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verdantas

Memo

Date	February 20, 2025
To	Bradley Kosco, City Engineer, City of Hudson
From	Chris Rybak
Subject	Woods of Western Reserve Storm Water Analysis
Project Number	242753

1. Introduction

Problem Description:

The City of Hudson requested an H&H analysis of their stormwater infrastructure in the Woods of Western Reserve neighborhood that was distressed during an extreme weather event. Verdantas has modeled the city's collection system on PCSWMM (H&H modeling software) to identify existing capacity issues and how the neighborhood would benefit from the detention storage benefits. The limits of the model were predetermined with the City to include major collection routes and is not a fully detailed collection system model. The model was analyzed against 5 design storms and alternatives were designed to relieve the local distress points at a 500 yr 24-hour storm event.

2. Basis of Development

The following section outlines the foundational steps taken to build the H&H model, ensuring its effectiveness in predicting stormwater behavior under different scenarios. The development process involves an analysis of various data sources and integrating these data sources to build a model that represents the existing infrastructure and helps identify potential capacity issues. This section provides a detailed overview of the steps

1. Data Sources
   The following are the data sources used to build the model to represent the existing infrastructure:
   1. Survey (City)
   2. Shapefiles (City)
   3. City AGOL
   4. Drawings linked to City AGOL
   5. Lidar

2. Model Summary and Development
   a. Hydrology
      Multiple rainfall timeseries (storms) were created as SCS Type II, cumulative rain format with 6-minute interval using 'Rainmaker' an internal software that utilizes the data from NOAA Atlas 14(National Oceanic and Atmospheric Administration) As shown in Figure 2-1.

Following five storms were created to run the model:

1. 10 year – 24 hours
2. 25 year – 24 hours
3. 50 year – 24 hours
4. 100 year – 24 hours
5. 500 year – 24 hours

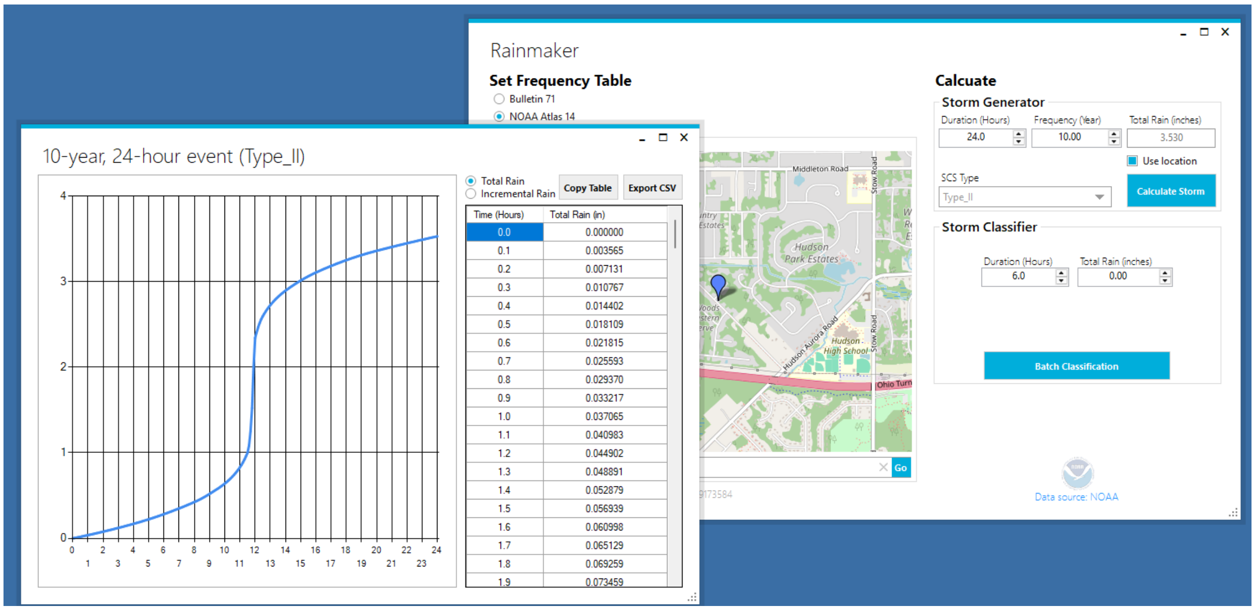


Figure 2-1 – Storm creation using Rainmaker

b. Sub catchments
   i. Surface/DEM – multiple tiles of 2019 lidar data downloaded from OGRIP were merged and was converted to a raster with cell size of 1ft x 1ft by using 'LAS to Raster' on ArcGIS Pro
   ii. 5-acre watersheds were created using the 'watershed delineation tool' on the DEM, in PCSWMM, to represent watersheds that impact and or drain into the study area
   iii. Length, slope and area were auto calculated by PCSWM. The sub catchments were modified to accurately represent the study area's collection system. Multiple 5-acre sub catchments were joined to capture larger areas that drain into the study area outlet drainage ditch.
   iv. Outlets – all the sub catchments are loaded to respective nodes. These are the collection systems were the watershed areas drain into.
   v. Infiltration method – Modified Horton
   vi. Impervious - 35% assumed for all the sub catchments

c. Network

The study area collection system was initially created using the shapefiles provided by the city, and was modified based on City AGOL, survey and drawings to represent them. New model components were added to represent control structures or where appropriate.

Model components:

i. Nodes – Manholes and catch basins provided by the city are represented as nodes in the model.
ii. Conduits – all the stormwater pipes and ditches are represented as conduits in the model.
Ditches – location of the ditches was identified based off city AGOL. The cross sections of the ditches were extracted using PCSWMM's 'Transect Creator' on a DEM merged with the survey data.
iii. Weirs/ Orifices – all control structures in the collection system are represented in the model as weirs and orifices based on the drawing specifications.
iv. Storages – the 5 detention/retention ponds identified are represented as a storage in the model with a tabular (Depth vs Area) storage curve based off the lidar, survey data and drawings.
v. Outfall – model was extended to the dual storm sewer culvert under Hudson Park Dr to understand any backwater impacts in the receiving stream. The receiving stream is south of Leeway St and identified on some maps as 'Ht Stream4'.

d. Ponding

The nodes were given a ponded area of 1000 sq ft to account for surcharge that occurs at the nodes when the infrastructure is at capacity. This was done to avoid any flood loss that could occur otherwise.

e. Existing Condition model summary

Table 2-1 contains a summary of all the components in the existing condition model that was used to perform level of service analyses and was the basis for all the alternative condition models.
Figure 2-2 contains the map of the existing collection system.

Table 2-1 - Existing Conditions Model Component Summary

Component	**Total**
Nodes (Manholes and catch basins)	102
Existing Conduits	4463 L. F
Existing Ditches	6888 L.F.
Sub catchments	43
Storage (Existing/)	4
Control structures (Weirs)	14
Control structures (Orifices)	2

Figure 2-2 – City of Hudson Collection System Existing Condition Model Overview

3. Level of Service Analysis

A level of service analysis was performed for the existing condition to identify capacity issues in the collection system and understand their performance to various storms. The existing condition models were analyzed against the following storms.

1. 10-year 24 hours
2. 25-year 24 hours
3. 50-year 24 hours
4. 100-year 24 hours
5. 500-year 24 hours

3.1 Existing Condition

The existing condition model was analyzed for the storms to identify the capacity issues at different locations in the system. The system is divided into three parts: East Branch (1), Middle Branch (2) and West Branch (3) as shown in Figure 3-1 to review drainage stress points. The stress points in the existing collection system were identified and color coded based on the design storm that exceeded system capacity and are shown in Figure 3-2. The profiles of each of the sections against the five storms are attached in the appendix to this document as profiles ranging from 3-1-1 to 3-3-2 (shown on Figure 3-1).

