APPENDIX C
POST-SHUTDOWN MONITORED NATURAL ATTENUATION (MNA) EVALUATION FOR THE FRONT VALLEY

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Post-Shutdown Monitored Natural Attenuation (MNA) Evaluation for the Front Valley

This appendix presents an assessment of the monitored natural attenuation (MNA) potential in the groundwater of the Front Valley (FV) at the Chemtronics Site in Swannanoa, Buncombe County, North Carolina (the Site) following shutdown of the existing FV groundwater extraction and treatment system[1]. MNA consists of long-term monitoring of the attenuation of groundwater constituents through natural biotic and abiotic mechanisms. Specifically, this appendix provides a review and evaluation of groundwater data collected following the shutdown (as reported in the Shutdown Report[2]) for general consistency with the pre-groundwater extraction and treatment system shutdown (pre-shutdown) MNA evaluation documented in the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* (FV MNA Report; dated June 30, 2015). This appendix is meant to be viewed alongside of, and in context with, the FV MNA Report and Shutdown Report (i.e., this appendix is not standalone). This appendix focuses solely on MNA within the FV; a similar comparison of pre- and post-shutdown data in the Back Valley (BV) of the Site is provided as **Appendix D** of the *Feasibility Study Report* (FS Report, dated July 2016).

As discussed in the FS Report, the remedial strategy envisioned for the FV is active source mass reduction remediation in select areas of the FV coupled with passive remediation approaches, including MNA. As such, MNA was evaluated as a component of each active remedial alternative considered in the FS Report.

The analysis presented in the previous FV MNA Report indicated ongoing natural attenuation, under pre-shutdown conditions, of the following 10 Site constituents (i.e., termed the MNA Target Compounds [MNA TCs]):

- tetrachloroethene (PCE)
- trichloroethene (TCE)
- cis-1,2-dichloroethane (cis-DCE)
- vinyl chloride (VC)
- 1,2-dichloroethane (1,2-DCA)
- carbon tetrachloride (CT)
- chloroform (CF)
- dichloromethane (DCM)
- perchlorate
- research department explosive (RDX)

[1] The FV groundwater extraction and treatment system shutdown began on September 25, 2014.
[2] Altamont, 2016a. Front Valley and Back Valley Extraction Well and Treatment System Temporary Shutdown Report. Chemtronics Site, Swannanoa, Buncombe County, North Carolina. January 15, 2016.

To document existing evidence of natural attenuation of the MNA TCs, a common "lines of evidence approach" was employed in the FV MNA Report to evaluate: (i) MNA TC concentration trends with distance and time; (ii) supporting geochemical and daughter product evidence; and (iii) direct evidence of natural attenuation. The following FV-specific factors were considered in the pre-shutdown assessment:

- the effect of multiple, small, geographically-distinct areas of interest (AOIs) in the FV on the nature and distribution of Site constituents in groundwater;
- the presence of multiple, individual groundwater plumes, some of which commingle as they migrate down-valley; and
- the influence of ongoing enhanced in situ bioremediation (EISB) pilot test activities completed in multiple areas of the FV on the pre-shutdown MNA assessment.

These factors were also considered during review of the post-shutdown data for the first two lines of evidence (i.e., concentration trends, geochemical conditions) described below. Additional direct evidence of natural attenuation (i.e., the third line of evidence) was not generated via molecular analysis or treatability testing during the shutdown period and therefore was not further considered herein.

As summarized in the following sections, post-shutdown MNA conditions are generally similar to those observed pre-shutdown based on a review of the first two lines of evidence (i.e., concentration trends, geochemical conditions). This is consistent with, and supported by, the prior observation of minimal effects that the shutdown had on groundwater hydraulic conditions, groundwater quality, and general plume geometry in the FV (see the Shutdown Report). Review of post-shutdown data, therefore, further supports that ongoing natural attenuation of the MNA TCs is occurring in FV groundwater and confirms inclusion of MNA as a component of each active remedial alternative evaluated in the FS Report.

Concentration Trends

Comparison of Pre- and Post-Shutdown Concentration Trends in Groundwater

The FV MNA Report included an evaluation of both spatial and temporal concentration trends in groundwater for each MNA TC. Review of pre-shutdown (baseline) concentration trends indicated the following: (i) concentrations of each MNA TC generally decrease with distance in each aquifer zone[3] along the direction of groundwater flow; and (ii) concentrations over time at

[3] Three primary aquifer systems exist beneath the Site: a Surficial Aquifer System (Zone AB), a Transition Zone Aquifer System (Zone CD), and a Bedrock Aquifer System (Zone EF). For a more detailed description, refer to the FV MNA Report.

many locations are declining throughout the plume. These observations are indicative of mass reduction and ongoing natural attenuation in FV groundwater under pre-shutdown conditions.

Monitoring associated with the shutdown program included both pre-shutdown (August/September 2014) and post-shutdown (August/September 2015) sampling at select FV wells screened within each aquifer zone. Pre- and post-shutdown data for MNA TCs are illustrated on **Figures 1a to 3-11b**. In general, post-shutdown MNA TC concentrations in groundwater are relatively consistent with or lower than pre-shutdown concentrations, as discussed further below.

FV-Wide Evaluation

To assess the potential for systemic changes in groundwater beneath the FV, summary statistics for the pre- and post-shutdown data sets from 2014 and 2015, respectively, were prepared, as illustrated on **Figures 1a and 1b**. Review of these data indicates similar or declining concentrations between pre- and post-shutdown[4]. Similarly, the number of locations with MNA TC detections (except for perchlorate, as noted below) was generally similar between pre- and post-shutdown. For perchlorate, the number of locations with detectable levels of perchlorate increased by five. These additional perchlorate detections, however, were low-level (generally J-flagged which in this case means near the reporting limit), below the applicable screening criteria[5], and at locations with sporadic perchlorate detections in the past. Collectively, this evaluation indicates that the MNA TC groundwater plumes (and therefore concentration trends with distance) are relatively stable, consistent with the conclusions of the Shutdown Report.

MNA TC Concentrations in Groundwater Relative to Screening Criteria

Pre- and post-shutdown concentrations of MNA TCs were compared to applicable screening criteria and grouped into "concentration categories" (e.g., less than screening criteria, 1 to 10 times screening criteria, etc.). This evaluation is illustrated in map view on **Figures 2a and 2b** for pre- and post-shutdown data, respectively. The comparison between **Figures 2a and 2b** indicate that 32 of the 45 locations sampled as part of the shutdown monitoring program remained in the same concentration category. As summarized below, eight monitoring locations moved down a concentration category (i.e., concentrations declined), while five locations moved up a category (i.e., concentrations increased), as detailed below:

- decline in concentration category:

[4] For select MNA TCs (e.g., cis-DCE, perchlorate), concentrations were significantly influenced by ongoing EISB pilot testing during the shutdown period (i.e., the observed concentration declines are unrelated to the shutdown).
[5] North Carolina Administrative Code Subchapter 02L Standards (2L Standards), Interim Maximum Allowable Concentration (IMAC) Standards, or for constituents without a 2L or IMAC, risk-based criteria from the *Baseline Risk Assessment* (Altamont, 2015a).

- Zone AB – MW-113-3, MW180-H38AB[6], and SW-151-1;
- Zone CD – MW-1BI, DW-151-1, DW-152-2, and MW192-P41CD; and
- Zone EF – MW177-M44F.

- increase in concentration category:
  - Zone AB – IW-104, IW-151-2, and SW-152-2; and
  - Zone CD – DW-104 and DW-151-2.

For each of the locations with an increase in concentration category and select representative locations with a decline in concentration category, temporal concentration trends are discussed further below in the *Groundwater Concentration Trends with Time* subsection. As discussed further below, the increases at select locations may be due to natural variability (i.e., not related to shutdown), especially when viewed in context of historical data.

In general, the evaluation indicates relative consistency between the pre- and post-shutdown data sets and pre- and post-shutdown groundwater concentration trends with distance.

Groundwater Concentration Trends with Distance

Figures 3-1a to 3-11a and **Figures 3-1b to 3-11b** present MNA TC groundwater concentration trends with distance for the pre- and post-shutdown data, respectively. Note that the pre-shutdown figures are identical to those presented in the FV MNA Report. For Zones AB and CD, each figure (i.e., **Figures 3-1a to 3-10b**) presents spatial trends for a given MNA TC using two approaches, including:

(1) data for select wells along the flow paths relative to the screening criteria; and

(2) average concentrations for select representative wells along seven transects that are roughly perpendicular to groundwater flow (henceforth referred to as transect averages).

The reader is referred to Section 5.1 of the FV MNA Report for additional information on the construction of these figures with respect to generalized flow paths, transects, selection of representative wells along flow paths/transects, annotation with the location of select AOIs, etc. For Zone EF, pre- and post-shutdown trends with distance from the most upgradient Zone EF well (BW-5) are provided on **Figure 3-11a and 3-11b** for each MNA TC, respectively. Note that for wells located within or near pilot test areas, data collected prior to EISB pilot test implementation are displayed on both the pre- and post-shutdown figures for Zones AB, CD, and EF to eliminate the potential use of biased values associated with the influence of EISB pilot testing activities.

[6] Concentration declines at this location are primarily due to EISB pilot test implementation in the B105 area.

Review of concentration versus distance plots indicates that, in general, spatial concentration trends in groundwater are similar pre- and post-shutdown. Concentrations of each MNA TC generally decrease with distance in each aquifer zone along the direction of groundwater flow. As noted in the FV MNA Report, the spatial concentration versus distance trends are influenced by the presence of multiple, geographically-distinct AOIs and/or commingled plumes in the FV. Differences when observed between pre- and post-shutdown are relatively small and are generally localized (e.g., perchlorate in wells IW-151-2 and DW-151-2 near B151 along Transect 4). Historical concentration trends at IW-151-2 and DW-151-2, as discussed in the *Groundwater Concentration Trends with Time* subsection below, indicate that the concentration changes began prior to the shutdown.

Groundwater Concentration Trends with Time

Pre- and post-shutdown data are provided in **Table 1** for select locations in the FV. Locations were selected after review of the data discussed above, and include areas with observed concentration declines (i.e., B113), areas with observed concentration increases for select MNA TCs (i.e., B104 and B151), and select locations hydraulically cross/downgradient of B151 (i.e., near B151, B140, and B152 and the property boundary). **Table 1** indicates that concentration increases post-shutdown, if observed, were relatively small (i.e., typically less than a factor of 2). Such minor changes may be due to natural variability.

Figures 4a to 4c illustrate groundwater concentration versus time trends at the locations listed in **Table 1** for PCE, TCE, 1,2-DCA, CF, perchlorate, and RDX (i.e., constituents considered indicator compounds for the FV). The groundwater concentration versus time trends indicate that concentrations of MNA TCs are generally stable or declining (up to several orders of magnitude) at many locations, consistent with the observations in the FV MNA Report. In fact, a reversal of prior upward concentration trends was observed at MW-113-1 (**Figure 4a**); this is likely indicative of natural attenuation and is unrelated to the shutdown program.

Concentration increases in groundwater for perchlorate and/or RDX were observed near the B151 area (i.e., SW-151-2, IW-151-2, and DW-151-2) despite concentration declines at most locations in this area for PCE, TCE, 1,2-DCA, and CF (**Figure 4b**). Increasing trends for perchlorate and/or RDX began at select locations in this area prior to the shutdown, indicating the need for continued groundwater monitoring to assess these concentration trends. Cross/downgradient of B151, perchlorate and RDX levels have remained relatively stable and/or declined (**Figure 4c**).

At MW154-O44C (a property boundary well), the current concentration of RDX in groundwater (0.5 micrograms per liter [µg/L]) is slightly greater than the applicable screening criteria (0.32 µg/L). MW154-O44C is the only FV property boundary well with concentrations currently above applicable screening criteria. As shown on **Figure 4c** however, RDX concentrations have

been declining at this location, similar to concentration declines at this location for perchlorate and, historically, TCE. In general, evaluation of post-shutdown concentration trends with time support the conclusions of the FV MNA Report that concentrations over time at many locations are declining throughout the groundwater plume.

Bulk Attenuation Rate Estimation

This section discusses estimation of bulk attenuation rates utilizing post-shutdown data for the FV. In comments on the MNA assessment for the BV, the Agencies requested estimation of MNA attenuation rates[7]. Geosyntec Consultants of NC, P.C. (Geosyntec) proposed use of distance-based rates, as recommended by Agency guidance[8], for both Zones AB and CD in the FV and BV during the September 30, 2015, technical meeting with the Agencies in Asheville, North Carolina. Two approaches based on concentration versus distance plots were proposed by Geosyntec, including:

- a qualitative approach, consistent with guidance documents[9,10], in which changes in concentration versus distance trends from year to year are visually assessed; and
- a quantitative approach, consistent with guidance documents[9,11], in which bulk attenuation rates (k) are estimated and compared from year to year.

Geosyntec completed the qualitative approach using the trend analysis (detailed in the *Groundwater Concentration Trends with Distance* subsection above) and the qualitative approach is discussed below.

Bulk attenuation rates were estimated for seven MNA TCs (PCE, TCE, cis-DCE, 1,2-DCA, CF, perchlorate, and RDX) following the approach outlined by EPA (2002)[11]. Bulk attenuation rates were not estimated for VC, CT, and DCM, as these constituents are not widely distributed in the FV (as discussed in the FV MNA Report). The approach to estimate bulk attenuation rates consisted of the following general steps, including:

- plotting and performing regression analysis on concentration versus distance plots for Zones AB and CD for each MNA TC (**Figure 5a to 5d**); and

[7] EPA, 2015. Comments on the April 2015 Assessment of Monitored Natural Attenuation (MNA) Potential in the Back Valley for the Chemtronics Superfund Site, Swannanoa, Buncombe County, North Carolina. August 6, 2015.
[8] EPA, 1999. Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites. OSWER Directive 9200.4-17P. April, 1999.
[9] EPA, 1998. Monitoring and Assessment of In-Situ Biocontainment of Petroleum Contaminated Ground-Water Plumes. EPA/60/SR-98/0220. July 1998.
[10] AFCEE, 2000. Designing Monitoring Programs to Effectively Evaluation the Performance of Natural Attenuation. January 2000.
[11] EPA, 2002. Calculation and Use of First-Order Rate Constants for Monitored Natural Attenuation Studies. EPA/540/S-02/500. November 2002.

- calculating the bulk attenuation rate as the product of the absolute value of the regression slope for each MNA TC by its respective contaminant velocity (v_c); estimated bulk attenuation rates are summarized in **Table 2**.

Each step is further described below.

Figures 5a to 5d show regression curves (with associated regression equations and correlation coefficients) of post-shutdown transect average groundwater concentrations versus distance for seven MNA TCs. Use of transect averages was proposed to the Agencies during the technical meeting discussed above, and is consistent with the conclusion in the FV MNA Report that average transect concentrations, in general, provided a useful approximation of the overall spatial trends that are representative of those observed for the individual wells located along the transect. Regression analysis of the FV spatial trends is somewhat complicated by the fact that there are multiple, geographically-distinct AOIs and/or commingled plumes in the FV (as discussed above). Therefore, professional judgement was used during the regression analysis to exclude select data points (as noted on **Figures 5a to 5d**), considering MNA TC distribution, plume maps, the understanding of FV hydrogeology, site history, effects of ongoing pilot testing, etc. For perchlorate and RDX, multiple regression analyses were performed to represent various regions of the FV, consistent with the groundwater plumes for these constituents (see, for example, Altamont [2015b][12]). The resulting value for each regression slope for each MNA TC and aquifer zone is summarized in **Table 2**.

Estimates for v_c by MNA TC and aquifer zone were calculated by dividing the estimated groundwater velocity (v_{gw}) for each zone by the respective retardation factor (R) as follows:

$$v_c = \frac{v_{gw}}{R} \qquad (1)$$

v_{gw} for each zone was calculated per the following:

$$v_{gw} = \frac{K\,i}{n} \qquad (2)$$

where:

- K is the hydraulic conductivity, estimated to be 0.5 foot per day (ft/day) for Zone AB and 1 ft/day for Zone CD (Altamont, 2016b[13]);

[12] Altamont, 2015b. 2014 Annual Assessment Monitoring Report. Chemtronics Site, Swannanoa, Buncombe County, North Carolina. April 8, 2015.
[13] Altamont, 2016b. Refined Hydrogeologic Conceptual Site Model Focused on the Back Valley. Chemtronics Site, Swannanoa, Buncombe County, North Carolina. February 19, 2016.

- i is the hydraulic gradient, estimated to be 0.034 foot/foot (ft/ft) for Zone AB and 0.028 ft/ft for Zone CD based on post-shutdown potentiometric data as presented in the Shutdown Report; and
- n is the soil porosity, assumed to be 0.21 for Zone AB and 0.3 for Zone CD (Altamont, 2016b[13]).

R for each MNA TC was calculated as follows:

$$R = 1 + \frac{K_{oc}\, f_{oc}\, \rho_b}{n} \qquad (3)$$

where:

- K_{oc} is the organic carbon-water partition coefficient for each MNA TC, as summarized in **Table 2**;
- f_{oc} is the fraction of organic carbon, which was assumed to be 0.002 kilogram/kilogram, consistent with EPA guidance[14];
- ρ_b is the bulk density of soil, which was assumed to be 1.48 kg per liter; and
- n is as stated above.

Values for Koc, foc, and ρ_b are consistent with those utilized in the *Baseline Risk Assessment*[15]. Estimates for v_c, calculated as outlined above, are provided in **Table 2**.

Estimated bulk attenuation rates ranged from approximately 4×10^{-5} to 3.5×10^{-5} day^{-1} in Zone AB and from approximately 5.5×10^{-5} to 8×10^{-4} day^{-1} for Zone CD (**Table 2**). In general, estimated bulk attenuation rates were slightly higher in Zone CD than Zone AB, consistent with the prevalence of more anaerobic conditions in deeper aquifer zones (MNA TCs are more amenable to anaerobic transformation as discussed in the FV MNA Report). Estimated bulk attenuation rates were generally higher for perchlorate and RDX compared to those of the other MNA TCs.

The qualitative and/or quantitative approach described and employed herein may be used, in part, as one of many metrics to assess the effectiveness of natural attenuation (in conjunction with other remedial measures) to meet remedial objectives for the Site.

[14] EPA, 1996. Soil Screening Guidance: User's Guide. Second Edition. EPA/540/R-96-018. Publication 9355.4-23. July 1996.
[15] Altamont, 2015a. Final Remedial Investigation Report. Chemtronics Site, Swannanoa, Buncombe County, North Carolina. December 21, 2015.

Geochemical Conditions

The FV MNA Report included an evaluation of select geochemical parameters to assess if pre-shutdown (baseline) geochemical conditions were conducive to natural attenuation processes. The pre-shutdown MNA assessment indicated that geochemical conditions (e.g., redox, pH, common electron acceptors/donors) were generally favorable for natural attenuation of MNA TCs via aerobic processes in each aquifer zone (including cometabolic aerobic processes), although conditions conducive to anaerobic transformation processes were also present in select locations throughout the FV (e.g., negative oxidation-reduction potential [ORP], detection of reduced species [i.e., methane, sulfide, dissolved iron and manganese]). While pre-shutdown data generally indicated aerobic groundwater in the FV, historical data indicated redox fluctuations at select locations, which may allow for both aerobic (metabolic or cometabolic) and anaerobic transformation processes to occur naturally.

Monitoring associated with the shutdown program included both pre-and post-shutdown field measurement of select geochemical parameters (i.e., pH, ORP, and dissolved oxygen [DO]) at select FV locations. **Table 3** summarizes pH, ORP, and DO data for FV locations sampled pre- and post-shutdown. In general, the post-shutdown geochemical data are consistent with the pre-shutdown data. The following general conclusions are based on a review of the geochemical data:

- post-shutdown pH data are similar to pre-shutdown data (i.e., groundwater pH is typically between 5 and 7 [Zones AB and CD] or between 6 and 8 [Zone EF]; pH tends to increase with depth [for example, see data for the MW-1 well cluster]);
- consistent with pre-shutdown data, post-shutdown ORP data indicate predominance of aerobic conditions (i.e., positive ORP) in each aquifer zone throughout most of the FV;
- ORP fluctuations between aerobic/anaerobic conditions were observed at select locations (e.g., MW255-K45EF) consistent with prior redox fluctuations noted in the FV; and
- post-shutdown DO data are generally consistent with pre-shutdown data, although there is more variability in pre- and post-shutdown DO data compared to the ORP and pH data sets (which is common for DO vs. ORP measurements).

Review of the pre- and post-shutdown data also indicates that geochemical influences resulting from the ongoing EISB pilot test activities are observed in the FV. For example, the pH increases and/or ORP/DO declines which are observed between pre- and post-shutdown at MW-147-1, MW180-H38AB, and/or MW183-O39CD are most likely related to ongoing EISB pilot test activities.

Collectively, review of the post-shutdown geochemical data generally supports the prior geochemical assessment presented in the FV MNA Report.

Conclusions

As summarized above, post-shutdown MNA groundwater conditions are generally similar to those observed pre-shutdown based on review of concentration trends and geochemical conditions. This is consistent with, and supported by, the prior observation of minimal effects that the shutdown had on groundwater hydraulic conditions, groundwater quality, and general plume geometry in the FV (see the Shutdown Report).

Collectively, the observations described herein and in the FV MNA Report indicate ongoing natural attenuation of the MNA TCs in FV groundwater as they migrate in the direction of groundwater flow. The pre- and post-shutdown MNA assessments for the FV further support evaluation of MNA as a component of each active remedial alternative in the FS Report.

TABLES

Table 1
Pre- and Post-Shutdown MNA Target Compound Data for Select Front Valley Wells
Chemtronics Site, Swannanoa, NC

		Category	Up-Valley	Up-Valley	Mid-Valley	Mid-Valley	Mid-Valley	Mid-Valley	Mid-Valley	Mid-Valley
		Area	B113	B113	B104-145	B104-145	B104-145	B104-145	B104-145	B104-145
		Zone	AB	AB	AB	AB	AB	AB	CD	CD
		Well	MW-113-3	MW-113-3	MW-104-1	MW-104-1	IW-104	IW-104	DW-104	DW-104
Parameter	Screening Criteria (µg/L)	Date	9/4/2014	8/28/2015	9/9/2014	8/27/2015	9/9/2014	8/27/2015	9/9/2014	8/5/2015 9/24/2015
Tetrachloroethene (PCE)	0.7		**0.3 J**	0.1 U	**0.1 J**	**0.1 J**	**2.4**	**3.8**	**48**	**74**
Trichloroethene (TCE)	3		0.1 U	0.1 U	0.1 U	0.1 U	**26**	**36**	**280**	**350**
cis-1,2-Dichloroethene (cis-DCE)	70		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.5 U	0.5 U
Vinyl Chloride (VC)	0.03		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.5 U	0.5 U
1,2-Dichloroethane (1,2-DCA)	0.4		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	**1 J**	**0.8 J**
Carbon Tetrachloride (CT)	0.3		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	**0.6 J**	**0.6 J**
Chloroform (CF)	70		0.1 U	**0.3 J**	**0.3 J**	**0.4 J**	**15**	**17**	**110**	**120**
Dichloromethane (DCM)	5		0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	1 U	1 U
Perchlorate	2		**24**	**4.2**	**29**	**36**	**1.7**	**1.1**	**0.3 J**	**0.4 J**
Research Department Explosive (RDX)	0.32		**14**	0.2 U	0.2 U	**1.8**	0.2 U	0.2 U	0.22 U	**0.34 J**

MNA - monitored natural attenuation.
Concentrations are in micrograms per liter (µg/L).
Screening criteria - North Carolina 2L or IMAC groundwater standards. For constituents without a 2L/IMAC, risk-based criteria from the *Final Remedial Investigation Report, Baseline Risk Assessment (Appendix L)* (Altamont, 2015a) were used.
Detected constituents are in **bold**.
Concentrations greater than the respective screening criteria are shadded in yellow.

Table 1
Pre- and Post-Shutdown MNA Target Compound Data for Select Front Valley Wells
Chemtronics Site, Swannanoa, NC

		Category	Down-Valley	Down-Valley	Down-Valley	Down-Valley	Down-Valley	Down-Valley	Down-Valley	Down-Valley	Down-Valley	Down-Valley	Down-Valley	Down-Valley
		Area	B150-151	B150-151	B150-151	B150-151	B150-151	B150-151	B150-151	B150-151	B150-151	B150-151	B150-151	B150-151
		Zone	AB	AB	AB	AB	CD	CD	AB	AB	AB	AB	CD	CD
		Well	SW-151-1	SW-151-1	IW-151-1	IW-151-1	DW-151-1	DW-151-1	SW-151-2	SW-151-2	IW-151-2	IW-151-2	DW-151-2	DW-151-2
Parameter	Screening Criteria (µg/L)	Date	9/4/2014	8/25/2015	9/3/2014	8/25/2015	9/8/2014	8/26/2015	9/4/2014	8/25/2015	9/3/2014	8/25/2015	9/8/2014	8/26/2015
Tetrachloroethene (PCE)	0.7		**4.2**	**0.2 J**	**23**	**7.6**	**74**	**49**	**0.5 J**	**3**	**11**	**3.8**	**4.8**	**1.1**
Trichloroethene (TCE)	3		**15**	**0.6**	**84**	**22**	**240**	**180**	**0.1 J**	**0.2 J**	**24**	**18**	**20**	**13**
cis-1,2-Dichloroethene (cis-DCE)	70		0.1 U	0.1 U	**0.1 J**	0.1 U	0.5 U	0.5 U	0.1 U	**0.2 J**	0.1 U	0.1 U	**0.1 J**	**0.1 J**
Vinyl Chloride (VC)	0.03		0.1 U	0.1 U	0.1 U	0.1 U	0.5 U	0.5 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
1,2-Dichloroethane (1,2-DCA)	0.4		0.1 U	0.1 U	**0.5 J**	**0.2 J**	**0.8 J**	**0.8 J**	0.1 U	0.1 U	**0.2 J**	**0.1 J**	**0.1 J**	**0.1 J**
Carbon Tetrachloride (CT)	0.3		0.1 U	0.1 U	**0.6**	**0.2 J**	**2 J**	**1.2 J**	0.1 U	0.1 U	**0.5 J**	**0.2 J**	**0.2 J**	0.1 U
Chloroform (CF)	70		**16**	**0.6**	**91**	**26**	**250**	**190**	0.1 U	**0.1 J**	**46**	**22**	**24**	**5.7**
Dichloromethane (DCM)	5		0.2 U	0.2 U	0.2 U	0.2 U	1 U	1 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
Perchlorate	2		**0.3 J**	**0.93 J**	**0.77 J**	**1.2**	**1.1**	**1**	**0.39 J**	**0.73 J**	**86**	**220**	**180**	**290**
Research Department Explosive (RDX)	0.32		0.2 U	0.2 U	**1.9**	**1.2**	**5.1**	**4.3**	**15**	**22**	**18**	**20**	**25**	**26**

MNA - monitored natural attenuation.
Concentrations are in micrograms per liter (µg/L).
Screening criteria - North Carolina 2L or IMAC groundwater standards. For constituents without a 2L/IMAC, risk-based criteria from the *Final Remedial Investigation Report, Baseline Risk Assessment (Appendix L)* (Altamont, 2015a) were used.
Detected constituents are in **bold**.
Concentrations greater than the respective screening criteria are shadded in yellow.

Table 1
Pre- and Post-Shutdown MNA Target Compound Data for Select Front Valley Wells
Chemtronics Site, Swannanoa, NC

		Category	Down-Valley	Down-Valley	Down-Valley	Down-Valley	Property Boundary	Property Boundary
		Area	B140	B140	B152	B152	Property Boundary	Property Boundary
		Zone	CD	CD	CD	CD	CD	CD
		Well	MW147-N42C	MW147-N42C	MW221-O40CD	MW221-O40CD	MW154-O44C	MW154-O44C
Parameter	Screening Criteria (µg/L)	Date	9/2/2014	8/24/2015	9/12/2014	9/10/2015	9/2/2014	8/24/2015
Tetrachloroethene (PCE)	0.7		**14**	**12**	**17**	**13**	0.1 U	0.1 U
Trichloroethene (TCE)	3		**19**	**19**	**57**	**46**	0.1 U	0.1 U
cis-1,2-Dichloroethene (cis-DCE)	70		**0.3 J**	**0.4 J**	**0.8**	**0.8**	0.1 U	0.1 U
Vinyl Chloride (VC)	0.03		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
1,2-Dichloroethane (1,2-DCA)	0.4		**0.3 J**	**0.2 J**	**0.4 J**	**0.3 J**	0.1 U	0.1 U
Carbon Tetrachloride (CT)	0.3		**0.3 J**	**0.3 J**	**1.1**	**0.7**	0.1 U	0.1 U
Chloroform (CF)	70		**67**	**71**	**93**	**65**	0.1 U	0.1 U
Dichloromethane (DCM)	5		0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
Perchlorate	2		**1.9**	**2.1**	**190**	**200**	**0.61 J**	**0.34 J**
Research Department Explosive (RDX)	0.32		**0.76**	**1.7**	**13**	**14**	**0.91**	**0.5**

MNA - monitored natural attenuation.
Concentrations are in micrograms per liter (µg/L).
Screening criteria - North Carolina 2L or IMAC groundwater standards. For constituents without a 2L/IMAC, risk-based criteria from the *Final Remedial Investigation Report, Baseline Risk Assessment (Appendix L)* (Altamont, 2015a) were used.
Detected constituents are in **bold**.
Concentrations greater than the respective screening criteria are shadded in yellow.

Table 2
Estimated Bulk Attenuation Rates for Select Front Valley MNA Target Compounds
Chemtronics Site, Swannanoa, North Carolina

MNA Target Compound	K_{oc} (L/kg) [2]	Retardation Factor, R [3]		Contaminant Velocity, v_c [4,5] (ft/day)		Regression Slope of Transect Average Concentration vs. Distance Plots (ft^{-1}) [6]		Bulk Attenuation Rate Constant, k (day^{-1}) [7]	
		Zone AB	Zone CD	Zone AB	Zone CD	Zone AB	Zone CD	Zone AB	Zone CD
Tetrachloroethene (PCE)	1.60E+02	3.3	2.6	0.025	0.036	-1.67E-03	-1.50E-03	4.15E-05	5.43E-05
Trichloroethene (TCE)	1.70E+02	3.4	2.7	0.024	0.035	-4.00E-03	-2.14E-03	9.53E-05	7.46E-05
cis-1,2-Dichloroethene (cis-DCE)	3.60E+01	1.5	1.4	0.054	0.069	-1.66E-03	-1.07E-03	8.91E-05	7.37E-05
1,2-Dichloroethane (1,2-DCA)	1.70E+01	1.2	1.2	0.065	0.080	-2.39E-03	-4.61E-03	1.56E-04	3.68E-04
Chloroform (CF)	4.00E+01	1.6	1.4	0.052	0.067	-3.26E-03	-3.60E-03	1.69E-04	2.41E-04
Perchlorate	N/A	1.0	1.0	0.081	0.093	-4.06E-03	-1.08E-03	3.29E-04	1.01E-04
						-2.66E-03	-4.05E-03	2.15E-04	3.78E-04
						N/A	-8.89E-03	N/A	8.30E-04
Research Department Explosive (RDX)	7.20E+00	1.1	1.1	0.073	0.087	-4.53E-03	-2.77E-03	3.33E-04	2.41E-04
						-4.75E-03	-5.14E-03	3.49E-04	4.48E-04

Notes:
1. MNA - Monitored Natural Attenuation.
2. K_{oc} - organic carbon-water partition coefficient; values obtained from the *Final Remedial Investigation Report, Baseline Risk Assessment* (Appendix L; Altamont, 2015a).
3. Retardation factors for each constituent and aquifer zone were calculated using: R=1+[(Koc*foc*ρb)/n], where foc=0.002 kg/kg, ρb=1.48 kg/L, and n=0.21 (Zone AB) and n=0.3 (Zone CD). R=1 was assumed for perchlorate. foc (fraction of organic carbon in soil) and ρb (bulk density) values obtained from the *Final Remedial Investigation Report, Baseline Risk Assessment* (Appendix L; Altamont, 2015a). n (porosity) values obtained from the *Refined Hydrogeologic Conceptual Site Model* (Altamont, 2016b), assuming values estimated for the Back Valley are representative for the Front Valley.
4. Contaminant velocity, in feet per day (ft/day), of each constituent and aquifer zone was calculated using: vc=vgw/R, where vgw is as described in the following note and R is as shown in the table.
5. Groundwater velocity (v_{gw}) of each aquifer zone was calculated using: v_{gw} = K*i/n, where K = 0.5 ft/day (Zone AB) and 1 ft/day (Zone CD), i = 0.034 ft/ft (Zone AB) and 0.028 ft/ft (Zone CD), and n is as stated above in Note 3. K (hydraulic conductivity) values obtained from the *Refined Hydrogeologic Conceptual Site Model* (Altamont, 2016b), assuming values estimated for the Back Valley are representative for the Front Valley. i (hydraulic gradient) values obtained from the Shutdown Report (Altamont, 2016a).
6. As shown on Figures 5a to 5d.
7. k (bulk attenuation rate constant) calculated using: k = - (Regression Slope) * v_c.
8. L - Liter.
9. kg - kilogram.
10. ft - foot.
11. N/A - not applicable.

Table 3
Comparison of Pre- and Post-Shutdown Field Parameter Data for the Front Valley[1]
Chemtronics Site, Swannanoa, NC

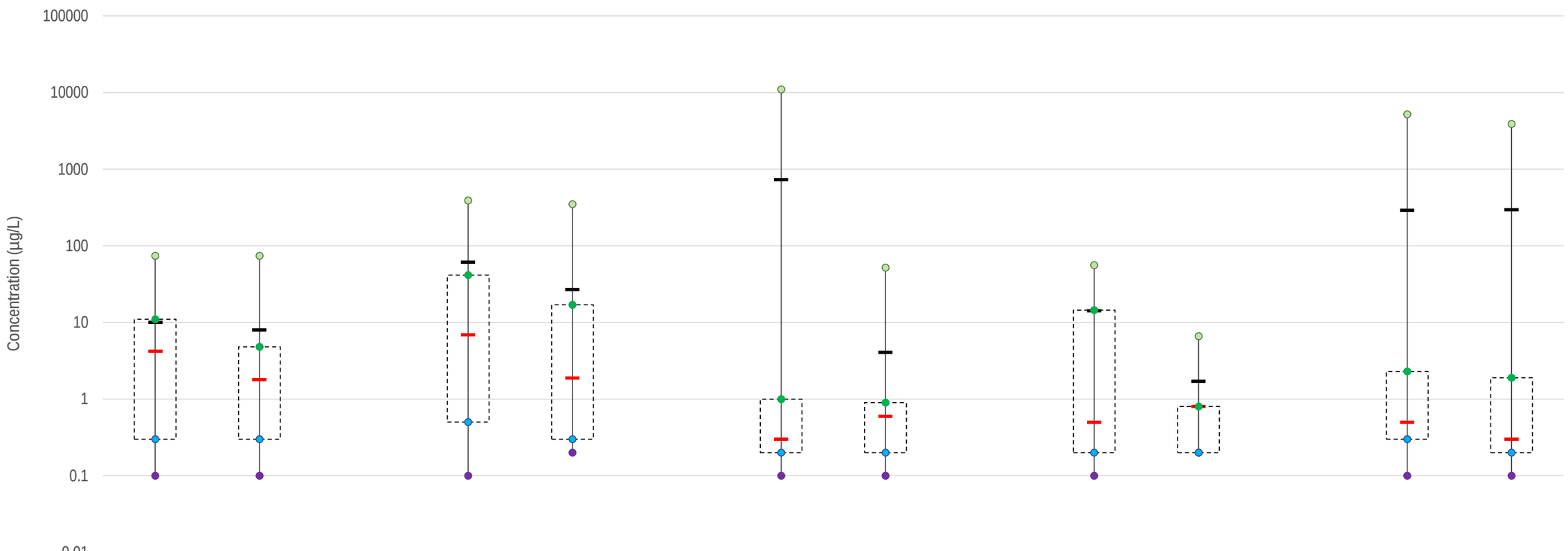
Legend[2]	pH	ORP (mV)	DO (mg/L)
	> 8	> 50	> 4
	6 to 8	50 to 0	2 to 4
	5 to 6	0 to -50	1 to 2
	< 5	< -50	< 1

Location	Zone	pH		ORP (mV)		DO (mg/L)	
		Pre-Shutdown (2014)	Post-Shutdown (2015)	Pre-Shutdown (2014)	Post-Shutdown (2015)	Pre-Shutdown (2014)	Post-Shutdown (2015)
MW-113-3	AB	5.22	5.56	280.2	225.1	1.22	3.69
MW-147-1		5.95	6.83	201.6	-54.2	3.50	0.41
SW-2		5.66	5.67	218.9	286.7	9.48	7.78
MW180-H38AB		6.35	7.10	-172.6	-86.5	0.27	0.52
M85L-10		6.05	6.08	-32.3	11.8	0.59	0.22
M85L-4		5.33	5.79	315.9	232.0	1.47	5.60
MW-1S		6.15	6.48	-14.7	58.9	1.60	2.94
IW-104		5.13	5.45	348.4	330.1	9.00	8.11
MW-104-1		4.26	4.61	393.4	375.3	6.93	5.96
IW-151-1		5.73	5.63	210.6	302.1	4.64	3.79
SW-151-1		5.04	5.08	336.1	337.1	1.68	0.39
IW-151-2		5.82	5.74	214.9	292.7	3.39	3.84
SW-151-2		5.13	5.30	338.2	315.1	4.37	0.48
SW-152-2		5.23	5.56	373.4	315.9	5.70	4.35
MW158-N44A		6.20	6.40	-59.5	-10.0	1.03	0.36
BW-4	CD	6.65	6.65	37.5	66.5	2.83	0.60
MW237-I37CD		5.88	5.88	170.1	222.9	2.66	2.29
DW-139		5.70	6.04	168.8	242.8	4.56	4.26
MW-1BI		6.88	6.94	-36.2	-14.0	0.76	3.04
DW-104		5.11	5.88	332.8	147.0	6.31	5.86
DW-151-1		5.58	5.81	120.2	248.9	3.88	3.28
DW-151-2		5.63	5.77	220.1	271.1	6.87	5.28
DW-152-2		5.59	5.76	178.9	248.3	4.27	2.06
MW144-M43C		6.11	6.15	186.9	214.5	8.70	5.22
MW183-O39CD		5.83	6.64	217.9	-90.2	5.94	0.72
MW221-O40CD		5.82	5.70	145.2	276.1	6.77	5.96
MW147-N42C		5.58	5.70	220.4	295.1	5.13	3.04
MW193-Q40CD		6.15	6.19	153.8	195.7	0.69	0.37
MW157-M44C		6.04	6.11	207.6	249.7	8.82	5.37
MW159-L45C		6.03	6.01	196.9	271.2	9.21	7.84
MW161-K46C		5.41	5.88	225.7	258.2	10.28	6.33
MW177-M44D		7.96	7.92	3.2	129.6	0.78	0.77
MW192-P41CD		6.48	6.57	-81.2	-20.4	0.41	0.39
MW155-P43C		5.83	6.07	349.1	239.4	2.47	0.99
MW154-O44C		6.37	5.94	173.2	268.3	0.39	0.27
MW174-F38E	EF	6.38	6.52	91.5	163.7	2.56	2.02
BW-5		7.93	7.70	72.8	122.1	8.83	4.52
MW-1BD		6.97	7.24	-72.5	36.19	0.89	1.31
MW229-L41EF		7.16	7.03	135.3	146.9	5.14	4.40
MW175-Q40E		6.02	6.02	157.6	226.8	6.00	5.39
MW175-Q40F		5.72	6.16	198.3	216.6	3.49	2.05
MW177-M44F		7.71	7.70	-40.9	131.3	2.15	1.16
MW202-P45EF		7.32	7.60	-52.2	-51.4	3.03	1.36
MW204-L45EF		6.99	7.25	-11.6	-35.9	2.23	1.12
MW222-K46EF		7.36	7.21	40.6	-2.3	3.44	0.74

Notes:

1. Pre- and post-shutdown samples collected in August/September 2014 and August/September 2015, respectively, in accordance with the *Revised Work Plan for Temporary Shutdown of the Front and Back Valley Extraction Wells and Treatment Systems* (Altamont, 2014).
2. Shading correlates with colors used to display field parameter data in the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* (Geosyntec, 2015).
3. ORP - oxidation-reduction potential.
4. mV - millivolt.
5. DO - dissolved oxygen.
6. mg/L - milligrams per liter.

