Mitman, Jeffrey

From:	Mitman, Jeffrey NRR
Sent:	Friday, February 19, 2010 6:05 PM
To:	James, Lois NRR
Cc:	Ferrante, Fernando
Subject:	RE: ACTION: provide BC with latest version of DRA/APOB's documentation of the generic dam failure frequency by COB 2/19/10
Attachments:	APOB Failure Rate Evaluation for Jocassee Dam Revised (3).doc

Lois, attached is the latest version of the requested analysis. Fernando and I have worked on in to incorporate the concerns regarding peer review (re ADM-504) and suggestions and issues raised by DE and others. I know of no additional changes which are required.

Fernando, I've made only very minor punctuation changes and formatting changes to your most recent version and I've accepted all Word revision mark changes.

To remove the "draft" designation it should be reviewed by Jim Vail as a co-author and the independent review needs to be performed (reperformed). I assume this would be by Steve.

Once this is completed we can formally transmit it again to the front office and put it in Adams as an official agency record.

Jeff

From: James, Lois
Sent: Friday, February 19, 2010 10:55 AM
To: Mitman, Jeffrey
Subject: ACTION: provide BC with latest version of DRA/APOB's documentation of the generic dam failure frequency by COB 2/19/10

Jeff,

Since you will be out next week and we need to continue work on the dam failure frequency, please email me the latest version of the document in word format. I believe you were making revisions based on reviewing LIC-504.

Lois

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U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Dam Failure Rate Evaluation

Probabilistic Risk Assessment (PRA) Analyst:	James Vail, Reliability and Risk Analyst, NRR/DRA/APOB
Probabilistic Risk Assessment (PRA) Analyst:	Fernando Ferrante, Reliability and Risk Analyst, NRR/DRA/APOB
Probabilistic Risk Assessment (PRA) Analyst:	Jeff Mitman, Senior Reliability and Risk Analyst, NRR/DRA/APOB
Peer Reviewer:	Steven A. Laur, Senior Technical Advisor NRR/DRA

GENERIC FAILURE RATE EVALUATION FOR JOCASSEE DAM BY DIVISION OF RISK ASSESSMENT'S PRA OPERATIONAL SUPPORT AND MAINTENANCE BRANCH

The following documents a generic dam failure rate analysis applicable to the Jocassee Dam performed by the PRA Operational Support and Maintenance Branch (APOB) of the Division of Risk Assessment (DRA) in the Office of Nuclear Reactor Regulation (NRR). The analysis, technical justifications, and databases used in support of the calculations for the derived value are briefly discussed. This evaluation was initially performed in 2007 but was not formally documented at that time.

Approach

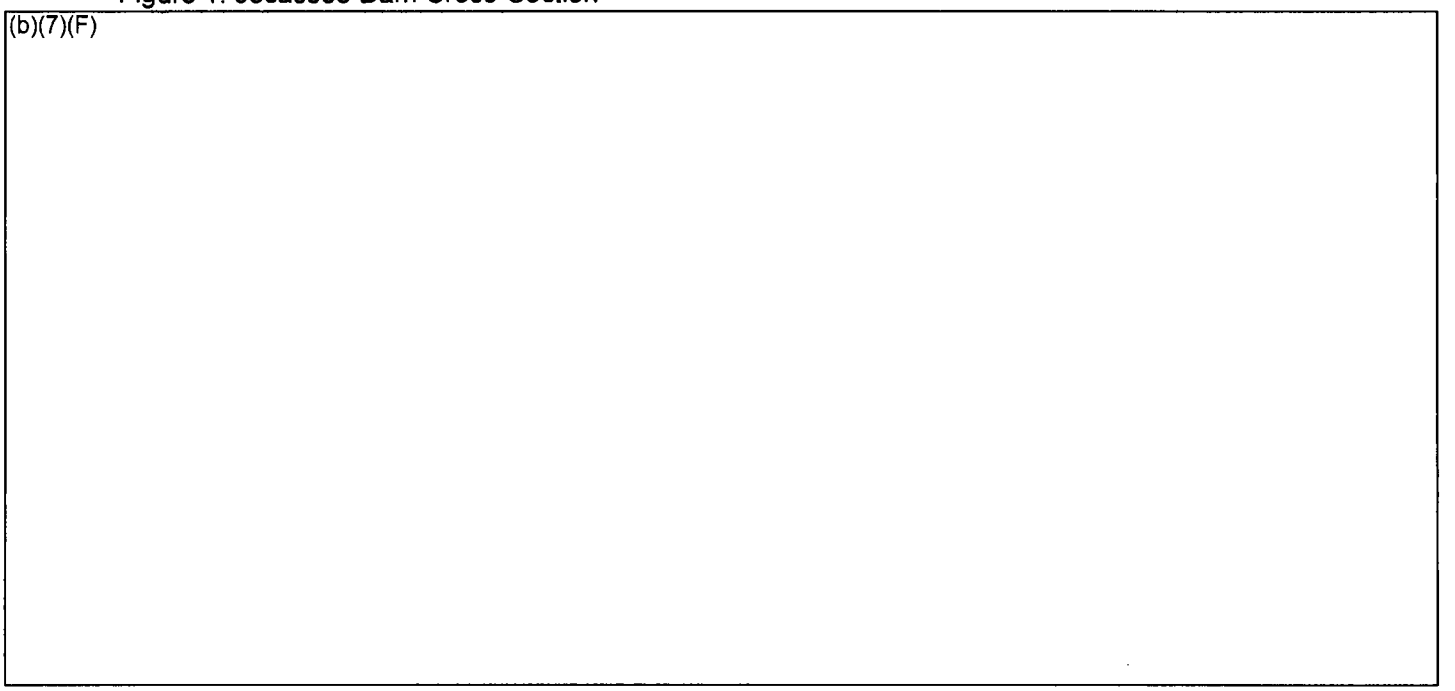
The approach used in deriving a generic failure rate value applicable to the Jocassee Dam included: (i) an evaluation of the physical characteristics and description of the dam, (ii) an assessment of the overall U.S. dam population for those with similar features to the Jocassee Dam, (iii) a study of U.S. dam performance information for failure events that may be applicable to this subset of the overall population, and (iv) a calculation of a point estimate for the failure rate given the observed failure events and the observed time period (in dam-years). For items (ii) and (iii), two databases were used as sources of information and will be discussed below.

Jocassee Dam Description

The Jocassee Dam is located in northwest South Carolina, forming a reservoir (Lake Jocassee) with a 7565-acre surface area, a water volume of 1,160,298 acre-feet, and a total drainage area of 147 sq-miles at full pond (1,110 feet elevation above mean sea level). The reservoir was created in 1973 with the construction of the dam. The Jocassee Dam is an embankment dam with an earthen core and rockfilled and random rockfilled zones (see Figure 1). The dam is 385 feet in height (1,125 crest elevation above mean sea level) and 1,825 feet in length and, along with two homogeneous earthfill dikes and a reinforced concrete spillway, is part of a hydroelectric station and pumped storage project. The underground powerhouse generating units receive water from two cylindrical intake towers through eight openings. The water is channeled from the intake towers to four hydro turbines by two bifurcated power tunnels which are constructed through the bedrock of the east abutment. Two gates 33 feet in height and 38 feet in width control the outflow of the spillway.

