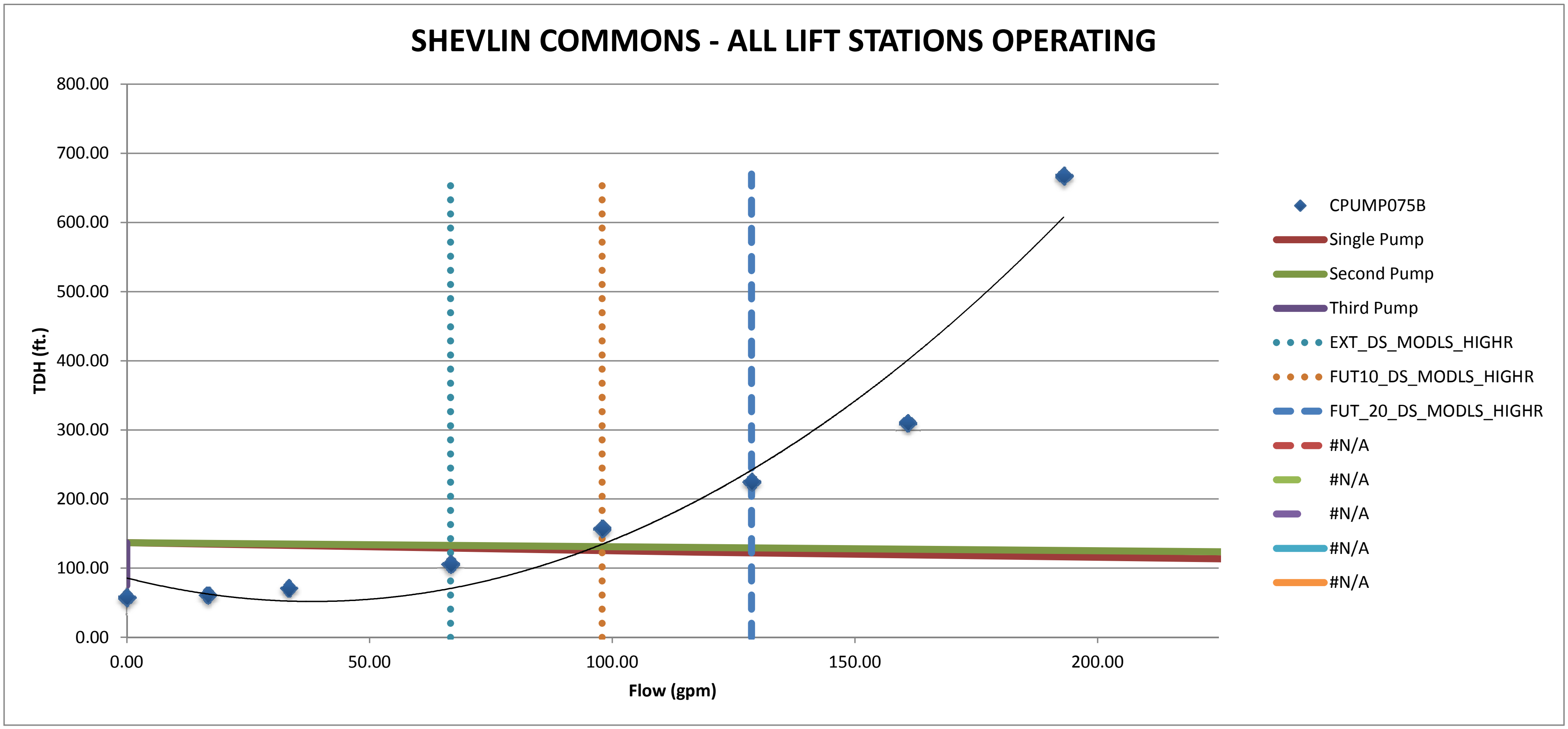


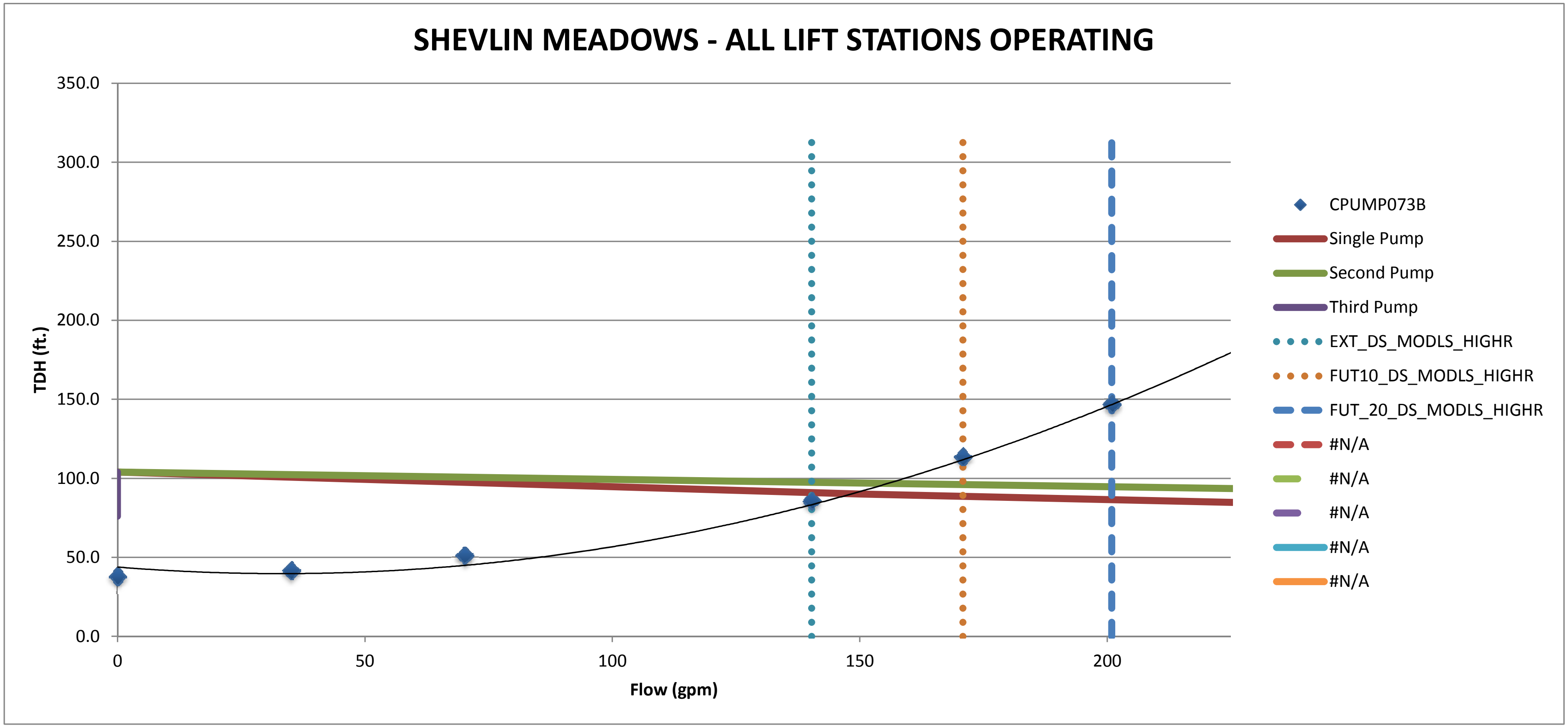
SERVICE STATION 1 - ALL LIFT STATIONS OPERATING: Pump 1
TDH (ft.)
500.0
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0
5
10
15
20
25
30
35
40
45
50
Flow (gpm)
CPUMP086A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

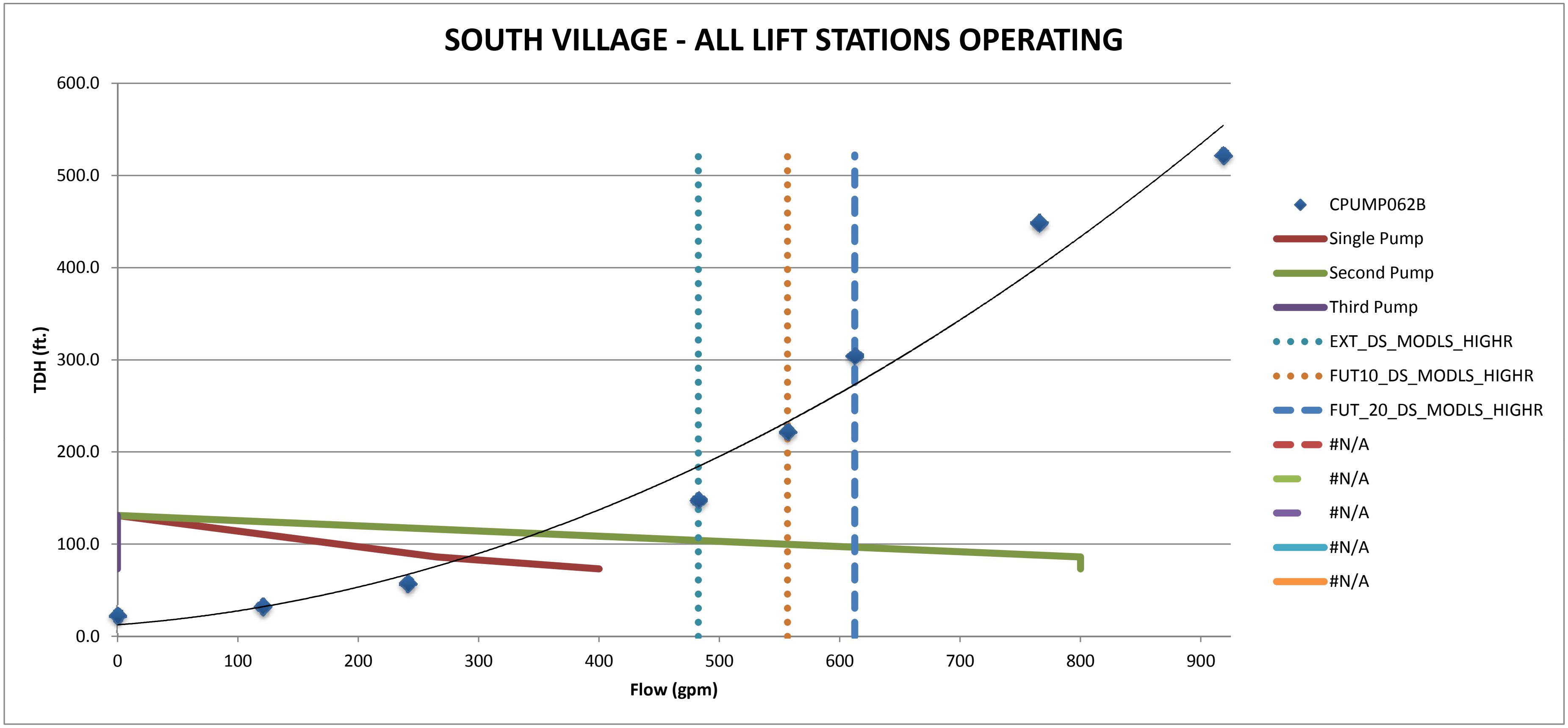


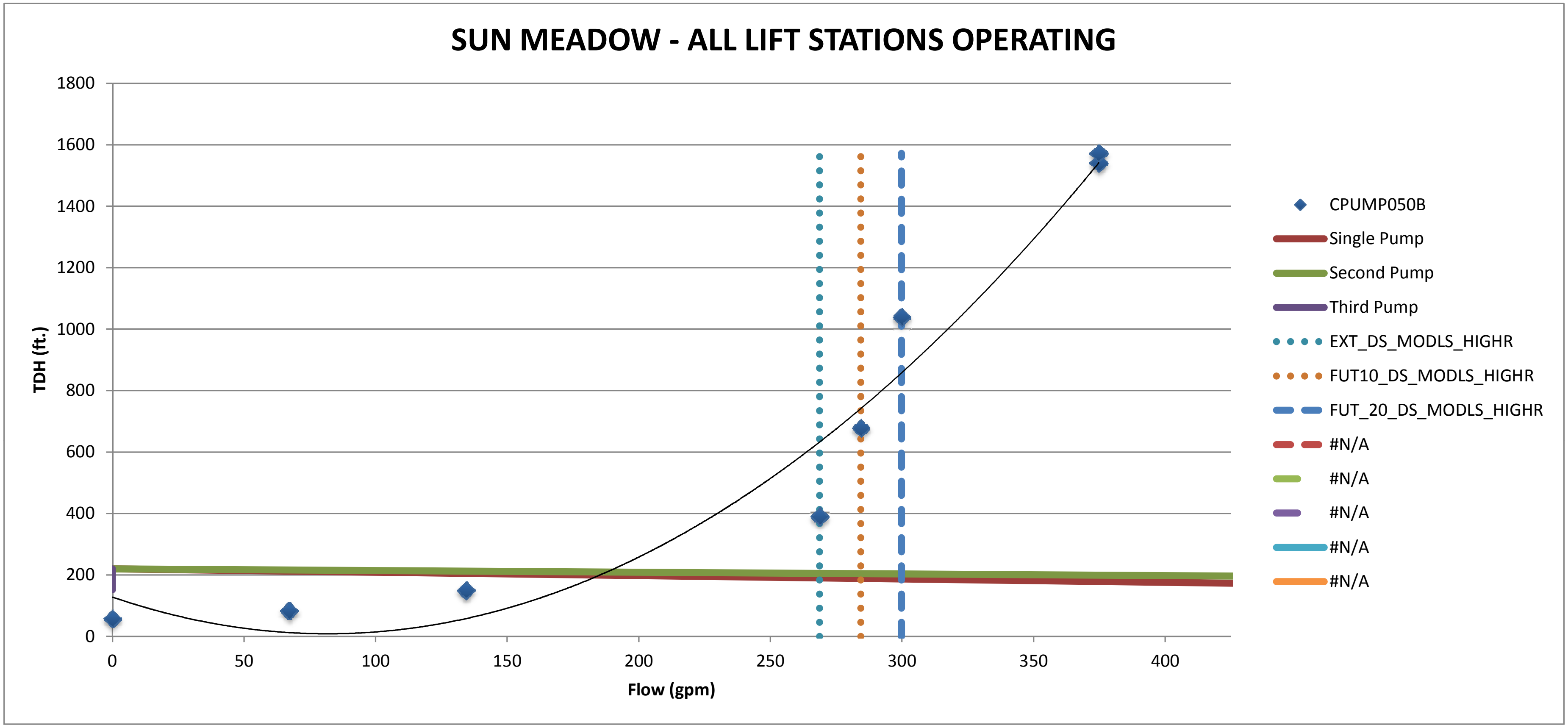
SERVICE STATION 1 - ALL LIFT STATIONS OPERATING: Pump 2
TDH (ft.)
500.0
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0
5
10
15
20
25
30
35
40
45
50
Flow (gpm)
CPUMP086A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A


SHADOW GLEN - ALL LIFT STATIONS OPERATING
TDH (ft.)
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
0
50
100
150
200
Flow (gpm)
CPUMP058A
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

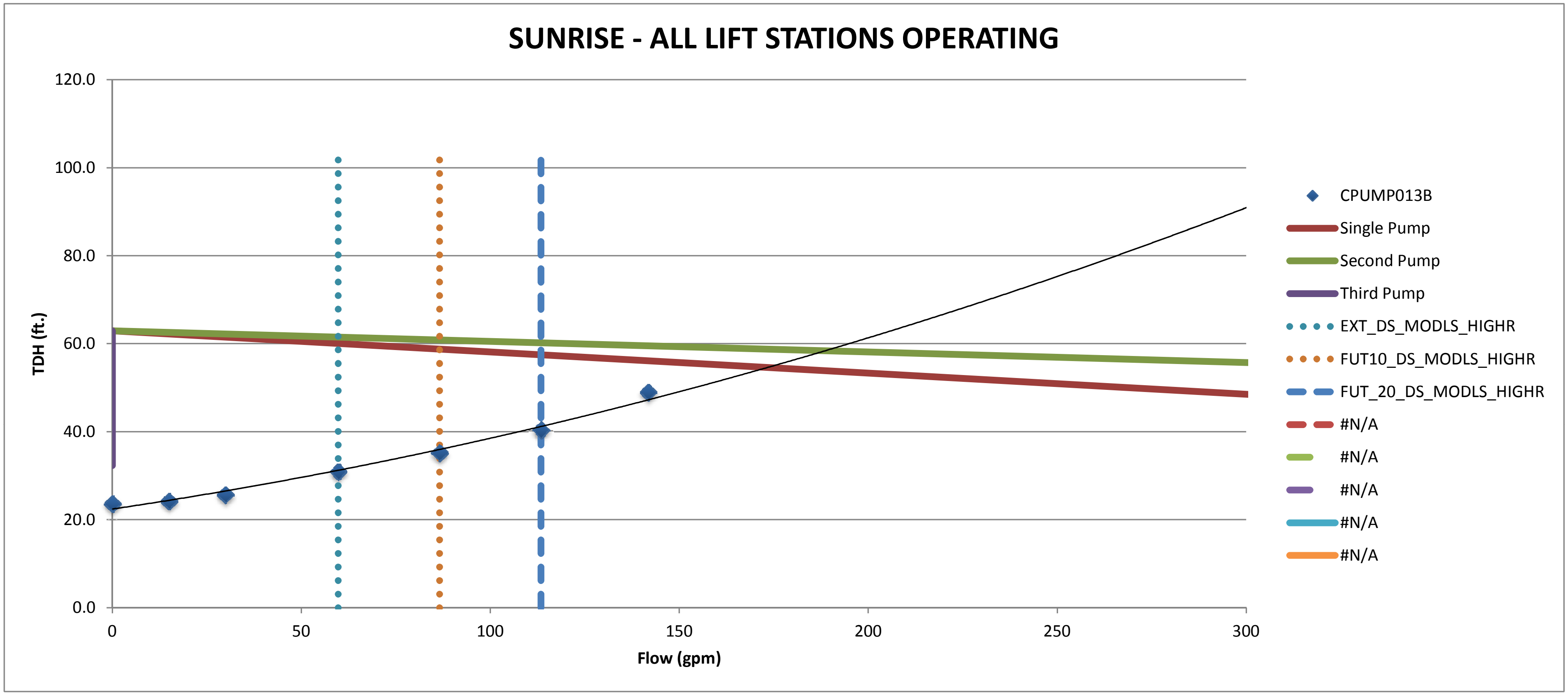

SHEVLIN COMMONS - ALL LIFT STATIONS OPERATING
TDH (ft.)
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
0.00
50.00
100.00
150.00
200.00
Flow (gpm)
CPUMP075B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A


SHEVLIN MEADOWS - ALL LIFT STATIONS OPERATING
TDH (ft.)
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0
50
100
150
200
Flow (gpm)
CPUMP073B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

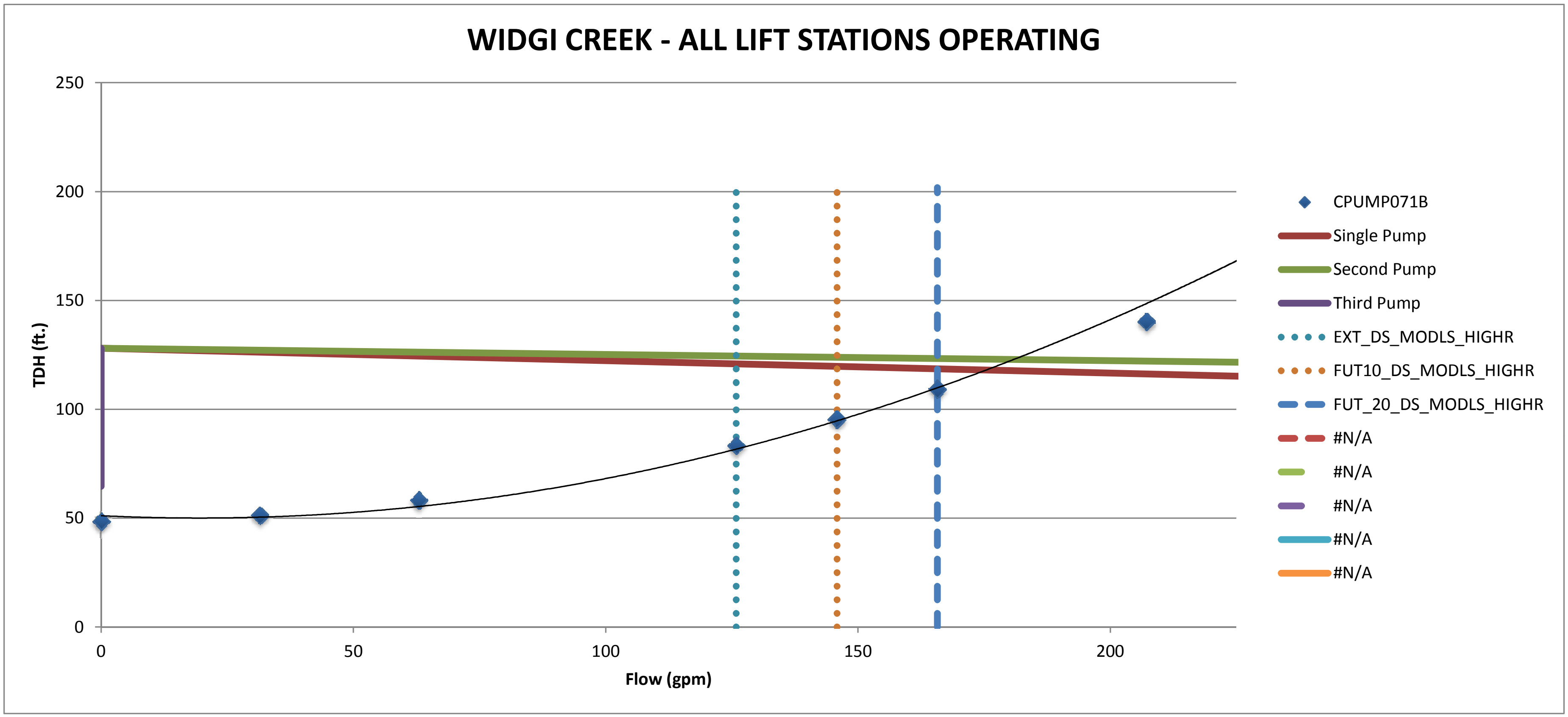

SOUTH VILLAGE - ALL LIFT STATIONS OPERATING
TDH (ft.)
600.0
500.0
400.0
300.0
200.0
100.0
0.0
0
100
200
300
400
500
600
700
800
900
Flow (gpm)
CPUMP062B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

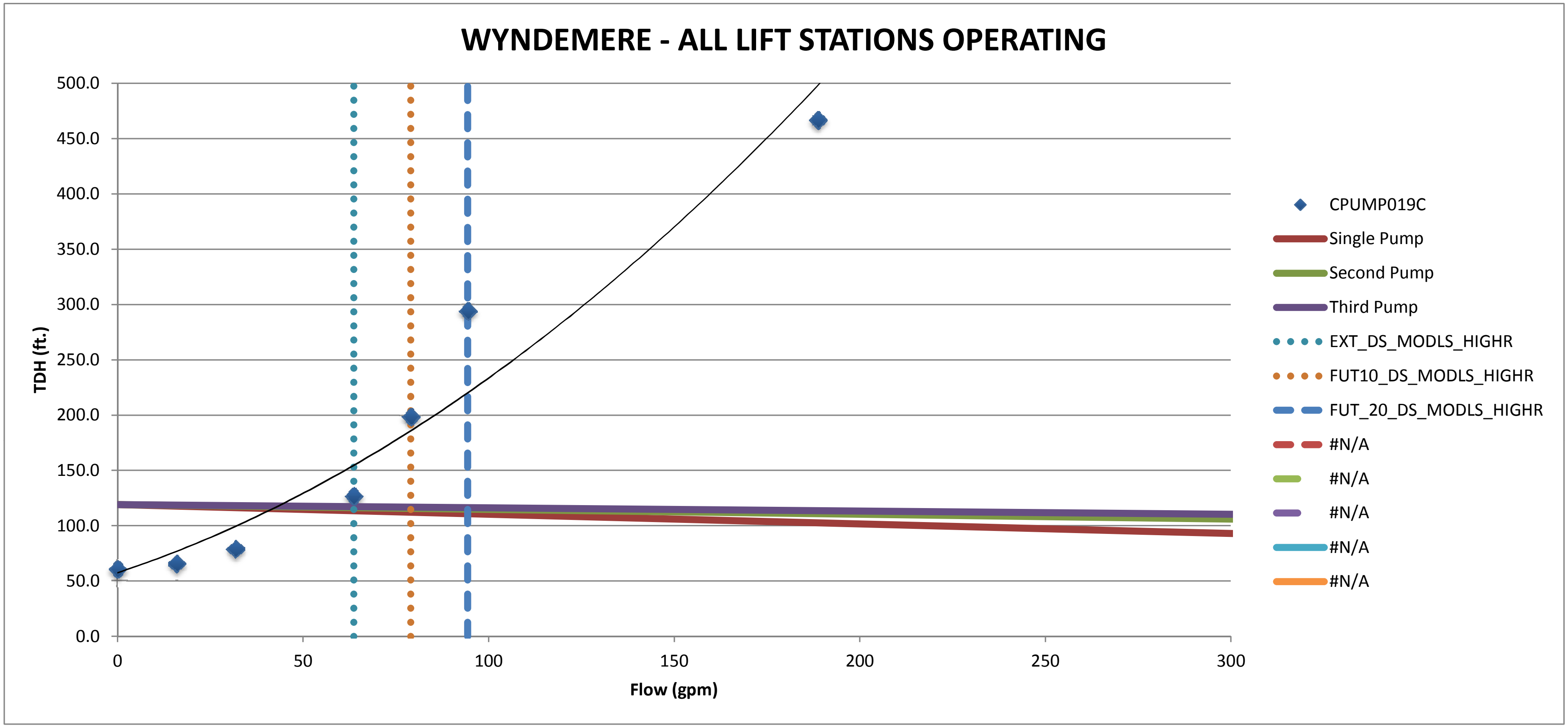


SUN MEADOW - ALL LIFT STATIONS OPERATING
TDH (ft.)
1800
1600
1400
1200
1000
800
600
400
200
0
0
50
100
150
200
250
300
350
400
Flow (gpm)
CPUMP050B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

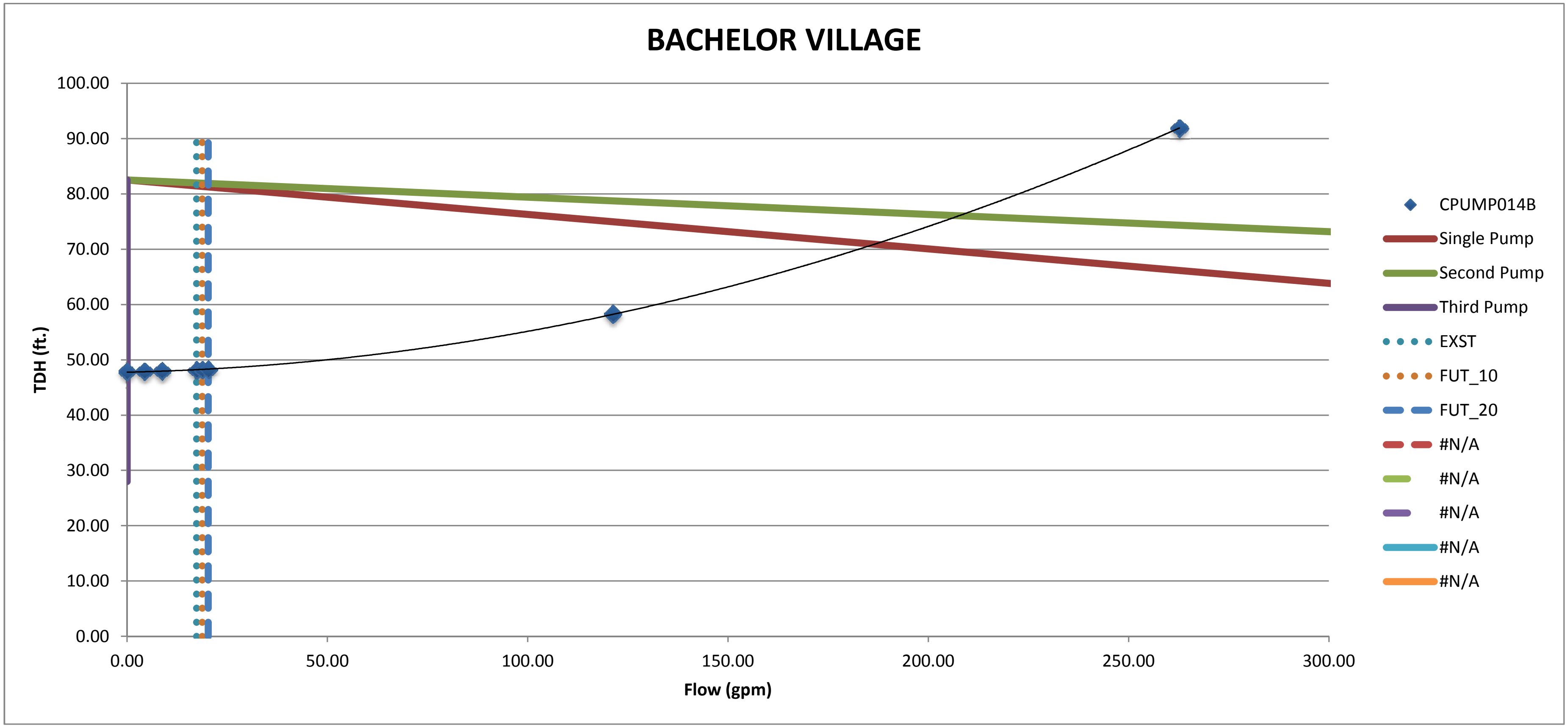


SUNRISE - ALL LIFT STATIONS OPERATING
120.0
100.0
80.0
60.0
40.0
20.0
0.0
TDH (ft.)
0
50
100
150
200
250
300
Flow (gpm)
CPUMP013B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A

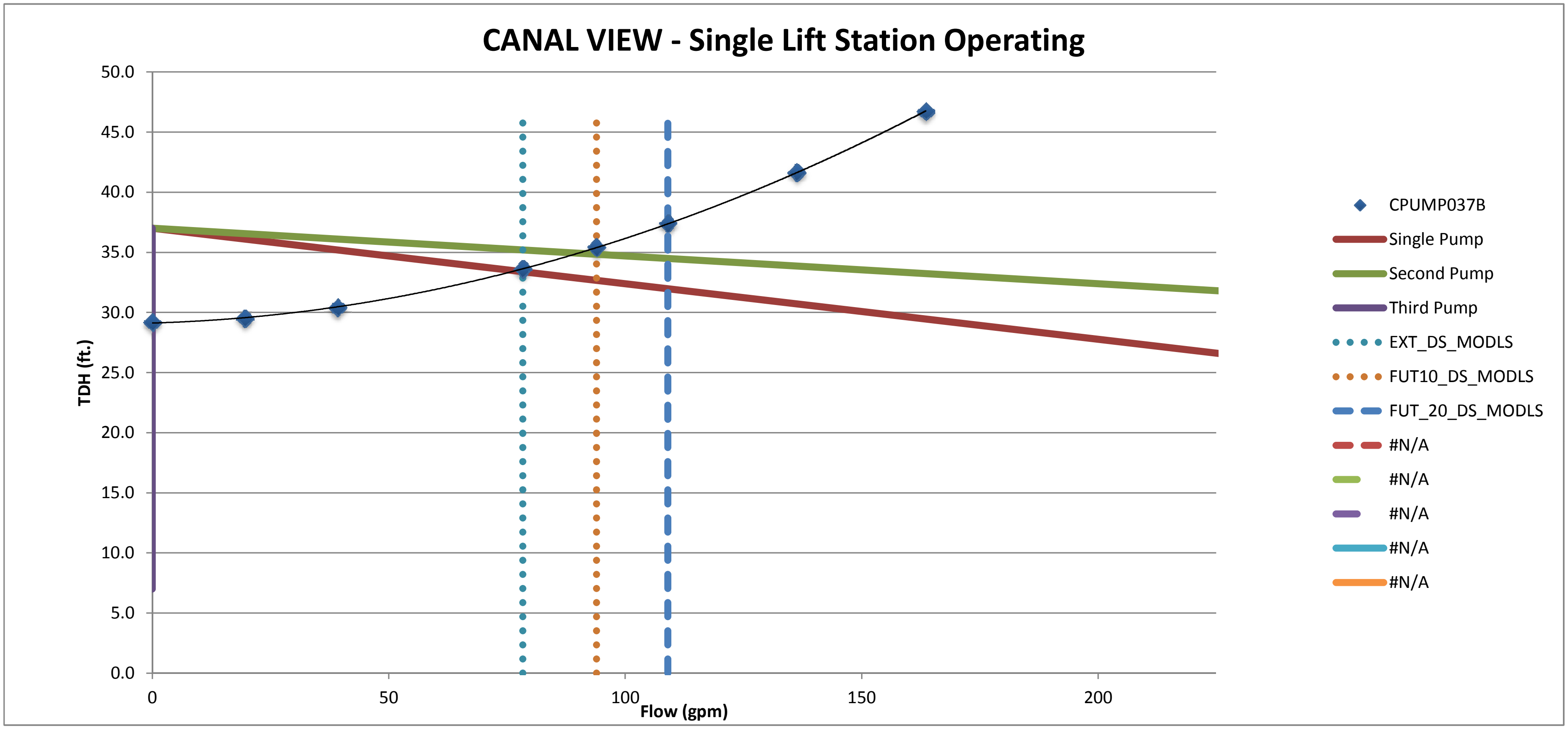

WIDGI CREEK - ALL LIFT STATIONS OPERATING
250
200
150
100
50
0
TDH (ft.)
0
50
100
150
200
Flow (gpm)
CPUMP071B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A



