Liquids in *The Croods*

DreamWorks Animation

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Artwork

Reference

Problem Scope

- Difficult art direction
  - Clear tropical water
  - Characters in fur-covered outfits
- Close up cameras
- Short time frame


Property of DreamWorks Animation


Property of DreamWorks Animation


Property of DreamWorks Animation


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Overview

- Liquids simulations don’t work out of the box
  - Need to art direct behavior / look
  - Mix commercial packages with in-house technology

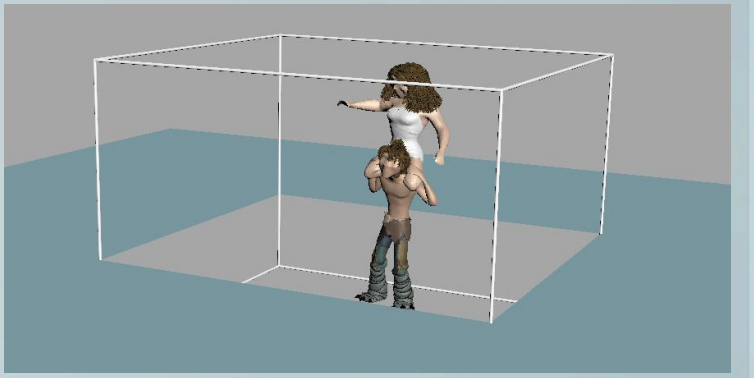
Overview

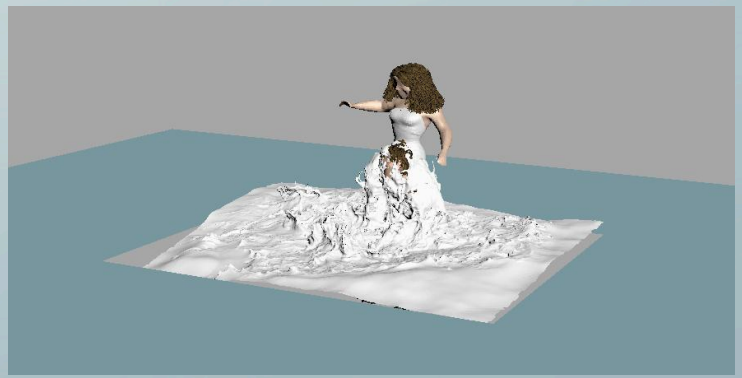
- Our approach is production friendly
  - No single piece dictates workflow
  - Break costly processes into simpler components
  - Many independent steps with quick turnaround

  - Iterations are easy!

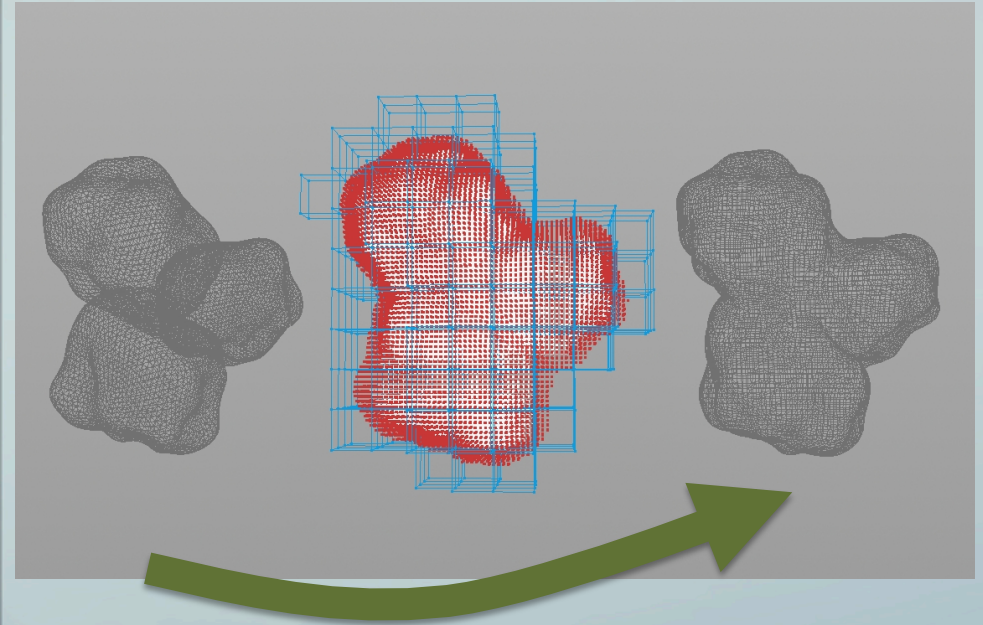
General Approach

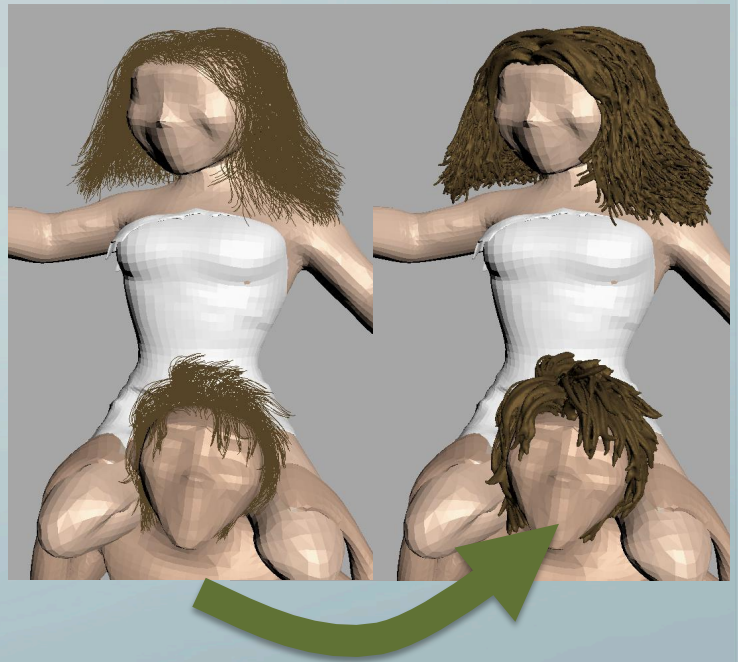
- Sim near characters
- Embed in procedural ocean
- Tons of independent secondary elements





Geometry Prep





Primary Simulation

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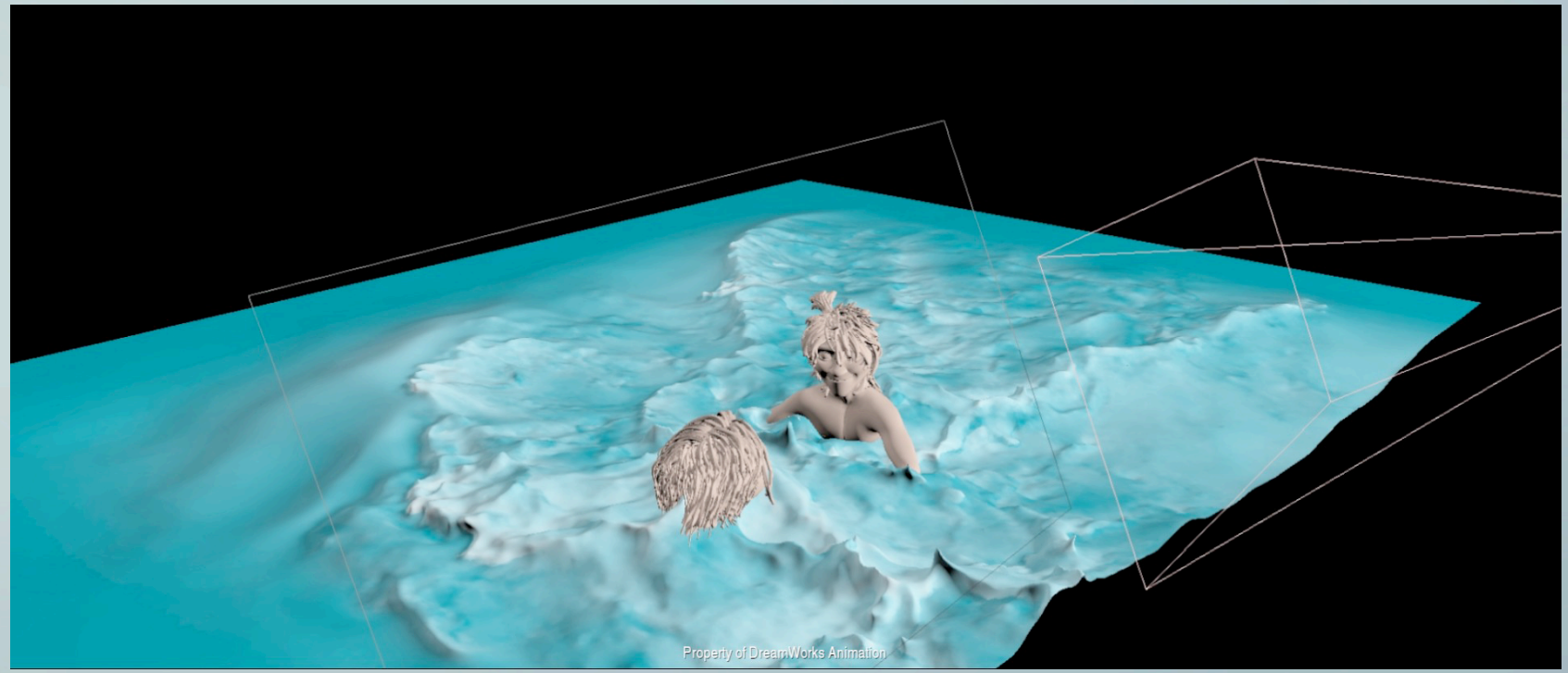
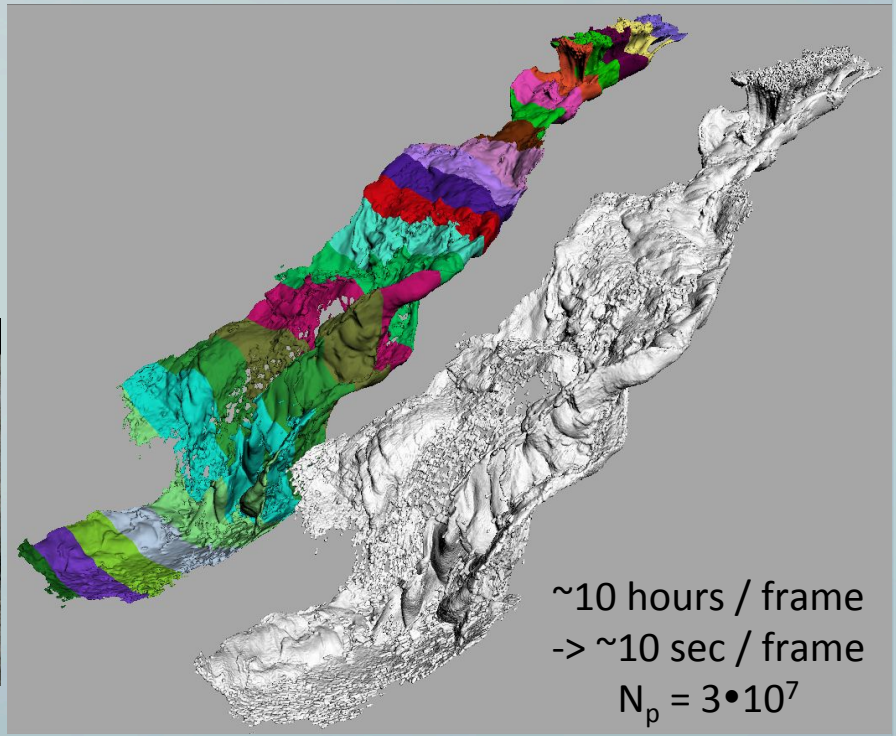


