Improving SWMM Modeling with GIS Tools

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Disclaimer

Some graphics are based on models provided by others

The use of these graphics does not imply endorsement by those who provided them

Improving SWMM Modeling with GIS Tools
Today's Webinar

EPA SWMM Background and History

SWMM GIS Tools

Leveraging the GIS tools in TUFLOW-SWMM models

TUFLOW

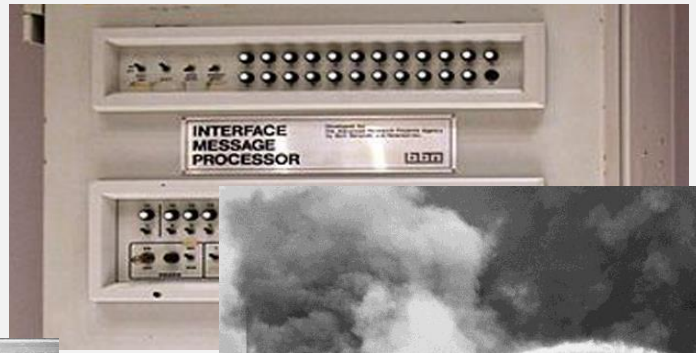
Improving SWMM Modeling with GIS Tools

EPA SWMM Background and History

Improving SWMM Modeling with GIS Tools
EPA SWMM Beginning

1969

Fed. Water Pollution Control Administration
Approved Grants to form a Joint Venture between
Metcalf & Eddy & University of Florida



https://www.darpa.mil/about-us/timeline/arpanet
https://www.shapr3d.com/history-of-cad/introduction
https://www.dcec-wi.org/blog/the-disaster-that-gave-birth-to-the-epa-the-1969-cuyahoga-river-fire

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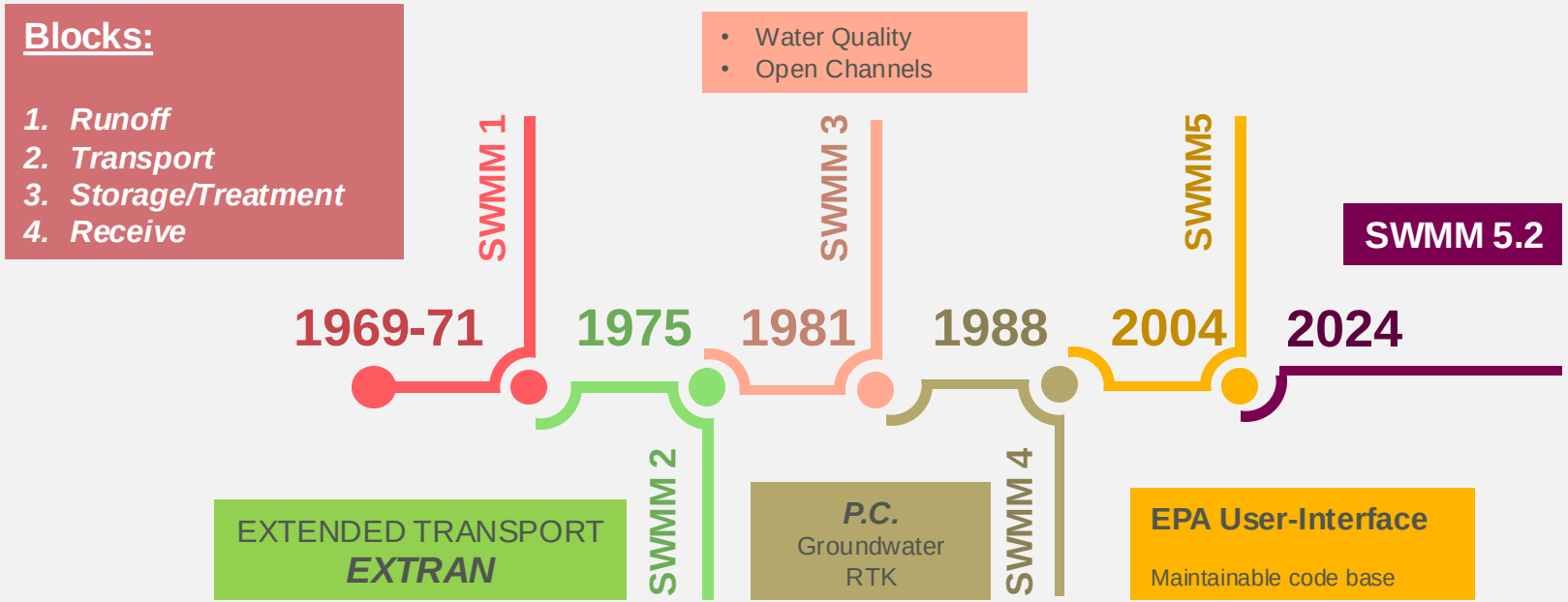
EPA SWMM History



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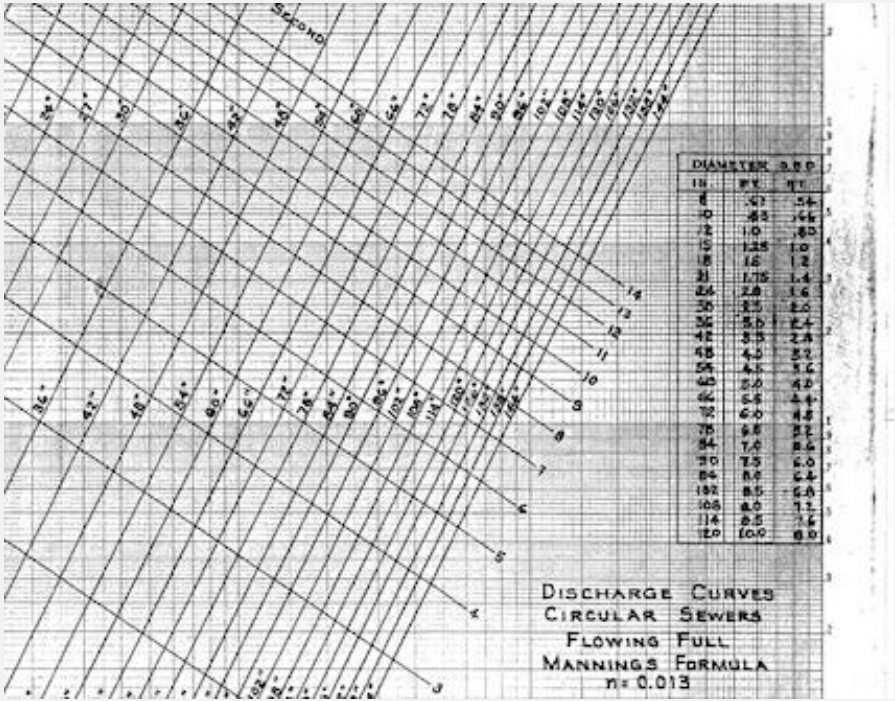
Improving SWMM Modeling with GIS Tools
Advancing Technology



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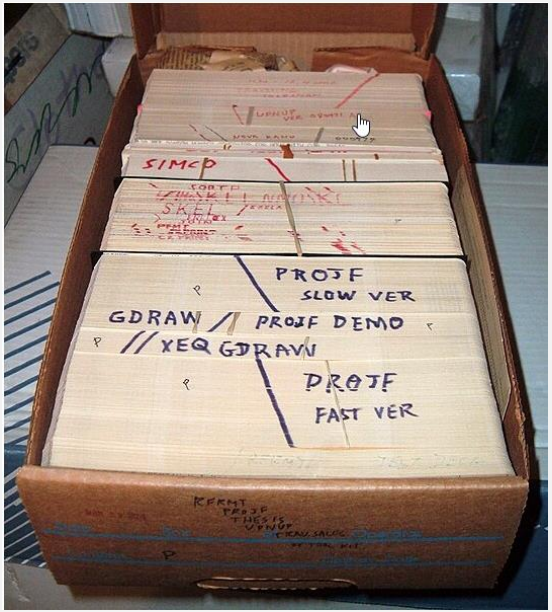
EPA SWMM Data

SWMM2.5 - 3



SWMM 2.5 and SWMM 3 punch cards box
LinkedIn – Robert Dickenson

SWMM4

```
#   PLOT_ALL_NODES
#   PLOT_ALL_CONDUITS
#   SWMM5_CALIBRATION_FILE
$EXTRAN
A1  'EXTRAN USER''S MANUAL EXAMPLE PROBLEM 1'
A1  'BASIC PIPE SYSTEM FROM FIGURE 3-1'
*
*
*  B0 LINE IS COMPLETELY OPTIONAL
*                     ISOL = 0 --> USUAL EXPLICIT EXTRAN SOLUTION
*                     ISOL = 1 --> SEMI-IMPLICIT SOLUTION
*                     ISOL = 2 --> ITERATIVE EXTRAN SOLUTION
*  NOTE: ISOL = 1 CAN ALSO BE INVOKED BY SETTING SURTOL < 0 AS EXPLAINED
*  ON USER'S MANUAL PAGE 32.
*                     KSUPER = 0 --> ASSUME NORMAL FLOW WHENEVER WATER SURFACE
*                                    SLOPE IS LESS THAN THE CONDUIT INVERT
*                                    SLOPE.  THIS IS THE USUAL (DEFAULT)
*                                    EXTRAN ASSUMPTION FOR SUPERCRITICAL FLOW.
*                     KSUPER = 1 --> ASSUME NORMAL FLOW WHENEVER THE FROUDE
*                                    FROUDE THAN OR EQUAL TO 1.0.
*                                    THIS IS A MORE REALISTIC ASSUMPTION
*                                    FOR SUPERCRITICAL FLOW.
*  ISOL KSUPER
B0  1    0
*  A LARGER TIME STEP IS USUALLY POSSIBLE USING ISOL = 1 OR 2, E.G.,
*   NTCYC DELT  TZERO NSTART INTER JNTER REDO
*B1  192   150.0  0.0    1     100   100    0
*
*  HERE, CONTINUE THE EXTRAN INPUT SHOWN IN TABLE 3-1 OF USER'S MANUAL.
*
*   NTCYC   DELT  TZERO NSTART INTER JNTER REDO
B1   1440   20.0  0.0    45    -1       1    0
*   METRIC NEQUAL  AMEN ITMAX SURTOL
B2     0      0      0.0   30   0.05
* NHPRT NQPRT NPLT LPLT NJSW
B3   6   6     6    6   3
```