Figure 1: Jocassee Dam Cross-Section

(b)(7)(F)



Databases

The staff used two databases to obtain information about the population of dams in the US: the National Inventory of Dams (NID), maintained by the US Army Corps of Engineers, and the National Performance of Dams Program (NPDP), developed by the Department of Civil and Environmental Engineering at Stanford University. The NID database contains data describing multiple attributes such as dimensions, type, impoundment characteristics, etc. The NPDP database contains a collection of dam incident reports searchable by various parameters including dam type, incident type, and consequences.

Failure Events

Table 1 lists the applicable dam failures initially derived from the NPDP database. To choose these 13 failures, the analysts used criteria based on the previously discussed dam characteristics (i.e., dam type and height). However, due to the ambiguity in the classification of the dam type (i.e., based on material composition) between and within the NID and NPDP databases, as well as the lack of information to establish an exact link with the Jocassee Dam characteristics for every data point, the staff determined that both rockfill dams and mixed-rockfill dams would be considered (i.e., those classified exclusively as rockfill dams as well as mixed dam types that include rockfill in their categorization). It should be noted that the NPDP database does not list any failures post-2006 and at least two well-known large dam failures in the U.S. are not included: the Big Bay Dam in Mississippi (March 2004) and the Taum Sauk Reservoir (December 2005) in Missouri. While the Big Bay Dam was an earthen dam (i.e., excluded based on dam type), the Taum Sauk Reservoir consisted of a concrete-faced rockfill dam approximately 100 feet in height and is, therefore, included in the current analysis.

Additionally, the list was screened using two criteria for failure events observed prior to (i) 1900, and (ii) 1940, under the assumption that events prior to these construction periods could

produce different results representative of distinct design practices. In part, this choice is due to the lack of information on the exact construction date of several dams in the database. The staff expended an extensive effort to determine the construction completion date for several dams for which the information is missing in the NPDP database (this information is included in Table 1).

Several failures listed in Table 1 have (or are assumed to have) occurred within a few years of either the start or completion of construction (e.g., the Lower Hell Hole Dam and the Frenchman Dam failures). Based on the information available and the estimated completion dates, the staff screened out such failures since the occurrence of the events is assumed to be related to the construction phase and, therefore, not applicable to a mature dam such as Jocassee.

Finally, the analysts chose to include the Dresser No. 4 Dam failure, because they deemed this dam to be similar to the Jocassee Dam in composition (i.e., a large mixed earthfill-rockfill dam), despite the fact that it is listed as a tailings dam (i.e., a dam theoretically built under lower standards of quality and maintenance).

Therefore, the final list of failures of dams similar to, and therefore applicable to, the Jocassee Dam includes 6 failures occurring between 1900 and 2005. These six failures are highlighted in Table 1. The staff included these failures based on the following criteria: (i) rockfill or mixed-rockfill dam type, (ii) dam height above 50 feet, (iii) failure occurring after 1900, and (iv) no failures during or within a few years of completion of construction. Note that if failures occurring prior to 1940 are screened, then only 4 events remain: (1) Taum Sauk, (2) Dresser No.4 Dam, (3) Skagway, and (4) Kern Brothers Reservoir.

Total Dam-years Calculation

To calculate the dam failure rate, the staff needed to also obtain the total number of dam-years of both failed and non-failed dams. The analysts extracted a subset of dams from the NID database based on a set of parameters to narrow the US population of dams to those reflecting the characteristics of the Jocassee Dam discussed above: rockfill dams at least 50 feet in height (where NID categorizes rockfill dams under the 'ER' label for dam type, which is the label used for the Jocassee Dam in NID). They assumed that dams above 50 feet in height appropriately reflect design practices and structural characteristics of larger dams such as Jocassee. This height criterion is consistent with the large dam definition established by the International Commission on Large Dams (ICOLD) which "defines a large dam as a dam with a height of 15m or more from the foundation." If dams are between 5-15m high and have a reservoir volume of more than 3 million m^3, the World Commission on Dams ("Dams and Development," November 2000) also classified such dams as large. Hence, the staff used a height of 15 meters (or approx. 50 feet) as a screening criterion.

The staff included the dam-year contributions from Skagway and the replacement for the failed Frenchman Dam, while those from Kern Brothers Reservoir, Dresser No. 4 Dam, Penn Forest, and the failed Frenchman Dam were not; the staff does not anticipate the contribution from these omissions to significantly impact the resulting dam-year total. The staff calculated the final result using the difference between the last year (2005) and either 1900 or 1940. For the 1900-2005 period, the staff obtained a total of 21,490 dam-years; while for 1940-2005 the result is 13,889 dam-years. See Table 2 for a tabulation of the dams and the associated dam-years.

Generic Point Estimate of the Dam Failure Rate

The staff calculated the point estimate by dividing the number of applicable dam failures by the total applicable dam-years; as described above this includes large, rockfill or mixed rockfill dams. Assuming a 1900-2005 range for the year of occurrence of the failure events and the dam-year estimation (based on completion year), the analysts obtained a failure rate of 2.8E-4 per dam-year. When considering a 1940-2005 range, the staff obtained a result of 2.9E-4 per dam-year. Based on the criteria discussed in the previous sections, the staff performed a simple sensitivity study in order to evaluate the changes due to screening failure events between 1900-2005 and 1940-2005 periods.

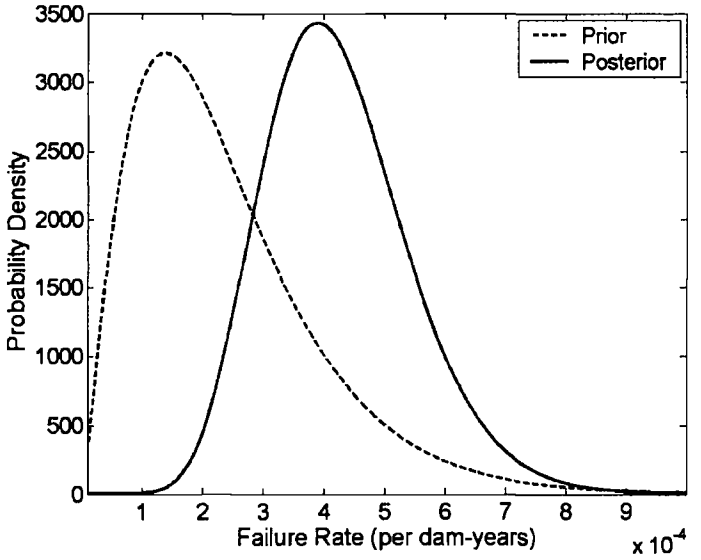
Because the NID database does not give information regarding the quality of design, construction and/or maintenance, and the NPDP database does not supply information on the dam health (i.e., is it well maintained?) at time of failure, the staff could not derive failure rates for above or below average built and maintained dams. This lack of information precluded the staff from making any judgment as to whether Jocassee is or is not an above average designed, constructed and maintained dam deserving of a failure frequency different than an average failure frequency.

