basically when the existing agreements or FERC requirements run up against those reservoir constraints, and then that determines what sort of impact occurs in the modelling versus some other sort of fixed rule, for example?

WILL ANDERSON: And the short answer is yes, that the shortage to the diversion demand is a function of water availability both from storage as defined by the storage parameters and the amount of available inflow. And in the case of the unimpaired flow alternatives, there is that portion of -- the portion of inflow is reserved for instream use, and the remainder would be available for diversion. So there is the two components -- the available from inflow for the growing season and the available from the storage at March 1st.

BARBARA: And then, I guess, one -- and this is maybe in the modelling. So you mentioned earlier that looking at one of those confluence gauges, for example, that is where the current compliance point is. So let's say you saw 100 CFS there. The unimpaired flow, however that is measured, was, you know, 80 CFS, and you have got 20 CFS of inflow. Does the modelling account for the fact that, say, 20 CFS of inflow is sort of a freebie

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from runoff, and so it is sort of not pulled out of the reservoir? Is that dynamic included in sort of the storage outputs?

WILL ANDERSON: Yes. For the alternatives --

BARBARA: So that is all built into the system?

WILL ANDERSON: Additional water would not be released to exceed the flow requirement.

BARBARA: Okay. Perfect.

WILL ANDERSON: So if you look at how much is downstream, then additional release would not be required if that is met by those flows.

BARBARA: Okay.

UNIDENTIFIED SPEAKER: One sort of similar question but upstream, when you are calculating the inflow -- you talked about inflow to Rim dams and unimpaired flow in your unimpaired flow calculation. That accounts for water that is captured upstream in other reservoirs; is that correct?

WILL ANDERSON: Right. The inflow time series is equivalent to the CalSim time flow series, which is not the same as the unimpaired flow, which would be the estimate of watershed flows upstream.

Did I -- am I getting to the germ of your question?

LES GROBER: Yes. So I think --

UNIDENTIFIED SPEAKER: I understand there is a difference. Which did you use?

WILL ANDERSON: We use the inflows to represent the amount of available water for the baseline and alternatives analysis, the actual inflows.

UNIDENTIFIED SPEAKER: So when you took 40 percent of the "unimpaired flow," you are taking 40 percent of the flow that hits New Malones or Exchequer or Don Pedro in that February through June time period?

WILL ANDERSON: The index of unimpaired flow may not actually hit the Rim Reservoir in the case of the

Tuolumne. Some of that would be diverted upstream, but we only have the inflows to allocate to our instream flow requirement. In other words, we don't modify upstream releases for this analysis.

LES GROBER: But the index is based on the unimpaired flow. It is looking at the total quantity of water. So it is not a percent of the inflow. It is a percent of the index, which is the total quantity of unimpaired water flow.

UNIDENTIFIED SPEAKER: Okay. That is what I wanted to know.

MIGUEL MATEO: Miguel Mateo with the Merced Irrigation District. Just a simple question on -- any reason why you chose 2009 as your demand year for your

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baseline?

WILL ANDERSON: Well, from my perspective, this is actually -- it goes to the CEQA requirement to evaluate the existing environment at the time that we made the notice of preparation. So if we are evaluating the total level of demand, we essentially have to evaluate multiple years within the modern context. So that could be the day that we have from the ag water management plans. It could be partially information by the reclamation evaluation by the level of demand that they put in the CalSim.

So 2009, that is the target, but we don't have enough data from one year to explain the total dynamics and demands in every year. For example, the hydrologic condition in 2009 would not form the entire 82-year simulation. That would include years of other conditions

such as -- I don't know exactly what water year type that
was. But I hope that answered your question.
MIGUEL MATEO: It is just because 2009 comes
after two critically dry years. So it may skew the
demand because usually after two dry years, the demand
could be lower than the average.
WILL ANDERSON: Well, we didn't use -- so 2009
is the evaluation context, but we don't just look at the
demands in 2009. We looked at, actually for the case of

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Merced, the total sweep of all diversions that are
represented in that model as well as the amounts of
diversions that are shown for every year that the data is
provided in the ag water management plans. And we have
to kind of look at both of those and decide where to land

on that.

And I will talk a little bit more about that in upcoming slides.

MIGUEL MATEO: Thank you.

UNIDENTIFIED SPEAKER: So, Will, you are saying that 2009 is basically the regulatory framework? You are using hydrology from '22 through 2003, but 2009 is just the regulatory framework within which the hydrology is moved through the system; is that right?

WILL ANDERSON: That would be the context for the baseline stream flow requirements, yes. I think that gentleman was asking more about "How do we get demands from that year?" And for demands, we have to look at multiple years to assess the 2009 level of demands, if you will.

UNIDENTIFIED SPEAKER: Right. The land use that was in existence at that time.

WILL ANDERSON: Right.

UNIDENTIFIED SPEAKER: Okay. Thanks.

BARBARA: While the microphone is passing me,

one question on, maybe, a follow-up on this unimpaired flow question. I am thinking about how the STM working group might implement this kind of framework. On a day-to-day basis are the -- like on the Stanislaus again, for example, is that NML gauge that is available on cediac, is that FNF, or full nature flow column, is that equivalent to an unimpaired flow, as you guys analyzed? And is it close enough -- if you could just comment on where, for example, an unimpaired flow value in realtime might come from, that would be helpful. Thanks.

LES GROBER: It would be gauges like that. With that being said, those familiar with the data know that they can be kind of problematic once you are trying to determine the full nature flow on a daily basis. So there is some work and determinations to be done to make sure that the information on the seven-day running average is good enough. Because since unimpaired flow is, you know, partly a calculated amount, "Is that the sweet spot?"

You know, I think when we went out the last time, we talked about a 14-day. And there is that tension there. You know? We want to be able to have a short enough time period to be reflective of the peakedness, which is important, you know, for biological function but not make it so short that it becomes unmanageable in the implementation.

So I think that is a fair comment to raise here, but the bottom line is we use the best available information for the modelling, which tends to be the monthly numbers. Distilling this down to the daily is going to have to be something that we work on in the implementation.

VALERIE KINCAID: This is Valerie Kincaid. You showed the difference between the WSE and the CalSim baselines on the Stanislaus. I guess I have two questions. One, can you explain how -- the difference between the CalSim baseline and the WSE baseline, not just in results but how you created or how those -- the inputs, I guess, to those two calculations would change?

And, secondly, do you have a comparison of the difference between the two baselines on the other rivers?

WILL ANDERSON: So for the first part, the differences between the two are because they are different allocation equations. I am not trained as a CalSim practitioner so I can't explain exactly how the code would evaluate the available flow and allocate that, but the WSE model closely matches what we see in the baseline based on the reservoir constraint parameters.

So if you look at the -- rather than a huge optimization equation that CalSim might use, we have a

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very simple method that allocates available water based on the reservoir constraints that we will talk about. We will walk through the allocation, yes.

So part two is, am I showing other results? I am not showing more CalSim versus WSE in the presentation today. We have documented that in appendix F1 for the other rivers, essentially for the same slides that we have been looking at here. And if there is something that is not there, we would be happy to provide it to illustrate that.

VALERIE KINCAID: Well, are there different reservoir constraints in the WSE versus the CalSim 2 for any of the three tributaries?

WILL ANDERSON: In the WSE model development, the constraints or the carryover guidelines plus the maximum draw from storage are essentially an imperial interpretation of CalSim's allocations. So these are the parameters that we have developed from looking at what

CalSim does in those situations, and we have essentially matched it pretty well.

I don't know if that answers the question, but it is -- they are imperial grammar. So it is not -- I am not -- I will have to get back to you on what the exact carryover storage requirement would be in CalSim, but essentially we see that the behavior is the same. So if

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it looks like a duck and walks like a duck, it is kind of like it is pretty close to a duck.

VALERIE KINCAID: Okay. Thank you.

GITA KAPAHI: I am just going to remind the speakers to identify yourselves, and then if there is a follow-up, if you could provide a card so that we can make sure that we get back to you. Thank you.

AMY KENDALL: Amy Kendall, ACR. My question is about carryover storage. Are you going to be going into how the alternatives were developed in the later slides?

WILL ANDERSON: I am going to show where we landed on that and some of the way that that works. So I will come up to that point.

Okay. Well, if there are no further questions, I don't know -- now would probably be a good time to take a short break, if that is okay. Maybe 10 or 15 minutes.

GITA KAPAHI: So I will just open it. Are there any other general questions on this -- on the presentation so far?

WILL ANDERSON: I can actually go -- if we want to hold to the schedule, I can do 15 minutes and then do --

GITA KAPAHI: Why don't we take a break.

WILL ANDERSON: Okay.

GITA KAPAHI: And then we will come back at a

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quarter to, and then we will resume with the presentations. Thank you.

LES GROBER: By that clock there?

GITA KAPAHI: Yeah. By the clock at the back of the room.

WILL ANDERSON: Thank you.

(Whereupon a break was taken.)

LES GROBER: It is 10:45. We would like to get started since we have a lot of material, please.

GITA KAPAHI: If we could have everyone take their seats, please, we are going to resume. Thank you.

LES GROBER: We were handed a card during the break on a question regarding carryover storage, how it was determined for the alternatives. That is going to be covered in some of the presentation that is coming up. So we will go through that, and then if the question is not answered, we will return to it.

So Will --

WILL ANDERSON: Okay. Thanks for coming back. I hope to have you on the edge of your seats here for the next part in talking about the instream flow allegations and the actual allocation scheme there.

So the next topic is on instream flow requirements, and so basically for baseline, we have got our biological opinion at Goodwin. We have got FERC flow

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requirements at La Grange on the Tuolumne, Shaffer Bridge requirements, and both the FERC-Cowell agreement and DFW Davis-Grunsky flows on the Merced. And we have got our 1641 requirements in Vernalis for flow insalinity as well as the spring pulse flows, which are lower than the base decision 1641 in VAMP implementation.

So the proposed flow requirements of the confluence of each major tributary -- once again, I am going to show the effects or the components of the flow to meet each of these flow requirements at the three UF denoted reaches here. Basically below Ripon, below Modesto, and below Steavenson.

This is a shortened diagram of how the stream flow target allocation works. We have got the major Rim Reservoir upstream diversions at the major diversion dam and your return flows or local inflows that may occur downstream of that above the target reach.

Now, in this case not shown on here, there could be additional inflows at La Grange, or, you know, in the case of Tulloch, there is certainly some major inflows that happened there. But this is a simplified diagram. We basically look at the target, evaluate available water from all of the inflows, calculate the diversions that are available and -- oops. There is a typo there -- reservoir release to meet the target.

So just for a little comparison of the proposed 40 percent unimpaired flow requirements to what the 2009 requirements are, in this case, we have got -- on the Stanislaus, we have got a biological opinion known as the appendix 2E flows, and we are showing on here the results of instream flow requirements for critical years on the low end. This is an average of the critical years that we have evaluated and for wet years on the high-end items. And those are the solid lines.

The dotted lines are the 40 percent of unimpaired flow requirements for February through June. The lower end is the average of critical years, and the higher end is the average for the wet years according to the San Joaquin 60-20-20 index. You can see that the critical year increase for 40 percent unimpaired flow is a minor but substantial increase to the RPA flows and that they are both above the existing 2E flow requirements.

For the Tuolumne, we are operating from the FERC settlement agreement flow requirements, which also has a year-type designation. They have both a spring and a fall pulse flow requirement. And in general, the 40 percent of unimpaired flow is always going to be higher than the baseline. Likewise, for the Merced, there is a combination for FERC and the Davis-Grunsky requirement,

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which actually comes into play at Shaffer Bridge, but this is the downstream. Actually, that is the literal requirements comparison, and we see that it is a much greater instream flow requirement.

So just a word about VAMP and the latest implementation of WSE including the San Joaquin RGA implementation. This is the double-step VAMP. Basically, if you have a couple dry years, it doesn't increase the requirement. But it basically takes over for the decision 1641 pulse flow from April 15th to May 15th, and that is in the model.

Just a picture of results, we showed this slide on Tuesday, and it is an example of the Tuolumne flows from the 1990 water year to '95. The red line is the baseline scenario based on the flow requirements that we have seen, and the dotted green line is the 40 percent scenario. The blue line is the unimpaired flow index at La Grange, as you can see from the dotted green line where more flows would be required.

Now, components of that flow -- and I want to see how this looks on the big screen here. It looks like the colors come into play pretty well. This is actually, "Out of the instream flow requirements that are met, what is the source of that flow?" In the light blue or the cyan on the base of these bars, these are monthly instream flows and CFS on the Tuolumne River at the Modesto reach. Cyan is the local inflows and accretions. And the red portion represents the additional flow that would be released to meet or maintain that instream flow requirement.

We see in '93 that there are actually flood control releases. In WSE, this would be where the reservoir volume would exceed the top of the conservation pool. The model will release that flow as a spill release.

Now -- go ahead.

ART GODWIN: Art Godwin. Are these all model flows or are these --

WILL ANDERSON: Yes. So this is now breaking down in the water supply effects model what is -- in the model universe, what would be occurring to meet the baseline flow requirements, and I am going to show 40 percent in a minute.

ART GODWIN: So if we had these requirements from 1990 to 1995?

WILL ANDERSON: That is correct, yes.

ART GODWIN: Okay. And then on the -- so on the Tuolumne then, are you using the flow requirement that was in existence from 1990 to 1995 or the one that was post '95?

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WILL ANDERSON: No. This would be the FERC settlement agreement of '95 that we are using to represent the baseline condition. So we are going to have 82 years of flows to meet the existing regulatory requirement for our baseline scenario, if that makes sense.

ART GODWIN: All right.

WILL ANDERSON: So I think these flows are actually greater than what actually occurred in '95.

So now I am going to switch to 40. So it is like the optometrist that gives you a different lens and says, "You know, how does that look?" The green here represents the flow releases that are to meet the 40 percent of unimpaired flow requirement, and that is in addition to or in lieu of the baseline flow requirements.

So if it is greater than the baseline flow requirement, it is shown as "all" to meet the 40 percent of unimpaired flow. In the other months that are not

February through June, you will see that the existing baseline is still in effect. And so these are -- I will go back and show you the baseline, and now we have the 40 percent flows. We can see what months these 40 percent instream flow requirements are and the reason for them.

We actually have a good amount of flow shifting, which is also light blue. But in the water year '93,

this is the case where some of that big flow also was moved to fall to reduce the indirect effect of lower temperatures when there isn't spill in the 40 percent alternative.

So next I am going to talk about the characterization of the irrigation district's diversion demand. And I am just going to show a couple of examples. The numbers that we have shown in appendix F1 -- and I would be happy to answer additional questions about this part. We are going to get into greater detail on this when we talk about the components from diversion to available applied water and how groundwater substitution works into that on next Monday's workshop. I will just give you a brief preview of the considerations that have gone into this.

Again, we have got the five major senior districts, CVP contractors. We have got a representation of a demand for each one of these. One of the main data sources other than CalSim, we have used the ag water management plans from 2012 as a basis for better understanding district operations, kind of the fate of the diverted water as we discussed earlier, the specific attributes of the conveyance systems, and what the efficiencies are there.

So the demand parameters, how we get from total

diversion, the components are maybe -- in some cases, municipal deliveries, seepage from regulating reservoirs, the minimum annual groundwater pumping offsets demand so we won't need to divert that surface water. There are areas where they may not be hooked up to the conveyance system, but they can be district lands. That would reduce that demand in accordance to that estimate there.

The model has been in development since the 2012 SED, and the 2015 plans are more recent. So we haven't incorporated all of the data in there.

LES GROBER: But we did do a query updating with more recent information in 2015; is that correct? Not necessarily for all of the system elements but for some of the data.

WILL ANDERSON: Right. For the WSE model, we were able to, you know, complete the WSE model level of demand analysis prior to the 2015 ag water management plans coming out. However, for the groundwater assessment, we did have to take a look at what happened in 2014 and some of the greater use in that time frame. So it is not for the WSE model, but for some of the other analyses, it was used. So just the depercolation fraction and distribution losses show actually how much was used as applied water there.

Here is just a picture of the generalized water balance with the simplified components that we have used. I know if you are operating a water district, it looks a lot more complicated than this, and it might have a lot more components. But we are interested in what is diverted from the river, how much might be lost through evaporation, how much is used for municipal use, how much is used for applied water and otherwise may be contributing to percolation of the groundwater basin.

For the WSE model, we used the CalSim monthly consideration of consumptive use of applied water. In other words, the crop ET requirement. And essentially we have to translate that to what is needed for surface water diversion. And we found that we tuned our diversion amounts to match what we think the level of demand is there.

This is an illustration of the raw CalSim consumptive use needs for each district for the 82-year time frame, and it is based on climate, so crop needs based on whether that is a wet or a dry year. You see a demand that goes up and down accordingly. And this you can compare back to our total diversion plot for 82 years where we saw a few shortages there, but it otherwise will follow the same pattern. And this is really key.

Here are illustrated some of the components of surface water diversions. And this is what I mean by ag

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water management plan parameters. We have to generalize an average of whether it is going to be applied water for crops or depercolation, what are the reservoir losses, and so on. And then those are then translated into the total diversion demand, which changes from year to year and even month to month. According to this pattern, we then have what the fate of what that water is. And so when we have shortages, we know kind of what is the fate of the shortage, if you will.

So to summarize that, just because it is a brief snapshot, we go from the CU, consumptive use, of applied water crop requirements to generalized efficiencies in that diagram and form the data that we have evaluated. We have got the minimum pumping from the management plans as well as some information requests that we have sent out to get an idea of what is the low end of the pumping that offsets that demand in every year.

And then we adjusted this consumptive use demand from about 9 to 15 percent based on the efficiencies in here to get the total surface demand as our level of demand. We think this is the most reasonable match with the operations models and the historical range where we think it should match the historical range. In the case of the Tuolumne, we would not expect it to match the diversions of the 1970s. It is a little lower now.

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But we use CalSim and ag water management plans and the office models all to inform us of what is the total demand -- level of demand. And we can't represent this just with the ag water management plan data because there aren't enough years, and as was pointed out, we can't just use 2009 as a basis. We have got to look at a whole spectrum of water year types and conditions.

So next, the moment you have all been waiting for, talking about, "How do the reservoir constraints work?" And I will attempt to illustrate this. I have scratched my head and thought, "What is the best way to describe this?" Essentially we have got the end of September carryover storage guidelines, which is not a hard and firm requirement. It is a guideline that works with the additional parameter of what fraction can be taken from storage, and both of these work to mimic the CalSim time series. And, also, alternatives add additional constraints to what can be diverted. We also have the minimum allocation fraction, and this will essentially keep allowable diversions from going to zero in some years but then will draw down the reservoir below the target. Again, these were developed empirically.

And then for the alternatives, we have got the drought refill provision, which will also constrain diversions in order to give a boost to the reservoir level so that it can meet carryover guidelines in the future. And that comes into play when there is a very low reservoir level and there is a lot of inflow. It will then kind of be a constraint -- it will be a maximum allocation for that year. It only comes into play in a few years, but kind of coming out of the drought, you will see the benefits of that.

Just an example here of the extreme variability that we are aware of. This is the available water and the 40 percent alternative for the Tuolumne River. Total volume that is available for diversion after the streamflow requirement, available from both storage and from inflows, can be a very low number. If inflows are very low, 40 percent of that is already going to the alternative. It can be a very low number.

Also, with extreme variability, we can see up to 3.5 million acre-feet, and maybe that is in 1986 or '97, one of the big years. But the median available water meets the total surface demand, which we see the range of the total surface demand is based on the wet and dry year types. So in most years, we will have a reliable supply essentially.

The way this is calculated is similar to the New Malones index as a basis for a starting point. We calculate the amount of storage in the reservoir at the

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end of February or March 1st and the anticipated inflow. We have got a perfect foresight. So we know what happens in CalSim, what is going to be inflow available from March through September. We then consider the reservoir constraints, the end of September guideline, and the percent draw from storage parameter -- and those both work together to get that allocation number. Then we subtract the streamflow requirements from March through September. So our flow requirement is February through June, but it will have certain requirements. In addition to that, the baseline requirements, et cetera, what is required to be instream is deducted from the inflow essentially. If there is sufficient water in the available calculation, then district demands are met 100 percent. If there is not enough, then diversions are curtailed.

So another way of restating that is we determine the streamflow requirement first, and then we determine the available water from the inflows after the requirement is deducted. We have got the available water in storage, and that is after the end of September carryover guideline and the percent draw are factored in. Then we have to compare that to the growing season demand, being the total surface demand from March through September.

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And then that allocation is the fraction of the diversion available. It is a fraction of that total growing season demand. So that is basically a percent of demand met for that growing season, and it continues through the next February of the irrigation year. So this is an example that I have put in appendix F1. As for the Stanislaus River in 1990, which was a critical year after a couple of critical years, we have got a fairly low reservoir storage at 657,000 acre-feet but only 310,000 expected as inflow from March through September.

If we take the -- let's see if this shows up here. Oops. All right. That didn't go but same as looking at it here. Looks like some things fell off the slide. Oops. All right. Well, a lit bit of technical difficulties on this one.

Essentially, on the left, we have got the end of September guideline at 85,000 acre-feet. We see in '91, '92 extremely low levels in New Malones and some effects of that. But essentially more of that, as shown in the hatched part of the bar, would be available for diversion. Take 80 percent of all of the storage down to that carryover guideline and compare that to when you have a higher guideline on the right -- in this case, 700,000 acre-feet. It makes much less available for

diversion.

Also in that alternative of the available draw would be 50 percent of that amount in storage above the guideline as well as what is available for diversion from inflows after the streamflow requirements are accounted for, both the 40 percent and any biological opinion required flows from July, August, and September.

So I am going to now look at this, over multiple years what happens. The blue bar on this chart is the total demand for diversion. The green line -- the green bar is the baseline diversion, and the red bar is the available diversion under the 40 percent alternative. And here we see the drought of record in terms of duration that we see lower allocations available in the 40 percent alternative for sequential years. And these are fairly severe curtailments. They were -- you know, we saw some of the greatest shortage on record from 1922 -- well, up to the 2003 period. It occurred in '91 and '92.

So here we see the New Malones Reservoir storage condition during that time frame, and we can see that essentially the reservoir storage guideline is keeping it at a higher level, whereas in baseline -- it is not showing up on my screen, but yeah. The tan line shows up pretty well on that screen of what happened in the

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baseline condition. We will see some temperature effects of that in the temperature model a little later this afternoon. So stay tuned on that.

Some exceptions to the rule of that allocation scheme, there is a minimum allocation, which basically allows drawdown below the carryover guideline. There is the end of drought refill, which could constrain diversions during a wet year after low reservoir conditions. There is existing agreements, such as the 1988 agreement, which would limit -- it would cap the Stanislaus senior districts at 600,000 acre-feet. And then if there is requirements at Vernalis, that could also be a factor in the model that would tend to reduce that slightly.

I am going to show a couple tables on here that are the resulting carryover guidelines and max draw parameter and the scenarios that we use flow shifting for the 40 percent flow alternative. We see that on the Stanislaus, we have got a minimum allocation of 35 percent or 210,000 acre-feet, a higher carryover guideline. The max draw is that empirical parameter that combines with the carryover storage. And we see that in 40 percent, that we also engage that flow shifting to fall. We will talk more about that a little later.

We have got a cut to 70 percent for the end of

drought storage refill. That 70 percent allocation is the max that can be taken to allow the reservoir to recharge. And, again, we are -- so there is a Vernalis minimum flow requirement in the alternatives of 1,000 CFS, which kicks in very rarely.

For the Tuolumne, essentially, in baseline, it very rarely gets below 800,000 acre-feet. It does in the '89 to '92 drought pretty severely. That is because there is a minimum allocation that we see where they would get at least 50 percent. It was kind of the lowest on record there up to the 2003 period. And then that minimum diversion would be at 33 percent in the alternatives with a 50 percent max draw from storage and, again, 70 percent storage refill.

For the Merced, we have a small minimum allocation because there is many years that availability is very low in the Merced. We have a little bit of boost to the carryover guideline to 300,000 acre-feet from 115 as a baseline guideline. There was a similar max draw of 50 percent. There is no storage refill contingency in the 40 percent alternative because when it is wet in the Merced, it spills.

Now, I am going to show the sensitivity to this carryover storage. You think, "Well, gosh. If there is a requirement or a guideline of 700,000 feet in New

Malones, how does that constrain deliveries" or "What would it be if we had a different carryover storage level?" And so this plot is intended to illustrate the effect on annual supply or available diversions for the 40 percent flow alternative for different values for the carryover storage parameter.

And we do see a slight reduction of the average annual supply. That is an average figure. So you might say there may be a statistic that would be a little more illustrating, which would be, "What is the effect on the annual supply in critical years," which would be a greater amount.

My animation doesn't work here. But essentially on the baseline, we are at very low levels in the Merced and Tuolumne, and then we are boosting up to 700,000 for New Malones. The Tuolumne River -- the carryover guideline is always at 800, but just the allowable minimum allocation is less than the alternatives so that that limits when it can go below that.

So I guess I should stop for a second and take any questions on the allocation scheme because I know that that is pretty clear as mud at this point. Hopefully not.

DEREK HILL: Derek Hill with the Fish and Wildlife Service. It is great to see sensitivity analyses. I am wondering if you did any related to the perfect foresight of inflows. Did you try to put a statistic additive to it to not perfectly forecast what the inflows would be?

WILL ANDERSON: No. Not at this time. We don't have that.

DEREK HILL: The district is using 90 percent; is that right? Normally when they start off, it is 90 percent of the forecast?

WILL ANDERSON: In my experience.

DEREK HILL: All right. Thanks.

WILL ANDERSON: And that would be conservative on supply, and that is -- yeah. Good question.

AMY KENDALL: Amy Kendall, HDR. So my question has to do with why the modeled alternatives would be different from how they are presented in chapter 3. It didn't have any mention of these maximum draw from storage parameters, and it seems to me like without this parameter, the operations could negatively affect temperature. You have to increase the carryover storage to protect the cold water pool.

So as I understand it, you have iteratively developed it by running the alternative, looking at the temperature model effects, and then, you know, making some adjustments to balance it out. Can you respond to

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that? Does that kind of adequately characterize it?

WILL ANDERSON: I don't disagree with any of those statements.

AMY KENDALL: Okay.

LES GROBER: And as you suggest, with the increased drawdowns that would occur to meet the flow requirements, that was found to have temperature effects. So this was done to not have those effects by increasing the carryover storage. So -- and I have to check. I'm not sure if we have a slide later because it is a question that had come up at the hearing as well. I mean, this shows the -- the chart that Will just showed that is on the screen shows the different water supply effects using a different carryover storage.

Similarly, the reason for selecting the carryover storage we did was to minimize those temperature effects that would occur by drying the reservoir down further. Do we have a slide for that yet?

Because I know we were going to do some temperature runs based on the --

WILL ANDERSON: We will show how that works in the temperature model and some of the temp effects of the difference in carryover storage.

So this would be a good time to point out that with these parameters, it is a way to operate the system,

and it is what we have shown for the development of the impacts analysis. It is by no means the only way to operate under the implementation plan. We have got adaptive implementation. We have got an operations group. These carryover storage guidelines are necessary for the analysis, and we can observe that they do have an effect on the system. But what those are, I'm sure, will be a topic of much discussion to come.

AMY KENDALL: So was there any sensitivity analysis done to obtain these parameters? They back off the Tuolumne, for example, in increments of 5 percent. And I was wondering, if I were to set up a model run how I would go about obtaining those.

For example, if you look at the exceedance curves for Don Pedro, the carryover storage is below 1 million acre-feet, which would be the years that you would be concerned about just as a rough guideline because it is the low storage years. Nearly all of the time the alternatives end with a higher carryover storage than the base case, and if that is not there as an alternative and it is there as a means of, you know, making the temperature impacts less severe, then I was wondering if there was any optimization or sensitivity analysis done for that.

LES GROBER: There was no -- I mean, I want to

make that point there was no attempt to optimize here, but there is a number of different errors that can be made with an analysis like this. The error that we did not want to make is to underestimate the water supply effects at the same time that we would not be mitigating for a temperature effect. So this was a number that was sufficient not to have a temperature effect later in the year, but it certainly might overestimate the water supply effect.

AMY KENDALL: Okay. One more question. So if we end with higher carryover storages increasing as the percent unimpaired flow increases for storages -- for example, in Don Pedro below 1 million acre-feet -- then could we not see temperature benefits from this increasing carryover storage?

LES GROBER: That is mostly to look at the effect for times after the February through June period. But I understand that your question is: "So if you have that carryover, how does that feed into the next year?" And I imagine the run will be -- the results of the run will be for the way that it was modeled. So I guess there would be some overall effect from that level of operation.

But I want to get back to the point that this is intended to compare and contrast the different percents of unimpaired flow and with the baseline. So it is for comparative purposes.

WILL ANDERSON: I would add just one more nuance to the carryover storage and in developing model alternatives. There is an aspect of reliability to having a carryover storage, where if you draw it all the way down and then have increased requirements in a successive year, then that would be -- have less available for consumptive use in the following year as well.

So if you look at the exceedance or the reliability curve, you can actually decrease the severity of a shortage in some years by shifting that to other less severe years. So if you think of drawing it all the way down, that leaves less for the next year's supply. Since instream flow is a fraction of what is coming in, which might be low if you don't have any supply in the next year, then that year could end up being worse. And so for a model scenario that has 82 years, we would tend to boost the reservoir level a little bit essentially to keep it from drying out the reservoirs as well as to decrease the negative temperature effects.

AMY KENDALL: Just to clarify, so it is a mitigation measure for water supply and for temperature?

WILL ANDERSON: I -- I'm --

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LES GROBER: Let's just say it was an assumption used for carryover storage because we are outside of the bound of how reservoirs are currently operated to reduce or eliminate the temperature effects that would occur after the February through June period.

WILL ANDERSON: Thank you, Les.

Okay. Are there additional questions on allocation? Let's just --

LEE BERGFELD: Hi. Lee Bergfeld with MBK Engineers or on behalf of Merced ID. It is kind of a little bit of a follow-up to the questions that were asked on carryover, but I will expand that to talk about the maximum draw percentage and the drop refill percentage as well.

And as I went through parts of the SED -- I won't say that I read it cover to cover -- but for the carryover, there is some discussion about that in appendix K and the program limitation that the state board may look at to implement a carryover. I believe the maximum draw from storage, it states in appendix F1, where this is not envisioned as a regulatory requirement -- and I think, Will, you have done a nice job of explaining that that is a model parameter included in here.

And then the drought refill criteria, I couldn't

really find anything in there -- I am not saying it is not there -- whether it would be a regulatory requirement or whether it is not. But the three of these I believe were essentially developed to mitigate the temperature impacts of the increased spring flow requirements. And I wonder if I could get a little bit of your perspective on, "Have we analyzed the proposed project if some of these are not included in the program of implementation or envision but are more of just model inputs or model parameters to arrive at how it could work in the future?"

LES GROBER: Well, first, as you point out, we do have a program implementation that there would be some reservoir carryover requirements included to offset any temperature effects, and also the same language is in there for health and safety needs. The reason for not including it as an explicit amount -- explicit requirement is for the reasons that Will has said, because we haven't optimized it. So we don't want to presume and establish any fixed number that wouldn't be a better number to presume how the reservoirs need to be operated.

Anybody here that does reservoir management knows that that is a complex thing. It is a big deal, and there is many things that could be done better optimally. That being said, we have modeled, I think, in this way -- it is a conservative estimate that probably tends to have the bigger water supply effect recognizing that you could probably achieve the same results through some more strategic optimal reservoir operation to reduce any temperature effects in the summer or fall months and still achieve both the instream flow goals of the objective and the program implementation.

LEE BERGFELD: All right. That is it. Thank you for that.

Any thoughts on the maximum draw from storage parameter that is included in the modelling in the analysis but is explicitly stated that it is not meant to be a regulatory requirement? And I did not see where it was mentioned as a requirement or part of the program or implementation.

LES GROBER: Yeah. That is also not a regulatory requirement.

BILL PARIS: All right. Bill Paris, MID. I have a two-part question. Did you run the 40 percent without the reservoir constraints?

WILL ANDERSON: The work that was done there predates me a little bit, and we just went back in the following -- since last Tuesday, when I have seen the interest in that, we have rerun that, and we can show some of those results a little later this afternoon in

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terms of the temperature effects. So yes, it was done, and that is more than a couple of years ago when that was originally set up to kind of derive these parameters. So I can't fully elucidate how those were derived only to say that they appear to work, and there is some sensitivity noted.

BILL PARIS: Okay. Just so I am clear, but putting aside the temperature effects, when you ran the continuous model from '22 to '03 without the reservoir constraints, were you able to do the 40 percent impaired flow? Or have you done impaired flow consistently, or did you need something in the reservoir constraint to make that 40 percent available?

WILL ANDERSON: In order to make it work with no constraints, we would have zero minimum allocations because when you have a low reservoir, that would dry it out. So in order for the lower constraint to work, it would have to have that effect as a very hard -- hard barrier.

BILL PARIS: Okay. And last question, I think, on this, you mentioned that there are temperature effects in the summer and fall. Can you describe the nature of those? Are those regulatory effects that are currently existing? Are those minimum instream flows that are built into the schedules? What is it exactly that you

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folks are trying to manage to or for or that you saw in the modelling that suggested that these reservoir constraints of any size were necessary?

WILL ANDERSON: Well, I can address two aspects of that that we will look at in terms of the temperature model. One of those is that it really has to do with the effects of the project. Kind of one of the overarching modelling objectives was to do no harm or to not -- have fewer days of meeting the EPA-7 datum criteria of the project as without. So that is kind of an overarching idea.

And the two places where we really see the effects of the project in the absence of carryover storage is temperatures in the fall and a change in the elevated temperatures when there are no spills. So in the baseline condition, without the flow requirements, the reservoirs are at a higher level and do not spill as much. There may be years without a carryover storage requirement -- first of all, that there is no spills at all. And then so the temperatures would be generally much higher all through the summer so you might see high spill flows.

The second aspect of that is that the flow shifting that we have done will account for that as well as the carryover storage. So carryover storage and flow

shifting are kind of intrinsically linked to meet those -- making sure that there are not negative temperature effects.

BILL PARIS: Can I ask a follow-up on that? So just to be clear, so absent the -- absent a reservoir carryover storage requirement, there would be -- temperatures would be higher under these scenarios notwithstanding existing flow schedules? So there would be more days of not achieving -- you picked 2003; is that what you were going for?

WILL ANDERSON: That is what we observed.

BILL PARIS: And can you -- do you have that? Is that something you can share? You mentioned earlier that you did a lot of iterations, and you could look and see. Can we see those iterations so we can understand sort of the inflection points --

WILL ANDERSON: A lot of that was prior to my work. We have some of those records that we have provided as public record act requests, some of the old runs. And I can -- we definitely are going to show some of those dynamics this afternoon with the temperature model. And it is definitely a topic worthy of discussion and comment.

LES GROBER: Just because -- this is a question that came up at the hearing last Tuesday. So confirming,

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so we have a couple of slides that show a comparison of what happens to temperatures if we didn't adjust the carryover storage requirements.

WILL ANDERSON: And, also, if we don't shift flows to fall.

LES GROBER: Okay.

UNIDENTIFIED SPEAKER: Actually, two questions --

GITA KAPAHI: Yeah. I have got two -- yeah. Sorry.

UNIDENTIFIED SPEAKER: It is okay.

GITA KAPAHI: I have got two back there, and then we will come to you, sir.

ROB SHERRICK: My name is Rob Sherrick with HDR. I am a water resources engineer, and I am working with models of this type, specifically the FERC Don Pedro relicensing model. I was looking at the WSE model, and in the assumptions in there for accretion on the Stanislaus, Tuolumne, and Merced sheets, there is a toggle that allows the user to change the percent of unimpaired objective from the downstream locations of Ripon, Modesto, and Steavenson to the upstream locations of Goodwin, La Grange, and Crocker-Huffman.

On average I found with a rough analysis using that toggle, about 20 percent of the unimpaired flow

objective -- for the 40 percent of unimpaired flow, about 20 percent that was met by natural accretions in the rivers for the whole run. I think -- I am not entirely sure, but it looks like those assumptions for accretion come from CalSim.

WILL ANDERSON: That is correct.

ROB SHERRICK: I was unable to find detailed documentation on the calculations in the SED or in CalSim documentation, but they are relied upon heavily for the alternatives analyzed. The 40 percent unimpaired flow objective actually ends up looking more like a 32 percent unimpaired flow objective for release flow. And so just given that it is such an important assumption, I would just like to know if you think that those values are reliable going into the future.

In estimates I made for the Don Pedro relicensing, I came up with estimates from 1987 to 2012, which were considerably less than what is in the model. And looking back at it now, in the most recent couple years of drought, I have estimated some values that are

near zero for accretion. So if you could, just comment
on that assumption and sensitivity to that assumption in
your model.
WILL ANDERSON: I am going to -- those are very
astute observations, and I am going to leave that comment

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to stand on its own and encourage you to include that in
your written comments.
ANNA BRATHWHEAT: Hi. My name is Anna
Brathwheat. I with the Modesto Irrigation District, and
I am a little bit off topic. I don't want to ask a
question about carryover storage, but I did have a
question about your slides 71 and 73 and how the
municipal component is built into the WSE model.
And so maybe just to lay out the question, so my

understanding is in chapter 9 the service providers and the groundwater impacts are separated out from the irrigation districts' water supply. So if there is no joint analysis in the SED that looks at groundwater impacts with the service providers having a decreased amount of supply, I am wondering if on the WSE model -- so on either slides 71 or 73 -- the municipal component that you showed on that slide, is that a toggle that you can either increase or decrease to reflect what the municipal demand is?

WILL ANDERSON: It can certainly be done. Our analysis considers the municipal supplies that are delivered directly from the irrigation districts to the Stanislaus Regional Water Authority and to the City of Modesto water treatment plant to be fixed values for both the baseline and the alternatives.

ANNA BRATHWHEAT: Okay. And when you did --

WILL ANDERSON: That would be about --

ANNA BRATHWHEAT: Go ahead. Sorry.

WILL ANDERSON: Pardon me. That would be about a 2009 level of demand.

ANNA BRATHWHEAT: Okay. So when you did the groundwater impact analysis, then you didn't just change that toggle; you just left it at full supply?

WILL ANDERSON: That is correct. And the groundwater issues will be discussed in further detail next week.

ANNA BRATHWHEAT: Right. Because they are not together, I just wanted to ask now how you got to each impact. So is that true for the surface water providers -- service providers as well when you did that analysis? You just decreased or increased the amount of water going into the service provider?

WILL ANDERSON: We didn't -- in the effects analysis, we have not modified the available surface water to the water treatment plants. Those are fixed quantities, and that is a component of demand. And so, essentially, when there is decreased availability, that would -- that would fall on the irrigation districts rather than on the municipalities in terms of our effects analysis.

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ANNE HUBER: I am Anne Huber. I work with ICF. We helped put together the SED, and for service providers, we analyze impacts qualitatively because we are -- you know, it is uncertain at this point to what degree their demands may be cut. So there is some consideration of potential reductions in supply to service providers, but it was not part of the groundwater analysis. For the groundwater analysis, the assumption was that all reduction and supply effected agriculture.

ANNA BRATHWHEAT: Okay. So there is no modelling to the service providers' impacts; the modelling is done for the groundwater impacts to the irrigation districts?

ANNE HUBER: Right. But we do consider that there is a potential that the service providers' supply will be reduced.

Thank you for the multiple questions.

UNIDENTIFIED SPEAKER: Thank you. For

clarification, the available water on slide 76, you have 150,000 there. How does that jive with slide 87? I see a reduction from 800 to 700,000. What am I missing there?

WILL ANDERSON: How do we --

UNIDENTIFIED SPEAKER: Is that available water just inflow or is that a combined -- that is the least

available water in the study period?

WILL ANDERSON: So the latter of the two, I am not clear on what you are referring to.

UNIDENTIFIED SPEAKER: Well, if the available water is 150,000 acre-feet -- and I assume that is the worst year -- then on slide 87, when you got to the sensitivity analysis, you show the range going from

800,000 down to 700,000. I would just think that something just doesn't make sense to me, or I am not following the train of thought.

WILL ANDERSON: Okay. So this is referring to average annual supply. So that is an average of annual supply over 82 years. So we see the effect on average of changing a carryover storage requirement.

The other slide was simply attempting to show the variability of what supply would be available after instream flow and with a carryover requirement. So this statistic is all rolled into that average, and that one shows the variability between the high and the low.

LES GROBER: And if we could step back, Dan Worth, the senior environmental scientist has joined us to provide a little bit more information about the question about the temperature effects after the February through June period and reservoir reoperation and flow shifting.

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DAN WORTH: Yes. So I heard one of the questions regarding temperature in other times of the year. I didn't hear all of Will's response, but I just wanted to say that reservoir storage targets were developed in this model and were designed to try to make temperature conditions no worse than baseline under the alternatives.

And one of the challenges is to -- under baseline conditions, we see years where there is reservoir spills late in the year. And one of the challenges is trying to, essentially, match the temperatures we saw under some of those spill conditions. And one of the ways that that was done was allowing some of the fisheries' water to be shifted to the other times of the year and then spilled in the river. And so the heavy lifting was done with the reservoir storage targets that Will talked about, and then some of these other things were matched with shifting some of the fish water to the fall.

So I don't know if that answered all of the questions that came up, but --

LES GROBER: And we can discuss this some more this afternoon in terms of the effects and the temperature modelling and the benefits.

DAN WORTH: And I will just add, without storage targets and storage rules, there would be significant changes to the temperature at other times of the year. If the -- if reservoir storage is allowed to drain, that would certainly make temperatures much warmer than what happened under baseline conditions. So there is a need to have storage rules and storage targets to keep the reservoirs spilling cold water in particularly the summer time period and the fall.

WILL ANDERSON: Thanks, Dan.

I believe there is another question.

CHRIS SHUTES: Hi. Chris Shutes with the California Sport and Fishing Protection Alliance. I am curious about the generation of the figures for the carryover storage numbers. First, you know, what each one is. Second, whether you did any sensitivity analysis in-between no requirement and the existing requirements that you generated. And, third, I want to confirm with Les. He said that that carryover may be a regulatory requirement, but it is not assigned in appendix K at this time. And I want to confirm if that is correct.

LES GROBER: I will confirm that we are not proposing any explicit carryover numbers for the reasons that I said earlier because we did optimize. We didn't do the detailed sensitivity, and the crafting of the entire program is intended to show what can be broadly

achieved but not necessarily coming up with the specificity. Because with that specificity would come constraints that may prevent us from doing the smarter operation, if you will.

With that being said, the program implementation is very clear that the board will establish such requirements that are needed to achieve the overarching fish and wildlife, including temperature goals, and to not cause any negative effects for times of the year where we are not expressly establishing a flow objective.

WILL ANDERSON: I would like to address the first part of the question, which is how the figure is derived. Essentially, for the exceedance plots, we are looking at the end of September resulting in carryover storage. This is a monthly calculated value. So it does, in effect, get lower after September in some years -- many years. But that is the target and the guideline and kind of like, you know, one way to look at it and evaluate the changes from year to year.

And the second part -- could you repeat part two?

CHRIS SHUTES: Actually, the first part was a little more specific, which was how you got to those numeric values and not just that you have an end of September number. I get that.

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WILL ANDERSON: Okay.

CHRIS SHUTES: But how you arrived at the numbers that you did. And the second part was, did you do any sensitivity analyses for intermediate values less than the numbers you arrived at and used but greater than zero?

LES GROBER: I -- we have not done the sensitivity analyses. We understand that this has been a comment and question and as to, "How much is the effect," and we will explore to see -- because you start having additional temperature effects. So the thought I infer from this as well is, "Is there a sweet spot in there that could reduce the water supply effect but still otherwise achieve temperature goals?" We did not do that.

UNIDENTIFIED SPEAKER: I just want to confirm Les's response to Chris. So you are not confirming a specific carryover number, but you are proposing carryover in your proposal plan?

LES GROBER: Yes. If necessary to not have negative temperature effects. Because we referred to temperature effects but also with regard to health and safety. So it is just to make sure that with the -- the overarching rationale is that by perturbing the system by having these higher flows in the spring, if there is not some other constraint in terms of operation, it could have some of these, you know, redirected effects. So we would have requirements to prevent those from happening. But the specific requirements are not yet provided, what we have and what we have modeled.

UNIDENTIFIED SPEAKER: Okay. Thank you.

VALERIE KINCAID: Thanks. Valerie Kincaid from the San Joaquin Tributaries Authority. There are three or four -- I don't know if you would call them assumptions or inputs that you had in an earlier slide. One was the drought refill requirements, the minimum allocation fractions, and the minimum diversion allocations. I was hoping -- and those are the slides that you just ran through, 83 through 86.

They show the impacts of those, but I am more concerned with how they were developed and, kind of, a brief explanation of the assumptions and mechanisms development calculations used to arrive at those. That wasn't part of this presentation. So if you could go through each one of those and explain what the drought refill provision is, how it was developed, and if you can, run through any calculations of how you get there and how it applies in these later slides.

Those later slides are in the SED, and I think, you know, for folks who have been to the SED, I know

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those slides. But my question -- and I was hoping this workshop would get to those -- is on the input assumptions and mechanisms that you used to develop those. So if you could kind of go through each one of those and explain how they were developed and how they work, not by result basis but by development, I think it would be really helpful. Thanks.

WILL ANDERSON: I am not able to step through -- I don't believe it is going to be satisfying. I can't step through the development of that. Simply to say that these are parameters that are inherent and important and critical for describing -- for our description of the system operation in terms of representing baseline. We think that it is -- these parameters describe, essentially, how the system operates in baseline in lieu of an optimization function in CalSim. It is essentially, "Here is what works in the baseline."

And when we go to the alternatives, those numbers have to be modified to make it work and to not dry out the reservoirs and to kind of distribute that risk in the shortage years in, yeah, the least impact possible, I should say.

ANNE HUBER: And I just want to add that I think before you even started work on this project, there was, sort of, a lengthy process of trial and error, and there

was a lengthy process of trial and error to determine what set of values would give -- maybe not optimal results because I'm sure not every possible combination was assessed, but multiple runs were made to pick good sets of values.

VALERIE KINCAID: I guess from a transparency perspective, from the regulated community's perspective, I understand the -- well, I don't understand the complexity, but I appreciate that there is a huge amount of complexity in iteratively arriving at those. But the problem is that that is what we want to see. I mean, that is what I would like to see. I don't know how that was developed or how it was arrived at, and I frankly thought that that was what this workshop was going to be about. I mean, I have been to the SED. I have seen the results. I want to know how we got there.

But having said that -- and it sounds like we are not going to do that today -- that is fine. I did have one follow-up question to Will's comments. Those parameters that I named and that were on that slide, you said something about them being in baseline. My understanding is those are actually model inputs, and those are things that are necessary for the model to work. Do you -- I guess I am confused about -- and maybe you mean modelling a baseline. But did I misunderstand?

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You don't think that those are actually in place in some sort of existing scenario that is on the ground today or in 2009, do you?

WILL ANDERSON: In the WSE model, it has a unique allocation scheme that incorporates those parameters that we found to mimic the CalSim baseline, that they are very -- they give the same results by working and interacting the way that they do. And so it is simply a way of reoperating the system continuously for 82 years that constrains deliveries in a way that works.

VALERIE KINCAID: Right. And I guess --

LES GROBER: And I would like to --

VALERIE KINCAID: So that is a modelling? That was something that was a model?

LES GROBER: Just to say it in a different way -- hopefully a somewhat different way and just going back to really the -- well, what we have done showing our work and the intent is, as Will had said, to show a way that the model of the system can run. That is not to be interpreted as an optimal way to make it run. This is one possible -- and as we document, it is a response to the perturbation of requiring bypass of higher amounts of flow from the reservoir at the 40 percent level and at the other alternatives looking at the range from 20 to 60

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percent.

Once you perturb the system in such a way, the first thing that you see is if you keep everything else the same, the reservoir runs dry. So we have had to make assumptions that we have described and disclosed about reservoir operation that prevent those things, like running reservoirs dry or temperature impacts in the summer and fall. It prevents from those occurring. It is not to be construed as the way or the only way that it can be done but a way that helps to show what would be the physical effects on the system by changing water supply and other things like that.