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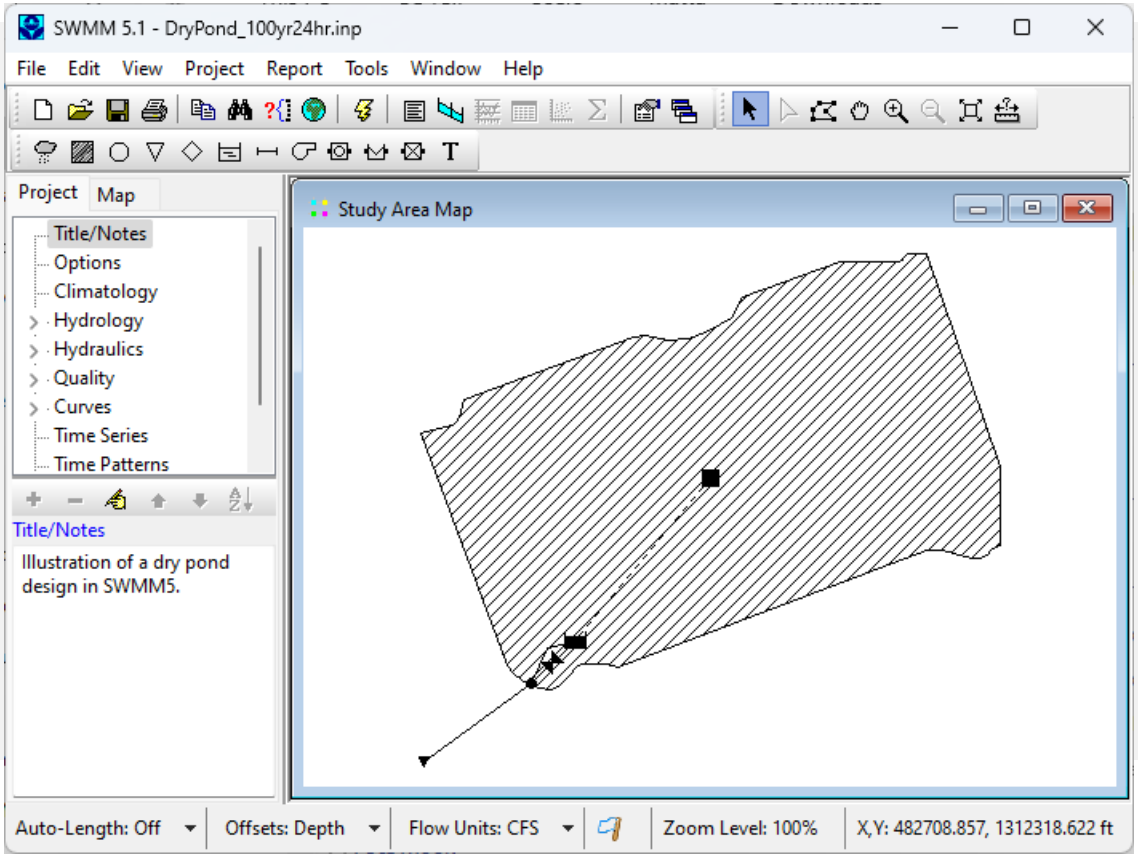
Improving SWMM Modeling with GIS Tools
EPA SWMM User Interface



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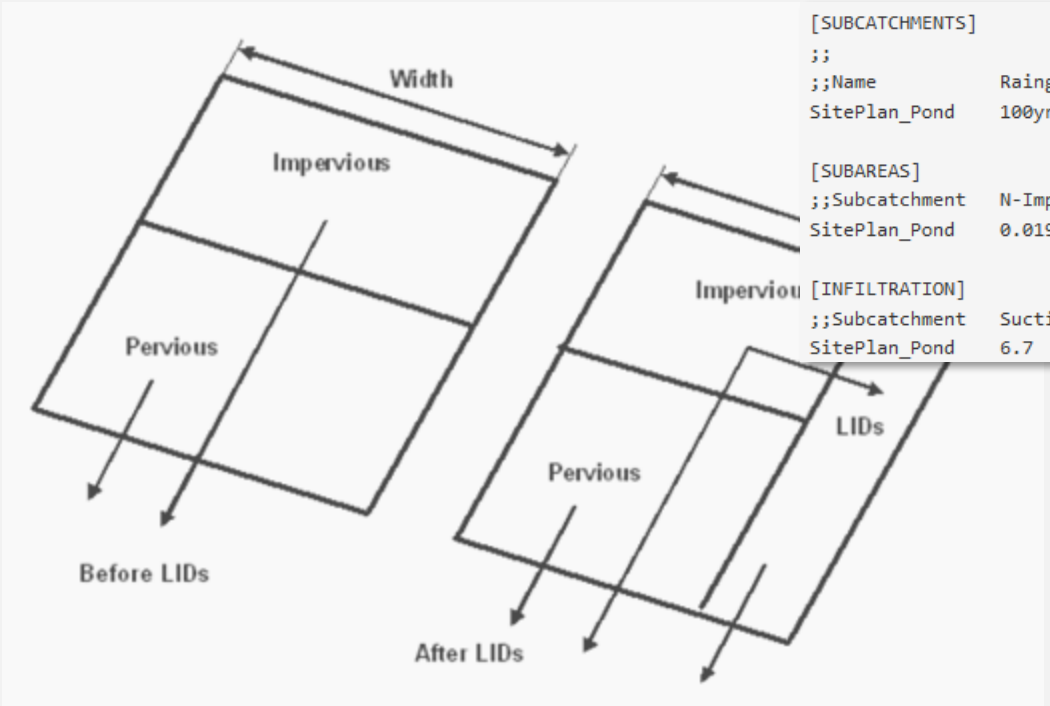
Improving SWMM Modeling with GIS Tools
EPA SWMM Background: Runoff




```
[SUBCATCHMENTS]
;;                                                    Total     Pcnt.             Pcnt.
;;Name           Raingage         Outlet              Area      Imperv   Width    Slope
SitePlan_Pond    100yr24hr_SCSType2-FL_11.4in Storage 1.4741 58.078  142.693  0.5

[SUBAREAS]
;;Subcatchment   N-Imperv   N-Perv     S-Imperv   S-Perv     PctZero    RouteTo    Pc
SitePlan_Pond    0.019      0.107      1.753      0.107      18.55      PERVIOUS   42

[INFILTRATION]
;;Subcatchment   Suction    HydCon     IMDmax
SitePlan_Pond    6.7        0.26       0.37
```

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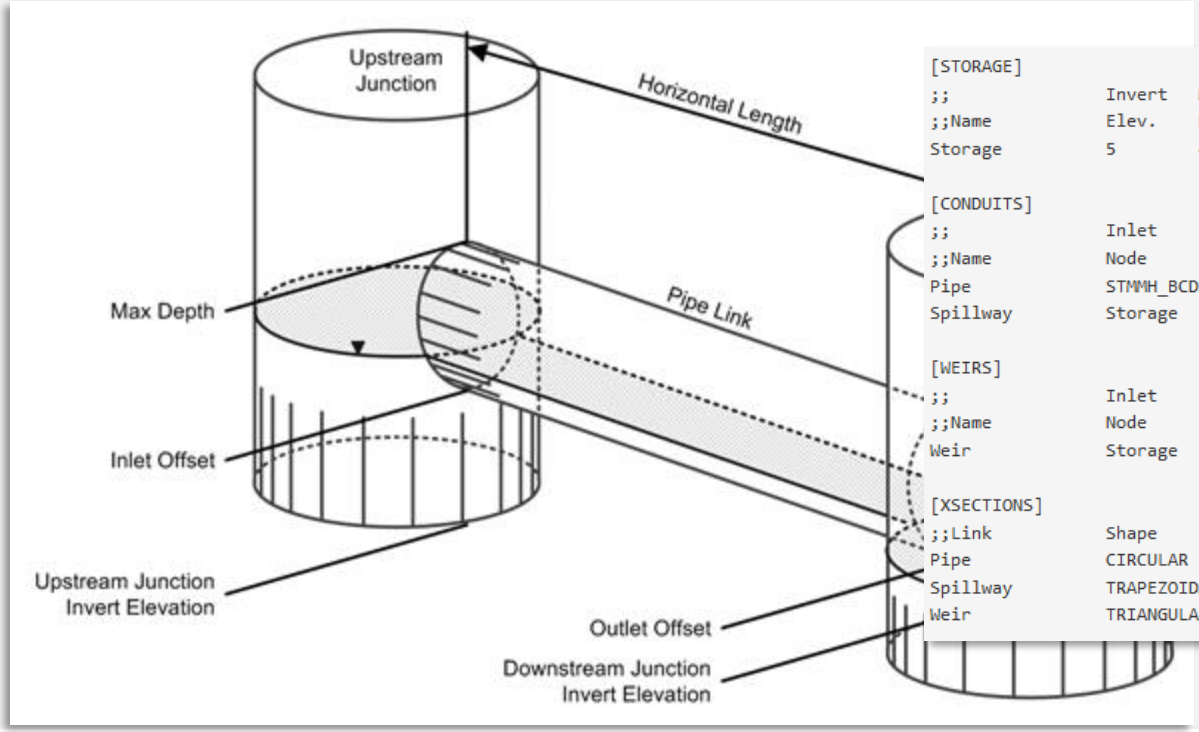
Improving SWMM Modeling with GIS Tools
EPA SWMM Background: Hydraulics




```
[STORAGE]
;;              Invert   Max.     Init.    Storage    Curve
;;Name          Elev.    Depth    Depth    Curve      Params
Storage         5        4        0        TABULAR    sStorage                  0

[CONDUITS]
;;              Inlet            Outlet                      Manning    Inlet
;;Name          Node             Node             Length     N          Offset
Pipe            STMMH_BCD2400    OF1              85         0.014      0
Spillway        Storage          STMMH_BCD2400    30         0.025      3.5

[WEIRS]
;;              Inlet            Outlet           Weir       Crest      Disch.
;;Name          Node             Node             Type       Height     Coeff.
Weir            Storage          STMMH_BCD2400    V-NOTCH    0          3.33

[XSECTIONS]
;;Link          Shape        Geom1            Geom2      Geom3      Geom4      Barr
Pipe            CIRCULAR     1.5              0          0          0          1
Spillway        TRAPEZOIDAL  0.5              2          5          5          1
Weir            TRIANGULAR   4                0.3        0          0
```