FIGURES



	n=25 PCE (Pre)	n=23 PCE (Post)		n=27 TCE (Pre)	n=27 TCE (Post)		n=15 cis-DCE (Pre)	n=15 cis-DCE (Post)		n=4 VC (Pre)	n=5 VC (Post)		n=24 1,2-DCA (Pre)	n=23 1,2-DCA (Post)
Minimum	0.1	0.1		0.1	0.2		0.1	0.1		0.1	0.2		0.1	0.1
Maximum	74	74		390	350		11000	52		56	6.6		5200	3900
Average	10.1	8		61.1	26.9		735	4.1		14.3	1.7		290	298
Median	4.2	1.8		6.9	1.9		0.3	0.6		0.5	0.8		0.5	0.3
25th%	0.3	0.3		0.5	0.3		0.2	0.2		0.2	0.2		0.3	0.2
75th%	11	4.8		41.5	17		1	0.9		14.5	0.8		2.3	1.9

Notes:

1. MNA TCs - Monitored Natural Attenuation Target Compounds.
2. Pre- and post-shutdown samples were collected in August/September 2014 and August/September 2015, respectively, from 45 Front Valley Zone AB, Zone CD and Zone EF wells. Summary statistics are based on detected constituents (i.e., non-detects were not included in the calculation of summary statistics). Note that dichloromethane (DCM), a MNA TC, was non-detect at each pre-/post-shutdown location; therefore, summary statistics are not provided for DCM.
3. µg/L – micrograms per liter.
4. "n" is the number of locations sampled in the pre-/post-shutdown events with a detection for the respective MNA TC.
5. MNA TC abbreviations:
PCE - tetrachloroethene
TCE - trichloroethene
cis-DCE - 1,2-cis-dichloroethene
VC - vinyl chloride
1,2-DCA - 1,2-dichloroethane
6. Concentrations of select MNA TCs (e.g., cis-DCE) were substantially influenced by ongoing enhanced in situ bioremediation (EISB) pilot testing during the shutdown period.

Comparison of Pre- and Post-Shutdown Concentrations for PCE, TCE, cis-DCE, VC, and 1,2-DCA in the Front Valley
Chemtronics Site, Swannanoa, North Carolina

Geosyntec consultants

Figure 1a

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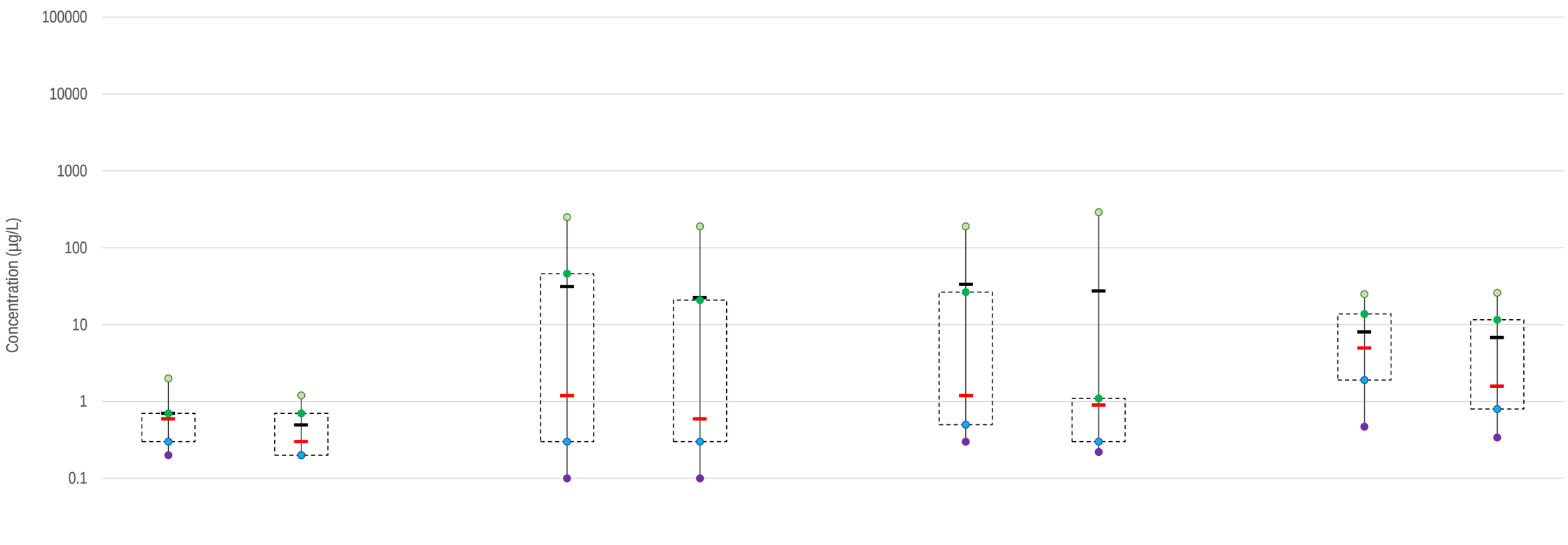

	n=8 CT (Pre)	n=7 CT (Post)		n=25 CF (Pre)	n=26 CF (Post)		n=23 Perchlorate (Pre)	n=28 Perchlorate (Post)		n=14 RDX (Pre)	n=14 RDX (Post)
Minimum	0.2	0.2		0.1	0.1		0.3	0.22		0.47	0.34
Maximum	2	1.2		250	190		190	290		25	26
Average	0.7	0.5		31.6	22.6		33.6	27.4		8	6.8
Median	0.6	0.3		1.2	0.6		1.2	0.9		5	1.6
25th%	0.3	0.2		0.3	0.3		0.5	0.3		1.9	0.8
75th%	0.7	0.7		46	20.8		26.5	1.1		13.8	11.6

Notes:

1. MNA TCs - Monitored Natural Attenuation Target Compounds.
2. Pre- and post-shutdown samples were collected in August/September 2014 and August/September 2015, respectively, from 45 Front Valley Zone AB, Zone CD and Zone EF wells. Summary statistics are based on detected constituents (i.e., non-detects were not included in the calculation of summary statistics). Note that dichloromethane (DCM), a MNA TC, was non-detect at each pre-/post-shutdown location; therefore, summary statistics are not provided for DCM.
3. µg/L – micrograms per liter.
4. "n" is the number of locations sampled in the pre-/post-shutdown events with a detection for the respective MNA TC.
5. MNA TC abbreviations:
CT - carbon tetrachloride CF - chloroform RDX - Research Department Explosive
6. Concentrations of select MNA TCs (e.g., perchlorate) were substantially influenced by ongoing enhanced in situ bioremediation (EISB) pilot testing during the shutdown period.

Comparison of Pre- and Post-Shutdown Concentrations for CT, CF, Perchlorate, and RDX in the Front Valley
Chemtronics Site, Swannanoa, North Carolina

Geosyntec consultants

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Figure 1b

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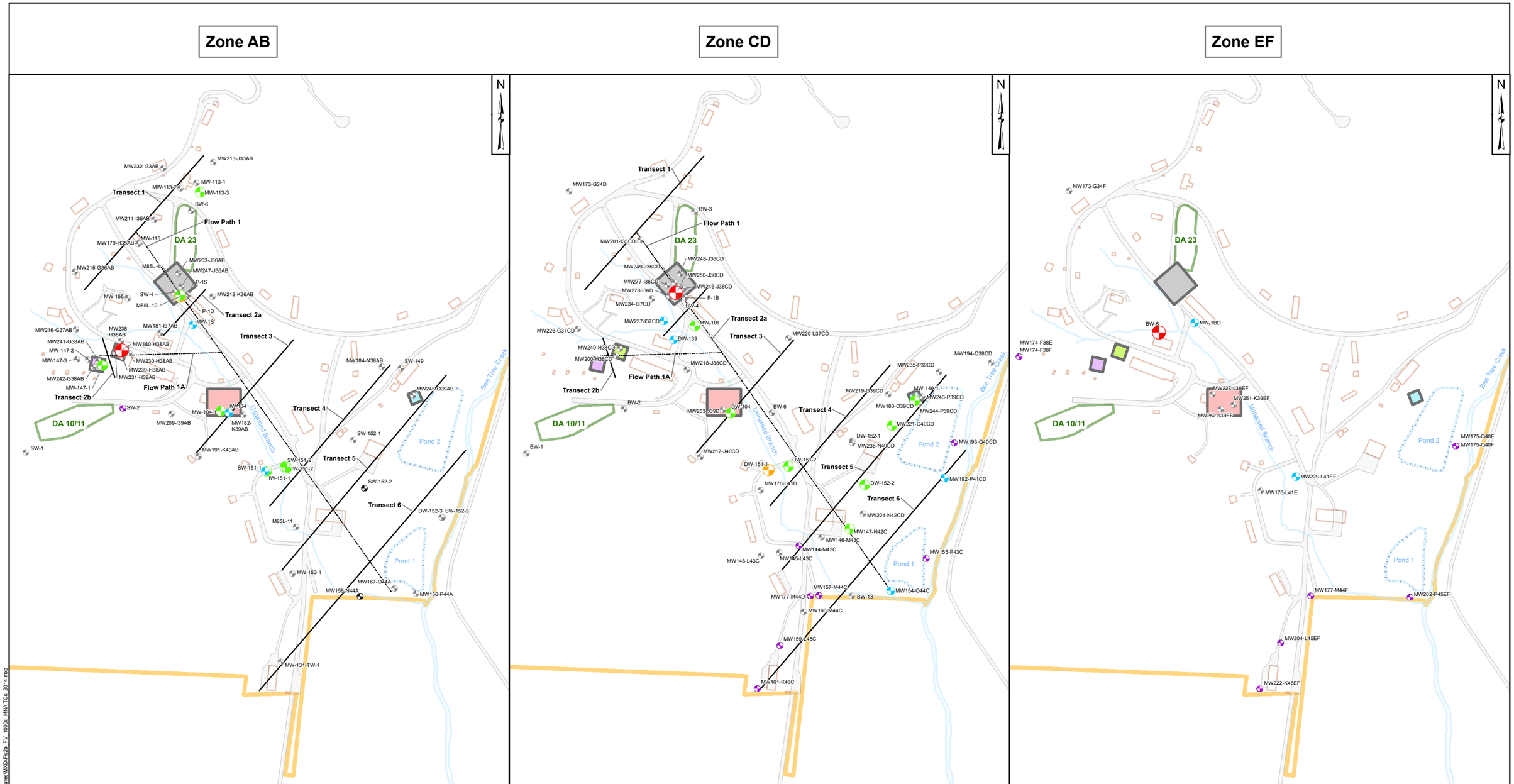

MNA Target Compounds

- Not Sampled
- Non-Detect
- MNA Transect
- Generalized Flow Path

- < Screening Criteria
- 1 to 10x Screening Criteria
- 10 to 100x Screening Criteria
- 100 to 1000x Screening Criteria
- >1000x Screening Criteria

- Disposal Area (DA)
- Stream
- Pond
- Road
- Existing or Former Building Area
- Chemtronics Property Boundary

Ongoing Pilot Test Area (PTA, Note 7)

- B105-139 PTA
- B147 PTA
- B149 PTA
- DA 23/B116 PTA
- B104 - 145 PTA

Notes:
1. MNA - monitored natural attenuation.
2. Screening criteria - North Carolina 2L or IMAC groundwater standards. For constituents without a 2L/IMAC, risk-based criteria from the *Final Remedial Investigation Report, Baseline Risk Assessment (Appendix L)* (Altamont, 2015a) were used.
3. MNA target compounds for the Front Valley include: tetrachloroethene (PCE); trichloroethene (TCE); cis-DCE (cis-1,2-dichloroethene); vinyl chloride (VC); 1,2-DCA (1,2-dichloroethane); carbon tetrachloride (CT); chloroform (CF); dichloromethane (DCM); perchlorate; and research department explosive (RDX).
4. For each location sampled as part of the pre-shutdown sample event in August/September 2014, MNA target compound data were compared to screening criteria. The maximum value relative to screening criteria is illustrated.
5. Injection wells and/or piezometers associated with Front Valley pilot testing at B105-139, B147, and B149 are not shown.
6. Extraction wells are not shown.
7. Although PTA outlines are shown on each zone's panel, the PTAs targeted specific aquifer zones, as follows: B105-139 (Zone AB); B147 (Zone AB); B149 (Zone CD); DA 23/B116 (Zone CD) and B104-145 (Zone D/EF).

0 300 600 1,200 Feet

Pre-Shutdown Comparison of MNA Target Compound Concentrations to Screening Criteria in the Front Valley
Chemtronics Site, Swannanoa, North Carolina

Geosyntec consultants

Figure **2a**

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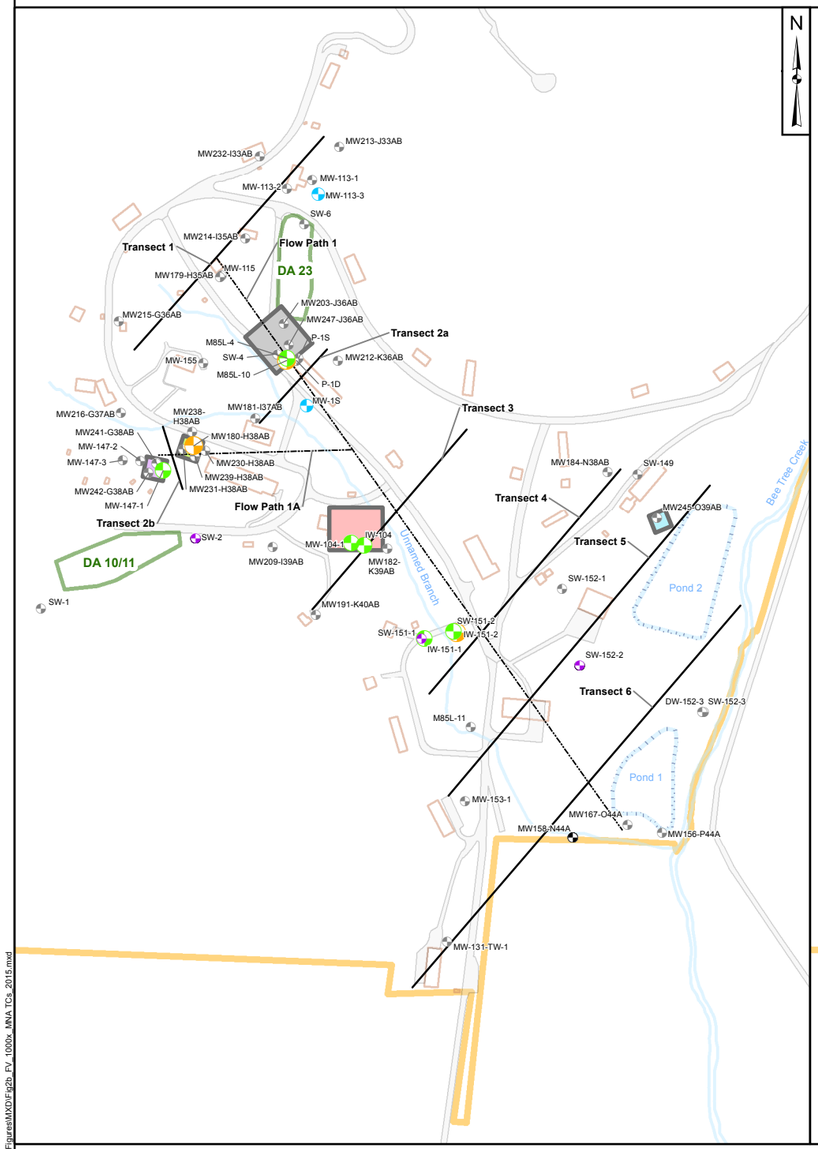
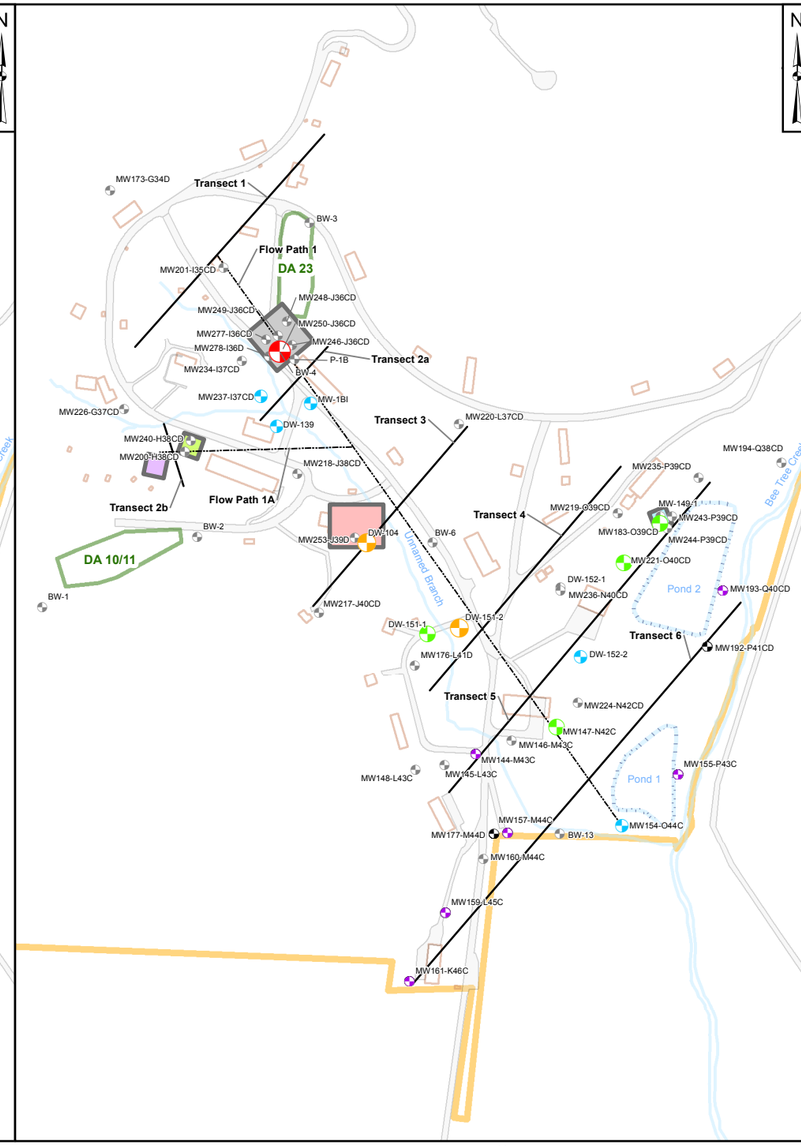
Path: \\aro-01\prj15\C\Chemtronics\MNA\Front Valley\Post-Shutdown\Figures\MXD\Fig2a_FV_1000x_MNA TCs_2014.mxd

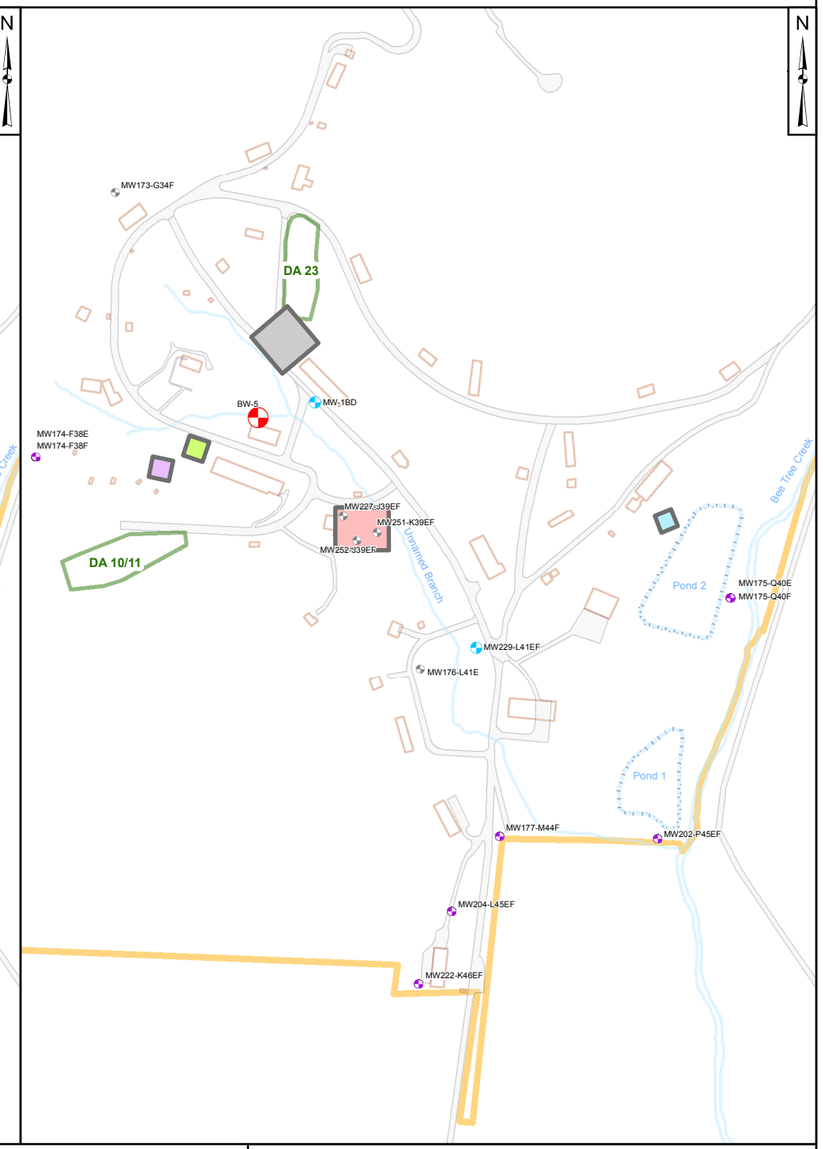
Zone AB



Zone CD



Zone EF



MNA Target Compounds

- Not Sampled
- Non-Detect
- MNA Transect
- Generalized Flow Path

- < Screening Criteria
- 1 to 10x Screening Criteria
- 10 to 100x Screening Criteria
- 100 to 1000x Screening Criteria
- >1000x Screening Criteria

- Disposal Area (DA)
- Stream
- Pond
- Road
- Existing or Former Building Area
- Chemtronics Property Boundary

Ongoing Pilot Test Area (PTA, Note 7)

- B105-139 PTA
- B147 PTA
- B149 PTA
- DA 23/B116 PTA
- B104 - 145 PTA

Notes:
1. MNA - monitored natural attenuation.
2. Screening criteria - North Carolina 2L or IMAC groundwater standards. For constituents without a 2L/IMAC, risk-based criteria from the *Final Remedial Investigation Report, Baseline Risk Assessment (Appendix L)* (Altamont, 2015a) were used.
3. MNA target compounds for the Front Valley include: tetrachloroethene (PCE); trichloroethene (TCE); cis-DCE (cis-1,2-dichloroethene); vinyl chloride (VC); 1,2-DCA (1,2-dichloroethane); carbon tetrachloride (CT); chloroform (CF); dichloromethane (DCM); perchlorate; and research department explosive (RDX).
4. For each location sampled as part of the post-shutdown sample event in August/September 2015, MNA target compound data were compared to screening criteria. The maximum value relative to screening criteria is illustrated.
5. Injection wells and/or piezometers associated with Front Valley pilot testing at B105-139, B147, and B149 are not shown.
6. Extraction wells are not shown.
7. Although PTA outlines are shown on each zone's panel, the PTAs targeted specific aquifer zones, as follows: B105-139 (Zone AB); B147 (Zone AB); B149 (Zone CD); DA 23/B116 (Zone CD) and B104-145 (Zone D/EF).

0 300 600 1,200 Feet

Post-Shutdown Comparison of MNA Target Compound Concentrations to Screening Criteria in the Front Valley

Chemtronics Site, Swannanoa, North Carolina

Geosyntec consultants

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Figure **2b**

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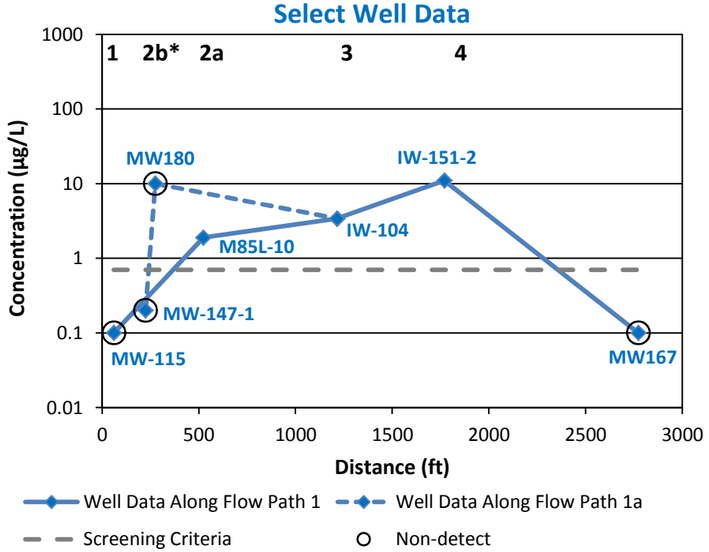
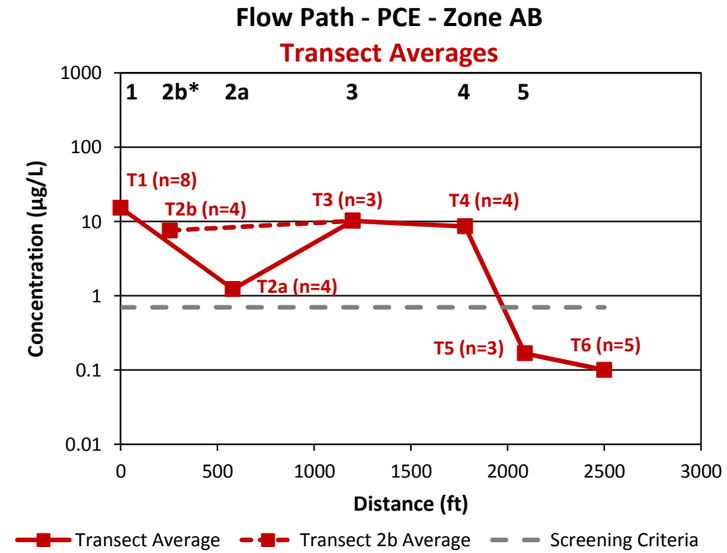
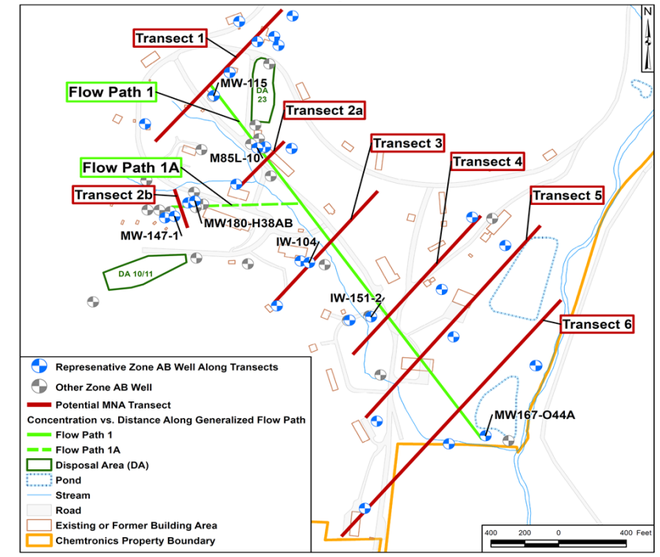
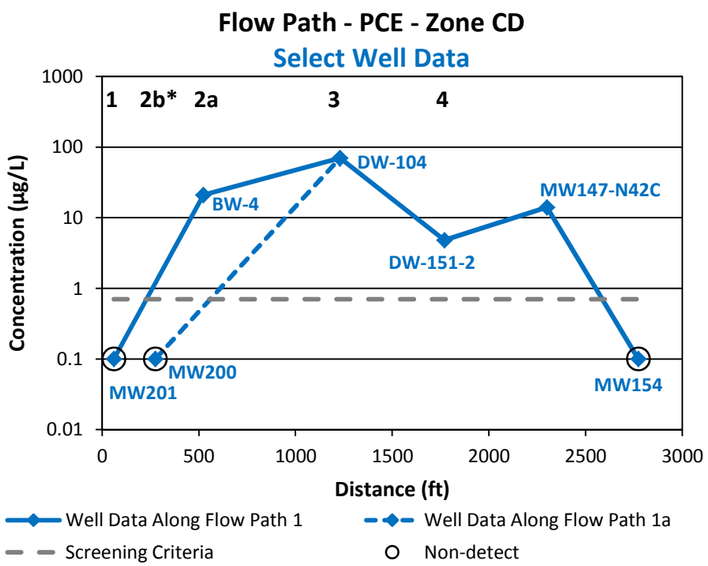
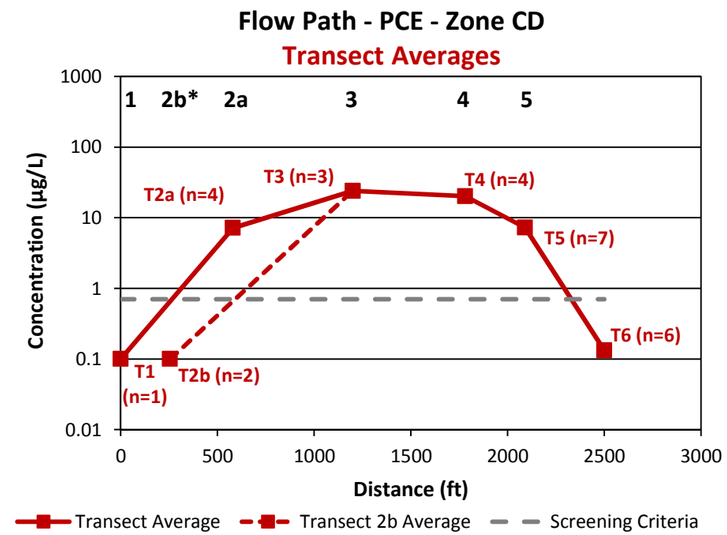
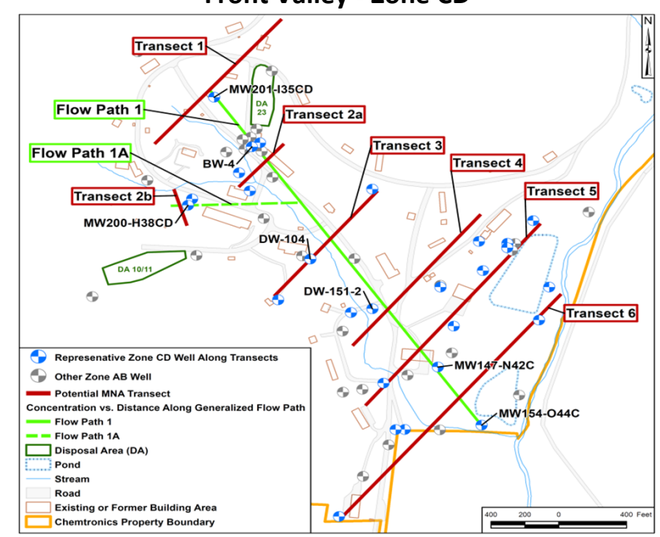












Notes:

1. µg/L – micrograms per liter.
2. Screening criteria are the North Carolina 2L or IMAC groundwater standards. For chemicals without a 2L/IMAC, the drinking water criteria from the *Final Remedial Investigation Report, Baseline Risk Assessment (Appendix L)* were used (Altamont, 2015a).
3. Non-detects are displayed at the method detection limit (MDL).
4. Transect average represents the average concentration (detections plus MDLs for non-detects) for wells along each MNA transect in each respective zone (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]).
5. T# (n=##) – Transect number (e.g., Transect 1, Transect 2a, etc.), where "n" is the number of samples included in the transect average.
6. For BW-4 and other pilot test wells (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]), pre-pilot data were used. Otherwise, data represent the most recent sample result between 2007 and 2014 for each analyte for each location.
7. PCE - tetrachloroethene.
8. Select Front Valley Areas of Interest (AOIs) are noted in each panel as follows:
   - **1** - B113, B114, B115
   - **2b*** - B147 & B105-139 (*Flow Path 1a only)
   - **2a** - DA 23/B116
   - **3** - B104-145
   - **4** - B150-151
   - **5** - B149 (Transect Averages only)

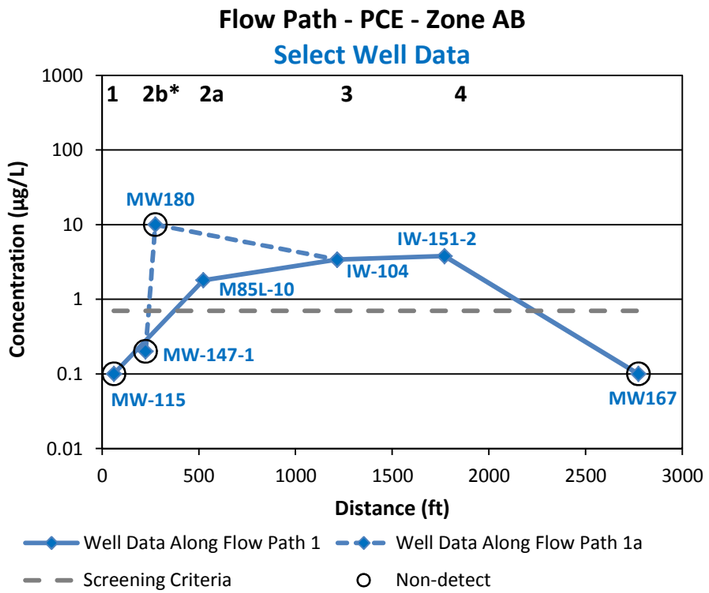
Pre-Shutdown PCE Concentration vs. Distance - Zones AB and CD
Chemtronics Site
Swannanoa, North Carolina

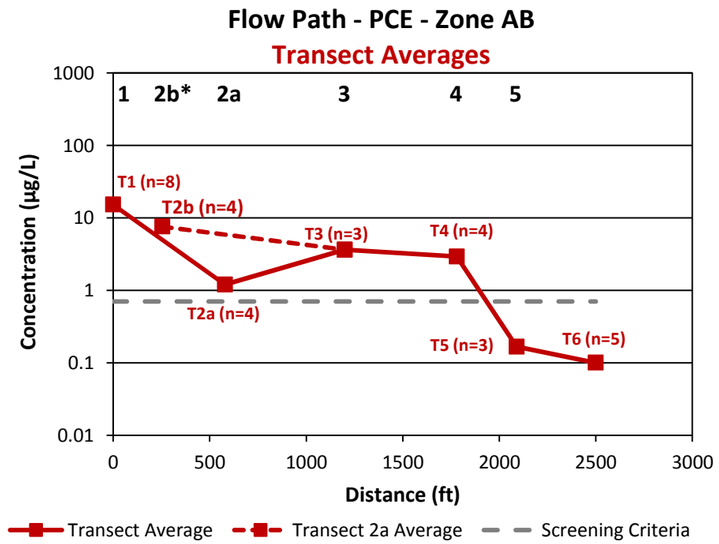
Geosyntec consultants

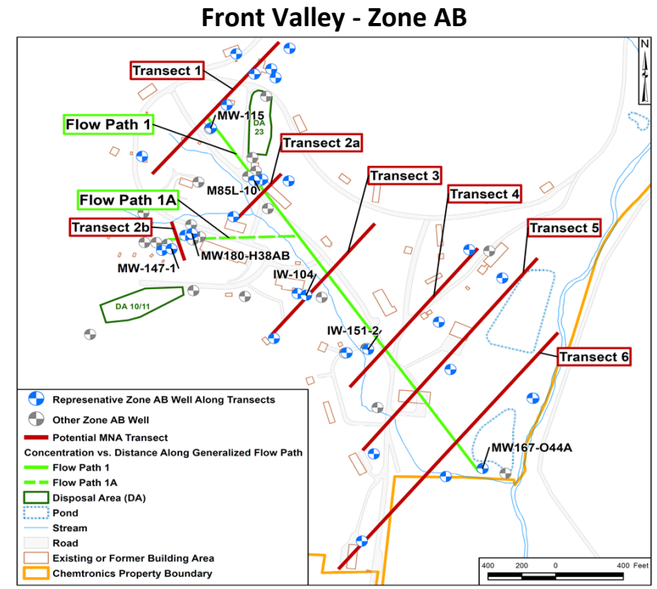
Kennesaw | July 2016

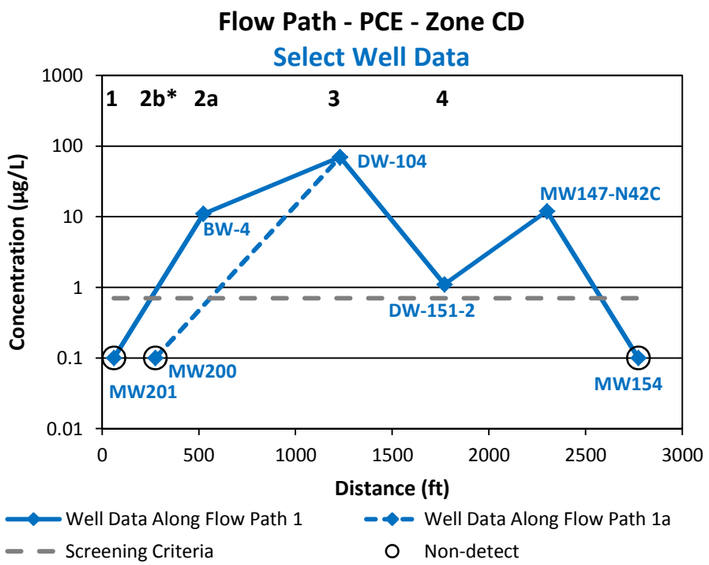
Figure 3-1a

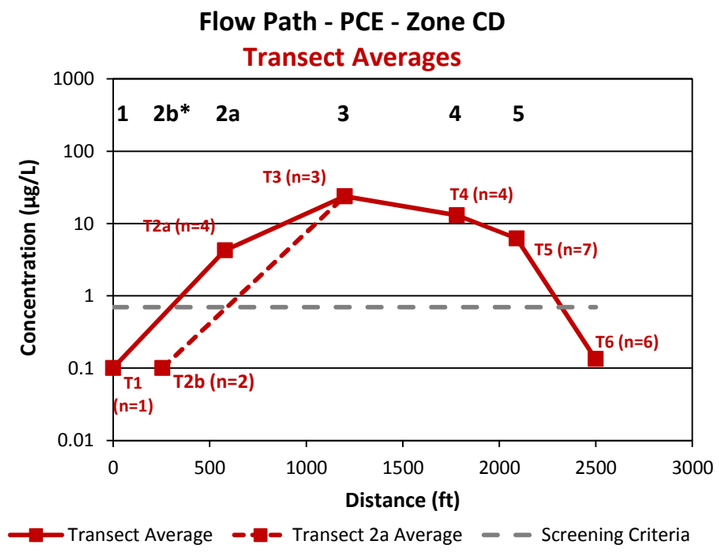
\\aro-01\prj$\C\Chemtronics\MNA\Front Valley\Post-Shutdown\Figures\MXD\[Fig3-1 to 3-10_FV AB CD Distance Trends.xlsx]RDX_FlowPath B

