



Workshop D-Geo Flow – Op weg naar een oplossing voor piping

Vera van Beek
Frits Dankers



Waarom is piping een probleem?

14 augustus 2017

20/01/2011 12:47

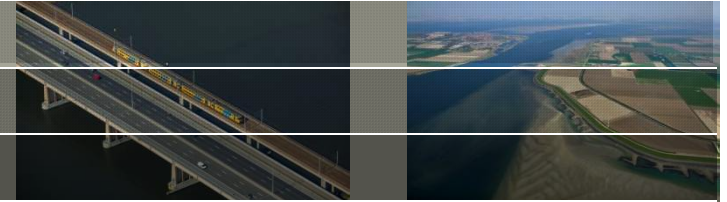
Bron: WSRL



Bron: Navin 2016

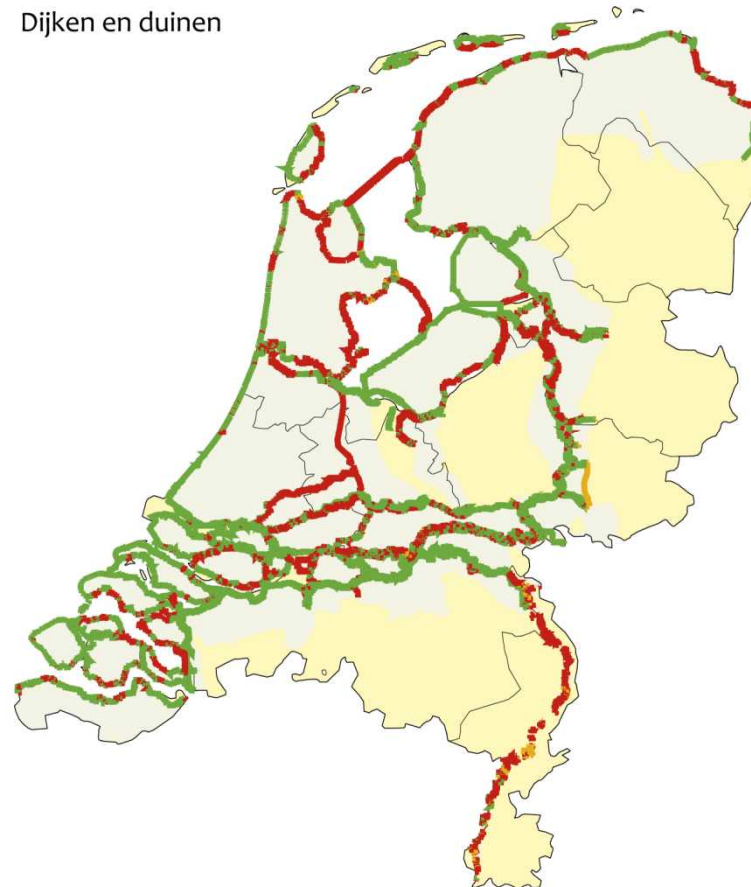
14 augustus 2017






Wat is het risico op piping?



Veiligheid van onderzochte primaire waterkeringen, 2013

Dijken en duinen



-  Voldoet aan de norm
-  Voldoet niet aan de norm
-  Nader onderzoek nodig
-  Dijkringgebied
-  Hoge gronden en buitendijks gebied

Bron: Inspectie Leefomgeving en Transport, 2013.

PBL/jun14
www.clo.nl/nl204304

14 augustus 2017

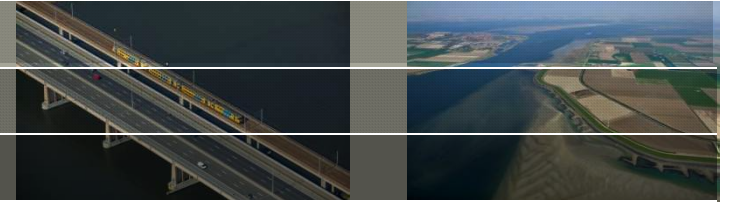
Deltares



Hoe pakken we het piping probleem aan?

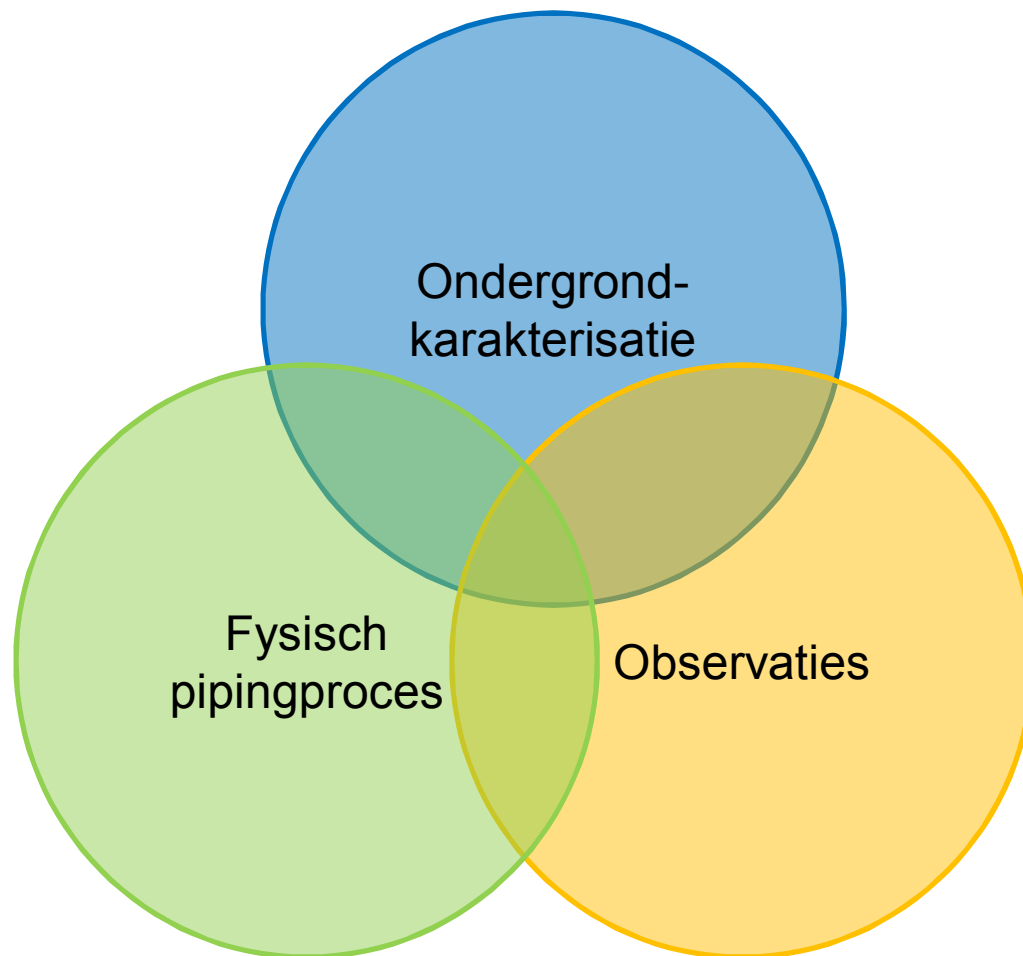
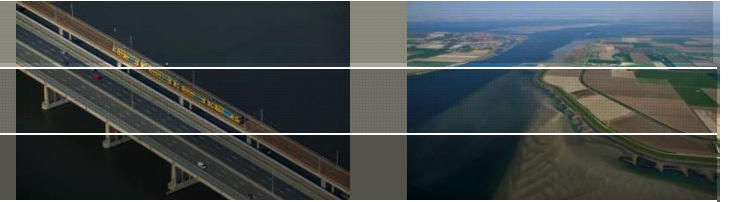
14 augustus 2017

