TO: BOARD OF DIRECTORS

FROM: MARIO E. IGLESIAS
GENERAL MANAGER

DATE: JULY 6, 2017

AGENDA ITEM
E-2
JULY 12, 2017

CONSIDER APPROVING CONTRACT AMENDMENT WITH MKN & ASSOCIATES TO AMEND BLACKLAKE SEWER MASTER PLAN TO INCLUDE A COMPREHENSIVE EVALUATION OF THE SEWER REGIONALIZATION STRATEGY

ITEM

Consider amending the scope of the Blacklake Sewer Master Plan ("Master Plan") to include a more comprehensive cost analysis of regionalizing the Blacklake Sewer System with the Town Sewer System and amend contract with MKN & Associates by $16,640 [RECOMMEND AMEND CONTRACT WITH MKN & ASSOCIATES BY $16,640 TO EXPAND THE BLACKLAKE SEWER MASTER PLAN TO INCLUDE THE EVALUATION OF A REGIONALIZATION STRATEGY]

BACKGROUND

The District first started work on the current Blacklake Sewer Master Plan ("Master Plan") in 2013 to evaluate the needs of the Water Reclamation Facility ("WRF") and collection system that serve the Blacklake community ("Community"). A master plan serves as a planning tool that evaluates future infrastructure needs relating to growth – establishing pipe sizes and treatment plant expansion needs – and a master plan can serve as an assessment tool that evaluates the life-cycle of each major component for the purpose of planning component replacement. Above all, a master plan is a forward looking document that, when used accordingly, aids administration and operation efforts in getting the most cost efficient use out of each system component.

The previous master plan for the Blacklake sewer enterprise was completed in 2007 and identified ageing infrastructure components that require additional investment to maintain and operate the WRF. A five-year rate study was completed shortly thereafter to define the resource needs and developed rates to meet those needs. It is industry practice to include an infrastructure assessment through the master plan process every 3 to 5 years.

The 2013 Master Plan effort was delayed due to cost concerns expressed by the Community and the need for Nipomo Community Services District ("NCSD") to focus on completing phase one of the Nipomo Supplemental Water Project. A concerted effort by the District to complete the Master Plan began again in 2016. A public draft was provided to the Blacklake Facilities Committee ("Committee") for review and comment in January 2017. Since that time NCSD staff has been working with the Blacklake Facilities Committee to share the Master Plan findings and explore options for providing the most efficient, cost effective sewer service to the Community.

At the NCSD April 2017 meeting with the Committee, members expressed a desire to gain a greater understanding of the regionalization strategy, an option described in the drafted Master Plan. While there are many alternative ideas identified in the Master Plan that provide the Community with some level of benefit, the idea of regionalizing the sewer systems by

combining the Blacklake Sewer WRF with the Southland Wastewater Treatment Plant ("WWTP") appealed to a majority of Committee members. Committee members were concerned that the regionalization strategy costs outlined in the Master Plan were not developed to the extent necessary for them to make an informed decision. There was consensus that the option to maintaining two separate systems was sufficient, but more information on the regionalization strategy cost was necessary.

To establish a level of confidence in the regionalization strategy cost estimate MKN & Associates will need to expand the scope of the Master Plan to further refine the costs associated with the option.

FISCAL IMPACT

The Blacklake enterprise has committed approximately $90,000 over four years towards completing the Master Plan. The additional $16,640 will bring the cost of the Master Plant to $106,640. The additional funding will come from the Blacklake enterprise funded replacement, Fund 830.

STRATEGIC PLAN

Goal 2. FACILITIES THAT ARE RELIABLE, ENVIRONMENTALLY SENSIBLE AND FFICIENT. Plan, provide for and maintain District facilities and other physical assets to achieve reliable, environmentally sensible, and efficient District operations.

2.2 Manage the collection system with the objective of zero spills and zero permit violations.

RECOMMENDATION

It is recommended that your Honorable Board consider amending the scope of the Blacklake Master Plan to include an in depth review of a regionalization strategy discussed therein, and to amend MKN & Associates' contract in the order of $16,640 to expand the scope of the Master Plan to more fully develop the regionalization strategy costs.

ATTACHMENTS

A. MKN & Associates Proposal

July 12, 2017

ITEM E-2

ATTACHMENT A

MKN & Associates, Inc.
PO Box 1604
Arroyo Grande, CA 93421
805-904-6530

June 23, 2017

Mario Iglesias
General Manager
Nipomo Community Services District
148 South Wilson
Nipomo, CA 93444
(Submitted Electronically)

RE: Proposal for Expanded Blacklake Wastewater Regionalization Evaluation

Dear Mario,

PROJECT UNDERSTANDING

Michael K. Nunley & Associates, Inc. (MKN) is pleased to provide this proposal to the Nipomo Community Services District (District) to complete an expanded evaluation to regionalize wastewater treatment at the Southland Wastewater Treatment Facility (WWTF). Regionalization was described in the Draft May 2017 Blacklake Sewer Master Plan (Master Plan) as an alternative to continuing operation of the Blacklake Water Reclamation Facility (WRF). The regionalization alternative consists of decommissioning the Blacklake WRF and installing a sewage lift station and force main to convey wastewater from the Blacklake area to the Town wastewater collection system, and gravity flow to the Southland WWTF for treatment and disposal. The Draft Blacklake Sewer Master Plan estimated potential savings over a 20-year life cycle of $2.5M for the regionalization alternative. The District is interested in further developing the regionalization concept and costs for Blacklake to present the alternatives to the community prior to completion of the Master Plan.

SCOPE OF WORK

Task Group 100 – Water Usage and Wastewater Flow Update

To present historical and current water usage/wastewater flow trends within the Blacklake development for the Master Plan, MKN will obtain water billing data and effluent flow data for the Blacklake WRF from the District for 2013 through 2016. Relevant tables throughout the Master Plan will be updated using this information. Updated flow information will be reviewed against estimated flow rates utilized throughout the Master Plan analyses. At this time, it is anticipated that the current flows will be similar or less than the flows used in the Master Plan, and the assessments will not need to be updated (sizing, capacity analyses, etc.).

