Data Quality Screening Using Trend Charts

Quality Assurance Office, Region 9 – October, 2011 VERSION 2

INTRODUCTION

Frequently the quality of results from data collection activities are difficult to assess due to the number of reports one needs to review and digest to reach a conclusion (see Figure 1). These reviews may take place months after data collection is conducted.
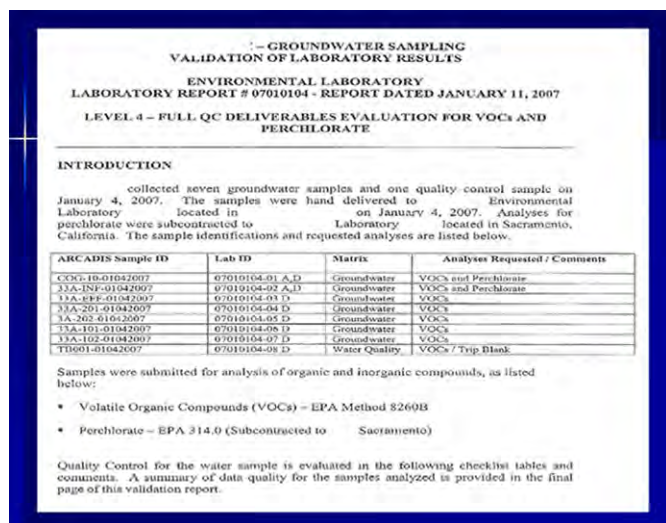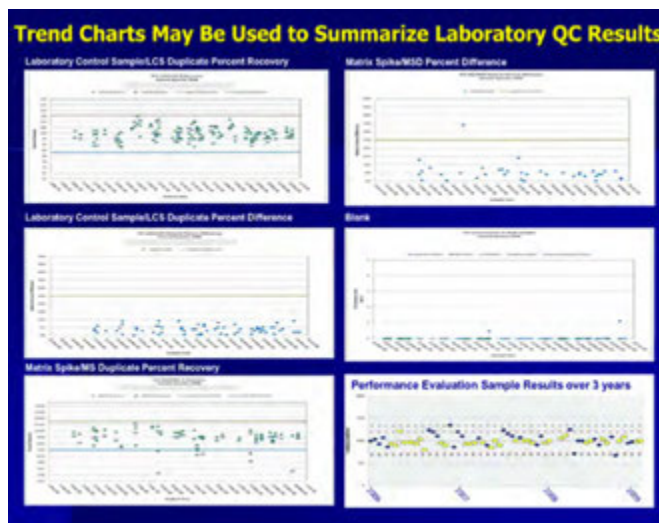

Figure 1

Figure 2

Trend charts are an effective, efficient oversight **screening** tool for Remedial Project Managers (RPMs), QA Officers (QAOs), field samplers and laboratory managers for monitoring data quality for specific contaminants of concern (COC). Figure 2 illustrates laboratory quality control (QC) results for a year or more. The visual display of data helps to identify patterns and trends that might go unnoticed using summary reports or numerical formats. Charts can be used to identify these patterns, to identify potential problems, and to suggest corrective measures. In addition, some graphical representations can be used to record, store and send information efficiently to others. Plots and graphs of the data are valuable tools for stakeholder interactions by providing a picture of the characteristics of the data[1].

The objective of this paper is to introduce trend charts to RPMs, QAOs, field samplers and laboratory managers for their use in effective and efficient tracking of Quality Assurance Project Plan (QAPP) implementation of laboratory, field, audit, and validation activities in near real time. Charts provide quantitative information as to whether a monitored activity is deviating from QAPP criteria i.e., accuracy, bias and precision, for tracking and isolating the sources of error, and for performing corrective action. Always consult a chemist before making decisions based on the information provided in trend charts.

Background and Description of Trend Charts

Trend charts are quantitative plots representing laboratory and field QC sample results for specific COC over time as opposed to snapshot narratives or tabulated information provided in quarterly reports.

Trend charts are composed of single or paired "limit" lines. Charts with a single limit line represent QC results that should rest either above (greater than (>)) or below (less than (<)) the line. Where lines are paired, QC results should lie between the limit lines. The limits represent laboratory and field QC (precision, accuracy, and bias (PAB) criteria – see pages 14-16). Environmentally influenced anomolies will periodically cause deviations from these limits to occur. Even with a flawless QA/QC program in place, scientific uncertainty is inevitable due to the real variation in the population being sampled. Deviations should always be

monitored. A single deviation should not be cause for concern provided overall long term performance meets limits, and one is not making decisions based on data that exceeded limits. Corrective action should take place where trends and patterns show deviation will likely occur.

Trend charts are related to but differ from control charts. Trend charts are **project specific and represent non-continuous QC checks**. Points making up the trend chart may be obtained from any laboratory performing analyses for a project.

Control charts are **laboratory and instrument specific; they also must be continuous.** Control charts continuously record a single laboratory's QC performance check results obtained from a single instrument.

Due to the non-continuous nature of trend charts, they may be produced from control chart points obtained from multiple laboratories, but the reverse is not true, as control charts are laboratory and instrument specific, and must be continuous.

Trend charts permit near real time evaluation to quantitatively screen the quality of laboratory and field QC sample results for specific COC over time, and for monitoring excursions from QC criteria established in the QAPP. For the laboratory QC results checked, the charts communicate what is covered in data validation reports in a clear, concise, quantitative, and graphical format. Other activities covered in QAPP e.g., field and laboratory audit findings and the percentage of data validated over time may similarly be charted.

- **Laboratory QC results** that may be tracked include: initial and continuing calibration, laboratory control sample, laboratory control sample duplicates, matrix spike (MS)/matrix spike duplicates (MSD) (or deuterated compound recoveries if MS/MSDs not performed), blanks, internal standards, serial dilutions, system performance check compounds, tunes and performance evaluation (PE) sample results.

Figure 3 contains a subset of laboratory QC charts that are available from US EPA's Contract Laboratory Program (CLP) Trending Analytical Data system. It represents laboratory QC results for initial and continuing calibration, deuterated compound recoveries, and blank results over three years from an actual site. Overall the QC results look satisfactory with the following boxed exceptions as
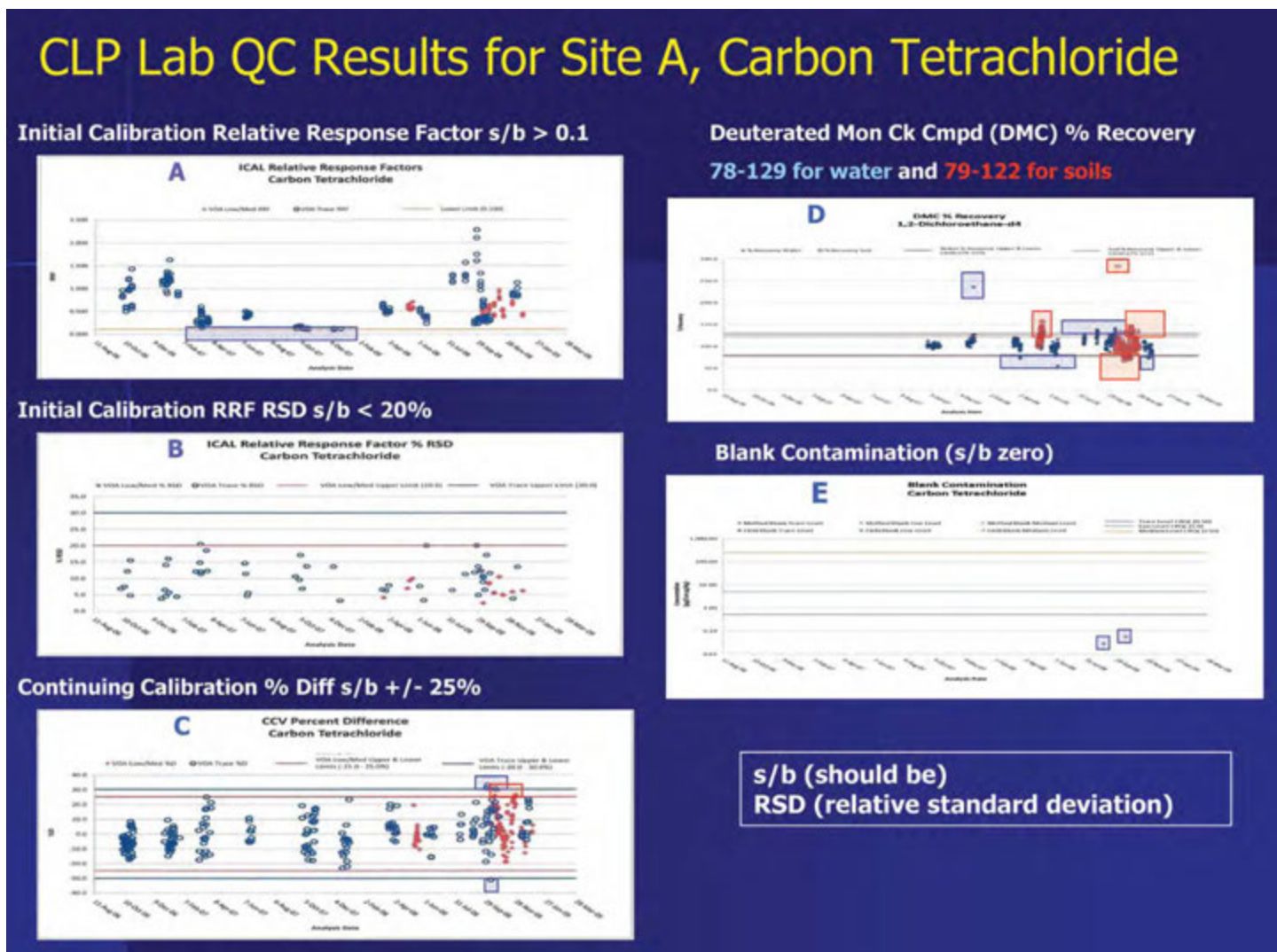
Figure 3

