ENERGY BALANCE TEST CASES

Prepared For: VSMP RAP, Water Quantity Subcommittee

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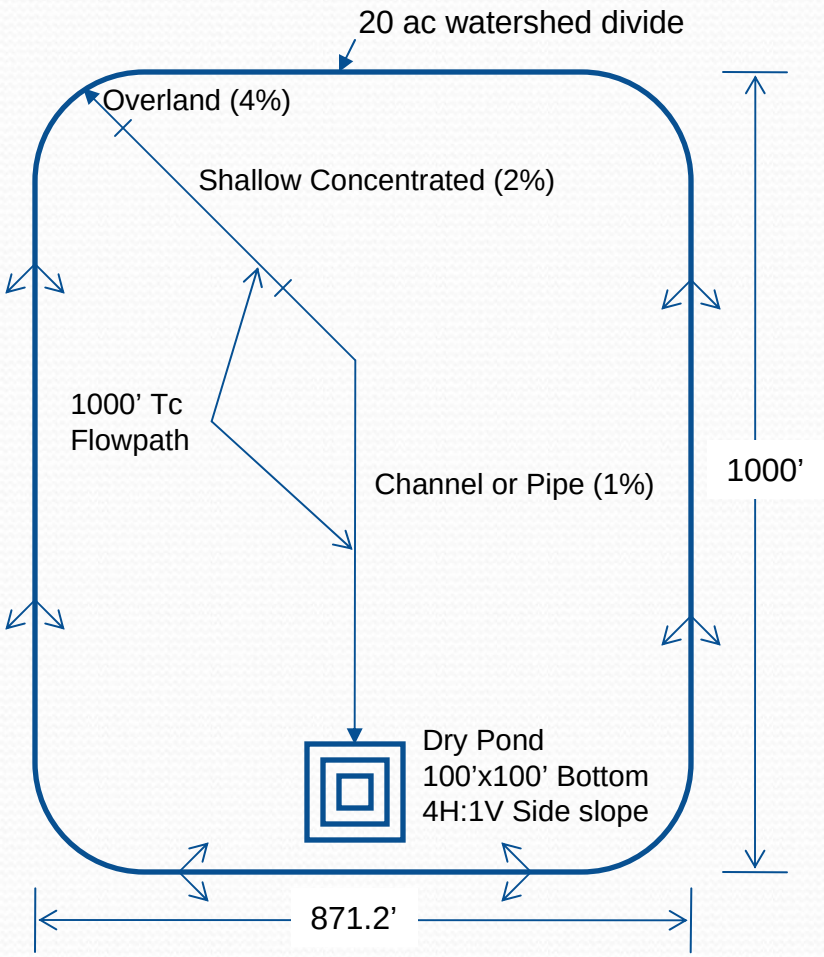
Dewberry

Hypothetical 20 Acre Site



Land Use	CN (HSG B)	CN (HSG C)	CN (HSG D)	Tc (min)
Woods	55	70	77	30
Pasture	61	74	80	20
SFD (1 ac)	68	79	84	15
SFD (0.25 ac)	75	83	87	10
Townhouse	85	90	92	7.5
Commercial	92	94	95	5
Impervious	98	98	98	5

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Hypothetical Tc Computations

	Overland Flow				Shallow Concentrated Flow				Pipe flow				Channel Flow							
Watershed Condition	Length (feet)	n	Slope (ft/ft)	Tt (min)	Length (feet)	Slope (ft/ft)	Vel (fps)	Tt (min)	Length (feet)	Slope (ft/ft)	Vel (fps)	Tt (min)	Length (feet)	n	Slope (ft/ft)	Vel (fps)	Tt (min)	Total Length (feet)	Total Tc (min)	Selected Tc (min)
Woods	150	0.4	0.04	21.84	500	0.02	2.3	3.62	0	0.01	0	0.00	350	0.05	0.01	3.5	1.67	1000	27.13	30
Pasture	125	0.24	0.04	12.54	400	0.02	2.3	2.90	0	0.01	0	0.00	475	0.05	0.01	3.5	2.26	1000	17.70	20
SFD (1ac)	100	0.24	0.04	10.49	300	0.02	2.3	2.17	0	0.01	0	0.00	600	0.05	0.01	3.5	2.86	1000	15.52	15
SFD (0.25ac)	75	0.24	0.04	8.33	200	0.02	2.9	1.15	725	0.01	10	1.21	0	0.05	0.01	3.5	0.00	1000	10.69	10
Townhouse	50	0.24	0.04	6.03	100	0.02	2.9	0.57	850	0.01	10	1.42	0	0.05	0.01	3.5	0.00	1000	8.02	7.5
Commercial	25	0.24	0.04	3.46	100	0.02	2.9	0.57	875	0.01	10	1.46	0	0.05	0.01	3.5	0.00	1000	5.49	5
Impervious	25	0.011	0.04	0.29	100	0.02	2.9	0.57	875	0.01	10	1.46	0	0.025	0.01	7	0.00	1000	2.33	5

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Test Cases

- Case 1 – Proposed VSMP Design of Dry Pond
  - 1-Yr Energy Bal: $Q_{dev} = IF * Q_{pre\text{-}dev} * RV_{pre\text{-}dev} / RV_{dev}$
    - IF = 0.8 for Pre-Dev = Pasture
    - IF = 1.0 for Pre-Dev = Forest
  - Standard 10-Yr Detention

- Case 2 – Exist VSMP Design of Dry ED Pond
  - 30-Hr Drawdown of 2 * WQV
  - Standard 2- and 10-Yr Detention

* Assume No Upstream Runoff Reduction

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Land Use Scenarios Tested

- Pre-Development Land Uses (HSG B, C & D)
  - Pasture (Good Condition)
  - Woods (Good Condition)
- Post-Development Land Uses (HSG B, C, & D)
  - SFD (1 acre lots)
  - SFD (0.25 acre lots)
  - Townhouse
  - Commercial
  - Impervious

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Results for Pre-Dev = Pasture

