



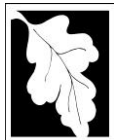
Massachusetts Department of Environmental
Protection Bureau of Waste Site Cleanup

WSC-CAM	Section: VI B
July 1, 2010	Revision No. 1
Final	Page 1 of 26

Quality Control Requirements and Performance Standards for the ***Analysis of Hexavalent Chromium, Cr(VI), by UV-Visible Spectrophotometry***, in Support of Response Actions under the Massachusetts Contingency Plan (MCP)

WSC – CAM – VI B

Quality Control Requirements and Performance Standards
for the **Analysis of Hexavalent Chromium, Cr(VI), by UV-
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Quality Control Requirements and Performance Standards for the ***Analysis of Hexavalent Chromium, Cr(VI), by UV-Visible Spectrophotometry***, in Support of Response Actions under the Massachusetts Contingency Plan (MCP)

VI. Miscellaneous Wet Chemical Methods

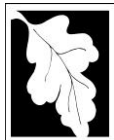
B. Quality Control Requirements and Performance Standards for WSC-CAM-VI B (Hexavalent Chromium)

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ACRONYM LIST

CAM	Compendium of Analytical Methods
CASN	Chemical Abstracts Service Number
CCB	Continuing calibration blank
CCV	Continuing calibration verification
Cr (III)	Trivalent Chromium
Cr(VI)	Hexavalent Chromium
HCl	Hydrochloric acid
HNO ₃	Nitric acid
LLCV	Low-level calibration verification
ICB	Initial calibration blank
ICV	Initial calibration verification
IDP	Initial demonstration of proficiency
IRAs	Immediate Response Actions
LCS/LCSD	Laboratory control sample / Laboratory control sample duplicate
LR	Linear range
MassDEP	Massachusetts Department of Environmental Protection
MB	Method blank
MCP	Massachusetts Contingency Plan
MD	Matrix duplicate
MDL	Method detection limit
MS	Matrix spike
MOHML	Massachusetts Oil and Hazardous Materials List
ORP	Oxidation/Reduction Potential
%D	Percent difference
%R	Percent recovery
r	Correlation coefficient
RAO	Response Action Outcome
RCs	Reportable Concentrations
RL	Reporting limit
RPD	Relative percent difference
RQs	Reportable Quantities
QA	Quality assurance
QC	Quality control

UNITS:

g	Gram
mg	Milligram
mg/L	Milligram per liter
mg/Kg	Milligram per kilogram
mL	Milliliter
nm	nanometer
µg/L	Microgram per liter
µm	Micrometer



Quality Control Requirements and Performance Standards for the ***Analysis of Hexavalent Chromium, Cr(VI), by UV-Visible Spectrophotometry***, in Support of Response Actions under the Massachusetts Contingency Plan (MCP)

1.0 Quality Control Requirements and Performance Standards for WSC-CAM-VI B

1.1 Overview of WSC-CAM-VI B

WSC-CAM-VI B, *Quality Control Requirements and Performance Standards for the Analysis of Hexavalent Chromium, Cr(VI), by UV-Visible Spectrophotometry in Support of Response Actions under the Massachusetts Contingency Plan (MCP)*, is a component of MassDEP's Compendium of Analytical Methods (CAM). Effective July 1, 2010, this revised CAM protocol, WSC-CAM-VI B, replaces the original Hexavalent Chromium CAM document, WSC-CAM-VI B (effective date, August 20, 2004). Refer to WSC-CAM-I A for an overview of the CAM process. Please note that while this protocol must be followed on and after the effective date of July 1, 2010 for the purpose of "Presumptive Certainty," the revised protocol may be used optionally prior to its effective date upon its publication on April 15, 2010.

This document provides Quality Control (QC) requirements and performance standards to be used in conjunction with the required analytical method SW-846 7196A (colorimetric using UV-Visible spectrophotometry) for the analysis of aqueous and solid samples for Hexavalent Chromium (Cr(VI)). The QC requirements and performance standards specified in this document in Table VI B-1 together with the analytical procedures described in EPA SW-846 Method 7196A, *Chromium, Hexavalent (Colorimetric)*, constitute the WSC-CAM-VI B protocol. All protocols included in the CAM are considered "methods" published by the MassDEP pursuant to the provisions of 310 CMR 40.0017(2). Use of EPA SW-846 7196A is a "Presumptive Certainty" requirement of WSC-CAM-VI B. Sample preservation, container and analytical holding time specifications for aqueous, soil, and sediment matrices for Hexavalent Chromium analyzed in support of MCP decision-making are presented in Appendix VI B-1 of this document and Appendix VII-A of WSC-CAM-VII A *Quality Assurance and Quality Control Guidelines for the Acquisition and Reporting of Analytical Data in Support of Response Actions Conducted Under the Massachusetts Contingency Plan (MCP)*. Data reporting requirements are also provided in WSC-CAM-VII A.

Overall usability of data produced using this CAM protocol should be evaluated for compliance with project-specific data quality objectives, regardless of "Presumptive Certainty" status. For more guidance on data usability, refer to MassDEP Policy #WSC-07-350, *MCP Representativeness Evaluations and Data Usability Assessments*.

1.1.1 Reporting Limits for Hexavalent Chromium by WSC-CAM-VI B

The reporting limit (RL) for Hexavalent Chromium (Cr(VI)) using WSC-CAM-VI B is dependent on the concentration of the lowest non-zero standard in the initial calibration or the low-level calibration verification (LLCV), analyzed under identical conditions as the sample, with adjustments made for the sample size, preparation factors, percent solids, dilution factors, etc., as required. The CAM RLs for Cr(VI) using the WSC-CAM-VI B protocol are:

- 5 - 10 µg/L for aqueous samples (surface water, groundwater, and drinking water); and
- 0.5 – 1.0 mg/kg for soil/sediment samples.



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For "Presumptive Certainty" purposes, if the typical CAM RLs are not achieved, respond "NO" to Question G of the "MassDEP MCP Analytical Protocol Certification Form" and address the CAM RL exceedance in the laboratory narrative.

Reporting limits lower than the above-referenced CAM RLs for Cr(VI) may be required to satisfy project requirements. The RL (based on the concentration of the lowest calibration standard or the LLCV) for Cr(VI) must be less than or equal to the MCP standards or criteria that the contaminant concentrations are being compared to (e.g., Method 1 Standards, benchmark values, background, etc.). Meeting MCP standards or criteria may require analytical modifications to improve sensitivity. All such modifications must be described in the laboratory narrative.

