Lower Rio Grande Valley Development Council Flood Infrastructure Fund (TWDB Commitment No. G1001288)

Hydraulic Model Data File Construction Code Deployment

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2 Introduction

The StormWater INfrastructure Geodata (SWING) is an ongoing effort to facilitate geospatial data collection using desktop and handheld devices, with a specific end-goal of feeding hydrologic and hydraulic models. The initial deployment, documented in this report, seeks to characterize urban stormwater infrastructure elements via mobile devices using the ArcGIS suite for use in U.S. EPA's StormWater Management Model. The data collection process can be reviewed in real-time and processed to convert it into .inp files that support an easier implementation in SWMM.

The SWING tool provides an end-user targeted capability to collect and utilize geospatial data specific to their stormwater conveyance systems. Critical to a hydraulic modeling effort is adequate characterization of collection and conveyance system with sufficient detail in critical locations to enable sufficient rigor and accuracy in the predictions for use in decision making. The tool is designed in such a way as to facilitate incremental data collection with feedback from a parallel modeling effort. This approach allows data collection to be informed by model sensitivity and model detail to be informed by data availability. Data collection and model development expenditures can then be limited to the scale and scope required by the management decision.

SWING enables the collection if stormwater infrastructure data using iOS or Android mobile devices. The mobile app can be utilized in the field using the devices GPS or from an office environment using Google Earth or other map overlays from which infrastructure can be geolocated. Internet connection is encouraged for real-time data upload; however, the offline option allows the user to download specific areas to use at sites with no internet connection. Data is uploaded later when the mobile device gets access to internet connection.

3 Feature Layers

Data collected is stored as shapefile layers representative of the most important elements within a stormwater system. In SWING, four layers are created to emulate SWMM’s main inputs: Nodes, Links, and Subcatchments, with details regarding their settings provided below.

3.1 Subcatchment Polygon Layer

This feature layer was created with the intention of helping the user draw the subcatchments along the system or the potential area of study, auto calculating the surface area and displaying it in hectares. Fields added to this feature layer, shown in Table 1, allow the user to add the values that better describe the subcatchments. The first column “ArcGIS Name” refers to the given name for each editable field of the subcatchment layer, these names were set to match the following dictionaries, 1) QGIS Dictionary for its SWMM Plugin, 2) The Stormwater Utility

Network Foundation Data Dictionary by (ESRI, n.d.). The second column "ArcGIS Alias" is the "ArcGIS Alias" which is limited to display layers' name. The third and fourth column display the name equivalence for the QGIS plugin and the Stormwater Utility Network Foundation Data Dictionary respectively. The fifth column, "Type", defines the data type, where:

a) String is for fields that store text, the value in parenthesis refers to the maximum number of characters.
b) Date, to store the date when the data is being collected.
c) Double, for high precise values (number with decimals).

The fifth column "Nullable", lists if the field can be left empty (True) or if it's required to be filled (False).

The fields of each row represent the characteristics of a subcatchment in SWMM.

Table 1. Name given to each layer for Subcatchment layer.

ArcGIS Name	ArcGIS Alias	QGIS	Stormwater Utility Network Foundation Data Dictionary	Type	Nullable
inspector	Inspector	N/A	inspector	String (35)	False
Date_Time	Date and Time	N/A	N/A	Date	False
Name	Subcatchment Area	Name	N/A	String (100)	True
Rain Gage	Rain Gage	Rain Gage	N/A	String (100)	True
Outlet	Outlet	Outlet	N/A	String (100)	True
Area	Area	Area	N/A	Double	True
Imperv	Imperv	Imperv	N/A	Double	True
Width	Width	Width	N/A	Double	True
Slope	Slope	Slope	slope	Double	True
CurbLen	CurbLen	CurbLen		Double	True
SnowPack	SnowPack	SnowPack	N/A	Double	True
N_Imperv	N_Imperv	N_Imperv	N/A	Double	True
N_Perv	N_Perv	N_Perv	N/A	Double	True
S_Imperv	S_Imperv	S_Imperv	N/A	Double	True
S_Perv	S_Perv	S_Perv	N/A	Double	True
PctZero	PctZero	PctZero	N/A	Double	True
RouteTo	RouteTo	RouteTo	N/A	String (100)	True
PctRouted	PctRouted	PctRouted	N/A	Double	True
nfMethod	nfMethod	InfMethod	Infiltration Feature	String (100)	True

SuctHead	SuctHead	SuctHead	N/A	Double	True
Conductiv	Conductiv	Conductiv	N/A	Double	True
InitDef	InitDef	InitDef	N/A	Double	True
MaxRate	MaxRate	MaxRate	N/A	Double	True
MinRate	MinRate	MinRate	N/A	Double	True
Decay	Decay	Decay	N/A	Double	True
DryTime	DryTime	DryTime	Dry	Double	True
MaxInf	MaxInf	MaxInf	N/A	Double	True
CurveNum	CurveNum	CurveNum	N/A	Double	True
Annotation	Notes	Annotation	notes	String (256)	True

3.2 Nodes (Junctions, Inlets, and Outfalls) Point Layer

This is a point layer created to geo-reference all the nodes in the stormwater system (junctions, inlets, and outfalls).