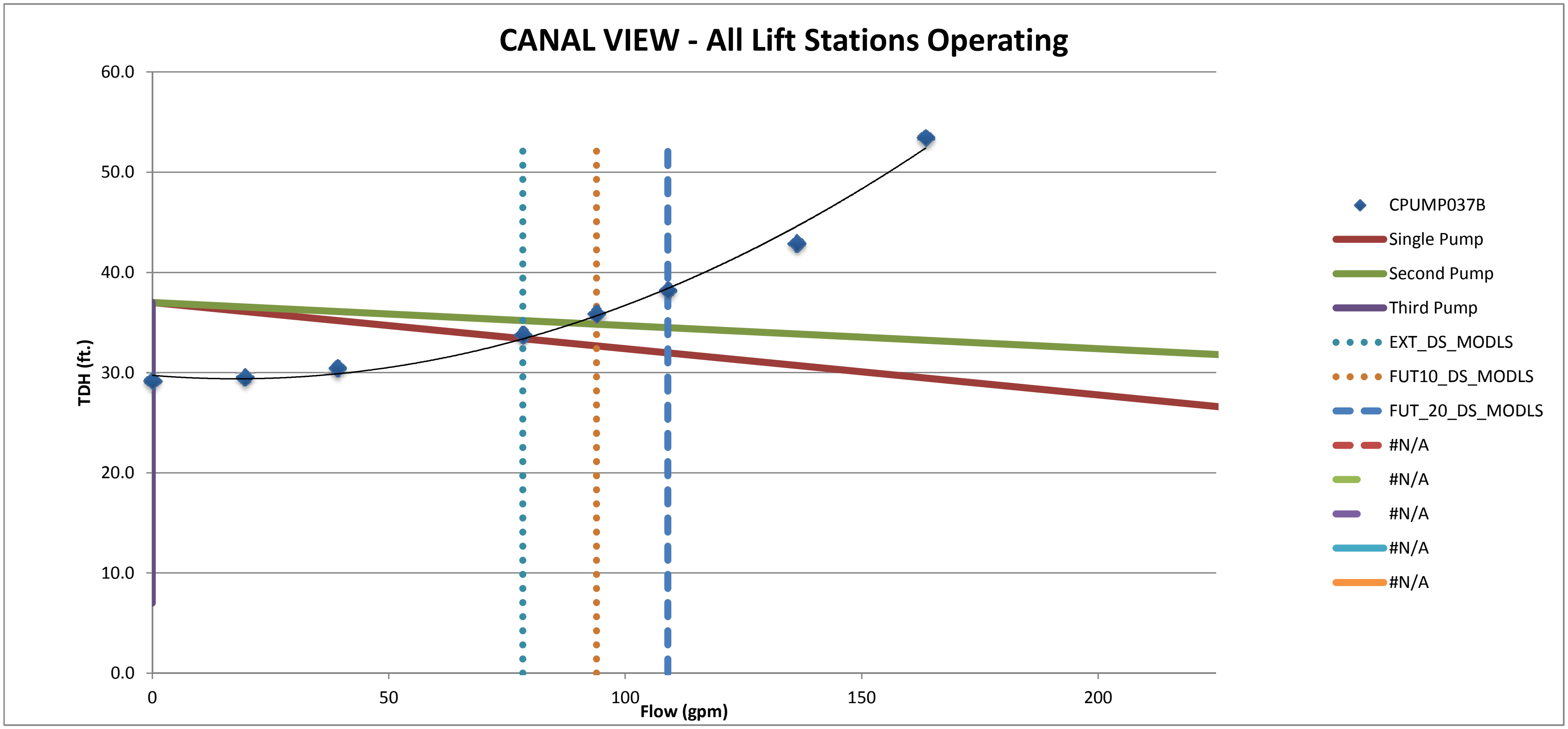
WYNDEMERE - ALL LIFT STATIONS OPERATING
TDH (ft.)
500.0
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0
50
100
150
200
250
300
Flow (gpm)
CPUMP019C
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS_HIGHR
FUT10_DS_MODLS_HIGHR
FUT_20_DS_MODLS_HIGHR
#N/A
#N/A
#N/A
#N/A
#N/A



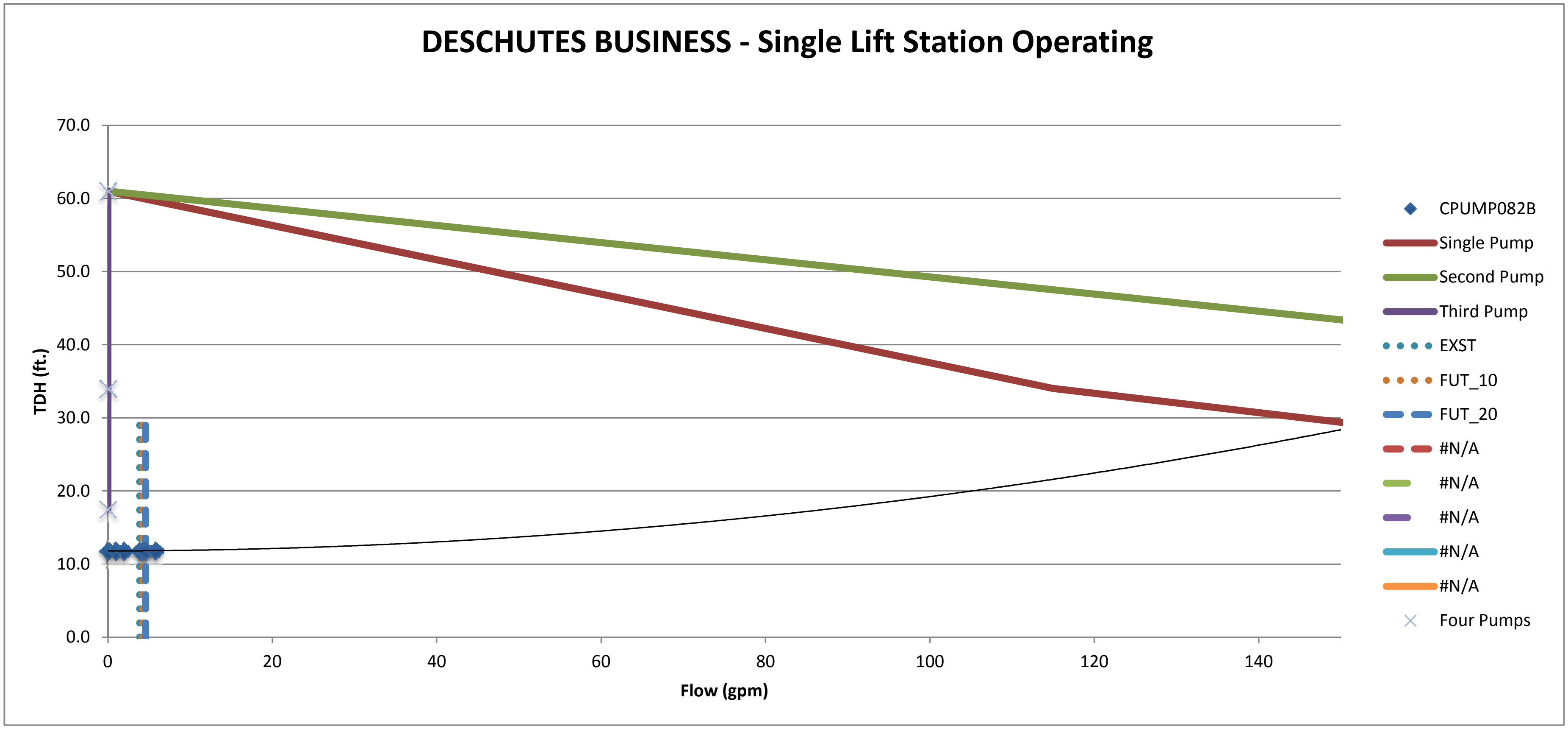
BACHELOR VILLAGE
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
TDH (ft.)
0.00
50.00
100.00
150.00
200.00
250.00
300.00
Flow (gpm)
CPUMP014B
Single Pump
Second Pump
Third Pump
EXST
FUT_10
FUT_20
#N/A
#N/A
#N/A
#N/A
#N/A



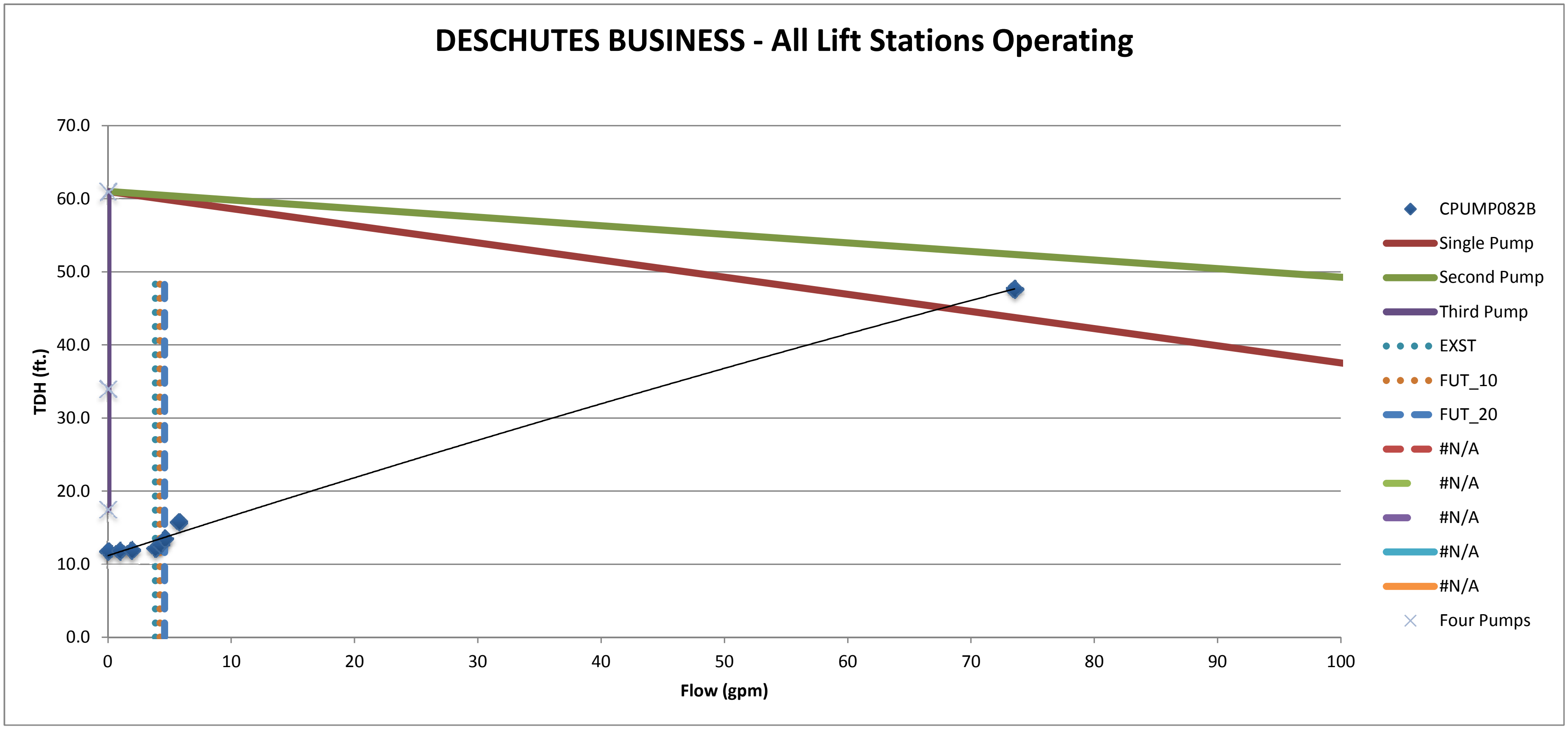
CANAL VIEW - Single Lift Station Operating
TDH (ft.)
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
50
100
150
200
Flow (gpm)
CPUMP037B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

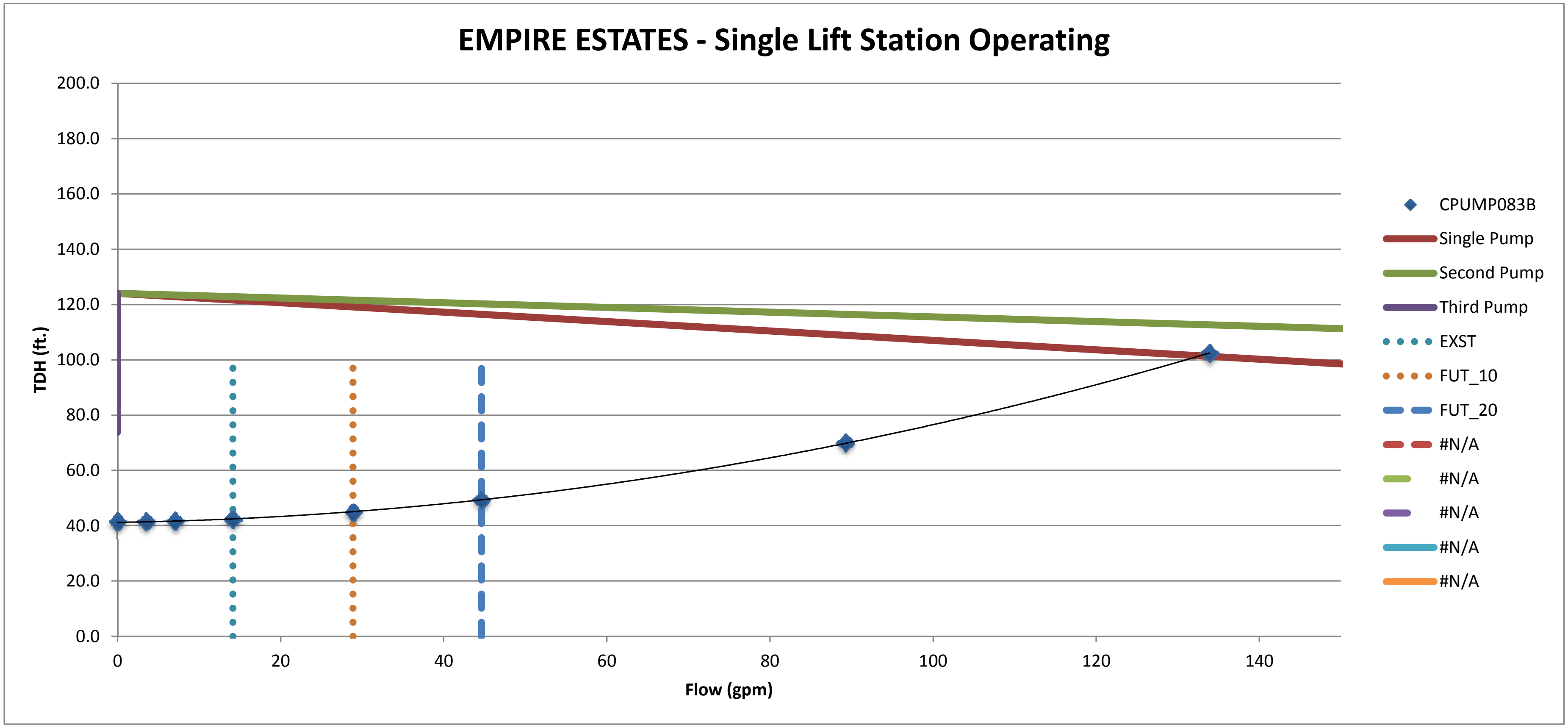


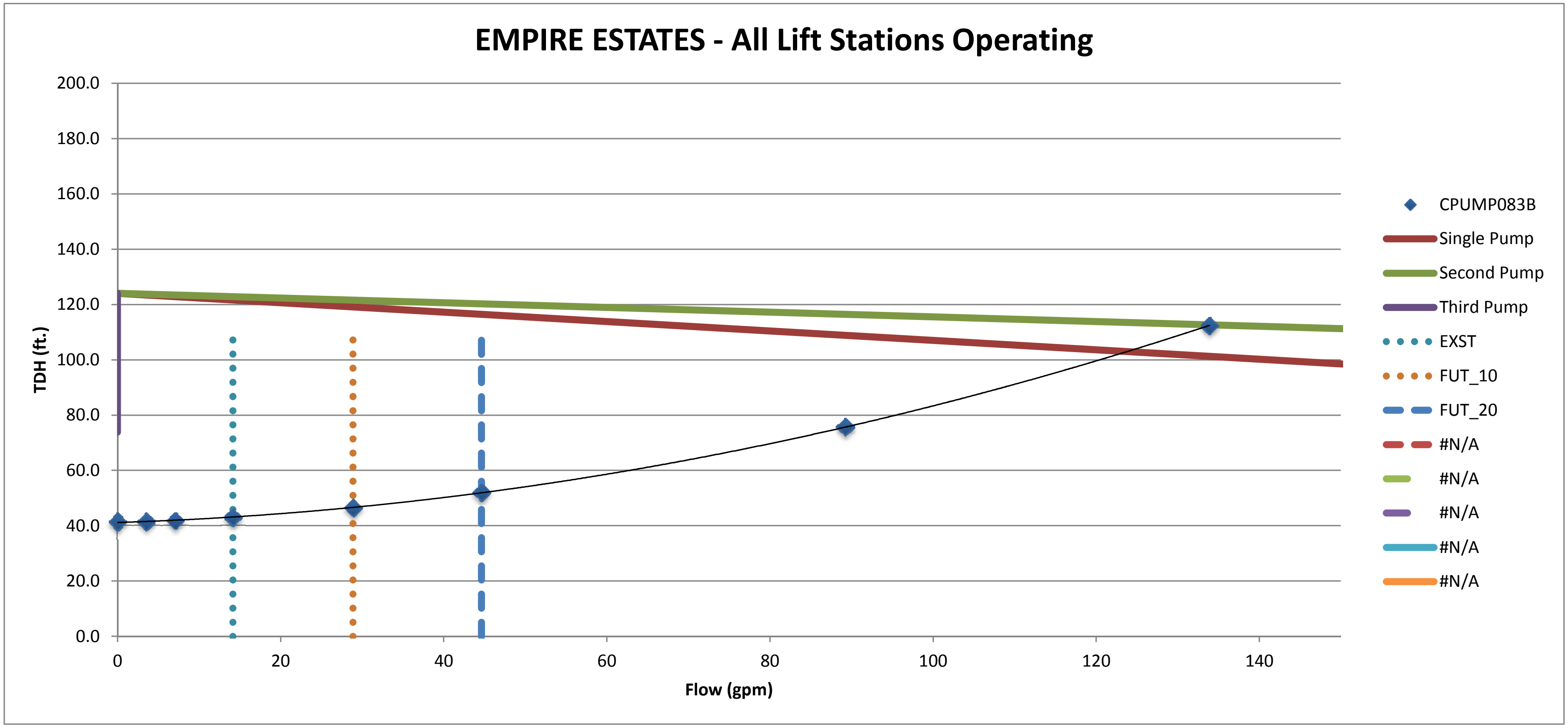
CANAL VIEW - All Lift Stations Operating
60.0
50.0
40.0
30.0
20.0
10.0
0.0
TDH (ft.)
0
50
100
150
200
Flow (gpm)
CPUMP037B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A



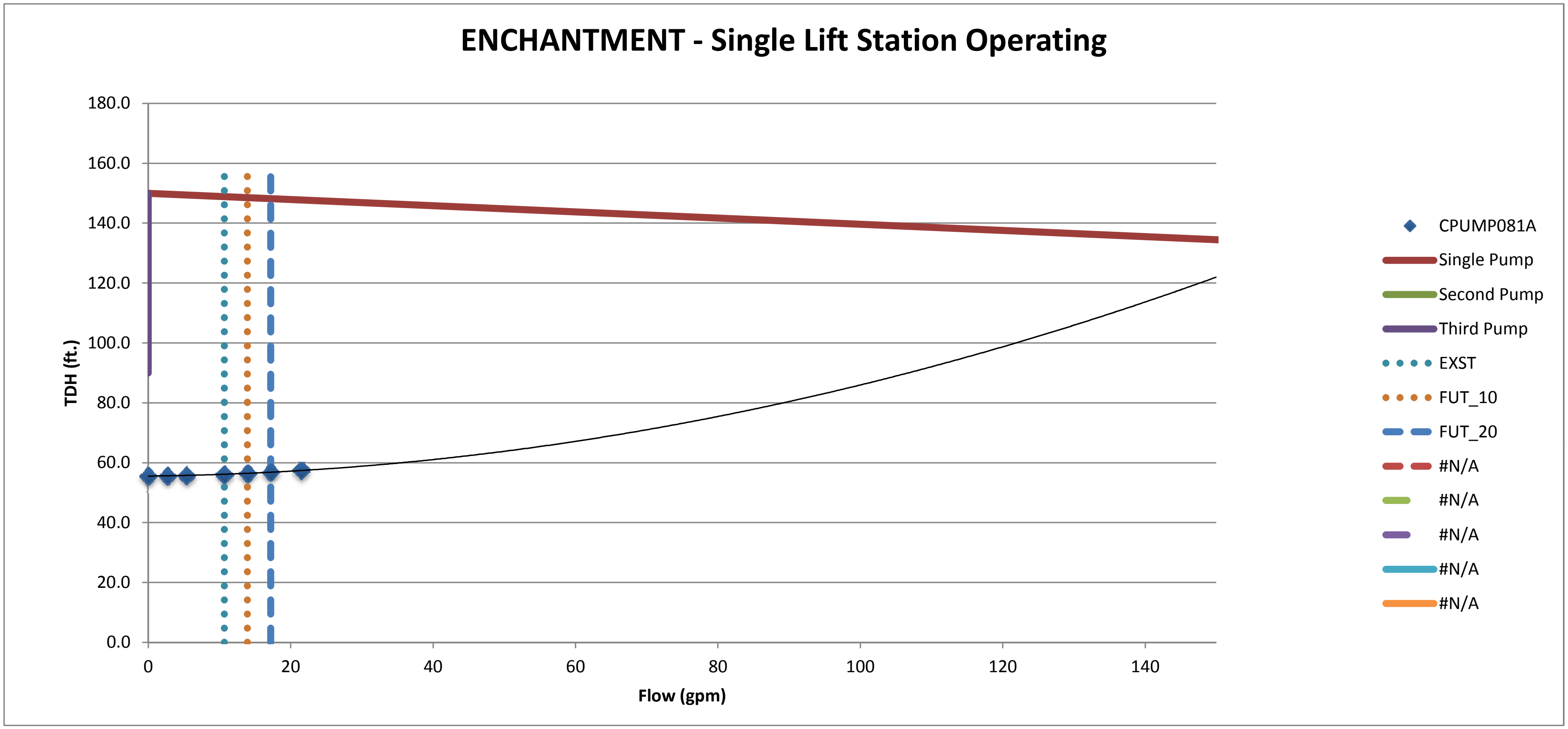
DESCHUTES BUSINESS - Single Lift Station Operating
TDH (ft.)
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
20
40
60
80
100
120
140
Flow (gpm)
CPUMP082B
Single Pump
Second Pump
Third Pump
EXST
FUT_10
FUT_20
#N/A
#N/A
#N/A
#N/A
#N/A
Four Pumps


DESCHUTES BUSINESS - All Lift Stations Operating
TDH (ft.)
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
10
20
30
40
50
60
70
80
90
100
Flow (gpm)
CPUMP082B
Single Pump
Second Pump
Third Pump
EXST
FUT_10
FUT_20
#N/A
#N/A
#N/A
#N/A
#N/A
Four Pumps

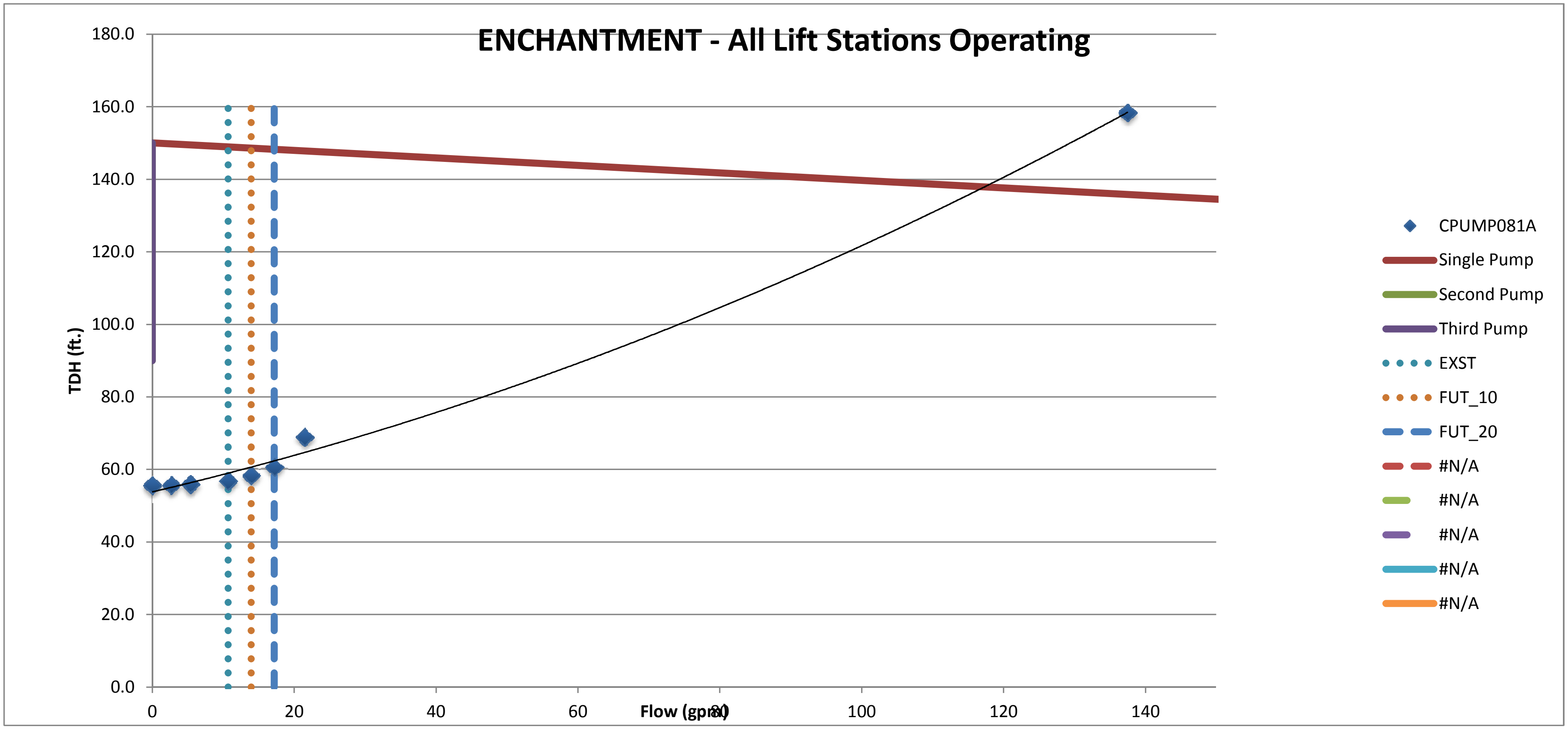

EMPIRE ESTATES - Single Lift Station Operating
TDH (ft.)
200.0
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0
20
40
60
80
100
120
140
Flow (gpm)
CPUMP083B
Single Pump
Second Pump
Third Pump
EXST
FUT_10
FUT_20
#N/A
#N/A
#N/A
#N/A
#N/A



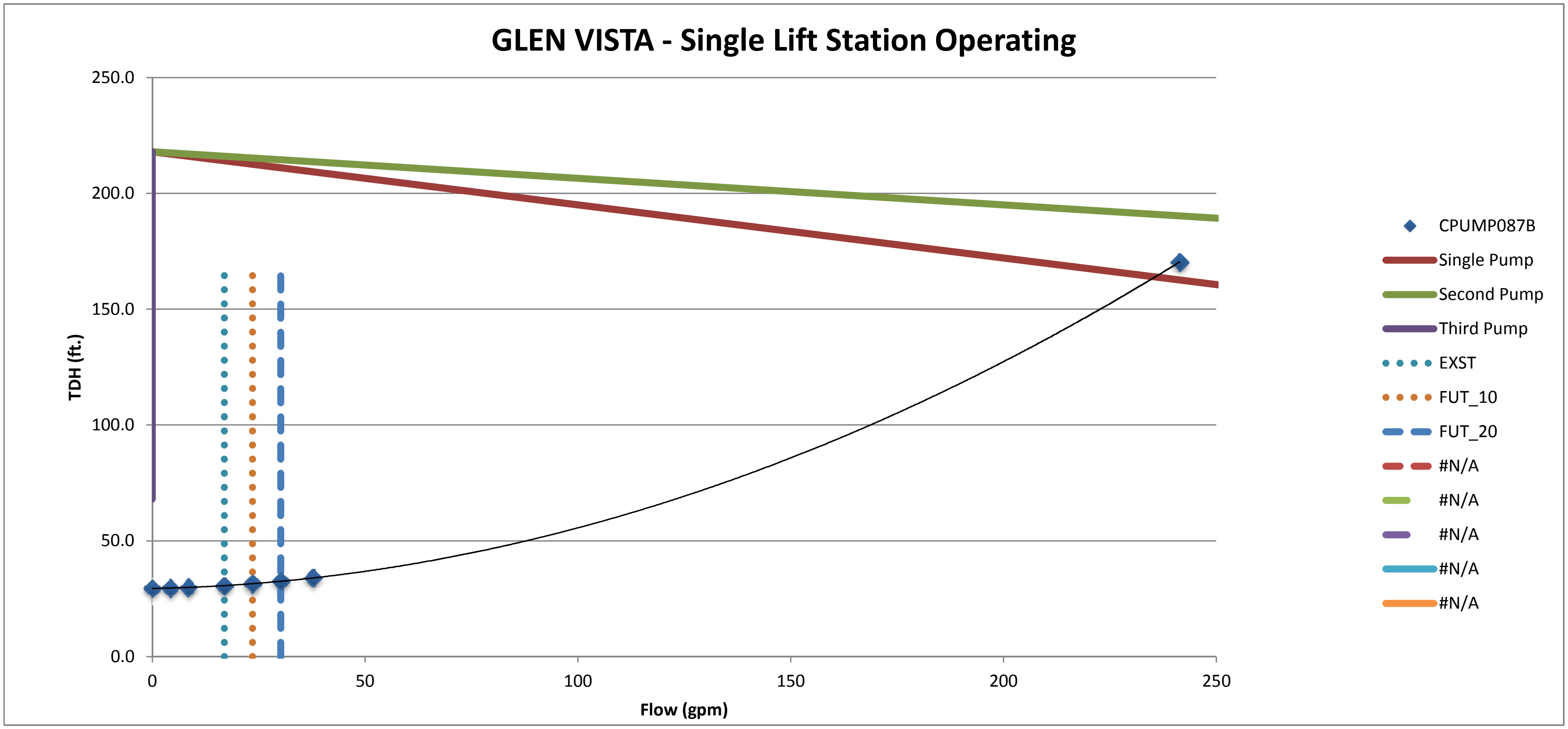
EMPIRE ESTATES - All Lift Stations Operating
200.0
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
TDH (ft.)
0
20
40
60
80
100
120
140
Flow (gpm)
CPUMP083B
Single Pump
Second Pump
Third Pump
EXST
FUT_10
FUT_20
#N/A
#N/A
#N/A
#N/A
#N/A



