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TECHNICAL MEMORANDUM

To: Brian Deason, EID

Date: December 30, 2021

From: Greg Young
Kris Olof

Subject: Updated Main Ditch Water Loss Analysis with 2020 Data

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The purpose of this memorandum is to provide the results of an analysis performed by Tully & Young to understand and quantify the water losses associated with water conveyance in the El Dorado Irrigation District's (EID) Upper Main Ditch (Main Ditch). The document refines the analysis from a prior memorandum used to support EID's CEQA document that assessed potential environmental impacts of the proposed project to pipe the water supply that is currently conveyed through the Main Ditch (hereafter the "Project"). Additionally, the document is intended to support EID's efforts to market for transfer the water that would be conserved through implementation of the Project until it is needed to support future growth within EID's service area. This memorandum incorporates the most recent operational data from 2020.

This memo presents the detailed underlying data supporting the analysis, a general characterization of the physical operations of the Main Ditch, and the analysis method and results.

Background and Summary

The purposes of the Project are to improve water conservation by reducing system losses from the unlined Main Ditch, and to improve water quality by piping the water delivered from the El Dorado Forebay (Forebay) to the Reservoir 1 Water Treatment Plant (WTP). Because the Main Ditch is uncovered and unlined, a portion of the water conveyed through the ditch is lost to seepage and evapotranspiration and the WTP has to contend with higher turbidity influent associated with sediment and water of unknown quality entering the ditch after water is released from Forebay. The U.S. Bureau of Reclamation has noted that losses from unlined earthen canals may be estimated to be one-third of the water conveyed or more.[1]

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[1] Reclamation research project: https://www.usbr.gov/research/projects/detail.cfm?id=845

However, for the Main Ditch, losses throughout the season vary based upon the flow rate. Past flow studies conducted by EID for the Main Ditch (Attachments 1 and 2) indicate losses from the canal due to seepage range from approximately 6% to 33% based on single measurements, depending on flow rate at the time of the measurement. As documented in Attachment 1, a study from 1977, EID's analysis estimated that when conveying the full water right at 40 cfs, approximately 1,300 acre-feet would be lost annually from the Main Ditch. **Table 1** summarizes the results of estimated loss rates including recently completed analysis for 2016 through 2020 operational data. The 2018 and 2019 data includes data for one gauge (referred to a gauge A-18) that was relocated after 2017 and again replaced in the spring of 2019. 2020 data was derived from the SCADA system and from end of year summary reports.

Approach

Digital water meter data was available beginning in 2009 of recorded releases from Forebay into the Main Ditch and from the Main Ditch into the WTP inlet. The loss in this section of the ditch would typically be determined from the difference between these two values with a correction for backwash return flows ahead of the WTP inlet meter. However, this meter was found to be producing erroneous data between 2009 and 2015, which resulted in the prior WTP flow records being deemed unreliable. Prior to the start of 2016 deliveries, the WTP inlet flow meter was replaced and calibrated, assuring more reliable data going forward. Separate single-day ditch flow measurements were also taken at various flow rates over the season (Attachment 3) to supplement and calibrate, if necessary, the WTP inlet meter data. With the improved data source, electronically recorded data (hereafter "SCADA data") during 2016 became the best source for deriving loss estimates and was used for EID's 2016 Upper Main Ditch Annual Water Loss analysis (Attachment 4). In winter 2016/2017, the primary gauge at the upper end of the Main Ditch (A-18) was damaged by winter storms and was replaced and re-calibrated in spring of 2017 prior to operation for the 2017 season, which was delayed until early June due to storm damage to upstream canal conveyance facilities. A comparison of 2017 data for calibration and an estimate of 2017 and 2018 seasonal loss (Attachment 6) are summarized in **Table 1**.

Construction activites on the upper end of the Main Ditch resulted in the replacement of the A-18 gauge again in the spring of 2019 and the installation at a slightly different location than used during 2018. Additionally, the location and water conditions resulted in staff replacing the gauging equipment with a equipment better suited to the site.

Table 1 – Summary of Flow Studies

Flow Study	Flow Rate/Quantity	Loss Estimate
1977 Environmental Assessment – Ditch Flow Measurement[2] (Attachment 1)	18 cfs 40 cfs	1 cfs (6%) 5.1 (13%)
2012 Ditch Flow Measurement (Attachment 2)[3]	8.5 cfs	2.8 cfs (33%)
EID 2016 Single-Day Ditch Flow Measurement (Attachment 3)	13.08 cfs 20.76 cfs 30.92 cfs	2.25 cfs (17.2%) 4.42 cfs (21.3%) 4.5 cfs (14.6%)
EID 2016 Upper Main Ditch Annual Water Loss Analysis - Forebay to Reservoir 1 WTP (Attachment 4)	5,296 af at varying rates over period of operation 3,464 af at 20 cfs July 7 – Sept 30	1,100 af (20.8%) over period of operation 617 ac-ft (17.8%) July 7 – Sept 30
2015 Sage Engineering Ditch Modeling (Attachment 5)	20 cfs 40 cfs	0.8 to 4.2 cfs 0.8 to 4.5 cfs
EID 2017 Upper Main Ditch Annual Water Loss - Forebay to Reservoir 1 WTP (Attachment 6)	4,555 af at 20 cfs over period of operation	867 af (19%) over period of operation
EID 2018 Upper Main Ditch Annual Water Loss - Forebay to Reservoir 1 WTP (Attachment 6)	5,642 af over period of operation 1636 af at 15 cfs June 28th – Aug 21st	1,420 af (25%) over period of operation 315 af (19.2%) June 28th – Aug 21st
EID 2019 Upper Main Ditch Annual Water Loss - Forebay to Reservoir 1 WTP (Attachment 6)	4,445 af over period of operation 2,751 af at 17 cfs June 25th – Sept 14st	1,085 af (24%) over period of operation 680 af (24.7%) June 25th – Sept 14th
EID 2020 Upper Main Ditch Annual Water Loss - Forebay to Reservoir 1 WTP (Attachment 6)	Estimated 3,945 af over period of operation 1,609 af at 15cfs July 26th-Sept 17th	Estaimted 1,211 af (31%) over period of operation 442 af (27.5%) July 26th- Sept 17th

[2] Losses between Forebay and Blair Road were estimated to be 0.8 cfs to 4 cfs (4 to 10 percent) at flow rates of 18 and 40 cfs, respectively. The length of the ditch between Forebay and the Reservoir 1 WTP is approximately 15,400 feet and Blair Road is approximately 3,200 feet upstream of Reservoir 1. When loss estimates are extrapolated to the entire length of the canal, the losses are estimated to be 1 cfs to 5.1 cfs (6 to 13 percent). (SAGE 2015).

[3] The length of the ditch between Forebay and the Reservoir 1 WTP is approximately 15,400 feet and Patrick Lane is approximately 1,800 feet upstream of Reservoir 1. When loss estimates are extrapolated to the entire length of the canal, the losses are estimated to be 2.8 cfs from the originally measured 2.47 cfs.

Tully & Young obtained and analyzed the entirety of the SCADA data collected by EID during 2016, 2017, 2018, 2019, and 2020, as well as recent soils testing and seepage modeling completed in December 2015 by SAGE Engineers (Attachment 5). The 2016, 2017, 2018, 2019, and 2020 data included recorded flows released from Forebay as well as flows entering the WTP. The difference between these two data sets, excluding backwash water returned ahead of the WTP meter, represents estimated water lost during conveyance in the Main Ditch. The 2016 data included a limited flow range (13 cfs to 31 cfs) with most data being collected during a long duration of steady 20 cfs flows. 2017 was operated at 20 cfs flow for the entire operating season which provides an additional 20 cfs data point for **Figure 3**. 2018 was operated at varying flow rates but was steady at around 15 cfs flow for the longest period, and 2019 operated the longest at 17 cfs. 2020 saw operations holding steady at 15 cfs but did have a gauging issue for two weeks at Reservoir 1 at the start of the 15 cfs period. Deriving a broader spectrum of estimated losses over varying flow rates required interpretations and extrapolations using data from the prior studies, professional understanding of hydraulics, and EID operator knowledge to develop relationships between flow rates and estimated losses. The results provide a basis that can be used for estimating historical losses, and for projecting future losses.

The 2016 data also provided enough diurnal detail throughout the summer to understand the approximate portion of flow "lost" to evaporation and bankside vegetation, referred to here as ETc as shorthand for channel evapotranspiration. From this information, the effect of ETc during the summer on overall loss percentages compared to that during winter months was assessed, the results of which are represented in **Table 2**.

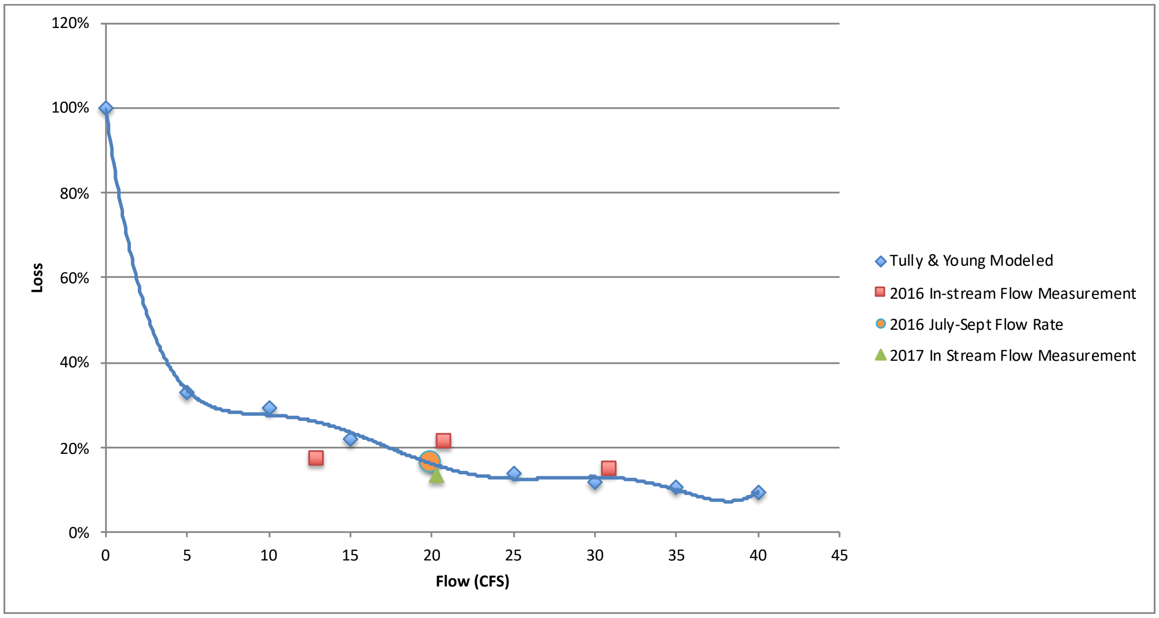
To derive estimated losses for flow rates outside the range recorded during the 2016 operations, several factors were assessed. After discussions with EID staff and review of mathematical models developed using the 2016 data, ditch cross section geometry was assessed to help develop loss rates outside the 2016 empirical range. A topographic survey of the ditch completed by Domenichelli & Associates for pipeline design and stormwater modeling provided cross sectional geometry useful for understanding the relationship between flow and wetted perimeter.

The 2017, 2018, 2019, and 2020 data further supported the conclusions of the 2016 data analysis and shows a clear pattern matching the 2016 ETc estimates.

Analytic Results

One key finding from assessing the full dataset was the percentage of flows lost while traveling between Forebay Reservoir and the WTP varied with the actual flow rate. Using the entire set of 2016 and 2017 data in conjunction with data points from prior studies, a representative curve and equation were developed to correlate flow to the loss percentage. **Figure 1** below demonstrates the derived representation of loss at varying flow rates. Also shown in **Figure 1** are the single ditch flow measurements, separate from the SCADA dataset, taken during the 2016 and 2017 seasons which closely correlate with the derived curve. This figure reflects the entirety of 2016 and 2017 SCADA data for the A-18 gage measuring flows out of Forebay, using the recorded losses at approximately 20 cfs (occurring between July 6 through September 28, 2016), and a best-fit curve derived using the wetted perimeter analysis to reflect loss percentages at a range of flow rates greater and less than the 20 cfs estimate. The wetted perimeter analysis is depicted in **Figure 2**.

Figure 1 – Loss vs. CFS[4]



It is important to note a few critical factors considered while developing the curve:

- Wetted perimeter data was used to model losses at flows greater and less than 20 cfs. The flow rate of 20 cfs was determined by Tully & Young to be the rate with the most accurate data for estimating losses due to the prolonged SCADA data set recorded at that flow.

- The slope and channel configuration, as described in the Domenichelli & Associates topographic survey and accompanying data, shows that wetted perimeter expands rapidly at low flows, but increases much more slowly above 5 cfs. The resulting relationship between average wetted perimeter and flow rate is presented in **Figure 2.**

- Based on available data and operational observation, flows below 5 cfs realize losses of a minimum of 33% and up to 100%.[5] This factor helped establish a functional, polynomial curve to reflect significantly decreasing loss percentages

[4] Since 2009, ditch customer water use between Forebay and the WTP has averaged approximately 28 acre-feet per year. This represents 0.5% of 2016 diversions and 0.2% for the full water right diversion of 15,080 acre-feet and is considered insignificant for this analysis.
[5] 33% minimum losses are tied to the 2012 measurement but are likely higher in this low flow range.

until around 10 cfs, when losses begin to be more consistent. It is noted that the WTP typically avoids operating when flow rates are below 7 cfs due to water quality considerations and operational efficiency objectives.

Comparing Study Results

Comparing the various study results to the modeled best-fit curve in **Figure 1** demonstrates: (1) the 1977 Study estimates higher losses at 40 cfs and lower losses at 18 cfs than the wetted perimeter analysis and the 2016 findings; (2) the SAGE analysis provides a broad theoretical range of loss that bounds the modeled curve; (3) the 2012, 2016, and 2017 single measurement flow data deviates somewhat above and below the derived curve; (4) 2018 measurements in a wetter year still trend nicely with the previously derived curve; (5) 2019 measurements in a normal year were slightly below the curve; and (6) 2020 measurements were slightly above the curve. These comparisons are all represented in **Figure 3**, which illustrates the derived curve under this analysis is a reasonable representation of likely losses.

Figure 2 – Wetted Perimeter vs. CFS

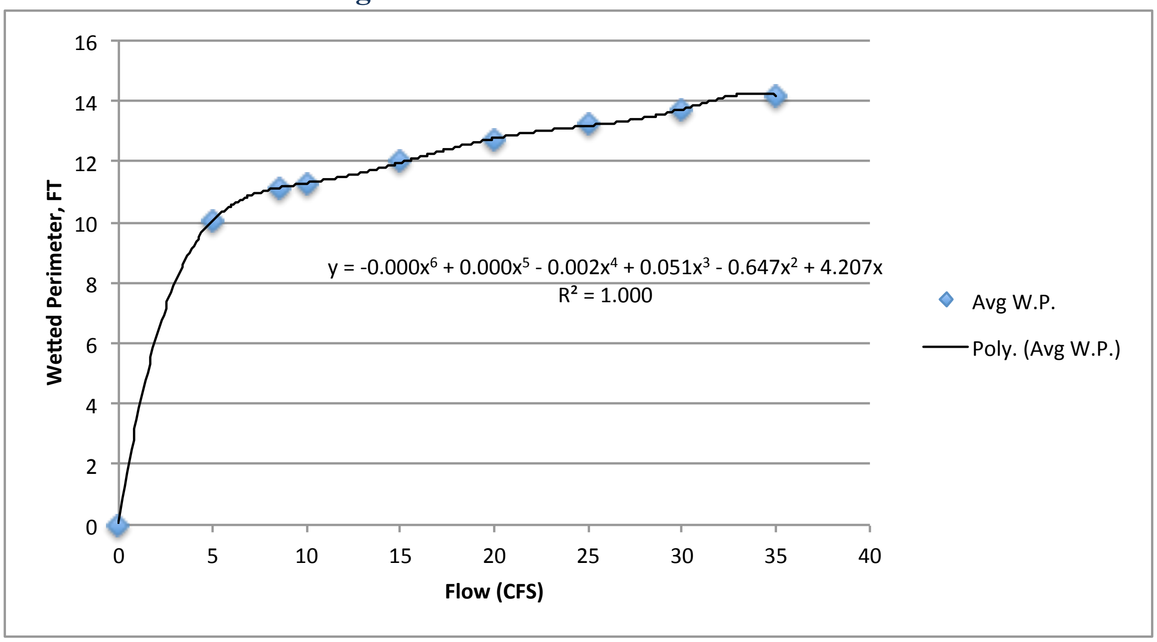
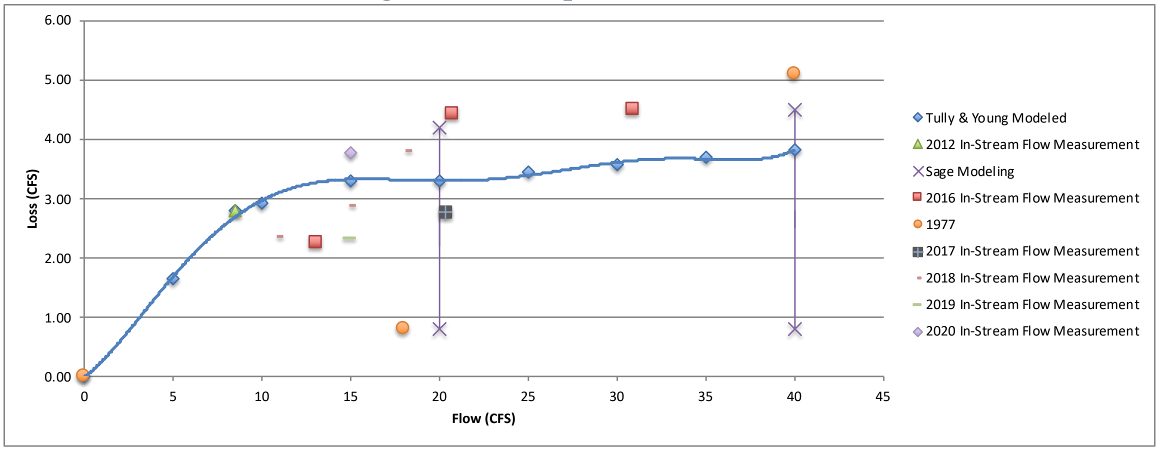


Figure 3 – Comparison of Studies



2020 Canal Flow Measurements Along Length

On 5/26/2020, EID Hydrologists Jordan Baxter conducted measurements in the canal along its length to assess what losses along the entire length. Here are measurement results on 5/26/20:

Magmeter at A18: 12.09 cfs	-Instant flow at time of survey
Reported A18 daily average: 11.97 cfs for day	-1% difference in instant vs average
1000 ft u/s of Pinewood Ln: 10.7 cfs	-11.5% loss
1000 ft d/s Pinewood Ln: 10.13 cfs	-16.2% loss
100 ft u/s Blaire Rd culvert: 7.38 cfs	-39.0% loss
Meter at Res 1 Inlet: 5.36 cfs	-55.7% loss

Unfortunately this was towards the beginning of the season so the canal was not fully wetted and thus we cannot derive any firm information. It does appear that losses are not uniform along the canal length.

Estimating Historic and Future Losses

Because the exact loss is not measurable at each increment of flow, the curve presented in **Figure 1** was translated to a look-up table to reflect the approximate percentage of loss for each increasing 5 cfs increment from 5 cfs to 40 cfs (see **Table 2**). The table also separately represents loss percentages during the two primary delivery periods of October-March and April-September considering the ETc factors described above.[6]

[6] Loss estimates for the April-September period include a component that represents ETc. During the winter period, ETc was assumed to not occur, since channel evaporation is very limited and bank vegetation is essentially dormant.

Table 2 – Seasonal Loss Percentages

	Oct 1-Mar 31	Apr 1-Sept 30
5-10cfs	28%	33%
10.1-15cfs	25%	29%
15.1-20cfs	18%	22%
20.1-25cfs	14%	16%
25.1-30cfs	12%	14%
30.1-35cfs	10%	12%
35.1-40cfs	9%	11%

Using the look-up table, losses can be estimated for the historical monthly flow records for 2009 through 2020 for releases from Forebay (referred to as Gage A-18). **Table 3** below presents the resulting monthly and annual loss estimates. Note that although the flow records indicated flows from Forebay during the months of October through December, the flows were approximately 1 cfs or less to provide ditch customers with water and were thus conservatively reflected as zero loss in the table. This tends to under-estimate seepage losses and does not capture carriage losses that occur during this period.

Table 3 – Calculated Loss

Loss (AF)	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	**Average**
Jan	162	156	139		157	102							143
Feb	180	151	112	122	194	145							151
Mar	167	177	154	145	223	142	136			109			157
Apr	247	179	198	145	256	194	220			187			204
May	268	222	265	231	241	232	226	172		229	185	133	219
Jun	245	205	256	262	240	242	257	240	198	241	239	294	243
Jul	239	221	222	203	248	251	207	228	204	204	257	382	239
Aug	226	229	221	204	221	245	266	205	269	248	258	261	238
Sep	244	222	216	263	239	232	193	199	197	201	146	224	215
Oct	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov	0	0	0	0	0	0	0	0	0	0	0	0	0
Dec	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Loss	**1,977**	**1,763**	**1,783**	**1,576**	**2,021**	**1,786**	**1,505**	**1,044**	**867**	**1,420**	**1,085**	**1,293**	**1,807**
Total Supplied	**11,585**	**8,289**	**6,998**	**7,318**	**12,048**	**8,663**	**5,421**	**5,467**	**4,555**	**5,642**	**4,445**	**3,945**	**8,617**
Percent Loss	**17%**	**21%**	**25%**	**22%**	**17%**	**21%**	**28%**	**19%**	**19%**	**25%**	**24%**	**33%**	**21%**

The look up table allows losses to also be estimated for historic periods when EID routinely conveyed up to 15,080 acre-feet annually through the Main Ditch. These historic higher flows pre-date the monthly digital records and were therefore not readily available for inclusion in this memo.

Conclusion

Using a look-up table that reflects the varying percentage of loss under different flow conditions and different seasons provides a supportable basis for estimating historic losses, and will be useful for establishing a method to identify quantifiable savings associated with the Project. Based on 2009 to 2020 data, minimum water savings of approximately 900 acre-feet per year and an average of approximately 1,800 acre-feet can be expected to result from piping the water supply that is currently conveyed through the Main Ditch.

Attachments (Available on request)

Attachment 1 – 1977 Ditch Flow Measurement
Attachment 2 – 2012 Ditch Flow Measurement
Attachment 3 – EID 2016 Single-day Ditch Flow Measurement
Attachment 4 – 2016 EID Upper Main Ditch Annual Water Loss Analysis
Attachment 5 – 2015 Sage Engineering Ditch Modeling
Attachment 6 – 2017, 2018, 2019, and 2020 EID Upper Main Ditch Annual Water Loss Analysis

B

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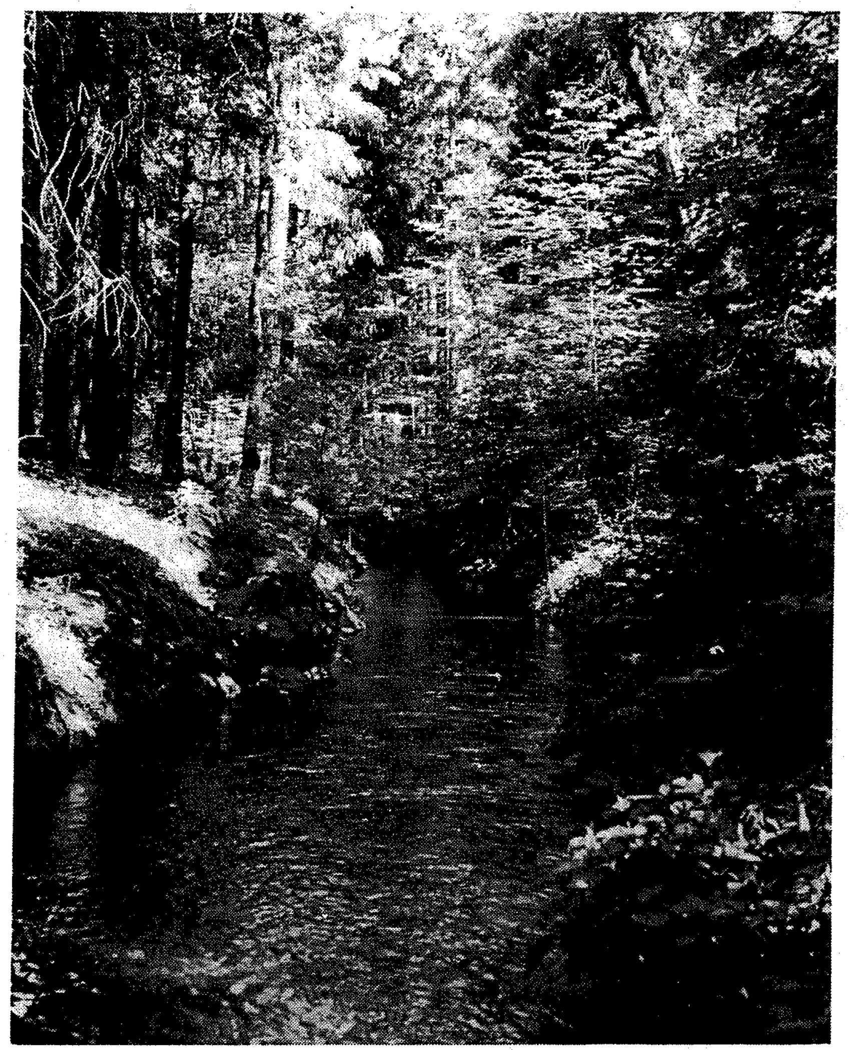
Attachment 1

Excerpt from

Environmental Assessment

Proposed El Dorado Main Canal Pipeline Project



El Dorado Irrigation District

In evaluating any of the proposed actions, it is useful to compare each to the project objectives to determine the degree to which each meets this set of objectives. This comparison is presented in the section on environmental impacts.