3.2.1 Attribute Table Description

ArcGIS Name	ArcGIS Alias	QGIS	Stormwater Utility Network Foundation Data Dictionary	Type	Nullable
latitude	Latitude (Y)	N/A	N/A	Double	True
longitude	Longitude (X)	N/A	N/A	Double	True
inspector	Inspector	N/A	inspector	String (35)	False
assettype	Node Type	N/A	assettype	String (25)	False
Elevation	Invert Elevation	Elevation	invertelev	Double	False
inlet_length	Inlet Length	N/A	N/A	Double	True
inlet_height_width	Height or Width	N/A	N/A	Double	True
MaxDepth	Maximum Depth	MaxDepth	N/A	Double	True
InitDepth	Initial Depth	InitDepth	N/A	Double	True
SurDepth	Surchage Depth	SurDepth	N/A	Double	True
Aponded	Aponded	Aponded	N/A	Double	True
Date_and_Time	Date and Time	N/A	N/A	Date	False

notes	Notes	N/A	notes	String (350)	True
discharge	Discharge	N/A	N/A	String (30)	True
pipe_connection	Pipe Connection	N/A	N/A	String (20)	True
inlet	Inlet	N/A	N/A	String (20)	True
weir	Weir	N/A	N/A	String (20)	True
bmp_flow_points	BMP Flow Points	N/A	N/A	String (30)	True

3.2.2 Type of Node

The “assettype” field refers to the type of node, the user has to select one of the following types of nodes:

- List for Node Type (structure under the manhole) assettype:

Code	Name
0	Unknown
5	Pump
23	Pipe Connection
26	Weir
28	Inlet
29	BMP Flow Points

3.2.2.1 Pipe Connection

If the user selects a Pipe Connection, code 23, one of the following options can be applied:

- If Node Type: DomainName($feature,"assettype") == 'pipe_connection'

Code	Label (Value)
0	Unknown
41	Coupling
42	Cross
43	Elbow

44	End Cap
45	Expansion Joint
48	Reducer
49	Reducing Cross
50	Reducing Tee
53	Sleeve
56	Tee
57	Transition
60	Over Under

3.2.2.2 Weir

If the Node Type option selected by the user is Weir, one the following options can be selected by the user:

If Node Type: DomainName($feature, "assettype") == 'weir'

Code	Name	Description
0	Unknown	Unknown type of weir.
281	Broad-Crested	A weir that typically spans the width of a bioswale, or channel, and operates with higher levels of downstream water.
282	Combination	A weir designed for areas of varying flows of water.
283	Labyrinth	A weir designed to control flow by an increased length in respect to the bioswale or channel's width.
284	Minimum Energy Loss	A weir designed for areas of heavy/torrential storms to minimize flooding upstream.
285	Sharp-Crested	A weir designed to take accurate measurements of flow and discharge.
286	V-Notch	A weir with a "V" shape to minimize the flow of a bioswale or open channel.

3.2.2.3 Inlet

If the node type selected is Inlet, one of the following options has to be selected:

If Node Type: DomainName($feature, "assettype") == 'inlet'

Code	Label (Value)
0	Unknown
204	Grate Inlet
205	Curb Opening Inlet
206	Trench Drain
207	Slotted Drain
208	Combination Inlet

Plus dimensions of the Inlet (length and width).

3.2.2.4 BMP Flow Points

If the Node Type selected is BMP Flow Points, one of the following options can be selected by the user.

- If Node Type: DomainName($feature, "assettype") == 'bmp_flow_points'

Code	Label (Value)	Description
0	Unknown	Unknown type of BMP flow point.
31	BMP Inlet	A flow point into a centralized or decentralized BMP.
32	BMP Treated Outlet	A flow point out of a centralized or decentralized BMP through which stormwater exits following sufficient retention time to allow for particle capture, biogeochemical cycling, or media filtration to reduce the effluent pollutant concentrations.
33	BMP Bypass Outlet	A flow point out of a centralized or decentralized BMP through which stormwater exits when the treatment capacity of the BMP has been exceeded. Stormwater has not had sufficient time to allow for particle capture, biogeochemical cycling, or media filtration, and effluent pollutant concentrations have not been reduced below the influent concentrations.
34	BMP Overflow Outlet	A flow point out of a centralized or decentralized BMP through which stormwater exits when the capacity of the BMP has been exceeded.

