AGENCY:	**City Council**
MEETING DATE:	**June 15, 2019**
DEPARTMENT:	**Public Works**
PRESENTED BY:	**Diane O'Connor**

AGENDA ITEM SUMMARY

TITLE:
Present City Water Supply Model, Including Development, Functionality, and Model Results

ISSUE:
This presentation is intended to help educate the City Council and the public about Fort Bragg's Water Supply Model. It includes some model history, the source and manipulation of model data, including source supply and water demand. It also includes some modeling results.

ANALYSIS:
The following text provides a brief explanation of each of the primary slides in the presentation.

SLIDE 1– Model History and Background
The water model was first built in early 2014, by Bonnie Lampley of Lawrence and Associates, located in Shasta Lake, CA. The water model uses data from 1973 to 2015 to analyze our ability to provide water to the citizens of Fort Bragg. This includes the drought of 1977, as well as the more recent drought of 2015. Numerous iterations occurred with former Public Works employees Terry Jo Barber, Sergio Fuentes and myself. A Special City Council Water Workshop was held on January 5, 2016, where Sergio Fuentes gave a brief demo of the Water Model as it was at that time. I worked with Bonnie Lampley from August 2017 to September of 2018, when I took over the functionality myself. I am much more confident that we are as close to the "real world" as we can get, with the information we have.

SLIDE 2 – Model Data
Daily precipitation data from the Fort Bragg Station 5N was obtained from usclimatedata.com, and daily evaporation volumes were calculated using evapotranspiration data from State of California Natural Resources Agency, Department of Water Resources. The model is not currently using the evaporation and precipitation volumes, as the impacts are negligible, but the data exists in case the situation changes.

The model uses the volume of water historically drawn from Newman Gulch and Waterfall Gulch, which have been metered since 1994, and compiles maximum flows for the Noyo River, based on actual flow and tidal data. Source intake data for Newman and Waterfall Gulch prior to 1994 was estimated using the 2008-2013 metered data.

Newman Gulch provides a legal maximum of 0.99 acre-feet (AF)/day, equivalent to 225 gallons per minute (gpm) or 0.5 cubic feet per second (cfs). Waterfall Gulch provides a legal maximum of 1.325 AF/day, equiv. to 300 gpm or 0.668 cfs. The Noyo River can legally provide up to a maximum of 5.95 AF/day, equiv. to 1345 gpm or 3 cfs. This translates to a maximum supply of 8.265 AF/day. ***The model considers what portion we can take of any of our supply sources on a daily basis.***

SLIDE 3 – Noyo Tidal Constraints
The Noyo source is constrained by the State Water Resources Control Board Division of Water Rights such that we must bypass 3 cfs during the summer (June-September) and 10 cfs during winter (October-May), whenever the tide is equal to or less than 2'.

SLIDE 4 – Sorting Tide Data
The historic tide data, obtained from CeNCOOS, the Central and Northern California Ocean Observatory System, and from NOAA, the National Oceanic and Atmospheric Association, was incorporated in the model for use in those calculations. The data was input as a large string of data, as provided by CeNCOOS, which the model then extracts to a usable form. The model calculates the number of hours that the tide will be above 2', 5', and 6.7' (King Tide), rounded to the nearest increment of 6 or 8 hours, for 4 or 3 tides/day, respectively.

The model excludes days which are impacted by King Tides when evaluating the Noyo contribution, although operationally we may pump some on those days. We took the conservative approach when using these data to determine the maximum amount of supply for each day. The model will also allow us to evaluate a situation in which the volume of water drawn from any of the sources becomes reduced due to regulatory or other considerations.

SLIDE 5 – Source Flow Constraints
Waterfall Gulch was recently restricted by US Fish and Wildlife, through a new Streambed Alteration Agreement, when we constructed the Summers Lane Reservoir. The new Agreement supersedes previous Agreements going back to 1977. We are now required to bypass 25% of the flow, unless we are in a drought situation, in which case the bypass can be reduced to 10%. Current modeling is set for a constant 25% bypass.

SLIDE 6 – Historic Water Supply Data
When Lampley created the model in 2014, she used some variation of the demand data from the 2012-2013 fiscal year to analyze all years. This was accomplished by creating some slight variations within the actual values but honoring the annual trend for all years in the model. I went back and reentered the volume of water filtered at the Treatment Plant, as demand, from 7/1/2010 to 12/31/2015. The volume of filtered water accounts for losses in the system. The metered sales volume for calendar year 2015 was about 195.5 million gallons (MG), while the filtered volume was almost 247 MG, a difference of just over 50 MG. The "demand" for the 2017-2018 fiscal year, was just under 247 MG, very close to the 2015 volume. It should be noted, however, that the demand for the **2018 calendar year was 262.4 MG**, an increase of a little over **6%** from the 2015 calendar year demand. Overall there has been a **decrease in demand of over 23%** since the 1995-1996 fiscal year.

SLIDE 7 – Model Constants and the User Interface
The volume of stored water available includes the amount of untreated water in the storage ponds at the Treatment Plant (9.2 AF or 3 MG) and in Newman Reservoir (0.9 AF or 0.3 MG). It also includes the treated water in the two older 1.5 MG tanks on Cedar Street, and the 0.3 MG tank on Highway 20, for a total of 10.1 AF, or 3.3 MG. These provide a total storage of **20.25 AF, or 6.6 MG**. At this point, I have not included the new 1.5 MG tank in the model, but it can easily be incorporated. Summers Lane Reservoir has a capacity of **44.3 AF, or 14.4 MG** of untreated water. These individual volumes result in a ***total storage capacity of 64.5 AF, or 21 MG***. The model allows us to "turn" the reservoir "off" and "on" to evaluate the effects it has on our supply. Running the model without Summers Lane Reservoir is a good "ground truth" for actual conditions in the past.

The water model allows the user to modify/adjust some of the parameters to evaluate various scenarios. We can change the % of flow that we can take from any of the 3 sources, or change the volume of bypass required for the Noyo or for Waterfall Gulch. We can increase demand by a % over the 2015 demand, and we can turn the Summers Lane Reservoir "on" and "off." We can adjust the modeled precipitation by a specific %, although we are not currently incorporating precipitation or evaporation, as their effects are insignificant to the model. We can also add the evaporative reduction devices to our ponds, which we are currently using. The last "dials" on the model are the ability to use groundwater, should the City ever have access to a groundwater source, and the volume of the groundwater that will be input to the system.

SLIDE 8 – Definition of Water Emergency Stages

The definition of a Water Emergency and the Stage criteria were defined and adopted by City Council as Ordinance 923-2016, amending FBMC Section 14.06. A Water Emergency is when "the City is unable to maintain a 10% buffer between its ability to replenish water in its storage tanks and the total daily demand for water." Stage 1 is defined as 10% goal of reducing water usage. Stage 2 is defined as 20% goal of reducing water usage. Stage 3 is defined as 30% goal of reducing water usage. Stage 4 is defined as "all available water sources cannot provide sufficient flow for water users or cannot maintain adequate flows or pressures for fire-fighting; and the conservation measures required by a Stage 1, Stage 2, and Stage 3 water emergency are no longer adequate to address the water shortage."

The Model automatically calculates a **Water Alert**, when demand exceeds 90% of supply, and **Stage 4**, when supply is exhausted. The **Stage 1** Water Emergency will be determined by evaluation of daily model results. The Water Alert is an early indication of the potential for a water shortage.

SLIDE 9 – Determining Stage 1 Criteria in the Model

The model evaluates supply and demand on a daily basis. On days when the demand exceeds the supply, water is drawn from storage. As a general rule, there is always some water entering Summers Lane Reservoir, from either, or both, Waterfall Gulch and Newman Gulch. The 10% buffer described above equates to approximately 11% of the storage volume of Summers Lane Reservoir. The model is not designed to evaluate this, but it can be determined by adjusting the demand at the User_Input tab and then reviewing the calculations until the drawdown reaches 11%. That will be the % increase that will trigger the Stage 1 Emergency. With Summers Lane we do not encounter Stage 1 Water Emergency until we reach a 6% increase in demand.

SLIDE 10 - Stage 4 Criteria

In the model, Stage 4 is triggered when all of the storage has been depleted. The current model hits Stage 4 in 2015, with Summers Lane on and Waterfall at 75%, at **180.1% of 2015 demand.** This equates to about **444.81 MG.**

SLIDE 11 – Example Run with Summers Lane Reservoir

Adding the reservoir greatly increases our stored water supply, reducing the severity of supply loss.

SLIDE 12 - Ground Truth Model with Actual 2015 Conditions

Storage without Summers Lane is 20.25 AF. An 11% drawdown equates to a volume of 18.0 AF. We hit the Stage 1 criteria on 8/7 with a low of 17.9 AF. Storage is full again from 8/11-8/22. We hit another low of 19.2 AF on 8/25. Storage is full again from 8/26-9/2. A low of 17.9 AF is encountered on 9/7. Storage is full again 9/9-9/21. A low of 18.9 is encountered on 9/24. Storage is full again 9/25-9/30. A low of 18.0 AF is encountered on 10/6. Storage is full again 10/8-10/18. A low of 19.1 is encountered on 10/23. Storage is full again on 10/24.

If the model was set up to determine the Stage 1 Water Emergency automatically, it would have counted 6 days. If the City declared Stage 1 on the first day we hit the 18 AF (8/7), and continue until there were no more days below 18 AF for the year (10/7), Stage 1 would have been declared for 61 days (from 8/7-10/6)

The City declared a Stage 1 Water Emergency at City Council on **8/10**. Stage 3 was declared at City Council on 9/30. On **10/26** Council issued the non-emergency water conservation ordinance. The timing of actual events relative to the modeling results gives us some confidence that the model is a fairly accurate representation.

