INNOVATIVE MODELLING METHODOLOGY

OF FINCH WEST LRT CORRIDOR SWM MODEL

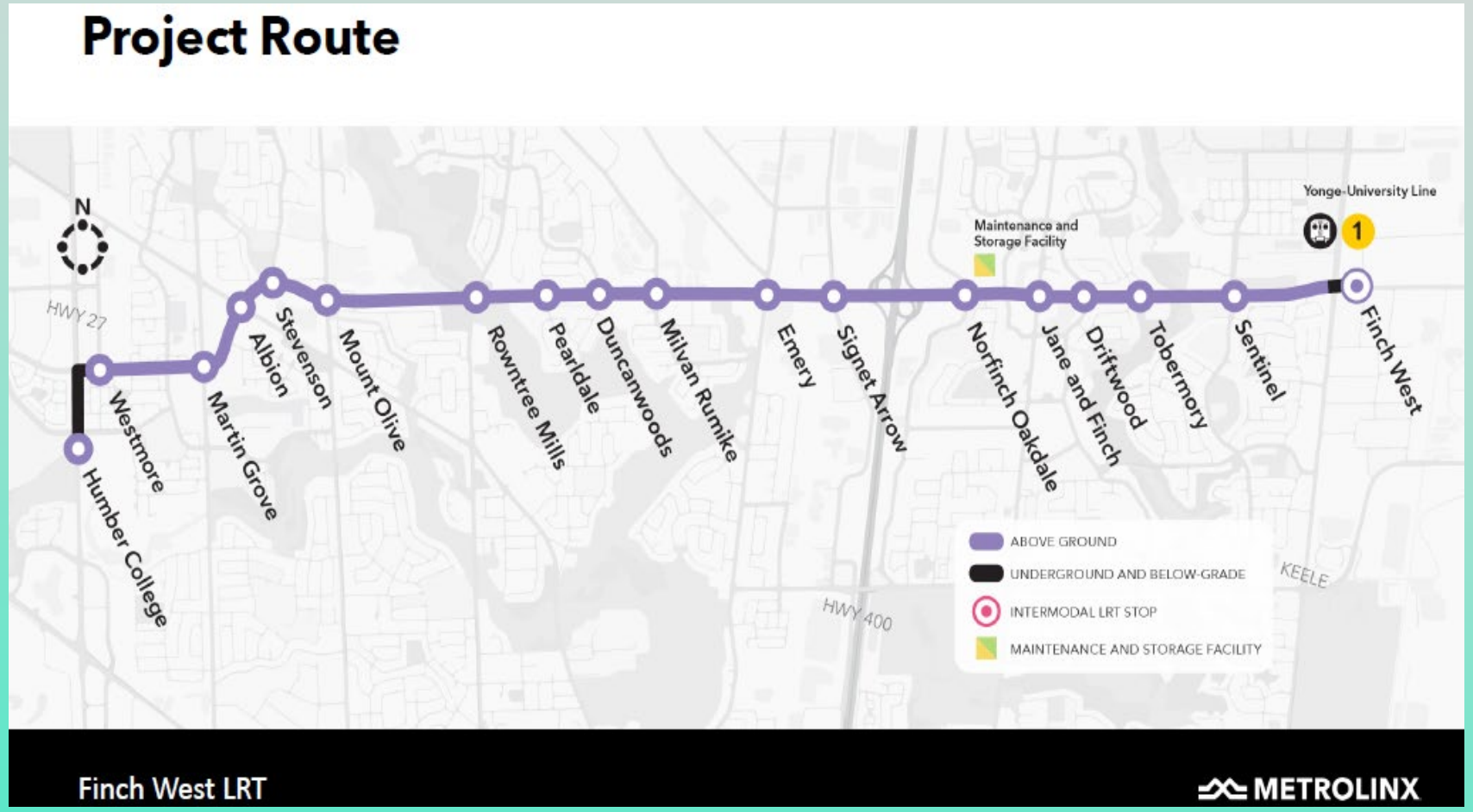
Julian Li PEng August, 2022

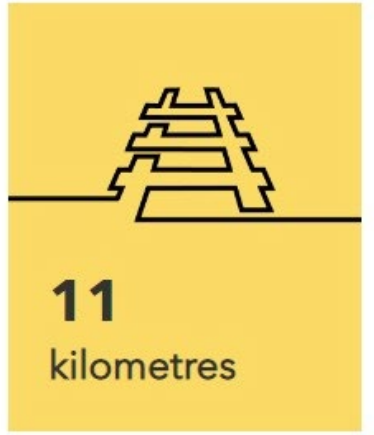
Transit Review, Toronto Water , City of Toronto

CONTENT

- Finch West LRT project and its three challenges for water engineering
- Surface flooding issue caused by LRT structure
- Traditional sewer modelling methodology and its shortcomings
- Develop the innovative modelling methodology
- FWLRT Application and its impacts on road design and flooding control.
- Impacts on new sewer system design at Highway 27.
- Possible application on normal roadway to test traffic lane flooding.

FINCH WEST LRT PROJECT OVERVIEW





The design review period covered 2018 to 2021 for Toronto Water Transit Review

THREE WATER ENGINEERING CHALLENGES IN FINCH WEST LRT PROJECT

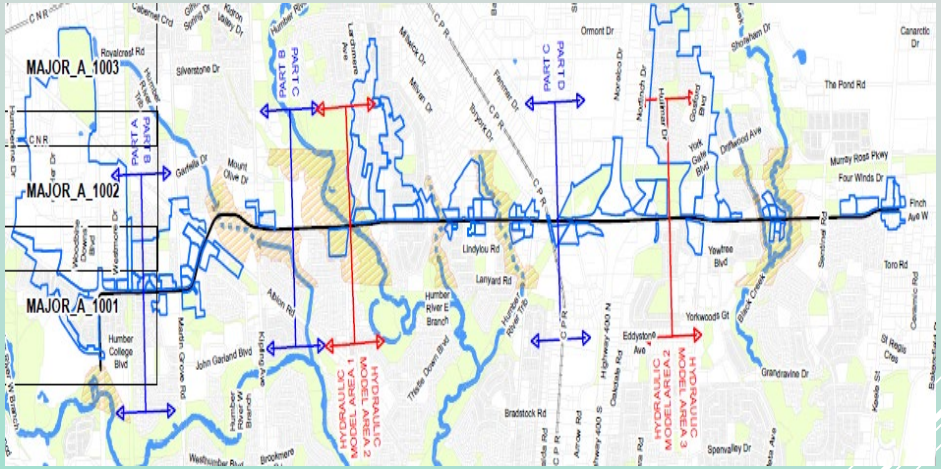
1. The corridor surface flooding analysis
2. Water crossing safety
3. Stray current corrosion control

