Conceptual Design for NE 93rd Street Culvert Replacement

December 31, 2010

Prepared for:

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APPENDICES

I. Background

Thornton Creek, including the Maple Creek tributary, is located within a highly urbanized watershed in northeast Seattle between Interstate 5 (I-5) and Lake Washington (see Appendix A for NE 93rd Street Culvert Existing Conditions Site Plan). The Thornton Creek watershed covers over 11 square miles beginning in the City of Shoreline, flowing south and southeast to the Matthews Beach area on Lake Washington. While most of the watershed is highly urbanized, comprised of mixed residential developments and large commercial properties, portions of the North and South Branches are buffered by a densely vegetated corridor. Due to its urban setting, the Thornton Creek system is flashy with large peaks associated with the urban runoff. The City of Seattle has undertaken a number of projects in the upstream basin to help reduce the flooding within the watershed and improve water quality.

Thornton Creek and Maple Creek cross a landscape that was created by repeated glaciations during the Pleistocene period extending from 12,000 to 2.5 million years before present. The most recent glaciation, referred to as the Vashon Stade of the Fraser Glaciation, ended about 13,500 years ago. These glaciations resulted in deposition of a complex sequence of massive to layered soil deposits referred to as recessional outwash, glacial till, advance outwash (Esperance Sand) and interglacial sediments. Recessional outwash, glacial till and advance outwash typically consist of mixtures of silt, sand and gravel. Most of the interglacial deposits are fine-grained consisting of silt and clay. Thornton Creek and Maple Creek have eroded through these deposits during the past 13,500 years to create the existing topographic conditions. These geologic and topographic conditions, along with urbanization of the overall watershed, are sensitive to erosion and landsliding because of the emergence of ground water onto steep slopes in the mid to lower elevations of the watershed, especially during the wet season (November through April). Several active and known landslide areas occur within the watershed. These landslides tend to be shallow debris flows (weathered soil zone failure usually less than 5-feet thick) which deliver sediment directly into Thornton Creek and Maple Creek.

The lower portion of the Thornton Creek watershed, including the confluence of Maple Creek at the NE 93rd Street Culvert site, is located in an area formerly occupied by the Lake Washington shoreline prior to the 9-foot lowering of the Lake Washington in the early 1900s during the construction of the Hiram M. Chittenden ship canal locks. For this reason, it is expected that the native soils that directly underlie the NE 93rd Street Culvert site are soft and compressible (soft silt and organic soils).

During the past 100 years, the NE 93rd Street Culvert site has experienced considerable surface modification by cuts and fills (typically fills) that have further modified the ground surface. Maple Creek, at this location, has been channelized through residential yard areas to the extent that the natural channel does not exist. Thornton Creek, especially in the area downstream of the NE 93rd Street Culvert, has been artificially channelized (concrete walls and rock walls). The lowering of the level of Lake Washington and creek channelization have combined to permanently change the gradients of these creeks which has related impacts to the natural sediment transport capabilities of these creeks. Flooding of these creeks is directly related to sedimentation of the channel where the gradient flattens appreciably. High flows during storm events transport some of this sediment to Lake Washington, but are not as effective as the natural system.

Thornton Creek at the NE 93rd Street Culvert is located adjacent to Matthews Beach Park approximately 1000-feet upstream of the confluence with Lake Washington. As previously described, this reach of Thornton Creek was most likely part of the Lake Washington shoreline and not an upland area prior to the construction of the Hiram M. Chittenden ship canal locks. Following the construction of the locks the lake level was lowered and this section of Thornton Creek was channelized in order to convey the flows to the lake. As the upstream area of the watershed developed, the flows began to exceed the capacity of the NE 93rd Street Culvert and the downstream channel, resulting in flooding during larger storm events. Due to the frequent flooding along Thornton Creek, Seattle Public Utilities (SPU) has undertaken a number of studies to look at the flows within Thornton Creek from a watershed perspective. The two most recent studies include the Thornton Creek H&H Modeling Technical Memorandum prepared by Entranco Engineers in January 2000 and the Flood Insurance Study for Thornton Creek and its Tributaries prepared by nhc in January 2010.

On December 3, 2007, the region experienced a significant rainfall event. The flows in Thornton Creek were measured at 395 cubic feet per second (cfs) which corresponded to a 50-year flood event or an event that has a 2 percent chance of being equaled or exceeded during any year. It was reported that 10 homes in this reach of Thornton Creek were significantly impacted by the flooding along with numerous roads. In addition to the frequent flooding in this reach, SPU staff has determined that the existing culvert under NE 93rd Street is beginning to show signs of structural fatigue.

II. Project Goals and Objectives

The team of Icicle Creek Engineers and PACE Engineers was retained by SPU to evaluate the modeling that had been completed previously along with available utility information in the area and develop a number of conceptual alternatives that would address the flooding and structural integrity of the NE 93rd Street Culvert. The following goals and objectives were jointly developed for this project.

1. Develop three conceptual design alternatives and preliminary cost estimates for the lower reaches of Thornton and Maple Creeks that address the flooding issue.

2. Address replacement/repair of the NE 93rd Street Thornton Creek Culvert.
   a. Maintain transportation functions.
   b. Provide full fish passage for all life stages and species of native salmonids.
   c. Pass flows beyond the 25-year event to meet drainage service levels.
   d. Minimize any flow constrictions that affect flooding conditions.

3. Improve stream, floodplain, riparian, and shoreline habitat.
    a. Ensure stream flows, stream channel configurations, gradient, and woody debris allow for proper sediment transport and minimize stream and culvert maintenance needs.
    b. Increase floodplain and stream capacity and natural floodplain and stream functions.
    c. Improve spawning and rearing conditions for native salmonids, with an emphasis on juvenile Chinook rearing habitat along the lake shoreline and in the creek.

4. Avoid negatively impacting use or access to Matthews Beach Park and private residences and identify opportunities to improve recreational amenities.
    a. Maintain public access to the park and lake shoreline.
    b. Maintain access to private residences.

5. Avoid modification of existing sewer and stormwater infrastructure to the maximum extent practicable.

The above-described structural integrity of the NE 93rd Street Culvert, the Thornton Creek and Maple Creek flooding, the in-stream sedimentation and impacts to pedestrian and vehicular access are all interconnected and should be addressed simultaneously.

III. Design Criteria

The following information was provided by SPU for use in the conceptual design:

- GIS data for the project area containing the following information:
    - Aerial image (2-foot contours)
    - Parcel information
    - Stream/ditch layer
    - Sewer layer
    - Storm layer
    - Utility nodes
- Flood Insurance Study for Thornton Creek
- Excerpts from the Thornton Creek H&H Modeling Technical Memorandum

In addition to the above information, PACE Engineers accessed their own GIS data files and searched the internet for any readily available information on Thornton Creek. The following information was included in our review:

- GIS water layer and electrical layer
- Flow data for USGS gage 12128000 at Thornton Creek
- Thornton Creek Five Year Action Agenda/Status
- Thornton Creek Watershed Characterization Report

Based upon our review of the existing information provided and our discussions with SPU staff, the following design criteria were established for this study:

- Limit flows in Thornton Creek Mainstem to the maximum channel capacity of Thornton Creek without overtopping.
- Minimize work on private property.
- Avoid significant utility relocation.
- No loss of parking stalls at Matthews Beach Park if possible.
- Pass at least the 25-year flow through the existing and proposed improvements.
- Improve in-stream and riparian habitat where possible.
- Design for seasonal lake level fluctuations.
- Consider subsurface soil conditions (compressible soils).
- Match existing road and driveway elevations.
- Follow Washington State Department of Fish and Wildlife (WDFW) design criteria.

In addition to the above design criteria, the following design parameters were established:

- 100–year flow in Thornton Creek 420 cfs.
- Maximum flow in Mainstem without flooding 260 ± cfs.
- Design flow for bypass system 160 ± cfs.
- Road grade at the NE 93rd Street Culvert Elevation 27 feet ± NAVD 88.
- Winter lake level (October to March) Elevation 17.57 feet NAVD 88.
- Maximum design water surface at NE 93rd Street Culvert Elevation 23 feet ± NAVD 88.
- Minimum water surface for high flow bypass at NE 93rd Street Culvert (approximately 2-year water surface) Elevation 19.8 feet ± NAVD 88.
- Maple Creek 100-year flow at the confluence Elevation 39 feet ± cfs.

This area received significant rainfall on Saturday, December 11, 2010, into Sunday morning, December 12, 2010. A preliminary analysis from SPU gauges estimate the rainfall at approximately a 25-year rainfall event for Thornton Creek Basin. The flows in lower Thornton Creek were estimated at approximately a 10-year flow event. PACE staff visited the site during the height of the storm and field verified that the above design criteria were appropriate (see Appendix F for photographs).

IV. Project Alternatives

Project representatives from Icicle Creek Engineers, PACE Engineers and SPU walked the site on October 25, 2010, to evaluate the site conditions and to begin discussing possible alternatives to address to the flooding issue. Following this field walk and review of available data, the following alternatives were presented to SPU on November 29, 2010, for consideration with a desired outcome of selecting three alternatives for further evaluation. The initial alternatives considered are listed below. All alternatives include a replacement of the culvert under NE 93rd Street. This culvert replacement is a key component of all the alternatives due to the evidence of structural damage and failure of the existing culvert. If this culvert were to fail it would create significant life safety issues since NE 93rd Street is the sole access in and out for ten residences.

Do Nothing

This alternative would keep Thornton Creek and Maple Creek as is. Flooding would continue as it currently exists. In addition to the flooding, the structural integrity of the NE 93rd Street Culvert would continue to deteriorate creating a potential life safety issue.

High Flow Bypass Pipe

This alternative would construct a high flow bypass pipe from the upstream side of the NE 93rd Street Culvert to Lake Washington. In order to pass 160 cfs with a downstream tailwater elevation of 17.57 feet (winter lake level) a 72-inch diameter pipe would be required (see Appendix C for calculations). The lack of cover over the pipe (in some locations the 72-inch diameter pipe would extend above the existing ground surface) and utility conflicts within the corridor make this alternative very difficult if not impossible to construct. Due to these factors this alternative was not selected by SPU and the project team for further evaluation.

Split Road with Center Channel / Median

The existing right-of-way along NE 93rd Street is 60-feet wide. This would allow enough room to construct a separate east and west bound lane with an overflow channel down the middle. This channel could be constructed as a vegetated swale that would convey the high flows from Thornton Creek. This channel could be in the range of 16-feet wide by 4- to 5-feet deep. A guardrail or railing would be needed due to depth of the channel and the side slopes required to fit the channel within the site. The downstream end of this channel would meander through the meadow portion of the Matthews Beach Park. This alternative would require a complete reconstruction of NE 93rd Street. This alternative was selected by SPU and the project team for further consideration.

Bypass Channel along North Shoulder

This alternative would construct a new overflow channel along the north shoulder of NE 93rd Street. The channel size would be similar to the above-described split road alternative. To make this cross section work a combination of the following items will need to be evaluated:

- Reduce the pavement width along NE 93rd Street.
- Shift the road section to south.
- Shift the Matthews Beach Park parking lot slightly to the north. This may require a small wall 3-to 5-feet high along the north edge of the parking lot.
- Relocate the existing utility poles or protect them in place along the north shoulder.

This alternative was selected by SPU and the project team for further consideration.

Bypass Channel along North Shoulder plus one-half of Roadway

This alternative is similar to Bypass Channel along the North Shoulder alternative described above except that that north half of the roadway would be slightly lowered to allow additional overflow down one-half of the roadway, leaving the south half of the roadway for access and emergency vehicles. The advantage of this alternative is the channel section could be reduced thereby eliminating the need to shift the parking lot to the north. The stability of the utility poles within the channel would still have to be addressed. This alternative was not selected by SPU and the project team for further consideration.

Increase Capacity of Existing Channel

This alternative would increase the capacity of the existing Thornton Creek channel by removing and/or raising obstructions and increasing the channel width through excavation and/or berming. This alternative would require easements from all downstream property owners and could possibly obligate the City of Seattle for future in-stream maintenance as well increase City of Seattle liability on private property. This alternative was selected by SPU and the project team for further consideration.

Split Roadway

This alternative would create a split roadway with the north and south lanes at different elevations. A landscape median would be used to transition the grade differential. In this alternative the north lane would be lowered approximately 4 feet. This lane would then be used to convey the flood flows down NE 93rd Street to the meadow portion of the park where it would enter a new bypass channel within the park. The south lane would be available for access and emergency vehicles during flood events. An alternative of this would be to place H20 load grating over the lowered channel and have both lanes at the same elevation (this grating is very expensive). Transitioning from the lowered north lane to the Matthews Beach Park parking lot and the upstream and downstream road sections would be difficult from a road geometry perspective. This alternative was not selected by SPU and the project team for further consideration.

Combination of the above Alternatives

It is highly likely that the selected alternative may include a combination or variation of the above alternatives.

V. Selected Alternatives

PACE Engineers conducted preliminary hydraulic calculations of the alternatives selected for further evaluation. These calculations are presented in Appendix C. The survey cross-sections that were used as a basis for the existing conditions analysis are presented in Appendix E. These cross-sections were surveyed by SPU in 2008. A summary of our selected alternatives are described below.

Thornton Creek

Alternative 1 – Bypass Channel along North Shoulder

The biggest technical challenge associated with this alternative is constructing a bypass channel of sufficient capacity that would avoid grade conflicts with the existing sewer line within NE 93rd Street but also be low enough to lower the 100-year water surface of Thornton Creek to prevent downstream flooding. In order to accomplish this, a very broad shallow channel is required. This channel could be constructed in the area between the NE 93rd Street Culvert and the west end of the Matthews Beach Park parking lot. This channel would cross over the sanitary sewer line. Once the channel crosses the sewer line it would be deepened and narrowed to a width that would fit between the north edge of NE 93rd Street and the south edge of the Matthews Beach Park parking lot (see Appendix B – Sheet 1). This channel would be approximately 20-feet wide by 5-feet deep at its deepest location. Once the channel reaches the meadow portion at the south end of Matthews Beach Park it would either be constructed as a new stream channel complete with in-stream habitat components and riparian vegetation that would meander through the park prior to discharging near the mouth of Thornton Creek or it could be constructed as a very broad and shallow grassed swale that would blend into the existing meadow and continue its passive recreational use. All components of this reach including aesthetics, in-stream and riparian habitat, and park use would be closely coordinated with the Seattle Parks Department and the WDFW. Depending on the alternative selected within the meadow there could be a significant cost differential. The area proposed for the new channel within the meadow is currently underwater during large rain events and would not significantly change the wetted area of the park.

In addition to the high flow bypass channel, a new box culvert would be constructed under NE 93rd Street. The existing culvert is approximately 96-inches deep by 90-inches wide based upon information provided by SPU. WDFW guidelines require the width of fish passable culverts to be a minimum 1.2 times the channel bank full width plus 2 feet. That would require the new culvert to be approximately 10.5-feet wide. We would also recommend the upstream end of the culvert to be rotated so that it crosses the road at a greater skew to better align the culvert with the upstream channel. Key elements of this alternative are listed below:

- The new bypass channel could be constructed with vegetation similar to the City's SEA Street projects and would provide water quality treatment in addition to flood control.
- Relocate approximately 180 feet of 8-inch diameter sewer line to create a perpendicular crossing.
- Concrete encasement of the relocated sewer line.
- Potential kayak drop off location adjacent to a new open water component near the existing mouth of Thornton Creek in the meadow potion of the park.
- Combined driveway for the Matthews Beach Sewer Pump Station and Matthews Beach Park.
- Two new culverts
    - one under NE 93rd Street designed to convey 260 cfs
    - one under the new bypass channel at the new park/pump station driveway that would convey 160 cfs
- Increase in available parking stalls at Matthews Beach Park.
- Protect the existing utility poles within the proposed channel or relocate out of the channel if not feasible.
- Preliminary sizing of the channel would not require relocating the Matthews Beach Park parking lot to the north. Minor restriping may be required.

Alternative 2 – Split Road with Center Channel / Median

The existing right-of-way along NE 93rd Street is 60-feet wide. This would allow enough room to construct a separate east and westbound lane with an overflow channel down the middle. This channel could be constructed as a vegetated swale similar to the City's SEA Street projects and would convey the high flows from Thornton Creek as well as provide water quality treatment from the road and potentially the Matthews Beach Park parking lot. This channel would be approximate 20-feet wide by 5-feet deep at its deepest location. A guardrail or railing would be needed due to space limitations in laying back the channel side slopes within the right-of-way. The existing 8-inch diameter sewer line within the 93rd Street right-of-way would be in conflict with the proposed channel. This would require relocating the sewer line to the north down the middle of the Matthews Beach Park parking lot. In addition, a new sewer line would be required along the south side of NE 93rd Street to serve the houses to the south. This alternative would also require a reconstruction of both the north and south lanes of NE 93rd Street (see Appendix B – Sheet 2).

Once the channel reaches the meadow portion at the south end of Matthews Beach Park it could either be constructed as a new stream channel complete with in-stream habitat components and riparian vegetation that would meander through the park prior to discharging near the mouth of Thornton Creek or it could be constructed as a very broad and shallow grassed swale that would blend into the existing meadow and continue its passive recreational use. All components of this reach including aesthetics, in-stream and riparian habitat, and park use would be closely coordinated with the Seattle Parks Department and the WDFW. Depending on the alternative selected within the meadow there could be a significant cost differential. The area proposed for the new channel within the meadow is currently underwater during large rain events and would not significantly change the wetted area of the park.

In addition to the high flow bypass channel, a new box culvert would be constructed under NE 93rd Street. The existing culvert is approximately 96-inches deep by 90-inches wide based upon information provided by SPU. WDFW guidelines require the width of fish passable culverts be a minimum 1.2 times the channel width plus 2 feet. That would require the new culvert to be approximately 10.5-feet wide. We would also recommend the upstream end of the culvert to be rotated so that is crosses the road at a greater skew to better align the culvert with the upstream channel. This new culvert would have an internal weir that would split the flows to the new overflow channel located between the north and south lanes of NE 93rd Street. The design of this element would need to be coordinated closely with WDFW and SPU maintenance. Key elements of this alternative are listed below:

- The new bypass channel could be constructed with vegetation similar to the City's SEA Streets to provide water quality treatment in addition to flood control.
- This alternative requires relocating the existing 8-inch diameter sewer line out of NE 93rd Street right-of-way plus a new sewer line on the south side of NE 93rd Street.
- Reconstruction of both travel lanes within NE 93rd Street.
- Potential kayak drop off location adjacent to a new open water component near the existing mouth of Thornton Creek in the meadow portion of the park.
- Combined driveway for the Matthews Beach Sewer Pump Station and Matthews Beach Park.
- Three new culverts
  - One under NE 93rd Street to convey Thornton Creek flows.
  - One downstream of the flow splitter to convey the high flows to the new bypass channel.
  - One at the intersection of NE 93rd Street and 51st Avenue NE to convey the flows into the Matthews Beach Park.
- Does not impact the existing utility poles along the north side of NE 93rd Street.

Alternative 3 - Increase Capacity of Existing Channel

Thornton Creek below NE 93rd Street is a channelized reach that was constructed when the lake was lowered after the construction of the ship canal locks. A portion of this reach is contained with a rock/concrete lined flume and the entire reach is lacking a floodplain that would convey high flows. In addition, the residents adjacent to the creek have placed a number of structures including decks, bridges and sheds within the stream corridor. Two options were evaluated for this alternative to increase capacity of Thornton Creek. The first option would be to construct a berm or set back levee to increase the channel capacity and pass the design flows for Thornton Creek without flooding. This option was rejected due to the fact that the low lying areas adjacent to the creek would not be able to drain if a levee or berm system was constructed.

The second option would be to increase the capacity by excavating a floodplain on both sides of the channel. The floodplain would be excavated at a water surface corresponding to the 2-year water surface elevation. Previous studies have shown this to be approximately 2 feet above the channel bottom. In order to convey the full 420 cfs, the top width of the floodplain would need to be approximately 35-feet wide. This floodplain width on each side of the channel may vary depending on existing structures and obstructions, but the overall width needs to be maintained (see Appendix B - Sheet 3).

In addition to the construction of a new floodplain channel, a new box culvert would be constructed under NE 93rd Street. The existing culvert is approximately 96-inches deep by 90-inches wide based upon information provided by SPU. WDFW guidelines require the width of fish passable culverts be a minimum 1.2 times the channel width plus 2 feet. That would require the new culvert to be approximately 10.5-feet wide. We would also recommend the upstream end of the culvert to be rotated so that is crosses the road at a greater skew to better align the culvert with the upstream channel. Key elements of this alternative are listed below:

- Excavation of a new floodplain channel on private property. This would require easements from all downstream property owners adjacent to the creek.
- Relocation and/or reconstruction of existing bridges, decks and sheds.
- Concrete walls to protect existing house foundations where the floodplain is close to the house.
- Agreements from the downstream property owners concerning maintenance of the new floodplain channel.
- More extensive permits and environmental coordination due to work within and adjacent to the Thornton Creek channel.

MAPLE CREEK

Maple Creek, a tributary to Thornton Creek, crosses Sand Point Way NE along the southern margin of NE 93rd Street. The creek parallels the road prior to flowing into Thornton Creek just below the NE 93rd Street Culvert. As previously described, this reach of Maple Creek has been completely modified by channelization through residential properties and at road (Sand Point Way NE) crossings. The channelization of Maple Creek upstream of the Sand Point Way NE crossing (pipe culvert) essentially eliminates natural sediment transport processes (all sediment is transported with no deposition), then at the downstream end of the Sand Point Way NE culvert the grade of the channel abruptly flattens resulting in a "basin" that accumulates sediment which requires ongoing maintenance from SPU to remove the sediment from this basin. In addition, this sedimentation decreases the capacity of the downstream channel contributing to the flooding to the two residences along NE 93rd Street west of Thornton Creek. The following alternatives described below will correct the flooding problem within the lower reach of Maple Creek.