So I -- we will attempt to -- and you will see some this afternoon -- to show not so much the sensitivity, but it is a simple presentation to show, "Well, if you don't have the increased reservoir carryover storage, you are going to blow up the system and have very high temperatures, if you keep demands and diversions for other uses at the same levels as we see on the baseline." So it is not a terribly interesting result, but we can show some of that. But we did not do an exhaustive review of different methods and sensitivities for seeing one of the any number of ways that you could operate the reservoirs.

VALERIE KINCAID: I understand that, but it

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would be -- and I fully understand that you can't look at every possibility. But it would be good to fully understand how you got to the one scenario that you analyzed.

LES GROBER: And the short answer to how we got to the one scenario, it was a scenario that we could demonstrate avoids those temperature effects and achieves the goals of the program.

WILL ANDERSON: Okay. It is now 12 o'clock. I am going to move on and just talk about one additional dynamic and a bunch of results, and then we will have an opportunity for some more questions prior to our 12:30 break.

So back to where we left off here, I was getting ready to talk about the concept of flow shifting, and this is an adaptive implementation method to move flow out of the February through June period to later in the year to counteract and offset some of these temperature effects that we observed in the figures in the document F1.2-7, just a generalized illustration of what it might look like and moving some of that spring flow pulse under the 40 percent alternative to the fall months.

And I am just going to show just how much and what years we do it. So this is the -- it takes place as an instream flow target, NCFS, at the downstream reach of

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each river. And on all three rivers, it occurs in wet years, and that counteracts the temperature effects of having fewer spills in wet years. In the Stanislaus, it occurs in every year type in October. And on the Merced, it takes place also in -- above normal types for the same reasons. Those are the CFS targets also in the document F1.2-25.

And next I am going to show you the total amounts that are shifted. These are average quantities shifted under each alternative to meet those flow targets. I see an average of -- in the 20,000 acre-feet up to 36,000 acre-feet on the Merced to meet those flow targets for producing those indirect temperature effects. But that is all I have on the WSE model methods.

I know we will have some additional questions coming up, but I am going to jump into the results of the model in other ways that we haven't looked at yet. Maybe you have, if you looked at the document. But I am going to go pretty quickly just to allow time for more questions since they are the most productive aspect of this session.

So in the executive summary, we show the average instream flow from February through June on each tributary. The fact is that the average instream flow would increase by 288,000 acre-feet, or about 26 percent, on average. We see that the average annual effects on surface water diversion from 30 to 50 percent alternatives range for the plan area from 149,000 acre-feet at the 30 percent objective up to 293,000 acre-feet, or 14 percent reduction, at the 40 percent alternative and a little greater -- a much greater reduction, 23 percent of average annual surface water diversions in the 50 percent alternative.

Did you have anything to add, Les? Okay. I saw you looking for the mic.

Okay. So another way to look at this is, "Well, that is the average number. What happens in different year types?" I see no change in wet years, very minimal change in above normal years but greater reductions in surface water availability for consumptive uses in below normal, dry, and critically dry years.

In dry years, that is a 30 percent reduction from what is essentially a full allocation. In the critically dry years, that is a 38 percent reduction from what is already in a drought year not fully meeting the agricultural needs.

Sir --

UNIDENTIFIED SPEAKER: It looks like the water supply is higher in the below normal and dry than it is in the wet; is that correct?

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WILL ANDERSON: Yes. That is an effect in the change in demand in dry years. So in a wet year type, when you have precipitation that would account for some of your crop needs, you would not need to divert as much. So the dry year type is when we see the highest diversion demand, and that is the year that we would see the reductions due to the lack of supply.

UNIDENTIFIED SPEAKER: So the water supply that is available includes inflow?

WILL ANDERSON: Right. So this is a roll-up of the results of 82 years of the model, and the -- if we see in the baseline condition, which is what we are comparing here is the baseline and the alternative, the dry years generally get full allocation, which is a slightly greater demand diversion requirement. And then in the alternative, that supply, because of the 40 percent of increase of -- 40 percent of unimpaired flow -- instream flow requirement is an increase from the baseline, then less is available in that year based on the reservoir condition and the reoperation and the constraints, all that we have described.

LES GROBER: I think if your question is, "Why does it look higher in those middle years," it is because in the wet years and above normal years, some of the -- it is both the availability and the demand. Some of that

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demand is met by precipitation so the demand/availability is greatest in those --

UNIDENTIFIED SPEAKER: So this is just a water supply demand that is met?

LES GROBER: That is correct.

UNIDENTIFIED SPEAKER: Okay. Thank you.

WILL ANDERSON: Thank you. Good question.

So at this point, we are going to talk about comparison of the WSE baseline and the alternatives in greater detail. Stop me, please, if there is something that strikes your fancy or interest that you would like to ask a question about or just to have a longer chance to look at these slides because there is a lot of charts and graphs here.

The first one here is the Stanislaus baseline flows from '90 to '95, which if we are going to look at a time series and pick some years to look at, I think the '89 to '92 drought and a couple following years is a really good example of what happens in drought years, which are the most interesting.

Here we see the inflows do comprise a fair portion of the monthly baseline flow requirements. We see additional release is needed to meet the RPA biological opinion index 2E flows, and we see the little bits in yellow are additional releases that reclamation

would need to make for New Malones to meet the Vernalis EC requirement.

Okay. So Les is speeding me up here. So if we go to the 40 percent alternative, we see what the aspects of the downstream resulting flows are from each component. We see the green is the unimpaired flow requirement releases. We also see the light blue on top. That would be additional releases if some of that flow shifted to the fall months in October for this and also in the spill year there in '93.

So Tuolumne, again, I believe is the same that we saw earlier, baseline, and we see the big spill year is in '93. There is increases with the 40 percent flow alternative, with a little bit of flow shifting in the wet year.

In the Merced, same story. It is fairly low instream flows at Steavenson and baseline. I do see spills in '93 for the 40 percent. We see higher instream flow requirements and lower spills in the '93 year.

Yes --

UNIDENTIFIED SPEAKER: Slide 1001, the previous slide, you don't have any VAMP flows on there?

WILL ANDERSON: We don't see them -- I was just looking at that. And we don't see the VAMP two-step flows coming into effect being depicted here in the

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successive critical years. I think that is a good question. I am not observing them in the model results for these years.

UNIDENTIFIED SPEAKER: That is interesting because of the way VAMP was structured with Merced providing both of the VAMP flows. You showed it on the other two trends.

WILL ANDERSON: Right. Well, it is --

UNIDENTIFIED SPEAKER: I don't know if there is any there. I can't see it.

WILL ANDERSON: It is listed on the legend, but we are not seeing releases that are attributable to VAMP in these particular years. So these are not the best years to look at for VAMP because if you have got -- if you are -- it has got that off-ramp and the double step in successive critical years, and we are looking at a bunch of critical years in a row. So it is an interesting dynamic, and it is one of the -- if you want complexity, that is the most complex aspect of the model, is how to incorporate those VAMP flows, and definitely it is a good comment, an astute observation.

So moving on, we have seen these components before. That is a new thing that we recently developed. So if you have a request of certain years that you want to look at, I think we can provide whatever is requested

there. So more of the four-panel plot, this is kind of our grand summary showing the February through June instream flow exceedance as well as the end of September storage exceedance on the top right.

We have got baseline, 20 percent, 40, and 60 percent alternatives all on here. The baseline is going to be the dark blue diamonds, and the 20 percent alternative is going to be the cyan circled. 40 percent is the green triangles, and the tan or orange boxes represent the 60 percent alternative.

So we can see in the top right that in baseline, New Malones is less than 700,000 acre-feet about 25 percent of the time, going below as low as 100,000 in the '91 and '92 time frame. Probably the most interesting aspect of this is the diversion delivery dynamics that -- oops. Let's see. I am going to go on through to the diversion exceedance plot here, which shows the reliability and availability of diversions for each of the lower San Joaquin River alternatives.

The baseline again is the dark blue diamonds where we see essentially 94 or 95 percent of years full demands being met. In the 20 percent alternative on the Stanislaus, we see that these are met in closer to 15 percent of the years. And then the 40 percent alternative, only 60 percent of years give an entire

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supply and meet demands, and you can see that the decreases in demand occur under the 40 percent alternative.

And at 60 is when it encompasses the wide range of alternatives that we have evaluated. It really does cause some extreme cuts. So that is, kind of, an upper limit of what the system would withstand. I don't think that is a desirable one but just for comparison purposes.

Back to the annual total diversions, this is the unordered -- same data as that exceedance plot. The dark blue line is the baseline diversions. We see some low years. We see some lower years and more of them in the alternative as we would expect. And that is the same story for each river. I will just step through, just to not favor any particular one of these things.

They have similar dynamics. Some of the differences are with New Don Pedro, it is drawn down less often in the baseline, and we observe that in the upper right -- the little blue triangles that, kind of, bottom out around there, around 600,000. And we see a greater reliability of supply in the Tuolumne except for there is some years that there is a 50 percent allocation. I am going to step forward into that one.

Here we see the total diversion from the Tuolumne River. This would be for Turlock and Modesto

Irrigation Districts. In baseline we see that for this 82-year period, the greatest cut that is in the scenario is about 50 percent allocation -- 50 percent of the max -- and then the 40 percent alternative, there is diversion cuts in more years. Again, what it looks like in a time series plot. I just rearranged the order.

So on the Merced, in the upper right, we can see that the reservoir end-of-September levels are drawn down to around just over 100,000 -- 120,000 in 10 percent of the years. And then our alternatives would boost that up to the 300,000 acre-foot mark. In terms of reliability, dry years on the Merced have a greater proportional impact than the other two watersheds where the baseline diversions are cut. You can see the drought years. In about 12 percent of years, I am seeing some pretty obscene -- fairly high shortages and then greater as we see the 20, 40, and 60 percent alternative for that year, just for a greater view.

So I won't belabor any of these, unless there is something that anybody would want to see about these.

LES GROBER: I would just like to call out, this is the for the Merced. The other tributaries, when you look at the exceedance plot for diversions, the 20 percent alternative pretty much tracks the baseline. Here in Merced, it shows that even at the 20 percent it

has that difference between baseline and the cyan. The dark blue and the cyan shows that you start losing water availability 25 percent of the time, even with that.

We will show a slide in a moment showing the project area as a whole. That is showing the project area as a whole, which is why we say, "Well, the 20 percent is generally reflective of the current condition," but even with that, the 20 percent has a water supply cost.

WILL ANDERSON: I will go ahead and jump to that slide just to continue that train of thought. This is the plan area total.

Okay. Go ahead, ma'am.

AMY KENDALL: Can we just go back a few slides to the exceedances?

WILL ANDERSON: For which reference?

AMY KENDALL: Any reservoir is fine, any of them.

WILL ANDERSON: For the reservoir --

AMY KENDALL: Yeah. Back a few. Yeah. So I am looking at around 55 percent exceedance from the top right corner -- -

WILL ANDERSON: Uh-huh.

AMY KENDALL: -- at the end of September storage.

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I am wondering why the alternatives need to be higher than the baseline for carryover storage. I understand that you are not trying to do harm, but I am just wondering why the carryover storage -- I just wanted to point that out. It is so much higher than the baseline. And how is that arrived at, and is there a reason?

WILL ANDERSON: It is arrived at because we have that set of parameters for the alternatives that is -- I wouldn't say -- it is somewhat from the simplicity of those parameters, the allowable draw and the carryover guidelines that those are constants. We don't change those in this analysis. And if you wanted to achieve -- they work together.

So it is not just a carryover guideline that you will have. And that is a hard target that you shoot for. It is more of the combination of the allowable draw to that target. So that will scale down as you get closer to the target and may, in fact, go below it if you have a minimum allocation.

What you are talking about is, "Well, maybe it doesn't need to be that high in all of those years that you might be able to utilize that." That would require

additional complexity in the parameterization. So if you
would say, "Well, we have X condition and whatever

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inflow," you might choose to go for a lower target. But
those two parameters that we have for the 40 percent
alternative result in this.

AMY KENDALL: Could you increase the maximum
allowable draw to get that a little closer? Would that
be a parameter that you could adjust?

WILL ANDERSON: That wouldn't essentially --

LES GROBER: As a hypothetical -- I mean, this
is a good discussion, but I think this comes back to the
same answer. By doing that, you could opt -- it seems
based on things like this, you could somehow optimize the

system and perhaps achieve the goals of, you know, not having any temperature effects and still achieve the instream flow and reduce some of the water supply effects, but we didn't do the optimization.

AMY KENDALL: Right. It wasn't really a question about optimization. I guess to clarify, I am just talking about for impact analysis. So to get more comparable and more apples to apples results, could it be a parameter that you adjust to get it a little bit closer to baseline so you are not seeing artificial effects from carryover storage?

WILL ANDERSON: I appreciate the comment, and it is on point. From modeler to modeler, if I were to add complexity to this analysis, which I am not going to do

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because Les would shoot me at this point --

AMY KENDALL: Good point.

WILL ANDERSON: -- what you could do is say under -- "Well, for this particular year based on this set of conditions, you may have more of a draw." But for us, we have the draw; we have the carryover storage. They work together, and they yield this result. So we have released the model, and I encourage you to play with it and ask questions if you want to run something like that.

AMY KENDALL: My curiosity came just from there, looking at the model and trying to do runs on my own. I was wondering how I would arrive at different parameters. Thank you.

WILL ANDERSON: I just have a couple more slides I want to roll into before the break, and then we will take any additional questions. We were looking at the total plan area results, and these are -- it is a composite of the three rivers, the three reservoirs, of instream flows, the three tributaries, and the total volume diversions at the upper left.

As Les pointed out, the baseline in 20 percent are kind of the closest to each other, where 40 percent is a greater cut to diversion reliability, and there is some differences that you see on each river based on

their specific attributes there. And we see just the bottom left is the resulting February through June flows on the San Joaquin River at Vernalis, and then in the lower right, we see the total February through June flow as a percent of unimpaired flow for each alternative.

And I would like to point out, this is fairly interesting that the resulting flow at Vernalis is, in some years, less than the percent unimpaired. One of those reasons is that the Vernalis unimpaired flow is kind of its own subject, and essentially we see some years that are higher than that and some years that are slightly less than that because the flows that we are allocating in the proposal are the 40 percent unimpaired flow at each of the tributaries.

So the grand total -- we have already seen the 30, 40, and 50 percent reductions in surface water diversion. Another -- this is a more blown up way of looking at that that shows the 35 percent and 45 percent -- so the 30 to 50 range. At the bottom, you can see the 30 percent is minus 149,000 acre-feet. 40

percent is 293; 50 percent is 465, just for future reference, if you would like to examine that.

So with that -- well, this is just by year type, the same parameter. I know it is getting close to lunch. I am going to just end that part of the presentation and

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take any additional questions. We have a couple minutes before the break.

DEREK HILL: Thanks. Will, can you go back to slide 92? I think on there you show what the average requirement is by year type, and I am wondering, have you looked at the daily values that cediac produces to see -- for example, let's take the wet for the 50 percent unimpaired. It shows an average of 2,500 TAF. What is the range in the seven-day running average for that condition? Is that in the SED? I haven't gotten through much of the SED. So I apologize if it is. I am just wondering what the variability is compared to the averages.

WILL ANDERSON: Right. This is the monthly average flows --

DEREK HILL: Right. But the proposal is to have a seven-day running average; right?

LES GROBER: That is correct. But we only run it with monthly averages.

DEREK HILL: Thanks.

ART GODWIN: Art Godwin. On the basin-wide analysis, the flow at Vernalis, was that a combination of CalSim on a main stem and the water supply effect model effects on the three tribs?

WILL ANDERSON: Right. So CalSim does have an input for the upper San Joaquin, and that is the same for each of all of our alternatives. So that does add to the result of the instream flows at Vernalis, and any return flows from the west side would also be included in that less any diversions to those downstream water users. That is correct.

BILL PARIS: Just a follow-up on -- Bill Paris, MID -- on Derek's question. So did I understand you guys right? You haven't modeled the proposal; is that correct? The proposal is not based on the monthly, and you are presenting monthly data. Have you modeled it in a less than monthly time step, and if so, can we see that data information?

LES GROBER: No. We only modeled it at the monthly time step for the -- because this is intended to be a budget of water, if you will, really. This is getting back to the adaptive implementation. We -- it is not -- we didn't do a daily model for showing this.

BILL PARIS: Is there a daily model available?

LES GROBER: Not that we have run except what we have run for temperature modelling.

WILL ANDERSON: The temperature model takes the monthly, and it runs on a daily time step. So there is some smoothing there, but it is essentially the monthly averages.

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LES GROBER: So, again, this kind of speaks to not being intended to optimize it. It shows what it could be if you look at it very broadly programmatically. So say for the temperature, of course you would see some other variations potentially, depending on how this is operated. If you had rigid adherence with a seven-day running average, you would expect to see somewhat different results. But we have looked at the monthly -- the very coarse monthly and then the coarse disaggregation of monthly and daily for the temperature effects.

BILL PARIS: Sure. But I guess I would flip that around and say from the impact perspective, modelling what you are going to require the regular community to comply with would be a more accurate picture of what those impacts might be.

LES GROBER: Are you suggesting that it would result in a different quantity of water at a seven-day average than on a monthly?

BILL PARIS: Yeah.

LES GROBER: Okay. You can provide that comment.

CHRIS SHUTES: Chris Shutes in response to Mr. Paris. For the Don Pedro relicensing, Dan Steiner built a dandy daily model, and if Dan would like to

modify it to allow us to run a percent of unimpaired, I would be thrilled to have the opportunity to use that to get more resolution. And I would note that Mr. Bergfeld from Merced did make that adjustment and, in fact, model proposals based on percent of unimpaired in the Merced relicensing, and it allows a lot greater granularity than the monthly model appears to. So I think that Mr. Paris'

interest is in his own hands or at least that of his
employer.

LES GROBER: And, again, I would -- we are happy to receive comments on this as part of the hearing in the written comments. So I appreciate all of the comments, but bringing it back to this is a programmatic analysis, and any such comments would have to demonstrate what different result one would be expecting to achieve and how it would be -- I can imagine in the details, it could be different, but why running this on a monthly time step is insufficient, one, to demonstrate what can be achieved broadly in terms of temperature improvements and broadly in terms of the water supply effects.

WILL ANDERSON: While they are preparing that mic, we are cutting into our lunch break a little bit. So I guess we'll take one more and break. We will have a chance to come back to any of this material, if we wish, after discussing the temperature model and so on.

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But go ahead, Lee.

LEE BERGFELD: Thank you. It is kind of a follow-up on the monthly versus daily as well as tiering off of Mr. Sherrick's comment earlier about the accretions in the local flow and their contributions to meeting the requirements.

Any analysis -- I understand you didn't do it daily but the water supply effects model currently assumes that 100 percent of that local flow could meet any minimum requirement or any canal demands if it comes in above the canals.

Any analysis just, kind of, looking at the daily variability of some of those local inflows that would lead to that assumption, that all of it would be available? It is not quite going to the level of detail of doing a full analysis on a daily basis, but I would question the assumption that 100 percent of it, when you are doing a monthly model, would be available. So I guess a question of whether it was looked at and a suggestion if it wasn't.

LES GROBER: And let me just understand the question. Say, for some of those accretions if it is, say, side flows are from a tributary, a smaller tributary, it might have a peakedness for argument's sake that could exceed, say, the 40 percent for, say, a short

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period of time but then not for the rest of the time; is that what you are referring to?

LEE BERGFELD: That is correct, Les. So, for example, on the Merced, there is a dry creek flow that comes in above Steavenson as well as other local flows, but that is one in particular. It is a drainage rainfall -- a runoff-driven drainage. So it is definitely more peaky than just a steady base flow that you can always count on being in the river.

LES GROBER: Sure. I mean, that is an interesting thought. And I will restate that we did the monthly time step modelling, and the modelling is used as comparative purposes for the baseline and the others. So, you know, a lot of things get lost in that averaging. It wouldn't necessarily be a detail that would be -- though interesting, I'm not sure how important, but please provide the comment.

LEE BERGFELD: Sure. Will do.

And one other, I guess, kind of follow-up comment because we have talked a lot about that the analysis was not done to optimize anything. But I think a lot of folks were kind of questioning things in terms of carryover storage and the maximum draw. And more of the question while we didn't optimize -- and I don't think that is a requirement under the CEQA document to

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look at the environmental impacts.

The question more being, "Did we analyze the effects of the proposed project?" And there is some things in there that are a little unclear in the SED as to what is the proposed project and what is not.

Although it is very clear -- and you have been very transparent about what was analyzed. And so I think that is driving a lot of the questions. That is a comment that you will see. I just wanted to make it clear as to context, I think, to a lot of the questions and the discussion that we have had this morning, which has been commented on.

LES GROBER: Great. Thank you.

GITA KAPAHI: So with that, I would like to propose that we break for lunch. If we could come back at 1:30 on that back clock, which would give you 55 minutes. Is that okay with everybody? Perfect. Thank you so much.

(Whereupon a lunch break was taken.)

LES GROBER: Welcome back, everybody. Everyone

-- for those you on the web, everybody -- there is about 15 of you folks here. Hopefully you have had a chance to grab some food out in the lobby from the holiday party. So we will commence with part two.

Any questions before we get started?

Seeing none, we will jump into the temperature modelling.

WILL ANDERSON: Thanks, Les. So earlier today, I mentioned in some of the discussion about the benefits of flow and the flow shifting and what happens in spill years and so on, I suggested that we will be showing that this afternoon, and we are. So this is the part where we discuss the HEC5Q temperature model and just a couple snapshots of the results that we get. Okay?

Can we get it up on the screen? Okay. Thank you.

This is just an intro slide here. So talking about the temp model, this will be a little more impromptu. And I really appreciate all of the good appointed questions, and we can continue to do some clarifying as we go along here. It has been a good discussion in terms of time. It probably won't take very long to go through these, but I am going to stop at each slide and go ahead and welcome some input and discussion on each of these dynamics.

So the temperature model, let me tell you a little bit about the background and how we used data from the water supply effects model. The version of the temperature that we are using was originally configured to use the CalSim node structure and inflows and assign them to specific cross sections of the temperature model. So WSE essentially mimics that. We will see about that, how that works. We are going to show some results and just some specific dynamics.

Now, we have got 34 years of temperature data, which in a six-hour time step is a huge, you know, DSS file of information, and we have to process that and look at how we are -- the change from the alternatives, see the effects of spills, the effects of flow shifting, other notable effects.

But for the SED and for the temperature effects and the potential benefits, we have rolled this massive dataset into some summary statistics, and Dan is going to talk a little bit more about that this afternoon. I am going to try to show visualizations of time series of temperature so we can get an intuitive feel for the examples of how operations of different flows and different storage levels of the reservoir affect the instream conditions.

So HEC stands for U.S. Army Corps of Engineers Hydrologic Engineering Center. They have got a suite of different hydrologic assessment models. You may have heard of HEC graphs. These are different ones. This one was designed for reservoir operations and instream temperature effects. The particular lower San Joaquin

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basin application was peer reviewed in 2009 as part of a CALFED project. There was more recent updates in 2013 by the California Department of Fish and Wildlife. These reports are referenced in appendix F1 and are part of our record, if you would like to see more about how our temperature model was developed.

The version we are using -- like I said, we use stream flows from the CalSim flow balance, which we are substituting in the WSE model flows, which use the same foundation and the same physical structure. So how do we do that? I will give Tim credit for this slide. In representing the system, the four major parameters that are passed over from the water supply effects model here are the boundary inflows, the storage conditions, and the evaporation. So it is water that has been no longer in the reservoir and also the result instream flows as a function of the operations.

We also have the upper San Joaquin boundary, as pointed out by Mr. Godwin, and we will evaluate the temperature in the three tributaries for this presentation. So the WSE model data is taken out of an Excel spreadsheet. There is a little plug-in that you can get for Microsoft Excel. It is called the DSS add-in. You can take any time series and put it into the -- the DSS is the HEC data storage. It is basically

a database visualization program for large data sets and large time series.

So we will get that monthly average WSE data, and it will then be transformed back into the CalSim notation for each node that it represents. Then there is a preprocessor written by Don Smith at RMA that then converts the monthly CalSim values to a daily time stem.

And there is a little bit of smoothing that has to happen with the reservoir condition because you can do a monthly average flow. That works no problem, but if you go from a reservoir storage condition at A, and then a month later it is at B, you have got to draw a line between them. So it does that.

After we are at a daily time step, then the temperature model will have additional specified parameters and boundary conditions, such as the reservoir temperature profile, which will evolve with the time and the climate data, such as the ambient air temperature, wind speed, and the local inflows.

The HWMS is our name for the interface. That is the RMA system. It is basically a graphical user interface that will help set up runs for the model to look at the system schematic, and we will see a picture of that in a second. The run files describe what years you are running and what time step and so on and the

means of the output files, et cetera. So this is all of the nitty-gritty details, but I am not going to talk about that for too long because we want to talk about some results.

So this is a picture of the same three-river structure as shown in the interface with example cross sections pointed out. These are actually the river miles. I don't know if there is a particular river mile scheme on that, but essentially it is the same physical system we have been talking about this morning.

This is a little more detail of where the specific nodes are in the model through the reservoirs; particular locations of interest, such as the major diversion dams -- Goodwin, La Grange, Crocker-Huffman -- some compliance points of interest, such as Orange Blossom Bridge, Knights Ferry, Oakdale, Ripon, and Stanislaus. We have got Basso Bridge, Highway 99, Tuolumne, Shaffer Bridge, Cressy, and Steavenson on the Merced.

So, again, I am just going to show a couple snapshots of the results here. Basically, we have got the same alternatives from the WSE that were set up in the temperature model baseline. We talked about the baseline conditions. We have got 20, 30, 40, 50, and 60 percent of unimpaired flow from February through June and all that entails in terms of flow scenarios.

The outputs are a six-hour time step, and we have got it from 1970 to 2003. This essentially ends -- well, at the end of the CalSim time frame, we have extended this --

Go ahead.

Right. We have provided -- we did some work to take WSE to the end of the CalSim time period and extend it through the most recent drought. And we didn't have all of the accretions and the depletions for this time period because CalSim hasn't been updated.

The main driver for this system for all of the dynamics is the Rim inflows. But -- and this is a big but -- and there is -- it is the reason why we didn't use any of the extended output as a basis for the findings of the effects analysis. Because everybody wants to see what it looks like if you run up to 2015 and go through the most recent drought.

If we make the assumption that the accretions and depletions, A, are fairly minor and, B, can be represented by similar year types from the historical records that we do have, then we can see how the system works up to 2015. I won't put a lot of weight on that. We have updated the HEC5Q model to 2010.

So I would advise caution in using that for

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those reasons that I have specified. If someone went and updated CalSim and had a complete set of accretions and depletions for all of those months, that would certainly be an improved result. We have not evaluated the adequacy of those surrogate years and how well that might represent the actual accretions and depletions, but it is useful to look at to see the potential system operation with those caveats.

Go ahead.

UNIDENTIFIED SPEAKER: All right. Just to clarify, those results were used for the SALSIM fishery's population models?

WILL ANDERSON: Yes.

UNIDENTIFIED SPEAKER: Thanks.

WILL ANDERSON: We will have a little more discussion of SALSIM a little later on.

So once we have run each alternative, we pull the results back into Excel using our DSS add-in, and we process the six-hour temp data and derive the -- out of the daily average, we then will have the seven-day average of daily maximums, which is useful for comparing to that EPA temperature criteria. Although the plots we see today will be the seven-day average of the daily maximum plots --

Go ahead, Mr. Godwin.

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ART GODWIN: Art Godwin. So for this modelling exercise, you took monthly data and converted it to daily and then the temperature model and converted that to six-hour time steps and then you took six-hour time steps and made that seven-day average daily max temperatures?

WILL ANDERSON: Right.

ART GODWIN: Okay.

WILL ANDERSON: So I am going to show a couple slides that just illustrate the benefits of instream flow or the change in the alternatives of what happens. On the top of this plot, we see the Tuolumne River at Modesto. This is the downstream reach flow from the water years 1990 to '94.

So the top slide shows -- in the solid line, we see the baseline flows in this dry year period that we have seen in some of the other slides in the previous presentation. We do see the wetter year in '93, and then for the dotted line, you see the alternative results for the 40 percent alternative flow scenario.

And on the lower plot, the baseline is again the solid line. It is a seven-day average of daily maximum temperatures at Modesto. And so we can clearly see the seasonal trend of hot in the summer and cold in the winter. The key change in the model is in the months February through June -- and we are going to zoom into a specific example of that in the year 1991.

And here we see a really big difference in the seven-day average daily maximum. I am not going to get into specific statistics, but these are all rolled up into how often they meet certain criteria and how often they are within a certain percentile distribution, et cetera, within the report.

Now, we can compare that situation in 1991 where we see a really good temperature benefit of the increased flow. This is a longitudinal profile, starting on the right side of the screen, with the release at La Grange moving downstream from right to left. We will see that the baseline condition is -- the solid line, it is warmer, and it warms quicker all the way down the confluence. The monthly average -- the seven-day average of daily maximum temperatures is around 70 degrees at the confluence for May of 1991.

And the dotted line represents the 40 percent flow alternative and also warming -- the warming more slowly as it moves downstream and the effects of the increased flow, the cold water there yielding a confluence temperature of -- a seven-day average of daily maximums a little bit greater than 60 degrees that reaches the San Joaquin.

Now, we can compare that to a series of wetter

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years here. In the case where the reservoir is full, it is spilling, and we are not releasing anything in addition to that as part of a 40 percent unimpaired flow alternative. So there is no change in flow. There is no change in temperatures when it is at the -- when it is spilling. And so, therefore, we see very little change in the temperatures, as we might expect. So it is -- the benefit is in dry years but not so much in wet years.

Next, we are going to talk about the dynamics of the reservoir storage levels that we have had a lot of discussion about. This example is Lake McClure and New Exchequer Reservoir on the Merced. The dry year time series starts out in water year 1990 through '94. So the top plot is of the reservoir storage condition at baseline at the solid line, and the dotted line represents the 40 percent alternative. We can see the difference between the baseline going between the 100,000 and 200,000 acre-feet condition, whereas the alternative is about 250,000-plus until 1992, when we have a fill and spill year at that point.

On the bottom plot, we see the temperature effects for the release out on Lake McClure. The baseline is the solid line again. And we see a much greater warming trend in the summer at a lower amount of cold pool, and the alternative is the dotted line, which

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shows less warming in the summer but quicker cooling -- or excuse me. The 40 percent alternative will be more full. So it cools less quickly in the wintertime as well.

On the -- by the time we get to 1993, there is no change because the reservoir condition is the same. So we can observe the '92 conditions -- change in conditions. For September of '92, again, the longitudinal profile release from Lake McClure and New Exchequer on the right-hand side, we see that the 40 percent alternative is at a higher, around a 300,000 acre-foot level, releasing at about a 55-degree average. Well, it is going to be a pretty consistent temperature there. Whereas the lower reservoir storage in September, it will be releasing at closer to 65 degrees. Now, there is not a lot of flow in September of '92, so they both warm very quickly and reach equilibrium not too far down the stream.

Next we can look at another month more towards the fill and spill area. In May of '93, the reservoir condition is slightly greater, in the 40 percent alternative. So it is -- but it is not as cold. But it warms less quickly as it moves downstream from right to left. The difference is between 45 to 47 degrees Fahrenheit in May. And with less flow, it warms very

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quickly; with more flow, that cold water is propelled downstream.

Are there any questions up to that point? I am just going to look at some more temperature plots.

Lee, go ahead.

LEE BERGFELD: Will, just a point. There is a minimum pool requirement in Lake McClure, which I know is not reflected in the baseline, but when you see these operations through the critical drought sequence, I don't believe the reservoir would be pulled down as low as it is coming down in the baseline.

The water supply effect model considers the 115 as a target, but in Merced's FERC license, it prohibits the release of water when storage is below 115 for anything other than the minimum flow requirements in the FERC license.

So, you know, just as a comment, as you look at these and you think, "Okay. We need to have this higher storage to prevent the temperature condition that you are predicting in the bottom in the baseline," I don't believe that temperature condition -- particularly as a release temperature out of Lake McClure -- is representative of the baseline because of the way the water supply effects model is simulating Lake McClure storage.

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Does that make sense?

WILL ANDERSON: I will have to chew on that for a little while. I value the input and the insight. I think in the most recent drought, we have seen some very low levels, and I'm not sure whether that is consistent with the comment.

LEE BERGFELD: That is a good point and, true, if there was a request for relaxation that went to both FERC and the state board in order to draw down the reservoir. But it is a requirement in the FERC license for Merced to maintain 115.

I would be happy to follow up with you. I can provide you the reference to the FERC license articles.

WILL ANDERSON: I would like to see how it comports with what you are saying.

LEE BERGFELD: Absolutely.

AMY KENDALL: Amy Kendall, HDR. This question doesn't have to do with carryover storage. It has to do with the inputs. I didn't see anywhere in the SED where meteorology was described. Can you verify which meteorology you used?

WILL ANDERSON: Well, let me get back to you on that.

AMY KENDALL: Okay.

WILL ANDERSON: I am happy to.

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LES GROBER: Anybody else? Do we have that information?

DAN WORTH: Wouldn't it have come from the HEC5Q temperature model?

WILL ANDERSON: I would hate to speculate on the record, but the source -- the original source of the temperature model was the DFW version. And so I would have to verify that it is that set of meteorological criteria -- inputs.

AMY KENDALL: You are referring to the CDFW, 2013?

WILL ANDERSON: That is what I am referring to. I would have to verify that.

AMY KENDALL: Okay. Earlier you cited a CALFED 2009 peer-reviewed version. Is the meteorology different? The reason I am going into this question is because much of the variability in temperature we are seeing -- because we are only modelling monthly flow, we are getting all of the sub-monthly and the sub-daily variability that is being analyzed from the meteorology.

So it is very important to verify that it has been calibrated, and it is very important to make sure that -- well, that the model was set up to account for a monthly average flow.

From what I understood and what I read in the

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CALFED and the CDFW 2013 report, they used daily flows in their calibration. And I just wanted to confirm their meteorology as well. So twofold, was the calibration verified for this set of results?

LES GROBER: Question/comment noted. We will try to get back to you offline, and please provide the comment.

WILL ANDERSON: I would add that at this stage of comparative scenarios, that it is -- there is not a calibration specifically used to get to that point. You have to go compare it to the actual observed data in the calibration, and that would be part of the peer-review exercise. And then once we go to comparative analysis, our baseline is similar to the historical baseline.

But for the reasons we have mentioned earlier, it is for this long period of record, assuming certain conditions were as they were in 2009, et cetera. So it wouldn't necessarily be expected to have the same events. But meteorology is actually a little more straightforward than that because we do have the historical meteorology, even if the flows are different.

And in terms of flow variability, flows do change sub-daily, but I would say that there is a little less variability in the flow from day one to day two than the inter -- between in the intraday.

I can't address that right now, but the accretion notes have been well noted.

Any more questions leading off of that?

Okay. So we have seen Merced profiles. Now we are going to look at the effects of flow shifting. Another look at Merced in the 1993 time frame, it was a very wet year. In the baseline alternative, there is essentially a spill, and the temperatures are maintained much lower later in the summer.

And then when we have the 40 percent alternative, in the absence of shifting any flow to the summertime, we do see a spike at that time because in the absence of flow requirements in the summer on the Merced, there is really not much flow. And so the temperatures are much warmer. So the effect of the project in this case, if we didn't shift flows, would be warmer than today's case.

Are we all in agreement? No?

UNIDENTIFIED SPEAKER: We would like to see that, and I think I have asked for that previously.

WILL ANDERSON: Okay.

UNIDENTIFIED SPEAKER: I'm sorry. I'm not trying to be argumentative, but I think we deserve to see the effects of the project and then the iterative steps you went through to mitigate for those problems.

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WILL ANDERSON: Okay. Thank you.

CHRIS SHUTES: I am Chris Shutes with the CSPA.

I have a question about what flow levels you used in the summer that you were -- that you got those big spikes.

WILL ANDERSON: Okay. Well, in Merced at summertime in the Steavenson, it is very close to zero flow. That is, I think, a reality that we see out there.

LES GROBER: But we operated to meet existing minimum instream flow requirements.

CHRIS SHUTES: So those are the FERC flows?

WILL ANDERSON: The FERC flows and the requirement at Shaffer Bridge.

CHRIS SHUTES: Right. Okay. And so -- all right. I had a related question.

At what point in the river are you evaluating the temperature impacts and then making a decision that you need to make an adjustment, and how did you determine that? Is it Shaffer or somewhere else?

WILL ANDERSON: Well, we are looking at various points along the river, and Dan is going to get to this next. So there is no -- I guess I should let him answer that.

DAN WORTH: So in chapter 7 of the SED, we did evaluate changes to the temperature throughout the summer time period. And -- but going back to the iterative

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process, I think we considered changes everywhere in the river during the summer time period, and some of that goes back a few years now. And it sounds like there is a need to try to show this iterative process a little bit better, but in chapter 7, the specific river locations and temperature criteria that were used are documented.

SAM RAUCH: Hi. Sam Rauch, NOAA Fisheries. If you get to this later, you can defer this question. But I would be interested in hearing about how this flow -- the flow that results from this assumed flow shifting relates to the modelling assumptions regarding meeting the October Vernalis flow requirement, which is still sort of a carryover from the current water quality control plan.

Basically, does the flow shift in water assume to contribute to that October Vernalis flow requirement?

WILL ANDERSON: Let's -- I want to get back to you on that, just to give you the correct -- to make sure we are all on the same page on that. So the flow shifting meets a minimum flow target, which in the case of the base case -- well, the flow shifting and -- let's get back to you on that.

So what we see when we then move some of the

spring flow to the fall -- so, again, we see the
improvements with the 40 percent flow alternative from

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February through June. Then we will shift some of that flow and eventually counteract that effect of the wet year. That is pretty much the essence of the flow shifting there. There is a lot of nuances to how it is implemented with up to 25 percent of the spring pulse but not usually that much to meet those targets.

But I welcome your written comments or questions.

Okay. So next I am going to show one more notable dynamic that really shows an example that at first makes you scratch your head and wonder what is going on in the model, but then it has a happy ending. And I am going to throw out a question to the audience to make sure that you are paying attention.

But Barb, you are not allowed to answer or anybody that works real closely on this working group.

Here we see the baseline temperatures at the release from New Malones in January through December of 1992. With the 40 percent alternative, the reservoir is at a fairly high level. Temperatures don't change that much in terms of the release, but we see something weird happening with the baseline release temperatures from New Malones.

Does anybody know --

UNIDENTIFIED SPEAKER: There is a water pool behind Old Malones that you are not able to access until the reservoir drops. And then you release that cold water, and it plunges the release temperatures out of New Malones. And then it quickly exhausts that resource, and the temperatures go back.

WILL ANDERSON: That is good. That is part of it. That is really key to the dynamics. There is a second step in here, which when I saw how the model was working, it is kind of encouraging.

And what happens as that drawdown happens and we are going from dropping below the level of New Malones? What is happening with the -- where does the water come from? Does anybody know? We will take it a step further.

Barb knows.

Can we get the microphone to Barb? I think she can explain.

No? Don't put you on the spot? Okay.

Okay. Well, I think what happens there is there is a lower outlet in the New Malones Reservoir. It is very rarely used. In fact, this is the only time frame that it was actually used, and I think that reportedly they are afraid to open the gates down there anymore for fear of not being able to shut them again.

But what happens when you go from a higher

reservoir storage level down to a lower one where you are starting to interact at that level, which is around -- well, it is greater than 75. But if we are somewhere between 100,000 and 250,000 acre-feet, they can no longer use the hydropower intake for New Malones. So they would have to withdraw that from the lower outlet.

And so they open the lower outlet and we get -- first, we get a spike of temperature as it is just using the warm water from the surface. And then we see a big drop as it pulls from the lower outlet. And then as that small amount is depleted, then the temperature goes up again.

So I thought that was an interesting observation of the temperature model actually knowing which outlet is in use and what the temperature is at that outlet. And there are slides from reclamation that they presented more recently to illustrate kind of -- and anticipate what might happen in 2015, if we hit extremely low levels again. But these were actually -- these were similar to what was observed in '92. So I thought you might like to see that.

This is -- in the green line, we see the elevation of the water surface in New Malones, and the red line is the time below, which releases from the lower outlet. So that is a complete explanation of that. I'm

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done. Thank you for abiding with that slide. I know your time is valuable.

So the next thing I am going to talk about fairly briefly is evaluation criteria and how they are compared to temperature model results. We basically use the -- for reference the US EPA Region 10 Salmon Guidance from 2003 for optimal temperatures based on a seven-day average of daily maximum statistics for various life stages. And Dan Worth here is going to talk more about that in a little while. But these are the basic criteria that we evaluate how much time are we either meeting or not meeting these criteria.

So the example of the Tuolumne from '90 to '95 is the same one. I just like to throw this up to remind us of the differences between the baseline and the 40 percent unimpaired flow. For the water year 1990, this is just a magnified view -- and I showed it last Tuesday -- of the difference between baseline and the 40 percent alternative.

Now, baseline is in the solid pale green line, and the 40 percent alternative is in the dotted line. And you can see the Delta or the difference between the alternatives. You don't see much in February, but you start to see it in March through May. And it gets to -- they both start to increase fairly rapidly in June, but there is a big delta between them, and you can also compare the lower to the higher of the criteria that Dan is going to talk about.

I want to give a visual of this for one year because then it helps to think about how they roll up to -- once you look at 34 years of this data just to keep in mind what kind of -- what the year looks like. If you look at a year where the flows aren't very different, like a very wet year or a spill year, there is not much change in the temperature, but there can be a big change in the temperature and the amount of time of meeting these criteria within these certain months.

Now, taking that a little more downstream to river mile 13 in the Tuolumne, the 40 percent alternative is still either within or very close to the -- between the lower and the upper -- I mean, near the upper criteria for the five stages, whereas the baseline condition is warming very rapidly at that point. So we see the effects of both the cold water and the greater release.

Are there any questions about that or comments?

Okay. Just one more shot of a longitudinal profile for April of 1990, which is the same period that we were just looking at for the prior two slides. Basically the first one would have been at the 3/4 river

upstream location. It is denoted here. This is a monthly average now of the seven-day average of daily maximums.

The second one, the more downstream, mile 13, would be more of a 1/4 river on the left-hand side of this longitudinal profile. And we see the baseline is the warmest line followed by the 20 percent in the red dotted line. The green is the 40 percent, and the purple dotted line, the lowest one, is 60 percent. So you don't get that much more of a temperature benefit from increasing from 40 to 60.

I am not going to dwell on the following slide, which is kind of the statistic rollup. The green squares indicate the benefit or increased number of days meeting this temperature criteria for each life stage. This is in the report. We had discussed the Merced in June on Tuesday, but I have got some extra slides if we have got time to discuss that.

So for further information on the WSE model and the HEC5Q temperature model analysis, I would refer you to chapter F1, and if there are still questions, please refer them to us and to me specifically. I would be happy to try to answer any additional questions.

AMY KENDALL: Amy Kendall. Are you aware of the model results at river mile 56.2? This is towards the

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downstream of the San Joaquin near the boundary condition. In the years 2005, 2006, 2009, and 2010, the temperatures in February through June oscillate from 35.6 to 104 degrees Fahrenheit. And did you see those model results, and could it be a sign of problems with model structure?

DAN WORTH: Can you specify where that is again?

AMY KENDALL: River mile 56.2 on the San Joaquin river. That is the node Mossdale. Any ideas about what could cause that sort of thing?

DAN WORTH: What year was that?

AMY KENDALL: 2005, 2006, 2009, and 2010.

DAN WORTH: And what months?

AMY KENDALL: February through June, nearly every day.

WILL ANDERSON: I can't answer that offhand, but I would be happy to look into it.

AMY KENDALL: Thank you. Follow-up question, with the knowledge of that, does that have any effects in the CalSim model that you are aware of?

WILL ANDERSON: I believe we are going to have a little more talk about CalSim in a little while.

DAN WORTH: Yes. Yeah, we will. It certainly would if that is being input into the CalSim model. It would affect potentially baseline conditions if it is

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occurring in baseline and also --

AMY KENDALL: Yeah. It occurs in all of the alternatives.

LES GROBER: Okay. And just to make sure, that is on the San Joaquin River?

AMY KENDALL: San Joaquin River, mile 56.2, and it was in all of the alternatives and the baseline. So I was a little alarmed when I saw a little model instability and concerned about model structure.

LES GROBER: Thank you.

ART GODWIN: Art Godwin. While we are on the subject of the San Joaquin River, I notice that you didn't show any results of the temperature model on the San Joaquin River. And from what I read in the SED is the temperature targets are almost never met.

DAN WORTH: That is correct. In the San Joaquin River, the temperature targets that we used, specifically this multiplication criteria, are not improved. There is no improvement in meeting the 57 degrees, and there are improvements in average temperature. So there is reductions in average temperature. There is reductions in the 90th percentile temperatures, but that really low criteria of 57 degrees for smoltification is not improved until you get to, I think, the 60 percent alternative. I think we saw some improvement.

WILL ANDERSON: Right. There is some at 60 percent.

DAN WORTH: Yeah.

AMY KENDALL: Dumb question, so where is the fish benefit?

DAN WORTH: We see small improvements in that criteria under the 60 percent alternative, and we see improvements in -- or we see reductions in average temperatures in April, May, and June under the 40 percent alternative. We see reductions in the 90th percentile temperatures in roughly March through June under the 40 percent alternative. So although those lower criteria aren't met, reduction in the highest -- the warmest temperatures is likely going to have positive benefits to fish.

AMY KENDALL: Well, the fish benefit is really

measured as a change in temperature and nothing else? So
you don't look at actual effects on the fish or the fish
populations? It is just if it is colder, then that is a
benefit?

DAN WORTH: Not necessarily.

LES GROBER: Well, looking at the increased
frequency of achieving certain temperature thresholds
that are beneficial of various lifetimes --

AMY KENDALL: Well, that is the same thing I

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just asked, only you are looking at it over a broader
time.

DAN WORTH: To just clarify, if the average
temperature was 100 degrees and we reduced it to 99
degrees or 95 degrees, that would not benefit salmon. So

the changes in temperature have to be within the range of temperatures that are a potential benefit to salmon. So we considered changes to temperature and considered if those changes were within ranges --

AMY KENDALL: Right.

DAN WORTH: -- that were beneficial to salmonids.

AMY KENDALL: But you looked at it as just a percent. So if it meets this temperature for X percent of the time as opposed to Y percent of the time, then that is better?

DAN WORTH: Going back to temperature criteria, if those good -- those protective temperature criteria are met more often, we did consider that to be beneficial.

AMY KENDALL: Right. But you didn't actually analyze the effects on fish or fish populations? It is just that if you met this temperature, then that is better?

DAN WORTH: If you met protective temperature

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criteria more often, that was considered better.

VALERIE KINCAID: Valerie Kincaid, San Joaquin Tributaries Authority. I have a couple questions about the flow shifting that we talked briefly about. And I think mostly they are clarifying questions. The flow shifting that you went over in your slides was not under an alternative. It is flow shifting within the model; is that correct?

WILL ANDERSON: The flow shifting within the --

within the alternatives that are represented in the model results for the 40, 50, and 60 percent of unimpaired flow incorporate an aspect of the adaptive implementation that moves that February through June flow to the other months to meet the streamflow targets that are specified in the model for that -- what is required to -- or what is determined to meet the objectives of the flow shift.

I don't know if that answers your question.

VALERIE KINCAID: Yeah, it does. So it sounds like that is part of the model. So there is no flow shifting built into the model?

My question is: What are the triggers for that flow shifting? When does it happen? How often does it happen? And how did you develop a mechanism to add flow shifting outside of the February through June period, which is kind of outside of the project period, into the modelling results?

WILL ANDERSON: It was -- so that is the major iterative step after the first -- the unimpaired flow alternative without shifting. When the observations were made that there were higher temperatures at certain times, certain months, and certain year types, then after those temperature results were observed, then flow shifting implementation was derived in the WSE that specified flow targets for those months and those year types to eventually fix the temperature impacts that would occur.