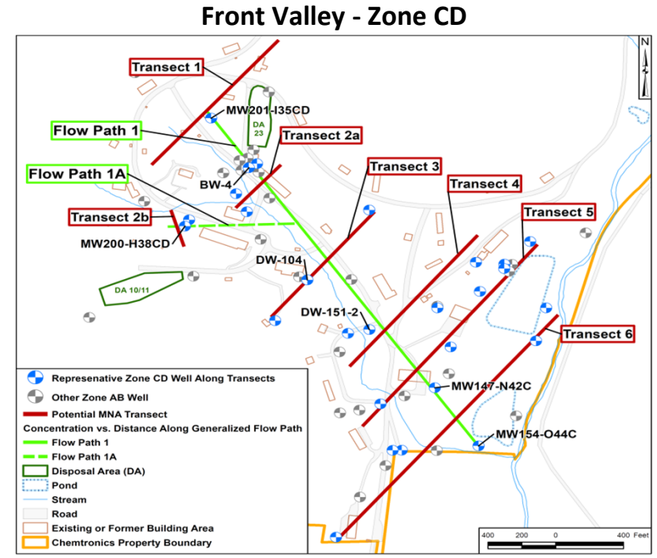












Notes:

1. µg/L – micrograms per liter.
2. Screening criteria are the North Carolina 2L or IMAC groundwater standards. For chemicals without a 2L/IMAC, the drinking water criteria from the *Final Remedial Investigation Report, Baseline Risk Assessment (Appendix L)* were used (Altamont, 2015a).
3. Non-detects are displayed at the method detection limit (MDL).
4. Transect average represents the average concentration (detections plus MDLs for non-detects) for wells along each MNA transect in each respective zone (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]).
5. T# (n=##) – Transect number (e.g., Transect 1, Transect 2a, etc.), where "n" is the number of samples included in the transect average.
6. For BW-4 and other pilot test wells (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]), pre-pilot data were used. Otherwise, data represent the most recent sample result between 2007 and 2014 for each analyte for each location.
7. PCE - tetrachloroethene.
8. Select Front Valley Areas of Interest (AOIs) are noted in each panel as follows:
   - **1** - B113, B114, B115
   - **2b*** - B147 & B105-139 (*Flow Path 1a only)
   - **2a** - DA 23/B116
   - **3** - B104-145
   - **4** - B150-151
   - **5** - B149 (Transect Averages only)

Post-Shutdown PCE Concentration vs. Distance - Zones AB and CD
Chemtronics Site
Swannanoa, North Carolina

Geosyntec consultants

Figure 3-1b

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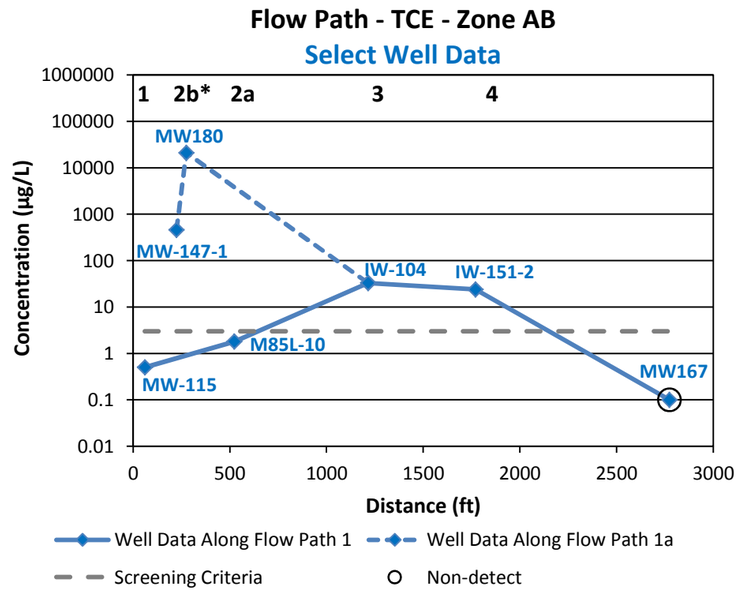
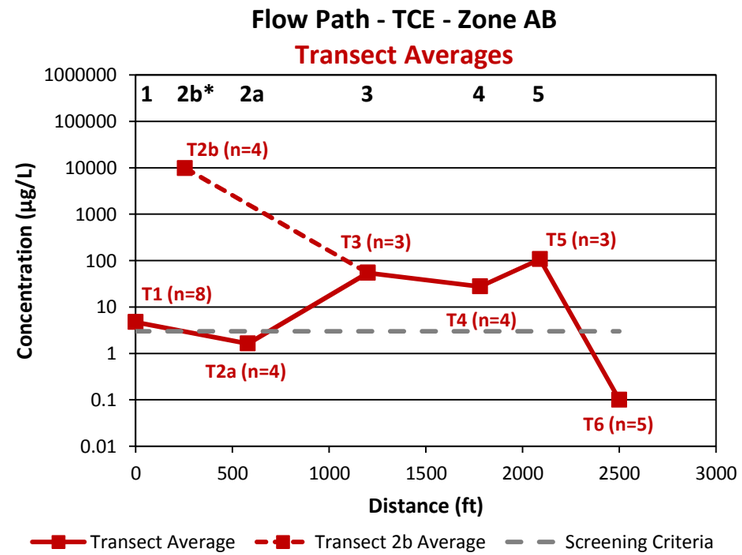
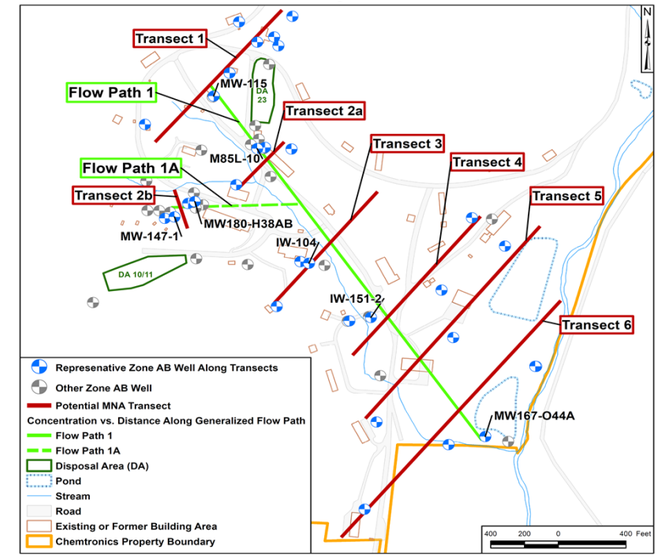
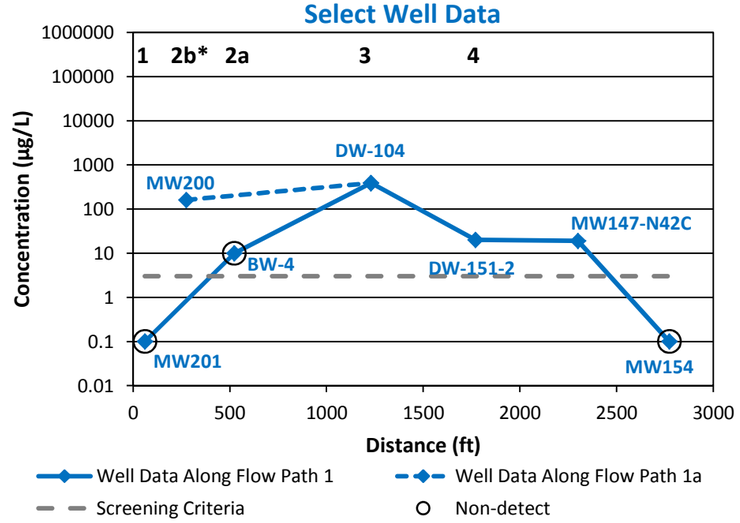
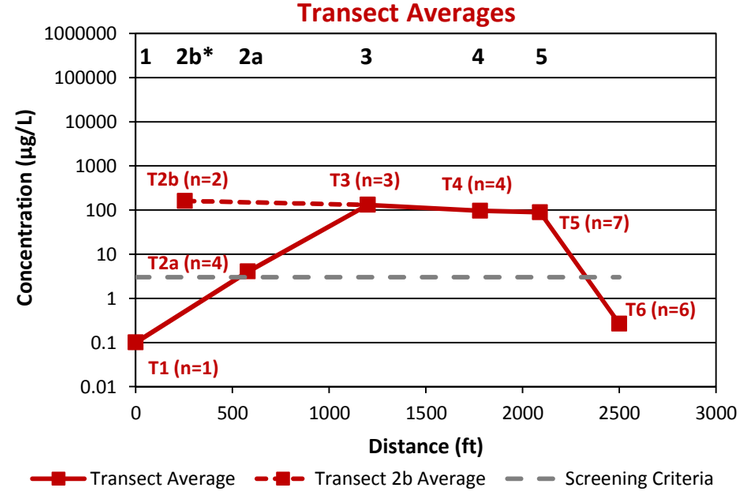
\\ kenn-fil1 pri\$ \C\Chemtronics\MNA\Front Valley\Post-Shutdown\Figures\MXD\[Fig3-1 to 3-10_FV AB CD Distance Trends.xlsx]ROX_FlowPath B

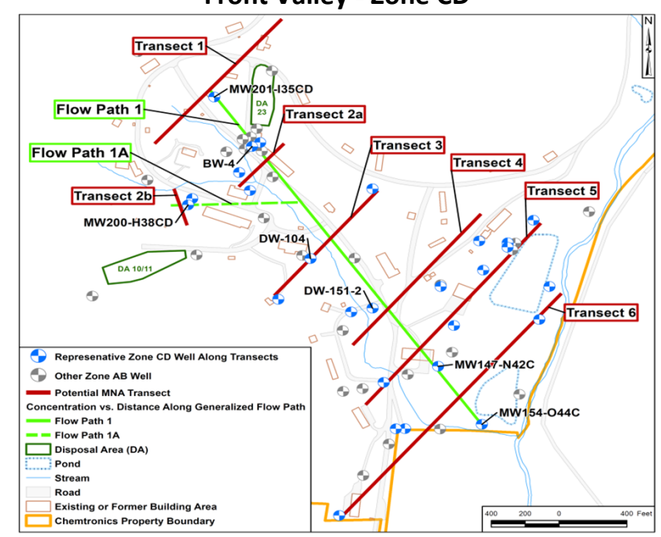












Notes:

1. µg/L – micrograms per liter.
2. Screening criteria are the North Carolina 2L or IMAC groundwater standards. For chemicals without a 2L/IMAC, the drinking water criteria from the *Final Remedial Investigation Report, Baseline Risk Assessment (Appendix L)* were used (Altamont, 2015a).
3. Non-detects are displayed at the method detection limit (MDL).
4. Transect average represents the average concentration (detections plus MDLs for non-detects) for wells along each MNA transect in each respective zone (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]).
5. T# (n=##) – Transect number (e.g., Transect 1, Transect 2a, etc.), where "n" is the number of samples included in the transect average.
6. For BW-4 and other pilot test wells (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]), pre-pilot data were used. Otherwise, data represent the most recent sample result between 2007 and 2014 for each analyte for each location.
7. TCE - trichloroethene.
8. Select Front Valley Areas of Interest (AOIs) are noted in each panel as follows:
   - **1** - B113, B114, B115
   - **2b*** - B147 & B105-139 (*Flow Path 1a only)
   - **2a** - DA 23/B116
   - **3** - B104-145
   - **4** - B150-151
   - **5** - B149 (Transect Averages only)

Pre-Shutdown TCE Concentration vs. Distance - Zones AB and CD
Chemtronics Site
Swannanoa, North Carolina

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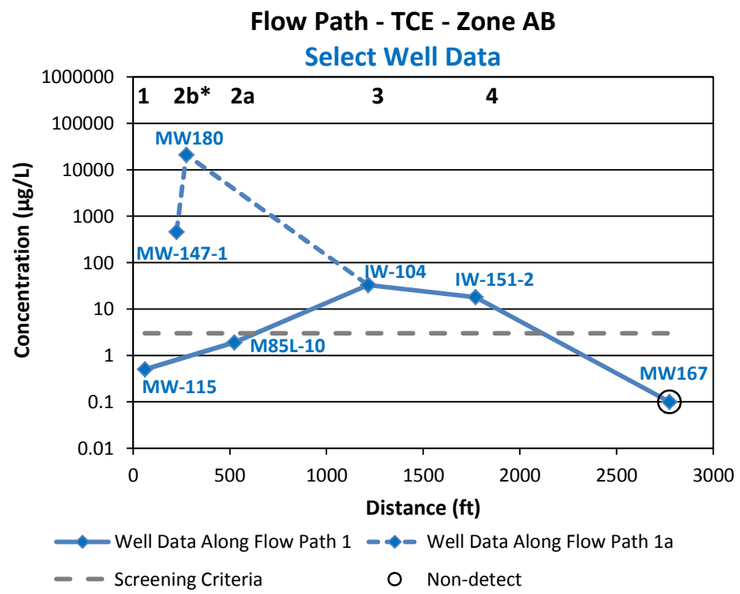
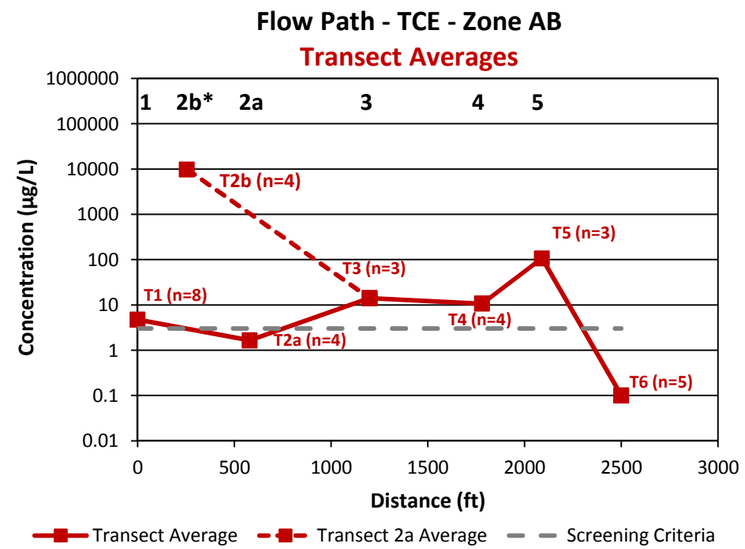
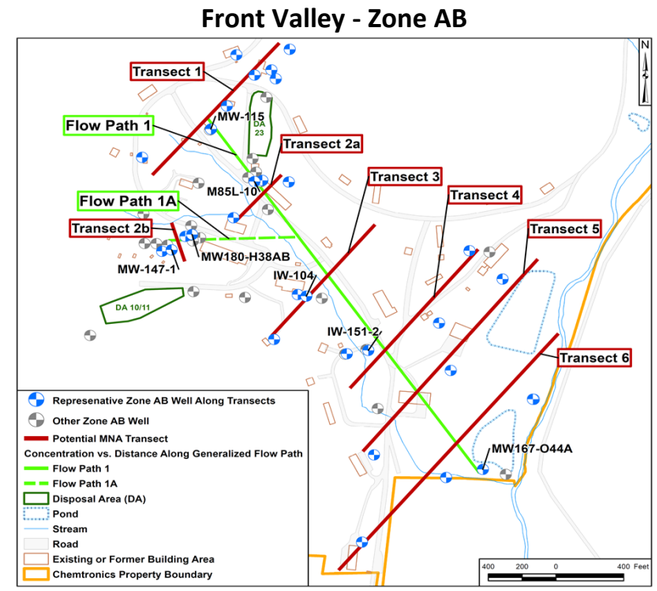
Kennesaw | July 2016

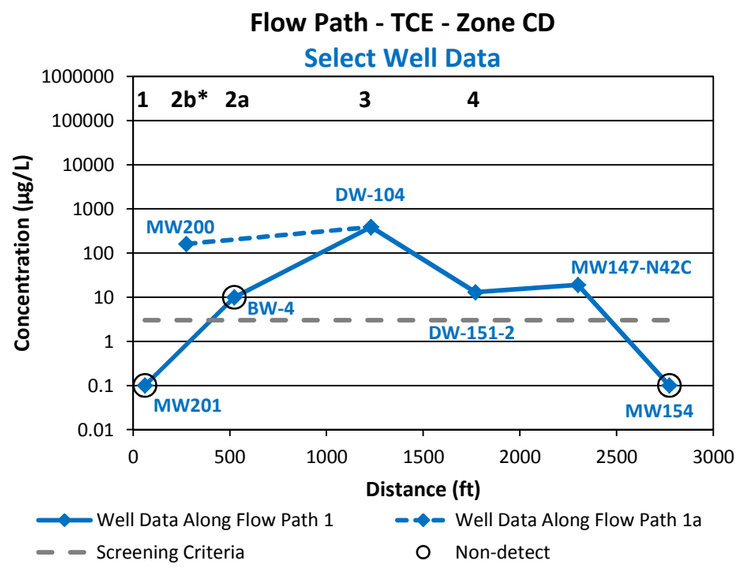
Figure 3-2a

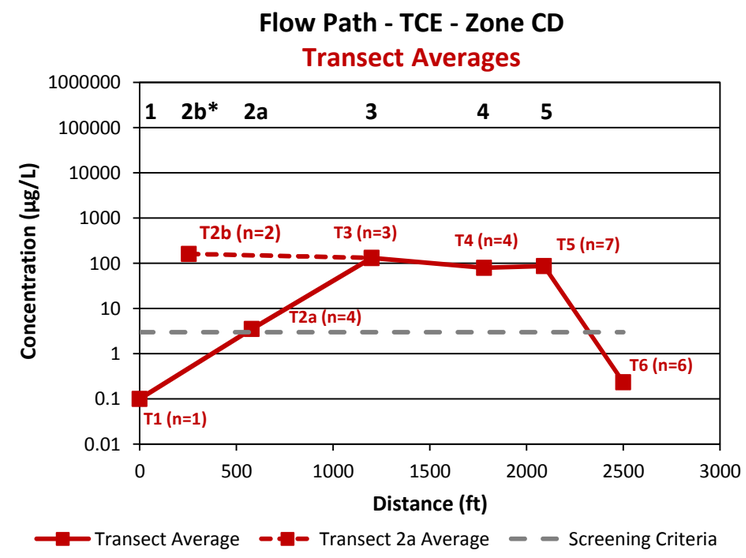
\\aro-01\prj$\C\Chemtronics\MNA\Front Valley\Post-Shutdown\Figures\MXD\[Fig3-1 to 3-10_FV AB CD Distance Trends.xlsx]RDX_FlowPath 8

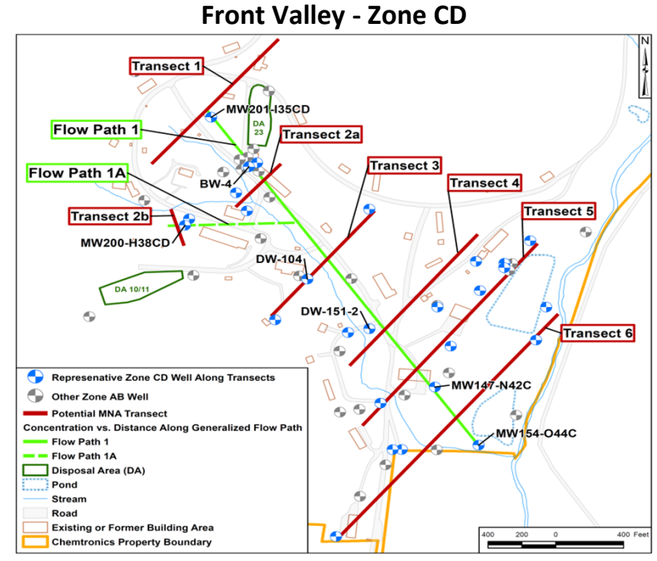












Notes:

1. µg/L – micrograms per liter.
2. Screening criteria are the North Carolina 2L or IMAC groundwater standards. For chemicals without a 2L/IMAC, the drinking water criteria from the *Final Remedial Investigation Report, Baseline Risk Assessment (Appendix L)* were used (Altamont, 2015a).
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5. T# (n=##) – Transect number (e.g., Transect 1, Transect 2a, etc.), where "n" is the number of samples included in the transect average.
6. For BW-4 and other pilot test wells (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]), pre-pilot data were used. Otherwise, data represent the most recent sample result between 2007 and 2014 for each analyte for each location.
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8. Select Front Valley Areas of Interest (AOIs) are noted in each panel as follows:
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   - **2a** - DA 23/B116
   - **3** - B104-145
   - **4** - B150-151
   - **5** - B149 (Transect Averages only)

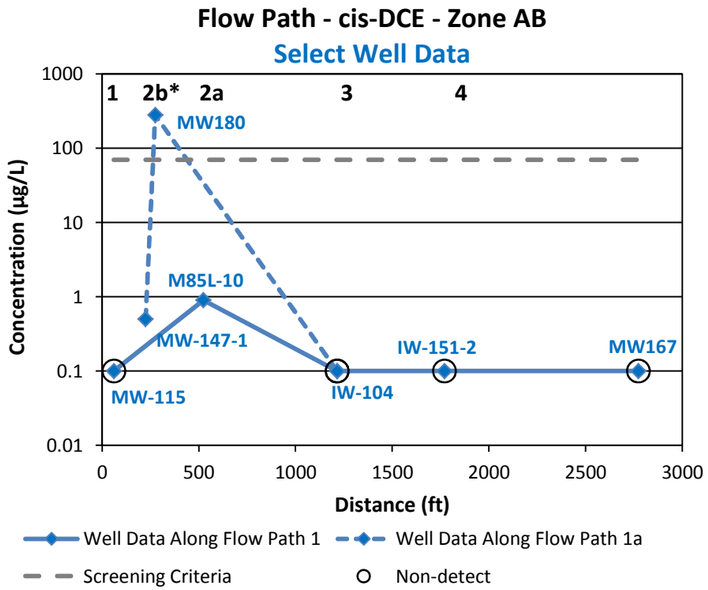
Post-Shutdown TCE Concentration vs. Distance - Zones AB and CD
Chemtronics Site
Swannanoa, North Carolina

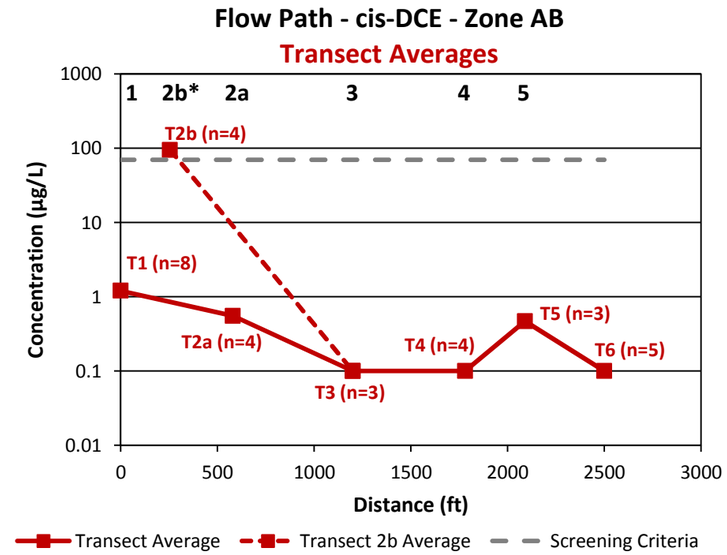
Geosyntec consultants

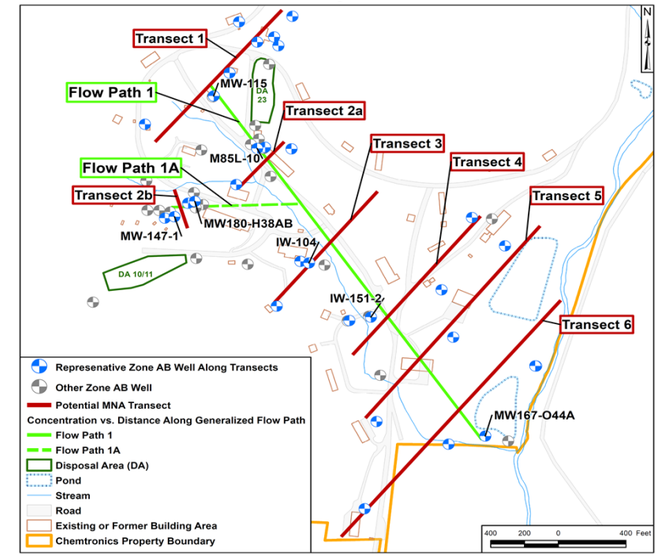
Kennesaw | July 2016

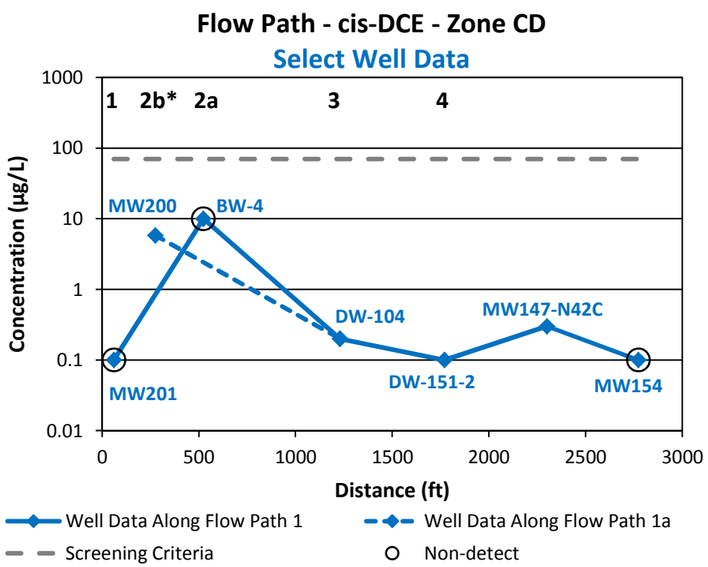
Figure 3-2b

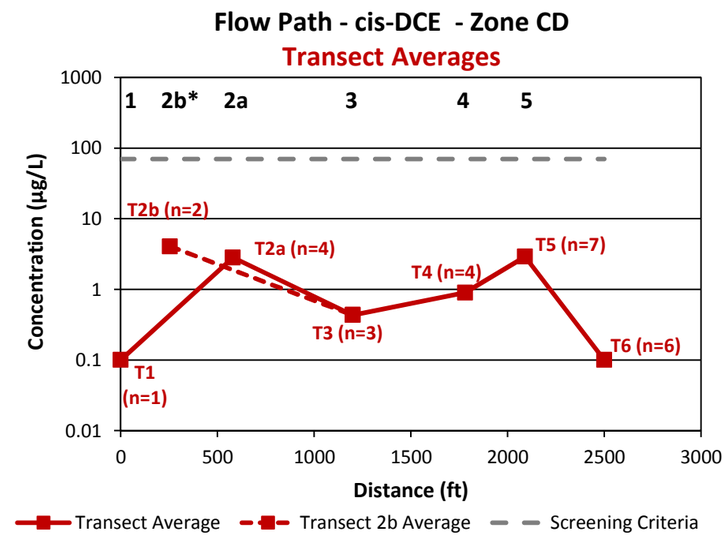
\\ tanc-01 (pf)\S\C\Chemtronics\MNA\Front Valley\Post-Shutdown\Figures\MXD\[Fig3-1 to 3-10_FV AB CD Distance Trends.xlsx]ROX_FlowPath B

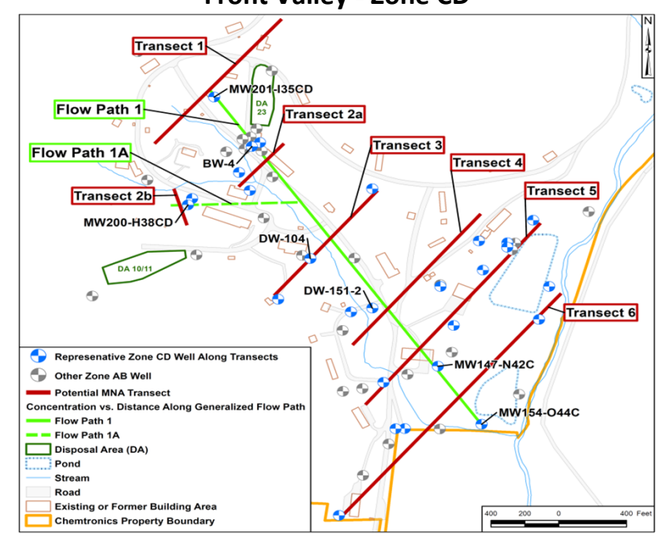












Notes:

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5. T# (n=##) – Transect number (e.g., Transect 1, Transect 2a, etc.), where "n" is the number of samples included in the transect average.
6. For BW-4 and other pilot test wells (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]), pre-pilot data were used. Otherwise, data represent the most recent sample result between 2007 and 2014 for each analyte for each location.
7. cis-DCE - cis-1,2-dichloroethene.
8. Select Front Valley Areas of Interest (AOIs) are noted in each panel as follows:
   - **1** - B113, B114, B115
   - **2b*** - B147 & B105-139 (*Flow Path 1a only)
   - **2a** - DA 23/B116
   - **3** - B104-145
   - **4** - B150-151
   - **5** - B149 (Transect Averages only)

Pre-Shutdown cis-DCE Concentration vs. Distance - Zones AB and CD
Chemtronics Site
Swannanoa, North Carolina

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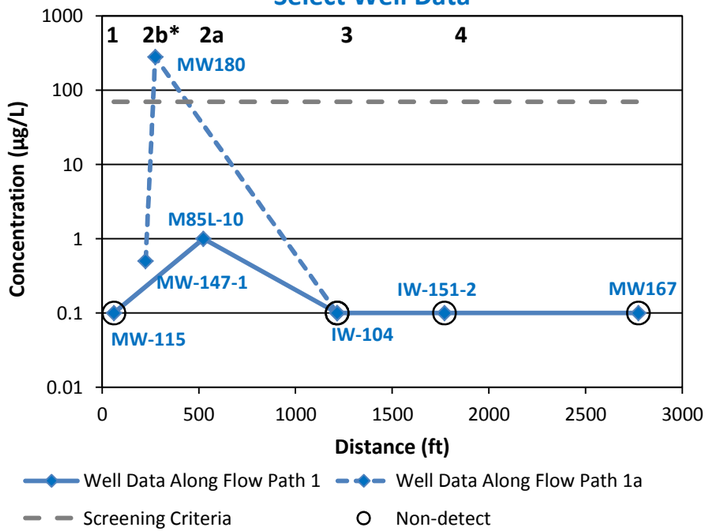
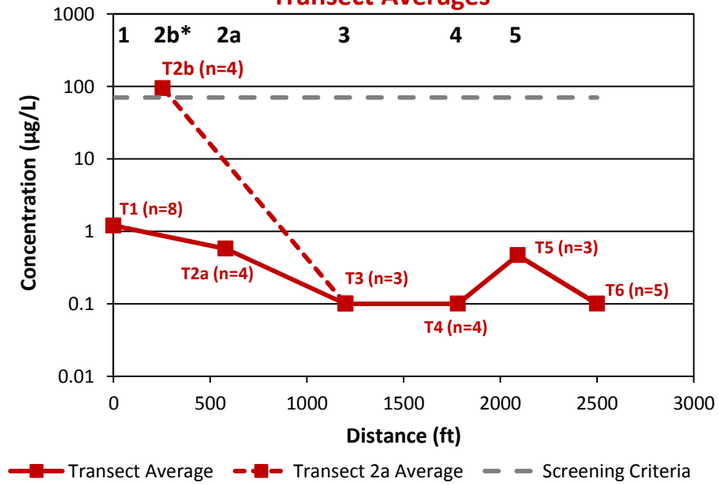
Figure 3-3a

\\aro-01\prj$\C\Chemtronics\MNA\Front Valley\Post-Shutdown\Figures\MXD\[Fig3-1 to 3-10_FV AB CD Distance Trends.xlsx]RDX_FlowPath B

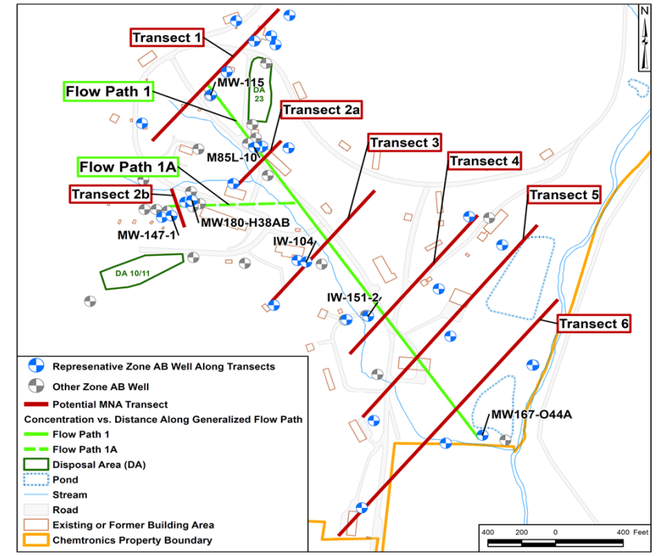
Flow Path - cis-DCE - Zone AB
Select Well Data



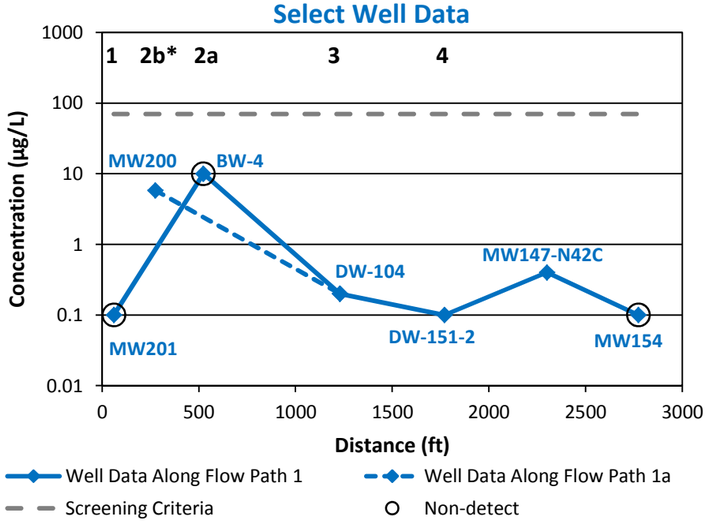
Flow Path - cis-DCE - Zone AB
Transect Averages



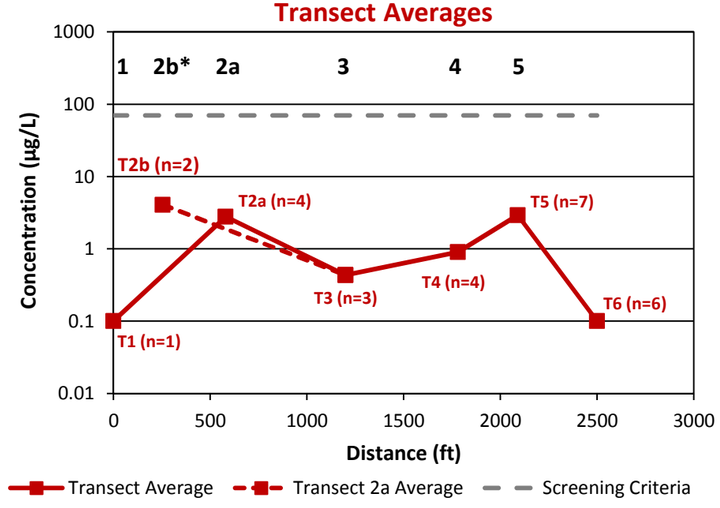
Front Valley - Zone AB



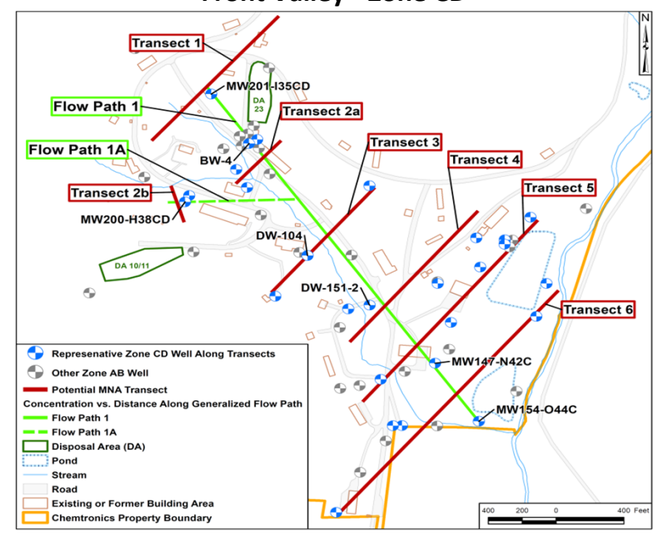
Flow Path - cis-DCE - Zone CD
Select Well Data



Flow Path - cis-DCE - Zone CD
Transect Averages



Front Valley - Zone CD



Notes:

1. µg/L – micrograms per liter.
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3. Non-detects are displayed at the method detection limit (MDL).
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5. T# (n=##) – Transect number (e.g., Transect 1, Transect 2a, etc.), where "n" is the number of samples included in the transect average.
6. For BW-4 and other pilot test wells (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]), pre-pilot data were used. Otherwise, data represent the most recent sample result between 2007 and 2014 for each analyte for each location.
7. cis-DCE - cis-1,2-dichloroethene.
8. Select Front Valley Areas of Interest (AOIs) are noted in each panel as follows:
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   - **2b*** - B147 & B105-139 (*Flow Path 1a only)
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   - **3** - B104-145
   - **4** - B150-151
   - **5** - B149 (Transect Averages only)

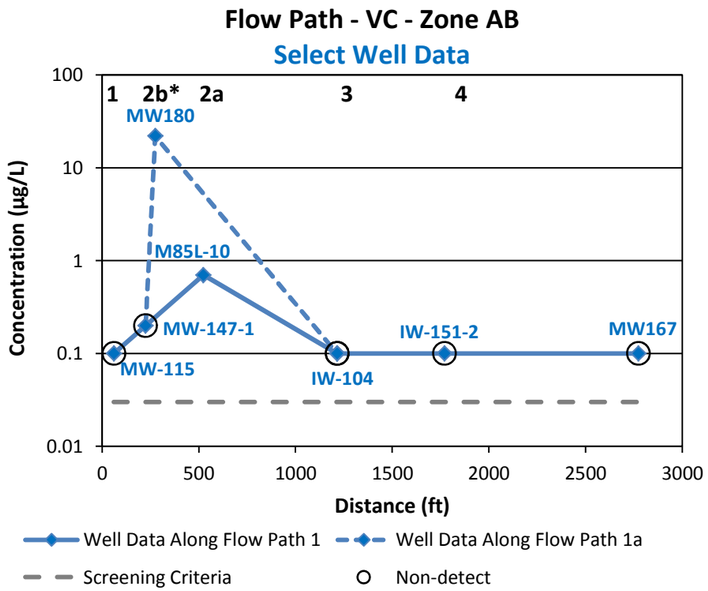
Post-Shutdown cis-DCE Concentration vs. Distance - Zones AB and CD
Chemtronics Site
Swannanoa, North Carolina

