

# + Upgrading Runway Safety: Planning, Design and Construction of RESAs at YVR

Benson Nguyen and Keith Shum

SWIFT September 22, 2016

Copyright © Hatch 2016. All Rights Reserved.

**HATCH**

# Overview

1. YVR (Vancouver International Airport)
2. RSA Overview
3. RSA Selection Process
4. Design
5. Construction
6. Challenges / Lessons Learned

Photo Credit: Jacob Bros. Construction





YVR

Terminal

Runway  
08L-26R  
(9,940ft)

Runway  
13-31  
(7,300ft)

Runway  
08R-26L  
(11,500ft)

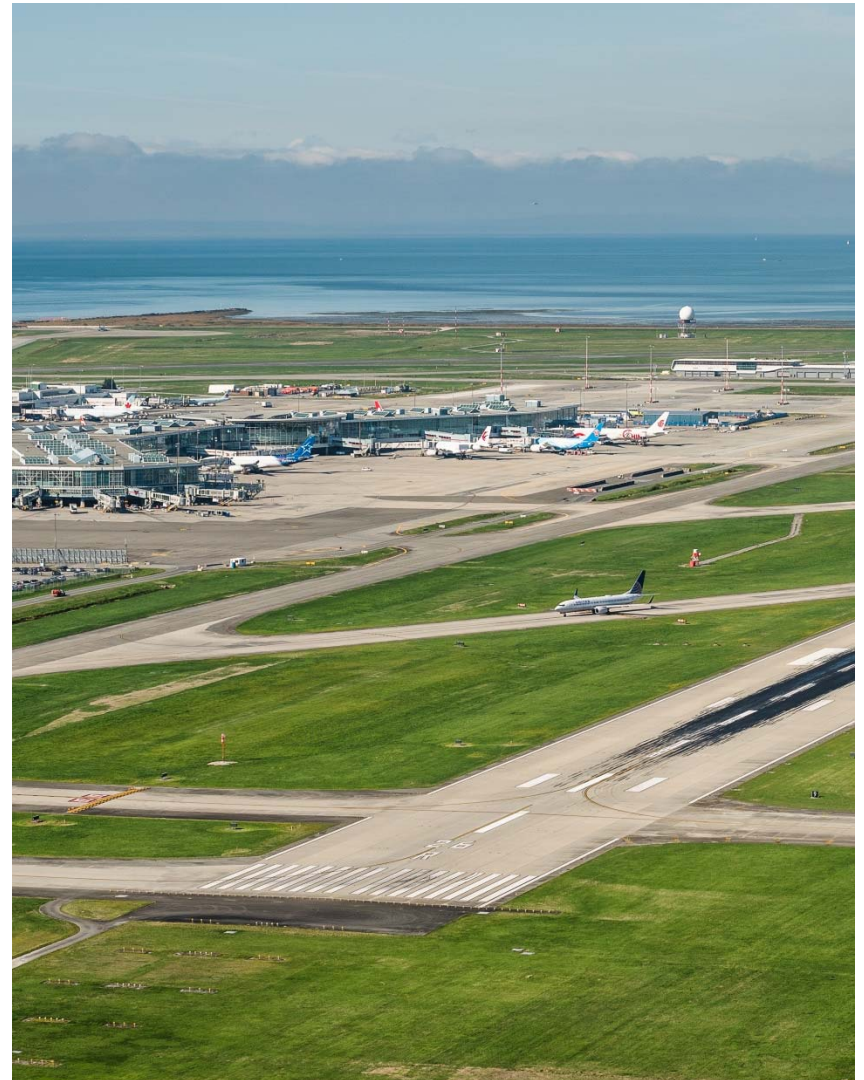
**HATCH**



# YVR

- Canada's second busiest airport
- In Year 2015, served:  
56 airlines  
20 million+ passengers,  
278,000+ aircraft movements, and  
272,000 metric tonnes cargo
- North Runway: 9,940ft (3,030m) – used  
mainly for arrivals.
- South Runway: 11,500ft (3,505m) –  
arrivals and departures
- Second only to LAX for international  
traffic on west coast NA
- Voted by Skytrax as best airport in  
North America for the 7th consecutive  
year

Copyright © Hatch 2016. All Rights Reserved.





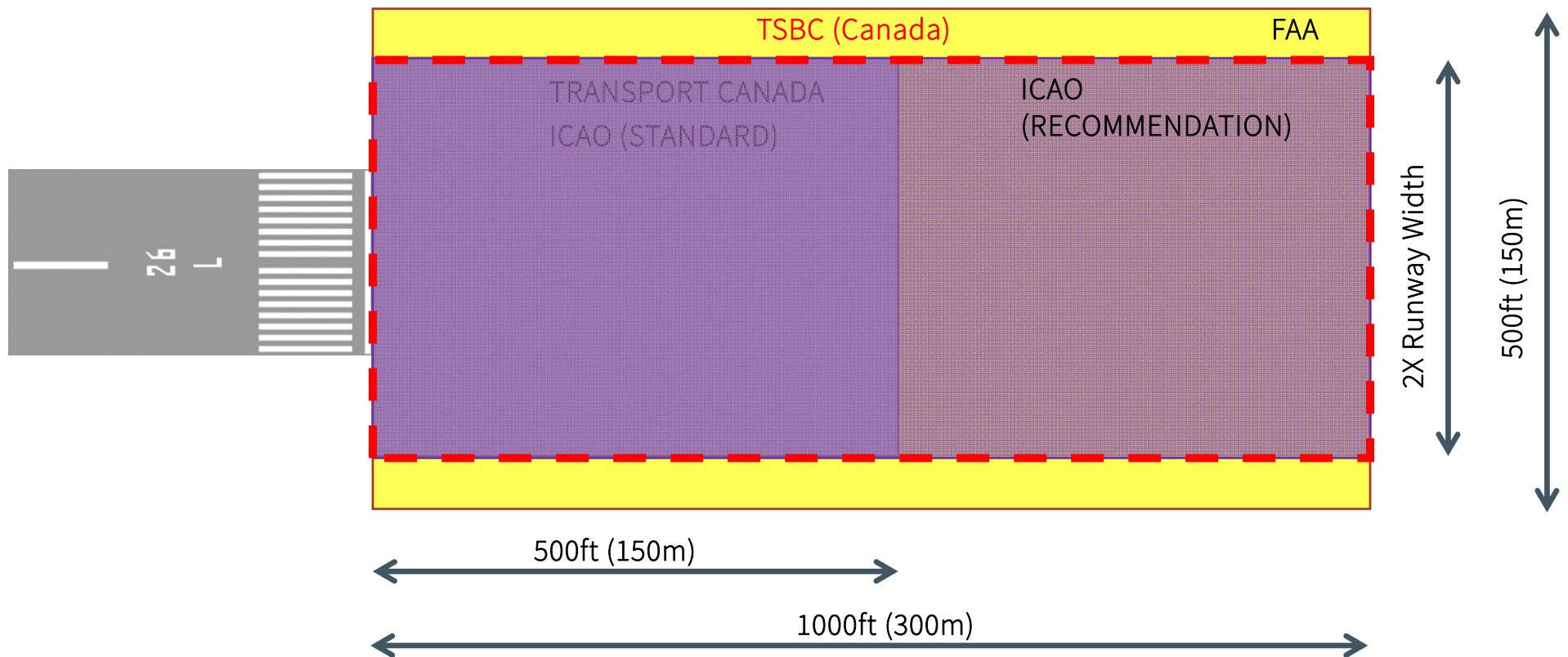
# RSA Overview

- “The objective of a runway end safety area is to have an area free of objects, other than frangible visual and navigational aids required to be there by function, so as to reduce the severity of damage to an aircraft overrunning or undershooting the runway and to facilitate the movement of rescue and fire fighting vehicles ” – TP312 5<sup>th</sup> Ed.
- “under dry conditions, be of sufficient strength to reduce the severity of structural damage to the critical aircraft overrunning / undershooting the runway”  
– NPA 2010-012 Runway End Safety Area

Wet Conditions!

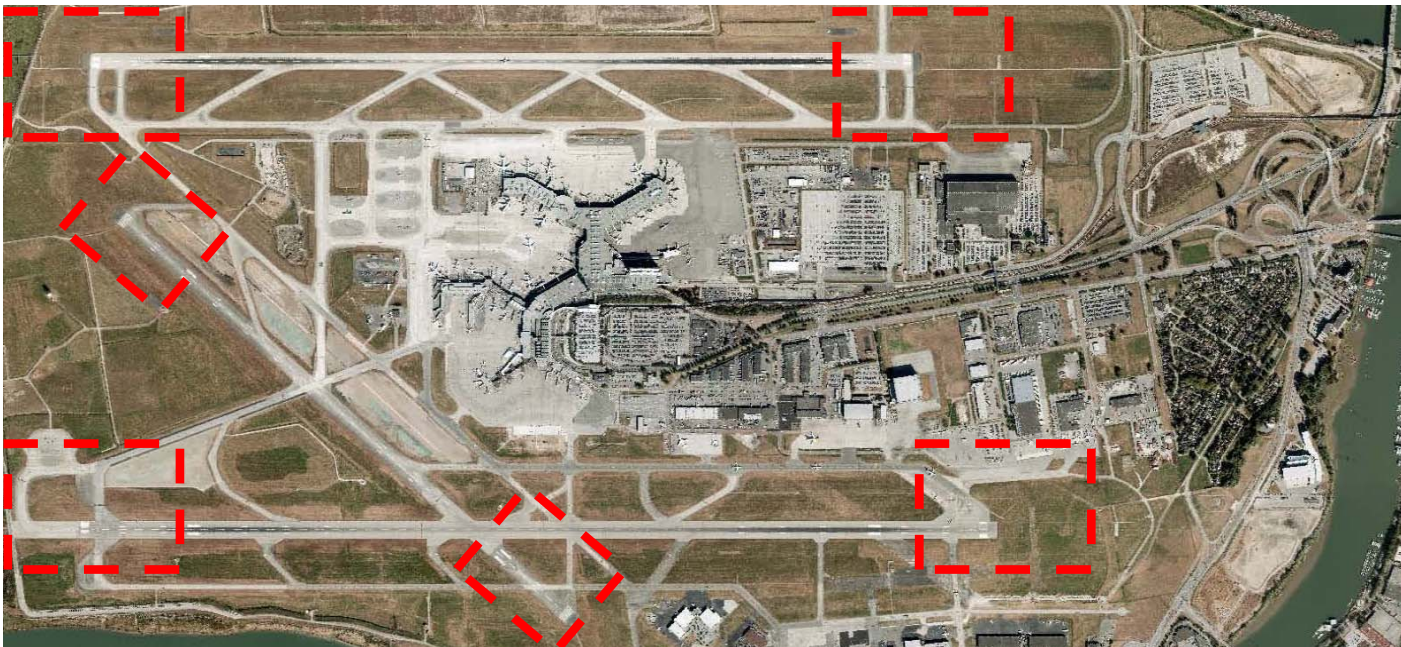


# RSA Overview





# RSA Selection Process



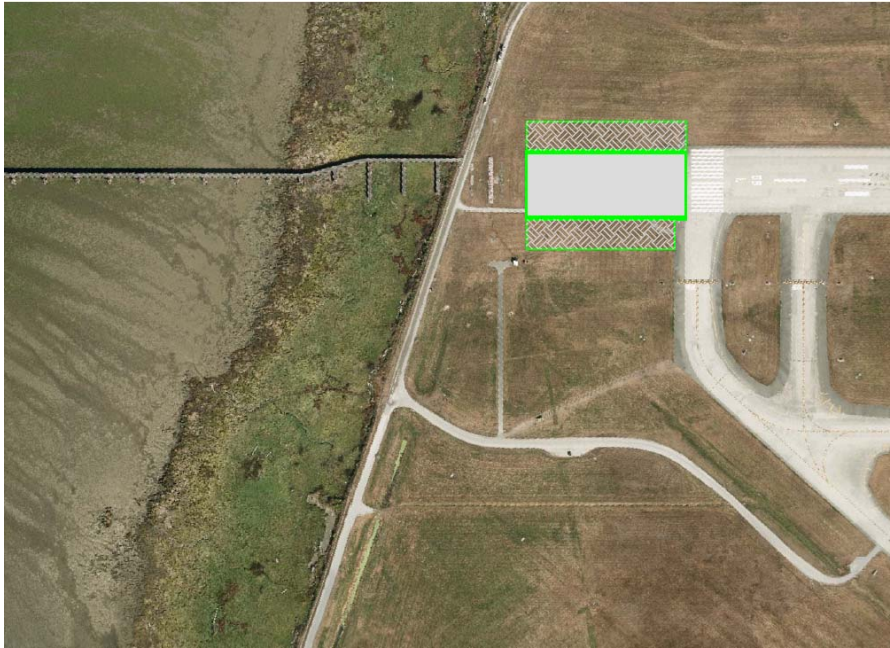
- RSA Options Report
  - Operations: TORA, TODA, ASDA, LDA
  - Construction Impacts
  - Capital Costs
  - Economic Benefits
  - Environment
  - Approvals
  - Community Impacts

11 Options evaluated!

# RSA Selection Process

08L End:

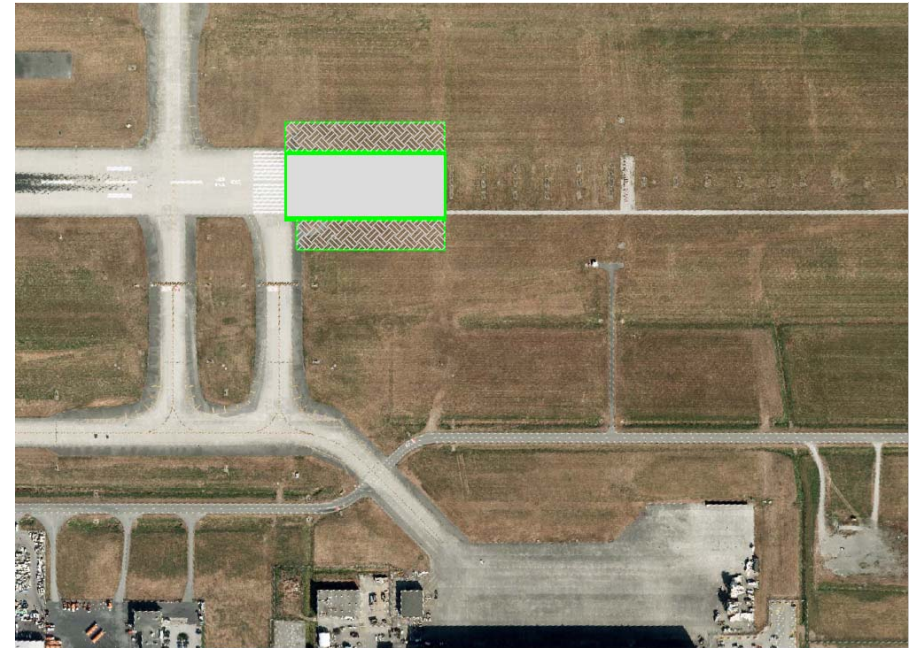
- 150m RSA



Copyright © Hatch 2016. All Rights Reserved.

