Hydrographic Analysis of Low-Flow Discharges and Pumpage Management Alternatives at Barton Springs, Austin, Texas

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and
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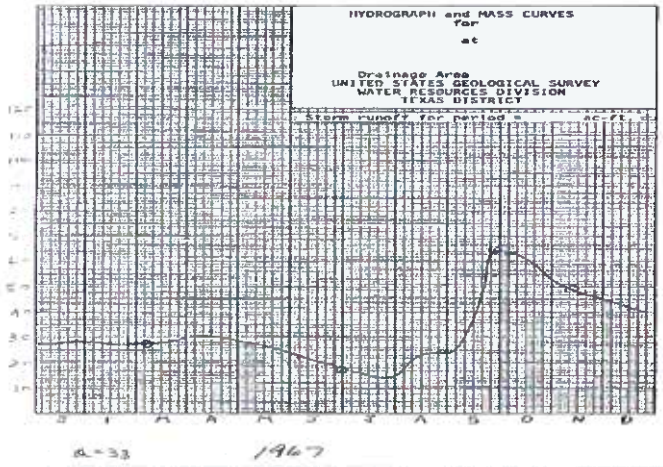
Purpose:

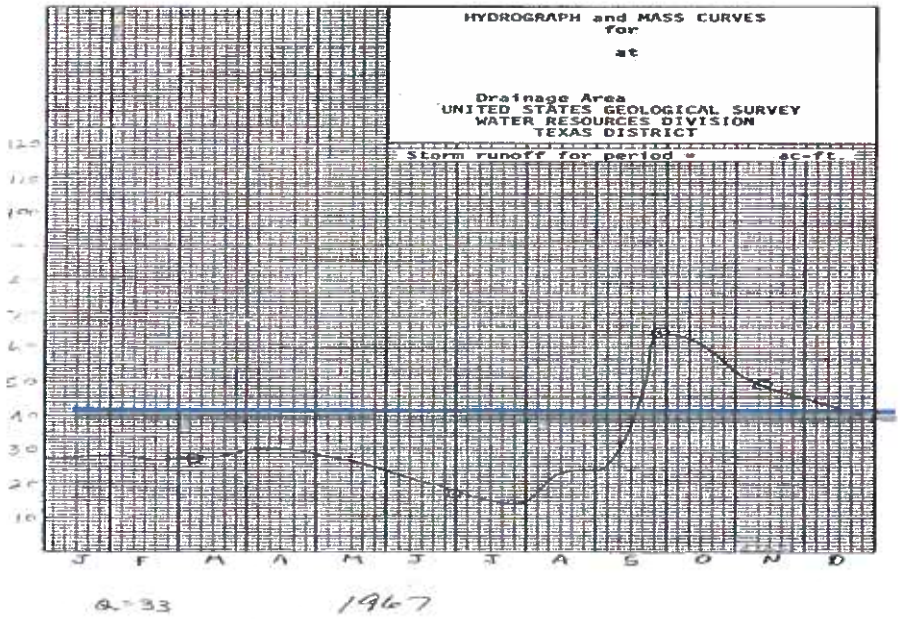
- To analyze the effects of alternative management strategies on low flow discharges at Barton Springs
- To make findings as part of the HCP process, pursuant to issuance of an incidental take permit by USFWS under the Endangered Species Act
- This evening: To present the data development and modeling study in multiple steps, leading to findings of significance for the District

1. Develop estimates of daily spring discharge for period 1917-1978

- Inferred from periodic measurements, precipitation, streamflow



- Recession rates and rising limbs inferred from recent recorded data
- Delimit data set to discharge values at or below 40 CFS

