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October 2, 2019

Ms. Jeanne Jackson
Friends of Gualala River
P.O. Box 1543
Gualala, CA 95445

Subject: Review of O'Connor Environmental, Inc. (OEI) Reports for the Little North Fork Gualala River, Timber Harvest Plan (THP) 1-18-095 MEN

Dear Ms. Jackson:

I have been retained by Friends of Gualala River (FoGR) to review and evaluate three reports prepared by OEI on behalf of Gualala Redwood Timber, LLC in support of THP compliance. The titles of these reports include:

1. Floodplain Study for the Little North Fork Gualala River (March 21, 2019);
2. Floodplain Inundation Duration Study for the Little North Fork Gualala River (July 10, 2019); and
3. Channel Migration Zone Evaluation for the Little Timber Harvest Plan, Little North Fork Gualala River, Mendocino County (August 2, 2019).

I am a Professional Geologist and Certified Hydrogeologist with over thirty years of technical and consulting experience in the fields of hydrology and hydrogeology. I have been providing professional hydrology and geomorphology services throughout California since 1989 and routinely manage and lead projects in the areas of surface- and groundwater hydrology, ecosystem restoration, water resources management, and geomorphology.

Objectives of the OEI studies included: estimating the extent of the 20-year floodplain; estimating the duration of floodplain inundation; and delineating the channel migration zone. Based on my review, it is my opinion that many of the findings presented in these reports are inaccurate due to the significant underestimation of the flow magnitude for the 20-year recurrence interval event on the Little North Fork Gualala River. The underestimation of this value will result in a reduction in the estimated extent and duration of floodplain inundation. The rationale for this opinion is presented below through the presentation of comments to OEI's reports as well as results of my own data and flood frequency analyses.

1. Comments on Floodplain Study Report (March 21, 2019)

Similarity of Flow Magnitudes between Navarro and Gualala River

OEI states that it is not possible to simulate flows within the Little North Fork watershed with a reasonable degree of certainty. OEI also determined that the area-normalized discharges[1] from the Navarro River are representative of area-normalized discharges on the Little North Fork of the Gualala River because they share similar climate, land cover and geomorphology. To substantiate this determination, they illustrate how the area-normalized runoff rates for the Navarro River (205 cfs/mi^2), SF Gualala River above Wheatfield Fork (212 cfs/mi^2), Wheatfield Fork (195 cfs/mi^2) and Francini Creek (230 cfs/mi^2) are similar for the December 31, 2005 peak flow event. They do not include the area-normalized runoff rate for the North Fork Gualala River gauge, stating it was not operated from 2000-2006. However, the USGS report a peak runoff rate of 13,600 cfs at the North Fork Gualala River gauge for the December 31, 2005 event, which equates to an area-normalized discharge of 288 cfs/mi^2 - a rate 41% higher than the Navarro River.

Comparison of historic annual peak flow data between the Navarro River and other Gualala River gauges contradicts the determination that area-normalized runoff rates for the Navarro River are representative of the Gualala River. Figure 1 plots area-normalized runoff rates for the Navarro (USGS 11468000), South Fork Gualala near Annapolis (USGS 11467500), South Fork Gualala River near the Sea Ranch (USGS 11467510) and North Fork Gualala River (USGS 11467553) gauges. These data indicate that unit runoff rates for the Gualala River gauges are consistently greater than those computed for the Navarro River gauge. This indicates that using area-normalized runoff rates from the Navarro River will significantly underestimate flow rates in the Gualala River watershed.

Flood frequency analysis of South Fork Gualala River.

OEI states that there are no stream flow gauges in the Gualala River watershed with records of sufficient length to perform flood frequency analyses. This conclusion is unsubstantiated. Pursuant to protocols in the USGS's Bulletin 17B flood frequency analysis method used by OEI (Interagency Advisory Committee on Water, 1982[2]), the suggested minimum length of annual peak flow records is 10 years. Bulletin 17C (England et al., 2019[3]), the 2019 update to the Bulletin 17B, also states a minimum of 10 years of data are required to complete a flood frequency analysis.