FINCH WEST LRT BUILDS ITS CENTRAL TRACK ISLAND
IN THE MIDDLE OF ROADWAY

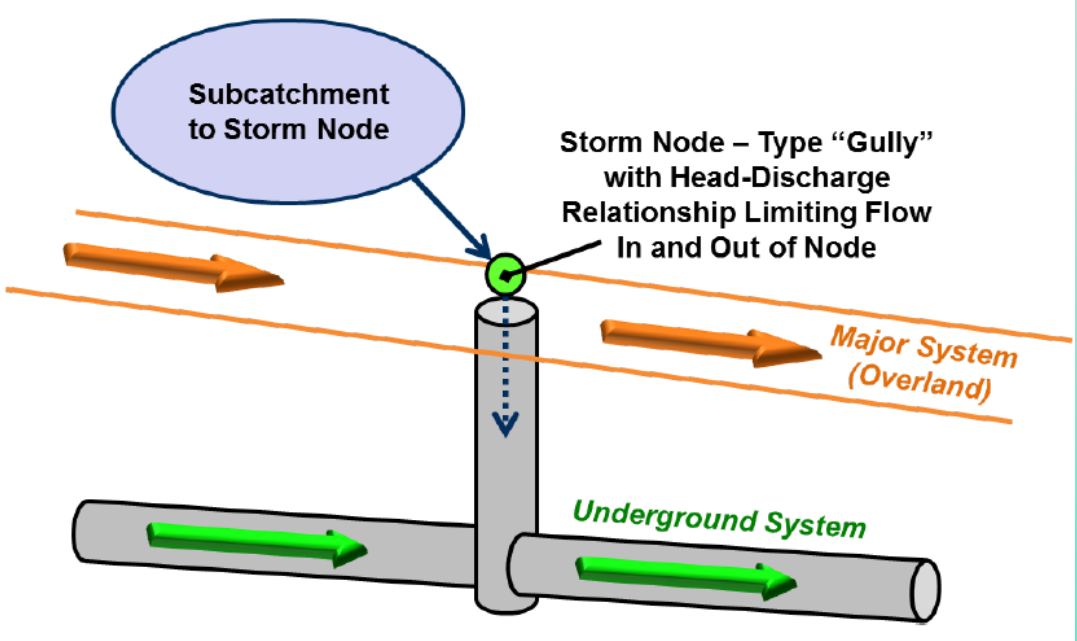
The LRT central island will separate the surface runoff flow between two sides of roadway, increase the complexity of surface flooding analyses of the corridor.

THE LRT INFRASTRUCTURES WILL MAKE NORTH SIDE OF FINCH WEST ROAD TO BE FLOODED MORE EASILY

- Toronto has a general north to south terrain slope.
- The overland storm runoff at Finch West Road mostly come from the contribution area at north of the corridor.
- The north side of roadway will keep most of storm runoff because the LRT island restrain the flow from north side to south side.
- The storm water hydraulic model should reflect the actual hydraulic situation, which is a technical challenge.

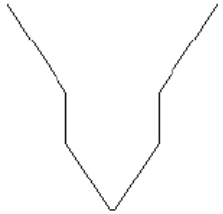


NORMAL DUAL DRAINAGE MODELLING METHODOLOGY



- Integrate major system (overland flow) and minor system (sewer) in one model.
- The storm node connecting major and minor systems normally are manholes, related catch-basins are assigned to the manhole.
- Subcatchment runoff is collected at storm node (MH), the inflow to the sewer at the MH will be determined by head-discharge relationship of related catch basins, the remaining flow will flow at overland flow path.
- The "Gully" type MHs are the interconnection points of major and minor systems, the backup flow from the sewer can overflow to the major system.
- The city of Toronto developed dual drainage models for basement flooding studies by InfoWorks.

OVERLAND FLOW PATH
IN NORMAL DUAL DRAINAGE MODEL

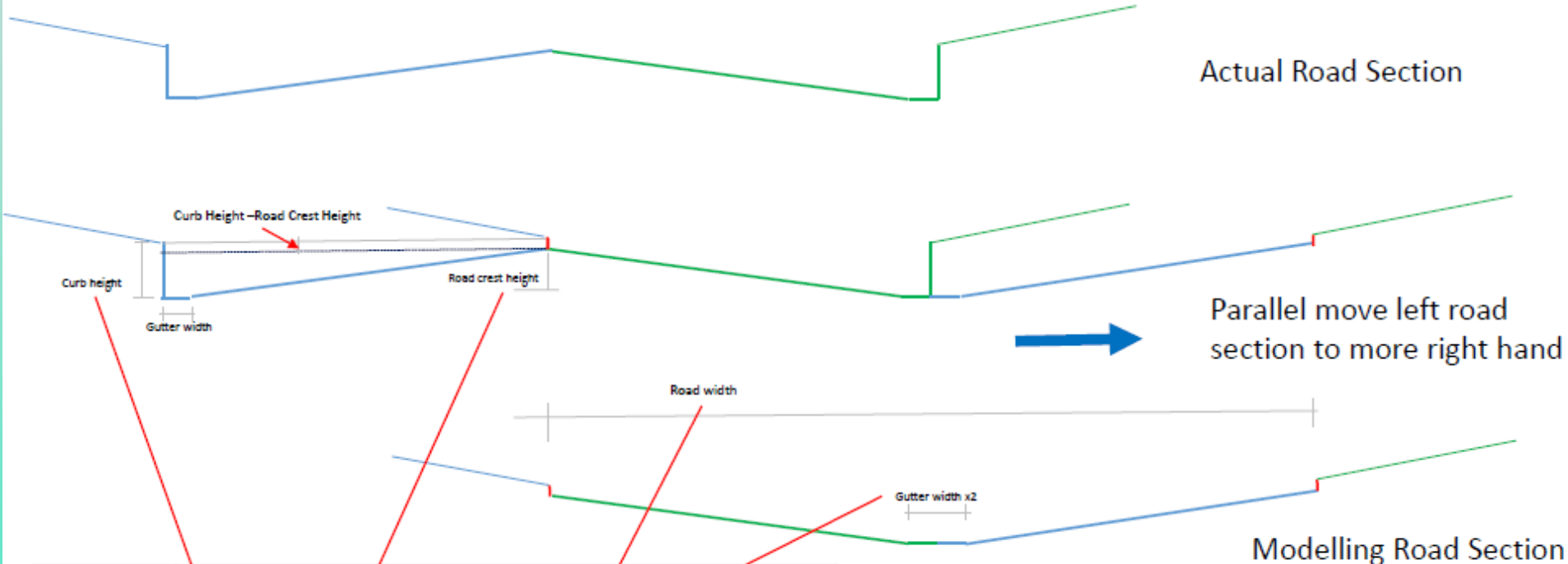
Overland Channel Type	Height (Per unit)	Width (Per unit)	Conceptual InfoWorks Input
Local Road	0.000000 0.320755 0.566038 1.000000	0.029126 0.441748 0.441748 1.000000	 Width=20,000 mm Height=300 mm
Collector Road (Multiple Lane)	0.000000 0.528302 0.566038 1.000000	0.022989 0.559387 0.559387 1.000000	 Width=24-30,000 mm Height=300 mm

- In urban areas, the overland system will primarily be made up of the road network.
- For local and collector roads, a user defined cross-section based on a typical crowned road with curb and slope within ROW normally would be a equivalent symmetrical cross-section, so only one flow channel is needed in model.