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Improving SWMM Modeling with GIS Tools

SWMM GIS Tools

TUFLOW

SWMM GIS Tools
Motivation

TUFLOW Added SWMM as Alternative 1D Engine

ESTRY (TUFLOW 1D) has Rich GIS Integration

Desired Similar Functionality for SWMM users

Created Tools within TUFLOW QGIS Plugin

Model data courtesy of the City of San Antonio (no endorsement implied)

TUFLOW

SWMM GIS Tools
Why Put SWMM Data in GIS?

Interchangeable – Easy to convert formats

Improved Mapping – Unlimited options

Easy to Post Online

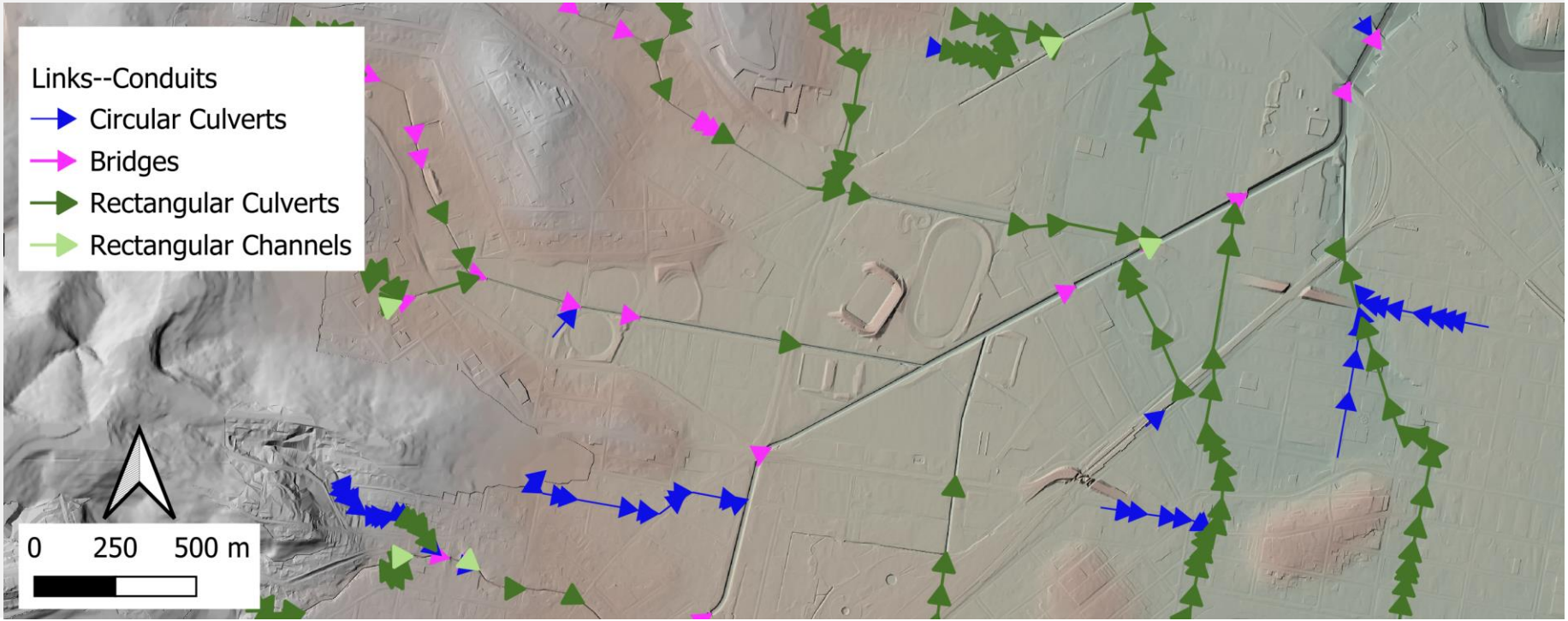
Universal – Used by nearly all Engineers

Free (QGIS) and Paid Options (ArcGIS)

