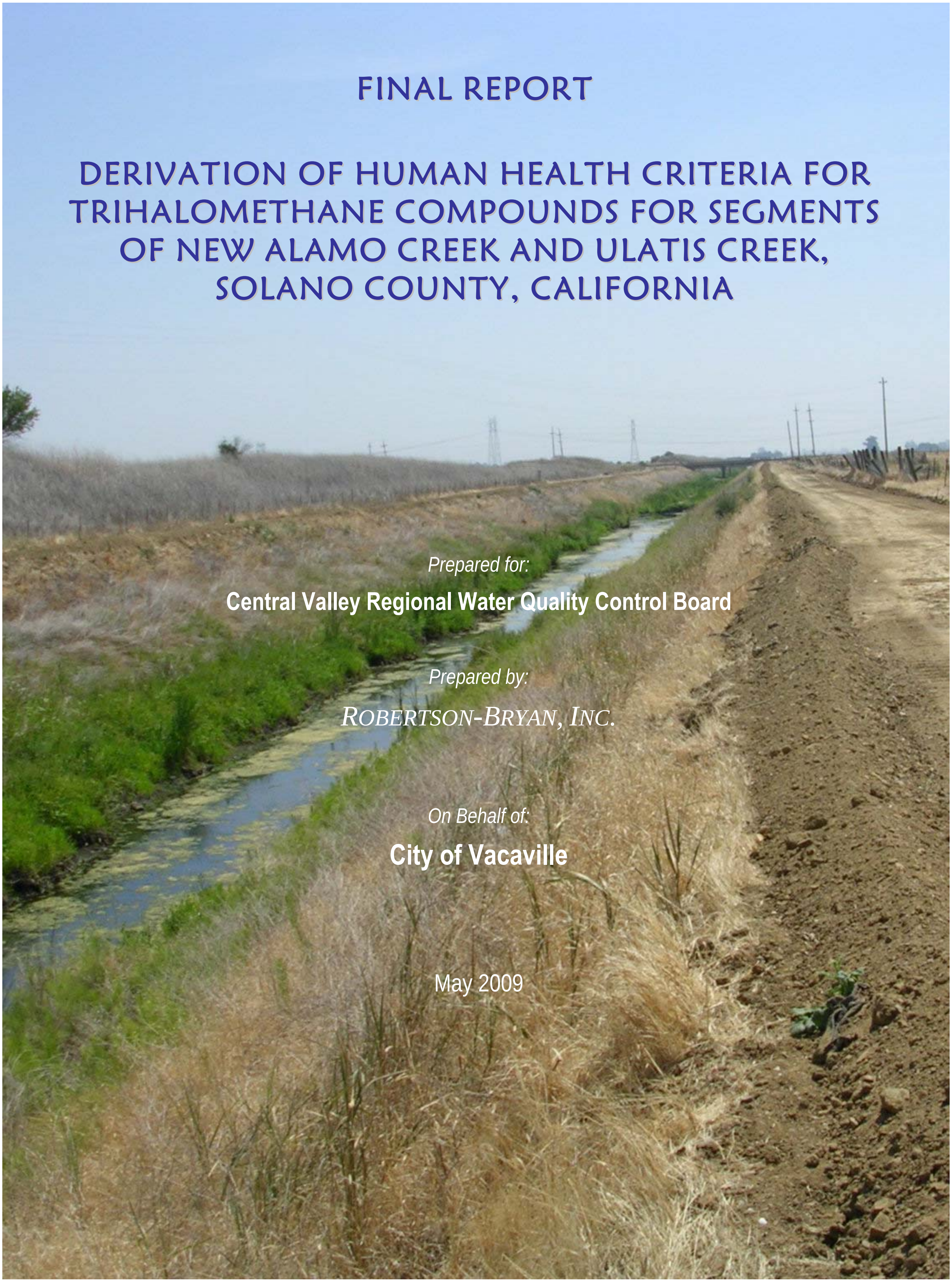

# FINAL REPORT

# DERIVATION OF HUMAN HEALTH CRITERIA FOR TRIHALOMETHANE COMPOUNDS FOR SEGMENTS OF NEW ALAMO CREEK AND ULATIS CREEK, SOLANO COUNTY, CALIFORNIA

*Prepared for:*

**Central Valley Regional Water Quality Control Board**

*Prepared by:*

*ROBERTSON-BRYAN, INC.*

*On Behalf of:*

**City of Vacaville**

May 2009

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# DERIVATION OF HUMAN HEALTH CRITERIA FOR TRIHALOMETHANE COMPOUNDS FOR SEGMENTS OF NEW ALAMO CREEK AND ULATIS CREEK, SOLANO COUNTY, CALIFORNIA

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May 2009

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# APPENDICES

# List of Acronyms and Abbreviations

| | |
|---|---|
| µg/L | micrograms per liter |
| AAEL | average annual effluent limitation |
| AMEL | average monthly effluent limitation |
| Basin Plan | water quality control plan |
| BOD | biochemical oxygen demand |
| BPTC | best practical treatment or control |
| CCR | California Code of Regulations |
| CFR | Code of Federal Regulations |
| City | City of Vacaville |
| COLD | cold freshwater habitat |
| CTR | California Toxics Rule |
| DBCM | dibromochloromethane |
| DCBM | dichlorobromomethane |
| Delta | Sacramento-San Joaquin Delta |
| DHS | Department of Health Services |
| DPH | Department of Public Health |
| D/DBPR | Disinfectant and Disinfection Byproducts Rules |
| ECA | effluent credit allowance |
| kg | kilograms |
| L | liters |
| MCL | maximum contaminant level |
| MEC | maximum effluent concentration |
| MDEL | maximum daily effluent limitation |
| MIGR | migration of aquatic organisms |
| mL | milliliter |
| MUN | municipal and domestic supply |
| NRWQC | national recommended water quality criteria |
| Regional Water Board | Regional Water Quality Control Board |
| ROS | regression on order statistics |
| SIP | Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California |
| SPWN | spawning, reproduction, and/or early development |
| State Water Board | State Water Resources Control Board |
| THM | trihalomethane |
| TSD | Technical Support Document |
| TSS | total suspended solids |
| UAA | use attainability analysis |
| U.S. EPA | United States Environmental Protection Agency |
| VPS | Vallejo Pump Station |
| WWTP | wastewater treatment plant |

# EXECUTIVE SUMMARY

## Background

The City of Vacaville (City) owns and operates the Easterly Wastewater Treatment Plant (Easterly WWTP), which provides service to the City and the unincorporated area of Elmira. Treated municipal wastewater is discharged directly into Old Alamo Creek, a tributary to New Alamo Creek, which is tributary to Ulatis Creek, which is tributary to Cache Slough. Cache Slough and the lower reach of Ulatis Creek are within the statutory boundary of the Sacramento-San Joaquin River Delta (Delta) (**Figure ES-1**).

The United States Environmental Protection Agency's (U.S. EPA) final approval of the dedesignations of the MUN, COLD, MIGR, and SPWN uses for Old Alamo Creek on August 7, 2006 resolved key Easterly WWTP compliance issues associated with discharges into Old Alamo Creek. This action was directed by State Water Resources Control Board (State Water Board) Order WQO 2002-0015, associated with the City's appeal of its 2001 NPDES permit. However, State Water Board Order WQO 2002-0015 did not specifically provide direction with respect to the designated beneficial uses of receiving waters downstream of Old Alamo Creek (Figure 1, orange highlighted reaches), perhaps because such receiving waters did not directly drive the receiving water and effluent limitations in the appealed NPDES permit. Nevertheless, promptly following issuance of the State Water Board Order, the City called to Regional Water Quality Control Board (Regional Water Board) staff's attention that limiting the water quality standards refinement actions to Old Alamo Creek would not fully resolve the current regulatory issues associated with the MUN beneficial use – including compliance problems associated with meeting promulgated water quality criteria for dibromochloromethane (DBCM) (also commonly referred to as chlorodibromomethane), dichlorobromomethane (DCBM) (also commonly referred to as bromodichloromethane), and chloroform. These compounds are members of a group of four compounds commonly referred to as "trihalomethanes" (THMs), the fourth member being bromoform. Subsequently, in January 2004 the Regional Water Board and the City entered into Agreement No. 03-910-150-0, "City of Vacaville Site-Specific Basin Plan Amendments for Old Alamo Creek and New Alamo Creek, Ulatis Creek and Cache Slough," for the purpose of evaluating water quality standards in regard to beneficial uses and water quality objectives. Agreement No. 03-910-150-0 expired prior to project completion and was renewed July 2008 by Agreement No. 08-900-150-0.

This expanded MUN standards refinement effort was required because Old Alamo Creek, being disconnected from its watershed, largely acts as an open conveyance channel of minimally diluted Easterly WWTP effluent that is then discharged into New Alamo Creek at the confluence of these two water bodies. Existing data showed at the time that MUN-related NPDES permit limitations, including for the THMs, and applicable criteria, would not be met within the lower

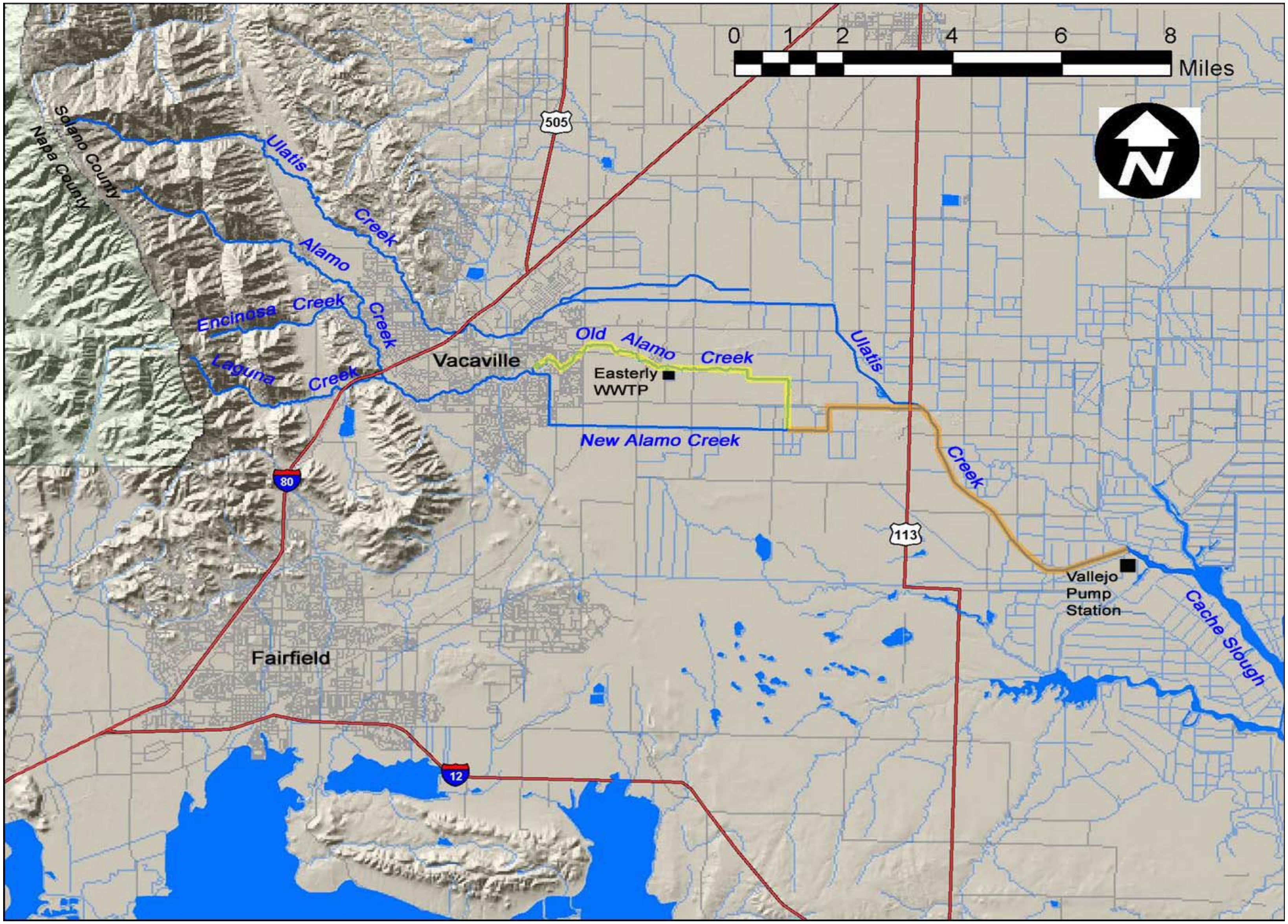


**Figure ES-1. Geographic location of the City of Vacaville's Easterly Wastewater Treatment Plant and receiving waters.**

reaches of New Alamo and Ulatis creeks. Consequently, following the Old Alamo Creek use dedesignations becoming effective, the MUN-related permitting issues resulting in compliance problems for the City's Easterly WWTP simply moved from the point of discharge into Old Alamo Creek (immediately adjacent to the plant outfall) to the confluence of Old Alamo Creek and New Alamo Creek, about 3.2 miles downstream of the outfall. The expanded MUN standards refinement effort has culminated in the findings and recommendations contained in this report.

The City conducted a Use Attainability Analysis (UAA) for the lower portions of New Alamo Creek and Ulatis Creek to determine whether the MUN beneficial use designation for the lower segments of these water bodies is appropriate. The UAA presented substantial information indicating that MUN is neither an existing nor an attainable use in these water body segments, and that no form of MUN use is reasonably expected to occur in the future in these water body segments based on system hydrologic and water quality characteristics, as well as the availability of higher quality water sources in the area (RBI 2007). Prior to the UAA report (RBI 2007) being finalized, this finding was supported by Ms. Leah Walker of the California Department of Public Health (DPH, formerly Department of Health Services (DHS)), who, when attending the Regional Water Board's California Environmental Quality Act public scoping meeting for this standards refinement project on June 28, 2007, stated that the DPH supports the dedesignation of MUN from the UAA study segments.

Regional Board staff agree that municipal uses are not existing and likely not attainable because of the existing hydrologic conditions and water quality characteristics. However, staff believe that it is important to maintain the MUN designation in order to maintain water quality in the lower New Alamo Creek and Ulatis Creek segments at a level sufficient to protect potential future transient and incidental use of water in the creeks for drinking water, should such a use occur. Therefore, site specific THM objectives would be appropriate for this potential limited use as a means of:

1) achieving a goal-level of human health protection for these segments with regard to THM levels, as specified by the State and Regional Water Board and U.S. EPA staff,
2) reasonably and cost-effectively resolving the significant THM regulatory compliance issue faced by the City in operating its Easterly WWTP, and
3) maintaining current levels of MUN protection for THMs within Cache Slough and downstream Delta waters.

This report provides the technical basis for developing and justifying site-specific DBCM, DCBM, and chloroform objectives for the protection of human health associated with the consumption of water and organisms from the lower reaches of New Alamo Creek and Ulatis Creek. These site-specific objectives will be submitted for adoption and approval through the State's Basin Plan amendment process and amendment to the California Toxics Rule (CTR) through U.S. EPA's regulatory process.[1] This report will serve as a technical reference to the Regional Water Board's Staff Report that proposes the site-specific objectives. The site-specific objectives will apply to New Alamo Creek from Old Alamo Creek to Ulatis Creek, and to Ulatis Creek from New Alamo Creek to Cache Slough (see Figure ES-1**,** orange highlighted segments). This report also describes key implementation and permitting considerations associated with the site-specific objectives.

**Alternative Site-specific Objectives and Implementation Approaches**

Alternative site-specific objectives for DBCM, DCBM, and chloroform applicable to New Alamo Creek and Ulatis Creek were derived based on acceptable cancer risk levels and site-specific considerations. **Table ES-1** summarizes the alternative site-specific objectives derived for the segments, and approaches for assessing compliance with each of the alternative set of objectives, should they be adopted and approved through the basin planning process.

Under implementation of either Alternative 1 or 3 objectives, the reasonable potential to cause an excursion of the site-specific objectives would be determined from the most recent three years of data available for New Alamo Creek at Brown-Alamo Dam, the initial accessible location at which Old Alamo Creek water is completely mixed with New Alamo Creek water, which is approximately 0.6 miles downstream of the terminus of Old Alamo Creek. An effluent limitation for regulated discharges contributing THMs to the segments would be required if the maximum concentration at Brown-Alamo Dam in the most recent three years of data is greater than the corresponding site-specific objective, and the discharge can be shown to cause or substantially contribute to that exceedance. Should effluent limitations be required for the Easterly WWTP, or any other future regulated discharge into Old Alamo Creek, the limitations would fully account for the attenuation of the DBCM, DCBM, and chloroform concentrations (due to both volatilization and dilution) between the point of discharge in Old Alamo Creek and the segment reaches to which the site-specific objectives apply. An attenuation factor would be calculated as the median of the individual attenuation factors determined from representative historical data. The effluent limitations would consist of an average monthly effluent limitation (AMEL) and a maximum daily effluent limitation (MDEL), consistent with the *Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California* (commonly referred to as the SIP) (SWRCB 2005). However, because the objectives are to protect human health from long-term (i.e., lifetime) exposure, effluent limitations for somewhat longer time frames such as average annual effluent limitation (AAEL) also would be appropriate and, therefore, are derived and discussed in this report.

[1] "Site-specific criteria, variances and other actions modifying criteria are neither prohibited nor limited by the CTR. The State, if it so chooses, still can make these changes to its water quality standards, subject to EPA approval. However, with this Federal rule in effect, the State cannot implement any modifications that are less stringent than the CTR without an amendment to the CTR to reflect these modifications." (Federal Register, Vol. 65, No. 97, p. 31703)

**Table ES-1. Summary of alternative site-specific objectives and implementation approaches.**

| Alternative Site-Specific Objectives (Values are specified as µg/L) | | | |
|---|---|---|---|
| **Constituent** | **Alternative 1: U.S. EPA NRWQC -** [1] **$10^{-5}$ Risk Level** | **Alternative 2: Limit to Existing Water Quality Throughout Segments** | **Alternative 3: Limit to Existing Water Quality and Achieve a $10^{-5}$ Composite Risk Level** |
| Dibromochloromethane | 4.0 | 4.9 | 2.6 |
| Dichlorobromomethane | 5.5 | 15.5 | 9.0 |
| Chloroform | 57 | 45.5 | 39.5 |
| **Implementation Approach** [2] | | | |
| Approach | A | B | A |

[1] Objectives calculated using U.S. EPA's approach for deriving its 2006 National Recommended Water Quality Criteria.
[2] Approach for assessing whether the Easterly WWTP discharge has reasonable potential to cause or contribute to an excursion above applicable site-specific objectives for the segments based on most recent three years of data:

A – Maximum concentration measured in New Alamo Creek at Brown-Alamo Dam is compared to the site-specific objectives for assessing whether controllable factors affecting THM levels have a reasonable potential to cause or substantially contribute to exceedances of the site-specific objectives. If needed, effluent limitations would be derived using the median attenuation factor calculated from representative historical data. The attenuation factor for each monitoring event would be calculated as the effluent concentration divided by the New Alamo Creek concentration measured at Brown-Alamo Dam for all months of the year (see Section 5.5.3).

B – Maximum measured concentration in Old Alamo Creek at terminus is compared to the site-specific objectives for assessing whether controllable factors affecting THM levels have a reasonable potential to cause or substantially contribute to exceedances of the site-specific objectives. If needed, effluent limitations would be derived using the median attenuation factor calculated from representative historical data for the months of November through March only to address volatilization losses within Old Alamo Creek. The attenuation factor for each monitoring event would be calculated as the effluent concentration divided by the Old Alamo Creek concentration at its terminus. Dilution credit would be calculated consistent with the SIP (SWRCB 2005) (see Section 5.5.3).

Under implementation of Alternative 2 objectives, the reasonable potential to cause an excursion above the site-specific objectives would be determined from the most recent three years of data available for Old Alamo Creek at the terminus (i.e., immediately upstream of New Alamo Creek's confluence with Old Alamo Creek, which is at the head of the segments to which the site-specific objectives would apply).

An effluent limitation would be required if the maximum concentration in Old Alamo Creek at its terminus in the most recent three years of data is greater than the corresponding Alternative 2 site-specific objective. Should effluent limitations be required, the limitations would fully account for the attenuation (i.e., reduction in concentration) of the DBCM, DCBM, and chloroform concentrations between the point of discharge and Old Alamo Creek's terminus. This would be accomplished by an attenuation factor that would account for losses within Old

Alamo Creek due to volatilization only. The attenuation factor would be calculated as the median of the individual attenuation factors determined from representative historical data collected during the non-irrigation season months of November through March only. Because Old Alamo Creek has been disconnected from its upper watershed, it does not convey significant watershed-derived flows that would provide dilution of Easterly WWTP discharges. Old Alamo Creek does, in its lower reach, convey agricultural flows during the irrigation season; hence, for the attenuation factor to primarily address volatilization (and not dilution as well), the attenuation factor would be determined from data collected outside the irrigation season (i.e., measured data during the 1 November through 31 March period of each year). When implementing Alternative 2 site-specific objectives, dilution credit would be accounted for in deriving effluent limitations according to the SIP instead of via the attenuation factor. The effluent limitations could consist of an AAEL, AMEL, and a MDEL.

**Assessment of Beneficial Use Protection**

Alternative 1 site-specific objectives were derived using U.S. EPA's criteria published in its 2006 National Recommended Water Quality Criteria (NRWQC) document, adjusted to a $10^{-5}$ cancer risk level. As such, these site-specific objectives would provide a $10^{-5}$ level of protection (i.e., risk of one additional cancer in 100,000 people assuming a lifetime of exposure) for people that consumed 2 liters per day (L/day) of water diverted from the New Alamo Creek and Ulatis Creek segments and consumed up to 17.5 grams per day (g/day) of fish/shellfish collected from the segments, for a 70-year lifetime. This is a very high level of protection even if people were consuming water and organisms from the segments for a 70-year lifetime at the daily rates assumed above, which is not occurring presently, and is not expected to occur in the future within the segments. Consequently, the Alternative 1 site-specific objectives actually would provide much higher levels of human health protection, because daily exposure rates and exposure duration associated with the segments are expected to be substantially less than that assumed for deriving these objectives, based on the UAA findings (RBI 2007) for these water body segments. Due to expected low levels of exposure, these site-specific objectives are anticipated to provide $10^{-6}$ or higher levels of human health protection for the segments. As such, the MUN beneficial use of the New Alamo Creek and Ulatis Creek segments would be fully protected following implementation of the Alternative 1 site-specific objectives.

Alternative 2 site-specific objectives were derived to: 1) provide a lifetime $10^{-5}$ or lower cancer risk level for DBCM, DCBM, and chloroform for parties that could potentially make transient and incidental MUN use of segments waters in the future; and 2) control and limit DBCM, DCBM, and chloroform concentrations within the segments to the upper end of the concentration distributions observed for these constituents, based on historical monitoring data. This was done by setting the site-specific objectives equal to the 99.9 percentile values observed at the upstream end of the segments, based on historical monitoring data, and confirming that these site-specific objectives would provide a lifetime $10^{-5}$ or lower cancer risk level, based on past, present and reasonably foreseeable levels of MUN use of segments waters.

At the U.S. EPA default exposure levels of consuming 2 L/day of water and up to 17.5 g/day of fish/shellfish from the segments for a 70-year lifetime, the Alternative 2 DBCM and DCBM objectives would provide a level of protection somewhat lesser than $10^{-5}$ but substantially greater than the minimum of $10^{-4}$ required by U.S. EPA, whereas the objective for chloroform would provide a level of protection slightly greater than $10^{-5}$. Nevertheless, current and anticipated future exposure levels associated with segment waters are anticipated to be substantially lower than 2 L/day of water and up to 17.5 g/day of fish/shellfish from the segments for a 70-year lifetime. Due to expected low levels of exposure, these objectives are anticipated to provide $10^{-6}$ or greater levels of human health protection. As such, the MUN beneficial use of the New Alamo Creek and Ulatis Creek segments would be fully protected following implementation of the Alternative 2 site-specific objectives.

Alternative 3 site-specific objectives were derived to limit DBCM, DCBM, and chloroform concentrations to existing maximum levels at Brown-Alamo Dam and provide a composite $10^{-5}$ level of protection for the three constituents at U.S. EPA's default exposure assumptions. As such, Alternative 3 objectives also would provide a high level of protection even if people were consuming 2 L/day of water and up to 17.5 g/day of fish/shellfish from the segments for a 70-year lifetime. At these exposure levels, the Alternative 3 DCBM objective would provide a level of protection slightly less than $10^{-5}$, but substantially greater than the minimum of $10^{-4}$ required by U.S. EPA, whereas the objectives for DBCM and chloroform would provide a level of protection slightly greater than $10^{-5}$. Thus, the "composite" risk level for all three constituents would effectively be $10^{-5}$. Nevertheless, current and anticipated future exposure levels are anticipated to be substantially lesser than these U.S. EPA default exposure levels. Due to expected low levels of exposure, these objectives are anticipated to provide $10^{-6}$ or greater levels of human health protection, similar to Alterative 1 and 2 objectives. Consequently, the MUN beneficial use of the New Alamo Creek and Ulatis Creek segments would be fully protected following implementation of the Alternative 3 site-specific objectives.

The adoption, approval, and implementation of Alternative 1, 2, or 3 site-specific objectives would pose no risk of causing excursions of currently applicable CTR THM criteria in Cache Slough or downstream Delta waters. As such, the MUN beneficial use of Cache Slough and downstream Delta waters would be fully protected following implementation of either Alternative 1, 2, or 3 site-specific objectives.

