

WDOA Division Project No. 181N

Town of Summit

Douglas County, WI

Cedar Corporation

604 Wilson Avenue  
Menomonie, Wisconsin 54751

# Alternative Hydraulic Analysis

## Gandy Dancer State Trail over Little Balsam Creek

April 2023



# Alternative Hydraulic Analysis for WDOA Division Project No. 181N Town of Summit, WI

Gandy Dancer State Trail Over Little Balsam Creek

Douglas County

April 2023

Prepared for:

Wisconsin Department of Administration & Wisconsin Department of Natural Resources



Prepared by: Cedar Corporation

604 Wilson Avenue  
Menomonie, Wisconsin 54751

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# 1 Introduction

## 1.1 Executive Summary

The Wisconsin Department of Administration (WDOA) and the Wisconsin Department of Natural Resources (WDNR) have proposed a bridge replacement project for the Gandy Dancer State Trail. The proposed project scope is to remove and replace an existing box culvert with a prestressed girder bridge.

A hydraulic study was previously completed and submitted to the WDNR on January 31, 2023. The results of the proposed model demonstrated an increase in water surface elevation downstream of the structure for the 100-year storm event.

## 1.2 Purpose and Intent

The purpose and intent of this report is to document the modifications necessary to eliminate the downstream water surface increase. This report will outline the hydraulic calculations used in determining the impact of the floodplain as a result of the modifications to the proposed structure.

## 1.3 Location

The project site is located on the Gandy Dancer State Trail over Little Balsam Creek (WBIC 2841700) and is located in North West Douglas County, in North Western Wisconsin. More specifically, the project site is located in the Town of Summit in the North East ¼ of the North West ¼ of section 10, T46N, R15W. The location is identified in the following figure below. An expanded location map and contour map can be found in Appendix A.



**Figure 1.1: Gandy Dancer State Trail General Location**

## 2 Existing Data

### 2.1 Existing Structure and Approaches

The existing structure is a 12-feet wide by 8-feet high box culvert. Photos of the existing box culvert and surrounding area can be found in Appendix A. A survey was conducted at the site to verify field conditions however original design was not available as the structure is not in the Wisconsin Department of Transportation - Highway Structure Index (HSI) database.

### 2.2 Flood Insurance Study (FIS) and Flood Insurance Rate Map (FIRM)

The current effective FEMA Flood Insurance Study (FIS) for Douglas County and Incorporated Areas dated February 2, 2012 did not study Little Balsam Creek

The Flood Insurance Rate Map (FIRM) for this area, map no 55031C0405D, is dated February 2, 2012. The shaded area of Little Balsam Creek is classified as Zone A. Zone A is an area of special flood hazard without base flood elevations. A copy of the FIRMette for this area can be found in Appendix B of this report.

### 2.3 Existing Data

A hydraulic model of the watershed was obtained from the WDNR. The hydraulic model however does not meet the requirements of NR116 therefore the floodplain of Little Balsam Creek is considered unstudied, Zone A. A site-specific hydraulic model is therefore required to determine the impact of project on the floodplain.

The 100-year storm event flow in the hydraulic model is 713 CFS. It was determined by others that this flow meets the criteria of NR116 and therefore can be used in the site-specific flood study.

### 2.4 LiDAR

LiDAR data was obtained from the WisconsinView database website. The LiDAR data, 2-foot contour lines, were used in the existing surface to supplement topographic survey data.

## 3 Hydraulic Analysis

### 3.1 Topographic Survey

A detailed topographic survey of the project site was completed with stream bank cross sections upstream and downstream. A surface model was created in AutoCAD Civil 3D using County LiDAR data with edits made based on the topographical data collected. It is important to note that the river channel between data collection points was approximated using survey data and aerial photography.

### 3.2 Model Notes

A previously submitted hydraulic model was created using the US Army Corp of Engineer's Hydrologic Engineering Center's River Analysis System release 6.2 also known as HEC-RAS 6.2. HEC-RAS is a hydraulic modeling software used to perform one-dimensional hydraulic calculations to determine water surface profiles.

The purpose of this model was to compare the backwater between the existing structure and the proposed structure. The goal was to verify that there is not an increase in the base flood elevation as a result of the new structure.

The existing structure is perpendicular to Gandy Dancer Trail whereas the Little Balsam Creek approaches and leaves the proposed structure at a skew. Therefore, the streambed will be reestablished as part of the project. The purpose of the streambed reestablishment is to provide a more natural flow path under the bridge. The centerline of the proposed stream reestablishment was used as the river alignment and cross sections were adjusted accordingly.

Seventeen cross sections (eight upstream and nine downstream) normal to the centerline flow the Little Balsam Creek Reestablishment were extracted from the surface model and modeled in HEC-RAS. Both the existing and proposed surface models were projected onto the hydraulic cross sections.

Boundary conditions are needed in the hydraulic model to establish a starting water surface at the end of the river system. The boundary conditions in the modeling were set to normal depth based on water surface shots 400 feet upstream and 550 feet downstream. Ineffective flow areas were calculated based on the constrictions of the existing or proposed structures.

The hydraulic analysis studied two different conditions; Existing conditions (existing box culvert), and alternate proposed conditions (proposed structure). The hydraulic analysis used the 100-year storm event flow from the watershed WDNR hydraulic model (713 CFS).

## 4 Alternative Hydraulic Analysis

A copy of the previous proposed model was used for this analysis and modified to determine the changes necessary to reduce the increase in downstream water surface elevation.

### 4.1 Stream Realignment Profile

The first modification evaluated to eliminate the downstream increase was a grade break in the proposed stream realignment profile at station 52+15 (station 7+87 for HEC-RAS alignment stationing). The slope of the stream was increased to 6-percent from station 52+15 to station 52+50 to lower the stream (station 7+52 to 7+87 for HEC-RAS alignment stationing). This decrease in grade provides a better transition from the proposed stream realignment to the existing stream. The proposed stream profile cannot be lowered any further upstream without the slopes of the overbanks surpassing a 2:1 slope.

A plan and profile of the stream depicting the changes to the profile can be found in Appendix C. The results of the model with the profile modification are summarized in Table 3.1: Summary of Hydraulic Data – Alternate Proposed Model (Modified Profile). A downstream increase still exists as shown in the summary below.

**Table 3.1. Summary of Hydraulic Data – Alternate Proposed Model (Modified Profile)**

| River Station | Existing 100-Year W.S. Elevation | Proposed (Modified Profile) 100-Year W.S. Elevation | Difference |
|---------------|----------------------------------|---|------------|
| 1400          | 966.93                           | 966.93  | 0.00       |
| 1360          | 965.66                           | 965.66  | 0.00       |
| 1300          | 965.42                           | 965.42  | 0.00       |
| 1255          | 963.98                           | 963.98  | 0.00       |
| 1200          | 962.55                           | 962.47  | -0.08      |
| 1150          | 963.16                           | 961.40  | -1.76      |
| 1120          | 961.82                           | 961.67  | -0.15      |
| 1110          | 961.84                           | 961.68  | -0.16      |
| 1000          | Bridge/Box Culvert               |   |            |
| 880           | 954.69                           | 955.36  | 0.67       |
| 865           | 954.28                           | 955.17  | 0.89       |
| 850           | 954.15                           | 954.56  | 0.41       |
| 750           | 952.21                           | 951.81  | -0.40      |
| 715           | 951.23                           | 951.12  | -0.11      |
| 625           | 948.26                           | 948.26  | 0.00       |
| 575           | 947.98                           | 947.98  | 0.00       |
| 550           | 947.36                           | 947.36  | 0.00       |
| 500           | 946.62                           | 946.62  | 0.00       |

## 4.2 Bench

The second modification evaluated to eliminate the downstream increase was a bench on the north side of the proposed stream from station 51+00 to 52+50 (7+52 to 9+02 for HEC-RAS alignment stationing). This benched area provides greater storage capacity and reduces water surface elevation.

HEC-RAS cross sections comparing the alternate proposed models (modified stream profile, and the addition of a bench) can be found in Appendix D. The results of the model with the bench included are summarized in Table 3.2: Summary of Hydraulic Data – Alternate Proposed Model (Bench). A downstream increase still exists as shown in the summary below.

**Table 3.2. Summary of Hydraulic Data – Alternate Proposed Model (Bench)**

| River Station | Existing 100-Year W.S. Elevation | Proposed (Bench) 100-Year W.S. Elevation | Difference |
|---------------|----------------------------------|--|------------|
| 1400          | 966.93                           | 966.93                                   | 0.00       |
| 1360          | 965.66                           | 965.66                                   | 0.00       |
| 1300          | 965.42                           | 965.42                                   | 0.00       |
| 1255          | 963.98                           | 963.98                                   | 0.00       |
| 1200          | 962.55                           | 962.47                                   | -0.08      |
| 1150          | 963.16                           | 961.4                                    | -1.76      |
| 1120          | 961.82                           | 961.67                                   | -0.15      |
| 1110          | 961.84                           | 961.68                                   | -0.16      |
| 1000          | Bridge/Box Culvert               |  |            |
| 880           | 954.69                           | 954.49                                   | -0.20      |
| 865           | 954.28                           | 954.41                                   | 0.13       |
| 850           | 954.15                           | 954.39                                   | 0.24       |
| 750           | 952.21                           | 952.58                                   | 0.37       |
| 715           | 951.23                           | 951.78                                   | 0.55       |
| 625           | 948.26                           | 948.26                                   | 0.00       |
| 575           | 947.98                           | 947.98                                   | 0.00       |
| 550           | 947.36                           | 947.36                                   | 0.00       |
| 500           | 946.62                           | 946.62                                   | 0.00       |



### 4.3 Proposed Stream Realignment Profile and Bench

The third modification evaluated to eliminate the downstream increase was a combination of the two previous modifications: the grade break in the stream realignment profile and the streambank bench.

The results of the alternate proposed model, including a diagram showing the location of the cross sections, can be found in Appendix E. The results of the model, including the profile modification and bench, are also summarized in Table 3.3: Summary of Hydraulic Data – Alternate Proposed Model. The floodplain increase no longer exists as shown in the summary below.

**Table 3.2. Summary of Hydraulic Data – Alternate Proposed Model**

| River Station | Existing 100-Year W.S. Elevation | Proposed (Bench) 100-Year W.S. Elevation | Difference |
|---------------|----------------------------------|--|------------|
| 1400          | 966.93                           | 966.93                                   | 0.00       |
| 1360          | 965.66                           | 965.66                                   | 0.00       |
| 1300          | 965.42                           | 965.42                                   | 0.00       |
| 1255          | 963.98                           | 963.98                                   | 0.00       |
| 1200          | 962.55                           | 962.47                                   | -0.08      |
| 1150          | 963.16                           | 961.4                                    | -1.76      |
| 1120          | 961.82                           | 961.67                                   | -0.15      |
| 1110          | 961.84                           | 961.68                                   | -0.16      |
| 1000          | Bridge/Box Culvert               |  |            |
| 880           | 954.69                           | 954.49                                   | -0.20      |
| 865           | 954.28                           | 953.9                                    | -0.38      |
| 850           | 954.15                           | 953.6                                    | -0.55      |
| 750           | 952.21                           | 951.81                                   | -0.40      |
| 715           | 951.23                           | 951.12                                   | -0.11      |
| 625           | 948.26                           | 948.26                                   | 0.00       |
| 575           | 947.98                           | 947.98                                   | 0.00       |
| 550           | 947.36                           | 947.36                                   | 0.00       |
| 500           | 946.62                           | 946.62                                   | 0.00       |

A map of the 100-Year floodplain for the alternate proposed model can be found in Appendix E.

## 5 Conclusions

The alternate hydraulic analysis shows that in order to eliminate the downstream water surface increase, the following modifications would be required:

1. A decrease in the profile of the proposed stream near the end of the channel realignment.
2. Include a bench on the north side of the proposed channel on the downstream side of the structure.

These two modifications would decrease the 100-year base flood elevation below existing conditions and meet the requirements of NR116.

## List of Appendices

The following appendices are referenced in this report and are included in this section, as follow:

- Appendix A: Location Map
- Appendix B: FIRMette
- Appendix C: Alternative Hydraulic Analysis (Modified Profile)
- Appendix D: Alternative Hydraulic Analysis (Bench)
- Appendix E: Alternative Hydraulic Analysis (Bench & Modified Profile)



## Appendix A: Location Map



# Project Site Location Map



- Legend**
- 2D Water Surface Elevation Grid
    - High : 937.629
    - Low : 853.184
  - Dams
    - Dams with FERC License
    - Dams
  - Record Flood Levels
  - Analysis Lines
    - Other
    - Flood Insurance Study
    - Letter of Map Revision
    - Case By Case Analysis
    - Bridge
  - Analysis Points
    - Other
    - Flood Insurance Study
    - Letter of Map Revision
    - Case By Case Analysis
    - Bridge
  - Analysis Catchments
  - Floodplain Storage
  - Cross Sections
  - Floodplains
    - Flood Fringe
    - Floodway
  - FERC Project Area Boundaries
  - DOT Bridges
  - Statewide Paper FIRM Index
  - Township
  - Section
  - Quarter-Quarter
  - County Boundary



NAD\_1983\_HARN\_Wisconsin\_TM

1: 7,920

DISCLAIMER: The information shown on these maps has been obtained from various sources, and are of varying age, reliability and resolution. These maps are not intended to be used for navigation, nor are these maps an authoritative source of information about legal land ownership or public access. No warranty, expressed or implied, is made regarding accuracy, applicability for a particular use, completeness, or legality of the information depicted on this map. For more information, see the DNR Legal Notices web page: <http://dnr.wi.gov/legal/>

**Notes**

**Client Name:** WI DFD / WI DNR

**Site Location:** Gandy Dancer Trail, T. of Summit,  
Douglas County

**Project No.1811N**

|  |                          |
|--|--------------------------|
| <b>Photo No.</b><br>1  | <b>Date:</b><br>6-7-2019 |
| <b>Direction Photo Taken:</b><br><br>South – looking upstream                |                          |
| <b>Description:</b><br><br>Approximate stream station 48+00 (See Sheet C102) |                          |



|   |                          |
|---|--------------------------|
| <b>Photo No.</b><br>2   | <b>Date:</b><br>6-7-2019 |
| <b>Direction Photo Taken:</b><br><br>South South – looking upstream           |                          |
| <b>Description:</b><br><br>Approximate stream station 48+00 (See Sheet C102). |                          |



**Client Name:** WI DFD / WI DNR

**Site Location:** Gandy Dancer Trail, T. of Summit,  
Douglas County

**Project No.** 1811N

|                       |                          |
|-----------------------|--------------------------|
| <b>Photo No.</b><br>3 | <b>Date:</b><br>6-7-2019 |
|-----------------------|--------------------------|

**Direction Photo Taken:**

North – Looking Downstream

**Description:**

Approximate Stream station 48+00 (See Sheet C102).



|                       |                          |
|-----------------------|--------------------------|
| <b>Photo No.</b><br>4 | <b>Date:</b><br>6-7-2019 |
|-----------------------|--------------------------|

**Direction Photo Taken:**

East

**Description:**

Approximate Stream station 48+00 (See Sheet C102).



**Client Name:** WI DFD / WI DNR

**Site Location:** Gandy Dancer Trail, T. of Summit,  
Douglas County

**Project No.** 1811N

|                       |                          |
|-----------------------|--------------------------|
| <b>Photo No.</b><br>5 | <b>Date:</b><br>6-7-2019 |
|-----------------------|--------------------------|

**Direction Photo Taken:**

North – Looking Downstream

**Description:**

Approximate Stream station 48+25 (See Sheet C102).



|                       |                          |
|-----------------------|--------------------------|
| <b>Photo No.</b><br>6 | <b>Date:</b><br>6-7-2019 |
|-----------------------|--------------------------|

**Direction Photo Taken:**

North

**Description:**

Approximate Stream station 48+50 (See Sheet C102). Inlet of Box Culvert





**Client Name:** WI DFD / WI DNR

**Site Location:** Gandy Dancer Trail, T. of Summit,  
Douglas County

**Project No.** 1811N

|                       |                          |
|-----------------------|--------------------------|
| <b>Photo No.</b><br>7 | <b>Date:</b><br>6-7-2019 |
|-----------------------|--------------------------|

**Direction Photo Taken:**

North – Looking Downstream

**Description:**

Approximate Stream station 48+00 (See Sheet C102). Inlet section of Box Culvert



|                       |                          |
|-----------------------|--------------------------|
| <b>Photo No.</b><br>8 | <b>Date:</b><br>6-7-2019 |
|-----------------------|--------------------------|

**Direction Photo Taken:**

South west

**Description:**

Approximate Stream station 51+50 (See Sheet C102). Outlet of Box Culvert



**Client Name:** WI DFD / WI DNR

**Site Location:** Gandy Dancer Trail, T. of Summit,  
Douglas County

**Project No.** 1811N

|                       |                          |
|-----------------------|--------------------------|
| <b>Photo No.</b><br>9 | <b>Date:</b><br>6-7-2019 |
|-----------------------|--------------------------|

**Direction Photo Taken:**

West

**Description:**

Approximate Stream station 51+50 (See Sheet C102).



|                        |                          |
|------------------------|--------------------------|
| <b>Photo No.</b><br>10 | <b>Date:</b><br>6-7-2019 |
|------------------------|--------------------------|

**Direction Photo Taken:**

Northwest

**Description:**

Approximate Stream station 51+50 (See Sheet C102).



**Client Name:** WI DFD / WI DNR

**Site Location:** Gandy Dancer Trail, T. of Summit,  
Douglas County

**Project No.** 1811N

|                        |                          |
|------------------------|--------------------------|
| <b>Photo No.</b><br>11 | <b>Date:</b><br>6-7-2019 |
|------------------------|--------------------------|

**Direction Photo Taken:**

North – Looking Downstream

**Description:**

Approximate Stream station 51+50 (See Sheet C102). Outlet of Box



|                        |                          |
|------------------------|--------------------------|
| <b>Photo No.</b><br>12 | <b>Date:</b><br>6-7-2019 |
|------------------------|--------------------------|

**Direction Photo Taken:**

North

**Description:**

Approximate Stream station 51+50 (See Sheet C102).



**Client Name:** WI DFD / WI DNR

**Site Location:** Gandy Dancer Trail, T. of Summit,  
Douglas County

**Project No.** 1811N

|                        |                          |
|------------------------|--------------------------|
| <b>Photo No.</b><br>13 | <b>Date:</b><br>6-7-2019 |
|------------------------|--------------------------|

**Direction Photo Taken:**

North – Looking Downstream

**Description:**

Approximate Stream station 51+60 (See Sheet C102). Outlet of Box



|                        |                          |
|------------------------|--------------------------|
| <b>Photo No.</b><br>14 | <b>Date:</b><br>6-7-2019 |
|------------------------|--------------------------|

**Direction Photo Taken:**

South

**Description:**

Approximate Stream station 51+50 (See Sheet C102).





## Appendix B: Firmette

# National Flood Hazard Layer FIRMette



92°13'59"W 46°29'29"N



0 250 500 1,000 1,500 2,000 Feet 1:6,000

92°13'22"W 46°29'4"N

Basemap: USGS National Map: Orthoimagery: Data refreshed October, 2020

## Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

|                                    |  |  |
|------------------------------------|--|--|
| <b>SPECIAL FLOOD HAZARD AREAS</b>  |  | Without Base Flood Elevation (BFE)<br><i>Zone A, V, A99</i>  |
|                                    |  | With BFE or Depth <i>Zone AE, AO, AH, VE, AR</i><br>Regulatory Floodway  |
| <b>OTHER AREAS OF FLOOD HAZARD</b> |  | 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile <i>Zone X</i> |
|                                    |  | Future Conditions 1% Annual Chance Flood Hazard <i>Zone X</i>  |
|                                    |  | Area with Reduced Flood Risk due to Levee. See Notes. <i>Zone X</i>  |
|                                    |  | Area with Flood Risk due to Levee <i>Zone D</i>  |
| <b>OTHER AREAS</b>                 |  | NO SCREEN Area of Minimal Flood Hazard <i>Zone X</i>   |
|                                    |  | Effective LOMRs  |
| <b>GENERAL STRUCTURES</b>          |  | Area of Undetermined Flood Hazard <i>Zone D</i>  |
|                                    |  | Channel, Culvert, or Storm Sewer   |
| <b>OTHER FEATURES</b>              |  | Levee, Dike, or Floodwall  |
|                                    |  | 20.2 Cross Sections with 1% Annual Chance Water Surface Elevation  |
| <b>MAP PANELS</b>                  |  | 17.5 Coastal Transect  |
|                                    |  | Base Flood Elevation Line (BFE)  |
|                                    |  | Limit of Study   |
|                                    |  | Jurisdiction Boundary  |
|                                    |  | Coastal Transect Baseline  |
|                                    |  | Profile Baseline   |
| <b>MAP PANELS</b>                  |  | Digital Data Available   |
|                                    |  | No Digital Data Available  |
|                                    |  | Unmapped   |
|                                    |  | The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.                                     |



This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on **12/28/2022 at 3:22 PM** and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

**NOTES TO USERS**

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The community map repository should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where Base Flood Elevations (BFEs) and/or Floodway Areas have been determined, users are encouraged to consult the Flood Insurance Study (FIS) Report for this jurisdiction. The FIS Report contains the Flood Insurance Study (FIS) Report that accompanies the FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, they should not be used for engineering or construction purposes in conjunction with the FIRM for purposes of construction and/or floodplain management.