SLIDE 13 - Maximum Growth While Retaining 5 MG Storage
The model indicates that we can manage a ***growth of 74.8%*** (174.8% in model) and still reserve 5 MG in storage. A growth of 74.8% equals to a total demand of **431.72 MG**.

SLIDE 14 - 60% Growth Analysis
The model indicates that we can still maintain 13.49 MG in storage under 2015 drought conditions, even with a loss of 25% of the Waterfall Gulch supply. A growth of 60% equals to a total demand of **395.17 MG**.

RECOMMENDED ACTION:
The workshop is intended to provide information. No actions are necessary.

ALTERNATIVE ACTION(S):
None.

FISCAL IMPACT:
N/A.

CONSISTENCY:
N/A.

IMPLEMENTATION/TIMEFRAMES:
N/A.

ATTACHMENTS:
1. PowerPoint Presentation

NOTIFICATION:
None.

City of Fort Bragg

Water Supply Model

Development, Functionality and Model Results

Diane O'Connor, Engineering Technician
Public Works Department

Water Model History

The water model was first built in early 2014, by Bonnie Lampley of Lawrence and Associates, located in Shasta Lake, CA. Numerous iterations occurred with Terry Jo Barber, Sergio Fuentes, and myself. A Special City Council Water Workshop was held on January 5, 2016, where Sergio gave a brief demo of the Water Model, as it was at that time.

I worked with Bonnie from August 2017 to September of 2018, when I took over the functionality myself. I am confident that we are as close to the "real world" as we can get, with the information we have.

Historic data as input to model

DAY	DAILY PRECIP		DAILY EVAP		NOYO	NEWMAN	SIMPSON/ WATERFALL
Period for model is water years 1974 - 2013; this period encompasses most recent drought periods	From Fort Bragg Station 5N, U.S. Climatedata		Based on ET of North Coast basins, converted to evap (ET/1.25); monthly data converted to daily by dividing the monthly value by the # days/month		1973-1994, est. from 2008-2013; 1994-2015, average daily from City's meters		
	INCHES	FEET	INCHES	FEET	GPM	GPM	GPM
10/1/1973	0.00	0.000	0.004	0.0004	298	315	141
10/2/1973	0.02	0.002	0.004	0.0004	298	315	141
10/3/1973	0.00	0.000	0.004	0.0004	298	315	141

"Raw" tide data from CeNCOOS (Central & Northern California Ocean Observatory System)

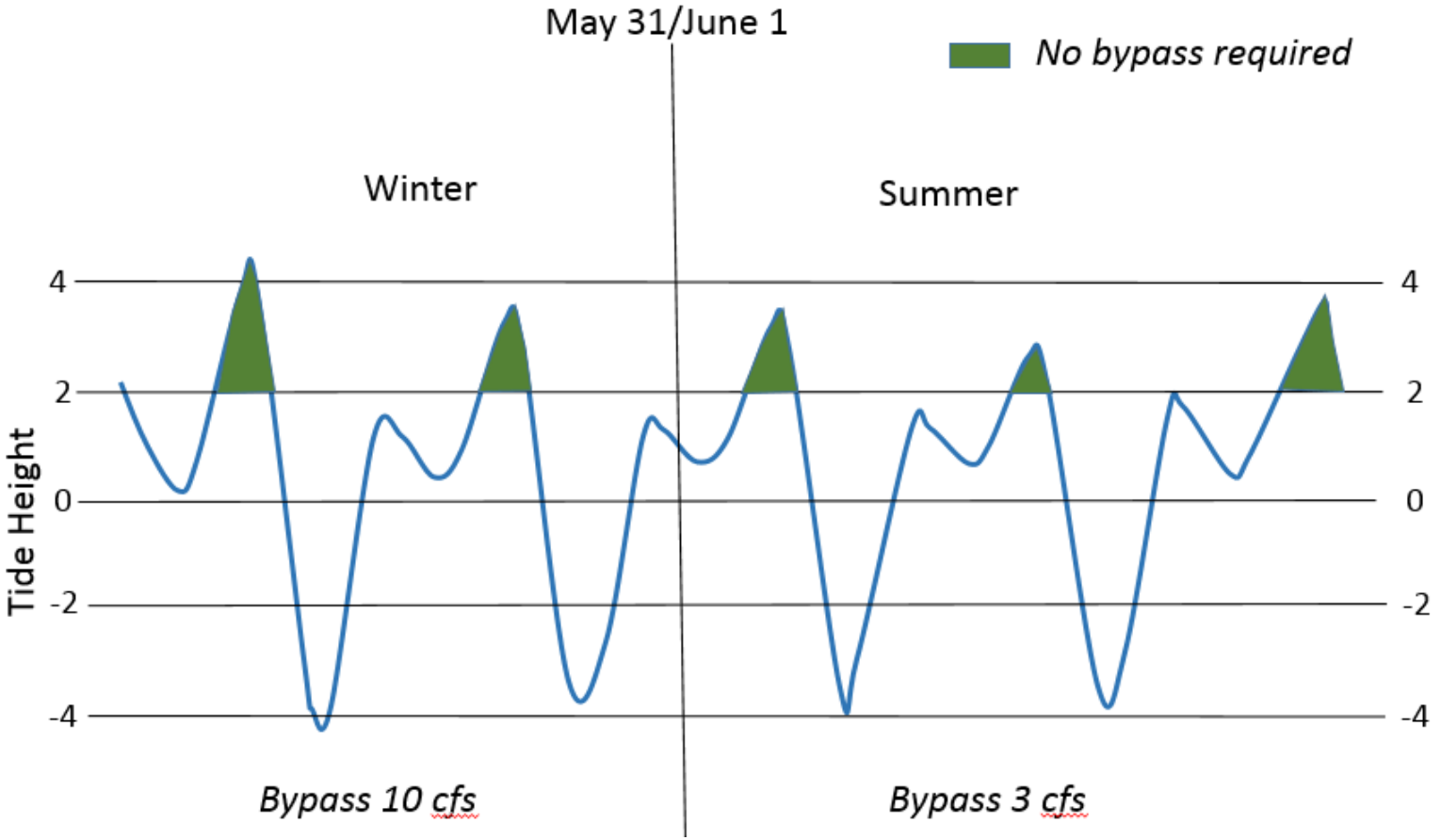
RAW DATA FROM CeNCOOS

10/01/1973 Mon	03:45AM PDT	4.2 H	10/01/1973 Mon	08:15AM PDT	2.9 L	10/01/1973 Mon	02:28PM PDT	5.4 H	10/01/1973 Mon	09:39PM PDT	0.4 L
10/02/1973 Tue	04:53AM PDT	4.0 H	10/02/1973 Tue	09:03AM PDT	3.1 L	10/02/1973 Tue	03:14PM PDT	5.1 H	10/02/1973 Tue	10:39PM PDT	0.6 L
10/03/1973 Wed	06:09AM PDT	3.9 H	10/03/1973 Wed	10:08AM PDT	3.3 L	10/03/1973 Wed	04:13PM PDT	4.9 H	10/03/1973 Wed	11:43PM PDT	0.8 L
10/04/1973 Thu	07:19AM PDT	4.0 H	10/04/1973 Thu	11:31AM PDT	3.3 L	10/04/1973 Thu	05:24PM PDT	4.7 H			
10/05/1973 Thu	12:45AM PDT	0.8 L	10/05/1973 Fri	08:09AM PDT	4.2 H	10/05/1973 Fri	12:51AM PDT	3.1 L	10/05/1973 Fri	06:38PM PDT	4.7 H
10/06/1973 Sat	01:38AM PDT	0.8 L	10/06/1973 Sat	08:46AM PDT	4.4 H	10/06/1973 Sat	01:53PM PDT	2.7 L	10/06/1973 Sat	07:44PM PDT	4.7 H
10/07/1973 Sun	02:23AM PDT	0.8 L	10/07/1973 Sun	09:16AM PDT	4.7 H	10/07/1973 Sun	02:42PM PDT	2.3 L	10/07/1973 Sun	08:41PM PDT	4.9 H

10/01/1973 Mon 03:45AM PDT 4.2 H 10/01/1973 Mon 08:15AM PDT 2.9 L 10/01/1973 Mon 02:28PM PDT 5.4 H 10/01/1973 Mon 09:39PM PDT 0.4 L

Noyo Diversion Order 1998 Amendment

"For the protection of fish and fish habitat, whenever the tide elevation at the mouth of the Noyo River is equal to or less than +2.0', Permittee shall maintain in the streambed immediately below the point of diversion a minimum flow of 10 cfs or the natural flow of the stream, whichever is less, for the period of October 1 through May 31, and 3 cfs or the natural flow of the stream, whichever is less, for the period June 1 through September 30.