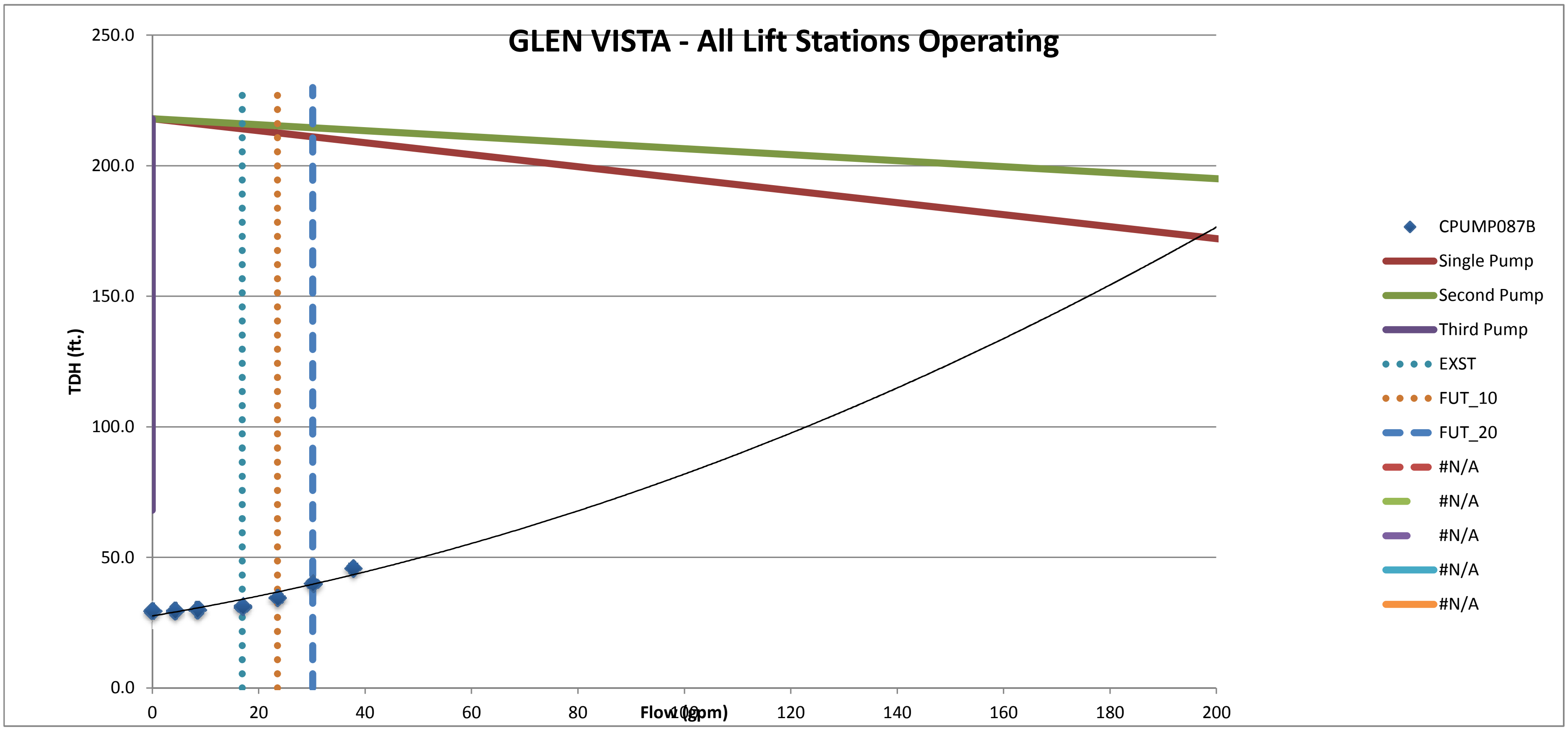
ENCHANTMENT - Single Lift Station Operating
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
TDH (ft.)
0
20
40
60
80
100
120
140
Flow (gpm)
CPUMP081A
Single Pump
Second Pump
Third Pump
EXST
FUT_10
FUT_20
#N/A
#N/A
#N/A
#N/A
#N/A

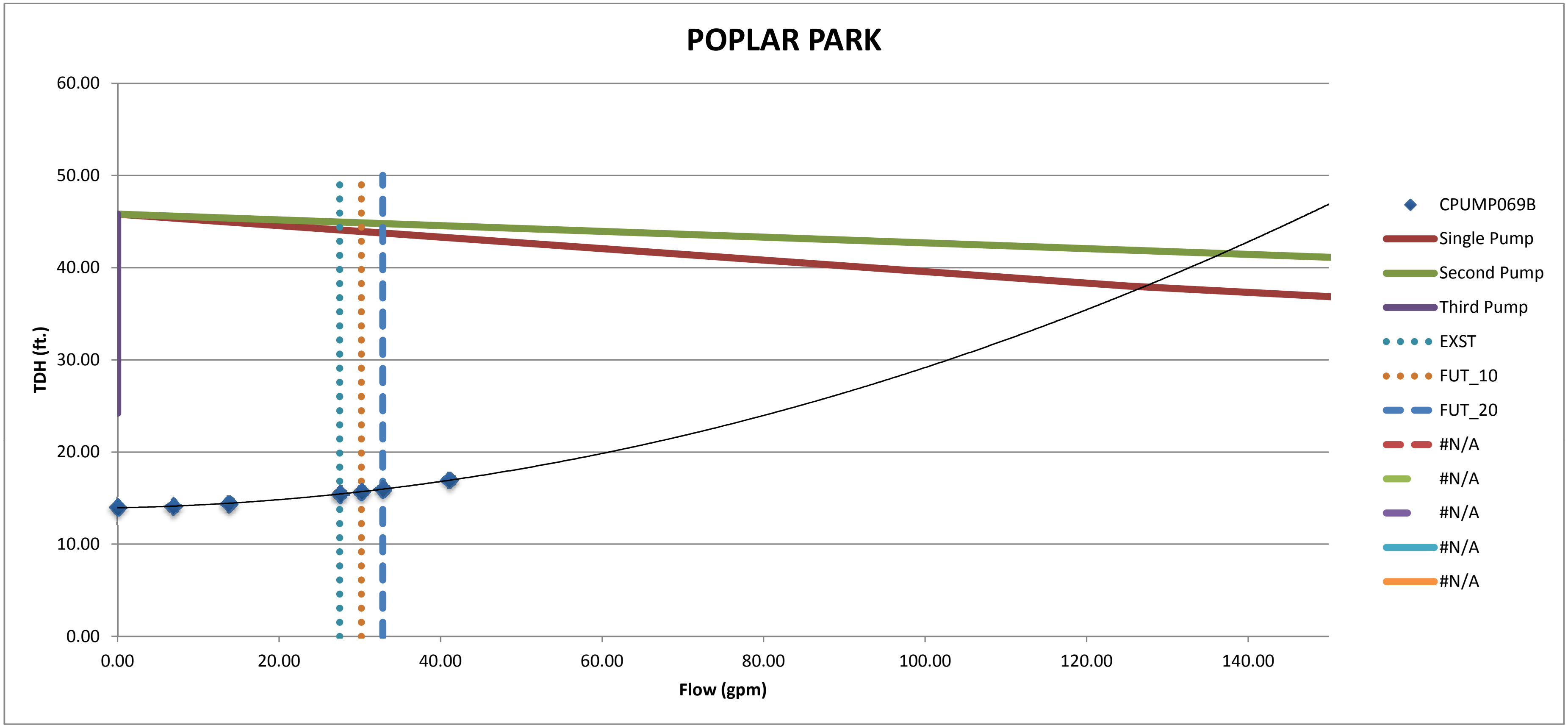


ENCHANTMENT - All Lift Stations Operating
TDH (ft.)
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0
20
40
60
Flow (gpm)
80
100
120
140
CPUMP081A
Single Pump
Second Pump
Third Pump
EXST
FUT_10
FUT_20
#N/A
#N/A
#N/A
#N/A
#N/A

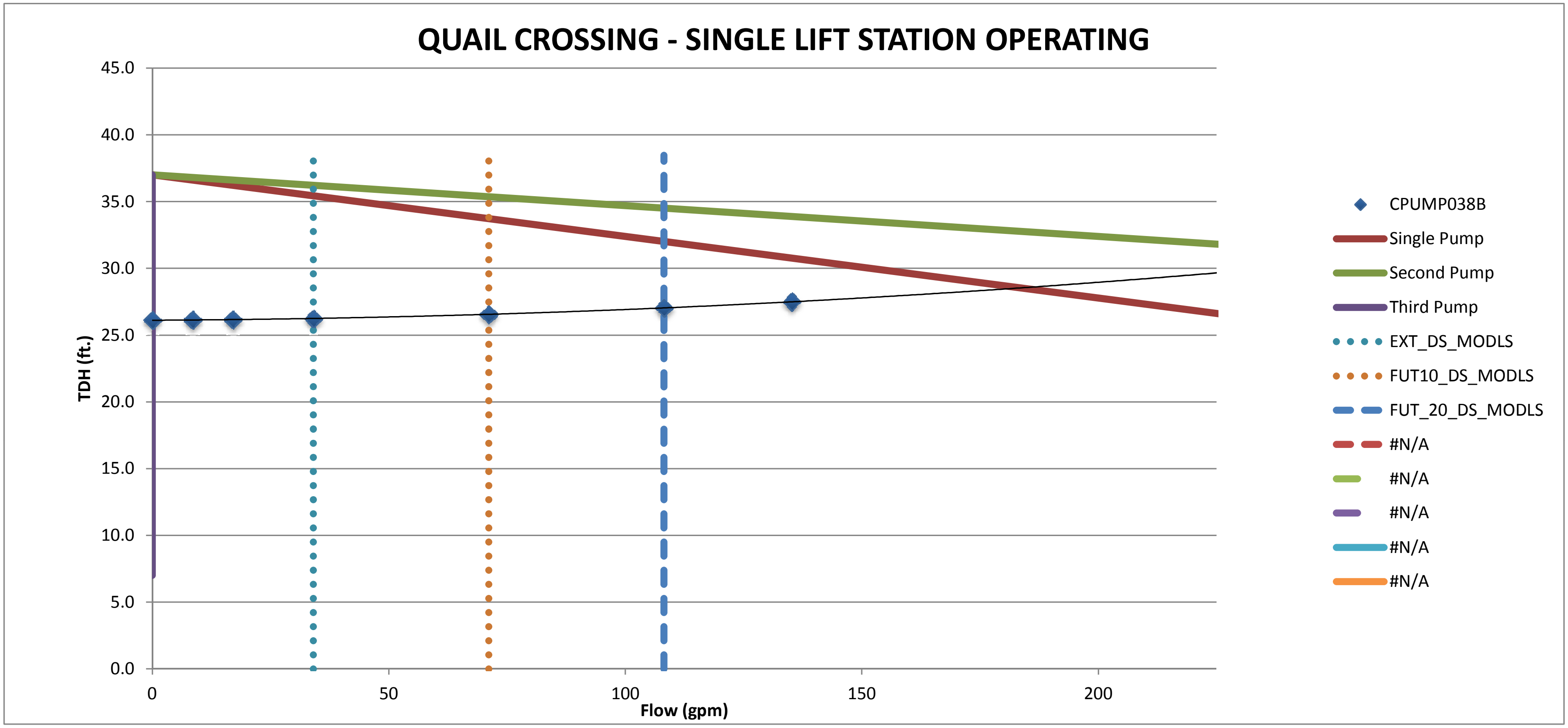


GLEN VISTA - Single Lift Station Operating
TDH (ft.)
250.0
200.0
150.0
100.0
50.0
0.0
0
50
100
150
200
250
Flow (gpm)
CPUMP087B
Single Pump
Second Pump
Third Pump
EXST
FUT_10
FUT_20
#N/A
#N/A
#N/A
#N/A
#N/A

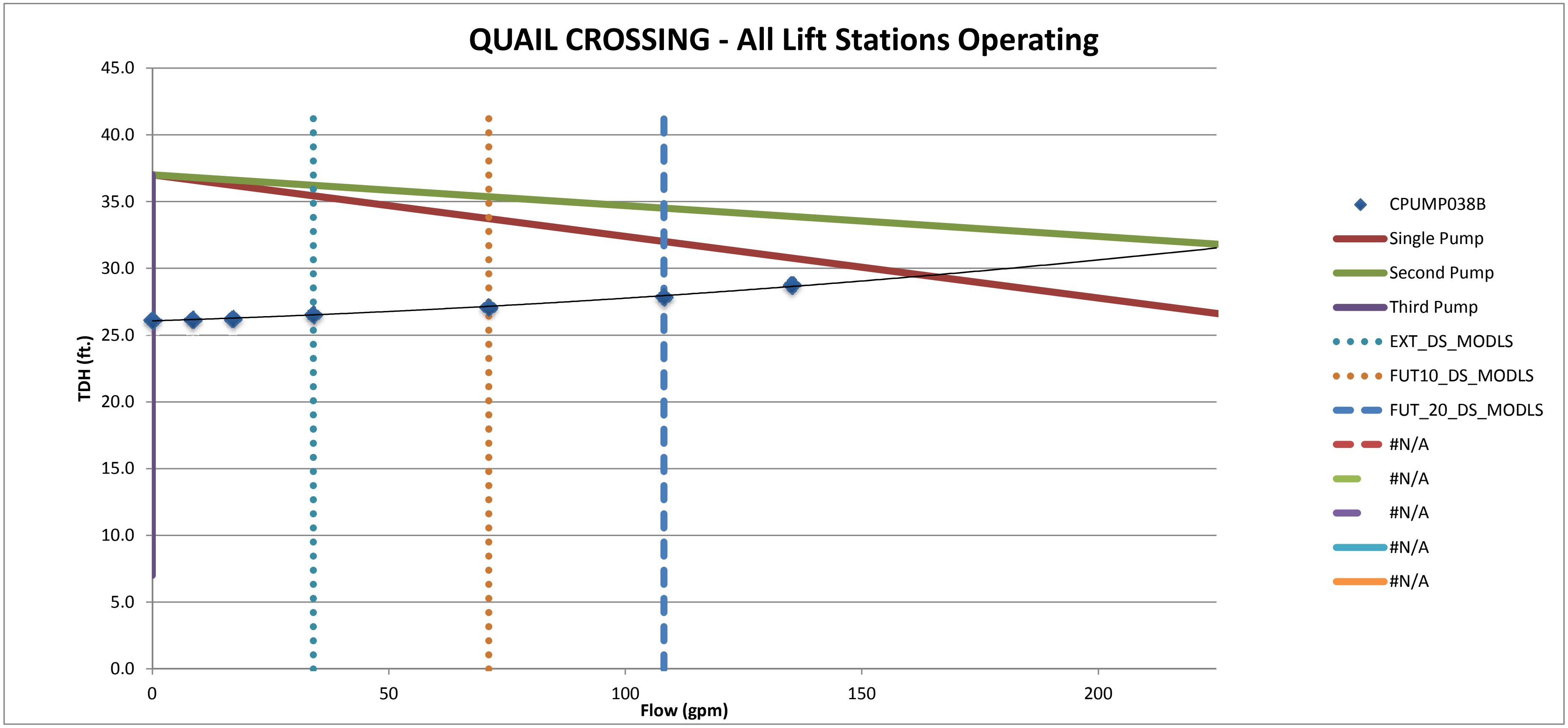

GLEN VISTA - All Lift Stations Operating
250.0
200.0
150.0
100.0
50.0
0.0
TDH (ft.)
0
20
40
60
80
100
120
140
160
180
200
Flow (gpm)
CPUMP087B
Single Pump
Second Pump
Third Pump
EXST
FUT_10
FUT_20
#N/A
#N/A
#N/A
#N/A
#N/A



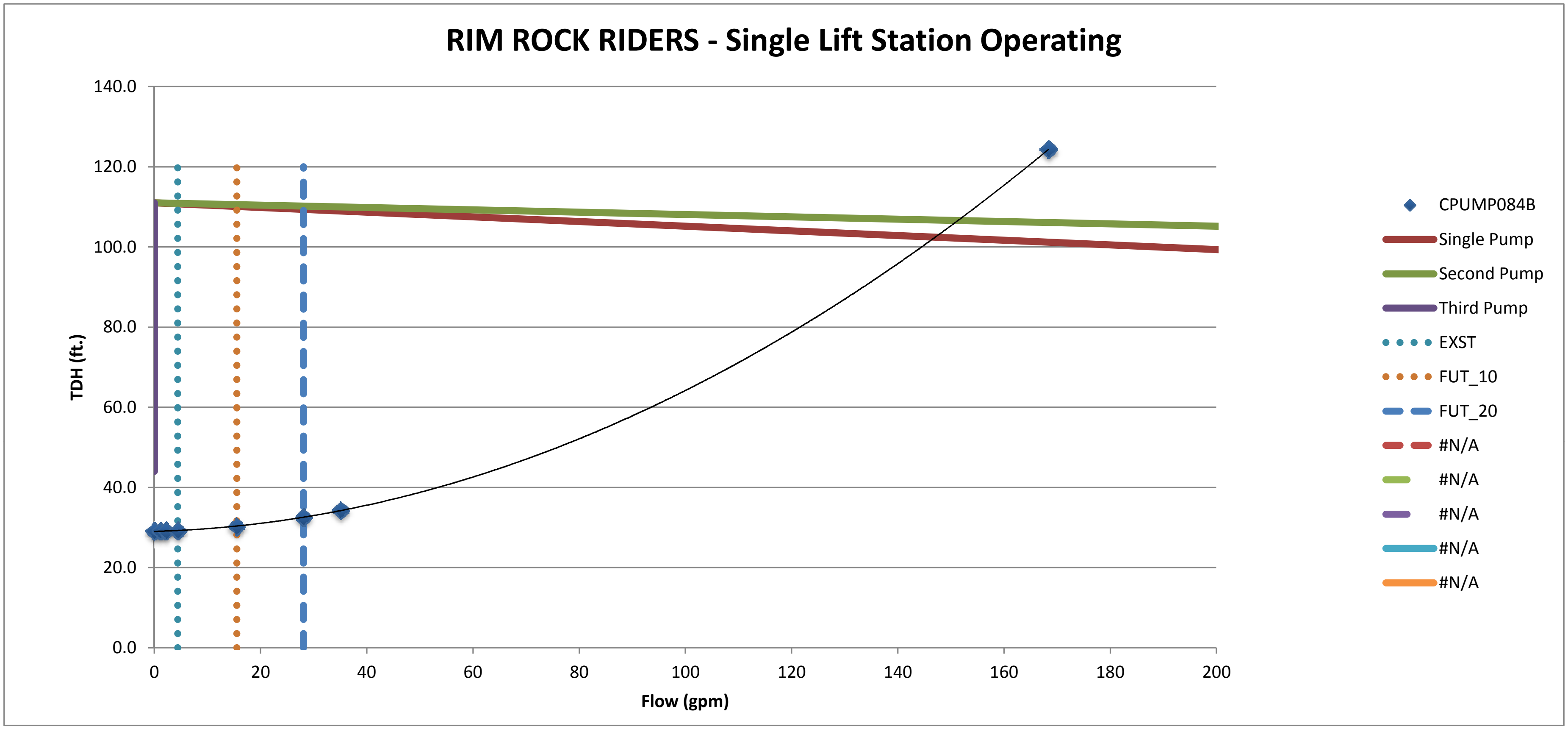
POPLAR PARK
60.00
50.00
40.00
30.00
20.00
10.00
0.00
TDH (ft.)
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
Flow (gpm)
CPUMP069B
Single Pump
Second Pump
Third Pump
EXST
FUT_10
FUT_20
#N/A
#N/A
#N/A
#N/A
#N/A

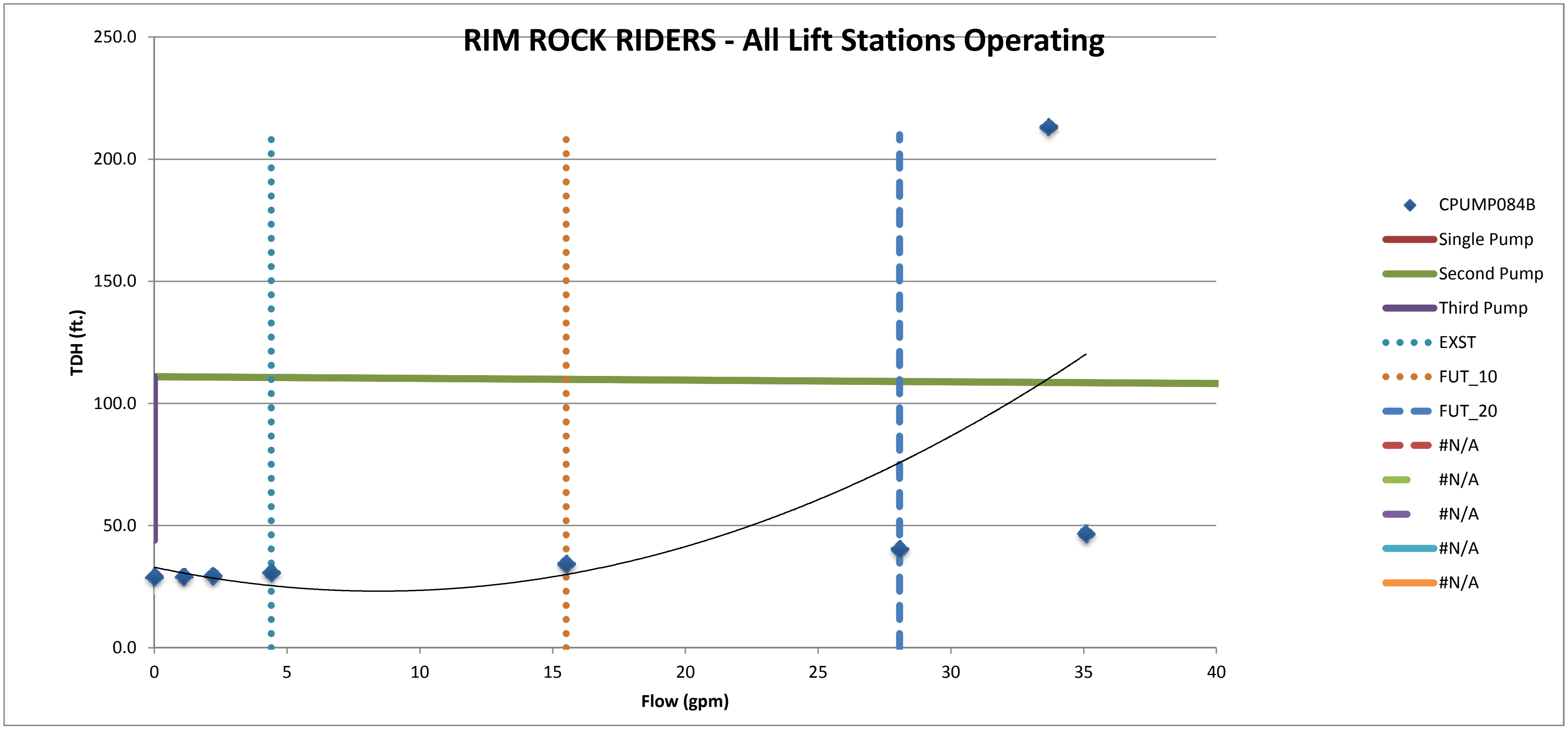


QUAIL CROSSING - SINGLE LIFT STATION OPERATING
TDH (ft.)
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
50
100
150
200
Flow (gpm)
CPUMP038B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

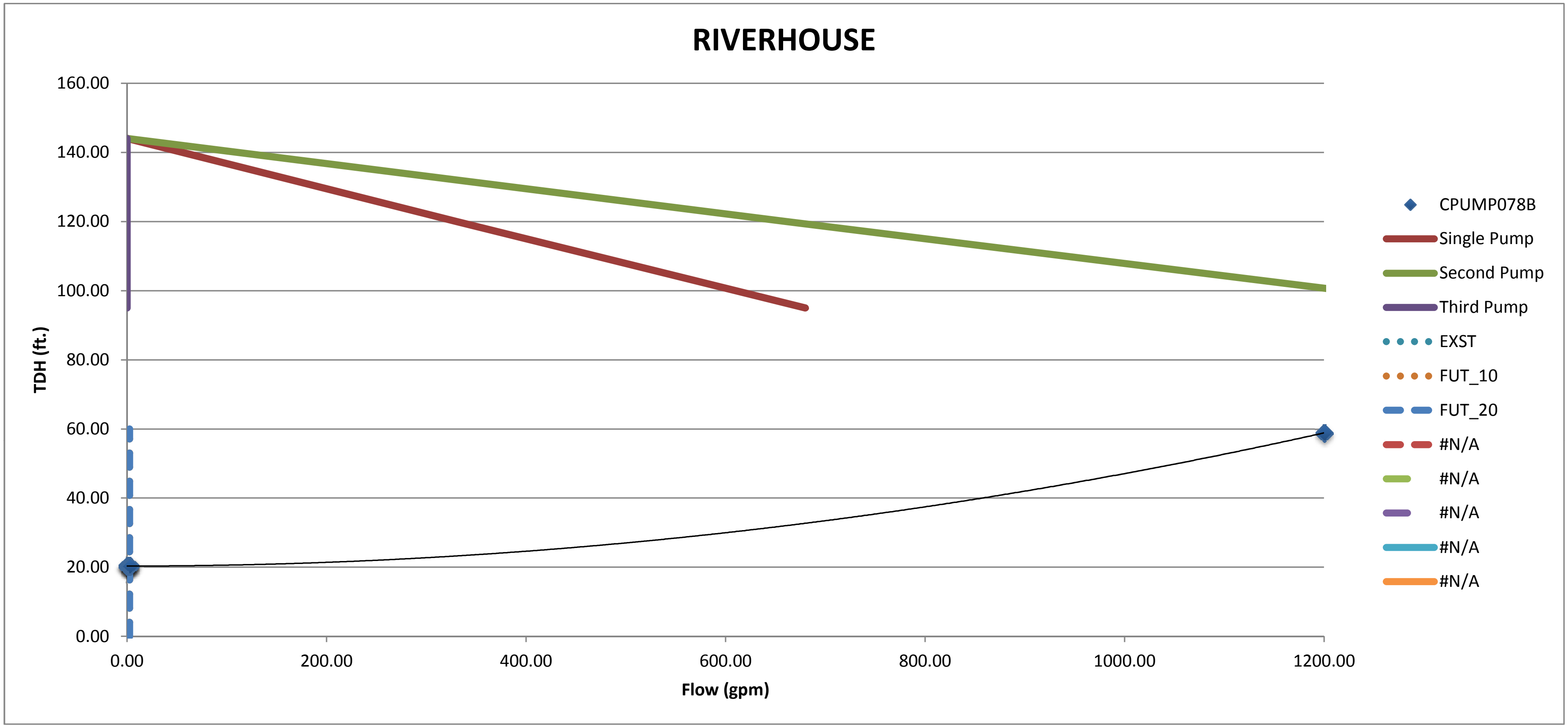


QUAIL CROSSING - All Lift Stations Operating
TDH (ft.)
Flow (gpm)
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
50
100
150
200
CPUMP038B
Single Pump
Second Pump
Third Pump
EXT_DS_MODLS
FUT10_DS_MODLS
FUT_20_DS_MODLS
#N/A
#N/A
#N/A
#N/A
#N/A

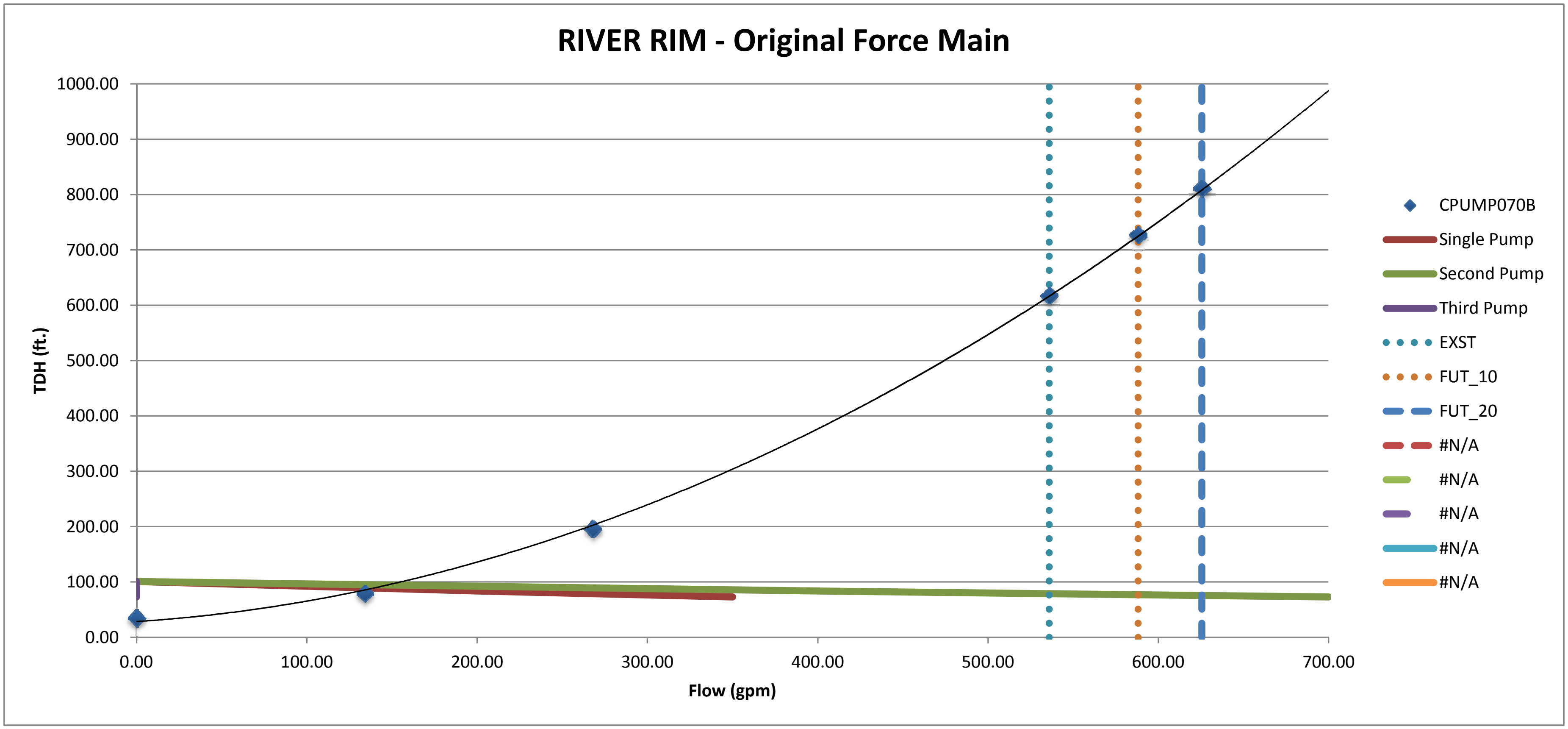

RIM ROCK RIDERS - Single Lift Station Operating
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
TDH (ft.)
0
20
40
60
80
100
120
140
160
180
200
Flow (gpm)
CPUMP084B
Single Pump
Second Pump
Third Pump
EXST
FUT_10
FUT_20
#N/A
#N/A
#N/A
#N/A
#N/A

