SWIFT Conference 2015

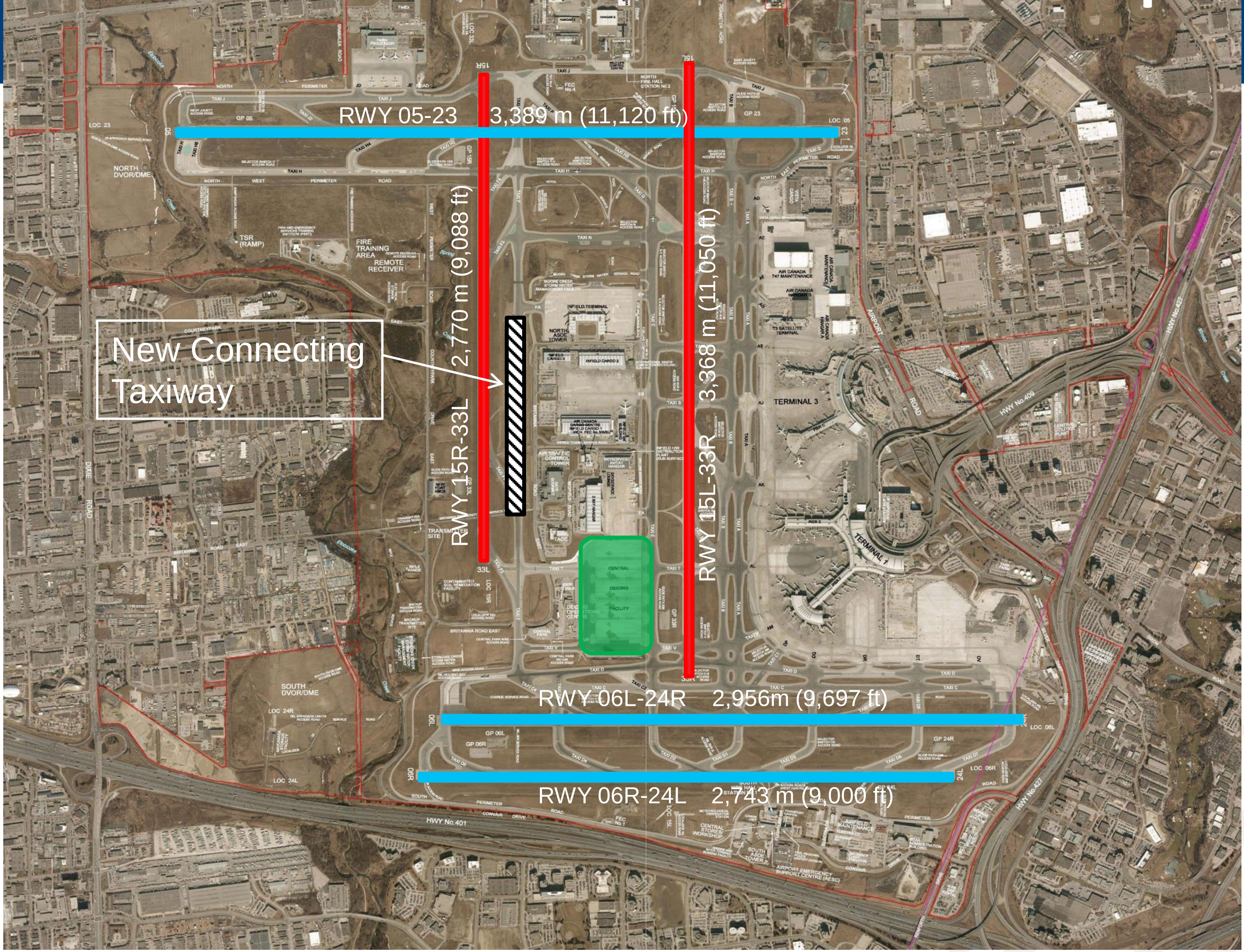
GTAA

Toronto Pearson
International Airport | Aéroport International

Connecting Taxiway between F and M at Toronto Pearson International Airport

Presented by: Kevin Chee, Senior Civil Engineer

Toronto Pearson: Current Airfield Map



Toronto Pearson Airport – Canada's Largest Airport

- 2014 Passenger Volume: 38.6 Million PAX.
- Ranking in North America: 2nd busiest airport (in terms of international passengers)
- Total airside paved areas: approx. 5,838,000 m2 (concrete and asphalt)
- # aircraft movements: approx. 433,000 annually
- Cargo processed: over 500,000 tonnes

Outline

Outline

- Why are we building this connecting taxiway
- Operational considerations prior to and during construction
- Design and implementation to meet current and future needs
- Conclusions

Why are we building it?

Issues

1. Taxiways Mike and Foxtrot are not a continuous route for arriving and departing aircraft, thus creating a flow issue when on a runway 33/15 operation.
2. Without the continuous taxiway, Nav Canada has to direct aircraft to cross 33R with all Terminal 3 traffic which increases the risk of runway incursions and reduces capacity.
3. Without the continuous taxiway, Runway 15R-33L has to be used as a taxiway to improve airside access to the infield facilities.

Issues

4. **Without the continuous taxiway, the only means of travelling to Runway 15R-33L without crossing an active runway is along Taxiway Echo. This constraint becomes a greater issue during deicing operations as the current configuration requires one deicing pad to be removed from service, which reduces throughput by 16%, and causes a change in operations and routes out of the CDF.**

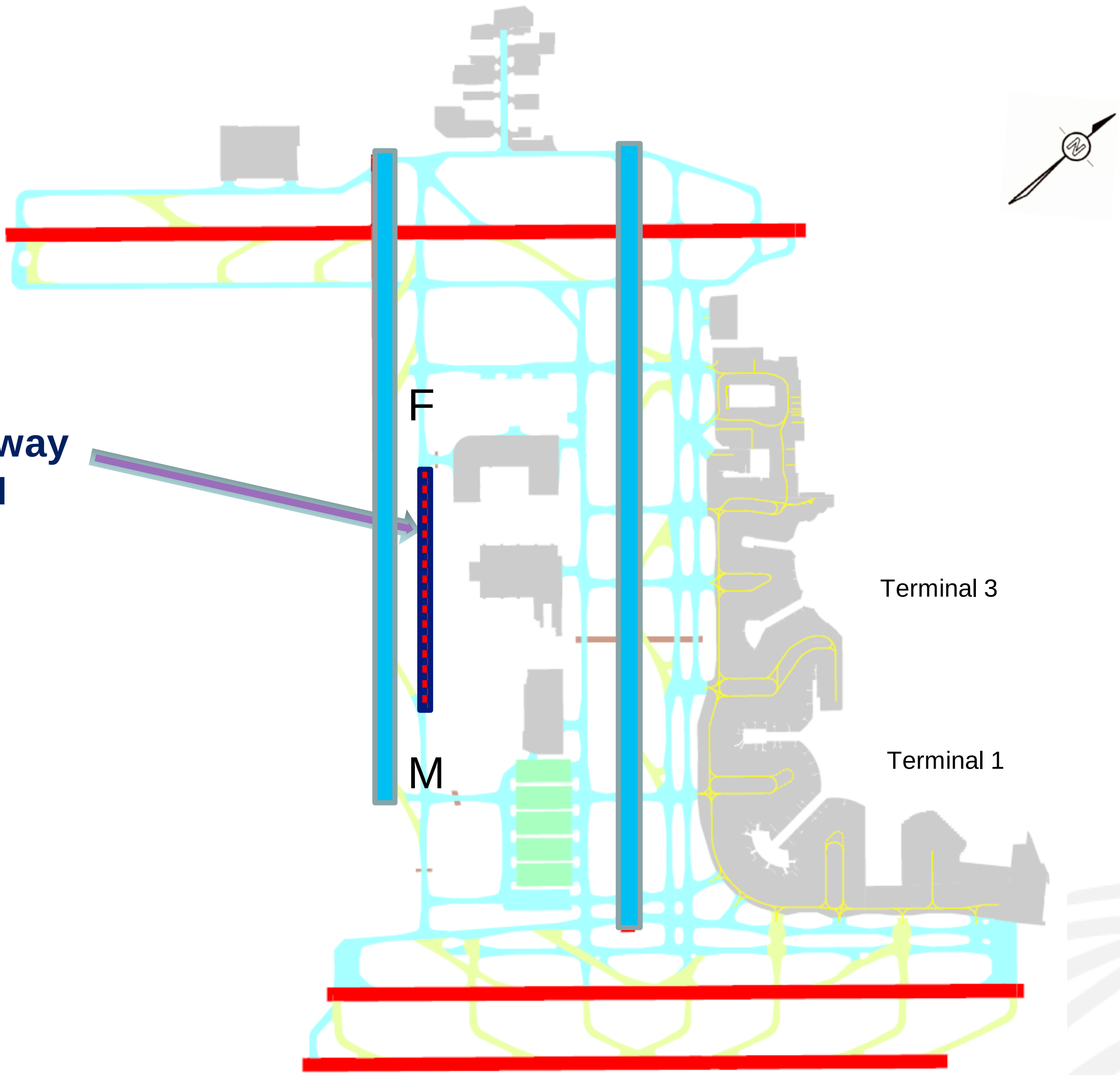
Issues

5. **Without the continuous taxiway, it creates a vulnerability in 33/15 operations. If an incident occurs on Taxiway Echo rendering it unserviceable, the only other means of transiting north during deicing operations involves multiple crossings of 15L, resulting in a loss of potential arrival slots for each crossing, and increased risk of runway incursions.**

Operational Considerations

Location of Connecting Taxiway between F & M

Connecting Taxiway between F and M



Operational Considerations

The senior management has decided to advance the project in July 2014 to have the connecting taxiway be constructed by the end of the year instead of 2015 to avoid any negative impact on the deicing facility as pointed out previously.

Therefore, we only have 5 months to design, tender and construct the project. It is almost impossible to meet the deadline if we can not do the design in-house and preorder the long lead items ahead of time.