						CASE #1 Prop VSMP 1-Yr Energy Bal (IF=0.8)			CASE #2 Ex VSMP Design for Dry ED Pond			
Developed Land Use / HSG	CN	1-Yr RVpre-dev (A-F)	1-Yr RVdev (A-F)	1-Yr Qpre-dev (cfs)	1-Yr Undetained Qdev (cfs)	1-Yr Qdev Reqd (cfs)	1-Yr Det Vol Reqd (A-F)	10-Yr Det Vol Reqd (A-F)	2 x WQV (A-F)	1-Yr Det Vol (A-F)	10-Yr Det Vol Reqd (A-F)	Prop / Exist 10- Yr Vol (%)
SFD 1 ac / B	68	0.3616	0.6980	2.1080	8.142	0.8737	0.2298	0.7031	0.3333	0.3503	0.7634	92%
SFD 0.25 ac / B	75	0.3616	1.1530	2.1080	18.101	0.5290	0.6767	1.4033	0.6333	0.6571	1.3908	101%
TH / B	85	0.3616	2.0574	2.1080	35.89	0.2964	1.7227	2.5755	1.0833	1.1881	2.4029	107%
Comm / B	92	0.3616	2.9301	2.1080	53.966	0.2081	2.6584	3.5793	1.4167	1.6909	3.2322	111%
Paved / B	98	0.3616	3.9006	2.1080	65.482	0.1564	3.6444	4.5926	1.6667	2.272	3.993	115%
SFD 1 ac / C	79	1.0800	1.4744	12.9020	21.326	7.5605	0.3531	0.8708	0.3333	0.512	1.0684	82%
SFD 0.25 ac / C	83	1.0800	1.8483	12.9020	30.443	6.0312	0.628	1.4201	0.6333	0.8183	1.6819	84%
TH / C	90	1.0800	2.6560	12.9020	46.204	4.1971	1.2078	2.2772	1.0833	1.3493	2.5372	90%
Comm / C	94	1.0800	3.2272	12.9020	58.383	3.4543	1.6415	2.8511	1.4167	1.7273	3.0924	92%
Paved / C	98	1.0800	3.9006	12.9020	65.482	2.8579	2.1295	3.3877	1.6667	2.1045	3.547	96%
SFD 1 ac / D	84	1.5627	1.9509	20.1570	28.943	12.9169	0.4193	0.9136	0.3333	0.628	1.1412	80%
SFD 0.25 ac / D	87	1.5627	2.2831	20.1570	37.647	11.0372	0.6734	1.3908	0.6333	0.9643	1.7871	78%
TH / D	92	1.5627	2.9301	20.1570	50.433	8.6001	1.0951	2.0156	1.0833	1.4413	2.5318	80%
Comm / D	95	1.5627	3.3851	20.1570	60.459	7.4443	1.3783	2.4082	1.4167	1.764	2.9971	80%
Paved / D	98	1.5627	3.9006	20.1570	65.482	6.4604	1.6594	2.7087	1.6667	2.0697	3.3437	81%

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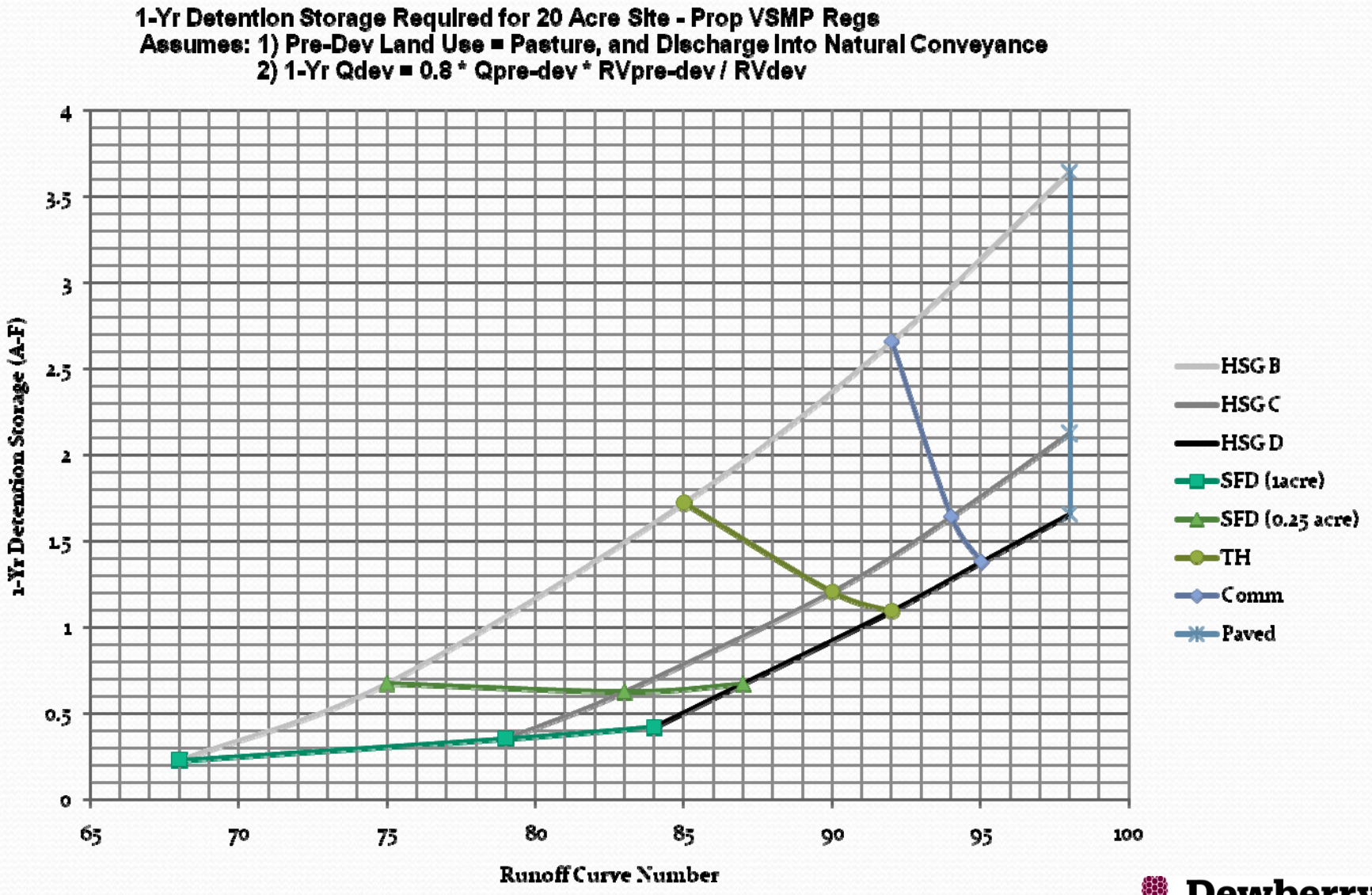
Results for Pre-Dev = Pasture