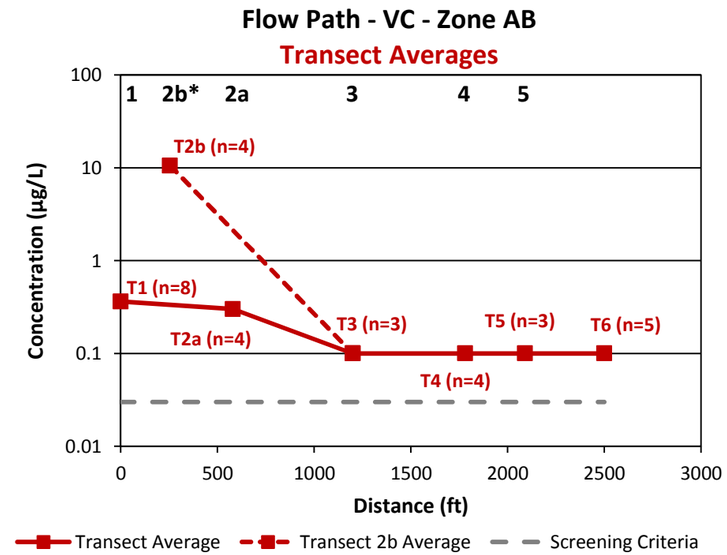
Geosyntec consultants

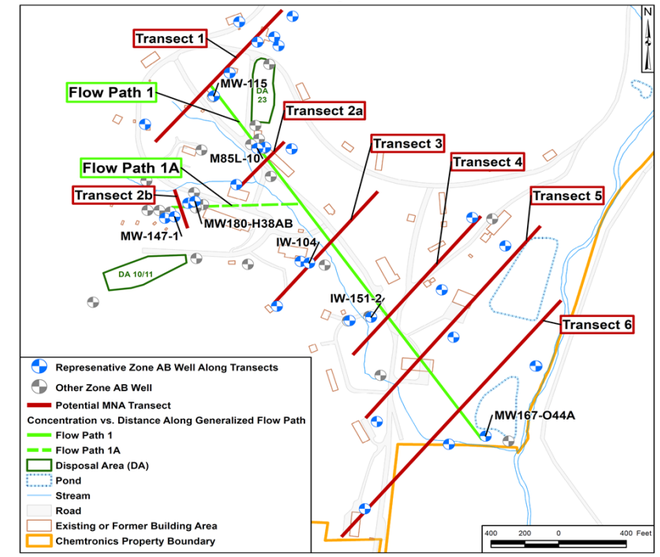
Kennesaw | July 2016

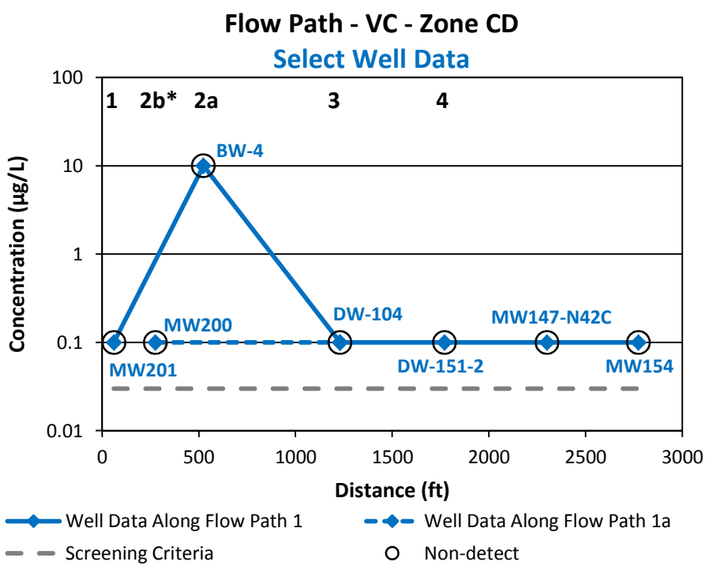
Figure 3-3b

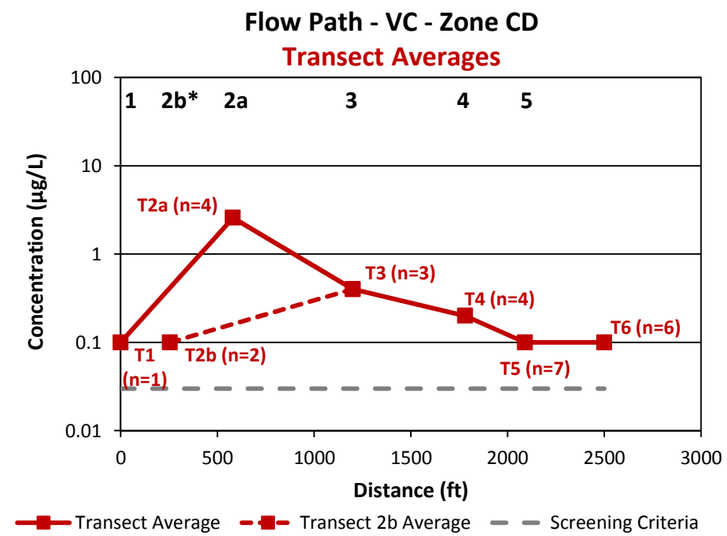
\\ tarc-fs1.prj$\C\Chemtronics\MNA\Front Valley\Post-Shutdown\Figures\MXD\[Fig3-1 to 3-10_PV AB CD Distance Trends.xlsx]ROX_FlowPath B

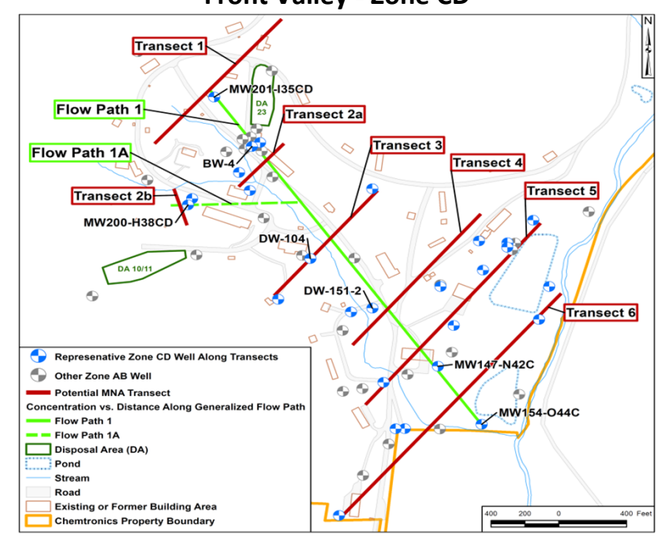












Notes:

1. µg/L – micrograms per liter.
2. Screening criteria are the North Carolina 2L or IMAC groundwater standards. For chemicals without a 2L/IMAC, the drinking water criteria from the *Final Remedial Investigation Report, Baseline Risk Assessment (Appendix L)* were used (Altamont, 2015a).
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4. Transect average represents the average concentration (detections plus MDLs for non-detects) for wells along each MNA transect in each respective zone (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]).
5. T# (n=##) – Transect number (e.g., Transect 1, Transect 2a, etc.), where "n" is the number of samples included in the transect average.
6. For BW-4 and other pilot test wells (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]), pre-pilot data were used. Otherwise, data represent the most recent sample result between 2007 and 2014 for each analyte for each location.
7. VC - vinyl chloride.
8. Select Front Valley Areas of Interest (AOIs) are noted in each panel as follows:
   - **1** - B113, B114, B115
   - **2b*** - B147 & B105-139 (*Flow Path 1a only)
   - **2a** - DA 23/B116
   - **3** - B104-145
   - **4** - B150-151
   - **5** - B149 (Transect Averages only)

Pre-Shutdown VC Concentration vs. Distance - Zones AB and CD
Chemtronics Site
Swannanoa, North Carolina

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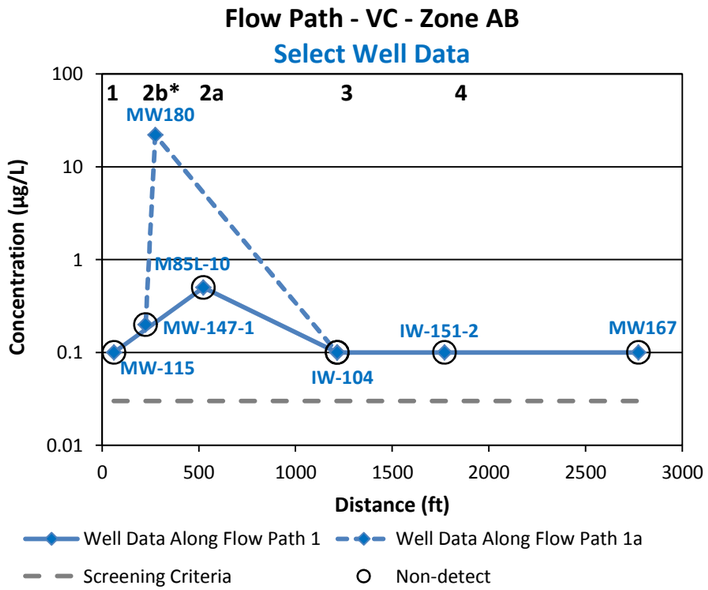
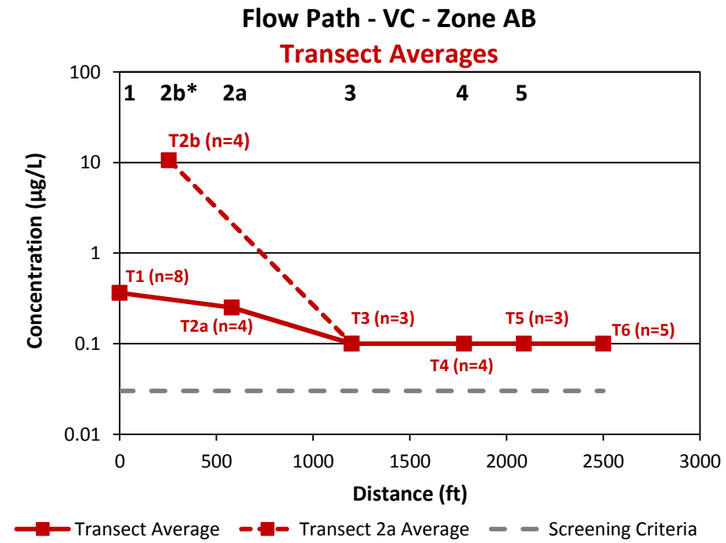
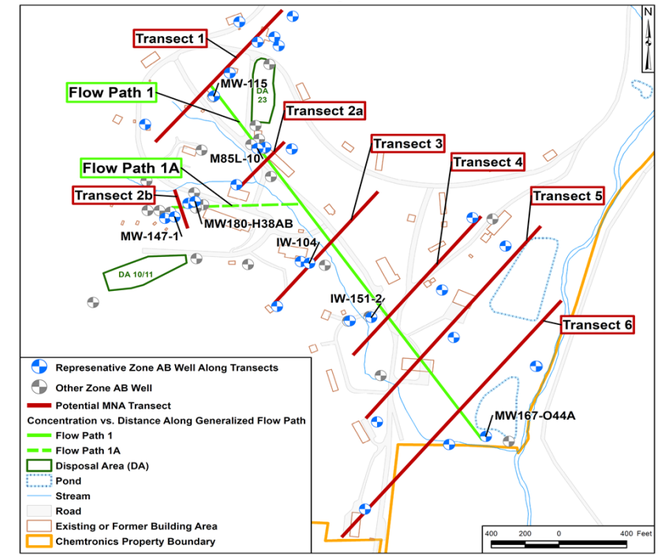
Kennesaw | July 2016

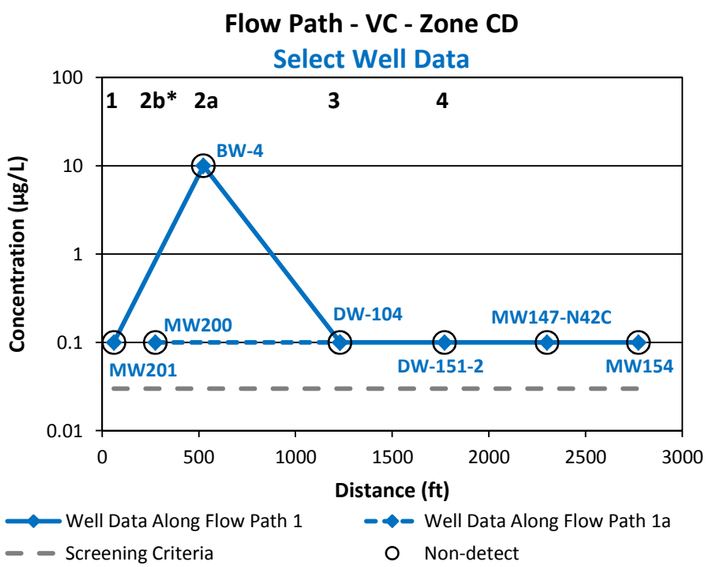
Figure 3-4a

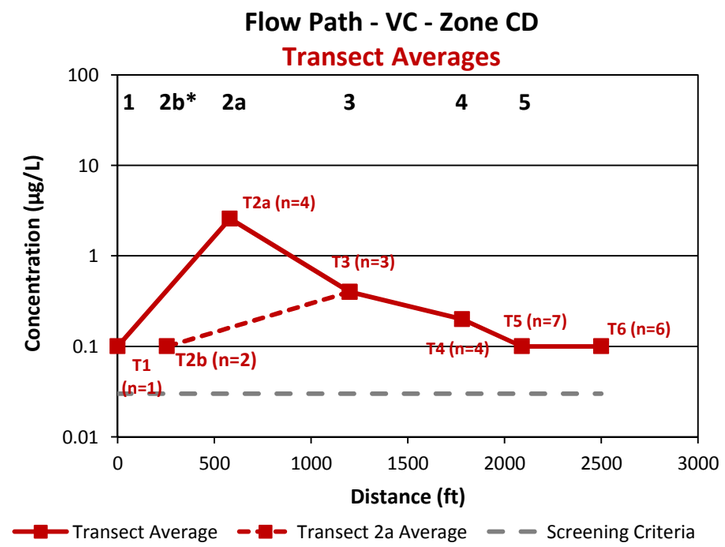
\\aro-01\prj$\C\Chemtronics\MNA\Front Valley\Post-Shutdown\Figures\MXD\[Fig3-1 to 3-10_FV AB CD Distance Trends.xlsx]RDX_FlowPath B

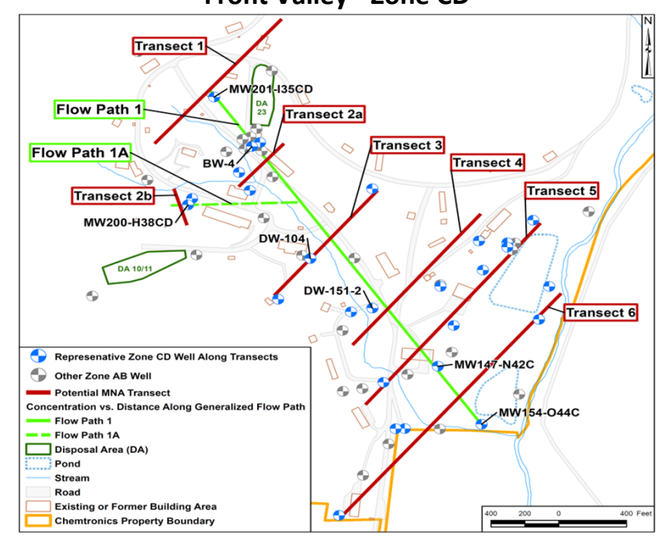












Notes:

1. µg/L – micrograms per liter.
2. Screening criteria are the North Carolina 2L or IMAC groundwater standards. For chemicals without a 2L/IMAC, the drinking water criteria from the *Final Remedial Investigation Report, Baseline Risk Assessment (Appendix L)* were used (Altamont, 2015a).
3. Non-detects are displayed at the method detection limit (MDL).
4. Transect average represents the average concentration (detections plus MDLs for non-detects) for wells along each MNA transect in each respective zone (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]).
5. T# (n=##) – Transect number (e.g., Transect 1, Transect 2a, etc.), where "n" is the number of samples included in the transect average.
6. For BW-4 and other pilot test wells (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]), pre-pilot data were used. Otherwise, data represent the most recent sample result between 2007 and 2014 for each analyte for each location.
7. VC - vinyl chloride.
8. Select Front Valley Areas of Interest (AOIs) are noted in each panel as follows:
   - **1** - B113, B114, B115
   - **2b*** - B147 & B105-139 (*Flow Path 1a only)
   - **2a** - DA 23/B116
   - **3** - B104-145
   - **4** - B150-151
   - **5** - B149 (Transect Averages only)

Post-Shutdown VC Concentration vs. Distance - Zones AB and CD
Chemtronics Site
Swannanoa, North Carolina

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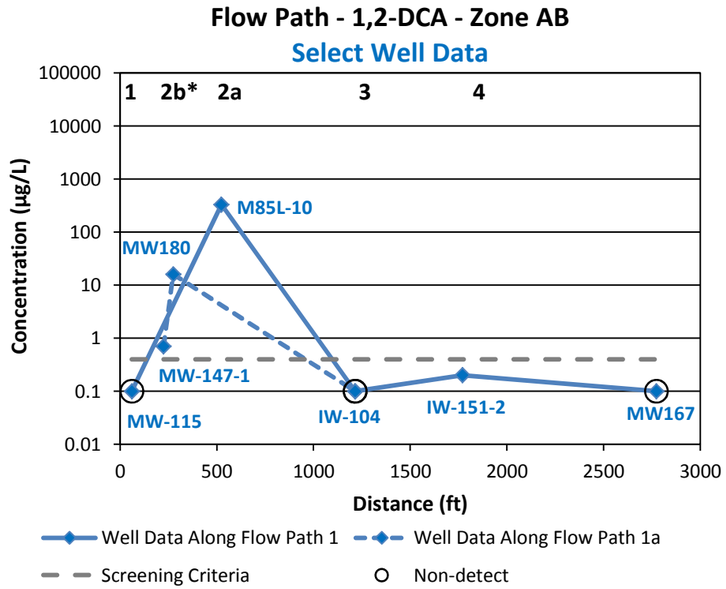
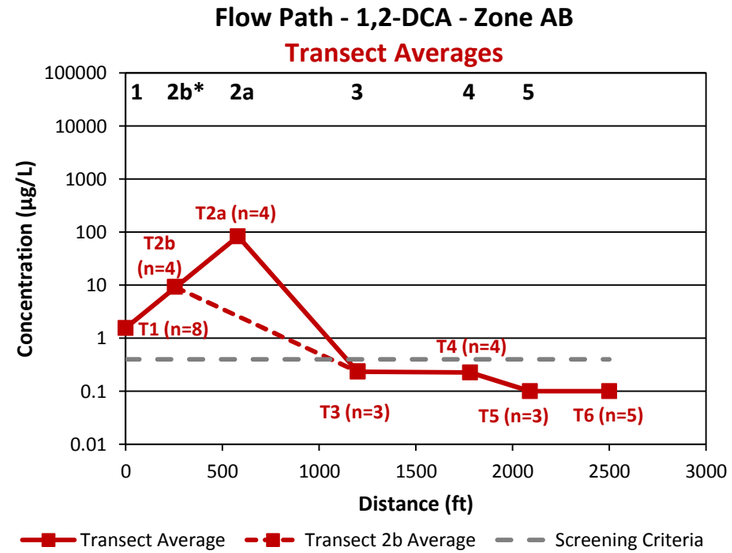
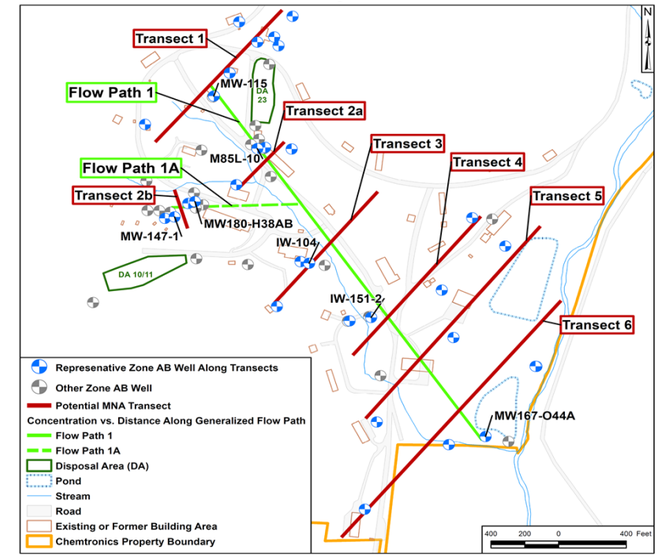
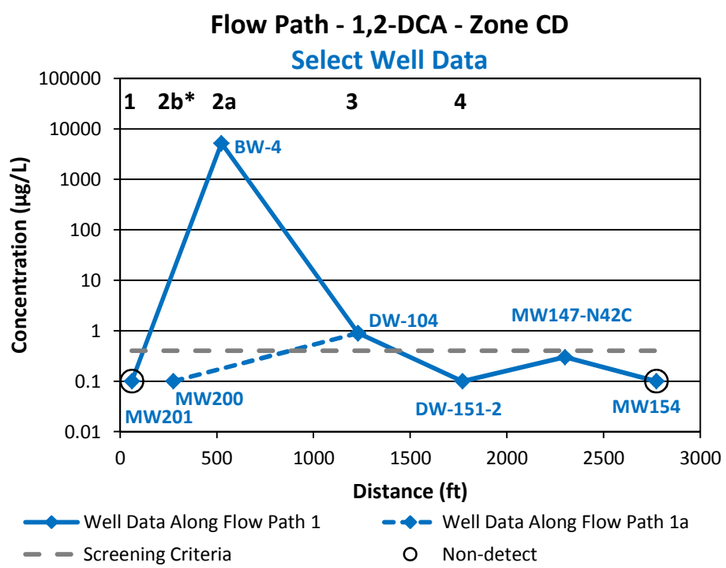
Figure 3-4b

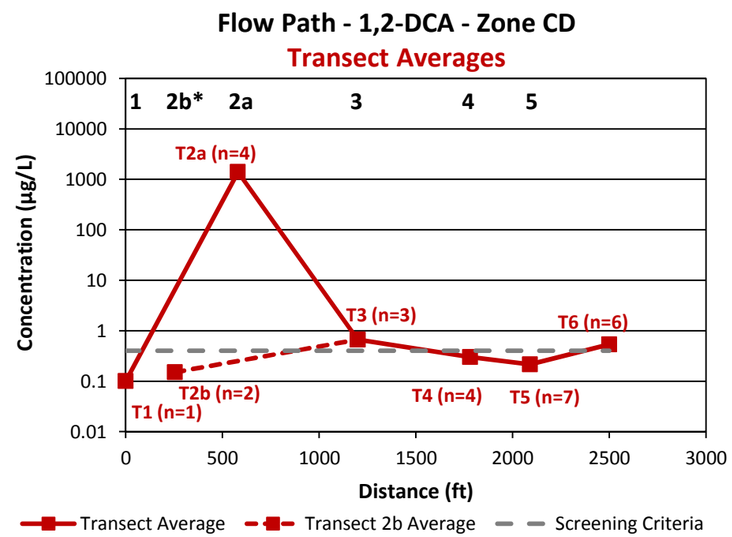
\\aro-01\prj$\C\Chemtronics\MNA\Front Valley\Post-Shutdown\Figures\MXD\[Fig3-1 to 3-10_FV AB CD Distance Trends.xlsx]RDX_FlowPath B

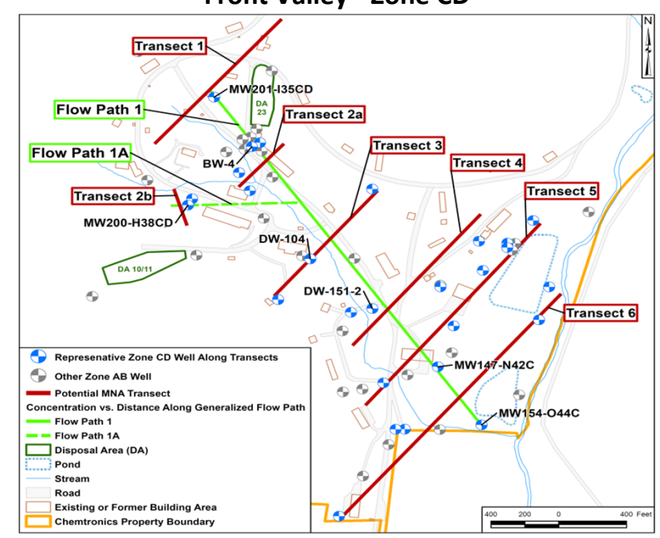












Notes:

1. µg/L – micrograms per liter.
2. Screening criteria are the North Carolina 2L or IMAC groundwater standards. For chemicals without a 2L/IMAC, the drinking water criteria from the *Final Remedial Investigation Report, Baseline Risk Assessment (Appendix L)* were used (Altamont, 2015a).
3. Non-detects are displayed at the method detection limit (MDL).
4. Transect average represents the average concentration (detections plus MDLs for non-detects) for wells along each MNA transect in each respective zone (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]).
5. T# (n=##) – Transect number (e.g., Transect 1, Transect 2a, etc.), where "n" is the number of samples included in the transect average.
6. For BW-4 and other pilot test wells (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]), pre-pilot data were used. Otherwise, data represent the most recent sample result between 2007 and 2014 for each analyte for each location.
7. 1,2-DCA - 1,2-dichloroethane.
8. Select Front Valley Areas of Interest (AOIs) are noted in each panel as follows:
   - **1** - B113, B114, B115
   - **2b*** - B147 & B105-139 (*Flow Path 1a only)
   - **2a** - DA 23/B116
   - **3** - B104-145
   - **4** - B150-151
   - **5** - B149 (Transect Averages only)

Pre-Shutdown 1,2-DCA Concentration vs. Distance - Zones AB and CD
Chemtronics Site
Swannanoa, North Carolina

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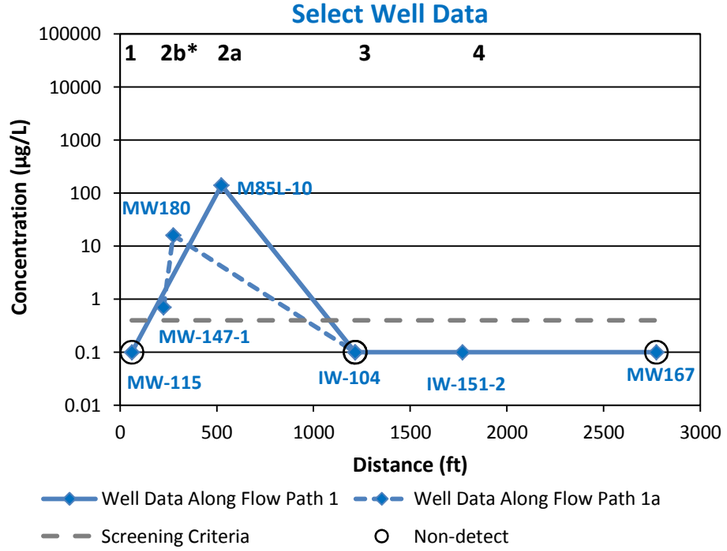
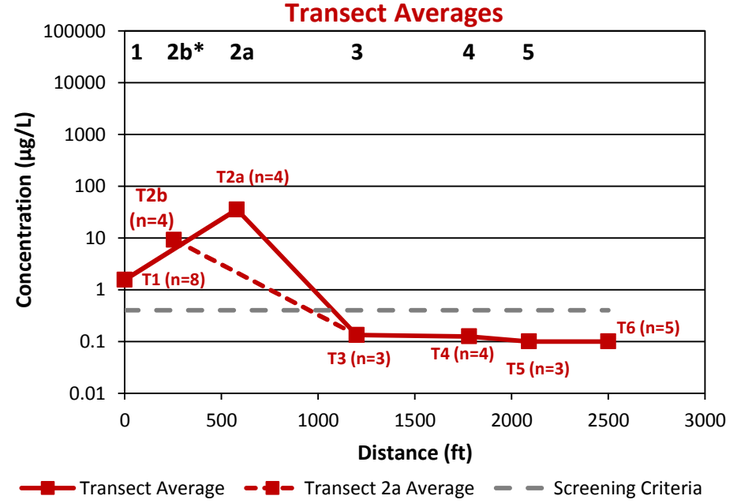
Figure 3-5a

\\aro-01\prj$\C\Chemtronics\MNA\Front Valley\Post-Shutdown\Figures\MXD\[Fig3-1 to 3-10_FV AB CD Distance Trends.xlsx]RDX_FlowPath B

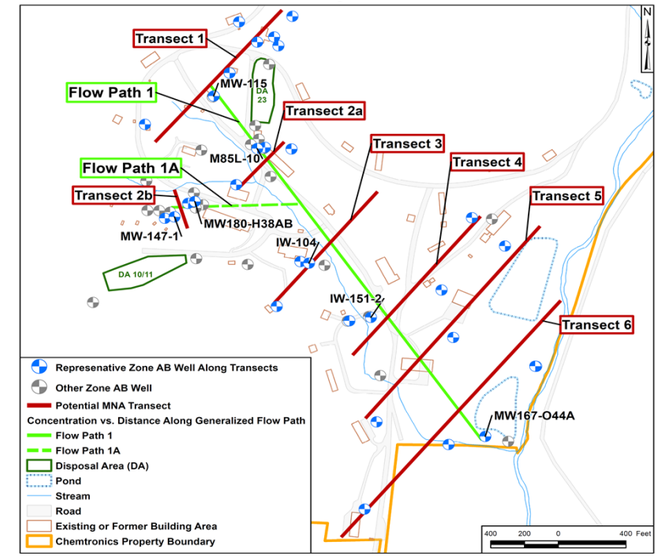
Flow Path - 1,2-DCA - Zone AB
Select Well Data



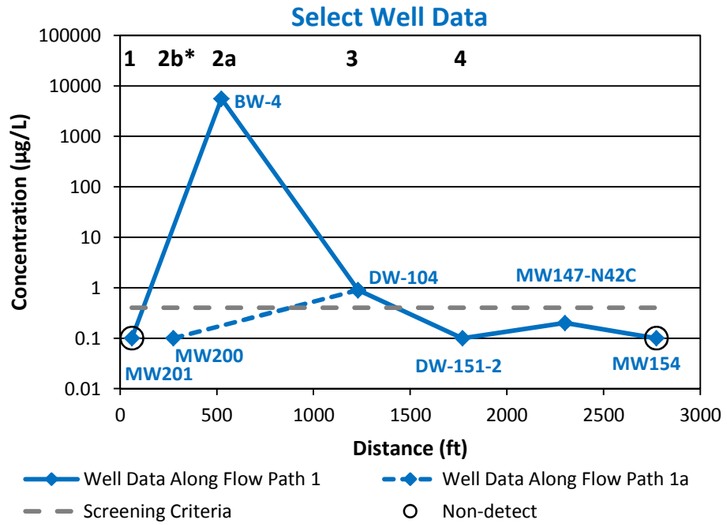
Flow Path - 1,2-DCA - Zone AB
Transect Averages



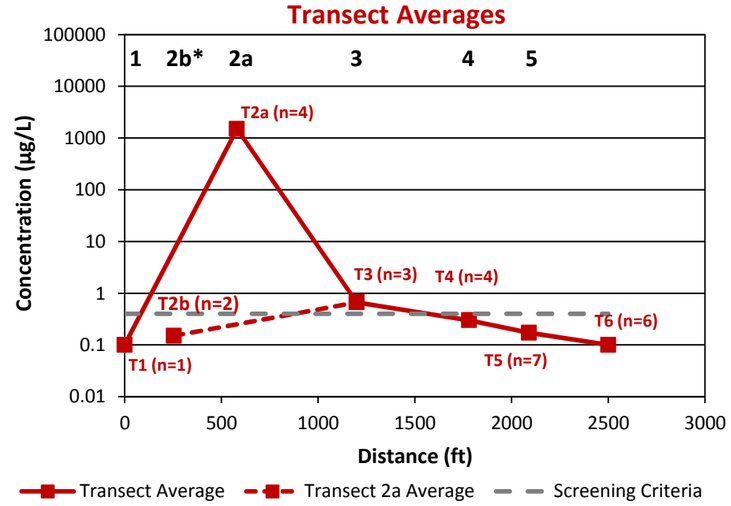
Front Valley - Zone AB



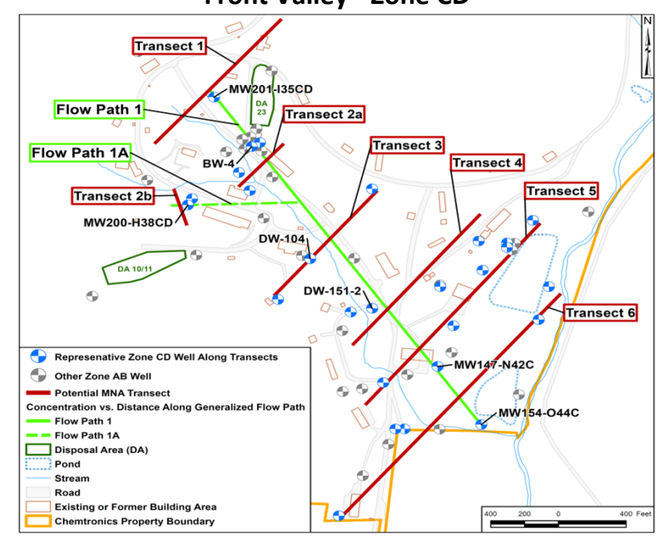
Flow Path - 1,2-DCA - Zone CD
Select Well Data



Flow Path - 1,2-DCA - Zone CD
Transect Averages



Front Valley - Zone CD



Notes:

1. µg/L – micrograms per liter.
2. Screening criteria are the North Carolina 2L or IMAC groundwater standards. For chemicals without a 2L/IMAC, the drinking water criteria from the *Final Remedial Investigation Report, Baseline Risk Assessment (Appendix L)* were used (Altamont, 2015a).
3. Non-detects are displayed at the method detection limit (MDL).
4. Transect average represents the average concentration (detections plus MDLs for non-detects) for wells along each MNA transect in each respective zone (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]).
5. T# (n=##) – Transect number (e.g., Transect 1, Transect 2a, etc.), where "n" is the number of samples included in the transect average.
6. For BW-4 and other pilot test wells (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]), pre-pilot data were used. Otherwise, data represent the most recent sample result between 2007 and 2014 for each analyte for each location.
7. 1,2-DCA - 1,2-dichloroethane.
8. Select Front Valley Areas of Interest (AOIs) are noted in each panel as follows:
   - **1** - B113, B114, B115
   - **2b*** - B147 & B105-139 (*Flow Path 1a only)
   - **2a** - DA 23/B116
   - **3** - B104-145
   - **4** - B150-151
   - **5** - B149 (Transect Averages only)

Post-Shutdown 1,2-DCA Concentration vs. Distance - Zones AB and CD
Chemtronics Site
Swannanoa, North Carolina

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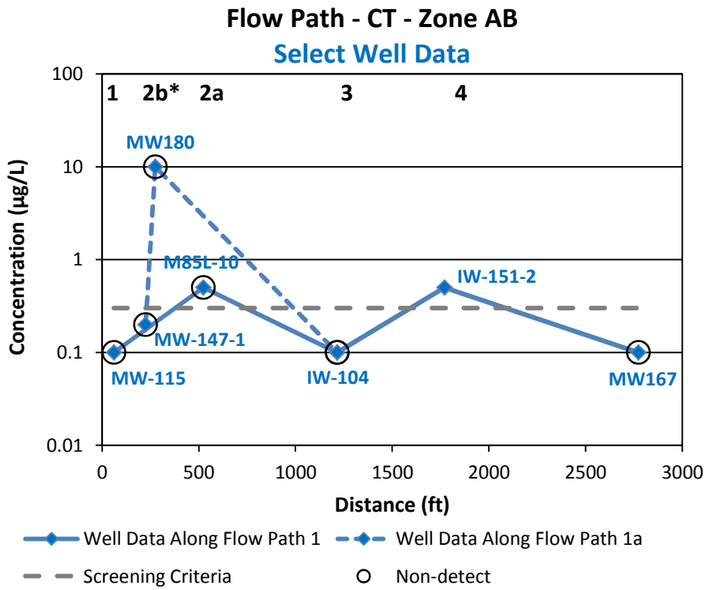
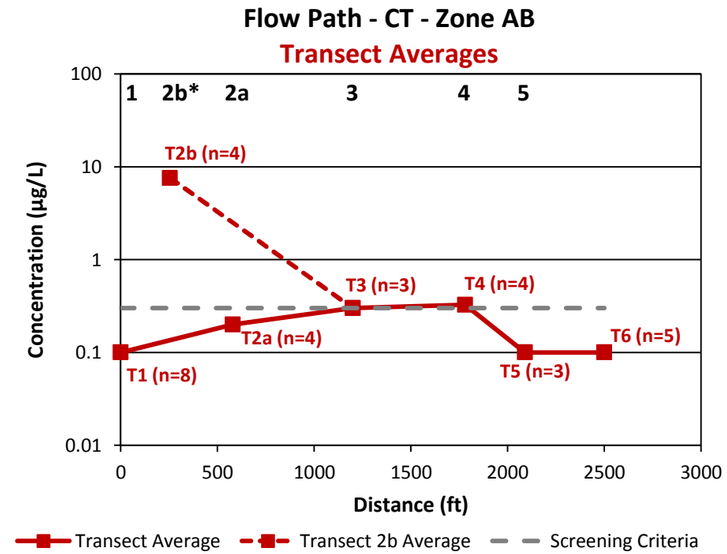
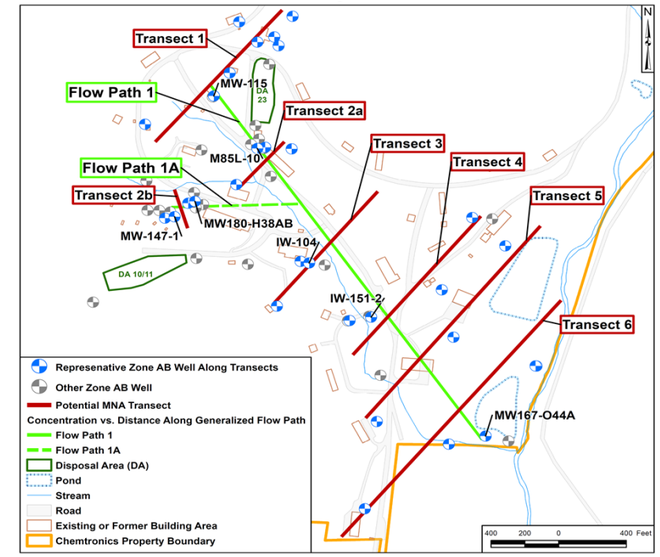
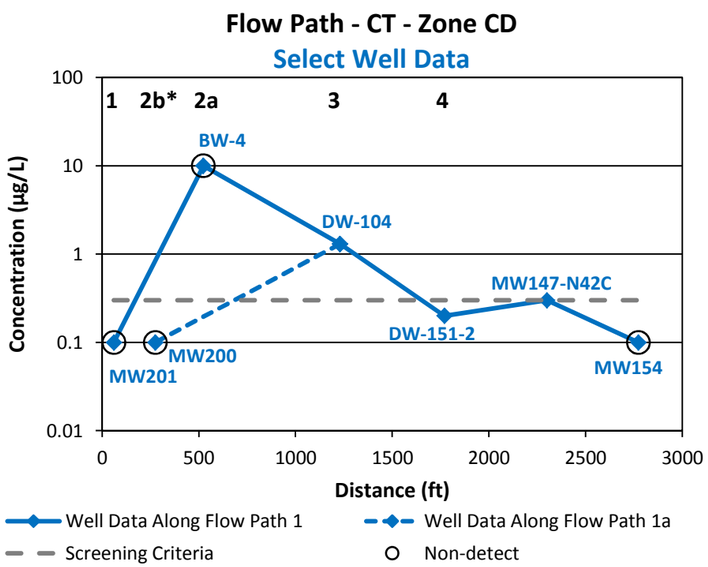
Figure 3-5b

