Effective Date: December 15, 1998

***WSE* Publication No. 1495**

Engineering Data Sheet

7218

Process: *Express*™ Expedited Remediation Site Strategy
Simultaneous Ground and Groundwater Remediation

Current Technology
Total remediation of a site is currently considered a two-task requirement. The contaminated soil is one task and the contaminated groundwater the other. In some instances the soil is remediated first and the groundwater second. On other projects the groundwater precedes the soil. In every case, however, total site remediation as described above generally takes some 10-25 years to accomplish. In this regard, remediation of the ground **above** the water table is accomplished by soil vapor extraction, thermal desorption, ex-situ soil washing, and a few other methods none of which are particularly effective or cost-effective. The time required to achieve target clean-up levels is measured in years, if not decades.

Cleaning Beneath the Vadose Zone
Not discussed above but part of the site clean-up equation is the necessity to clean the ground **below** the water table. This requirement comes into play wherever groundwater levels fluctuate and/or when dense non-aqueous phase liquids (DNAPL) are found in the contaminants of concern (COC). Groundwater treatment usually consists of a pump-and-treat approach, in which the groundwater is extracted, treated, and then discharged to the environment (lake, river, or land irrigation). Just recently, the concept of treating a contaminated plume with reinjection of the treated water down gradient from the plume is becoming recognized. Successful treating of a plume is actually more difficult than it appears to be because the contamination is three dimensional rather than two dimensional as is often characterized in site plans. If the groundwater is the first task, continuing contamination of the plume can occur from the still contaminated soil. If groundwater is the second task, continuing contamination of the plume can occur from soil that hasn't been effectively cleaned. In either case, the time required for complete aquifer cleaning is considerable. And this is true regardless of the rate of pumping because the rate of plume cleaning is controlled by the rather slow rate of leaching the COC from the soil rather than the rate of pumping. Consequently, the time necessary for effective plume treatment is measured in years or even decades.

Total site remediation time and costs can be decreased by an order of magnitude by implementing simultaneous ground and groundwater treatment. In every instance using a combination of soil washing/leaching and in-situ biological treatment can rapidly clean the contaminated ground. Bacteria, however, are far more effective at biochemically oxidizing the COC than is water at leaching the same contaminants. The faster the soil is cleaned the faster the contaminated groundwater plume can be cleaned. Biological treatment is achieved by percolating very clean water with essential nutrients and dissolved oxygen added. In addition, the same water is injected just beyond the contaminated plume in order to hydraulically drive the water towards the extraction wells. The rate of site clean-up is now controlled by the rate of pumping rather than the rate of leaching because biological treatment is achieved rapidly. As the dissolved oxygen disappears from the recirculated water, biological treatment changes from aerobic to anaerobic. Ultimately aerobic treatment will prevail throughout as the organic load and associated oxygen demand decreases. Under aerobic conditions, lysis will also eventually occur which converts the last vestiges of contamination into carbon dioxide and water, both of which are components of natural groundwater. See engineering drawings S-1003 and S-1004. *Contaminated soil does not require a contaminated aquifer to apply this process. The initial injection of make-up water is all that is required to start the comprehensive biological processes working.*

