Review of the TU/WB/ESH Proposal

Prepared for:
California State Water Resources Control Board
Division of Water Rights

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1 Introduction

On April 30, 2009, Trout Unlimited, Wagner and Bonsignore Consulting Engineers, and Ellison, Schneider, and Harris, LLP submitted Joint Recommendations for the North Coast Instream Flow Policy[1] (TU/WB/ESH proposal). The TU/WB/ESH Proposal contains recommendations for water right procedures and recommended review standards for calculating bypass flows and rates of diversions. This review focuses on the scientific aspects of the review standards for calculating bypass flows and rates of diversion that are described in Section 5 and the Appendix of the TU/WB/ESH Proposal. Responses to the water right procedures recommendations can be found in a separate document.

1.1 TU/WB/ESH Proposal Scientific Aspects

The TU/WB/ESH Proposal is a proposed alternative to the Draft Policy[2].
Both the TU/WB/ESH Proposal and the Draft Policy limit diversions with the intention of protecting the fishery resource. These limitations are implemented by limiting the season when diversion is allow, by requiring a minimum bypass flow, by limiting the cumulative diversions, and by placing restrictions on onstream dams. The Draft Policy provides protective regional criteria and allows for site-specific studies. The TU/WB/ESH Proposal focuses on conceptual site-specific methods to determine the flow thresholds and suggests some alternative regional estimates.

The TU/WB/ESH Proposal allows a fundamental shift in approach from the Draft Guidelines by NMFS-DFG[3] and the Draft Policy in that diversion flows are allowed below the spawning flow threshold. In addition, the TU/WB/ESH Proposal allows projects above the upper limit of spawning habitat to operate without a minimum bypass flow if the project passes a special test. State Water Board staff is considering developing revisions to the Draft Policy to address situations in which diversions could operate with reduced or no minimum bypass flows and rates of diversion while still being protective of salmonid habitat.

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[1] TU/WB/ESH Proposal, Microsoft Word document “2009-04-30 AB 2121 Joint Recs review draft secs 1-9.doc”

[2] Policy For Maintaining Instream Flows in Northern California Coastal Stream, State Water Resources Control Board, Draft dated March 14, 2008.

[3] <u>Guidelines for maintaining instream flows to protect fisheries resources downstream of water diversions in mid-California coastal streams</u> (an update of the May 22, 2000 guidelines), California Department of Fish and Game and National Marine Fisheries Service (DFG-NMFS), June 2002.

Table 1 lists the scientific aspects in the TU/WB/ESH Proposal, briefly describes the proposed implementation of each aspect, and lists the comparable criteria in the Draft Policy.

Table 1. Scientific Aspects of TU/WB/ESH Proposal Compared to Draft Policy Criteria

Scientific Aspect	Proposed Mechanism for Implementation	Comparable Draft Policy Criteria
Winter Low Flow Threshold	flow threshold below which no diversion is allowed	Minimum Bypass Flow, Draft Policy Section 2.3.2 and 4.1.8
Salmon Spawning Flow	flow threshold at which cumulative diversions may increase from a lower rate to a higher rate	n/a
Flow Management Objectives	limit cumulative diversions to one of two rates depending on unimpaired flow	Maximum Cumulative Diversion, Draft Policy Section 2.3.3 and 4.1.8
Cumulative Effects Test	test to assess whether a minimum bypass flow would be needed for projects above the upper limit of spawning habitat	Revisions to Draft Policy are being considered that would assess whether a minimum bypass flow and/or maximum cumulative diversion would be needed for projects above the upper limit of anadromy
Minimum Bypass Term	implementation of the minimum bypass term requirements	Minimum Bypass Flow, Draft Policy Section 2.3.2 and 4.1.8
Season of Diversion	calendar period during which diversion is allowed that avoid upstream or downstream additive impacts to fishery resource	Season of Diversion, Draft Policy Section 2.3.1
Onstream Dams	onstream dam requirements to avoid upstream or downstream additive impacts to fishery resources	Permitting Requirements for Onstream Dams, Draft Policy Section 4.4
Upper Limit of Spawning Habitat	the protocol for calculating Upper Limit of Spawning Habitat	Determination of the Upper Limit of Anadromy, Draft Policy Section 4.1.4

The TU/WB/ESH Proposal presumes that restricting the amount of diversion that occurs below the flow required for salmon spawning (as determined following the proposed criteria) would sustain good juvenile rearing habitat. This is similar to the assumption applied in the Draft Policy but with the critical difference that the TU/WB/ESH proposal allows diversion below the spawning flow, down to a substantially lower magnitude minimum bypass flow. This minimum bypass flow identified in the TU/WB/ESH proposal is termed the 'Winter Low Flow' threshold and is based on preserving a basic lower flow limit for biological purposes other than protecting spawning and upstream passage.

This report provides a technical evaluation of the review standards for calculating bypass flows and rates of diversion described in Section 5 and the Appendix of the TU/WB/ESH Proposal. The discussion covers the following: (1) technical description,

(2) assessment of completeness, scientific basis and soundness, practicality, and (3) initial review of protectiveness. A summary of the findings of the initial review are provided. This report also provides a description and results of a scientific assessment of the protectiveness of certain scientific aspects of the proposal using available transect and hydrology information from existing validation sites within the Policy area.

2 Review by Scientific Aspect

2.1 Winter Low Flow Threshold

Section 5.2.2 of the TU/WB/ESH Proposal describes the Winter Low Flow as:

> *The Winter Baseline Flow Threshold (*i.e., Winter Low Flow, or Q_{WLF}*) is a streamflow threshold important to managing several steelhead and salmon life history needs in small North Coast California streams: (1) maintaining good benthic macroinvertebrate habitat in riffles to foster high stream productivity, (2) preventing redd desiccation and maintaining hyporheic subsurface flows, (3) sustaining high quality and abundant juvenile salmonid winter rearing habitat, and (4) facilitating smolt out-migration.*

The Winter Low Flow is implemented in the TU/WB/ESH Proposal in the same way that the MBF criterion is implemented in the Draft Policy; as flow thresholds below which no diversion is allowed. The Winter Low Flow is therefore functionally a minimum bypass flow threshold.

2.1.1 Proposed Methodologies

Site Specific Method

Section IV of the Appendix to the proposal, Guidance for Estimating Q_{WLF} and Q_S, provides two site specific field methods to calculate the Winter Low Flow in watersheds less than 10 square miles:

1. Methodology Based on BMI Habitat Mapping (Appendix Section IV): The proposal recommends a methodology for defining the Winter Low Flow as the overall asymptote of the benthic macroinvertebrate (BMI) habitat rating curves developed based on habitat mapping at riffles.

2. Interim Methodology Based on RCT Particle Depth (Appendix Section IV): Because , "*no BMI habitat rating curve has been constructed for a small North Coast California stream*", the proposal recommends an interim methodology that estimates the Winter Low Flow as the streamflow at the median riffle crest thalweg (RCT) that inundates the dominant particle size of the riffles (quantified as the D_{84} in a 100 rock-count).

No site-specific method is provided to calculate the Winter Low Flow for watersheds greater than 10 square miles.

Regional Method

Section 5.9.2.B proposes that "*Applicants may use the February Median flow as an estimate of Q_{WLF}.*" Section IV of the Appendix recommends using the February median flow as an estimate of Winter Low Flow as an initial regional estimate in-lieu of rock counts and until benthic macroinvertebrate habitat mappings are complete. No watershed size limitation is given for the regional method.

2.1.2 Review of the Completeness

Site Specific Method

The methods proposed are conceptual in nature. The proposal states that further testing and evaluation are required for each methodology. The proposed methods require a literature survey and compilation or collection of field data for a range of stream sizes to verify practicality and protectiveness across the Policy area.

1. Methodology Based on BMI Habitat Mapping (Appendix Section IV): Although the BMI habitat mapping site-specific methodology to calculate the Winter Low Flow in watersheds less than 10 square miles is described in detail, it is still not clear when this methodology would be used in place of the interim methodology based on RCT particle depth nor how and when the interim methodology would be reviewed and perhaps adjusted based on the BMI habitat mapping.

2. Interim Methodology Based on RCT Particle Depth (Appendix Section IV): The RCT particle depth interim methodology to calculate the Winter Low Flow in watersheds less than 10 square miles is incomplete. The proposal states that this method will be reviewed and could be adjusted. There is insufficient guidance given to avoid confusion that may arise during implementation regarding the appropriate value of D_{84} to apply, and the elevation datum against which it should be compared.

No site-specific method is provided to calculate the Winter Low Flow for watersheds greater than 10 square miles.

Regional Method

The proposal recommends that the February median flow could be used as a regional method to calculate the Winter Low Flow, but provided no technical basis. Given that the Winter Low Flow is applied as a diversion threshold similar to the MBF, this part of the proposal is identical to the DFG-NMFS Draft Guidelines and thus it is assumed that the same methods to estimate the February median flow would apply.

2.1.3 Review of the Scientific Basis and Soundness

Site Specific Method

No data or literature citations are provided to support the suggestion that the site specific methodologies will provide a means for calculating a specific flow rate that is protective.

1. Methodology Based on BMI Habitat Mapping (Appendix Section IV)

The proposal does not fully explain the basis for target median particle size[4], inundation depth, and BMI nor does it state the specific relationship between these three parameters. Optimal values of substrate size, depth, and BMI are not defined.

No supporting data or studies are identified indicating that minimum depth of inundation equal to submersion of median particle size is the appropriate metric. No definitive approach is presented for establishing how the datum elevation should be measured (i.e., inundation relative to what baseline level).

The method refers to "highly productive BMI habitat" but this is not necessarily synonymous with a highly diverse BMI community which is a usual measure of stream health. For example, a highly productive BMI habitat may be extremely low in diversity, dominated by one taxon that is highly tolerant to stressful stream conditions (sedimentation, high temperatures, pollutants, etc.).

The method does not include any measure of BMI community. The BMI community varies within and among streams, due to many biotic and abiotic conditions beyond substrate and velocity.

2. Interim Methodology Based on RCT Passage Depth (Appendix Section IV)

This is a site specific method for use in small streams proposed for interim use due to the current unavailability of BMI habitat rating curves. No information is provided on how this method "*could be adjusted based on the results of site specific studies using the habitat mapping methodology*".

No data or studies are identified that support the assertion that the median RCT inundating the D_{84} particle is the appropriate target protective flow level, or that the D_{84} is the appropriate criterion to use.

There is no scientific basis provided for assuming that the example winter low flow calculation result for Davenport Creek is representative of what may be expected in

[4] Particle size will vary from site to site and within a site.

other streams in the Policy area. The lower result for Sullivan Gulch is not evaluated to the same level as for Davenport Creek and this analysis should be provided to support the applicability of the method to other streams.

Regional Method

No supporting data or reasoning is provided to support the use of the February Median flow to estimate the Winter Low Flow.

2.1.4 Review of Practicality as Applied to Water Rights Administration

More detail is needed outlining which site specific method to apply and how to determine a specific stream flow level before the practicality can be assessed.

The regional method is practical as applied to water rights administration.

2.1.5 Initial Assessment of Protectiveness

Site Specific Method

The Winter Low Flow as estimated by the interim methodology based on RCT particle depth appears to be underprotective as a minimum bypass flow threshold in most validation site cases evaluated. As seen in Appendix A, the proposed Winter Low Flow allows diversion at very low flows in the validation sites. The percent of unimpaired flow diverted is greatest over the base flow range and can exceed 70% at very low flows according to the rating curves presented in Figures A-2 through A-13. For example, Figure A-23a depicts a representative scenario in Salmon Creek where between 20-30% of unimpaired flow, or around 2.3 cfs, is diverted under the TU/WB/ESH Proposal the first seven days in the graph. The percentage drops as runoff events occur, but remains relatively high at about 20% at moderate flow levels, with diversion rates around 13 cfs (also see summary of percent impairment ranges at low flows for all sites in Table A-2 of Appendix A) . These diversion rates during base are unlikely to be protective of habitat needs during base flows and are generally inconsistent with the original premise behind the DFG-NMFS 2000 Draft Guidelines that water should only be available for diversion from the higher flow range.

This potential problem of diverting at base flow may also be seen in the TU/WB/ESH Proposal The example given for Davenport Creek (5.52 cfs) results in a relatively high minimum bypass flow threshold, but Sullivan Gulch, which drains more than twice the area than Davenport Creek, appears to need a much lower flow (≤1 cfs) to meet the D_{84} criterion (cf. figure 5 in TU/WB/ESH Proposal). .

The Davenport Creek example depicted in Figure 9 of the TU/WB ESH Proposal indicates that the calculated Winter Low Flow (5.52 cfs) is approximately the point above which the coho salmon spawning habitat-flow curves level off in that site. This analogous point on the steelhead spawning habitat-flow curves corresponds to the level of habitat used to identify the site-specific flow level in each validation site included in the derivation of the regional MBF relation for the Draft Policy[5] Given the difference in habitat suitability criteria presented in the Task 3 Report[6], the corresponding steelhead spawning flow that is functionally equivalent to the validation site flows used to derive the regional MBF relation would be greater, and thus it is possible the Winter Low Flow requirement may be slightly under-protective in Davenport Creek if steelhead are present.

Regional Method

The Task 3 Report demonstrates that the February median flow (see Table A-1) may be under-protective as a regional spawning criterion in small streams. It may or may not be suitable as a regional criterion for the Winter Low Flow threshold, but its protectiveness in the context of the proposed two-stage diversion approach is not demonstrated in the TU/WB/ESH Proposal. As reported in Table A-1, the magnitude of the estimated February median flow is between 1-3 orders of magnitude greater than the site-specific winter low flow for nearly all validation sites except Carneros Creek.

The proposed Winter Low Flow site specific methods are for site specific studies in small watersheds, not for development of protective regional criteria. Based on the results of the validation site assessment, the Winter Low Flow threshold allows diversion at very low flow and this threshold should not be used in the development of a regional MBF criterion because it would likely be under-protective regionally.

2.2 Salmon Spawning Flow Threshold

Section 5.2.1 of the TU/WB/ESH Proposal describes the Salmon Spawning Flow as:

> *The Salmon and Steelhead Spawning and Migration Flow Threshold ("Salmon Spawning Flow" or Q_S) is a streamflow threshold important for managing the protection of two steelhead and salmon life history needs in small North Coast California streams: (1) maintaining natural abundance and availability of spawning habitat; and (2) minimizing unnatural adult exposure, stress, vulnerability, and delay during adult spawning migration.*

[5] Policy for Maintaining Instream Flows in Northern California Coastal Streams, Division of Water Rights, State Water Resources Control Board, March 2008 Draft.
[6] North Coast Instream Flow Policy: Scientific Basis and Development of Alternatives Protecting Anadromous Salmonids, Task 3 Report, R2 Resource Consultants, Inc, March 2008 Administrative Draft.

The Salmon Spawning Flow criterion is different in concept and principle and is implemented differently from the MBF criterion in the Draft Policy. The proposal allows diversion above and below the Salmon Spawning Flow; thus, it is not implemented in the same way as the MBF criterion, which is a threshold below which diversion is not permitted. The two criteria should, therefore, not be confused with one another in the context of protecting biological functions

2.2.1 Proposed Methodologies

Site Specific Method

Section III of the Appendix to the proposal, entitled Guidance for Estimating Q_{WLF} and Q_S, provides two site specific field methodologies and analytical framework to calculate the Salmon Spawning Flow in watersheds less than 10 square miles:

1. *Methodology Based on Habitat Mapping (Appendix Section III)*: The proposal recommends setting the Salmon Spawning Flow at the highest streamflow that sustains habitat at individual sites with a minimum area 15 ft^2 for coho and 10 ft^2 for steelhead.

2. *Interim Methodology Based on RCT Fish Depth (Appendix Section III):* The proposal recommends an interim methodology to estimate the Salmon Spawning Flow as the streamflow that produces the minimum fish depths at the median RCT on a composite habitat rating curve. The proposed minimum fish depth is determined based on the fish that spawn in the vicinity of the diversion: 0.7 ft for steelhead; 0.8 ft for coho and steelhead; and1.0 ft for Chinook, coho and steelhead.

No site-specific method is provided for watersheds greater than 10 square miles.

Regional Method

No regional method is provided to calculate the Salmon Spawning Flow in watersheds less than 10 square miles. Section 5.9.2.A states that the regional estimate of the Salmon Spawning Flow is "*to be re-calculated by agency staff*".

For watersheds larger than 10 square miles, Section 5.9 states that:

> *In larger watersheds (i.e., those greater than about 10 square miles), Q_{WLF} will result in deeper flows than Q_S. Where that is true, applicants should substitute the calculation of Q_{WLF} for Q_S where the policy would otherwise call for a calculation of Q_S.*

2.2.2 Review of the Completeness

The methods proposed are conceptual in nature. The proposal states that further testing and evaluation is required for each methodology.

<u>Site Specific Method</u>

1. *Methodology Based on Habitat Mapping (Appendix Section III)*: The habitat mapping site-specific method is described in detail but it is not clear when this method would be used in place of the interim fish depth method or how and when the fish depth method would be reviewed and perhaps adjusted based on the habitat mapping.

2. *Interim Methodology Based on RCT Fish Depth (Appendix Section III):* The fish depth site specific interim methodology is essentially complete in concept but the proposal states that this method will be reviewed and could be adjusted.

No site-specific method is provided for watersheds greater than 10 square miles.

<u>Regional Method</u>

No regional method is provided to calculate the Salmon Spawning Flow in watersheds less than 10 square miles.

No information is provided on how the regional estimate of the Salmon Spawning Flow is "*to be re-calculated by agency staff*". The Draft Policy used a mean regression to fit data points that were considered protective at the site specific scale and conservatively increased the regression intercept by 3 standard errors to be protective at the regional scale.

2.2.3 Review of the Scientific Basis and Soundness

No data or literature citations are provided to support the suggestion that the methodologies will provide a means for making a decision on a specific spawning flow rate that is protective.

<u>Site Specific Method</u>

The analysis in Section III of the Appendix relies on a limited number of streams representing a small range of drainage areas. The applicability of the methods proposed is not demonstrated in a larger regional context. The suitability of the methods appears to reflect professional opinion as opposed to a conclusion drawn from a larger data set.

1. Methodology Based on Habitat Mapping (Appendix Section III):

The habitat mapping approach (termed by the author in the past as "Expert Habitat Mapping" and, more recently in the fisheries literature, as "Demonstration Flow Assessment") is labor intensive and may be questionable with respect to reproducibility and interpolation/extrapolation (e.g., Gard 2009[7]). This is a site-specific methodology that generates habitat-flow curves that lead to flow choices that are not substantially dissimilar in magnitude compared with PHABSIM and 2-D modeling. The habitat mapping approach is a possible alternative approach, but its superiority has not been scientifically demonstrated.

There is no supporting explanation or basis for how the various habitat-flow curves shown in Figure 6 are integrated together to create a single composite curve shown in Figure 8. There are no biologically meaningful mathematical methods identified and explained sufficiently to support one compositing algorithm over another (e.g., simple average, weighted average, curve matching, window filters/tapering, etc.).

It is unclear why the general redd area criterion proposed for coho salmon (15 ft^2) is greater than for steelhead (10 ft^2). This is in contrast to generally accepted data differences that reflect larger bodied steelhead digging larger area redds than coho (e.g., Shapovalov and Taft 1954[8]; Bjornn and Reiser 1991[9]).

2. Interim Methodology Based on RCT Fish Depth (Appendix Section III)

Frequency histogram data or supporting literature citations that support stated fish body depth criteria are not provided. The proposed 0.8 ft and 1.0 ft criteria are generally consistent with the Draft Policy criteria which may imply acceptance of the Draft Policy criteria. However, the rationale for why the depth criterion is 0.7 ft for steelhead alone and 0.8 ft for both steelhead and coho is not provided nor does the proposal appear to make sense in this respect because steelhead tend to be larger bodied.

The RCT fish depth method appears to rely on professional opinion that the median measurement at each flow is the appropriate instream flow level to specify. The assumption that the RCT result is a suitable surrogate for Salmon Spawning Flow is not demonstrated. There are no data or studies provided supporting the method and its criteria. Each riffle crest will have its own unique, non-linear stage-discharge rating curve. For assessing instream flow needs at the site specific level, each riffle-specific

[7] Demonstration flow assessment and 2-D modeling: Perspectives based on Instream flow studies and evaluation of restoration projects, Fisheries 34(7): 320-329, Gard, M., 2009.

[8] Shapovalov, L., and A.C. Taft. 1954. The life histories of the steelhead rainbow trout (*Salmo gairdneri gairdneri*) and silver salmon (*Oncorhynchus kisutch*), with special reference to Waddell Creek, California, and recommendations regarding their management. California Department of Fish and Game, Fish Bulletin No. 98.

[9] Bjornn, T.C., and D.W. Reiser. 1991. Habitat requirements of salmonids in streams. Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19: 83-138.

curve should be evaluated first to identify the appropriate flow level for passage at, or spawning upstream of, the riffle crest location. The collective data can then be evaluated explicitly and directly for biological meaningfulness. The biological meaningfulness of the median criterion involves more subjectivity and opinion than other methods.

<u>Regional Method</u>

Data supporting the claim (Section 5.9) that the Winter Low Flow results in deeper flows than the Salmon Spawning Flow in larger watersheds (i.e., those greater than about 10 square miles) are not provided, and neither are clear definitions provided regarding which specific measures of the Winter Low Flow (BMI Habitat Mapping, D_{84}-based RCT approach, or regional February median flow) and spawning flows (RCT- or habitat mapping-based) are being referenced. For example, the site specific assessment in Appendix A demonstrates that at the validation sites, the Winter Low Flow calculated using the D_{84}-based RCT method is characteristically 2-3 orders of magnitude smaller than the RCT-based Salmon Spawning Flow in the sites with drainage areas greater than 10 square miles (Table A-1). Greater specificity is required regarding definitions of specific flow measures being compared.

2.2.4 Review of Practicality as Applied to Water Rights Administration

<u>Site Specific Method</u>

The level of field effort and documentation required of applicants to calculate the site specific Salmon Spawning Flow may be greater for the habitat mapping method than the RCT Fish Depth interim method or the methods described in the Draft Policy.

1. Methodology Based on Habitat Mapping (Appendix Section III): The use of fixed wing aircraft to obtain aerial photography with sufficient resolution for habitat mapping (see page 32 of the TU/WB/ESH Proposal) is not feasible for many if not most small streams in the Policy area because of canopy cover and relief shading effects, and small channel size relative to typical photograph resolution. In addition, hiring a fixed wing with sufficient photographic resolution could be prohibitively expensive for many applicants. Instead, applicants would need to use a relatively sophisticated helium balloon equipped with special cameras followed by aerial photographic georeferencing in GIS or other photogrammetric software. This could also become expensive, especially if only a limited number of consultants are available with this capability, leading to supply-demand imbalances on cost.

2. Interim Methodology Based on RCT Fish Depth (Appendix Section III): The RCT surveys as described in Appendix Section III of the proposal appear to require a large number of field measurements. Pages 28-29 of the proposal requires that the RCT depth and discharge be measured at 15 or more riffle crests per POD during at least 6 to 8 surveys to span the range of typical base flows and receding storm flows. Assuming that each cross-section profile must be resurveyed each time to ensure no change in stage-discharge relation, this would amount to 120 transect surveys and up to 8 discharge measurements per POD and POI. Assuming a minimum of two persons in the field for safety reasons, and approximately 16 person hours total for each field visit including mobilization and demobilization, this would amount to roughly 128 person hours for field work per POD or POI. Data reduction, analysis and documentation would likely take about 16-24 person hours. In comparison, a typical simplified PHABSIM study to develop spawning or juvenile habitat-flow relations might involve 18 transect surveys and 3 discharge measurements, for a total of 48 person hours in the field. Data reduction, analysis and documentation would take roughly another 24-36 person hours per POD or POI. Total minimum effort for each would then be about 152 person hours for the RCT method, and 84 person hours for the simplified PHABSIM approach for each POD and POI. Thus the RCT method may not be as cost effective as implied in the TU/WB/ESH Proposal.

<u>Regional Method</u>

No regional method is provided for watersheds less than 10 square miles therefore the majority of water right applicants will be obliged to use the site specific method.

2.2.5 Initial Assessment of Protectiveness

<u>Site Specific Method</u>

The two site specific methods proposed result in very different levels of flow protection. There is no clear biological basis provided for choosing one site-specific method over the other, the selection criterion for which method to apply appears arbitrary at present. In addition, the method of implementation of the Salmon Spawning Flow in the minimum bypass permit term greatly affects the protectiveness of this threshold as discussed in Section 2.5.

The protectiveness of the two site-specific Salmon Spawning Flow methods in conjunction with the proposed method to calculate allowable diversion rate is discussed in greater detail in Section 2.3.

1. Methodology Based on Habitat Mapping (Appendix Section III): In the habitat mapping methodology, the positioning of Qs on the right hand side of the habitat-flow curve may be overly protective at the site specific level if only relatively little diversion can be permitted. As seen in Table A-1 of Appendix A, the habitat mapping-based method results in values of Q_s in most validation sites that are from twice to more than ten times the results of the RCT-based method. This can be seen visually in Figure A-1 of Appendix A, where the data scatter for the habitat mapping-based results plot substantially above the flows derived using other methods.

2. Interim Methodology Based on RCT Fish Depth (Appendix Section III): There may be a logical inconsistency in the statement on page 31 that flows at the Salmon Spawning Flow will cover the backs of migrating fish. If a 10% diversion level is allowed at unimpaired flow levels below the Salmon Spawning Flow, then the diversion may result in the impacts that the Salmon Spawning Flow is stated to protect against. This potential effect is not evaluated. The protectiveness of the RCT fish depth method is not sufficiently demonstrated, and examples provided are for a limited range of stream sizes. The RCT fish depth method is also generally insensitive to stream size and thus becomes progressively less protective with increasing stream size.

<u>Regional Method</u>

The methods presented to estimate the Salmon Spawning Flow are for site specific study. No data are presented supporting the use of results of these site-specific methods to develop regional criteria.

2.3 Flow Management Objectives

The Flow Management Objectives limit the cumulative diversion above the points of evaluation. This is implemented in the proposal in the same way that the MCD criterion is implemented in the Draft Policy.

2.3.1 Proposed Methodologies

Section 5.3 of the TU/WB/ESH Proposal provides Flow Management Objectives that define acceptable changes in stage at the median riffle crest thalweg (RCT) at the points of evaluation from “cumulative diversions”. These stage limits are provided as a function of the daily average unimpaired flows (Q_D):

- *When Q_D exceeds Q_S, diversions shall cumulatively cause no more than 0.1 ft change in depth at the median Riffle Crest Thalweg at the Points of Evaluation.* [Note: Section 5.6.5 states without further proof that meeting this Flow Management Objective will protect channel forming flows.]
- *When Q_D is between Q_{WLF} and Q_S, diversions shall cumulatively cause no more than 0.05 ft change in depth at the median Riffle Crest Thalweg at the Points of Evaluation.*
- *Q_D is less than Q_{WLF}, diversions are not allowed except as stated in section 5.6 [small projects above the Upper Limit of Spawning Habitat].*

Section 5.3.1 states that that rate of diversion limitations are used to meet the Flow Management Objectives as follows:

> *Applicants may comply with the cumulative rate of diversion management objectives using either a fixed rate of diversion (e.g., X cfs) or a variable rate of diversion based on a specified percentage of the daily streamflows (e.g., Y% of Q_D).*

Site Specific Method

In Section 5.3, the Flow Management Objectives state that "*Points of Evaluation for this purpose* [calculation of the Maximum Cumulative Rate of Diversion that results in compliance with the flow management objectives] *shall include the Upper Limit of Spawning Habitat and points of interest downstream from there"*.

Section 5.3.1 states that calculation of the Maximum Cumulative Rate of Diversion corresponding to a specific change in stage at a given flow rate at a Point of Evaluation requires development of a site-specific Q - RCT_m rating curve, as described in Section V of the Appendix to the proposal Guidance for Estimating Q_{WLF} and Q_S. Note: This maximum cumulative rate of diversion would need to account for all diversions in the watershed, and would not necessarily be the rate of diversion assigned to one particular project.

Section 5.8.2 describes the implementation of the Maximum Cumulative Rate of Diversion below the Upper Limit of Spawning Habitat as:

> *Diversions located below the Upper Limit of Spawning Habitat shall include a Maximum Cumulative Diversion (MCD) rate limitation consistent with the Management Objective limiting diversions to those that cumulatively cause no more than a change in depth of 0.1 ft at the median RCT when flows (Q_D) exceed Q_S, or to 0.05 ft at the median RCT when flows are between Q_{WLF} and Q_S, depending on the method selected for estimating the bypass.*

Section 5.6.5 describes requirements for the Maximum Cumulative Rate of Diversion above the Upper Limit of Spawning Habitat:

> *Projects above the Upper Limit of Spawning Habitat require a separate Maximum Cumulative Diversion (MCD) limitation only when needed to avoid cumulatively exceeding the objective to divert no more than that which causes a 0.1 ft change in depth when flows exceed Q_S, as calculated at 1 square mile and points of interest below.*

Section 5.6.5.A allows for the adjustment of the 1 square mile point of evaluation used in the determination of the Maximum Cumulative Rate of Diversion for projects above the Upper Limit of Spawning Habitat:

Applicants may substitute a site-specific determination of Upper Limit of Spawning Habitat for the 1 square mile point of evaluation only if site-specific information demonstrates that doing so will not impact channel forming flows in Class 1 streams above Upper Limit of Spawning Habitat.

For example, large watersheds where the Upper Limit of Spawning Habitat is farther downstream than would be expected (because of a waterfall, or a large municipal dam) may have habitat for resident fish or other resources covered by the policy above the Upper Limit of Spawning Habitat, which require channel forming flows.

Regional Method

Section 5.3.2 provides preliminary regional estimates of Maximum Cumulative Rate of Diversion for use in the absence of site specific Q- RCT_m rating curves. The proposed regional estimates are:

- *When $Q_D > Q_S$, diversions shall not exceed [15-20][10] % of Q_D (approximately 0.1 ft change in median RCT depth).*
- *When Q_D is between Q_{WLF} and Q_S, diversions shall not exceed [10-15][11] % of Q_D (approximately 0.05 ft change in median RCT depth).*

Section 5.8.2 provides a regional method for the implementation of the Maximum Cumulative Rate of Diversion below the Upper Limit of Spawning Habitat as:

In the absence of site-specific studies, diversions may be limited at a rate of 10% of Q_D (if diverting when flows are between Q_{WLF} and Q_S) or 20% of Q_D (if diverting when flows are above Q_S).

2.3.2 Review of the Completeness

This approach relies on site-specific study. The approach is in the conceptual stage and requires more detailed analysis to demonstrate it is protective before it can be applied.

No information is provided on how to calculate the daily average unimpaired flows.

The implementation of the proposal's maximum cumulative diversion describes including a "*rate limitation consistent with the Management Objective to limit diversions to those that cumulatively cause no more than*" the acceptable change in depth. The

[10] The parties are conducting additional analyses to refine this relationship, but expect the number to fall within the range of 15-20%. For present purposes, the text that follows uses 20%.
[11] The parties are conducting additional analyses to refine this relationship, but expect the number to fall within the range of 10-15%. For present purposes, the text that follows uses 10%.

method to determine this rate limitation in consideration of the existing diversions upstream of the point of evaluation is not defined.

Figures 10 and 11 are incomplete. There is no discussion or evaluation of impacts to the stream flow hydrograph below the POD.

2.3.3 Review of the Scientific Basis and Soundness

The rationale or basis for having multiple stages of diversion and applying multiple flow threshold criteria is not provided.

There is little to no supporting explanation or basis for how the 0.05 ft/[10-15% of Q_D], 0.10 ft/[15-20% of Q_D], Salmon Spawning Flow, and Winter Low Flow criteria were identified as being protective for the site specific or regional applications. Nor was there supporting information demonstrating that 15-20 % reduction in QD is equivalent to 0.1 ft change in median RCT depth; or that 10-15 % reduction in QD is equivalent to 0.05 ft change in median RCT depth. The diversion allocation approach proposed appears to be based on professional judgment and is conceptual in nature.

The method does not address the problem of discontinuity in the diversion flow when the unimpaired flow approaches the Salmon Spawning Flow: diversion can increase more or less suddenly as flows rise. The effect of this discontinuity on stream flow and habitat are not addressed or supported with data and literature.

2.3.4 Review of Practicality as Applied to Water Rights Administration

The site specific cumulative diversion rate limitations based on change of depth at a given point would be difficult to enforce because the diversion rate limitation at the POD is dependant on the actions of upstream diverters. The optional variable rate of diversion based on a specified percentage of the daily streamflow would also be difficult to enforce because the diversion rate limitation is constantly changing. Diversion rate limitations stated in flow rate in cfs are more practical and simple to enforce.

It is relatively straightforward to design a passive head works (e.g., a custom weir) to allow a diversion rate that increases with flow and to require supporting design and as-built documentation. Enforcement of a variable rate could involve additional effort.

2.3.5 Initial Assessment of Protectiveness

<u>Site Specific Method</u>

It is unclear whether habitat availability would be adversely affected when flows approach the Salmon Spawning Flow and Winter Low Flow.

The Flow Management Objectives were assessed at the validation sites as described in Appendix A. A Winter Low Flow minimum bypass threshold was estimated for each site following the proposed D_{84} RCT depth inundation method. Two alternative Salmon Spawning Flows were estimated for each site based respectively on the RCT fish passage depth and spawning habitat mapping methods. These estimates were then applied following the example rate of diversion calculations described on page 39 of the TU/WB/ESH Proposal to develop two alternative sets of site-specific rating curves relating impaired flow to unimpaired flow. The resulting rating curves were then analyzed using unimpaired flow time series for each site. Diversion rates were calculated for each site and divided into the unimpaired flow to calculate the percent of flow diverted over the range of flows potentially occurring within a site. The assessment indicates that the proposed Flow Management Objectives, based on the Salmon Spawning Flow criterion calculated by either the RCT fish depth or the habitat mapping site specific methods, combined with the Winter Low Flow criterion, calculated using the interim methodology based on RCT particle depth, generally allow a greater diversion rate at both low and high flows than the Draft Policy in small streams with drainage areas smaller than about 3-5 mi^2.(see Table A-2 in Appendix A). The greatest effect of the proposed methods on fish habitat availability is predicted to occur over the winter base flow range. In all cases, the proposed Flow Management Objectives allow essentially continuous diversion during base flows over the winter diversion season, which could adversely affect upstream passage and spawning habitat more frequently than the Draft Policy. The Draft Policy does not allow diversion flows when unimpaired flow is lower than the flow required for spawning flow.

The Flow Management Objectives proposed by TU/WB/ESH generally result in comparable diversion rates around the 1.5 year flood level for both Salmon Spawning Flow site specific methods.

In smaller streams with drainage areas smaller than about 3-5 mi^2, the greater allowable diversion rate during flood flows suggests that the proposed RCT fish depth or the habitat mapping site specific methods would result in greater reductions in channel size and changes in morphology than the Draft Policy because the amount expressed as a percentage of the 1.5 year flood is greater than 5% (e.g., as high as approximately 13% of the 1.5 year flood in the Dry Creek tributary site; Table A-2). In larger streams, the Draft Policy allows comparable or more diversion over the high flow range than the proposed RCT and habitat mapping methods, as seen for example in the asymptotic right hand tails of the percent diversion rate rating curves in Figure A-5b (Policy percent diversion rate and TU/WB/ESH Proposal percent diversion rates converge at high flows in Huichica Creek) and Figure A-12b (Policy percent diversion greater than TU/WB/ESH Proposal percent diversion rates in Franz Creek).

<u>Regional Method</u>

Allowing diversion of 20% of Q_D when flows are above Q_S is highly unlikely to be protective of channel maintenance needs because, in principle, 20% of the 1.5 year flood could be diverted at that unimpaired flow level and more could be diverted at higher flows. This potential reduction of the bankfull flow corresponds to a 9% decrease[12] in channel width, depth and D_{50} which would essentially amount to imposing a scaled-down hydrograph representative of a smaller stream channel.

2.4 Cumulative Effects Test

2.4.1 Proposed Methodology

Section 5.6.4 of the TU/WB/ESH Proposal describes a cumulative effects test for projects above the upper limit of spawning habitat to assess whether a minimum bypass flow would be needed for the project. This cumulative effects test is a site specific, volume-based method that "*may estimate functional equivalence with the Flow Management Objectives*" and would be used in-lieu of the standard methods of meeting the Flow Management Objectives.