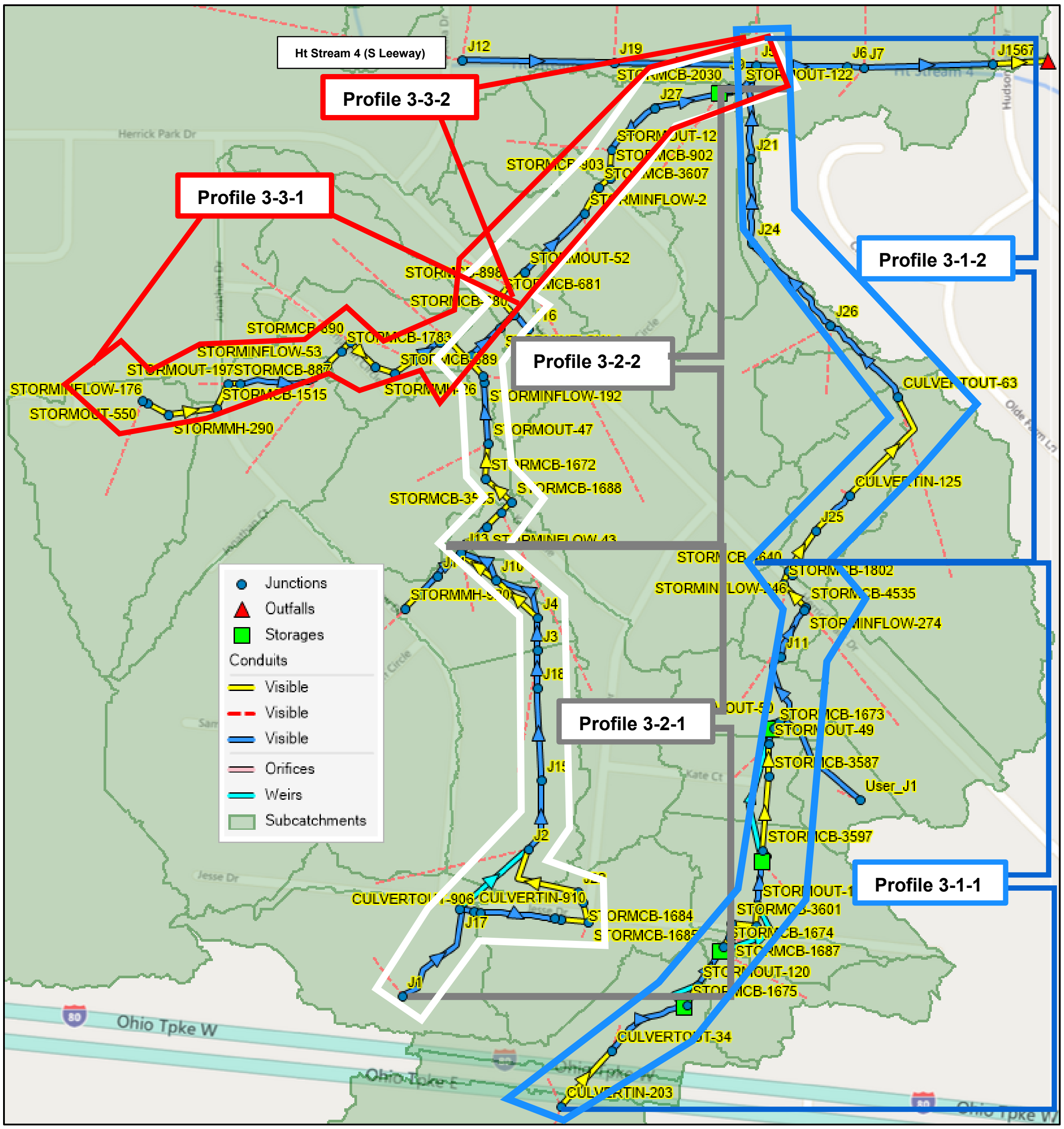


Figure 3-1 – Study area sections

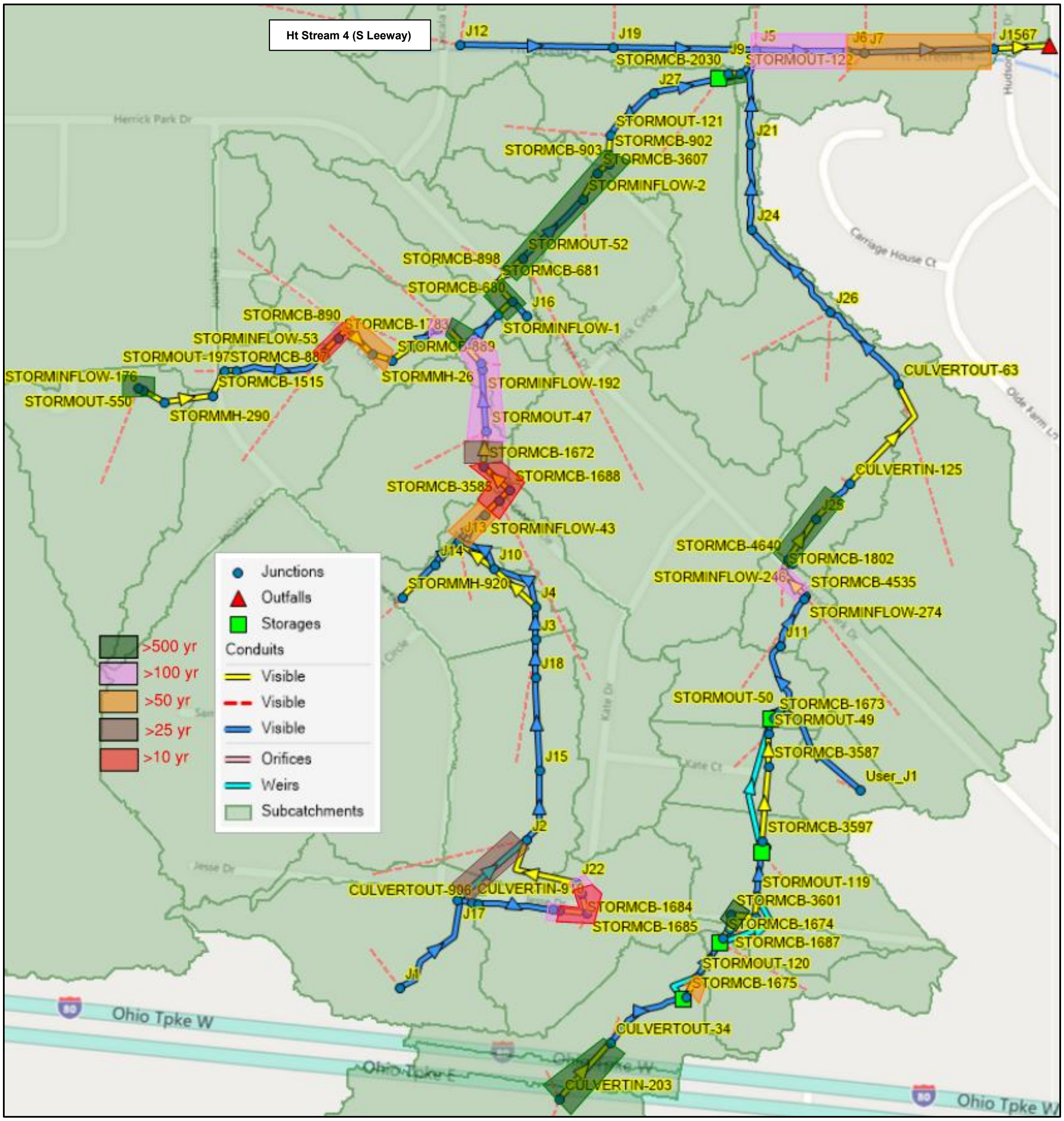


Figure 3-2 – Stress point map

4. Alternatives

There are seven alternatives modelled to address the capacity issues that occur in the system. A summary of the modeled alternatives is given below. The storage ponds identified to address capacity issues are modelled as storage nodes. The storage nodes were built with a control outlet and an emergency overflow to regulate the water flowing from the storage basin to the existing collection system. All alternative models were developed to manage the impacts of a 500-year 24-hour storm, addressing the system for the most severe storm. The impact was also checked against the 10 year and 25-year storm events. The storage area and the depth components were developed after understanding the feasibility of the storage ponds in areas identified with the city. Storage feasibility considered measuring the available land virtually (Survey data, DEM, Nearmap aerials) against available contours that could be converted into a storage pond without affecting the backyards of the residents.

All alternatives assume a flap gate on the Herrick Park Detention Pond outlet due backwater impacts from Ht Stream 4 and maintaining the maximum available pond volume for the drainage area upstream of it.

4.1 Alternative 1 – South of Turnpike

Alternative 1 was developed (Figure 4-1) to reduce distress on the culvert under the turnpike and storm sewers between the various existing detention ponds downstream of the culvert. This retention pond reduces the peak flow through the turnpike culvert and downstream detention pond system.

The storage in the model considers a 100,000 sq ft area and a depth of 5 ft with an outlet control pipe and emergency spillway to the upstream of the turnpike culvert. The resulting impacts occur only in the East Branch. Profiles of these impacts are provided in Profiles 4-1-1 and 4-1-2 in the appendix.

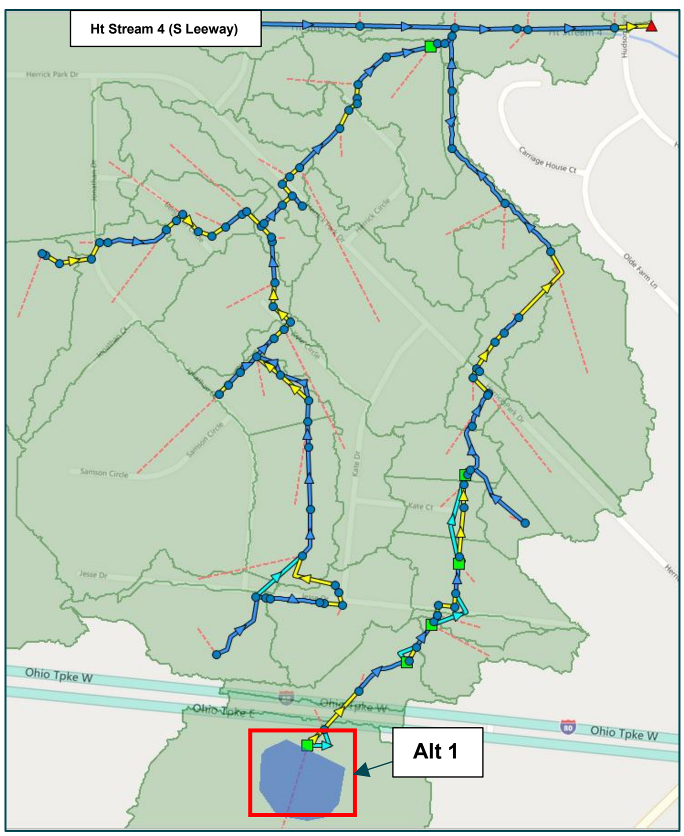


Figure 4-1 – Alternative 1 Storage Pond

4.2 Alternative 2 – North of Turnpike

Alternative 2 was developed (Figure 4-2) to reduce distress in storm sewers between the various existing detention ponds downstream of the culvert. This retention pond reduces the peak flow through the downstream detention pond system.

The storage pond expands upon the existing dry pond in the same location. The storage pond is redeveloped by adding an additional 60,000 sq ft to the existing pond with a depth of 6 ft. The resulting impacts occur only in the East Branch. Profiles of these impacts are provided in Profiles 4-2-1 and 4-2-2 in the appendix.

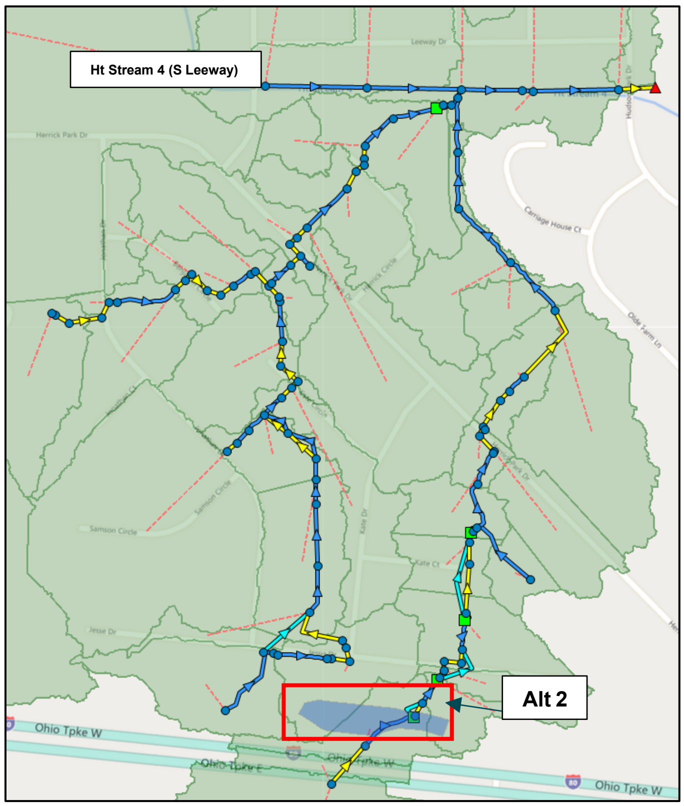


Figure 4-2 – Alternative 2 Storage Pond

4.3 Alternative 3 – NE Herrick Park Dr

Alternative 3 was developed (Figure 4-3) northeast of Herrick Park Dr and south of Old Farm Ln. This was developed to reduce the stress points that occur in the East Branch near Herrick Park Dr, where the infrastructure wasn't able withstand the 100-year and 500-year storms.

The alternative consists of a storage pond in the downstream end of the existing culvert with a parallel storm sewer from Herrick Park Dr to the proposed storage pond. The two of the relieving measures were analyzed before combining them:

a. A parallel sewer line was introduced to alleviate the capacity issues. This relieved the ponded area upstream from Herrick Park Dr but increased the flow and hydraulic grade line in the downstream ditches.
b. The addition of a detention pond alone did not impact the surcharged or ponded nodes and manholes upstream near Herrick Park Dr, as the sewer line was already at capacity and was being relieved when it reached the ditch. The addition of the detention pond reduced the increased peak flows and resulting hydraulic grade line impacts to the downstream ditches.

Therefore, this alternative is a combination of capacity improvements and storage basin, to relieve sewer capacity stress without impacting the downstream ditches.The storage pond is developed with an area of 30,000 sq ft and a depth of 6ft. The parallel storm sewer is built as a 2.5 ft diameter sewer and estimated at 735 feet long, connecting the downstream end of the ditch south of Herrick Park Dr to the storage pond. The resulting impacts occur only in the East Branch. Profiles of these impacts are provided as Profiles 4-3-1 and 4-3-2 in the appendix.

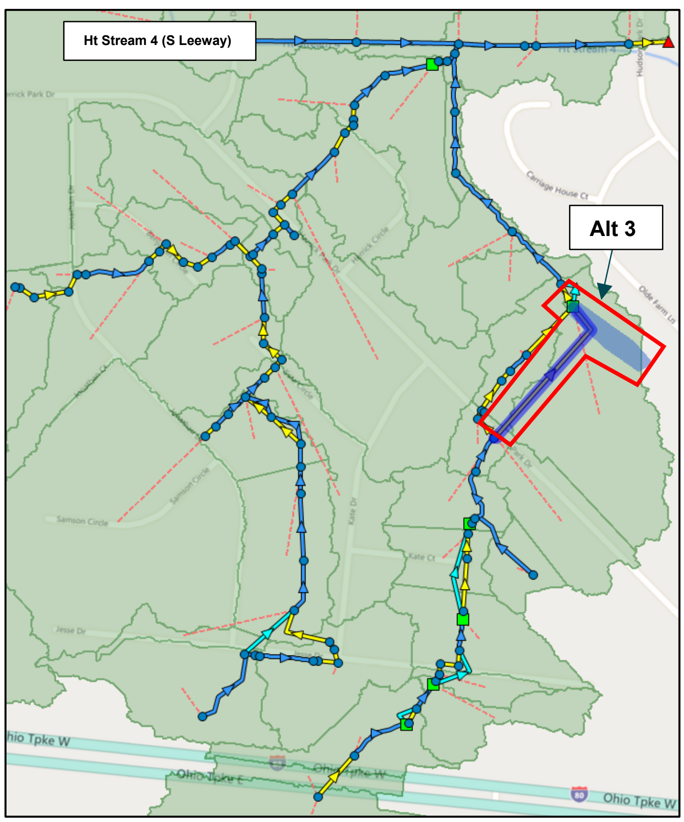


Figure 4-3 – Alternative 3 Storage Pond and Parallel Sewer

4.4 Alternative 4 – NW Turnpike

Alternative 4 was developed (Figure 4-4) northwest of turnpike. This was developed to reduce the stress points that occur in the sewer system at the intersection of Kate Dr and Jesse Dr where the infrastructure couldn't withstand the 10 year and up storms. Additionally, overtopping of Jesse Dr occurs during the 25 year and up storms.

The alternative consists of a storage pond and a parallel storm sewer. The storage pond is in the upstream end of the existing ditch with an outlet control structure and an emergency spillway to the sewer south of Jesse Dr. The parallel sewer was introduced from the intersection to the existing swale system to the backyards.

The storage pond is developed with an area of 20,000 sq ft and a depth of 4 ft. The parallel sewer is built as 2 ft diameter sewer with an estimated length of 118 ft. The resulting impacts occur in the Middle Branch. Profiles of the impacts are attached as Profiles 4-4-1, 4-4-2 and 4-4-3 in the appendix. Impacts are minimal downstream of where the Middle Branch and West Branch intersect.

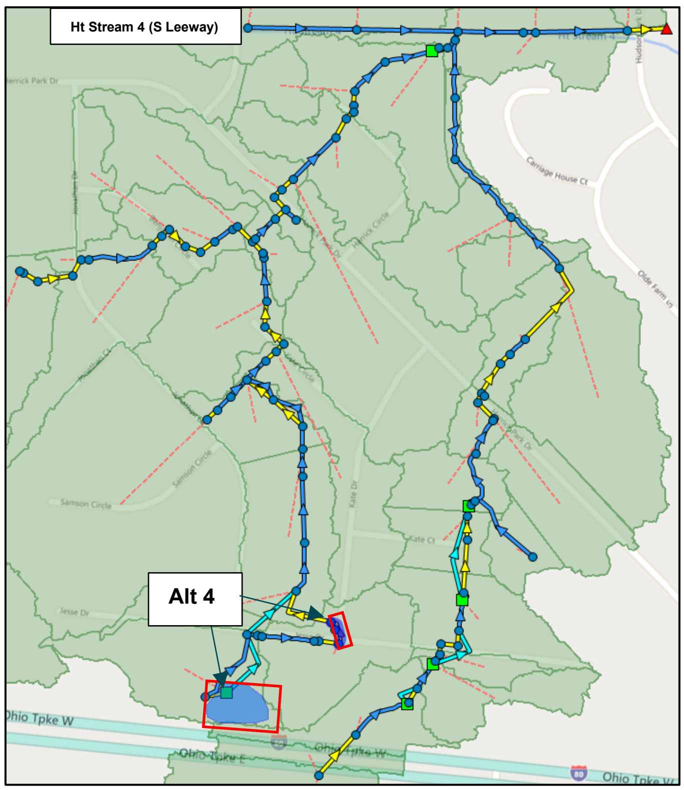


Figure 4-4 Alternative 4 Storage Pond and Parallel Sewer

4.5 Alternative 5 – Jonathan Dr

Alternative 5 was developed (Figure 4-5) to reduce distress in storm sewers near the south of Benjamin circle, where the existing infrastructure is stressed at 10-year and 50-year storms. This storage reduces the peak flow through the downstream sewer.

