# 5th International Conference on Natural Channel Systems

## Streamline your Design with Civil3D

Niagara Falls, Ontario
September 26-27, 2016

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# Agenda

1 Project Objectives

2 Challenges in Stream Design Optimization

3 Streamline Your Design with Civil 3D

4 Design Advantages

5 Next Steps

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# Project Objectives

- Urban land development heavily relies on optimization
- Sites are optimized to:
  - Maximize developable land
  - Minimize construction costs
- Developers will explore multiple options until a site is optimized
- How can this be applied to stream restoration?

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# Challenges in Stream Design

- Significant number of design criteria
- Large amount of detail (fine grading) is required
- Difficult to quickly optimize a design:
  - Creation of individual Civil 3D points/surfaces is a slow process
  - Feature lines, 3D polylines and corridors are not easily manipulated
- The goal of this presentation is to show a process that can make stream restoration optimization an easier process

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# Streamline Your Design

- Stantec has developed a process to help optimize stream design
- To speed up the design, macros in Visual Basic can be use to share data between programs
  - SR CAD Tools – Civil 3D
  - Breakline Program – Excel

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# Design Process – Channel Alignment

- Using reference reach data, create a channel alignment
- The alignment is made up of lines (riffles) and curves (pools)
- Create a profile with the proposed alignment and existing topographic data
- Export data into Excel

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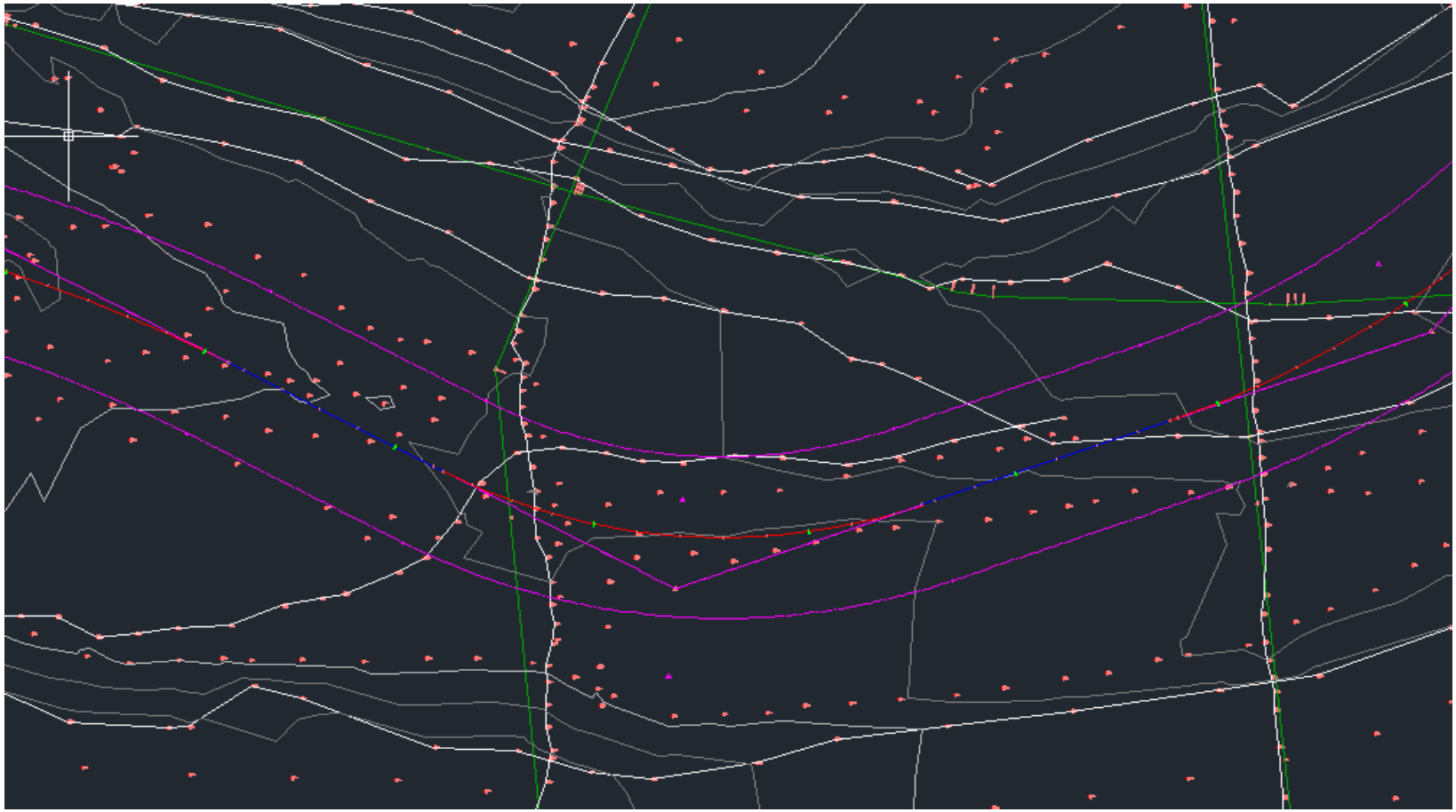
# Design Process – Channel Alignment