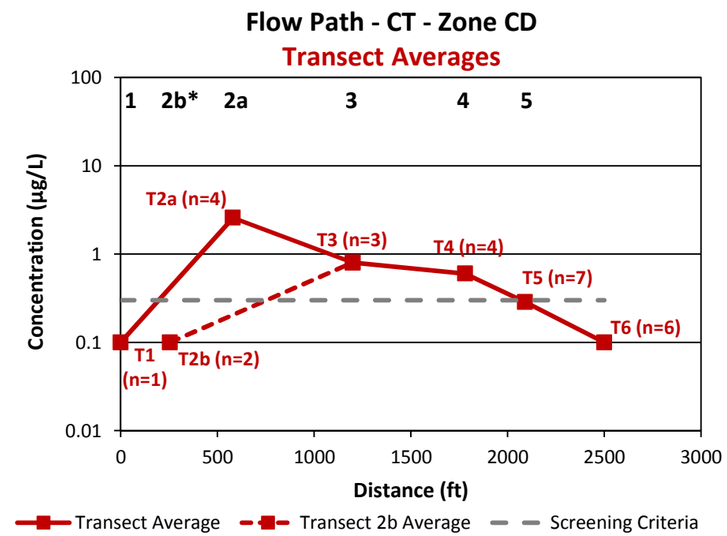
\\ tarc-fs1.prj\S:\C\Chemtronics\MNA\Front Valley\Post-Shutdown\Figures\MXD\[Fig3-1 to 3-10_FV AB CD Distance Trends.xlsx]ROX_FlowPath B

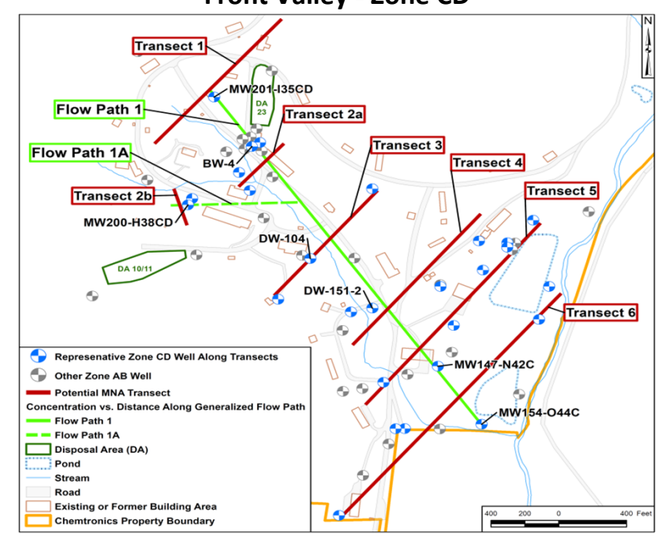












Notes:

1. µg/L – micrograms per liter.
2. Screening criteria are the North Carolina 2L or IMAC groundwater standards. For chemicals without a 2L/IMAC, the drinking water criteria from the *Final Remedial Investigation Report, Baseline Risk Assessment (Appendix L)* were used (Altamont, 2015a).
3. Non-detects are displayed at the method detection limit (MDL).
4. Transect average represents the average concentration (detections plus MDLs for non-detects) for wells along each MNA transect in each respective zone (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]).
5. T# (n=##) – Transect number (e.g., Transect 1, Transect 2a, etc.), where "n" is the number of samples included in the transect average.
6. For BW-4 and other pilot test wells (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]), pre-pilot data were used. Otherwise, data represent the most recent sample result between 2007 and 2014 for each analyte for each location.
7. CT - carbon tetrachloride.
8. Select Front Valley Areas of Interest (AOIs) are noted in each panel as follows:
   - **1** - B113, B114, B115
   - **2b*** - B147 & B105-139 (*Flow Path 1a only)
   - **2a** - DA 23/B116
   - **3** - B104-145
   - **4** - B150-151
   - **5** - B149 (Transect Averages only)

Pre-Shutdown CT Concentration vs. Distance - Zones AB and CD
Chemtronics Site
Swannanoa, North Carolina

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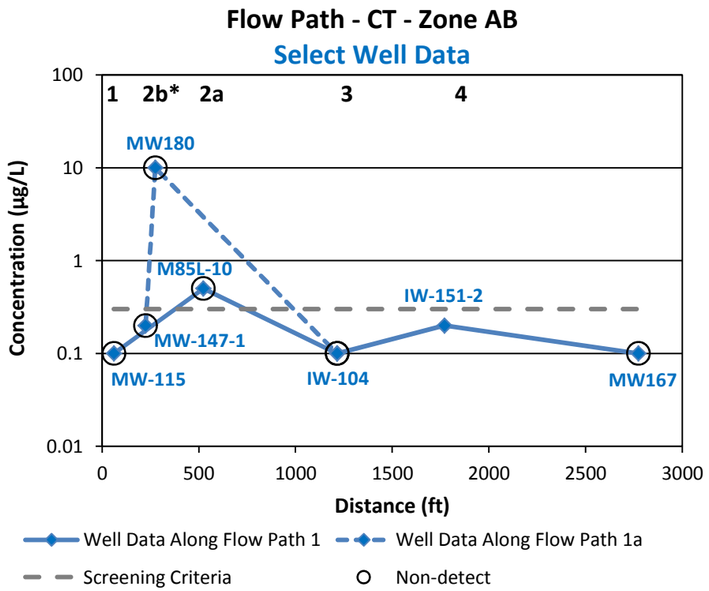
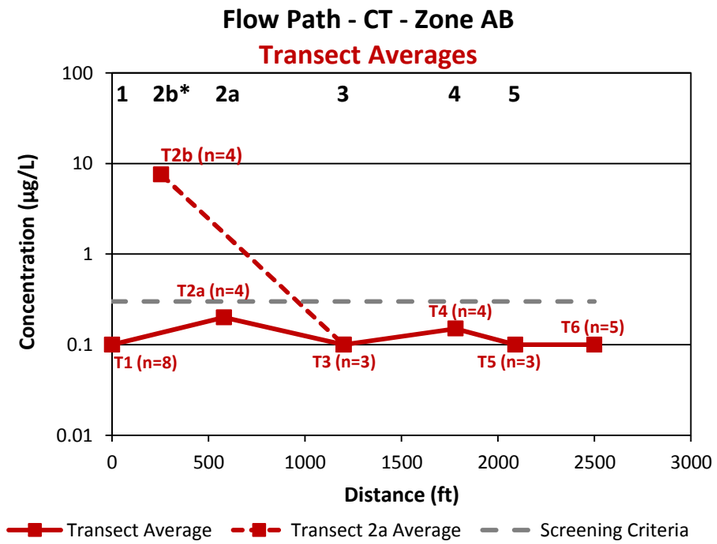
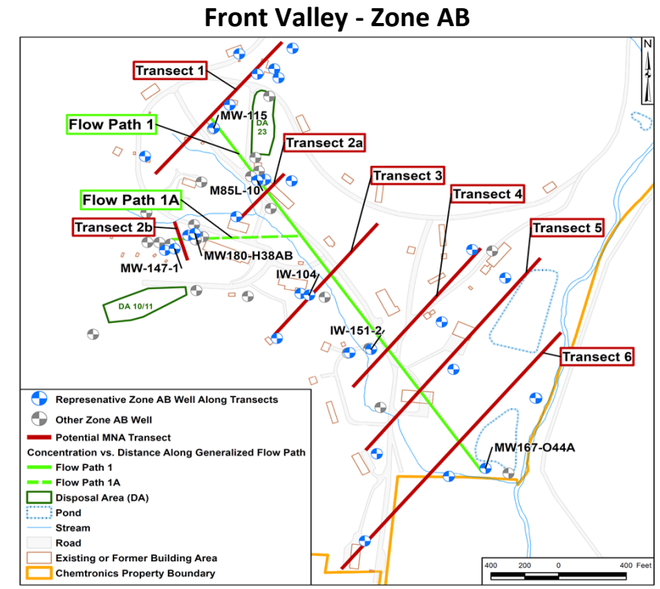
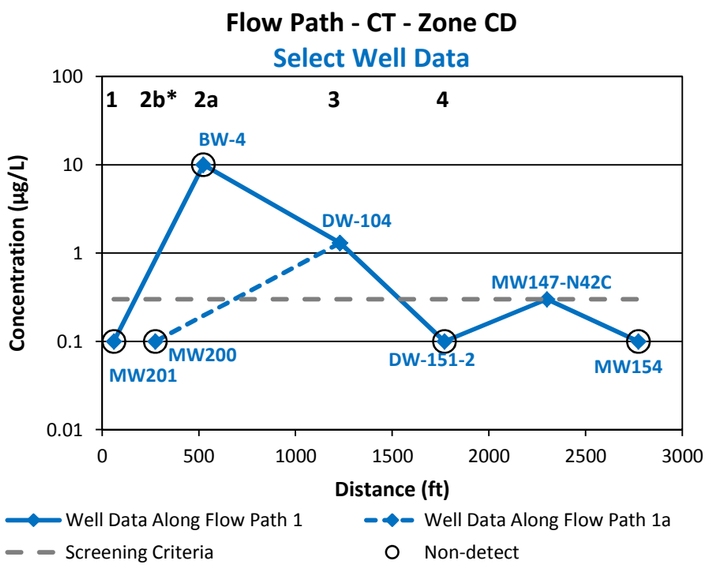
Figure 3-6a

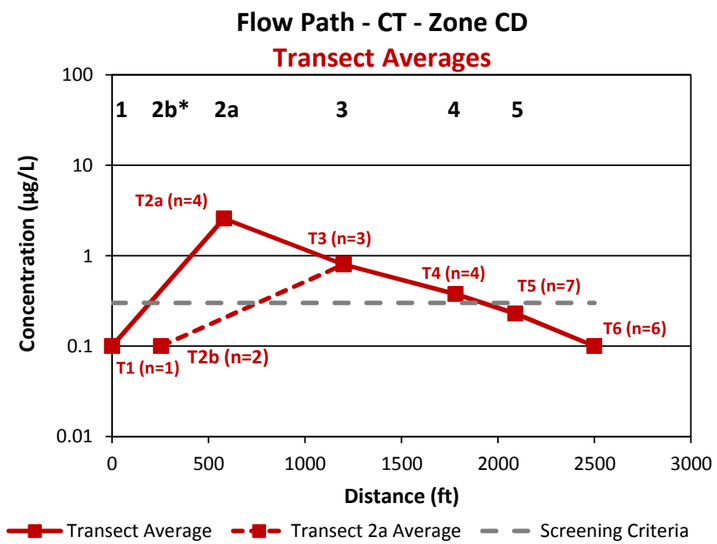
\\aro-01\prj$\C\Chemtronics\MNA\Front Valley\Post-Shutdown\Figures\MXD\[Fig3-1 to 3-10_FV AB CD Distance Trends.xlsx]RDX_FlowPath B

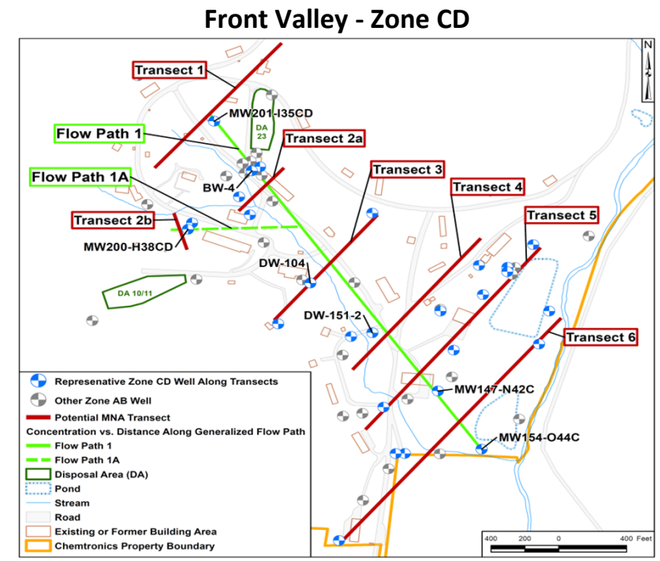












Notes:

1. µg/L – micrograms per liter.
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3. Non-detects are displayed at the method detection limit (MDL).
4. Transect average represents the average concentration (detections plus MDLs for non-detects) for wells along each MNA transect in each respective zone (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]).
5. T# (n=##) – Transect number (e.g., Transect 1, Transect 2a, etc.), where "n" is the number of samples included in the transect average.
6. For BW-4 and other pilot test wells (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]), pre-pilot data were used. Otherwise, data represent the most recent sample result between 2007 and 2014 for each analyte for each location.
7. CT - carbon tetrachloride.
8. Select Front Valley Areas of Interest (AOIs) are noted in each panel as follows:
   - **1** - B113, B114, B115
   - **2b*** - B147 & B105-139 (*Flow Path 1a only)
   - **2a** - DA 23/B116
   - **3** - B104-145
   - **4** - B150-151
   - **5** - B149 (Transect Averages only)

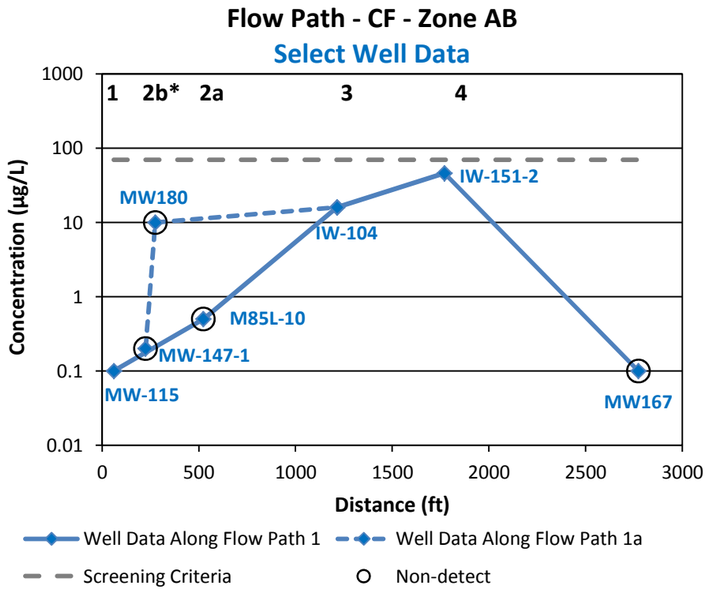
Post-Shutdown CT Concentration vs. Distance - Zones AB and CD
Chemtronics Site
Swannanoa, North Carolina

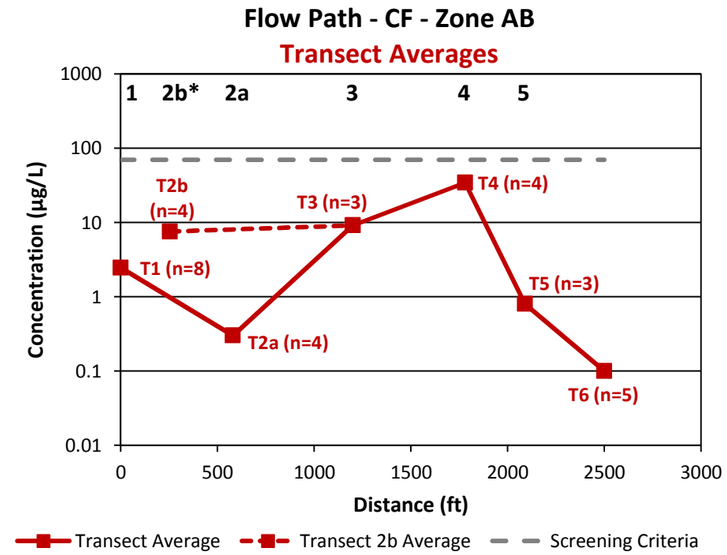
Geosyntec consultants

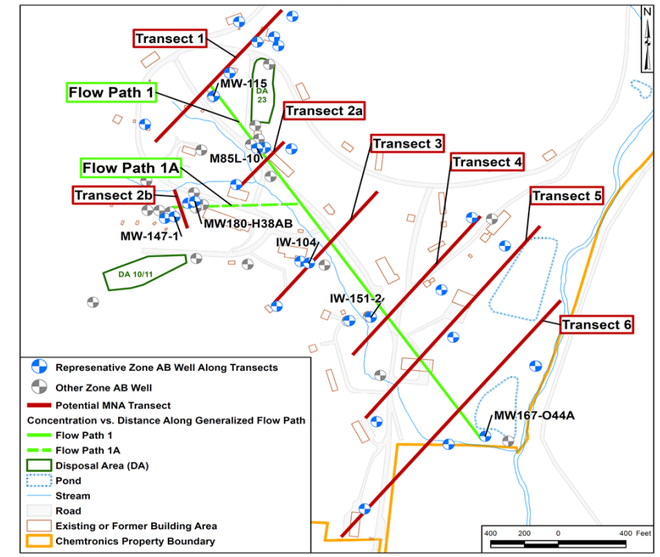
Kennesaw | July 2016

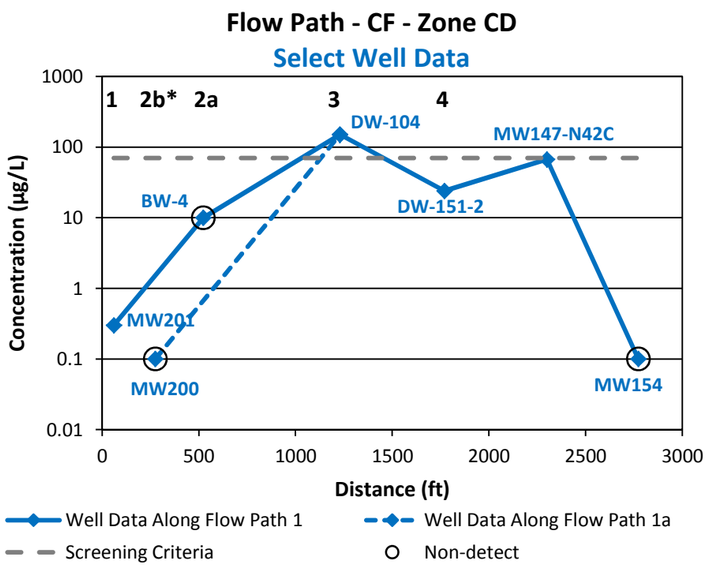
Figure 3-6b

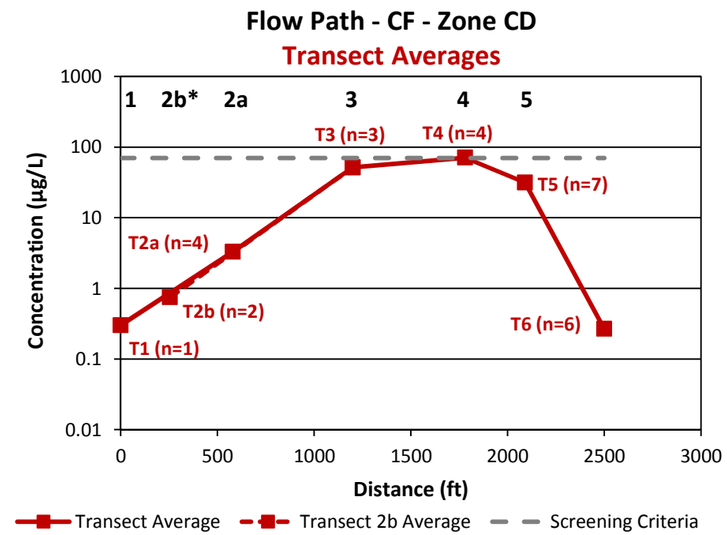
\\ tarc-dc1.prj$\C:\Chemtronics\MNA\Front Valley\Post-Shutdown\Figures\MXD\[Fig3-1 to 3-10_FV AB CD Distance Trends.xlsx]BOX_FlowPath B

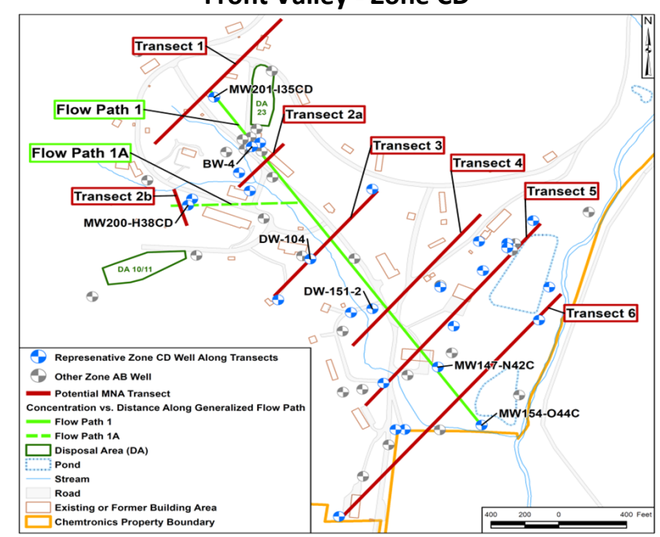












Notes:

1. µg/L – micrograms per liter.
2. Screening criteria are the North Carolina 2L or IMAC groundwater standards. For chemicals without a 2L/IMAC, the drinking water criteria from the *Final Remedial Investigation Report, Baseline Risk Assessment (Appendix L)* were used (Altamont, 2015a).
3. Non-detects are displayed at the method detection limit (MDL).
4. Transect average represents the average concentration (detections plus MDLs for non-detects) for wells along each MNA transect in each respective zone (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]).
5. T# (n=##) – Transect number (e.g., Transect 1, Transect 2a, etc.), where "n" is the number of samples included in the transect average.
6. For BW-4 and other pilot test wells (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]), pre-pilot data were used. Otherwise, data represent the most recent sample result between 2007 and 2014 for each analyte for each location.
7. CF - chloroform.
8. Select Front Valley Areas of Interest (AOIs) are noted in each panel as follows:
   - **1** - B113, B114, B115
   - **2b*** - B147 & B105-139 (*Flow Path 1a only)
   - **2a** - DA 23/B116
   - **3** - B104-145
   - **4** - B150-151
   - **5** - B149 (Transect Averages only)

Pre-Shutdown CF Concentration vs. Distance - Zones AB and CD
Chemtronics Site
Swannanoa, North Carolina

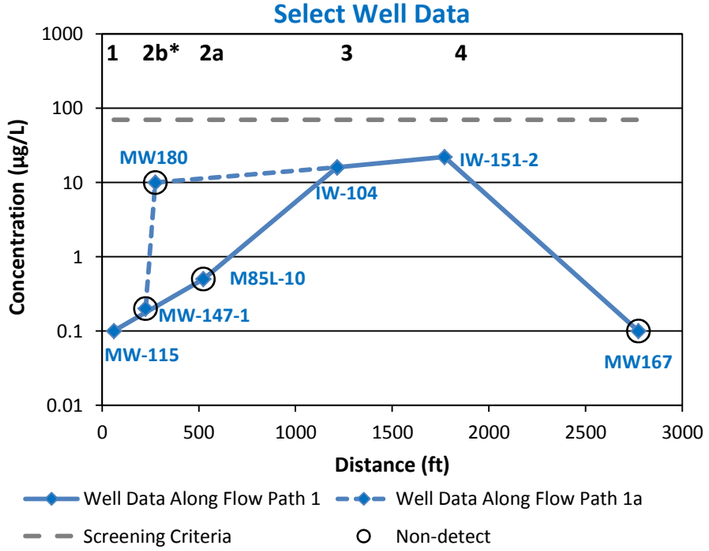
Geosyntec consultants

Kennesaw | July 2016

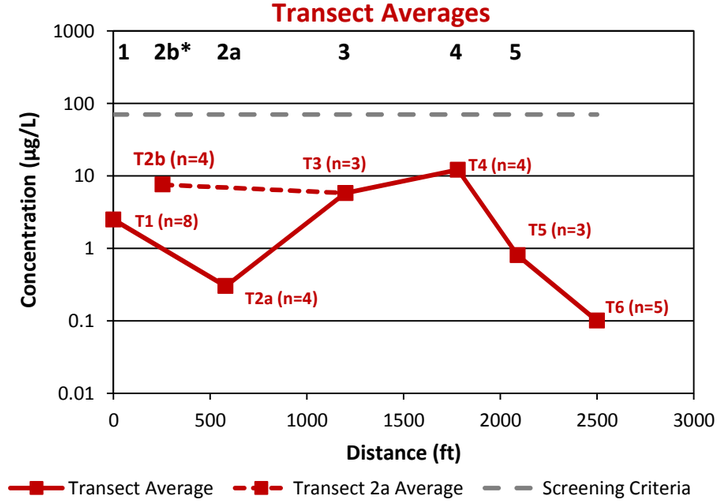
Figure 3-7a

\\aro-01\prj$\C\Chemtronics\MNA\Front Valley\Post-Shutdown\Figures\MXD\[Fig3-1 to 3-10_FV AB CD Distance Trends.xlsx]RDX_FlowPath B

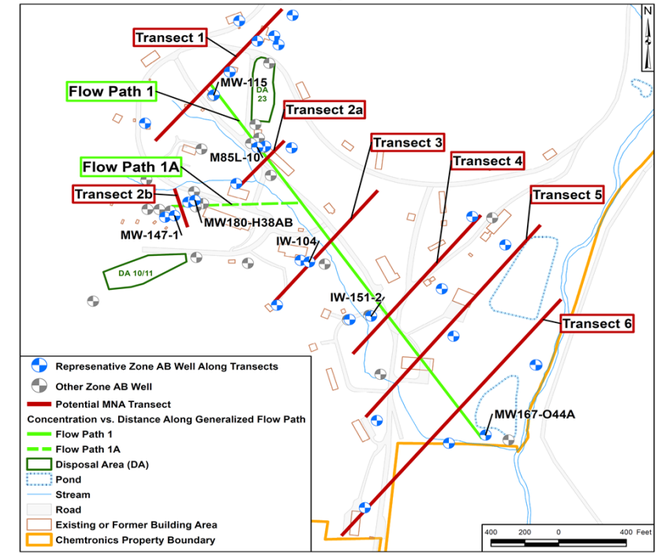
Flow Path - CF - Zone AB
Select Well Data



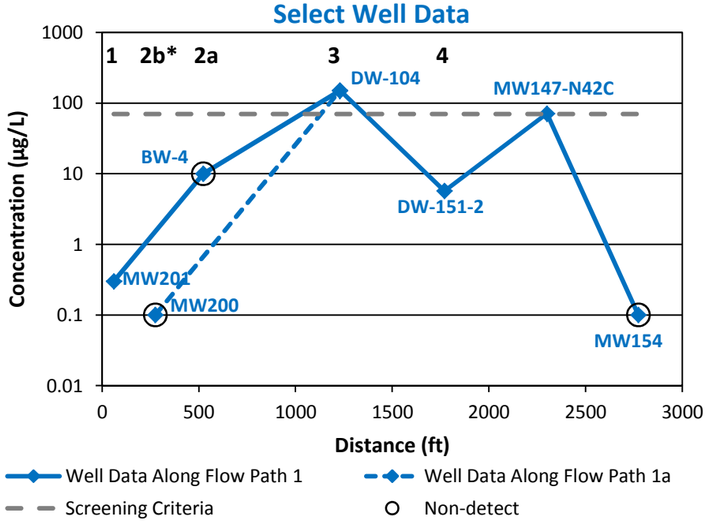
Flow Path - CF - Zone AB
Transect Averages



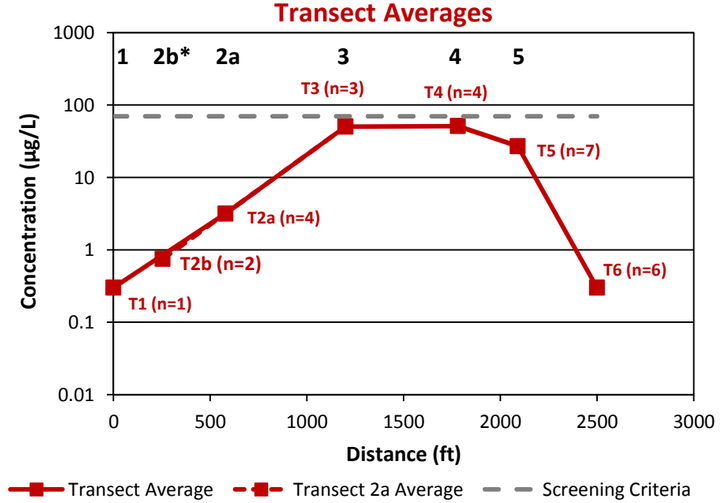
Front Valley - Zone AB



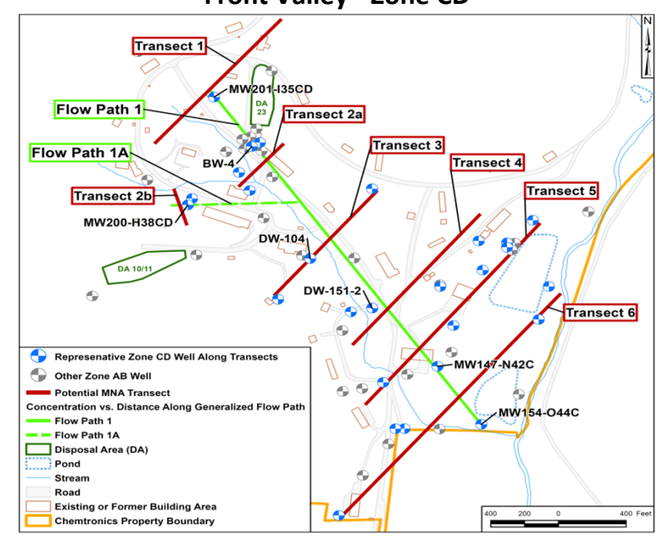
Flow Path - CF - Zone CD
Select Well Data



Flow Path - CF - Zone CD
Transect Averages



Front Valley - Zone CD



Notes:

1. µg/L – micrograms per liter.
2. Screening criteria are the North Carolina 2L or IMAC groundwater standards. For chemicals without a 2L/IMAC, the drinking water criteria from the *Final Remedial Investigation Report, Baseline Risk Assessment (Appendix L)* were used (Altamont, 2015a).
3. Non-detects are displayed at the method detection limit (MDL).
4. Transect average represents the average concentration (detections plus MDLs for non-detects) for wells along each MNA transect in each respective zone (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]).
5. T# (n=##) – Transect number (e.g., Transect 1, Transect 2a, etc.), where "n" is the number of samples included in the transect average.
6. For BW-4 and other pilot test wells (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]), pre-pilot data were used. Otherwise, data represent the most recent sample result between 2007 and 2014 for each analyte for each location.
7. CF - chloroform.
8. Select Front Valley Areas of Interest (AOIs) are noted in each panel as follows:
   - **1** - B113, B114, B115
   - **2b*** - B147 & B105-139 (*Flow Path 1a only)
   - **2a** - DA 23/B116
   - **3** - B104-145
   - **4** - B150-151
   - **5** - B149 (Transect Averages only)

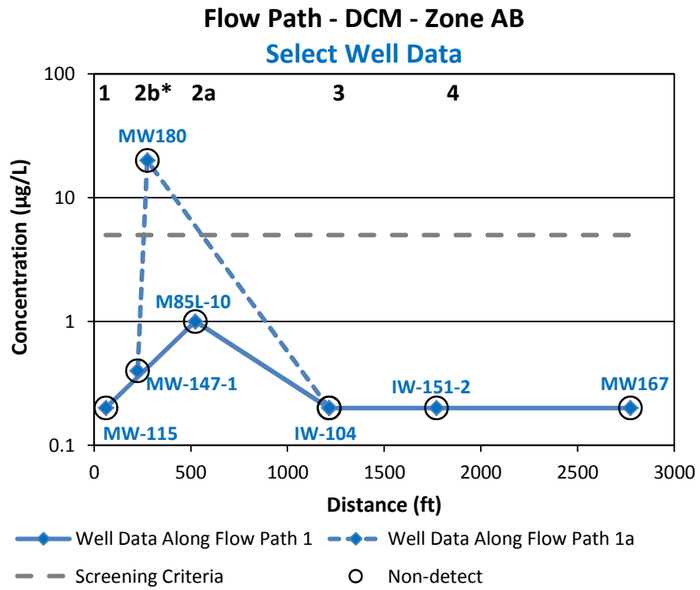
Post-Shutdown CF Concentration vs. Distance - Zones AB and CD
Chemtronics Site
Swannanoa, North Carolina

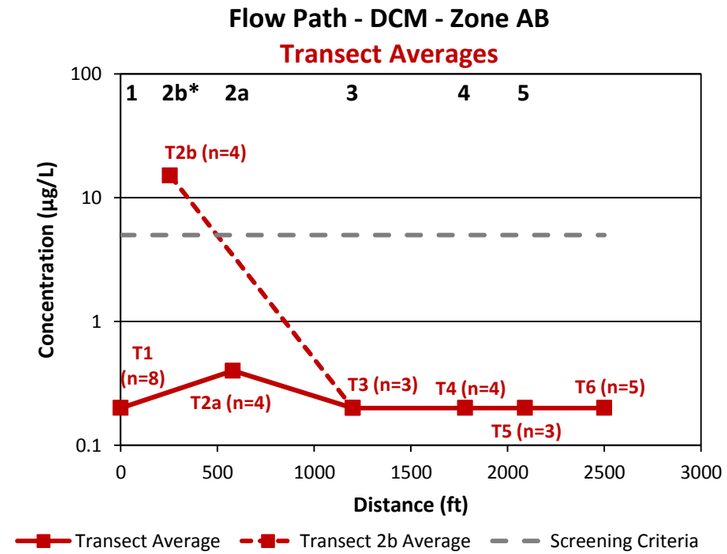
Geosyntec consultants

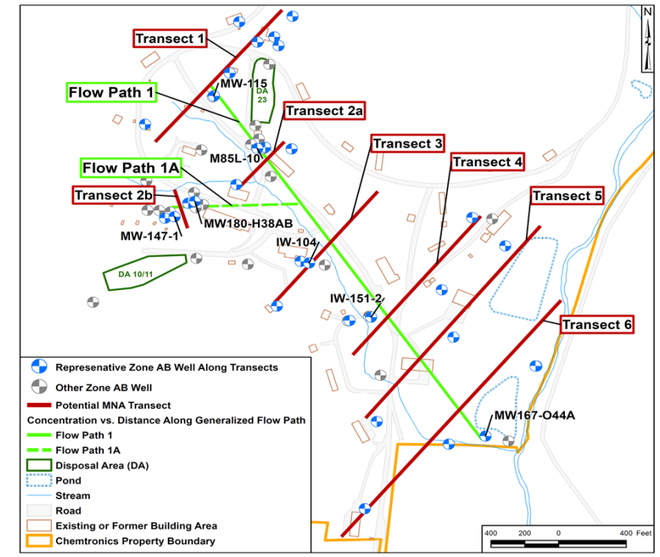
Figure 3-7b

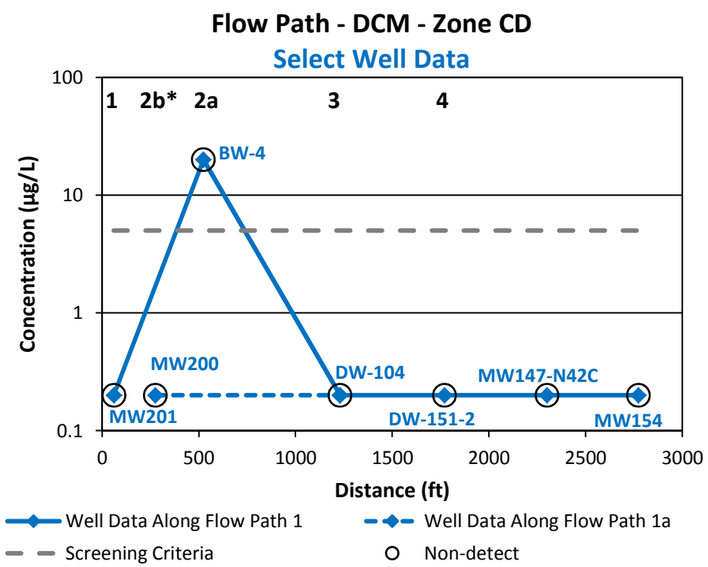
Kennesaw | July 2016

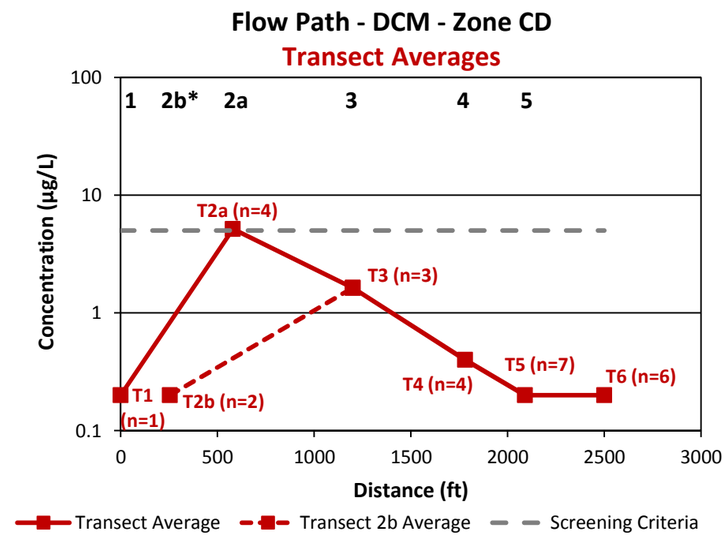
\\ tarc-fs1.prj$\C\Chemtronics\MNA\Front Valley\Post-Shutdown\Figures\MXD\[Fig3-1 to 3-10_FV AB CD Distance Trends.xlsx]ROX_FlowPath B

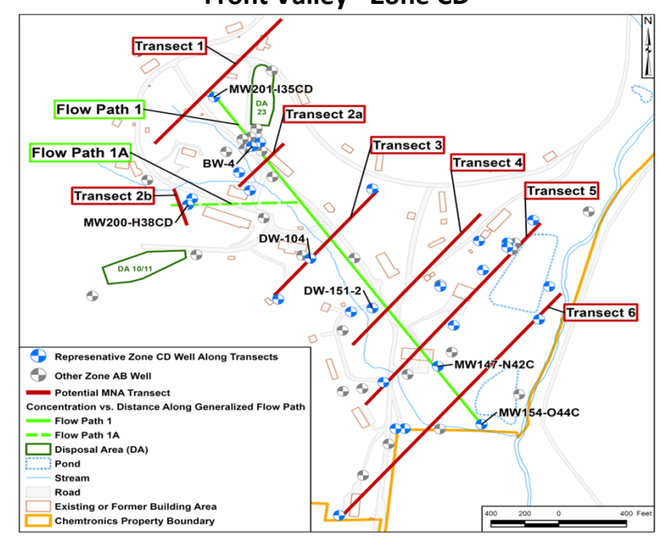












Notes:

1. µg/L – micrograms per liter.
2. Screening criteria are the North Carolina 2L or IMAC groundwater standards. For chemicals without a 2L/IMAC, the drinking water criteria from the *Final Remedial Investigation Report, Baseline Risk Assessment (Appendix L)* were used (Altamont, 2015a).
3. Non-detects are displayed at the method detection limit (MDL).
4. Transect average represents the average concentration (detections plus MDLs for non-detects) for wells along each MNA transect in each respective zone (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]).
5. T# (n=##) – Transect number (e.g., Transect 1, Transect 2a, etc.), where "n" is the number of samples included in the transect average.
6. For BW-4 and other pilot test wells (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]), pre-pilot data were used. Otherwise, data represent the most recent sample result between 2007 and 2014 for each analyte for each location.
7. DCM - dichloromethane.
8. Select Front Valley Areas of Interest (AOIs) are noted in each panel as follows:
   - **1** - B113, B114, B115
   - **2b*** - B147 & B105-139 (*Flow Path 1a only)
   - **2a** - DA 23/B116
   - **3** - B104-145
   - **4** - B150-151
   - **5** - B149 (Transect Averages only)