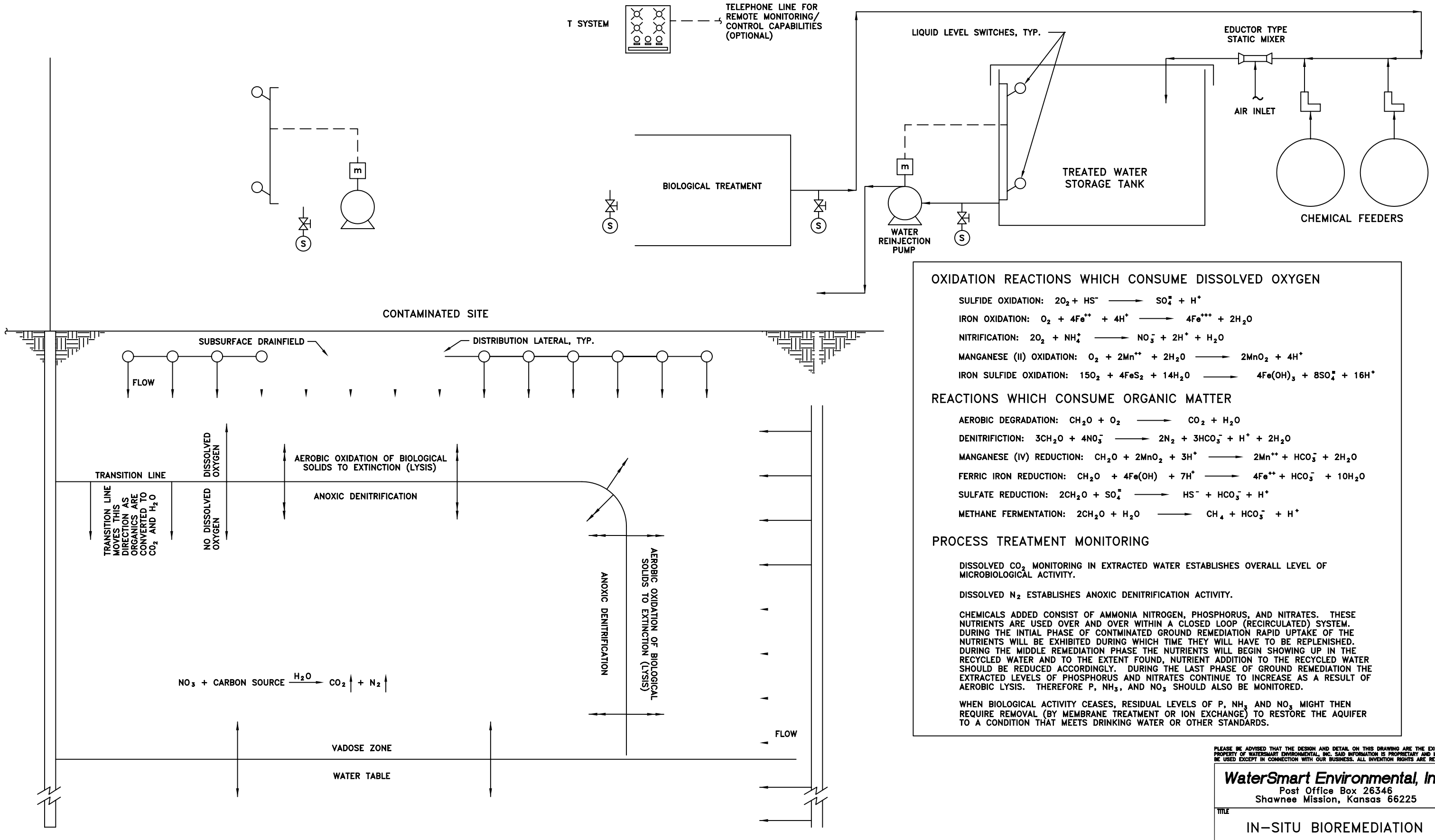
Future Trends
The simultaneous treatment of ground and groundwater is cutting edge technology and just now becoming recognized by the EPA in pilot plant studies. This combination treatment approach is now referred to as intrinsic remediation (IR) or remediation by natural attenuation. The several beneficial processes at work include dispersion, dilution, sorption, volatilization, abiotic transformation, aerobic oxidization, and anoxic reduction. Brownfield developers as well as the owners of contaminated sites and their remediation consultants are urged to embrace this rapid and economical method for total site remediation.

To be effective, the remediation contractor must have a thorough grasp of biological treatment technology as well as the cleaning of groundwater to high levels of purification. Contractor expertise in these two disciplines is essential if the site owner expects to achieve the time and cost savings possible through the principle of simultaneous ground and groundwater remediation. The issuing of negotiated design/build contracts based on performance can result in further expediting the remediation work.

Attached are two reprint articles, both excellent technical papers on this emerging science. For further insight into this total site remediation technique we recommend Remediation Of Petroleum Contaminated Soils by Eve Riser Roberts (1998 Lewis Publishers, an imprint of CRC Press LLC)

The engineers and scientists at WaterSmart Environmental welcome your ground and groundwater treatment inquiries with enthusiasm.

From the Engineering Department of
WaterSmart
Environmental, Inc.