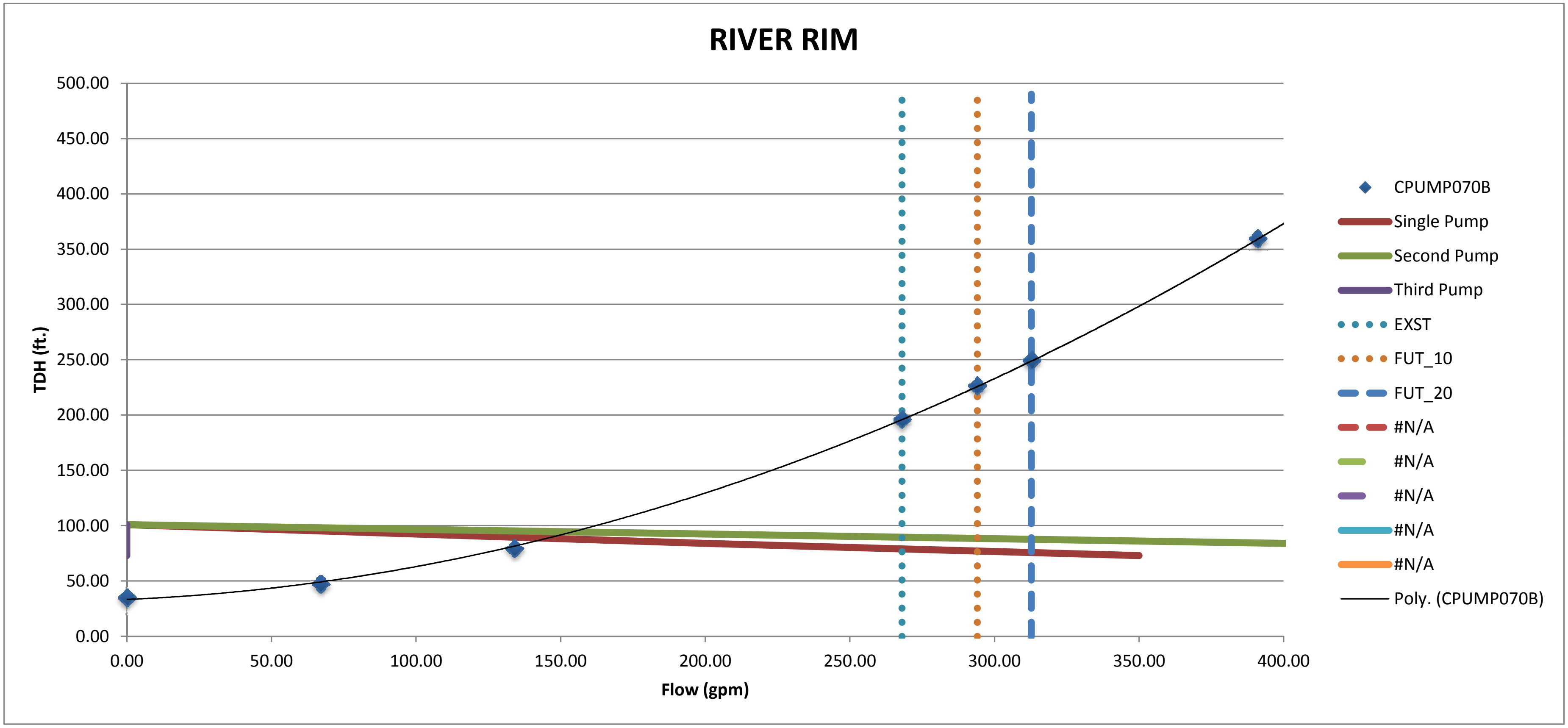


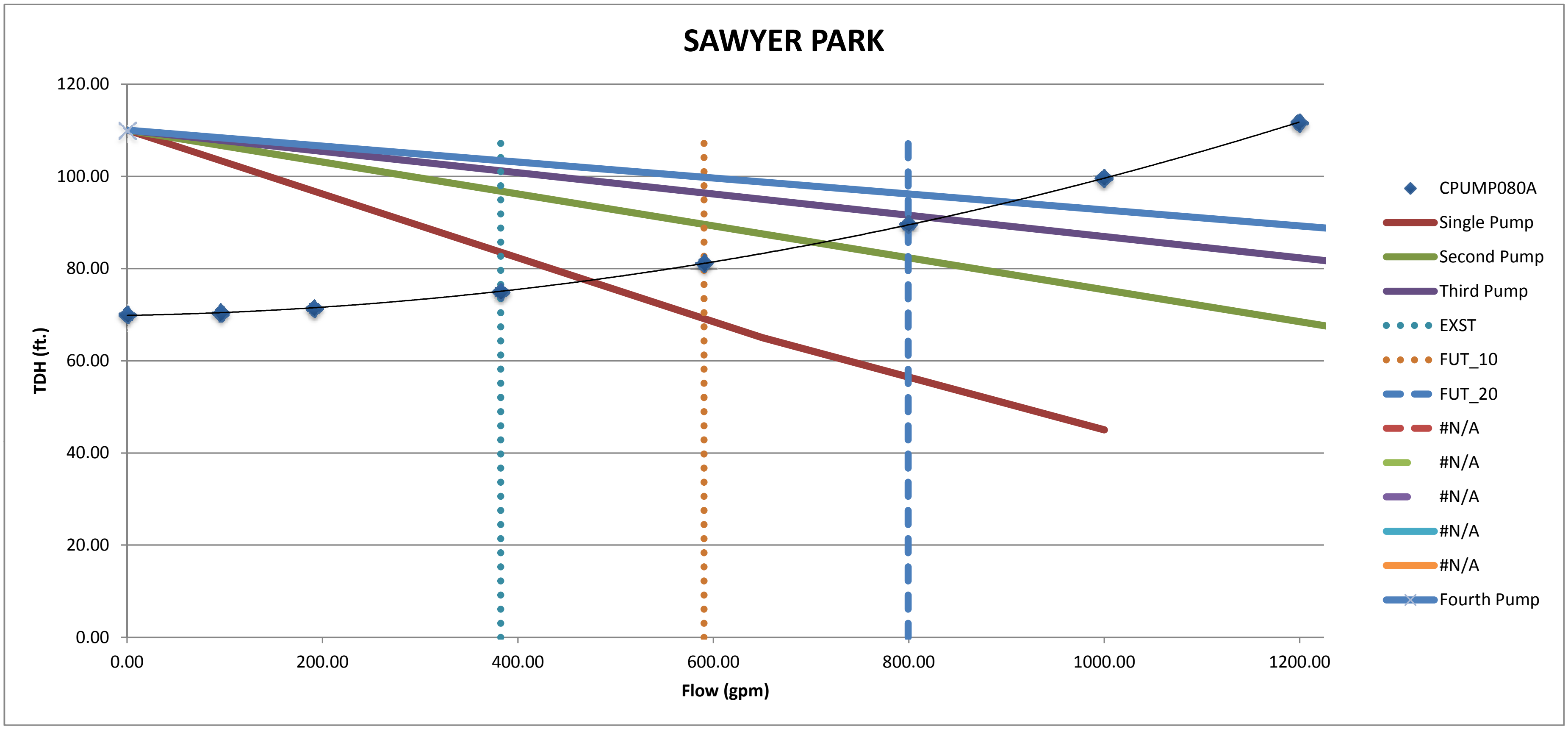
RIM ROCK RIDERS - All Lift Stations Operating
250.0
200.0
150.0
100.0
50.0
0.0
TDH (ft.)
0
5
10
15
20
25
30
35
40
Flow (gpm)
CPUMP084B
Single Pump
Second Pump
Third Pump
EXST
FUT_10
FUT_20
#N/A
#N/A
#N/A
#N/A
#N/A

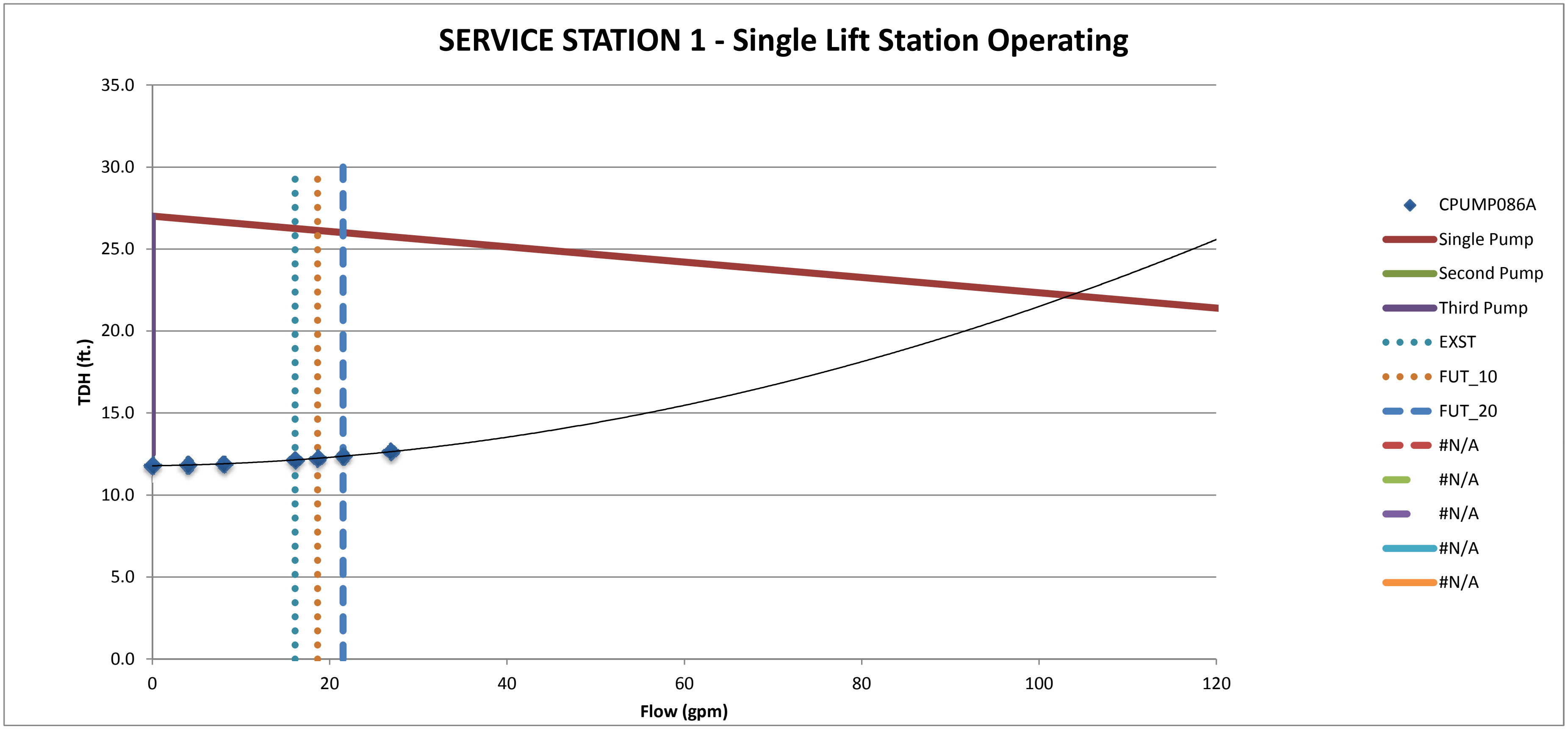


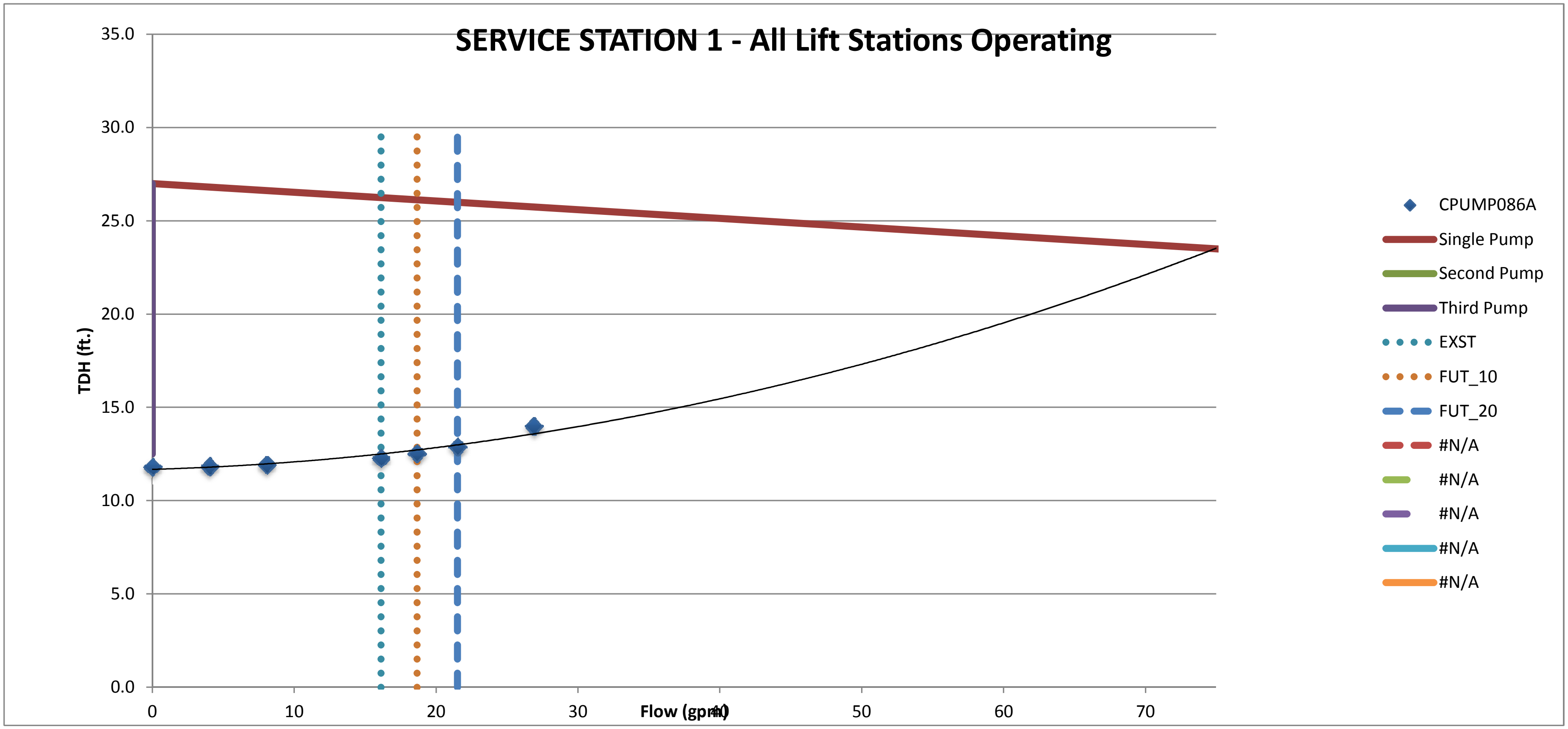
RIVERHOUSE
TDH (ft.)
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0.00
200.00
400.00
600.00
800.00
1000.00
1200.00
Flow (gpm)
CPUMP078B
Single Pump
Second Pump
Third Pump
EXST
FUT_10
FUT_20
#N/A
#N/A
#N/A
#N/A
#N/A


RIVER RIM - Original Force Main
TDH (ft.)
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
0.00
100.00
200.00
300.00
400.00
500.00
600.00
700.00
Flow (gpm)
CPUMP070B
Single Pump
Second Pump
Third Pump
EXST
FUT_10
FUT_20
#N/A
#N/A
#N/A
#N/A
#N/A

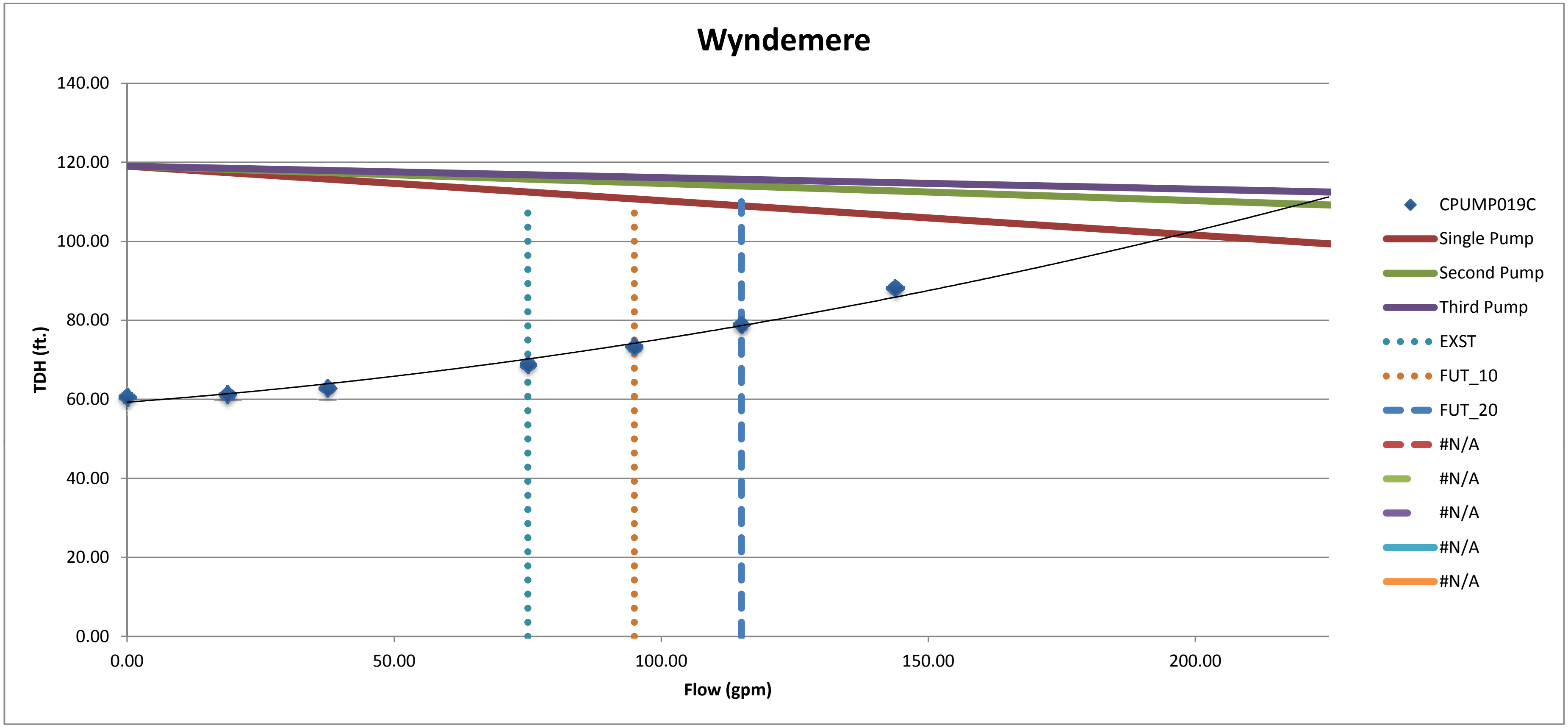

RIVER RIM
TDH (ft.)
500.00
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
0.00
50.00
100.00
150.00
200.00
250.00
300.00
350.00
400.00
Flow (gpm)
CPUMP070B
Single Pump
Second Pump
Third Pump
EXST
FUT_10
FUT_20
#N/A
#N/A
#N/A
#N/A
#N/A
Poly. (CPUMP070B)


SAWYER PARK
120.00
100.00
80.00
60.00
40.00
20.00
0.00
TDH (ft.)
0.00
200.00
400.00
600.00
800.00
1000.00
1200.00
Flow (gpm)
CPUMP080A
Single Pump
Second Pump
Third Pump
EXST
FUT_10
FUT_20
#N/A
#N/A
#N/A
#N/A
#N/A
Fourth Pump


SERVICE STATION 1 - Single Lift Station Operating
TDH (ft.)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
20
40
60
80
100
120
Flow (gpm)
CPUMP086A
Single Pump
Second Pump
Third Pump
EXST
FUT_10
FUT_20
#N/A
#N/A
#N/A
#N/A
#N/A



SERVICE STATION 1 - All Lift Stations Operating
TDH (ft.)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
10
20
30
Flow (gpm)
40
50
60
70
CPUMP086A
Single Pump
Second Pump
Third Pump
EXST
FUT_10
FUT_20
#N/A
#N/A
#N/A
#N/A
#N/A


Wyndemere
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
TDH (ft.)
0.00
50.00
100.00
150.00
200.00
Flow (gpm)
CPUMP019C
Single Pump
Second Pump
Third Pump
EXST
FUT_10
FUT_20
#N/A
#N/A
#N/A
#N/A
#N/A

MSA

APPENDIX 5A

Supplemental Information for Project Unit Costs

APPENDIX 5A
SUPPLEMENTAL INFORMATION FOR PROJECT UNIT COSTS

Introduction

This appendix presents project unit cost tables and project cost curves for collection system assets described in Section 5—Project Unit Costs and Cost Analysis. Project unit costs presented here provide the cost basis for the optimization process used to evaluate collection system alternatives, as referenced in Section 6—Optimization. Project unit costs are also used for development of the final Capital Improvement Project (CIP) budgets associated with the collection system improvements recommended for adoption by the City; see Section 7—Capital Improvement Program. All costs identified in this section reference 2013 U.S. dollars.

Component Unit Costs

The component costs of manholes, air & and vacuum valves, and cleanouts are provided as a component unit cost, because these are incorporated into other project unit costs and can therefore only be summarized as a component unit cost.

Manholes

Project unit costs for trenched new gravity pipes and interceptors, and trenched gravity pipe and interceptor upgrades, presented in Table 5A-6 and Table 5A-7, include the cost of manholes. Manhole materials and installation component unit costs used in calculating manhole unit costs ($/LF) are presented in Table 5A-1. The material and installation costs shown do not include application of mark-ups for construction, or project unit costs. Cost data from the *(City of Bend) Collection System Master Plan Final Report, MWH, July 2007* and the *Collection System Master Plan Addendum No. 4, CH2MHill, May 2011* were used as the basis for estimating the cost of manholes.

Table 5A-1
Manhole Material and Installation Costs

Pipe Diameter (inches)	Manhole Cost by Depth ($/each)							
	0-5 (ft)	5-10 (ft)	10-15 (ft)	15-20 (ft)	20-25 (ft)	25-30 (ft)	30-35 (ft)	35-40 (ft)
8	4,786	4,786	5,991	7,550	9,021	11,370	12,603	14,223
10	4,786	4,786	5,991	7,550	9,021	11,370	12,603	14,223
12	4,786	4,786	5,991	7,550	9,021	11,370	12,603	14,223
18	4,786	4,786	5,991	7,550	9,021	11,370	12,603	14,223
24	4,786	4,786	5,991	7,550	9,021	11,370	12,603	14,223
30	7,949	7,949	10,378	13,382	15,551	18,948	21,393	24,110

Pipe Diameter (inches)	Manhole Cost by Depth ($/each)							
	0-5 (ft)	5-10 (ft)	10-15 (ft)	15-20 (ft)	20-25 (ft)	25-30 (ft)	30-35 (ft)	35-40 (ft)
36	7,949	7,949	10,378	13,382	15,551	18,948	21,393	24,110
42	9,949	9,949	13,285	16,984	20,315	24,393	27,761	31,353
48	9,949	9,949	13,285	16,984	20,315	24,393	27,761	31,353
54	10,888	10,888	14,573	18,725	22,183	26,570	30,280	34,178
60	11,778	11,778	15,826	20,354	24,109	28,794	32,867	37,098
66	12,668	12,668	17,079	21,983	26,035	31,017	35,453	40,018
72	13,558	13,558	18,332	23,612	27,961	33,240	38,039	42,938
78	14,447	14,447	19,585	25,241	29,887	35,463	40,625	45,858
84	15,337	15,337	20,838	26,870	31,813	37,687	43,211	48,778
90	16,227	16,227	22,091	28,499	33,739	39,910	45,797	51,698
96	17,117	17,117	23,344	30,128	35,664	42,133	48,383	54,618
102	18,007	18,007	24,597	31,757	37,590	44,356	50,969	57,539
108	18,897	18,897	25,850	33,386	39,516	46,580	53,555	60,459

Air & Vacuum Valves and Cleanouts

Project unit costs for trenched force mains, presented in Table 5A-10, include the unit costs of air & vacuum valves and cleanouts. Air and vacuum valve cleanout materials and installation costs used in calculating pressure system manhole unit cost ($/EA) are presented in Table 5A-2. The material and installation costs shown do not include application of mark-ups for construction or project unit costs. Cost data from the *(City of Bend) Collection System Master Plan Final Report, MWH, July 2007* and the *Collection System Master Plan Addendum No. 4, CH2MHill, May 2011* was used as the basis for estimating the cost of air & vacuum valves and cleanouts.

Table 5A-2
Air & Vacuum Valves, Cleanout Material, and Installation Cost

Pipe Diameter (inches)	Air & Vacuum Valves and Cleanout Cost ($/each)
6	9,749
8	10,349
10	13,549
12	15,349
18	17,149
24	18,949
30	20,749
36	20,749
48	20,749

Linear Asset Project Unit Costs

The following tables present project unit costs used in calculation of capital cost (initial cost) for the referenced category of work. Operation and Maintenance (O&M) costs are not included in the project unit costs, but are accounted for in equivalent uniform annual cost analysis conducted within the optimization process.

Surface Restoration

Project unit costs for linear asset projects, presented in tables 5A-6 through 5A-10, do not include the unit costs ($/LF) for surface restoration. The cost of surface restoration during construction of linear assets is dependent on the existing roadway surface in the following alignments: dirt or gravel surfaces, local road surface, or arterial road surfaces.

Surface restoration costs ($/LF) used in calculating the project unit cost of a project are presented in Table 5A-3, Table 5A-4 and Table 5A-5. Cost data from the *(City of Bend) Collection System Master Plan Final Report, MWH, July 2007* and the *Collection System Master Plan Addendum No. 4, CH2MHill, May 2011* was used as the basis for estimating the cost of surface restoration for dirt or gravel surfaces and local and arterial streets up to 15 feet deep. At a depth greater than 15 feet for local and arterial streets, construction is assumed to require full street restoration, including asphalt, striping, median, sidewalk, curb and gutter. Current local unit cost data and sources such as *RS Means* were used as the basis for estimating the cost of deeper sewer surface restoration.

Table 5A-3
Dirt or Gravel Surface Restoration Project Unit Costs

Pipe Diameter (inches)	Total Capital Cost by Depth ($/ft)							
	0-5 (ft)	5-10 (ft)	10-15 (ft)	15-20 (ft)	20-25 (ft)	25-30 (ft)	30-35 (ft)	35-40 (ft)
8	16	16	16	16	16	16	16	16
10	16	16	16	16	16	16	16	16
12	16	16	16	16	16	16	16	16
18	16	16	16	16	16	16	16	16
24	16	16	16	16	16	16	16	16
30	18	18	18	18	18	18	18	18
36	21	21	21	21	21	21	21	21
42	23	23	23	23	23	23	23	23
48	23	23	23	23	23	23	23	23
54	26	26	26	26	26	26	26	26
60	28	28	28	28	28	28	28	28
66	30	30	30	30	30	30	30	30
72	33	33	33	33	33	33	33	33
78	35	35	35	35	35	35	35	35
84	37	37	37	37	37	37	37	37
90	39	39	39	39	39	39	39	39
96	41	41	41	41	41	41	41	41
102	43	43	43	43	43	43	43	43
108	46	46	46	46	46	46	46	46

Table 5A-4
Local Road Surface Restoration Project Unit Costs

Pipe Diameter (inches)	Total Capital Costs by Depth ($/ft)							
	0-5 (ft)	5-10 (ft)	10-15 (ft)	15-20 (ft)	20-25 (ft)	25-30 (ft)	30-35 (ft)	35-40 (ft)
8	20	20	20	145	145	145	145	145
10	20	20	20	145	145	145	145	145
12	20	20	20	145	145	145	145	145
18	23	23	23	145	145	145	145	145
24	26	26	26	145	145	145	145	145
30	35	35	35	145	145	145	145	145
36	39	39	39	145	145	145	145	145
42	44	44	44	145	145	145	145	145
48	44	44	44	145	145	145	145	145
54	50	50	50	145	145	145	145	145
60	54	54	54	145	145	145	145	145
66	58	58	58	145	145	145	145	145
72	62	62	62	145	145	145	145	145
78	66	66	66	145	145	145	145	145
84	70	70	70	145	145	145	145	145
90	74	74	74	145	145	145	145	145
96	78	78	78	145	145	145	145	145
102	82	82	82	145	145	145	145	145
108	86	86	86	145	145	145	145	145

Table 5A-5
Arterial Road Surface Restoration Project Unit Costs

Pipe Diameter (inches)	Total Capital Costs by Depth ($/ft)							
	0-5 (ft)	5-10 (ft)	10-15 (ft)	15-20 (ft)	20-25 (ft)	25-30 (ft)	30-35 (ft)	35-40 (ft)
8	46	46	46	220	220	220	220	220
10	46	46	46	220	220	220	220	220
12	46	46	46	220	220	220	220	220
18	53	53	53	220	220	220	220	220
24	59	59	59	220	220	220	220	220
30	79	79	79	220	220	220	220	220
36	89	89	89	220	220	220	220	220
42	99	99	99	220	220	220	220	220
48	99	99	99	220	220	220	220	220
54	113	113	113	220	220	220	220	220
60	122	122	122	220	220	220	220	220
66	132	132	132	220	220	220	220	220
72	141	141	141	220	220	220	220	220
78	150	150	150	220	220	220	220	220
84	159	159	159	220	220	220	220	220
90	169	169	169	220	220	220	220	220
96	178	178	178	220	220	220	220	220
102	187	187	187	220	220	220	220	220
108	197	197	197	220	220	220	220	220

Trenched New Gravity Pipes and Interceptors

Project unit costs for trenched new gravity pipes are presented in Table 5A-6. Project unit costs include the cost of manholes, but do not include the cost of surface restoration for the roadway surface associated with the alignment of a specific project. Cost data from the *(City of Bend) Collection System Master Plan Final Report, MWH, July 2007* and the *Collection System Master Plan Addendum No. 4, CH2MHill, May 2011* was used as the basis for estimating the cost of trenched new gravity pipes and interceptors.

Table 5A-6
Trenched New Gravity Pipe and Interceptor Project Unit Costs

Pipe Diameter (inches)	Total Pipe Capital Cost by Depth ($/ft)							
	0-5 (ft)	5-10 (ft)	10-15 (ft)	15-20 (ft)	20-25 (ft)	25-30 (ft)	30-35 (ft)	35-40 (ft)
8	207	207	332	534	807	1,068	1,464	2,006
10	230	230	359	556	815	1,072	1,477	2,014
12	247	247	377	575	824	1,077	1,491	2,022
18	304	304	439	632	863	1,103	1,532	2,080
24	354	354	493	681	894	1,175	1,563	2,092
30	449	449	600	793	992	1,320	1,677	2,164
36	489	489	643	834	1,024	1,371	1,709	2,179
42	540	540	701	894	1,082	1,454	1,779	2,243
48	598	598	753	945	1,138	1,519	1,841	2,256
54	663	663	830	1,019	1,182	1,589	1,867	2,286
60	722	722	895	1,082	1,233	1,662	1,920	2,324
66	782	782	959	1,146	1,284	1,736	1,977	2,370
72	841	841	1,023	1,209	1,336	1,810	2,036	2,419
78	900	900	1,088	1,273	1,387	1,883	2,090	2,463
84	960	960	1,152	1,336	1,438	1,957	2,148	2,513
90	1,019	1,019	1,217	1,399	1,490	2,030	2,211	2,570
96	1,078	1,078	1,281	1,463	1,541	2,104	2,266	2,619
102	1,138	1,138	1,346	1,526	1,592	2,178	2,329	2,677
108	1,197	1,197	1,410	1,590	1,644	2,251	2,387	2,729

Trenched Gravity Pipe and Interceptor Upgrades

Project unit costs for trenched gravity pipe and interceptor upgrades are presented in Table 5A-7 and include the cost of new manholes. The costs do not include the cost of surface restoration for the roadway surface associated with the alignment of a specific project. Cost data from the *(City of Bend) Collection System Master Plan Final Report, MWH, July 2007* and the *Collection System Master Plan Addendum No. 4, CH2MHill, May 2011* was used as the basis for estimating the cost of trenched gravity pipe and interceptor upgrades.

Table 5A-7
Trenched Gravity Pipe and Interceptor Upgrade Project Unit Costs

Pipe Diameter (inches)	Total Capital Cost by Depth ($/ft)							
	0-5 (ft)	5-10 (ft)	10-15 (ft)	15-20 (ft)	20-25 (ft)	25-30 (ft)	30-35 (ft)	35-40 (ft)
8	282	282	408	610	883	1,143	1,540	2,082
10	305	305	435	632	891	1,148	1,553	2,090
12	322	322	453	650	899	1,152	1,566	2,098
18	380	380	515	708	938	1,179	1,608	2,156
24	429	429	569	757	970	1,250	1,639	2,167
30	532	532	684	876	1,075	1,403	1,760	2,247
36	572	572	726	917	1,107	1,454	1,792	2,262
42	623	623	784	977	1,165	1,537	1,862	2,326
48	681	681	836	1,028	1,221	1,602	1,924	2,383
54	746	746	913	1,102	1,265	1,672	1,950	2,369
60	805	805	978	1,165	1,316	1,746	2,003	2,407
66	865	865	1,042	1,229	1,368	1,819	2,060	2,453
72	924	924	1,106	1,292	1,419	1,893	2,119	2,502
78	983	983	1,171	1,356	1,470	1,966	2,173	2,546
84	1,043	1,043	1,235	1,419	1,521	2,040	2,231	2,596
90	1,102	1,102	1,300	1,482	1,573	2,113	2,294	2,653
96	1,161	1,161	1,364	1,546	1,624	2,187	2,349	2,702
102	1,221	1,221	1,429	1,609	1,675	2,261	2,412	2,760
108	1,280	1,280	1,493	1,673	1,727	2,334	2,470	2,812

Trenched Inline Storage

Project unit costs for trenched inline storage are presented in Table 5A-8. Project unit costs include the cost of manhole entrance/diversion structures, bypass pumping, and reconnection of existing services, but do not include the cost of surface restoration for the roadway surface associated with the alignment of a specific project. When surface restoration cost is applied, the cost assumes restoration of the full roadway width regardless of the inline storage cross section used. Current unit cost data sources such as *RS Means* were used as the basis for estimating the cost of trenched inline storage.

Table 5A-8
Trenched Inline Storage Project Unit Costs

Cross Section WxD (ft)	Total Capital Cost by Depth ($/ft)							
	0-5 (ft)	5-10 (ft)	10-15 (ft)	15-20 (ft)	20-25 (ft)	25-30 (ft)	30-35 (ft)	35-40 (ft)
6x6	0	2,943	4,132	5,331	6,527	7,750	8,425	9,626
6x8	0	2,960	4,149	5,348	6,544	7,767	8,442	9,643
6x10	0	0	4,177	5,376	6,573	7,795	8,470	9,671
6x12	0	0	0	5,417	6,614	7,836	8,609	9,810
8x6	0	3,473	4,960	6,457	7,951	9,471	10,443	11,942
8x8	0	3,526	5,012	6,509	8,003	9,523	10,496	11,995
8x10	0	0	5,088	6,585	8,079	9,599	10,572	12,070
8x12	0	0	0	6,688	8,182	9,702	10,772	12,271
10x6	0	4,015	5,799	7,594	9,386	11,203	12,474	14,270
10x8	0	4,115	5,899	7,694	9,486	11,303	12,574	14,370
10x10	0	0	6,041	7,836	9,628	11,445	12,715	14,512
10x12	0	0	0	8,027	9,819	11,636	13,005	14,801
12x6	0	4,570	6,652	8,744	10,833	12,948	14,516	16,610
12x8	0	4,731	6,813	8,905	10,995	13,110	14,678	16,772
12x10	0	0	7,044	9,136	11,225	13,341	14,909	17,003
12x12	0	0	0	9,452	11,541	13,656	15,334	17,367

Trenched Siphon Structure

Project unit costs for trenched siphon structure are presented in Table 5A-9. Project unit costs include the cost of manhole entrance/diversion structures, and double-barrel siphon pipe, but does not include the cost of surface restoration for the roadway surface associated with the alignment of a specific project. Current unit cost data sources such as *RS Means* were used as the basis for estimating the cost of trenched siphon structure.