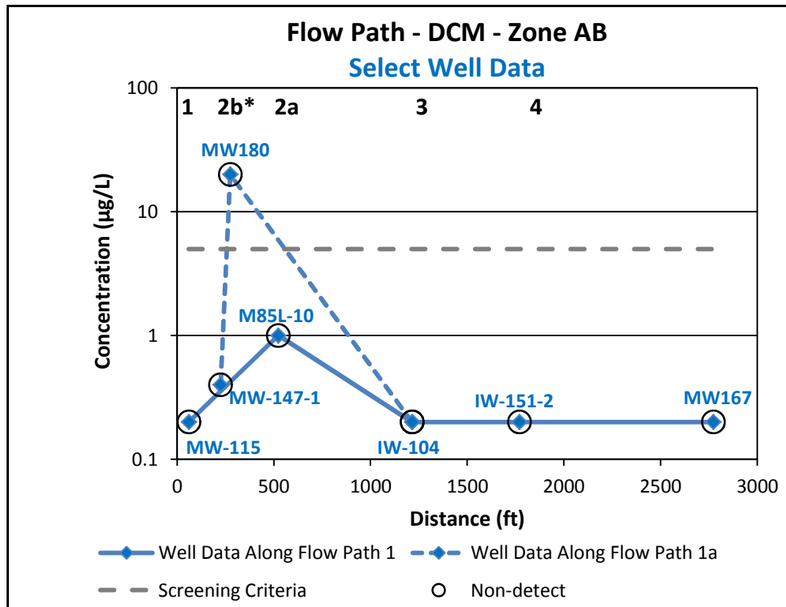
Pre-Shutdown DCM Concentration vs. Distance - Zones AB and CD
Chemtronics Site
Swannanoa, North Carolina

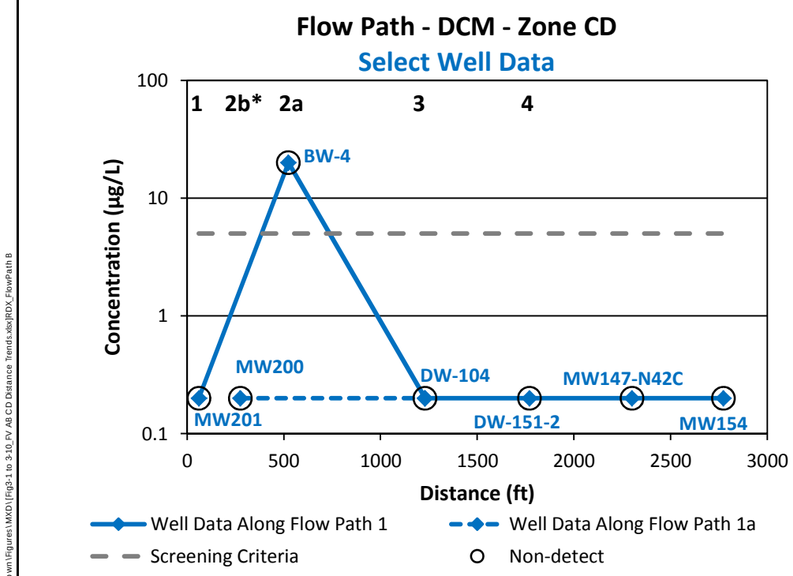
Geosyntec consultants

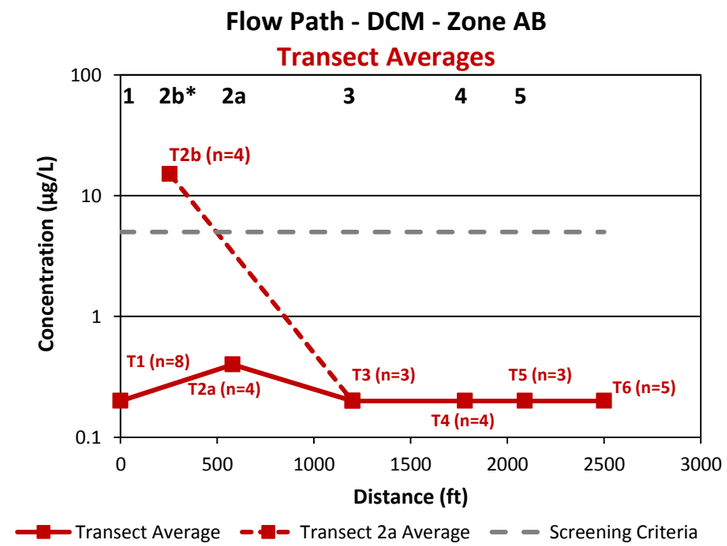
Kennesaw | July 2016

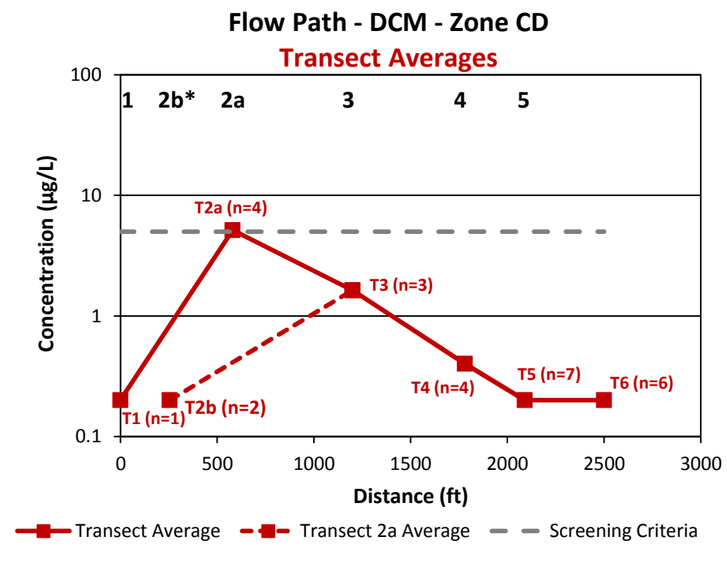
Figure 3-8a

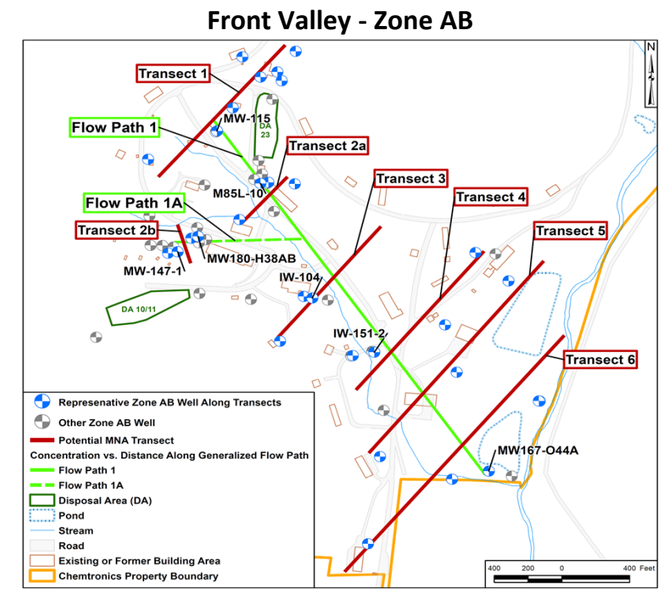
\\aro-01\prj$\C\Chemtronics\MNA\Front Valley\Post-Shutdown\Figures\MXD\[Fig3-1 to 3-10_FV AB CD Distance Trends.xlsx]RDX_FlowPath B

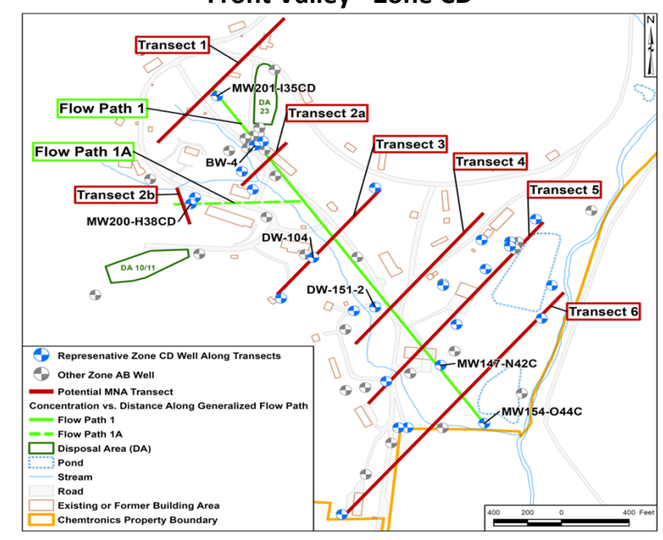












Notes:

1. µg/L – micrograms per liter.
2. Screening criteria are the North Carolina 2L or IMAC groundwater standards. For chemicals without a 2L/IMAC, the drinking water criteria from the *Final Remedial Investigation Report, Baseline Risk Assessment (Appendix L)* were used (Altamont, 2015a).
3. Non-detects are displayed at the method detection limit (MDL).
4. Transect average represents the average concentration (detections plus MDLs for non-detects) for wells along each MNA transect in each respective zone (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]).
5. T# (n=##) – Transect number (e.g., Transect 1, Transect 2a, etc.), where "n" is the number of samples included in the transect average.
6. For BW-4 and other pilot test wells (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]), pre-pilot data were used. Otherwise, data represent the most recent sample result between 2007 and 2014 for each analyte for each location.
7. DCM - dichloromethane.
8. Select Front Valley Areas of Interest (AOIs) are noted in each panel as follows:
   - **1** - B113, B114, B115
   - **2b*** - B147 & B105-139 (*Flow Path 1a only)
   - **2a** - DA 23/B116
   - **3** - B104-145
   - **4** - B150-151
   - **5** - B149 (Transect Averages only)

Post-Shutdown DCM Concentration vs. Distance - Zones AB and CD

Chemtronics Site
Swannanoa, North Carolina

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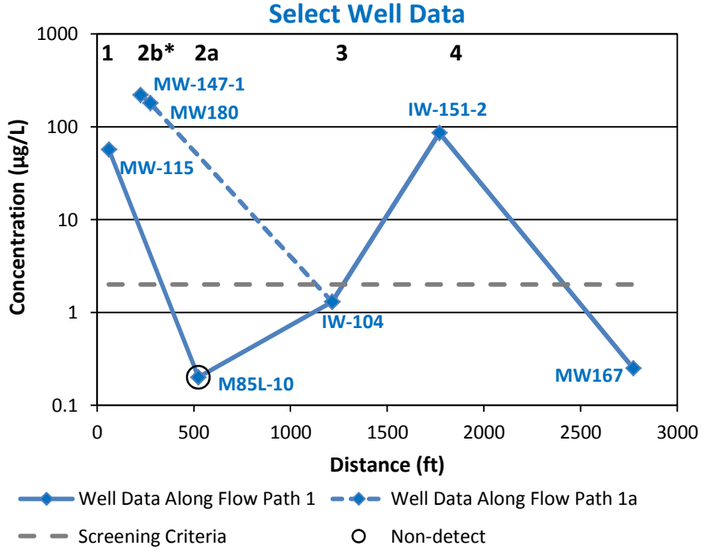
Figure 3-8b

\\ane-fs1 (pt)\S\C\Chemtronics\MNA\Front Valley\Post-Shutdown\Figures\MXD\[Fig3-1 to 3-10_FV AB CD Distance Trends.xlsx]ROX_FlowPath B

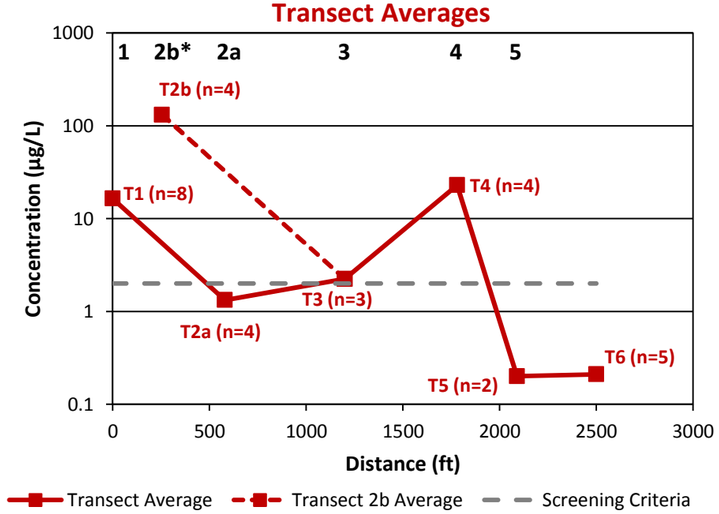
Flow Path - Perchlorate - Zone AB

Select Well Data

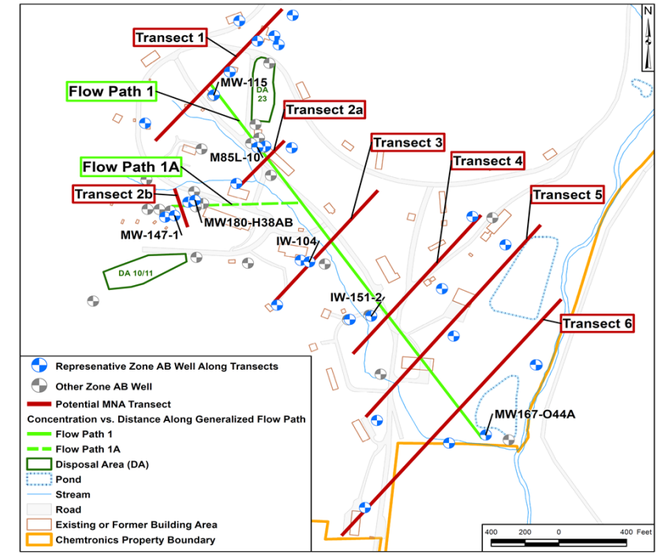


Flow Path - Perchlorate - Zone AB

Transect Averages

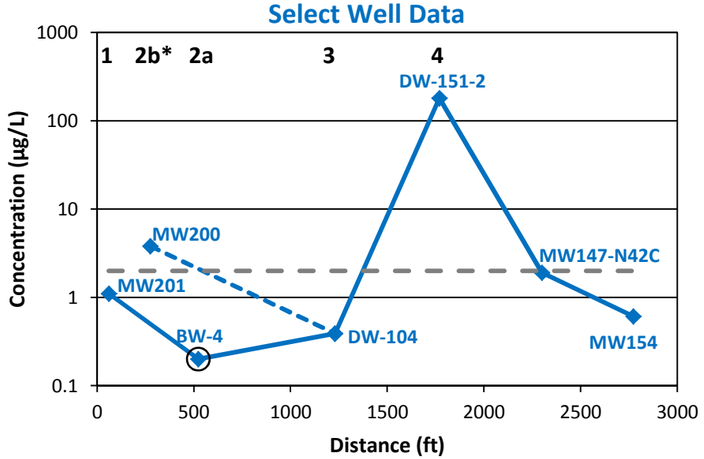


Front Valley - Zone AB



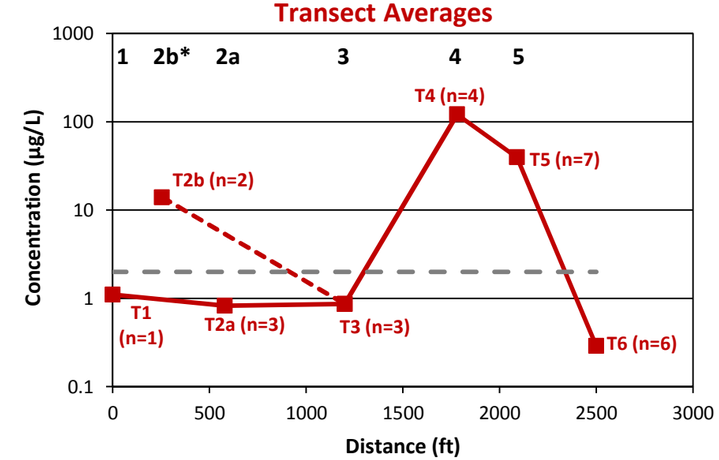
Flow Path - Perchlorate - Zone CD

Select Well Data

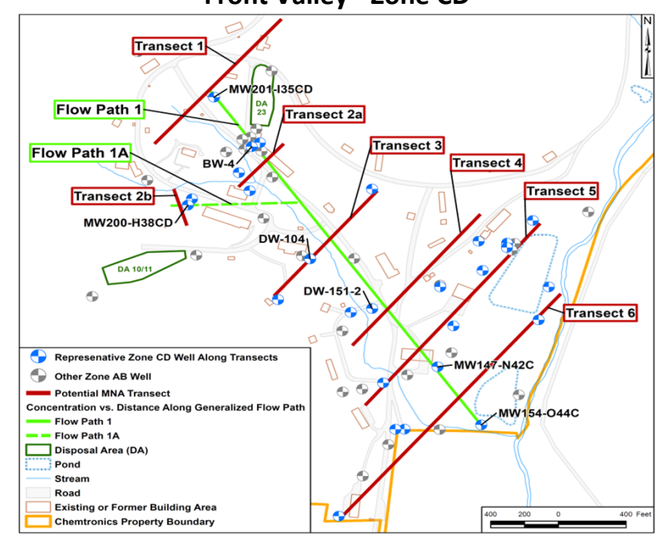


Flow Path - Perchlorate - Zone CD

Transect Averages



Front Valley - Zone CD



Notes:

1. µg/L – micrograms per liter.
2. Screening criteria are the North Carolina 2L or IMAC groundwater standards. For chemicals without a 2L/IMAC, the drinking water criteria from the *Final Remedial Investigation Report, Baseline Risk Assessment (Appendix L)* were used (Altamont, 2015a).
3. Non-detects are displayed at the method detection limit (MDL).
4. Transect average represents the average concentration (detections plus MDLs for non-detects) for wells along each MNA transect in each respective zone (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]).
5. T# (n=##) – Transect number (e.g., Transect 1, Transect 2a, etc.), where "n" is the number of samples included in the transect average.
6. For BW-4 and other pilot test wells (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]), pre-pilot data were used. Otherwise, data represent the most recent sample result between 2007 and 2014 for each analyte for each location.
7. Select Front Valley Areas of Interest (AOIs) are noted in each panel as follows:
   - **1** - B113, B114, B115
   - **2b*** - B147 & B105-139 (*Flow Path 1a only)
   - **2a** - DA 23/B116
   - **3** - B104-145
   - **4** - B150-151
   - **5** - B149 (Transect Averages only)

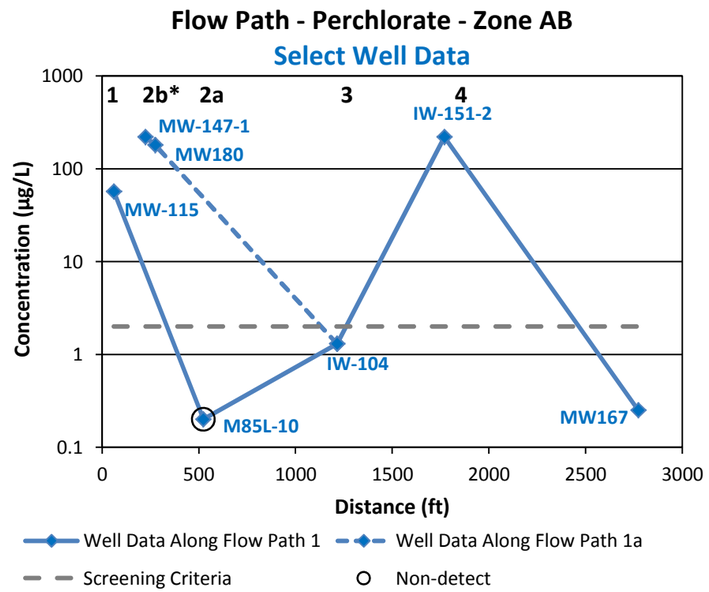
Pre-Shutdown Perchlorate Concentration vs. Distance - Zones AB and CD
Chemtronics Site
Swannanoa, North Carolina

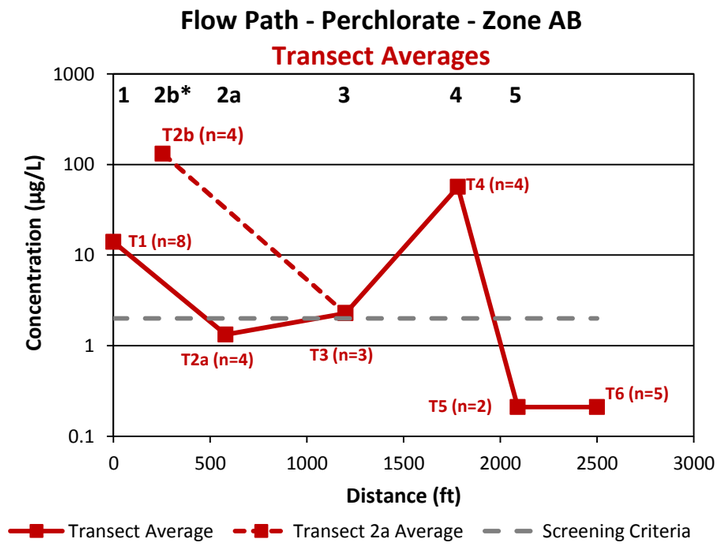
Geosyntec consultants

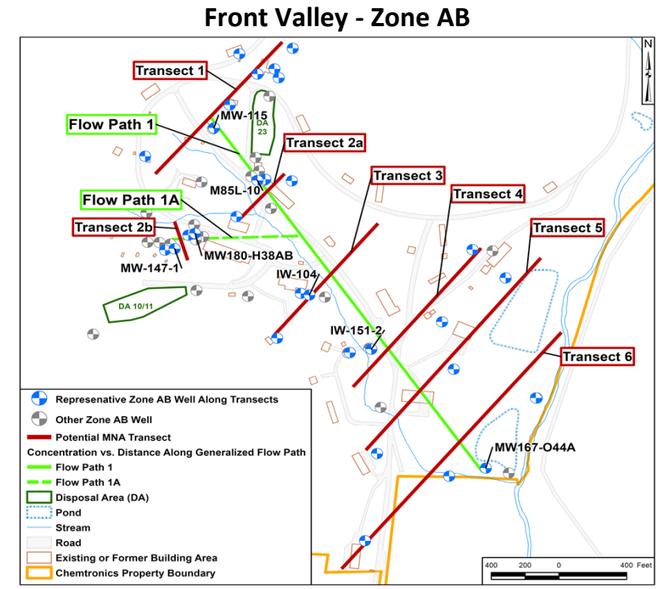
Kennesaw | July 2016

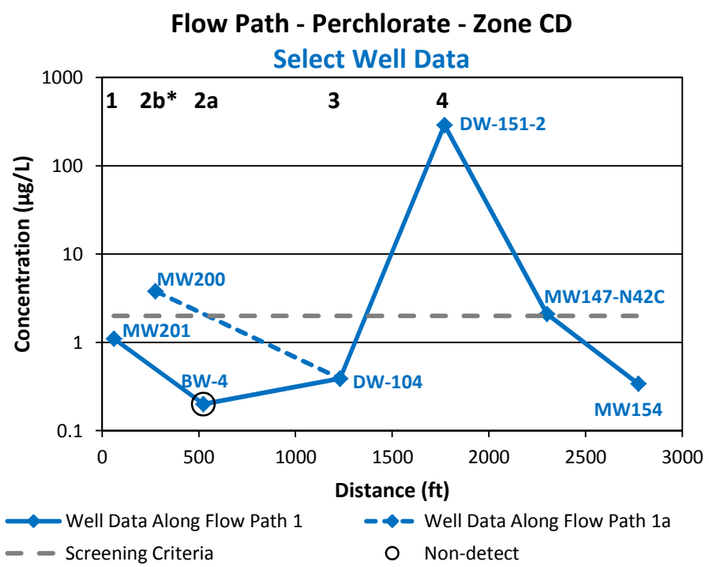
Figure 3-9a

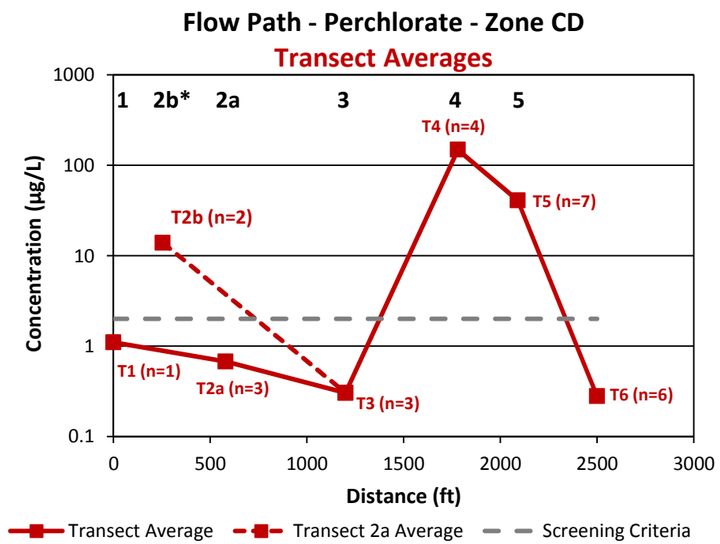
\\ tarc-fs1.prj\S\C\Chemtronics\MNA\Front Valley\Post-Shutdown\Figures\MXD\[Fig3-1 to 3-10_PV AB CD Distance Trends.xlsx]ROX_FlowPath B

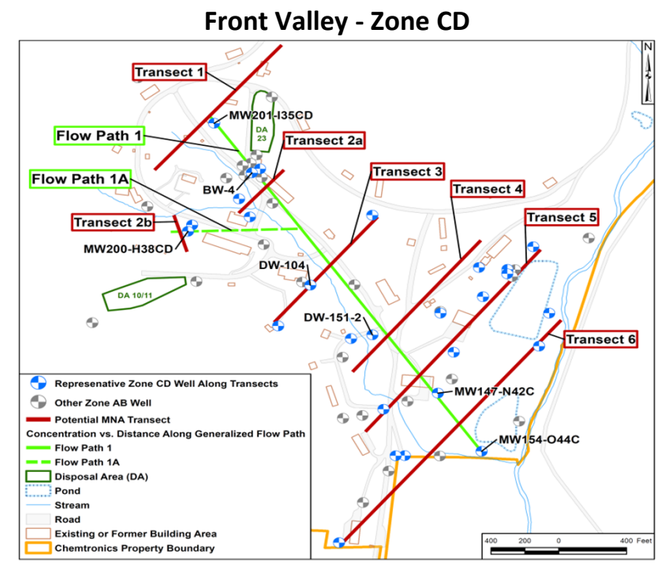












Notes:

1. µg/L – micrograms per liter.
2. Screening criteria are the North Carolina 2L or IMAC groundwater standards. For chemicals without a 2L/IMAC, the drinking water criteria from the *Final Remedial Investigation Report, Baseline Risk Assessment (Appendix L)* were used (Altamont, 2015a).
3. Non-detects are displayed at the method detection limit (MDL).
4. Transect average represents the average concentration (detections plus MDLs for non-detects) for wells along each MNA transect in each respective zone (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]).
5. T# (n=##) – Transect number (e.g., Transect 1, Transect 2a, etc.), where "n" is the number of samples included in the transect average.
6. For BW-4 and other pilot test wells (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]), pre-pilot data were used. Otherwise, data represent the most recent sample result between 2007 and 2014 for each analyte for each location.
7. Select Front Valley Areas of Interest (AOIs) are noted in each panel as follows:
   - **1** - B113, B114, B115
   - **2b*** - B147 & B105-139 (*Flow Path 1a only)
   - **2a** - DA 23/B116
   - **3** - B104-145
   - **4** - B150-151
   - **5** - B149 (Transect Averages only)

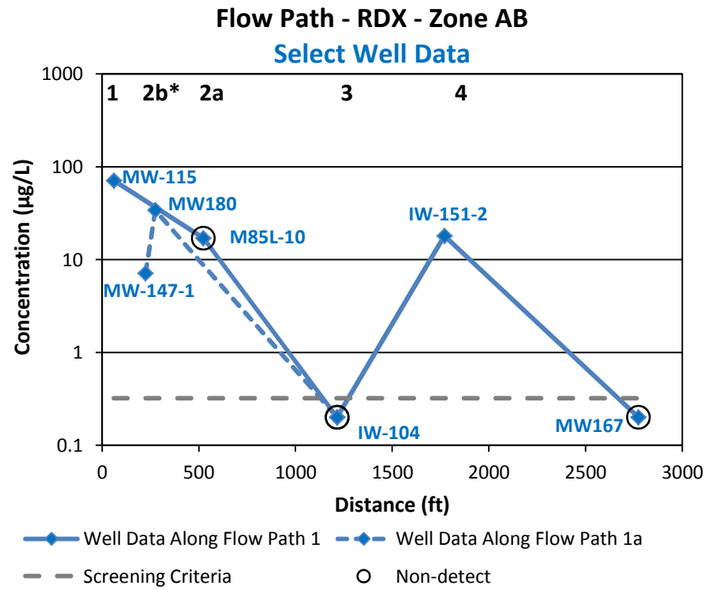
Post-Shutdown Perchlorate Concentration vs. Distance - Zones AB and CD
Chemtronics Site
Swannanoa, North Carolina

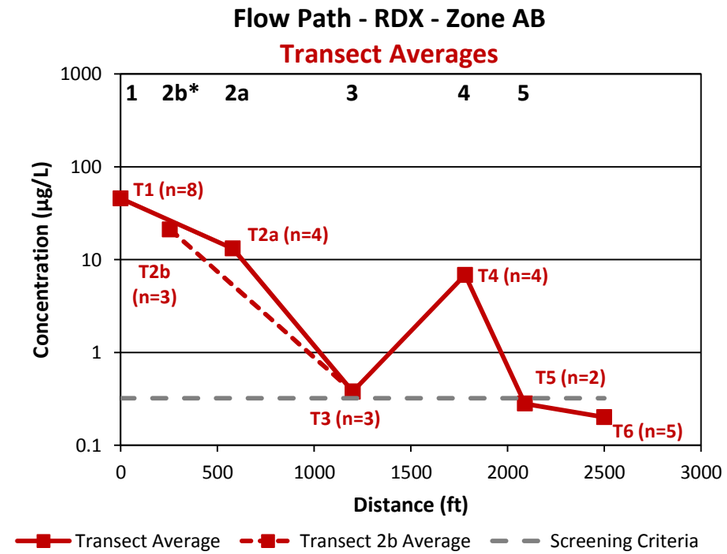
Geosyntec consultants

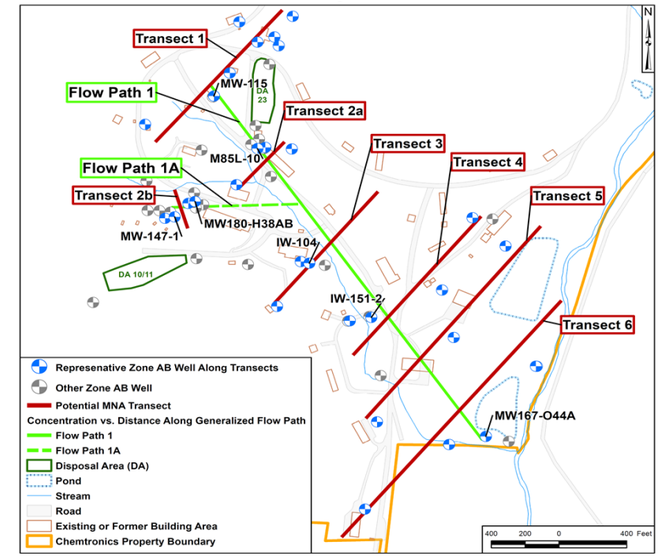
Kennesaw | July 2016

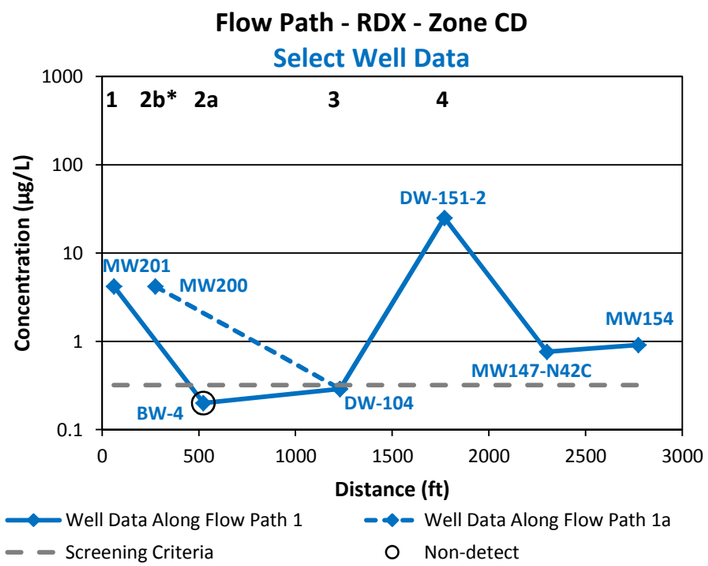
Figure 3-9b

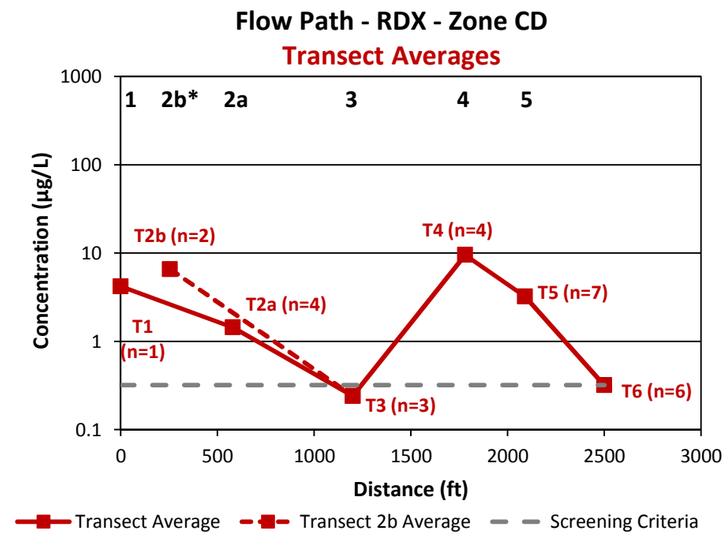
\\aro-01\prj$\C\Chemtronics\MNA\Front Valley\Post-Shutdown\Figures\MXD\[Fig3-1 to 3-10_FV AB CD Distance Trends.xlsx]RDX_FlowPath B

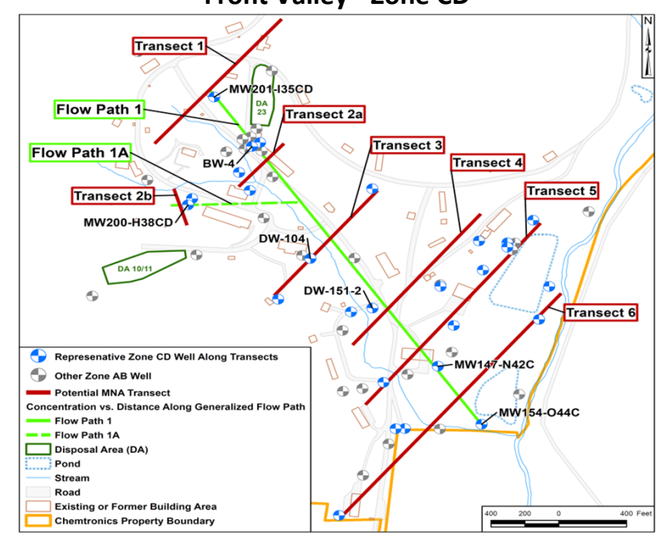












Notes:

1. µg/L – micrograms per liter.
2. Screening criteria are the North Carolina 2L or IMAC groundwater standards. For chemicals without a 2L/IMAC, the drinking water criteria from the *Final Remedial Investigation Report, Baseline Risk Assessment (Appendix L)* were used (Altamont, 2015a).
3. Non-detects are displayed at the method detection limit (MDL).
4. Transect average represents the average concentration (detections plus MDLs for non-detects) for wells along each MNA transect in each respective zone (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]).
5. T# (n=##) – Transect number (e.g., Transect 1, Transect 2a, etc.), where "n" is the number of samples included in the transect average.
6. For BW-4 and other pilot test wells (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]), pre-pilot data were used. Otherwise, data represent the most recent sample result between 2007 and 2014 for each analyte for each location.
7. RDX - Research Department Explosive.
8. Select Front Valley Areas of Interest (AOIs) are noted in each panel as follows:
   - **1** - B113, B114, B115
   - **2b*** - B147 & B105-139 (*Flow Path 1a only)
   - **2a** - DA 23/B116
   - **3** - B104-145
   - **4** - B150-151
   - **5** - B149 (Transect Averages only)

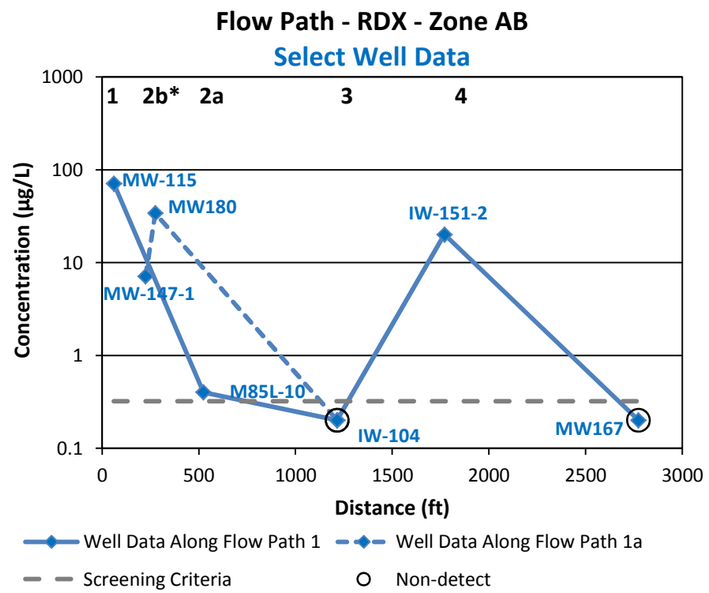
Pre-Shutdown RDX Concentration vs. Distance - Zones AB and CD
Chemtronics Site
Swannanoa, North Carolina