- **7 weeks for Design**
- **4 weeks for Tendering**
- **10 weeks for Construction**

Operational Considerations

Since the proposed connecting taxiway is located at the developed maneuvering area and adjacent to the groundside infield facilities therefore special considerations, procedures and staging plans must be developed and put in-place prior to starting the construction to minimize operational impact and to speed up the construction so that the taxiway will be ready for winter:

- **Downgrading Runway 15R-33L from Precision Approach to Non-Instrument runway to reduce Obstacle Limitation Surfaces (OLS) for the take-off/approach surface of the inner edge from 150m to 75m**

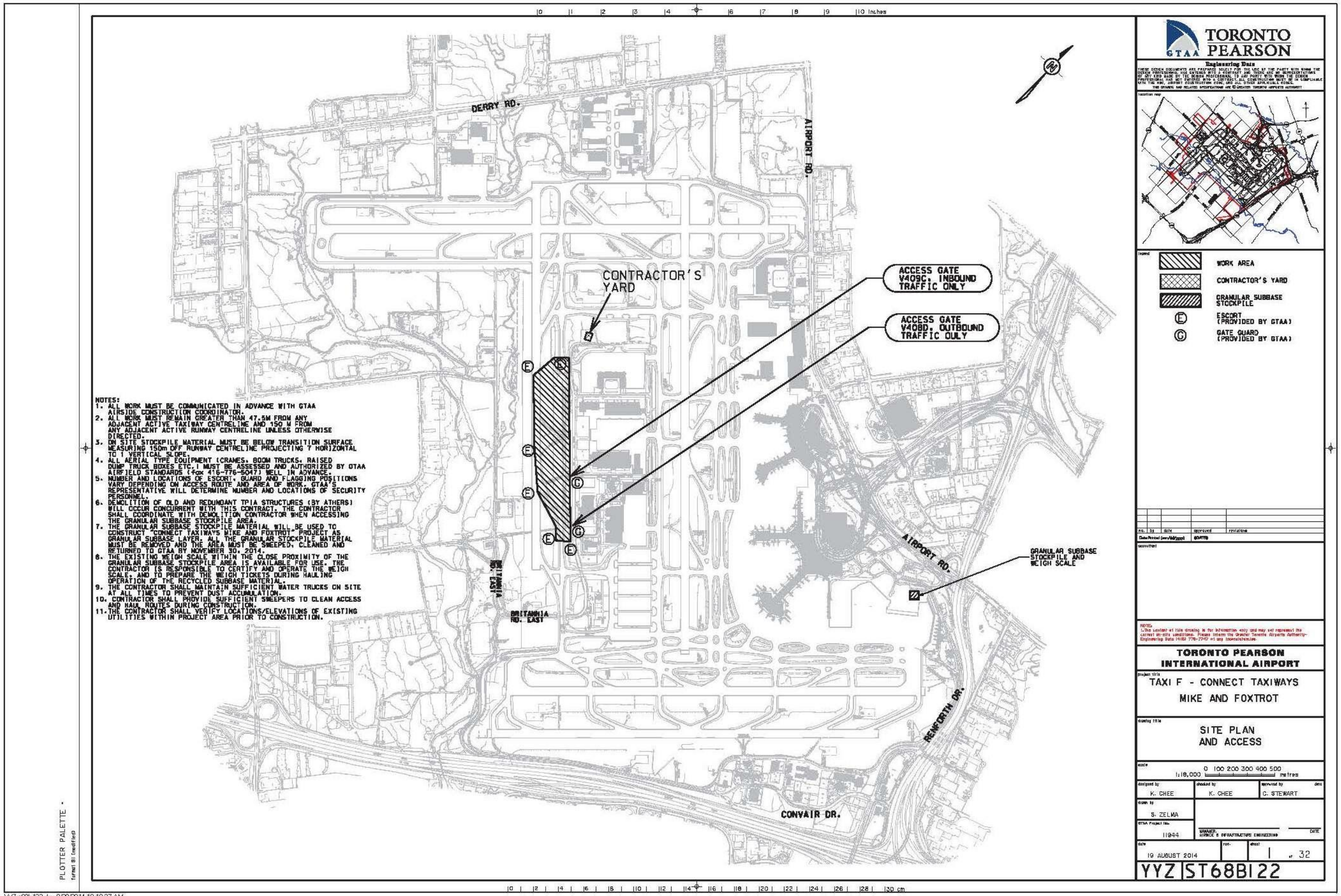
Operational Considerations

- Adjusting bus turn around area (Mississauga Transit) to allow taxiway Foxtrot development
- Installing retaining wall to accommodate taxiway grading requirements
- Dividing the area of work into four segments to minimize operational impact
- Creating a play pan area for construction work to minimize incursions on active maneuvering area
- Establishing one way traffic flow pattern within the construction area to minimize traffic congestion and to avoid potential traffic safety incident

