Case Study – A Permeable Reactive Barrier for Denitrification

Watertech2014
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April 12, 2014

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Overview

- Site Background
- Theory
- Permeable Reactive Barrier Design
- Photos
- Data
- Conclusions

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Site Background

- Northern Alberta Site – Active Fertilizer distribution facility
- Nitrate plume traveling south, shallow groundwater velocity approximately 1.5 metres per year
- Nitrate concentrations up to 1,400 mg/L in shallow groundwater traveling offsite

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Site Background

- Approximately 120 m south to nearest potable well from leading edge of plume
- Domestic Use Aquifer pathway eliminated
- Viterra wished to proactively address potential offsite liabilities
- Permeable Reactive Barrier (PRB) selected as a cost effective way to limit the nitrate flux traveling off-Site

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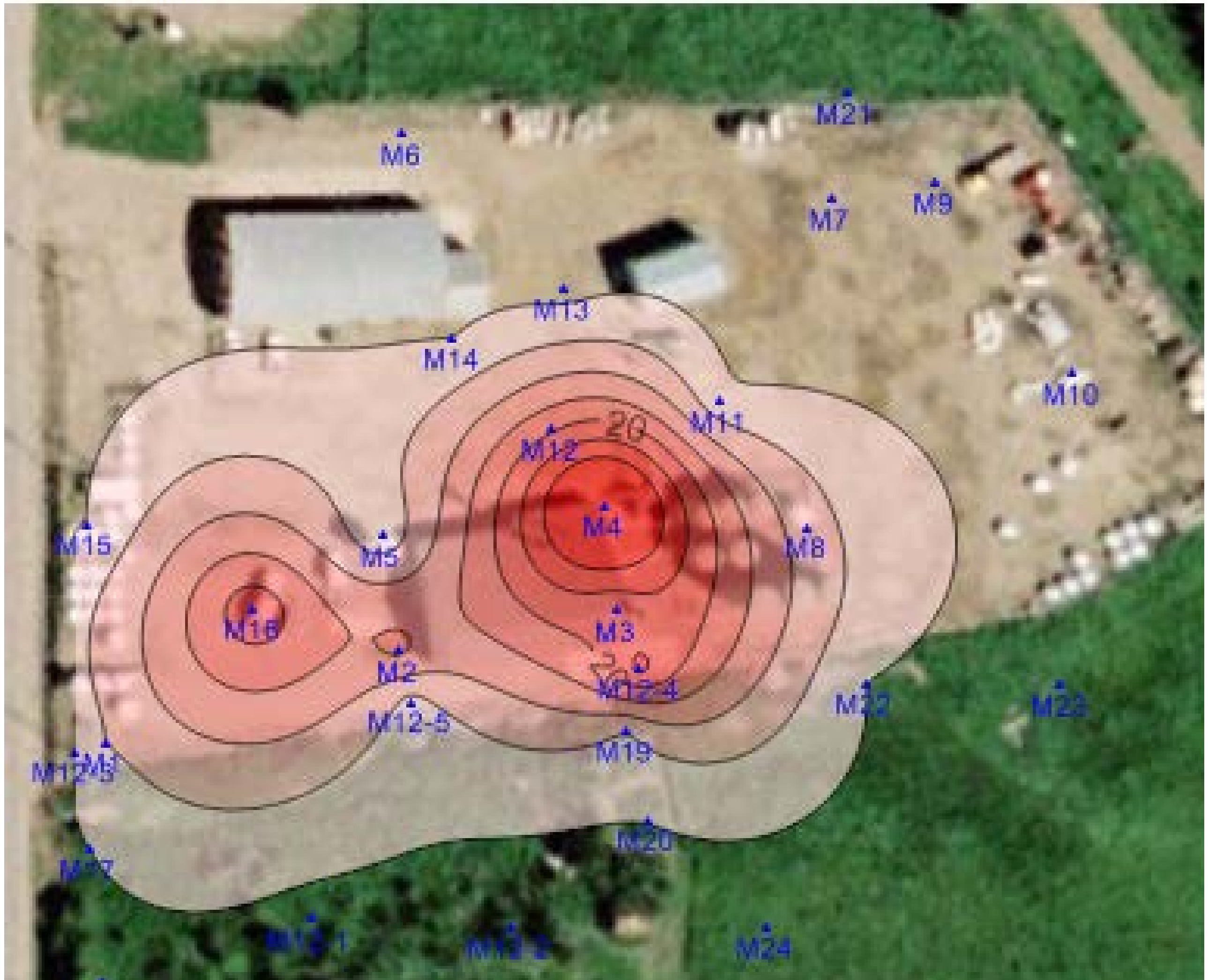
Site Background