Task Group 200 – Expanded Blacklake Regionalization Evaluation

To more fully develop the regionalization concept and associated capital improvement costs within the Master Plan, MKN will complete the following tasks:

- Prepare a summary of the recommended Blacklake capital improvement projects (described in the Master Plan), delineating which projects should occur before regionalization, which would occur after, and which would be obsolete;
- Develop a schedule for implementation of improvements for the regionalization alternative (permitting, design, construction);
- Develop repair and replacement reserve recommendations for the Blacklake sewer collection system, including anticipated life remaining for major components and recommended annual reserves to address replacements and repairs; and
- Provide recommendation for connection fee based on repair, replacement, and capital improvements required for ongoing maintenance of the collection system and participation in the Southland WWTF

Task Group 300 – Address Comments on Public Draft

MKN will review and revise the May 2017 Draft Master Plan based on comments provided by the District. Based on an initial review of the comments, MKN assumes that the majority of the report will remain unchanged and that additional clarification will be included as part of the Master Plan's Executive Summary.

Task Group 400 – Preparation of Draft Final and Final Sewer Master Plan

A Draft Final Master Plan will be compiled with the additional evaluation and information described in Task Groups 100 to 300. District staff will be provided with three (3) hard copies and an electronic copy in PDF format for review. After a consolidated set of comments from District staff and the Facilities/ Water Resources Committee are received, MKN will provide a revised Draft Final Master Plan (including three (3) hard copies and a PDF) for the District's final review prior to presenting to the Board.

MKN will present an overview of the findings and recommendations of the Draft Final Master Plan at a regularly scheduled District Board meeting. Comments on the Draft Final will be integrated into the Final Master Plan. Six (6) hard copies and a PDF of the Final Master Plan will be provided.

Task Group 500 – Meetings

MKN anticipates the following meetings for this project:

- Draft Final review meeting with District staff and/or Committee
- Draft Final Presentation to the Board

FEE AND SCHEDULE

The anticipated report schedule is summarized in the table below. It assumes a District review period of two weeks between the draft and final submittal.

Task	Weeks from Notice-to-Proceed
Receipt of water usage for Blacklake customers and wastewater flows for Blacklake WRF (2013 -2016)	1 week
Expanded Blacklake Regionalization Evaluation	4 weeks

Draft Final Sewer Master Plan	7 weeks
Draft Final Review Meeting	9 weeks
Revised Draft Final Sewer Master Plan	12 weeks
Board Presentation	TBD

MKN proposes to complete this project on a time and materials basis, with a total budget that will not be exceeded without written authorization from the District. The budget is summarized below and a detailed breakdown is provided in the attached spreadsheet.

Project Task	Proposed Fee
Task Group 100 – Water Usage and Wastewater Flow Update	$1,540
Task Group 200 – Expanded Blacklake Regionalization Evaluation	$5,490
Task Group 300 – Address Comments on Public Draft	$2,160
Task Group 400 – Preparation of Draft Final and Final Sewer Master Plan	$5,880
Task Group 500 – Meetings	$1,570
Total Budget	**$16,640**

Thank you for providing Michael K. Nunley and Associates with the opportunity to provide professional engineering services for your project. If you have any questions regarding this proposal, please contact me at eshields@mknassociates.us or by phone at (805) 904-6530 x105.

Sincerely,

Eileen Shields, PE
Principal Engineer

CC: Peter Sevcik, PE

Attachments:

Budget Worksheet
Fee Schedule

Budget for Expanded Blacklake Wastewater Regionalization Evaluation

	Principal Engineer	Project Engineer	Water Resources Planner	Assistant Engineer	Administrative Assistant	Total Hours	ODCs	Total Labor	**Total Cost**
Task Group 100 – Water Usage and Wastewater Flow Update									
Present Current Water Usage and Wastewater Flows	0	0	4	8	0	12	$ -	$ 1,540	**$ 1,540**
Subtotal	**0**	**0**	**4**	**8**	**0**	**12**	**$ -**	**$ 1,540**	**$ 1,540**
Task Group 200 – Expanded Blacklake Regionalization Evaluation									
Expanded Blacklake Regionalization Evaluation	4	0	16	8	0	28	$ -	$ 3,860	**$ 3,860**
Schedule and Updated CIP Costs	6	4	0	0	0	10	$ -	$ 1,630	**$ 1,630**
Subtotal	**10**	**4**	**16**	**8**	**0**	**38**	**$ -**	**$ 5,490**	**$ 5,490**
Task Group 300 – Address Comments on Public Draft									
Address Comments on Public Draft (as provided by NCSD)	2	0	6	8	0	16	$ -	$ 2,160	**$ 2,160**
Subtotal	**2**	**0**	**6**	**8**	**0**	**16**	**$ -**	**$ 2,160**	**$ 2,160**
Task Group 400 – Preparation of Draft Final and Final Sewer Master Plan									
Draft Final Master Plan Preparation	2	4	16	0	2	24	$ 150	$ 3,200	**$ 3,350**
Revised Draft Final Master Plan Preparation	4	0	0	0	2	6	$ 150	$ 810	**$ 960**
Final Master Plan Preparation	2	0	6	0	2	10	$ 300	$ 1,270	**$ 1,570**
Subtotal	**8**	**4**	**22**	**0**	**6**	**40**	**$ 600**	**$ 5,280**	**$ 5,880**
Task Group 500 – Meetings									
Draft Final review meeting with District staff and/or Committee	2	0	2	0	0	4	$ 30	$ 620	**$ 650**
Draft Final Presentation to the Board	2	0	4	0	0	6	$ 30	$ 890	**$ 920**
Subtotal	**4**	**0**	**6**	**0**	**0**	**10**	**$ 60**	**$ 1,510**	**$ 1,570**
TOTAL BUDGET	**24**	**8**	**54**	**24**	**6**	**116**	**$ 660**	**$ 15,980**	**$ 16,640**