Table 5A-9
Trenched Siphon Structure Project Unit Costs

Pipe Diameter (inches)	Total Capital Cost by Depth ($/ft)							
	0-5 (ft)	5-10 (ft)	10-15 (ft)	15-20 (ft)	20-25 (ft)	25-30 (ft)	30-35 (ft)	35-40 (ft)
8	492	492	739	1,126	1,631	2,139	2,850	3,820
10	547	547	809	1,200	1,685	2,179	2,970	3,966
12	595	595	868	1,273	1,771	2,299	3,097	4,121
18	726	726	1,015	1,423	1,901	2,420	3,272	4,362
24	841	841	1,144	1,551	2,003	2,611	3,402	4,452
30	1,136	1,136	1,500	1,962	2,415	3,157	3,937	4,983
36	1,230	1,230	1,601	2,061	2,500	3,287	4,032	5,053
42	1,401	1,401	1,814	2,300	2,768	3,631	4,382	5,422
48	1,544	1,544	1,948	2,439	2,921	3,814	4,567	5,612
54	1,717	1,717	2,155	2,652	3,076	4,036	4,709	5,681
60	1,875	1,875	2,335	2,840	3,247	4,265	4,905	5,858
66	2,034	2,034	2,515	3,027	3,418	4,492	5,109	6,050
72	2,193	2,193	2,694	3,215	3,587	4,720	5,314	6,244
78	2,352	2,352	2,874	3,402	3,756	4,946	5,509	6,428
84	2,511	2,511	3,053	3,589	3,925	5,172	5,711	6,623
90	2,670	2,670	3,233	3,776	4,093	5,397	5,923	6,833
96	2,829	2,829	3,412	3,963	4,262	5,622	6,119	7,022
102	2,989	2,989	3,592	4,149	4,429	5,847	6,330	7,233
108	3,148	3,148	3,771	4,336	4,597	6,072	6,529	7,429

Trenched Force Main

Project unit costs for trenched force mains are presented in Table 5A-10 and are applicable to new force mains installed in new or existing trenches, and include new air & vacuum valves and cleanouts. The costs include no bypass pumping, reconnection of services, or surface restoration for the roadway surface associated with the alignment of a specific project. Cost data from the *(City of Bend) Collection System Master Plan Final Report, MWH, July 2007* and the *Collection System Master Plan Addendum No. 4, CH2MHill, May 2011* was used as the basis for estimating cost of trenched force main.

Table 5A-10
Trenched Force Main Project Unit Costs

Pipe Diameter (inches)	Total Capital Cost ($/ft)
4	192
6	215
8	235
10	288
12	330
18	377
24	450
30	556
36	617
42	759

Trenchless River/Railroad/Highway Crossing Force Main

Project unit costs for trenchless river/railroad/highway crossing force mains are presented in Table 5A-11. These costs assume horizontal directional drilling in rock and include the cost of entry and receiving pits. Project unit costs assume no bypass pumping, reconnection of services, or surface restoration. Current unit cost data sources such as *RS Means* and estimates of unit costs from contractors with recent and applicable experience were used as the basis for estimating the cost of trenchless river/railroad/highway crossing force mains.

Table 5A-11
Trenchless River/Railroad/Highway Crossing
Force Main Project Unit Costs

Pipe Diameter (inches)	Total Capital Cost ($/ft)
8	304
10	375
12	448
18	891
24	1,201
30	1,497
36	1,866
42	3,053
48	4,589

Trenchless Canal/Railroad/Highway Crossing Gravity Pipe

Project unit costs for trenchless canal/railroad/highway crossing gravity pipe are presented in Table 5A-12. Project unit costs assume bore and jack construction techniques deployed in rock conditions and include the cost of entry and receiving pits, but do not include the costs for bypass pumping, reconnection of services, or surface restoration. Current unit cost data sources such as *RS Means* and unit cost estimates from construction contractors with recent and applicable experience were used as the basis for estimating the cost of trenchless canal/railroad/highway crossing gravity pipe.

Table 5A-12
Trenchless Canal/Railroad/Highway Crossing
Gravity Pipe Project Unit Costs

Pipe Diameter (inches)	Total Capital Cost ($/ft)
8	1,191
10	1,402
12	1,464
18	2,268
24	2,461
30	3,458
36	4,107
42	4,990
48	5,523
54	6,453
60	7,919
66	8,802
72	10,269

Trenchless Gravity Pipe Upgrades

Project unit costs for trenchless gravity pipe upgrades are presented in Table 5A-13. Project unit costs assume use of pipe bursting and pipe reaming techniques and include entry and receiving pits, bypass pumping and reconnection of services. Reference to available data for the total construction cost of similar projects undertaken in Oregon and the Northwest within last 15 years was used as the basis for estimating the cost of trenchless gravity pipe upgrades.

Table 5A-13
Trenchless Gravity Pipe Upgrade Project Unit Costs

Pipe Diameter (inches)	Total Capital Cost ($/ft)
8	189
10	198
12	212
18	294
24	433

Trenchless Gravity Pipe Rehabilitation

Project unit costs for trenchless gravity pipe rehabilitation are presented in Table 5A-14 and assume the use of cured-in-place pipe (CIPP) techniques. Project unit costs assume bypass pumping and reconnection of services. Reference to available data for the total construction cost of similar projects undertaken in Oregon and the Northwest within last 15 years was used as the basis for estimating the cost of trenchless gravity pipe rehabilitation.

Table 5A-14
Trenchless Gravity Pipe Rehabilitation Project Unit Costs

Pipe Diameter (inches)	Total Capital Cost ($/ft)
8	152
10	157
12	163
18	195
24	243
30	309
36	391
42	491
48	608
54	742
60	892
66	1,060
72	1,245

Nonlinear Asset Project Unit Costs

The following cost equations/cost curves provide project unit costs for estimating the capital cost (initial cost) of the referenced category of work. O&M cost is not included in the project unit cost, but is accounted for in equivalent uniform annual cost analysis conducted within the optimization process.

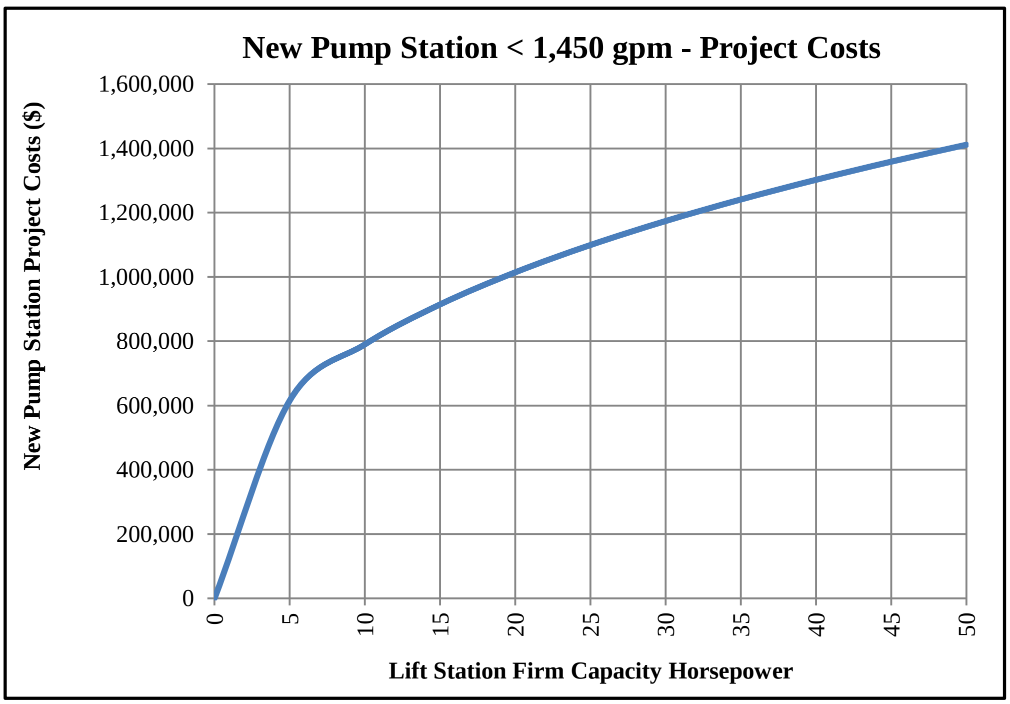
New Lift Stations

Equations 5A-1 and 5A-2, and the cost curves below, were used as the project cost basis for new lift stations, with cost as a function of peak wet weather flow and total dynamic head at peak wet weather flow. Equations account for cost of land acquisition, site development, building systems, mechanical, electrical, and instrumentation and controls. Reference to available data for the total construction cost of similar projects undertaken in Oregon and the Northwest within last 15 years was used to estimate the cost of new lift stations.

New Area Lift Stations < 1,450 gpm (2.0 MGD) Rated Capacity

Equation 5A-1: $Cost(\$) = 344{,}543*(H*Q/(3960*0.60))^{0.3604}$

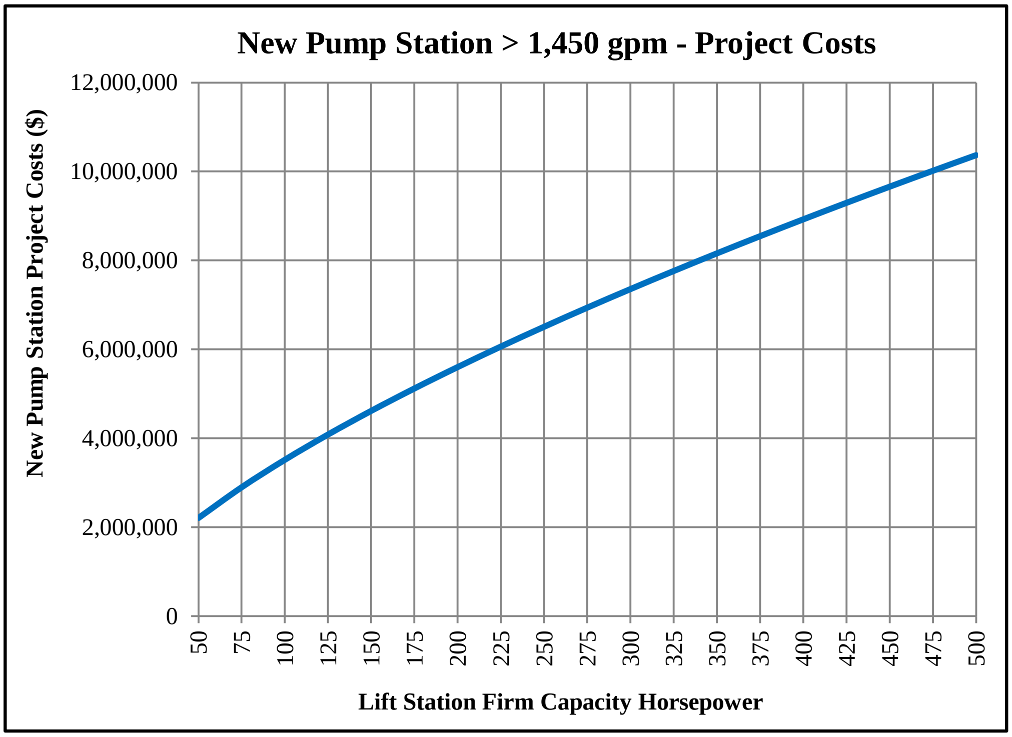
Figure 5A-1
New Pump Station < 1,450 gpm - Project Costs



New Regional Lift Stations > 1,450 gpm Rated Capacity

Equation 5A-2: $Cost(\$) = 159{,}271*(H*Q/(3960*0.60))^{0.6719}$

Figure 5A-2
New Pump Station > 1,450 gpm - Project Costs



Decommissioning Lift Stations

Project unit cost for the decommissioning of area lift stations is $28,000 lump sum. This includes work to demolish, abandon force main and remove the lift station and all appurtenances. This project unit cost will be used if a lift station is no longer needed due to connection to the gravity system. The cost of gravity connection and any other necessary connections use other applicable project unit costs.

Existing Lift Station Upgrades

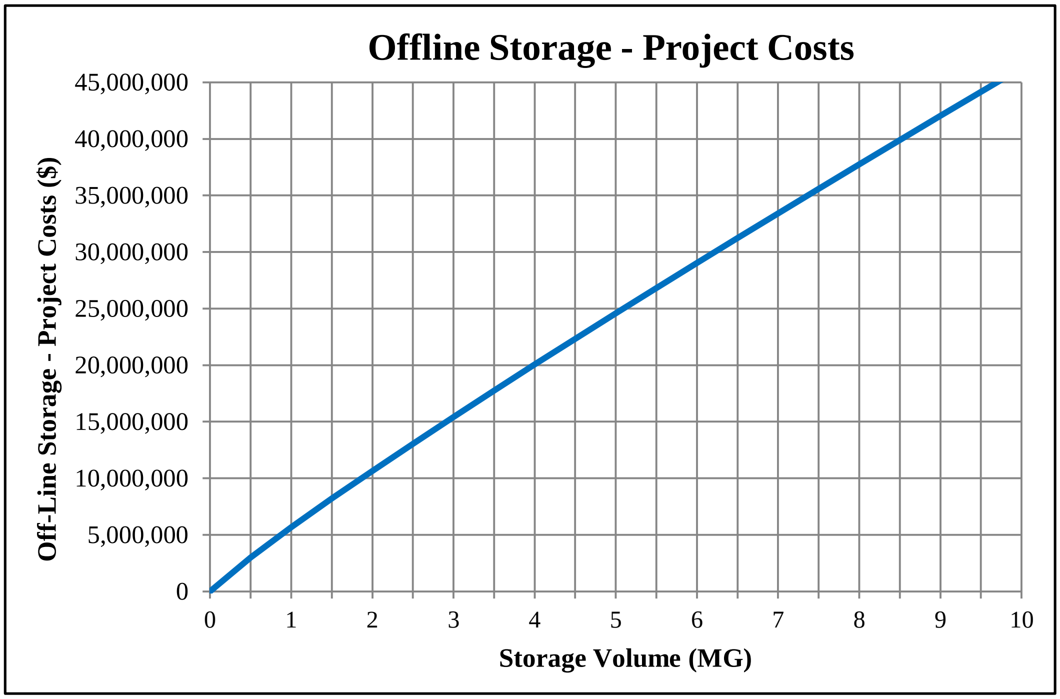
The cost for existing lift station upgrades is dependent on lift station specifics and the overall project components that are required. The cost development effort took several variables into account, including condition and operational input from the City O&M Department, the size of the lift station, site constraints and engineering judgment. Based on these factors, upgrade costs were broken into four cost categories; $100,000, $139,000, $150,000 or $345,000. Depending on the specific project the unit cost provides for installation of a new prefabricated wet well, and upgrade of mechanical and electrical systems. Equipment supplier estimates, available City bid tabs and construction costs of similar work undertaken in Oregon, Washington and Idaho within last 15 years was used to develop estimates for the existing lift station upgrades.

Offline Storage

Equation 5A-3 was used as the cost basis for offline storage with project unit costs as functions of storage volume expressed in millions of gallons, and includes costs associated with land procurement, engineering, construction, and administrative and legal services. Reference to available data for the total construction cost of similar projects undertaken in the United States within last 15 years was used to estimate the cost of offline storage.

Equation 5A-3: $Cost(\$) = 1{,}000{,}000 * 5.1708 * (Volume)^{0.9028} + 493{,}880 * (Volume)$

Figure 5A-3
Offline Storage - Project Costs



Satellite Treatment Facilities

Equations 5A-4, 5A-5, and 5A-6 describe the low, average and high project cost estimates for satellite treatment with cost as function of design average flow expressed in gallons per day. The range of estimated cost bracketed by the curves provides for variance in treatment complexity and land area requirements.

Estimated costs include engineering, construction, and administrative and legal services. Costs do not include land acquisition for either treatment facilities, treated water storage facilities or treated water disposal facilities. The cost of conveyance piping from the collection system to treatment facilities, or piping from treatment facilities to a treated water reuse/disposal site is also not included.

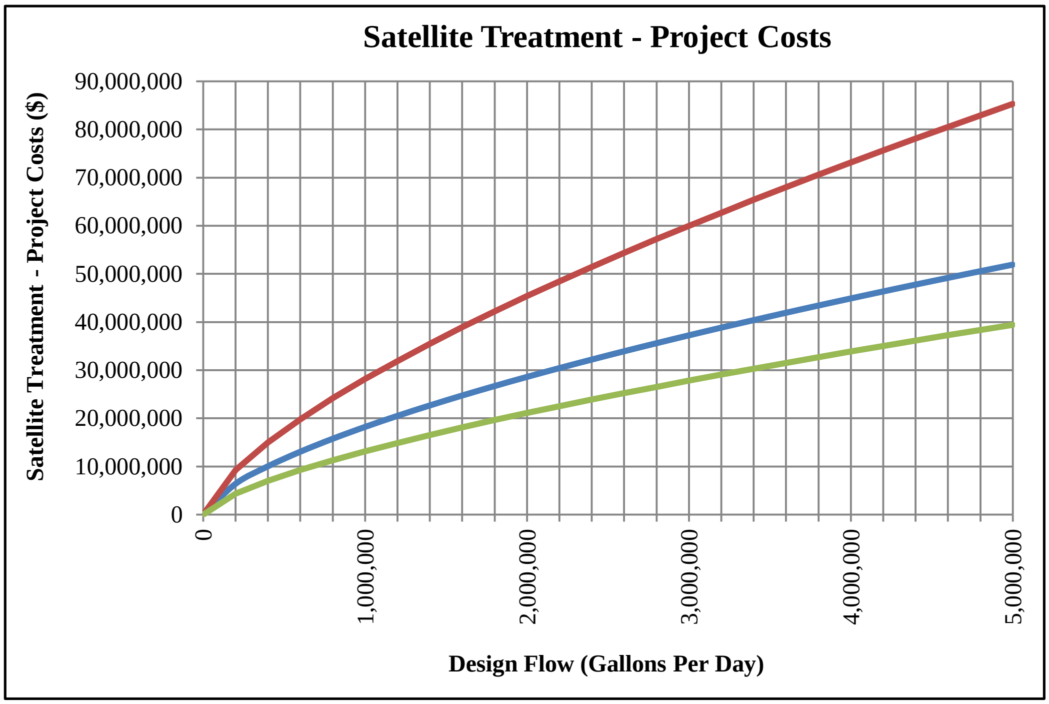
Reference to published cost curves and available data for the total construction cost of similar projects undertaken in Oregon and the Northwest within last 15 years was used to estimate the cost of Satellite Treatment Facilities.

Equation 5A-4: $Cost(\$)_{low} = 1{,}047.0 * (Flow_{Design\ Average})^{0.6831}$

Equation 5A-5: $Cost(\$)_{average} = 2{,}288.0 * (Flow_{Design\ Average})^{0.6502}$

Equation 5A-6: $Cost(\$)_{high} = 2{,}085.9 * (Flow_{Design\ Average})^{0.6884}$

Figure 5A-4
Satellite Treatment - Project Costs



APPENDIX 6A

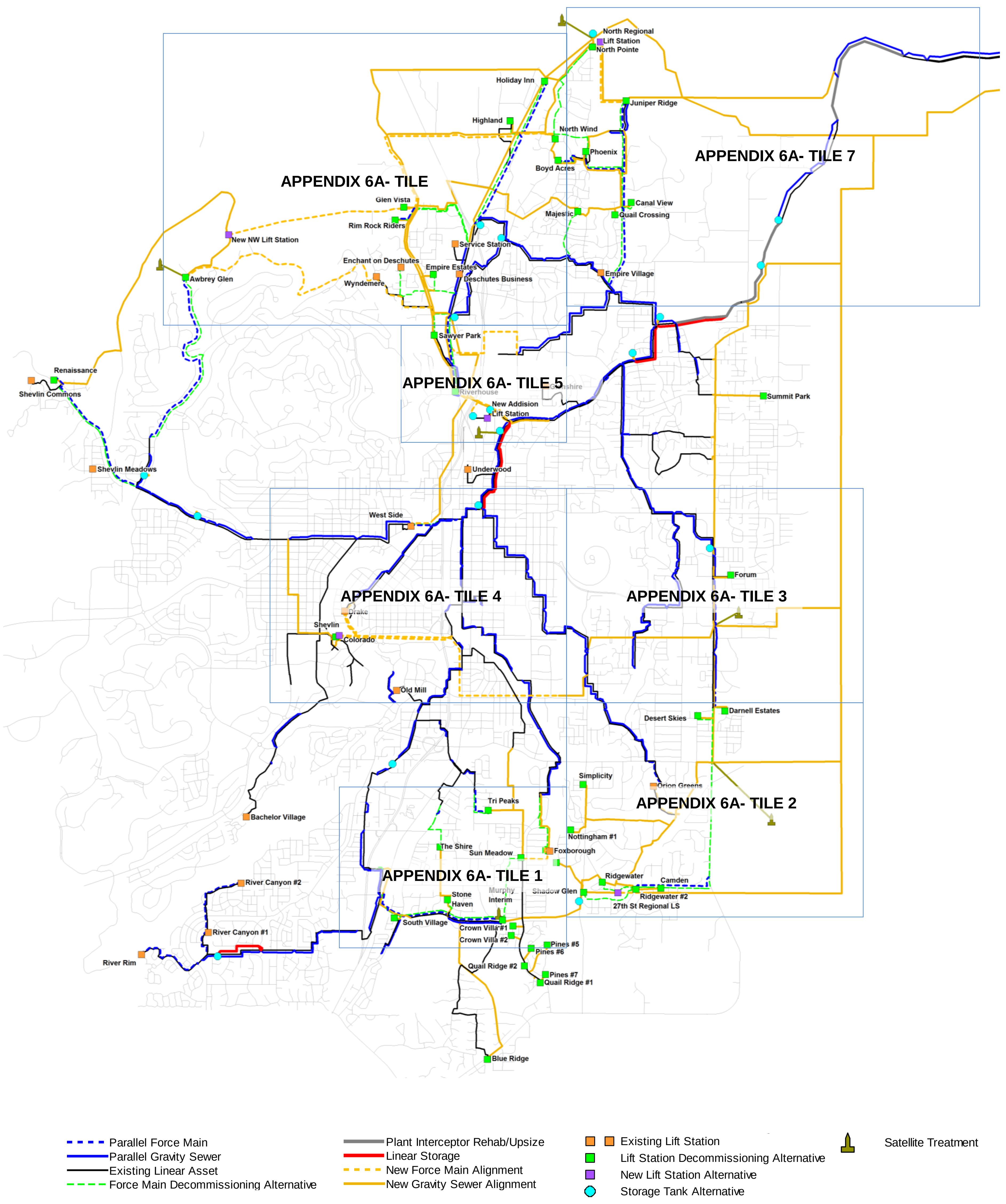
Optimization Solution Alternatives

APPENDIX 6A
Optimization Solution Alternatives

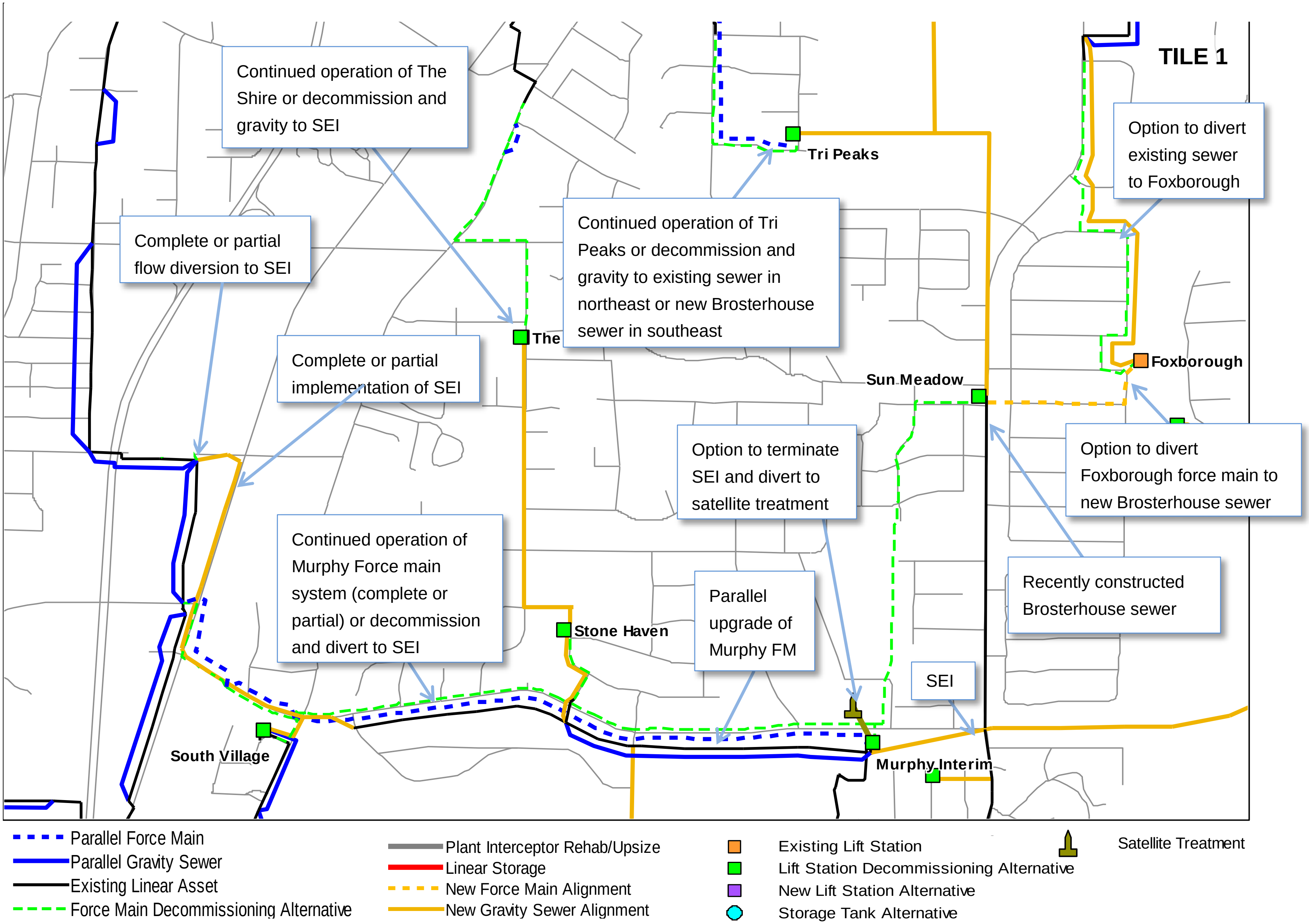
As described in Section 6, the capital improvement alternatives evaluated in the optimization analysis include:

- Improvements along existing alignments.
- New alignment alternatives.
- New lift stations and existing lift station upgrades and decommissioning alternatives.
- Storage tank alternatives (restricted to wet-weather operation).
- Linear transport/storage alternatives (restricted to wet-weather operation).
- Satellite treatment alternatives.

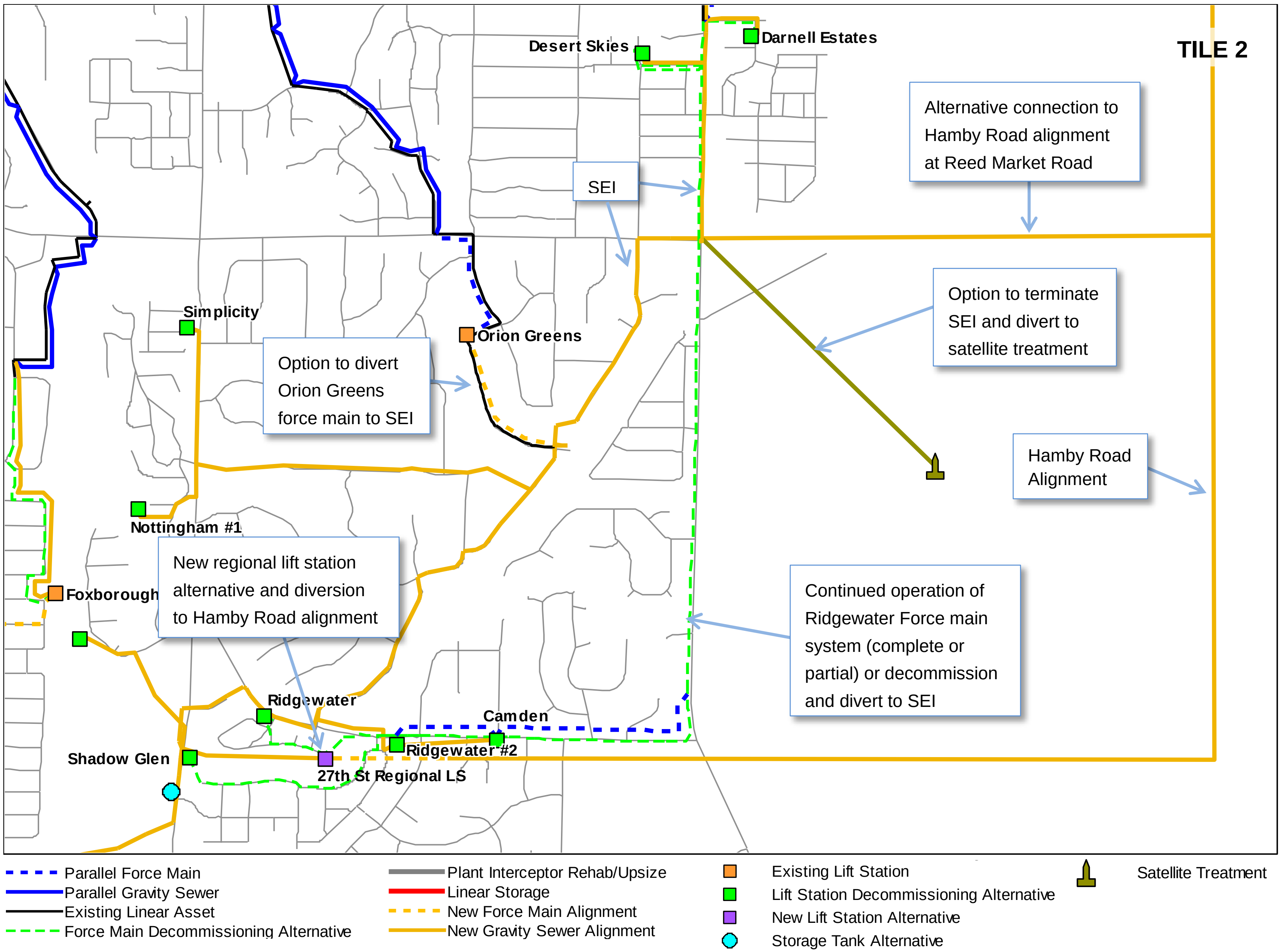
This appendix presents detailed figures and associated descriptions of the improvement alternatives included in the final optimization. Generic descriptions of each type of improvement and how it is evaluated in the optimization is presented in Section 6.