The cumulative effects test is described as follows:

- *Cumulative depletion of not more than 5% of the seasonal (November 1 to March 31) volume measured downstream where the watershed measures 1 square mile and points of interest below; or*
- *Cumulative depletion of not more than 10% of the seasonal volume measured at 1 square mile and points of interest below, if reservoirs operating with no bypass collectively deplete no more than 5% average annual volume; or*
- *A site-specific study demonstrating that the project's cumulative impacts are consistent with the management objectives.*

The cumulative effects test provides thresholds of cumulative downstream volume depletion. Section 5.6.4 describes the cumulative effects test outcomes associated with whether a fill and spill reservoir would be allowed to operate without a minimum bypass flow, whether a project would need to bypass the Winter Low Flow, or whether the project would need to bypass a proportionate share of the Salmon Spawning Flow. These are described more fully in the minimum bypass term section (Section 2.5) of this document.

The point of evaluation of the cumulative effects is 1 square mile. This 1 square mile point of evaluation can be adjusted as follows:

> *If there is evidence that the Upper Limit of Spawning Habitat is significantly higher or significantly lower in the watershed than the 1 square mile point of evaluation, and that the location of the Upper Limit of Spawning Habitat would affect the outcome of the cumulative effects test in section 5.6.4, the applicant shall prepare a*

[12] Estimated from Figure 2-1, Task 3 Report. *Predicted long-term potential changes in channel width, depth, and grain size distribution resulting from a reduction in bankfull flow due to diversion in Policy area streams potentially supporting anadromous salmonids.*

> *site-specific assessment of the Upper Limit of Spawning Habitat. If the Upper Limit of Spawning Habitat is significantly higher or significantly lower in the watershed than 1.0 square mile, the 1 square mile point of evaluation shall be adjusted accordingly.*

Section 5.6.5 states that the results of the cumulative effects test can be used to determine whether a diversion rate limitation is needed to protect channel maintenance flows:

> *Projects above Upper Limit of Spawning Habitat that score well enough on the cumulative effects test in section [5.6.4] so that they do not require a Q_S bypass do not require a separate Maximum Cumulative Diversion (MCD) limitation to protect channel forming flows. Their scores on the cumulative effects test indicate that they satisfy (or provide functional equivalence to) the Flow Management Objectives without such a limitation.*
>
> *Projects above the Upper Limit of Spawning Habitat require a separate Maximum Cumulative Diversion (MCD) limitation only when needed to avoid cumulatively exceeding the objective to divert no more than that which causes a 0.1 ft change in depth when flows exceed Q_S, as calculated at 1 square mile and points of interest below.*

2.4.2 Review of the Completeness

The flow management objective of limiting stage changes to 0.1 ft depth does not address the flow at which this should be evaluated, nor the flow range over which the 0.1 ft criterion is biologically and geomorphically meaningful.

Clearer criteria need to be provided to describe the required "*evidence that the Upper Limit of Spawning Habitat is significantly higher or significantly lower in the watershed than the 1 square mile point of evaluation, and that the location of the Upper Limit of Spawning Habitat would affect the outcome of the cumulative effects test in section 5.6.4*".

2.4.3 Review of the Scientific Basis and Soundness

No supporting data, literature, or rationale is provided for the 5%, 10%, 1 mi^2 criteria.

There is no discussion of effects to fish habitat or channel morphology using literature or data.

2.4.4 Review of Practicality as Applied to Water Rights Administration

A site specific analysis will likely be required for most applications.

2.4.5 Initial Assessment of Protectiveness

As discussed in Appendix J of the Task 3 Report, volume-based criteria can be non-protective, resulting in large instantaneous diversion rates and low stream flows.

Projects that divert more than 20% of Q_D when flows exceed the Salmon Spawning Flow could, in principle, divert this amount when Q_D=1.5 year flood which could potentially adversely affect channel morphology.

Protectiveness cannot be discerned with information provided.

No further assessment of the functional equivalence of the Cumulative Effects Test (CET) was made because the impacts of the use of the CET volume based limitations instead of the stage limitations provided in the Flow Management Objectives is (1) highly site-specific and depends on operations and (2) is applicable only above the Upper Limit of Spawning Habitat which excludes all the validation sites.

2.5 Minimum Bypass Term

2.5.1 Proposed Methodologies

The proposed minimum bypass term describes the implementation upstream or downstream of the upper limit of spawning habitat.

<u>Upstream of the Upper Limit Of Spawning Habitat, Watershed 0.1 Square Mile or Less</u>

Section 5.6.1 of the TU/WB/ESH Proposal describes the minimum bypass term requirements for fill and spill projects above the upper limit of spawning habitat located on watersheds 0.1 square mile (64 acres) or less as:

> *Projects located on watersheds 0.1 square mile (64 acres) and less that cumulatively satisfy the Flow Management Objectives or provide a functional equivalence as estimated by the Cumulative Effects Test in section [5.6.4] may operate as "fill and spill" reservoirs with no minimum bypass flow.*

Upstream of the Upper Limit Of Spawning Habitat, Watershed More than 0.1 Square Mile

Section 5.6.2 and 5.6.3 of the TU/WB/ESH Proposal describes the minimum bypass term requirements for projects above the upper limit of spawning habitat:

> *All other projects above the Upper Limit of Spawning Habitat [projects that are not fill and spill reservoirs, or projects in watersheds greater than 0.1 sq. mi] that cumulatively satisfy the Flow Management Objectives or provide a functional equivalence as measured by the Cumulative Effects Test in section [5.6.4] shall bypass Q_{WLF}.*
>
> *All projects above the Upper Limit of Spawning Habitat [all watershed sizes, and including fill and spill reservoirs] that do not cumulatively satisfy the Flow Management Objectives and do not provide a functional equivalence as measured by the Cumulative Effects Test in section [5.6.4] shall bypass an amount sufficient to provide a proportionate share of Q_S at the Upper Limit of Spawning Habitat.*

Downstream of the Upper Limit of Spawning Habitat

Section 5.8.1 of the TU/WB/ESH Proposal describes implementation of the minimum bypass term requirements below the upper limit of spawning habitat as:

> *Diversions located downstream of the Upper Limit of Spawning Habitat may comply with the Management Objectives in one of two ways.*
>
> *The first method is the simplest: include a permit term requiring a bypass flow of Q_S.*
>
> *A second method is possible where the project can limit cumulative diversions when flows are between Q_{WLF} and Q_S to rates that would not change stage by more than 0.05 ft. For these projects, it is also possible to comply with the Management Objectives by establishing a bypass flow of Q_{WLF} and a correspondingly lower cumulative rate of diversion. Because approvals of permits under the method described in this paragraph will make it very difficult for any upstream existing but un-permitted fill and spill reservoir to be processed using the small projects cumulative effects test in 5.6.4 (and their continued operation would create cumulative effects greater than those estimated for the new permit), the State Water Board will consider the upstream projects in the cumulative rate of diversion, to ensure that the projects cumulatively satisfy the Flow Management Objectives. The method described in this paragraph is most viable where there are no upstream diversions.*

The mode of bypass is described in Section 5.7 as either:

> *A. Active Management*
>
> *Onstream reservoirs where the drainage area at the POD is no greater than 1.0 square miles, or 640 acres, may operate with active management of bypass flows, provided that the applicant shall monitor and report rates of flow immediately below the POD as well as diversions and reservoir levels, according to the terms specified in policy section ___ [monitoring].*
>
> *B. Passive Management*
> *Diversions where the drainage area at the POD exceeds 1.0 square miles should operate with passive management of bypass flows.*

2.5.2 Review of the Completeness

The approach is conceptual in nature. The term "*cumulatively satisfy the Flow Management Objectives*" needs to be clearly defined.

2.5.3 Review of the Scientific Basis and Soundness

<u>Upstream of the Upper Limit Of Spawning Habitat, Watershed 0.1 Square Mile or Less</u>

No data or analyses are provided to demonstrate that 0.1 mi^2 fill and spill reservoirs do not adversely affect fish habitat.

No data or analysis are provided to demonstrate that watersheds of 0.1 sq mile or less do not produce streamflow of sufficient duration or depth to support aquatic life.

<u>Upstream of the Upper Limit Of Spawning Habitat, Watershed More than 0.1 Square Mile</u>

No information is provided on how to estimate the proportionate share of Q_S at the Upper Limit of Spawning Habitat however, this is the same approach taken by the Draft Policy.

<u>Downstream of the Upper Limit of Spawning Habitat</u>

The minimum bypass term is the implementation of the Salmon Spawning Flow and Winter Low Flow and relies on scientific defensibility of the methods used to determine the Salmon Spawning Flow and Winter Low Flow and the whether first or second method of implementation is used to calculate the minimum bypass flow permit term.

2.5.4 Review of Practicality as Applied to Water Rights Administration

Upstream of the Upper Limit Of Spawning Habitat

If a project meets the Flow Management Objectives or passes the Cumulative Effects Test, no minimum bypass term or a term equal to the Winter Low Flow is required. This would require more effort during the water right permit process but would either require no enforcement or be practical to apply and enforce.

Downstream of the Upper Limit of Spawning Habitat, Method 1

The first method of implementation of the minimum bypass term (permit term requiring a bypass flow of the Salmon Spawning Flow and all lower flow rates) is practical to apply and enforce.

Downstream of the Upper Limit of Spawning Habitat, Method 2

The second method that allows a lower minimum bypass term at the Winter Low Flow threshold and has a two-tiered cumulative diversion rate limitation above and below the Salmon Spawning Flow will be more difficult to enforce.

2.5.5 Initial Assessment of Protectiveness

The protectiveness of the minimum bypass term is dependant on the protectiveness of the Salmon Spawning Flow, Winter Low Flow, Flow Management Objects, and Cumulative Effects Test methods.

Upstream of the Upper Limit Of Spawning Habitat

The protectiveness of the minimum bypass term is dependant on the results and efficacy of the site-specific Cumulative Effects Test.

Downstream of the Upper Limit of Spawning Habitat, Method 1

The first method of implementation of the minimum bypass term (permit term requiring a bypass flow of the Salmon Spawning Flow and all lower flow rates) would likely be protective in the case of the habitat mapping method because the resulting Salmon

Spawning Flow is generally higher than the regional MBF value required by the Draft Policy, as seen in Table A-1 of Appendix A. The RCT method may or may not be protective as it is comparable or less than the Draft Policy regional MBF value (also seen in Table A-1).

Downstream of the Upper Limit of Spawning Habitat, Method 2

The second method that allows a lower minimum bypass term at the Winter Low Flow threshold and has a two-tiered cumulative diversion rate limitation above and below the Salmon Spawning Flow will be likely not be protective because diversions are allowed at base flow when instream flows can be critical for spawning and other biological functions.

2.6 Season of Diversion

Section 5.4 of the TU/WB/ESH Proposal defines the season of diversion as "*December 15 to March 31, unless a site-specific study demonstrates that a different season is appropriate*".

The Draft Guidelines by NMFS-DFG[13] also recommended a diversion season of December 15 to March 31. The TU/WB/ESH Proposal provides no scientific basis or justification for the proposed season of diversion which may imply acceptance of the NMFS-DFG recommendations. However, Chapter 5 in the Task 3 Report did assess a diversion season of December 15 to March 31 and found it to be protective.

2.7 Onstream Dams

Section 5.4 of the TU/WB/ESH Proposal describes the proposed onstream dam requirements as:

> *Section __ of this policy contains onstream dam requirements that avoid upstream or downstream additive impacts such as (1) interrupting fish migratory patterns, (2 interrupting downstream movement of gravel, woody debris, or aquatic benthic macroinvertebrates, (3) causing loss of riparian habitat or wetlands, or (4) creating habitat for non-native species.*

No additional details are provided. The proposed onstream dam requirements are the same as the passage and mitigation plans required by the Draft Policy which may imply acceptance of the Draft Policy recommendations.

[13] Guidelines for maintaining instream flows to protect fisheries resources downstream of water diversions in mid-California coastal streams (an update of the May 22, 2000 guidelines), California Department of Fish and Game and National Marine Fisheries Service (DFG-NMFS), June 2002.

2.8 Upper Limit of Spawning Habitat

Section 5.10 describes the Upper Limit of Spawning Habitat as follows:

> *The Upper Limit of Spawning Habitat for a given stream is the stream reach that includes the uppermost habitat that may support anadromous fish spawning under unimpaired conditions (in normal and above-normal water year types). A protocol for calculating Upper Limit of Spawning Habitat with a site specific study is adopted as a technical appendix to the policy (see ___). For some purposes, such as a site-specific calculation of QS, multiple Upper Limits of Spawning Habitats for multiple species may need to be determined in order to assure flows protective of steelhead at one depth and Chinook at a greater depth farther downstream.*

The technical appendix that describes the protocol for calculating Upper Limit of Spawning Habitat with a site specific study has not yet been provided and can not be evaluated at this time.

3 Summary

Table 1 provides a summary of findings from review of each aspect as discussed Section 2.

Table 2. Summary of Findings from Review of Scientific Aspects

Aspect	Methodology	Complete ?	Adequate Scientific Basis Provided?	Practical?	Protective?
Winter Low Flow Threshold	BMI Habitat Mapping	Yes	No	No	Unable to determine
	RCT Particle Depth	No	No	Uncertain	No
	Regional	Yes	No	Yes	No
Salmon Spawning Flow Threshold	Habitat Mapping	Yes	No	No	Uncertain
	RCT Fish Depth	No	No	No	Uncertain
	Regional	No	No	No	Unable to determine
Flow Management Objectives	Site Specific	No	No	No	No
	Regional	No	No	Uncertain	No
Cumulative Effects Test		No	No	Uncertain	Unable to determine
Minimum Bypass Term	Method 1	Yes	No	Yes	Yes
	Method 2	No	No	No	No
Season of Diversion		Yes	No[14]	Yes	Yes
Onstream Dams		No	No	Unable to determine	Unable to determine
Upper Limit of Spawning Habitat		No	No	Unable to determine	Unable to determine

[14] The TU/WB/ESH Proposal provides no scientific basis or justification for the proposed season of diversion which may imply acceptance of the NMFS-DFG recommendations. However, the Task 3 Report did assess a diversion season of December 15 to March 31 and found it to be protective.

APPENDIX A

Validation Site Assessment of the TU/WB/ESH Proposal Methodologies for Establishing Site Specific Winter Low Flow and Spawning Flow Thresholds and for Calculating Diversion Rates

Methods

Winter Low Flow and Salmon Spawning Flow

The rate of diversion calculation described on page 39 of the TU/WB/ESH Proposal is a two-tiered approach that involves specifying (i) a Winter Low Flow which serves as a minimum bypass threshold below which diversion is not permitted (analogous to the MBF element of the Policy), and (ii) a Salmon Spawning Flow above and below which different rates of diversion are allowed. We evaluated the effect of applying the two-tiered rate of diversion calculation proposed by TU/WB/ESH on flows at the same validation sites used in the development and assessment of the Policy diversion season, MBF, and MCD elements. Because two methods were proposed specifically for determining the Salmon Spawning flow, we applied each method independently and assessed the results of applying one or the other in the two-tiered diversion rate calculation. The following summarizes the method pairings evaluated:

1. Winter Low Flow interim methodology based on RCT and Salmon Spawning Flows based on habitat mapping

2. Winter Low Flow interim methodology based on RCT and Salmon Spawning Flows based on RCT fish depth

We accordingly applied the Winter Low Flow interim methodology based on RCT particle depth and the two site specific Salmon Spawning Flow methods to the validation site transect data collected in support of development of the Policy to estimate the Salmon Spawning Flows (based respectively on habitat mapping and based on RCT fish depth) and the Winter Low Flow for those sites. The East Fork Russian River Tributary site was not evaluated because spawning habitat was not sampled.

The following approximations were made in order to reasonably apply the conceptual methods proposed in the TU/WB/ESH Proposal:

1. The passage transects were generally placed over riffle crests in the validation sites; thus, it was possible to develop rating curves for each transect that plotted riffle crest thalweg (RCT) depth against flow, using stage-discharge relationships established in the previous analysis for the Policy development. As a crude approximation of the median RCT depth-flow curve, we averaged the two transect RCT depths for the same flow to generate a ‘site RCT depth – flow curve’. The rating curves were extended hydraulically to approximately the 1.5 year flood estimate or the highest flow in the estimated unimpaired flow time series, whichever was larger.

2. We used the D_{84} particle size from our pebble counts conducted across representative riffles and adjacent bars to define the site D_{84} value (Table A-1).

The pebble count samples were collected originally for the purpose of representing effects of channel roughness on stage-discharge predictions at the sampled transects and, therefore, appeared suitable for this analysis. We then identified the flow at which the site average RCT depth equaled the D_{84} value to approximate the Winter Low Flow threshold (Table A-1).

3. We used the same 0.8 ft depth criterion for steelhead as used in the Draft Policy and in the TU/WB/ESH Proposal for cases where both steelhead and coho were present. The flow corresponding to the site average RCT depth equaling 0.8 ft was identified as an estimate of one variant of the Salmon Spawning Flow. We called this the RCT method spawning flow (Table A-1).

4. The spawning transects were used to identify the alternative Salmon Spawning Flow based on habitat mapping methods. The steelhead usable width-flow curves depicted in Appendix H of the Task 3 Report were used to identify the upper flow resulting in a usable width equal to 2 feet. The highest flow of the two transects, or the flow when only a single transect was sampled, was used as the estimate of the Salmon Spawning Flow corresponding to Figure 5 in the TU/WB/ESH Proposal. We selected 2 ft as a minimum redd width criterion, analogous to the 15 ft^2 minimum redd area criterion in the TU/WB/ESH Proposal (a corresponding redd width was not defined in the TU/WB/ESH Proposal). We called this the habitat mapping method spawning flow (Table A-1).

<u>Application of Proposed Flow Management Objectives and Minimum Bypass Flow Methodology</u>

We ran two flow scenarios following the Flow Management Objectives diversion allocation scheme proposed by TU/WB/ESH, where (i) no diversion occurred when unimpaired flows were less than the Winter Low Flow, (ii) diversion was allowed to result in no more than 0.05 ft stage change on the RCT depth-flow curve when unimpaired flows were between the Winter Low Flow and one of the two alternative proposed Salmon Spawning Flow thresholds, and (iii) diversion was allowed to result in no more than 0.10 ft stage change on the RCT depth-flow curve when unimpaired flows exceeded the specified spawning flow. The two flow scenarios thus corresponded to using the proposed Flow Management Objectives and Method 2 of implementing the minimum bypass flow requirements with one or the other of the two site specific study methods to estimate the Salmon Spawning Flow.

For each flow scenario, we calculated (i) diversion rate vs. unimpaired flow rating curves for each site over a large flow range that extended to approximately the 1.5 year return flow or higher to allow simulation of flows in unimpaired flow time series, and (ii) % of unimpaired flow diverted (% diversion rate) vs. unimpaired flow rating curves for each site over the entire flow range.

The diversion-unimpaired flow rating curves were used to calculate time series of diversion rates for two selected flood events approximating (i) the 1.5 year peak flood event and (ii) a smaller event.

Results

Table A-1 lists the resulting values of the site specific Winter Low Flow and regional February Median Flow minimum bypass thresholds, and the two alternative Salmon Spawning flows estimated for the validation sites following the general principles outlined in the TU/WB/ESH Proposal. Also listed are the validation site spawning flows used to develop the Draft Policy MBF regression, and the corresponding Draft Policy regional regression value at each validation site that would be specified only if site specific data were not available. The data in the table are plotted in Figure A-1, where it can be seen that the validation site Salmon Spawning Flow magnitude determined using the RCT fish depth method is relatively insensitive to drainage area. The site specific spawning flow magnitude determined using the habitat mapping method is generally higher than the site specific flows used to derive the MBF regional regression. The validation site Winter Low Flow magnitude is extremely low, reflecting the D_{84} depth criterion proposed, which is generally small for most validation sites. Thus, the two streams (Sullivan Gulch and Davenport Creek) from which data were used as the basis for developing the proposed concepts do not appear to be regionally representative.

The impaired-unimpaired flow rating curves were plotted against a similar curve developed for the Draft Policy regionally protective criteria (alternatives MBF3 and MCD2 in the Task 3 Report) and are presented in Figures A-2 through A-13. Figures A-14 through A-25 depict the effects of the Policy and suggested TU/WB/ESH diversion protocols on temporal variation in diversion rate and impaired flows using actual hydrographs, to compare the hydrograph resulting from implementing the different diversion calculation approaches.

Table A-2 summarizes comparisons of the resulting diversion – unimpaired flow rating curves for the two flow scenarios following the Flow Management Objectives in the TU/WB/ESH Proposal and the Draft Policy regional criteria, based on the results depicted in Figures A-2 to A-25. The proposed RCT fish depth and habitat mapping methods generally allow a greater diversion rate at both low and high flows than the Policy in small streams with drainage areas < about 3-5 mi^2. Greatest impact of the proposed methods to fish habitat availability is predicted to occur over the winter base flow range. The diversion rate allowed by both the RCT fish depth and habitat mapping methods may be around 25%-45% of unimpaired base flow in small streams. In larger streams, the diversion rate allowed by the proposed RCT fish depth and habitat mapping methods may be around 20%-40% and 15%-40% of unimpaired base flow, respectively. These numbers are based on the limited number of hydrographs evaluated, whereas the rating curves allow for potential diversions of around 15%-75% of unimpaired base flow in small streams and 7%-65% in larger streams.

In larger streams, the Draft Policy regional criteria allow more diversion over the high flow range than the proposed RCT fish depth and habitat mapping methods. The two methods generally result in comparable diversion rates around the 1.5 year flood level. The larger allowable diversion rate during flood flows in streams with drainage areas smaller than about 3-5 mi^2 suggests that the proposed RCT and habitat mapping methods would result in greater changes to channel size and morphology in such streams because the amount expressed as a percentage of the 1.5 year flood is greater than 5% (e.g., as high as approximately 13% of the 1.5 year flood in the Dry Creek tributary site).

In all cases, the RCT fish depth and habitat mapping methods as proposed allow essentially continuous diversion during base flows over the winter diversion season, which could adversely affect upstream passage and spawning habitat more frequently than the policy. The Draft Policy generally does not allow diversion during base flows.

Table A-1. Comparisons of TU/WB/ESH Proposed Flow Thresholds applied to the Validation Sites Compared With the Draft Policy's Site Specific Spawning Flow and Regional MBF

Validation Site			TU/WB/ESH Proposed Flow Thresholds (cfs)				Draft Policy (cfs)		
Name	Drainage Area (mi^2)	D_{84} (mm)	Winter Low Flow	Regional Method (February Median Flow)	Spawning Flow (RCT Method)	Spawning Flow (Habitat Mapping Method)	Site Specific Steelhead Spawning Flow at Transect 1	Site Specific Steelhead Spawning Flow at Transect 2	Regional MBF
Dry Creek Tributary	1.19	48	0.26	6.8	24.1	41.7	19.11	—	20
Dunn Creek	1.88	34	0.05	4.3	13.5	41.5	25.25	21.24	18
Carneros Creek	2.75	21/158	1.17	2.7	15.4	76.3	29.11	18.87	23
Huichica Creek	4.92	48	0.11	6.1	7.4	55.9	14.88	—	33
Olema Creek	6.47	69	1.13	19	34.7	120.8	93.42	55.26	51
Pine Gulch Creek	7.83	30	0.45	16	43.0	24.7	—	18.31	43
Warm Springs Creek	12.2	35	0.60	39	35.8	148.5	29.18	23.1	101
Santa Rosa Creek	12.5	29	0.05	25	16.5	116.0	45.38	17.09	54
Albion River	14.4	31	0.13	21	25.2	201.4	34.41	66.47	53
Salmon Creek	15.7	40	0.37	21	33.9	57.3	25.84	24.19	64
Franz Creek	15.7	36	0.08	15	24.1	293.4	75.11	19.13	61
Lagunitas Creek	34.3	67	0.23	83	14.4	321.3	116.83	38.49	125

Table A-2. Comparisons of Unimpaired Flow - Diversion Flow Rating Curves, and Example Hydrographs for the Validation Sites.

Validation Site		Diversion Rate (cfs)		% Diversion Rate		Maximum % Diversion Rate, Example Hydrograph Base Flows [1]
Name	**Drainage Area (mi^2)**	**Low Streamflows**	**High Streamflows**	**Low Flows**	**High Flows ≤ 1.5 yr Flood**	
Dry Creek Tributary	1.19	Policy: No Diversion RCT & Habitat Methods: Allow Diversion at Very Low Flow	Policy up to ~ 50% of RCT & Habitat Method	Policy: No Diversion; RCT & Habitat Methods ~ 16% to 49% of Unimpaired Flow, Greatest at ~0.7 cfs	Policy Diversion ≥ 5% RCT & Habitat Methods ≥ ~13%	RCT ~ 45% Habitat ~ 45%
Dunn Creek	1.88	Policy: No Diversion RCT & Habitat Methods: Allow Diversion at Very Low Flow	Policy up to ~ 50% of RCT & Habitat Method	Policy: No Diversion; RCT & Habitat Methods ~ 14% to 73% of Unimpaired Flow, Greatest at ~0.2 cfs	Policy Diversion ≥ 5% RCT & Habitat Methods ≥ ~10%	RCT ~ 45% Habitat ~ 45%
Carneros Creek	2.75	Policy: No Diversion RCT & Habitat Methods: Allow Diversion at Very Low Flow	Policy comparable (~200%-60%) to RCT & Habitat Method	Policy: No Diversion; RCT/Habitat Method ~ 14%/10% to 32% of Unimpaired Flow, Greatest at ~1-2 cfs	Policy Diversion ≥ 5% RCT & Habitat Methods ≥ ~8%	RCT ~ 30% Habitat ~ 30%
Huichica Creek	4.92	Policy: No Diversion RCT & Habitat Methods: Allow Diversion at Very Low Flow	Policy comparable to RCT & Habitat Method	Policy: No Diversion; RCT/Habitat Method ~ 15%/8% to 50% of Unimpaired Flow, Greatest at ~0.4 cfs	Policy Diversion ≥ 5% RCT & Habitat Methods ≥ ~5%	RCT ~ 35% Habitat ~ 35%
Olema Creek	6.47	RCT & Habitat Methods: Allow Diversion at Very Low Flow	*Policy Flow Not Evaluated*	RCT/Habitat Method ~ 14%/10% to 43% of Unimpaired Flow, Greatest at ~2.0 cfs	RCT & Habitat Methods ≤ ~3% at flood flows (*1.5 yr flood not determined*)	RCT ~ 25% Habitat ~ 15%
Pine Gulch Creek	7.83	Policy: No Diversion RCT & Habitat Methods: Allow Diversion at Very Low Flow	Policy ~300%-100% of RCT & Habitat Method	Policy: No Diversion; RCT & Habitat Methods ~ 13% to 55% of Unimpaired Flow, Greatest at ~1.0 cfs	Policy Diversion ≥ 5% RCT & Habitat Methods ≥ ~5%	RCT ~ 40% Habitat ~ 40%
Warm Springs Creek	12.2	Policy: No Diversion RCT & Habitat Methods: Allow Diversion at Very Low Flow	Policy ~300%-100% of RCT & Habitat Method	Policy: No Diversion; RCT/Habitat Method ~ 10%/7% to 53% of Unimpaired Flow, Greatest at ~2.0 cfs	Policy Diversion ≥ 5% RCT & Habitat Methods ≥ ~5%	RCT ~ 20% Habitat ~ 15%

Validation Site		Diversion Rate (cfs)		% Diversion Rate		Maximum % Diversion Rate, Example Hydrograph Base Flows [1]
Name	Drainage Area (mi^2)	Low Streamflows	High Streamflows	Low Flows	High Flows ≤ 1.5 yr Flood	
Santa Rosa Creek	12.5	Policy: No Diversion RCT & Habitat Methods: Allow Diversion at Very Low Flow	Policy ~300%-75% of RCT & Habitat Method	Policy: No Diversion; RCT & Habitat Method ~ 13% to 58% of Unimpaired Flow, Greatest at ~0.2 cfs	Policy Diversion ≥ 5% RCT & Habitat Methods ≥ ~6%	RCT ~ 30% Habitat ~ 30%
Albion River	14.4	Policy: No Diversion RCT & Habitat Methods: Allow Diversion at Very Low Flow	Policy ~300%-130% of RCT & Habitat Method	Policy: No Diversion; RCT/Habitat Method ~ 12%/9% to 66% of Unimpaired Flow, Greatest at ~0.5 cfs	Policy Diversion ≥ 5% RCT & Habitat Methods ≥ ~5%	RCT ~ 30% Habitat ~ 30%
Salmon Creek	15.7	Policy: No Diversion RCT & Habitat Methods: Allow Diversion at Very Low Flow	Policy ~400%-120% of RCT & Habitat Method	Policy: No Diversion; RCT/Habitat Method ~ 12%/8% to 58% of Unimpaired Flow, Greatest at ~1.0 cfs	Policy Diversion ≥ 5% RCT & Habitat Methods ≥ ~4%	RCT ~ 40% Habitat ~ 40%
Franz Creek	15.7	Policy: No Diversion RCT & Habitat Methods: Allow Diversion at Very Low Flow	Policy ~400%-120% of RCT & Habitat Method	Policy: No Diversion; RCT/Habitat Method ~ 13%/8% to 66% of Unimpaired Flow, Greatest at 0.4 cfs	Policy Diversion ≤ 5% RCT & Habitat Methods ≤ ~5%	RCT ~ 35% Habitat ~ 35%
Lagunitas Creek	34.3	RCT & Habitat Methods: Allow Diversion at Very Low Flow	*Policy Flow Not Evaluated*	RCT/Habitat Method ~ 16%/7% to 42% of Unimpaired Flow base flow), Greatest at ~0.2 cfs	RCT & Habitat Methods ≤ ~3% at flood flows (*1.5 yr flood not determined*)	RCT ~ 20% Habitat ~ 20%

[1] – When flows are below the Draft Policy regional MBF; numbers are rounded to nearest 5%.

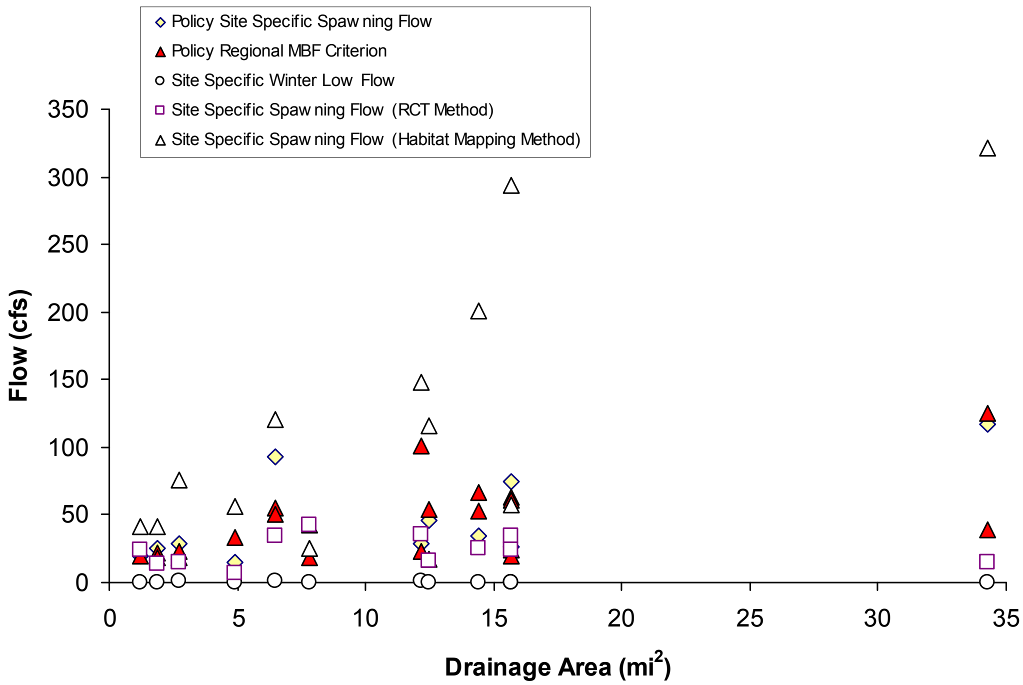
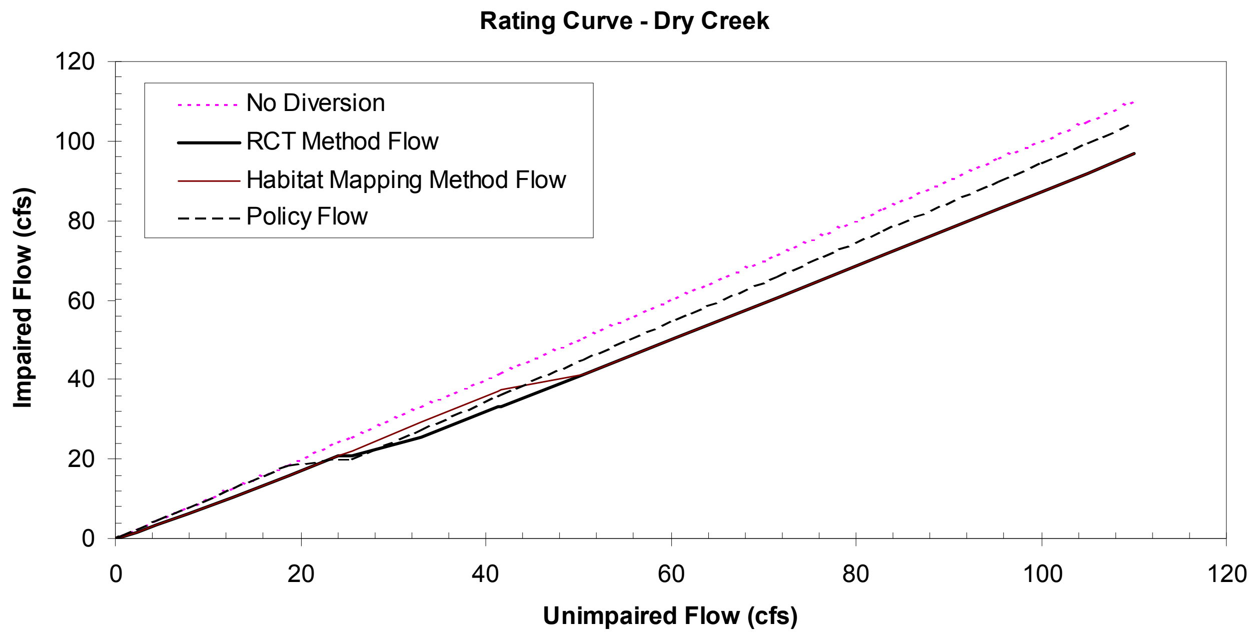


Figure A-1. Comparison of site-specific flows estimated for the validation sites following the procedures laid out in the TU/WB/ESH Proposal with the site specific steelhead spawning flows developed from site specific data and used in the development of the regional regression, and the corresponding regression estimates that would be applied if site specific data were unavailable.