26R End:

- 150m RSA



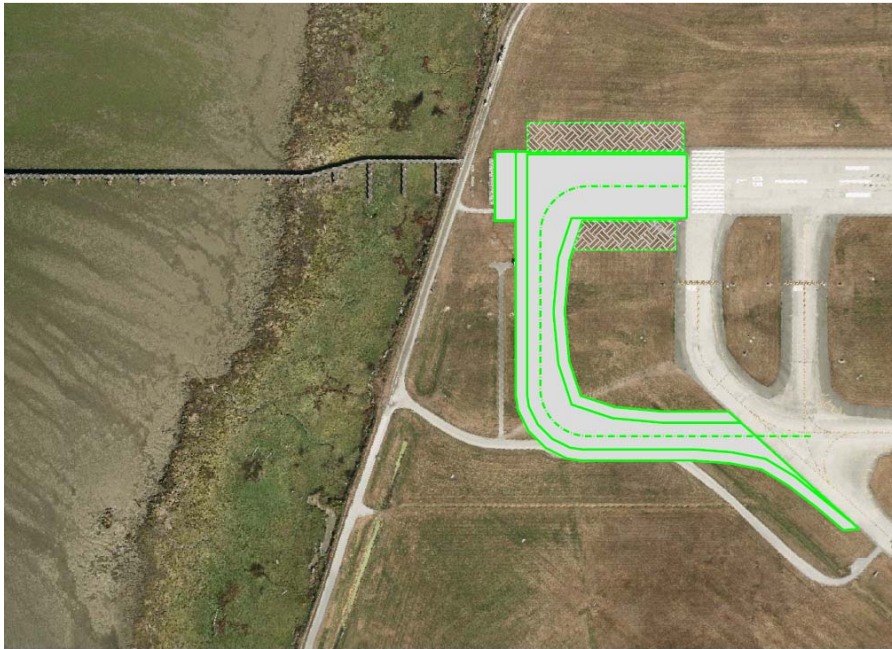
**HATCH**



# RSA Selection Process

08L End:

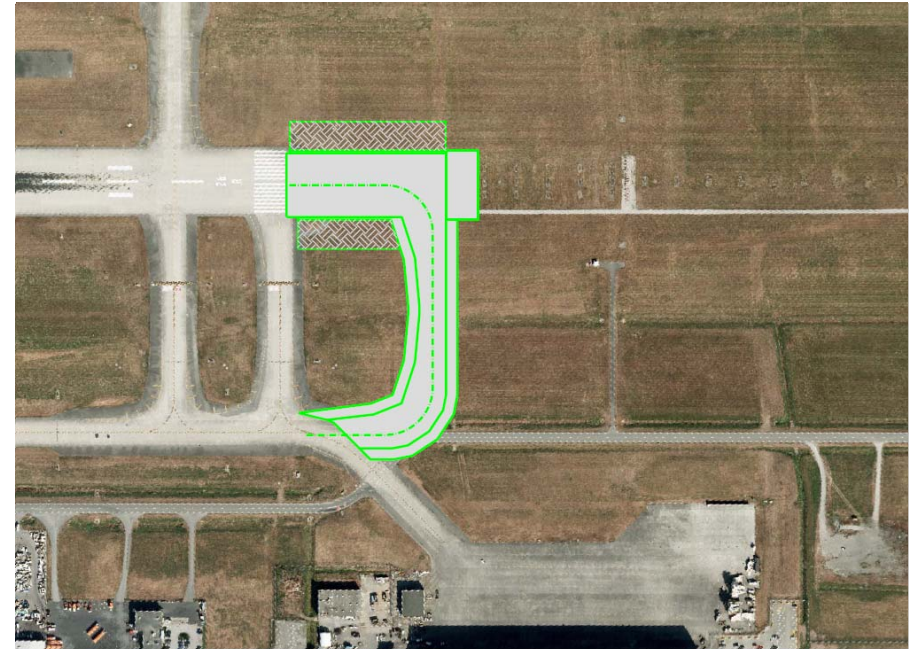
- 150m RSA and Taxiway



Copyright © Hatch 2016. All Rights Reserved.

26R End:

- 150m RSA and Taxiway

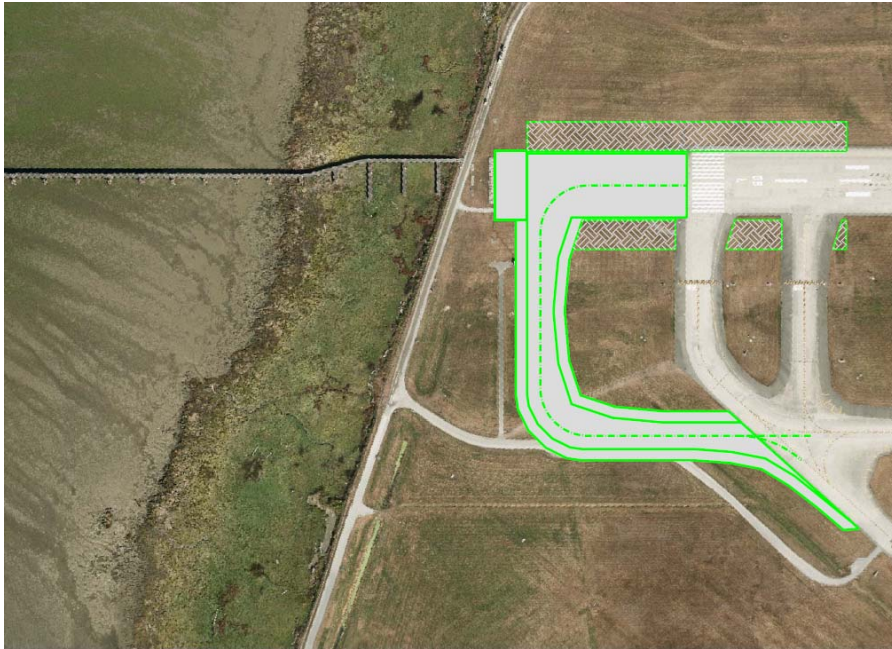


**HATCH**

# RSA Selection Process

08L End:

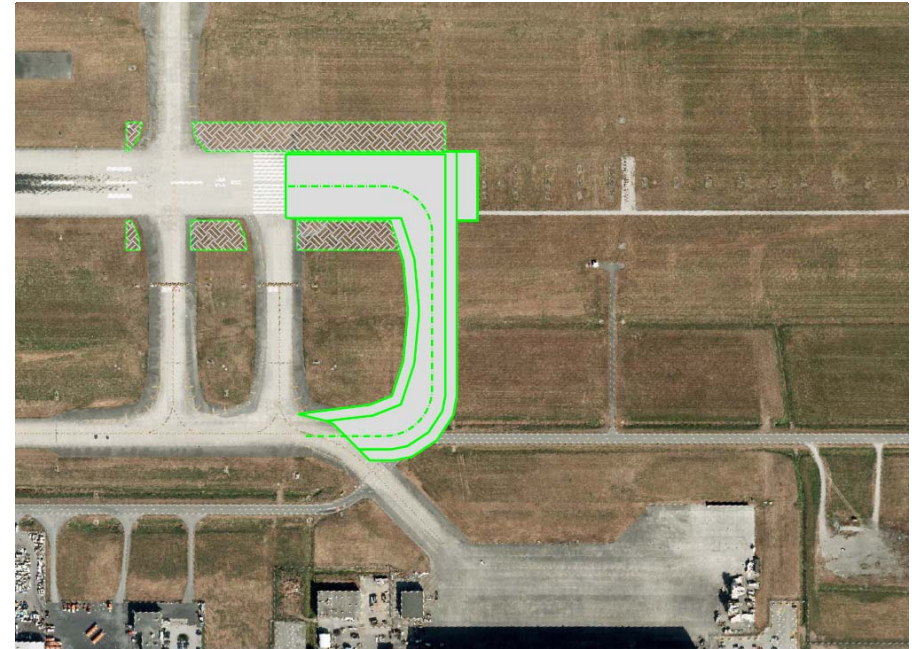
- 300m RSA and Taxiway



Copyright © Hatch 2016. All Rights Reserved.

26R End:

- 300m RSA and Taxiway



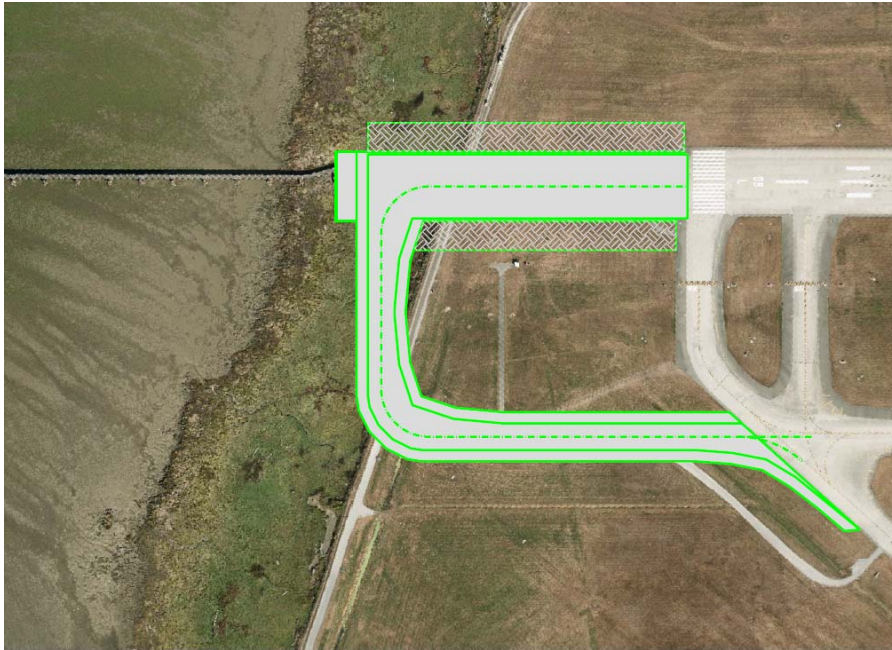
HATCH



# RSA Selection Process

08L End:

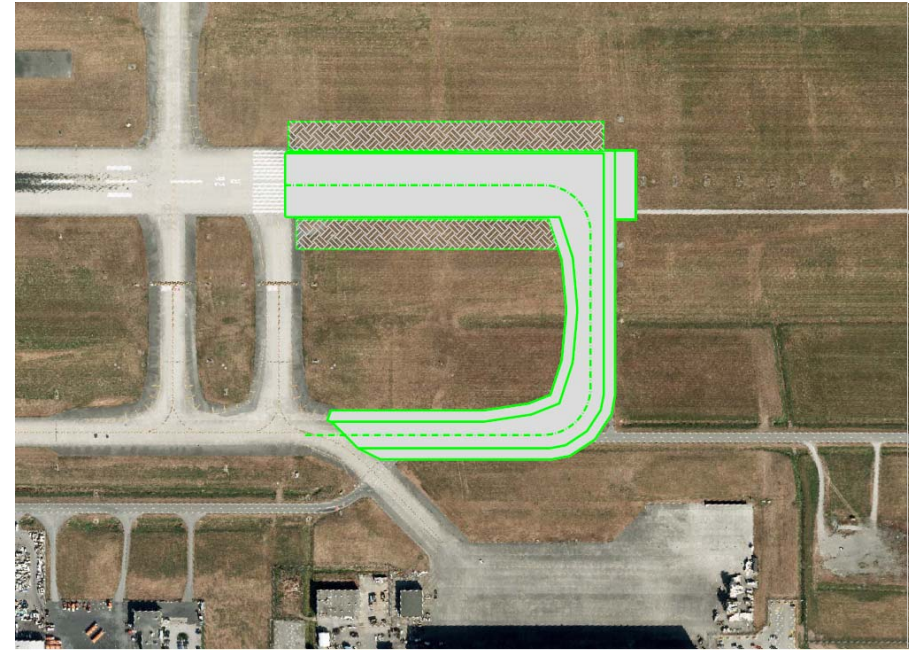
- 300m RSA and Taxiway (usable)



Copyright © Hatch 2016. All Rights Reserved.

26R End:

- 300m RSA and Taxiway (usable)



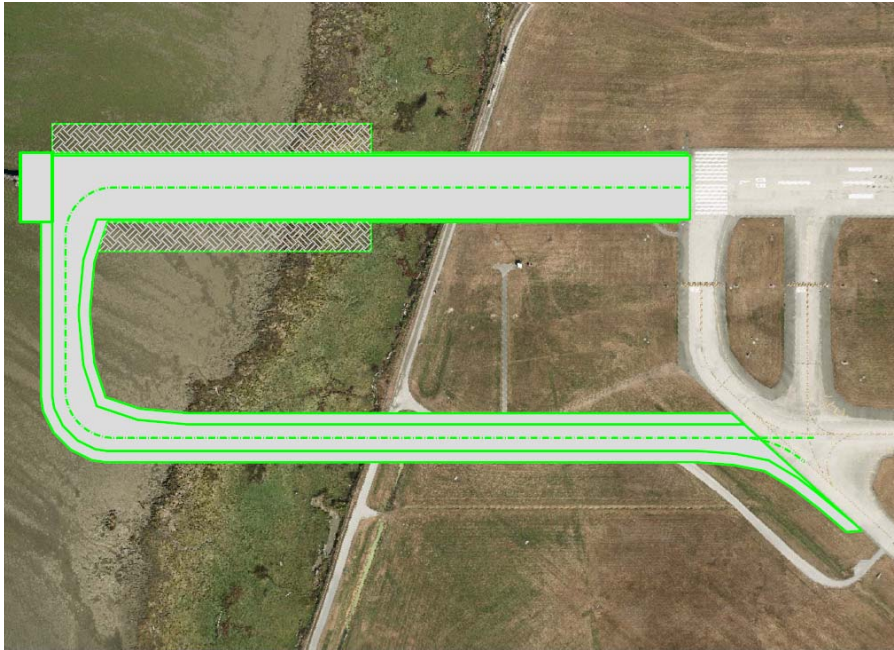
**HATCH**

# RSA Selection Process

08L End:

- 300m RSA and Taxiway (extension)

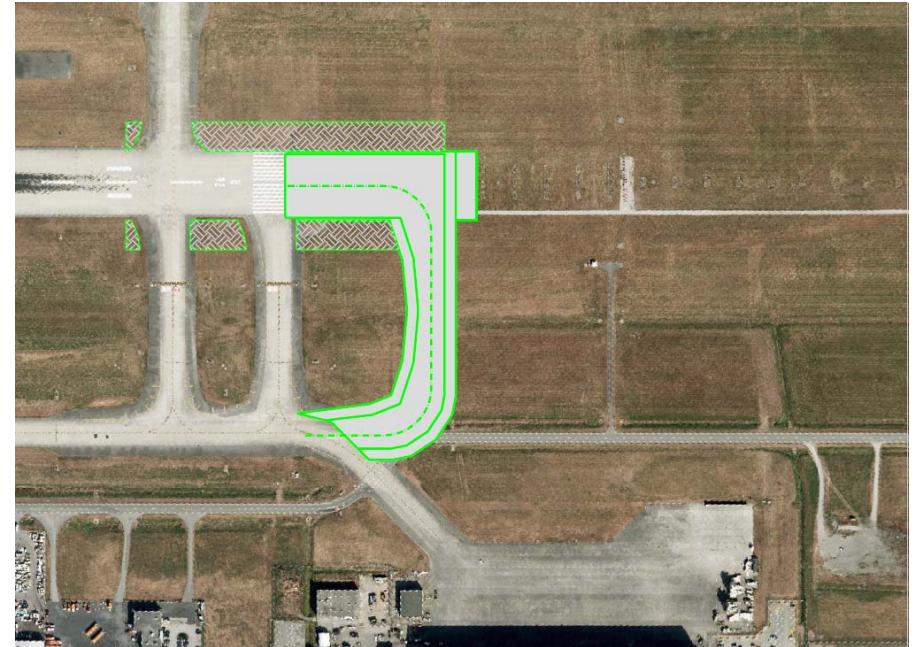
Undecided



Copyright © Hatch 2016. All Rights Reserved.

26R End:

- 300m RSA and Taxiway (extension)



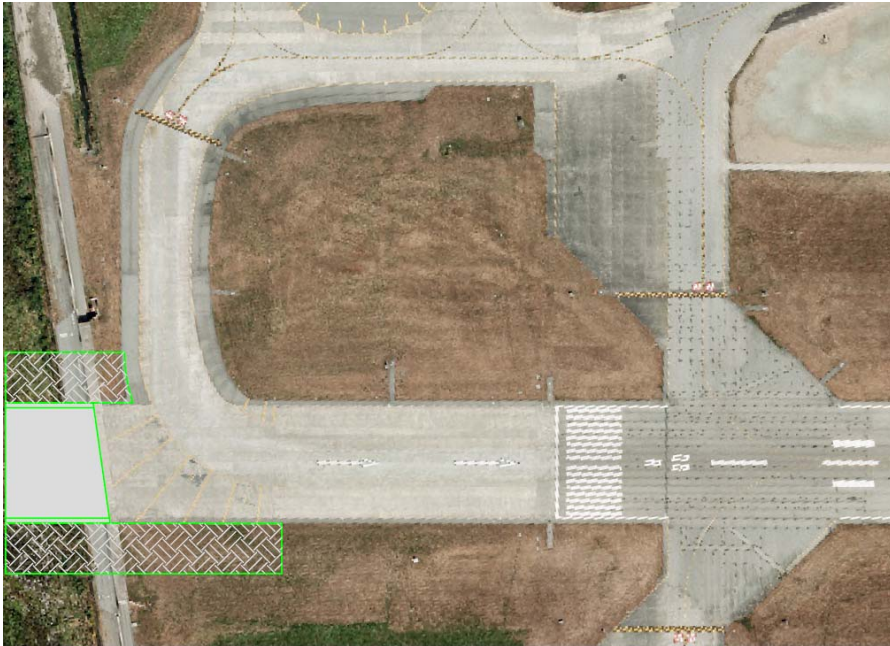
HATCH



# RSA Selection Process

08R End:

- 150m RSA



Copyright © Hatch 2016. All Rights Reserved.

26L End:

- 150m RSA



**HATCH**

# RSA Selection Process

08R End:

- 150m RSA



Copyright © Hatch 2016. All Rights Reserved.