Alternative A – Direction Drill near the Burke Gilman Trail

This alternative would divert the majority of the Maple Creek flow to Thornton Creek upstream of the Burke Gilman Trail (BGT) in a new pipe. Due to the depth of both Maple Creek and Thornton Creek below the BGT, a direction drill would be required. The slope of this pipe would be sufficient to keep the sediment in suspension to Thornton Creek where it would be conveyed by the high flows of Thornton Creek. A vault could be installed within the BGT to collect sediment. The effectiveness of the vault may be limited since it is believed that this sediment load in Maple Creek is insignificant to the overall sediment load within Thornton Creek. We expect that a control structure would be installed at the upstream end of the new culvert. This control structure would allow a base flow to be maintained in Maple Creek not only from an environmental perspective but also to maintain a water feature for the downstream properties. Mitigation would most likely be required by WDFW to put this reach of Maple Creek in a pipe (see Appendix B - Sheet 4).

Alternative B – New Pipe from Sand Point Way NE to Thornton Creek

This alternative would construct a new pipe from the downstream end of the culvert under Sand Point Way NE in a northeasterly direction to Thornton Creek. The grades would allow easy open excavation of this pipe to the Thornton Creek buffer. The slope of this pipe would be sufficient to keep the sediment in suspension to Thornton Creek where it would be conveyed by the high flows of Thornton Creek (see Appendix B – Sheet 4). We expect that the lower 200-feet of the Maple Creek channel would be eliminated. This would require mitigation for the loss of habitat by WDFW. We expect that there would be sufficient mitigation associated with the high flow bypass of Thornton Creek through the meadow portion of Matthews Beach Park.

Alternative C – New Channel or Pipe along Existing Alignment

This alternative would construct a new pipe or channel from the downstream end of the culvert under Sand Point Way NE along the existing Maple Creek alignment (see Appendix B – Sheet 4). The downstream drop within Maple Creek would be eliminated to allow sufficient grade to keep the sediment in suspension to Thornton Creek where it would be conveyed by the high flows of Thornton Creek. Any mitigation for the loss of habitat required by WDFW would be constructed within the high flow bypass of Thornton Creek through the meadow portion of Matthews Beach Park.

We have not been made aware of any reports of Maple Creek overtopping Sand Point Way NE at the upstream end of the culvert. If this were not the case, then the proposed improvements for Maple Creek in Alternatives A and B would include a new culvert crossing under Sand Point Way NE.

Comparison of Alternatives

Thornton Creek

H = High M = Medium L = Low	Impacts to Mathews Beach Park	Relocate Sanitary Sewer	Impacts to Private Property	Ease of Construction	Environmental Impacts	Impacts to Existing Utility Pole	Ongoing Maintenance
Alternative 1 – Bypass Channel along North Shoulder	M	M	L	H	L	H	L
Alternative 2 – Split Road with Center Channel/Median	M	H	L	M	M	L	M
Alternative 3 – Increase Capacity of Existing Channel	L	L	H	L	H	L	M

Maple Creek

H = High M = Medium L = Low	Environmental Impacts	Ease of Construction	Sediment Control	Easements Required
Alternative A – Direction Drill near the Burke Gilman Trail	M	L	M	L
Alternative B – New Pipe from Sand Point Way NE to Thornton Creek	L	M	M	L
Alternative C – New Channel or Pipe along Existing Alignment	M	H	M	M

Environmental/Permit Constraints

All alternatives for Thornton Creek and Maple Creek will require City of Seattle permits and State of Washington Environmental permits through the JARPA process. Those alternatives that construct new facilities within the Thornton Creek and/or Maple Creek channels will require more extensive environmental analysis and scrutiny through the permitting process and may require federal permits from the U.S. Army Corps of Engineers. All alternatives will require close coordination between Seattle Parks Department, SPU, WDFW and Seattle Department of Transportation.

VI. Project Costs

The following construction cost estimates are based upon the attached conceptual plans (see Appendix D for cost estimate details). The costs for right-of-way are not included. Sales tax has been included but may be omitted as part of Rule 121 depending on the selected alternative.

Thornton Creek

Alternative	Estimated Construction Cost
Alternative 1 – Bypass Channel along North Shoulder	$ 1,127,412
Alternative 2 – Split Road with Center Channel/Median	$ 1,503,216
Alternative 3 – Increase Capacity of Existing Channel	$ 674,027

Maple Creek

Alternative	Estimated Construction Cost
Alternative A – Direction Drill near the Burke Gilman Trail	$ 427,762
Alternative B – New Pipe from Sand Point Way NE to Thornton Creek	$ 36,655
Alternative C – New Channel or Pipe Along Existing Alignment	$ 44,698

VII. Recommended Alternative

Based upon a comparison of the design criteria, ease of construction, and total project costs, it appears that Thornton Creek Alternative 1 and Maple Creek Alternative B provide the most cost effective solutions. The final decision would need to be based upon further discussions with WDFW, SPU staff and the impacted property owners.

APPENDIX A:

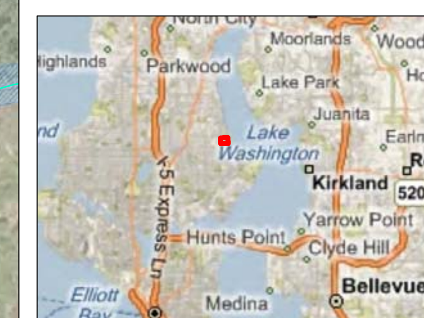
NE 93rd Street Culvert

Existing Conditions Site Plan

NE 93rd St Culvert - Existing Conditons Site Plan

Legend

- Manholes
- Sewer Main Line
- Water Main Line
- Culvert
- Stream
- Ditch
- Floodplain
- Parcel



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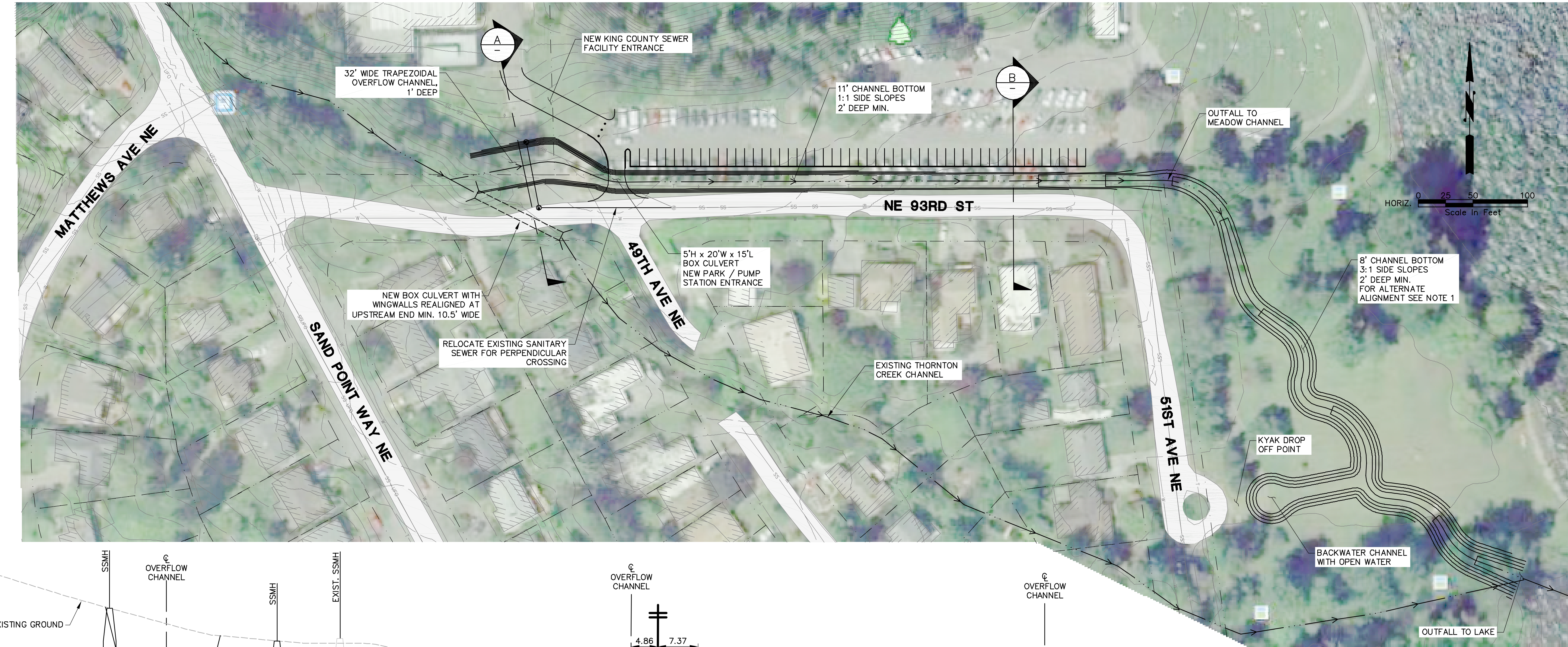
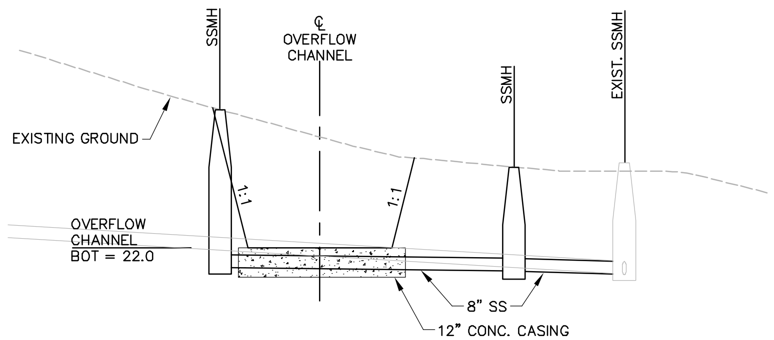
APPENDIX B:

NE 93rd Street Culvert

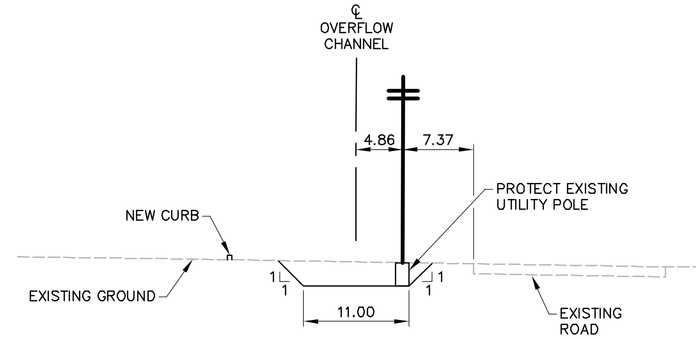
Conceptual Alternatives –

Thornton Creek and Maple Creek





SECTION A
N.T.S.



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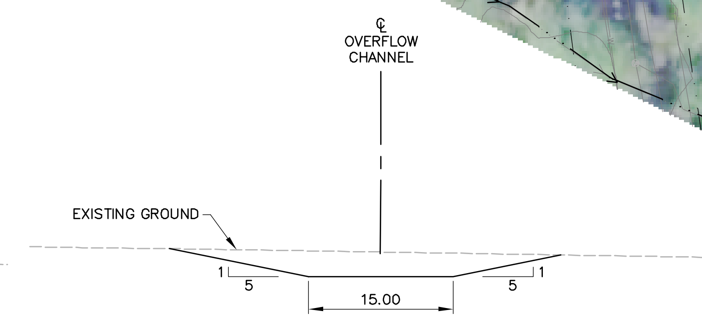
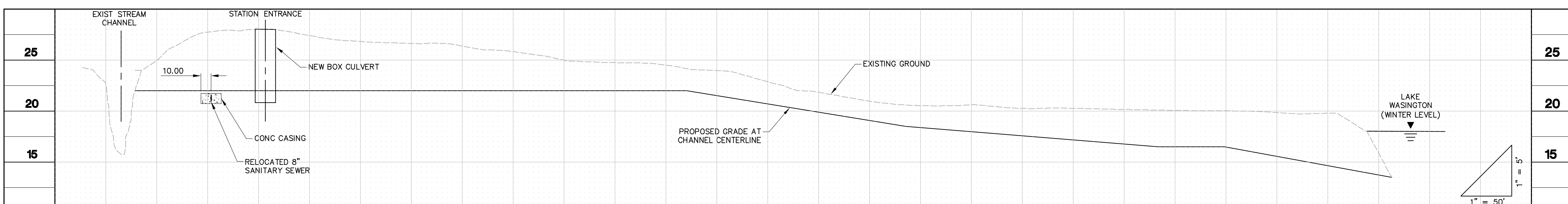


SECTION C (ALTERNTE SECTION)
N.T.S.

NOTES:

1. ALTERNATE ALIGNMENT CHANNEL 15' WIDE SWALE WITH 5:1 SIDE SLOPES, 2' DEEP INTEGRATED INTO OPEN MEADOW. SEE SECTION C.
2. DESIGN FLOW EXIST CHANNEL 260 CFS AND 160 CFS OVERFLOW CHANNEL (BASED ON 100 YR FLOWS FROM NHC STUDY).



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DRAWN	RDH
CHECKED	JER

SYM	REVISION	DATE	BY	APP'D

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Kirkland, WA 98033
p. 425.827.2014 | f. 425.827.5043
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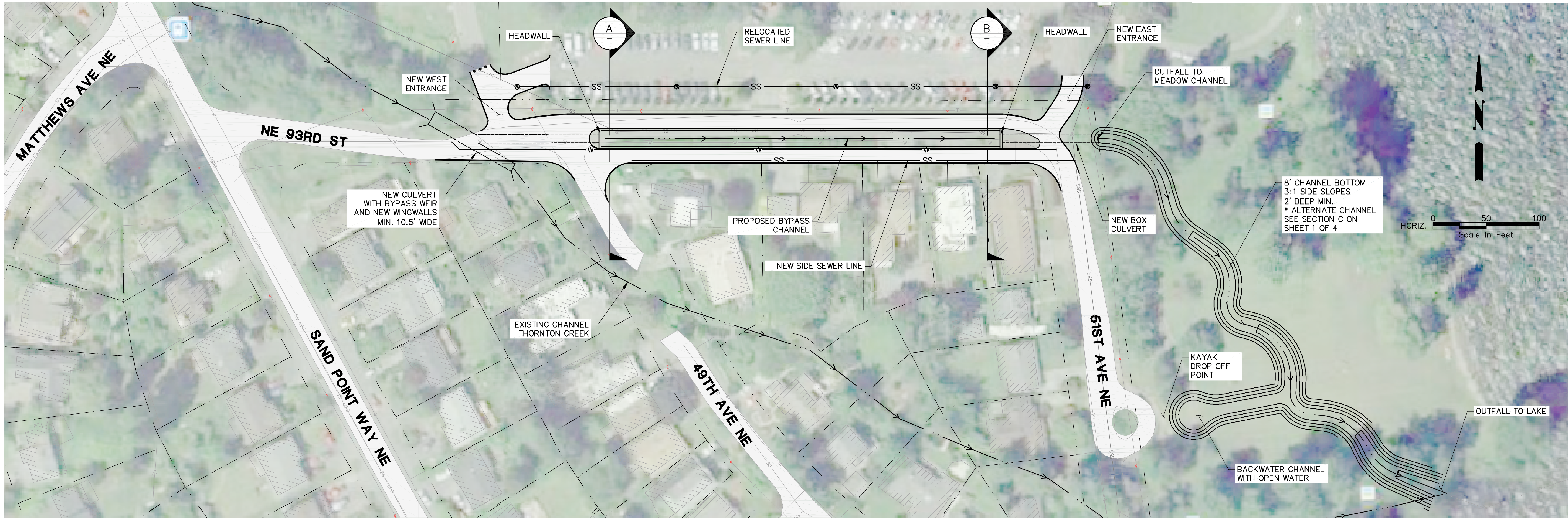
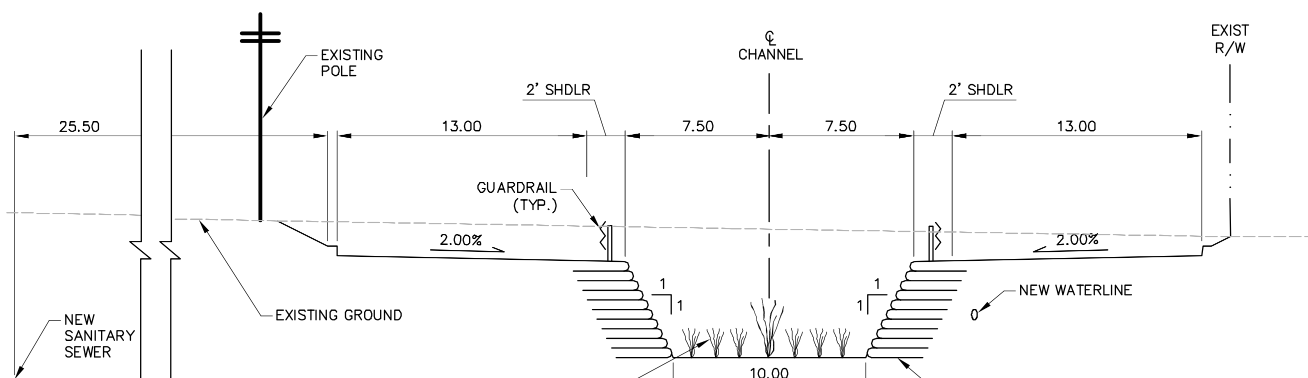
Seattle Public Utilities

DATE DEC. 2010
SCALE 1"=50'

NE 93RD ST CULVERT
THORNTON CREEK – ALTERNATIVE 1
BYPASS CHANNEL ALONG NORTH SHOULDER

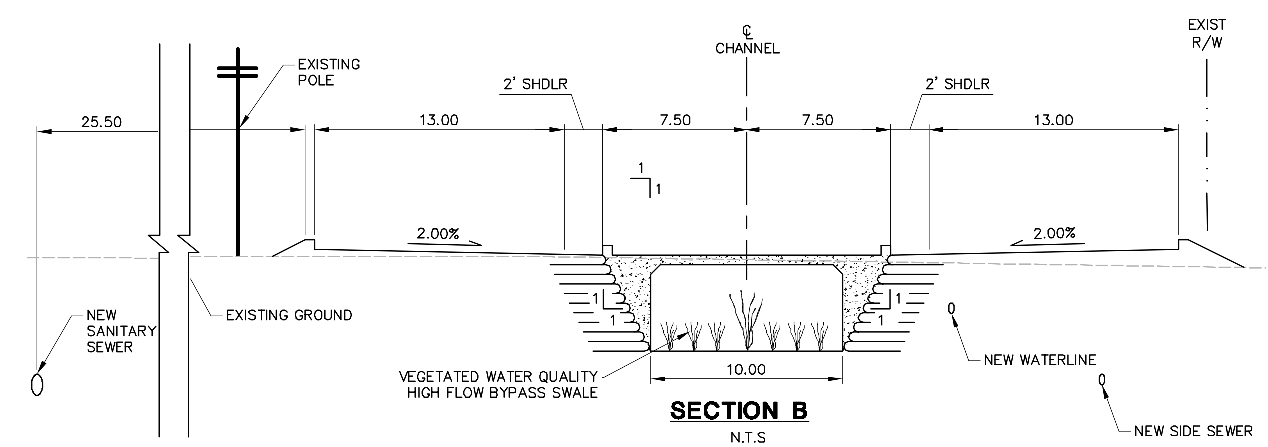
JOB NUMBER **10634.00**
DWG NAME: D10634_OPT01
SHEET 1 OF 4





SECTION A

N.T.S

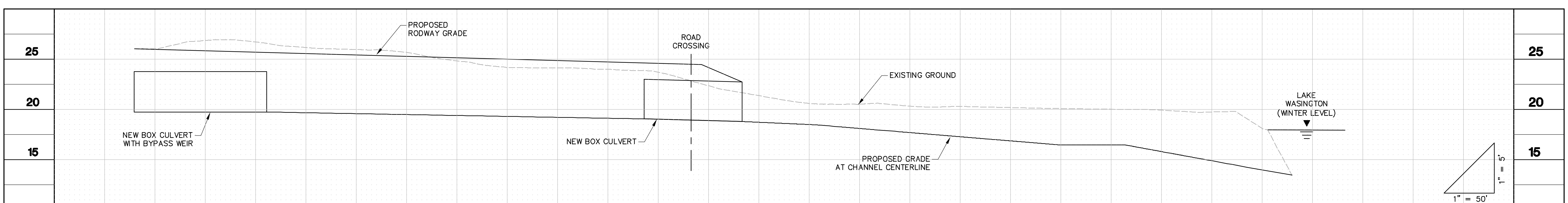


SECTION B

N.T.S

NOTES:

1. DESIGN FLOW EXIST CHANNEL 260 CFS AND 160 CFS OVERFLOW CHANNEL (BASED ON 100 YR FLOWS FROM NHC STUDY)



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PLOT TIME: 12/29/2010 6:30 PM
USER NAME: RICHARD HERMAN
XREF FILES: X10634_GIS_SRV, X10634_BDR