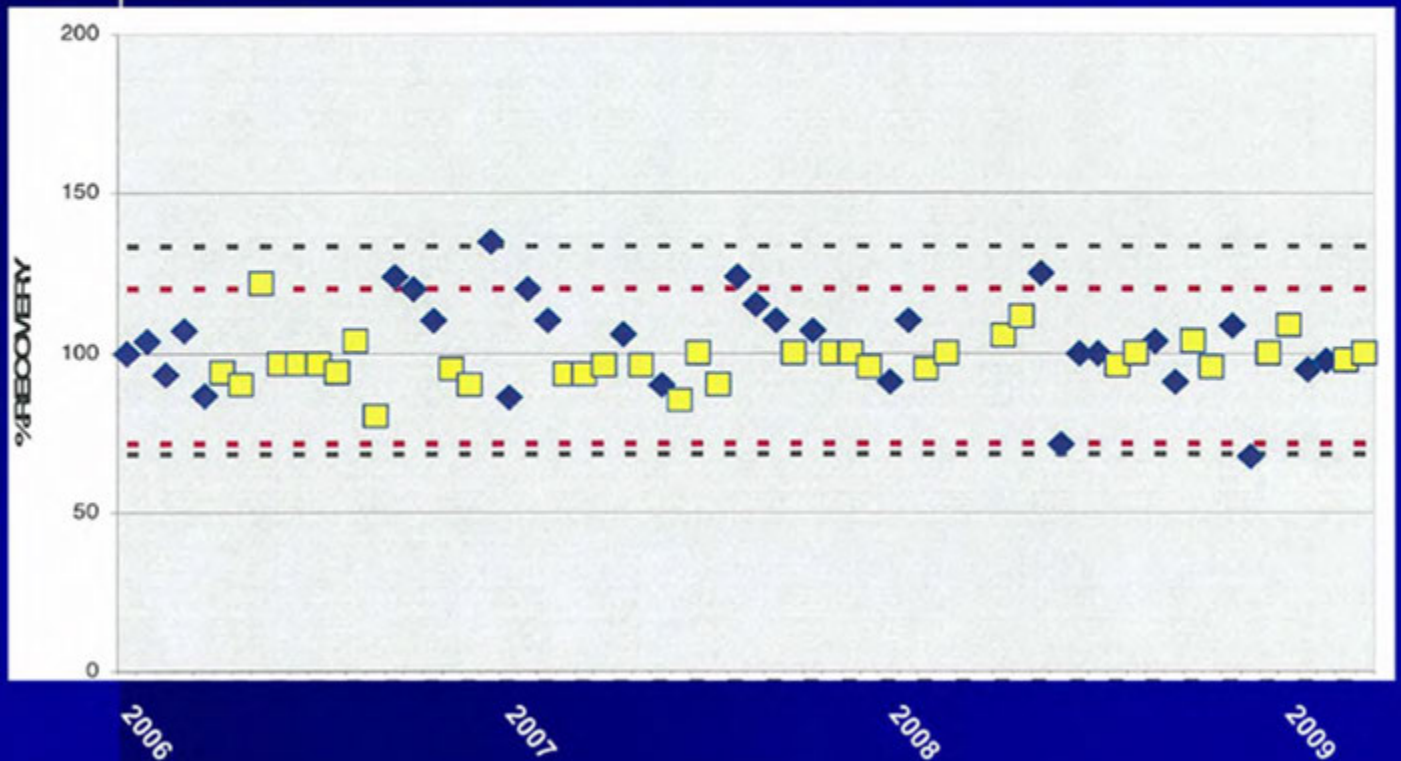## Performance evaluation results for three years for two laboratories

Figure 4

they fail to meet greater than or paired limits for soil (red data points and limit lines) and water (blue data points and limit lines).

Figure 3 chart evaluations:

A) Initial Calibration Relative Response Factor (RRF). Excursions occur for water (blue) in March, October, December 2007.

B) Initial Calibration RRF Relative Standard Deviation (RSD). No excursions.

C) Continuing Calibration. Excursions occur for soil (red +/- 25% criteria) in September and November 2008. For water, excursions occur (blue +/-30% criteria) in September 2008.

D) Deuterated monitoring check compounds. Excursions occur for soil in May, October and November 2008 and water in January, April, June, July, August, September and December 2008.

E) Blank contamination occurred in August and October, 2008.

Note also that excursions may follow a pattern, with more appearing in certain months than others (e.g., September – December 2008 in the above example provided). This pattern may indicate a decline in performance that should be looked into to minimize recurrence.

One should use sample results associated with QC excursions with caution, consulting with a chemist or validating associated data packages for increased confidence in determining how data may be used, if at all.

Figure 4 provides examples of performance evaluation sample results from two laboratories (yellow square and blue diamond) from 2006-2009. The recovery criteria for laboratory results represented by the yellow squares is 75-120, and show relatively stable and acceptable performance, with one borderline deviation from criteria in 2006. The recovery criteria for laboratory results represented by the blue diamonds is wider 70-130 and show some trending (four-five down-up cycles), and three borderline deviations (near the beginning of 2007, mid 2008, and early 2009).

Other elements covered in a QAPP may also be tracked:

- **Field QC results** for blank and duplicate recovery. Figure 5 provides examples of QC samples collected by two different samplers, a novice and experienced trainer. Although there are no QC criteria or red lines bounding these QC results, samplers should strive to minimize error from being introduced. Trainer results show less error for duplicates (5% as opposed to 15% for the novice) and blank samples (no contamination as opposed to some contamination for the novice).

Note that throughout the chart displays, actual sample results may also be presented to track impact of deviations on results.

- **Field and Laboratory Audit Findings:** Charts on Figure 6 show the dates audits were conducted and the number of findings made. Optimally, there should be no findings. The number of field audit findings (approximately 50) is cause for concern due to the impact of sampling on sample results.

  If there are numerous and significant findings, and corrective actions are not effective (i.e., repeated audits do not help to correct deficiencies), other samplers should be considered.

- **Data Validation**. The red line in Figure 7 shows the percentage of validation committed to in the QAPP, and the bars represent the percentage of data validated over the year. The graph on the right shows they did not meet the commitment of 10%.

Tracking performance by activity will allow one to focus on and isolate areas needing improvement, e.g., if a laboratory QC results meet criteria, while field sampling criteria are exceeded, corrective action should focus on the field activity.

Alternatively, if laboratory QC results fail criteria while field QC show acceptable results, initial review and corrective action should focus on the laboratory. The effect of field activities should not be excluded as contributing to error; however, initial investigation should begin with the laboratory.

Effective Use of Trend Charts

Figures 8, 9, and 10 are further examples of how to interpret the trend charts by activity. Some of the charts are presented twice; e.g., some charts from Figure 8 and 9 were included in Figure 10 to demonstrate the different conclusions that may be reached based on what appears in the charts.

Begin by aligning the charts by date to determine 1) whether results are in conformance with plan requirements; 2) whether data quality objectives are being met; and 3) source of deficiencies (laboratory, field, or validation).

Whenever reviewing trend charts, look at the overall performance over time. A single divergence may be acceptable if the overall performance meets criteria, **_provided_** a critical decision is not based on that data point, a satisfactory explanation has been provided and corrective action has been taken. Assistance may be obtained from the QA Office to investigate any point(s) that diverge from QAPP criteria.

One can check for trends such as in Figure 11, which depicts a systemic error (high bias) that could be corrected. Upon correction, nearly all data meets acceptance criteria.
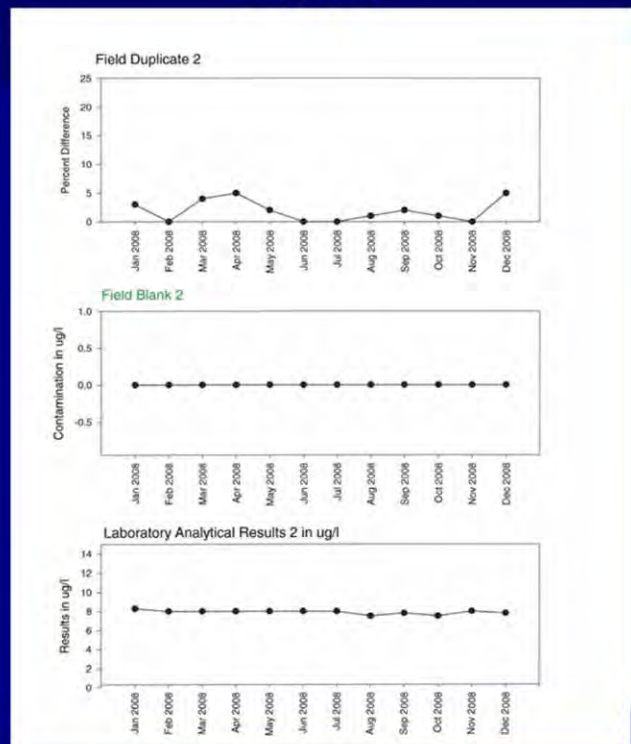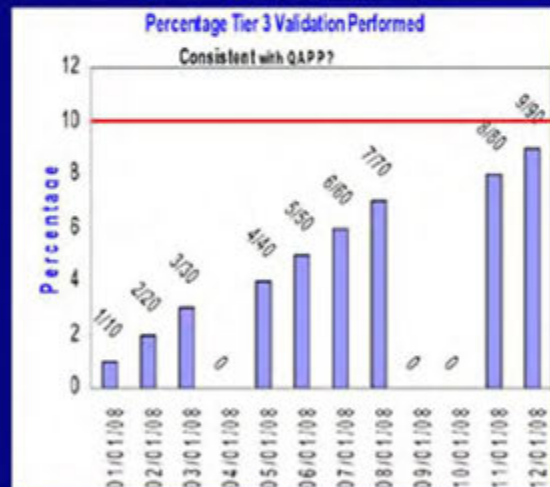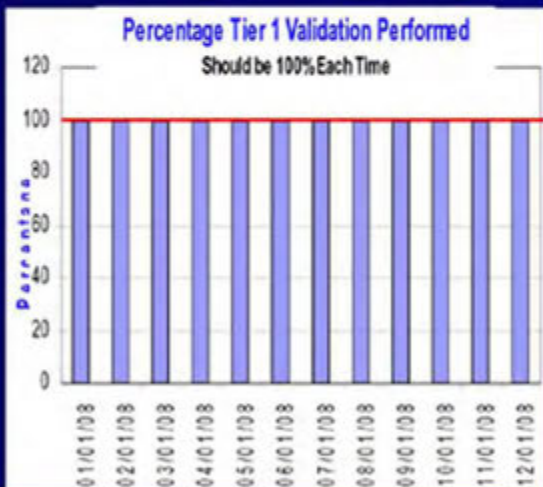