ROAD CROSS-SECTION SIMPLIFICATION
IN DUAL DRAINAGE MODEL

Road cross section simplification in Dual Drainage Model

Julian Li Toronto Water July 15, 2019



Overland Channel Type	Height (Per unit)	Width (Per unit)	Conceptual InfoWorks Input
Local Road	0.000000 0.320755 0.566038 1.000000	0.029126 0.441748 0.441748 1.000000	Width=20.000 mm Height=300 mm

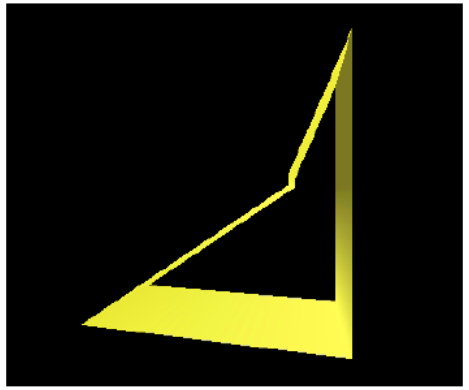
Pre-condition: Curb Height –Road Crest Height > = 0

APPLICATION OF NORMAL DUAL DRAINAGE MODEL

IN FWLRT 30 % DESIGN STAGE

COL_TYP_4LANES_FWLRT
SYMMETRIC
(PROPOSED ROAD GEOMETRY: FULL SPAN)

	Height	Width
1	0.00000	0.03472
2	0.46667	0.81250
3	0.50000	0.81250
4	1.00000	1.00000
MAX	300mm	28800mm



LHS_COL_HALF_FWLRT
ASYMMETRIC
(PROPOSED ROAD GEOMETRY: HALF SPAN)

	Height	Left Hand Side	Right Hand Side
1	0.00000	0.03623	1.00000
2	0.52830	0.81250	1.00000
3	0.56604	0.81250	1.00000
4	1.00000	1.00000	1.00000
MAX	300mm	14400mm	14400mm

Figure 11: Custom 1D Conduit Geometry for Proposed Major Flow Links (Right: Full Span, Left: Half Span)

- Still using one equivalent symmetrical cross-section for whole Finch West LRT corridor at proposed condition.
- No flooding difference between north side road lanes and south side road lanes,
- Because the corridor is widened by adding the central LRT island, the flooding depth at proposed condition would be less than the flooding depth at existing condition

The modelling methodology and its results don't reflect actual field situations

FWLRT

CoT Drainage Modelling

Minutes of Meeting

Meeting No:	23
Meeting Date:	Thu 2019-Aug-29
Meeting Duration:	9:00 - 10:30
Meeting Location:	121 Bloor St, 9th Flr, Toronto Yonge Room
Tele-Conference Number:	N/A
Tele-Conference ID:	N/A

038	May-16				This was discussed at the bi-weekly City Transportation meeting on 5/13 where Transportation team had no objections but had questions. Metrolinx clarified the trench drains within the guideway is subject to Mx review, and the intersection drainage and connection to City sewers will be subject to CoT review	INFO	C
038	May-16				ARUP asked Mx about the acceptable depth and veloCity for overland flow across the guideway. Mx responded that the design needs to demonstrate that the guideway structure is safe during the flooding and can maintain usual operation after the flooding. ARUP to show a more developed design of the area to show this	ARUP	C
038	May-23				Track design changes will be confirmed in the next couple weeks. ARUP to review how these changes affect to the roadway and drainage and update at a TW meeting in the next weeks	ARUP	C
038	Jun-06				Mosaic is awaiting confirmation of rail design changes. Once confirmed, Mosaic will review road drainage at this location	ARUP	C
038	Jul-18				York Gate Drainage	ARUP/MTC	C

Fri 05/24/2019 9:58 AM

Julian Li

RE: DBN #201- R0- Finch West LRT: Proposed Track Drainage Modelling Methodology

To

Cc

So, the modelling methodology should be improved to an integrated methodology, which can be used to simulate real hydraulic condition of Finch West LRT corridor in overland flow system, sewer system and the hydraulic interaction between them.

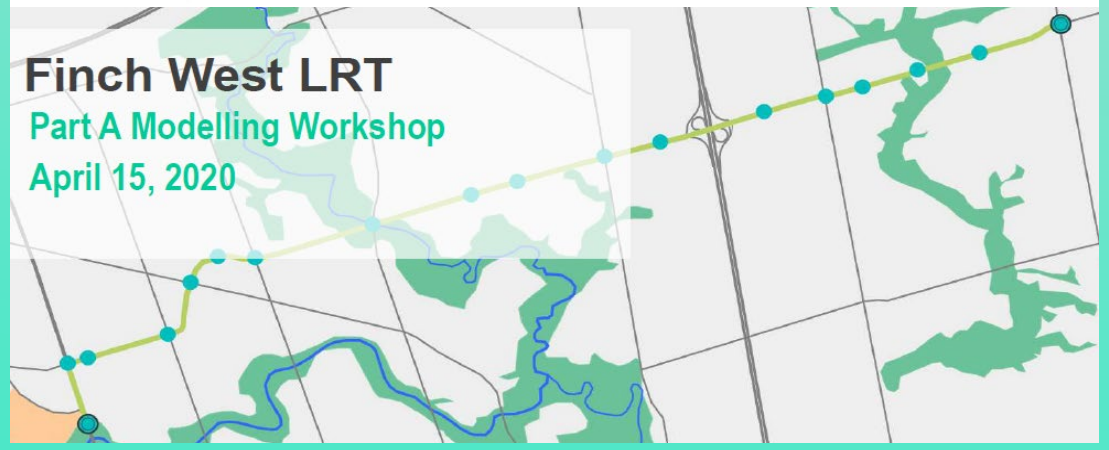
The possible concerns could include:

1. The overland flow paths, reflect real hydraulic condition about central track island, north side roadway, south side roadway and the hydraulic connection between them.
2. Contribution areas to these three overland flow paths.
3. The inflow graph of track catch basin and roadway catch basin, which is important for interaction between minor and major systems.
4. The overland flow path variation at LRT stop and road intersection.
5. Track drainage minor system and municipal sewer system

