A Sensor Network for Real-Time Damage Location and Assessment

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Next Generation SCADA* for Prevention and Mitigation of Water System Infrastructure Disaster

Joint Venture Project under NIST TIP*

University of California, Irvine (UCI)
Orange County Sanitation District (OCSD)
Irvine Ranch Water District (IRWD)
Santa Ana Watershed Project Authority (SAWPA)
Earth Mechanics Inc (EMI)

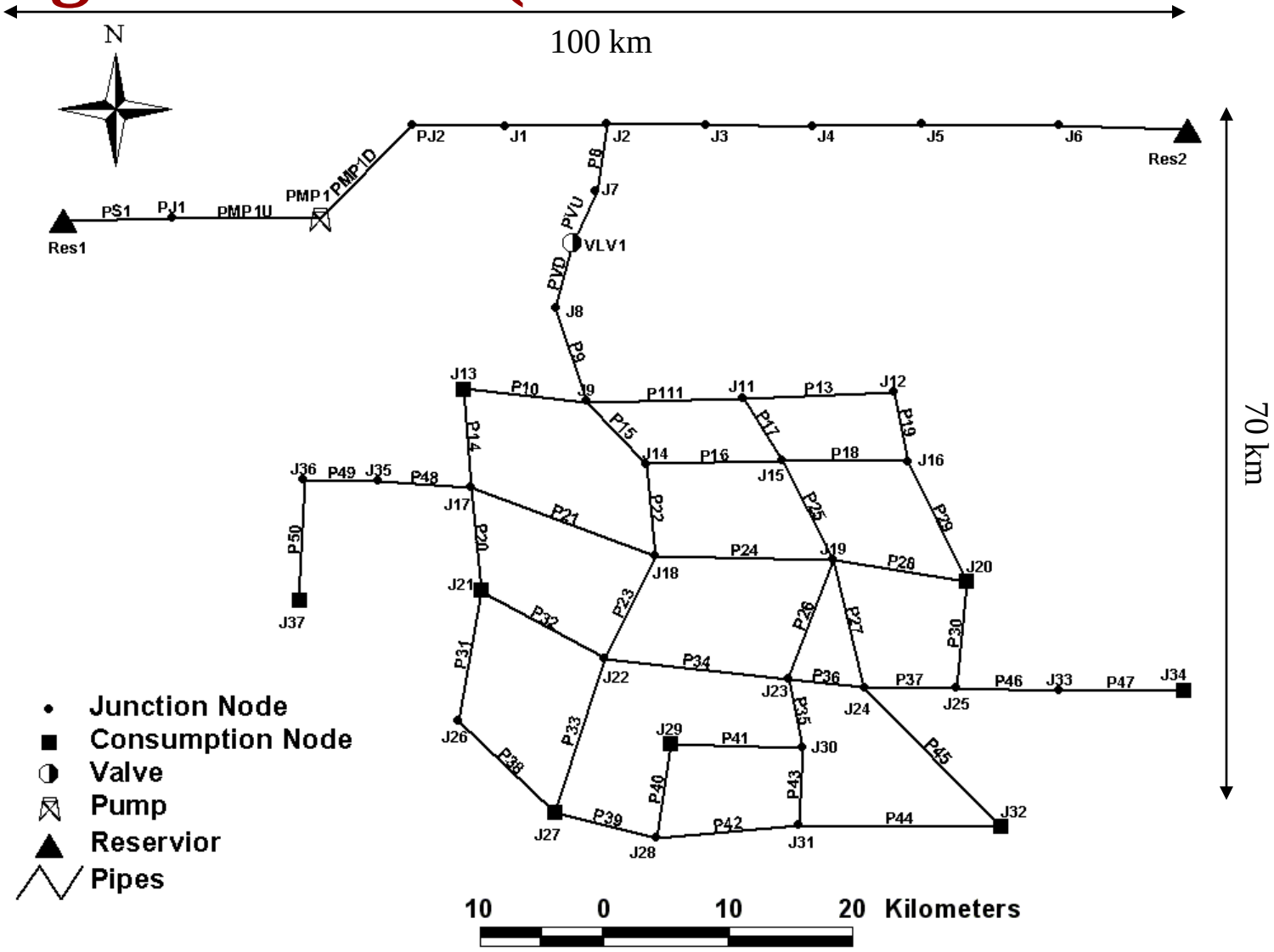
*Supervisory Control and Data Acquisition
* Technology Innovation Program