### Consistency with the Federal and State Antidegradation Policies

Upon implementation of the Alternative 1, 2, or 3 site-specific objectives, existing segment beneficial uses would remain unchanged, and the DBCM, DCBM, and chloroform concentrations within the segments would continue to be at levels that have been historically observed. Adoption, approval, and implementation of Alternative 1, 2, or 3 site-specific objectives for the New Alamo Creek and Ulatis Creek segments would not cause any new or increased volume of waste to be discharged to surface waters and thus would not result in a lowering of water quality. Moreover, the Easterly WWTP facilities and their operations have been optimized to minimize the use of chlorine and, thus, formation of THMs to the extent practicable, which represents best practicable treatment or control (BPTC) for the Easterly WWTP with regard to THMs.

The site-specific objectives assure that the level of water quality necessary to protect the segment's beneficial uses, including the MUN use, would be maintained and protected. In addition, any discharge to the creek segments must be regulated to ensure that downstream water quality standards are met. Any new point-source discharge or increased volume of waste discharge to the segments that could cause degradation in DBCM, DCBM, chloroform, or other water quality parameters, would require an antidegradation analysis prior to the State permitting the new or expanded-capacity discharge and any associated water quality degradation. Implementation of the site-specific objectives would not change the levels of THMs allowed in Cache Slough and downstream waters, as regulated by the CTR.

Based on documented current and future expected exposure levels within the segments (that are substantially lower than the default U.S. EPA exposure levels assumed for deriving the site-specific objectives), regulation of present controllable factors affecting water quality to achieve the site-specific objectives within the segments would provide on the order of $10^{-6}$ or higher levels of human health protection for MUN. Achieving compliance with current CTR criteria within the New Alamo Creek and Ulatis Creek segments (which provide $10^{-6}$ level of protection when consuming 2 L/day of water diverted from the segments and consuming up to 6.5 g/day of fish/shellfish collected from the segments for a 70-year lifetime – a level of exposure not currently occurring or expected to occur in the future within the segments) would require extensive modifications and upgrades to the Easterly WWTP at an estimated capital cost of at least $34.8 million and substantially increased annual WWTP operations and maintenance costs (West Yost & Associates 2008).

Because exposure levels associated with consuming 2 L/day of water diverted from the segments and up to 6.5 g/day of fish/shellfish collected from the segments are not currently occurring and are not expected to occur in the future, because $10^{-6}$ or higher levels of human health protection for DBCM, DCBM, and chloroform would be provided under the site-specific objectives based on current and expected future levels of exposure within the segments, and because implementation of the site-specific objectives would not change the CTR criteria applicable to Cache Slough and downstream Delta waters or the ability to comply with those criteria, it is in the best interest of the people of the State to adopt and implement the site-specific DBCM, DCBM, and chloroform objectives for the segments rather than to modify the Easterly WWTP at an estimated capital cost of $34.8 million to the City of Vacaville.

Based on these considerations, adoption and approval of either Alternative 1, 2, or 3 objectives would be consistent with the federal and State antidegradation policies.

# 1 INTRODUCTION

## 1.1 Background

The City of Vacaville (City) owns and operates the Easterly Wastewater Treatment Plant (Easterly WWTP), which provides service to the City and the unincorporated area of Elmira. Treated municipal wastewater is discharged directly into Old Alamo Creek, a tributary to New Alamo Creek, which is tributary to Ulatis Creek, which is tributary to Cache Slough. Cache Slough and the lower reach of Ulatis Creek are within the statutory boundary of the Sacramento-San Joaquin River Delta (Delta) (**Figure 1**).

Upon its adoption by the Central Valley Regional Water Quality Control Board (Regional Water Board) on March 15, 2001, the City appealed its NPDES permit (Order No. 5-01-044, NPDES No. CA0077691) to the State Water Resources Control Board (State Water Board). The State Water Board held a hearing on the City's permit (SWRCB/OCC File A-1375) and adopted Order WQO 2002-0015 addressing this appeal on October 3, 2002. Among other things, this State Water Board Order directed the Regional Water Board to promptly initiate a Use Attainability Analysis (UAA) to consider dedesignating various aquatic life uses and the municipal and domestic supply (MUN) use for Old Alamo Creek (Figure 1, yellow highlighted water body). The State Water Board made this recommendation because designation of these beneficial uses via the "tributary statement"[2] and State Water Board Resolution No. 88-63 contained in the Regional Water Board's Water Quality Control Plan for the Central Valley Region (Basin Plan) has resulted in NPDES permit limitations for certain constituents that could not be met without costly modifications to the Easterly WWTP, yet available evidence suggested that these uses are neither existing nor attainable uses in Old Alamo Creek. Hence, refinement of the use designations through the UAA process provided a prudent course of action to resolve regulatory issues for discharges into Old Alamo Creek and technical studies began on Old Alamo Creek through a United States Environmental Protection Agency (U.S. EPA) contract with Tetra Tech Inc., with additional support provided by the City and its consultant, Robertson-Bryan, Inc.

On April 28, 2005, following completion of the UAA process, the Regional Water Board adopted Resolution No. R5-2005-0053, amending the Basin Plan. The amendment dedesignated the beneficial uses of MUN, cold freshwater habitat (COLD), migration of aquatic organisms (MIGR), and spawning, reproduction and/or early development (SPWN) assigned to Old Alamo Creek. On February 1, 2006, the State Water Board approved these same amendments to the Basin Plan. Also on February 1, 2006, the State Water Board approved a site-specific exception

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[2] The beneficial uses of the Easterly WWTP receiving waters (Old Alamo Creek {prior to 2006}, New Alamo Creek and the portion of Ulatis Creek not located within the legal boundary of the Delta) are not explicitly defined in the Basin Plan, thus, the Regional Water Board has applied the tributary statement and State Water Board Resolution No. 88-63 to assign the MUN beneficial use of the Delta to these water bodies. That beneficial use designation is assumed in this report.

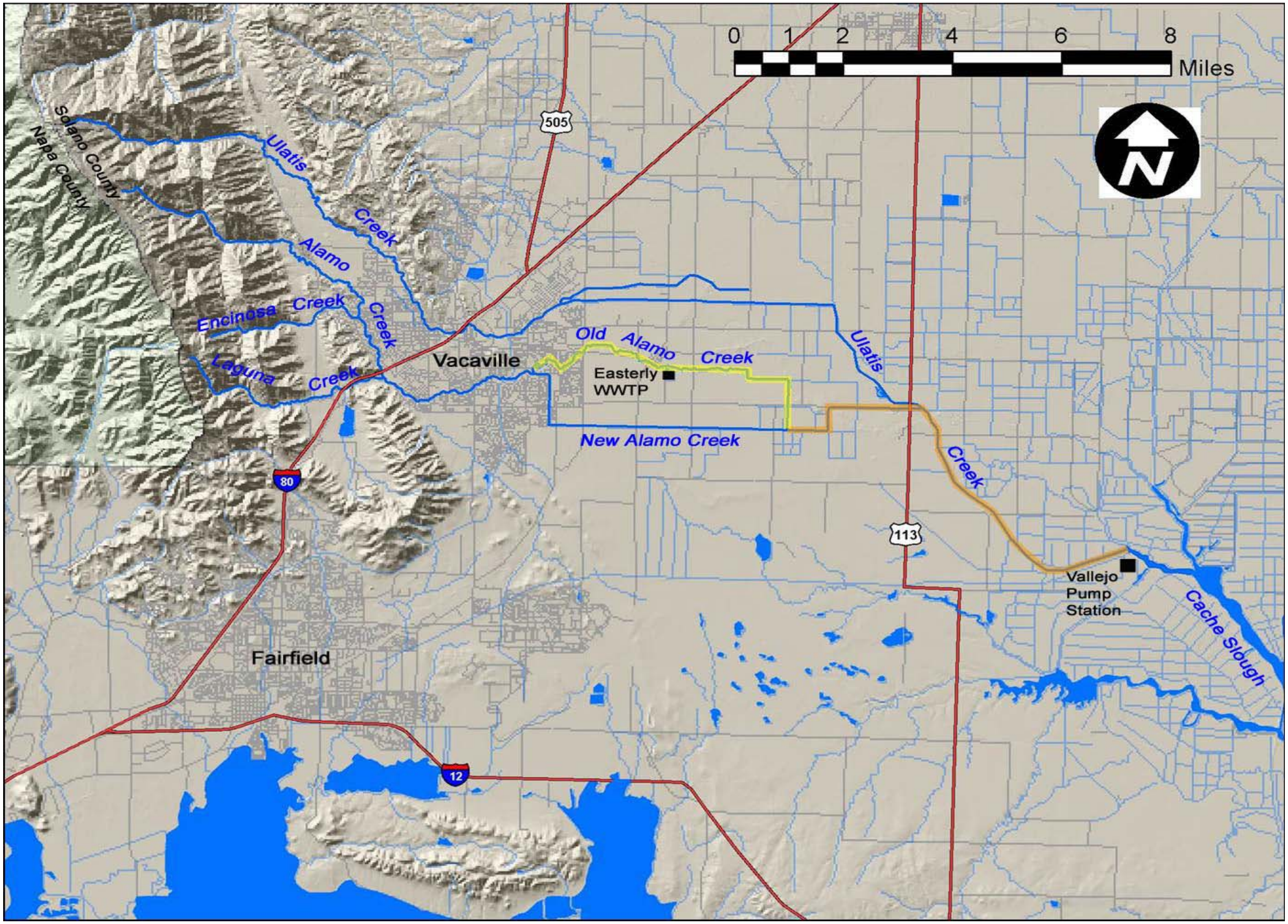


**Figure 1. Geographic location of the City of Vacaville's Easterly Wastewater Treatment Plant and receiving waters.**

to the State's Sources of Drinking Water Policy (State Water Board Resolution No. 88-63) for Old Alamo Creek. These amendments also were approved by the Office of Administrative Law. U.S. EPA's final approval of the dedesignations of the MUN, COLD, MIGR, and SPWN uses for Old Alamo Creek on August 7, 2006 resolved key Easterly WWTP compliance issues associated with discharges into Old Alamo Creek. However, the State Water Board Order WQO 2002-0015 did not specifically provide direction with respect to the designated beneficial uses of receiving waters downstream of Old Alamo Creek (Figure 1, orange highlighted reaches), perhaps because such receiving waters did not directly drive the receiving water and effluent limitations in the appealed NPDES permit. Nevertheless, promptly following issuance of the State Water Board Order, the City called to Regional Water Board staff's attention that limiting the water quality standards refinement actions to Old Alamo Creek would not fully resolve the current regulatory issues associated with the MUN beneficial use – including compliance problems associated with meeting promulgated water quality criteria for dibromochloromethane (DBCM) (also commonly referred to as chlorodibromomethane), dichlorobromomethane (DCBM) (also commonly referred to as bromodichloromethane), and chloroform. These compounds are members of a group of four compounds commonly referred to as "trihalomethanes" (THM), the fourth member being bromoform. Subsequently, in January 2004 the Regional Water Board and the City entered into Agreement No. 03-910-150-0, "City of Vacaville Site-Specific Basin Plan Amendments for Old Alamo Creek and New Alamo Creek, Ulatis Creek and Cache Slough," for the purpose of evaluating water quality standards in regard to beneficial uses and water quality objectives. Agreement No. 03-910-150-0 expired prior to project completion and was renewed July 2008 by Agreement No. 08-900-150-0.

This expanded standards refinement effort was required because Old Alamo Creek, being disconnected from its watershed, largely acts as an open conveyance channel of minimally diluted Easterly WWTP effluent that is then discharged into New Alamo Creek at the confluence of these two water bodies. Existing data showed at the time that MUN-related NPDES permit limitations, including for the THMs, and applicable criteria, would not be met within the lower reaches of New Alamo and Ulatis creeks. Consequently, following the Old Alamo Creek use dedesignations becoming effective, the permitting issues resulting in compliance problems for the City's Easterly WWTP simply moved from the point of discharge into Old Alamo Creek (immediately adjacent to the plant site) to the confluence of Old Alamo Creek and New Alamo Creek, about 3.2 miles downstream of the outfall. The expanded MUN standards refinement effort has culminated in the findings and recommendations contained in this report.

At the direction of the agencies, the City conducted a UAA for New Alamo Creek and Ulatis Creek to determine whether the MUN beneficial use designation for the lower segments of these water bodies is appropriate. MUN is defined by the Basin Plan as: "uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply" (Regional Water Board 2007a). The water body segments evaluated were:

- New Alamo Creek, from Old Alamo Creek to Ulatis Creek; and
- Ulatis Creek, from New Alamo Creek to Cache Slough.

The UAA presented substantial information indicating that MUN is neither an existing nor an attainable use in these water body segments, and that no form of MUN use is reasonably expected to occur in the future in these water body segments based on system hydrologic and water quality characteristics, as well as the availability of higher quality water sources in the area (RBI 2007). Prior to the UAA report (RBI 2007) being finalized, this finding was supported by Ms. Leah Walker of the California Department of Public Health (DPH, formerly Department of Health Services (DHS)), who, when attending the Regional Water Board's California Environmental Quality Act public scoping meeting for this standards refinement project on June 28, 2007, stated that the DPH supports the dedesignation of MUN from the UAA study segments.

Regional Board staff agree that municipal uses are not existing and likely not attainable because of the existing hydrologic conditions and water quality characteristics. However, staff believe that it is important to maintain the MUN designation in order to maintain water quality in the lower New Alamo Creek and Ulatis Creek segments at a level sufficient to protect potential future transient and incidental use of water in the creeks for drinking water, should such a use occur. Therefore, site specific THM objectives would be appropriate for this potential limited use as a means of:

1) achieving a goal-level of human health protection for these segments with regard to THM levels, as specified by the State and Regional Water Board and U.S. EPA staff,
2) reasonably and cost-effectively resolving the significant THM regulatory compliance issue faced by the City in operating its Easterly WWTP, and
3) maintaining current levels of MUN protection for THMs within Cache Slough and downstream Delta waters.

## 1.2 Purpose and Intended Use of Report

This report was prepared to derive site-specific objectives for DBCM, DCBM, and chloroform for the lower segments of New Alamo Creek and Ulatis Creek, based on a level of human health protection identified by the State and Regional Water Board and U.S. EPA staff as an appropriate level of MUN protection for current, projected future, and goal levels of use within these segments. No site-specific human health objectives are being derived for bromoform, because the Easterly WWTP discharge does not contribute bromoform to the segments at concentrations above currently applicable bromoform criteria. Applicable bromoform criteria are currently met within the segments.

This report provides the technical basis for developing and justifying site-specific DBCM, DCBM, and chloroform objectives for the protection of human health associated with the consumption of water and organisms from the lower reaches of New Alamo Creek and Ulatis

Creek. These site-specific objectives will be submitted for adoption and approval through the State's Basin Plan amendment process and as amendment to the California Toxics Rule (CTR)[1] through U.S. EPA's regulatory process. This report will serve as a technical reference to the Regional Water Board's Staff Report that proposes the site-specific objectives. The site-specific objectives will apply to New Alamo Creek from Old Alamo Creek to Ulatis Creek, and to Ulatis Creek from New Alamo Creek to Cache Slough (Figure 1**,** orange highlighted segments). This report also describes implementation, compliance assessment, and permitting considerations associated with the site-specific objectives.

## 1.3 Report Organization

This report is organized into the following sections:

- Section 2 – describes the beneficial uses of the New Alamo Creek and Ulatis Creek segments.
- Section 3 – describes the current state-wide human health criteria for DBCM, DCBM, and chloroform.
- Section 4 – describes the historical and projected future concentrations of DBCM, DCBM, and chloroform in the segments.
- Section 5 – describes the derivation of alternative site-specific DBCM, DCBM, and chloroform objectives.
- Section 6 – defines site-specific implementation approaches for the Easterly WWTP for regulatory purposes that, together with their respective site-specific objectives, constitute alternative Basin Plan amendments for the segments.
- Section 7 – characterizes the level of MUN protection provided by the alternative site-specific objectives for the segments and for downstream waters
- Section 8 – provides an analysis of adopting site-specific objectives with respect to consistency with the federal and State antidegradation policies.
- Section 9 – addresses economic considerations.
- Section 10 – provides references cited in this report.

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[1] "Site-specific criteria, variances and other actions modifying criteria are neither prohibited nor limited by the CTR. The State, if it so chooses, still can make these changes to its water quality standards, subject to EPA approval. However, with this Federal rule in effect, the State cannot implement any modifications that are less stringent than the CTR without an amendment to the CTR to reflect these modifications." (Federal Register, Vol. 65, No. 97, p. 31703)

# 2 BENEFICIAL USES

Water quality standards consist of the designated beneficial uses of a water body or water body segment, the water quality criteria/objectives necessary to support those uses, and must also include an antidegradation policy that protects existing uses and high water quality (U.S. EPA 1994). The beneficial uses of New Alamo Creek and Ulatis Creek, and the basis of the use designations, are described below. In addition, the UAA findings for the lower reaches of these water bodies, and the nature of the drinking water consumption to be protected through maintaining the MUN use designation, are presented and discussed.

## 2.1 Designated Uses

The Basin Plan explicitly identifies the beneficial uses for approximately 100 water bodies within the Central Valley region of California (Regional Water Board 2007a). For water bodies without explicitly identified uses, the Regional Water Board applies the "tributary statement," which states:

> "*The beneficial uses of any specifically identified water body generally apply to its tributary streams…In some cases a beneficial use may not be applicable to the entire body of water. In these cases the Regional Water Board's judgment will be applied. It should be noted that it is impractical to list every surface water body in the Region. For unidentified water bodies, the beneficial uses will be evaluated on a case-by-case basis*." (Regional Water Board 2007a, p. II-2.00)

New Alamo Creek and Ulatis Creek are within the Central Valley Region of California, and tributary to Delta waters, with the lower reach of Ulatis Creek located within the boundary of the Delta. The beneficial uses of New Alamo Creek and the reach of Ulatis Creek upstream of the Delta boundary are not explicitly defined in the Basin Plan. The Regional Water Board has applied the tributary statement to assign the beneficial uses of the Delta to New Alamo Creek and the upper reaches of Ulatis Creek. The beneficial uses of the Delta include irrigation and stock watering agricultural supply (AGR), industrial process (PRO) and service supply (IND), contact (REC-1) and non-contact (REC-2) water recreation, freshwater habitat for warm (WARM) and cold (COLD) species, migration (MIGR) water for both warm (striped bass, sturgeon, and shad) and cold (salmon and steelhead) freshwater species, spawning (SPWN) for warm water species (striped bass, sturgeon, and shad), wildlife habitat (WILD), navigation (NAV), and municipal and domestic supply (MUN).

Furthermore, the Basin Plan is interpreted to have designated all water bodies that do not have explicit beneficial use designations as having the MUN use. The Basin Plan states:

> "*Water Bodies within the basins that do not have beneficial uses designated in Table II-1 are assigned MUN designations in accordance with the provisions*

*of State Water Board Resolution No. 88-63 which is, by reference, a part of this Basin Plan, except as provided below:*

*• Old Alamo Creek (Solano County) from its headwaters to the confluence with New Alamo Creek*

*These MUN designations in no way affect the presence or absence of other beneficial use designations in these water bodies. In making any exemptions to the beneficial use designation of MUN, the Regional Board will apply the exceptions listed in Resolution 88-63 (Appendix Item 8).*" (Regional Water Board 2007a, p. II-3.00)

Thus, by identification of MUN as an existing use for Delta waters in the Basin Plan, application of the Basin Plan's tributary statement, and State Water Board Resolution No. 88-63 (the Sources of Drinking Water Policy), the Regional Water Board has determined the MUN use to be designated for New Alamo Creek and Ulatis Creek.

As stated in the above Basin Plan excerpt, as a result of the 2006 Basin Plan amendments, MUN is not a beneficial use of Old Alamo Creek, which is tributary to New Alamo Creek and is the direct receiving water for the Easterly WWTP effluent. As identified in Section 1.1 of this report, a second UAA effort was initiated for the lower reaches of New Alamo Creek and Ulatis Creek, following the initiation of the Old Alamo Creek UAA, as part of the effort to refine MUN standards in these downstream water body segments, thereby more completely addressing the Easterly WWTP MUN-related compliance issues that were only partially addressed in State Water Board Order WQO 2002-0015 and subsequent actions.

## 2.2 Findings from New Alamo Creek and Ulatis Creek UAA for the MUN Use

The UAA conducted for the lower segments of New Alamo Creek and Ulatis Creek evaluated whether the MUN use has ever occurred in the study segments, if water quality and hydrologic conditions have ever been such that the MUN use was attainable, and if attaining the MUN use in the future is practicable. The UAA relied on site visits; records searches; and interviews with adjacent landowners, local water agencies/districts, and local health agency personnel to determine whether the MUN use has ever occurred. The UAA considered water quality and hydrologic data; past, present, and anticipated future watershed land uses; and the source water characteristics to determine whether the MUN has been attained, and whether it is expected to be obtained in the future. The following summarizes the UAA findings.

Water rights records, field surveys, and interviews indicate that the MUN use has not occurred in the UAA study segments since November 28, 1975[1], nor has water quality conducive to its use occurred within the segments. Thus, MUN is not an existing use of New Alamo Creek from Old Alamo Creek to Ulatis Creek, nor Ulatis Creek from New Alamo Creek to Cache Slough.

There is little or no natural flow input from the upper watershed during the irrigation season (i.e., generally from late-May/early-June through October). The water that is present in the UAA study segments during this time of year is imported, fully-allocated irrigation water, which is not available for diversion by a new MUN user, combined with Easterly WWTP effluent, agricultural drainage water, and urban runoff – the latter sources being unsuitable for MUN use.

During the precipitation season, highly impaired source water conditions exist. Although agricultural drainage water is not present during the precipitation season, storm water runoff from adjacent urban and agricultural lands and Easterly WWTP effluent is present. For the study period 1998-2006, the dilution ratio (New Alamo Creek flow:Easterly WWTP flow) was 5:1 or less approximately 90% of the time. For this same period, the dilution ratio (Ulatis Creek flow:Easterly WWTP flow) was 10:1 or less approximately 80% of the time and was 5:1 or less approximately 60% of the time. Only during short periods (e.g., hours to days) surrounding large precipitation events does natural runoff from upper watershed areas adequately dilute these other low quality source waters to produce water quality conditions within the UAA study segments that are potentially suitable for MUN use (RBI 2007).

Human-caused contamination of the water quality within New Alamo Creek and Ulatis Creek further contribute to current non-attainability of the MUN use in these segments. Segment water quality is dictated by the primary sources of the water, which are agricultural drainage water, agricultural and urban storm water runoff, and Easterly WWTP discharges. The combined factors that currently make water quality within the UAA study segments unsuitable for the MUN use have occurred throughout the November 28, 1975 to present period. The surrounding agricultural and urban land uses that result in the available sources of poor quality water to the UAA study segments are not likely to be changed in a manner that would make the available water suitable for MUN use. Thus, MUN is not attainable based on water quality conditions (RBI 2007).

Water having the above characteristics is unsuitable for MUN supply, particularly when higher quality alternative sources are available within the area (DHS 1995; DHS 1997; L. Walker, DHS, pers. comm., June 28, 2007). For this reason, the California Department of Health Services (now the Department of Public Health or DPH) discouraged the use of Cache

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[1] Beneficial uses attained on or after November 28, 1975 are considered "existing uses," which means there is evidence that the use has occurred on or after November 28, 1975, or that water quality has been, at any time since this date, sufficient to allow the use to occur. (40 CFR § 131.3(e))

Slough water by the City of Vallejo (DHS 1995, 1997). The justification for not using Cache Slough as a drinking water source is magnified for the UAA study segments, because UAA study segment water is a primary source water to the Vallejo Pump Station site, yet it does not receive any or as much dilution with higher quality Cache Slough water compared to waters at the Vallejo Pump Station site.

## 2.3 Type/Degree of MUN Use to be Protected in Creek Segments and Downstream Waters

After completion of the UAA, State Water Board staff directed that the MUN use be maintained for the creek segments in the standards refinement process, and that site-specific objectives protective of potential future exposure levels at the state's goal level of protection for potential transient and incidental use be developed and adopted for the segments. Because neither changes to the MUN use nor to the THM criteria to protect the use are being proposed for Cache Slough or downstream Delta waters, both the use and its present level of protection regarding THM constituents would remain unchanged in these downstream waters by any changes to water quality standards in New Alamo Creek and Ulatis Creek.

# 3 CURRENT STATEWIDE HUMAN HEALTH CRITERIA

Human health criteria for DBCM and DCBM applicable to New Alamo Creek and Ulatis Creek have been promulgated by U.S. EPA at the federal level through the CTR. The CTR promulgated human health criteria for protection through the consumption of water and aquatic organisms and consumption of aquatic organisms only. The criteria for the consumption of water and organisms apply to all water bodies in California designated with the MUN use. The criteria for the consumption of aquatic organisms only apply to water bodies that are not designated MUN. The CTR did not promulgate criteria for chloroform, because U.S. EPA was re-evaluating the scientific basis for chloroform criteria at the time the CTR was promulgated. U.S. EPA has published recommended ambient water quality criteria for chloroform. The Basin Plan does not contain individual water quality objectives for any of the THM compounds. There is a maximum contaminant level (MCL) applicable to tap water for the sum of the THMs (DBCM, DCBM, chloroform, and bromoform). **Table 1** summarizes the current water quality criteria for DBCM, DCBM, and chloroform as well as the DPH MCL applicable to tap water.