Project Need

The need for the project relates directly to each of the foregoing objectives. The purpose of this section is to describe the nature and extent of the need for some action by EID and to present all available information that substantiates and reinforces that need.

Water Losses

Various estimates of water losses from the ditch have been made, but until recently none was substantiated by actual field measurements or tests. On June 7, 1977, Mr. E. M. Padjen, a licensed civil engineer experienced in the measurement of surface flows, was retained by several property owners residing in the Blair Road area to quantify losses in the EID ditch. Mr. Padjen made one set of measurements using a current meter at Pine Wood Lane and another set at the Blair Road crossing of the EID canal. His figures indicate that, at a flow of approximately 15 cfs, losses from the ditch in that 1.7-mile stretch would equal approximately 3 percent of the flow, or slightly less than 0.5 cfs.

In June and July 1977, the EID staff was trained by the U. S. Bureau of Reclamation in the use of current meters to estimate the discharge in the canal. The EID staff took several sets of measurements on the ditch at locations immediately downstream from Forebay Reservoir, at the Pinewood Lane crossing of the ditch, and at the Blair Road crossing of the ditch. While there are some variations in the computed losses, the tests seem to show that at a discharge of 40 cfs that the ditch loses about 9 percent of its flow between Forebay and the Blair Road bridge (about 3.5 cfs). The figures further show that about two-thirds of this loss (6 percent of the ditch flow) is lost between Pinewood Lane and Blair Road at this flow. These figures indicate that at full deliveries to the ditch under the PG&E contract, losses would amount to about 1,260 acre-feet per year in this section. Appendix G further explains these loss estimates.

When considering the test results, it is important to note that the measurement of flowing water in an irregularly-shaped ditch using a current meter is subject to error. Each individual measurement may be off from 5 to 8 percent. It is possible (although not probable) that errors in measuring could account for part or all of the indicated losses. It is also possible that the losses could be greater than those measured. However, it is known that discharges in downstream springs in the Blair Road area increase following an increase in flow in the ditch. This response of the springs is the reverse of the normal rainfall pattern in the area, thus indicating a strong relationship between these spring flows and flows in the ditch, as well as indicating that the seepage losses from the ditch do increase as the water level in the ditch increases.

Estimates of losses for the rest of the ditch are not presently available. Two series of flow measurements were made to evaluate losses downstream from the Blair Road crossing. However, during the days the measurements were made, PG&E changed the flows out of Forebay Reservoir several times. As a result, the measurements are not usable, although they do indicate that some losses may occur. Between Blair Road crossing and Reservoir No. 1, seepage is evident downhill from the canal. No seepage was observed downstream from Reservoir No. 1 along the canal.

As a result, the 1,260 acre-foot per year estimate does understate the losses, to an unknown degree.

Maximize Use of Available Water

During the severe 1977 drought year, EID has had to cut back total district-wide water use by approximately 42 percent. This is one of the greatest reductions in water supply that has had to be imposed in any area of California during the drought. Both domestic and agricultural uses have been cut back significantly. Most dramatic however, has been the effect on the non-commercial agricultural uses which have not been allocated any water whatsoever. Only property owners who are able to demonstrate a commercial and viable agricultural operation have been allocated water for agricultural purposes. This has been necessary to provide adequate water for domestic, commercial, agricultural and industrial endeavors in the district.

The situation is further pointed up by the fact that Sly Park Reservoir had an average annual inflow from 1960 to 1976 of about 35,000 acre-feet. At the end of last year, Sly Park contained only 7,675 acre-feet of water in its 41,000 acre-foot capacity. Inflow for the year amounted to only 3,167 acre-feet -- a new record low. As a result, the principal water supply for EID in 1977 is the flow from Forebay Reservoir through the main canal.

APPENDIX G

COMPUTATION OF SEEPAGE LOSSES FROM EID MAIN CANAL

Flow measurements were made by E. M. Padjen on June 7, 1977 and by EID staff in June and July 1977. The Padjen measurements indicate a loss of 3 percent of the flow between Pinewood Lane and the Blair Road crossing at a flow of 18 cfs. The EID measurements indicate a loss of between 9 and 10 percent between Forebay and Blair Road crossing, with about a 6 percent loss in the reach measured by Padjen, at flows of 40 cfs.

By prorating Padjen's loss estimate back to Forebay, including the Forebay-Pinewood Lane reach which he did not measure, a total of 4.5 percent loss at 18 cfs flow could be postulated. It should then be possible to plot the losses, both by percent loss and by cfs loss, to extrapolate losses for this reach of the canal at any flow. These assumptions are plotted on the attached figures.

The data upon which these charts are based may be in error. The measured flows vary enough from actual flows to account for a good portion of the measured losses, or to substantially understate the losses. Since other evidence corroborates that seepage losses do occur, and that the degree of loss varies with the flow in the canal, the charts have been drawn up and are used as the best available data. They must be used cautiously, however, and accepted as a guide only, not as a definitive answer.

These charts were used to determine the losses used in the assessment, based on the following computations:

Loss at full flow:

May 15-Oct 15:	4 cfs x 1.98 acre-feet/cfs-day x 152 days	= 1,200 acre-feet
Oct 15-May 15:	0.15 cfs x 1.98 acre-feet/cfs-day x 213 days	= 63 acre-feet
		1,263 acre-feet

Use 1,260 acre-feet

Loss at 7 cfs flow year-around:

0.15 cfs x 1.98 acre-feet/cfs-day x 365 days = 108 acre-feet

Use 110 acre-feet

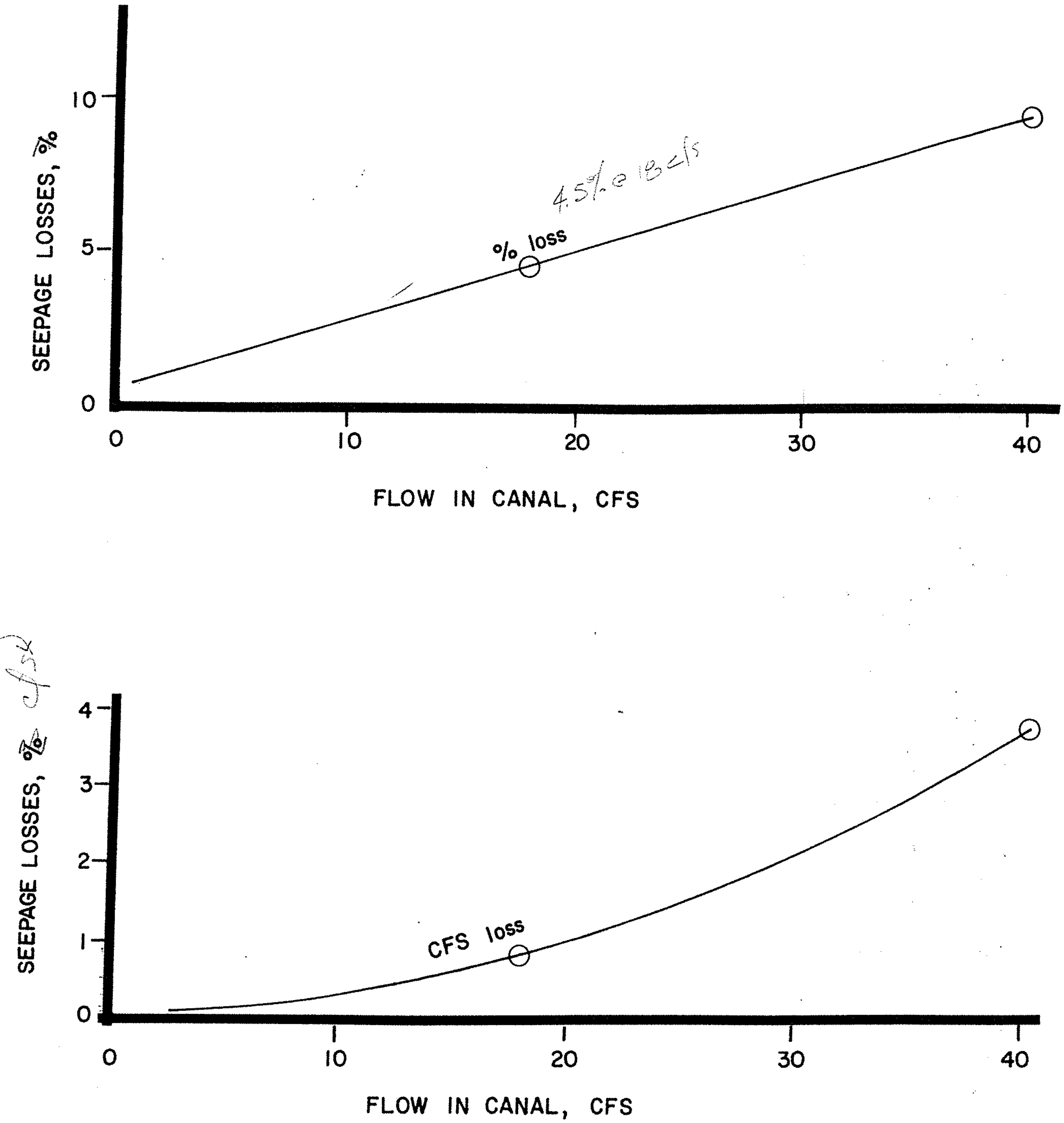
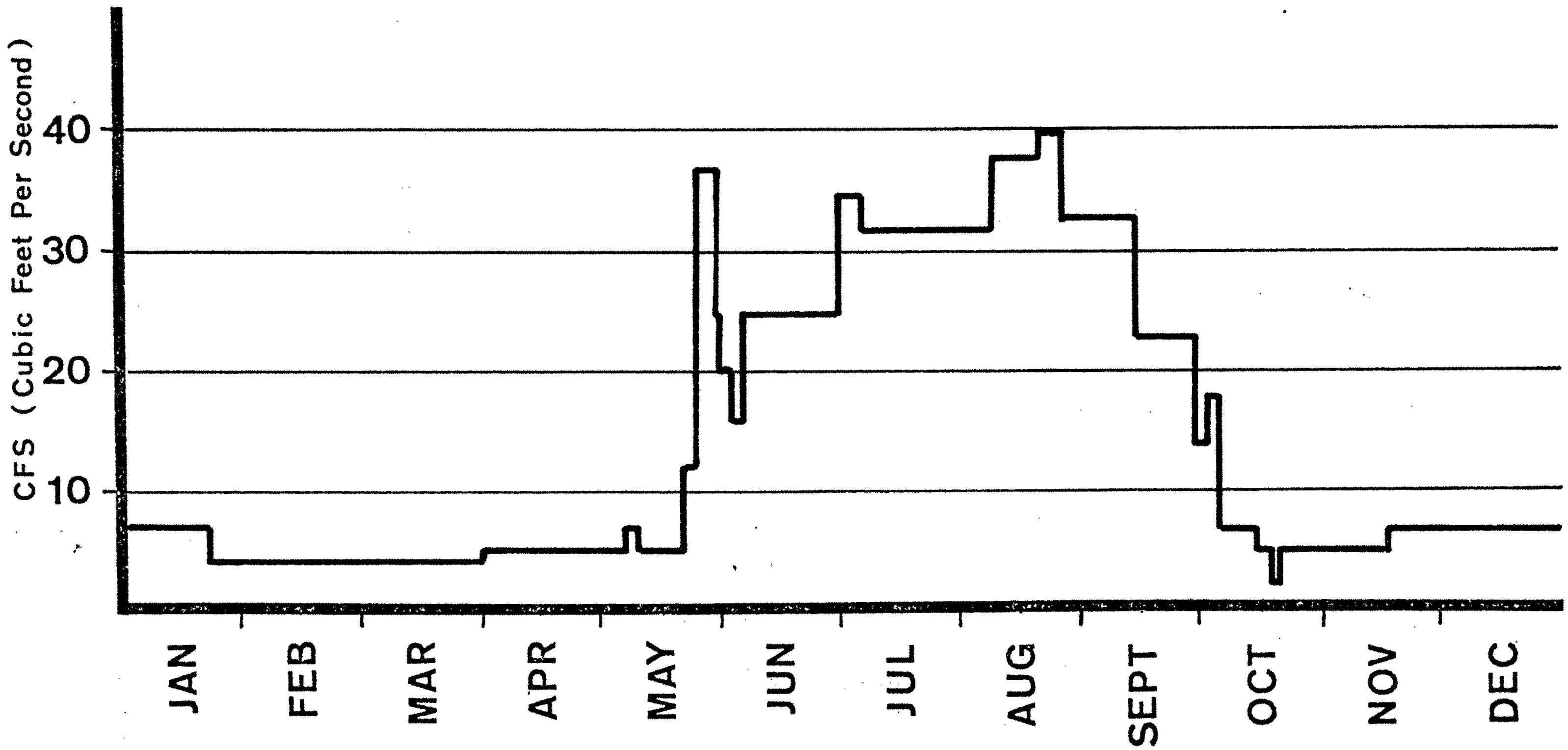
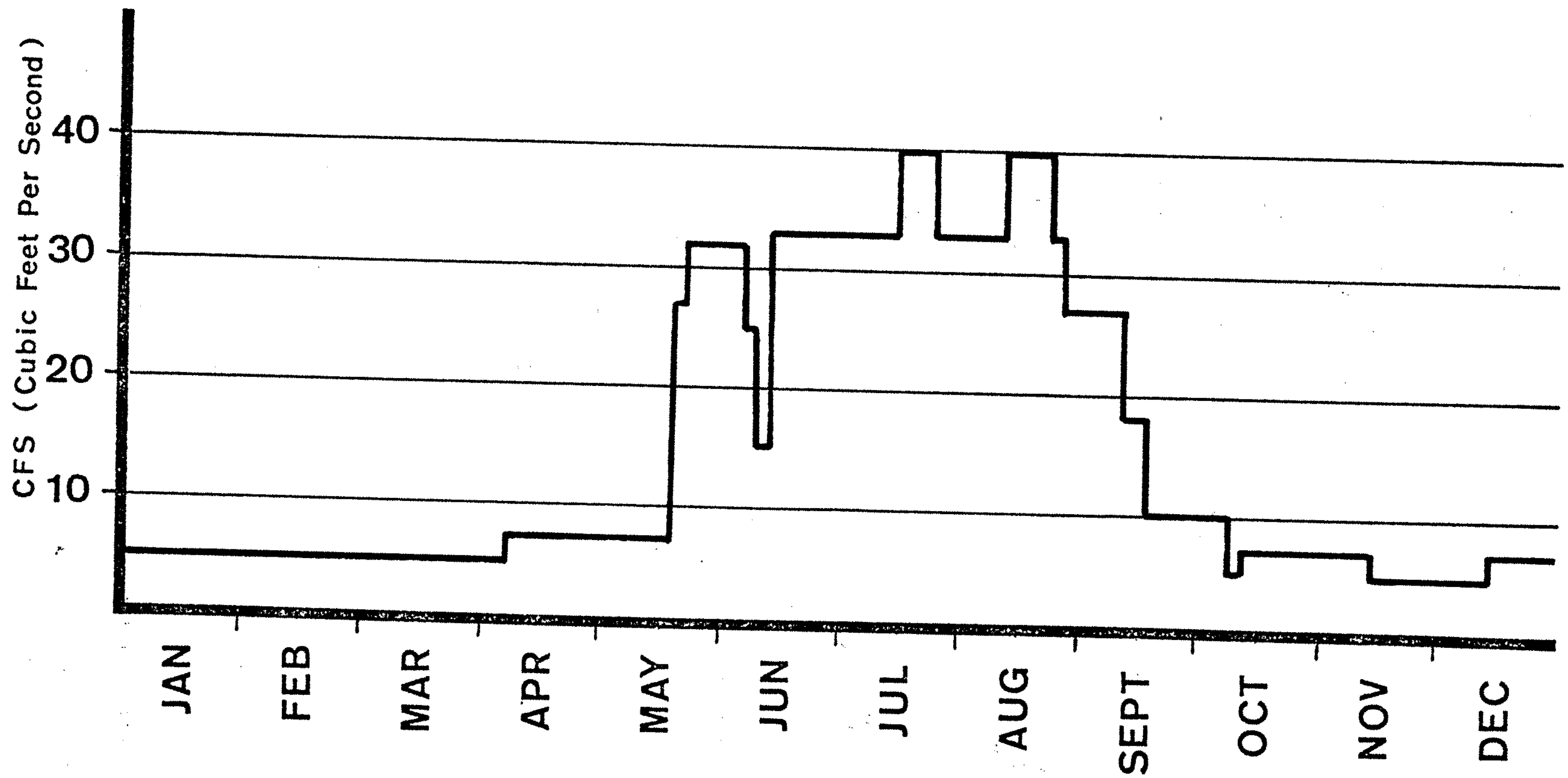


FIGURE G1. APPROXIMATE SEEPAGE LOSSES IN EL DORADO MAIN CANAL, FOREBAY TO BLAIR ROAD CROSSING

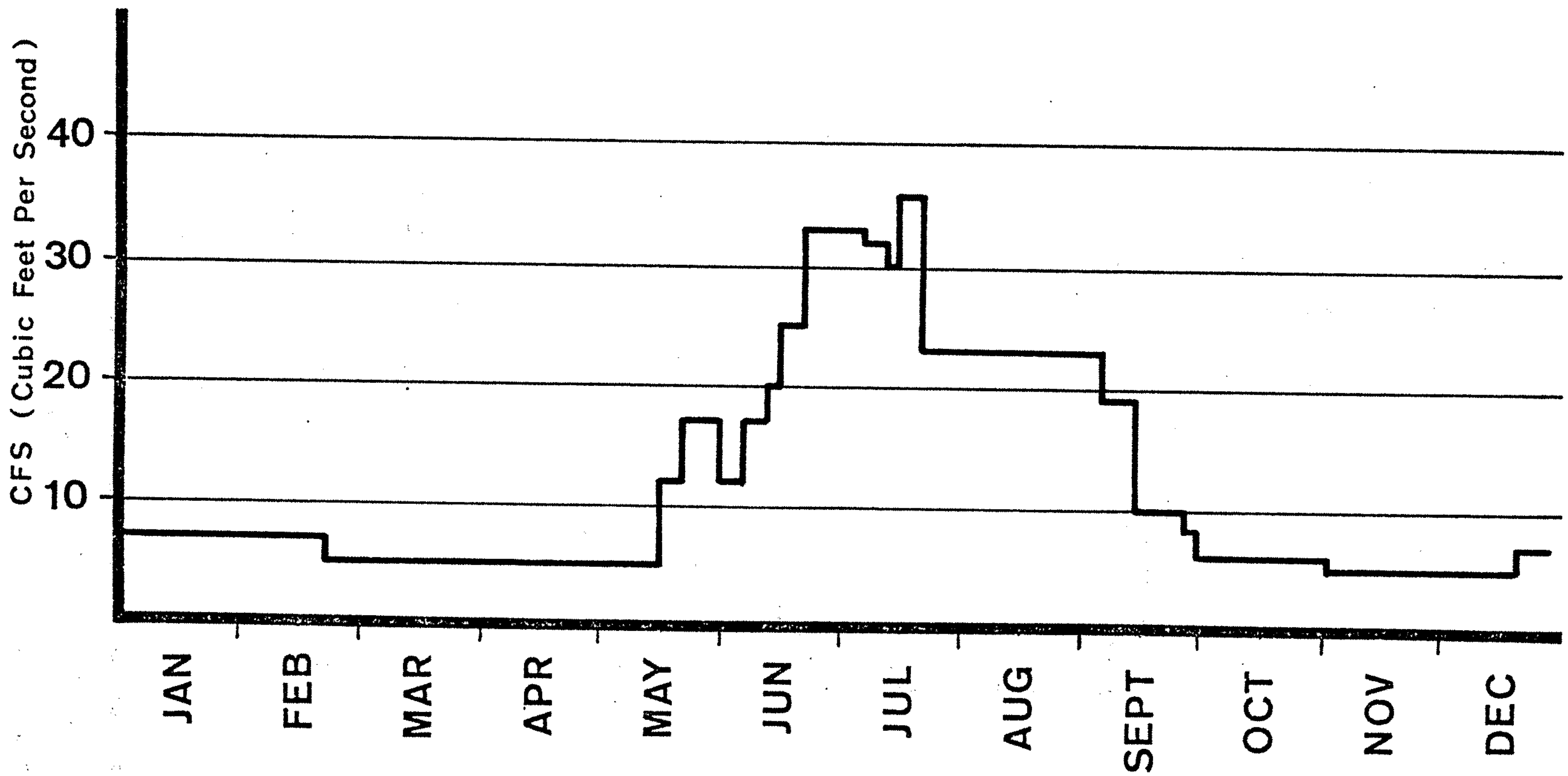
APPENDIX H



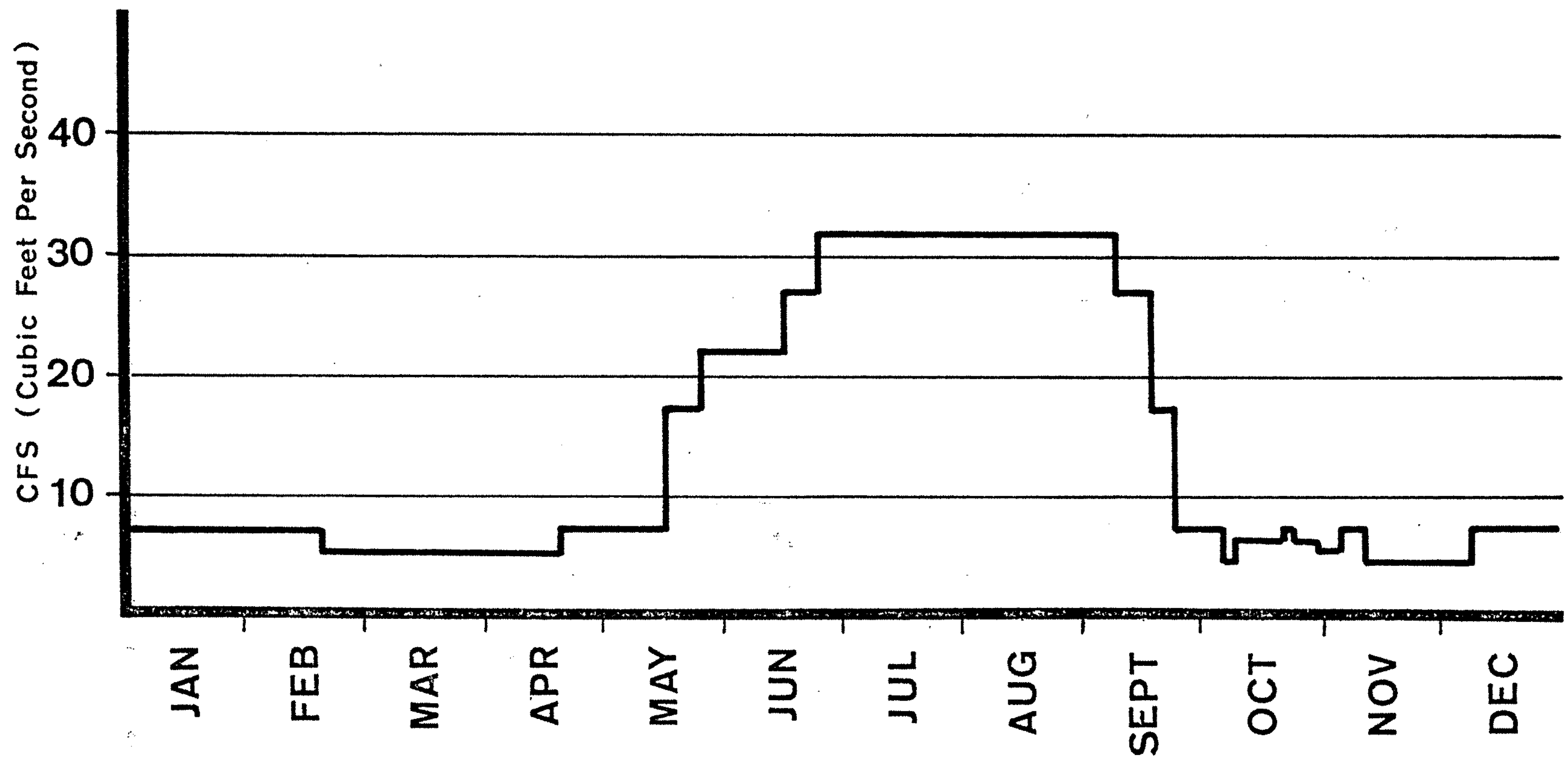
Recorded discharge from Forebay Reservoir in the EID Main Canal for Calendar Year 1969