In order to demonstrate and quantify the difference in peak flow rates from the Gualala and Navarro River watersheds during storms of the same recurrence interval, Figure 2 was prepared, which plots flood frequency curves for area-normalized discharge (cfs/mi^2)

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[1] The area-normalized discharge is computed by dividing the peak flow rate reported at a gauge and dividing by the drainage area above (upstream) of the gauge.

[2]Interagency Committee on Water Data, 1982, Guidelines for determining flood flow frequency, Bulletin 17B: Inter-agency Committee on Water Data, Hydrology Subcommittee, Technical Report, 189p.

[3] England, J.F., Jr., Cohn, T.A., Faber, B.A., Stedinger, J.R., Thomas, W.O., Jr., Veilleux, A.G., Kiang, J.E., and Mason, R.R., Jr., 2018, Guidelines for determining flood flow frequency—Bulletin 17C (ver. 1.1, May 2019): U.S. Geological Survey Techniques and Methods, book 4, chap. B5, 148 p., https://doi.org/10.3133/tm4B5.

between the rivers. Because of time and budget constraints, the flood frequency analyses were completed using the annual-maximum series method as described by Dunne and Leopold (1978)[4]. The flood frequency curve for the Navarro River was prepared using 69 years of record (1951-2019) compares very closely to the curve presented in OEI's March 2019 Report. The flood frequency analysis completed for the South Fork Gualala River used a combination of 33 years of annual peak flow records from the South Fork Gualala near Annapolis (USGS 11467500) and South Fork Gualala River near the Sea Ranch (USGS 11467510) gauges. The data from these gauges represent a broken record from two different time intervals – 21 years (1951-1971) from the "near Annapolis" gauge and 12 years (2008-2019) from the "near the Sea Ranch" gauge. Although these South Fork Gualala River gauges are not in the exact same location (see Figure 3), the USGS reports they each measure runoff from a 161 square mile drainage area. There are no large intervening tributary drainages introduced between their locations, therefore no mechanism to significantly alter peak flow rates between them. Combining these records in lieu of completing flood frequency analysis on them individually, increases the data population and reduces the error in the peak flow estimates.

The flood frequency curves presented in Figure 2 indicate that for any given recurrence interval, area-normalized peak flows on the South Fork Gualala River are significantly larger than those computed for the Navarro River. Table 1 presents selected area-normalized discharge rates for peak flows with recurrence intervals from 2- to 100-years[5]. As part of their hydraulic model development for the project, OEI estimated a 20-year discharge of 1,263 cfs for the 7.3 square mile Little North Fork watershed using the 173 cfs/mi^2 area-normalized discharge rate calculated for the Navarro River. However, this rate is significantly lower than the 20-year recurrence interval discharge rate of 313 cfs/mi^2 estimated for the South Fork Gualala River. Assuming the South Fork Gualala River area-normalized discharge rates are a better estimate of flow conditions on the Little North Fork, the peak flow used in OEI's floodplain inundation modeling is representative of a discharge having a recurrence interval falling somewhere between 2.5- and 5-years, not a 20-year event.

Elsewhere in their March 2019 report (page 366.10), OEI states that the area-normalized discharge (207 cfs/mi^2) for the February 19, 2019 storm event on the South Fork Gualala River (33,400 cfs) is representative of a 35-year event. However, comparing this area-normalized discharge to the South Fork Gualala River flood frequency estimates presented in Table 1, suggests the February 2019 peak flow event has a recurrence interval of only 5 years. This also calls into question OEI's conclusion that the backwater elevation of the February 26, 2019 event at the USGS's North Fork gauge is a "conservative estimate" of a 20-year event, when this event is only a 5-year event. Thus, in addition to underestimating the 20-year discharge used in their floodplain study, the downstream backwater boundary condition used by OEI in their hydraulic modeling is representative of a 5-year event, not a 20- to 35-year event. Therefore, the findings and

[4] Dunne, T. and Leopold, L.B., 1978, Water in Environmental Planning. W.H. Freeman and Company, New York, 818p.

[5] The 50- and 100-year recurrence interval area-normalized discharges for the South Fork Gualala River were estimated by extrapolating the curve presented in Figure 2.

conclusions presented in the March 2019 report should be considered inaccurate as they do not represent a peak flow event on the Little North Fork with a 20-year recurrence interval.

