Calculation No: CDQ000020080014

Attachment A18-1

Source: Reference A3

Computation of Area, Velocity, Velocity head, and Discharge for One bay. Gate Opening Proto = [illegible]

COMPUTED [illegible] DATE 10-

CHECKED WLA DATE 10-16-67

Test No.	H. Proto ft.	H. Model ft.	H. + .580 ft.	Width Model ft.	A model ft.²	Qm 3 bays cfs	V model ft/sec	$\frac{V^2}{2g}$ ft.	$H.+\frac{V^2}{2g}$ Model ft.	$H.+\frac{V^2}{2g}$ Proto ft.	Q 1 bay Model	corr. fact	Q_c 1 bay Model	Q Proto 1 bay
														7247
428	3399	.971	1.551	4.082	6.331	7.411	1.171	.021	.992	34.72	2.470	1.0010	2.472	17915
429	33.99	.971	1.551	"	6.331	7.411	1.171	.021	.992	34.72	2.470	"	"	"
430	34.02	.972	1.552	"	6.335	7.411	1.170	.021	.993	34.76	"	"	"	"
431	34.16	.976	1.556	"	6.352	7.411	1.167	.021	.997	34.90	"	"	"	"
432	34.55	.987	1.567	"	6.396	7.411	1.159	.021	1.008	35.28	"	"	"	"
433	35.88	1.025	1.605	"	6.552	7.411	1.131	.020	1.045	36.58	"	"	"	"
434	39.41	1.126	1.706	"	6.964	7.411	1.064	.018	1.144	40.04	"	"	"	"
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
436	48.72	1.392	1.972	"	8.050	7.411	.921	.013	1.405	49.18	"	"	"	"
437	50.54	1.444	2.024	"	8.262	7.411	.897	.013	1.457	51.00	"	"	"	"
438	41.79	1.194	1.774	"	7.241	7.411	1.023	.016	1.210	42.35	"	"	"	"
439	38.01	1.086	1.666	"	6.801	7.960	1.170	.021	1.107	38.75	2.653	"	2.656	19,248
440	38.08	1.088	1.668	"	6.809	7.933	1.165	.021	1.109	38.82	2.644	"	2.647	19,183
441	38.15	1.090	1.670	"	6.817	7.933	1.164	.021	1.111	38.89	2.644	"	"	"
442	38.40	1.097	1.677	"	6.846	7.960	1.163	.021	1.118	39.13	2.653	"	2.656	19,248
443	39.17	1.119	1.699	"	6.935	7.960	1.148	.021	1.140	39.90	2.653	"	"	"
444	41.16	1.176	1.756	"	7.168	7.960	1.110	.019	1.195	41.83	"	"	"	"
445	45.85	1.310	1.890	"	7.716	7.960	1.032	.016	1.326	46.41	"	"	"	"
446	43.85	1.253	1.833	"	7.482	7.960	1.064	.018	1.271	44.48	"	"	"	"
447	49.60	1.417	1.997	"	8.152	7.986	.980	.015	1.432	50.12	2.662	"	2.665	19,313
448	41.90	1.197	1.777	"	7.254	8.494	1.171	.021	1.218	42.63	2.831	"	2.834	20,538
449	42.14	1.204	1.784	"	7.282	8.524	1.170	.021	1.225	42.88	2.841	"	2.844	20,610
450	41.90	1.197	1.777	"	7.254	8.494	1.171	.021	1.218	42.63	2.831	"	2.834	20,538
451	43.89	1.254	1.834	"	7.486	8.494	1.135	.020	1.274	44.59	2.831	"	2.834	20,538
452	46.38	1.325	1.905	"	7.776	8.494	1.092	.019	1.344	47.04	2.831	"	2.834	20,538
453	48.90	1.397	1.977	"	8.070	8.494	1.052	.017	1.414	49.49	2.831	"	2.834	20,538
454	49.60	1.417	1.997	"	8.152	8.494	1.042	.017	1.434	50.19	2.831	"	2.834	20,538
455	46.02	1.315	1.895	"	7.735	9.015	1.165	.021	1.336	46.76	3.005	"	3.008	21,799
456	46.02	1.315	1.895	"	7.735	9.015	1.165	.021	1.336	46.76	3.005	"	3.008	21,799
457	46.10	1.317	1.897	"	7.744	9.019	1.165	.021	1.338	46.83	3.006	"	3.009	21,806
458	48.16	1.376	1.956	"	7.984	8.992	1.126	.020	1.396	48.86	2.997	"	3.000	21,741
459	50.58	1.445	2.025	"	8.266	9.019	1.091	.019	1.464	51.24	3.006	"	3.009	21,806
460	47.08	1.345	1.925	"	7.858	9.019	1.148	.020	1.365	47.78	3.006	"	3.009	21,806