Billing Rates	**$/hr**
Principal Engineer	175
Project Engineer	145
Water Resources Planner	135
Assistant Engineer	125
Administrative Assistant	55

Mileage to be reimbursed at IRS rate

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TO: BOARD OF DIRECTORS

FROM: MARIO E. IGLESIAS
GENERAL MANAGER

DATE: JULY 6, 2017

AGENDA ITEM
E-3
JULY 12, 2017

RECEIVE AND DISCUSS REPORT ON KEY WELL INDEX FROM DISTRICT'S GEO-HYDROLOGIST AND CONSIDER POSSIBLE ACTIONS UNDER STAGE IV OF THE DISTRICT'S WATER SHORTAGE RESPONSE AND MANAGEMENT PLAN

ITEM

Receive and discuss report on Key Wells Index (KWI) and consider possible actions under Stage IV of the District's Water Shortage Response and Management Plan [RECOMMEND RECEIVE REPORT, REVIEW AND TAKE PUBLIC COMMENT, AND CONSIDER NEED FOR POSSIBLE ACTIONS UNDER THE DISTRICT'S WATER SHORTAGE RESPONSE AND MANAGEMENT PLAN]

BACKGROUND

The Nipomo Mesa Management Area Technical Group ("NMMA") released the KWI on June 23, 2017 [Attachment A]. With the KWI level remaining in Severe Criterion, Stage IV actions from the NMMA Water Shortage Response Plan [Attachment B] and the Nipomo Community Services District ("District") Water Shortage Response and Management Plan ("WSRMP") [Attachment C] remain in effect.

With the above average rainfall amounts experienced on the Nipomo Mesa last winter, there was an expectation by the District that the KWI would respond and improve measurably. And with the majority of the State of California declaring an end to the drought, District customer's shared that expectation.

The District's Geo-Hydrologist presentation [Attachment D] attempts to explain why the KWI responded as it did. While the Nipomo Mesa water purveyors are subject to the NMMA endorsed Water Shortage Response Plan the actions needed to reach the conservation objective is descresionary. Your Board can review the actions outlined in its WSRMP and consider if additional actions should be taken or if there are current actions that can be altered. The WSRMP was drafted prior to the Nipomo Supplemental Water Project ("NSWP") was completed, so there may be opportunities for the NSWP to provide additional options.

FISCAL IMPACT

There is a significant impact of the District's ability to raise funds to complete the NSWP with the restrictions on issuing new service connections. Remaining in Stage IV of the WSRMP will require continued water conservation in the community and will put pressure on water sales revenue.

STRATEGIC PLAN

Goal 1. WATER SUPPLIES. Actively plan to provide reliable water supply of sufficient quality and quantity to serve both current customers and those in the long-term future.

RECOMMENDATION

It is recommended that your Board receive the report, take public comment and discuss possible actions in response to remaining at Stage IV of the District's WSRMP.

ATTACHMENTS

A. NMMA Key Wells Index Press Release
B. NMMA Water Shortage Response Plan Table
C. Nipomo Community Services District WSRMP Table
D. Dr. Newton's Key Wells Index Presentation