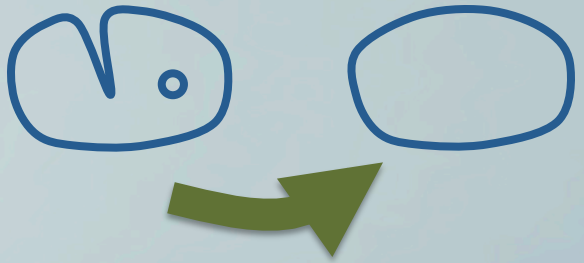
Particle Surfacing

- Monolithic solutions inadequate

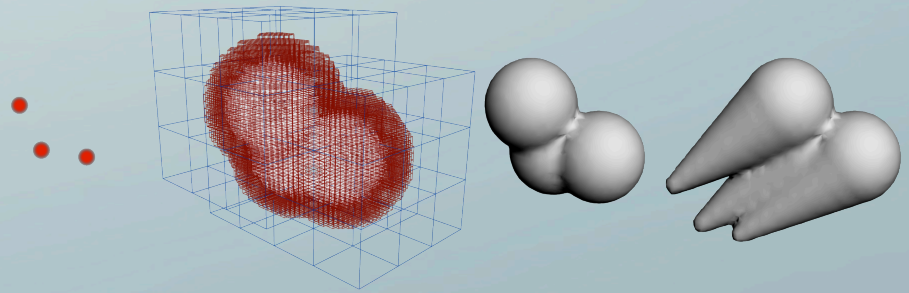


Particle Surfacing

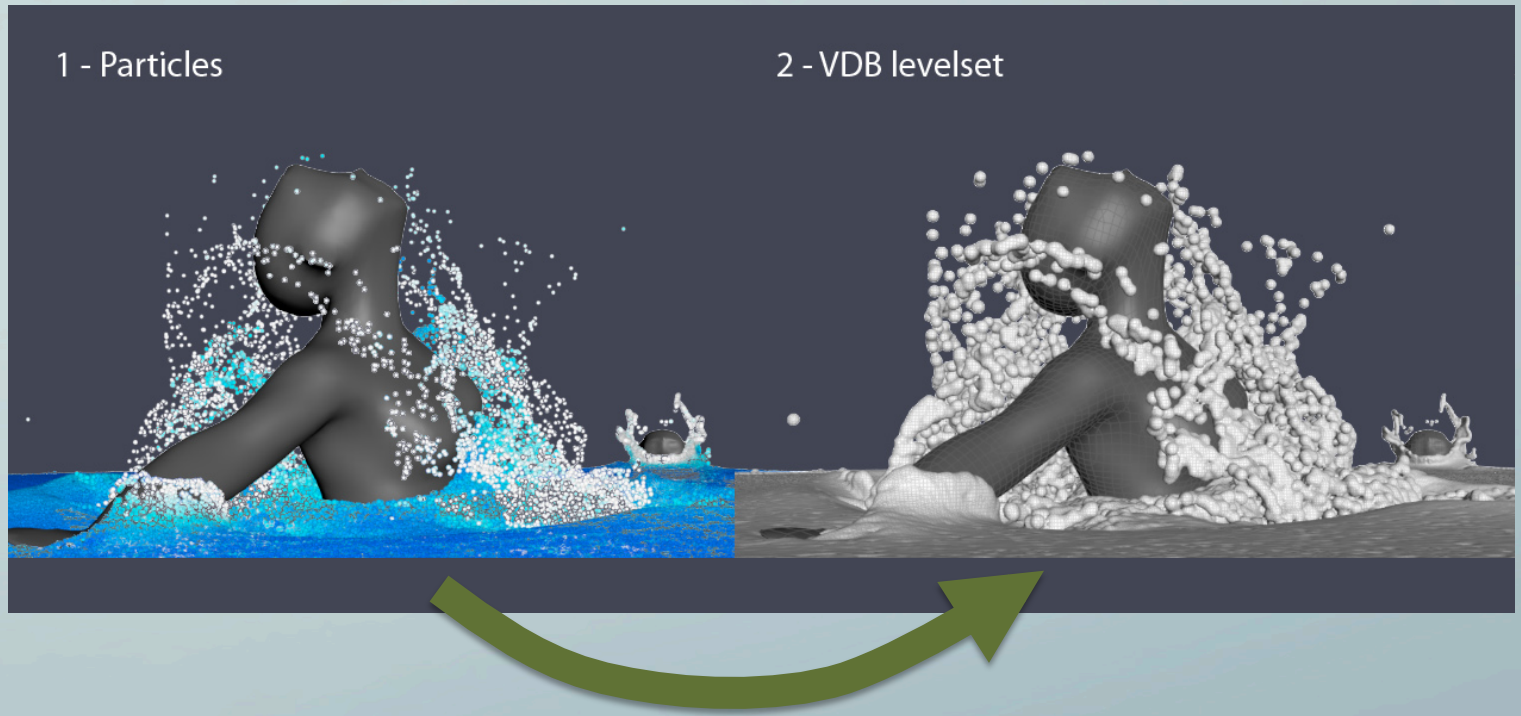
- Artists want control
  - Remove artifacts / holes
  - Accentuate sharp features
  - Smooth flat areas



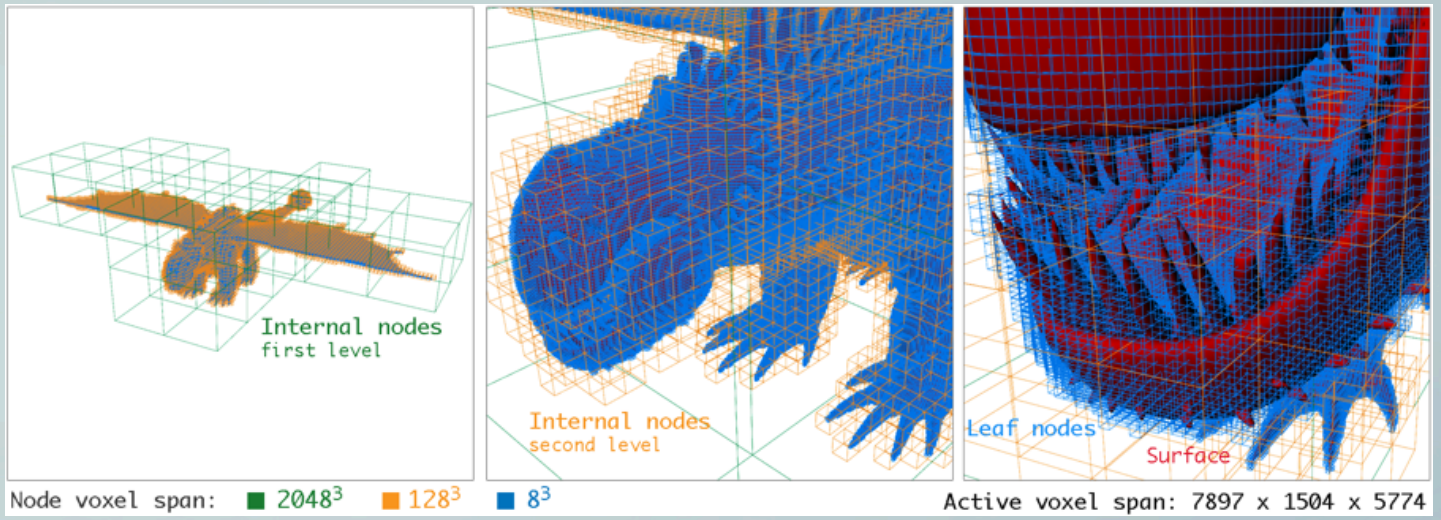
  - And make it fast!



Particle to LS



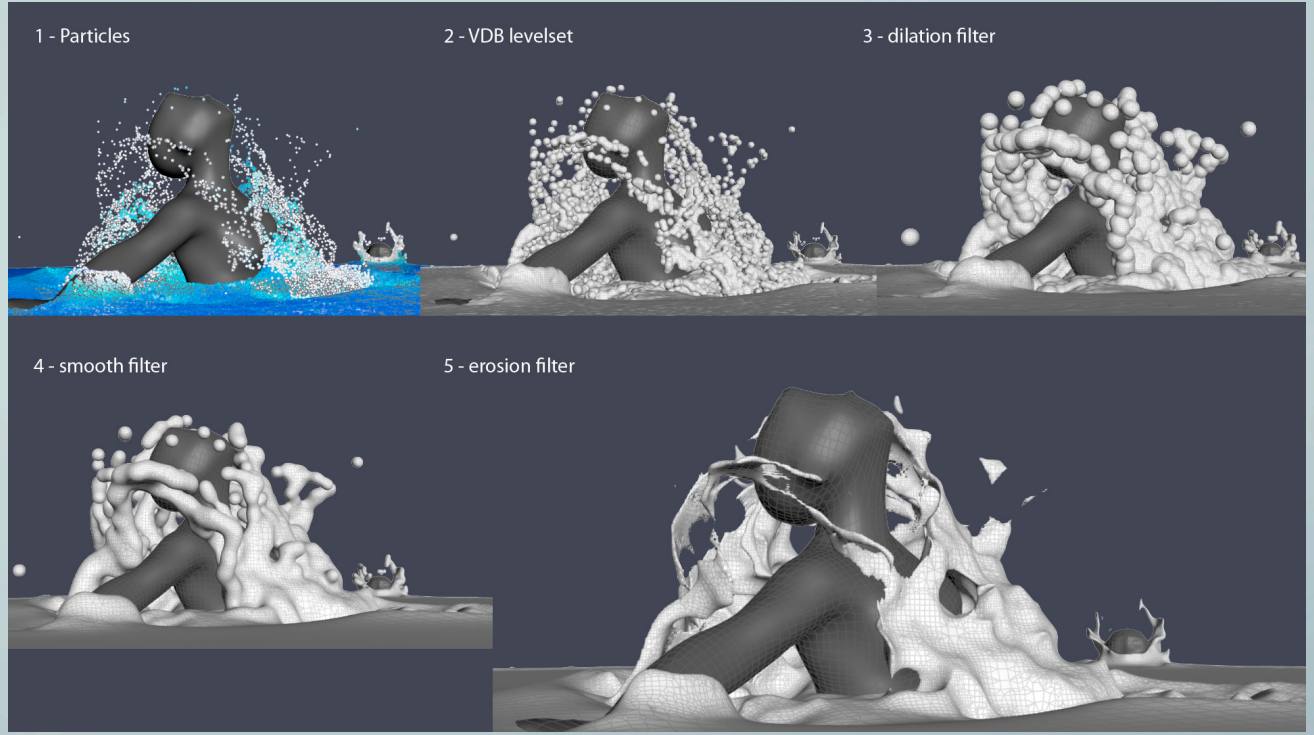
VDB LS

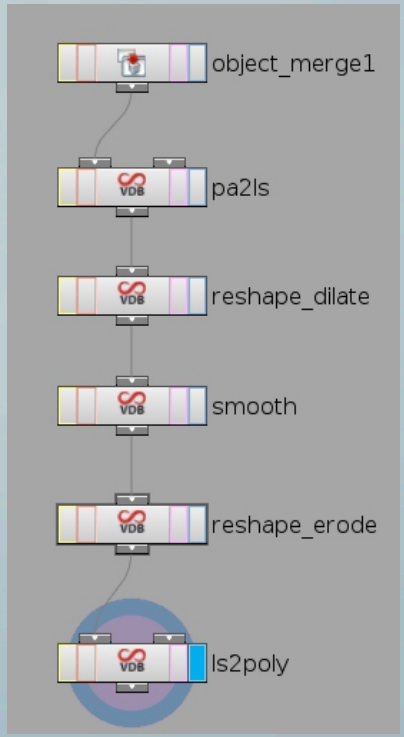


228 million sparse voxels vs 69 billion dense voxels
>1GB memory footprint vs 1/4 TB dense grid

Museth, K. VDB: High-resolution sparse volumes with dynamic topology. ACM Trans. Graph. 32, 3. 2013