3.3 Links (Conduits, Open Channel, Culverts) Polyline Layer

3.3.1 Attribute Table

ArcGIS Name	ArcGIS Alias	QGIS	Stormwater Utility Network Foundation Data Dictionary	Type	Nullable
inspector	Inspector	N/A	inspector	String (35)	False
Date_Time	Date and Time	N/A	N/A	Date	False
assettype	Conduit Type	N/A	assettype	String (25)	False
Length	Length	Length	N/A	Double	True
pipemat	Pipe	N/A	N/A	String (40)	True
open_channel	Open Channel	N/A	N/A	String (12)	True
culvert	Culvert	N/A	N/A	String (15)	True
pipe_slope	Pipe Slope	N/A	slope	Double	True
pipe_diameter	Pipe Diameter	N/A	Stormwater_Pipe_Diameter	Double	True
max_height	Maximum Height	N/A	N/A	Double	True
bottom_height	Bottom Height	N/A	N/A	Double	True
left_slope	Left Slope	N/A	N/A	Double	True
right_slope	Right Slope	N/A	N/A	Double	True
structure_shape	Shape of the Structure	N/A	N/A	Double	True
FromNode	Start Point	FromNode	N/A	Double	True
ToNode	End Point	ToNode	N/A	Double	True
notes	Notes	N/A	N/A	String (350)	True

3.3.2 Type of Conduit

The asset type field that refers to the type of conduit displays the following options:

Code	Name
0	Unknown
4	Pipe

5	Open Channel
6	Culvert

3.3.2.1 Pipe

If the user selects the option Pipe (code = 4) , the user will have to select one of the next two options:

Type of Material:

If DomainName($feature, "assettype") == 'pipemat' :

//If other indicate it in the notes section.

Code	Value
0	Unknown
2	Asbestos Cement - AC
7	Concrete (Non-Reinforced) - CP
11	Copper - COP
13	Ductile Iron - DIP
18	Galvanized Pipe - GP
19	Glass Reinforced Cement - GRC
20	High Density Polyethylene - HDPE
23	Polyethylene - PE
25	Polyvinyl Chloride - PVC
26	Pre-Stressed Concrete Cylinder - PCCP
27	Reinforced Concrete - RCP
30	Steel - SP
100	Other - ZZ

Pipe Diameter:

If DomainName($feature, "assettype") == 'pipe':

Code	Value
0	Unknown
0.5	1/2"
0.75	3/4"

1	1"
1.25	1 1/4"
1.5	1 1/2"
2	2"
2.5	2 1/2"
3	3"
4	4"
6	6"
8	8"
10	10"
12	12"
14	14"
15	15"
16	16"
18	18"
20	20"
24	24"
30	30"
36	36"
40	40"
42	42"
48	48"
54	54"
60	60"
66	66"
72	72"
75	75"

3.3.2.2 Type of Channel

If the user selects the option Open Channel (code = 5), the user will have to select the type of open channel:

If DomainName($feature, "assettype") == 'open_channel':

For open Channel:

Code	Name
0	Unknown
43	Natural
44	Vegetated
45	Hardened

If the user selects the option Culvert (code = 6), the user has to select the type of culvert and the shape of it:

If DomainName($feature, "assettype") == 'Culvert'

Code	Name	Description
0	Unknown	Unknown type of culvert.
81	Pipe Culvert	A culvert made of pipe and typically surrounded by soil or natural materials.
82	Pipe Arch	A culvert made of a pipe that has been shaped into a specific width to form an arch.
83	Box Culvert	A culvert in a box or rectangular shape allowing for the flow of stormwater through an open channel under a roadway
84	Arch Culvert	A culvert in an arch shape allowing for the flow of stormwater through an open channel under a roadway.
85	Bridge Culvert	A culvert allowing for the flow of stormwater through an open channel under a bridge.

If DomainName($feature, "assettype") == 'open_channel': or DomainName($feature, "assettype") == 'Culvert' :

Name	Code
Unknown	0
Circular	1
Rectangular	2
Trapezoidal	3
Triangular	4
Parabolic	5
Rectangular Triangular	6
Irregular	7

Closed Rectangular	8
Other	9

3.3.3 Dimensions

Based on the selected shape of the conduit cross-section, Figure 1, the user can add the dimensions of the conduit, i.e., maximum height, bottom height, left slope, right slope, and top width.

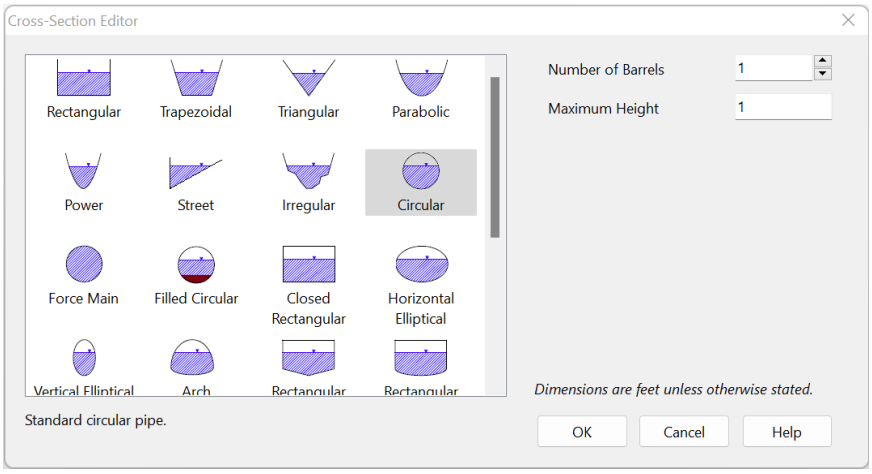

Figure 1. Cross-Section Editor menu in SWMM.