1.1.2 Initial Demonstration of Proficiency for WSC-CAM-VI B

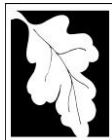
Each laboratory that uses the WSC-CAM-VI B protocol is required to operate a formal quality assurance program. The minimum requirements of this program consist of an initial demonstration of laboratory proficiency, ongoing analysis of standards and blanks to confirm acceptable continuing performance, the digestion/analysis of laboratory control samples (LCS) and/or matrix spikes (MS) to assess accuracy and LCS duplicates or matrix duplicates (MD) to assess precision.

Laboratories must document and have on file an Initial Demonstration of Proficiency for each combination of sample preparation and determinative method being used. These data must meet or exceed the performance standards as presented in Table VI B-1 of this protocol. General requirements for performing the Initial Demonstration of Proficiency can be found in SW-846 Chapter One and Section 8 of SW-846 Methods 7196A and 3060A. The data associated with the Initial Demonstration of Proficiency must be kept on file at the laboratory and made available to potential data users on request. The data associated with the Initial Demonstration of Proficiency for WSC-CAM-VI B must include the following:

QC Element	Performance Criteria
Initial Calibration	See WSC-CAM-VI B, Table VI B-1, for Performance Criteria
Continuing Calibration	
Method Blanks	
Percent Recovery for LCS & MS Solids: Soluble MS & Insoluble MS recoveries	
Relative Percent Difference (RPD) for LCS Duplicate (LCSD) or MD	

Laboratories are encouraged to actively monitor pertinent QC performance standards described in Table VI B-1 to assess analytical trends (i.e., systematic bias, etc) and improve overall method performance by preempting potential non-conformances.

For the WSC-CAM-VI B protocol, laboratory-specific control limits must meet or exceed (demonstrate less variability than) the performance standards for each QC element listed in Table VI B-1. It should be noted that the performance standards listed in Table VI B-1 are based on multiple-laboratory data,



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which are in most cases expected to demonstrate more variability than performance standards developed by a single laboratory.

This protocol is restricted to use by, or under the supervision of, analysts who are experienced in using colorimetric UV-Visible spectrophotometry as a quantitative tool for environmental analyses and knowledgeable in the minimization of interferences described in this method.

1.2 Summary of SW-846 Method 7196A

SW-846 Method 7196A is the determination of Cr(VI) by UV-Visible spectrophotometry. This analytical method may be used directly for the determination of dissolved Cr(VI) in aqueous environmental samples (groundwaters and surface waters) and in extracts or as the determinative step in the analysis of Cr(VI) in soils, sediments and other solid waste materials that have been digested (prepared) using SW-846 Method 3060A, *Alkaline Digestion for Hexavalent Chromium*.

Three types of Chromium may be of interest in environmental samples: Total Chromium, Cr(VI), and trivalent chromium (Cr(III)). Total Chromium may be determined by inductively coupled plasma-atomic emission spectrometry (ICP-AES), graphite furnace atomic absorption (GFAA), or ICP-mass spectrometry (ICP-MS). Refer to the appropriate MassDEP CAM protocols (WSC-CAM-III A, III C or III D) for specific analytical and reporting requirements. Cr(III) is not measured directly; rather, it is defined as the difference between the Total Chromium and the Cr(VI) concentrations, as follows:

$$\text{Chromium (III)} = \text{Total Chromium} - \text{Chromium (VI)}$$

Cr(VI) is determined by the addition of an excess of diphenylcarbazide in acid solution yielding a red-violet product in the treated sample. Quantitation for Cr(VI) in the treated dissolved or digested sample is based on the color absorption of this red-violet product at 540-nm wavelength using a UV-Visible spectrophotometer. Absorbance (peak height) is measured as a function of Cr(VI) concentration, based on a multi-level calibration curve.

1.3 Sample Digestion/Preparation Methods for WSC-CAM-VI B

Aqueous samples for analysis by WSC-CAM-VI B do not require preparation/digestion prior to analysis. Solid samples (soil, sediment, sludge, waste) for analysis by WSC-CAM-VI B must be prepared/digested using SW-846 Method 3060A, which is an alkaline digestion procedure for extracting Cr(VI) from solid samples. Alkaline digestion is the required preparative step for the analysis of soils, sediments, sludges and similar waste materials under the WSC-CAM-VI B protocol. The pH of the digestate must be carefully adjusted and monitored during the alkaline digestion to maintain the native chromium species in the environmental sample (i.e., prevent transformation of one species of chromium to another species). During sample digestion using SW-846 Method 3060A, the pH must be maintained at pH 7.5 ± 0.5 in order to obtain a valid extract for analysis by WSC-CAM-VI B using SW-846 Method 7196A.

To accurately measure all Cr(VI) in a solid matrix, three criteria must be satisfied:

- (1) The digestion solution must solubilize all forms of Cr(VI),



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- (2) The conditions of the digestion must not cause reduction of native Cr(VI) to Cr(III), which can cause a low bias, and
- (3) The conditions of the digestion must not cause oxidation of native Cr(III) to Cr(VI), which can cause a high bias.

SW-846 Method 3060A meets these criteria for most solid matrices. Under the alkaline conditions of the digestion, minimal reduction of Cr(VI) or oxidation of native Cr(III) occurs. The efficiency (measured as percent recovery) of the extraction procedure is assessed using MS recovery data for soluble (potassium chromate) and insoluble (lead chromate) forms of Cr(VI), coupled with the measurement of other soil properties, such as oxidation reduction potential (ORP by measurement of Eh) and pH. See Section 1.6 for further details on these measurements.

Recovery of the insoluble Cr(VI) spike is used to assess efficiency and maintenance of non-reductive conditions during the digestion process. Method-induced oxidation (Cr(III) converted to Cr(VI)) is usually not observed except in soils high in manganese and amended with soluble Cr(III) salts or freshly precipitated Cr(OH)₃.

1.4 Method Interferences

Samples submitted to a laboratory for trace metal analysis may become contaminated by numerous routes during both sampling and analysis. Potential sources of contamination may include:

- Metallic or metal-containing containers and sampling equipment,
- Laboratory acids or reagents,
- Improperly cleaned or stored equipment, and
- Atmospheric inputs such as dirt and dust.

Several common interferences and corrective measures are described, as follows.

- The color reaction of Cr(VI) with diphenylcarbazide is highly selective for Cr(VI) and generally free from interferences. Refer to Section 3.0 of SW-846 Method 7196A for further information on analytical interferences, which explains that even relatively high concentrations of potential interferents (molybdenum, mercury salts, iron, vanadium) do not cause a problem with Cr(VI) analysis if performed as specified by SW-846 Method 7196A.
- Results for Cr(VI) for soils or wastes that contain levels of Cr(III) greater than 4x the reporting limit for Cr(VI) may be biased high due to method-induced oxidation that can occur during the the alkaline digestion (SW-846 Method 3060A) The addition of Mg⁺² in a phosphate buffer to the alkaline solution has been shown to suppress oxidation.