Design and Implementation

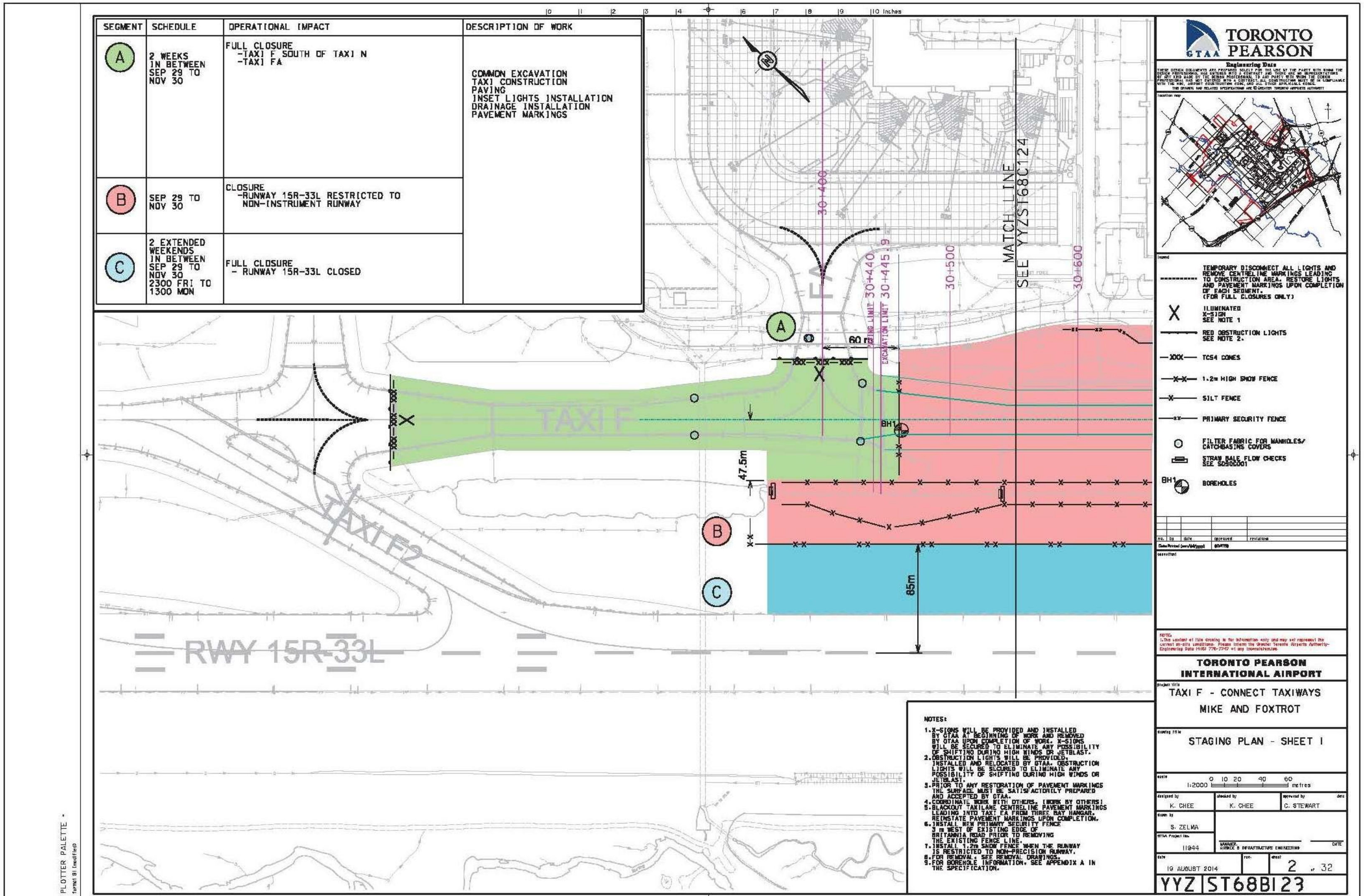
Design and Implementation

Design Consideration – Traffic Flow



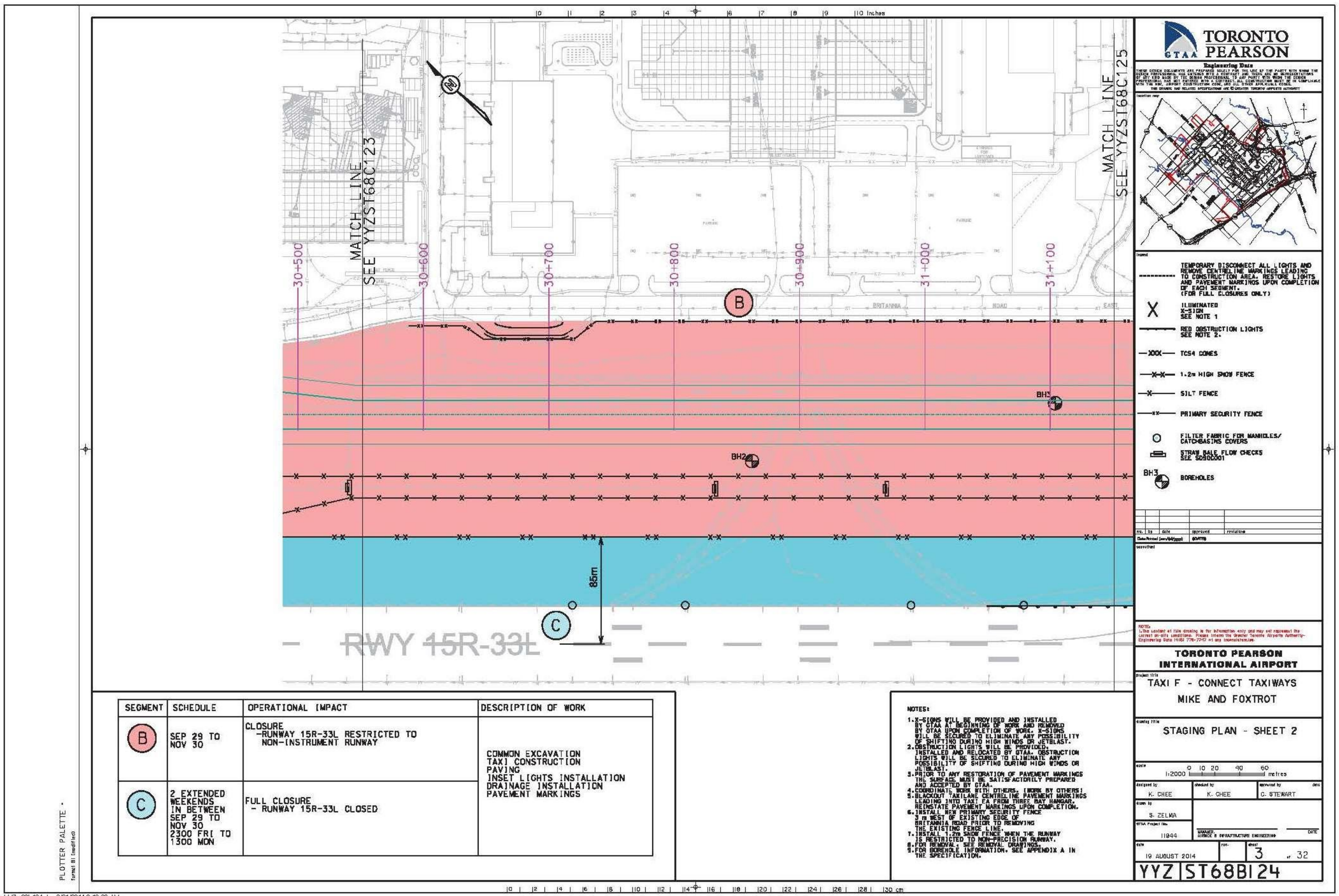
Design and Implementation

Design Consideration – Phasing Plan



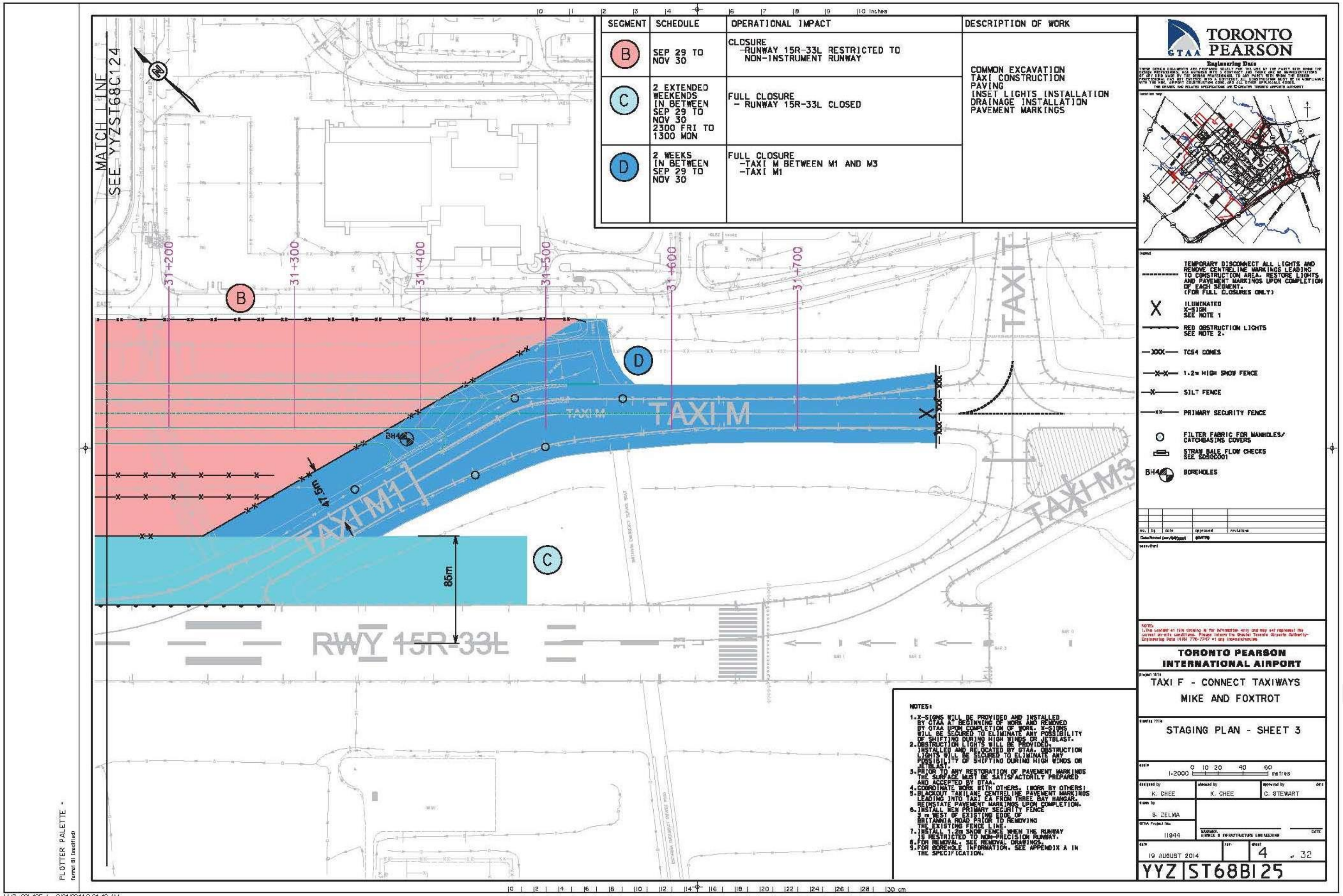
Design and Implementation

Design Consideration – Phasing Plan



Design and Implementation

Design Consideration – Phasing Plan



Design and Implementation

Design Consideration – Surface Drainage

- Capture surface runoff by providing ditches on either side of the taxiway
- Regrade existing ditch inlets/outlets as necessary to provide positive drainage at the tie-in of the new ditches
- Grade taxiway strip on either side of the taxiway centreline according to TP312 requirements

Design and Implementation

Design Consideration – Sub Drainage

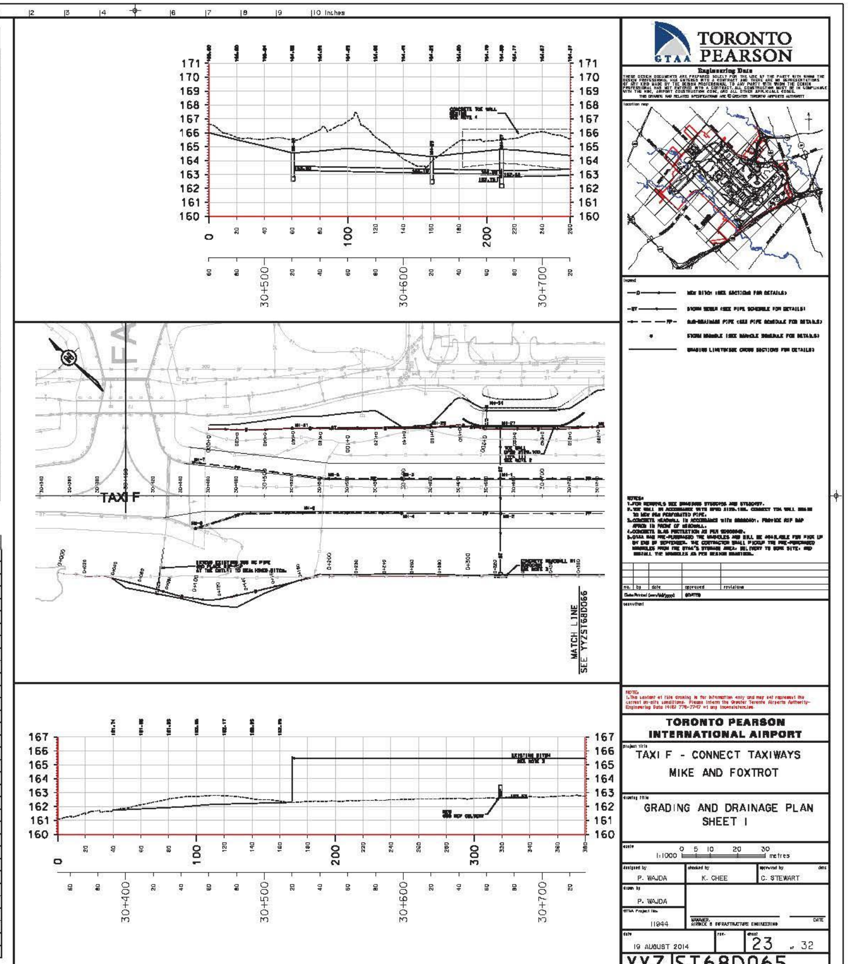
- Based on the results of the CCTV inspection, it has been confirmed that there is no need to replace existing adjacent sub drains at this time.

- Install new aircraft load rated catchbasins for the new sub drains on either side of the taxiway and connect to adjacent storm sewers or ditches.

MH/CB(s) Schedule, Grading and Drainage Plan

MANHOLE	STATION	OFFSET		TYPE	T/G ELEV.	BOTTOM OF MH	EAST		SOUTH		WEST		NORTH		DEPTH
							INVERT	PIPE SIZE	INVERT	PIPE SIZE	INVERT	PIPE SIZE	INVERT	PIPE SIZE	
MH-1	30 + 670	11.5	L	P	165.62	162.27	162.72	600RCP	163.46	250 PPP	162.72	600 RCP	163.46	250 PPP	3.36
MH-3	30 + 598.4	11.5	L	L	165.57	163.17			163.62	250 PPP			163.62	250 PPP	2.41
MH-5	30 + 546.5	11.5	L	L	165.80	163.33			163.78	250 PPP			163.78	250 PPP	2.48
MH-7	30 + 449.04	23.2	L	L	167.38	164.22			164.67	250 PPP			166.10 INVERT ASSUMED. CONFIRM AND CHECK OUT ONSITE	250 PPP	3.17
MH-9	30 + 765.08	11.5	L	L	166.14	163.25			163.70	250 PPP			163.70	250 PPP	2.90
MH-11	30 + 860.08	11.5	L	L	166.59	163.51			163.96	250 PPP			163.96	250 PPP	3.09
MH-13	30 + 955.08	11.5	L	L	166.87	163.77			164.22	250 PPP			164.22	250 PPP	3.11
MH-15	31 + 060.08	11.5	L	L	167.15	164.03			164.48	250 PPP			164.48	250 PPP	3.13
MH-17	31 + 145.08	11.5	L	L	167.52	164.29			164.74	250 PPP			164.74	250 PPP	3.24
MH-19	31 + 245.08	11.5	L	L	167.83	164.55			165.00	250 PPP			165.00	250 PPP	3.29
MH-21	31 + 335.08	11.5	L	L	167.83	164.80			165.25	250 PPP			165.25	250 PPP	3.04
MH-23	31 + 430.08	11.5	L	L	167.66	165.06			165.51	250 PPP			165.51	250 PPP	2.61
MH-25	31 + 475.20	11.5	L	L	167.58	165.18			165.62 INVERT ASSUMED. CONFIRM AND CHECK OUT ONSITE	250 PPP			165.63	250 PPP	2.41
MH-2	30 + 670	11.5	R	P	165.62	162.25	162.70	600RCP	163.37	250 PPP	162.70	600 RCP	163.10	250 PPP	3.38
MH-4	30 + 598.4	11.5	R	L	165.57	162.82			163.27	250 PPP			163.27	250 PPP	2.76
MH-6	30 + 527.7	11.5	R	L	165.99	163.00			163.45	250 PPP			163.45	250 PPP	3.00
MH-8	30 + 450.39	22.8	R	L	167.09	164.31			164.76	250 PPP			164.77 INVERT ASSUMED. CONFIRM AND CHECK OUT ONSITE	250 PPP	2.79
MH-10	30 + 765.08	11.5	R	L	166.14	163.28			163.73	250 PPP			163.73	250 PPP	2.87
MH-12	30 + 860.08	11.5	R	L	166.60	163.65			164.10	250 PPP			164.10	250 PPP	2.96
MH-14	30 + 955.08	11.5	R	L	166.88	164.02			164.47	250 PPP			164.47	250 PPP	2.87
MH-16	31 + 060.08	11.5	R	L	167.15	164.39			164.84	250 PPP			164.84	250 PPP	2.77
MH-18	31 + 145.08	11.5	R	L	167.52	164.76			165.21	250 PPP			165.21	250 PPP	2.77
MH-20	31 + 245.08	11.5	R	L	167.82	165.13			165.69	250 PPP			165.58	250 PPP	2.69
MH-22	31 + 335.08	11.5	R	L	167.79	165.06			165.51	250 PPP			165.51	250 PPP	2.74
MH-24	31 + 430.66	11.5	R	L	167.57	164.87				250 PPP	165.32 INVERT ASSUMED. CONFIRM AND CHECK OUT ONSITE	250 PPP	165.32	250 PPP	2.71
MH-27	30 + 670.00	50.0	L	D	164.80	162.38			162.83	300 HDPE	162.76	600 RCP	162.76	300 HDPE	2.43
MH-29	30 + 620.00	50.0	L	F	164.29	162.65			163.10	300 HDPE					1.65
MH-31	30 + 520.00	50.0	L	F	164.45	162.85			163.30	300 HDPE					1.60
MH-33	30 + 740.00	50.0	L	F	164.17	162.52							162.97	300 HDPE	1.66
MH-34	30 + 660.00	64.0	L	OPSD 701.010	168.31	166.02					166.32	300 HDPE			2.29
MH-13A	30 + 000	11.5	L	L	166.99	163.52	163.97	600RCP	164.35	250 PPP	163.97	600 RCP	164.35	250 PPP	3.48