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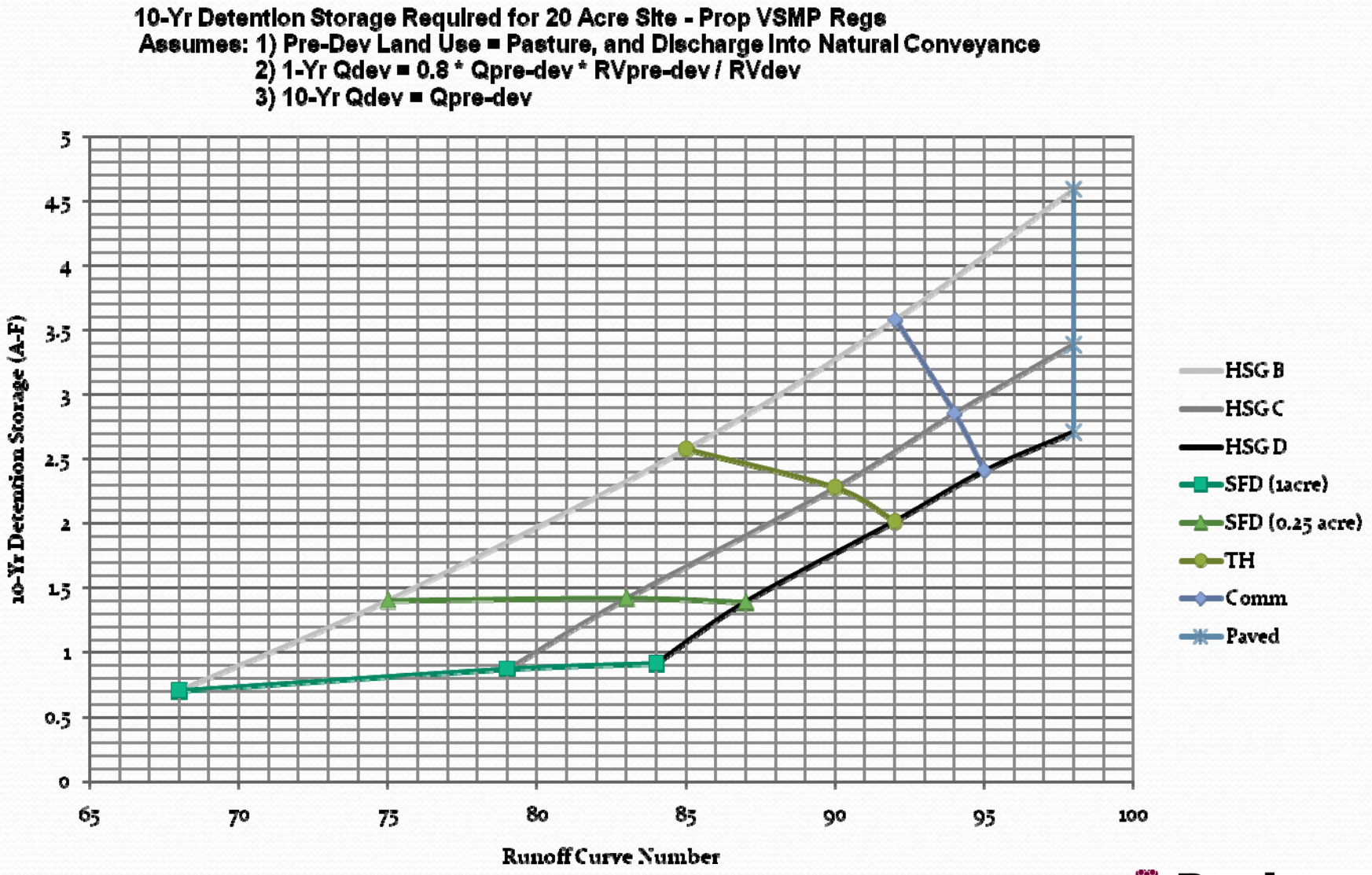

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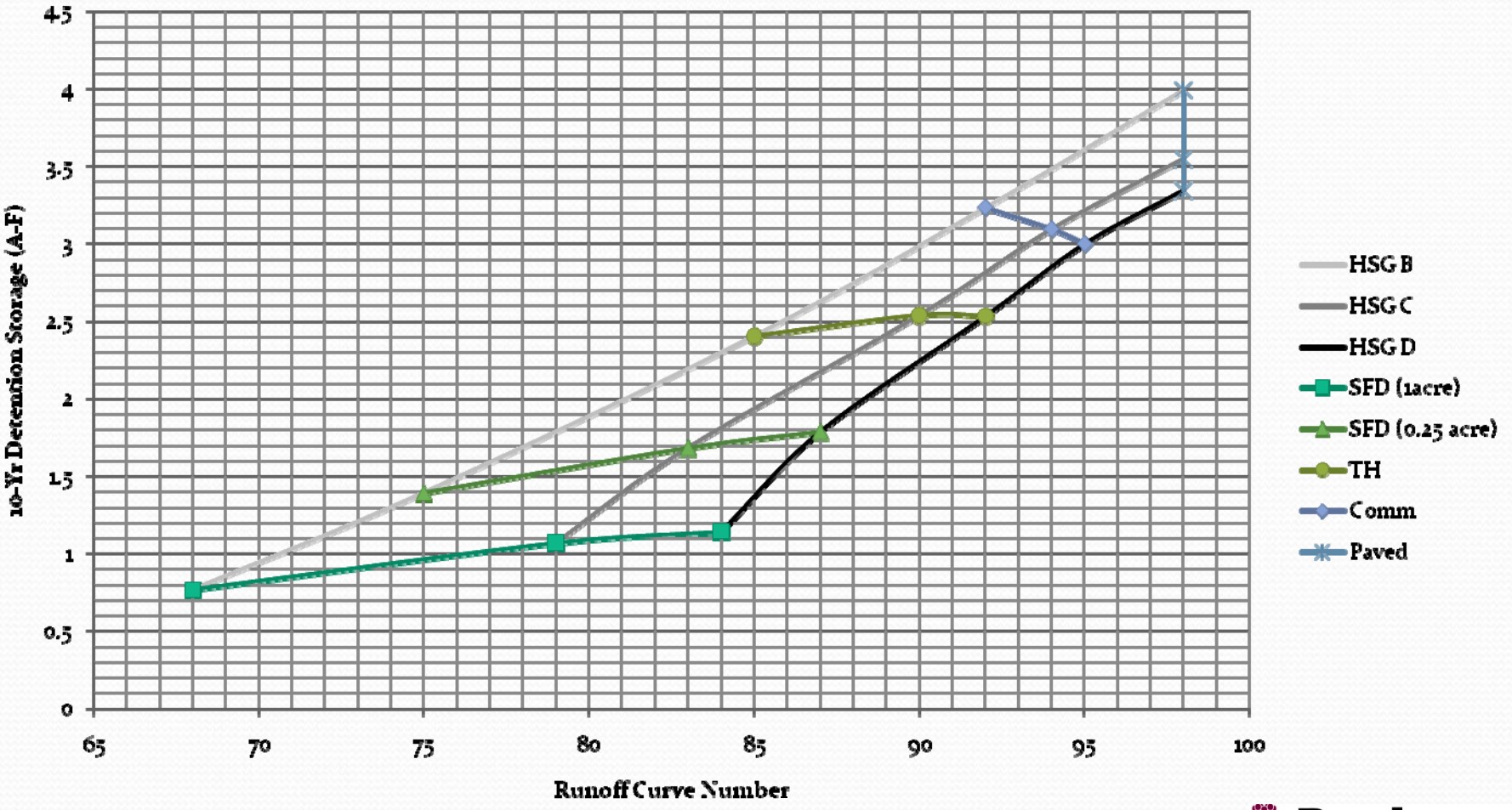
Results for Pre-Dev = Pasture

10-Yr Detention Storage Required for 20 Acre Site - Exist VSMP Regs
Assumes: 1) Pre-Dev Land Use = Pasture
2) 30-Hr Drawdown of 2xWQV per Exist SWM Regs for Dry ED Pond
3) 2-Yr and 10-Yr Qdev = Qpre-dev