OXIDATION REACTIONS WHICH CONSUME DISSOLVED OXYGEN

SULFIDE OXIDATION: $2O_2 + HS^- \longrightarrow SO_4^= + H^+$

IRON OXIDATION: $O_2 + 4Fe^{++} + 4H^+ \longrightarrow 4Fe^{+++} + 2H_2O$

NITRIFICATION: $2O_2 + NH_4^+ \longrightarrow NO_3^- + 2H^+ + H_2O$

MANGANESE (II) OXIDATION: $O_2 + 2Mn^{++} + 2H_2O \longrightarrow 2MnO_2 + 4H^+$

IRON SULFIDE OXIDATION: $15O_2 + 4FeS_2 + 14H_2O \longrightarrow 4Fe(OH)_3 + 8SO_4^= + 16H^+$

REACTIONS WHICH CONSUME ORGANIC MATTER

AEROBIC DEGRADATION: $CH_2O + O_2 \longrightarrow CO_2 + H_2O$

DENITRIFICTION: $3CH_2O + 4NO_3^- \longrightarrow 2N_2 + 3HCO_3^- + H^+ + 2H_2O$

MANGANESE (IV) REDUCTION: $CH_2O + 2MnO_2 + 3H^+ \longrightarrow 2Mn^{++} + HCO_3^- + 2H_2O$

FERRIC IRON REDUCTION: $CH_2O + 4Fe(OH) + 7H^+ \longrightarrow 4Fe^{++} + HCO_3^- + 10H_2O$

SULFATE REDUCTION: $2CH_2O + SO_4^= \longrightarrow HS^- + HCO_3^- + H^+$

METHANE FERMENTATION: $2CH_2O + H_2O \longrightarrow CH_4 + HCO_3^- + H^+$

PROCESS TREATMENT MONITORING

DISSOLVED CO_2 MONITORING IN EXTRACTED WATER ESTABLISHES OVERALL LEVEL OF MICROBIOLOGICAL ACTIVITY.

DISSOLVED N_2 ESTABLISHES ANOXIC DENITRIFICATION ACTIVITY.

CHEMICALS ADDED CONSIST OF AMMONIA NITROGEN, PHOSPHORUS, AND NITRATES. THESE NUTRIENTS ARE USED OVER AND OVER WITHIN A CLOSED LOOP (RECIRCULATED) SYSTEM. DURING THE INTIAL PHASE OF CONTMINATED GROUND REMEDIATION RAPID UPTAKE OF THE NUTRIENTS WILL BE EXHIBITED DURING WHICH TIME THEY WILL HAVE TO BE REPLENISHED. DURING THE MIDDLE REMEDIATION PHASE THE NUTRIENTS WILL BEGIN SHOWING UP IN THE RECYCLED WATER AND TO THE EXTENT FOUND, NUTRIENT ADDITION TO THE RECYCLED WATER SHOULD BE REDUCED ACCORDINGLY. DURING THE LAST PHASE OF GROUND REMEDIATION THE EXTRACTED LEVELS OF PHOSPHORUS AND NITRATES CONTINUE TO INCREASE AS A RESULT OF AEROBIC LYSIS. THEREFORE P, NH_3, AND NO_3 SHOULD ALSO BE MONITORED.

WHEN BIOLOGICAL ACTIVITY CEASES, RESIDUAL LEVELS OF P, NH_3 AND NO_3 MIGHT THEN REQUIRE REMOVAL (BY MEMBRANE TREATMENT OR ION EXCHANGE) TO RESTORE THE AQUIFER TO A CONDITION THAT MEETS DRINKING WATER OR OTHER STANDARDS.

PROCESS TREATMENT SCHEM/

WaterSmart Environmental, Inc.
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TITLE: IN-SITU BIOREMEDIATION