Additionally, the staff recognizes that ambiguity and lack of complete information with respect to dam type, construction completion data, and dam incident reporting, may result in variations in the failure rate estimation. Therefore, the staff performed a simple sensitivity study in order to evaluate the changes due to screening failure events and cut-off year criteria. The results are shown in Table 3 and clearly indicated that the results exhibit small variations for the period cut-off selected (1900-2005 and 1940-2005) and the number of failures considered (6 and 4, respectively). Additionally, the extent of the variation in the point estimate is shown for other number of failures and cut-off years based on the subset of dams selected.

Bayesian Estimate of the Dam Failure Rate

To evaluate the dam failure rate uncertainty, the staff conducted a Bayesian analysis of the failure rate for the 1900-2005 period via an Empirical Bayes approach (Atwood, 2003). In this approach, an empirical prior distribution is derived from the number of failures and dam-years for each dam category identified in the NID and NPDP databases. The number of dam failure events is modeled as a Poisson distribution and the conjugate prior is assumed to follow a Gamma distribution (i.e., the conjugate prior in a Gamma-Poisson model). Following the Empirical Bayes approach, the prior distribution derived from the data is a Gamma distribution with parameters $\alpha = 2.4026$ and $\beta = 10095$ (i.e., mean equal to 2.4E-4/dam-years). By updating the corresponding subset of the analysis (e.g., rockfill dams and failure events with characteristics deemed to be applicable to the Jocassee Dam) with this prior, the resulting posterior distribution has parameters $\alpha = 12.40$ and $\beta = 29255$, which corresponds to a Gamma distribution with mean equal to 4.2E-4/dam-years, a 5^{th} percentile of 2.5E-4/dam-years, and a 95^{th} percentile of 6.4E-4/dam-years. Figure 2 indicates both the generic dam prior and the posterior specific to rockfill dams.

Figure 2: Failure Rate Probability Distributions Used in Bayesian Updating



Conclusions

The staff estimated generic dam failure rates which it considers applicable to the Jocassee Dam. The point estimate fluctuates around a 2E-4/dam-year value. Given the nature of the data and the assumptions involved in narrowing the applicable failure events and subset of the U.S. dam population comparable to this specific dam, the staff performed a simple sensitivity analysis for the failure rate and included an estimate using a Bayesian approach. This yielded a range between 1.4E-4 per dam-year and 4.3E-4 per dam-year (5^{th} – 95^{th} percentile) around a mean of 2.7E-4 per dam-year. In other words, while a value between 1E-4/dam-year and 5E-4/dam-year could be possible under the set of assumptions and criteria used above, the staff concludes that results lower than 1E-4 per dam-year are not presently justifiable based on available statistical information.

A literature review performed by the authors for statistical studies of dam failures appears to corroborate this conclusion. Such studies were found in Baecher et al (1980), Donnelly (1994), ICOLD (1995), Foster (2000a), and Foster et al (2000b). Additionally, the ANS/ANSI External Events PRA standard mentions the use of databases for the development of dam failure rates, where these "databases must be used with care, depending on how closely the specific dam fits into the database. The mean failure rate for all U.S. dams is in the range between about 10^{-4} and 10^{-5}/year," and that "for some modern dams with extensive engineering, values below 10^{-5}/year have been quoted," finally concluding that an "accurate and useful probabilistic analysis of any specific dam would require detailed engineering evaluations."

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10/5/2012

Table 1: Initial List of dam failure events applicable to the Jocassee Dam

Dam Name	Incident Year	Completion Year (Est.)	Incident Type	Dam Typ	Height (ft)	Description from NID Database (Except from Staff)
Taum Sauk	2005	1963	Overtopping	Rockfill	94	Overtopped due to over-pumping of reservoir. Independent analysis indicated several root causes (e.g., lack of monitoring, spillway).
Dresser No.4 Dam	1975	Unknown	Piping	Earth Rockfill /Tailings	105	Catastrophic failure that created a breach 300 feet wide in the levee.
Skagway	1965	1925	Inflow Flood - Hydrologic Event	Rockfill	79	The dam failed during a flood in 1965.
Hell Hole	1964	1964	Not Known	Rockfill	410	Dam failed during construction. Overtopped by 100 feet - washing out most of the fill.
Penn Forest	1960	1960	Piping	Concrete Earth Rockfill	151	Partial failure. Sinkhole occurred in upstream slope of dam.
Frenchman Dam	1952	1951	Inflow Flood - Hydrologic Event	Rockfill	63	Runoff from melting snow. A dike section was overtopped early morning April 15, 1952. Later that day, dam breached.
Kern Brothers Reservoir	1949	Unknown	Settlement	Earth Rockfill	54	Failure due to excessive settlement of fill.
Lake Francis	1899	1899	Piping	Earth Rockfill	79	Blowout failure under concrete spillway weir structure during period of heavy spillway flow. Spillway failure thought to be due to piping in soft saturated foundation.
Lafayette	1928	1928	Embankment Slide	Earth Rockfill	132	Foundation slide during construction (at 120 feet). Height raised to 170 feet in 1932. Not sure if this is considered a failure.
Manitou	1924	1917	Seepage	Earth Rockfill	123	Partial failure was disintegrating and converted into gravel fill.
Lyman	1915	1912	Piping	Earth Rockfill	76.4	Failure by piping through abutment; undermined by passage of water under cap of lava rock which flanked dam and extended beneath spillway. Main part of dam uninjured.
Lower Otay	1916	1897	Spillway	Earth Rockfill	154	Foundation slide during construction (at 120 feet). Height raised to 170 feet in 1932. Not sure if this is considered a failure.
Black Rock	1909	1908	Piping	Earth Rockfill	70	Failure by piping through abutment; undermined by passage of water under cap of lava rock which flanked dam and extended beneath spillway. Portion of spillway dropped 7 feet; some fill at south end washed out. Main part of dam uninjured.