26L End:

- 150m RSA and taxiway



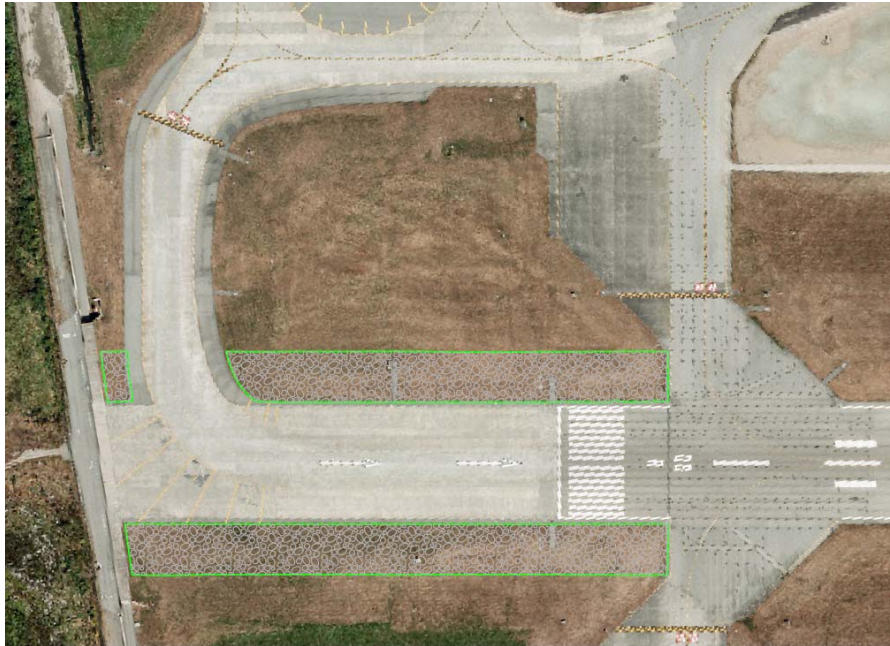
**HATCH**



# RSA Selection Process

08R End:

- 300m RSA

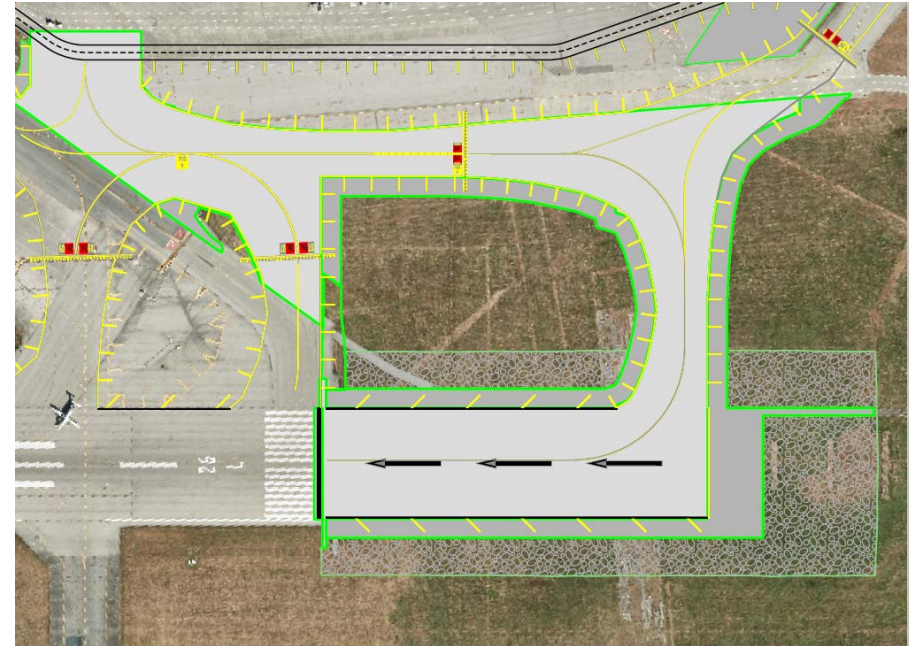


Copyright © Hatch 2016. All Rights Reserved.

26L End:

- 300m RSA and taxiway

Preferred Option



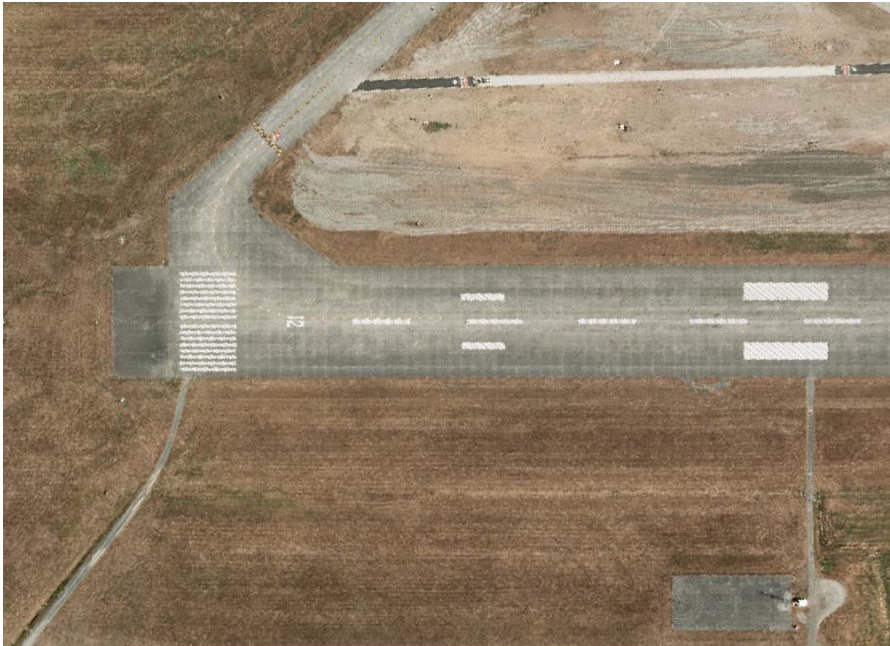
HATCH



# RSA Selection Process

13 End:

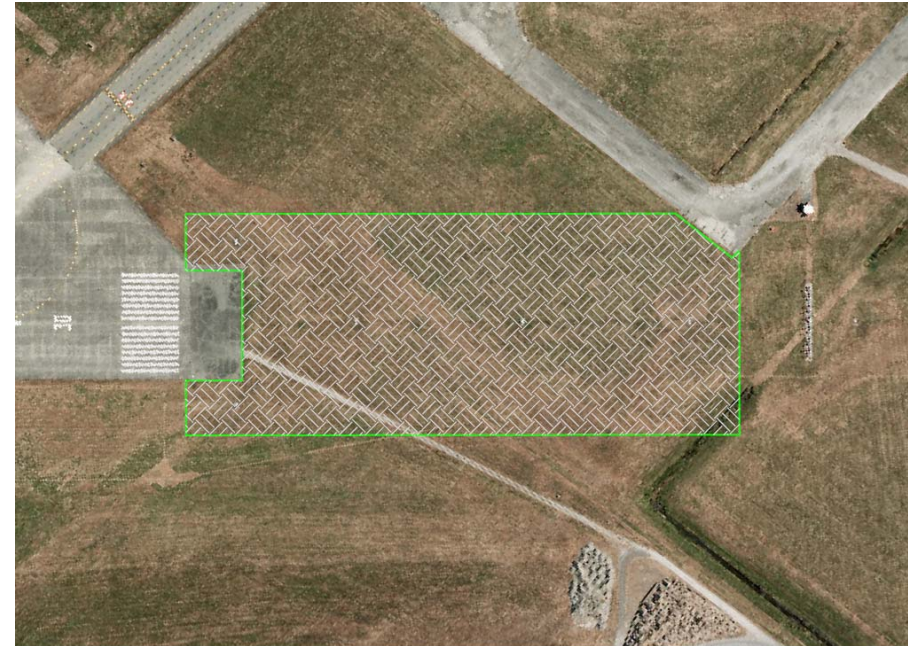
- No RSA



Copyright © Hatch 2016. All Rights Reserved.

31 End:

- 300m RSA

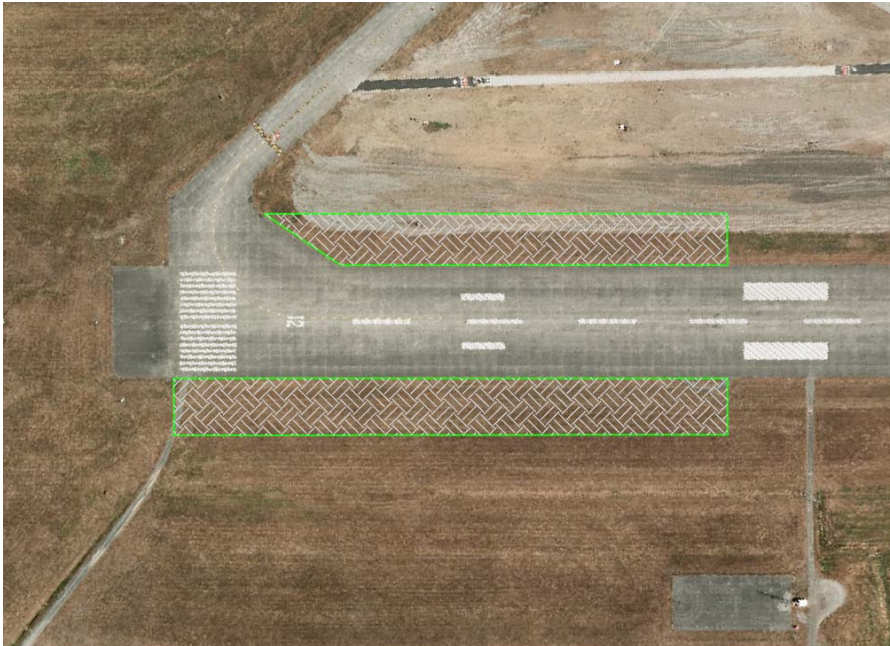


**HATCH**

# RSA Selection Process

13 End:

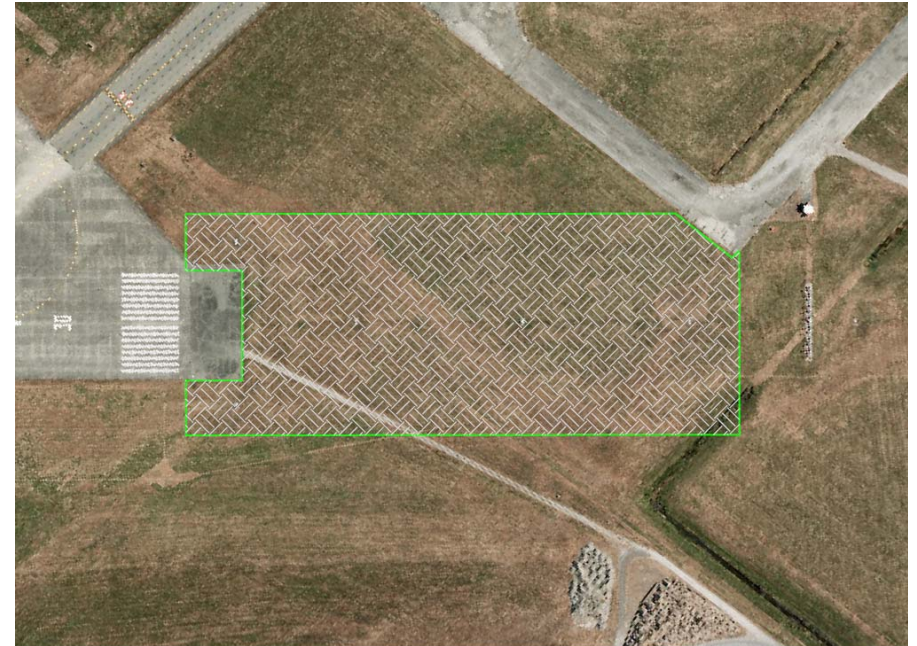
- 300m RSA



Copyright © Hatch 2016. All Rights Reserved.

31 End:

- 300m RSA



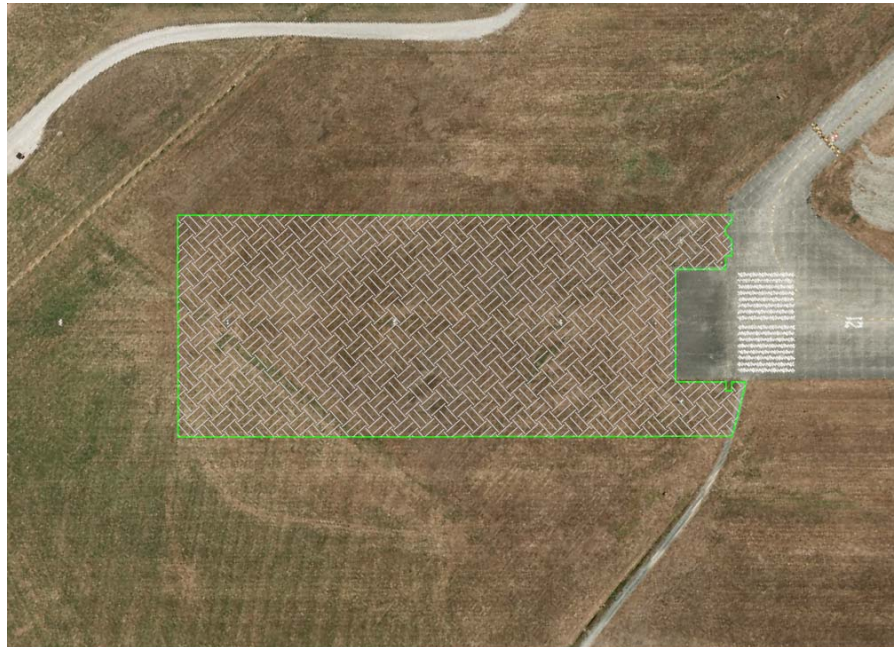
**HATCH**



# RSA Selection Process

13 End:

- 300m RSA

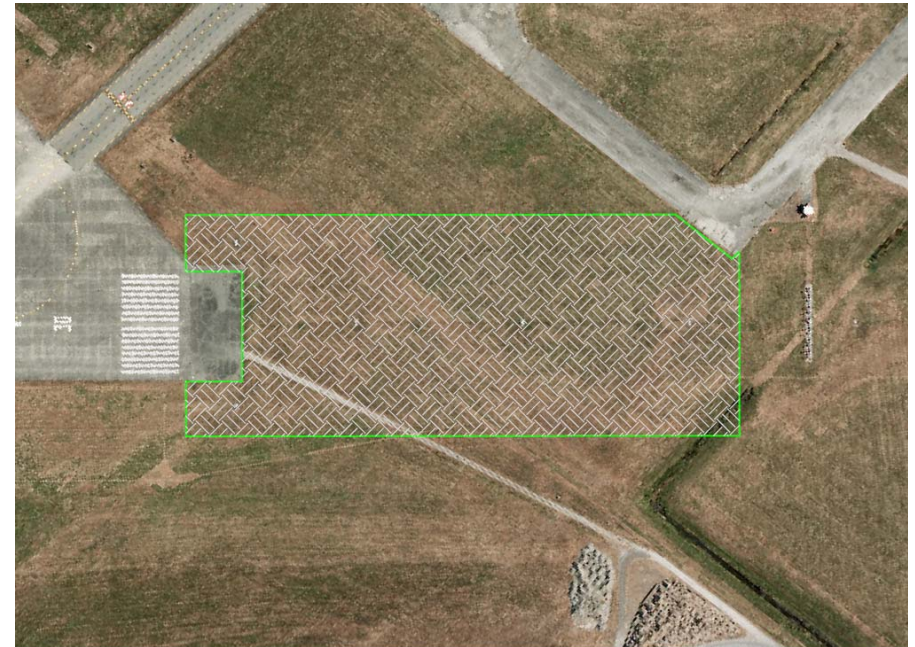


Copyright © Hatch 2016. All Rights Reserved.

31 End:

- 300m RSA

Preferred Option



**HATCH**

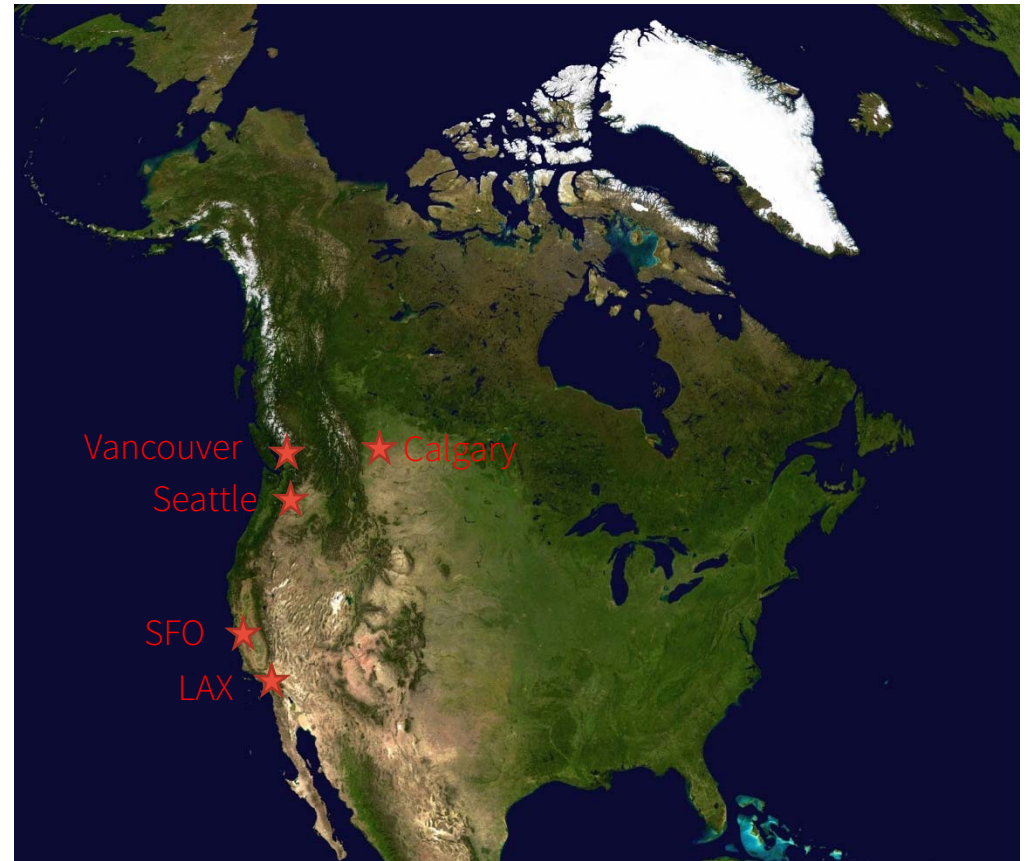
# RSA Selection Process

Why 1000ft RSA?