DESIGNED JER					
DRAWN RDH					
CHECKED JER					
SYM	REVISION	DATE	BY	APP'D	

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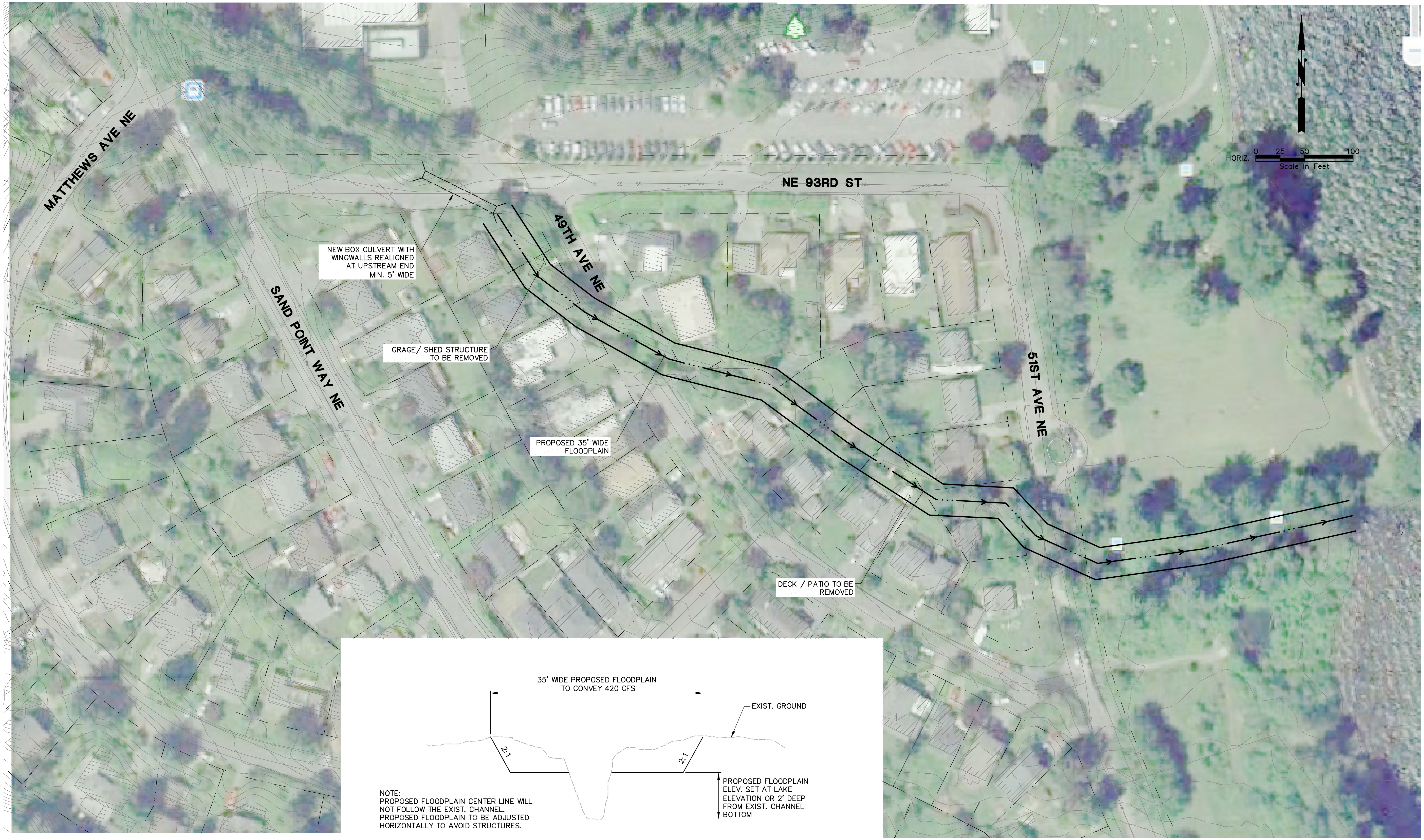
DATE DEC. 2010
SCALE 1"=50'

NE 93RD ST CULVERT
THORNTON CREEK – ALTERNATIVE 2
SPLIT ROAD WITH CENTER CHANNEL/MEDIAN

JOB NUMBER **10634.00**
DWG NAME: D10634_OPT02
SHEET 2 OF 4



NOTE:
PROPOSED FLOODPLAIN CENTER LINE WILL NOT FOLLOW THE EXIST. CHANNEL. PROPOSED FLOODPLAIN TO BE ADJUSTED HORIZONTALLY TO AVOID STRUCTURES.

TYPICAL CHANNEL X-SECTION

N.T.S.

FILE NAME: P:\P10\10634 93RD ST CULVERT\CAD\REFS\D10634_OPT03.DWG
SAVE TIME: 12/28/2010 3:15:56 PM
PLOT TIME: 12/29/2010 6:34 PM
USER NAME: RICHARD HERRMAN
XREF FILES: X10634_GIS_SRV, X10634_BDR,

DESIGNED JER					
DRAWN RDH					
CHECKED JER	SYM	REVISION	DATE	BY	APP'D

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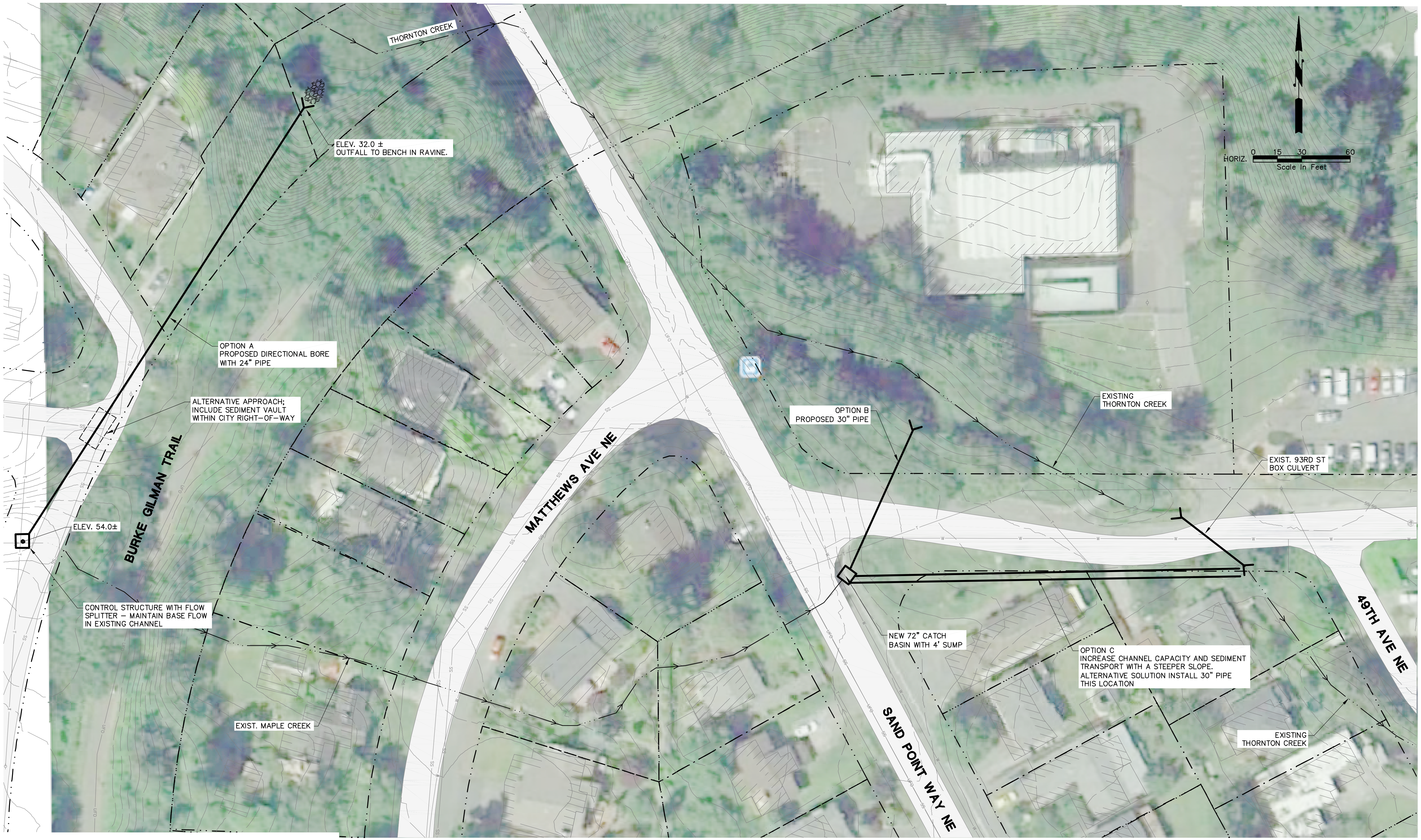
DATE DEC. 2010
SCALE 1"=50'

NE 93RD ST CULVERT
THORNTON CREEK – ALTERNATIVE 3
INCREASE CAPACITY OF EXISTING CHANNEL

JOB NUMBER 10634.00
DWG NAME: D10634_OPT03
SHEET 3 OF 4



NOTES:

1. DESIGN FLOW (100 YR EVENET) LOWER MAPLE CREEK 39 CFS FROM NHC STUDY.

FILE NAME: P:\P10\10634 93RD ST CULVERT\CAD\REFS\D10634_OPT04.DWG
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XREF FILES: X10634_GIS_SRV, X10634_BDR,

DESIGNED JER					
DRAWN RDH					
CHECKED JER					
	SYM	REVISION	DATE	BY	APP'D

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DATE: DEC. 2010
SCALE: 1"=30'

NE 93RD ST CULVERT

MAPLE CREEK – A, B & C ALTERNATIVES

JOB NUMBER: **10634.00**
DWG NAME: D10634_OPT04
SHEET 4 OF 4

APPENDIX C:

Hydraulic Calculations

BACKWATER CALCULATION OF A 72-INCH PIPE WITH A TAILWATER ELEVATION AT 17.56 FEET (WINTER LAKE ELEVATION)

```
BACKWATER COMPUTER PROGRAM FOR PIPES
     Pipe data from file:72in_OFP.bwp

     Using a broad-crested weir at intermediate junctions
       Individual CB's subject to surcharged condition
       should be simulated by raising the overflow elevation
       to an appropriate height above the rim elevation.
      Tailwater Elevation:17.56 feet
          Discharge Range:100. to 200. Step of 10. [cfs]
       Overflow Elevation:27.  feet
                     Weir:NONE
        Upstream Velocity:10. feet/sec
```

ROAD ELEVATION NEAR EXISTING NE 93RD STREET CULVERT

PIPE NO. 1: 900 LF - 72"CP @ 0.89% OUTLET: 12.00 INLET: 20.00 INTYP: 5 INLET DATA: KE=.50 K=.0098 M=2.0 C=.0398 Y=.67

Q(CFS)	HW(FT)	HW ELEV.	*	N-FAC	DC	DN	TW	DO	DE	HWO	HWI	*	DXN	VBH	VUH	EHU	VCH	VNH	VEH	VOH
100.00	2.70	22.70	*	0.012	2.70	1.97	5.56	5.56	2.70	*****	2.26	*	0.37	0.19	1.55	1.55	1.02	2.38	1.02	0.21
110.00	2.83	22.83	*	0.012	2.83	2.07	5.56	5.56	2.83	*****	2.49	*	0.32	0.24	1.55	1.55	1.09	2.52	1.09	0.25
120.00	2.97	22.97	*	0.012	2.97	2.17	5.56	5.56	2.97	*****	2.71	*	0.28	0.28	1.55	1.55	1.15	2.63	1.15	0.30
130.00	3.09	23.09	*	0.012	3.09	2.26	5.56	5.56	3.09	*****	2.94	*	0.24	0.33	1.55	1.55	1.22	2.77	1.22	0.35
140.00	3.21	23.21	*	0.012	3.21	2.35	5.56	5.56	3.21	*****	3.15	*	0.20	0.38	1.55	1.55	1.29	2.89	1.29	0.41
150.00	3.37	23.37	*	0.012	3.33	2.44	5.56	5.56	3.33	*****	3.37	*	0.16	0.44	1.55	1.55	1.35	3.00	1.35	0.47
160.00	3.59	23.59	*	0.012	3.45	2.53	5.56	5.56	3.45	*****	3.59	*	0.13	0.50	1.55	1.55	1.41	3.10	1.41	0.53
170.00	3.80	23.80	*	0.012	3.56	2.62	5.56	5.56	3.56	*****	3.80	*	0.10	0.56	1.55	1.55	1.47	3.19	1.47	0.60
180.00	4.02	24.02	*	0.012	3.67	2.70	5.56	5.56	3.67	*****	4.02	*	0.07	0.63	1.55	1.55	1.53	3.31	1.53	0.67
190.00	4.24	24.24	*	0.012	3.77	2.79	5.56	5.56	3.77	*****	4.24	*	0.04	0.70	1.55	1.55	1.60	3.38	1.60	0.75
200.00	4.45	24.45	*	0.012	3.87	2.87	5.56	5.56	3.87	*****	4.45	*	0.01	0.78	1.55	1.55	1.67	3.49	1.67	0.83

HIGH FLOW REQUIRED TO CONVEY IN OVERFLOW SYSTEM

MAXIMUM WATER SURFACE WITHOUT DOWNSTREAM FLOODING

BACKWATER CALCULATION OF A 48-INCH PIPE WITH A TAILWATER ELEVATION AT 17.56 FEET (WINTER LAKE ELEVATION)

```
BACKWATER COMPUTER PROGRAM FOR PIPES
     Pipe data from file:48in_OFP.bwp

     Using a broad-crested weir at intermediate junctions
       Individual CB's subject to surcharged condition
       should be simulated by raising the overflow elevation
       to an appropriate height above the rim elevation.
      Tailwater Elevation:17.56 feet
          Discharge Range:100. to 200. Step of 10. [cfs]
       Overflow Elevation:27.  feet
                     Weir:NONE
        Upstream Velocity:10. feet/sec
```

ROAD ELEVATION NEAR EXISTING NE 93RD STREET CULVERT

PIPE NO. 1: 900 LF - 48"CP @ 0.56% OUTLET: 16.00 INLET: 21.00 INTYP: 5 INLET DATA: KE=.50 K=.0098 M=2.0 C=.0398 Y=.67

Q(CFS)	HW(FT)	HW ELEV.	*	N-FAC	DC	DN	TW	DO	DE	HWO	HWI	*	DXN	VBH	VUH	EHU	VCH	VNH	VEH	VOH
100.00	3.60	24.60	*	0.012	3.04	2.87	1.56	2.87	3.04	*****	3.60	*	0.00	0.98	1.55	1.55	1.48	1.67	1.48	1.67
110.00	4.16	25.16	*	0.012	3.18	3.11	1.56	3.11	3.18	*****	4.16	*	0.00	1.19	1.55	1.55	1.64	1.71	1.64	1.71
120.00	4.74	25.74	*	0.012	3.30	3.42	1.56	3.30	3.42	4.43	4.74	*	0.07	1.42	1.55	1.55	1.82	1.71	1.71	1.82
130.00	5.78	26.78	*	0.012	3.42	4.00	1.56	3.42	4.84	5.78	5.37	*	0.22	1.66	1.55	1.55	2.01	1.66	1.66	2.01
OVERFLOW ENCOUNTERED AT 140.00 CFS DISCHARGE																				
140.00	7.08	28.08	*	0.012	3.52	4.00	1.56	3.52	5.74	7.08	6.05	*	0.10	1.93	1.55	1.55	2.22	1.93	1.93	2.22
150.00	8.49	29.49	*	0.012	3.60	4.00	1.56	3.60	6.72	8.49	6.78	*	0.05	2.22	1.55	1.55	2.47	2.22	2.22	2.47
160.00	10.01	31.01	*	0.012	3.67	4.00	1.56	3.67	7.78	10.01	7.57	*	0.03	2.52	1.55	1.55	2.73	2.52	2.52	2.73
170.00	11.63	32.63	*	0.012	3.73	4.00	1.56	3.73	8.92	11.63	8.40	*	0.02	2.85	1.55	1.55	3.02	2.85	2.85	3.02
180.00	13.39	34.39	*	0.012	3.78	4.00	1.56	3.78	10.16	13.39	9.28	*	0.01	3.19	1.55	1.55	3.33	3.19	3.19	3.33
190.00	15.26	36.26	*	0.012	3.82	4.00	1.56	3.82	11.48	15.26	10.21	*	0.01	3.55	1.55	1.55	3.67	3.55	3.55	3.67
200.00	17.23	38.23	*	0.012	3.85	4.00	1.56	3.85	12.88	17.23	11.20	*	0.01	3.94	1.55	1.55	4.04	3.94	3.94	4.04

HIGH FLOW REQUIRED TO CONVEY IN OVERFLOW SYSTEM

DEPTH TO BOTTOM WIDTH COMPARISON FOR BYPASS CHANNEL NORTH OF NE 93RD STREET ALTERNATIVE 1

Rating Table for Trapezoidal Channel

Project Description	
Project File	c:\haestead\academic\fmw\10634.fm2
Worksheet	Trap. Bypass Channel
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Bottom Width

Constant Data		
Mannings Coefficient	0.030	
Channel Slope	0.010000 ft/ft	
Left Side Slope	1.000000 H : V	
Right Side Slope	1.000000 H : V	
Discharge	160.00	cfs

Input Data	Minimum	Maximum	Increment
Depth	1.00	3.00	0.25 ft

Rating Table

Depth (ft)	Bottom Width (ft)	Velocity (ft/s)	
1.00	32.47	4.78	PROPOSED BOTTOM WIDTH CROSSING SEWER LINE
1.25	22.43	5.41	
1.50	16.56	5.91	
1.75	12.77	6.30	
2.00	10.13	6.60	PROPOSED BOTTOM WIDTH PAST SEWER LINE
2.25	8.19	6.81	
2.50	6.68	6.97	
2.75	5.48	7.07	
3.00	4.47	7.14	

TRAPEZOIDAL BYPASS CHANNEL NORTH OF NE 93RD STREET
ALTERNATIVE 1
1:1 Side Slope @ 160 CFS

Worksheet for Trapezoidal Channel

Project Description	
Project File	c:\haestead\academic\fmw\10634.fm2
Worksheet	Trap. Bypass Channel
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Bottom Width

Input Data		
Mannings Coefficient	0.030	
Channel Slope	0.010000	ft/ft
Depth	3.00	ft
Left Side Slope	1.000000	H : V
Right Side Slope	1.000000	H : V
Discharge	160.00	cfs

Results		
Bottom Width	4.47	ft
Flow Area	22.42	ft²
Wetted Perimeter	12.96	ft
Top Width	10.47	ft
Critical Depth	2.76	ft
Critical Slope	0.013706	ft/ft
Velocity	7.14	ft/s
Velocity Head	0.79	ft
Specific Energy	3.79	ft
Froude Number	0.86	
Flow is subcritical.		

DEPTH TO BOTTOM WIDTH COMPARISON
FOR BYPASS CHANNEL DOWN CENTER OF NE 93RD STREET
ALTERNATIVE 2

Rating Table for Rectangular Channel

Project Description	
Project File	c:\haestead\academic\fmw\10634.fm2
Worksheet	Vert. Wall Bypass Channel
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Bottom Width

Constant Data		
Mannings Coefficient	0.030	
Channel Slope	0.010000	ft/ft
Discharge	160.00	cfs

Input Data	Minimum	Maximum	Increment
Depth	1.00	3.00	0.25 ft

Rating Table

Depth (ft)	Bottom Width (ft)	Velocity (ft/s)
1.00	33.57	4.77
1.25	23.80	5.38
1.50	18.19	5.86
1.75	14.66	6.24
2.00	12.28	6.52
2.25	10.59	6.72
2.50	9.34	6.85
2.75	8.38	6.94
3.00	7.62	7.00

PROPOSED BOTTOM WIDTH

VERTICAL WALL BYPASS CHANNEL
DOWN CENTER OF NE 93RD STREET
ALTERNATIVE 2

Vert Wall Channel @ 160 cfs
Worksheet for Rectangular Channel

Project Description	
Project File	c:\haestead\academic\fmw\10634.fm2
Worksheet	Vert. Wall Bypass Channel
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Bottom Width

Input Data		
Mannings Coefficient	0.030	
Channel Slope	0.010000	ft/ft
Depth	3.00	ft
Discharge	160.00	cfs

Results		
Bottom Width	7.62	ft
Flow Area	22.87	ft^2
Wetted Perimeter	13.62	ft
Top Width	7.62	ft
Critical Depth	2.39	ft
Critical Slope	0.018774	ft/ft
Velocity	7.00	ft/s
Velocity Head	0.76	ft
Specific Energy	3.76	ft
Froude Number	0.71	
Flow is subcritical.		

DEPTH TO BOTTOM WIDTH COMPARISON FOR DEEP CHANNEL WITHIN MEADOW AREA SHOWN IN ALTERNATIVES 1 AND 2

Rating Table for Trapezoidal Channel

Project Description	
Project File	c:\haestead\academic\fmw\10634.fm2
Worksheet	Deep Bypass Channel in Park
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Bottom Width

Constant Data	
Mannings Coefficient	0.030
Channel Slope	0.010000 ft/ft
Left Side Slope	3.000000 H : V
Right Side Slope	3.000000 H : V
Discharge	160.00 cfs

Input Data	Minimum	Maximum	Increment
Depth	1.00	3.00	0.10 ft

Rating Table

Depth (ft)	Bottom Width (ft)	Velocity (ft/s)
1.00	31.36	4.66
1.10	26.47	4.89
1.20	22.60	5.09
1.30	19.46	5.27
1.40	16.86	5.43
1.50	14.67	5.56
1.60	12.80	5.68
1.70	11.17	5.78
1.80	9.74	5.87
1.90	8.47	5.94
2.00	7.33	6.00
2.10	6.29	6.05
2.20	5.34	6.09
2.30	4.46	6.12
2.40	3.64	6.15
2.50	2.88	6.16
2.60	2.16	6.18
2.70	1.49	6.18
2.80	0.84	6.18

PROPOSED DEPTH FOR STREAM CHANNEL IN MEADOW

DEEP CHANNEL WITHIN MEADOW AREA (WHERE APPLICABLE)
SHOWN IN ALTERNATIVES 1 AND 2

Deep Bypass Channel in Park @ 160CFS

Worksheet for Trapezoidal Channel

Project Description	
Project File	c:\haestead\academic\fmw\10634.fm2
Worksheet	Deep Bypass Channel in Park
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Bottom Width

Input Data		
Mannings Coefficient	0.030	
Channel Slope	0.010000	ft/ft
Depth	2.00	ft
Left Side Slope	3.000000	H : V
Right Side Slope	3.000000	H : V
Discharge	160.00	cfs

Results		
Bottom Width	7.33	ft
Flow Area	26.65	ft^2
Wetted Perimeter	19.98	ft
Top Width	19.33	ft
Critical Depth	1.89	ft
Critical Slope	0.012493	ft/ft
Velocity	6.00	ft/s
Velocity Head	0.56	ft
Specific Energy	2.56	ft
Froude Number	0.90	
Flow is subcritical.		