Table 2: Dam-Year Tabulation

FRANCIS, LAKE	CA00866	2000	79	1,905	5	5
DIAMOND VALLEY LAKE	CA01410	2000	284	800,000	5	10
HANSEN RECREATIONAL LAKE	CA01448	1999	50	85	6	16
LOLONIS VINEYARDS	CA01423	1999	67	209	6	22
SEVEN OAKS	CA10324	1999	550	145,600	6	28
MELROSE AVENUE	CA01400	1998	57	52	7	35
AMARGOSA CREEK	CA01406	1998	65	1,187	7	42
HICKS CANYON RB	CA01414	1997	60	110	8	50
DENNIS NO 2	CA01398	1997	60	148	8	58
RMG WEST TAILINGS DAM	NV10508	1997	94	9,567	8	66
LOS VAQUEROS	CA01396	1997	197	100,000	8	74
ARUNDELL BARRANCA	CA01412	1996	57	155	9	83
SEA RANCH	CA01411	1996	61	300	9	92
ILLINOIS CREEK HEAP LEACH DAM	AK00261	1996	83	103	9	101
CHASE GULCH	CO02786	1996	100	1,250	9	110
Slack	AZ00225	1995	54.7	59	10	120
Gold Gulch 1A	AZ00224	1995	106	110	10	130
HUCKLEBERRY CREEK DAM	AR01522	1995	110	23,342	10	140
BEE CANYON RB	CA01380	1994	62	243	11	151
BRICK FLAT PIT CONT	CA01397	1994	85	220	11	162
ROUND CANYON RB	CA01378	1994	98	286	11	173
JAMESTOWN MINES T	CA01245	1994	200	12,100	11	184
MACKS CREEK	ID00480	1993	52.5	489	12	196
RED DOG TAILINGS DAM	AK00201	1993	172	24,757	12	208
LANGTRY	CA01350	1992	50	525	13	221
SANDS HILL SLURRY IMPOUNDMENT DAM	OH02839	1992	131	1,200	13	234
HEITZ	CA01345	1991	87	272	14	248
BRADLEY LAKE SPILLWAY DAM	AK83023	1991	115	284,150	14	262
BRADLEY LAKE DAM	AK83016	1991	125	284,150	14	276
L PETERS CAN RB	CA01207	1990	52	206	15	291
PANTHER CREEK RESERVOIR	AR01496	1990	57	280	15	306
CENTENNIAL	CA01246	1990	62	635	15	321
MOLYCORP TAILING DAM 5A	NM00531	1990	73	3,630	15	336
PAD 8 OVERFLOW POND DAM	SC02578	1990	80	55	15	351
MCCOY/COVE TAILINGS STORAGE FACILITY	NV10301	1990	140	22,425	15	366
HOMESTAKE TAILINGS	CA01205	1990	169	0	15	381
PLYMOUTH EFFL	CA01189	1989	59	187	16	397
HARVEY PLACE	CA01222	1989	72	3,700	16	413
RED DOG WATER SUPPLY DAM	AK00200	1989	75	684	16	429
DOVE CANYON	CA01248	1989	88	415	16	445
NEW SPICER MEADOW	CA01224	1989	262	189,000	16	461
CSP MULE CREEK	CA01185	1988	51	535	17	478
FOSS VALLEY	CA01268	1988	56	800	17	495
FOOTHILL PARK	CA00868	1988	88	67	17	512
DAY CREEK DB	CA01232	1988	90	140	17	529
Schoens	AZ00207	1988	143.6	82,000	17	546
YATESVILLE DAM	KY82201	1988	156	83,300	17	563
RAMONA	CA01215	1988	228	12,200	17	580
Mt St Helens Sediment Retention Structure	WA00558	1988	240	126,000	17	597
ANTELOPE	CA01213	1987	57	764	18	615
STEVENOT	CA01301	1987	70	150	18	633
BALSAM MEADOW	CA01263	1986	127	2,040	19	652
BRADFORD	CA01263	1985	58	440	20	672
JAYNE S LAKE	CA01262	1985	70	1,225	20	692
PAPILLION CREEK & TRIB. SITE 18	NE62202	1985	90	18,282	20	712
DAVIS CREEK	CA01223	1985	105	6,079	20	732
RED MOUNTAIN RES	CA00225	1985	120	1,350	20	752
EDWARDS RES	CA01240	1985	120	596	20	772
TRABUCO	CA01241	1984	108	138	21	793
TERROR LAKE	AK83008	1984	193	108,000	21	814
GARNETT, CITY OF, CEDAR CREEK RESERVOIR	KS07006	1983	70	24,000	22	836
ANDREW CADEMARTORI	CA01274	1983	80	142	22	858
CULMBACK	WA00208	1983	262	153,260	22	880
CALERO	CA01209	1982	55	2,832	23	903
FLAT ROCK CREEK SITE 1	AR01442	1982	57	509	23	926
MERLO	CA01313	1982	74	930	23	949
COEN C-3	CA01317	1982	97	460	23	972
Gold Gulch #2	AZ00194	1982	116.3	590	23	995
SOLOMON GULCH SPILLWAY	AK83021	1981	55	31,500	24	1,019
COMAL RIVER WS SCS SITE 2 DAM	TX04788	1981	75	19,024	24	1,043
STANLEY A MAHR RES	CA01280	1981	79	166	24	1,067
LAS LLAJAS	CA01217	1981	96	1,250	24	1,091
SOLOMON GULCH	AK00027	1981	115	31,500	24	1,115
Jennings Randolph	MD00089	1981	298	130,900	24	1,139
LAKEPORT	CA01230	1980	51	650	25	1,164
PORTOLA	CA01183	1980	53	586	25	1,189
SAND CREEK	CA01180	1980	60	1,050	25	1,214
CUCAMONGA CR DB	CA01277	1980	60	355	25	1,239
DEER CANYON DB	CA01231	1980	78	24	25	1,264
PEA RIDGE TAILINGS DAM	MO30473	1980	150	4,100	25	1,289
PAINTSVILLE DAM	KY82202	1980	160	73,500	25	1,314
APPLEGATE DAM	OR00624	1980	242	89,300	25	1,339
GRINDING ROCK	CA01184	1979	55	330	26	1,365
FLAT TOP MINE-#1 IMPOUNDMENT	AL01519	1979	75	35	26	1,391
BESSIE MINES-#3 IMPOUNDMENT	AL01525	1979	100	95	26	1,417
SOULAJULE	CA01083	1979	122	10,700	26	1,443
UPPER OSO	CA01145	1979	142	3,700	26	1,469
WASTEWATER STORAGE	CA01137	1978	75	212	27	1,496
SANTA MONICA DB	CA01134	1978	102	79	27	1,523
QUARTZ	CA01146	1978	104	1,500	27	1,550
SAFE SHUTDOWN IMPOUNDMENT DAM	TX04912	1977	70	900	28	1,578
LOS ANGELES RES	CA01081	1977	130	10,000	28	1,606