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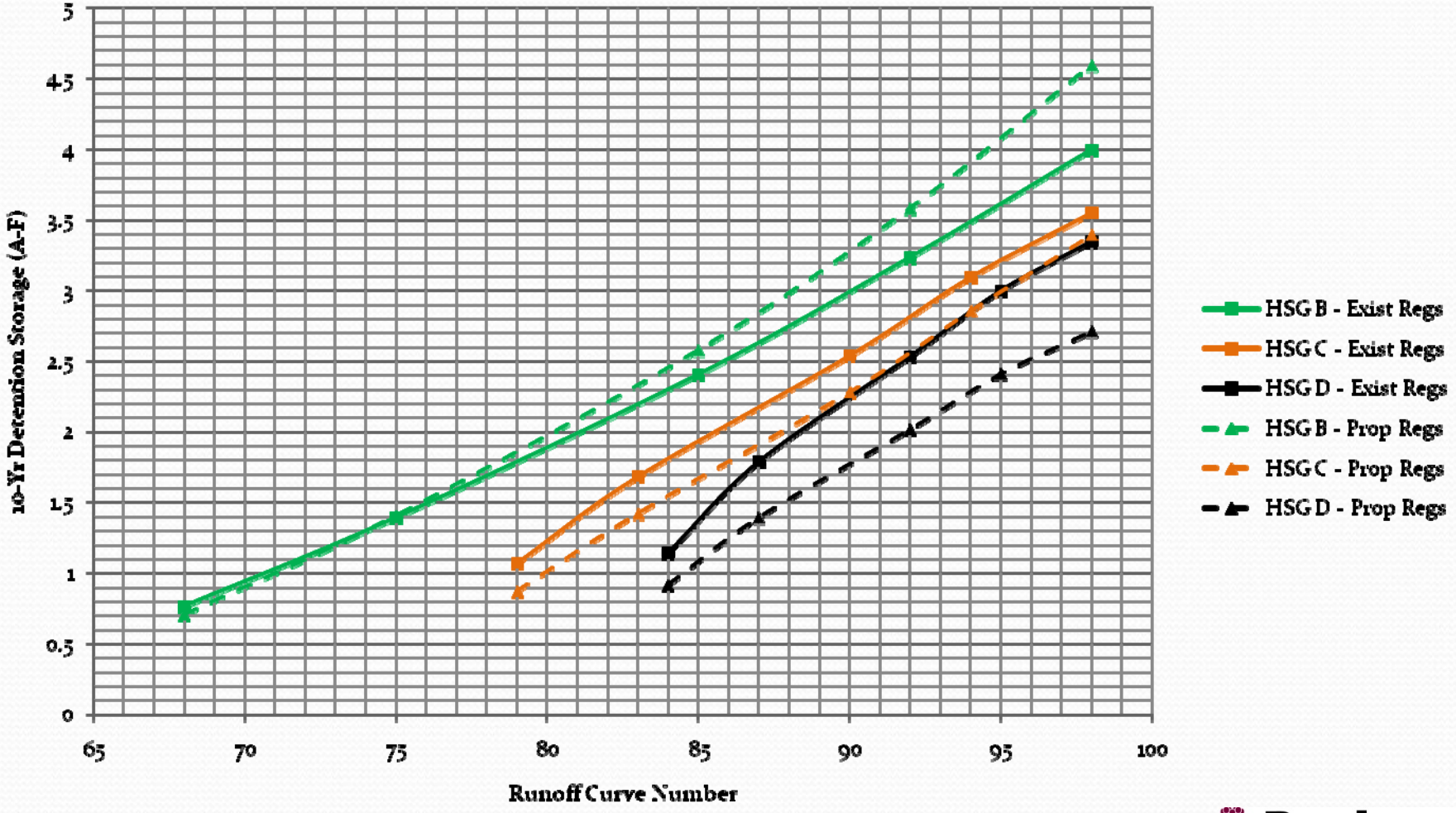
Results for Pre-Dev = Pasture

Compare 10-Yr Storage Required for 20 Acre Site (Pre-Dev = Pasture)
1) Prop VSMP Regs for Dry Pond: 1-Yr Energy Balance (IF = 0.8) and Std. 10-Yr Detention
2) Exist VSMP Regs for Dry ED Pond: 30-Hr Drawdown of 2 x WQV and Std. 2- & 10-Yr Detention



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Results for Pre-Dev = Forest

Developed Land Use / HSG	CN	1-Yr RVpre-dev (A-F)	1-Yr RVdev (A-F)	1-Yr Qpre-dev (cfs)	1-Yr Undetained Qdev (cfs)	CASE #1 Prop VSMP 1-Yr Energy Bal (IF=1.0) 1-Yr Qdev Reqd (cfs)	1-Yr Det Vol Reqd (A-F)	10-Yr Det Vol Reqd (A-F)	CASE #2 Ex VSMP Design for Dry ED Pond 2 x WQV (A-F)	1-Yr Det Vol (A-F)	10-Yr Det Vol Reqd (A-F)	Prop / Exist 10- Yr Vol (%)
SFD 1 ac / B	68	0.1594	0.6980	0.2740	8.142	0.0626	0.6184	1.0760	0.3333	0.3673	1.0196	106%
SFD 0.25 ac / B	75	0.1594	1.1530	0.2740	18.101	0.0379	1.0836	1.7227	0.6333	0.6701	1.6504	104%
TH / B	85	0.1594	2.0574	0.2740	35.89	0.0212	1.9913	2.8800	1.0833	1.2717	2.7144	106%
Comm / B	92	0.1594	2.9301	0.2740	53.966	0.0149	2.8568	3.8772	1.4167	1.8809	3.5728	109%
Paved / B	98	0.1594	3.9006	0.2740	65.482	0.0112	3.8166	4.9021	1.6667	2.6085	4.4094	111%
SFD 1 ac / C	79	0.8152	1.4744	6.8090	21.326	3.7644	0.5059	1.3042	0.3333	0.5677	1.4075	93%
SFD 0.25 ac / C	83	0.8152	1.8483	6.8090	30.443	3.0030	0.7908	1.8150	0.6333	0.8638	1.9525	93%
TH / C	90	0.8152	2.6560	6.8090	46.204	2.0898	1.4625	2.7256	1.0833	1.4033	2.8109	97%
Comm / C	94	0.8152	3.2272	6.8090	58.383	1.7199	1.967	3.3437	1.4167	1.7779	3.325	101%
Paved / C	98	0.8152	3.9006	6.8090	65.482	1.4230	2.57	3.9656	1.6667	2.1597	3.7898	105%
SFD 1 ac / D	84	1.3076	1.9509	12.9630	28.943	8.6886	0.5583	1.3246	0.3333	0.7264	1.5794	84%
SFD 0.25 ac / D	87	1.3076	2.2831	12.9630	37.647	7.4243	0.8045	1.7732	0.6333	1.0234	2.1145	84%
TH / D	92	1.3076	2.9301	12.9630	50.433	5.7850	1.2516	2.4029	1.0833	1.4925	2.8281	85%
Comm / D	95	1.3076	3.3851	12.9630	60.459	5.0075	1.5618	2.8166	1.4167	1.8103	3.263	86%
Paved / D	98	1.3076	3.9006	12.9630	65.482	4.3457	1.8809	3.1528	1.6667	2.1145	3.6118	87%