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# Design Process – Cross Sections

- Use dimensionless data (reference reach) to size cross sections
- Apply cross sections to the alignment
  - Riffle cross section at the PC and PT
  - Pool cross section at the curve apex
- Transition between pools and riffles creates runs and glides

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# Design Process – Cross Sections

| RIFFLE X-Section | | |
|---|---|---|
| **Width/Depth** | 18 | |
| ***Max Depth Ratio** | 1.5 | |
| **Width** | 31.5 | |
| **Depth** | 1.75 | |
| **Bankfull Area** | 55 | |
| **Riffle Side Slope** | 3 | :1 |
| **% Low Flow Channel** | 35% | |
| **Low Flow Side Slopes** | 3 | :1 |
| **Max depth** | 2.6 | |
| **$D_{trymain}$** | 1.296 | |
| Low flow area | 19.25 | |
| Low Flow Design Q | | 25 cfs |
| **Total Area** | **55.00** | **sqft** |

| POOL X-Section | | |
|---|---|---|
| **Max Depth Ratio | 2.8 | |
| Pool Max Depth | 4.9 | |
| Point Bar Slopes | 10 | :1 |
| ***Width Ratio | 1.1 | |
| Width of Pool | 34.6 | |
| Point Bar Ratio | 3 | |
| **OPTIONAL POOL ADJUSTMENT** | | |
| Area of Pool | 83.6 | |
| 3rd Slope Pool | 0 | ft |
| 4thSlope Pool | 0.5 | ft |
| 5th Meander Bank pt | 3.75 | ft |
| Meander Bank Slope | 3.37 | |

**Press to Calculate Area**

## Verification of Calculations

OKAY - The calculation of flow channel depth is okay.

OKAY - The calculation involving Lower Bankful Area, Steepen Riffle..., and depth ration is verified.

*equals Dmax/Dbkf

**equals Dpool/Dbkf

*** equals Wpool/Wbkf

| | | | | |
|---|---|---|---|---|
| Calc Q | 438 | Size Channel to Des Q | 1.22 yr | |
| Slope | 2.75% | | 82% | Entrenchment Ratio |
| Mannings' n | 0.045 | | | |
| Des Q | 0.56 | | 8. fps | |

| Floodplain Adjustment | Floodplain Side Slopes | |
|---|---|---|
| 30 | 25 | :1 |
| | **Floodplain Bench Slopes** | |
| | 200 | :1 |

