

Nieuw Internationaal Vliegveld Mexico City

Integraal Geotechnisch Ontwerp

GEOTECHNIEKDAG 2017

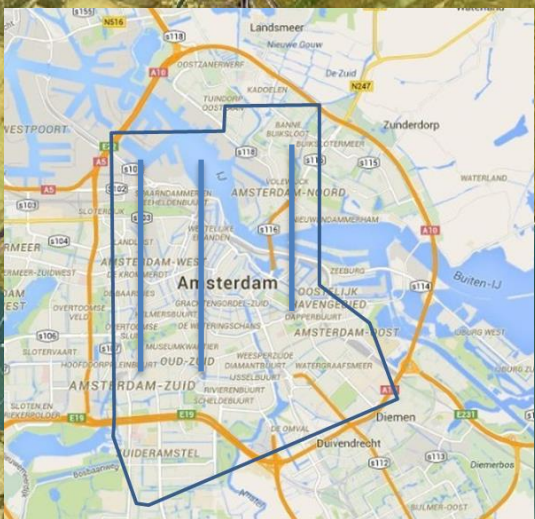
Martin de Kant
Ruud Steenbakkers
Daniele Festa



Inhoud

1. Project NAICM
2. Kenmerken van de projectlocatie
3. Ontwerp grondverbetering
4. Uitvoering
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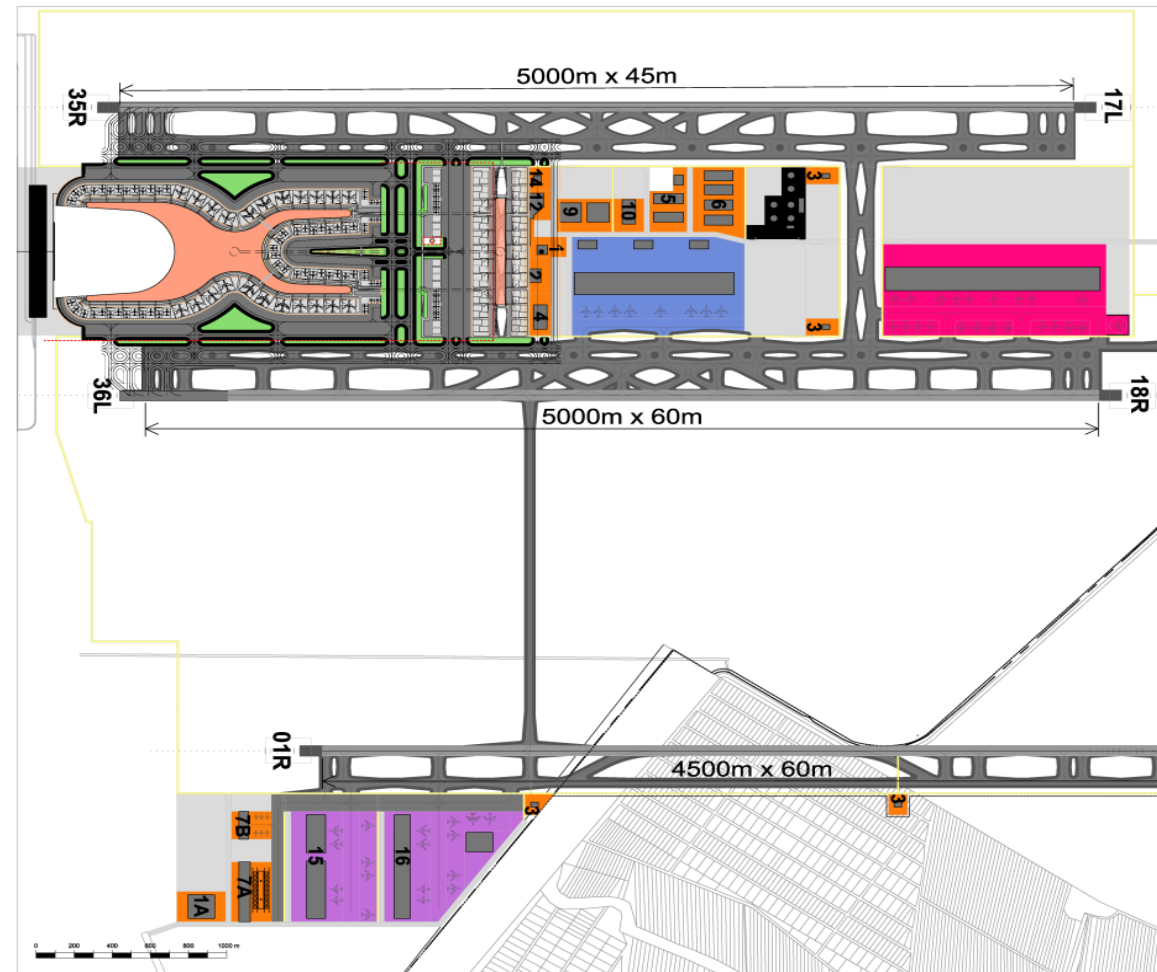




Project NAICM



Project Airside Civil Works



Airside Civil Works

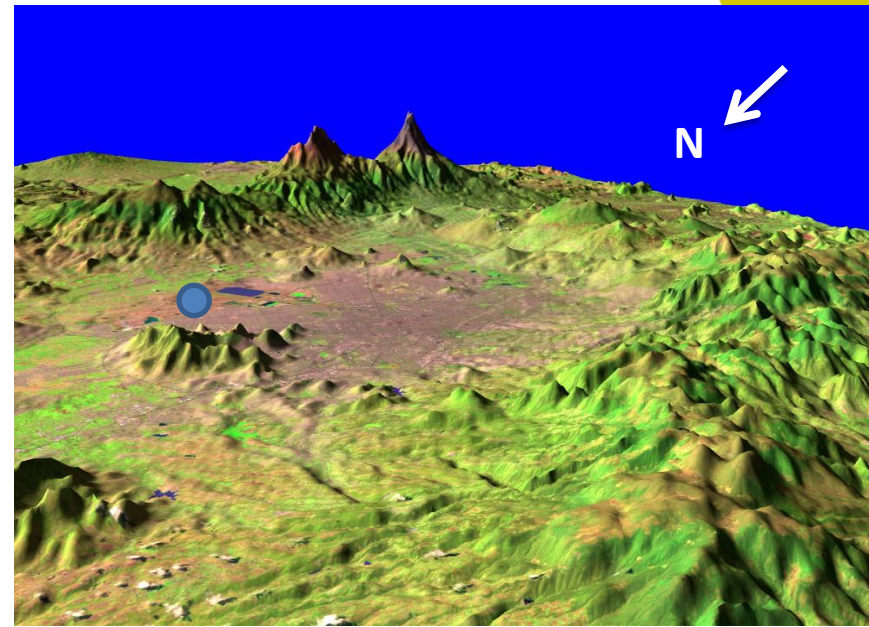
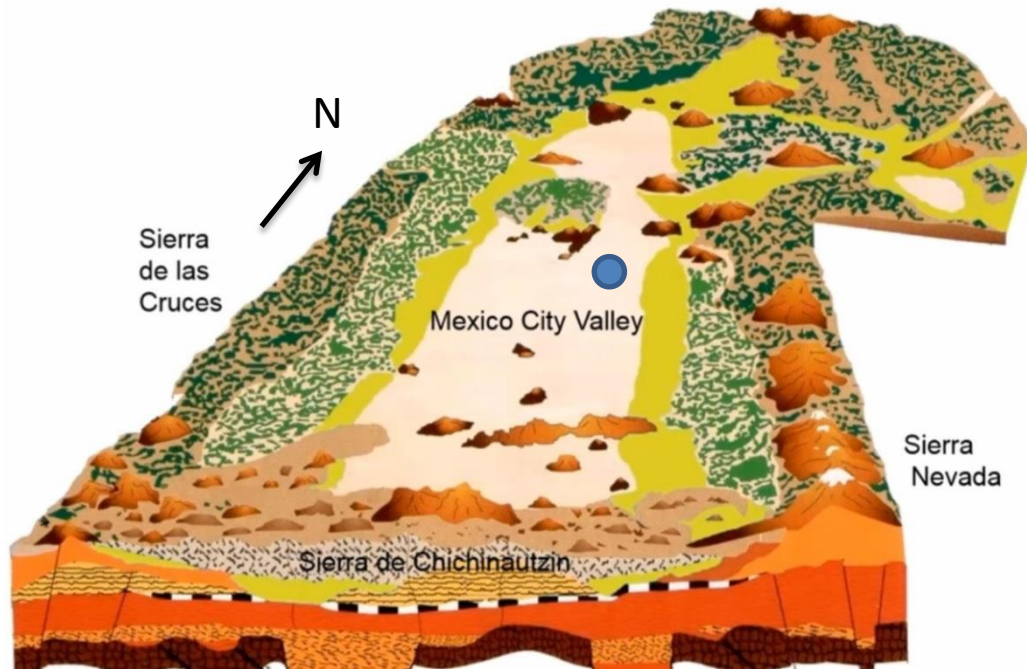
- Verharding
- Gebouwen
- Tunnels
- Waterbeheersing
- Utilities, MEP en Aviation Special Systems

Project Airside Civil Works

- Naco/RoyalHaskoningDHV in joint Venture
- Klant: GACM (airport authority)
- PMC: Parsons
- Reviewers: II-UNAM (university)
Expert panels