“Raw” tide data from CeNCOOS (Central & Northern California Ocean Observatory System)

10/01/1973 Mon 03:45AM PDT	4.2 H	10/01/1973 Mon 08:15AM PDT	2.9 L	10/01/1973 Mon 02:28PM PDT	5.4 H	10/01/1973 Mon 09:39PM PDT	0.4 L

This part of the model “counts” the hours (rounded to increments of 6 or 8, for 4 or 3 tides/day, respectively) that the tide is above 2’, 5’, and 6.7’ (King Tide)

	PARSE VALUES				COUNT HOURS >2				COUNT HOURS >5				COUNT HOURS >6.7				SUM HRS >2	SUM HRS >5	SUM HRS >6.7
10/1/1973	4.2	2.9	5.4	0.4	6	6	6	0	0	0	6	0	0	0	0	0	18	6	0
10/2/1973	4	3.1	5.1	0.6	6	6	6	0	0	0	6	0	0	0	0	0	18	6	0
10/3/1973	3.9	3.3	4.9	0.8	6	6	6	0	0	0	0	0	0	0	0	0	18	0	0
10/4/1973	4	3.3	4.7	#N/A	8	8	8	0	0	0	0	0	0	0	0	0	24	0	0
10/5/1973	0.8	4.2	3.1	4.7	0	6	6	6	0	0	0	0	0	0	0	0	18	0	0
10/6/1973	0.8	4.4	2.7	4.7	0	6	6	6	0	0	0	0	0	0	0	0	18	0	0
10/7/1973	0.8	4.7	2.3	4.9	0	6	6	6	0	0	0	0	0	0	0	0	18	0	0
10/8/1973	0.8	5	1.7	5	0	6	0	6	0	6	0	6	0	0	0	0	12	12	0
10/9/1973	0.9	5.3	1.2	5	0	6	0	6	0	6	0	6	0	0	0	0	12	12	0
10/10/1973	1.1	5.6	0.6	5.1	0	6	0	6	0	6	0	6	0	0	0	0	12	12	0
10/11/1973	1.3	5.9	0	5	0	6	0	6	0	6	0	6	0	0	0	0	12	12	0
10/12/1973	1.6	6.2	-0.4	#N/A	0	8	0	0	0	8	0	0	0	0	0	0	8	8	0
10/13/1973	4.9	1.9	6.4	-0.7	6	0	6	0	0	0	6	0	0	0	0	0	12	6	0

% of “constrained” flow available for use (User_Input)
In this case 75% of the flow

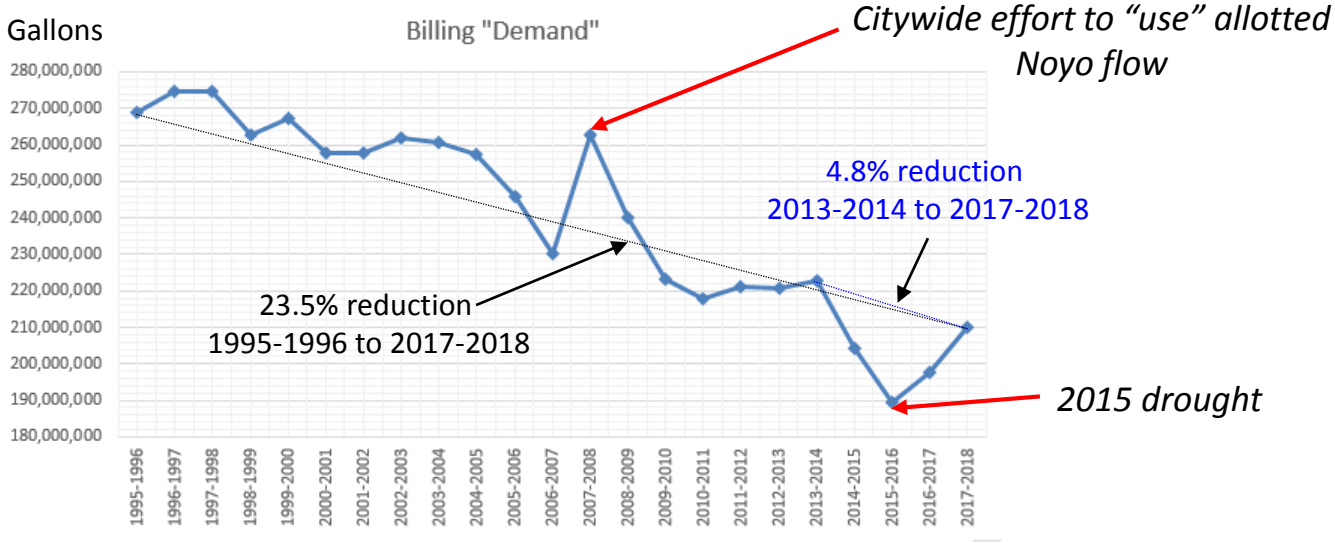
“Constrained” source volumes

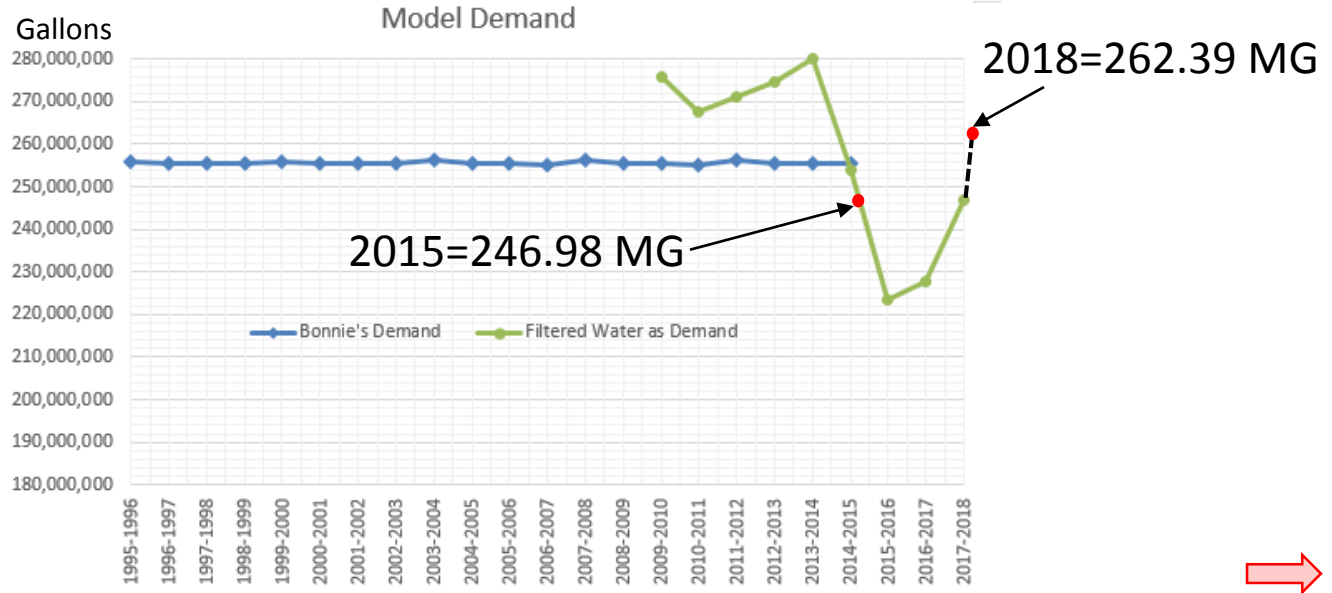
Day	REVISED NEWMAN	REVISED WATERFALL	REVISED NOYO
	AF/DAY	(AF/DAY)	(AF/DAY)
	NOT TO EXCEED FLOW OF 0.99 AF/DAY	From Data sheet, converted to af/day - reduced by chosen %, less amount to remain	From Data sheet Diane Calc (Max 5.95 AF)
10/1/1973	0.990	0.47	4.46
10/2/1973	0.990	0.47	4.46
10/3/1973	0.990	0.47	4.46
10/4/1973	0.990	0.47	5.95
10/5/1973	0.990	0.47	4.46
10/6/1973	0.990	0.47	5.95
10/7/1973	0.990	0.47	5.95
10/8/1973	0.990	0.47	5.95
10/9/1973	0.990	0.47	5.95
10/10/1973	0.990	0.47	5.95

WATERFALL RESTRICTED	WATERFALL RESTRICTED
NOT TO EXCEED 1.325 AF/DAY (299.82 GPM)	constrained by user amount
AF	AF
0.62	0.47
0.62	0.47
0.62	0.47
0.62	0.47

Historic Demand Trends

Day	Beginning Volume (AF)	City Demand (AF/DAY)
	From end of previous day	From Data sheet - converted to af/day - multiplied by growth factor if used
7/30/2015	64.6	3.3
7/31/2015	64.6	3.1
8/1/2015	64.6	3.0
8/2/2015	64.6	2.8
8/3/2015	64.6	3.3
8/4/2015	64.6	3.0
8/5/2015	64.6	3.0





2015 calendar year metered **billing** is 195,544,404 Gallons
2015 calendar year metered **filtered** is 246,979,900 Gallons
2017-2018 Fiscal year metered **filtered** is 246,742,000 Gallons
2018 calendar year metered **filtered** is 262,390,000 Gallons

User Interface (User_Input Tab)

Model Constants:

Existing Newman Reservoir	0.9	acre-feet
New Summers Lane Reservoir	**44.3**	**acre-feet**
Raw Water Storage	9.2	acre-feet
Finished Water Storage	10.1	acre-feet
Groundwater availability (maximum, non-drought)	0.4	acre-feet per day
Water Alert Trigger	Raw water source capacity at least 10% above demand	

Adjust flow %

Use Summers Lane Reservoir

Adjust volume of bypass
We now bypass 25% of flow at Waterfall Gulch

Increase demand from 2015

Model Input Adjustments You Can Make:

Reduce Noyo flow?	100%	<-- as percent of measured flow
Amount of flow that must remain in Noyo River?	10	<-- amount to leave in Noyo, Oct 1 - May 31 (cfs)
	3	<-- amount to leave in Noyo, Jun 1 - Sep 30 (cfs)
Height of tide that controls pumping?	2.0	<-- height of tide that controls pumping (feet)
Reduce Newman Gulch flow?	100%	<-- percent of historic measured flow
Reduce Waterfall Gulch flow?	100%	<-- percent of historic measured withdrawal
Amount of flow that must remain in Waterfall G.?	0.0	<-- enter amount to leave in Waterfall G. (cfs) (enter 0.000001 to ignore factor)
Use new Summers Lane Reservoir?	n	<-- enter Y or N
Use evaporation on raw water storage?	0.00	<-- approximate daily amount in acre-feet
Use evaporation reduction device on new reservoir?	0%	<-- percent reduction due to device
Adjust daily precipitation?	100%	<-- percent change from historic values
Increase City demand? If using 2015 graphs, demand is for 2015	100%	<-- **percent of 2015 production**
Use groundwater from former park site?	N	<-- Y or N
Groundwater pumpage? (200 gpm original)	100	<-- as total gallons per minute from well field

What is a Water Emergency?