Figure 5

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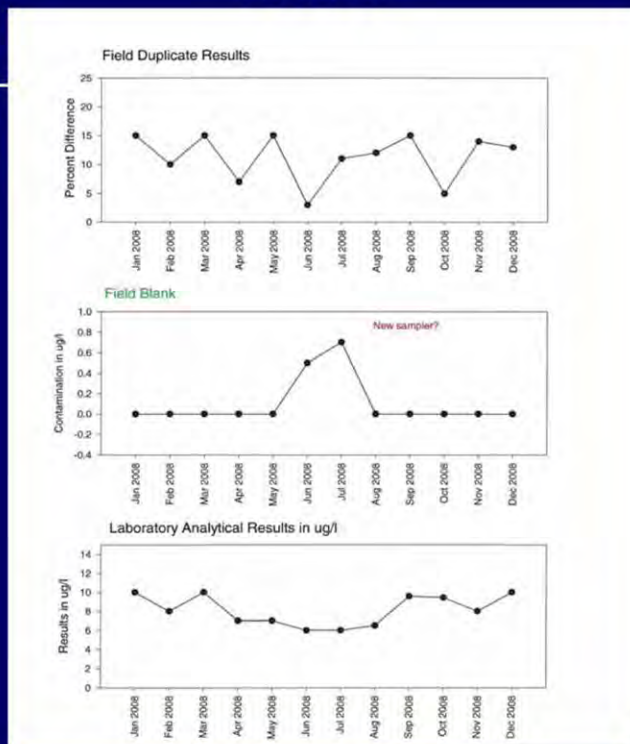
Field and Lab Audit Findings

Figure 6

Percentage of Data Validated
Consistent with QAPP?

Tier 1 = Screening

Tier 3 = Full Validation

Figure 7

Figure 8a, Laboratory QC Check results for TRICHLOROETHENE

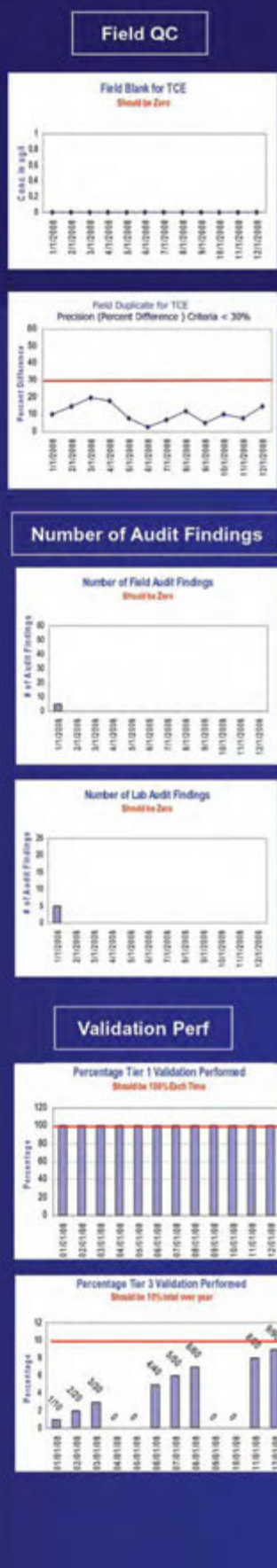**Field QC, Number of Audit Findings, and Data Validation Charts**

Figure 8. Shows all charts – laboratory, field, audit, and validation results aligned by date for determining if/when QC criteria were met, and when specific activities were completed. Results from these QC checks show good performance (within red error bars) or above or below criteria specified. **Corrective action** should be performed on audit findings and where validation falls short. On December 1, 2008, only 9% validated whereas performance criteria calls for 10% to be validated.

Figures 8b and 8c are expanded views of Figure 8a.

Figure 8a

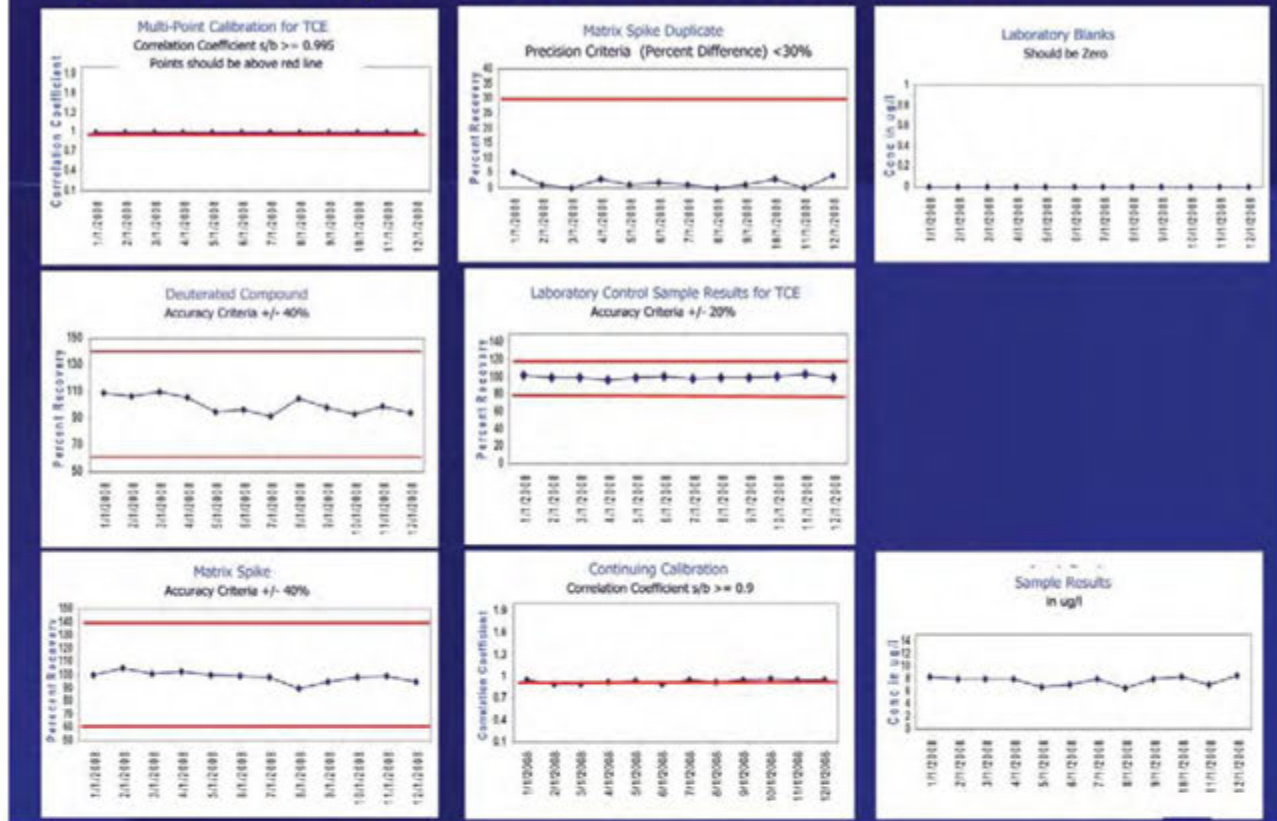Figure 8b, Laboratory QC Check results for TRICHLOROETHENE

Figure 8b

Figure 8c, Field QC, Number of Audit Findings, and Data Validation Charts
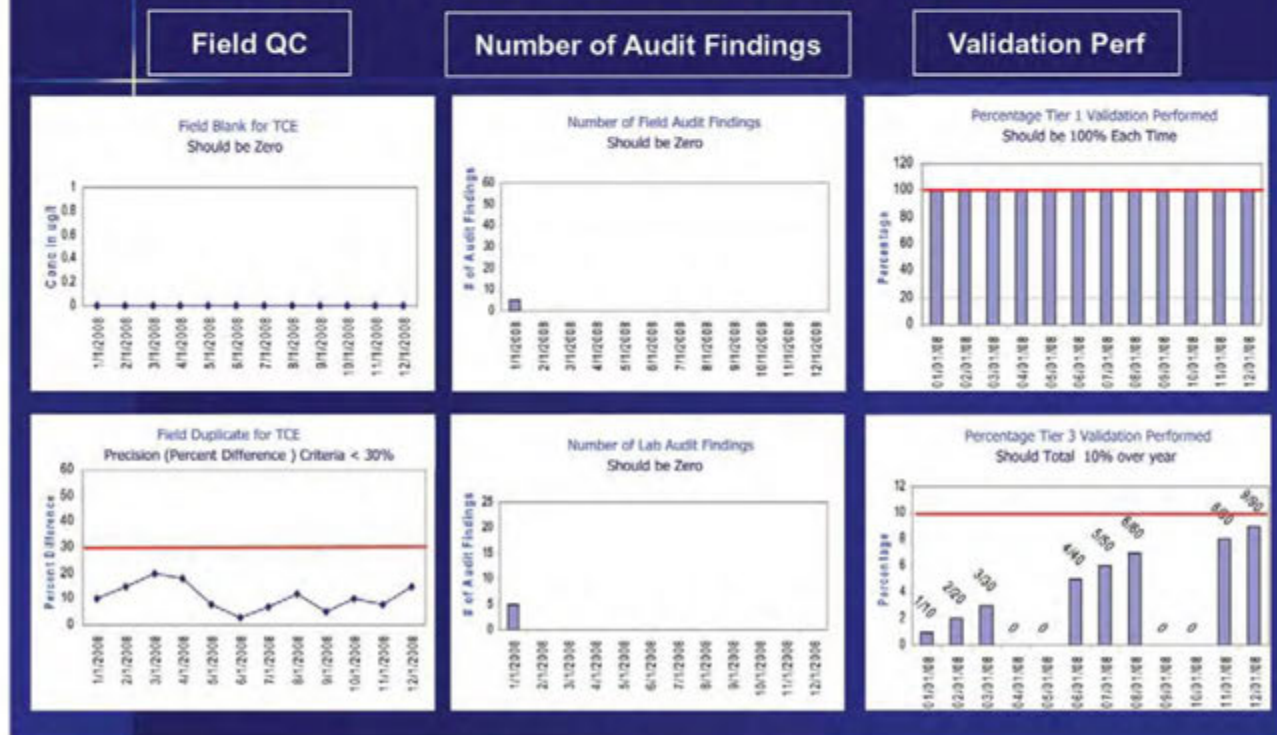
Figure 8c

Figures 9a and 9b. Results from these QC checks show poor performance often above or outside of red error bars both in the field and laboratory. There were numerous audit findings both in the field and laboratory; validation also not performed in conformance with QAPP. **Corrective action is needed in all areas charted.** The source of error may be identified through pattern identification. In the charts, field QC results for January and March appear to be impacted by laboratory performance as they seem to follow laboratory QC results that exceeded criteria (e.g., deuterated compound, matrix spike, matrix spike duplicate, and laboratory control sample).