Kenmerken projectlocatie - Geologie



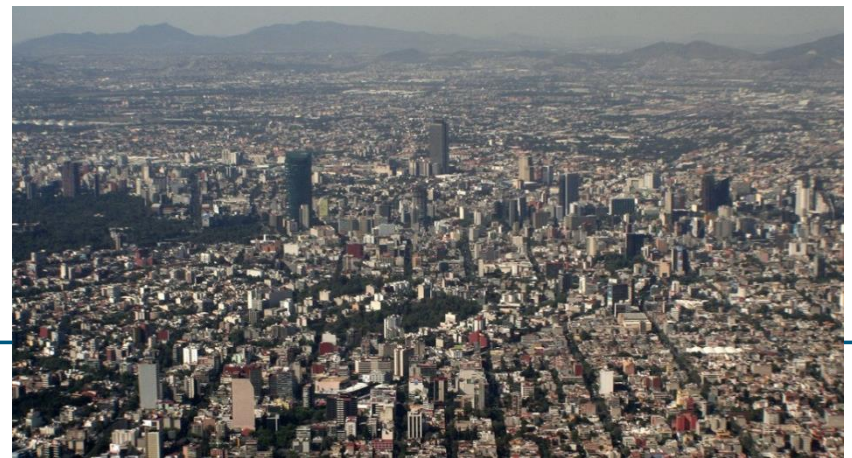
Kenmerken projectlocatie - Geologie



Bird's Eye View of Tenochtitlan in 1519
(Reconstruction, National Museum of Anthropology
of Mexico City)