- Seattle
- Los Angeles
- Calgary
- San Francisco (EMAS)

Mandate on safety

- West coast airports believe in 1000ft RSA





# Real Estate

Where real estate is limited:

- Reduce declared distances
- Reduce code classification of runway
- Install EMAS
- Combination of above

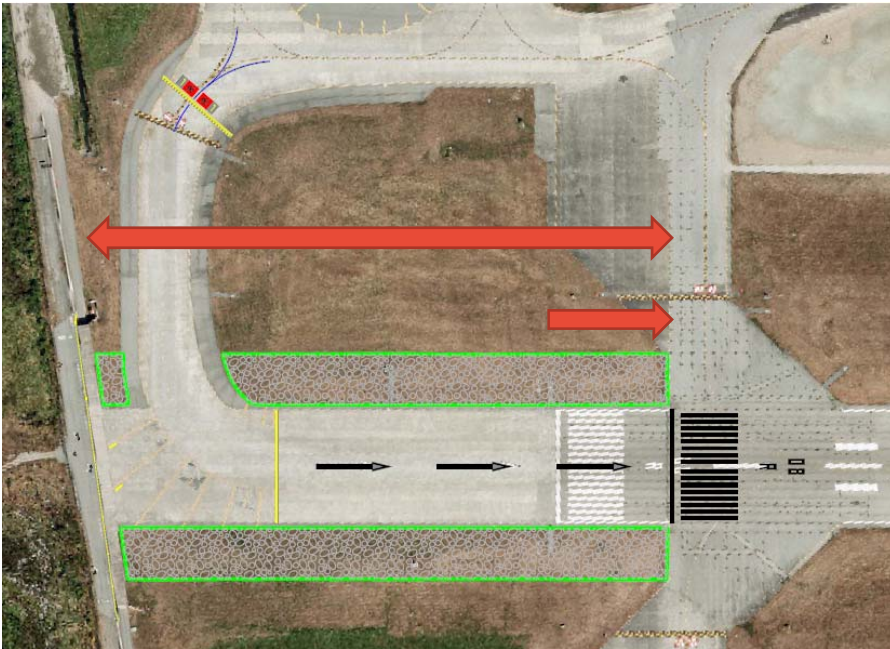


Source: Key West International Airport, 2011. Cessna Citation brake failure after landing

# RSA Design at YVR

## 08R End:

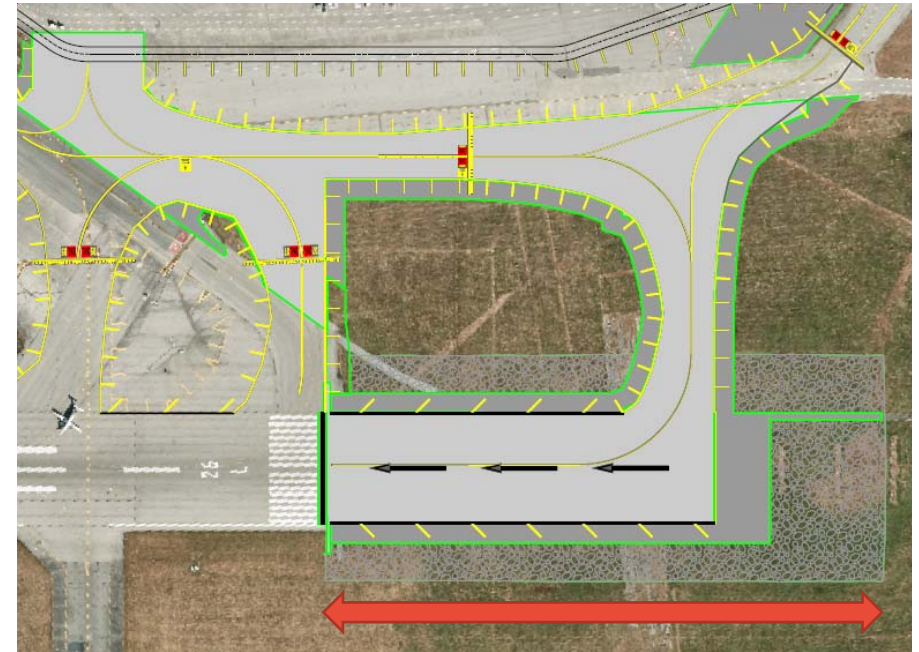
- RSA Graded Strip
- Threshold moved 200ft (60m) east



Copyright © Hatch 2016. All Rights Reserved.

## 26L End:

- PCC and HMAC pavement, new Taxiway D7, D9, D realignment
- RSA Graded Strip



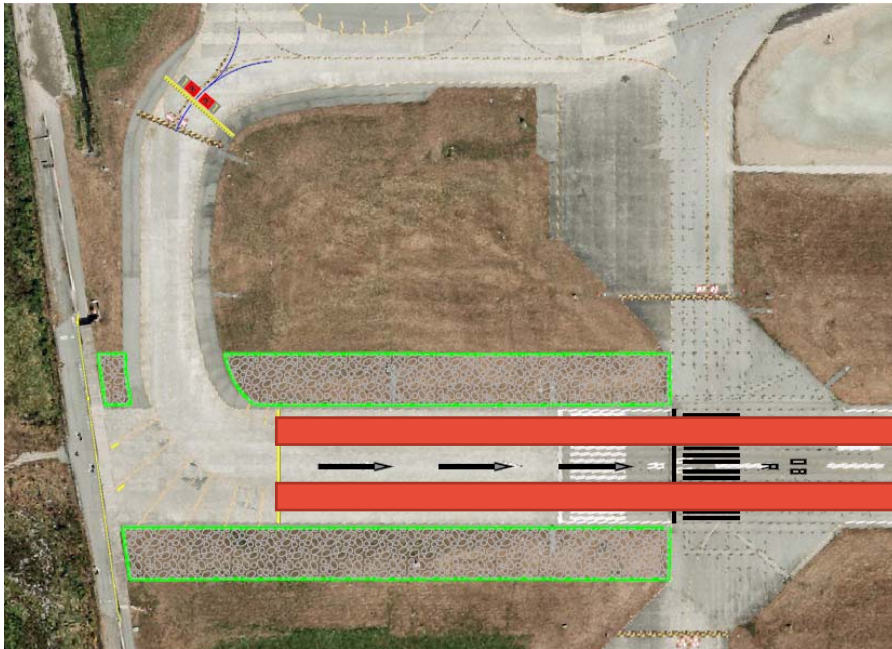
HATCH



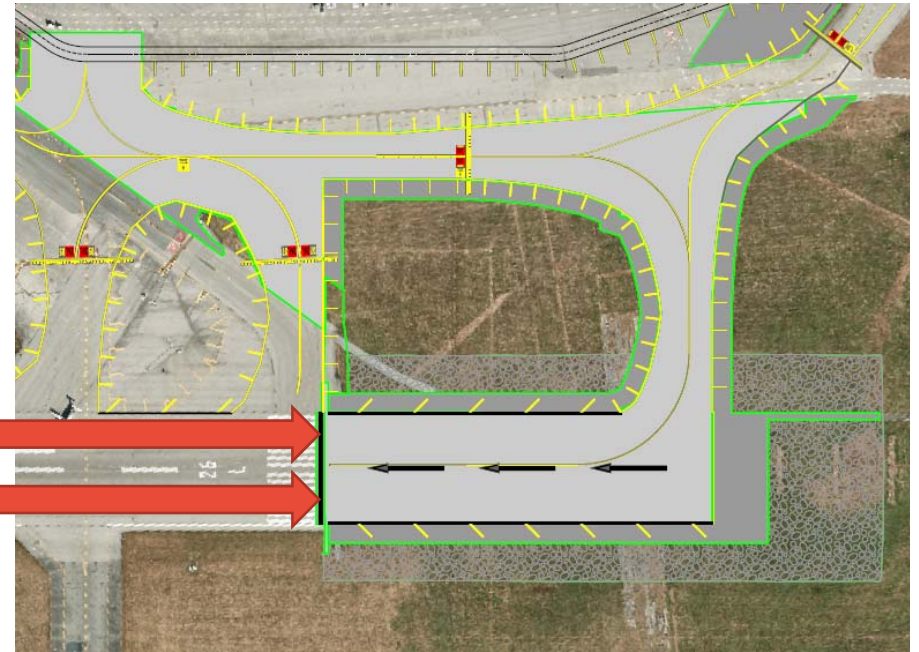
# Declared Distances - TORA

08R End:

- Existing TORA (11,500ft)
- New TORA (11,500ft) **Same**



26L End:



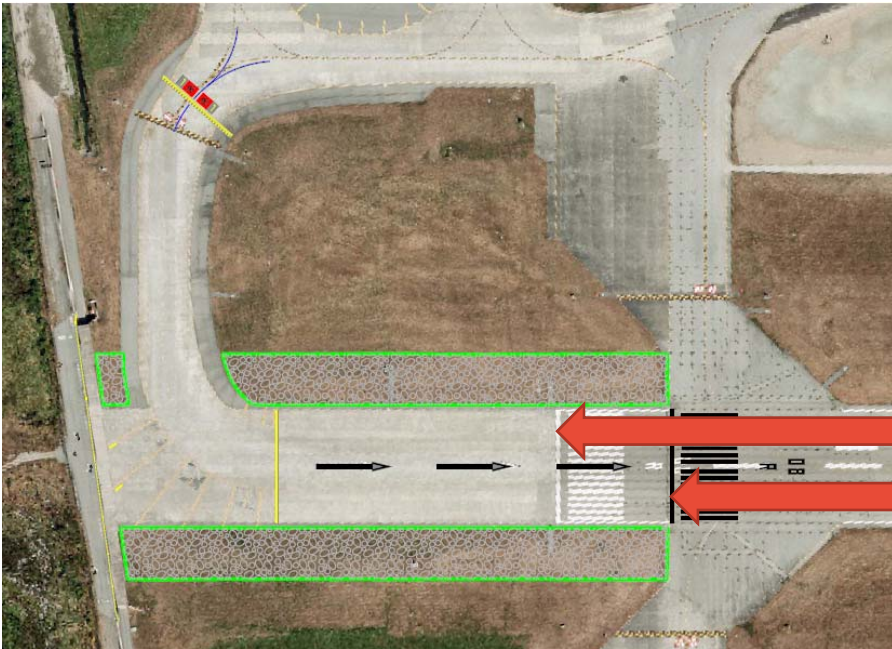
Copyright © Hatch 2016. All Rights Reserved.

**HATCH**

# Declared Distances - TORA

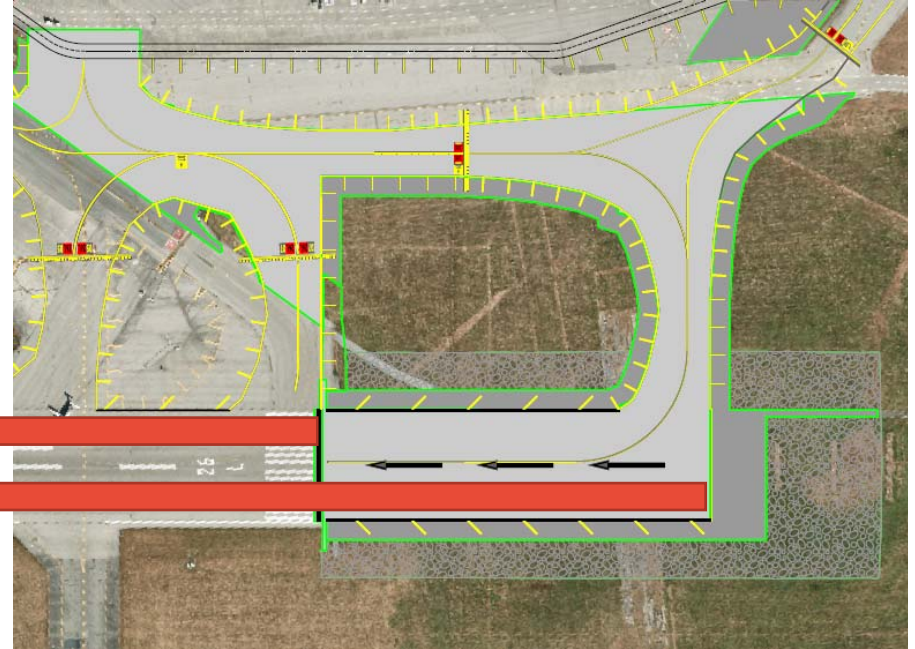
## 08R End:

- Existing TORA (11,500ft)
- New TORA (11,500ft) **Same**



## 26L End:

- Existing TORA (11,000ft)
- New TORA (11,500ft) **+500ft**



Copyright © Hatch 2016. All Rights Reserved.

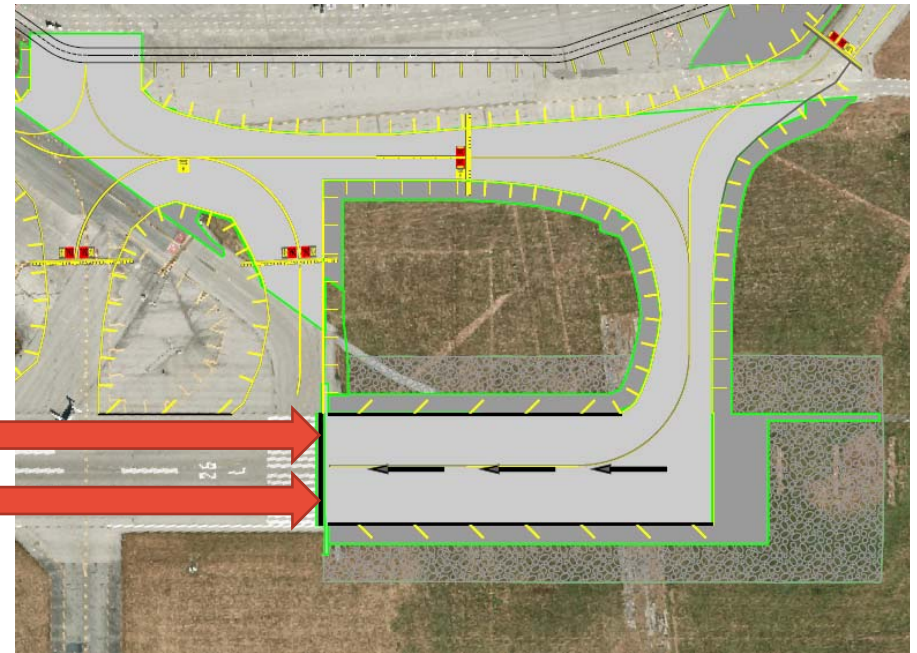
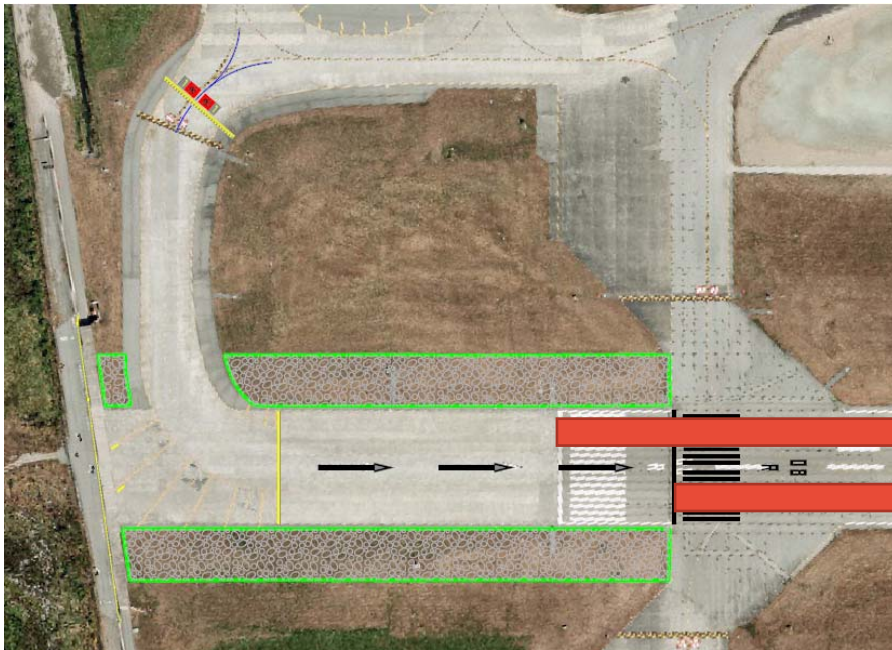
**HATCH**



# Declared Distances - LDA

08R End:

- Existing LDA (11,000ft)
- New LDA (10,800ft) **-200ft**



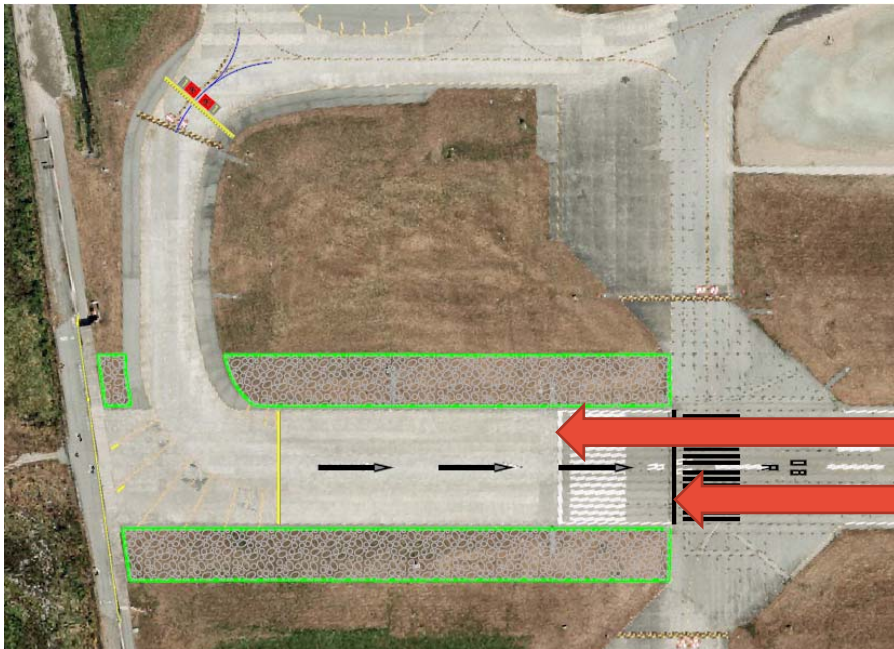
Copyright © Hatch 2016. All Rights Reserved.