NEED MORE FLOODPLAIN

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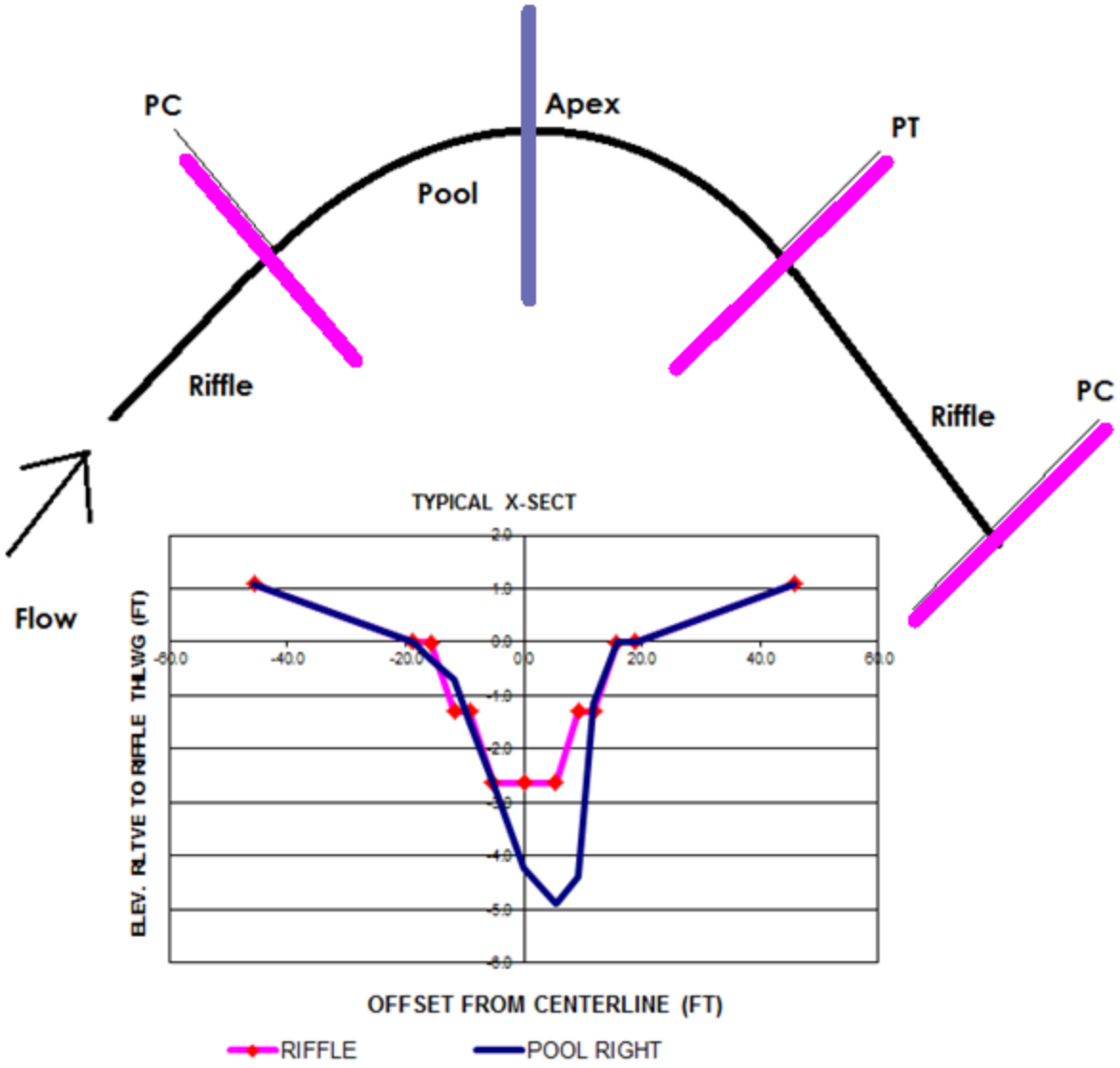
# Design Process – Cross Sections

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# Design Process – Profile

- Set bankfull slope along the reach
- Using bankfull, apply riffle and pool depths to the alignment
- Adjust the channel slope to match existing ground features