It is less clear, but appears to occur again in October and November in laboratory QC samples for deuterated compound, matrix spike duplicate, laboratory control sample, and laboratory blanks. At other times the laboratory results appear to be within limits, but field results do not track or follow laboratory QC results.

Although initially thought that corrective action should be with the laboratory (January and March), additional evaluation of the laboratory and field charts support corrective action for both activities. The number of audit findings both in the field and laboratory support this conclusion, as there is no indication that corrective actions were taken to address findings. Percent validation also did not meet the QAPP commitment.

Figure 9a
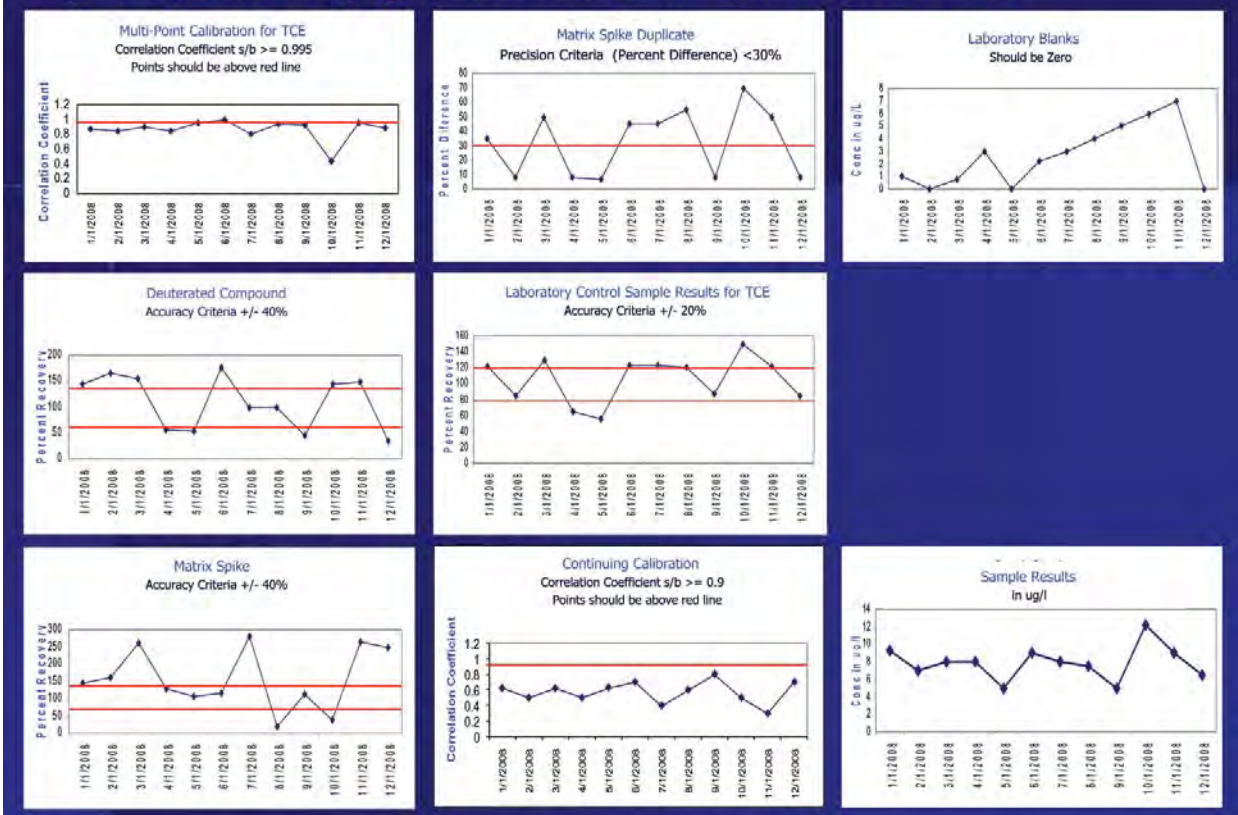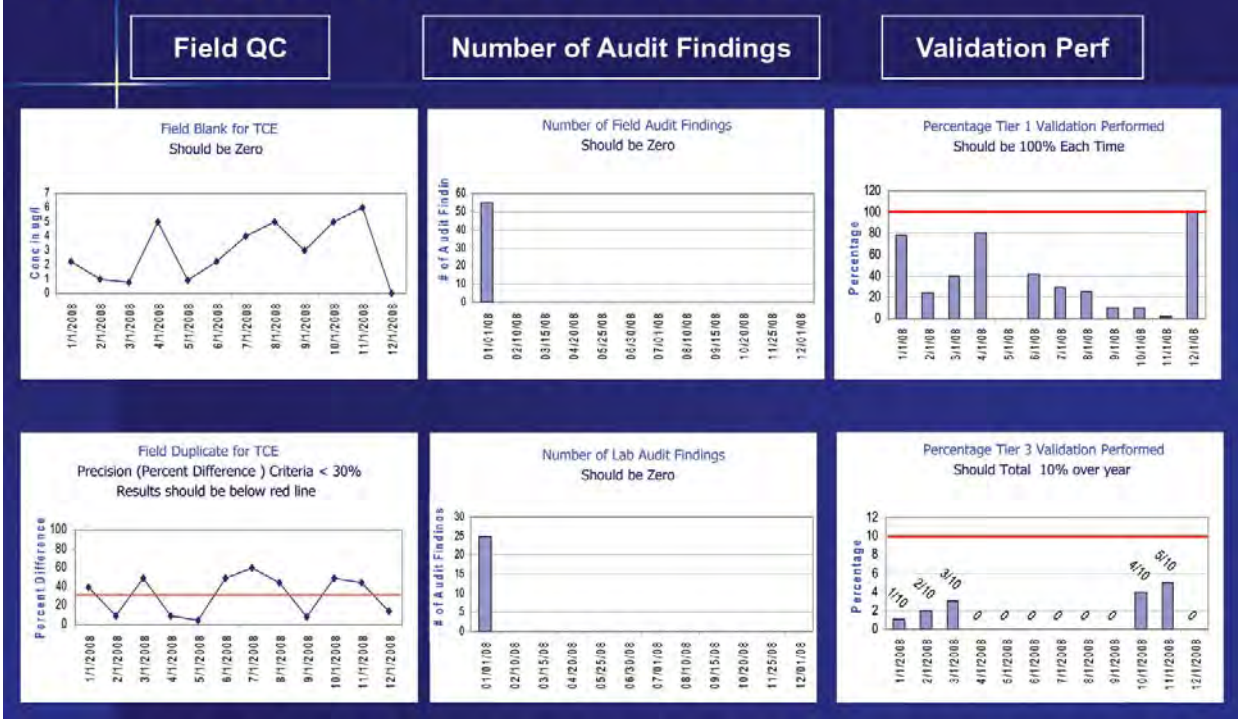

Figure 9b

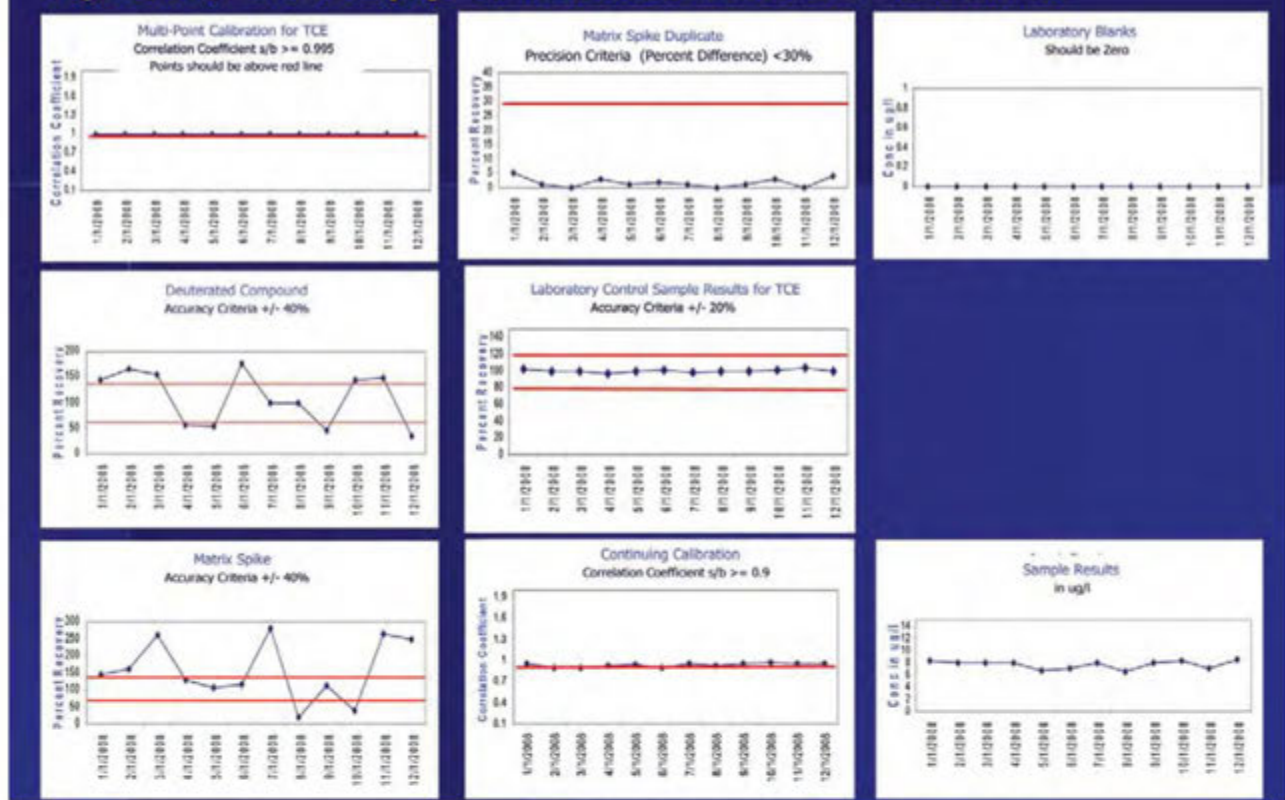Figure 10a, Laboratory QC Check results for TRICHLOROETHENE