Department of Civil and Environmental Engineering

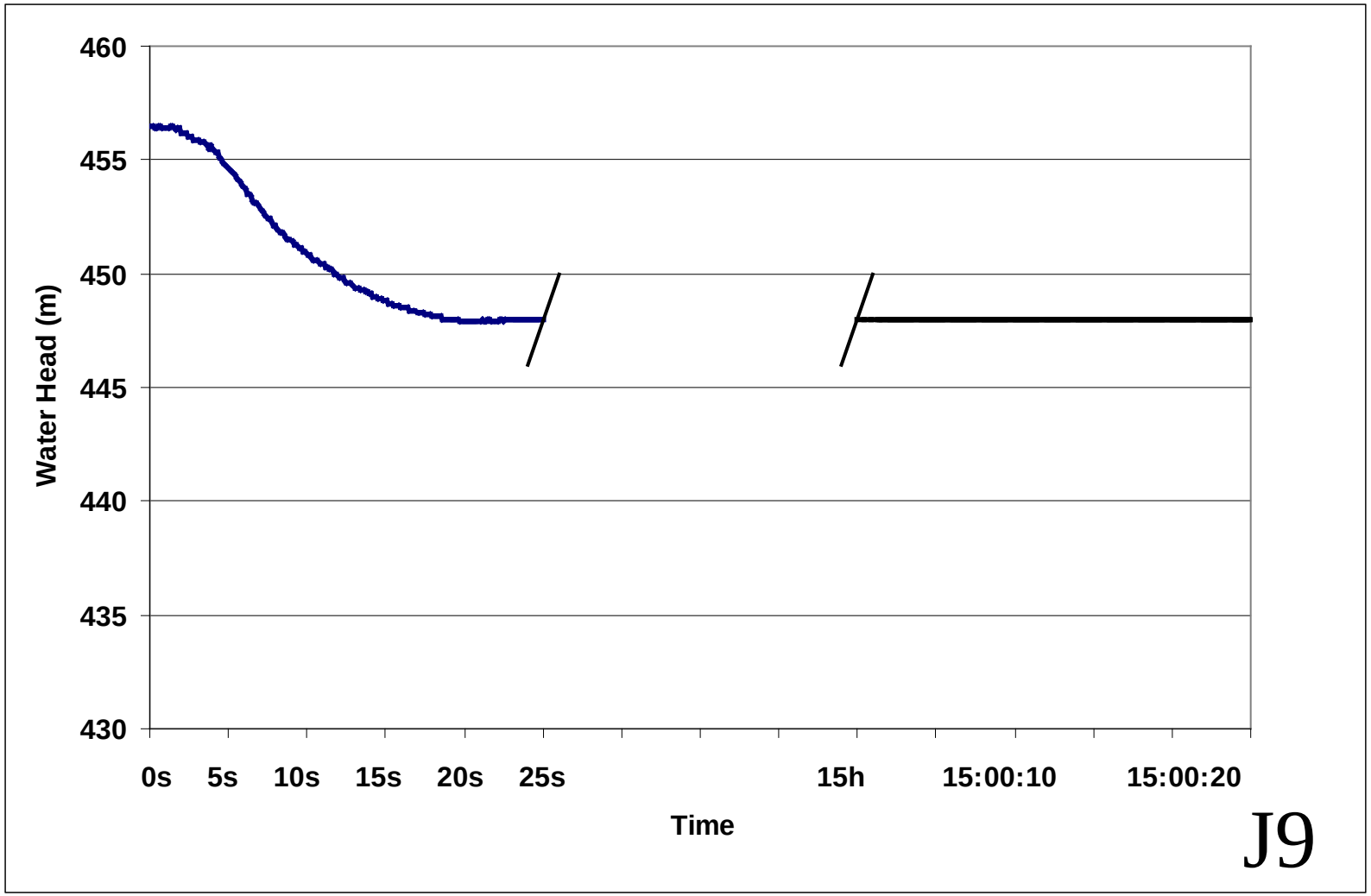
UNIVERSITY *of* CALIFORNIA IRVINE

- **Conventional SCADA System (Supervisory Control And Data Acquisition system) senses and controls operational perturbations in pressure, flow rate, temperature, etc. But sensors are installed at key components such as pump stations, but usually not in pipe networks.**
- **Nexed generation SCADA system will have sensors in pipe network to identify pipe damage in real time.**
- **Challenge: must cover a vast area, transmit sensor data long distance to a control center, need a large number of robust sensors, and power supply for sensing and data transmission.**

Damage Detection (transient flow:Hammer)