**Coastal Base Flood Elevations** shown on this map apply only landward of 0.0 foot from the mean high water line. For areas where Coastal Base Flood Elevations have been determined, users are encouraged to consult the FIS Report for this jurisdiction. For information regarding conversion of Coastal Base Flood Elevations to the same vertical datum, refer to the National Geospatial Information Administration's Coastal Flood Elevation Conversion Manual at <http://www.ngs.noaa.gov/CFS/Products/Manuals/CBFEConversionManual.pdf>.

Boundaries of the floodways were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with the exception of Zone VE floodway boundaries, which were determined by the FIS Report for this jurisdiction. Other pertinent floodway data are provided in the Flood Insurance Study Report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by flood control structures. For information on flood control structures for this jurisdiction, refer to the FIS Report for information on flood control structures for this jurisdiction.

The projection used in the preparation of this map was Universal Transverse Mercator (UTM), Zone 18N, datum of 1983. For information regarding conversion of FIRM data to other datum, refer to the FIS Report for this jurisdiction. For information regarding conversion of FIRM data to other datum, refer to the FIS Report for this jurisdiction. For information regarding conversion of FIRM data to other datum, refer to the FIS Report for this jurisdiction.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same vertical datum. For information regarding conversion of FIRM data to other datum, refer to the FIS Report for this jurisdiction. For information regarding conversion of FIRM data to other datum, refer to the FIS Report for this jurisdiction.

**NGS Information Services**  
NOAA, NIMS12  
National Geospatial Survey  
SSM-C-3, #6202  
Silver Spring, Maryland 20910-3282  
(301) 713-3242

To obtain current elevation, description, and/or location information for bench marks in this jurisdiction, refer to the FIS Report for this jurisdiction. For information regarding conversion of FIRM data to other datum, refer to the FIS Report for this jurisdiction.

**Base map information** shown on this FIRM was provided by Douglas County. The original map was prepared and approved in Spring of 2006 to create a 1:200 scale digital orthophoto with 1-foot ground resolution.

**Corporate limits** shown on this map are based on the best data available at the time of publication. Users are encouraged to verify current corporate limits with the community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map of the community and a listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

For information on available products associated with this FIRM visit the **Map Service Center (MSC)** website at <http://msc.fema.gov>. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of the map. Many of these products can be ordered or obtained directly from the MSC website.

If you have **questions about this map**, how to order products, or the National Flood Insurance Program in general, please call the **FEMA Map Information Center (MIC)** at 1-877-FEMA-Map or (1-877-336-2627) or visit the FEMA website at <http://www.fema.gov>.

**LEGEND**

**SPECIAL FLOOD HAZARD AREAS (SFHA) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD**  
The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Areas (SFHA) are shown on this map in various colors and patterns. The SFHA are defined by the Flood Insurance Study (FIS) Report for this jurisdiction. For information regarding conversion of FIRM data to other datum, refer to the FIS Report for this jurisdiction.

**ZONE A:** No Base Flood Elevation Determination  
**ZONE AE:** Special Flood Hazard Areas (SFHA) subject to inundation by the 1% annual chance flood (100-year flood).  
**ZONE AH:** Flood depths of 1 to 3 feet (shallow areas of ponding).  
**ZONE AO:** Flood depths of 3 to 6 feet (moderate areas of ponding).  
**ZONE AR:** Special Flood Hazard Areas (SFHA) subject to inundation by the 1% annual chance flood (100-year flood) with average depths of 6 to 9 feet (moderate areas of ponding).  
**ZONE AV:** Areas to be protected from the 1% annual chance flood by a levee or other flood control structure.  
**ZONE VE:** Coastal flood zone with velocity hazard (wave action).  
**ZONE V:** Coastal flood zone with velocity hazard (wave action).

**FLOODWAY AREAS IN ZONE AE**  
The floodway is the channel or a stream plus any adjacent floodplain areas that must be kept free of obstructions to the 1% annual chance flood (100-year flood) to prevent substantial increases in flood heights.

**OTHER FLOOD AREAS**  
**ZONE X:** Areas of 0.2% annual chance flood, areas of the annual chance flood with average depths of less than 1 foot or with average areas less than 1 square mile, and areas protected by levees from the 1% annual chance flood.  
**ZONE D:** Areas determined to be outside the 0.2% annual chance floodplain.  
**ZONE K:** Areas in which flood hazards are undetermined, but possible.

**CONSTANT BARRIER RESOURCES SYSTEM (CBRS) AREAS**  
**OTHERWISE PROTECTED AREAS (OPA)**  
CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

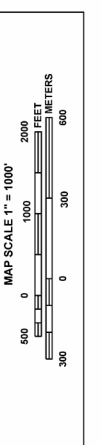
**0.2% Annual Chance Floodplain Boundary**  
**Floodway boundary**  
**Zone D boundary**  
**Zone K and OPA boundary**  
**Boundary of Special Flood Hazard Areas (SFHA) and Floodway Areas**  
**Base Flood Elevation (BFE) and velocity hazard (wave action) in feet**  
**Base Flood Elevation (BFE) and velocity hazard (wave action) in feet**

**Other symbols:**  
Cross section line  
Tract line  
Canal  
Bridge  
45° 02' 30" 39° 02' 32"  
3100000 FT  
Elevation in feet  
DX510 X  
M 1.5

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction. To determine flood insurance availability in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-658-6620.

**EFFECTIVE DATES OF REVISIONS TO THIS PANEL**  
EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP: February 2, 2012

**MAP REPOSITORIES**  
Refer to Map Repositories list on map index.



**NFIP** **FIRM** **PANEL 0405D**

**FLOOD INSURANCE RATE MAP**  
**DOUGLAS COUNTY,**  
**WISCONSIN**  
**AND INCORPORATED AREAS**

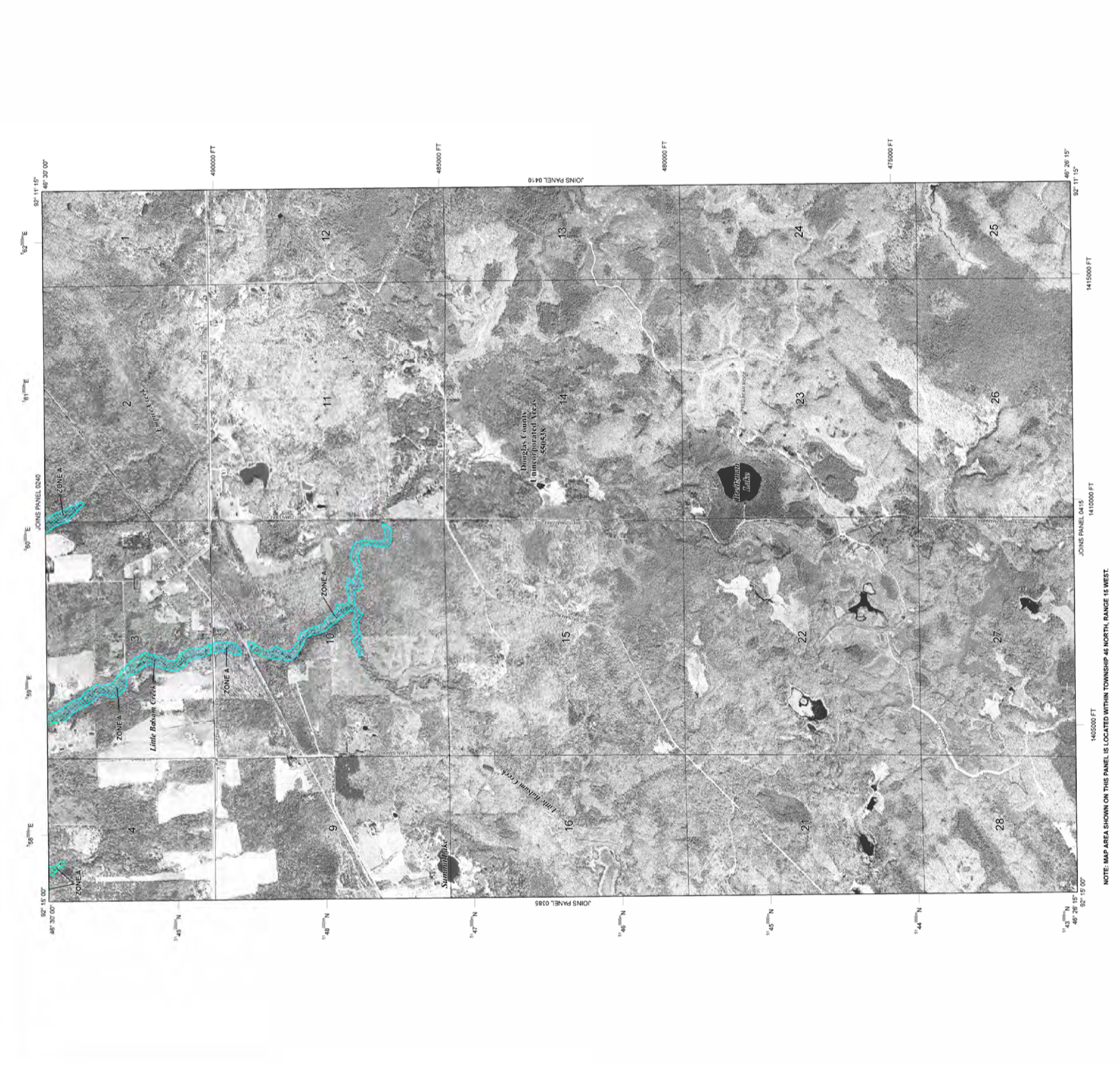
**PANEL 405 OF 895**  
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

**CONTAINS:** FIRM PANEL 0405D  
**COMMUNITY:** DOUGLAS COUNTY  
**NUMBER:** 50033  
**SUFFIX:** D

**Notice to User:** The Map Number shown below the Community Number shown above should be used on insurance applications for the subject community.

**MAP NUMBER** 50033C0405D  
**EFFECTIVE DATE** FEBRUARY 2, 2012

**Federal Emergency Management Agency**



NOTE: MAP AREA SHOWN ON THIS PANEL IS LOCATED WITHIN TOWNSHIP 46 NORTH, RANGE 15 WEST.



## Appendix C: Alternative Hydraulic Analysis (Modified Profile)

Data and calculations referenced in this report follow:

1. Plan and Profile – Stream Realignment
2. HEC-RAS Output Summary – Modified Stream Profile vs Existing Conditions





| Reach            | River Sta | Profile  | Plan                               | Q Total<br>(cfs) | Min Ch El<br>(ft) | W.S. Elev<br>(ft) | Crit W.S.<br>(ft) | E.G. Elev<br>(ft) | E.G. Slope<br>(ft/ft) | Vel Chnl<br>(ft/s) | Flow Area<br>(sq ft) | Top Width<br>(ft) | Froude # Chl |
|------------------|-----------|----------|------------------------------------|------------------|-------------------|-------------------|-------------------|-------------------|-----------------------|--------------------|----------------------|-------------------|--------------|
| Little Balsam Cr | 1400      | 100-Year | Existing Conditions                | 713.00           | 961.95            | 966.93            | 966.93            | 968.43            | 0.010005              | 11.53              | 114.48               | 43.77             | 0.95         |
| Little Balsam Cr | 1400      | 100-Year | Prop Conditions (Modified Profile) | 713.00           | 961.95            | 966.93            | 966.93            | 968.43            | 0.010005              | 11.53              | 114.48               | 43.77             | 0.95         |
| Little Balsam Cr | 1360      | 100-Year | Existing Conditions                | 713.00           | 961.66            | 965.66            | 965.66            | 967.28            | 0.011180              | 10.55              | 82.61                | 29.92             | 0.97         |
| Little Balsam Cr | 1360      | 100-Year | Prop Conditions (Modified Profile) | 713.00           | 961.66            | 965.66            | 965.66            | 967.28            | 0.011180              | 10.55              | 82.61                | 29.92             | 0.97         |
| Little Balsam Cr | 1300      | 100-Year | Existing Conditions                | 713.00           | 960.27            | 965.42            |                   | 965.85            | 0.002648              | 6.38               | 212.68               | 68.93             | 0.50         |
| Little Balsam Cr | 1300      | 100-Year | Prop Conditions (Modified Profile) | 713.00           | 960.27            | 965.42            |                   | 965.85            | 0.002648              | 6.38               | 212.68               | 68.93             | 0.50         |
| Little Balsam Cr | 1255      | 100-Year | Existing Conditions                | 713.00           | 959.59            | 963.98            | 963.98            | 965.52            | 0.010338              | 11.31              | 107.99               | 42.41             | 0.96         |
| Little Balsam Cr | 1255      | 100-Year | Prop Conditions (Modified Profile) | 713.00           | 959.59            | 963.98            | 963.98            | 965.52            | 0.010338              | 11.31              | 107.99               | 42.41             | 0.96         |
| Little Balsam Cr | 1200      | 100-Year | Existing Conditions                | 713.00           | 958.00            | 962.55            | 962.55            | 964.43            | 0.010530              | 11.42              | 78.64                | 24.86             | 0.96         |
| Little Balsam Cr | 1200      | 100-Year | Prop Conditions (Modified Profile) | 713.00           | 958.50            | 962.47            | 962.47            | 963.82            | 0.011335              | 9.62               | 90.75                | 40.58             | 0.96         |
| Little Balsam Cr | 1150      | 100-Year | Existing Conditions                | 713.00           | 955.77            | 963.16            | 959.29            | 963.35            | 0.000612              | 3.76               | 250.37               | 48.06             | 0.25         |
| Little Balsam Cr | 1150      | 100-Year | Prop Conditions (Modified Profile) | 713.00           | 957.50            | 961.40            | 961.38            | 962.75            | 0.011085              | 9.58               | 90.21                | 39.66             | 0.95         |
| Little Balsam Cr | 1120      | 100-Year | Existing Conditions                | 713.00           | 954.55            | 961.82            | 960.21            | 963.20            | 0.005100              | 9.54               | 88.59                | 19.96             | 0.64         |
| Little Balsam Cr | 1120      | 100-Year | Prop Conditions (Modified Profile) | 713.00           | 956.50            | 961.67            |                   | 962.36            | 0.004206              | 7.01               | 137.60               | 50.40             | 0.61         |
| Little Balsam Cr | 1110      | 100-Year | Existing Conditions                | 713.00           | 954.24            | 961.84            | 959.67            | 963.08            | 0.004881              | 9.00               | 85.92                | 14.23             | 0.58         |
| Little Balsam Cr | 1110      | 100-Year | Prop Conditions (Modified Profile) | 713.00           | 956.50            | 961.68            | 960.48            | 962.28            | 0.003475              | 6.60               | 148.61               | 52.31             | 0.56         |
| Little Balsam Cr | 1000      |          |                                    | Culvert          |                   |                   |                   |                   |                       |                    |                      |                   |              |
| Little Balsam Cr | 880       | 100-Year | Existing Conditions                | 713.00           | 950.00            | 954.69            | 954.69            | 956.96            | 0.011048              | 12.10              | 59.16                | 37.87             | 1.00         |
| Little Balsam Cr | 880       | 100-Year | Prop Conditions (Modified Profile) | 713.00           | 951.50            | 955.36            | 955.36            | 956.47            | 0.010406              | 9.09               | 114.29               | 61.81             | 0.91         |
| Little Balsam Cr | 865       | 100-Year | Existing Conditions                | 713.00           | 949.76            | 954.28            | 954.25            | 955.84            | 0.012298              | 11.44              | 92.22                | 45.21             | 1.03         |
| Little Balsam Cr | 865       | 100-Year | Prop Conditions (Modified Profile) | 713.00           | 951.00            | 955.17            |                   | 955.61            | 0.005000              | 6.50               | 197.28               | 89.80             | 0.64         |
| Little Balsam Cr | 850       | 100-Year | Existing Conditions                | 713.00           | 949.50            | 954.15            | 954.15            | 955.62            | 0.010201              | 10.81              | 104.79               | 47.33             | 0.94         |
| Little Balsam Cr | 850       | 100-Year | Prop Conditions (Modified Profile) | 713.00           | 950.76            | 954.56            | 954.56            | 955.47            | 0.009831              | 8.58               | 139.27               | 83.04             | 0.88         |
| Little Balsam Cr | 750       | 100-Year | Existing Conditions                | 713.00           | 947.04            | 952.21            | 951.20            | 953.15            | 0.004689              | 8.26               | 118.13               | 35.27             | 0.66         |
| Little Balsam Cr | 750       | 100-Year | Prop Conditions (Modified Profile) | 713.00           | 947.47            | 951.81            | 951.28            | 952.78            | 0.006844              | 8.22               | 107.50               | 39.18             | 0.76         |
| Little Balsam Cr | 715       | 100-Year | Existing Conditions                | 713.00           | 946.74            | 951.23            | 951.23            | 952.85            | 0.010454              | 11.30              | 98.53                | 35.80             | 0.97         |
| Little Balsam Cr | 715       | 100-Year | Prop Conditions (Modified Profile) | 713.00           | 947.16            | 951.12            | 951.12            | 952.44            | 0.011694              | 9.46               | 88.45                | 38.50             | 0.96         |
| Little Balsam Cr | 625       | 100-Year | Existing Conditions                | 713.00           | 944.83            | 948.26            | 948.26            | 949.32            | 0.010565              | 9.01               | 118.66               | 63.16             | 0.92         |
| Little Balsam Cr | 625       | 100-Year | Prop Conditions (Modified Profile) | 713.00           | 944.83            | 948.26            | 948.26            | 949.32            | 0.010565              | 9.01               | 118.66               | 63.16             | 0.92         |
| Little Balsam Cr | 575       | 100-Year | Existing Conditions                | 713.00           | 943.37            | 947.98            |                   | 948.50            | 0.003914              | 7.04               | 183.70               | 61.56             | 0.59         |
| Little Balsam Cr | 575       | 100-Year | Prop Conditions (Modified Profile) | 713.00           | 943.37            | 947.98            |                   | 948.50            | 0.003914              | 7.04               | 183.70               | 61.56             | 0.59         |
| Little Balsam Cr | 550       | 100-Year | Existing Conditions                | 713.00           | 943.00            | 947.36            | 946.97            | 948.32            | 0.007378              | 9.14               | 135.06               | 53.05             | 0.80         |
| Little Balsam Cr | 550       | 100-Year | Prop Conditions (Modified Profile) | 713.00           | 943.00            | 947.36            | 946.97            | 948.32            | 0.007378              | 9.14               | 135.06               | 53.05             | 0.80         |
| Little Balsam Cr | 500       | 100-Year | Existing Conditions                | 713.00           | 942.44            | 946.62            | 946.62            | 947.87            | 0.009690              | 10.16              | 120.36               | 54.43             | 0.92         |
| Little Balsam Cr | 500       | 100-Year | Prop Conditions (Modified Profile) | 713.00           | 942.44            | 946.62            | 946.62            | 947.87            | 0.009690              | 10.16              | 120.36               | 54.43             | 0.92         |



## Appendix D: Alternative Hydraulic Analysis (Bench)

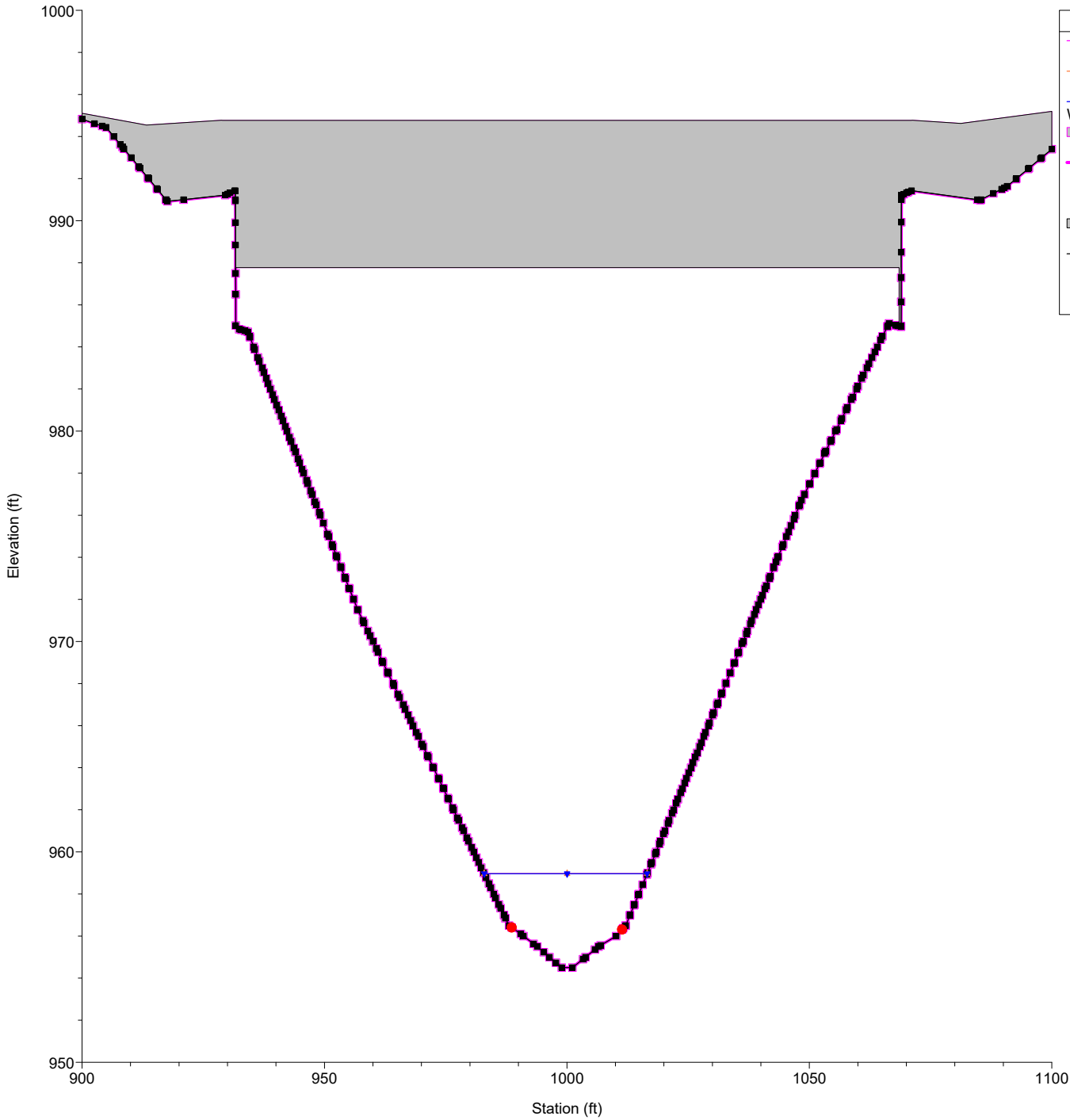
Data and calculations referenced in this report follow:

1. HEC-RAS Cross Sections – Bench vs Modified Stream Profile
2. HEC-RAS Output Summary – Bench vs Existing Conditions

GandyDancer Plan: 1) Prop Conditions (Bench) 2) Prop Conditions (Modified Profile)

Flow: Design Flows

River = Little Balsam Cr Reach = Little Balsam Cr RS = 1000 BR

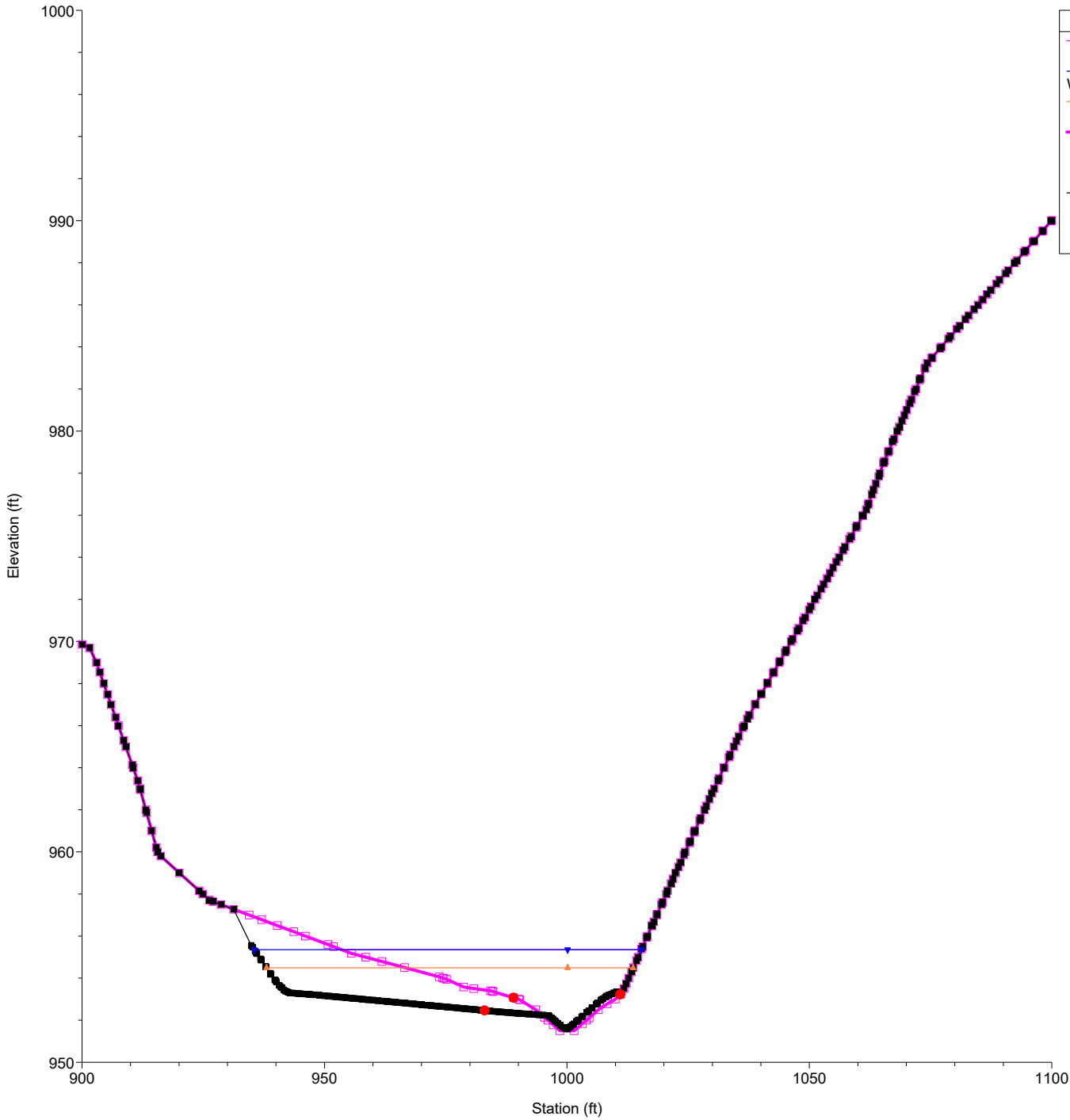


| Legend   |   |
|--|---|
| WS 100-Year - Prop Conditions (Modified Profile)                           | ▲ |
| WS 100-Year - Prop Conditions (Bench) - Prop Conditions (Bench)            | ▲ |
| WS 100-Year - Prop Conditions (Modified Profile) - Prop Conditions (Bench) | ▼ |
| - Prop Conditions (Modified Profile)                                       | ■ |
| Ground - Prop Conditions (Modified Profile)                                | ■ |
| Bank Sta - Prop Conditions (Modified Profile)                              | ● |
| - Prop Conditions (Bench)  | ■ |
| Ground - Prop Conditions (Bench)   | ■ |
| Bank Sta - Prop Conditions (Bench)   | ● |

GandyDancer Plan: 1) Prop Conditions (Bench) 2) Prop Conditions (Modified Profile)

Flow: Design Flows

River = Little Balsam Cr Reach = Little Balsam Cr RS = 880

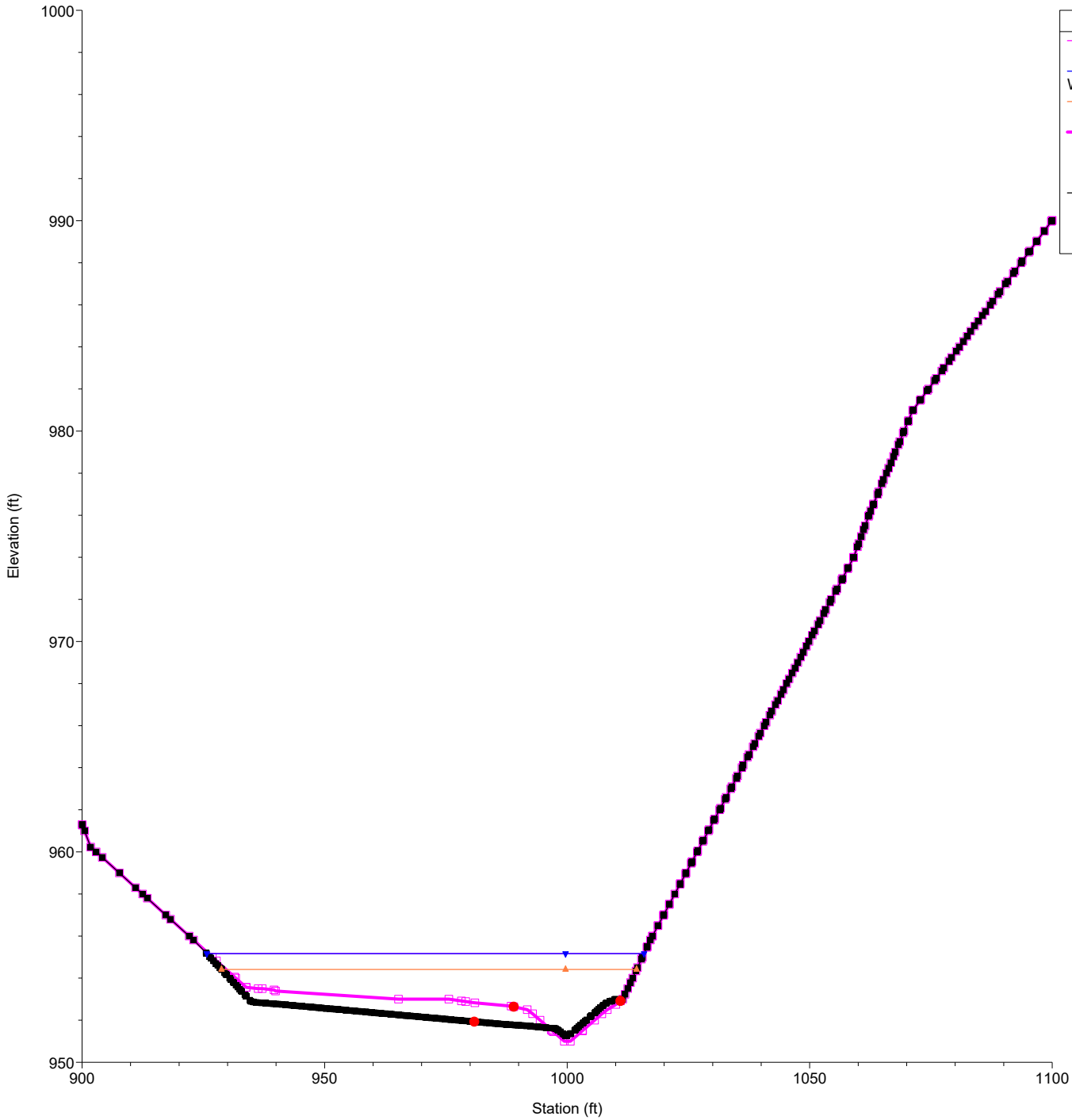


| Legend   |   |
|--|---|
| WS 100-Year - Prop Conditions (Modified Profile)                           | ▲ |
| WS 100-Year - Prop Conditions (Modified Profile) - Prop Conditions (Bench) | ▲ |
| WS 100-Year - Prop Conditions (Bench) - Prop Conditions (Bench)            | ▲ |
| Ground - Prop Conditions (Modified Profile)                                | ■ |
| Bank Sta - Prop Conditions (Modified Profile)                              | ● |
| Ground - Prop Conditions (Bench)   | ■ |
| Bank Sta - Prop Conditions (Bench)   | ● |

GandyDancer Plan: 1) Prop Conditions (Bench) 2) Prop Conditions (Modified Profile)

Flow: Design Flows

River = Little Balsam Cr Reach = Little Balsam Cr RS = 865

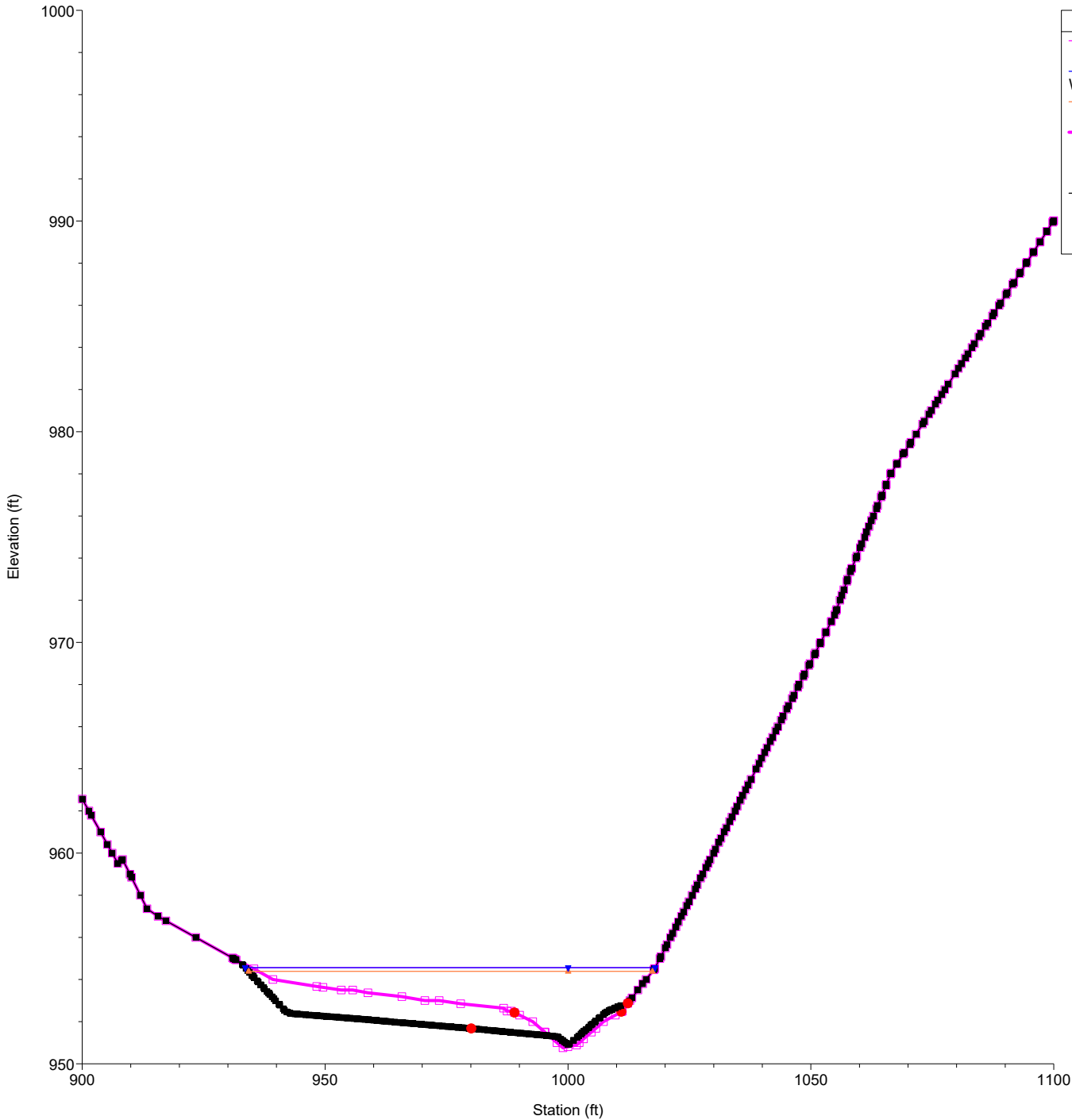


| Legend   |   |
|--|---|
| WS 100-Year - Prop Conditions (Modified Profile)                           | ▼ |
| WS 100-Year - Prop Conditions (Modified Profile) - Prop Conditions (Bench) | ▲ |
| WS 100-Year - Prop Conditions (Bench) - Prop Conditions (Bench)            | ▲ |
| Ground - Prop Conditions (Modified Profile)                                | □ |
| Bank Sta - Prop Conditions (Modified Profile)                              | ● |
| Ground - Prop Conditions (Bench)   | ■ |
| Bank Sta - Prop Conditions (Bench)   | ● |

GandyDancer Plan: 1) Prop Conditions (Bench) 2) Prop Conditions (Modified Profile)

Flow: Design Flows

River = Little Balsam Cr Reach = Little Balsam Cr RS = 850

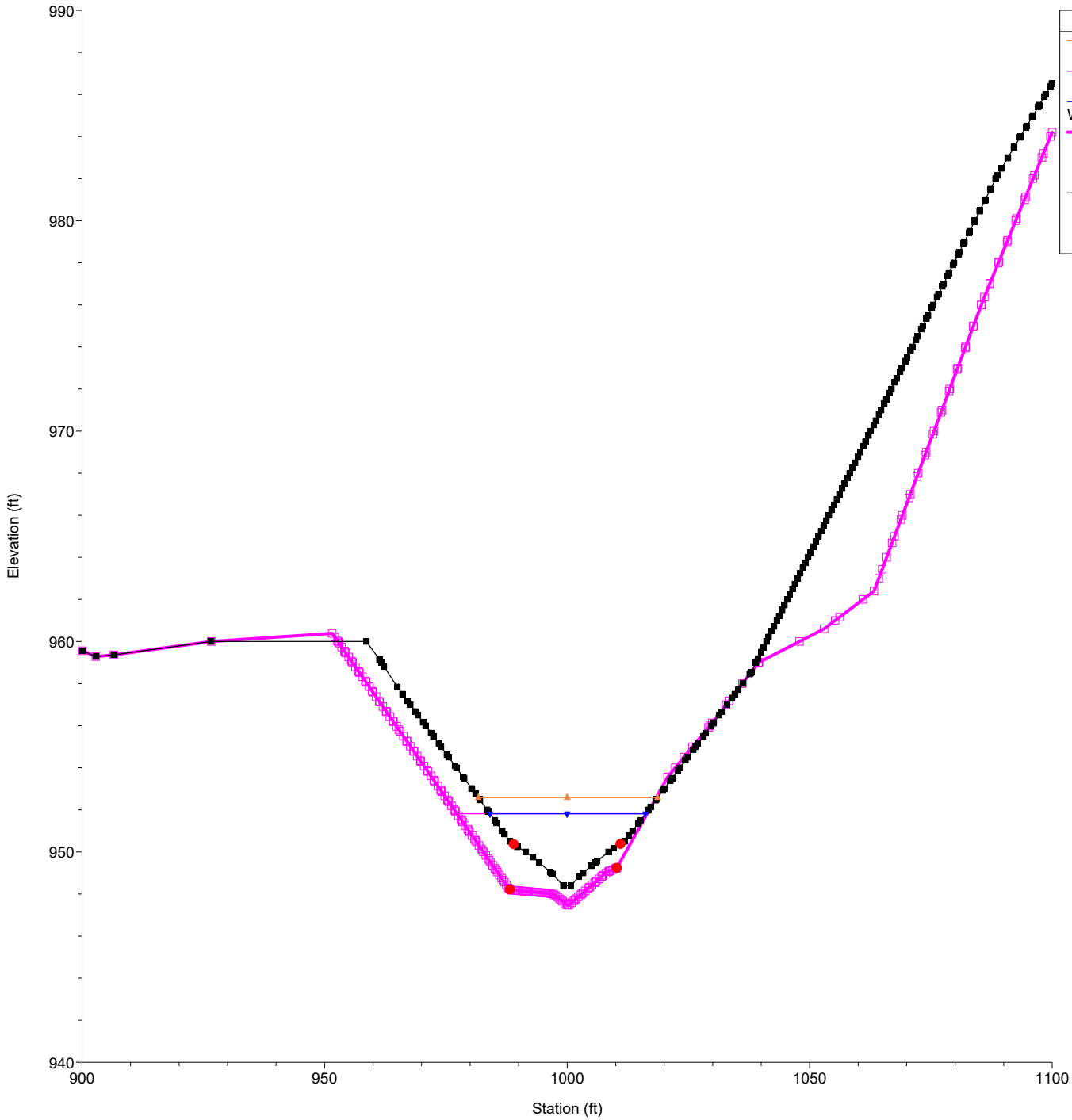


| Legend   |                                  |
|--|----------------------------------|
| WS 100-Year - Prop Conditions (Modified Profile)                           | Blue line with downward triangle |
| WS 100-Year - Prop Conditions (Modified Profile) - Prop Conditions (Bench) | Orange line with upward triangle |
| WS 100-Year - Prop Conditions (Bench) - Prop Conditions (Bench)            | Black line with square           |
| Ground - Prop Conditions (Modified Profile)                                | Magenta line with square         |
| Bank Sta - Prop Conditions (Modified Profile)                              | Red line with circle             |
| Ground - Prop Conditions (Bench)   | Black line with square           |
| Bank Sta - Prop Conditions (Bench)   | Red line with circle             |

GandyDancer Plan: 1) Prop Conditions (Bench) 2) Prop Conditions (Modified Profile)