Ordinance of 1/25/2016 reads that a Water Emergency is declared when “the City is unable to maintain a 10% buffer between its ability to replenish water in its storage tanks and the total daily demand for water”.

Stage 1 is defined as 10% goal of reducing water usage

Stage 2 is defined as 20% goal of reducing water usage

Stage 3 is defined as 30% goal of reducing water usage

Stage 4 is defined as “all available water sources cannot provide sufficient flow for water users or cannot maintain adequate flows or pressures for fire-fighting; and the conservation measures required by a Stage 1, Stage 2, and Stage 3 water emergency are no longer adequate to address the water shortage”.

The Model automatically calculates a **Water Alert**, when demand exceeds 90% of supply, and **Stage 4**, when supply is exhausted. **Stage 1** Water Emergency will be determined by evaluation of daily model results.

Determining Stage 1 Water Emergency Criteria for Fall of 2015

Summers Lane holds 44.3 AF. If it is 98% full, that equates to 43.4 AF. 11% drawdown leaves a volume of 38.6 AF. Added to the other storage (20.2) equals ***58.8 AF***
With the reservoir full, ***we don't reach Stage 1 until we increase demand by 6%.***

Increase City demand? If using 2015 graphs, demand is for 2015 106% <-- percent of 2015 production

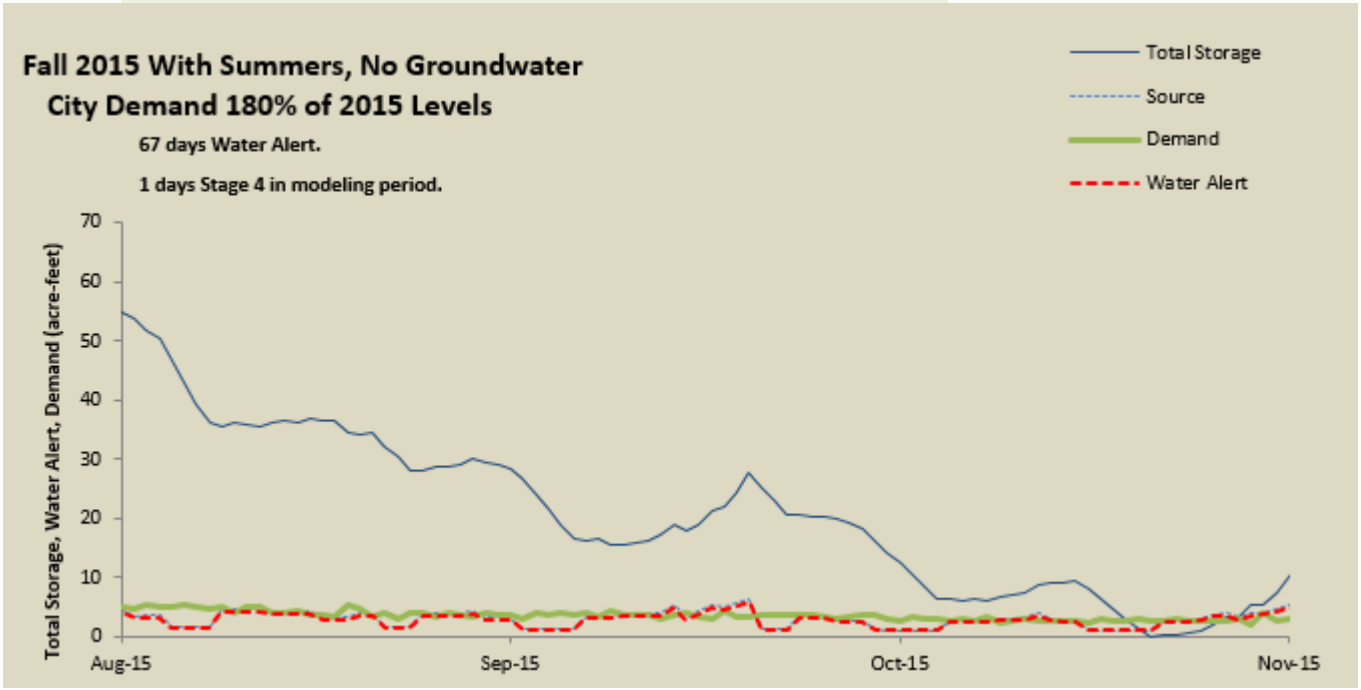
Day	Beginning Volume	City Demand	Newman	REVISED NEWMAN	REVISED WATERFALL	REVISED NOYO	Summers Withdrawl (if used)	FINAL ENDING VOLUME
	(AF)	(AF/DAY)	(AF/DAY)	AF/DAY	(AF/DAY)	(AF/DAY)	(AF/DAY)	(AF/DAY)
	From end of previous day	From Data sheet - converted to af/day - multiplied by growth factor if used	From Data sheet, converted to af/day, reduced by User Input %	NOT TO EXCEED FLOW OF 0.99 AF/DAY	From Data sheet, converted to af/day - reduced by chosen %, less amount to remain	From Data sheet Diane Calc (Max 5.95 AF)	Amount to be drawn from reservoir if needed (when used)	Final Ending Volume
8/5/2015	64.6	3.0	1.4	0.990	0.55	0.00	1.44	63.1
8/6/2015	63.1	3.1	1.4	0.990	0.55	0.00	1.60	61.5
8/7/2015	61.5	3.0	1.4	0.990	0.55	0.00	1.47	60.1
8/8/2015	60.1	2.8	1.4	0.990	0.55	0.00	1.29	58.8
8/9/2015	58.8	3.1	1.4	0.990	0.55	3.19	0.00	60.4
8/10/2015	60.4	2.3	1.4	0.990	0.55	3.12	0.00	62.8
8/11/2015	62.8	3.0	1.4	0.990	0.55	3.16	0.00	64.5
8/12/2015	64.5	2.9	1.4	0.990	0.55	3.05	0.00	64.6

Stage 4 Criteria 2015

Day	Beginning Volume (AF) From end of previous day
10/21/2015	3.1
10/22/2015	1.3
10/23/2015	0.0
10/24/2015	0.3
10/25/2015	0.3

Model Input Adjustments You Can Make:

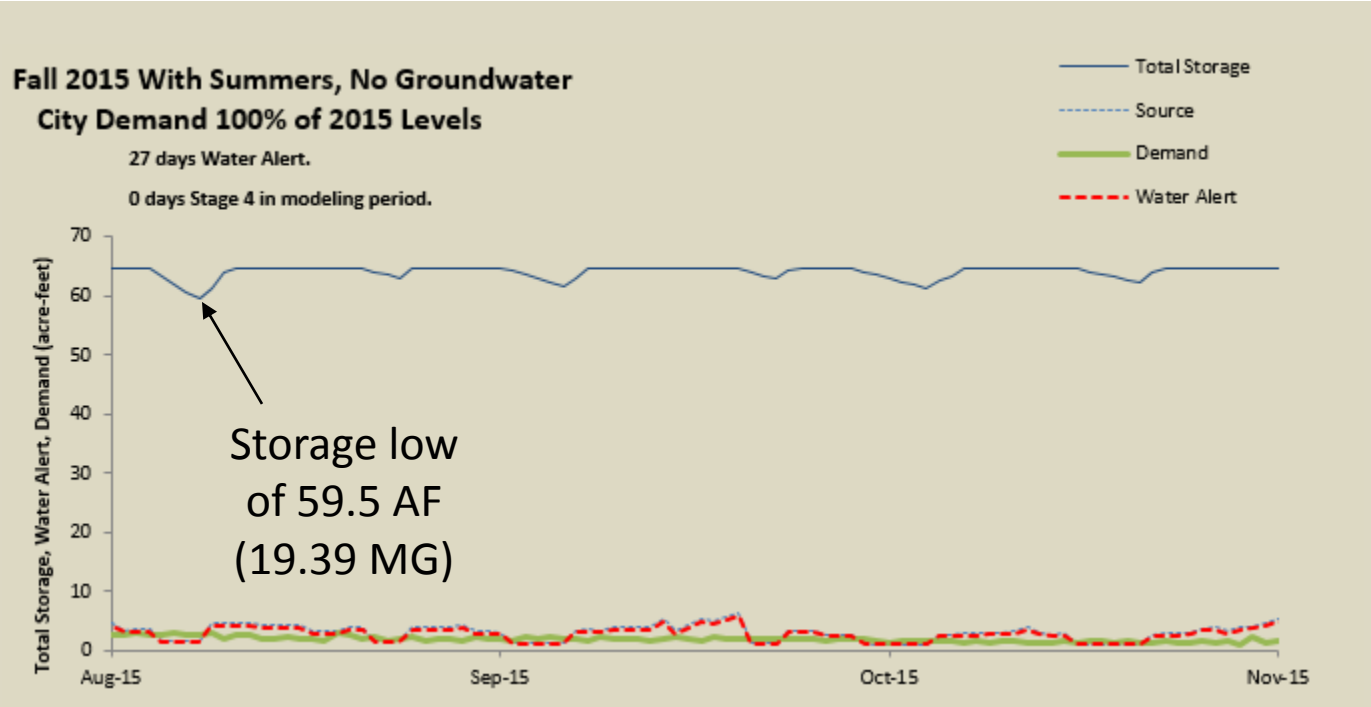
Reduce Noyo flow?	100%	<-- as percent of measured flow
Amount of flow that must remain in Noyo River?	10	<-- amount to leave in Noyo, Oct 1 - May 31 (cfs)
	3	<-- amount to leave in Noyo, Jun 1 - Sep 30 (cfs)
Height of tide that controls pumping?	2.0	<-- height of tide that controls pumping (feet)
Reduce Newman Gulch flow?	100%	<-- percent of historic measured flow
Reduce Waterfall Gulch flow?	75%	<-- percent of historic measured withdrawal
Amount of flow that must remain in Waterfall G.?	0.0	<-- enter amount to leave in Waterfall G. (cfs) (enter 0.000001 to ignore factor)
Use new Summers Lane Reservoir?	y	<-- enter Y or N
Use evaporation on raw water storage?	0.00	<-- approximate daily amount in acre-feet
Use evaporation reduction device on new reservoir?	0%	<-- percent reduction due to device
Adjust daily precipitation?	100%	<-- percent change from historic values
Increase City demand? If using 2015 graphs, demand is for 2015	**180.1%**	**<-- percent of 2015 production**
Use groundwater from former park site?	N	<-- Y or N
Groundwater pumpage? (200 gpm original)	100	<-- as total gallons per minute from well field