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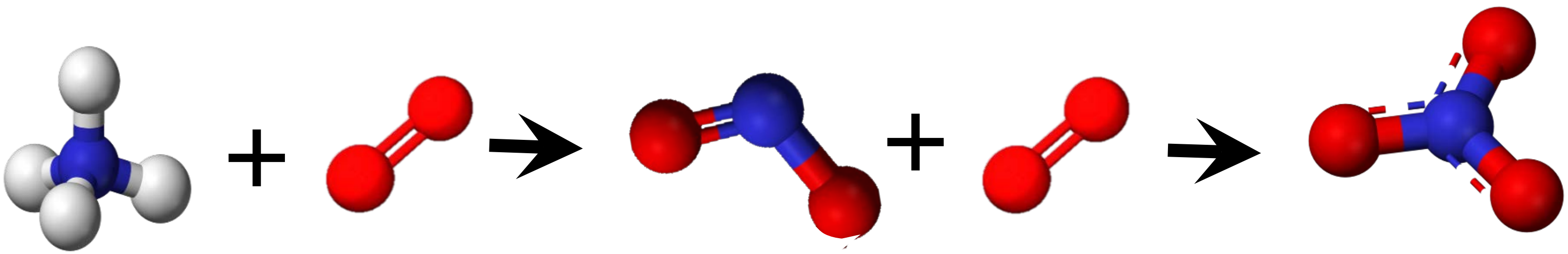
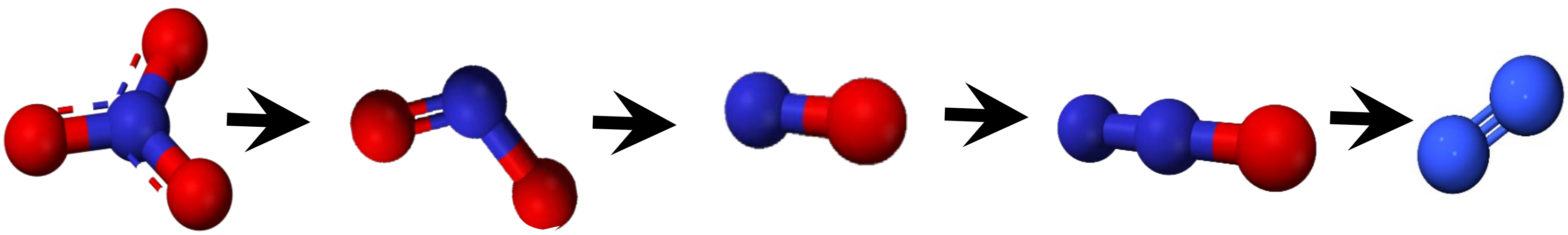
Nitrification Theory



Ammonia NH_3 + Oxygen O_2 → Nitrite NO_2^- + Oxygen O_2 → Nitrate NO_3^-

- Requires Oxygen as electron acceptor
- Autotrophic, inorganic carbon (CO_2 and HCO_3^-) for growth
- Reduces alkalinity

Denitrification Theory



Nitrate	Nitrite	Nitric Oxide	Nitrous Oxide	Nitrogen
NO_3^-	NO_2^-	NO	N_2O	N_2

- Requires organic carbon
- Only occurs under anaerobic conditions
- Produces alkalinity

Literature review

- Wood chips effective for long term denitrification – more than 25 years
- Largest volume for a PRB
- Highest influent nitrate levels of 100 mg/L
- Efficiencies between 50 and 80 %
- Initial spike in downstream levels
- Downstream reductions – double retention time

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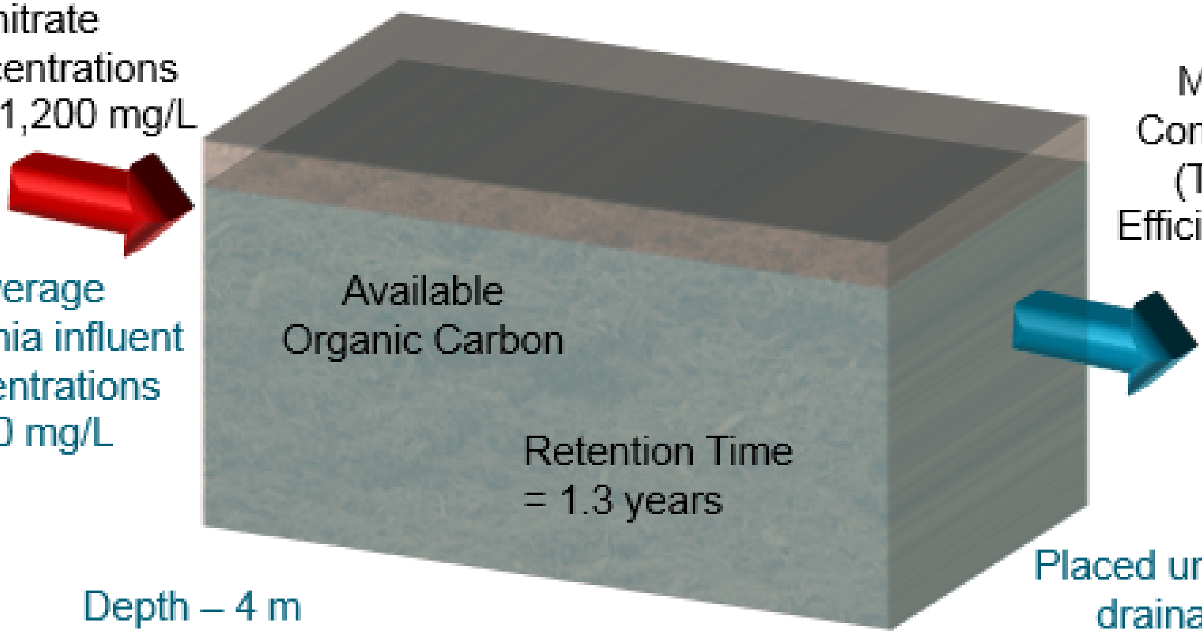
Design Considerations