July 12, 2017

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ATTACHMENT A

Nipomo Mesa Management Area 2017 Key Wells Index

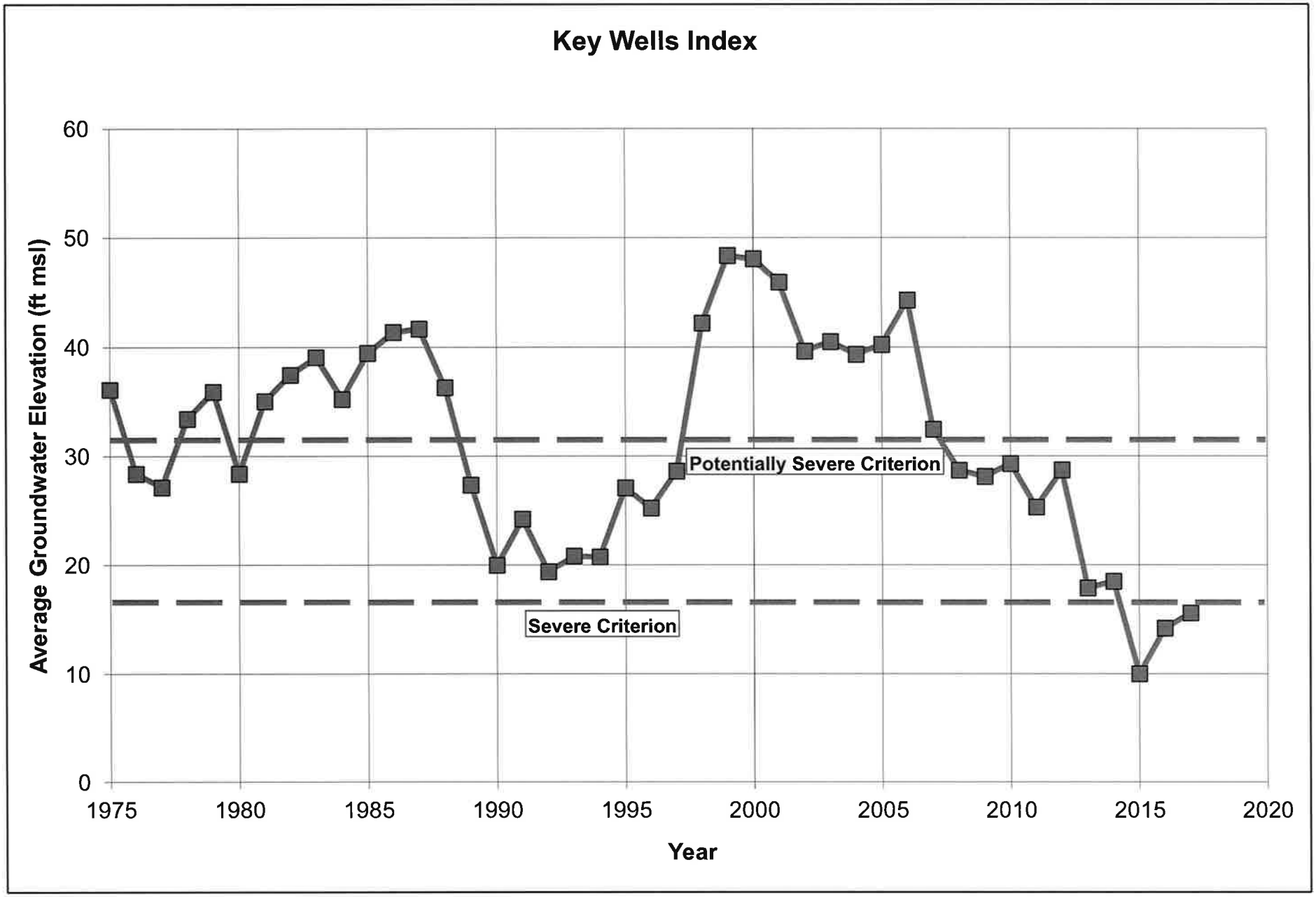
Severe Water Shortage Conditions

The Nipomo Mesa Management Area ("NMMA") Technical Group ("TG") established groundwater level and groundwater quality criteria to track overall basin conditions within the NMMA. The criteria include the Key Wells Index ("KWI"), which combines groundwater level data from eight selected wells distributed throughout the inland portion of the Management Area. Water level measurements are made in NMMA groundwater wells representing the basin as a whole and are used to compute the KWI during the spring of each year.

The TG uses the KWI to help identify trends in basin groundwater levels and has compiled KWI data for the period from 1975 to the present. Groundwater levels have changed in the NMMA over time, and in the last five years are at levels that are lower than at any other time from 1975 (Figure 1).

One of the NMMA TG's court-required duties is to determine when conditions of "Potentially Severe Water Shortage Conditions" or "Severe Water Shortage Conditions" have been reached. The 2017 KWI value (15.6 ft msl) has increased from the previous year (14.2 ft msl) but remains within the Severe Water Shortage Condition (16.5 ft msl). This is the third consecutive year the KWI value is in Severe Water Shortage Condition and therefore signifies a Stage V NMMA Water Shortage Response.

Details of the KWI, as well as the agreed upon responses to Potentially Severe Water Shortage Condition and Severe Water Shortage Condition, are explained in further detail in the NMMA TG's annual report of groundwater conditions. The report's attachments include a response plan to groundwater shortage and an associated well management plan, including the NMMA Water Shortage Response Stages. The NMMA annual report for calendar year 2015, including these attachments, is available as a digital document at http://www.scefiling.org/filingdocs/19763/97302/240182e_8thxAnnualxReportxxxCalendarxYearx2015.pdf.


Key Wells Index
Average Groundwater Elevation (ft msl)
60
50
40
30
20
10
0
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Year
Potentially Severe Criterion
Severe Criterion

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ATTACHMENT B

NMMA WATER SHORTAGE RESPONSE STAGES

Endorsed by NMMA Technical Group April 14, 2014

STAGE	GROUNDWATER SUPPLY CONDITION	RESPONSE - GENERAL DESCRIPTION*	DURATION of RESTRICTION
I	Always in place.	Voluntary measures and outreach to encourage best water management practices and conservation.	Always in place.
II	Potentially Severe Water Shortage Condition declaration pursuant to NMMA Water Shortage Condition and Response Plan.	Goal: voluntary 20% reduction in groundwater production – supported with aggressive public outreach and customer communications.	Until Potentially Severe Water Shortage Condition does not exist.
III	Severe Water Shortage Condition declaration pursuant to NMMA Water Shortage Condition and Response Plan.	Goal: 30% reduction in groundwater production – supported with mandatory conservation restrictions.	Until Severe Water Shortage Conditions no longer exist pursuant to NMMA criteria.**
IV	Severe Water Shortage Condition declaration pursuant to NMMA Water Shortage Condition and Response Plan, lasting more than 1 year from the initial declaration; or Severe Water Shortage declaration pursuant to NMMA declaration triggered by both the Key Well Index and the Coastal Area Criterion.	Goal: 50% reduction in groundwater production – supported with mandatory conservation restrictions.	Until Severe Water Shortage Conditions no longer exist pursuant to NMMA criteria.
V	Severe Water Shortage Condition declaration pursuant to NMMA Water Shortage Condition and Response Plan, lasting more than 2 years from the initial declaration, based on both the Key Well Index and Coastal Area Criterion.	Goal: 60% reduction in groundwater production – supported with mandatory conservation restrictions.	Until Severe Water Shortage Conditions no longer exist pursuant to NMMA criteria.

* This is a general descriptor. Detailed response to meeting the applicable goal is the responsibility of each NMMA purveyor. The NMMA parties acknowledge that Golden State Water Company and Rural Water Company must obtain CPUC approval and hold public hearings before implementing any aspect of this water shortage response.

** The Technical Group may determine Severe Water Shortage Conditions no longer exists when groundwater quality criteria threshold are no longer exceeded in a single measurement.

General Notes

1. Potentially Severe and Severe Water Shortage Conditions, Key Well Index and Coastal Area Criteria are defined in the NMMA Water Shortage Conditions Response Plan, April 13, 2009.
2. Reductions goals are to be based on average usage, prior to the delivery of supplemental water, as follows:
    a. For Woodlands Mutual Water Company – based on average same month production for a single year prior to declaration of Stage III.
    b. For Nipomo CSD, Golden State Water Company and Rural Water Company – based on average same month production for the five years prior to declaration of Stage III. Individual purveyors may use other baselines in their respective responses if dictated by their respective regulatory bodies.
3. Each NMMA purveyor will implement programs to meet the reduction levels.
4. When drought Stage III or higher is in effect, Managers will meet monthly to report previous months production and coordinate efforts.
5. The Technical Group may revisit and revise this response plan should conditions change and after the full implementation of the Nipomo Supplemental Water deliveries.