DEQUEEN	AR01201	1977	160	370,600	28	1,634
NEW U SAN LEANDRO	CA01082	1977	182	42,000	28	1,662
LITTLE BLUE RUN	PA00917	1977	400	73,000	28	1,690
SUNFLOWER	CA01116	1976	50	420	29	1,719
LAKE CO SAN DIST 2	CA01108	1976	77	870	29	1,748
HOLMAN	CA01128	1976	101	250	29	1,777
MISSION VIEJO, LAKE	CA01122	1976	123	4,300	29	1,806
NEW LAKE ARROWHEAD	CA01124	1976	225	1,970	29	1,835
WILLIAM L. JESS	OR00612	1976	345	500,000	29	1,864
POND 2B	CA01092	1975	55	89	30	1,894
FOREST MEADOWS	CA01120	1975	60	117	30	1,924
LIVE OAK RES	CA01084	1975	105	2,500	30	1,954
TRAMPAS CANYON	CA01123	1975	183	5,700	30	1,984
EAGLE RANCH	CA01101	1974	55	300	31	2,015
ASU/NORRIS BRANCH	NC01524	1974	112	782	31	2,046
ELDERBERRY FB	CA01080	1974	179	28,400	31	2,077
MOKELUMNE HILL	CA01111	1973	52	52	32	2,109
BOYD NO 2	CA01054	1973	53	670	32	2,141
J C JACOBSEN	CA00587	1973	56	1,620	32	2,173
JOCASSEE SPILLWAY	SC02757	1973	64	1,287,788	32	2,205
RESERVOIR A	CA01112	1973	93	180	32	2,237
NOCKAMIXON	PA00734	1973	102	71,000	32	2,269
ROBERT A SKINNER	CA00223	1973	109	43,800	32	2,301
JEFF DAVIS	CA00309	1973	114	1,800	32	2,333
PERRIS	CA00054	1973	130	131,452	32	2,365
LAUREL DAM	KY03046	1973	282	435,600	32	2,397
CASTAIC	CA00044	1973	340	323,700	32	2,429
JOCASSEE	SC00529	1973	385	1,287,788	32	2,461
RANCHO SECO	CA00825	1972	58	2,950	33	2,494
EWING	CA00903	1972	63	887	33	2,527
Lower Rimrock Dam	WA00036	1972	87	550	33	2,560
CHESBRO	CA00995	1972	79	1,250	33	2,593
CRAWFORD RANCH	CA00977	1972	80	340	33	2,626
LAUREL CREEK	PA00578	1972	135	4,080	33	2,659
WESTLAKE RES	CA00904	1972	158	9,200	33	2,692
YANKEE DOODLE TAILINGS DAM	MT01425	1972	570	7,200	33	2,725
CANADA ROAD	CA00055	1971	52	74	34	2,759
STRAZA	CA01064	1971	62	185	34	2,793
LACKAWANNA	PA00913	1971	69	14,200	34	2,827
ALISAL CREEK	CA00731	1971	93	2,342	34	2,861
TURNER	CA00905	1971	111	2,000	34	2,895
MANITOU	CO00426	1971	124	1,100	34	2,929
POWAY	CA00909	1971	162	3,300	34	2,963
DON PEDRO	CA00281	1971	568	2,030,000	34	2,997
MURRAY	CA01061	1970	55	117	35	3,032
PALO VERDE	CA00789	1970	67	730	35	3,067
ANTHONY HOUSE	CA00964	1970	75	3,840	35	3,102
L VAN NORMAN BYPASS	CA00101	1970	78	240	35	3,137
Willow Springs	AZ00088	1970	87.7	4,230	35	3,172
DIXON	CA00878	1970	116	2,500	35	3,207
Silver Basin	AZ00022	1970	160	6,000	35	3,242
TERMINAL	CA00888	1969	53	844	36	3,278
Clear Branch Creek Dam	OR00451	1969	111	4,000	36	3,314
BIG CREEK	CA00652	1969	120	7,650	36	3,350
WOOD CREEK LAKE DAM	KY00088	1969	183	29,101	36	3,386
LOPEZ	CA00887	1969	186	52,500	36	3,422
WIDE CANYON	CA00803	1968	84	1,490	37	3,459
COYOTE CREEK	CA00572	1968	92	3,375	37	3,496
SUMMIT RES	CA00148	1968	124	220	37	3,533
EAU GALLE	WI00780	1968	127	56,900	37	3,570
SANTA YNEZ CANYON	CA00100	1968	157	356	37	3,607
WALNUT CANYON	CA00869	1968	187	2,570	37	3,644
DEL VALLE	CA00043	1968	222	77,100	37	3,681
MINERAL HOT SPRINGS LAKE	CA01026	1967	54	37	38	3,719
SWAN	CA00985	1967	59	550	38	3,757
HILLSIDE RANCH	CA01067	1967	60	210	38	3,795
MAGNOLIA	CA00968	1967	68	4,150	38	3,833
INDIAN CREEK	CA00894	1967	71	3,160	38	3,871
MSD TREATMENT PLANT DAM	NC00320	1967	75	385	38	3,909
WALNUT CR CLRWELL	CA00175	1967	102	25	38	3,947
EL TORO RES	CA00875	1967	106	877	38	3,985
MOLYCORP TAILINGS	CA01394	1967	116	309	38	4,023
FOSTER	OR00012	1967	126	61,000	38	4,061
Cabin Creek Upper	CO01239	1967	215	1,800	38	4,099
HOMESTAKE PROJECT	CO00673	1967	265	45,870	38	4,137
Fauchene Lake Main	CA00256	1966	51	4,020	39	4,176
HAWKEYE	CA01052	1966	66	140	39	4,215
RIGHETTI	CA00725	1966	83	680	39	4,254
McSwain	CA00242	1966	97	10,000	39	4,293
Cheveton Canyon	AZ00046	1966	100	8,542	39	4,332
GRIZZLY VALLEY	CA00039	1966	115	83,000	39	4,371
N. FORK OF POUND DAM	VA19501	1966	122	11,293	39	4,410
SAN JOAQUIN RES	CA00853	1966	224	3,036	39	4,449
LOWER HELL HOLE	CA00857	1966	410	208,400	39	4,488
HARTZELL	CA00727	1965	50	300	40	4,528
Yards Creek Upper - West Dike	NJ83004	1965	52	4,900	40	4,568
HAYNES RES	CA01030	1965	67	5,870	40	4,608
REBA	CA00642	1965	70	240	40	4,648
UPPER BLUE	CO00871	1965	75	2,635	40	4,688
DUTCH FLAT 2 FB	CA00258	1965	77	185	40	4,728
Youngs River Reservoir	OR03632	1965	81	12,000	40	4,768
GRASSHOPPER HOLLOW TAILINGS DAM	WV06523	1965	129	1,280	40	4,808
WOOD RANCH	CA00850	1965	146	11,000	40	4,848
Dutch Flat Afterbay	CA00257	1965	165	2,040	40	4,888