**Table 1. Adopted statewide human health criteria, MCL, and U.S. EPA recommended criteria for dibromochloromethane, dichlorobromomethane, and chloroform.**

| Constituent | California Toxics Rule Criteria (µg/L) | | DPH MCL (µg/L) | U.S. EPA Recommended Criteria (µg/L) |
|---|---|---|---|---|
| | Organisms Only | Water & Organisms | | Water & Organisms |
| Dibromochloromethane (DBCM) | 34 [1] | 0.41 [1] | 80 (for the sum of the THMs) [4] | 0.40 [1,2] |
| Dichlorobromomethane (DCBM) | 46 [1] | 0.56 [1] | | 0.55 [1,2] |
| Chloroform | [Reserved] [3] | [Reserved] [3] | | 5.7 [1,2,5]<br>68 (draft) [6] |

1 Based on a $10^{-6}$ cancer risk level. Organism only criteria only apply to water bodies not having a MUN designation, such as Old Alamo Creek (65 FR 31719).
2 U.S. EPA National Recommended Water Quality Criteria (2006).
3 U.S. EPA reserved promulgation of criteria for chloroform in the California Toxics Rule (CTR) to allow for reassessment based on new information.
4 Implemented as a 12-month running average of sample concentrations collected quarterly.
5 Proposed for CTR, reserved in final CTR.
6 *Ambient Water Quality Criterion for the Protection of Human Health: Chloroform - Revised Draft*. EPA-822-R-04-002. Office of Water. Washington, D.C. (not a final recommendation)

The CTR criteria were developed using U.S. EPA's 1980 ambient water quality criteria approach (U.S. EPA 1980). Criteria for DBCM and DCBM were derived based on a $10^{-6}$ cancer risk. The proposed CTR contained a human health criterion for chloroform of 5.7 µg/L for the consumption of water and organisms, also based on a $10^{-6}$ cancer risk. The final CTR reserved promulgation of chloroform criteria to consider new data and analysis on chloroform's mode of action. U.S. EPA has since developed draft chloroform criteria based on non-cancer effects thresholds that are protective against cancer effects as well (U.S. EPA 2003). The revised draft chloroform criteria were derived using the equation for non-cancer effects (see p. 59 of U.S. EPA's draft recommended criteria document – EPA-822-R-04-002, December 2003). The reason for this, as stated in the draft criteria document (p. 28) is "*[A]vailable evidence indicates that chloroform induced carcinogenicity is secondary to cytotoxicity and regenerative hyperplasia, and that doses below the RfD do not result in cytolethality (and hence do not result in increased risk of cancer)*." The revised, draft recommended criterion for chloroform is 68 µg/L for the protection of human health through consumption of water and organisms. U.S. EPA's current recommended criteria for DBCM and DCBM were calculated according to an updated methodology for human health criteria derivation. U.S. EPA's DBCM, DCBM, and chloroform criteria were published in their 2006 summary of National Recommended Water Quality Criteria (NRWQC) (U.S. EPA 2006).

The Stage 1 and Stage 2 Disinfectant and Disinfection Byproducts rules apply to drinking water served at the tap, and contain a total THM MCL of 80 µg/L. Title 22 of the California Code of Regulations (CCR), Section 64439 references the most current U.S. EPA drinking water regulations for compliance with the THM MCL. However, unlike other CCR sections with MCLs (i.e., 64431, 64444, 64449), neither Section 64439 nor Table 64533-A (Disinfection Byproducts MCLs) of the CCR is incorporated by reference in the Basin Plan as a water quality objective for chemical constituents. Thus, the 80 µg/L MCL is not directly applicable as a water quality objective through the narrative water quality objective for chemical constituents in the Basin Plan.

# 4 HISTORICAL AND PROJECTED FUTURE RECEIVING WATER THM CONCENTRATIONS

The following sections describe the historical and projected future concentrations of DBCM, DCBM, and chloroform in the Easterly WWTP effluent and downstream locations to provide context for the need to derive site-specific objectives for segments of New Alamo and Ulatis Creek, and to assess the potential for compliance with site-specific objectives derived and presented herein, upon their becoming effective.

## 4.1 Historical THM Concentrations

The City of Vacaville collected DBCM, DCBM, and chloroform concentration data for the Easterly WWTP effluent and a number of downstream locations in Old Alamo Creek, New Alamo Creek, Ulatis Creek, and Cache Slough. **Table 2** summarizes the names and locations of the monitoring sites, which are shown in **Figure 2**. Generally, data were collected once per month during the period September 2002 through August 2007.

**Table 2. Name and location of water quality monitoring sites including distance downstream from the Easterly Wastewater Treatment Plant outfall.**

| Site Number | Site Name | Water Body | Distance from outfall (miles) | Distance up/downstream in miles (nearest confluence) |
|---|---|---|---|---|
| 1 | Easterly WWTP outfall | Old Alamo | Zero | -- |
| 2 | End of Old Alamo | Old Alamo | 3.2 | -- |
| 3 | New Alamo at Lewis Rd. | New Alamo | Not applicable – upstream location | 1.5 upstream (New-Old Alamo) |
| 4 | New Alamo below Old Alamo | New Alamo | 3.7 | 0.5 downstream (New-Old Alamo) |
| 5 | End of New Alamo | New Alamo | 6.4 | 0.1 upstream (New Alamo-Ulatis) |
| 6 | Ulatis Creek above New Alamo | Ulatis | Not applicable – upstream location | 0.2 upstream (New Alamo-Ulatis) |
| 7 | Maine Prairie Rd. on Ulatis | Ulatis | 7.0 | 0.6 downstream (New Alamo-Ulatis) |
| 8 | Brown Rd on Ulatis | Ulatis | 8.9 | 2.5 downstream (New Alamo-Ulatis) |
| 9 | Ulatis above Vallejo Pump Station | Ulatis | 11.2 | Just upstream (Ulatis-Cache) |
| 10 | Vallejo Pump Station | Cache Slough | 11.9 | Just downstream (Ulatis-Cache) |

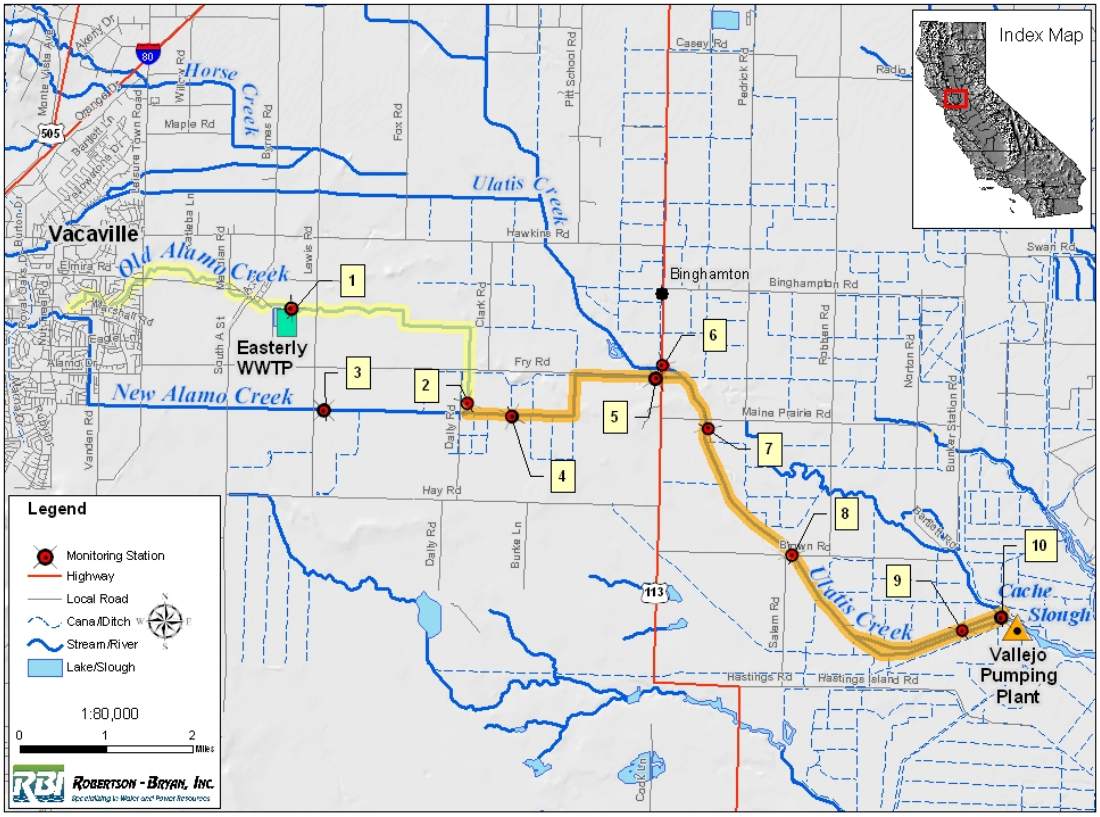


**Figure 2. Location of the Easterly Wastewater Treatment Plant, its receiving waters, and water quality monitoring sites. Sites 3 and 6 are upstream of diluted effluent flows.**

DBCM, DCBM, and chloroform are volatile compounds. Thus, their concentrations in surface waters as they are transported downstream are non-conservative, decreasing over distance and time. In the New Alamo Creek and Ulatis Creek segments, irrigation-related flows, urban runoff, and stormwater further contribute to reducing DBCM, DCBM, and chloroform concentrations. DBCM, DCBM, and chloroform data for all locations were plotted and are shown in **Figure 3**, **Figure 4**, and **Figure 5**, respectively. For illustration purposes only, all non-detect results are shown as equal to zero. **Appendix A** contains tables with the summary statistics provided in the graphs.

DBCM concentrations in the receiving waters have been above the current CTR criterion of 0.41 µg/L from the Easterly WWTP outfall downstream to the end of New Alamo Creek (Figure 3). DBCM concentrations have historically been less than the CTR criterion in Ulatis Creek at the Maine Prairie Road monitoring location, which is located just downstream of the confluence with New Alamo Creek, and at the remaining downstream locations.

DCBM concentrations in the receiving water have been above the current CTR criterion of 0.56 µg/L from the Easterly WWTP outfall downstream to Ulatis Creek at Brown Road (Figure 4). DCBM concentrations have historically been less than the CTR criterion in Ulatis Creek at the monitoring station located upstream of the defunct Vallejo Pump Station (VPS) and in Cache Slough at the defunct VPS.

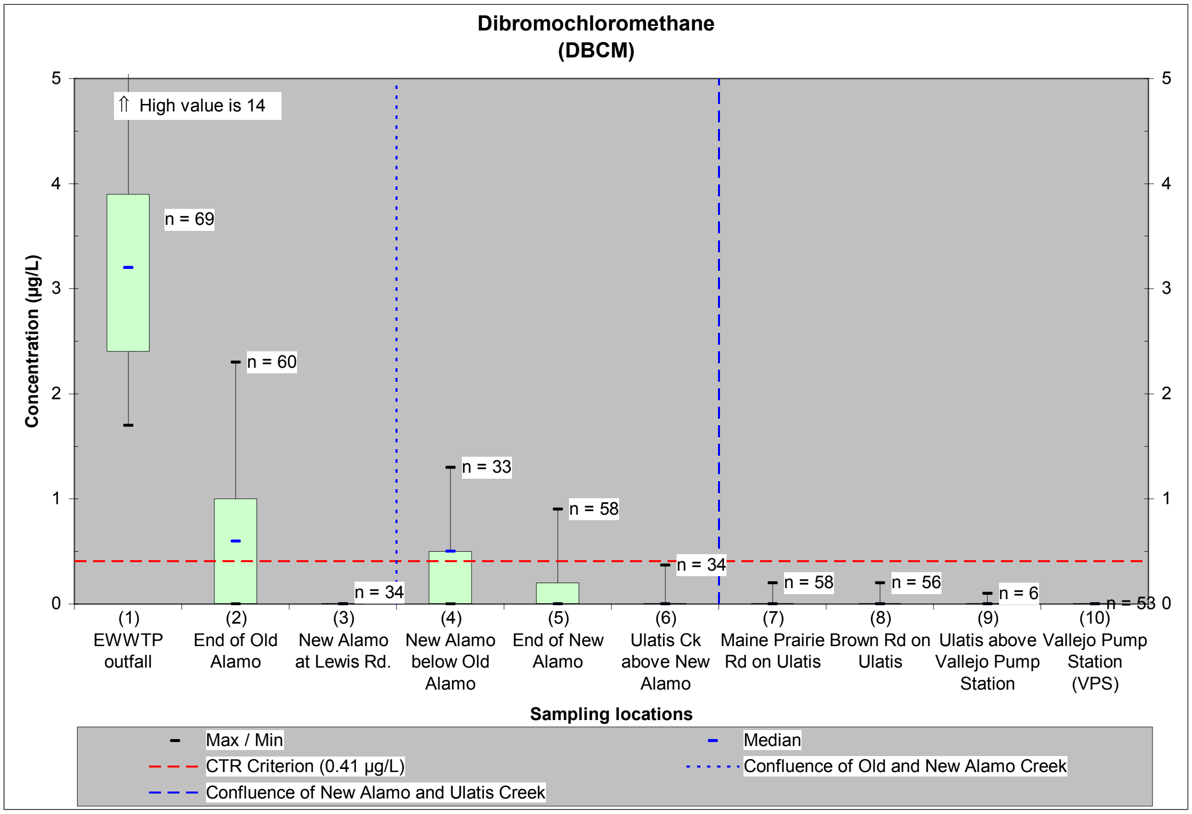


**Figure 3. Historical concentrations of dibromochloromethane (DBCM) in the Easterly Wastewater Treatment Plant effluent and at downstream locations. Sites 3 and 6 are upstream of diluted effluent flows.**

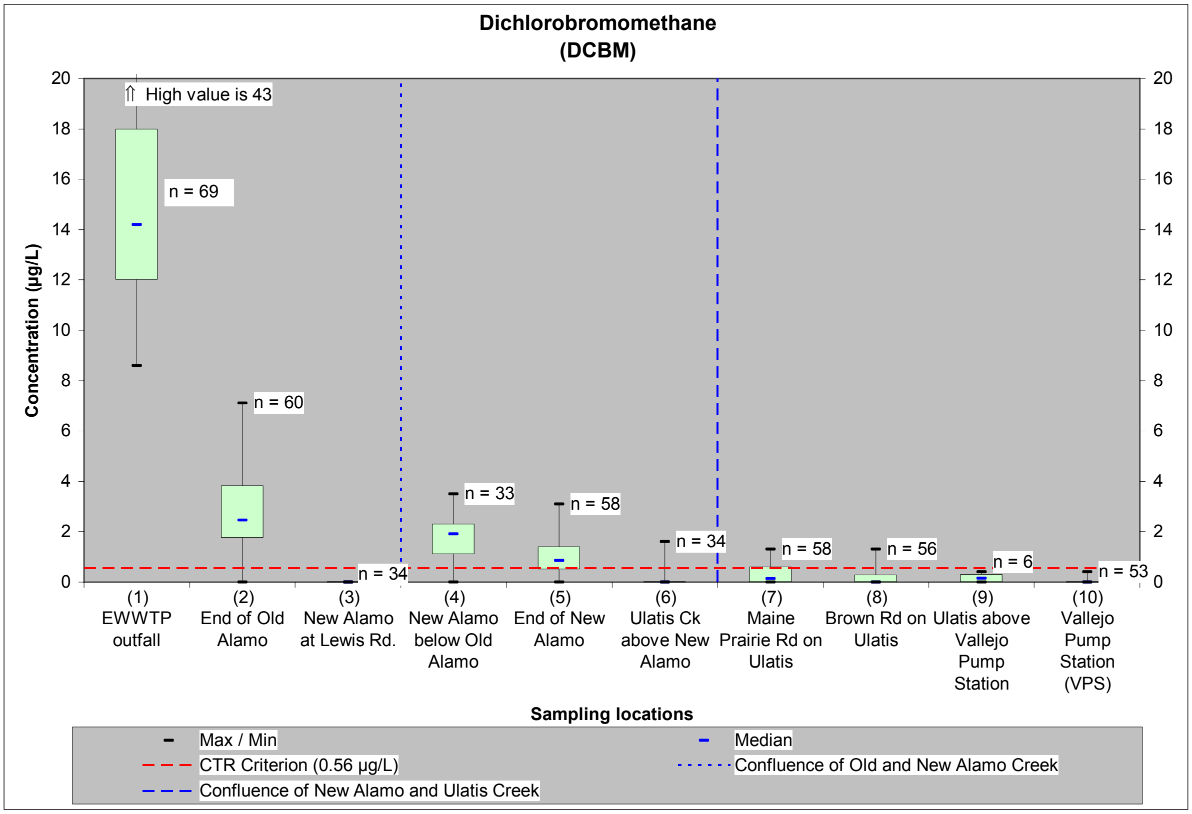


**Figure 4. Historical concentrations of dichlorobromomethane (DCBM) in the Easterly Wastewater Treatment Plant effluent and at downstream locations. Sites 3 and 6 are upstream of diluted effluent flows.**

Chloroform concentrations in the receiving waters have been above U.S. EPA's current recommended criterion of 5.7 µg/L from the Easterly WWTP outfall downstream to Ulatis Creek at Brown Road (Figure 5). Chloroform concentrations have historically been less than U.S. EPA's current recommended criterion in Ulatis Creek at the monitoring station located upstream of the defunct VPS and in Cache Slough at the defunct VPS.

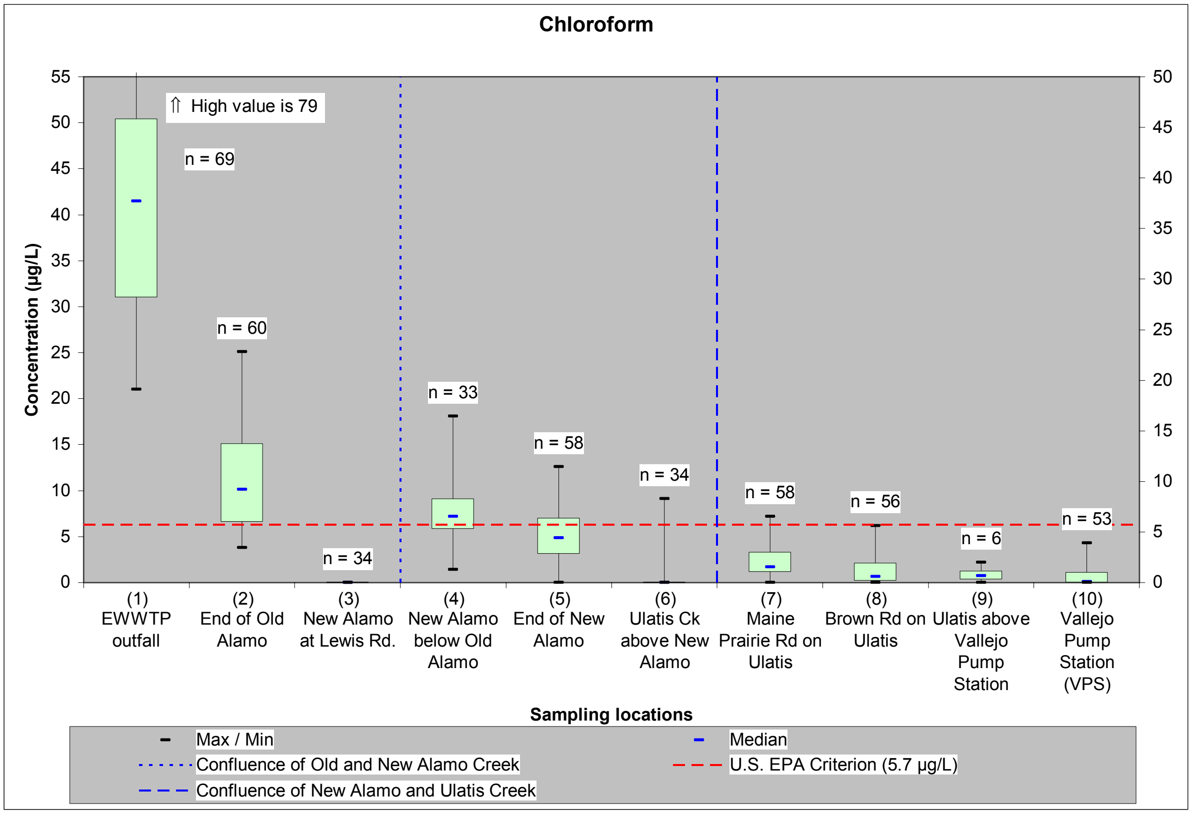


**Figure 5. Historical concentrations of chloroform in the Easterly Wastewater Treatment Plant effluent and at downstream locations. Sites 3 and 6 are upstream of diluted effluent flows.**

## 4.2 Volatilization of THM Compounds in Old Alamo Creek

There are extended periods during the non-irrigation season when little to no precipitation has occurred and there is no dilution of the Easterly WWTP effluent in Old Alamo Creek (Tetra Tech 2004). This is due in large part to Old Alamo Creek having been disconnected from its watershed at the time New Alamo Creek was constructed, in the mid 1960s. During the non-irrigation period of the year, attenuation of DBCM, DCBM, and chloroform concentrations in Old Alamo Creek is primarily through volatilization. During the irrigation season, DBCM, DCBM, and chloroform concentrations in Old Alamo Creek also are attenuated by dilution, which can be highly variable within and among years. Understanding and quantifying the volatilization of the DBCM, DCBM, and chloroform is important to the future assessment of the reasonable potential for the Easterly WWTP discharge to contribute to exceedances of the site-specific objectives in the segments, and to properly deriving effluent limitations for one or more of these THMs, should effluent limitations be required.

The concentration of DBCM, DCBM, and chloroform at the terminus of Old Alamo Creek (historically referred to as "R-7" based on this location being referred to as monitoring location R-7 in the City's 2001 NPDES permit monitoring and reporting program) is of interest because this is the most downstream (from the Easterly WWTP discharge) extent of where the MUN use has been dedesignated. Because MUN would remain a designated use in New Alamo Creek, the concentration of THMs at the terminus of Old Alamo Creek is indicative of the concentration that enters the first downstream water body where MUN applies (i.e., New Alamo Creek).

The percent reduction in the effluent concentration at the terminus of Old Alamo Creek was plotted to evaluate seasonality and identify the sub-set of data that represents reduction in DBCM, DCBM, and chloroform concentrations due solely to volatilization. Effluent and terminus of Old Alamo Creek concentrations determined from samples collected the same day were used to calculate the percent reduction in effluent concentration at the terminus of Old Alamo Creek for a total of 60 values. For purposes of this analysis, non-detect data were transformed to equal one-half the reporting limit, which conservatively estimates the reduction in effluent concentration. **Figure 6** illustrates a definite seasonality to the percent reduction in effluent DBCM, DCBM, and chloroform concentrations between the point of discharge from the Easterly WWTP and the terminus of Old Alamo Creek.

A dilution study performed during November 2003 (Flow Science 2005) found that Easterly WWTP effluent was diluted only 1.1:1 (total flow:effluent flow) at the Brown-Alamo Dam on New Alamo Creek; thus, flow in Old Alamo Creek during this period was likely comprised of only Easterly WWTP effluent. The percent reduction in effluent concentration during November 2003 was as follows:

- 70% for DBCM;
- 75% for DCBM; and
- 52% for chloroform.

Based on these percentages, the patterns shown in Figure 6, and the known system hydrology (Tetra Tech 2004, Flow Science 2005), the November – March data are considered representative of conditions when attenuation of the DBCM, DCBM, and chloroform concentrations in Old Alamo Creek is due to volatilization, with little to no attenuation due to dilution with stormwater or urban runoff. Table 3 provides summary statistics of the percent reduction in effluent concentration at the terminus of Old Alamo Creek. The November 2003 percentages fall within the ranges that have historically occurred and are close to the mean and median percent reductions. Therefore, the use of all November – March data to characterize periods of no dilution and attenuation due only to volatilization is appropriate and conservative.