Scriptable

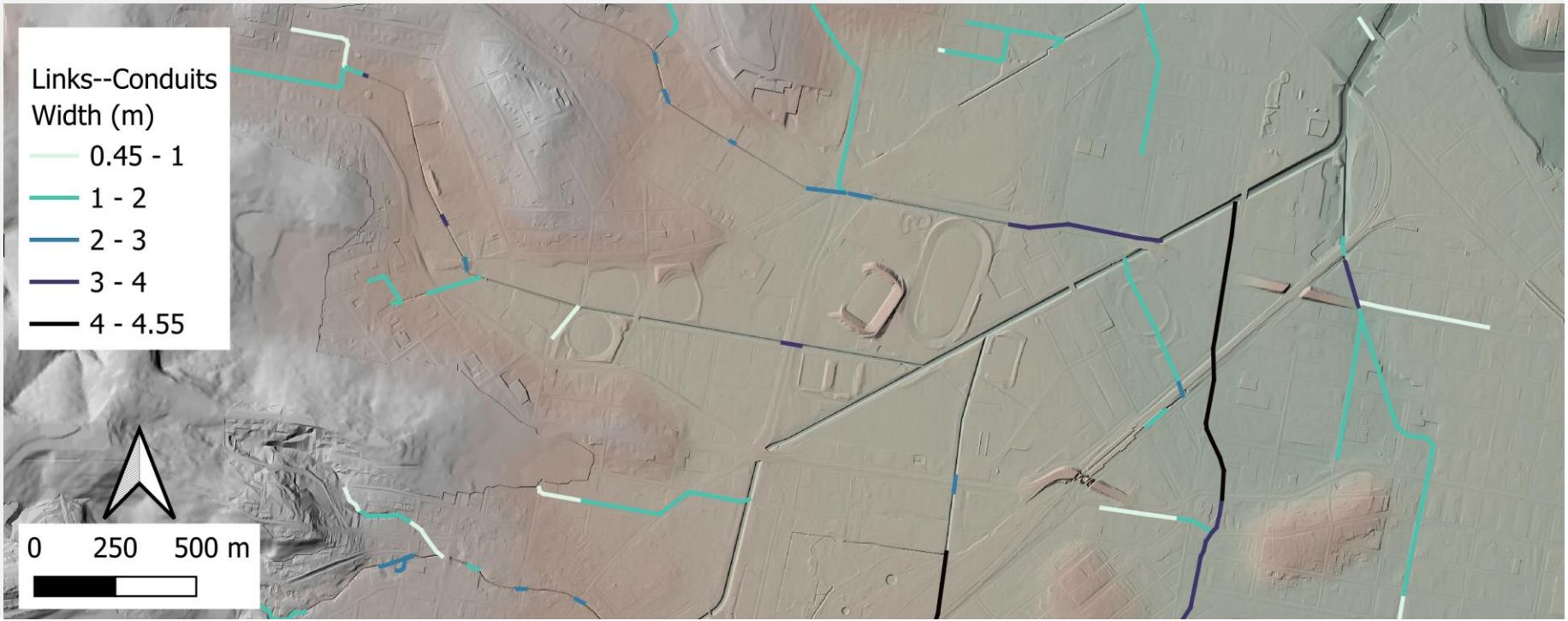
TUFLOW

SWMM GIS Tools
GIS Symbology – The Sky is the Limit



TUFLOW

SWMM GIS Tools
GIS Symbology – The Sky is the Limit



TUFLOW

SWMM GIS Tools
GIS Symbology – The Sky is the Limit

TUFLOW

SWMM GIS Tools
GIS Symbology – The Sky is the Limit

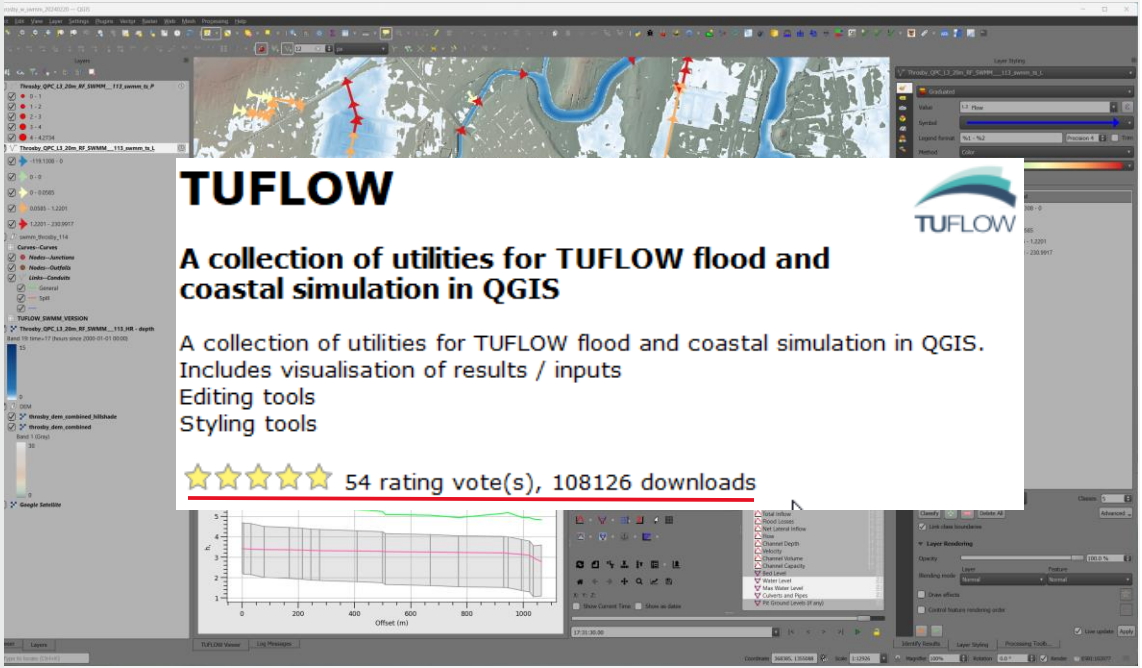
TUFLOW

SWMM GIS Tools
TUFLOW QGIS Plugin Introduction

QGIS is Free and Open-source GIS Application

TUFLOW Plugin

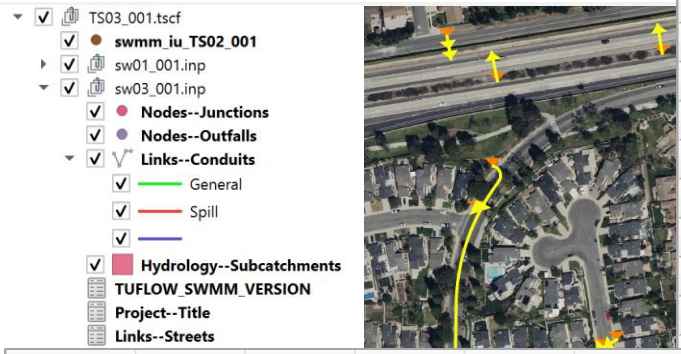
- **Free**
- **Downloaded from the plugin repository**
- **Tools for**
  - TUFLOW 2D model data
  - TUFLOW 1D model data (ESTRY)
  - And now SWMM



TUFLOW

SWMM GIS Tools
GeoPackage files

- SQLite database
- Open non-proprietary format
- Multiple layers within a single file (Functions as a geo-database)
- Interoperable
  - QGIS
  - ArcGIS
- Spatially Indexed – super fast
- Spatial and non-spatial data



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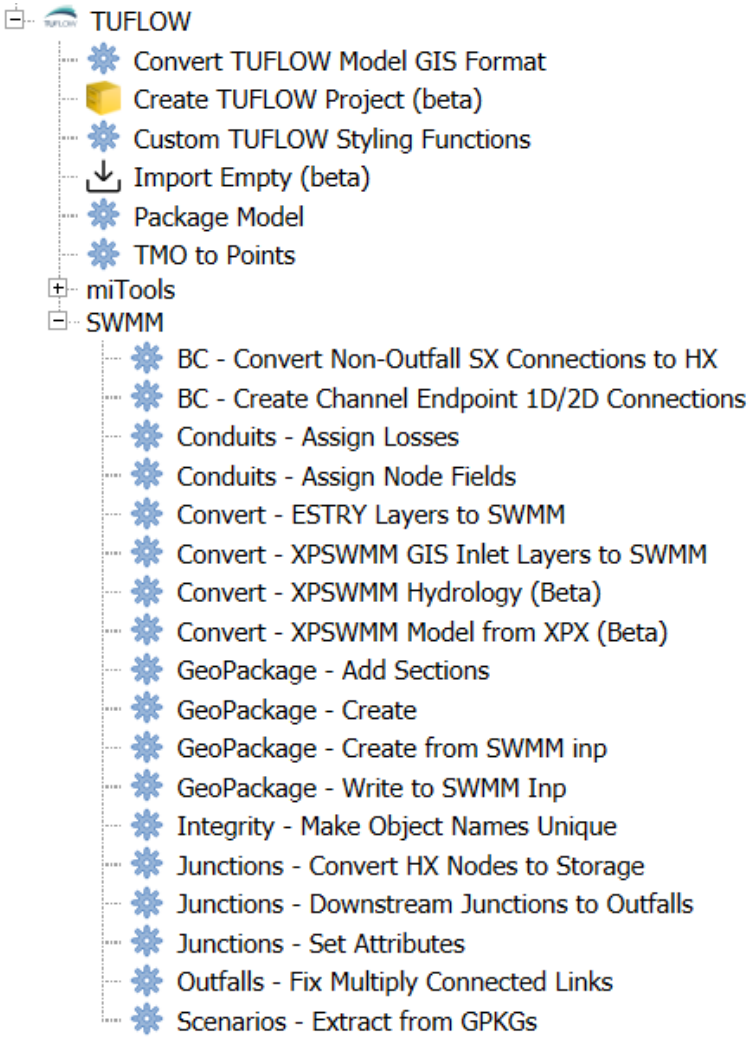
1	1	FLOW_UNITS	CMS
2	2	INFILTRATION	GREEN_AMPT
3	3	FLOW_ROUTING	DYNWAVE
4	4	LINK_OFFSETS	DEPTH
5	5	FORCE_MAIN_E...	H-W
6	6	IGNORE_RAINF...	NO
7	7	IGNORE_SNOW...	YES
8	8	IGNORE_GROU...	YES
9	9	IGNORE_RDII	YES
10	10	IGNORE_QUALI...	YES
11	11	ALLOW_PONDI...	YES
12	12	SKIP_STEADY_S...	YES
13	13	SYS_FLOW_TOL	1
14	14	LAT_FLOW_TOL	1
15	15	START_DATE	2020-01-01
16	16	START_TIME	00:00
17	17	END_DATE	2000-01-01
18	18	END_TIME	06:00
19	19	REPORT_START...	2000-01-01
20	20	REPORT_START...	00:00
21	21	SWEEP_START	01/01
22	22	SWEEP_END	01/01