APPENDIX 6A- TILE 7
APPENDIX 6A- TILE
APPENDIX 6A- TILE 5
APPENDIX 6A- TILE 4
APPENDIX 6A- TILE 3
APPENDIX 6A- TILE 2
APPENDIX 6A- TILE 1
North Regional Lift Station
North Pointe
Juniper Ridge
Holiday Inn
Highland
North Wind
Phoenix
Boyd Acres
Canal View
Quail Crossing
Majestic
Glen Vista
Rim Rock Riders
New NW Lift Station
Service Station
Enchant on Deschutes
Empire Estates
Wyndemere
Deschutes Business
Empire Village
Awbrey Glen
Sawyer Park
Renaissance
Shevlin Commons
Riverhouse
New Addision Lift Station
Summit Park
Underwood
Shevlin Meadows
West Side
Forum
Drake
Shevlin
Colorado
Old Mill
Desert Skies
Darnell Estates
Simplicity
Orion Greens
Tri Peaks
Bachelor Village
Nottingham #1
The Shire
Sun Meadow
Foxborough
River Canyon #2
Ridgewater
Camden
Stone Haven
Murphy Interim
Shadow Glen
Ridgewater #2
27th St Regional LS
South Village
Crown Villa #1
Crown Villa #2
River Canyon #1
Pines #5
Pines #6
River Rim
Quail Ridge #2
Pines #7
Quail Ridge #1
Blue Ridge
Parallel Force Main
Parallel Gravity Sewer
Existing Linear Asset
Force Main Decommissioning Alternative
Plant Interceptor Rehab/Upsize
Linear Storage
New Force Main Alignment
New Gravity Sewer Alignment
Existing Lift Station
Lift Station Decommissioning Alternative
New Lift Station Alternative
Storage Tank Alternative
Satellite Treatment

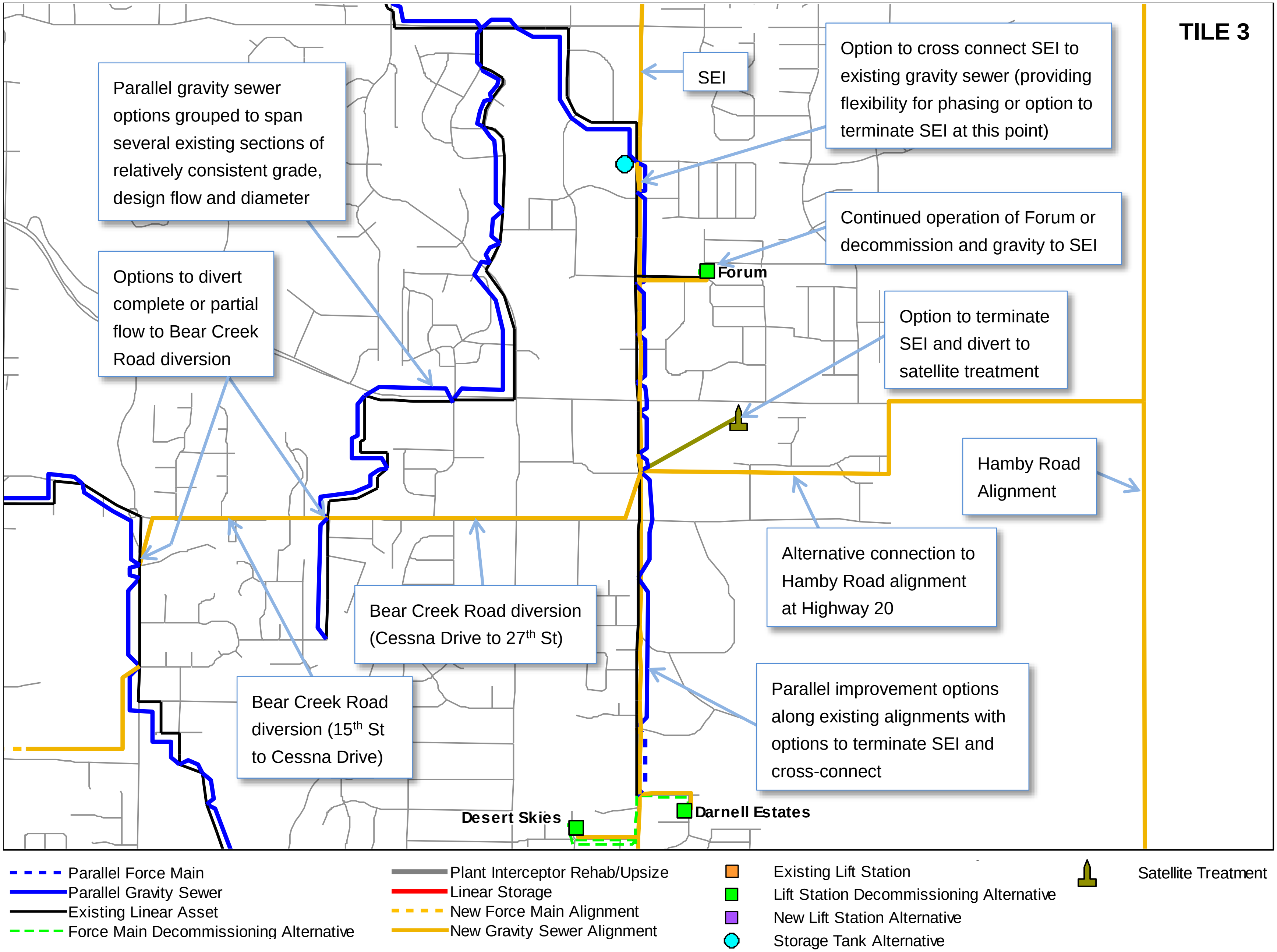
APPENDIX 6A
Optimization Solution Alternatives



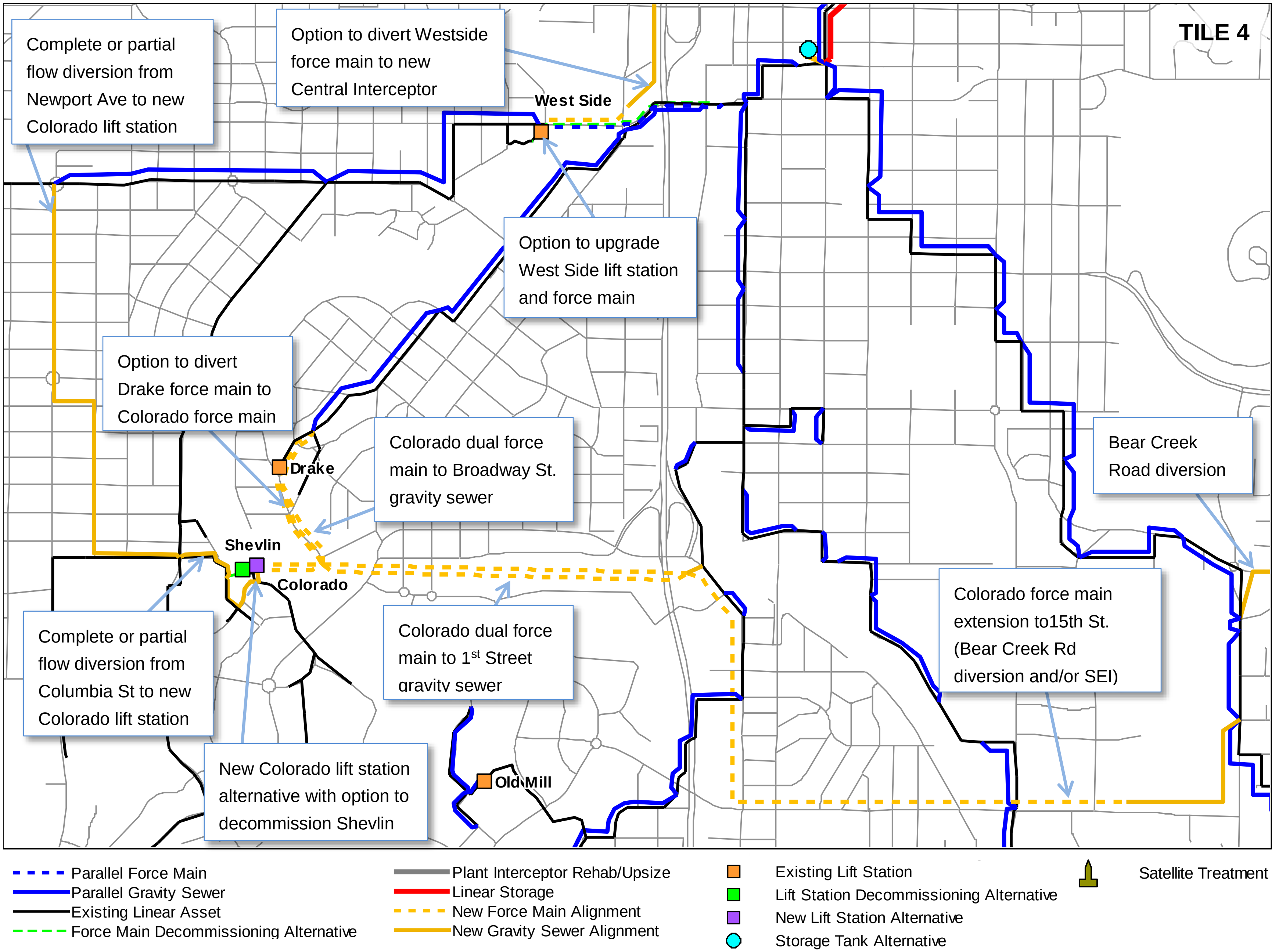
APPENDIX 6A
Optimization Solution Alternatives



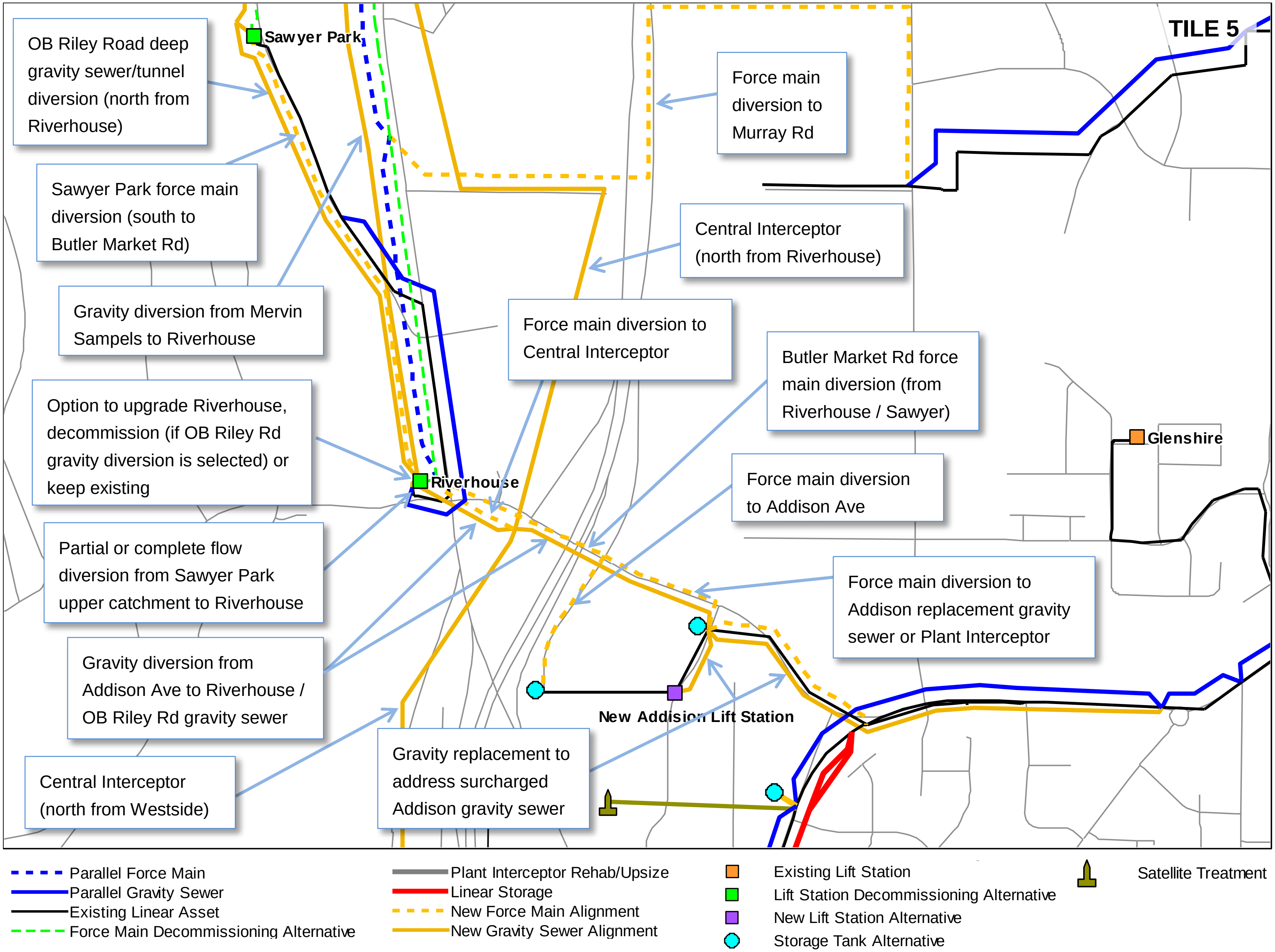
APPENDIX 6A
Optimization Solution Alternatives



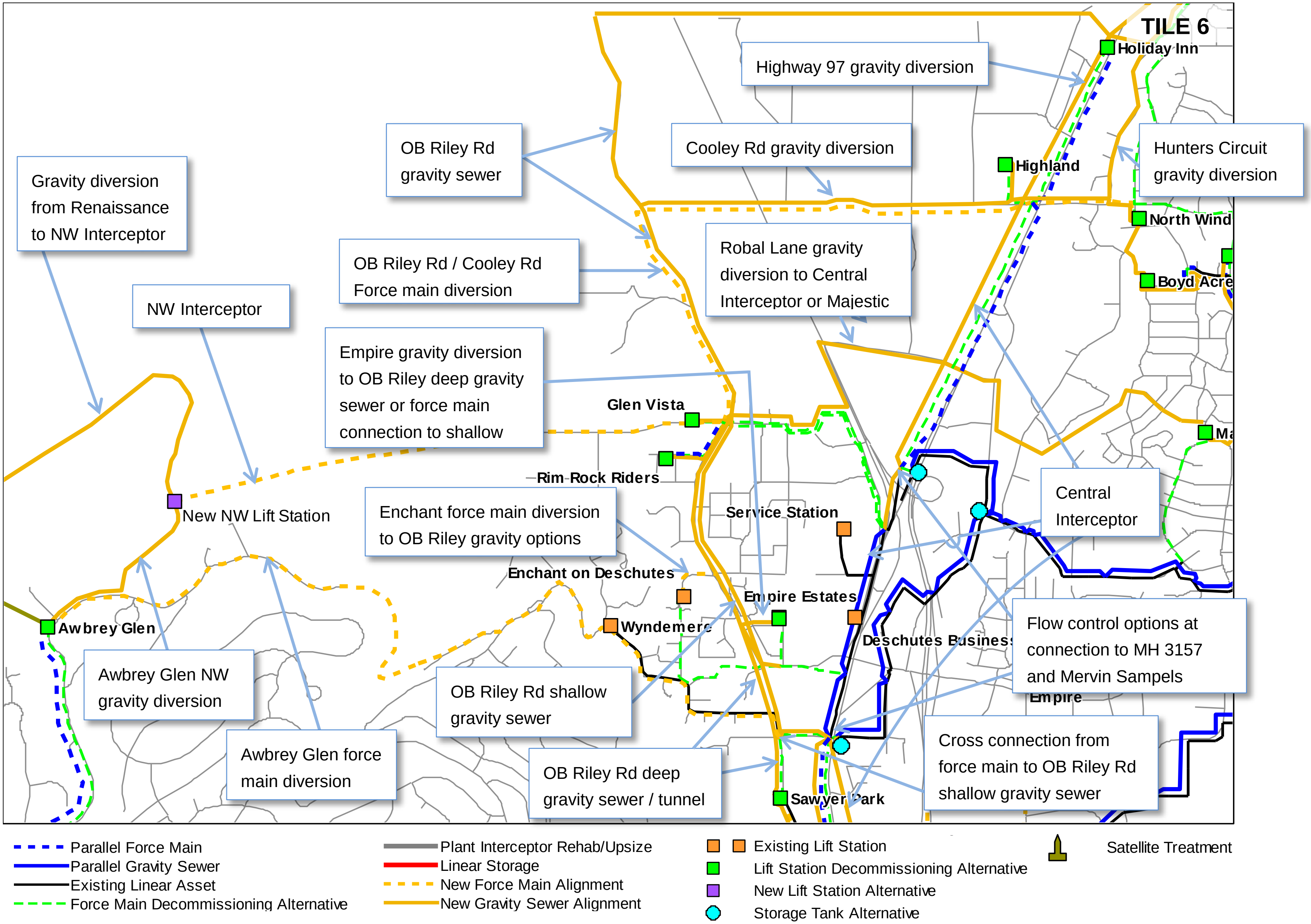
APPENDIX 6A
Optimization Solution Alternatives



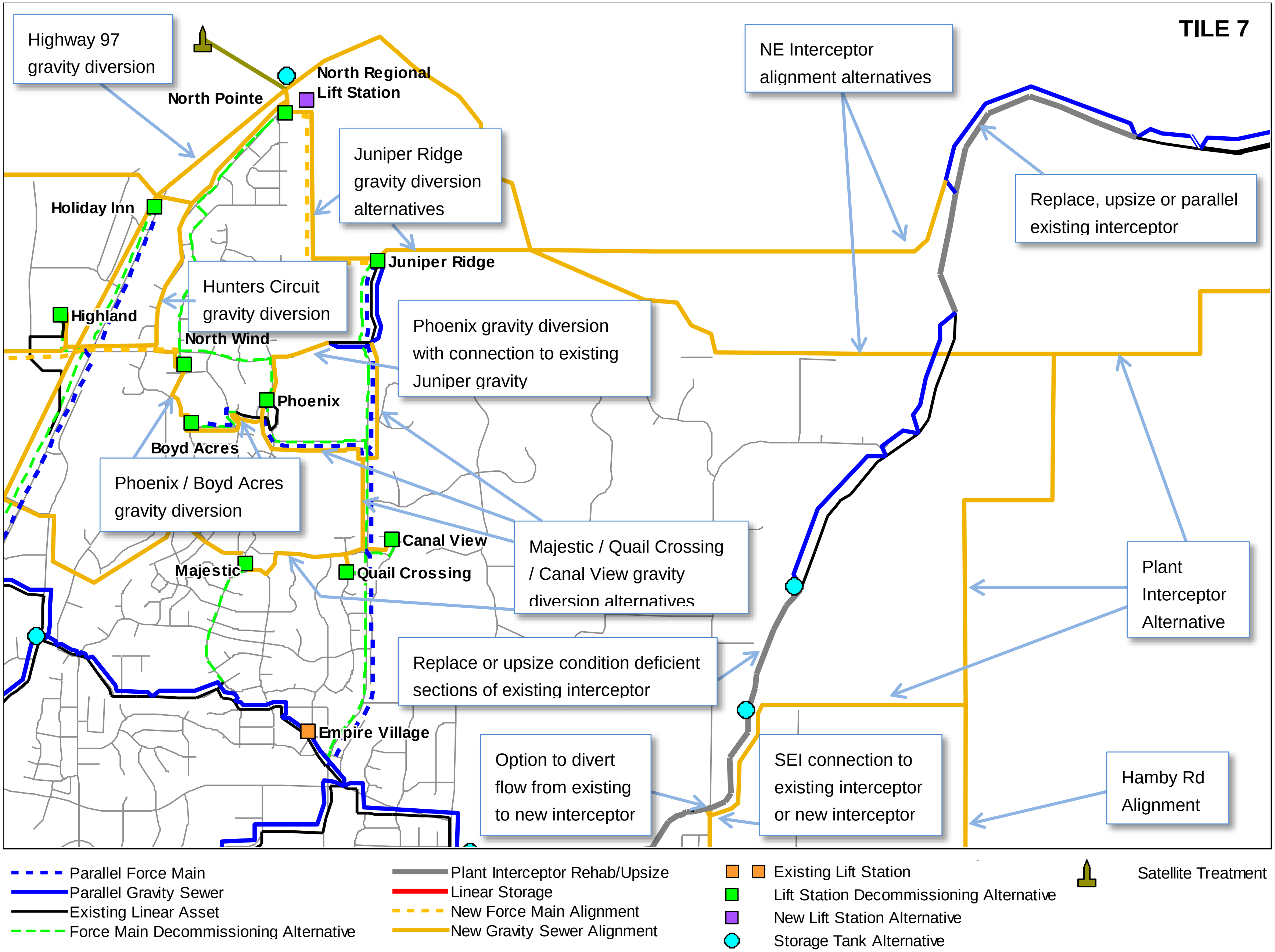
APPENDIX 6A
Optimization Solution Alternatives



APPENDIX 6A
Optimization Solution Alternatives



APPENDIX 6A
Optimization Solution Alternatives



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APPENDIX 6B

Initial Optimization Solutions

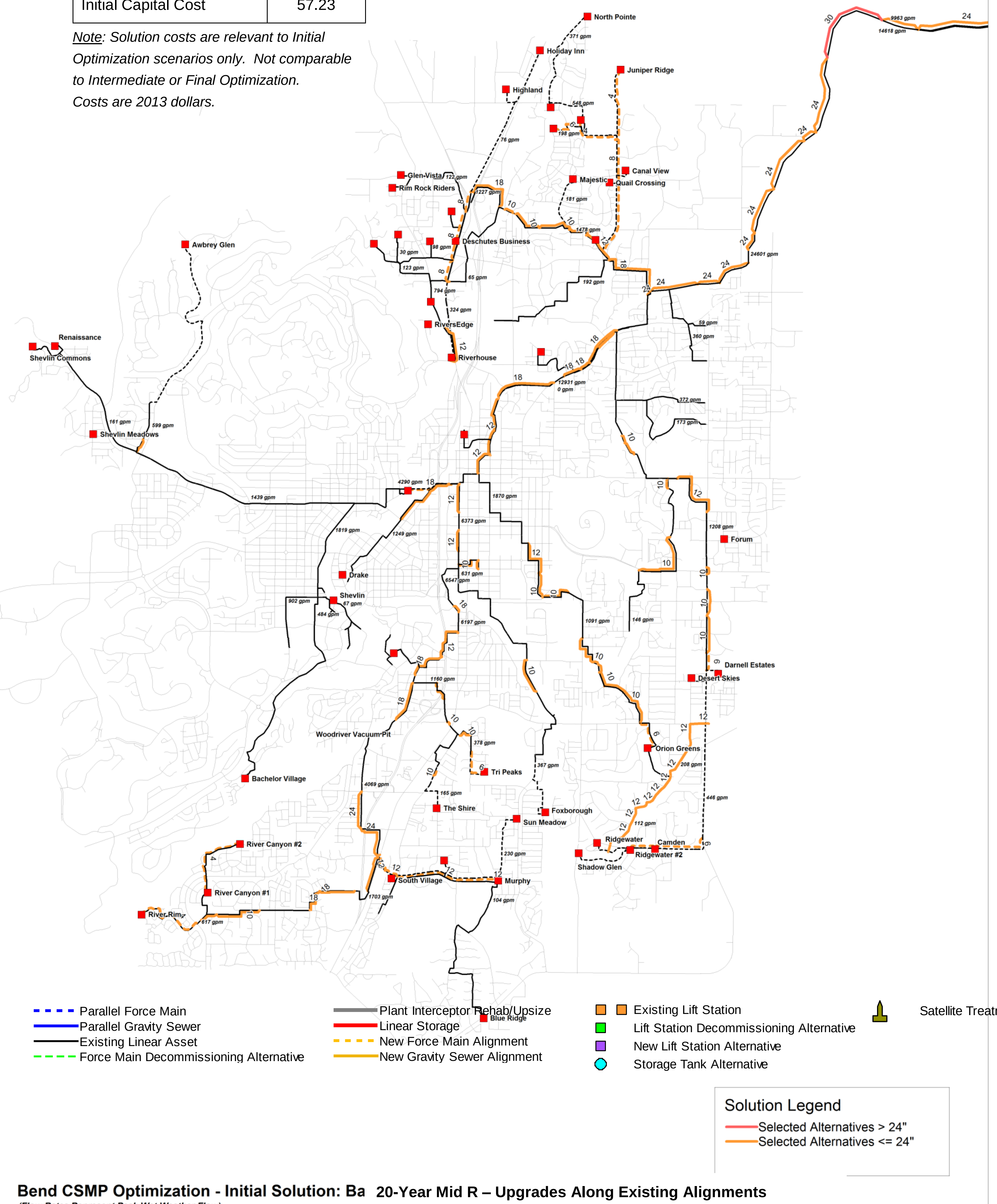
Plan view layouts and cost summaries of the initial optimization solutions are presented in this appendix for the following scenarios:

- Upsize Existing Infrastructure – The only improvement alternatives included in this scenario were improvements along existing alignments. New alignment alternatives, storage, and satellite treatment alternatives were not included. Sensitivity analyses were completed for both the Mid-R and High-R scenarios.
- All Options – All improvement alternatives were evaluated in this scenario. Sensitivity analyses were completed for both the Mid-R and High-R scenarios.
- All Options Except Storage – This scenario was performed to demonstrate the effect of excluding the storage alternatives selected in the All Options High-R scenario.

Appendix 6B
Initial Optimization
20-Year Mid-R – Upgrades Along Existing Alignments

Cost Item	Cost ($M)
40-Year Life-Cycle Cost	159.20
Initial Capital Cost	57.23

Note: Solution costs are relevant to Initial Optimization scenarios only. Not comparable to Intermediate or Final Optimization. Costs are 2013 dollars.



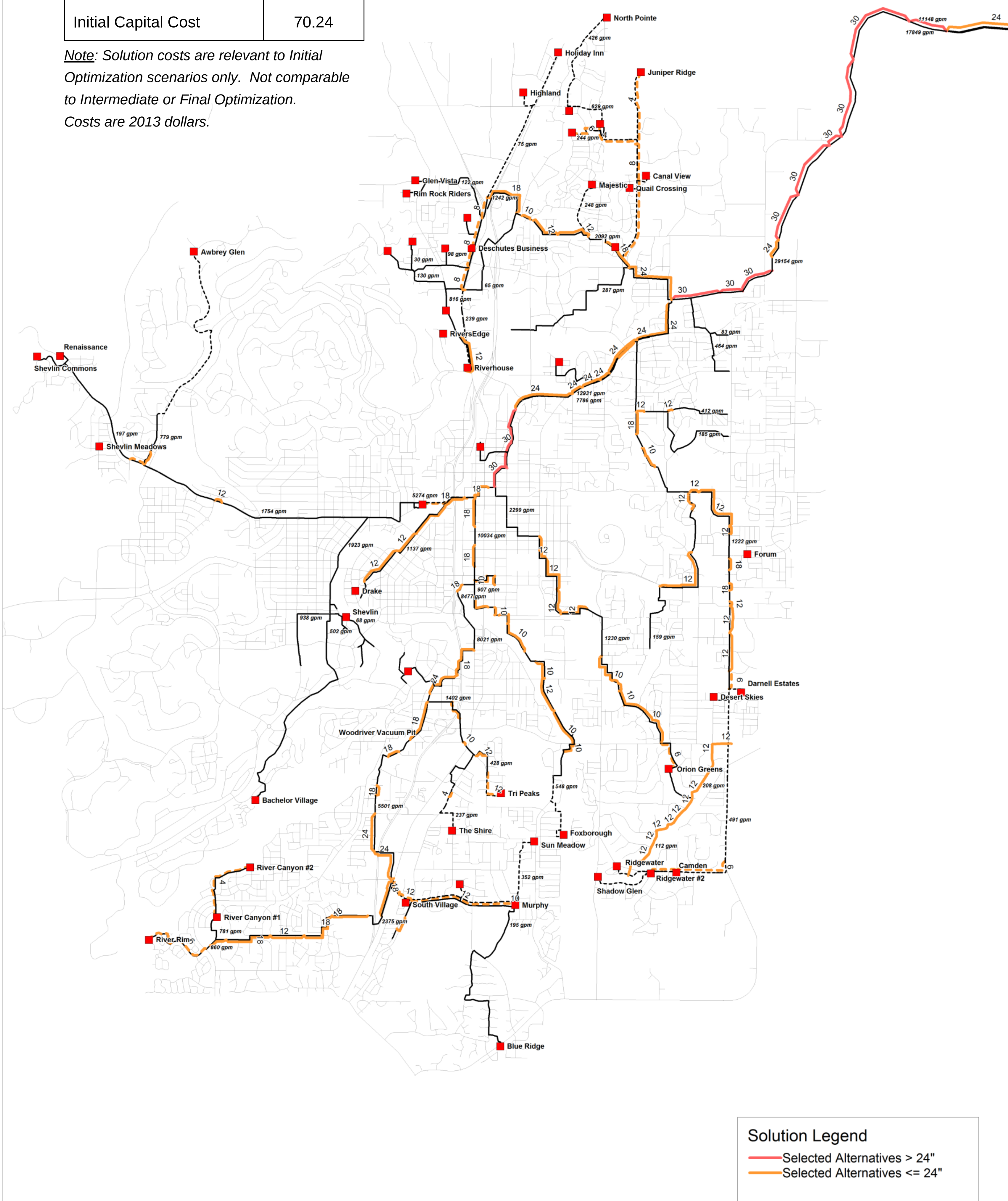
20-Year Mid R – Upgrades Along Existing Alignments

<u>Initial Optimization</u>

20-Year High-R – Upgrades Along Existing Alignments

Cost Item	Cost ($M)
40-Year Life-Cycle Cost	192.80
Initial Capital Cost	70.24

<u>Note</u>: Solution costs are relevant to Initial Optimization scenarios only. Not comparable to Intermediate or Final Optimization. Costs are 2013 dollars.



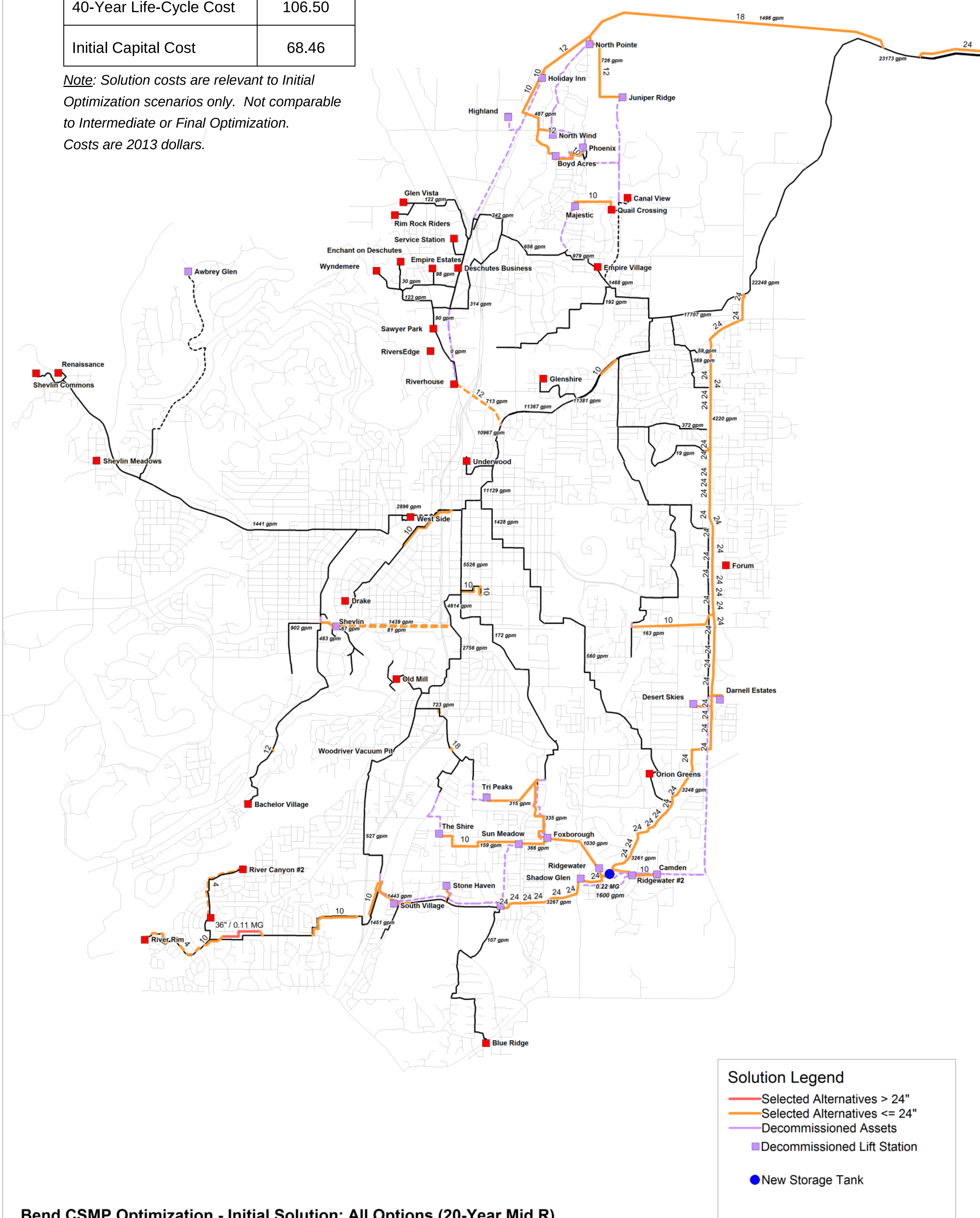
Bend CSMP Optimization - Initial Solution: **20-Year High R – Upgrades Along Existing Alignments**
(Flow Rates Represent Peak Wet Weather Flow)

Initial Optimization

20-Year Mid-R

Cost Item	Cost ($M)
40-Year Life-Cycle Cost	106.50
Initial Capital Cost	68.46

Note: Solution costs are relevant to Initial Optimization scenarios only. Not comparable to Intermediate or Final Optimization. Costs are 2013 dollars.