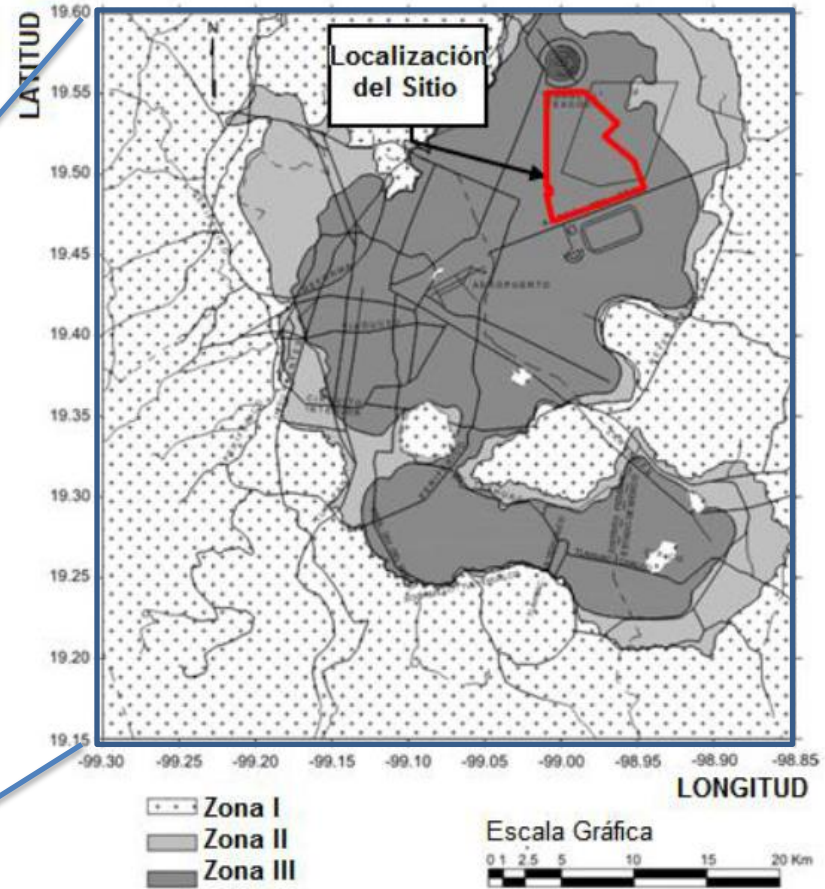


Mexico City 1875 J.M. Velasco Gómez



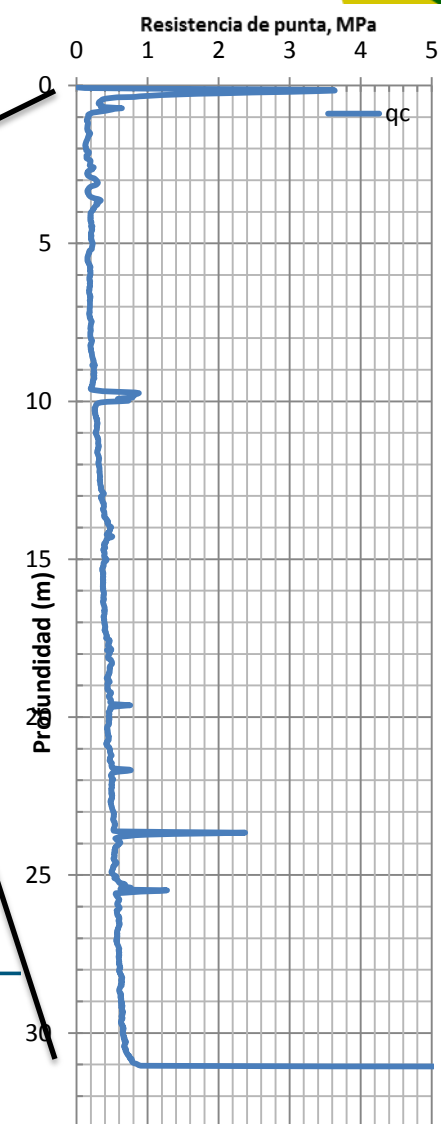
Mexico City anno nu

Kenmerken projectlocatie - Stratigrafie

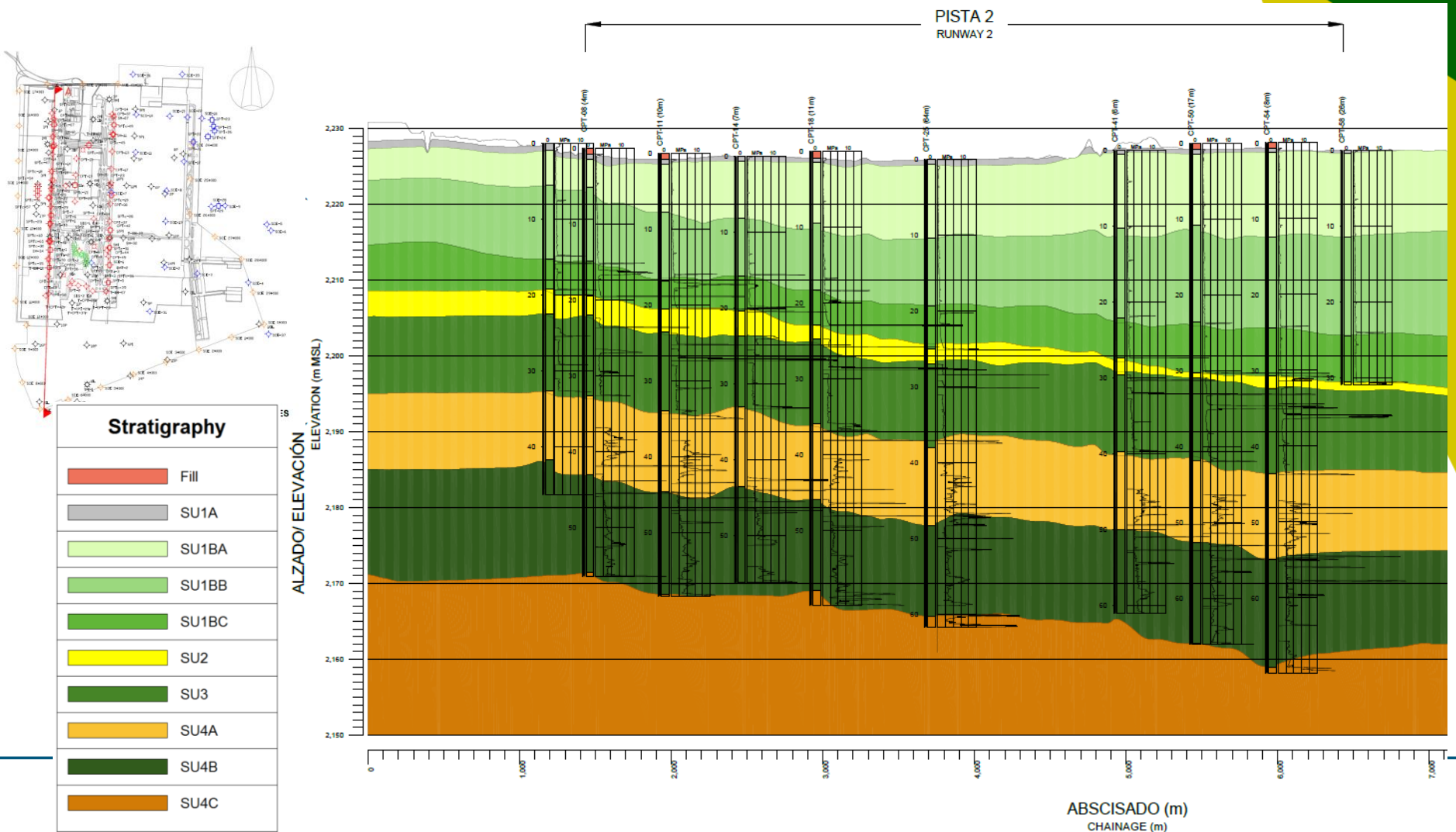


Kenmerken projectlocatie - Stratigrafie

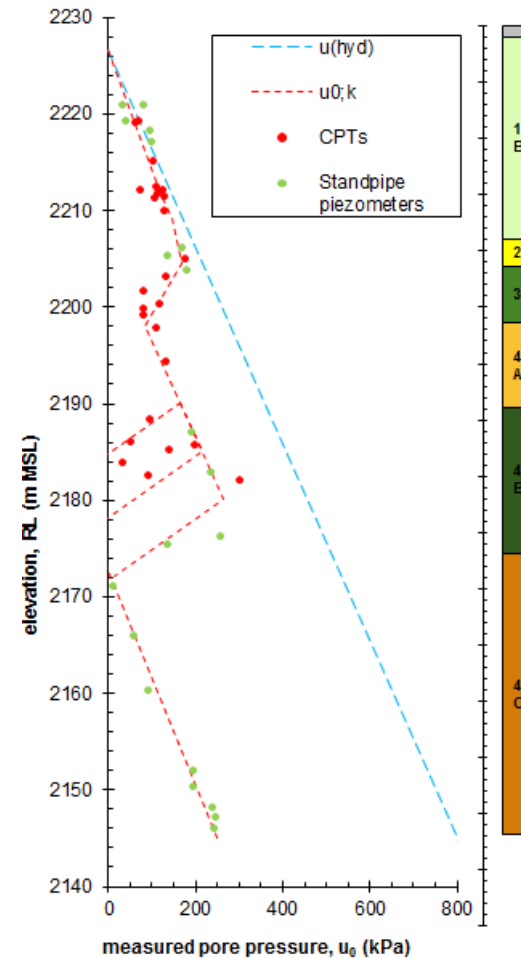
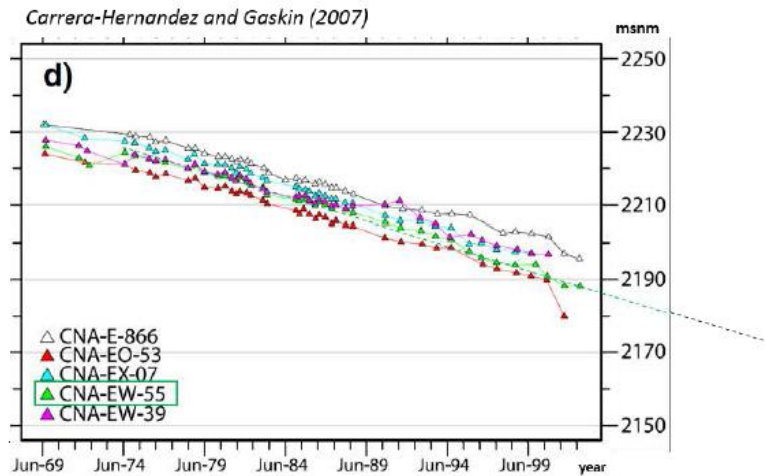
Unidad de Suelo / Soil Unit	Soil Description	Texto Español/ Thickness (m)
1A	Costra Superficial (CD) / Desiccated Crust (DC)	0.4 – 2.0
1BA	Formación Arcillosa Superior (FAS)	16.5 – 36.0
1BB		
1BC		
2	Capa Dura (CD)	0.2 – 5.5
3	Formación Arcillosa Inferior (FAI)	5.5 – 15.0
4	Depósitos Profundos (DP): -	
4A	Serie Estratificada Superior (SES)	8.0 – 12.5
4B	Formación Arcillosa Profunda (FAP)	9.0 – 12.0
4C	Serie Estratificada Inferior (SEI)	Not proven



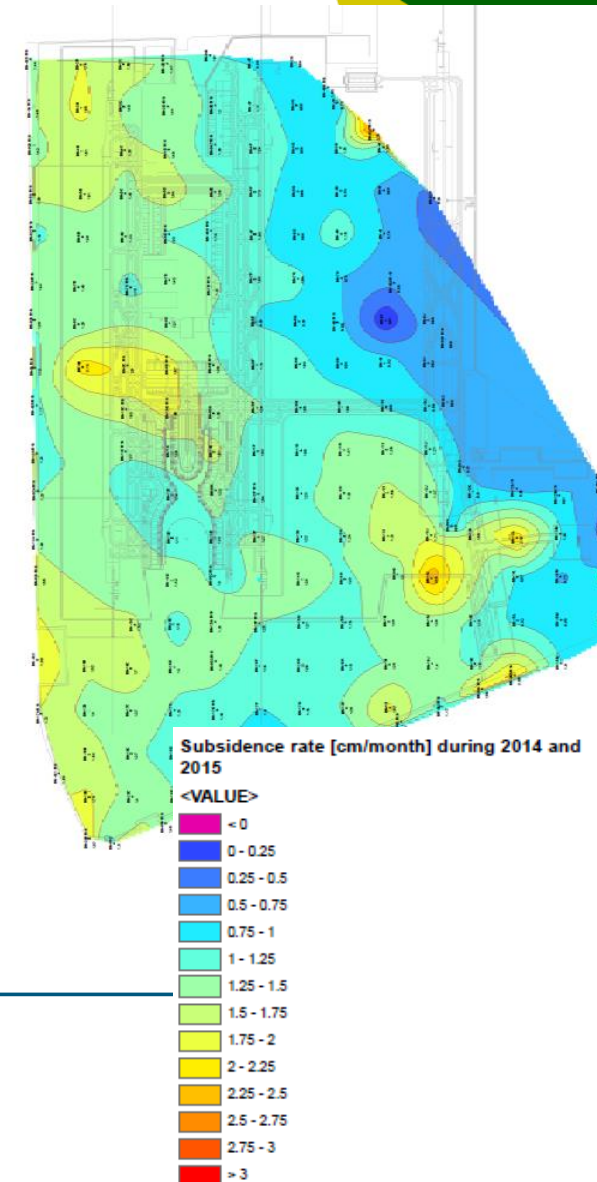
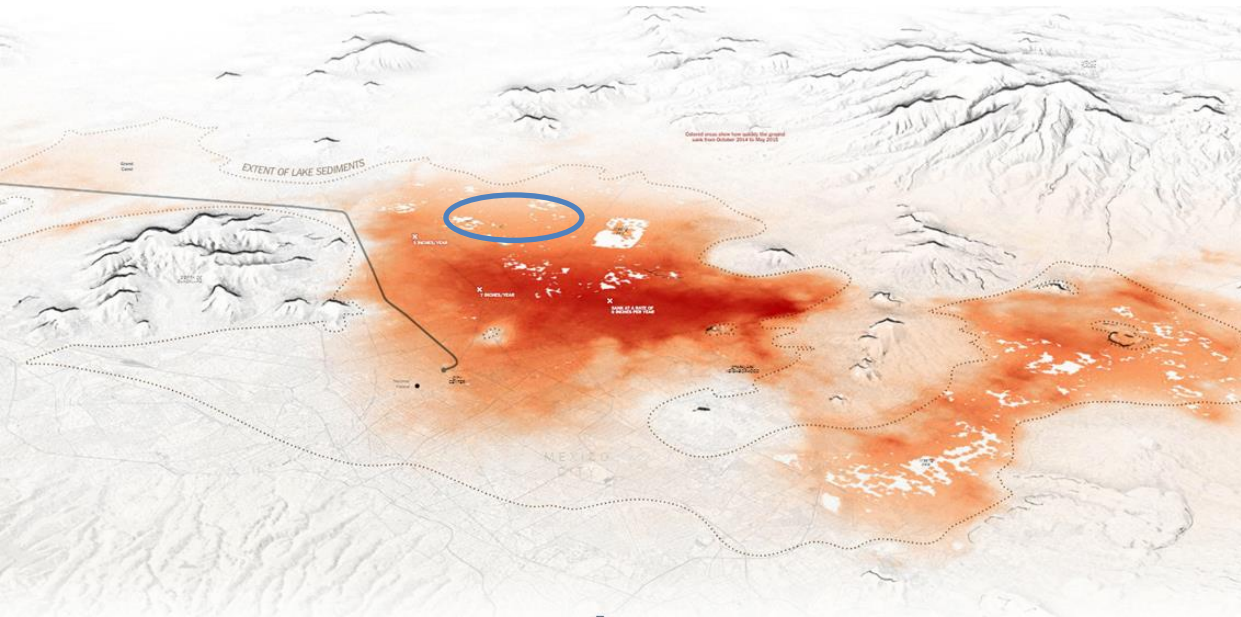
Kenmerken projectlocatie - Stratigrafie



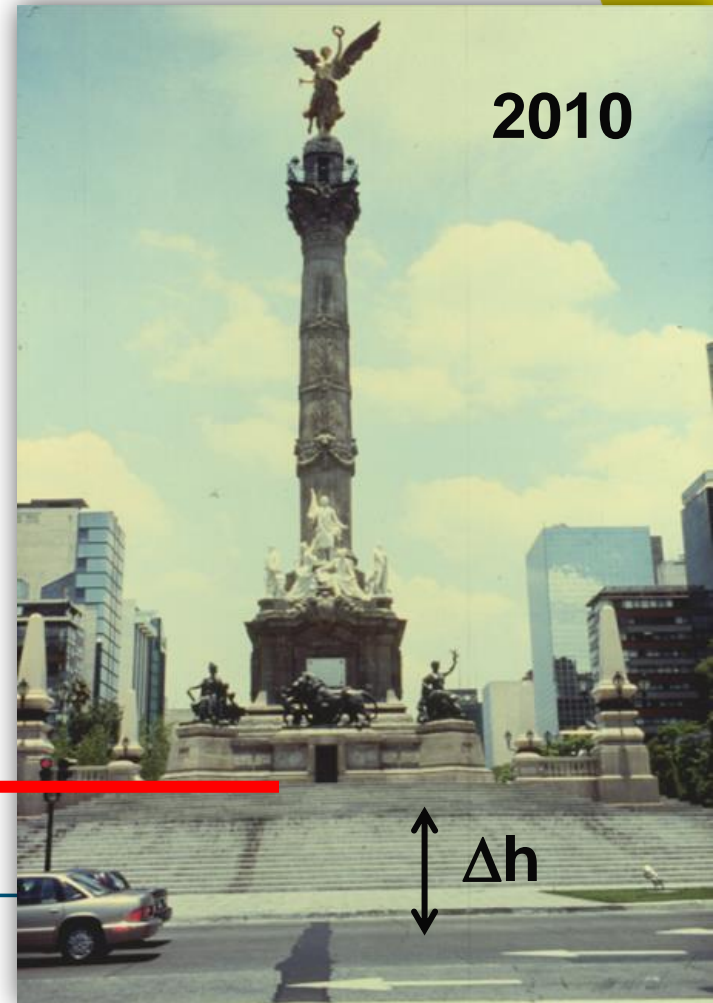
Kenmerken projectlocatie - Geohydrologie