Thanks,

Julian Li

Toronto Water Metrolinx Project Team

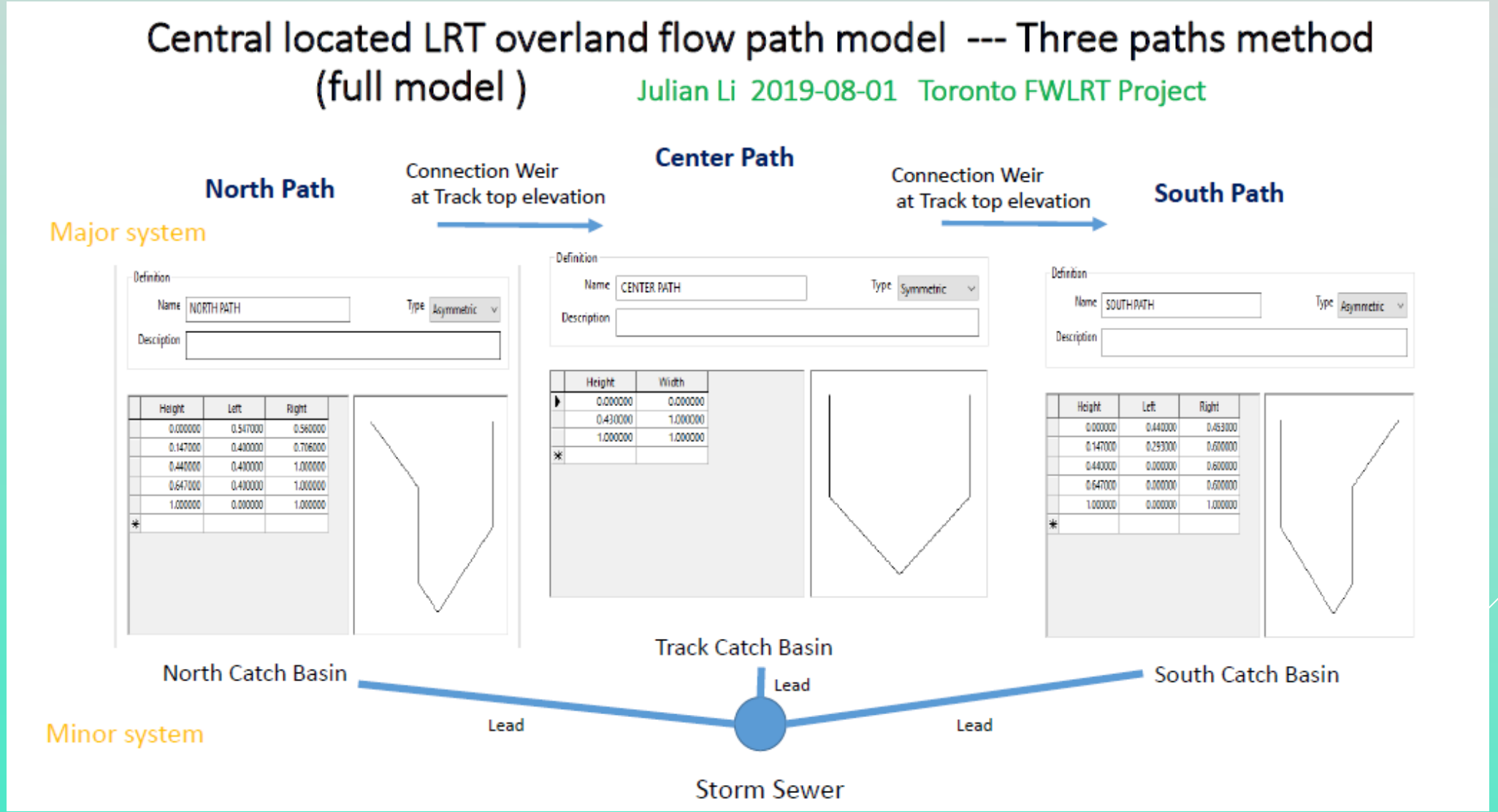


TECHNICAL COMMUNICATION, DISCUSSION AND COORDINATION

- Biweekly meetings by CoT, Metrolinx, Project company, design consulting company and technical adviser of the project.
- Many modelling workshops.
- Toronto Water provided many technical reviewing comments, requiring the model should reflect actual field conditions and working together with all technical partners.
- At 2019 summer, I provided related technical suggestions that were fully discussed and adopted.

FULL MODEL: THREE OVERLAND PATHS

MODELLING CENTRAL LOCATED LRT CORRIDOR



FULL MODEL: THREE OVERLAND PATHS

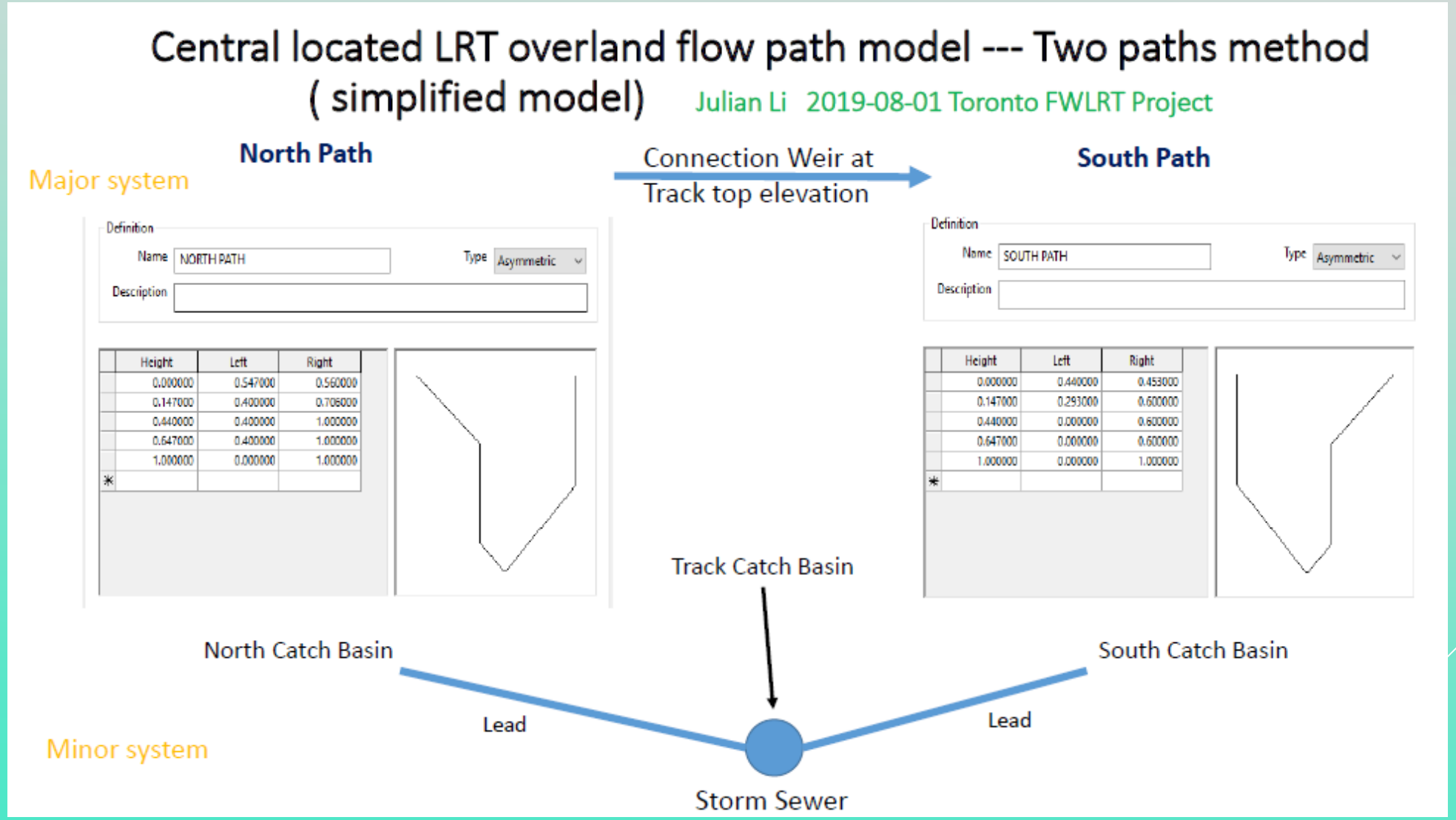
MODELLING CENTRAL LOCATED LRT CORRIDOR

- Three separated overland flow channels to simulate two side roadways and central LRT lane.
- Two side roadway cross-sections use asymmetric section to reflect actual situation.
- The major storm nodes of overland flow paths will be catch basins, not manholes. Catch basin will directly collect subcatchment runoff.
- The catch basin leads will be included in the model.
- Connection weirs will be added at adjacent paths to hydraulically integrate three paths as a whole corridor.