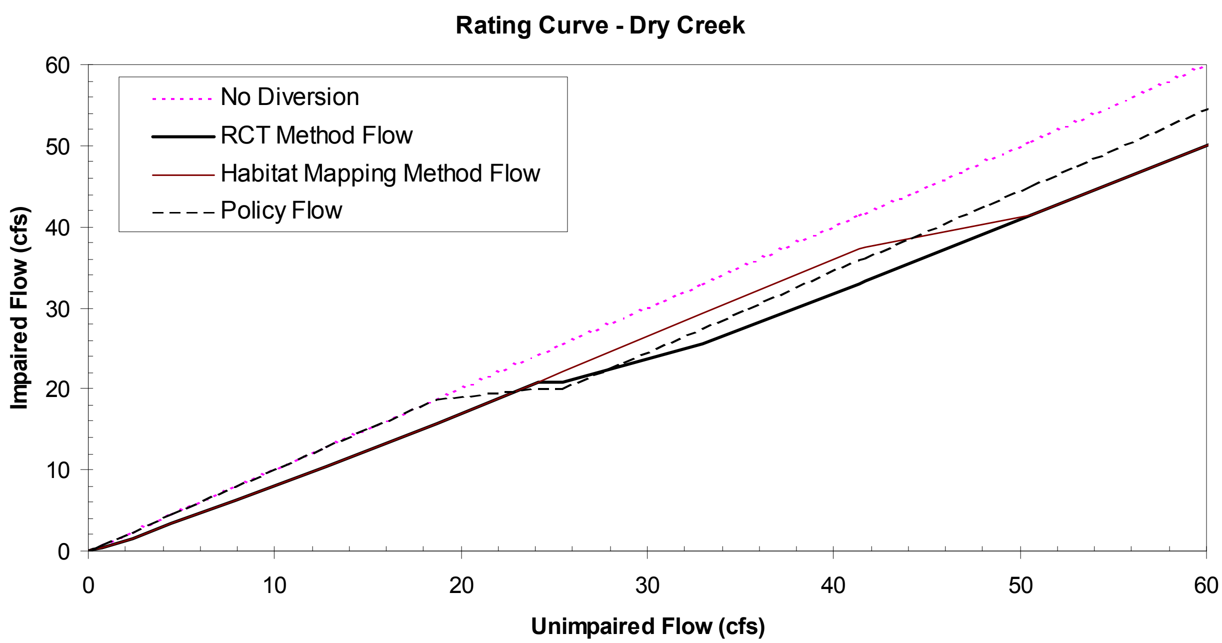
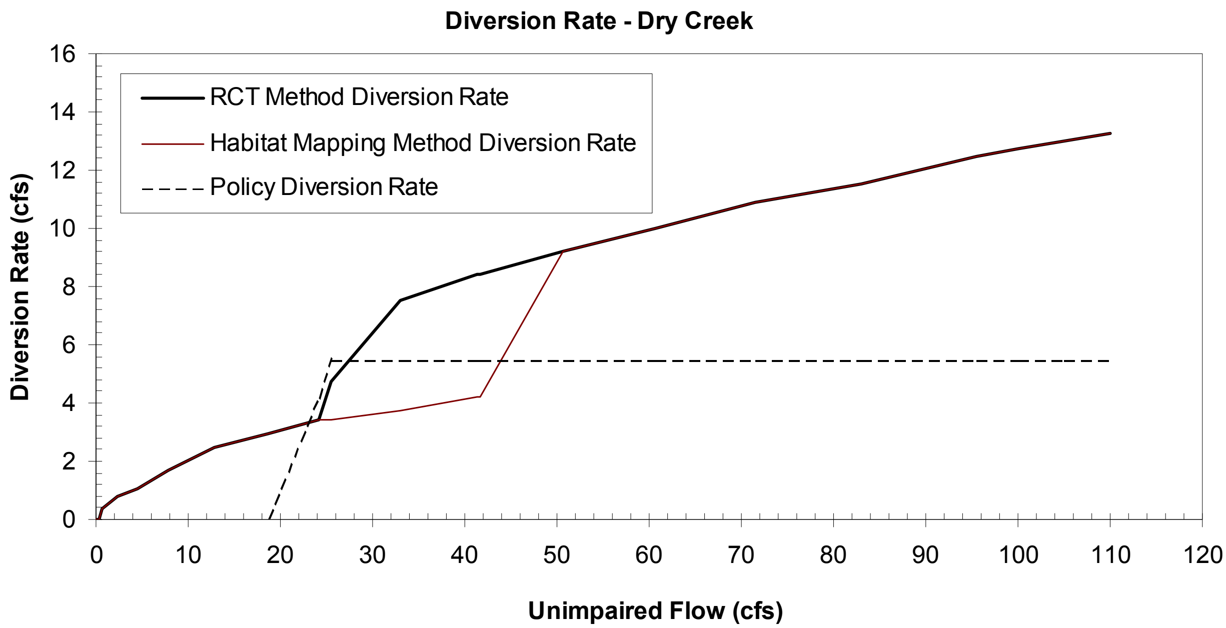


Figure A-2a. Impaired-unimpaired flow rating curves calculated for the Dry Creek validation site. No diversion corresponds to the 1:1 line. The other lines are the resulting impaired flow resulting from implementation of (i) the draft Policy, and the TU/WB/ESH Proposal where the upper spawning flow threshold is determined using (ii) the RCT method, and (iii) the habitat mapping method. The lower graph is a blow-up of the upper graph in the low-flow image.



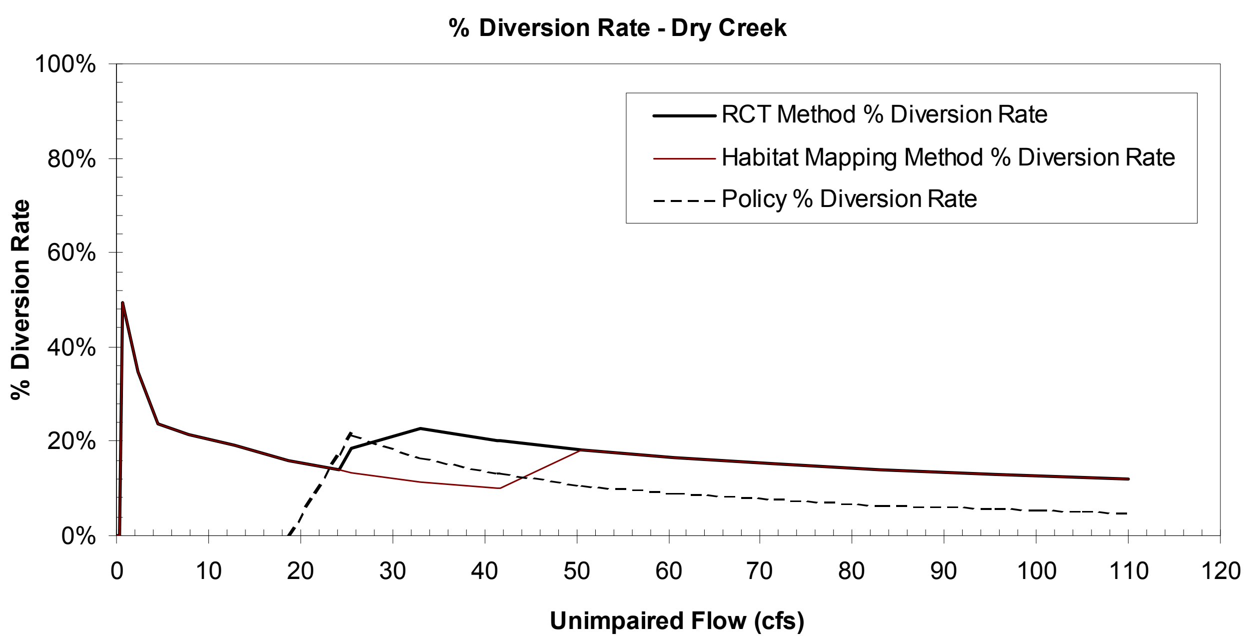
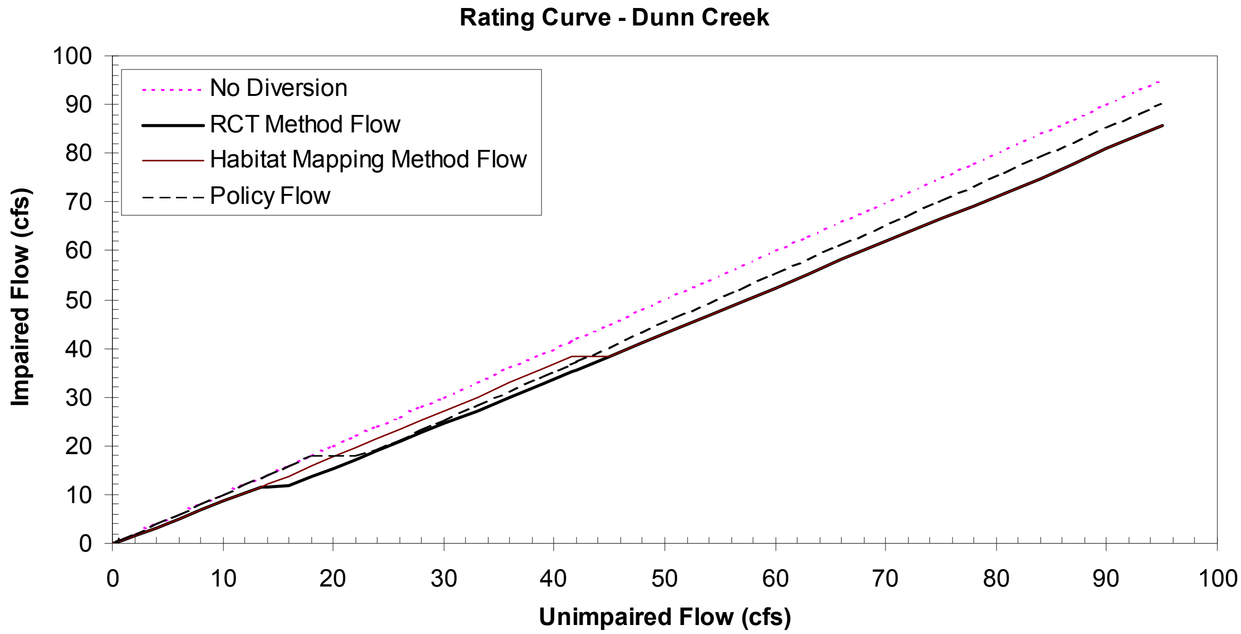


Figure A-2b. Diversion-impaired flow rating curves calculated for the Dry Creek validation site. The upper graph is the flow rate diverted in cfs, the lower graph is the corresponding percent of unimpaired flow diverted for the three diversion scenarios evaluated and graphed in Figure A-1a.



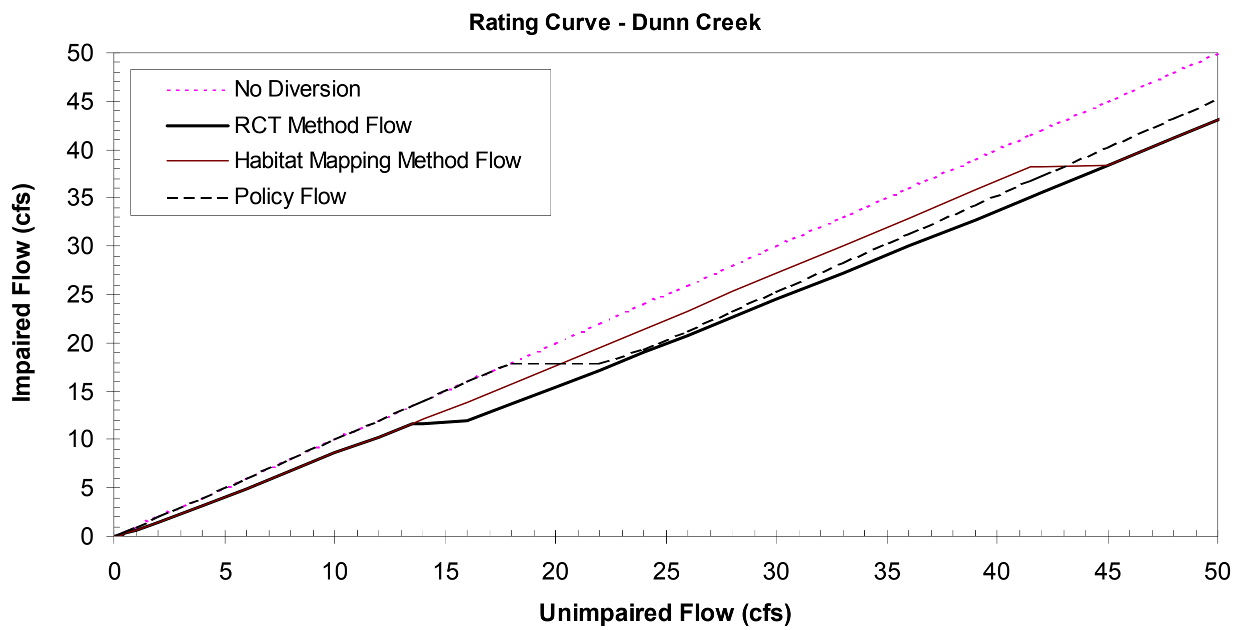
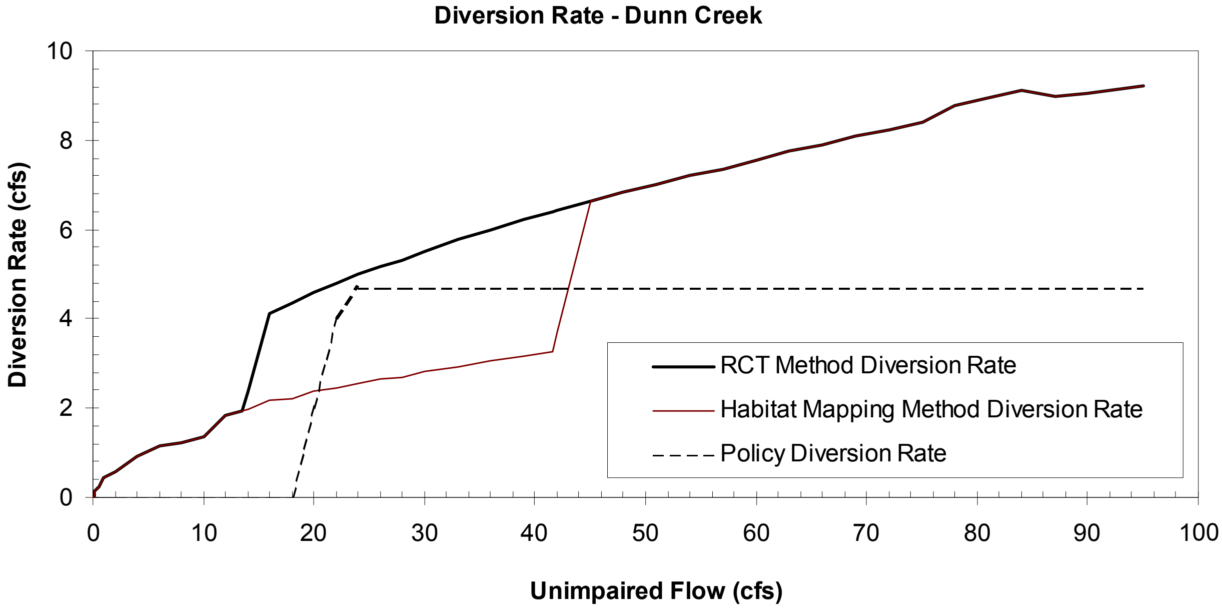


Figure A-3a. Impaired-unimpaired flow rating curves calculated for the Dunn Creek validation site. No diversion corresponds to the 1:1 line. The other lines are the resulting impaired flow resulting from implementation of (i) the draft Policy, and the TU/WB/ESH Proposal where the upper spawning flow threshold is determined using (ii) the RCT method, and (iii) the habitat mapping method. The lower graph is a blow-up of the upper graph in the low-flow image.



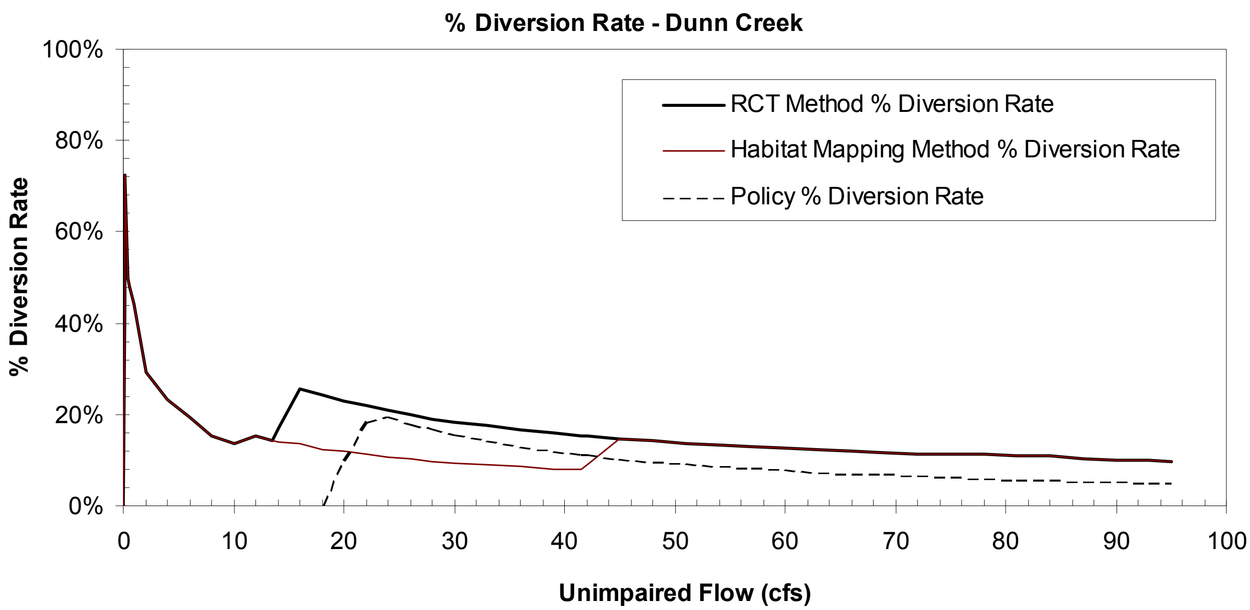
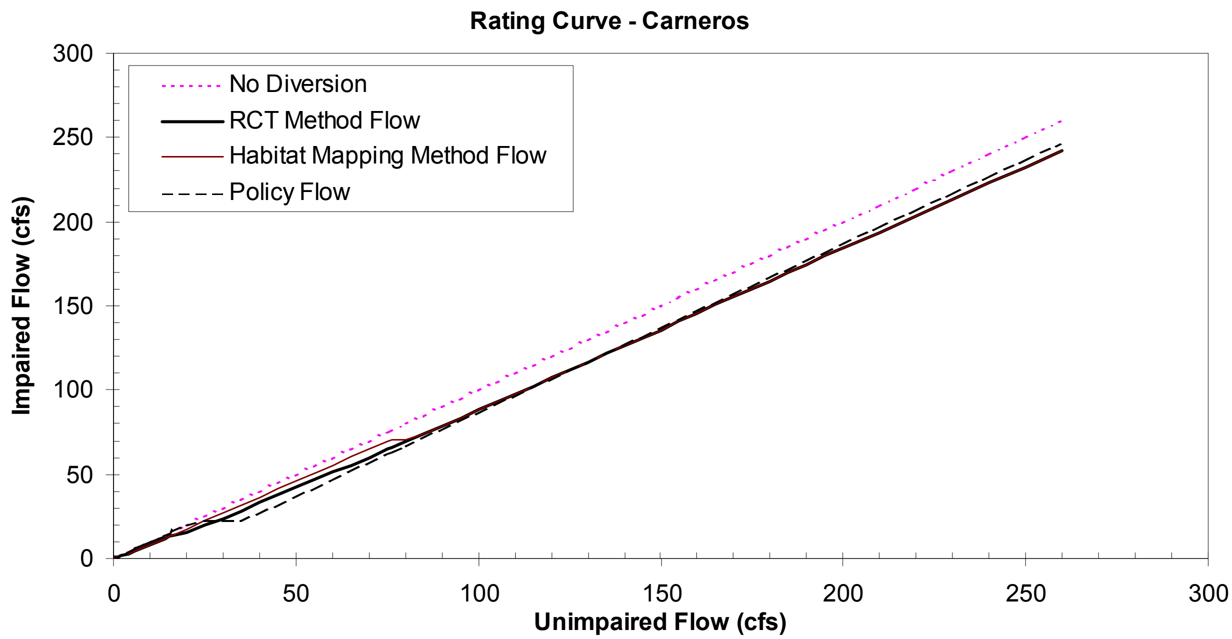


Figure A-3b. Diversion-impaired flow rating curves calculated for the Dunn Creek validation site. The upper graph is the flow rate diverted in cfs, the lower graph is the corresponding percent of unimpaired flow diverted for the three diversion scenarios evaluated and graphed in Figure A-2a.



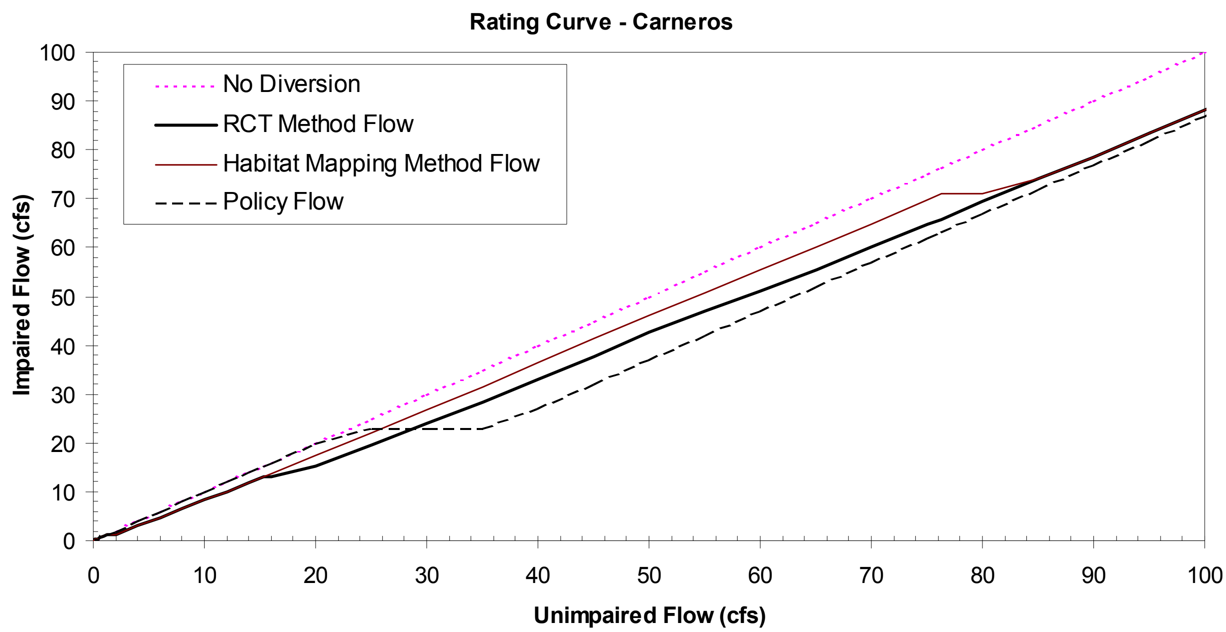
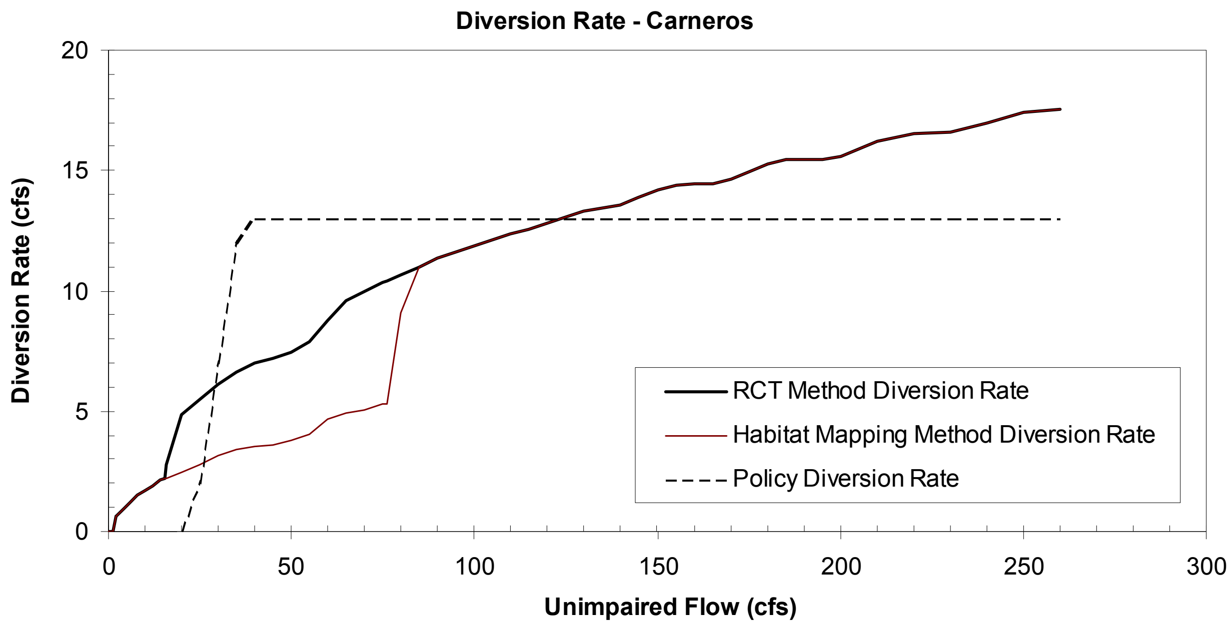


Figure A-4a. Impaired-unimpaired flow rating curves calculated for the Carneros Creek validation site. No diversion corresponds to the 1:1 line. The other lines are the resulting impaired flow resulting from implementation of (i) the draft Policy, and the TU/WB/ESH Proposal where the upper spawning flow threshold is determined using (ii) the RCT method, and (iii) the habitat mapping method. The lower graph is a blow-up of the upper graph in the low-flow image.



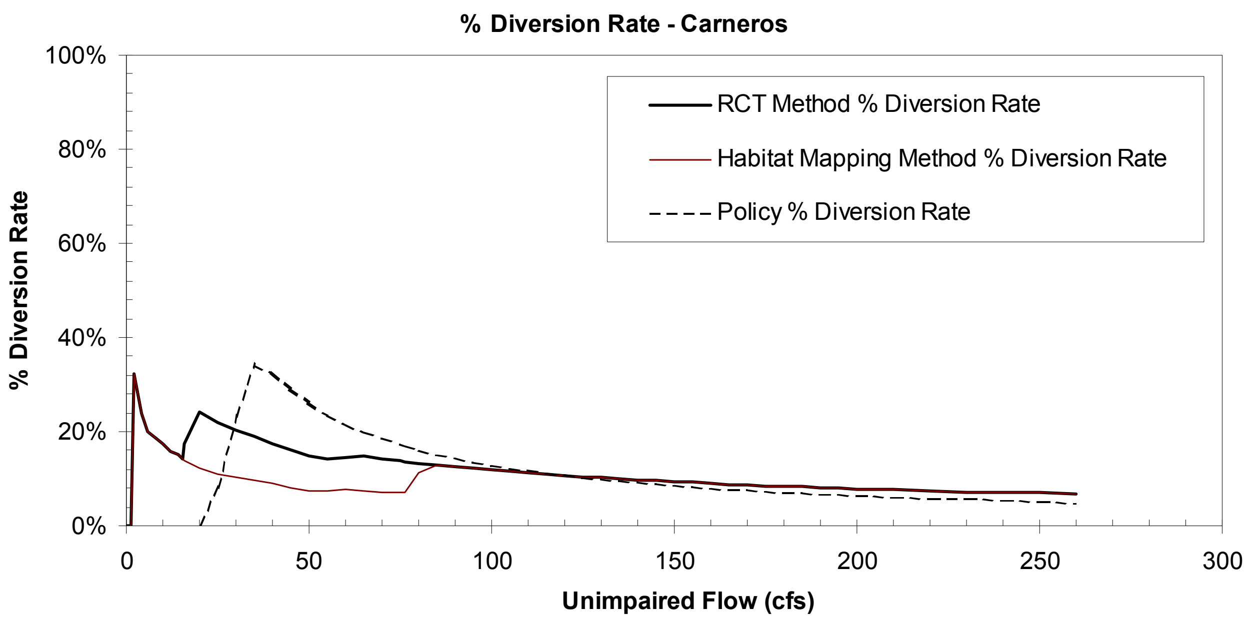
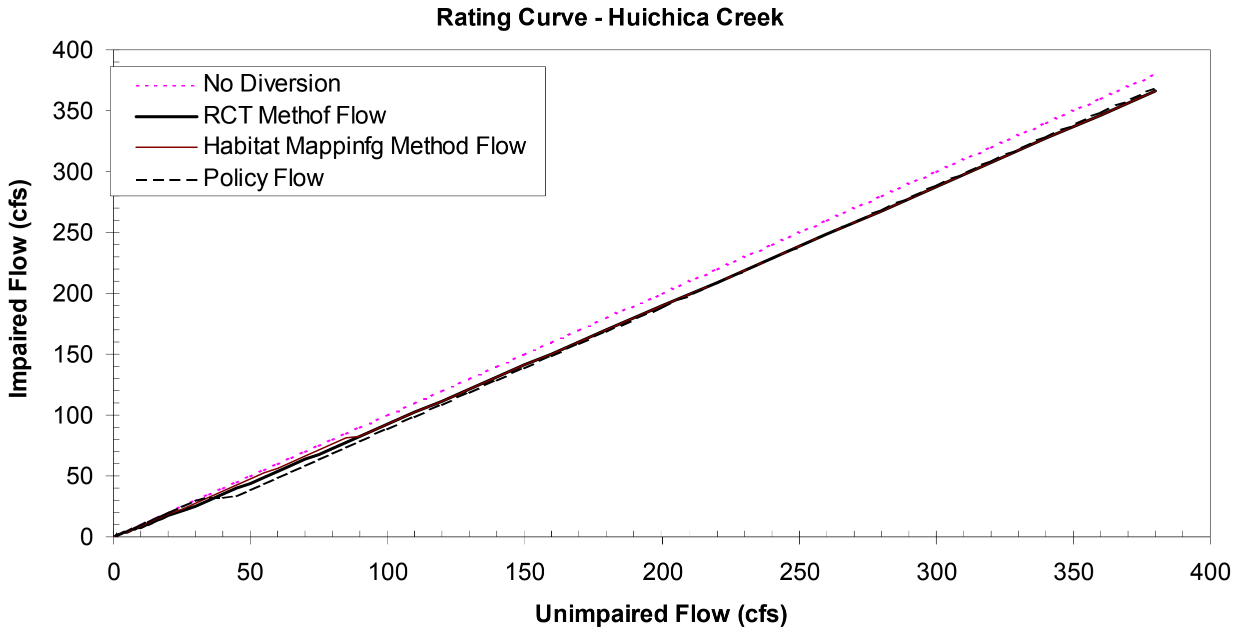


Figure A-4b. Diversion-impaired flow rating curves calculated for the Carneros Creek validation site. The upper graph is the flow rate diverted in cfs, the lower graph is the corresponding percent of unimpaired flow diverted for the three diversion scenarios evaluated and graphed in Figure A-3a.



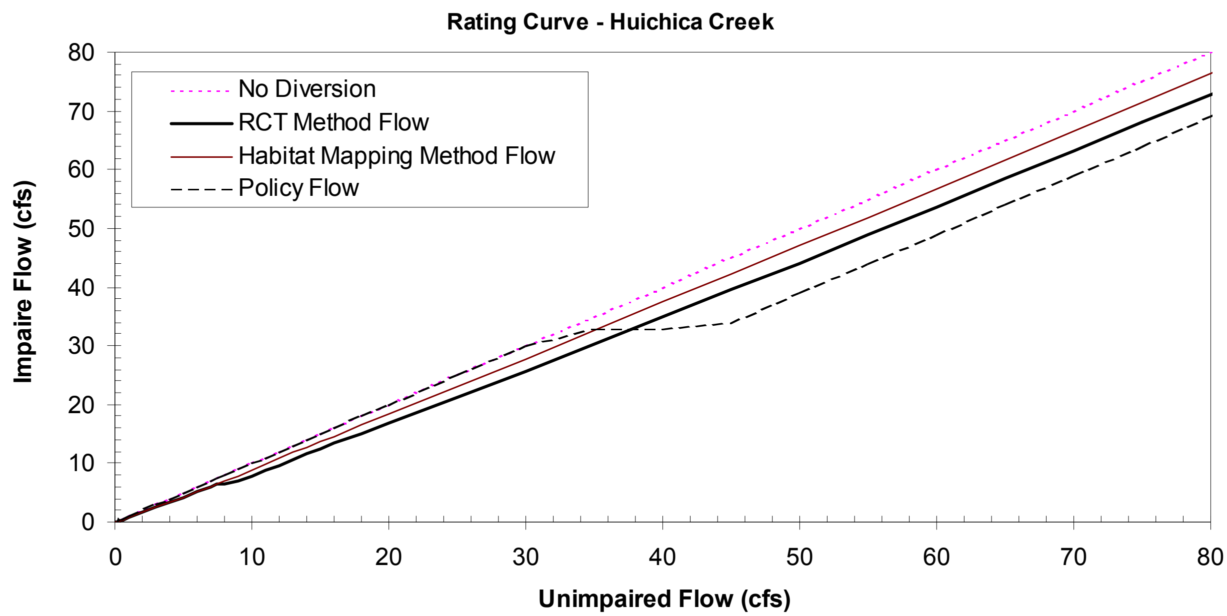
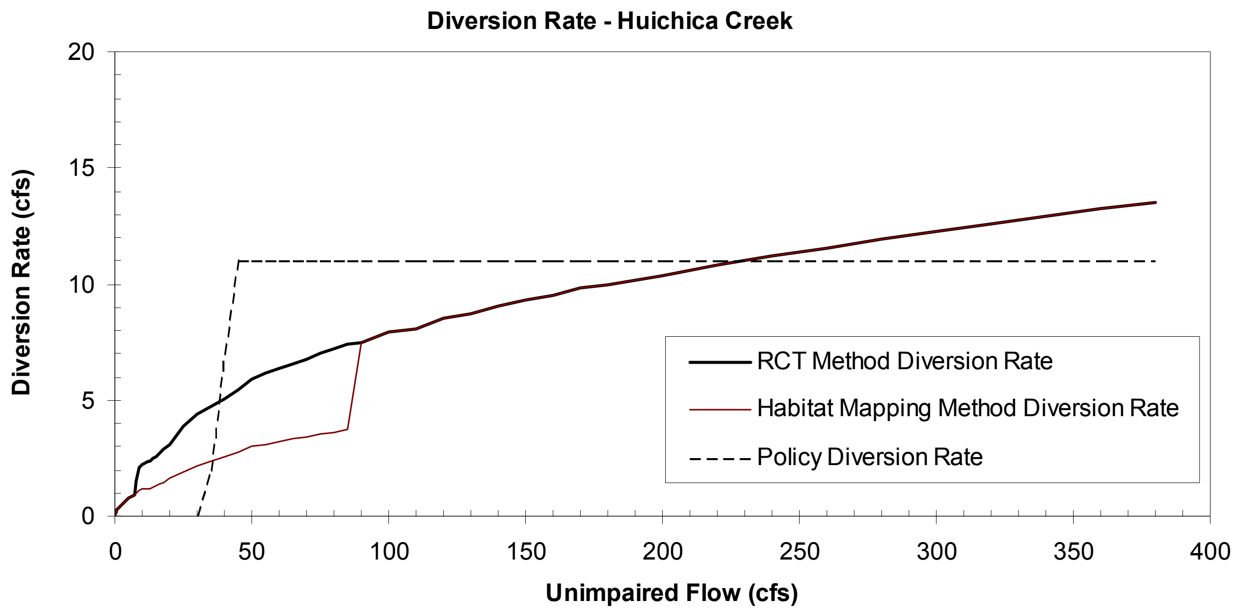


Figure A-5a. Impaired-unimpaired flow rating curves calculated for the Huichica Creek validation site. No diversion corresponds to the 1:1 line. The other lines are the resulting impaired flow resulting from implementation of (i) the draft Policy, and the TU/WB/ESH Proposal where the upper spawning flow threshold is determined using (ii) the RCT method, and (iii) the habitat mapping method. The lower graph is a blow-up of the upper graph in the low-flow image.