Table 1: Area-normalized discharge rates for selected recurrence intervals

Recurrence Interval	SF Gualala R. cfs/mi^2	Navarro R. cfs/mi^2	Percentage SF Gualala R. to Navarro R.
100	434	265	164%
50	382	228	168%
20	313	179*	175%
10	261	142	183%
5	209	105	198%
2.5	156	69	228%
2	139	57	246%

***Note: OEI estimated the area-normalized discharge of 173 cfs/mi2 for 20-year recurrence on the Navarro River. The small difference in this value to that presented here is due to different flood frequency analysis methods.**

2. Comments on Floodplain Inundation Duration Study Report (July 10, 2019)

Because the OEI floodplain inundation duration study uses the same peak flow and downstream backwater boundary conditions as the model described in the March 2019 report, this study underestimates the peak flow and water level boundary conditions. As a result, their unsteady state modeling underestimates the area and duration of inundation experienced during peak flow event having a 20-year recurrence interval. In addition to the comments provided above on the March 2019 report, this conclusion is supported by comparing modeled versus measured water levels at the USGS North Fork Gualala River gauge. Figure 4 of OEI's July 2019 report presents simulated stage for the North Fork gauge in addition to simulated inflows/outflows on the Little North Fork and modeled precipitation intensity. Figure 4 of this letter report presents OEI's Figure 4 and superimposes the measured water levels (gage height) for the North Fork gauge as reported by the USGS over the model period. Comparison of the modeled "stage" and measured "gage height" indicates the OEI model underestimates the peak water level at the USGS gauge by 5-feet (simulated maximum level of 14 feet vs. measured maximum level of 19 feet). Conversely, the model estimates the baseflow water levels prior to the storm at 9 feet, whereas the measured water levels were less than 3 feet. This comparison of simulated versus measured water levels indicate the model is underestimating inundation levels and durations at the lower end of the modeled project reach (there is no water level monitoring data available for comparison to simulation results in upstream portions of the model). Given the model inflow boundary condition is significantly less than the 20-year recurrence event, it is not surprising the model significantly underestimates water levels as presented in Figure 4. Therefore, the findings and conclusions presented in the July 2019 report should be considered inaccurate as they do not represent a peak flow event with a 20-year recurrence interval.

3. <u>Comments on Channel Migration Zone Evaluation Report (August 2, 2019)</u>

Per our current agreement, I was not able to redo or verify the Office Review analyses to verify findings. Nor did I have the opportunity to complete a Field Evaluation to verify OEI's findings. Based on my review of the Channel Migration Report, I have the following comments.

- OEI's discussion of overbank flow was somewhat qualitative. It would be helpful to know how a continuum of flow magnitudes (e.g., peak flows with recurrence intervals ranging from 2- to 100-years) interact with the floodplain and secondary channels. Channel avulsion may be a long-term process and dependent on flow magnitude. Channel avulsion may behave more as an episodic process triggered by flows with recurrence intervals greater than the 20-year recurrence. The absence of observable channel migration over a 60 year period does not preclude historic or future channel migration.

- The report seems to focus on evidence on the formation or trajectory towards channel avulsion. There didn't appear to be discussion about the possibility that secondary or floodplain channel features were historically the active channel that have been abandoned and are filling in. The presence of such features would be evidence for and delineators of the channel migration zone.

Please feel free to contact me with any questions regarding the material and conclusions contained in this letter.