Flow: Design Flows

River = Little Balsam Cr Reach = Little Balsam Cr RS = 750



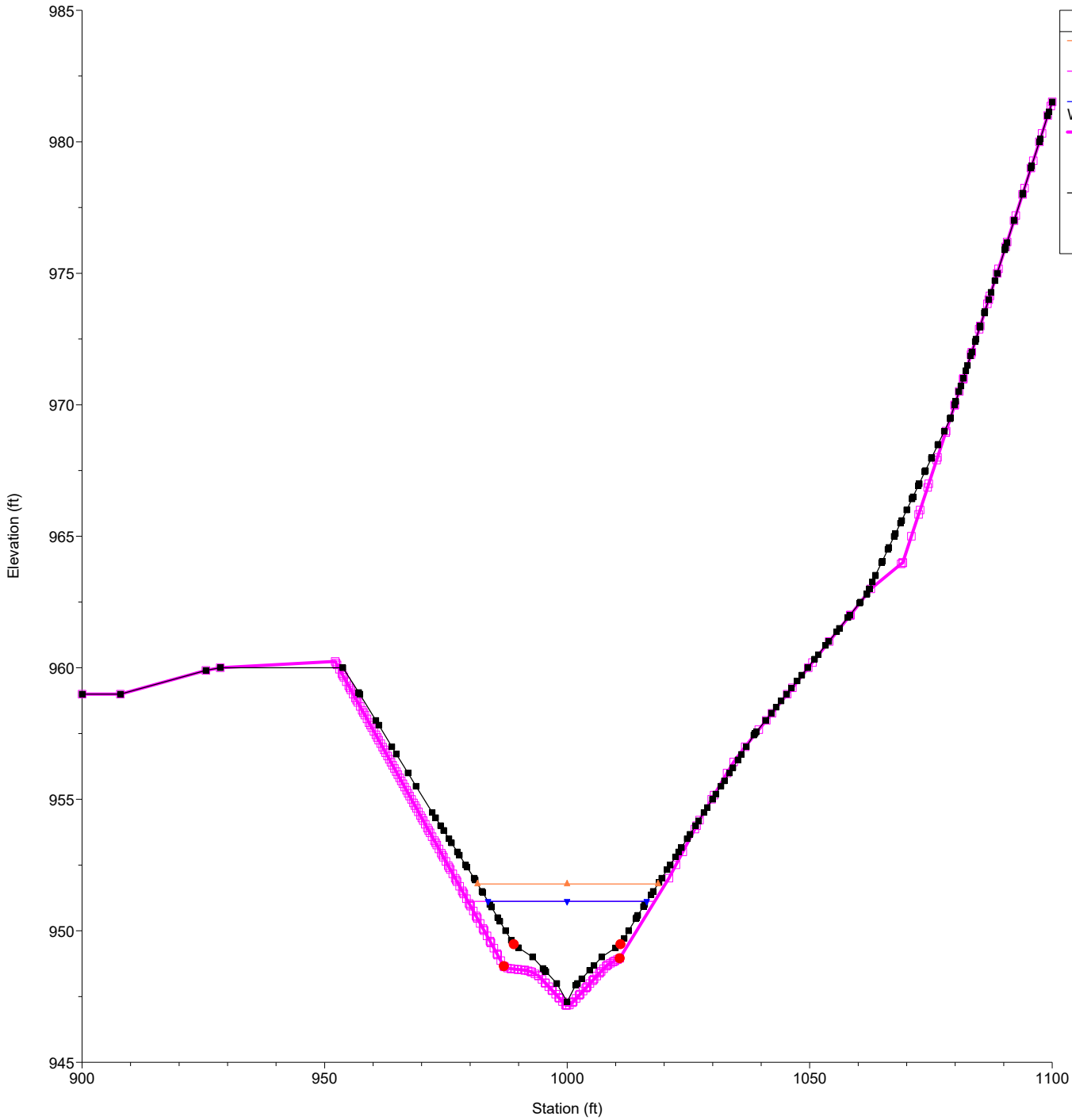
| Legend  |  |
|---|--|
| WS 100-Year - Prop Conditions (Bench) - Prop Conditions (Bench)                       |  |
| WS 100-Year - Prop Conditions (Modified Profile) - Prop Conditions (Bench)            |  |
| WS 100-Year - Prop Conditions (Modified Profile) - Prop Conditions (Modified Profile) |  |
| Ground - Prop Conditions (Modified Profile)   |  |
| Bank Sta - Prop Conditions (Modified Profile)   |  |
| Ground - Prop Conditions (Bench)  |  |
| Bank Sta - Prop Conditions (Bench)  |  |



GandyDancer Plan: 1) Prop Conditions (Bench) 2) Prop Conditions (Modified Profile)

Flow: Design Flows

River = Little Balsam Cr Reach = Little Balsam Cr RS = 715

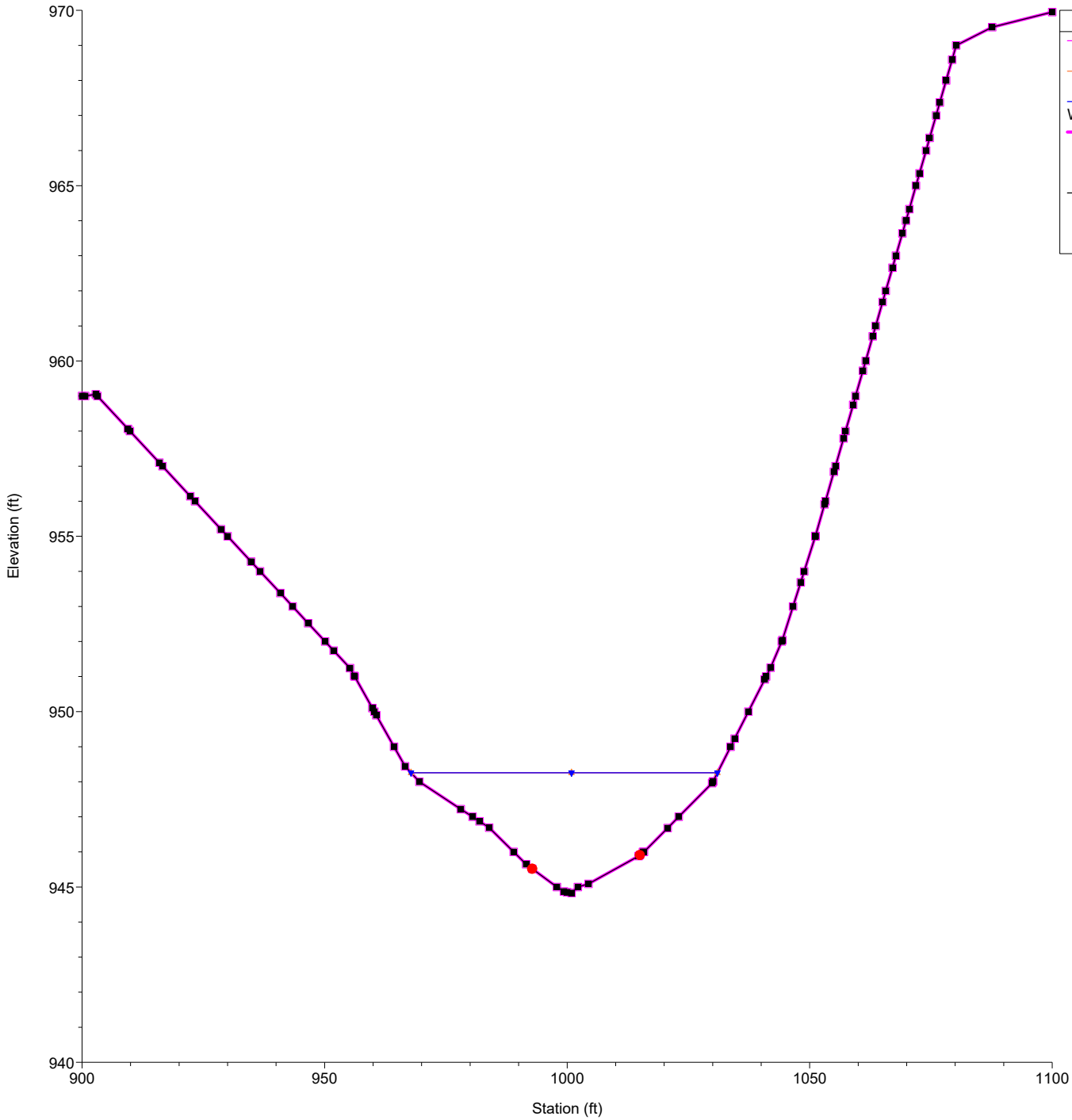


| Legend   |   |
|--|---|
| WS 100-Year - Prop Conditions (Bench) - Prop Conditions (Bench)            | ▲ |
| WS 100-Year - Prop Conditions (Modified Profile)                           | ▼ |
| WS 100-Year - Prop Conditions (Modified Profile) - Prop Conditions (Bench) | ▼ |
| Ground - Prop Conditions (Modified Profile)                                | □ |
| Bank Sta - Prop Conditions (Modified Profile)                              | ● |
| Ground - Prop Conditions (Bench)   | ■ |
| Bank Sta - Prop Conditions (Bench)   | ● |

GandyDancer Plan: 1) Prop Conditions (Bench) 2) Prop Conditions (Modified Profile)

Flow: Design Flows

River = Little Balsam Cr Reach = Little Balsam Cr RS = 625



| Legend   |   |
|--|---|
| WS 100-Year - Prop Conditions (Modified Profile)                           | ▲ |
| WS 100-Year - Prop Conditions (Bench) - Prop Conditions (Bench)            | ▼ |
| WS 100-Year - Prop Conditions (Modified Profile) - Prop Conditions (Bench) | ◆ |
| Ground - Prop Conditions (Modified Profile)                                | ■ |
| Bank Sta - Prop Conditions (Modified Profile)                              | ● |
| Ground - Prop Conditions (Bench)   | ■ |
| Bank Sta - Prop Conditions (Bench)   | ● |

| Reach            | River Sta | Profile  | Plan                    | Q Total<br>(cfs) | Min Ch El<br>(ft) | W.S. Elev<br>(ft) | Crit W.S.<br>(ft) | E.G. Elev<br>(ft) | E.G. Slope<br>(ft/ft) | Vel Chnl<br>(ft/s) | Flow Area<br>(sq ft) | Top Width<br>(ft) | Froude # Chl |
|------------------|-----------|----------|-------------------------|------------------|-------------------|-------------------|-------------------|-------------------|-----------------------|--------------------|----------------------|-------------------|--------------|
| Little Balsam Cr | 1400      | 100-Year | Existing Conditions     | 713.00           | 961.95            | 966.93            | 966.93            | 968.43            | 0.010005              | 11.53              | 114.48               | 43.77             | 0.95         |
| Little Balsam Cr | 1400      | 100-Year | Prop Conditions (Bench) | 713.00           | 961.95            | 966.93            | 966.93            | 968.43            | 0.010005              | 11.53              | 114.48               | 43.77             | 0.95         |
| Little Balsam Cr | 1360      | 100-Year | Existing Conditions     | 713.00           | 961.66            | 965.66            | 965.66            | 967.28            | 0.011180              | 10.55              | 82.61                | 29.92             | 0.97         |
| Little Balsam Cr | 1360      | 100-Year | Prop Conditions (Bench) | 713.00           | 961.66            | 965.66            | 965.66            | 967.28            | 0.011180              | 10.55              | 82.61                | 29.92             | 0.97         |
| Little Balsam Cr | 1300      | 100-Year | Existing Conditions     | 713.00           | 960.27            | 965.42            |                   | 965.85            | 0.002648              | 6.38               | 212.68               | 68.93             | 0.50         |
| Little Balsam Cr | 1300      | 100-Year | Prop Conditions (Bench) | 713.00           | 960.27            | 965.42            |                   | 965.85            | 0.002648              | 6.38               | 212.68               | 68.93             | 0.50         |
| Little Balsam Cr | 1255      | 100-Year | Existing Conditions     | 713.00           | 959.59            | 963.98            | 963.98            | 965.52            | 0.010338              | 11.31              | 107.99               | 42.41             | 0.96         |
| Little Balsam Cr | 1255      | 100-Year | Prop Conditions (Bench) | 713.00           | 959.59            | 963.98            | 963.98            | 965.52            | 0.010338              | 11.31              | 107.99               | 42.41             | 0.96         |
| Little Balsam Cr | 1200      | 100-Year | Existing Conditions     | 713.00           | 958.00            | 962.55            | 962.55            | 964.43            | 0.010530              | 11.42              | 78.64                | 24.86             | 0.96         |
| Little Balsam Cr | 1200      | 100-Year | Prop Conditions (Bench) | 713.00           | 958.00            | 962.55            | 962.55            | 964.43            | 0.010530              | 11.42              | 78.64                | 24.86             | 0.96         |
| Little Balsam Cr | 1150      | 100-Year | Existing Conditions     | 713.00           | 957.77            | 963.16            | 959.29            | 963.35            | 0.000612              | 3.76               | 250.37               | 48.06             | 0.25         |
| Little Balsam Cr | 1150      | 100-Year | Prop Conditions (Bench) | 713.00           | 957.50            | 961.40            | 961.38            | 962.75            | 0.011085              | 9.58               | 90.21                | 39.66             | 0.95         |
| Little Balsam Cr | 1120      | 100-Year | Existing Conditions     | 713.00           | 954.55            | 961.82            | 960.21            | 963.20            | 0.005100              | 9.54               | 88.59                | 19.96             | 0.64         |
| Little Balsam Cr | 1120      | 100-Year | Prop Conditions (Bench) | 713.00           | 956.50            | 961.67            |                   | 962.36            | 0.004206              | 7.01               | 137.60               | 50.40             | 0.61         |
| Little Balsam Cr | 1110      | 100-Year | Existing Conditions     | 713.00           | 954.24            | 961.84            | 959.67            | 963.08            | 0.004881              | 9.00               | 85.92                | 14.23             | 0.58         |
| Little Balsam Cr | 1110      | 100-Year | Prop Conditions (Bench) | 713.00           | 956.50            | 961.68            | 960.48            | 962.28            | 0.003475              | 6.60               | 148.61               | 52.31             | 0.56         |
| Little Balsam Cr | 1000      |          |                         | Culvert          |                   |                   |                   |                   |                       |                    |                      |                   |              |
| Little Balsam Cr | 880       | 100-Year | Existing Conditions     | 713.00           | 950.00            | 954.69            | 954.69            | 956.96            | 0.011048              | 12.10              | 59.16                | 37.87             | 1.00         |
| Little Balsam Cr | 880       | 100-Year | Prop Conditions (Bench) | 713.00           | 951.58            | 954.49            | 954.49            | 955.34            | 0.015215              | 8.58               | 128.56               | 75.61             | 1.04         |
| Little Balsam Cr | 865       | 100-Year | Existing Conditions     | 713.00           | 949.76            | 954.28            | 954.25            | 955.84            | 0.012298              | 11.44              | 92.22                | 45.21             | 1.03         |
| Little Balsam Cr | 865       | 100-Year | Prop Conditions (Bench) | 713.00           | 951.25            | 954.41            |                   | 954.88            | 0.006904              | 6.45               | 174.69               | 85.59             | 0.72         |
| Little Balsam Cr | 850       | 100-Year | Existing Conditions     | 713.00           | 949.50            | 954.15            | 954.15            | 955.62            | 0.010201              | 10.81              | 104.79               | 47.33             | 0.94         |
| Little Balsam Cr | 850       | 100-Year | Prop Conditions (Bench) | 713.00           | 950.92            | 954.39            |                   | 954.77            | 0.004878              | 5.75               | 188.09               | 83.15             | 0.61         |
| Little Balsam Cr | 750       | 100-Year | Existing Conditions     | 713.00           | 947.04            | 952.21            | 951.20            | 953.15            | 0.004689              | 8.26               | 118.13               | 35.27             | 0.66         |
| Little Balsam Cr | 750       | 100-Year | Prop Conditions (Bench) | 713.00           | 948.39            | 952.58            | 952.58            | 953.96            | 0.011373              | 9.67               | 87.27                | 36.94             | 0.96         |
| Little Balsam Cr | 715       | 100-Year | Existing Conditions     | 713.00           | 946.74            | 951.23            | 951.23            | 952.85            | 0.010454              | 11.30              | 98.53                | 35.80             | 0.97         |
| Little Balsam Cr | 715       | 100-Year | Prop Conditions (Bench) | 713.00           | 947.30            | 951.78            | 951.78            | 953.16            | 0.011399              | 9.66               | 87.33                | 37.21             | 0.96         |
| Little Balsam Cr | 625       | 100-Year | Existing Conditions     | 713.00           | 944.83            | 948.26            | 948.26            | 949.32            | 0.010565              | 9.01               | 118.66               | 63.16             | 0.92         |
| Little Balsam Cr | 625       | 100-Year | Prop Conditions (Bench) | 713.00           | 944.83            | 948.26            | 948.26            | 949.32            | 0.010565              | 9.01               | 118.66               | 63.16             | 0.92         |
| Little Balsam Cr | 575       | 100-Year | Existing Conditions     | 713.00           | 943.37            | 947.98            |                   | 948.50            | 0.003914              | 7.04               | 183.70               | 61.56             | 0.59         |
| Little Balsam Cr | 575       | 100-Year | Prop Conditions (Bench) | 713.00           | 943.37            | 947.98            |                   | 948.50            | 0.003914              | 7.04               | 183.70               | 61.56             | 0.59         |
| Little Balsam Cr | 550       | 100-Year | Existing Conditions     | 713.00           | 943.00            | 947.36            | 946.97            | 948.32            | 0.007378              | 9.14               | 135.06               | 53.05             | 0.80         |
| Little Balsam Cr | 550       | 100-Year | Prop Conditions (Bench) | 713.00           | 943.00            | 947.36            | 946.97            | 948.32            | 0.007378              | 9.14               | 135.06               | 53.05             | 0.80         |
| Little Balsam Cr | 500       | 100-Year | Existing Conditions     | 713.00           | 942.44            | 946.62            | 946.62            | 947.87            | 0.009690              | 10.16              | 120.36               | 54.43             | 0.92         |
| Little Balsam Cr | 500       | 100-Year | Prop Conditions (Bench) | 713.00           | 942.44            | 946.62            | 946.62            | 947.87            | 0.009690              | 10.16              | 120.36               | 54.43             | 0.92         |

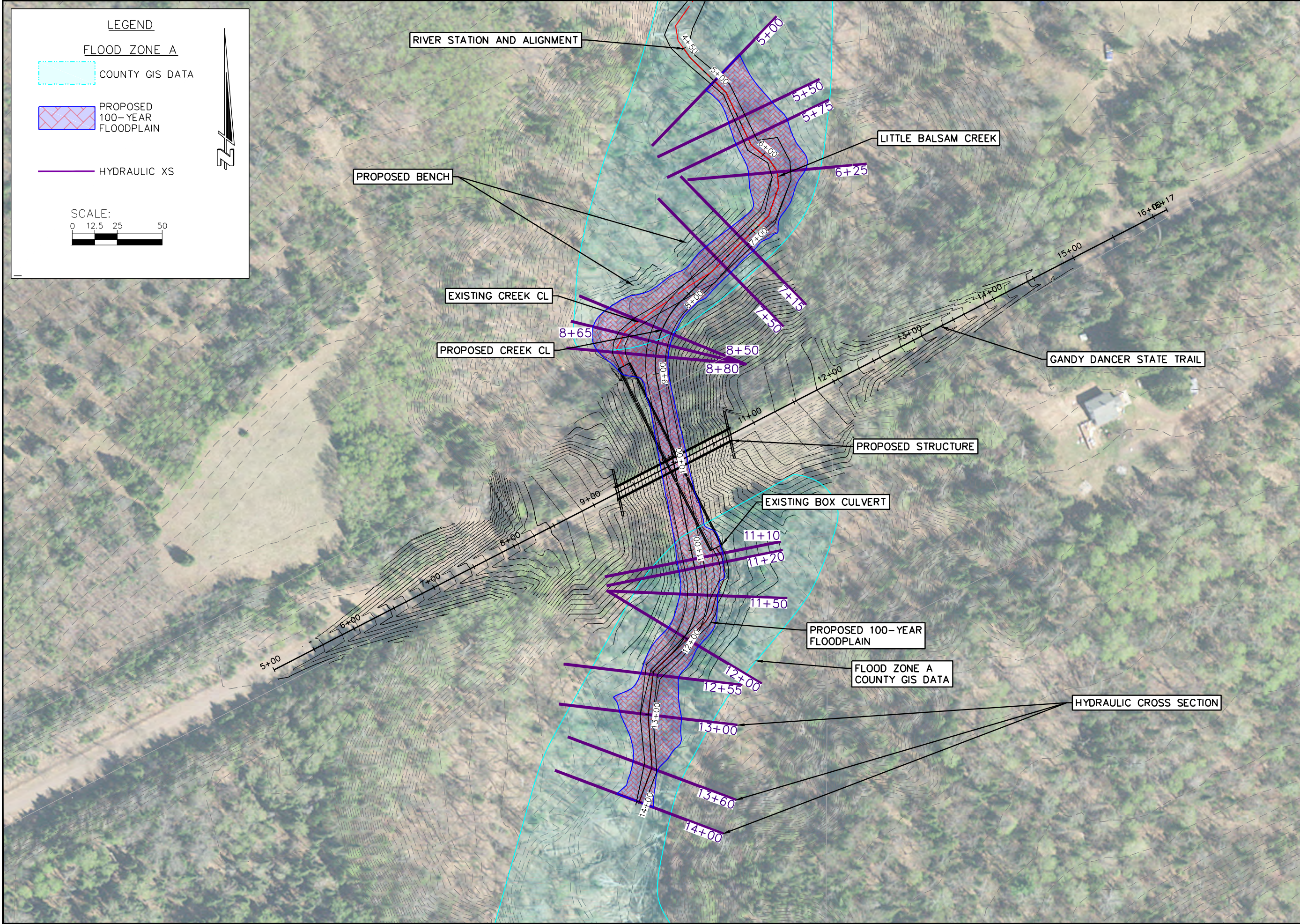


## Appendix E: Alternative Hydraulic Analysis (Bench & Modified Profile)

Data and calculations referenced in this report follow:

1. Hydraulic Cross Sections Layout
2. HEC-RAS Cross Sections – Alternate Hydraulic Analysis vs Existing Conditions
3. HEC-RAS Output Summary – Alternate Hydraulic Analysis
4. Alternate Hydraulic Analysis – 100-Year Floodplain

I:\Clients-Memo\W0779 Wis Dept of Administration\121 181N - Candy Dancer ST Repair-Replace Box Culvert Under Trail\10000 Reports\Hydraulics\00 Calculations\DWG\HYD Base30it.dwg 03/16/23 11:18:00 AM