1.5 Quality Control Requirements for WSC-CAM-VI B

1.5.1 General QC Requirements

For general quality control procedures for all inorganic methods, including SW-846 Method 7196A, refer to SW-846 Chapter One. General QC procedures to evaluate the instrument's operation can also be



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found in SW-846 Chapter One, Section 2.0, and include evaluation of calibrations and performance of sample analyses.

1.5.2 Specific QC Requirements and Performance Standards for WSC-CAM-VI B

Specific QC requirements and performance standards for Hexavalent Chromium using the WSC-CAM-VI B protocol are presented in Table VI B-1. Refer to WSC-CAM-VII A for field QC requirements. **Note that a project-specific matrix spike (MS) must be performed for hexavalent chromium to evaluate accuracy in a solid matrix (soil/sediment) at a frequency of one per 20 samples per matrix.** Strict compliance with the QC requirements and performance standards, as well as satisfying the CAM's other analytical and reporting requirements will provide a data user with "Presumptive Certainty" in support of Response Actions under the MCP. The concept of "Presumptive Certainty" is explained in detail in Section 2.0 of WSC-CAM-VII A.

While optional, parties electing to utilize these protocols will be assured of "Presumptive Certainty" of data acceptance by agency reviewers. In order to achieve "Presumptive Certainty" for analytical data, parties must:

- (a) Use the analytical method specified for the selected CAM protocol;
- (b) Incorporate **all** required analytical QC elements specified for the selected CAM protocol;
- (c) Implement, as necessary, required corrective actions and analytical response actions for **all** non-conforming analytical performance standards;
- (d) Evaluate and narrate, as necessary, **all** identified CAM protocol non-compliances; and
- (e) Comply with **all** the reporting requirements specified in WSC-CAM-VII A, including retention of reported and unreported analytical data and information for a period of ten (10) years.

In achieving "Presumptive Certainty" status, parties will be assured that analytical data sets:

- ✓ Satisfy the broad QA/QC requirements of 310 CMR 40.0017 and 40.0191 regarding the scientific defensibility, precision and accuracy, and reporting of analytical data; and
- ✓ May be used in a data usability and representativeness assessment, as required in 310 CMR 40.1056(2)(k) for Response Action Outcome (RAO) submittals, consistent with the guidance described in MassDEP Policy #WSC-07-350, *MCP Representativeness Evaluations and Data Usability Assessments*.

1.6 Special Analytical Considerations for WSC-CAM-VI B

- Matrix Spike (MS) Recovery – **A MS is required for WSC-CAM-VI B for hexavalent chromium in solid matrices (soil/sediment) at a frequency of one per 20 samples per matrix. Both a Soluble-MS and Insoluble-MS are required to be performed on a project-specific basis for Cr(VI) in solid matrices.** Consistent with USEPA Region I data validation guidance, MassDEP requires rejection of non-detected inorganic results with <30% recovery in the MS. If the recovery is <30% and non-detected results were found for Cr(VI), the laboratory must follow the required corrective actions listed on Table VI B-1.



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- Laboratories are not required to monitor whether or not matrix spikes are performed on soil/sediment samples at a frequency of one per 20 samples per matrix. This is the responsibility of the data user.
- For “Presumptive Certainty” purposes, if the data user does not submit a soil/sediment sample for MS analysis, Question H of the “MassDEP MCP Analytical Protocol Certification Form” must be answered NO and this must be noted in the laboratory narrative.
- When both Total Chromium and Cr(VI) are to be measured in a solid sample, separate sample containers must be collected for each parameter, such that the integrity of the sample for Cr(VI) is maintained prior to digestion (i.e., sample jar not opened prior to alkaline digestion). Therefore, the analysis of pH and ORP cannot be performed on a sample from the container used for Cr(VI).
- Determinative methods that utilize automated flow injection analysis (FIA) systems manufactured by Lachat, Technicon and OI Corporation, etc. that use diphenylcarbazide as the color development reagent and maintain the ratio of reagent and sample volumes specified by SW-846 Method 7196A to accommodate automation are considered equivalent for the analysis of dissolved hexavalent chromium both in aqueous environmental samples and the alkaline digestate produced by SW-846 Method 3060A. Manufacturer’s instructions should be consulted for a more detailed discussion of potential method-specific interferences and operational issues. The quality control requirements and performance standards described in Table VI B-1 may be applied directly to these methods.
- During sample digestion using SW-846 Method 3060A, the pH must be maintained at pH 7.5 ± 0.5 in order to obtain a valid extract for analysis by WSC-CAM-VI B using SW-846 Method 7196A. Failure to meet the pH specifications of the method requires re-digestion of the samples. See Section 7.7 of SW-846 Method 3060A for further information.
- Oxidizing/Reducing Conditions in Sample Matrix – For compliance with WSC-CAM-VI B, determination of the reducing/oxidizing tendency of each soil type and/or sediment matrix for each analytical batch is required when measuring Cr(VI). This is accomplished by characterization of each sample for the two additional analytical parameters: pH and ORP. It should be noted that the analysis of pH and ORP must be performed upon receipt at the laboratory (within 24 hours of collection) or in the field during sample collection. Analysis of these parameters can establish the tendency of Cr(VI) to exist or not exist in the unspiked sample(s) and assists in the interpretation of QC data for MS recoveries that are outside of the acceptance criteria. Methods for these additional parameters are as follows:
 - pH by SW-846 Method 9045D for preparation of soil/sediment slurry and then analysis via pH probe measurement directly in the soil/sediment slurry, and
 - ORP (Eh) using SW-846 Method 9045D for preparation of soil/sediment slurry and then analysis via Eh (probe) measurement directly in the soil/sediment slurry using ASTM Method D 1498-08.

Evaluation of Eh-pH should be performed as described in Section 8.5 of SW-846 Method 3060A, using the information presented in Appendix VI B-4 (Eh/pH Phase Diagram) of this WSC-CAM-VI B protocol. Additional information on evaluation of Cr(VI) soluble-MS and insoluble-MS recoveries in solid matrices can be found in the *Quality Control Flow Chart* included as Figure 1 in SW-846 Method 3060A.



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Other direct and indirect indicators of reducing/oxidizing tendency that may be useful in characterizing the soil/sediment and in interpretation of MS recovery results that are outside of acceptance limits include:

- Ferrous iron
- Sulfides
- Total Organic Carbon (TOC)
- Chemical Oxygen Demand (COD)
- Biological Oxygen Demand (BOD)

1.7 Analyte List for WSC-CAM-VI B

The MCP analyte list for WSC-CAM-VI B consists of Hexavalent Chromium (also known as Chromium(VI), Cr(VI), or Cr⁺⁶), CASN 18540-29-9, as measured directly in aqueous samples or in alkaline digestates.