Q = 17,915'

VOID

Q = 19,241

Q = 20,548

Q = 21,795

To 461

Calculation No: CDQ000020080014

Attachment A18-2

Source: Reference A3

Computation of Area, Velocity, Velocity head, and Discharge for One bay. Gate Opening Proto = 16.4338

COMPUTED HMG DATE 10-17-67
CHECKED WLA DATE 10-17-67

Test No.	H. Proto ft.	H. Model ft.	H. + .580 ft.	Width Model ft.	A model ft.²	Qm 3 bays cfs	V model ft/sec	$\frac{V^2}{2g}$ ft.	H. + $\frac{V^2}{2g}$ Model ft.	H. + $\frac{V^2}{2g}$ Proto ft.	Q 1 bay Model	Corr. fact	Q_c 1 bay Model	Q Proto 1 bay
461	46.27	1.322	1.902	4.082	7.764	9.019	1.162	.021	1.343	47.00	3.006	1.0010	3.009	21,806
462	50.05	1.430	2.010	"	8.205	9.492	1.157	.021	1.451	50.79	3.164	"	3.167	22,951
463	50.09	1.431	2.011	"	8.209	9.492	1.156	.021	1.452	50.82	"	"	"	"
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
465	50.51	1.443	2.023	"	8.258	9.484	1.148	.021	1.464	51.24	3.161	"	3.164	20,930
466	50.79	1.451	2.031	"	8.291	9.484	1.144	.020	1.471	51.49	"	"	"	"
467	34.13	.975	1.555	"	6.348	7.126	1.123	.020	.995	34.83	2.375	"	2.377	17,226
468	32.52	.929	1.509	"	6.160	7.126	1.157	.021	.950	33.25	"	"	"	"
469	39.76	1.136	1.716	"	7.005	7.126	1.017	.016	1.152	40.32	"	"	"	"
470	37.38	1.068	1.648	"	6.727	7.126	1.059	.017	1.085	37.98	"	"	"	"
471	42.46	1.213	1.793	"	7.319	7.126	.974	.015	1.228	42.98	"	"	"	"
472	49.39	1.411	1.991	"	8.127	7.105	.874	.012	1.423	49.81	2.368	"	2.370	17,175
473	45.29	1.294	1.874	"	7.650	7.126	.932	.013	1.307	45.75	2.375	"	2.377	17,226
474	36.47	1.042	1.622	"	6.627	7.105	1.073	.018	1.060	37.10	2.368		2.370	17,175
475	33.85	.967	1.547	"	6.315	6.014	.952	.014	.981	34.34	2.005	"	2.007	14,545
476	36.30	1.037	1.617	"	6.601	6.014	.911	.013	1.050	36.75	"	"	"	"
477	38.75	1.107	1.687	"	6.886	6.014	.873	.012	1.119	39.17	"	"	"	"
478	41.02	1.172	1.752	"	7.152	6.022	.842	.011	1.183	41.41	2.007	"	2.009	14,559
479	45.08	1.288	1.868	"	7.626	6.039	.792	.010	1.298	45.43	2.013	"	2.015	14,603
480	31.08	.888	1.468	"	5.992	6.039	1.008	.016	.904	31.64	2.013	"	2.015	14,603
481	33.95	.970	1.550	"	6.327	3.899	.616	.006	.976	34.16	1.300	"	1.301	9,428
482	31.04	.887	1.467	"	5.988	3.899	.651	.007	.894	31.29	1.300	"	1.301	"
483	28.42	.812	1.392	"	5.682	3.899	.686	.007	.819	28.66	1.300	"	1.301	"