DEPTH TO BOTTOM WIDTH COMPARISON FOR SHALLOW WIDE CHANNEL WITHIN MEADOW AREA SHOWN IN ALTERNATIVES 1 AND 2

Rating Table for Trapezoidal Channel

Project Description	
Project File	c:\haestead\academic\fmw\10634.fm2
Worksheet	Shallow Bypass Channel in Park
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Bottom Width

Constant Data		
Mannings Coefficient	0.030	
Channel Slope	0.010000 ft/ft	
Left Side Slope	5.000000 H : V	
Right Side Slope	5.000000 H : V	
Discharge	160.00	cfs

Input Data	Minimum	Maximum	Increment
Depth	1.00	2.50	0.10 ft

Rating Table

Depth (ft)	Bottom Width (ft)	Velocity (ft/s)	
1.00	30.39	4.52	
1.10	25.36	4.71	
1.20	21.34	4.88	
1.30	18.03	5.02	
1.40	15.26	5.13	← **PROPOSED DEPTH FOR GRASS SWALE IN MEADOW**
1.50	12.89	5.23	
1.60	10.83	5.31	
1.70	9.02	5.37	
1.80	7.39	5.42	
1.90	5.92	5.46	
2.00	4.57	5.49	
2.10	3.33	5.51	
2.20	2.17	5.52	
2.30	1.08	5.53	

SHALLOW WIDE CHANNEL WITHIN MEADOW AREA
SHOWN IN ALTERNATIVES 1 AND 2

Shallow Park Overflow Channel @ 160 CFS
Worksheet for Trapezoidal Channel

Project Description	
Project File	c:\haestead\academic\fmw\10634.fm2
Worksheet	Shallow Bypass Channel in Park
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Bottom Width

Input Data		
Mannings Coefficient	0.030	
Channel Slope	0.010000	ft/ft
Depth	2.00	ft
Left Side Slope	5.000000	H : V
Right Side Slope	5.000000	H : V
Discharge	160.00	cfs

Results		
Bottom Width	4.57	ft
Flow Area	29.14	ft^2
Wetted Perimeter	24.97	ft
Top Width	24.57	ft
Critical Depth	1.89	ft
Critical Slope	0.012860	ft/ft
Velocity	5.49	ft/s
Velocity Head	0.47	ft
Specific Energy	2.47	ft
Froude Number	0.89	
Flow is subcritical.		

DEPTH TO BOTTOM WIDTH COMPARISON FOR HIGH FLOW CHANNEL
UPGRADE TO EXISTING FLUME WITHIN BACKYARDS
ALTERNATIVE 3

Rating Table for Trapezoidal Channel

DESIGN FLOW 450 CFS
LOW FLOW CHANNEL 70 CFS
FLOODPLAIN FLOW 380 CFS

Project Description	
Project File	c:\haestead\academic\fmw\10634.fm2
Worksheet	Backyard Creek Upgrade
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Constant Data		
Mannings Coefficient	0.030	
Channel Slope	0.010000 ft/ft	
Left Side Slope	1.000000 H : V	
Right Side Slope	1.000000 H : V	
Discharge	380.00	cfs

Input Data	Minimum	Maximum	Increment
Bottom Width	15.00	35.00	1.00 ft

Rating Table

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	
15.00	2.66	8.09	
16.00	2.56	7.98	
17.00	2.47	7.88	
18.00	2.39	7.79	
19.00	2.32	7.69	
20.00	2.25	7.59	
21.00	2.18	7.50	
22.00	2.13	7.41	
23.00	2.07	7.32	
24.00	2.02	7.24	
25.00	1.97	7.16	
26.00	1.92	7.08	
27.00	1.88	7.00	
28.00	1.84	6.92	
29.00	1.80	6.85	
30.00	1.76	6.78	← **DEPTH OF FLOODPLAIN EXCAVATION**
31.00	1.73	6.71	
32.00	1.70	6.65	
33.00	1.67	6.58	
34.00	1.64	6.52	
35.00	1.61	6.46	

HIGH FLOW CHANNEL SIZING FOR EXISTING FLUME UPGRADE WITHIN BACKYARDS—ALTERNATIVE 3

30' Bottom Width @ 380 CFS

Worksheet for Trapezoidal Channel

Project Description	
Project File	c:\haestead\academic\fmw\10634.fm2
Worksheet	Backyard Creek Upgrade
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Channel Slope	0.010000 ft/ft	
Left Side Slope	1.000000 H : V	
Right Side Slope	1.000000 H : V	
Bottom Width	30.00	ft
Discharge	380.00	cfs

Results		
Depth	1.76	ft
Flow Area	56.04	ft²
Wetted Perimeter	34.99	ft
Top Width	33.53	ft
Critical Depth	1.68	ft
Critical Slope	0.011860 ft/ft	
Velocity	6.78	ft/s
Velocity Head	0.71	ft
Specific Energy	2.48	ft
Froude Number	0.92	
Flow is subcritical.		

APPENDIX D:

Cost Estimates

ENGINEER'S SUMMARY OF QUANTITIES & COSTS

Seattle Public Utilities **Prepared by : SCM**

NE 93rd Street Culvert Replacement - THORNTON CREEK ALTERNATIVE 1 **December 31, 2010**

ITEM NO.	SPEC SECTION	DESCRIPTION	PLAN QUANTITY	UNIT	UNIT PRICE	COST
1		Mobilization	1	LS	$80,000.00	$80,000
2		Contractor Supplied Surveying and Staking	1	LS	$5,000.00	$5,000
3		Erosion Control Measures	1	LS	$8,000.00	$8,000
5		SPU 8" Sewer Relocation	1	LS	$22,000.00	$22,000
6		93rd Trapiziodal Channel Excavation *	1	LS	$45,000.00	$45,000
7		Box Culverts (2 Total)	1	LS	$200,000.00	$200,000
8		Park Channel Excavation *	1	LS	$105,000.00	$105,000
9		Asphalt Concrete Paving	1	LS	$6,000.00	$6,000
10		North Channel w/ Wall (Fully Landscape & No LWD)	1	LS	$125,000.00	$125,000
11		Meadow Stream **	1	LS	$196,000.00	$196,000

Subtotal:	$792,000
Contingency (30%):	$237,600
Sales Tax (9.5%)	$97,812
Total:	**$1,127,412**

* Includes haul-off of excavated material
** 40' Riparian Corridor fully landscaped with 20 habitat structures per 100'

ENGINEER'S SUMMARY OF QUANTITIES & COSTS

Seattle Public Utilities **Prepared by : SCM**

NE 93rd Street Culvert Replacement - THORNTON CREEK ALTERNATIVE 2 **December 31, 2010**

ITEM NO.	SPEC SECTION	DESCRIPTION	PLAN QUANTITY	UNIT	UNIT PRICE	COST
1		Mobilization	1	LS	$105,000.00	$105,000
2		Contractor Supplied Surveying and Staking	1	LS	$8,000.00	$8,000
3		Erosion Control Measures	1	LS	$12,000.00	$12,000
4		SPU 8" Sewer Relocation and Side Sewer Laterals	1	LS	$115,000.00	$115,000
5		8" Water Main Relocation (incl. 4 services)	1	LS	$80,000.00	$80,000
6		93rd Trapiziodal Channel Excavation *	1	LS	$60,000.00	$60,000
7		Box Culverts (3 Total)	1	LS	$425,000.00	$425,000
8		Park Channel Excavation *	1	LS	$105,000.00	$105,000
9		Asphalt Concrete Paving	1	LS	$46,000.00	$46,000
10		Center Channel with Wall (Fully Landscape & No LWD)	1	LS	$100,000.00	$100,000
11		Meadow Stream **	1	LS	$196,000.00	$196,000

Subtotal:	$1,056,000
Contingency (30%):	$316,800
Sales Tax (9.5%)	$130,416
Total:	**$1,503,216**

* Includes haul-off of excavated material, removal of ex. utilities

** 40' Riparian Corridor with 20 habitat structures per 100'

ENGINEER'S SUMMARY OF QUANTITIES & COSTS

Seattle Public Utilities **Prepared by : SCM**

NE 93rd Street Culvert Replacement - THORNTON CREEK ALTERNATIVE 3 **December 31, 2010**

ITEM NO.	SPEC SECTION	DESCRIPTION	PLAN QUANTITY	UNIT	UNIT PRICE	COST
1		Mobilization	1	LS	$47,000.00	$47,000
2		Contractor Supplied Surveying and Staking	1	LS	$4,000.00	$4,000
3		Erosion Control Measures	1	LS	$20,000.00	$20,000
5		Ex. Structure Removal/Foundation Support/Pedestrian Bridges	1	LS	$100,000.00	$100,000
6		Thornton Creek Expansion Excavation	1	LS	$110,000.00	$110,000
7		Box Culvert (1 Total)	1	LS	$132,500.00	$132,500
10		Backyard Channel Final Landscaping w/ No LWD	1	LS	$60,000.00	$60,000

Subtotal:	$473,500
Contingency (30%):	$142,050
Sales Tax (9.5%)	$58,477
Total:	**$674,027**

Note: Costs do not include right-of-way or easement acquisition

ENGINEER'S SUMMARY OF QUANTITIES & COSTS

Seattle Public Utilities **Prepared by : SCM**

NE 93rd Street Culvert Replacement - Maple Creek ALTERNATIVE A **December 31, 2010**

ITEM NO.	SPEC SECTION	DESCRIPTION	PLAN QUANTITY	UNIT	UNIT PRICE	COST
1		Mobilization	1	LS	$30,000.00	$30,000
2		Contractor Supplied Surveying and Staking	1	LS	$1,000.00	$1,000
3		Erosion Control Measures	1	LS	$1,000.00	$1,000
4		24" HDPE DR 9 Directional Bore	380	LF	$700.00	$266,000
5		Final Landscaping	1	LS	$2,500.00	$2,500

Subtotal:	$300,500
Contingency (30%):	$90,150
Sales Tax (9.5%)	$37,112
Total:	**$427,762**

ENGINEER'S SUMMARY OF QUANTITIES & COSTS

Seattle Public Utilities **Prepared by : SCM**

NE 93rd Street Culvert Replacement - Maple Creek ALTERNATIVE B **December 31, 2010**

ITEM NO.	SPEC SECTION	DESCRIPTION	PLAN QUANTITY	UNIT	UNIT PRICE	COST
1		Mobilization	1	LS	$2,600.00	$2,600
2		Contractor Supplied Surveying and Staking	1	LS	$1,000.00	$1,000
3		Erosion Control Measures	1	LS	$2,000.00	$2,000
4		24" LCPE Pipe/Culvert	110	LF	$65.00	$7,150
5		72" Catch Basin w/ 4' Deep Sump	1	EA	$10,000.00	$10,000
6		Asphalt Conc. Paving	1	LS	$500.00	$500
7		Final Landscaping	1	LS	$2,500.00	$2,500

Subtotal:	$25,750
Contingency (30%):	$7,725
Sales Tax (9.5%)	$3,180
Total:	**$36,655**

ENGINEER'S SUMMARY OF QUANTITIES & COSTS

Seattle Public Utilities — **Prepared by : SCM**

NE 93rd Street Culvert Replacement - Maple Creek ALTERNATIVE C — **December 31, 2010**

ITEM NO.	SPEC SECTION	DESCRIPTION	PLAN QUANTITY	UNIT	UNIT PRICE	COST
1		Mobilization	1	LS	$3,100.00	$3,100
2		Contractor Supplied Surveying and Staking	1	LS	$1,000.00	$1,000
3		Erosion Control Measures	1	LS	$2,000.00	$2,000
4		24" LCPE Pipe/Culvert	220	LF	$65.00	$14,300
5		72" Catch Basin w/ 4' Deep Sump	1	EA	$10,000.00	$10,000
6		Final Landscaping	1	LS	$1,000.00	$1,000

Subtotal:	$31,400
Contingency (30%):	$9,420
Sales Tax (9.5%)	$3,878
Total:	**$44,698**

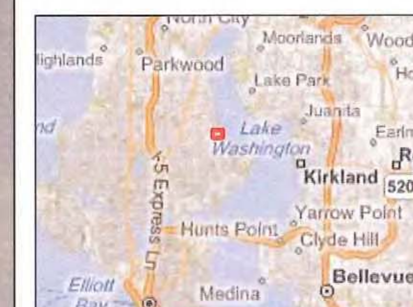
APPENDIX E:

FEMA Map and Cross-Sections

NE 93rd Street FEMA Cross-Sections

Legend

- Cross Section
- Manholes
- Sewer Main Line
- Water Main Line
- Culvert
- Stream
- Ditch
- Floodplain
- Parcel



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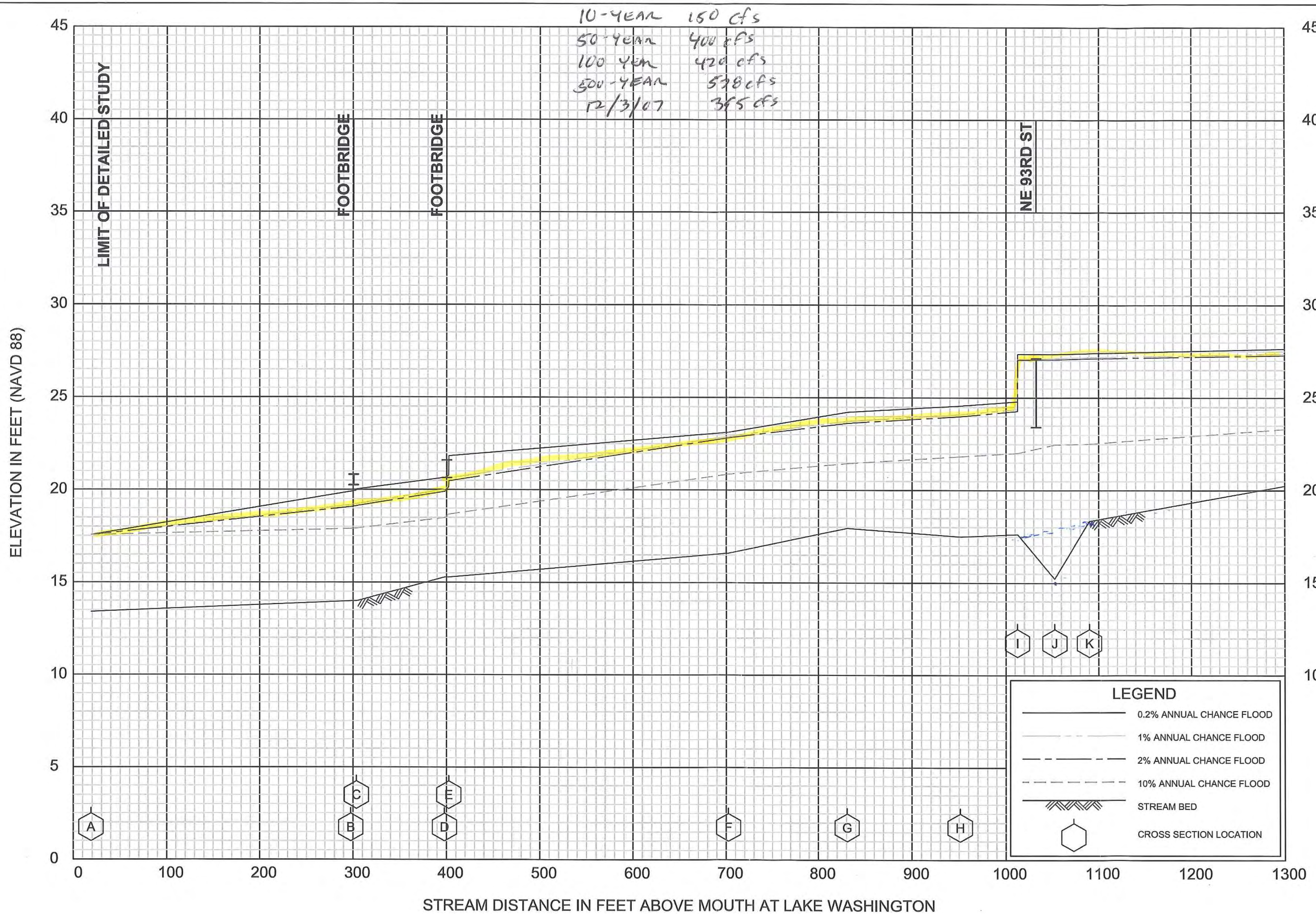
PACE
An Engineering Services Company