**HATCH**

# Declared Distances - LDA

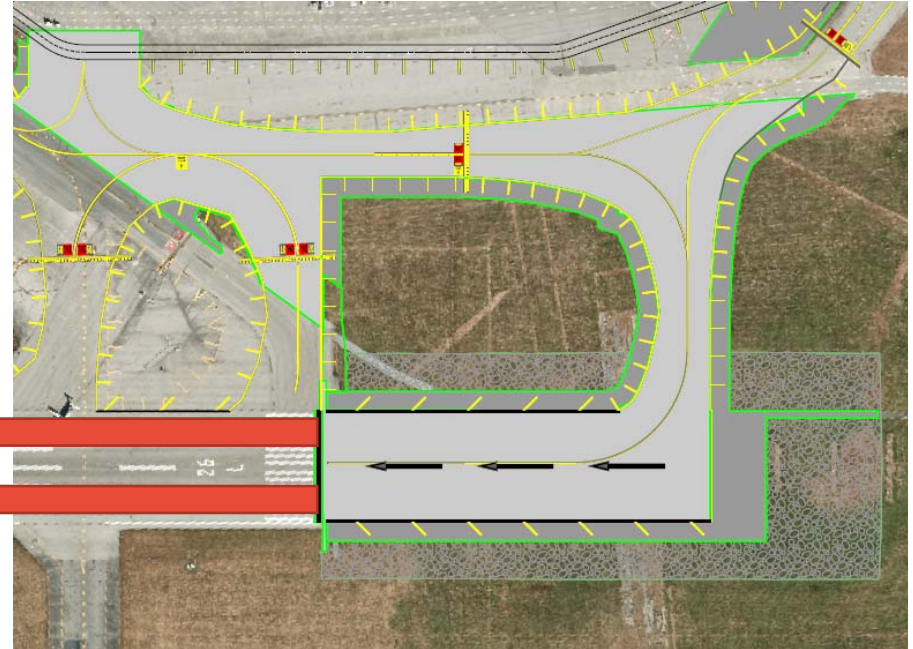
## 08R End:

- Existing LDA (11,000ft)
- New LDA (10,800ft) **-200ft**



## 26L End:

- Existing LDA (11,000ft)
- New LDA (10,800ft) **-200ft**

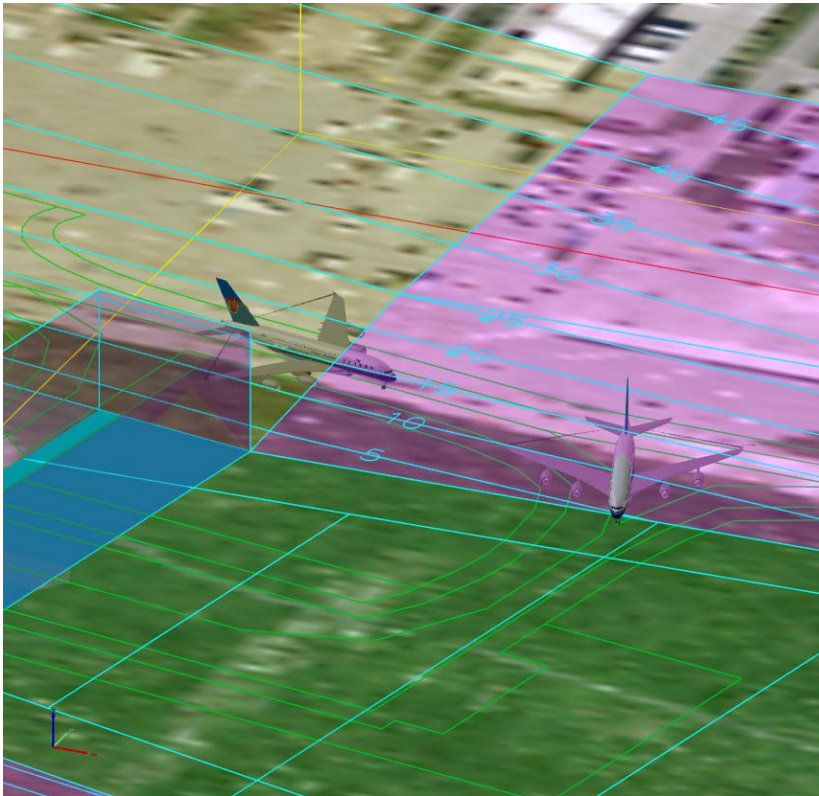


Copyright © Hatch 2016. All Rights Reserved.

**HATCH**



# Obstacle Limitation Surfaces



Copyright © Hatch 2016. All Rights Reserved.

- 3D PDF of OLS:
  - AutoCAD Civil 3D
  - Sketch-up
  - Navisworks
- Located Runway Holding Position Marking
- Display temporary aircraft re-routing to operations and other stakeholders

**HATCH**

# Pavement Design and Cost Optimization

FAARFIELD - Modify and Design Section PCC in Job RESA

Section Names  
GradedArea  
HMAC  
PCC

Status

Airplane

Back Help Life Modify Structure Design Structure Save Structure

RESA PCC Des. Life = 20

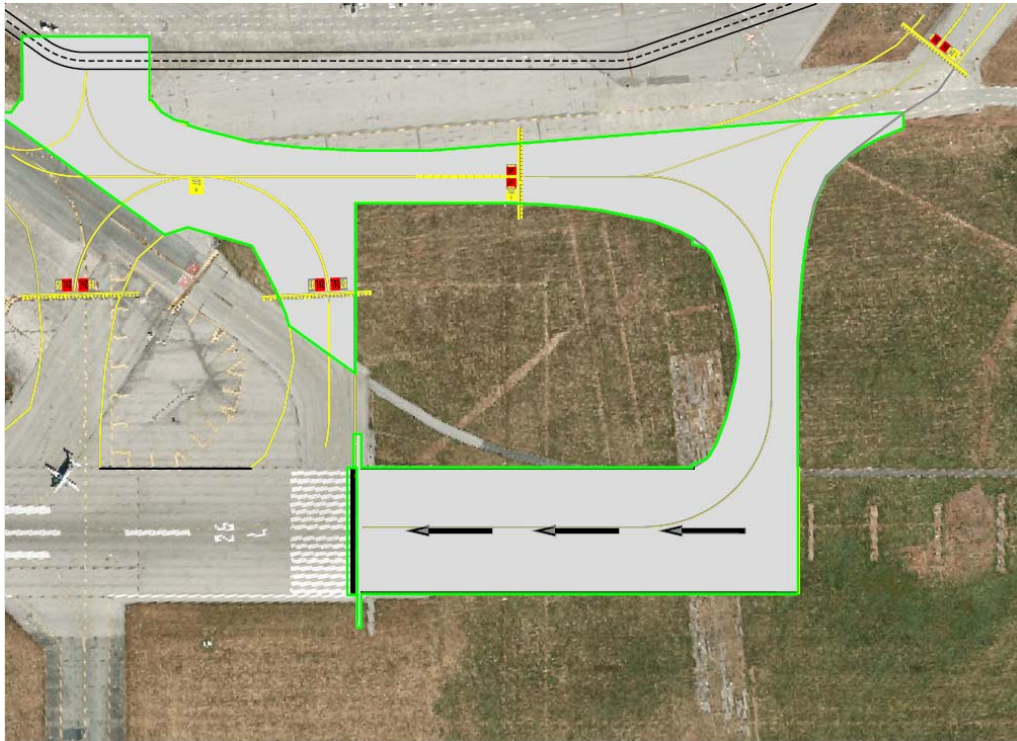
Layer Material	Thickness (mm)	Modulus or R (MPa)
PCC Surface	490.0	4.80
P-304 CTB	250.0	3,447.38
P-209 Cr Ag	200.0	517.11
P-154 UnCr Ag	700.0	275.79
Subgrade	k = 14.6	30.00

Total thickness to the top of the subgrade, t = 1,640.0 mm

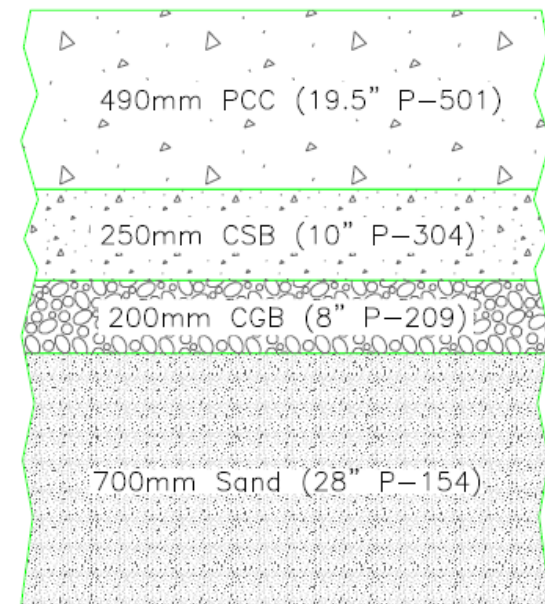
- FAARFIELD
- Subgrade (Geotechnical Investigation)
- Aircraft Mix
- Pavement Layers
- Layer Thickness
- Local Material Unit Rates
- Material Availability
- Contractor Equipment Capabilities
- Underground Utilities



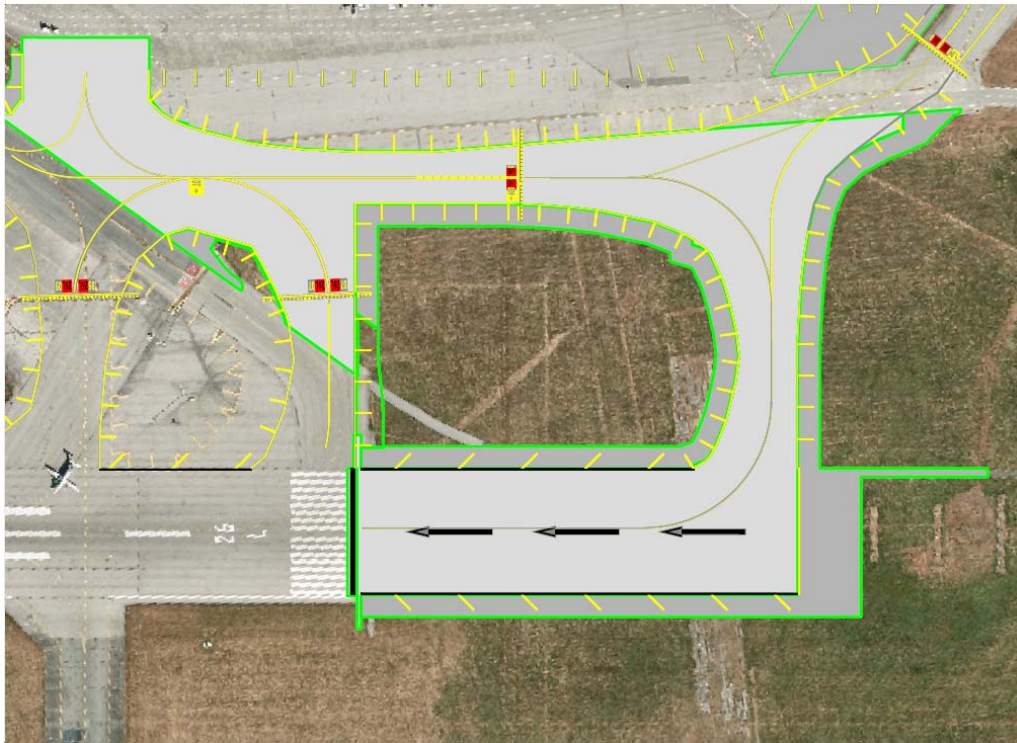
# Pavement Sections



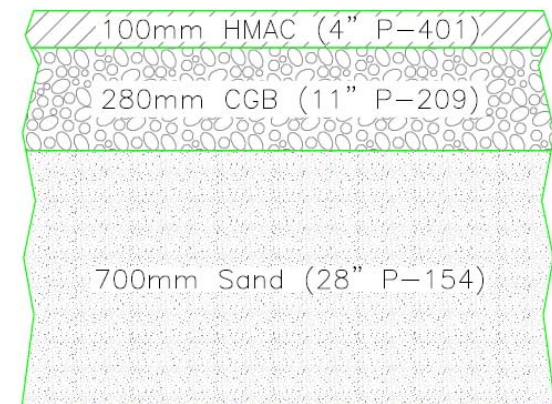
PCC: Runway / Taxiway



# Pavement Sections

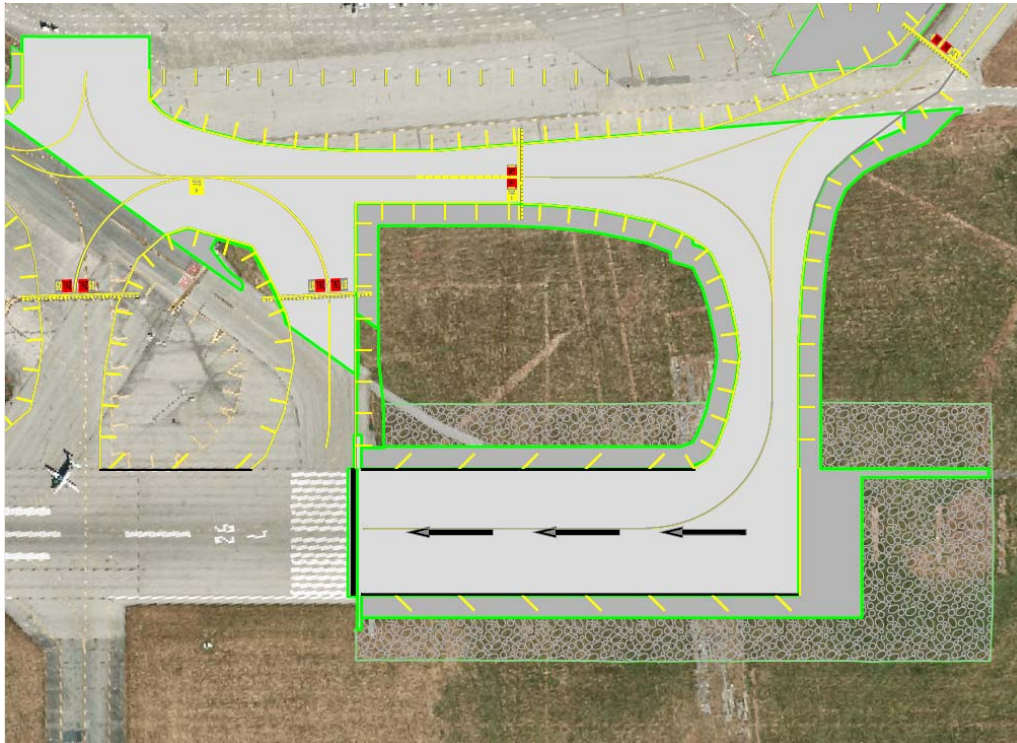


HMAC: Shoulder / Blast Pad

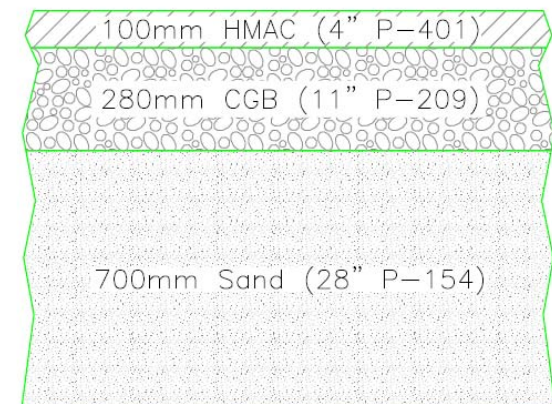




# Pavement Sections



RSA Graded Strip



# Construction



Copyright © Hatch 2016. All Rights Reserved.