Een visie op piping



Visie opgesteld door RWS, Deltares en POV-Piping: Omgaan met piping

1. No regret maatregelen voor urgente dijktrajecten
2. Beginnen met in kaart brengen van de ondergrond
3. Areaal beter vaststellen
4. Langere termijn: doorontwikkeling van pipingmodellen, innovatieve maatregelen en afwegingsmethodieken



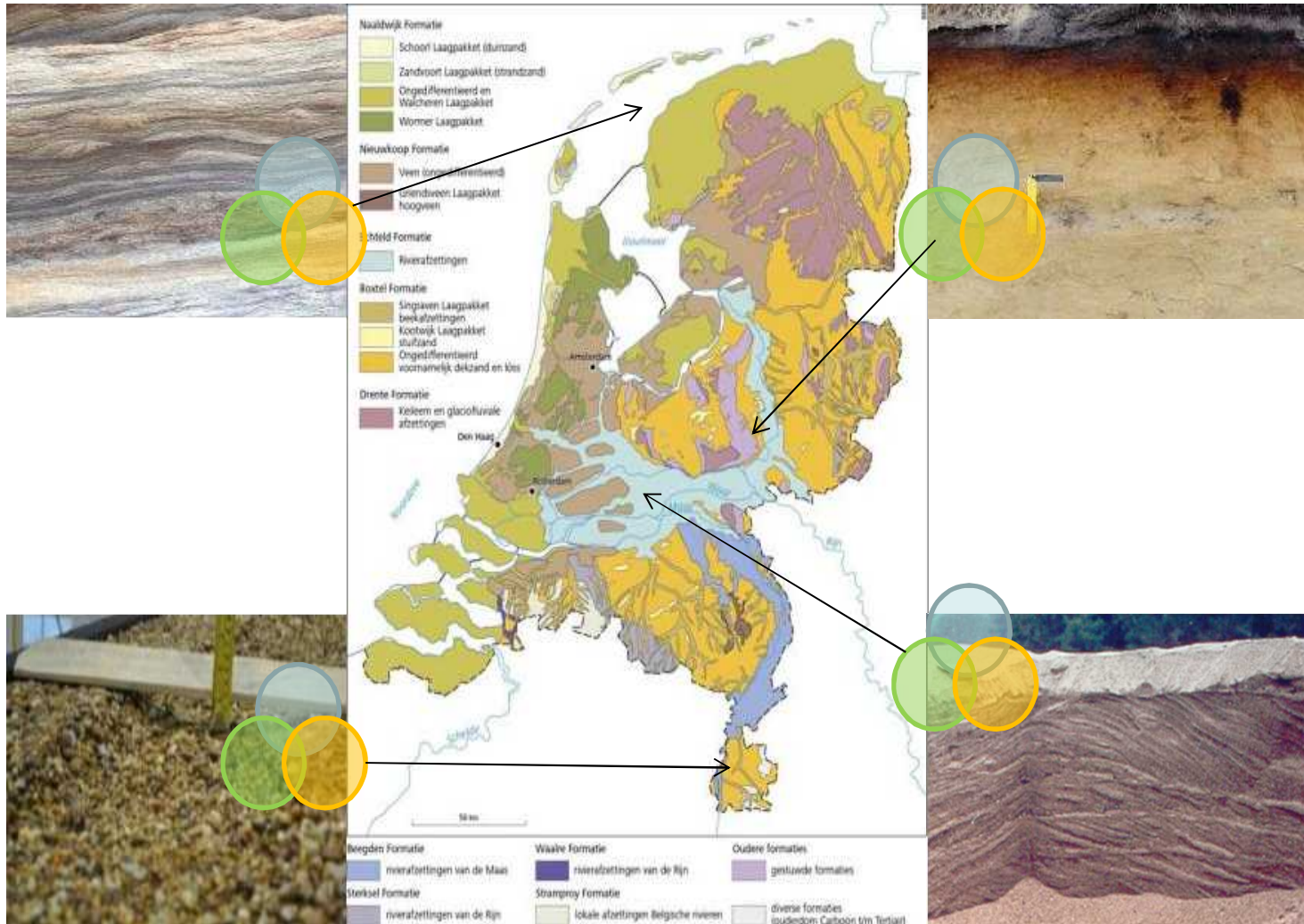
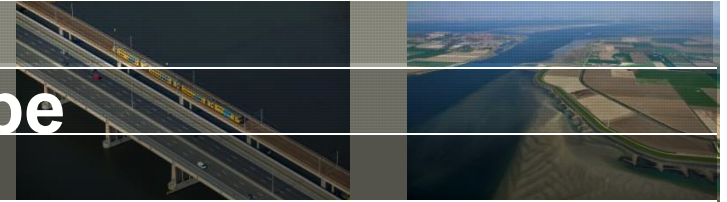
*naar de ondergrond
gedifferentieerd*

***eenvoudig** waar het
kan en **complex** waar
het nodig is*

*slim en zinvol **meten***

*benutten **observaties**
uit de praktijk*

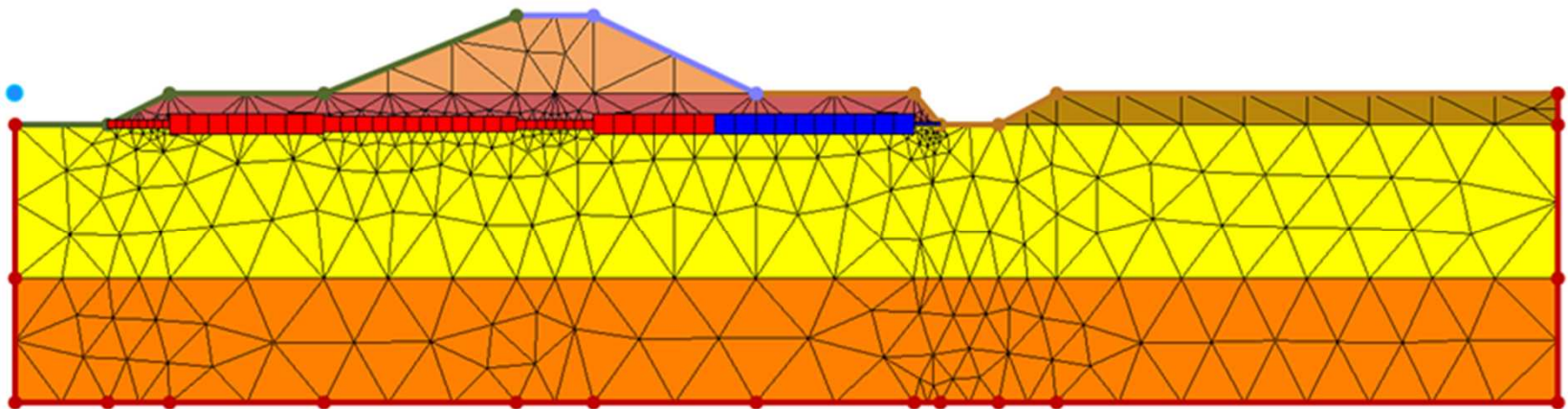
Differentiatie naar afzettingstype



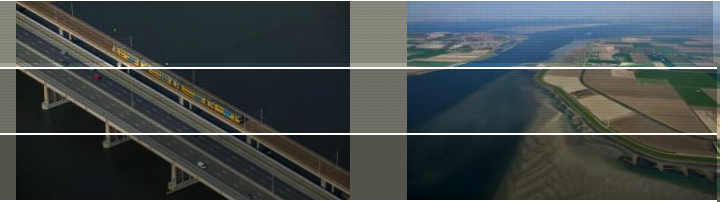
D-Geo Flow – onderdeel van pipingvisie

Binnen de gedifferentieerde aanpak is het nodig:

- Het effect van complexere configuraties mee te kunnen nemen in de pipingberekening
- Tijdsafhankelijk te rekenen



DGFlow en D-Geo Flow



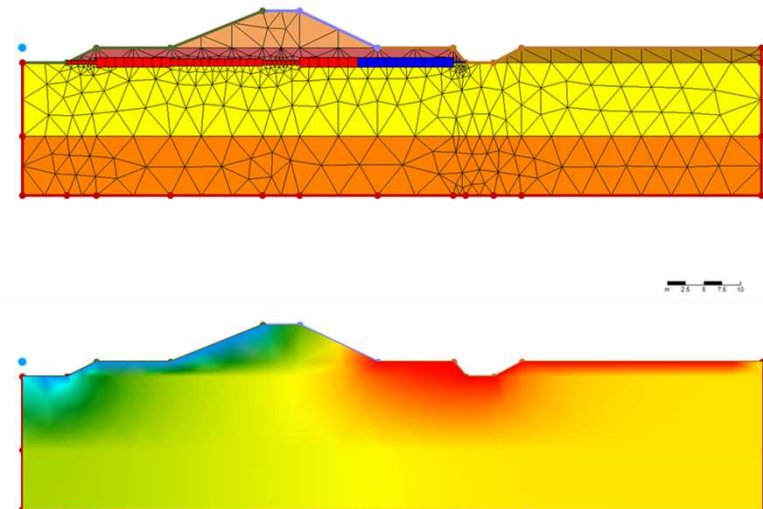
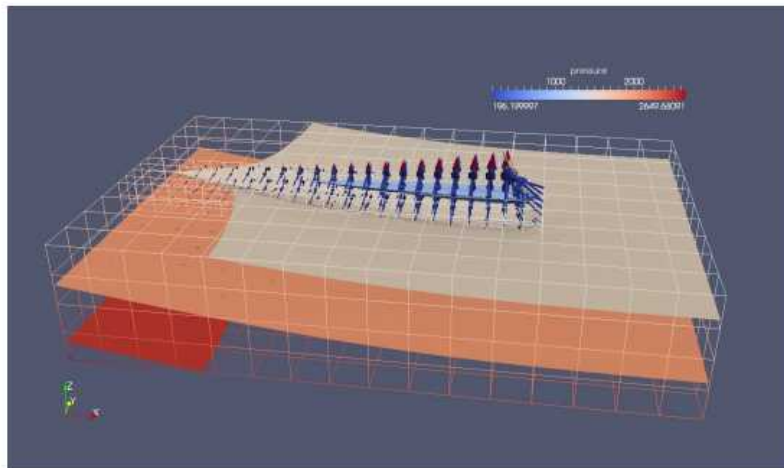
DGFlow

- 2D en 3D
- Transiente stroming
- Verzadigd en onverzadigd
- Piping module

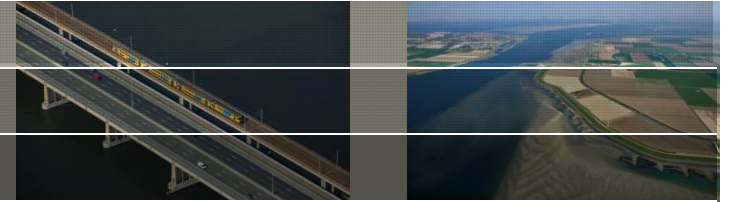


D-Geo Flow (GUI)

- 2D
- Transiente stroming
- Verzadigd en onverzadigd
- Piping module

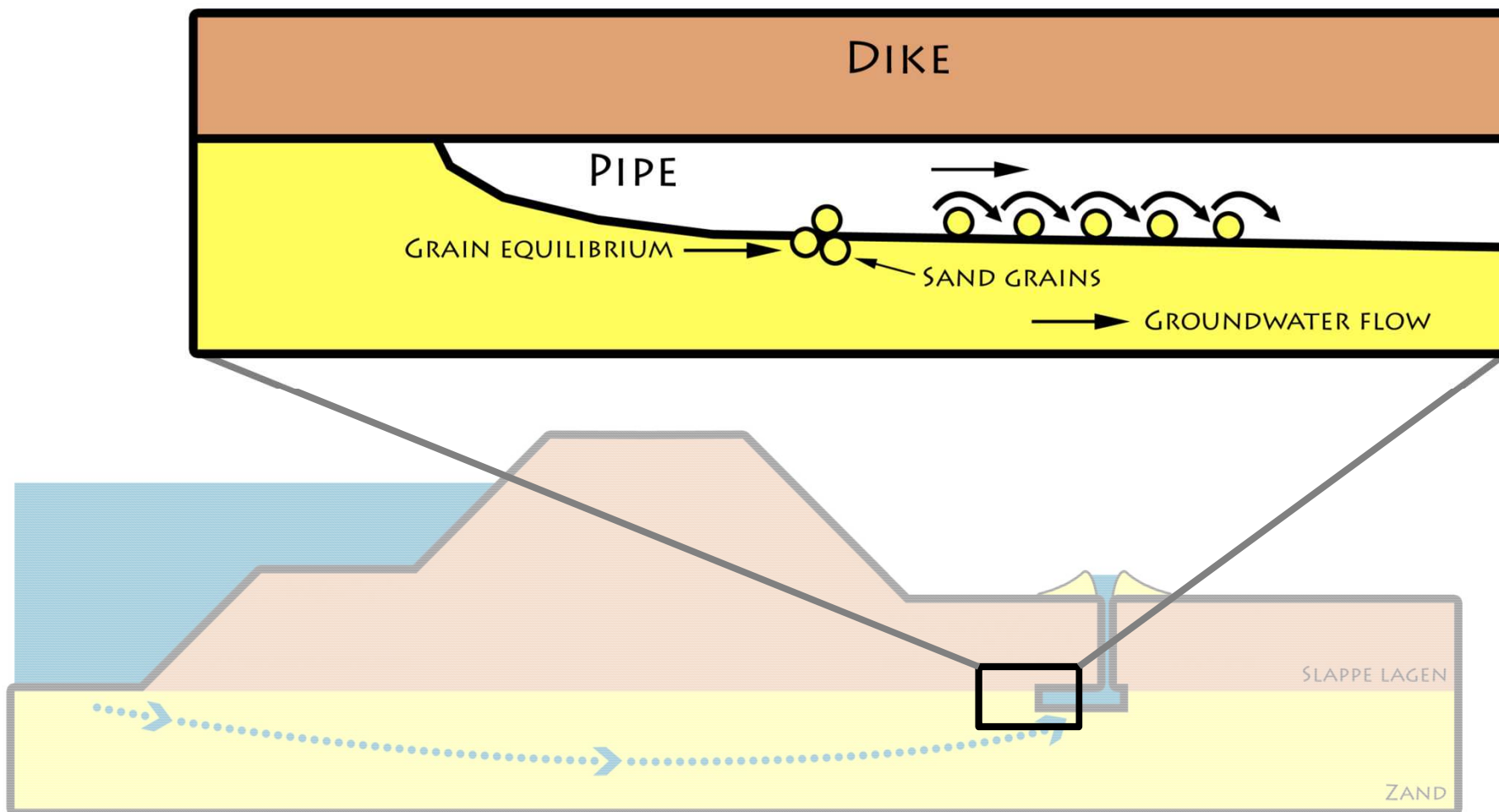
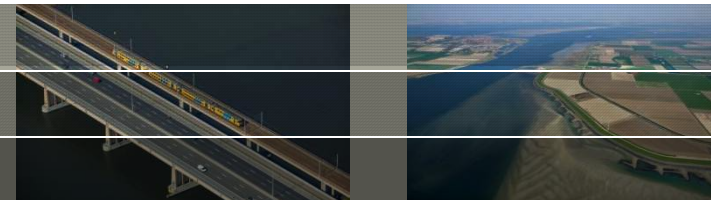


