Integrating GIS and hydraulic modelling for efficient water networks management
March 2011, Cape Town, SA

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The Urban Infrastructure Challenges

Agenda

1. Bentley Solutions
2. Water Geospatial and Modelling Solutions Overview
3. Water Products Description
4. Application Examples
5. Demo
6. Contact Information
About Bentley

World’s leading provider of software for infrastructure design, construction and operations:

#1 in GIS for Utilities
#1 in Water Modelling
#1 in Building Performance
#1 in Structural Engineering
#1 in Roads and Transit Design
#1 in Bridge Engineering

Global Business:
- Over 3,000 colleagues in 45 countries
- $500M revenues
Solutions

- Bridges
- Buildings
- Cadastre and Land Development
- Campuses
- Communications
- Electric and Gas Utilities
- Factories
- Metals and Mining
- Oil and Gas
- Roads
- Rail and Transit
- Power Generation
- Water and Wastewater

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Bentley Solutions

1. Intra-operable infrastructure software portfolio
   • Multi-discipline built on a common V8i platform
   • Supports the Design-Build-Operate lifecycle
   • Encompasses the full spectrum of infrastructure

2. Professional services and learning
   • Support for implementation and all change issues

3. Professional communities networking
   • Local and global communication opportunities
The Water Industry Scope

- The **Water Industry** provides:
  1. Drinking water services
  2. Wastewater services (including sewage treatment) and
  3. Drainage and flood protection services

  To: households, industry and governmental organizations.

- The Haestad family of products integrated within Geospatial framework is a backbone of the Bentley Water Solutions offer to the Water Industry market segments
Water & Wastewater Industry Drivers

• Regulatory Compliance
  – Adequate Supply & Treatment capacity
  – Protecting Water Quality
  – Business performance

• Reliability & Safety of Infrastructure
  – Consistently achieving target levels of services
  – Maintaining aging infrastructure
  – Avoiding failure and emergency planning

• Budget
  – Reducing costs while improving services
  – Asset investment planning for aging infrastructure
  – Aging workforce
Water Industry Solutions Architecture

- sisNET Water (Bentley Water)
- Expert Designer
- MicroStation
- GeoSpatial Server & ProjectWise
- Interoperability Connectors
- Enterprise Connectors
- Web Publishing
- Web clients
- sisNET WWater (Bentley WWater)
- SewerGEMS / CAD
- Hammer
- StormCAD / HEC-Pack
- GasAnalysis
- WaterGEMS /CAD
- AutoCAD
- ArcGIS
- GIS AM products
- Hydraulic modelling products
- WaterGEMS /CAD
- SewerGEMS /CAD
- Hammer
- StormCAD / HEC-Pack
- GasAnalysis
- WaterGEMS /CAD
- AutoCAD
- ArcGIS
- Web clients
- Web Publishing
- GeoSpatial Server & ProjectWise
- Interoperability Connectors
- Enterprise Connectors
- SCADA & Loggers
- Proprietary GIS Databases
- Enterprise Data Stores
- Ancillary Files w/ RDBWS
- Business Documents
- Ancillary Files w/ RDBWS
- Data Files
- Data Files w/ Database Linkages
- Spatial Databases
- Web Services
- Web Publishing
- Web clients
- GIS AM products
- Hydraulic modelling products
- Expert Designer
What Makes our Water Solutions GIS-integrated?

1. Multi platform environment
   An environment for every user with full GIS integration

2. Model building
   Leverage virtually any data source

3. Model management
   Streamlined editing with hydraulic intelligence

4. Hydraulic analysis
   Engineering tools for real world decisions

5. Results interpretation
   From model results to engineering knowledge
1. Multi Platform Environment

An environment for every user

- Less data duplication. More integration
- Facilitate learning curve
- Increased team communication
- Users of different backgrounds can collaborate

BENEFITS

- AutoCAD
  WaterCAD shown
- Stand-Alone
  PondPack shown
- ArcGIS
  SewerGEMS shown
- ...and MicroStation!

Available for:
- CivilStorm
- WaterGEMS
- SewerGEMS

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2. Model Building

Leverage virtually any data source

**Data**
- CAD drawings
  - Network topology, node elevations, scaled lengths, some physical data, etc.
- Databases & spreadsheets
  - Demand information, operational strategies, field data, water quality, etc.
- Geospatial data
  - Network topology, water consumption data, node elevations, diameters, materials, etc.