The storage pond is introduced in the existing ditch just east of Jonathan Dr. and has an area of 20,000 sq ft with a depth of 4.5 ft. The resulting impacts occur only in the West Branch. Profiles of these impacts are attached in the appendix as Profile 4-5-1 and 4-5-2. Impacts are minimal near where the West Branch and Middle Branch intersect and further downstream.

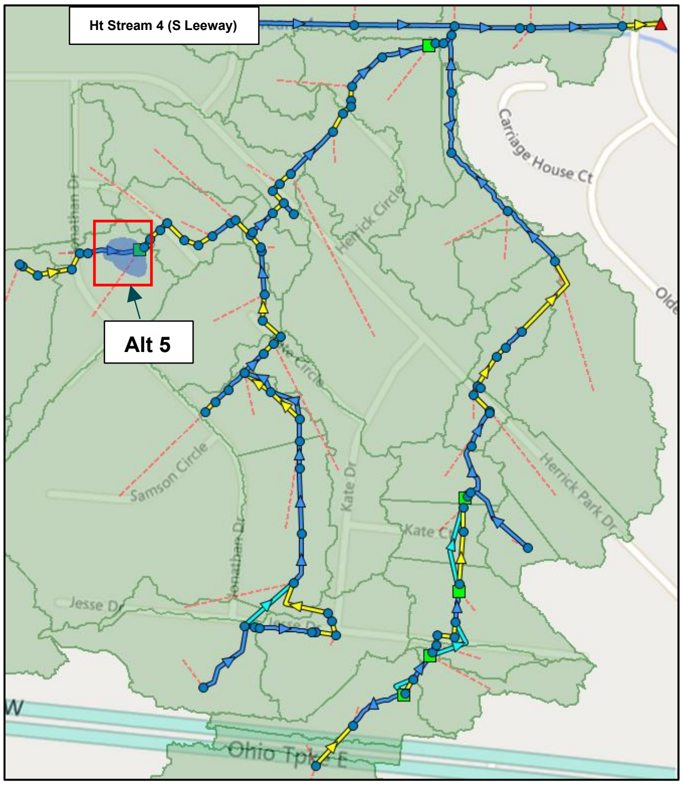


Figure 4-5 Alternative 5 Storage Pond

4.6 Alternative 6 – Alternative 4 &5 combined

Alternative 6 was developed (Figure 4-6) to understand the combined impacts of Alternative 4 and 5 on the system downstream of the intersection of the Middle Branch and West Branch to Herrick Park detention pond. The impact of alternative 5 was more localized and had less than 0.5 feet of impact in the called-out area (Figure 4-6). Profiles of these impacts are attached in the appendix as Profile 4-6.

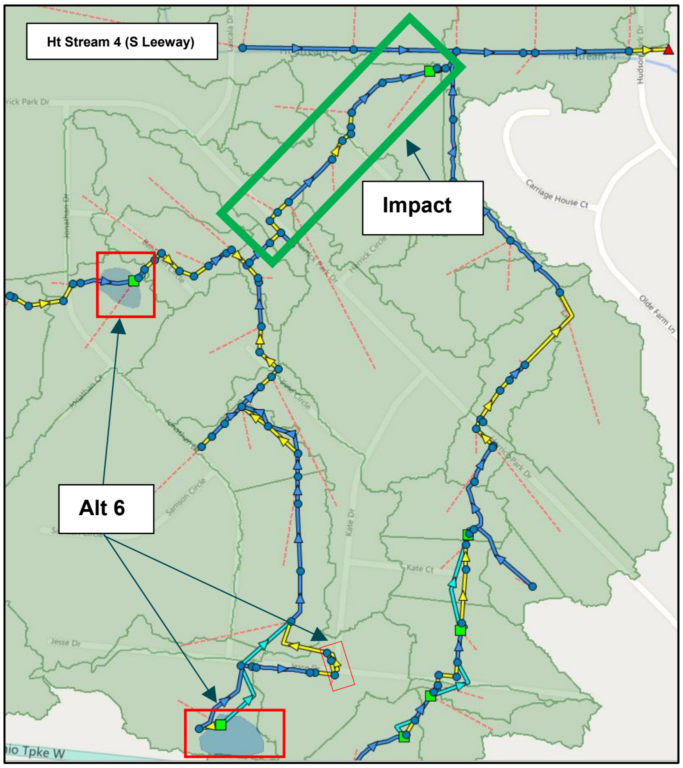


Figure 4-6 Alternative 6

4.7 Alternative 7 – All Alternatives combined

Alternative 7 was developed (Figure 4-7) to understand the impacts of Alternative 1 through 5 in the most downstream end along Ht Stream 4 leading to the Dual culvert outlet. The result of this alternative had localized impacts and no regional impact with minimal impact at the downstream end along Ht Stream 4. The impact resulted in a less than 0.4 feet HGL reduction in profiles in any storm event. The results were not considered significant enough to profile for this alternative.

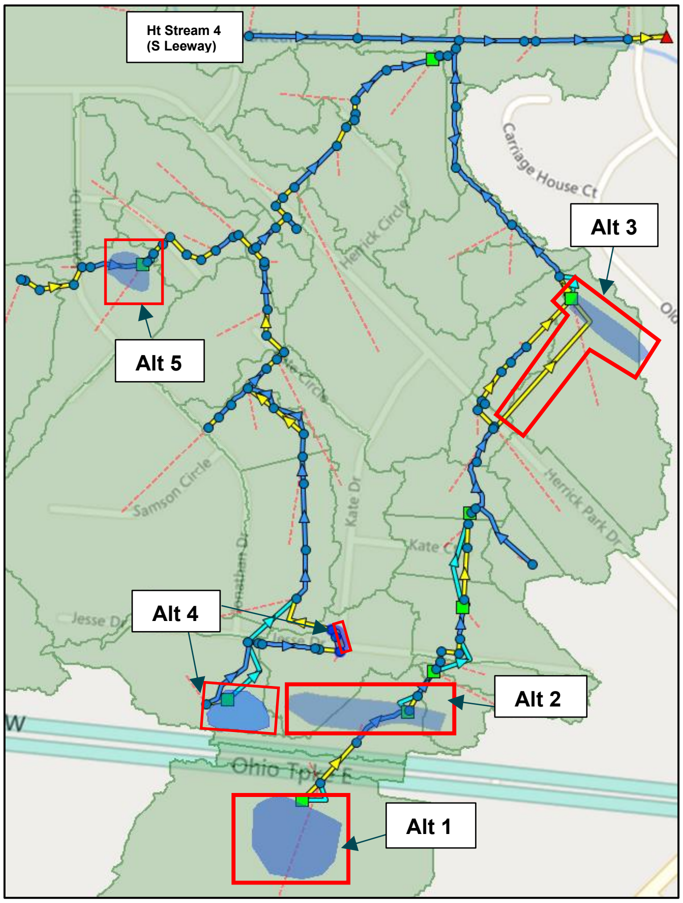


Figure 4-7 Alternative 7 combined

4.8 Alternative 8 – Herrick Park Detention Pond Capacity

Alternative 8 reviewed the possibility of increasing the capacity of Herrick Park Detention Pond. Review of this alternative indicates that there is no room for expansion of the pond area and that the depth of the pond is already maximized that any additional depth would have minimal impact on the system.

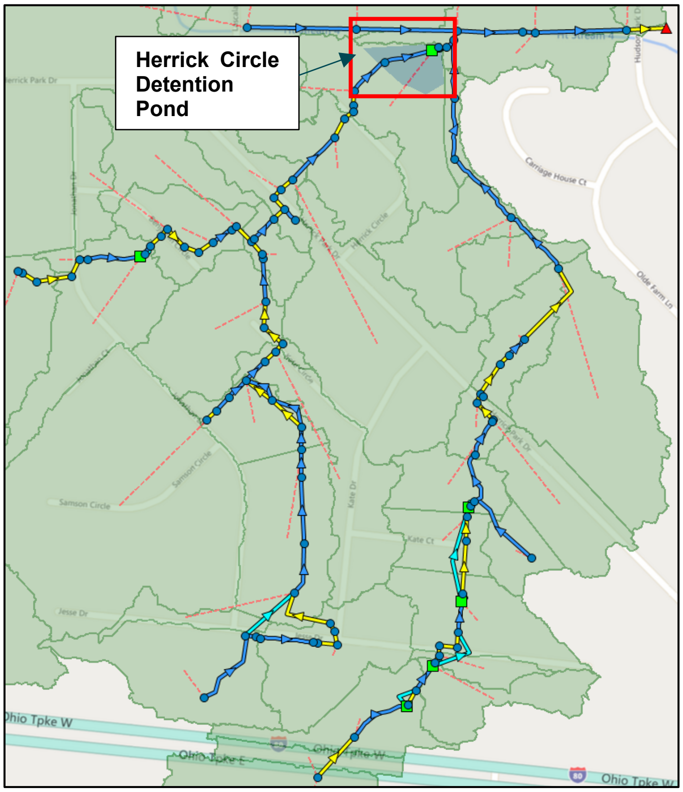


Figure 4-8 Alternative 8

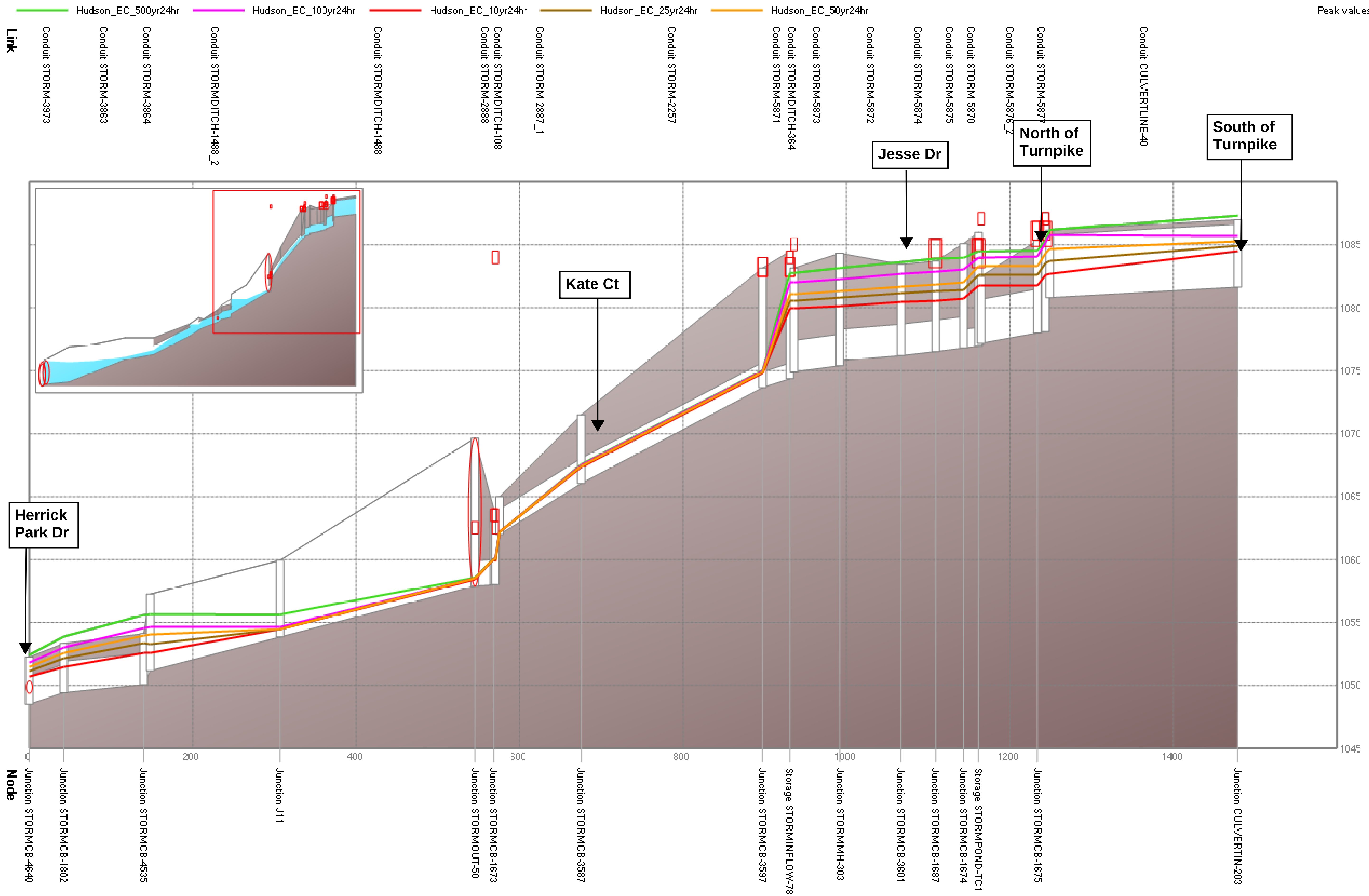
5. Summary

The analysis indicates that the neighborhood stormwater system benefits on a localized level from the addition of detention facilities rather than a regional level. Alternatives 1, 4 and 5 should be reviewed against historical flood complaints to further identify additional benefits to the community.