**HATCH**



# Runway 26L 3 Year Construction Contract



- 2015 Earthworks and Sand Preload

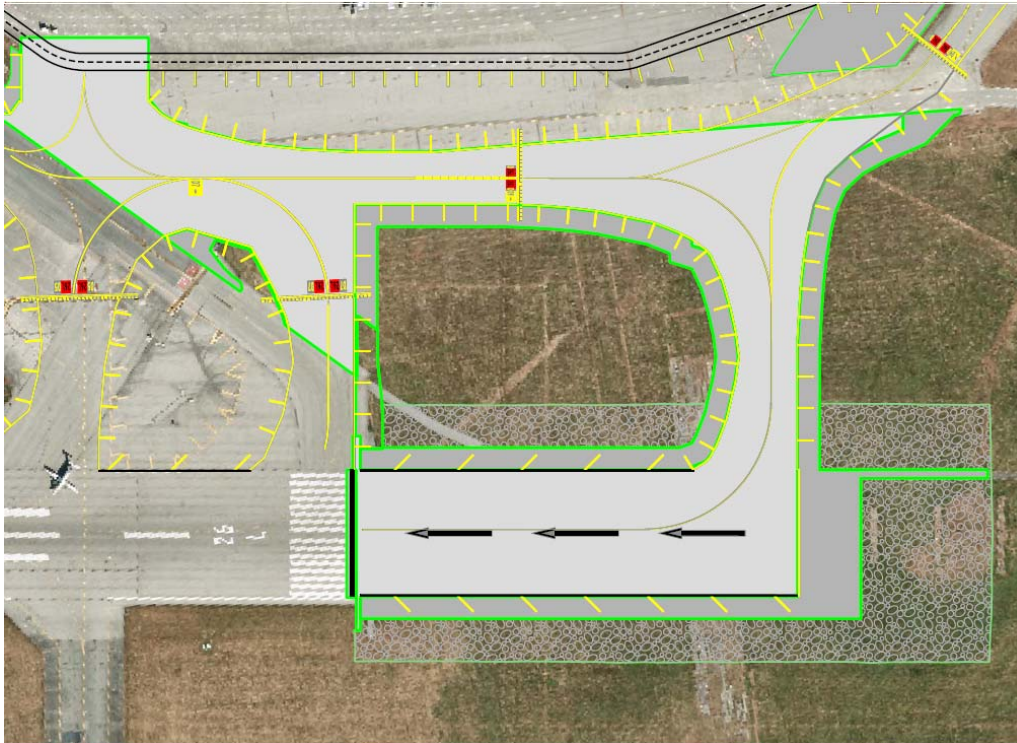
# Runway 26L 3 Year Construction Contract



- 2015 Earthworks and Sand Preload
- 2016 Paving and Electrical Works South



# Runway 26L 3 Year Construction Contract



- 2015 Earthworks and Sand Preload
- 2016 Paving and Electrical Works South
- 2017 Paving and Electrical Works North

## Work Hours

- Runway closure between 22:00 to 06:00
- Return runway back to service at 06:00
- Real production time is about 7.0 to 7.5 hours
- 2015 - 5 nights a week (Thursday and Saturday off)
- 2016 – 6 nights a week (Saturday off)





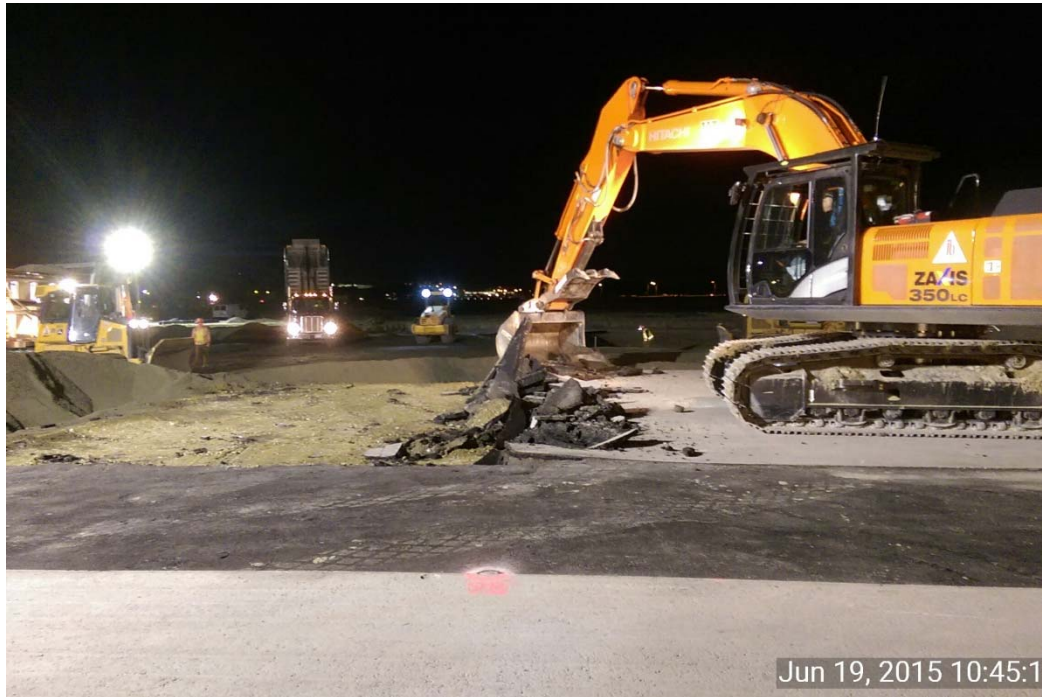
# Contractor

- Contractor is experienced in airside construction
- Same contractor in 2015 and 2016
- Beat out slip-form paving in favor of fixed form paving
- How? They decided to open up a batch plant and amortize it over a few years and also the contractor was local.
- Required extensive iterations of concrete mixes
- Resulted in a very tight schedule – very few mistakes can be made

Copyright © Hatch 2016. All Rights Reserved.



# 2015 Earthworks and Sand Preload



- Earthworks
- Drainage
- Sand Preload / Surcharge
- Erosion Control / Jet Blast
  - CSB placed on top of surcharge
  - Flexterra added to hydroseed
- Electrical



# 2015 Earthworks and Sand Preload



- Earthworks
- Drainage
- Sand Preload / Surcharge
- Erosion Control / Jet Blast
  - CSB placed on top of surcharge
  - Flexterra added to hydroseed
- Electrical

# 2015 Earthworks and Sand Preload



- Earthworks
- Drainage
- Sand Preload / Surcharge
- Erosion Control / Jet Blast
  - CSB placed on top of surcharge
  - Flexterra added to hydroseed
- Electrical



# 2015 Earthworks and Sand Preload



- Earthworks
- Drainage
- Sand Preload / Surcharge
- Erosion Control / Jet Blast
  - CSB placed on top of surcharge
  - Flexterra added to hydroseed
- Electrical

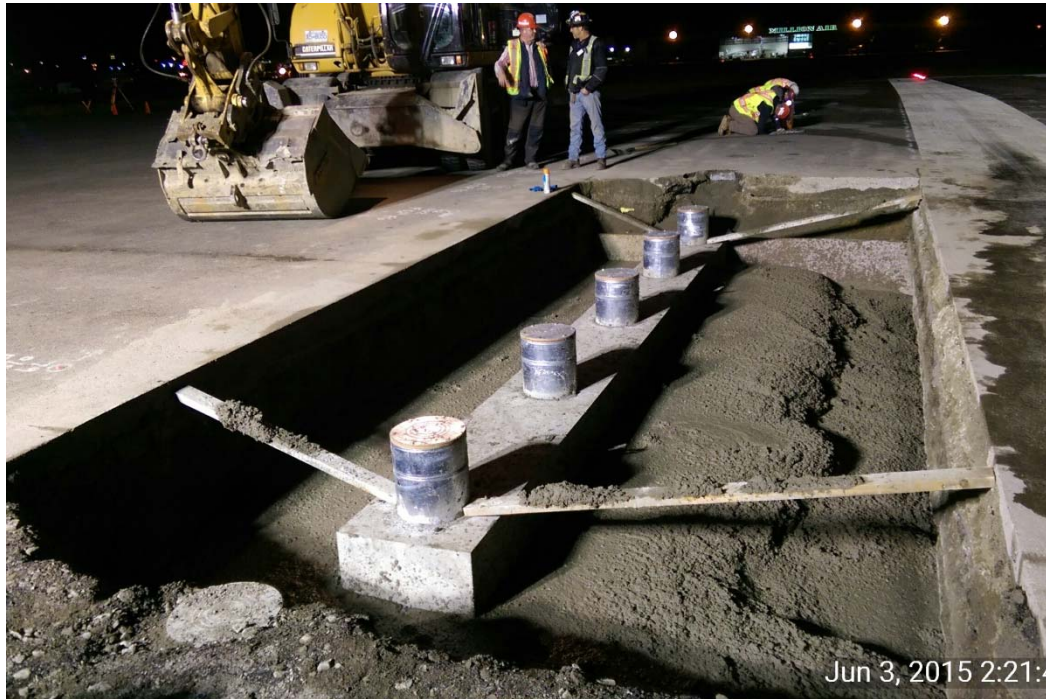
# 2015 Earthworks and Sand Preload



- Earthworks
- Drainage
- Sand Preload / Surcharge
- Erosion Control / Jet Blast
  - CSB placed on top of surcharge
  - Flexterra added to hydroseed
- Electrical



# 2015 Earthworks and Sand Preload



- Earthworks
- Drainage
- Sand Preload / Surcharge
- Erosion Control / Jet Blast
  - CSB placed on top of surcharge
  - Flexterra added to hydroseed
- Electrical

# 2015 Earthworks and Sand Preload



- Earthworks
- Drainage
- Sand Preload / Surcharge
- Erosion Control / Jet Blast
  - CSB placed on top of surcharge
  - Flexterra added to hydroseed
- Electrical



# 2015 Earthworks and Sand Preload



- Earthworks
- Drainage
- Sand Preload / Surcharge
- Erosion Control / Jet Blast
  - CSB placed on top of surcharge
  - Flexterra added to hydroseed
- Electrical

# 2016 Paving and Electrical - South



- Preload Removal
- Drainage
- Crushed Granular Base (CGB)
- Cement Stabilized Base (CSB)
- Portland Cement Concrete (PCC)
- Electrical



# 2016 Paving and Electrical - South



- Preload Removal
- Drainage
- Crushed Granular Base (CGB)
- Cement Stabilized Base (CSB)
- Portland Cement Concrete (PCC)
- Electrical

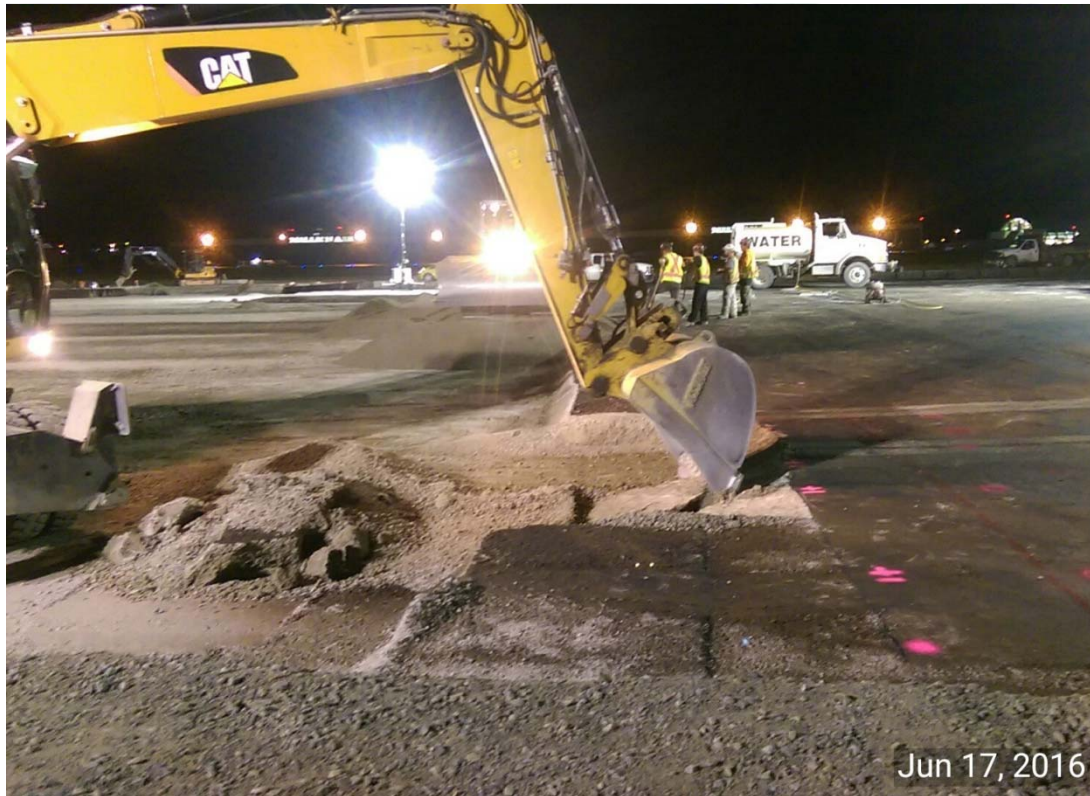
# 2016 Paving and Electrical - South



- Preload Removal
- Drainage
- Crushed Granular Base (CGB)
- Cement Stabilized Base (CSB)
- Portland Cement Concrete (PCC)
- Electrical



# 2016 Paving and Electrical - South



- Preload Removal
- Drainage
- Crushed Granular Base (CGB)
- Cement Stabilized Base (CSB)
- Portland Cement Concrete (PCC)
- Electrical

# 2016 Paving and Electrical - South



- Preload Removal
- Drainage
- Crushed Granular Base (CGB)
- Cement Stabilized Base (CSB)
- Portland Cement Concrete (PCC)
- Electrical

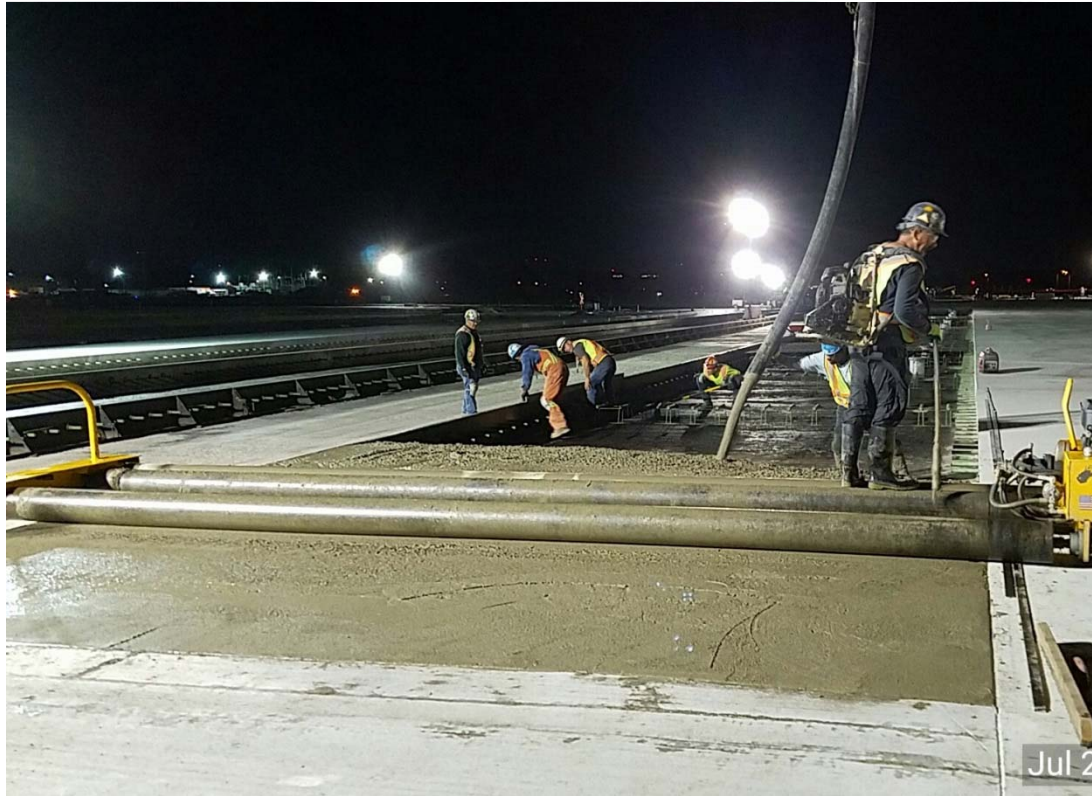


# 2016 Paving and Electrical - South



- Preload Removal
- Drainage
- Crushed Granular Base (CGB)
- Cement Stabilized Base (CSB)
- Portland Cement Concrete (PCC)
- Electrical