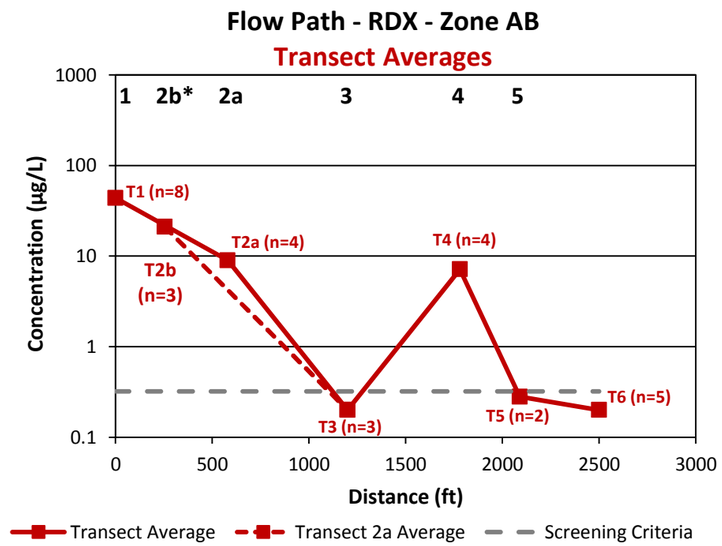
Geosyntec consultants

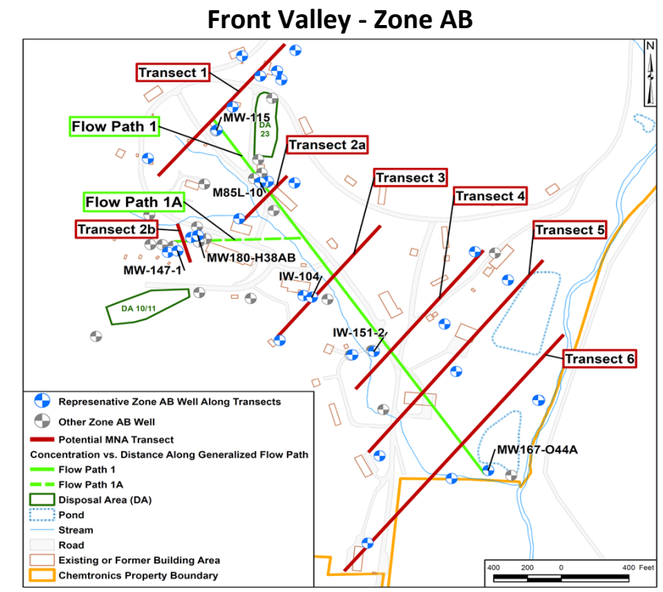
Kennesaw | July 2016

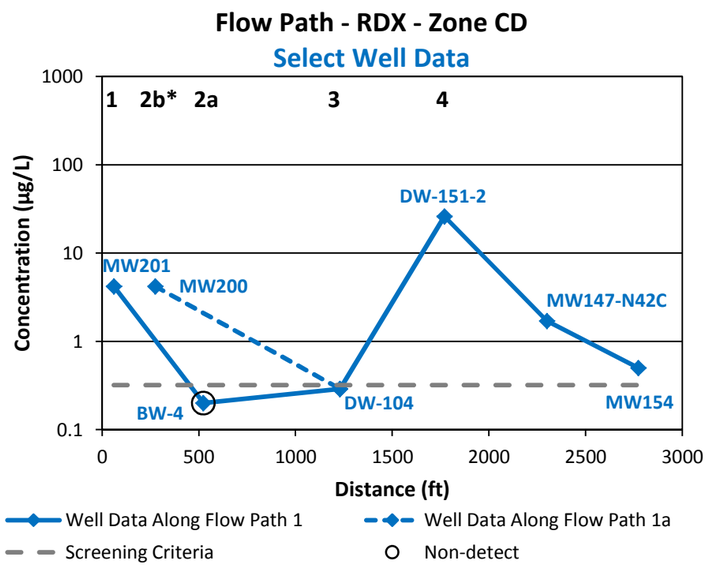
Figure 3-10a

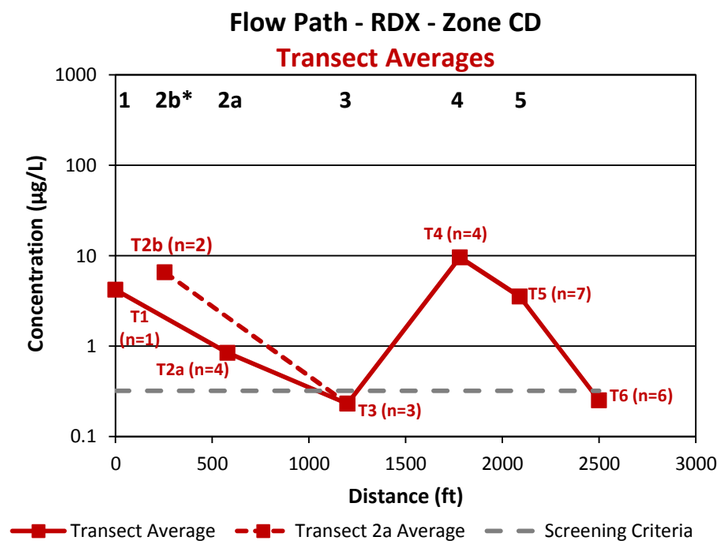
\\aro-01\prj$\C\Chemtronics\MNA\Front Valley\Post-Shutdown\Figures\MXD\[Fig3-1 to 3-10_FV AB CD Distance Trends.xlsx]RDX_FlowPath 8

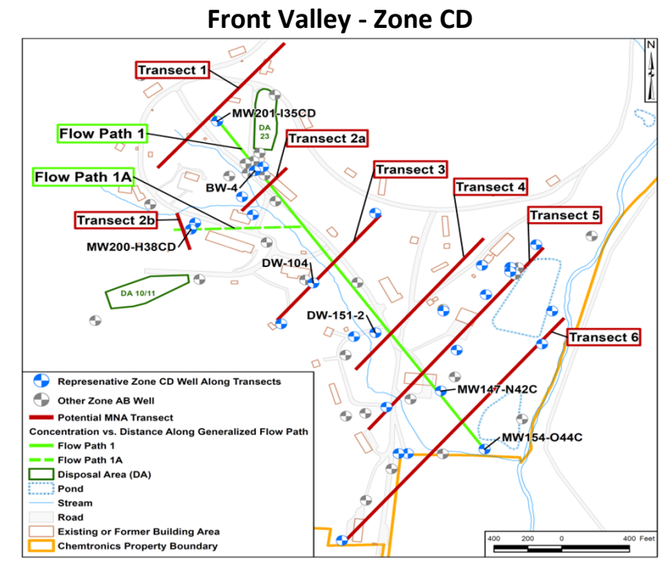












Notes:

1. µg/L – micrograms per liter.
2. Screening criteria are the North Carolina 2L or IMAC groundwater standards. For chemicals without a 2L/IMAC, the drinking water criteria from the *Final Remedial Investigation Report, Baseline Risk Assessment (Appendix L)* were used (Altamont, 2015a).
3. Non-detects are displayed at the method detection limit (MDL).
4. Transect average represents the average concentration (detections plus MDLs for non-detects) for wells along each MNA transect in each respective zone (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]).
5. T# (n=##) – Transect number (e.g., Transect 1, Transect 2a, etc.), where "n" is the number of samples included in the transect average.
6. For BW-4 and other pilot test wells (see Table 5-1 of the *Assessment of Monitored Natural Attenuation (MNA) Potential in the Front Valley* [Geosyntec, 2015]), pre-pilot data were used. Otherwise, data represent the most recent sample result between 2007 and 2014 for each analyte for each location.
7. RDX - Research Department Explosive.
8. Select Front Valley Areas of Interest (AOIs) are noted in each panel as follows:
   - **1** - B113, B114, B115
   - **2b*** - B147 & B105-139 (*Flow Path 1a only)
   - **2a** - DA 23/B116
   - **3** - B104-145
   - **4** - B150-151
   - **5** - B149 (Transect Averages only)

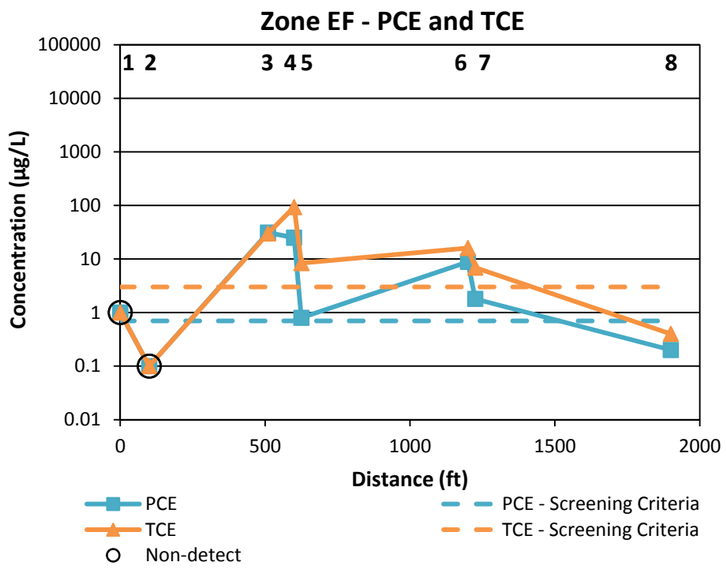
Post-Shutdown RDX Concentration vs. Distance - Zones AB and CD
Chemtronics Site
Swannanoa, North Carolina

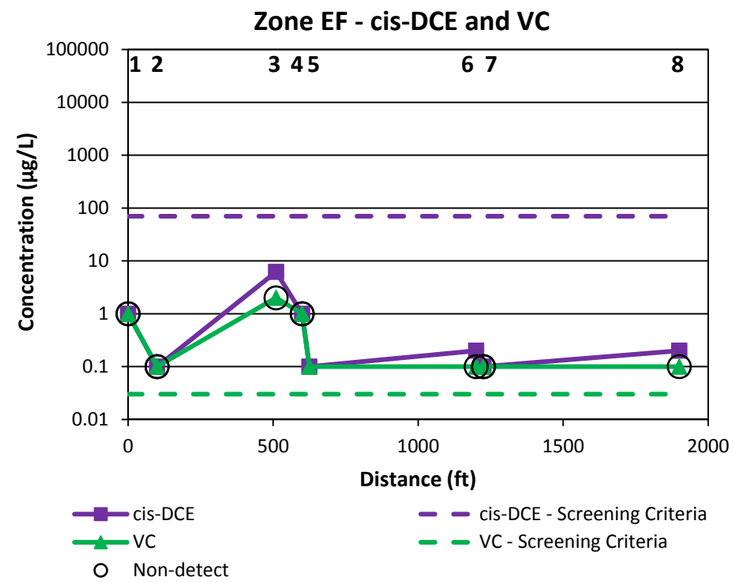
Geosyntec consultants

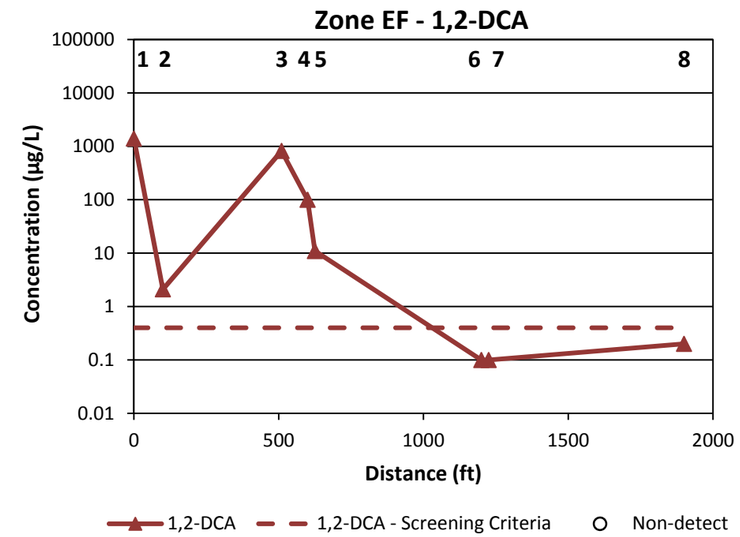
Kennesaw | July 2016

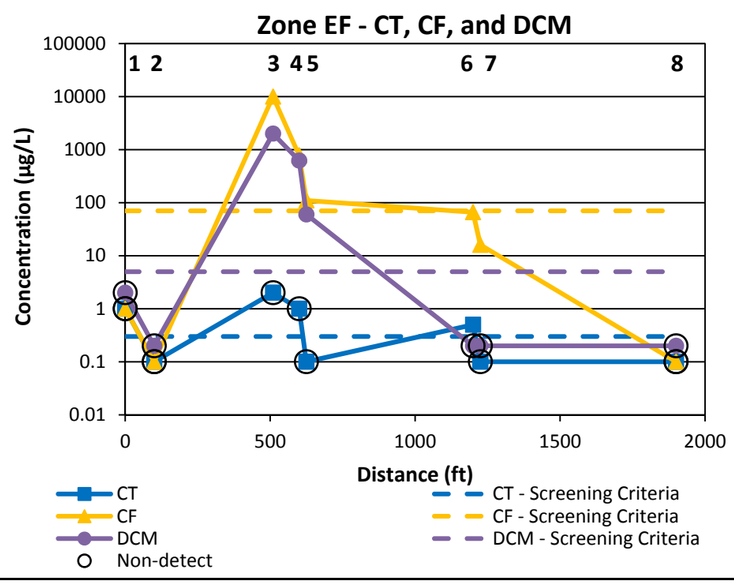
Figure 3-10b

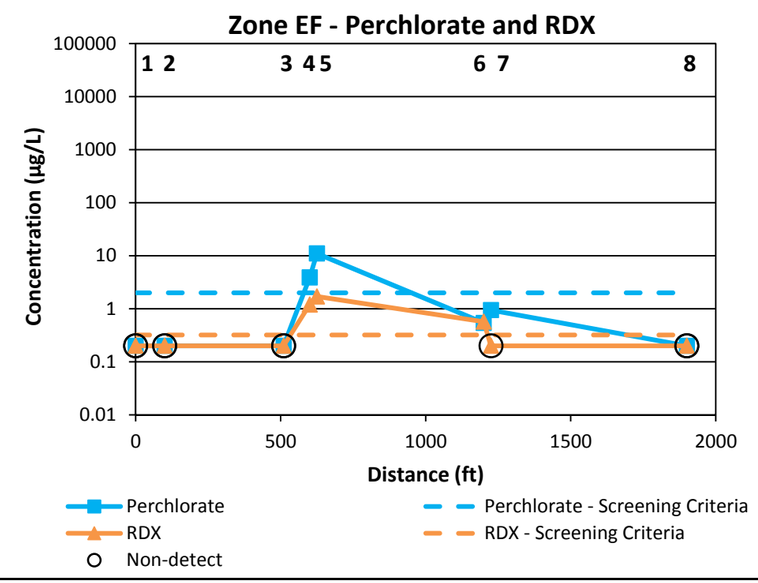
L:\ann-01 (pf)\S\C\Chemtronics\MNA\Front Valley\Post-Shutdown\Figures\MXD\[Fig3-1 to 3-10_FV AB CD Distance Trends.xlsx]RDX_FlowPath B

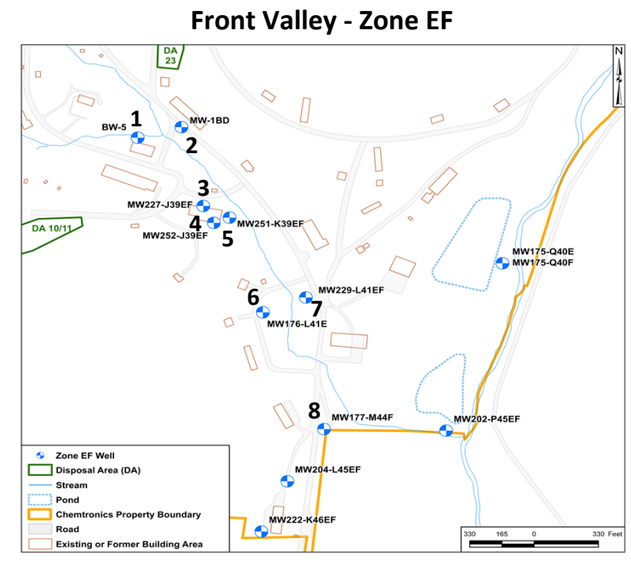












Notes:

1. µg/L – micrograms per liter.
2. Screening criteria are the North Carolina 2L or IMAC groundwater standards. For chemicals without a 2L/IMAC, the drinking water criteria from the *Final Remedial Investigation Report, Baseline Risk Assessment (Appendix L)* were used (Altamont, 2015a).
3. Non-detects are displayed at the method detection limit (MDL).
4. Monitored Natural Attenuation (MNA) Target Compounds (TC) abbreviations:

PCE - tetrachloroethene	TCE - trichloroethene	cis-DCE - cis-1,2-dichloroethene
VC - vinyl chloride	1,2-DCA - 1,2-dichloroethane	CT - carbon tetrachloride
CF - chloroform	DCM - dichloromethane	RDX - Research Department Explosive

5. Data are from 2014, except as follows: (i) data for MW176-L41E are from 2011, the last time this well was sampled; (ii) data from MW227-J39EF, MW252-J39EF, and MW251-K39EF are from 2013 prior to implementation of the B104 recirculation pilot test.

5. Zone EF wells locations are noted in each panel as follows:

1 - BW-5	**5** - MW251-K39EF
2 - MW-1B	**6** - MW176-L41E
3 - MW227-J39EF	**7** - MW229-L41EF
4 - MW252-J39EF	**8** - MW177-M44EF

Zone EF - Pre-Shutdown MNA TC Concentrations vs. Distance from BW-5
Chemtronics Site
Swannanoa, North Carolina

Geosyntec consultants

Figure 3-11a

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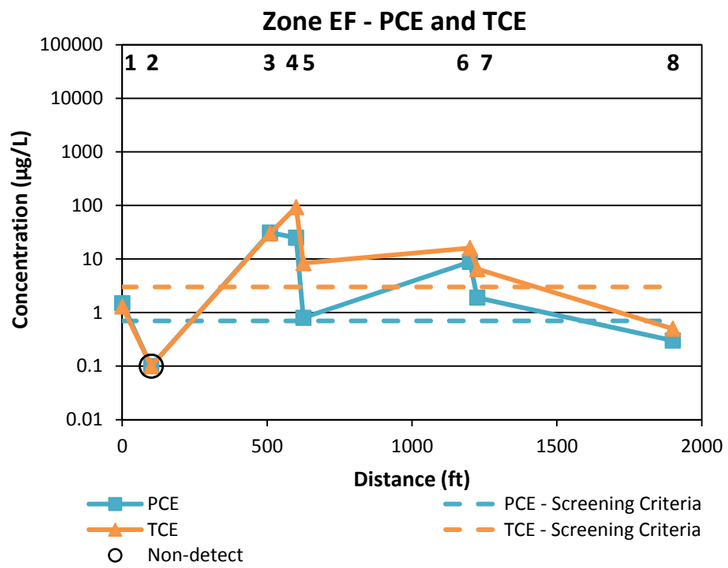
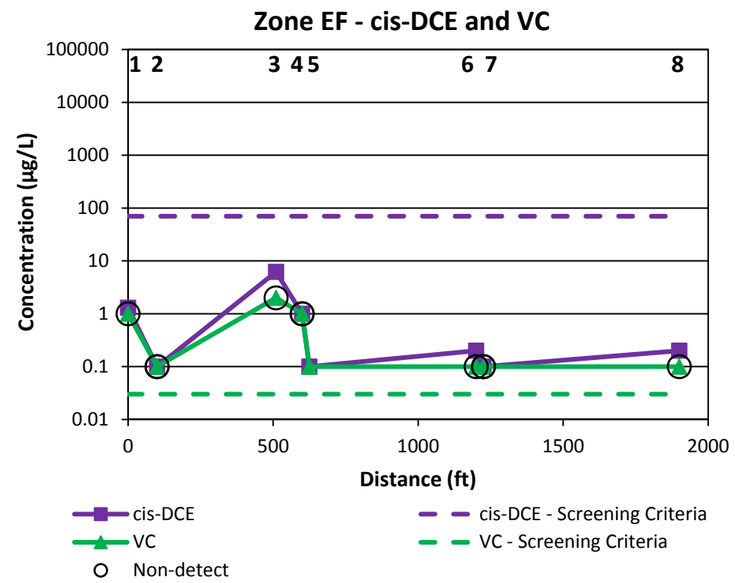
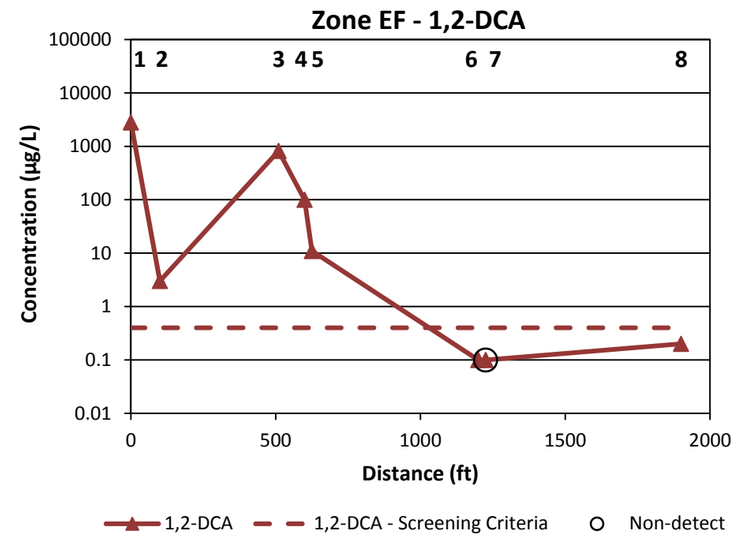
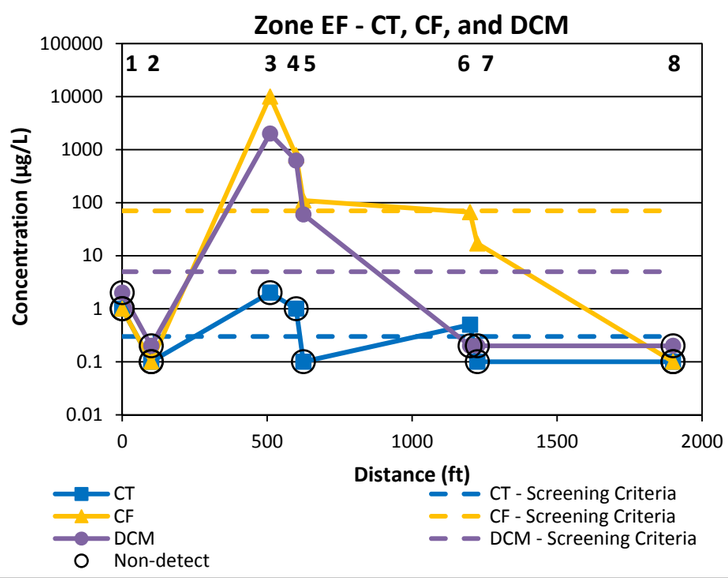
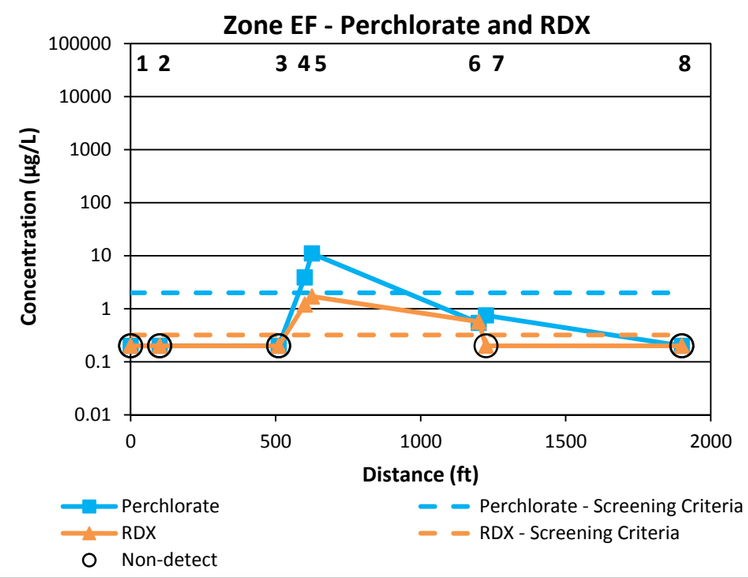
\\ tarc-01 pt\S \C\Chemtronics\MNA\Front Valley\Post-Shutdown\Figures\MKD\[Fig3-11_FV Zone EF Trends.xlsx]ZoneEF_FlowPath_PostSD

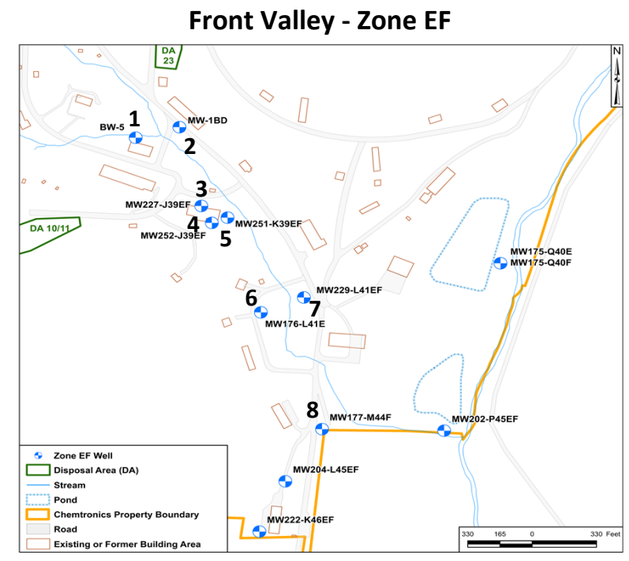












Notes:

1. µg/L – micrograms per liter.
2. Screening criteria are the North Carolina 2L or IMAC groundwater standards. For chemicals without a 2L/IMAC, the drinking water criteria from the *Final Remedial Investigation Report, Baseline Risk Assessment (Appendix L)* were used (Altamont, 2015a).
3. Non-detects are displayed at the method detection limit (MDL).
4. Monitored Natural Attenuation (MNA) Target Compounds (TC) abbreviations:

PCE - tetrachloroethene	TCE - trichloroethene	cis-DCE - cis-1,2-dichloroethene
VC - vinyl chloride	1,2-DCA - 1,2-dichloroethane	CT - carbon tetrachloride
CF - chloroform	DCM - dichloromethane	RDX - Research Department Explosive

5. Data are from Fall 2015, except as follows: (i) data for MW176-L41E are from 2011, the last time this well was sampled; (ii) data from MW227-J39EF, MW252-J39EF, and MW251-K39EF are from 2013 prior to implementation of the B104 recirculation pilot test.

5. Zone EF wells locations are noted in each panel as follows:

1 - BW-5	**5** - MW251-K39EF
2 - MW-1B	**6** - MW176-L41E
3 - MW227-J39EF	**7** - MW229-L41EF
4 - MW252-J39EF	**8** - MW177-M44EF

Zone EF - Post-Shutdown MNA TC Concentrations vs. Distance from BW-5

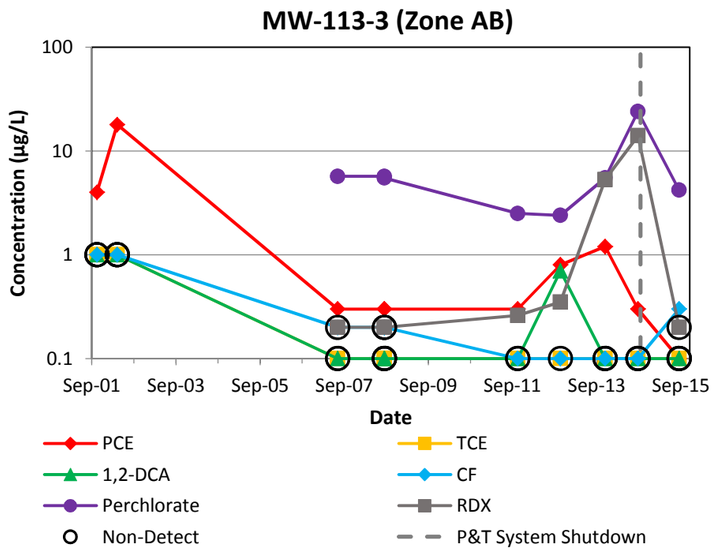
Chemtronics Site
Swannanoa, North Carolina

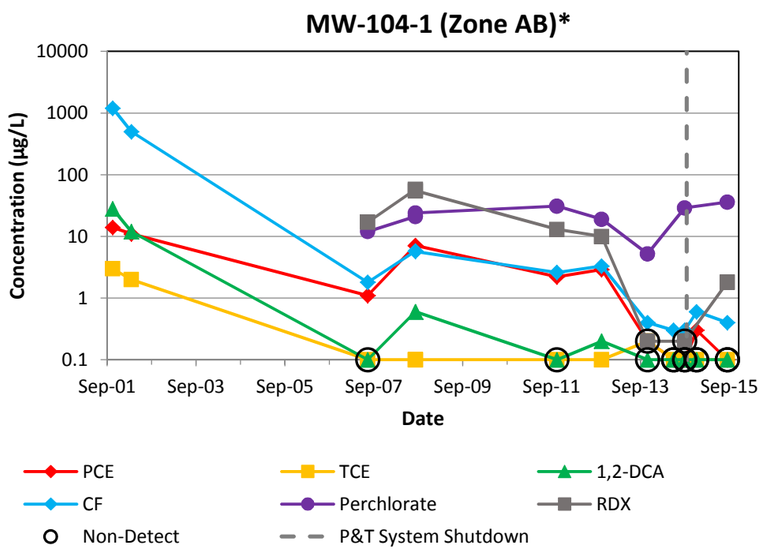
Geosyntec consultants

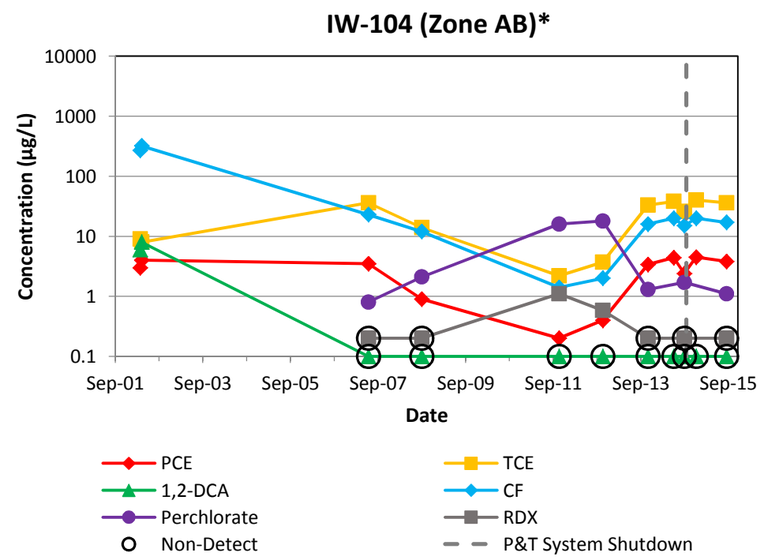
Figure 3-11b

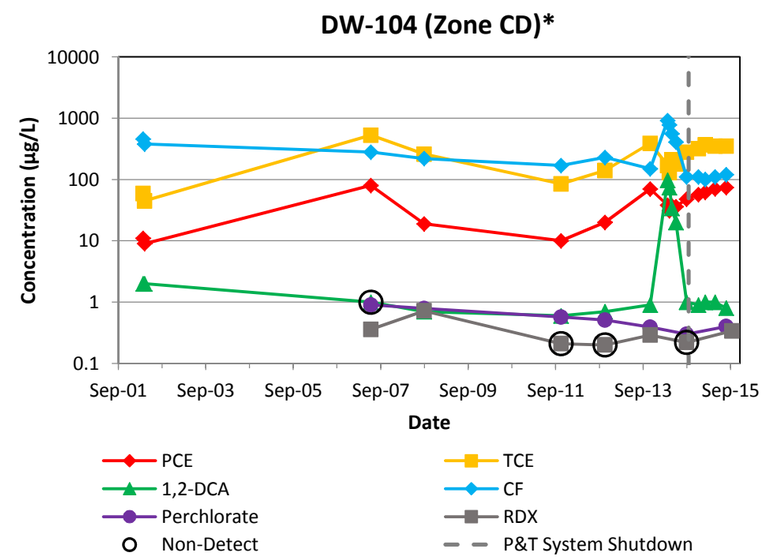
Kennesaw | July 2016

\\ tarc-01 pt\S \C\Chemtronics\MNA\Front Valley\Post-Shutdown\Figures\MKD\[Fig3-11_FV Zone EF Trends.xlsx]ZoneEF_FlowPath_PostSD









Notes:

1. MNA TCs - Monitored Natural Attenuation Target Compounds.
2. µg/L – micrograms per liter.
3. PCE - tetrachloroethene.
4. TCE - trichloroethene.
5. 1,2-DCA - 1,2-dichloroethane.
6. CF - chloroform.
7. RDX - Research Department Explosive.
8. For reference, the screening criteria (North Carolina 2L or IMAC groundwater standards) are 0.7 µg/L for PCE, 3 µg/L for TCE, 0.4 µg/L for 1,2-DCA, 70 µg/L for CF, 2 µg/L for perchlorate, and 0.32 µg/L for for RDX.
9. Non-detects are displayed at the method detection limit (MDL).
10. * - implementation of the B104 recirculation pilot test from November 2013 to December 2014 may have influenced time trends for MW-104-1, IW-104, and DW-104 .

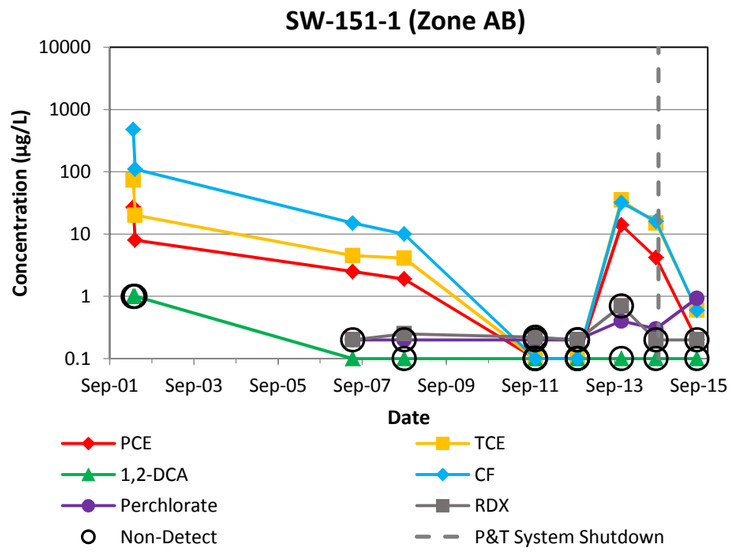
Time Trends for Select MNA TCs at MW-113-3, MW-104-1, IW-104, and DW-104
Chemtronics Site
Swannanoa, North Carolina

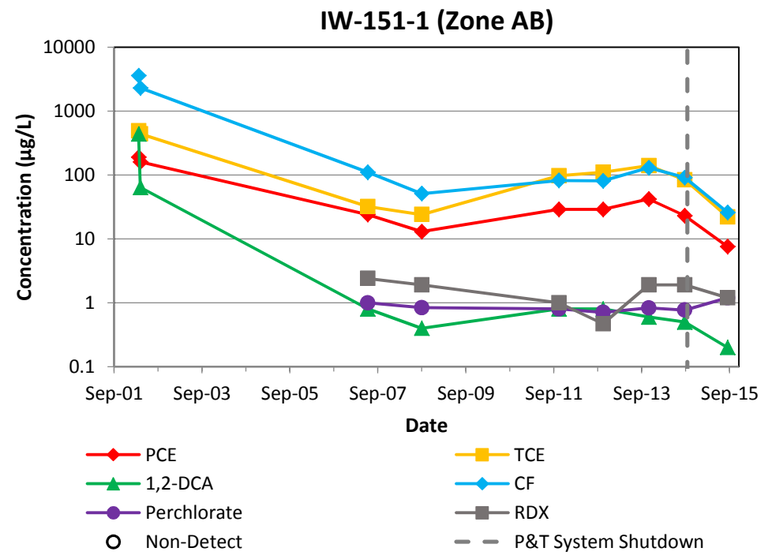
Geosyntec consultants

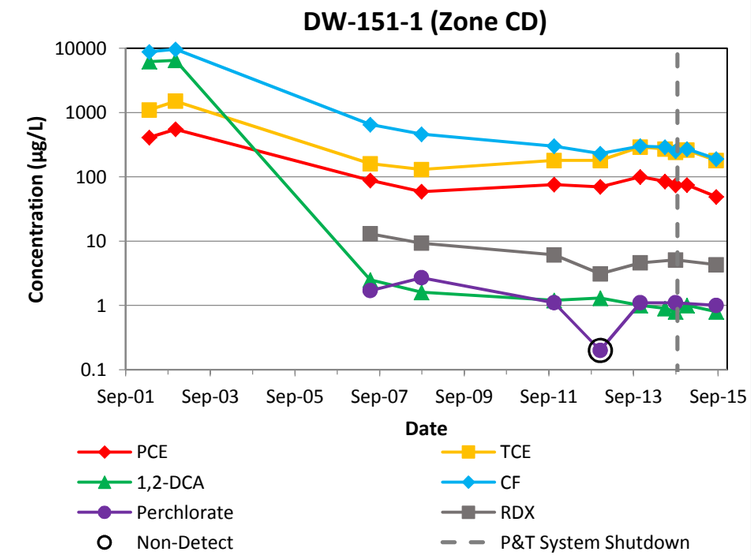
Figure 4a

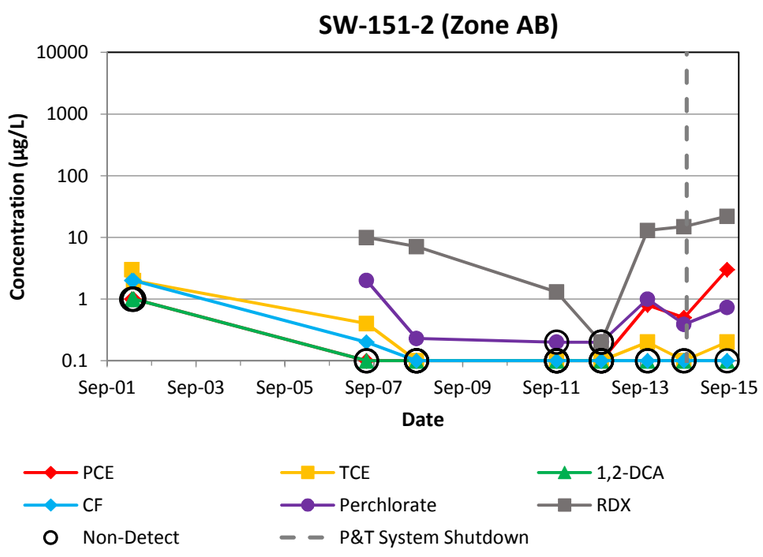
Kennesaw | July 2016

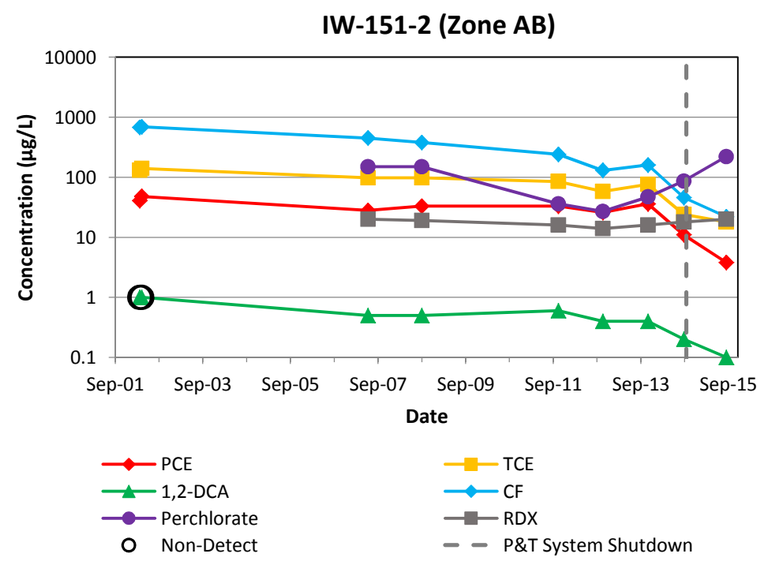
\\aro-01\prj$\C\Chemtronics\MNA\Front Valley\Post-Shutdown\Figures\MXD\[Fig4_Time Trends for Select Wells.xlsx]Time Trend - Misc Wells

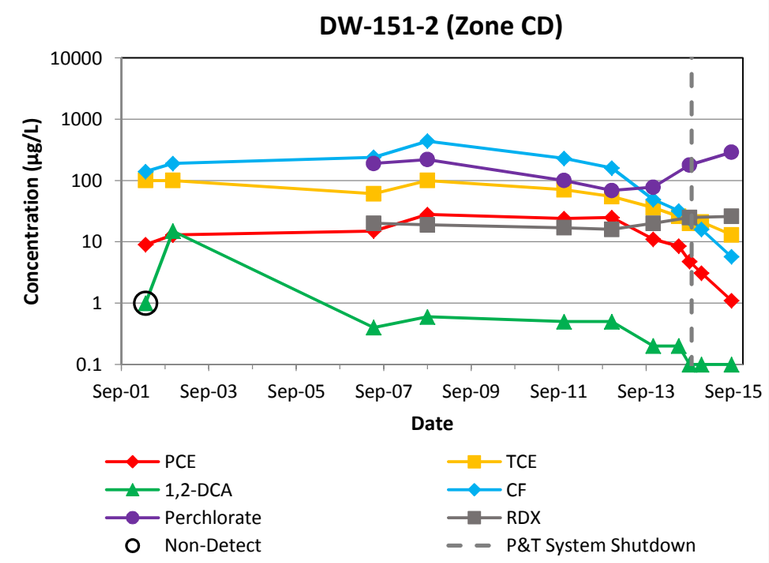












Notes:

1. MNA TCs - Monitored Natural Attenuation Target Compounds.
2. µg/L – micrograms per liter.
3. PCE - tetrachloroethene.
4. TCE - trichloroethene.
5. 1,2-DCA - 1,2-dichloroethane.
6. CF - chloroform.
7. RDX - Research Department Explosive.
8. For reference, the screening criteria (North Carolina 2L or IMAC groundwater standards) are 0.7 µg/L for PCE, 3 µg/L for TCE, 0.4 µg/L for 1,2-DCA, 70 µg/L for CF, 2 µg/L for perchlorate, and 0.32 µg/L for for RDX.
9. Non-detects are displayed at the method detection limit (MDL).