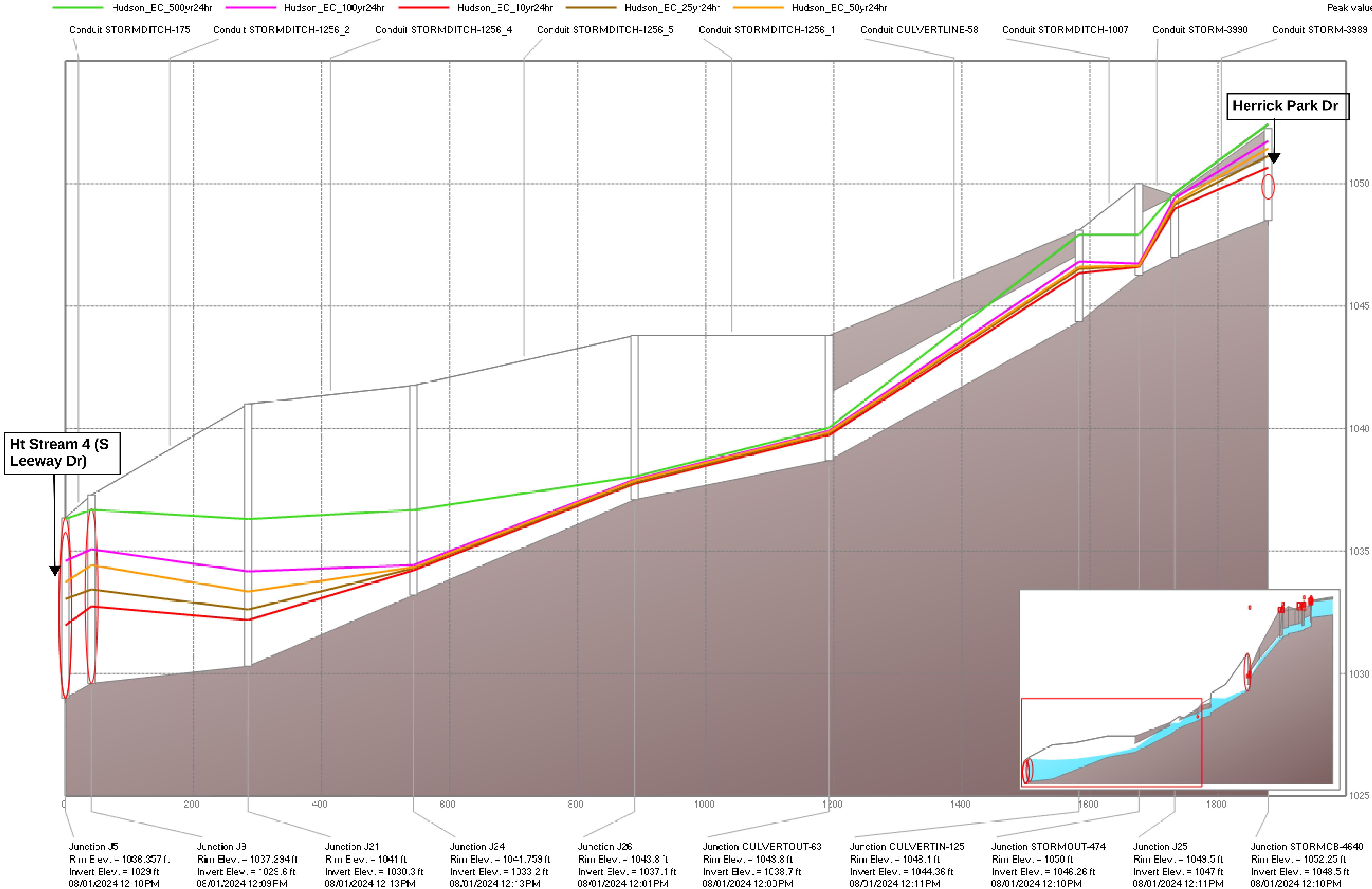
Appendix

Existing Conditions Profiles

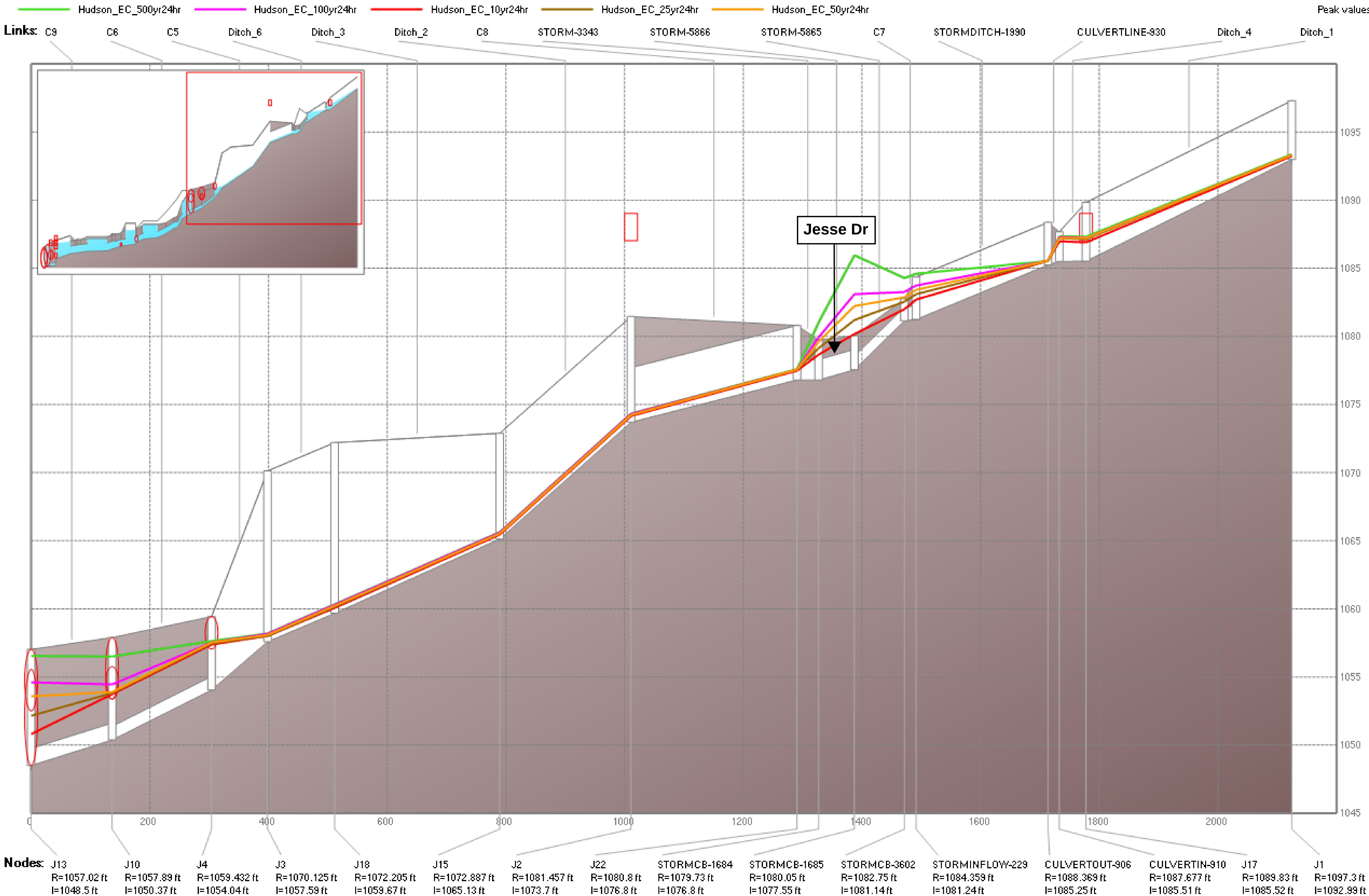
Profile 3-1-1 Existing Condition Profile



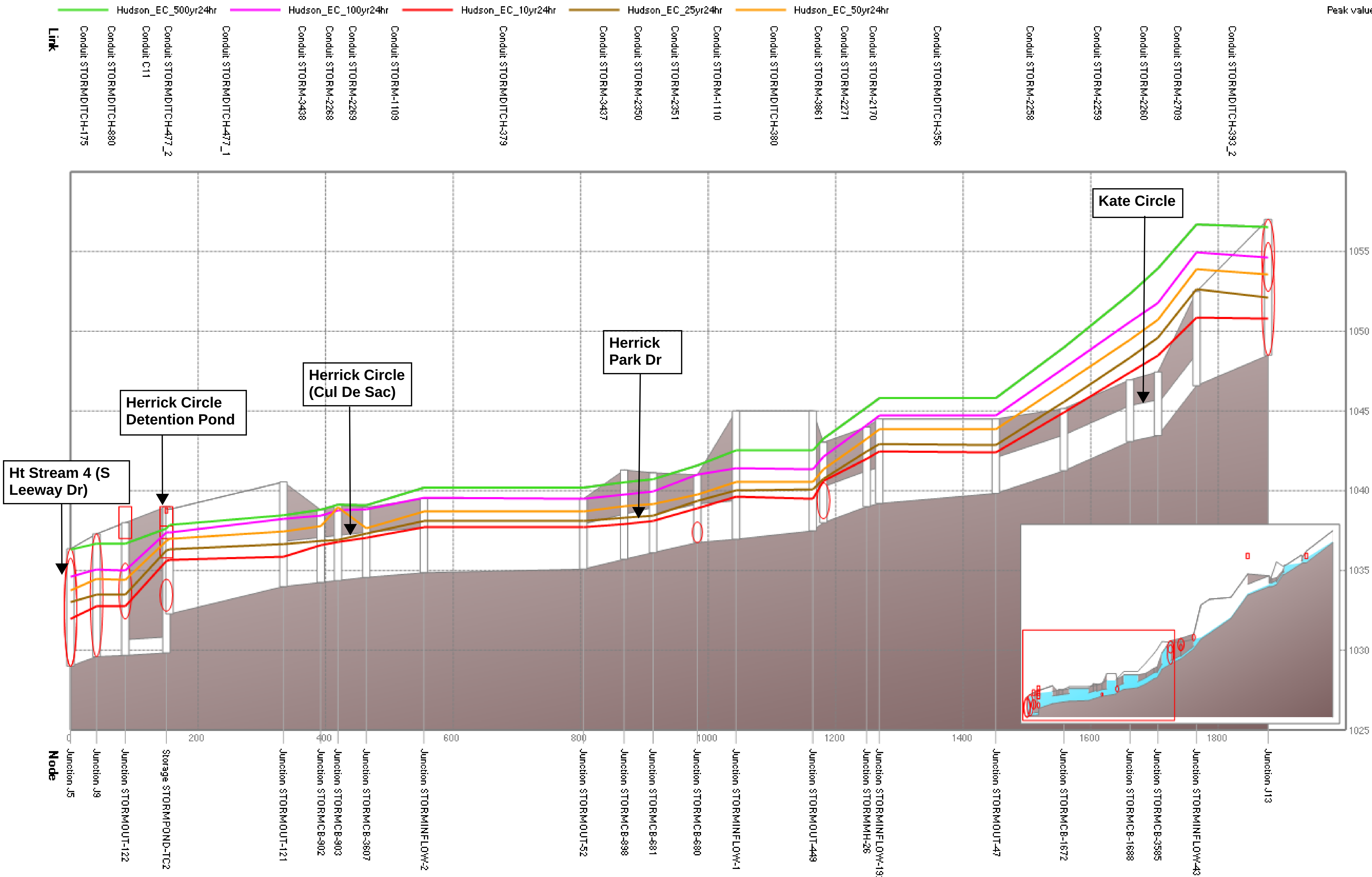
Profile 3-1-2 Existing Condition Profile