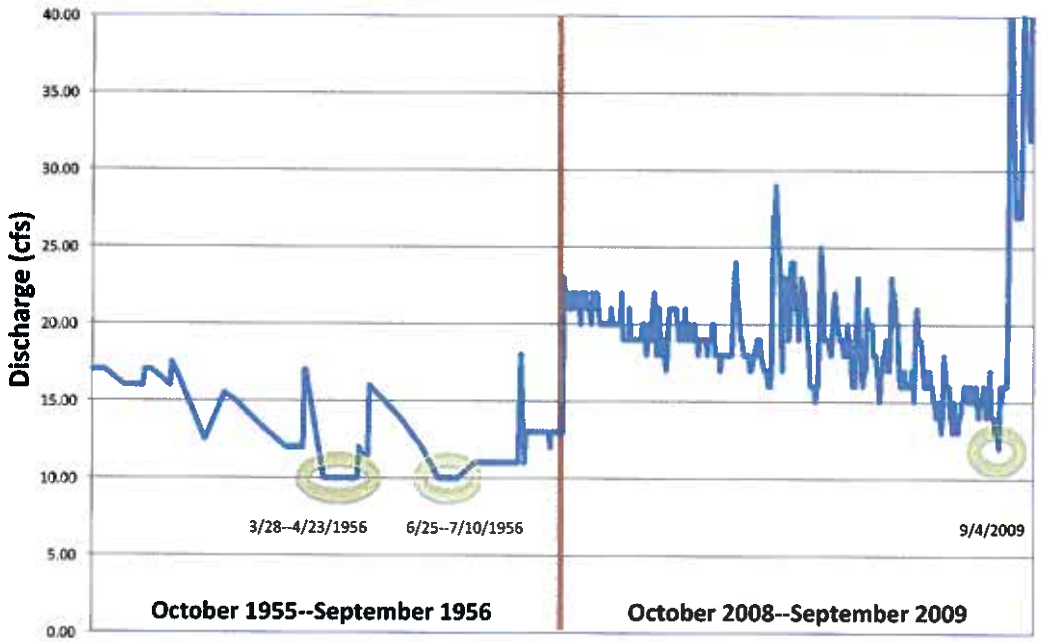


1. Develop estimates of daily spring discharge for period 1917-1978

2. Compile daily mean spring discharge data for 1978-2009

- delimit data set to discharges <40 cfs

Discharge Hydrographs at Drought Stage: 1956 and 2009



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1. Develop estimates of daily spring discharge for period 1917-1978

2. Compile daily mean spring discharge data for 1978-2009

3. Estimate monthly pumpage rates over period of record

- extrapolated pumpage, based on pop. growth, 1900-1989

- used permit data and estimates of exempt wells, 1989-2009

- extrapolated pumpage based on pop. growth,1900-1990

Year	Hays Cty. Pop.	Austin MSA Pop.	Hays Cty. Ann Gr. Rate	Austin MSA Ann. Gr. Rate	Assumed Ann. Gr. Rate BS-	Avg. Pumpage Rate (CFS)
2000	97,589	1,249,763	**4.9%**	**4.00%**	**8.9%**	*
1990	65,614	846,227	**6.2%**	**3.80%**	**10.0%**	*
1980	40,594	585,051	**4.7%**	**3.90%**	**8.6%**	**2.74**
1970	27,642	398,938	**3.9%**	**2.80%**	**6.7%**	**1.19**
1960	19,934	301,261	**1.2%**	**1.60%**	**2.8%**	**0.61**
1950	17,840	256,645	**1.6%**	**1.80%**	**3.4%**	**0.45**
1940	15,349	214,603	**0.3%**	**1.10%**	**1.0%**	**0.32**
1930	14,915	192,123	**-0.6%**	**1.10%**	**1.0%**	**0.28**
1920	15,920	168,279	**0.3%**	**0.30%**	**1.0%**	**0.26**
1910	15,518	162,947	**1.0%**	**0.90%**	**1.0%**	**0.25**
1900	14,142	148,210	-	-	-	**0.25**