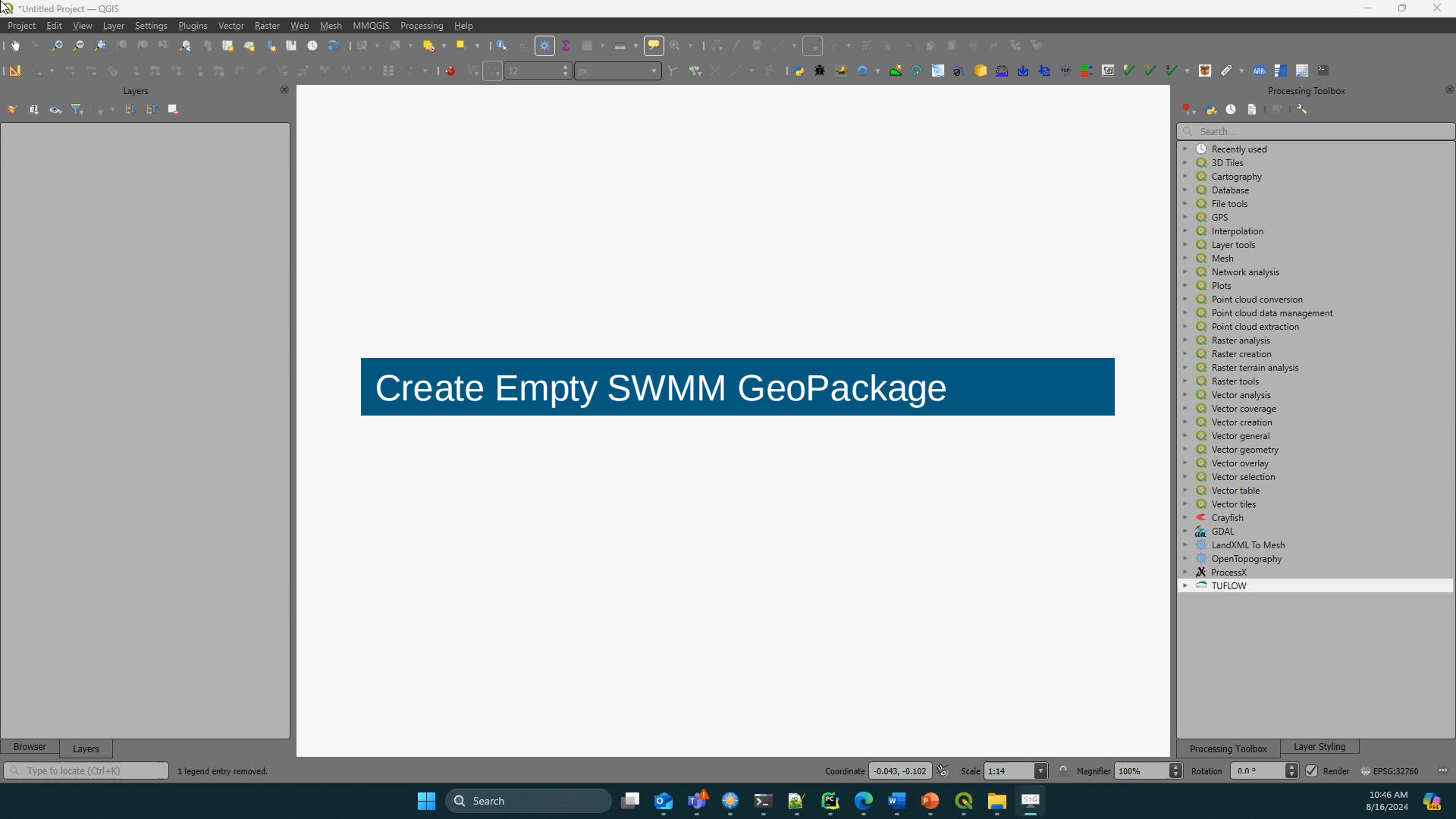
	fid	Name	Elev	Ymax	Y0	Ysur	Apond
1	1	Pit10	40.8	0	0	0	0
2	2	Pit11	40.6	0	0	0	0
3	3	Pit13	40	0	0	0	0
4	4	Pit15	41.4739	0	0	0	0
5	5	Pit17	41.81778	0	0	50	1
6	6	Pit18	41.91283	0	0	0	0
7	7	Pit19	42.19779	0	0	0	0
8	8	Pit2	41.96784	0	0	0	0
9	9	Pit3	41.84937	0	0	50	1
10	10	Pit4	41.95067	0	0	0	0
11	11	Pit5	42.4	0	0	0	0
12	12	Pit6	42.35	0	0	0	0
13	13	Pit7	41.65546	0	0	0	0
14	14	Pit9	41.30769	0	0	0	0

SWMM GIS Tools
TUFLOW Plugin - SWMM Tools

- **SWMM GeoPackage files**
  - Create/Add sections
  - Convert to and from EPA SWMM inp files
- **Integrity Tools**
- **Model Editing Tools**
- **Model Conversions (to SWMM)**
  - From ESTRY
  - From XPSWMM



TUFLOW


*Untitled Project — QGIS
Project Edit View Layer Settings Plugins Vector Raster Web Mesh MMQGIS Processing Help
Layers
Create Empty SWMM GeoPackage
Processing Toolbox
Search...
Recently used
3D Tiles
Cartography
Database
File tools
GPS
Interpolation
Layer tools
Mesh
Network analysis
Plots
Point cloud conversion
Point cloud data management
Point cloud extraction
Raster analysis
Raster creation
Raster terrain analysis
Raster tools
Vector analysis
Vector coverage
Vector creation
Vector general
Vector geometry
Vector overlay
Vector selection
Vector table
Vector tiles
Crayfish
GDAL
LandXML To Mesh
OpenTopography
ProcessX
TUFLOW
Browser
Layers
Processing Toolbox
Layer Styling
Type to locate (Ctrl+K)
1 legend entry removed.
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Magnifier 100%
Rotation 0.0 °
Render
EPSG:32760
Search
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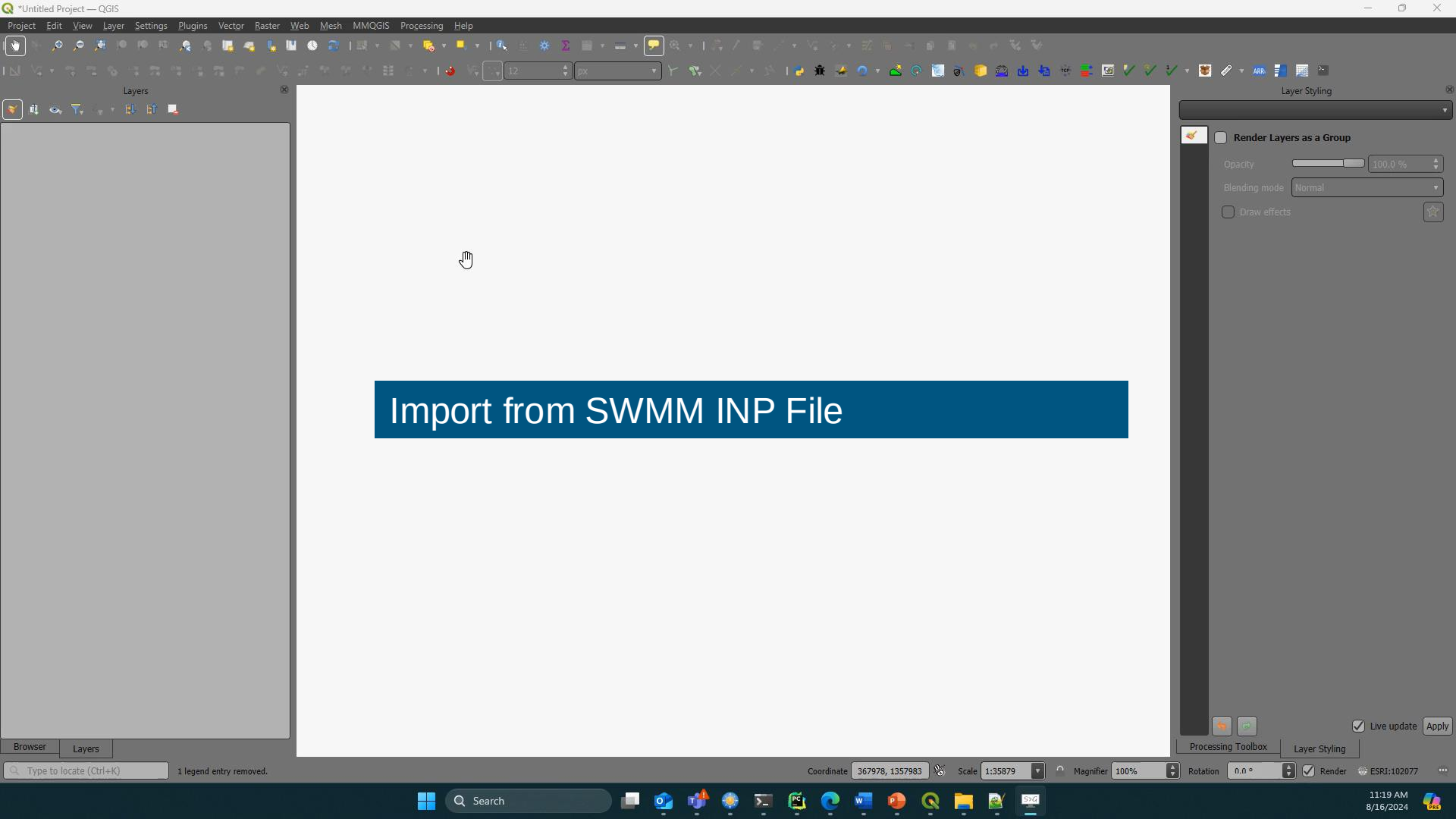
8/16/2024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Project Edit View Layer Settings Plugins Vector Raster Web Mesh MMQGIS Processing Help
Layers
Import from SWMM INP File
Layer Styling
Render Layers as a Group
Opacity
100.0 %
Blending mode
Normal
Draw effects
Live update
Apply
Browser
Layers
Processing Toolbox
Layer Styling
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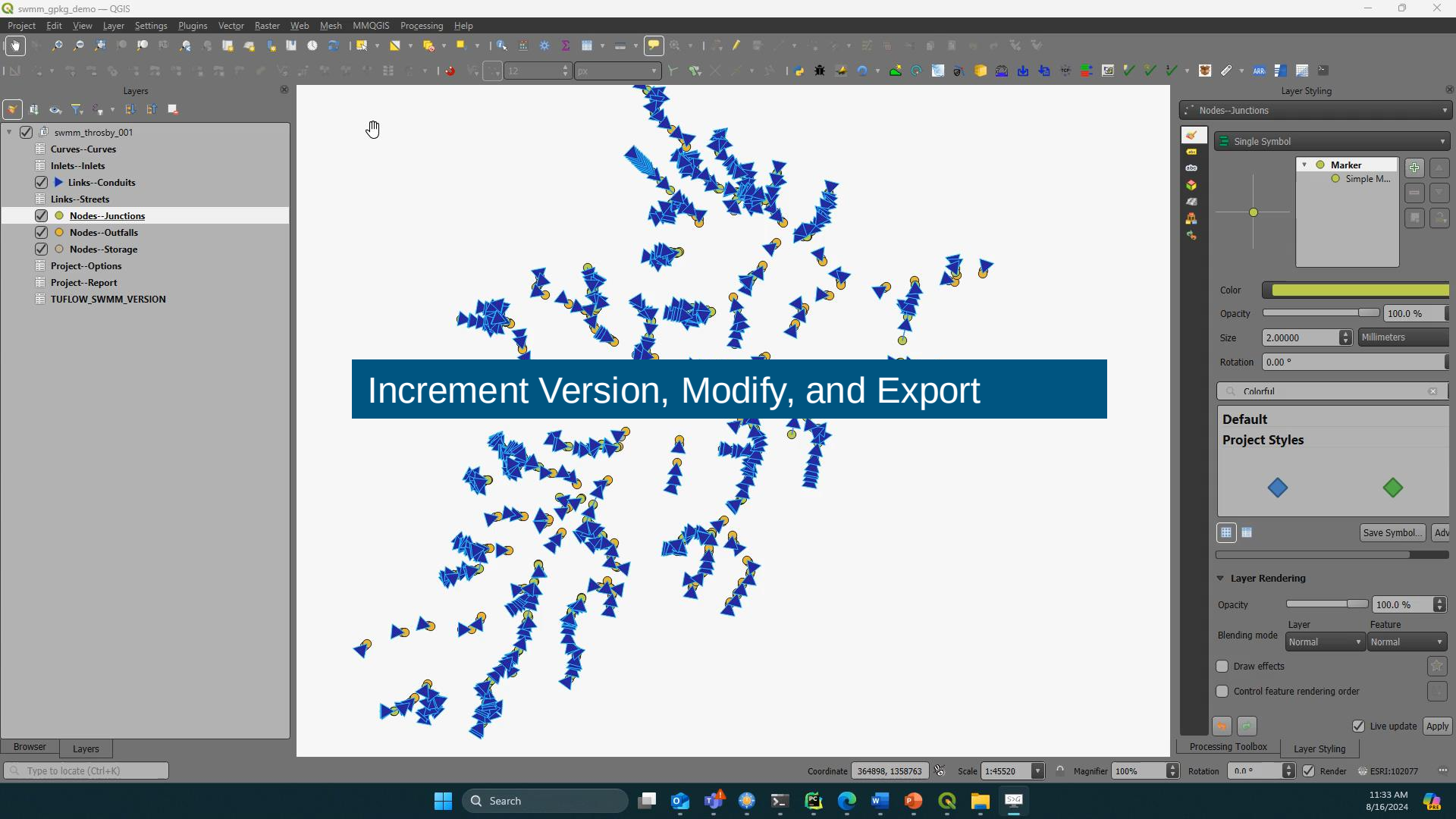
8/16/2024

