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In Situ Groundwater Nitrification and De Nitrification Remediation Processes – From Bench Scale Testing to Full Scale Remediation

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Elevated concentrations of ammonia and nitrate in water present a potential freshwater aquatic life and human health concern. Discharges of ammonia and nitrate contaminated groundwater to aquatic environments are a growing public concern, and elevated concentrations of nitrate in drinking water present a human health concern. The processes governing nitrification and de nitrification can be controlled in a cost-effective manor to provide in-situ remediation of ammonia or nitrate contaminated groundwater.

Laboratory scale nitrification and de-nitrification tests were conducted utilizing groundwater obtained from an ammonia and nitrate impacted site. The bench scale tests confirmed that nitrification and de nitrification of the groundwater at the site was viable with the addition of appropriate amendments.

Following successful bench scale testing, an in-situ pilot scale test site was constructed to assess the potential of attaining significant ammonia and nitrate reductions under field conditions, using various amendment application rates.

The pilot test nitrification trial to reduce concentrations of ammonia involves: adding oxygen and nutrients to extracted ammonia contaminated groundwater; and subsequent injection of oxygen and nutrient amended groundwater to encourage in-situ nitrifying bacteria to convert ammonia to nitrate.

The conversion of ammonia to nitrate occurs through the following reactions:

$NH_4^+ + 2/3\ O_2 \rightarrow NO_2^- + 2H^+ + H_2O$

$NO_2^- + ½\ O_2 \rightarrow NO_3^-$

As a result, the following overall reaction occurs:

$NH_4^+ + 7/6\ O_2 \rightarrow NO_3^- + 2H^+ + H_2O$

During in-situ pilot testing ammonia concentrations were reduced from 58 mg-N/L to 6.0 mg N/L in approximately 120 days.

The pilot test de-nitrification trial to reduce concentrations of nitrate involves: adding carbon and nutrients to extracted nitrate contaminated groundwater; and subsequent injection of carbon and nutrient amended groundwater to encourage in-situ de-nitrifying bacteria to convert nitrate to nitrogen gas.

The conversion of nitrate to nitrogen gas occurs through the following reaction:

$2NO_3^- + 1.5(CH_3COOH) \rightarrow N_2 + 3CO_2 + 3H_2O$

(Acetic acid or another carbon source)

During in-situ pilot testing nitrate concentrations were reduced from 66 mg-N/L to 0.2 mg-N/L in approximately 14 days.

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Based upon the successful ammonia and nitrate reductions in the pilot scale test, a full scale in situ nitrification and de-nitrification remediation system was installed at the site across the ammonia and nitrate plume along a transect prior to entering a freshwater aquatic life receptor. Over a period of several years of full scale nitrification and de-nitrification system operation, the following was achieved:

- Reductions in ammonia and nitrate concentrations along the width of the impacted plume prior to entering a freshwater aquatic life receptor.
- Reductions in the loading of ammonia and nitrate to the fresh water aquatic life receptor into which the impacted plume was discharging.
- Significant cost savings as compared to other ammonia and nitrate remediation methods.

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Mr. Mailath is a Principal Hydrogeologist at Trace Associates Inc., with over 30 years of experience in the environmental consulting field for a variety of industries. His specialties are the assessment of soil and groundwater contamination, migration processes, contaminant fate, groundwater remediation and management, groundwater resource evaluation, management and licencing, analytic and numeric groundwater modelling, remediation technology development regulatory liaison, surface and groundwater interaction, and expert testimony. His expertise includes municipal and industrial waste contaminant fate, impact evaluation, and risk assessment. He has prepared industry guidelines and has been an instructor at workshops regarding contaminant assessment, remediation, and environmental impact assessment.