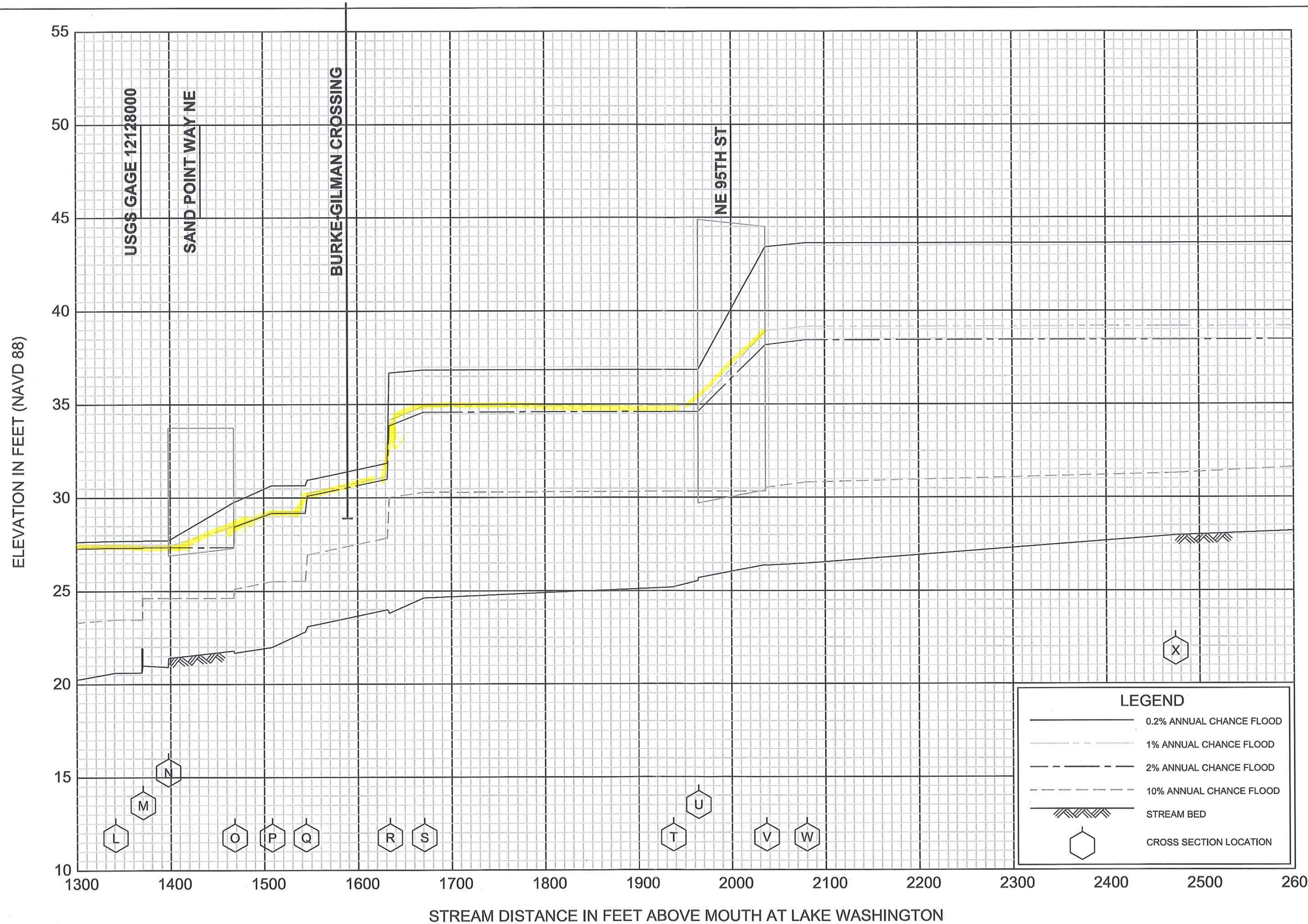
FLOOD PROFILES

THORNTON CREEK MAINSTEM

FEDERAL EMERGENCY MANAGEMENT AGENCY

KING COUNTY, WA

& INCORPORATED AREAS

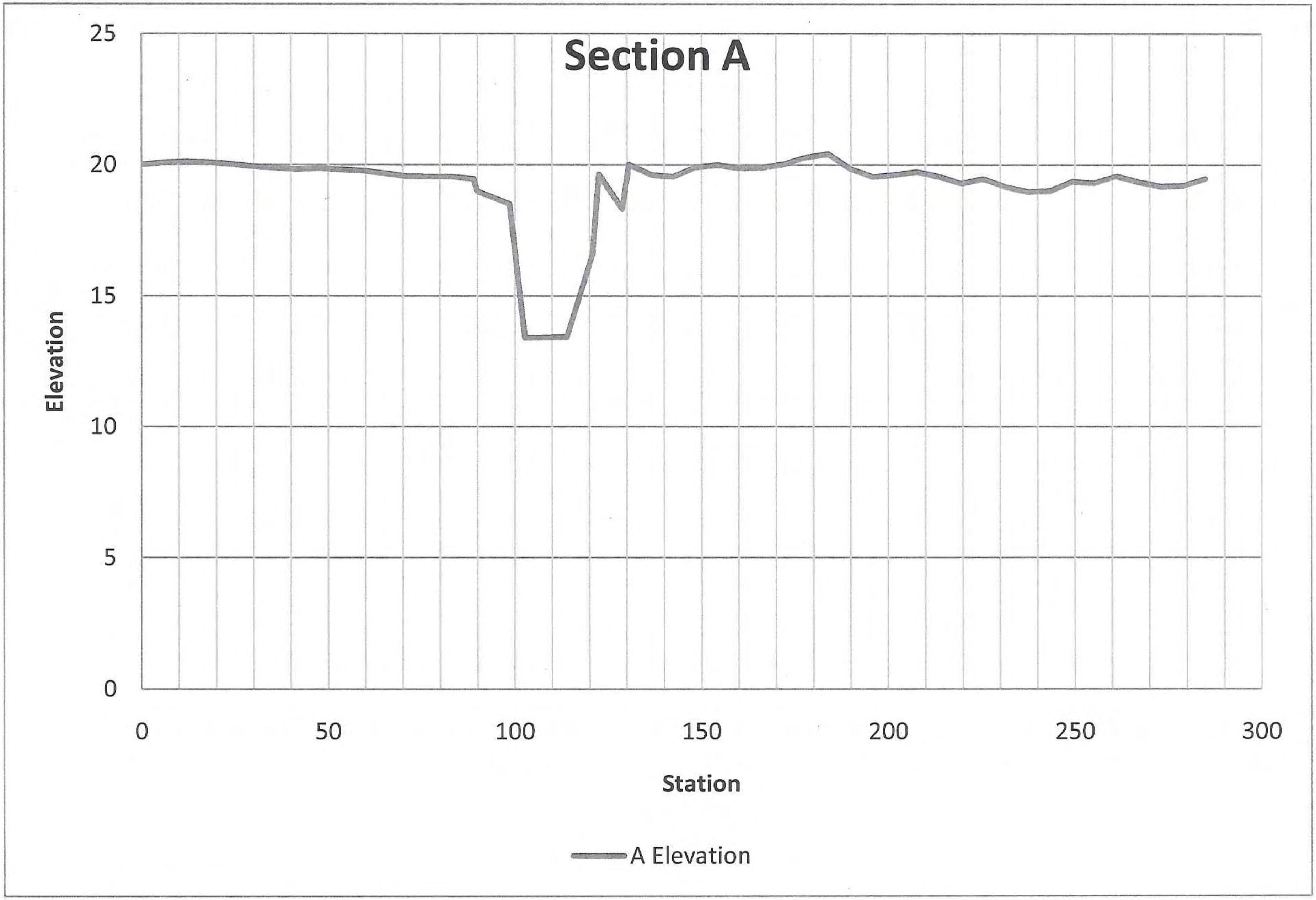


FLOOD PROFILES

THORNTON CREEK MAINSTEM

FEDERAL EMERGENCY MANAGEMENT AGENCY

KING COUNTY, WA
& INCORPORATED AREAS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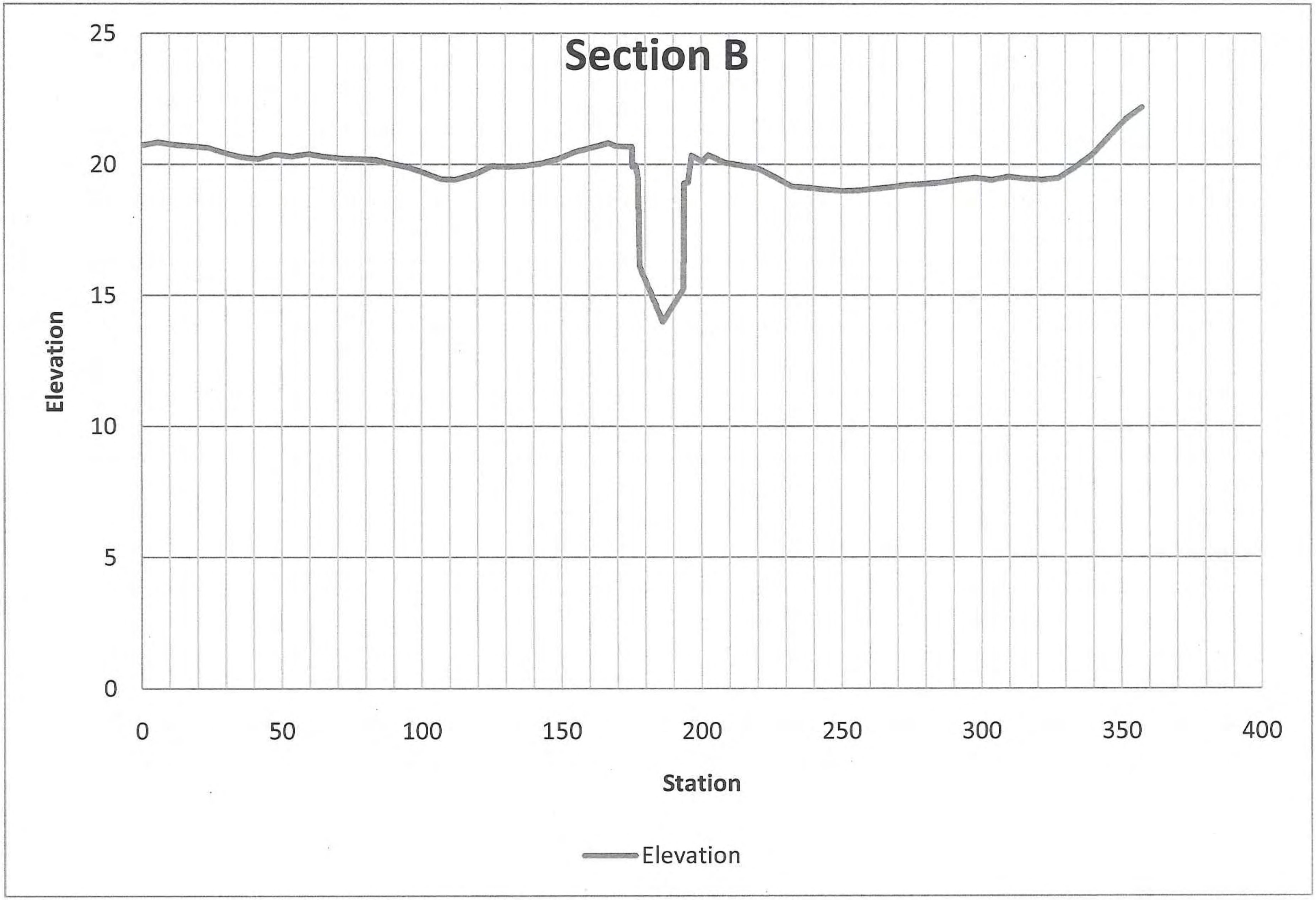
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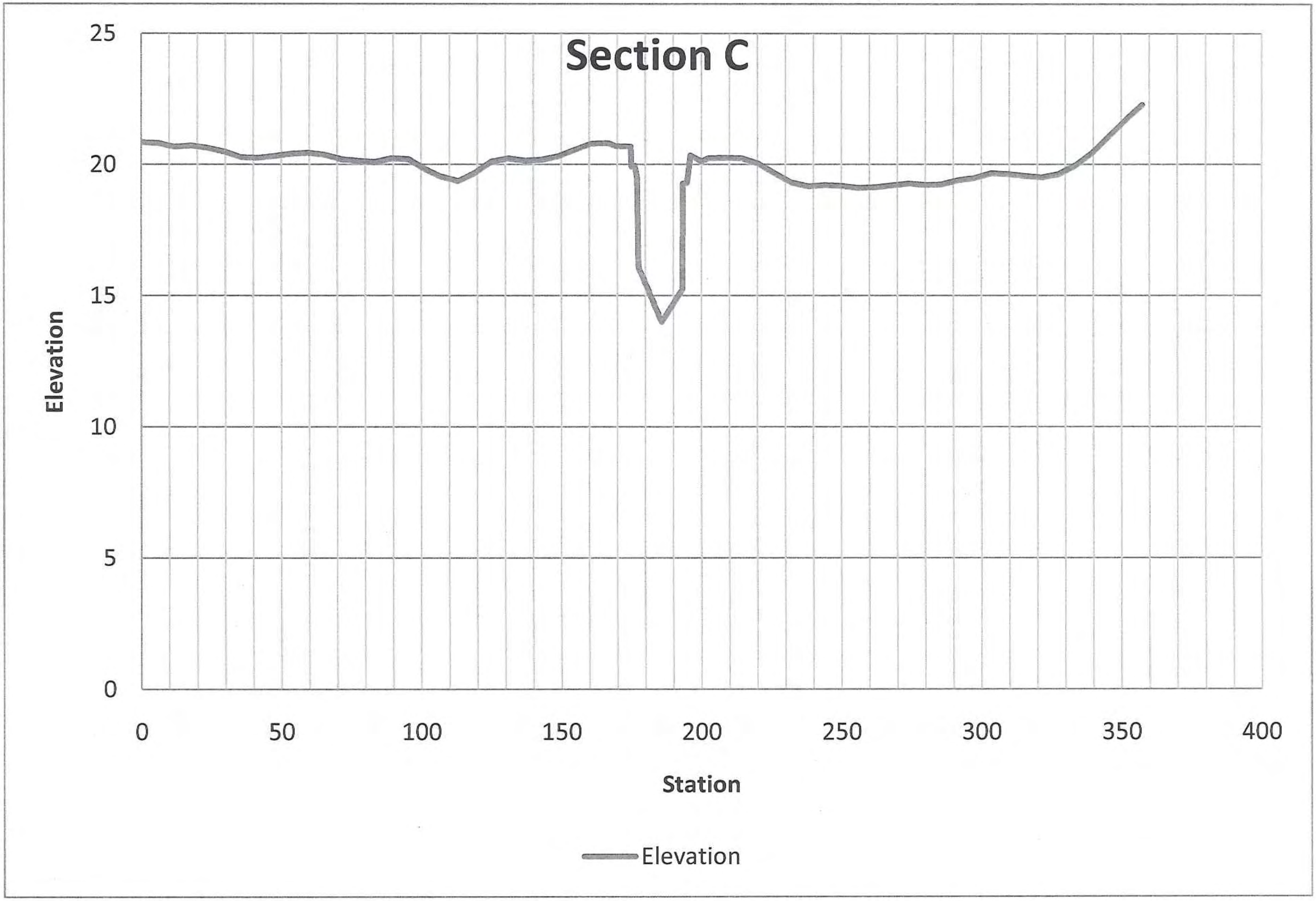

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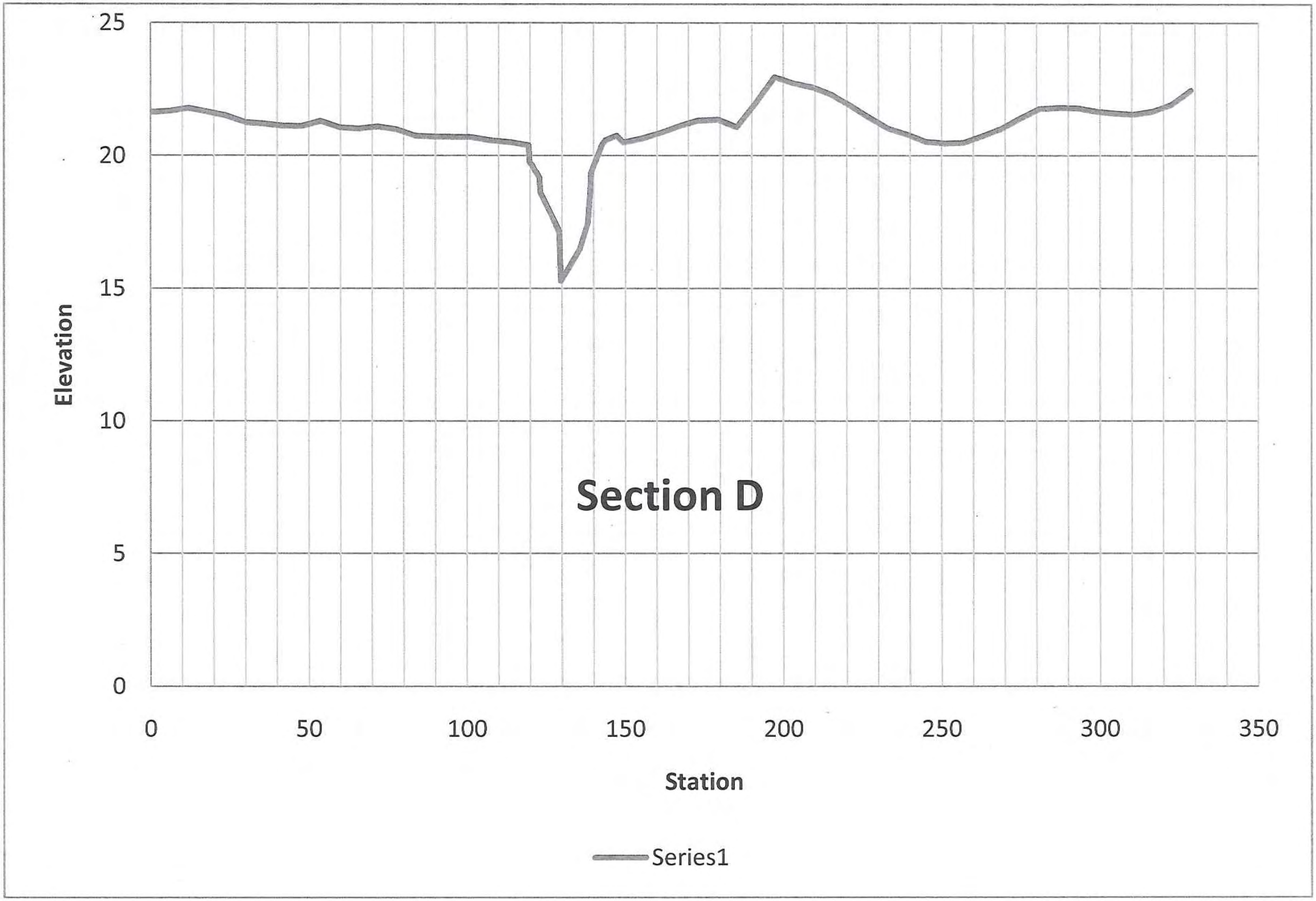

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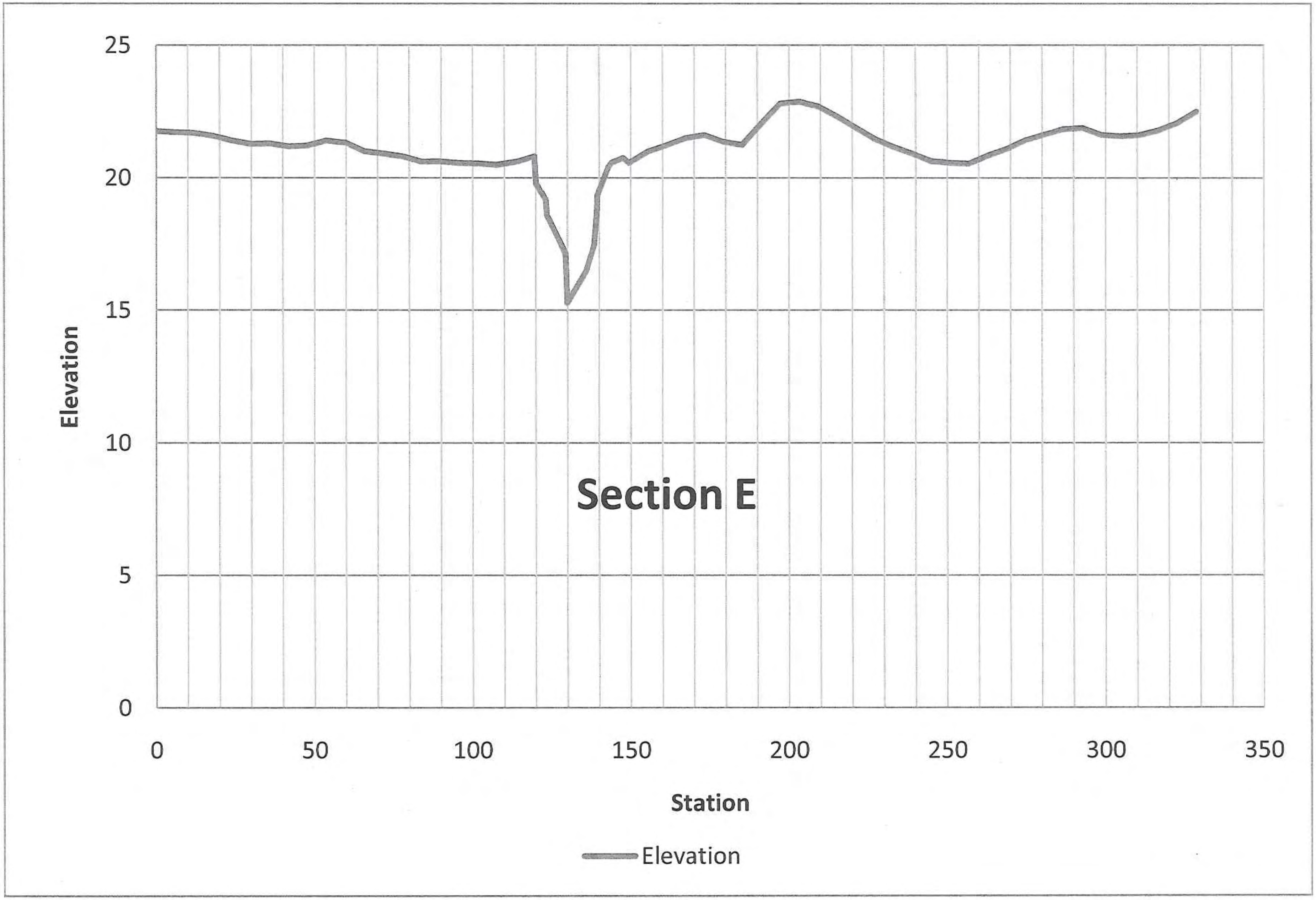
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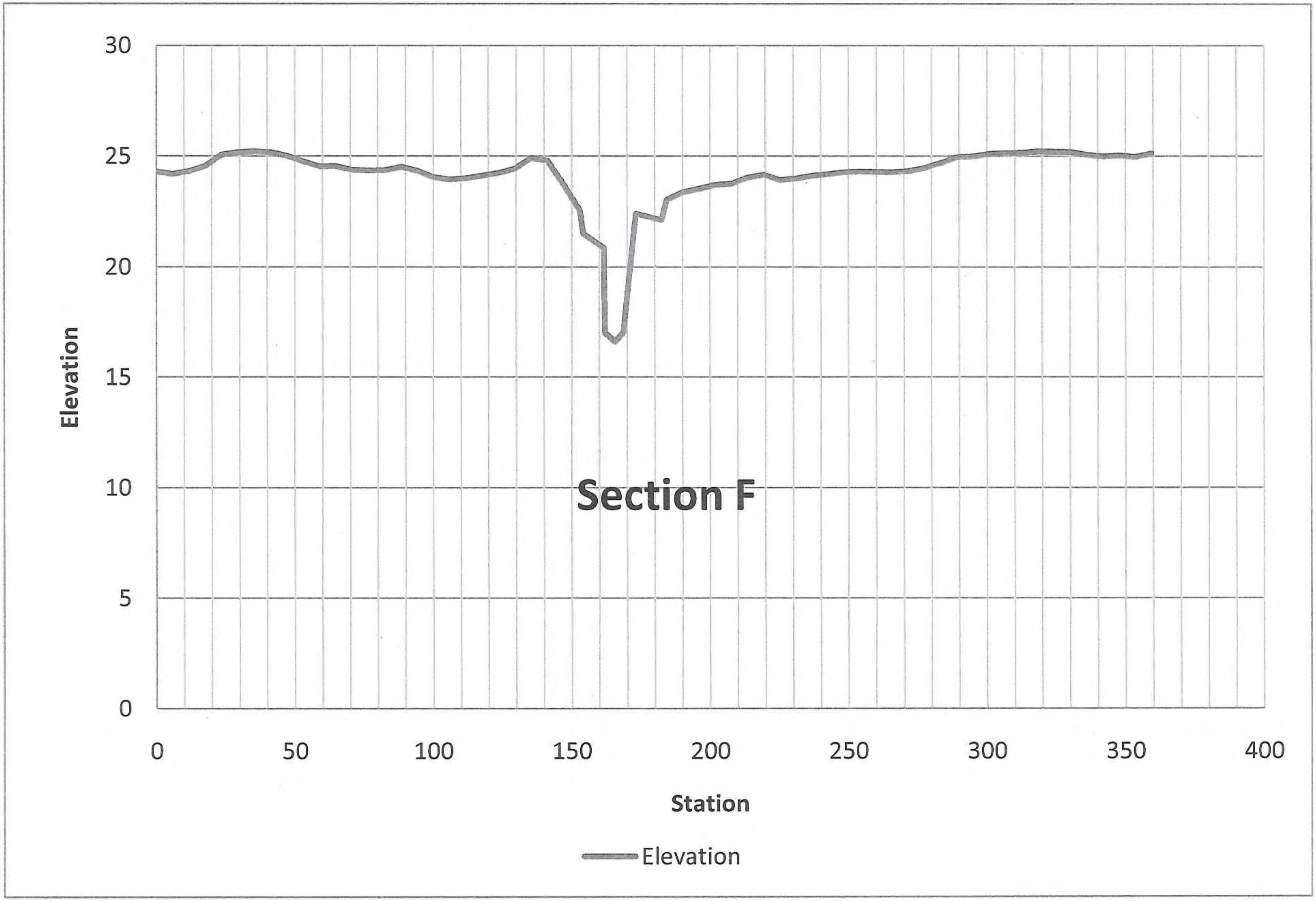