4 Interface Development

The SWING interface is developed through a series of forms that define the data that should be collected for each layer.

4.1 Subcatchments

For the Subcatchment layer, the form builder is depicted in Figure 2.

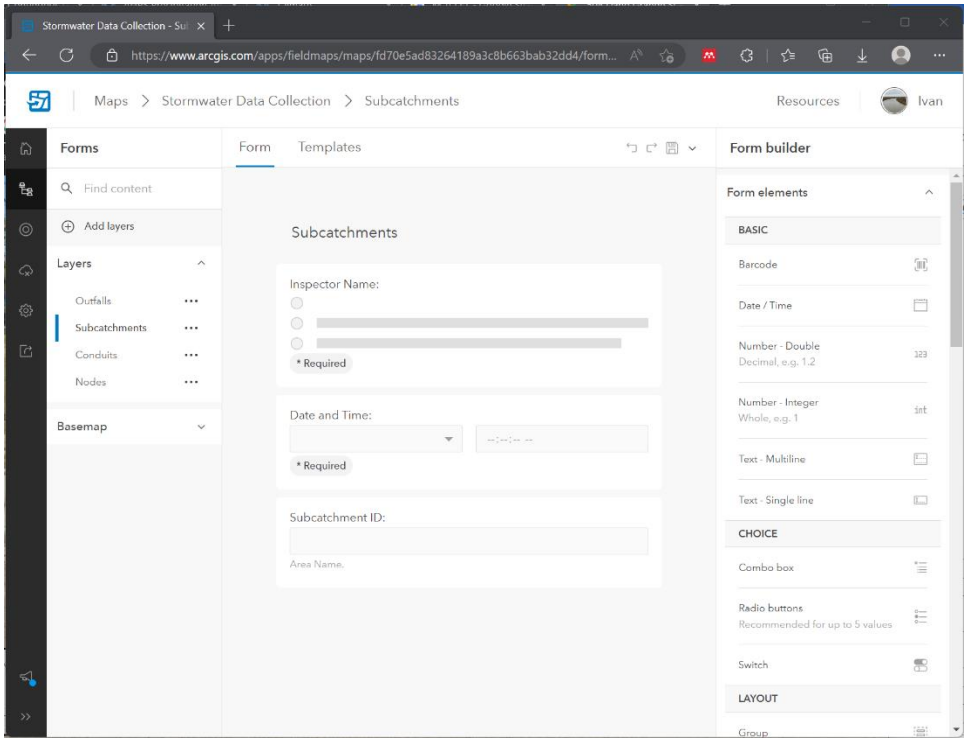

Figure 2. Subcatchment Formbuilder

4.2 Nodes

The type of nodes are defined in the form depicted in Figure 3.

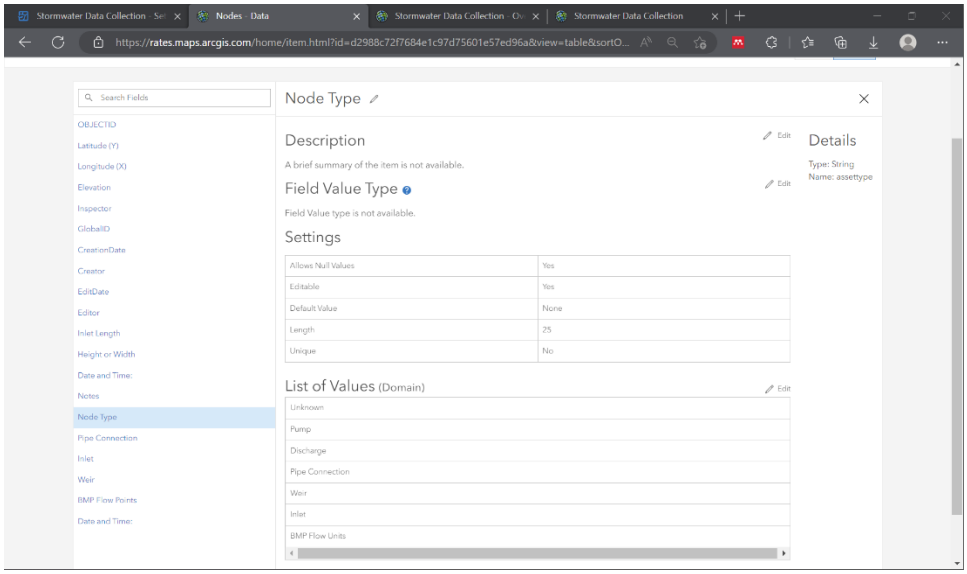

Figure 3. Type of Nodes

Figure 4 depicts the attributes being defined for nodes.