D-Geo Flow

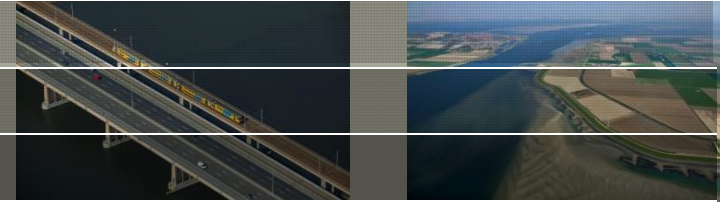


- D-Geo Flow is een gezamenlijke ontwikkeling van RWS en Deltares
- D-Geo Flow wordt gereleased als een beta-versie (v1.0) en is een startpunt voor doorontwikkeling.
- D-Geo Flow wordt kosteloos verstrekt aan geïnteresseerde partijen na tekenen van het contract, wat recht geeft op:
 - Versie 1.0
 - Eerste lijn support
 - Eenmalige registratie per bedrijf, met meerdere installaties.
- Verdere verbeteringen via actieve gebruikers community en pilotprojecten
- Uiterlijk in 2019 zal D-Geo Flow worden opgenomen in de ontwikkellijn van RWS/I&M

Theorie piping in D-Geo Flow

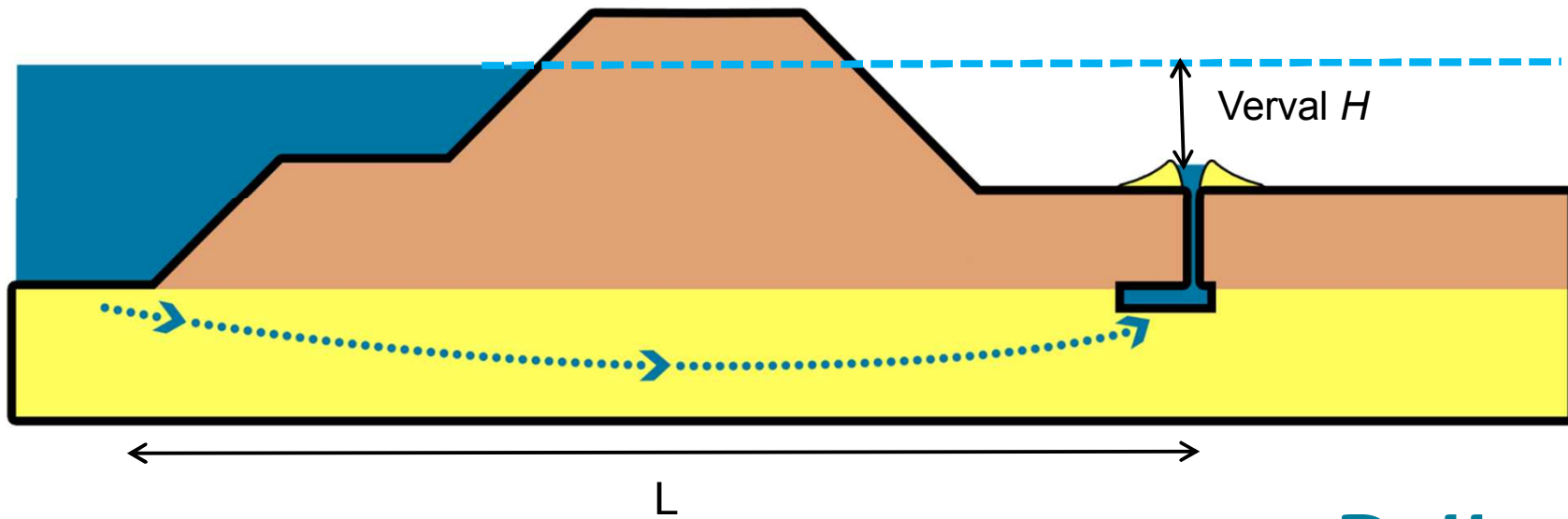
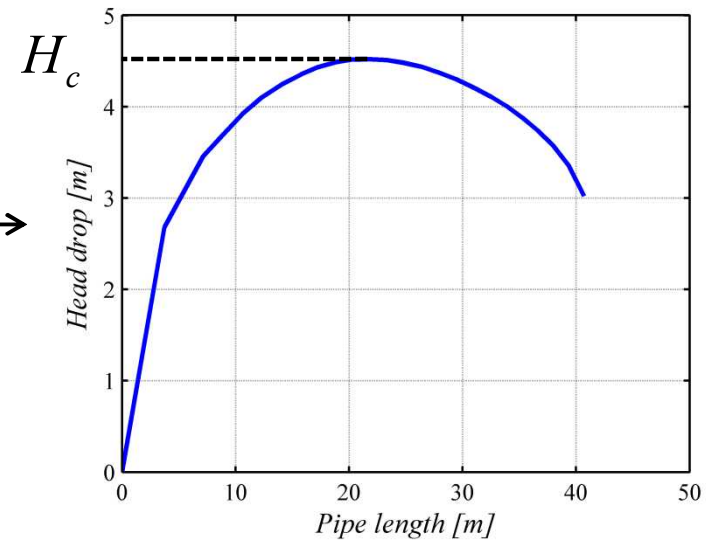