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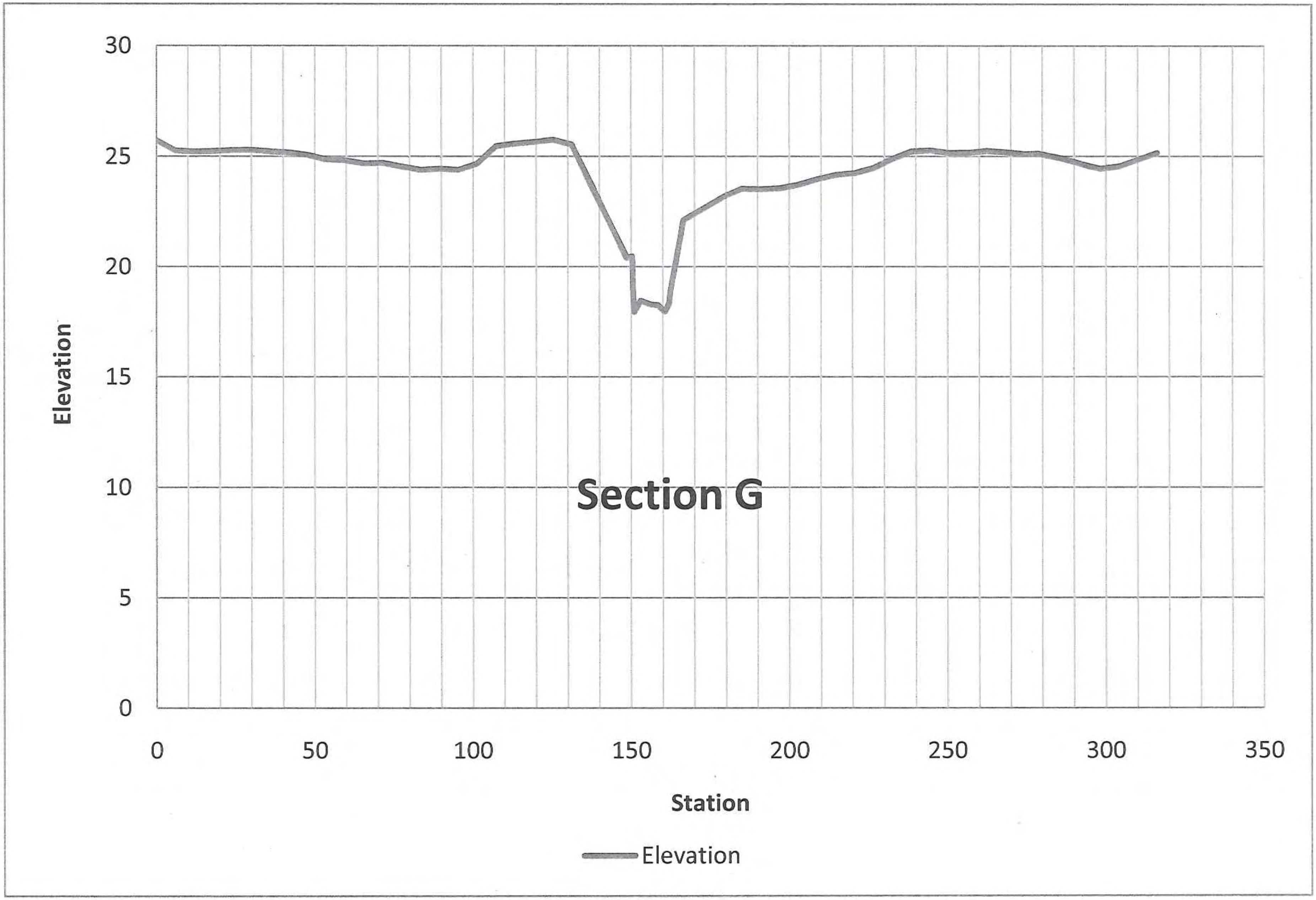

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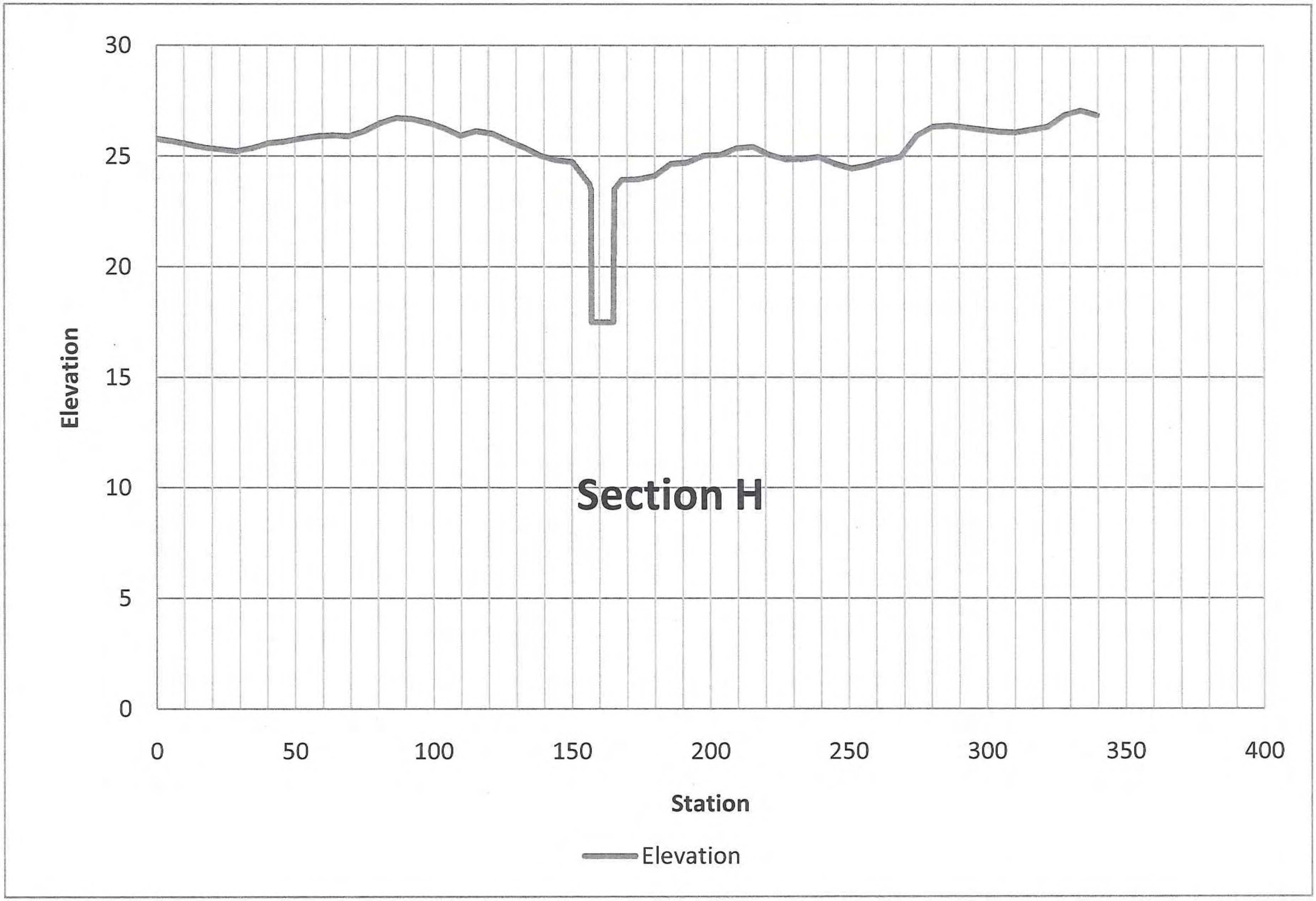
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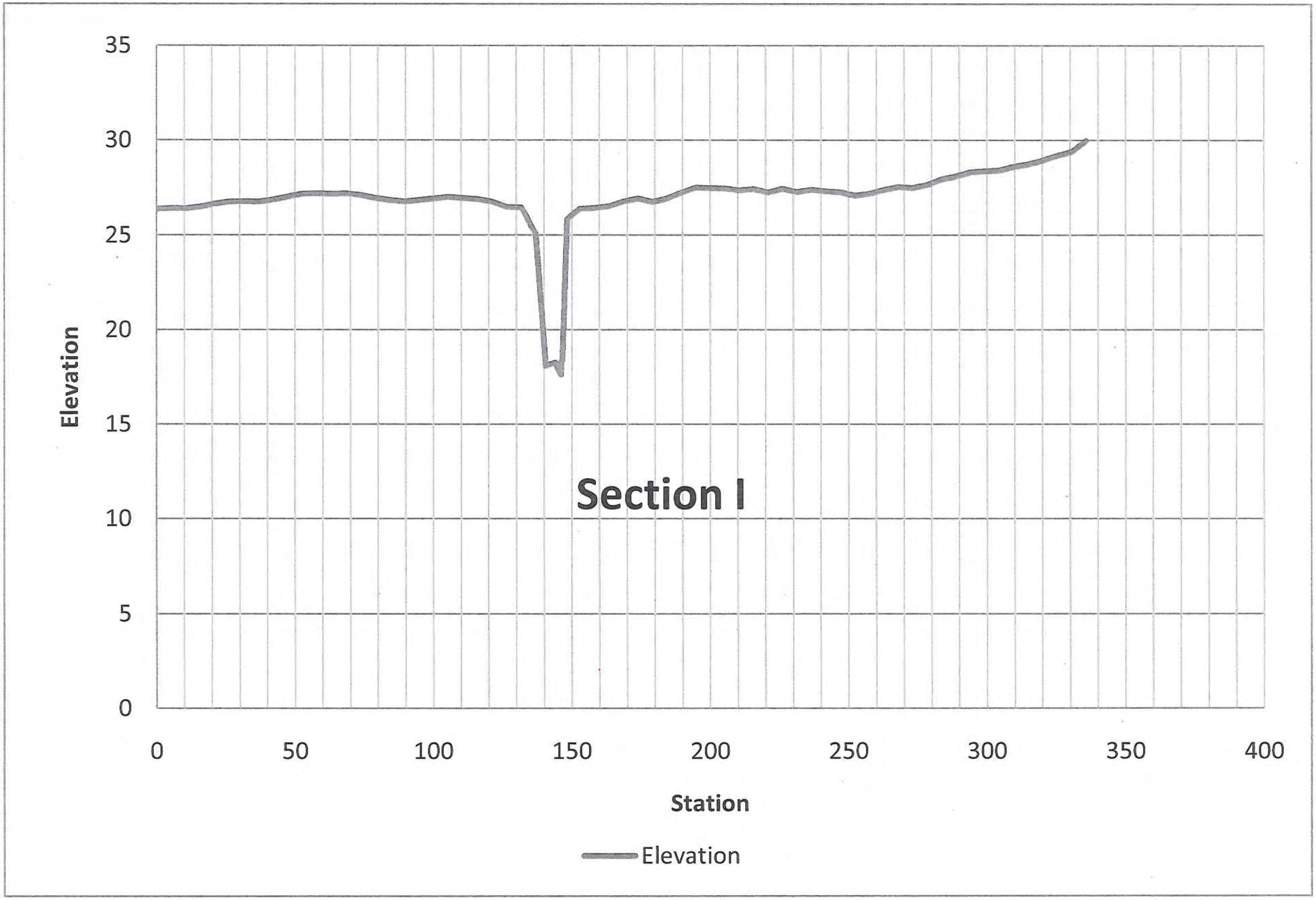
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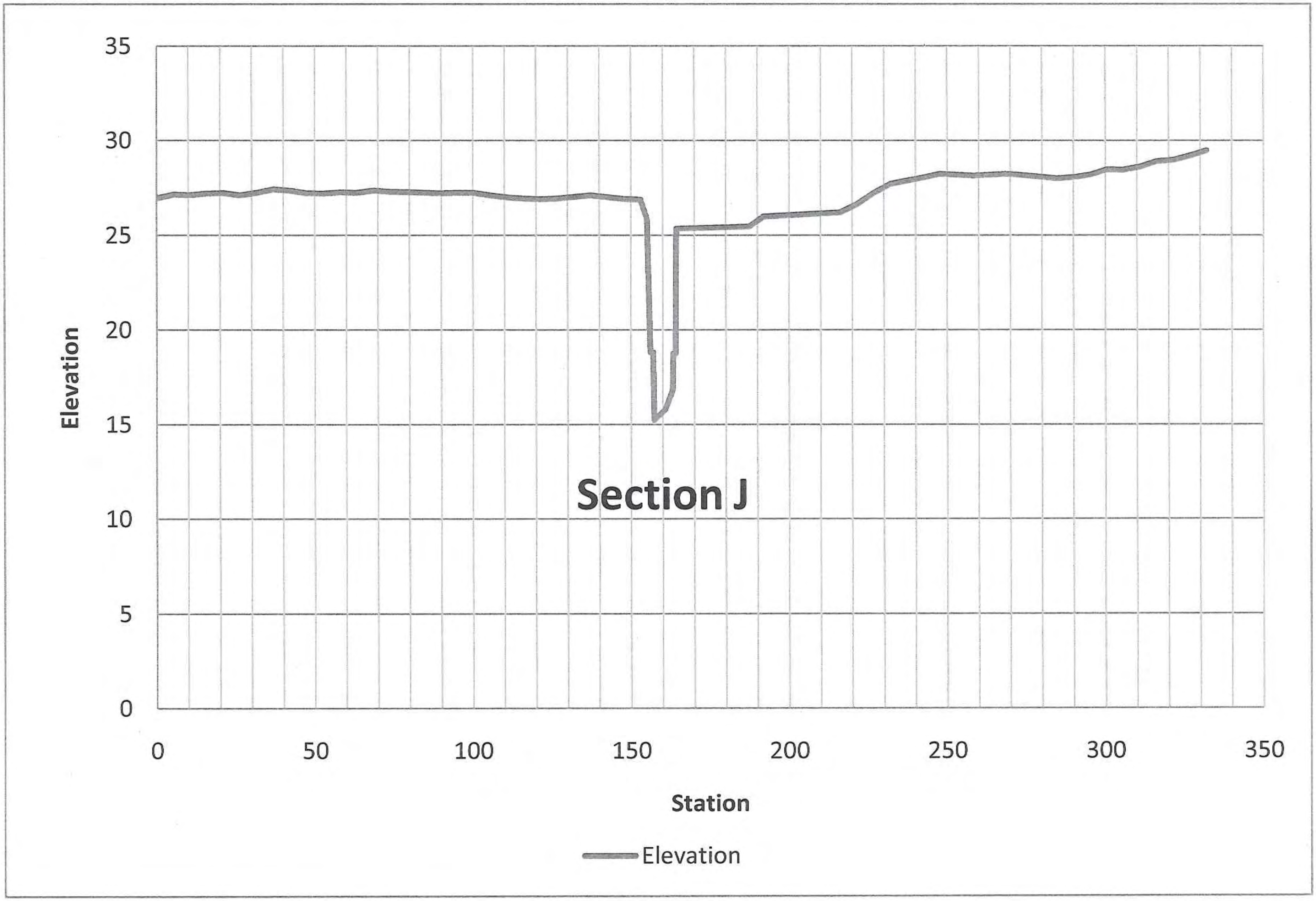
Elevation



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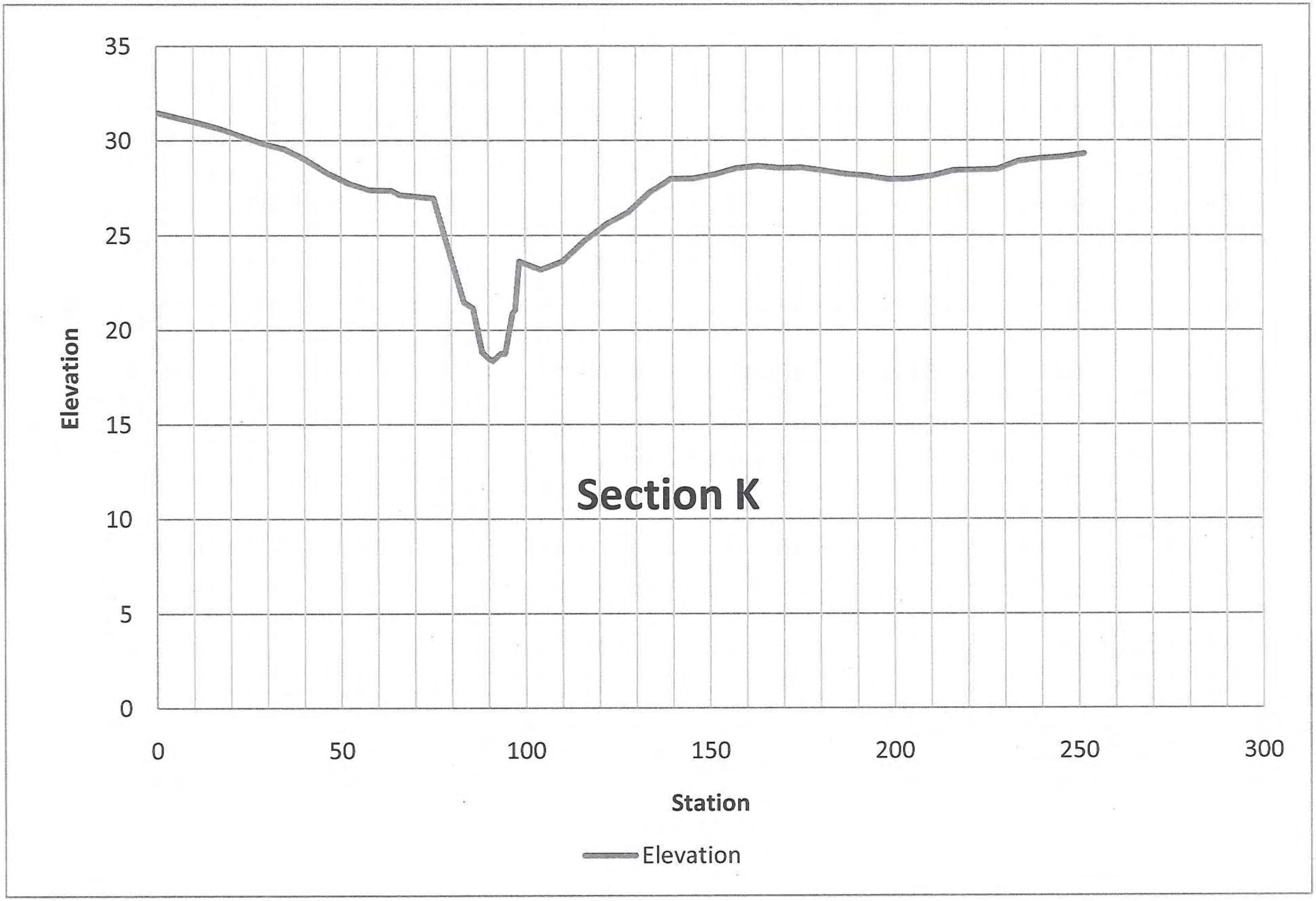

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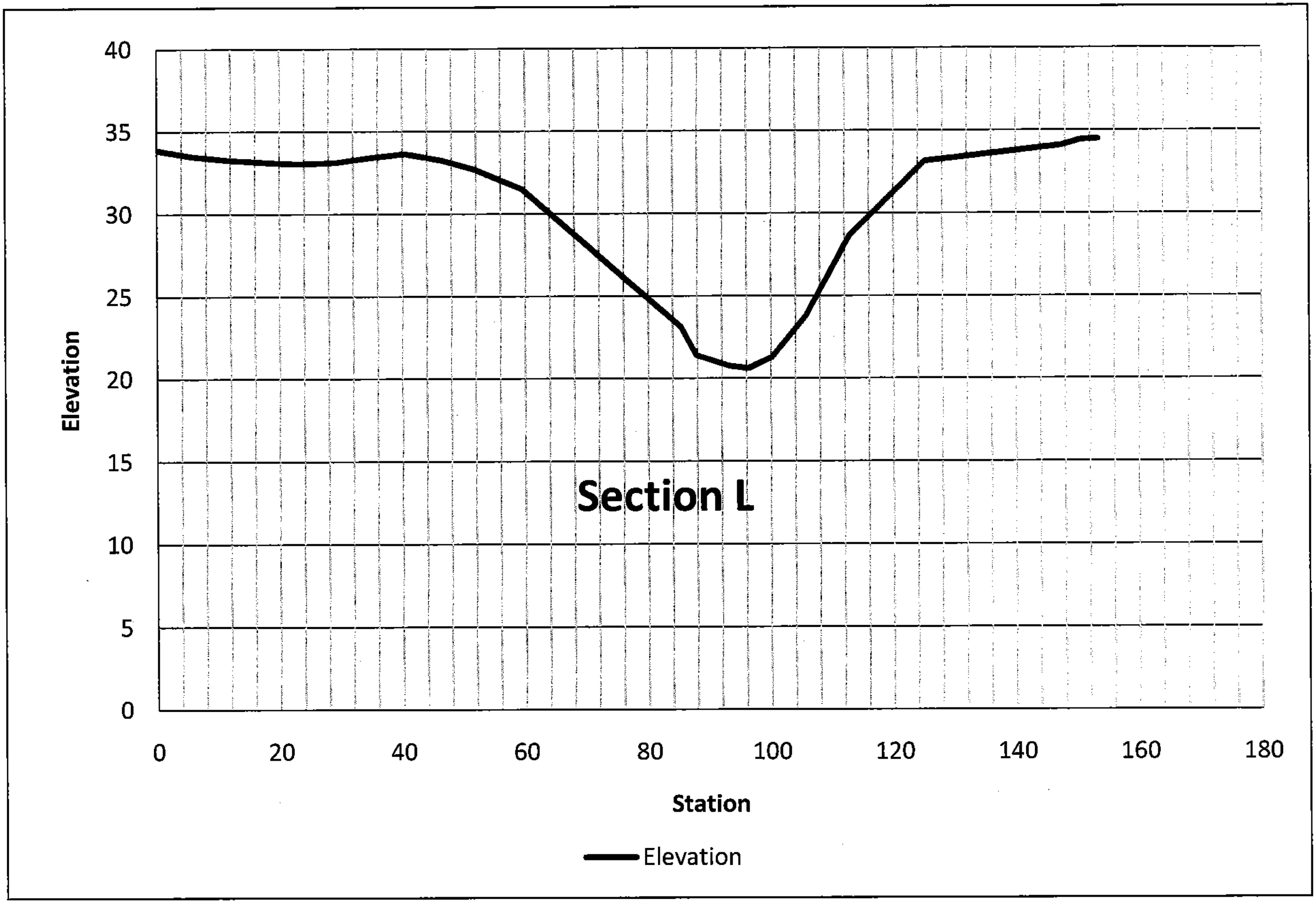