July 12, 2017

ITEM E-3

ATTACHMENT C

NCSD WATER SHORTAGE RESPONSE AND MANAGEMENT PLAN

Key Features of the Plan

	Stage I	Stage II	Stage III	Stage IV	Stage V
TRIGGER ON	No trigger	Potentially Severe Water Shortage exists	Severe Water Shortage declared	Severe Water Shortage for more than 1 year or is triggered by both Key Wells Index and Coastal Criterion	Severe Water Shortage for more than 2 years AND is triggered by both Key Wells Index and Coastal Criterion
TRIGGER OFF	**Normal usage**	Potentially Severe Water Shortage ends	Severe Water Shortage ends	Severe Water Shortage ends	Severe Water Shortage ends
TARGET REDUCTIONS					
CONSERVATION OBJECTIVE	Ongoing conservation education	More intensive education	Target 30% reduction in District ground water production	Target 50% reduction in District GW production	Target 60% reduction in District GW production
IF TARGET REDUCTIONS NOT MET (POSSIBLE ACTIONS TO REACH CONSERVATION OBJECTIVE)					
WATER RATES	Four Tier escalating	Four Tier escalating	Stage III Drought rates	Stage IV Drought rates	Stage V drought rates
CUSTOMER CONSERVATION MEASURES	• Fix plumbing and irrigation leaks • Irrigate 8PM to 9AM only. • Check irrigation systems monthly • Avoid excessive run off • Recirculate water in water features • Mandates issued by State of CA	• All Stage I Measures • Cover Swimming Pools and spas • Do not use water on exterior surfaces	• All Stage I and II measures • Turn off irrigation systems. Minimum irrigation to preserve high-value landscape. • Do not fill swimming pools or spas. Drain ornamental water features • No water for dust control, construction. • No water to wash cars or equipment	• All Stage I, II, and III measures. • No District water for irrigation or any outdoor uses. • All customers are asked to use the minimum amount of water necessary.	• All Stage I, II, and III measures. • No District water for irrigation or any outdoor uses. • All customers are asked to use the minimum amount of water necessary.
APPLICATIONS FOR WATER SERVICE	Applications are accepted and processed	Applications are accepted and processed	New applications NOT accepted. Existing applications processed with supplemental water	New applications NOT accepted. Suspend processing existing applications	New applications NOT accepted. Suspend processing existing applications
SUPPLEMENTAL WATER	Allocated to All New Projects	Allocated to All New Projects	Allocated to All New Projects	No Water Allocated to Projects in the application process.	No Water Allocated to Projects in the application process.
NEW SERVICE CONNECTIONS	New service connections are made	New service connections are made	New service connections are made	New connections Only to completed commitments	No new service connections are made

July 12, 2017

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ATTACHMENT D

TECHNICAL MEMORANDUM

TO: Mario Iglesias, General Manager NCSD

FROM: Brad Newton, Ph.D., P.G.

RE: Technical Memorandum #33 – Rainfall and Key Wells Index

DATE: July 6, 2017

INTRODUCTION

The central coast, like much of California, had an above-average amount of rain over the recent winter. While rivers and reservoirs have filled across the state, groundwater aquifers recover much slower than surface water - often years or decades. The Nipomo area received approximately 25 inches of rainfall, 155% of the average rainfall since 1975 (Figure 1). However, the Nipomo area's groundwater supply did not improve to a level sufficient to lift it out of Stage IV of the Water Shortage Response and Management Plan.

Groundwater surface elevations underlying the Nipomo Mesa are regularly measured at many places (wells) across the mesa. The Nipomo Mesa Management Area ("NMMA") Technical Group ("TG") established groundwater level and groundwater quality criteria to track overall basin conditions within the NMMA. The criteria include the Key Wells Index ("KWI"), which combines groundwater level data from eight selected wells distributed throughout the inland portion of the Management Area. Water level measurements are made in NMMA groundwater wells representing the basin as a whole and are used to compute the KWI during the spring of each year. The KWI was defined for each year from 1975 to present as the average of the normalized spring groundwater data from each of the eight wells. The lowest value of the KWI could be considered the "historical low" within the NMMA. The 2017 KWI value (15.6 feet mean sea level [ft msl]) has increased from the previous year (14.2 ft msl) but remains within the Severe Water Shortage Conditions (16.5 ft msl). This is the third consecutive year the KWI value is in Severe Water Shortage Conditions, which signifies a Stage IV NMMA Water Shortage Response (Figure 2).

The Nipomo Mesa Management Area (NMMA) Technical Group (TG) has not reviewed this technical memorandum, its findings, or any presentation of this evaluation.

BACKGROUND

In Technical Memorandum #30 - Fall 2014 Ground Water Index and Hydrologic Inventory Analysis, dated December 5, 2014 (TM#30), a water balance approach was presented that

Newton Geo-Hydrology Consulting Services
P.O. Box 2081, Santa Barbara, CA 93120 • (805) 636-6619 • bnewton@NGHcorp.com

estimates how much water is available in storage. This water balance approach inventories the hydrologic processes of rainfall that recharges groundwater and each component of the water balance was ranked by the correlation coefficient to the Ground Water Index (GWI). The GWI was shown to generally follow the same historical trends as the KWI (Figure 3). Correlation does not require a causal relationship, however in this case, where ground water elevations are the integration of these hydrologic processes, causality is implicit. The water balance equations and the correlation results were presented at the December 10, 2014 NCSD Board of Directors meeting:

Land Surface Water Balance

$$R = Ru + I_r + E,$$

$$P = I_p,$$

$$I_{tot} = I_r + I_p = R + P, \text{ when Ru and E assumed to equal zero,}$$

Soil Profile Water Balance

$$\Delta Ss = I_{tot} - CU - Re,$$

Substituting for "I_{tot}" and rearranging yields,

$$Re = R + P - CU - \Delta Ss;$$

Aquifer Water Balance

$$\Delta Sgw = Re + F_{in} - F_{out} - P,$$

Substituting for "Re",

$$\Delta Sgw = R - CU - \Delta Ss + F_{in} - F_{out},$$

Summary Water Balance

$$KWI \cong GWI \cong \Delta Sgw = R - CU - \Delta Ss + F_{in} - F_{out},$$

where:

R	= Rainfall (measured),
Ru	= Runoff (assumed zero),
E	= Evaporation from surface (assumed zero)
I_r	= Infiltration of Rainfall (calculated from water balance),
I_p	= Infiltration of Pumped Water (calculated from water balance),
CU	= Consumptive Use (calculated from land use and climate),
ΔSs	= Change in Soil Storage (calculated from I, CU, and soil properties),
Re	= Recharge (calculated from I_{tot} and ΔSs),
ΔSgw	= Change in Ground Water (calculated from water balance),

F_{in} = Ground Water Flow In (calculated from groundwater gradients and stratigraphy),

F_{out} = Ground Water Flow Out (calculated from groundwater gradients and stratigraphy),

P = Pumped Water (measured).

The results presented in the TM#30, demonstrate that the relationship between the cumulative sum of departure from the mean rainfall ($CSDM_r$) and GWI has the highest correlation coefficient, 0.713. In other words, the variation in the $CSDM_r$ explains 71% of the variation in the GWI over time. This is anticipated in this basin where groundwater is primarily replenished by rainfall. The relationship between the KWI and $CSDM_r$ is very similar to the relationship between the GWI and the $CSDM_r$. The KWI plotted along with the $CSDM_r$ shows a clear graphical correlation between the two series, although the correlation has not been quantified (Figure 4). An apparent disconnect between the correlation of the two series occurs around the year 2011. No formal evaluation of the water balance during the year 2011 has been conducted at this time.

DISCUSSION

Rainfall that infiltrates the soil surface is either stored in the soil profile until it is evaporated or transpired by overlying vegetation, or it percolates downward recharging shallow or deep groundwater aquifers. While in general, changes in groundwater elevations are correlated to rainfall variability, less frequent events like drought are not well represented in these statistics. Nonetheless, the water balance equations formalizing these hydrologic processes may be sufficient to glean insights to these less frequent events and there impacts on groundwater elevations. One of the assumptions in the analyses of general conditions is that the change in soil storage goes to zero over the long-term ($\Delta Ss = 0$), which is not necessarily true during extreme events over the short-term.

Often during a drought, soil profiles are depleted in moisture (ΔSs trend is negative) as compared to typical conditions when soil profiles hold some amount of rain water during the summer months. Following a drought, the first amount of rainfall infiltrating the soil surface replenishes the depleted soil (ΔSs trend is positive) and does not percolate downward to recharge the groundwater aquifers. Once the soil profile moisture is replenished ($\Delta Ss = 0$), any additional rain water infiltrating the soil will cause downward percolation recharging the shallow or deep groundwater aquifers. This hydrologic process regarding soil profiles depleted of moisture is analogous to a dry sponge in a kitchen sink. The first amount of water applied to

the dry sponge does not result in any drips. However, if water is continually supplied to the sponge, eventually the sponge cannot hold any additional water and the next amount of water drips out.

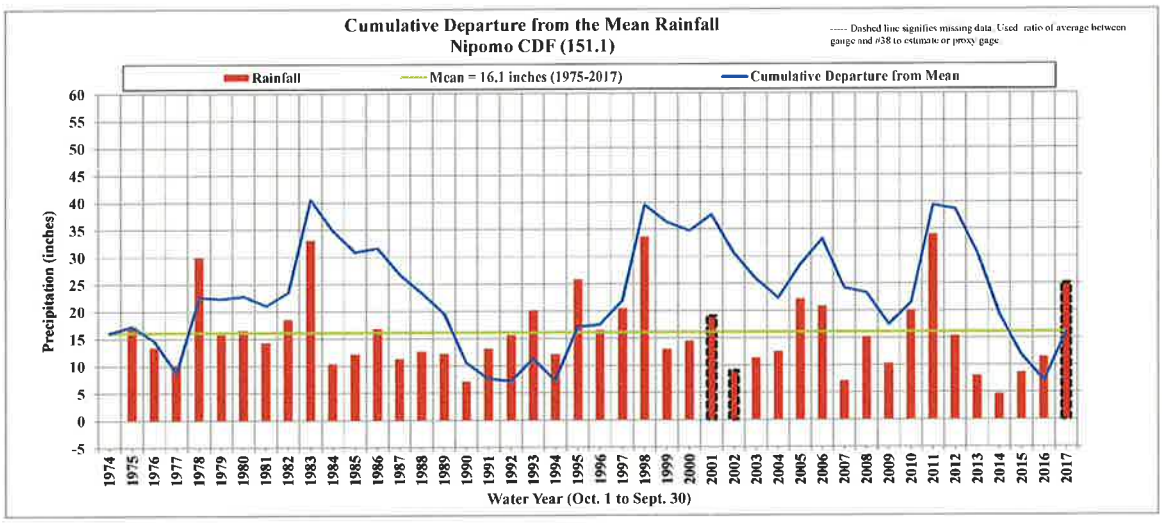


Figure 1: Annual rainfall measured at Nipomo CDF (151.1) plotted along with the cumulative sum of departure from the mean rainfall ($CSDM_r$).