Het Sellmeijer model

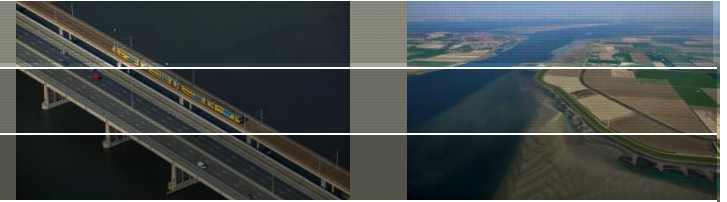


1. Strooming door het zandpakket
2. Strooming door de pipe
3. Evenwicht van korrels

$\rightarrow H_{eq} \rightarrow$



Het Sellmeijer model



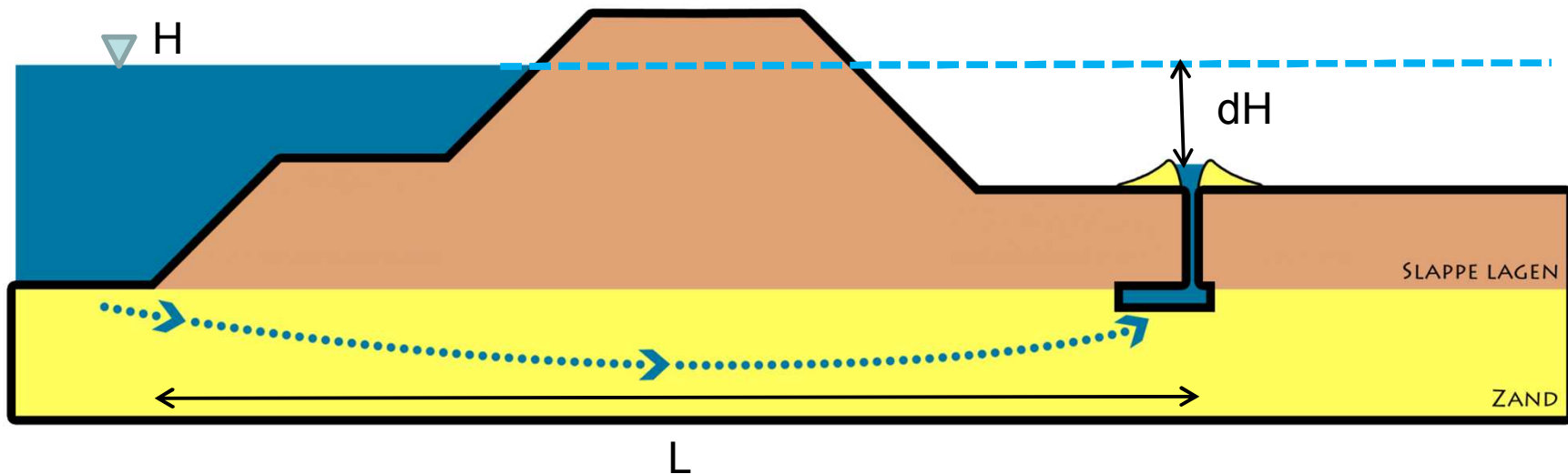
1. Stroming door het zandpakket
2. Stroming door de pipe
3. Evenwicht van korrels

$$\rightarrow \frac{H_c}{L} = F_R F_S F_G$$

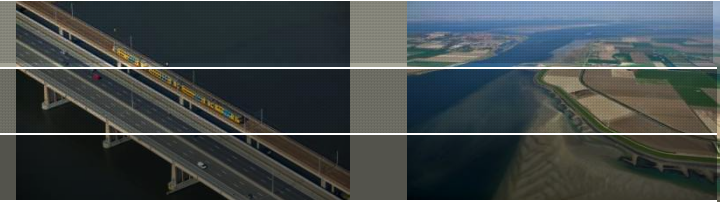
$$F_R = \eta \frac{\gamma'_p}{\gamma_w} \tan \vartheta$$

$$F_S = \frac{d_{70}}{\sqrt[3]{\kappa L}}$$

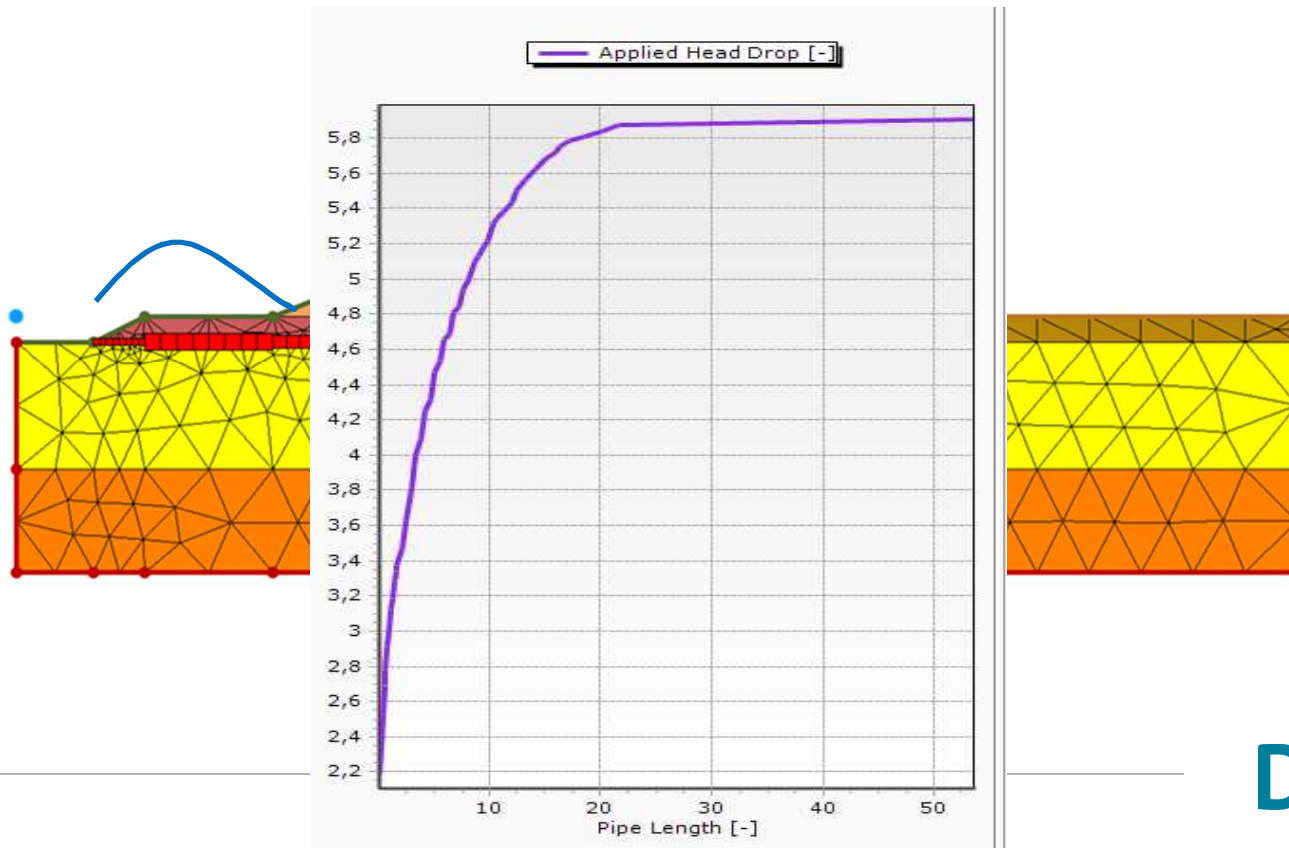
$$F_G = 0.91 \left(\frac{D}{L} \right)^{\frac{0.28}{\left(\frac{D}{L} \right)^{2.8} + 0.04} - 1}$$