The full model has clear conceptions to simulate three actual overland flow paths, and there are enough hydraulic connections among these three paths and sewer system

SIMPLIFIED MODEL: TWO OVERLAND PATHS

MODELLING CENTRAL ISLAND LRT CORRIDOR



SIMPLIFIED MODEL: TWO OVERLAND PATHS

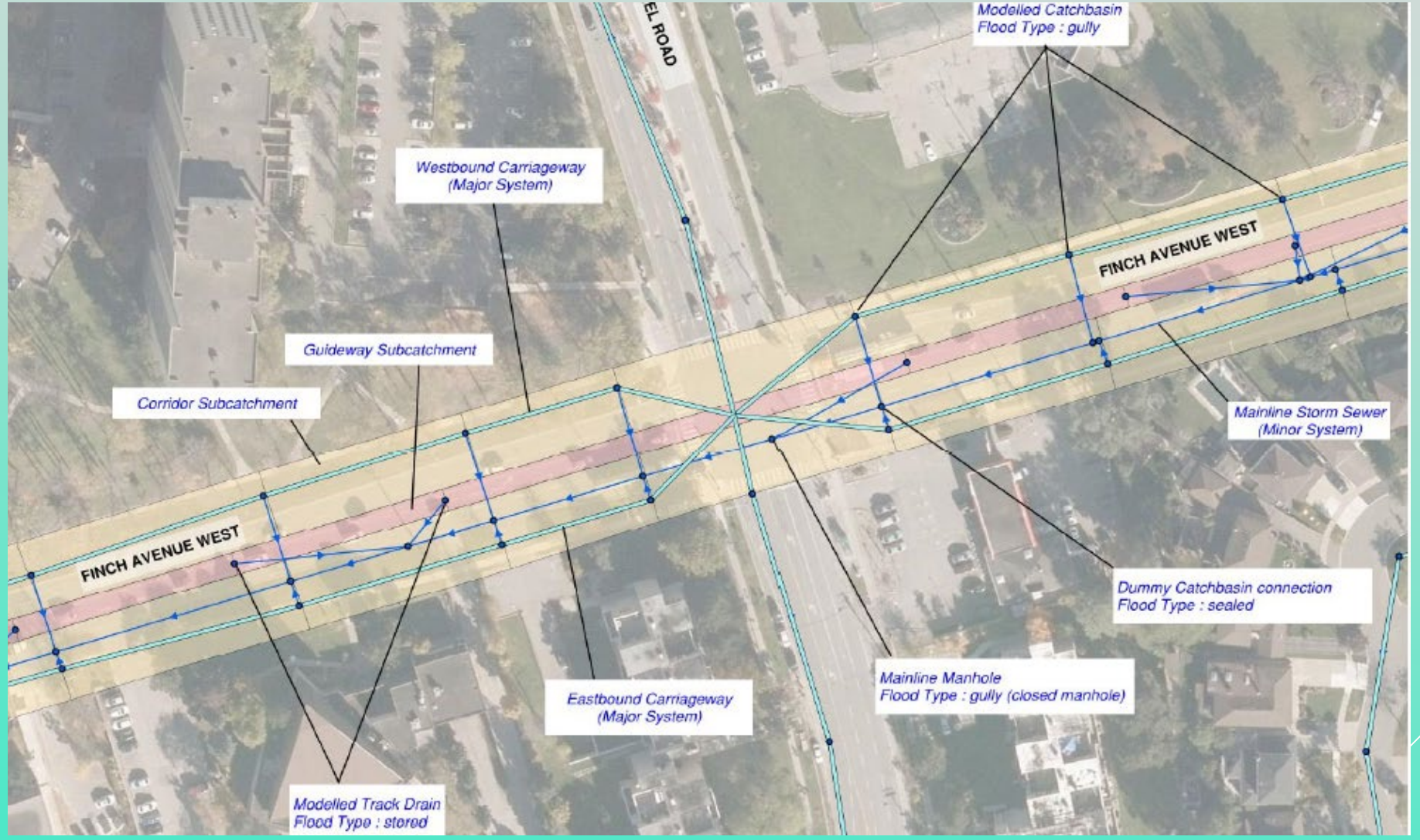
MODELLING CENTRAL ISLAND LRT CORRIDOR

The LRT track and station drainage system will be designed by separated hydraulic analysis, but the pipes, catch basins and overland path could not be included in the corridor system model.

- The subcatchment area of LRT central island itself will be relative small, the track drainage system could be designed without the inflowing restrain of track catch basins and pipes to collect the runoff.
- The subcatchment runoff can be directly assigned to municipal sewer pipe or manhole.
- The track catch basin is located higher than roadway catch basin, the backup sewer flow will firstly overflow to road way

The simplified two paths model can simulate general hydraulic performs of central island LRT corridor like FWLRT

FINAL FWLRT SWM MODEL ADOPTED TWO PATHS METHODOLOGY



DIFFERENT FLOODING DEPTHS OF ROAD LINES

UNDER 100 YEAR STORM SHOWN IN THE MODEL

ROAD CROSS-SECTION DESIGN CHANGE

-ACCORDING TO SWM MODEL FLOODING CONTROL

- Toronto Wet Weather Flow Management guide line requires the maximum ponding depth at new Arterial Road is to the crown of the road under 100 year storm, mostly means no curb overtopping.
- FWLRT roadway is a existing roadway realignment for the LRT, the major system design criteria include:

---If the exiting condition has no curb overtopping, the proposed condition should have no curb overtopping.

---If the exiting condition has curb overtopping, the proposed condition should be no worse than existing condition.

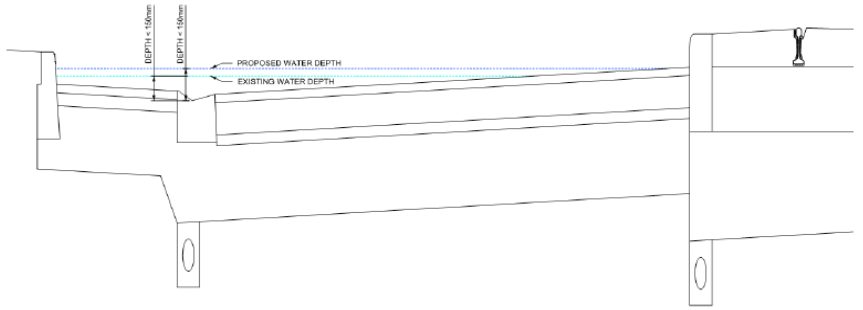
- The existing curb height is about 150 mm.
- New SWM model already shows the overland flow could concentrate on one side of the roadway because of central LRT island, then the possibility of curb overtopping and flooding to nearby properties will be increased at the side.
- The solution could be increasing the overland flow path hydraulic capacity to reduce the flooding possibility.