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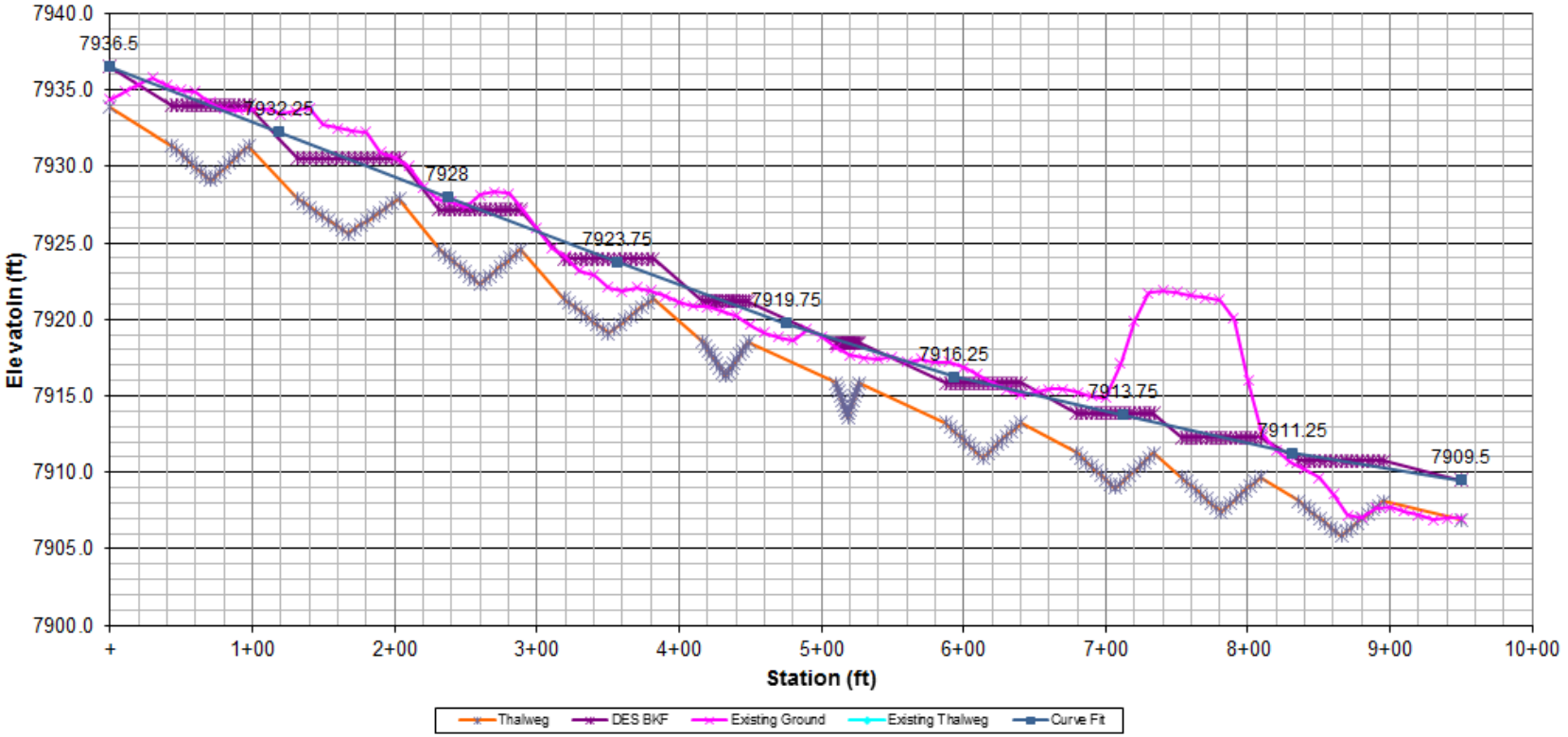
# Design Process – Profile




Show BKF Elevation | Hide BKF Elevations | Show TW Elevations | Hide TW Elevations

Total Amount of Structure Drop: 0 FT

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PT | + | +97 | 2+03 | 2+89 | 3+82 | 4+49 | 5+27 | 6+40 | 7+34 | 8+09 | 8+95 |
| PC | +44 | 1+32 | 2+31 | 3+19 | 4+17 | 5+10 | 5+87 | 6+80 | 7+53 | 8+36 | 9+50 |
| BKF-SLOPE | 5.79% | 10.12% | 11.72% | 10.56% | 8.05% | 4.40% | 4.30% | 5.02% | 8.05% | 5.81% | 2.29% |
| STRUCT DROP | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| HEAD OF RIFFLE | 7936.50 | 7933.98 | 7930.51 | 7927.19 | 7923.99 | 7921.17 | 7918.47 | 7915.85 | 7913.87 | 7912.30 | 7910.74 |
| HEAD OF POOL | 7933.98 | 7930.51 | 7927.19 | 7923.99 | 7921.17 | 7918.47 | 7915.85 | 7913.87 | 7912.30 | 7910.74 | 7909.50 |
| TW PC ELEV | 7933.88 | 7931.36 | 7927.89 | 7924.57 | 7921.36 | 7918.55 | 7915.84 | 7913.23 | 7911.25 | 7909.68 | 7908.12 |
| TW PT ELEV | 7931.36 | 7927.89 | 7924.57 | 7921.36 | 7918.55 | 7915.84 | 7913.23 | 7911.25 | 7909.68 | 7908.12 | 7906.88 |

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# Design Process – Surface

- Between the alignment, profile and the cross sections, a series of northings, eastings and elevations can be calculated
- Use Excel to create feature lines along each channel feature
- The Excel file can be imported into Civil3D
- The import process can also be done through macros or a csv/text file with points
- Use Civil3D to create a floodplain