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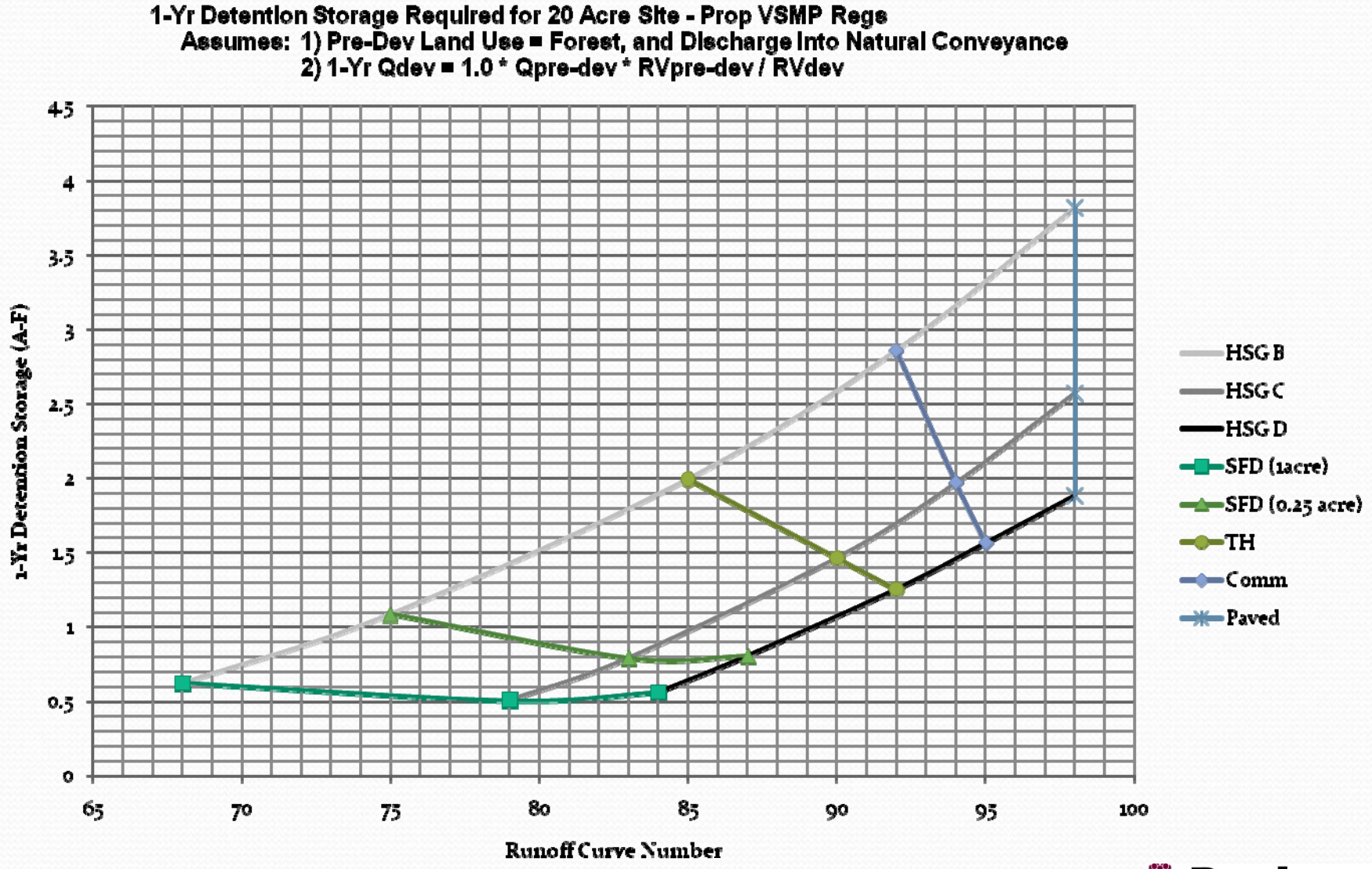
Results for Pre-Dev = Forest



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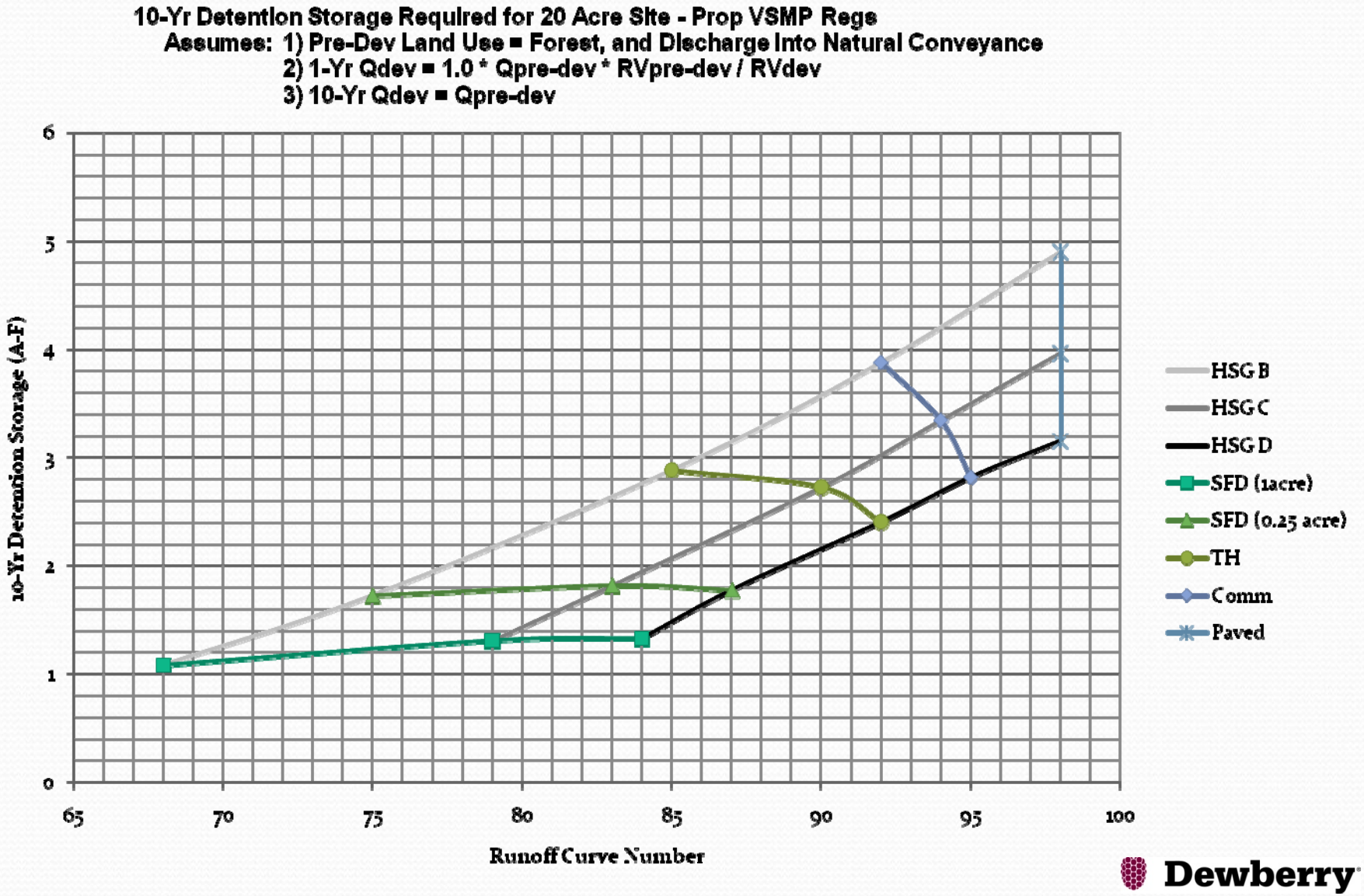