Figure10a

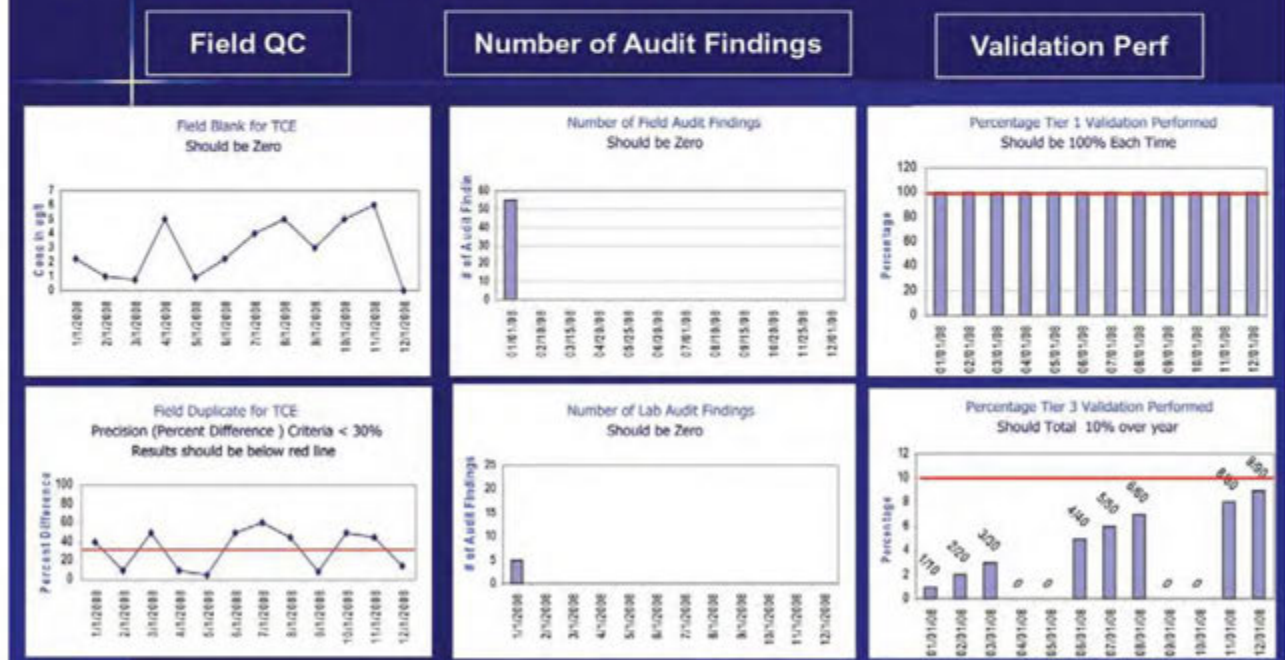Figure 10b, Field QC, Number of Audit Findings, and Data Validation Charts

Figure10b

Figures 10a and 10b. With exception of laboratory deuterated compound and matrix spike results, shows good laboratory control. Field QC results and number of audit findings are significant. Validation performed in near conformance with plan. **Corrective action is needed in the field** (overcome sampling deficiences captured in field blank, field duplicate and field audit charts) **and laboratory** (overcome effects from matrix [based on laboratory deuterated compound and matrix spike, results likely impacted by matrix, which may necessitate selection of another method or modification of existing method to overcome interferences, and that perform within acceptable limits] and laboratory audit findings). Validation also fell short by one percent and should also be addressed.

Figure 11, HIGH BIAS in Laboratory QC Samples
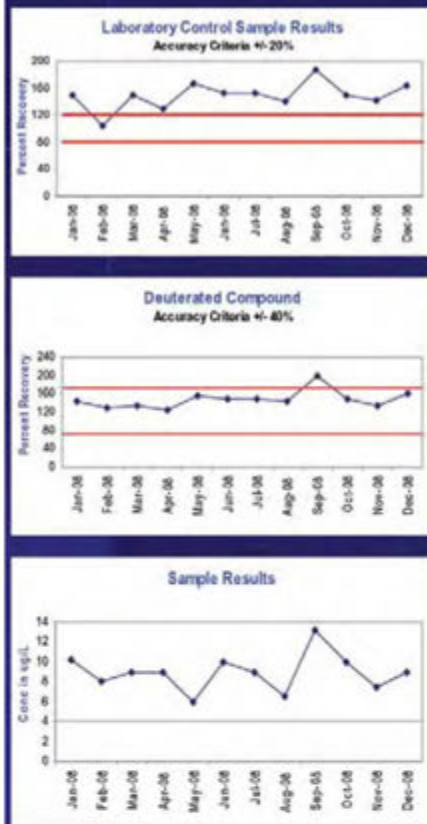
Graphs on left show a high bias. The laboratory should check if this is a systemic problem that may be easily corrected.

When corrected, graphs on right show improved performance and reliability in results, though some points still borderline (e.g., Lab Control Sample results for Apr, May and Dec 08) and outside of limits (Feb and Sep 08).

This is significant if results near action or regulatory limits of 13 ug/l (results now ~ 12 as opposed to ~ 14 ug/l).
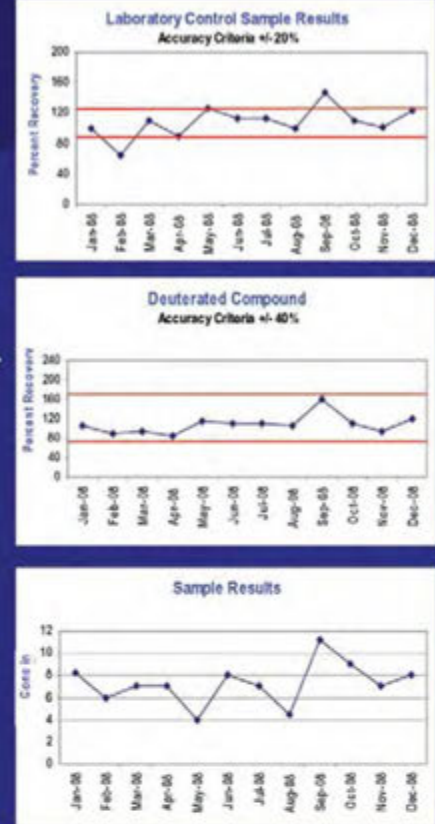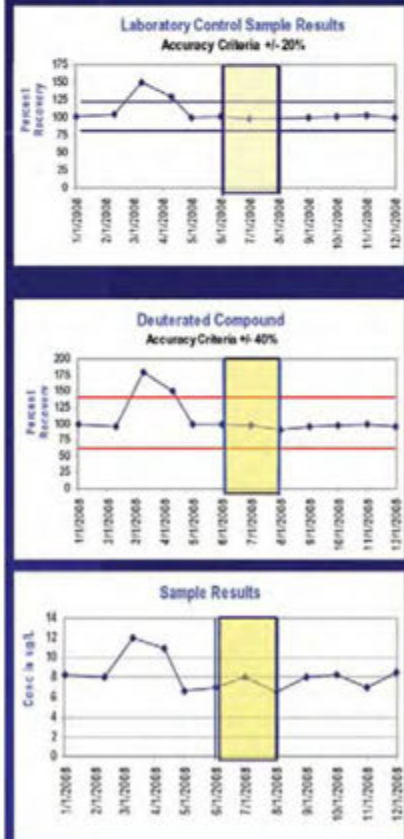
Figure 11

Figure 12, Effective Use of Resources

Validation erroneously performed on highlighted results where QC shown within limits.

Trend charts can identify areas to perform validation (i.e., areas out of performance criteria) for resource savings and to determine how the data produced out of performance criteria may be used, if at all.

Figure 12

One can also check if validation resources were effectively deployed. For example, Figure 12 shows validation was performed on results that met performance criteria. The validation should focus on those results that did not meet criteria.

Once QC results are in a database, one can examine the data for use in many different ways. For example, Figure 13 depicts QC data, associated chart, and site conditions associated with the QC data set. The ability to see developments, e.g., plume expansion or contraction on a near real time basis, is valuable for decision making, particularly if trying to control the plume with remediation.

One can also chart two line graphs on one chart, provided criteria and scales are similar (Figure 14). Or one can chart all QC results on one page for a comprehensive view of data quality (Figure 15).

Source of Trend Chart Points and How They Are Produced

When the laboratory performs analysis on project samples, they generate QC samples for determining whether the analytical system is performing within method or project PAB specifications (Figure 16).

With the exception of blanks, which should always be non-detect, a known concentration of a standard is typically spiked into the QC sample composed of laboratory reagent water or into actual sample (MS/MSD, deuterated monitoring compound, or surrogate). The QC sample is analyzed and results compared against what was spiked into the QC sample, and should be close to what was spiked into it. The laboratory performs PAB calculations (see Figure 17) on the QC sample results to determine their performance and whether they met QC limits of the method or QAPP specific PAB criteria.

Sensitivity, PAB are central to determining data quality, understanding what the trend charts are communicating and how to effectively use them.