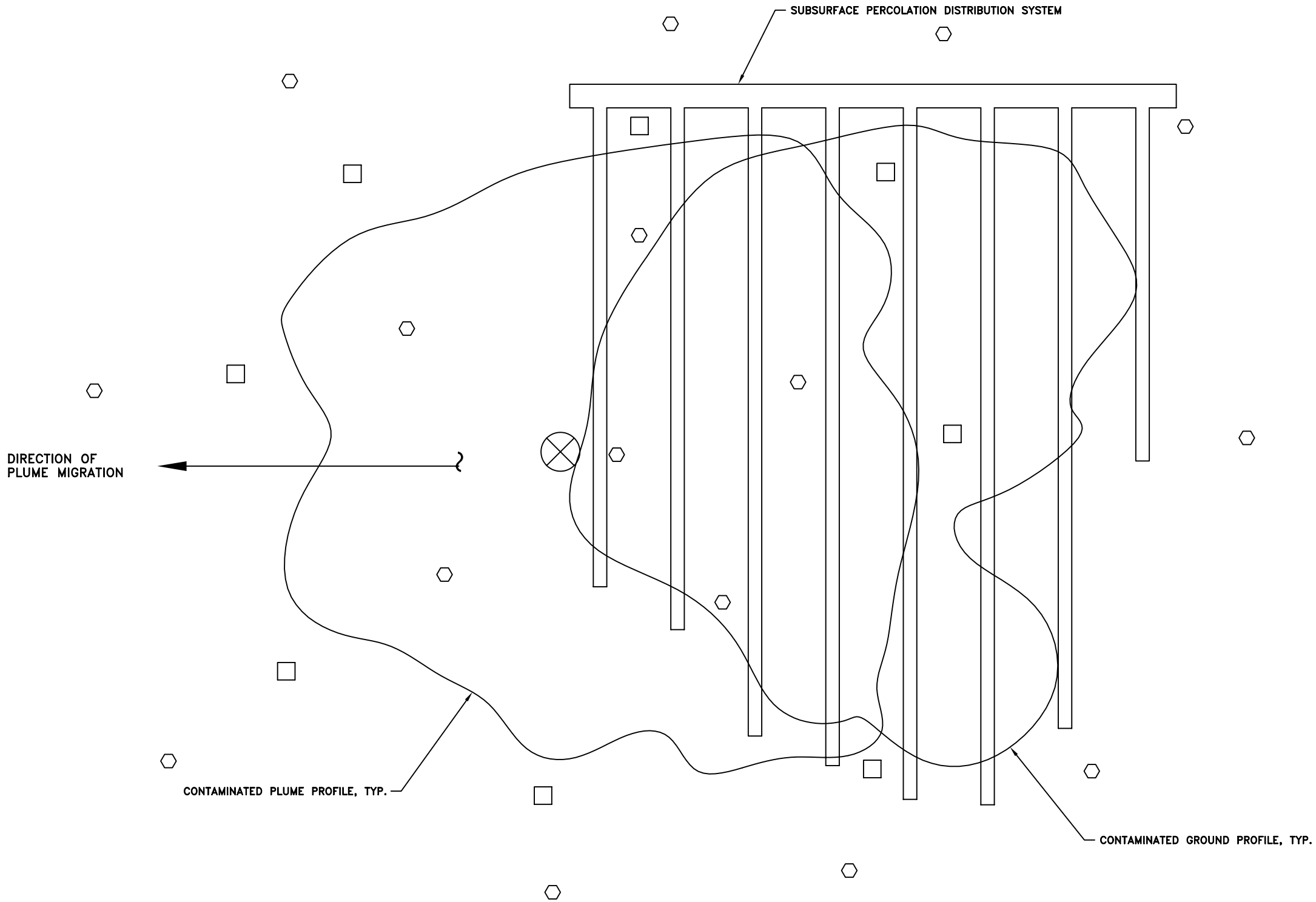
JOB: SIMULTANEOUS GROUND AND GROUNDWATER REMEDIATION

REV.	DATE	DESCRIPTION	BY	CHK

SCALE: NONE | DRAWN: B.E.H. | DWG. NO.: S-1003
DATE: 7/6/96 | CHECKED: C.G.S.

DO NOT SCALE DRAWING. USE DIMENSIONS ONLY.

Plot Date 8-13-97/1500 Plot Scale 1=1 PRODUCED ON AUTOCAD RELEASE 13



LEGEND

- MONITORING WELL
- INJECTION WELL
- EXTRACTION WELL

SITE PLAN

Plot Date 8-13-97/1500 Plot Scale 1=1 PRODUCED ON AUTOCAD RELEASE 13

WaterSmart Environmental, Inc.
Post Office Box 26346
Shawnee Mission, Kansas 66225

TITLE: TYPICAL IN-SITU BIOREMEDIATION PLAN

JOB: SIMULTANEOUS GROUND AND GROUNDWATER REMEDIATION

REV.	DATE	DESCRIPTION	BY	CHK

SCALE: NONE | DRAWN: B.E.H. | DWG. NO.: S-1004
DATE: 7/6/96 | CHECKED: C.G.S.

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