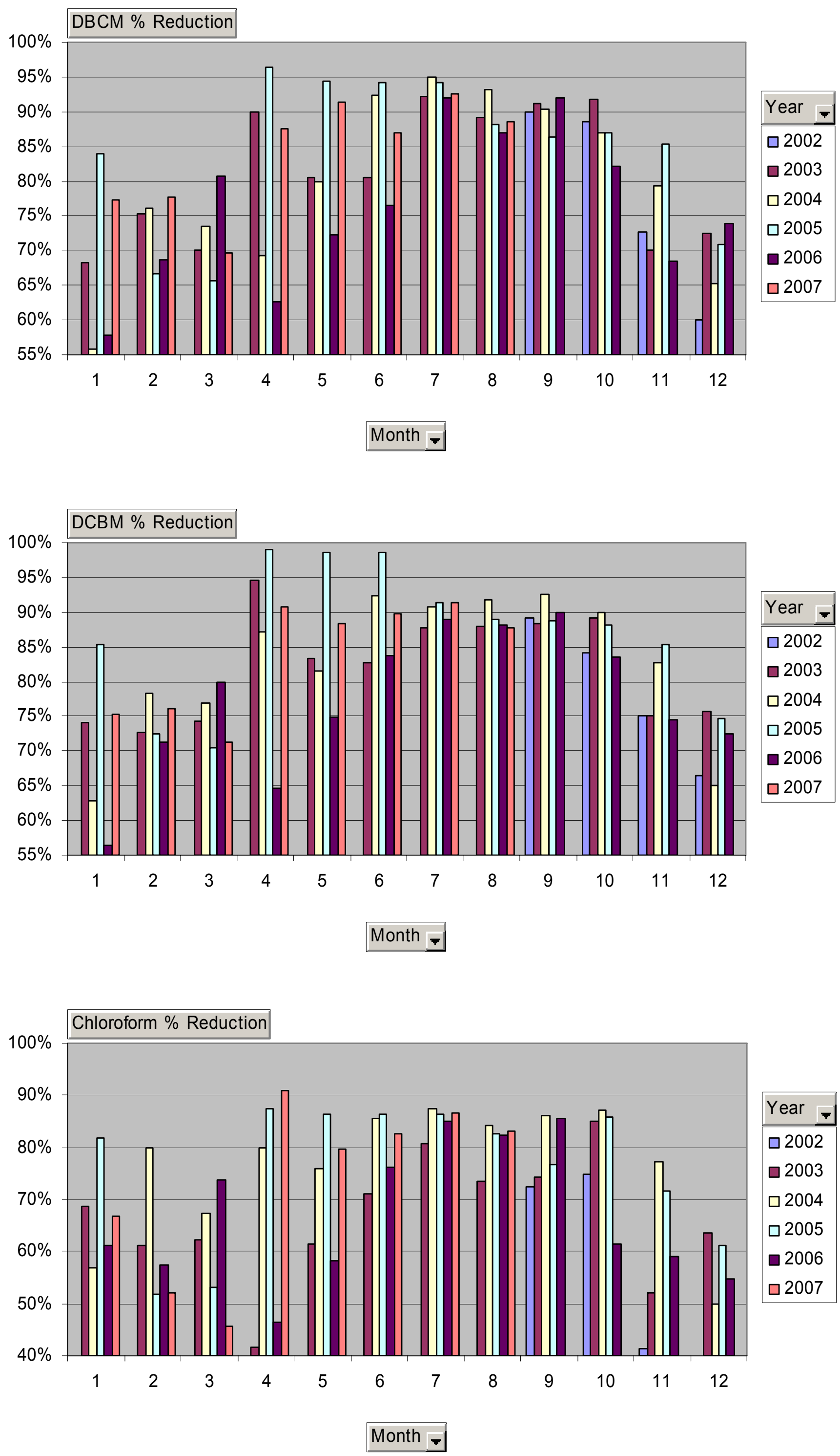


**Figure 6. Percent reduction of Easterly Wastewater Treatment Plant effluent concentration in Old Alamo Creek immediately upstream of New Alamo Creek.**

**Table 3. Percent reduction in Easterly Wastewater Treatment Plant effluent concentration in Old Alamo Creek immediately upstream of New Alamo Creek for the months November through March for the years 2002-2007.**

| Compound | Minimum | Median | Mean | Maximum |
|---|---|---|---|---|
| Dibromochloromethane | 56% | 71% | 71% | 85% |
| Dichlorobromomethane | 56% | 74% | 74% | 85% |
| Chloroform | 28% | 61% | 60% | 82% |

## 4.3 Easterly WWTP Process Optimization Evaluation

The potential for THM compounds to be present in wastewater effluent is affected by the presence of organic THM precursors in the wastewater effluent and the amount of chlorine used to disinfect the treated wastewater. Biochemical oxygen demand (BOD), total suspended solids (TSS), and coliform bacteria concentrations in the final effluent provide an indication of the WWTP's ability to remove THM precursors. The amount of chlorine needed to adequately disinfect treated wastewater is dependent on a number of factors, including treatment plant design, turbidity/TSS levels, and chemical usage.

The Easterly WWTP is comprised of two parallel plants: the North Plant and the newly constructed South Plant. The treatment system consists of headworks, primary sedimentation basins, aeration basins, secondary clarifiers, chlorination and dechlorination facilities, emergency ponds, dissolved aeration floatation thickeners, anaerobic digesters, biosolids storage ponds, biosolids belt filter presses and biosolids drying beds. To ensure that NPDES permit requirements will be met, the City has optimized existing operations and has instituted a number of measures to improve overall plant performance and to reduce chlorine demand, which, in turn, reduces THM formation. These are identified and further discussed below.

- **Increased Mean Cell Residence Time (MCRT) and Extended Aeration.** MCRT is the average length of time that a microorganism remains in an activated sludge treatment process. MCRT may also be expressed in terms of solids retention time or sludge age. Extended aeration activated sludge processes have an older sludge population (held longer within the system). This population is made up of a large number of different types of bacteria, and bacteria responsible for nutrient removal tend to take longer to grow. Both of these measures increase plant stability, provide a buffer for shock loads and seasonal temperature changes, ensure that the WWTP produces fully nitrified effluent, and increased BOD and TSS removal efficiencies.

- **Ferric Chloride Addition**. Ferric chloride is added for odor control and as a coagulant for improved precipitation of solids. This measure has increased solids settleability as determined by the sludge volume index (SVI). Improved solids removal also provides for increased metals removal.

- **Chlorination Modifications.** A Water Champ® system has been installed for sodium hypochlorite disinfection. This system has the ability to provide the mixing intensity required to maximize chemical reaction while using less energy. Rapid mixing is very important for optimizing pathogen removal. In addition, the newly constructed chlorine contact basin has a length to width ratio of 51:1 to maximize contact time and disinfection efficiency.

The Easterly WWTP has a history of high removal efficiencies for BOD and TSS, and low effluent concentrations of BOD, TSS, and coliform bacteria. The following summarizes the BOD and TSS removal efficiencies from 2005-2007:

- BOD – monthly average removal of 98.5% ±0.4% with a range from 97.3% to 99.2% for the years 2005–2007.
- TSS – monthly average removal of 98.5% ±0.6% with a range from 97.1% to 99.4% for the years 2005–2007.

Concentrations of BOD, TSS, and coliform bacteria in the Easterly WWTP effluent are as follows:

- BOD – 4.03 mg/L ± 0.96 mg/L as a monthly average for the years 2005–2007.
- TSS – 4.36 mg/L ± 1.67 mg/L as a monthly average for the years 2005–2007.
- Coliform – median daily and median 7-day values are <2 MPN/100 mL for the years 2005–2007.
    - The daily value interquartile range (25–75 percentile of data) is from <2 MPN/100 mL to 4 MPN/100 mL.
    - The 7-day median value interquartile range is from <2 MPN/100 mL to 2 MPN/100 mL.

These removal efficiencies and concentrations indicate that the Easterly WWTP is achieving efficient, tertiary treatment level reduction of organics that may include THM precursors.

In summary, the Easterly WWTP process has been optimized to minimize the use of sodium hypochlorite and, thus, formation of THMs to the extent practicable and thus represents best practicable treatment or control (BPTC) for the Easterly WWTP. Sodium hypochlorite use has been minimized through the minimization of contaminants to be disinfected, removal of chlorination interferences (e.g., solids removal), maximized separation and removal of sludge, maximized effluent mixing with sodium hypochlorite, and maximized contact time and disinfection efficiency.

## 4.4 Projected Future THM Concentrations

Because the Easterly WWTP process has been optimized to the extent practicable to maximize the removal of THM precursors and minimize chlorine demand, and because the volatilization rates within Old Alamo Creek are not expected to change significantly in the future, the statistical distribution of DBCM, DCBM, and chloroform concentrations that have been observed historically at the terminus of Old Alamo Creek (R-7) is expected to remain the same in the future. Analysis of the historical data reveals that there is no seasonality to the Easterly WWTP effluent concentrations of THM compounds; therefore, the range of effluent concentrations observed may be expected to occur during any month.

While the historical data set of DBCM, DCBM, and chloroform concentrations for Old Alamo Creek and New Alamo Creek is for a five-year period, the maximum concentrations observed in this period do not necessarily represent maximum concentrations that have occurred or may occur in the future. Statistical methods were employed to characterize the historical data distributions of measured concentrations of DBCM, DCBM, and chloroform in Old Alamo Creek and New Alamo Creek. Upon statistically defining the distributions of measured values, probabilities of occurrence were defined (detailed in **Appendix B**). **Table 4** summarizes the DBCM, DCBM, and chloroform concentrations for probabilities that define the upper end of the data distributions for Old Alamo Creek at the terminus (i.e., immediately upstream of the New Alamo Creek confluence) and for New Alamo Creek at Brown-Alamo Dam. A 99.9% probability of occurrence means that 99.9% of the time, the concentration of the THM compound will be at or below that level, at the specified location. Conversely, a 99.9% probability of occurrence means that 0.1% of the time, the concentration will be higher than that specified. The entire data set available for both locations contributed to the development of the probability distributions in Table 4.

**Table 4. Dibromochloromethane, dichlorobromomethane, and chloroform concentrations at specified probabilities of occurrence. Probabilities are based on lognormal distributions.**

| Probability | Dibromochloromethane | Dichlorobromomethane | Chloroform |
|---|---|---|---|
| Location: Old Alamo Creek at Terminus | | | |
| 99.99% | 7.6 | 22.9 | 61.8 |
| 99.98% | 6.7 | 20.5 | 56.6 |
| 99.97% | 6.2 | 19.2 | 53.7 |
| 99.96% | 5.9 | 18.3 | 51.7 |
| 99.95% | 5.6 | 17.6 | 50.2 |
| 99.94% | 5.4 | 17.0 | 48.9 |
| 99.93% | 5.3 | 16.6 | 47.9 |
| 99.92% | 5.1 | 16.2 | 47.0 |
| 99.91% | 5.0 | 15.8 | 46.2 |
| 99.9% | 4.9 | 15.5 | 45.5 |
| Location: New Alamo Creek at Brown-Alamo Dam | | | |
| 99.99% | 3.4 | 11.6 | 50.7 |
| 99.98% | 3.1 | 10.6 | 46.2 |
| 99.97% | 2.9 | 10.0 | 43.6 |
| 99.96% | 2.7 | 9.6 | 41.9 |
| 99.95% | 2.6 | 9.3 | 40.5 |
| 99.94% | 2.6 | 9.0 | 39.5 |
| 99.93% | 2.5 | 8.8 | 38.6 |
| 99.92% | 2.4 | 8.7 | 37.8 |
| 99.91% | 2.4 | 8.5 | 37.1 |
| 99.9% | 2.3 | 8.4 | 36.5 |

# 5 SITE-SPECIFIC HUMAN HEALTH OBJECTIVES DEVELOPMENT

This section presents the derivation of site-specific human health objectives for DBCM, DCBM, and chloroform. The site-specific objectives to be adopted for the New Alamo Creek and Ulatis Creek segments must meet the following criteria:

1) achieve a goal-level of human health protection for potential transient and incidental use of segment waters with regard to THM levels, as specified by the State and Regional Water Board and U.S. EPA staff,
2) reasonably and cost-effectively resolve the significant THM regulatory compliance issue faced by the City of Vacaville in operating its Easterly WWTP, and
3) maintain current levels of MUN protection for THMs within Cache Slough and downstream Delta waters.

Based on available toxicological information compiled by others (U.S. EPA 1986, Regional Water Board 2007b), the designated beneficial use most sensitive to DBCM, DCBM, and chloroform is the MUN use. Toxicological effects in aquatic life are observed at concentrations orders of magnitude higher than in humans (due to the different exposure routes and durations), and the remaining receiving water uses (AGR, PRO, IND, REC-1, REC-2, WILD, and NAV) would be unaffected by site-specific changes to the objectives for DBCM, DCBM, and chloroform.

Three sets of alternative site-specific objectives for DBCM, DCBM, and chloroform are presented below. All three sets of objectives would be protective of all the beneficial uses of the New Alamo Creek and Ulatis Creek segments, including the MUN use, at a level consistent with U.S. EPA guidance and State policy.

## 5.1 Alternative 1 – U.S. EPA NRWQC Methodology - $10^{-5}$ Risk Level

Site-specific objectives for DBCM, DCBM, and chloroform derived under this alternative are based on U.S. EPA's NRWQC adjusted to a one-in-100,000 ($10^{-5}$) cancer risk level, based on an assumed exposure associate with consuming 2 L/day of water and up to 17.5 g/day of fish/shellfish from the segments for a 70-year lifetime. The following sections describe the methodology and site-specific considerations used to derive objectives at this risk level, and the resulting objectives.

### *5.1.1 Methodology*

This alternative's objectives are derived consistent with the methodologies used for the DBCM, DCBM, and chloroform criteria presented in U.S. EPA's most recent NRWQC compilation published in 2006 (U.S. EPA 2006). A primary assumption in the development of U.S. EPA's current recommended criteria for DBCM, DCBM, and chloroform is that they are potential human carcinogens. U.S. EPA (2003) developed a revised draft chloroform criterion for the consumption of water and organisms of 68 µg/L, based on a non-cancer endpoint. However, these recommended criteria have not yet completed the public review and comment process. Consequently, U.S. EPA's current recommended criterion for chloroform (U.S. EPA 2006), not its 2003 draft recommended criterion for chloroform, is used as the basis for deriving the site-specific chloroform objective for the New Alamo Creek and Ulatis Creek segments under this alternative. [1]

The criteria for DBCM, DCBM, and chloroform presented in U.S. EPA'S 2006 NRWQC document are:

- DBCM – 0.40 µg/L
- DCBM – 0.55 µg/L
- Chloroform – 5.7 µg/L

These criteria were derived using a one-in-a-million ($10^{-6}$) cancer risk level for a 70-year lifetime exposure and the following default input assumptions:

- Human body weight = 70 kilograms (kg)
- Drinking water intake = 2 liters per day (L/day)

In addition, the DBCM and DCBM criteria are derived using a 17.5 grams per day (g/day) fish/shellfish consumption rate and the chloroform criterion is derived using a 6.5 g/day fish/shellfish consumption rate.

#### *5.1.2 Site-specific Considerations*

U.S. EPA encourages states to use information specific to the region or water body for which criteria are being developed (U.S. EPA 2000). For reasons described in the following sections, water body-specific cancer risk levels are being estimated as part of the development and assessment of the site-specific objectives for the New Alamo Creek and Ulatis Creek segments. However, it should be noted that, in an abundance of caution and to assure a high-level of protection to all potentially exposed groups, exposure factors for drinking water and fish consumption used in the development and assessment of these site-specific numeric objectives are based on U.S. EPA's default exposure levels for the derivation of the national recommended criteria, rather than the actual/anticipated exposure levels for segment waters, which are known to be substantially lower (RBI 2007). This

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[1] In the Federal Register notice for the proposed chloroform criterion U.S. EPA states, "Water quality criteria published by EPA are the Agency's recommended water quality criteria until EPA revises or withdraws the criteria. EPA supports using the current section 304(a) criteria for those chemicals for which criteria are being updated and considers them to be scientifically sound until the Agency publishes final revised 304(a) criteria." *Federal Register* / Vol. 69, No. 12 / Tuesday, January 20, 2004.

approach assures that site-specific objectives derived would actually provide much higher levels of protection for the segments, based on actual segment exposure levels that have occurred and are expected to occur in the future (RBI 2007), which are substantially lower than U.S. EPA's default assumptions cited herein. Nevertheless, U.S. EPA's default exposure assumptions are used herein to best facilitate relative comparison of level of protection among alternatives and to assure that the level of protection associated with the site-specific objectives derived is highly conservative for any potential future level of transient and incidental MUN use of segment waters.

#### 5.1.2.1 Risk Level

The CTR criteria for carcinogens were derived using a $10^{-6}$ risk level for a 70-year lifetime exposure. The rationale was based, in part, on historical practices by the State. The standards adopted in the *California Ocean Plan* and now repealed *Enclosed Bays and Estuaries Plan* and *Inland Surface Waters Plan* contained a $10^{-6}$ risk level for most carcinogens. The preamble of the CTR acknowledges that the State has the discretion to adopt water quality criteria that result in a higher risk level, as long as the most highly exposed subpopulations are protected (65 FR 31699):

> *"EPA, in its recent human health methodology revisions, proposed acceptable lifetime cancer risk for the general population in the range of $10^{-5}$ to $10^{-6}$. EPA also proposed that States and Tribes ensure the most highly exposed populations do not exceed a $10^{-4}$ risk level….EPA, therefore, believes that derivation of criteria at the 10-6 risk level is a reasonable risk management decision protective of designated uses under the CWA. While outside the scope of this rule, EPA notes that States and Tribes, however, have the discretion to adopt water quality criteria that result in a higher risk level (e.g., $10^{-5}$). EPA expects to approve such criteria if the State or Tribe has identified the most highly exposed subpopulation within the State or Tribe, demonstrates the chosen risk level is adequately protective of the most highly exposed subpopulation, and has completed all necessary public participation."*

U.S. EPA intends to publish future national ambient water quality criteria at a $10^{-6}$ risk level, which it considers appropriate for the general population (U.S. EPA 2000, p. 1-8 and 2-6). However, U.S. EPA acknowledges that on a local level (e.g., statewide, regional, or water body basis) a $10^{-5}$ risk level may be appropriate as long as the most highly exposed population groups do not exceed a one-in-10,000 ($10^{-4}$) risk level (U.S. EPA 2000, p. 2-6). In fact, the federal and State drinking water MCL for total THMs of 80 µg/l protects at a cancer risk level somewhat greater than (i.e., somewhat less protective than) $10^{-5}$ for the consumption of tap water statewide and nationally.

In the case of New Alamo Creek, from Old Alamo Creek to Ulatis Creek, and Ulatis Creek, from New Alamo Creek to Cache Slough, MUN is not an existing use nor does the available evidence support that it is an attainable use (RBI 2007). Nevertheless, the MUN use for these segments is being maintained and shall be protected consistent with U.S. EPA guidance cited above, and the State's desired goal-level of MUN protection for these segments which is based on a recognition of no historical or current MUN use of segment waters, but the potential for future transient and incidental use. Based on the lack of an existing MUN use within these segments and the low potential for future use, the most exposed group in the future also would be the only exposed group for these water body segments. Therefore, consistent with U.S. EPA guidance and State policy considerations, alternative site-specific human health objectives are derived herein based on risk levels lesser than (i.e., more protective than) $10^{-4}$, and generally at or approaching $10^{-5}$ even if the most highly exposed group consumes 2L/day of water and 17.5 g/day of fish and shellfish from the segments for a 70-year lifetime (i.e., U.S. EPA's default exposure assumptions), which is a substantially higher exposure than is expected to actually occur for any group of people regarding segment waters.

#### 5.1.2.2 Drinking Water and Fish Consumption Rates and Exposure Duration

In order for the risk factor selected to provide the level of human health protection intended, key measures of exposure must be defined. These measures are: 1) water consumption rate (water consumed having been diverted from the segments); 2) organism consumption rate (fish and shellfish collected from the water body segments); and 3) the duration of time that such consumption occurs. Although water is not currently diverted and consumed from the New Alamo Creek and Ulatis Creek segments and has a low expectation to be in the future, a goal level of protection is assumed that would allow the consumption of 2 L/day of water diverted from the segments for a 70-year lifetime. Because fish consumption rates associated with the segments have not been determined site-specifically, U.S. EPA's default organism consumption rate used for deriving the 2006 NRWQC (i.e., up to 17.5 g/day of fish/shellfish for a 70-year lifetime) is assumed for deriving the site-specific objectives for the segments. These assumed U.S. EPA NRWQC water and organism consumption rates and duration of consumption are highly conservative (i.e., would result in highly protective site-specific objectives) based on past, present and anticipated future levels of water consumption from these effluent-dominated water body segments (RBI 2007), and the anticipated organism consumption rates – both of which are substantially lesser than the U.S. EPA NRWQC default exposure rates assumed for deriving and evaluating the protectiveness of the alternative site-specific objectives herein.

### *5.1.3 Objectives Derivation*

U.S. EPA's 2006 NRWQC for DBCM, DCBM, and chloroform are 0.40 µg/L, 0.55 µg/L, and 5.7 µg/L, respectively (U.S. EPA 2006). These 2006 NRWQC adjusted for $10^{-5}$ risk level can be determined by simply multiplying the original $10^{-6}$-based criteria by 10. The resulting site-specific objectives for Alternative 1 are:

- 4.0 µg/L for DBCM;
- 5.5 µg/L for DCBM; and

- 57 µg/L for chloroform.

The point of compliance for these objectives would be in New Alamo Creek at Brown-Alamo Dam, which is the first location downstream of the confluence with Old Alamo Creek that is safely accessible year-round for data collection and approximates the initial location where Old Alamo Creek water (which contains Easterly WWTP effluent) is fully mixed with New Alamo Creek water. The implementation of Alternative 1 objectives is further discussed in Section 5.5.

## 5.2 Alternative 2 – Limit to Existing Water Quality

Site-specific objectives derived under this alternative would limit DBCM, DCBM, and chloroform maximum concentrations to existing levels, which would provide between a $10^{-4.6}$ and $10^{-5.1}$ level of cancer risk protection for people that consume 2 L/day of water diverted from the segments and consume up to 17.5 g/day of fish/shellfish captured from the segments for a 70-year lifetime. This alternative's objectives are based on the existing water quality of Old Alamo Creek at its terminus, and thus would prevent any further degradation with respect to maximum THM levels in the New Alamo and Ulatis creek segments. The following sections describe the methodology and site-specific considerations used to derive the Alternative 2 objectives, the resulting objectives, and the level of protection provided.

### *5.2.1 Methodology*

The Alternative 2 objectives were derived to: 1) provide a lifetime $10^{-5}$ or lower cancer risk level for DBCM, DCBM, and chloroform for parties that could potentially make transient and incidental MUN use of segments waters in the future; and 2) control and limit DBCM, DCBM, and chloroform concentrations within the segments to the upper end of the concentration distributions observed for these constituents, based on historical monitoring data. This was done by setting the site-specific objectives equal to the 99.9 percentile values observed at the upstream end of the segments, based on historical monitoring data, and confirming that these site-specific objectives would provide a lifetime $10^{-5}$ or lower cancer risk level, based on past, present and reasonably foreseeable levels of MUN use of segments waters. To accomplish this, the methodology for deriving objectives under this alternative consisted of evaluating the historical data sets for DBCM, DCBM, and chloroform for Old Alamo Creek at its terminus – immediately prior to its confluence with New Alamo Creek at the head of the segments. The existing water quality at this location was selected to derive the objectives, because it is at this location that water from Old Alamo Creek, which does not have an MUN designation, enters New Alamo Creek, which does have an MUN designation.

As described in Section 4.4, while the data set for Old Alamo Creek at the terminus covers a five year period, it does not necessarily represent the entire range of concentrations that has occurred or may occur in the future. Thus, statistical methods were applied to the entire data set ($n$=60) to first determine whether the data are distributed normally or lognormally and then (upon defining the statistical distribution), define the probability of occurrence of the

DBCM, DCBM, and chloroform concentrations. Table B-5 in Appendix B summarizes the concentrations of DBCM, DCBM, and chloroform in Old Alamo Creek at the terminus for probabilities of occurrence ranging from 50% to 99.99%. Table B-5 also lists the corresponding equivalent cancer risk, for relative comparison among alternatives, assuming an exposure from consuming 2 L/day of water diverted from the segments and up to 17.5 g/day of fish/shellfish captured from the segments for a 70-year lifetime. These exposure assumptions were taken from U.S. EPA's NRWQC methodology and default exposure assumptions described in Section 5.2.2.

### 5.2.2 Site-specific Considerations

As described above in Section 5.1.2, U.S. EPA acknowledges that on a local level (e.g., statewide, regional, or water body basis) a risk level greater than (i.e., less protective than) $10^{-6}$ may be appropriate as long as the most highly exposed population groups do not exceed a $10^{-4}$ risk level (U.S. EPA 2000, p. 2-6). Furthermore, the water in the New Alamo Creek and Ulatis Creek segments has not been in the past, nor is currently, diverted and consumed from the segments and has a low expectation to be used in this manner in the future. Therefore, objectives that would protect at U.S. EPA's minimum required $10^{-4}$ risk level or better, when assuming U.S. EPA's default consumption rates of 2 L/day of water and up to 17.5 g/day of fish/shellfish for a 70-year lifetime (i.e., a high exposure level), would actually provide much higher levels of protection for the segments, based on actual segment exposure levels that have occurred and are expected to occur in the future (RBI 2007), which are substantially lower than U.S. EPA's default assumptions cited here. Nevertheless, U.S. EPA's default exposure assumptions are used herein to best facilitate relative comparison of level of protection among alternatives and to assure that the level of protection associated with the site-specific objectives derived is highly conservative for any potential future level of MUN use of segment waters.

### 5.2.3 Objectives Derivation

To establish objectives that limit maximum levels of DBCM, DCBM, and chloroform in the future to existing maximum levels, concentrations in Old Alamo Creek at its terminus corresponding to the 99.9% probability of occurrence were selected (see Appendix B, Table B-5). The 99.9% probability of occurrence represents the reasonable upper bound concentrations occurring in the Old Alamo Creek water as it enters and begins mixing with New Alamo Creek. The resulting site-specific objectives for Alternative 2 and the corresponding risk levels are:

- 4.9 µg/L for DBCM ($10^{-4.9}$ risk level);
- 15.5 µg/L for DCBM ($10^{-4.6}$ risk level); and
- 45.5 µg/L for chloroform ($10^{-5.1}$ risk level).

Because these objectives were derived, in part, to reflect existing water quality conditions at the terminus of Old Alamo Creek, the point of compliance for these objectives also would be the terminus of Old Alamo Creek. The implementation of Alternative 2 objectives is further discussed in Section 5.5.

## 5.3 Alternative 3 – Limit to Existing Water Quality and Achieve a $10^{-5}$ Composite Risk Level

Site-specific objectives derived under this alternative would provide a composite $10^{-5}$ level of cancer risk protection, assuming U.S. EPA's NRWQC methodology, including consumption of 2 L/day of water and up to 17.5 g/day of fish/shellfish. This alternative is similar to Alternative 1 in that the additive or composite cancer risk for consuming all three compounds is approximately $10^{-5}$, but it differs from Alternative 1 in that the objectives for DBCM and chloroform are somewhat more restrictive and that for DCBM is somewhat less restrictive, based on historical concentrations observed in New Alamo Creek near the head of the segments. This alternative is similar to Alternative 2 in that its implementation would limit maximum concentrations to existing levels, preventing further degradation with respect to THM levels in the New Alamo and Ulatis creek segments. It differs from Alternative 2 in that the location used to derive the objectives, and thus where compliance would be assessed, is Brown-Alamo Dam within New Alamo Creek rather than the terminus of Old Alamo Creek. The following sections describe the methodology and site-specific considerations used to derive the Alternative 3 objectives.