Sincerely,

Greg Kamman, PG, CHG
Principal Hydrologist

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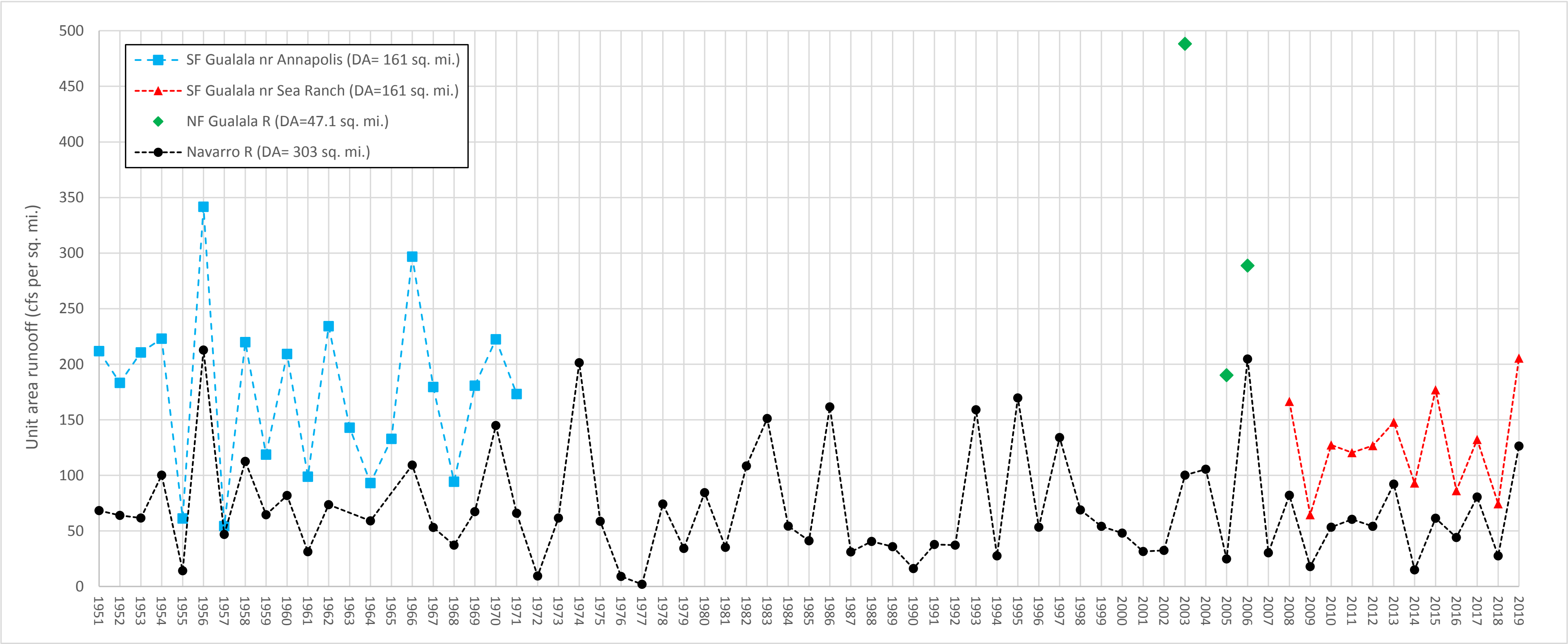


Figure 1: Area-normalized runoff rates for annual maximum peak flow.