Capped with 0.3 m clean clay

Influent
nitrate
Concentrations
Up to 1,200 mg/L



Midstream
Concentrations
(Treatment
Efficiency – 80%)

Average
ammonia influent
concentrations
200 mg/L

Depth – 4 m
Width – 2 m
Length – 120 m
Volume – 960 m3

Carbon Source
Pine wood chips

Placed under existing
drainage Ditch
to ensure saturation

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PRB Design

- Design life in excess of 20 years
- Hydraulic Conductivity of PRB was higher than surrounding soils based on slug tests
- Groundwater level an average of 0.8 metres below ground surface

PRB Design

- Reasons to go offsite to the south:
  - No disruptions to operations
  - Further nitrification of ammonia from 500 to 200 mg/L
  - Presence of drainage ditch would ensure PRB remained saturated
  - Land was unproductive due to drainage issues

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PRB Preconstruction July 2011

PRB Design

- Benefits to adjacent landowner
  - Recycled metal, hauled debris away
  - Improved the drainage, landscaping of the area
  - “Reclaimed” about one acre of land, baled for the first time in summer 2013

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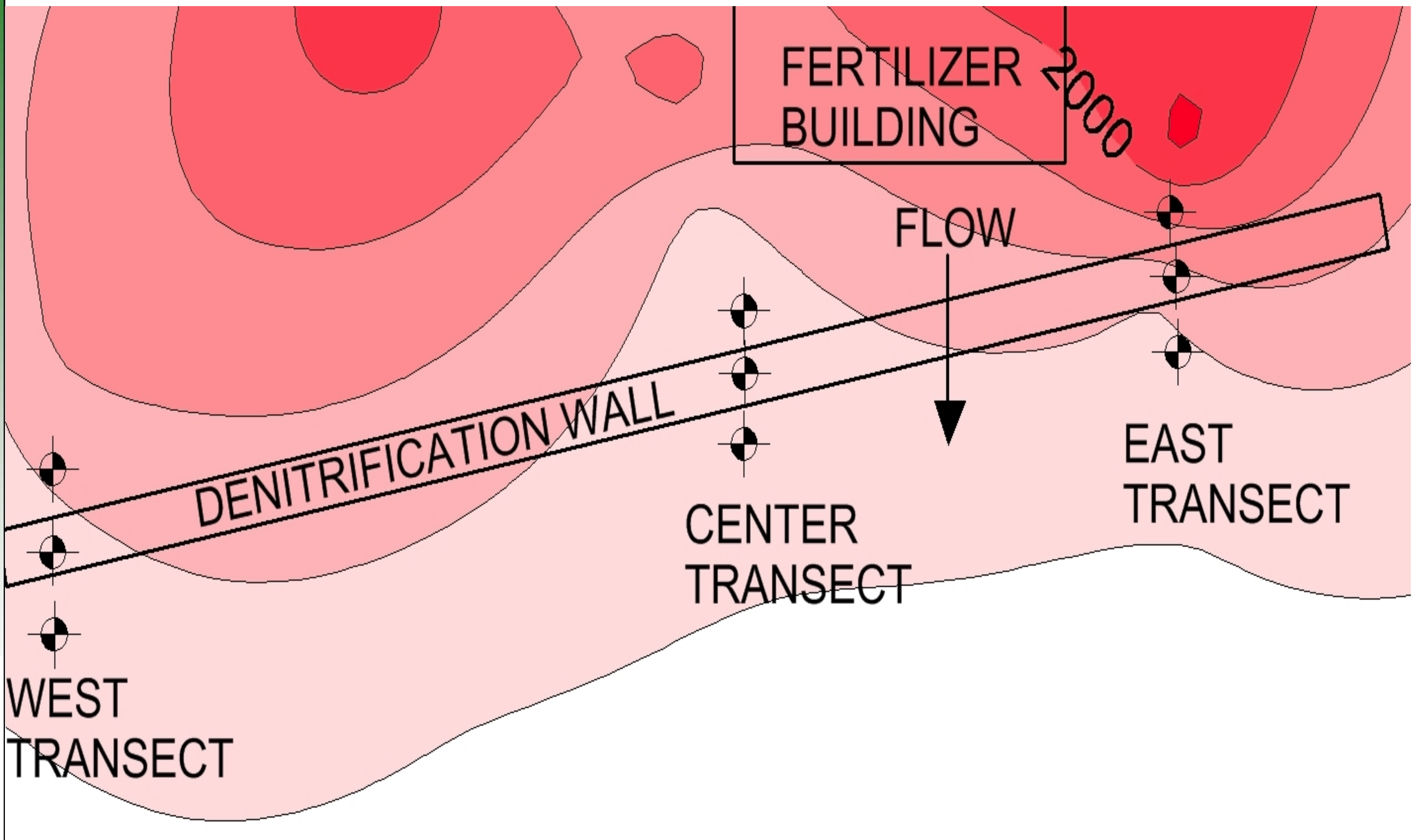
PRB Construction June 2012