Sensitivity is the capability of a method or instrument to discriminate between measurement responses representing different levels or amounts of the variable of interest.

Accuracy measures how close QC results are the "true" value. One spikes in a known concentration of Compound X into the QC sample. The QC sample is is then analyzed to determine the concentration of Compound X. The QC result (amount recovered) is then compared against the "true" value to determine how close the laboratory recovery is to "true". The assessment of accuracy includes both accuracy and precision and is usually expressed as bias or percent bias. See Figure 18 for example accuracy/bias calculation.

Bias describes the degree of accuracy and assigns a "direction" relative to the "true" value or expected result. It manifests itself in the systematic or persistent over or

underreporting of a QC test results and may be positive (high) or negative (low). When interpreting trend charts, the closer the accuracy result is to a 100% recovery, the better. However, one will likely encounter accuracy results over 100% or under 100% recovery, indicating a high or low bias, respectively, from the true value (see figure 19).
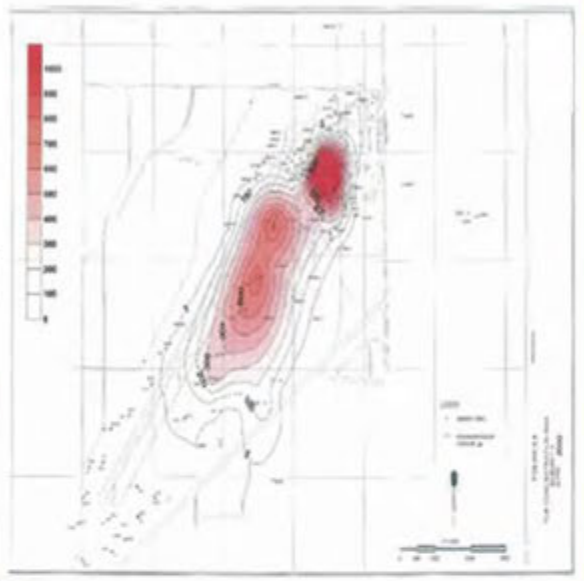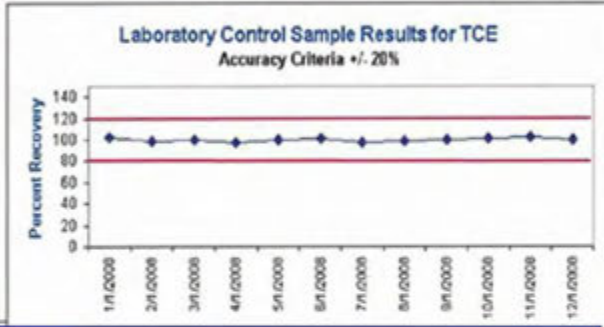
Value of Trend Charts
- Ease of tracking QAPP implementation over time for laboratory and field QC, audits conducted, and validation using visual charts rather than numerous text reports.

- Improve oversight and control of data quality due to ease in interpretation by those responsible for oversight and implementation of QAPP.

- Permit efficient self monitoring and tracking of QC results by parties responsible for implementing QAPP e.g., laboratory and field staff for determining excursions from QAPP criteria (e.g., +/- 15% accuracy criteria).

- Assimilate meaning of QC results and impact on sample results quickly.

- Spot out of control events/trends for performing corrective action.

- Convey information to others succinctly and transparently to enable their immediate understanding of the important characteristics of the data.

- Select data for validation based on charts, resulting in resource savings.

- Evaluate data collected from other sources, potentially with different objectives and criteria, if QC data available for charting. Data collected from other sources is often referred to as secondary data.

- Promote transparency and open government.

Limitations
- Trend charts are an effective broad brush tool. Fine tuned oversight still is necessary to determine cause of exceedances.

- Inappropriate use of trend chart results. Project chemist should be consulted on the use of QC data that exceed limits before making decisions with sample results associated with that exceedance.

- Limited to a set of COC, not entire target compound list in a method (e.g., EPA Method 8260). Use of charts may be cumbersome if COC exceed 10 at this time.

- Conventional validation should be performed for a one time sampling event where the target compound is unknown, and decisions will be based on that one event.

Figure 13

Figure 14

Summary of all QC results tracked over time
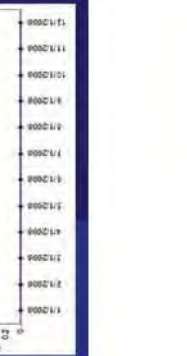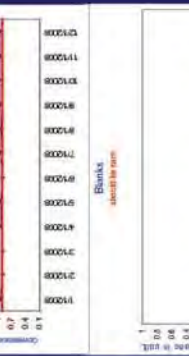
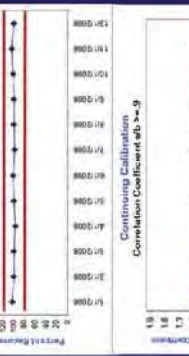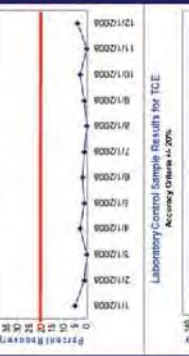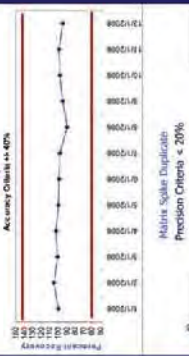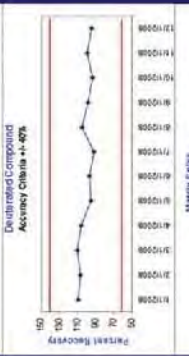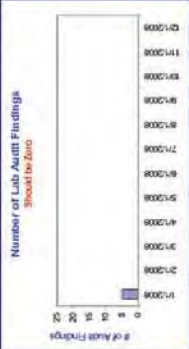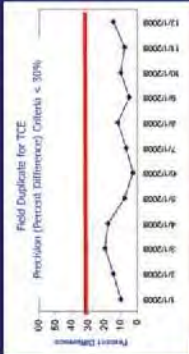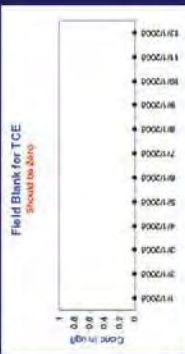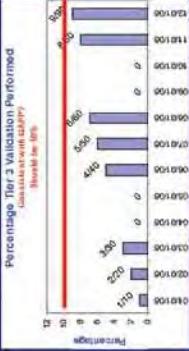| Laboratory QC	PE Sample	No. of Audit Findings	Field QC	Validation Perf
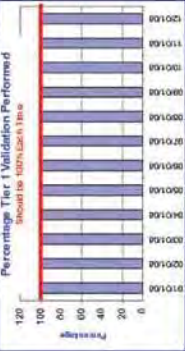
Site Condition 2008
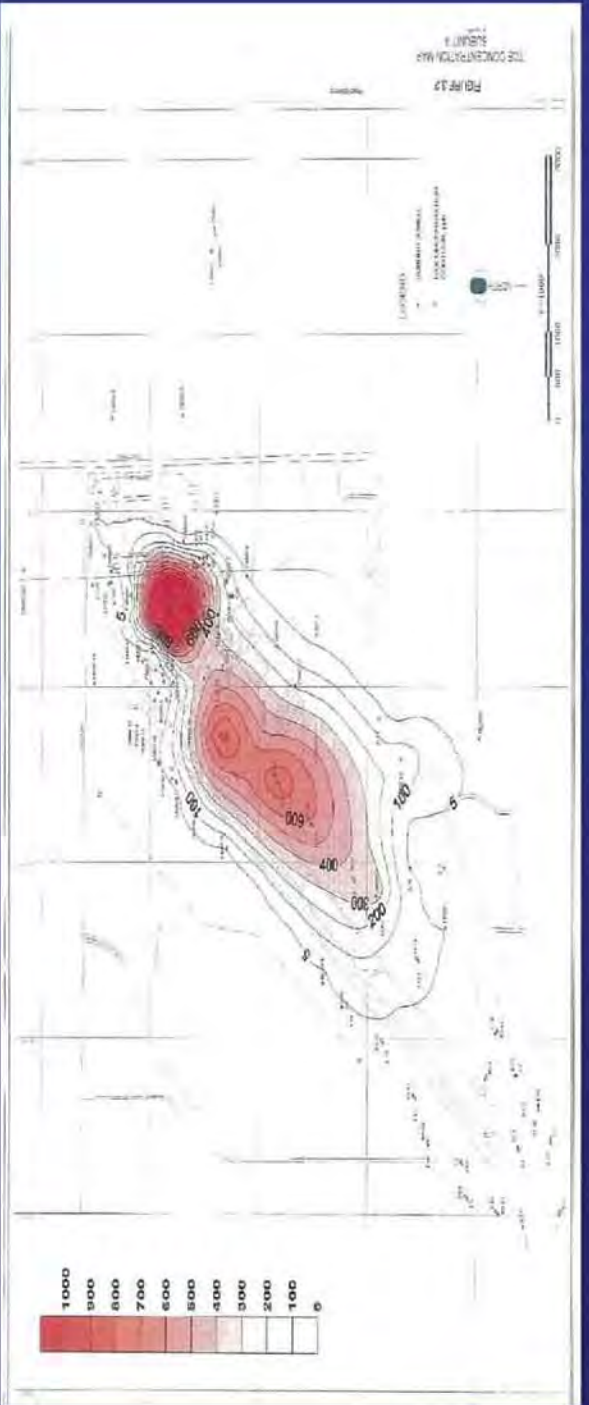
What Can You Chart?
Batch of Samples

Samples sent to the lab

QC Samples Lab Generates per batch received

Cal   LCS   MS   MSD   Surr *   Blank   Cont cal
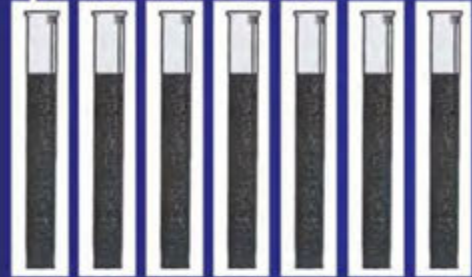
- I/O Calibration – accuracy
- I/O Continuing Calibration - precision
- I/O Lab Control Sample (LCS) – accuracy
- I/O Matrix Spike (MS) – accuracy and matrix effects/interference
- I/O Matrix Spike Duplicate (MSD) – precision
- O   Surrogate Spike – accuracy, method bias and extraction efficiency
        surrogates are spiked into every sample, not per batch
- I/O Blank - contamination
- I   Duplicates - Precision

- Legend I = inorganic; O = organic; with exception of blanks, all QC samples are spiked with a known concentration of compound or element.