VALERIE KINCAID: Was there a threshold? I mean, the way the model works, is there a threshold at which point flow in the February through June period makes temperatures so high at X point, and then at that X point -- that trigger point we have got a flow shift? Can you tell me what that point is or what would the temperature -- I guess what the temperature would be?

When you see a certain temperature -- I mean, I am assuming what you are saying when you say "iterative" is you run it with the February through June modelling, and then you see temperatures that are too high. And so you say, "Oh, we don't want that. So we are going to flow shift. We are going to move some of the flow outside of that period." What is that trigger

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temperature?

WILL ANDERSON: So I would answer your question

by saying, no, there is not a trigger temperature. It
was -- we see the magnitude in duration of increased
temperatures above baseline in the year types, and it is
different from each river. And so these were -- the
amount of that flow target was determined through trial
and error to find a certain number of CFS -- a certain
flow target in that month for that particular river that
essentially would reduce the amount of time that the
temperature criteria would not be met and reduce that so
that the project effects would not cause a negative
impact.

VALERIE KINCAID: Okay. And then one other
follow-up question --

DAN WORTH: Just to follow up on that, the
temperature criteria that we were looking at are the same
temperature criteria that are described in chapter 7 and

chapter 19.

VALERIE KINCAID: Right. I guess I was just asking if there was a -- and I got my answer, but to that point, maybe it is not a temperature. Maybe it is a quantity of days that fall below the temperature requirement. Were you looking to, kind of, optimize at a certain point and a trigger? And it sounds like you said

you just kind of ran it until you came up with something that you liked.

A follow-up question, did you -- is there any modelling in the SED, or did you guys run the model? And if you ran it, did you disclose that it just showed only February through June unimpaired flow, or is there -- is there any run that doesn't include flow shifting? I guess that is a better question.

LES GROBER: Let me just jump in to see if I can add some --

Looks like you need some help over there. Okay.

VALERIE KINCAID: Thanks, Gita.

LES GROBER: There is some -- I think Will even showed a slide on this of some flow shifting when you are lowering reservoir elevations and you have then less need for spill. There is some flow shifting built in -- completely built in because you are not getting the benefit of those spills, and the colder water is part of those spills. That is why there is some built-in flow shifting, particularly at the higher percents of unimpaired flow and in wetter years, the above normal wetter years.

As I recall, most of that was happening even in the Stanislaus. So that is some of the built-in flow shifting. Beyond that, there was some additional

built-in flow shifting just because as you get, again, to the higher percents of unimpaired flows, there is some amount that you would need just to make sure that you are not making temperatures worse in the fall. And that starts happening at -- the 30, 35 percent and above is when we start seeing that.

So we just shifted some larger blocks of water to say, "Well, you can maintain temperatures where they were under the baseline condition." So it is something less than the maximum of flow shifting that is allowed in the program of limitations to assure that by obtaining these higher February through June flows, you weren't going to have an effect other times of the year with increased temperatures.

Again, this is -- it is intended to show that it is possible but not exactly the way it has to happen. Every year is going to be a little bit different, but that is why there is the allowance for above the 30 percent flow shifting of up to 10 percent of the amount over that.

VALERIE KINCAID: That is helpful. Just to be clear, that -- I am assuming that that means that is how you ran it, and there wasn't a run done without that input assumption.

LES GROBER: There is no run done with no flow

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shifting at all. Correct.
VALERIE KINCAID: Thanks.
DAN WORTH: I am just going to clarify that statement. So the 20 percent has no flow shifting, and the 30 percent has no flow shifting. So those two runs have no flow shifting.
LES GROBER: Yeah. Thank you for that. I just meant for -- nothing at the -- when you get above -- when you are starting at 35 percent and above, then there is some flow shifting built into each.
VALERIE KINCAID: And just out of curiosity, it is interesting that you said the lower percentage runs don't have them. Can you explain that to me, a little bit of why they wouldn't have flow shifting and why the higher flows would?
WILL ANDERSON: Well, it is because of the

perturbation in the system. The change due to the project by reoperation was not found to have the negative effects that we start to see in 35 and 40 percent alternatives. So in other words, it wasn't necessary to do that because you don't see as much reduced spill, and the amount of time that the temperature criteria are met did not appear to be as drastic.

And in response to runs and disclosure, there was a lot of prior work that we released as part of the

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O'Loughlin Paris record act request. And there is some runs where these parameters, I believe if I am correct on this, would have been adjusted sometime ago in the runs in the B8 and B9 temperature series that were included on that thumb drive.

I am not directly familiar with what was done there, but there is quite a bit of work that has been disclosed. We did go back and revisit this recently with the latest model WSE. Because all of that was done with a water supply effects model version -- prior version that we then have continued to, kind of, refine it and find the level of demands that we are comfortable with and all of the dynamics that we have done. And so we actually have done additional runs on that at that one slide.

Let's see. For the effects of flow shifting and non-flow shifting, here was something that we recently revisited with our latest model version, which would be apples to apples with what we have published, and I would be happy to disclose that.

Okay. Mr. Shutes?

CHRIS SHUTES: I am just making the observation that I understand what you did with the model, but it seems to me that you need to take some kind of swag at defining what the project is and what the criteria are

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that Ms. Kincaid pointed out, what the locations are that you are looking at, what the temperature thresholds are that you are looking at, and some kind of idea of how you determined this other than having a -- since your adaptive management group is not going to be able to look at effects after the fact, some kind of idea of how they are going to, you know -- a process to make a determination if, in fact, that is what you are going to do and if that is really part of the project. It really just doesn't seem like you have defined the project.

WILL ANDERSON: Thank you.

BILL PARIS: Bill Paris, Modesto ID. In response to Ms. Kincaid's question, you had mentioned -- somebody had mentioned minimum flows then in the summer and the fall months that you were looking for. Is that going to be a requirement? Is that sort of an assumption that with the carryover storage requirements that there will be flow requirements on the back end, that if they aren't met through the existing flow schedules that that shifting will have to occur, and those flows will have to be met as a regulatory matter?

LES GROBER: The program implication allows for the flow shifting for the -- say, for the 40 percent, 10 percent of that can be flow shifted. So it is not required, but that -- because there is so much variability in the system and uncertainty, it allows for that quantity, but it is not required. So that is getting back at this is to be managed as a block of water.

BILL PARIS: I understood. And I am not trying to be argumentative, but we had talked before about how, although it is not defined, there will be a carryover storage. I believe I have accurately characterized that. I am asking, even if we don't know the specifics, will there be a related minimum flow requirement?

I mean, again, not to be argumentative but it stands to reason that putting water in storage just to leave it there doesn't make any sense. So if we are going to have this carryover storage, there logically seems to be an implied obligation that at the appropriate times, there will be a higher flow requirement on the back end. And I am just asking if you can kind of --

LES GROBER: There is not envisioned to have a specific flow requirement associated with that carryover.

BILL PARIS: Okay. Thank you.

LEE BERGFELD: Lee Bergfeld with MBK. On the issue of flow shifting, any consideration of how flow shifting interacts with the flood control requirements of the reservoirs? And where I am going with that is in looking through the water supply effects model, it

appears that on the Merced in wet and above normal years, there is always a volume of water that is shifted.

And that can occur even in years when, through the February through June period, the reservoir is at flood control levels. So the ability to "store" that water and meet those shifting requirements at some point in the future, we are already meeting through spill the 40 percent requirement. We can't back off our release to hold that water into storage, and, therefore, it would have to come out of storage and effectively be displacing water stored by Merced MID for the purposes of shifting in the future months.

Any thought process on that? And it gets to some questions by Mr. Shutes and others about, you know, the implementation as you sit and try to figure out how are we going to operate through this and come up with a plan, I believe by January 10th each year, to operate and thinking about that shifting dynamic with the flood control diagram.

LES GROBER: That is an interesting -- please make that comment because I think if I am hearing correctly, there is concern with that. If -- you are saying there would be limited opportunity to flow shift without having some additional -- well, I'm actually not sure.

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I don't think that would fall out to the additional water supply effect. Because we would still -- I think we still -- that is part of the reason it is, perhaps, even overestimated in terms of that water supply effect. I don't think there would be, in the way you have described it, any additional effect. But it certainly is not -- it doesn't seem that it would be an optimal operation in some years, which is why in some specific years, there might be some alternate operation.

LEE BERGFELD: Yes. I guess just my question is whether or not that dynamic had been considered in the analysis. And then to clarify, the water supply effects model is releasing it every year. It is shifting this volume of water in any wet or above normal year, based on my review. That is my understanding. And so it is not overestimating the water -- it may be overestimating the water supply impacts, depending again on how this is actually implemented.

But it also may be overestimating the ability to shift flows if, through the implementation process, it were to be agreed that you can't shift flows when you are spilling at the reservoir. So something for consideration.

LES GROBER: Thank you.

WILL ANDERSON: Well, if there are no further
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questions, we are running a little bit ahead of schedule.

LES GROBER: I think this would probably be a good time for a break then and then start with the next module at -- by -- which clock is it? Let's start in about 15 minutes. So 5 until 3:00.

WILL ANDERSON: Thank you.

(Whereupon a break was taken.)

LES GROBER: Okay. Welcome back. Okay. Dan, it is up to you.

DAN WORTH: Good afternoon. My name is Daniel Worth. I am a senior environmental scientist in the division of water rights, and today Brittany and Will and I are going to talk about three of the topics that are represented in chapter 19 of the SED. Specifically we will talk about the temperature benefits, floodplain benefits, and CalSim.

This project is designed to restore the pattern in some limited magnitude of flow that are more closely aligned to the conditions to which native fish species are adapted. The benefits of increased instream flows expected from this project have a functional useful effect and are evaluated and quantified in the SED in two key ways.

First, we evaluated increased detainment of beneficial water temperatures for salmonids over space, more river miles, and time -- more days. Second, we evaluated increased flood inundation also in space and time, meaning more acreage is inundated more of the time, thus benefitting growth and survival of juvenile salmonids.

Water temperature is one of the most important habitat features there are in the San Joaquin basin for native fish. Water temperatures affect behavior, disease, predation, migration, reproduction, growth, smoltification, and having habitats like floodplain or spawning areas are not useful unless temperature conditions are adequate within those areas.

To evaluate potential temperature benefits of the proposed project -- we evaluated temperature benefits of the proposed project. We evaluated temperature statistics in three primary ways. We used the US EPA temperature criteria as a benchmark to evaluate improved temperature conditions. We also evaluated potential changes to average temperatures and changes to the 90th percentile temperatures. First, I will walk through how we used the EPA temperature criteria to evaluate potential changes to habitat for salmon and steelhead.

So we are looking at all of the days in the month of May between 1970 and 2003 at river mile 28.1. And this is a distribution of those seven datum

temperature results. And for this example, we used the EPA's core rearing juvenile criteria of 60.8. You can see from this figure that under baseline conditions, 59 percent of the days in May were less than 60.8 degrees Fahrenheit. This figures shows how the distribution of daily temperatures looks under the 40 percent alternative. Now, you can see that 98 percent of the days have a temperature that is less than 60.8 degrees Fahrenheit.

This figure shows the data for both baseline and the 40 percent unimpaired flow. The shift in data going from baseline to 40 percent unimpaired flow shows that the criteria of 60.8 is met an additional 39 percent of the time. And there is supposed to be a box there that shows you the math, but it disappeared.

So the way this is shown in chapter 19 it looks something like this. The red box on the left shows that temperatures were less than 60.8 degrees Fahrenheit 59 percent of the time during May at this river location. The red box on the right shows that under the 40 percent alternative, temperatures less than 60.8 degrees were met an additional 39 percent of the time. And these numbers are additive. So under the 40 percent unimpaired flow alternative, the temperature criteria are expected to be met 98 percent of the time.

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The table also shows other months and other unimpaired flow scenarios. So I am not expecting you to try to read this, but in chapter 19, you can see this table. It is table 19-6. And I just wanted to show you that that data presented on the last slide is the data that is within the blue box. And that same shift is indicated by the red boxes.

So this data is within the blue box, and this bigger table shows additional months that -- and additional river locations. It shows the confluence at approximately 1/4 river, 1/2 river, 3/4 river, and the dam release going from downstream to upstream. And it is read the same way as that last table. So it is the amount of time that the criteria was met under baseline conditions and then under different unimpaired flow scenarios.

So we showed many river locations, and we showed all times of the year. And we did this for all of the rivers, including the San Joaquin River. The green boxes represent improvement in the amount of time that the US EPA criteria was met, which is greater than 10 percent improvement. So if an alternative met the criteria an additional 10 percent of the time, we highlighted the box green. And if it was met 10 percent less often, then it would have been highlighted red.

ART GODWIN: Art Godwin. I noticed you have temperature improvements in, say, September, and I am wondering what the source of that is. Is that from flow shifting or -- because we are only talking about a February through June flow requirement. So how do you get benefits in September?

DAN WORTH: Yeah. Some of that, if not all of that, is related to flow shifting and possibly shifting a little bit more flow than we needed to shift to exactly match baseline.

ART GODWIN: Thank you.

DAN WORTH: Now, I will just show how we evaluated changes to average temperatures.

UNIDENTIFIED SPEAKER: So we don't think any

part of that improvement in the non-February through June
could be from the carryover storage increasing?

DAN WORTH: Yes. There is potential
improvements from storage. There is potential
improvements from flow shifting. Flow shifting does
increase storage by default.

UNIDENTIFIED SPEAKER: That too.

DAN WORTH: So it is a combination of factors.

Now, I will discuss how we evaluated changes to
average river temperatures. So this is the same data
that we looked at before except now we are going to look

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at changes to average temperature. Under baseline
conditions, the average river temperature in the Tuolumne

River is 59.6 degrees Fahrenheit at this location. Under the 40 percent unimpaired flow scenario, the addition of flow to the river causes average river temperatures to get colder. The average shifts to 55.9 degrees Fahrenheit, and that shift is illustrated here. It is 3.7 degrees colder.

That shift in average river temperature from the previous slide is shown here by the red boxes, and this is an additional table in addition to that last table. Again, all months and multiple river locations are shown in chapter 19. In this table, the green cells that have shifts of one degree or more are highlighted green if they are one degree colder, and they are highlighted red if there were changes that were one degree warmer.

Now, we are going to look at how the 90th percentile temperatures were evaluated. The 90th percentile temperature represents the temperature in which 90 percent of the data is below and 10 percent of the data is above. This provides useful information about the hottest temperatures that fish may experience over some given time period.

Under baseline conditions during May at river mile 28.1, the 90th percentile temperature is 66.2

degrees. Under the 40 percent flow alternative, the 90th percentile temperature shifts to 59.4 degrees, and that is a shift of 6.8 degrees. This table shows all months and all river locations that were evaluated. Again, the confluence, 1/4 river, 1/2 river, 3/4 river, and then the dam release. The red boxes show that same shift as the previous slide.

And on the Tuolumne River, we see particularly large reductions in the 90th percentile temperatures. So there is big reductions in the hottest temperatures on the Tuolumne.

So in summary, there is potential for big improvements in temperature conditions from increased flows. These results include no optimization. Optimizing flow shaping would improve temperatures for key life stages. US EPA criteria were used only as a benchmark and are not proposed as objectives.

Now, we are going to move to floodplains. Floodplains have been shown to be extremely important to native fish. They can improve food availability, predator avoidance. They can result in faster growth and better survival of native fish species, such as the Sacramento splittail spawn, on floodplains between

February through June. We used floodplain versus flow relationships, such as this one, to evaluate potential

improvements to floodplain inundation to the proposed project.

These relationships were developed by the U.S. Fish and Wildlife Service for the Stanislaus and Tuolumne rivers and the State Water Board developed the relationship for the Merced River and CBEC at the request of FISHBIO developed these relationships in the San Joaquin River.

The exceedance table shows one of the ways we evaluated floodplain inundation benefits. On the left side of this table, we show a series of increasing flows.

The next column shows floodplain acreage associated with those flows. These acreage values were estimated by the groups identified on that previous slide.

Now, if you look at the red box on the left side, I will walk you through how this works. The red box that shows 17 percent means that monthly average May flow was greater than 2,000 CFS 17 percent of the time under baseline conditions. We can also say that 17 percent of the May months have a monthly average floodplain inundation greater than 305 acres.

The other red box shows that this flow and the associated floodplain acreage is now exceeded an additional 51 percent of the time under the 40 percent unimpaired flow scenario. Under this scenario, monthly

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average May flows are greater than 2,000 CFS 68 percent of the time. So again, those values are additive to the baseline. That is the increase or the change in the amount of time that those flows are exceeded. And you will notice there is a stepwise increase in the potential for floodplain improvement as you go from 20 to 60 percent.

The blue box with the red squares on this table shows the information that I have presented on the previous slide. So chapter 19 shows the same information for all months from February to June and for all river lo -- all rivers -- the Stanislaus, the Tuolumne, and the Merced and the San Joaquin River. And you will see from this slide that most of the potential for floodplain improvement, as we modeled flows, occurs from April through June.

This is a figure that summarizes floodplain benefits using a metric called "acre days," which is simply the number of acres inundated per day and added over some time period. This figure shows the annual average acre days from April to June on the Tuolumne River over an 82-year time period. This shows the same annual average acre days of inundation on the Tuolumne River except this shows just the drier water year types.

We typically see the warmest potential

improvements in floodplain inundation during these drier water years. There is potential for large increases in floodplain inundation, especially in dry years. Results are not optimized for floodplain habitat. Bigger results are possible from flow shaping, and flows can be optimized to achieve desired water depths and durations of inundation through that optimization process.

Now, I am going to turn it over to Brittany to talk about CalSim.

BRITTANY KAMMERER: Hi. I'm Brittany Kammerer. I am also a senior environmental scientist here at the water board with the division of water rights. So I am going to briefly go over SALSIM and the simulation model that was developed by the California Department of Fish and Wildlife. So it is something that we looked at in the SED, but it is something that we didn't rely on. So I am going to go over the reasons for that.

So just to give a brief model overview, it tracks daily growth, movement, and survival of Chinook -- fall-run Chinook salmon in the San Joaquin as a function

of flow temperature, predation, and other factors. It was designed to estimate changes in juveniles produced by each tributary in a series of modules, and these also include total juveniles out migrating to the Delta, total juveniles entering into the ocean, and also total adults
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returning to the tributaries.

So this is also discussed in the SED. There is some -- yeah. There is some limitations of SALSIM. So I am going to go over what those are to clarify the understanding of limitation. So the first four years are priming years, and I will discuss these in the next few slides. There are also increases that include an ocean crash, which affects adult returns during 2005 to 2009.

And the data used to construct the model has many uncertainties. So there is a number of uncertainties, meaning, for example, the rotary trap data, there is a lack of confidence in that and also some of the movement and survival data used to build the model. And these are some things we have discussed with the CDFW. So they will also be able to answer some questions.

Okay. So the first four years are priming years. So earlier we saw some slides -- or a slide highlighting the relationship between flow and fish abundance in the San Joaquin being related to flow 2.5 years earlier. So if you look at that relationship, it highlights how the first four years are priming years.

So I am going to try to point -- hopefully, this is clear. The 1, 2, and 2.5 years include those first 4 years of priming years. And so the first -- the fifth year is really the first year where you can really accurately use the model. And somehow the last five year box disappeared, but those last five years reflect an ocean crash.

And so in the Pacific Ocean in 2005 and 2006, there was a large ocean crash in the Chinook salmon fisheries, and the fisheries actually closed in 2009. And those are based on the population life histories where returns come back year 1, 2, and 3. So the last five years reflect that ocean crash -- so you can see that in abundance trends in this graph. And this is also in the SED in figure 19-14.

So that is highlighted probably more clearly in this table, where the 16-year average used to build the model -- the 16 years used to build the model are reflected in table 19-13, where you see that 100 fish number that lots of folks have been talking about. And if you include the flow shifting, then the numbers are greatly improved. However, if you look at just those seven years that are effective, the numbers improve quite a bit. So they pretty much double.

So that is one part of why we didn't rely on SALSIM, and it was also not useful for the SED based on the conditions proposed in our SED. So the magnitudes of the flows are greater than the conditions used to build the model. And so these are some things that we have

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discussed with the CDFW.

So in its current form, SALSIM was also not very accurate with regards to temperature. So it is oversensitive relative to egg mortality. So for example, it begins to -- we began to see egg mortality around 13 degrees Celsius, which are actually great conditions for Chinook salmon eggs. And similarly, juvenile mortality is undersensitive relative to lethal temperatures.

So the model sees juveniles surviving at 30 degrees Celsius, which are actually lethal for Chinook salmon. So in its current form, it also underestimates the benefits of floodplain inundation during the spring time period. So it doesn't see the increase in acreage that occurs with increased flows.

So to summarize, we looked at the results that SALSIM produces; however, we didn't rely on them. And instead we relied on the results that Dan went over using temperature habitat to evaluate temperature benefits, so the US EPA criteria and also the 90th percentile criteria and also average -- averages. And, likewise, we used floodplain habitat to evaluate floodplain benefits, so primarily acreage.

And with that, I am going to hand it back over to Dan to summarize.

DAN WORTH: So I just wanted to take this

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opportunity to say that the focus is often on fall-run Chinook salmon, but I would like to remind everyone that there is other native fish in this basin. There is fish like sturgeon and steelhead and splittail that would benefit tremendously from improved flow conditions in the San Joaquin basins in the tributaries. And although we use fall-run Chinook salmon as an indicator species and they get all of the attention when it comes to press, there is a lot of other really important native fish species in the San Joaquin basin that we expect will benefit tremendously from this proposed project.

So with that, we will take some questions, if there is any questions.

VALERIE KINCAID: Valerie Kincaid, San Joaquin Tributaries Authority. I had a question about floodplain analysis, and do you use the 30-day modelling results for the floodplain?

DAN WORTH: Yes. They were based on monthly average flows.

VALERIE KINCAID: So then -- and you will -- this question will reflect my layperson's view of modelling and daily improvement. But does that mean that if you saw an acre day improvement in the month of June, you would count 30 days? Does that make sense?

DAN WORTH: No.

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VALERIE KINCAID: So if you are doing a monthly estimate and you see floodplain habitat improvements, my guess is you would either have to count it or not. So how does that work?

DAN WORTH: Well, the monthly average flow -- well, first of all, that exceedance table that I showed was based on monthly average flow. To calculate acre days, that monthly average flow gets assigned to each day in that year for that month. So if the monthly average flow is 2,000 CFS for a certain year, every day within that month gets that 2,000 CFS flow to calculate acre days.

VALERIE KINCAID: Okay. So you would count either an entire month of acre days or not?

DAN WORTH: You would calculate an acre day for every day in that month, or you would calculate acre days for every day in that month.

VALERIE KINCAID: And they would be the same quantity of floodplain inundation, wouldn't they? I mean, you wouldn't have one day being higher or lower than the next if you have a monthly?

DAN WORTH: Yes. Every day would be the same.

VALERIE KINCAID: Right. Okay. And then I know this was touched on in another hearing, but can you talk about whether or not or maybe why -- why didn't you look

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at other aspects of floodplain inundation, like duration and depth and that kind of thing and if you think that is important or not or if all floodplain days are created equal?

DAN WORTH: So we didn't look at duration because we used monthly average flows. So we couldn't evaluate, you know, how often something happened for a ten-day period. So we didn't look at that specifically. And in terms of depths and velocities, this is a big programmatic evaluation over an 82-year time period, and with the flow optimization we talked about, you could try to inundate floodplains to certain depths and certain durations.

We simply tried to show that there is an increased potential for floodplain inundation under these higher alternatives. So the potential increases and things could be optimized in realtime.

VALERIE KINCAID: Thanks.

DORENE D'ADAMO: Dorene D'Adamo for the state board. I have a question about the different models for -- that were used for the San Joaquin and the Merced on floodplain inundation.

DAN WORTH: Okay.

DORENE D'ADAMO: Could you compare them?

DAN WORTH: So in terms of these relationships

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that were developed, I could discuss these more, if you would like.

DORENE D'ADAMO: Well, I am just wanting to better understand. They were done by different agencies. So are they the exact same, or are there differences in the approaches used?

DAN WORTH: So there are differences. So they all developed relationships like this -- floodplain versus discharge relationships. And the relationships developed for the Stanislaus and Tuolumne River were developed by the U.S. Fish and Wildlife Service. And the details of those studies are briefly described in chapter 19 and are cited in chapter 19.

And what the U.S. Fish and Wildlife Services did on the Stanislaus and the Tuolumne is used GIS techniques and provided some additional ground truthing. So it is kind of a mapping exercise with some ground truthing. And they took out things like ponds that are within the floodplain. So they subtracted things out that aren't necessarily floodplains. And then they simply calculate -- they determine where there is an inflection point in river width as discharge increases. So they figure out where a floodplain starts to spill out of a channel onto the floodplain and use mapping techniques to calculate the additional acreage that is outside of the

main river channel. CBEC did a similar type of study. I think they used LIDAR, but I would have to go back and look at exactly what data they used.

And then for the Merced River, we used cross-section data from the HEC5Q temperature model and calculated a similar thing that the U.S. Fish and Wildlife Service calculated on the other two rivers. We determined where there was an inflection point in channel width as you increase discharge and then calculated in-channel acreage of -- I guess just in-channel acreage and then calculated out-of-channel acreage. You can calculate floodplain acreage based on that.

And it is my understanding that on the Merced River, there will be a more detailed study at sometime in the near future.

What is that?

The U.S. Fish and Wildlife Service intends to do a more detailed study on the Merced River.

ROB SHERRICK: Hi. This is Rob Sherrick from HDR. A quick note on the acre days. Since you used a monthly analysis, it seems like it would make more sense to use a metric of acre months, just to be clear about how it was calculated to say that it is a monthly flow rate. It is an acre month, not an acre.

Do you think that you would get different results if you included a duration component, a depth component, and possibly a seven-day following the unimpaired index percent of unimpaired? Do you think that would change these floodplain inundation results and the changes that you see between the alternatives?

LES GROBER: Rather than speculate on what we would see, I just -- we want to bring it back to the program of implementation and the adaptive imputation component. This is meant to show at a programmatic level what you could achieve, you know, first for comparative purposes, baseline versus the alternative. So the things that you were describing would apply to, you know, each of those in terms of the -- some of the variability of the things that you would see.

But perhaps even more importantly, this is intended to be a quantity of water, a budget if you will, February through June to be shaped. So certainly by definition, you could achieve exactly this because if you wanted, you could achieve these kind of static flows on a monthly basis, but the thought is that you could actually achieve something much better by shaping the flows to just get the biggest bang for the buck for the limited quantity of water.

But, you know, comments like this are well taken to, you know, provide comments on thoughts and concerns

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that we would be -- are interested in hearing.

ROB SHERRICK: Thank you. The second part has to do with the metric of using the Tuolumne Fish and Wildlife Service numbers for the wetted area for acreage. In the relicensing process, an extensive two-dimensional hydraulic model was developed for the Tuolumne River, and I was just wondering why that wasn't used. It has very detailed information and actually goes a step further and develops usable area and not just wetted area. And so I just wanted to know about that.

LES GROBER: And you can provide, you know, comments on suggestions for things like that, but I keep wanting to bring it back to the programmatic nature of the analysis, you know, looking at the 82 years of data and the subset for the temperature modelling, things like that. There is, you know, many more detailed models. You have more detailed refined analyses, which I think could be useful for the actual operation, but this was intended to show very broadly what the effects and benefits could be.

DAN WORTH: Any questions about temperature, floodplain, SALSIM?

WILL ANDERSON: Or any of the other models for that matter. We will open the floor.

LES GROBER: I just wanted to refer back to a

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previous comment/observation about the temperatures for 2005, 2006, 2009, 2010. I think -- was that Amy Kendall that had made those comments? Thank you for those comments and observations, but when we had a huddle here, I just want to point out that that is some of when the -- that is the use of the extended model after the 1922 through 2003, which was principally done to do, kind of, a comparative analysis for drought. You know, how does a full period of record compare to the more recent drought years?

But the comment -- it is a good comment, something that we would be looking into further. Because it certainly -- if that is some of the temperature data that was fed into SALSIM, it could be another thing that has led to some of the results. So it is something that we will look into further. But it is not at that period -- the period used for the benefits analysis and the effects analysis of the SED. That is the core time period of 1992 to 2003.

WILL ANDERSON: And just to be clear, the temperature actually starts in 1970, and we don't have that prior.

LES GROBER: So temperature, of course, is a

subset of that. So temperature benefits is 1970 to 2003.
UNIDENTIFIED SPEAKER: My concern is that if we

don't know what is causing the instability, it could be occurring elsewhere, in years other than those. And it could be affecting model results that we just don't see in other -- it just calls into question the stability elsewhere. And just because the results look reasonable -- we need to look into why -- what would have caused that and whether it is affecting other model results.
LES GROBER: True. And the comment itself, we will look into that. But, you know, one of those -- when you refer to the stability, since that was used for other

purposes, very low flow conditions, it could be very much affected by the meteorology.

But it is something that we will explore. But I think it is important, you know, just for the core modelling period. That is where there was the greater review and rigor for the use for the temperature model that was at the 1990 through 2003 period as well as for the 1922 to 2003 for the effects analysis.

DAN WORTH: I will add that in chapter 7, we show minimum and maximum temperatures under different scenarios, and we don't see those 100-plus-degree temperatures. But your point is taken into -- what is that?

UNIDENTIFIED SPEAKER: The result I am referring to was never plotted.

DAN WORTH: Okay. So we do show other river locations in the San Joaquin River but maybe not that particular river model.

LES GROBER: Are there any further questions? Did we actually end up ahead of schedule?

At least one other point, we had mentioned that there was some interest in the -- you know, continued interest in the reservoir reoperation and what would occur under a situation when there were no reservoir operations. Even though it is not the specific topic for next Monday, we are going to try to have something that would show that so you can, kind of, discern what would happen if you had water as minimum storage as something that tracked the current operation and applied that to the report.

But I think as it has been said a number of times today, among many other things, what you would see is like if you bring that -- if you are drawing it down more frequently, which you would with now the additional demands of both having to make the 40 percent unimpaired flow release or whatever the alternative is in conjunction with trying to maintain levels of delivery, you would have much bigger temperature effects for other times of the year that you don't otherwise see.

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But to help discern some of that, we will try to bring some of that to the next meeting.

Board Member Dorene D'Adamo --

DORENE D'ADAMO: Thanks for that reminder that you are going to be looking into that and providing additional information. We got a lot of questions today, and I had asked and I know some of the other board members had asked similar questions last week. And so I would just like to get some information as to timing as to when you think you will have that information available. And then if you could also let folks know what you are thinking in terms of the other requests that we had, and that is looking at overlaying the SED on four years of drought, similar to, say, the last four years. I know that is something that you were going to be gathering some additional information on.

And then I had a question also about the VAMP. So go ahead and answer that, and then I will come back to the VAMP.

LES GROBER: Yeah. We actually started pulling some of that information together because we have a drought chapter but a comparison of what we will have -- and we can bring that to the next workshop as well -- a comparison of some of the averages over critically dry years and compare that to what happens on average, say,

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during the period of record in the most recent drought. And our preliminary analysis shows, just to add value to it, that it is very similar to that more historic drought of '87 to '92. We will bring that to the next workshop as well, even though it is not specifically the topic for the upcoming workshop.

DORENE D'ADAMO: Great. And then before moving onto VAMP, it reminds me of another question I had on last week's workshop -- board workshop, and that is trying to hone in a little bit more on the specific months. In particular, looking at June and the benefits -- the fish benefits of the flows in June and then also looking at the water supply effects for June, I don't know what kind of time would be involved, but it would be good if we could just look at each month. So I don't know if that is something that you were thinking of including in the workshop on the 12th, looking at the individual months, specifically June.

LES GROBER: We tried to cover that. We didn't, I guess, cover that fully today. But I bring this back to another big thought that I have with regard to the proposal, that this is intended to be, in the end, a budget of water for that February through June period. In some of the tables that we have presented today, it shows that there is benefits in June, and I will ask Dan to speak to that in just a moment.

So that is really a two-pronged answer. One, it is the overarching benefit of that February through June budget of water, which ties to many of the comments that we are getting here today. We agree that there is better ways that you can operate the system and optimize the improvements that could be achieved, in particular, if you use that budget of water February through June to get the biggest bang for the buck.

But for the other part, June also has benefits. We heard part of a, you know, presentation at the hearing last Tuesday that, you know, we tend to always focus on various life stages and pushing, you know, the same class size fish out of a certain time. But those old periods are, you know, kind of important.

And now I will hand it off to the biologist to actually make sense of all of that.

DAN WORTH: So if I may, could you switch back to mine for just a second and then go to the end of the presentation? So let me start out with this slide. So this is a daily estimate of passage of unmarked Chinook salmon at a rotary trap near Modesto, and this is done by FISHBIO. Again, this is the lower Tuolumne River. And we see the estimate pass through time from January to June 21st. And this is 2006. It looks like a wetter

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year.

And I have put a red line on there, and the red line shows the end of May. And we see that during the June time period, there are certain years that June has quite a few fish migrating downstream. And if you look at multiple years -- so this is '96 through 2005. And this is the Oakdale screw trap on the Stanislaus River.

You will see that in certain years there are quite a few fish that migrate past -- past the end of May. Some of these years, it looks like the data cuts off abruptly, and that might be because the rotary screw trap was pulled. So this might not represent all fish that migrated down the river. Sometimes they pull the rotary screw traps if they aren't catching fish or maybe for other reasons.

But this type of figure shows that for certain years that June is extremely important, especially when you consider different life stages of fish. When you look at the smelts that migrate downstream during any particular year, June can be a very important month for the smelts. And we heard about the importance of different life history strategies -- you know, the fry, the par, and the smelts -- and how it is important to try to protect all of those different strategies.

So in certain years, June is certainly very

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important, and I do want to show this is the Stanislaus River, the Oakdale screw trap. This is data from '95 to 2009. This is -- now, we are looking at fork length of the vertical axis and time or month on the X axis, or the horizontal axis.

And what you can see from this figure is that there is a group of fish that are less than one year old, and they are -- they migrate -- so these are fish that are less than one year old. So they were born sometime earlier in the year. And for these less than one-year-old fish, we see quite a few of them that migrate in June. Steelhead typically migrate later in the year than fall-run Chinook salmon. And so June is particularly important for steelhead.

DORENE D'ADAMO: And do you distinguish between native and hatchery? I know we had some testimony last week where they were able to -- UC Davis and NOAA had some information about being able to distinguish --

DAN WORTH: So for these fish that are shown on this plot here, I'm not sure if they determined the parental origin of these fish. So I'm not sure that they determined where the parents came from. Did the parents come from some other river and then swim into the

Stanislaus and lay their eggs? I'm not sure that these
individual fish have had that assessment done.

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DORENE D'ADAMO: Okay. Well, this is helpful. Thank you. And if you could go back to the series of charts, it is kind of hard for me to see. But are those all -- do you have all of the years in which -- this is based on rotary screw tap information?

DAN WORTH: Correct.

DORENE D'ADAMO: And that is just on the Stanislaus?

DAN WORTH: This is the length of all sampled juvenile Chinook salmon at Oakdale on the Stanislaus River in these years, '96 to 2005, And there are individual annual reports for each year. And that probably shows additional information.

DORENE D'ADAMO: On each river?

DAN WORTH: Yes. There are rotary screw trap reports for each river.

DORENE D'ADAMO: Do you have that in the SED in an appendix?

DAN WORTH: So a lot of the fish timing was first evaluated in the scientific basis report, which is appendix C, chapter 3, and that was done in 2012 initially. And there is some additional discussions in chapter 7 about timing.

DORENE D'ADAMO: Okay. And I should have thought about this earlier when we were talking about the

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water supply effects analysis, but this is an issue that I will be continuing to ask questions on, sort of the bookends of February and June. And I was hoping to, in these workshops, have a little bit of a discussion about -- you know, a more open discussion just because board meetings often don't lend themselves to that kind of a discussion. So to the extent that we have more time today or continuing on into the 12th looking at sort of a comparison between migration and water supply impacts for those bookend months, particularly June.

DAN WORTH: Yeah. And I would just like to add that these are fish that are in the tributaries in these figures and that there is probably some additional benefit of trying to get them down the San Joaquin River. And so it is not just about trying to get fish out of each of these tributaries; it is trying to get them into the Delta.

DORENE D'ADAMO: I understand. I am looking more to get the information about, you know, what are the conditions? You are saying in certain years, it is going to be very important. So I am looking to, kind of, drill down on how many fish, what months, what year type, when is it really important.

I know the individual from UC Davis, a doctor -- I can't remember her name, but in a discussion with her,

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she had indicated that, you know, June could be important if there are fish present and, you know, probably this might be something in terms of functional flow, looking at, you know, how to get the fish out, you know, with a more limited use of water.

And that goes back to my question about the water supply effects for the month of June. I keep hearing from the irrigation -- and I know we don't have all of the IDs here -- some discussion about, "What are the water supply effects expected to be in the month of June with a 40 percent of unimpaired flow?"

And I expect the irrigation districts will be telling us their point of view when we go to the upcoming workshops, you know, in Stockton, Modesto, et cetera, but it would be great to have you-all point us in the direction, either telling us what those water supply effects are or pointing us to the documents to let folks know how you view those water supply effects for the month of June.

LES GROBER: Sure. We have heard that comment.

So we can come up with that -- we will try to come up with that amount even as early as the next workshop. But it is -- it is going to be important to present that in balance against the way we have been presenting this as a package in a block of water. Because June -- the reason

that is important is it is going to be not a small water supply effect. Because June is a big month in the San Joaquin River basin, and that cuts both ways.

It is a big month in terms of the benefit and also the -- not necessarily directly just in the month of June but in terms of the budget of water. But it is also -- it is a big month in terms of water supply. So we will try to tease that out so that we can present that at the next meeting.

DORENE D'ADAMO: That would be great. Thanks.

Now, my last question on the VAMP -- and I understand because of the NOP going out in 2009 and that the VAMP was in effect at that time. So I understand why it was included in the baseline, but I think from the perspective of trying to sort of better determine water supply effects, it is not currently in place.

And so I would like to, maybe, get your help on how to best structure a question to you so that we could tease out the VAMP. And in light of the fact that it is not in existence right now, to have it in baseline, it seems to me that it could be skewing the water supply effects. And so could you do a run without the VAMP so that we could get a better determine -- like, right now, the overall average, I can't remember what you -- it is, like, 12 percent on average.

In critically dry years, there is a higher percentage of water supply impact. If we didn't have the VAMP in the baseline, what sort of an adjustment would there be on the average annual water supply impact, and what sort of an adjustment would it look like in the critically dry years? I am just not that familiar with how VAMP functioned. I know they are different year types. And so I am just sitting here, kind of, guessing. I would like to get the benefit of, you know, your view of if the VAMP were not in the baseline.

LES GROBER: Well, and if it is not -- that is not in the baseline, then it begs a question of what else is different. There is always a limit of how much analysis one does, and you look at the full implementation of the plan and the provision of flow being hypothetical just from the Stanislaus. So there is a lot of what-ifs. We can try to tease it out to maybe try to quantify, you know, how much that means, but, you know, we are putting a lot of information together in a short period of time. So we will see what we can do with that.

DORENE D'ADAMO: Right. I mean, otherwise, I am left to kind of figure, you know, talking with folks one-on-one how much was in the VAMP, and then I will do my own calculations. And I would rather not rely on my

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math.

LES GROBER: Sure. And it is always a

relative -- it is looking at the relative effect from a baseline, but your point -- I hear your point.

I can return back for your other question. Though we don't have the table, I will just show a couple of charts that Jason can put up in the other PowerPoint to just address your question about the drought years and the recent years.

So here is a series of three time series that are showing -- this is the first for the Stanislaus. And to orient you, it is looking at the full period of record. So now, it is that base model time period, the CalSim period from 1922 to 2003 and also the extended time period to through 2015 to get at, "How does the model time period look," and "How do you compare the most recent drought with past droughts?"

So it is showing the monthly -- oh, no. This is the annual. Sorry. This is the annual runoff, and it is looking at the water year runoff, the February through June runoff, the average runoff for the time period, and the runoff deficit and cumulative runoff deficits. So this is pulled from, I guess, chapter 21 in the SED.

So something to observe there in terms of the cumulative runoff deficit and the runoff deficit, those

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two lower bars, it shows that the most recent drought kind of tracks. It is very similar to the drought period from 1987 through 1992. And you see a similar pattern for the Tuolumne and also for the Merced. We will have another table, which will show the summary statistics of these.

And bottom line, what the summary statistic shows is that if you take that five-year drought period, the '87 through '92, it is very similar to the average of all critically dry years. It is actually a little bit wetter just because those -- not all of those dry years were created the same. Some were a little bit wetter than others.

So this is doing a couple of things. So in general, the time period has considered, you know, generally the types of drought -- the magnitude of drought that has happened in the past, though with some slight differences. So we will present more on this at the next meeting.

ART GODWIN: Art Godwin. I want to take this down a notch, if I could. We were talking about lots of modelling scenarios and what-ifs and things that could happen. But do you, Les, see things happening in the

real world? How are we going to determine the block of
water from February through June as early as January?

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How are we going to operate the system on a realtime
basis shaping water for temperature, for floodplain, for
flow shifting? How are we going to make all of those
determinations on a realtime basis and still meet the
seven-day average daily max and seven-day running average
flows with a block of water? And what happens if we
underestimate or overestimate the block?

LES GROBER: I don't know if you have any idea
how much I like that question because that is so
forward-thinking. And how do we actually do this?
Because -- and that is why settlement will be so

important for this, too. And it is just the types of things that we need to be thinking about now and in the future.

But a short answer to the start that you described is we already know a lot about the system. We know what we have done in the VAMP. We know that certain time periods are more important than others. That is why we kind of emphasized, you know, high pulse flows, like in an April/May time period. We know that every year is a little bit different. We know that we didn't do everything we could possibly want in the river because there is just not enough water to do it all.

So how do we maximize that beneficial use of water? So to give an example and based on what we do know, we won't know a lot about the hydrology in January or February when plans will have to be prepared, but we will know things like what the carryover storage is, and we will know what is happening out of the window now. So an example would be, "Well, based on what we have in terms of carryover storage and what we know in general, we know that depending on one's perspective" -- I am going to say something. Maybe it will make you smile.

40 percent is not a lot of water. But how do we get the biggest bang for the buck on that? We will want to shoot for a pulse flow that is even higher than that, that is 50 percent of unimpaired flow or something higher than 40 percent. So starting in February and tracking conditions, that is kind of a provisional plan. In April and May, we want to pulse that something bigger than 40 percent of unimpaired flow, which means that we have to

bank some water in the early months, February /March, and kind of watch as the water year unfolds and as we get information of how much is actually there.

So it is kind of a relative plan to have a rough plan of what you plan to do in the big picture and trueing it up as that information comes in and with the requirement being in the end the block of water it would track on the seven-day average, the 40 percent of unimpaired flow. That being said, if a plan is created

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and then situations -- things change beyond what had been envisioned in terms of, "It looks like now we have to spill or something because conditions got so good," something like that, all of those contingencies should be identified in the plan.

But, ultimately, you just have to comply with what the elements of the plan are to plan for how you would be shaping the water in that current year. And then it would include elements depending on what the general hydrology is and how it gets tuned up. "Well, we think we will want to save some of this so we have water in the summer and the fall for temperature control."

Every year is going to be different, and this is when all of the models and all of the expertise that sit in this room will have to come to pair to figure out, "How do you actually do this thing now within this budget of water?" But some of these discussions in the much more than two or three minutes that I have described this is the discussion for the STM working group, for the settlement groups to figure out how you would implement this within the construct that the board is presenting.

CHRIS SHUTES: Chris Shutes with CSPA again. A couple of comments, one, if you are not looking at VAMP, I think you need to decide what you are going to put in its place. Are you going to not have anything at all, or

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are you going to have D1641, which VAMP basically replaced? That would -- and, I mean, then since D1641, maybe it was implemented in 2012. I don't recall.

But, really, during the drought it wasn't implemented. So was that really the baseline? Because we have been operating under TUCPs at least for the last three years, it becomes pretty hard to figure out where you are going.

The other thing I wanted to mention and remind board member Dorene D'Adamo was that Dr. Sturrock and Dr. Johnson in their presentation last Tuesday talked a lot about the importance of different life stages and sort of going to what Mr. Worth went into, the different timing, and I think the steelhead point is pretty well taken, particularly in the larger years.

In the drier years, the benefit may not be as great because of water temperature and other concerns in the Delta. But, certainly, in the bigger water years, you get a big boost, and conditions maybe not only improve but actually are significantly important for fish, as they are in some cases rearing and in some cases passing through the Delta.

DAN WORTH: And I will just touch on the drier water years. With our temperature benefits analysis, those drier water years are the water years when we see the largest benefits to temperature. It may be possible to make June or at least the end of May going into early June much better for fish in those drier water years.

LES GROBER: Going once? That is right. Any other comments or anything else that if we can we should bring to the next workshop?

GITA KAPAHI: So a couple of things. I did hear from a few folks that they wanted to write out some comments on cards and present those for follow up. So you had mentioned that you were going to put your name and contact information.

Okay. If you want to write those down and give them to program set up, that would be great. There are more cards. If you need one, just holler. I believe the next technical workshop is a week from today, on Monday, the 12th, with a similar format with presentations and comments, et cetera.

Any other --

LES GROBER: I just wanted to -- because I am looking over at the attorneys -- remind everybody again the purpose of this -- and we have gotten some great comments and some great questions. But this can't replace the hearing or the comment period. We are trying to make it to the extent so that we can answer some questions here so that you can provide us with more

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targeted comments/questions.

With that being said, you know, the formal responses to any comments/questions that we get will take place when we release the revised draft including a response to comments.

BILL PARIS: This is Bill Paris, Modesto. And this kind of gets to what Les was mentioning now and prior when you said, "anything for the camp for next week." To get to that point, I think it should be less reproducing results that we have already seen and more focused on the analysis and the tools that were used. Much of this was taken right from the SED, and frankly, it wasn't particularly helpful. And it lends to questions more that either you guys aren't expecting or it seems argumentative from our side.

I really would like to see more analysis, more of the tools, the assumptions, how they were used, why they were used, the iterations you went through and less of the results, unless the results can elucidate and illuminate some of those types of analyses. But -- and for long stretches of today, it was just, frankly, a reproduction of results that we have already seen.

So I guess from my own perspective, I would like to see more analysis and more emphasis on the tools at the next workshop. Thank you.

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UNIDENTIFIED SPEAKER: Is this slideshow going to be posted tomorrow?

LES GROBER: Well, we will try to post it tomorrow or the next day.

UNIDENTIFIED SPEAKER: Yeah.

LES GROBER: Okay. And in terms of the presentation, I will try to take the comments and provide more information next time, but we are also -- there is a lot of misunderstanding, it seems, of how we have done our work and the work we are showing. So we just want to make sure -- we appreciate that you and many others really get it and want to get into the details of the thing, but we also just want to make sure that we are explaining what we have done so that there isn't misinformation out there.

But thanks. Your comment is well taken.

GITA KAPAHI: With that, I think that we are done for the day. Thank you very much for your thoughtful comments and questions, and we will see you in one week for the next technical workshop. Thank you.

(End of recording.)

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I, AMANDA L. JOHNSON, CSR No. 13922, do hereby declare as follows:

That pursuant to the request of Shelly McLean, I did transcribe video files as requested by Shelly McLean.

I declare under the penalty of perjury that the foregoing is transcribed as true and correct to the best of my ability.

DATED at Modesto, California, this ___________ day of __________________, 2016.