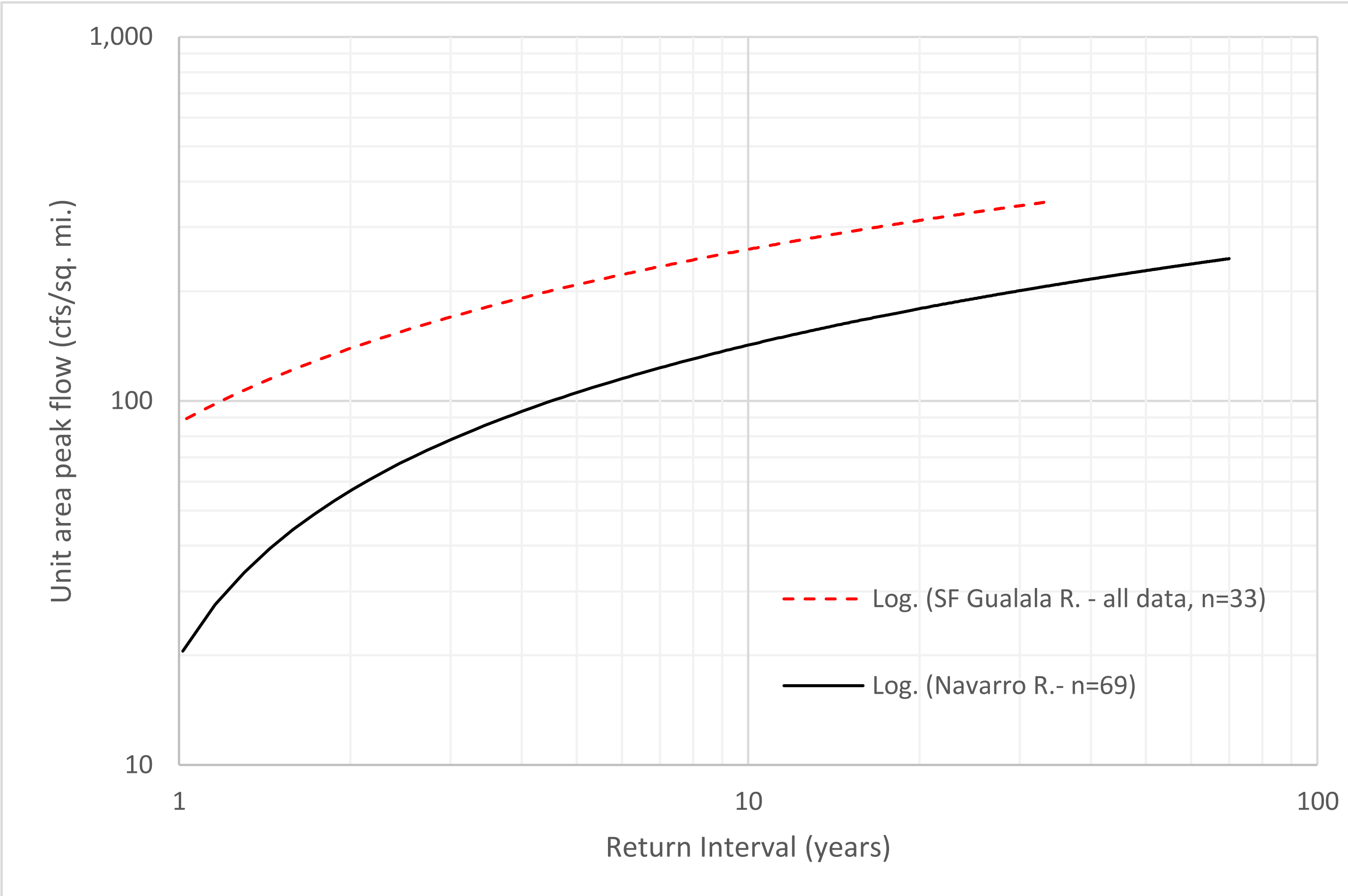


Figure 2: Flood frequency curves of area-normalized runoff rates for the Navarro near Navarro (USGS 1146800) and combined data for the South Fork Gualala River near Annapolis (USGS11467500) and South Fork Gualala River near the Sea Ranch (USGS 11467510).