### *5.3.1 Methodology*

This alternative's objectives are derived to: 1) provide approximately a $10^{-5}$ composite level of cancer risk protection ; and 2) prevent further degradation of water quality with respect to maximum THM levels in New Alamo and Ulatis creeks. To accomplish this, the methodology for deriving objectives under this alternative consisted of evaluating the historical data set for New Alamo Creek at Brown-Alamo Dam to identify the concentrations of the THM compounds that would provide a composite $10^{-5}$ risk level of protection, assuming U.S. EPA's default exposure levels. The Brown-Alamo Dam location, which is approximately 0.6 miles downstream of the confluence with Old Alamo Creek, was selected because it is the first location downstream of the confluence safely accessible for monitoring year-round, and because it approximates the initial location where Old Alamo Creek water (which contains Easterly WWTP effluent) is fully mixed with New Alamo Creek water.

As described in Section 4.4, while the data set at this location covers a five year period, it does not necessarily represent the entire range of concentrations that has occurred or may occur in the future. Thus, statistical methods were applied to the entire data set ($n$ = 33) to first determine whether the data are distributed normally or lognormally and then (upon defining the statistical distribution), define the probability of occurrence of the DBCM, DCBM, and chloroform concentrations. Then, for each concentration associated with specified probabilities of occurrence, a composite cancer risk level was determined. Table

B-4 in Appendix B summarizes the concentrations of DBCM, DCBM, and chloroform for New Alamo Creek at Brown-Alamo Dam for probabilities of occurrence ranging from 50% to 99.99%. Table B-4 also lists the corresponding equivalent cancer risk, assuming U.S. EPA's NRWQC methodology and default exposure assumptions described in Section 5.3.2.

### *5.3.2 Site-specific Considerations*

As described above in Section 5.1.2, U.S. EPA acknowledges that on a local level (e.g., statewide, regional, or water body basis) a risk level greater than (i.e., less protective than) $10^{-6}$ may be appropriate as long as the most highly exposed population groups do not exceed a $10^{-4}$ risk level (U.S. EPA 2000, p. 2-6). Furthermore, the water in the New Alamo Creek and Ulatis Creek segments has not been in the past, nor is currently, diverted and consumed from the segments and has a low expectation to be used in this manner in the future. Therefore, objectives that would protect at U.S. EPA's minimum required $10^{-4}$ risk level or better, when assuming U.S. EPA's default consumption rates of 2 L/day of water and up to 17.5 g/day of fish/shellfish for a 70-year lifetime (i.e., a high exposure level), would actually provide much higher levels of protection for the segments, based on actual segment exposure levels that have occurred in the past and are expected to occur in the future (RBI 2007), which are substantially lower than U.S. EPA's default assumptions cited here. Nevertheless, U.S. EPA's default exposure assumptions are used herein to best facilitate relative comparison of level of protection among alternatives and to assure that the level of protection associated with the site-specific objectives derived is highly conservative for any potential future level of transient and incidental MUN use of segment waters that could occur.

### *5.3.3 Objectives Derivation*

To establish objectives that provide a composite level of protection of $10^{-5}$ and limit DBCM, DCBM, and chloroform concentrations to prevent further degradation with respect to maximum concentrations of these compounds, the 99.94% probability of occurrence served as the basis for the objectives (see Appendix B, Table B-4). The resulting site-specific objectives for Alternative 3 and corresponding risk levels are:

- 2.6 µg/L for DBCM ($10^{-5.2}$ risk level);
- 9.0 µg/L for DCBM ($10^{-4.8}$ risk level); and
- 39.5 µg/L for chloroform ($10^{-5.2}$ risk level).

Because these objectives were derived, in part, to reflect existing water quality conditions in New Alamo Creek at Brown-Alamo Dam, the point of compliance for these objectives would be Brown-Alamo Dam. The implementation of Alternative 3 objectives is further discussed in Section 5.5.

## SITE-SPECIFIC IMPLEMENTATION CONSIDERATIONS

### 5.4 Objectives Application

The preamble to the CTR states (65 FR 31687):

> *"EPA, in its recent human health methodology revisions, proposed acceptable lifetime cancer risk for the general population in the range of $10^{-5}$ to $10^{-6}$. EPA also proposed that States and Tribes ensure the most highly exposed populations do not exceed a $10^{-4}$ risk level."* (emphasis added)

This statement is presented again here to emphasize that for constituents such as THMs, human health criteria are intended to protect people against development of cancer over a lifetime of exposure to low doses of the constituent in water and food consumed. This has been a consistent concept of U.S. EPA's over the years, as noted in its Technical Support Document (TSD) (U.S. EPA 1991) which states:

> *"Developing permit limits for pollutants affecting human health is somewhat different from setting limits for other pollutants because the exposure period is generally longer than 1 month, and can be up to 70 years, and the average exposure rather than the maximum exposure is usually of concern."*

This is a critically important concept when it comes to implementing the site-specific THM objectives derived for the segments. Because compliance monitoring intends to assess the water body's compliance with applicable human health objectives derived to provide protection over a lifetime of exposure, reasonable averaging periods could be applied for compliance assessment purposes, as long as beneficial uses are protected. In fact, it would be extremely conservative to assess compliance with criteria based on long-term (e.g., up to 70 year) exposure durations based upon any individual measurement or even a monthly average, because values from individual measurements or short-term averages would only be reflective of the true long-term average concentration in the water body by chance. It is more likely that individual measurements or short-term averages would under or over estimate the true long-term average concentration. An annual average would provide an appropriate time frame for assessing compliance with long-term human health objectives for THMs, based on a 70-year lifetime of exposure. Based on these considerations, compliance with the state's current drinking water MCL of 80 µg/L (total THMs), applicable to treated drinking water supplies, is assessed as a 12-month running average of sample concentrations collected quarterly.

Given the goal of ensuring compliance with the long-term human health objectives, the following implementation procedures for the site-specific THM objectives include longer term averaging periods for effluent limitations. The implementation procedures described below would ensure that the following TSD considerations are met: 1) the site-specific objectives would be met over the long-term; and 2) a defensible method of calculating effluent limitations is provided.

## 5.5 Regulatory Implementation for the Easterly Wastewater Treatment Plant

### *5.5.1 Surveillance and Monitoring*

The City already monitors various effluent and receiving water constituents, including THM compounds, under the Monitoring and Reporting Program of its NPDES permit (Order No. R5-2008-0055; NPDES No. CA0077691). Upon the site-specific THM objectives becoming effective, the Regional Water Board would re-open the City's NPDES permit to make the appropriate modifications to the permit, at which time the Monitoring and Reporting Program could be amended to require monitoring for DBCM, DCBM, and chloroform, for example, in Old Alamo Creek at its terminus (i.e., just upstream from New Alamo Creek). Consequently, no new surveillance or monitoring program would be required as part of implementing new site-specific THM objectives.

Although no new surveillance and monitoring program would need to be developed and implemented as part of implementing the anticipated Basin Plan amendments for the proposed site-specific objectives, additional monitoring of DBCM, DCBM, and chloroform by the City is needed to determine whether discharges from the Easterly WWTP have a "reasonable potential" to cause or significantly contribute to an instream excursion above the new objectives, upon their becoming effective. While the intent is to include such additional monitoring requirements in the Easterly WWTP Monitoring and Reporting Program, such additional monitoring is not otherwise required and, therefore, would need to be specified in the Basin Plan amendment so that it would be added to the Easterly WWTP Monitoring and Reporting Program upon the City's NPDES permit being re-opened subsequent to the site-specific objectives becoming effective. For site-specific objective implementation monitoring purposes, it is recommended that the City additionally monitor for DBCM, DCBM, and chloroform in the Easterly WWTP's final effluent and the receiving water (e.g., Old Alamo Creek or New Alamo Creek, depending on the site-specific objectives adopted) monthly for a one-year period during the 5-year term of each subsequently renewed NPDES permit for the Easterly WWTP, or at a frequency consistent with other priority pollutant monitoring in subsequent permits.

How the additional monitoring data would be used to assess reasonable potential and to derive effluent limitations, should reasonable potential occur for one or more of the site-specific objectives, are discussed further below.

### *5.5.2 Reasonable Potential Analysis*

The *Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California* (commonly referred to as the SIP) is the State's policy for control of toxic pollutants. The SIP's basic procedure for determining whether a discharge may cause, have a reasonable potential to cause, or contribute to an excursion above an applicable priority pollutant criterion or objective (when the constituent has been detected in the effluent and the receiving water background concentrations for the constituent are below the criterion) are summarized below (SWRCB 2005, Section 1.3).

- Identify applicable water quality criteria/objectives and determine the lowest (most stringent) water quality criterion or objective for the pollutant applicable to the receiving water (C).
- Determine the observed maximum pollutant concentration for the effluent (MEC).
- Compare the MEC (or the adjusted MEC, as appropriate) to the C. If the MEC is greater than or equal to C, then reasonable potential exists, an effluent limitation is required, and the analysis for the subject pollutant is complete.

Following the site-specific objectives becoming effective and the monitoring discussed above being implemented, results from the monitoring would be used to assess whether the City's discharge from its Easterly WWTP has reasonable potential to cause or significantly contribute to an in-stream excursion above the long-term human health site-specific THM objectives applicable to the lower segment of New Alamo Creek, the first downstream water body where the site-specific objectives would be applicable.

In an effort to resolve the City's current THM compliance issue while fully protecting human health and achieving the goal level of protection desired by the State for potential future MUN uses, the following approaches for assessing reasonable potential are proposed as part of implementation procedures for the alternative site-specific objectives. These approaches are consistent with the spirit and intent of the SIP (SWRCB 2005), but include site-specific adjustments to the portion of the SIP procedure that compares the MEC to the criterion. This adjustment accommodates a site-specific situation not contemplated in the SIP where: 1) Old Alamo Creek, the direct receiving water of the Easterly WWTP, does not have a MUN designation, 2) New Alamo Creek, the first water body to which Old Alamo Creek is tributary a few miles downstream, does have an MUN designation, and 3) DBCM, DCBM, and chloroform undergo substantial volatilization within Old Alamo Creek.

#### 5.5.2.1 Alternative 1 and 3 Objectives

The proposed Alternative 1 and 3 site-specific objectives are:

| Constituent | Alternative 1 Objectives | Alternative 3 Objectives |
|---|---|---|
| DBCM | 4.0 µg/L | 2.6 µg/L |
| DCBM | 5.5 µg/L | 9.0 µg/L |
| Chloroform | 57.0 µg/L | 39.5 µg/L |

Compliance Assessment Monitoring Location. The point of measurement for routine monitoring to determine whether reasonable potential to cause an excursion of a site-specific objective exists would be New Alamo Creek at Brown-Alamo Dam, the initial accessible location where Old Alamo Creek water is fully mixed with that of New Alamo Creek, which is located approximately 0.6 miles downstream of the New Alamo-Old Alamo Creek confluence.

Compliance Assessment Approach. For Alternative 1 or 3 objectives, the need for water-quality based effluent limitations for discharges to Old Alamo Creek that ultimately enter New Alamo Creek will be determined in a two-step manner. First, the maximum effluent concentration (MEC) for DBCM, DCBM and chloroform shall be determined and compared to the site-specific objectives for DBCM, DCBM, and chloroform applicable to the New Alamo Creek and Ulatis Creek segments. If the MEC does not exceed the applicable site-specific objective, there is no reasonable potential and no need for a water quality-based effluent limitation. Second, the maximum concentrations of DBCM, DCBM and chloroform at Brown-Alamo Dam shall be determined and compared to the site-specific objectives for DBCM, DCBM, and chloroform. If the maximum concentrations of DBCM, DCBM or chloroform at Brown-Alamo Dam do not exceed the site-specific DBCM, DCBM, and chloroform objectives, then no reasonable potential exists for these constituents for any discharge occurring to Old Alamo Creek. Conversely, if the maximum concentrations of DBCM, DCBM or chloroform at Brown-Alamo Dam exceed the applicable site-specific objectives for these segments, then water quality-based effluent limitations are necessary for any discharge into Old Alamo Creek for which the MEC also exceeded the site-specific objectives for DBCM, DCBM and chloroform, and thus caused or contributed to the exceedance within the segments. The most recent three years of measured effluent and Brown-Alamo Dam THM concentrations would be used to make this determination.

#### 5.5.2.2 Alternative 2 Objectives

The proposed Alternative 2 site-specific objectives are:

| Constituents | Alternative 2 Objectives |
|---|---|
| DBCM | 4.9 µg/L |
| DCBM | 15.5 µg/L |
| Chloroform | 45.5 µg/L |

Compliance Assessment Monitoring Location. The point of measurement for routine monitoring to determine whether reasonable potential to cause an excursion of a site-specific objective exists would be the terminus of Old Alamo Creek, which is immediately upstream of New Alamo Creek, the first downstream location with a MUN beneficial use designation.

Compliance Assessment Approach. For Alternative 2 objectives, the need for water-quality based effluent limitations for discharges to Old Alamo Creek, that ultimately enter New Alamo Creek, will be determined in a two-step manner. First, the maximum effluent concentration (MEC) for DBCM, DCBM and chloroform shall be determined and compared to the site-specific objectives for DBCM, DCBM, and chloroform applicable to the New

Alamo Creek and Ulatis Creek segments. If the MEC does not exceed the applicable site-specific objective, there is no reasonable potential and no need for a water quality-based effluent limitation. Second, the maximum concentrations of DBCM, DCBM and chloroform at the terminus of Old Alamo Creek shall be determined and compared to the site-specific objectives for DBCM, DCBM, and chloroform. If the maximum concentrations of DBCM, DCBM or chloroform at the terminus of Old Alamo Creek do not exceed the site-specific DBCM, DCBM, and chloroform objectives, then no reasonable potential exists for these constituents for any discharge occurring to Old Alamo Creek. Conversely, if the maximum concentrations of DBCM, DCBM or chloroform at the terminus of Old Alamo Creek exceed the applicable site-specific objectives for these segments, then water quality-based effluent limitations are necessary for any discharge into Old Alamo Creek for which the MEC also exceeded the site-specific objectives for DBCM, DCBM and chloroform, and thus caused or contributed to the exceedance within the segments. The most recent three years of measured effluent and terminus of Old Alamo Creek THM concentrations would be used to make this determination.

### *5.5.3 Deriving NPDES Effluent Limitations Should Reasonable Potential Exist*

When longer-term effluent limitations (e.g., annual) are employed, which is reasonable for long-term human health criteria/objectives that are based on a 70-year lifetime exposure (at the criteria/objective concentration), the MDEL and AMEL provide upper bounds to the concentrations allowed in meeting the long-term average, as well as provide a measure of effluent compliance during operational periods less than a year. The following sections describe how annual average, monthly average, and maximum daily effluent limitations would be derived for each set of alternative site-specific objectives.

#### 5.5.3.1 Alternative 1 and 3 Objectives

In the case of calculating effluent limitations to achieve Alternative 1 and 3 objectives in New Alamo Creek for DBCM, DCBM, and chloroform, an attenuation factor must be determined and used. Attenuation is the lessening of the concentration between two locations. In this case, it is the lessening of concentration between the effluent discharge location and a compliance monitoring location at Brown-Alamo Dam, in New Alamo Creek. Inclusion of an attenuation factor in this case addresses the unique circumstance of having:

1) an intervening water body (i.e., Old Alamo Creek) with less stringent water quality standards;
2) volatilization of DBCM, DCBM, and chloroform as water travels down Old Alamo Creek; and
3) dilution of effluent discharges by Old Alamo Creek water and by New Alamo Creek water between the confluence of New and Old Alamo Creek and the monitoring location of Brown-Alamo Dam.

An attenuation factor to account for THM volatilization in Old Alamo Creek and dilution within Old Alamo and New Alamo creeks would be applied to the calculation of effluent limitations. The attenuation factor would be the median of the individual measured attenuation factors determined between the effluent discharge location and Brown-Alamo Dam on New Alamo Creek, based on all representative historical data collected during all months of the year. This is appropriate because both volatilization and dilution that occur between the effluent discharge location and the compliance monitoring location at Brown-Alamo Dam are being addressed via the attenuation factor. The median of all representative historical monitoring event attenuation factors would be used for deriving effluent limitations because it is the long-term average concentration that is relevant for such human health criteria. Use of the median attenuation value (rather than the mean value) results in less bias from atypically high or low individual sample values.

Attenuation factors for each monitoring event would be calculated as follows:

Attenuation Factor = Measured effluent concentration ÷
Measured Brown-Alamo Dam concentration

As an example for a given monitoring event, if the regulated effluent discharge into Old Alamo Creek had a concentration of 20 µg/l and the sample collected at Brown-Alamo Dam that day had a concentration of 5 µg/l, then the sample event attenuation factor would be 20/5 = 4.0.

Again, the final attenuation factor used for deriving effluent limitations would be the median attenuation factor derived from all representative historical monitoring data for all months of the year.

The Effluent Credit Allowance (ECA) would be calculated as:

ECA = Attenuation Factor x C

Where C is the site-specific objective.

Dilution credit (D) and ambient background concentration (B) within New Alamo Creek (per Section 1.4 of the SIP (SWRCB 2005)) are accounted for in the attenuation factor by having the compliance monitoring location at Brown-Alamo Dam.

Annual average, monthly average, and daily maximum effluent limitations would be derived for each constituent for which reasonable potential to cause an excursion of a water quality objective has been demonstrated. These effluent limitations would be calculated as follows:

Average Annual Effluent Limitation (AAEL) shall be set equal to the ECA.

Average Monthly Effluent Limitation (AMEL) shall be calculated as:

AMEL = ECA x AMEL multiplier.

Maximum Daily Effluent Limitation (MDEL) shall be calculated as:

MDEL = ECA x (MDEL multiplier/AMEL multiplier).

The AMEL multiplier and the MDEL multiplier would be calculated in accordance with the procedures in the SIP (SWRCB 2005).

Other than calculation of the effluent limitations as described above, all other provisions of the SIP that apply when water quality-based effluent limitations are found to be necessary would also apply when implementing the site-specific objectives for DBCM, DCBM, and chloroform for the lower segments of New Alamo Creek and Ulatis Creek.

An example calculation of effluent limitations for Alternative 1 and 3 objectives, which are assessed in New Alamo Creek at Brown-Alamo Dam, is provided in **Appendix C**.

#### 5.5.3.2 Alternative 2 Objectives

In the case of calculating effluent limitations to achieve Alternative 2 objectives in New Alamo Creek for DBCM, DCBM, and chloroform, an attenuation factor also must be determined and used. However, the attenuation factor in this case is somewhat different due to the monitoring dataset from which the objectives were derived being based upon data collected at the terminus of Old Alamo Creek (immediately prior to its confluence with New Alamo Creek) rather than the Brown-Alamo Dam location. In addition, this attenuation factor is the lessening of the concentration between the effluent discharge location (e.g., the Easterly WWTP) and the monitoring location of the terminus of Old Alamo Creek due primarily to volatilization within Old Alamo Creek, and thus does not account for dilution within Old Alamo Creek or dilution within New Alamo Creek. Because Old Alamo Creek has been disconnected from its upper watershed, it does not convey significant watershed-derived flows that would provide dilution of Easterly WWTP discharges. Old Alamo Creek does, in its lower reach, convey agricultural flows during the irrigation season. Therefore, monitoring data collected during the non-irrigation months of November through March would be used to determine the attenuation due to volatilization only, when little to no dilution within Old Alamo Creek is occurring (see Section 4.2 for additional discussion on volatilization within Old Alamo Creek).

The attenuation factor for this implementation approach would thus be the median of the individual measured attenuation factors determined between the effluent discharge location and the terminus of Old Alamo Creek, based on all representative historical measurements during the November through March period of the year, when agricultural water is not conveyed in Old Alamo Creek (RBI 2008). Using only the November through March monitoring data for deriving the attenuation factor assures that the attenuation factor addresses primarily loss due to volatilization within Old Alamo Creek, so that dilution can be addressed separately, and in a manner most consistent with the SIP, as shown below. Attenuation factors for each monitoring event conducted during the November through March period would be calculated as follows:

Attenuation Factor = Measured effluent concentration ÷
Measured concentration at terminus of Old Alamo Creek

As an example for a given monitoring event, if the regulated effluent discharge into Old Alamo Creek had a concentration of 20 µg/l and the sample collected at the terminus of Old Alamo Creek that day had a concentration of 5 µg/l, then the sample event attenuation factor would be 20/5 = 4.0.

Again, the final attenuation factor used for deriving effluent limitations would be the median attenuation factor derived from representative historical monitoring data for the months of November through March of each year.

The Effluent Credit Allowance (ECA) would be calculated as:

ECA = Attenuation Factor x [C + D(C-B)] when $C > B$

ECA = Attenuation Factor x C when $C \leq B$

Where C, D, and B are the site-specific objective, dilution credit, and ambient background concentration as defined by the SIP (SWRCB 2005).

In deriving effluent limitations, dilution credit and ambient background concentration (within New Alamo Creek) would be addressed according to SIP procedures rather than in the attenuation factor as is proposed for Alternative 1 and 3 objectives.

Annual average, monthly average, and daily maximum effluent limitations would be derived for each constituent for which reasonable potential has been demonstrated. These effluent limitations would be calculated as follows:

Average Annual Effluent Limitation (AAEL) shall be set equal to the ECA.

Average Monthly Effluent Limitation (AMEL) shall be calculated as:

AMEL = ECA x AMEL multiplier.

Maximum Daily Effluent Limitation (MDEL) shall be calculated as:

MDEL = ECA x (MDEL multiplier/AMEL multiplier).

The AMEL multiplier and the MDEL multiplier would be calculated in accordance with the procedures in the SIP (SWRCB 2005).

Other than calculation of the effluent limitations as described above, all other provisions of the SIP that apply when water quality-based effluent limitations are found to be necessary would also apply when implementing the site-specific objectives for DBCM, DCBM, and chloroform for the lower segments of New Alamo Creek and Ulatis Creek.

An example calculation of effluent limitations for Alternative 2 objectives, which are assessed at the terminus of Old Alamo Creek, is provided in Appendix C.

The approaches to deriving effluent limitations for DBCM, DCBM, and chloroform, described above, are consistent with the spirit and intent of U.S. EPA's TSD (U.S. EPA 1991) and the SIP (SWRCB 2005). Moreover, the approaches are consistent with State and federal regulations and would assure compliance with the site-specific objectives in the New Alamo Creek and Ulatis Creek segments and, therefore, would assure protection of beneficial uses at the levels intended. A summary of the alternative site-specific DBCM, DCBM, and chloroform objectives and implementation approaches is provided in **Table 5**.

**Table 5. Summary of alternative site-specific objectives and compliance assessment approaches**

| Alternative Site-Specific Objectives (Values are specified as µg/L) | | | |
|---|---|---|---|
| **Constituent** | **Alternative 1: U.S. EPA NRWQC,[1] $10^{-5}$ Risk Level** | **Alternative 2: Limit to Existing Water Quality Throughout Segments** | **Alternative 3: Limit to Existing Water Quality and Achieve a $10^{-5}$ Composite Risk Level** |
| Dibromochloromethane | 4.0 | 4.9 | 2.6 |
| Dichlorobromomethane | 5.5 | 15.5 | 9.0 |
| Chloroform | 57 | 45.5 | 39.5 |
| **Implementation Approach [2]** | | | |
| Location for Compliance Assessment | New Alamo Creek at Brown-Alamo Dam | Old Alamo Creek Terminus | New Alamo Creek at Brown-Alamo Dam |
| Effluent Limitation Derivation Approach | A | B | A |

[1] Objectives calculated using U.S. EPA's approach for deriving its 2006 National Recommended Water Quality Criteria.
[2] Approach for assessing whether the Easterly WWTP discharge has reasonable potential to cause or contribute to an excursion above applicable site-specific THM objectives for the segments based on most recent three years of data:

A – Maximum concentration measured in New Alamo Creek at Brown-Alamo Dam is compared to the site-specific objectives for assessing whether controllable factors affecting THM levels have a reasonable potential to cause or substantially contribute to exceedances of the site-specific objectives. If needed, effluent limitations would be derived using the median attenuation factor calculated from representative historical data. The attenuation factor for each monitoring event would be calculated as the effluent concentration divided by the New Alamo Creek concentration measured at Brown-Alamo Dam (see Section 5.5.3).

B – Maximum measured concentration in Old Alamo Creek at terminus is compared to the site-specific objectives for assessing whether controllable factors affecting THM levels have a reasonable potential to cause or substantially contribute to exceedances of the site-specific objectives. If needed, effluent limitations would be derived using the median attenuation factor calculated from representative historical data for the months of November through March only to address volatilization losses within Old Alamo Creek. The attenuation factor for each monitoring event would be calculated as the effluent concentration divided by the Old Alamo Creek concentration at its terminus. Dilution credit would be calculated consistent with the SIP (SWRCB 2005) (see Section 5.5.3).