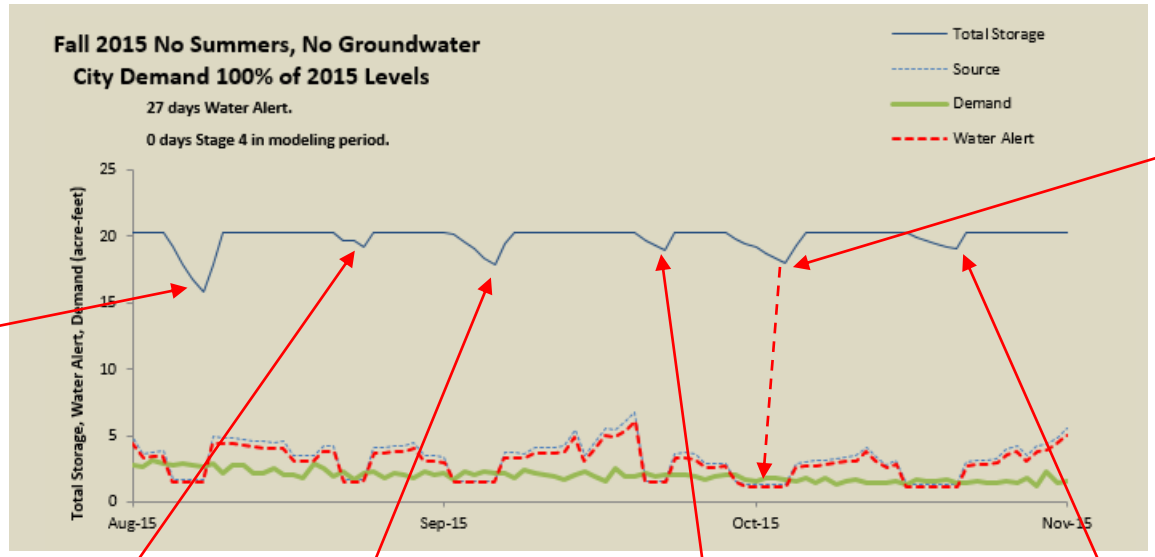
Example run with Summers Lane Reservoir

Model Input Adjustments You Can Make:

Reduce Noyo flow?	100%	<-- as percent of measured flow
Amount of flow that must remain in Noyo River?	10	<-- amount to leave in Noyo, Oct 1 - May 31 (cfs)
	3	<-- amount to leave in Noyo, Jun 1 - Sep 30 (cfs)
Height of tide that controls pumping?	2.0	<-- height of tide that controls pumping (feet)
Reduce Newman Gulch flow?	100%	<-- percent of historic measured flow
Reduce Waterfall Gulch flow?	75%	<-- percent of historic measured withdrawal
Amount of flow that must remain in Waterfall G.?	0.0	<-- enter amount to leave in Waterfall G. (cfs) (enter 0.000001 to ignore factor)
Use new Summers Lane Reservoir?	y	<-- enter Y or N
Use evaporation on raw water storage?	0.00	<-- approximate daily amount in acre-feet
Use evaporation reduction device on new reservoir?	0%	<-- percent reduction due to device
Adjust daily precipitation?	100%	<-- percent change from historic values
Increase City demand? If using 2015 graphs, demand is for 2015	100%	**<-- percent of 2015 production**
Use groundwater from former park site?	N	<-- Y or N
Groundwater pumpage? (200 gpm original)	100	<-- as total gallons per minute from well field



Ground truth - Fall of 2015 without Summers Lane, 100% of Waterfall Gulch



Date	AF
8/1/2015	20.3
8/2/2015	20.3
8/3/2015	20.3
8/4/2015	20.3
8/5/2015	20.3
8/6/2015	19.2
8/7/2015	17.9
8/8/2015	16.8
8/9/2015	15.9
8/10/2015	17.9
8/11/2015	20.3
8/12/2015	20.3
8/13/2015	20.3
8/14/2015	20.3
8/15/2015	20.3
8/16/2015	20.3
8/17/2015	20.3
8/18/2015	20.3
8/19/2015	20.3
8/20/2015	20.3
8/21/2015	20.3
8/22/2015	20.3
8/23/2015	19.7
8/24/2015	19.7
8/25/2015	19.2
8/26/2015	20.3
8/27/2015	20.3
8/28/2015	20.3
8/29/2015	20.3
8/30/2015	20.3
8/31/2015	20.3

Date	AF
9/1/2015	20.3
9/2/2015	20.3
9/3/2015	20.2
9/4/2015	19.5
9/5/2015	19.1
9/6/2015	18.4
9/7/2015	17.9
9/8/2015	19.4
9/9/2015	20.3
9/10/2015	20.3
9/11/2015	20.3
9/12/2015	20.3
9/13/2015	20.3
9/14/2015	20.3
9/15/2015	20.3

Date	AF
9/16/2015	20.3
9/17/2015	20.3
9/18/2015	20.3
9/19/2015	20.3
9/20/2015	20.3
9/21/2015	20.3
9/22/2015	19.7
9/23/2015	19.4
9/24/2015	18.9
9/25/2015	20.3
9/26/2015	20.3
9/27/2015	20.3
9/28/2015	20.3
9/29/2015	20.3
9/30/2015	20.3

Date	AF
10/1/2015	19.8
10/2/2015	19.4
10/3/2015	19.3
10/4/2015	18.8
10/5/2015	18.4
10/6/2015	18.0
10/7/2015	19.3
10/8/2015	20.3
10/9/2015	20.3
10/10/2015	20.3
10/11/2015	20.3
10/12/2015	20.3
10/13/2015	20.3
10/14/2015	20.3
10/15/2015	20.3
10/16/2015	20.3
10/17/2015	20.3
10/18/2015	20.3
10/19/2015	19.9
10/20/2015	19.7
10/21/2015	19.5
10/22/2015	19.2
10/23/2015	19.1
10/24/2015	20.3
10/25/2015	20.3
10/26/2015	20.3
10/27/2015	20.3
10/28/2015	20.3
10/29/2015	20.3
10/30/2015	20.3
10/31/2015	20.3

If the model was set up to determine the Stage 1 automatically, it would have counted 6 days. If the City declared Stage 1 on the first day we hit or fell below 18 AF (8/7), and continue until there were no more days below 18 AF for the fall (10/7), Stage 1 would have been declared for 61 days (from 8/7-10/6)