PRB Post Construction June 2012

PRB Post Construction May 2013

PRB Post Construction August 2013

Results



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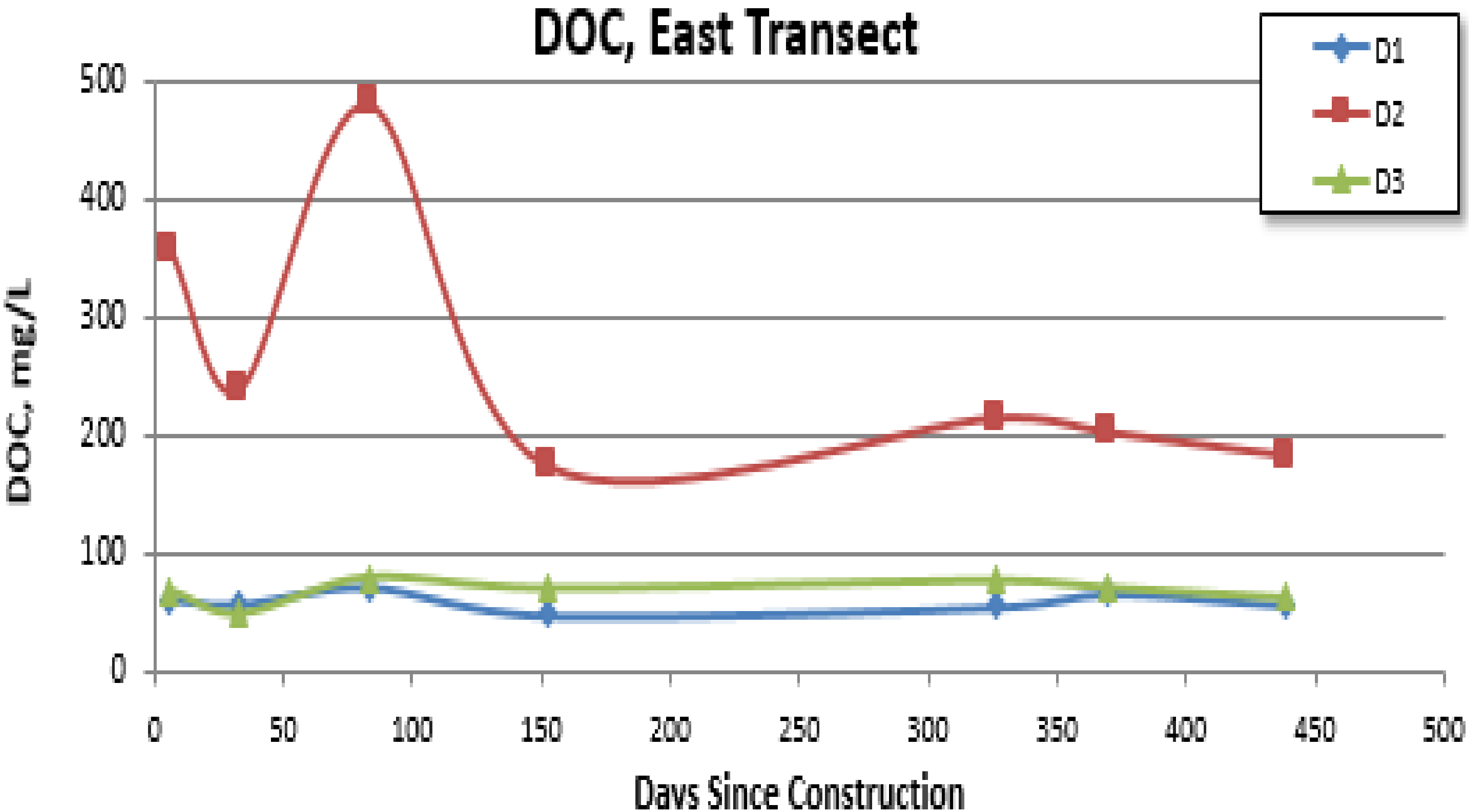
Results – Dissolved Organic Carbon