* obtained from BSEACD permit data

- permit data and estimates of exempt wells, 1989-2009

FiscalYear	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	AVERAGE
1989	6.9	6.4	5.8	5.0	4.7	3.5	4.0	5.1	15.5	6.6	7.3	5.5	6.4
1990	5.9	4.7	3.8	3.8	3.2	3.2	2.8	3.3	4.1	6.1	4.9	5.8	4.3
1991	4.9	4.6	3.4	3.6	3.3	3.2	3.6	3.4	3.9	4.4	5.2	4.9	4.0
1992	4.2	4.7	3.6	3.5	3.5	3.7	3.7	4.5	4.5	5.3	7.2	7.5	4.6
1993	6.6	5.6	3.6	3.8	3.4	4.1	4.1	4.4	4.9	5.7	8.1	10.2	5.4
1994	7.6	6.0	4.4	4.2	4.3	4.1	4.1	5.1	4.6	7.0	9.3	7.1	5.7
1995	5.6	5.3	4.3	3.9	4.0	4.0	4.1	4.8	5.0	5.9	8.0	7.9	5.2
1996	6.3	6.2	4.7	4.5	4.4	5.4	5.2	6.2	6.7	6.8	8.9	7.1	6.0
1997	5.6	5.7	5.1	4.3	4.5	4.1	4.5	4.4	5.3	5.1	9.0	10.0	5.6
1998	9.3	8.0	5.4	4.6	4.5	4.9	5.0	6.4	9.1	10.9	9.3	8.8	7.2
1999	7.0	6.2	5.1	4.9	4.9	5.4	5.1	6.8	5.7	8.4	8.2	11.3	6.6
2000	10.0	9.7	7.0	6.1	5.8	5.8	5.9	7.2	8.1	8.1	12.0	11.7	8.1
2001	11.4	6.8	5.6	5.8	5.3	5.9	6.2	7.0	8.1	12.1	13.5	13.6	8.4
2002	8.1	7.4	6.7	5.5	5.6	6.1	6.6	8.4	11.8	11.3	9.4	13.0	8.3
2003	10.9	7.2	5.9	5.6	5.6	5.8	6.0	8.5	10.7	10.2	11.4	12.6	8.4
2004	9.2	8.0	6.1	6.3	6.0	5.9	6.6	7.1	8.2	8.1	9.7	11.6	7.7
2005	10.6	7.9	6.1	6.5	6.8	6.1	6.4	8.6	9.1	13.2	12.5	13.2	8.9
2006	13.6	10.4	9.0	8.3	7.9	6.7	7.1	8.7	9.5	10.9	11.2	13.9	9.8
2007	9.7	7.3	6.4	5.9	5.6	5.6	6.3	7.0	7.8	8.6	7.3	10.3	7.3
2008	9.5	9.1	8.1	7.5	6.6	8.1	8.6	8.6	10.7	13.3	10.3	10.8	9.3
2009	11.0	9.0	8.1	6.2	5.4	5.8	5.8	6.6	7.7	7.7	10.4	9.5	7.8
Mthly Avg.	8.3	7.0	5.6	5.2	5.0	5.1	5.3	6.3	7.7	8.4	9.2	9.8	6.9
Ratio of avg. mthly.-to-annualized avg. mthly. pumpage	**1.198**	**1.009**	**0.815**	**0.757**	**0.726**	**0.741**	**0.770**	**0.912**	**1.109**	**1.210**	**1.331**	**1.422**	**1.000**

1. Develop estimates of daily spring discharge for period 1917-1978
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4. **Apply seasonal variations to pumpage rates**

   - hind-casting using 1989-2009 seasonal peak-to-average ratios

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Fiscal Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	AVG
Mthly Avg. (CFS)	8.3	7.0	5.6	5.2	5.0	5.1	5.3	6.3	7.7	8.4	9.2	9.8	6.9
Avg. mthly.–to-annualized avg. mthly. Ratio	**1.20**	**1.01**	**0.81**	**0.76**	**0.73**	**0.74**	**0.77**	**0.91**	**1.11**	**1.21**	**1.33**	**1.42**	**1.00**

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5. **Develop "Naturalized Flow" regime assuming no pumpage occurred**

   - subtract pumpage rates from spring discharge

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5. Develop "Naturalized Flow" regime assuming no pumpage occurred

6. Develop conservation - pumpage management scenarios

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Alternative I:	No Action (no HCP)	14 cfs *
Alternative II:	Best Administerable	11 cfs *
Alternative III:	Best Attainable	8.0 cfs *
Alternative IIIA:	Proposed Alternative	7.2 cfs *

* max. est. pumpage during Alarm or Critical Drought

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6. Develop conservation - pumpage management scenarios

7. **Impose scenarios on the Naturalized Flows**

    - four discharge scenarios over 93-year period of record

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5. Develop "Naturalized Flow" regime assuming no pumpage occurred
6. Develop conservation - pumpage management scenarios
7. Impose scenarios on the Naturalized Flows