Amanda L. Johnson

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BEFORE THE CALIFORNIA

STATE WATER RESOURCES CONTROL BOARD

0DRAFT SUBSTITUTE ENVIRONMENTAL DOCUMENT IN SUPPORT OF POTENTIAL CHANGES TO THE WATER QUALITY CONTROL PLAN FOR THE SAN FRANCISCO BAY-SACRAMENTO/SAN JOAQUIN DELTA ESTUARY; SAN JOAQUIN RIVER FLOWS AND SOUTHERN DELTA WATER QUALITY	CITY AND COUNTY OF SAN FRANCISCO'S LIST OF APPENDICES

The City and County of San Francisco ("San Francisco") hereby provides its List of Appendices to its Comments to the Draft Substitute Environmental Document in Support of Potential Changes to the Bay-Delta Plan:

APPX NO.	**DESCRIPTION**
1	Declaration of Steven R. Ritchie in Support of Comments by the City and County of San Francisco to the Draft Substitute Environmental Document in Support of Potential Changes to the Bay-Delta Plan.
2	Declaration of Matt Moses in Support of Comments by the City and County of San Francisco to the Draft Substitute Environmental Document in Support of Potential Changes to the Bay-Delta Plan.

APPX NO.	**DESCRIPTION**
3	*Bay Area Socioeconomic Impacts Resulting from Instream Flow Requirements for the Tuolumne River*, The Brattle Group, prepared by David Sunding, Ph.D., March 15, 2017.
4	Declaration of Jonathan P. Knapp in Support of Comments by the City and County of San Francisco to the Draft Substitute Environmental Document in Support of Potential Changes to the Bay-Delta Plan.
5	Memo from Leslie Moulton-Post Leslie Moulton-Post, Alisa Moore, Karen Lancelle, Chris Mueller, Environmental Science Associates to San Francisco City Attorney's Office, *CEQA Adequacy Review of the Desalination Water Supply Alternative in the Draft Substitute Environmental Document (SED) in Support of Potential Changes to the Water Quality Control Plan for the San Francisco Bay-Sacramento / San Joaquin Delta Estuary: San Joaquin River Flows and Southern Delta Water Quality*, March 15, 2017.
6	Memo from Leslie Moulton-Post and Jill Hamilton, Environmental Science Associates to San Francisco City Attorney's Office, *Adequacy Review of In-Delta Diversion Alternative Analysis in State Water Board SED*, March 15, 2017.

Dated: March 16, 2017

DENNIS J. HERRERA
City Attorney

By:___________/s/____________________
JONATHAN P. KNAPP
Deputy City Attorney

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APPENDIX 1

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BEFORE THE CALIFORNIA

STATE WATER RESOURCES CONTROL BOARD

DRAFT SUBSTITUTE ENVIRONMENTAL DOCUMENT IN SUPPORT OF POTENTIAL CHANGES TO THE WATER QUALITY CONTROL PLAN FOR THE SAN FRANCISCO BAY-SACRAMENTO/SAN JOAQUIN DELTA ESTUARY; SAN JOAQUIN RIVER FLOWS AND SOUTHERN DELTA WATER QUALITY	DECLARATION OF STEVEN R. RITCHIE IN SUPPORT OF COMMENTS BY THE CITY AND COUNTY OF SAN FRANCISCO TO THE DRAFT SUBSTITUTE ENVIRONMENTAL DOCUMENT IN SUPPORT OF POTENTIAL CHANGES TO THE BAY-DELTA PLAN

1. I, Steven R. Ritchie, declare:

2. I am employed as the Assistant General Manager for Water of the San Francisco Public Utilities Commission ("SFPUC"). In this capacity, I am responsible for overseeing water system operations and planning from the Hetch Hetchy Water and Power System ("HHWPS") through the Hetch Hetchy Regional Water System ("RWS") to the City Distribution Division and the management of lands and natural resources.

3. The information contained in this declaration is true of my own personal knowledge, unless stated otherwise, and if called upon to do so, I could and would competently testify thereto.

4. The Raker Act only allows San Francisco to divert water from the Tuolumne River during high flow periods, and requires that San Francisco bypass all flow to the Districts during dry periods. For example, during the recent drought, in FY 2014-2015, San Francisco was only able to divert 22,000 acre-feet ("AF") from the Tuolumne River.

5. The percentage of average reduction in unimpaired flow into the Delta that is attributable to San Francisco's use of water from the Tuolumne River (which, in turn, reduces flow into the San Joaquin River) may be determined by dividing San Francisco's average annual water supply exported from the Tuolumne River, as described in the Final Program Environmental Impact Report for the San Francisco Public Utilities Commission's Water System Improvement Program ("Final WSIP PEIR" or "WSIP")), *i.e.*, 218 million gallons per day ("mgd"), or 244,000 AF/year, (WSIP, at 5.3.1-5), by the total average unimpaired inflow into the Delta, as computed by the California Department of Water Resources, of 29,003,000 AF.[1] Thus, San Francisco's exports from the Tuolumne River account for approximately 0.8 percent of total unimpaired Delta inflow per year. (244,000 AF/29,003,000 AF = 0.8 percent unimpaired flow.) In fact, in recent years, San Francisco has exported less water from the Tuolumne River than the WSIP average, *i.e.*, San Francisco delivered 205 mgd from the Tuolumne River to the Bay Area, or 230,000 AF/year, in fiscal year ("FY") 2012-

[1] Estimates of Natural and Unimpaired Flows for the Central Valley of California: Water Years 1922-2014, March 2016 (DRAFT), Department of Water Resources, Bay-Delta Office, *available at* https://msb.water.ca.gov/documents/86728/a702a57f-ae7a-41a3-8bff-722e144059d6, at 5-4.

2013, and delivered 150 mgd from the Tuolumne River, or 168,000 AF, in FY 2015-2016. *See* Table J-1, Based Usage (mgd) and Allocation Rates, included hereto as Attachment 1.

6. Although during the 1987-1992 drought San Francisco purchased approximately 107,848 AF of water, San Francisco only procured a small fraction of that amount from either the Modesto Irrigation District ("MID") or the Turlock Irrigation District ("TID," collectively referred to as the "Districts"). The only water transfer completed during the 1987-1992 drought with either of the Districts was a 1990 water transfer from MID to San Francisco for 5,288 AF ("1990 Transfer Agreement"). Although pursuant to the 1990 Transfer Agreement, MID was required to "utilize its best efforts to make available to [San Francisco] up to 20,000 acre-feet of pumped drainage water," (1990 Transfer Agreement, at ¶ 2), MID only made 5,288 AF available to San Francisco for purchase, and of that amount, only 4,891 AF was actually delivered). During the 1987-1992 drought, San Francisco obtained a commitment from the California Department of Water Resources' ("DWR") Drought Emergency Bank for 69,000 AF and from Placer County Water Agency ("PCWA") for 33,560 AF. Of these amounts, only 52,000 AF was actually delivered by DWR, and only 21,042 AF was actually delivered by PCWA. *See* Water Transfer During 1987-1992 Drought Period, included hereto as Attachment 2.

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7. Based on the hydrological record from 1987 through 1992, the Districts would be required, between February and June, to bypass a total of 707,841 AF during the 6-year period under the existing FERC Flow Schedule. Assuming continuation of the 1995 Side Agreement, approximately 365,954 AF of this amount would be bypassed by the Districts on San Francisco's behalf. For example, under a 40 percent unimpaired flow objective, and assuming 1987-1992 hydrology, the Districts would be required to bypass, between February and June, 107,504 AF/year for 6 years, or 645,024 AF, in addition to the FERC flow schedule. Thus, based on the historical 1987-1992 hydrology, and assuming implementation of a 40 percent unimpaired flow objective, between February and June, during the 6-year drought sequence the Districts would be required to bypass approximately 707,841 AF under the existing FERC Flow Schedule and an additional 1,424,328 AF (645,024 AF + 779,304 AF) for a total volume of 2,132,169 AF.

I declare under penalty of perjury, under the laws of the State of California, that the foregoing is true and correct and that if called as a witness I could competently testify thereto.

Executed this 14th day of March, 2017 in San Francisco, California.

Steven R. Ritchie

ATTACHMENT 1

Table J-1
Base Usage (mgd) and Allocation Rates[7]

(1) Usage	(2) Definition	(3) 2010-11	(4) 2011-12	(5) 2012-13[6]	(6) 2013-14	(7) 2014-15	(8) 2015-16
1. Gross S.F. Co. line	B.1	71.7	71.6	71.2	68.4	64.0	61.8
2. Daly City portion	B.2	0.2	0.3	0.3	0.1	0.1	0.1
3. Net S.F.	(1-2)	71.5	71.3	70.9	68.3	63.9	61.7
4. Other suburban raw water	B.4	0.6	0.6	0.5	0.5	0.4	0.4
5. Other suburban treated water	B.5	3.0	3.1	3.1	2.8	2.6	2.2
6. Total other suburban	(4+5)	3.6	3.7	3.6	3.3	3.0	2.6
7. Total City usage	(3+6)	75.1	75.0	74.5	71.6	66.9	64.3
8. Total wholesale usage[1]	B.8	143.7	144.4	148.3	149.6	128.0	110.8
9. Total system usage	(7+8)	218.8	219.4	222.8	221.2	194.9	175.1
10. Wholesale alloc. rate	(8/9)	65.68%	65.82%	66.56%	67.63%	65.67%	63.28%
11. City alloc. rate	(100%-10)	34.32%	34.18%	33.44%	32.37%	34.33%	36.72%
12a. HHWPD input (Oakdale)	B.12	165.9	192.3	205.2	239.7	187.6	150.2
12b. Deliveries to LLNL	B.12	-0.8	-0.7	-0.8	-0.7	-0.6	-0.6
12c. HH to San Ant. Res.	B.12	0.0	-2.1	-7.9	-21.2	-12.1	-4.2
12d. Sunol Valley WTP	B.12	35.8	29.0	21.4	10.1	16.8	27.0
12e. Harry Tracy WTP	B.12	44.5	22.1	26.1	21.2	29.3	35.9
12f. Raw water deliveries	B.12	0.6	0.6	0.5	0.5	0.4	0.4
12g. Deliveries to Coastside Co. WD	B.12	1.7	1.6	1.7	1.9	1.5	1.2
12h. Crys. Sprs. Bal. Res.	B.12	0.0	0.0	0.0	0.0	0.0	0.0
12i. Spill to CS Res.	B.12	-25.8	-23.8	-24.4	-28.5	-31.3	-28.1
12j. Terminal Reservoirs	B.12	0.0	0.0	0.0	0.0	0.0	0.0
12k.Other Sources[2]	B.12	-4.8	2.5	0.0	-0.2	-0.3	-1.0
12k. (1) SCVWD Intertie[3,7]	*B.12*	*-2.6*	*2.5*	*0.0*	*-0.2*	*-0.3*	*-0.4*
12k. (2) EBMUD Intertie[3]	*B.12*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
12k. (3) Conj. Use Groundwater[4]	*B.12*	*-2.2*	*0.0*	*0.0*	*0.0*	*0.0*	*-0.6*
13. Total system input	B.13	217.1	221.5	221.8	222.8	191.3	180.8
14. Jt. sys. loss red. fact.	(9/13)	1.0000	0.9905	1.0000	0.9928	1.0000	0.9685
15. Daly City red. factor	(3/1)	0.9972	0.9958	0.9958	0.9985	0.9984	0.9984
16. Total suburban	(6+8)	147.3	148.1	151.9	152.9	131.0	113.4
17. Suburban red. factor	(8/16)	0.9756	0.9750	0.9763	0.9784	0.9771	0.9771
18. HHWPD Deliveries above Oakdale[5]	B.18	0.4	0.3	0.4	0.4	0.3	0.3
19. HH Reduction Factor[5]	B.19	99.76%	99.84%	99.81%	99.83%	99.84%	99.80%

1. Total Wholesale Customer usage is adjusted to account for water delivered to Wholesale Customers participating in the groundwater conjunctive use project [line 12k.(3)].

2. Other sources of water were not separately identified in J-tables prior to FY2009-10.

3. Negative values represent water delivered from SFPUC to EBMUD and/or SCVWD. Positive values represent water delivered to SFPUC from EBMUD and/or SCVWD.

4. Negative values represent water delivered to participating Wholesale Customers in lieu of groundwater pumping. Positive values represent water added to the system in the form of increased groundwater pumping by the participating Wholesale Customers or the SFPUC, when SFPUC wells become operational (target date 2016).

5. Not calculated in J-tables prior to FY2009-10.

6. Adjustment Line 8, (7) FY2012-13: Total Wholesale Usage. Line 8 adjusted higher by 0.4 mgd over the Sept. 20, 2013 submitted FY2012-13 Table J-1. The adjustment is due to meter error at CalWater Service - San Mateo.

7. Original FY2014-15 SCVWD Intertie value -0.6 submitted Sep 18, 2015. The revised value -0.3 replaces the original value. Table J-1 with revised value of -0.3 resubmitted on Oct 27, 2015.

11/2/2016

ATTACHMENT 2

Agency Water Was Purchased From	WTR Purchased (AF)	WTR Delivered (AF)	Cost Purchase + Delivery	Water Stored @ Kern	EST Water Delivery Cost	WTR Sold to CDFG	Revenue from Sold WTR		Legal & Assoc.	Pumping & Treat costs	Construct costs	
1990 Placer County Water Agency	10,703	7,492	$1,531,992							$576,884	$777,201	Sunol blowoff location ?
1990 Modesto Irrigation District	5,288	4,891	$746,122							$376,607		
								Insurance	$70,900		$940,000	cost of S.A. turnout
1991 Ca. Drought Emergency Bank	50,000	33,000	$12,310,025	17,000	$4,396,622					$2,541,000		
1991 Placer County Water Agency	22,857	13,550	$4,232,696			5,920	$177,600			$1,043,350		
								Legal/Admin	$571,882			
1992 Ca. Emergency Drought Bank	19,000	19,000	$3,366,824							$1,463,000		
Total	107,848	77,933	$22,187,659	17,000	$4,396,622	5,920	$177,600		$642,782	$6,000,841	$1,717,201	

Placer County water was delivered through Folsom reservoir - carriage water is 20% of purchased water
1992 Ca. Emergency drought water bank $72/AF for water and $105.2/AF for wheeling
amount delivered through SBA direct 4,432 all in October
amount delivered by exchange with San Luis 14,568 Oct- Dec storage fee: $18.60/AF

DWR charged O&M monthly fees on turnouts

PCWA water was surplus
DWR water was ag. Water transferred to urban

WATER PURCHASE SUMMARY RUN DATE: 08-Mar-94
FILE NAME: WTRPURCH

AGENCY WATER WAS PURCHASED FROM	WTR PURCHASED (AF)	WTR DELIVERED (AF)	COST PURCHASE+DEL	WATER STORED @ KERN /AF	EST WATER DELIVERY COST	WATER SOLD TO DFG /AF	REVENUE REC'D FROM DFG		LEGAL & ASSOC FEES	PUMPING & TREATMT COSTS	CONSTRUCT COSTS
1990 PLACER COUNTY WATER AGENCY	10.703	7,492	$1,531,992							$576,884	$777,201
1990 MODESTO IRRIGATION DISTRICT	5,288	4,891	746,122							376,607	
								INSURANCE	70,800		940,000
1991 CALIFORNIA DROUGHT EMERGENCY BANK	50,000	33,000	12,310,025	17,000	$4,396,622					2,541,000	
1991 PLACER COUNTY WATER AGENCY	22,857	13,550	4,232,696			5,920	$177,600			1,043,350	
								LEGAL/ADMIN	571,882		
1992 CALIFORNIA DROUGHT EMERGENCY BANK	19,000	19,000	3,366,824							1,463,000	
TOTAL	107,848	77,933	$22,187,659	17,000	$4,396,622	5,920	$177,600		$642,682	$6,000,841	$1,717,201

DIRECT COST OF DELIVERED WATER PER AF	$282.42
PUMPING AND TREATMENT COSTS PER AF	$77.00
est. based on 92/93 actual:Pump $26;Treat $51	
INDIRECT COSTS FOR DELIVERED WATER PER A	$30.28
TOTAL COST OF WATER DELIVERED PER AF	$389.70

WATER PURCHASE COSTS	
PCWD	3034077
MID	237951
DWR1991	8750000
DWR 1992	1368000
Total	13390028
purchase cost/a	$124
net purch cost/	$172

NOTES:
KERN COUNTY WATER AGENCY CONTRACT TERMS STORES THE WATER UNTIL 12/31/96.
KERN COUNTY WATER AGENCY CONTRACT TERMS CAN BE EXTENDED WITH APPROVALS FROM DWR AND NEGOTIATED ADDITIONAL COSTS.

THE SUNOL TURNOUT IS TEMPORARY, BUT WE HAVE ASKED DWR TO MAKE IT PERMANENT.
IF DWR APPROVES THE REQUEST, CITY PLANNING (OER) WILL NEED TO APPROVE AND SOME ADDITONAL CONTRUCTION WILL BE NEEDED TO DOWNSIZE THE PIPE AND PROTECT IT FROM THE HEAT AND SUN.
IF ALL APPROVALS,PERMITS AND CONSTRUCTION ARE DONE, WE SHOULD ADD THIS TO THE LONGTERM OPERATING AGREEMENT WITH DWR FOR THE SAN ANTONIO TURNOUT.

ALL INDIRECT COSTS CURRENTLY ON THIS SCHEDULE (2/2/94) ARE ESTIMATES

1992 Bank water Total cost 3,366,824
19,000 af x $72/af = $1,368,000 purchase
$1,998,824 wheeling

1,998,824 ÷ 19,000 = $105.20/af
wheeling cost

APPENDIX 2

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BEFORE THE CALIFORNIA

STATE WATER RESOURCES CONTROL BOARD

DRAFT SUBSTITUTE ENVIRONMENTAL DOCUMENT IN SUPPORT OF POTENTIAL CHANGES TO THE WATER QUALITY CONTROL PLAN FOR THE SAN FRANCISCO BAY-SACRAMENTO/SAN JOAQUIN DELTA ESTUARY; SAN JOAQUIN RIVER FLOWS AND SOUTHERN DELTA WATER QUALITY	DECLARATION OF MATT MOSES IN SUPPORT OF COMMENTS BY THE CITY AND COUNTY OF SAN FRANCISCO TO THE DRAFT SUBSTITUTE ENVIRONMENTAL DOCUMENT IN SUPPORT OF POTENTIAL CHANGES TO THE BAY-DELTA PLAN

I, Matt Moses, declare:

1. I am employed as Water Resources Engineer of the Water Enterprise of the San Francisco Public Utilities Commission ("SFPUC"). In this capacity, I am responsible for quantitative analysis for the Regional Water System operated by SFPUC.

2. I have been employed in this capacity at SFPUC for 3 years, and I have 12 years of experience in quantitative analysis of California municipal water supplies.

3. I authored the memorandum entitled "SFPUC Analysis of Proposed Changes to Tuolumne River Flow Criteria." I am personally familiar with the hydrologic records used to prepare the memorandum, which are maintained in the ordinary course of business by the SFPUC in its operation of the Hetch Hetchy Regional Water System. A true and correct copy of the memorandum is attached as Attachment 1, and is based on analysis that I performed in my capacity as a Water Resources Engineer for SFPUC.

I declare under penalty of perjury, under the laws of the State of California, that the foregoing is true and correct and that if called as a witness I could competently testify thereto.

Executed this 14th day of March, 2017 in San Francisco, California.

[signature]

Matt Moses

ATTACHMENT 1

San Francisco Water Power Sewer
Services of the San Francisco Public Utilities Commission

March 14, 2017

Subject: **SFPUC Analysis of Proposed Changes to Tuolumne River Flow Criteria**

Prepared by: Matt Moses, Water Resources Engineer

Introduction

The State Water Resources Control Board (SWRCB) released the Recirculated Draft Substitute Environmental Document (SED) in Support of Potential Changes to the Water Quality Control Plan for the San Francisco Bay-Sacramento San Joaquin Delta Estuary, San Joaquin River Flows and Southern Delta Water Quality, in September 2016. Staff at the San Francisco Public Utilities Commission (SFPUC) reviewed the proposed changes and evaluated their effects on the SFPUC Regional Water System (RWS). The results of the SFPUC analysis are presented in this memorandum.

SFPUC used the Hetch Hetchy / Local Simulation Model (HHLSM) to estimate the effects of proposed Tuolumne River flow standards on the SFPUC RWS. The HHLSM model and the water supply planning methodology (including the design drought sequence) are described in the Water Supply System Modeling Report (Steiner, 2007). The methods and results of the modeling analysis used to evaluate the SED alternatives are described below.

SFPUC RWS Service Area Demands

Three levels of service area water demand were simulated for the RWS:

- 265 million gallons per day, as an annual average (MGD), which represents the total contractual obligation to wholesale customers of 184 MGD, plus an estimate of future demand of 81 MGD for the San Francisco retail service area.
- 223 MGD, which was the actual water delivery to the RWS service area (including wholesale and retail) in fiscal year 2012-2013. This was the last complete fiscal year before supply rationing was initiated.
- 175 MGD, which was the actual water delivery to the RWS service area (including wholesale and retail) in fiscal year 2015-2016. This represents a 21.5% reduction from fiscal year 2012-2013 demands. In response to drought conditions, SFPUC requested rationing within the retail

and wholesale service area during this period, and the State of California also mandated rationing for all municipal water agencies during this period. The reduced demand relative to fiscal year 2012-2013 is attributed to these calls for rationing.

These demand levels are used in model simulations to represent the amount of surface water from the SFPUC RWS that would be delivered to the service area in the absence of any water supply shortage. In years when surface water supply is sufficient, the demand is met entirely by delivery of surface water. In years when surface water delivery is insufficient, the demand is met by a combination of surface water delivery, groundwater delivery (from the regional groundwater storage and recovery program in the Westside Basin), and also by delivery of less than the full demand for water supply (or rationing). In the case of the 175 MGD level of demand, any rationing applied in the model simulations should be considered additional to the delivery shortage that is inherently included in that demand assumption (see 3rd bullet above). See the description of the design drought planning methodology for a discussion of how rationing levels are determined. Also, see the SFPUC 2015 Urban Water Management Plan (Chapter 6) for a description of other components of service area demand that are met by conservation, water recycling, and other groundwater supplies.

SFPUC Contribution to Unimpaired Flow Requirement

The contributions that SFPUC would make to the proposed flow standards were calculated for four levels of required flow: 20%, 30%, 40% and 50% of unimpaired flow on the Tuolumne River at La Grange from February through June of each year. Flow shifting and other possible adaptive management adjustments of the unimpaired flow standard are discussed in the SED document, but are not described in sufficient detail to include in model analysis. Therefore flow shifting was not included in the SFPUC analysis. In the SFPUC analysis, the La Grange stream gage was treated as the point of compliance, and accretions and depletions to the Tuolumne River downstream of La Grange were not included in the calculation of required flow.

The calculation of SFPUC contribution to the unimpaired flow requirement included the following considerations:

- The minimum in-stream flow schedule in the existing FERC license at New Don Pedro Reservoir was assumed to be in place. The releases to meet this schedule were assumed to be made by the irrigation districts that operate New Don Pedro Reservoir (Districts) consistent with the existing side agreement between San Francisco and the Districts under the current FERC license.
- The responsibility to meet flows required by the SED alternatives from February through June in excess of the existing FERC schedule was assumed to be shared between SFPUC and the irrigation districts. The SFPUC share is assumed to be 51.7% of the required flow that is in excess of the FERC schedule.

See Figure 1 for additional discussion of the assumed contributions to the proposed unimpaired flow standards.

System Configuration for SFPUC Model Analysis

The SFPUC water supply system was simulated for these analyses as including the facilities described in the 2018 WSIP variant, with two differences noted below. This includes the completion of the suite of WSIP projects. A summary of these facilities is presented in Table 1, and a more detailed description is provided in the Final Program Environmental Impact Report for the San Francisco Public Utilities Commission's Water System Improvement Program (Final WSIP PEIR), in Appendix O3, 2018 WSIP Variant. Two differences from the Final WSIP PEIR, Appendix O3 facility assumptions were incorporated into this analysis:

- In-stream flow releases from Crystal Springs Reservoir to San Mateo Creek were included in this simulation. The average volume of these releases is approximately 3,900 AF per year.
- Annual water supply transfers from the Districts to SFPUC were not included in this analysis. An annual transfer of 2,300 AF was assumed from the Districts to the SFPUC Water Bank Account in the WSIP 2018 simulation.

The same configuration was used for the RWS in each of the SED alternative analyses described here. Three levels of RWS system-wide demand were evaluated (265 MGD, 223 MGD, and 175 MGD), as described above. For each level of system-wide demand, four levels of contribution to a Tuolumne River unimpaired flow standard were evaluated (20%, 30%, 40% and 50%) as described above. A scenario with no additional contribution from the RWS to the Tuolumne River (referred to as the base case) was also evaluated for each of the 3 demand levels considered. Because there are no variations in the system facilities, the results of the simulations at different unimpaired flow standards can be directly compared within each level of system demand, and differences between them may be ascribed to the SED alternatives.

Water Supply Planning Methodology and the Design Drought

SFPUC uses a water supply planning methodology that allows the performance of the RWS to be evaluated for a range of conditions, including varying facility configurations, changes in service area demand and changes in in-stream flow requirements. This methodology involves the simulation of a hydrologic sequence referred to as the design drought, which consists of the hydrology from years 1986 through 1992, followed by the hydrology from years 1976 and 1977. This sequence represents a wet year in which system storage is filled, followed by an 8-year sequence of dry conditions. In applying the SFPUC water supply planning methodology, an initial model simulation of the system is performed for the design drought sequence, using the system configuration to be evaluated. Then the ability of the system to deliver water to the service area through the entire design drought sequence is reviewed. If water supply runs out before the end of the design drought sequence in the initial model run, then system-wide water supply rationing is added and the scenario is re-run. This process continues iteratively until a model simulation of the system is achieved in which the water supply in storage at the end of the design drought sequence is brought to the system "dead pool," where no additional storage is available for delivery (simulated as 96,775 acre-feet). Drawing system storage down to the dead pool without going below it indicates that water supply delivery, including the adjusted amount of rationing, is maintained through the design drought sequence.

Rationing is initiated in the model simulations by comparing the total system storage to threshold values. When total system storage is below a given threshold at the end of the annual snowmelt season (treated as the end of the June timestep), a system-wide water supply rationing level that corresponds to that storage threshold will be initiated for the following year. More than one threshold and corresponding level of rationing can be used, so that increasing levels of rationing can be simulated during an extended dry period. As described above, these storage thresholds and rationing levels are developed uniquely for each specific combination of water supply system facilities, water demand, and in-stream flow responsibility. In configurations with greater net demands for water supply relative to available supplies and total system storage, rationing will be relatively greater and may be initiated at a higher value of total system storage than in configurations with relatively lesser water demands. These unique combinations of rationing and storage levels are established to maintain delivery through the design drought planning sequence for each system configuration evaluated.

Once rationing levels and corresponding storage threshold values are established for a particular system configuration using this methodology, they can be used to simulate the operation of that system through the historical record of hydrology. While the design drought sequence does not occur in the historical hydrology, the rationing and storage threshold values that are adjusted to allow a system configuration to maintain water delivery through the design drought sequence can be used to evaluate system performance in the historical record. The responses of the system to other dry sequences that have occurred historically indicate how the given system configuration would be operated by SFPUC in similar sequences in the future. Through use of this planning method, SFPUC is able to simulate a response to declining water supply in storage that is appropriate for the system conditions being evaluated.

For the current analysis of SED alternatives, this water supply planning methodology, including establishment of rationing levels and storage triggers using the design drought sequence, was performed for each combination of system demand and SED flow alternative evaluated. The resulting rationing levels and triggers were then used to simulate operations in the 91-year hydrologic record from 1921-2011.

Results of SFPUC Model Analysis

The SFPUC water supply planning methodology was applied to 15 water system configurations that were developed to evaluate the effects of the SED proposal. These configurations include the four levels of Tuolumne River flow contribution described above, plus the base case in which no additional flow is released to the Tuolumne River, for a total of 5 SED scenarios. These SED scenarios were evaluated at the 3 levels of SFPUC RWS system demand described above. Levels of rationing and associated system storage thresholds were determined so that each of these 15 scenarios would maintain water supply delivery through the design drought sequence. Then these scenarios were each simulated using the historical hydrologic record from 1920 through 2011.

Water Supply Impacts: Water supply rationing is used as an indicator of negative impact to the SFPUC water supply system. The SFPUC water supply planning methodology was used to set rationing levels for the SED alternatives, as described above. A summary of system-wide water supply rationing is presented for all 15 simulations in Tables 2, 3 and 4. Table 2 presents the SED scenarios evaluated at a RWS demand of 265 MGD. Table 3 presents the SED scenarios evaluated at a RWS demand of 223 MGD. Table 4 presents the SED scenarios evaluated at a RWS demand of 175 MGD. For each level of demand evaluated, the only differences between the simulations are the release requirements at La Grange and the adjusted drought rationing levels that are developed through the water supply planning methodology. The effects of the SED alternatives can be evaluated by comparison of simulation results to the base case.

The results presented in Tables 2 through 4 each demonstrate a pattern of increased water supply rationing corresponding to increased level of SFPUC contribution to the unimpaired flow requirement. Since the total system demands are altered through simulated contribution to the unimpaired flow requirement, the timing and degree of water supply rationing imposed through the water supply planning methodology are also altered.

Table 2 presents the 5 SED scenarios evaluated at a SFPUC system-wide demand of 265 MGD. In the base case (no contribution to an unimpaired flow standard), water supply rationing is required in 10 out of 91 years evaluated, and the highest level of system-wide water supply rationing required is 20%. When SFPUC contribution to a 20% unimpaired flow standard is evaluated, water supply rationing is required in 16 out of 91 years, and the highest level of system-wide rationing required is 40%. This pattern continues as the unimpaired flow requirement is increased. The alternative identified for implementation in the SED is based on a 40% unimpaired flow requirement, which would require the SFPUC system to impose rationing in 24 years out of the 91-year record, and which would include system-wide rationing levels of up to 54% at a demand level of 265 MGD.

Table 3 presents the 5 SED scenarios evaluated at a SFPUC system-wide demand of 223 MGD. In the base case, water supply rationing is not required, because this level of demand is able to be delivered through the SFPUC water supply planning methodology for the system configuration being evaluated (which includes the completed facilities included in the WSIP 2018 variant). A pattern of increased occurrence and magnitude of water supply rationing similar to that described in Table 2 is demonstrated for the SED alternatives shown in Table 3. When SFPUC contribution to a 40% unimpaired flow standard is evaluated, water supply rationing is required in 19 out of 91 years, and the highest level of system-wide rationing required is 49%.

Table 4 presents the 5 SED scenarios evaluated at a SFPUC system-wide demand of 175 MGD. It should be noted, as described above, that this level of system demand represents present conditions during the drought in 2015 and 2016, and therefore already reflects the implementation of drought rationing. No additional rationing is required in the base case run at the 175 MGD demand level, or in the scenario that includes a 20% unimpaired flow requirement. When SFPUC contribution to a 40% unimpaired flow standard is evaluated for this system demand, additional water supply rationing is required in 16 out of 91 years, and the highest level of system-wide rationing required is 32%.

Hydropower Generation Impacts: Optimized power generation at SFPUC facilities involves operational changes at the daily timescale or in smaller time increments, because changes in power demand and power cost occur at those timescales. The monthly time-step model that was used for this analysis was developed at an appropriate time-step to evaluate water supply conditions in the Hetch Hetchy system, but it only provides bulk estimates of the power generation that occurs through use of the system. Therefore, a detailed analysis of all expected changes in SFPUC power generation is not available from these model results. However, one pattern does stand out in the monthly timestep results for power generation: When water supply rationing is implemented in response to reduced system storage in the SED alternatives, SFPUC hydropower generation is reduced at the generation facilities that are situated in-line with the water supply delivery pipeline, specifically Kirkwood Powerhouse and Moccasin Powerhouse. These hydropower generation facilities are operated when water supply deliveries are made from Hetch Hetchy Reservoir to the Bay Area. When water supply rationing is implemented in response to decreased levels of water in storage, it causes less water to be transmitted through these generating facilities, with the result that less power is generated. The water supply planning model used for this analysis is appropriate for evaluation of this pattern; the pattern of reduced power generation during water supply rationing is driven by annual or multi-year shortages in water supply, which are captured by the model.

Table 5 presents the annual average estimates of power generation for SED alternatives at the 265 MGD level of SFPUC system demand. Periods in which rationing was implemented for multiple years were identified, and the annual average generation is presented for each of these periods. Refer to Table 2 for the water supply rationing levels implemented in these simulations. The relative change in generation from the base case is also shown in Table 5 as a percentage. Average decreases in generation at Kirkwood and Moccasin Powerhouses in time periods when rationing was implemented is less than 10% in the SED alternatives that include 20% and 30% unimpaired flow requirements. Generation at Kirkwood and Moccasin Powerhouses decreases by more than 10% in the scenarios that include 40% and 50% unimpaired flow requirements.

Tables 6 and 7 are presented in the same format as Table 5. They show changes in Kirkwood and Moccasin Powerhouse generation for the SED alternatives at 223 MGD SFPUC system demand and 175 MGD system demand, respectively. As shown in Table 6, the 20% and 30% unimpaired flow alternatives do not cause a 10% reduction in generation at Kirkwood and Moccasin Powerhouses. The 40% and 50% unimpaired flow alternatives presented in Table 6 exhibit reduced generation at these facilities on the order of 10%. The power generation results presented in Table 7 do not generally include changes on the order of 10% or greater.

An order-of-magnitude estimate of the monetary cost of these changes in generation can be provided by multiplying the differences in generation by a value representing the price received for power. The average Day Ahead price for power from March 2016 through February 2017 was calculated for this purpose, and rounded to $30 per megawatt-hour. Based on the changes in generation presented in Tables 5 and 6, the monetary cost of decreased generation for the 40% or 50% unimpaired alternatives would be approximately $2 million per year. This cost would be expected to be incurred in years when water supply rationing is implemented in the 40% unimpaired flow alternative.

Comments on Analysis Presented in SED

The following comments describe points of confusion in interpreting the SED document and differences in assumptions and methods between SFPUC staff analysis and the work presented in the SED.

Flow Shifting

The SWRCB proposal calls for minimum streamflow of 30% to 50% of unimpaired flow from February through June of each year, with actual required levels of flow within this range to be determined by a committee, based on criteria to be determined in a program of implementation. From the description in the document, actual implementation of the proposal could include flow shifting from the February - June period to later periods. A time-series of flow shifts is calculated in the SWRCB Water Supply Effects (WSE) model provided with the SED, but it is unclear whether the rules used to develop those flow shifts reflect how similar decisions would be made upon implementation; because these decisions are deferred until later, the actual flow schedule that would be required in future years is not clearly described in the SED document. Therefore, the SFPUC analysis did not include any flow shifting or other deviations from the nominal unimpaired flow fraction from February to June of each year. To evaluate the SED alternatives, the SFPUC calculated the contribution to streamflow that would be made at 20%, 30%, 40% and 50% unimpaired flow standards and incorporated these contributions into the modeling analysis of SFPUC system performance.

Location of Measurement and Compliance

The flow standard proposed by SWRCB for the Tuolumne River would be implemented at the USGS stream gage at Modesto, according to Table 3 of Appendix K of the SED document. However, the amount of flow that would be required by the standard is calculated in the WSE model using the record of unimpaired flow developed for the Tuolumne River at New Don Pedro Reservoir (DWR, 2007), which is located about 35 river miles upstream of the Modesto gage. In the pre-defined alternatives included in the WSE model, it is assumed that natural accretions and other return flows to the Tuolumne River that occur between New Don Pedro Reservoir and the Modesto gage contribute to the compliance with the flow standard, and therefore reduce the amount of required water release at New Don Pedro Reservoir. The compliance standard calculated in the WSE is therefore the unimpaired flow at New Don Pedro Reservoir, to be met at the Modesto gage. But the description of the compliance standard provided in Table 3 of Appendix K is unimpaired flow on the Tuolumne River, with compliance met at the Modesto gage. Unimpaired flow at Modesto is higher than unimpaired flow at La Grange by the amount of natural accretions that occur between the two locations. It is not clearly stated in the SED that compliance would be measured as calculated in the WSE model. In fact, the simple statement of the proposed standard in Appendix K implies otherwise. It is also not clear that the estimated level of accretions and return flows would occur under the changed water use regime proposed in the SED alternatives. For example, reduced agricultural irrigation due to implementation of the SED proposal could cause a reduction in irrigation return flows, which would require more release from New Don Pedro Reservoir to meet the standard, relative to the WSE model assumptions. Increased groundwater pumping could have a similar effect on return flows. As described above, the SFPUC modeling analysis assumed that the La Grange stream gage would be the point of compliance, and that accretions below La Grange would not affect compliance. If an unimpaired flow standard were established at the

Modesto gage without modification to account for return flows, then the analysis presented here will have underestimated the resulting impacts to SFPUC water supply. It is worth noting that the analysis presented in the SED would then have also underestimated these impacts.

Vernalis Flow Standard

An additional in-stream flow requirement of 1,000 cubic feet per second at Vernalis is included in the SED, and is assigned to the water users on the San Joaquin River tributaries. It is likely that this standard would be met most of the time if the proposed alternative (30% to 50% unimpaired flow on the tributaries) were implemented. The few periods in which additional releases from storage could be required to meet the proposed Vernalis standard would be low-flow periods in which the quantity of valley floor accretion to the San Joaquin River becomes important. The degree to which accretions to the San Joaquin River from natural inflow and agricultural return flows would be modified in low-flow periods if the proposed SED alternative were implemented is unknown. As discussed above for the Tuolumne River, changes in irrigation practice and groundwater pumping could cause important changes to these accretions to the San Joaquin River during low-flow periods. SFPUC could not realistically evaluate the need for additional releases from storage to meet the Vernalis requirement in dry years. It is possible that the SFPUC analysis of water supply impacts is underestimated because contribution to the Vernalis flow standard is not included.

Impact Analysis

In the analysis of SFPUC water supply presented in Appendix L of the SED, RWS operation including the proposed flow standards is approximated by subtracting the calculated amount of contribution to the unimpaired flow standard from the historical value of the SFPUC water bank account balance in New Don Pedro Reservoir. Impacts to the system are then estimated using two different approaches: One method assumes that SFPUC only has a responsibility to contribute to the stream flow requirement when an estimated value of the water bank account balance is positive. The other assumes that SFPUC would contribute at all times. In both cases, the calculation is used to estimate the amount of water that SFPUC would need to purchase or otherwise develop. Both methods included in the SED quantify this amount of water to purchase as the estimated volume below zero to which the water bank account has fallen in these analyses. One of the effects of these methods of quantification is that contributions to meet the proposed flow standards that do not cause the re-calculated water bank account balance to become negative are not counted as impacts, even if those contributions represent a significant volume reduction in the re-calculated storage of the RWS. This happens in 1987 in the analysis presented in the SED, which is particularly significant because this is the first dry year in a long sequence of dry years in the historic record. Similar impacts to SFPUC water storage occur in other dry years (1994, 2002) in the analysis presented in the SED, but these impacts are not quantified in the analysis presented in Appendix L, apparently because the re-calculated water bank account balance is greater than zero. Use of a different metric that includes the contribution of water supply from SFPUC storage in all years would improve the analysis presented in the SED. For reference, Tables 8 and 9 are provided, which show the average annual volume of contribution from SFPUC system storage that is required under the SED alternatives.

By contrast, the SFPUC model analysis simulates the actual operation of the RWS, which includes making releases from upstream reservoirs to keep the water bank account balance positive, and also includes the implementation of rationing when total system storage becomes depleted. In these simulations, the effect on RWS storage of making contributions to the proposed flow standards is dispersed through the system, instead of being captured entirely in the water bank account. As described above in the discussion of the SFPUC water supply planning methodology, the need for water supply rationing on the RWS is based on the total value of system storage. The estimated system-wide rationing, driven by changes in storage, are used to quantify the effects of the proposed flow standards. As shown in Tables 2, 3 and 4, water supply rationing is applied in the same dry years noted above (1987, 1994, 2002) as a result of SFPUC contribution to the SED proposed alternative.

Table 1 – Notes on System Configuration for Model Simulations

SFPUC RWS System Components as Included in Model Simulations for SED Analysis	Notes
Completed WSIP Transmission Projects	Full pipeline capacity and periodic outages for pipeline inspection and maintenance were assumed.
Completed WSIP Reservoir Capacity	Calaveras Reservoir construction was assumed to be complete in these simulations. Full storage capacity at Calaveras is 31,500 MG (97,000 AF); full storage capacity at Crystal Springs Reservoir is 22,150 MG (68,000 AF).
Completed Treatment Plant Expansions	Full capacity is 160 MGD at SVWTP, 140 MGD at HTWTP.
Westside Basin Conjunctive Use	The regional conjunctive use project is represented in model simulations as a reduction in Peninsula surface water demand in dry years and a corresponding increased surface water delivery to facilitate groundwater recharge in some wet years. A supply equivalent to 7.2 MGD is assumed to be available over an extended drought sequence.
SF Groundwater	SFGW is expected to begin operating in 2017. This is represented as a 4 MGD reduction in retail surface water demand in all years at the 265 MGD level of demand.
SF Recycled Water	Projects in development. Represented as a 3.9 MGD demand reduction in all years at the 265 MGD level of demand.
SF Conservation	Considered to be ongoing. Represented as a demand reduction.
Tuolumne River Transfer from New Don Pedro to SFPUC – Not Included	No agreements for transfers are in place as of March 2017.
BDPL and SJPL Maintenance	Represented as periodic capacity constraints.
Calaveras Instream flow and ACDD Bypass Flow	Due to begin when Calaveras Reservoir is brought online following construction.
Crystal Springs Instream flow	Began in Jan. 2015.
Upper Alameda Creek Recapture Project	Due to begin operation when releases from Calaveras Reservoir for the instream flow requirement are started.
Minimum Instream Flows below Hetch Hetchy System Reservoirs	Instream flow releases per USFWS permits.
FERC Minimum Flows below LaGrange	Releases for compliance with the 1995 FERC schedule were assumed to continue per the current agreement between CCSF, MID and TID.
Releases to meet SED minimum instream flow February through June	Releases greater than required in the 1995 FERC flow schedule are assumed to be shared per 4th agreement by CCSF, MID and TID. No flow shifting outside of the February through June window was assumed.

Table 1 summarizes important system configuration details. For background information and additional configuration details, see Water Supply System Modeling Report (Steiner, 2007) and the Final WSIP PEIR (CCSF, 2008).

Table 2 – Comparison of SFPUC RWS Annual Water Supply Delivery Capability for the SED Alternatives at an Annual Demand of 265 MGD

SFPUC Fiscal Year (July-June)	Base Case			20% UF at La Grange			30% UF at La Grange			40% UF at La Grange			50% UF at La Grange		
	TAF/yr	MGD	Rationing (% of Total)	TAF/yr	MGD	Rationing (% of Total)	TAF/yr	MGD	Rationing (% of Total)	TAF/yr	MGD	Rationing (% of Total)	TAF/yr	MGD	Rationing (% of Total)
FY20-21	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY21-22	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY22-23	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY23-24	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY24-25	297	265	0%	238	212	20%	209	186	30%	179	160	40%	91	82	69%
FY25-26	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY26-27	297	265	0%	297	265	0%	297	265	0%	297	265	0%	91	82	69%
FY27-28	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY28-29	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY29-30	297	265	0%	297	265	0%	209	186	30%	179	160	40%	91	82	69%
FY30-31	297	265	0%	238	212	20%	209	186	30%	179	160	40%	91	82	69%
FY31-32	267	238	10%	209	186	30%	179	160	40%	135	121	54%	91	82	69%
FY32-33	297	265	0%	297	265	0%	297	265	0%	297	265	0%	91	82	69%
FY33-34	297	265	0%	297	265	0%	297	265	0%	179	160	40%	91	82	69%
FY34-35	297	265	0%	238	212	20%	179	160	40%	179	160	40%	91	82	69%
FY35-36	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY36-37	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY37-38	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY38-39	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY39-40	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY40-41	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY41-42	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY42-43	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY43-44	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY44-45	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY45-46	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY46-47	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY47-48	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY48-49	297	265	0%	297	265	0%	209	186	30%	179	160	40%	91	82	69%
FY49-50	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY50-51	297	265	0%	297	265	0%	297	265	0%	297	265	0%	91	82	69%
FY51-52	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY52-53	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY53-54	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY54-55	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY55-56	297	265	0%	297	265	0%	209	186	30%	179	160	40%	91	82	69%
FY56-57	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY57-58	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY58-59	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY59-60	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY60-61	297	265	0%	238	212	20%	209	186	30%	179	160	40%	91	82	69%
FY61-62	267	238	10%	209	186	30%	179	160	40%	135	121	54%	91	82	69%
FY62-63	297	265	0%	297	265	0%	297	265	0%	179	160	40%	91	82	69%
FY63-64	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY64-65	297	265	0%	297	265	0%	297	265	0%	179	160	40%	91	82	69%
FY65-66	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY66-67	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY67-68	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY68-69	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY69-70	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY70-71	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY71-72	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY72-73	297	265	0%	297	265	0%	209	186	30%	179	160	40%	91	82	69%
FY73-74	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY74-75	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY75-76	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY76-77	267	238	10%	238	212	20%	209	186	30%	179	160	40%	91	82	69%
FY77-78	238	212	20%	209	186	30%	179	160	40%	135	121	54%	91	82	69%
FY78-79	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY79-80	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY80-81	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY81-82	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY82-83	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY83-84	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY84-85	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY85-86	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY86-87	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY87-88	297	265	0%	238	212	20%	209	186	30%	179	160	40%	91	82	69%
FY88-89	267	238	10%	209	186	30%	179	160	40%	135	121	54%	91	82	69%
FY89-90	267	238	10%	238	212	20%	179	160	40%	135	121	54%	91	82	69%
FY90-91	238	212	20%	209	186	30%	179	160	40%	135	121	54%	91	82	69%
FY91-92	238	212	20%	209	186	30%	179	160	40%	135	121	54%	91	82	69%
FY92-93	238	212	20%	179	160	40%	150	134	49%	135	121	54%	91	82	69%
FY93-94	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY94-95	297	265	0%	238	212	20%	209	186	30%	135	121	54%	91	82	69%
FY95-96	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY96-97	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY97-98	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY98-99	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY99-00	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY00-01	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY01-02	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY02-03	297	265	0%	297	265	0%	297	265	0%	297	265	0%	91	82	69%
FY03-04	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY04-05	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY05-06	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY06-07	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY07-08	267	238	10%	238	212	20%	209	186	30%	179	160	40%	91	82	69%
FY08-09	297	265	0%	297	265	0%	297	265	0%	179	160	40%	91	82	69%
FY09-10	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%
FY10-11	297	265	0%	297	265	0%	297	265	0%	297	265	0%	297	265	0%

Yellow highlights indicate that water provided to the RWS includes supply from of the Westside Basin conjunctive use groundwater project.

Red highlights indicate that water supply rationing is implemented. The years in which rationing occurs also include use of the Westside Basin groundwater project.