LS Filtering / Morphological Ops





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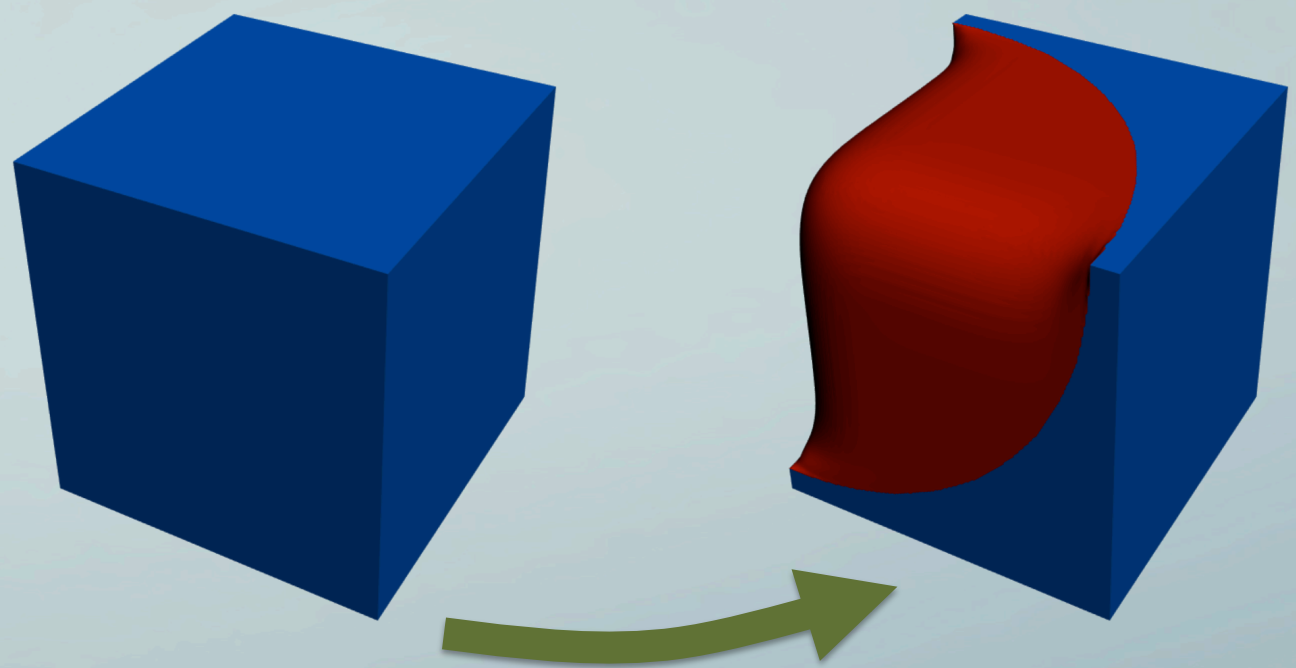

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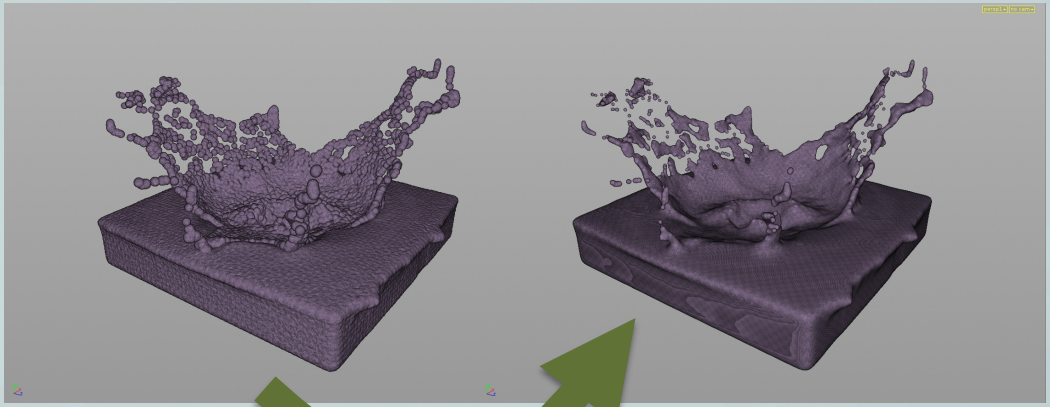
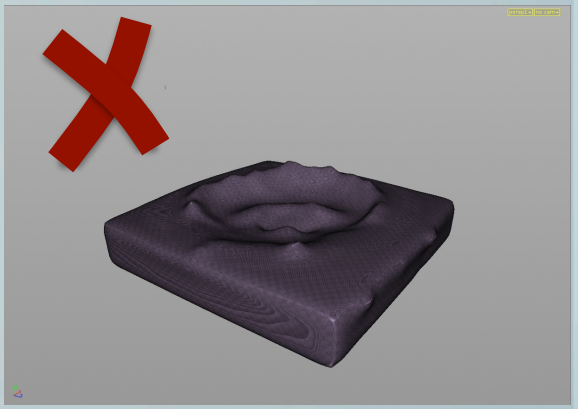
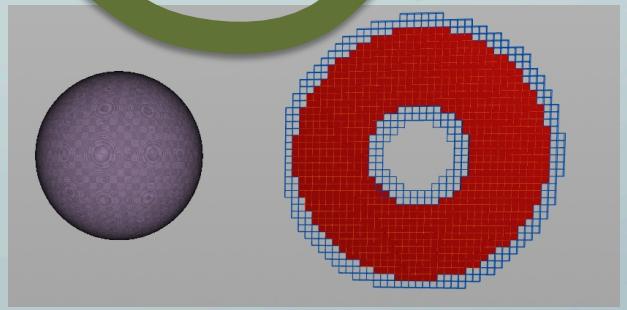
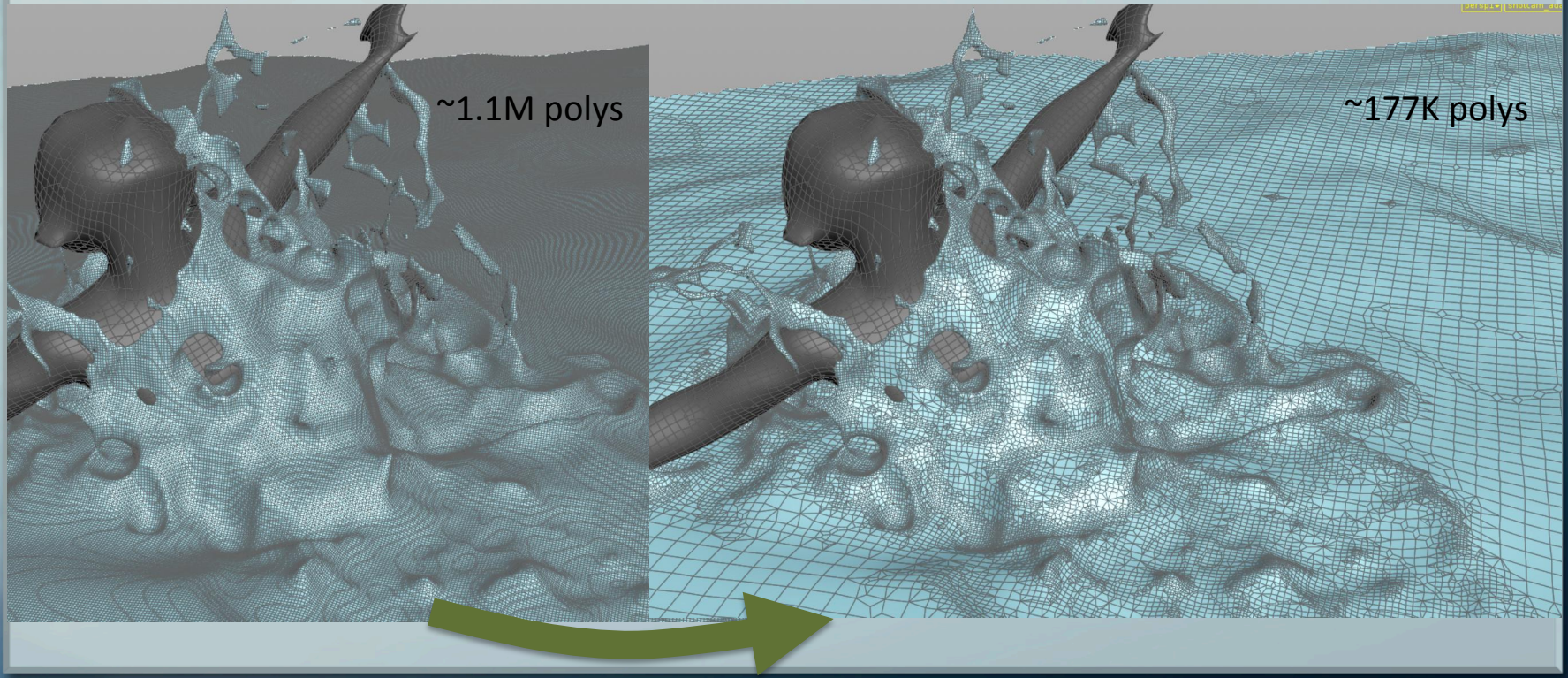