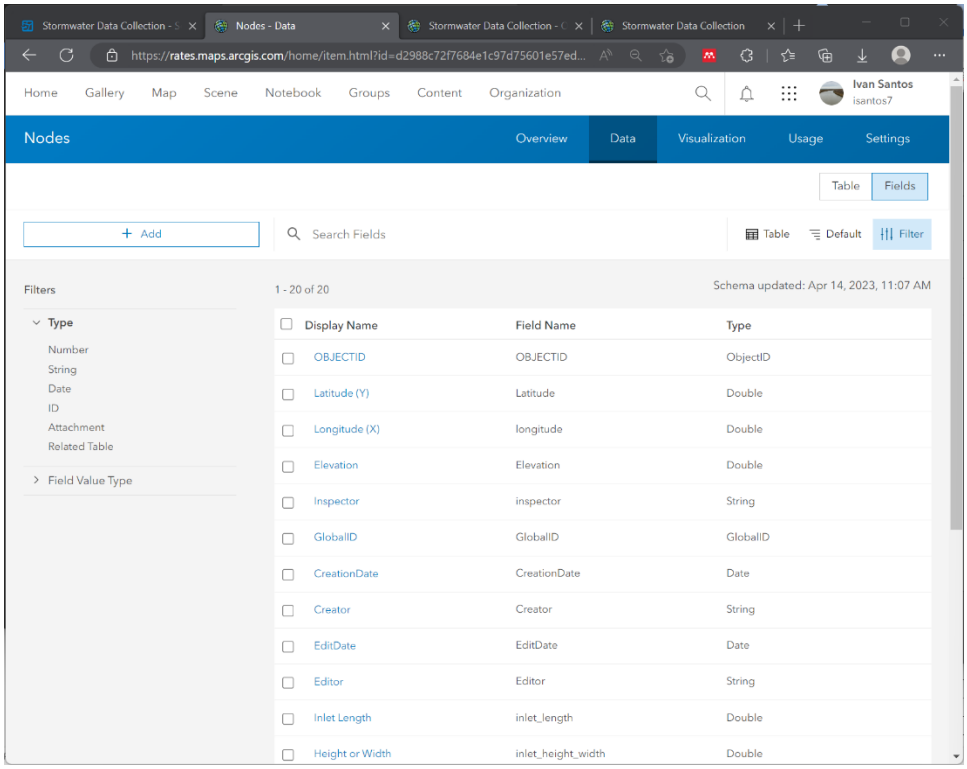

Figure 4. Node Attributes

A separate form is used for defining the visualization template for nodes (Figure 5).

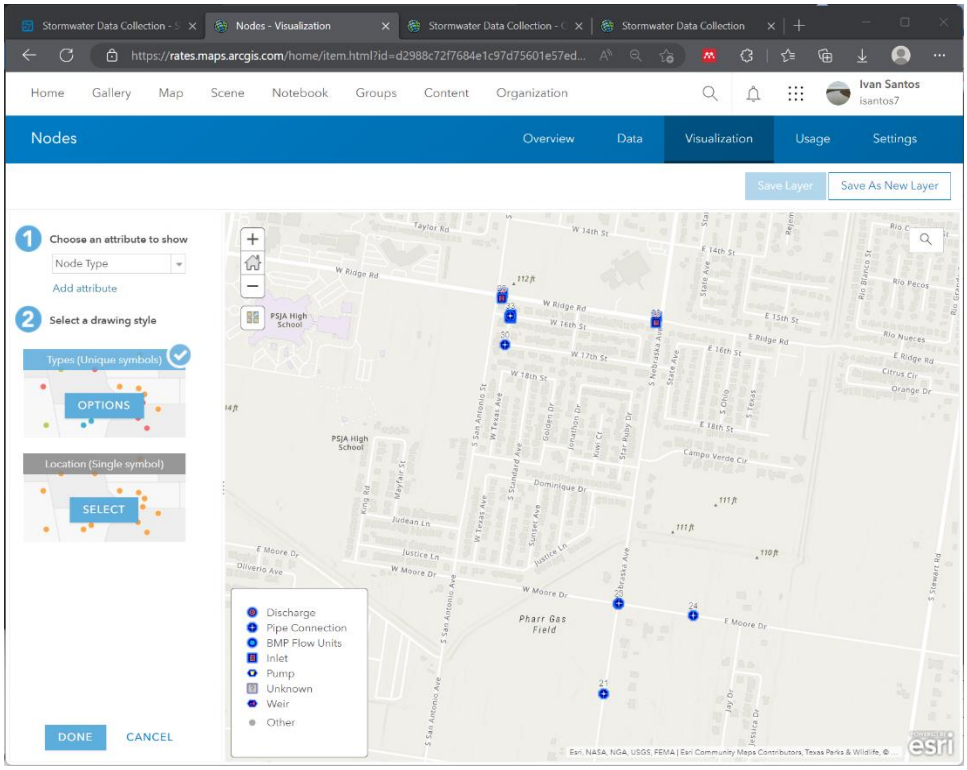

Figure 5. Node Visualization

4.3 Conduits

As with nodes, conduit types are defined in their own form (Figure 6).