Figure 16

Determining Data Quality
Types of Measurements on QC Samples

- **ACCURACY/BIAS**

$$\text{Percent Recovery} = \frac{\text{Amount Recovered (Results)}}{\text{Amount Spiked (True Value)}} \times 100$$

Measures how close you are to the "True Value;" the closer the number, the better.

- **PRECISION**

$$\text{Relative Percent Difference (RPD)} = \frac{|\text{Dup 1* – Dup 2*}|}{[(\text{Dup 1*} + \text{Dup 2*})/2]} \times 100$$

*Dup = results from lab duplicates
Smaller RPDs the better, results reproducible
Larger RPDs, the more unpredictable is the resulting data

Figure 17

Example Accuracy/Bias Calculations

$$\frac{20\ ug/l}{30\ ug/l} \times 100 = 67\%$$

$$\frac{29\ ug/l}{30\ ug/l} \times 100 = 97\%$$

ACCURACY/BIAS ASSOCIATED WITH SPIKED SAMPLES

Measures how close you are to the "True Value." The closer the results to the true value, the better (i.e., recovery of 100%).
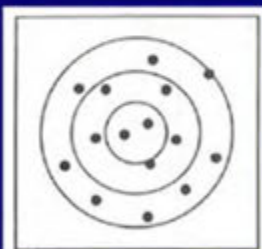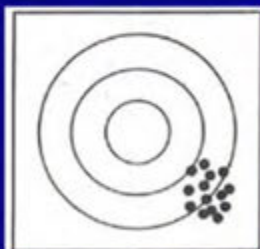
Figure 18

BIAS

Figure 19

Precision is defined as a measure of agreement among repeated measurements of the same property under identical, or substantially similar, conditions. The equation for calculating precision is presented in Figures 17 and 20.

Results from PAB calculations (Figures 17, 18, and 20) are plotted on the charts. These criteria, for the most part, are dependent on analytical method criteria; they may also be based on project specific criteria. In no case, should PAB criteria be less stringent than those identified in the method.

It may be challenging to meet PAB criteria with some analytes, e.g., emerging compounds where methods are in development. QA Office representatives should be contacted to request assistance with QC data interpretation in these cases.

CONCLUSION

Trend charts produce a quick visual method for use in assessing QC results and QA oversight of QAPP implementation over time. Core QC elements may be tracked in the field and laboratory. Laboratories produce the data used in preparing these charts, with most producing charts upon request.

Trend charts use may be extended to quantify results of performance evaluation samples, field laboratory audits, and data validation. They permit one to see trends in a timely manner, for corrective action when needed. Due to their ease in interpretation, they permit improved oversight and control of data quality, for corrective action when needed. The chemist should be consulted when making a critical decision based on the data provided in the trend charts.

The discussion in this paper is based on recent work completed for Region 9 sites and is subject to revision as more QC information becomes available. Mention of trade names or commercial products does not constitute endorsement or recommendations for use.

[1] Data Quality Assessment: A Reviewer's Guide, EPA QA-G9R, EPA/240/B-06/002, February 2006.

FREQUENTLY ASKED QUESTIONS (FAQs)

1. What software was used to prepare the charts and may I have access to it?
Any graphical package may be used. Microsoft Excel was used to produce the majority of figures in this paper, primarily due to its ability to accept data and present in graphical format.

2. What is the cost of producing charts?
Minimal, if anything, as QC data is already being produced by the laboratory.

Trend charts monitoring laboratory performance are already available to Regional QA Offices for the Superfund Contract Laboratory Program (CLP) at website: http://epasmoweb.dyncsc.com/scstr/. They cover initial and continuing calibration, deuterated compound recovery (similar to surrogate recovery), and blank results.

Region 9 laboratory will produce QC results for the following: laboratory control sample, matrix spike, matrix spike duplicate, blank, and surrogates. Region 9's experience with PRP laboratories has also been successful.

3. Who will be responsible for producing the charts?
Laboratories, contractors, grant, cooperative, and interagency agreement recipients performing data collection.

4. Who will be responsible for managing the charts?
RPM's and the QA Office will have equal responsibility in managing data uploading due to the security firewall. The data system will house trend charts for laboratory QC, field QC, number field and laboratory audit, validation, and performance evaluation sample results by site, with ability to append charts from prior years for a full documentation of QC results obtained over the life of the project.

5. How frequently should charting results be reported?
For those immediately involved in producing data and reporting to oversight parties, it should be reported daily to enable tracking of the source of error and corrective action. For those in an oversight role, results may be charted quarterly or more frequently, if needed.

6. Can trend charts be used to demonstrate laboratory proficiency at the beginning of a project?
Yes, however, one should ask for control charts, as opposed to trend charts, for the COC at concentrations of concern at the beginning of a project or whenever using a new laboratory. Once charts have been obtained, determine whether they meet project completeness criteria. For example, if the charts show excursions outside of project limits 25% of the time over the past 100 days and the project requires a completeness of 95% over the same period, the laboratory may not be suitable as the charts show they only meet 75% completeness (75/100 x 100% = 75%, see completeness definition in glossary). Results may not be usable 25% of the time and will not meet completeness criteria.

One should require the laboratory's commitment to meet project specific criteria on the method specified instrument used by the laboratory to produce project results. "Best Practices for Detection and Deterrence of Laboratory Fraud," 1997, California Military Environmental Coordination Committee contains contains additional including reviewing laboratory Quality Assurance Project Plans, Standard Operating Procedures, recent audit reports performed by credible organizations, self audits, review of control charts for past 100 days for analytical method and concentrations of interest, performance evaluation sample results, etc.

7. How often should field and laboratory audits be conducted?
Ideally, audits should be conducted when beginning to work with a new field contractor or laboratory, and as frequently as necessary thereafter. This is to ensure the "systems" are within control criteria to improve confidence in field and laboratory ability to produce data of the quality specified in the QAPP. If one doesn't have ability to conduct audits, be sure to use a contractor with credible performance history; i.e., obtain control charts for prior QC results for COCs and concentrations of concern, PE sample results, audit reports from other reputable organizations, etc.

8. My laboratory is stating that it cannot produce the charts suggested by Figures 8b, 9a, and 10a. Is there a core set of QC elements that should be obtained?
All laboratories should already be producing the following: Initial and continuing calibration, laboratory control sample, laboratory control sample duplicates, matrix spike (MS)/ matrix spike duplicates (MSD) (or deuterated compound recoveries if MS/MSDs are not performed), blanks, and performance evaluation (PE) sample results. One should require an explanation be provided where they are not. If other QC checks are sought (samples properly preserved, holding time met), one may chart these responses as well.

9. Can trend charts be used in lieu of validation reports for contaminants of concern?
No. As stated in the title of this document, trend charts are a screening tool. Validation should coninue to be conducted where QC results deviate from criteria. The charts presented in this paper cover some of the core laboratory QC checks that are performed, and are limited to those checks specifically. There are many other QC checks reviewed in the validation process beyond those identified in the previous question or the charts presented in this paper; e.g., holding time, proper preservation, chain of custody, system performance check compounds, serial dilutions, tuning, internal standards, and others which may also be charted. Greater certainty is achieved with charting of additional QC checks for determining if validation should be performed.

This question merits revisiting if the additional QC checks performed during validation are also captured in trend charts, as QC results do not change whether captured in validation reports or trend charts, and the objectives of both are to bring deficiencies to light for the data user.

10. What other field sampling activity should I track besides blanks and duplicates?

Anything that is quantifiable and specified in the QAPP including:

- calibration standards (expiration, stability);
- daily instrument calibration results (to monitor changes and need for potential instrument maintenance);
- well depth;
- well stabilization results for each well (monitor changes [e.g., changes in pH affects chemical form {mobility} and microbial activity. Dissolved oxygen affects aerobic and anaerobic metabolism of chlorinated compounds such as tricholoroethene and affects activity kinetics] and need for well maintenance due to silting and corrosion).
  - pH,
  - conductivity,
  - temperature,
  - redox (oxidation-reduction),
  - dissolved oxygen,
  - turbidity.

11. Why do the charts look different, some with data points being connected by lines and others not? Is one way more appropriate than the other?

The charts may be represented in either format and should always be referred to as trend charts. The lines connecting data points were used mainly to emphasize and more easily track the temporal progression of QC results.

12. How do you use the charts for screening data obtained from other sources, potentially with different data and method quality objectives?

Comparability is of vital importance for projects using existing data. It is a qualitative term that expresses the confidence that two data sets can contribute to common interpretation and analysis.

When using data from a variety of sources or sampling events, it is important to be sure that the data are similar.

This response limits itself to the analytical sensitivity and QC elements (including holding time, proper preservation) for determining data comparability using trend charts. Comparability determination of field sample collection, design (collected at a certain depth, time of year) and collection QC should be determined separately as they will have a direct impact.

Trend charts may be used to efficiently and quantitatively determine analytical data comparability whether the analytical methodology is the same or differs (e.g., performance based methods used).

Data obtained from other sources must meet current sensitivity and QC acceptance limits. Sample and associated QC results must come from the same "batch" (i.e., set of QC results [initial and continuing calibration, laboratory control sample, DMC, blank results] reflect those analyzed concurrently with the sample) when screening. Do not mix or match other source QC data sets, selecting only those

QC results that meet current criteria or limits, e.g., selecting control sample QC results from Laboratory 1, DMC QC results from Laboratory 2, blank recovery from Laboratory 3, etc.

Once batch QC results are obtained, analytical trend charts may then be created using QC results only, no matter whether they were obtained directly or from other sources. Similar to data obtained directly, one needs to chart the date, QC acceptance limits (single or paired), and QC results to screen for acceptability.