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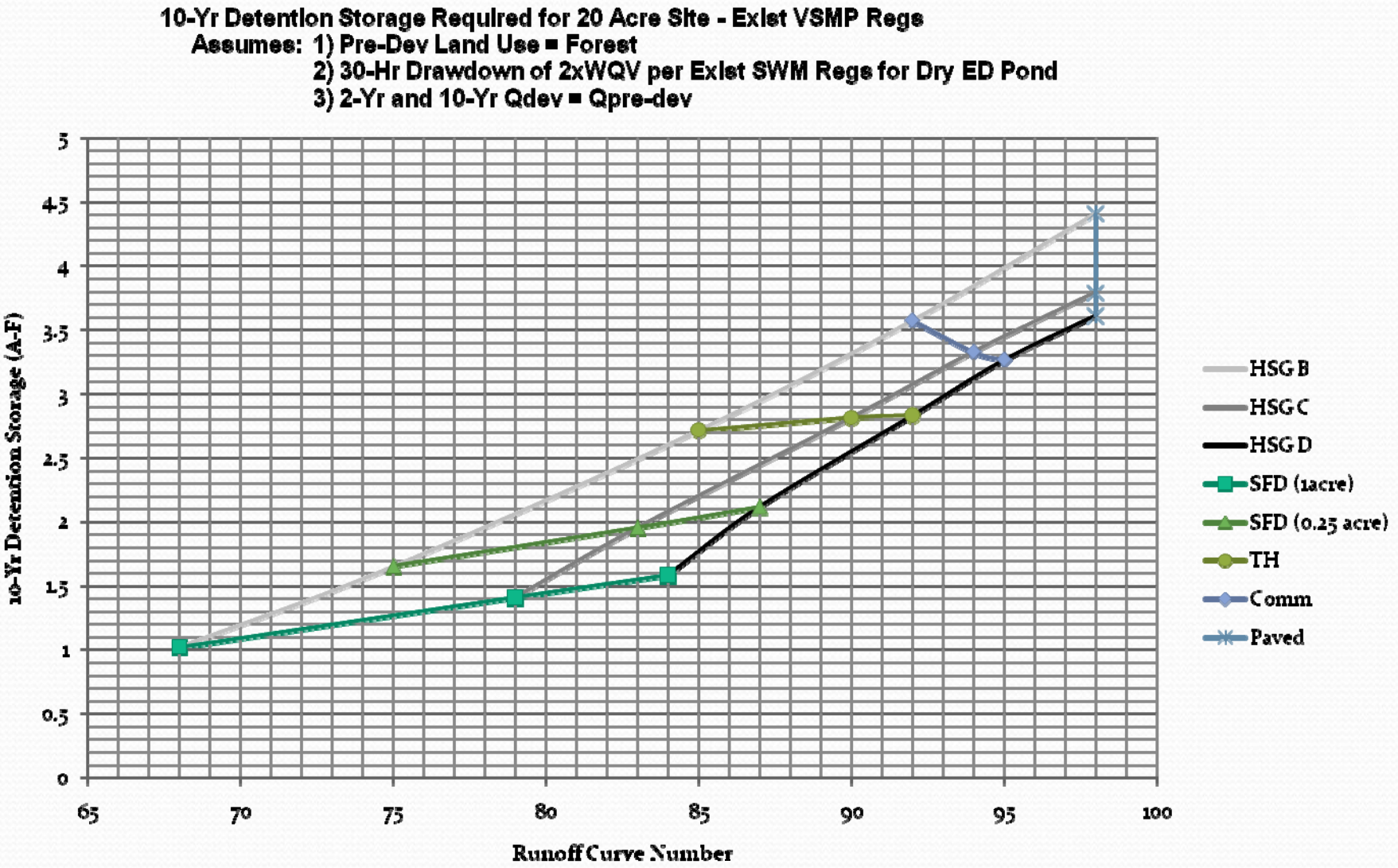

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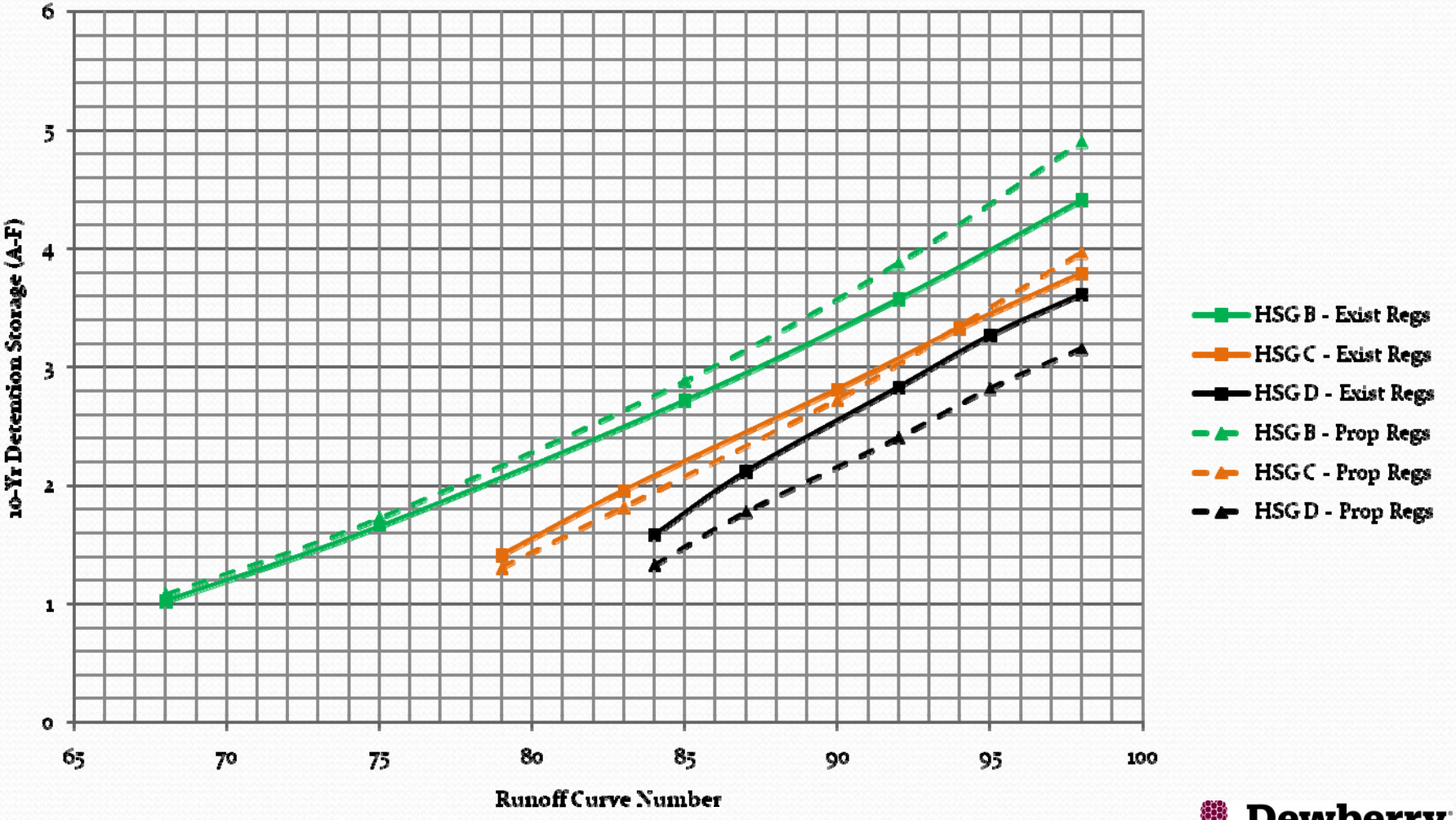
Results for Pre-Dev = Forest