Kenmerken projectlocatie - Bodemdaling



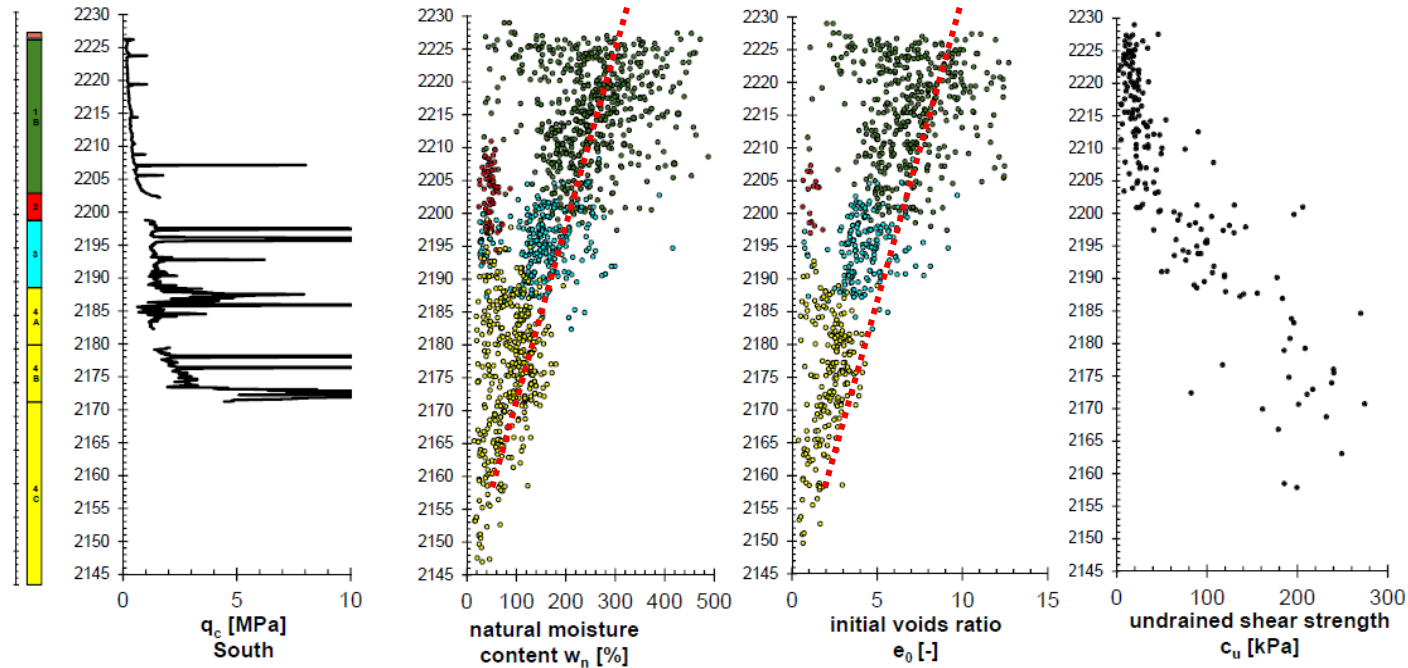
Kenmerken projectlocatie - Bodemdaling



Kenmerken projectlocatie - Bodemdaling

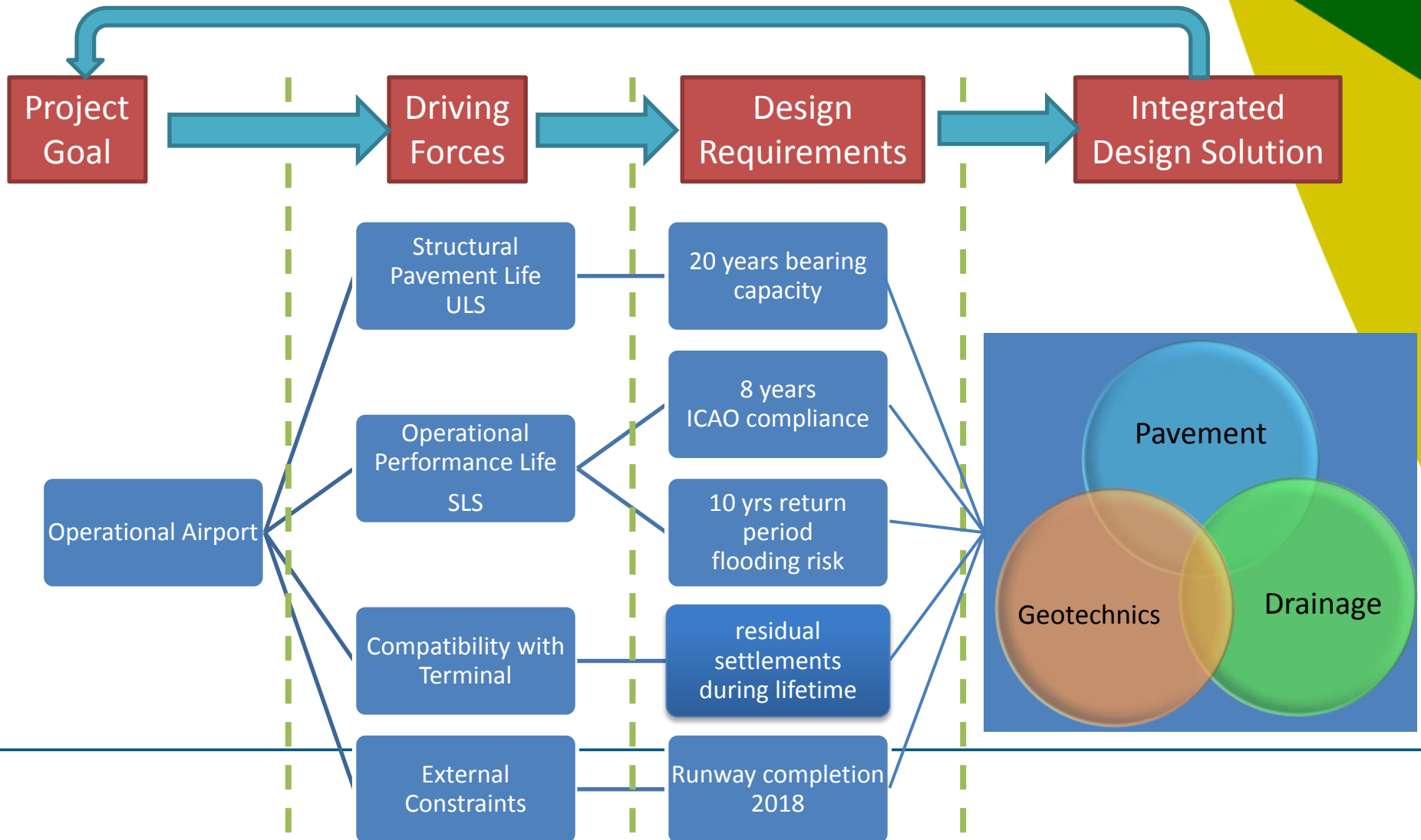


Kenmerken projectlocatie - Parameters

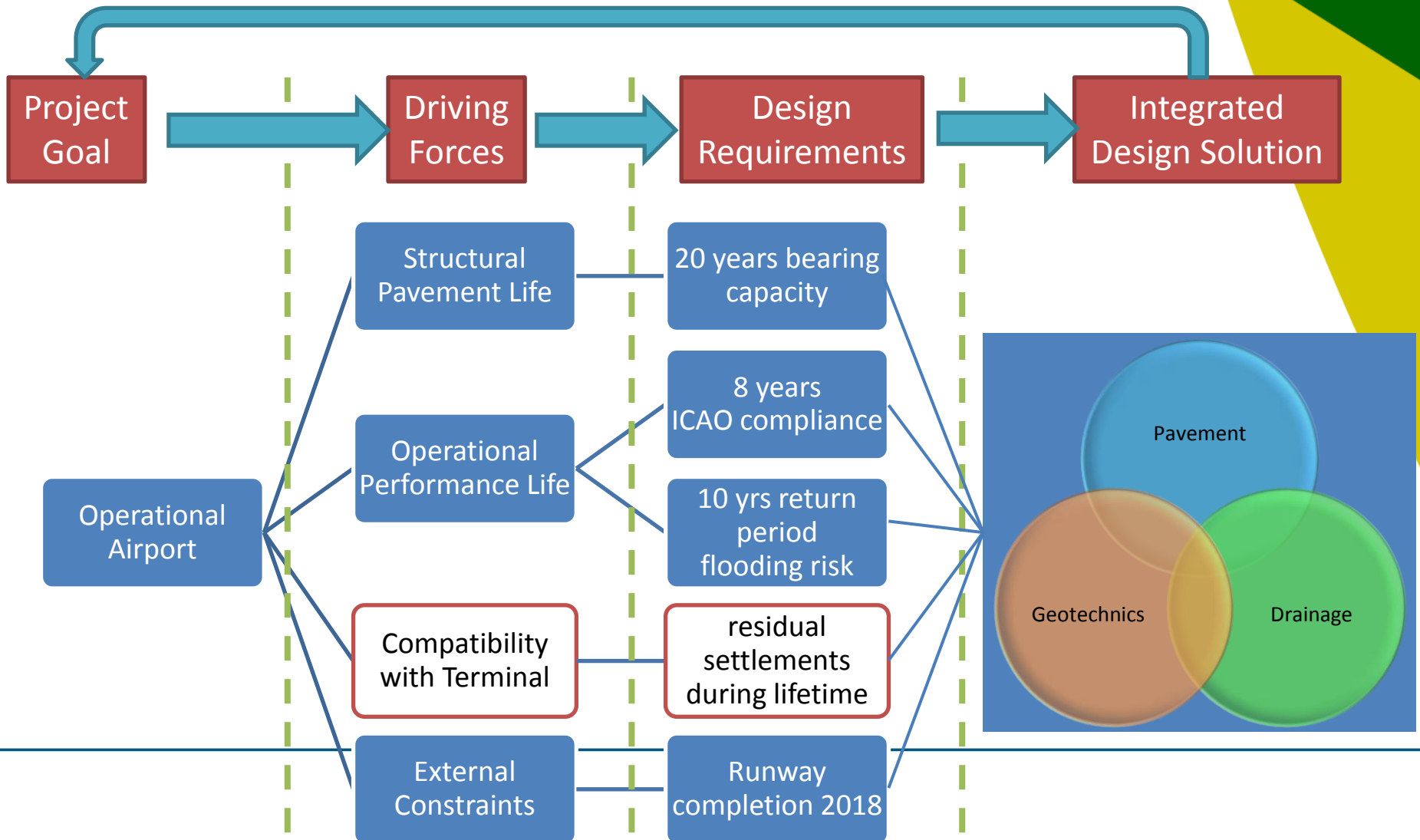


Grondlaag	Γ_{sat} [kN/m ³]	w_n [%]	Cc [-]	e_0 [-]	OCR [-]	K_v [m/s]
DC	13.8	125	1.9	3.5	3.0	1×10^{-7}
FAS	12.5	285	6.1	7.7	1.4	4.6×10^{-9}
CD	16.5	45	n.v.t.	1.2	1.0	6.5×10^{-5}
FAI	12.9	155	4.0	4.4	1.4	2.6×10^{-9}