It is the responsibility of the data user, in concert with the laboratory, to establish the range and required RL for the target analytes. Sources of various MassDEP standards and criteria are as follows:

- Reportable Quantities (RQs) and Concentrations (RCs) as described in 310 CMR 40.1600, The Massachusetts Oil and Hazardous Materials List (MOHML), in Subpart P of the MCP may be found at the following URL: <https://www.mass.gov/site-cleanup-regulations-policies-forms-more>.
- An online searchable Oil & Hazardous Materials List of RQs and RCs values may be found at the following URL: <https://www.mass.gov/service-details/oil-hazardous-material-list>.
- An updated list of MCP Method 1 Standards may be found at the following URL: <https://www.mass.gov/site-cleanup-regulations-policies-forms-more>.

Cr(VI) has promulgated MCP Method 1 groundwater/soil standards.



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Table VI B-1: Specific QC Requirements and Performance Standards for Hexavalent Chromium using WSC-CAM-VI B

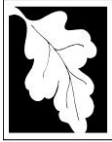
Required QC Parameter	Data Quality Objective	Required Performance Standard	Required Deliverable?	Rejection Criteria per WSC-07-350 ¹	Required Corrective Action	Required Analytical Response Action
Initial Demonstration of Proficiency (IDP)	Laboratory Analytical Accuracy & Precision	(1) Must be performed prior to using method on samples. (2) Must be performed for each matrix. (3) Must follow requirements in Section 1.1.2 of this protocol.	No	NA	Refer to Section 1.1.2 of this protocol.	NA
Preparation of Samples & Additional Measurements	Accuracy and Representativeness	(1) For Hexavalent Chromium, Cr(VI), solid samples must be pretreated/digested prior to analysis. See SW-846 7196A, 3060A, and Section 1.3 of this CAM protocol for appropriate preparation procedures. Note: pH of alkaline digestates of solid samples must be maintained at 7.5 ± 0.5 . Follow requirements in Section 7.7 of SW-846 3060A. (2) Additional measurements of pH and ORP (Eh) are required for soil/sediment samples. See Section 1.6 of this CAM protocol for further details.	No	NA	NA	NA
Initial Calibration	Laboratory Analytical Accuracy	(1) Frequency: Daily prior to sample analysis, when daily calibration QC samples (LLCV, CCV, CCB) are not in control, or when major instrument maintenance is performed. (2) Initial Calibration: minimum of a calibration blank plus five calibration standards. (3) Low-level standard in calibration must be at or below the RL. High level standard in calibration defines the upper end of the linear calibration range. (4) Linear regression with correlation coefficient $r \geq 0.995$.	No	NA	Perform instrument maintenance as necessary; recalibrate as required by method.	Suspend all analyses until initial calibration meets criteria.
Initial Calibration Verification (ICV)	Laboratory Analytical Accuracy	(1) Frequency: Immediately after each initial calibration. (2) Prepared using standard source different than used for initial calibration: undigested. (3) Concentration level near mid-point of curve. (4) Percent recovery must be 85-115%.	No	NA	(1) Reanalyze ICV; if acceptable, no further action required. (2) If reanalysis is still outside of criteria, recalibrate and reanalyze ICV.	Suspend all analyses until ICV meets criteria.



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Table VI B-1: Specific QC Requirements and Performance Standards for Hexavalent Chromium using WSC-CAM-VI B

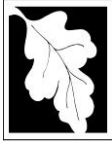
Required QC Parameter	Data Quality Objective	Required Performance Standard	Required Deliverable?	Rejection Criteria per WSC-07-350 ¹	Required Corrective Action	Required Analytical Response Action
Initial Calibration Blank (ICB)	Laboratory Analytical Sensitivity (instrument drift & contamination)	(1) Frequency: Immediately after ICV. (2) Undigested. (3) Cr(VI) must be <RL.	No	NA	(1) Reanalyze ICB; if acceptable, no further action required. (2) If reanalysis is still outside of criteria, recalibrate and reanalyze ICV & ICB.	Suspend all analyses until ICB meets criteria.
Low-Level Calibration Verification (LLCV)	Laboratory Analytical Sensitivity (verify low-end of calibration range / verify RL)	(1) Frequency: Daily prior to sample analysis if initial calibration is not performed on same day as sample analysis. If initial calibration is performed on same day as sample analysis and includes the RL as the low-level standard in the initial calibration curve (as required by calibration), then LLCV is not required. (2) Prepared using same source as initial calibration standards: undigested. (3) Concentration level must be at the level of the RL for Cr(VI). (4) Percent recovery must be 70-130%.	No	NA	(1) Reanalyze LLCV; if acceptable, no further action required. (2) If reanalysis is still outside of criteria and concentrations of Cr(VI) are ≤10x RL in associated field samples, recalibrate and reanalyze LLCV and associated samples. (3) If concentrations of Cr(VI) are >10x RL in associated field samples, include explanation in laboratory narrative; no further action required.	Suspend all analyses until LLCV meets criteria unless the concentrations of Cr(VI) are >10x RL in the associated field samples.
Continuing Calibration Verification (CCV)	Laboratory Analytical Accuracy	(1) Frequency - Every 20 field samples and at the end of the analytical run. (2) Prepared using same source as initial calibration standards: undigested. (3) Concentration level near midpoint of curve. (4) Percent recovery must be 85-115%.	No	NA	(1) Reanalyze CCV; if acceptable, no further action required. (2) If reanalysis is still outside of criteria, recalibrate and reanalyze all associated samples since last compliant CCV – unless (3) applies. (3) If recovery is high (>115%) and all associated sample results are non-detected, no corrective action required.	If (3) applies, include explanation in laboratory narrative.
Continuing Calibration Blank (CCB)	Laboratory Analytical Sensitivity (instrument drift & contamination)	(1) Frequency - Every 20 field samples following CCV and at the end of the analytical run.	No	NA	(1) Reanalyze CCB; if acceptable, no further action required.	If (3) applies, include explanation in laboratory narrative.