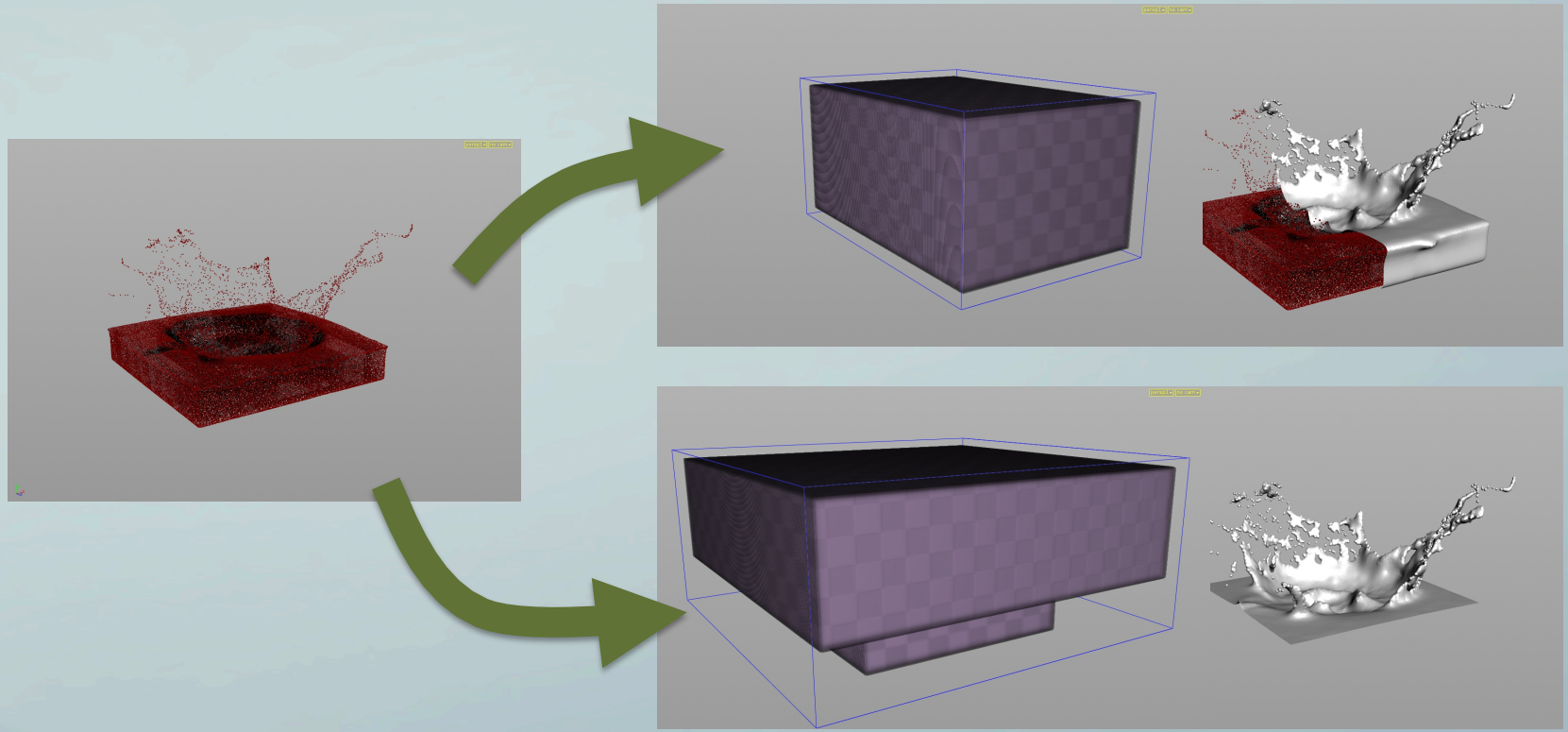




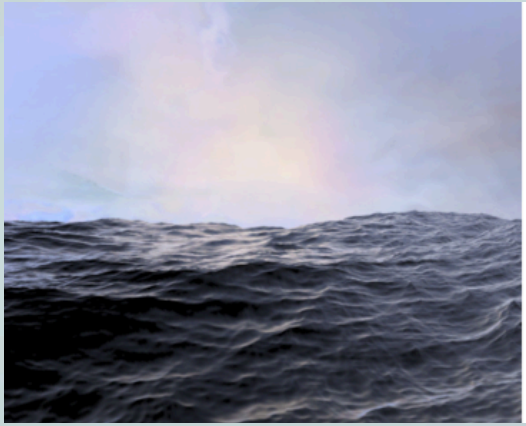
Adaptive meshing

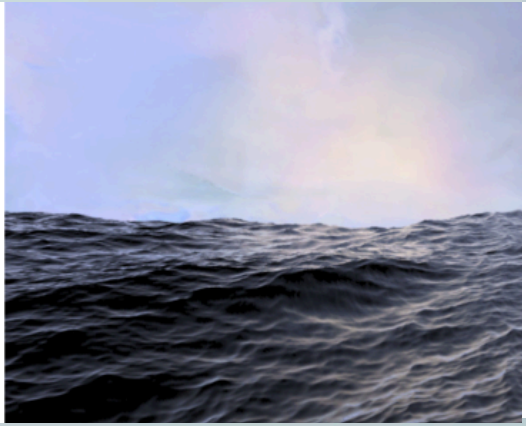


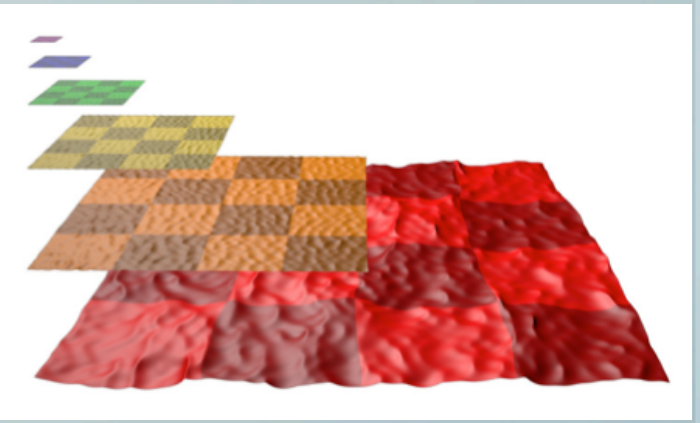
Masked meshing



Procedural Ocean







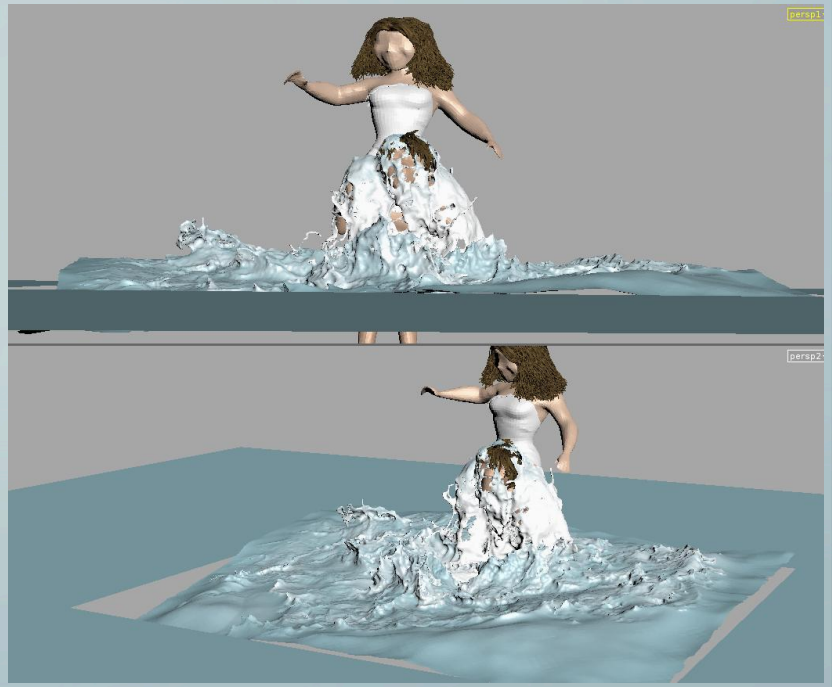
4k ~109s

4k ~0.02s

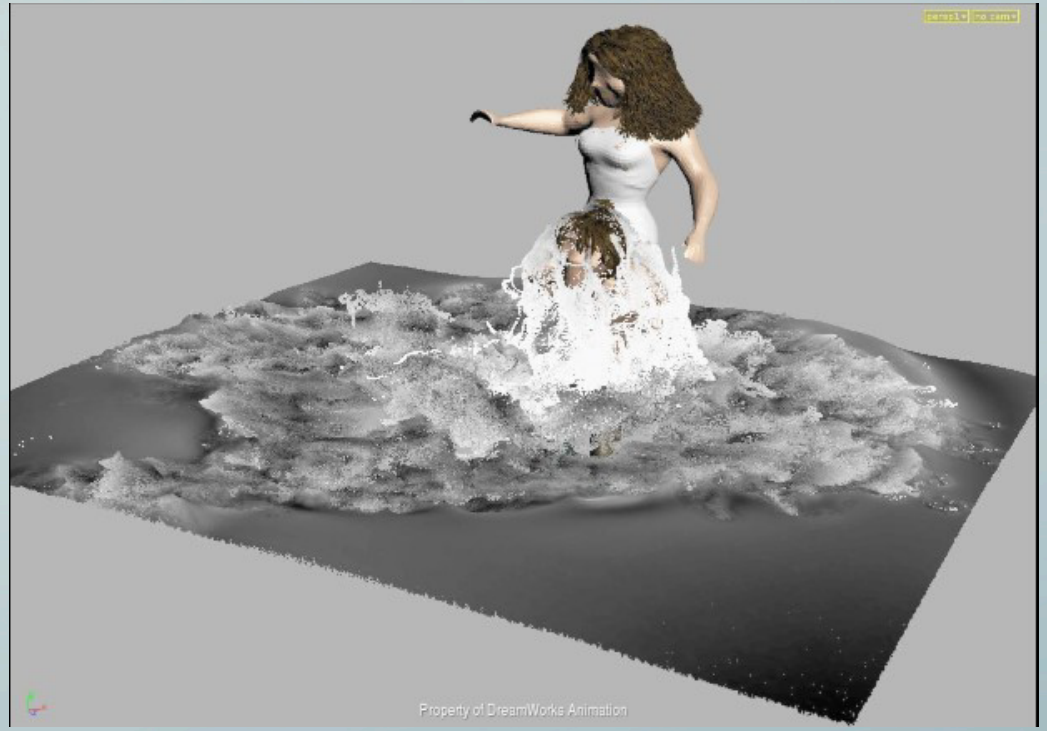
Gornowicz, G. Fast oceans at high resolution. Dreamworks Animation Technical Report. 2009

Procedural Ocean

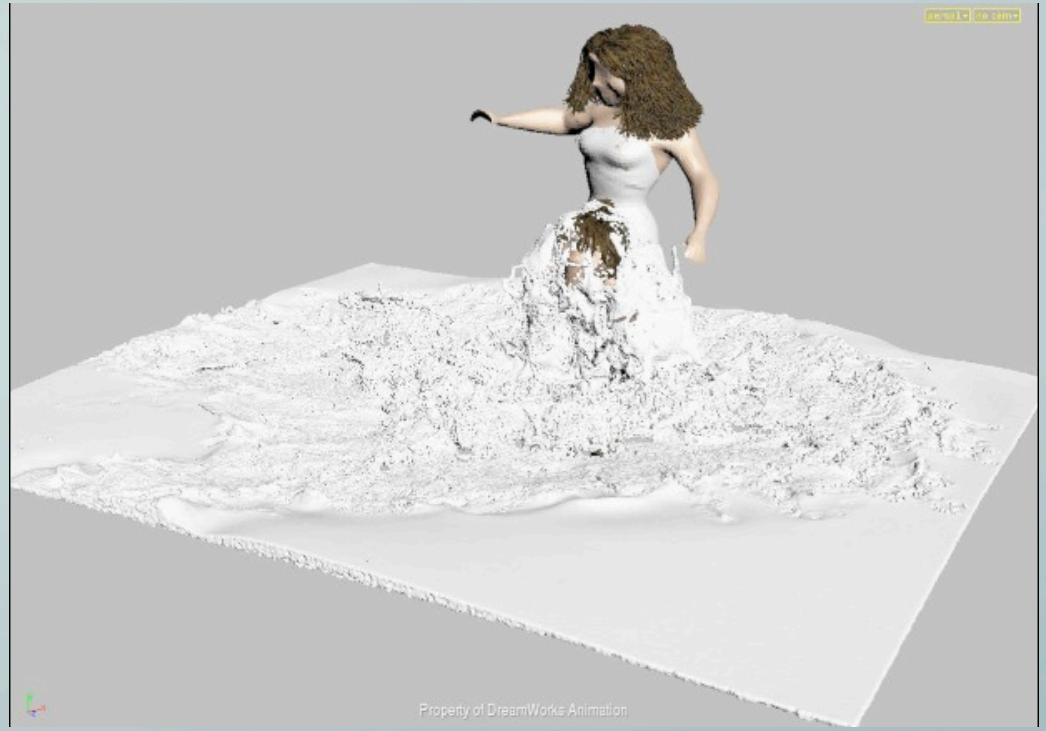
- Not everywhere
- Not only at rendertime
  - deform LS per secondary elements
- The seam is tricky!