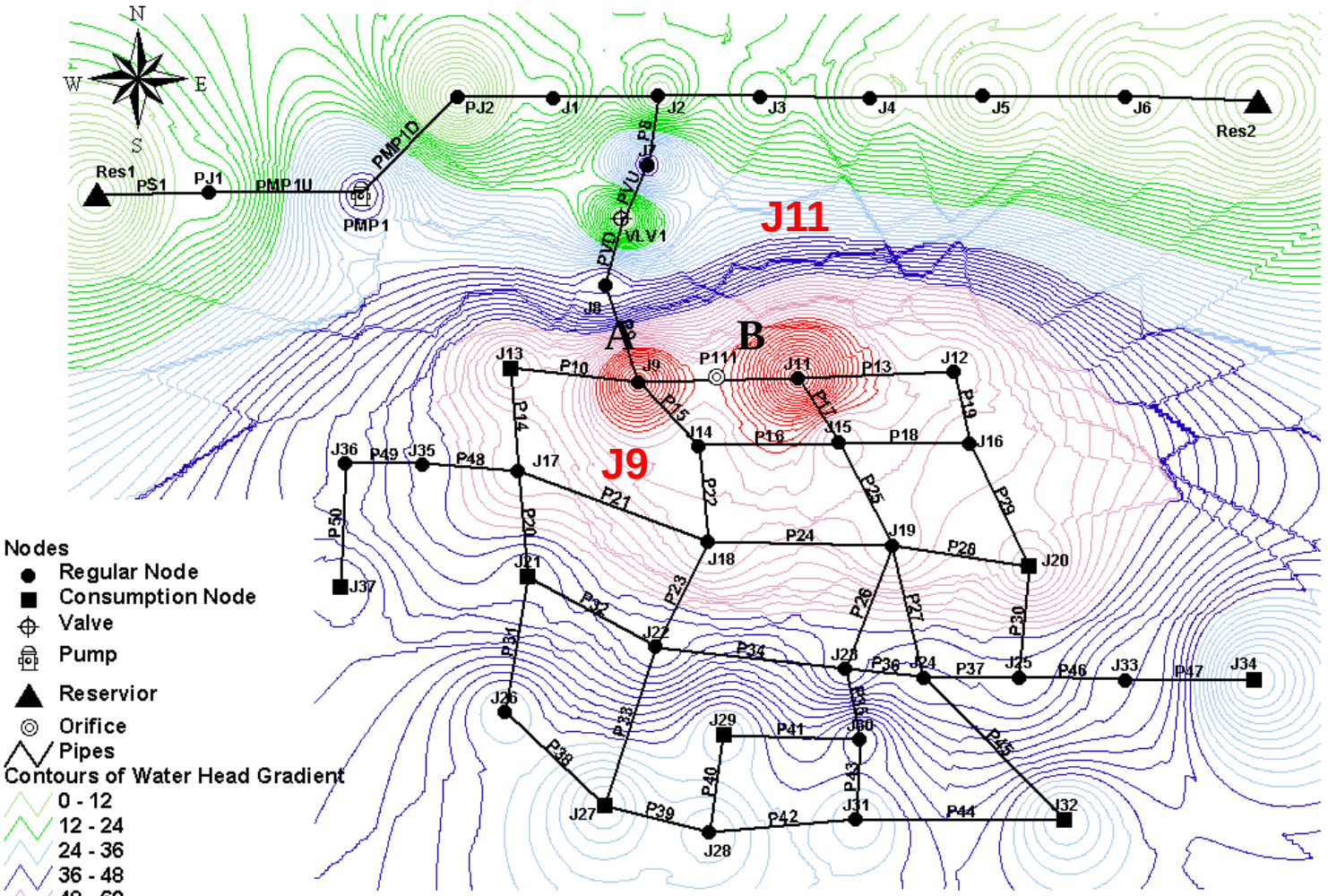


Pipe Breaks at P111 and Not Fixed



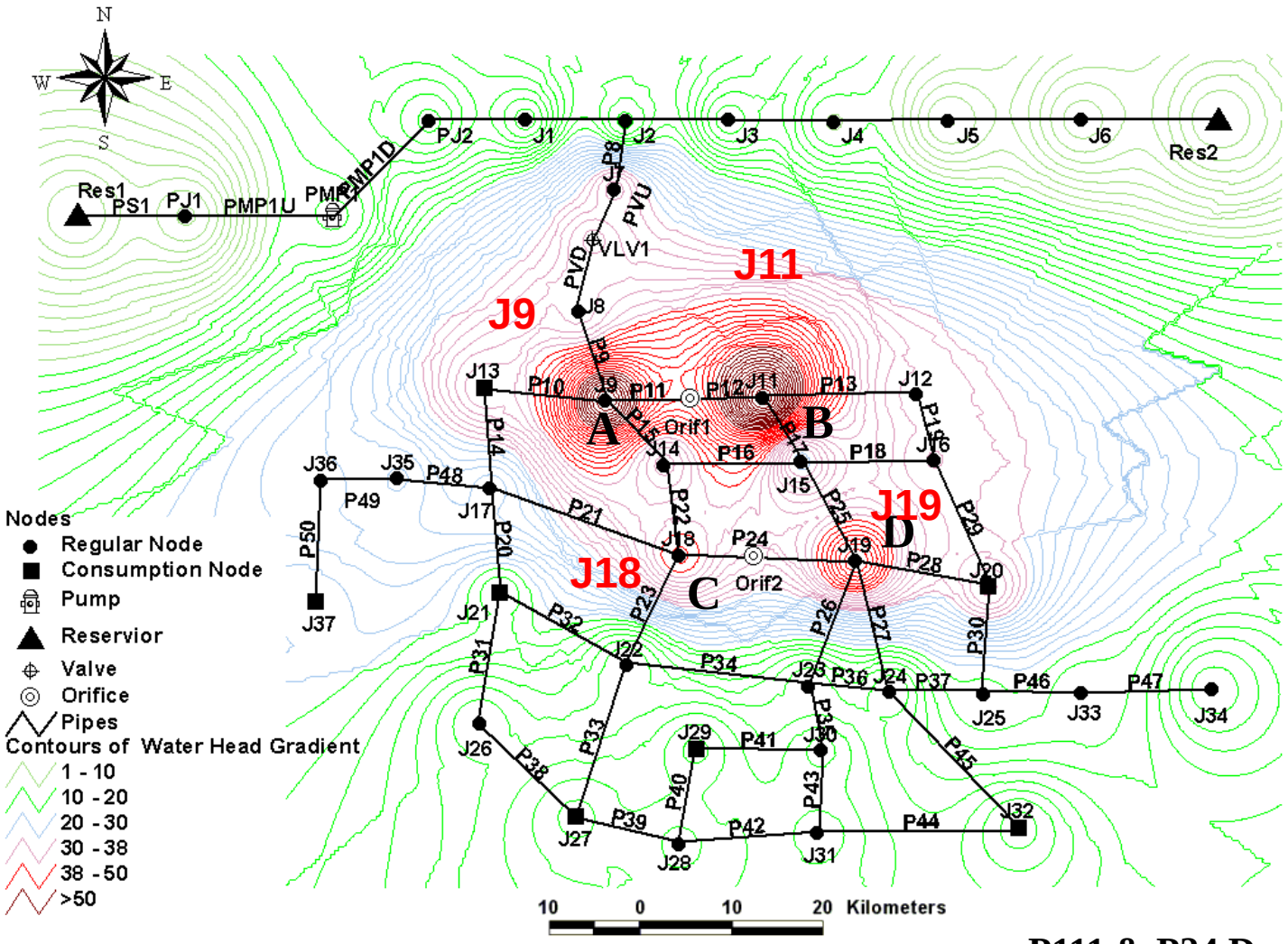
Contour of Water Head Gradient

$$D = \left| \frac{H_2 - H_1}{t_2 - t_1} \right|$$



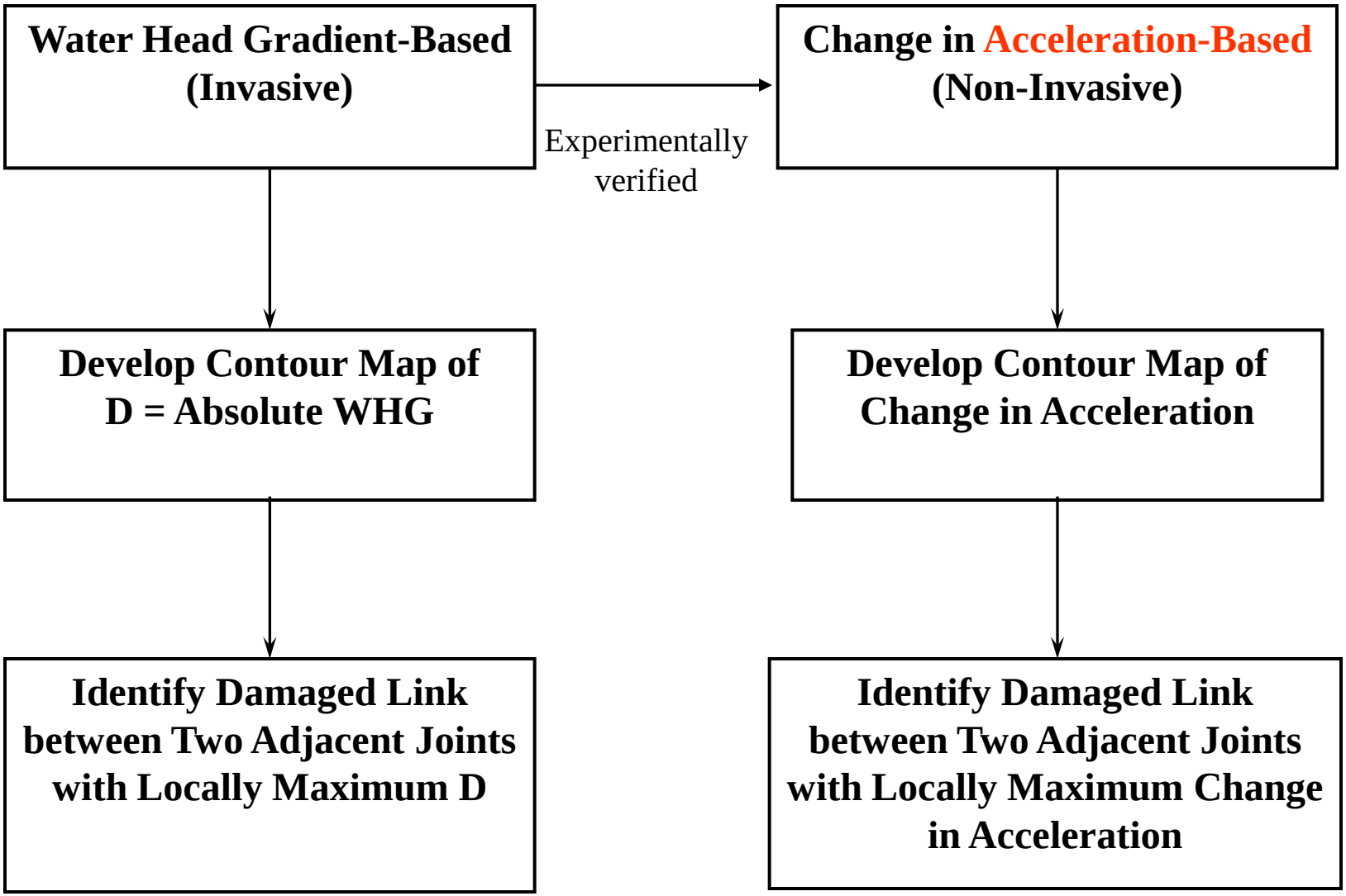
P111 Damage

Contour of Water Head Gradient

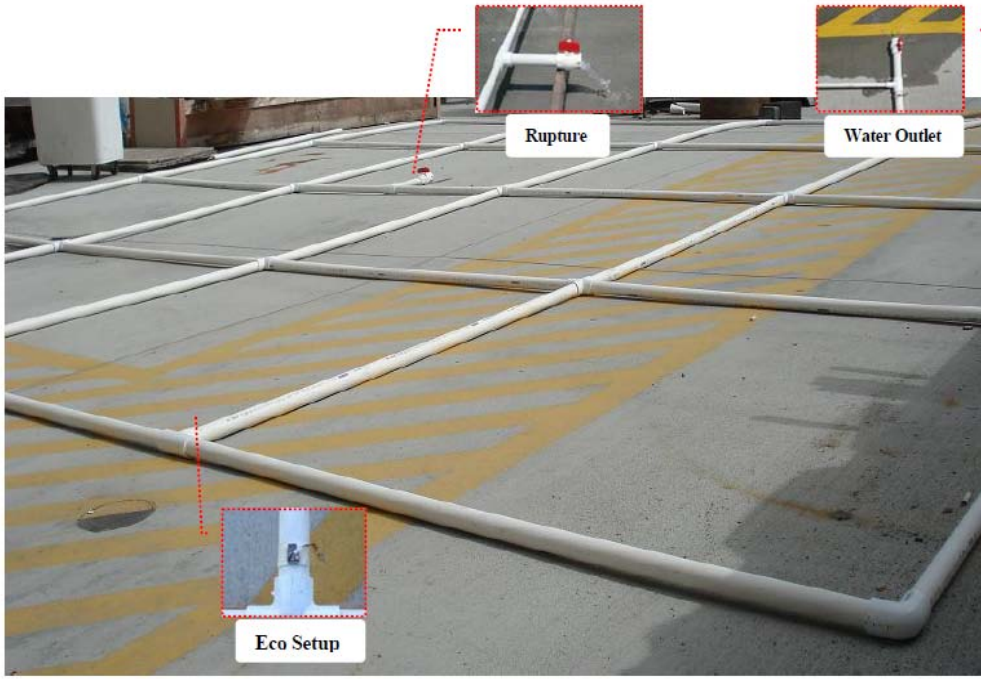


P111 & P24 Damage

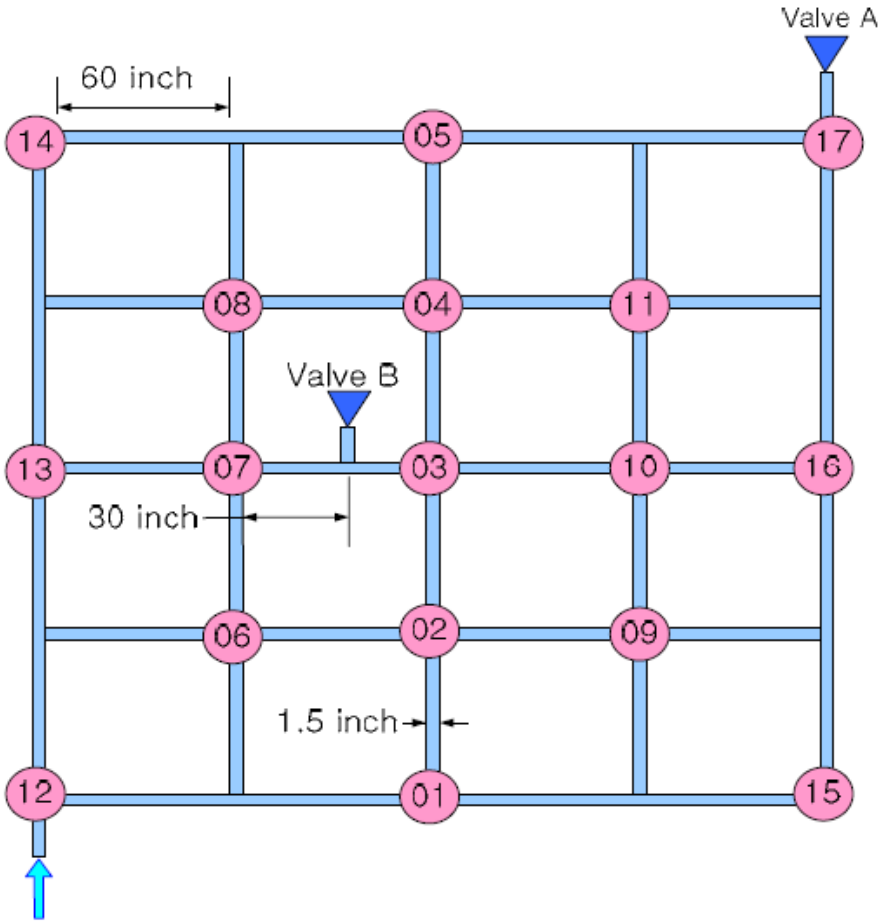