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Table VI B-1: Specific QC Requirements and Performance Standards for Hexavalent Chromium using WSC-CAM-VI B

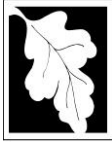
Required QC Parameter	Data Quality Objective	Required Performance Standard	Required Deliverable?	Rejection Criteria per WSC-07-350 ¹	Required Corrective Action	Required Analytical Response Action
		(2) Un-digested. (3) Cr(VI) must be <RL.			(2) If reanalysis is still outside of criteria, recalibrate and reanalyze all associated samples since last compliant CCB – unless (3) applies. (3) If concentration of Cr(VI) in CCB is >RL but all associated sample results are either non-detected or >10x concentration of Cr(VI) in CCB level, no corrective action required.	
Method Blank (MB)	Laboratory Method Sensitivity (contamination evaluation)	(1) Frequency - One per analytical or digestion batch of ≤20 field samples. (2) Must be prepared/digested with the samples using the same preparation method as the samples. (3) Cr(VI) must be <RL.	Yes	NA	(1) Reanalyze MB; if acceptable, no further action required. (2) If reanalysis is still outside of criteria, redigest and reanalyze MB and all associated field samples in batch – unless (3) applies. (3) If concentration of Cr(VI) in MB is >RL but all associated sample results are either non-detected or >10x concentration of Cr(VI) in MB, no corrective action required	If (3) applies, include explanation in laboratory narrative.
Laboratory Control Sample (LCS)	Laboratory Analytical Accuracy	(1) Frequency – One per analytical or digestion batch of ≤20 field samples. (2) Must be matrix-matched by digesting with the samples using the same preparation method. CAM requires a Standard Reference Material (SRM) be prepared and analyzed with solid field samples as the “solid LCS.” An SRM is a soil or sediment matrix that contains hexavalent chromium at a known concentration and with 95% confidence limits. (3) Concentration level for aqueous LCS near	Yes	Aqueous LCS: Recovery <50%: Cr(VI) results in associated samples may be rejected.	(1) Reanalyze LCS; if acceptable, no further action required. (2) If reanalysis is still outside of criteria and LCSD is in-control for Cr(VI), no corrective action required. (3) If LCS and LCSD are both outside of criteria, re-digest and reanalyze LCS/LCSD and all associated field samples in	Report recovery exceedances in laboratory narrative.



Quality Control Requirements and Performance Standards for the ***Analysis of Hexavalent Chromium, Cr(VI), by UV-Visible Spectrophotometry***, in Support of Response Actions under the Massachusetts Contingency Plan (MCP)

Table VI B-1: Specific QC Requirements and Performance Standards for Hexavalent Chromium using WSC-CAM-VI B

Required QC Parameter	Data Quality Objective	Required Performance Standard	Required Deliverable?	Rejection Criteria per WSC-07-350 ¹	Required Corrective Action	Required Analytical Response Action
		<p>mid-point of curve.</p> <p>(4) Percent recovery for Cr(VI) must be 80-120% for aqueous LCS and within vendor control limits (95% confidence limits) for solid LCS.</p>			batch.	
LCS Duplicate (LCSD)	Laboratory Analytical Accuracy & Precision	<p>(1) Frequency: One per analytical or digestion batch of ≤20 field samples ONLY if not performing project-specific MD.</p> <p>(2) Must be matrix-matched by digesting with the samples using the same preparation method. CAM requires a solid SRM be prepared and analyzed with solid field samples as the "solid LCSD." An SRM is a soil or sediment matrix that contains hexavalent chromium at a known concentration and with 95% confidence limits.</p> <p>(3) Concentration level must be same as LCS. Analyze immediately following LCS.</p> <p>(4) Percent recovery for Cr(VI) must be 80-120% for aqueous LCS and within vendor control limits (95% confidence limits) for solid LCS.</p> <p>(5) RPDs must be ≤20 for aqueous LCS/LCSD and ≤30 for solid LCS/LCSD.</p>	Yes	Same as above for LCS for recovery evaluation.	<p>(1) Reanalyze LCSD; if acceptable, no further action required.</p> <p>(2) If reanalysis is still outside of recovery criteria for Cr(VI) and LCS is in-control for Cr(VI), no corrective action required.</p> <p>(3) If LCSD and LCS are both outside of recovery criteria, re-digest and reanalyze LCS/LCSD and all associated field samples in batch.</p>	Report recovery and RPD exceedances in laboratory narrative.
Matrix Spike (MS) <i>Aqueous Samples Only</i> Project-Specific	Method Accuracy in Sample Matrix	<p>(1) Frequency: One per digestion batch of ≤20 field samples per matrix is strongly recommended (designated by data user on COC or at project set-up).</p> <p>(2) Concentration level near mid-point of curve.</p> <p>(3) Percent recovery must be 75-125%.</p>	Yes ONLY when requested by the data user	Recovery <30%: affects non-detects for Cr(VI) in all associated samples.	<p>(1) Reanalyze MS; if acceptable, no further action required.</p> <p>(2) After reanalysis, if MS recovery is 30-74% or >125% and LCS was in control, no corrective action is required.</p> <p>(3) If MS recovery is <30% and associated with non-detected results, re-digest (homogenize sample well) and reanalyze sample/MS pair. Report results and narrate.</p>	<p>Report MS exceedances in laboratory narrative</p> <p>If redigested due to recoveries <30%, report both sets of sample/MS data.</p>



Quality Control Requirements and Performance Standards for the **Analysis of Hexavalent Chromium, Cr(VI), by UV-Visible Spectrophotometry**, in Support of Response Actions under the Massachusetts Contingency Plan (MCP)

Table VI B-1: Specific QC Requirements and Performance Standards for Hexavalent Chromium using WSC-CAM-VI B

Required QC Parameter	Data Quality Objective	Required Performance Standard	Required Deliverable?	Rejection Criteria per WSC-07-350 ¹	Required Corrective Action	Required Analytical Response Action
Matrix Duplicate (MD) Project-Specific	Method Precision in Sample Matrix	(1) Frequency: One per digestion batch of ≤20 field samples per matrix is strongly recommended (designated by data user on COC or at project set-up). (2) Prepare by digesting and analyzing an additional aliquot of the same field sample used for MS. (3) RPD for Cr(VI) must be ≤20 for aqueous and ≤35 for solids.	Yes ONLY when requested by the data user	NA	Narrate.	Report exceedances in laboratory narrative.
Soluble Matrix Spike (MS) <i>Solid Samples Only</i> Project-Specific	Method Accuracy in Sample Matrix	(1) Frequency - One per 20 field samples per matrix; designated by data user on COC or at project set-up. (2) Soluble spike = Potassium Chromate (K ₂ Cr ₂ O ₇). (3) Percent recovery of Cr(VI) must be 75-125%.	Yes ONLY when requested by the data user	Recovery <30%; affects non-detects for Cr(VI) in all associated samples. Exception: Low recovery of Cr(VI) in soil/sediment may be acceptable if supported by pH and ORP data that demonstrate reducing conditions.	Evaluate LCS. If LCS within acceptance limits, evaluate pH/Eh of sample using figure in Appendix VI B-4. Alternatively, perform mass balance as per Section 8.5.2 of SW-846 3060A. If reducing conditions exist, no further action required. If reducing conditions do not exist: (1) Reanalyze MS; if acceptable, no further action required. (2) After reanalysis, if MS recovery is 30-74% or >125% and LCS was in control, no corrective action is required. (3) If MS recovery is <30% and associated with non-detected results, re-digest (homogenize sample well) and reanalyze sample/MS pair. Report results and narrate.	Report MS exceedances in laboratory narrative and note oxidation/reduction characteristics of sample. If redigested due to recoveries <30%, report both sets of sample/MS data.
Insoluble Matrix Spike (MS) <i>Solid Samples Only</i> Project-Specific	Method Accuracy in Sample Matrix	(1) Frequency - One per 20 field samples per matrix; designated by data user on COC or at project set-up. (2) Insoluble spike = Lead Chromate (PbCrO ₄).	Yes ONLY when requested by the data user	Recovery <30%; affects non-detects for Cr(VI) in	Evaluate LCS. If LCS within acceptance limits, evaluate pH/Eh of sample using figure in Appendix VI B-4.	Report MS exceedances in laboratory narrative and note oxidation/reduction