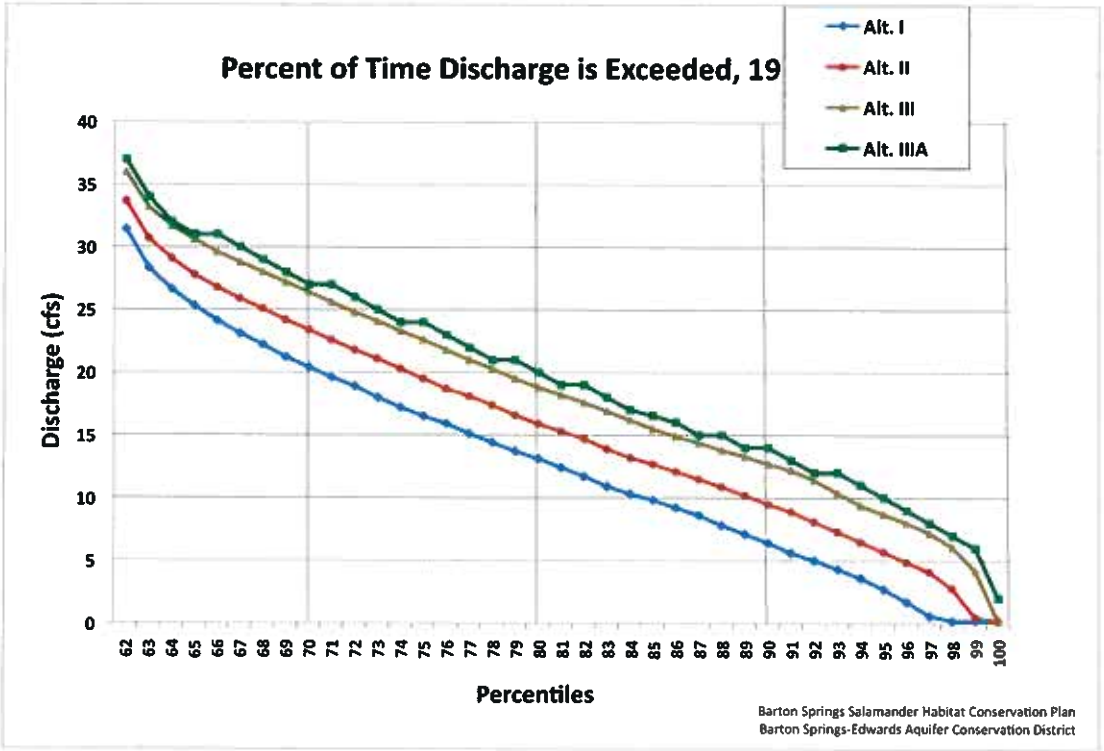
8. **Conduct statistical analyses**
    A. **Exceedence Frequencies: probability that a given discharge would or would not be exceeded**

    B. **Low-flow frequency duration: probability that the discharge for a given duration (7, 14 and 30 days) would or would not be exceeded in a given year**

8. Conduct statistical analyses – Exceedence Frequencies

Question:

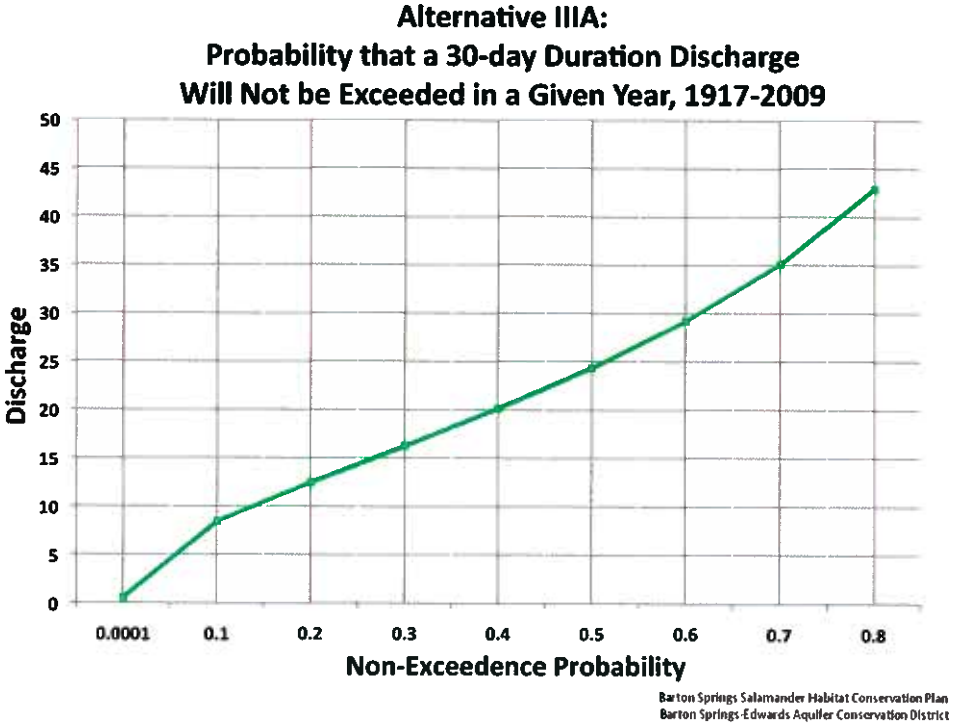
What is the likelihood that discharge at Barton Springs be in excess of 20 CFS, based on an analysis of the period of record?