Although not part of or triggered by this standards refinement process or its outcome, for the purposes of assessing reasonable potential, the MEC for DBCM and DCBM are currently compared (and shall continue to be compared in the future) to the CTR organism only criteria for these constituents, which are applicable to Old Alamo Creek – the direct receiving water of the Easterly WWTP. Both the reasonable potential assessment for the CTR organism only criteria and derivation of effluent limitations, should reasonable potential to cause an excursion of the water quality criteria exist, is currently (and will continue to be in the future) directed by the SIP's procedures in Sections 1.3 and Section 1.4 (SWRCB 2005). As such, the Basin Plan amendments for the site-specific DBCM, DCBM, and chloroform objectives applicable to the New Alamo and Ulatis creek segments would in no way affect regulation of the CTR organism only criteria for DBCM and DCBM currently applicable to Old Alamo Creek.

# 6 ASSESSMENT OF BENEFICIAL USE PROTECTION

Water quality criteria/objectives must be protective of the most sensitive beneficial uses. The most sensitive beneficial use for the THM compounds evaluated herein is MUN. The site-specific objectives presented in the previous section have been derived to protect this use. The following subsections describe how implementation of these site-specific objectives would protect the MUN use within the segments and within Cache Slough and downstream Delta waters.

## 6.1 New Alamo and Ulatis Creek Segments

As has been described elsewhere in this report, a UAA has been conducted that produced substantial evidence to indicate that MUN is neither an existing nor attainable use of New Alamo Creek, downstream of Old Alamo Creek, nor is it an existing or attainable use of Ulatis Creek, downstream of New Alamo Creek (RBI 2007). Nevertheless, the MUN use would remain a designated use and site-specific objectives that provide the goal level of THM protection sought by the State and Regional Water Boards and U.S. EPA shall be developed, adopted, and approved for the segments through the State's basin planning process.

### *6.1.1 Alternative 1 Objectives*

Alternative 1 objectives would provide a $10^{-5}$ level of protection (i.e., risk of one additional cancer in 100,000 people over a lifetime of exposure) for people that consumed 2 L/day of water diverted from the segments and consumed up to 17.5 g/day of fish/shellfish collected from the segments, for a 70-year lifetime. This is a very high level of protection even if people were consuming water and organisms from the segments for a 70-year lifetime at the daily rates identified above, which is not occurring presently, and is not expected to occur in the future. Consequently, these objectives actually would provide much higher levels of human health protection because daily exposure rates and exposure duration associated with the segments is expected to be substantially less than that assumed for deriving the Alternative 1 objectives. Due to expected low levels of exposure, these site-specific objectives are anticipated to provide $10^{-6}$ or higher levels of human health protection for the segments.

### *6.1.2 Alternative 2 and 3 Objectives*

The level of protection that the Alternative 2 and 3 objectives would provide, assuming U.S. EPA's NRWQC methodology and consumption for 2 L/day of water and up to 17.5 g/day of fish/shellfish for a 70-year lifetime, is provided in **Table 6**.

**Table 6. Alternative 2 and 3 THM objectives and corresponding risk levels.**

| Constituent | Alternative 2 | | Alternative 3 | |
|---|---|---|---|---|
| | Objectives | Risk Level | Objectives | Risk Level |
| Dibromochloromethane | 4.9 | $10^{-4.9}$ | 2.6 | $10^{-5.2}$ |
| Dichlorobromomethane | 15.5 | $10^{-4.6}$ | 9.0 | $10^{-4.8}$ |
| Chloroform | 45.5 | $10^{-5.1}$ | 39.5 | $10^{-5.2}$ |

Alternative 2 and 3 objectives would provide a high level of protection even if people were consuming water and organisms from the segments at U.S. EPA's default NRWQC rates cited above, for a 70-year lifetime. At these assumed exposure levels, the Alternative 2 DBCM and DCBM objectives would provide a level of protection somewhat lesser than $10^{-5}$ but substantially greater than the minimum of $10^{-4}$ required by U.S. EPA, whereas the objective for chloroform would provide a level of protection slightly greater than $10^{-5}$. The Alternative 3 DCBM objective would provide a level of protection slightly less than $10^{-5}$, but substantially greater than the minimum of $10^{-4}$ required by U.S. EPA, whereas the objectives for DBCM and chloroform would provide a level of protection slightly greater than $10^{-5}$.

Exposure at these assumed levels is not presently occurring within the segments and is not expected to occur at these daily rates and durations in the future. Consequently, Alternative 2 and 3 objectives actually would provide much greater levels of human health protection because daily exposure rates and exposure duration associated with the segments is expected to be substantially lesser than that assumed for deriving and assessing the objectives. Due to expected low levels of exposure, these objectives are anticipated to provide $10^{-6}$ or greater levels of human health protection for segment waters. As such, the MUN beneficial use of the New Alamo Creek and Ulatis Creek segments would be fully protected following implementation of the Alternative 2 or Alternative 3 site-specific objectives presented herein.

## 6.2 Cache Slough and Downstream Delta Waters

Adoption, approval, and implementation of the site-specific THM objectives cannot cause or substantially contribute to an excursion above CTR criteria for DBCM and DCBM or U.S. EPA recommended criteria for chloroform that would remain applicable for regulatory purposes downstream of the segments (i.e., in Cache Slough and downstream Delta waters). These criteria, based on a $10^{-6}$ risk level, are:

| Constituent | Criterion | Source |
| --- | --- | --- |
| DBCM | 0.41 µg/L | CTR |
| DCBM | 0.56 µg/L | CTR |
| Chloroform | 5.7 µg/L | 2006 U.S. EPA NRWQC |

Figure 3, Figure 4, and Figure 5 (see Section 4.1 of this report) show that historically, DBCM, DCBM, and chloroform concentrations at the defunct City of Vallejo pump station (which is in Cache Slough immediately downstream of the confluence of Ulatis Creek with Cache Slough) have always been below the above-listed, applicable THM criteria for Cache Slough. Concentrations of THMs are further reduced within Cache Slough, downstream of the Vallejo pump station, due to large dilution within the main body of Cache Slough. Consequently, adoption, approval, and implementation of Alternative 1, 2, or 3 site-specific objectives – all of which would effectively limit THM concentrations within the New Alamo Creek and Ulatis Creek segments in the future to levels that have historically occurred in these segments – would pose no risk of causing excursions of currently applicable THM criteria in Cache Slough or downstream Delta waters. Therefore, all waters downstream of the segments would experience THM concentrations that correspond to $10^{-6}$ or greater levels of protection (i.e., risk of one addition cancer or less in 1,000,000 people following a lifetime of exposure). As such, the MUN beneficial use of Cache Slough and downstream Delta waters would be fully protected following implementation of any of the site-specific THM objectives presented herein.

# 7 ANTIDEGRADATION POLICY ANALYSIS

Both U.S. EPA (40 CFR 131.12) and the State of California (State Board Resolution 68-16) have adopted antidegradation policies as part of their approach to regulating water quality. The Regional Water Board must ensure that its actions do not violate the federal or State antidegradation policies. This section of the report analyzes whether adoption, approval, and implementation of the proposed site-specific THM objectives would be consistent with the federal and State antidegradation policies.

## 7.1 Federal Antidegradation Policy

The federal antidegradation policy, 40 CFR 131.12(a), states in part:

> *"(1) Existing instream water uses and the level of water quality necessary to protect the existing uses shall be maintained and protected.*
>
> *(2) …. Where the quality of waters exceed levels necessary to support propagation of fish, shellfish, and wildlife and recreation in and on the water, that quality shall be maintained and protected unless the State finds, after full satisfaction of the intergovernmental coordination and public participation provisions of the State's continuing planning process, that allowing lower water quality is necessary to accommodate important economic or social development in the area in which the waters are located….*
>
> *(3) Where high quality waters constitute an outstanding National resource, such as waters of National and State parks and wildlife refuges and waters of exceptional recreational or ecological significance, that water quality shall be maintained and protected."*

## 7.2 State Antidegradation Policy

Antidegradation provisions of State Board Resolution No. 68-16 ("Statement of Policy With Respect to Maintaining High Quality Waters in California") state, in part:

> "*1. Whenever the existing quality of water is better than the quality established in policies as of the date on which such policies become effective, such existing high quality will be maintained until it has been demonstrated to the State that any change will be consistent with maximum benefit to the people of the State, will not unreasonably affect present and anticipated beneficial use of such water and will not result in water quality less than that prescribed in the policies.*
>
> *2. Any activity which produces or may produce a waste or increased volume or concentration of waste and which discharges or proposes to discharge to existing high quality waters will be required to meet waste discharge requirements which will*

*result in the best practicable treatment or control of the discharge necessary to assure that (a) a pollution or nuisance will not occur and (b) the highest water quality consistent with maximum benefit to the people of the State will be maintained.*"

## 7.3 Consistency of Site-specific Objectives Adoption with Antidegradation Policies

### *7.3.1 Consistency with Federal Policy*

Upon implementation of Alternative 1, 2, or 3 site-specific objectives, existing segment beneficial uses would remain unchanged, and the THM concentrations within the segments are expected to continue to be maintained at historical levels. The action of adopting the site-specific objectives, itself, would not result in increased loading of THMs to the segments, relative to past and present conditions, and thus would not result in a lowering of water quality. Moreover, by design of the site-specific objectives themselves, the level of water quality necessary to protect the segment's beneficial uses, including the MUN use, would be maintained and protected. Approval of any new or increase in allowable discharge of THMs into the water bodies covered by these site-specific objectives would have to undergo permit-specific antidegradation analysis.

### *7.3.2 Consistency with State Policy*

Adoption, approval, and implementation of Alternative 1, 2, or 3 site-specific objectives for the New Alamo Creek and Ulatis Creek segments would not, itself, cause any new or increased volume of waste to be discharged to surface waters. Moreover, the action would not cause any increase beyond current levels in the discharge of THMs or other pollutants to the creek segments and thus would not result in a lowering of water quality. THM concentrations within the segments are expected to remain at levels that have been historically observed. In addition, any discharge to the creek segments must be regulated to ensure that downstream water quality standards are met. Any new point-source discharge or increased volume of waste discharge to the segments that could cause degradation in THM or other water quality parameters would require an antidegradation analysis prior to the State permitting the new or expanded-capacity discharge and any associated water quality degradation.

The Easterly WWTP initiated discharges to surface waters at its present location in 1960. THM concentrations in the creek segments as of October 28, 1968, the date on which the state antidegradation policy became effective, are unknown. Nevertheless, the Regional Water Board made findings in the recently renewed NPDES permit issued to the City to operate the Easterly WWTP (Order No. R5-2008-0055; NPDES No. CA0077691) that states (p. F-40, Section IV.D.4 Satisfaction of Antidegradation Policy):

"*This Order includes effluent limitations that will require Title 22 tertiary treatment or equivalent to achieve compliance, which is a high level of treatment that is considered best practicable treatment or control (BPTC) for most constituents in the wastewater and will result in attaining water quality standards applicable to the* *discharge. The Order includes less stringent effluent limitations for some constituents. However, as discussed in detail in Section IV.D.3., above, the new limitations are fully protective of the beneficial uses of the receiving water and are in compliance with federal anti-backsliding regulation. … The permitted surface water and groundwater discharges are consistent with the antidegradation provisions of 40 CFR 131.12 and State Water Board Resolution 68-16. Compliance with the requirements of this Order will result in the use of best practicable treatment or control of the discharge. The impact on existing water quality will be insignificant."*

The Easterly WWTP facilities and their operations have been optimized to minimize the use of chlorine and, thus, formation of THMs. The current permit includes effluent limitations that will require seasonal Title 22 tertiary treatment, or equivalent. The upgrade to tertiary treatment will increase the quality of the effluent and the higher quality effluent will ensure that chlorine use and THM formation will remain similar to existing conditions, or decrease slightly. In addition, the State addressed consistency with the federal and State antidegradation policies when it dedesignated the MUN use for Old Alamo Creek (see Regional Water Board Resolution No. R5-2005-0053).

The above-referenced findings are consistent with previous State Water Board actions on antidegradation for these receiving waters and indicate that the current Easterly WWTP discharge and its associated effects on receiving water quality are consistent with the State's antidegradation policy. Because the action of adopting the site-specific objectives would not, itself, result in increased loading of THMs to the segments, relative to current conditions, existing water quality with respect to THMs would be maintained. Moreover, the site-specific objectives are anticipated, based on expected exposure levels within the segments, to provide $10^{-6}$ or higher levels of human health protection for MUN, the use most sensitive to THM concentrations. Consequently, MUN and other segment beneficial uses would remain protected. Compliance with the site-specific THM objectives, upon their becoming effective, would not allow lower THM water quality than prescribed in the policies within the segments or within downstream Delta waters.

Although existing water quality pertaining to THMs would not change in the segments or downstream waters upon the site-specific objectives becoming effective, the site-specific objectives would allow higher DBCM and DCBM concentrations in the New Alamo Creek and Ulatis Creek segments than do the existing CTR criteria for these same constituents. However, as stated previously, any new point-source discharge or increased volume of waste discharge to the segments that could cause a degradation in THM or other water quality parameters, relative to current water quality, would require an antidegradation analysis prior to the State permitting the new or expanded-capacity discharge and any associated water quality degradation. The site-specific objectives would have no effect on the levels of these constituents allowed in Cache Slough and downstream waters, as regulated by the CTR. Furthermore, if it is determined that any increases in THMs allowed in the water bodies covered by these site-specific objectives are causing exceedances of the downstream water quality criteria, then the allowable loadings into the upstream water bodies would need to be lowered to protect the downstream waters. This would be accomplished by waste discharge requirements imposed through NPDES permits to assure the applicable criteria are met in downstream waters.

The site-specific objectives would, as an aggregate, provide approximately a $10^{-5}$ level of protection at the exposure levels assumed for deriving the objectives, which would not preclude the future use of these water bodies for MUN. Based on documented current and future expected exposure levels within the segments (that are substantially lower than those assumed for deriving and evaluating the site-specific objectives), regulation of present controllable factors affecting water quality to achieve the site-specific objectives within the segments would provide on the order of $10^{-6}$ or higher levels of human health protection for MUN. Achieving compliance with current CTR criteria within the segments (which provide $10^{-6}$ level of protection when consuming 2 L/day of water diverted from the segments and consuming up to 6.5 g/day of fish/shellfish collected from the segments for a 70-year lifetime – a level of exposure not currently occurring or expected to occur in the future within the segments) would require extensive modifications and upgrades to the Easterly WWTP at an estimated cost of at least $34.8 million (West Yost & Associates 2008). In the future, should these water bodies be contemplated for MUN use, then the site-specific objectives could be re-assessed to ensure that they are still protective of the use, if necessary. This could be done during the triennial review of the Basin Plan.

Based on these considerations, adoption and approval of either Alternative 1, 2, or 3 objectives would be consistent with the federal and State antidegradation policies.

# 8 ECONOMIC CONSIDERATIONS

This section describes the economic effects of adopting, approving, and implementing the site-specific objectives derived and evaluated herein versus a "no project scenario" where the site-specific objectives are not implemented and the City of Vacaville is required to construct additional facilities. Should site-specific THM objectives for the segments not be adopted, additional Easterly WWTP facilities would have to be constructed in an effort to comply with the CTR criteria for DBCM, DCBM, and U.S. EPA's recommended criteria for chloroform in the segments of New Alamo Creek and Ulatis Creek.

In a memorandum to D. Tompkins, Utilities Director of the City of Vacaville dated August 29, 2008, West Yost & Associates described the facilities required to be added to the City's Easterly WWTP in order to comply with its renewed NPDES permit. The majority of the following text describing the additional facilities and costs has been taken directly from the West Yost & Associates (2008) memorandum in order to present, in this report, preliminary estimates of the costs associated with reducing effluent THM concentrations in an effort to comply with final THM NPDES effluent limitations based on meeting CTR THM criteria within the segments.

West Yost & Associates (2008) characterized and evaluated three plant modification scenarios. The distinguishing characteristics of each scenario are as follows.

1) Base Case Scenario A: Seasonal Filtration and Title 22 disinfection during the summer months only. Blending elimination would be accomplished, in part, through the equalization of raw sewage in the North Plant process tankage.

2) Base Case Scenario B: Same as Base Case Scenario A except that blending elimination would be accomplished, in part, through the equalization of primary effluent in the North Plant process tankage.

3) Alternative Scenario: Reduction of THMs. This alternative would include many of the elements of the Base Case alternatives but would replace the plant's existing chlorine based disinfection system with a ultra-violet (UV) light disinfection system in order to reduce the formation of THMs in the treatment plant. The effluent filtration system also would need to be capable of operating year-round, as part of an effective UV disinfection system.

The purpose of the UV disinfection process in the "Alternative Scenario" is to accomplish effluent disinfection without the use of chlorine, which is known to combine with residual organics in the effluent to form THMs. For purposes of the West Yost & Associates (2008) memorandum, provision of a UV disinfection system was used for the purpose of determining the cost of meeting the CTR THM criteria within the segments. However, there is growing uncertainty regarding whether the use of UV for effluent disinfection will be sufficient to reliably comply with the CTR requirements for the following reasons.

1. The elimination of THM formation in the plant does not address the THMs that may be in the effluent that were also in the influent wastewater when it arrived at the plant.

2. Although the post-chlorination disinfection system is the largest use of chlorine at the plant, it is not the only use. Other uses for chlorine for which there are no alternatives include: Return Activate Sludge (RAS) chlorination for sludge bulking control; effluent filter cleaning operations; and providing a chlorine residual in the recycled water used for sprayers and in-plant equipment (referred to as "3W" water in West Yost & Associates (2008)) in order to protect the plant staff from exposure to aerosols.

3. Review of historical data shows that UV disinfection plants presently operating in California have not always complied with THM effluent limitations based on CTR THM criteria.

The preliminary cost estimated for each of these scenarios is presented in **Table 7**.

**Table 7. Preliminary estimate of total project capital costs for alternative compliance scenarios.**

| Summary Description of Alternative Scenario | Estimated Total Project Cost |
|---|---|
| **Base Case - Scenario A:** Blending elimination (raw sewage equalization); denitrification; seasonal filtration. | $129,450,000 |
| **Base Case - Scenario B:** Blending elimination (primary effluent equalization); denitrification; seasonal filtration. | $133,360,000 |
| **Alternative Scenario:** Blending elimination; denitrification; year-round filtration, THM reduction. | $164,230,000 |

Source: West Yost & Associates (2008).

The modifications to the existing treatment facilities for the "Alternative Scenario" also would affect the operation and maintenance costs at the plant, relative to not implementing the THM reduction facilities. Although not quantified at this time, these modifications are expected to increase (likely substantially) the overall annual operation and maintenance costs at the plant.

Based on the information presented above, the "Base Case A" scenario cost of $129,450,000 can be subtracted from the "Alternative Scenario" cost of $164,230,000 to produce an estimated cost of $34.8 million to construct additional facilities to produce year-round filtration and UV disinfection at the Easterly WWTP in an effort to comply with CTR-based THM effluent limitations.

**Table 8** summarizes key implementation considerations and economic impacts to various parties associated with adopting and implementing the site-specific objectives versus modifying the Easterly WWTP to comply with CTR THM criteria currently applicable to the segments.

**Table 8. Comparison of implementation considerations and economic impacts of implementing site-specific THM objectives for New Alamo Creek and Ulatis Creek segments versus modifying the Easterly WWTP in an attempt to comply with current CTR criteria in the segments.**

| Issue | Adoption and Approval of Site-specific Objectives | Modify Easterly WWTP |
|---|---|---|
| Implementation Considerations | • Development, adoption, and approval of site-specific objectives through State's Basin Plan amendment process<br>• Amendment to CTR through U.S. EPA's regulatory process | • Design and construction of additional and new facilities at the Easterly WWTP<br>• Operation of additional facilities<br>• May not completely resolve regulatory problems associated w/ THM compliance in New Alamo and Ulatis Creek segments |
| Direct Capital Cost for City of Vacaville | $1 Million [a] | $34.8 Million [b] |
| Operations and Maintenance cost for City of Vacaville | none | Substantial increase[c] over existing annual O&M cost for Easterly WWTP |
| Direct Cost to Other Parties | none | none |

[a] Cost to develop and process the proposed Basin Plan amendments.

[b] Initial capital cost estimate (West Yost Associates Memorandum to David Tompkins of the City of Vacaville dated August 29, 2008).

[c] Not quantified at the time this report was prepared.

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# Appendix A

## Receiving Water Data Tables

The following data tables provide the statistics supporting Figure 3, Figure 4, and Figure 5. For illustration purposes, all non-detect data are represented as zero.

| **Dibromochloromethane (DBCM)** | EWWTP outfall | End of Old Alamo | New Alamo at Lewis Rd. | New Alamo below Old Alamo | End of New Alamo | Ulatis Ck above New Alamo | Maine Prairie Rd on Ulatis | Brown Rd on Ulatis | Ulatis above Vallejo Pump Station | Vallejo Pump Station (VPS) |
|---|---|---|---|---|---|---|---|---|---|---|
| Begin Date | 9/10/2002 | 9/10/2002 | 9/10/2002 | 9/10/2002 | 9/10/2002 | 9/10/2002 | 9/10/2002 | 9/10/2002 | 9/10/2002 | 9/10/2002 |
| End Date | 5/6/2008 | 8/14/2007 | 8/14/2007 | 8/14/2007 | 8/14/2007 | 8/14/2007 | 8/14/2007 | 8/14/2007 | 8/14/2007 | 8/14/2007 |
| Lower quartile | 2.4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Minimum | 1.7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Median | 3.2 | 0.60 | 0 | 0.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Maximum | 14 | 2.3 | 0 | 1.3 | 0.9 | 0.37 | 0.2 | 0.2 | 0.1 | 0 |
| Upper quartile | 3.9 | 1 | 0 | 0.5 | 0.2 | 0 | 0 | 0 | 0 | 0 |
| n | n = 69 | n = 60 | n = 34 | n = 33 | n = 58 | n = 34 | n = 58 | n = 56 | n = 6 | n = 53 |
| n > 0.41 µg/L | 69 | 38 | 0 | 17 | 7 | 0 | 0 | 0 | 0 | 0 |
| Mileage | 0 | 3.2 | -1.5 | 3.7 | 6.4 | -0.2 | 7 | 8.9 | | 11.9 |

| **Dichlorobromomethane (DCBM)** | EWWTP outfall | End of Old Alamo | New Alamo at Lewis Rd. | New Alamo below Old Alamo | End of New Alamo | Ulatis Ck above New Alamo | Maine Prairie Rd on Ulatis | Brown Rd on Ulatis | Ulatis above Vallejo Pump Station | Vallejo Pump Station (VPS) |
|---|---|---|---|---|---|---|---|---|---|---|
| Begin Date | 9/10/2002 | 9/10/2002 | 9/10/2002 | 9/10/2002 | 9/10/2002 | 9/10/2002 | 9/10/2002 | 9/10/2002 | 9/10/2002 | 9/10/2002 |
| End Date | 5/6/2008 | 8/14/2007 | 8/14/2007 | 8/14/2007 | 8/14/2007 | 8/14/2007 | 8/14/2007 | 8/14/2007 | 8/14/2007 | 8/14/2007 |
| Lower quartile | 12 | 1.75 | 0 | 1.1 | 0.5 | 0 | 0 | 0 | 0 | 0 |
| Minimum | 8.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Median | 14.2 | 2.5 | 0 | 1.9 | 0.86 | 0 | 0.14 | 0 | 0.15 | 0 |
| Maximum | 43 | 7.1 | 0 | 3.5 | 3.1 | 1.6 | 1.3 | 1.3 | 0.4 | 0.4 |
| Upper quartile | 18 | 3.825 | 0 | 2.3 | 1.4 | 0 | 0.6 | 0.285 | 0.3 | 0 |
| n | n = 69 | n = 60 | n = 34 | n = 33 | n = 58 | n = 34 | n = 58 | n = 56 | n = 6 | n = 53 |
| n > 0.56 µg/L | 69 | 57 | 0 | 32 | 40 | 2 | 18 | 10 | 0 | 0 |
| Mileage | 0 | 3.2 | -1.5 | 3.7 | 6.4 | -0.2 | 7 | 8.9 | | 11.9 |

| **Chloroform** | EWWTP outfall | End of Old Alamo | New Alamo at Lewis Rd. | New Alamo below Old Alamo | End of New Alamo | Ulatis Ck above New Alamo | Maine Prairie Rd on Ulatis | Brown Rd on Ulatis | Ulatis above Vallejo Pump Station | Vallejo Pump Station (VPS) |
|---|---|---|---|---|---|---|---|---|---|---|
| Begin Date | 9/10/2002 | 9/10/2002 | 9/10/2002 | 9/10/2002 | 9/10/2002 | 9/10/2002 | 9/10/2002 | 9/10/2002 | 9/10/2002 | 9/10/2002 |
| End Date | 5/6/2008 | 8/14/2007 | 8/14/2007 | 8/14/2007 | 8/14/2007 | 8/14/2007 | 8/14/2007 | 8/14/2007 | 8/14/2007 | 8/14/2007 |
| Lower quartile | 31 | 6.6 | 0 | 5.8 | 3.1 | 0 | 1.125 | 0.2 | 0.325 | 0 |
| Minimum | 21 | 3.8 | 0 | 1.4 | 0 | 0 | 0 | 0 | 0 | 0 |
| Median | 41.5 | 10.1 | 0 | 7.2 | 4.85 | 0 | 1.7 | 0.65 | 0.75 | 0.1 |
| Maximum | 79 | 25.1 | 0 | 18.1 | 12.6 | 9.1 | 7.2 | 6.2 | 2.2 | 4.3 |
| Upper quartile | 50.4 | 15.125 | 0 | 9.1 | 7.025 | 0 | 3.3 | 2.125 | 1.25 | 1.1 |
| n | n = 69 | n = 60 | n = 34 | n = 33 | n = 58 | n = 34 | n = 58 | n = 56 | n = 6 | n = 53 |
| n > 5.7 µg/L | 69 | 53 | 0 | 25 | 21 | 1 | 5 | 1 | 0 | 0 |
| Mileage | 0 | 3.2 | -1.5 | 3.7 | 6.4 | -0.2 | 7 | 8.9 | | 11.9 |

# Appendix B

## Statistical Analyses of the Historical THM Data

The purpose of this appendix is to statistically characterize and define the distribution of dibromochloromethane (DBCM), dichlorobromomethane (DBCM), and chloroform data historically collected in Old Alamo Creek at the terminus (i.e., just upstream from New Alamo Creek) and in New Alamo Creek at Brown-Alamo Dam. In order to define the upper end of the historical data distribution and to project future concentrations, statistical distributions were determined from the measured THM datasets to calculate the probability of occurrence for each THM. As discussed in the Technical Support Document for Water Quality-based Toxics Control (TSD) (U.S. EPA 1991), the assumed distribution for effluent data above the detection limit is lognormal while the distribution of monthly averages (based on multiple data points) is assumed to be normally distributed. Environmental water quality data often shows a positive skew toward higher values that is best represented by a lognormal distribution. If a normal distribution is incorrectly assumed, probabilities from the normal distribution will under predict the true probability of occurrence for higher values at the upper tail end of the distribution.