Example 1, Current QC Limits (Criteria) Wider or Greater than Data Acquired from Other Sources

Figure AA.

Laboratory Control Sample Results for Trichloroethylene (TCE)
Other Source Accuracy Criteria +/- 25% (Red Line)
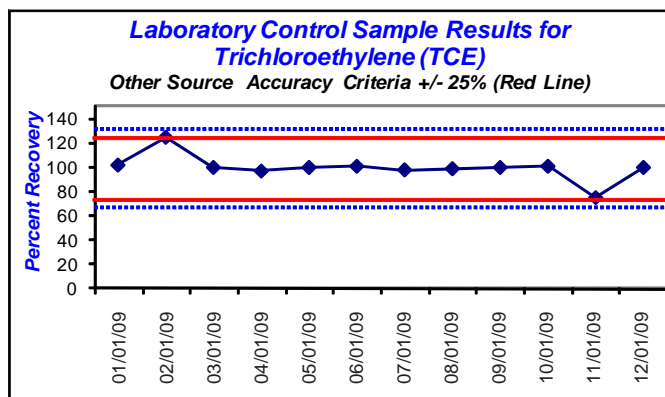
Where current QC project criteria for recovery is +/- 30%, one would be able to use all data acquired from other sources that fall within current project criteria. This is because the current criteria are wider, broader than the other source criteria (+/-25%). All results fall within the +/- 30% limit (blue dashed lines) in Figure AA.

Figure BB.

Duplicate
Other Source Precision criteria < 20% (Red line)
Current Precision Criteria < 30% (Blue dash line)
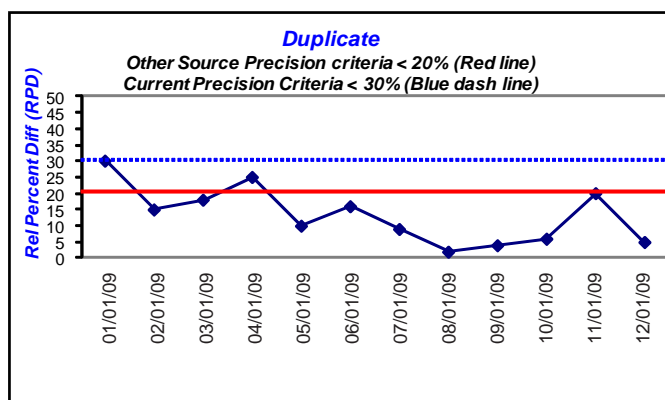
Where current QC project criteria for duplicate percent difference limit is 30%, and other source limit is 20%, all QC results that are less than 30% (blue dashed line in Figure BB) may be used for the current project. In Figure BB, all results with exception of January 2009 are acceptable. The data point for January 2009 is marginally acceptable and should be verified with a chemist to determine usability for the current project.

Figure CC.

Laboratory Control Sample Results for Trichloroethylene (TCE)
Other Source Accuracy Criteria +/- 25% (Red Line)
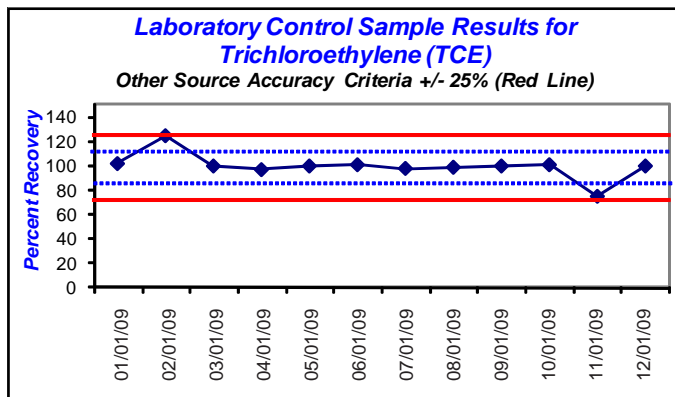
Example 2, Current Project QC Limits (Criteria) More Stringent or Less than Data Acquired from Other Sources

Using the Other Source limits from Figure AA (+/- 25%), if current project criteria are more stringent (+/- 15%), one would only be able to use other source QC results (and associated sample results) meeting current criteria. The tighter more stringent limits exclude other source QC results for February and November 2009 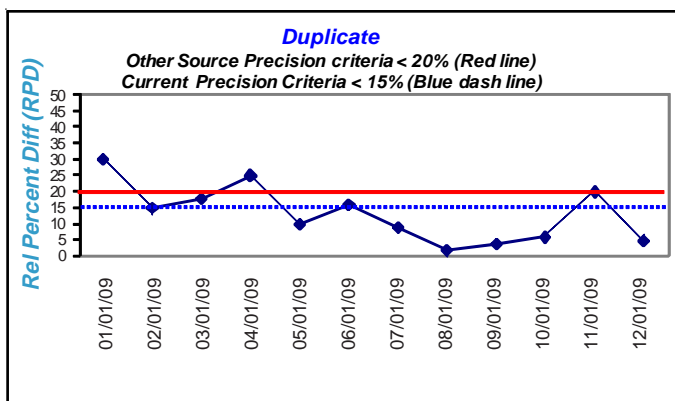in Figure CC (blue dashed lines), as they do not met current project recovery limits. If these results are used, they should be used with a qualifier.

Figure DD.

Duplicate
Other Source Precision criteria < 20% (Red line)
Current Precision Criteria < 15% (Blue dash line)

Using the same other source percent difference limits as in Figure BB (i.e., < 20%), where current project criteria for duplicate percent difference limit is <15%, all other source QC results that are less than 15% (blue dashed lines in Figure DD) may be used for the current project i.e., May, July-October and December 2009 in Figure DD. Marginally acceptable data points occur in February and June, 2009 and should be verified with a chemist to determine usability. Points associated with January, March, April, and November, 2009 fail to meet current criteria and should be excluded or used with a qualifier.

Any combination of other source data criteria may be encountered. QC limits for data from other sources must be reasonable and not be so wide or great as to render the results meaningless. Greater uncertainty is introduced with wider or greater limits (see Figure 18, Equation 1 and Figure

20, Equation 3). Check with a chemist on what is considered reasonable as this will vary with method. Once QC data from other sources are reviewed and found acceptable, one can apply current criteria to determine whether data from other sources may be used for present purposes (Figures AA-DD).

GLOSSARY
(from Contract Laboratory Program, SOM1.1, 5/2005 and SW-846, Revision 6, February 2007)

Blank: An analytical sample designed to assess specific sources of laboratory contamination. See individual definitions for the following types of blanks: instrument blank, method blank, and storage blank.

- **Instrument blank**: A blank designed to determine the level of contamination associated with the analytical instruments.

- **Method blank**: A method blank is analyzed with each batch of samples processed to assess contamination levels in the laboratory.

- **Storage blank**: Reagent water (two 40.0 ml aliquots) stored with volatiles samples in a sample delivery group. It is analyzed after all samples have been analyzed for the sample set or sample delivery group (SDG) and is used to determine the level of contamination acquired during storage.

Closing Continuing Calibration Verification: Last analytical standard run every 12 hours to verify the initial calibration accuracy of the system.

Comparability: A qualitative term that expresses the confidence that two data sets can contribute to common interpretation and analysis (e.g., compare sample collection methods, analytical procedures, holding times, stability issues and QA/QC protocols).

Quantitative measures of comparability are also available involving statistical tests that measure the similarity or difference between two or more data sets.

Comparability should be carefully evaluated in order to establish whether two data sets can be considered equivalent in regard to the measurement of a specific variable or groups of variables.

Completeness: A measure of the amount of valid data obtained from a measurement system, expressed as a percentage of the number of valid measurements that should have been collected according to the study design (i.e., measurements that were planned to be collected). Percent completeness is calculated using the following formula:

$$\text{Percent completeness} = \frac{\text{number of valid measurements}}{\text{Total number of measurements planned}} \times 100$$

Deuterated Monitoring Compounds (DMCs): Compounds added to every calibration standard, blank, and sample used to evaluate the efficiency of the extraction/purge-and-trap procedures, and the performance of the Gas Chromatograph/Mass Spectrometer (GC/MS) systems. DMCs are isotopically labeled (deuterated) analogs of native target compounds. DMCs are not expected to be naturally detected in the environmental media.

Field QC: Any QC samples submitted from the field to the laboratory. Examples include, but are not limited to: Field blanks, field duplicates, and field spikes.

Initial Calibration: Analysis of analytical standards for a series of different specified concentrations; used to define the quantitative response, linearity, and dynamic range of the response of the mass spectrometer (MS) or electron capture detector (ECD) to the target compounds.

Internal Standards: Compounds added to every standard, blank, matrix spike and matrix spike duplicate (MS/MSD), sample (for volatiles), and sample extract (for semivolatiles) at a known concentration, prior to analysis. Instrument responses to internal standards are used as the basis for quantitation of the target compounds.

Laboratory Control Sample (LCS): An internal laboratory QC sample used to monitor the capability of the laboratory to perform the analytical method.

Matrix Spike (MS): Aliquot of a sample (water or soil) taken from one of the field samples to be analyzed within an SDG, fortified (spiked) with known quantities of specific compounds, and subjected to the entire analytical procedure in order to indicate the appropriateness of the method for the matrix by measuring recovery.

Matrix Spike Duplicate (MSD): A second aliquot of the same sample as the Matrix Spike (above) that is spiked in order to determine the precision of the method.

Opening Continuing Calibration Verification: First analytical standard run every 12 hours to verify the initial calibration of the system.

Performance Evaluation (PE) Sample: A sample of known composition and concentration used to evaluate Laboratory performance.

Reagent Water: Water in which the compounds of concern or interferants are not observed at the method detection limit.

Representativeness: The measure of the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition or environmental condition. Central to representativeness is assurance that both the sampling and measurement processes are free from known biases.

Surrogates: For pesticides and aroclors, compounds added to every blank, sample, matrix spike and matrix spike duplicates (MS/MSDs), and standard. Surrogates are used to evaluate analytical efficiency by measuring recovery. Surrogates are not expected to be detected in environmental media.