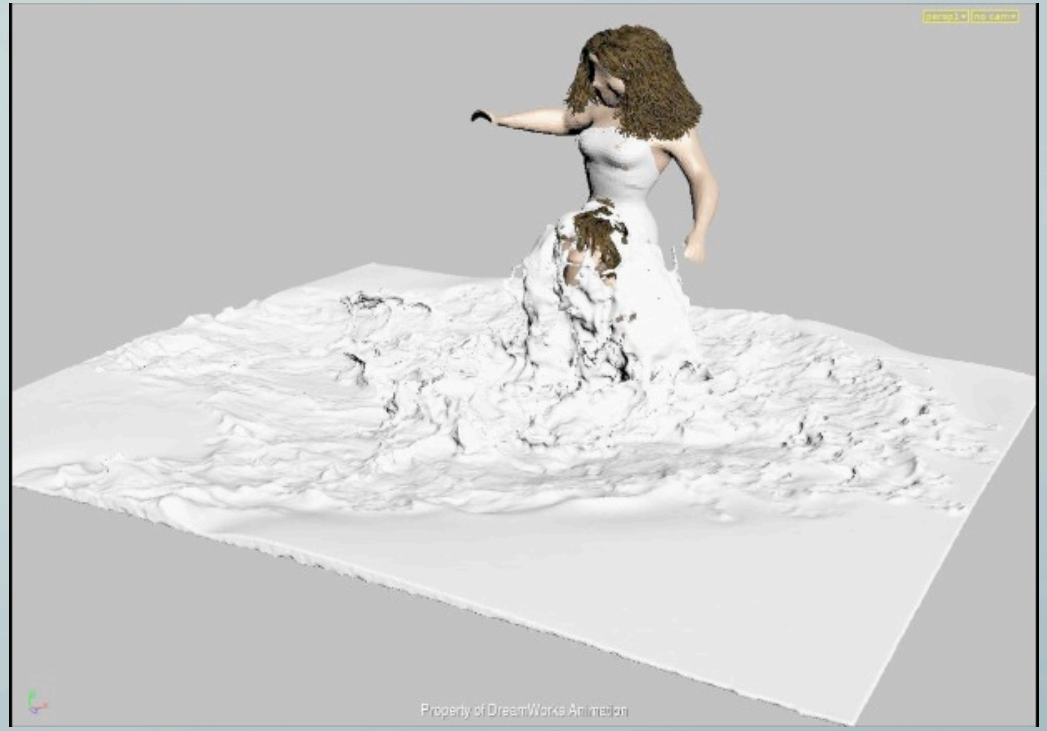
Mesh strategy



Mesh strategy



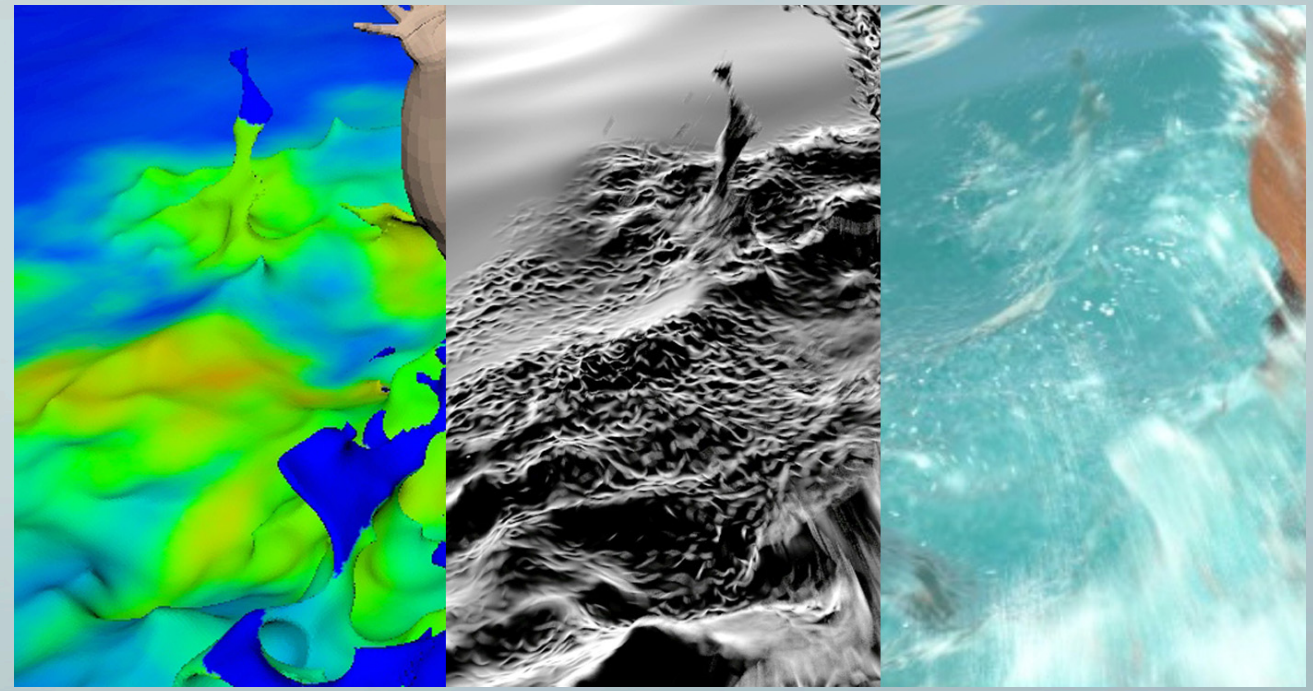
Mesh strategy



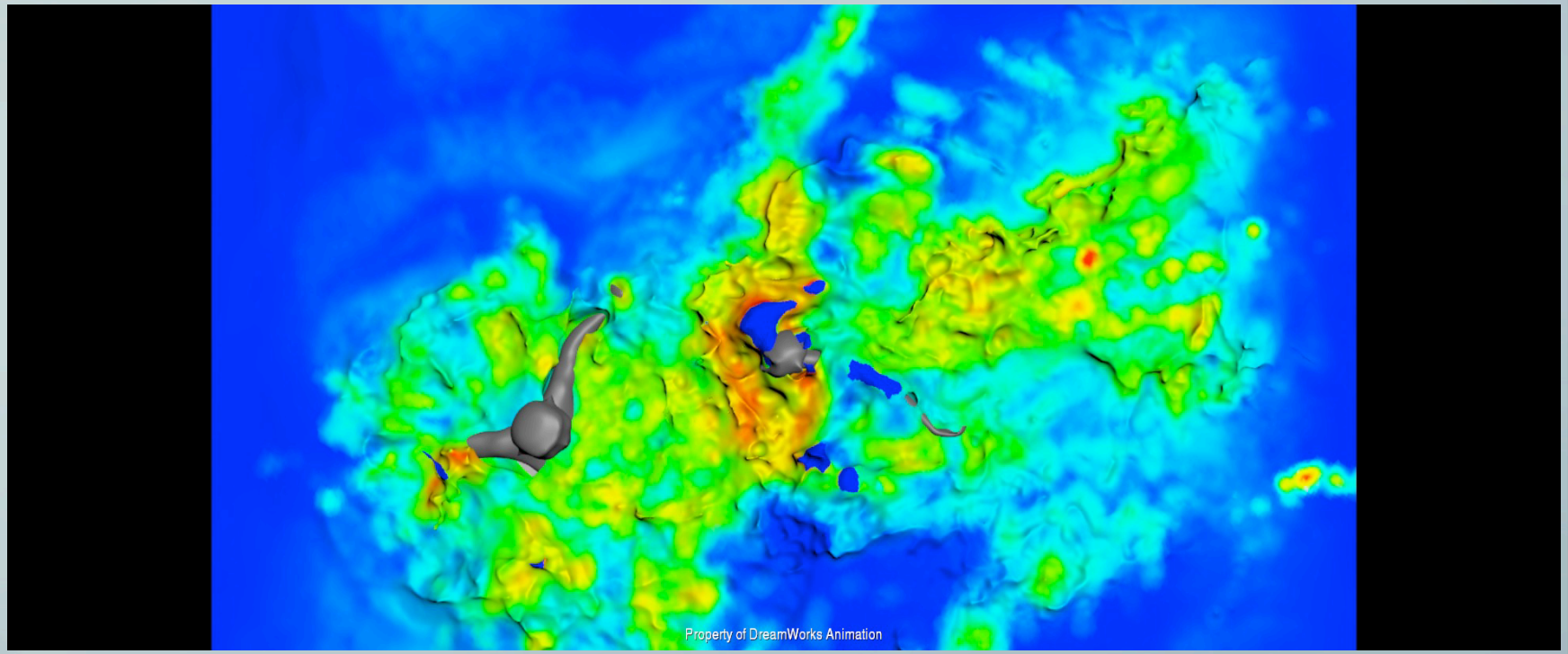
Mesh strategy

Mesh strategy

Micro-detail turbulence



Micro-detail turbulence

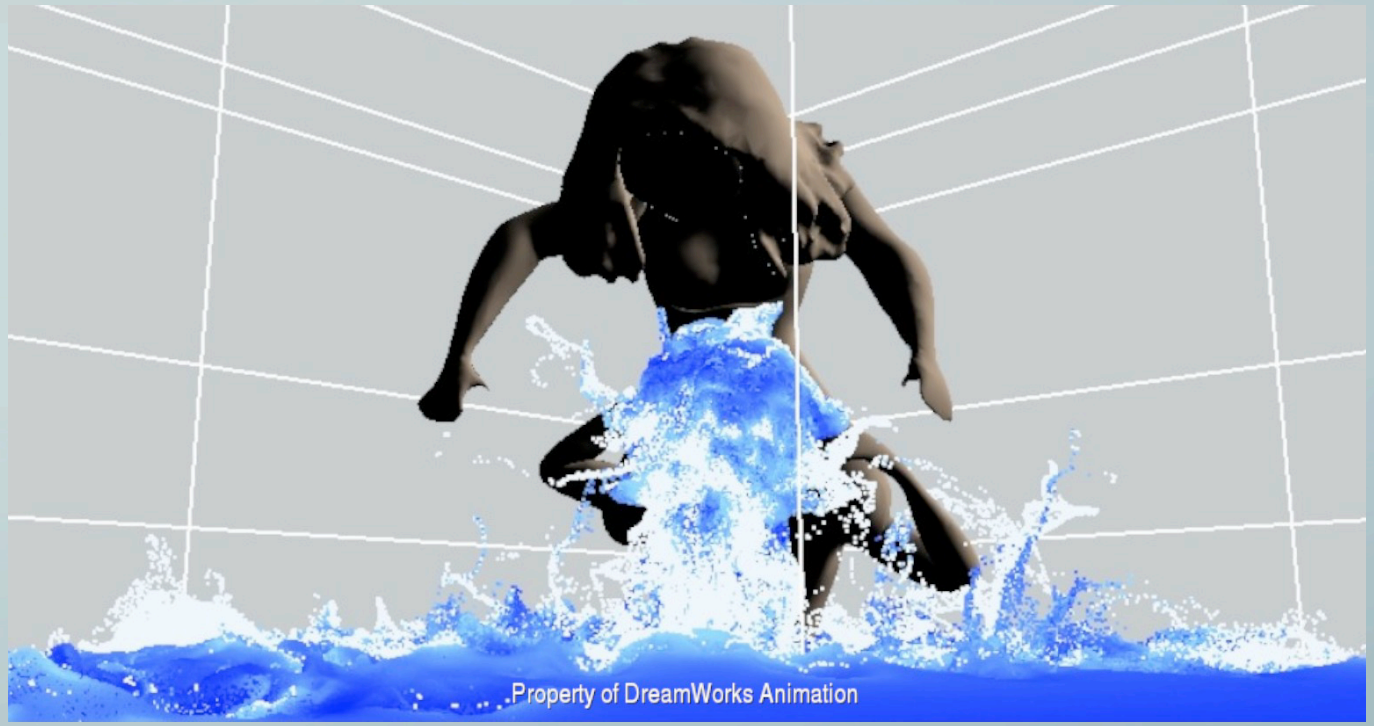


Micro-detail turbulence

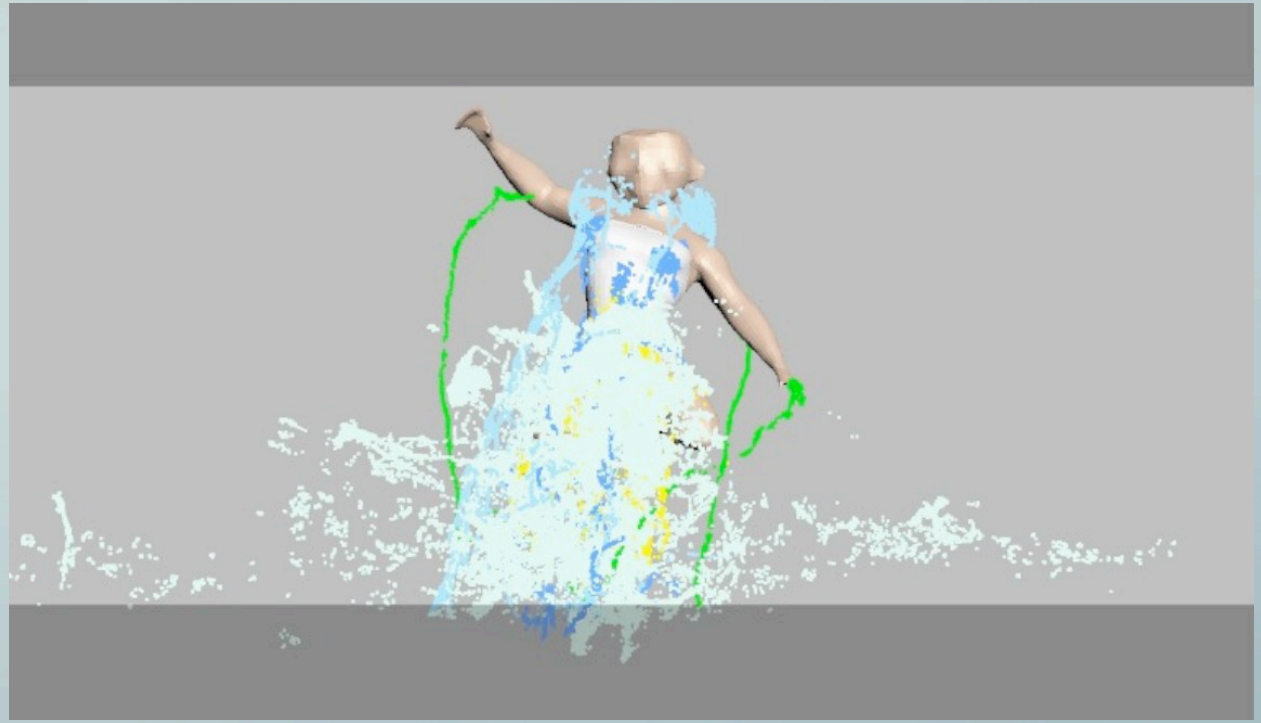
Secondary Elements

- Don’t try to do too much in main simulation
- Decouple for maximum control
  - Numerical grid analysis per particle/sph emission
  - Very fast turn around
  - Not restricted by domain