JACKSON CREEK	CA00867	1965	193	22,000	40	4,928
JACKSON MEADOWS	CA00254	1965	195	52,500	40	4,968
SAN ANTONIO	CA00813	1965	202	350,000	40	5,008
FALL CREEK	OR00007	1965	205	125,000	40	5,048
IRON CANYON	CA00417	1965	214	24,300	40	5,088
L L ANDERSON	CA00856	1965	231	111,333	40	5,128
MCCLOUD	CA00416	1965	240	35,300	40	5,168
SUMMERSVILLE DAM	WV06702	1965	390	413,400	40	5,208
GRIZZLY CREEK	CA00553	1964	50	76	41	5,249
ADA ROSE, LAKE	CA00871	1964	50	138	41	5,290
BERNARDO RES	CA00118	1964	54	30	41	5,331
Clinch River Flyash Dam #1	VA16703	1964	55	1,240	41	5,372
BRENTWOOD PARK	CA00851	1964	58	80	41	5,413
Camp Kwoneesum Dam	WA00131	1964	60	120	41	5,454
SCOUT LAKE	CA00563	1964	63	1,140	41	5,495
Clinch River Flyash Dam #2	VA16702	1964	65	157	41	5,536
SAN LORENZO CR	CA00841	1964	65	380	41	5,577
HARBOR VIEW	CA00830	1964	65	28	41	5,618
SENIOR CANYON	CA01019	1964	76	73	41	5,659
FISHPOND LAKE DAM	KY00042	1964	105	1,156	41	5,700
ANTELOPE	CA00037	1964	113	22,566	41	5,741
JAMES H TURNER	CA00132	1964	193	50,500	41	5,782
BRIONES	CA00172	1964	273	67,520	41	5,823
ROUND BUTTE	OR00549	1964	440	535,000	41	5,864
COUGAR	OR00015	1964	519	219,000	41	5,905
FOOTHILL REG PARK	CA01057	1963	51	109	42	5,947
LARSON	CA00712	1963	54	325	42	5,989
CULL CREEK	CA00840	1963	55	310	42	6,031
NIMS LAKE DAM	MO30064	1963	57	6,280	42	6,073
Canyon Creek Meadows Reservoir	OR00385	1963	58	400	42	6,115
MARSH CREEK	CA00809	1963	59	4,425	42	6,157
WARD CREEK	CA00839	1963	71	130	42	6,199
LAKE SYMPSON DAM	KY00045	1963	73	4,994	42	6,241
MAST	CA00972	1963	85	380	42	6,283
LOWER SUNSET DB	CA01161	1963	86	37	42	6,325
TAUM SAUK PS UPPER	MO30040	1963	94	4,350	42	6,367
MATANZAS CREEK	CA00794	1963	95	1,500	42	6,409
Loon Lake Auxiliary	CA83099	1963	102	76,500	42	6,451
LOON LAKE	CA00820	1963	108	76,500	42	6,493
VILLA PARK	CA00829	1963	118	15,800	42	6,535
PALISADES RES	CA00843	1963	146	147	42	6,577
VIRGINIA RANCH	CA00842	1963	152	57,000	42	6,619
MAERKLE	CA00844	1963	165	800	42	6,661
CAMANCHE	CA00173	1963	171	417,120	42	6,703
CAMP FAR WEST	CA00227	1963	185	104,500	42	6,745
JOHN W FLANNAGAN DAM	VA05101	1963	250	145,700	42	6,787
UNION VALLEY	CA00818	1963	453	230,000	42	6,829
TOWBALYLA	CA00589	1962	51	376	43	6,872
MAYHEW RESERVOIR	CA00897	1962	53	18	43	6,915
MINERS RANCH	CA00275	1962	55	912	43	6,958
BOSCH NO 2	CA01044	1962	55	37	43	7,001
HIGHLAND CREEK	CA00828	1962	75	3,500	43	7,044
Lynx Lake	AZ00049	1962	89.2	2,764	43	7,087
PATTERSON	CA00895	1962	100	46	43	7,130
HERNANDEZ	CA00848	1962	124	18,000	43	7,173
OLIVE HILLS RES	CA00870	1962	140	185	43	7,216
DEVELOPMENT NO. 2 DAM	OR00317	1962	145	25,000	43	7,259
ROBERT W MATTHEWS	CA00833	1962	150	51,800	43	7,302
PONDEROSA DIV	CA00274	1962	160	4,750	43	7,345
MARK EDSON	CA00807	1962	162	20,000	43	7,388
CHET HARRITT	CA00236	1962	200	9,790	43	7,431
WILSON DB	CA01162	1961	50	84	44	7,475
DANVILLE	CA00184	1961	75	45	44	7,519
NORTH	CA00183	1961	82	244	44	7,563
BETHANY FOREBAY	CA00033	1961	85	5,250	44	7,607
SEEGER	CA00209	1961	115	22,400	44	7,651
ROSEMONT	CO00471	1961	120	3,155	44	7,695
FRENCHMAN	CA00032	1961	129	55,477	44	7,739
OXBOW	ID00057	1961	175	58,200	44	7,783
CORNWALL TAILINGS	PA00597	1961	200	3,880	44	7,827
LITTLE GRASS VY	CA00269	1961	210	93,010	44	7,871
FRANCIS E WALTER DAM	PA00008	1961	239	160,290	44	7,915
SLY CREEK	CA00272	1961	271	65,050	44	7,959
LEWIS SMITH	AL01420	1961	300	1,670,700	44	8,003
SANTA ANITA DB	CA01155	1960	56	116	45	8,048
BIG DALTON DB	CA01158	1960	59	193	45	8,093
WILLIAM, LAKE	CA00586	1960	86	340	45	8,138
LITTLE DALTON DB	CA01154	1960	71	234	45	8,183
DICKSON HILL	CA00885	1960	90	23	45	8,228
MALONEY	CA00180	1960	107	68	45	8,273
ASH CREEK	UT00010	1960	138	12,250	45	8,318
NEWELL	CA00156	1960	182	8,991	45	8,363
WHALE ROCK	CA00029	1960	193	40,662	45	8,408
MAMMOTH POOL	CA00443	1960	406	123,000	45	8,453
BIG CANYON	CA00891	1959	65	600	46	8,499
RATTLESNAKE CAN	CA00855	1959	79	1,480	46	8,545
BELL CANYON	CA00149	1959	95	2,530	46	8,591
ICE HOUSE	CA00814	1959	150	37,120	46	8,637
CARIBOU AFTERBAY	CA00413	1959	184	2,400	46	8,683
EARTHQUAKE LAKE	MT00882	1959	200	59,500	46	8,729
J W WISDA	CA00053	1958	50	45	47	8,776
SIERRA MADRE VIL	CA01158	1958	50	109	47	8,823
EARL THOMAS RES	CA00119	1958	58	107	47	8,870
Pena Blanca	AZ00028	1958	72	1,240	47	8,917