**LEGEND**

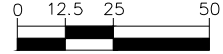
FLOOD ZONE A

COUNTY GIS DATA

PROPOSED 100-YEAR FLOODPLAIN

HYDRAULIC XS

SCALE:



|                |          |
|----------------|----------|
| JOB NO.        | NO. 181N |
| DRAWN BY       | JMD      |
| CHECKED BY     | ###      |
| DATE           | JAN 2022 |
| REVISIONS      |          |
| REFERENCE FILE | ###      |
| DRAWING FILE   | ###      |

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**BOX CULVERT REMOVAL  
AND NEW BRIDGE CONSTRUCTION  
GANDY DANCER STATE TRAIL  
HYDRAULIC CROSS SECTION LAYOUT**

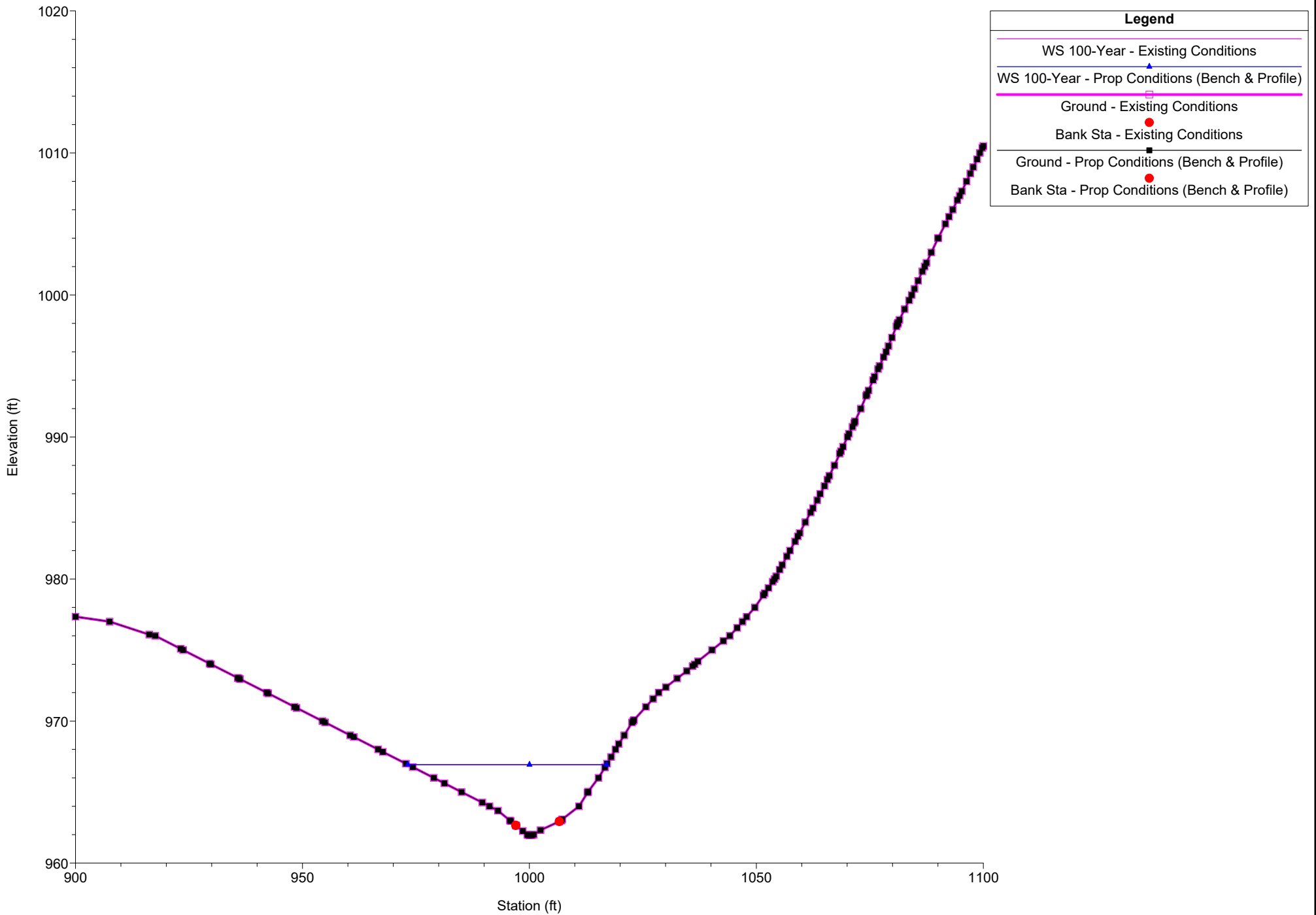
GandyDancer

Plan: 1) Prop Conditions (Bench & Profile)

2) Existing Conditions

Flow: Design Flows

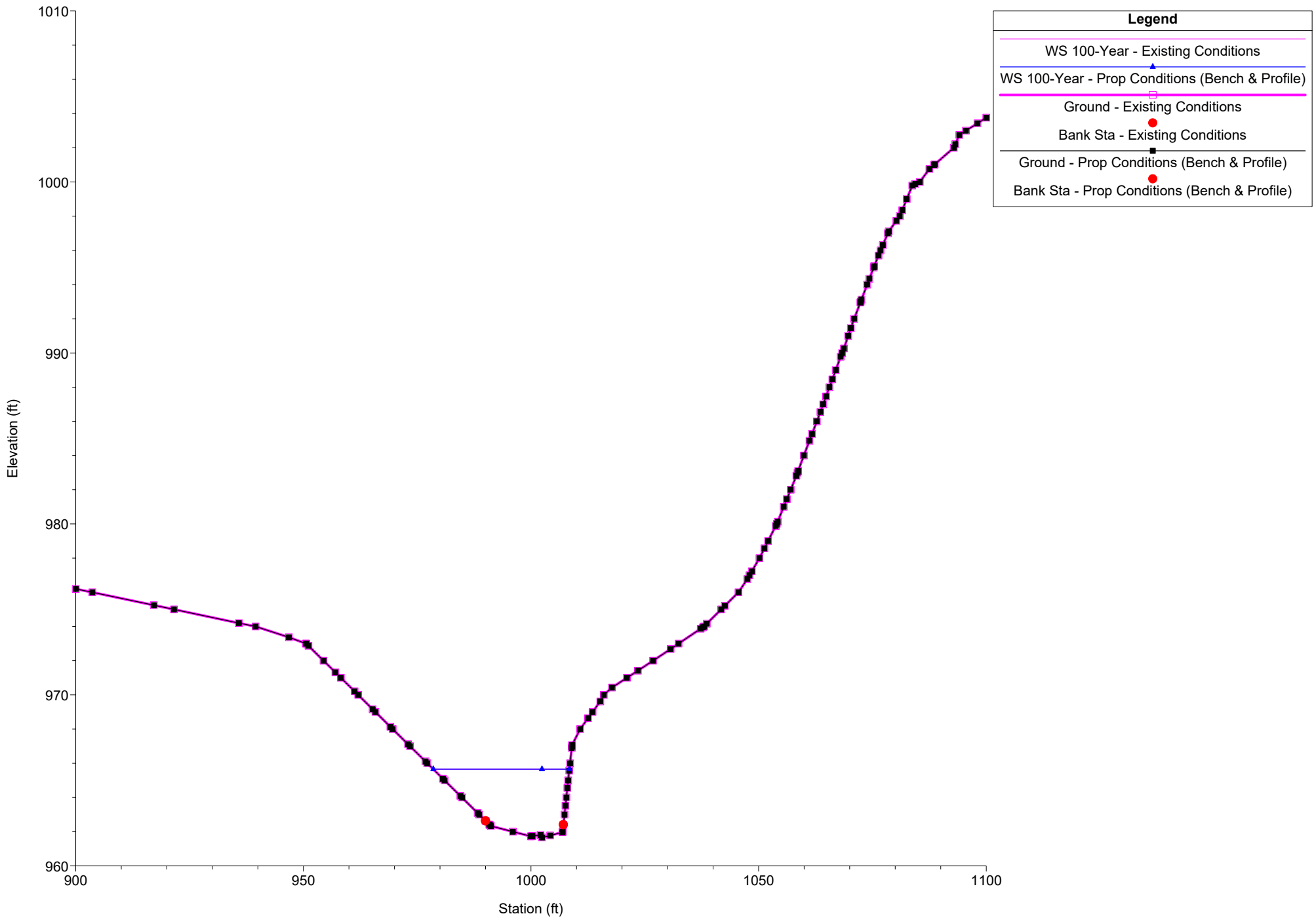
River = Little Balsam Cr Reach = Little Balsam Cr RS = 1400



GandyDancer Plan: 1) Prop Conditions (Bench & Profile) 2) Existing Conditions

Flow: Design Flows

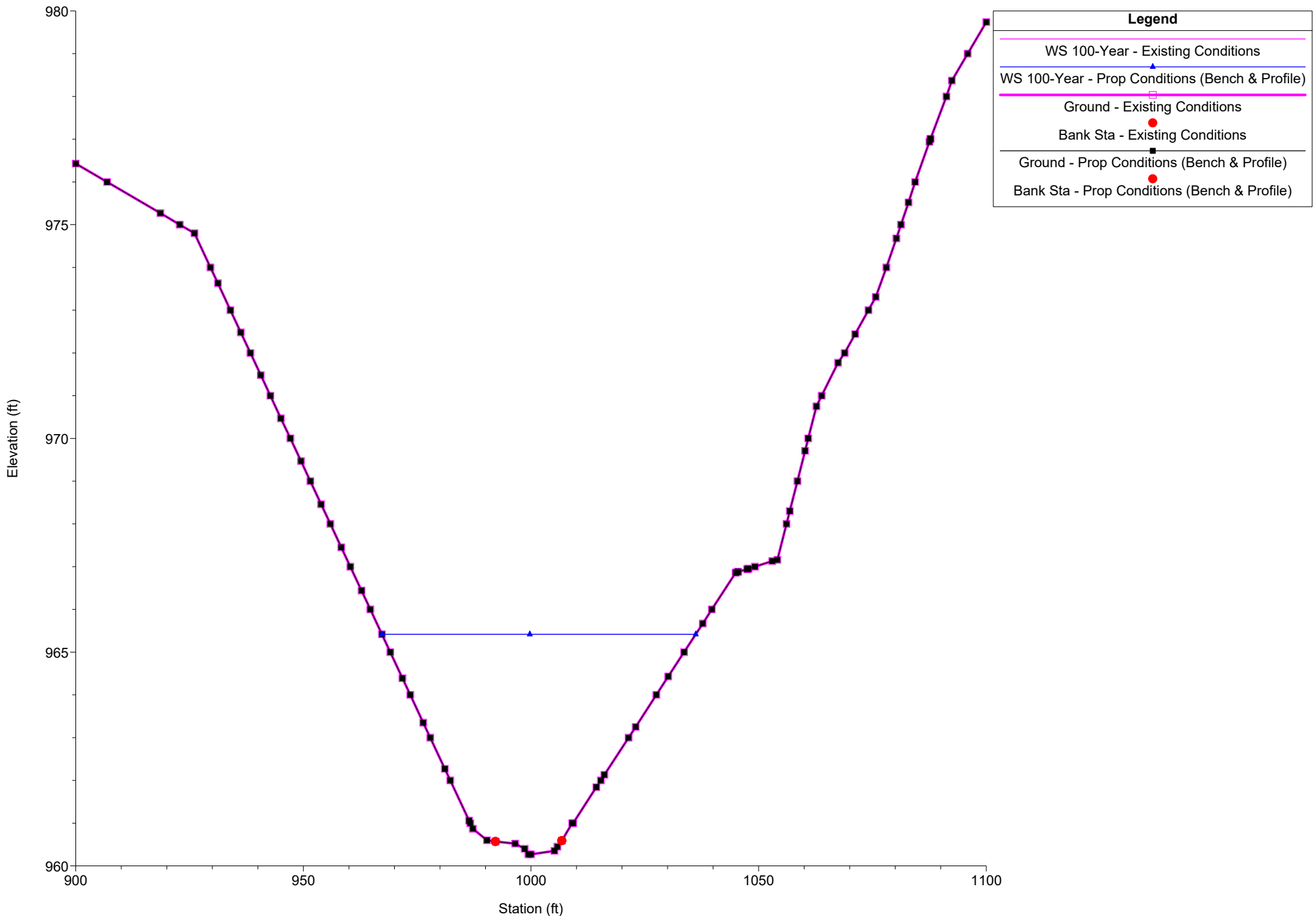
River = Little Balsam Cr Reach = Little Balsam Cr RS = 1360



GandyDancer Plan: 1) Prop Conditions (Bench & Profile) 2) Existing Conditions

Flow: Design Flows

River = Little Balsam Cr Reach = Little Balsam Cr RS = 1300



**Legend**

- WS 100-Year - Existing Conditions
- WS 100-Year - Prop Conditions (Bench & Profile)
- Ground - Existing Conditions
- Bank Sta - Existing Conditions
- Ground - Prop Conditions (Bench & Profile)
- Bank Sta - Prop Conditions (Bench & Profile)



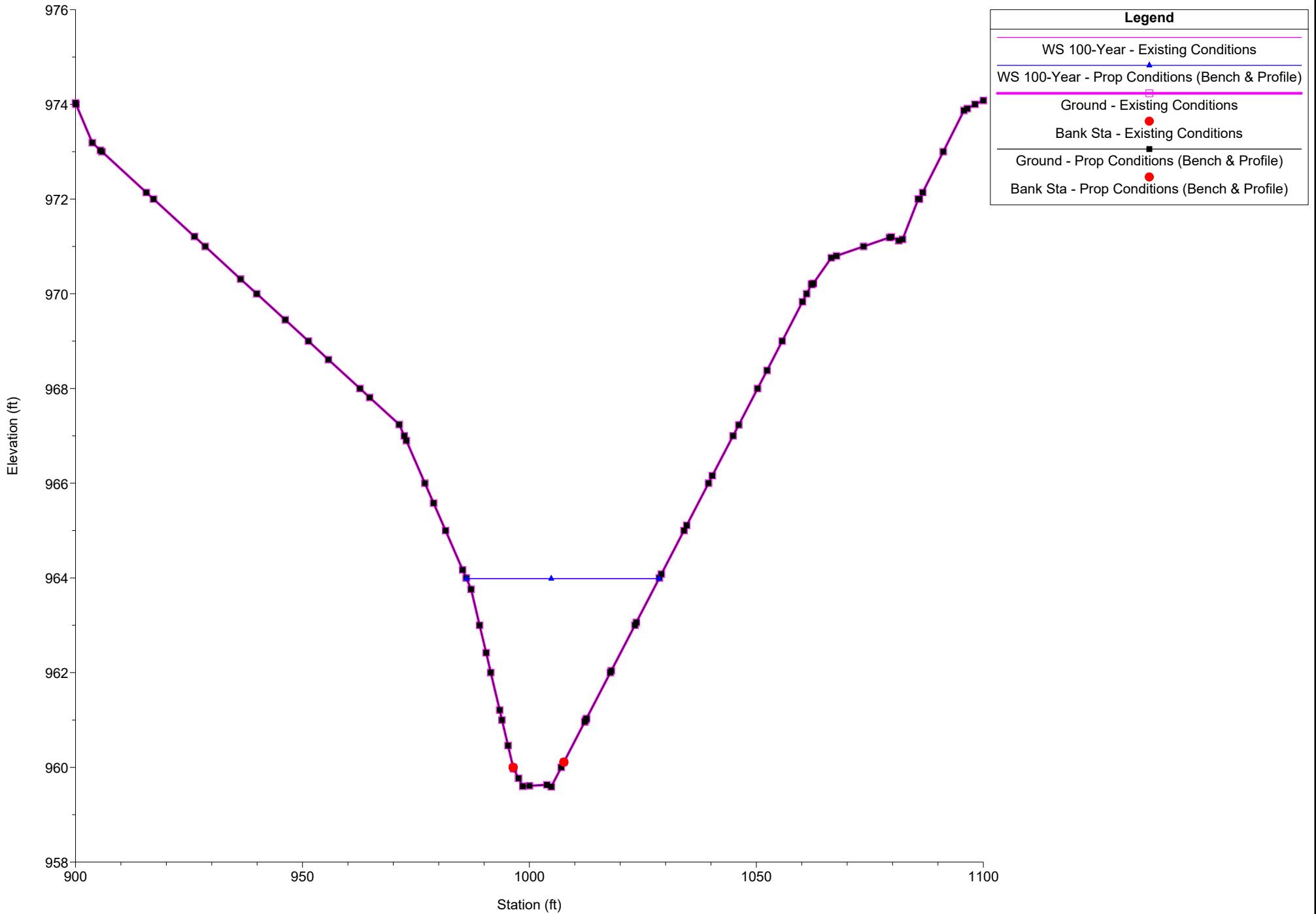
GandyDancer

Plan: 1) Prop Conditions (Bench & Profile)

2) Existing Conditions

Flow: Design Flows

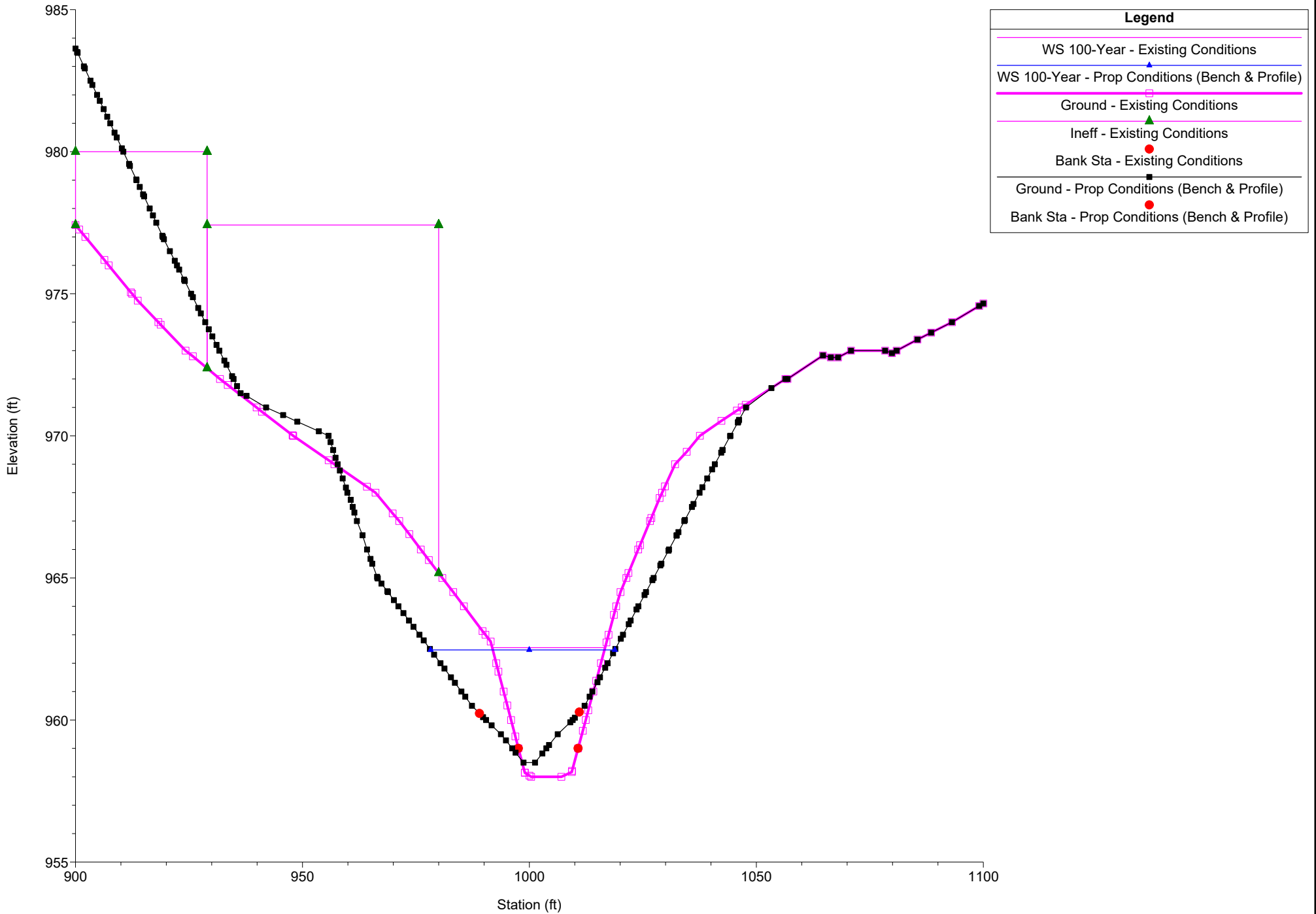
River = Little Balsam Cr Reach = Little Balsam Cr RS = 1255