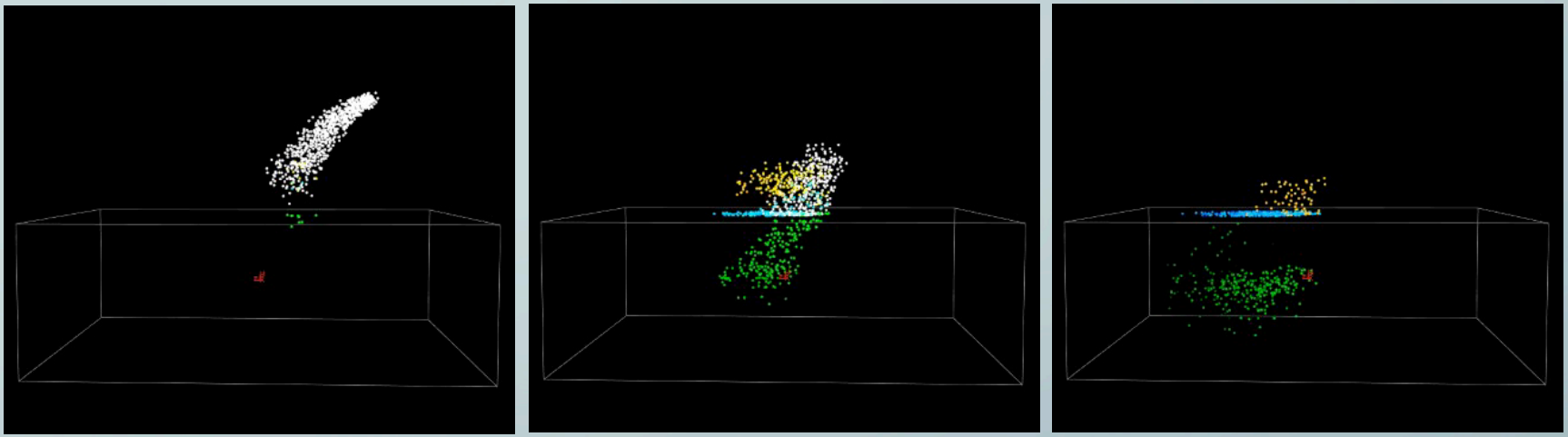
Secondary Elements



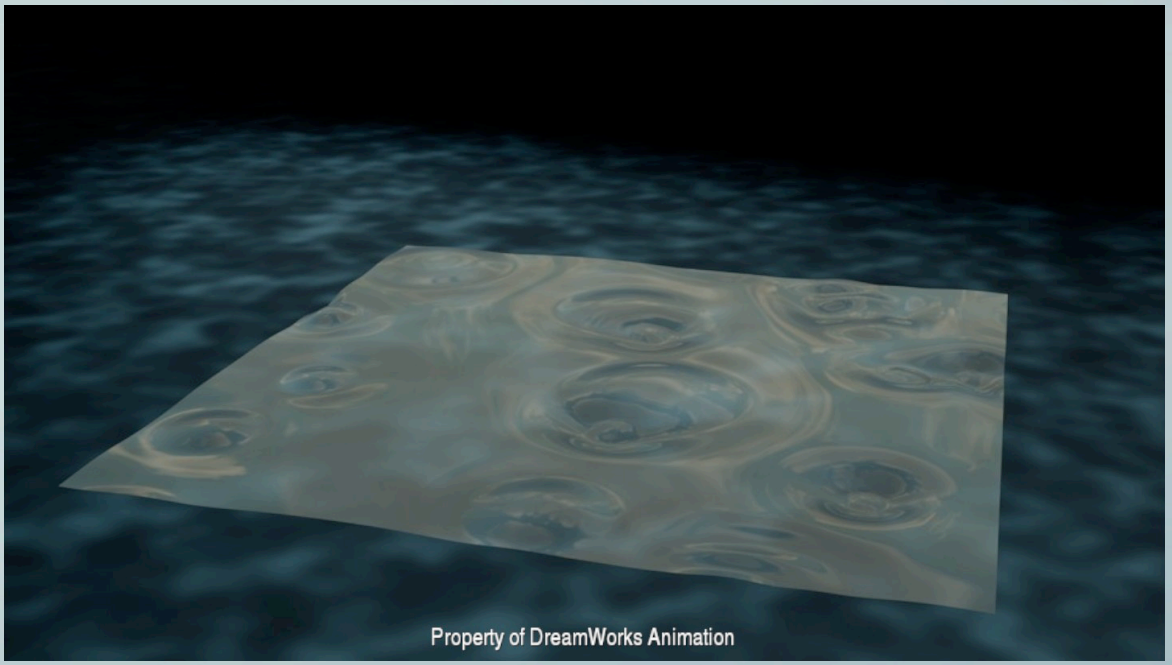
Secondary Elements



Re-entry (Tertiary Elements)

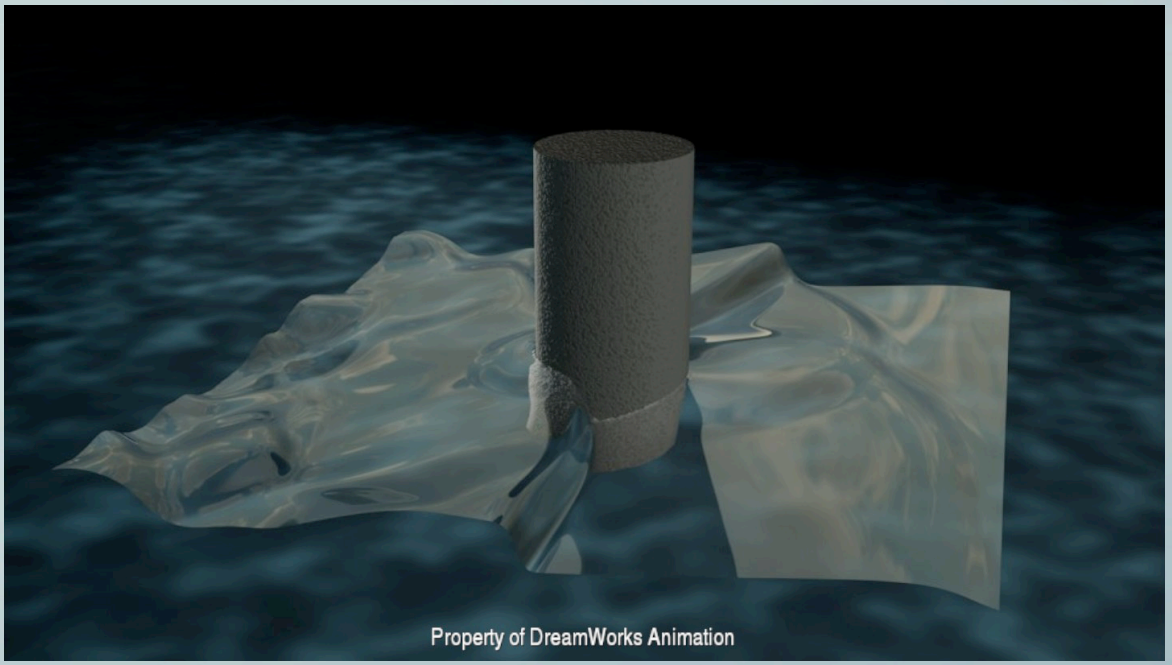


Ripple / Shallow water solver



Waltman, J. and Henderson, R. Water surface animation for Madagascar: Escape 2 Africa. Siggraph Talks, 2009

Ripple / Shallow water solver



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Ripple / Shallow water solver

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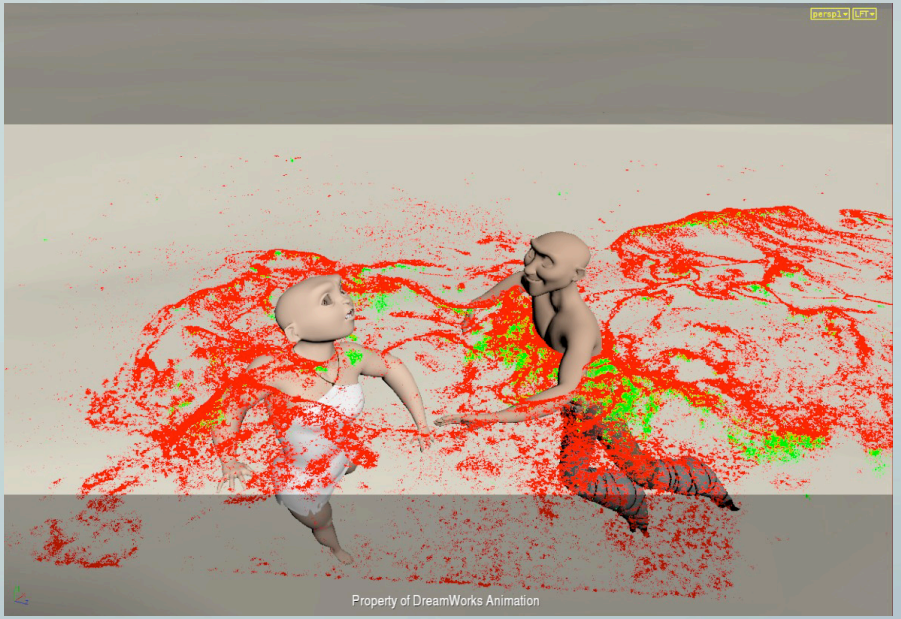
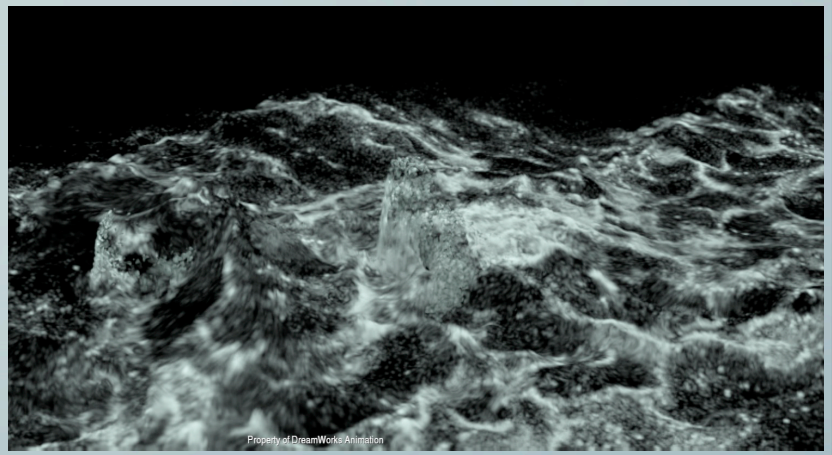
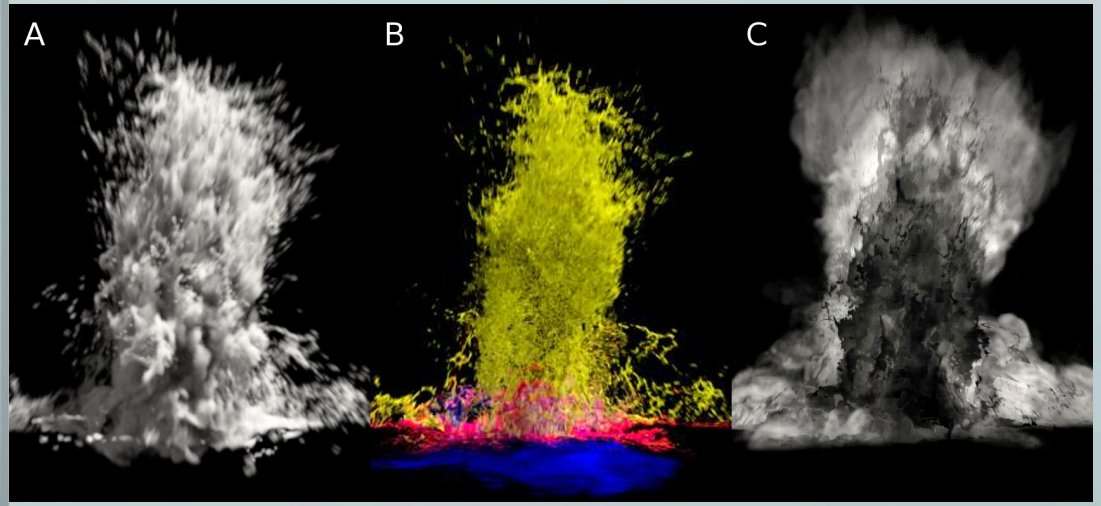
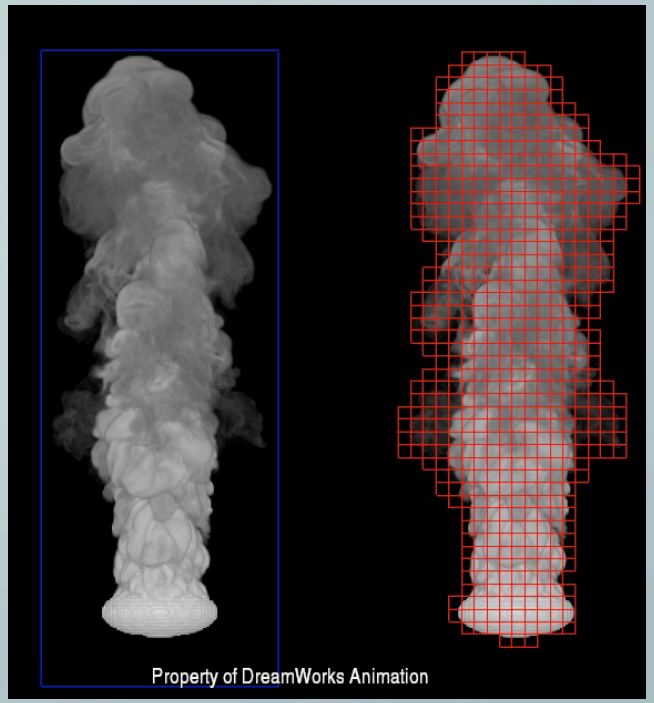
Surface Foam