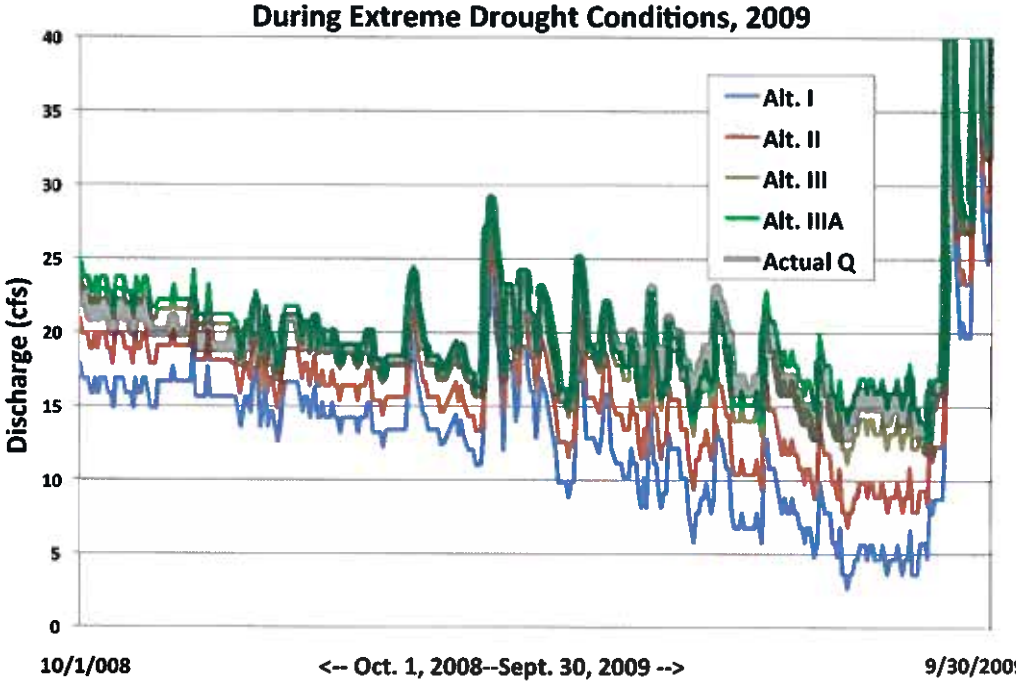
8. Conduct statistical analyses – Low flow frequency duration

Question:

What is the likelihood that the continuous 30-day discharge at Barton Springs will not exceed 20 CFS in any given year?