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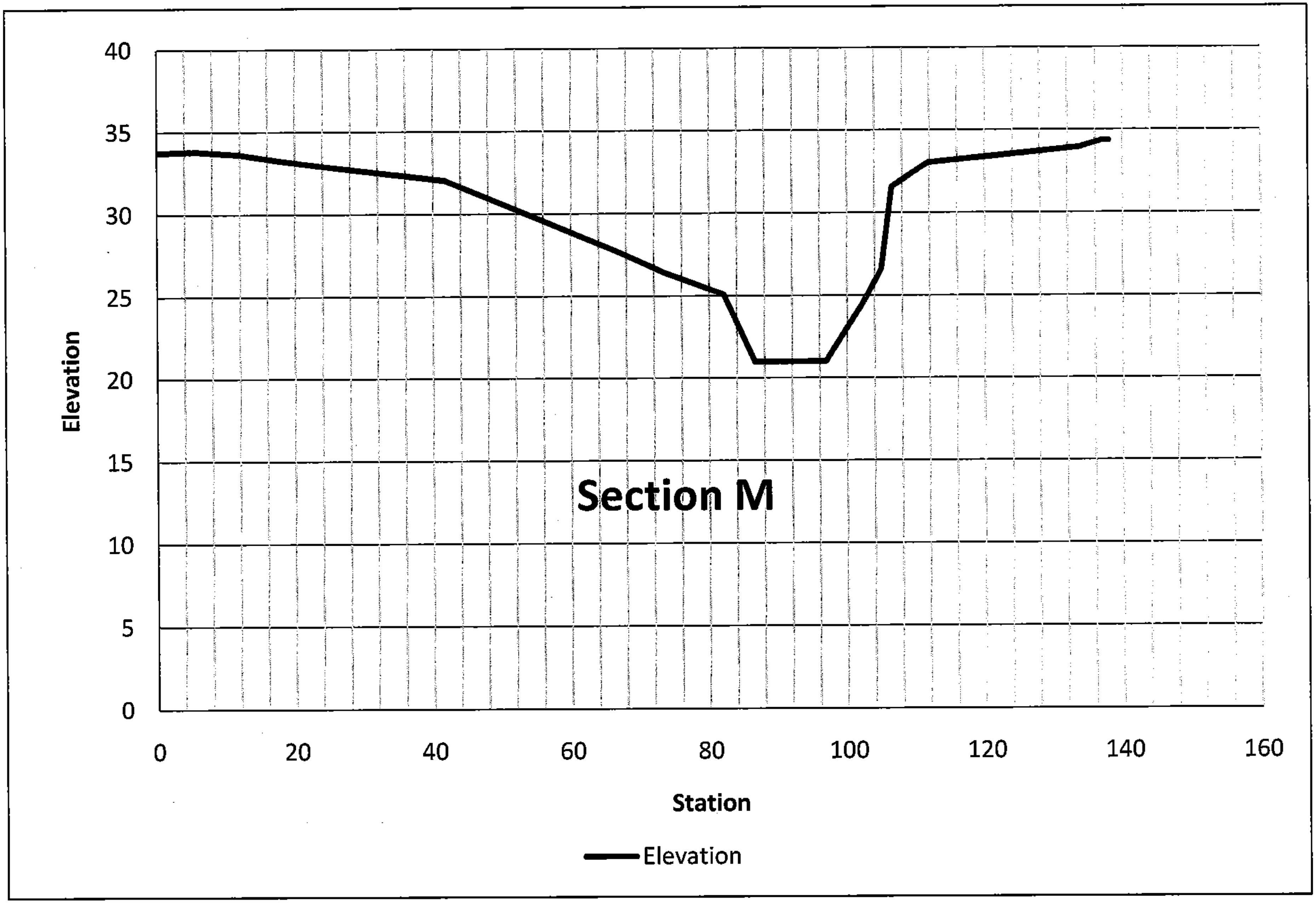

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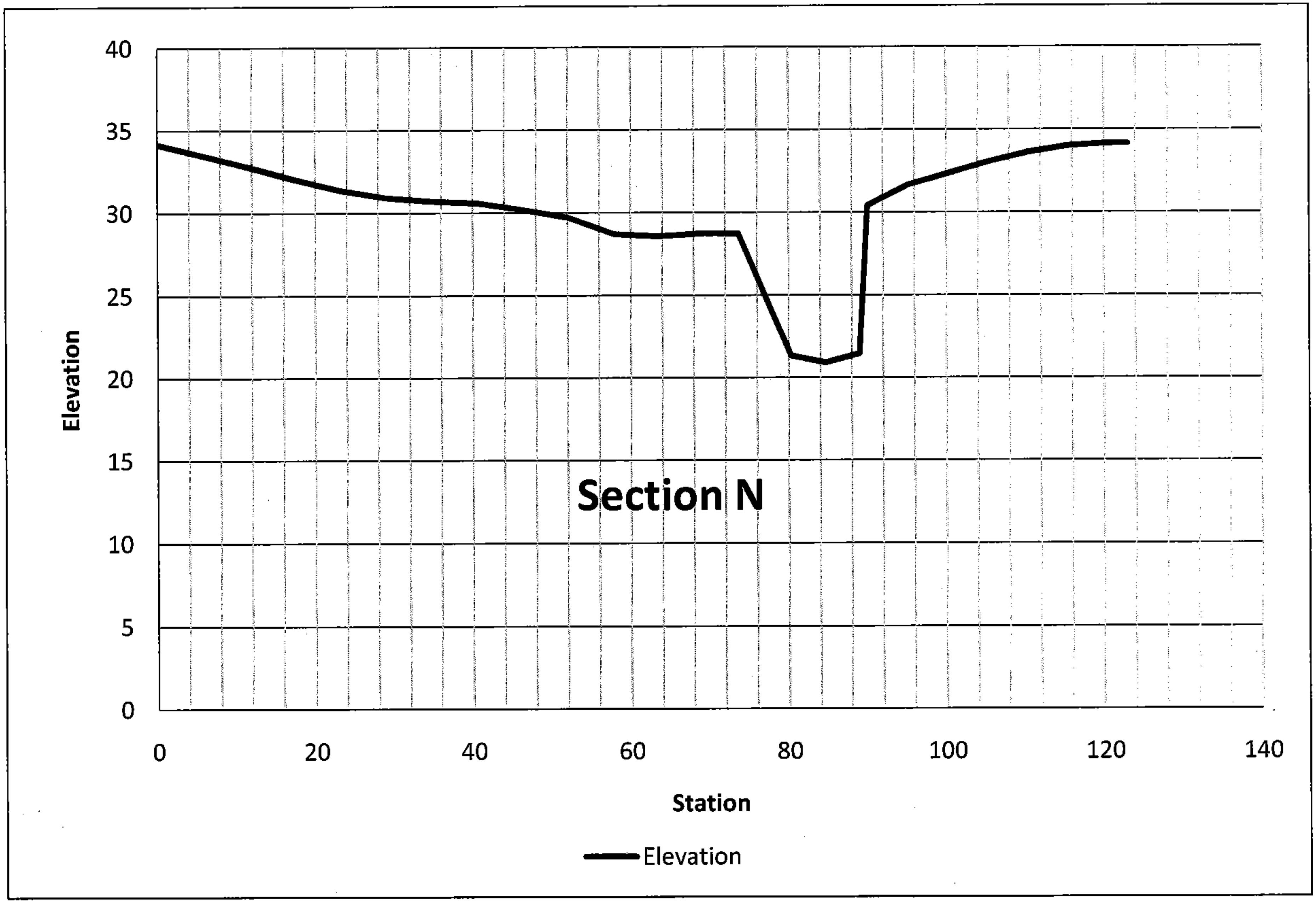
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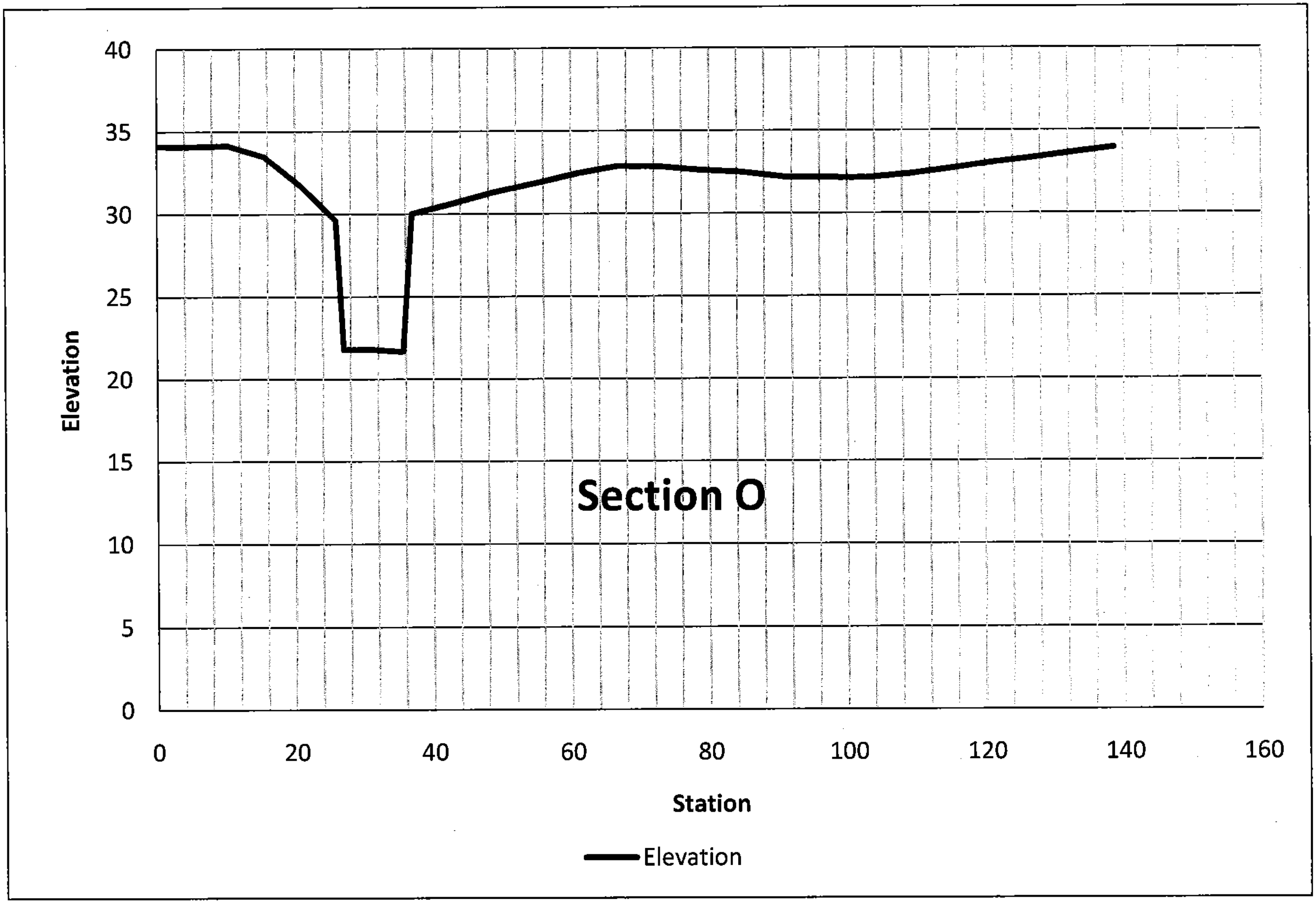

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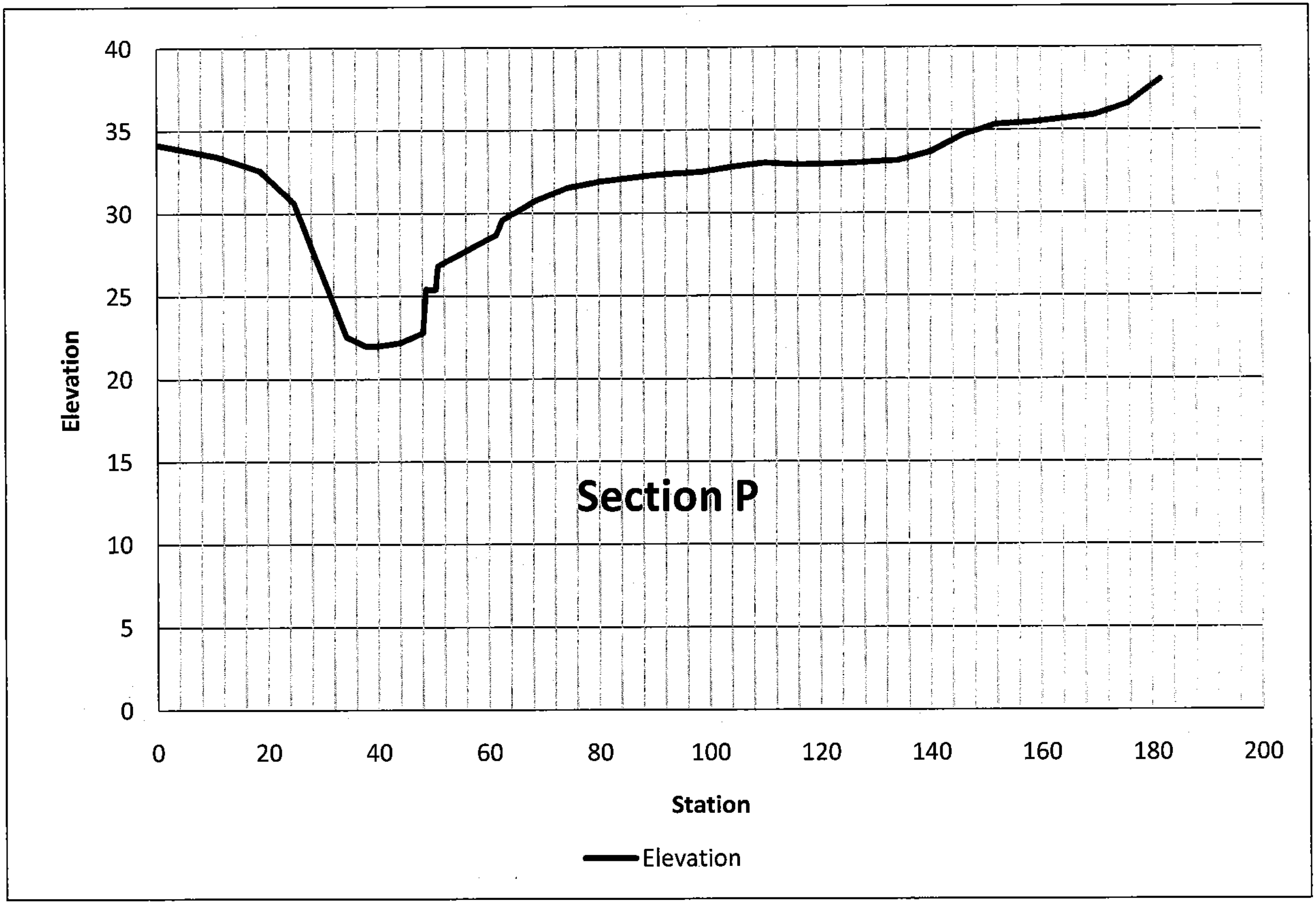
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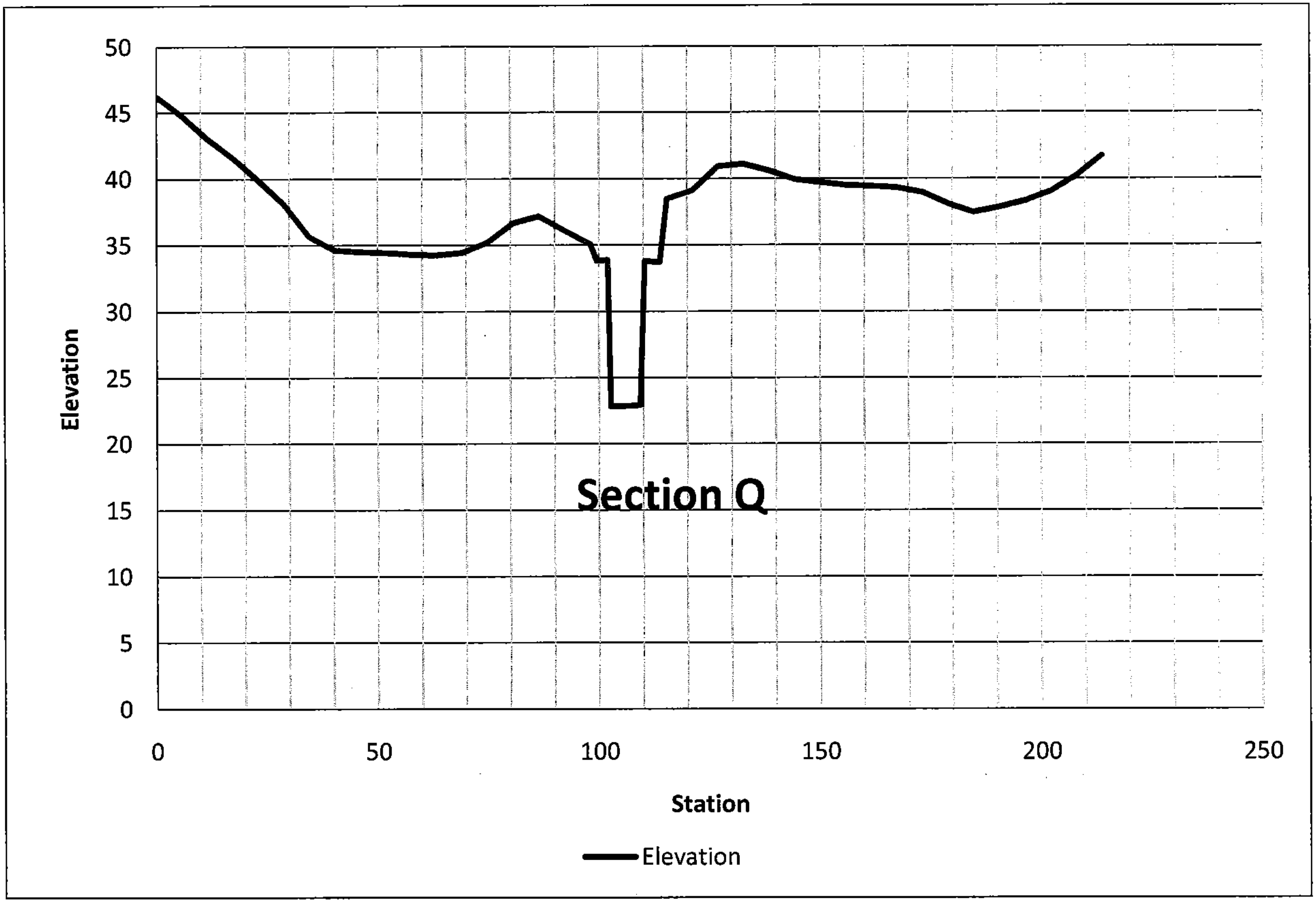