Maximum Drought Water Supply – Reserve 5 MG Storage

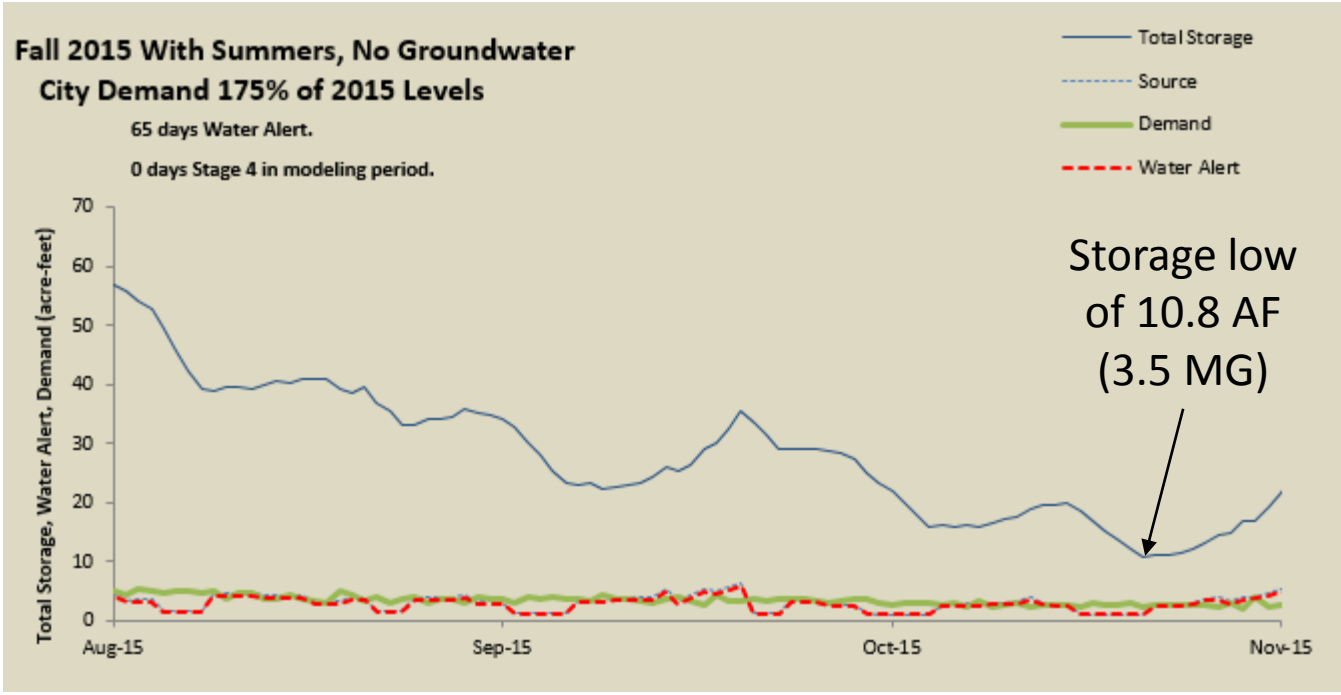
Day	Beginning Volume (AF)
	From end of previous day
10/20/2015	15.4
10/21/2015	13.9
10/22/2015	12.1
10/23/2015	10.8
10/24/2015	11.1
10/25/2015	11.2
10/26/2015	11.6

10.8 AF = 3.5 MG
New Tank = 1.5 MG

Model Input Adjustments You Can Make:

Reduce Noyo flow?	100%	<-- as percent of measured flow
Amount of flow that must remain in Noyo River?	10	<-- amount to leave in Noyo, Oct 1 - May 31 (cfs)
	3	<-- amount to leave in Noyo, Jun 1 - Sep 30 (cfs)
Height of tide that controls pumping?	2.0	<-- height of tide that controls pumping (feet)
Reduce Newman Gulch flow?	100%	<-- percent of historic measured flow
Reduce Waterfall Gulch flow?	75%	<-- percent of historic measured withdrawal
Amount of flow that must remain in Waterfall G.?	0.0	<-- enter amount to leave in Waterfall G. (cfs) (enter 0.000001 to ignore factor)
Use new Summers Lane Reservoir?	y	<-- enter Y or N
Use evaporation on raw water storage?	0.00	<-- approximate daily amount in acre-feet
Use evaporation reduction device on new reservoir?	0%	<-- percent reduction due to device
Adjust daily precipitation?	100%	<-- percent change from historic values
Increase City demand? If using 2015 graphs, demand is for 2015	**174.8%**	**<-- percent of 2015 production**
Use groundwater from former park site?	N	<-- Y or N
Groundwater pumpage? (200 gpm original)	100	<-- as total gallons per minute from well field

74.8% growth = 431 MG



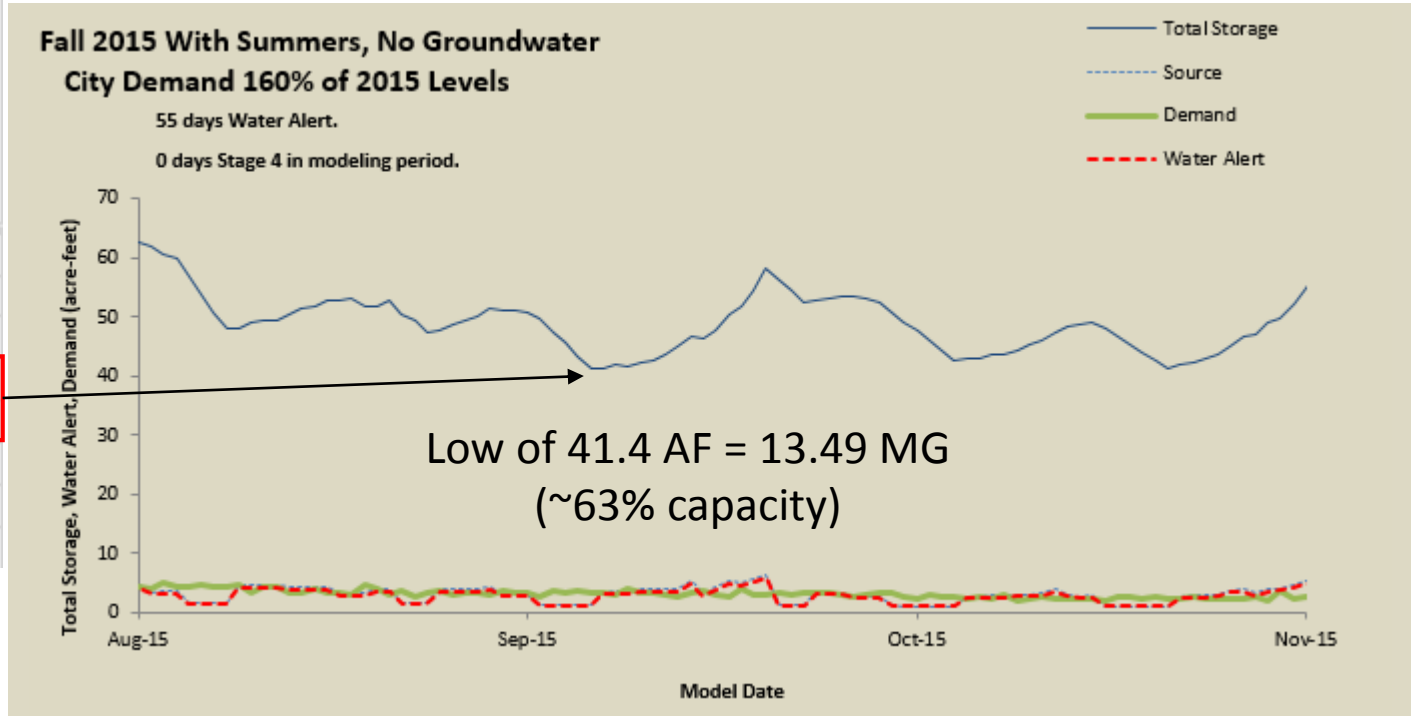
60% Growth Analysis

Model Input Adjustments You Can Make:

Reduce Noyo flow?	100%	<-- as percent of measured flow
Amount of flow that must remain in Noyo River?	10	<-- amount to leave in Noyo, Oct 1 - May 31 (cfs)
	3	<-- amount to leave in Noyo, Jun 1 - Sep 30 (cfs)
Height of tide that controls pumping?	2.0	<-- height of tide that controls pumping (feet)
Reduce Newman Gulch flow?	100%	<-- percent of historic measured flow
Reduce Waterfall Gulch flow?	75%	<-- percent of historic measured withdrawal
Amount of flow that must remain in Waterfall G.?	0.0	<-- enter amount to leave in Waterfall G. (cfs) (enter 0.000001 to ignore factor)
Use new Summers Lane Reservoir?	y	<-- enter Y or N
Use evaporation on raw water storage?	0.00	<-- approximate daily amount in acre-feet
Use evaporation reduction device on new reservoir?	0%	<-- percent reduction due to device
Adjust daily precipitation?	100%	<-- percent change from historic values
Increase City demand? If using 2015 graphs, demand is for 2015	160%	**<-- percent of 2015 production**
Use groundwater from former park site?	N	<-- Y or N
Groundwater pumpage? (200 gpm original)	100	<-- as total gallons per minute from well field

60% growth = 395 MG

Day	Beginning Volume (AF) — From end of previous day
9/4/2015	47.4
9/5/2015	45.6
9/6/2015	43.4
9/7/2015	41.4
9/8/2015	41.4
9/9/2015	42.0
9/10/2015	41.6
9/11/2015	42.1



Low of 41.4 AF = 13.49 MG
(~63% capacity)

Live Demo

What parameters would you like me to use?