GandyDancer Plan: 1) Prop Conditions (Bench & Profile) 2) Existing Conditions

Flow: Design Flows

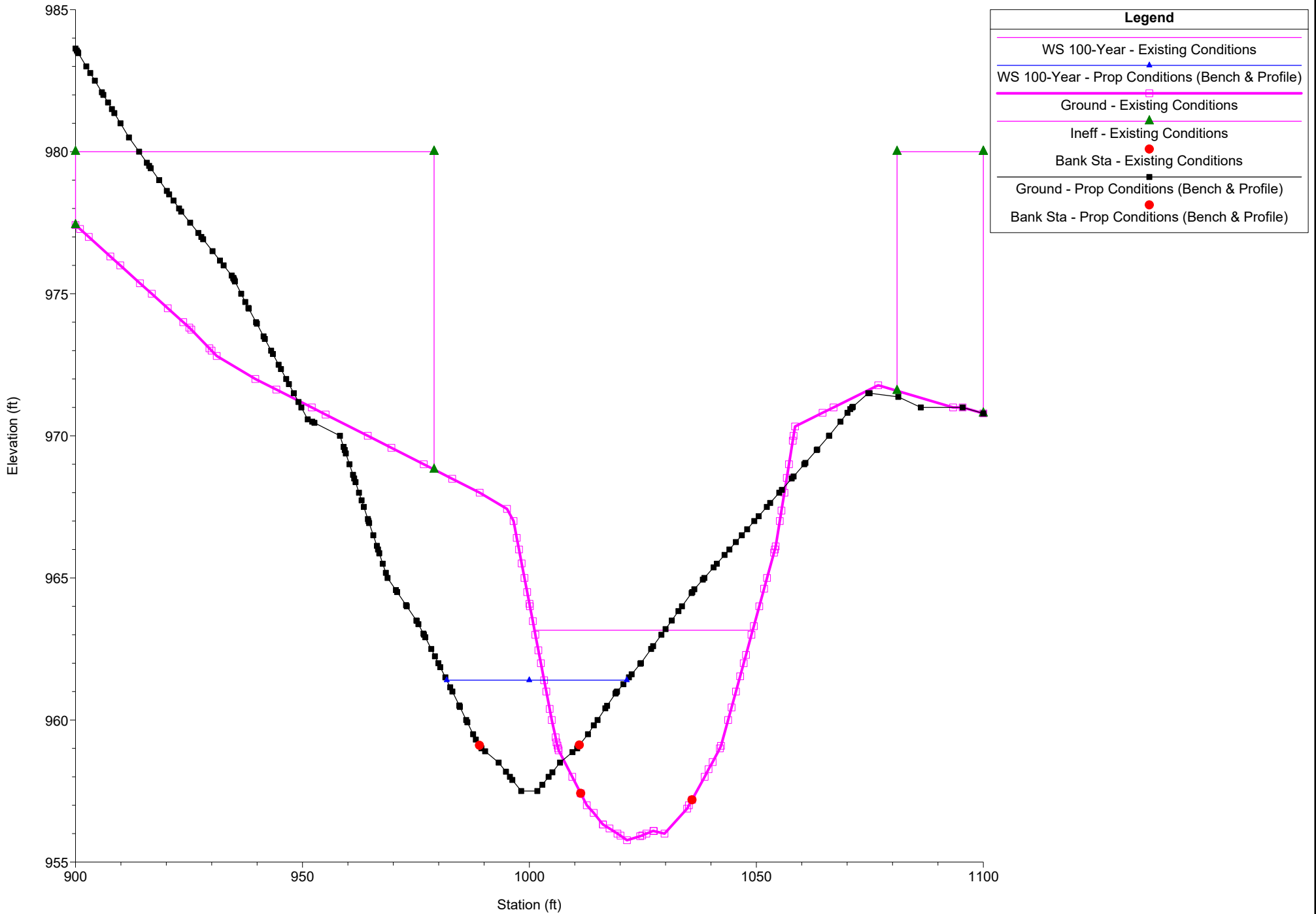
River = Little Balsam Cr Reach = Little Balsam Cr RS = 1200



GandyDancer Plan: 1) Prop Conditions (Bench & Profile) 2) Existing Conditions

Flow: Design Flows

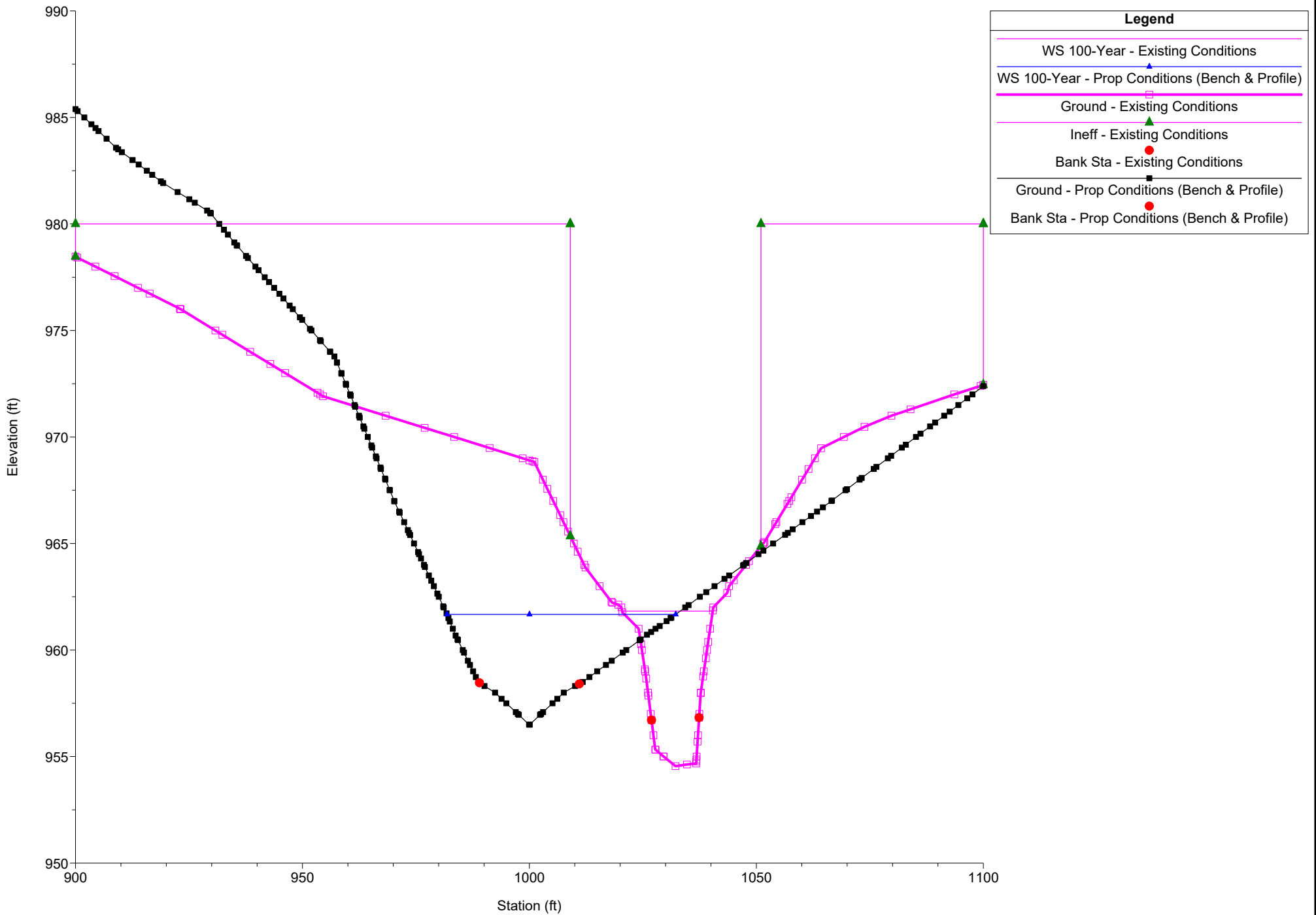
River = Little Balsam Cr Reach = Little Balsam Cr RS = 1150



GandyDancer Plan: 1) Prop Conditions (Bench & Profile) 2) Existing Conditions

Flow: Design Flows

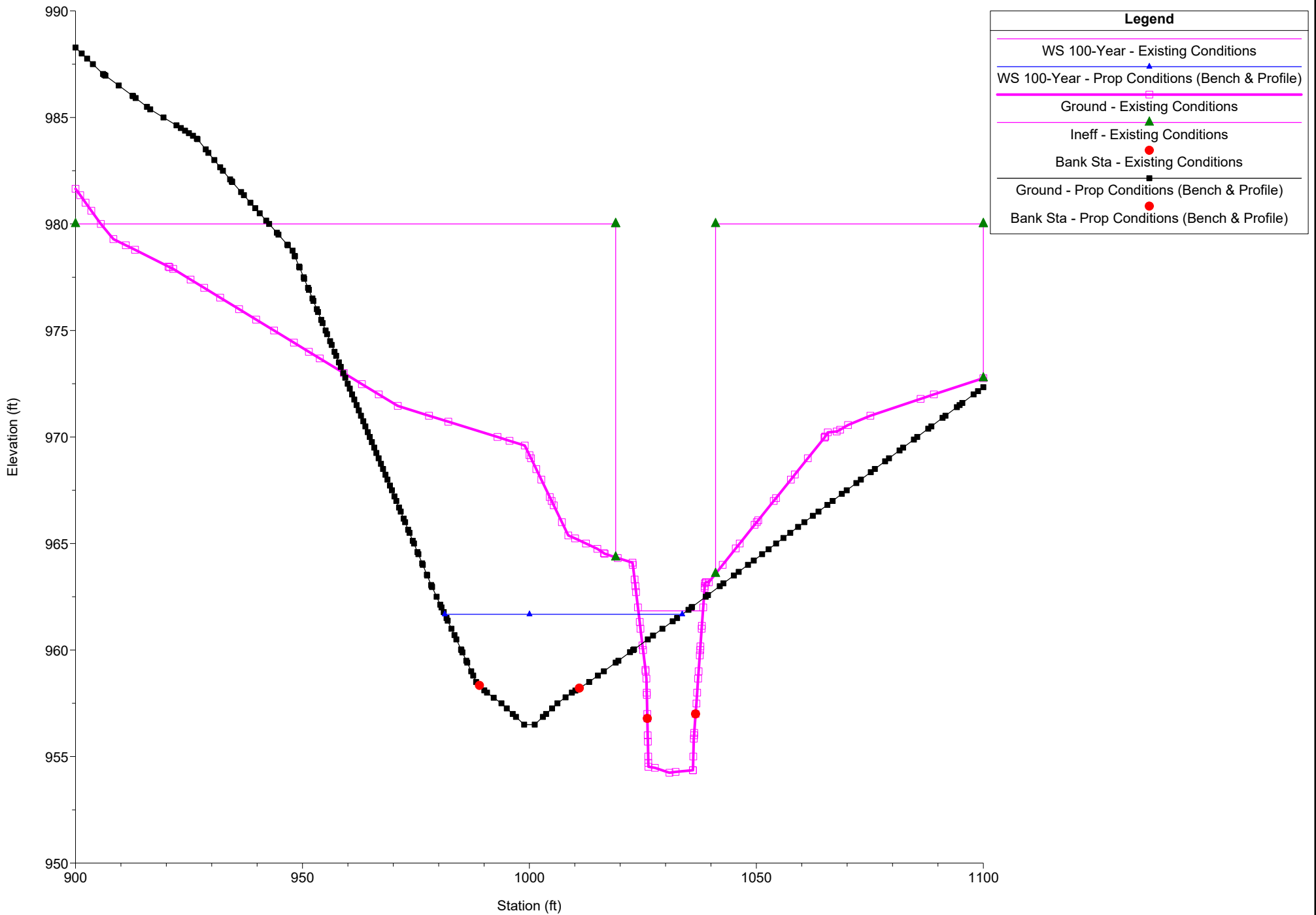
River = Little Balsam Cr Reach = Little Balsam Cr RS = 1120



GandyDancer Plan: 1) Prop Conditions (Bench & Profile) 2) Existing Conditions

Flow: Design Flows

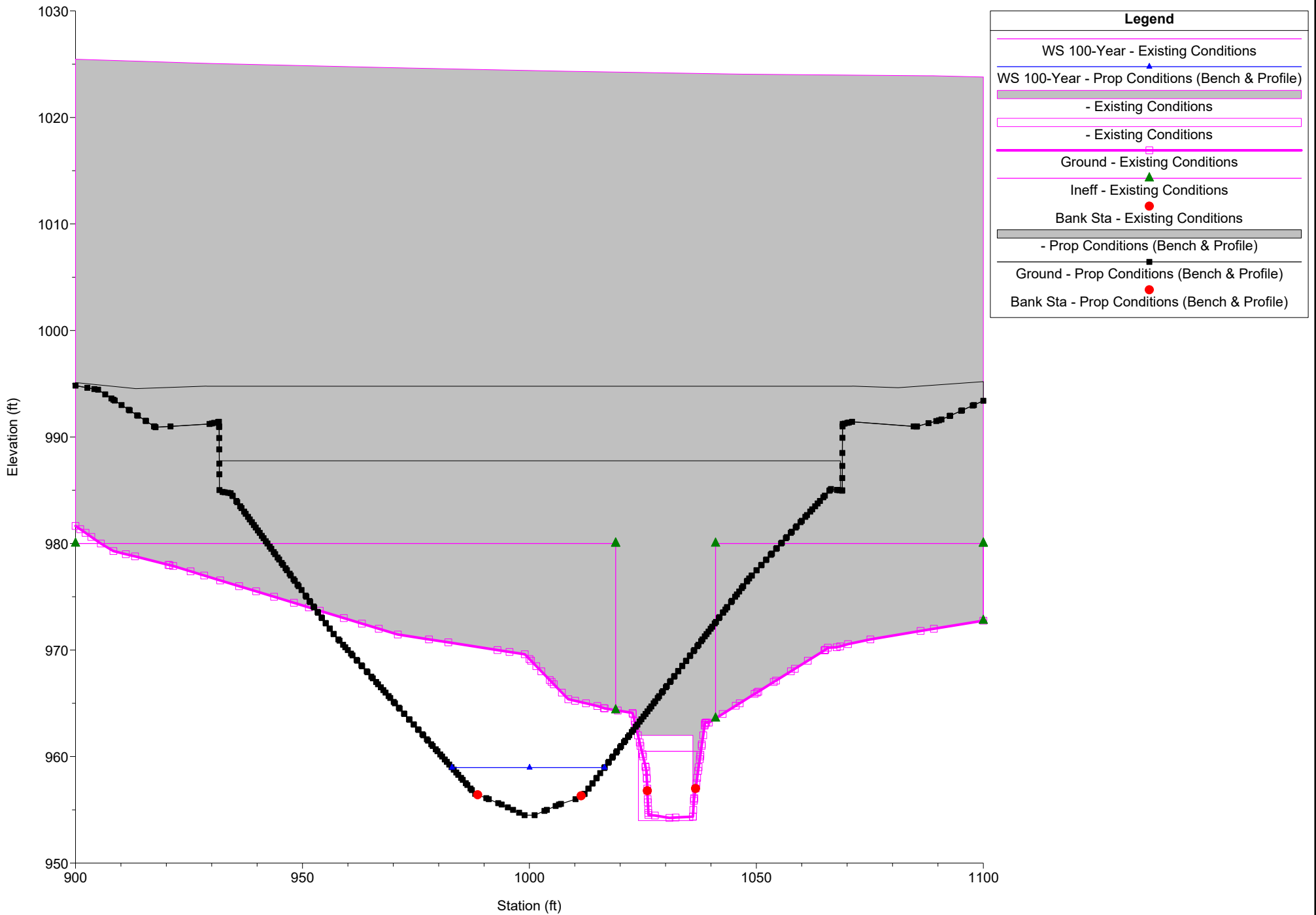
River = Little Balsam Cr Reach = Little Balsam Cr RS = 1110



GandyDancer Plan: 1) Prop Conditions (Bench & Profile) 2) Existing Conditions

Flow: Design Flows

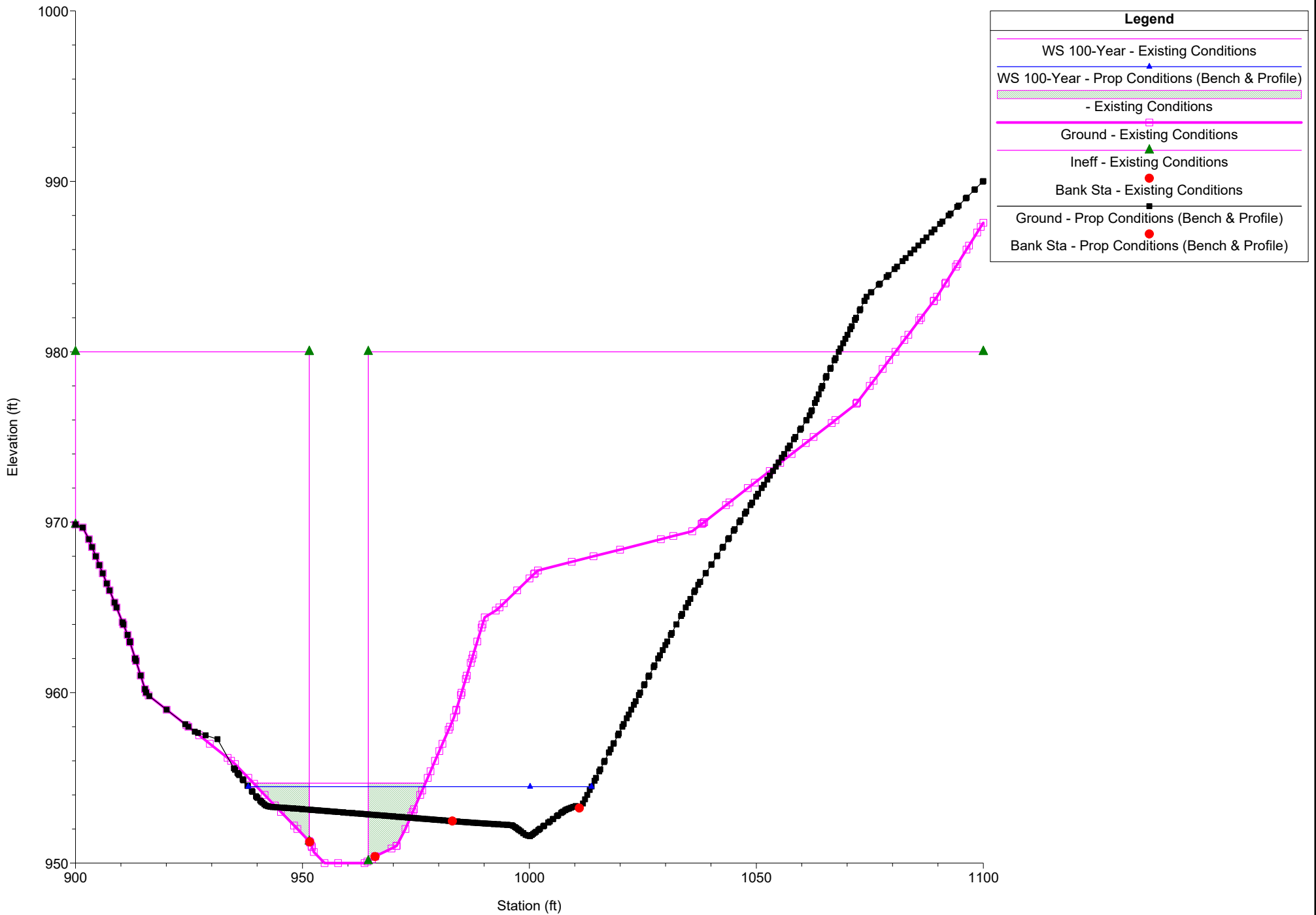
River = Little Balsam Cr Reach = Little Balsam Cr RS = 1000 BR



GandyDancer Plan: 1) Prop Conditions (Bench & Profile) 2) Existing Conditions

Flow: Design Flows

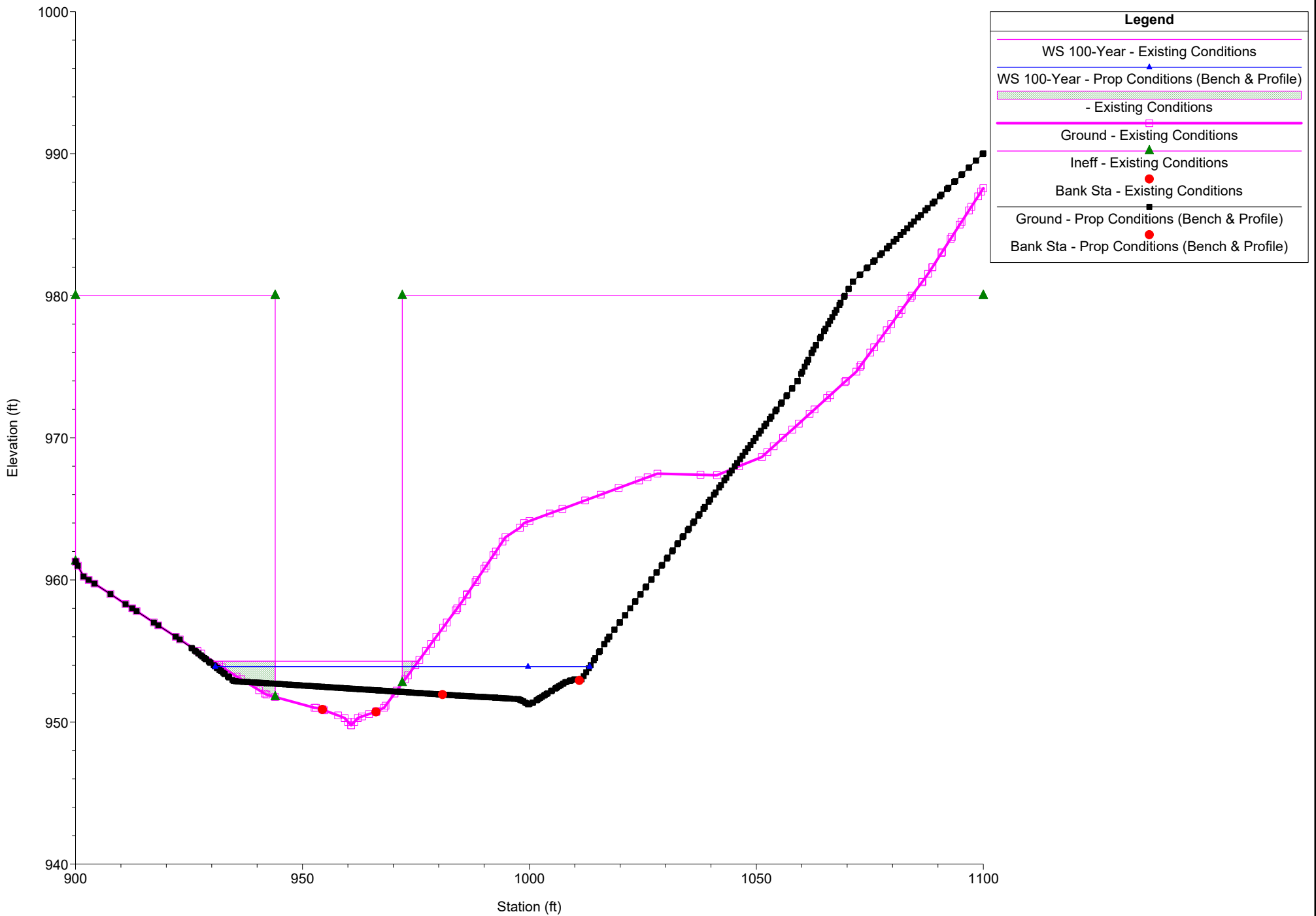
River = Little Balsam Cr Reach = Little Balsam Cr RS = 880