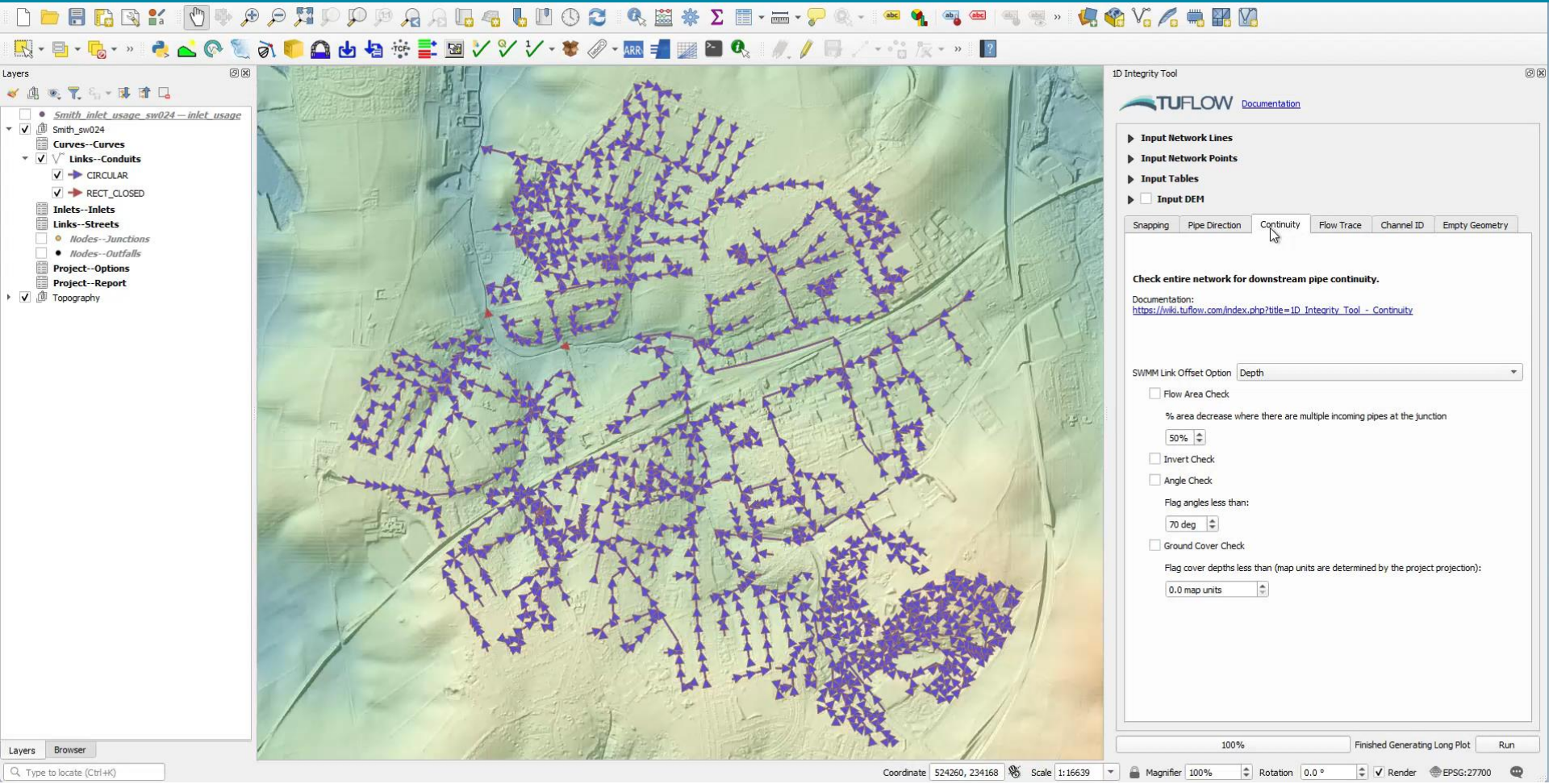

swmm_gpkg_demo — QGIS
Project Edit View Layer Settings Plugins Vector Raster Web Mesh MMQGIS Processing Help
Layers
swmm_throsby_001
Curves--Curves
Inlets--Inlets
Links--Conduits
Links--Streets
Nodes--Junctions
Nodes--Outfalls
Nodes--Storage
Project--Options
Project--Report
TUFLOW_SWMM_VERSION
Increment Version, Modify, and Export
Layer Styling
Nodes--Junctions
Single Symbol
Marker
Simple M...
Color
Opacity
100.0 %
Size
2.00000
Millimeters
Rotation
0.00 °
Colorful
Default
Project Styles
Save Symbol...
Layer Rendering
Opacity
100.0 %
Blending mode
Layer
Feature
Normal
Normal
Draw effects
Control feature rendering order
Live update
Apply
Processing Toolbox
Layer Styling
Browser
Layers
Type to locate (Ctrl+K)
Coordinate 364898, 1358763
Scale 1:45520
Magnifier 100%
Rotation 0.0 °
Render
ESRI:102077
Search
11:33 AM
8/16/2024