ROAD CROSS-SECTION DESIGN CHANGE

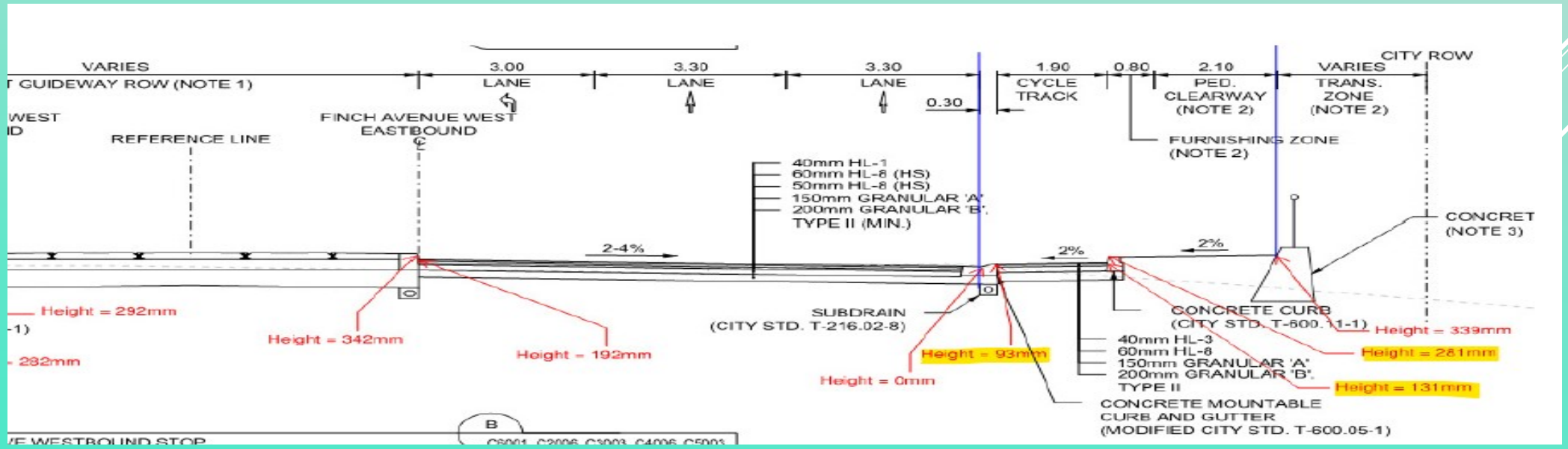
-ACCORDING TO SWM MODEL FLOODING CONTROL

- The road design has been changed by adding a new low curb beside the bike line.
- Two curbs have a total curb height about 275 mm (including the bike lane slope), increasing the major system capacity a lot.

Major System

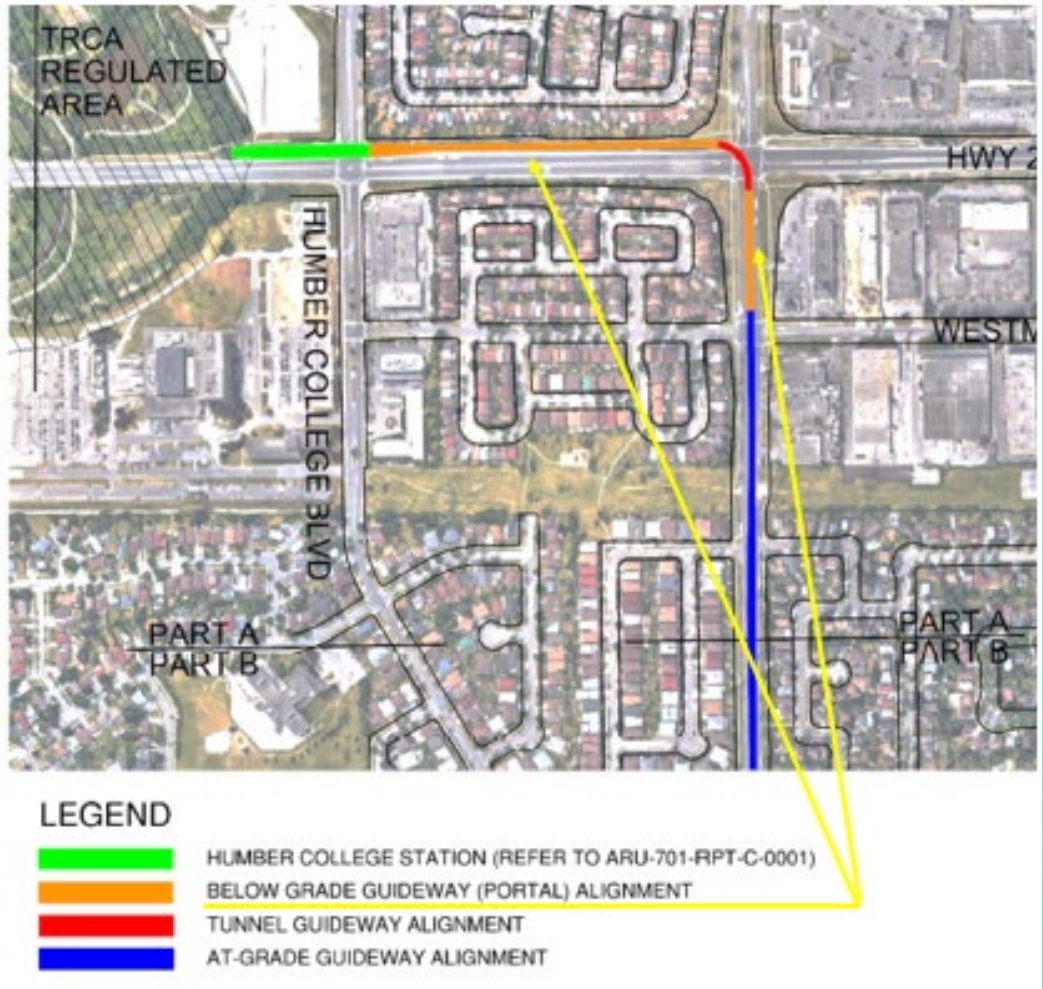


- Existing flow depth is less than 150 mm
- Proposed flow depth is less than 150 mm
- Action – Keep flow depth less than 150 mm. Modified cross-section has 275 mm curb