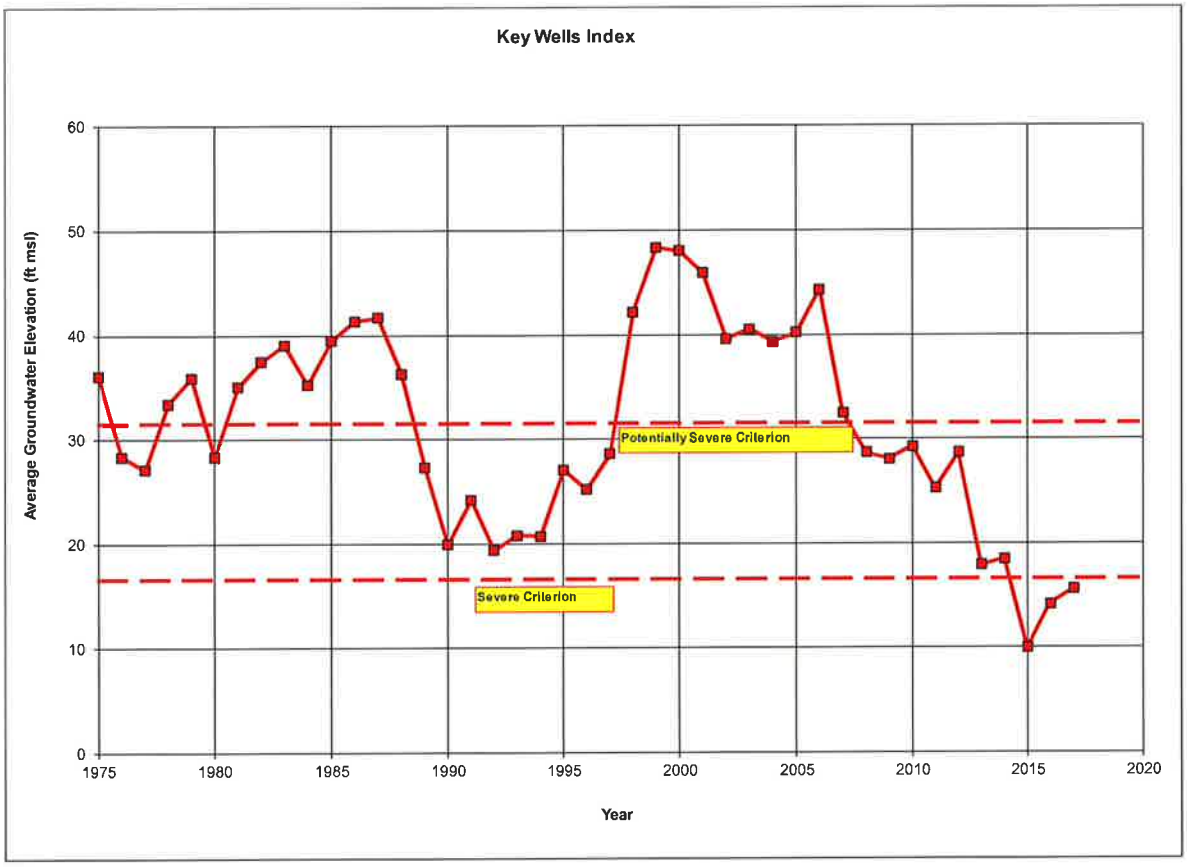


Figure 2: Key Wells Index (KWI)