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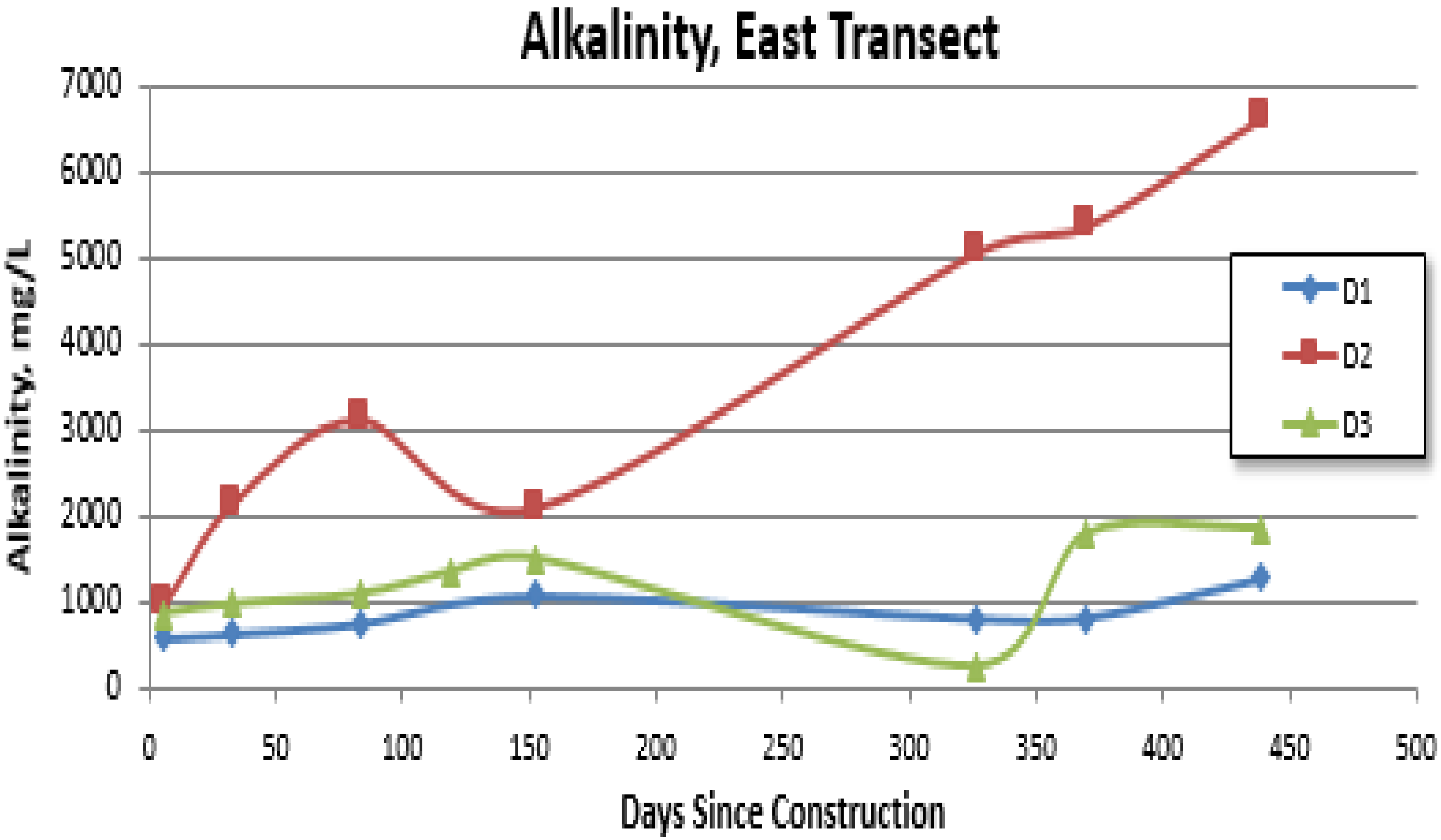
Results – Alkalinity