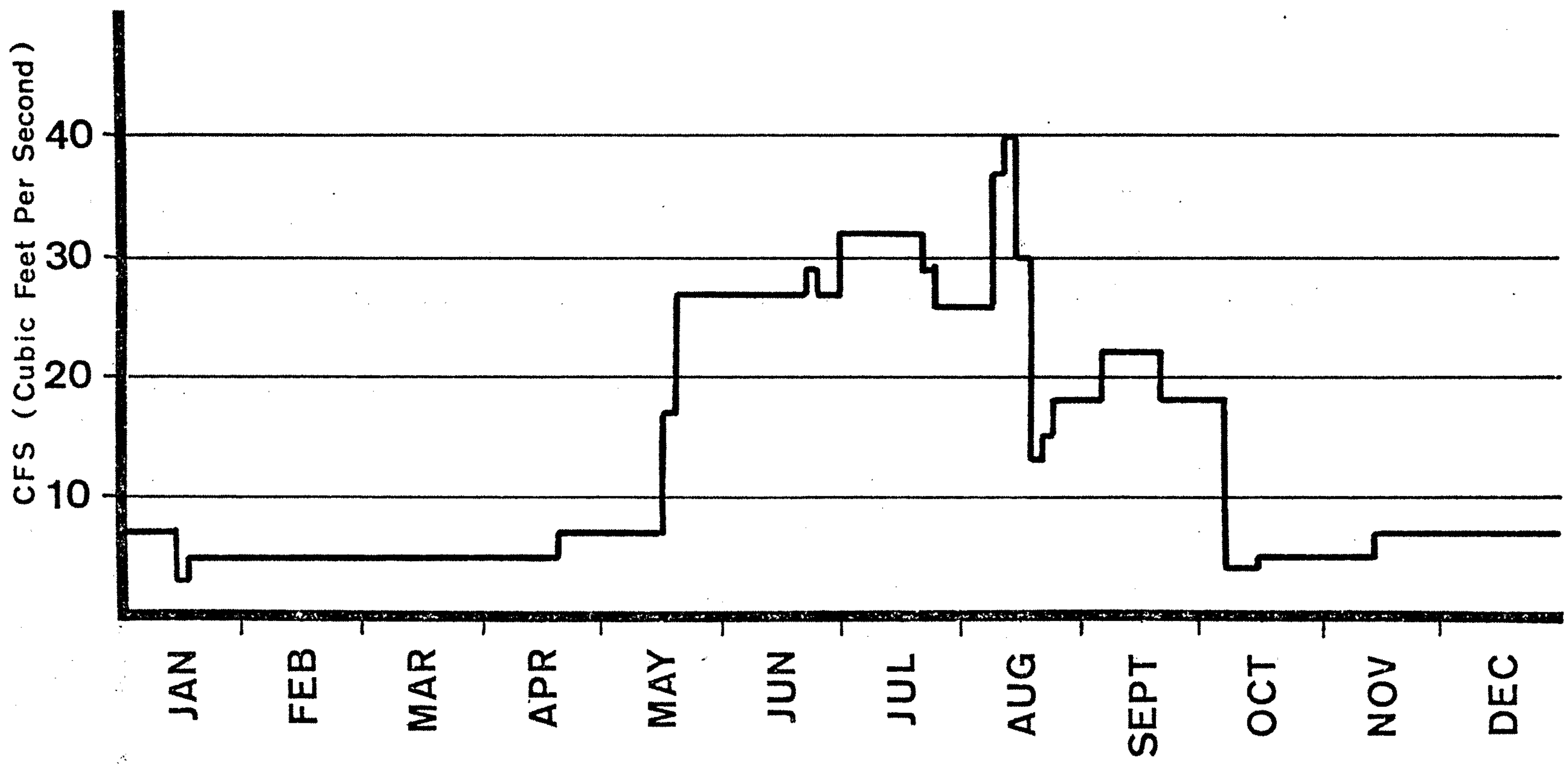
Recorded discharge from Forebay Reservoir in the EID Main Canal for Calendar Year 1970



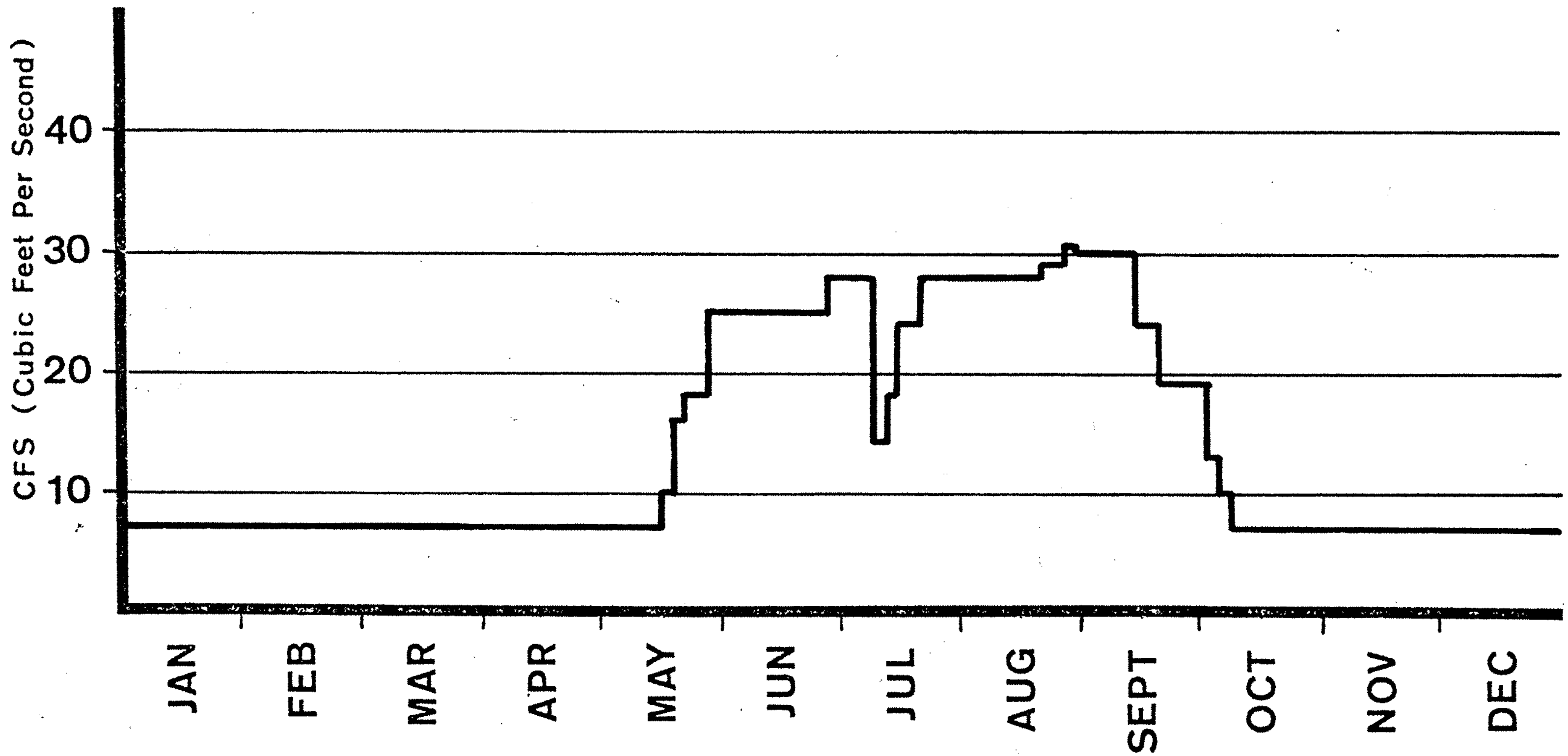
Recorded discharge from Forebay Reservoir in the EID Main Canal for Calendar Year 1971



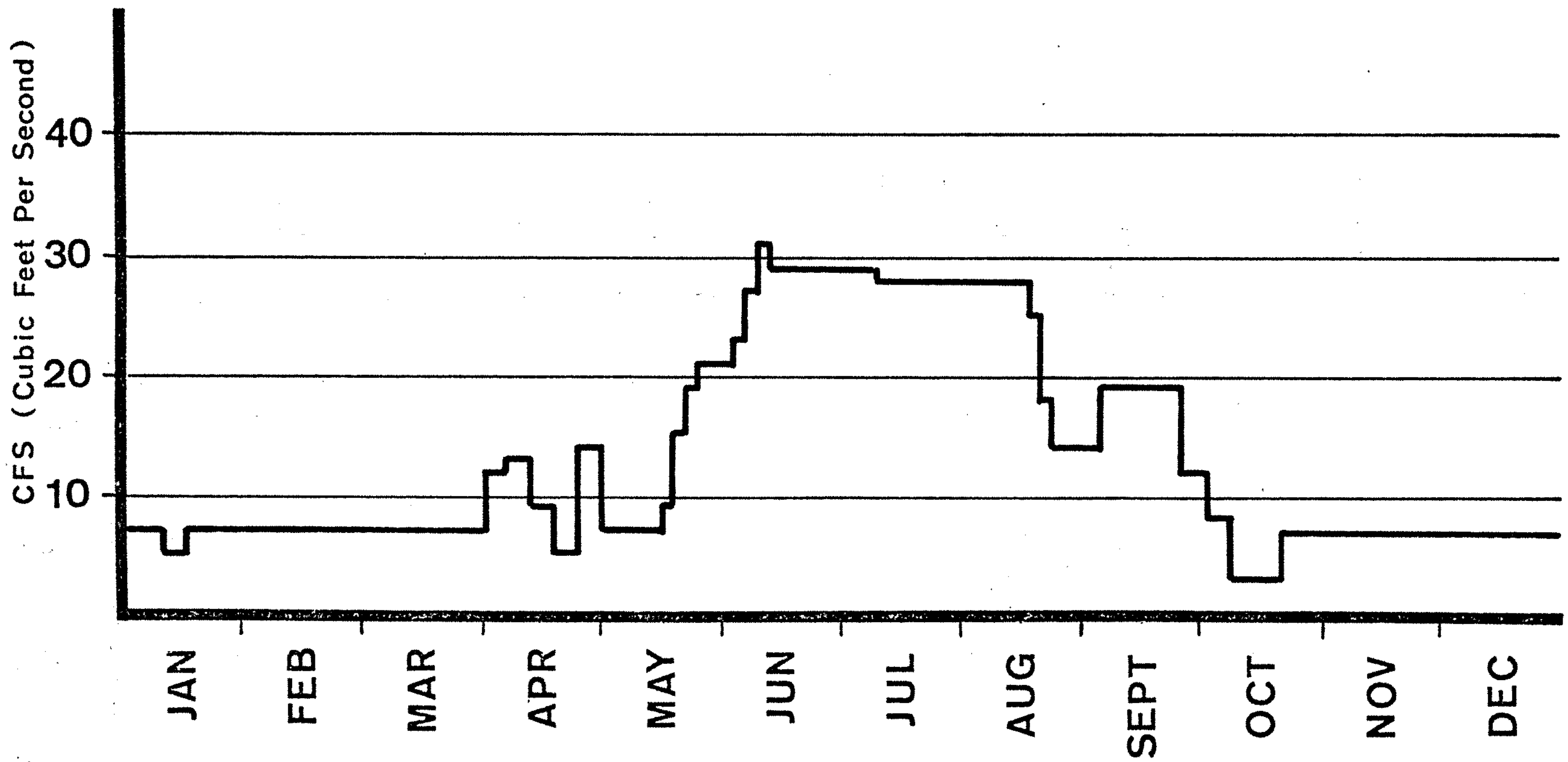
Recorded discharge from Forebay Reservoir in the EID Main Canal for Calendar Year 1972



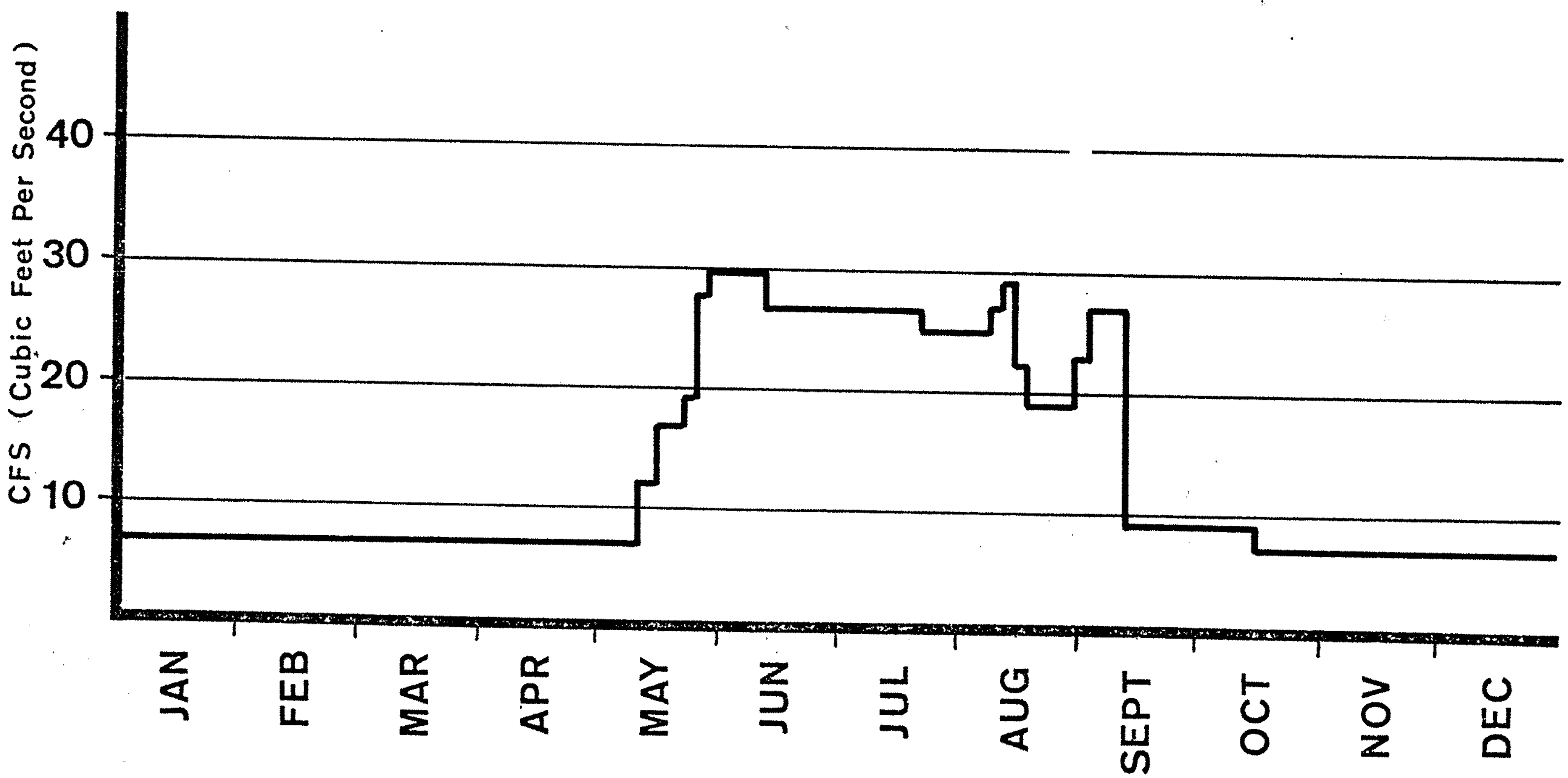
Recorded discharge from Forebay Reservoir in the EID Main Canal for Calendar Year 1973



Recorded discharge from Forebay Reservoir in the EID Main Canal for Calendar Year 1974



Recorded discharge from Forebay Reservoir in the EID Main Canal for Calendar Year 1975



Recorded discharge from Forebay Reservoir in the EID Main Canal for Calendar Year 1976

ERRATA SHEET

Environmental Assessment of Proposed
El Dorado Main Canal Pipeline Project
August 19, 1977

Page 7 under Maximize Use of Available Water, first paragraph, second line: "42 percent" should read "58 percent".

Page 19, bottom of page, last line: "Placer County" should read "El Dorado County".

Page 29, delete first sentence on page, add: "Bacteriological quality has been tested on a long-term basis. Additional, more intensive testing was performed for this report. The discussions in this assessment are based on these recent tests."

Page 37, below the table, add: "Source: Storer and Usinger, 1963."

Page 46, second paragraph, first indented line should read: "Water supply: Georgetown Divide Public Utilities District..."

Page 58, last paragraph, under Water Sources, the sixth sentence, beginning "The Coloma-Lotus Ditch diverts..." should be deleted. Add: "The district has rights to about 6,900 acre-feet per year from the Coloma-Lotus Ditch, and diverts about 600 acre-feet annually. The district also has rights to 1,300 acre-feet on Weber Creek."

Page 61, Table 15 excludes data for the Coloma-Lotus Ditch.

Page 62, Table 16, add to bottom of table: "Source: El Dorado Irrigation District, 1976".

Page 65, third full paragraph, seventh line: "Indian Hill Reservoir" should read "Union Hill Reservoir".

Page 141, in the left margin of the lower chart, the vertical axis "Seepage losses, %" should read "Seepage losses, cfs".

Pages 103-105, Bibliography, add:

California. Department of Finance, Population Research Unit, 1977. Provisional Projections of California Counties to 2000. Report 77P-1, August 1, 1977, photocopy, 6 pp.

EDCPD — see El Dorado County Planning Department.

El Dorado Irrigation District, 1952. The Story of Water: From Miner's Ditch to Sly Park Dam. 16 pp.

Storer, Tracy I., and Robert L. Usinger...

Delete:

EID (additions to) El Dorado...

San Francisco Chronicle...

ENVIRONMENTAL SETTING OF THE PROJECT

Physical Environment

Soils

The soils in the project area are derived from metamorphic or volcanic conglomeritic rocks. The most common soils in the area are the Cohasset loams and the Aiken loams. Minor soils occurring in the project area are the Josephine very rocky or gravelly loams, the Mariposa-Josephine very rocky loam, and the McCarthy cobbly loam. These soils are described below and located on the soil map (Figure 1).

Cohasset Series. The Cohasset series are well drained soils underlain by weathered andesitic conglomerate at a depth of more than 40 inches. These soils are gently sloping to strongly sloping on smooth ridges or are moderately steep to steep on sides of ridges.

Vegetation is mainly coniferous forest and associated hardwoods.

In representative profile, the surface layer is brown and reddish brown, slightly acid cobbly loam about 14 inches thick. The subsoil is reddish-brown and yellowish red, medium acid cobbly heavy loam and cobbly clay loam about 32 inches thick. Parent rock is slightly weathered andesitic conglomerate at a depth of about 46 inches.

The Cohasset soils are a dominant soil type in the project area. The three Cohasset soils found here are: the Cohasset loam, 3-9 percent slope; Cohasset loam, 9-15 percent slope; and the Cohasset loam, 15-30 percent slope.

Aiken Series. The Aiken series are well drained soils underlain by deeply-weathered andesitic conglomerate at a depth of 4 feet or more. The soils are gently sloping to moderately steep on wide smooth ridges and the sides of ridges. Vegetation is mainly coniferous forest and associated hardwoods.

In representative profile, the surface layer is brown and reddish brown, medium acid loam and clay loam about 24 inches thick with subsoil red and yellowish red. Medium acid and strongly acid heavy clay loam and clay are found to a depth of more than 72 inches.

The soil supports woodland and deciduous fruit orchards.

The Aiken soils common in the project area are: Aiken loam, 3-9 percent slope eroded; Aiken loam, 9-15 percent; and the Aiken loam, 15-30 percent slope.

McCarthy Series. The McCarthy series are well drained soils underlain by volcanic conglomerate and Breccia at a depth of 24-40 inches. These soils are strongly sloping on ridges and are steep on side slopes. These soils mainly support coniferous forest and associated hardwoods with scattered areas of brush.

In representative profile, the surface layer is dark grayish brown and brown, slightly acid cobbly loam about 10 inches thick. The subsoil is strong brown, medium acid, very cobbly loam about 28 inches thick. This is underlain by weathered andesitic conglomerate.

The McCarthy soil found in the project area is the McCarthy cobbly loam, 9-50 percent slope.

Josephine Series. The Josephine series are well drained soils underlain by vertically-tilted schists, slates and contact metamorphic rocks at a depth of 40-60 inches. These soils are gently rolling to very steep on mountainous uplands. Vegetation is mainly coniferous forest and associated hardwoods with scattered areas of brush.

In representative profile, the surface layer is yellowish-brown and reddish-yellow, medium acid and strongly acid silt loam about 14 inches thick. The upper part of the subsoil is reddish-yellow, very strongly acid silty clay loam about 19 inches thick. The lower part of the subsoil is yellow, very strongly acid, very gravelly silt loam, and is underlain by slate at a depth of 50 inches.

The two Josephine soils found in the project area are: the Josephine very rocky loam, 15-50 percent slope; and the Josephine gravelly loam, 9-15 percent slope.

Mariposa Series. The Mariposa series are well drained soils underlain by vertically-tilted schists and slate which contact metamorphic rocks at a depth of 15-30 inches, and are restricted to sloping or rolling to very steep terrain on mountainous uplands. Vegetation is mainly mixed coniferous forest and associated hardwoods and brush.

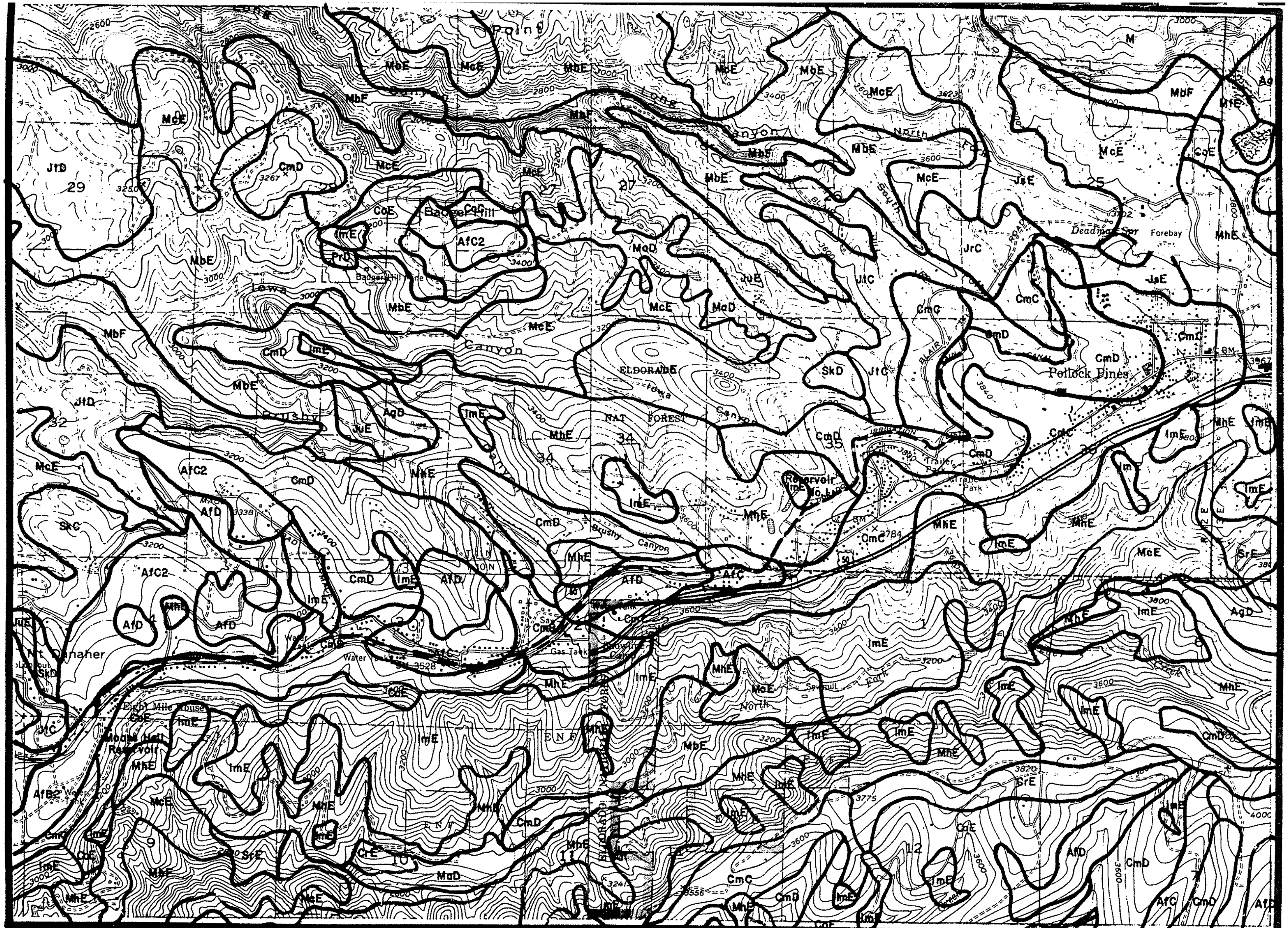


FIGURE 1 SOILS ADJACENT TO EID MAIN CANAL

In representative profile, the surface layer is pink, medium acid, gravelly silt loam about 8 inches thick. The subsoil is reddish yellow, medium acid and strongly acid gravelly silt loam about 18 inches thick. This is underlain by schists or slate at a depth of about 26 inches.

The Mariposa-Josephine very rocky loam is found in the project area.

Soil Permeability and Canal Flows. The EID main canal is affected by the underlying soils in several ways.

First the ditch, as an earth lined channel, is subject to water losses in transit, through seepage. The soils are classified by the Soil Conservation Service (SCS) according to permeability which is a measure of how fast water will move through the soil, expressed in inches per hour. In the project area soil permeabilities are rated as moderate and moderately rapid to moderately slow. (See Table 2). That means the water moves at a rate somewhere between .2 and 6.3 inches per hour depending on local conditions. The range of permeabilities shows the soils can allow substantial amounts of water to percolate, where the more permeable soils exist.

The soils in the project area are all rated by SCS as having severe limitations on their suitability for use as septic tank filter fields. This limitation is due to slope which can be as much as 50 percent. The soil can be very permeable locally and transmit water at a rate up to 6.3 inches per hour.

Geology

The oldest rocks in the project area are Paleozoic graywackes and volcanics (Calaveras formation) laid down in shallow seas between 600 and 230 million years ago. One hundred forty to 70 million years ago these sediments were turned steeply on end, metamorphosed into hornfels, slates and schists and intruded by granitic rocks and gold-bearing quartz veins. These intrusive granitic rocks form the core of the present Sierra Nevada. A long period of erosion followed, wearing down the mountains and depositing gold-bearing gravels in the river beds. In the early Cenozoic (65 million years ago) volcanism on the east side of the Sierra deposited rhyolitic ash and flows (Valley Springs formation). The andesitic tuffs and mud flow breccias of the Mehrten formation were deposited in the middle Cenozoic (about 25 million years ago).

TABLE 2

SOIL CAPABILITIES AND CHARACTERISTICS

Soil	Erosion Hazard	Permeability of Subsoil	Runoff	Septic Tank Filter Field Suitability
Cohasset loam				
CmB, 3-9% slope	Slight	Moderate	Slow to medium	Severe
CmC, 9-15% slope	Slight to moderate	Moderately rapid to moderately slow	Slow to medium	Severe
CmD, 15-30% slope	Slight to high	Moderately rapid to moderately slow	Slow to medium	Severe
Aiken loam				
AfB2, 3-9% slope, eroded	Slight	Moderate	Slow to medium	Severe
AfC, 9-15% slope	Slight to moderate	Moderately rapid to moderately slow	Slow to medium	Severe
AfD, 15-30% slope	Slight to high	Moderately rapid to moderately slow	Slow to medium	Severe
Josephine				
JsE, very rocky loam, 15-50% slope	Slight to high	Moderately rapid to moderately slow	Medium to rapid	Severe
JrC, gravelly loam, 9-15% slope	Slight to moderate	Moderately rapid to moderately slow	Slow to medium	Severe
McCarthy				
MhE, cobbly loam, 9-50% slope	Moderate to high	Moderately rapid to moderately slow	Medium to rapid	Severe
Mariposa-Josephine				
McE, very rocky loam,	Slight to high	Moderately rapid	Medium to rapid	Severe

During the Pliocene (3 million years ago) block faulting uplifted the eastern edge of the Sierra along a major fault. A new, west-flowing stream pattern was established, cutting deep canyons through the volcanic debris and tertiary river deposits into the granitic and meta-volcanic bedrock. The lava flows remain as remnants capping the ridges.