DEER LAKE	CA00579	1958	72	260	47	8,964
SAN MARCOS	CA00785	1958	85	320	47	9,011
MIDDLEFIELD RES	CA00896	1958	147	22	47	9,058
Wishon Main	CA00411	1958	265	129,000	47	9,105
Courtright	CA00412	1958	315	123,000	47	9,152
MCMAHON	CA00701	1957	52	520	48	9,200
MURRY	CA01013	1957	54	715	48	9,248
LUNGA DAM	VA17901	1957	56	9,600	48	9,296
A L CHAFFIN	CA00552	1957	65	450	48	9,344
ARROYO SECO	CA00613	1957	67	2,433	48	9,392
SMALL CANYON	CA00314	1957	68	20	48	9,440
PLEASANT VALLEY	CA00098	1957	87	3,825	48	9,488
UVAS	CA00807	1957	118	10,000	48	9,536
PARADISE	CA00287	1957	175	11,500	48	9,584
NACIMIENTO	CA00812	1957	210	350,000	48	9,632
LA VERNE, LAKE	CA00983	1956	50	54	49	9,681
COIT	CA01011	1956	54	275	49	9,730
SOUTH	CA00181	1956	58	158	49	9,779
SYCAMORE	CA00800	1956	63	860	49	9,828
ALESSANDRO	CA00798	1956	66	370	49	9,877
TEJON STORAGE 2	CA00729	1956	67	860	49	9,926
ANNADEL NO 1	CA00056	1956	67	395	49	9,975
Fool Hollow	AZ00051	1956	78	5,617	49	10,024
PINE CREEK	CA00808	1956	87	225	49	10,073
MONTGOMERY	CO00372	1956	112	6,100	49	10,122
CHERRY VALLEY	CA00125	1956	315	273,500	49	10,171
MOSKOWITE	CA00583	1955	50	472	50	10,221
BEVANS CREEK	CA00582	1955	51	215	50	10,271
PORTAL PH FOREBAY	CA00442	1955	65	325	50	10,321
DICK WEEK	CA00585	1955	70	3,140	50	10,371
SAWPIT DB	CA01157	1955	82	152	50	10,421
ELMER J CHESBRO	CA00806	1955	95	8,086	50	10,471
Steer Branch Dam	VA19503	1955	210	40	50	10,521
LUCKY PEAK	ID00288	1955	340	307,000	50	10,571
HARRISON STREET	CA00797	1954	50	208	51	10,622
NULL	CA00933	1954	54	188	51	10,673
RICHARDSON	CA00994	1954	65	520	51	10,724
PINON CANYON DETENTION	CO00105	1954	73	561	51	10,775
UPPER STONE CANYON	CA00097	1954	111	425	51	10,826
GARVEY RES	CA00217	1954	160	1,610	51	10,877
VERMILION VALLEY	CA00441	1954	167	125,000	51	10,928
PETERS	CA00208	1954	230	32,900	51	10,979
FRENCHMAN DAM	MT00003	1953	63	21,000	52	11,031
EAGLE ROCK	CA00094	1953	113	254	52	11,083
GREEN VERDUGO	CA00096	1953	118	99	52	11,135
JAMES J LENIHAN	CA00293	1953	208	21,430	52	11,187
CRYSTAL	CA00573	1952	51	105	53	11,240
DEBELL	CA00686	1952	53	120	53	11,293
SUTRO RESERVOIR	CA00135	1952	55	96	53	11,346
SCHUBIN	CA01045	1952	55	225	53	11,399
POMPONIO RANCH	CA01008	1952	63	256	53	11,452
Lower Bear	CA00409	1952	245	54,000	53	11,505
MALLACOMES	CA00591	1951	57	200	54	11,559
NIEGEL	CA01047	1951	61	145	54	11,613
RICKEY	CA01009	1951	64	47	54	11,667
Little Hell s Canyon	AZ00215	1951	69.5	1,545	54	11,721
NOVATO CREEK	CA00321	1951	71	4,430	54	11,775
MIDDLE CREEK DAM	MT00018	1951	110	10,230	54	11,829
BELLETT	CA00542	1950	54	90	55	11,884
GLEN MARTIN	CA00754	1950	55	33	55	11,939
DIEDERICH RES	CA00064	1950	60	174	55	11,994
PEABODY	CA00685	1950	63	88	55	12,049
MARLOWE HEIRS REFUSE DAM-WHITE OAK BRANCH	KY00665	1950	80	316	55	12,104
STOCKTON CREEK	CA00699	1950	95	388	55	12,159
AUSTRIAN	CA00680	1950	185	6,200	55	12,214
LEROY ANDERSON	CA00294	1950	235	91,280	55	12,269
SYPHON CANYON	CA00749	1949	59	500	56	12,325
GLENOAKS 968 RES	CA00065	1949	62	28	56	12,381
QUEENS CREEK	NC00333	1949	78	718	56	12,437
BON TEMPE	CA00207	1949	98	4,300	56	12,493
LOS PADRES	CA00692	1949	148	3,100	56	12,549
BIG DRY CREEK	CA01075	1948	50	30,200	57	12,606
JACOBS CREEK	CA00232	1948	53	587	57	12,663
LA HERRADURA	CA00582	1948	73	110	57	12,720
French Lake	CA00247	1948	100	13,800	57	12,777
SCOTTS FLAT	CA00253	1948	175	49,000	57	12,834
MUD MOUNTAIN DAM	WA00300	1948	425	106,000	57	12,891
KUHN	CA00683	1947	67	85	58	12,949
DOS PUEBLOS	CA00730	1946	78	300	59	13,008
CONN CREEK	CA00104	1946	125	31,000	59	13,067
RECTOR CREEK	CA00011	1946	164	4,587	59	13,126
RUBIO DB	CA00202	1944	64	44	61	13,187
PIT 5 COND EMBANK	CA00403	1943	61	1,147	62	13,249
ELYSIAN	CA00089	1943	71	187	62	13,311
NANTAHALA	NC00371	1942	250	128,000	63	13,374
CHORRO CREEK	CA01076	1941	77	90	64	13,438
ORANGE COUNTY RESERVOIR	CA00218	1941	103	217	64	13,502
LONG VALLEY	CA00090	1941	128	183,465	64	13,566
THORPE	NC00378	1941	150	67,100	64	13,630
THORPE LAKE DAM #1 (NP&L FERC)	NC00336	1941	150	-	64	13,694
CALAVERA	CA00781	1940	67	520	65	13,759
GRANT LAKE	CA00089	1940	87	47,525	65	13,824
CHEVY CHASE 1290	CA01078	1940	90	17	65	13,889
MUNICIPAL	CA00155	1939	58	189	66	13,955