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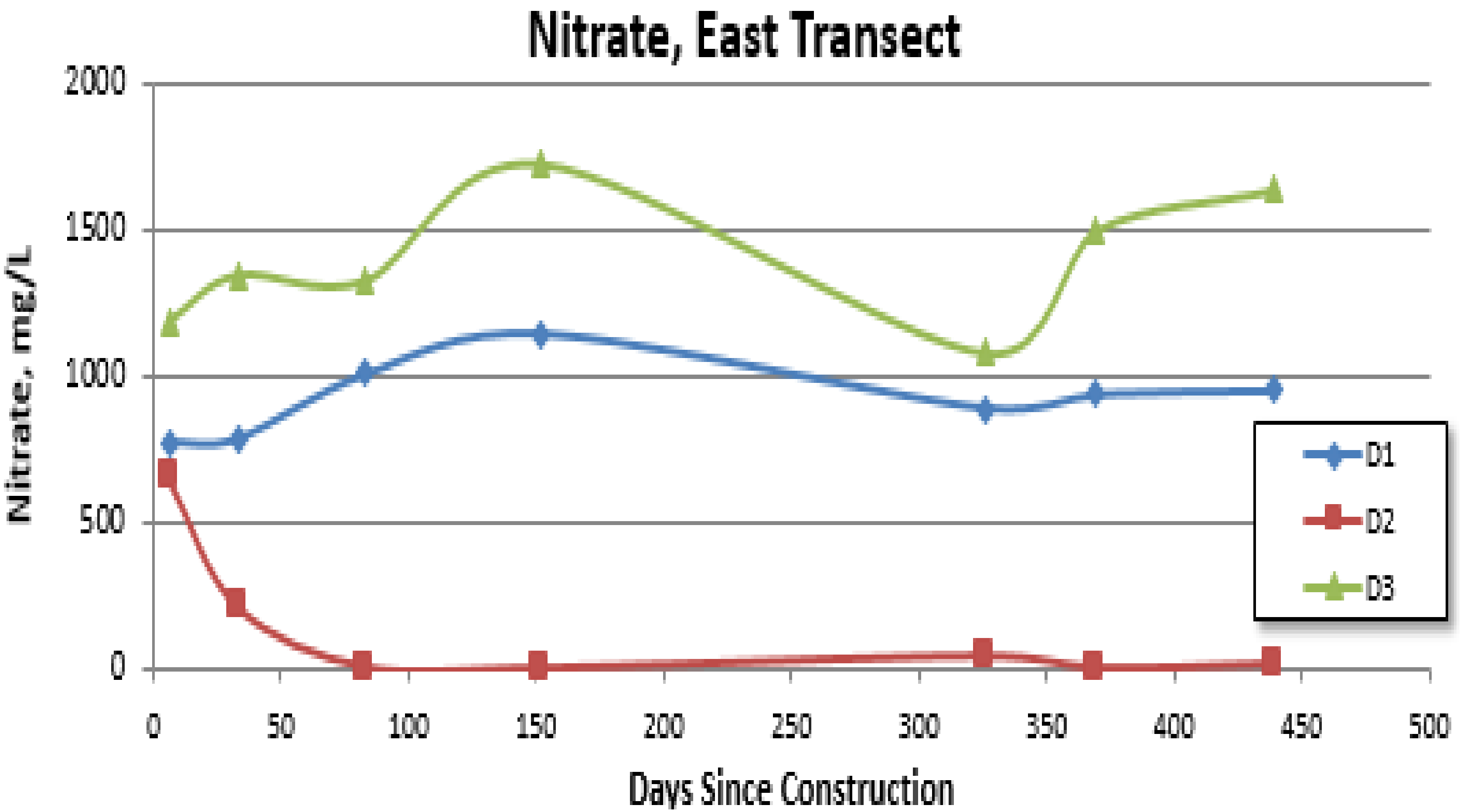
Results – Nitrate



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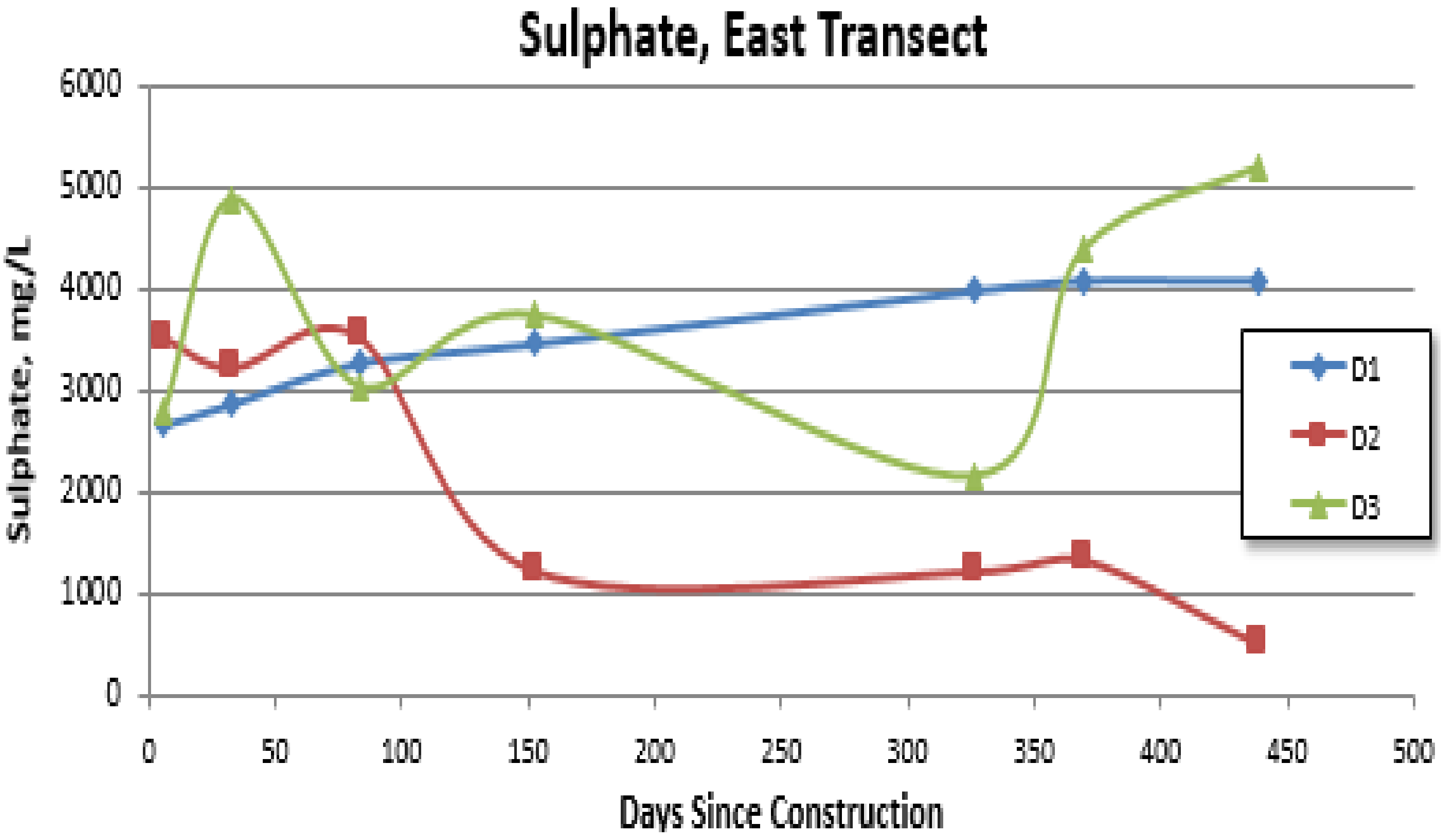
Results – Sulphate