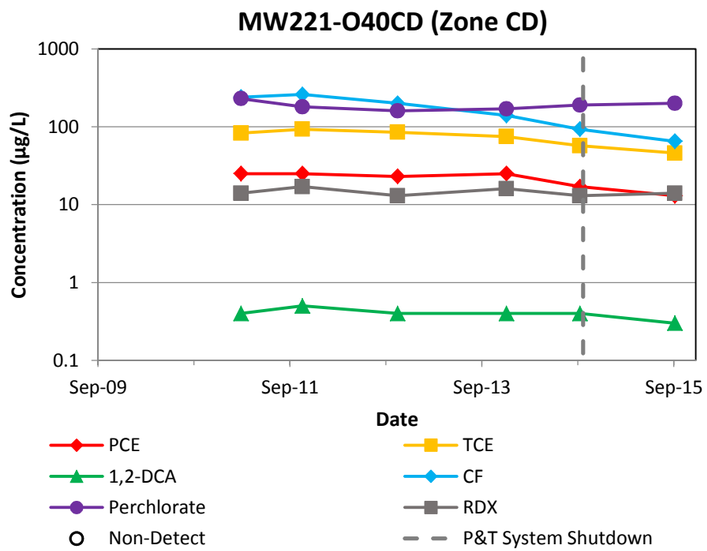
Time Trends for Select MNA TCs at B151 Wells
Chemtronics Site
Swannanoa, North Carolina

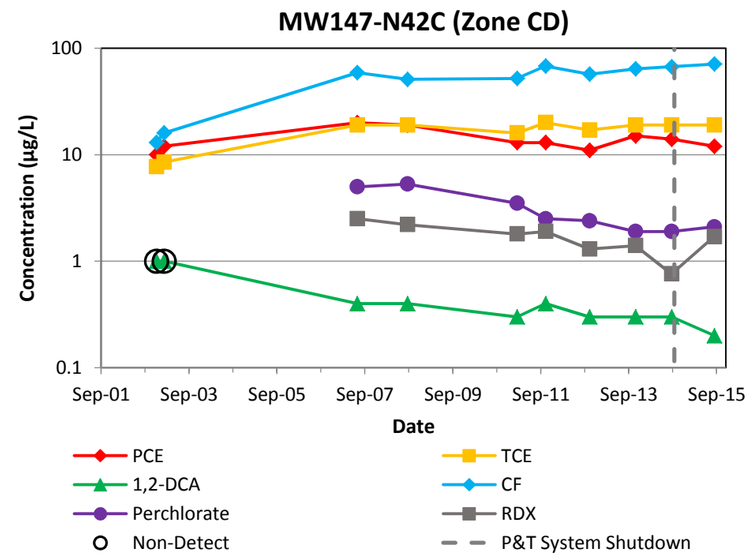
Geosyntec consultants

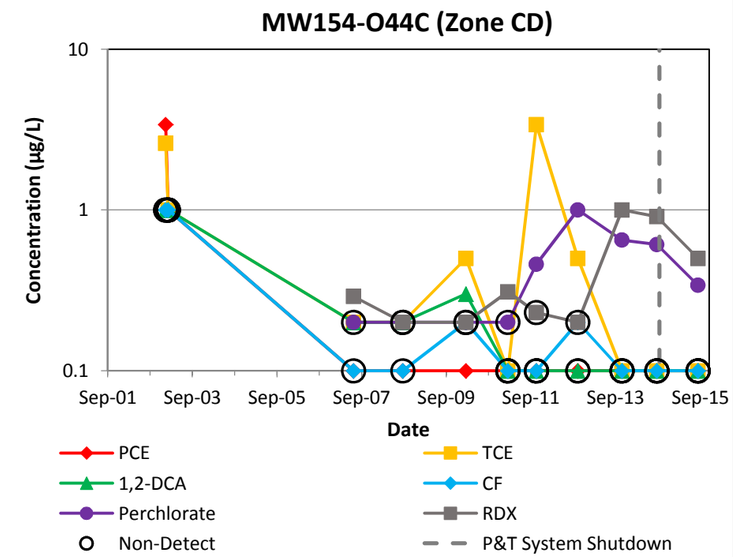
Figure 4b

Kennesaw | July 2016

\\ aro-01 tpi\$\$ \C\ Chemtronics\ MNA\ Front Valley\ Post-Shutdown\ Figures\ MXD\ [Fig4_Time Trends for Select Wells.xlsx]Time Trend - Misc Wells







Notes:

1. MNA TCs - Monitored Natural Attenuation Target Compounds.
2. µg/L – micrograms per liter.
3. PCE - tetrachloroethene.
4. TCE - trichloroethene.
5. 1,2-DCA - 1,2-dichloroethane.
6. CF - chloroform.
7. RDX - Research Department Explosive.
8. For reference, the screening criteria (North Carolina 2L or IMAC groundwater standards) are 0.7 µg/L for PCE, 3 µg/L for TCE, 0.4 µg/L for 1,2-DCA, 70 µg/L for CF, 2 µg/L for perchlorate, and 0.32 µg/L for for RDX.
9. Non-detects are displayed at the method detection limit (MDL).

Time Trends for Select MNA TCs at MW221-O40CD, MW147-N42C, and MW154-O44C

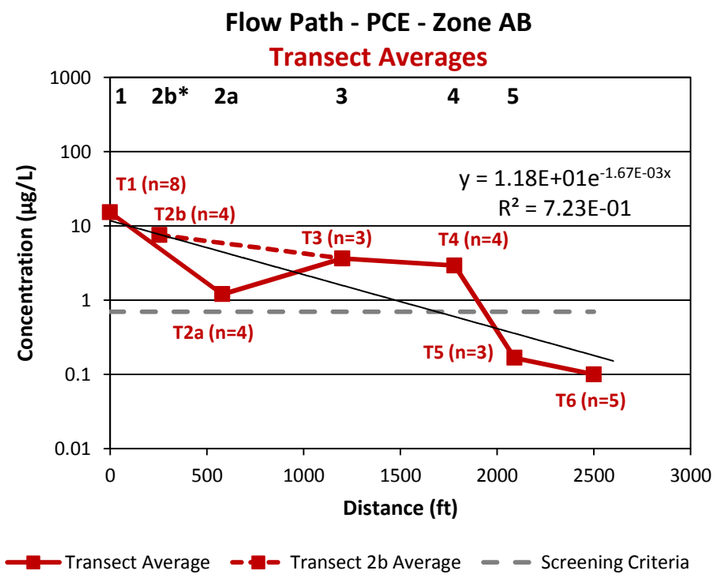
Chemtronics Site
Swannanoa, North Carolina

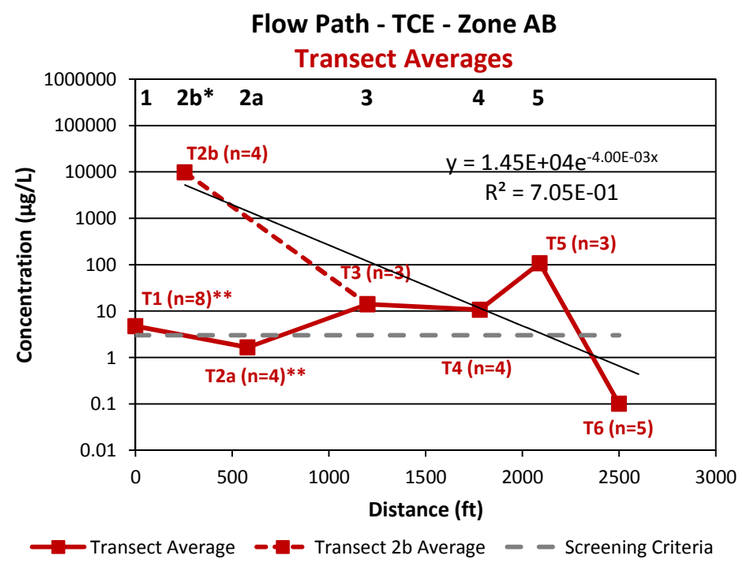
Geosyntec consultants

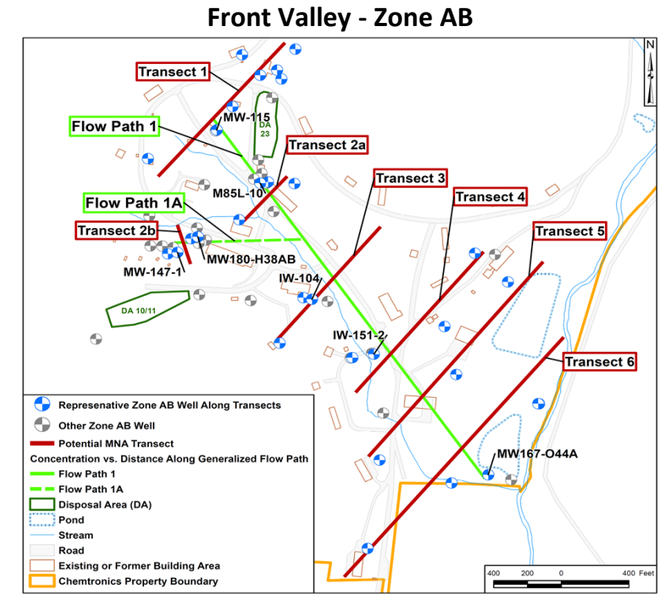
Figure 4c

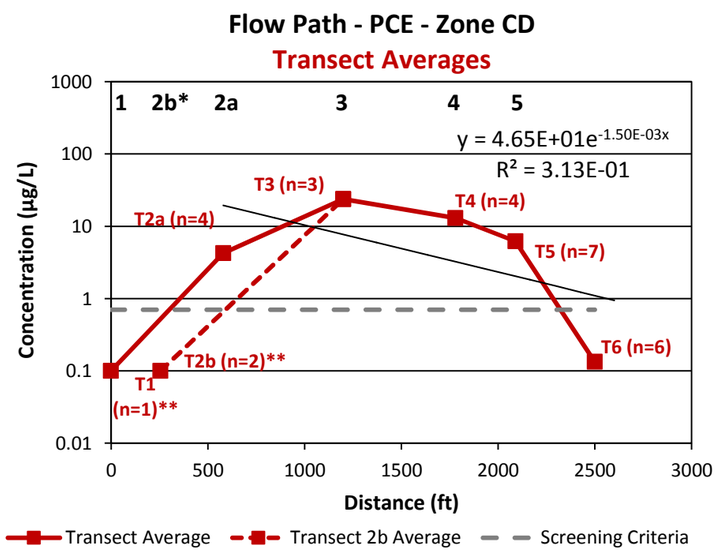
Kennesaw | July 2016

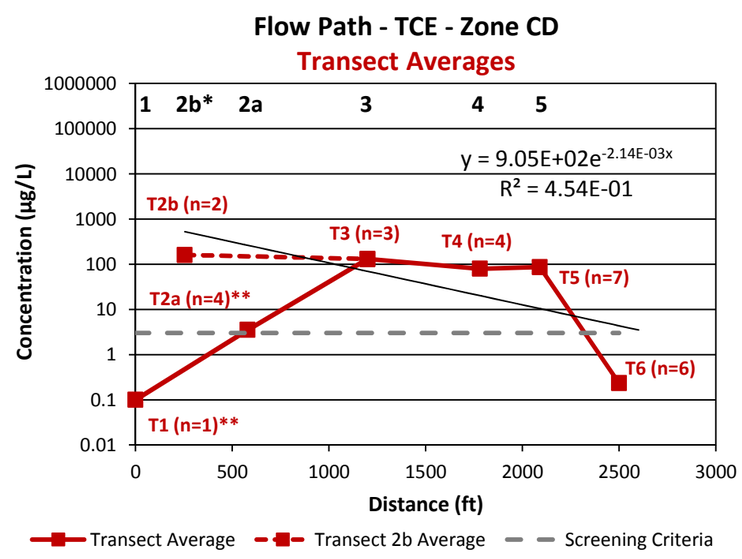
\\ taro-01 \pj$\C\Chemtronics\MNA\Front Valley\Post-Shutdown\Figures\MXD\[Fig4_Time Trends for Select Wells.xlsx]Time Trend - Misc Wells

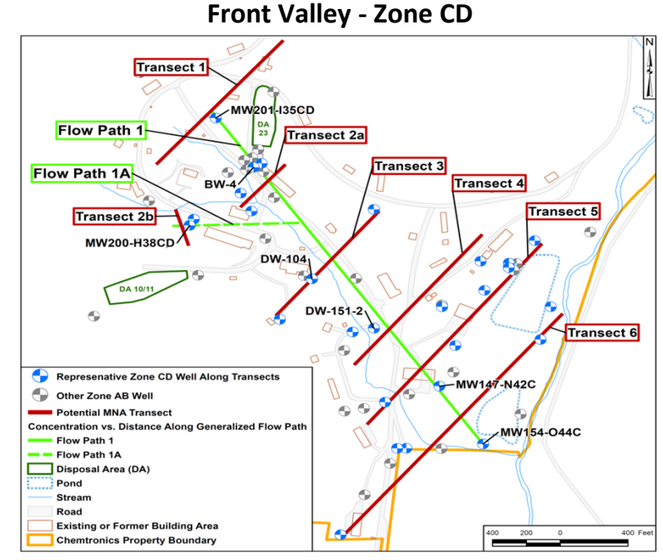












Notes:

1. µg/L – micrograms per liter.
2. Screening criteria are the North Carolina 2L or IMAC groundwater standards. For chemicals without a 2L/IMAC, the drinking water criteria from the *Final Remedial Investigation Report, Baseline Risk Assessment (Appendix L)* were used (Altamont, 2015a).
3. Non-detects are displayed at the method detection limit (MDL).
4. Transect average represents the average concentration (detections plus MDLs for non-detects) for wells along each MNA transect in each respective zone.
5. T# (n=##) – Transect number (e.g., Transect 1, Transect 2a, etc.), where "n" is the number of samples included in the transect average.
6. ** - Excluded from regression
7. PCE - tetrachloroethene; TCE - trichloroethene.
8. Select Front Valley Areas of Interest (AOIs) are noted in each panel as follows:
   - **1** - B113, B114, B115
   - **2b*** - B147 & B105-139 (*Flow Path 1a only)
   - **2a** - DA 23/B116
   - **3** - B104-145
   - **4** - B150-151
   - **5** - B149 (Transect Averages only)

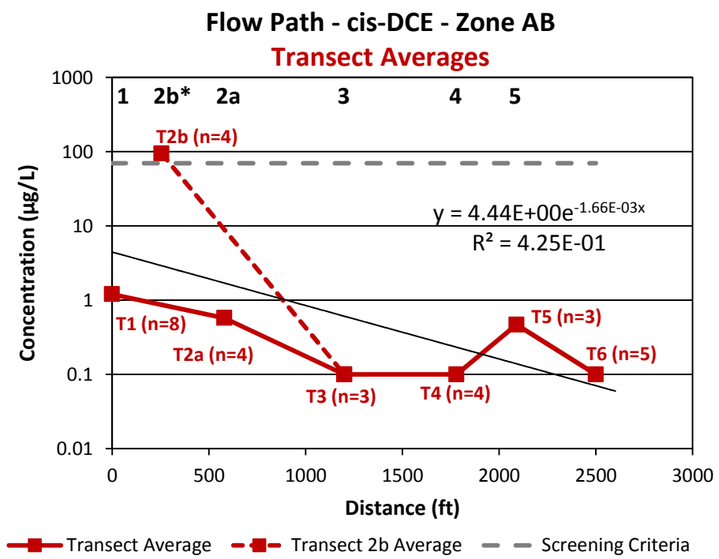
Regression of Post-Shutdown Transect Average Concentration vs. Distance for PCE and TCE
Chemtronics Site, Swannanoa, North Carolina

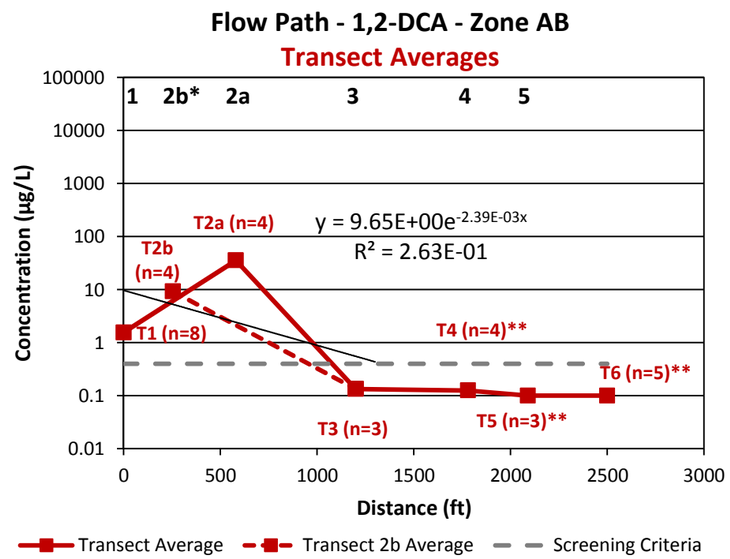
Geosyntec consultants

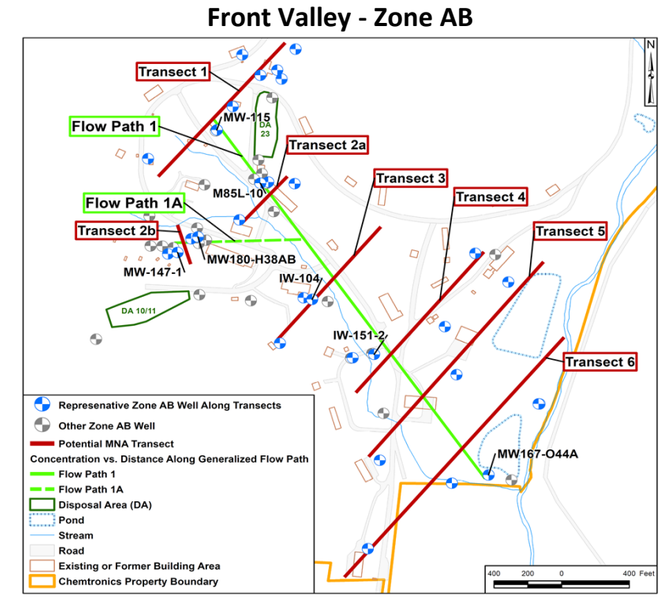
Kennesaw | July 2016

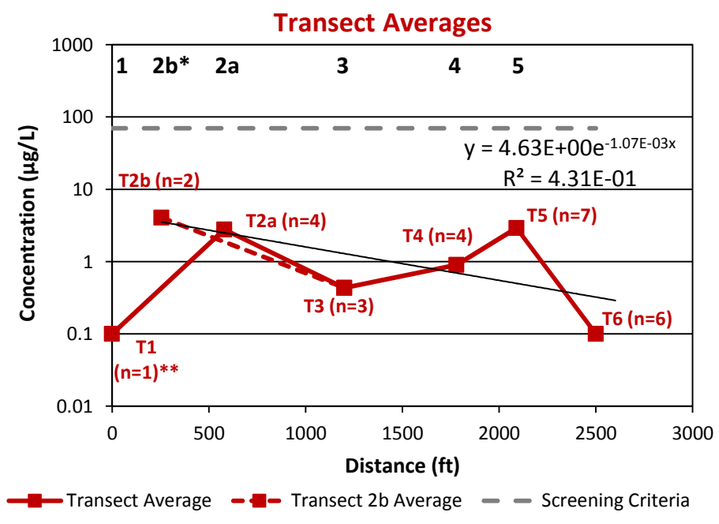
Figure 5a

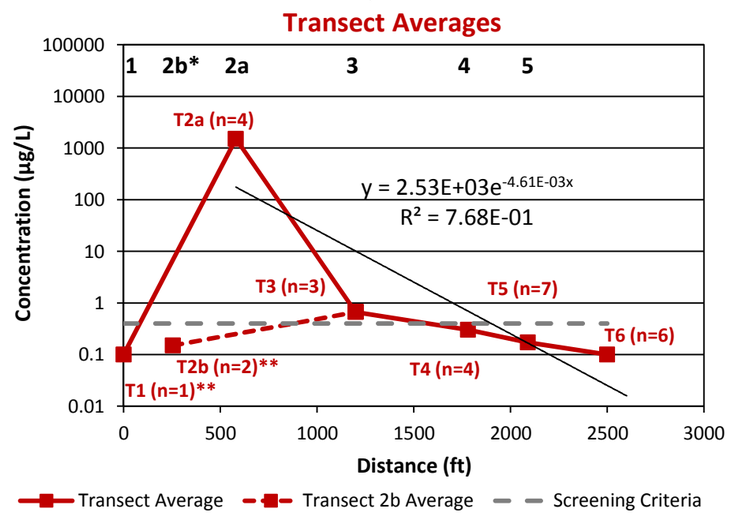
\\aro-01\prj1$\C\Chemtronics\MNA\Front Valley\Post-Shutdown\Figures\MXD\[Fig5_Regression Figures.xlsx]ROX

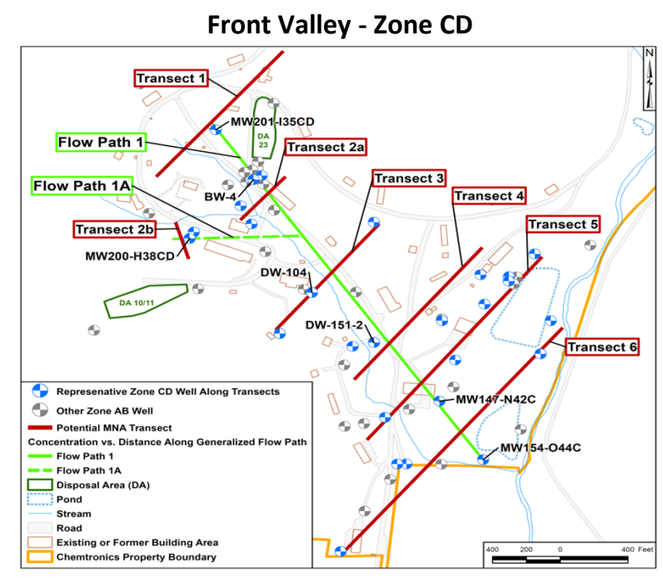












Notes:

1. µg/L – micrograms per liter.
2. Screening criteria are the North Carolina 2L or IMAC groundwater standards. For chemicals without a 2L/IMAC, the drinking water criteria from the Final Remedial Investigation Report, Baseline Risk Assessment (Appendix L) were used (Altamont, 2015a).
3. Non-detects are displayed at the method detection limit (MDL).
4. Transect average represents the average concentration (detections plus MDLs for non-detects) for wells along each MNA transect in each respective zone.
5. T# (n=##) – Transect number (e.g., Transect 1, Transect 2a, etc.), where "n" is the number of samples included in the transect average.
6. ** - Excluded from regression
7. cis-DCE - cis-1,2-dichloroethene; 1,2-DCA - 1,2-dichloroethane.
8. Select Front Valley Areas of Interest (AOIs) are noted in each panel as follows:
   - **1** - B113, B114, B115
   - **2b*** - B147 & B105-139 (*Flow Path 1a only)
   - **2a** - DA 23/B116
   - **3** - B104-145
   - **4** - B150-151
   - **5** - B149 (Transect Averages only)

Regression of Post-Shutdown Transect Average Concentration vs. Distance for cis-DCE and 1,2-DCA
Chemtronics Site, Swannanoa, North Carolina

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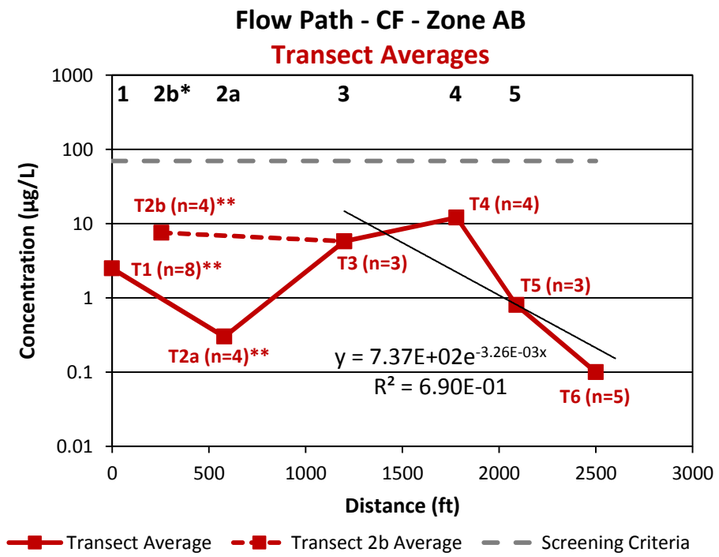
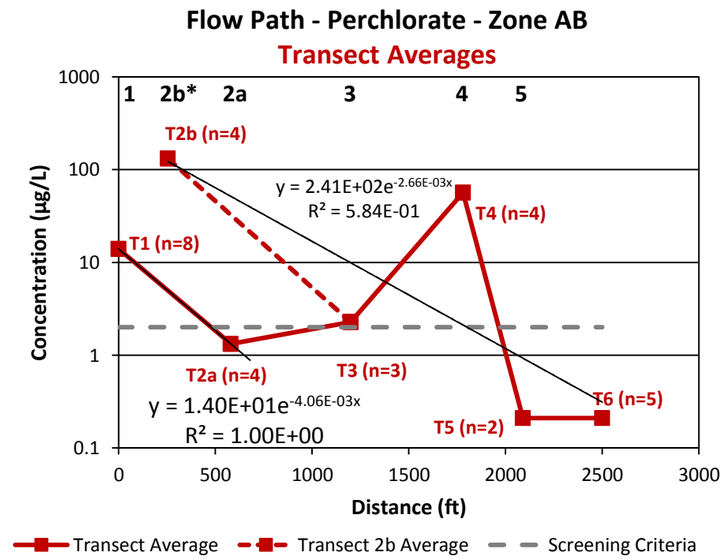
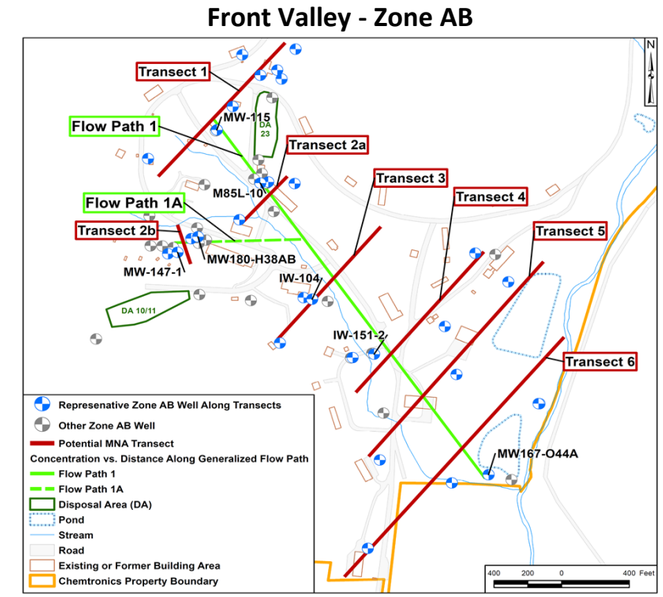
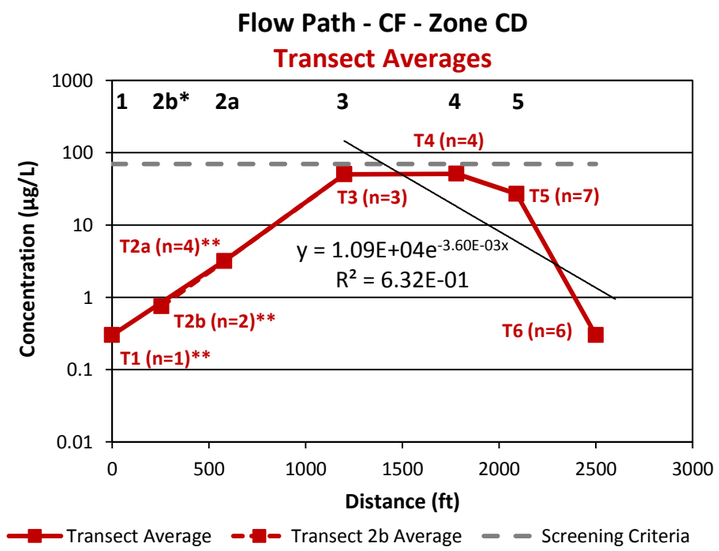
Figure 5b

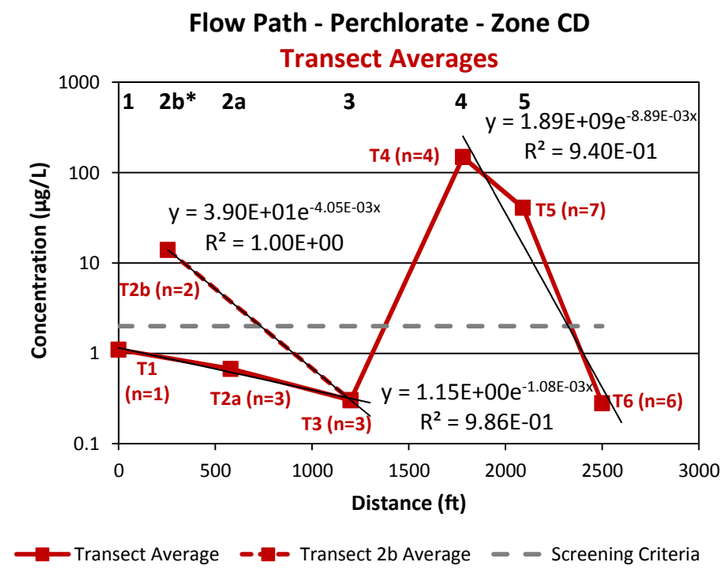
\\aro-01\prj1$\C\Chemtronics\MNA\Front Valley\PostShutdown\Figures\MXD\[Fig5_Regression Figures.xlsx]RDX

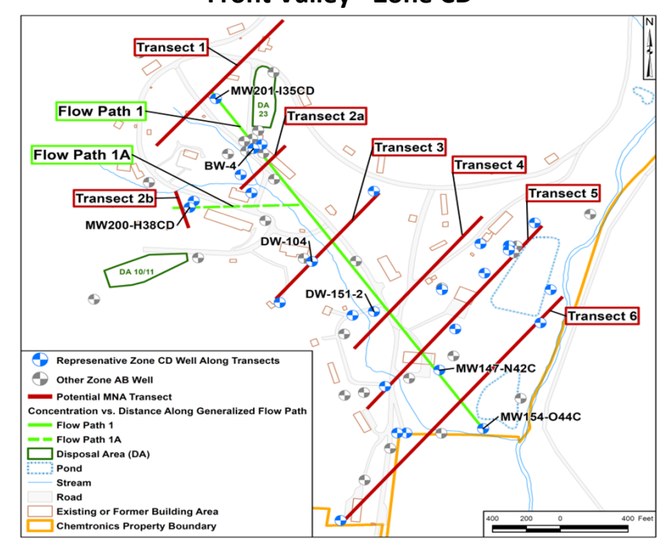












Notes:

1. µg/L – micrograms per liter.
2. Screening criteria are the North Carolina 2L or IMAC groundwater standards. For chemicals without a 2L/IMAC, the drinking water criteria from the Final Remedial Investigation Report, Baseline Risk Assessment (Appendix L) were used (Altamont, 2015a).
3. Non-detects are displayed at the method detection limit (MDL).
4. Transect average represents the average concentration (detections plus MDLs for non-detects) for wells along each MNA transect in each respective zone.
5. T# (n=##) – Transect number (e.g., Transect 1, Transect 2a, etc.), where "n" is the number of samples included in the transect average.
6. ** - Excluded from regression.
7. CF - chloroform.
8. Select Front Valley Areas of Interest (AOIs) are noted in each panel as follows:
   - **1** - B113, B114, B115
   - **2b*** - B147 & B105-139 (*Flow Path 1a only)
   - **2a** - DA 23/B116
   - **3** - B104-145
   - **4** - B150-151
   - **5** - B149 (Transect Averages only)

Regression of Post-Shutdown Transect Average Concentration vs. Distance for CF and Perchlorate
Chemtronics Site, Swannanoa, North Carolina

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Figure 5c

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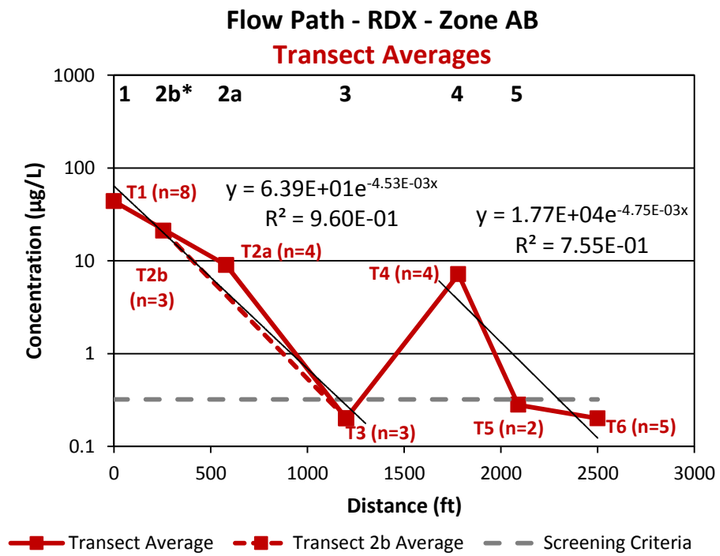
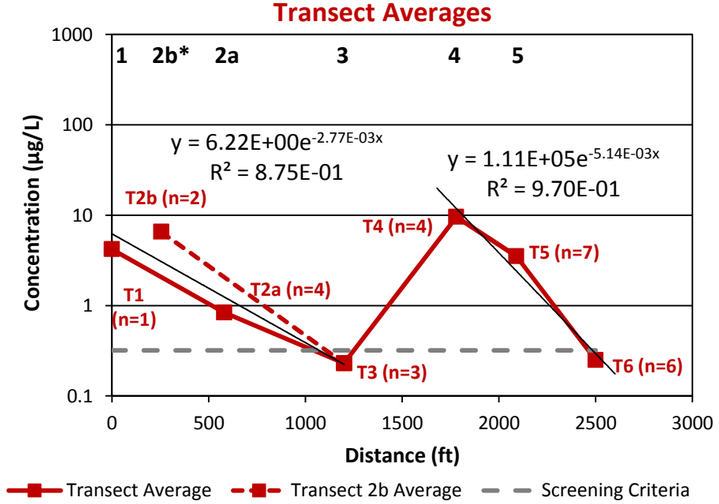
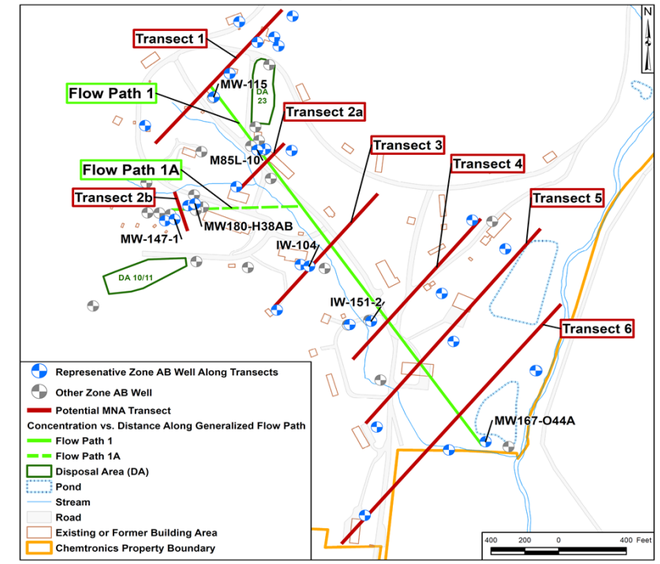
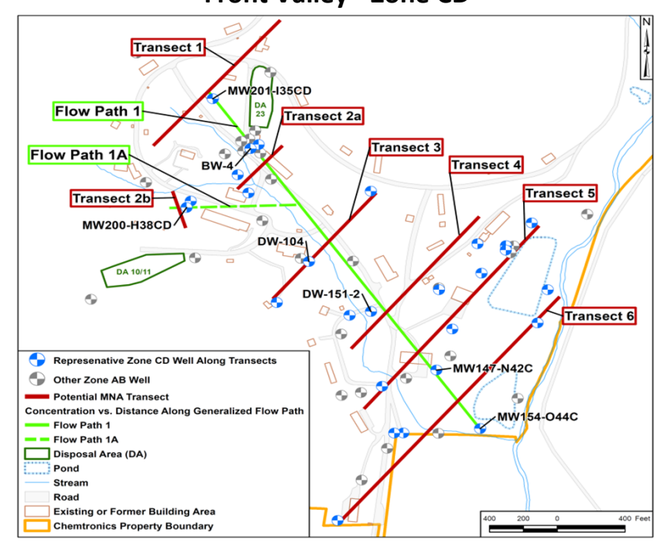
\\aro-01\prj1$\C\Chemtronics\MNA\Front Valley\Post-Shutdown\Figures\MXD\[Fig5_Regression Figures.xlsx]RDX









Notes:

1. µg/L – micrograms per liter.
2. Screening criteria are the North Carolina 2L or IMAC groundwater standards. For chemicals without a 2L/IMAC, the drinking water criteria from the Final Remedial Investigation Report, Baseline Risk Assessment (Appendix L) were used (Altamont, 2015a).
3. Non-detects are displayed at the method detection limit (MDL).
4. Transect average represents the average concentration (detections plus MDLs for non-detects) for wells along each MNA transect in each respective zone.
5. T# (n=##) – Transect number (e.g., Transect 1, Transect 2a, etc.), where "n" is the number of samples included in the transect average.
6. ** - Excluded from regression.
7. RDX - Research Department Explosive.
8. Select Front Valley Areas of Interest (AOIs) are noted in each panel as follows:
   - **1** - B113, B114, B115
   - **2b*** - B147 & B105-139 (*Flow Path 1a only)
   - **2a** - DA 23/B116
   - **3** - B104-145
   - **4** - B150-151
   - **5** - B149 (Transect Averages only)

Regression of Post-Shutdown Transect Average Concentration vs. Distance for RDX
Chemtronics Site, Swannanoa, North Carolina

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Figure 5d

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\\aro-01\prj1$\C\Chemtronics\MNA\Front Valley\Post-Shutdown\Figures\MXD\[Fig5_Regression Figures.xlsx]RDX