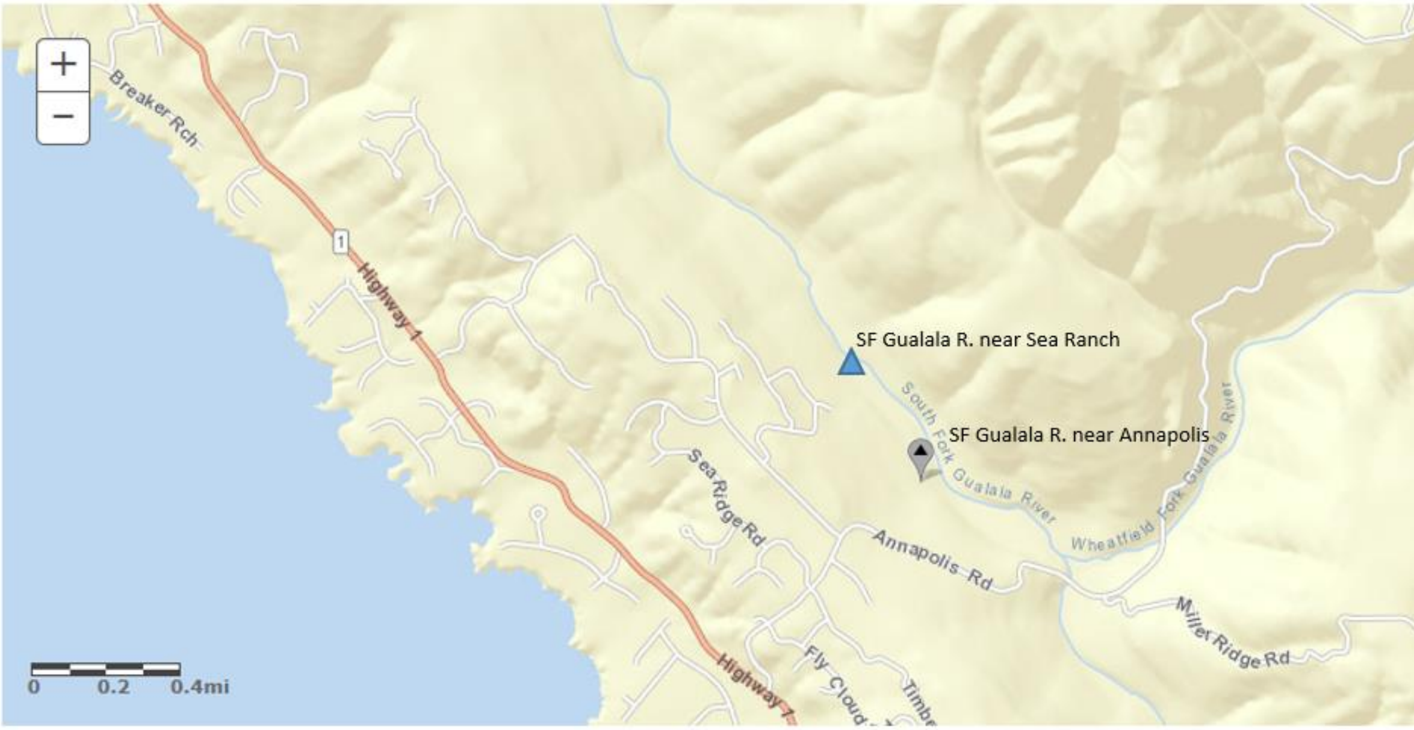
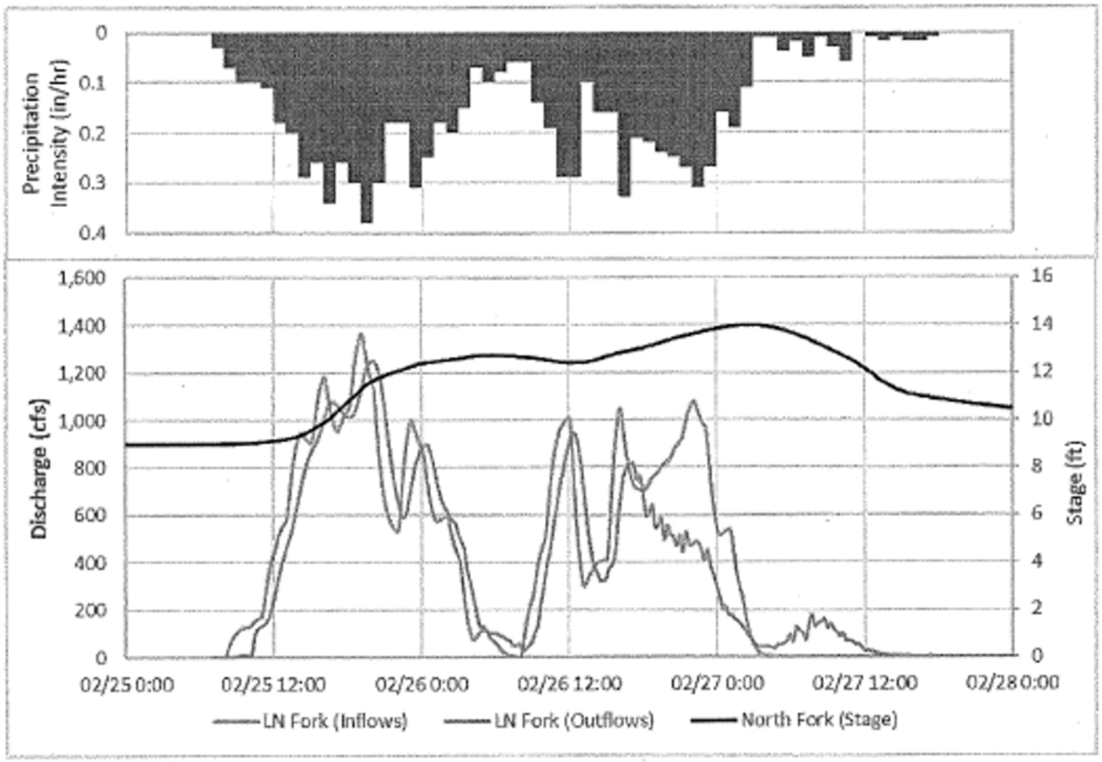