Quality Control Requirements and Performance Standards for the **Analysis of Hexavalent Chromium, Cr(VI), by UV-Visible Spectrophotometry**, in Support of Response Actions under the Massachusetts Contingency Plan (MCP)

Table VI B-1: Specific QC Requirements and Performance Standards for Hexavalent Chromium using WSC-CAM-VI B

Required QC Parameter	Data Quality Objective	Required Performance Standard	Required Deliverable?	Rejection Criteria per WSC-07-350 ¹	Required Corrective Action	Required Analytical Response Action
		(3) Percent recovery of Cr(VI) must be 75- 125%.		all associated samples. Exception: Low recovery of Cr(VI) in soil/sediment may be acceptable if supported by pH and ORP data that demonstrate reducing conditions.	Alternatively, perform mass balance as per Section 8.5.2 of SW-846 3060A. If reducing conditions exist, no further action required. If reducing conditions do not exist: (1) Reanalyze MS; if acceptable, no further action required. (2) After reanalysis, if MS recovery is 30-74% or >125% and LCS was in control, no corrective action is required. (3) If MS recovery is <30% and associated with non-detected results, re-digest (homogenize sample well) and reanalyze sample/MS pair. Report results and narrate.	characteristics of sample. If redigested due to recoveries <30%, report both sets of sample/MS data.
General Reporting Issues	NA	(1) Measurements of ORP (as Eh) and pH must be performed and reported for each solid matrix type. (2) Non-detected values must be reported with the sample-specific RL for Cr(VI) using all appropriate preparation/dilution factors. (3) The laboratory must only report values \geq the sample-specific RL. (4) Sample concentrations that exceed the highest calibration standard must be diluted and reanalyzed to fall within the linear calibration range. (5) Results for soils/sediments must be reported on a dry-weight basis for comparison to MCP regulatory standards. (6) Results must be reported with 2 or more	NA	NA	NA	(1) The performance of dilutions must be documented in the laboratory narrative or on the report form. Unless due to elevated concentrations of Cr(VI), reasons for dilutions must be explained in the laboratory narrative. (2) If samples are not preserved properly or are not received with an acceptable cooler temperature, note the non-conformances in the laboratory narrative. (3) If samples are



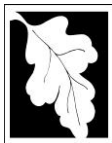
Quality Control Requirements and Performance Standards for the ***Analysis of Hexavalent Chromium, Cr(VI), by UV-Visible Spectrophotometry***, in Support of Response Actions under the Massachusetts Contingency Plan (MCP)

Table VI B-1: Specific QC Requirements and Performance Standards for Hexavalent Chromium using WSC-CAM-VI B

Required QC Parameter	Data Quality Objective	Required Performance Standard	Required Deliverable?	Rejection Criteria per WSC-07-350 ¹	Required Corrective Action	Required Analytical Response Action
		<p>“significant figures” if \geq RL. If reporting values below the RL, report with 1 or more “significant figures”.²</p> <p>(7) Refer to Appendix VI B-1 for chain-of-custody requirements regarding preservation, cooler temperature, and holding times.</p>				<p>digested and/or analyzed outside of the holding time, note the non-conformances in the laboratory narrative.</p> <p>(4) Narrate any additional method non-compliance or sample-specific anomaly.</p>

¹As per Appendix IV of MassDEP Policy #WSC-07-350, *MCP Representativeness Evaluations and Data Usability Assessments*, September 2007, if these results are observed, data users should consider nondetect results as unusable and detected results as estimated with a significant low bias.

²Reporting protocol for “significant figures” is a policy decision included for standardization and consistency for reporting of results and is not a definition of “significant” in the scientific or mathematical sense.



Quality Control Requirements and Performance Standards for the ***Analysis of Hexavalent Chromium, Cr(VI), by UV-Visible Spectrophotometry***, in Support of Response Actions under the Massachusetts Contingency Plan (MCP)

2.0 Data Usability Assessment

Specific guidance applicable to all Class A, B or C RAO Statements, including partial RAOs, for preparation of Representativeness Evaluations and Data Usability Assessments pursuant to 310 CMR 40.1056(2)(k) of the MCP is provided in *MCP Representativeness Evaluations and Data Usability Assessments* (Policy #WSC-07-350). This document provides general information regarding the purpose and content of these required evaluations as a component of and in support of an RAO submittal. The most current version of this document may be found at the following URL: <https://www.mass.gov/site-cleanup-regulations-policies-forms-more>.

Overall usability of data produced using this CAM protocol should be evaluated for compliance with project-specific data objectives using MassDEP Policy #WSC-07-350, regardless of “Presumptive Certainty” status.

3.0 Reporting Requirements for WSC-CAM-VI B

3.1 General Reporting Requirements for WSC-CAM-VI B

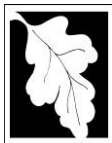
General environmental laboratory reporting requirements for analytical data used in support of assessment and evaluation decisions at MCP disposal sites are presented in WSC-CAM-VII A, Section 2.4. This guidance document provides limited recommendations for field QC, as well as the required content of the laboratory report, which includes:

- Laboratory identification information,
- Analytical results and supporting information,
- Sample- and batch-specific QC information,
- Laboratory Report Certification Statement,
- Copy of the Analytical Protocol Certification Form,
- Laboratory narrative contents, and
- Chain-of-custody form requirements.