IMPACTS ON HIGHWAY 27 NEW SEWER DESIGN

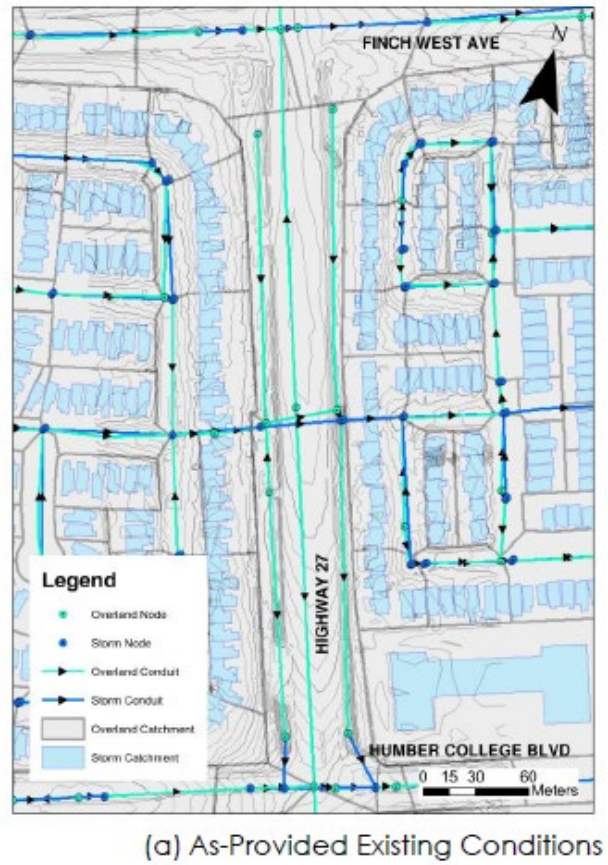
FWLRT Part A route design around Finch & Highway 27



- Finch West LRT west end station is Humber College Station at High way 27.
- The station is underground , and the below grade guideway will extend to Finch West Road , it goes as a tunnel under the intersection, then the guideway ascend to surface before Finch & Westmore intersection.

IMPACTS ON HIGHWAY 27 NEW SEWER DESIGN

Existing sewer system at Highway 27



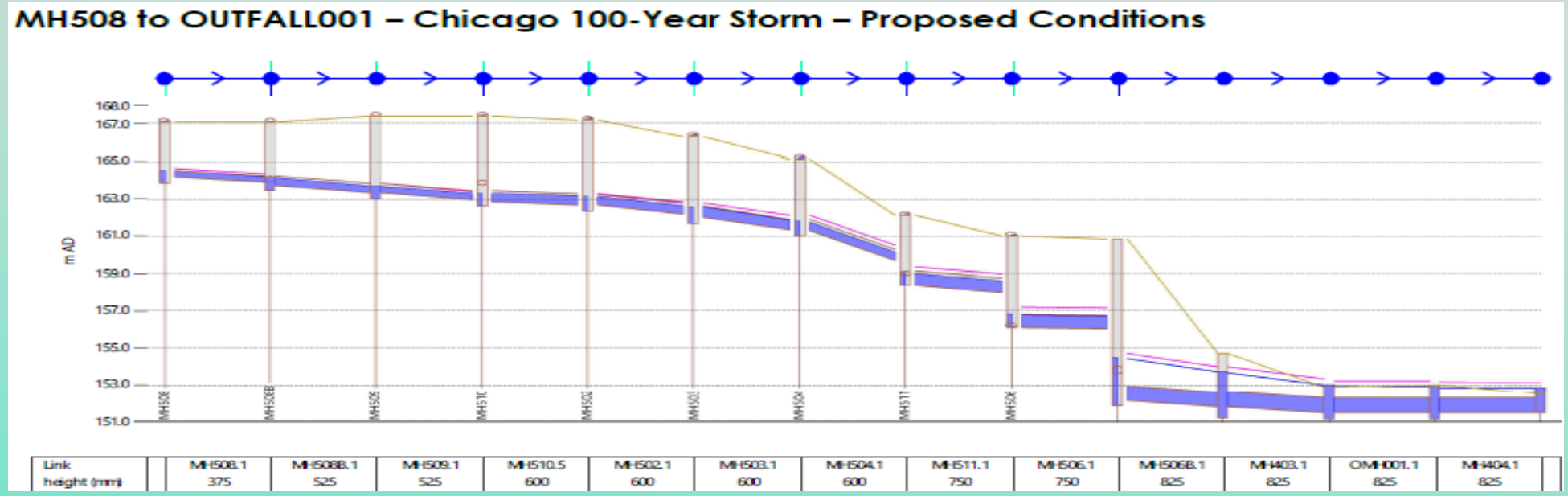
(a) As-Provided Existing Conditions

- There is no local sewer system along high way 27 at the south of Finch West.
- A 1200 mm storm sewer crossing Highway 27 at the north of Humber College Boulevard.
- Another 900 mm storm sewer crossing Highway 27 at Humber College Boulevard intersection.
- The high way surface flow will run along the road way and road side swales to Humber River.
- The capacity of these crossing sewer pipes are limited, and their down stream areas are prone to possible basement flooding.

Figure 20: Locations of storm sewers (Minor System) surcharged in 10yr design storm (highlighted red) (Existing)

IMPACTS ON HIGHWAY 27 NEW SEWER DESIGN

Proposed Highway 27 sewer at 60 % design stage



- Finch West LRT project has to build a new storm sewer along the Highway 27 for the LRT track drainage, but the runoff collection coverage could be only for LRT track drainage plus Highway 27 road surface at the maximum within the project scope.
- At 60 % design stage, the new sewer has relative small pipe sizes from 375 mm to 825 mm, and a new outfall to Humber River.
- The proposed new storm sewer is not big enough to work as a local trunk sewer for the community and possible new development.