SECTION	TYPE	DIA	LENGTH	SLOPE	UPSTREAM MH	DOWNSTREAM MH	UPSTREAM INV	DOWNSTREAM INV
L1.1	PPP	250	98.1	0.91%	MH-7	MH-5	164.67	163.78
L1.2	PPP	250	52.3	0.31%	MH-5	MH-3	163.78	163.62
L1.3	PPP	250	72.2	0.22%	MH-3	MH-1	163.62	163.46
L2.1	PPP	250	45.2	0.27%	MH-25	MH-23	165.63	165.51
L2.2	PPP	250	95.0	0.27%	MH-23	MH-21	165.51	165.25
L2.3	PPP	250	95.0	0.26%	MH-21	MH-19	165.25	165.00
L2.4	PPP	250	95.0	0.27%	MH-19	MH-17	165.00	164.74
L2.5	PPP	250	95.0	0.27%	MH-17	MH-15	164.74	164.48
L2.6	PPP	250	50.0	0.26%	MH-15	MH-13A	164.48	164.35
L2.7	PPP	250	45.0	0.29%	MH-13A	MH-13	164.35	164.22
L2.8	PPP	250	95.0	0.27%	MH-13A	MH-11	164.22	163.96
L2.9	PPP	250	95.0	0.27%	MH-11	MH-9	163.96	163.70
L2.10	PPP	250	95.0	0.25%	MH-9	MH-1	163.70	163.46
R1.1	PPP	250	42.4	3.09%	MH-8	MH-6	164.76	163.45
R1.1	PPP	250	71.1	0.25%	MH-6	MH-4	163.45	163.27
R1.2	PPP	250	71.2	0.24%	MH-4	MH-2	163.27	163.10
R4.1	PPP	250	95.0	0.39%	MH-20	MH-18	165.58	165.21
R4.2	PPP	250	95.0	0.39%	MH-18	MH-16	165.21	164.84
R4.3	PPP	250	95.0	0.39%	MH-16	MH-14	164.84	164.47
R4.4	PPP	250	95.0	0.39%	MH-14	MH-12	164.47	164.10
R4.5	PPP	250	95.0	0.39%	MH-12	MH-10	164.10	163.73
R4.6	PPP	250	95.0	0.38%	MH-10	MH-2	163.73	163.37
R2.1	PPP	250	95.0	0.20%	MH-22	MH-24	165.51	165.32
R3.2	PPP	250	95.6	0.19%	MH-20	MH-22	165.69	165.51
L3.1	HDPE	300	100.0	0.20%	MH-31	MH-29	163.30	163.10
L3.2	HDPE	300	50.0	0.20%	MH-29	MH-27	163.10	163.00
L3.3	HDPE	300	70.0	1.63%	MH-33	MH-27	163.97	162.83
A1.1	RCP	600	36.9	0.51%	MH-27	MH-1	162.76	162.95
A1.2	RCP	600	25.0	0.48%	MH-1	MH-2	162.95	162.83
A1.3	RCP	600	42.2	0.50%	MH-2	HEADWALL H1	162.83	162.62
A2.1	RCP	600	39.1	0.26%	HEDWALL H2	MH-13A	164.07	163.97
A2.2	RCP	600	70.9	0.25%	MH-13A	HEDWALL H3	163.97	163.79
A3.1	HDPE	300	8.7	0.57%	MH-34	RIP-RAP TREATMENT	166.32	166.27



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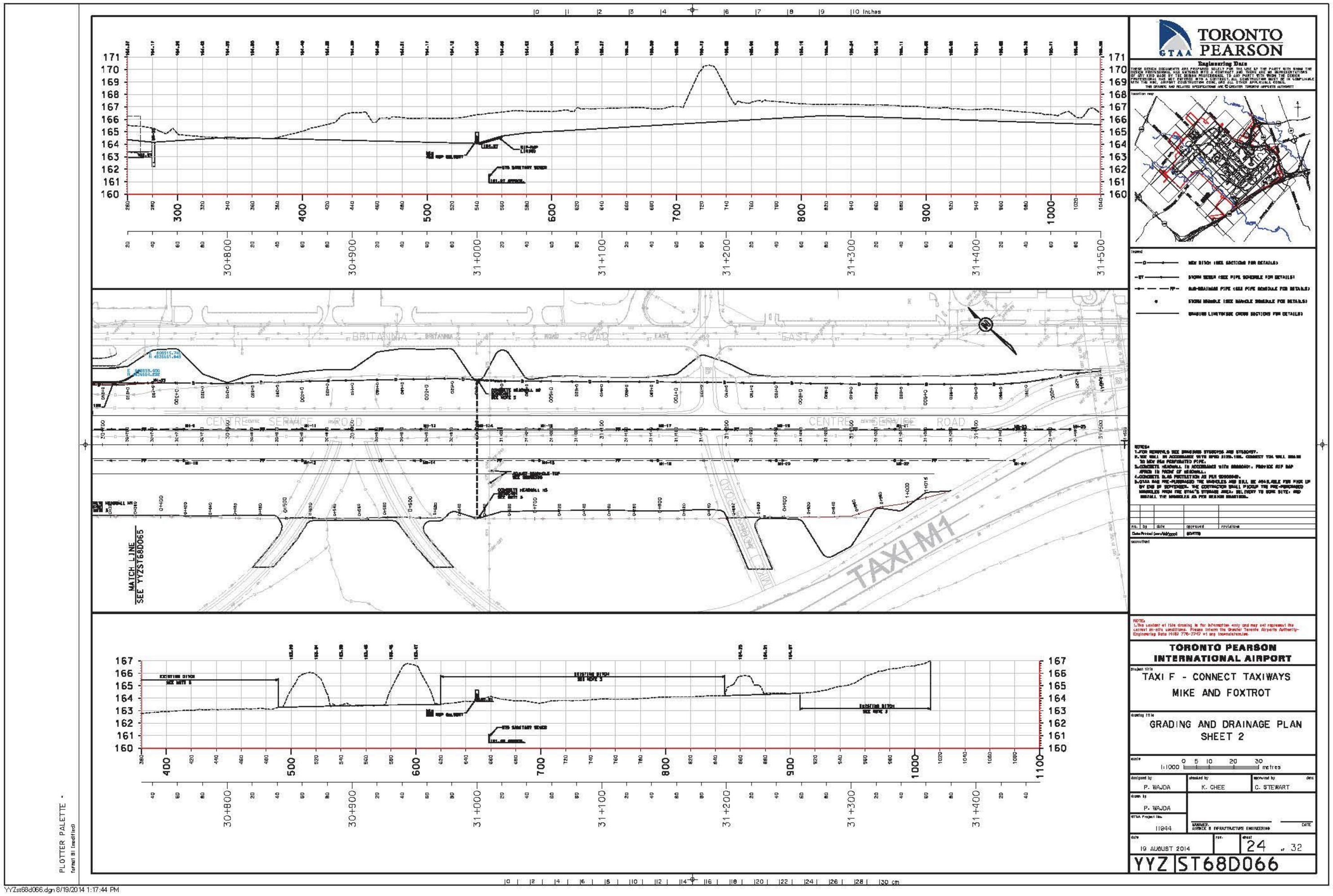
Grading and Drainage Plan



Design and Implementation

Design Consideration – Pavement Design Criteria

- **Subgrade bearing strength of 75kN (≈CBR=5.0) is based on Peto MacCallum Ltd. geotechnical investigation report completed in July 2014.**

- **Existing recycled crushed concrete material from old T2 demolition project has been tested and verified by Peto MacCallum Ltd. which is meeting GTAA granular subbase specification.**

- **Minimum frost protection depth of 0.7m is based on freezing index of 571 Degrees Celcius Days in accordance with Transport Canada design manual (ASG -19/AK-68-12).**

Design and Implementation

Design Consideration – Pavement Design Criteria

Aircraft Movement - Conventional Pavement Approach

- **Based on 2013 Code E and New Large Aircraft movement data and assuming 2.5% of annual growth for next 20 years, the total design aircraft movement is estimated and summarized as follows:**

Design Aircraft	Gross Taxi Weight (tons)	Annual Departures	% Annual Growth	Total Departures for 20-yr
A330-300	230.900	4,080	2.5	102,000
A340-200/300	275.895	475	2.5	11,875
A340-500/600	365.200	1,685	2.5	42,125
A380-800	562.001	315	2.5	7,875
B747-400ER	414.130	2,095	2.5	52,375
B747-8	443.613	65	2.5	1,625
B777-200LR	348.359	2,520	2.5	63,00
B777-300ER	352.441	6,665	2.5	166,625
B787-8(1)	220.446	315	2.5	7,875
DC10-30	264.444	60	2.5	1,500
MD11	287.124	440	2.5	11,000

(1) Since B787-8 is not in service yet, the annual departures as indicated in the above table is only the estimated number for design evaluation purpose which may be operated at GTAA in the future.

Design and Implementation

Design Consideration – Pavement Design Criteria

Aircraft Movement - Perpetual Pavement Approach

- **Based on 2013 Code E and New Large Aircraft movement data and assuming 2.5% of annual growth for next 40 years, the total design aircraft movement is estimated and summarized as follows:**

Design Aircraft	Gross Taxi Weight (tons)	Annual Departures	% Annual Growth	Total Departures for 40-yr
A330-300	230.900	4,080	2.5	244,800
A340-200/300	275.895	475	2.5	28,500
A340-500/600	365.200	1,685	2.5	101,100
A380-800	562.001	315	2.5	18,900
B747-400ER	414.130	2,095	2.5	125,700
B747-8	443.613	65	2.5	3,900
B777-200LR	348.359	2,520	2.5	151,200
B777-300ER	352.441	6,665	2.5	399,900
B787-8(1)	220.446	315	2.5	18,900
DC10-30	264.444	60	2.5	3,600
MD11	287.124	440	2.5	26,400

(1) Since B787-8 is not in service yet, the annual departures as indicated in the above table is only the estimated number for design evaluation purpose which may be operated at GTAA in the future.