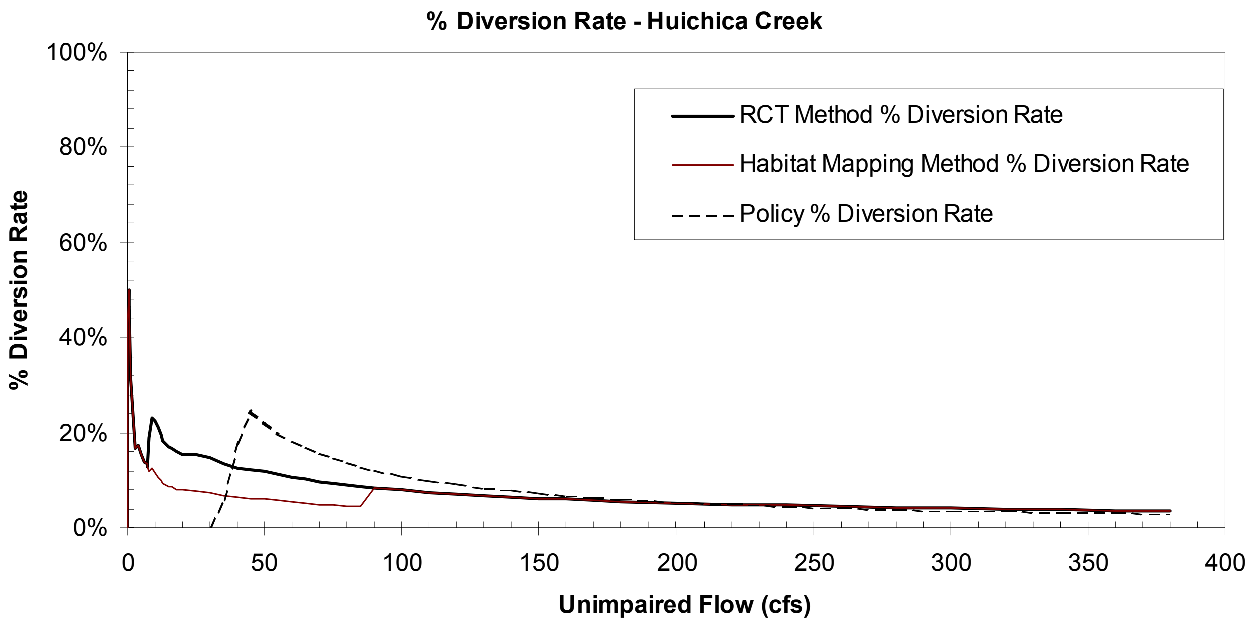
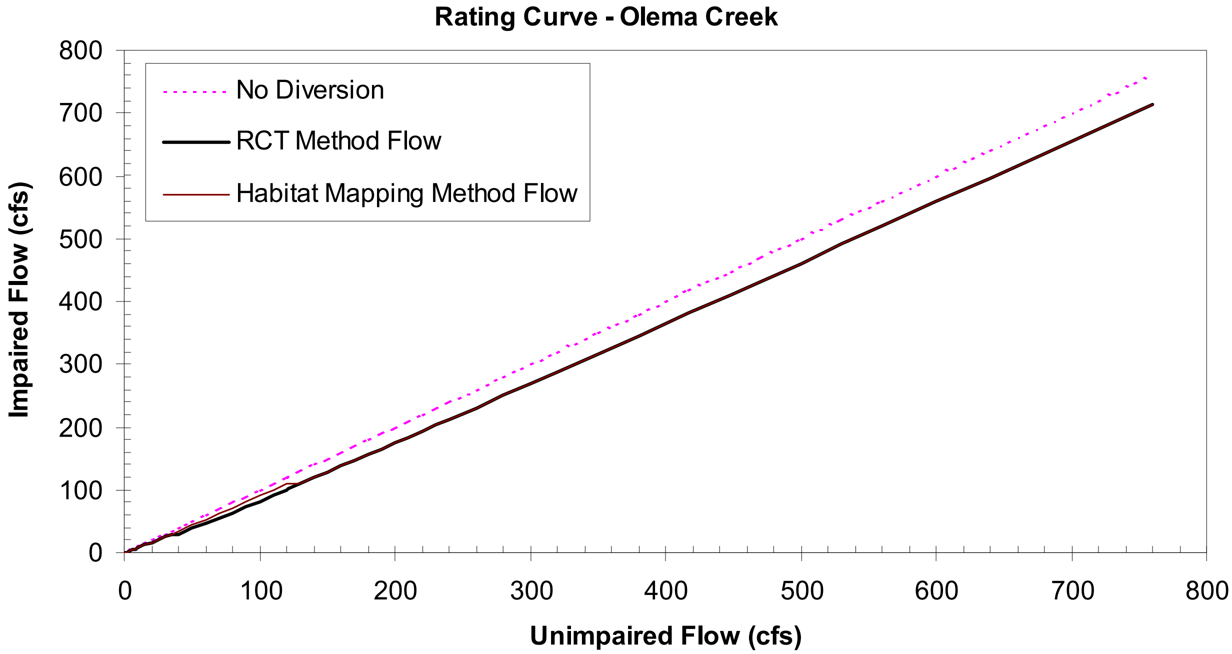


Figure A-5b. Diversion-impaired flow rating curves calculated for the Huichica Creek validation site. The upper graph is the flow rate diverted in cfs, the lower graph is the corresponding percent of unimpaired flow diverted for the three diversion scenarios evaluated and graphed in Figure A-4a.



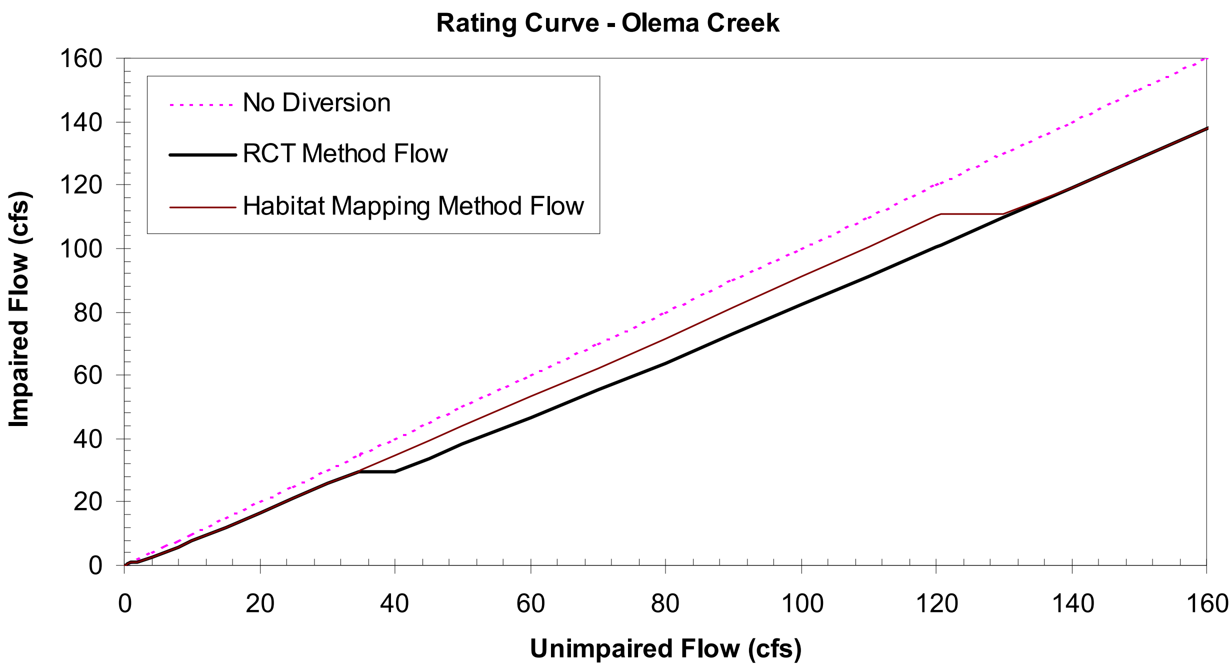
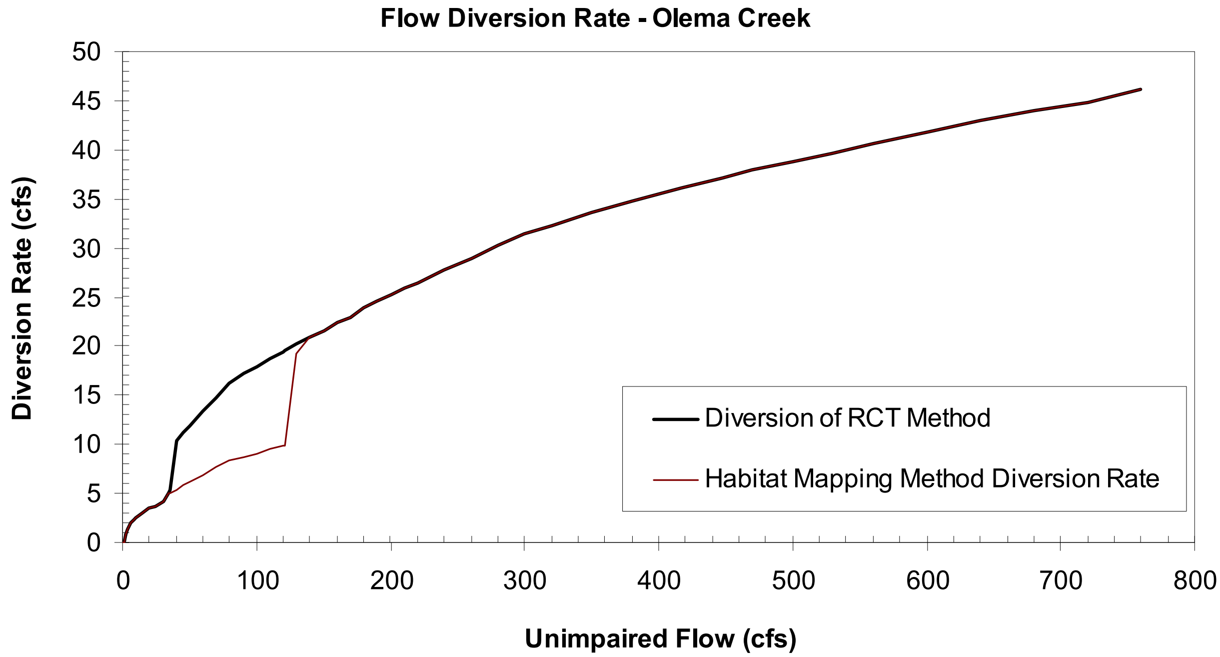


Figure A-6a. Impaired-unimpaired flow rating curves calculated for the Olema Creek validation site. No diversion corresponds to the 1:1 line. The other lines are the resulting impaired flow resulting from implementation of the TU/WB/ESH Proposal where the upper spawning flow threshold is determined using (i) the RCT method, and (ii) the habitat mapping method. The lower graph is a blow-up of the upper graph in the low-flow image. The Policy curve is not presented because the 1.5 year flood was not estimated for this site.



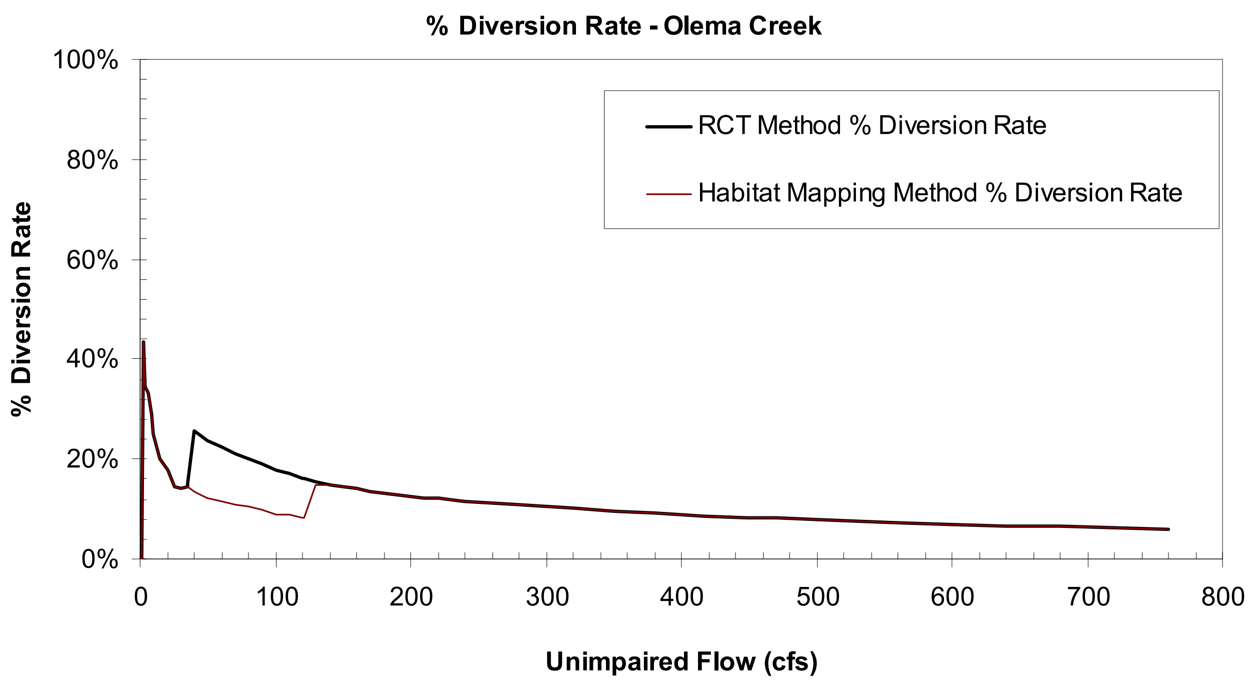
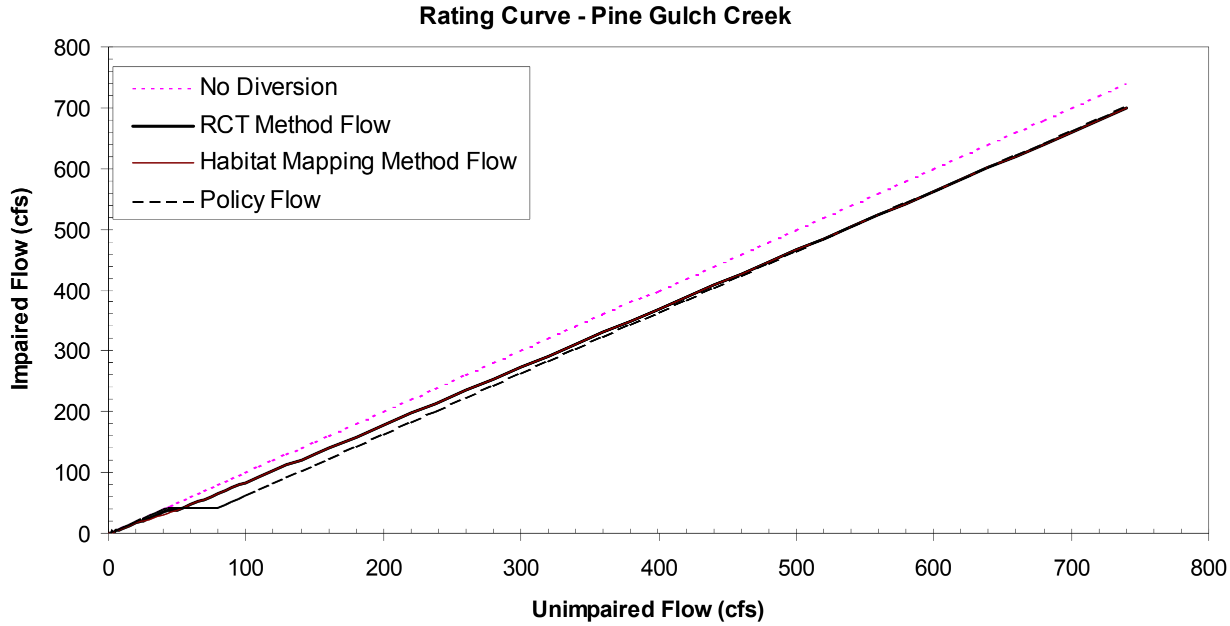


Figure A-6b. Diversion-impaired flow rating curves calculated for the Olema Creek validation site. The upper graph is the flow rate diverted in cfs, the lower graph is the corresponding percent of unimpaired flow diverted for the two diversion scenarios evaluated and graphed in Figure A-5a.



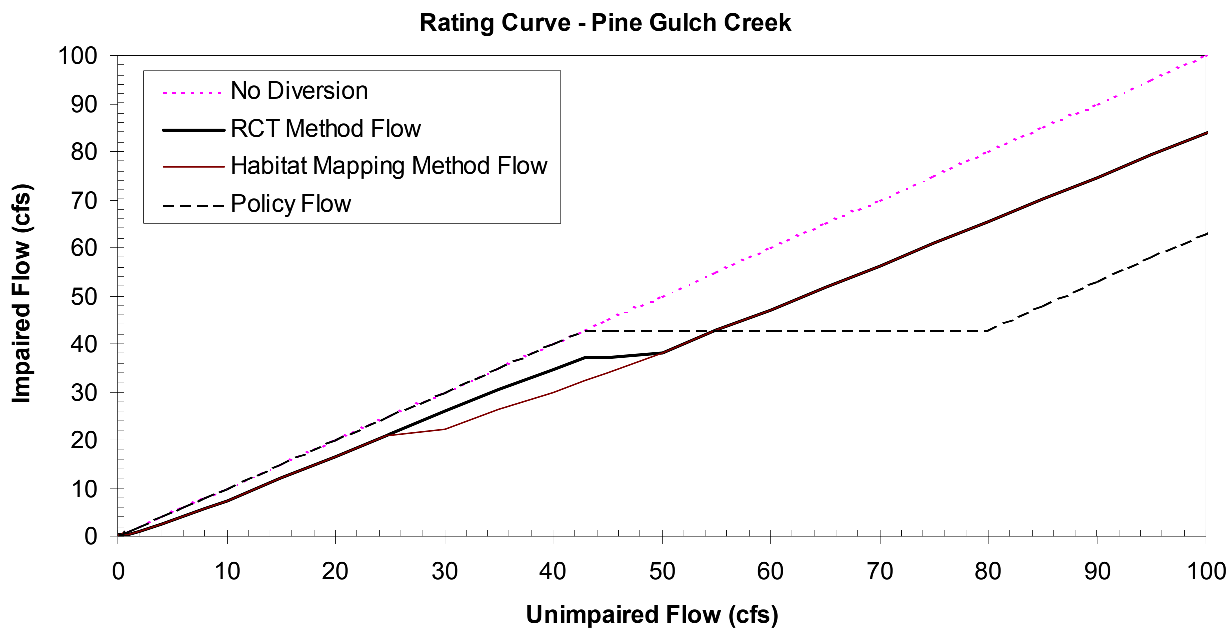
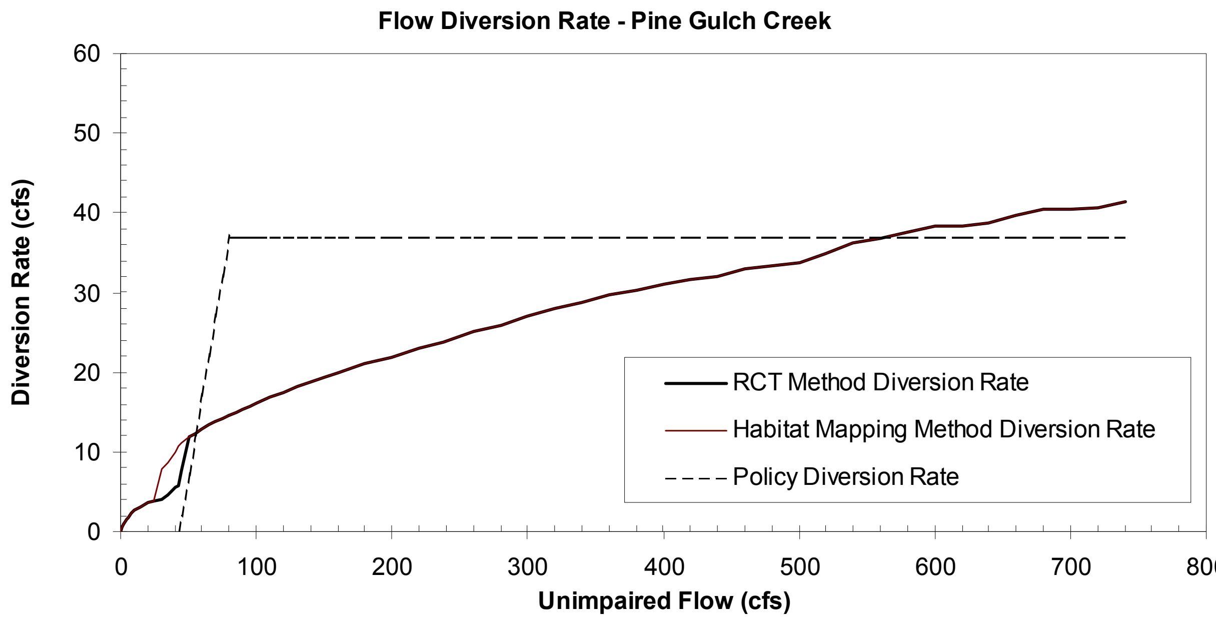


Figure A-7a. Impaired-unimpaired flow rating curves calculated for the Pine Gulch Creek validation site. No diversion corresponds to the 1:1 line. The other lines are the resulting impaired flow resulting from implementation of (i) the draft Policy, and the TU/WB/ESH Proposal where the upper spawning flow threshold is determined using (ii) the RCT method, and (iii) the habitat mapping method. The lower graph is a blow-up of the upper graph in the low-flow image.



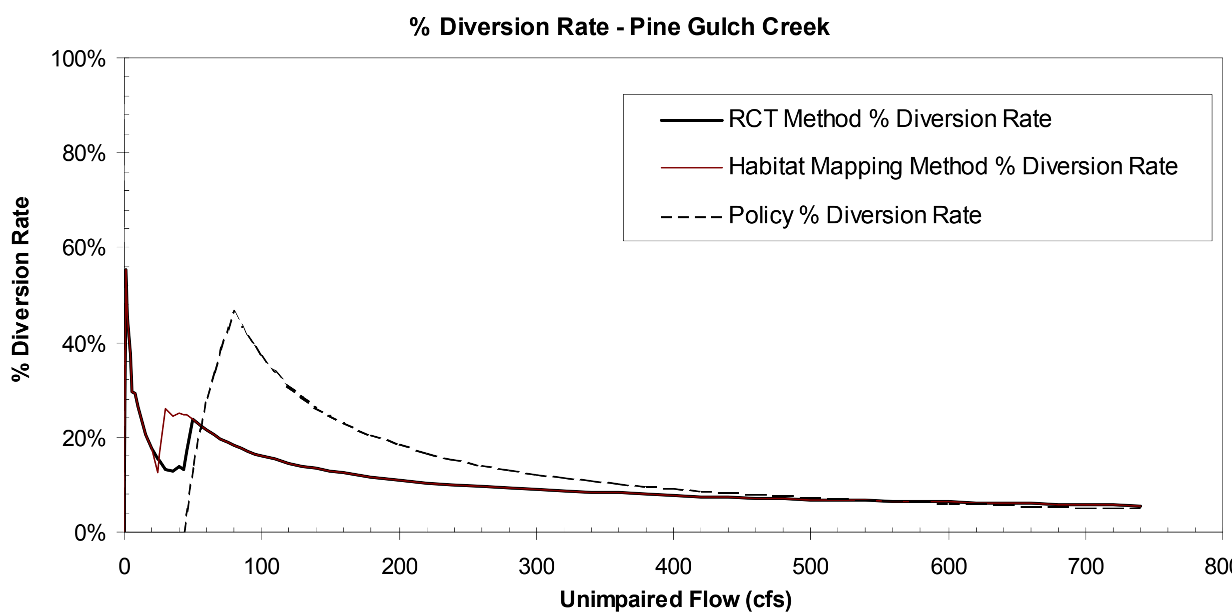
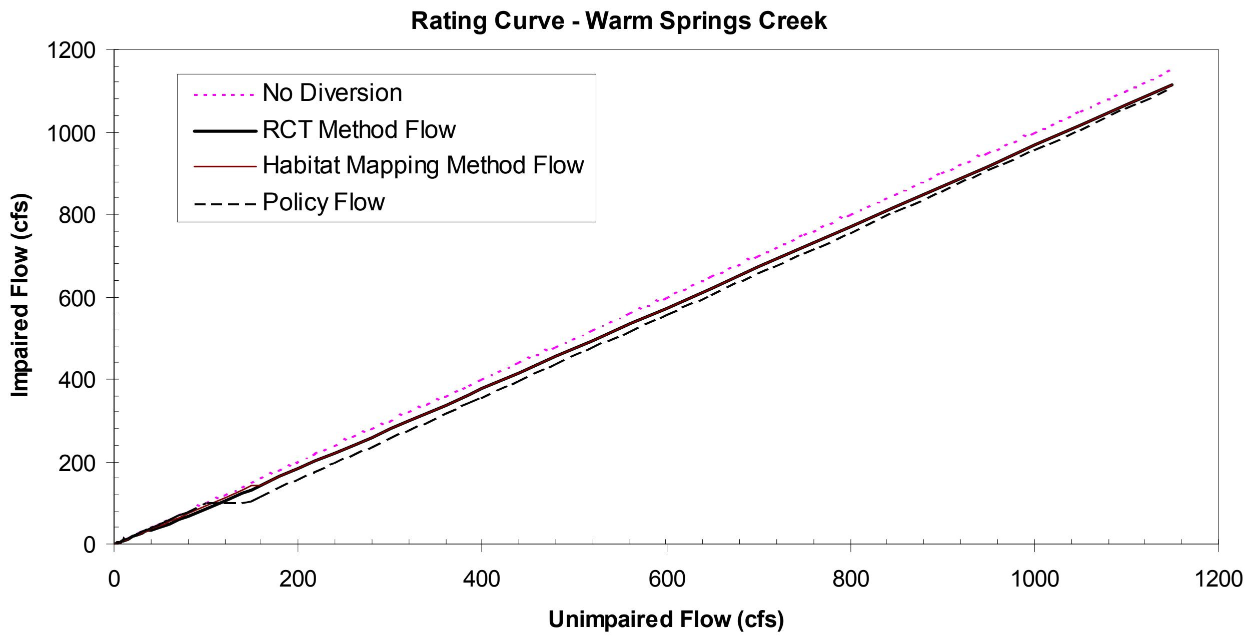


Figure A-7b. Diversion-impaired flow rating curves calculated for the Pine Gulch Creek validation site. The upper graph is the flow rate diverted in cfs, the lower graph is the corresponding percent of unimpaired flow diverted for the three diversion scenarios evaluated and graphed in Figure A-6a.



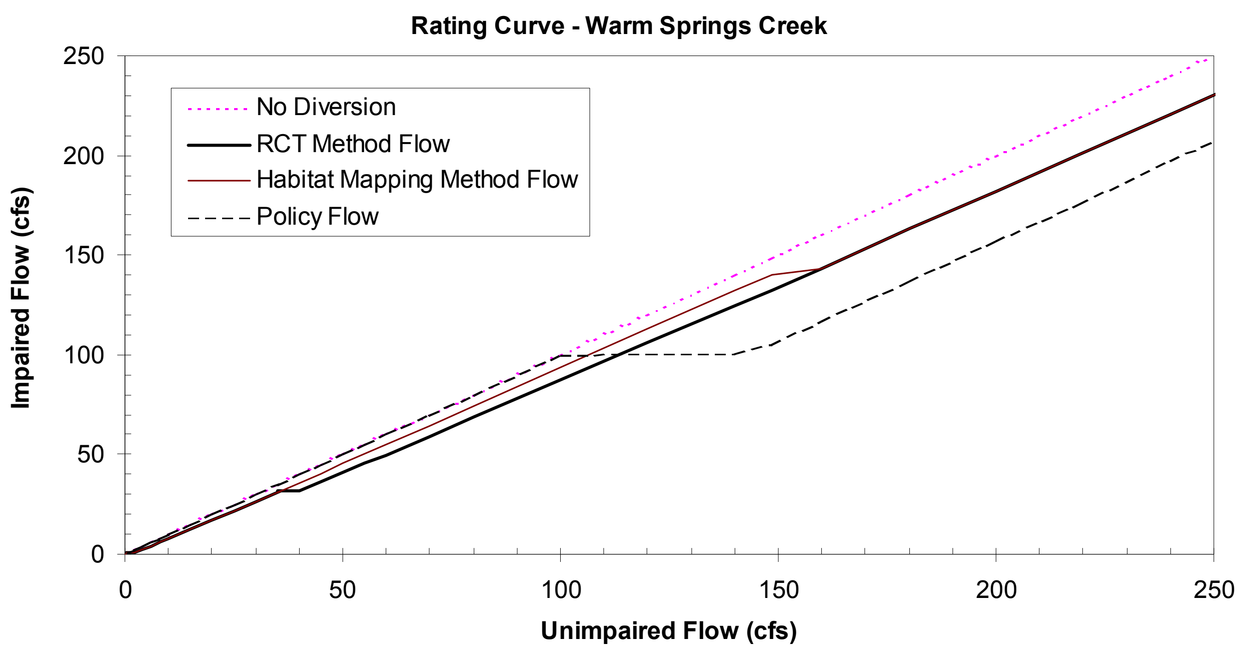
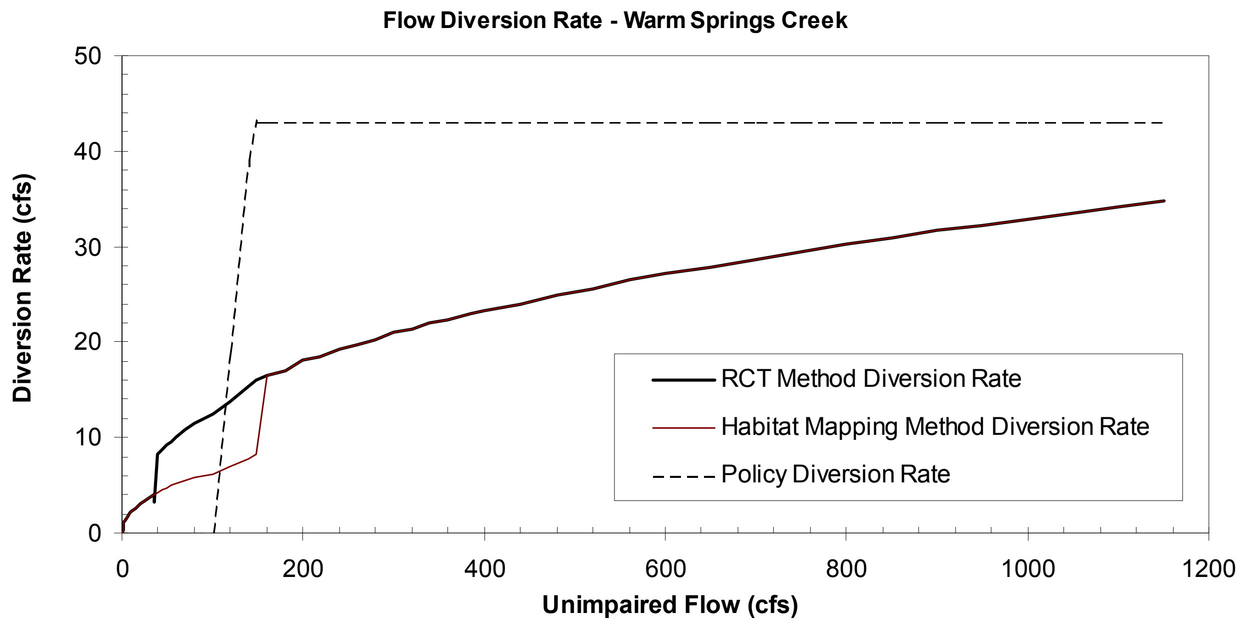


Figure A-8a. Impaired-unimpaired flow rating curves calculated for the Warm Springs Creek validation site. No diversion corresponds to the 1:1 line. The other lines are the resulting impaired flow resulting from implementation of (i) the draft Policy, and the TU/WB/ESH Proposal where the upper spawning flow threshold is determined using (ii) the RCT method, and (iii) the habitat mapping method. The lower graph is a blow-up of the upper graph in the low-flow image.



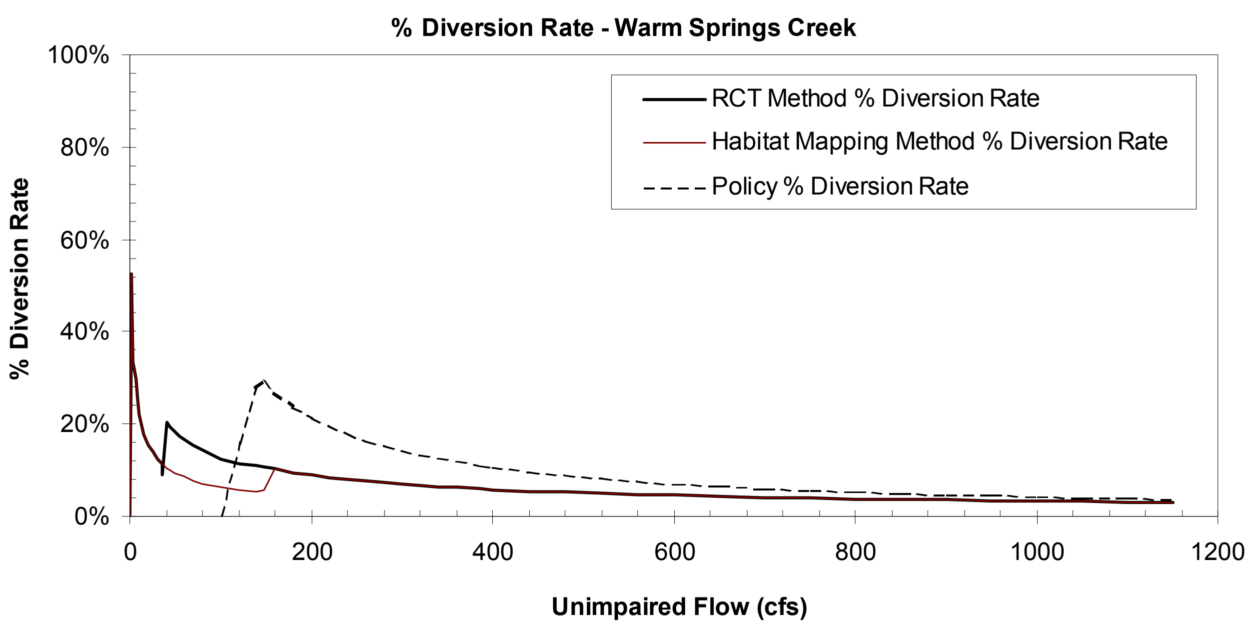
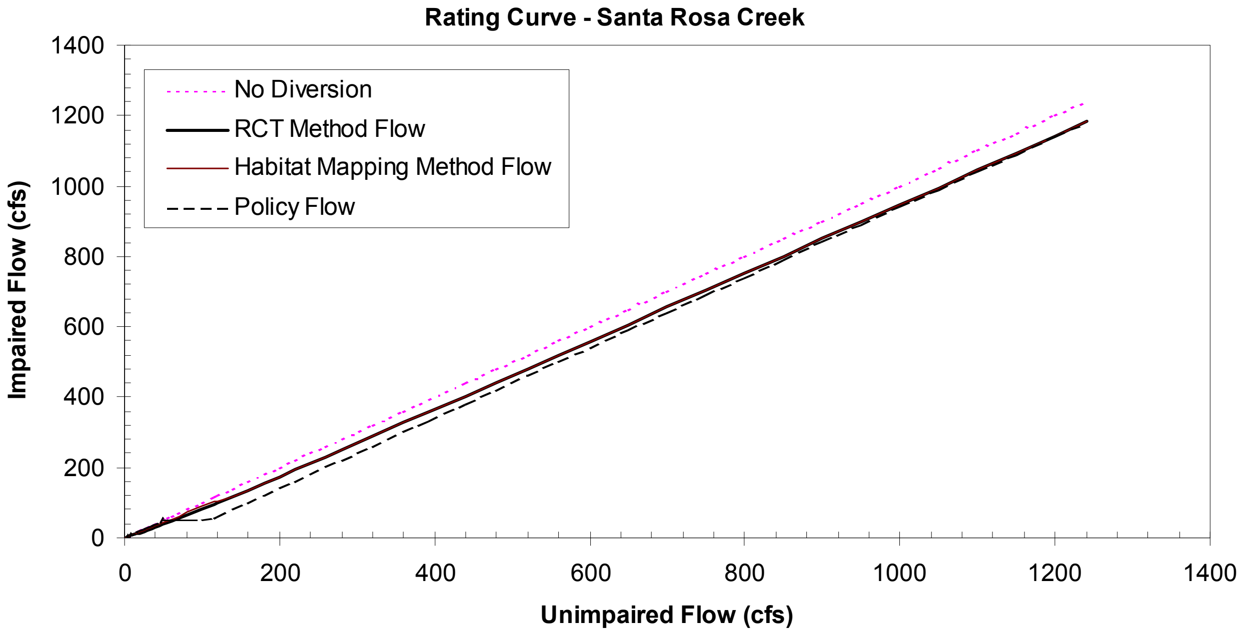


Figure A-8b. Diversion-impaired flow rating curves calculated for the Warm Springs Creek validation site. The upper graph is the flow rate diverted in cfs, the lower graph is the corresponding percent of unimpaired flow diverted for the three diversion scenarios evaluated and graphed in Figure A-7a.