Ontwerp - Framework

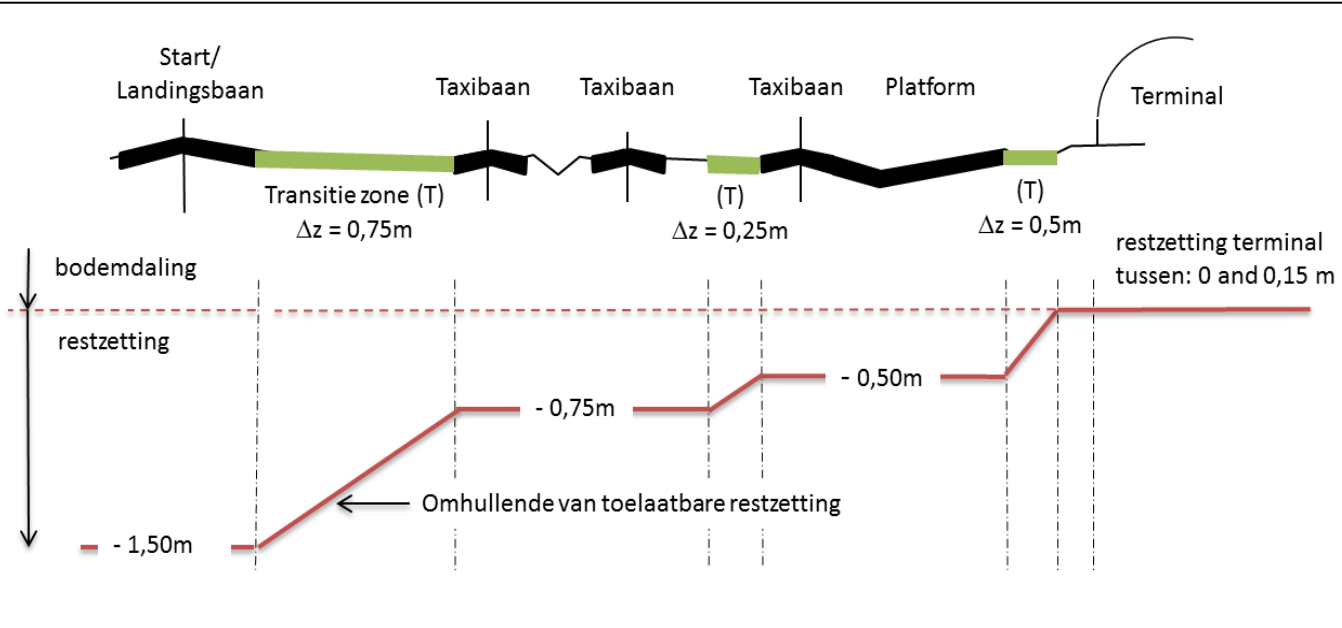


Ontwerp - Framework



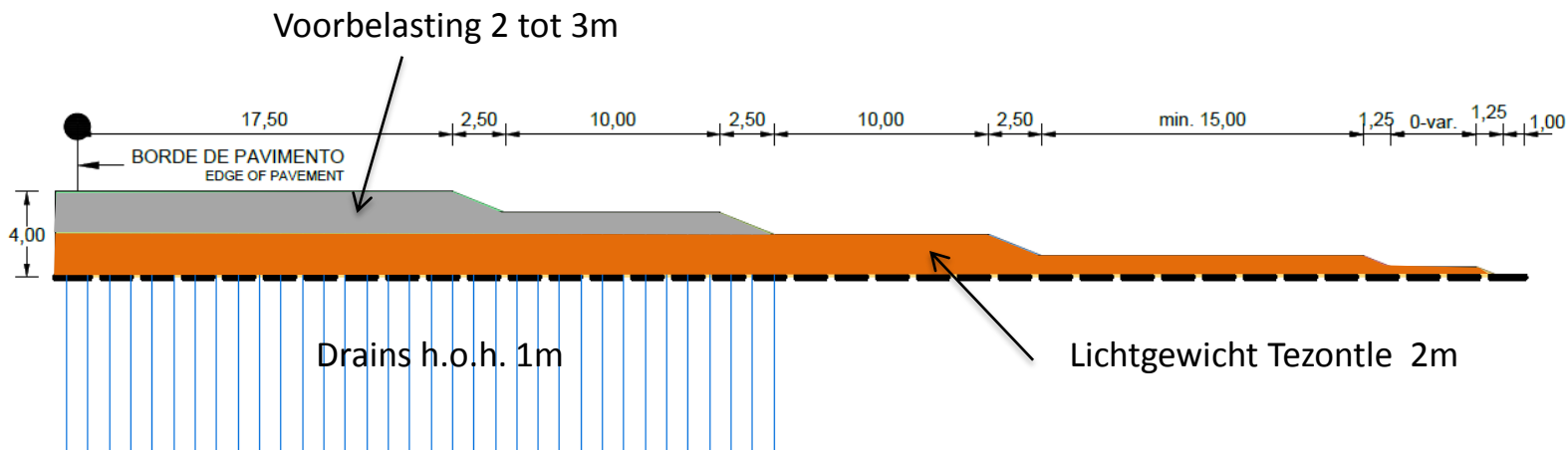
Ontwerp - eisen

- Interface met Passagiers terminal
- Toegewezen transitie zones

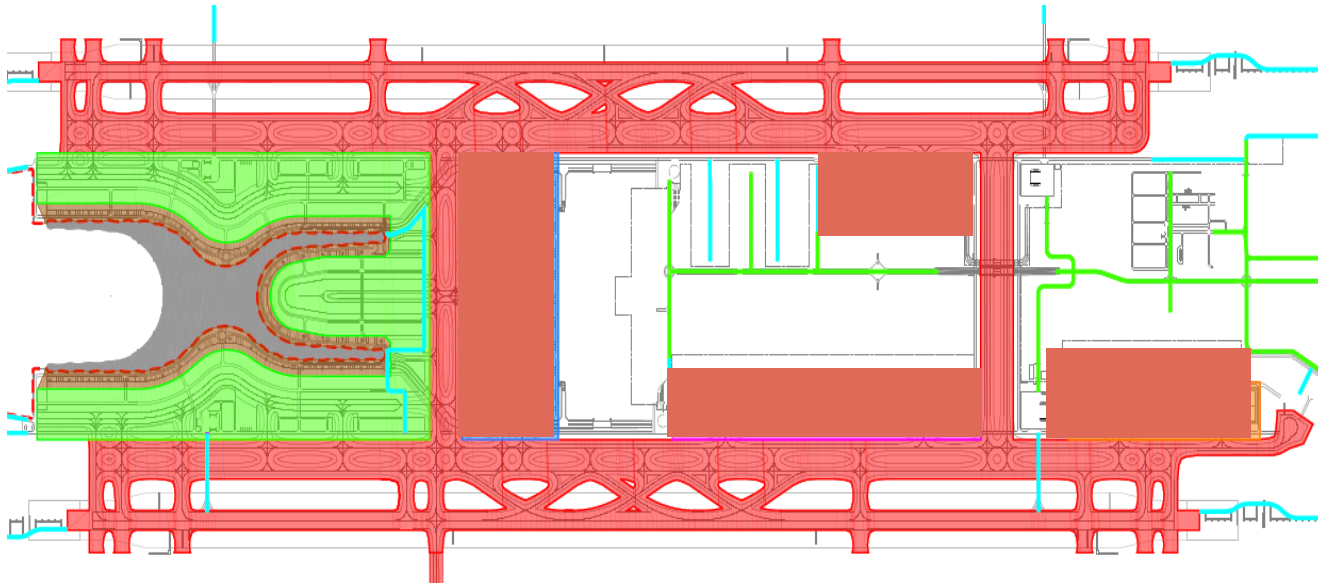


Ontwerp – integrale oplossing

- Traditioneel: voorbelasting met verticale drainage
- Gedurende 12 maanden
- Vulkanisch materiaal “Tezontle”