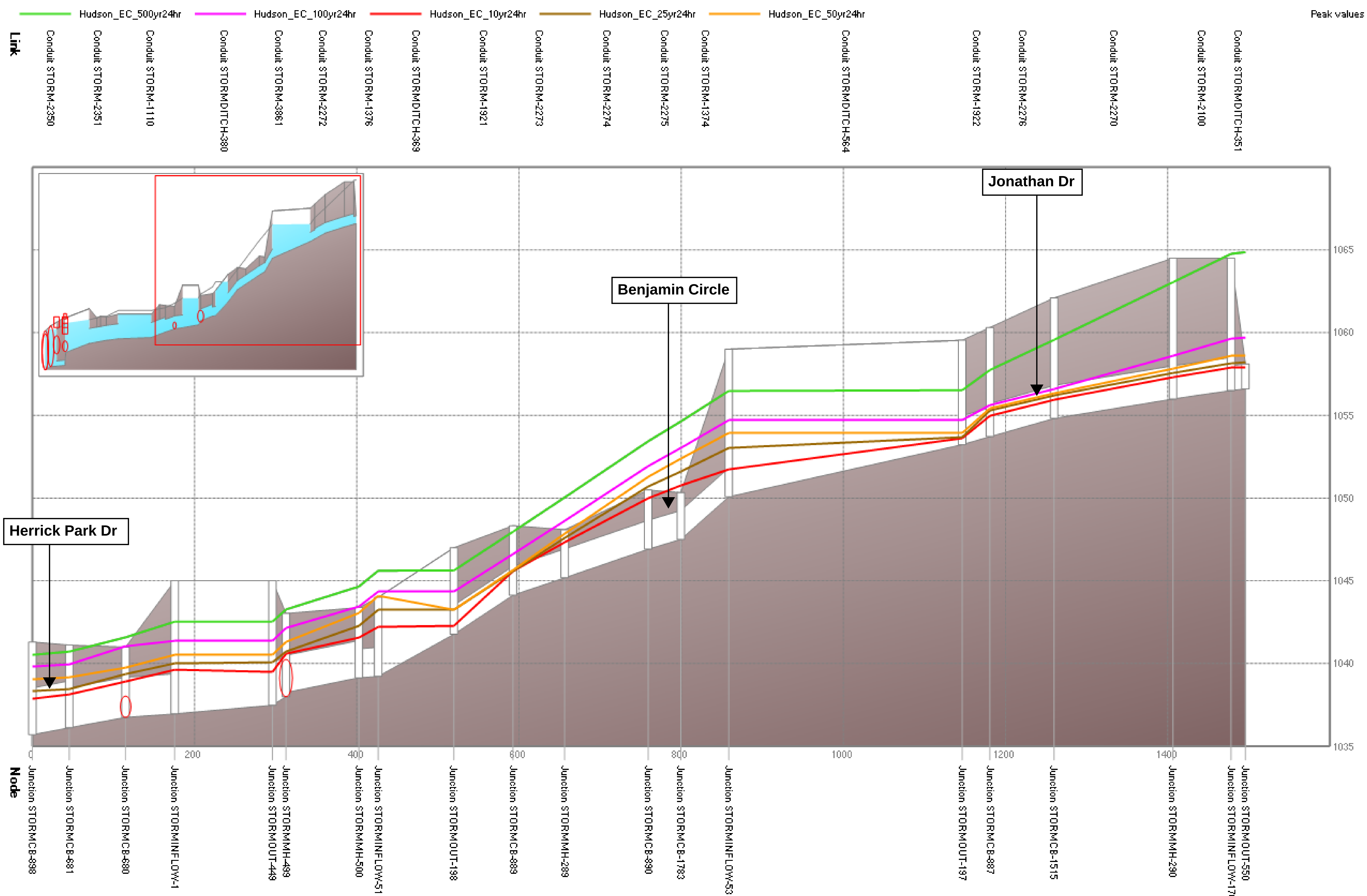
Profile 3-2-1 Existing Condition Profile



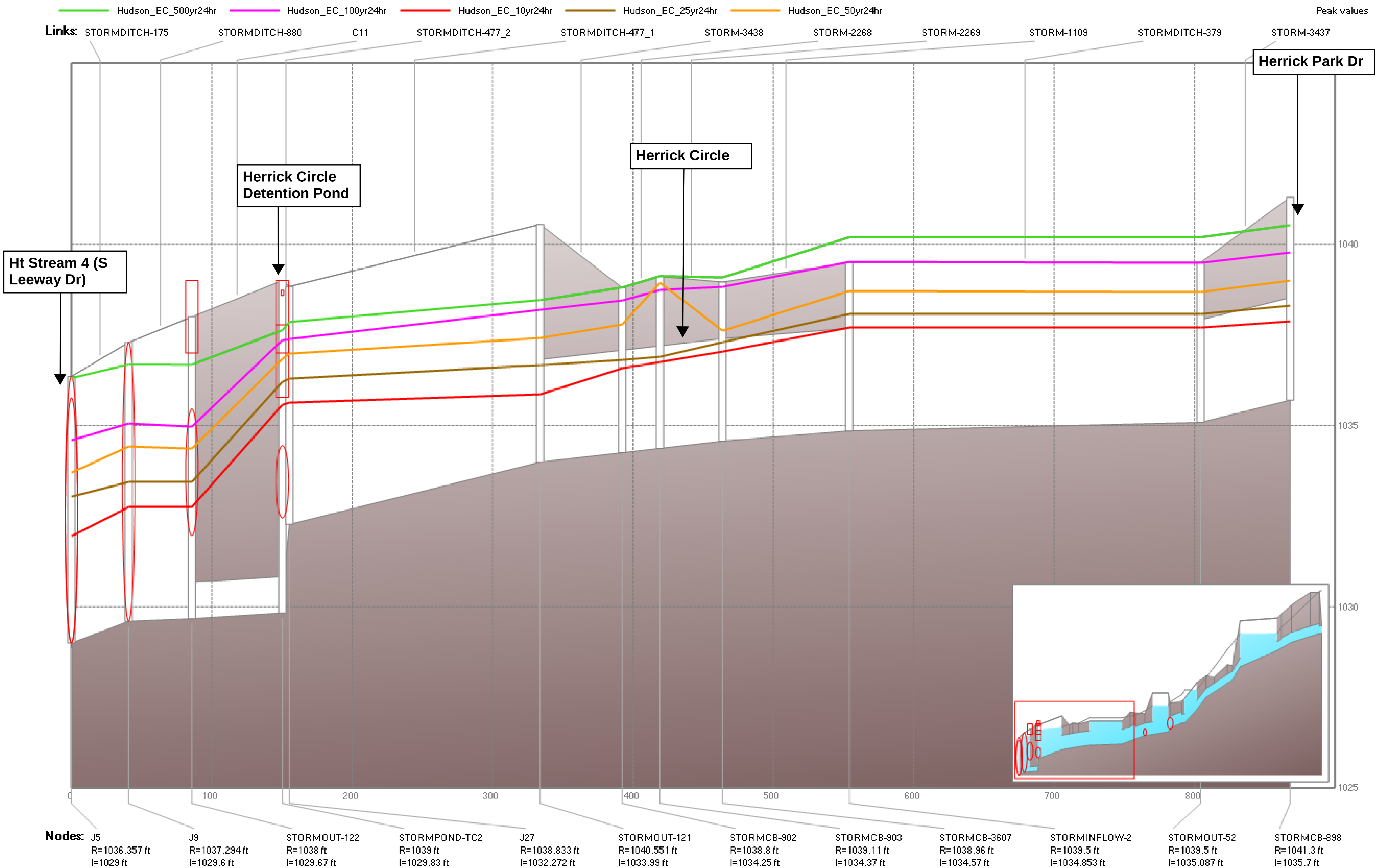
Profile 3-2-2 Existing Condition Profile