Damage Identification Methodology



Setup for Preliminary Experiment

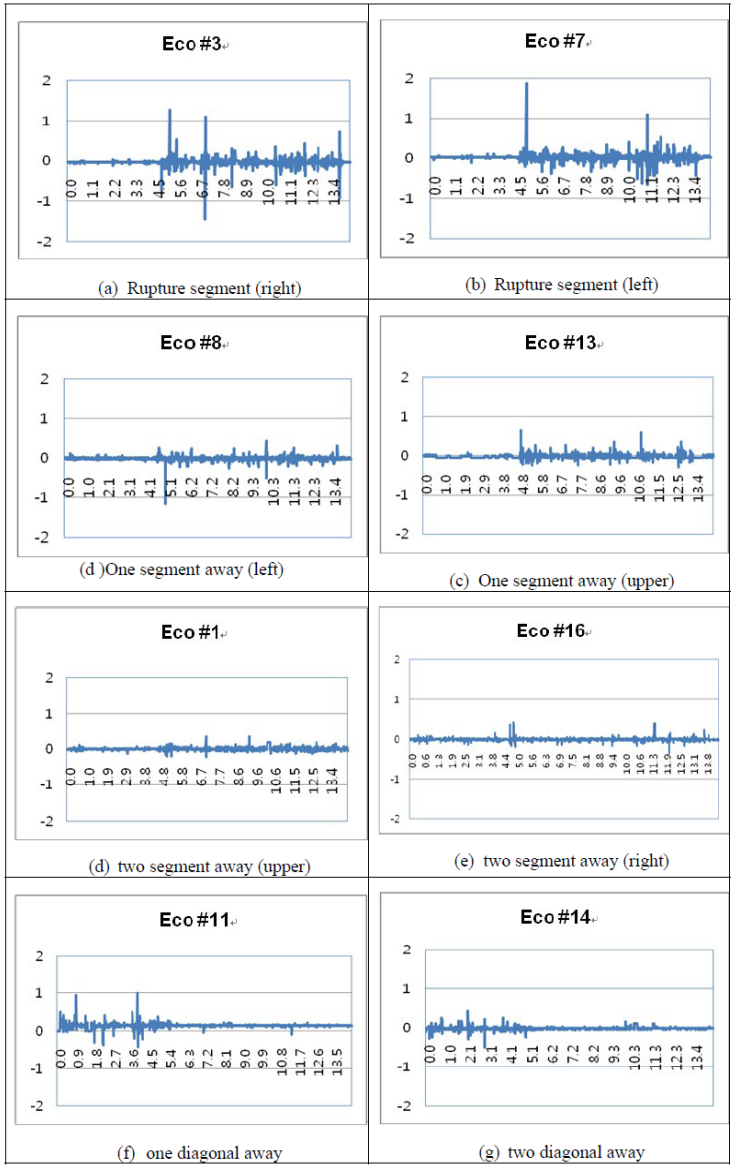


(a) Photo of PVC Water Pipe Network

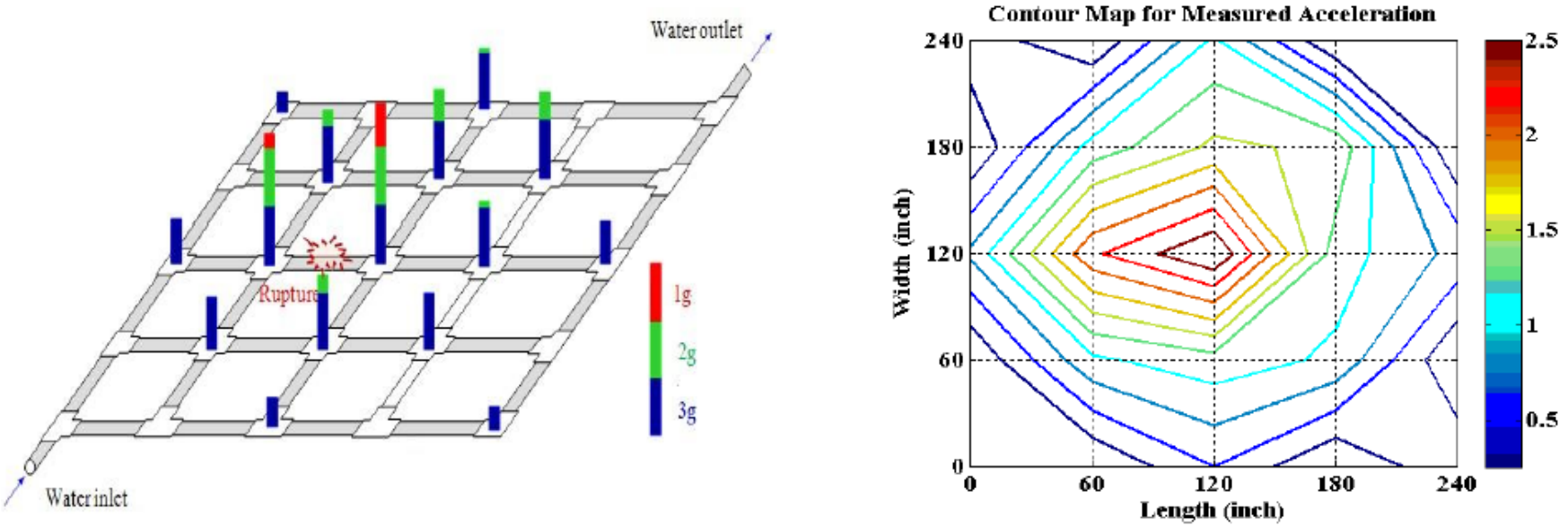


(b) Dimension of PVC Water Pipe Network and locations where 17 Eco sensors

Acceleration Data Measured by Eco Nodes



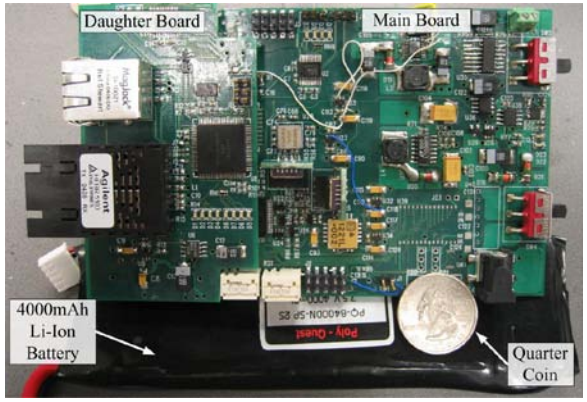
Simulation Results for a Miniature Water Pipe Network



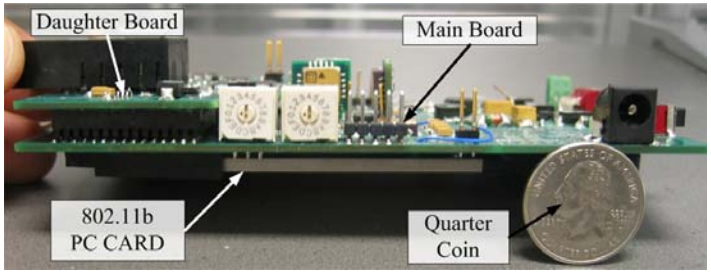