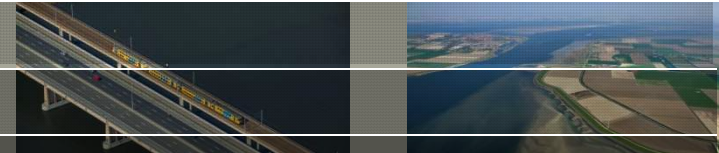
Piping module: D-Geo Flow



- De pipe is gemodelleerd met lijnelementen
- De diepte van het lijnelement wordt vergroot totdat de korrels in grensevenwicht zijn.
- Een nieuw element wordt geopend als het evenwicht wordt overschreden in het element aan de kop van de pipe



Voorbeeld



River_dike_tutorial - Delta Shell

File Home View Map

North Arrow Legend Scale Bar 15 Decorations

Zoom Previous Zoom Next Query Features

Map Coordinate System Export As Image Query Time Series

Show Profile Draw polygon origin Cross-section tools

Project Start Page DgFlow Model

- River_dike_tutorial
 - DgFlow Model
 - Input
 - Materials
 - Boreholes
 - Boundary Conditions
 - Pipes
 - Grid
 - Output

Map

- Map
 - DgFlow Model
 - Origin point
 - Results
 - Pipe
 - Head
 - Pressure
 - Velocity
 - Permeability_X
 - Permeability_Y
 - Water
 - Pipe
 - Boreholes
 - Boundary conditions
 - Unstructured Grid
 - CrossSection

Properties Folder

General

Name	Output
------	--------

Name
Name of the folder shown to the user.

Messages

Selected object of type: TreeFolderProperties	6/14/2017 7:41:52 AM
Selected object of type: VectorLayerPolygonProperties	6/14/2017 7:41:45 AM
Selected object of type: VectorLayerPolygonProperties	6/14/2017 7:41:44 AM
Selected object of type: UnstructuredGridLayer	6/14/2017 7:41:39 AM
Selected object of type: VectorLayerLineProperties	6/14/2017 7:41:38 AM

Messages Time Navigator

Undo / Redo Chart Map Toolbox

Voorbeeld

The screenshot displays a GIS software interface with several key components:

- Project Tree (Left):** A hierarchical tree view showing the project structure. The 'Output' folder is highlighted with a red box. The structure includes: River_dike_tutorial > DgFlow Model > Input > Materials > Boreholes > Boundary Conditions > Pipes > Grid > Output.
- Model Diagram (Center):** A flow diagram of the 'DgFlow Model'. It shows the following components: Input, Materials (Soils), Boreholes, Boundary Conditions, Pipes, Grid, and Output. The 'Soils' component is expanded to show a legend with the following items: Blanket (orange circle), Dike (red circle), Aquifer top (pink circle), Aquifer bottom (brown circle), and Blanket polder side (yellow circle). Below this, there are folders for Water, Boreholes, Boundary Conditions, Pipes, and Grid, followed by an 'Output' folder.
- Map Legend (Right):** A legend for the map view. It shows a list of layers with checkboxes: DgFlow Model (checked), Origin point (checked), Results (unchecked), Pipe (checked), Head (unchecked), Pressure (unchecked), Velocity (unchecked), Permeability_X (unchecked), Permeability_Y (unchecked), Water (unchecked), Pipe (unchecked), Boreholes (unchecked), Boundary conditions (unchecked), Unstructured Grid (unchecked), and CrossSection (checked). A vertical color bar is visible next to the legend, showing yellow, pink, and brown segments.
- Properties Panel (Bottom Left):** A panel showing the 'General' properties of the selected 'Output' folder. The 'Name' field contains the text 'Output'.
- Message Panel (Bottom Center):** A panel showing a list of messages with timestamps: 7:41:52 AM, 7:41:45 AM, 7:41:44 AM, 7:41:39 AM, and 7:41:38 AM.
- Map View (Right):** A map view showing a cross-section of a river and dike system. The legend is applied to the map, showing the corresponding colors for the different layers.

Voorbeeld

River_dike_tutorial - Delta Shell

File Home View Map

North Arrow Legend Scale Bar 15 Decorations

Zoom Previous Zoom Next Query Features Query Time Series Tools

Map Coordinate System Export As Image

Show Profile Grid Profile Edit

Draw polygon Go to origin Cross-section tools

Project Start Page DgFlow Model

- River_dike_tutorial
 - DgFlow Model
 - Input
 - Materials
 - Boreholes
 - Boundary Conditions
 - Pipes
 - Grid
 - Output

Map

- DgFlow Model
 - Origin point
 - Results
 - Pipe
 - Head
 - Pressure
 - Velocity
 - Permeability_X
 - Permeability_Y
 - Water
 - Pipe
 - Boreholes
 - Boundary conditions
 - Unstructured Grid
 - CrossSection

m 5 10 15 20

Properties Folder

General

Name	Output

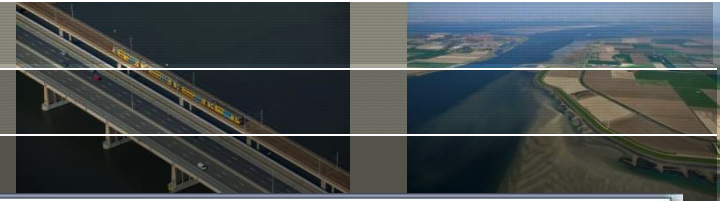
Messages

Selected object of type: TreeFolderProperties	6/14/2017 7:41:52 AM
Selected object of type: VectorLayerPolygonProperties	6/14/2017 7:41:45 AM
Selected object of type: VectorLayerPolygonProperties	6/14/2017 7:41:44 AM
Selected object of type: UnstructuredGridLayer	6/14/2017 7:41:39 AM
Selected object of type: VectorLayerLineProperties	6/14/2017 7:41:38 AM

Messages Time Navigator

Undo / Redo Chart Map Toolbox

Voorbeeld - invoer



River_dike_tutorial - Delta Shell

File Home View

Paste Copy Cut Delete New Model Import New Folder

Project

- DgFlow Model
 - Input
 - Materials
 - Boreholes
 - Boundary Conditions
 - Riverside head boundary
 - Head
 - Polder level
 - Head

Properties

DgFlow model properties

Time properties

Start time	2017-05-24 00:00:00
End time	2017-05-25 00:00:00
Time step	00:05:00

Output properties

Output Step Interval	1
Output time step	00:05:00

Settings

NDim	2
Analysis	flow
MPicard	1000
Gravity	10
ErrLin	1E-12
ErrNonLin	1E-06
Working Directory	C:\Users\bee\AppData\Local\Delta Shell
File Name	DgTestXXX

Advanced Mode

Advanced Mode	False
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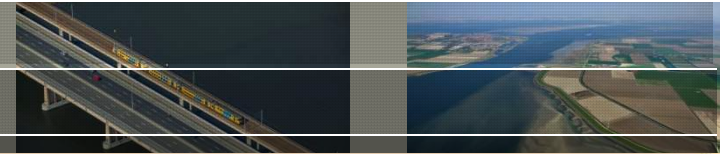
Map

- DgFlow Model
 - Origin point
 - Results
 - Pipe
 - Boreholes
 - Boundary conditions
 - Unstructured Grid
 - CrossSection