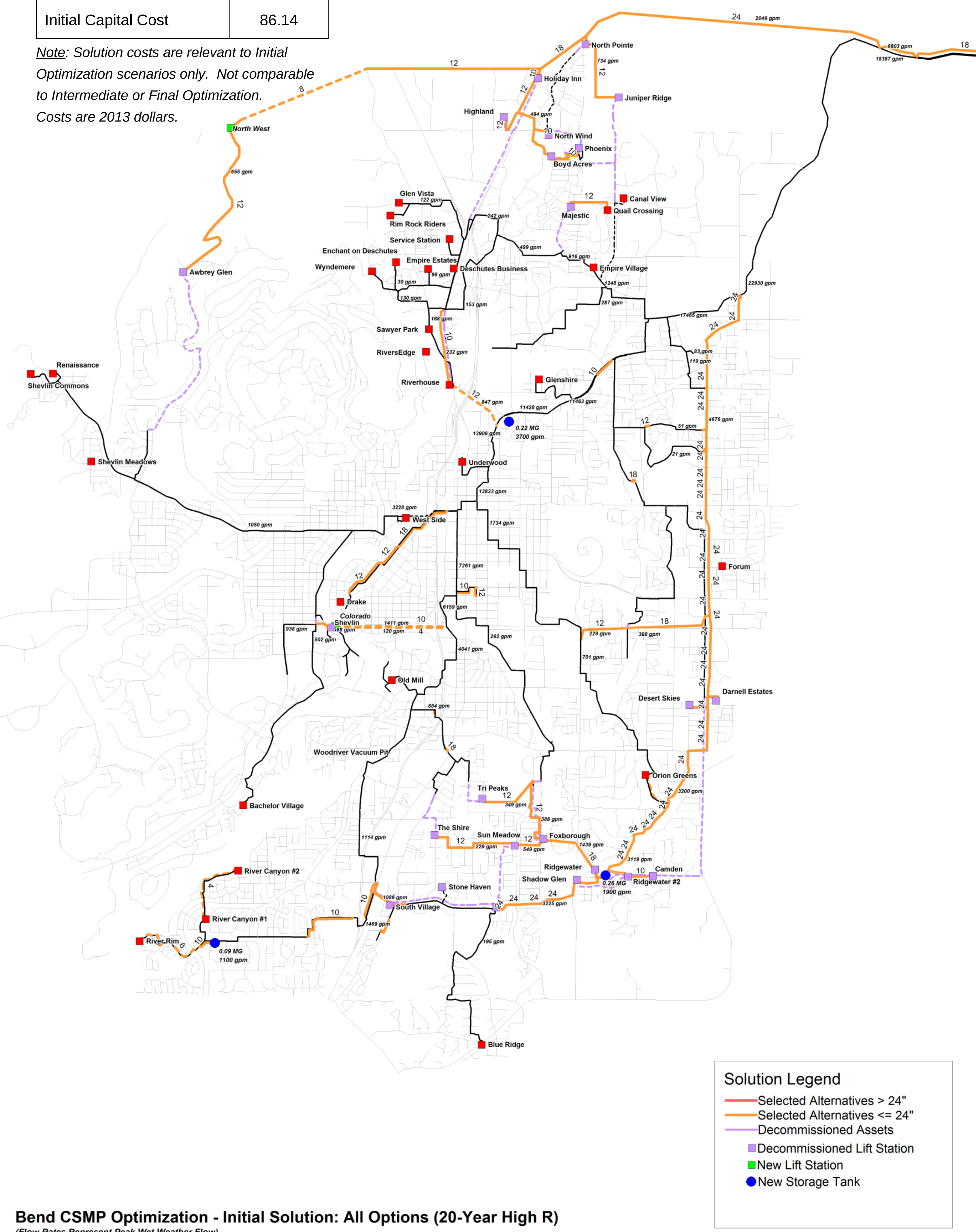
Bend CSMP Optimization - Initial Solution: All Options (20-Year Mid R)
(Flow Rates Represent Peak Wet Weather Flow)

Initial Optimization

20-Year High-R

Cost Item	Cost ($M)
40-Year Life-Cycle Cost	123.22
Initial Capital Cost	86.14

Note: Solution costs are relevant to Initial Optimization scenarios only. Not comparable to Intermediate or Final Optimization. Costs are 2013 dollars.



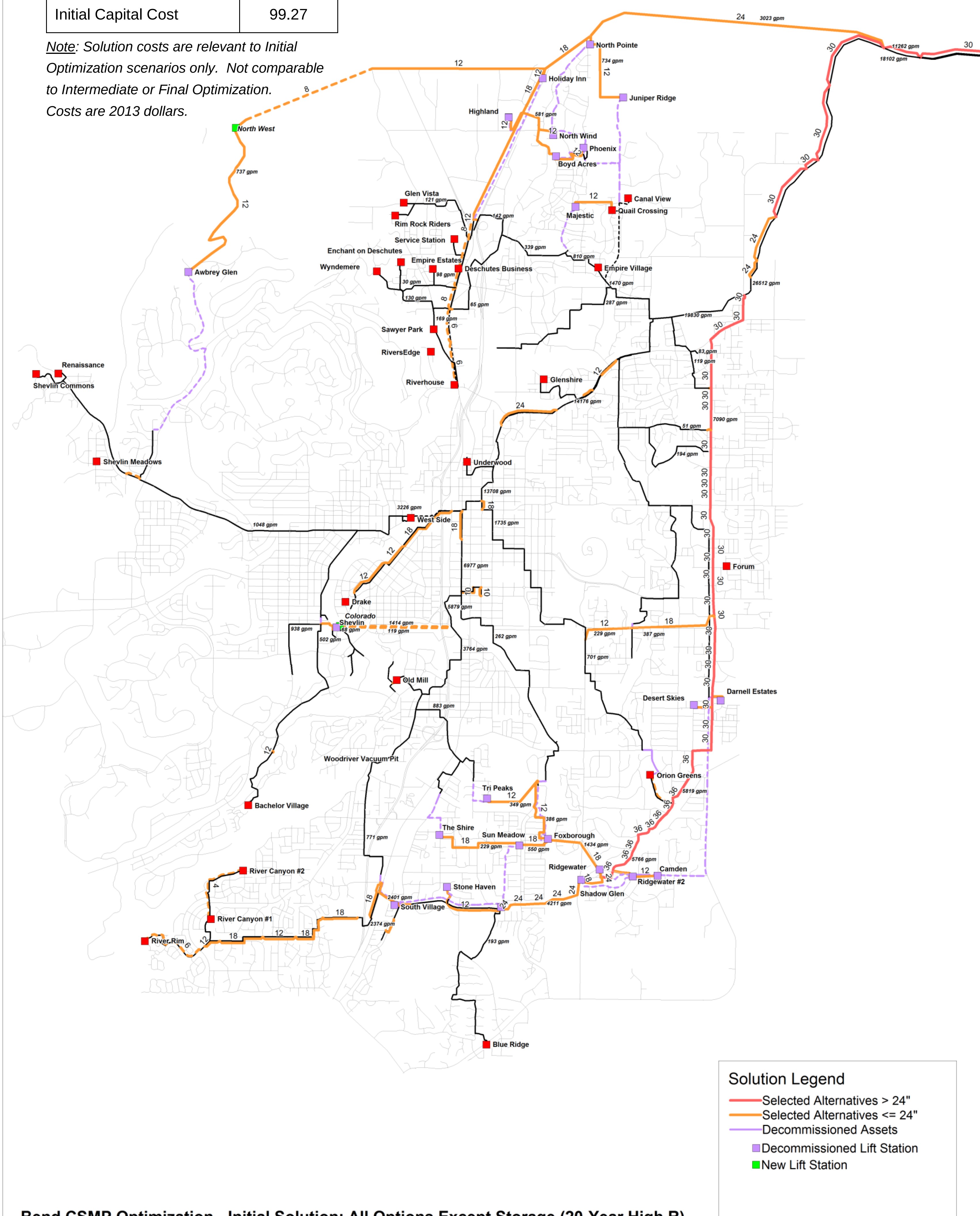
Bend CSMP Optimization - Initial Solution: All Options (20-Year High R)
(Flow Rates Represent Peak Wet Weather Flow)

Initial Optimization

20-Year High-R – No Storage Alternatives

Cost Item	Cost ($M)
40-Year Life-Cycle Cost	143.20
Initial Capital Cost	99.27

Note: Solution costs are relevant to Initial Optimization scenarios only. Not comparable to Intermediate or Final Optimization. Costs are 2013 dollars.



Bend CSMP Optimization - Initial Solution: All Options Except Storage (20-Year High R)
(Flow Rates Represent Peak Wet Weather Flow)

APPENDIX 6C

Intermediate Optimization Solutions

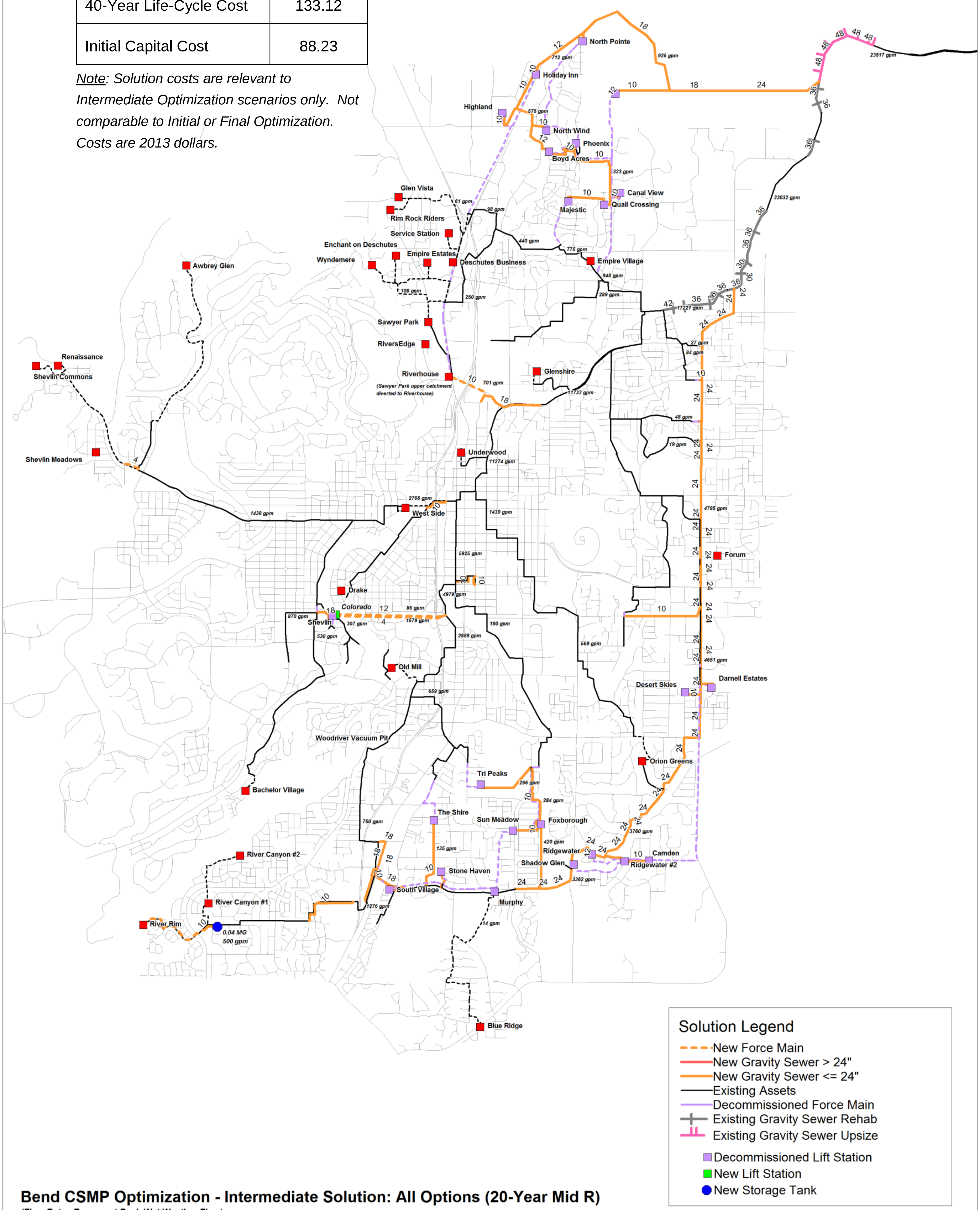
Plan view layouts and cost summaries of the intermediate optimization solutions are presented in this appendix for the following scenarios:

- 20-Year Mid-R.
- 20-Year High-R.
- 20-Year High-R with 10% Water Conservation.
- 20-Year High-R with Additional 25% Loading.
- Intermediate Phased Solution - based on Existing High-R, 10-Year Mid-R, 20-Year Mid-R and Contingency Projects for flows higher than 20-Year Mid-R.

Appendix 6C
Intermediate Optimization
20-Year Mid-R

Cost Item	Cost ($M)
40-Year Life-Cycle Cost	133.12
Initial Capital Cost	88.23

Note: Solution costs are relevant to Intermediate Optimization scenarios only. Not comparable to Initial or Final Optimization. Costs are 2013 dollars.



Bend CSMP Optimization - Intermediate Solution: All Options (20-Year Mid R)
(Flow Rates Represent Peak Wet Weather Flow)

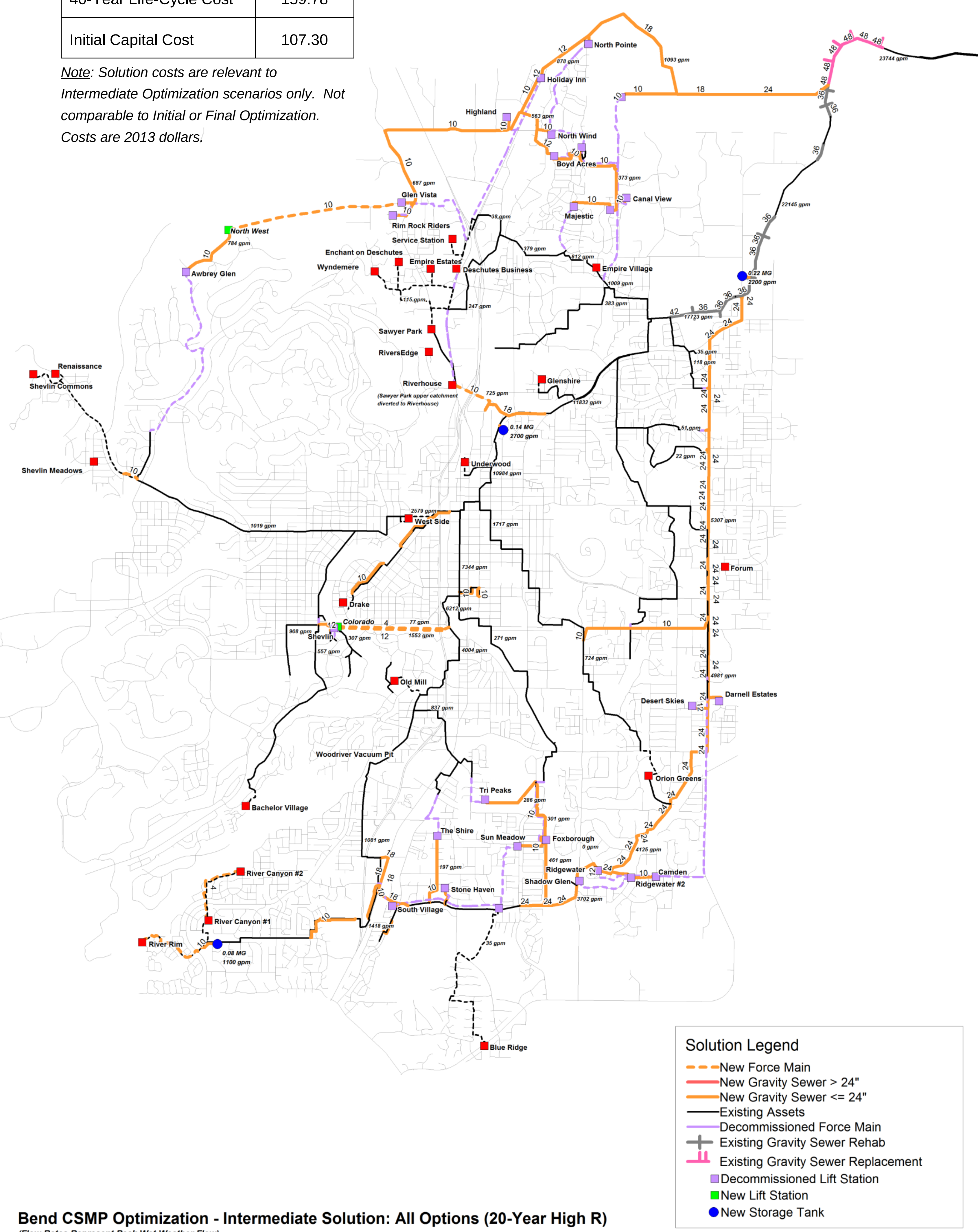
NOTE: Solution cost reflects SEI at design size of 30" north of Ridgewater

Intermediate Optimization

20-Year High-R

Cost Item	Cost ($M)
40-Year Life-Cycle Cost	159.78
Initial Capital Cost	107.30

Note: Solution costs are relevant to Intermediate Optimization scenarios only. Not comparable to Initial or Final Optimization. Costs are 2013 dollars.



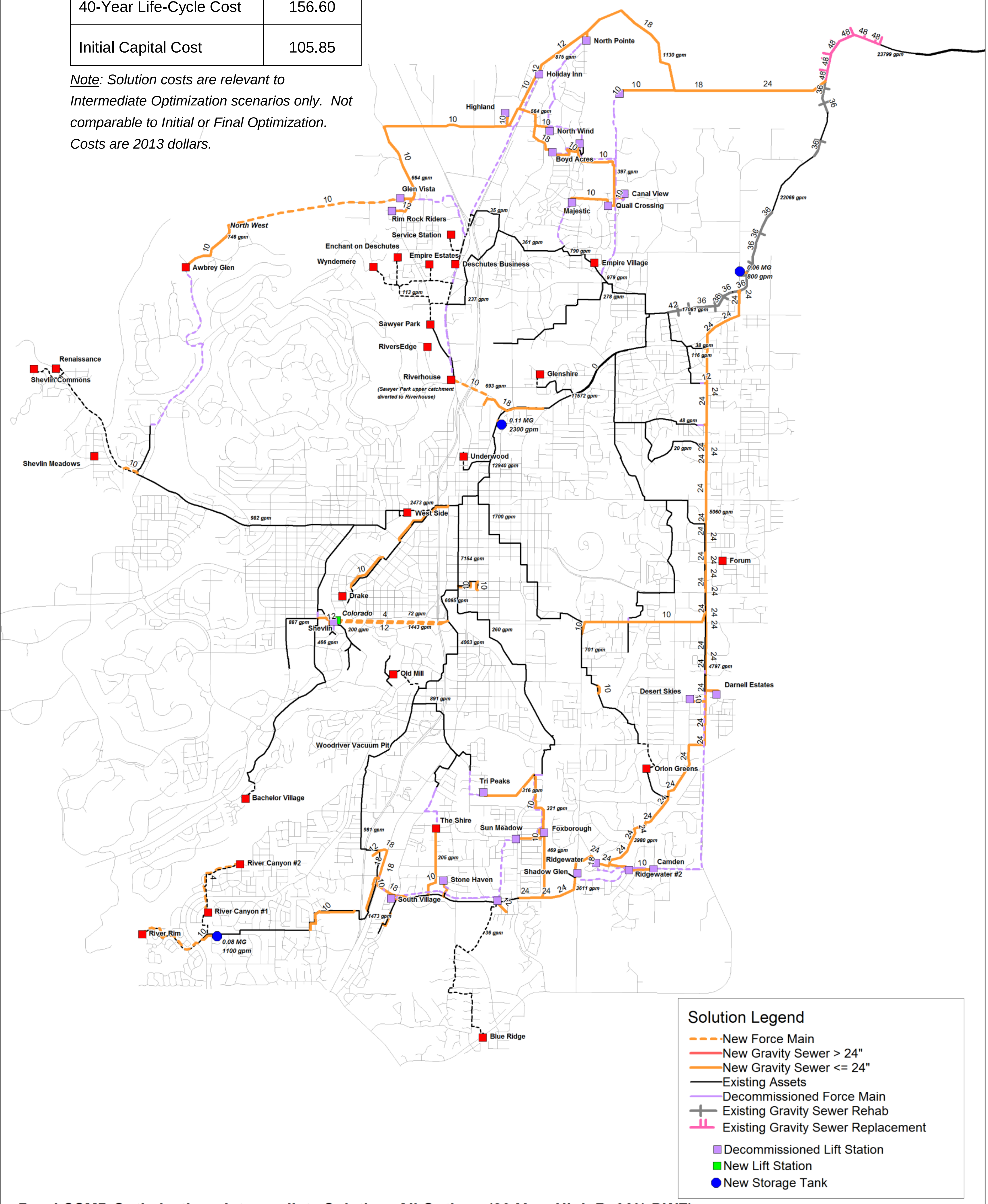
Bend CSMP Optimization - Intermediate Solution: All Options (20-Year High R)
(Flow Rates Represent Peak Wet Weather Flow)

Intermediate Optimization

20-Year High-R with 10% Water Conservation

Cost Item	Cost ($M)
40-Year Life-Cycle Cost	156.60
Initial Capital Cost	105.85

Note: Solution costs are relevant to Intermediate Optimization scenarios only. Not comparable to Initial or Final Optimization. Costs are 2013 dollars.



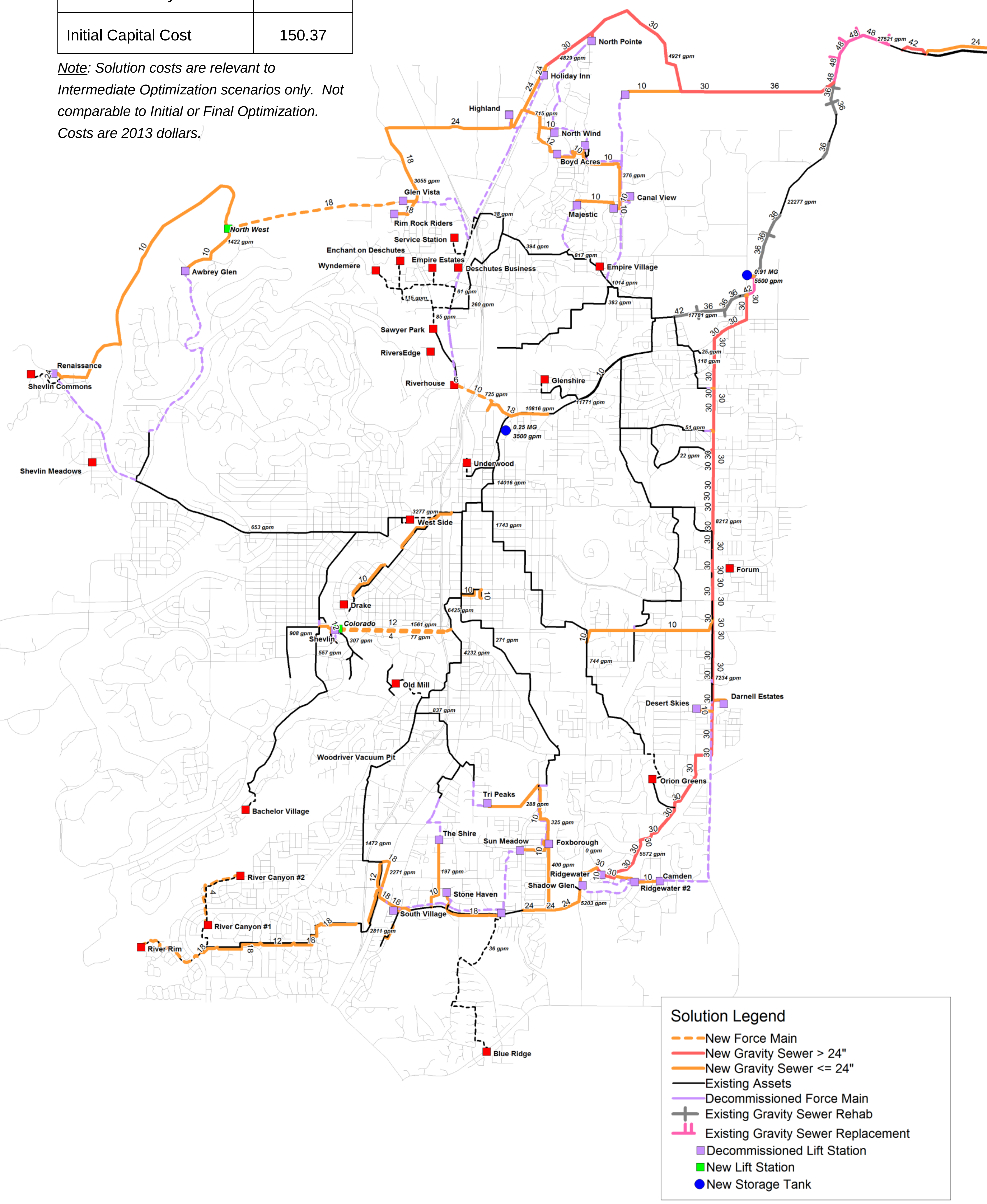
Bend CSMP Optimization - Intermediate Solution: All Options (20-Year High R, 90% DWF)
(Flow Rates Represent Peak Wet Weather Flow)
(10% Water Conservation Scenario)

<u>Intermediate Optimization</u>

20-Year High-R with 25% Additional Loading

Cost Item	Cost ($M)
40-Year Life-Cycle Cost	192.09
Initial Capital Cost	150.37

<u>Note</u>: Solution costs are relevant to Intermediate Optimization scenarios only. Not comparable to Initial or Final Optimization. Costs are 2013 dollars.



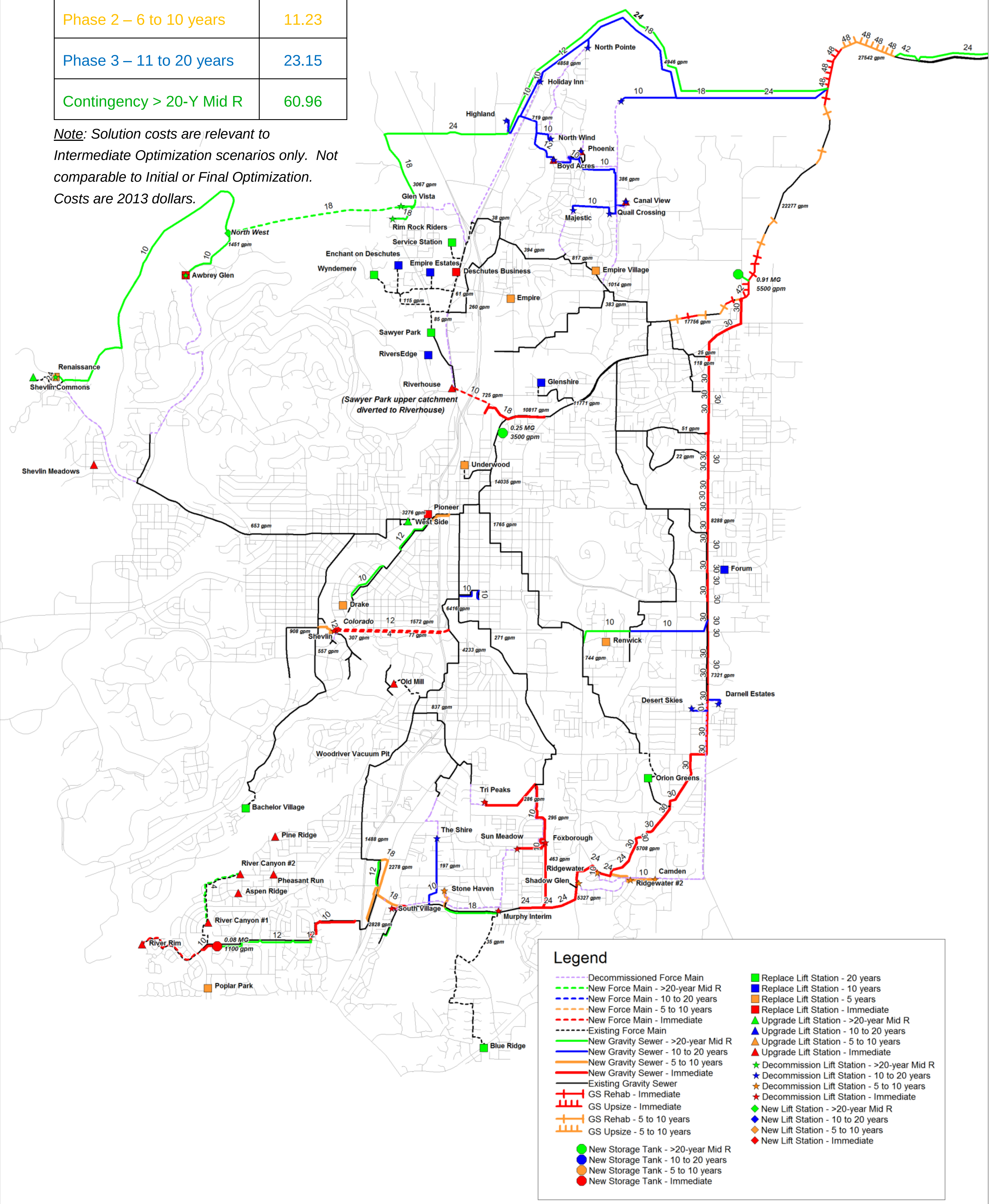
Bend CSMP Optimization - Intermediate Solution: All Options (20-Year High R + 25% Growth)
(Flow Rates Represent Peak Wet Weather Flow)

Intermediate Optimization

Project Phasing

Cost Item	Cost ($M)
Phase 1 – 1 to 5 years	53.85
Phase 2 – 6 to 10 years	11.23
Phase 3 – 11 to 20 years	23.15
Contingency > 20-Y Mid R	60.96

Note: Solution costs are relevant to Intermediate Optimization scenarios only. Not comparable to Initial or Final Optimization. Costs are 2013 dollars.



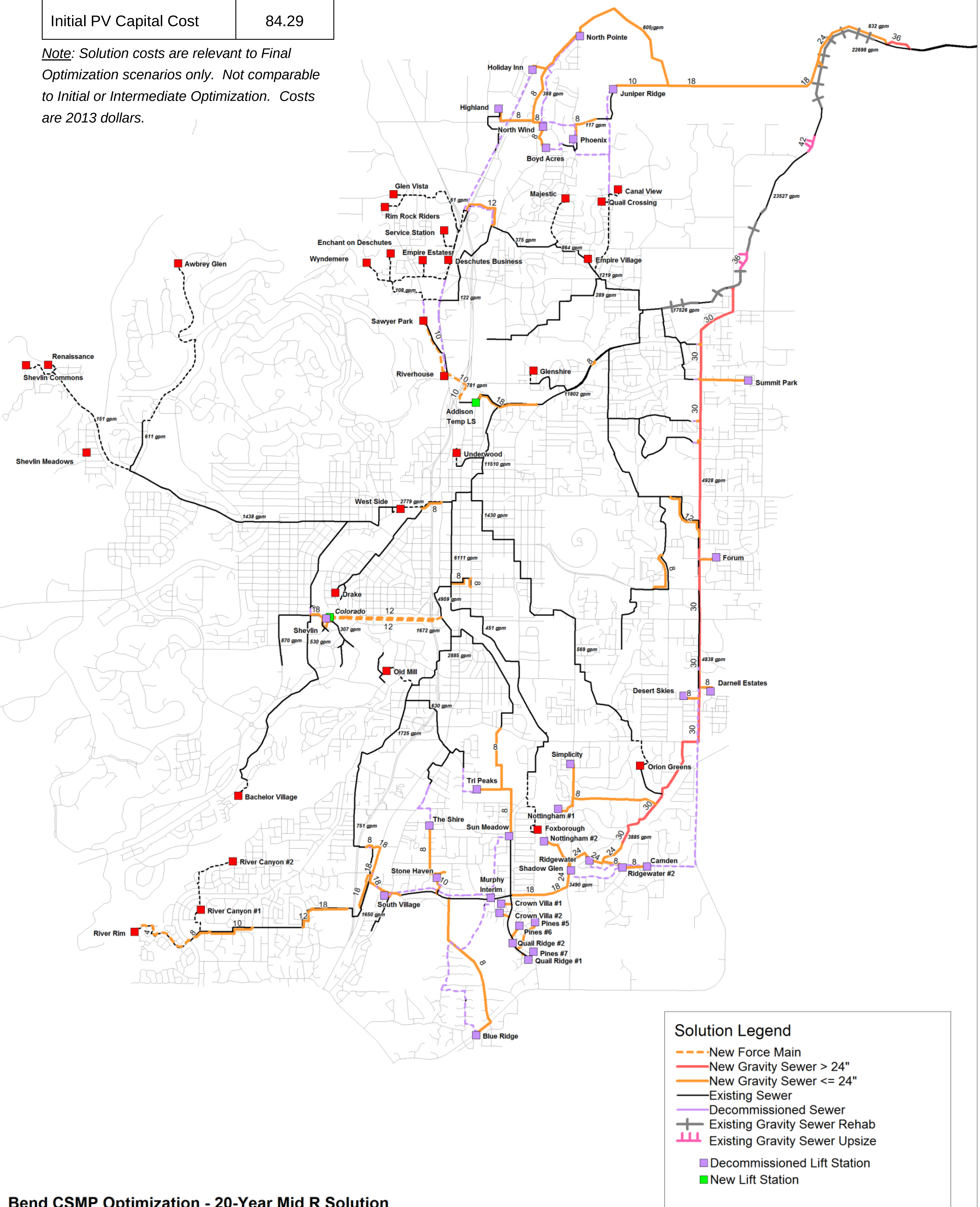
Bend CSMP Optimization - Intermediate Solution: Phased Improvements
(Flow Rates Represent Peak Wet Weather Flow)

Final Optimization

20-Year Mid-R

Cost Item	Cost ($M)
40-Year Life-Cycle Cost	114.92
Initial PV Capital Cost	84.29

Note: Solution costs are relevant to Final Optimization scenarios only. Not comparable to Initial or Intermediate Optimization. Costs are 2013 dollars.