3.2 Specific Reporting Requirements for WSC-CAM-VI B

Specific QC requirements and performance standards for WSC-CAM-VI B are presented in Table VI B-1. Specific reporting requirements for WSC-CAM-VI B are summarized below in Table VI B-2 as “Required Analytical Deliverables (**YES**)”. These routine reporting requirements must always be included as part of the laboratory deliverable for this method. It should be noted that although certain items are not specified as “Required Analytical Deliverables (**NO**)”, these data must be available for review during an audit and may also be requested on a client-specific basis.

Soil and sediment results must be reported on a dry-weight basis. Refer to ASTM Method D2216, Determination of Moisture Content of Soils and Sediments, for more detailed analytical and equipment specifications.



Quality Control Requirements and Performance Standards for the **Analysis of Hexavalent Chromium, Cr(VI), by UV-Visible Spectrophotometry**, in Support of Response Actions under the Massachusetts Contingency Plan (MCP)

Table VI B-2 Routine Reporting Requirements for WSC-CAM-VI B (SW-846 7196A)

Parameter	Required Analytical Deliverable
Initial Calibration	NO
Initial Calibration Verification (ICV)	NO
Initial Calibration Blank (ICB)	NO
Low-Level Calibration Verification (LLCV)	NO
Continuing Calibration Verification (CCV)	NO
Continuing Calibration Blank (CCB)	NO
Method Blank (MB)	YES
Laboratory Control Sample (LCS)	YES
LCS Duplicate	YES
Matrix Spike Sample (MS) - Aqueous	YES <i>(if requested by data user)</i>
Matrix Duplicate (MD) - Aqueous or Solid	YES <i>(if requested by data user)</i>
Soluble Matrix Spike (MS) - Solid	YES <i>(if requested by data user)</i>
Insoluble Matrix Spike (MS) - Solid	YES <i>(if requested by data user)</i>
pH and ORP (Eh) – Solid (for each soil type and/or sediment matrix for each analytical batch)	YES
Identification and Quantitation	NO
General Reporting Issues	YES

3.2.2 Sample Dilution

Under circumstances that sample dilution is required because the concentration of Cr(VI) exceeds the concentration of the highest calibration standard or due to matrix interference, the RL for Cr(VI) must be adjusted (increased) in direct proportion to the Dilution Factor (DF).

The revised RL for the diluted sample, RL_d :

$$RL_d = DF \times \text{Lowest Calibration Standard for Cr(VI)}$$

It should be understood that samples with elevated RLs as a result of a dilution may not be able to satisfy MCP standards/criteria in some cases if the RL_d is greater than the applicable MCP standard or



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criterion to which the concentration is being compared. All dilutions must be fully documented in the laboratory narrative.



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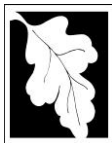
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Appendix VI B-1

Sample Collection, Preservation, and Handling Procedures for Hexavalent Chromium Analyses

Sample preservation, container and analytical holding time specifications for aqueous, soil, and sediment matrices for Hexavalent Chromium (Cr(VI)) conducted in support of MCP decision-making are summarized below and presented in Appendix VII-A of WSC-CAM-VII A, Quality Assurance and Quality Control Guidelines for Sampling, Data Evaluation, and Reporting Activities for the Massachusetts Contingency Plan (MCP). Additional guidance may be found in SW-846, Chapter Three.



Quality Control Requirements and Performance Standards for the **Analysis of Hexavalent Chromium, Cr(VI), by UV-Visible Spectrophotometry**, in Support of Response Actions under the Massachusetts Contingency Plan (MCP)

Matrix	Container ¹	Preservation ⁵	Holding Time ²
Concentrated Waste	125 mL wide-mouth glass or polyethylene bottle	Cool to ≤ 6°C but not frozen	Extract within 30 days of collection. Analyze within 7 days after extraction. Store at 4°C until analyzed.
Aqueous Cr(VI)	500 mL glass or polyethylene bottle	Cool to ≤ 6°C but not frozen	24 hours
Dissolved/Filtered Cr(VI)	500 mL glass or polyethylene bottle	Filter (0.45 µm) on site or at the laboratory within 24 hours of collection, prior to analysis. Cool to ≤ 6°C but not frozen.	24 hours
Soil/Sediment Cr(VI)	(1) 4-ounce glass jar with teflon-lined cap ³	Samples should be collected with non-metallic devices and stored field-moist at ≤ 6°C but not frozen.	30 days to digestion; 7 days from digestion to analysis ⁴ . Store samples and alkaline digestates at 4 ± 2°C until analyzed.
Soil/Sediment pH and ORP (Eh)	(1) 4-ounce glass jar with teflon-lined cap	Cool to ≤ 6°C but not frozen	24 hours

¹The collection of multiple sample containers per sample location may be required to collect enough sample for matrix QC.

²Holding time begins from time of sample collection. As per Appendix IV of MassDEP Policy #WSC-07-350, *MCP Representativeness Evaluations and Data Usability Assessments*, September 2007, if the holding time is exceeded by >2x, data users should consider non-detect results as unusable and detected results as estimated (low bias).

³If both Total Chromium and Cr(VI) are to be measured in a solid sample, separate sample jars must be collected for each analysis, such that the Cr(VI) sample container remains unopened until alkaline digestion commences.

⁴Soil/Sediment holding time as listed in SW-846 Method 3060A (December 1996).

⁵If samples were received by the laboratory on the same day of collection and were stored and transported to the laboratory on ice, cooler temperatures above 6°C are acceptable.



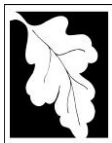
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Appendix VI B-2

Data Deliverable Requirements for Data Audits



Quality Control Requirements and Performance Standards for the **Analysis of Hexavalent Chromium, Cr(VI), by UV-Visible Spectrophotometry**, in Support of Response Actions under the Massachusetts Contingency Plan (MCP)

If requested by MassDEP, submission of the information listed below may be required to perform a data audit to verify compliance with the analytical methods and to evaluate accuracy and reliability of the reported results. These deliverables represent a “full data package” including all sample documentation from receipt through preparation, analysis, and data reporting. The laboratory must ensure that these deliverables are available, in the event a data audit is performed. The laboratory is required to retain these deliverables for a period of 10 years from the date generated.