Design and Implementation

Design Consideration – Pavement Thickness Design

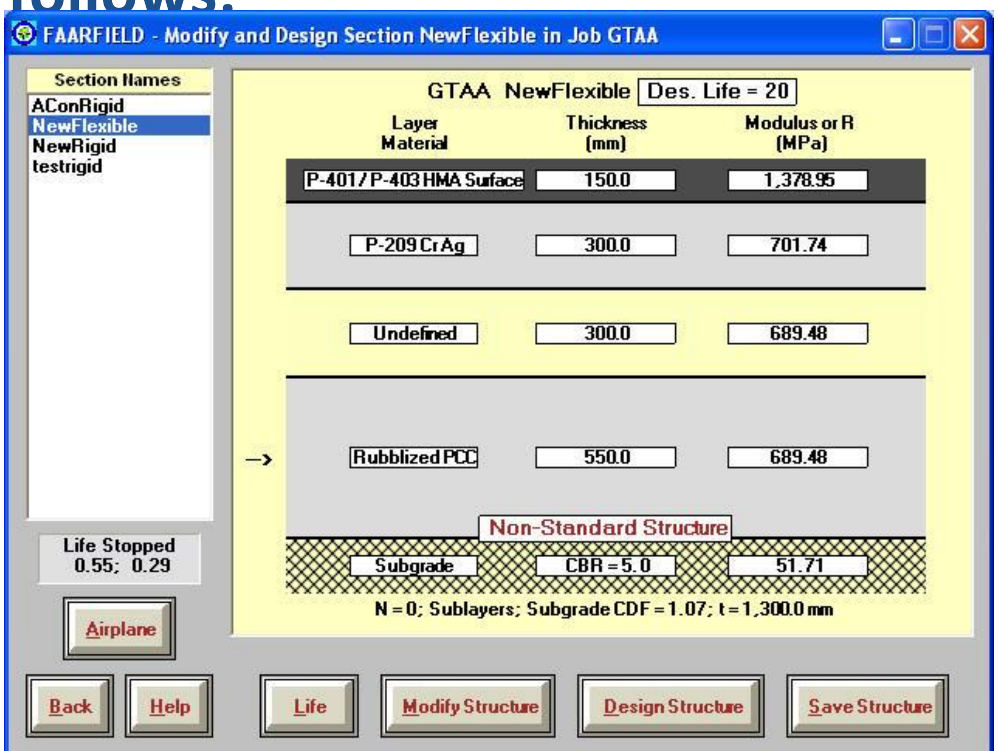
- The pavement thickness design is based on FAA Advisory Circular AC 150/5320-6E Airport Pavement Design and Evaluation procedures by using FAARFIELD v1.3 software which is developed by FAA Technical Centre.

- Also, other design method based on published pavement thickness design charts by Transport Canada is used for comparison purpose; though such charts do not take directly into consideration of cumulative damage factor, air traffic intensity, growth and aircraft mix.

Design and Implementation

Design Consideration – Pavement Thickness Design

- **Based on the FAA FAARFIELD software using the above estimated aircraft movement data for next <u>20</u> years, the pavement thickness is estimated as follows:**



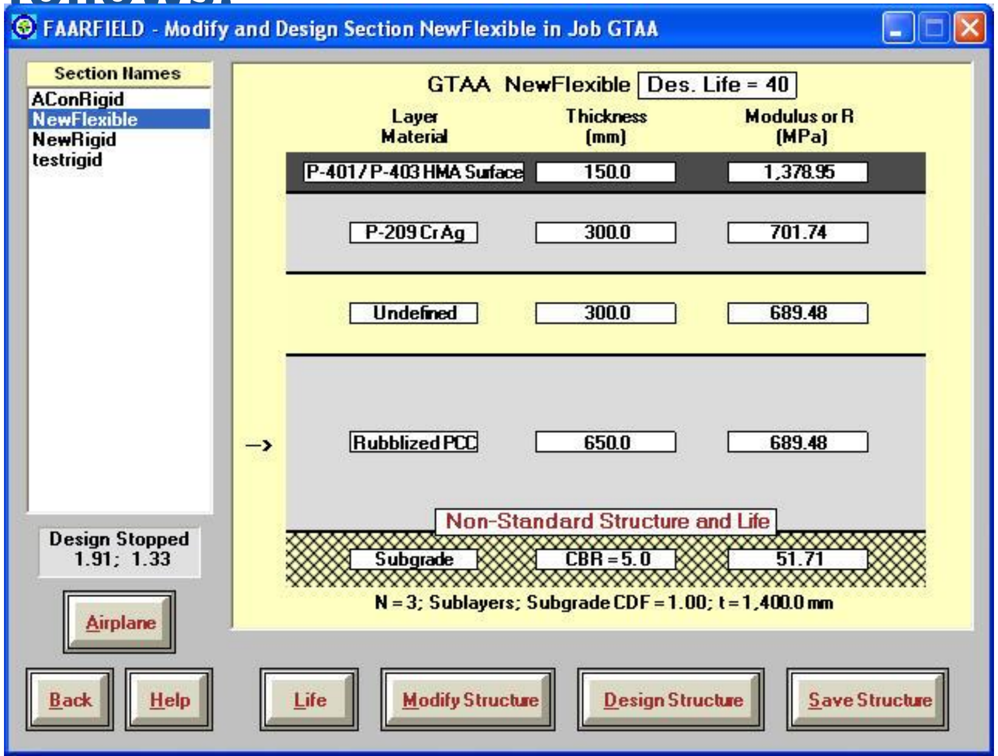
Equivalent granular thickness is 2000mm

HMAC: 150mm
Base: 300mm
Levelling Course: 300mm
Crushed PCC Subbase: 550mm

Design and Implementation

Design Consideration – Pavement Thickness Design

- Based on the FAA FAARFIELD software using the above estimated aircraft movement data for next 40 years, the pavement thickness is estimated as follows:



Equivalent granular thickness is 2200mm

HMAC:	150mm
Base:	300mm
Levelling Course:	300mm
Crushed PCC Subbase:	650mm

Design and Implementation

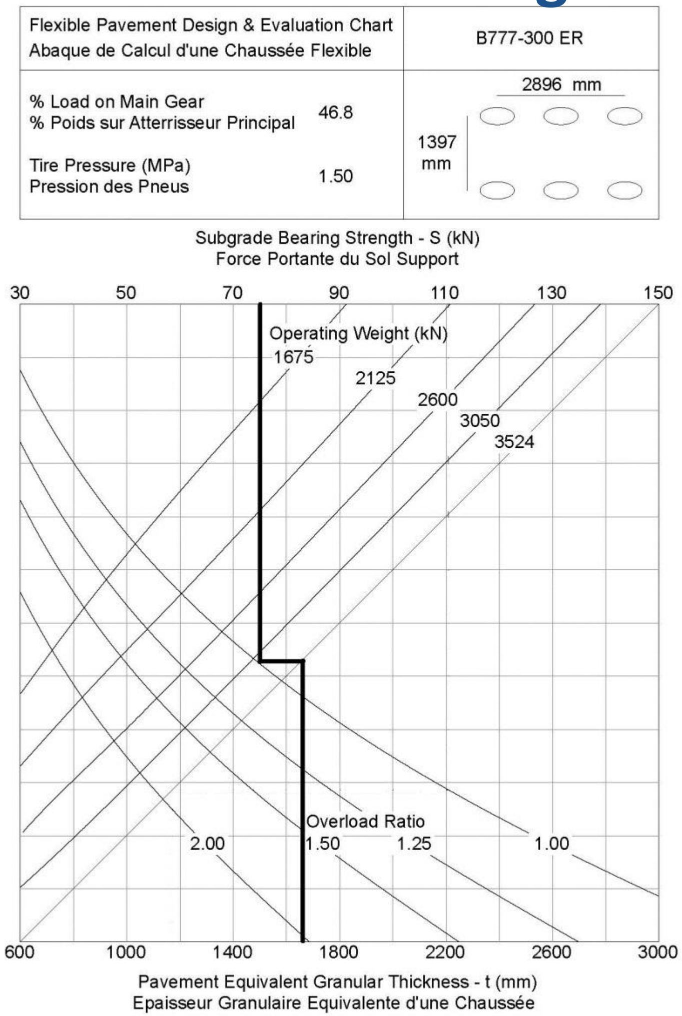
Design Consideration – Pavement Thickness Design

The use of Transport Canada, Technical Programs, "Aircraft Pavement Design & Evaluation Chart Package for Aircraft" is illustrated on the right for B777-300ER, subgrade bearing strength of 75kN and overload ratio of 1.00.

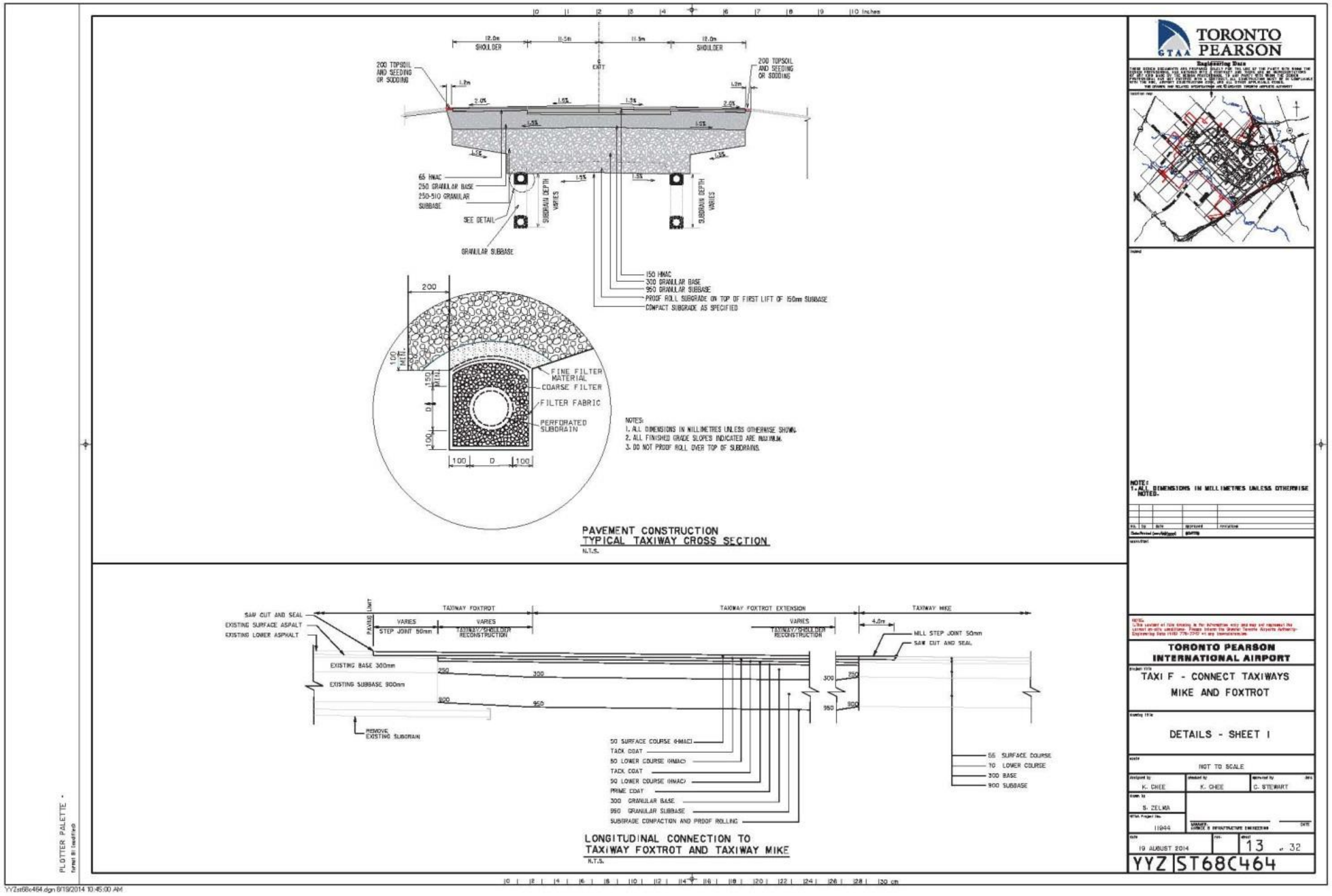
A pavement of equivalent granular thickness of 1680mm is obtained therefore the thickness of each pavement layer is designed as follows:

HMAC:	150mm
Base:	300mm
Levelling Course:	300mm
Crushed PCC Subbase:	375mm

Since the Transport Canada method does not directly take into consideration of cumulative damage factor, air traffic intensity, growth and aircraft mix, the pavement structure is expected to be thinner than the FAA design method.