Ontwerp – integrale oplossing



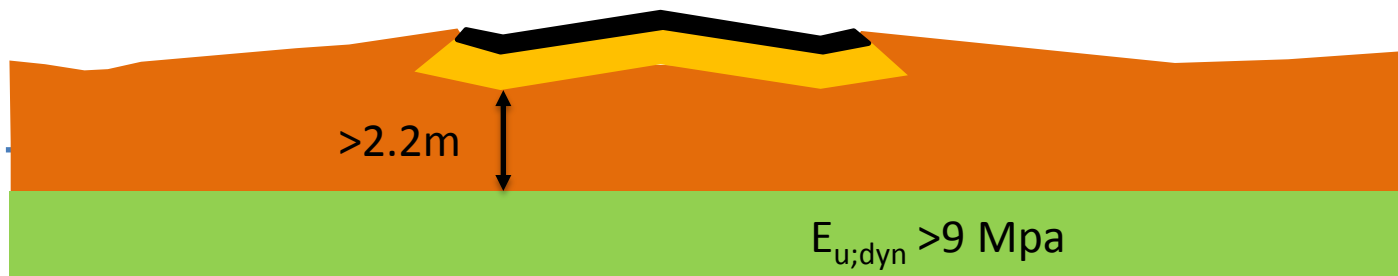
Voorbelasten, 2/3m met verticale drains



Vacuum consolidatie, rondom terminal

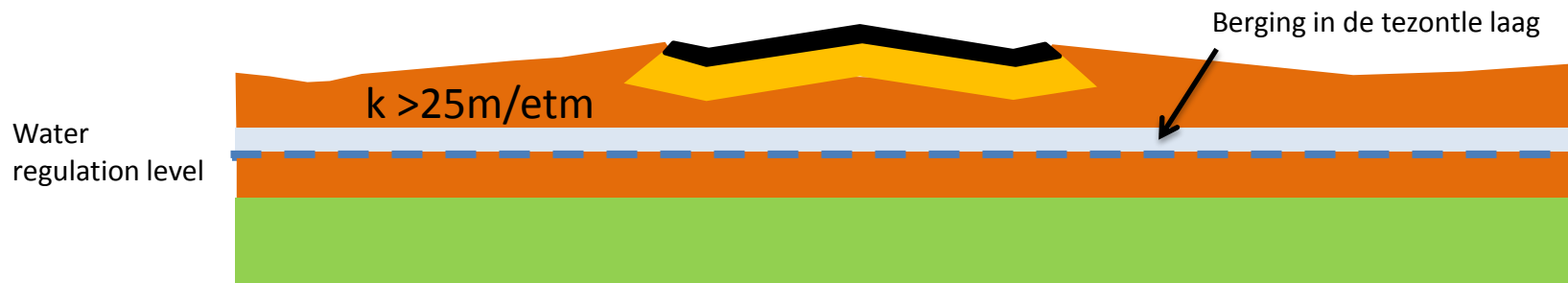
Ontwerp – integrale oplossing

- Verharding, draagvermogen:
 - minimale dikte fundatielaag 2.2m
 - grondverbetering noodzakelijk $E_{u,dyn} > 9 \text{ MPa}$



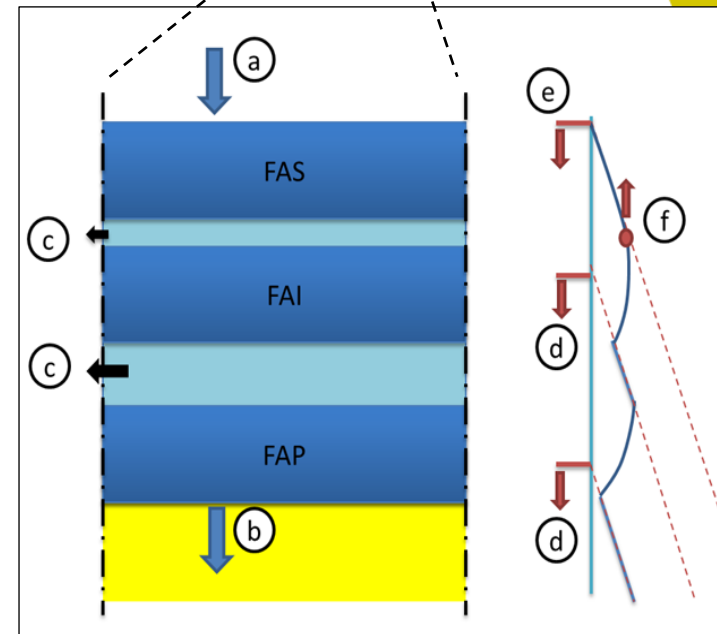
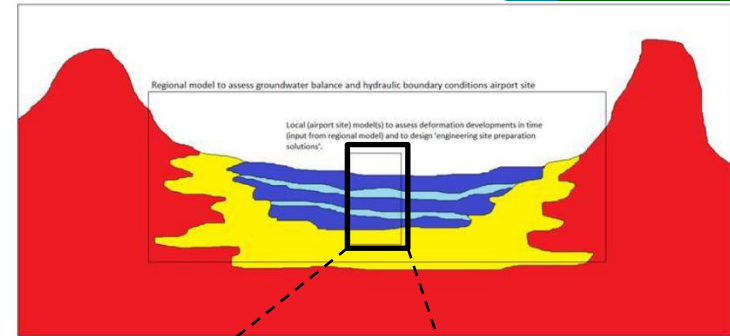
Ontwerp – integrale oplossing

- Verharding, draagvermogen:
 - minimale dikte fundatielaag 2.2m
 - grondverbetering noodzakelijk $E_{u;dyn} = 7\text{MPa} \rightarrow >9\text{MPa}$
- Drainage:
 - berging van water reduceert benodigde pompcapaciteit en buisdiameters, en reduceert zettingen



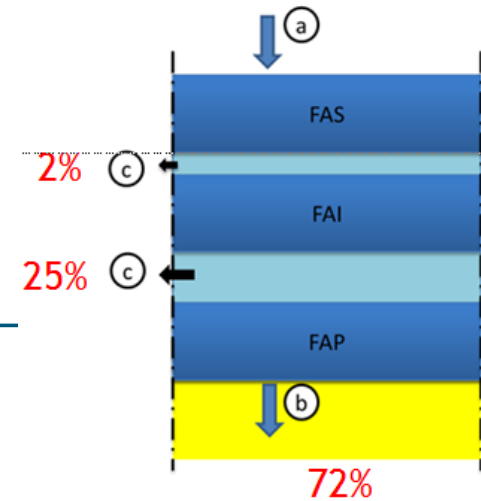
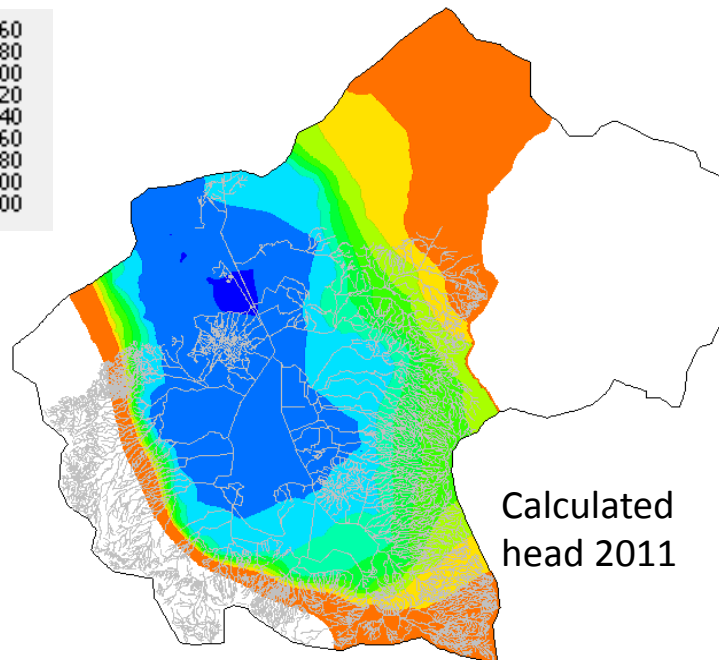
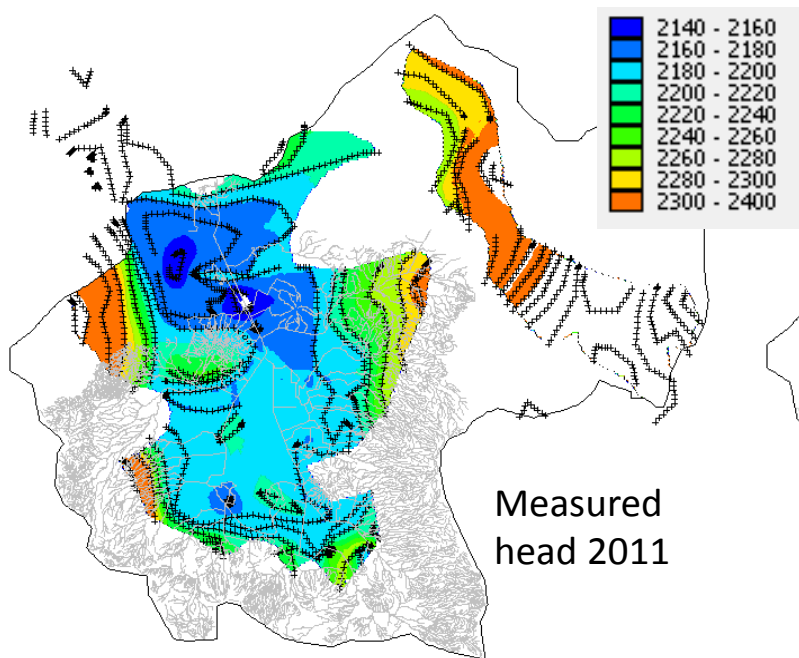
Ontwerp - Modelling

- Complex geohydrologische systeem met veel onbekenden
- Hoe te modelleren?
 - Wat zijn de boundary conditions voor het zettingsmodel?
 - Kan zetting worden opgeteld bij bodemdaling (2 aparte modellen)?
 - Wat is de invloed van verticale drains op de bodemdaling