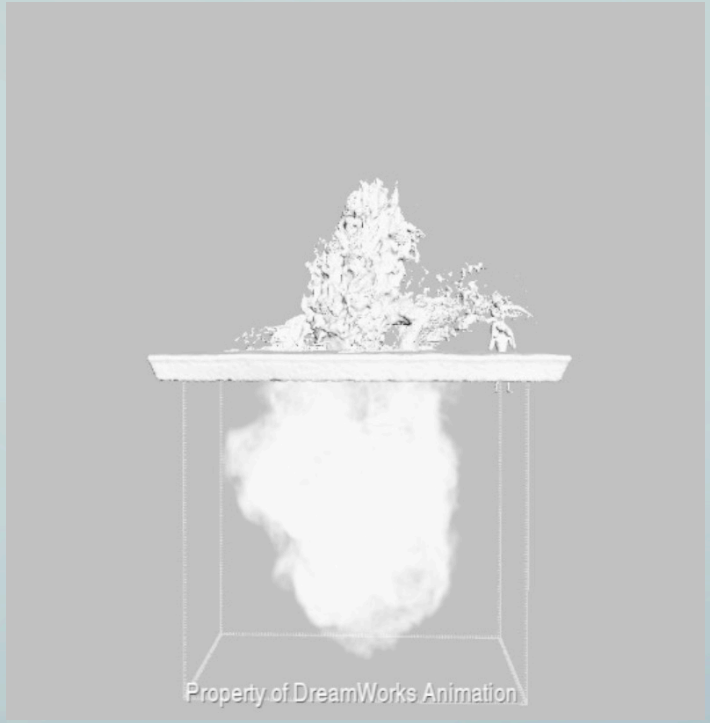
Volumetrics

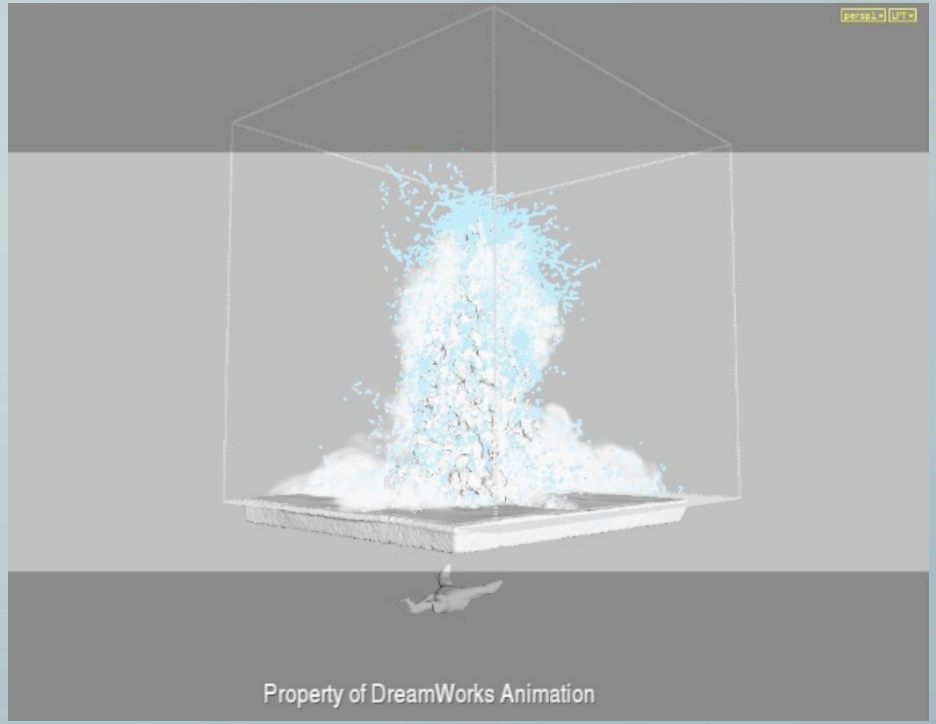




Henderson, R. Scalable fluid simulation in linear time on shared memory multiprocessors. DigiPro, 2012

Volumetrics

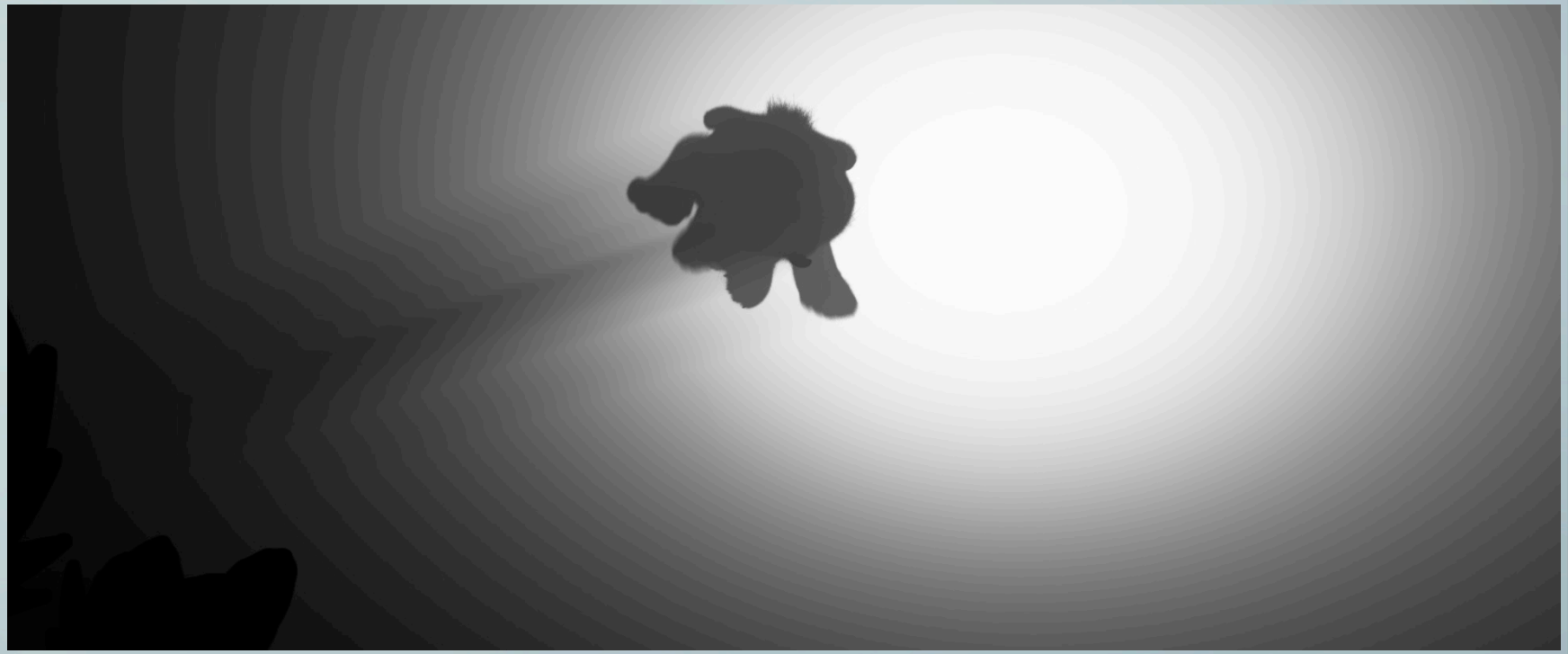




Volumetrics

Underwater Atmosphere

Underwater Atmosphere



Underwater Atmosphere

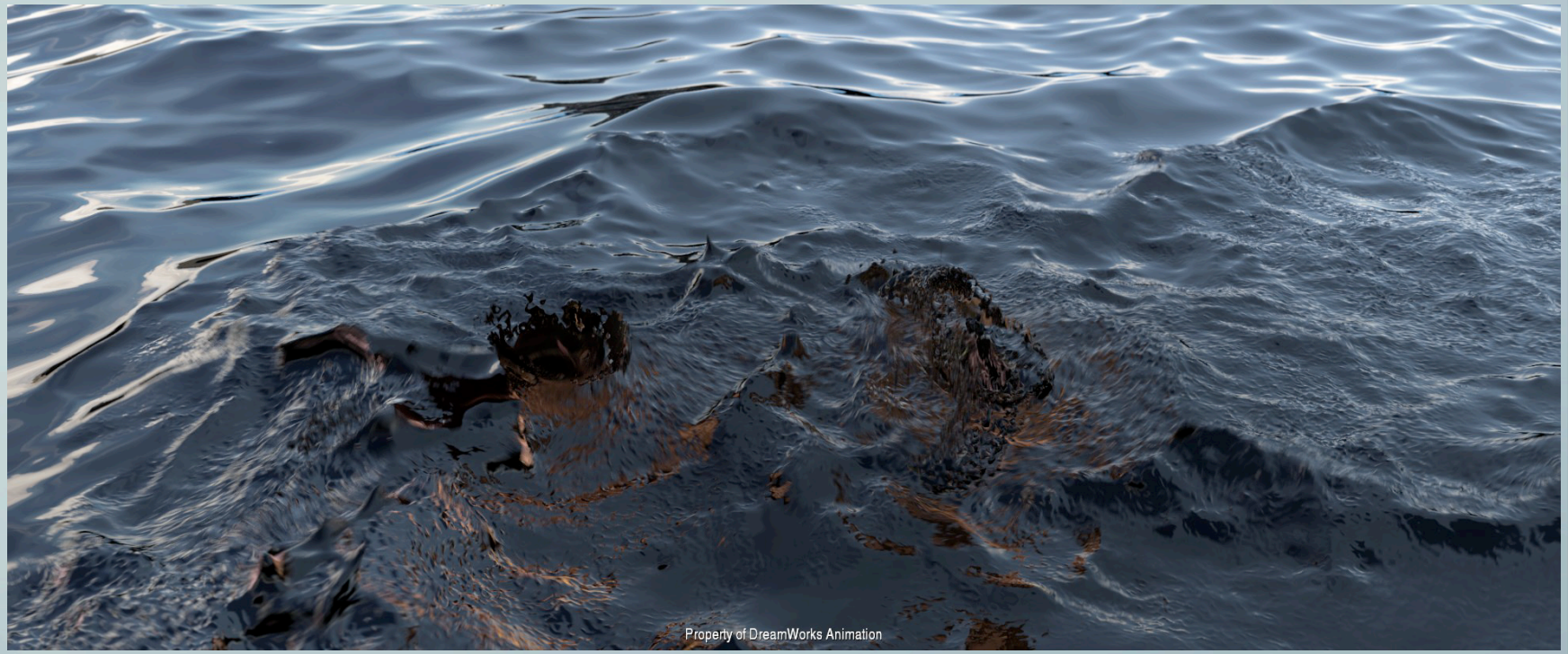
Lighting / Integration

- DWA Reyes-based render / Nuke
- Geometry
  - main water mesh, ballistics (and other secondary meshes), large underwater bubbles, crap in the water, tiny droplets as particles
- Volumetric
  - surface foam, aeration, near-interface bubbles, aerial mist, underwater haze, silt, god-rays, and whitewater (suspended inside the meshes)