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KIMBALL CREEK	CA00310	1939	80	344	66	14,021
PALOS VERDES RES	CA00215	1939	82	1,100	66	14,087
NORTH FORK	CA00299	1939	100	6,150	66	14,153
YELLOW WATER MAIN DAM	MT00012	1938	55	8,100	67	14,220
RANCHO DEL CIEVRO	CA00719	1938	65	165	67	14,287
SUNSET N BASIN	CA00134	1938	74	275	67	14,354
SUTTENFIELD	CA00010	1938	76	600	67	14,421
C L TILDEN PARK	CA00161	1938	88	268	67	14,488
GREGORY, LAKE	CA00224	1938	90	2,100	67	14,555
MATHEWS	CA00212	1938	264	182,000	67	14,622
SAN GABRIEL NO 1	CA00200	1938	320	44,183	67	14,689
GLACIER LAKE NORTH DAM	MT00068	1937	57	4,980	68	14,757
UNIV MOUND S BN	CA00133	1937	61	250	68	14,825
CHERRY FLAT	CA00158	1936	60	500	69	14,894
EATON WASH DB	CA00201	1936	63	721	69	14,963
WEST VALLEY	CA00300	1936	65	23,000	69	15,032
ALMADEN	CA00289	1936	110	2,000	69	15,101
COYOTE	CA00287	1936	140	23,666	69	15,170
BIG CANYON CR	CA00611	1935	63	395	70	15,240
LAKE QUIVIRA, CITY OF, LAKE QUIVIRA DAM	KS02974	1935	80	2,996	70	15,310
CALERO	CA00288	1935	90	9,850	70	15,380
STEVENS CREEK	CA00292	1935	130	3,800	70	15,450
GUADALUPE	CA00290	1935	142	3,460	70	15,520
COGSWELL	CA00190	1935	266	8,969	70	15,590
BOUQUET CANYON	CA00088	1934	190	36,505	71	15,661
UPPER HOLLYWOOD	CA00087	1933	87	196	72	15,733
SANTIAGO CREEK	CA00298	1933	136	25,000	72	15,805
PETERS CANYON	CA00746	1932	54	1,090	73	15,878
WHITTIER RES NO 4	CA00153	1931	55	32	74	15,952
SWANZY LAKE	CA00144	1931	88	107	74	16,026
SALT SPRINGS	CA00382	1931	332	141,900	74	16,100
MOCCASIN LOWER	CA00122	1930	60	554	75	16,175
GRIZZLY	CO01545	1930	65	987	75	16,250
FELT LAKE	CA00670	1930	67	900	75	16,325
Haskins Creek Dam	OR00115	1930	85	704	75	16,400
BRAND PARK	CA00061	1930	99	32	75	16,475
LAFAYETTE	CA00183	1929	132	4,250	76	16,551
GEUNOC LAKE	CA00564	1928	50	3,237	77	16,628
WUEST	CA00780	1928	50	280	77	16,705
COYOTE FLAT	CA00513	1928	52	5,250	77	16,782
THOMPSON CREEK	CA00198	1928	66	543	77	16,859
BUCKS STORAGE	CA00332	1928	122	103,000	77	16,936
PUDDINGSTONE	CA00194	1928	147	16,342	77	17,013
BIG TOOTH	CO00445	1927	120	205	78	17,091
BOWMAN	CA00245	1927	175	64,000	78	17,169
PHILBROOK	CA00345	1926	85	5,180	79	17,248
CURRY, LAKE	CA00140	1926	107	10,700	79	17,327
BLACK ROCK CR	CA00693	1925	57	30	80	17,407
SKAGWAY	CO00481	1925	79	3,570	80	17,487
THOMPSON	CA00445	1925	114	1,010	80	17,567
DIX RIVER DAM	KY00316	1925	287	230,500	80	17,647
BRIDGEPORT	CA00284	1924	63	44,100	81	17,728
ENCINO	CA00070	1924	168	9,789	81	17,809
STONE CANYON	CA00083	1924	188	10,372	81	17,890
HENDERSON	CA00005	1923	56	500	82	17,972
EL DORADO FOREBAY	CA00375	1923	91	472	82	18,054
DRINKWATER	CA00077	1923	105	92	82	18,136
CAPLES LAKE	CA00378	1922	71	21,580	83	18,219
Spruce Hollow	MD00349	1920	50	150	85	18,304
SAN PABLO	CA00186	1920	170	43,193	85	18,389
Daggs	AZ00013	1919	88	13,750	86	18,475
BOX ELDER CREEK (CHATFIELD)	UT00050	1918	50	511	89	18,564
MAIN STRAWBERRY	CA00388	1916	143	18,312	89	18,653
Drews Reservoir	OR00049	1914	83	65,000	91	18,744
CUCHARAS #5	CO01146	1913	145	103,000	92	18,836
SAND CANYON	CA00854	1912	58	960	93	18,929
Lyman	AZ00004	1912	76.4	44,500	93	19,022
MORENA	CA00110	1912	181	50,206	93	19,115
VALLEY, LAKE	CA00361	1911	74	8,127	94	19,209
Wenas Dam	WA00002	1911	90	5,500	94	19,303
SAWMILL LAKE	CA00250	1910	50	3,040	95	19,398
CENTRAL	CA00162	1910	55	485	95	19,493
HILLSIDE	CA00446	1910	81	12,683	95	19,588
RELIEF	CA00390	1910	145	15,122	95	19,683
CRANE VAL STOR	CA00337	1910	145	45,410	95	19,778
STANISLAUS FB	CA00391	1908	60	340	97	19,875
MARIE, LAKE	CA00004	1908	60	170	97	19,972
SABRINA	CA00448	1908	70	8,376	97	20,069
MADIGAN, LAKE	CA00141	1908	89	1,744	97	20,166
KUNKLE	CA00344	1907	54	253	98	20,264
PHOENIX LAKE	CA00206	1907	90	612	98	20,362
HERMAN, LAKE	CA00851	1905	51	2,210	100	20,462
BERRYMAN RES	CA00168	1905	60	45	100	20,562
PIEDMONT	CA00170	1905	64	60	100	20,662
DESABLA FOREBAY	CA00343	1903	53	280	102	20,764
MEADOW LAKE	CA00381	1903	77	5,160	102	20,866
ESTATES	CA00169	1903	93	58	102	20,968
TERMINAL	CO00895	1902	103	29,800	103	21,071
CHOLLAS	CA00107	1901	50	310	104	21,175
Hogan Dam	VA15504	1900	60	1,285	105	21,280
Upper Bear	CA63276	1900	77	7,400	105	21,385
BEAR RIVER	CA00379	1900	83	6,818	105	21,490
TORESON	CA00483	1898	55	1,140	107	21,597
BEAR GULCH	CA00658	1896	81	672	109	21,706

River Reservoir #3	AZ00007	1896	68.5	3,195	109	21,815
FREY, LAKE	CA00142	1894	83	1,075	111	21,926
RED ROCK NO 1	CA00510	1893	83	10,000	112	22,038
FOREST LAKE	CA00690	1892	80	427	113	22,151
SUMMIT	CA00171	1891	61	117	114	22,265
COWELL RESERVIOR	CA00046	1890	50	175	115	22,380
SEQUOIA LAKE	CA00709	1888	51	1,370	117	22,497
YOSEMITE, LAKE	CA00241	1888	53	8,101	117	22,614
EMERALD LAKE 1 LOWER	CA00686	1885	57	45	120	22,734
PHOENIX	CA00389	1880	52	455	125	22,859
SPENSER LAKE	CA00673	1876	87	73	129	22,988
FORDYCE, LAKE	CA00357	1873	143	48,900	132	23,120
SAN ANDREAS	CA00129	1870	107	19,027	135	23,255
TEMESCAL, LAKE	CA00160	1869	116	200	136	23,391
PILARCITOS	CA00128	1866	103	3,100	139	23,530
EMERY	CA00618	1850	53	630	155	23,685
NOTRE DAME	CA00674		51	120		
LOWER STEHLY	CA01227		60	145		
AUXILIARY RESERVOIR C	CA01456		65	3,700		
LANG CREEK DETN BN	CA01368		67	263		
SLICKROCK CREEK	CA01444		155	220		
WESINER HOLLOW SLURRY DAM	PA01641		192	3,948		

Table 3: Failure Rate Sensitivity Analysis

			# NUMBER OF FAILURES					
CUT-OFF	DAM-YEARS	# DAMS	1	2	3	4	5	6
ALL	25137	484	4.0E-5	8.0E-5	1.2E-4	1.6E-4	2.0E-4	2.4E-4
1900	21490	466	4.7E-5	9.3E-5	1.4E-4	1.9E-4	2.3E-4	2.8E-4
1910	19778	449	5.1E-5	1.0E-4	1.5E-4	2.0E-4	2.5E-4	3.0E-4
1920	18389	434	5.4E-5	1.1E-4	1.6E-4	2.2E-4	2.7E-4	3.3E-4
1930	16475	410	6.1E-5	1.2E-4	1.8E-4	2.4E-4	3.0E-4	3.6E-4
1940	13889	373	7.2E-5	1.4E-4	2.2E-4	2.9E-4	3.6E-4	4.3E-4
1950	12269	346	8.2E-5	1.6E-4	2.5E-4	3.3E-4	4.1E-4	4.9E-4
1960	8453	270	1.2E-4	2.4E-4	3.6E-4	4.7E-4	5.9E-4	7.1E-4
1970	3242	143	3.1E-4	6.2E-4	9.3E-4			
1980	1339	82	7.5E-4					
1990	381	36						
			FAILURE RATE GIVEN NUMBER OF FAILURES & CUTOFF YEAR					