Comparison of Management Alternatives During Extreme Drought Conditions, 2009



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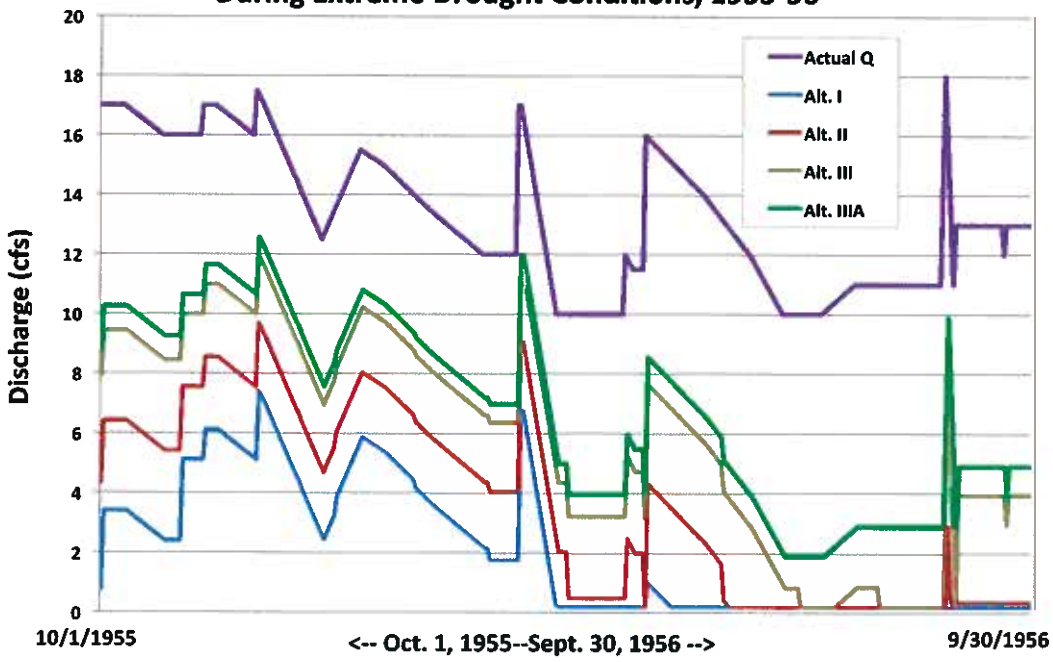
Comparison of Management Alternatives During Extreme Drought Conditions, 1955-56



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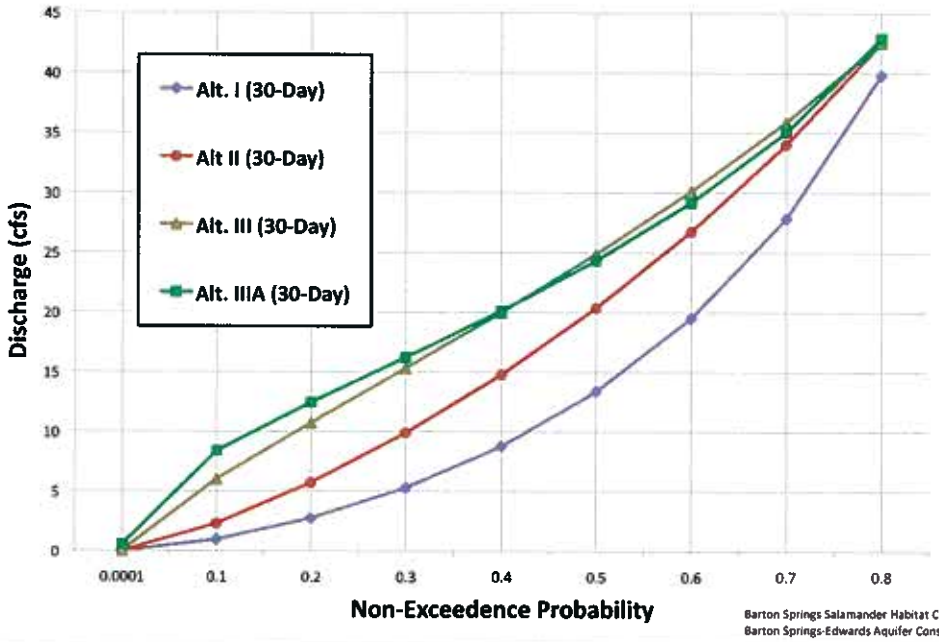
Findings

- The District's policies and rules can be modeled to estimate effects on discharge.
- Dramatic differences in discharge are evidenced by the alternative management scenarios.
- The droughts of 1951-56 and 2009 can be evaluated. The study shows dramatic impacts as a result of the District's drought-stage management programs.
- Cessation of spring discharge is likely under moderate management scenarios.
- Modeling of the 2009 drought allows an examination of the District's groundwater management programs. The study indicates that projected spring discharges under Alternative IIIA are comparable to actual recorded discharges during the drought (during the time that the District's enhanced measures were in place). The drought-stage analysis corroborates assumptions made in the HCP.

Thank you for your attention.