A statistical assessment was made for both lognormal and normal distributions to determine their suitability in fitting the measured data for each THM at each location. Distributional assessments were made with U.S. EPA statistical software ProUCL (version 4.00.02) because it provides a more robust handling of non-detect values using regression on order statistics (ROS) than the SIP procedure, which uses half the detection limit for non-detects (U.S. EPA 2007). First, estimates were made for non-detect values by fitting the detected values to an assumed distribution (e.g., lognormal ROS). If normal ROS estimates for non-detects resulted in several negative numbers, then that normal distributional fit was considered invalid. Next the goodness of the fit was evaluated for the whole dataset (i.e., detects and estimated non-detect values) using, as relevant, quantile-quantile plots (Q-Q) plots), Shapiro-Wilks, Kolmogorov-Smirnov, and Lilliefors (a special case of Kolmogorov-Smirnov) statistical tests. Shapiro-Wilks is used for smaller datasets (N<50). To test the goodness of the fit for lognormal distributions, the dataset is log-transformed and then the transformed dataset is tested for normality with the above referenced statistical tests. The determination for statistically significant fits ($\alpha = 0.05$) for each THM and each location is summarized in **Table B-1** along with the number of non-detects in the dataset.

Both normal and lognormal distributions fit the DCBM data at Brown-Alamo Dam, so the dataset was examined more closely. The dataset at Brown-Alamo Dam (n=33) is much smaller than the dataset in Old Alamo Creek at the terminus (n=60). Furthermore, the dataset at Brown-Alamo Dam primarily consists of data collected during the April–October irrigation season (n=25) versus the November–March non-irrigation season (n=8). Since hydrographs of New Alamo Creek show rapid fluctuations in streamflow in response to rainfall, the highest THM values are expected to occur between significant rainfall events during the non-irrigation season (i.e., when irrigation and agricultural return flows are not present and winter base flow is low). **Table B-2** shows that the limited dataset at Brown-Alamo Dam does not include the highest anticipated THM concentration that are expected to have occurred during the monitoring period, based on the dataset at the terminus of Old Alamo Creek. For DBCM and DCBM, there is only one measurement at Brown-Alamo Dam corresponding to dates for the top 10 highest measurements at the terminus of Old Alamo Creek. Consequently, the high values expected to be part of the data set at Brown-Alamo Dam, based on measurements at the terminus of Old Alamo Creek, are simply not represented due to sparse monitoring at Brown-Alamo Dam during the months when the highest concentrations occurred in the system.

**Table B-1. Statistically significant (α = 0.05) distribution fits to lognormal or normal regression on order statistics (ROS) distributions for measured trihalomethane data calculated with ProUCL 4.0 (U.S. EPA 2007).**

| THM Constituent | Size of Dataset | Non-Detects | Statistical Test (α = 0.05) | Critical Value | Test Value for Normal Fit | Test Value for Lognormal Fit | Conclusion |
|---|---|---|---|---|---|---|---|
| **Old Alamo Creek (all data)** | | | | | | | |
| DBCM | 60 | 22 | Lilliefors ROS | <0.114 | 0.117 | 0.071 | Lognormal |
| DCBM | 60 | 3 | Lilliefors ROS | <0.114 | 0.116 | 0.091 | Lognormal |
| Chloroform | 60 | 0 | Lilliefors | <0.114 | 0.138 | 0.086 | Lognormal |
| **Brown-Alamo Dam (all data)** | | | | | | | |
| DBCM | 33 | 11 | Shapiro-Wilks ROS | >0.931 | 0.907 | 0.964 | Lognormal |
| DCBM | 33 | 1 | Shapiro-Wilks ROS | >0.931 | 0.971 | 0.938 | Lognormal [1] |
| Chloroform | 33 | 0 | Shapiro-Wilks | >0.931 | 0.906 | 0.946 | Lognormal |

Notes:
ROS = Regression on order statistics
[1] Both normal and lognormal distributions are statistically significant fits. Lognormal fit chosen as best fit given limited non-irrigation season data at Brown-Alamo Dam.

In light of the previous discussion and whereas both normal and lognormal distributions are statistically good fits (α = 0.05) for the DCBM data, the lognormal distribution was chosen as the better fit since it provides a more accurate prediction of the probabilities of high DCBM values at Brown-Alamo Dam. This is further supported by January 2009 daily THM monitoring by the City at Brown-Alamo Dam, which found a higher average DCBM value (2.9 µg/L vs. 1.8 µg/L) and higher maximum DCBM value (4.8 µg/L vs. 3.5 µg/L) than previously seen in the historical (n=33) DCBM dataset used to evaluate normality/lognormality. The THM data set used to evaluate normality/lognormality is presented in Table B-2. The January 2009 THM data are presented in Table B-3.

**Table B-2. Trihalomethane concentrations in Old Alamo Creek (OAC) at its terminus and the corresponding value, when measured, at Brown-Alamo Dam, ranked from highest to lowest for each constituent based on the value at OAC.**

| Dibromochloromethane (µg/L) | | | Dichlorobromomethane (µg/l) | | | Chloroform (µgL) | | |
|---|---|---|---|---|---|---|---|---|
| Date | End of OAC | Brown Alamo Dam | Date | End of OAC | Brown Alamo Dam | Date | End of OAC | Brown Alamo Dam |
| 3/8/05 | 2.3 | | 2/11/03 | 7.1 | | 2/6/07 | 25.1 | 18.1 |
| 2/11/03 | 1.9 | | 3/8/05 | 5.9 | | 3/16/07 | 23.9 | 14.9 |
| 9/13/05 | 1.9 | | 1/6/04 | 5.2 | | 12/3/02 | 21 | |
| 8/8/06 | 1.7 | 1.3 | 3/9/04 | 5.1 | | 2/11/03 | 21 | |
| 1/10/06 | 1.6 | | 3/11/03 | 4.9 | | 3/11/03 | 20 | |
| 3/11/03 | 1.5 | | 2/7/06 | 4.9 | 1.9 | 12/5/06 | 19.2 | 15.8 |
| 1/6/04 | 1.5 | | 9/13/05 | 4.8 | | 12/2/03 | 19 | |
| 4/18/06 | 1.38 | | 1/10/06 | 4.8 | | 12/13/05 | 19 | |
| 1/8/03 | 1.3 | | 12/2/03 | 4.6 | | 10/24/06 | 17.4 | 14.3 |
| 3/9/04 | 1.3 | | 4/18/06 | 4.6 | | 1/9/07 | 17.3 | 15.1 |
| 4/13/04 | 1.2 | 1.2 | 1/8/03 | 4.4 | | 11/5/02 | 17 | |
| 12/2/03 | 1.1 | | 5/9/06 | 4.3 | 2.1 | 2/7/06 | 17 | 6.5 |
| 2/4/04 | 1.1 | | 3/16/07 | 4.2 | 2.9 | 11/14/06 | 17 | 8.6 |
| 2/7/05 | 1.1 | | 2/6/07 | 4.1 | 3.5 | 1/6/04 | 16 | |
| 2/7/06 | 1 | 0.25 | 12/5/06 | 3.9 | 3.2 | 5/9/06 | 15.5 | 7.2 |
| 5/9/06 | 1 | 0.5 | 12/13/05 | 3.8 | | 3/9/04 | 15 | |
| 5/11/04 | 0.9 | 0.8 | 12/3/02 | 3.7 | | 3/8/05 | 15 | |
| 12/3/02 | 0.8 | | 2/4/04 | 3.7 | | 4/9/03 | 14 | 5.8 |
| 6/3/03 | 0.8 | 0.7 | 8/8/06 | 3.6 | 2.9 | 4/18/06 | 13.9 | |
| 6/6/06 | 0.8 | 0.5 | 5/11/04 | 3.5 | 3.4 | 2/7/05 | 13 | |
| 5/6/03 | 0.7 | 0.7 | 2/7/05 | 3.3 | | 9/13/05 | 13 | |
| 12/13/05 | 0.7 | | 11/14/06 | 3.3 | 1.7 | 11/8/05 | 13 | |
| 3/16/07 | 0.7 | 0.5 | 1/9/07 | 3.2 | 3 | 11/4/03 | 12 | 9.1 |
| 1/11/05 | 0.63 | | 6/6/06 | 3.1 | 2.1 | 2/4/04 | 12 | |
| 11/5/02 | 0.6 | | 11/5/02 | 3 | | 5/11/04 | 12 | 11 |
| 11/4/03 | 0.6 | 0.25 | 12/7/04 | 3 | | 1/10/06 | 12 | |
| 3/14/06 | 0.6 | 0.1 | 10/24/06 | 2.8 | 2.6 | 6/6/06 | 12 | 8.2 |
| 11/14/06 | 0.6 | 0.3 | 6/3/03 | 2.6 | 2 | 1/8/03 | 11 | |
| 12/5/06 | 0.6 | 0.5 | 11/4/03 | 2.5 | 1.9 | 12/7/04 | 11 | |
| 2/6/07 | 0.6 | 0.5 | 11/8/05 | 2.5 | | 8/14/07 | 10.2 | 15 |
| 12/7/04 | 0.59 | | 3/14/06 | 2.4 | 0.6 | 4/13/04 | 10 | 8.7 |
| 11/16/04 | 0.54 | | 8/9/05 | 2.3 | | 8/9/05 | 9.7 | |
| 8/9/05 | 0.5 | | 4/13/04 | 2.2 | 1.9 | 5/8/07 | 9 | 10.1 |
| 10/11/05 | 0.5 | | 5/6/03 | 2 | 1.8 | 6/3/03 | 8.7 | 6.9 |
| 11/8/05 | 0.5 | | 8/14/07 | 2 | 2.9 | 10/16/02 | 8.6 | |
| 10/24/06 | 0.5 | 0.5 | 10/16/02 | 1.9 | | 5/6/03 | 8.5 | 6.4 |
| 1/9/07 | 0.5 | 0.5 | 11/16/04 | 1.9 | | 10/11/05 | 8.3 | |
| 6/12/07 | 0.5 | 0.6 | 1/11/05 | 1.9 | | 11/16/04 | 8.2 | |
| 9/10/02 | 0.25 | | 10/11/05 | 1.9 | | 6/12/07 | 8.2 | 8.9 |
| 10/16/02 | 0.25 | | 7/11/06 | 1.9 | 1.1 | 7/10/07 | 8.1 | 8.1 |
| 4/9/03 | 0.25 | 0.25 | 6/12/07 | 1.9 | 2.3 | 9/12/06 | 7.8 | 5.3 |
| 7/8/03 | 0.25 | 0.5 | 7/10/07 | 1.9 | 2 | 8/12/03 | 7.7 | 5.3 |
| 8/12/03 | 0.25 | 0.25 | 7/12/05 | 1.8 | | 7/11/06 | 6.9 | 4.4 |
| 9/9/03 | 0.25 | 0.5 | 9/12/06 | 1.8 | 1.2 | 4/17/07 | 6.7 | 7.6 |
| 10/15/03 | 0.25 | 0.25 | 5/8/07 | 1.8 | 2.2 | 9/10/02 | 6.6 | |
| 6/8/04 | 0.25 | 0.25 | 7/8/03 | 1.6 | 1.9 | 7/12/05 | 6.6 | |
| 7/13/04 | 0.25 | 0.25 | 9/9/03 | 1.4 | 1.5 | 8/8/06 | 6.6 | 6.1 |
| 8/10/04 | 0.25 | 0.25 | 10/15/03 | 1.3 | 1.1 | 10/15/03 | 6.5 | 5.8 |
| 9/7/04 | 0.25 | 0.25 | 7/13/04 | 1.3 | 1 | 9/9/03 | 6.4 | 5.9 |
| 10/18/04 | 0.25 | 0.25 | 9/10/02 | 1.2 | | 7/8/03 | 6.2 | 7.9 |
| 4/19/05 | 0.25 | | 8/12/03 | 1.2 | 1 | 10/18/04 | 6.1 | 3.2 |
| 5/10/05 | 0.25 | | 4/17/07 | 1.2 | 1.4 | 4/19/05 | 5.9 | |
| 6/14/05 | 0.25 | | 10/18/04 | 1.1 | 0.6 | 3/14/06 | 5.8 | 1.4 |
| 7/12/05 | 0.25 | | 6/8/04 | 1 | 1 | 6/14/05 | 5.5 | |
| 7/11/06 | 0.25 | 0.3 | 8/10/04 | 1 | 0.8 | 5/10/05 | 5.3 | |
| 9/12/06 | 0.25 | 0.2 | 9/7/04 | 0.9 | 1.1 | 8/10/04 | 5.2 | 4.9 |
| 4/17/07 | 0.25 | 0.25 | 4/9/03 | 0.6 | 0.25 | 7/13/04 | 4.9 | 4.3 |
| 5/8/07 | 0.25 | 0.5 | 4/19/05 | 0.25 | | 9/7/04 | 4.7 | 6.6 |
| 7/10/07 | 0.25 | 0.4 | 5/10/05 | 0.25 | | 6/8/04 | 3.9 | 4.3 |
| 8/14/07 | 0.25 | 0.5 | 6/14/05 | 0.25 | | 1/11/05 | 3.8 | |
| Median | 0.60 | 0.50 | Median | 2.45 | 1.90 | Median | 10.10 | 7.20 |
| Average | 0.70 | 0.45 | Average | 2.74 | 1.84 | Average | 11.35 | 8.23 |
| Maximum | 2.30 | 1.30 | Maximum | 7.10 | 3.50 | Maximum | 25.10 | 18.10 |

Table B-3. Trihalomethane concentrations in the Easterly WWTP effluent at the outfall, Old Alamo Creek (OAC) at its terminus, and in New Alamo Creek at Brown-Alamo Dam (BAD) collected by the City of Vacaville during January 2009.

| Morning | 1/5/09 AM | | | 1/6/09 AM | | | 1/7/09 AM | | | 1/8/09 AM | | | 1/9/09 AM | | | Weekly Maximum | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Analyte | Outfall | OAC | BAD | Outfall | OAC | BAD | Outfall | OAC | BAD | Outfall | OAC | BAD | Outfall | OAC | BAD | Outfall | OAC | BAD |
| DBCM | 2.1 | 0.8 | 0.5 | 1.8 | 0.5 | 0.5 | 1.3 | 0.6 | 0.5 | 1.4 | 0.4 | 0.4 | 1.4 | 0.4 | 0.4 | 2.1 | 0.8 | 0.6 |
| DCBM | 12.7 | 3.7 | 2.9 | 13.2 | 3.3 | 2.5 | 11.1 | 3.7 | 2.9 | 12.7 | 2.9 | 2.9 | 11.8 | 2.4 | 2.3 | 13.2 | 5.0 | 4.3 |
| Chloroform | 43.3 | 16.0 | 12.7 | 49.3 | 15.1 | 11.6 | 38.8 | 16.6 | 13.6 | 49.6 | 15.6 | 15.5 | 45.6 | 15.3 | 11.6 | 51.0 | 23.7 | 20.5 |

| Afternoon | 1/5/09 PM | | | 1/6/09 PM | | | 1/7/09 PM | | | 1/8/09 PM | | | 1/9/09 PM | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Analyte | Outfall | OAC | BAD | Outfall | OAC | BAD | Outfall | OAC | BAD | Outfall | OAC | BAD | Outfall | OAC | BAD |
| DBCM | 1.3 | 0.5 | 0.5 | 1.4 | 0.8 | 0.6 | 1.9 | 0.5 | 0.5 | 1.2 | 0.7 | 0.4 | 1.3 | 0.5 | 0.2 |
| DCBM | 10.6 | 3.4 | 2.9 | 12.4 | 5.0 | 4.3 | 11.2 | 4.2 | 3.3 | 11.8 | 4.9 | 2.4 | 12.2 | 3.2 | 1.4 |
| Chloroform | 38.3 | 15.8 | 13.3 | 48.9 | 23.7 | 20.5 | 39.0 | 20.6 | 18.0 | 48.0 | 23.0 | 15.3 | 51.0 | 17.5 | 13.1 |

| Morning | 1/12/09 AM | | | 1/13/09 AM | | | 1/14/09 AM | | | 1/15/09 AM | | | 1/16/09 AM | | | Weekly Maximum | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Analyte | Outfall | OAC | BAD | Outfall | OAC | BAD | Outfall | OAC | BAD | Outfall | OAC | BAD | Outfall | OAC | BAD | Outfall | OAC | BAD |
| DBCM | 1.3 | 0.4 | 0.3 | 1.6 | 0.4 | 0.3 | 1.6 | 0.6 | 0.5 | 1.7 | 0.5 | 0.4 | 2.0 | 0.7 | 0.6 | 2.0 | 0.8 | 0.7 |
| DCBM | 12.0 | 2.8 | 2.2 | 13.7 | 3.0 | 2.2 | 13.4 | 3.8 | 3.2 | 13.0 | 2.9 | 2.7 | 14.1 | 4.2 | 3.8 | 14.1 | 5.4 | 4.8 |
| Chloroform | 50.6 | 16.5 | 12.6 | 55.8 | 16.1 | 12.3 | 50.8 | 19.0 | 16.2 | 47.8 | 14.3 | 13.2 | 46.1 | 16.8 | 15.1 | 55.8 | 28.1 | 24.1 |

| Afternoon | 1/12/09 PM | | | 1/13/09 PM | | | 1/14/09 PM | | | 1/15/09 PM | | | 1/16/09 PM | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Analyte | Outfall | OAC | BAD | Outfall | OAC | BAD | Outfall | OAC | BAD | Outfall | OAC | BAD | Outfall | OAC | BAD |
| DBCM | 1.2 | 0.4 | 0.3 | 1.5 | 0.7 | 0.6 | 1.5 | 0.6 | 0.3 | 1.7 | 0.8 | 0.7 | 2.0 | 0.7 | 0.4 |
| DCBM | 12.0 | 3.5 | 2.0 | 13.2 | 5.4 | 4.7 | 12.4 | 4.1 | 2.1 | 13.0 | 5.4 | 4.8 | 14.1 | 4.1 | 2.4 |
| Chloroform | 54.4 | 21.4 | 15.7 | 53.7 | 28.1 | 24.1 | 49.5 | 22.1 | 16.6 | 45.4 | 25.3 | 22.5 | 46.9 | 20.1 | 16.2 |

| Afternoon | 1/19/09 PM | | | 1/20/09 PM | | | 1/21/2009 | | | 1/22/09 PM | | | 1/23/09 PM | | | Weekly Maximum | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Analyte | Outfall | OAC | BAD | Outfall | OAC | BAD | Outfall | OAC | BAD | Outfall | OAC | BAD | Outfall | OAC | BAD | Outfall | OAC | BAD |
| DBCM | 1.2 | 0.3 | 0.2 | 2.1 | 0.5 | 0.3 | 1.9 | 0.5 | 0.5 | 1.9 | 1.0 | 0.3 | 1.7 | 0.7 | 0.6 | 2.1 | 1.0 | 0.6 |
| DCBM | 11.3 | 2.9 | 2.6 | 15.2 | 3.9 | 2.5 | 12.7 | 3.7 | 3.5 | 13.7 | 6.2 | 1.8 | 14.1 | 4.3 | 3.4 | 15.2 | 6.2 | 3.5 |
| Chloroform | 43.8 | 18.1 | 15.6 | 48.4 | 19.4 | 15.6 | 38.6 | 16.1 | 14.0 | 43.2 | 24.3 | 7.3 | 49.1 | 18.3 | 14.9 | 49.1 | 24.3 | 15.6 |
| | | | | | Sample Time > | | 0838 | 1155 | 1215 | | | | | | | | | |

| | Study Minimums | | | Study Averages | | | Study Maximums | | |
|---|---|---|---|---|---|---|---|---|---|
| Analyte | Outfall | OAC | BAD | Outfall | OAC | BAD | Outfall | OAC | BAD |
| DBCM | 1.2 | 0.3 | 0.2 | 1.6 | 0.6 | 0.4 | 2.1 | 1.0 | 0.7 |
| DCBM | 10.6 | 2.4 | 1.4 | 12.7 | 3.9 | 2.9 | 15.2 | 6.2 | 4.8 |
| Chloroform | 38.3 | 14.3 | 7.3 | 47.2 | 19.2 | 15.3 | 55.8 | 28.1 | 24.1 |

THM concentrations for various probabilities of occurrence were calculated for New Alamo Creek at Brown-Alamo Dam (**Table B-4**) and Old Alamo Creek at the terminus (**Table B-5**). These tables indicate the THM concentration that corresponds to specified probabilities of occurrence. For calculations of probabilities, ROS was used to estimate the non-detect values prior to fitting the data distribution. The corresponding cancer risk levels, also presented in the tables below, were derived based on the U.S. EPA's NRWQC methodology that assumes consumption of 2 L/day of water and up to 17.5 g/day of fish/shellfish from the water body (at the criterion concentration) for a 70-year lifetime.

**Table B-4. Probability (based on lognormal distribution) of occurrence for trihalomethane concentrations (µg/L) in New Alamo Creek at Brown-Alamo Dam.**

| Data Period: 11/2002 to 8/14/2007 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Probability | Dibromochloromethane | | Dichlorobromomethane | | Chloroform [2] | | Composite Index for Three THMs [1] Log (Cancer Risk) |
| | µg/L | Log(CR) | µg/L | Log(CR) | µg/L | Log(CR) | |
| 99.99% | 3.4 | -5.07 | 11.6 | -4.67 | 50.7 | -5.05 | -4.89 |
| 99.98% | 3.1 | -5.12 | 10.6 | -4.72 | 46.2 | -5.09 | -4.93 |
| 99.97% | 2.9 | -5.14 | 10.0 | -4.74 | 43.6 | -5.12 | -4.96 |
| 99.96% | 2.7 | -5.16 | 9.6 | -4.76 | 41.9 | -5.13 | -4.98 |
| 99.95% | 2.6 | -5.18 | 9.3 | -4.77 | 40.5 | -5.15 | -4.99 |
| 99.94% | 2.6 | -5.19 | 9.0 | -4.78 | 39.5 | -5.16 | -5.00 |
| 99.93% | 2.5 | -5.20 | 8.8 | -4.79 | 38.6 | -5.17 | -5.01 |
| 99.92% | 2.4 | -5.21 | 8.7 | -4.80 | 37.8 | -5.18 | -5.02 |
| 99.91% | 2.4 | -5.22 | 8.5 | -4.81 | 37.1 | -5.19 | -5.03 |
| 99.9% | 2.3 | -5.23 | 8.4 | -4.82 | 36.5 | -5.19 | -5.04 |
| 99.8% | 2.1 | -5.29 | 7.5 | -4.87 | 32.7 | -5.24 | -5.09 |
| 99.6% | 1.8 | -5.34 | 6.6 | -4.92 | 29.1 | -5.29 | -5.14 |
| 99.5% | 1.7 | -5.36 | 6.4 | -4.94 | 27.9 | -5.31 | -5.16 |
| 99.4% | 1.7 | -5.38 | 6.2 | -4.95 | 27.0 | -5.32 | -5.17 |
| 99.2% | 1.6 | -5.41 | 5.8 | -4.97 | 25.6 | -5.35 | -5.20 |
| 99% | 1.5 | -5.43 | 5.6 | -4.99 | 24.5 | -5.37 | -5.22 |
| 98% | 1.3 | -5.50 | 4.8 | -5.06 | 21.3 | -5.43 | -5.28 |
| 97% | 1.2 | -5.54 | 4.4 | -5.09 | 19.5 | -5.47 | -5.32 |
| 96% | 1.1 | -5.57 | 4.1 | -5.12 | 18.2 | -5.50 | -5.35 |
| 95% | 1.0 | -5.60 | 3.9 | -5.15 | 17.2 | -5.52 | -5.38 |
| 90% | 0.8 | -5.69 | 3.2 | -5.23 | 14.2 | -5.60 | -5.46 |
| 85% | 0.7 | -5.76 | 2.8 | -5.29 | 12.5 | -5.66 | -5.52 |
| 80% | 0.6 | -5.81 | 2.6 | -5.33 | 11.3 | -5.70 | -5.56 |
| 75% | 0.6 | -5.85 | 2.3 | -5.37 | 10.4 | -5.74 | -5.60 |
| 70% | 0.5 | -5.89 | 2.2 | -5.41 | 9.6 | -5.77 | -5.64 |
| 60% | 0.4 | -5.96 | 1.9 | -5.47 | 8.3 | -5.84 | -5.70 |
| 50% | 0.4 | -6.02 | 1.6 | -5.53 | 7.3 | -5.89 | -5.76 |

Notes: Log(CR) = logarithm of cancer risk, based on consumption of 2L/day of water and 17.5 g fish and shellfish/day for a 70-year lifetime.