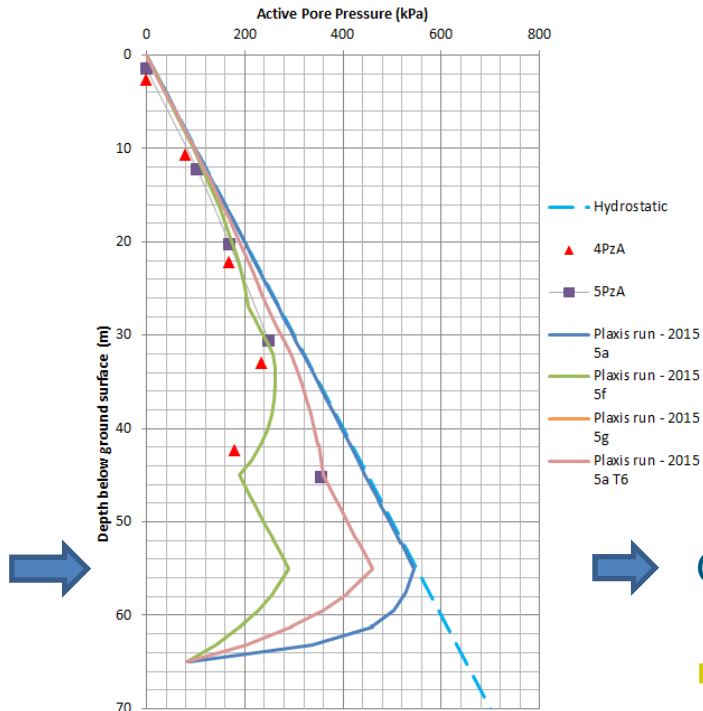
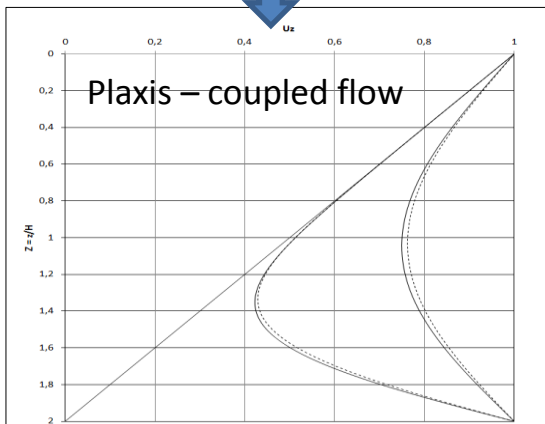
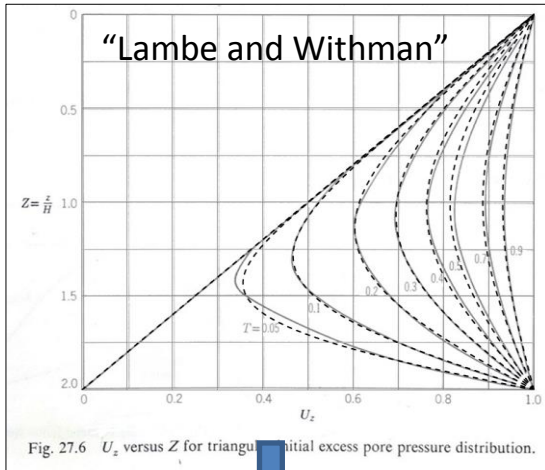


- a) Infiltratie met toekomstige reductie
- b) Onttrekking
- c) Strooming door aquifers
- d) Stijghoogte verlaging
- e) Daling grondwaterstand ?
- f) Consolidatie

Ontwerp - Modelling



Ontwerp - Modelling

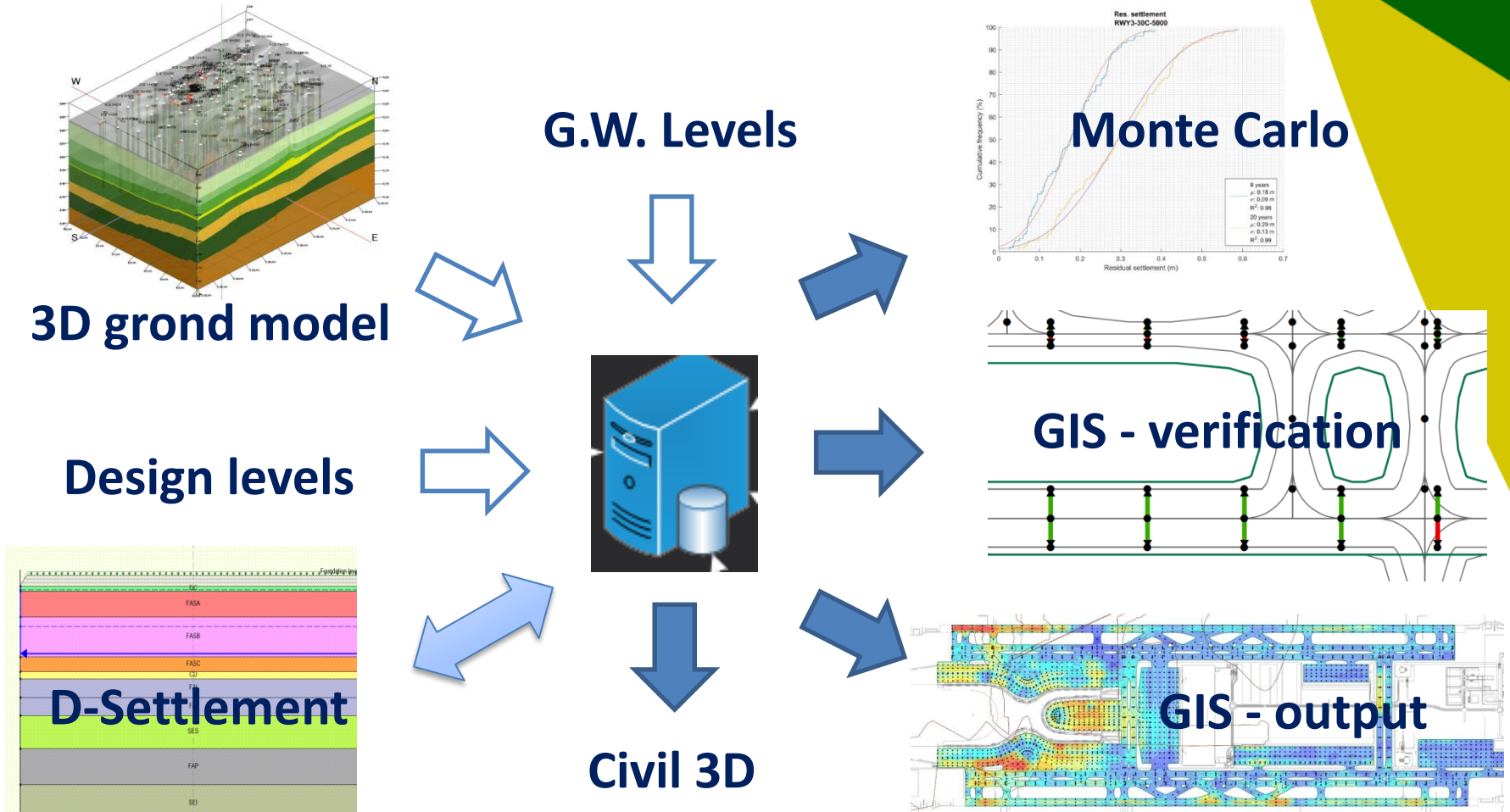


➔ Onderzoek fenomenen

■ Superpositie mag

■ Invloed drains op bodemdaling gering

Ontwerp - Digital Model-based Engineering



Uitvoering



Uitvoering



Uitvoering

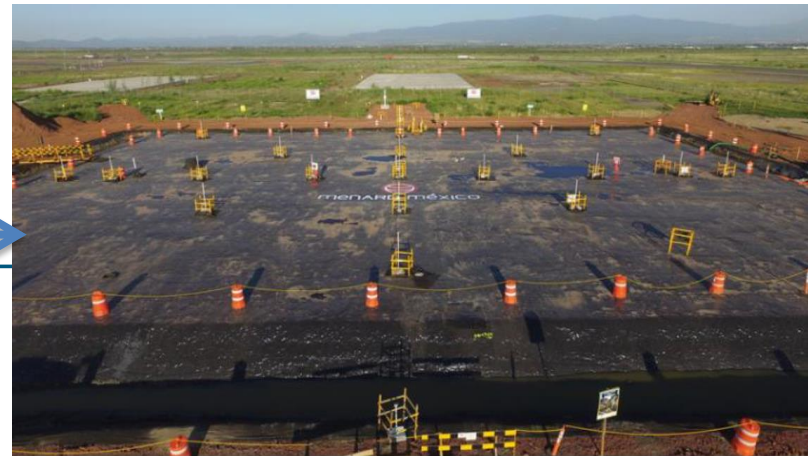
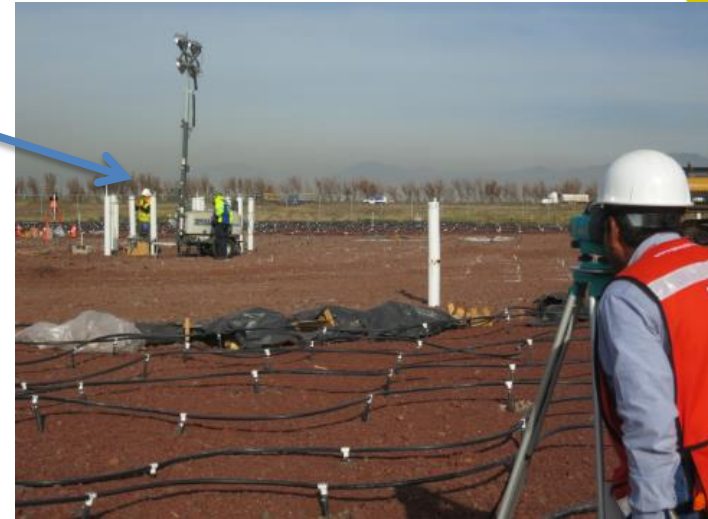