(a) Visualized image for measure acceleration data (b) Contour Map drown by measured data

Acceleration Data Measured by Eco Nodes

MEMS* based DuraNode and Eco



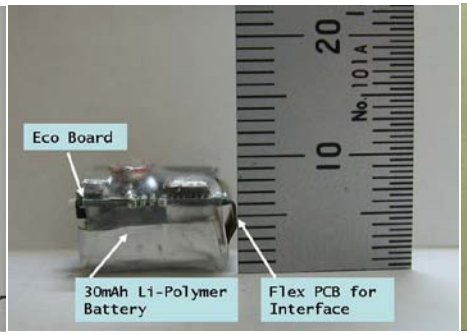
(a) Top View



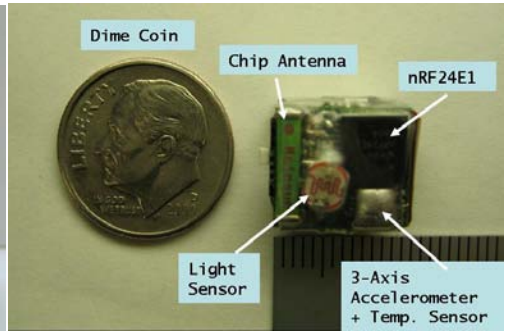
(b) Side View

DuraNode

(a) On the finger



(b) Side View



(c) Top View

Eco

* Micro Electro Mechanical system