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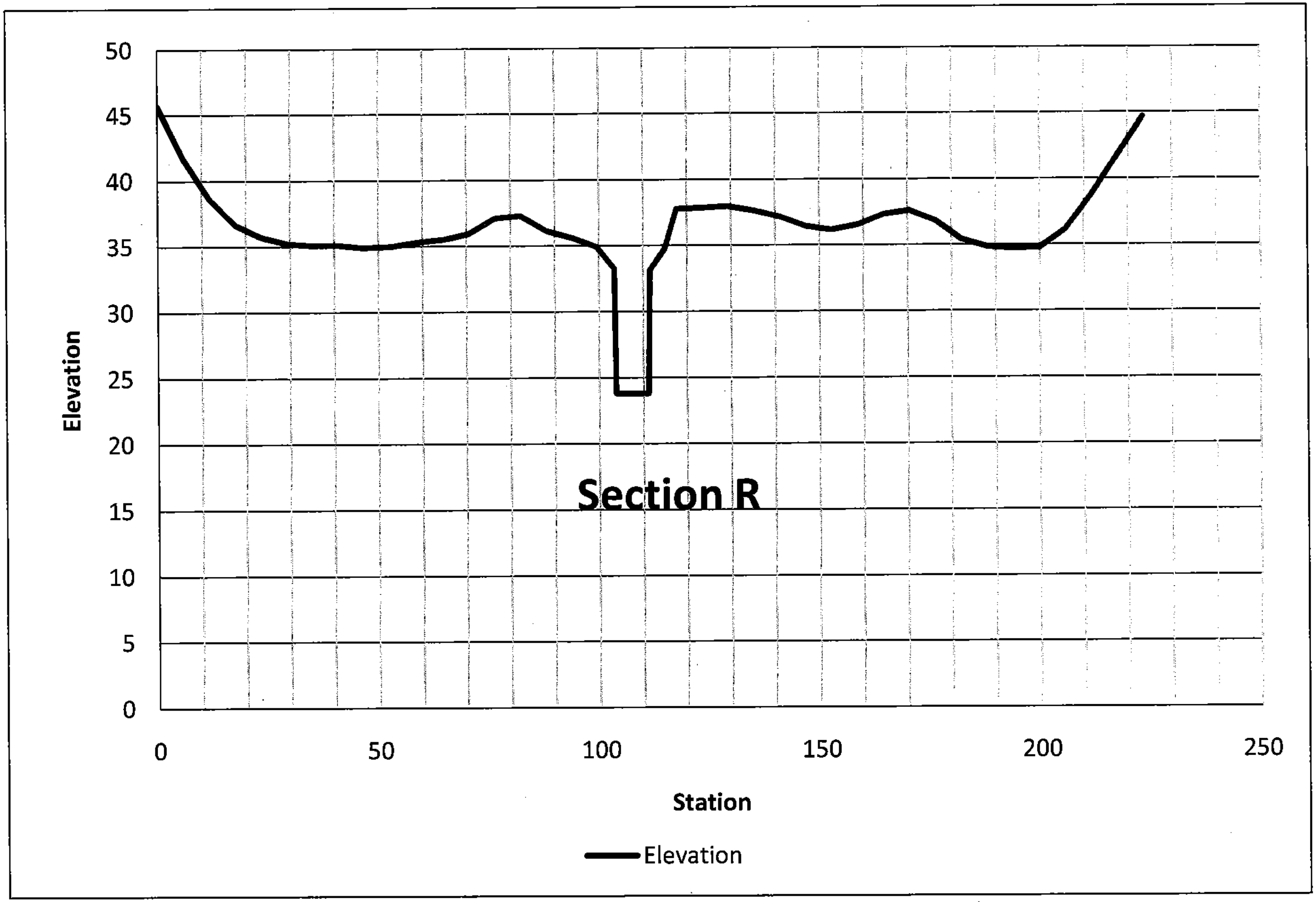
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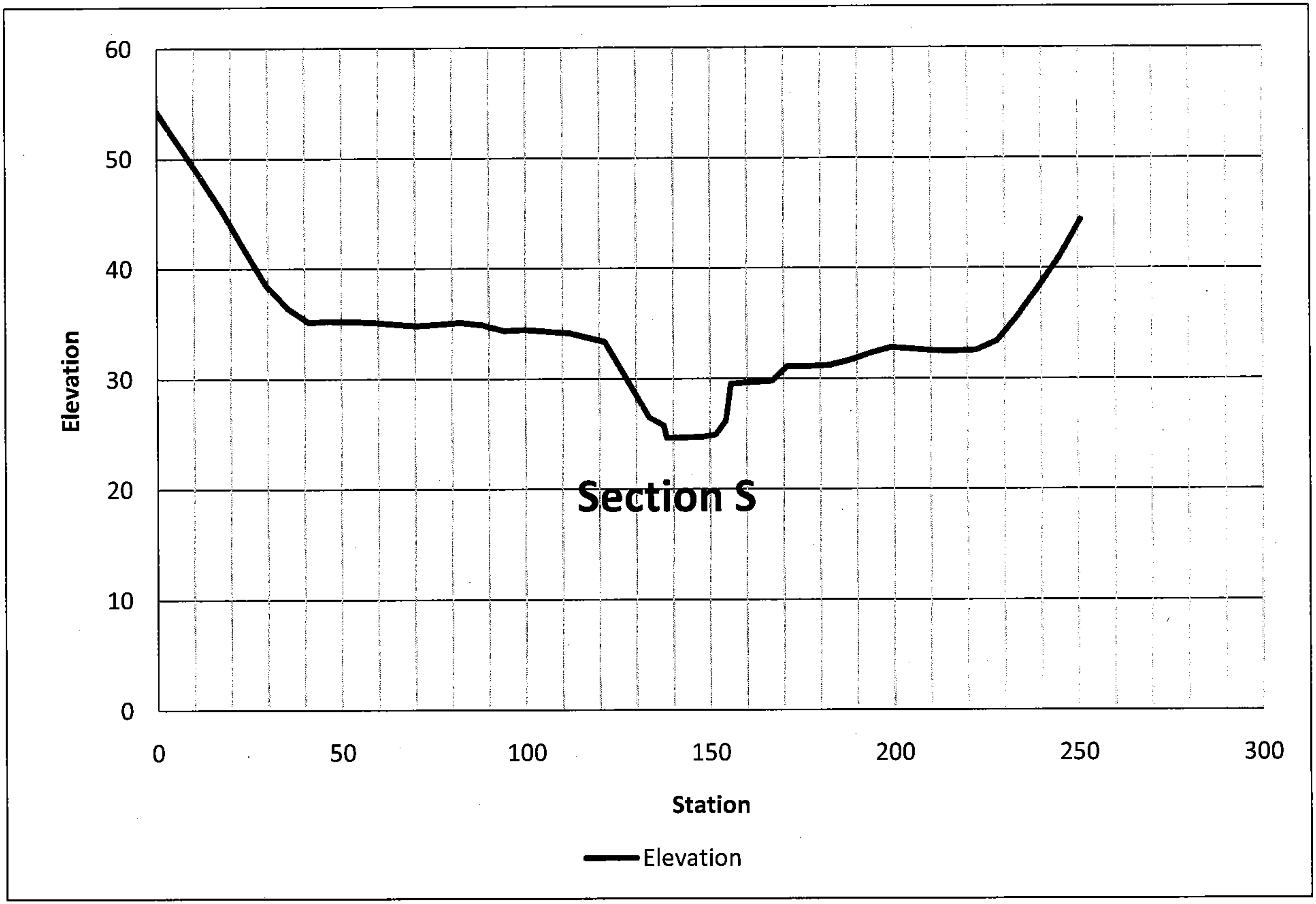

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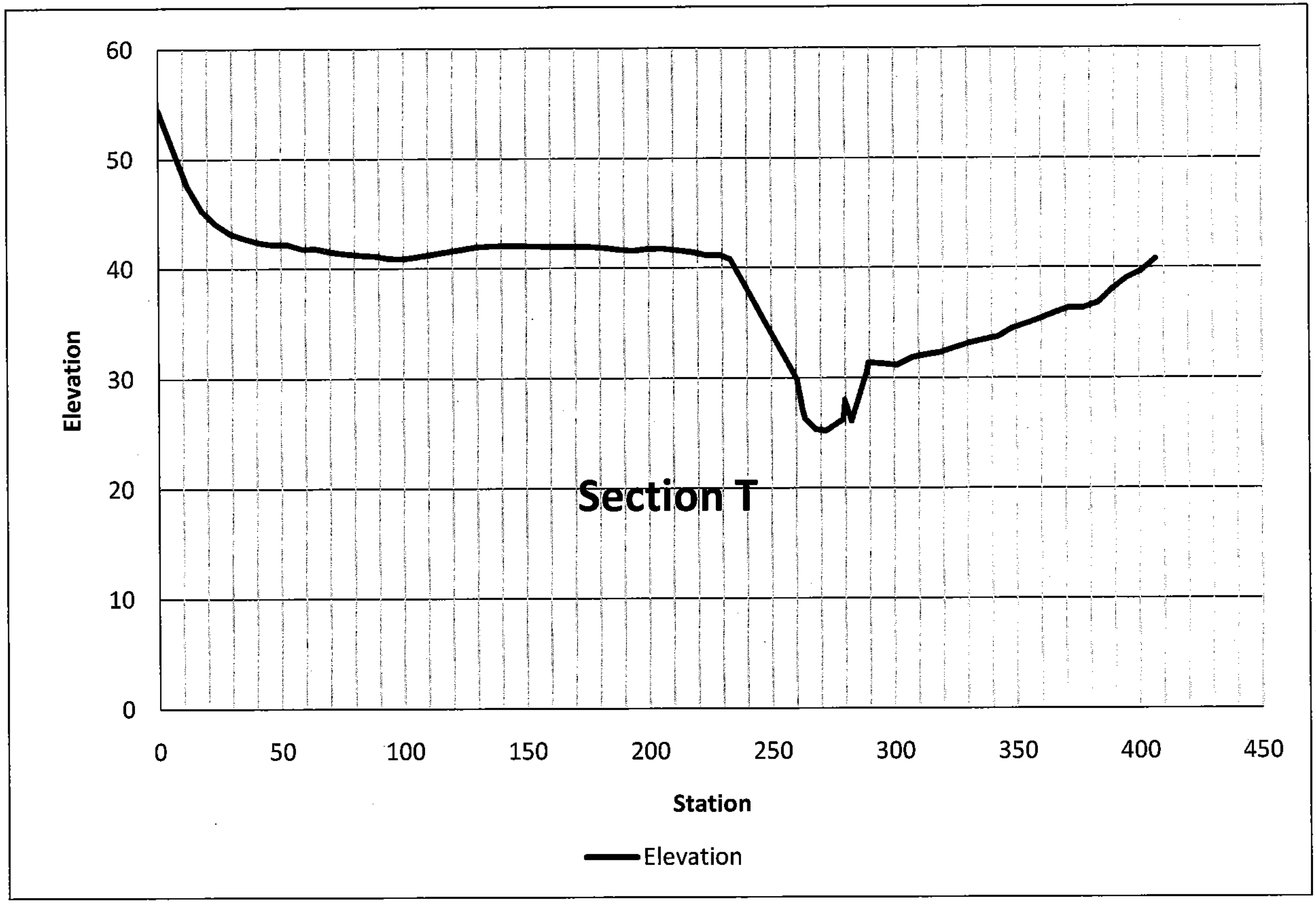

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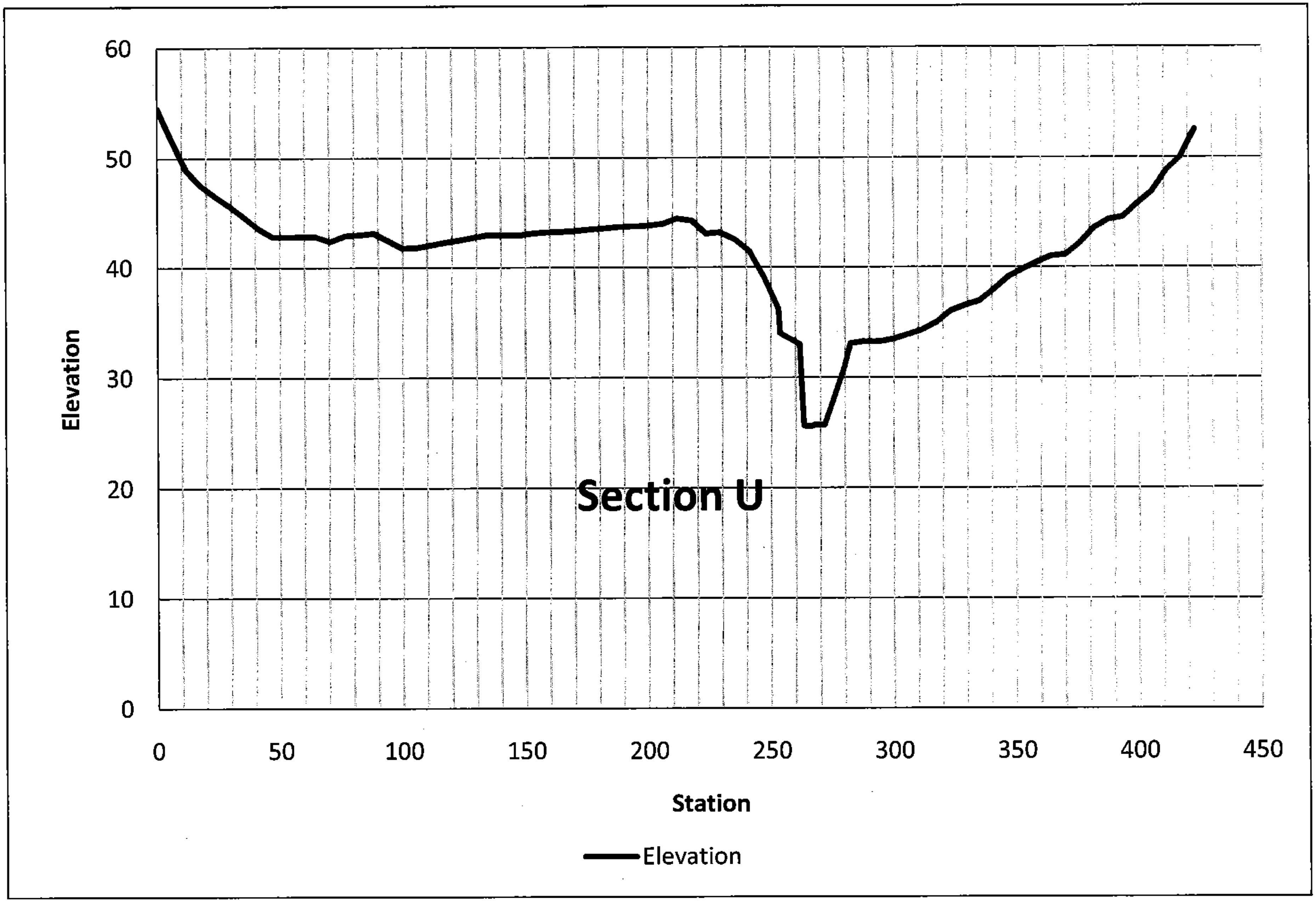
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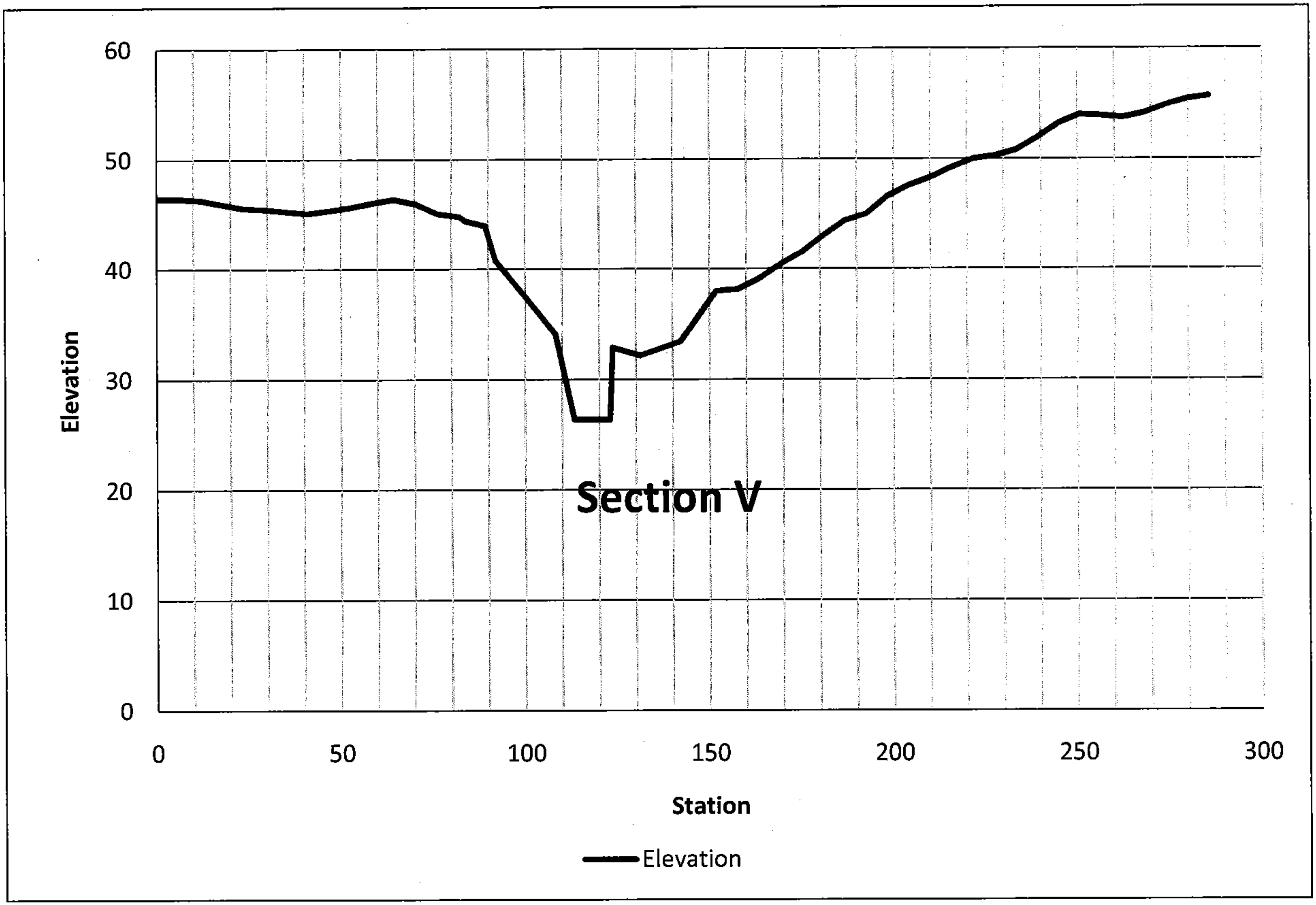

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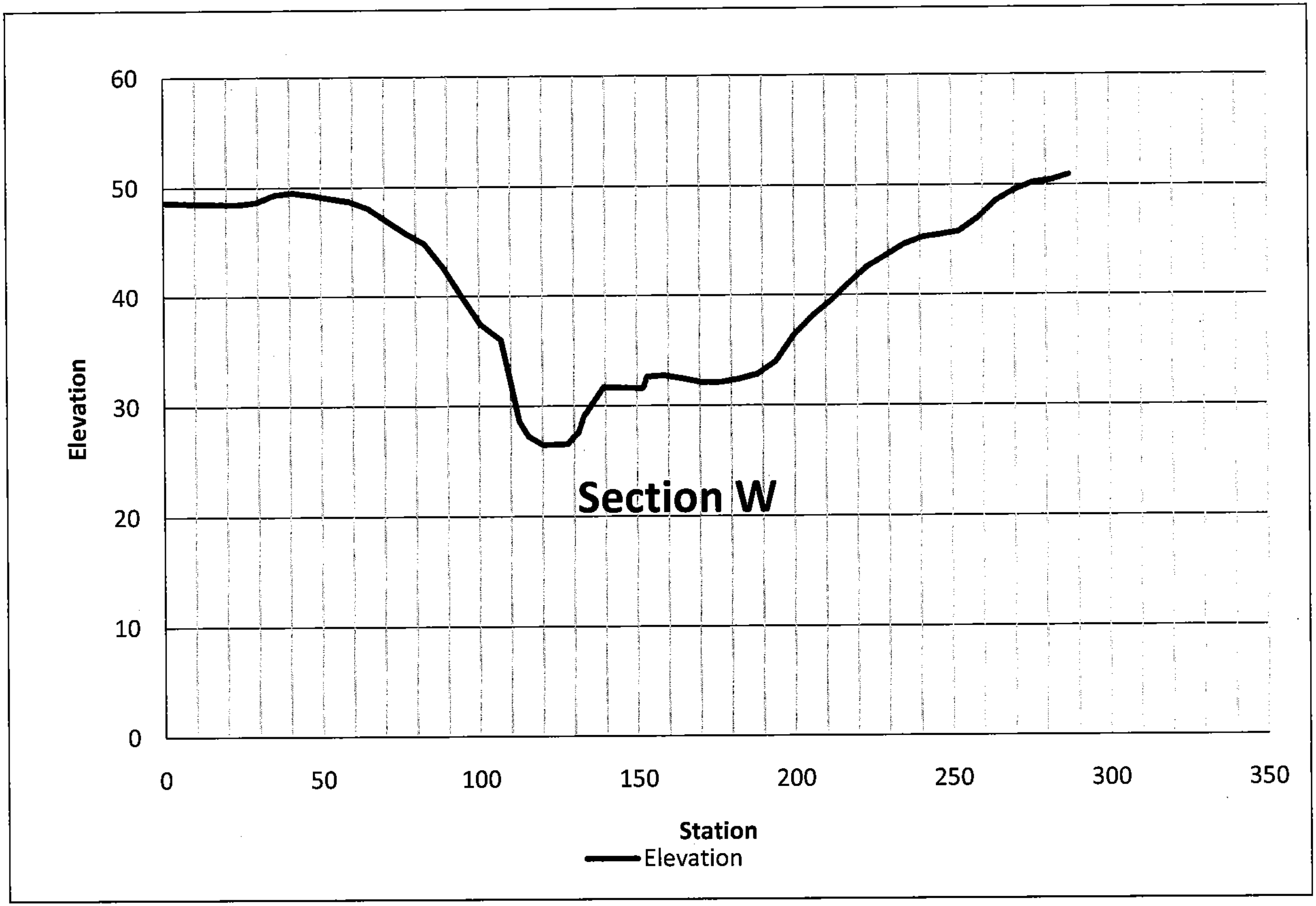
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APPENDIX F:

December 12, 2010 Photographs


DECEMBER 12, 2010
PHOTOGRAPH
LOCATIONS

1

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