Compare 10-Yr Storage Required for 20 Acre Site (Pre-Dev = Forest)
1) Prop VSMP Design of Dry Pond: 1-Yr Energy Balance (IF = 1.0) and Std. 10-Yr Detention
2) Exist VSMP Design of Dry ED Pond: 30-Hr Drawdown of 2 x WQV and Std. 2- and 10-Yr Detention



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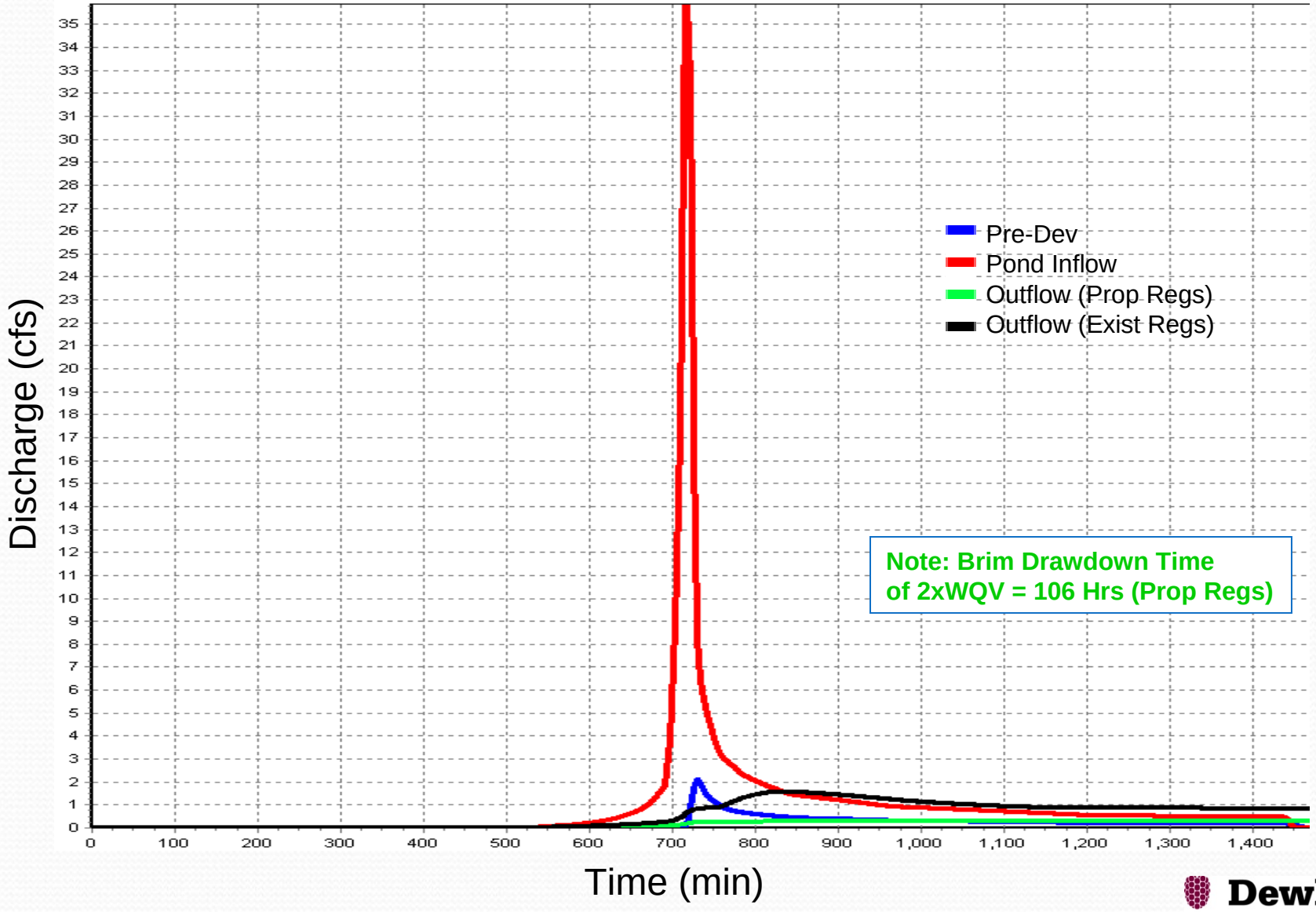
1-Yr Hydrographs for TH (Pre-Dev = Pasture, HSG B)



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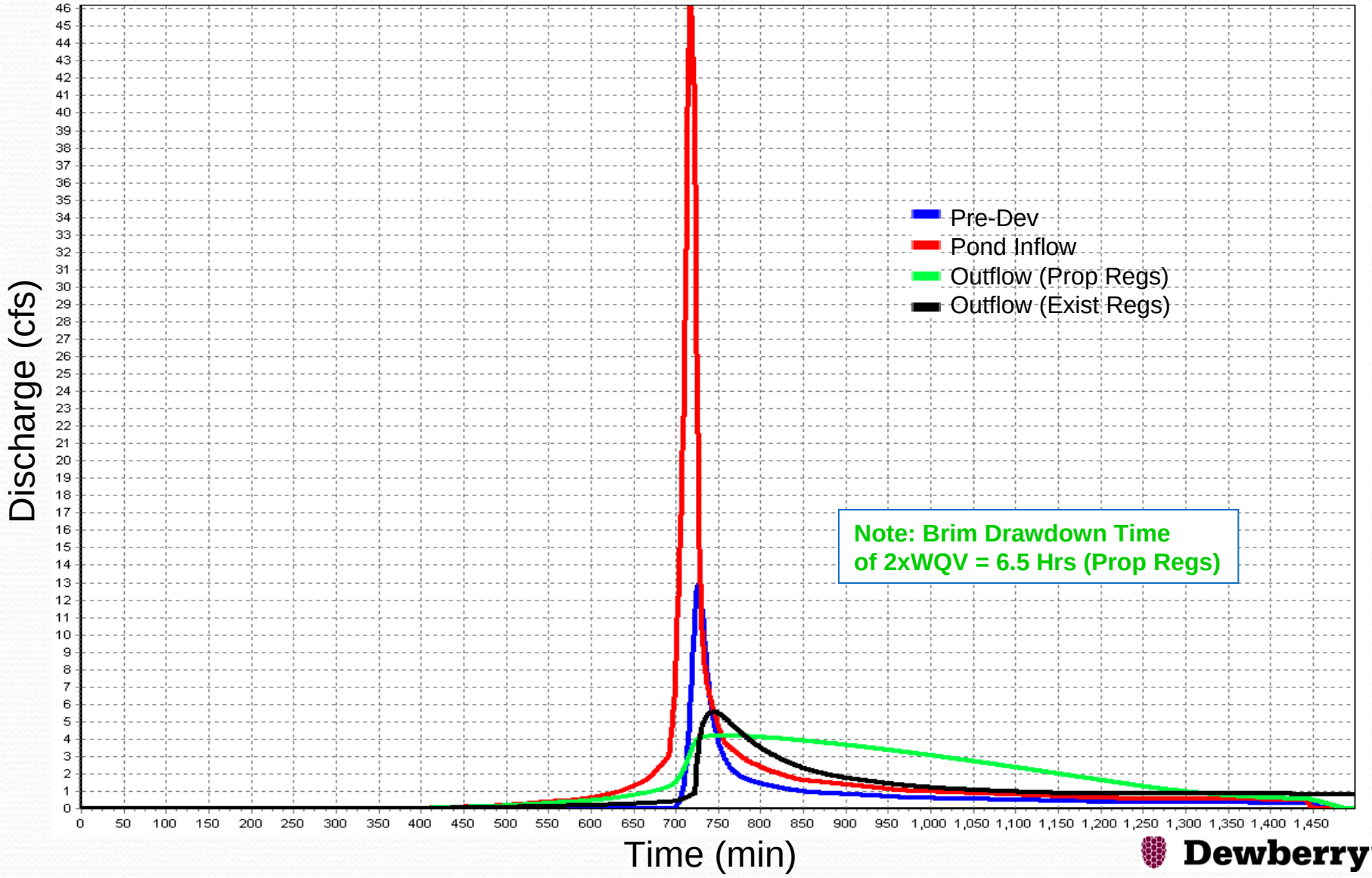
1-Yr Hydrographs for TH (Pre-Dev = Pasture, HSG C)