Start time

Start time model run

Voorbeeld – invoer materials



River_dike_tutorial - Delta Shell

File Home View Map

Cut Copy Paste Delete New Model Import New Folder New Item Run All Run Current Run Script Run

Project

- River_dike_tutorial
 - DgFlow Model
 - Input
 - Materials
 - Soils
 - Blanket
 - Dike
 - Aquifer top
 - Aquifer bottom
 - Blanket polder side
 - Water

Properties

Soil Properties

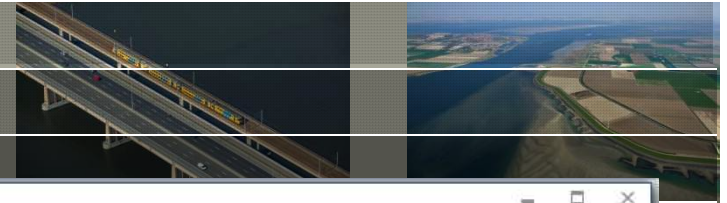
Soil Properties	
General	
Name	Aquifer top
Color	255; 228; 225
Other	
Porosity [-]	0,3
Compressibility [m ² /N]	0
Submerged Particle Density [kg/m ³]	1650
D70 [m]	0,0002
η [-]	0,25
θ [deg]	37
Permeability	
Hydraulic Conductivity - X [m/day]	10
Intrinsic permeability - X [m ²]	1,15741E-011
Hydraulic Conductivity - Y [m/day]	10
Intrinsic permeability - Y [m ²]	1,15741E-011
Fluid Density [N/m ³]	1000
Fluid Viscosity [Ns/m ²]	0,001

Name
Name of the soil

Name
Name of the soil

Selected object of type: DgFlowProjectTreetemPropertie 6/13/2017 4:31:53 PM
 Selected object of type: SoilProperties 6/13/2017 4:31:36 PM
 Selected object of type: SoilProperties 6/13/2017 4:31:13 PM
 Selected object of type: TreeFolderProperties 6/13/2017 4:31:12 PM

Voorbeeld – invoer materials



River_dike_tutorial - Delta Shell

File Home View Map

Paste Copy Delete Clipboard New Import New Folder New Item Run All Run Current Run Script Run Find Feedback Show Log About Help

Project

- Blanket
- Dike
- Aquifer top
- Aquifer bottom
- Blanket polder side
- Water
- Boreholes
- Boundary Conditions
- Pipes
- Grid
- Output

Properties

Water properties

Water Properties

Name	Water
Compressibility [m ³ /N]	0
State seepage	Steady
Density [kg/m ³]	1000
Viscosity [Ns/m ²]	0,001

Start Page DgFlow Model

Map

- DgFlow Model
 - Origin point
 - Results
 - Pipe
 - Boreholes
 - Boundary conditions
 - Unstructured Grid
 - CrossSection
 - Aquifer top
 - Aquifer bottom
 - Blanket
 - Dike
 - Blanket polder side

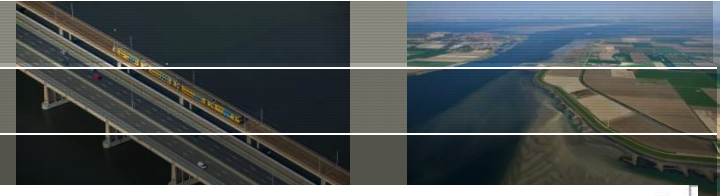
Messages

No view registered for : DeltaShell.Plugins.DgFlow.DataO	6/13/2017 4:42:17 PM
Selected object of type: WaterProperties	6/13/2017 4:42:13 PM
Selected object of type: SoilProperties	6/13/2017 4:31:54 PM
Selected object of type: DgFlowProjectTreeItemPropertie	6/13/2017 4:31:53 PM
Selected object of type: SoilProperties	6/13/2017 4:31:36 PM

Messages Time Navigator

Undo / Redo Chart Map Toolbox

Voorbeeld – invoer geometrie



Project

- River_dike_tutorial
 - DgFlow Model
 - Input
 - Materials
 - Soils
 - Blanket
 - Dike
 - Aquifer top
 - Aquifer bottom
 - Blanket polder side
 - Water
 - Boreholes
 - Borehole 1
 - Borehole 2
 - Borehole 3
 - Borehole 4
 - Borehole 6
 - Borehole 7
 - Borehole 5
 - Borehole 8
 - Borehole 9
 - Borehole 10
 - Borehole 11
 - Borehole 12

Start Page DgFlow Model

Properties

DgFlowBoreholeProperties_DisplayName

General

Name	Borehole 1
X	0
TopLevel	-2
Number of layers	2

Messages

Selected object of type: DgFlowBoreholeProperties	6/13/2017 4:48:57 PM
No view registered for : DeltaShell.Plugins.DgFlow.Gui.NodePresenters.DgFlowProjectTreeItem	6/13/2017 4:48:55 PM
Selected object of type: DgFlowProjectTreeItemProperties	6/13/2017 4:48:54 PM

Voorbeeld – invoer boundary conditions

Project: River_dike_tutorial

- DgFlow Model
 - Input
 - Materials
 - Soils
 - Blanket
 - Dike
 - Aquifer top
 - Aquifer bottom
 - Blanket polder side
 - Water
 - Boreholes
 - Boundary Conditions
 - Riverside head boundary**
 - Head
 - Polder level
 - Head
 - Polderside boundary
 - No flow
 - Pipes
 - Grid
 - Output

Properties: Boundary properties

General

Name: **Riverside head boundary**

Boundary Type: **Submerged**

Line color: **75; 110; 187**

Time Series Data:

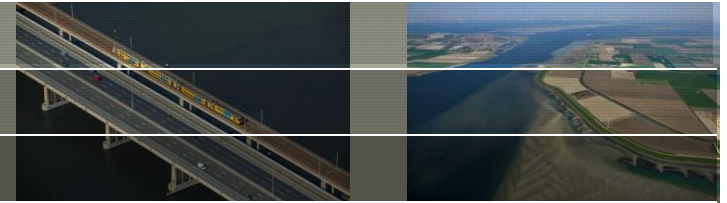
Time [-]	Head [m]
2016-05-24 00:00:00	2
2016-05-24 12:00:00	6,5
2016-05-25 00:00:00	2

Graph: Head [m] vs Time [-]

Messages:

- No view registered for : Riverside head boundary [Head, Flux, Pressure] nr 0 (6/13/2017 4:56:47 PM)
- Selected object of type: DgFlowBoundaryProperties (6/13/2017 4:56:44 PM)
- Selected object of type: DgFlowBoundaryProperties (6/13/2017 4:56:42 PM)
- Selected object of type: TimeSeriesProperties (6/13/2017 4:56:41 PM)

Voorbeeld – invoer pipe



Project

- Input
 - Materials
 - Soils
 - Blanket
 - Dike
 - Aquifer top
 - Aquifer bottom
 - Blanket polder side
 - Water
 - Boreholes
 - Boundary Conditions
 - Riverside head boundary
 - Head
 - Polder level
 - Head
 - Polderside boundary
 - No flow
 - Pipes
 - Pipe
 - Grid
- Output