Profile 3-3-1 Existing Condition Profile

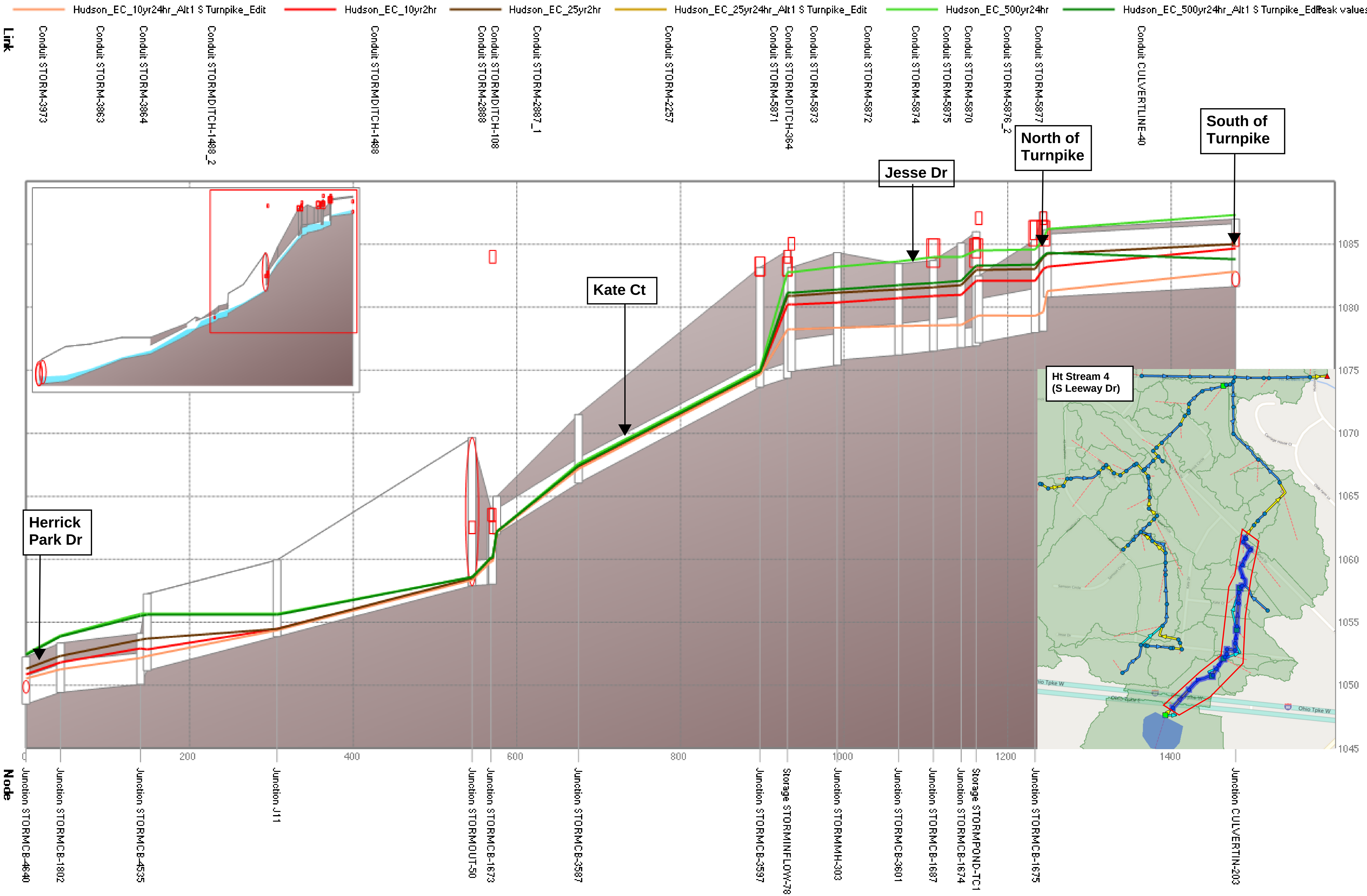


Profile 3-3-2 Existing Condition Profile

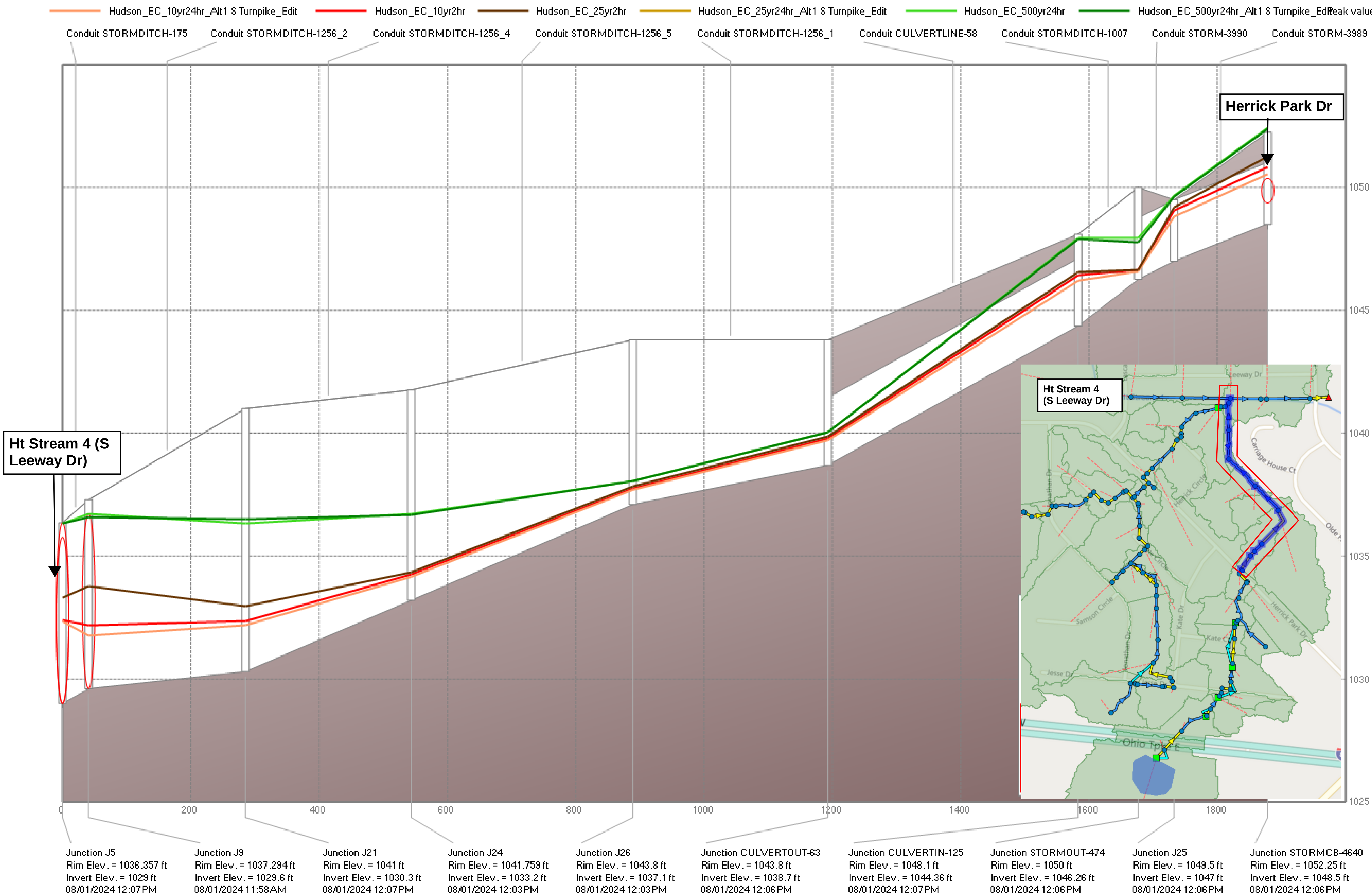


Alternative Conditions Profiles

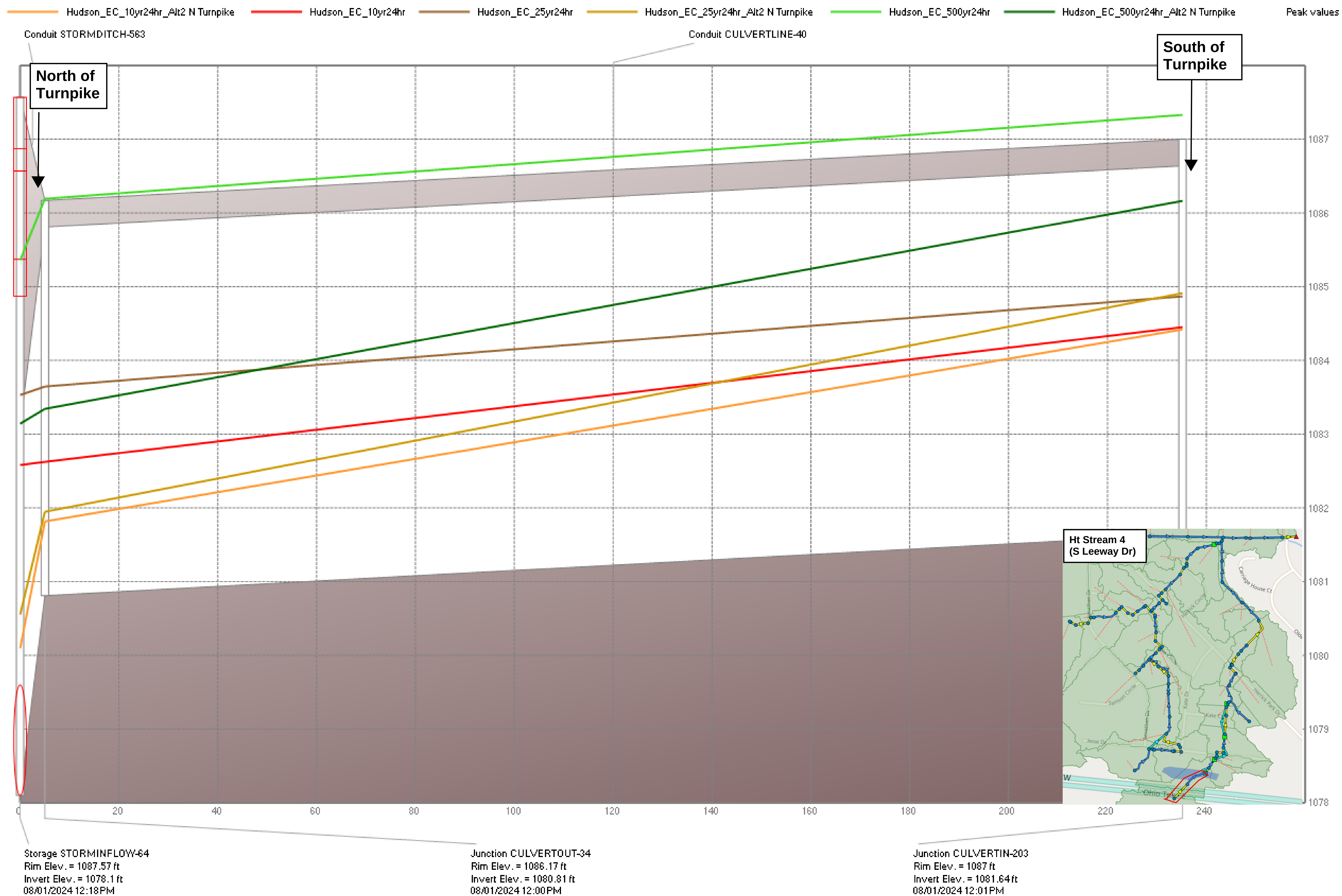
Profile 4-1-1 Alternative 1(South of Turnpike)
Existing vs Alternative



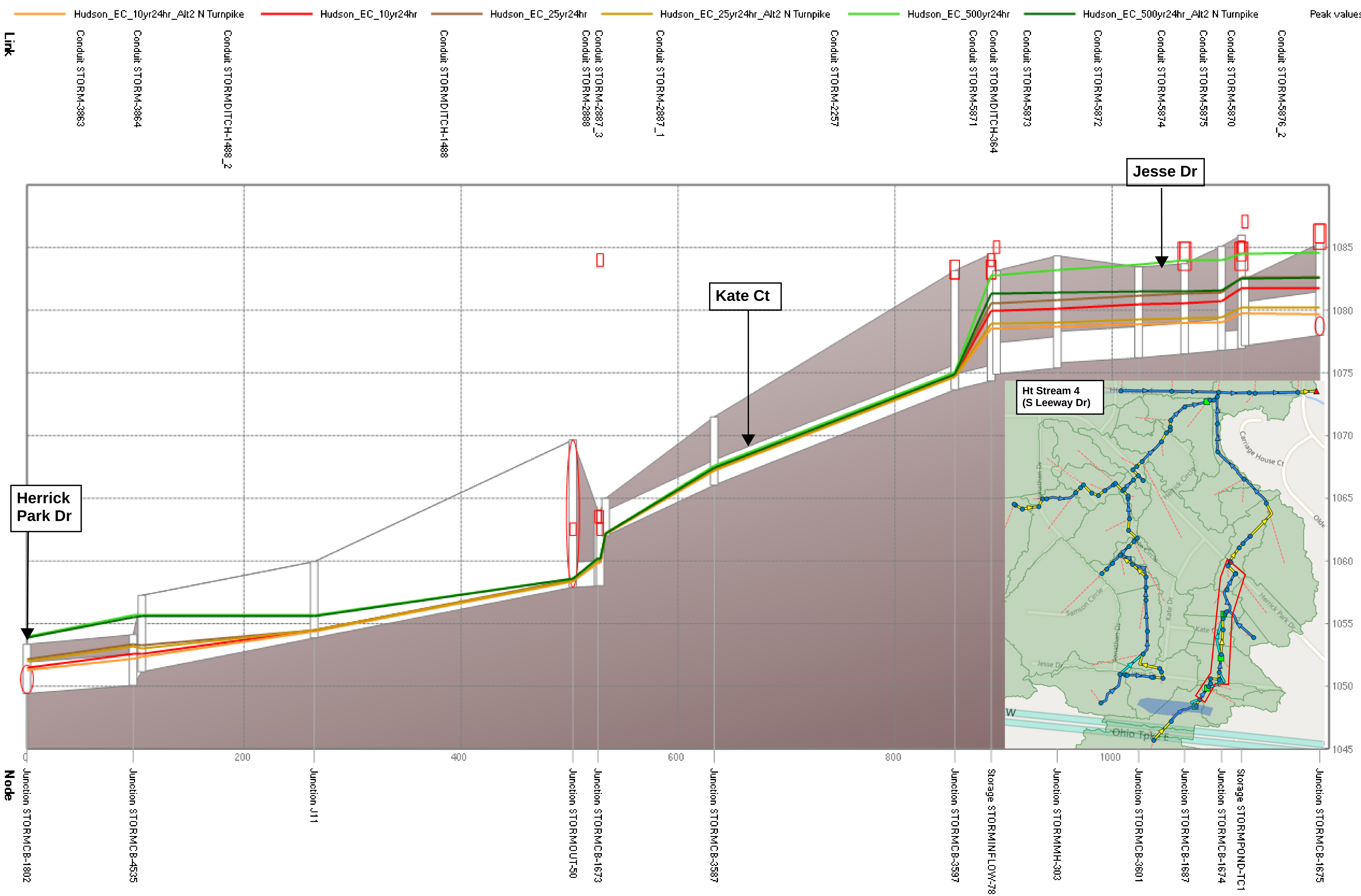
Profile 4-1-2 Alternative 1(South of Turnpike)
Existing vs Alternative



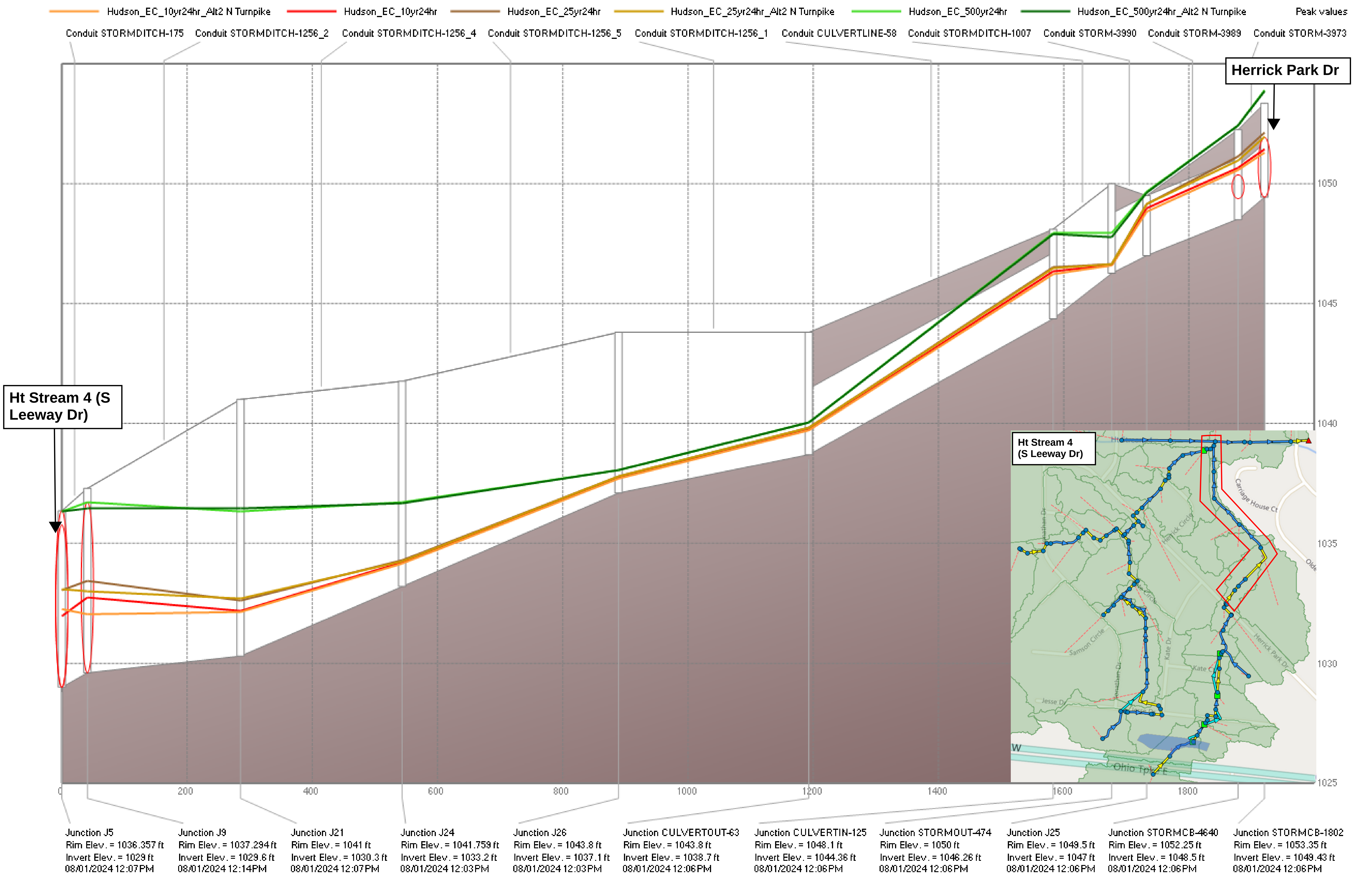
Profile 4-2-1 Alternative 2 (North of Turnpike)
Existing vs Alternative