The project area is on the gently sloping west side of the Sierra Nevada block, on a west-trending ridge dividing the South Fork of the American River and Webber Creek.

There are no active faults in the project area. The foothill fault system has had no movement since the late Mesozoic (100 million years ago). Any earthquake shock which could affect the project area would originate in the Basin and Range province to the east. Shocks greater than intensity VI have not occurred in the last 100 years. Shocks of intensity VII to VIII should be anticipated, however, during the next few centuries from very strong earthquakes in the Basin and Range Tectonic province (United States Bureau of Reclamation, 1974).

Surface Water Hydrology and Quality

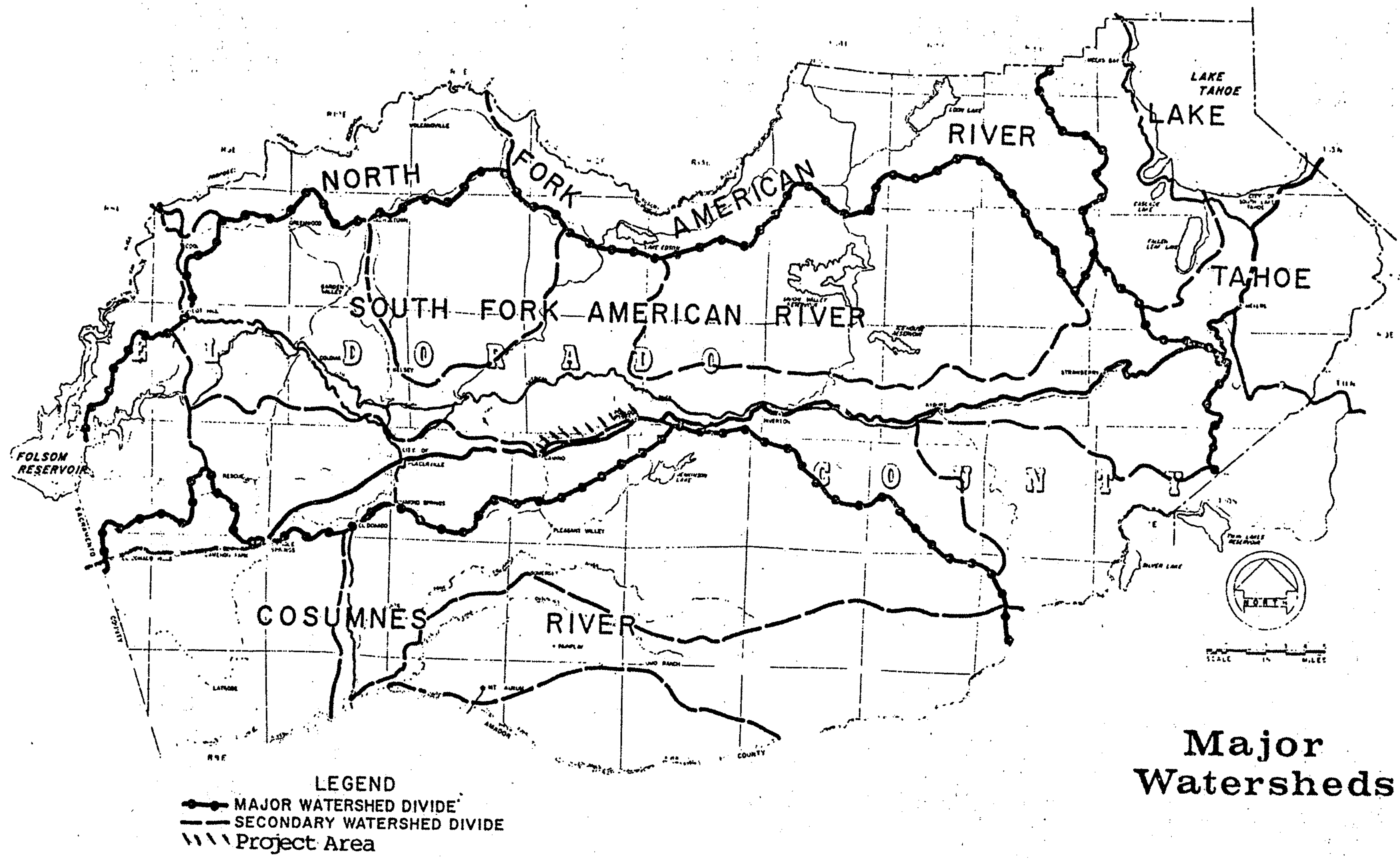
El Dorado County contains 4 major and 18 minor watersheds. The El Dorado Irrigation District encompasses portions of the two largest: the South Fork of the American River and the Cosumnes River watersheds (see accompanying map).

The project area is within the South Fork of the American River drainage basin, near the southerly margin, on a ridge which forms the divide between two minor watersheds.

The water carried in the ditch originates in the South Fork of the American River. Pacific Gas & Electric diverts the water at Kyburz and conveys it 23 miles by gravity as surface flow in a ditch built in the same time period as the EID ditch. The water is delivered to PG&E's Forebay Reservoir, the point of origin of the EID ditch.

Chemical water quality in the ditch is very good. A report of chemical analysis is given in Table 3..

Physical quality of the water is generally good, although turbidity is a significant problem. Recent tests of physical quality (Table 4) show that turbidity increases significantly as water flows along the ditch. The worst effect occurs in the area downstream from Reservoir No. 1, primarily due to the steep gradient and resulting erosive force of the flows.



Major Watersheds

Table 3

REPORT OF CHEMICAL ANALYSIS
FOREBAY

Location	Res. #1	Forebay	Forebay #5	Camino Ditch
Date Sampled	10-4-71	5-25-76	12-15-76	7-1-76
Hardness	12	10	9	12
Bicarbonate	18	15	15	18
Carbonate	0	0	0	0
Hydroxide	0	0	0	
Alkalinity	15	12	12	15
Calcium	3.6	3.3	2.4	4.0
Magnesium	.73	.58	.71	0.5
Iron (total)	.50	.09	.00	0.02
Manganese	.06	.00	.00	0.01
Sodium	1.2	2.3	2.8	2.9
Potassium	.8	.7		
Chlorides	3.5	3.0	4.3	3.8
Sulfates	1.5	0.	0.	1
Fluorides	.05	.0	.0	0.1
Nitrates	.05	.00	.03	0.02
pH	7.5	7.2	7.1	7.4
Conductivity	31.5 MHOS/cm			105
Color		8		12
Turbidity			.44	2.2

Source: El Dorado Irrigation District, 1977c.

Table 4

PHYSICAL CHARACTERISTICS OF EID DITCH,
MEASURED AT 40 CFS FLOW

	Conductivity	Turbidity	Dissolved Oxygen
Forebay Reservoir	300	3 JTUs	8.1
Gilmore Road	290	5	8.1
Upstream from Moose Hall Reservoir	310	15	8.1

Source: El Dorado Irrigation District, August 9, 1977.

Bacteriological quality of the raw ditch water has only recently been tested. Initial tests run by the county indicated fecal-coliform present. The county tests do not indicate the full magnitude of the contamination, so El Dorado ran tests in their own lab. Results from both agencies are summarized in Table 5.

The tests indicate levels typical of untreated raw water supplies. They do not indicate any public health problems to be present at the time of testing. Chlorination would probably disinfect the water sufficiently well to provide for public safety.

Surface runoff from rainfall is intercepted by the canal throughout much of its length. Between Halsey Forebay Reservoir and Reservoir No. 1, all natural drainage courses, overland flow and roadway drainage enters the EID canal. About 345 acres of land are tributary, including residential and commercial acres of Pollock Pines (see Figure 2).

From Reservoir No. 1 to Moose Hall Reservoir, the tributary area is considerably narrower, since the canal more nearly follows the ridge line. In this reach about 100 acres of residential, commercial and vacant land, including considerable frontage on Pony Express Trail, is tributary to the canal. Pipe culverts draining roads in the area frequently empty directly into the canal.

According to EID staff (pers. comm.) the storm drainage of the area has been tributary to the canal since it was constructed over 100 years ago. In effect, this has protected downstream lands from storm drainage water, particularly in the Pollock Pines area. It has also intercepted and diverted whatever natural stream flow occurred in the various drainage courses during the wet season. The frequency and duration of the natural flows in these small streams are unknown.

It is probable that high intensity rainfall or rapid snowmelt in the Camino-Pollock Pines area could cause the flows in the canal to exceed capacity, flooding lands downstream. These occurrences would be short-lived, and none has been formally reported to EID (pers. comm.)

Table 5

1977 BACTERIAL TESTS: RAW CANAL WATER

Date/Agency	Forebay Pump		Reservoir #1		Moose Hall	
	Total Coliform	Fecal Coliform	Total Coliform	Fecal Coliform	Total Coliform	Fecal Coliform
June 27 El Dorado County Health Department	>16	16	>16	16	>16	16
June 29 El Dorado County Health Department		>16		>16		5.1*
July 5 El Dorado County Health Department		16		>16		>16
July 6 El Dorado County Health Department		16		>16		>16
July 11 El Dorado County Health Department		5.1		>16		>16
July 13 El Dorado County Health Department		>16		>16		>16
July 21 El Dorado Irrigation District	140	17	49	9	79	79
July 27 El Dorado Irrigation District	17	17	79	79	240	49
August 2 El Dorado Irrigation District	240	240	350	350	49	49

*Sample inadvertently taken below polymer feed.

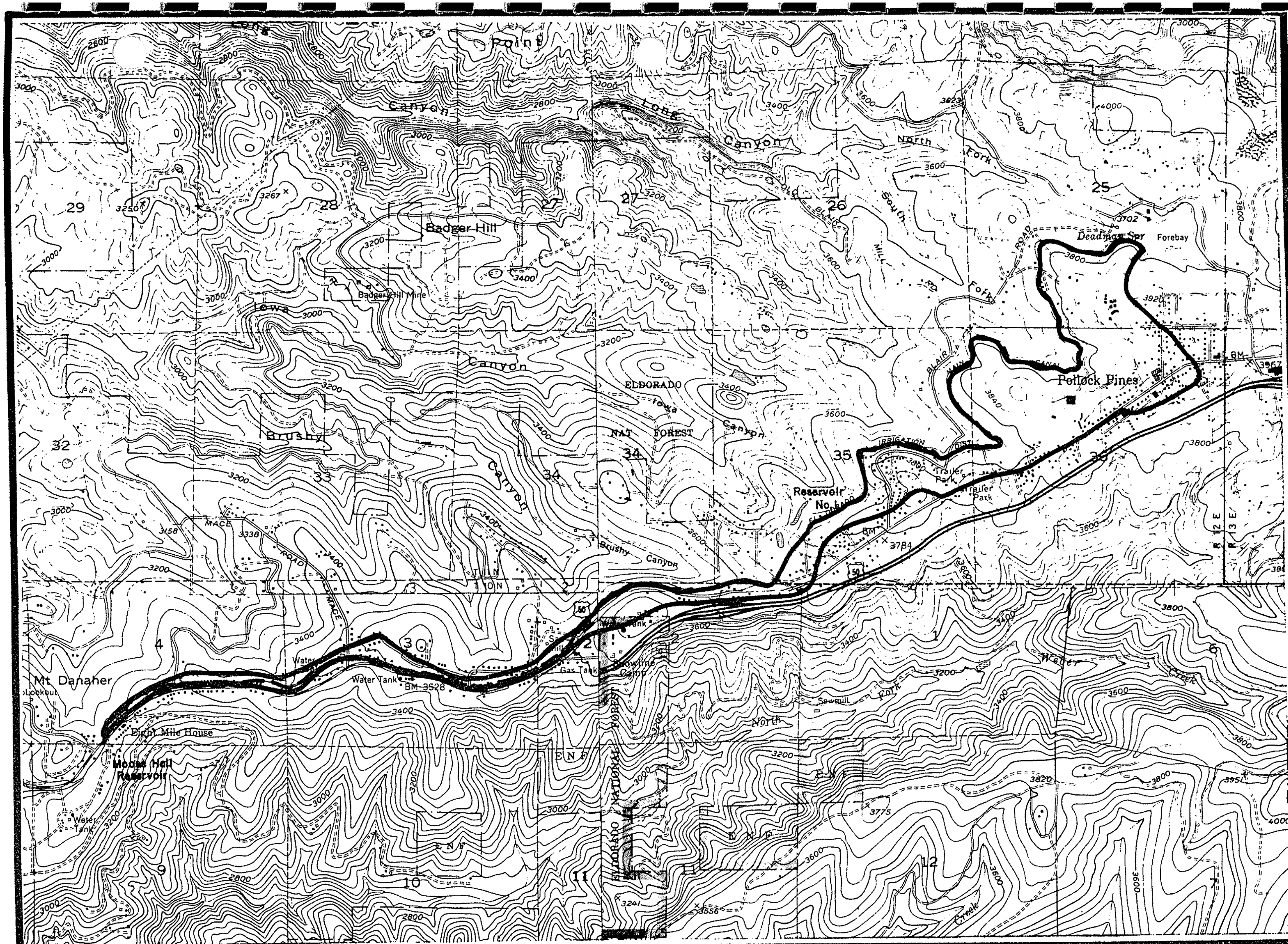


FIGURE 2 DRAINAGE AREAS TRIBUTARY TO El DORADO MAIN CANAL

Quality of runoff water from undisturbed forest lands in the American River watershed is generally excellent. Urban runoff contains numerous pollutants, including nutrients, significant amounts of heavy metals, pesticides, and fecal-coliform (Sartore, et al., 1974). Since the areas tributary to the canal are a mixture of urban uses and relatively undisturbed forest, the quality of runoff water is anticipated to be of better quality than urban runoff, while containing constituents typical of urban runoff in reduced concentrations.

The timing of runoff is dependent on precipitation. The first heavy rain of the season will carry a sudden surge of accumulated pollutants into the canal at one time. The more closely spaced the periods of runoff are, the lesser the impact of each occurrence relative to pollutant concentration.

Groundwater

Groundwater is a limited source of water to the EID. There are no groundwater basins of any size in the area. Local residents have been able to supply limited amounts for household use by drilling shallow wells, but yields are typically meager (EID, 1977).

Most geologic formations in the area are relatively poor sources of groundwater. Wheeldon (1977), in a recent study of the Camino-Fruitridge-Pollock Pines area, has found the Mehrten formation (in which the ditch is located) to contain pervious zones which could supply groundwater during seasons of adequate rainfall. The Mehrten formation caps the Camino-Pollock Pines Ridge and is underlain by the Calaveras formation (see map). Groundwater seeps down to the impervious Calaveras formation underneath, and then migrates laterally to emerge as springs. Little water is retained as storage and "several dry seasons in a row might deplete this water source if these areas undergo extensive development" (Wheeldon, 1977).

Net available groundwater in the area studied by Wheeldon was estimated at 44,100 acre-feet, (Wheeldon, 1977). This figure was reached by calculating average precipitation times acreage then subtracting estimated evapotranspiration and stream runoff, and was based partly on data from the Pleasant Valley area. The study does not address the feasibility of wells for public water supply.

Seepage losses through the earth-lined canal contribute an estimated 1,260 acre-feet per year to the local groundwater. This seepage from the canal has a strong influence on the local groundwater regime. Springs downslope from the canal demonstrate this influence by mirroring the flow pattern in the canal. The normal hydrologic pattern for stream flow is for the period of peak discharge to occur during the winter and spring period of heavy rainfall. The springs in the Blair Road area exhibit the reverse of this normal pattern, having periods of high flow in the summer when the canal carries an increased flow and low flow in the winter, when the canal carries a reduced flow. Whether flow in these springs is completely dependent on seepage from the canal, or whether canal seepage merely enhances a natural flow is not known.

Groundwater along the ditch probably flows generally towards the northward, being consumptively used by vegetation, surfacing in the springs and streams, or recharging downslope areas. Some of the seepage water probably returns to the South Fork of the American River, but the quantity is not known.

Most of the homes in the Blair Road area and along Old Blair Mill Road rely on individual private wells for their water supply. Seepage from Forebay Reservoir and the EID main canal may provide the primary recharge for these wells. Without actually eliminating seepage from the ditch, it is impossible to estimate the importance of recharge due to ditch losses relative to well yields.

Climate

The western slope of the Sierra Nevada range is charaterized by warm sunny summers and moderate to heavy winter precipitation. Temperatures range from the sub-zero to well above 100 degrees.

Marine air masses travel east from the Pacific and begin their ascent of the Sierra slope heavily laden with water vapor. Precipitation increases with elevation up to about 6,000 feet then decreases. Average seasonal rainfall ranges from 37.6 inches at Placerville (elevation 1,900) to 50 inches at Pacific House (elevation 3,400). Snowfall increases with elevation up to 9,000 feet then decreases. Average seasonal snowfall ranges from 10 inches at Placerville to 50 inches at Pacific House. Precipitation in the past two seasons has been far below normal with water shortages resulting.

Attachment 2

Main Ditch Instream Flow Measurements at Forebay and Patrick lane

AquaCalc 5000 (tm) by JBS Instruments
Firmware Version AQCUSH8c (c)1995-2000

GAGE ID#	Patrick Ln DS of grizzly	
DATE	1/27/2012	
TRANSECT	7	
USER ID#	4675	
SH BEGIN	0.58	
SH END	0.58	
GH BEGIN	0.58	
GH END	0.58	
EST. DISCHARGE	0	
EST. Q (ADJ)	6.04	
METER ID#	1	
AQUACALC ID#	0	
SOUNDING WT.	0	
START MEAS. AT	LEW	
METER TYPE	Pygmy ST2	
METER CONST. C1	0.9604	
	0.0312	
METER CONST. C2	METER CONST. C3	0.96
METER CONST. C4	0.0312	
METER CONST. C5	0	
MEASUREMENT TIME	40	
MEAS. SYSTEM	SAE	
PERCENT SLOPE	0	
TOTAL VERTICALS	18	
TOTAL STATIONS	18	
TOTAL WIDTH	7.5	
TOTAL AREA	10.1	
TOTAL DISCHARGE	6.04	
PCT DIFFERENCE	-29%	
MEAN VELOCITY	0.6	
WETTED PERIMETER	9.74	
HYDRAULIC RADIUS	1.04	
MANNING FACTOR	0	

OB	DIST	DEPTH	ICE	REVS	TIME	COS:VF	LOC	COEF	CLOCK	VEL	AREA	FLOW(Q)	FLAGS
1	0	0	0	0	0	1	6	1	0:00	0	0	0	
2	0.7	0	0	0	0	1	6	1	0:00	0	0	0	
3	1	1.3	0	14	40	1	6	1	11:45	0.367	0.52	0.191	
4	1.5	1.35	0	22	40.9	1	6	1	11:46	0.548	0.675	0.37	1
5	2	1.4	0	30	40.1	1	6	1	11:47	0.75	0.7	0.525	1
6	2.5	1.4	0	37	40.5	1	6	1	11:48	0.909	0.7	0.636	1
7	3	1.4	0	34	40.2	1	6	1	11:49	0.843	0.7	0.59	1
8	3.5	1.4	0	32	40.2	1	6	1	11:50	0.796	0.7	0.557	1
9	4	1.4	0	29	40	1	6	1	11:51	0.727	0.7	0.509	1
10	4.5	1.4	0	29	40	1	6	1	11:52	0.727	0.7	0.509	1
11	5	1.4	0	29	40.5	1	6	1	11:53	0.719	0.7	0.503	1
12	5.5	1.4	0	29	41	1	6	1	11:54	0.71	0.7	0.497	1
13	6	1.4	0	27	40.3	1	6	1	11:55	0.675	0.7	0.473	1
14	6.5	1.4	0	22	41.1	1	6	1	11:55	0.545	0.7	0.382	1
15	7	1.4	0	11	42.4	1	6	1	11:56	0.28	0.7	0.196	
16	7.5	1.4	0	3	43.6	1	6	1	11:58	0.097	0.7	0.068	4
17	8	1.4	0	2	44.5	1	6	1	11:59	0.074	0.49	0.036	4
18	8.2	0	0	0	0	1	6	1	0:00	0	0	0	

AquaCalc 5000 (tm) by JBS Instruments

Firmware Version AQCUSH8c (c)1995-2000

GAGE ID#	A-18	
DATE	1/27/2012	
TRANSECT	6	
USER ID#	4675	
SH BEGIN	0.58	
SH END	0.58	
GH BEGIN	0.58	
GH END	0.58	
EST. DISCHARGE	0	
	8.51	
	METER	
EST. Q (ADJ)	ID#	1
AQUACALC ID#	0	
SOUNDING WT.	0	
START MEAS. AT	REW	
METER TYPE	Pygmy ST2	
METER CONST. C1	0.9604	
METER CONST. C2	0.0312	
METER CONST. C3	0.9604	
METER CONST. C4	0.0312	
METER CONST. C5	0	
MEASUREMENT TIME	40	
MEAS. SYSTEM	SAE	
PERCENT SLOPE	0	
TOTAL VERTICALS	18	
TOTAL STATIONS	18	
TOTAL WIDTH	7.4	
TOTAL AREA	7.89	
TOTAL DISCHARGE	8.51	
PCT DIFFERENCE	0	
MEAN VELOCITY	1.08	
WETTED PERIMETER	8.54	
HYDRAULIC RADIUS	0.92	
MANNING FACTOR	0	

OB	DIST	DEPTH	ICE	REVS	TIME	COS:VF	LOC	COEF	CLOCK	VEL	AREA	FLOW(Q)	FLAGS
1	0	0	0	0	0	1	6	1	0:00	0	0	0	
2	0.8	0	0	0	0	1	6	1	0:00	0	0	0	
3	1.1	0.4	0	42	40.1	1	6	1	10:46	1.037	0.16	0.166	
4	1.6	0.9	0	48	40.2	1	6	1	10:47	1.178	0.45	0.53	1
5	2.1	1.1	0	31	40.4	1	6	1	10:48	0.768	0.55	0.422	
6	2.6	1.2	0	40	40.1	1	6	1	10:49	0.989	0.6	0.593	1
7	3.1	1.1	0	41	40.2	1	6	1	10:50	1.011	0.55	0.556	1
8	3.6	1.25	0	31	40.8	1	6	1	10:51	0.761	0.625	0.476	1
9	4.1	1.3	0	46	40	1	6	1	10:52	1.136	0.65	0.738	1
10	4.6	1.3	0	47	40.2	1	6	1	10:53	1.154	0.65	0.75	1
11	5.1	1.2	0	46	40.1	1	6	1	10:54	1.133	0.6	0.68	1
12	5.6	1.25	0	41	41	1	6	1	10:55	0.992	0.625	0.62	1
13	6.1	1.25	0	45	40.7	1	6	1	10:57	1.093	0.625	0.683	1
14	6.6	1.3	0	48	40.3	1	6	1	10:58	1.175	0.65	0.764	1
15	7.1	1.25	0	59	40.4	1	6	1	10:59	1.434	0.625	0.896	1
16	7.6	1.1	0	54	40.2	1	6	1	11:00	1.321	0.44	0.581	1
17	7.9	0.3	0	25	40.5	1	6	1	11:01	0.624	0.09	0.056	
18	8.2	0	0	0	0	1	6	1	0:00	0	0	0	

Conversation Record

Who: Gene Gutenberger, EID Assistant Hydrographer

Date: December 2, 2015

Subject: Flow metering completed January 27, 2012 to identify losses along Main Ditch

Gene Gutenberger was requested by Reservoir 1 Plant personnel to perform flow monitoring along the Main Ditch because of the low flow reaching the plant compared to releases from Forebay. The flow monitoring was completed on January 27, 2012. The flow rate just downstream of Gage A18 was 8.51 cfs and matched the A18 flow meter. The flow rate at Patrick Land downstream of Grizzly was 6.04 cfs, indicating a 29% loss. Gene indicated that he observed multiple crawdad burrows. Later a crew found larger holes that where repaired by filling them with bentonite.

Prepared by: Tracey Eden-Bishop

Note: According to plant records, the plant started up on January 25, 2012.

Attachment 3

2016 Instream Flow Study

Result Summary

Date	Downstream of Forebay Gage A18 (cfs)	Upstream of Reservoir 1 Inlet (cfs)	Difference (cfs)	Percent Loss (%)
June 1, 2016	13.08	10.83	2.25	17.2%
June 8, 2016	20.76	16.34	4.42	21.3%
July 1, 2016	30.92	26.42	4.50	14.6%

Photographs and discharge measurement summaries attached.