# 2016 Paving and Electrical - South



- Preload Removal
- Drainage
- Crushed Granular Base (CGB)
- Cement Stabilized Base (CSB)
- Portland Cement Concrete (PCC)
- Electrical



# 2016 Paving and Electrical - South



- Preload Removal
- Drainage
- Crushed Granular Base (CGB)
- Cement Stabilized Base (CSB)
- Portland Cement Concrete (PCC)
- Electrical

# 2016 Paving and Electrical - South



- Preload Removal
- Drainage
- Crushed Granular Base (CGB)
- Cement Stabilized Base (CSB)
- Portland Cement Concrete (PCC)
- Electrical

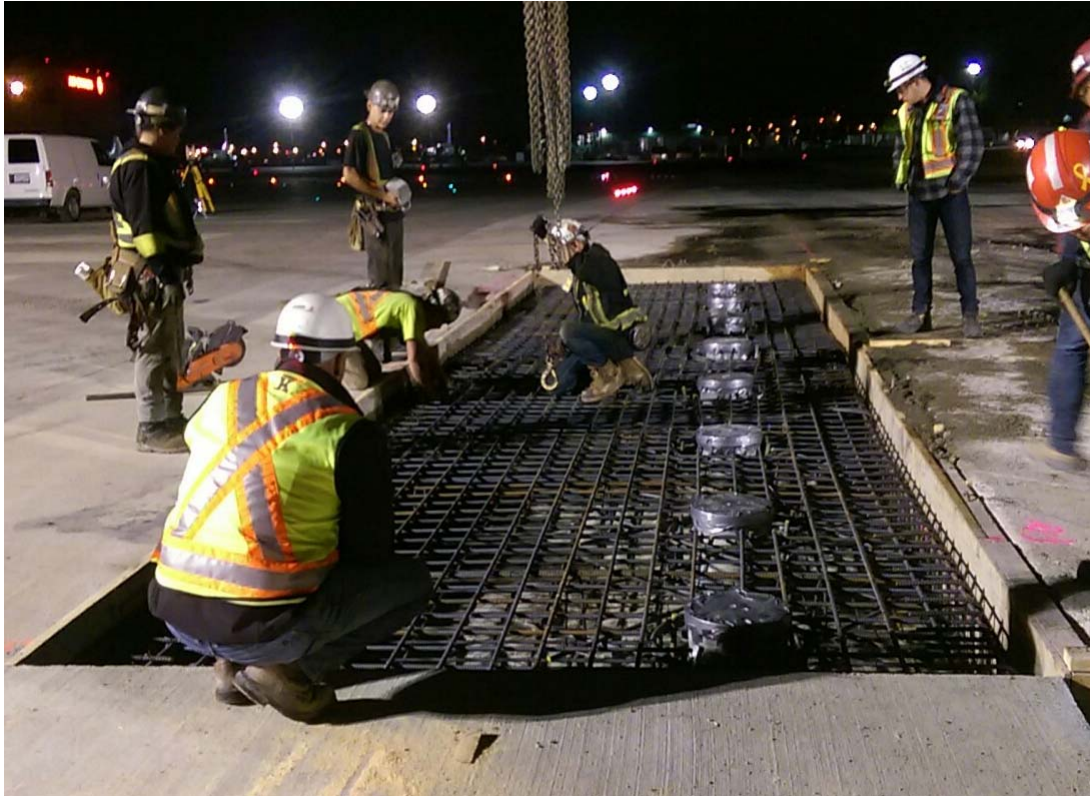
# 2016 Paving and Electrical - South



- Preload Removal
- Drainage
- Crushed Granular Base (CGB)
- Cement Stabilized Base (CSB)
- Portland Cement Concrete (PCC)
- Electrical



# 2016 Paving and Electrical - South



- Preload Removal
- Drainage
- Crushed Granular Base (CGB)
- Cement Stabilized Base (CSB)
- Portland Cement Concrete (PCC)
- Electrical

# 2016 Paving and Electrical - South



- Preload Removal
- Drainage
- Crushed Granular Base (CGB)
- Cement Stabilized Base (CSB)
- Portland Cement Concrete (PCC)
- Electrical

# 2016 Paving and Electrical - South



- Preload Removal
- Drainage
- Crushed Granular Base (CGB)
- Cement Stabilized Base (CSB)
- Portland Cement Concrete (PCC)
- Electrical



# 2016 Paving and Electrical - South



- Preload Removal
- Drainage
- Crushed Granular Base (CGB)
- Cement Stabilized Base (CSB)
- Portland Cement Concrete (PCC)
- Electrical

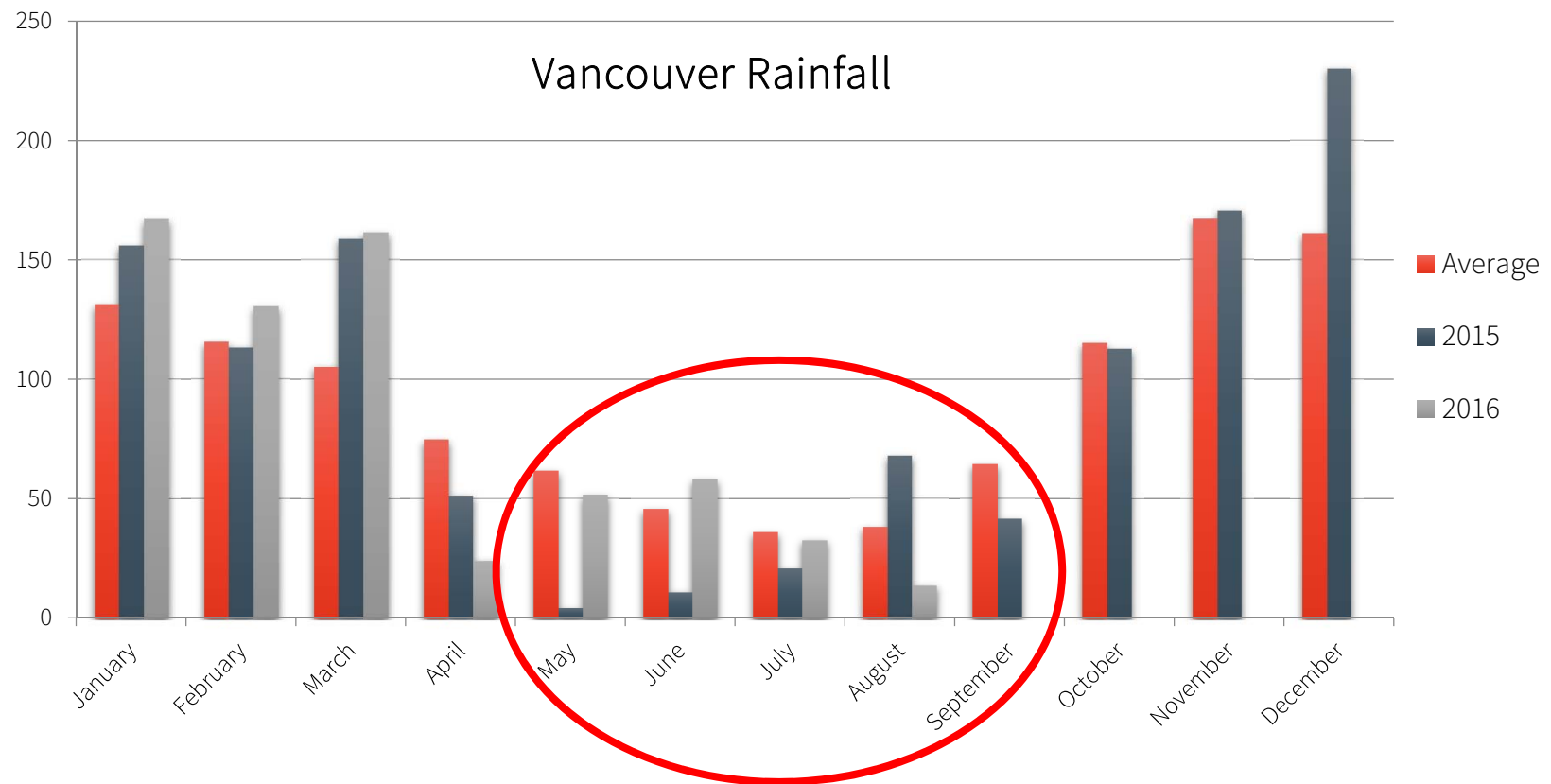
# Proof roller

- Old proof roller was unreliable
- Weighs 100,000 lbs
- 4 solid rubber pneumatic tires at 90psi representing overlapping stresses in pavement from aircraft
- Tow behind designed for loaders
- 1 pass on subbase
- 3 passes on CGB (P-209)

Copyright © Hatch 2016. All Rights Reserved.



# Vancouver's Climate





# Runway Strip



Copyright © Hatch 2016. All Rights Reserved.

**HATCH**

# Runway Strip

## Characteristics

**3.1.5.3** Where a portion of the runway safety area abutting the edge of the runway is paved, the pavement is flush with the abutting surface and extends symmetrically on each side of the runway.

**3.1.5.4** The unpaved portion of the runway safety area that abuts a paved surface has a maximum drop of 5 cm at the paved edge.

## **Slopes on Runway Safety Area**

### **Longitudinal slope changes**

**3.1.5.5** Slope changes on the runway safety area are gradual with no abrupt changes or sudden reversals.

**3.1.5.6** The longitudinal slope of the runway safety area prior to the threshold and beyond the runway, and stopway, where provided, is as specified in Table 3.1.5.6.



# Runway Strip



Copyright © Hatch 2016. All Rights Reserved.

**HATCH**



# Runway Strip



Copyright © Hatch 2016. All Rights Reserved.

**HATCH**

# Runway Strip

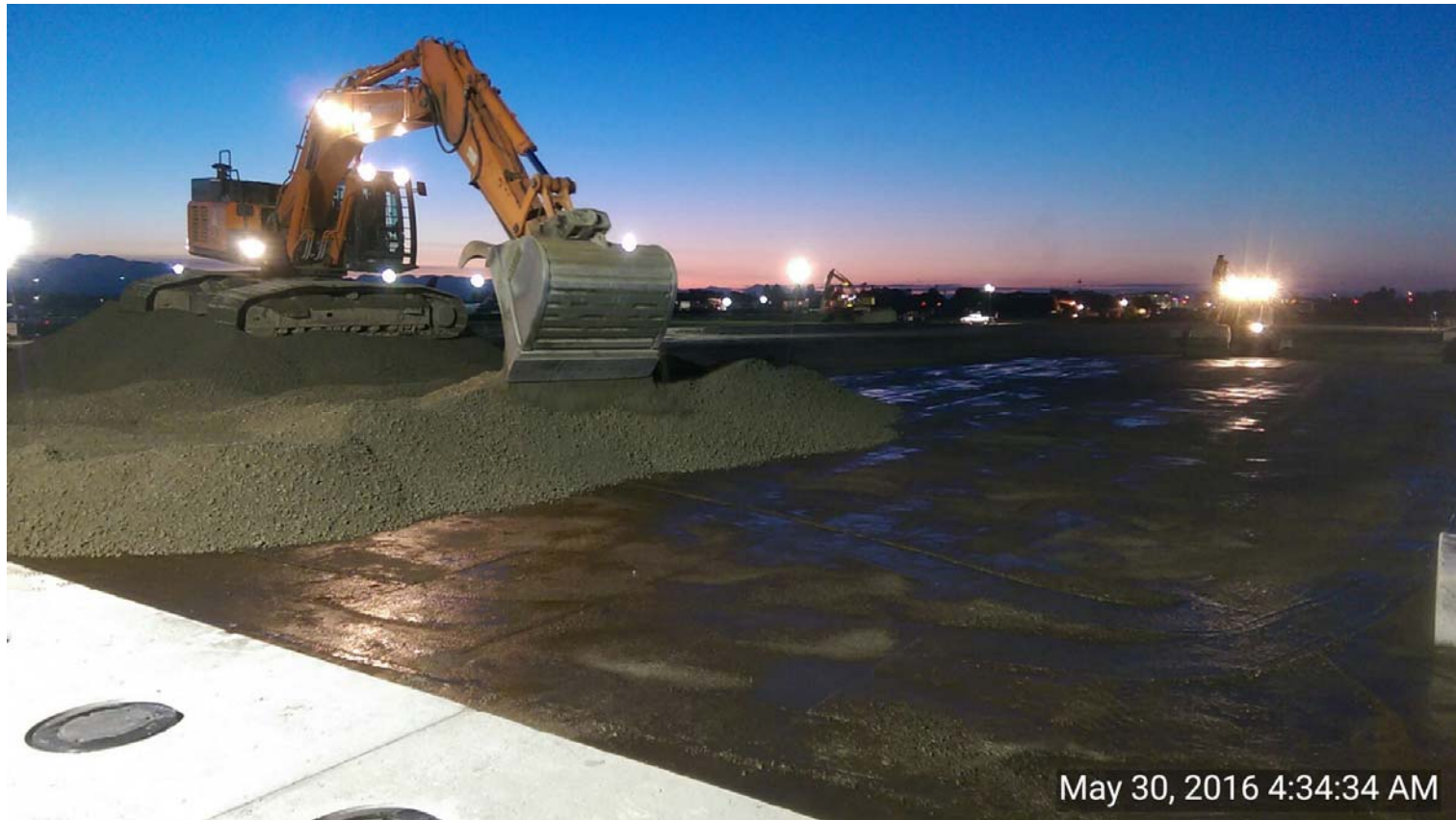


Copyright © Hatch 2016. All Rights Reserved.

**HATCH**



# Runway Strip



Copyright © Hatch 2016. All Rights Reserved.

**HATCH**



# Runway Strip

- Communicated with stakeholders and shortened the runway by 60 meters (200 ft) so that the runway strip ends at the pavement edge
- PAPIs were moved 60 meters
- Threshold was displaced
- Temporary Signage placed on the opposite end of the runway indicated shortened runway
- NOTAM issued to pilots



# Challenges and Lessons Learned



Copyright © Hatch 2016. All Rights Reserved.

**HATCH**

# Control Joints

## **Standard Green Cutting PCC**

- Typically provides nice clean edges
- Green cut when concrete has hardened enough to sawcut without spalling – could be anywhere between 4 – 10 hours depending on conditions and concrete
- Runway in service after 06:00, cannot sawcut

## **Crack Inducer**

- Leave in place
- Can apply immediately after or before placement
- Requires insertion tool or material embedded in concrete beforehand. May cause unwanted surface imperfections.