Table 3 – Comparison of SFPUC RWS Annual Water Supply Delivery Capability for the SED Alternatives at an Annual Demand of 223 MGD

SFPUC Fiscal Year (July-June)	Base Case			20% UF at La Grange			30% UF at La Grange			40% UF at La Grange			50% UF at La Grange		
	TAF/yr	MGD	Rationing (% of Total)	TAF/yr	MGD	Rationing (% of Total)	TAF/yr	MGD	Rationing (% of Total)	TAF/yr	MGD	Rationing (% of Total)	TAF/yr	MGD	Rationing (% of Total)
FY20-21	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY21-22	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY22-23	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY23-24	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY24-25	250	223	0%	250	223	0%	188	168	25%	151	135	39%	94	84	62%
FY25-26	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY26-27	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY27-28	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY28-29	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY29-30	250	223	0%	250	223	0%	250	223	0%	151	135	39%	94	84	62%
FY30-31	250	223	0%	250	223	0%	188	168	25%	151	135	39%	94	84	62%
FY31-32	250	223	0%	225	201	10%	166	148	34%	151	135	39%	94	84	62%
FY32-33	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY33-34	250	223	0%	250	223	0%	250	223	0%	250	223	0%	94	84	62%
FY34-35	250	223	0%	250	223	0%	188	168	25%	151	135	39%	94	84	62%
FY35-36	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY36-37	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY37-38	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY38-39	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY39-40	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY40-41	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY41-42	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY42-43	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY43-44	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY44-45	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY45-46	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY46-47	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY47-48	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY48-49	250	223	0%	250	223	0%	250	223	0%	151	135	39%	94	84	62%
FY49-50	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY50-51	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY51-52	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY52-53	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY53-54	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY54-55	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY55-56	250	223	0%	250	223	0%	250	223	0%	250	223	0%	94	84	62%
FY56-57	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY57-58	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY58-59	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY59-60	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY60-61	250	223	0%	250	223	0%	188	168	25%	151	135	39%	94	84	62%
FY61-62	250	223	0%	225	201	10%	166	148	34%	151	135	39%	94	84	62%
FY62-63	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY63-64	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY64-65	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY65-66	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY66-67	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY67-68	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY68-69	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY69-70	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY70-71	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY71-72	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY72-73	250	223	0%	250	223	0%	250	223	0%	151	135	39%	94	84	62%
FY73-74	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY74-75	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY75-76	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY76-77	250	223	0%	250	223	0%	188	168	25%	151	135	39%	94	84	62%
FY77-78	250	223	0%	195	174	22%	166	148	34%	151	135	39%	94	84	62%
FY78-79	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY79-80	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY80-81	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY81-82	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY82-83	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY83-84	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY84-85	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY85-86	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY86-87	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY87-88	250	223	0%	250	223	0%	188	168	25%	151	135	39%	94	84	62%
FY88-89	250	223	0%	225	201	10%	188	168	25%	151	135	39%	94	84	62%
FY89-90	250	223	0%	225	201	10%	188	168	25%	151	135	39%	94	84	62%
FY90-91	250	223	0%	195	174	22%	166	148	34%	127	113	49%	94	84	62%
FY91-92	250	223	0%	195	174	22%	166	148	34%	127	113	49%	94	84	62%
FY92-93	250	223	0%	195	174	22%	166	148	34%	127	113	49%	94	84	62%
FY93-94	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY94-95	250	223	0%	250	223	0%	188	168	25%	151	135	39%	94	84	62%
FY95-96	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY96-97	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY97-98	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY98-99	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY99-00	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY00-01	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY01-02	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY02-03	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY03-04	250	223	0%	250	223	0%	250	223	0%	250	223	0%	94	84	62%
FY04-05	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY05-06	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY06-07	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%
FY07-08	250	223	0%	250	223	0%	250	223	0%	250	223	0%	94	84	62%
FY08-09	250	223	0%	250	223	0%	250	223	0%	151	135	39%	250	223	0%
FY09-10	250	223	0%	250	223	0%	250	223	0%	250	223	0%	94	84	62%
FY10-11	250	223	0%	250	223	0%	250	223	0%	250	223	0%	250	223	0%

Yellow highlights indicate that water provided to the RWS includes supply from of the Westside Basin conjunctive use groundwater project.

Red highlights indicate that water supply rationing is implemented. The years in which rationing occurs also include use of the Westside Basin groundwater project.

Table 4 – Comparison of SFPUC RWS Annual Water Supply Delivery Capability for the SED Alternatives at an Annual Demand of 175 MGD

SFPUC Fiscal Year (July-June)	Base Case			20% UF at La Grange			30% UF at La Grange			40% UF at La Grange			50% UF at La Grange		
	TAF/yr	MGD	Rationing (% of Total)	TAF/yr	MGD	Rationing (% of Total)	TAF/yr	MGD	Rationing (% of Total)	TAF/yr	MGD	Rationing (% of Total)	TAF/yr	MGD	Rationing (% of Total)
FY20-21	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY21-22	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY22-23	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY23-24	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY24-25	196	175	0%	196	175	0%	196	175	0%	158	141	20%	119	106	39%
FY25-26	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY26-27	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY27-28	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY28-29	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY29-30	196	175	0%	196	175	0%	196	175	0%	196	175	0%	119	106	39%
FY30-31	196	175	0%	196	175	0%	196	175	0%	158	141	20%	119	106	39%
FY31-32	196	175	0%	196	175	0%	196	175	0%	158	141	20%	119	106	39%
FY32-33	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY33-34	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY34-35	196	175	0%	196	175	0%	196	175	0%	158	141	20%	119	106	39%
FY35-36	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY36-37	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY37-38	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY38-39	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY39-40	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY40-41	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY41-42	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY42-43	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY43-44	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY44-45	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY45-46	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY46-47	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY47-48	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY48-49	196	175	0%	196	175	0%	196	175	0%	196	175	0%	119	106	39%
FY49-50	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY50-51	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY51-52	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY52-53	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY53-54	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY54-55	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY55-56	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY56-57	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY57-58	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY58-59	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY59-60	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY60-61	196	175	0%	196	175	0%	196	175	0%	158	141	20%	119	106	39%
FY61-62	196	175	0%	196	175	0%	177	158	10%	158	141	20%	119	106	39%
FY62-63	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY63-64	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY64-65	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY65-66	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY66-67	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY67-68	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY68-69	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY69-70	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY70-71	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY71-72	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY72-73	196	175	0%	196	175	0%	196	175	0%	158	141	20%	119	106	39%
FY73-74	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY74-75	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY75-76	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY76-77	196	175	0%	196	175	0%	196	175	0%	158	141	20%	119	106	39%
FY77-78	196	175	0%	196	175	0%	177	158	10%	158	141	20%	119	106	39%
FY78-79	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY79-80	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY80-81	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY81-82	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY82-83	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY83-84	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY84-85	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY85-86	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY86-87	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY87-88	196	175	0%	196	175	0%	196	175	0%	158	141	20%	119	106	39%
FY88-89	196	175	0%	196	175	0%	177	158	10%	158	141	20%	119	106	39%
FY89-90	196	175	0%	196	175	0%	196	175	0%	158	141	20%	119	106	39%
FY90-91	196	175	0%	196	175	0%	177	158	10%	133	118	32%	75	67	62%
FY91-92	196	175	0%	196	175	0%	177	158	10%	133	118	32%	75	67	62%
FY92-93	196	175	0%	196	175	0%	177	158	10%	133	118	32%	75	67	62%
FY93-94	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY94-95	196	175	0%	196	175	0%	196	175	0%	158	141	20%	119	106	39%
FY95-96	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY96-97	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY97-98	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY98-99	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY99-00	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY00-01	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY01-02	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY02-03	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY03-04	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY04-05	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY05-06	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY06-07	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY07-08	196	175	0%	196	175	0%	196	175	0%	196	175	0%	119	106	39%
FY08-09	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY09-10	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%
FY10-11	196	175	0%	196	175	0%	196	175	0%	196	175	0%	196	175	0%

Yellow highlights indicate that water provided to the RWS includes supply from of the Westside Basin conjunctive use groundwater project.

Red highlights indicate that water supply rationing is implemented. The years in which rationing occurs also include use of the Westside Basin groundwater project.

Table 5 – Comparison of SFPUC Hydropower Generation for the SED Alternatives at an Annual RWS Demand of 265 MGD

Time Period	Base Case	20% UF at La Grange		30% UF at La Grange		40% UF at La Grange		50% UF at La Grange	
	Average Annual Generation at Kirkwood and Moccasin Powerhouses (MWh)	Average Annual Generation at Kirkwood and Moccasin Powerhouses (MWh)	Average Change from Base Case (%)	Average Annual Generation at Kirkwood and Moccasin Powerhouses (MWh)	Average Change from Base Case (%)	Average Annual Generation at Kirkwood and Moccasin Powerhouses (MWh)	Average Change from Base Case (%)	Average Annual Generation at Kirkwood and Moccasin Powerhouses (MWh)	Average Change from Base Case (%)
FY 1929-30 through FY 1934-35	885,000	868,000	-2%	843,000	-5%	807,000	-9%	753,000	-15%
FY 1960-61 through FY 1962-63	860,000	815,000	-5%	801,000	-7%	766,000	-11%	742,000	-14%
FY 1976-77 through FY 1977-78	744,000	726,000	-2%	704,000	-5%	670,000	-10%	591,000	-21%
FY 1987-88 through FY 1994-95	846,000	818,000	-3%	796,000	-6%	766,000	-9%	740,511	-12%

Table 5 presents the average annual generation (in megawatt-hours) that was simulated at the Kirkwood and Moccasin Powerhouses for the years indicated at an annual system demand of 265 MGD. These powerhouses are located on the water supply delivery pathway between Hetch Hetchy Reservoir and the SFPUC service area, which allows power generation while water deliveries are made. During periods of water supply rationing (See Table 2), the flow of water through these powerhouses is reduced, and generation is also reduced.

Table 6 – Comparison of SFPUC Hydropower Generation for the SED Alternatives at an Annual RWS Demand of 223 MGD

Time Period	Base Case	20% UF at La Grange		30% UF at La Grange		40% UF at La Grange		50% UF at La Grange	
	Average Annual Generation at Kirkwood and Moccasin Powerhouses (MWh)	Average Annual Generation at Kirkwood and Moccasin Powerhouses (MWh)	Average Change from Base Case (%)	Average Annual Generation at Kirkwood and Moccasin Powerhouses (MWh)	Average Change from Base Case (%)	Average Annual Generation at Kirkwood and Moccasin Powerhouses (MWh)	Average Change from Base Case (%)	Average Annual Generation at Kirkwood and Moccasin Powerhouses (MWh)	Average Change from Base Case (%)
FY 1929-30 through FY 1934-35	854,000	848,000	-1%	828,000	-3%	798,000	-7%	767,000	-10%
FY 1960-61 through FY 1962-63	825,000	814,000	-1%	782,000	-5%	781,000	-5%	767,000	-7%
FY 1976-77 through FY 1977-78	761,000	739,000	-3%	694,000	-9%	657,000	-14%	600,000	-21%
FY 1987-88 through FY 1994-95	839,000	818,000	-3%	789,000	-6%	766,000	-9%	740,611	-12%

Table 6 presents the average annual generation (in megawatt-hours) that was simulated at the Kirkwood and Moccasin Powerhouses for the years indicated at an annual system demand of 223 MGD. These powerhouses are located on the water supply delivery pathway between Hetch Hetchy Reservoir and the SFPUC service area, which allows power generation while water deliveries are made. During periods of water supply rationing (See Table 3), the flow of water through these powerhouses is reduced, and generation is also reduced.

Table 7 – Comparison of SFPUC Hydropower Generation for the SED Alternatives at an Annual RWS Demand of 175 MGD

Time Period	Base Case	20% UF at La Grange		30% UF at La Grange		40% UF at La Grange		50% UF at La Grange	
	Average Annual Generation at Kirkwood and Moccasin Powerhouses (MWh)	Average Annual Generation at Kirkwood and Moccasin Powerhouses (MWh)	Average Change from Base Case (%)	Average Annual Generation at Kirkwood and Moccasin Powerhouses (MWh)	Average Change from Base Case (%)	Average Annual Generation at Kirkwood and Moccasin Powerhouses (MWh)	Average Change from Base Case (%)	Average Annual Generation at Kirkwood and Moccasin Powerhouses (MWh)	Average Change from Base Case (%)
FY 1929-30 through FY 1934-35	809,000	812,000	0%	810,000	0%	797,000	-1%	774,000	-4%
FY 1960-61 through FY 1962-63	779,000	777,000	0%	768,000	-1%	768,000	-1%	761,000	-2%
FY 1976-77 through FY 1977-78	725,000	725,000	0%	710,000	-2%	669,000	-8%	622,000	-14%
FY 1987-88 through FY 1994-95	810,000	809,000	0%	797,000	-2%	772,000	-5%	745,463	-8%

Table 7 presents the average annual generation (in megawatt-hours) that was simulated at the Kirkwood and Moccasin Powerhouses for the years indicated at an annual system demand of 175 MGD. These powerhouses are located on the water supply delivery pathway between Hetch Hetchy Reservoir and the SFPUC service area, which allows power generation while water deliveries are made. During periods of water supply rationing (See Table 4), the flow of water through these powerhouses is reduced, and generation is also reduced.

Table 8 – Average Annual Contribution from SFPUC System Storage, as Calculated from Record

SFPUC Contribution to Flow Standard Calculated from Unimpaired Flow Record (AF) **Average Contribution from Feb-Jun of Each Year**							
Tuolumne River Unimpaired Flow Standard, Feb-Jun	Critical	Dry	Below Normal	Above Normal	Wet	Average in 91-year Record	Average during 6-Year Drought (1987-92)
Base	0	0	0	0	0	0	0
20%	42,902	50,362	66,868	82,300	135,242	82,927	49,329
30%	80,028	97,818	126,641	158,410	244,131	154,130	90,175
40%	117,470	146,358	191,356	239,106	354,479	227,663	131,021
50%	155,253	194,938	256,920	320,986	465,048	301,699	172,026

Annual averages presented in Table 8 are calculated using a 91-year record of unimpaired flow on the Tuolumne River from 1921 through 2011. Averages by water year type are presented for years in that record, according to San Joaquin Valley Water Year Hydrologic Classification (per D-1641). SFPUC contribution to the unimpaired flow standards is calculated as described on Figure 1.

Table 9 – Average Annual Contribution from SFPUC System Storage, as Simulated in System Model

Simulated SFPUC Contribution to Flow Standard After Accounting for Spills (AF) **Average Contribution from Feb-Jun of Each Year (simulated demand of 265 MGD)**							
Tuolumne River Unimpaired Flow Standard, Feb-Jun	Critical	Dry	Below Normal	Above Normal	Wet	Average in 91-year Record	Average during 6-Year Drought (1987-92)
Base	0	0	0	0	0	0	0
20%	42,293	37,427	41,276	11,909	5,002	24,313	48,939
30%	78,684	79,251	94,208	34,645	12,130	52,702	89,265
40%	116,137	131,201	157,446	74,532	24,885	89,505	129,884
50%	154,153	181,782	223,041	137,969	42,760	132,750	170,755

Annual averages presented in Table 9 are from 91-year simulations of the SFPUC water supply system using the hydrologic record from 1921 through 2011. Averages by water year type are presented from the simulations using San Joaquin Valley Water Year Hydrologic Classification (per D-1641). The simulation of the SFPUC reservoir system allows in-stream flow requirements to be met first by any water that spills from storage, and requires releases from storage to meet the remainder of the SFPUC responsibility for flow. The inclusion of spill accounting in Table 9 is the only difference from Table 8. Note that the SFPUC responsibility is greatly diminished in wetter year types in Table 9, relative to Table 8, and is substantially the same in the drier year types.

Figure 1 – Example Calculation of SFPUC Contribution to Unimpaired Flow Standards Proposed in SED

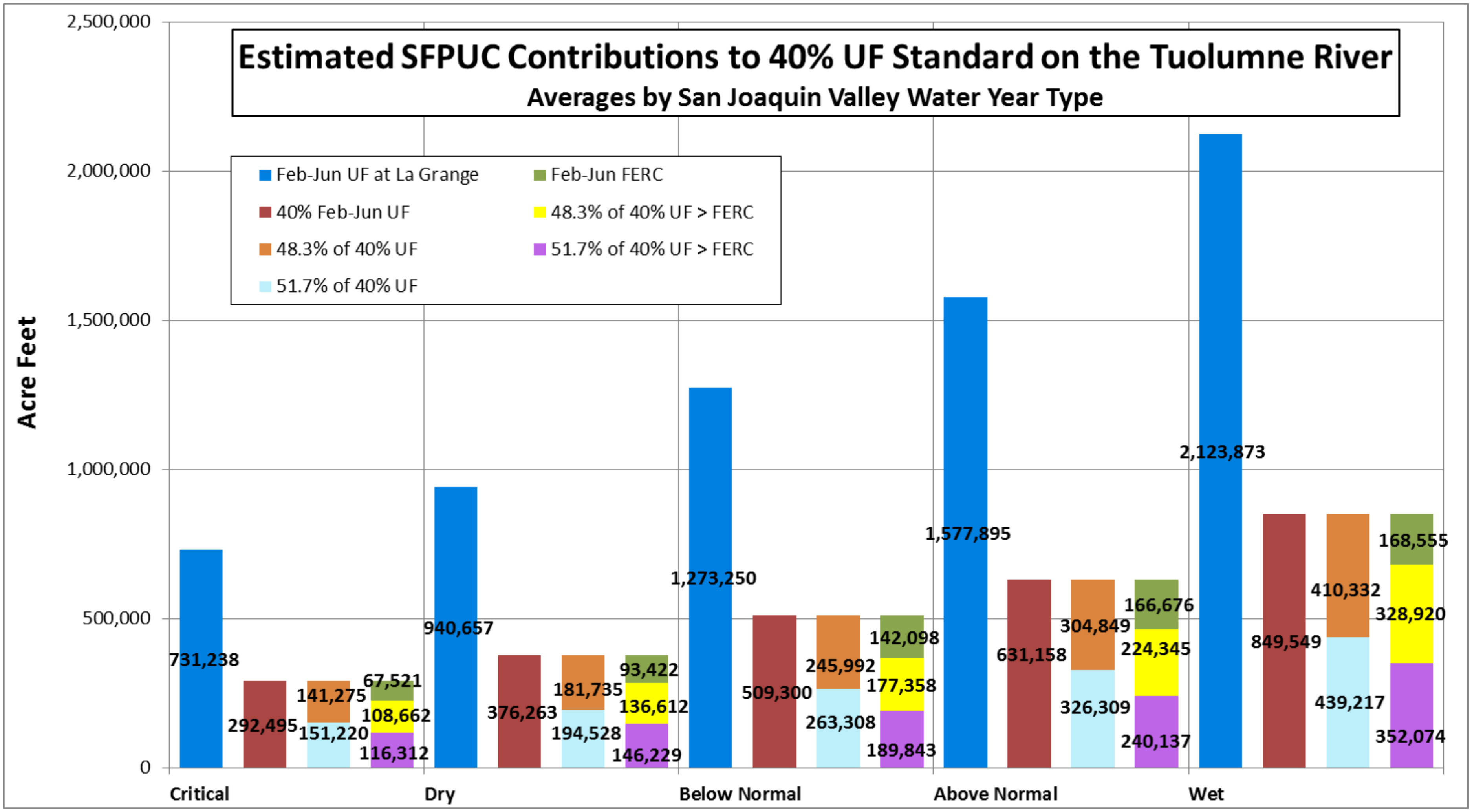

Figure 1 presents average values of unimpaired flow (UF) on the Tuolumne River at La Grange, summed for the period from February through June, for San Joaquin Valley water year types (Feb-Jun UF at La Grange). Also shown is the volume equal to 40% of the total unimpaired flow at La Grange from February through June (40% Feb-Jun UF), which is the estimated SED flow proposal. That volume is then shown split into fractions equal to 51.7% and 48.3% of 40% of unimpaired flow (51.7% of 40% UF; 48.3% of 40% UF). Finally, the volume from February through June of the current FERC release schedule at La Grange is shown averaged by water year type (Feb-Jun FERC), and the remaining difference between the FERC schedule and 40% of unimpaired flow is shown split into fractions of 51.7% and 48.3% (51.7% of 40% UF > FERC; 48.3% of 40% UF > FERC). For the current evaluation of SED alternatives, the SFPUC contribution was calculated for each month using the method described for the “51.7% of 40% UF > FERC” values. All averages shown in Figure 1 are calculated for water years 1921 through 2011.

APPENDIX 3

Bay Area Socioeconomic Impacts Resulting from Instream Flow Requirements for the Tuolumne River

PREPARED FOR

San Francisco Public Utilities Commission

PREPARED BY

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March 15, 2017

THE Brattle GROUP

This report was prepared for the San Francisco Public Utilities Commission. All results and any errors are the responsibility of the authors and do not represent the opinion of The Brattle Group or its clients.

Acknowledgement: We acknowledge the valuable contributions of many individuals to this report and to the underlying analysis, including members of The Brattle Group for peer review.

Introduction

This report concerns the socioeconomic impacts of current and projected dry-year water shortages within the Hetch Hetchy Regional Water System ("RWS") service area in the San Francisco Bay Area. The RWS is owned and operated by the San Francisco Public Utilities Commission ("SFPUC") and has a service territory that includes the City and County of San Francisco ("CCSF" or "San Francisco"), and that of the SFPUC's 26 wholesale customers in San Mateo, Santa Clara and Alameda Counties ("Wholesale Customers").[1]

The water shortages evaluated in this report result from instream flow requirements proposed to be imposed for the Tuolumne River by the State Water Resources Control Board. These shortages are likely to be coincident with dry-year conditions in which non-RWS water supplies otherwise available to the CCSF and the Wholesale Customers are reduced.[2] Specifically, we examine shortages for the 30%, 40% and 50% unimpaired flow scenarios, as well as under baseline conditions.

Socioeconomic impacts are assessed from the perspective of the households and businesses that consume water provided by the RWS. The socioeconomic impact analysis focuses on several standard measures of impact under both current and projected future demands: economic welfare, business sales, and employment.3 The method used to estimate these impacts is described in the report *Socioeconomic Impacts of Water Shortages within the Hetch Hetchy Regional Water System Service Area*, prepared by The Brattle Group in 2014. The version of the impact model used in this report has been updated to incorporate the Plan Bay Area projections of population and employment, and the most recent estimates of household income from the U.S. Census Bureau.

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1 The RWS also serves Cordilleras Mutual Water Company on a wholesale basis; however due to their small size they were not included in this analysis. In addition, the SFPUC serves one wholesale customer outside San Francisco, Groveland Community Service District in Tuolumne County, as well as retail customers in the Town of Sunol and Lawrence Livermore National Laboratory in Alameda County. These outside San Francisco accounts represent a small fraction of overall RWS demands, and consequently, socioeconomic impacts on these customers are not estimated in this report.

2 Non-RWS supplies reference supplies available to service demand that are not provided by the RWS system.

3 Business sales are measured as revenues generated in the following sectors: manufacturing, wholesale trade, information, real estate and rental and leasing, professional, scientific, and technical services, educational services, health care and social assistance, arts, entertainment, and recreation, accommodation and food services, and other services (except public administration).

These figures are used in the forecast of 2040 water demands for San Francisco and the Wholesale Customers.

Shortage Calculations

The estimation of socioeconomic impacts resulting from water shortages occurs via a multi-step process. Water shortages (defined as total demand minus available supply) are estimated relative to two different levels of baseline demand. First, the impacts of instream flow criteria are evaluated under a demand of 223 mgd on the RWS, which corresponds to the pre-drought, normalized level of demand on the RWS.[4] Second, impacts are evaluated under RWS demand of 265 mgd, which is equal to the SFPUC's maximum supply commitment to the RWS customers. This level of demand is also consistent with forecasts of RWS demand developed by The Brattle Group projected to occur in 2040.

For both the pre-drought and 2040 analyses, RWS demands are calculated taking into account the current and anticipated alternative water supplies, including active conservation, available to SFPUC and the Wholesale Customers for both normal and dry years. That is, RWS demand is calculated as a residual, or total demand minus available alternative supplies. Table 1 displays the amount of dry-year alternative supplies for CCSF and the Wholesale Customers, for both the 223 and 265 mgd demand scenarios. These figures were provided by SFPUC and BAWSCA.

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4 Pre-drought, normalized demand represents current demand under normal economic and weather conditions.

Table 1
Dry Year Alternative Supplies and Active Conservation
(mgd)

	Recycled Supplies	Total Alternative Supplies	Active Conservation
223 MGD			
Wholesale Customers	10.24	69.26	
CCSF	0.00	2.20	
265 MGD			
Wholesale Customers	17.81	81.46	15.00
CCSF	4.00	9.00	5.20

The figures in Table 1 indicate that alternative supplies are projected to increase significantly in the RWS service area over the next two decades. Despite this increase, it will be demonstrated in subsequent sections of this report that future losses resulting from reduced RWS deliveries are somewhat larger than at present.

To calculate shortages for each agency, water supplies available from the RWS in each unimpaired flow scenario and hydrological traces[5] are first allocated between the CCSF and the Wholesale Customers in aggregate, based on the Water Shortage Allocation Plan adopted as part of the 25-year 2009 Water Supply Agreement (WSA). The supplies available to the Wholesale customers collectively are then allocated among the individual Wholesale Customers in proportion to an Allocation Basis.[6] For the purposes of estimating the socioeconomic impacts of water shortages, available supplies for each agency are then allocated across the following sectors: single-family residential (SFR), multi-family residential (MFR), commercial and industrial (CI), dedicated irrigation (DI), and other.

5 A hydrologic trace is a sequence of RWS water supplies available over the historic hydrology, assuming a given level of demand.

6 The Allocation Basis for each Wholesale Customer is calculated based on two components: the fixed Wholesale Customers' Individual Supply Guarantee, as stated in the WSA, and the variable Base/Seasonal Component, calculated using the monthly water use for three consecutive years prior to the onset of the drought for each of the Wholesale Customers for all available water supplies.

This method yields estimates of water shortage specific to each sector and Wholesale Customer, for each unimpaired flow scenario and each year in the hydrological trace. Economic relationships that translate these shortages into estimates of social welfare, output, and employment losses are then applied. These economic impact relationships, which are conceptually similar to dose-response functions used in medical research, are developed through econometric analyses of past water use behavior.

Tables 2 displays the maximum shortages for each sector evaluated across the historic hydrology and assuming a 223 mgd level of RWS demand. Maximum shortages occur in 1992 conditions, reflecting the severe water supply restrictions occurring at the end of the six-year drought lasting from 1987 to 1992.

Table 2
Maximum Shortages under RWS Demand of 223 MGD
(mgd/percent)[7]

	CCSF							Wholesale					
	DI	SFR	MFR	CI	Other	Total		DI	SFR	MFR	CI	Other	Total
Base Case	0.00 0%	0.00 0%	0.00 0%	0.00 0%	0.00 0%	0.00 0%	Base Case	0.00 0%	0.00 0%	0.00 0%	0.00 0%	0.00 0%	0.00 0%
30% Unimpaired	0.00 0%	4.92 30%	6.88 30%	6.31 30%	1.13 7%	19.24 25%	30% Unimpaired	13.91 67%	31.79 32%	5.51 15%	7.86 15%	3.98 16%	63.05 27%
40% Unimpaired	0.00 0%	8.19 50%	11.46 50%	7.74 37%	5.22 30%	32.62 42%	40% Unimpaired	14.19 69%	42.43 42%	11.74 32%	13.65 26%	5.91 23%	87.92 37%
50% Unimpaired	0.00 0%	10.65 65%	13.61 59%	10.52 50%	8.70 50%	43.49 56%	50% Unimpaired	14.19 69%	50.82 50%	15.39 41%	19.96 38%	7.75 30%	108.12 46%

Table 3 displays the same information for the 265 mgd level of demand. The percent shortages are fairly equivalent to those in Table 2, reflecting the fact that both total demand and non-RWS supplies are projected to grow over the coming two decades.

7 San Franicisco dedicated irrigation accounts are characterized by sector (residential or commercial and industrial). Thus, shortages to dedicated irrigation ("DI") are taken through shortages to SFR, CI, and other. For the wholesale customers, dedicated irrigation usage is separated by source, namely whether irrigation accounts are serviced by recycled water or other supplies. When determining shortages, the model first allocates conservation to dedicated irrigation not serviced by recycled water and reduces this amount by 100%.

Table 3
Maximum Shortages under RWS Demand of 265 MGD
(mgd/percent)[8]

	CCSF							Wholesale					
	DI	SFR	MFR	CI	Other	Total		DI	SFR	MFR	CI	Other	Total
Base Case	0.00	1.36	0.00	0.00	0.00	1.36	Base Case	9.43	31.18	7.06	8.26	0.78	56.72
	0%	6%	0%	0%	0%	2%		46%	25%	15%	12%	2%	19%
30%	0.00	8.43	7.87	7.74	4.94	28.98	30%	9.43	60.14	25.18	27.63	14.61	136.98
Unimpaired	0%	38%	30%	30%	30%	32%	Unimpaired	46%	44%	36%	29%	25%	37%
40%	0.00	10.99	9.94	7.74	4.94	33.62	40%	9.43	66.16	28.69	30.43	15.74	150.45
Unimpaired	0%	50%	38%	30%	30%	37%	Unimpaired	46%	47%	39%	33%	28%	40%
50%	0.00	13.24	13.12	12.91	8.24	47.50	50%	9.43	80.22	35.45	41.78	23.90	190.79
Unimpaired	0%	60%	50%	50%	50%	52%	Unimpaired	46%	57%	46%	42%	40%	49%

Subsequent sections of the report detail the economic implications of water shortages caused by the Tuolumne River instream flow requirements detailed in the SED. Before reporting these impact calculations, however, it is instructive to consider the magnitude of these projected shortages in comparison to Plan Bay Area growth projections.

Water Availability and Growth Projections

The Plan Bay Area contains projections of employment and population to 2040. Tables 4 and 5 display these projections by county. In general, Plan Bay Area anticipates significant growth of employment over this period, particularly in Alameda, San Francisco and Santa Clara counties.

8 *Id.*

Table 4
Plan Bay Area Employment Growth by County
(from 2010 levels)

County	No Project	Main Streets	Connected Neighborhoods	Big Cities
Alameda	38%	40%	39%	39%
San Francisco	42%	44%	46%	42%
San Mateo	17%	20%	18%	18%
Santa Clara	41%	39%	39%	42%

Source: Plan Bay Area 2040, http://planbayarea.org/.
The scenarios above are described as follows:
"No Project" illustrates trends under currently adopted local general plans and zoning.
"Main Streets" places future population and employment growth in the downtowns in all Bay Area cities.
"Connected Neighborhoods" places future population and employment growth in medium-sized cities.
"Big Cities" concentrates future population and employment growth within San Jose, San Francisco and Oakland.

Plan Bay Area anticipates a similar pattern of population growth, with more population growth projected to occur in San Francisco and Santa Clara counties than is the case with job growth.

Table 5
Plan Bay Area Population Growth by County
(from 2010 levels)

County	No Project	Main Streets	Connected Neighborhoods	Big Cities
Alameda	29%	35%	36%	24%
San Francisco	34%	40%	36%	46%
San Mateo	25%	29%	25%	23%
Santa Clara	28%	34%	37%	73%

Source: Plan Bay Area 2040, http://planbayarea.org/.
The scenarios above are described as follows:
"No Project" illustrates trends under currently adopted local general plans and zoning.
"Main Streets" places future population and employment growth in the downtowns in all Bay Area cities.
"Connected Neighborhoods" places future population and employment growth in medium-sized cities.
"Big Cities" concentrates future population and employment growth within San Jose, San Francisco and Oakland.

The large maximum shortages displayed in Tables 2 and 3 call these growth patterns into question. In San Francisco County, for example, it is questionable whether a projection of 42% job growth is realistic given that businesses in the city can expect 50% water shortages in a multi-year drought. Similarly, it is dubious that developers in Santa Clara County would be willing or able to build enough housing units to support up to 73% growth in population, when those same households would be subjected to 56% water restrictions during the driest periods. The apparent mismatch between Bay Area growth projections and expected dry-year shortages raises the question of whether the instream flow restrictions in the SED would alter patterns of growth in the Bay Area.

Economic Impacts: Welfare Losses

Welfare loss estimates are based on relationships that capture the amount consumers would pay to avoid a shortage of a given magnitude. Economists refer to this value as "willingness to pay" ("WTP"). Consumers' WTP to avoid a water shortage is estimated by observing how consumers have responded to price changes in the past. Water rates increase over time and vary across agencies. By observing how consumption changes as water rates change, we can estimate the "price elasticity of demand", or the responsiveness of demand to price. This price elasticity can then be used to determine how much consumers would be willing to pay to achieve various levels of consumption, and conversely how much they would be willing to pay to avoid reducing their consumption levels.[9]

Separate price elasticities are used for different sectors and agencies to account for variation in responsiveness to price. Resulting welfare loss estimates for the CCSF and the Wholesale Customers in aggregate, under pre-drought normalized demand, are presented below in Table 6. The tables in this report display impacts for the 1987-1992 drought, which is the period of the most significant shortages over the hydrologic record

Table 6
Welfare Losses Associated with RWS Demand of 223 MGD
($ millions)

	CCSF				Wholesale			
	Base Case	30% Unimpaired	40% Unimpaired	50% Unimpaired	Base Case	30% Unimpaired	40% Unimpaired	50% Unimpaired
1987	$0	$40	$86	$217	$0	$146	$248	$476
1988	$0	$40	$86	$217	$0	$146	$248	$476
1989	$0	$40	$86	$217	$0	$146	$248	$476
1990	$0	$65	$138	$217	$0	$206	$342	$476
1991	$0	$65	$138	$217	$0	$206	$342	$476
1992	$0	$65	$138	$217	$0	$206	$342	$476
Total	$0	$313	$671	$1,305	$0	$1,055	$1,771	$2,853

Note: Maximum losses across the historic hydrologic trace occur in 1992.

Over the 1987-92 drought, impacts for San Francisco range from $313 million to over $1.3 billion in lost welfare. For the Wholesale Customers, equivalent losses range from $1.1 billion to

9 For more on the specific method used to determine residential and business WTP and welfare loss, see Buck, S., M. Auffhammer, S. Hamilton and D. Sunding, "Measuring Welfare Losses from Urban Water Supply Disruptions," *Journal of the Association of Environmental and Resource Economists* (September 2016): 743-778.

$2.9 billion. Welfare loss estimates under projected RWS demand of 265 mgd are presented below in Table 7.

Table 7
Welfare Losses Associated with RWS Demand of 265 MGD
($ millions)

	CCSF				Wholesale			
	Base Case	30% Unimpaired	40% Unimpaired	50% Unimpaired	Base Case	30% Unimpaired	40% Unimpaired	50% Unimpaired
1987	$0	$71	$137	$480	$0	$428	$580	$1,209
1988	$0	$137	$283	$480	$160	$580	$874	$1,209
1989	$0	$137	$283	$480	$160	$580	$874	$1,209
1990	$6	$137	$283	$480	$296	$580	$874	$1,209
1991	$6	$137	$283	$480	$296	$580	$874	$1,209
1992	$6	$220	$283	$480	$296	$771	$874	$1,209
Total	$18	$841	$1,552	$2,882	$1,206	$3,518	$4,950	$7,254

Note: Maximum losses across the historic hydrologic trace occur in 1992.

Welfare losses are significantly larger in the 265 mgd case. For CCSF, welfare losses from the 30% - 50% Unimpaired Flow scenarios range from $841 million to $2.9 billion. For San Francisco's Wholesale Customers, losses range from $3.5 billion to $7.3 billion over the 1987-92 hydrology.

It has been suggested that the low level of RWS water sales occurring in 2015-16 could be used to evaluate impacts assuming a "new normal" level of RWS demand of 175 mgd. This approach would be highly misleading for several reasons. The figure of 175 mgd was the level of actual purchases of RWS water during the drought – it is not a level of demand. Given prevailing rates and economic conditions, customers would have preferred to purchase more water during this period, but were prevented from doing so by the Governor's mandate to reduce water usage as implemented by the State Water Resources Control Board. The actual demand during the drought was the 223 mgd employed in this report. Restricting purchases below this amount results in economic losses of the type presented in this report. To call a restricted level of purchases the new level of demand simply assumes away any economic loss.

In 2015-16, the Wholesale Customers reduced residential consumption by around one-quarter in response to the Governor's mandate. In San Francisco, residential consumption changes by roughly half this amount due to the already low level of consumption in the city. In the 30% Unimpaired scenario, residential cutbacks reach 38% in San Francisco and 44% in the Wholesale Customer service area under the 223 mgd level of RWS demand, well beyond the shortages experienced by customers in the service area during the severe recent drought.

Economic Impacts: Business Output and Employment Losses

The other measures of socioeconomic impact evaluated are sales and employment. Business output, defined as the value of sales of all business establishments in a particular area, is a standard way of measuring economic activity. Employment is another summary measure of economic activity and is defined as the number of full-time equivalent jobs in the given area. Dry-year shortages have the potential to influence business sales and employment when businesses are forced to curtail their water consumption.

Changes in output under each scenario are based on the shortages incurred by the CI sector in each Wholesale Customer's service territory. Given a CI water shortage, county-specific output multipliers[10] are used to translate a percent change in water availability to the CI sector into a percent change in business revenue. Separate multipliers are used for relatively moderate shortages (below 15%) and for more severe shortages (over 15%), to account for the fact that an additional cut back in water supply becomes more difficult to manage the further supply has already been reduced.

Averaging multipliers across the industries included in the analysis (see footnote 3), based on their share of annual payroll in the Wholesale Customers' service territories, each percent shortage under 15% translates into 0.038% lower sales revenue in the commercial sector, and 0.128% lower sales revenue in the industrial sector. Each percent shortage above 15% translates into a sales revenue reduction of 0.402% in the commercial sector and 0.470% in the industrial sector. Resulting output losses under pre-drought normalized demand are shown in Table 8 below.

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10 MHB Consultants, Inc., "The Economic Impact of Water Delivery Reductions on the San Francisco Water Department's Commercial and Manufacturing Customers," 1994. Tables 13 and 14 (pp. 48, 50).

Table 8
Output Losses Associated with RWS Demand of 223 MGD
($ millions)

	CCSF				Wholesale			
	Base Case	30% Unimpaired	40% Unimpaired	50% Unimpaired	Base Case	30% Unimpaired	40% Unimpaired	50% Unimpaired
1987	$0	$0	$6,597	$14,589	$0	$4,012	$6,630	$33,447
1988	$0	$0	$6,597	$14,589	$0	$4,012	$6,630	$33,447
1989	$0	$0	$6,597	$14,589	$0	$4,012	$6,630	$33,447
1990	$0	$6,597	$9,315	$14,589	$0	$6,212	$16,282	$33,447
1991	$0	$6,597	$9,315	$14,589	$0	$6,212	$16,282	$33,447
1992	$0	$6,597	$9,315	$14,589	$0	$6,212	$16,282	$33,447
Total	$0	$19,792	$47,738	$87,536	$0	$30,671	$68,736	$200,681

Note: Maximum losses across the historic hydrologic trace occur in 1992.

Table 8 indicates that under pre-drought levels of demand, commercial and industrial shortages result in output losses of between $19.8 and $87.5 billion for San Francisco, and from $30.7 to over $200 billion in the Wholesale Customers service area. Output losses under projected 2035 demand are shown in Table 9 below.

Table 9
Output Losses Associated with RWS Demand of 265 MGD
($ millions)

	CCSF				Wholesale			
	Base Case	30% Unimpaired	40% Unimpaired	50% Unimpaired	Base Case	30% Unimpaired	40% Unimpaired	50% Unimpaired
1987	$0	$0	$3,465	$18,240	$0	$8,640	$14,164	$50,960
1988	$0	$3,465	$8,248	$18,240	$561	$14,164	$35,179	$50,960
1989	$0	$3,465	$8,248	$18,240	$561	$14,164	$35,179	$50,960
1990	$0	$3,465	$8,248	$18,240	$4,158	$14,164	$35,179	$50,960
1991	$0	$3,465	$8,248	$18,240	$4,158	$14,164	$35,179	$50,960
1992	$0	$8,248	$8,248	$18,240	$4,158	$28,654	$35,179	$50,960
Total	$0	$22,109	$44,707	$109,440	$13,596	$93,952	$190,057	$305,759

Note: Maximum losses across the historic hydrologic trace occur in 1992.

As expected, losses under 265 mgd demand are larger than assuming pre-drought demands. For CCSF, output losses over the 1987-92 drought total between $22.1 and $109.4 billion. For the Wholesale Customer service area, output losses range from $94.0 to $305.8 billion over this same period.

Using a similar method, agency-specific multipliers[11] are used to translate shortages in the CI sectors into changes in employment. Job losses under pre-drought normalized demand conditions are presented in Table 10.

11 MHB Consultants, Inc., "The Economic Impact of Water Delivery Reductions on the San Francisco Water Department's Commercial and Manufacturing Customers," 1994. Tables 13 and 14 (pp. 48, 50).

Table 10
Job Losses Associated with RWS Demand of 223 MGD
(full-time equivalent jobs)

	CCSF				Wholesale			
	Base Case	30% Unimpaired	40% Unimpaired	50% Unimpaired	Base Case	30% Unimpaired	40% Unimpaired	50% Unimpaired
1987	0	0	27,981	62,202	0	13,169	25,651	85,603
1988	0	0	27,981	62,202	0	13,169	25,651	85,603
1989	0	0	27,981	62,202	0	13,169	25,651	85,603
1990	0	27,981	39,619	62,202	0	24,433	55,384	85,603
1991	0	27,981	39,619	62,202	0	24,433	55,384	85,603
1992	0	27,981	39,619	62,202	0	24,433	55,384	85,603
Total	0	83,943	202,800	373,214	0	112,806	243,107	513,619

Note: Maximum losses across the historic hydrologic trace occur in 1992.

For CCSF, job losses under 1987-92 hydrology range from 83,943 annual FTE over the six-year drought, to 373,214 under the 50% Unimpaired Flow scenario. For the Wholesale Customers, annual FTE losses are between 112,806 and 513,619 under the same conditions. Job losses under RWS demands of 265 mgd are shown in Table 11.

Table 11
Job Losses Associated with RWS demand of 265 MGD
(full-time equivalent jobs)

	CCSF				Wholesale			
	Base Case	30% Unimpaired	40% Unimpaired	50% Unimpaired	Base Case	30% Unimpaired	40% Unimpaired	50% Unimpaired
1987	0	0	13,777	73,886	0	35,361	43,227	117,533
1988	0	13,777	33,237	73,886	482	43,227	86,826	117,533
1989	0	13,777	33,237	73,886	482	43,227	86,826	117,533
1990	0	13,777	33,237	73,886	19,004	43,227	86,826	117,533
1991	0	13,777	33,237	73,886	19,004	43,227	86,826	117,533
1992	0	33,237	33,237	73,886	19,004	72,261	86,826	117,533
Total	0	88,346	179,961	443,317	57,976	280,529	477,355	705,197

Note: Maximum losses across the historic hydrologic trace occur in 1992.

As in the case of output losses, job losses are larger in the 265 mgd demand case than under pre-drought demands. San Francisco job losses range from 88,346 annual FTE to 443,317 annual FTE. Losses are significantly larger for the Wholesale Customers and range from 280,529 to 705,197 lost annual FTE over the six-year drought.

Rate Impacts from Water Shortages

SFPUC and the Wholesale Customers recover fixed costs through volumetric rates. That is, rate structures in the Bay Area are such that water rates are well in excess of variable operating costs. As a result, when sales fall through supply restrictions, water rates must increase to balance water utility budgets.

For the 265 mgd demand scenario, water rates in CCSF will need to increase by 4% in the 30% Unimpaired case, by 7% in the 40% Unimpaired case, and by 16% in the 50% Unimpaired case. For the Wholesale Customers, rates will need to increase by 6% in the 30% Unimpaired case, by 9% in the 40% Unimpaired case, and by 15% in the 50% Unimpaired case. Even with these significant rate increases, which come on top of some of the highest water rates among California water utilities, cities will be forced to make heavier use of balancing accounts and other financial reserves to cope with the budgetary instability caused by less reliable water supplies.

Comparison to SWRCB Economic Analysis

The economic analysis contained in Chapters 20 and 16 and Appendix L of the SED is unrealistic and should not be relied upon by the SWRCB as a basis for decision-making. The main analysis in Chapter 20 largely assumes away the real problem faced by San Francisco and its Wholesale Customers by positing that dry-year transfers with MID and TID can replace lost supplies. This approach is overly simplistic, and ignores recent experience with transfers among Tuolumne River users. By artificially minimizing the economic impacts of the contemplated instream flow regulations, the SED places Bay Area water consumers at significant risk of large future water shortages and economic losses.

The SED assumes that in dry periods like 1987-92, SFPUC is able to purchase more than 200,000 acre-feet annually at a price of $1,000 per acre-foot to replace lost RWS supplies. This assumption is unrealistic and contrary to recent experience. SFPUC's Water System Improvement Program (WSIP) evaluated dry-year water transfers from MID and TID of 25 mgd. Subsequent analysis revised this volume down to a mere 2 mgd, and SFPUC and the Districts were unable to agree on the terms of a transfer of even this minimal amount. Indeed, during the last drought, CCSF and the Wholesale Customers endured significant reductions of per capita water use and even then were unable to acquire transfer water from MID and TID.

Conclusions

Over the next 25 years, forecasted growth in the residential, commercial, and industrial sectors will strain the RWS's ability to meet the water needs of homes and businesses in its service territory. Currently, the RWS provides nearly all of the water for the CCSF and approximately 65% of the water demanded by Wholesale Customers. Fourteen of the 26 Wholesale Customers receive 100 percent of their water supply from the RWS. Collectively, the RWS supplies nearly three-quarters of the water demanded by the entire customer base in the RWS service area.

Low per capita water use reveals a substantial investment in water conservation measures including installation of water-efficient appliances, and suggests subsequent conservation may be expensive and result in smaller water savings. Per capita residential use in the RWS service area is 44 gallons per capita per day (gpcd) in San Francisco and 77 gpcd across all sectors. Average per capita residential consumption in the Wholesale Customer service area was 64.7 gpcd in FY 2014-15 and gross per capita consumption was 105.7 gpcd. By comparison, at the peak in FY 1986-87, gross per capita consumption in the Wholesale Customer service area was 186.5 gpcd. Further, residential consumption in the RWS service area is well below the statewide average of 76.6 gpcd. Similarly, while many water agencies have invested in non-RWS supplies, subsequent investments may call on expensive technologies with less-certain results. For these reasons, current and projected future non-RWS water supplies are not sufficient to mitigate the adverse impacts of reduction in RWS supplies, especially since these reductions will likely coincide with shortages on non-RWS supplies. In fact, welfare losses due to reductions on RWS supply are larger in part because these reductions would come at a time when the non-RWS supplies are also stressed.

Overall, the analysis reveals that even after accounting for growth in non-RWS supplies under dry-year conditions, reductions on RWS supplies have the potential to cause significant socioeconomic impacts in the Bay Area. Welfare losses to customers, lost economic output from area businesses, and reductions in employment are likely to result from interruptions in water supply. The magnitude and duration of these impacts will depend on growth, climate, conservation, and investment in non-RWS supplies, but the impacts from instream flow requirements examined in this report are likely to constitute a major disruption to the Bay Area economy.

CAMBRIDGE
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APPENDIX 4

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BEFORE THE CALIFORNIA

STATE WATER RESOURCES CONTROL BOARD

DRAFT SUBSTITUTE ENVIRONMENTAL DOCUMENT IN SUPPORT OF POTENTIAL CHANGES TO THE WATER QUALITY CONTROL PLAN FOR THE SAN FRANCISCO BAY-SACRAMENTO/SAN JOAQUIN DELTA ESTUARY; SAN JOAQUIN RIVER FLOWS AND SOUTHERN DELTA WATER QUALITY	DECLARATION OF JONATHAN P. KNAPP IN SUPPORT OF COMMENTS BY THE CITY AND COUNTY OF SAN FRANCISCO TO THE DRAFT SUBSTITUTE ENVIRONMENTAL DOCUMENT IN SUPPORT OF POTENTIAL CHANGES TO THE BAY-DELTA PLAN

I, Jonathan P. Knapp, declare:

1. I am employed as a Deputy City Attorney with the San Francisco City Attorney's Office.

2. On behalf of the City and County of San Francisco and the San Francisco Public Utilities Commission ("San Francisco"), I submitted a request for public records to the State Water Resources Control Board ("State Water Board") on October 14, 2016 concerning the State Water Board's proposed amendment to the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary and the draft revised Substitute Environmental Document ("SED") for the proposed amendment ("PRA Request"). The PRA Request is included hereto as Attachment 1.