GandyDancer Plan: 1) Prop Conditions (Bench & Profile) 2) Existing Conditions

Flow: Design Flows

River = Little Balsam Cr Reach = Little Balsam Cr RS = 865

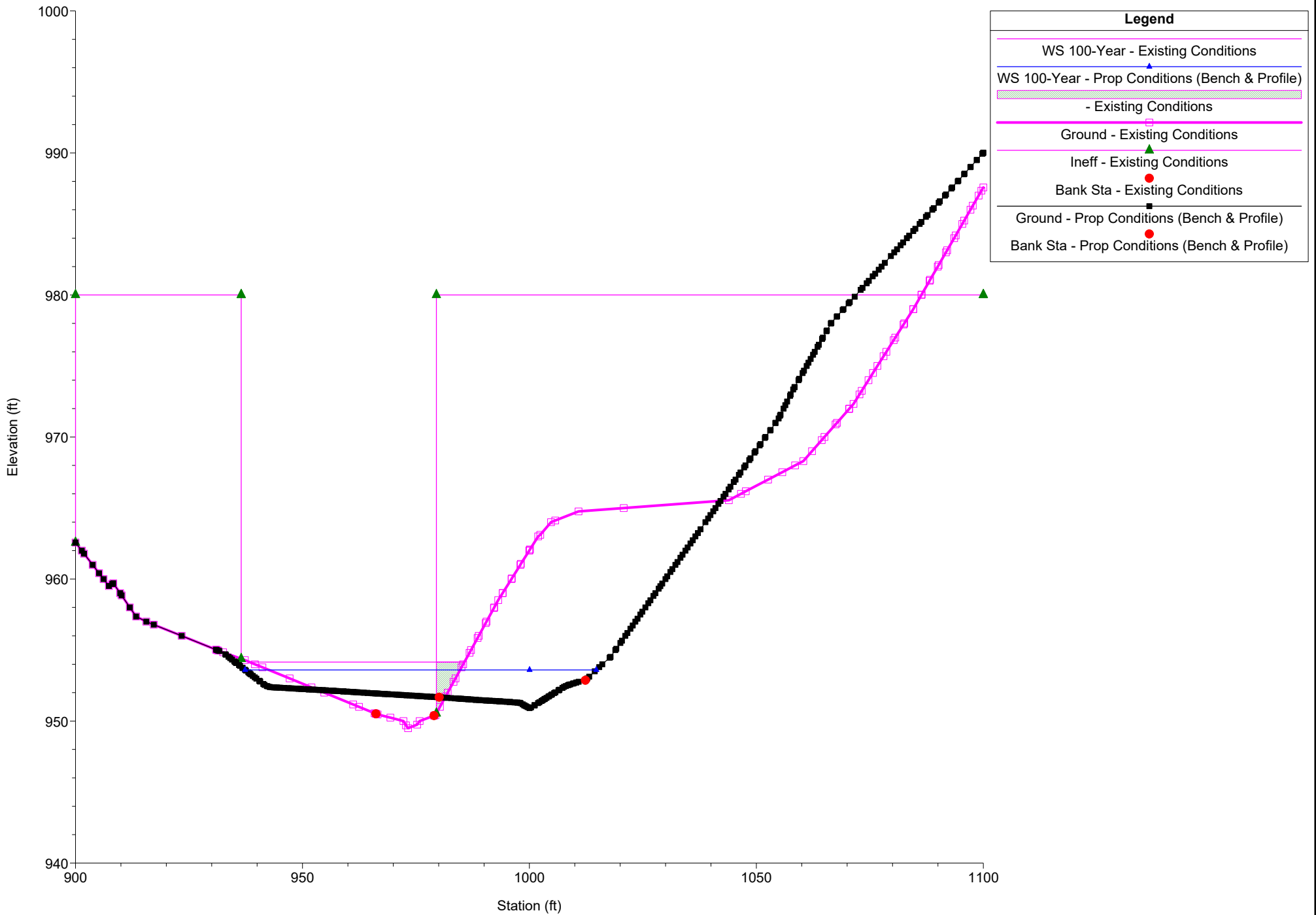




GandyDancer Plan: 1) Prop Conditions (Bench & Profile) 2) Existing Conditions

Flow: Design Flows

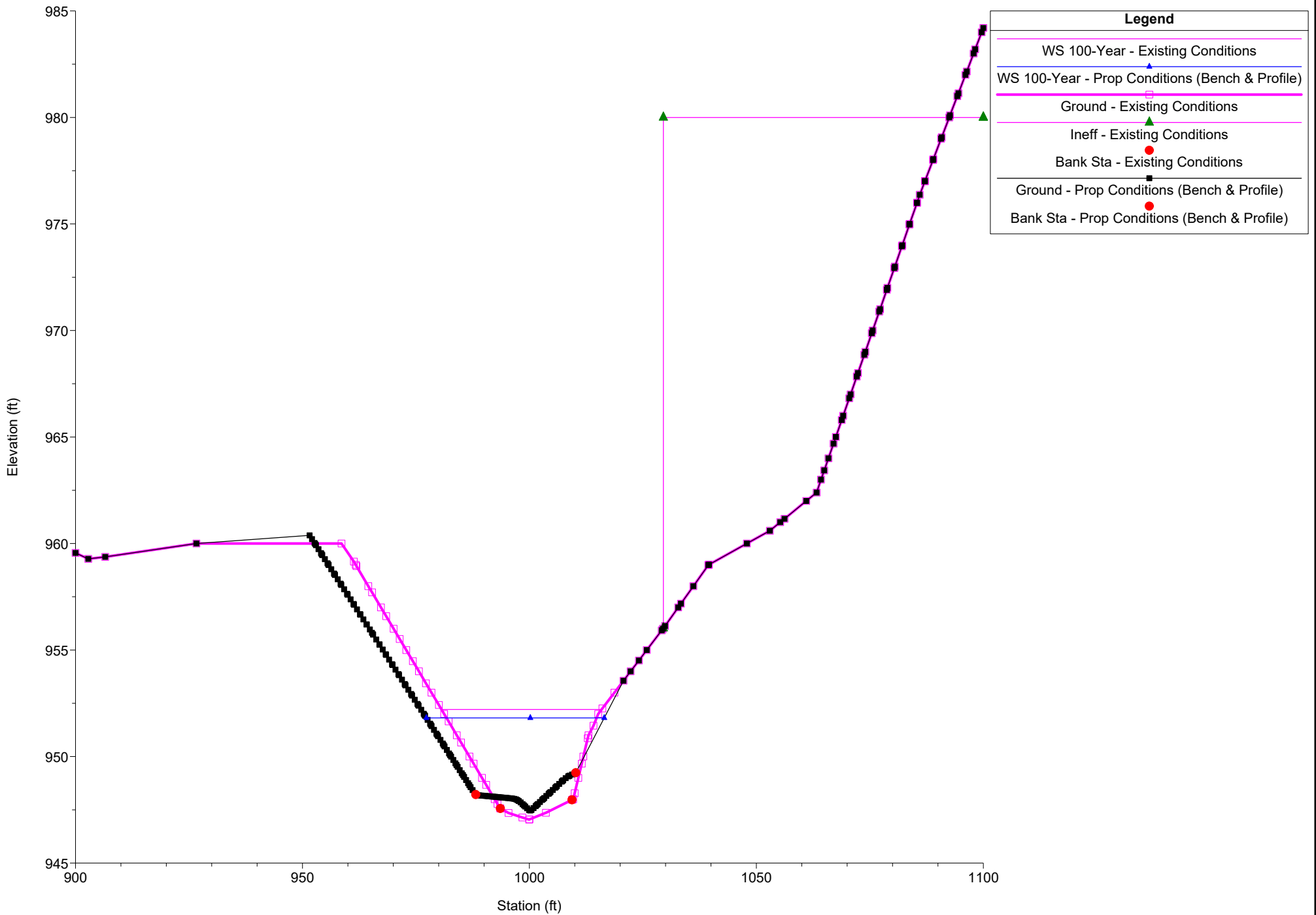
River = Little Balsam Cr Reach = Little Balsam Cr RS = 850



GandyDancer Plan: 1) Prop Conditions (Bench & Profile) 2) Existing Conditions

Flow: Design Flows

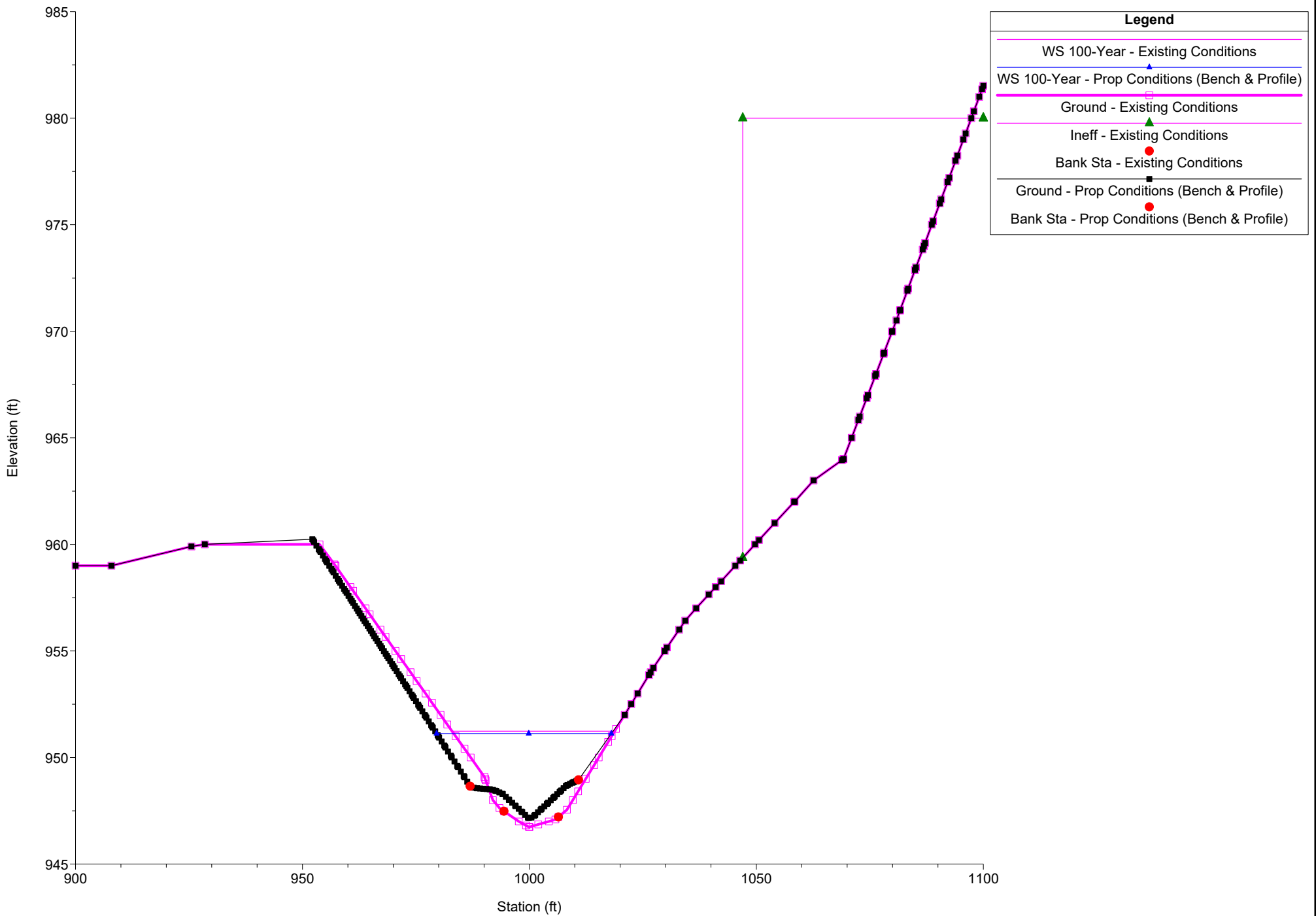
River = Little Balsam Cr Reach = Little Balsam Cr RS = 750



GandyDancer Plan: 1) Prop Conditions (Bench & Profile) 2) Existing Conditions

Flow: Design Flows

River = Little Balsam Cr Reach = Little Balsam Cr RS = 715



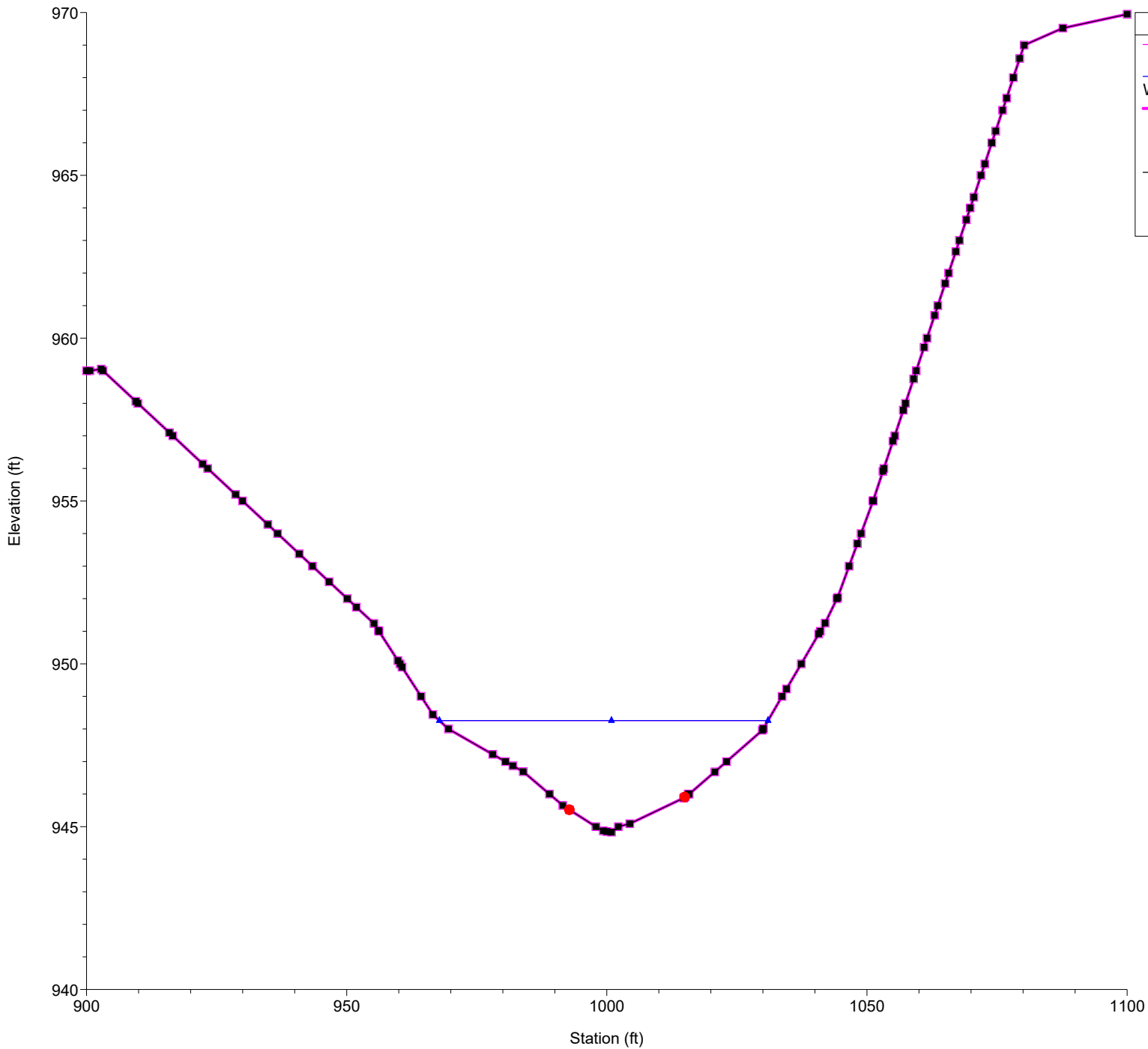
GandyDancer

Plan: 1) Prop Conditions (Bench & Profile)

2) Existing Conditions

Flow: Design Flows

River = Little Balsam Cr Reach = Little Balsam Cr RS = 625



**Legend**

- WS 100-Year - Existing Conditions
- WS 100-Year - Prop Conditions (Bench & Profile)
- Ground - Existing Conditions
- Bank Sta - Existing Conditions
- Ground - Prop Conditions (Bench & Profile)
- Bank Sta - Prop Conditions (Bench & Profile)

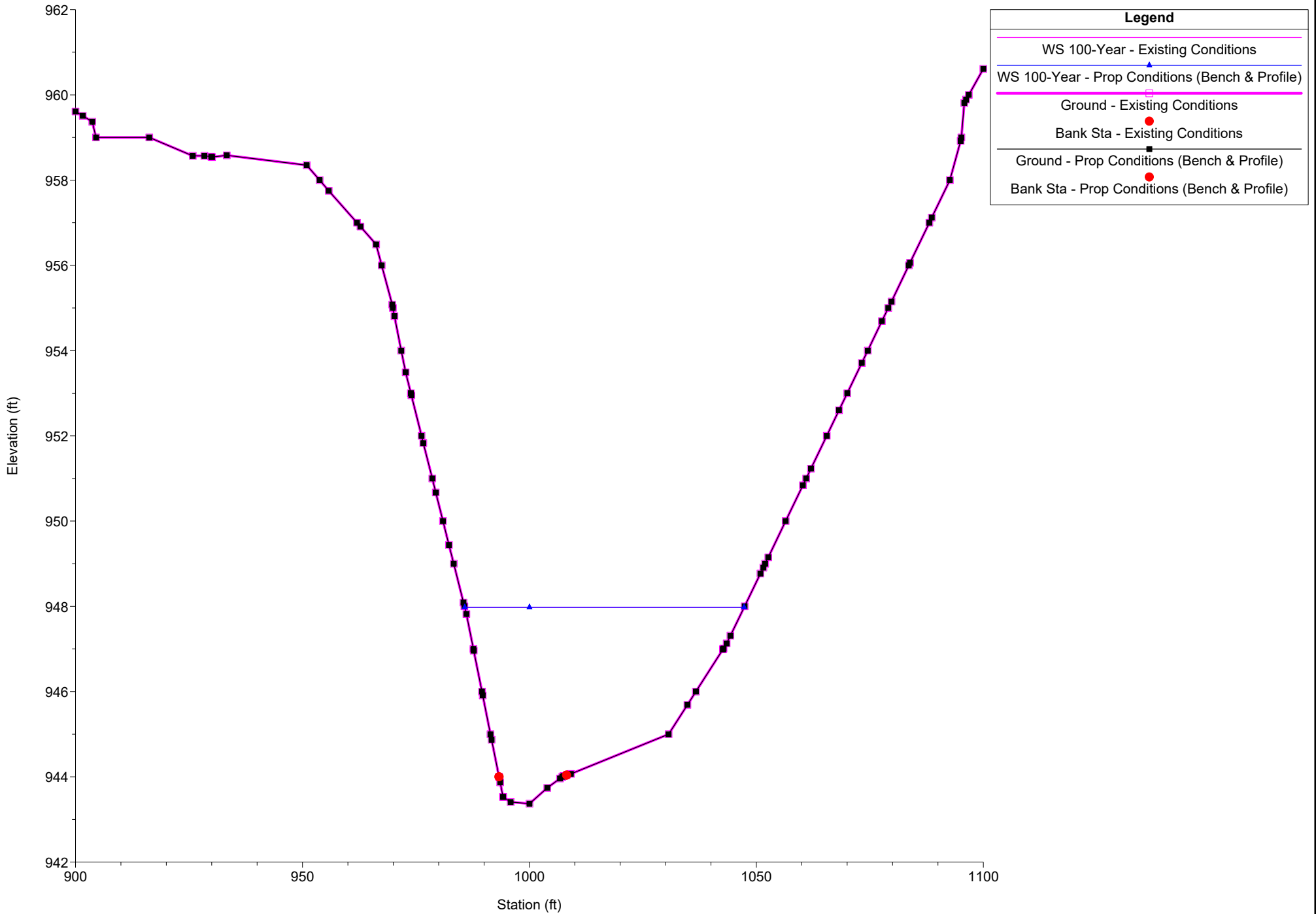
GandyDancer

Plan: 1) Prop Conditions (Bench & Profile)