Uitvoering

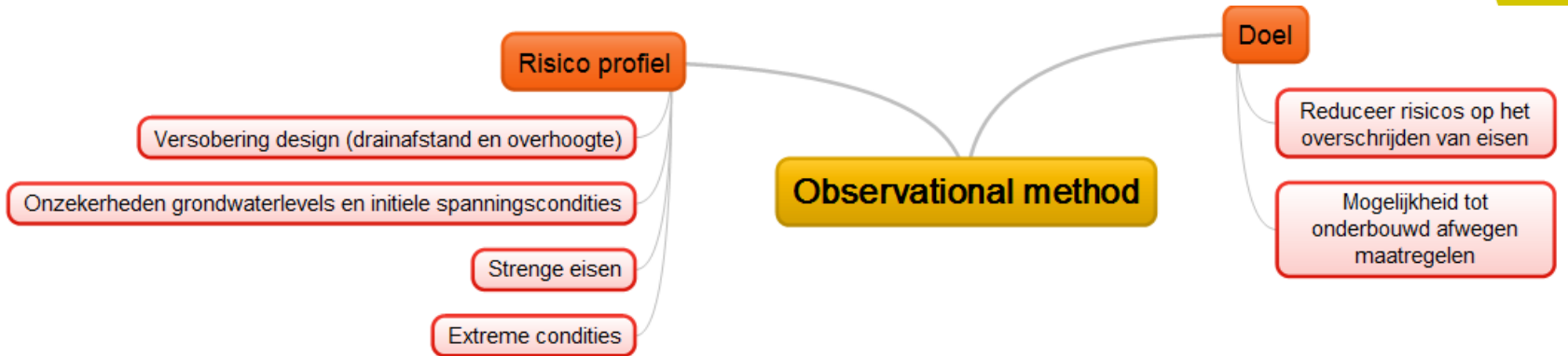


Vacuüm Consolidatie Proeven

- 1) proef met membraam
- 2) proef zonder membraam (Drain-to-Drain)

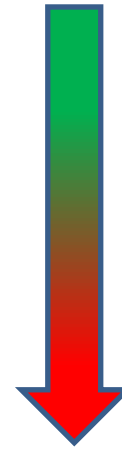


Observational method

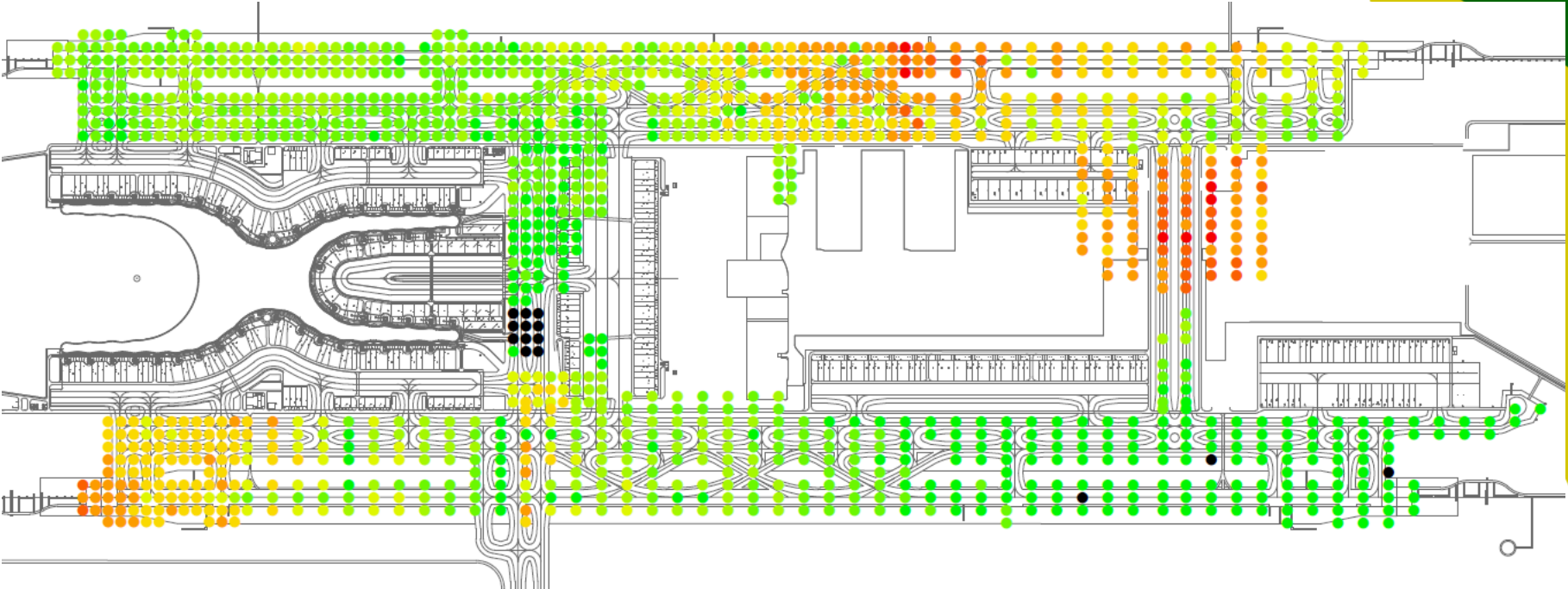


Observational Method - Modificaties

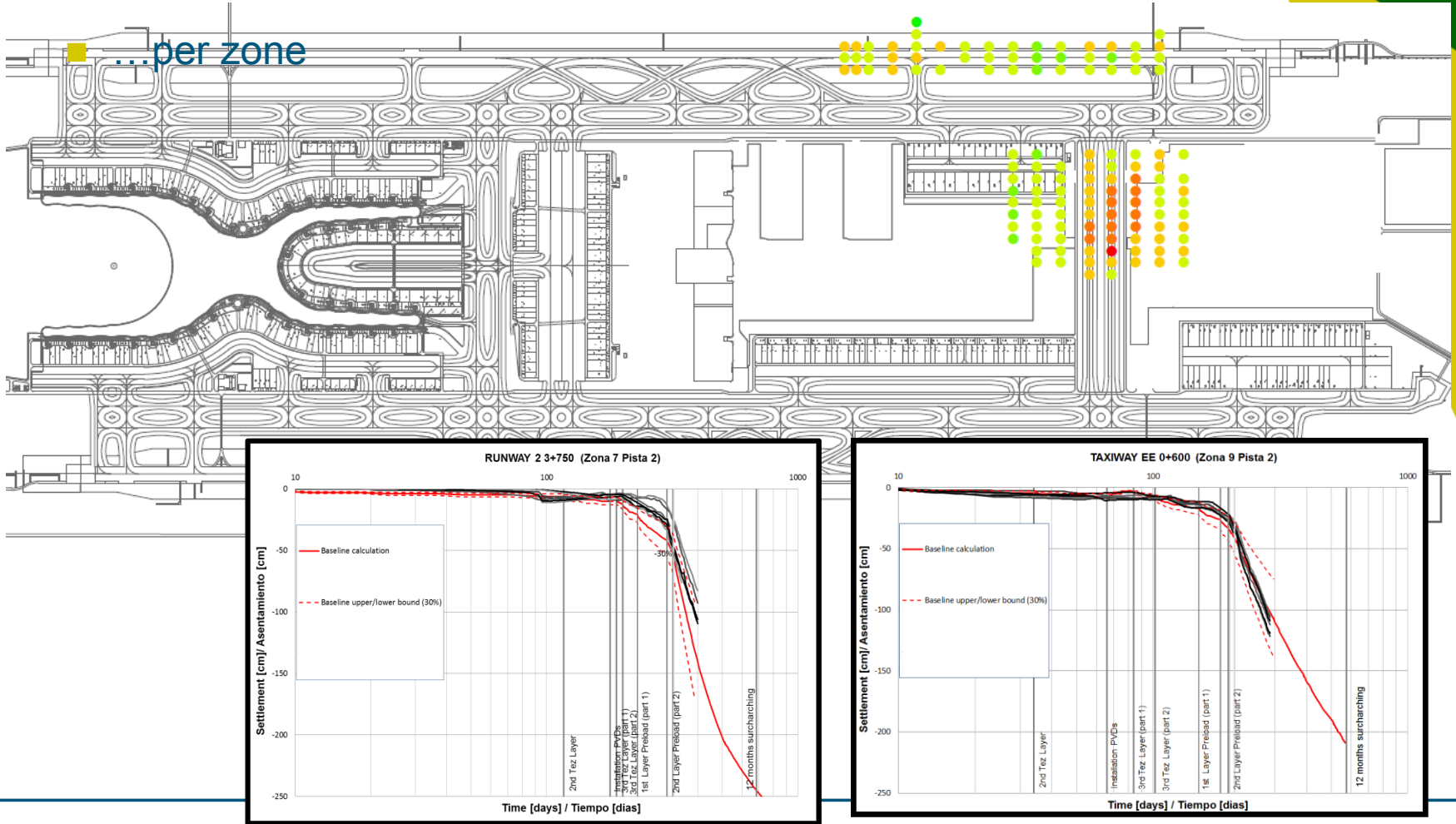
- Aanpassen voorbelasting (grootte, tijd)
- Verlagen grondwaterstand tijdens uitvoering
- Aanpassen verharding (CTB laag)
- Aanpassen verticaal alignement
- Intensiever onderhoud (< 8 jaar)



Observational Method – Back analyses



Observational Method – Back analyses



“Lessons learned”

- Bij dit project is de beheersing van geotechnische risico's alleen mogelijk met toepassing van de Observational Method.
- Bij dit project was de aanpak met geautomatiseerde en gekoppelde modellen onmisbaar. Alleen op deze wijze was het mogelijk het project te beheersen in termen van planning, kwaliteit, optimalisatie en databeheer.
- Bij projecten in “afwijkende omstandigheden” altijd kritisch beoordelen of gangbare geotechnische modellen en aannamen geldig zijn.



Dank U
Vragen?