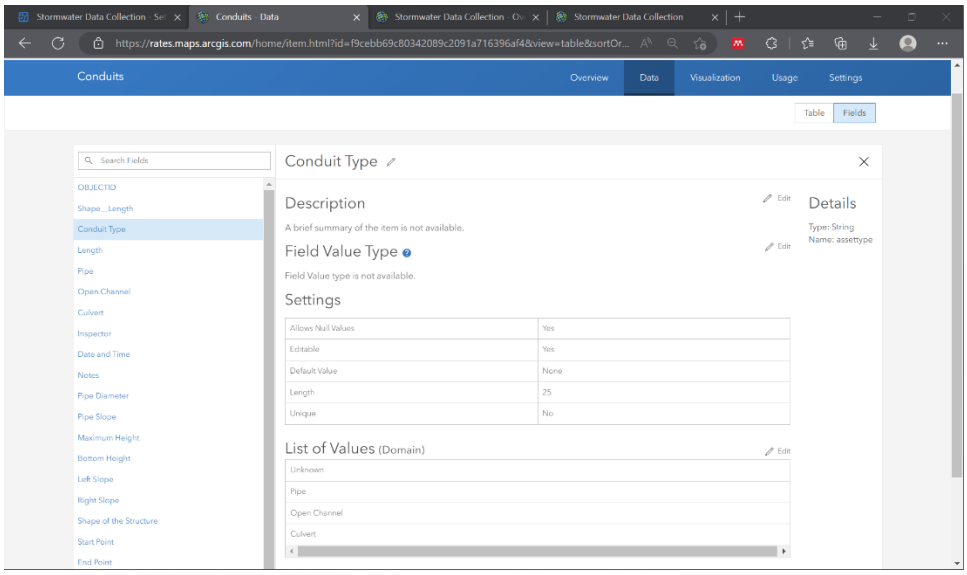

Figure 6. Types of Conduits

Figure 7 depicts the form used for conduit configuration.

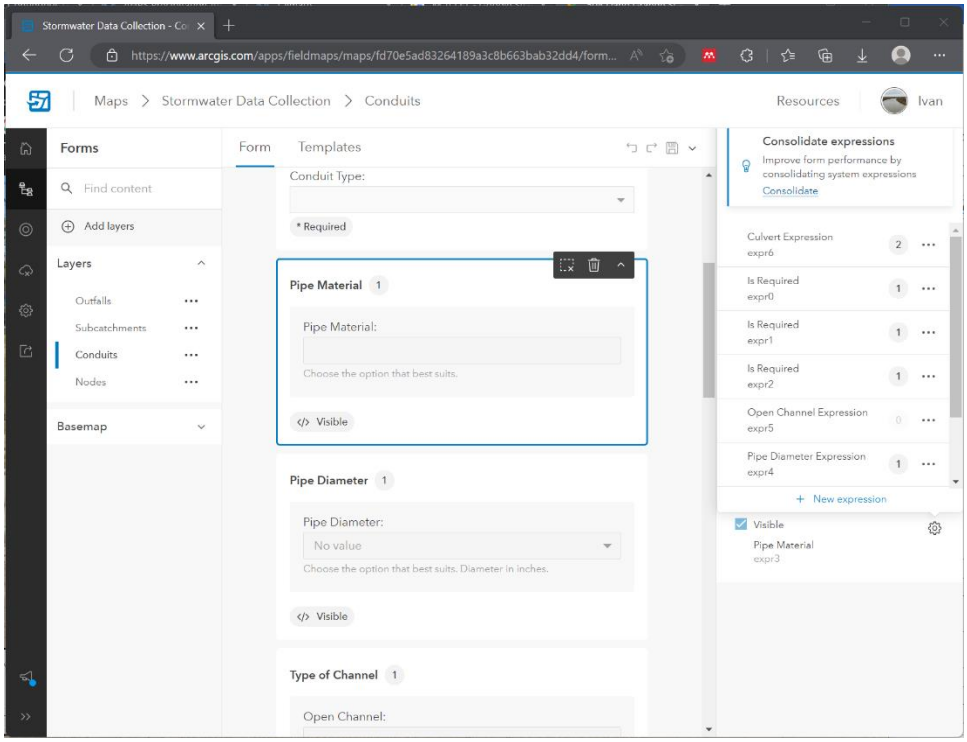

Figure 7. Conduit Configuration

4.4 Web Map Development

A Web Map is developed that contains all the layers and will be displayed for the Field Map (Figure 8 and Figure 9).