Specifications of Eco and Base Station

	Eco	Base Station
Size (mm)	13 x 11 x 8	76.2 x 114.3 x 31.7
Sensor	Triaxial accelerometer ±3g	None
Power Consumption	Max. 100mW	4.5W
Max. Air Data Rate (bps)	1 Mbps	2 Mbps
Battery	40mAh Li-Polymer (3.7V)	DC 6V/2A
Wired Interface	Serial, SPI	10/100 base/T Ethernet
Wireless Interface	2.4GHz Shockburst	2.4GHz Enhanced
Radio Range (m)	10 ~ 20	10~20
Cost ($) @ 1000	30-50	100

(a) 2.4GHz RF Module

(b) Microcontroller Board

Base Station


Traffic
More...
Map
Satellite
Irvine Regional Pk
Irvine Lake / Irvine Lake Pipeline
N
E Chapman Ave
Canyon View Ave
Crawford Canyon Rd
Newport Blvd
S Hewes St
S Esplanade St
E Fairhaven Ave
Foothill Blvd
North Tustin
Tustin Foothills
Hewes Ave
La Loma Dr
E 17th St
Holt Ave
Newport Ave
Red Hill Ave
La Colina Dr
Irvine Blvd
Browning Ave
Tustin Ranch Rd
Jamboree Rd
261
241
E Santiago Canyon Rd
Co Highway S18
Santiago Canyon Rd
Eastern Transportation
Orchard Hills
El Toro Rd
1 mile
1 km
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Conclusions:

- **Proof of concept 1s achieved by small scale experiment**

Future Research:

- **Large Scale Laboratory Experiment (100 ft X 100 ft, 4 in diameter PVC pipe)**
- **Field Experiment**
- **Development of Next Generation SCADA**