Improving SWMM Modeling with GIS Tools

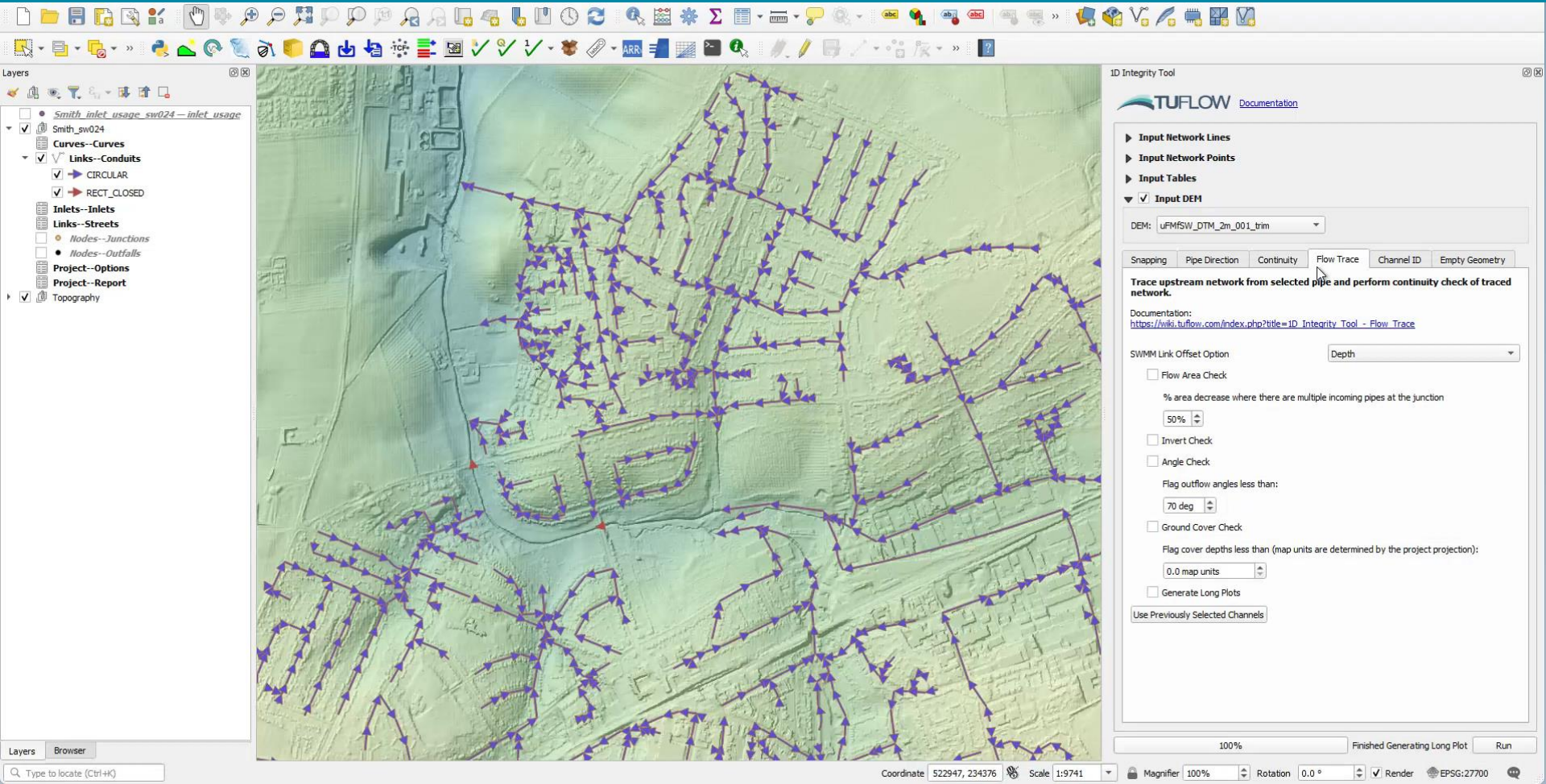
1D Integrity Tools

TUFLOW

Pipe Integrity Tool: Continuity Check



Pipe Integrity Tool: Flow Trace



Improving SWMM Modeling with GIS Tools

SWMM coupled with TUFLOW

TUFLOW

TUFLOW
Linkages to 1D Models

- 1990 ESTRY (TUFLOW 1D)
- 2006 XPSWMM
- 2006 FloodModeller (ISIS)
- 2012 12D Dynamic Drainage Analysis (SWMM)
- 2024 TUFLOW-SWMM

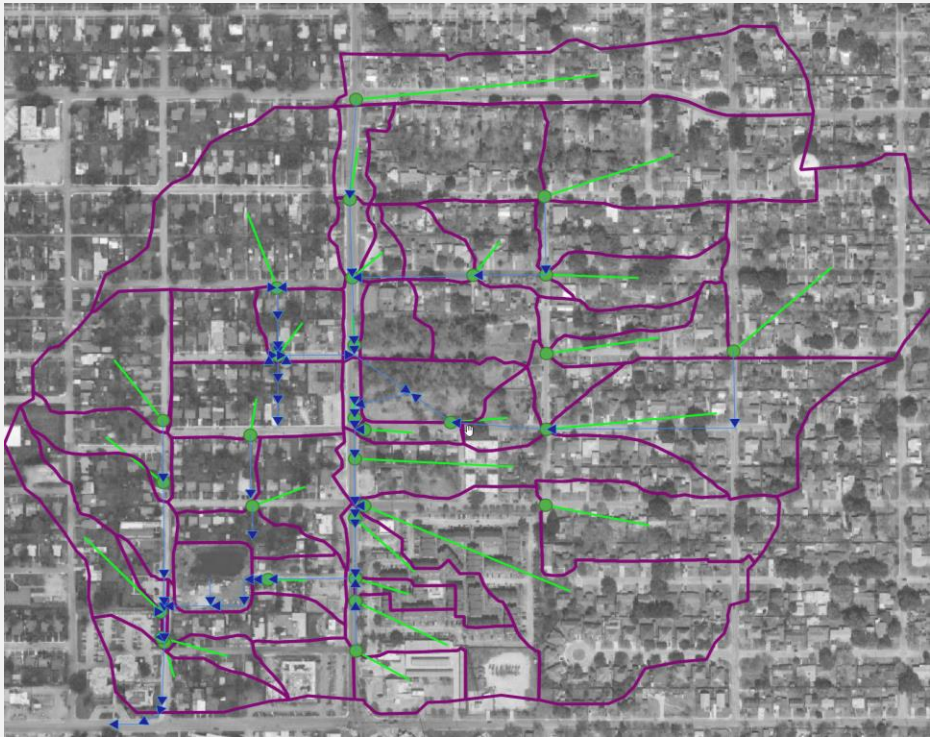
TUFLOW

TUFLOW-SWMM Introduction

Reasons we Added SWMM:

- **Allow users to leverage existing models**
- **Many potential users familiar with SWMM**
- **SWMM embedded in many applications**
- **3rd party editing and visualization tools exist**

TUFLOW-SWMM uses EPA SWMM 5 inp files (can be generated from the GIS tools or separately)



Model data courtesy of the City of San Antonio (no endorsement implied)

TUFLOW

TUFLOW-SWMM
Value Added Features

1. 1D/2D Models

a) 2D solver (GPU, SGS, Quadtree)

b) HEC-22 inlets and direct 1D/2D connections

c) Rain on grid or SWMM hydrology

2. Scenarios and Events

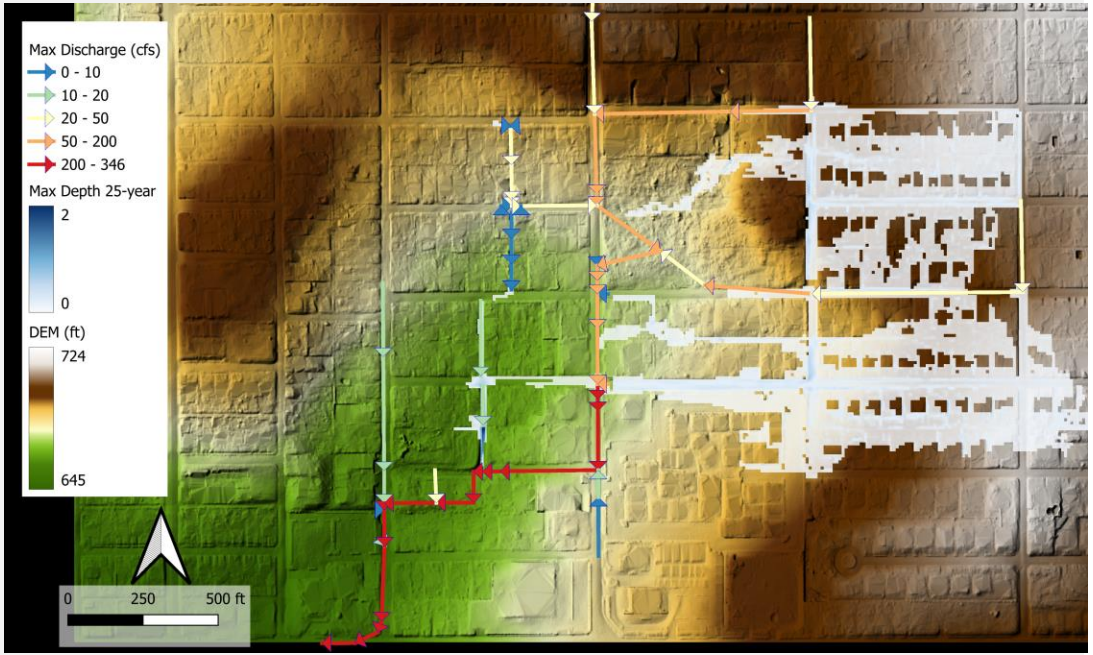
a) Alternatives without duplicating input data

b) Curves from bc database

3. GeoPackage Time-series Results

a) Symbolize node and link results

b) Time-series and profile



Model data courtesy of the City of San Antonio (no endorsement implied)

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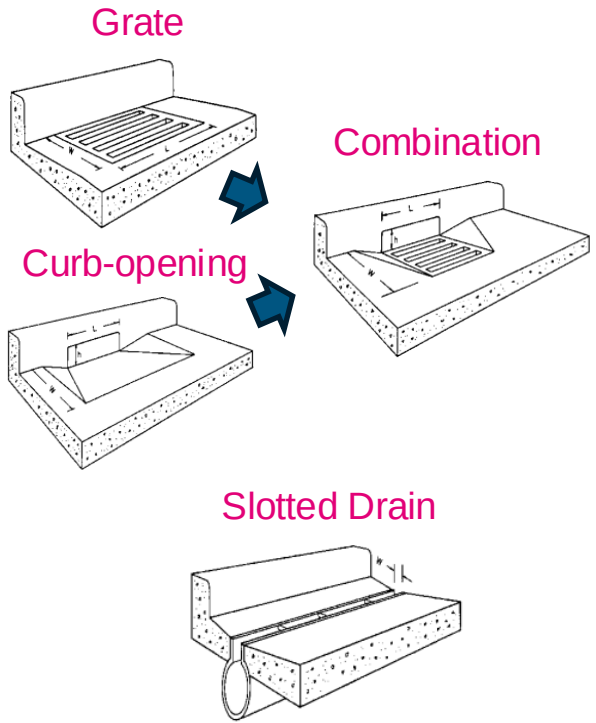
TUFLOW-SWMM – 1D/2D Modeling
Stormwater Pipe Network Inlets