Forebay Gage A-18 (upstream of instream flow measurement site)

Instream flow measurement site downstreatm of Gage A-18

Instream flow measurement site upstream of Reservoir 1


Instream flow measurement site upstream
of Reservoir 1 (looking upstream)

Discharge Measurement Summary

Date Generated: Thu Jun 2 2016

File Information

File Name	A1860116.WAD
Start Date and Time	2016/06/01 09:30:35

Site Details

Site Name	A18 HEAD OF DITCH
Operator(s)	JDB

System Information

Sensor Type	FlowTracker
Serial #	P5644
CPU Firmware Version	3.9
Software Ver	2.30
Mounting Correction	0.0%

Units (English Units)

Distance	ft
Velocity	ft/s
Area	ft^2
Discharge	cfs

Discharge Uncertainty

Category	ISO	Stats
Accuracy	1.0%	1.0%
Depth	0.2%	1.5%
Velocity	0.8%	1.9%
Width	0.1%	0.1%
Method	2.0%	-
# Stations	2.6%	-
Overall	**3.5%**	**2.6%**

Summary

Averaging Int.	40	# Stations	19
Start Edge	REW	Total Width	11.400
Mean SNR	46.5 dB	Total Area	9.632
Mean Temp	55.12 °F	Mean Depth	0.845
Disch. Equation	Mid-Section	Mean Velocity	1.3578
		Total Discharge	**13.0779**

Supplemental Data (Gauge Height Change = 0.000ft)

#	Time	Location	Gauge Height	Rated Flow	Comments
1	Wed Jun 1 09:28:05 PDT 2016	0.000	0.730		
2	Wed Jun 1 10:02:17 PDT 2016	3.100	0.730		

Measurement Results

St	Clock	Loc	Method	Depth	%Dep	MeasD	Vel	CorrFact	MeanV	Area	Flow	%Q
0	09:30	14.50	None	0.000	0.0	0.0	0.0000	1.00	0.0000	0.000	0.0000	0.0
1	09:30	13.80	0.6	1.000	0.6	0.400	1.6722	1.00	1.6722	0.650	1.0868	8.3
2	09:32	13.20	0.6	1.050	0.6	0.420	1.4058	1.00	1.4058	0.630	0.8852	6.8
3	09:34	12.60	0.6	1.100	0.6	0.440	1.5420	1.00	1.5420	0.660	1.0173	7.8
4	09:35	12.00	0.6	1.150	0.6	0.460	1.3606	1.00	1.3606	0.690	0.9383	7.2
5	09:36	11.40	0.6	1.200	0.6	0.480	1.6335	1.00	1.6335	0.720	1.1758	9.0
6	09:38	10.80	0.6	1.250	0.6	0.500	1.4934	1.00	1.4934	0.750	1.1196	8.6
7	09:41	10.20	0.6	1.250	0.6	0.500	1.4984	1.00	1.4984	0.750	1.1233	8.6
8	09:42	9.60	0.6	1.200	0.6	0.480	1.5151	1.00	1.5151	0.720	1.0905	8.3
9	09:44	9.00	0.6	1.000	0.6	0.400	1.4718	1.00	1.4718	0.600	0.8827	6.7
10	09:45	8.40	0.6	0.900	0.6	0.360	1.4593	1.00	1.4593	0.540	0.7876	6.0
11	09:46	7.80	0.6	1.100	0.6	0.440	1.3445	1.00	1.3445	0.660	0.8870	6.8
12	09:47	7.20	0.6	0.900	0.6	0.360	1.1864	1.00	1.1864	0.540	0.6403	4.9
13	09:49	6.60	0.6	0.800	0.6	0.320	1.1060	1.00	1.1060	0.480	0.5305	4.1
14	09:50	6.00	0.6	0.700	0.6	0.280	0.9249	1.00	0.9249	0.420	0.3883	3.0
15	09:51	5.40	0.6	0.500	0.6	0.200	0.7874	1.00	0.7874	0.300	0.2361	1.8
16	09:52	4.80	0.6	0.450	0.6	0.180	0.7844	1.00	0.7844	0.270	0.2118	1.6
17	09:54	4.20	0.6	0.300	0.6	0.120	0.3002	1.00	0.3002	0.255	0.0767	0.6
18	09:54	3.10	None	0.000	0.0	0.0	0.0000	1.00	0.0000	0.000	0.0000	0.0

Rows in italics indicate a QC warning. See the Quality Control page of this report for more information.

Discharge Measurement Summary

Date Generated: Thu Jun 2 2016

File Information

File Name	MD060116.WAD
Start Date and Time	2016/06/01 11:13:16

Site Details

Site Name	MAIN DITCH ABV RES1
Operator(s)	JDB

System Information

Sensor Type	FlowTracker
Serial #	P5644
CPU Firmware Version	3.9
Software Ver	2.30
Mounting Correction	0.0%

Units (English Units)

Distance	ft
Velocity	ft/s
Area	ft^2
Discharge	cfs

Discharge Uncertainty

Category	ISO	Stats
Accuracy	1.0%	1.0%
Depth	0.1%	0.5%
Velocity	0.3%	1.1%
Width	0.1%	0.1%
Method	0.8%	-
# Stations	2.3%	-
Overall	**2.7%**	**1.6%**

Summary

Averaging Int.	40	# Stations	22
Start Edge	REW	Total Width	13.400
Mean SNR	37.8 dB	Total Area	30.428
Mean Temp	57.50 °F	Mean Depth	2.271
Disch. Equation	Mid-Section	Mean Velocity	0.3559
		Total Discharge	**10.8299**

Supplemental Data

#	Time	Location	Gauge Height	Rated Flow	Comments
1	Wed Jun 1 11:11:06 PDT 2016	0.000	2.600		

Discharge Measurement Summary

Date Generated: Thu Jun 9 2016

File Information

File Name	A1860816.WAD
Start Date and Time	2016/06/08 11:40:44

Site Details

Site Name	A18 HEAD OF DITCH
Operator(s)	JDB

System Information

Sensor Type	FlowTracker
Serial #	P5644
CPU Firmware Version	3.9
Software Ver	2.30
Mounting Correction	0.0%

Units (English Units)

Distance	ft
Velocity	ft/s
Area	ft^2
Discharge	cfs

Discharge Uncertainty

Category	ISO	Stats
Accuracy	1.0%	1.0%
Depth	0.2%	0.4%
Velocity	0.6%	1.3%
Width	0.1%	0.1%
Method	1.9%	-
# Stations	2.5%	-
Overall	**3.4%**	**1.7%**

Summary

Averaging Int.	40	# Stations	20
Start Edge	REW	Total Width	11.900
Mean SNR	47.0 dB	Total Area	12.471
Mean Temp	58.42 °F	Mean Depth	1.048
Disch. Equation	Mid-Section	Mean Velocity	1.6644
		Total Discharge	**20.7567**

Supplemental Data

#	Time	Location	Gauge Height	Rated Flow	Comments
1	Wed Jun 8 11:36:03 PDT 2016	0.000	0.940		

Measurement Results

St	Clock	Loc	Method	Depth	%Dep	MeasD	Vel	CorrFact	MeanV	Area	Flow	%Q
0	11:40	15.10	None	0.000	0.0	0.0	0.0000	1.00	0.0000	0.000	0.0000	0.0
1	11:40	14.30	0.6	1.150	0.6	0.460	2.1827	1.00	2.1827	0.805	1.7569	8.5
2	11:43	13.70	0.6	1.250	0.6	0.500	2.1211	1.00	2.1211	0.750	1.5901	7.7
3	11:44	13.10	0.6	1.300	0.6	0.520	2.0531	1.00	2.0531	0.780	1.6006	7.7
4	11:45	12.50	0.6	1.400	0.6	0.560	1.6273	1.00	1.6273	0.840	1.3663	6.6
5	11:46	11.90	0.6	1.450	0.6	0.580	1.6211	1.00	1.6211	0.870	1.4098	6.8
6	11:48	11.30	0.6	1.450	0.6	0.580	1.7339	1.00	1.7339	0.870	1.5080	7.3
7	11:49	10.70	0.6	1.450	0.6	0.580	1.7792	1.00	1.7792	0.870	1.5474	7.5
8	11:50	10.10	0.6	1.450	0.6	0.580	1.7618	1.00	1.7618	0.870	1.5322	7.4
9	11:51	9.50	0.6	1.350	0.6	0.540	1.7851	1.00	1.7851	0.810	1.4454	7.0
10	11:52	8.90	0.6	1.300	0.6	0.520	1.6988	1.00	1.6988	0.780	1.3244	6.4
11	11:53	8.30	0.6	1.300	0.6	0.520	1.7172	1.00	1.7172	0.780	1.3387	6.4
12	11:55	7.70	0.6	1.200	0.6	0.480	1.3504	1.00	1.3504	0.720	0.9720	4.7
13	11:56	7.10	0.6	1.100	0.6	0.440	1.2828	1.00	1.2828	0.660	0.8463	4.1
14	11:57	6.50	0.6	0.950	0.6	0.380	1.3825	1.00	1.3825	0.570	0.7878	3.8
15	11:58	5.90	0.6	0.800	0.6	0.320	1.3665	1.00	1.3665	0.480	0.6555	3.2
16	11:59	5.30	0.6	0.650	0.6	0.260	1.3127	1.00	1.3127	0.390	0.5117	2.5
17	12:01	4.70	0.6	0.550	0.6	0.220	0.9557	1.00	0.9557	0.330	0.3152	1.5
18	12:02	4.10	0.6	0.400	0.6	0.160	0.8261	1.00	0.8261	0.301	0.2484	1.2
19	12:02	3.20	None	0.000	0.0	0.0	0.0000	1.00	0.0000	0.000	0.0000	0.0

Rows in italics indicate a QC warning. See the Quality Control page of this report for more information.

Discharge Measurement Summary

Date Generated: Thu Jun 9 2016

File Information

File Name	MD060816.WAD
Start Date and Time	2016/06/08 12:50:04

Site Details

Site Name	MAIN DITCH AT RES 1
Operator(s)	JDB

System Information

Sensor Type	FlowTracker
Serial #	P5644
CPU Firmware Version	3.9
Software Ver	2.30
Mounting Correction	0.0%

Units (English Units)

Distance	ft
Velocity	ft/s
Area	ft^2
Discharge	cfs

Discharge Uncertainty

Category	ISO	Stats
Accuracy	1.0%	1.0%
Depth	0.1%	0.6%
Velocity	0.4%	1.5%
Width	0.1%	0.1%
Method	0.9%	-
# Stations	2.2%	-
Overall	**2.6%**	**1.9%**

Summary

Averaging Int.	40	# Stations	23
Start Edge	REW	Total Width	13.500
Mean SNR	38.4 dB	Total Area	31.254
Mean Temp	60.79 °F	Mean Depth	2.315
Disch. Equation	Mid-Section	Mean Velocity	0.5227
		Total Discharge	**16.3363**

Supplemental Data

#	Time	Location	Gauge Height	Rated Flow	Comments
1	Wed Jun 8 12:48:04 PDT 2016	0.000	2.670		

Discharge Measurement Summary

Date Generated: Thu Jun 9 2016

File Information		Site Details	
File Name	MD060816.WAD	Site Name	MAIN DITCH AT RES 1
Start Date and Time	2016/06/08 12:50:04	Operator(s)	JDB

Measurement Results

St	Clock	Loc	Method	Depth	%Dep	MeasD	Vel	CorrFact	MeanV	Area	Flow	%Q
0	12:50	15.90	None	0.000	0.0	0.0	0.0000	1.00	0.0000	0.000	0.0000	0.0
1	*12:50*	*15.30*	*0.6*	*0.600*	*0.6*	*0.240*	*0.0489*	*1.00*	*0.0489*	*0.360*	*0.0176*	*0.1*
2	12:51	14.70	0.6	1.200	0.6	0.480	0.3412	1.00	0.3412	0.720	0.2457	1.5
3	12:53	14.10	0.8/0.2	1.700	0.2	1.360	0.4009	1.00	0.3993	1.020	0.4073	2.5
3	12:52	14.10	0.8/0.2	1.700	0.8	0.340	0.3976					
4	12:55	13.50	0.2/0.8	2.100	0.2	1.680	0.5115	1.00	0.4833	1.260	0.6090	3.7
4	12:56	13.50	0.2/0.8	2.100	0.8	0.420	0.4551					
5	12:58	12.90	0.8/0.2	2.300	0.2	1.840	0.6198	1.00	0.5646	1.380	0.7792	4.8
5	12:57	12.90	0.8/0.2	2.300	0.8	0.460	0.5095					
6	12:59	12.30	0.2/0.8	2.600	0.2	2.080	0.6585	1.00	0.6076	1.560	0.9480	5.8
6	13:00	12.30	0.2/0.8	2.600	0.8	0.520	0.5568					
7	13:02	11.70	0.8/0.2	2.750	0.2	2.200	0.7100	1.00	0.6168	1.650	1.0178	6.2
7	13:01	11.70	0.8/0.2	2.750	0.8	0.550	0.5236					
8	13:03	11.10	0.2/0.8	2.900	0.2	2.320	0.7021	1.00	0.5886	1.740	1.0242	6.3
8	13:04	11.10	0.2/0.8	2.900	0.8	0.580	0.4751					
9	13:07	10.50	0.8/0.2	3.100	0.2	2.480	0.6670	1.00	0.5664	1.860	1.0537	6.5
9	13:06	10.50	0.8/0.2	3.100	0.8	0.620	0.4659					
10	13:08	9.90	0.2/0.8	3.000	0.2	2.400	0.6778	1.00	0.6332	1.800	1.1399	7.0
10	13:09	9.90	0.2/0.8	3.000	0.8	0.600	0.5886					
11	13:11	9.30	0.8/0.2	3.000	0.2	2.400	0.6742	1.00	0.5804	1.800	1.0448	6.4
11	13:10	9.30	0.8/0.2	3.000	0.8	0.600	0.4865					
12	13:12	8.70	0.2/0.8	3.000	0.2	2.400	0.6660	1.00	0.5551	1.800	0.9993	6.1
12	13:13	8.70	0.2/0.8	3.000	0.8	0.600	0.4442					
13	13:15	8.10	0.8/0.2	3.000	0.2	2.400	0.6283	1.00	0.6047	1.800	1.0885	6.7
13	13:14	8.10	0.8/0.2	3.000	0.8	0.600	0.5810					
14	13:16	7.50	0.2/0.8	3.000	0.2	2.400	0.6677	1.00	0.5843	1.800	1.0519	6.4
14	13:17	7.50	0.2/0.8	3.000	0.8	0.600	0.5010					
15	13:18	6.90	0.8/0.2	3.000	0.2	2.400	0.6529	1.00	0.5886	1.800	1.0596	6.5
15	13:18	6.90	0.8/0.2	3.000	0.8	0.600	0.5243					
16	13:19	6.30	0.2/0.8	3.000	0.2	2.400	0.6286	1.00	0.5600	1.800	1.0082	6.2
16	13:20	6.30	0.2/0.8	3.000	0.8	0.600	0.4915					
17	13:22	5.70	0.8/0.2	3.000	0.2	2.400	0.5761	1.00	0.4823	1.800	0.8682	5.3
17	13:21	5.70	0.8/0.2	3.000	0.8	0.600	0.3885					
18	13:24	5.10	0.2/0.8	2.900	0.2	2.320	0.5121	1.00	0.4980	1.740	0.8667	5.3
18	13:24	5.10	0.2/0.8	2.900	0.8	0.580	0.4839					
19	*13:27*	*4.50*	*0.8/0.2*	*2.500*	*0.2*	*2.000*	*0.4672*	*1.00*	*0.3574*	*1.500*	*0.5362*	*3.3*
19	*13:26*	*4.50*	*0.8/0.2*	*2.500*	*0.8*	*0.500*	*0.2477*					
20	13:29	3.90	0.6	1.750	0.6	0.700	0.3215	1.00	0.3215	1.311	0.4216	2.6
21	13:30	3.00	0.6	1.000	0.6	0.400	0.1985	1.00	0.1985	0.749	0.1487	0.9
22	13:30	2.40	None	0.000	0.0	0.0	0.0000	1.00	0.0000	0.000	0.0000	0.0

Rows in italics indicate a QC warning. See the Quality Control page of this report for more information.

Discharge Measurement Summary

Date Generated: Tue Jul 5 2016

File Information

File Name	A1870116.WAD
Start Date and Time	2016/07/01 09:55:14

Site Details

Site Name	A18 MAIN DITCH
Operator(s)	JDB

System Information

Sensor Type	FlowTracker
Serial #	P5644
CPU Firmware Version	3.9
Software Ver	2.30
Mounting Correction	0.0%

Units (English Units)

Distance	ft
Velocity	ft/s
Area	ft^2
Discharge	cfs

Discharge Uncertainty

Category	ISO	Stats
Accuracy	1.0%	1.0%
Depth	0.1%	1.0%
Velocity	0.5%	1.6%
Width	0.1%	0.1%
Method	0.9%	-
# Stations	2.0%	-
Overall	**2.5%**	**2.1%**

Summary

Averaging Int.	40	# Stations	25
Start Edge	REW	Total Width	13.650
Mean SNR	46.1 dB	Total Area	17.050
Mean Temp	66.88 °F	Mean Depth	1.249
Disch. Equation	Mid-Section	Mean Velocity	1.8138
		Total Discharge	**30.9246**

Supplemental Data (Gauge Height Change = 0.000ft)

#	Time	Location	Gauge Height	Rated Flow	Comments
1	Fri Jul 1 09:51:41 PDT 2016	0.000	1.230		
2	Fri Jul 1 10:53:58 PDT 2016	3.000	1.230		

Discharge Measurement Summary

Date Generated: Tue Jul 5 2016

File Information

File Name A1870116.WAD
Start Date and Time 2016/07/01 09:55:14

Site Details

Site Name A18 MAIN DITCH
Operator(s) JDB

Measurement Results

St	Clock	Loc	Method	Depth	%Dep	MeasD	Vel	CorrFact	MeanV	Area	Flow	%Q
0	09:55	16.65	None	0.000	0.0	0.0	0.0000	1.00	0.0000	0.000	0.0000	0.0
1	09:55	15.90	0.6	0.500	0.6	0.200	1.7369	1.00	1.7369	0.387	0.6730	2.2
2	09:59	15.10	0.8/0.2	1.500	0.2	1.200	2.7201	1.00	2.4173	0.975	2.3567	7.6
2	09:58	15.10	0.8/0.2	1.500	0.8	0.300	2.1145					
3	10:00	14.60	0.2/0.8	1.600	0.2	1.280	2.9091	1.00	2.5989	0.800	2.0792	6.7
3	10:02	14.60	0.2/0.8	1.600	0.8	0.320	2.2887					
4	10:05	14.10	0.8/0.2	1.700	0.2	1.360	2.6089	1.00	2.3675	0.850	2.0125	6.5
4	10:04	14.10	0.8/0.2	1.700	0.8	0.340	2.1260					
5	10:06	13.60	0.2/0.8	1.700	0.2	1.360	2.4846	1.00	2.1048	0.850	1.7892	5.8
5	10:08	13.60	0.2/0.8	1.700	0.8	0.340	1.7251					
6	10:12	13.10	0.2/0.6/0.8	1.700	0.2	0.680	1.8914	1.00	1.9650	0.850	1.6704	5.4
6	10:12	13.10	0.2/0.6/0.8	1.700	0.6	0.680	1.7766					
6	10:10	13.10	0.2/0.6/0.8	1.700	0.8	1.360	2.4154					
7	10:15	12.60	0.8/0.2	1.800	0.2	1.440	2.2795	1.00	1.7766	0.900	1.5988	5.2
7	10:14	12.60	0.8/0.2	1.800	0.8	0.360	1.2736					
8	*10:16*	*12.10*	*0.2/0.6/0.8*	*1.800*	*0.2*	*1.440*	*2.2762*	*1.00*	*1.7148*	*0.900*	*1.5432*	*5.0*
8	*10:18*	*12.10*	*0.2/0.6/0.8*	*1.800*	*0.6*	*0.720*	*1.7740*					
8	*10:16*	*12.10*	*0.2/0.6/0.8*	*1.800*	*0.8*	*0.360*	*1.0351*					
9	10:20	11.60	0.8/0.2	1.800	0.2	1.440	2.2618	1.00	1.9831	0.900	1.7847	5.8
9	10:19	11.60	0.8/0.2	1.800	0.8	0.360	1.7044					
10	10:21	11.10	0.2/0.8	1.800	0.2	1.440	2.2694	1.00	1.8304	0.900	1.6472	5.3
10	10:22	11.10	0.2/0.8	1.800	0.8	0.360	1.3914					
11	10:24	10.60	0.8/0.2	1.800	0.2	1.440	2.2828	1.00	1.4711	0.900	1.3239	4.3
11	10:23	10.60	0.8/0.2	1.800	0.8	0.360	0.6594					
12	10:25	10.10	0.2/0.8	1.700	0.2	1.360	2.3576	1.00	1.5796	0.850	1.3427	4.3
12	10:26	10.10	0.2/0.8	1.700	0.8	0.340	0.8015					
13	10:30	9.60	0.8/0.2	1.700	0.2	1.360	2.3274	1.00	1.9746	0.850	1.6785	5.4
13	10:29	9.60	0.8/0.2	1.700	0.8	0.340	1.6217					
14	*10:31*	*9.10*	*0.2/0.8*	*1.600*	*0.2*	*1.280*	*2.3009*	*1.00*	*1.8337*	*0.800*	*1.4670*	*4.7*
14	*10:32*	*9.10*	*0.2/0.8*	*1.600*	*0.8*	*0.320*	*1.3665*					
15	*10:34*	*8.60*	*0.2/0.6/0.8*	*1.500*	*0.2*	*1.200*	*2.2933*	*1.00*	*1.5033*	*0.750*	*1.1275*	*3.6*
15	*10:35*	*8.60*	*0.2/0.6/0.8*	*1.500*	*0.6*	*0.600*	*1.5341*					
15	*10:33*	*8.60*	*0.2/0.6/0.8*	*1.500*	*0.8*	*0.300*	*0.6516*					
16	10:38	8.10	0.8/0.2	1.500	0.2	1.200	2.2707	1.00	1.6685	0.750	1.2514	4.0
16	10:37	8.10	0.8/0.2	1.500	0.8	0.300	1.0663					
17	10:40	7.60	0.6	1.400	0.6	0.560	1.4144	1.00	1.4144	0.700	0.9900	3.2
18	10:43	7.10	0.6	1.300	0.6	0.520	1.5607	1.00	1.5607	0.650	1.0143	3.3
19	10:45	6.60	0.6	1.200	0.6	0.480	1.7769	1.00	1.7769	0.600	1.0663	3.4
20	10:46	6.10	0.6	1.000	0.6	0.400	1.8481	1.00	1.8481	0.500	0.9240	3.0
21	10:47	5.60	0.6	0.850	0.6	0.340	1.6755	1.00	1.6755	0.468	0.7834	2.5
22	10:48	5.00	0.6	0.700	0.6	0.280	1.3304	1.00	1.3304	0.420	0.5589	1.8
23	10:49	4.40	0.6	0.500	0.6	0.200	0.4836	1.00	0.4836	0.500	0.2418	0.8
24	10:49	3.00	None	0.000	0.0	0.0	0.0000	1.00	0.0000	0.000	0.0000	0.0

Rows in italics indicate a QC warning. See the Quality Control page of this report for more information.

Discharge Measurement Summary

Date Generated: Tue Jul 5 2016

File Information

File Name	R1070116.WAD
Start Date and Time	2016/07/01 12:03:34

Site Details

Site Name	RES 1 070116
Operator(s)	JDB

System Information

Sensor Type	FlowTracker
Serial #	P5644
CPU Firmware Version	3.9
Software Ver	2.30
Mounting Correction	0.0%

Units (English Units)

Distance	ft
Velocity	ft/s
Area	ft^2
Discharge	cfs

Discharge Uncertainty

Category	ISO	Stats
Accuracy	1.0%	1.0%
Depth	0.1%	0.8%
Velocity	0.3%	1.3%
Width	0.1%	0.1%
Method	0.9%	-
# Stations	2.4%	-
Overall	**2.8%**	**1.9%**

Summary

Averaging Int.	40	# Stations	21
Start Edge	REW	Total Width	12.799
Mean SNR	43.7 dB	Total Area	25.742
Mean Temp	68.19 °F	Mean Depth	2.011
Disch. Equation	Mid-Section	Mean Velocity	1.0264
		Total Discharge	**26.4219**

Supplemental Data

#	Time	Location	Gauge Height	Rated Flow	Comments
1	Fri Jul 1 12:47:21 PDT 2016	2.401	2.550		

Discharge Measurement Summary

Date Generated: Tue Jul 5 2016

File Information	
File Name	R1070116.WAD
Start Date and Time	2016/07/01 12:03:34

Site Details	
Site Name	RES 1 070116
Operator(s)	JDB

Measurement Results

St	Clock	Loc	Method	Depth	%Dep	MeasD	Vel	CorrFact	MeanV	Area	Flow	%Q
0	12:03	15.20	None	0.000	0.0	0.0	0.0000	1.00	0.0000	0.000	0.0000	0.0
1	12:03	14.40	0.6	0.850	0.6	0.340	0.5774	1.00	0.5774	0.595	0.3437	1.3
2	12:04	13.80	0.6	1.200	0.6	0.480	0.8809	1.00	0.8809	0.720	0.6344	2.4
3	12:08	13.20	0.8/0.2	1.900	0.2	1.520	0.9882	1.00	0.9137	1.140	1.0417	3.9
3	12:07	13.20	0.8/0.2	1.900	0.8	0.380	0.8392					
4	12:09	12.60	0.2/0.8	2.200	0.2	1.760	1.0171	1.00	0.8565	1.320	1.1307	4.3
4	12:10	12.60	0.2/0.8	2.200	0.8	0.440	0.6959					
5	12:12	12.00	0.8/0.2	2.300	0.2	1.840	1.1404	1.00	1.0581	1.380	1.4602	5.5
5	12:11	12.00	0.8/0.2	2.300	0.8	0.460	0.9757					
6	12:13	11.40	0.2/0.8	2.300	0.2	1.840	1.2096	1.00	1.0966	1.380	1.5134	5.7
6	12:14	11.40	0.2/0.8	2.300	0.8	0.460	0.9836					
7	12:16	10.80	0.8/0.2	2.300	0.2	1.840	1.2982	1.00	1.2044	1.380	1.6622	6.3
7	12:15	10.80	0.8/0.2	2.300	0.8	0.460	1.1106					
8	12:17	10.20	0.2/0.8	2.300	0.2	1.840	1.3455	1.00	1.2234	1.380	1.6884	6.4
8	12:18	10.20	0.2/0.8	2.300	0.8	0.460	1.1014					
9	12:20	9.60	0.8/0.2	2.250	0.2	1.800	1.4127	1.00	1.2892	1.350	1.7406	6.6
9	12:19	9.60	0.8/0.2	2.250	0.8	0.450	1.1657					
10	12:21	9.00	0.2/0.8	2.250	0.2	1.800	1.2533	1.00	1.2006	1.350	1.6210	6.1
10	12:22	9.00	0.2/0.8	2.250	0.8	0.450	1.1480					
11	12:24	8.40	0.8/0.2	2.300	0.2	1.840	1.3855	1.00	1.2802	1.380	1.7667	6.7
11	12:23	8.40	0.8/0.2	2.300	0.8	0.460	1.1749					
12	12:25	7.80	0.2/0.8	2.400	0.2	1.920	1.2841	1.00	1.1859	1.440	1.7078	6.5
12	12:26	7.80	0.2/0.8	2.400	0.8	0.480	1.0876					
13	12:28	7.20	0.8/0.2	2.400	0.2	1.920	1.2313	1.00	1.0942	1.440	1.5757	6.0
13	12:27	7.20	0.8/0.2	2.400	0.8	0.480	0.9570					
14	12:29	6.60	0.2/0.8	2.500	0.2	2.000	1.1375	1.00	0.9701	1.500	1.4554	5.5
14	12:30	6.60	0.2/0.8	2.500	0.8	0.500	0.8028					
15	12:32	6.00	0.8/0.2	2.700	0.2	2.160	1.1864	1.00	1.0180	1.620	1.6495	6.2
15	12:32	6.00	0.8/0.2	2.700	0.8	0.540	0.8497					
16	12:33	5.40	0.2/0.8	2.700	0.2	2.160	0.9324	1.00	0.9037	1.620	1.4642	5.5
16	12:34	5.40	0.2/0.8	2.700	0.8	0.540	0.8750					
17	12:36	4.80	0.8/0.2	2.700	0.2	2.160	1.0302	1.00	0.9186	1.620	1.4884	5.6
17	12:35	4.80	0.8/0.2	2.700	0.8	0.540	0.8071					
18	12:37	4.20	0.2/0.8	2.250	0.2	1.800	0.8907	1.00	0.8755	1.686	1.4764	5.6
18	12:38	4.20	0.2/0.8	2.250	0.8	0.450	0.8602					
19	12:42	3.30	0.8/0.2	1.600	0.2	1.280	0.7185	1.00	0.6962	1.438	1.0014	3.8
19	12:40	3.30	0.8/0.2	1.600	0.8	0.320	0.6739					
20	12:40	2.40	None	0.000	0.0	0.0	0.0000	1.00	0.0000	0.000	0.0000	0.0

Rows in italics indicate a QC warning. See the Quality Control page of this report for more information.