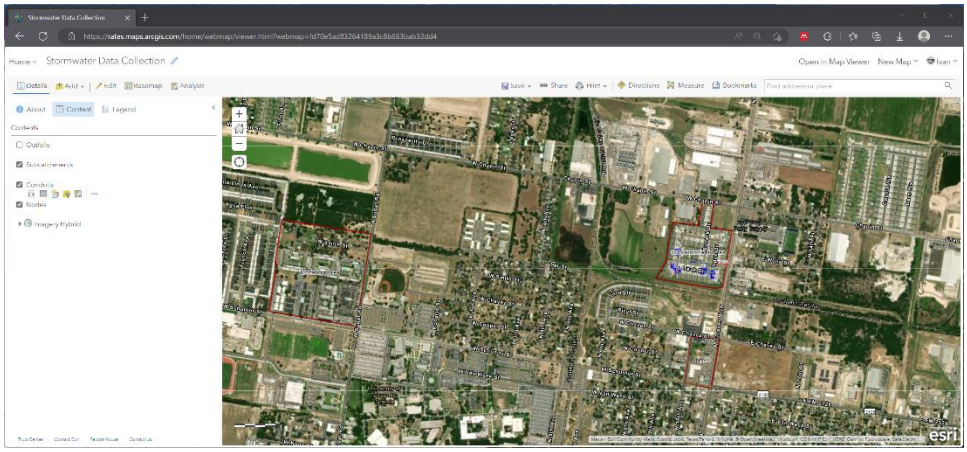

Figure 8. Stormwater data collection web map, with: 1) Nodes, 2) Subcatchments, 3) Conduits, and the Imagery Hybrid base map.

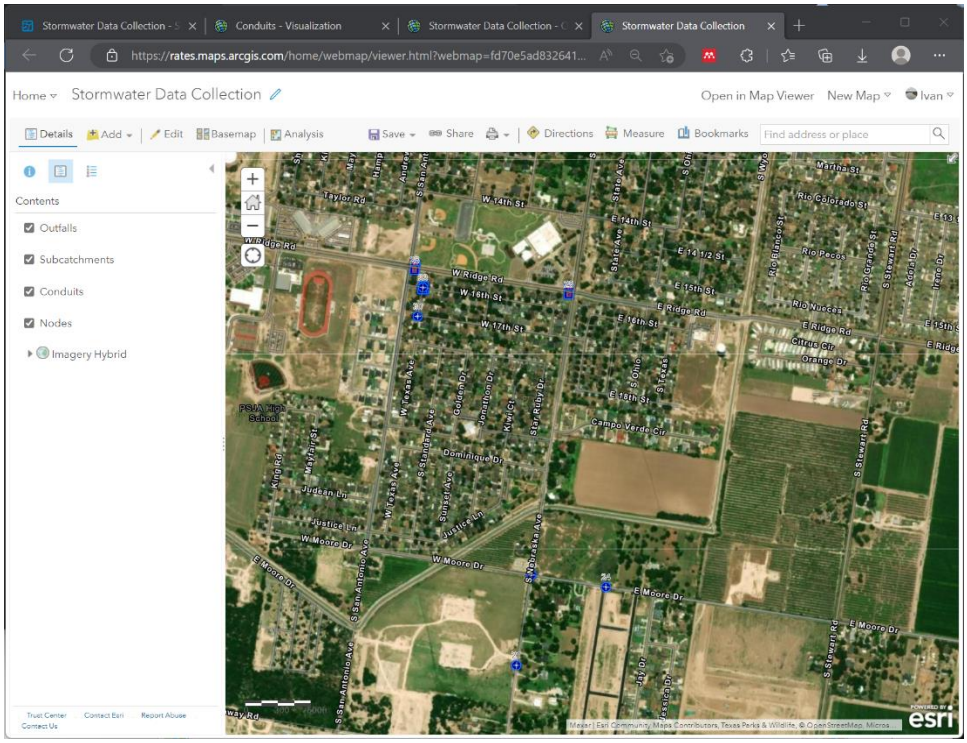

Figure 9. Web Map

5 Field App

5.1 Field App Development

ArcGIS Field Maps is an all-in-one app that uses data-driven maps and mobile forms to help workers perform data capture and editing, find assets and information, and report their real-time locations. ArcGIS Field Maps is the go-to field app that streamlines the critical workflows mobile personnel use every day. Because it is built on ArcGIS, everyone—whether in the field or the office—will benefit from using the same data.

Pros:

- When is not feasible to work outdoors, some data can be collected from the office.
- Easy to use in the field (user can see collected data in the map).
- Better GUI and easy to use.
- Easy to keep track of progress.
- Pipelines/Subcathments can be directly drawn on the platform.