IMPACTS ON HIGHWAY 27 NEW SEWER DESIGN

New SWM model identified possible flooding risk to the below grade guideway

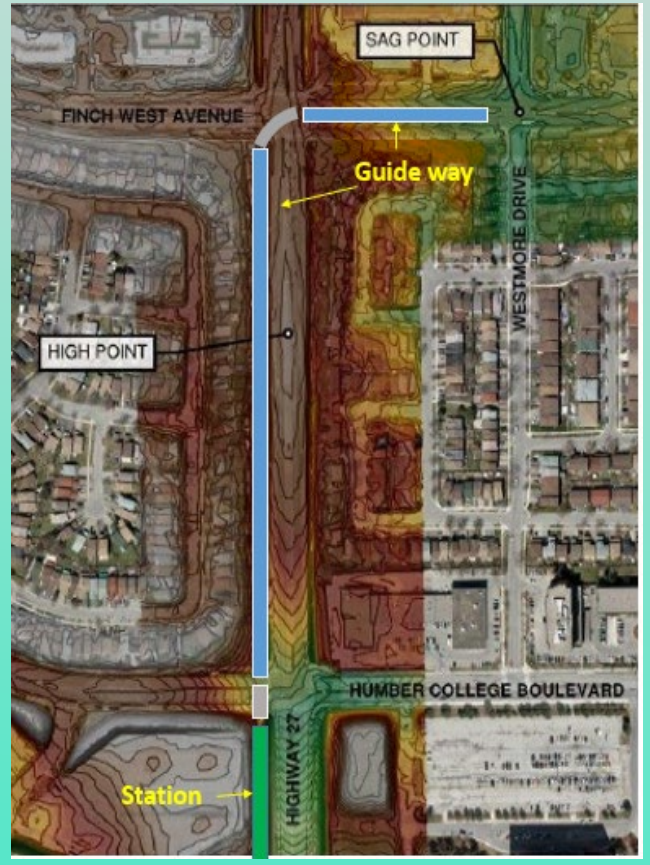
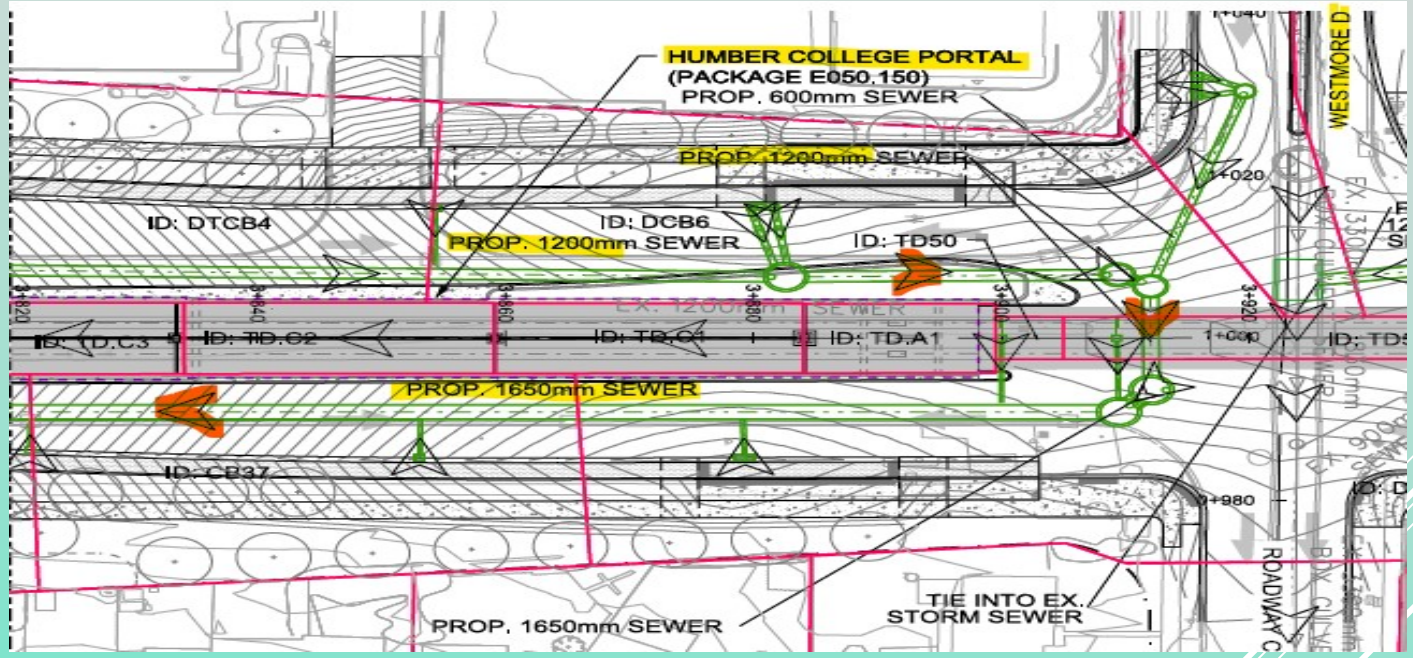


Figure 22: Westmore Drive Storm Sewer Pipe from MH4366496642 to CN3959

- Finch & Westmore intersection is the sag point of a big area
- The intersection is also the connection point of the below grade guideway and surface tracks.
- The new SWM model simulated high flooding depth at north west corner with the risk of flooding the guideway.
- The existing down stream sewer and major system have no capacity to mitigate the risk.

IMPACTS ON HIGHWAY 27 NEW SEWER DESIGN

A large size relief sewer along High way 27 is designed to mitigate LRT flooding risk



- A new 1650 mm storm sewer will collect upstream sewer flow and some surface flow at the low spot , going along Highway 27 and discharging to Humber River.
- The new Highway 27 sewer will be sized as 1650 mm to a 1900mm X1200 mm outfall.

ADDITIONAL BENEFITS OF THE RELIEF SEWER

- The existing upstream flow at Finch West is diverted to new sewer, which helps to mitigate the basement flooding problem of downstream area, and produce new capacity for future development.
- The relief sewer has big pipe size and long distance to Humber River, which can work as a local trunk sewer at the same time to save city cost.
- These two existing sewers crossing highway 27 could connect with the new sewer and discharge the upstream flow to Humber River.

---help to mitigate the basement flooding problem for both upstream and downstream areas.

---add new sewer capacity for future development in the whole area.

POSSIBLE FUTURE APPLICATION ON NORMAL ROADWAY

TO TEST TRAFFIC LANES FLOODING

Ministry of Transportation
Highway Surface Drainage

Drainage Design Standards

SD –3 Flow Spread on to Travel Lanes

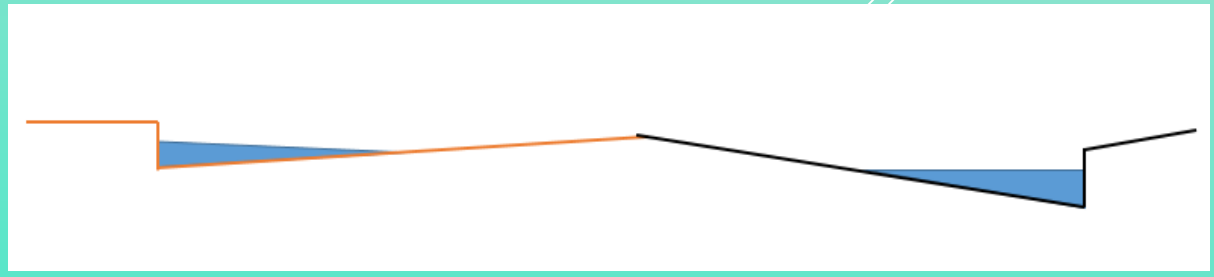
Figure SD3.1 Spread at Medians and Curbs

Toronto Wet Weather Management Guideline

(6) For convenience and safety, the maximum pavement encroachment by ponding on streets during the 1 in 2 year storm (minor) are as follows:

(a) Local roads – No curb overtopping and flow may spread to crown of street.
(b) Collector roads - No curb overtopping and flow spread must leave at least one lane free of water.
(c) Arterial roads - No curb overtopping and flow spread must leave at least one lane free of water in each direction.
(d) Freeway – No encroachment is allowed on any traffic lanes.

- MTO has flow spread standard on travel lanes
- Toronto City has the standard to keep at least one lane free of water under 2 year storm
- There is no existing technical method to test water flow spread on travel lanes and judge the standard compliance .
- If the flooding depth can be calibrated, the new TWO overland paths model could be used to test water flow spread, including the roadway with horizontal slope.



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Saeid Behnia of CoT, ECS
Mike Jacobs
Lawrence Shintani of CoT, TW

Thank you !

Any questions?