Attachment 4

Upper Main Ditch 2016 Water Loss
Forebay to Reservoir 1 Water Treatment Plant

2016 Operations Summary

The Reservoir 1 Water Treatment Plant came on line May 26, 2016. Water loss calculations begin June 1, 2016 to allow for watering up the ditch and stabilizing seepage. Losses are based on the difference between Forebay Gage A-18 and the flow meter at the Reservoir 1 Water Treatment Plant, less backwash water returned ahead of the meter. As shown in Figure 1 and 2, flows were ramped up to 30 cfs in June to allow for incremental instream flow measurement. In early July, the flow rate was reduced to 20 cfs and continued at that rate until the end of September when the water treatment plant was taken off line for Project 184 maintenance. Flow continued in the ditch at 0.5 to 1 cfs to deliver water to ditch customers until late October when flow was shut down to dry up the ditch for construction of the Blair Road Bridge Replacement Project. Total water loss is underestimated to the extent carriage losses associated with delivering water to raw water customers after the treatment plant was taken off line are not included in the calculations. Flow in late June is corrected for meter spikes that resulted in replacement of the parshall flume transducer.

Table 1 – 2016 Upper Main Ditch Water Loss

July 7, 2016 - September 30, 2016		June 1, 2016 - September 30, 2016	
Forebay A-18 Gage	3,464	Forebay A-18 Gage	5,296
Plant Inlet	2,847	Plant Inlet	4196
Water loss	617	Water loss	1,100
Percent loss	17.8%	Percent loss	20.8%

Figure 1 – Forebay versus Reservoir 1 Headworks (Cubic-feet/second)

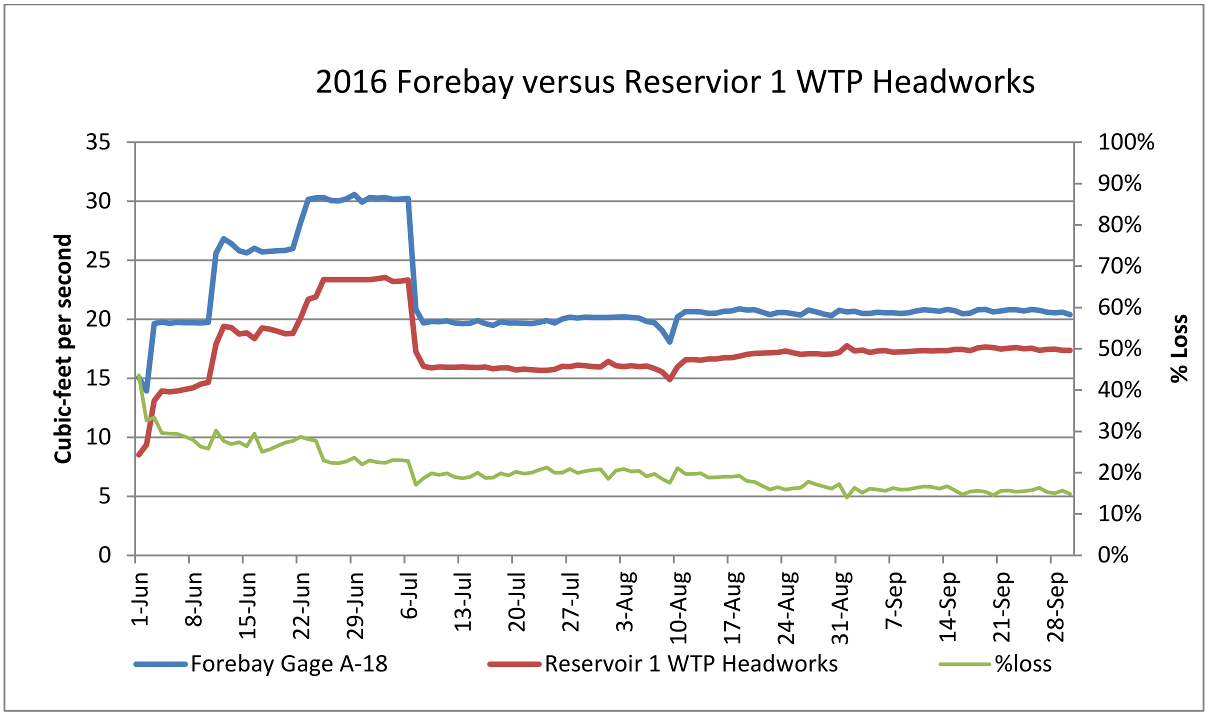
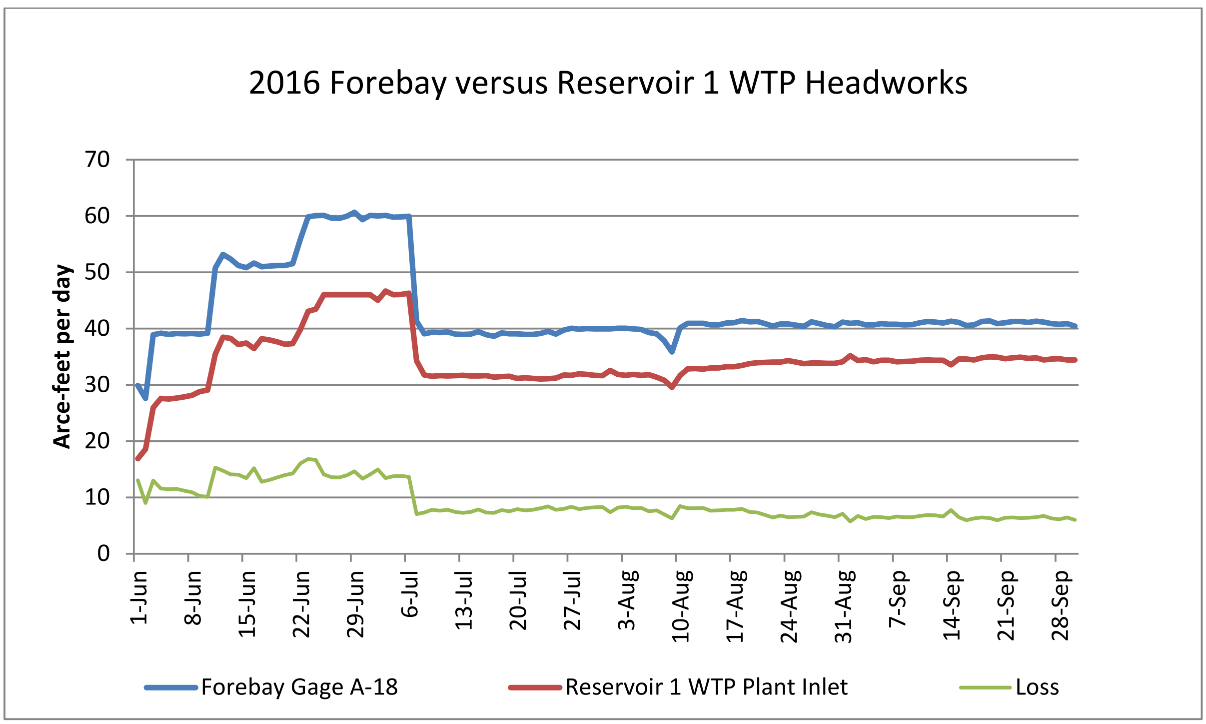


Figure 2 – Forebay versus Reservoir 1 Headworks (Acre-feet/day)



Attachment 5

TECHNICAL MEMORANDUM

To: Tracey Eden-Bishop
El Dorado Irrigation District

From: Ryan M. Abernathy, P.E. # 79136
Zack Washburn, C.E.G. #2624

Date: December 16, 2015

Re: SEEPAGE ESTIMATE
EID Upper Main Ditch
El Dorado County, California
Project No. 15-144.00

SAGE Engineers, Inc. (SAGE) is pleased to submit this memorandum presenting estimates of seepage loss from the approximately 3-mile-long Upper Main Ditch, in El Dorado County, California. This work was performed to assist El Dorado Irrigation District (EID) in securing water conservation grants for the Upper Main Ditch Piping project. The project consists of the construction of a new pipeline within portions of the unlined Upper Main Ditch (canal) alignment, which connects Forebay Reservoir to the Reservoir 1 Water Treatment Plant (WTP). The remaining pipe is proposed to be installed beneath Blair Road, which roughly parallels the existing canal alignment. The pipeline will eliminate approximately 3 miles of open ditch and is intended to reduce water loss between the facilities. Our findings indicate a minimum water loss of 2 to 11 percent due to seepage through the canal at flows of 40 cubic feet per second (cfs), and a 4 to 21 percent loss at flows of 20 cfs. These are likely minimum estimates because they do not include losses associated with animal burrows, areas of shallow and/or fractured rock, evapotranspiration, etc.

This memorandum describes our scope of work, and summarizes observations from a limited geologic reconnaissance, procedures used for percolation and permeability testing, seepage modelling, and estimated losses in the following sections.

SCOPE OF WORK

We performed a limited field exploration program in general accordance with the scope of services presented in our proposal dated November 6, 2015 and our Master Services Agreement with EID dated January 1, 2014. Specifically, our scope consisted of:

- Reviewing readily available geologic maps and reports, and an environmental assessment provided by EID. Based on our literature review and access along the canal, we identified locations suitable for limited field exploration (percolation and permeability testing).
- Performing five (5) percolation (perc) tests in shallow excavations in the canal bottom.
- Driving 3-inch diameter Shelby tubes with a 20 pound slide hammer to collect samples from the canal adjacent to each perc test.

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- Laboratory testing of five (5) samples for permeability testing using ASTM method D5084.
- Reviewing the results of perc and permeability testing and modelling seepage from the canal using SEEP/W software for 2 soil/rock conditions at flow rates of 20 and 40 cfs.
- Reviewing literature for and estimating the amount of evapotranspiration along the canal.
- Preparing this memorandum, which summarizes geologic conditions, field procedures, test results, modeling, and seepage estimates.

PREVIOUS LOSS ESTIMATES

We reviewed the Environmental Assessment for the Proposed El Dorado Canal Pipeline Project (Jones and Stokes, 1977), which includes estimates of seepage and evapotranspiration losses based on flow measurements performed by Mr. E. M. Padjin (C.E.) and trained EID staff in July of 1977. They found that loss generally scaled with flow rate. Between Forebay Reservoir and the Blair Road crossing (STA[1] 120+50 feet), they estimated losses of 0.8 cfs and 4 cfs (4 to 10 percent) at flow rates of 18 and 40 cfs, respectively (Attachment 1). When these loss estimates are extrapolated to the entire length of the canal that will be replaced (15,400 feet), the losses are estimated to be 1 cfs to 5.1 cfs (6 to 13 percent).

In 2012, EID performed additional flow measurements (EID, 2015a). They measured 8.51 cfs at the upstream end of the canal and 6.04 cfs just downstream of Patrick Lane, which equates to approximately 2.5 cfs (29 percent) water loss. Patrick Lane is approximately 1,800 feet upstream of the water treatment plant. They noted the presence of multiple animal burrows and voids in the canal, the larger of which were later filled with bentonite.

EID continuously measures flow at the Forebay Reservoir water rights reporting gauge A18 and at the Reservoir 1 WTP headworks. Review of flow monitoring data from 2009 through 2014 indicates annual water losses in the range of 10% and 23% (EID, 2015b).

GEOLOGIC RECONASSANCE

To provide geotechnical recommendations for a previous phase of the Upper Main Ditch piping project, we met with Domenichelli & Associates (D&A) on October 22, 2015 to perform a geologic reconnaissance of the upper approximate ½-mile-long reach of the canal from Forebay Reservoir (forebay) to the Pinewood Lane crossing. From STA 1+00 to STA 4+50, we observed fractured meta-sedimentary rock exposed in the bank excavation and locally in the canal bottom. The rock exposed in the bank is generally closely to moderately fractured (2" to 12" spacing), moderately hard, and moderately strong. Although we were not able to fully classify the rock in the canal bottom due to flowing water (<½ cfs), the rock is generally consistent with regional geologic mapping that show this portion of the canal underlain by Paleozoic-aged marine rocks (Wagner et al., 1981).

Farther downstream, from STA 4+50 to Pinewood Lane (STA 25+25), we observed reddish brown fine-grained soil exposed in the banks and berm. We observed similar fine-grained soil with occasional andesitic cobbles during a walkdown from Pinewood Lane to the water treatment plant (STA 158+84) with EID on the same date. The regional geologic map indicates that the portion of the canal downstream of

[1] Approximate stationing (STA) based on AutoCAD drawing received from Domenichelli & Associates on November 24, 2015

STA 4+50 is underlain by volcanic rocks of the Mehrten Formation, which commonly weather to material consistent with the observed soil.

PERCOLATION TESTING

Procedures

SAGE geologists Matt Buche and Zack Washburn met representatives of EID at Forebay Reservoir on November 18th and 19th, 2015 to perform perc testing at select locations on the Upper Main Ditch. Upon arrival, we observed flow in the bottom of the canal, at about the same rate as observed during our October reconnaissance, estimated to be approximately 0.10 cfs coming from intermittent flow from the Forebay Dam seepage pump station. After discussing possible effects of the water on the perc tests with EID, we elected to run the tests on topographic high spots in the canal bottom that were not inundated.

We used a post hole digger (clamshell) to create cylindrical excavations (test holes) in the canal bottom as shown on Attachment 1. The test holes were 6 inches in diameter and ranged from 12 to 18 inches in depth. We placed a folding stick ruler at the base of each test hole to measure water levels during testing. We also placed two inches of gravel in the bottom of the holes to protect from scouring when adding water for the tests. Typically test holes are presoaked to saturate the soil; however, the ground was still saturated by the minor flow in the canal. Accordingly, we did not presoak the test holes.

Each test hole was initially filled with water to a level of 6 inches of above the top of the gravel. We performed falling head tests by measuring the drop in the water level at 30 minute intervals. After each measurement, we added water to raise the water level to the starting elevation (6 inches above the gravel). Testing continued until three consecutive measurements differed by less than 1/8 inch.

Percolation Test Results

Table 1 shows the approximate stationing and measured percolation rates for each of the five tests performed. Flowing water was present at the upper two perc test locations and standing water was observed within 80 lineal feet of the third perc test, located at STA 86+50. The measured percolation rates at these locations may be minimums due to possible increased pore pressure around the test holes.

TABLE 1- SUMMARY OF PERCOLATION TEST RESULTS

Test Location	Material Type	Measured Percolation Rate (min/inch)	Estimated Hydraulic Conductivity[2] (cm/day)	Estimated Hydraulic Conductivity[3] (cm/day)	Estimated Hydraulic Conductivity[4] (cm/day)
4+50	fine-grained soil	96	4	<8.3	4.7
26+00	fine-grained soil	120	4	<8.3	6.3
86+50	fine-grained soil	480	NA[5]	<8.3	1.5
130+00	coarse-grained soil	20	20	16½	47
134+50	coarse-grained soil/weathered rock	8	50	>50	NA

[2] Based on Amoozegar, A., Comparison of saturated hydraulic conductivity and percolation rate: Implications for designing septic tank systems, 1997.

[3] Based on Natural Resources Conservation Service, Table 4 on page 12 of Soil Potential Ratings, Subsurface Sewage Disposal Systems for Single Family Residences, February 2009.

[4] Based on Mulqueen, J. and Rodgers, M., Percolation Testing and Hydraulic Conductivity of Soils for Percolation Areas, 2001.

[5] Not available because percolation rate is beyond the limits of the correlation

The percolation rates range from 8 to 480 minutes per inch (MPI). Based on Soil Conservation Service (SCS) reports, the Environmental Assessment (Jones and Stokes, 1977) cites perc rates ranging from 0.2 to 6.3 inches per hour for the soil along the canal. Converting the SCS rates from inches per hour, yields rates of 9.5 to 300 MPI, similar to our measurements.

To compare the measured perc rates with the following permeability test results, we used 3 different methods to estimate hydraulic conductivity from the percolation rates, as indicated in Table 1. Note that the terms "hydraulic conductivity" and "permeability" are used interchangeably in practice and in this memorandum.

PERMEABILITY TESTING

We collected relatively undisturbed rock and soil samples from the bottom of the canal and berm using a 20 pound slide hammer to drive 3-inch diameter Shelby tubes adjacent to each perc test. We submitted four (4) samples collected from the canal bottom and one (1) from the berm for laboratory permeability testing using ASTM method D5084. Permeability is the measure of the ability of a material to allow fluid to pass through it. Test D5084 measures the rate at which water passes through a fully saturated sample and is usually reported in units of centimeters per second (cm/sec). The permeability test results are included with this memorandum as Appendix A and summarized in the Table 2. Note, the table also provides test results in more usable units of cm/day to allow for better comprehension of the data.

TABLE 2 - SUMMARY OF PERMEABILITY TEST RESULTS

Sample Number	Sample Location	Position in Canal	Lab Test Permeability (cm/sec)	Lab Test Permeability (cm/day)
Perm 1	4+50	berm	1.78 e-4	15.38
Perm 2	26+00	bottom	3.83 e-6	0.33
Perm 3	86+50	bottom	2.87 e-7	0.02
Perm 4	130+00	bottom	1.19 e-6	0.10
Perm 5	134+50	bottom	1.45 e-4	12.53

SEEPAGE MODELING

Procedures

Based on the limited number of samples collected and the potential variability in permeability along the canal, we elected to average the permeabilities measured from the canal bottom samples in our model. We divided the canal into four equal length segments, each representing 3,971 feet of native canal bank and bottom. We used the permeability from sample Perm 1 to model the fill comprising the berm along the full length of the canal. Canal cross sections were established for modeling purposes from the 100-foot-cross sections cut in the Civil 3D file prepared by D&A (D&A, November 2015).

We analyzed the four canal cross sections using SEEP/W version 8.15.3.11339 by GEO-SLOPE, 2012. In our models, we assumed that the canal reaches steady state conditions, meaning that the canal runs at constant head sufficiently long so that the seepage velocities do not vary with time. Furthermore, we assumed that the canal runs constantly so that the soil becomes fully saturated. To help determine that these assumptions and others were appropriate, we ran sensitivity cases that varied the saturated/nonsaturated condition, groundwater table, preferential flow ratios, canal head, and impermeable boundary depth. We found that most of these assumptions did not have a large effect on the seepage volume. See the Seepage Estimates section, below, for further discussion on the sensitivity cases.

The permeabilities used in our models were directly based on the lab-determined values presented in Tables 2 and 3. However, because the permeability values estimated from our percolation testing were generally an order of magnitude higher than the lab values (see Table 3 for comparison), we ran the models with the permeabilities increased by one order of magnitude to establish a potential range of seepage loss.

The models were analyzed assuming both 40 cfs and 20 cfs canal flows. Based on discussions with D&A, this results in approximate canal heads of 2.5 and 1.33 feet, respectively, above the bottom of the canal. The results of the seepage modeling are discussed below.

TABLE 3 – COMPARISON OF LAB PERMEABILITIES WITH ESTIMATED RATES FROM PERC TESTING

Test Location	Lab Test Permeability (cm/sec)	Lab Test Permeability (cm/day)	Estimated Hydraulic Conductivity from Perc Test[3] (cm/day)	Estimated Hydraulic Conductivity from Perc Test[4] (cm/day)	Estimated Hydraulic Conductivity from Perc Test[5] (cm/day)
4+50	1.78 e-4	15.38 (sample from berm)	4 (perc test from bottom)	<8.3 (perc test from bottom)	4.7 (perc test from bottom)
26+00	3.83 e-6	0.33	4	<8.3	6.3
86+50	2.87 e-7	0.02	NA	<8.3	1.5
130+00	1.19 e-6	0.10	20	16 ½	47
134+50	1.45 e-4	12.53	50	>50	NA

Seepage Estimates

Based on the seepage modeling for 40 cfs canal flow, we estimate the seepage losses to range from about 0.8 to 4.5 cfs (2 to 11 percent). For the 20 cfs canal flow, we estimate seepage losses of about 0.8 to 4.2 cfs (4 to 21 percent). As previously mentioned, the range in the loss estimates is primarily due to the difference in conductivities measured from permeability testing (lower values) versus those estimated from percolation testing (higher values).

We found that the seepage models were sensitive to changes in preferential flow direction (horizontal vs. vertical) and depth to an impermeable layer. Bedded clay layers can have a preferential horizontal flow direction typically up to 4 times the vertical direction (ASDSO, 2014). Additionally, most seepage models assume an impermeable layer/boundary at depth. By varying the preferential flow ratio and impermeable boundary depth, we estimate the ranges of water loss presented above. Based on our experience with unlined canals, the uncertainty in the parameters established for the seepage models, the variability of the canal materials in areas not observed for this study, and the sensitivity of the calculated flow estimates to some of the key model parameters, we believe the upper end of our loss estimate range to be more likely than the lower end.

OTHER SOURCES OF POSSIBLE WATER LOSS

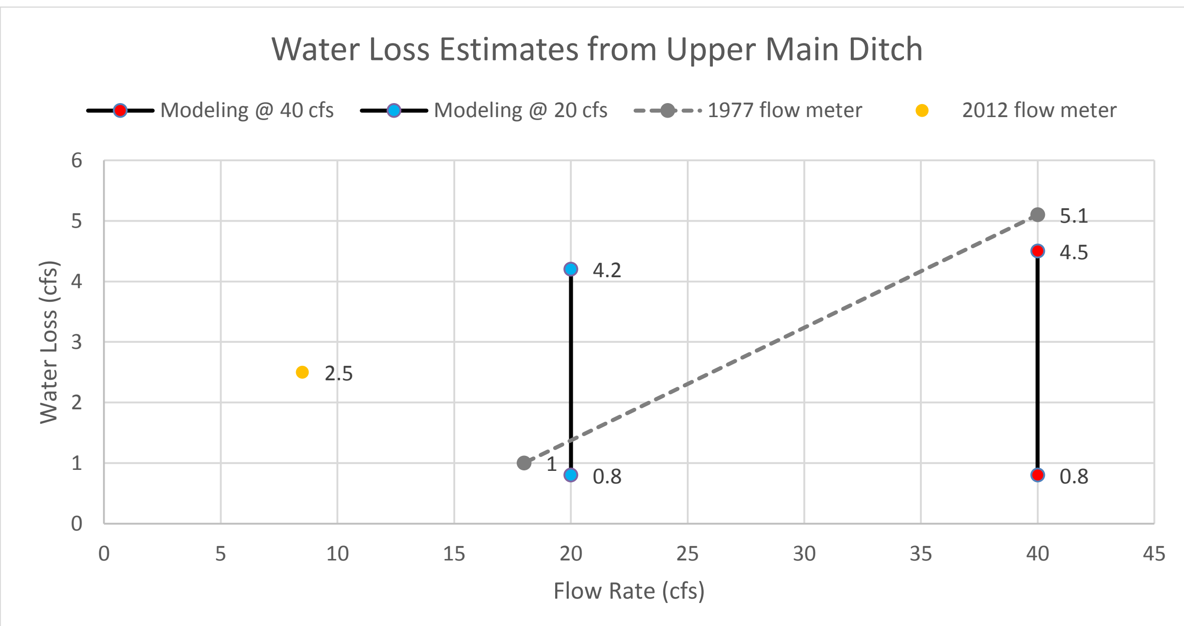
We reviewed readily available publications to estimate potential water loss from the canal due to evapotranspiration (sum of evaporation and transpiration from plants and trees). Although it is difficult to quantify evapotranspiration (ET), there are numerous models that attempt to do so. The models range from simple temperature and radiation-driven equations to more complex algorithms.

We reviewed a study that measured actual evapotranspiration using instruments on towers above the forest canopy at the Blodgett Research Station (Fisher et al., 2004). The research station is located about 10 miles north of the canal, underlain by the same soil type and geologic formation (Cohasset Series soil and Mehrten Formation), and covered with similar trees species (Ponderosa Pine, Douglas Fir, White Fir and Incense Cedar). The instruments measure flux and record up to 200 watts per square meter of evapotranspiration during the summer months. This amount equates to approximately 0.1 cfs or ¼ percent of water loss from the canal due to ET.