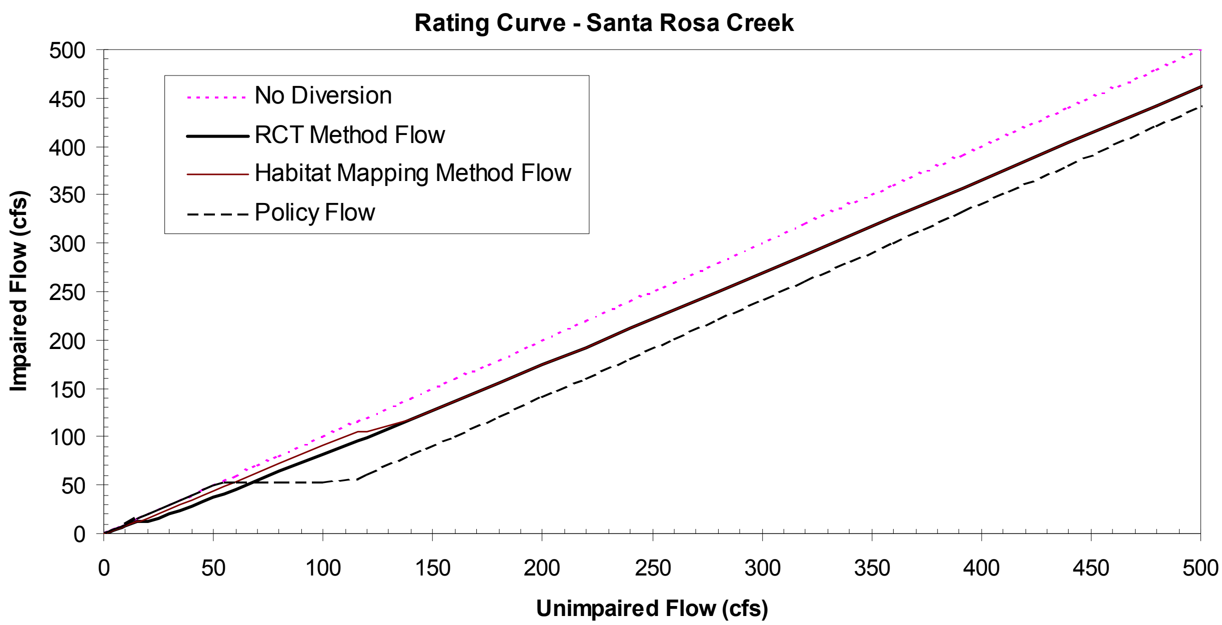


Figure A-9a. Impaired-unimpaired flow rating curves calculated for the Santa Rosa Creek validation site. No diversion corresponds to the 1:1 line. The other lines are the resulting impaired flow resulting from implementation of (i) the draft Policy, and the TU/WB/ESH Proposal where the upper spawning flow threshold is determined using (ii) the RCT method, and (iii) the habitat mapping method. The lower graph is a blow-up of the upper graph in the low-flow image.

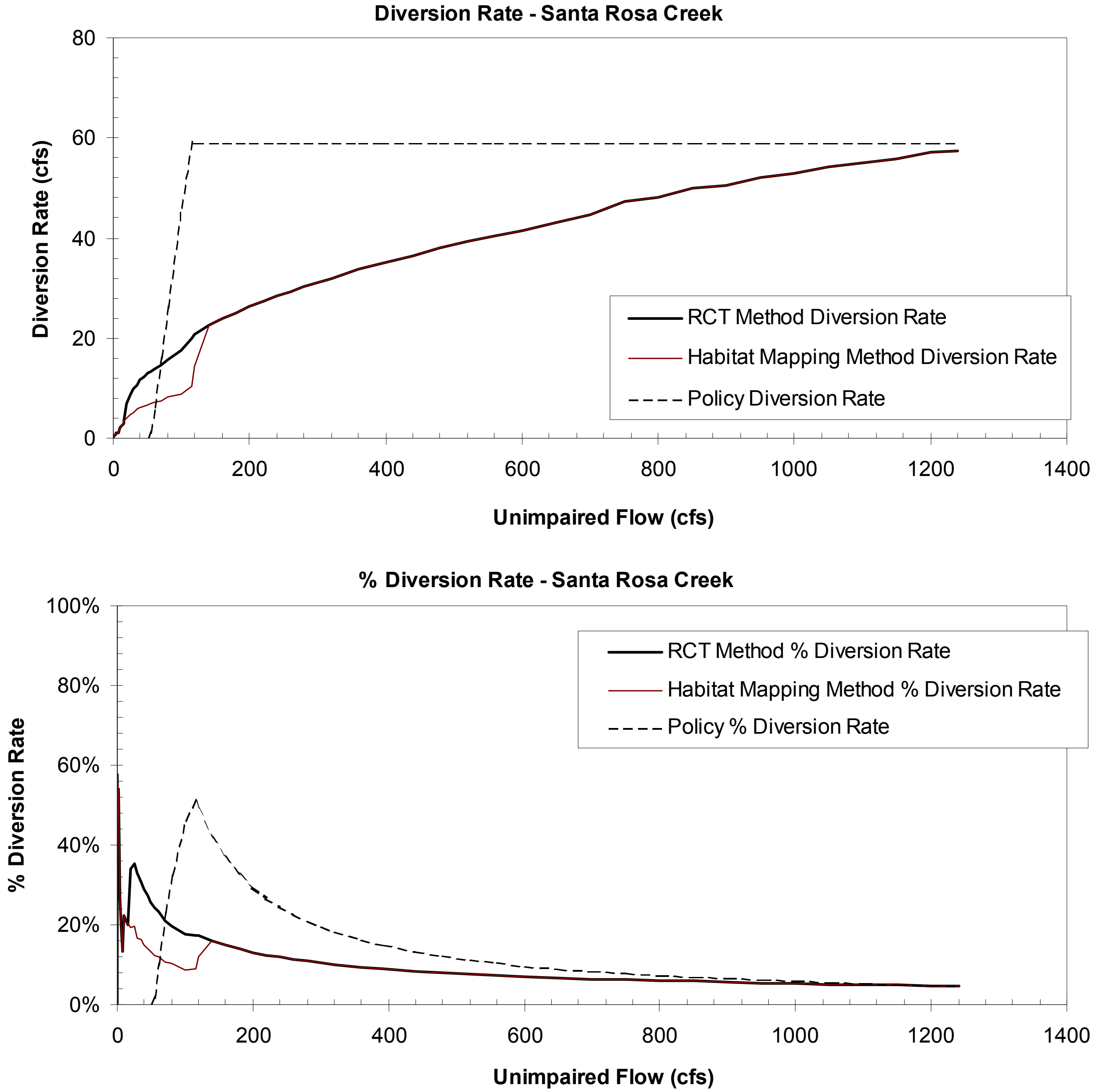
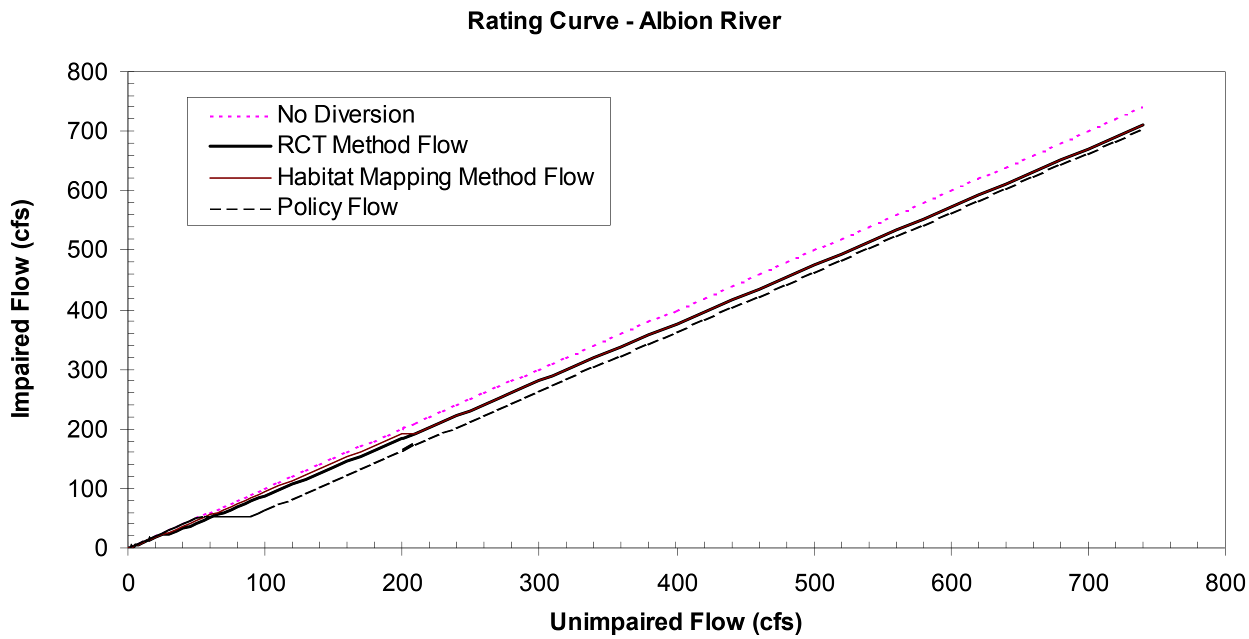


Figure A-9b. Diversion-impaired flow rating curves calculated for the Santa Rosa Creek validation site. The upper graph is the flow rate diverted in cfs, the lower graph is the corresponding percent of unimpaired flow diverted for the three diversion scenarios evaluated and graphed in Figure A-8a.



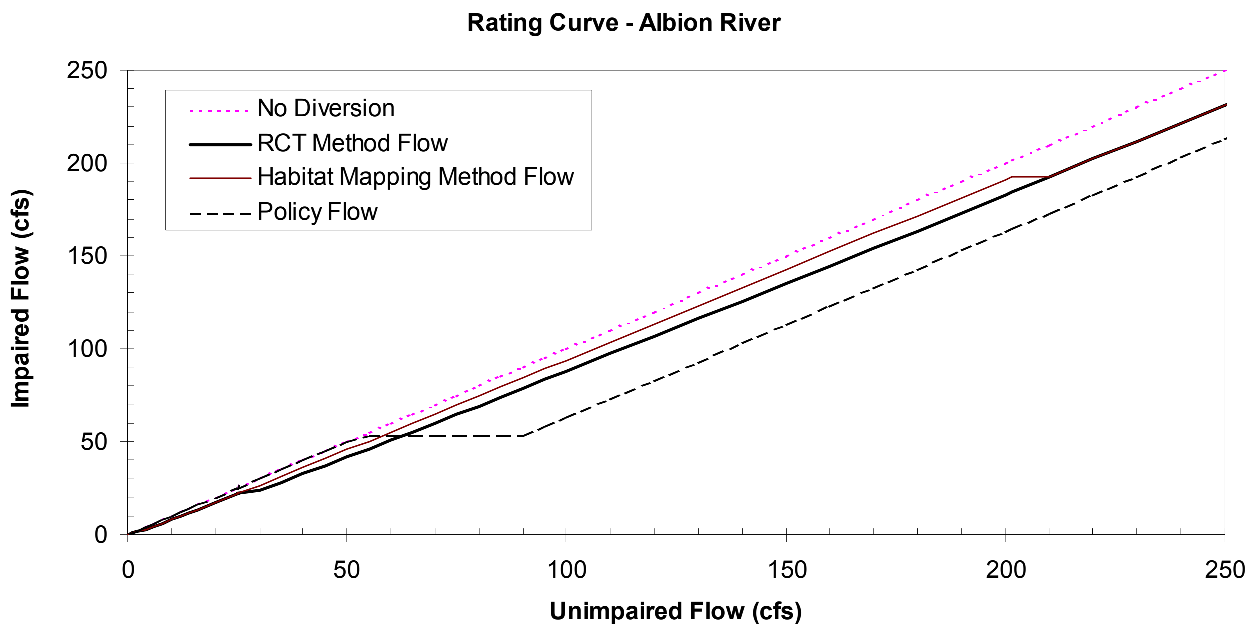
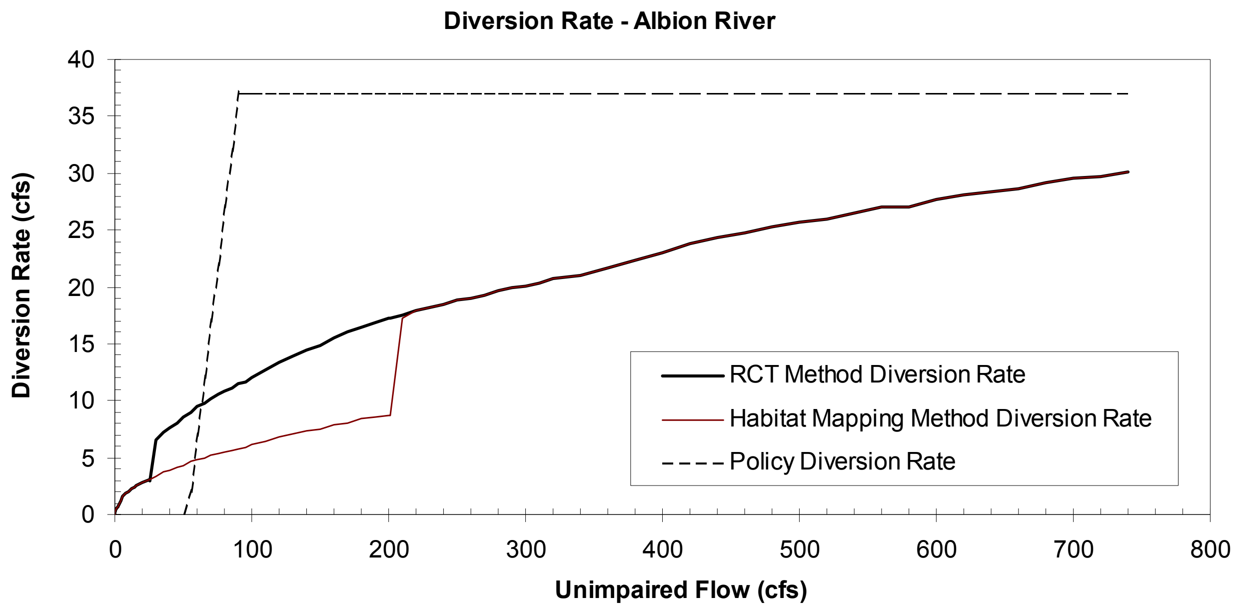


Figure A-10a. Impaired-unimpaired flow rating curves calculated for the Albion River validation site. No diversion corresponds to the 1:1 line. The other lines are the resulting impaired flow resulting from implementation of (i) the draft Policy, and the TU/WB/ESH Proposal where the upper spawning flow threshold is determined using (ii) the RCT method, and (iii) the habitat mapping method. The lower graph is a blow-up of the upper graph in the low-flow image.



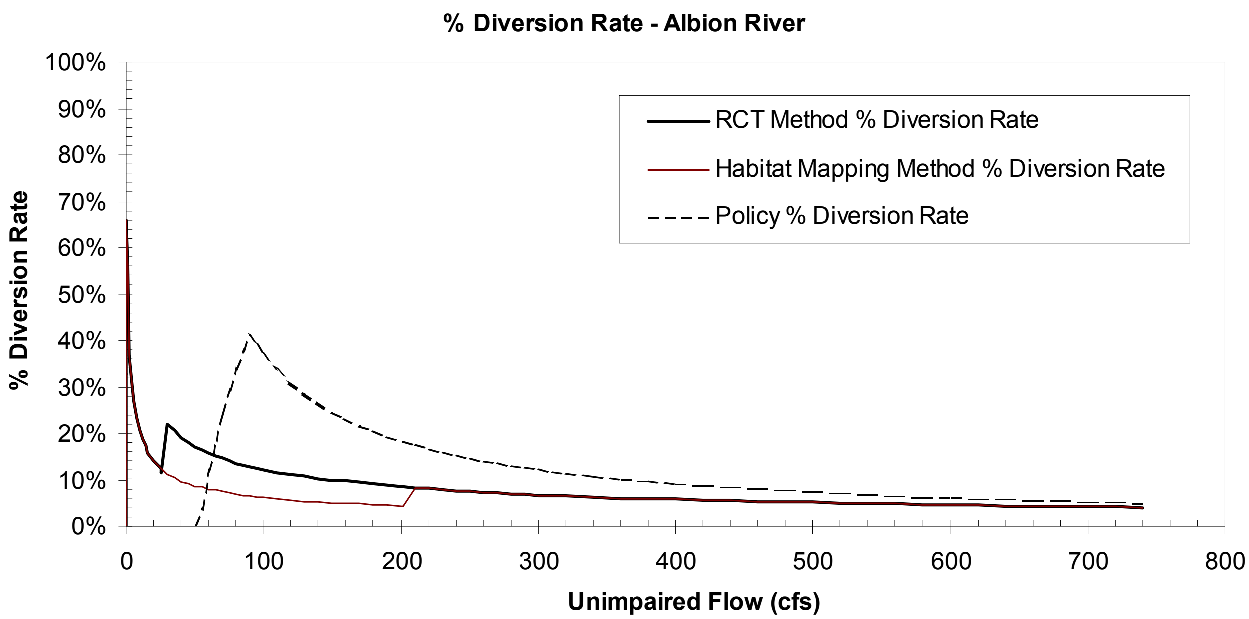
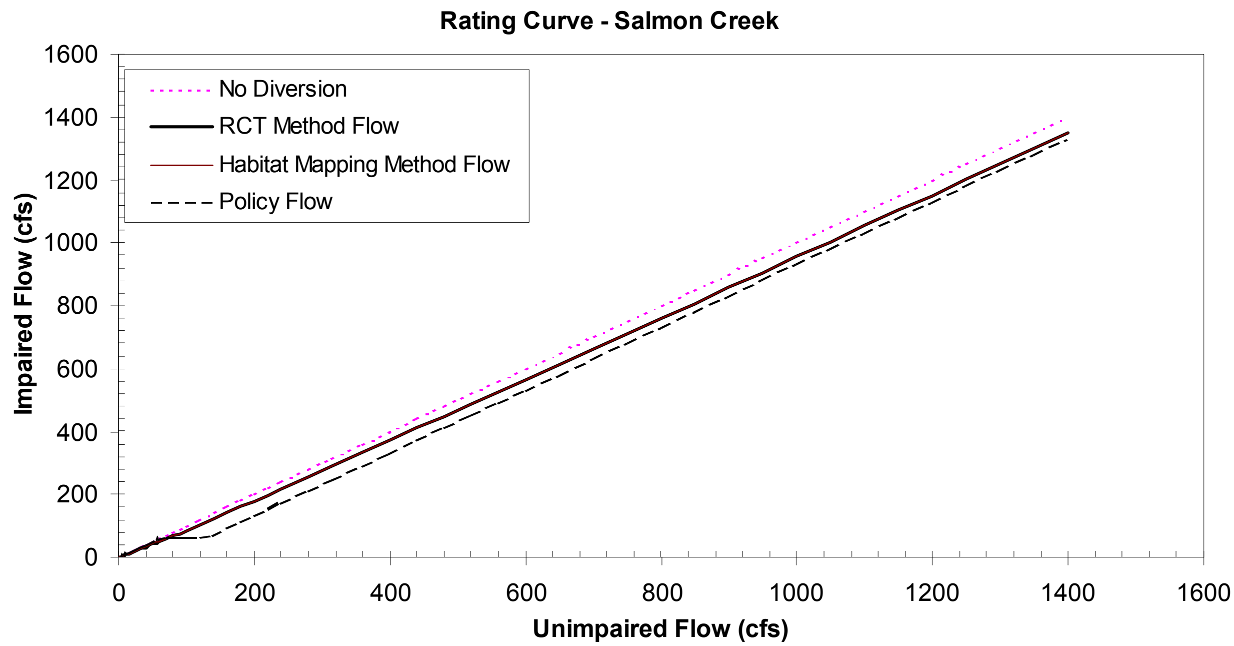


Figure A-10b. Diversion-impaired flow rating curves calculated for the Albion River validation site. The upper graph is the flow rate diverted in cfs, the lower graph is the corresponding percent of unimpaired flow diverted for the three diversion scenarios evaluated and graphed in Figure A-9a.



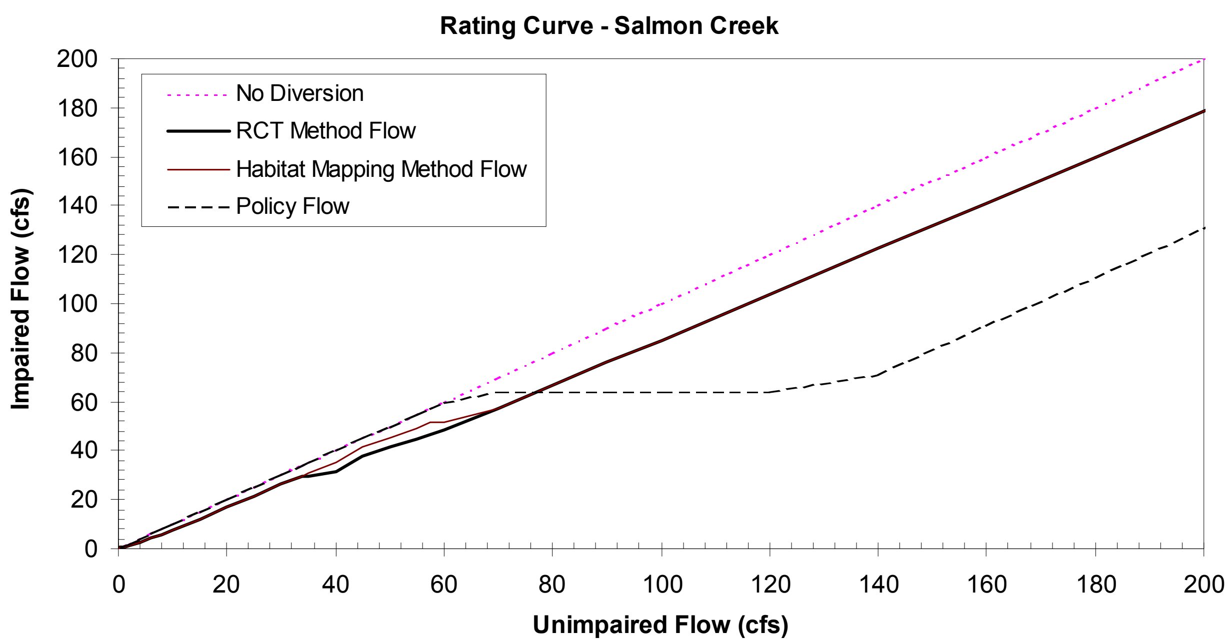
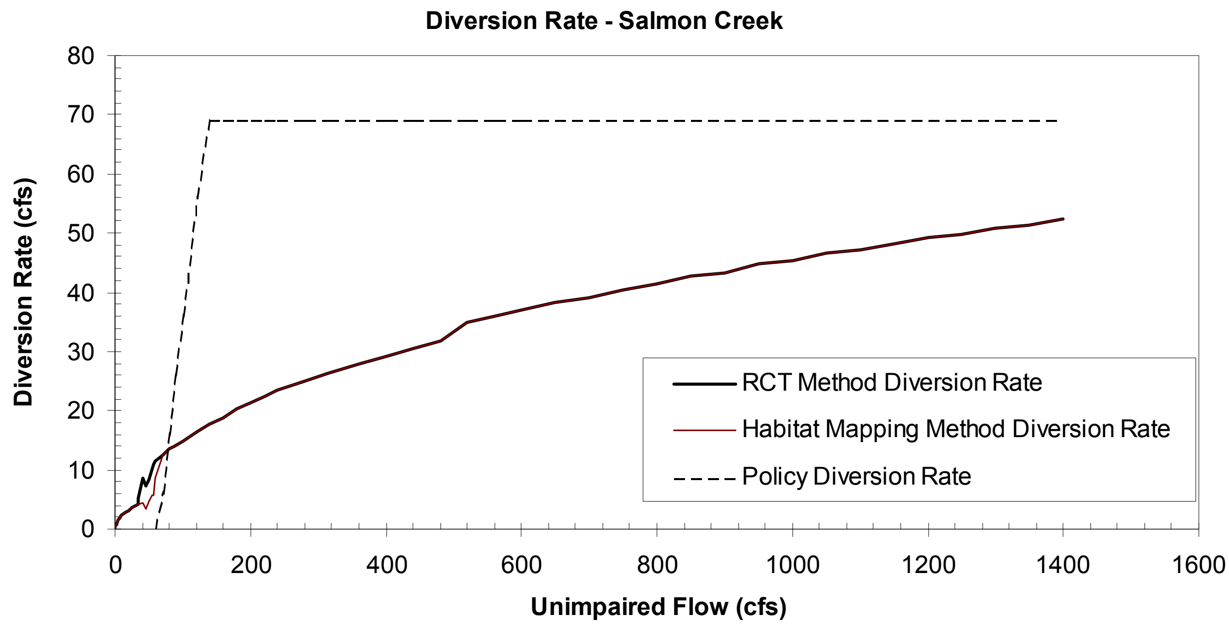


Figure A-11a. Impaired-unimpaired flow rating curves calculated for the Salmon Creek validation site. No diversion corresponds to the 1:1 line. The other lines are the resulting impaired flow resulting from implementation of (i) the draft Policy, and the TU/WB/ESH Proposal where the upper spawning flow threshold is determined using (ii) the RCT method, and (iii) the habitat mapping method. The lower graph is a blow-up of the upper graph in the low-flow image.



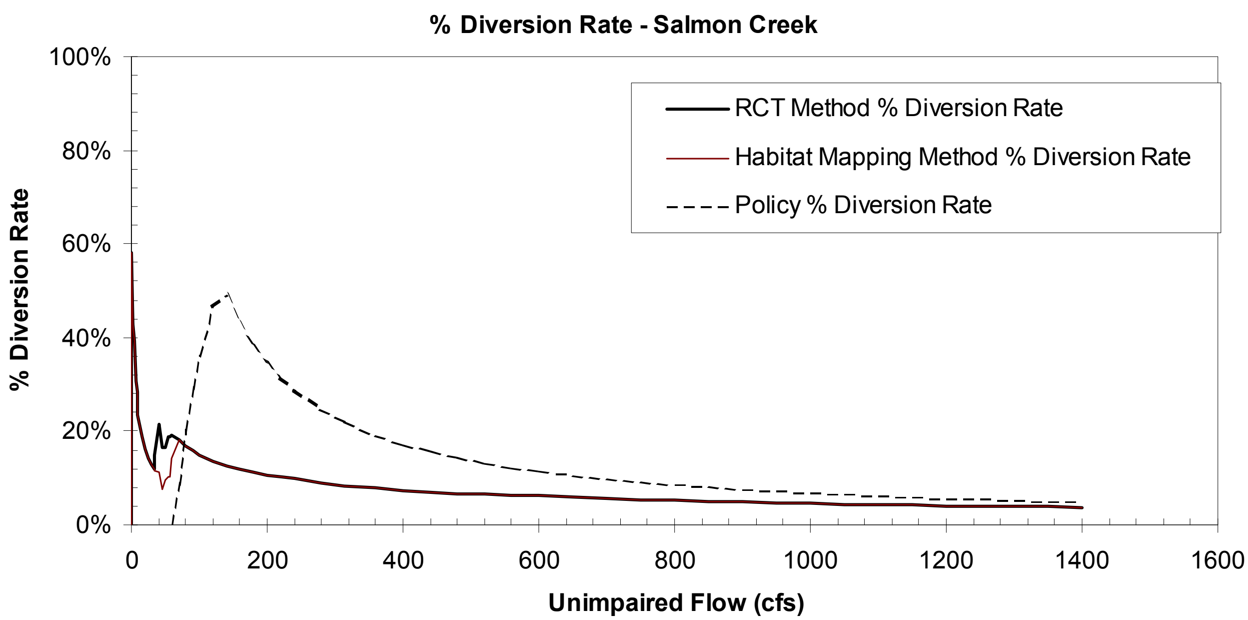
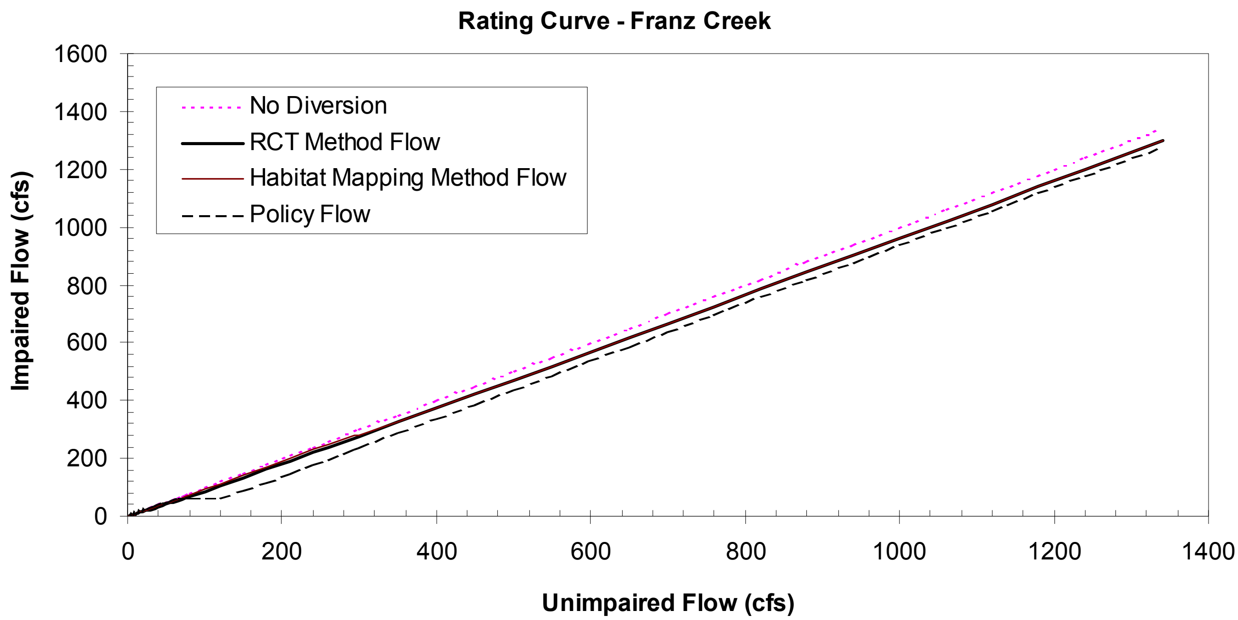


Figure A-11b. Diversion-impaired flow rating curves calculated for the Salmon Creek validation site. The upper graph is the flow rate diverted in cfs, the lower graph is the corresponding percent of unimpaired flow diverted for the three diversion scenarios evaluated and graphed in Figure A-10a.



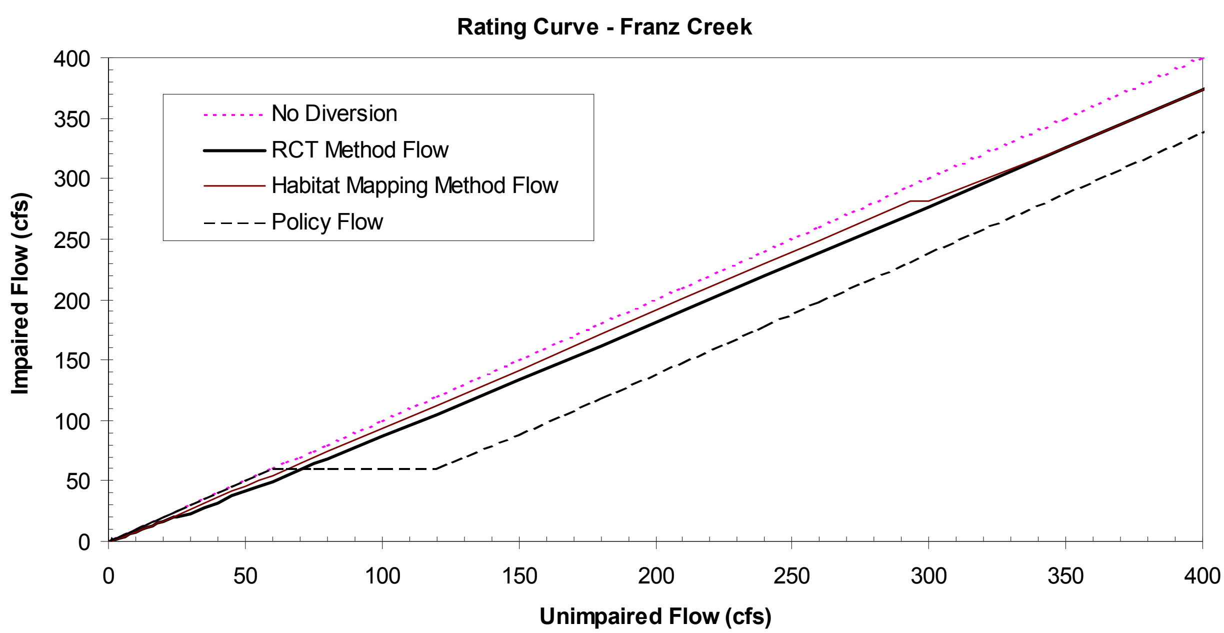
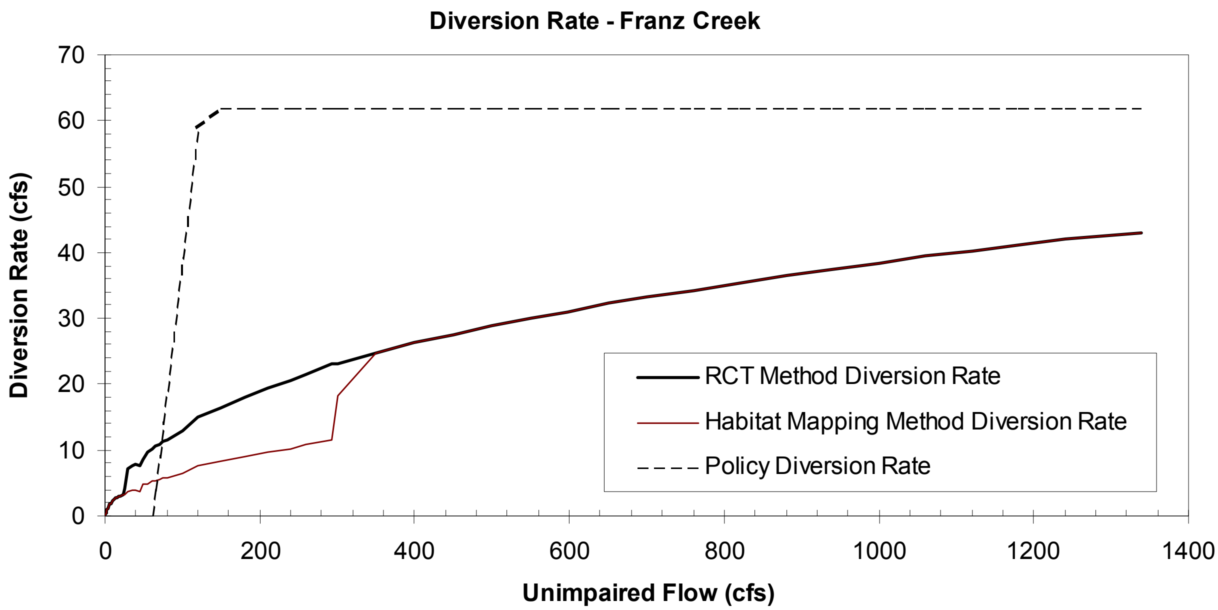


Figure A-12a. Impaired-unimpaired flow rating curves calculated for the Franz Creek validation site. No diversion corresponds to the 1:1 line. The other lines are the resulting impaired flow resulting from implementation of (i) the draft Policy, and the TU/WB/ESH Proposal where the upper spawning flow threshold is determined using (ii) the RCT method, and (iii) the habitat mapping method. The lower graph is a blow-up of the upper graph in the low-flow image.



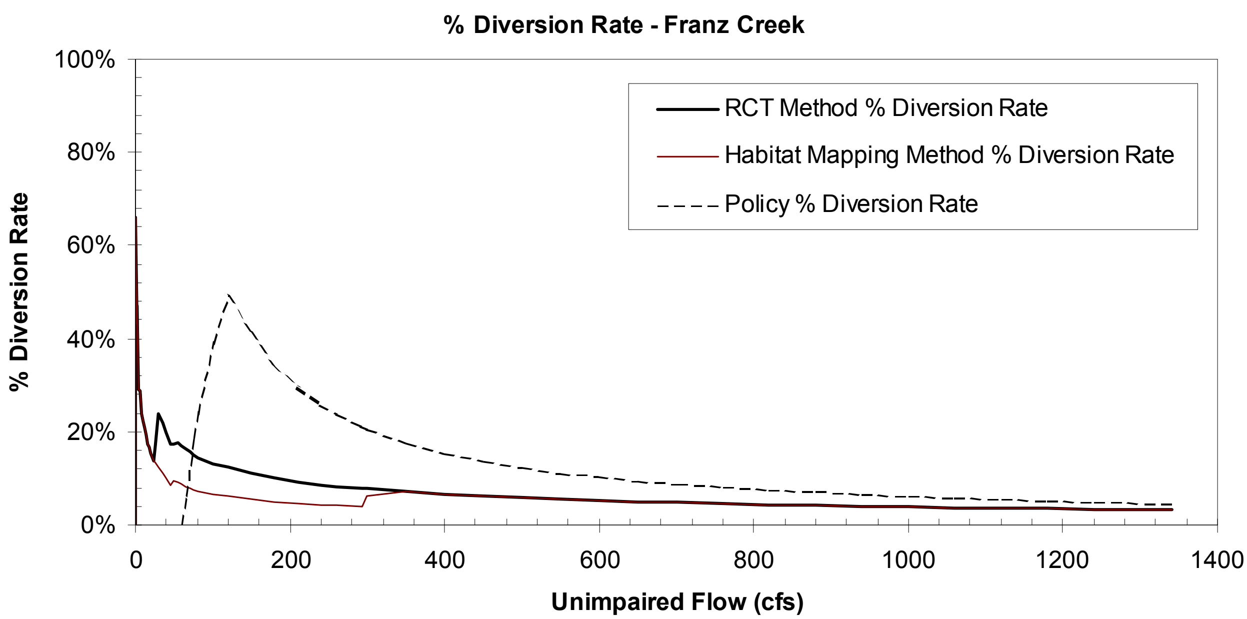


Figure A-12b. Diversion-impaired flow rating curves calculated for the Franz Creek validation site. The upper graph is the flow rate diverted in cfs, the lower graph is the corresponding percent of unimpaired flow diverted for the three diversion scenarios evaluated and graphed in Figure A-11a.