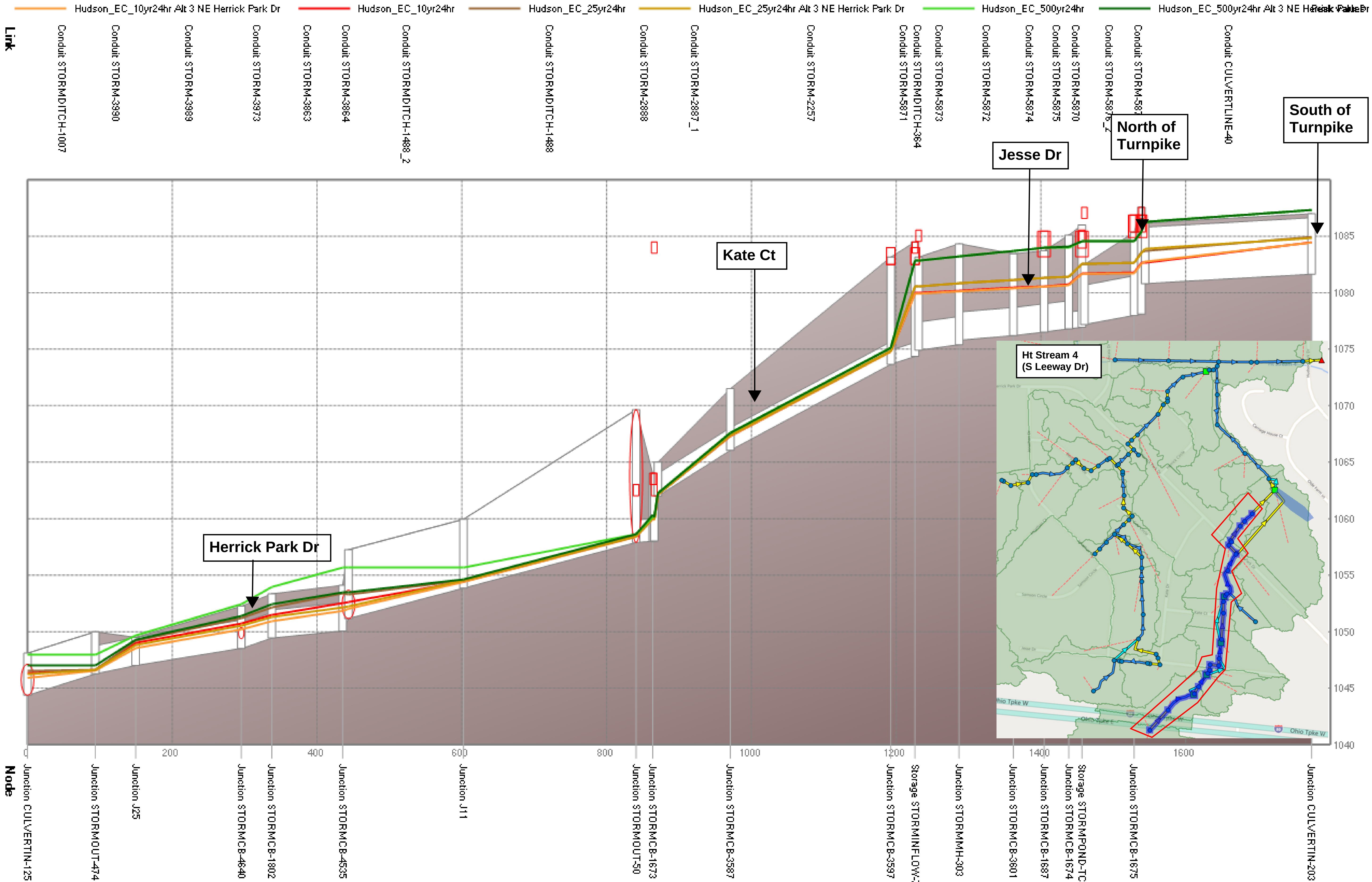
Profile 4-2-2 Alternative 2 (North of Turnpike)
Existing vs Alternative



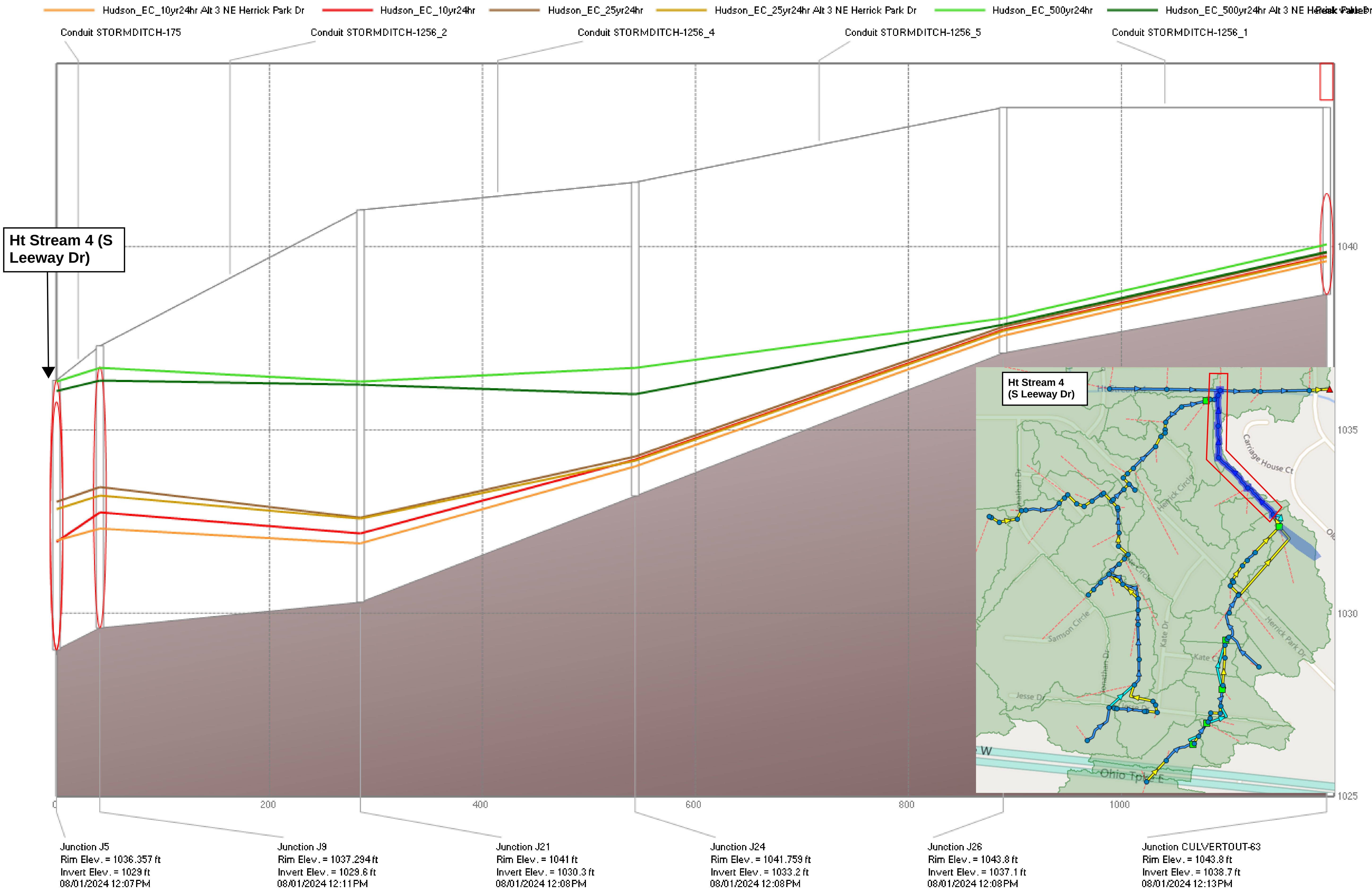
Profile 4-2-3 Alternative 2 (North of Turnpike)
Existing vs Alternative



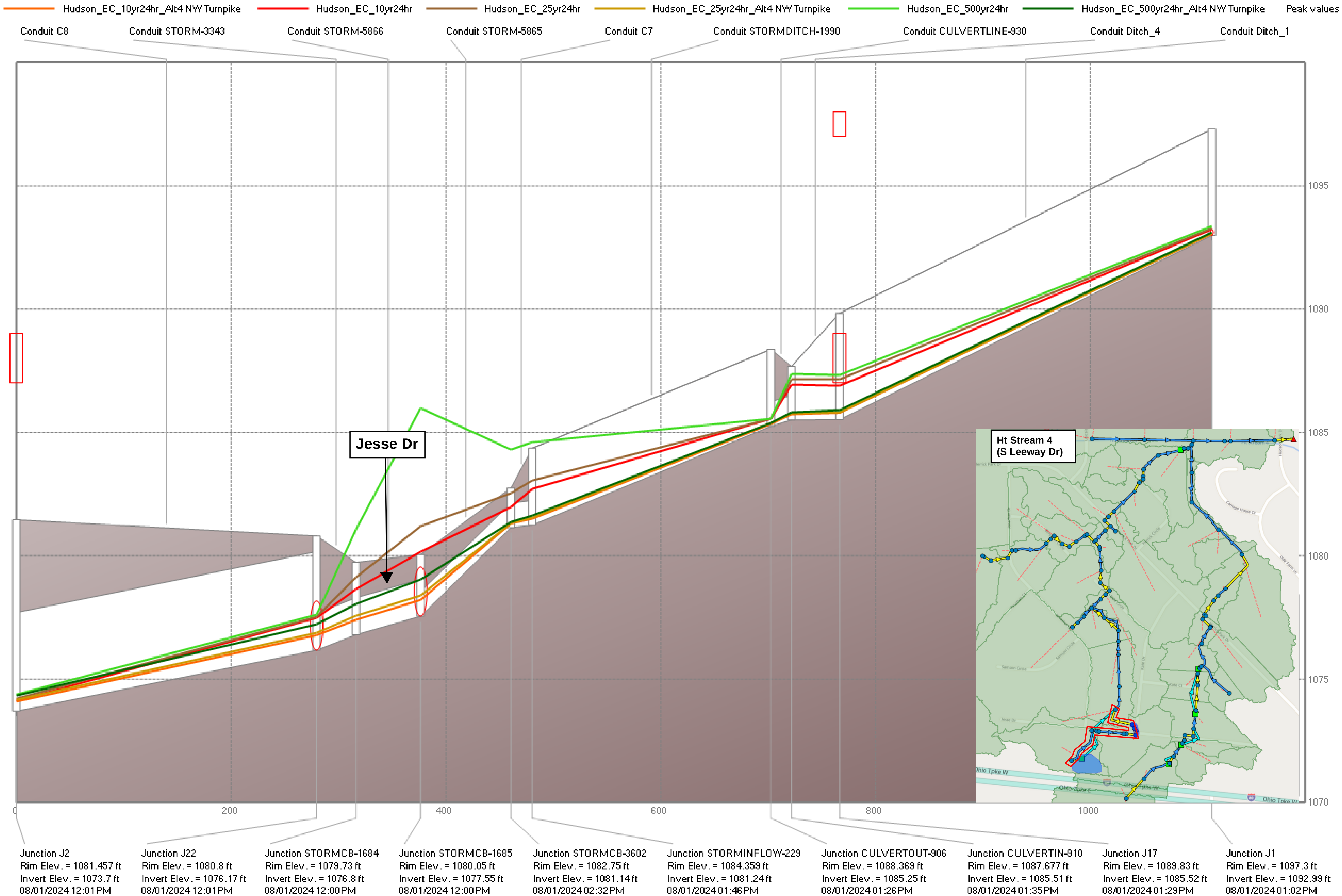
Profile 4-3-1 Alternative 3 (NE Herrick Park Dr)
Existing vs Alternative



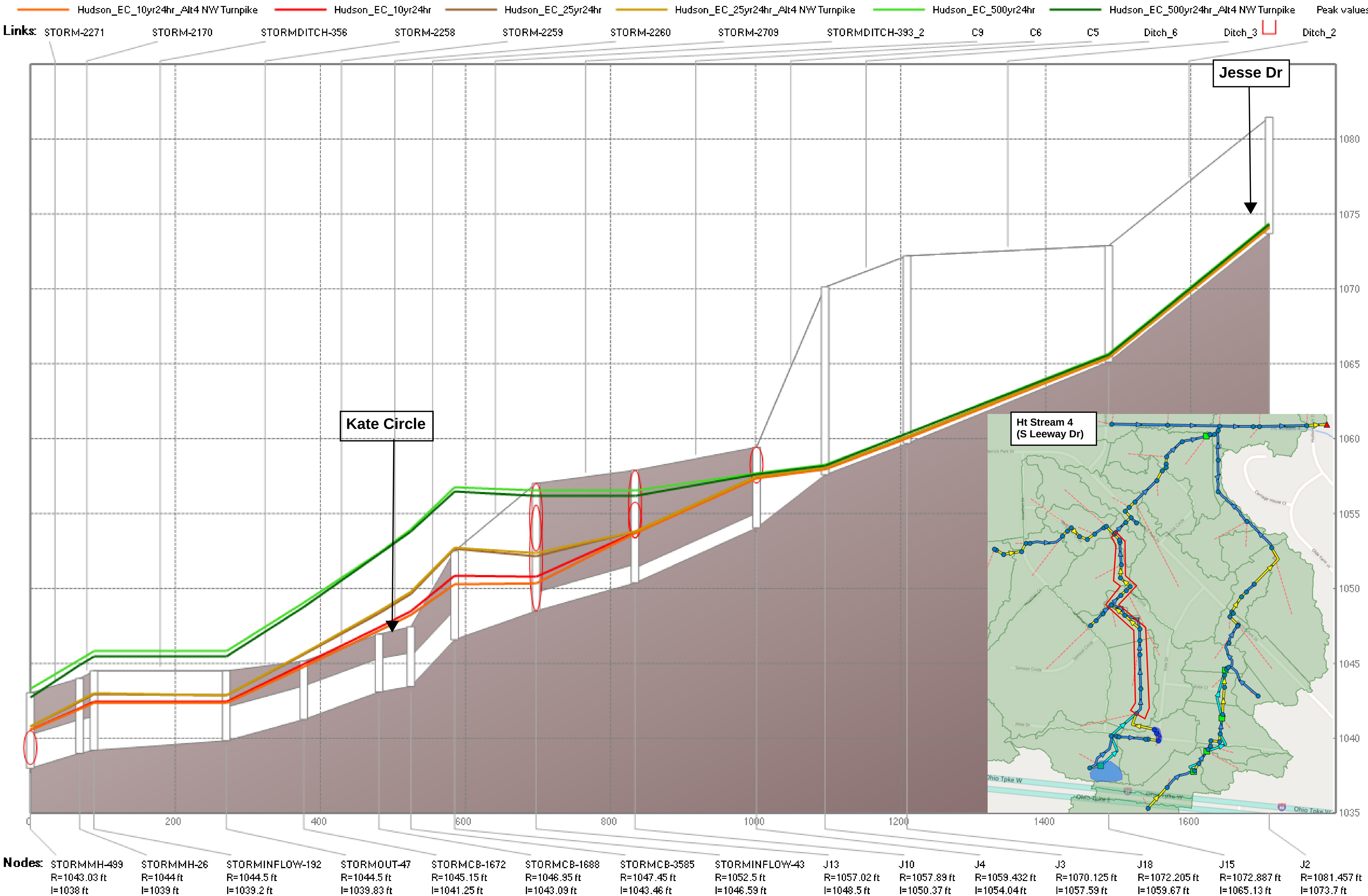
Profile 4-3-2 Alternative 3 (NE Herrick Park Dr)
Existing vs Alternative