We observed rodent burrows in the banks and berm during our reconnaissance and walkdown. It is likely that additional water loss, that is not included in our model, is occurring through burrows and other pathways, such as zones of shallow and/or fractured rock. The observation of seasonal springs that form during the dry summer months on the downhill side of the canal (Jones and Stokes, 1977) suggests that water flows through larger voids or at least areas of higher permeability are present that were not represented in our model.

COMPARISON OF SEEPAGE ESTIMATES AND CONCLUSIONS

The following chart presents water loss estimates from our modeling with those from flow meter measurements for comparison and discussion. At flows of 40 cfs, the high end of the modeled range is similar to the 1977 flow meter estimates. Conversely, at 20 cfs the low end of the modeled range generally coincides with the 1977 measurements. In general, the upper limit of the modeled seepage losses are within the range of Forebay/Reservoir 1 WTP flow metering data (EID, 2015b).



The water loss estimated by EID in 2012 is greater than both the estimates from 1977 data and our seepage. The reason for this is unknown, but may be due to other sources of potential water loss as discussed above, possibly degradation of the berm and resulting increased water loss, or imprecise measurements of the cross sectional area used in the flow meter estimates.

There are numerous factors that contribute to uncertainty in the water loss estimates, including: limited conductivity data with only 5 data points (permeability samples) for 3 miles of canal; and the possible increased pore pressure due to flowing water and resulting lower percolation rates. Also it is important to consider that conductivity values typically range a few orders of magnitude, even within the same soil or rock type. Based on the available data, it appears that at flows of 40 cfs on the order of 10 percent of the water that leaves the forebay is lost during travel to the treatment plant.

LIMITATIONS

This technical memorandum has been prepared for the sole use of El Dorado Irrigation District and its agents, specifically for design of the improvements described herein for the subject project. The seepage estimates presented in this technical memorandum are solely professional opinions based on limited percolation testing, limited permeability testing, SEEP/W modelling, and professional experience with similar projects. SAGE is not responsible for the data and methods presented by others.

The information provided in this technical memorandum is valid for a period of three (3) years from the date of issuance. Conditions may arise that were not apparent at the time of this design (e.g., changes in design geometries, soil design parameters, loadings, etc.). In addition, changes in applicable standard of practice can occur, whether from legislation or the broadening of knowledge. Accordingly, the information provided in this technical memorandum may be invalidated, wholly or partially, by changes outside of our control. Should changes occur that might affect the design presented herein, SAGE should be notified to evaluate the validity of this technical memorandum to those changes. This document may not be reproduced for any other reason than pertains to the project for which it was prepared.

Attachments:

Attachment 1 – Percolation and Flow Test Locations (prepared by D&A)
Appendix A - Sierra Testing Laboratories – Lab Test Results

References:

Amoozegar, A., Comparison of saturated hydraulic conductivity and percolation rate: Implications for designing septic tank systems, 1997.

Association of State Dam Safety Officials (ASDSO), 2014, Dam Safety Technical Seminar, Seepage through Earth Dams, April 1-2, 2014.

Domenichelli & Associates, Civil 3D EID-051-Main Ditch working file, sent November 23, 2015.

Eldorado Irrigation District a, Conversation Record, Flow metering completed January 27, 2012 to identify losses along Main Ditch, December 2, 2015

Eldorado Irrigation District b, personal communication with EID staff, December 16, 2015.

Fisher, J. B., et al., Evapotranspiration models compared on a Sierra Nevada forest ecosystem, 2004.

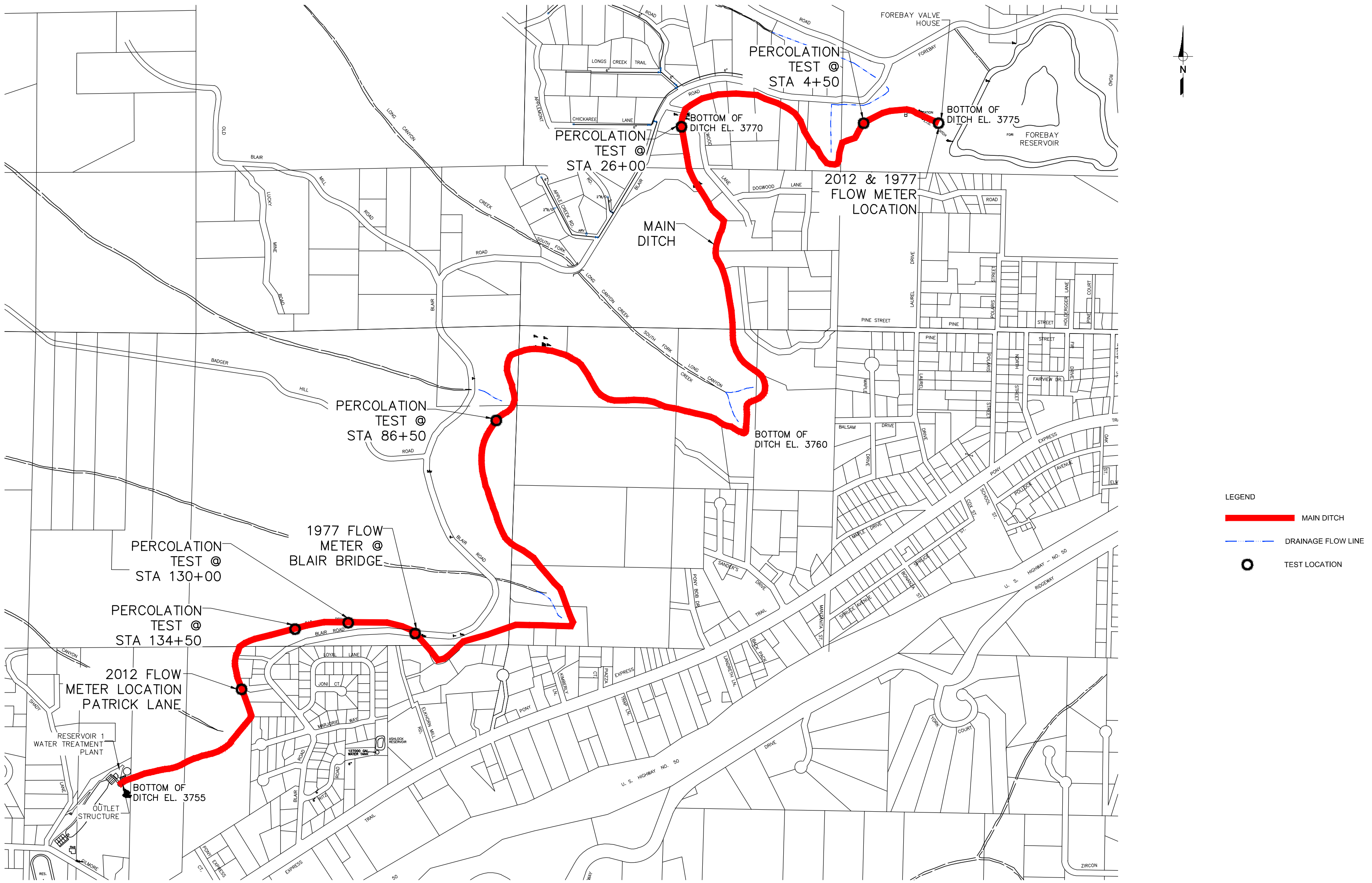
GEO-SLOPE International Ltd., Seepage Modeling with SEEP/W, An Engineering Methodology, July 2012.

Jones and Stokes Associates, Environmental Assessment of the El Dorado Canal Pipeline Project, August 19, 1977.

Natural Resources Conservation Service, Table 4 on page 12 of Soil Potential Ratings, Subsurface Sewage Disposal Systems for Single Family Residences, February 2009, (http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_010822.pdfVirginia Department).

Mulqueen, J. and Rodgers, M., Percolation Testing and Hydraulic Conductivity of Soils for Percolation Areas, 2001.

Wagner, D.L., Jennings, C.W., Bedrossian, T.L., and Bortugno, E.J, 1981, Geologic Map of the Sacramento Quadrangle, California Division of Mines and Geology, scale 1:250,000.



REV	DATE	BY	DESCRIPTION

SCALE: 1"=400'

WARNING 0 1/2 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE.

DESIGNED
DRAWN
CHECKED

EL DORADO IRRIGATION DISTRICT

2890 MOSQUITO ROAD - P.O. BOX 1047
PLACERVILLE, CALIFORNIA 95667

EID UPPER MAIN DITCH

PERCOLATION & FLOW TESTING LOCATIONS

FIGURE

Z:\PROJECT FILES\EID-051-UPPER MAIN DITCH DESIGN\PREVIOUS DESIGN\EXHIBIT_ALIGNMENTS.DWG
20151215.160510

HYDRAULIC CONDUCTIVITY TEST REPORT

SAMPLE DATA

Sample Identification: Perm 1A Berm
Location: Roots & Weeds
Remarks:

Sample Depth, ft.: 0-18"
Sample Type: Driven Liner

Lab No.: S44504

TEST RESULTS

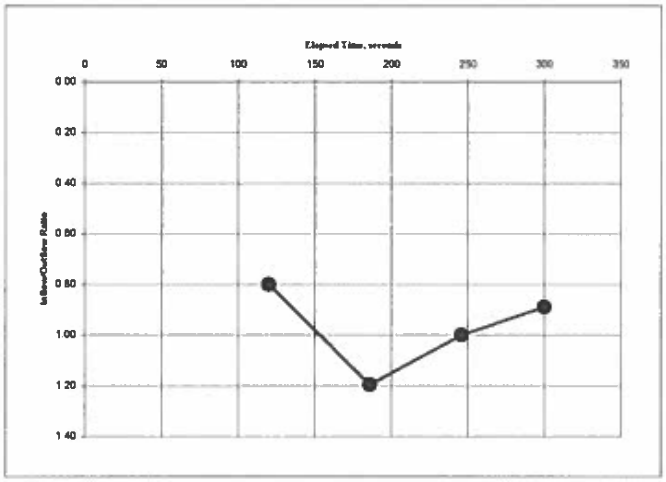
Permeability, cm/sec.: 1.78E-04

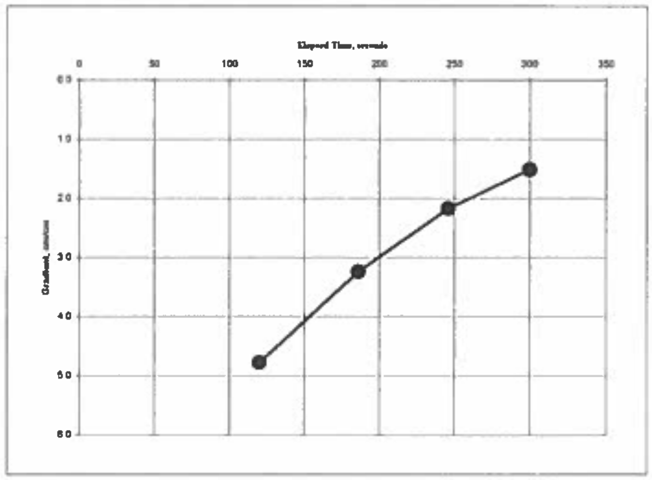
Average Hydraulic Gradient: 2.9

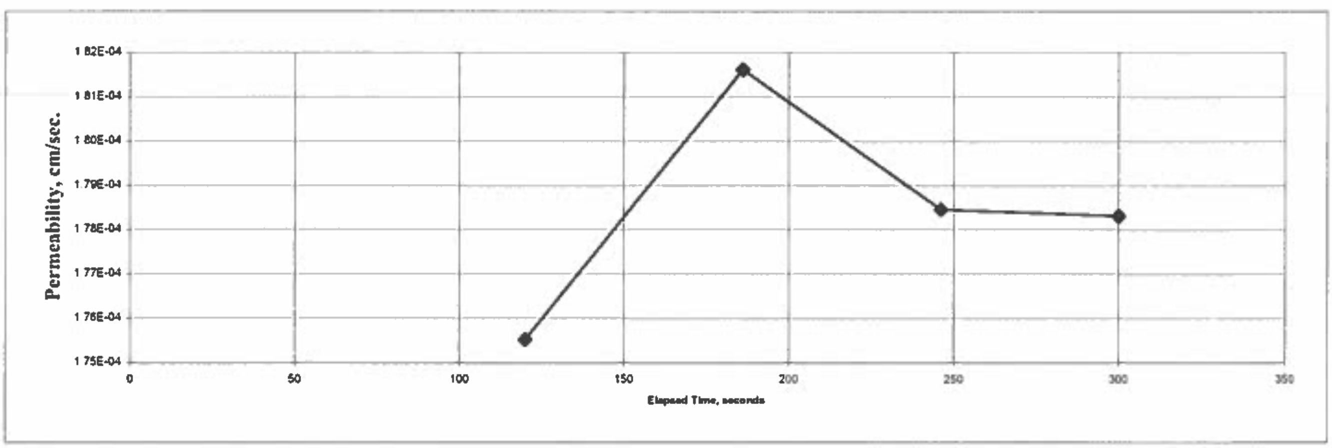
Effective Confining Pressure, psi: 5

TEST SAMPLE DATA

Before Test		After Test	
Specimen Height, cm:	6.73	Specimen Height, cm:	6.73
Specimen Diameter, cm:	7.14	Specimen Diameter, cm:	7.14
Dry Unit Weight, pcf:	72.0	Dry Unit Weight, pcf:	74.3
Moisture Content, %	26.1	Moisture Content, %	34.0







Test Method: ASTM D5084 Method C

PROJECT NUMBER:	15-120	November 19, 2015

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GEOTECHNICAL AND MATERIALS TESTING SERVICES

485 Pierroz Rd, Unit D, Placerville, CA 95667
Ph 530-622-1101 Fax 530-622-1191

EID UMD

HYDRAULIC CONDUCTIVITY TEST REPORT

SAMPLE DATA

Sample Identification: Perm 2 Bottom — Sample Depth, ft.: 0-8" — Lab No.: S44505

Location: 0 — Sample Type: Driven Liner

Remarks:

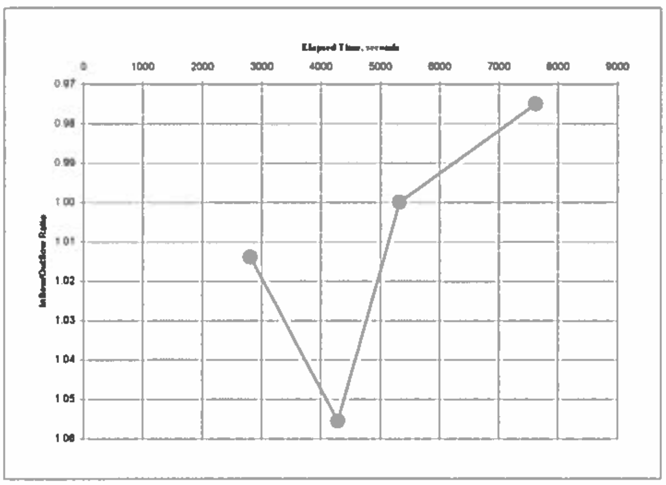
TEST RESULTS

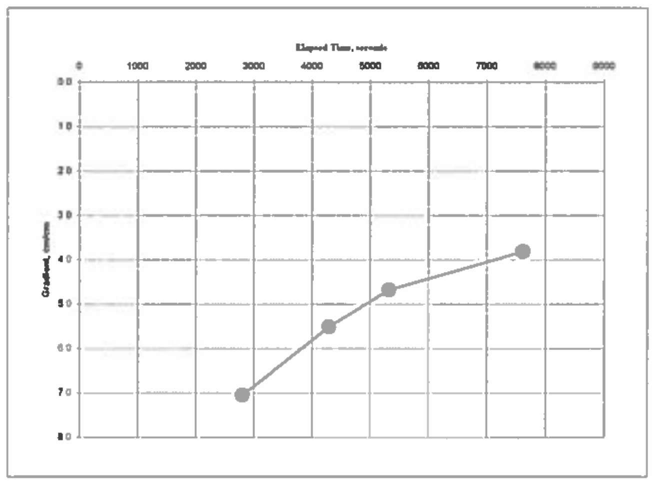
Permeability, cm/sec.: 3.83E-06 — **Average Hydraulic Gradient: 5.3**

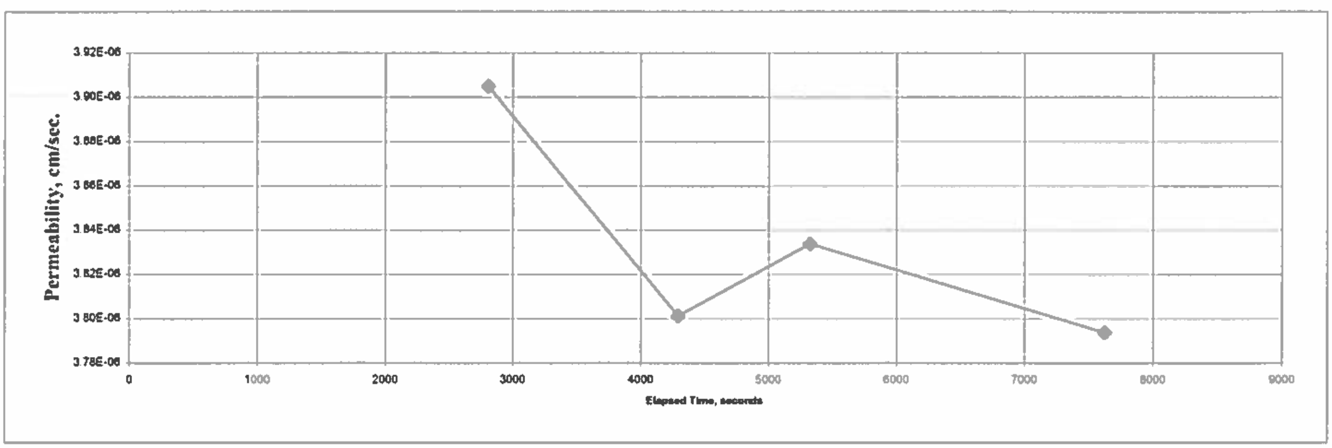
Effective Confining Pressure, psi: 5

TEST SAMPLE DATA

Before Test		After Test	
Specimen Height, cm:	7.11	Specimen Height, cm:	7.11
Specimen Diameter, cm:	7.19	Specimen Diameter, cm:	7.19
Dry Unit Weight, pcf:	80.6	Dry Unit Weight, pcf:	78.7
Moisture Content, %	37.6	Moisture Content, %	41.6







Test Method: ASTM D5084 Method C

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HYDRAULIC CONDUCTIVITY TEST REPORT

SAMPLE DATA

Sample Identification: Perm 3 Bottom
Sample Depth, ft.: 0-9"
Lab No.: S44506
Location: 0
Sample Type: Driven Liner
Remarks:

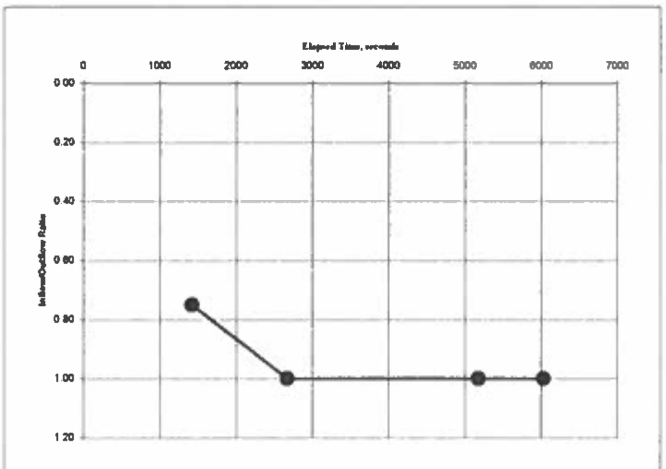
TEST RESULTS

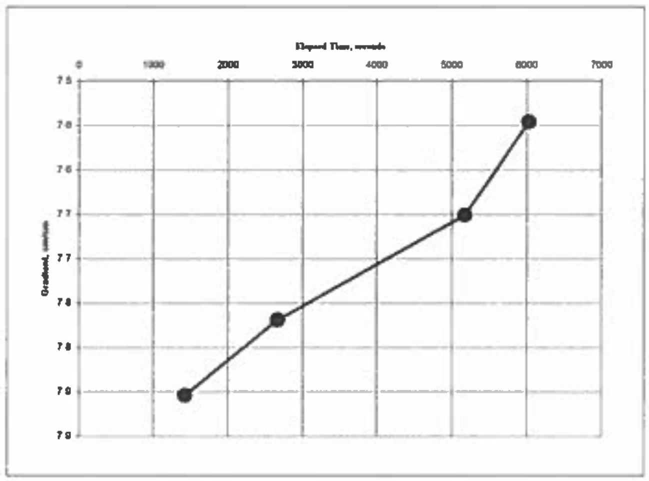
Permeability, cm/sec.: 2.61E-07
Average Hydraulic Gradient: 7.7

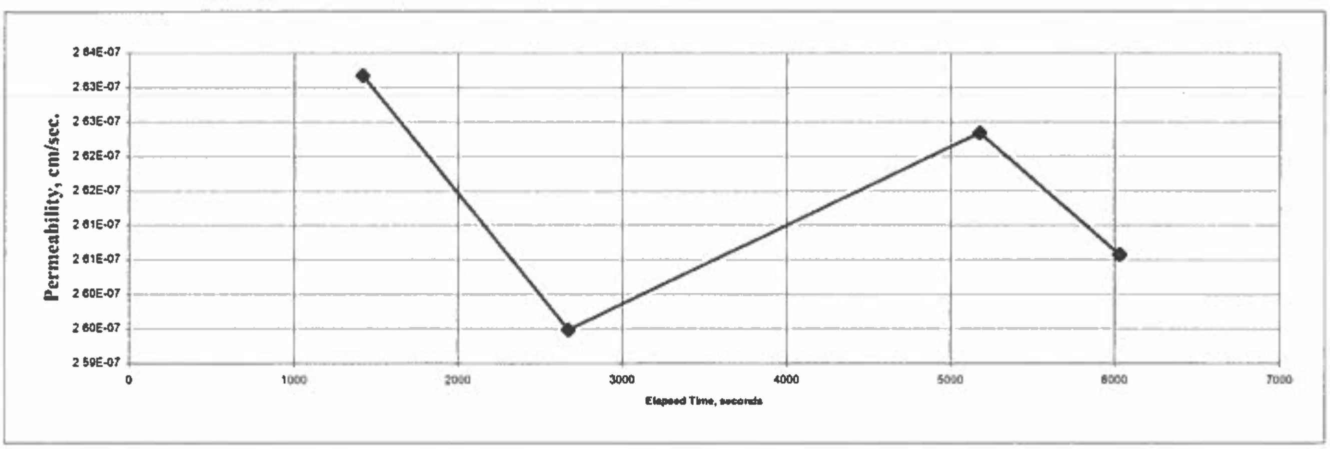
Effective Confining Pressure, psi: 5

TEST SAMPLE DATA

Before Test		After Test	
Specimen Height, cm:	7.62	Specimen Height, cm:	7.62
Specimen Diameter, cm:	7.19	Specimen Diameter, cm:	7.19
Dry Unit Weight, pcf:	83.1	Dry Unit Weight, pcf:	83.0
Moisture Content, %	37.2	Moisture Content, %	39.8







Test Method: ASTM D5084 Method C

PROJECT NUMBER:	15-120	November 24, 2015	
SIERRA TESTING LABORATORIES, INC. GEOTECHNICAL AND MATERIALS TESTING SERVICES 485 Pierroz Rd, Unit D, Placerville, CA 95667 Ph 530-622-1101 Fax 530-622-1191			EID UMD

HYDRAULIC CONDUCTIVITY TEST REPORT

SAMPLE DATA

Sample Identification: Perm 4 Bottom
Sample Depth, ft.: 0-9"
Lab No.: S44507
Location: 0
Sample Type: Driven Liner
Remarks:

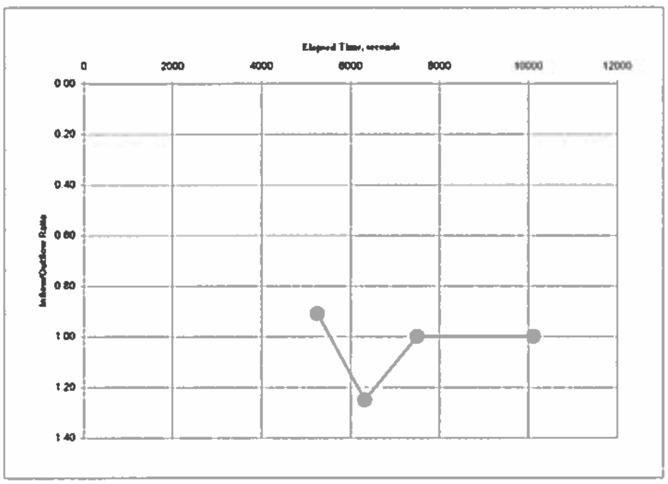
TEST RESULTS

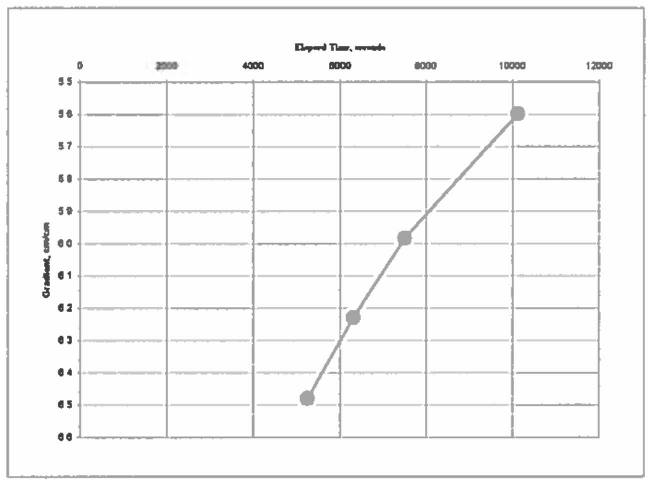
Permeability, cm/sec.: 1.19E-06
Average Hydraulic Gradient: 6.1