3. In the PRA Request, among other documents, San Francisco sought "[a]ll public records containing information that served as the basis for Staff's conclusion that the volume of water identified in the 2016 Draft SED, Appendix L, at page L-21, Table L.4.-2, would be available for purchase by San Francisco from the Modesto Irrigation District and Turlock Irrigation District (collectively referred to as the 'Districts') during a six-year drought if LSJR Alternatives 2, 3, or 4 were implemented." (*See* Attachment 1, at 1.)

4. In response to this request, the State Water Board provided, among other documents, an electronic copy of an April 21, 1995 agreement between San Francisco and the Districts that requires San Francisco to make annual payments to the Districts in return for the Districts meeting all the minimum flow requirements provided for in a 1996 settlement agreement related to the Districts' Federal Energy Regulatory Commission license for the Don Pedro Hydroelectric Project ("1995 Side Agreement").

5. In the PRA Request San Francisco also sought "[a]ll public records containing information that served as the basis for Staff's analysis in the 2016 Draft SED that identify 'recent water purchases involving both [Modesto Irrigation District ('MID'] and [Turlock Irrigation District ('TID'], as well as by other agricultural districts in California, as stated in the 2016 Draft SED at page

20-48, including, but not limited to, the price of the water and volume(s) transferred." (*See* Attachment 1, at 1-2.)

6. In response to this request, the State Water Board provided, among other documents, an electronic copy of the Agricultural Water Management Plan 2015 Update for the Modesto Irrigation District.

7. San Francisco also requested "[a]ll public records containing information that served as the basis for Staff's analysis of the possible effects of LSJR Alternatives on hydropower generation, including, but not limited to, hydropower generation by San Francisco." (*See* Attachment 1, at 3.)

8. In response to this request, the State Water Board provided, among other documents, an e-mail chain that includes an e-mail dated August 15, 2016 from Nicole L. Williams, Senior Environmental Planner, ICF International, to State Water Board staff members William Anderson and Timothy Nelson. The e-mail chain is included hereto as Attachment 2.

9. I received the State Water Board's response to the PRA request. The State Water Board responded via a series of letters that included USB flash drives with electronic copies of documents. I personally reviewed these letters and the documents provided. The information contained in this declaration is true of my own personal knowledge.

I declare under penalty of perjury, under the laws of the State of California, that the foregoing is true and correct and that if called as a witness I could competently testify thereto.

Executed this 16th day of March, 2017 in San Francisco, California.

Jonathan P. Knapp

ATTACHMENT 1

CITY AND COUNTY OF SAN FRANCISCO

DENNIS J. HERRERA
City Attorney

OFFICE OF THE CITY ATTORNEY

JONATHAN P. KNAPP
Deputy City Attorney

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October 14, 2016

Sent Via U.S. Mail and Electronic Mail
Tom Howard
Executive Director
State Water Resources Control Board
1001 I Street
Sacramento, CA 95814-0100
Tom.Howard@waterboards.ca.gov

RE: *Public Records Act Request*

Dear Mr. Howard,

This office represents the San Francisco Public Utilities Commission ("SFPUC"), operator of the Hetch Hetchy Regional Water System ("RWS"). On behalf of the SFPUC and the City and County of San Francisco ("San Francisco"), we respectfully submit this request for records pursuant to the California Public Records Act, Government Code Sections 6250, *et seq.*, and Article I, Section 3 of the California Constitution.

The State Water Resources Control Board ("State Water Board") released proposed updates to the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary ("Plan Amendment") and the draft revised Substitute Environmental Document for the Plan Amendment ("2016 Draft SED") on September 15, 2016. The 2016 Draft SED recognizes that under two of the proposed Lower San Joaquin River alternatives ("LSJR Alternatives"), *i.e.*, LSJR Alternatives 3 and 4 – that would require 40 to 60-percent of the unimpaired flow of the Tuolumne River to remain in the river from February through June – San Francisco's rights to divert water from the Tuolumne River may be significantly impacted. In order to ascertain the information relied on by State Water Board Staff ("Staff") as the basis for its analyses of water supply and economic impacts to San Francisco and its wholesale customers, San Francisco submits the following request for public records.

As used herein, "public records" has the definition of "Public records" prescribed in Government Code Section 6252(e).

San Francisco requests the following information:

1. All public records containing information that served as the basis for Staff's conclusion that the volume of water identified in the 2016 Draft SED, Appendix L, at page L-21, Table L.4.-2, would be available for purchase by San Francisco from the Modesto Irrigation District and Turlock Irrigation District (collectively referred to as the "Districts") during a six-year drought if LSJR Alternatives 2, 3, or 4 were implemented.

2. All public records containing information that served as the basis for Staff's analysis in the 2016 Draft SED that identify "recent water purchases involving both [Modesto Irrigation District ("MID")] and [Turlock Irrigation District ("TID")], as well as by other

agricultural districts in California," as stated in the 2016 Draft SED at page 20-48, including, but not limited to, the price of the water and volume(s) transferred.

3. All public records containing information that served as the basis for Staff's estimate of the $1,000/acre-foot of water purchase price used in Staff's analysis of the contemplated water transfer to San Francisco, as analyzed in the 2016 Draft SED.

4. All public records containing information that served as the basis for, and depicts Staff's analysis of, the scope of environmental impact to the Districts that would result were the Districts to transfer the volumes of water identified in the 2016 Draft SED, Appendix L, at page L-21, Table L.4.-2, during a six-year drought if LSJR Alternatives 2, 3, or 4 were implemented.

5. All public records containing information that served as the basis for Staff's analysis of the economic, environmental, and legal feasibility of San Francisco developing, constructing and operating an in-Delta diversion facility as described in the 2016 Draft SED. (See *e.g.*, 2016 Draft SED, at page 16-68.)

6. All public records containing information that served as the basis for Staff's conclusion that "changing circumstances since 2008 (e.g., Pelagic Organism Decline, climate change, California WaterFix, and the State Water Board's Final Report on the Development of Flow Criteria for the Sacramento Delta Flow Criteria [citation omitted])," as stated at page 16-68 of the 2016 Draft SED, merit consideration of the referenced in-Delta diversion project as a feasible source of replacement water supply for San Francisco in the 2016 Draft SED.

7. All public records containing information that served as the basis for Staff's analysis of the cost to San Francisco of water to be diverted via the proposed in-Delta diversion facility discussed in the 2016 Draft SED.

8. All public records containing information that served as the basis for, and depicts Staff's analysis of, the permitting process and scope of environmental impact from a desalination facility at Mallard Slough with a capacity of 56,000 acre-feet/year, as contemplated in the 2016 Draft SED. (*See* 2016 Draft SED, at page 16-74.)

9. All public records containing information that served as the basis for Staff's analysis of the cost to San Francisco of water to be obtained from San Francisco's participation in the development and construction of a desalination plant at Mallard Slough, as contemplated in the 2016 Draft SED.

10. All public records containing information and analysis that served as the basis for Staff's conclusion that the "Regional Groundwater Storage and Recovery project would yield over 60 TAF per drought cycle" for San Francisco, as stated at page L-20 of the 2016 Draft SED, if LSJR Alternatives 3 or 4 were implemented.

11. All public records containing information that served as the basis for Staff's development of conceptual elements for adaptive implementation of each of the LSJR Alternatives, including criteria that would drive decision-making about whether to require more flow

or less flow on the tributary rivers, and criteria that would result in deferring flow releases from the specified February-June period until later in the year.

12. All public records containing information that served as the basis for Staff's representation of adaptive implementation in the Water Supply Effects model, and all public records containing information regarding and depicting Staff's analysis of the model results.

13. All public records containing information that served as the basis for Staff's analysis of the possible effects of LSJR Alternatives on hydropower generation, including, but not limited to, hydropower generation by San Francisco.

14. All public records containing information that served as the basis for Staff's analysis of the possible effects of LSJR Alternatives on California electric grid reliability, including any consideration of impacts to the electric grid related to the implementation of the State Water Board's "Once Through Cooling" Policy.

15. All public records containing information that served as the basis for Staff's calculation of unimpaired flow of the Tuolumne River at Modesto.

16. All public records containing information that served as the basis for Staff's analysis of water use along the lower San Joaquin River between the Stanislaus, Tuolumne and Merced rivers ("SJR Tributaries") and Vernalis, including analysis of measures and actions to ensure that the environmental goals of the proposed Plan Amendment are achieved.

17. All public records containing information that served as the basis for Staff's analysis of the amount of water from the SJR Tributaries that is expected to reach Vernalis under each proposed LSJR Alternative.

18. All public records containing information that served as the basis for Staff's analysis of the amount of water that is expected to contribute to Delta outflow from the SJR Tributaries under each proposed LSJR Alternative, and the amount of water that is expected to be diverted from the Delta under each LSJR Alternative.

19. All public records containing information that served as the basis for Staff's conclusion that flows from the Upper San Joaquin River, including flows released from Friant Dam, would not be considered in its analysis of the proposed Plan Amendment and the LSJR Alternatives.

20. More specifically, all public records containing information that served as the basis for Staff's conclusion that although "[f]lows released from Friant Dam for fish protection or for flood control would contribute to the [San Joaquin River] flow at Vernalis," such flows "are not part of the plan amendments or alternatives evaluated [by Staff]." 2016 Draft SED, at page 2-2.

21. All public records containing information that served as the basis for Staff's conclusion that "[w]hen the percentage of unimpaired flow requirement is insufficient" to meet the

> "minimum base flow of 1,000 cfs, based on a minimum 7-day running average, at Vernalis at all times," then "the Stanislaus River shall provide 29 percent, the Tuolumne River 47 percent and the Merced River 24 percent of the additional total outflow needed to achieve and maintain the required base flow at Vernalis." (2016 Draft SED, Appendix K, at page 29).

Pursuant to Government Code Section 6253(b), we ask that you make the public records identified above "promptly available" upon our payment of any required copying or statutory fees. To the extent possible, we would prefer to receive the requested public records in electronic format. San Francisco is willing to pay any reasonable costs for the production of the requested public records, and/or provide a deposit in advanced, as necessary.

We believe that no express provisions of law exist that exempt the public records from disclosure. As you determine whether this request seeks copies of disclosable public records, be mindful that Article 1, Section 3(b)(2) of the California Constitution requires you to broadly construe a statute, court rule, or other authority if it furthers the right of access to the information we have requested, and to narrowly construe a statute, court rule, or other authority if it limits our right of access.

If a portion of the information we have requested is exempt from disclosure by express provisions of law, Government Code Section 6253(a) additionally requires segregation and deletion of the material in order that the remainder of the information may be released. If you determine that an express provision of law exists to exempt from disclosure all or a portion of the material we have requested, Government Code Section 6253(c) requires that the State Water Board notify San Francisco of the reasons for the determination not later than 10 days from your receipt of this request. In "unusual circumstances," as specifically defined in Government Code Section 6253(c), this deadline may be extended by no more than 14 days. Notably, Government Code Section 6253(d) prohibits the use of the 10-day period, or any provisions of the Public Records Act, "to delay or obstruct the inspection or copying of public records."

Thank you for your prompt attention to our request.

Very truly yours,

DENNIS J. HERRERA
City Attorney

Jonathan P. Knapp
Deputy City Attorney

Sent Via Electronic Mail Only

cc: Michael Lauffer, State Water Board Chief Counsel
Michael Carlin, Deputy General Manager and Chief Operating Officer, SFPUC
Steven Ritchie, Assistant General Manager, Water Enterprise, SFPUC
Ellen Levin, Deputy Manager, Water Enterprise, SFPUC

ATTACHMENT 2

From:	Huber, Anne
To:	Williams, Nicole; Anderson, William@Waterboards; Nelson, Timothy@Waterboards
Cc:	Lindsay, Larry@Waterboards; Landau, Katheryn@Waterboards; Crain, Pat
Subject:	RE: SWRCB Phase I SED: follow up on priority list and Appendix J comments - Hydroelectric parameters
Date:	Friday, August 26, 2016 9:37:12 AM
Attachments:	tri-dam_project_article_409.pdf Merced draft FERC EIS.pdf Merced River Hydroelectric Project - Fact Sheet.pdf Oakdale and South San Joaquin Irrigation Dist Application additional water.pdf Scoping Document 1 for La Grange Hydroelectric Project No. 14581.pdf Hydropower parameter info.docx

Hi All,

Pat Crain and I looked for maximum flow capacity and head information for Tulloch, La Grange, McSwain, and Merced Falls hydroelectric facilities. I have attached some relevant documents (as many as I think will go through with email). We have one additional document, the Tri-Dam Project construction report, which is too big for email. The Word file includes our notes. Here's a summary of what we saw:

Merced Falls

- Flow capacity in WSE = 1,750 cfs - This number is in the Merced FERC draft EIS
- WSE Head = 26 feet - FERC draft EIS says that Merced Falls has a normal impoundment elevation of 344 feet, and that the max height of the dam is 34 feet. 26 feet seems reasonable, but we didn't see it explicitly mentioned anywhere.

McSwain

- Flow capacity in WSE = 2,700 cfs - This number is in the Merced ID fact sheet and the Merced FERC draft EIS
- WSE head = 54 feet - This number is in the Merced ID fact sheet

La Grange

- Flow capacity in WSE = 1,250 cfs - scoping document 1 indicates capacity of 580 cfs. Not clear if additional capacity was added later.
- WSE head = 50 feet - scoping document 1 indicates head of 115 feet. Not clear if this is a specification for the turbine or actual head, although info indicates that it may be the actual head (info from Pat regarding scoping document 1: the output matches what they report for max power production from the plant. If you look at the site you will see that the plant is actually run off a canal quite a way from the dam [Figure 2]. The dam is 131 feet high, so it makes sense that further down the canal the penstocks would be lower, so the 115 feet make sense to me.)

Tulloch

- Flow capacity in WSE = 1,700 cfs - Recreation plan for Black Creek Arm day use area indicates capacity of 1,800 cfs.
- WSE head = 149 feet - Summary report on the Tri-Dam Project indicates maximum head of 153 feet, so 149 may be reasonable.

-----Original Message-----
From: Williams, Nicole
Sent: Thursday, August 25, 2016 8:54 PM
To: Anderson, William@Waterboards; Nelson, Timothy@Waterboards
Cc: Lindsay, Larry@Waterboards; Landau, Katheryn@Waterboards; Huber, Anne
Subject: RE: SWRCB Phase I SED: follow up on priority list and Appendix J comments

Hi All - we have dug up some answers to this. Anne is going to compile and will send around for your consideration.

Cheers, Nicole

NICOLE L. WILLIAMS
Senior Environmental Planner
ICF INTERNATIONAL
o 916.231.9614
icfi.com
-----Original Message-----
From: Williams, Nicole
Sent: Monday, August 22, 2016 8:58 AM
To: 'Anderson, William@Waterboards'; Nelson, Timothy@Waterboards
Cc: Lindsay, Larry@Waterboards; Landau, Katheryn@Waterboards; Huber, Anne
Subject: RE: SWRCB Phase I SED: follow up on priority list and Appendix J comments

Okay. I'm going to see if someone here can help track this down through FERC documents or something else. Unless someone else has a better idea...?

-----Original Message-----
From: Anderson, William@Waterboards [mailto:William.Anderson@waterboards.ca.gov]
Sent: Saturday, August 20, 2016 12:18 AM
To: Nelson, Timothy@Waterboards; Williams, Nicole
Cc: Lindsay, Larry@Waterboards; Landau, Katheryn@Waterboards; Huber, Anne
Subject: RE: SWRCB Phase I SED: follow up on priority list and Appendix J comments

I also looked but did not find the mythical res ops folder. -Will A.

From: Nelson, Timothy@Waterboards
Sent: Friday, August 19, 2016 4:43 PM
To: Williams, Nicole; Anderson, William@Waterboards
Cc: Lindsay, Larry@Waterboards; Landau, Katheryn@Waterboards; huber, anne@icfi.com
Subject: RE: SWRCB Phase I SED: follow up on priority list and Appendix J comments

Hello Nicole,

I looked for the folder on the S drive, but could not find it. Will is in training until next Friday as well (he may be in late sometimes). He is likely the one to have the hard copy folder.

Tim

From: Williams, Nicole [mailto:Nicole.Williams@icfi.com]
Sent: Friday, August 19, 2016 2:48 PM
To: Anderson, William@Waterboards; Nelson, Timothy@Waterboards
Cc: Lindsay, Larry@Waterboards; Landau, Katheryn@Waterboards; huber, anne@icfi.com
Subject: RE: SWRCB Phase I SED: follow up on priority list and Appendix J comments

Hi Will and Tim, We modified some language in Appendix J, but wanted to follow up with highlighted below. Any luck? Cheers, Nicole

NICOLE L. WILLIAMS
Senior Environmental Planner
ICF INTERNATIONAL
o 916.231.9614
icfi.com
From: Williams, Nicole
Sent: Tuesday, August 16, 2016 11:36 AM
To: 'Anderson, William@Waterboards'; 'Nelson, Timothy@Waterboards'
Cc: 'Lindsay, Larry@Waterboards'; 'Landau, Katheryn@Waterboards'; Huber, Anne
Subject: RE: SWRCB Phase I SED: follow up on priority list and Appendix J comments

Hi Will and Tim, I looked at the Feb 2012 version and the Public Version of Appendix J and the public version of Appendix F.1 (since Lucas suggested maybe they were in an older version X). I do not see references related to head and flow capacity.

Did either of you look in the folder (network) or hard copy folder Lucas called "reservoir operations" as he suggested in the email? Find anything?

Are our next steps: looking at FERCE documentation? Look at the dam websites?

Cheers, Nicole

NICOLE L. WILLIAMS
Senior Environmental Planner
ICF INTERNATIONAL
o 916.231.9614
icfi.com

From: Anderson, William@Waterboards [mailto:William.Anderson@waterboards.ca.gov]
Sent: Tuesday, August 16, 2016 8:14 AM

To: Williams, Nicole
Subject: RE: SWRCB Phase I SED: follow up on priority list and Appendix J comments

Nicole, the purple box is from the WSE model where Lucas entered these constants that Tim was referring to in the original comment. I was just running to ground with all the info I currently have. - Will A.

From: Williams, Nicole
Sent: Monday, August 15, 2016 10:36 PM
To: 'Anderson, William@Waterboards'; 'Nelson, Timothy@Waterboards'
Cc: 'Lindsay, Larry@Waterboards'; 'Landau, Katheryn@Waterboards'; Huber, Anne
Subject: RE: SWRCB Phase I SED: follow up on priority list and Appendix J comments

Hum…had I read past your email I would have answered my own question.

I'll see if I can dig up an older version of the appendix and see if that sheds any light on it.

Cheers, Nicole

From: Williams, Nicole
Sent: Monday, August 15, 2016 10:00 PM
To: 'Anderson, William@Waterboards'; Nelson, Timothy@Waterboards
Cc: Lindsay, Larry@Waterboards; Landau, Katheryn@Waterboards; Huber, Anne
Subject: RE: SWRCB Phase I SED: follow up on priority list and Appendix J comments

Thanks Will. I'm a little confused about the purple box of numbers below – that's from the calcs worksheet? So Lucas is saying they weren't pulled from the FERC relicense documentation?

Cheers, Nicole

NICOLE L. WILLIAMS
Senior Environmental Planner
ICF INTERNATIONAL
o 916.231.9614
icfi.com
From: Anderson, William@Waterboards [mailto:William.Anderson@waterboards.ca.gov]
Sent: Monday, August 15, 2016 3:22 PM
To: Williams, Nicole; Nelson, Timothy@Waterboards
Cc: Lindsay, Larry@Waterboards; Landau, Katheryn@Waterboards; Huber, Anne
Subject: FW: SWRCB Phase I SED: follow up on priority list and Appendix J comments

Nicole:

See below comments from Lucas.

I have not worked with these values (WSE "Hydropower_Calcs" worksheet; columns O, S, W, AA rows 3-4), and I do not know the source. It would be worth corroborating them from available information (the FERC license documentation). They do appear reasonable.

[cid:image001.png@01D1FA38.D48DCB30]

Regarding page J-5. Your solution sounds reasonable.

Additional notes based on my cursory look at App. J:
In the intro 2nd paragraph "elevations head" should be "elevation head."
Need to cite a source for the hydropower Eqn. J-1 (although any general hydro text would do, it's fairly universal) and efficiency "assumed to be 80 percent in for all facilities". Could clarify units that head is in ft, weight of water is (62.4 lb. / cu. ft.), remove the symbol before the γ, and Q is in cfs.

-Will A.

From: Sharkey, Lucas@Waterboards
Sent: Monday, August 15, 2016 2:18 PM
To: Anderson, William@Waterboards
Subject: RE: SWRCB Phase I SED: follow up on priority list and Appendix J comments

They are not in the Appendix? Is it JUST the Head and Flow ? Flow I think came from the FERC documents on those rivers. They generally had a maximum flow through the pipe works. It was not scientific and may not have been based on the actual turbines in each of those dams. They could also just be from one of the Dam websites. If I had info, it should be in a folder (network) or hard copy folder I called "reservoir operations".
Not sure why I did not document that anywhere?? Sure it is not in an old "Appendix X" version?

Head (Tailwater/elevation of turbine to operating capacity of dam). If I had the info from the FERC documents, I used that. But if I did not, I believe the Head is possibly a guestimate from looking at the aerials, and topo maps at each dam. I know Tulloch and or Goodwin have a operational curve, but it appears I simplified and assumed these were non-operational dams, or operated with such fluctuation that it would likely not change. They are re-regulating dams for the most part and do not store water for more than several hours/days allowing the ability to release steady flows down river and the Big dams to ramp up flows every night for maximum energy when price is highest if even by fractions of cents.

There is also a chance they came from CALSIM, but less likely.

Lucas

From: Anderson, William@Waterboards
Sent: Monday, August 15, 2016 1:46 PM
To: Sharkey, Lucas@Waterboards
Subject: FW: SWRCB Phase I SED: follow up on priority list and Appendix J comments

Lucas,
Any clue as to the first part? TIA.

-Will A.

From: Williams, Nicole [mailto:Nicole.Williams@icfi.com]
Sent: Monday, August 15, 2016 11:32 AM
To: Anderson, William@Waterboards; Nelson, Timothy@Waterboards
Cc: huber, anne@icfi.com<mailto:anne@icfi.com>; Landau, Katheryn@Waterboards; Lindsay, Larry@Waterboards
Subject: SWRCB Phase I SED: follow up on priority list and Appendix J comments

Hi Will and Tim, Tim made the following two comments on the priority list related to Appendix J.

· First there are some constants used in WSE for head and flow capacity at the following reservoirs: Tulloch, La Grange, McSwain, and Merced Falls. However, these constants are not mentioned in the appendix and I don't know their source. Anne and I think the constants came from Lucas a long, long time ago (galaxy far, far away…). So we thought checking with Will might be the first step to find out if Will came across anything like this in his unpacking/repacking/reorganizing of WSE (if Tim hasn't already checked with Will)?

· The following paragraph from page J-5 of the appendix: Hydropower generated from facilities on reservoirs upstream of the rim dams on the Stanislaus and Tuolumne Rivers is assumed to be unaffected by the LSJR alternatives. The storage capacity of these upstream reservoirs, as needed to shift flows between spring and summer months, is limited and much less than such capacity available downstream in the major reservoirs and is therefore assumed to have no changes in operation. The Merced River has no major hydropower reservoirs upstream of Lake McClure (New Exchequer Dam). Is this still ok even though we say in chapter 14 that impacts are significant and unavoidable with regards to lower reservoir levels in the extended plan area? Good catch. We will edit the text in Appendix J to remove that reservoirs/dams upstream of the rim dams would be unaffected by the LSJR alternatives and to reflect that given the relatively small amount of hydropower generated upstream when compared to the rim dams (Table J-1)) this information was not modeled and Appendix J only focuses on modeling changes associated with the rim dams. In addition, we could add a sentence that says the upstream hydropower effects are qualitatively discussed in the EPA section of Chapter 14 (so people don't think we've left it out).

Let us know what you think.

Cheers, Nicole

NICOLE L. WILLIAMS | Senior Environmental Planner | (o) 916.231.9614 | (m) 530.867.0470 | nicole.williams@icfi.com<mailto:nicole.williams@icfi.com> | icfi.com<http://www.icfi.com/> ICF

INTERNATIONAL | 630 K Street Suite 400 Sacramento CA 95814 | Please note a new mobile number as of 2/19/16 Please consider the environment before printing this e-mail.

APPENDIX 5

550 Kearny Street
Suite 800
San Francisco, CA 94108
415.896.5900 phone
415.896.0332 fax

www.esassoc.com

date March 15, 2017

to San Francisco City Attorney's Office

cc Ellen Levin – SFPUC, Rob Donlan – Ellison and Schneider

from Leslie Moulton-Post, Alisa Moore, Karen Lancelle, Chris Mueller

subject CEQA Adequacy Review of the Desalination Water Supply Alternative in the Draft Substitute Environmental Document (SED) in Support of Potential Changes to the Water Quality Control Plan for the San Francisco Bay-Sacramento / San Joaquin Delta Estuary: San Joaquin River Flows and Southern Delta Water Quality

Purpose

This memo evaluates the environmental analyses contained in the State Water Resources Control Board's (SWRCB) Substitute Environmental Document in Support of Potential Changes to the Water Quality Control Plan for the San Francisco Bay-Sacramento/San Joaquin Delta Estuary: San Joaquin River Flows and Southern Delta Water Quality (SED) Recirculated Draft (SCH#2012122071). Specifically, this memo addresses the adequacy of the SWRCB's description and analysis of environmental impacts in the SED of a desalination project option to replace some or all the significant water supply reduction to the San Francisco Public Utilities Commission (SFPUC) that would result from implementation of the Lower San Joaquin River (LSJR) Alternatives 3 or 4 described and evaluated in the SED.

The SED's description of a water supply desalination option for the SFPUC builds on information developed for another project – the Bay Area Regional Desalination Project (BARDP). Thus, this memo provides and overview of the BARDP, describes how the BARDP concept is identified and referenced in the SED analysis, and identifies feasibility concerns, constraints, and unresolved issues associated with this project concept as envisioned in the SED. The memo relies on the following information sources:

- Recirculated Draft Substitute Environmental Document in Support of Potential Changes to the Water Quality Control Plan for the San Francisco Bay-Sacramento San Joaquin Delta Estuary, September 2016 (SED), Section 16.2.6 *Water Supply Desalination*, Appendix H, *Supporting Materials for Chapter 16*, and Appendix L, *City and County of San Francisco Analysis* (referred to as the SED)
- Bay Area Regional Desalination Project Site Specific Analyses Final Report Delta Modeling Tasks, Contra Costa Water District (CCWD), January 2014 (referred to as BARDP Site Specific Delta Modeling Report)
- Bay Area Regional Desalination Project Institutional Task Technical Memorandum #2, Analysis of Feasible Scenarios, September 29, 2011 (Analysis of Feasible Scenarios)
- *Pilot Testing at Mallard Slough Pilot Plant Engineering Report*, Prepared by MWH for the Bay Area Regional Desalination Project, June 2010 (Pilot Plant Report)
- SFPUC *Water System Improvement Program Final Program Environmental Impact Report* (WSIP PEIR) Chapter 8, WSIP Variants and Impact Analysis

- *Bay Area Regional Desalination Project Feasibility Study*, prepared for CCWD, East Bay Municipal Utility District (EBMUD), SFPUC, and Santa Clara Valley Water District (SCVWD) by URS, July 2007
- Supplement to the Precise Development Plan and Desalination Plant Project Final Environmental Impact Report, City of Carlsbad, California, San Diego County Water Authority (Lead Agency), August 2016

Background Information: Regional Desalination Project

The SED indicates that a desalination plant on the order of 50 million gallons per day (mgd) capacity would be needed to fully compensate for the water supply shortfall that would result from the SWRCB's proposed water quality plan revisions under select alternatives (LSJR Alternatives 3 and 4). The SED description of a water supply desalination option for the SFPUC builds on the description and studies completed to date on the Bay Area Regional Desalination Project (BARDP). The 50+ mgd desalination project concept envisioned in the SED is twice the size of the BARDP's 20 mgd plant proposed for the existing Mallard Slough Pump Station site. Given the SED's reliance on the BARDP description and studies, background about the BARDP is provided below.

Bay Area Regional Desalination Project

The BARDP was initiated in 2003 as a joint effort by the Bay Area's five largest water agencies[1] to explore the potential for a regional desalination project to provide an additional water source, diversify the area's water supply, and foster long-term regional sustainability. To date, the agencies have completed pre-feasibility studies to identify potential fatal environmental or technical flaws, feasibility and institutional studies, and pilot testing. Over this period the agencies have refined their water demands for the project and narrowed the number of possible sites for the desalination plant. The most recent iteration of the BARDP was evaluated by the Contra Costa Water District in the BARDP Site Specific Delta Modeling Report, which evaluated impacts of a desalination plant operating at the Mallard Slough Pump Station site that would divert 25 mgd for 11 months each year[2] during all hydrologic years, for an annual diversion of 26,100 AFY. The plant would operate with an expected 80 percent recovery rate, producing 20 mgd or 20,900 AFY of desalinated product water. Brine generated by desalination, estimated to be about 20 percent of the intake water volume (about 5 mgd), would be blended with effluent from the Central Contra Costa Sanitary District (CCCSD) or Delta Diablo Sanitation District (DDSD) wastewater treatment plants before release into Suisun Bay.[3]

Since the 2014 BARDP Site Specific Delta Modeling Report, regional water supply planning for the five water agencies has shifted its focus to center on a broader planning effort known as Bay Area Regional Reliability, the purpose of which is to identify projects and processes to enhance water supply reliability across the region, leverage existing infrastructure investments, facilitate water transfers during critical shortages, and improve

1 The BARDP member agencies are SFPUC, CCWD, East Bay Municipal Utilities District (EBMUD), Santa Clara Valley Water District (SCVWD), and Zone 7 Water Agency (Zone 7).

2 Operation of all CCWD intakes, including at the Mallard Slough Pump Station, is restricted during a 30-day no-diversion period pursuant to a biological opinion issued by the U.S. Fish and Wildlife Service and National Marine Fisheries Service and an incidental take permit issued by the California Department of Fish and Wildlife. The default timing assumed for the no-diversion period is April 1-30, but can be changed by the fishery agencies (BARDP Site Specific Delta Modeling Report, pp. 73-74).

3 DDSD discharges into New York Slough; however its capacity is more limited and according to the BARDP Site Specific Delta Modeling Report would only be able to accommodate the projected volume of BARDP brine until 2015 under its current NPDES permit. CCCSD discharges to Suisun Bay.

climate change resiliency. While the BARDP per se has not progressed further, it is included in the projects to be considered in this regional planning effort.[4]

The 20 mgd desalination facility evaluated in the BARDP Site Specific Delta Modeling Report at the Mallard Slough Pump Station site was found to be technically feasible based on a pilot study implemented in 2008-2009 at the site. The pilot study focused on select key feasibility questions, first and foremost questions about the source water quality, treatability, and ability of the treatment process to reliably produce the desired finished water quality that would meet participating agencies standards and be compatible for blending into their existing water distribution systems. The pilot study also assessed the potential for impacts to listed fish species known to occur in the area of the proposed intake (delta smelt and longfin smelt) as a result of entrainment or impingement, as well as questions related to brine disposal, including the technical and regulatory feasibility of potential options for blending and disposal of brine via existing local wastewater outfalls and the potential impacts of such brine disposal in terms of water quality impacts and impacts to sensitive aquatic resources including listed species.

The pilot study verified the technical feasibility of a desalination facility diverting 25 mgd at Mallard Slough (producing 20 mgd of product water) to meet the water quality targets of partner agencies despite the complex water quality of the delta in that area (due to tidal effects within San Francisco and Suisun Bays).[5] Specifically, the pilot study: (1) found that the two types of pretreatment systems it evaluated could produce suitable product water quality, although additional site-specific study would be needed to determine certain parameters when the full-scale site is identified; (2) determined the two-stage desalination process that would meet treated water quality goals with a high recovery rate throughout the range of salinity variation expected for the BARDP; (3) identified opportunities for managing brine; (4) evaluated two methods for post-treatment stabilization, both of which produced stable product water that could be blended with EBMUD aqueduct water and CCWD multi-purpose pipeline water; and (5) evaluated water quality based on water at the intake location in Mallard Slough, while noting that water quality elsewhere in Suisun Bay could be different, if the intake were located there. The pilot study included finished water compatibility studies to verify the compatibility of the desalinated product water that would be conveyed in EBMUD and CCWD pipelines; biological sampling, which identified the potential to entrain longfin smelt and delta smelt larvae at certain times of the year; and toxicity studies to evaluate the toxicity of the brine on selected organisms.

Following the pilot study, the BARDP Site Specific Delta Modeling Report included site-specific analyses for a 20 mgd plant to evaluate (1) potential water quality impacts of the desalination facility and brine disposal; (2) potential impacts on sensitive fish populations; and (3) conjunctive operation of the desalination facility with the Los Vaqueros Reservoir. That study concluded that the desalination project at that location was technically feasible and identified the following unresolved issues that would need to be addressed during subsequent phases of project development, environmental evaluation and permitting:

- **Institutional**
    - Additional coordination between the five BARDP partner agencies would be required during dry years when partner demand exceeded both available BARDP production capacity and storage. Excess

4 SFPUC, *2015 Urban Water Management Plan for the City and County of San Francisco*, June 2016, p. 7-8, Section 7.4.2.

5 MWH, *Pilot Testing at Mallard Slough Pilot Plant Engineering Report*, Prepared for the Bay Area Regional Desalination Project, June 2010.

BARDP production can be stored in Los Vaqueros Reservoir in non-drought years through an exchange with CCWD, and the stored BARDP water can be released from the reservoir in drought years. Under current EBMUD system limitations on timing and flow rates, not all drought year demands of the partner agencies can be met with the use of water stored in the existing 160,000 acre-foot-capacity Los Vaqueros Reservoir.[6] When the annual partner demand exceeds both the available BARDP production capacity and storage, deliveries to the partners would be less than the demand. The BARDP Site Specific Delta Modeling Report did not make any assumptions about how water would be allocated among partners during shortages. It was expected that the allotment of water during shortages would be negotiated if the BARDP partnership continues forward. Possible options when demand exceeds supply include all partners receiving an equal percent reduction of their stated demand, all partners equally dividing the available supply, or only a subset of partners receiving water during drought years.[7]

- During critically dry years BARDP operations would need to be coordinated with the Central Valley Project, State Water Project, and the City of Antioch (upstream water users) to ensure water quality standards in the Bay Delta are met.[8]

- Modeling conducted for the CCWD feasibility study optimized delivery of the stored water by delivering bulk releases on a schedule compatible with CCWD system operating rules up to the maximum pipeline intertie capacity, and delivering the stored water based on agencies' annual demand at the earliest available opportunity each year. This modeling assumed that "EBMUD has sufficient flexibility to wheel water to the other partners on this schedule [deliver the stored BARDP water that will be needed in a given year to meet specified demands at the earliest available opportunity each year], or otherwise exchange the BARDP deliveries with local storage for short periods of time, and that the other partners have local storage or other flexibility within their systems to absorb the water when it is delivered." The physical capacity of local storage or other options for the agencies to absorb deliveries on the schedule that was modeled would need to be verified.

- **Water Quality**

  - To confirm that operation of a new desalination plant at Mallard Slough would be able to comply with Bay-Delta water quality regulations, additional modeling would be required as new Delta water projects and regulatory programs are planned, including the new flow criteria for the Delta set by the SWRCB as part of the update to the Water Quality Control Plan for the San Francisco Bay-Sacramento San Joaquin Delta Estuary and the California WaterFix (then called the Bay-Delta Conservation Plan).[9]

  - Additional modeling would also be required to better characterize near field brine impacts on water quality.[10]

6 BARDP Site Specific Delta Modeling Report, p 113, Section 3.1
7 BARDP Site Specific Delta Modeling Report, p. 122, Section 3.5.
8 BARDP Site Specific Delta Modeling Report, p. 27, Section 1.10.
9 BARDP Site Specific Delta Modeling Report, p. 27, Section 1.10.
10 BARDP Site Specific Delta Modeling Report, p. 20, Section 1.8.

- **Fisheries**
  - Future project planning and evaluation studies need to more specifically analyze both general environmental impacts of project construction and operation to aquatic species to identify appropriate project design features and mitigation measures and, specifically need to address impacts to listed species to achieve compliance with state and federal endangered species regulations. Regarding potential fish entrainment, the BARDP Site Specific Delta Modeling Report found that changes to operations and intake design could reduce or avoid impacts to fisheries and that a "preferred combination of minimization and avoidance measures will be evaluated if the project proceeds with an environmental impacts analysis at a later date in the future."[11]

SED Water Supply Desalination Option

Chapter 16 describes the SED evaluation of "other indirect actions" associated with the Lower San Joaquin River Alternatives 2, 3 and 4. It identifies actions the regulated community, including the City and County of San Francisco (CCSF), could take to reduce potential reservoir or water supply effects associated with implementing the LSJR alternatives, including "desalination of ocean or brackish water." Chapter 16 considers a desalination treatment plant at the Mallard Slough site identified for the BARDP, operating during all hydrologic years, but having a capacity of approximately 50,000 or 56,000 AFY (SED p. 16-74) (i.e., a plant that would divert approximately 50 mgd of raw water, as compared to the 20 mgd plant diverting 26,100 AFY assumed in the BARDP Site Specific Delta Modeling Report).

The SED's description of the Water Supply Desalination option is presented in Section 16.2.6 on pages 16-70 to 16-75 and is based primarily on information presented in several studies prepared as part of the BARDP, in particular, the 2014 BARDP Site Specific Delta Modeling Report, the Final Draft Bay Area Regional Desalination Project Greenhouse Gas Analysis by Kennedy/Jenks,[12] and the SFPUC's Water System Improvement Program Final Program Environmental Impact Report (WSIP PEIR). The SED also briefly summarizes impacts that were identified for the Poseidon Desalination Facility in Carlsbad, California (San Diego County), a 56,000 AFY facility the SED suggests is closer to the size that would be needed to address water supply shortfalls under LSJR alternatives.

General Comments on Feasibility of the SED Water Supply Desalination Option

The SED assumes that it is feasible to construct and operate a desalination facility approximately twice the size of that evaluated for the BARDP (diverting 50,000 to 56,000 AFY of raw water or about 50 mgd), located at the Mallard Slough site evaluated for the BARDP pilot study and BARDP Site Specific Delta Modeling Report. However, the SED does not substantiate the assumption that this larger, 50 mgd desalination facility is feasible at

11 BARDP Site Specific Delta Modeling Report, p. 70, Section 2.1.

12 Kennedy/Jenks Consultants, *Final Draft Bay Area Regional Desalination Project Greenhouse Gas Analysis*, Prepared for Bay Area Regional Desalination Project, 11 January 2013.

the Mallard Slough site. Concerns about the feasibility of the desalination plant option envisioned in the SED include the following:

- **Site Size.** Would the desalination project envisioned in the SED fit at the assumed Mallard Slough site? A 2007 feasibility study conducted for the BARDP concluded that the CCWD property at Mallard Slough could not accommodate a desalination plant that could treat 65 mgd of raw water, which would require about 18.5 acres.[13] The SED does not provide an estimate of the size of the site needed for the large plant it envisions; however, based on the 2007 study it is assumed that siting a larger facility at Mallard Slough would likely require the purchase of additional land. This in turn would require identifying an appropriate adjacent parcel and willing seller and could displace existing habitat or other land uses. The area surrounding Mallard Slough appears largely to consist of wetlands. The SED did not address the feasibility of expanding the CCWD site to accommodate a larger desalination plant.

- **Water rights**. It is not apparent that sufficient water rights and licenses would be available or could be obtained to withdraw the amount of water proposed for the SED desalination project. Specifically, in order to operate a desalination plant at Mallard Slough with a production capacity greater than 22,400 AFY, additional water rights would need to be obtained and that process "could take over 10 years."[14]

- **Larger intake**. A larger intake would be needed for plant larger than the 20 mgd facility proposed in the BARDP studies, as the capacity of the existing intake is 40 mgd. The feasibility of siting and permitting the construction and operation of a larger intake at Mallard Slough is uncertain given constraints identified for the 20 mgd plant and is not addressed in the SED.

- **Brine Discharge**. The BARDP studies identify brine blending and discharge constraints for a 20 mgd plant that would be further exacerbated by a larger facility. Blending the amount of brine generated by a larger facility with the dry weather outflows of the two wastewater treatment plants currently proposed to be used by the BARDP (CCCSD or DDSD) would exceed the discharge capacities of either plant, affecting the feasibility of the SED proposal if brine dilution is a necessary condition for water quality purposes. The SED assumes that the approximately 10 mgd of brine generated by a larger desalination facility could be discharged via CCCSD or DDSD[15] outfalls. Table 1-5 of the BARDP Site Specific Delta Modeling Report identifies the projected treatment plant flows for DDSD and CCCSD.[16] As indicated there, under their current NPDES permits, DDSD does not have capacity to accommodate this amount of additional flow now and by 2020 CCCSD would not have capacity to accommodate 10 mgd of additional flow.
    - 2015 dry weather discharge at DDSD was estimated to be 16.4 mgd and its NPDES permitted discharge capacity is 16.5 mgd.

13 URS, *Bay Area Regional Desalination Project Feasibility Study*, July 2007.

14 *Bay Area Regional Desalination Project Institutional Task Technical Memorandum #2: Analysis of Feasible Scenarios*, September 19, 2011, p. 9, Section III.C.

15 Regarding the outfalls identified for BARDP brine discharge in the BARDP Site Specific Delta Modeling Report, the SED refers to brine disposal at "CCWD or DDWD" [*sic*]. The BARDP modeling report evaluated the effects of discharging brine with CCCSD and DDSD effluent via those plant's outfalls.

16 BARDP Site Specific Delta Modeling Report, p. 18.

  - By 2020 CCCSD's dry weather discharge is projected to be 44 mgd, and its NPDES permitted discharge capacity is 53.8 mgd.

  The BARDP Site Specific Delta Modeling Report indicates that CCCSD would be unable to accommodate the anticipated 5 mgd of brine from the BARDP by 2030. The larger SED plant would accelerate the time by which an alternative disposal strategy would need to be developed and its potential water quality impacts evaluated. The SED fails to address this or the probability of whether a new or larger-capacity outfall would be required or permitted in the Delta.

- **Water storage and distribution**. Conjunctive operation of Los Vaqueros Reservoir (whereby excess desalinated product water would be stored in non-drought years and released for use in drought years) would be subject to existing EBMUD system limitations on timing and flow rates. The BARDP Site Specific Delta Modeling Report found that 71 percent of drought-year demands could be met with the use of interannual storage in the reservoir, and that pretreatment of water to be released to EBMUD's system could increase this level to 84 percent.[17] While the BARDP Site Specific Delta Modeling Report concluded that EBMUD infrastructure had adequate capacity to wheel this percentage of needed supplies to partner agencies during a drought, given the existing limitations it is reasonable to expect that EBMUD infrastructure will constrain deliveries of the much higher volumes of water that would need to be delivered to CCSF and potentially other agencies during drought periods under LSJR Alternatives 3 and 4. In addition to physical capacity limitations, the two existing interties that link other water systems to the SFPUC system – the EBMUD/SFPUC Emergency Interie in Hayward and the SFPUC/SCVWD Emergency Intertie in Milpitas – were constructed to allow water transfers during emergencies. Use of these interties on a regular basis would require new memoranda of understanding between the affected agencies, and potentially additional environmental review, or other permits and approvals.

Adequacy of Environmental Analysis

Inconsistent Information and Unclear Application of Other Environmental Studies

Section 16.2.6 of the SED describes and tries to make use of several environmental impact analyses prepared for different iterations of a BARDP desalination plant over the past decade as well as the certified EIR prepared for the much larger Carlsbad desalination plant located in a very different geography on the coast in southern California. The SED provides only a vague indication of how these other project analyses might apply to the desalination water supply option the SED anticipates would be needed as an "additional action" to address drought-period supply shortfalls under LSJR alternatives. Citing the BARDP Site Specific Delta Modeling Report, Section 16.2.6 presents information on a desalination project with a "maximum capacity of 28,000 AFY" (SED p. 16-71), and under "Summary of Potential Action" (pp. 16-72 to 16-73) describes a desalination project similar to the BARDP described in the BARDP Site Specific Delta Modeling Report: it would be located at Mallard Slough, store excess water in normal and wet years in Los Vaqueros Reservoir, and meet demands of BARDP partner agencies consistent with information presented in the BARDP modeling report. (This

17 BARDP Site Specific Delta Modeling Report, p 5, Executive Summary.

information presented in the SED is generally consistent with but not identical to the project evaluated in the BARDP Site Specific Delta Modeling Report.[18])

The SED discussion of "Potential Environmental Effects" (pp. 16-73 to 16-75) describes the significant impacts the 2008 WSIP PEIR identified for the BARDP evaluated in the PEIR as part of a WSIP variant. As summarized in the SED, the PEIR determined that operation of the BARDP would result in potentially significant and unavoidable impacts on hydrology and water quality, biological resources, and energy resources; and that significant impacts associated with the following resources could likely be reduced to less than significant with the implementation of mitigation measures: land use and visual quality; geology, soils, and seismicity; air quality; cultural resources; GHG emissions; hazards; noise and vibration; traffic, transportation, and circulation; public services and utilities; recreational resources; and agricultural resources."

The SED discussion of potential environmental effects then summarizes the results of the 2014 BARDP Site Specific Delta Modeling Report and the 2013 Kennedy/Jenks analysis of greenhouse gas emission (which evaluated the same BARDP project as the BARDP Site Specific Delta Modeling Report), stating that the BARDP modeling report found that changes in ambient water quality associated with BARDP operations and brine disposal were too small to be accurately measured in the field and that during most conditions operations would not have a significant impact on water quality or beneficial uses. To avoid impacts during critically dry water years, the BARDP Site Specific Delta Modeling Report stated that BARDP operations would need to be coordinated with operations of the CVP, SWP, and the City of Antioch. The SED notes that the greenhouse gas analysis quantified GHG emissions from BARDP operations and identified measures and projects to reduce potential GHG emissions.

The discussion presented in Chapter 16 suggests that the site-specific BARDP Site Specific Delta Modeling Report and Kennedy/Jenks analysis for the 26,100 AFY BARDP largely address concerns about significant unavoidable impacts that were identified in the WSIP PEIR for the 20 mgd BARDP. However, the SED does not address how the conclusions of the BARDP analyses it cites could change with a larger water supply desalination project. The SED acknowledges that a larger facility than those evaluated in BARDP studies would be needed. The SED states that a larger facility "(e.g., 56,000 AF/y) would have similar *types* of construction and operation impacts" (emphasis added) but fails to acknowledge or address how the *magnitude* or *significance* of such impacts may change with a larger desalination facility and, considering such changes, whether a larger plant would be permitable or otherwise feasible. The SED states that the "[l]ong-term operational impacts of a large desalination facility with a capacity of 56,000 AFY would be similar in nature to those described in the feasibility studies as well as in the WSIP PEIR for the BARDP," and identifies the following as the primary impacts of a desalination facility:

- Biological resources impacts due to marine life entrainment and brine discharge
- Air Quality/GHG/Energy impacts due to energy demand of treatment
- Routine transport and disposal of hazardous materials due to use of additional chemicals for treatment
- Impacts on open space and recreation areas

18 Differences between the BARDP described in the 2014 feasibility study and the SED discussion of the BARDP at Mallard Slough include daily and annual diversion rates: the BARDP Site Specific Delta Modeling Report identifies a diversion rate of 25 mgd (not 21 mgd as stated in the SED) and annual diversions of 26,100 AFY (not 28,000 AFY) based on diversions occurring 11 months per year (BARDP Site Specific Delta Modeling Report, p. 114, Section 3.3).

The SED does not indicate the significance of these impacts. As discussed above, the BARDP feasibility studies and WSIP PEIR reach different conclusions as to the significance of several of these impacts.