[1] Composite Index:. Converted from log(CR) to cancer risk, averaged, and then converted back to log(CR).

[2] There were no non-detect data for chloroform, therefore, regression on order statistics (ROS) was not necessary.

**Table B-5. Probability (based on lognormal distribution) of occurrence for trihalomethane concentrations (µg/L) at end of Old Alamo Creek.**

| Data Period: 11/2002 to 8/14/2007 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Probability | Dibromochloromethane | | Dichlorobromomethane | | Chloroform | | Composite Index for Three THMs [1] Log (Cancer Risk) |
| | µg/L | Log(CR) | µg/L | Log(CR) | µg/L | Log(CR) | |
| 99.99% | 7.6 | -4.72 | 22.9 | -4.38 | 61.8 | -4.97 | -4.62 |
| 99.98% | 6.7 | -4.78 | 20.5 | -4.43 | 56.6 | -5.00 | -4.67 |
| 99.97% | 6.2 | -4.81 | 19.2 | -4.46 | 53.7 | -5.03 | -4.70 |
| 99.96% | 5.9 | -4.83 | 18.3 | -4.48 | 51.7 | -5.04 | -4.72 |
| 99.95% | 5.6 | -4.85 | 17.6 | -4.50 | 50.2 | -5.06 | -4.74 |
| 99.94% | 5.4 | -4.87 | 17.0 | -4.51 | 48.9 | -5.07 | -4.75 |
| 99.93% | 5.3 | -4.88 | 16.6 | -4.52 | 47.9 | -5.08 | -4.76 |
| 99.92% | 5.1 | -4.89 | 16.2 | -4.53 | 47.0 | -5.08 | -4.77 |
| 99.91% | 5.0 | -4.90 | 15.8 | -4.54 | 46.2 | -5.09 | -4.78 |
| 99.9% | 4.9 | -4.91 | 15.5 | -4.55 | 45.5 | -5.10 | -4.79 |
| 99.8% | 4.2 | -4.98 | 13.7 | -4.61 | 41.0 | -5.14 | -4.85 |
| 99.6% | 3.6 | -5.05 | 11.9 | -4.67 | 36.8 | -5.19 | -4.91 |
| 99.5% | 3.4 | -5.07 | 11.3 | -4.69 | 35.4 | -5.21 | -4.93 |
| 99.4% | 3.3 | -5.09 | 10.9 | -4.70 | 34.4 | -5.22 | -4.95 |
| 99.2% | 3.0 | -5.12 | 10.2 | -4.73 | 32.7 | -5.24 | -4.97 |
| 99% | 2.9 | -5.14 | 9.7 | -4.75 | 31.4 | -5.26 | -4.99 |
| 98% | 2.4 | -5.23 | 8.2 | -4.82 | 27.5 | -5.32 | -5.07 |
| 97% | 2.1 | -5.28 | 7.4 | -4.87 | 25.3 | -5.35 | -5.11 |
| 96% | 1.9 | -5.32 | 6.8 | -4.91 | 23.7 | -5.38 | -5.15 |
| 95% | 1.8 | -5.35 | 6.4 | -4.93 | 22.5 | -5.40 | -5.17 |
| 90% | 1.4 | -5.46 | 5.1 | -5.03 | 18.9 | -5.48 | -5.27 |
| 85% | 1.2 | -5.53 | 4.4 | -5.10 | 16.8 | -5.53 | -5.33 |
| 80% | 1.0 | -5.59 | 3.9 | -5.15 | 15.3 | -5.57 | -5.39 |
| 75% | 0.9 | -5.64 | 3.5 | -5.19 | 14.1 | -5.61 | -5.43 |
| 70% | 0.8 | -5.69 | 3.2 | -5.23 | 13.1 | -5.64 | -5.47 |
| 60% | 0.7 | -5.77 | 2.7 | -5.30 | 11.5 | -5.70 | -5.54 |
| 50% | 0.6 | -5.85 | 2.3 | -5.37 | 10.1 | -5.75 | -5.60 |

Notes: Log(CR) = logarithm of cancer risk, based on consumption of 2L/day of water and 17.5 g fish and shellfish/day for a 70-year lifetime..

[1] Composite Index: Converted from log(CR) to cancer risk, averaged, and then converted back to log(CR).

# Appendix C

## Example Derivation of NPDES Permit Effluent Limitations

**Table C–1. Example derivation of NPDES effluent limitations for Alternative 1 site-specific objectives – Approach A.**

| Constituent | Dibromochloromethane | Dichlorobromomethane | Chloroform |
|---|---|---|---|
| **TYPE** | HH, Long-term | HH, Long-term | HH, Long-term |
| Units | µg/L | µg/L | µg/L |
| **Criteria (applicable in downstream segments)** | **4.0** | **5.5** | **57** |
| **Median Attentuation Factor (1)** | **5.80** | **8.95** | **5.15** |
| Location | New Alamo Cr. @ BAD | New Alamo Cr. @ BAD | New Alamo Cr. @ BAD |
| Begin sample date | 9/10/2002 | 9/10/2002 | 9/10/2002 |
| End sample date | 8/14/2007 | 8/14/2007 | 8/14/2007 |
| count | n = 33 | n = 33 | n = 33 |
| **Maximum concentration at BAD** | **1.3** | **3.5** | **18.1** |
| mean | 0.45 | 1.84 | 9.76 |
| std deviation | 0.27 | 0.87 | 4.67 |
| **CV** | 0.59 | 0.47 | 0.48 |
| **z-statistic** (95% probability basis) | 1.645 | 1.645 | 1.645 |
| **z-statistic** (99% probability basis) | 2.326 | 2.326 | 2.326 |
| ECA | 23.200 | 49.225 | 293.550 |
| ECA multiplier | NA | NA | NA |
| LTA | NA | NA | NA |
| **Sampling n** | 4 | 4 | 4 |
| **AMEL** | **23.2** | **49.2** | **293.6** |
| AMEL Multiplier (95%) | 1.54 | 1.43 | 1.43 |
| MDEL Multiplier (99%) | 3.07 | 2.56 | 2.59 |
| **MDEL** | **46.2** | **88.4** | **531.0** |

Notes:
AMEL = Average monthly effluent limitation
BAD = Brown-Alamo Dam
MDEL = Maximum daily effluent limitation
NA = Not applicable, due to long-term average criteria
(1) Median value; Effluent/(New Alamo Creek @ BAD); see Table C-3

In the above table, the maximum concentration measured at Brown–Alamo Dam is less than the C (Alternative 1 objectives), thus, effluent limitations would not be needed in this example. Effluent limitations are, nevertheless, derived to illustrate the steps in the calculation. The ECA is calculated as:

ECA = Attenuation Factor x C

C is the site-specific objective and the attenuation factor is the median of the individually calculated attenuation factors derived from representative historical data for all months of the year (see Table C-2 on the next page).

The AAEL is then set equal to the ECA.

The AMEL and MDEL are calculated as:

AMEL = ECA x AMEL multiplier

MDEL = ECA x MDEL multiplier/AMEL multiplier

The AMEL and MDEL multipliers are determined from the equations provided in Section 1.4.0 of the SIP (SWRCB 2005). The SIP specifies that if the sampling frequency is four times per month or less, than the "n" for determining the AMEL multiplier shall be set equal to 4.

**Table C–2. Example derivation of NPDES effluent limitations for Alternative 3 site-specific objectives – Approach A.**

| Constituent | Dibromochloromethane | Dichlorobromomethane | Chloroform |
|---|---|---|---|
| **TYPE** | HH, Long-term | HH, Long-term | HH, Long-term |
| Units | µg/L | µg/L | µg/L |
| **Criteria (applicable in downstream segments)** | **2.6** | **9.0** | **39.5** |
| **Median Attentuation Factor (1)** | **5.80** | **8.95** | **5.15** |
| Location | New Alamo Cr. @ BAD | New Alamo Cr. @ BAD | New Alamo Cr. @ BAD |
| Begin sample date | 9/10/2002 | 9/10/2002 | 9/10/2002 |
| End sample date | 8/14/2007 | 8/14/2007 | 8/14/2007 |
| count | n = 33 | n = 33 | n = 33 |
| **Maximum concentration at BAD** | **1.3** | **3.5** | **18.1** |
| mean | 0.45 | 1.84 | 9.76 |
| std deviation | 0.27 | 0.87 | 4.67 |
| **CV** | 0.59 | 0.47 | 0.48 |
| **z-statistic** (95% probability basis) | 1.645 | 1.645 | 1.645 |
| **z-statistic** (99% probability basis) | 2.326 | 2.326 | 2.326 |
| ECA | 15.080 | 80.550 | 203.425 |
| ECA multiplier | NA | NA | NA |
| LTA | NA | NA | NA |
| **Sampling n** | 4 | 4 | 4 |
| **AMEL** | **15.1** | **80.6** | **203.4** |
| AMEL Multiplier (95%) | 1.54 | 1.43 | 1.43 |
| MDEL Multiplier (99%) | 3.07 | 2.56 | 2.59 |
| **MDEL** | **30.0** | **144.6** | **367.9** |

Notes:
AMEL = Average monthly effluent limitation
BAD = Brown-Alamo Dam
MDEL = Maximum daily effluent limitation
NA = Not applicable, due to long-term average criteria
(1) Median value; Effluent/(New Alamo Creek @ BAD); see Table C-3

In the above table, the maximum concentration measured at Brown–Alamo Dam is less than the C (Alternative 3 objectives), thus, effluent limitations would not be needed in this example. Effluent limitations are, nevertheless, derived to illustrate the steps in the calculation. The ECA is calculated as:

ECA = Attenuation Factor x C

C is the site-specific objective and the attenuation factor is the median of the individually calculated attenuation factors derived from representative historical data for all months of the year (see Table C-3 on the next page).

The AAEL is then set equal to the ECA.

The AMEL and MDEL are calculated as:

AMEL = ECA x AMEL multiplier

MDEL = ECA x MDEL multiplier/AMEL multiplier

The AMEL and MDEL multipliers are determined from the equations provided in Section 1.4.0 of the SIP (SWRCB 2005). The SIP specifies that if the sampling frequency is four times per month or less, than the “n” for determining the AMEL multiplier shall be set equal to 4.

**Table C–3. Attenuation Factors for Dibromochloromethane (DBCM), Dichlorobromomethane (DCBM), and Chloroform for New Alamo Creek at Brown-Alamo Dam.** Attenuation Factor = Effluent Concentration /New Alamo Creek at Brown-Alamo Dam Concentration).

| Dibromochloromethane (DBCM) | | | | |
|---|---|---|---|---|
| Year | Month | Effluent (µg/L) | End of OAC (µg/L) | Attenuation Factor |
| 2003 | 4 | 2.5 | 0.5 | 5.00 |
| | 5 | 3.6 | 0.7 | 5.14 |
| | 6 | 4.1 | 0.7 | 5.86 |
| | 7 | 3.2 | 0.5 | 6.40 |
| | 8 | 2.3 | 0.5 | 4.60 |
| | 9 | 2.8 | 0.5 | 5.60 |
| | 10 | 3 | 0.5 | 6.00 |
| | 11 | 2 | 0.5 | 4.00 |
| 2004 | 4 | 3.9 | 1.2 | 3.25 |
| | 5 | 4.5 | 0.8 | 5.63 |
| | 6 | 3.3 | 0.5 | 6.60 |
| | 7 | 4.9 | 0.5 | 9.80 |
| | 8 | 3.7 | 0.5 | 7.40 |
| | 9 | 2.6 | 0.5 | 5.20 |
| | 10 | 1.9 | 0.5 | 3.80 |
| 2006 | 2 | 3.2 | 0.5 | 6.40 |
| | 3 | 3.1 | 0.1 | 31.00 |
| | 5 | 3.6 | 0.5 | 7.20 |
| | 6 | 3.4 | 0.5 | 6.80 |
| | 7 | 3.1 | 0.3 | 10.33 |
| | 8 | 13 | 1.3 | 10.00 |
| | 9 | 3.1 | 0.2 | 15.50 |
| | 10 | 2.8 | 0.5 | 5.60 |
| | 11 | 1.9 | 0.3 | 6.33 |
| | 12 | 2.3 | 0.5 | 4.60 |
| 2007 | 1 | 2.2 | 0.5 | 4.40 |
| | 2 | 2.7 | 0.5 | 5.40 |
| | 3 | 2.3 | 0.5 | 4.60 |
| | 4 | 2 | 0.5 | 4.00 |
| | 5 | 2.9 | 0.5 | 5.80 |
| | 6 | 3.8 | 0.6 | 6.33 |
| | 7 | 3.4 | 0.4 | 8.50 |
| | 8 | 2.2 | 0.5 | 4.40 |
| | | | **Median** | **5.80** |

| Dichlorobromomethane (DCBM) | | | | |
|---|---|---|---|---|
| Year | Month | Effluent (µg/L) | End of OAC (µg/L) | Attenuation Factor |
| 2003 | 4 | 11 | 0.5 | 22.00 |
| | 5 | 12 | 1.8 | 6.67 |
| | 6 | 15 | 2 | 7.50 |
| | 7 | 13 | 1.9 | 6.84 |
| | 8 | 10 | 1 | 10.00 |
| | 9 | 12 | 1.5 | 8.00 |
| | 10 | 12 | 1.1 | 10.91 |
| | 11 | 10 | 1.9 | 5.26 |
| 2004 | 4 | 17 | 1.9 | 8.95 |
| | 5 | 19 | 3.4 | 5.59 |
| | 6 | 13 | 1 | 13.00 |
| | 7 | 14 | 1 | 14.00 |
| | 8 | 12 | 0.8 | 15.00 |
| | 9 | 12 | 1.1 | 10.91 |
| | 10 | 11 | 0.6 | 18.33 |
| 2006 | 2 | 17 | 1.9 | 8.95 |
| | 3 | 12 | 0.6 | 20.00 |
| | 5 | 17.1 | 2.1 | 8.14 |
| | 6 | 19.1 | 2.1 | 9.10 |
| | 7 | 17.2 | 1.1 | 15.64 |
| | 8 | 30.3 | 2.9 | 10.45 |
| | 9 | 18 | 1.2 | 15.00 |
| | 10 | 17 | 2.6 | 6.54 |
| | 11 | 12.9 | 1.7 | 7.59 |
| | 12 | 14.2 | 3.2 | 4.44 |
| 2007 | 1 | 13 | 3 | 4.33 |
| | 2 | 17.1 | 3.5 | 4.89 |
| | 3 | 14.6 | 2.9 | 5.03 |
| | 4 | 13 | 1.4 | 9.29 |
| | 5 | 15.5 | 2.2 | 7.05 |
| | 6 | 18.5 | 2.3 | 8.04 |
| | 7 | 22 | 2 | 11.00 |
| | 8 | 16.3 | 2.9 | 5.62 |
| | | | **Median** | **8.95** |

| Chloroform | | | | |
|---|---|---|---|---|
| Year | Month | Effluent (µg/L) | End of OAC (µg/L) | Attenuation Factor |
| 2003 | 4 | 24 | 5.8 | 4.14 |
| | 5 | 22 | 6.4 | 3.44 |
| | 6 | 30 | 6.9 | 4.35 |
| | 7 | 32 | 7.9 | 4.05 |
| | 8 | 29 | 5.3 | 5.47 |
| | 9 | 25 | 5.9 | 4.24 |
| | 10 | 43 | 5.8 | 7.41 |
| | 11 | 25 | 9.1 | 2.75 |
| 2004 | 4 | 50 | 8.7 | 5.75 |
| | 5 | 50 | 11 | 4.55 |
| | 6 | 27 | 4.3 | 6.28 |
| | 7 | 39 | 4.3 | 9.07 |
| | 8 | 33 | 4.9 | 6.73 |
| | 9 | 34 | 6.6 | 5.15 |
| | 10 | 47 | 3.2 | 14.69 |
| 2006 | 2 | 40 | 6.5 | 6.15 |
| | 3 | 22 | 1.4 | 15.71 |
| | 5 | 37 | 7.2 | 5.14 |
| | 6 | 50.4 | 8.2 | 6.15 |
| | 7 | 46.2 | 4.4 | 10.50 |
| | 8 | 37.4 | 6.1 | 6.13 |
| | 9 | 53.7 | 5.3 | 10.13 |
| | 10 | 45 | 14.3 | 3.15 |
| | 11 | 41.5 | 8.6 | 4.83 |
| | 12 | 42.4 | 15.8 | 2.68 |
| 2007 | 1 | 52 | 15.1 | 3.44 |
| | 2 | 52.3 | 18.1 | 2.89 |
| | 3 | 43.9 | 14.9 | 2.95 |
| | 4 | 73 | 7.6 | 9.61 |
| | 5 | 44.5 | 10.1 | 4.41 |
| | 6 | 47.1 | 8.9 | 5.29 |
| | 7 | 61 | 8.1 | 7.53 |
| | 8 | 60 | 15 | 4.00 |
| | | | **Median** | **5.15** |

**Table C–4. Example derivation of NPDES effluent limitations for Alternative 2 site-specific objectives – Approach B.**

| Constituent | Dibromochloromethane | Dichlorobromomethane | Chloroform |
|---|---|---|---|
| **TYPE** | HH, Long-term | HH, Long-term | HH, Long-term |
| Units | µg/L | µg/L | µg/L |
| **Criteria (applicable in downstream segments)** | **4.9** | **15.5** | **45.5** |
| **Median Attentuation Factor (1)** | **3.43** | **3.91** | **2.57** |
| Location | Terminus of OAC | Terminus of OAC | Terminus of OAC |
| Begin effluent sample | 9/10/2002 | 9/10/2002 | 9/10/2002 |
| End effluent sample | 8/14/2007 | 8/14/2007 | 8/14/2007 |
| count | n = 60 | n = 60 | n = 60 |
| **Maximum concentration at OAC** | **2.3** | **7.1** | **25.1** |
| mean | 0.70 | 2.74 | 11.35 |
| std deviation | 0.51 | 1.54 | 5.40 |
| **CV** | 0.73 | 0.56 | 0.48 |
| **z-statistic** (95% probability basis) | 1.645 | 1.645 | 1.645 |
| **z-statistic** (99% probability basis) | 2.326 | 2.326 | 2.326 |
| ECA | 16.807 | 60.605 | 116.935 |
| ECA multiplier | NA | NA | NA |
| LTA | NA | NA | NA |
| **Sampling n** | 4 | 4 | 4 |
| **AMEL** | **16.8** | **60.6** | **116.9** |
| AMEL Multiplier (95%) | 1.68 | 1.52 | 1.43 |
| MDEL Multiplier (99%) | 3.69 | 2.95 | 2.58 |
| **MDEL** | **36.9** | **118.0** | **211.1** |

Notes:
AMEL = Average monthly effluent limitation
MDEL = Maximum daily effluent limitation
NA = Not applicable, due to long-term average criteria
OAC = Old Alamo Creek
(1) Median value; Effluent/(End of Old Alamo Creek); Nov-Mar when no irrigation flows are present; see Table C-5

In the above table, the maximum concentration at the terminus of Old Alamo Creek is less than the C (Alternative 2 objectives), thus, effluent limitations would not be needed in this example. Effluent limitations are, nevertheless, derived to illustrate the steps in the calculation. The ECA is calculated as:

ECA = Attenuation Factor x [C + D(C-B)]

C is the site-specific objective and the attenuation factor is the median of the individually calculated attenuation factors derived from representative historical data for the November through March months of the year (see Table C-5 on the next page). D and B are dilution credit and background concentration as defined by the SIP (SWRCB 2005). In this example, no dilution credit is provided in the calculation of the effluent limitations.

The AAEL is then set equal to the ECA.

The AMEL and MDEL are calculated as:

AMEL = ECA x AMEL multiplier

MDEL = ECA x MDEL multiplier/AMEL multiplier

The AMEL and MDEL multipliers are determined from the equations provided in Section 1.4.0 of the SIP (SWRCB 2005). The SIP specifies that if the sampling frequency is four times per month or less, than the “n” for determining the AMEL multiplier shall be set equal to 4.

**Table C–5. Attenuation Factors for Dibromochloromethane (DBCM), Dichlorobromomethane (DCBM), and Chloroform for Old Alamo Creek.** Attenuation Factor = Effluent Concentration /End of Old Alamo Creek Concentration for the months of November through March of each year.

| Dibromochloromethane (DBCM) | | | | |
|---|---|---|---|---|
| Year | Month | Effluent (µg/L) | End of OAC (µg/L) | Attenuation Factor |
| 2002 | 11 | 2.2 | 0.6 | 3.67 |
| | 12 | 2 | 0.8 | 2.50 |
| 2003 | 1 | 4.1 | 1.3 | 3.15 |
| | 2 | 7.7 | 1.9 | 4.05 |
| | 3 | 5 | 1.5 | 3.33 |
| | 11 | 2 | 0.6 | 3.33 |
| | 12 | 4 | 1.1 | 3.64 |
| 2004 | 1 | 3.4 | 1.5 | 2.27 |
| | 2 | 4.6 | 1.1 | 4.18 |
| | 3 | 4.9 | 1.3 | 3.77 |
| | 11 | 2.6 | 0.54 | 4.81 |
| | 12 | 1.7 | 0.59 | 2.88 |
| 2005 | 1 | 3.9 | 0.63 | 6.19 |
| | 2 | 3.3 | 1.1 | 3.00 |
| | 3 | 6.7 | 2.3 | 2.91 |
| | 11 | 3.4 | 0.5 | 6.80 |
| | 12 | 2.4 | 0.7 | 3.43 |
| 2006 | 1 | 3.8 | 1.6 | 2.38 |
| | 2 | 3.2 | 1 | 3.20 |
| | 3 | 3.1 | 0.6 | 5.17 |
| | 11 | 1.9 | 0.6 | 3.17 |
| | 12 | 2.3 | 0.6 | 3.83 |
| 2007 | 1 | 2.2 | 0.5 | 4.40 |
| | 2 | 2.7 | 0.6 | 4.50 |
| | 3 | 2.3 | 0.7 | 3.29 |
| | | | **Median** | **3.43** |

| Dichlorobromomethane (DCBM) | | | | |
|---|---|---|---|---|
| Year | Month | Effluent (µg/L) | End of OAC (µg/L) | Attenuation Factor |
| 2002 | 11 | 12 | 3 | 4.00 |
| | 12 | 11 | 3.7 | 2.97 |
| 2003 | 1 | 17 | 4.4 | 3.86 |
| | 2 | 26 | 7.1 | 3.66 |
| | 3 | 19 | 4.9 | 3.88 |
| | 11 | 10 | 2.5 | 4.00 |
| | 12 | 19 | 4.6 | 4.13 |
| 2004 | 1 | 14 | 5.2 | 2.69 |
| | 2 | 17 | 3.7 | 4.59 |
| | 3 | 22 | 5.1 | 4.31 |
| | 11 | 11 | 1.9 | 5.79 |
| | 12 | 8.6 | 3 | 2.87 |
| 2005 | 1 | 13 | 1.9 | 6.84 |
| | 2 | 12 | 3.3 | 3.64 |
| | 3 | 20 | 5.9 | 3.39 |
| | 11 | 17 | 2.5 | 6.80 |
| | 12 | 15 | 3.8 | 3.95 |
| 2006 | 1 | 11 | 4.8 | 2.29 |
| | 2 | 17 | 4.9 | 3.47 |
| | 3 | 12 | 2.4 | 5.00 |
| | 11 | 12.9 | 3.3 | 3.91 |
| | 12 | 14.2 | 3.9 | 3.64 |
| 2007 | 1 | 13 | 3.2 | 4.06 |
| | 2 | 17.1 | 4.1 | 4.17 |
| | 3 | 14.6 | 4.2 | 3.48 |
| | | | **Median** | **3.91** |

| Chloroform | | | | |
|---|---|---|---|---|
| Year | Month | Effluent (µg/L) | End of OAC (µg/L) | Attenuation Factor |
| 2002 | 11 | 29 | 17 | 1.71 |
| | 12 | 29 | 21 | 1.38 |
| 2003 | 1 | 35 | 11 | 3.18 |
| | 2 | 54 | 21 | 2.57 |
| | 3 | 53 | 20 | 2.65 |
| | 11 | 25 | 12 | 2.08 |
| | 12 | 52 | 19 | 2.74 |
| 2004 | 1 | 37 | 16 | 2.31 |
| | 2 | 60 | 12 | 5.00 |
| | 3 | 46 | 15 | 3.07 |
| | 11 | 36 | 8.2 | 4.39 |
| | 12 | 22 | 11 | 2.00 |
| 2005 | 1 | 21 | 3.8 | 5.53 |
| | 2 | 27 | 13 | 2.08 |
| | 3 | 32 | 15 | 2.13 |
| | 11 | 46 | 13 | 3.54 |
| | 12 | 49 | 19 | 2.58 |
| 2006 | 1 | 31 | 12 | 2.58 |
| | 2 | 40 | 17 | 2.35 |
| | 3 | 22 | 5.8 | 3.79 |
| | 11 | 41.5 | 17 | 2.44 |
| | 12 | 42.4 | 19.2 | 2.21 |
| 2007 | 1 | 52 | 17.3 | 3.01 |
| | 2 | 52.3 | 25.1 | 2.08 |
| | 3 | 43.9 | 23.9 | 1.84 |
| | | | **Median** | **2.57** |