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# Design Process – Surface

- The surface creation process can be programed in Visual Basic,  Stantec calls these:
  - SR CAD Tools – Civil 3D
  - Breakline Program – Excel
- The use of Visual Basic speeds up design iterations
- Design iterations takes seconds

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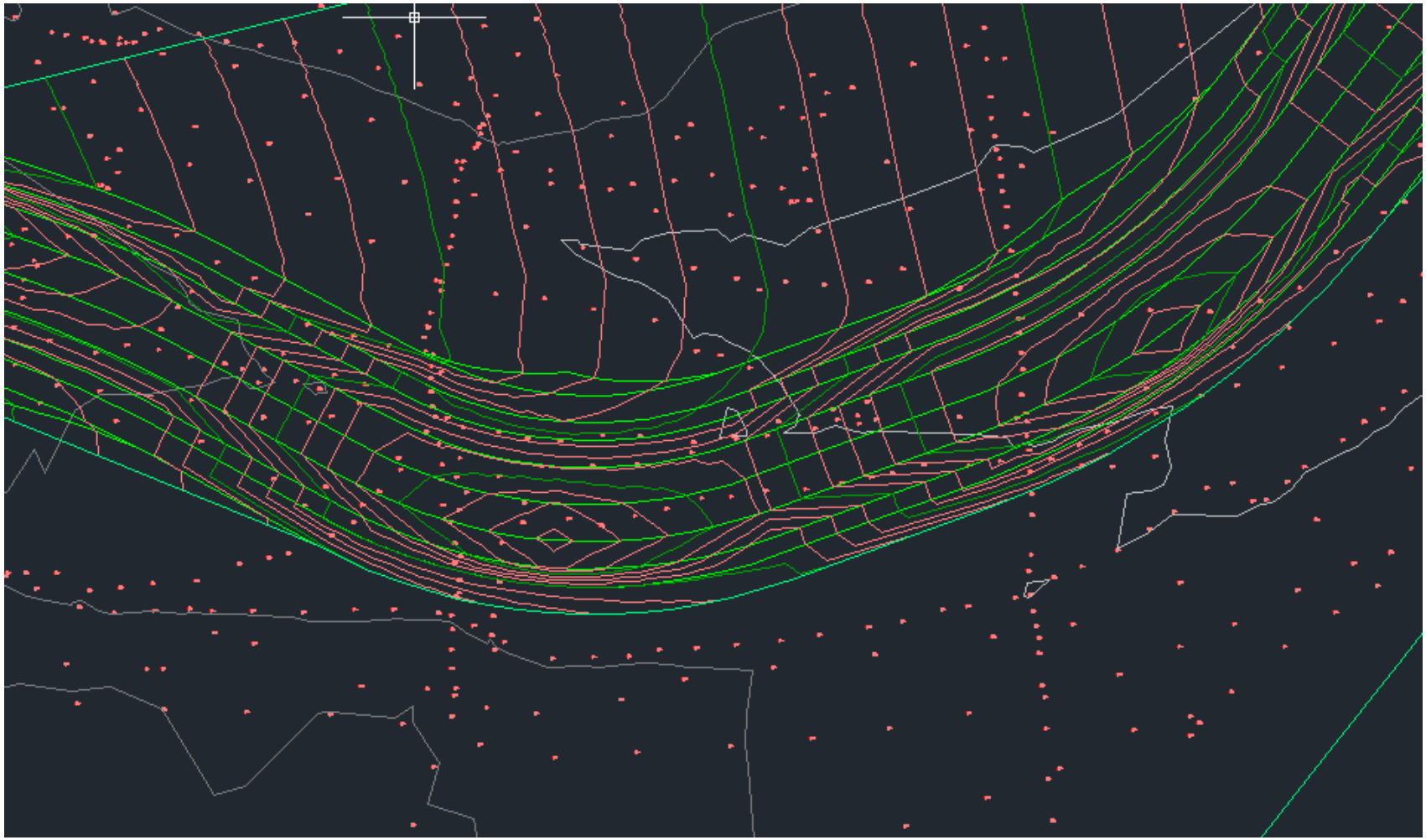
# Design Process – Surface



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# Design Optimization

- Slope variation to ensure the channel follows existing topography
- Calculate a cut/fill balance (project or localized)
- Identify areas for material reuse