Figure 3: Location of the USGS gauges South Fork Gualala River near Annapolis (USGS11467500) and South Fork Gualala River near the Sea Ranch (USGS 11467510).



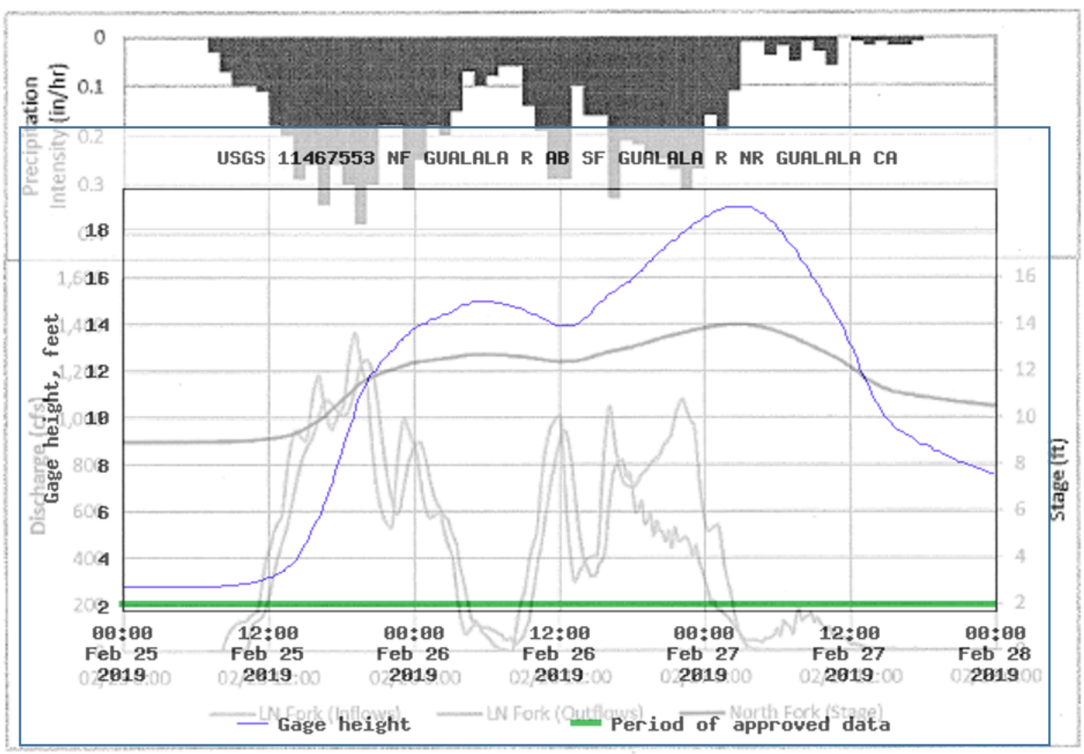


Figure 4: Modeled vs. measured water levels at North Fork Gualala River gauge (USGS 11467553). Upper graph is Figure 4 from OEI's July 2019 report. Lower graph includes plot of measured water levels by USGS at North Fork Gauge superimposed on OEI's Figure 4. Note, for the purpose of this figure, the terms "stage" and "gage height" are synonymous.