455

Q = 22,940

Q = 17,213

Q = 14,567

Q = 9428

TAILWATER HEADS
PROTO G.O. 16.4338'

COMPUTED WLA DATE 10-16-67
CHECKED GAS DATE 8-11-2008

Test No.	Model ×35	Proto
428	.215	7.53
429	.391	13.69
430	.453	15.86
431	.509	17.82
432	.566	19.81
433	.631	22.09
434	.703	24.61
435	VOID	VOID
436	.900	31.50
437	.948	33.18
438	.747	26.15
439	.326	11.41
440	.476	16.66
441	.519	18.17
442	.580	20.30
443	.639	22.37
444	.700	24.50
445	.782	27.37
446	.746	26.11
447	.859	30.07
448	.466	16.31
449	.593	20.76
450	.419	14.66
451	.700	24.50
452	.752	26.32
453	.795	27.82
454	.807	28.24
455	.516	18.06
456	.400	14.00
457	.587	20.54
458	.739	25.86
459	.787	27.54
460	.700	24.50
461	.646	22.61

Test No.	Model ×35	Proto
462	.404	14.14
463	.575	20.13
464	VOID	VOID
465	.678	23.73
466	.709	24.82
467	.621	21.74
468	.536	18.76
469	.729	25.52
470	.688	24.08
471	.789	27.62
472	.952	33.32
473	.854	29.89
474	.673	23.55
475	.690	24.15
476	.744	26.04
477	.804	28.14
478	.861	30.14
479	.961	33.64
480	.632	22.12
481	.846	29.61
482	.771	26.98
483	.705	24.68

Computation of Area, Velocity, Velocity head, and Discharge for One bay. Gate Opening Proto = 22.1753'