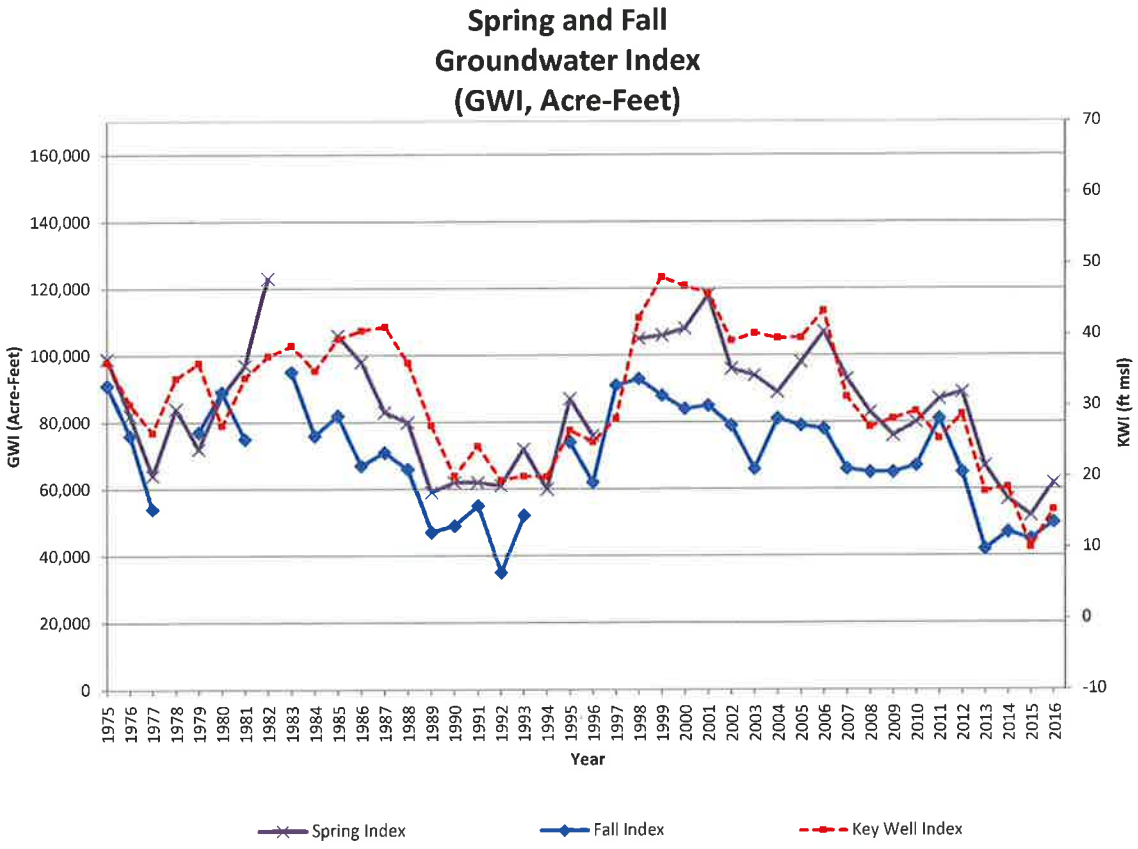


Figure 3: KWI plotted with Spring and Fall GWI

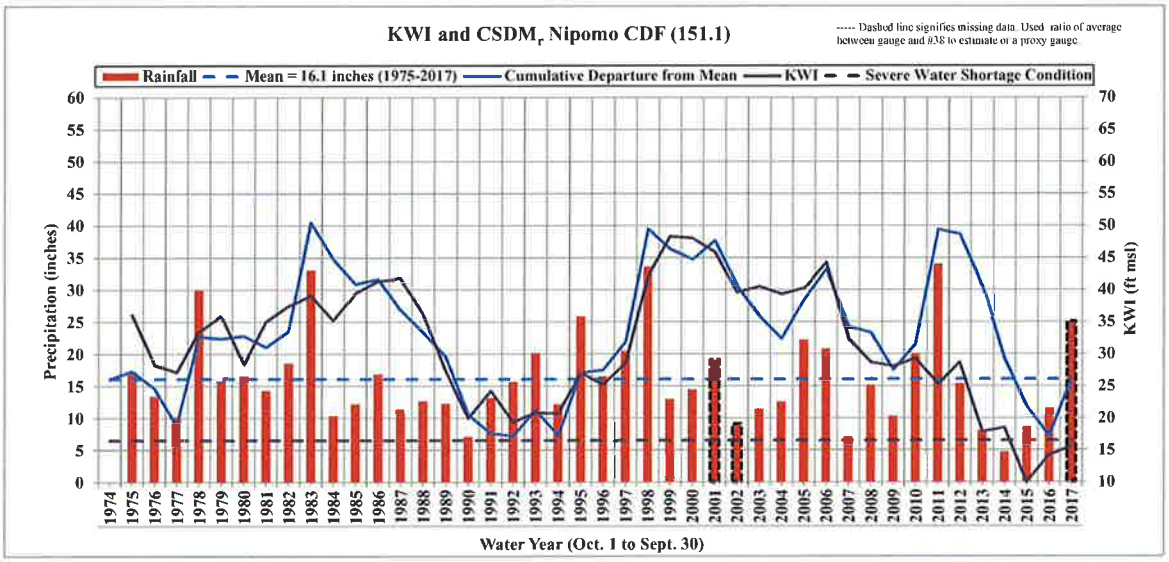
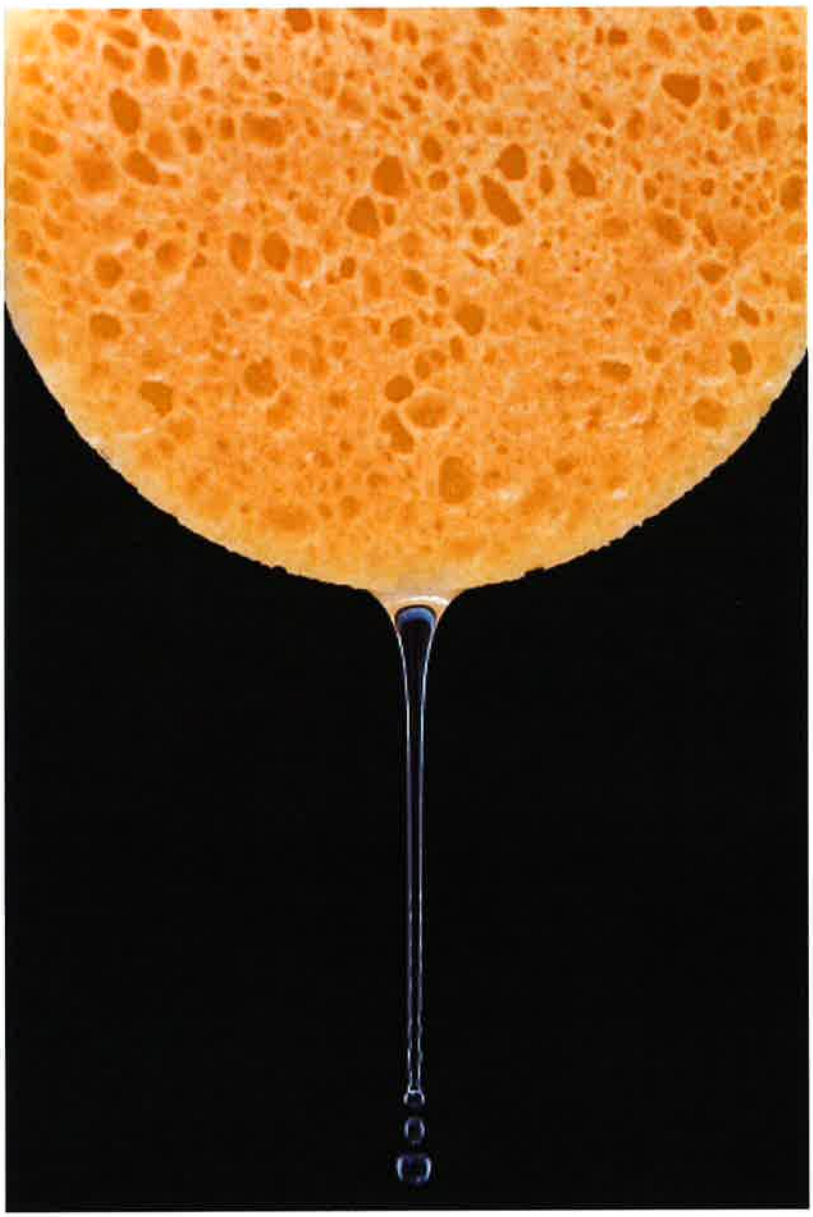


Figure 4: KWI plotted with $CSDM_r$



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