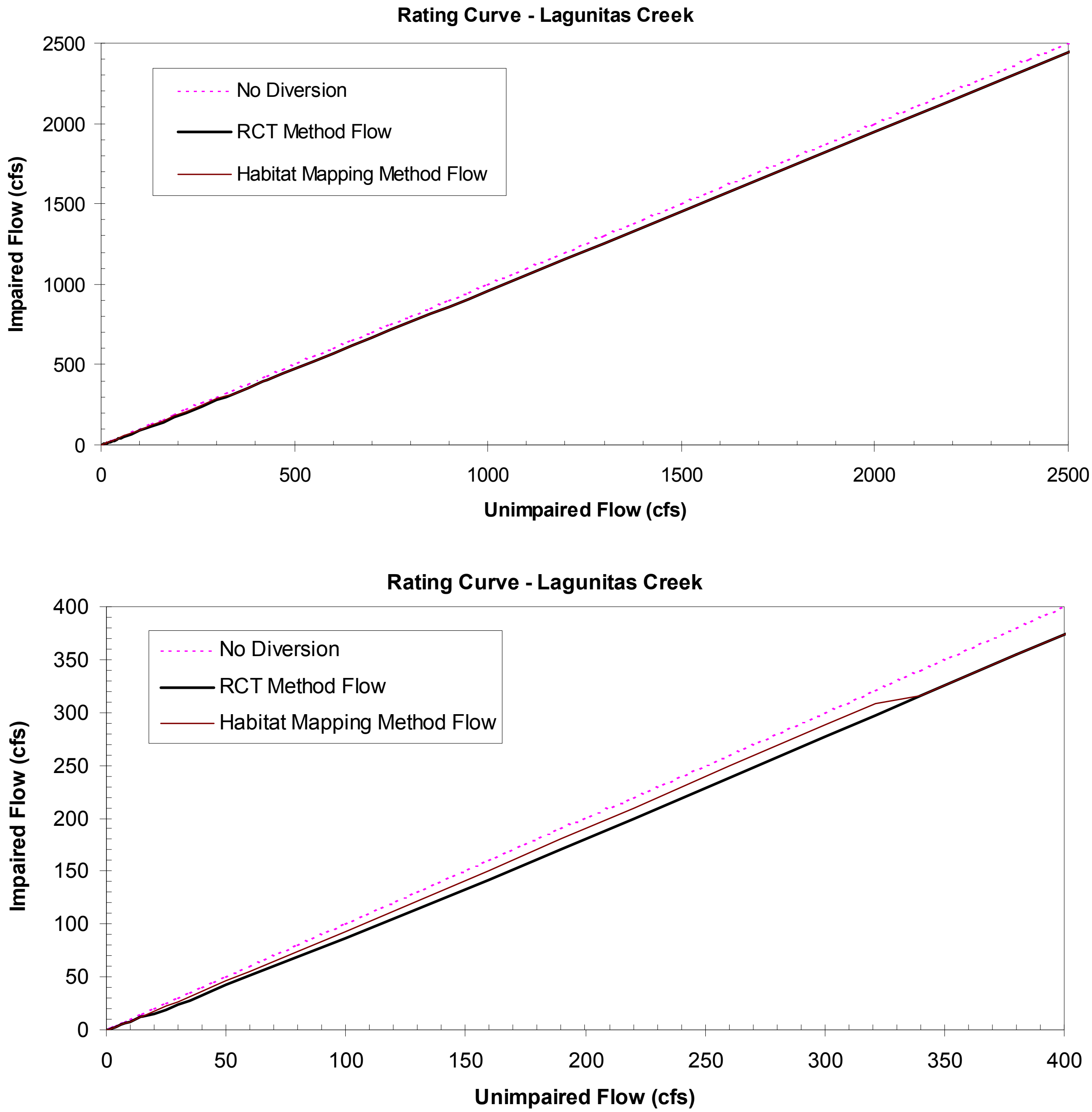
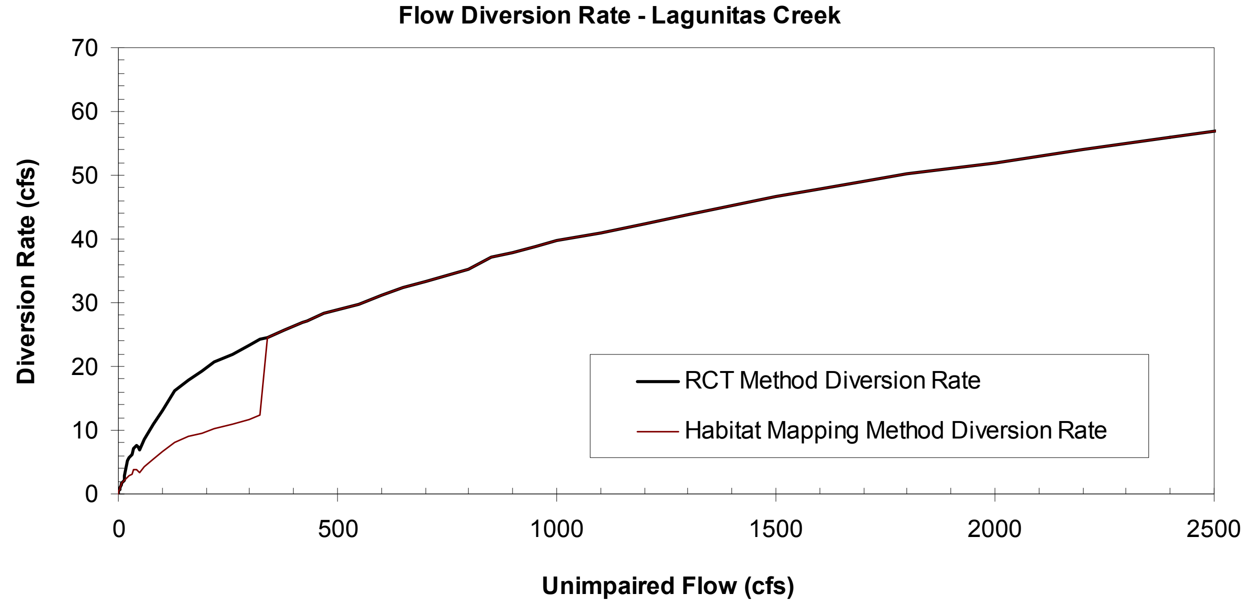


Figure A-13a. Impaired-unimpaired flow rating curves calculated for the Lagunitas Creek validation site. No diversion corresponds to the 1:1 line. The other lines are the resulting impaired flow resulting from implementation of the TU/WB/ESH Proposal where the upper spawning flow threshold is determined using (i) the RCT method, and (ii) the habitat mapping method. The lower graph is a blow-up of the upper graph in the low-flow image. The Policy curve is not presented because the 1.5 year flood was not estimated for this site.



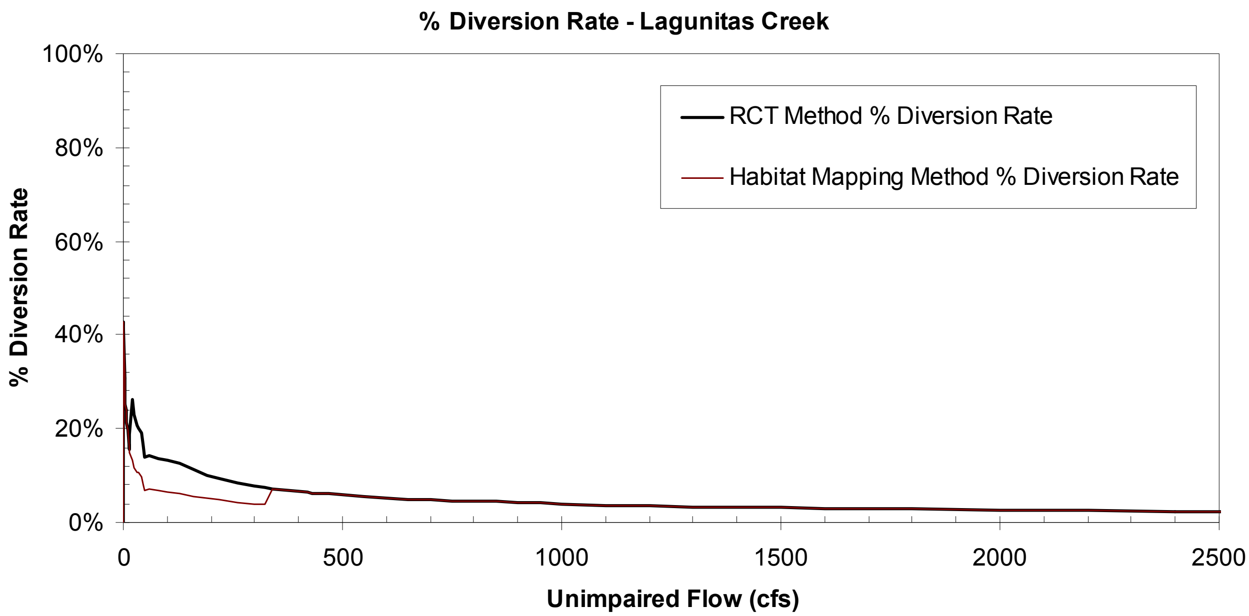
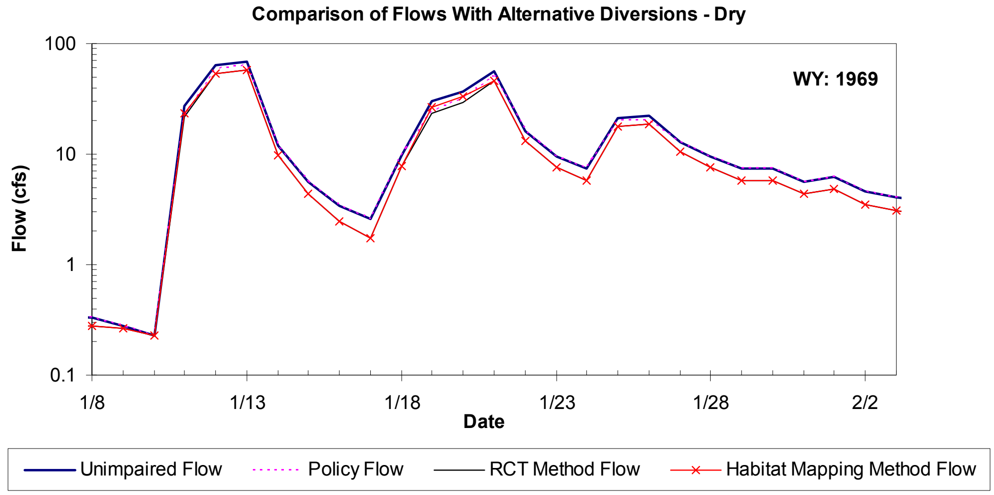
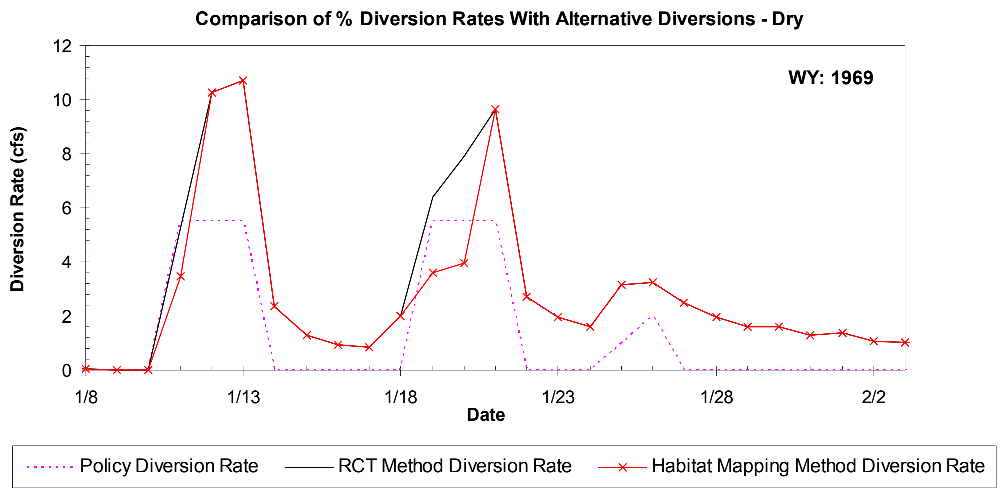


Figure A-13b. Diversion-impaired flow rating curves calculated for the Lagunitas Creek validation site. The upper graph is the flow rate diverted in cfs, the lower graph is the corresponding percent of unimpaired flow diverted for the two diversion scenarios evaluated and graphed in Figure A-12a.





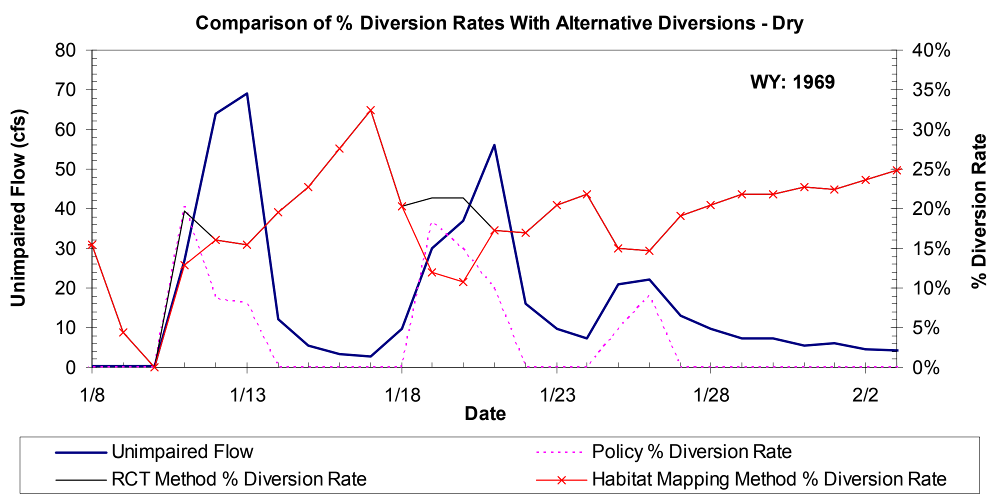


Figure A-14a. Example application of the method proposed by TU/WB/ESH for calculating diversion rate during a high flow event in the Dry Creek validation site. Diversion rates and resulting impaired flows are calculated for the Policy and the two alternative spawning flow methods proposed by TU/WB/ESH.

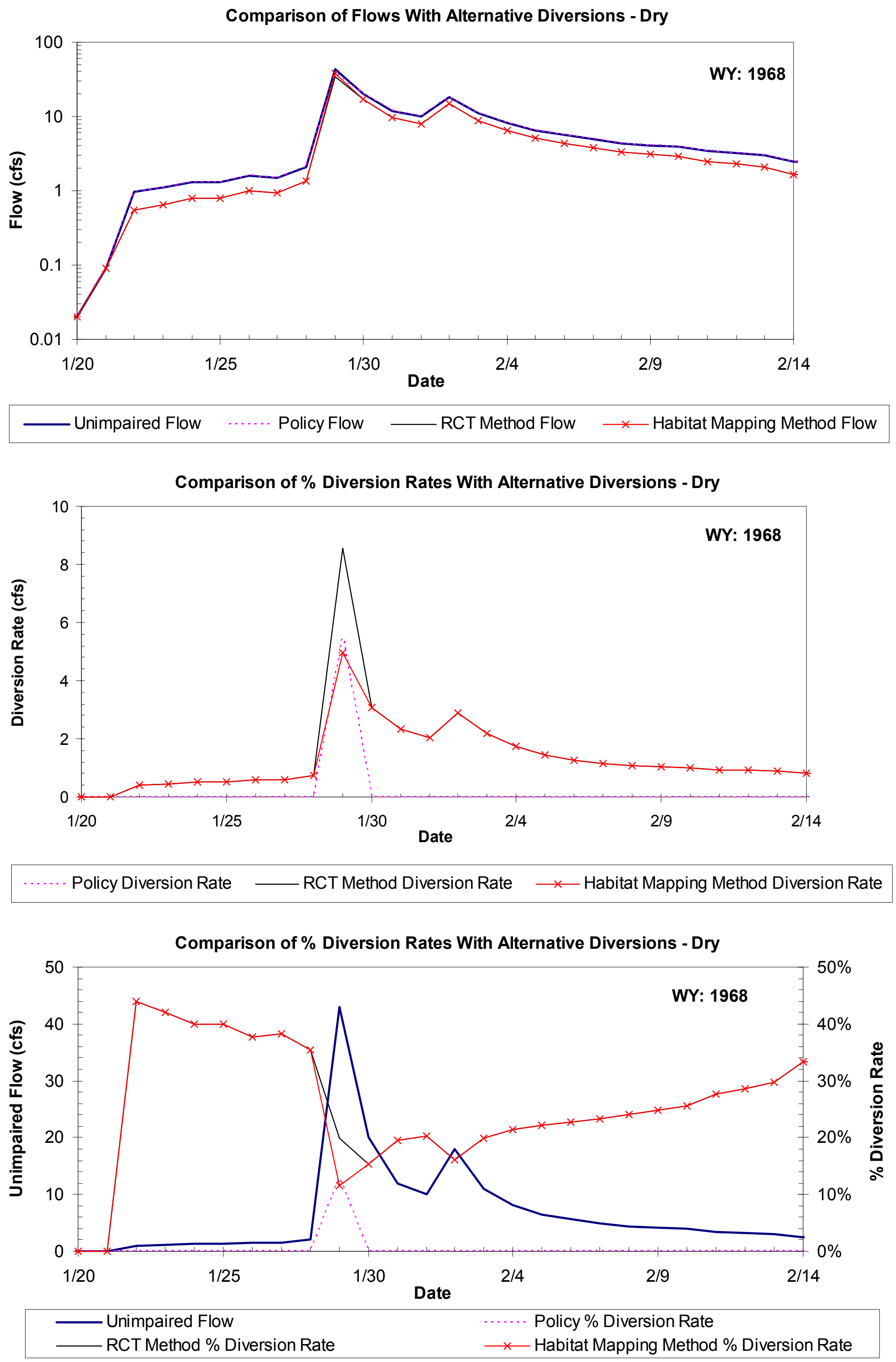
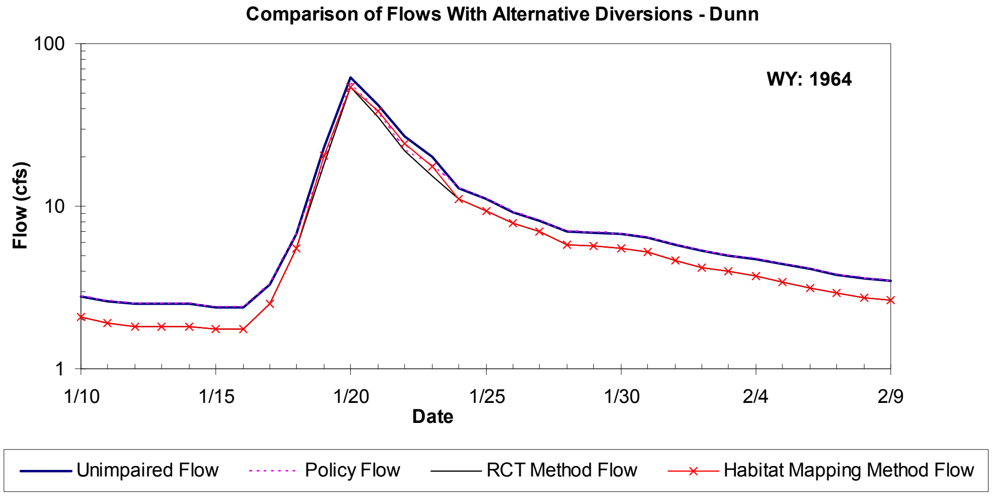
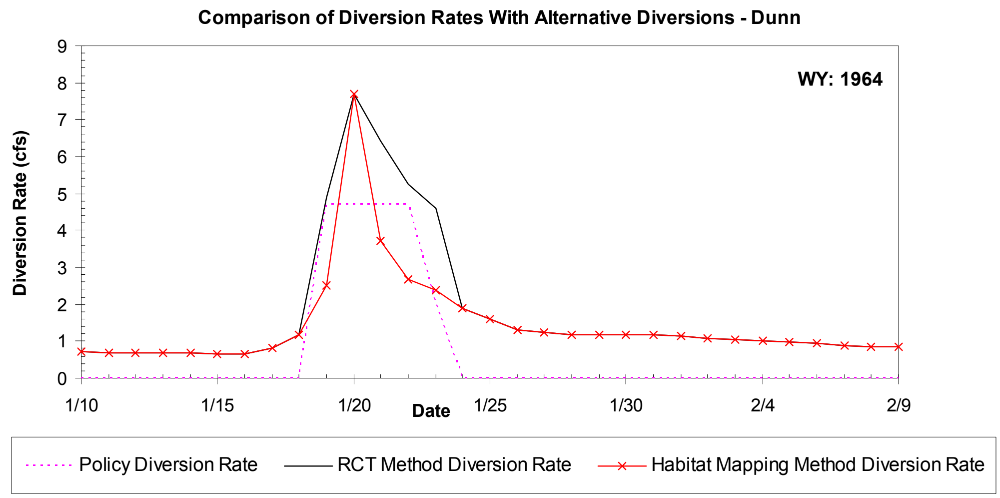


Figure A-14b. Another example application of the method proposed by TU/WB/ESH for calculating diversion rate during a high flow event in the Dry Creek validation site. Diversion rates and resulting impaired flows are calculated for the Policy and the two alternative spawning flow methods proposed by TU/WB/ESH.





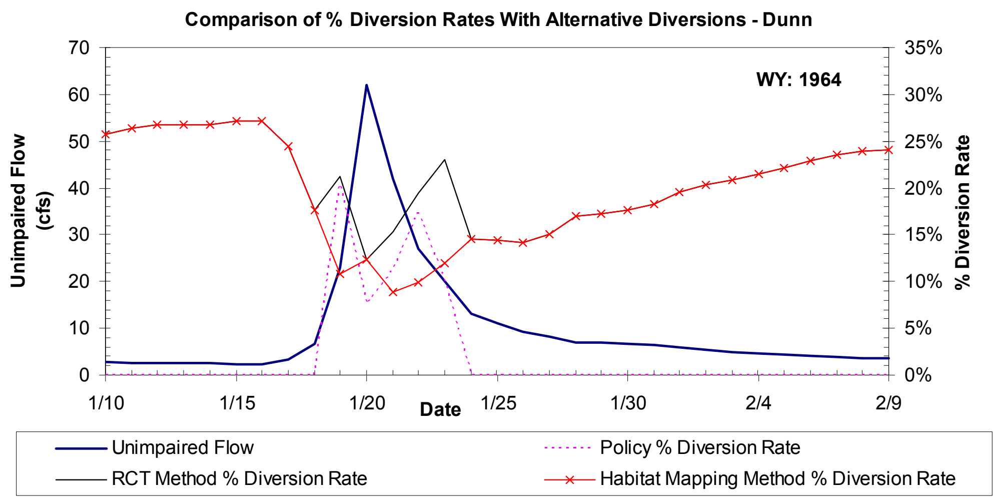


Figure A-15a. Example application of the method proposed by TU/WB/ESH for calculating diversion rate during a high flow event in the Dunn Creek validation site. Diversion rates and resulting impaired flows are calculated for the Policy and the two alternative spawning flow methods proposed by TU/WB/ESH.

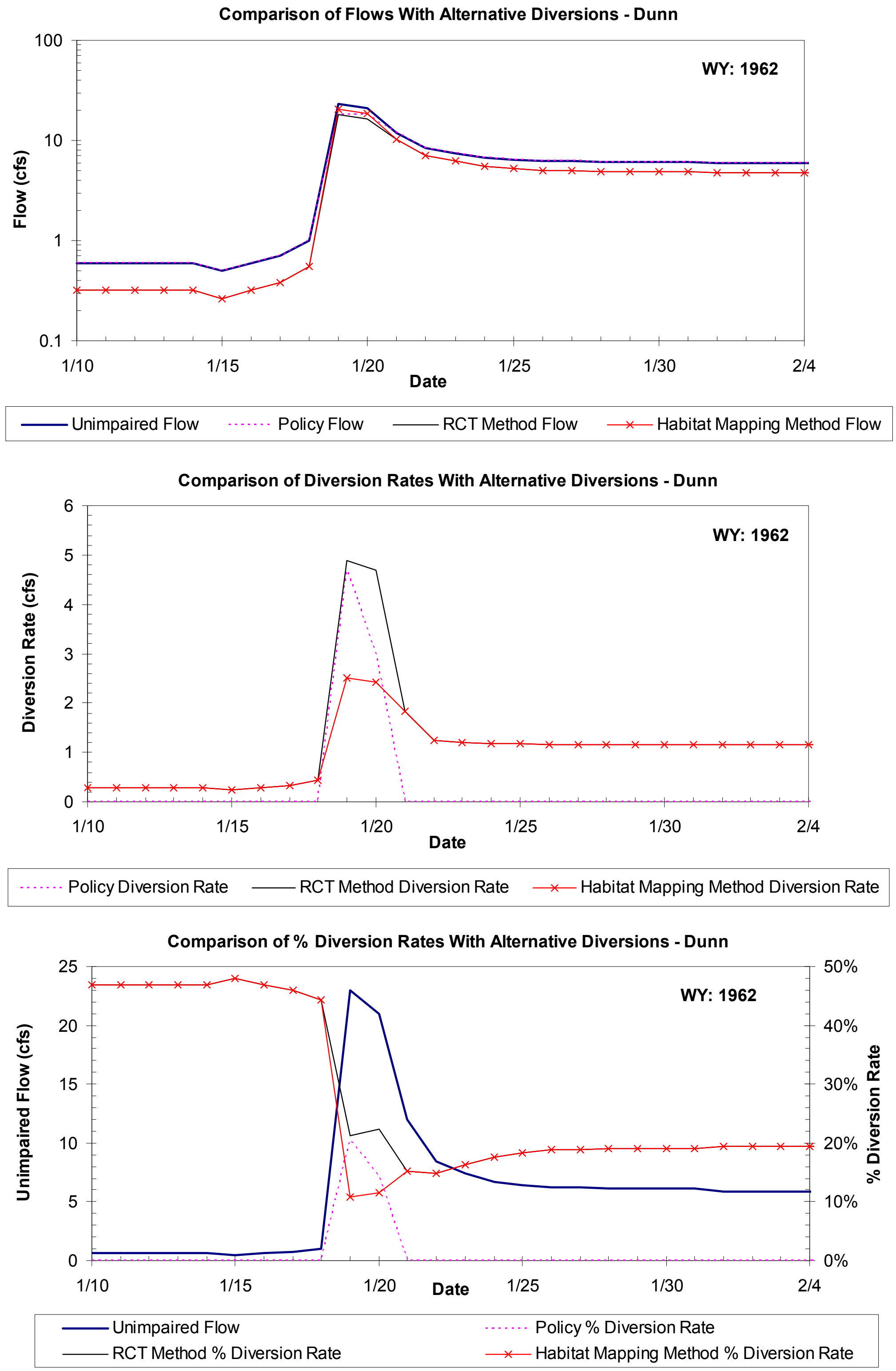
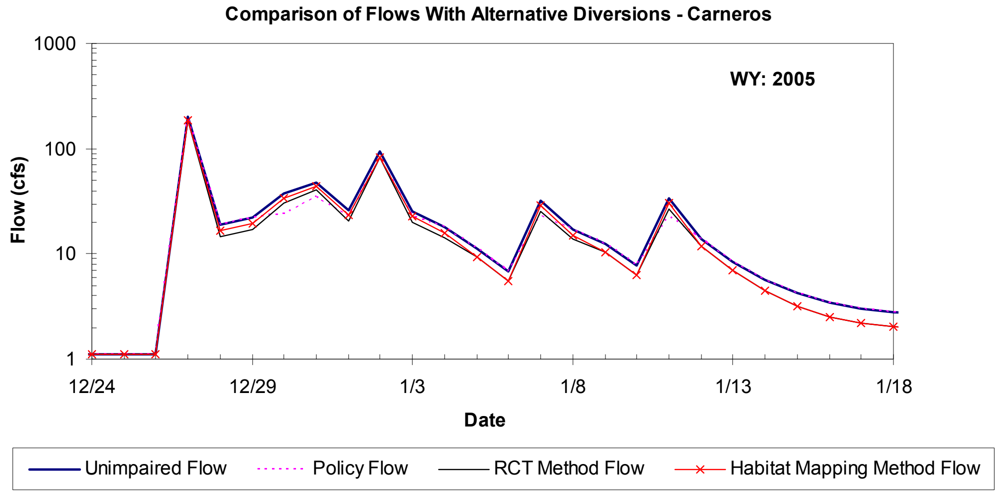
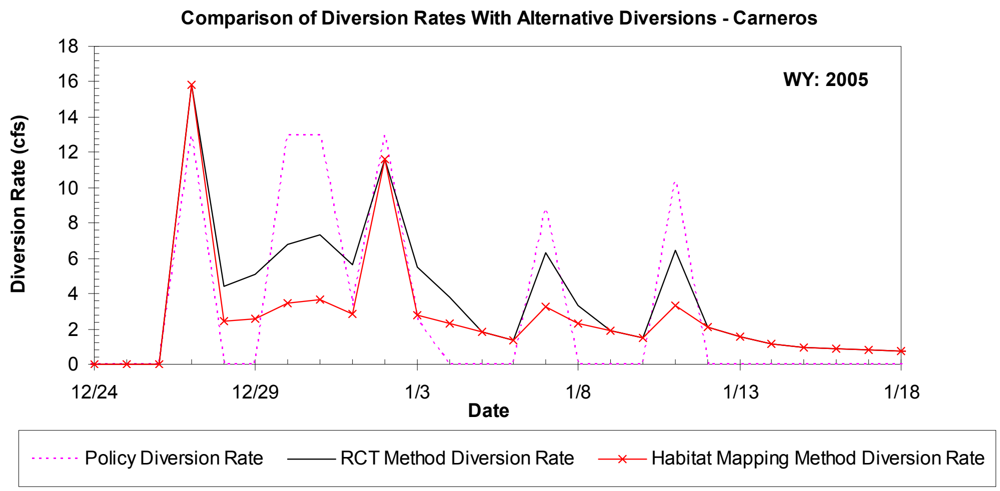


Figure A-15b. Another example application of the method proposed by TU/WB/ESH for calculating diversion rate during a high flow event in the Dunn Creek validation site. Diversion rates and resulting impaired flows are calculated for the Policy and the two alternative spawning flow methods proposed by TU/WB/ESH.





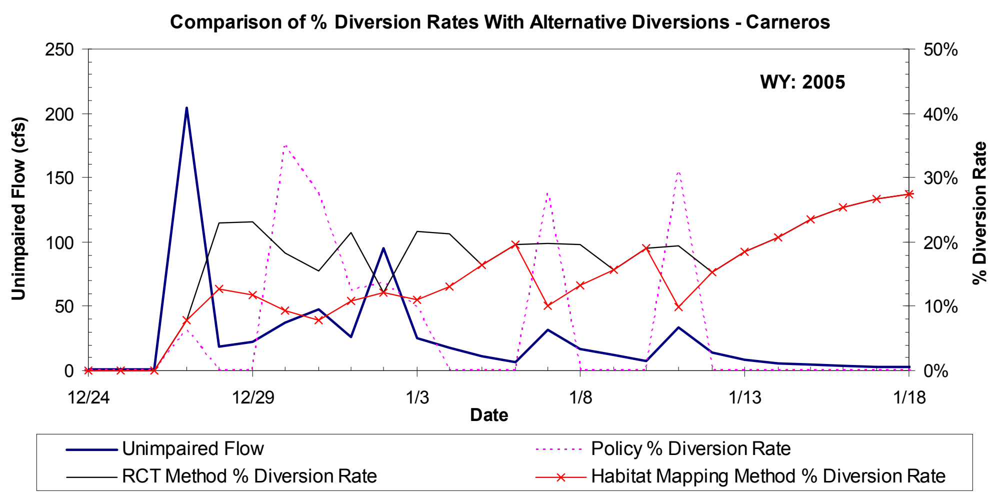
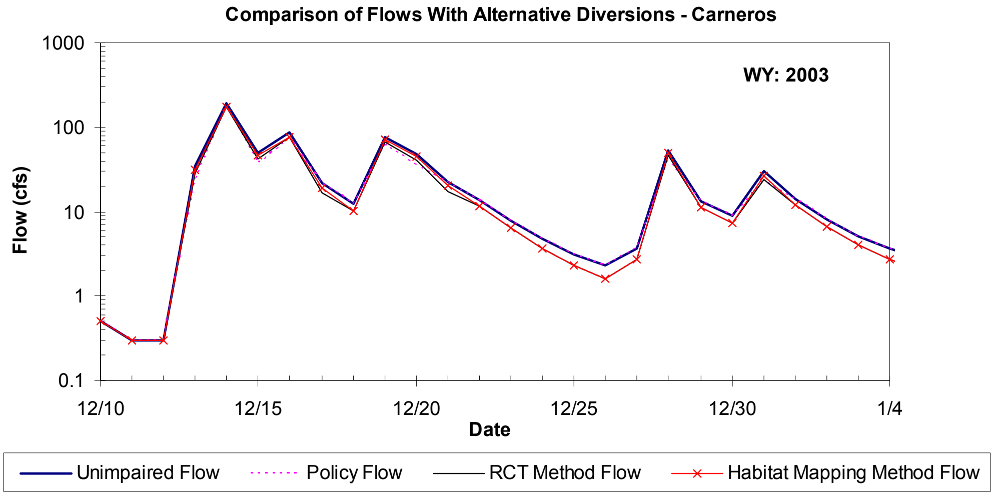
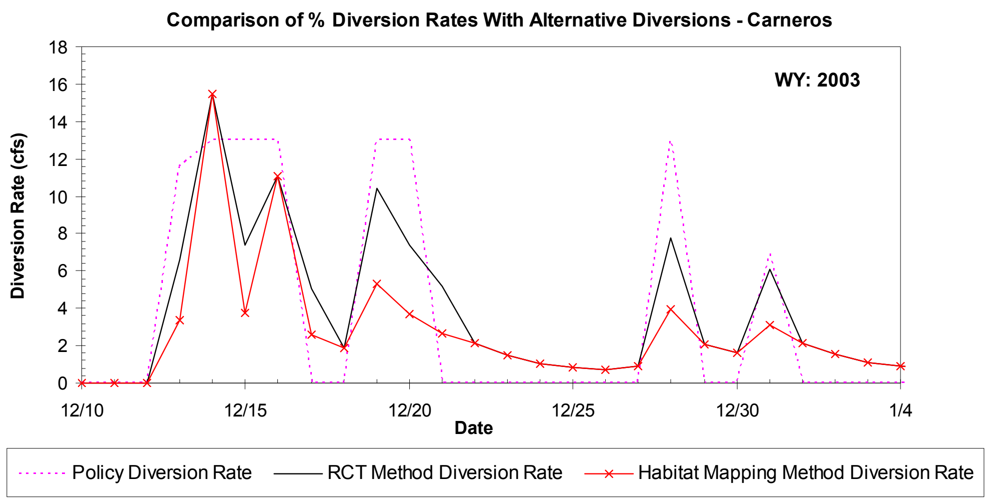


Figure A-16a. Example application of the method proposed by TU/WB/ESH for calculating diversion rate during a high flow event in the Carneros Creek validation site. Diversion rates and resulting impaired flows are calculated for the Policy and the two alternative spawning flow methods proposed by TU/WB/ESH.