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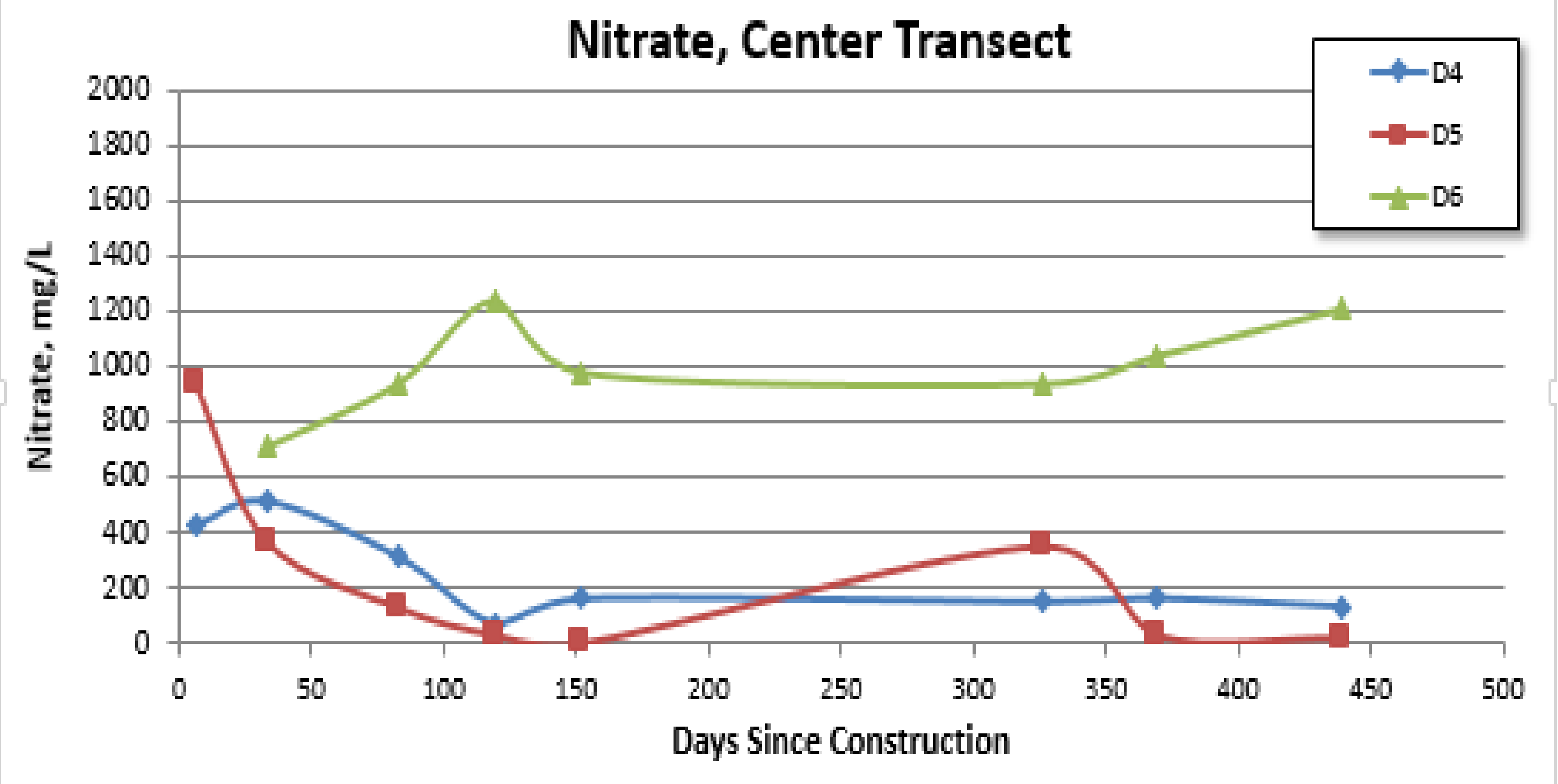
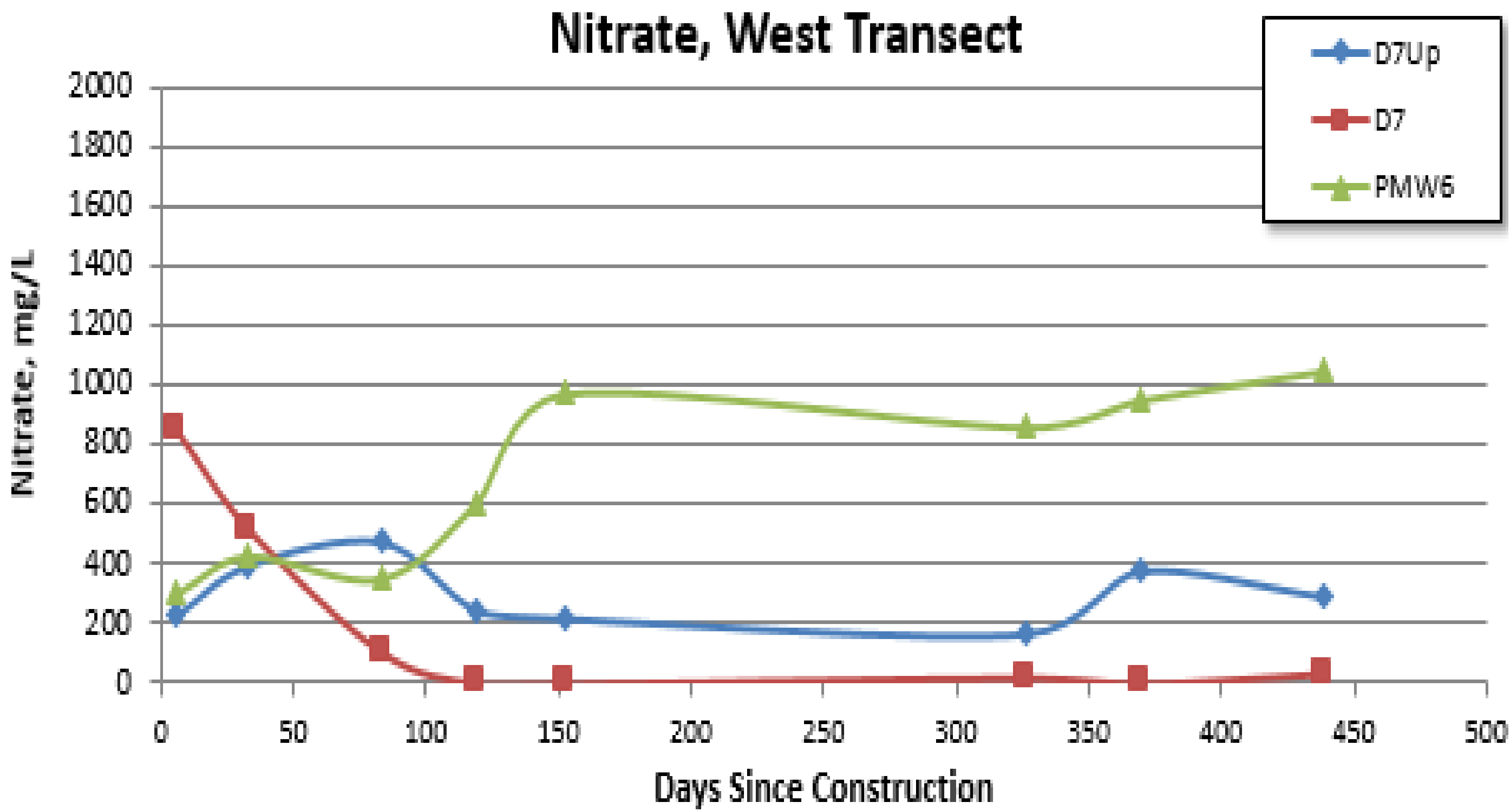
Nitrate - Center



Nitrate – West Transect



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Results

- PRB performing well
- Average Nitrate reduction of 95%
- Downstream nitrate concentrations have not yet shown a reduction – anticipated during 2014
- Sulphate reduction of 85% in east transect

Acknowledgements

- Michael Edmonds, Viterra Inc.
- Crop Production Services Inc.
- PINTER & Associates Team

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THANK YOU

PINTER & Associates Ltd.