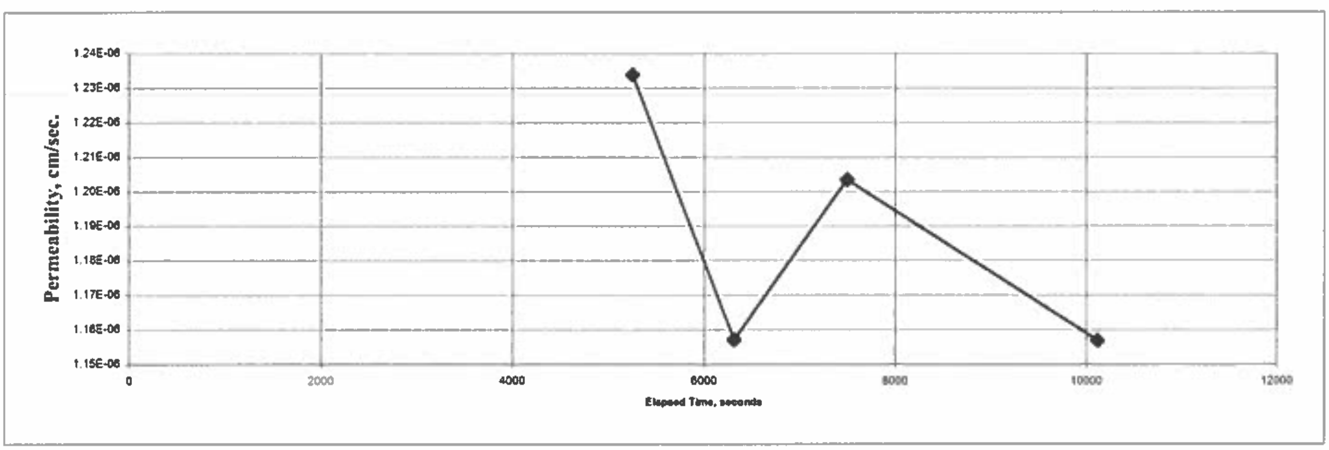
Effective Confining Pressure, psi: 5

TEST SAMPLE DATA

Before Test		**After Test**	
Specimen Height, cm:	7.87	Specimen Height, cm:	7.77
Specimen Diameter, cm:	7.14	Specimen Diameter, cm:	7.14
Dry Unit Weight, pcf:	72.7	Dry Unit Weight, pcf:	74.6
Moisture Content, %	50.8	Moisture Content, %	49.7







Test Method: ASTM D5084 Method C

PROJECT NUMBER:	**15-120**	November 24, 2015	

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HYDRAULIC CONDUCTIVITY TEST REPORT

SAMPLE DATA

Sample Identification: Perm 5 Bottom   Sample Depth, ft.: 0-9"   Lab No.: S44508
Location: Broken, very weathered rock   Sample Type: Driven Liner
Remarks:

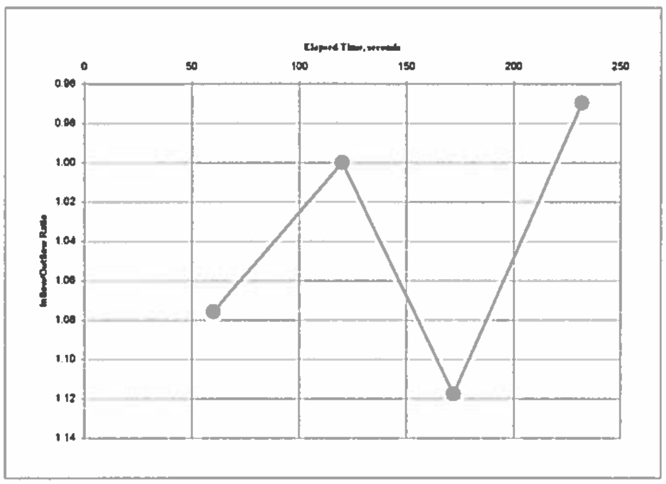
TEST RESULTS

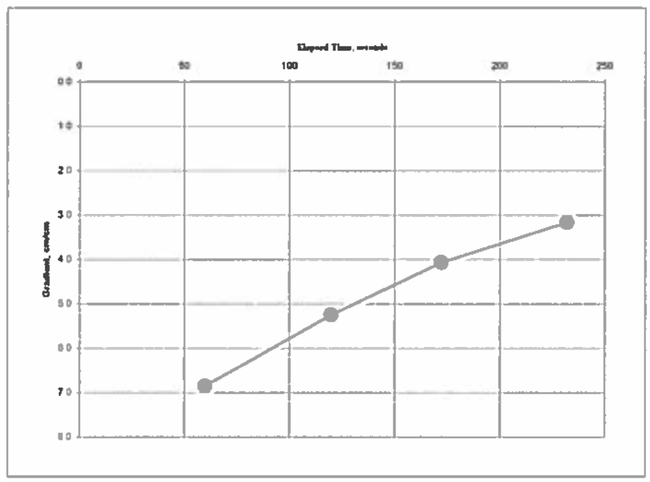
Permeability, cm/sec.: 1.45E-04   **Average Hydraulic Gradient: 4.8**

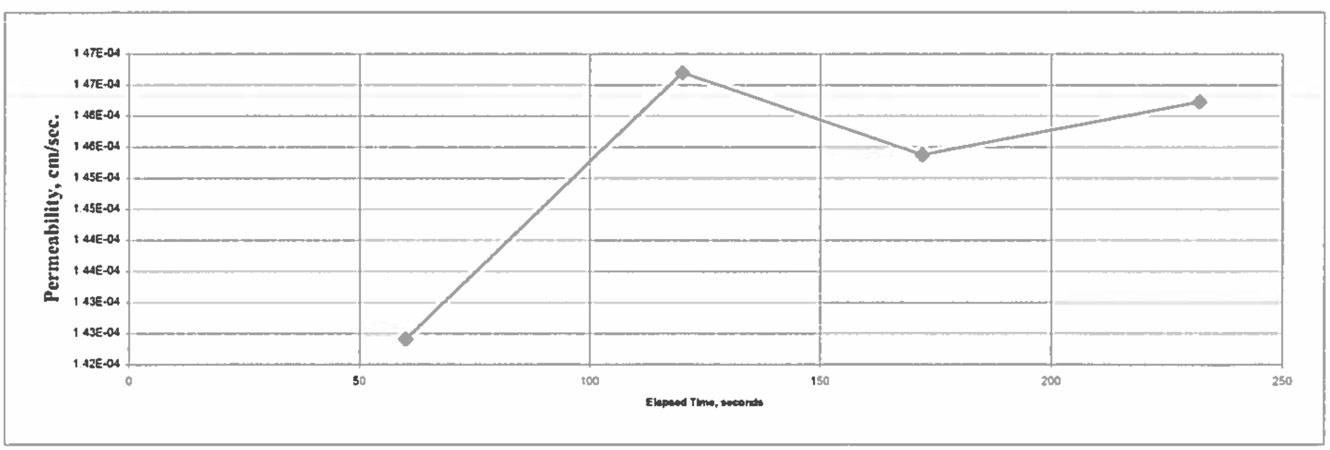
Effective Confining Pressure, psi: 5

TEST SAMPLE DATA

Before Test		**After Test**	
Specimen Height, cm:	7.62	Specimen Height, cm:	7.62
Specimen Diameter, cm:	7.14	Specimen Diameter, cm:	7.14
Dry Unit Weight, pcf:	60.6	Dry Unit Weight, pcf:	64.7
Moisture Content, %	69.9	Moisture Content, %	60.3







Test Method: ASTM D5084 Method C

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Attachment 6

Upper Main Ditch 2017, 2018, 2019, and 2020 Water Loss
Forebay to Reservoir 1 Water Treatment Plant

This attachment includes the detailed annual analysis for 2017 through 2020.

2017 Operations Summary

The Reservoir 1 Water Treatment Plant came on line later in 2017 with the plant not ramping up until June 7th. Water began flowing a few days prior to water up the ditch and stabilize losses. Losses are based on the difference between Forebay Gage A-18 and the flow meter at the Reservoir 1 Water Treatment Plant, less backwash water returned ahead of the meter. As shown in Figure 1 and 2, flows were ramped up to 20 cfs in June and continued at that rate until the end of September when the water treatment plant was taken off line for Project 184 maintenance. Flow continued in the ditch at 0.5 to 1 cfs to deliver water to ditch customers until late October. Total water loss is underestimated to the extent carriage losses associated with delivering water to raw water customers after the treatment plant was taken off line are not included in the calculations.

Table 1 – 2017 Upper Main Ditch Water Loss

June 7 through October	
Forebay A-18 Gauge	4,555
Plant Inlet	3,688
Water Loss	867
Percent Loss	19%

Figure 1 – Forebay versus Reservoir 1 Headworks (Cubic-feet/second)

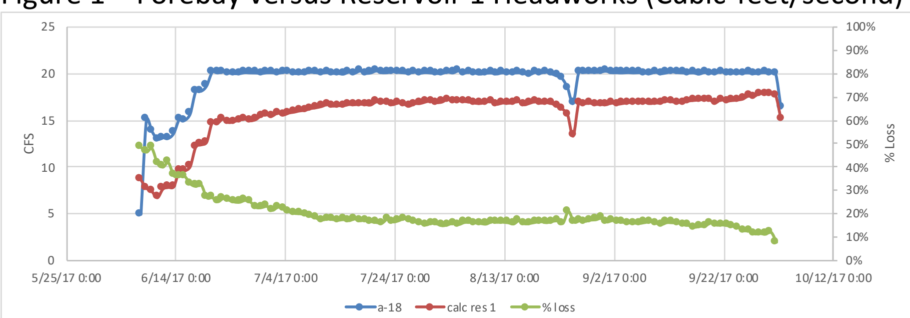
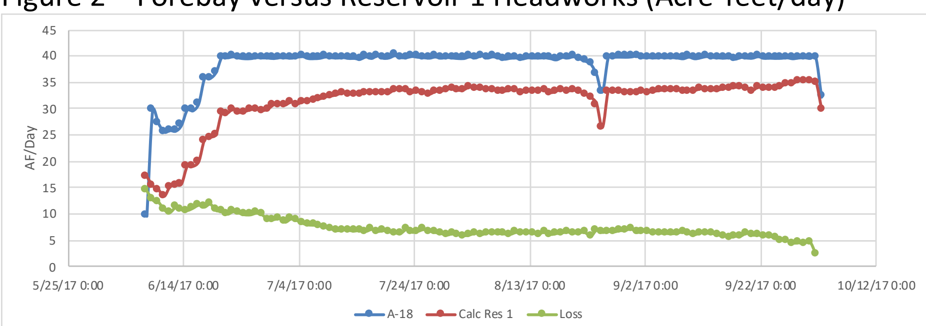


Figure 2 – Forebay versus Reservoir 1 Headworks (Acre-feet/day)



2018 Operations Summary

The Reservoir 1 Water Treatment Plant came on line at the end of March 2018. Ditch flows began a few days before the plant was brought on line to water up the ditch and stabilize losses. Losses are based on the difference between Forebay Gage A-18 and the flow meter at the Reservoir 1 Water Treatment Plant, less backwash water returned ahead of the meter. As shown in Figure 1 and 2, flows were initially in the 10 cfs range early in the spring and were ramet to approximately 18 cfs in early May. A spike in flows in late June reached over 20 cfs but stabilized at 15 cfs through late August before ramping down to 10cfs and continued at that rate until the end of September when and another flow spike over 20 cfs and then the water treatment plant was taken off line for Project 184 maintenance. Flow continued in the ditch at 0.5 to 1 cfs to deliver water to ditch customers until late October. Total water loss is underestimated to the extent carriage losses associated with delivering water to raw water customers after the treatment plant was taken off line are not included in the calculations.

Table 1 – 2018 Upper Main Ditch Water Loss

All season		June 28th – Aug 21st	
Forebay A-18 Gauge	5,642	Forebay A-18 Gauge	1,636
Plant Inlet	4,222	Plant Inlet	1,321
Water Loss	1,420	Water Loss	315
Percent Loss	25%	Percent Loss	19.2%

Figure 1 – Forebay versus Reservoir 1 Headworks (Cubic-feet/second)

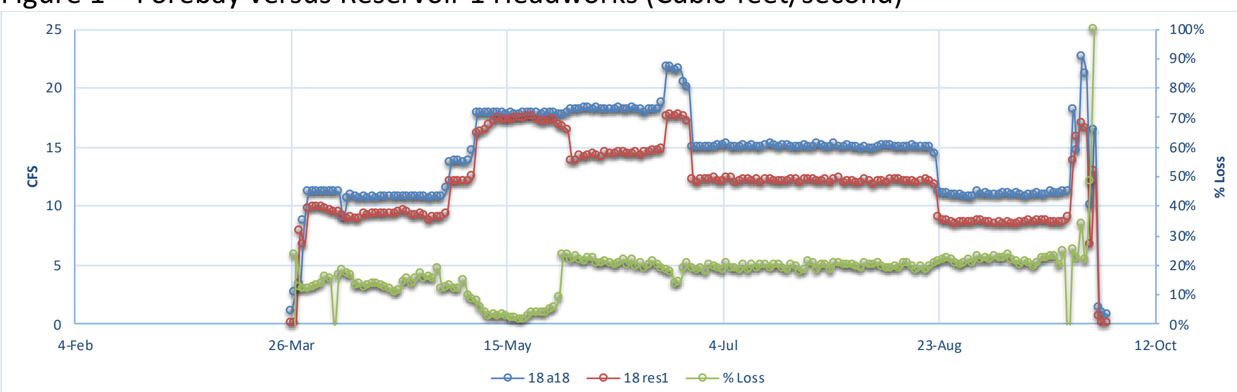
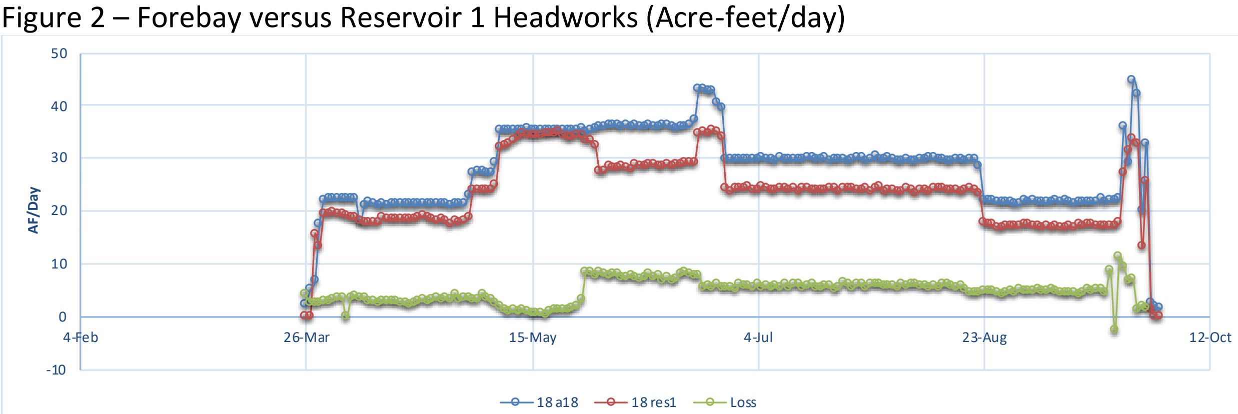


Figure 2 – Forebay versus Reservoir 1 Headworks (Acre-feet/day)



2019 Operations Summary

The Reservoir 1 Water Treatment Plant came on line on May 1 of 2019. Ditch flows began a few days before the plant was brought on line to water up the ditch and stabilize losses. The Gauge A-18 was replaced prior to the start of the season due to construction activates and now records data in a slightly different and more appropriate location. Losses are based on the difference between the new forebay gauge A-18 and the flow meter at the Reservoir 1 Water Treatment Plant, less backwash water returned ahead of the meter. As shown in Figure 1 and 2, flows were initially in the 10 cfs range early for a short period before being increased to 17 cfs in early June. This flow continued until the ditch was taken offline in late September. Total water loss is underestimated to the extent carriage losses associated with delivering water to raw water customers after the treatment plant was taken off line are not included in the calculations.

Table 1 – 2019 Upper Main Ditch Water Loss

All season		June 25th – Sept 14th	
Forebay A-18 Gauge	4,445	Forebay A-18 Gauge	2,751
Plant Inlet	3,361	Plant Inlet	2,071
Water Loss	1,085	Water Loss	680
Percent Loss	24%	Percent Loss	24.7%

Figure 1 – Forebay versus Reservoir 1 Headworks (Cubic-feet/second)

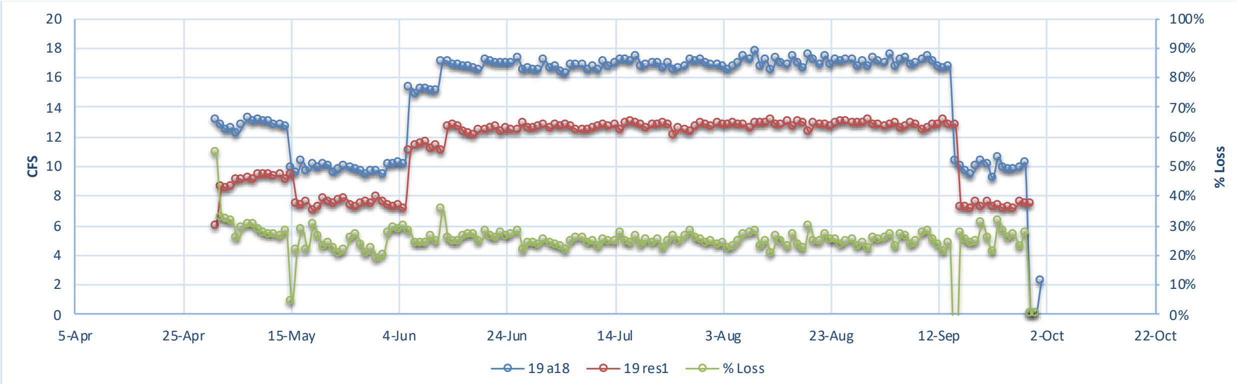
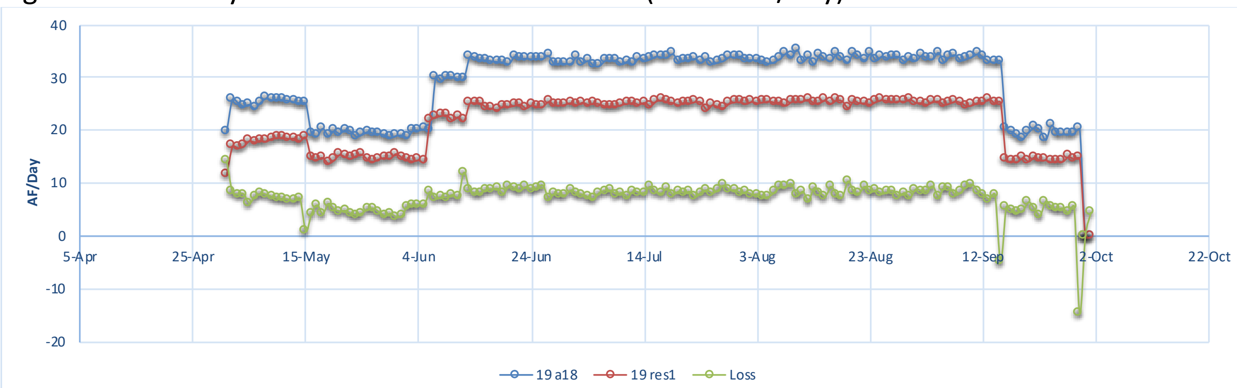


Figure 2 – Forebay versus Reservoir 1 Headworks (Acre-feet/day)



2020 Operations Summary

The Reservoir 1 Water Treatment Plant came on line on May 14 of 2020. Ditch flows began a few days before the plant was brought on line to water up the ditch and stabilize losses. The Gauge A-18 was replaced in 2019 at a new location. 2020 data is from the same location as 2019. Losses are based on the difference between the new forebay gauge A-18 and the flow meter at the Reservoir 1 Water Treatment Plant, less backwash water returned ahead of the meter. As shown in Figure 1 and 2, flows were initially in the 12 cfs range early for a short period before being increased to 15 cfs in July. This flow continued until the ditch was taken offline in late September. Total water loss is underestimated to the extent carriage losses associated with delivering water to raw water customers after the treatment plant was taken off line are not included in the calculations. Due to a gauge error at the Plant Inlet, data from July 1 to July 24th must be ignored resulting in losses estimated during this period. Figure 3 and 4 show the revised Forebay vs Headworks with estimated data to replace erroneous data. Data in Figures 3 and 4 was estimated using A-18 data and the loss projections from Table 2 in the December 2021 updated memo. Given that the error occurred early in the use period, a conservative loss estimate is appropriate.

Table 1 – 2020 Upper Main Ditch Water Loss

All season (estimated)		July 26th – Sept 17th	
Forebay A-18 Gauge	3,945	Forebay A-18 Gauge	1,609
Plant Inlet	2,734	Plant Inlet	1,167
Water Loss	1,211	Water Loss	442
Percent Loss	31%	Percent Loss	27.5%

Figure 1 – Forebay versus Reservoir 1 Headworks (Cubic-feet/second)

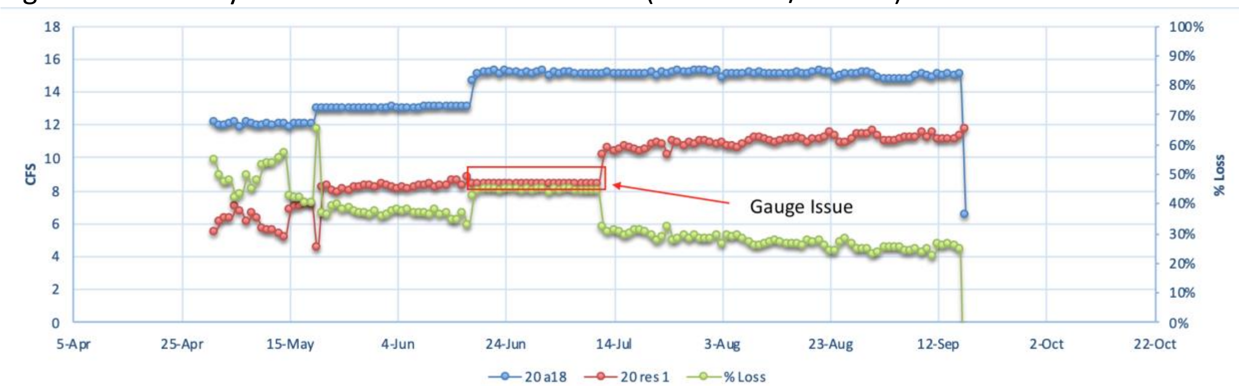


Figure 2 – Forebay versus Reservoir 1 Headworks (Acre-feet/day)

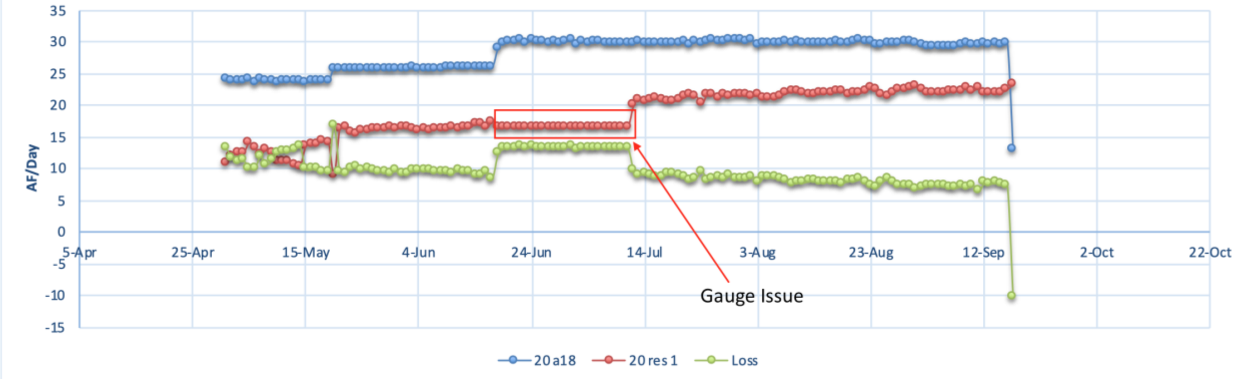


Figure 3 – Forebay versus Reservoir 1 Headworks (Cubic-feet/second)

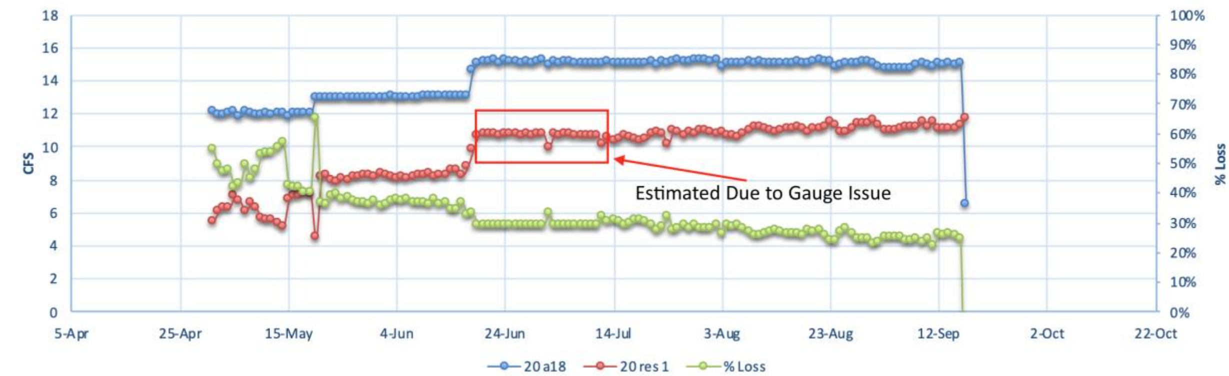


Figure 4 – Forebay versus Reservoir 1 Headworks (Acre-feet/day)