5.2 Field App Publishing and Access

The current version of the SWING Field App is available at the URL below. Alternatively, the QR code in Figure 10 can be scanned for the same end.

https://fieldmaps.arcgis.app/?itemID=fd70e5ad83264189a3c8b663bab32dd4&referenceContext=open&portalURL=https%3A%2F%2FRATES.maps.arcgis.com

Figure 10. Scan QR Code to Download SWING Field App

5.3 Field App Results

5.3.1 Subcatchments

Only three options need to be filled; Inspector Name, Data and Time, and Subcatchment ID (Figure 13). The rest will be filled out in post-processing. Figure 11 and Figure 12 depict the subcatchement visualization during data collection.

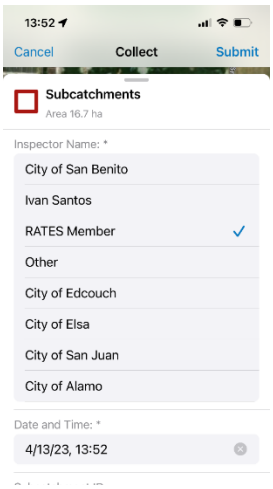

Figure 11.Subcatchment Information

Figure 12. Subcatchment Data Collection (1)

Figure 13. Subcatchment Data Collection (2)

5.3.2 Nodes

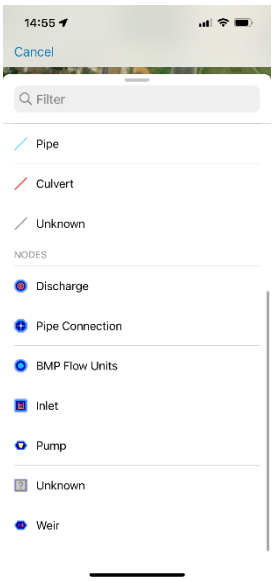

Figure 15. Node Data Collection (1)

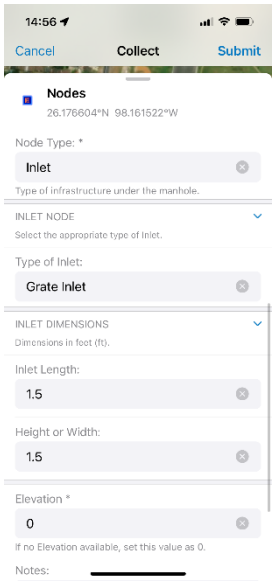

Figure 14. Node Data Collection (2)

Node data collection is depicted in Figure 14 and Figure 15.

5.3.3 Conduits

Figure 16 and Figure 17 depict the data collection screens for open channels and pipes.

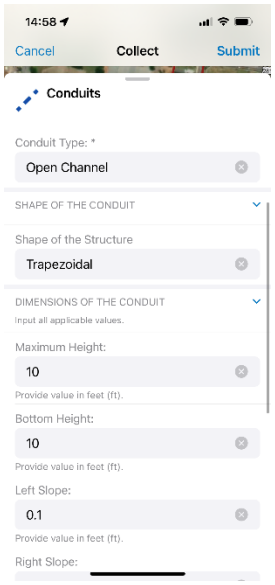

Figure 17. Channel Data Collection

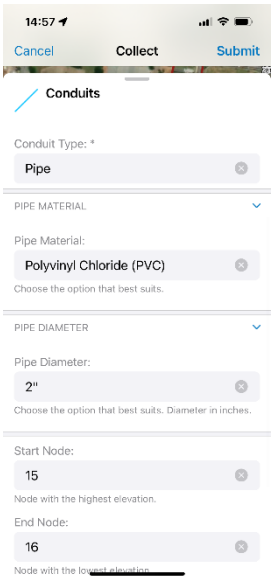

Figure 16. Pipe Data Collection

6 Conclusions

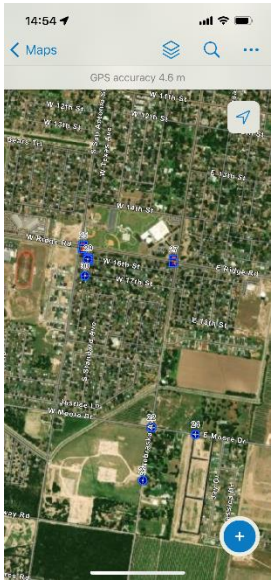

Figure 18. Test Data Collection in San Juan, TX

SWING was tested in several field locations in conjunction with the preliminary SWMM modeling efforts (Figure 18). Several observations and recommendations were drawn during this process.

- Data can be collected directly from a field or virtual inspection.
- It is highly recommended to draw the Subcatchment areas prior to field visits. By doing this, the field crew can efficiently plan their routes.
- SWMM can aid cities with limited knowledge or access to GIS software to characterize the stormwater system using a mobile device.
- Produced shapefiles can be exported for ingestion by SWMM