DELIVERABLE REQUIREMENTS FOR DATA AUDITS WSC-CAM-VI B (Hexavalent Chromium (Cr(VI): SW-846 7196A)	
Laboratory Narrative	Must comply with the required laboratory narrative contents as described in WSC-CAM-VII A
Sample Handling Information	Chain-of-custody (external and internal), sample receipt logs (cooler temperatures and sample pH), correspondences
Miscellaneous Logs	Dry weight logs; Analytical logs; Refrigerator logs
Initial Calibration Data	Raw instrument data for initial calibration, including calculation of linear or non-linear regression and correlation coefficient values; Concentrations of calibration standards used
Initial Calibration Verification and Initial Calibration Blank Data	Percent recoveries for all ICVs; ICV source & true value; Results and raw instrument data for ICV and ICB
Low-Level Calibration Verification, Continuing Calibration Verification, and Continuing Calibration Blank Data	Percent recoveries for all LLCV and CCV; LLCV and CCV source & true value; Results and raw instrument data for LLCV, CCV, and CCB
Sample Results for Cr(VI) for all samples and for pH and ORP (Eh) for solid samples	Sample result forms with dilution factors, units, reporting limits, method reference, date of preparation, date of analysis; Raw instrument data; Percent solids results; Sample preparation/distillation logs (initial and final weights/volumes; preparation method reference)
Method Blank Results	Method Blank results, units, reporting limits; Raw instrument data; Preparation logs
LCS/LCS Duplicate Results and/or SRM results	Summary of results, including concentrations detected, concentrations spiked or known (vendor limits) if SRM, percent recoveries and RPDs; Raw instrument data; Preparation logs
MS Results – if analyzed: Soluble and Insoluble MS for solid samples MD Results – if analyzed	Summary of results, project-specific sample ID, unspiked sample concentration, concentration detected, concentration spiked, percent recoveries and RPDs; Raw instrument data; Preparation logs
Soil/Sediment: pH of digestate during alkaline digestion (SW-846 Method 3060A)	pH documentation of digestate during alkaline digestion for all soil/sediment samples



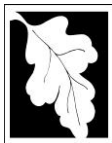
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Appendix VI B-3

Analysis Sequence for Hexavalent Chromium by WSC-CAM-VI B

Typical analytical sequence for Hexavalent Chromium (Cr(VI)) using WSC-CAM-VI B:

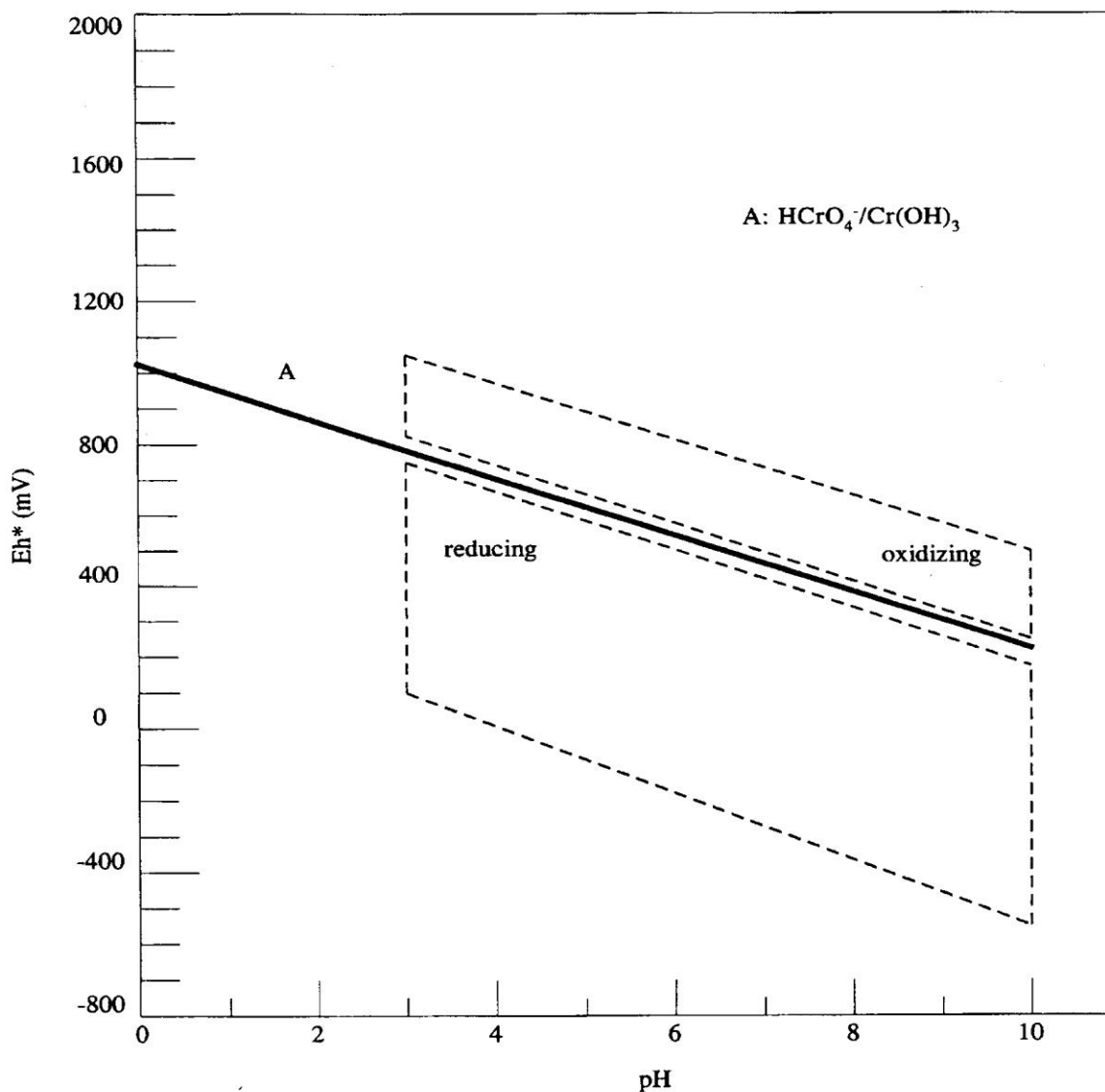
- Initial Calibration
- ICV
- ICB
- LLCV – only required if initial calibration curve not performed on same day as analysis or performed on the same day but does not have a low-level standard at the level of the RL
- MB
- LCS
- LCSD – only required if not performing a project-specific MD
- 17 samples – include the project-specific MS and/or MD, if applicable
- CCV
- CCB
- 20 samples
- CCV
- CCB
- Etc. (continue 20 samples and CCV/CCB pairs)
- CCV – ending
- CCB – ending



Quality Control Requirements and Performance Standards for the **Analysis of Hexavalent Chromium, Cr(VI), by UV-Visible Spectrophotometry**, in Support of Response Actions under the Massachusetts Contingency Plan (MCP)

Appendix VI B-4

Eh/pH Phase Diagram



* Note the Eh values plotted on this diagram are corrected for the reference electrode voltage: 244 mV units must be added to the measured value when a separate calomel electrode is used, or 199 mV units must be added if a combination platinum electrode is used.