Pavement Structure and Connecting Details

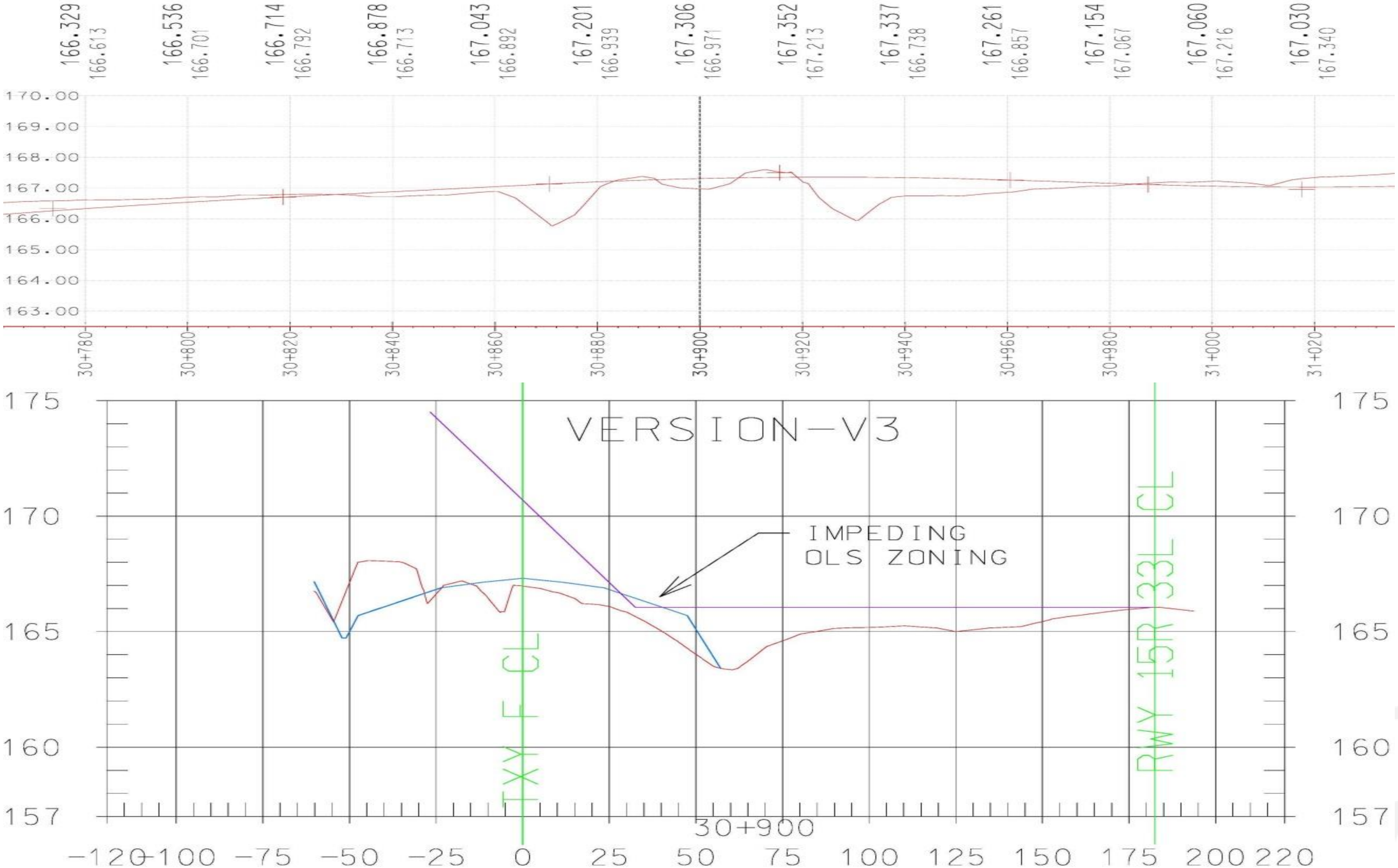


Design and Implementation

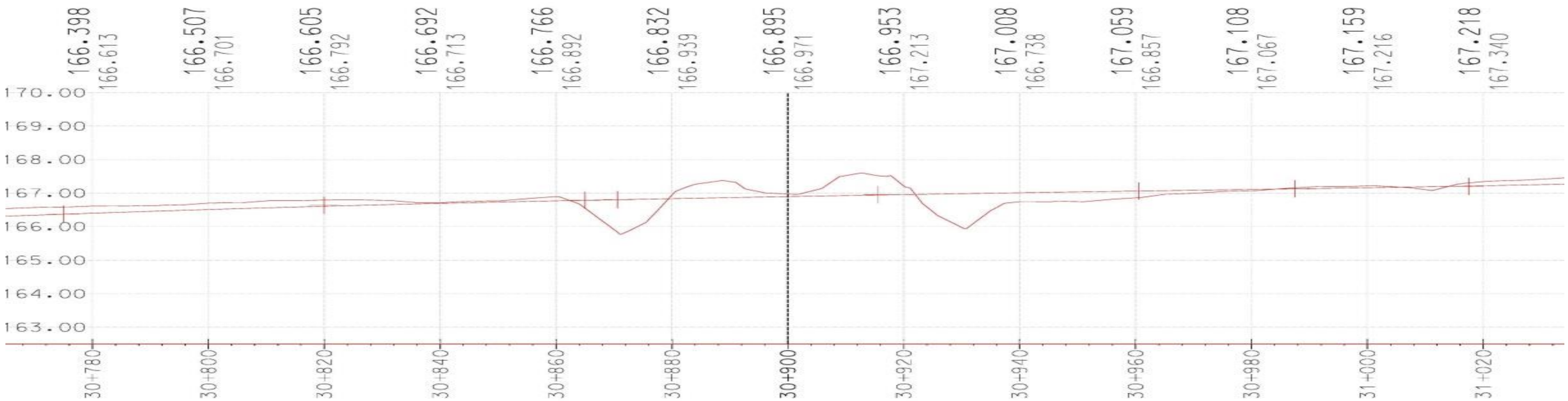
Design Consideration – TP312 compliance

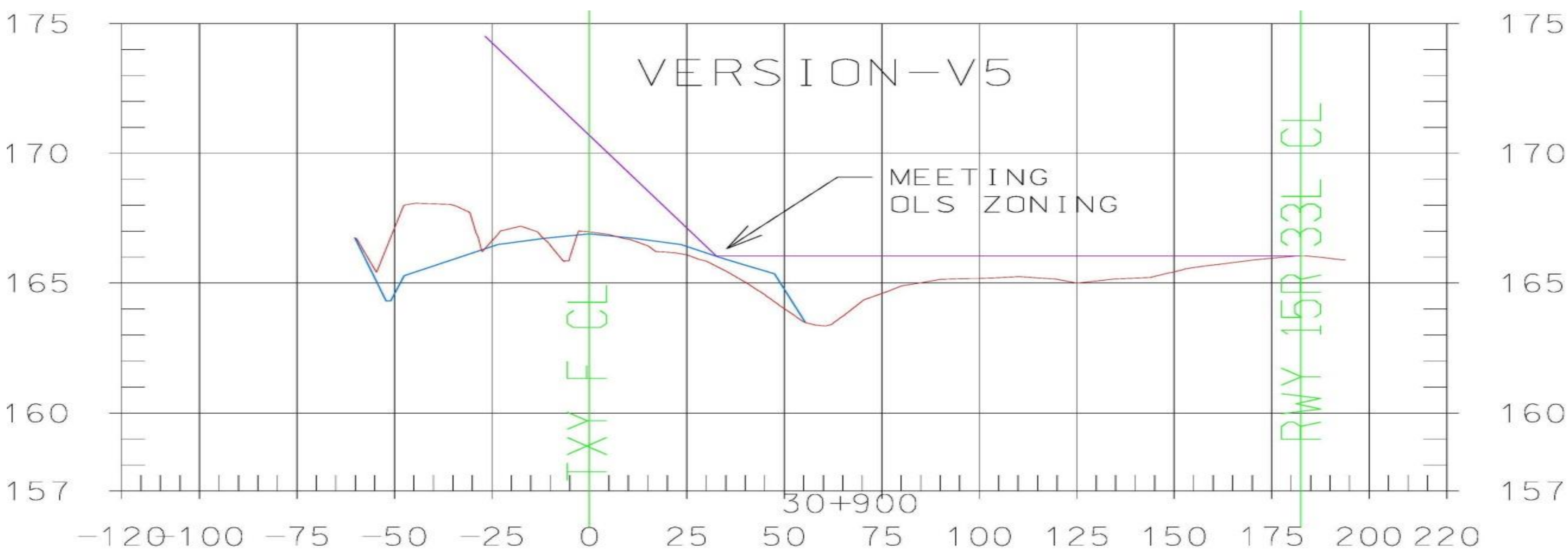
- In order to minimize the construction time and the project cost, we need to balance the cut and fill quantity as much as possible but at the same time to comply with the TP312 requirements and recommendations for a Code E taxiway:
  - Obstacle Limitation Surfaces of the Transition Surface Slope max. 7H:1V
  - Longitudinal slope $\leq$ to 1.5%
  - Longitudinal slope changes not exceeding 1% per 30m
  - Sight distance to be able to see the whole surface of the taxiway for a distance at least 300m from 3m above at any point
  - Transverse slope $\leq$ 1.5%