Lighting / Integration

Lighting / Integration

Lighting / Integration



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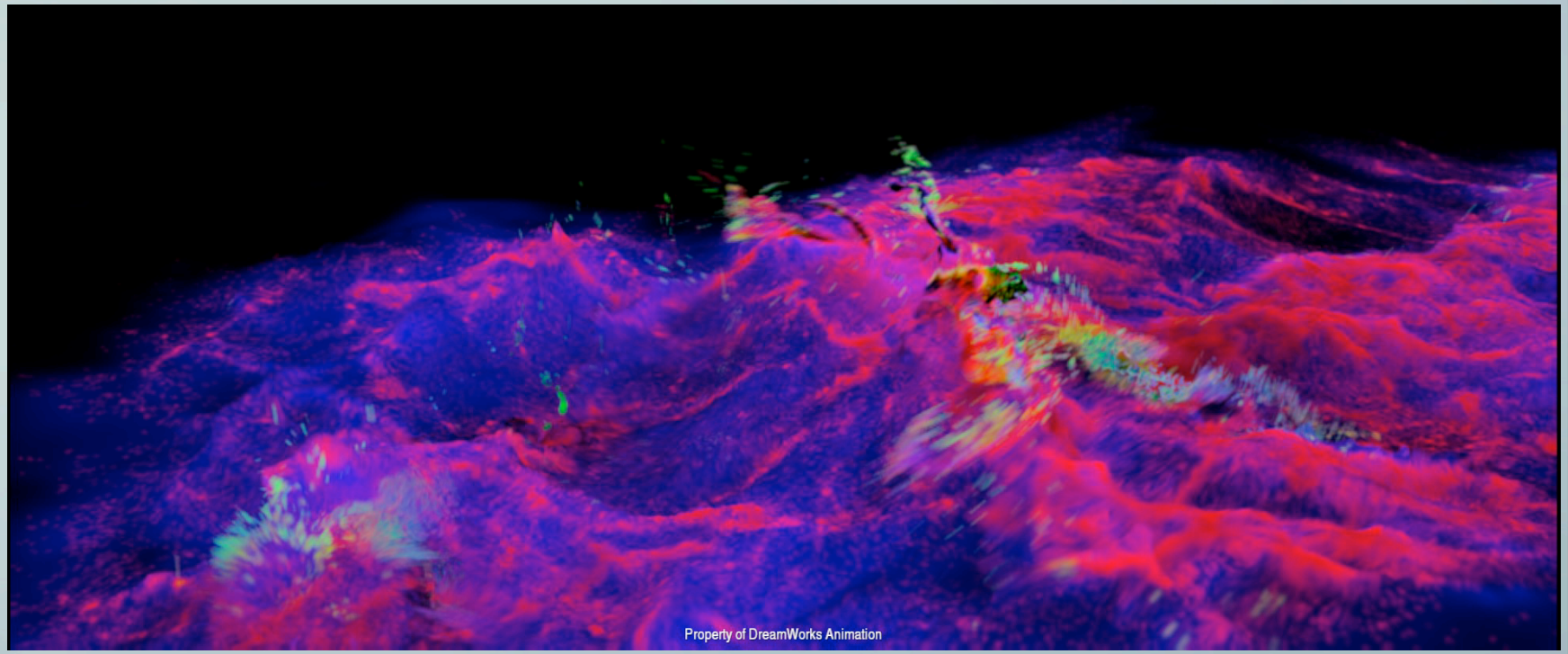

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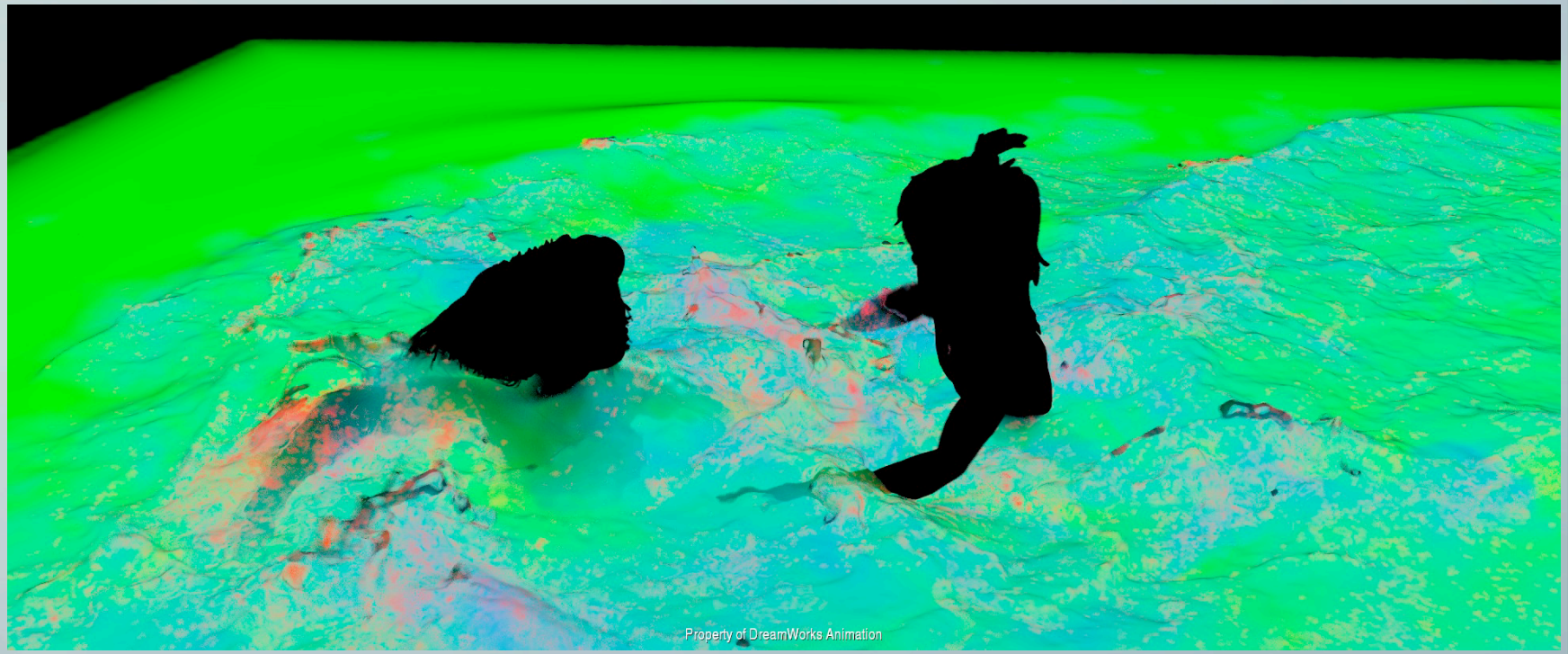

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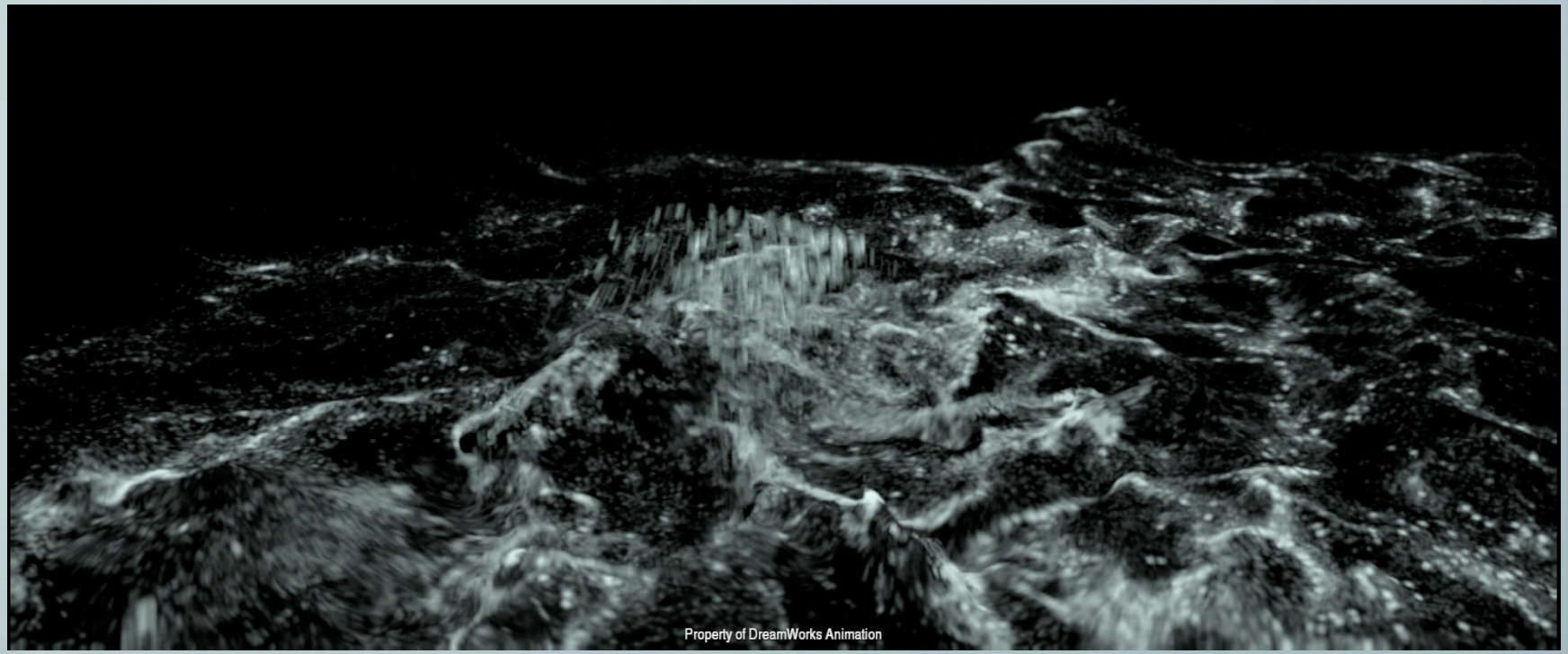

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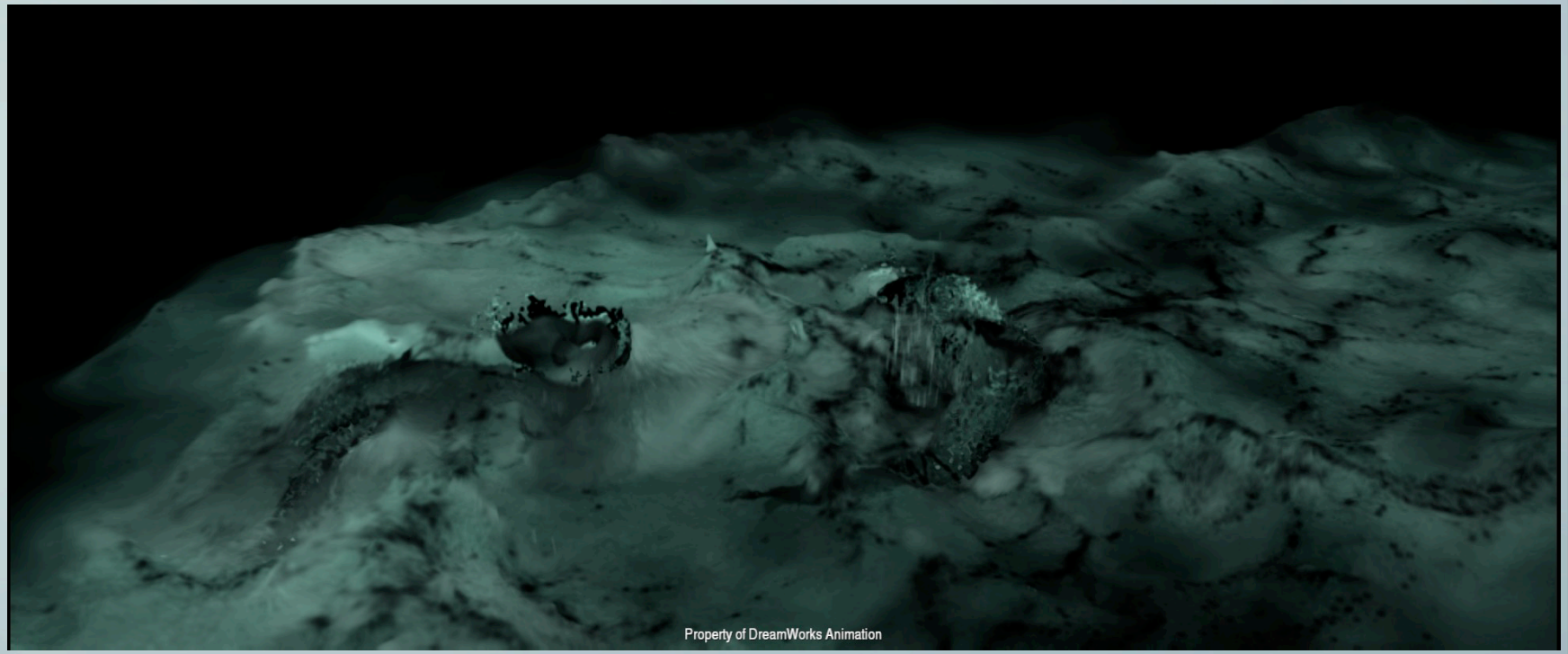


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Conclusion

- Our approach is production friendly
  - No single piece dictates workflow
  - Break costly processes into simpler components
  - Many independent steps with quick turnaround
  - Give control to the artists!

Thanks!

John Lee
Bert Poole

Mark Newport
Shinsaku Arima
Celu Ramasamy
Kent Lidke
Alan Cheney
Andy Hayes

FX R+D

Questions?

Go check out our OpenVDB course!

Wednesday 2pm Room 304 A-D