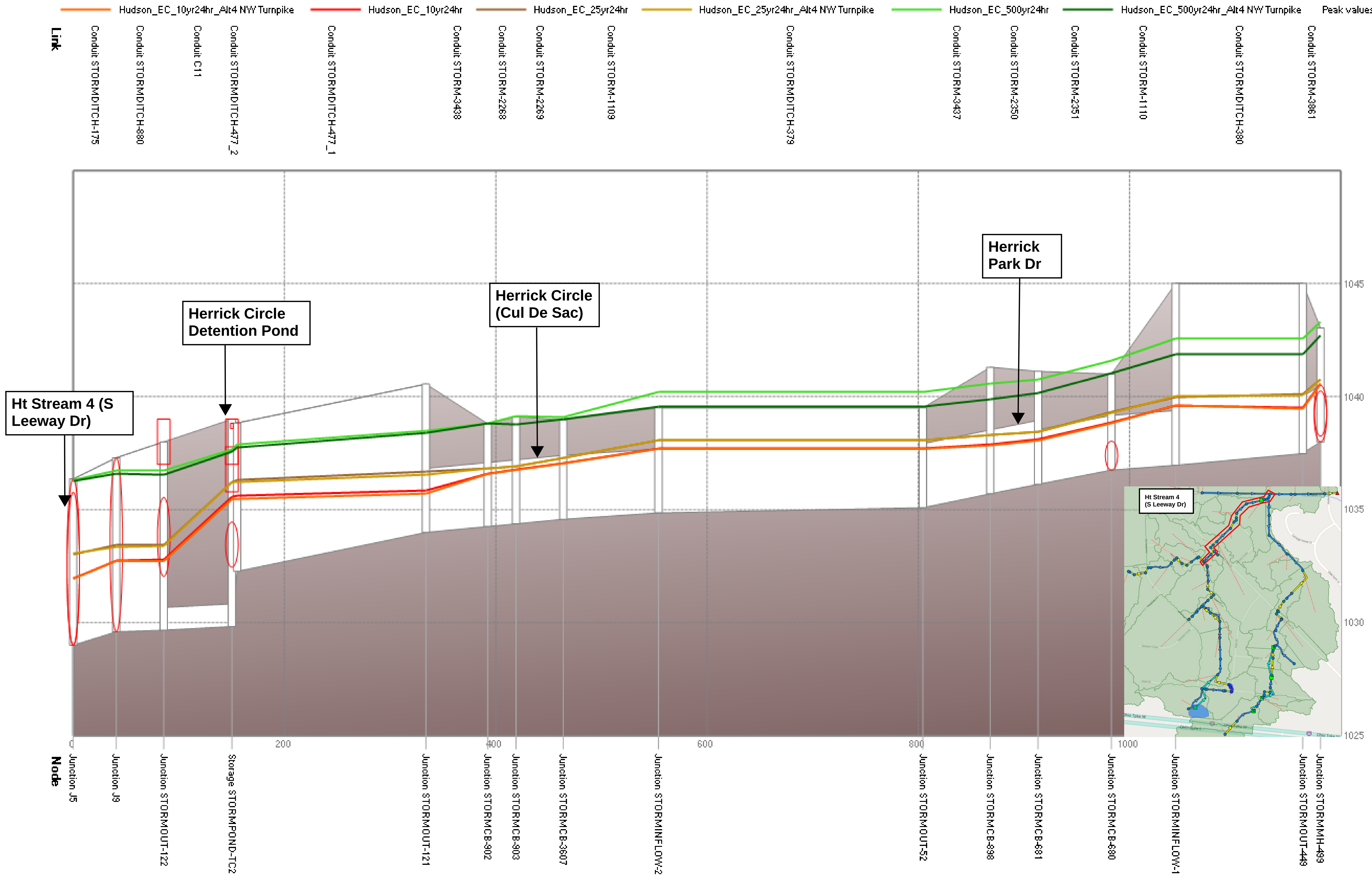
Profile 4-4-1 Alternative 4 (NW Turnpike)
Existing vs Alternative



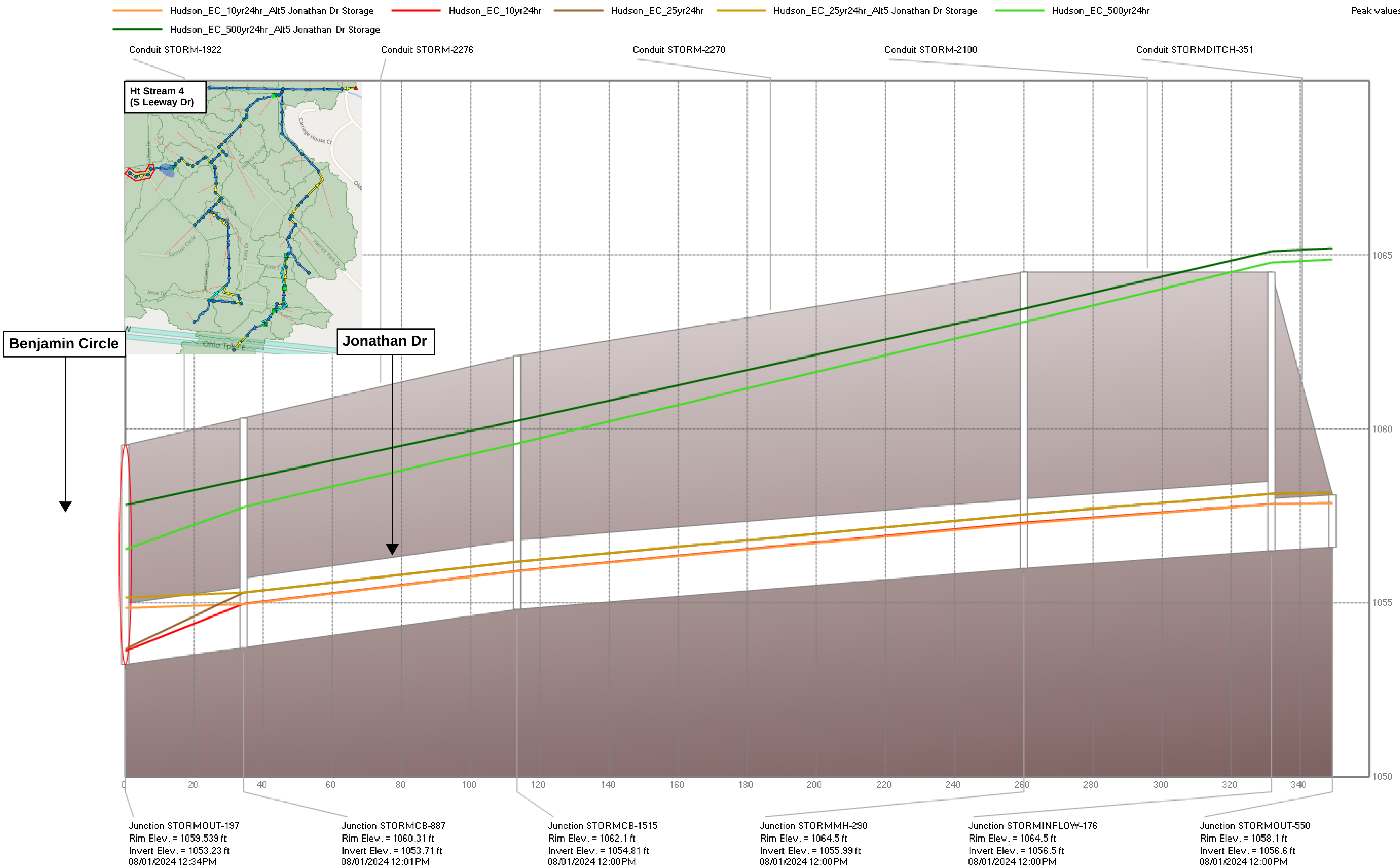
Profile 4-4-2 Alternative 4 (NW Turnpike)
Existing vs Alternative



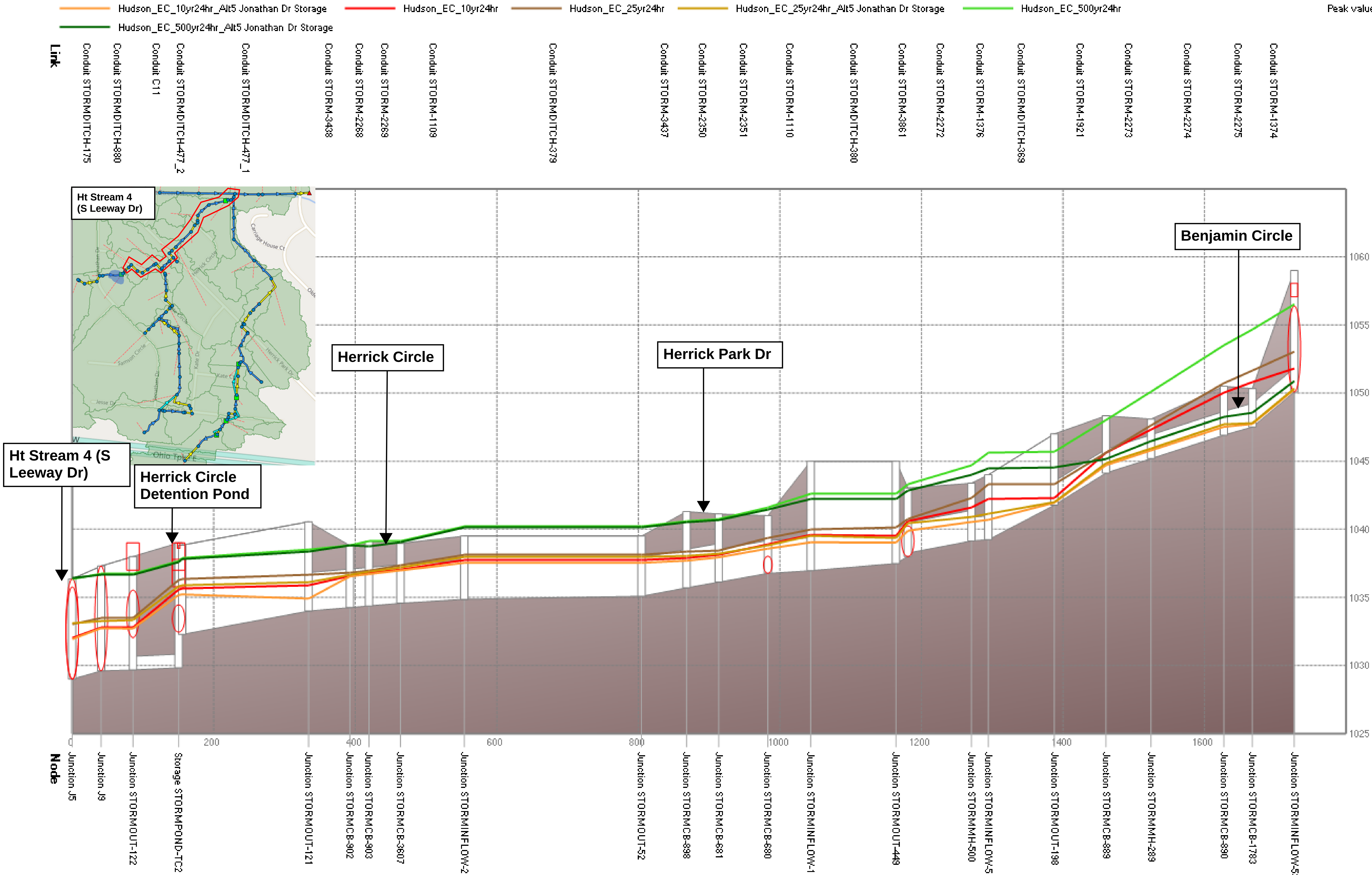
Profile 4-4-3 Alternative 4 (NW Turnpike)
Existing vs Alternative



Profile 4-5-1 Alternative 5 (Jonathan Dr)
Existing vs Alternative



Profile 4-5-2 Alternative 5 (Jonathan Dr)
Existing vs Alternative



Profile 4-6 - Alternative 6 (Jonathan Dr and NW Turnpike)
Existing vs Alternative