COMPUTED HMG PJC DATE

CHECKED DATE

Test No.	H. Proto ft.	H. Model ft.	H. + .580 ft.	Width Model ft.	A model ft.²	Qm 3 bays cfs	V model ft/sec	$\frac{V^2}{2g}$ ft.	$H.+\frac{V^2}{2g}$ Model ft.	$H.+\frac{V^2}{2g}$ Proto ft.	Q 1 bay Model	Corr. fact	Q_c 1 bay Model	Q Proto 1 bay
484	33.88	.968	1.548	4.082	6.319	9.554	1.512	.036	$1.00\overset{4}{3}$	$35.1\overset{4}{3}$	3.185	1.001	3.188	23,103
485	34.20	.977	1.557	4.082	6.356	9.554	1.503	.035	1.012	35.42	3.185	1.001	3.188	23,103
486	33.92	.969	1.549	4.082	6.323	9.554	1.511	.035	1.004	35.14	3.185	1.001	3.188	23,103
487	34.93	.998	1.578	4.082	6.441	9.554	1.483	.034	1.032	36.12	3.185	1.001	3.188	23,103
488	37.14	1.061	1.641	4.082	6.699	9.554	1.426	.032	1.093	38.26	3.185	1.001	3.188	23,103
489	42.28	1.208	1.788	4.082	7.299	9.554	1.309	.027	$1.23\overset{5}{X}$	$43.\overset{22}{50}$	3.185	1.001	3.188	23,103
490	46.76	1.336	1.916	4.082	7.821	9.554	1.222	.023	1.359	47.56	3.185	1.001	3.188	23,103
491	49.84	1.424	2.004	4.082	8.180	9.554	1.168	.021	$1.4\overset{4}{8}5$	$\overset{50.57}{\cancel{49.88}}$	3.185	1.001	3.188	23,103
492	38.04	1.087	1.667	4.082	6.805	10.358	1.522	.036	1.123	39.31	3.453	1.001	3.456	25,044
493	38.05	1.087	1.667	4.082	6.805	10.358	1.522	.036	1.123	39.31	3.453	1.001	3.456	25,044
494	38.15	1.090	1.670	4.082	6.817	10.358	1.519	.036	1.126	39.41	3.453	1.001	3.456	25,044
495	38.64	1.104	1.684	4.082	6.874	10.387	1.511	.035	1.139	39.87	3.462	1.001	3.465	25,111
496	40.67	1.162	1.742	4.082	7.111	10.358	1.457	.033	1.195	41.83	3.453	1.001	3.456	25,044
497	44.52	1.272	1.852	4.082	7.560	10.358	1.370	.029	1.301	45.54	3.453	1.001	3.456	25,044
498	48.26	1.379	1.959	4.082	7.997	10.358	1.295	.026	1405	49.18	3.453	1.001	3.456	25,044
499	50.33	1.438	2.018	4.082	8.237	10.358	1.257	.025	1.463	51.21	3.453	1.001	3.456	25,044
500	41.93	1.198	1.778	4.082	7.258	11.036	1.521	.036	1.234	43.19	3.679	1.001	3.683	26,691
501	41.93	1.198	1.778	4.082	7.258	11.041	1.521	.036	1.234	43.19	3.680	1.001	3.684	26,698
502	42.10	1.203	1.783	4.082	7.278	11.067	1.521	.036	1.239	43.37	3.689	1.001	3.693	26,763
503	42.35	1.210	1.790	4.082	7.307	11.081	1.516	.036	1.246	43.61	3.694	1.001	3.698	26,799
504	43.19	1.234	1.814	4.082	7.405	11.078	1.496	.035	1.269	44.42	3.693	1.001	3.697	26,792
505	44.87	1.282	1.862	4.082	7.601	11.051	1.454	.033	1.315	46.03	3.684	1.001	3.688	26,727
506	47.84	1.367	1.947	4.082	7.948	11.062	1.392	.030	1.397	48.90	3.687	1.001	3.691	26,749
507	51.80	1.480	2.060	4.082	8.409	11.070	1.316	.027	1.507	52.75	3.690	1.001	3.694	26,770
508	45.78	1.308	1.888	4.082	7.707	11.715	1.520	.036	1.344	47.04	3.905	1.001	3.909	28,329
509	45.75	1.307	1.887	4.082	7.703	11.742	1.524	.036	1.343	47.01	3.914	1.001	3.918	28,394
510	45.78	1.308	1.888	4.082	7.707	11.694	1.517	.036	1.344	47.04	3.898	1.001	3.902	28,278
511	45.99	1.314	1.894	4.082	7.731	11.729	1.517	.036	1.350	47.25	3.910	1.001	3.914	28,365
512	46.55	1.330	1.910	4.082	7.797	11.694	1.500	.035	1.365	47.78	3.898	1.001	3.902	28,278
513	47.56	1.359	1.939	4.082	7.915	11.707	1.479	.034	1.393	48.76	3.902	1.001	3.906	28,307
514	50.02	1.429	2.009	4.082	8.201	11.710	1.428	.032	1.461	51.14	3.903	1.001	3.907	28,314
515	50.19	1.434	2.014	4.082	8.221	12.412	1.510	.035	1.469	51.42	4.137	1.001	4.141	30,010
516	50.30	1.437	2.017	4.082	8.233	12.452	1.512	$.03\overset{5}{6}$	[illegible]	[illegible]	4.151	1.001	4.155	30,111

Q = 23,103

Q = 25,054

Q = 26,749

Q = 28,324

Calculation No: CDQ000020080014

Attachment A18-5

Source: Reference A3

Computation of Area, Velocity, Velocity head, and Discharge for One bay. Gate Opening Proto = 22.1753