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# Design Advantages

- Quickly improve a design through multiple iterations
- Easily adjust a design to fit project changes
- Visually identify conflicts or design issues
- Quickly create cross-sections at any point along the channel
- Easily update hydraulic models (e.g. HEC-RAS)
- Accurately complete  quantity estimates
- Reduce construction costs
- Minimize construction deviation from the design
- Improve construction efficiency

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# Next Steps

- Use in post-construction monitoring
- Use the design to create a visualization of the completed project
  - Public consultation
  - Marketing
- Improving the design process

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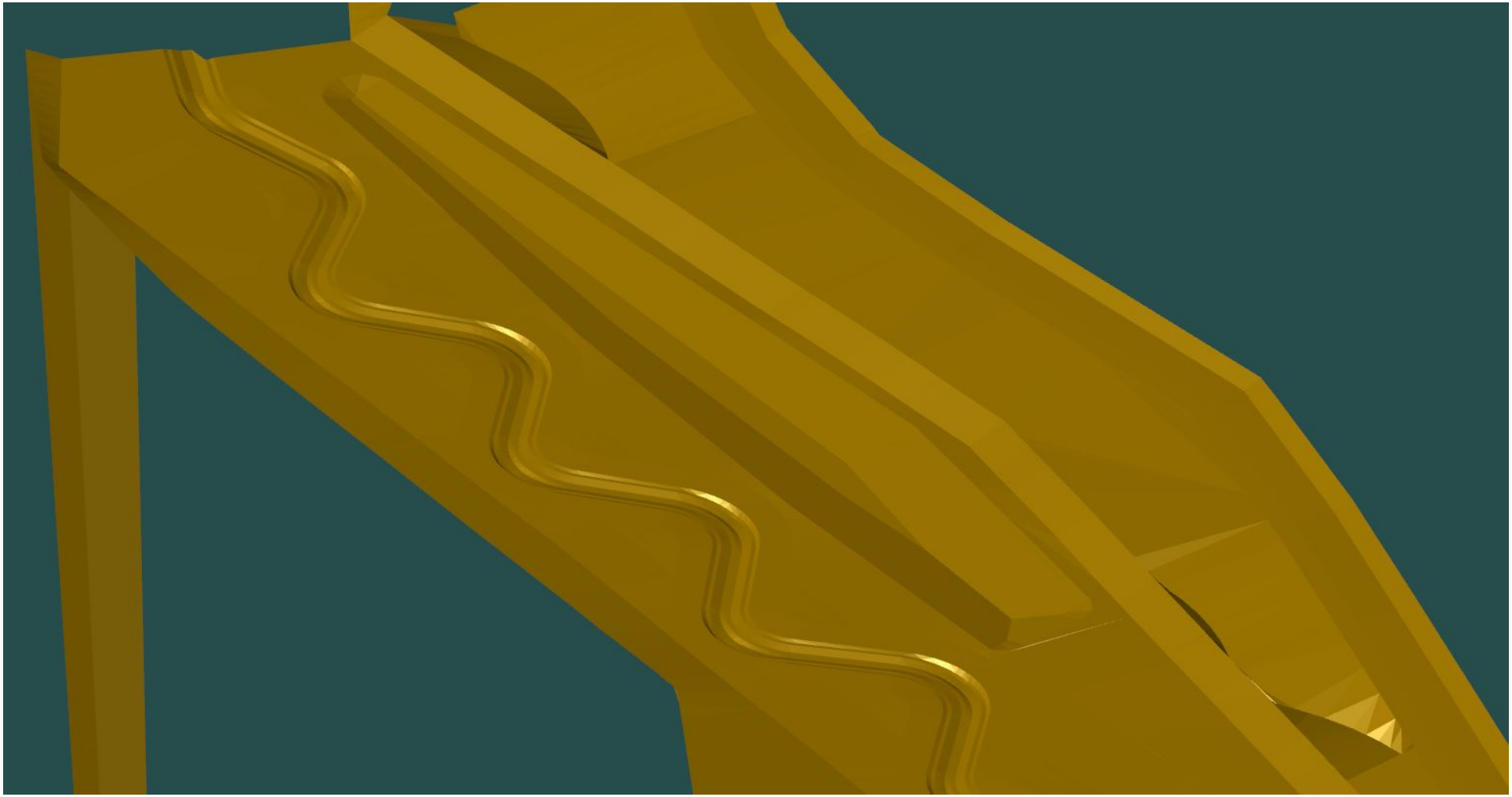
# Next Steps



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