Start Page | DgFlow Model | Borehole 1 | Head

Properties

DgFlowPipeDataProperties_DisplayName

General

Name	Pipe
------	------

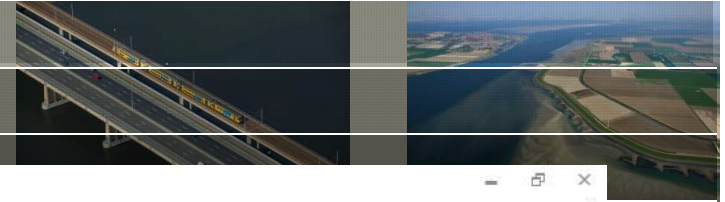
Position

Start: X	6
Exit: X	60
Y-Position	-2

Messages

- Selected object of type: DgFlowPipeDataProperties 6/13/2017 5:04:39 PM
- Selected object of type: VectorLayerProperties 6/13/2017 5:04:37 PM

Voorbeeld – mesh generation



River_dike_tutorial - Delta Shell

File Home View Map

North Arrow Legend Scale Bar Decorations

Zoom Previous Zoom Next Query Features

Map Coordinate System Export As Image Query Time Series

Show Profile Edit Grid Profile

Draw polygon + origin Cross-section tools

Project

- Borehole 4
- Borehole 6
- Borehole 7
- Borehole 5
- Borehole 8
- Borehole 9
- Borehole 10
- Borehole 11
- Borehole 12
- Boundary Conditions
- Pipes
- Grid
- Output
- Pipe Results

Properties

DgFlowProjectTreeItemProperties

Mesh Data

- Coarseness 2,5
- Pipe Coarseness 6

Mesh Parameters

- Cell Count 2064
- Min Angle 5,09
- Max Angle 158,70

Coarseness

Mesh Coarseness

Start Page DgFlow Model

Map

- DgFlow Model
 - Origin point
 - Results
 - Pipe
 - Boreholes
 - Boundary conditions
 - Unstructured Grid
 - CrossSection

Messages

Icon	Message	Time
Selected	Selected object of type: DgFlowProjectTreeItemProperties	6/15/2017 9:25:39 AM
Selected	Selected object of type: VectorLayerPolygonProperties	6/15/2017 9:25:35 AM
Selected	Selected object of type: DgFlowGeometryProperties	6/15/2017 9:22:18 AM
Selected	Selected object of type: UnstructuredGridLayer	6/15/2017 9:22:16 AM
Selected	1x: DgFlowGeometryProperties	6/15/2017 9:22:05 AM

Messages Time Navigator

Undo / Redo Chart Map Toolbox

Voorbeeld – output: head and pipe

The screenshot displays the DgFlow Model software interface. The main window shows a 2D cross-section of a pipe with a head profile. The head profile is color-coded, with blue representing the highest head and red representing the lowest head. The pipe is shown as a horizontal line with a green border. The interface includes several panels:

- Project:** A tree view showing the model structure. The 'Output' folder is expanded, showing 'Pipe Results' with sub-items: Equilibrium Head Drop, Pipe Element Active, Head in Pipe, Velocity in Pipe, Height in Pipe, and Pipe Element Length.
- Properties:** A panel for the 'Pipe Element Active' layer, showing its name and opacity (1).
- Time Navigator:** A timeline showing the simulation period from 05/24/2017 09:58:10 to 25-May-17 12:00 PM. A red vertical line indicates the current time step.
- Map:** A legend for the map view, showing the 'Pipe Element Active' layer selected.

The bottom of the interface features a toolbar with buttons for 'Messages', 'Time Navigator', 'Undo / Redo', 'Chart', 'Map', and 'Toolbox'.

14 augustus 2017

Voorbeeld – output Critical head

River_dike_tutorial - Delta Shell

File Home View Charting Chart

Export as Image Export Increase Font Sizes Decrease Font Sizes Ruler Style Tools

Project River_dike_tutorial DgFlow Model

- Input
 - Materials
 - Boreholes
 - Boundary Conditions
 - Riverside head boundary
 - Head
 - Polder level
 - Head
 - Polderside boundary
 - No flow
 - Pipes
 - Grid
- Output
 - Pipe Results
 - Equilibrium Head Drop
 - Pipe Element Active
 - Head in Pipe
 - Velocity in Pipe
 - Height in Pipe

DgFlow Model Head in Pipe Equilibrium Head Drop

Csv export

Pipe Length [-]	Applied Head Drop [-]
3,8854	4,0938
4,3125	4,25
4,7396	4,3125
5,1667	4,4688
5,5938	4,5313
6,0208	4,6563
6,4479	4,6875
6,875	4,8125
7,3021	4,8438
7,7292	4,9375
8,1563	5
8,5833	5,0938
9,0104	5,125
9,4375	5,1875
9,8646	5,2188
10,292	5,3125
10,719	5,3438
11,146	5,375
12	5,4375
12,438	5,5
13,313	5,5625
14,188	5,625
15,063	5,6875
15,938	5,7188
16,375	5,75
17,25	5,7813
18,563	5,8125
20,313	5,8438
21,625	5,875
53,667	5,9063

Applied Head Drop [-]

Map

Properties

Time Navigator

Messages Time Navigator

Undo / Redo Chart Map Toolbox

Voorbeeld – output head distribution

The screenshot displays the DgFlow Model software interface. The 'Project' tree on the left shows the model structure, with 'Pipe Results' expanded to show 'Head in Pipe'. The 'Properties' panel shows the 'General' tab with 'Name: Results' and 'Number of layers: 7'. The main window shows the 'Head in Pipe' results table and a corresponding line graph.

Offset [-]	Head [m]
0	5,5921
0,33333	5,3633
0,66667	5,1784
1	5,028
1,3333	4,9017
1,6667	4,7914
2	4,6935
2,3333	4,6046
2,6667	4,523
3	4,4475
3,3333	4,3772
3,6667	4,3111
4,0417	4,2413
4,4583	4,1682
4,875	4,0994
5,2917	4,0344
5,7083	3,9726
6,125	3,9137
6,5417	3,8573
6,9583	3,8032
7,375	3,7513
7,7917	3,7012
8,2083	3,6527
8,625	3,6058
9,0417	3,5603
9,4583	3,516

The graph shows the head distribution over an offset of 0 to 50. The head starts at approximately 5.6 m at offset 0 and decreases to approximately 3.5 m at offset 50. The curve is smooth and shows a slight change in slope around offset 35.

The Time Navigator at the bottom shows the simulation time as 05/24/2017 09:55:00. The delay is 0.1 sec. The time range is from May-17 12:00 AM to May-17 12:00 PM.

Google Earth

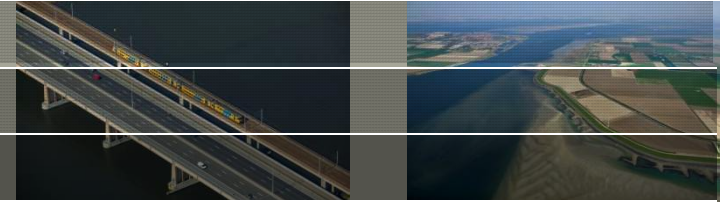


Op weg naar een oplossing voor piping?

Image © 2016 DigitalGlobe

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Meer informatie en contact



- Software verkrijgbaar/downloadbaar vanaf **1 juli a.s.** en mailing volgt z.s.m.
- Software vragen? Software@deltares.nl
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