Regarding a larger desalination facility, the SED points to a project-level EIR recently completed for a desalination plant on the coast in Carlsbad, California (San Diego County). That analysis determined that the only significant unavoidable impacts were cumulative regional impacts on air quality for the production of ozone and PM10, and that impacts on the following resources would be less than significant after mitigation: cultural resources, hazards and hazardous materials, hydrology and water quality, land use and planning, and traffic and circulation. The SED acknowledges that "there are many geographic differences between the San Francisco Bay–Delta and Carlsbad," but fails to address the implications of such differences (such as existing environmental stresses on the Delta and the presence in the Delta of endangered species), and appears to dismiss such differences because the analysis of the Carlsbad facility identified "similar environmental impacts" to those identified for the BARDP.

The SED discussion of a water supply desalination option to address LSJR alternatives only summarizes conclusions of the other project analyses that have reached differing conclusions about the significance of impacts in key topic areas. The SED indicates that the *types* of impacts would be similar. The SED discussion in Chapter 16 draws *no* conclusions as to significance of the impacts the larger 50 mgd desalination plant at Mallard Slough envisioned in the SED would have, and does not connect the discussion of the various analyses to impact summary Table ES-22 presented in the Executive Summary.

The summary of impacts presented in the SED Executive Summary, Table ES-22, CEQA Significance Summary of LSJR Alternatives – Other Indirect Actions, for "Water Supply Desalination" indicates that during operations the water supply desalination option would have significant unavoidable impacts related to biological resources, greenhouse gas emissions, hydrology and water quality, and utilities and service systems. According to the table, potentially significant and unavoidable impacts could occur during construction for the following topics: aesthetics, agriculture and forestry resources, air quality, cultural resources, geology and soils, hazards and hazardous materials, land use and planning, public services, recreation, and transportation and traffic; and would have no impacts on mineral resources or population and housing. No text is provided explaining these impact conclusions or linking them to the discussion in Section 6.2.6.

While the basis for the conclusions in the summary table is not obvious, it is reasonable to assume that the severity of many of the impacts identified for the BARDP would increase with a larger plant, and that some *additional* impacts may remain significant after mitigation. Considering the significant unavoidable impacts that were identified in the WSIP PEIR and the impacts and issues that remain to be addressed following the BARDP Site Specific Delta Modeling Report, it is reasonable to expect that a desalination plant at Mallard Slough with twice the intake capacity assumed for the BARDP could have significant unavoidable impacts on biological resources including endangered species, water quality and hydrology, and potentially significant unavoidable impacts related to greenhouse gas and air pollutant emissions. Energy demand for a large plant could result in adverse impacts on utilities and service systems, which may be the reason the SED executive summary table identifies this impact significant and unavoidable.

The inadequacy of the impact analysis thus raises additional questions about the feasibility of the desalination plant anticipated in the SED because, given its probable environmental impacts, it is far from obvious such a plant could be permitted.

Failure to Adequately Address or Identify Impacts

- Because the SED largely relies on the BARDP Site Specific Delta Modeling Report, which addresses effects of a smaller desalination project, the SED fails to adequately address or identify the impacts of the larger desalination project envisioned in the SED, as follows:

    - The water quality and hydrology modeling conducted for the BARDP Site Specific Delta Modeling Report assumed a facility with half the capacity of that proposed in the SED. Without providing any support for the statement, the SED asserts that "a facility that is larger than the BARDP (e.g. 56,000 AF/y) would have similar types of construction and operation impacts" and does not address the effect of the larger plant. While it is reasonable to assume that a larger facility would have similar *types* of impacts, arguably the *severity*, and potentially the significance, of some impacts would increase with a larger project.

    - The SED states that "the increased electrical demand as a result of a larger design capacity…could result in increases in GHG emissions and air quality impacts under operating conditions" presumably compared to the impact associated with the amount of GHG emissions identified for the BARDP, but does not elaborate on the environmental implications of the increased electrical or energy demand.

    - Pumping rates greater than the 25 mgd diversion volume evaluated in the BARDP Site Specific Delta Modeling Report could result in exceedance of 0.2 feet per second approach velocity[19], which is the limit on approach velocity established by the USFWS to protect delta smelt.[20] The SED fails to address the potential impact of increased intake volume related to compliance with approach velocity requirements and smelt entrainment. The SED also fails to discuss whether other measures identified in the BARDP modeling report to reduce the risk of entrainment (such as adaptively determining the BARDP diversion rate based on real-time field monitoring, decreasing the slot size of the Mallard Slough Pump Station screen, and relocating the intake to the main channel) would also be effective and feasible for the larger facility.

    - Although the capacity of the existing intake is 40 mgd,[21] the SED fails to address potential impacts associated with construction of a new intake having the capacity to accommodate the 50 mgd source water diversion rate needed for the larger facility. Temporary disturbance of bottom sediments could cause water quality degradation from chemicals in sediments or construction materials during intake construction. The capacity of the existing 40 mgd pump station would also need to be increased, which could also result in construction-related impacts.

    - The SED assumes that brine generated by a larger facility would be blended with the dry weather outflows of the two wastewater treatment plants currently proposed to be used by the BARDP (CCCSD or DDSD). However, the larger proportion of brine generated by the larger desalination plant to treatment plant outflow would potentially result in greater water quality impacts than currently discussed in the SED, which does not provide meaningful, substantive consideration of the water quality impacts of increased brine discharge. (See also the discussion under General Comments

19 BARDP Site Specific Delta Modeling Report, p. 73, Table 2-1.

20 BARDP Site Specific Delta Modeling Report, p. 78, Section 2.5.5

21 MWH, *Pilot Testing at Mallard Slough Pilot Plant Engineering Report*, p. 1-22.

on Feasibility above regarding potential capacity constraints related to using the outfalls for brine discharge.)

- The SED cites the BARDP Site Specific Delta Modeling Report conclusion that "during critically dry water years, BARDP operations would need to be coordinated with CVP, SWP, and the City of Antioch operations to avoid impacts" on water quality from brine discharge (SED p. 16-74), but does not provide meaningful, substantive consideration of the potential for such coordination to successfully avoid water quality impacts, given the larger source water intake and brine discharge volumes. It is reasonable to expect that doubling the brine discharge alone would make avoidance of impacts substantially more challenging, and increase the likelihood that water quality impacts would not be avoided.

- The SED acknowledges that desalination facilities "are typically relatively energy intensive" and therefore a larger facility would increase GHG and air pollutant emissions, but fails to evaluate the effects of the energy requirements of the larger desalination facility envisioned in the SED on local or regional energy supplies or facilities or whether it would result in the need for additional capacity. The discussion of impacts identified in the WSIP PEIR (SED p. 16-74) states that mitigation "could likely" reduce impacts on public services and utilities to a less than significant level, whereas SED Table ES-22 indicates that the impacts of desalination plant operations on utilities and service systems are expected to be significant and unavoidable. No meaningful explanation is provided for either conclusion.[22]

- The SED fails to adequately consider the potential for operations at the desalination plant to result in impacts related to the use of chemical transport and storage, dismissing the increase in chemical use as negligible because the desalination plant would likely be constructed within or adjacent to existing treatment facilities (SED p. 16-74). However, as stated on p. 16-71, the SED analysis assumes the desalination plant and intake would be "located at the existing Mallard Slough intake/pump station site." The pump station is not within or adjacent to a water treatment facility, and chemical use at the pump station would likely be much more limited than at a treatment facility. In addition, the type of chemicals needed for operation of a reverse osmosis desalination plant may differ from those used at a traditional water treatment plant. In addition, the area from the pump station site at the end of Mallard Slough to Suisun Bay appears largely to be wetlands, which may be particularly vulnerable to the effects of an accidental hazardous materials spill. Therefore the SED characterization of the increase in chemical use and storage at the proposed desalination plant site is unsupported.

Impacts associated with different geographies

The SED acknowledges, but does not describe in any detail or draw any conclusions about the geographical differences between the San Francisco Bay-Delta and coastal Carlsbad and how these differences might affect impacts. The differences in geography (as well as differences in some project facilities) that could affect typical desalination plant impacts include:

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22 Complicating the referenced discussion on p. 16-74, is the fact that the discussion refers to SED Appendix H, which largely consists of a table of measures identified in the WSIP PEIR to mitigate the impacts of the WSIP *Advanced Disinfection Project*. Appendix H acknowledges that additional measures may be needed for desalination facility impacts, but it does not discuss either impacts or mitigation related to increased power demand.

- **Brine disposal location.** The Carlsbad project disposes brine through the adjacent power plant's existing cooling water discharge system to the ocean, where mixing conditions disperse the discharged brine. Modeling conducted for the Carlsbad EIR showed "the importance of 'in-the-pipe' dilution and natural mixing conditions as a means of diluting and dispersing the [reverse osmosis] plant discharge."[23] By contrast, the 50 mgd desalination project assumed in the SED would dispose of brine by blending with WWTP effluent (assuming available outfall capacity) prior to release into Suisun Bay. Thus, the hydrology and water quality issues would be different. Whereas the Carlsbad plant uses an existing power plant outfall located in an area with natural mixing conditions that speed the dilution of the discharge, the WWTP outfalls that may be used in Suisun Bay are likely to be located in lower energy environments with lower mixing potential compared to the ocean. In addition, the mixing or in-pipe dilution ratios for the Carlsbad facility are not discussed and could be very different than the SED desal option. There could be a higher brine-to-effluent ratio at the Delta WWTP outfalls resulting in less dilution prior to discharge compared to the brine-to-cooling water ratio at Carlsbad, which could affect the degree of potential impact. The Delta is already a stressed estuarine ecosystem that could be more sensitive to a steady influx of brine than would the ocean environment. If the purpose of including information about the conclusions of the Carlsbad analysis was to suggest that a large plant in the Delta would have similar less than significant impacts, the SED analysis was deficient in not providing more information on how differences in geography could change conclusions about impacts.

- **Intake location.** Impingement and entrainment of aquatic species at open water intakes are key concerns associated with desalination plant operations. The Carlsbad project does not require a new intake; instead it diverts spent cooling water from an adjacent power plant's cooling water discharge system as its source water. The power plant intake draws water from a constructed lagoon and discharges to the ocean. According to the Carlsbad EIR (pages 4.3-35 and 4.3-42), the desalination plant operation would not require the power plant to increase the quantity of water withdrawn nor would it increase the velocity of the water withdrawn and therefore would have no impingement-related impacts. The only entrainment impacts the Carlsbad plant would have are to organisms that survived the power plant intake and cooling system. The EIR found that because the additional effect on larval fishes would be very low and because the most frequently entrained species had widespread distribution and high reproductive potential, the ecological effects due to any additional entrainment from the desalination plant was less than significant. As discussed in the section above, unlike the Carlsbad plant, a new intake would be required for the desalination plant envisioned in the SED at the Mallard Slough site. The magnitude of effects of an open water intake depends in part on the sensitivity of the specific area. The Delta is recognized to be an important ecosystem that provides habitat for endangered species and is already under considerable environmental stress. Therefore, entrainment and impingement effects of an intake in the Delta would very likely have greater impacts on endangered or other special status species than an intake at Carlsbad.

- **Air basin status.** In reference to the Carlsbad facility, the SED states that "[c]umulative regional impact [*sic*] on air quality for the production of ozone and PM10 were determined to be significant and unavoidable," which would presumably indicate that the SED has determined the air quality impact of the proposed larger facility would be significant and unavoidable based on production of ozone and PM10. This conclusion from the Carlsbad facility environmental analysis is based on the existing air quality in

23 City of Carlsbad, Supplement to the Precise Development Plan and Desalination Plant Project Final Environmental Impact Report, Section 4.3 Biological Resources, page 4.5-50.

the Carlsbad air basin. The San Francisco Bay Air Basin, to which the SED facility would contribute emissions, is also designated non-attainment for state and federal standards for PM2.5, which is not discussed in the SED impact evaluation. Moreover, the SED Executive Summary impact table ES-22, CEQA Significance Summary of LSJR Alternatives – Other Indirect Actions, indicates that the SED Water Supply Desalination project would not have significant unavoidable air quality impacts during operations. The SED also fails to explain the conclusion reflected in Table ES-22 that the air quality impact of desalination facility operations would not be significant, or if significant, could be mitigated.

APPENDIX 6

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date March 15, 2017

to San Francisco City Attorney's Office

from Leslie Moulton-Post, Jill Hamilton, and Chris Mueller

subject Adequacy Review of In-Delta Diversion Alternative Analysis in State Board SED

Purpose

This memo evaluates the environmental analyses contained in the State Water Resources Control Board's (SWRCB) Substitute Environmental Document in Support of Potential Changes to the Water Quality Control Plan for the San Francisco Bay-Sacramento/San Joaquin Delta Estuary: San Joaquin River Flows and Southern Delta Water Quality (SED) Recirculated Draft (SCH #2012122071). Specifically, this memo addresses the adequacy of the SWRCB's description and analysis of environmental impacts of an in-Delta diversion project to replace San Francisco's reduced water supply if Lower San Joaquin River (LSJR) Alternatives 3 or 4 described and evaluated in the SED are approved and implemented.

Background Information: SED Description and Evaluation of In-Delta Diversion

Chapter 16 (Section 16.2.5) describes the SED evaluation of "other indirect actions" associated with the Lower San Joaquin River Alternatives 2, 3 and 4. It identifies actions the regulated community -- including the City and County of San Francisco (CCSF) -- could take to reduce potential reservoir or water supply effects associated with implementing the LSJR alternatives, including the "Transfer/Sale of Surface Water" that could purportedly be implemented through in-Delta Diversions. The SED's description of the in-Delta Diversion option is presented on pages 16-68 and 16-69 and is based on one of several potential water supply options presented in the San Francisco Public Utility Commission's (SFPUC) Water Supply Options (WSO) Report, published in 2007. That report evaluated numerous potential alternatives to the SFPUC's proposed Water System Improvement Program (WSIP), which was approved in 2008. Specifically, the description in the SED is based on the WS3-1 alternative described in Section 5.2 of the WSO Report and Section 5.1 of WSO Report Appendix C, and would include a new Delta intake drawing from either the California Aqueduct or the Delta-Mendota Canal, a pumping plant, pipeline, Delta water treatment plant (WTP), and a new blending facility. Like the 2007 WSO report, the SED assumes that the 18-acre WTP and blending facility would be located at the SFPUC's Tesla Portal. The SED acknowledges that the design capacity of the WS3-1 alternative would not completely offset the supply shortages.[1] The SED's analysis of the environmental impacts of the in-Delta Diversion option, presented on pages 16-69 and 16-70, incorporates some of the environmental analysis conducted for WS3-1 (presented in

1 On page 16-68 the SED states, "This design capacity would replace a portion of the supplies potentially reduced by the higher range of the LSJR alternatives (i.e., LSJR 4) and would likely be needed *in addition to other supplies* under certain LSJR alternatives given the amount of water potentially needed by the SFPUC…." On page 16-69 the SED states "The size of the project *may need to be larger than* what was examined in the WSO report …." [Emphasis added.]

Appendix H [Environmental Evaluations] of Appendix C of the WSO report, and Attachment 2 of Appendix H of the SED). Table 16-38 (beginning on page 16-309) identifies potential mitigation measures that could be implemented for construction and operation of the in-Delta Diversion option, among other options.

General Comments of Adequacy of Description, Feasibility and Environmental Evaluation of In-Delta Diversion Option

ESA has identified several deficiencies in the description and the analysis of the in-Delta Diversion option presented in the SED, as follows.

Feasibility. The SED does not substantiate the assumption that the in-Delta Diversion option is feasible. The SED identifies some of the factors identified in the WSO report that are critical to the feasibility of this option while ignoring others. The WSO report (page 5-11) clearly states that "In the case of the Delta diversion alternative, the likelihood of obtaining a long-term water sale contract and a through-Delta wheeling contract is considered extremely low. Furthermore, any Delta wheeling agreement would be subject to environmental pumping restrictions, and the SFPUC would be considered last in line" behind CVP or SWP contractors. In the performance evaluation of the Delta diversion option (Table 5-2, page 5-8), the WSO report indicates that "Dry year purchases may be especially difficult to negotiate," that there would be a "Potential diminution of supply from potential regulatory 'droughts' associated with the ESA [Endangered Species Act]," and that with the In-Delta Diversion the SFPUC would experience a "Risk of not serving full demand within [the] modeled delivery window." Regarding the competition the SFPUC would face in obtaining additional supplies, the detailed evaluation of the WS3-1 option in Appendix C of the WSO report recognizes that "SWP and CVP contractors are looking for supplemental water supplies, particularly during drought years…"

Recognizing that it was "highly unlikely" that the SFPUC would achieve year-round diversions (WSO report page 5-1), the WSO analysis assumed that at best the SFPUC would be limited to receiving its annual Delta water supply during a three-month period, and sized facilities accordingly. Yet the WSO report (WSO report, Appendix C, page 5-7) also indicates that the in-Delta diversion project may have even less than a three-month period during which water could be diverted, and that the proposed facilities may therefore need to be larger than those described. Larger facilities, if feasible, could cause additional and/or more severe environmental impacts, including disturbance or loss of agricultural land, wildlife habitat, or open space, because a larger area would be needed for larger-capacity diversion and treatment facilities; increased energy demand with associated air quality and GHG-related impacts; and increased potential for soil erosion and associated degradation of surface water quality, among other potential effects. The potential need for or feasibility of larger facilities and associated impacts were not addressed in the SED. The WSO analysis stated that additional studies would be needed to determine whether the SFPUC could accommodate the diversion of the 28,000 acre-feet per year (afy) annual supply over a period less than three months. As the SED acknowledges (Draft 2016 SED at 16-68), the volume of water considered in the WSO report (28,000 afy) is substantially less than the reductions of SFPUC deliveries that could occur in drought years under LSJR alternatives.

Outdated Information About Facility Site Availability. The analysis presented in the SED relies on outdated information and, therefore, fails to provide a complete analysis of feasibility and environmental effects. As indicated in the sources listed at the end of the table included in SED Appendix H, Attachment 2 (Annual Delta Diversion – Environmental Issues), the environmental investigations were conducted in 2004 and 2005. No attempt was made to verify whether substantive changes have occurred in the physical or regulatory settings, which in turn affect the feasibility of the project and impact significance. After approving the WSIP in 2008, the SFPUC has proceeded to implement many of the Capital Improvement Projects called for in the WSIP, including several at and in the immediate vicinity of the facility locations identified in the SED. As a result, much of the area identified for the 18-acre water treatment plant at the Tesla Portal is now occupied by other facilities, a fact that undermines the conclusion in the SED that this site could accommodate the needed facilities. (The WSO report acknowledges that other WSIP projects are planned at Tesla and that locations would need to be coordinated.) This information was readily available had the EIR preparers consulted Google Earth. Further, implementation of the San Joaquin Pipeline System Project may have constrained the SFPUC's ability to site another large-diameter pipeline within the San Joaquin Pipelines right-of-way, another new fact raising a substantial project feasibility issue.

Inadequate Environmental Analysis and Failure to identify Significant Impacts. The westernmost portion of the San Joaquin Pipeline System Project, one of the SFPUC's WSIP projects, substantially overlaps with the locations identified for the Delta Diversion facilities. The San Joaquin Pipeline System Project includes various pipeline improvements between Foothill Tunnel at Oakdale Portal and the Coast Range Tunnel at Tesla Portal as well as facility improvements at Tesla Portal. The project includes a new pipeline beginning west of the San Joaquin River and ending west of Tesla Portal. Presumably the SFPUC's pipeline right-of-way west of the Delta Mendota Canal is similar to (or the same as) the alignment assumed in the SED for the in-Delta Diversion option. The EIR for the San Joaquin Pipeline System Project,[2] which the City and County of San Francisco certified in 2009, identifies several significant impacts *not identified in the SED* that implementation of the Delta Diversion facilities would most likely also have, including the following:

- Impacts to the following special status species were not identified in the SED for Delta Diversion Facilities:
  - Special status bats
  - American badger
  - White-tailed kite
  - Northern Harrier
  - Golden Eagle
  - Aleutian cackling goose
  - Loggerhead shrike
  - Tricolored Blackbird
  - Raptors and migratory birds
  - Western Pond Turtle
  - San Joaquin whipsnake and California Horned Lizards
- Impacts to paleontological resources due to excavation in fossil bearing soils
- Impacts to historic resources. The EIR identifies the following facilities are potentially eligible for the National Register of Historic Places and California Register of Historic Places
  - Delta Mendota Canal
  - California Aqueduct
  - San Joaquin Pipelines 1 and 2

2 San Francisco Planning Department, *Final Environmental Impact Report, San Joaquin Pipeline System Project*, State Clearinghouse No. 2007032138, San Francisco Case No. 2007.0118E, June 11, 2009.

- Air Quality: potential exposure to emissions and odors from pockets of methane and hydrogen sulfide that could be encountered and released during tunneling operations for crossing under Interstate 5, Interstate 580, Chrisman Road, and potentially under other infrastructure.

- Utilities and Public Services: Pipeline construction could result in potential damage to or disruption of regional and local public utilities including natural gas pipelines, electric lines, oil pipelines, and local water lines that cross or extend along the SJPL right-of-way west of the Delta Mendota Canal and California Aqueduct (SJPL FEIR, at 4.13-32 and Figures 4.13-1(d) and 4.13-1(e)).

Selective Inclusion and Exclusion of Information. The SED chooses to include some information from the WSO report concerning environmental impacts but excludes other information. The SWRCB selected information in an appendix of an appendix to the WSO report without referencing discussions of environmental issues identified in the main body of the WSO report. The material relied on in Appendix H of Appendix C of the WSO report focuses on impacts associated with facility construction; it does not address effects of facility operation on the Delta and elsewhere. With respect to impacts to the Delta, the WSO report (Table 5-2, page 5-8) acknowledges that the hydrologic and biological effects to the Delta from operation of a Delta Diversion are unknown. Table 5-2 (page 5-8 to 5-9) also identifies numerous water quality issues and effects on water users and seismic risks associated with the use Delta supplies. The Delta is subject to liquefaction; an earthquake could result in widespread levee failures, impairing the ability of the CVP and SWP to operate. Potential impacts to the SFPUC include service interruptions, construction of new facilities to alleviate the risk of failure and service interruptions during its construction, and higher costs. Several other examples where the description and analysis of the Delta Diversion seem to lack objectivity are identified in the detailed comments presented below.

Inappropriate Basis for Conclusions Regarding Impact Significance. As indicated in some of the detailed comments presented below, the SED makes inappropriate comparisons to draw conclusions about the significance of impacts associated with the Delta Diversion option. Elsewhere, unsubstantiated, conclusory statements are also relied on.

Impacts Associated with Differences in Project Characteristics. The SED acknowledges that the Delta Diversion as characterized in the WSO report would not have sufficient capacity to offset the supply shortages associated with some of the LSJR Alternatives; thus, the SED relies on environmental evaluation of a smaller project than would be needed. However, the report does not provide meaningful, substantive consideration of the differences, in terms of how the in-Delta Diversion would be implemented under the SED compared to the WSO concept, and how the impacts disclosed might also differ if the project were of a larger capacity.

Specific Comments on SED Description and Environmental Evaluation of In-Delta Diversion

1. The statement in the SED discussion of In-Delta Diversions (SED, page 16-68) that “Reductions in surface water diversions *are possible* [emphasis added] as a result of approving an LSJR alternative and the respective program of implementation” is an understatement. It is reasonably foreseeable that reductions in surface water diversions would be an inevitable consequence of approval and implementation of LSJR Alternatives 2, 3 or 4 because, as the analysis presented in SED Appendix L shows, CCSF would have a water bank deficit under baseline conditions based on both (1) analysis of a six-year drought and (2) the 21-year period of record (SED Appendix L Tables L.4-2 and L.4-3, respectively). In both cases (each analyzed

under two scenarios[3]), the deficits would increase under Alternatives 2, 3, and 4. Moreover, the description of every other indirect and additional action identified in Chapter 16 indicates that reductions in surface water diversions *are expected* as a result of approval and implementation of an LSJR alternative (Draft 2016 SED, page 16-5, 16-16, 16-40, 16-48, 16-70 and 16-75).

2. The statement (SED, page 16-68) that the project as described in the WSO "would require relatively little new infrastructure" mischaracterizes this option, which would require a new intake on the Delta Mendota Canal or California Aqueduct, a pumping plant, a large-diameter (60-inch) pipeline, a new water treatment plant occupying 18 acres, and a blending facility.

3. The SED states (SED, page 16-68) "These reductions in surface water could potentially affect SFPUC by reducing some portion of its current water supply obtained from the Tuolumne River *during a 6-year drought* [emphasis added], as described in Appendix L, *City and County of San Francisco Analyses*." However, the analysis prepared by Matt Moses (2017) indicates that the modeling conducted by SWRCB underestimates the severity of water shortages that would affect San Francisco.[4]

4. The SED states (SED, page 16-68) "As described in SFPUC documents, specifically the Water Supply Options (WSO) report (SFPUC 2007), SFPUC has several options for augmenting or increasing its water supply including diverting water from the Sacramento–San Joaquin Delta (Delta)." It would be more accurate to say that SFPUC has *evaluated* several options for augmenting or increasing its water supply, some of which – including in-Delta diversions – the SFPUC concluded had an extremely low chance of successful implementation (see WSO report page 5-11). The SED fails to support why this option is now considered feasible.

5. The SED states (SED, page 16-68): "In the 2008 WSIP Programmatic Environmental Impact Report (PEIR), SFPUC concluded that the in-Delta diversion option was infeasible, in part, because it would not achieve consistent year-round diversions due to uncertainties regarding the availability of water supplies and pumping capacities (SFPUC 2008). Nonetheless, a discussion of this possible water supply option has been included in light of the changing circumstances since 2008 (e.g., Pelagic Organism Decline, climate change, California WaterFix, and the State Water Board's *Final Report on the Development of Flow Criteria for the Sacramento Delta Flow Criteria* [State Water Board 2010])."

    a. The discussion selectively addresses some of the reasons why this potential alternative in the WSIP PEIR was found to be infeasible but ignores others. For example, the PEIR also states (page 9-126) that because of the numerous institutional and regulatory uncertainties associated with this alternative (largely dependent on how and where the SFPUC would purchase the water), it was unknown if this alternative could achieve the WSIP level of service goals for delivery and water supply reliability. The PEIR also notes that the quality of Delta water supplies would be lower than water in the Hetch Hetchy system, and that while this alternative would avoid or reduce impacts on Tuolumne River resources that would occur under the WSIP (as proposed), "it would result in other, distinct significant environmental impacts on the Delta and associated environmental resources (e.g., fisheries, aquatic habitat and species, riparian habitat, and water quality affecting other beneficial

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3 The scenarios consist of two potential interpretations of responsibilities under the Fourth Agreement between CCSF, Turlock Irrigation District, and Modesto Irrigation District.

4 For example, assuming San Francisco was responsible for bypassing flow in compliance with a 40 percent unimpaired flow objective on the Tuolumne River, and a reoccurrence of 1987-1992 hydrology, San Francisco's water supply would be reduced by 129,884 afy for each of the 6 years of the drought, resulting in a loss of an additional 10,884 afy, or 65,304 acre-feet in total for the 6-year period, as compared to the State Water Board's calculations. *See* Declaration of Matt Moses in Support of Comments by the City and County of San Francisco to the Draft Substitute Environmental Document in Support of Potential Changes to the Bay-Delta Plan ("Moses Decl."), Attachment 1, *SFPUC Analysis of Proposed Changes to Tuolumne River Flow Criteria*, March 2017 (referred to below as "SFPUC Analysis of Changes to Flow Criteria"), at 16, Table 9. *C.f.* SED, Appendix L, at L-21, Table L.4-2 (where the SED estimates that, assuming a reoccurrence of 1987-1992 hydrology, the largest potential water supply reduction San Francisco could experience if the State Water Board implemented a 40 percent unimpaired flow objective on the Tuolumne River would be 119,000 afy for each year of a 6-year drought).

uses)." Regarding impacts associated with facility construction and operation, the PEIR found that the Delta Diversion alternative would neither avoid nor lessen the effects that would result from construction and operation of WSIP improvement projects, and that facilities beyond those required for the WSIP would need to be constructed and operated. The PEIR states that these facilities would be located in a combination of open space, rural settings, and dense urban settings, resulting in a range of additional environmental impacts. Thus, the Delta Diversions alternative was eliminated from further consideration in the WSIP PEIR because it would have uncertain water supply reliability and an unknown ability to reduce impacts on Tuolumne River resources, as well as significant additional environmental impacts.

b. The discussion does not explain here – or anywhere -- how the "changing circumstances" now render this potential alternative feasible. While the referenced changed or changing circumstances would be reasons to reassess the potential feasibility and impacts of an alternative previously considered feasible, all of the circumstances in this list raise concerns of more restrictive environmental conditions and therefore greater project impacts and/or stricter regulation that likely make a new in-Delta diversion even less feasible. In addition, the California WaterFix has not yet been approved and implemented, and as such its characteristics may change. We are not aware of any information in the record for the WaterFix proceeding which suggests that project could serve additional users such as the SFPUC or make through-Delta transfers and in-Delta diversions more feasible.

6. The SED states (SED, at 16-68): "A delta diversion project would potentially allow SFPUC to use any of the rivers that flow into the Delta as a water supply source, instead of the Tuolumne River. Under this type of project, it is anticipated water would be purchased from any user upstream from the Delta or from a State Water Project (SWP) or Central Valley Project (CVP) contractor south of the Delta. A new connection to either the California Aqueduct or the Delta-Mendota Canal would be constructed to accommodate the transfer."

   This subject text implies that flows from the Lower San Joaquin and Sacramento Rivers are a readily available water supply source. CCSF is not currently a CVP or SWP contractor. As a result, the WSO (Appendix C, pp. 5-3 – 5-8) identifies numerous constraints regarding supply availability and reliability that are not addressed in the SED. These include:

   a. "The SWP and CVP provide preference to existing contractor deliveries and diversions... non-contractor diversions are considered the lowest priority (the SFPUC is a non-contractor for both projects)." (WSO Report Appendix C at 5-5.) Both the SWP and CVP systems are already oversubscribed under current conditions; thus, it is questionable just how readily available long-term contracts are. According to the DWR's *State Water Project Final Delivery Capability Report 2015* (page 127, Table 6-4), the estimated long term average deliveries to SWP contractors under existing conditions is only 62 percent of the contractors' maximum Table A amounts, and far less than this (28 to 33 percent) during dry periods. As stated in the WSIP PEIR (page 9-26),

      > *The agencies with the rights to the greatest quantities of water in the state, the U.S. Bureau of Reclamation (USBR) and California Department of Water Resources (DWR), would not be sources of new water supply contracts/agreements because of their commitments to existing contractors and to the protection, restoration, and enhancement of fish and wildlife habitat. Challenges to water purchases and transfers pertain to restrictions associated with entitlements, contracts, and water rights; permitting requirements; effects caused by the cessation of water application to an area (e.g., land fallowing, economic impacts); Delta pumping restrictions; and wheeling arrangements.*

      The SWRCB did not contact either DWR or USBR as to whether these agencies consider the in-Delta diversion as characterized in the SED to be feasible, or whether water released from either state or federal water project storage would be available for transfer to non-contractors. At a minimum, the SED should acknowledge that the ability of the SFPUC to secure one or more long-term water contracts is speculative and outside the control of the SFPUC. This is a matter of public record.

b. Given that these systems are already oversubscribed, it is reasonable to conclude that any long-term transfer of contract water, or any other water rights or supplies, would be strongly opposed by existing downstream SWP and CVP contractors, in-Delta diverters, etc.

c. Any such long-term transfer of contract water should include an analysis of system hydraulics and hydrologic assumptions, under varying conditions, quantitatively demonstrating the effects of such transfers on downstream contractors, in-Delta diverters, etc. Alternatively, the SED should acknowledge that downstream contractors may be adversely affected.

7. Section 16.2.5 includes the following statement: "The size of the [in-Delta diversion] project may need to be larger than what was examined in the WSO report." As noted above, the SED does not provide any information that demonstrates this alternative is feasible, nor has it substantiated assertions that changing conditions make an in-Delta diversion option more feasible today than in 2005. This statement, indicating that the diversion would need to be larger than that considered and rejected for the WSIP PEIR, further undermines the SED conclusion that the in-Delta diversion is a feasible option to offset the supply shortages to the SFPUC associated with some of the LSJR Alternatives.

8. The statement that, "Effects associated with exporting water from the Delta are being debated and analyzed by U.S. Bureau of Reclamation (USBR), DWR, and various fisheries agencies as part of the California WaterFix process" (SED, at 16-69) implies that those analyses are evaluating an in-Delta diversion by the SFPUC as part of California WaterFix. While the WaterFix identifies SWRCB's Delta Water Quality Control Plan update as a cumulative project (and the SED identifies the WaterFix as a cumulative project), there is no evidence that in-Delta diversions by the SFPUC discussed in SED Chapter 16 were modeled or considered feasible in WaterFix analyses.

9. The SED states (SED, page 16-69):

> "If water was purchased from a contractor upstream of the Delta, there may be an increase in Delta exports, which could affect Delta fish. This effect would likely be very small due to the size (39 cfs to SFPUC versus 10,000 cfs of combined exports) and would be minimized by operating under current fisheries agencies and State Water Board regulations and requirements."

It is a well-established principle in analyzing impacts under CEQA that the relevant question to be addressed is not the relative amount of change compared to adverse effects that have already occurred, but whether any additional amount of impact should be considered significant in light of the existing conditions. To claim that the effect of diverting 39 cubic feet per second would be "very small" is not a substitute for an actual analysis of the effects. Moreover, to claim that the effect would be "minimized" by operating under current fisheries agencies and State Water Board requirements does not prove that the diversion *can be* consistent with these restrictions.

10. The SED's analysis (SED, page 16-69) of the ability of the existing power grid to support pumping and treatment operations and, consequently, the need for new electrical facilities is inadequate and based on an inappropriate basis of comparison, as indicated in the following text:

> "Potable water treatment and pumping facilities are typically relatively energy intensive; however, the overall increased electrical load would be extremely small compared to the existing electrical load from

the large Delta export pumps. Therefore, it is unlikely to require the construction of major new power generation or transmission facilities."

Whether the overall increased electrical load (which is not quantified even in the broadest terms in the SED) would be small compared to the existing electrical load from Delta export pumps is immaterial and fails to answer the question of whether the existing facilities have remaining capacity or if new power generation or transmission facilities are needed. Indeed, with implementation of LSJR Alternatives 3 or 4 the CCSF would have even less energy at their disposal for operating the regional water system but greater energy needs due to additional pumping and treatment requirements, potentially increasing power generation demands.[5]

11. The SED states (SED, page 16-70) "The operation of Delta diversion facilities may require a slight increase in chemical transport and storage; however, because the facilities would likely be constructed within or adjacent to existing treatment facilities, the increase would be negligible compared to existing chemical use and transport at these locations." The statement inappropriately characterizes the effect of risks associated with increased chemical transport and storage as negligible based on the "small" increase in chemical use without either quantifying, even in the most general terms, what the increase in chemical use is, much less what the chemicals are. The existing "treatment" facilities at Tesla Portal simply provide disinfection; they do not provide filtration or include a water filtration plant. Delta water would require filtration and the full range of chemicals used by a modern filter plant. The WTP that would need to be constructed would therefore contain substantially more hazardous materials (water treatment chemicals) than existing operations at the Tesla Portal.

12. The SED states (SED, page 16-70) that, "The Delta diversion facilities would be constructed in areas that are already disturbed by urban development, and most facilities would be located within existing facility footprints and rights-of-way." This statement overlooks the fact that the SFPUC has already developed much of the area identified in the WSO for other facilities at the Tesla Portal, and thus is inaccurate and misleading.

13. The SED states (SED, Appendix L, City and County of San Francisco Analyses, page L-24), "This, or other in-Delta diversions, may be able to divert water that was left in the Tuolumne River as a result of increased instream flows under LSJR Alternatives 2, 3, or 4. The water rights and contractual obligations of SFPUC and other water right holders would need to be determined." Such an option would have all the adverse environmental effects of in-Delta diversions identified above: It would require substantial new infrastructure, including a new intake, pumping plant, large-diameter (60-inch) pipeline, WTP occupying 18 acres, and a blending facility; to treat Delta water the new WTP would contain substantially more hazardous water treatment chemicals than existing disinfection operations at the Tesla Portal; this option would likewise increase energy demand for pumping and water treatment; and would face constraints on space for the new facilities at the Tesla Portal.

    As discussed above, this in-Delta diversion option would also have effects on Delta biological resources and hydrology that have not been evaluated. Such an option would be similar to "WSIP7," one of the 28 alternatives evaluated as part of WSIP planning, except that WSIP7 called for withdrawing SFPUC water that had been left in the Tuolumne River from the lower Tuolumne River, near its confluence with the San Joaquin River, rather than from the Delta. During WSIP planning, WSIP7 was retained for additional analysis in the 2007 WSO report as alternative WS3-2. In addition to environmental impacts, the 2007 WSO report identified the following source water availability and reliability issues associated with alternative WS3-2,

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5 *See* Comments by the City and County of San Francisco to the Draft Substitute Environmental Document in Support of Potential Changes to the Bay-Delta Plan ("San Francisco's Comment"), at 63 (explaining that "if San Francisco was responsible for complying with a new unimpaired flow objective on the Tuolumne River, then during dry hydrologic conditions the SFPUC would be compelled to implement water supply rationing in order to preserve system storage. Consequently, less water would flow through the SFPUC's water supply delivery pipeline, thereby reducing hydropower generation at facilities situated along the route of the delivery pipeline, *i.e.*, Kirkwood Powerhouse and Moccasin Powerhouse.").

which would also apply to this alternative: it would require renegotiation of water rights with the Modesto Irrigation District and Turlock Irrigation District; agreement with all interested parties including resource agencies for releasing water to the lower Tuolumne; and state approval for diverting SFPUC water at the diversion point (in this case, the Delta rather than the lower Tuolumne River); and SFPUC would lose rights to water spilled from the New Don Pedro Water Bank (2007 WSO Report Table 5-2, at 5-8). Thus, while the statement in SED Appendix L that water rights and contractual obligations of the SFPUC and others “would need to be determined” is correct, it understates the uncertainty that would be inherent in such negotiations and the potential for the SFPUC to negotiate the right to recapture from the Delta water that had been left in the Tuolumne River, while retaining SFPUC’s ability to use the New Don Pedro water bank, among other concerns.

In conclusion, as the above comments indicate, the SED has failed to substantiate its assumption that an in-Delta Diversion option is feasible and to adequately address the environmental impacts that would result from such an option. The SED analysis of environmental impacts associated with the in-Delta Diversion option must be expanded and revised to adequately evaluate the impacts outlined above and identify feasible mitigation measures where appropriate to address significant impacts.

ATTACHMENT 2:

SFPUC ALTERNATIVE

City and County of San Francisco
San Francisco Public Utilities Commission

Alternative to promote the expansion of fall-run Chinook salmon and *Oncorhynchus mykiss* populations in the lower Tuolumne River while maintaining water supply reliability

March 2017

1 INTRODUCTION

The Turlock and Modesto Irrigation Districts (Districts) have funded over 200 publically available studies relevant to salmonids and their habitat in the lower Tuolumne River, including a recent set of studies and models developed by the Districts in the course of the Federal Energy Regulatory Commission (FERC) relicensing of the Don Pedro Project (FERC No. 2299). The publically available studies include investigations of river substrate composition, geomorphology, riparian habitats, floodplain habitats, hydrologic studies, predation studies, *Oncorhynchus mykiss (O. mykiss)* population studies, and fall-run Chinook and *O. mykiss* redd surveys. In addition, the Districts fund numerous publically reported monitoring efforts and compile these data to understand trends in salmonid populations and habitat conditions.

In this document, the San Francisco Public Utilities Commission (SFPUC) proposes a comprehensive alternative for management of salmonids within the lower Tuolumne River, based primarily on lower Tuolumne River specific studies and relevant scientific literature. This alternative is designed to:

1. Promote the expansion and maintenance of fall-run Chinook salmon and *O. mykiss* populations in the lower Tuolumne River;
2. Maintain water supply reliability for users of the Tuolumne River.

Components of the alternative include:

- **Habitat management** – proposed measures to improve existing physical habitats;
- **Predation management** – proposed measures to reduce the detrimental effects of non-native predators on salmonids;
- **Environmental flow management** – proposed releases from Don Pedro Reservoir that are designed to improve habitat conditions;
- **Hatchery management** – proposed measures to reduce undesirable effects of current hatchery practices on the lower Tuolumne River fall-run Chinook population.

The anticipated outcomes of the alternative are also evaluated, along with an analysis of estimated water supply effects on the SFPUC's Hetch Hetchy Regional Water System.

2 HABITAT MANAGEMENT

2.1 Coarse Sediment Augmentation

2.1.1 Issue Description

Spawning gravel studies (Stillwater Sciences 2013a and McBain & Trush 2004) report downstream movement and loss of spawning gravels on the lower Tuolumne River. Stillwater Sciences (2013a) reported a relatively slow loss of coarse sediment in a 12.4-mile long reach below La Grange Dam. From river mile (RM) 45 to RM 52, there was a reported loss of roughly 8,000 tons of coarse material between 2005 and 2012. High flow events in 2006 and 2011 locally scoured the bed and redistributed fine and coarse sediment.

Stillwater Sciences (2013a) indicates that at a flow of approximately 225 cubic feet per second (cfs), current spawning gravel theoretically supports 25,000 to 30,000 female fall-run Chinook spawners and 800,000 *O. mykiss* between RM 23 and 52. However, fall-run Chinook salmon population modeling (Stillwater Sciences 2013b) suggests that fall-run Chinook spawning may become limiting at escapements in excess of approximately 10,000 female spawners due to superimposition and preference for upstream locations. Additional gravel in the upper reaches of the lower Tuolumne River should provide capacity for larger escapements.

2.1.2 Resource Goals

- Increase spawning habitat quantity and quality throughout the gravel-bedded reach;
- Increase capacity and productivity of spawning habitat;

2.1.3 Measure

Undertake a two-phase, ten-year program of gravel augmentation from RM 39 to RM 52 (Figure 1); conduct annual fall-run and *O. mykiss* spawning surveys; conduct a repeat spawning gravel study (similar to Stillwater Sciences 2013a) in 10 years to identify and guide the scope of future actions. The total five-year Phase I program could contribute approximately 70,000 cubic yards of coarse sediment, or 100,000 tons as compared to a loss over eight years of 8,000 tons, or 1,000 tons/year. The Phase II program would use monitoring data to make determinations on future locations and quantities.

2.1.4 Potential Implementation Issues

During placement, turbidity levels will increase. However, if placement coincided with smolt outmigration, this may produce a positive result by potentially reducing predator sight feeding effectiveness.

2.1.5 Cost

Capital and monitoring costs of $17,000,000 over ten years.[1]

2.2 Experimental Gravel Cleaning

2.2.1 Issue Description

Spawning gravel studies (Stillwater Sciences 2013a and McBain & Trush 2004) report quality of spawning gravels can be adversely affected by in-filling of coarse sediment by fines which can impede hyporheic flows through redds and affect egg viability.

2.2.2 Resource Goals

Improve quality of spawning gravels through a program of experimental gravel cleaning to remove fine sediments. The primary sources of these fine sediments are intermittent tributaries (e.g., Peaslee and Gasburg creeks) entering the lower Tuolumne River below La Grange Diversion Dam.

2.2.3 Measure

Conduct a five-year program of experimental gravel cleaning using a gravel ripper and pressure wash operated from a backhoe to reduce embedded fine sediment in spawning gravels between RM 42 and 52 (Figure 1). Each year of this experimental method would consist of three weeks of cleaning pre-selected gravel patches coinciding with May pulse flows and smolt outmigration to provide increased turbidity, potentially reducing predation. Cleaned areas will be monitored each year following gravel cleaning.

Gravel cleaning operations in high infill areas integrated with pulse flows will maximize benefit to outmigrating salmon by inducing a sediment plume. Gravel cleaning areas will be coordinated with redd surveys to minimize impact to *O. mykiss.*

Gravel cleaning has the potential to expand availability of high quality gravel, which would improve spawning and egg incubation for fall-run Chinook and *O. mykiss*. Lower Tuolumne River field experiments using emergence traps showed average egg to emergence survival of 32% (TID/MID 1992b). New gravel is assumed to provide 50% emergence survival and cleaned gravel emergence

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[1] The assignment of costs associated with implementing the SFPUC alternative has not been determined.

survival is assumed to be 40% based on TID/MID (1992b). No direct estimates of survival to emergence for gravel augmentation sites are available for the Tuolumne.

2.2.4 Potential Implementation Issues

For short periods, increased turbidity may exceed state water quality standards, but the benefits to spawning success and smolt survival are likely to outweigh any lasting effects of short-term increased turbidity. Cleaning performed in May to avoid impacts to remaining *O. mykiss* redds. Redds are located at riffles, which are likely not subject to silt deposition.

2.2.5 Cost

Capital and monitoring cost of $2,400,000 over five years.

2.3 *O. mykiss* Habitat Complexity

2.3.1 Issue Description:

Large Woody Debris (LWD) is limited in the lower Tuolumne River (Stillwater Sciences 2013c). LWD captured by Don Pedro Reservoir does not possess the size that would constitute favorable LWD-induced habitat in the lower Tuolumne River. The role of LWD in habitat formation decreases with increases in channel width; average lower Tuolumne River width is 119 ft (Stillwater Sciences 2013c). Of the 505 pieces tallied by Stillwater Sciences (2013c) within Don Pedro Reservoir and below La Grange Dam, none were longer than 52 ft and 80% of LWD within the lower Tuolumne River was located in habitat not preferred by *O. mykiss* (runs and pools).

However, *O. mykiss* spawning and rearing habitat in the upper reaches of the lower Tuolumne River could potentially be improved by introduction of suitably sized boulder material for the purpose of introducing greater instream structure and complexity. Interstitial spaces in cobble and boulder substrate are a key attribute for *O. mykiss* winter habitat suitability (Hartman 1965; Chapman and Bjorn 1969; Meyer and Griffith 1997). Juvenile *O. mykiss*, adult *O. mykiss*, and juvenile Chinook salmon are expected to benefit from the increased habitat diversity, cover, and localized hydraulic complexity that introduced boulder material would provide.

2.3.2 Resource Goals

Increase complexity of physical instream habitat between RM 42 and RM 50 to primarily benefit juvenile *O. mykiss*.

2.3.3 Measure

Source and place boulder-size stone between RM 42 and 50 (see Figure 1). The program would take place over five years and consist of boulder placement in select sub-reaches each summer followed by monitoring through the next fall and spring to evaluate use. Annual snorkel surveys would be conducted to examine boulder habitat use and localized substrate conditions. Boulder size would be approximately 1- to 1.5-cubic yards. Stream margin placement would be preferred; suitably sized LWD may be added to boulder areas to increase complexity.

2.3.4 Potential Implementation Issues

Boulder placement could potentially interfere with recreational use. Selection of sub-reaches for placement and location of boulders should be accomplished with input from a team of biologists, engineers, and recreational users.

2.3.5 Cost

$1.7 million over five years.

2.4 Riparian Vegetation Planting

2.4.1 Issue Description

A stream's riparian corridor provides benefits to freshwater aquatic systems and the biota that live within and around it (Welsch 1991).

Physical conditions and processes in the lower Tuolumne River currently support natural recruitment of some native riparian species, such as narrow-leaf willow and box elder, while other native riparian plants, such as Fremont cottonwood Goodding's black willow, and other willow species show limited natural recruitment (Stillwater Sciences 2013d). Limited recruitment of these species outside of actively replanted restoration areas is evidenced by the lack of young cohorts observed during both the 1996 and 2012 riparian vegetation field surveys (McBain & Trush 2000 and Stillwater Sciences 2013d). However, the growth and survival of these species in large, actively replanted restoration sites (e.g. Grayson Ranch and Big Bend) demonstrate that active restoration can be a workable means of bringing these native community types back to the lower Tuolumne River.

2.4.2 Resource Goals

Maintain and expand native riparian vegetation community types along the lower Tuolumne River.

2.4.3 Measure

Provide a lump sum of $500,000 for the purpose of implementing a focused native riparian vegetation planting program. The program should focus on native riparian species such as Fremont cottonwood, Goodding's black willow, shining and red willow, which exhibit lower rates of natural recruitment. At a replanting cost assumed to be $3,000/acre, this measure would support restoration of 12 miles of shoreline assuming a 100-foot-wide shoreline zone.