**Model building tools**
- ModelBuilder
  - Multi-source model creation
- LoadBuilder
  - Demand assignment from geospatial data
- Shapefile & database synch
  - Synchronized model connections
- TRex
  - Automated elevation extraction
- Polyline to Pipe
  - CAD to hydraulic model conversion utility
3. Model Management

Streamlined editing with hydraulic intelligence

Engineering Libraries & Prototypes

Enter information once, use it many times

FlexUnits

Change units on the fly

FlexTables

Fast and easy data edition

Scenario Control Center

Unlimited “what if” alternatives
4. Hydraulic Analysis

Engineering tools for real world decisions

Avoid street flooding with **StormCAD**

Keep rainfall runoff problems at control with **PondPack**

Analyze complex systems with **CivilStorm**

Comply with local regulations with **CulvertMaster**

Save time with quick calculations from **FlowMaster**

Find optimum designs staying under budget with **SewerCAD**
5. **Results Interpretation**

From model results to engineering knowledge

- Multi scenario, time variable graphs
- Customizable reporting
- Geospatial visualization
- Advanced engineering profiling with animation
- Animated plan views with annotation and color coding
SOLUTION

Products
sisNET Multi-Utility AM Solution

- Based on Bentley Map / MicroStation
- A solution for: electricity, gas, water, sewerage, district heating & cooling telecommunication
- Open, configurable, data model
- Powerful data creation tools in 2D and 3D
- Additional modules for specific applications
- Integrated maintenance management
- Integration options into 3rd party applications (e.g. SAP)
sisNET Thematic Mapping and Analysis
Bentley Water GIS AM solution
WaterGEMS Hydraulic Modelling Solution
WaterGEMS
Water distribution design, modeling and optimization with GIS integration

Hydraulic modeling

GIS Integration
Bentley GIS Solution
or
ESRI GIS Solution

Model Builder & LoadBuilder

Bi-directional GIS-model synchronization; Water demand assignment

TRex

Automated elevation extraction

• Darwin Designer: network rehabilitation
• Darwin Calibrator: leakage detection
• Darwin Scheduler: energy efficiency
Bi-directional Synchronization between GIS data and Hydraulic Model

Build model from GIS/CAD

Model sources

Correct GIS/CAD when modeler needs to update data

Hydraulic model
SCADA Connect

1) Configure the data source for the Real-time and Historical Scada data.
2) Map the Scada signals to the Hydraulic elements in the model and how the data is used: Initial and boundary conditions and / or real-time optimisation (calibration).
HAMMER

Transient analysis and water hammer modeling

- Avoid catastrophic failure of pipes & equipment
- Use the rigorous Method of Characteristics
- Model any transient event
- Simulate any surge protection device
- Complete integration with WaterGEMS/CAD

Prevent system damage
Develop cost-effective surge control strategies
Trim construction and O&M budgets
Model any surge protection device
Minimize wear and tear on pipes
Simulate any transient condition
Design and operate with greater reliability
Eliminate costly over design
Ensure the longevity of your water system
Prepare for power failures
Protect your operators
Improve water quality
Minimize service interruptions
Expert Designer Water V8i
Streamlined, Intelligent Distribution Design for Water Utilities

- Comprehensive Water Utility Network Design
- Open Architecture with Intuitive Interface
- Workload Management
- Multiple Design Formats
- Dynamic Cost Estimates
- Built-In Data Model and Templates
- Integrated Work Management
- Editing Tools and Data Validation
- Automated Layout
- Standard and Custom Reporting
- Context-Sensitive Help

Bentley Expert Designer Water improves efficiency and throughput of distribution design by merging network design and work management in a single environment. It includes sophisticated functionality for design layout, work order management, estimating, optimization, job closeout, and process measurement and tracking.
Example Applications
Rehabilitation Planning

- Pipe network rehabilitation
- Find the most cost-effective solution
- Overcome pressure deficiencies
- Projected demand increases (20 years ahead)
- WaterCad and Darwin Designer (genetic algorithm optimisation)

Thames Water DMA in UK: 1,500 pipes
Rehabilitation Planning (cont.)

"Manual" Solution
£4.16M

GA Optimised Solution
£2.14M
Capital Investment Planning (CIP)

- Growing demand
- Service level improvements
- Optimise design
- Meet criteria
  - Flow
  - Pressure
  - Tank storage
  - Minimum cost
- Master plan

City in USA:
- 300,000 inhabitants
- Contain 31 reservoirs, 14 wells, 116 pumps and more than 1600 km of pipelines
CIP: Example Results
## CIP: Pipe Installation Priority

<table>
<thead>
<tr>
<th>Pipeline Project</th>
<th>8% Growth (20.06 mgd)</th>
<th>13% Growth (21.00 mgd)</th>
<th>18% Growth (21.92 mgd)</th>
<th>24% Growth (23.03 mgd)</th>
<th>30.4% Growth (24.22 mgd)</th>
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<tbody>
<tr>
<td></td>
<td>Dia</td>
<td>Cost (10^3)</td>
<td>Dia</td>
<td>Cost (10^3)</td>
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<td>Total Cost ($)</td>
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<td>723,540</td>
<td>780,350</td>
<td>1,853,100</td>
<td>2,958,300</td>
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</table>
Sewer Deterioration Modelling