Back Up Slides

Historic Noyo flow and daily intake calculations - Winter

	100%														
DAY	NOYO FLOW		AMOUNT TO LEAVE IN NOYO	TIDES (TIME >2')	TIDES (TIME >5')	TIDES (TIME >6.7')	CHECK IF NOYO PUMPING POSSIBLE BASED ON QUALITY								NOYO RESTRICTED BY TIDES
Period for model is water years 1974 - 2013; this period encompasses most recent drought periods	From USGS 11468500 Noyo R. Near Fort Bragg; flow reduced at choice of user (column G) **Yellow is revised per USGS, the following BOLD data was added**			Tide data from CeNCOOS, Fort Bragg Landing Station; hours/day tides >2' estimated from tide data	Tide data from CeNCOOS, Fort Bragg Landing Station; hours/day tides >5' estimated from tide data	Tide data from CeNCOOS, Fort Bragg Landing Station; hours/day tides >6.7' estimated from tide data	If tide is >5' at any time during the day and flow is < 1 OR if tide >6.7' and flow is < 2.5 cfs, then Noyo offline (0 = offline, 1 = ok to pump)	Manage flows in winter with bypass, Tide <2' 10 cfs bypass required	Constrain to max 3 CFS	Manage flows in summer with bypass, Tide <2' - 3 cfs bypass required	Constrain to max 3 CFS	Flow rate when tide ≤2' (sum of previous 2 constrained)	Total available flow during tide ≤2'	Total available flow when tide >2'	Total Noyo flow for 24 hour period (sum of below and above 2' tide in AF) MAX 5.95
	CFS	CFS	CFS	HRS	HRS	HRS	0=King Tide	CFS	CFS	CFS	CFS	CFS	CF	CF	AF
10/1/1973	7.6	7.6	10.0	18	6	0	1	0.0	0.0	0.0	0.0	0.0	0	194,400	4.46
10/2/1973	7.2	7.2	10.0	18	6	0	1	0.0	0.0	0.0	0.0	0.0	0	194,400	4.46
10/3/1973	7.2	7.2	10.0	18	0	0	1	0.0	0.0	0.0	0.0	0.0	0	194,400	4.46
10/4/1973	6.8	6.8	10.0	24	0	0	1	0.0	0.0	0.0	0.0	0.0	0	259,200	5.95
10/5/1973	6.8	6.8	10.0	18	0	0	1	0.0	0.0	0.0	0.0	0.0	0	194,400	4.46
10/6/1973	17.0	17.0	10.0	18	0	0	1	7.0	3.0	0.0	0.0	3.0	64,800	194,400	5.95
10/7/1973	60.0	60.0	10.0	18	0	0	1	50.0	3.0	0.0	0.0	3.0	64,800	194,400	5.95
10/8/1973	33.0	33.0	10.0	12	12	0	1	23.0	3.0	0.0	0.0	3.0	129,600	129,600	5.95
10/9/1973	21.0	21.0	10.0	12	12	0	1	11.0	3.0	0.0	0.0	3.0	129,600	129,600	5.95

10/1/73 – flow of 7.6 cfs – must bypass 10 cfs when tide =<2’ so only pump when tide >2’. Tide >2’ for 18 hours so 7.6 * 3600 (seconds/hour) * 18 = 194,400 CF or 4.46 AF

10/8/73 – flow of 33 cfs – must bypass 10 cfs when tide =<2’ but still have 23 cfs available when tide >2’. Tide <2’ for 12 hours. Can only pump 3 cfs max, so 3 * 3600 (seconds/hour) * 12 = 129,600 CF. Will also pump 3 cfs for 12 hours that tide is >=2’ so another 129,600 CF. The sum is 259,200 CF, or 5.95 AF, which is our current daily maximum.

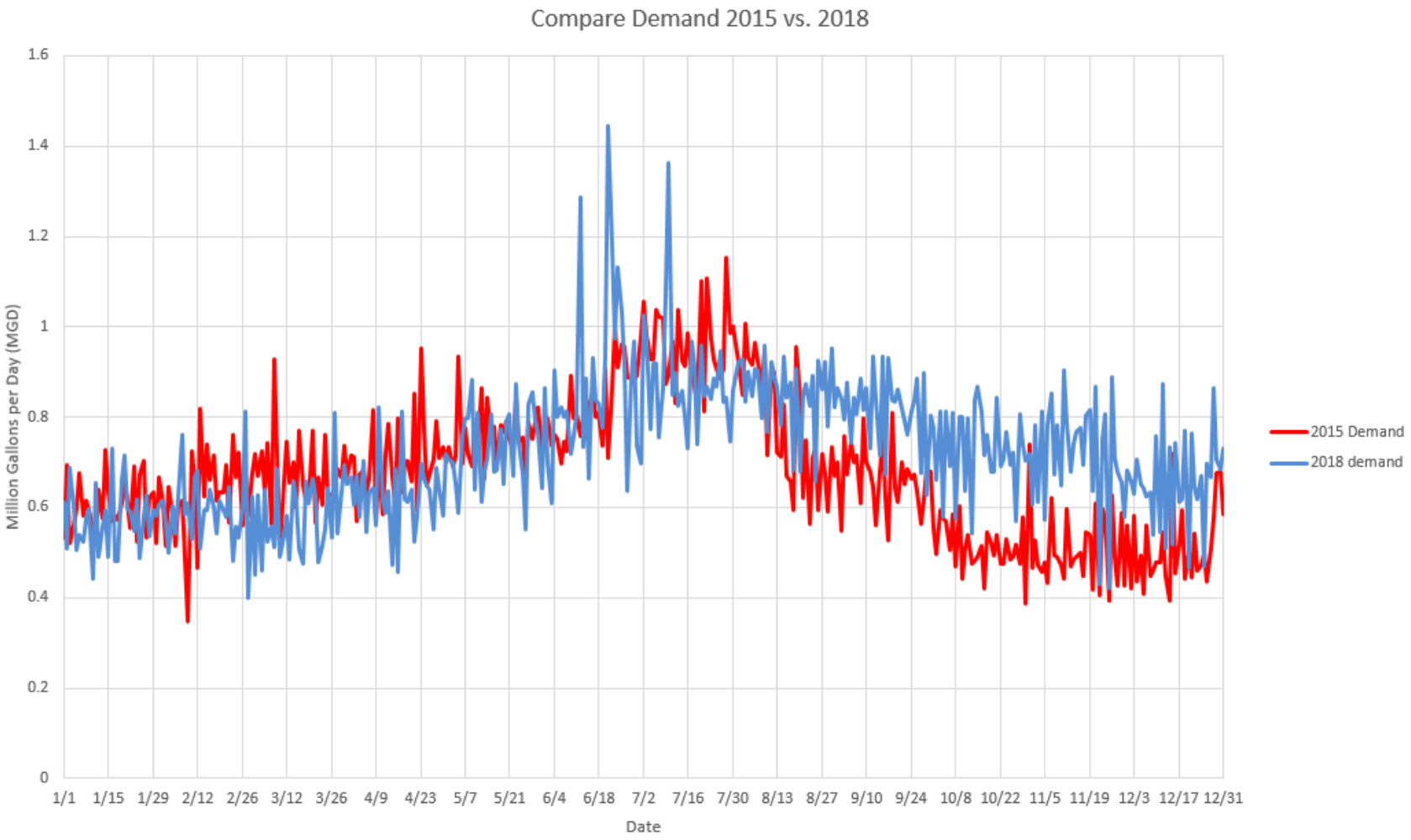
Historic Noyo flow and daily intake calculations - Summer

DAY	NOYO FLOW		AMOUNT TO LEAVE IN NOYO	TIDES (TIME >2')	TIDES (TIME >5')	TIDES (TIME >6.7')	CHECK IF NOYO PUMPING POSSIBLE BASED ON QUALITY								NOYO RESTRICTED BY TIDES
Period for model is water years 1974 - 2013; this period encompasses most recent drought periods	From USGS 11468500 Noyo R. Near Fort Bragg; flow reduced at choice of user (column G) **Yellow is revised per USGS, the following BOLD data was added**			Tide data from CeNCOOS, Fort Bragg Landing Station; hours/day tides >2' estimated from tide data	Tide data from CeNCOOS, Fort Bragg Landing Station; hours/day tides >5' estimated from tide data	Tide data from CeNCOOS, Fort Bragg Landing Station; hours/day tides >6.7' estimated from tide data	If tide is >5' at any time during the day and flow is < 1 OR if tide >6.7' and flow is < 2.5 cfs, then Noyo offline (0 = offline, 1 = ok to pump)	Manage flows in winter with bypass, Tide <2' 10 cfs bypass required	Constrain to max 3 CFS	Manage flows in summer with bypass, Tide <2' - 3 cfs bypass required	Constrain to max 3 CFS	Flow rate when tide ≤2' (sum of previous 2 constrained)	Total available flow during tide ≤2'	Total available flow when tide >2'	Total Noyo flow for 24 hour period (sum of below and above 2' tide in AF) MAX 5.95
	CFS	CFS	CFS	HRS	HRS	HRS	0=King Tide	CFS	CFS	CFS	CFS	CFS	CF	CF	AF
9/8/1977	0.8	0.8	3.0	18	6	0	0	0.0	0.0	0.0	0.0	0.0	0	0	0.00
9/9/1977	1.5	1.5	3.0	18	6	0	1	0.0	0.0	0.0	0.0	0.0	0	97,200	2.23
9/10/1977	0.8	0.8	3.0	18	6	0	0	0.0	0.0	0.0	0.0	0.0	0	0	0.00
9/11/1977	1.3	1.3	3.0	12	12	0	1	0.0	0.0	0.0	0.0	0.0	0	56,160	1.29
9/12/1977	0.9	0.9	3.0	12	12	0	0	0.0	0.0	0.0	0.0	0.0	0	0	0.00
9/13/1977	1.0	1.0	3.0	8	8	0	1	0.0	0.0	0.0	0.0	0.0	0	28,800	0.66
9/14/1977	1.5	1.5	3.0	12	12	0	1	0.0	0.0	0.0	0.0	0.0	0	64,800	1.49
9/15/1977	1.3	1.3	3.0	12	12	0	1	0.0	0.0	0.0	0.0	0.0	0	56,160	1.29
9/16/1977	2.0	2.0	3.0	12	12	0	1	0.0	0.0	0.0	0.0	0.0	0	86,400	1.98
9/17/1977	2.8	2.8	3.0	12	6	0	1	0.0	0.0	0.0	0.0	0.0	0	120,960	2.78
9/18/1977	4.5	4.5	3.0	18	6	0	1	0.0	0.0	1.5	1.5	1.5	32,400	194,400	5.21
9/19/1977	19.0	19.0	3.0	18	6	0	1	0.0	0.0	16.0	3.0	3.0	64,800	194,400	5.95
9/20/1977	17.0	17.0	3.0	24	8	0	1	0.0	0.0	14.0	3.0	3.0	0	259,200	5.95

9/8/77 – flow of 0.8 cfs – but have King Tide (Tide>6.7', flow<3cfs) so the model neglects the entire day.