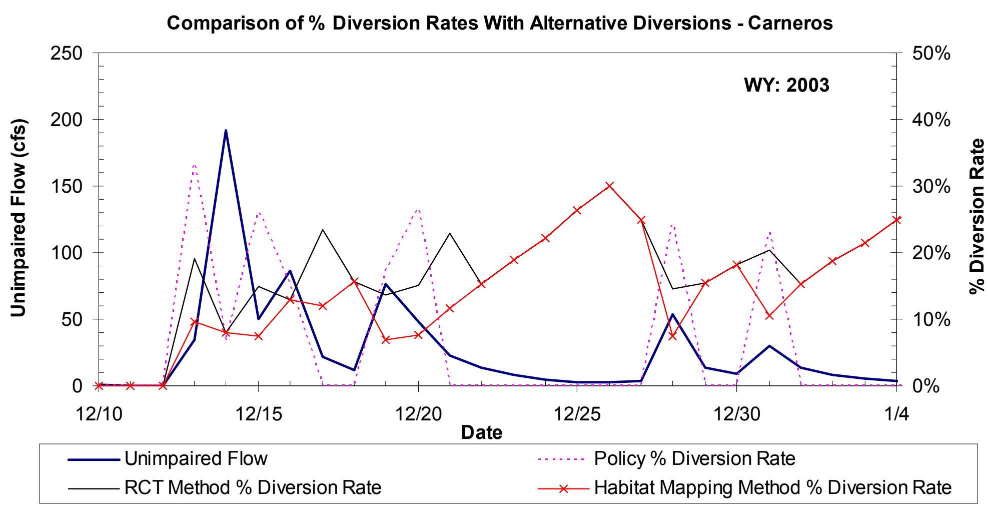


Figure A-16b. Another example application of the method proposed by TU/WB/ESH for calculating diversion rate during a high flow event in the Carneros Creek validation site. Diversion rates and resulting impaired flows are calculated for the Policy and the two alternative spawning flow methods proposed by TU/WB/ESH.

Figure A-17a. Example application of the method proposed by TU/WB/ESH for calculating diversion rate during a high flow event in the Huichica Creek validation site. Diversion rates and resulting impaired flows are calculated for the Policy and the two alternative spawning flow methods proposed by TU/WB/ESH.

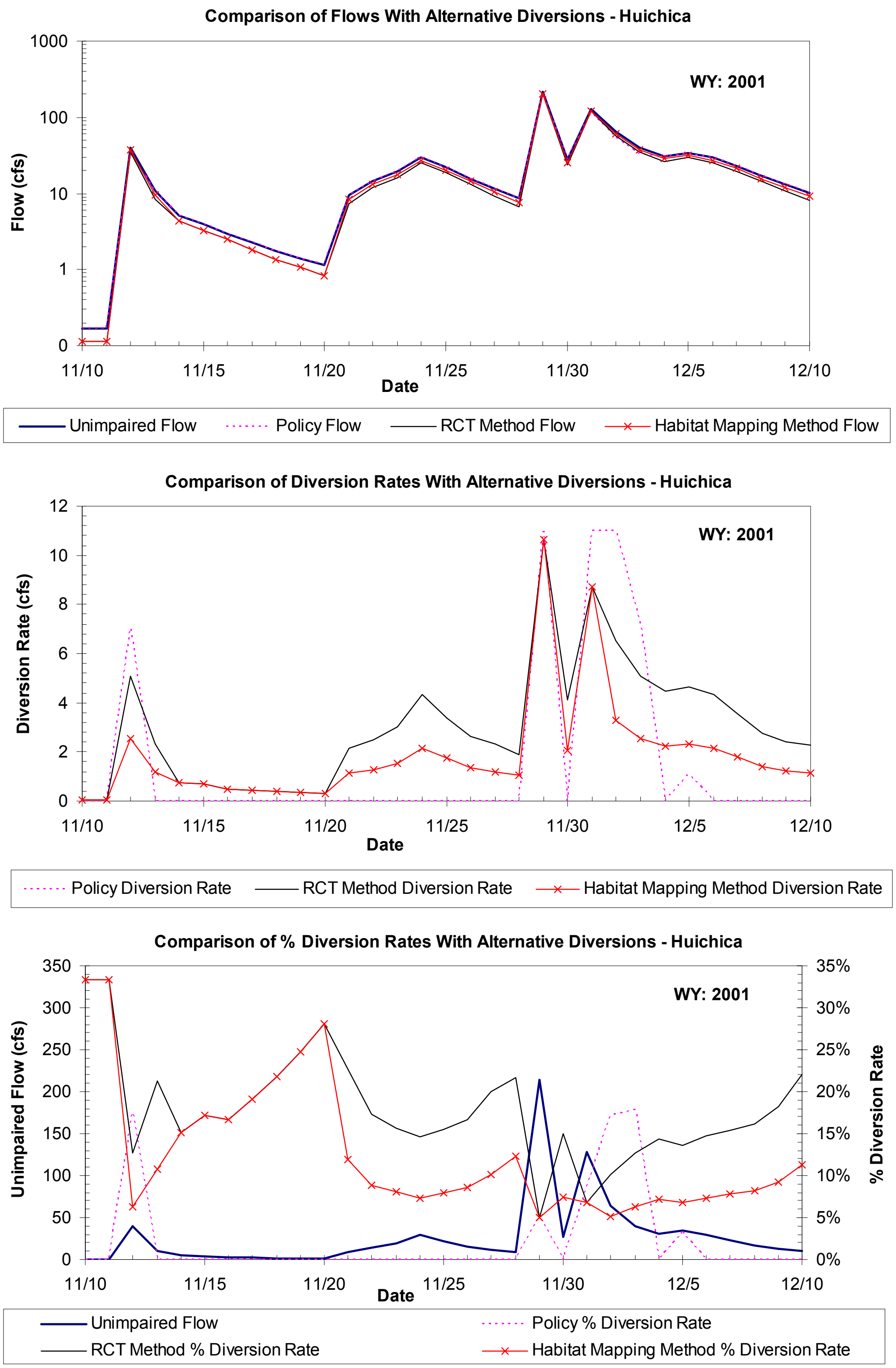


Figure A-17b. Another example application of the method proposed by TU/WB/ESH for calculating diversion rate during a high flow event in the Huichica Creek validation site. Diversion rates and resulting impaired flows are calculated for the Policy and the two alternative spawning flow methods proposed by TU/WB/ESH.

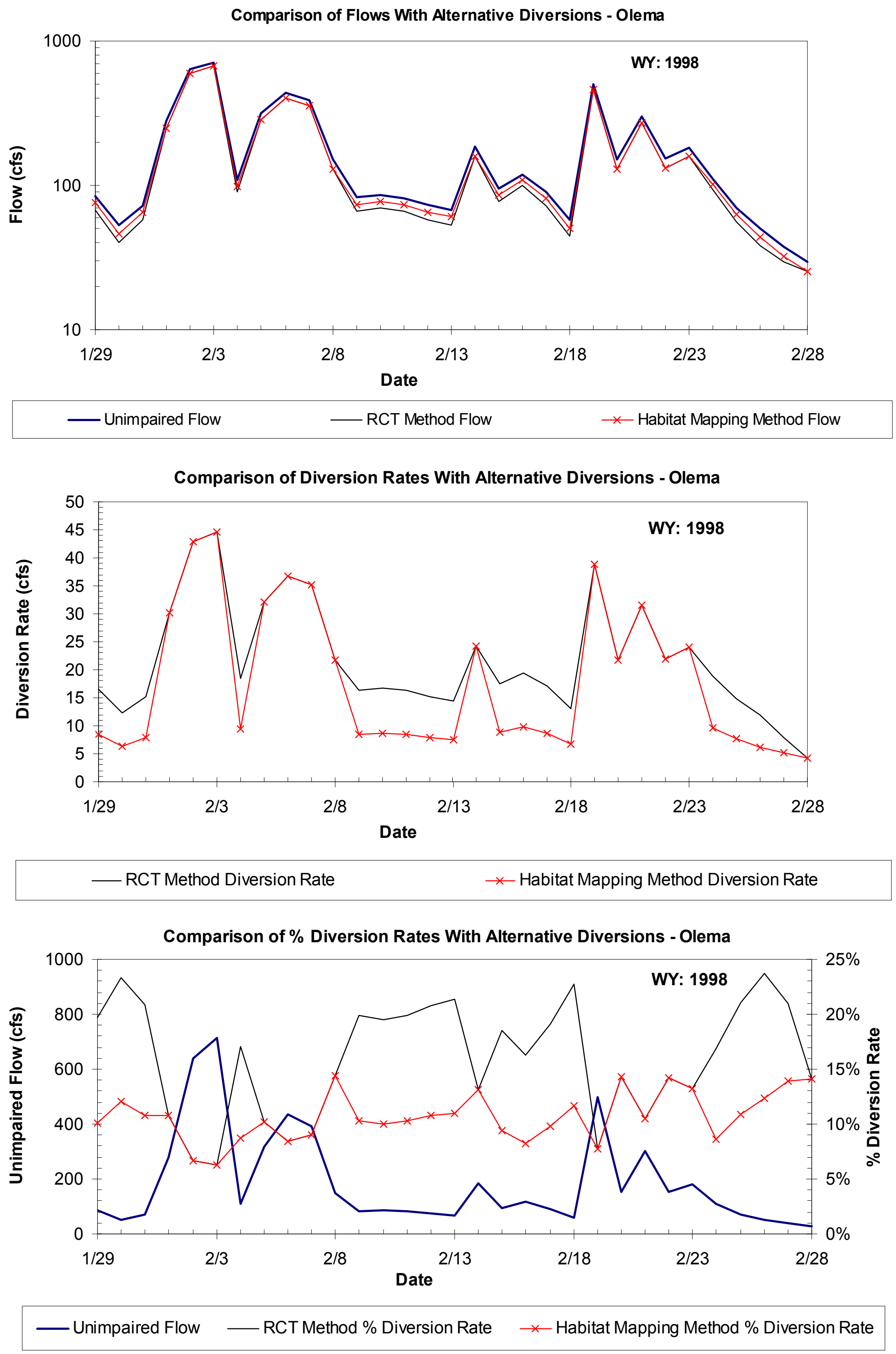


Figure A-18a. Example application of the method proposed by TU/WB/ESH for calculating diversion rate during a high flow event in the Olema Creek validation site. Diversion rates and resulting impaired flows are calculated for the two alternative spawning flow methods proposed by TU/WB/ESH.

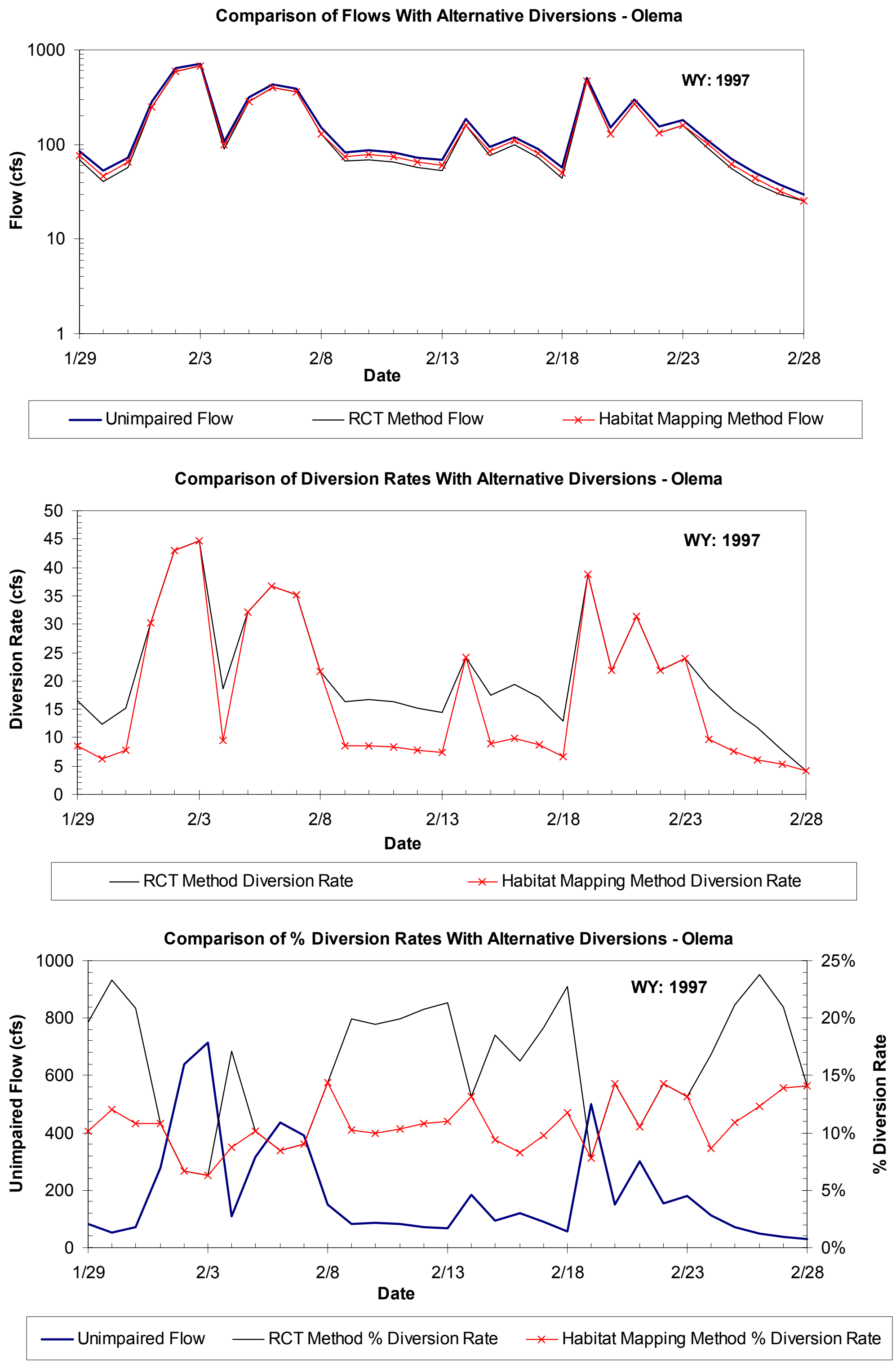


Figure A-18b. Another example application of the method proposed by TU/WB/ESH for calculating diversion rate during a high flow event in the Olema Creek validation site. Diversion rates and resulting impaired flows are calculated for the two alternative spawning flow methods proposed by TU/WB/ESH.

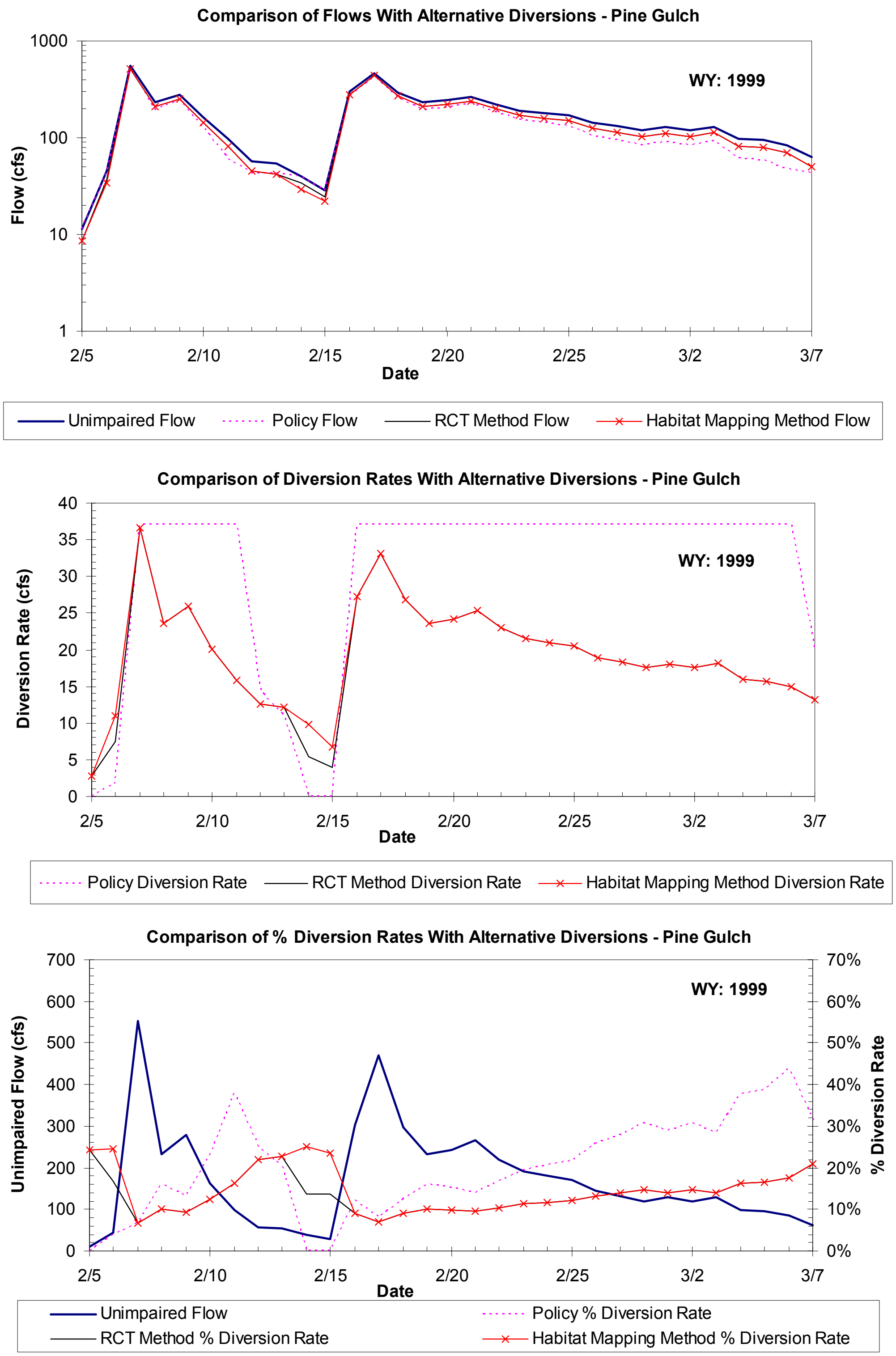
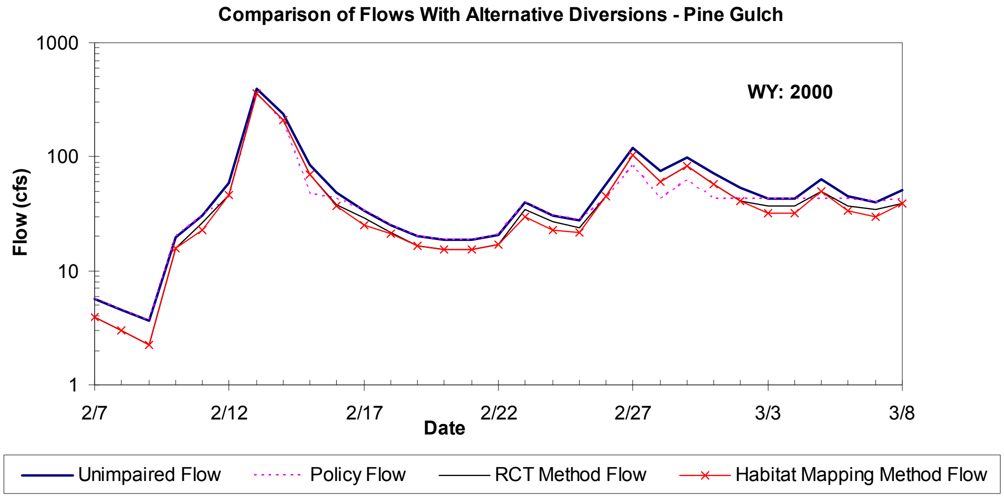
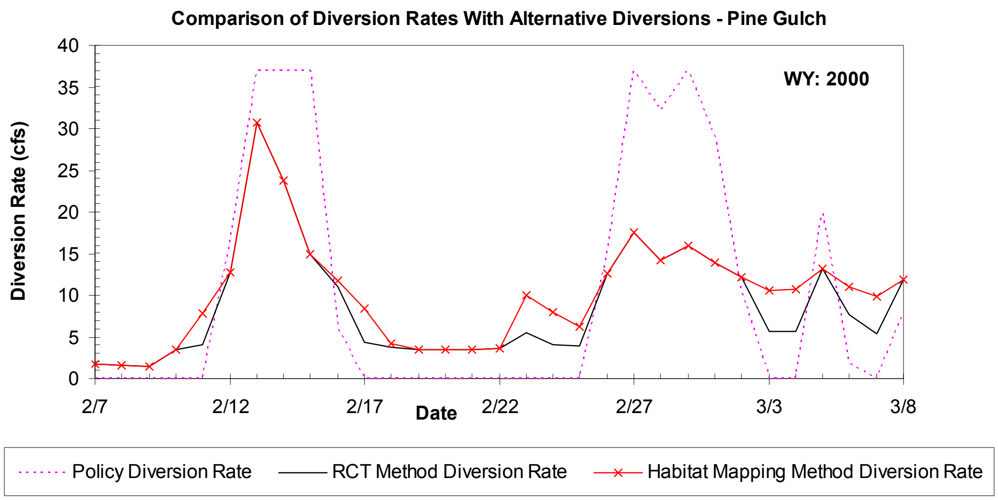


Figure A-19a. Example application of the method proposed by TU/WB/ESH for calculating diversion rate during a high flow event in the Pine Gulch Creek validation site. Diversion rates and resulting impaired flows are calculated for the Policy and the two alternative spawning flow methods proposed by TU/WB/ESH.





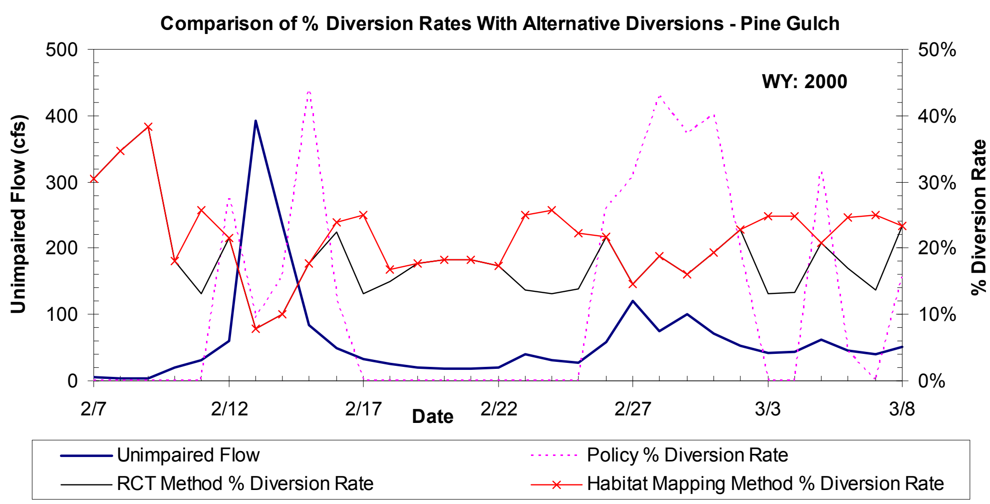


Figure A-19b. Another example application of the method proposed by TU/WB/ESH for calculating diversion rate during a high flow event in the Pine Gulch Creek validation site. Diversion rates and resulting impaired flows are calculated for the Policy and the two alternative spawning flow methods proposed by TU/WB/ESH.

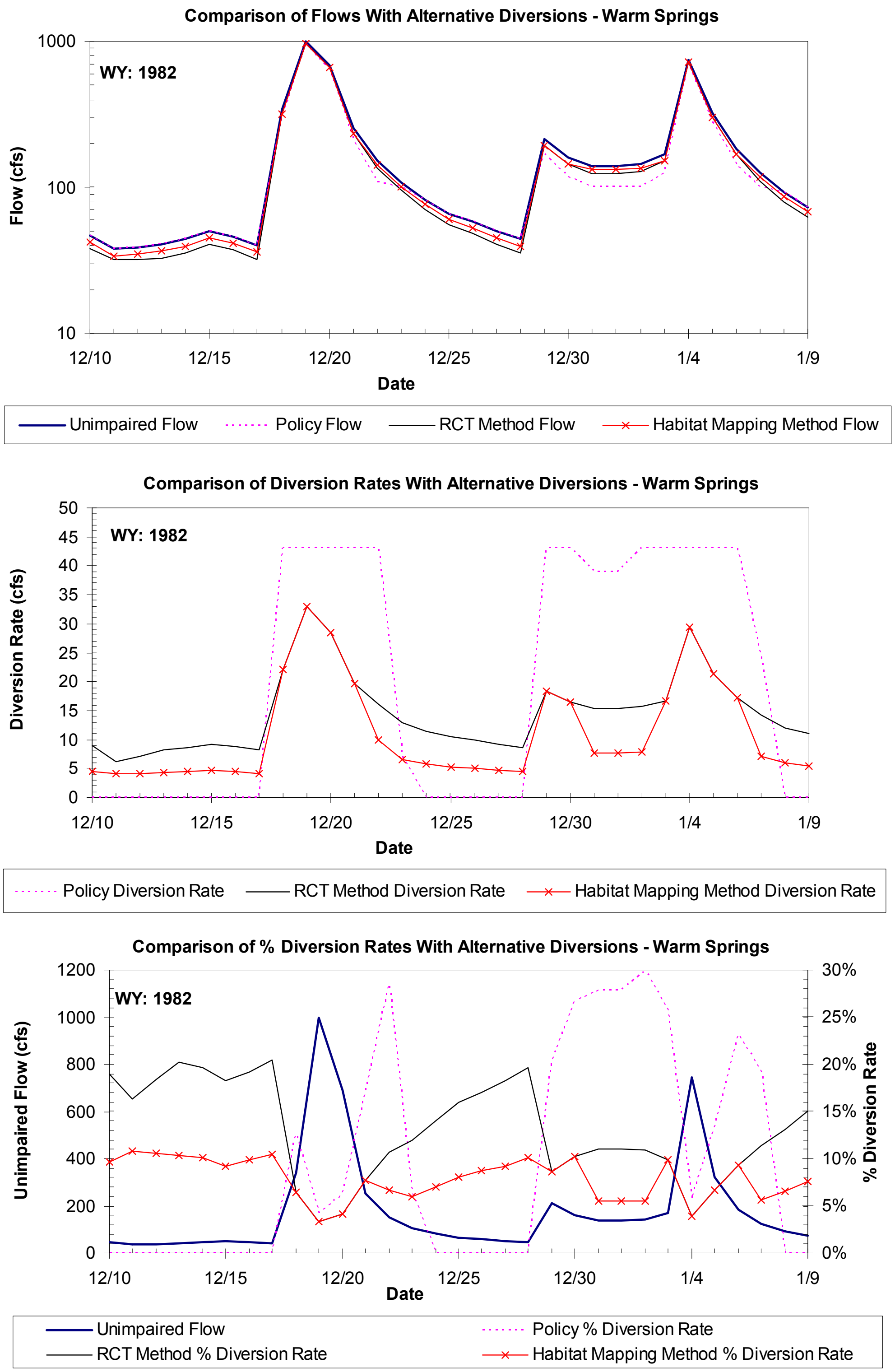
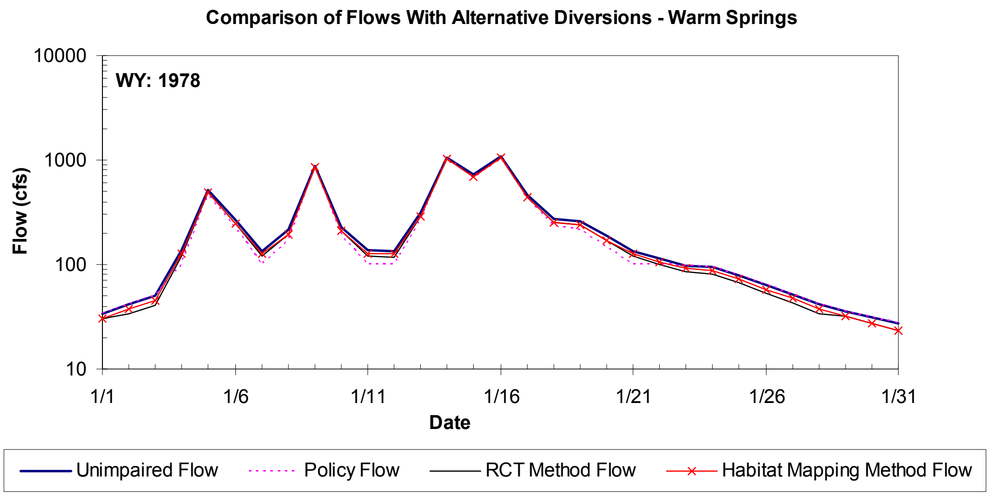
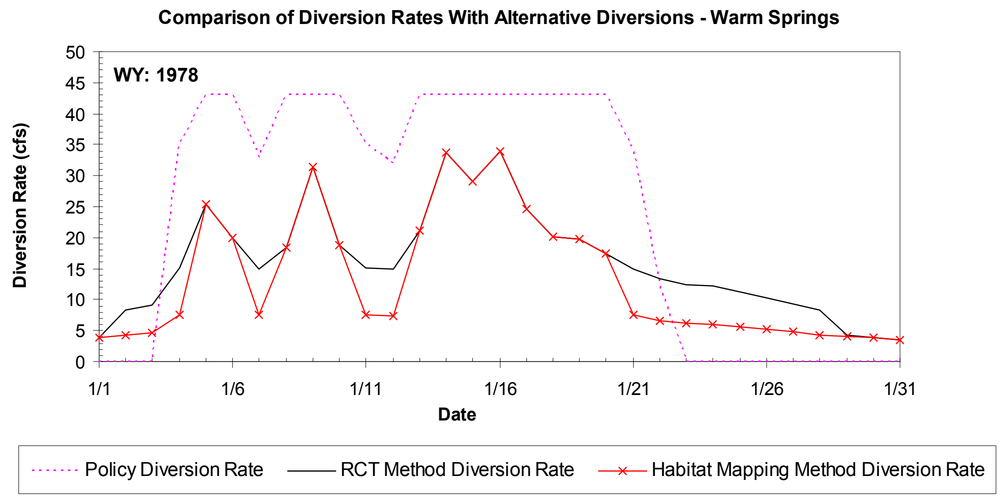


Figure A-20a. Example application of the method proposed by TU/WB/ESH for calculating diversion rate during a high flow event in the Warm Springs Creek validation site. Diversion rates and resulting impaired flows are calculated for the Policy and the two alternative spawning flow methods proposed by TU/WB/ESH.





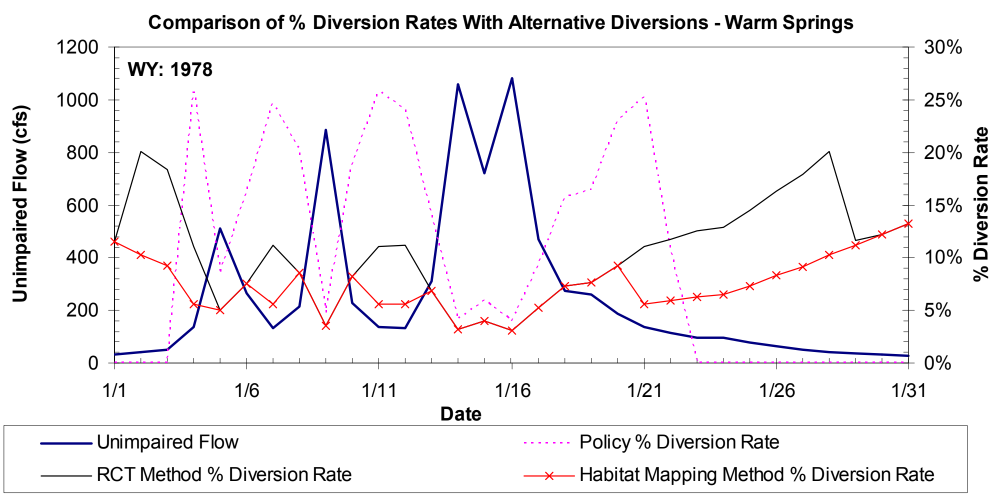


Figure A-20b. Another example application of the method proposed by TU/WB/ESH for calculating diversion rate during a high flow event in the Warm Springs Creek validation site. Diversion rates and resulting impaired flows are calculated for the Policy and the two alternative spawning flow methods proposed by TU/WB/ESH.

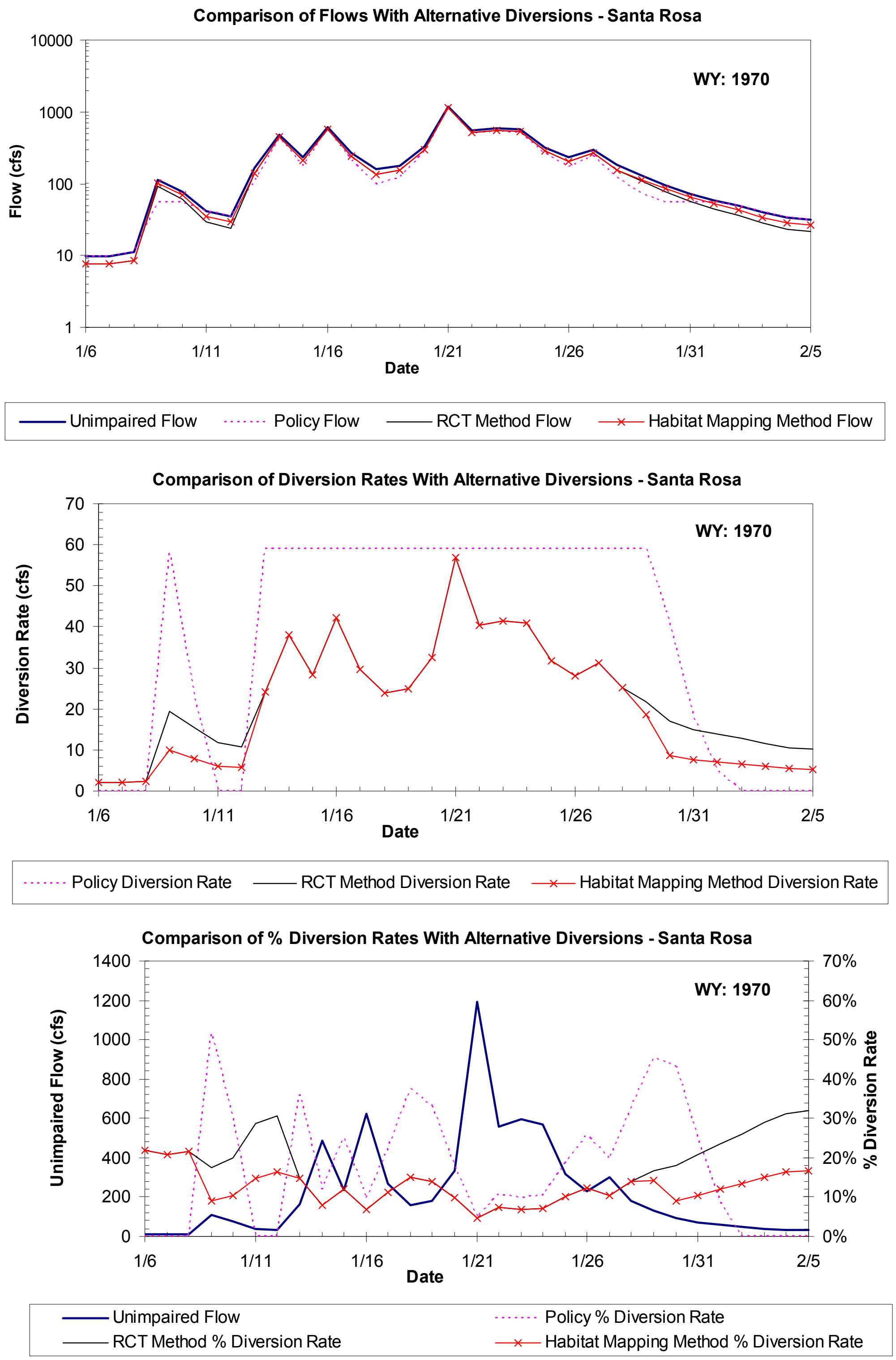


Figure A-21a. Example application of the method proposed by TU/WB/ESH for calculating diversion rate during a high flow event in the Santa Rosa Creek validation site. Diversion rates and resulting impaired flows are calculated for the Policy and the two alternative spawning flow methods proposed by TU/WB/ESH.