Causes of Sewer Flooding

- Blockages: 45%
- Equipment failure: 5%
- Collapses: 5%
- Hydraulic overload: 45%
Sewer Deterioration Modelling

Sewer Attribute Base

- Pipe performance
- Pipe service
- Installation age / era
- Size
- Material
- Depth
- Gradient
- Function
- Cross section
- Soil, traffic load, mining etc.

Timisoara city in Romania: combined sewer system
Solution Techniques

- Bentley Sewer as AM & SewerGEMS for hydraulic performance assessment
- Genetic Programming for deterioration modeling
- Bayesian Probabilistic Network for Failure Risk Assessment and Uncertainty
Deterioration Model Example

- CoD = 90%
- op – operational condition grade
- Age – age of sewer
- s24 – ‘section 24 sewers’ (old, small bore)

$BL = 0.091978 \cdot op + 0.10927 \cdot Age \cdot s24$

$R^2 = 0.9036$
Failure Risk Model Example

Average failure of 40 cases

Material
- Plastic
- Concrete
- Earthenware
- Iron
- Mat_Other

Probability of Failure (%)

Ground
- Clay
- Made
- Sand
- Other

Size
- Size_Small
- Size_Mod
- Size_Big

Age
- Age_Young
- Age_Mod
- Age_Old
Pipes Renewal Planning

Part of integrated AM practice
- Condition assessment tool
- Tool to rank each pipe based on several “aspects”
- Calculate a score for each aspect
- Combine scores for overall ranking
- Part of WaterGEMS
- WaterGEMS and GIS results display tools
Leakage Detection

- Cause water companies / utilities lose revenues (NRW)
- Use hydraulic model as a base
- Integrate with optimization technology
- Predict leakage hotspots (unreported leakages)

DMA in UK: Oldham area

Real consumption

Metered consumption
Leakage Detection Benchmark

- A DMA water system in UK
- High leakage rate
- Apply the latest leakage detection model in **WaterGEMS**
- Enable informed field survey
Real-time SCADA Modelling

Security
- Planning and outage analysis
- Real time predictions
- Leakage detection & Demand inversion
- Forensics

Energy Management
- Optimal pumps scheduling

Water Quality
- Emergency management
- Planning
- Forensics

Operator Training & Learning

City in Greece:
- 47 signals were mapped and used in WaterGEMS for real-time decision support
Pumping Scheduling Optimization using Darwin Scheduler

- DMZ system (United Utilities)
- 57 Ml/day
- 11 pump stations and 9 tanks
- Energy cost: £330K/year
- Recorded daily energy cost: £912
- Modeled daily energy cost: £983
## Energy Cost comparison

<table>
<thead>
<tr>
<th>Pump ID</th>
<th>Existing controls</th>
<th>Optimized controls</th>
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<tbody>
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<td>Pump utilization (%)</td>
<td>Daily cost (£)</td>
<td>Pump utilization (%)</td>
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<td>7.92</td>
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<td>21</td>
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<tr>
<td>PILWTH</td>
<td>82</td>
<td>236.19</td>
<td>40</td>
</tr>
<tr>
<td>NEWMRKT</td>
<td>23</td>
<td>111.63</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Total cost (£)</td>
<td>983.12</td>
<td></td>
</tr>
</tbody>
</table>

- **Overall saving is** **29%** of original energy cost
Real-time Reporting, Forecasting, Optimization and Control
# Bentley Institute Learning Offerings

<table>
<thead>
<tr>
<th>What</th>
<th>How</th>
<th>Options</th>
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<tbody>
<tr>
<td>Classroom Learning</td>
<td>Instructor-led</td>
<td>Scheduled Courses, Account-Specific Courses, Enterprise Training Subscription</td>
</tr>
<tr>
<td>Distance Learning</td>
<td>Instructor-led</td>
<td>Scheduled Courses, Account-Specific Courses, Enterprise Training Subscription</td>
</tr>
<tr>
<td>OnDemand eLearning</td>
<td>Self-paced</td>
<td>Bentley LEARN, Enterprise Training Subscription</td>
</tr>
</tbody>
</table>
Bentley Institute Press
Contact Information and Resources

www.bentley.com/water

communities.bentley.com

www.bentley.com/waterloss

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Tank You for Your Attention

A SUSTAINABLE BUILT ENVIRONMENT

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