Transition Surface Verification

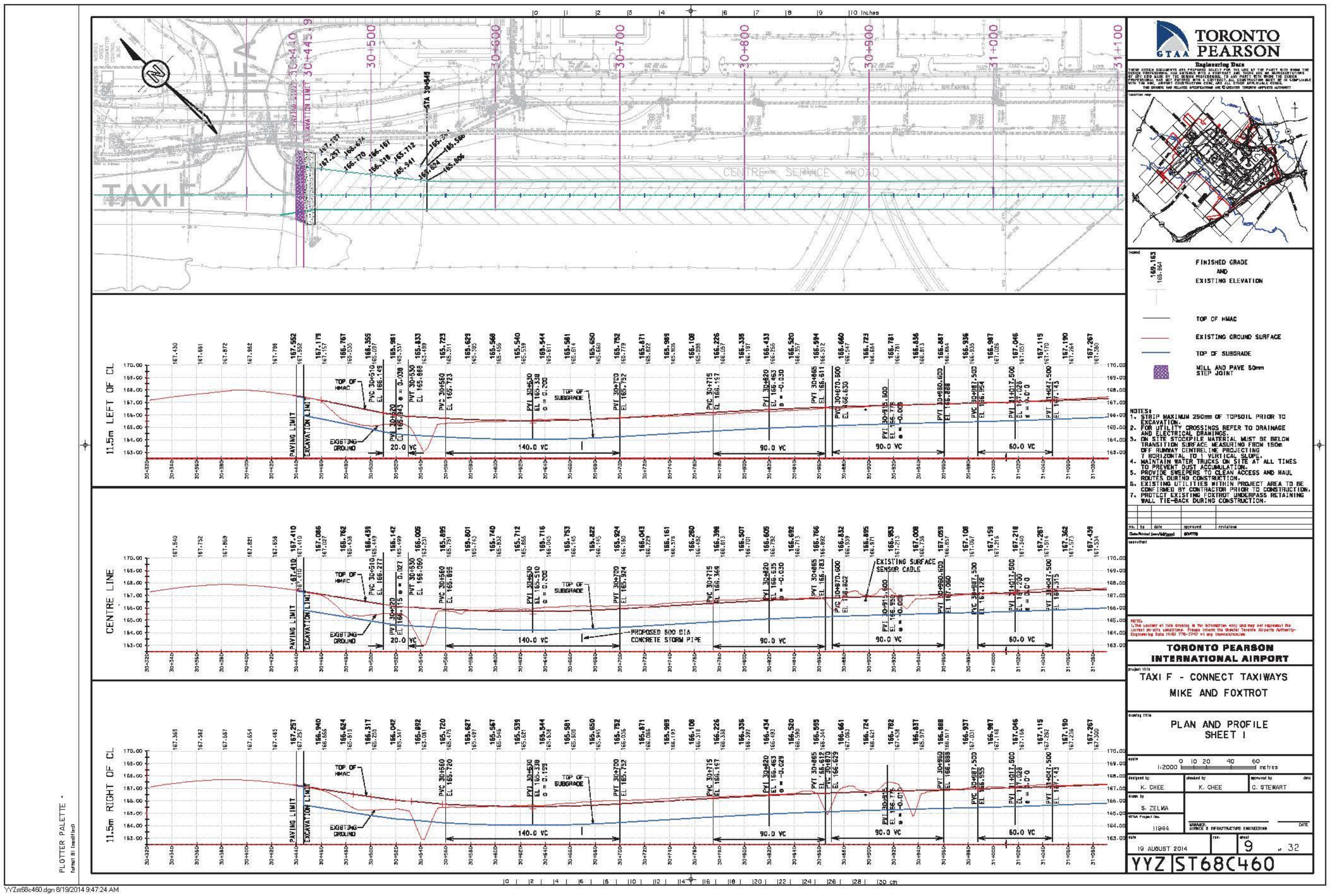


Transition Surface Verification





Plan and Profile



Design and Implementation

Design Consideration – Sustainability

- Select Perpetual Pavement design approach instead of Conventional Pavement design.
- Recycle existing crushed PCC as granular subbase material
- Specify echelon paving to reduce cold joints and joint sealant material
- Specify LED centerline inset lighting, edge lights, guidance signs and wig wags

Design and Implementation

Design Consideration – Future Needs

- To meet future expansion requirement and minimize future operational impact to an active taxiway, a future rapid exit is considered and accommodated as much as possible by preinstalling the underground utilities such as subdrain stubs, electrical conduits and inset cans, strengthening shoulder pavement, etc. within the work limit of the current taxiway alignment.

- To minimize future maintenance down time on maneuvering surface, perpetual pavement and echelon paving are selected for this taxiway.

Design and Implementation

Design Consideration – Electrical

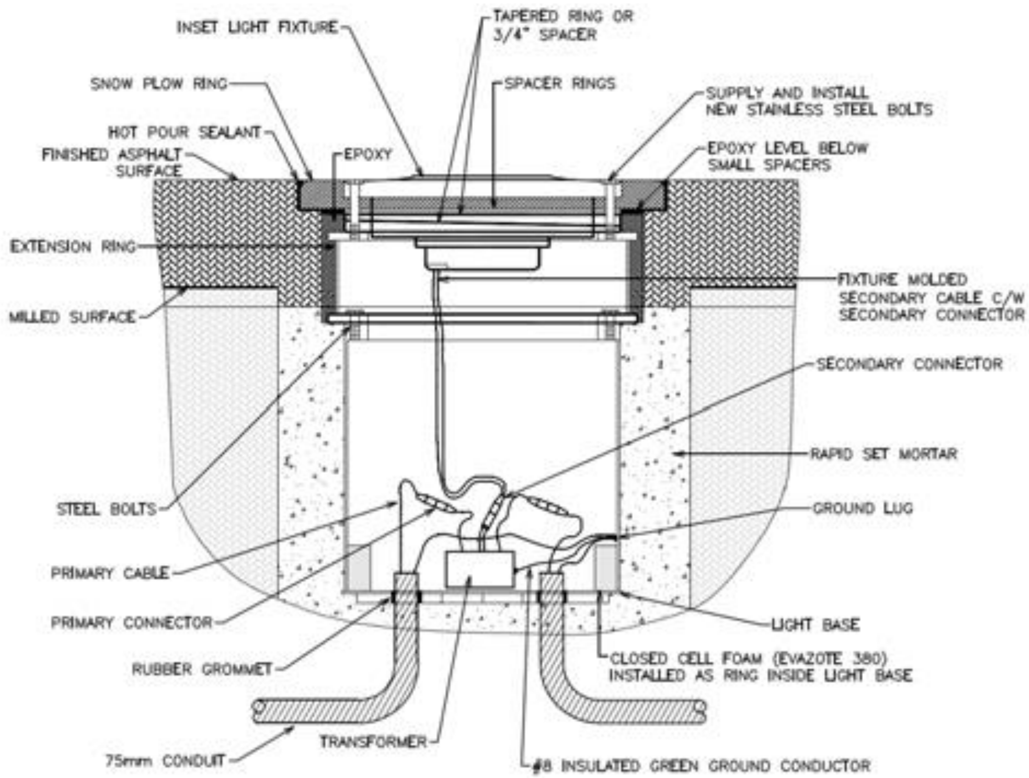
- Select deep can installation approach on LED centreline inset light using primary feed method

- Select LED type guidance signs and edge lights on all new installation and also convert all impacted existing guidance signs and edge lights to LED type

- Replace existing wig wags with new LED type

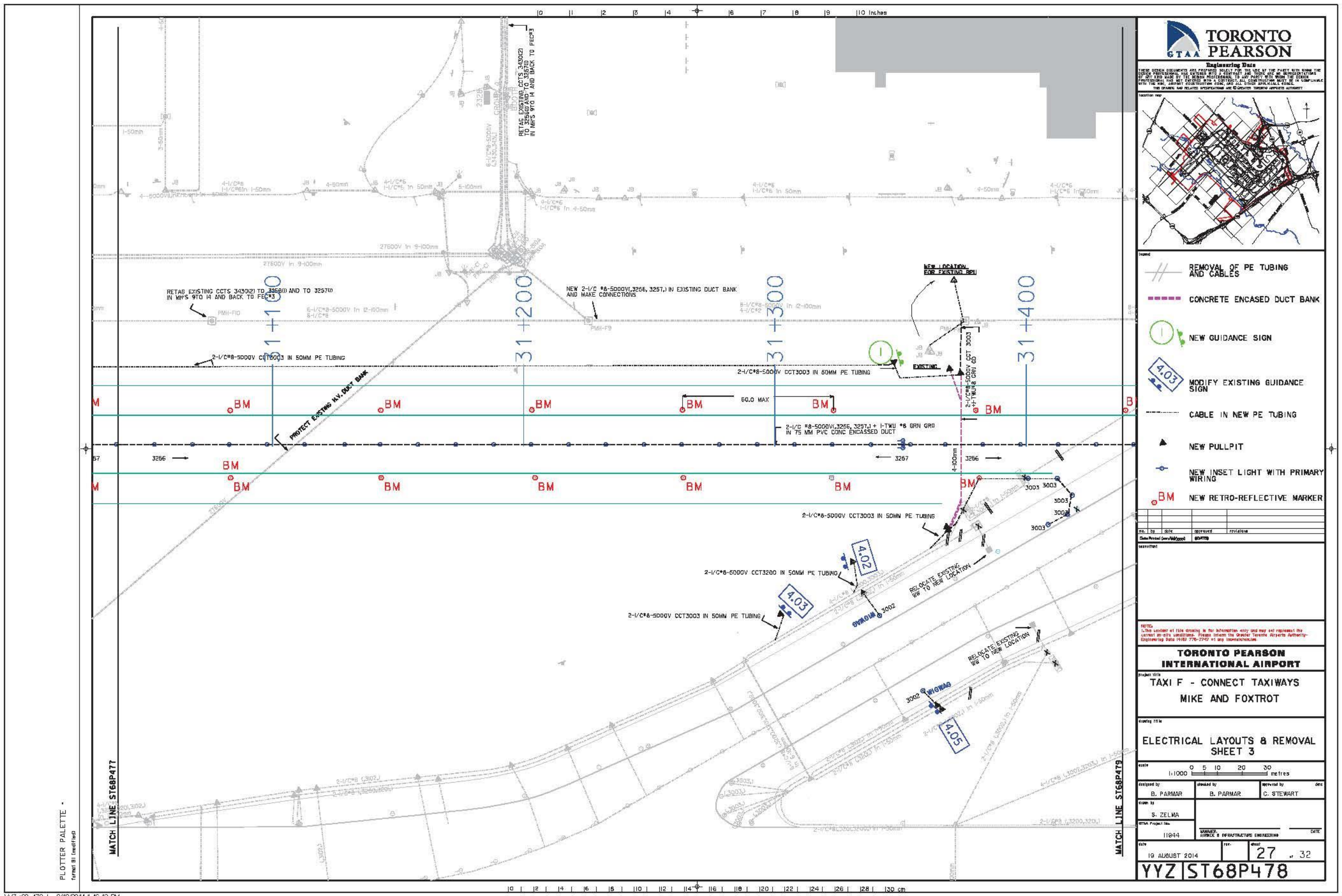
- Drain inset cans and duct banks to nearest storm MH/CB(s)