2.4.4 Potential Implementation Issues

Landowner cooperation and approval must be obtained.

2.4.5 Cost

One time cost of $500,000

2.5 Water Hyacinth

2.5.1 Issue Description

Infestations of water hyacinth (*Eichhornia crassipes*) can adversely affect water quality, adult salmon migration, salmon outmigration monitoring, and other uses of the river including recreation. Dense growths of water hyacinth can obstruct and disrupt the adult fall-run Chinook salmon migration, and may be a significant factor influencing salmon escapement counts in the SJR tributaries (TID/MID 2014 and FishBio 2014).

2.5.2 Resource Goals

Assist California Department of Boating and Waterways with water hyacinth removal efforts on the lower Tuolumne River to reduce hyacinth's effects on native aquatic resources and uses affected by water hyacinth infestations.

2.5.3 Measure

Provide monetary or personnel support for water hyacinth removal efforts on the lower Tuolumne River.

2.5.4 Potential Implementation Issues

None identified.

2.5.5 Cost

$100,000/year during years when uses are significantly impaired.

3 PREDATION MANAGEMENT

3.1 Fish Counting & Barrier Weir

3.1.1 Issue Description

Monitoring studies (snorkeling and seine surveys) and predation studies conducted in 1992 and 2012 (TID/MID 1992a and FishBio 2013a) indicate a persistent and substantial population of non-native fish species, including black bass and striped bass, in the lower Tuolumne River. Striped bass have been documented ranging throughout the lower Tuolumne River, up to La Grange Diversion Dam. Striped bass are highly mobile and account for approximately 15% of the loss due to predation on the lower Tuolumne River (FishBio 2013a).

Low juvenile Chinook salmon survival has been documented on the lower Tuolumne River, and predation by non-native predators appears to be a major contributor to high rates of juvenile mortality (FishBio 2013a). From 2007 through 2013, the smolt survival index[2] on the lower Tuolumne River averaged 9.5%, and ranged from 2.7% to 28%. From 2008 through 2013, fry survival index averaged 5.4%, and for four of the years was less than 1%. A recent otolith study indicates fry leaving the Tuolumne River are poorly represented in future escapement, indicating a potential survival advantage for fish emigrating at larger sizes (Stillwater Sciences 2016).

3.1.2 Resource Goals

Manage the adverse impact of predation by non-native bass on fall-run Chinook salmon. A corollary benefit would likely be reduced predation on juvenile *O. mykiss*.

3.1.3 Measure

A permanent counting and barrier weir would be installed at RM 25.8 (Figure 1), and will serve multiple purposes. The weir would prohibit the upstream movement of striped bass (primarily) and other bass species into the prime rearing areas for juvenile Chinook and *O. mykiss*. By preventing bass movement upstream of RM 25.8, predation above that point is expected to be reduced. Striped bass will likely congregate below the barrier, and would be the target of suppression and removal efforts (see predator suppression and removal measure below) prior to spring outmigration pulse flows (see outmigration pulse measure below).

Installation of the weir, combined with implementation of the predator suppression and removal measure described below is expected to reduce predation on lower Tuolumne River juvenile Chinook. The permanent weir will have other benefits, including acting as the new counting weir, which would be usable year round and not require removal when flows exceed 1,500 cfs. The 5 foot high weir will include a Denil-type fishway and counting window, allow species separation, and provide a salmon viewing opportunity for the public.

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[2] Computed as the percent of smolts passing the Waterford rotary screw trap (RST) (located at RM 29.8) divided by the percent of smolts passing the Grayson RST (located at RM 5.2). The fry survival index is computed similarly.

3.1.4 Potential Implementation Issues

The weir may be viewed to be in conflict with river recreation, but this is not necessarily the case. The weir would be fitted with a safe passage chute for non-motorized craft, and not require a portage. Motorized craft would be excluded but such use is low under present conditions.

3.1.5 Cost

Capital cost of $12 million; monitoring cost of $320,000/year.

3.2 Predator Suppression and Removal

3.2.1 Issue Description

See issue description in Fish Counting & Barrier Weir measure above.

3.2.2 Resource Goals

Substantially reduce the adverse impact of predation by non-native fish on fall-run Chinook salmon. A corollary benefit would likely be reduced predation on juvenile *O. mykiss*.

3.2.3 Measure

Non-native bass species would be targeted for active removal above and below the barrier weir (Figure 1). Removal efforts directly below the barrier weir would increase immediately before implementing an outmigration pulse flow (see outmigration pulse flow measure below).

Removal efforts may include derbies and bounties. Other efforts would include advocating for season extensions, higher bag limits, and smaller catchable size. These efforts, if successful, would likely reduce bass abundance, particularly above the barrier weir, and over time, improve fall-run Chinook juvenile survival. Based on 2012 population estimates (FishBio 2013a), to remove 10% of the current black bass population would require capture of about 660 fish. Monitoring would consist of black bass abundance surveys every three years.

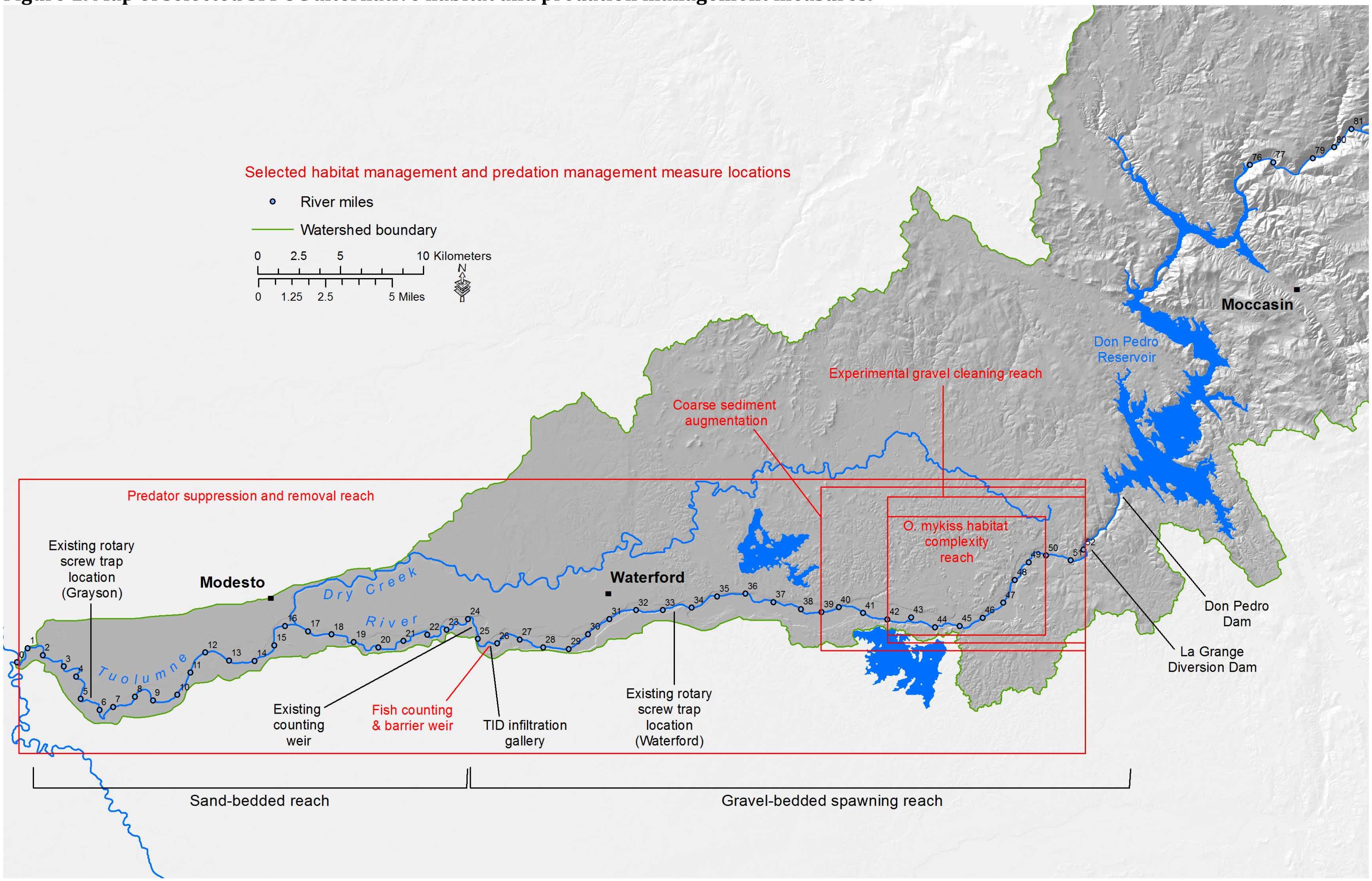
3.2.4 Potential Implementation Issues

Parties interested in striped bass and black bass fishing may object to changes in regulations and potential population reductions.

3.2.5 Cost

Capital cost of $150,000; annual cost of $115,000/year.

Figure 1. Map of selected SFPUC alternative habitat and predation management measures.



4 ENVIRONMENTAL FLOW MANAGEMENT

All proposed releases described below would be made from Don Pedro Reservoir; accretion is not assumed to contribute to meeting the proposed release requirements. All cited weighted useable area (WUA) percentages are derived from Stillwater Sciences (2013e).

4.1 Water year typing

The instream flow schedule described below uses the 5 water year types of the San Joaquin Valley Water Year Hydrologic Classification, as defined in the current Bay-Delta Water Quality Control Plan (Revised Water Right Decision 1641, SWRCB 2000).

4.2 Summer *O. mykiss* Rearing (June 1 – September 30)

4.2.1 Issue Description

Monitoring indicates that rainbow trout (*Oncorhynchus mykiss*, or *O. mykiss*) are generally found in habitats upstream of RM 42 with peak fry densities occurring in May, June, and possibly into July (Stillwater Sciences 2013f, 2013g). Summertime flow management for *O. mykiss* juveniles requires striking a balance between hydraulic and temperature habitat suitability. Higher flows in early summer (June through mid- July) tend to push weaker-swimming fry to downstream areas, increasing their vulnerability to predation and subsequent higher temperatures (Stillwater Sciences 2013f, 2013g); thus, lower flows are incorporated into this flow measure from June 1 to July 15, with slightly higher flows from July 16 to September 30.

4.2.2 Resource Goals

Increase and maintain the lower Tuolumne River *O. mykiss* population by balancing habitat capacity with summer water temperature management in the predominant *O. mykiss* reach of RM 42 to RM 50.

4.2.3 Measure[3]

From June 1 to July 15 (*O. mykiss* fry rearing)

- W, AN, BN water years - 150 cfs (78% WUA)
- D, C water years - 100 cfs (85% WUA).

From July 16 to September 30 (*O. mykiss* juvenile rearing)

- W, AN, BN water years - 250 cfs (96% WUA)
- D, C water years - 175 cfs (99% WUA).

[3] Turlock Irrigation District (TID) has installed an infiltration gallery (IG) at about RM 25.9. The proposed *O. mykiss* rearing flows are conditioned on TID using the IG to recapture a portion of the summertime flows: 50 cfs would be withdrawn from June 1 to July 15 during BN, AN and W water years, and up to 100 cfs would be withdrawn during all water years from July 16 to Sept 30. *O. mykiss* typically occupy the reach between RM 42 and 50 during the summertime period, thus the infiltration gallery would likely not impact core *O. mykiss* habitat.

4.3 Fall-Run Chinook Spawning (October 1 through December 15)

4.3.1 Issue Description

Improved spawning success is expected to increase the number of juveniles, which will promote increased outmigration numbers.

4.3.2 Resource Goals

- Improve spawning habitat for adult fall-run Chinook.

Mid-October through mid-December is the primary spawning period for fall-run Chinook. Combined with measures to improve quantity and quality of spawning gravels, this flow schedule improves overall spawning habitat. Improved spawning success will increase the number of juveniles, which will promote increased outmigration numbers.

4.3.3 Measure

In 2012, 95% of all redds were established between October 29 and November 29 (FishBio 2013b). Peak spawning occurred the week of November 12. In 2012/2013, 1.4% of redds were documented after December 15 and in 2014/2015, it was 5.8%. At a flow of 250 cfs, spawning habitat is 95% of maximum WUA and at 175 cfs it is 80% of maximum WUA.

From October 1 to December 15:

- W, AN, and BN water years – 250 cfs
- D and C water years – 175 cfs

4.4 Fall-Run Chinook Fry-Rearing (December 16 through February 28)

4.4.1 Issue Description

Many fall-run Chinook leave the Tuolumne River as fry, which are not well represented in returning adults (<5%) (Stillwater Sciences 2016). In recent years, parr and smolt sized emigrants represented the vast majority of returning Tuolumne-origin adults, implying a survival advantage for fish emigrating at larger sizes (Stillwater Sciences 2016). Retaining more fry in the upper river reaches of the lower Tuolumne River to grow to smolt size is expected to increase natural escapement, other factors being equal. Fry habitat is not a factor limiting Chinook populations on the lower Tuolumne River (Stillwater Sciences 2013b).

4.4.2 Resource Goals

- Increase suitable fry rearing habitat in the lower Tuolumne River.
- Increase the number of fry remaining in the upper reaches of the lower Tuolumne River.

4.4.3 Measure

Fry emergence peaks in late January through mid-February (Stillwater Sciences 2013b, 2013f). Fry habitat is greatest at 50 cfs, and decreases to 88% WUA at 100 cfs and at 150 cfs it is 75%, continuing to decrease at higher flows. Long term seining data since 2001 shows higher flows during the fry rearing period tend to push fry downriver, increasing vulnerability to predators and higher temperatures in May (Stillwater Sciences 2013b). In-channel fry habitat is not limiting in the gravel bedded reaches of lower Tuolumne River at these flows.

For the period December 16 to February 28:

- W, AN, and BN water years – 175 cfs
- D and C water years – 150 cfs

4.4.4 Potential Implementation Issues

Reducing flows for the benefit of the fry life stage has the potential to affect egg viability of late spawners. However, based on spawning surveys and depth of redd pots, the small change in stage is unlikely to affect localized flows or result in desiccation. Monitoring will be required to confirm spawning timing and minimize impact to egg viability

4.4.5 Cost

Redd surveys and egg viability monitoring at a cost of $50,000/year.

4.5 Fall-Run Chinook Juvenile Rearing (March 1 – April 15)

4.5.1 Issue Description

Increasing the population of rearing juvenile salmon in the upper reaches of the lower Tuolumne River will increase number of smolts and outmigration numbers.

4.5.2 Resource Goals

- Increase suitable juvenile rearing habitat in the gravel bedded reaches of the lower Tuolumne River.
- Increase the number of juveniles remaining in the upper reaches of the lower Tuolumne River.

4.5.3 Measure

Hydraulically suitable habitat for juvenile fall-run Chinook rearing is maximized at 150 cfs and exceeds 97% WUA at flows from 100 to 200 cfs. Juvenile habitat at these flows is not limiting. The majority of in-river Chinook have reached at least parr size by the end of March (Stillwater Sciences 2013b). Juveniles have substantially better swimming ability and river temperatures are also favorable during this time period (Stillwater Sciences 2013b, 2013f).

From March 1 through April 15:

- BN, AN, W water years - 200 cfs
- D and C water years - 150 cfs

4.5.4 Potential Implementation Issues

Greater numbers of *O. mykiss* may be spawning during this time frame. At 200 cfs, spawning habitat it is just under 80% of maximum WUA. At 400 cfs it is 98%; however, Chinook juvenile habitat is reduced to 80% of maximum at 400 cfs.

4.6 Fall-run Chinook Outmigration Baseflow (April 16 through May 31)

4.6.1 Issue Description

Increasing the population of rearing juvenile salmon in the upper reaches of the lower Tuolumne River will increase number of smolts and outmigration numbers.

4.6.2 Resource Goals

Maintain favorable conditions in the upper reaches of the lower Tuolumne River for juvenile salmon, including growth and reduced predation (in combination with predation management measures).

4.6.3 Measure

Hydraulically suitable habitat for juvenile fall-run Chinook rearing is maximized at 150 cfs and exceeds 97% WUA at flows from 100 to 200 cfs. At 250 cfs, it drops to 92%. Many fall-run Chinook are large parr by mid-April. Juvenile habitat at these flows is not limiting. Increasing flows above those provided through April 15 serve to keep river temperatures favorable. For example, at RM 29, a flow of 250 cfs maintains river temperatures below 24°C until maximum daily air temps exceed 85°F. At these flows, *O. mykiss* spawning habitat will increase from 78% to 87% of maximum WUA.

From April 16 to May 31:

- BN, AN, W water years – 250 cfs
- D and C water years – 175 cfs

4.7 Outmigration Pulse (April/May)

4.7.1 Issue Description

All other factors being equal, greater numbers of outmigrants should result in greater and more consistent numbers of returning adults.

4.7.2 Resource Goals

Increase outmigration success of fall-run Chinook salmon in the Tuolumne River.

4.7.3 Measure

With the onset of smoltification, juveniles will emigrate volitionally or due to one or more hypothesized cues. To encourage this movement and to increase survival, pulse flows would be provided which are carefully timed to coincide with the periods when large numbers of fish are of large parr or smolt size, circa >65 mm. Included in this measure is the close monitoring of spawning timing and river temperatures, supplemented by snorkel surveys or seining, to calibrate size-at-smoltification for the purpose of timing the spring pulse flows. RST monitoring would continue to inform estimated smolt survival in response to pulse flows. Timing pulse flows to when large numbers of juveniles are likely motivated to move, combined with spawning gravel improvements and predator control measures, is expected to substantially improve Tuolumne River outmigration survival. The pulse flow volumes are as follows:

- W and AN WYs - 150 TAF
- BN and D WYs - 100 TAF
- First year C WY - 35 TAF, subsequent sequential C WYs - 11 TAF

4.7.4 Potential Implementation Issues

Balancing with *O. mykiss* use of river habitats for spawning and rearing. Adding habitat complexity may reduce potential effects.

4.7.5 Cost

Monitoring costs are approximately $300,000 per year.

4.8 Gravel Mobilization

4.8.1 Issue Description

Spawning gravel studies (Stillwater Sciences 2013a and McBain & Trush 2004) report reductions in quality of coarse sediment due to reduced scale and frequency of high flows. Gasburg and Peaslee creeks are likely sources of fine sediment causing gravel infilling, which can impede hyporheic flows through redds and reduce egg viability. Under past and present flow regimes, gravel mobilization occurs less frequently than under pre-project conditions due to a reduced frequency of high flow events as a result of the Don Pedro Project's flood control purposes.

4.8.2 Resource Goals

- Improve the quality of spawning gravels via more frequent gravel mobilization and transport releases.

Increasing the frequency of gravel mobilization events is expected to enhance fall-run Chinook and *O. mykiss* productivity by periodically flushing accumulated fines from spawning gravels.

4.8.3 Measure

During Wet ("W") and/or Above Normal ("AN") water years when adequate spills are forecasted to be available, provide two to four days of releases between 6,000 and 7,000 cfs as measured at the La Grange USGS gage to mobilize spawning gravels. This measure will increase the frequency of gravel mobilization compared to existing spill operations.

Bedload transport measurements on the Trinity River in northern California and Rush Creek in eastern California show that coarse and fine bedload transport rates are steady for 2–3 days, then drop by 50% or more thereafter (McBain & Trush 2006). Minimum thresholds for significant bed mobility at Riffle 4B on the lower Tuolumne River are estimated to be between 5,400 and 6,880 cfs (McBain and Trush 2000, 2004).

4.8.4 Potential Implementation Issues

Flows in this range have been reported to affect crop production in certain areas below RM 10.

4.8.5 Cost

Operational and monitoring cost of $10,000 per year.

5 HATCHERY MANAGEMENT

5.1.1 Issue Description

Current management of production hatcheries in the Central Valley is incompatible with any effort to increase and maintain natural populations of fall-run Chinook salmon. Since the 1980's the state's hatcheries, in particular, have released juvenile fall-run Chinook further away from hatcheries ("off-site" releases) with increasing frequency to avoid mortality from predation, water diversions, and poor water quality (Huber and Carlson 2015). This practice has promoted unacceptably high rates of straying (California HSRG 2012), up to 8 times greater (Kormos et al. 2012 and Palmer–Zwahlen et al. 2013) than the estimated background rate of 5-10% (Cramer 1991) for on-site releases.

There is broad concern that off-site releases and resultant high rates of straying have led to introgression of hatchery and natural fall-run Chinook populations, reducing the fitness of both, masking natural fall-run Chinook population declines, and decreasing population productivity, abundance, and life history diversity. Fall-run Chinook salmon appear to be genetically similar in the Central Valley (Williamson and May 2005), which is at least partly due to off-site releases (Garza et al. 2008). Christie et al. (2014) found that early generation hatchery salmonid reproductive success can average around half of natural population reproductive success when spawning in the wild, which may reduce the fitness of an entire population. Widespread straying due to off-site releases probably limits opportunities for local adaptation to tributary conditions (Garza et al. 2008). While the suitability of functional juvenile migration corridors must be addressed, it is clear that the practice of off-site release must end (California HSRG 2012).

Stray hatchery fall-run Chinook now make up a large proportion of adults returning to the Tuolumne River, where no hatchery exists, and the proportions of hatchery fish have been increasing in recent years (Stillwater Sciences 2016). While current hatchery management has in some years resulted in short-term increases in adult returns, current policies are a threat to the long-term future viability of all natural fall-run Chinook populations and undermine the effectiveness of measures implemented to improve physical habitat conditions in Central Valley rivers and the Delta, including those described above for the lower Tuolumne River.

5.1.2 Resource Goals

- Reduce undesirable impacts of stray hatchery fall-run Chinook salmon on any remaining natural fall-run Chinook salmon in the lower Tuolumne River.

5.1.3 Measure

To reduce the undesirable impacts of existing production hatchery practices on fall-run Chinook salmon, the California Department of Fish and Wildlife, National Marine Fisheries Service, and United States Fish and Wildlife Service urgently need to:

- Implement the recommendations of the California Hatchery Scientific Review Group (California HSRG 2012), including the cessation of off-site releases.
- Explore methods for managing non-native predators and their preferred habitats in the Delta and tributaries to reduce hatchery and natural juvenile salmonid mortality.
- Implement 100% marking and tagging at all Central Valley hatcheries to allow for accurate accounting of returning hatchery vs. natural adult fall-run Chinook.
- Concurrent with 100% marking, explore the possible development of a mark-selective fall-run Chinook salmon fishery to support the re-establishment and protection of all natural Central Valley fall-run Chinook salmon populations.

5.1.4 Potential Implementation Issues

California HSRG (2012) identifies several issues that limit the ability of state-operated hatcheries, in particular, to meet hatchery program goals, and provides recommendations to overcome these issues. California HSRG (2012) also provides a number of implementation recommendations and describes areas of needed research.

6 ANTICIPATED OUTCOMES

A series of computer models relying on site-specific, empirical data collected over the last 20 years have been developed for the lower Tuolumne River. These models enable users to evaluate future conditions under different alternatives. The models were developed in consultation with resource agencies, including the State Water Resource Control Board, during the Federal Energy Regulatory Commission (FERC) relicensing of the Don Pedro Project (FERC No. 2299). Certain components of the SFPUC alternative were analyzed using these models to estimate relative comparisons to a base case representing current conditions on the lower Tuolumne River.

The base case is described in the Don Pedro Project Final License Application, Exhibit B, Appendix B. See individual model reports listed below for each model's base parameterization. The base case and model documentation are available online at www.donpedro-relicensing.com.

Models relevant to the SFPUC alternative include:

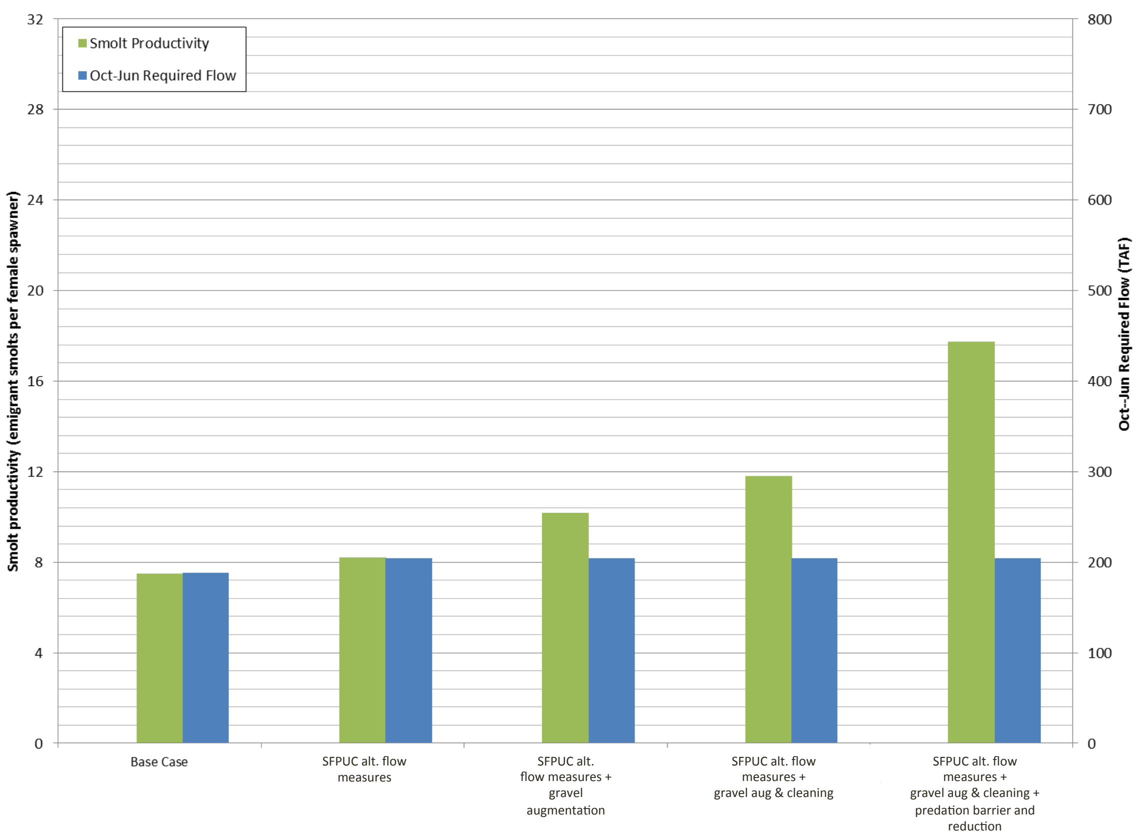
- W&AR-02: Project Operations/Water Balance Model (Steiner 2013);
- W&AR-03: Don Pedro Reservoir Temperature Model (HDR 2013);
- W&AR-16: Lower Tuolumne River Temperature Model (Stillwater Sciences 2013h); and,
- W&AR-06: Tuolumne River Chinook Salmon Population Model (Stillwater Sciences 2013b).

SFPUC alternative flow management measures were applied to the Project Operations, Reservoir Temperature, River Temperature, and in-river Chinook Salmon Population models. To simulate the implementation of selected SFPUC alternative habitat and predation management measures on fall-run Chinook salmon, parameter changes (modified from the base case) described below were also applied to the Chinook Salmon Population Model:

- Gravel Augmentation – Spawning gravel areas were increased in 4 locations to represent the results of Phase I, including 51,627 ft^2 at RM 51 (riffle A5/A6), 205,990 ft^2 at RM 47 (Basso Pool), 206,294 ft^2 RM 44 (Bobcat Flat) and 5,052 ft^2 at RM 41.7 (Turlock Lake State Recreation Area). For these added gravel areas, emergence to survival was increased from 32% to 50%, assuming only a modest increase in newly placed gravel quality.
- Gravel Cleaning – Cleaned patches at the end of the five-year experimental program were represented by a modest increase from 32% survival to emergence in the base case to 40% for the SFPUC alternative for all non-augmented gravels in the reach from RM 42-52.
- Predator Removal and Barrier Weir – These measures were modeled as a 15% decrease in predation rate upstream of the proposed RM 25.8 barrier weir, and a 5% decrease below.

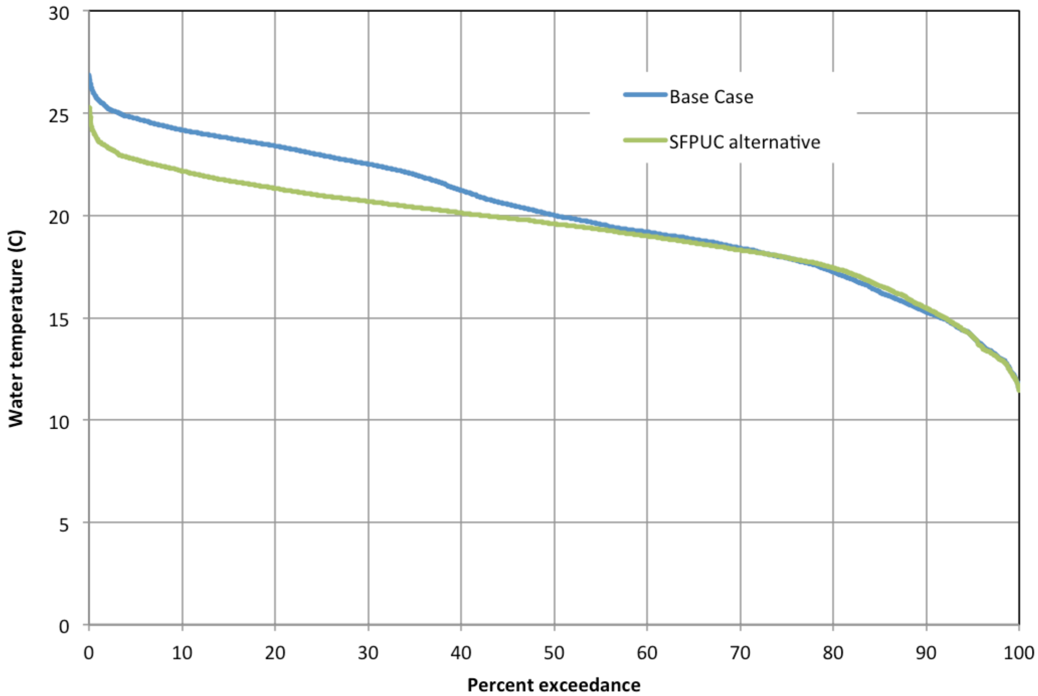
Results of the modeling exercise suggest that proposed flow management measures, combined with modeled representations of selected habitat and predation management measures may provide a significant relative increase in fall-run Chinook smolt productivity, represented by the number of emigrant smolts per female spawner, relative to the base case (Figure 2).

Figure 2. Tuolumne River Chinook Salmon Population Model (Stillwater Sciences 2013b) output illustrating average smolt productivity estimates and October-June release volumes under the base case and SFPUC alternative.



Output of the River Temperature Model indicates improved summer temperature conditions for *O. mykiss* relative to the base case (Figure 3). Recent work by Verhille et al (2016) found lower Tuolumne River *O. mykiss* juveniles within 95% of optimum metabolic performance between 18 and 24°C and optimum between 21 and 22°C. Effects of SFPUC alternative measures have not been evaluated at the population level for *O. mykiss*.

Figure 3. Lower Tuolumne River temperature model (Stillwater Sciences 2013h) output showing 7 day average daily maximum water temperature exceedence values at RM 39.5, June through September, for the base case and SFPUC alternative flow management measures.



7 WATER SUPPLY EFFECTS

The SFPUC performed water supply analysis for the Hetch Hetchy Regional Water System (RWS) to evaluate the effects of the proposed SFPUC alternative. The modeling methodology used for this analysis was as described in the memorandum titled "*SFPUC Analysis of Proposed Changes to Tuolumne River Flow Criteria*" dated March 14, 2017, attached. Analysis was performed for three levels of RWS system-wide demand: 265 million gallons per day (MGD), 223 MGD, and 175 MGD. Within each level of demand, two scenarios were evaluated: the current conditions or "base case", and the flow management measures in the SFPUC alternative. No other changes were made to system configuration within each level of demand, which allows the results of simulations for like demands to be compared to evaluate the effects of the SFPUC alternative.

Water supply rationing is used as an indicator of negative impact to the SFPUC water supply system. Through application of the SFPUC water supply planning methodology, decreased water supply in system storage in dry years will lead to increased occurrence and magnitude of rationing. Tables 7-1, 7-2 and 7-3 present system-wide rationing in the base case and the SFPUC alternative for system demands of 265 MGD, 223 MGD and 175 MGD, respectively. As shown in Table 7-1, system-wide rationing is required for the base case in 10 out of 91 years in the historical record, and the largest magnitude of rationing required in this sequence is 20%. In the SFPUC alternative, system-wide rationing is required in 15 years out of 91, and the largest magnitude of rationing is 25%. As shown in Table 7-2, rationing is not required in the base case at a system demand of 223 MGD, but 10% rationing is required in 3 years out of 91 in the SFPUC alternative. Rationing is not required for the base case or SFPUC alternative at 175 MGD.

Table 7-1: Comparison of SFPUC RWS Annual Water Supply Delivery Capability for Current Conditions (Base Case) and SFPUC Alternative at an Annual Demand of 265 MGD. Yellow highlights indicate that water provided to the RWS includes supply from of the Westside Basin conjunctive use groundwater project. Red highlights indicate that water supply rationing is implemented. The years in which rationing occurs also include use of the Westside Basin groundwater project.

SFPUC Fiscal Year (July-June)	Base Case at 265 MGD Total Deliveries			SFPUC Alternative Total Deliveries		
	TAF/yr	MGD	Rationing (% of Total)	TAF/yr	MGD	Rationing (% of Total)
FY20-21	297	265	0%	297	265	0%
FY21-22	297	265	0%	297	265	0%
FY22-23	297	265	0%	297	265	0%
FY23-24	297	265	0%	297	265	0%
FY24-25	297	265	0%	253	226	15%
FY25-26	297	265	0%	297	265	0%
FY26-27	297	265	0%	297	265	0%
FY27-28	297	265	0%	297	265	0%
FY28-29	297	265	0%	297	265	0%
FY29-30	297	265	0%	297	265	0%
FY30-31	297	265	0%	297	265	0%
FY31-32	267	238	10%	253	226	15%
FY32-33	297	265	0%	297	265	0%
FY33-34	297	265	0%	297	265	0%
FY34-35	297	265	0%	253	226	15%
FY35-36	297	265	0%	297	265	0%
FY36-37	297	265	0%	297	265	0%
FY37-38	297	265	0%	297	265	0%
FY38-39	297	265	0%	297	265	0%
FY39-40	297	265	0%	297	265	0%
FY40-41	297	265	0%	297	265	0%
FY41-42	297	265	0%	297	265	0%
FY42-43	297	265	0%	297	265	0%
FY43-44	297	265	0%	297	265	0%
FY44-45	297	265	0%	297	265	0%
FY45-46	297	265	0%	297	265	0%
FY46-47	297	265	0%	297	265	0%
FY47-48	297	265	0%	297	265	0%
FY48-49	297	265	0%	297	265	0%
FY49-50	297	265	0%	297	265	0%
FY50-51	297	265	0%	297	265	0%
FY51-52	297	265	0%	297	265	0%
FY52-53	297	265	0%	297	265	0%
FY53-54	297	265	0%	297	265	0%
FY54-55	297	265	0%	297	265	0%
FY55-56	297	265	0%	297	265	0%
FY56-57	297	265	0%	297	265	0%
FY57-58	297	265	0%	297	265	0%
FY58-59	297	265	0%	297	265	0%
FY59-60	297	265	0%	297	265	0%
FY60-61	297	265	0%	253	226	15%
FY61-62	267	238	10%	253	226	15%
FY62-63	297	265	0%	297	265	0%
FY63-64	297	265	0%	297	265	0%
FY64-65	297	265	0%	297	265	0%
FY65-66	297	265	0%	297	265	0%
FY66-67	297	265	0%	297	265	0%
FY67-68	297	265	0%	297	265	0%
FY68-69	297	265	0%	297	265	0%
FY69-70	297	265	0%	297	265	0%
FY70-71	297	265	0%	297	265	0%
FY71-72	297	265	0%	297	265	0%
FY72-73	297	265	0%	297	265	0%
FY73-74	297	265	0%	297	265	0%
FY74-75	297	265	0%	297	265	0%
FY75-76	297	265	0%	297	265	0%
FY76-77	267	238	10%	253	226	15%
FY77-78	238	212	20%	223	199	25%
FY78-79	297	265	0%	297	265	0%
FY79-80	297	265	0%	297	265	0%
FY80-81	297	265	0%	297	265	0%
FY81-82	297	265	0%	297	265	0%
FY82-83	297	265	0%	297	265	0%
FY83-84	297	265	0%	297	265	0%
FY84-85	297	265	0%	297	265	0%
FY85-86	297	265	0%	297	265	0%
FY86-87	297	265	0%	297	265	0%
FY87-88	297	265	0%	253	226	15%
FY88-89	267	238	10%	253	226	15%
FY89-90	267	238	10%	253	226	15%
FY90-91	238	212	20%	223	199	25%
FY91-92	238	212	20%	223	199	25%
FY92-93	238	212	20%	223	199	25%
FY93-94	297	265	0%	297	265	0%
FY94-95	297	265	0%	253	226	15%
FY95-96	297	265	0%	297	265	0%
FY96-97	297	265	0%	297	265	0%
FY97-98	297	265	0%	297	265	0%
FY98-99	297	265	0%	297	265	0%
FY99-00	297	265	0%	297	265	0%
FY00-01	297	265	0%	297	265	0%
FY01-02	297	265	0%	297	265	0%
FY02-03	297	265	0%	297	265	0%
FY03-04	297	265	0%	297	265	0%
FY04-05	297	265	0%	297	265	0%
FY05-06	297	265	0%	297	265	0%
FY06-07	297	265	0%	297	265	0%
FY07-08	267	238	10%	253	226	15%
FY08-09	297	265	0%	297	265	0%
FY09-10	297	265	0%	297	265	0%
FY10-11	297	265	0%	297	265	0%

Table 7-2: Comparison of SFPUC RWS Annual Water Supply Delivery Capability for Current Conditions (Base Case) and SFPUC Alternative at an Annual Demand of 223 MGD. Yellow highlights indicate that water provided to the RWS includes supply from of the Westside Basin conjunctive use groundwater project. Red highlights indicate that water supply rationing is implemented. The years in which rationing occurs also include use of the Westside Basin groundwater project.

SFPUC Fiscal Year	Base Case at 223 MGD Total Deliveries			SFPUC Alternative Total Deliveries		
	TAF/yr	MGD	Rationing (% of Total)	TAF/yr	MGD	Rationing (% of Total)
FY20-21	250	223	0%	250	223	0%
FY21-22	250	223	0%	250	223	0%
FY22-23	250	223	0%	250	223	0%
FY23-24	250	223	0%	250	223	0%
FY24-25	250	223	0%	250	223	0%
FY25-26	250	223	0%	250	223	0%
FY26-27	250	223	0%	250	223	0%
FY27-28	250	223	0%	250	223	0%
FY28-29	250	223	0%	250	223	0%
FY29-30	250	223	0%	250	223	0%
FY30-31	250	223	0%	250	223	0%
FY31-32	250	223	0%	250	223	0%
FY32-33	250	223	0%	250	223	0%
FY33-34	250	223	0%	250	223	0%
FY34-35	250	223	0%	250	223	0%
FY35-36	250	223	0%	250	223	0%
FY36-37	250	223	0%	250	223	0%
FY37-38	250	223	0%	250	223	0%
FY38-39	250	223	0%	250	223	0%
FY39-40	250	223	0%	250	223	0%
FY40-41	250	223	0%	250	223	0%
FY41-42	250	223	0%	250	223	0%
FY42-43	250	223	0%	250	223	0%
FY43-44	250	223	0%	250	223	0%
FY44-45	250	223	0%	250	223	0%
FY45-46	250	223	0%	250	223	0%
FY46-47	250	223	0%	250	223	0%
FY47-48	250	223	0%	250	223	0%
FY48-49	250	223	0%	250	223	0%
FY49-50	250	223	0%	250	223	0%
FY50-51	250	223	0%	250	223	0%
FY51-52	250	223	0%	250	223	0%
FY52-53	250	223	0%	250	223	0%
FY53-54	250	223	0%	250	223	0%
FY54-55	250	223	0%	250	223	0%
FY55-56	250	223	0%	250	223	0%
FY56-57	250	223	0%	250	223	0%
FY57-58	250	223	0%	250	223	0%
FY58-59	250	223	0%	250	223	0%
FY59-60	250	223	0%	250	223	0%
FY60-61	250	223	0%	250	223	0%
FY61-62	250	223	0%	250	223	0%
FY62-63	250	223	0%	250	223	0%
FY63-64	250	223	0%	250	223	0%
FY64-65	250	223	0%	250	223	0%
FY65-66	250	223	0%	250	223	0%
FY66-67	250	223	0%	250	223	0%
FY67-68	250	223	0%	250	223	0%
FY68-69	250	223	0%	250	223	0%
FY69-70	250	223	0%	250	223	0%
FY70-71	250	223	0%	250	223	0%
FY71-72	250	223	0%	250	223	0%
FY72-73	250	223	0%	250	223	0%
FY73-74	250	223	0%	250	223	0%
FY74-75	250	223	0%	250	223	0%
FY75-76	250	223	0%	250	223	0%
FY76-77	250	223	0%	250	223	0%
FY77-78	250	223	0%	225	201	10%
FY78-79	250	223	0%	250	223	0%
FY79-80	250	223	0%	250	223	0%
FY80-81	250	223	0%	250	223	0%
FY81-82	250	223	0%	250	223	0%
FY82-83	250	223	0%	250	223	0%
FY83-84	250	223	0%	250	223	0%
FY84-85	250	223	0%	250	223	0%
FY85-86	250	223	0%	250	223	0%
FY86-87	250	223	0%	250	223	0%
FY87-88	250	223	0%	250	223	0%
FY88-89	250	223	0%	250	223	0%
FY89-90	250	223	0%	250	223	0%
FY90-91	250	223	0%	225	201	10%
FY91-92	250	223	0%	250	223	0%
FY92-93	250	223	0%	225	201	10%
FY93-94	250	223	0%	250	223	0%
FY94-95	250	223	0%	250	223	0%
FY95-96	250	223	0%	250	223	0%
FY96-97	250	223	0%	250	223	0%
FY97-98	250	223	0%	250	223	0%
FY98-99	250	223	0%	250	223	0%
FY99-00	250	223	0%	250	223	0%
FY00-01	250	223	0%	250	223	0%
FY01-02	250	223	0%	250	223	0%
FY02-03	250	223	0%	250	223	0%
FY03-04	250	223	0%	250	223	0%
FY04-05	250	223	0%	250	223	0%
FY05-06	250	223	0%	250	223	0%
FY06-07	250	223	0%	250	223	0%
FY07-08	250	223	0%	250	223	0%
FY08-09	250	223	0%	250	223	0%
FY09-10	250	223	0%	250	223	0%
FY10-11	250	223	0%	250	223	0%

Table 7-3: Comparison of SFPUC RWS Annual Water Supply Delivery Capability for Current Conditions (Base Case) and SFPUC Alternative at an Annual Demand of 175 MGD. Yellow highlights indicate that water provided to the RWS includes supply from of the Westside Basin conjunctive use groundwater project. Red highlights indicate that water supply rationing is implemented. The years in which rationing occurs also include use of the Westside Basin groundwater project.

SFPUC Fiscal Year	Base Case at 175 MGD Total Deliveries			SFPUC Alternative Total Deliveries		
	TAF/yr	MGD	Rationing (% of Total)	TAF/yr	MGD	Rationing (% of Total)
FY20-21	196	175	0%	196	175	0%
FY21-22	196	175	0%	196	175	0%
FY22-23	196	175	0%	196	175	0%
FY23-24	196	175	0%	196	175	0%
FY24-25	196	175	0%	196	175	0%
FY25-26	196	175	0%	196	175	0%
FY26-27	196	175	0%	196	175	0%
FY27-28	196	175	0%	196	175	0%
FY28-29	196	175	0%	196	175	0%
FY29-30	196	175	0%	196	175	0%
FY30-31	196	175	0%	196	175	0%
FY31-32	196	175	0%	196	175	0%
FY32-33	196	175	0%	196	175	0%
FY33-34	196	175	0%	196	175	0%
FY34-35	196	175	0%	196	175	0%
FY35-36	196	175	0%	196	175	0%
FY36-37	196	175	0%	196	175	0%
FY37-38	196	175	0%	196	175	0%
FY38-39	196	175	0%	196	175	0%
FY39-40	196	175	0%	196	175	0%
FY40-41	196	175	0%	196	175	0%
FY41-42	196	175	0%	196	175	0%
FY42-43	196	175	0%	196	175	0%
FY43-44	196	175	0%	196	175	0%
FY44-45	196	175	0%	196	175	0%
FY45-46	196	175	0%	196	175	0%
FY46-47	196	175	0%	196	175	0%
FY47-48	196	175	0%	196	175	0%
FY48-49	196	175	0%	196	175	0%
FY49-50	196	175	0%	196	175	0%
FY50-51	196	175	0%	196	175	0%
FY51-52	196	175	0%	196	175	0%
FY52-53	196	175	0%	196	175	0%
FY53-54	196	175	0%	196	175	0%
FY54-55	196	175	0%	196	175	0%
FY55-56	196	175	0%	196	175	0%
FY56-57	196	175	0%	196	175	0%
FY57-58	196	175	0%	196	175	0%
FY58-59	196	175	0%	196	175	0%
FY59-60	196	175	0%	196	175	0%
FY60-61	196	175	0%	196	175	0%
FY61-62	196	175	0%	196	175	0%
FY62-63	196	175	0%	196	175	0%
FY63-64	196	175	0%	196	175	0%
FY64-65	196	175	0%	196	175	0%
FY65-66	196	175	0%	196	175	0%
FY66-67	196	175	0%	196	175	0%
FY67-68	196	175	0%	196	175	0%
FY68-69	196	175	0%	196	175	0%
FY69-70	196	175	0%	196	175	0%
FY70-71	196	175	0%	196	175	0%
FY71-72	196	175	0%	196	175	0%
FY72-73	196	175	0%	196	175	0%
FY73-74	196	175	0%	196	175	0%
FY74-75	196	175	0%	196	175	0%
FY75-76	196	175	0%	196	175	0%
FY76-77	196	175	0%	196	175	0%
FY77-78	196	175	0%	196	175	0%
FY78-79	196	175	0%	196	175	0%
FY79-80	196	175	0%	196	175	0%
FY80-81	196	175	0%	196	175	0%
FY81-82	196	175	0%	196	175	0%
FY82-83	196	175	0%	196	175	0%
FY83-84	196	175	0%	196	175	0%
FY84-85	196	175	0%	196	175	0%
FY85-86	196	175	0%	196	175	0%
FY86-87	196	175	0%	196	175	0%
FY87-88	196	175	0%	196	175	0%
FY88-89	196	175	0%	196	175	0%
FY89-90	196	175	0%	196	175	0%
FY90-91	196	175	0%	196	175	0%
FY91-92	196	175	0%	196	175	0%
FY92-93	196	175	0%	196	175	0%
FY93-94	196	175	0%	196	175	0%
FY94-95	196	175	0%	196	175	0%
FY95-96	196	175	0%	196	175	0%
FY96-97	196	175	0%	196	175	0%
FY97-98	196	175	0%	196	175	0%
FY98-99	196	175	0%	196	175	0%
FY99-00	196	175	0%	196	175	0%
FY00-01	196	175	0%	196	175	0%
FY01-02	196	175	0%	196	175	0%
FY02-03	196	175	0%	196	175	0%
FY03-04	196	175	0%	196	175	0%
FY04-05	196	175	0%	196	175	0%
FY05-06	196	175	0%	196	175	0%
FY06-07	196	175	0%	196	175	0%
FY07-08	196	175	0%	196	175	0%
FY08-09	196	175	0%	196	175	0%
FY09-10	196	175	0%	196	175	0%
FY10-11	196	175	0%	196	175	0%

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