Duration-Frequency Analysis: Probability that a 30-day Duration Discharge Will Not be Exceeded in a Given Year, 1917-2009



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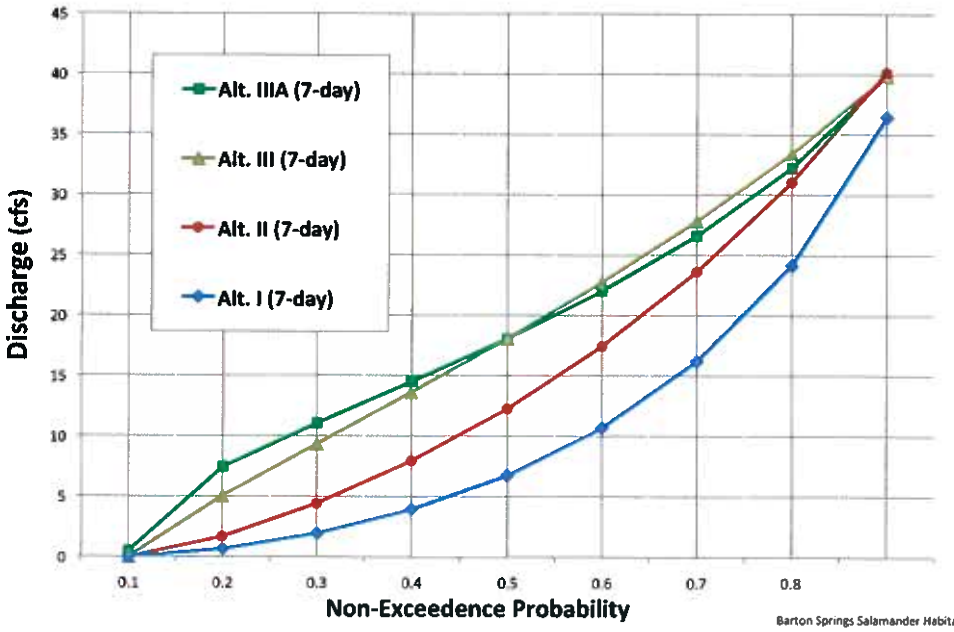
Duration-Frequency Exceedence Analysis: Probability that a 7-day Duration Discharge Will Not be Exceeded in a Given Year, 1917-2009



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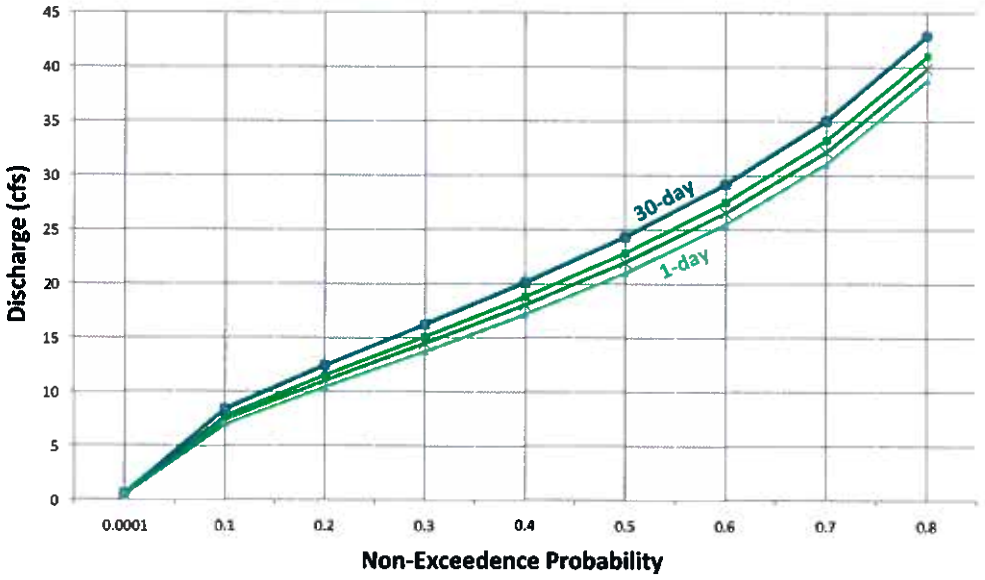
Alternative IIIA:
Probability that a Discharge of 1-, 7-, 14-, or 30-day Duration Will Not be Exceeded in a Given Year, 1917-2009



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