Deep Inset Can Installation Detail

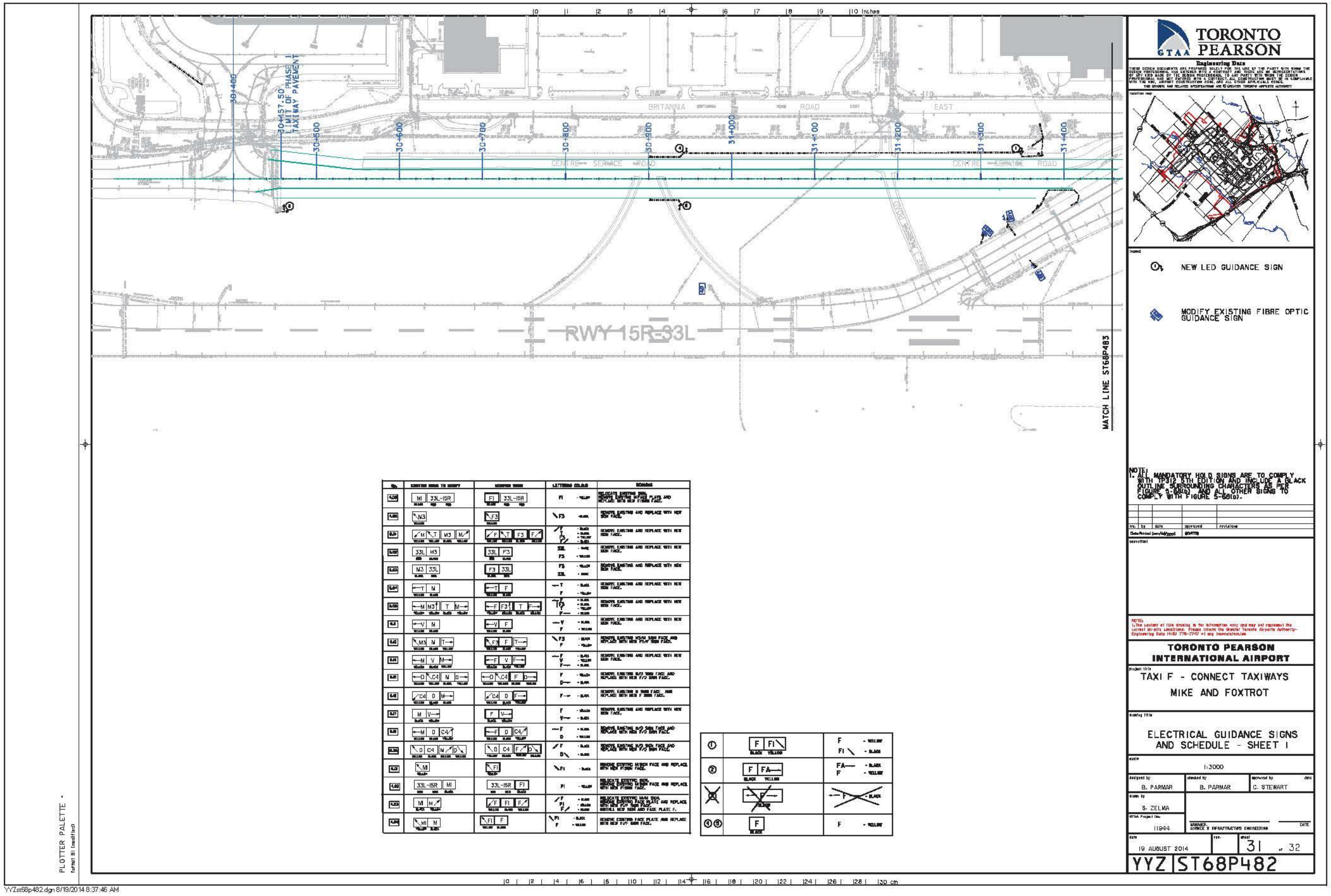


Deep Can installation using Primary Feed Method including drain pipe to nearest MH/CB

Electrical Layouts and Removal



Electrical Guidance Signs and Schedule



Construction Photos

Construction Photos

Mobilization

Installation of environmental measures prior to starting any earth work

Construction Photos

Stripping topsoil

Common excavation

Construction Photos

Re-aligning bus turn around area to allow taxiway construction. Temporary bus turn around area is set up at the Infield Cargo 2 parking lot

Construction Photos

Retaining wall installation to accommodate taxiway grading requirement

Construction Photos

Daylighting the existing utilities using hydrovac method in congested area prior to relocating the primary security fence line

Construction Photos

Concrete encased power duct bank crossing proposed taxiway alignment

Construction Photos

Connecting storm pipe to a catch basin

Laying down storm pipe and backfill with granular

Connecting storm pipe to headwall

Construction Photos

Laying down subdrain pipe

Laying down subdrain manhole

Backfilling with clear stones and wrapping around with geotextile

Construction Photos

Proof rolling subgrade layer to identify any soft spot.

Construction Photos

Placing recycled concrete aggregate as granular subbase material

Applying water to obtain adequate moisture level

Adequate compaction effect to achieve compaction required

Construction Photos

Constructing granular layers under extreme weather condition. Adequate QA & QC control are required to ensure no frozen ground & material are placed between layers.

Completion of granular base layer prior to electrical conduit installation and asphalt paving

Construction Photos

Installing deep can centreline lighting using primary feed method and providing drain pipe to nearest MH/CB(s)

Construction Photos

Applying prime coat prior to placing 1st base course asphalt layer

Echelon paving 1st base course asphalt to eliminate longitudinal cold joint on the main taxiway. Shuttle buggy to reduce the possibility of segregation

Construction Photos

Checking in-situ asphalt density on each subsequent asphalt layer using nuclear gauge

Checking asphalt compaction temperature on each subsequent asphalt layer

Construction Photos

Applying tack coat and echelon paving 2nd base course asphalt

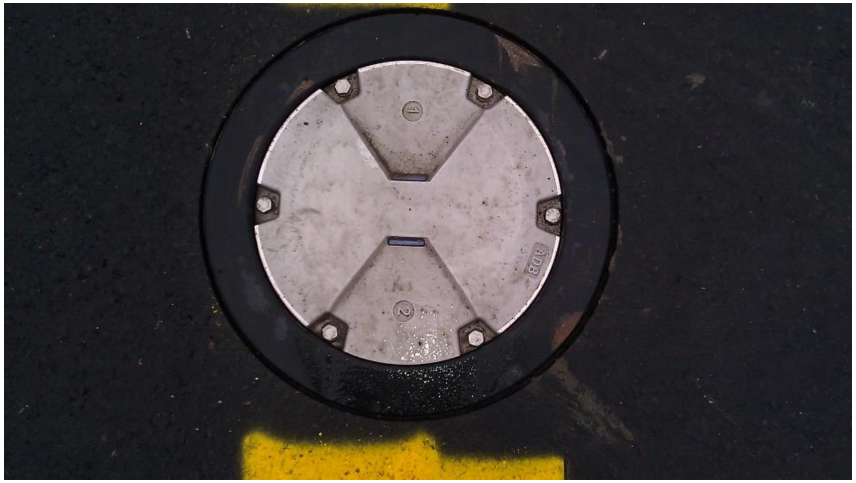
Construction Photos

Applying tack coat and echelon paving surface course asphalt layer

Construction Photos

Cutting back longitudinal cold joint, applying prime coat and placing shoulder asphalt

Construction Photos



Locating base inset can, coring asphalt, feeding wire, installing top inset can, transformer, spacer ring, snow plow ring and LED inset light

Construction Photos

In order to ensure a sustainable future, LED guidance sign, LED inset light and LED wig wag are selected for this project

Construction Photos

Placing pavement marking

Final clean up on taxiway prior to opening

Conclusions

Conclusions

Project Facts: Construction started on Sept 25 and completed on Dec 15

Common Excavation & Backfilling on Site	28,700 m3
Common Excavation & Disposal off Site	39,000 m3
Granular Subbase from Crushed concrete	51,300 t
Granular Subbase Levelling course	35,000 t
Granular Base	34,000 t
HMAC Surface	3,400 t
HMAC Base	6,600 t
HMAC Shoulder	4,100 t

Conclusions

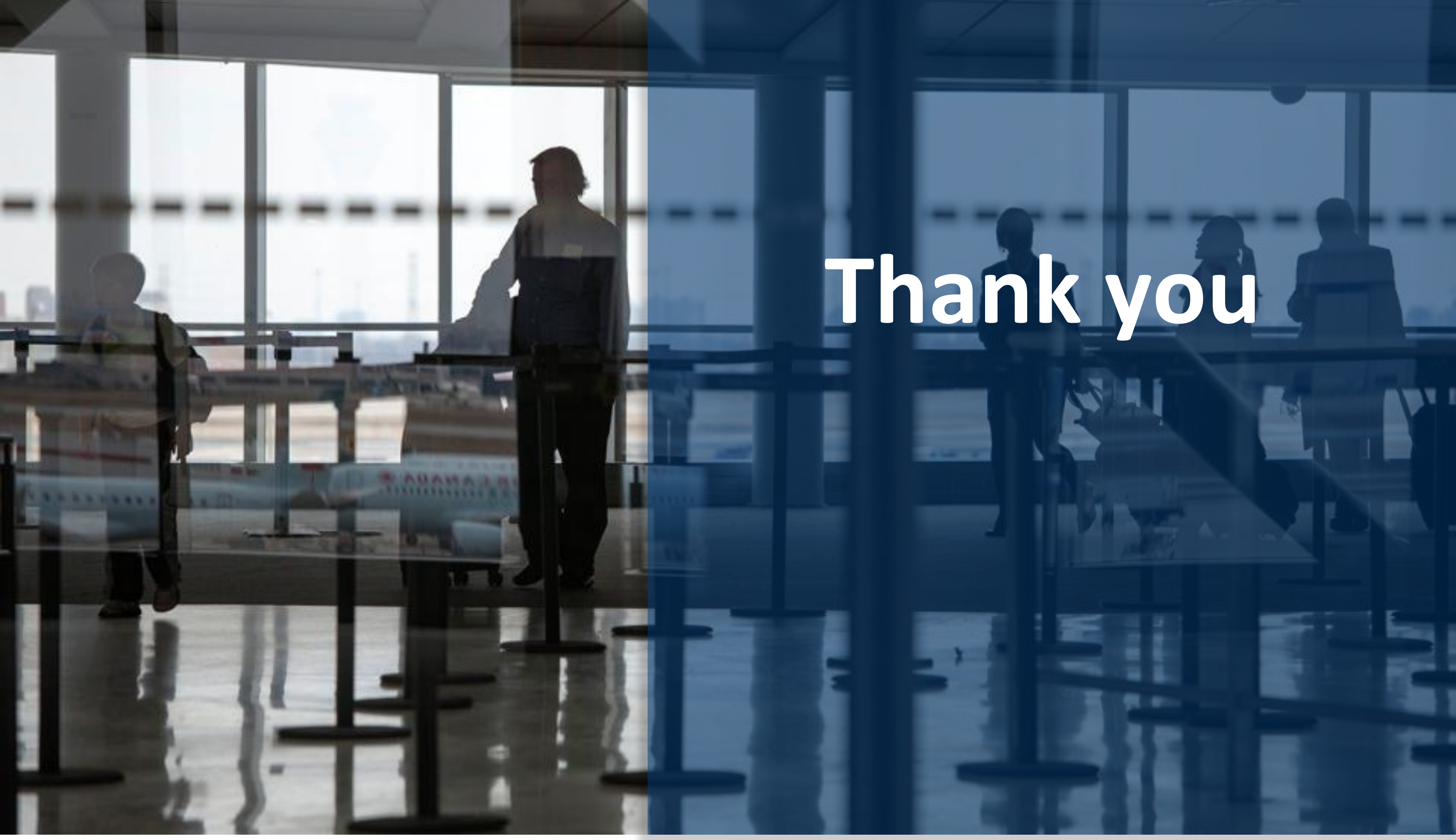
Lessons Learned

→ Engagement, communication, planning and coordination in advance between clients, tenants, internal and external stakeholders are the key factors for success.

→ Experienced Contractor with good airport knowledge is a must for success.

→ To ensure a sustainable future, perpetual pavement and LED lighting are viable options when compared with convention pavement and traditional lighting.

→ Project was completed on time and on budget.



Thank you

GTAA

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