2) Existing Conditions

Flow: Design Flows

River = Little Balsam Cr Reach = Little Balsam Cr RS = 575

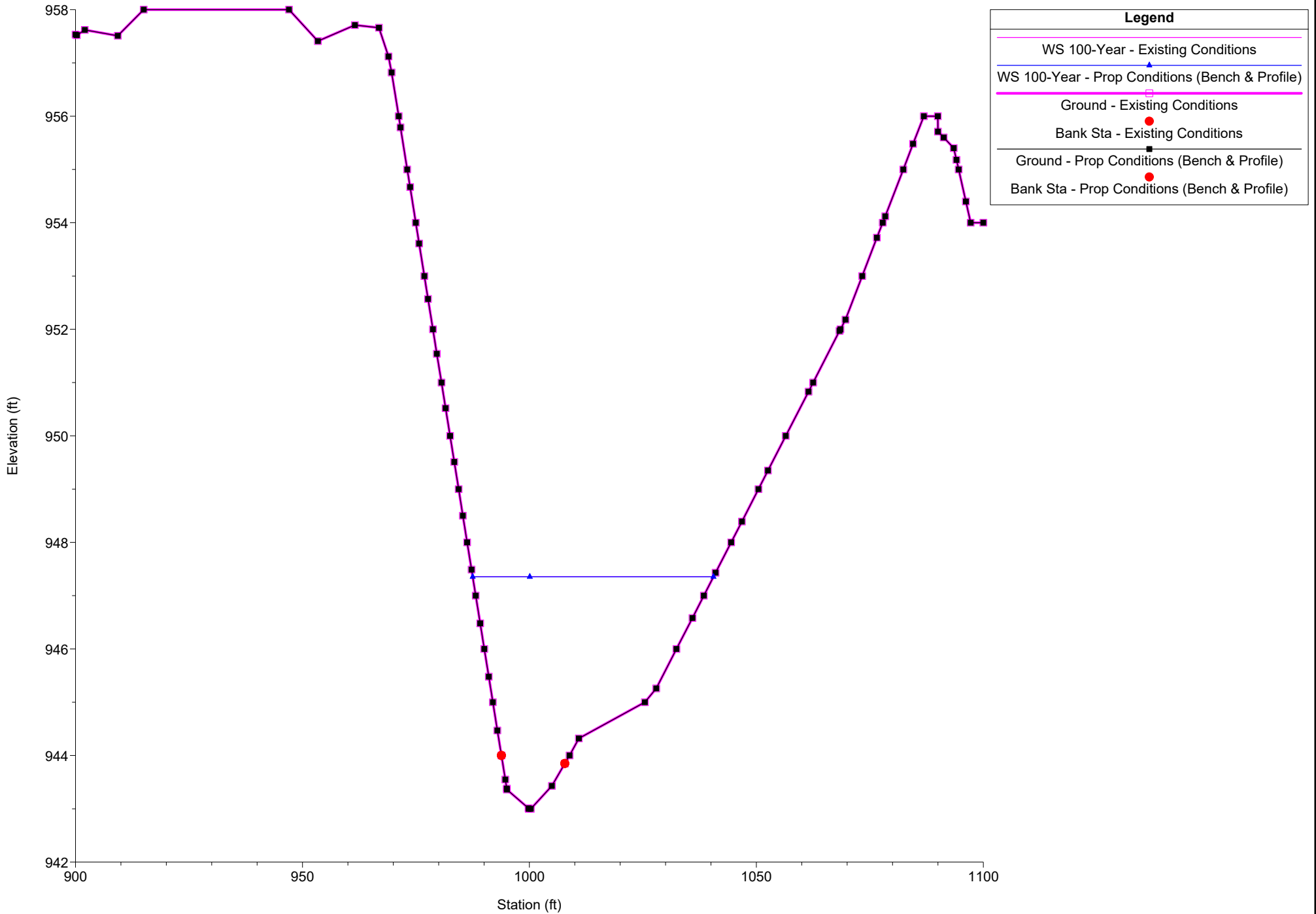


GandyDancer

Plan: 1) Prop Conditions (Bench & Profile) 2) Existing Conditions

Flow: Design Flows

River = Little Balsam Cr Reach = Little Balsam Cr RS = 550

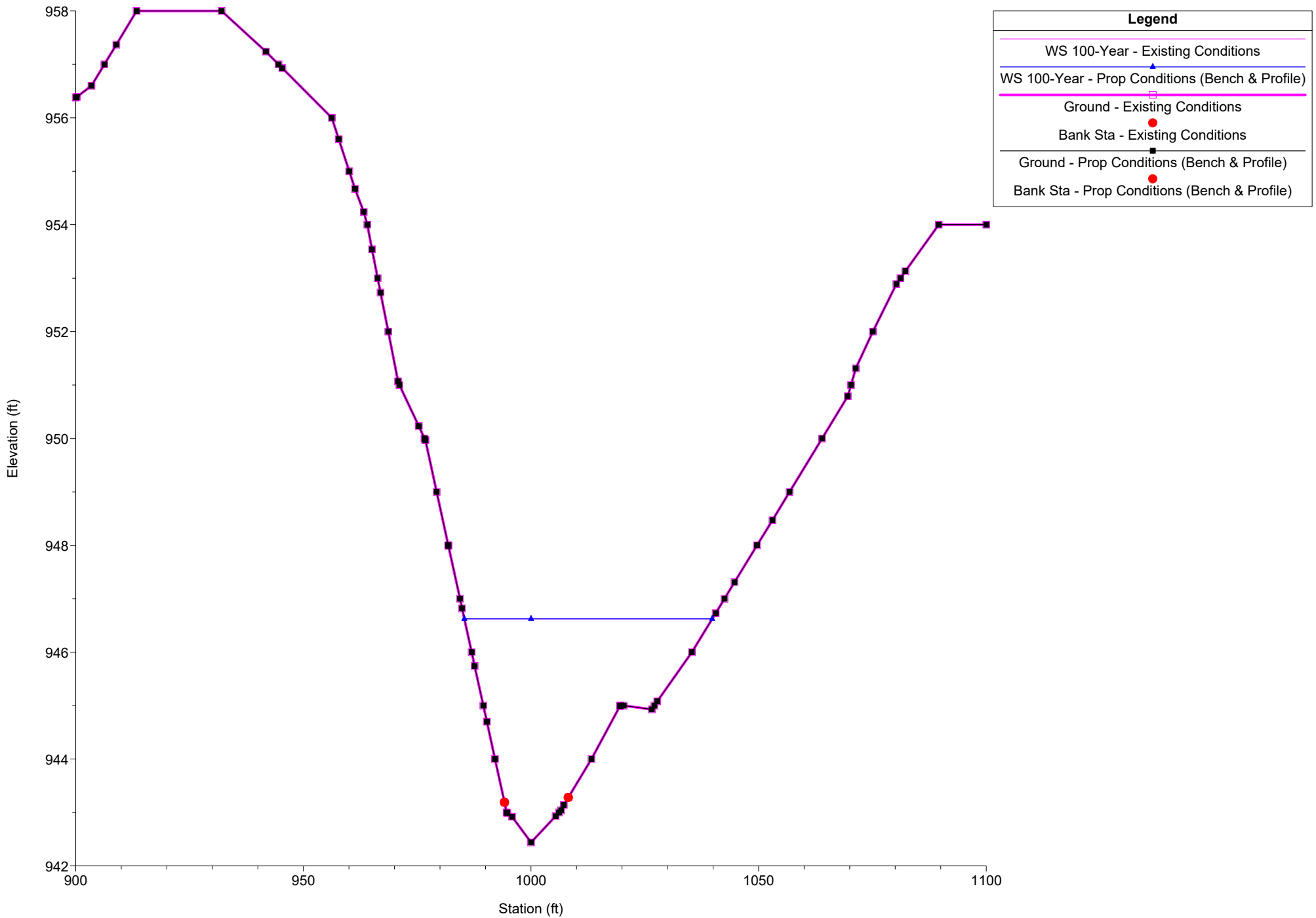


GandyDancer

Plan: 1) Prop Conditions (Bench & Profile) 2) Existing Conditions

Flow: Design Flows

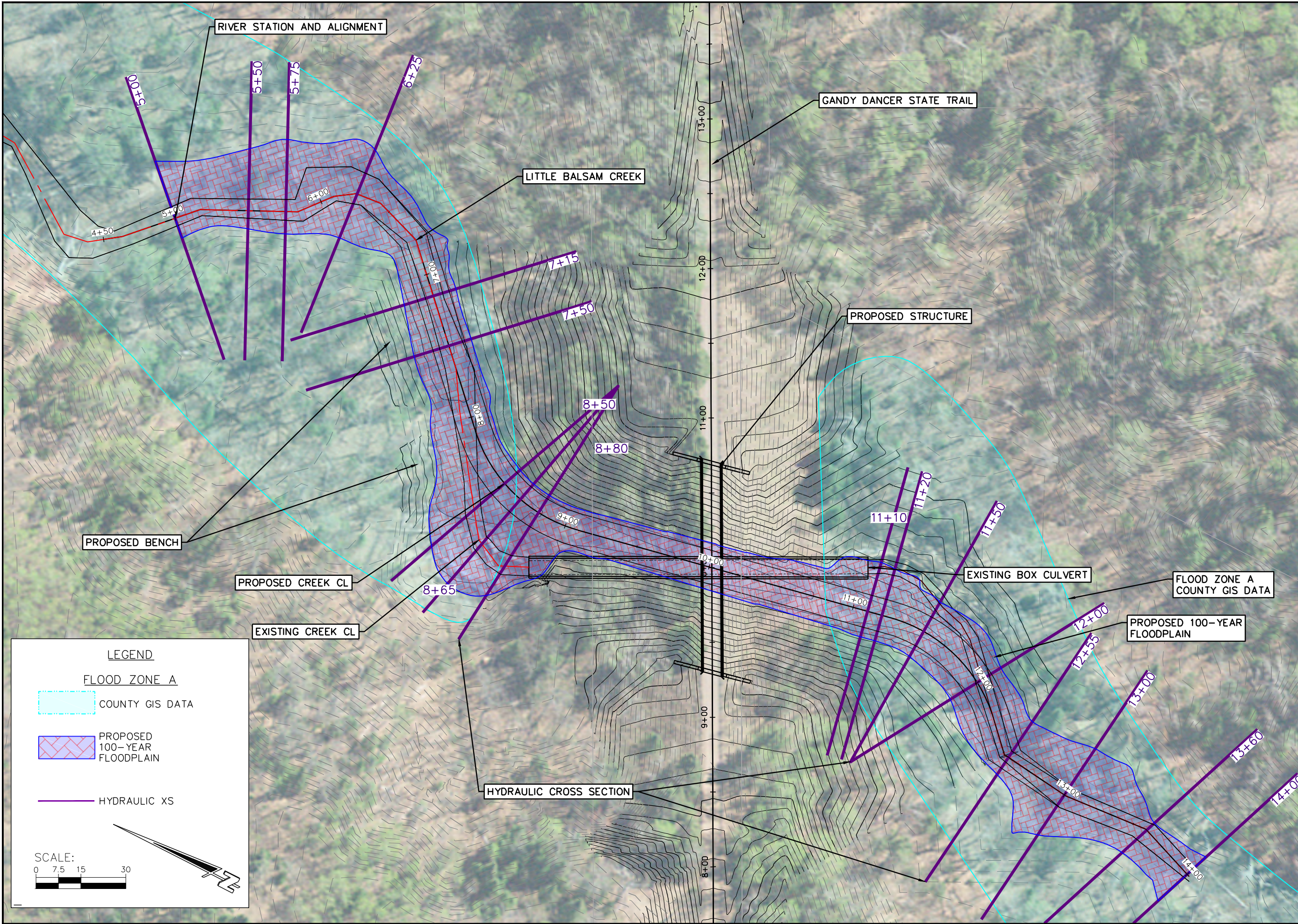
River = Little Balsam Cr Reach = Little Balsam Cr RS = 500



| Reach            | River Sta | Profile  | Plan                              | Q Total<br>(cfs) | Min Ch El<br>(ft) | W.S. Elev<br>(ft) | Crit W.S.<br>(ft) | E.G. Elev<br>(ft) | E.G. Slope<br>(ft/ft) | Vel Chnl<br>(ft/s) | Flow Area<br>(sq ft) | Top Width<br>(ft) | Froude # Chl |
|------------------|-----------|----------|-----------------------------------|------------------|-------------------|-------------------|-------------------|-------------------|-----------------------|--------------------|----------------------|-------------------|--------------|
| Little Balsam Cr | 1400      | 100-Year | Existing Conditions               | 713.00           | 961.95            | 966.93            | 966.93            | 968.43            | 0.010005              | 11.53              | 114.48               | 43.77             | 0.95         |
| Little Balsam Cr | 1400      | 100-Year | Prop Conditions (Bench & Profile) | 713.00           | 961.95            | 966.93            | 966.93            | 968.43            | 0.010005              | 11.53              | 114.48               | 43.77             | 0.95         |
| Little Balsam Cr | 1360      | 100-Year | Existing Conditions               | 713.00           | 961.66            | 965.66            | 965.66            | 967.28            | 0.011180              | 10.55              | 82.61                | 29.92             | 0.97         |
| Little Balsam Cr | 1360      | 100-Year | Prop Conditions (Bench & Profile) | 713.00           | 961.66            | 965.66            | 965.66            | 967.28            | 0.011180              | 10.55              | 82.61                | 29.92             | 0.97         |
| Little Balsam Cr | 1300      | 100-Year | Existing Conditions               | 713.00           | 960.27            | 965.42            |                   | 965.85            | 0.002648              | 6.38               | 212.68               | 68.93             | 0.50         |
| Little Balsam Cr | 1300      | 100-Year | Prop Conditions (Bench & Profile) | 713.00           | 960.27            | 965.42            |                   | 965.85            | 0.002648              | 6.38               | 212.68               | 68.93             | 0.50         |
| Little Balsam Cr | 1255      | 100-Year | Existing Conditions               | 713.00           | 959.59            | 963.98            | 963.98            | 965.52            | 0.010338              | 11.31              | 107.99               | 42.41             | 0.96         |
| Little Balsam Cr | 1255      | 100-Year | Prop Conditions (Bench & Profile) | 713.00           | 959.59            | 963.98            | 963.98            | 965.52            | 0.010338              | 11.31              | 107.99               | 42.41             | 0.96         |
| Little Balsam Cr | 1200      | 100-Year | Existing Conditions               | 713.00           | 958.00            | 962.55            | 962.55            | 964.43            | 0.010530              | 11.42              | 78.64                | 24.86             | 0.96         |
| Little Balsam Cr | 1200      | 100-Year | Prop Conditions (Bench & Profile) | 713.00           | 958.50            | 962.47            | 962.47            | 963.82            | 0.011335              | 9.62               | 90.75                | 40.58             | 0.96         |
| Little Balsam Cr | 1150      | 100-Year | Existing Conditions               | 713.00           | 955.77            | 963.16            | 959.29            | 963.35            | 0.000612              | 3.76               | 250.37               | 48.06             | 0.25         |
| Little Balsam Cr | 1150      | 100-Year | Prop Conditions (Bench & Profile) | 713.00           | 957.50            | 961.40            | 961.38            | 962.75            | 0.011085              | 9.58               | 90.21                | 39.66             | 0.95         |
| Little Balsam Cr | 1120      | 100-Year | Existing Conditions               | 713.00           | 954.55            | 961.82            | 960.21            | 963.20            | 0.005100              | 9.54               | 88.59                | 19.96             | 0.64         |
| Little Balsam Cr | 1120      | 100-Year | Prop Conditions (Bench & Profile) | 713.00           | 956.50            | 961.67            |                   | 962.36            | 0.004206              | 7.01               | 137.60               | 50.40             | 0.61         |
| Little Balsam Cr | 1110      | 100-Year | Existing Conditions               | 713.00           | 954.24            | 961.84            | 959.67            | 963.08            | 0.004881              | 9.00               | 85.92                | 14.23             | 0.58         |
| Little Balsam Cr | 1110      | 100-Year | Prop Conditions (Bench & Profile) | 713.00           | 956.50            | 961.68            | 960.48            | 962.28            | 0.003475              | 6.60               | 148.61               | 52.31             | 0.56         |
| Little Balsam Cr | 1000      |          |                                   | Culvert          |                   |                   |                   |                   |                       |                    |                      |                   |              |
| Little Balsam Cr | 880       | 100-Year | Existing Conditions               | 713.00           | 950.00            | 954.69            | 954.69            | 956.96            | 0.011048              | 12.10              | 59.16                | 37.87             | 1.00         |
| Little Balsam Cr | 880       | 100-Year | Prop Conditions (Bench & Profile) | 713.00           | 951.58            | 954.49            | 954.49            | 955.34            | 0.015215              | 8.58               | 128.56               | 75.61             | 1.04         |
| Little Balsam Cr | 865       | 100-Year | Existing Conditions               | 713.00           | 949.76            | 954.28            | 954.25            | 955.84            | 0.012298              | 11.44              | 92.22                | 45.21             | 1.03         |
| Little Balsam Cr | 865       | 100-Year | Prop Conditions (Bench & Profile) | 713.00           | 951.25            | 953.90            | 953.90            | 954.72            | 0.016080              | 8.44               | 131.46               | 82.49             | 1.06         |
| Little Balsam Cr | 850       | 100-Year | Existing Conditions               | 713.00           | 949.50            | 954.15            | 954.15            | 955.62            | 0.010201              | 10.81              | 104.79               | 47.33             | 0.94         |
| Little Balsam Cr | 850       | 100-Year | Prop Conditions (Bench & Profile) | 713.00           | 950.92            | 953.60            | 953.60            | 954.45            | 0.016422              | 8.41               | 125.12               | 77.37             | 1.07         |
| Little Balsam Cr | 750       | 100-Year | Existing Conditions               | 713.00           | 947.04            | 952.21            | 951.20            | 953.15            | 0.004689              | 8.26               | 118.13               | 35.27             | 0.66         |
| Little Balsam Cr | 750       | 100-Year | Prop Conditions (Bench & Profile) | 713.00           | 947.47            | 951.81            | 951.28            | 952.78            | 0.006844              | 8.22               | 107.50               | 39.18             | 0.76         |
| Little Balsam Cr | 715       | 100-Year | Existing Conditions               | 713.00           | 946.74            | 951.23            | 951.23            | 952.85            | 0.010454              | 11.30              | 98.53                | 35.80             | 0.97         |
| Little Balsam Cr | 715       | 100-Year | Prop Conditions (Bench & Profile) | 713.00           | 947.16            | 951.12            | 951.12            | 952.44            | 0.011694              | 9.46               | 88.45                | 38.50             | 0.96         |
| Little Balsam Cr | 625       | 100-Year | Existing Conditions               | 713.00           | 944.83            | 948.26            | 948.26            | 949.32            | 0.010565              | 9.01               | 118.66               | 63.16             | 0.92         |
| Little Balsam Cr | 625       | 100-Year | Prop Conditions (Bench & Profile) | 713.00           | 944.83            | 948.26            | 948.26            | 949.32            | 0.010565              | 9.01               | 118.66               | 63.16             | 0.92         |
| Little Balsam Cr | 575       | 100-Year | Existing Conditions               | 713.00           | 943.37            | 947.98            |                   | 948.50            | 0.003914              | 7.04               | 183.70               | 61.56             | 0.59         |
| Little Balsam Cr | 575       | 100-Year | Prop Conditions (Bench & Profile) | 713.00           | 943.37            | 947.98            |                   | 948.50            | 0.003914              | 7.04               | 183.70               | 61.56             | 0.59         |
| Little Balsam Cr | 550       | 100-Year | Existing Conditions               | 713.00           | 943.00            | 947.36            | 946.97            | 948.32            | 0.007378              | 9.14               | 135.06               | 53.05             | 0.80         |
| Little Balsam Cr | 550       | 100-Year | Prop Conditions (Bench & Profile) | 713.00           | 943.00            | 947.36            | 946.97            | 948.32            | 0.007378              | 9.14               | 135.06               | 53.05             | 0.80         |
| Little Balsam Cr | 500       | 100-Year | Existing Conditions               | 713.00           | 942.44            | 946.62            | 946.62            | 947.87            | 0.009690              | 10.16              | 120.36               | 54.43             | 0.92         |
| Little Balsam Cr | 500       | 100-Year | Prop Conditions (Bench & Profile) | 713.00           | 942.44            | 946.62            | 946.62            | 947.87            | 0.009690              | 10.16              | 120.36               | 54.43             | 0.92         |



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|----------------|----------|
| JOB NO.        | NO. 181N |
| DRAWN BY       | JMD      |
| CHECKED BY     | ###      |
| DATE           | JAN 2022 |
| REVISIONS      |          |
| REFERENCE FILE | ###      |
| DRAWING FILE   | ###      |

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GANDY DANCER STATE TRAIL  
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