19/11/77 – flow of 1.3 cfs – must bypass 3 cfs when tide =<2' so only pump when tide >2'. Tide >2' for 12 hours so 1.3 * 3600 (seconds/hour) * 12 = 56,160 CF or 1.29 AF

9/18/77 – flow of 4.5 cfs – must bypass 3 cfs when tide =<2' but still have 1.5 cfs available when tide <=2'. Tide <=2' for 6 hours so 1.5 * 3600 (seconds/hour) * 6 = 32,400 CF. Will also pump 3 cfs for 18 hours that tide is >=2' so another 194,400 CF. The sum is 226,800 CF, or 5.21 AF.


Compare Demand 2015 vs. 2018
Million Gallons per Day (MGD)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1/1 1/15 1/29 2/12 2/26 3/12 3/26 4/9 4/23 5/7 5/21 6/4 6/18 7/2 7/16 7/30 8/13 8/27 9/10 9/24 10/8 10/22 11/5 11/19 12/3 12/17 12/31
Date
2015 Demand
2018 demand

Example run with Summers Lane Reservoir

Calcs Tab

Day	Beginning Volume	City Demand	Newman	REVISED NEWMAN	REVISED WATERFALL	REVISED NOYO	Summers Withdrawl (if used)	FINAL ENDING VOLUME	Daily Flow	Ending Volume	Ending Volume	Water Alert?	Sum of inflows	Water Alert criteria
	(AF)	(AF/DAY)	(AF/DAY)	AF/DAY	(AF/DAY)	(AF/DAY)	(AF/DAY)	(AF/DAY)	AF/DAY		(AF)		(AF)	(AF)
	From end of previous day	From Data sheet - converted to af/day - multiplied by growth factor if used	From Data sheet, converted to af/day, reduced by User Input %	NOT TO EXCEED FLOW OF 0.99 AF/DAY	From Data sheet, converted to af/day - reduced by chosen %, less amount to remain	From Data sheet Diane Calc (Max 5.95 AF)	Amount to be drawn from reservoir if needed (when used)	Final Ending Volume	daily inflow less demand	Beginning volume - city + total inflow - NO RESERVOIR	Beginning volume - city + total inflow - WHEN USING RESERVOIR	Water Alert 1=yes , 0 if not	Sum of Waterfall+ Noyo+Newman Max 8.265 AF	Water Alert Criteria (90% of inflow)
7/31/2015	64.6	3.0	1.8	0.990	0.56	3.21	0.00	64.6	1.80	0.0	64.6	0.0	4.75	4.3
8/1/2015	64.6	2.8	1.4	0.990	0.55	3.15	0.00	64.6	1.86	0.0	64.6	0.0	4.70	4.2
8/2/2015	64.6	2.6	1.4	0.990	0.55	1.91	0.00	64.6	0.84	0.0	64.6	0.0	3.45	3.1
8/3/2015	64.6	3.1	1.4	0.990	0.55	2.07	0.00	64.6	0.52	0.0	64.6	0.0	3.61	3.2
8/4/2015	64.6	2.9	1.4	0.990	0.55	2.13	0.00	64.6	0.82	0.0	64.6	0.0	3.67	3.3
8/5/2015	64.6	2.8	1.4	0.990	0.55	0.00	1.27	63.3	-1.27	0.0	63.3	1.0	1.54	1.4
8/6/2015	63.3	3.0	1.4	0.990	0.55	0.00	1.42	61.9	-1.42	0.0	61.9	1.0	1.54	1.4
8/7/2015	61.9	2.8	1.4	0.990	0.55	0.00	1.30	60.6	-1.30	0.0	60.6	1.0	1.54	1.4
8/8/2015	60.6	2.7	1.4	0.990	0.55	0.00	1.13	59.5	-1.13	0.0	59.5	1.0	1.54	1.4
8/9/2015	59.5	2.9	1.4	0.990	0.55	3.19	0.00	61.3	1.84	0.0	61.3	0.0	4.73	4.3
8/10/2015	61.3	2.2	1.4	0.990	0.55	3.12	0.00	63.8	2.47	0.0	63.8	0.0	4.66	4.2

Data Tab

DAY	NOYO FLOW	AMOUNT TO LEAVE IN NOYO	TIDES (TIME >2')	TIDES (TIME >5')	TIDES (TIME >6.7')	CHECK IF NOYO PUMPING POSSIBLE BASED ON QUALITY								NOYO RESTRICTED BY TIDES
Period for model is water years 1974 - 2013; this period encompasses most recent drought periods	From USGS 11468500 Noyo R. Near Fort Bragg; flow reduced at choice of user (column G) **Yellow is revised per USGS, the following BOLD data was added**		Tide data from CeNCOOS, Fort Bragg Landing Station; hours/day tides >2' estimated from tide data	Tide data from CeNCOOS, Fort Bragg Landing Station; hours/day tides >5' estimated from tide data	Tide data from CeNCOOS, Fort Bragg Landing Station; hours/day tides >6.7' estimated from tide data	If tide is >5' at any time during the day and flow is < 1 OR if tide >6.7' and flow is < 2.5 cfs, then Noyo offline (0 = offline, 1 = ok to pump)	Manage flows in winter with bypass, Tide <2' 10 cfs bypass required	Constrain to max 3 CFS	Manage flows in summer with bypass, Tide <2' - 3 cfs bypass required	Constrain to max 3 CFS	Flow rate when tide ≤2' (sum of previous 2 constrained)	Total available flow during tide ≤2'	Total available flow when tide >2'	Total Noyo flow for 24 hour period (sum of below and above 2' tide in AF) MAX 5.95
	CFS	CFS	CFS	HRS	HRS	HRS	0=King Tide	CFS	CFS	CFS	CFS	CFS	CF	CF	AF
7/31/2015	2.14	2.1	3.0	18.1	12.5	0.0	1	0.0	0.0	0.0	0.0	0.0	0	139,699	3.21
8/1/2015	2.06	2.1	3.0	18.5	6.9	0.0	1	0.0	0.0	0.0	0.0	0.0	0	137,320	3.15
8/2/2015	1.99	2.0	3.0	11.6	11.6	0.0	1	0.0	0.0	0.0	0.0	0.0	0	82,983	1.91
8/3/2015	1.99	2.0	3.0	12.6	12.6	0.0	1	0.0	0.0	0.0	0.0	0.0	0	90,028	2.07
8/4/2015	2.05	2.1	3.0	12.5	12.5	0.0	1	0.0	0.0	0.0	0.0	0.0	0	92,619	2.13
8/5/2015	2.15	2.2	3.0	12.5	12.5	6.2	0	0.0	0.0	0.0	0.0	0.0	0	0	0.00
8/6/2015	2.15	2.2	3.0	12.5	12.5	6.1	0	0.0	0.0	0.0	0.0	0.0	0	0	0.00
8/7/2015	2.19	2.2	3.0	6.0	6.0	6.0	0	0.0	0.0	0.0	0.0	0.0	0	0	0.00
8/8/2015	2.26	2.3	3.0	17.7	12.5	5.9	0	0.0	0.0	0.0	0.0	0.0	0	0	0.00
8/9/2015	2.19	2.2	3.0	17.6	12.5	0.0	1	0.0	0.0	0.0	0.0	0.0	0	138,890	3.19
8/10/2015	2.15	2.2	3.0	17.6	5.8	0.0	1	0.0	0.0	0.0	0.0	0.0	0	135,966	3.12

Ground truth - Fall of 2015 without Summers Lane, 100% of Waterfall Gulch

Storage without Summers Lane is 20.25 AF. An 11% drawdown equates to a volume of 18.0 AF.

We hit the Stage 1 criteria on 8/7 with a low of 17.9 AF. Storage is full again from 8/11-8/22. We hit another low of 19.2 AF on 8/25. Storage is full again from 8/26-9/2. A low of 17.9 AF is encountered on 9/7. Storage is full again 9/9-9/21. A low of 18.9 is encountered on 9/24. Storage is full again 9/25-9/30. A low of 18.0 is encountered on 10/6. Storage is full again 10/8-10/18. A low of 19.1 is encountered on 10/23. Storage is full again on 10/24.

If the model was set up to determine the Stage 1 automatically, it would have counted 6 days at Stage 1. If the City declared Stage 1 on the first day we hit the 18 AF (8/7), and continue until there were no more days below 18 AF for the year (10/7), Stage 1 would have been declared for 61 days (from 8/7-10/6)

The City declared a Stage 1 water emergency at City Council on 8/10/2015. Stage 3 was declared at City Council on 9/30. On 10/26 Council issued the non-emergency water conservation ordinance. On 11/9 City Council resolution confirmed the continued existence of a local drought emergency. On 11/23 the Stage 3 was lowered to a Stage 1 or Stage 2. The Water Workshop was held on 1/5/2016. On 1/25 a new water conservation ordinance was passed, and we reconfirmed a drought emergency monthly throughout 2016.