Based on Federal Highway Administration HEC 22 Urban Drainage Design Manual

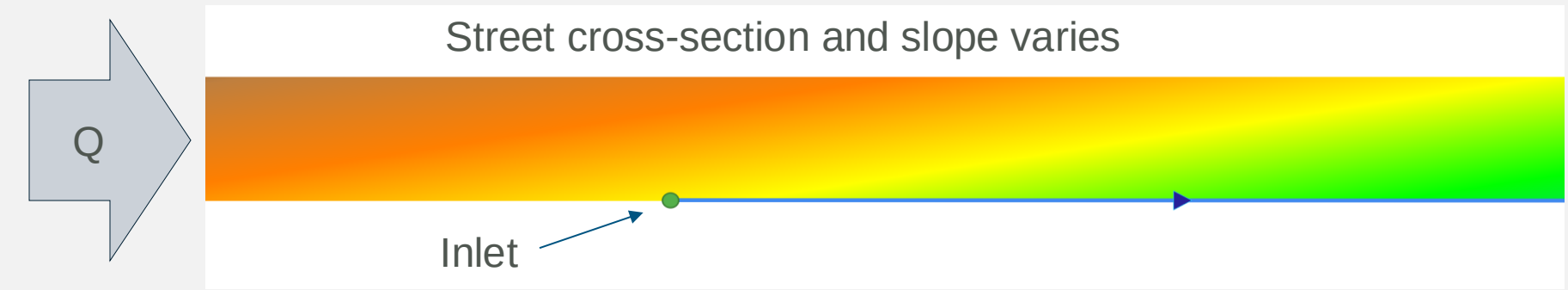
- Multiple inlet types including based upon custom curves
- On Sag inlets driven by WSE (from 2D model)
- On Grade inlets incorporate approach flows and velocities (from 2D)
- Uses modified EPA SWMM code to compute capture discharge



Inlet diagrams from HEC No 22, Third Edition

TUFLOW

TUFLOW-SWMM
Inlet (1D/2D Connection) Benchmarking



Comparison	HEC-22	TUFLOW-SWMM
Example 4-1: Flow spread in gutter (m)	2.7	2.9
Example 4-8: Capture flow P-50 Grate (cms)	0.091	0.090
Example 4-9a1: Capture flow curb inlet (cms)	0.031	0.030
Example 4-10: Capture flow inlet (cms)	0.049	0.047

TUFLOW

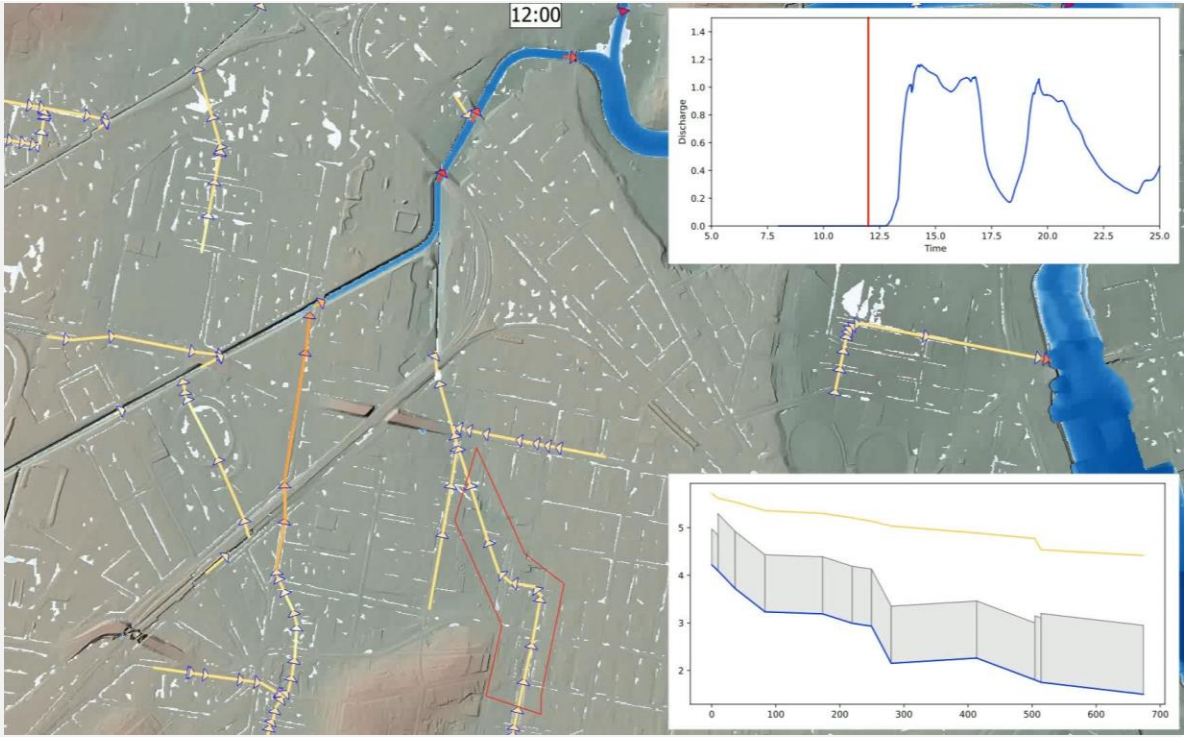
TUFLOW-SWMM
Result Viewing QGIS

2D (TUFLOW)

- Mesh or Raster coloring
- Time-series plots

1D (SWMM)

- GeoPackage based
- Channel and node results
- Dynamic color/size symbology base by result magnitude
- Time-series plots
- Section plots



TUFLOW

TUFLOW-SWMM – 1D/2D Modeling
Result Viewing using ArcGIS

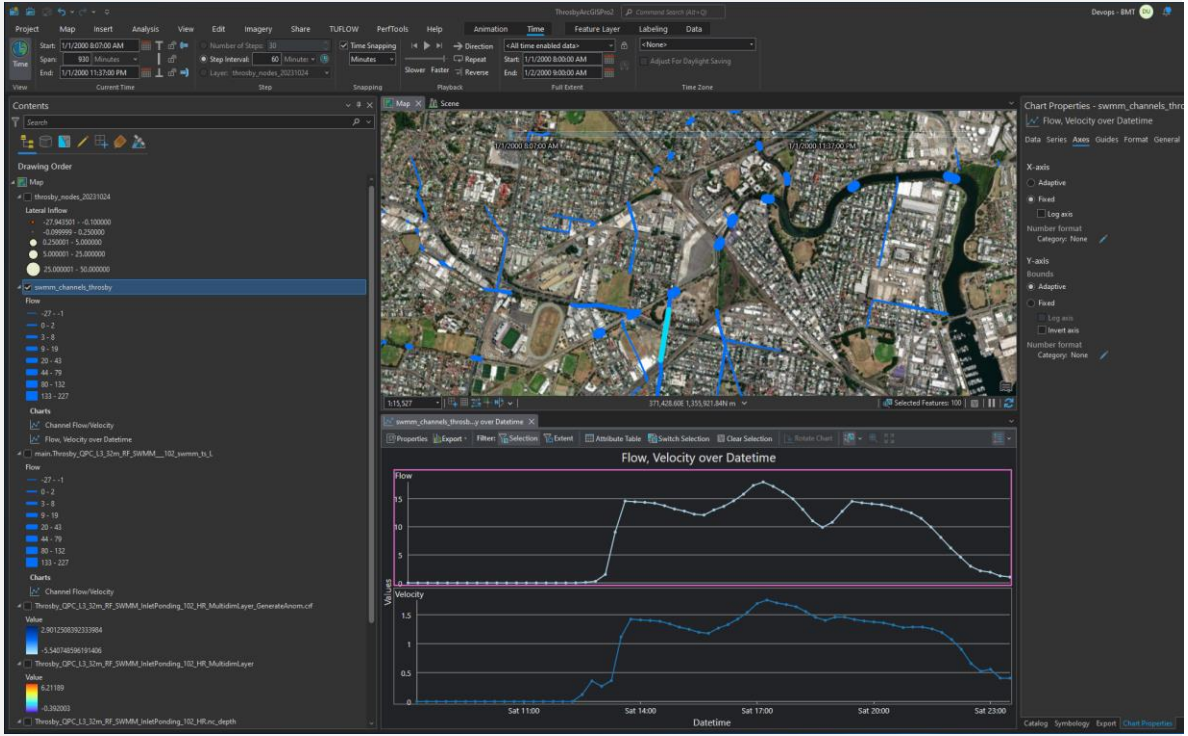
2D (TUFLOW)

- Contours
- Animations

1D (SWMM)

- GeoPackage based
- Channel and node results

Hint: Sometimes converting to ESRI formats reduces issues.



TUFLOW

TUFLOW-SWMM
Learning Resources

Free Tutorials: https://wiki.tuflow.com/TUFLOW_SWMM_Tutorial_Introduction

1. 1D SWMM Culverts
2. 1D SWMM Pipe Network / 2D TUFLOW Direct Rainfall Hydrology
3. 1D SWMM Pipe Network / 1D SWMM Urban Hydrology
4. 1D SWMM Pipe Network / 1D SWMM Urban Hydrology: Executing multiple events from a single model
5. XPSWMM to TUFLOW SWMM - How to convert an XPSWMM model to TUFLOW SWMM

TUFLOW 2023 Release Notes https://docs.tuflow.com/classic-hpc/release/latest

Past TUFLOW webinars: https://www.tuflow.com/library/webinars/

Email support@tuflow.com or sales@tuflow.com: Let us know if you have questions or need help?

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