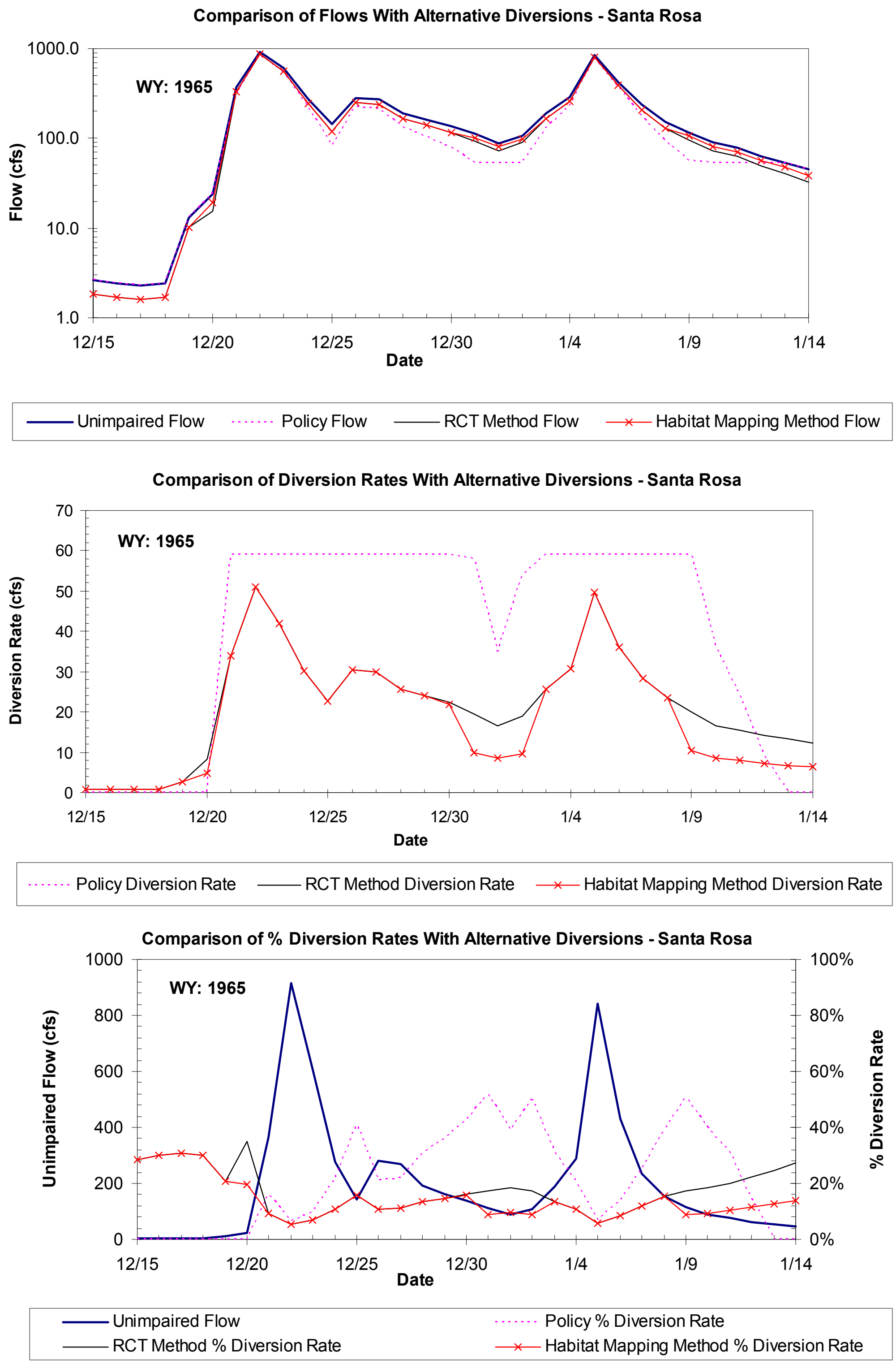


Figure A-21b. Another example application of the method proposed by TU/WB/ESH for calculating diversion rate during a high flow event in the Santa Rosa Creek validation site. Diversion rates and resulting impaired flows are calculated for the Policy and the two alternative spawning flow methods proposed by TU/WB/ESH.

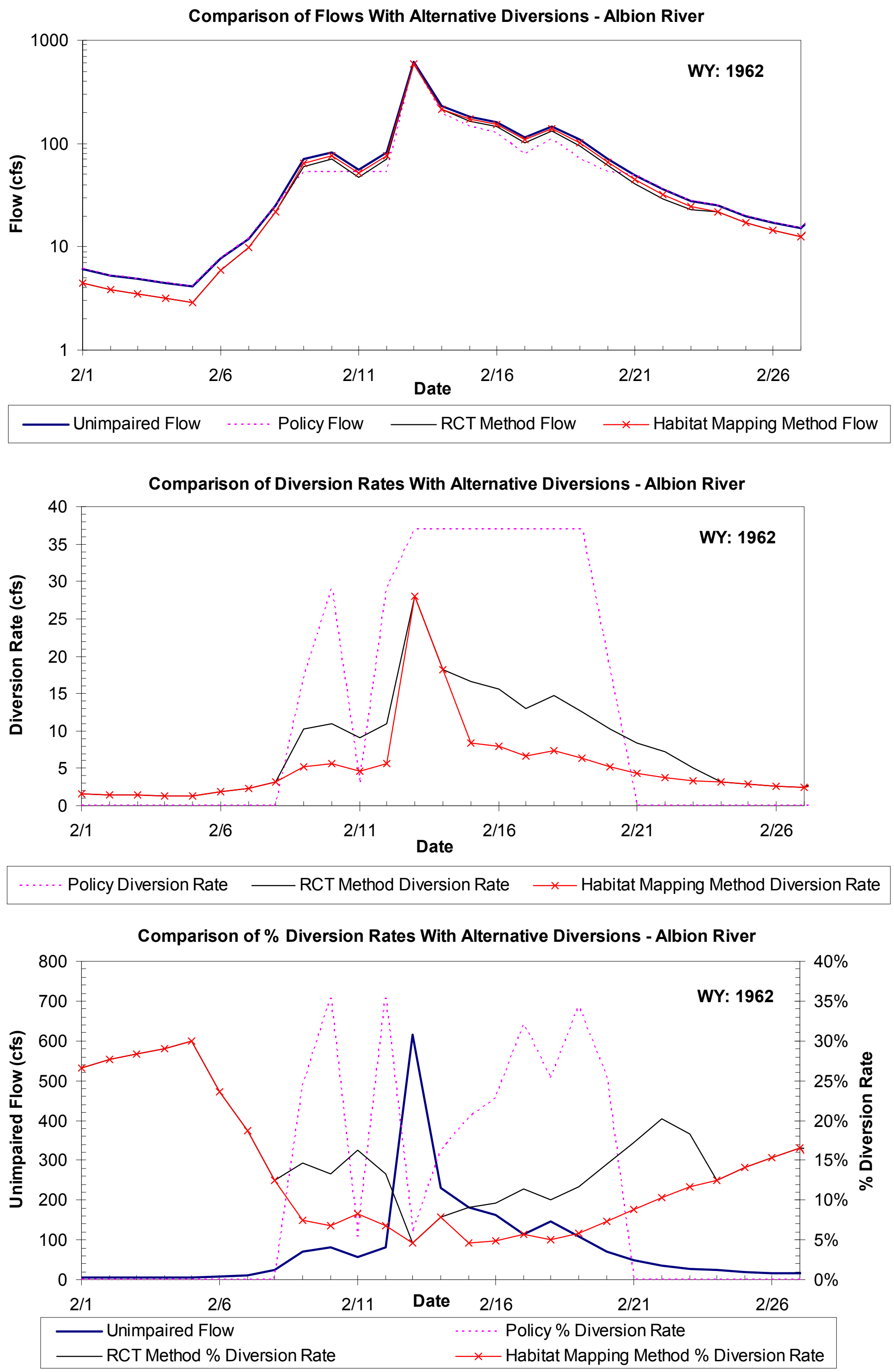
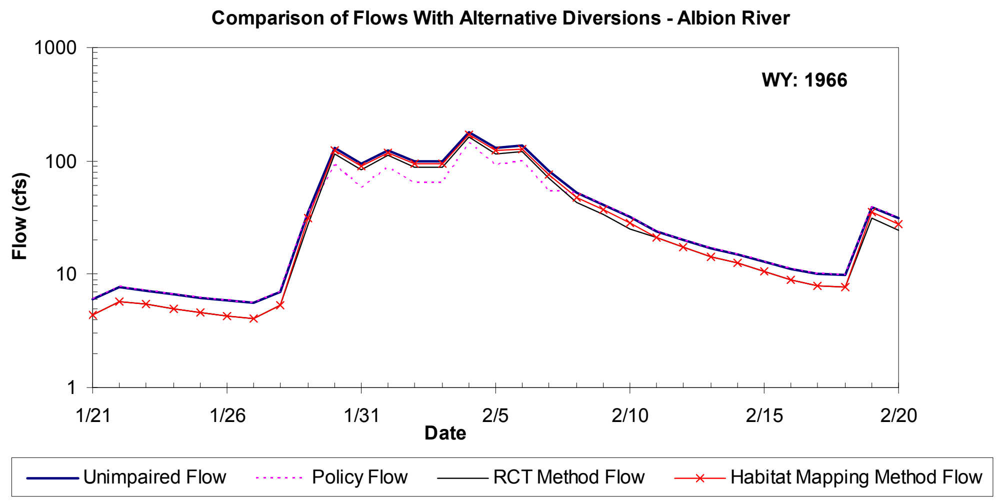
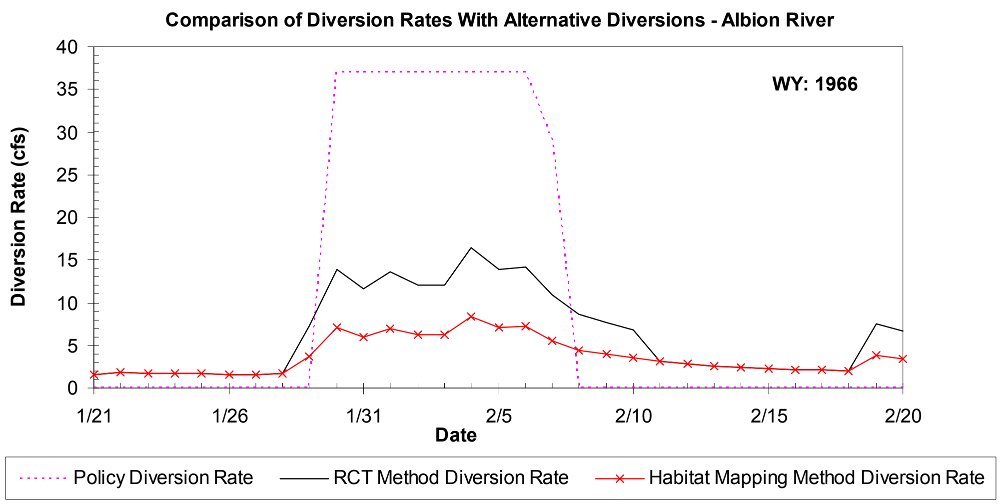


Figure A-22a. Example application of the method proposed by TU/WB/ESH for calculating diversion rate during a high flow event in the Albion River validation site. Diversion rates and resulting impaired flows are calculated for the Policy and the two alternative spawning flow methods proposed by TU/WB/ESH.





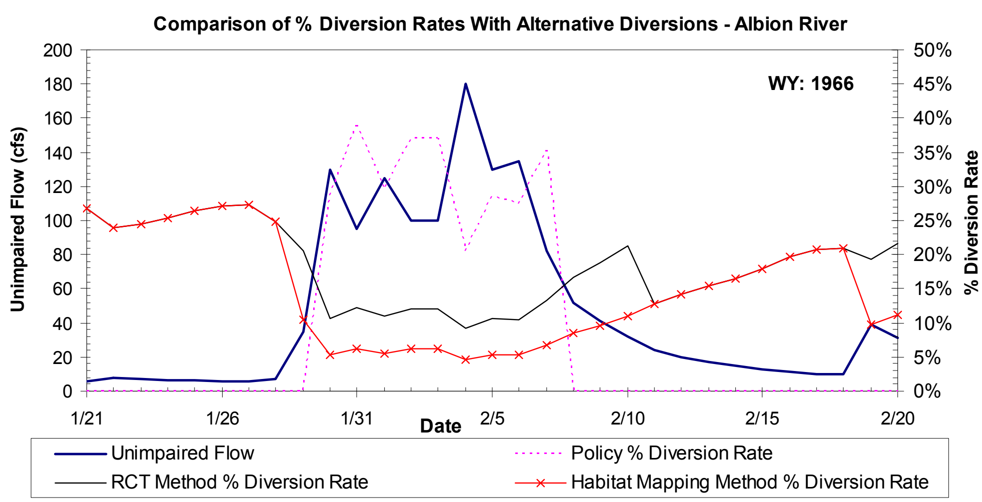


Figure A-22b. Another example application of the method proposed by TU/WB/ESH for calculating diversion rate during a high flow event in the Albion River validation site. Diversion rates and resulting impaired flows are calculated for the Policy and the two alternative spawning flow methods proposed by TU/WB/ESH.

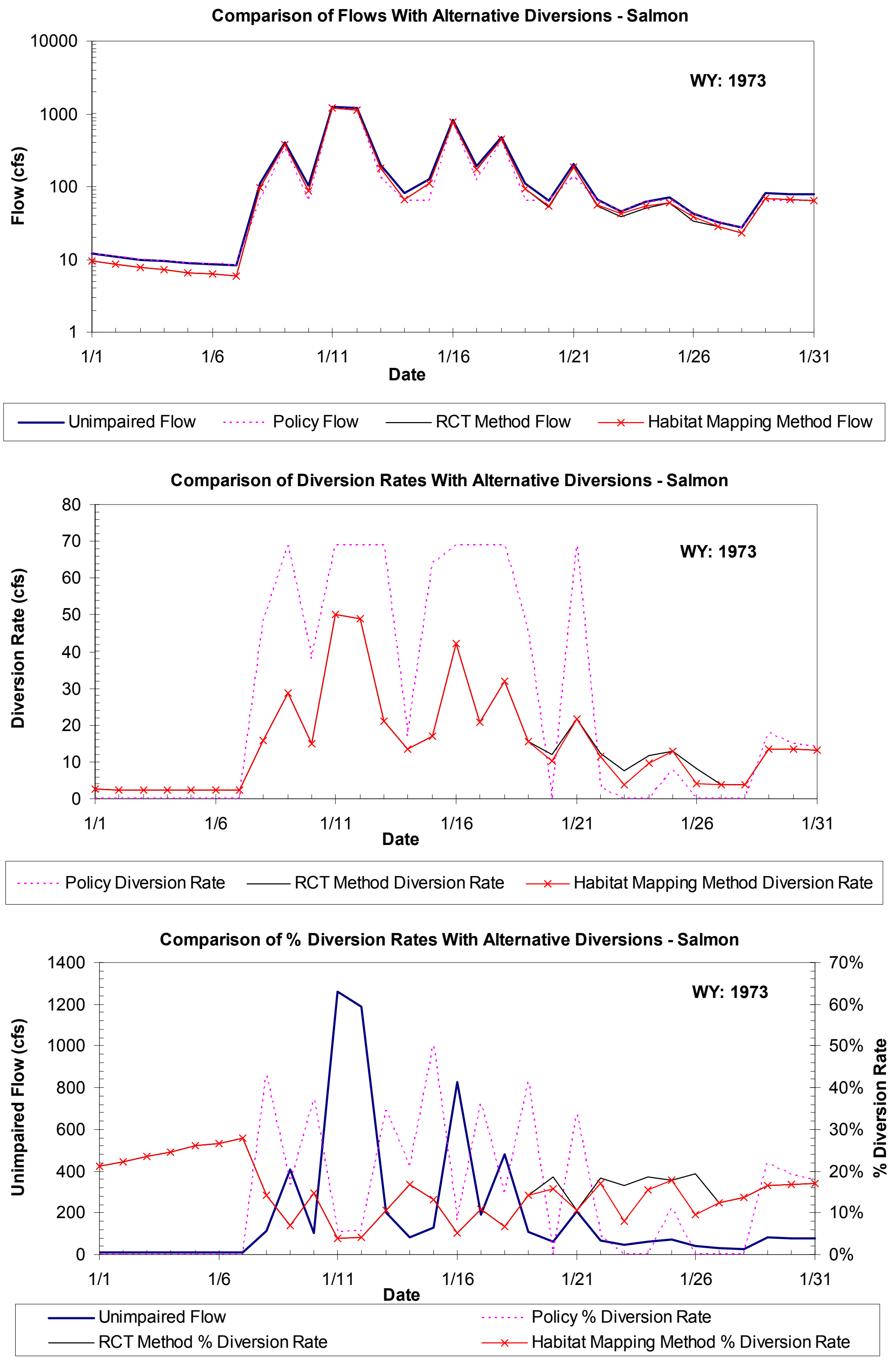


Figure A-23a. Example application of the method proposed by TU/WB/ESH for calculating diversion rate during a high flow event in the Salmon Creek validation site. Diversion rates and resulting impaired flows are calculated for the Policy and the two alternative spawning flow methods proposed by TU/WB/ESH.

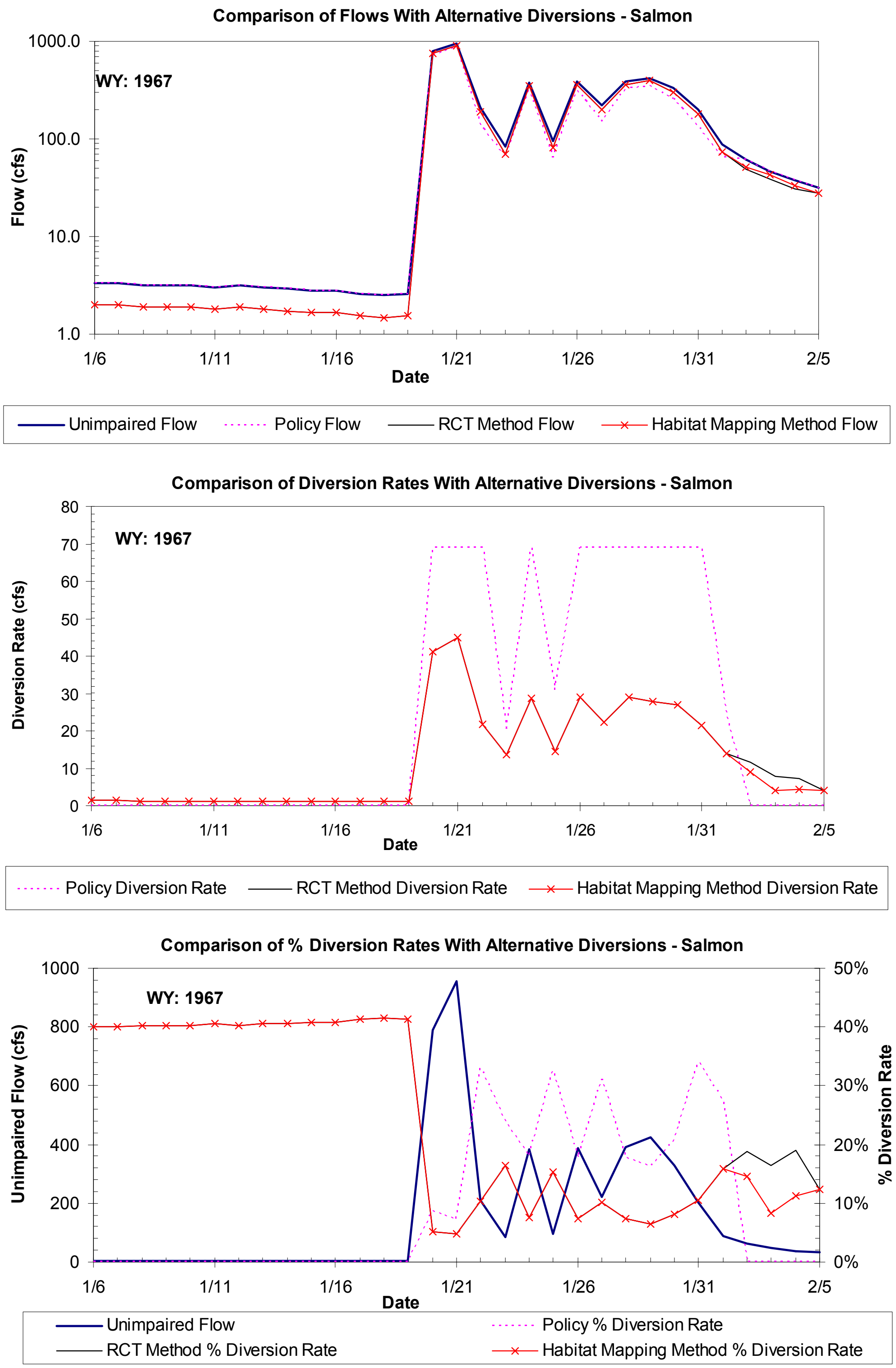


Figure A-23b. Another example application of the method proposed by TU/WB/ESH for calculating diversion rate during a high flow event in the Salmon Creek validation site. Diversion rates and resulting impaired flows are calculated for the Policy and the two alternative spawning flow methods proposed by TU/WB/ESH.

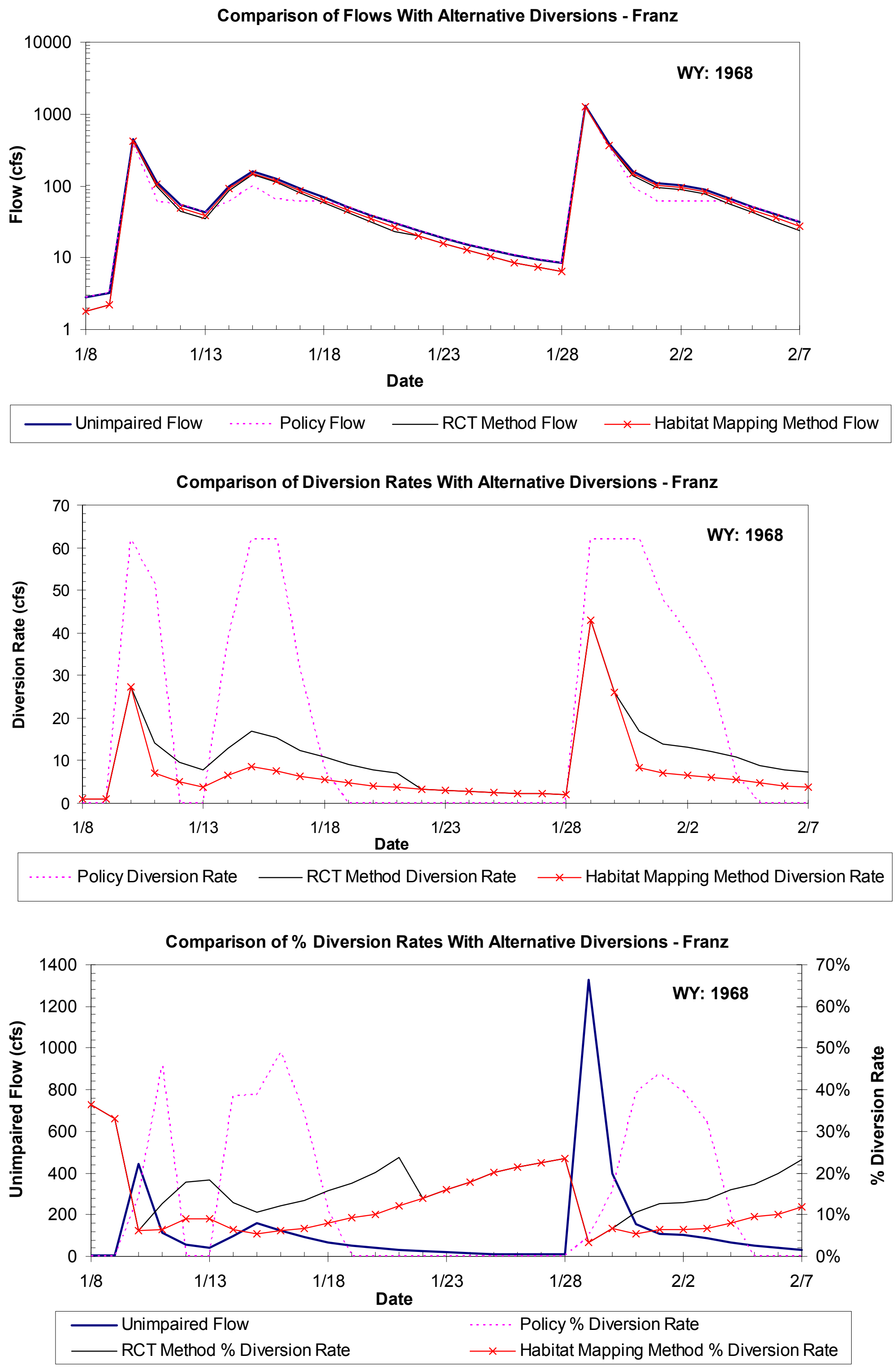


Figure A-24a. Example application of the method proposed by TU/WB/ESH for calculating diversion rate during a high flow event in the Franz Creek validation site. Diversion rates and resulting impaired flows are calculated for the Policy and the two alternative spawning flow methods proposed by TU/WB/ESH.

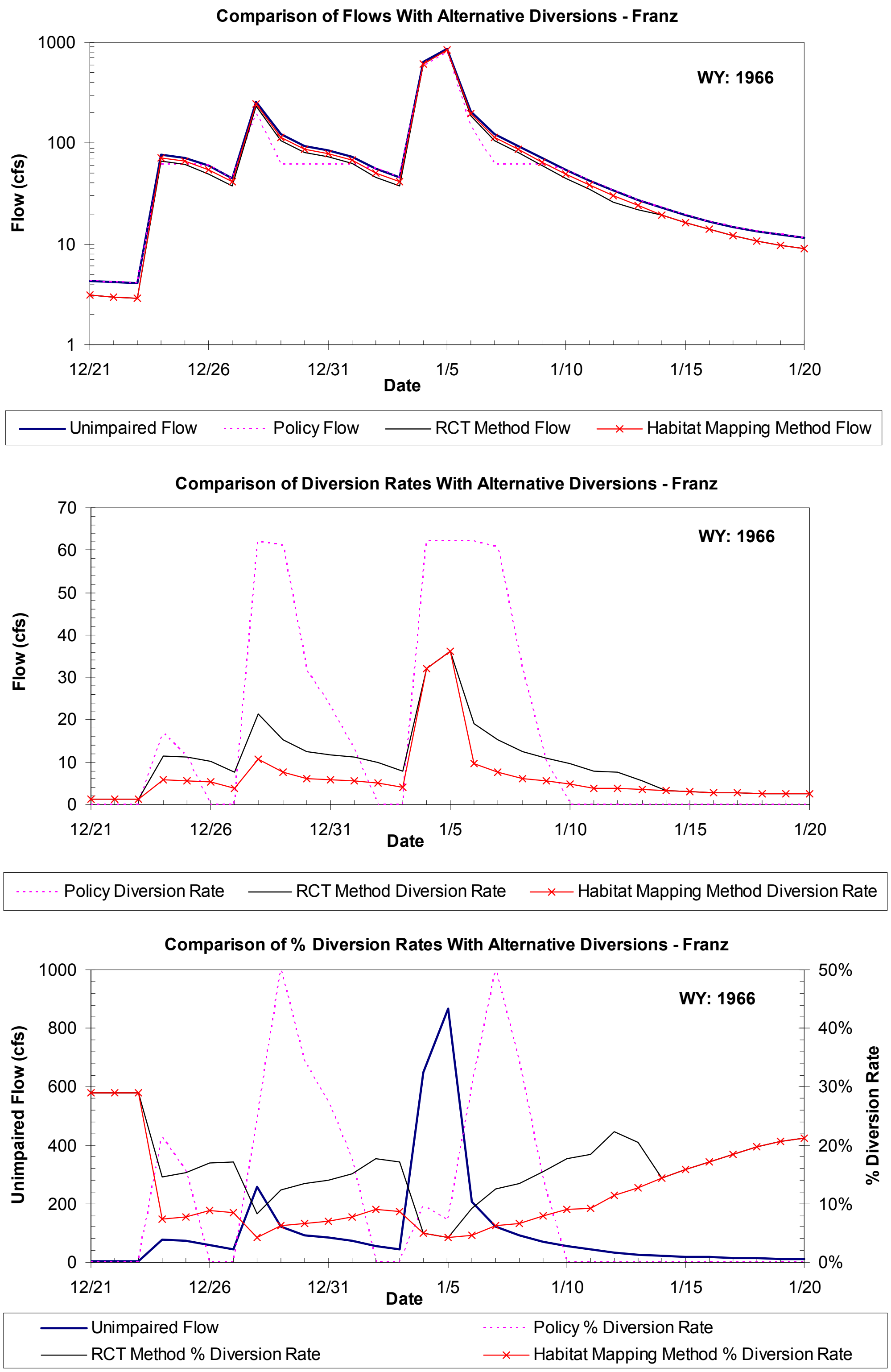


Figure A-24b. Another example application of the method proposed by TU/WB/ESH for calculating diversion rate during a high flow event in the Franz Creek validation site. Diversion rates and resulting impaired flows are calculated for the Policy and the two alternative spawning flow methods proposed by TU/WB/ESH.

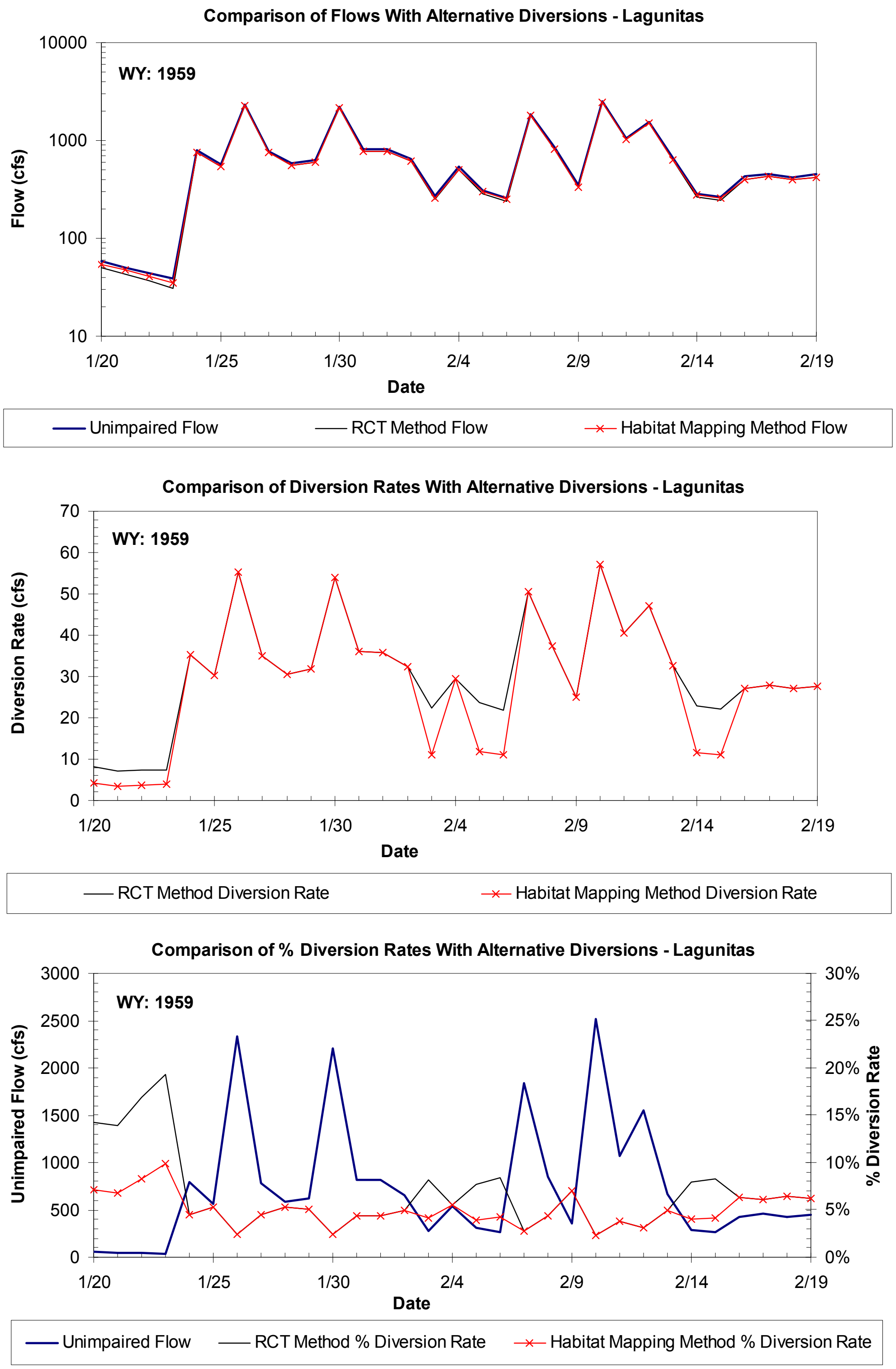


Figure A-25a. Example application of the method proposed by TU/WB/ESH for calculating diversion rate during a high flow event in the Lagunitas Creek validation site. Diversion rates and resulting impaired flows are calculated for the two alternative spawning flow methods proposed by TU/WB/ESH.

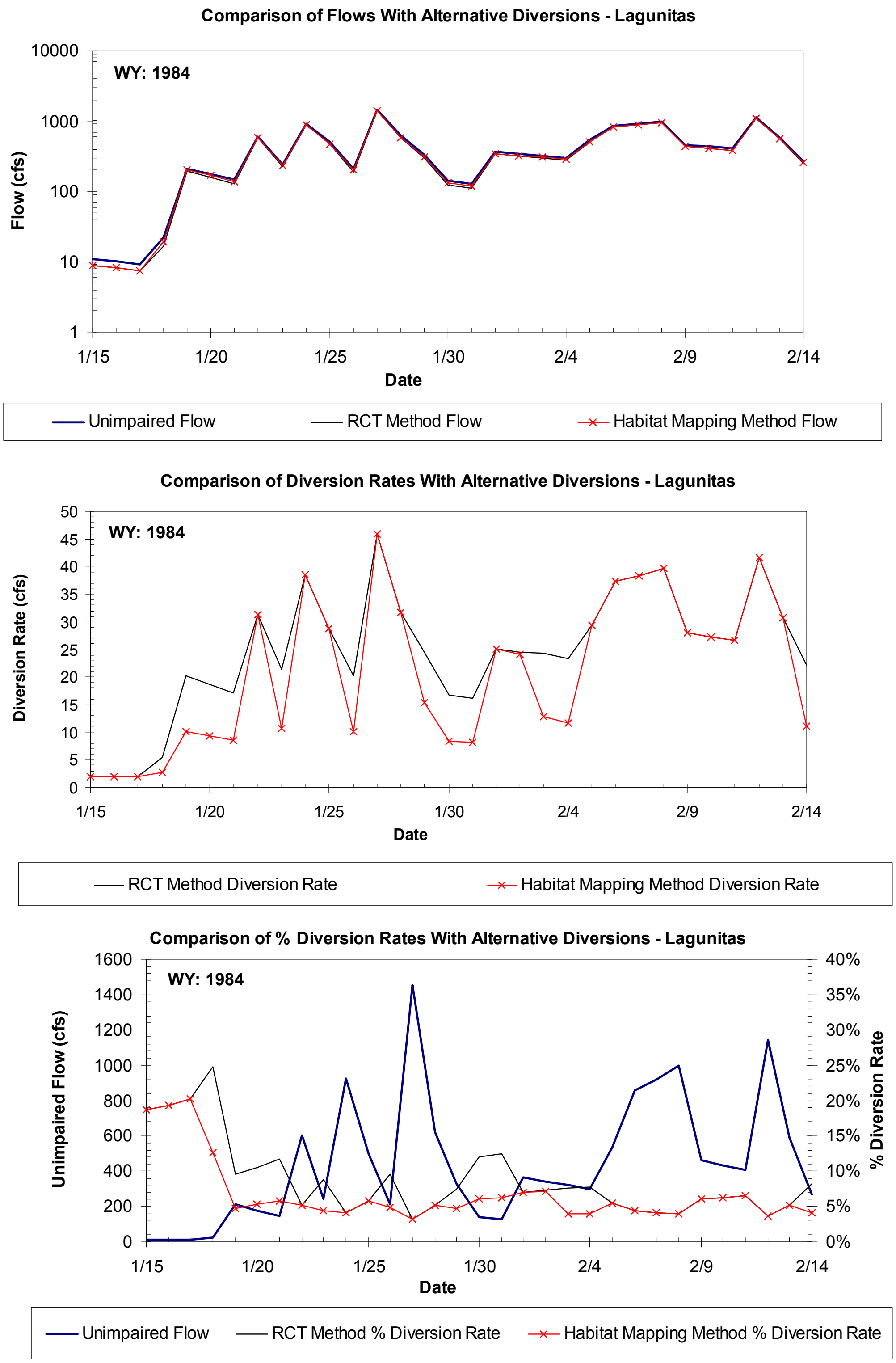


Figure A-25b. Another example application of the method proposed by TU/WB/ESH for calculating diversion rate during a high flow event in the Lagunitas Creek validation site. Diversion rates and resulting impaired flows are calculated for the two alternative spawning flow methods proposed by TU/WB/ESH.