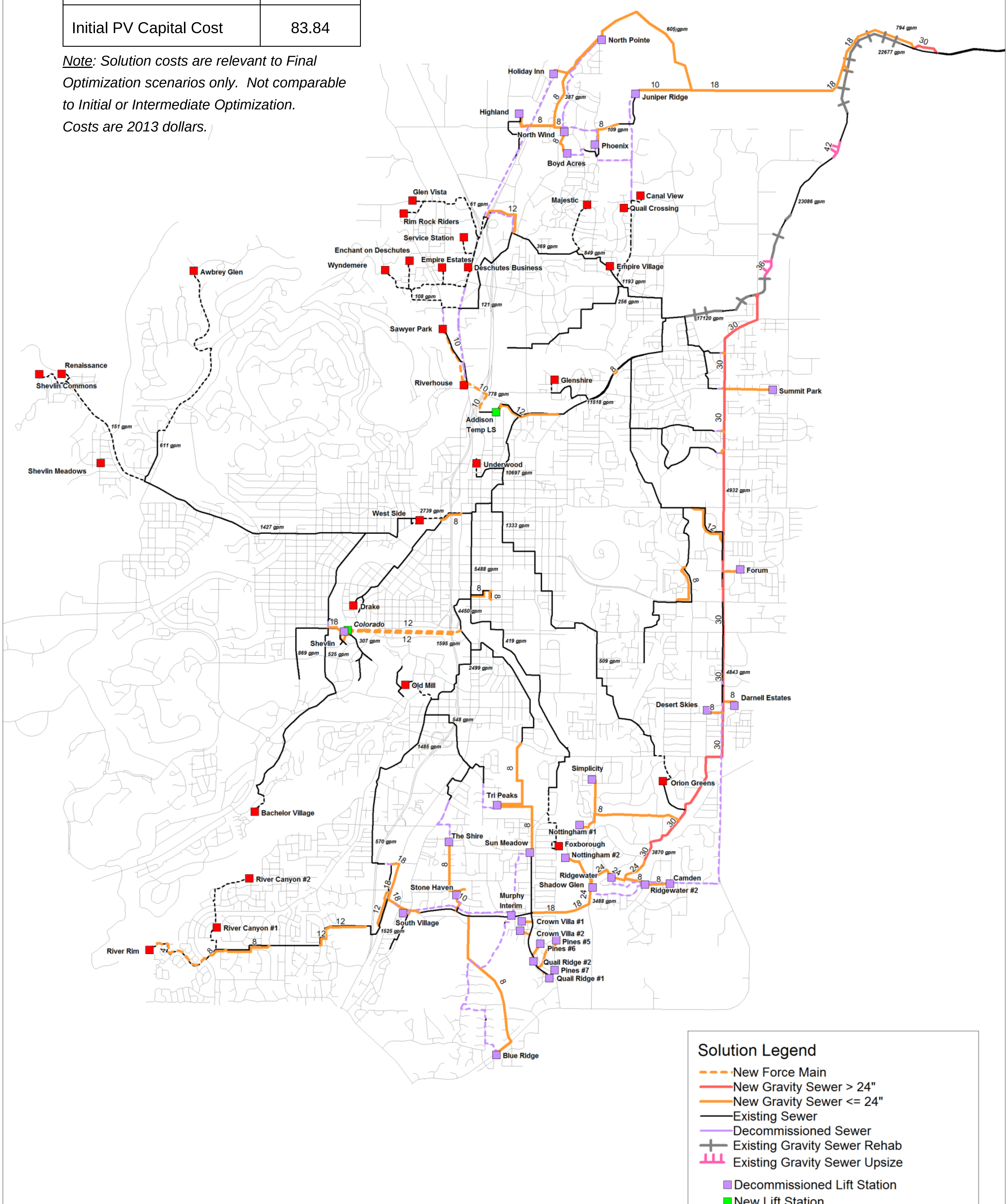
Bend CSMP Optimization - 20-Year Mid R Solution
(Flow Rates Represent Peak Wet Weather Flow)

Final Optimization

20-Year Mid-R -10% Water Conservation

Cost Item	Cost ($M)
40-Year Life-Cycle Cost	114.06
Initial PV Capital Cost	83.84

Note: Solution costs are relevant to Final Optimization scenarios only. Not comparable to Initial or Intermediate Optimization. Costs are 2013 dollars.



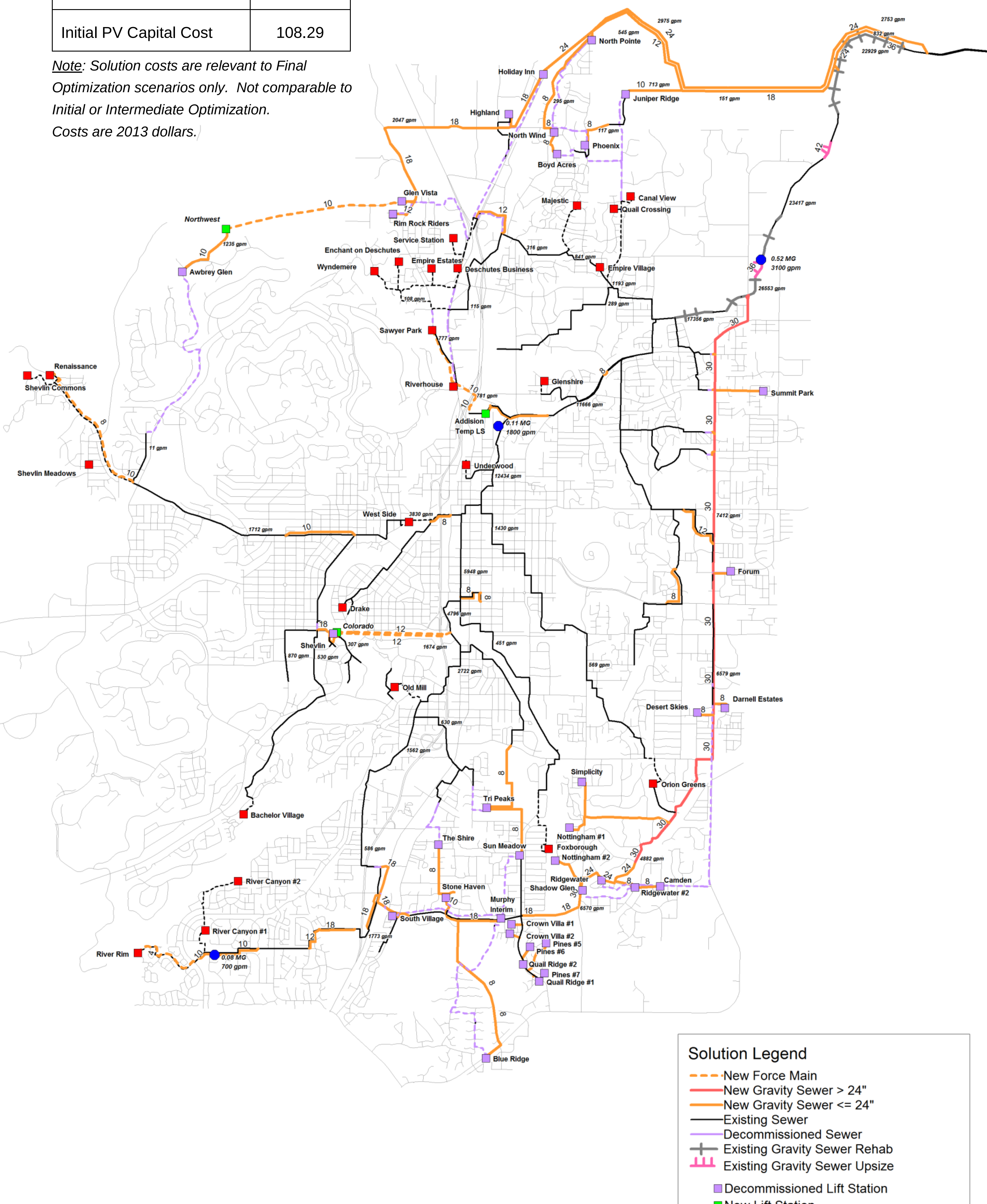
Bend CSMP Optimization - 20-Year Mid R -10% Conservation Solution
(Flow Rates Represent Peak Wet Weather Flow)

Final Optimization

20-Year Mid-R +25% Loading (With NW Diversion)

Cost Item	Cost ($M)
40-Year Life-Cycle Cost	155.64
Initial PV Capital Cost	108.29

Note: Solution costs are relevant to Final Optimization scenarios only. Not comparable to Initial or Intermediate Optimization.
Costs are 2013 dollars.



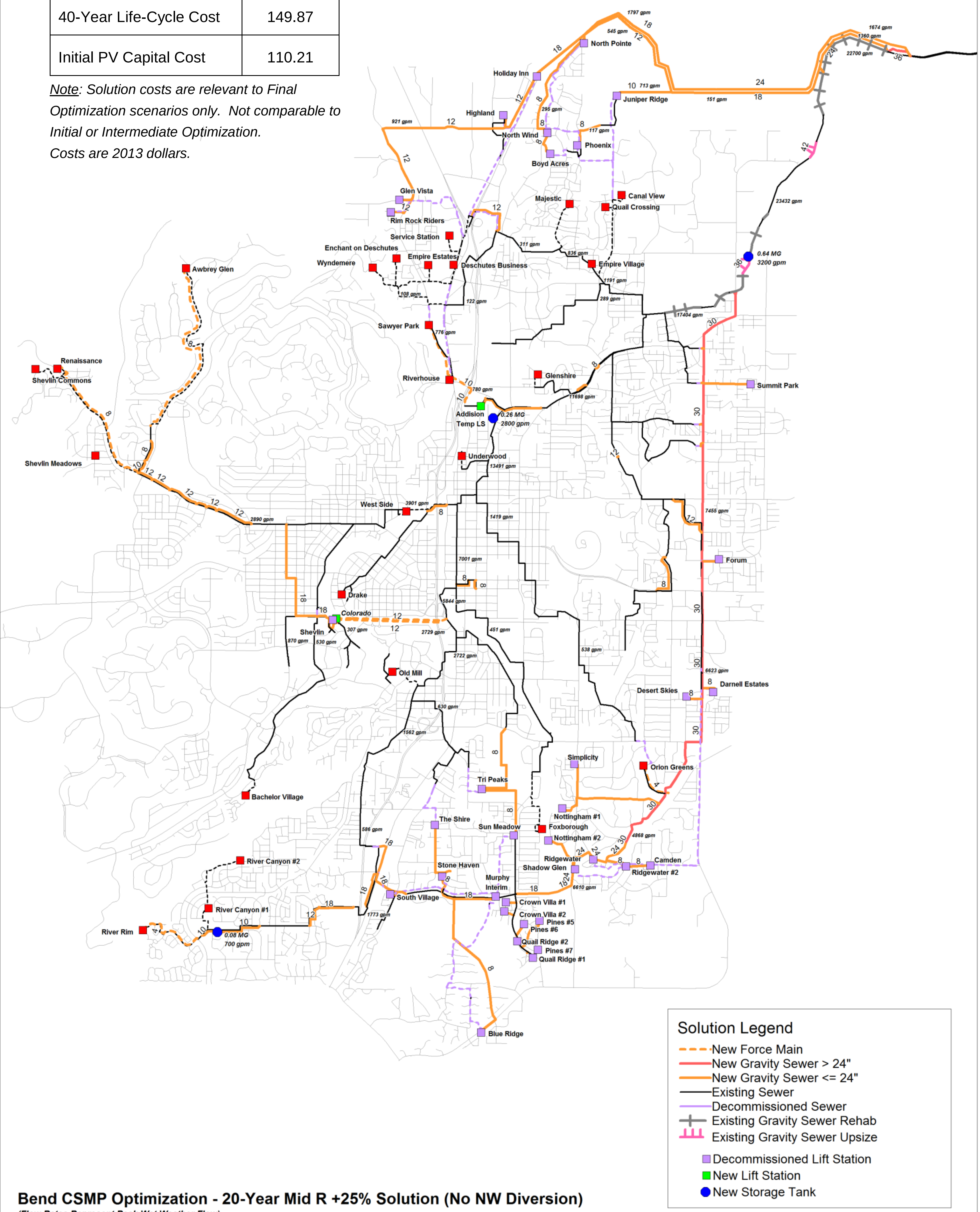
Bend CSMP Optimization - 20-Year Mid R +25% Solution (With NW Diversion)
(Flow Rates Represent Peak Wet Weather Flow)

Final Optimization

20-Year Mid-R +25% Loading (Without NW Diversion)

Cost Item	Cost ($M)
40-Year Life-Cycle Cost	149.87
Initial PV Capital Cost	110.21

Note: Solution costs are relevant to Final Optimization scenarios only. Not comparable to Initial or Intermediate Optimization.
Costs are 2013 dollars.



Bend CSMP Optimization - 20-Year Mid R +25% Solution (No NW Diversion)
(Flow Rates Represent Peak Wet Weather Flow)

MSA

APPENDIX 6D

Final Optimization Solutions

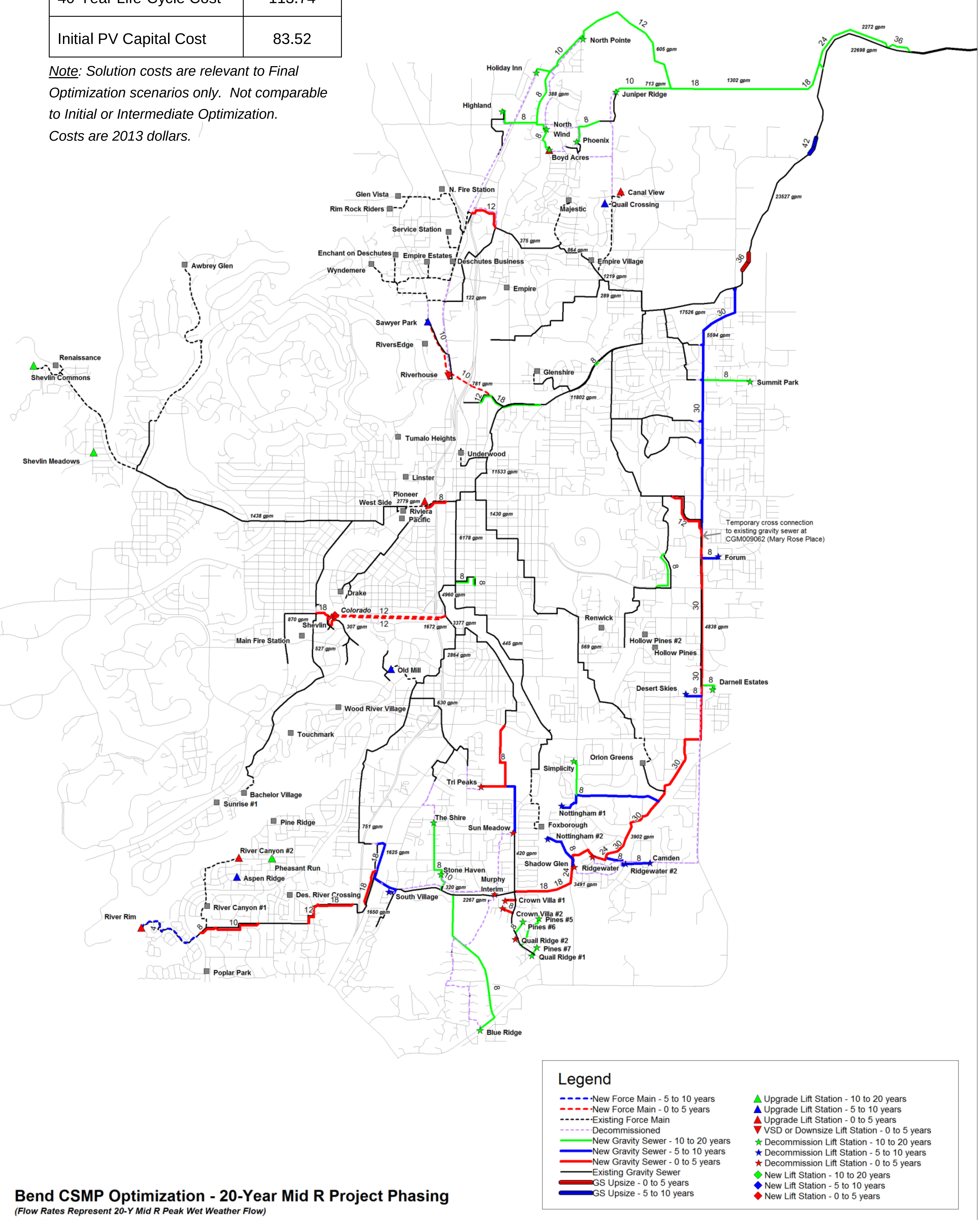
Plan view layouts and cost summaries of the intermediate optimization solutions are presented in this appendix for the following scenarios:

- Phased Improvements based on optimization scenarios for:
    - Existing Mid-R.
    - 10-Year Mid-R.
    - 20-Year Mid-R.
- 20-Year Mid-R (without phasing)
- 20-Year Mid-R -10% Water Conservation
- 20-Year Mid-R +25% Loading with Northwest Diversion
- 20-Year Mid-R +25% Loading without Northwest Diversion

Appendix 6D
Final Optimization
20-Year Mid-R – Phased Improvements

Cost Item	Cost ($M)
40-Year Life-Cycle Cost	113.74
Initial PV Capital Cost	83.52

Note: Solution costs are relevant to Final Optimization scenarios only. Not comparable to Initial or Intermediate Optimization. Costs are 2013 dollars.

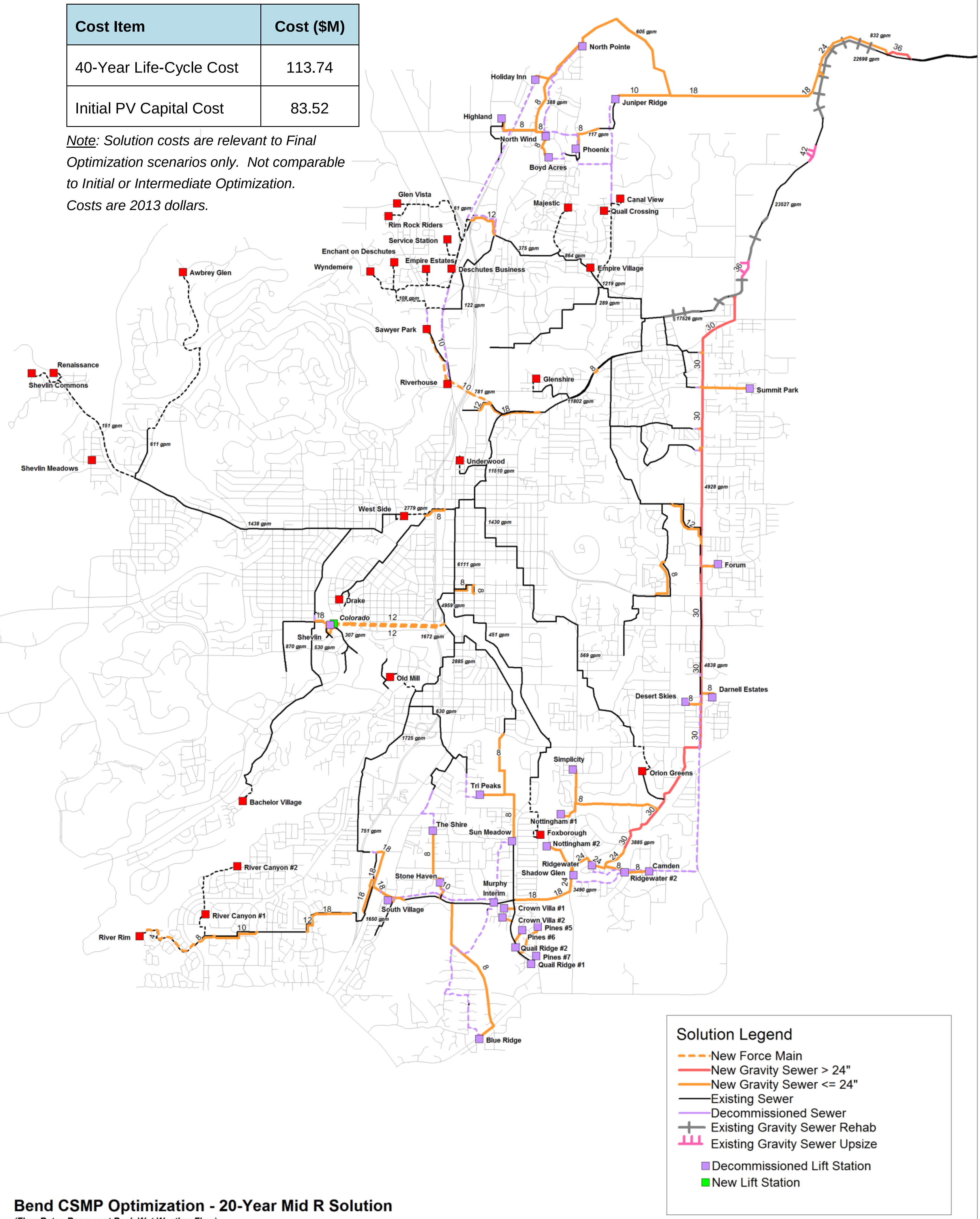


Bend CSMP Optimization - 20-Year Mid R Project Phasing
(Flow Rates Represent 20-Y Mid R Peak Wet Weather Flow)
June 30, 2014

Appendix 6-D
Final Optimization
20-Year Mid-R

Cost Item	Cost ($M)
40-Year Life-Cycle Cost	113.74
Initial PV Capital Cost	83.52

Note: Solution costs are relevant to Final Optimization scenarios only. Not comparable to Initial or Intermediate Optimization. Costs are 2013 dollars.



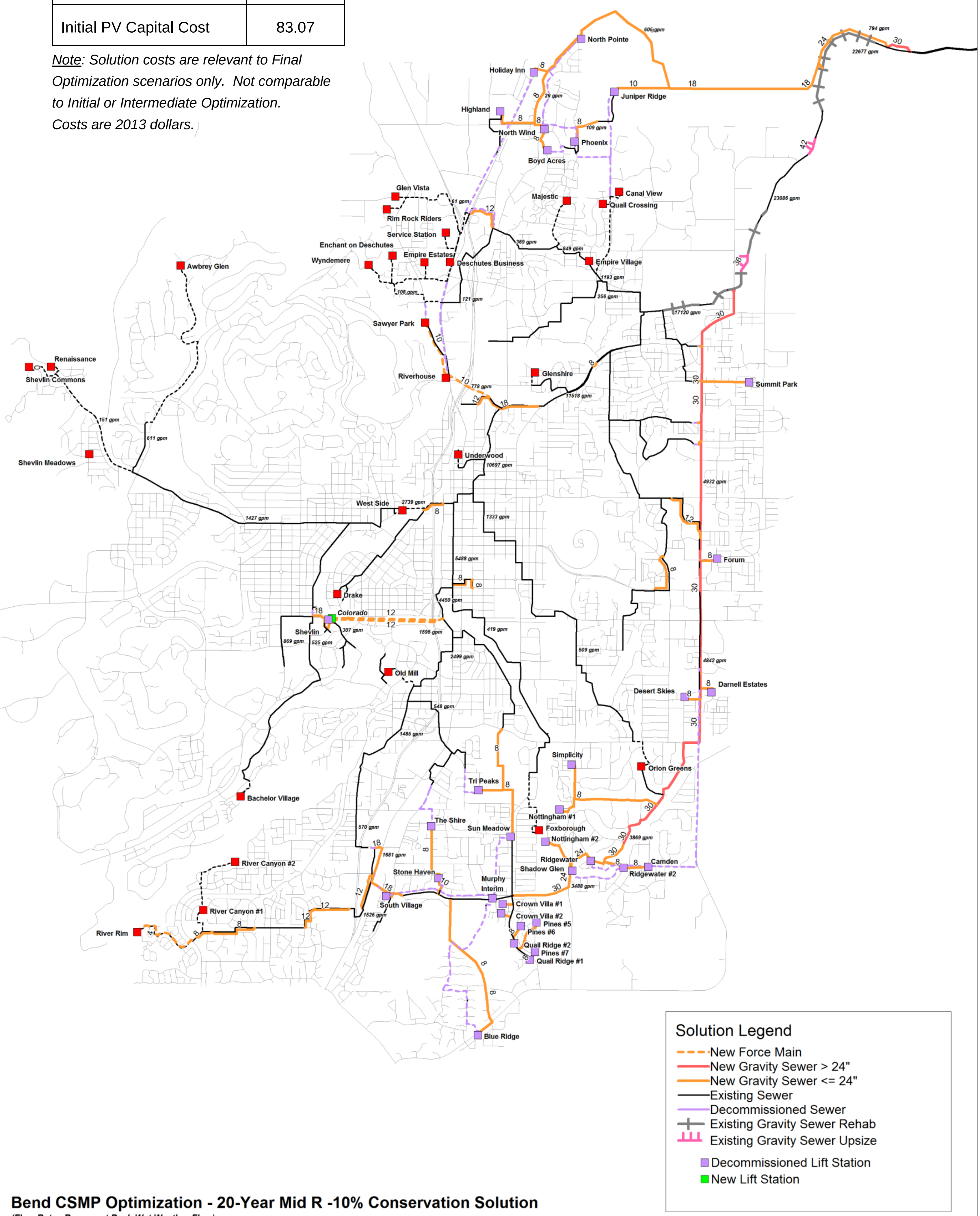
Bend CSMP Optimization - 20-Year Mid R Solution
(Flow Rates Represent Peak Wet Weather Flow)

Final Optimization

20-Year Mid-R -10% Water Conservation

Cost Item	Cost ($M)
40-Year Life-Cycle Cost	112.88
Initial PV Capital Cost	83.07

Note: Solution costs are relevant to Final Optimization scenarios only. Not comparable to Initial or Intermediate Optimization. Costs are 2013 dollars.



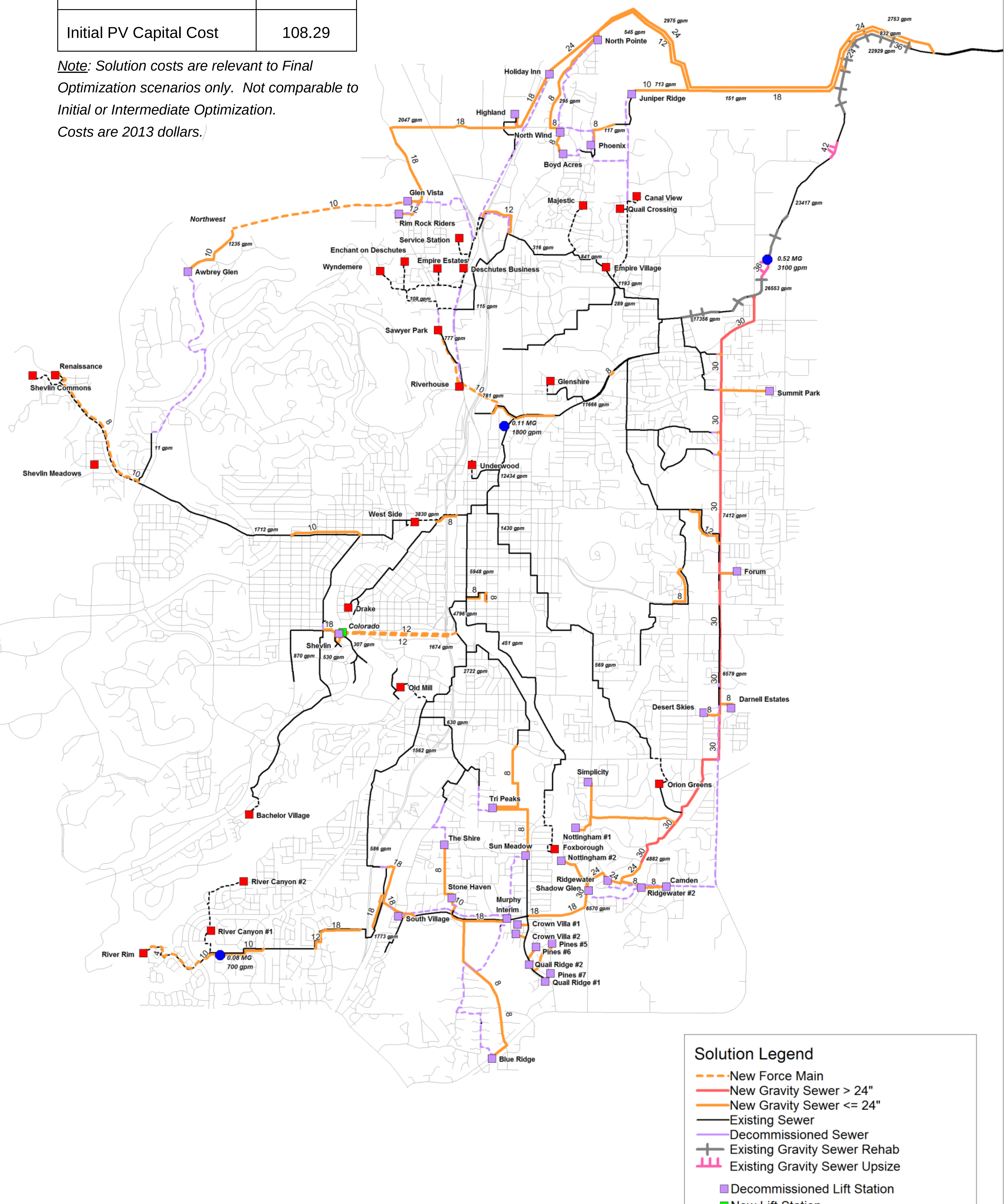
Bend CSMP Optimization - 20-Year Mid R -10% Conservation Solution
(Flow Rates Represent Peak Wet Weather Flow)

Final Optimization

20-Year Mid-R +25% Loading (With NW Diversion)

Cost Item	Cost ($M)
40-Year Life-Cycle Cost	155.64
Initial PV Capital Cost	108.29

Note: Solution costs are relevant to Final Optimization scenarios only. Not comparable to Initial or Intermediate Optimization.
Costs are 2013 dollars.



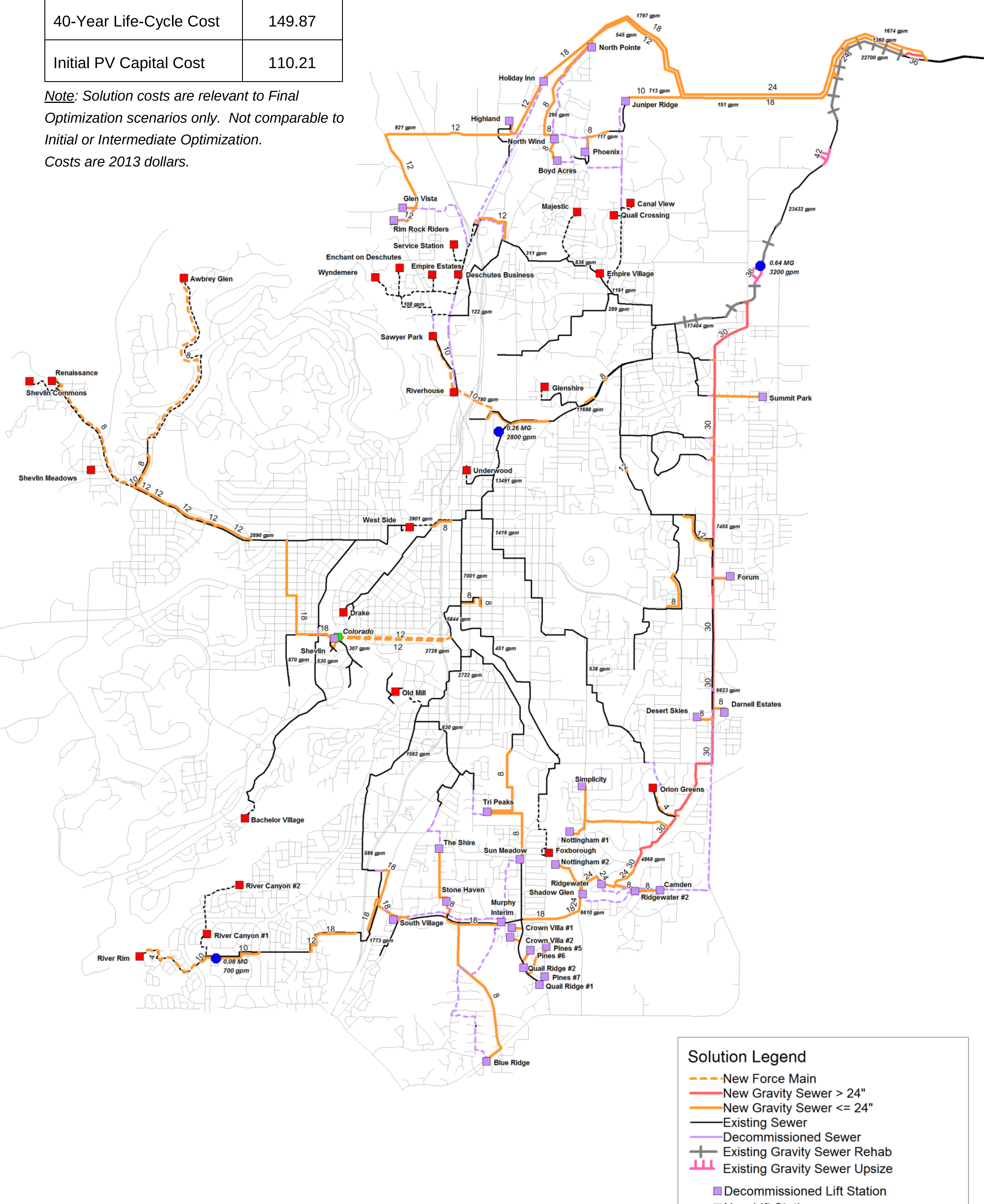
Bend CSMP Optimization - 20-Year Mid R +25% Solution (With NW Diversion)
(Flow Rates Represent Peak Wet Weather Flow)

Final Optimization

20-Year Mid-R +25% Loading (Without NW Diversion)

Cost Item	Cost ($M)
40-Year Life-Cycle Cost	149.87
Initial PV Capital Cost	110.21

Note: Solution costs are relevant to Final Optimization scenarios only. Not comparable to Initial or Intermediate Optimization.
Costs are 2013 dollars.



Bend CSMP Optimization - 20-Year Mid R +25% Solution (Without NW Diversion)
(Flow Rates Represent Peak Wet Weather Flow)

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OREGON

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