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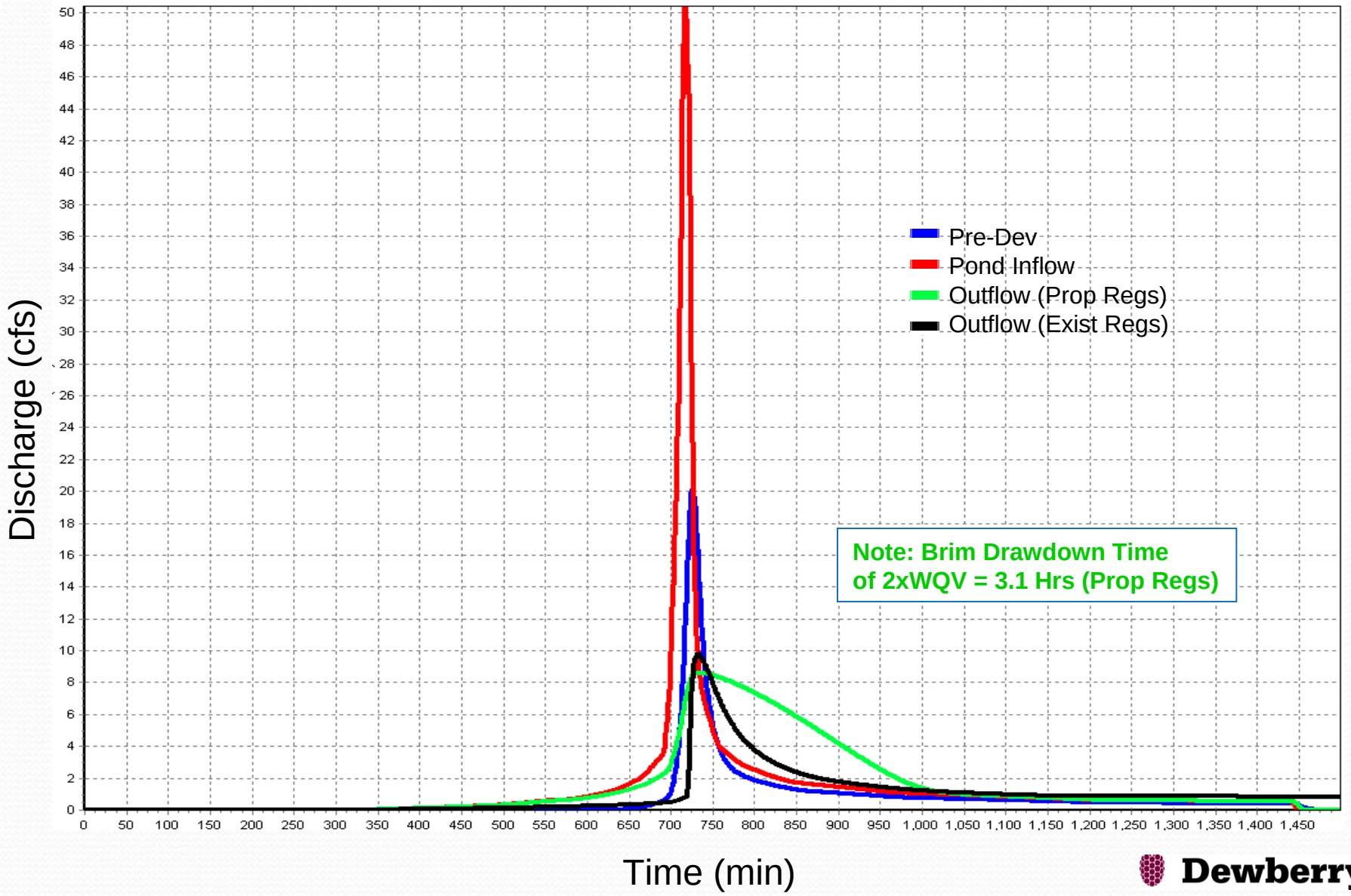
1-Yr Hydrographs for TH (Pre-Dev = Pasture, HSG D)



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Prop Regs: 1-Yr Energy Balance Brim Drawdown Times

	(Pre-Dev = Pasture)			(Pre-Dev = Forest)		
Land Use / HSG	1-Yr Orifice Area (SF)	2 x WQV Drawdown (Hrs)	1-Yr Vol Drawdown (Hrs)	1-Yr Orifice Area (SF)	2 x WQV Drawdown (Hrs)	1-Yr Vol Drawdown (Hrs)
SFD 1 ac / B	0.188	*	6.4	0.0087	168.2	237.6
SFD 0.25 ac / B	0.0704	29.7	30.9	0.0042	498.7	684.4
TH / B	0.0272	105.6	140.7	0.0018	1596.5	2330.9
Comm / B	0.0164	206.5	308.6	0.00112	3023.8	4738.4
Paved / B	0.01105	339.0	565.2	0.00074	5062.4	8708.6
SFD 1 ac / C	1.338	1.1	1.1	0.567	2.6	3.3
SFD 0.25 ac / C	0.828	*	2.5	0.374	6.0	6.4
TH / C	0.441	6.5	7.0	0.2041	14.1	16.9
Comm / C	0.323	10.5	11.5	0.1505	22.5	27.7
Paved / C	0.243	15.4	18.0	0.1133	33.1	43.7
SFD 1 ac / D	2.116	0.7	0.8	1.255	1.2	1.9
SFD 0.25 ac / D	1.4706	1.4	1.5	0.918	2.3	2.6
TH / D	0.939	3.1	3.1	0.5997	4.8	5.2
Comm / D	0.743	*	4.5	0.4769	7.1	7.5
Paved / D	0.6014	*	6.2	0.3865	9.7	10.5

* 1-Yr detention volume < 2 x WQV

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Observations

- In general, Dry Pond under Prop Regs will be smaller than ED Pond under Exist Regs and drawdown times will be shorter (< 30 hours) if soils are HSG C or D.
- In general, Dry Pond under Prop Regs will be larger than ED Pond under Exist Regs and drawdown times will be longer (> 30 hours) if soils are HSG A or B and much longer (>> 30 hours) if Pre-Dev land use is also forested.
- Dry Pond under Prop Regs designed for 1-Yr Energy Balance and Std. 10-Yr detention will also provide Std. 2-Yr detention.
- Dry Pond under Prop Regs may be smaller if runoff reduction measures are implemented upstream.

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