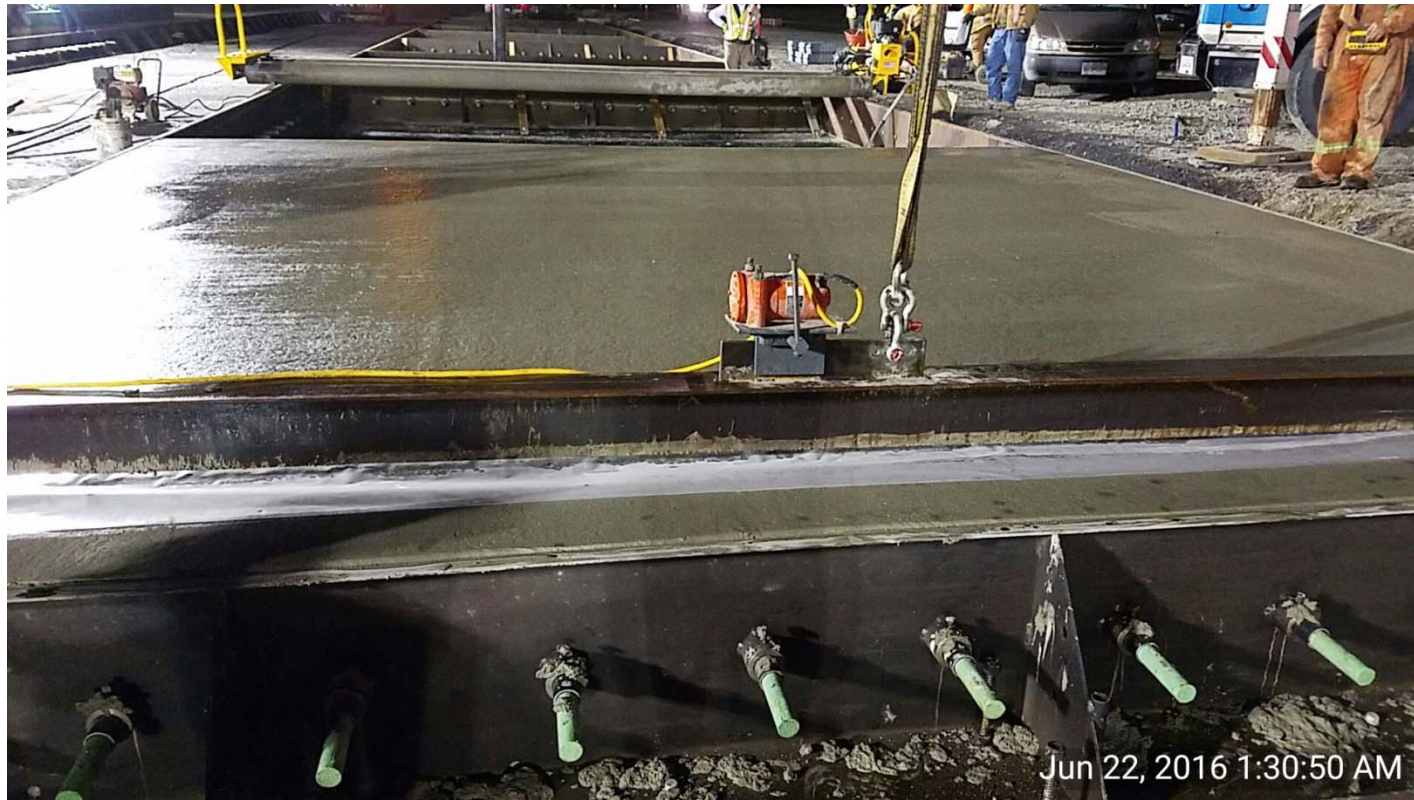
# Control Joints



Copyright © Hatch 2016. All Rights Reserved.

**HATCH**

# Control Joints

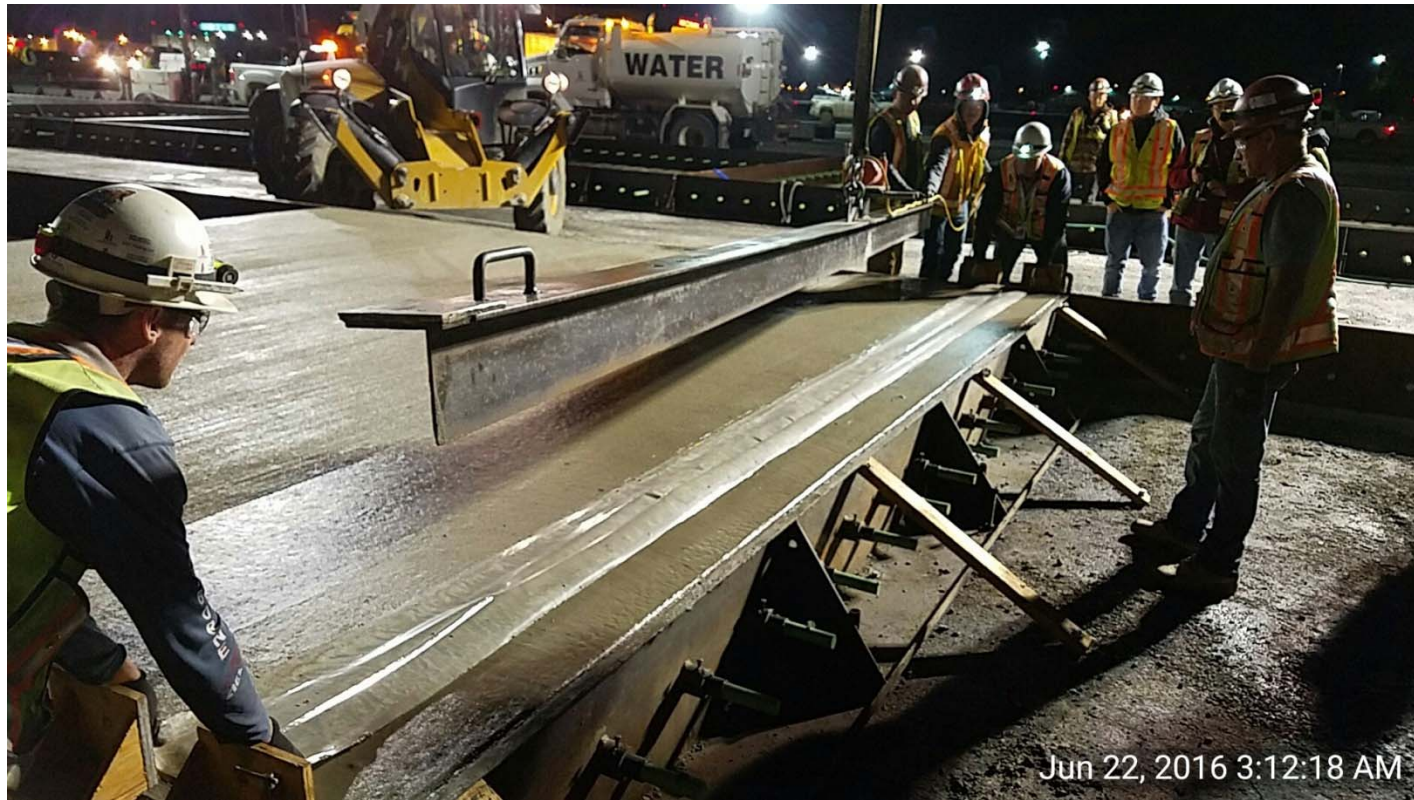


Copyright © Hatch 2016. All Rights Reserved.

**HATCH**



# Control Joints

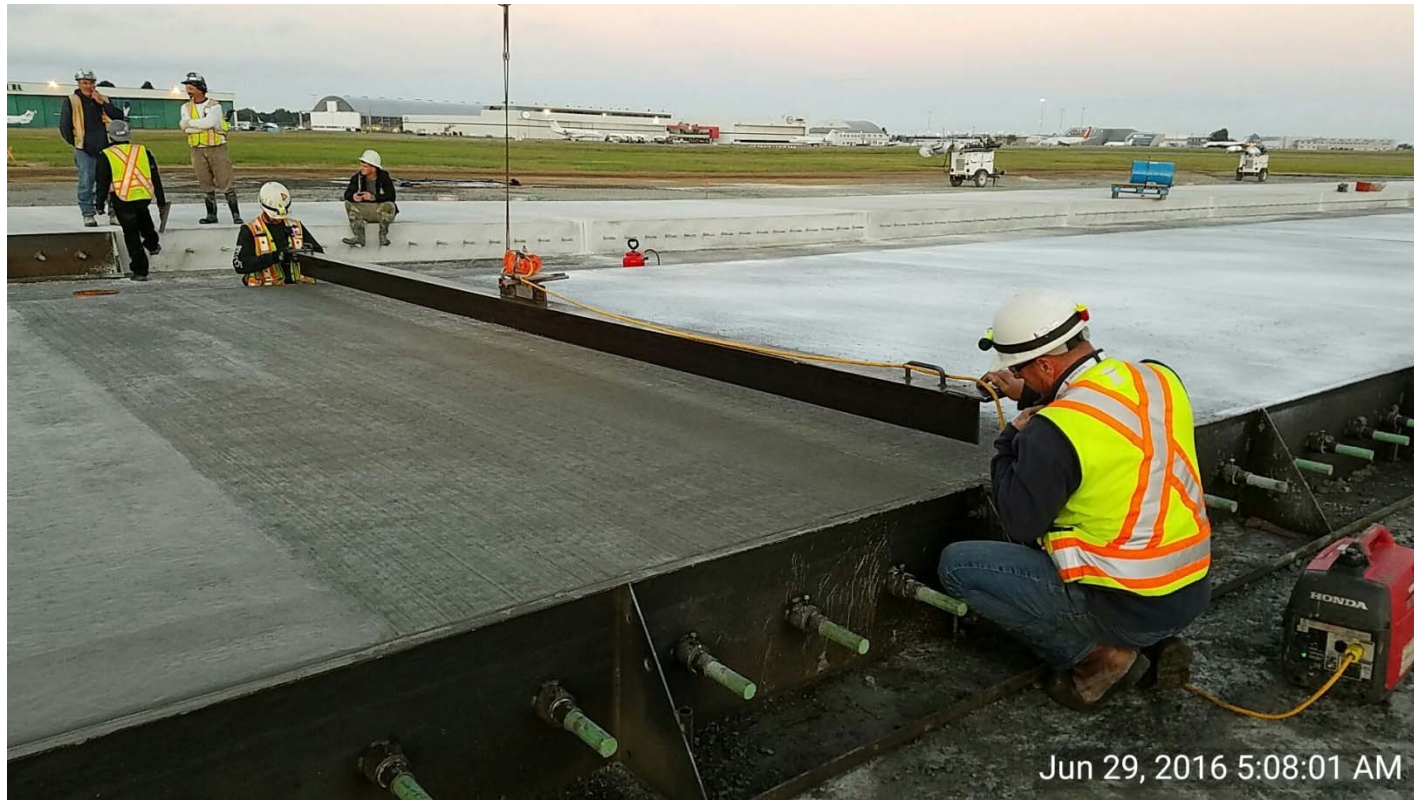


Copyright © Hatch 2016. All Rights Reserved.

**HATCH**



# Control Joints



Copyright © Hatch 2016. All Rights Reserved.

**HATCH**

# Control Joints



Copyright © Hatch 2016. All Rights Reserved.

**HATCH**



# Delineate!



Copyright © Hatch 2016. All Rights Reserved.

**HATCH**



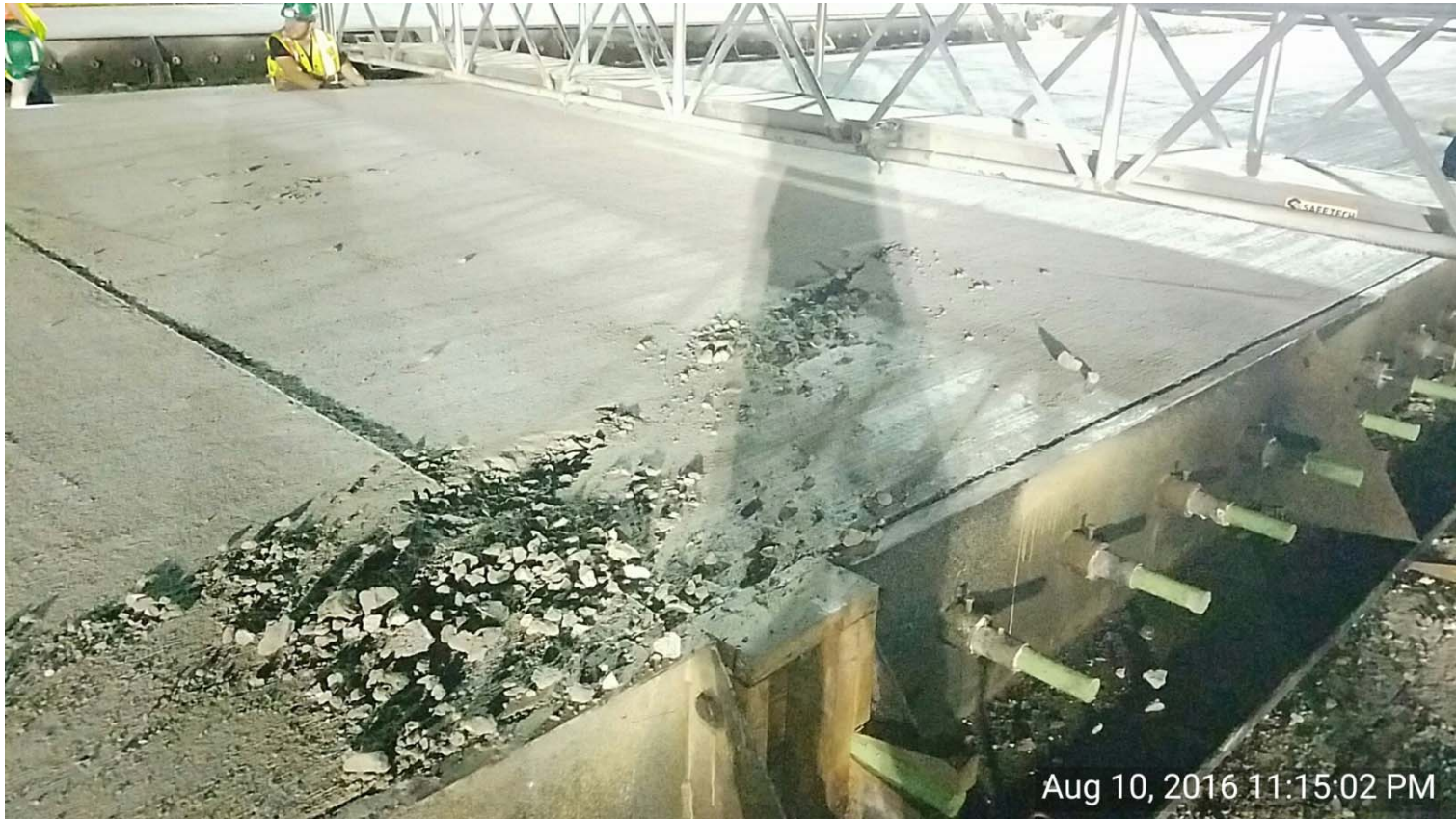
# Delineate!



Copyright © Hatch 2016. All Rights Reserved.

**HATCH**

# Jet Blast



Copyright © Hatch 2016. All Rights Reserved.

**HATCH**



# Do Not Hire Drunks



Copyright © Hatch 2016. All Rights Reserved.

**HATCH**



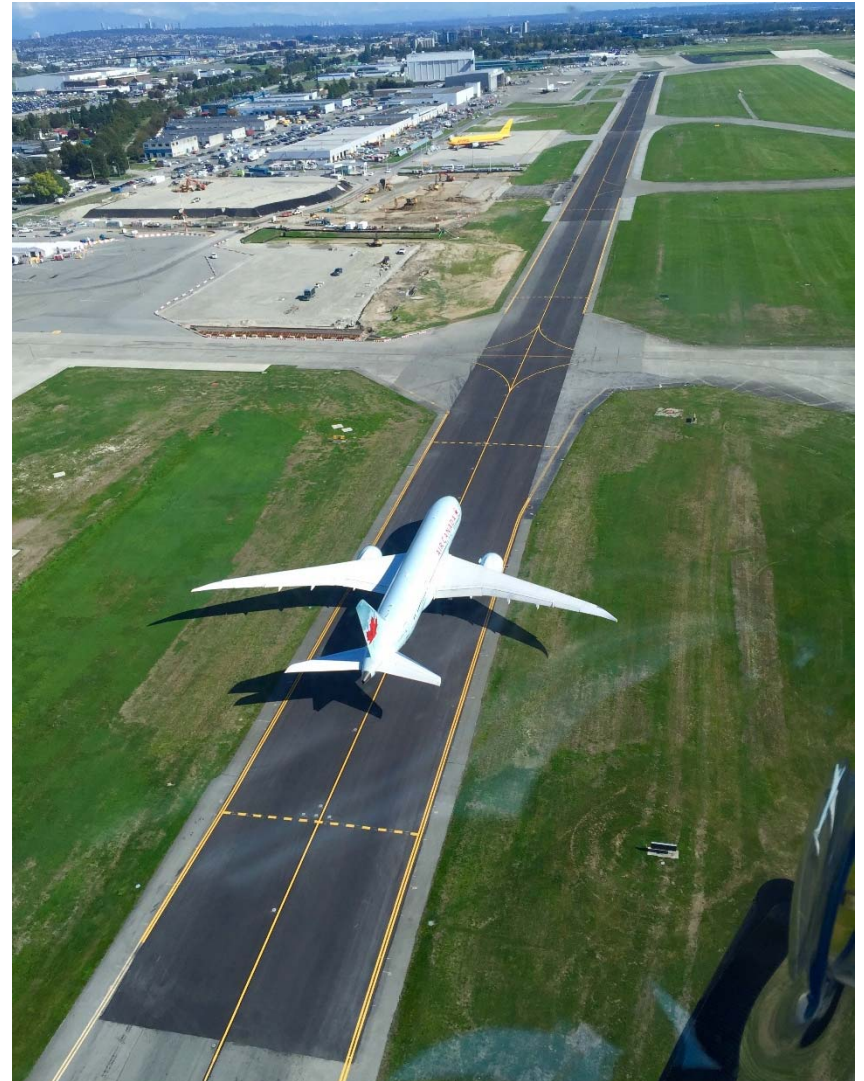
## The S Word....



# Acknowledgements

- Vancouver International Airport Authority (YVRAA)
- Jacob Bros Construction (GC)
- Bay Hill (airfield lighting)
- Gastaldo (PCC placing and finishing)
- WinVan (asphalt paving)
- Hicks (pavement markings)
- Metro Surveys
- Securiguard
- WSP (QA)

Copyright © Hatch 2016. All Rights Reserved.





# Questions



Copyright © Hatch 2016. All Rights Reserved.