COMPUTED WLA DATE 10-21-67

CHECKED Umc DATE 10-21-67

WLA 10-24-67

Test No.	H. Proto ft	H. Model ft.	H. + .580 ft.	Width Model ft.	A model ft^2	Qm 3 bays cfs	V model ft/sec.	$\frac{V^2}{2g}$ ft.	$H + \frac{V^2}{2g}$ Model ft.	$H + \frac{V^2}{2g}$ Proto ft.	Q 1 bay Model	Corr. fact.	Q_c 1 bay Model	Q Proto 1 bay
517	50.26	1.436	2.016	4.082	8.229	12.428	1.510	.0354	1.471	51.48	4.143	1.0010	4.147	30,05
518	51.14	1.461	2.041	"	8.331	12.420	1.491	.0345	1.495	52.32	4.140	"	4.144	30,03
519	50.58	1.445	2.025	"	8.266	12.468	1.508	.0354	1.480	51.80	4.156	"	4.160	30,14
520	34.44	.984	1.564	"	6.384	8.824	1.382	.0300 ~~.0290~~	1.014	35.49	2.941	"	2.944	21,33
521	36.40	1.040	1.620	"	6.613	8.827	1.335	.0279	1.068	37.38	2.942	"	2.945	21,34
522	38.40	1.097	1.677	"	6.846	8.821	1.288	.0259	1.123	39.30	2.940	"	2.943	21,32
523	40.95	1.170	1.750	"	7.144	8.821	1.235	.0239	1.194	41.79	2.940	"	2.943	21,32
524	4~~2~~3.30	1.237	1.817	"	7.417	8.821	1.189	.0220	1.259	44.06	2.940	"	2.943	21,32
525	45.32	1.295	1.875	"	7.654	8.821	1.152	.0206	1.316	46.06	2.940	"	2.943	21,32
526	48.23	1.378	1.958	"	7.993	8.811	1.102	.0196	1.397	48.90	2.937	"	2.940	21,30
527	34.65	.990	1.570	"	6.409	7.994	1.247	.0243	1.014	35.49	2.665	"	2.668	19,33
528	31.43	.898	1.478	"	6.033	7.986	1.324	.0271	.925	32.37	2.662	"	2.665	19,31
529	36.61	1.046	1.626	"	6.637	7.992	1.204	.022	1.061	[illegible]	2.664	"	2.667	19,32
530	39.52	1.129	1.709	"	6.976	7.986	1.145	.0208	1.149	40.22 ~~39.47~~	2.662	"	2.665	19,31
531	41.79	1.194	1.774	"	7.241	7.994	1.104	.0188	1.213	42.46 ~~36.39~~	2.665	"	2.668	19,33
532	43.75	1.250	1.830	"	7.470	7.986	1.069	.0178	1.268	44.38 ~~39.04~~	2.662	"	2.665	19,313
533	34.72	.992	1.572	"	6.417	4.592	.716	.008	1.000	35.00	1.531	"	1.533	11,110
534	32.02	.915	1.495	"	6.103	4.542	.744	.009	.924	32.34	1.514	"	1.516	10,986
535	29.92	.855	1.435	"	5.858	4.542	.775	.009	.864	30.24	1.514	"	1.516	10,986
536	37.10	1.060	1.640	"	6.694	4.542	.678	.007	1.067	37.35	1.514	"	1.516	10986
542	34.48	.985	1.565	"	6.388	6.502	1.018	.016	1.001	35.04	2.167	"	2.169	15,719
543	32.03	.915	1.495	"	6.103	"	1.065	.018	.933	32.66	2.167	"	"	"
544	36.94	1.041	1.621	"	6.617	6.475	.979	.015	1.056	36.96	2.158	"	2.160	15,65
545	38.43	1.098	1.678	"	6.850	6.502	.949	.014	1.112	38.92	2.167	"	2.169	15,719
546	40.57	1.159	1.739	"	7.099	"	.916	.013	1.172	41.02	2.167	"	"	"
547	37.21	1.063	1.643	"	6.707	8.798	1.312	.027	1.090	38.15	2.933	"	2.936	21,277
548	30.56	.873	1.453	"	5.931	"	1.483	.034	.907	31.75	"	"	"	"
549	31.05	.887	1.467	"	5.988	"	1.469	.034	.921	32.24	"	"	"	"
550	32.73	.935	1.515	"	6.184	"	1.423	.031	.966	33.81	"	"	"	"

30,071

;4

Q=21,328

Q=19,323

Q=11,017

Q=15,108

Q=21,277

19 Q

'0-526

'47-550

21300

Calculation No: CDQ000020080014

Attachment A18-6

Source: Reference A3

Tailwater Heads

G.O. PROTO = 22.1753'

COMPUTED WLA DATE 10-20-67

CHECKED WMG DATE 10-20-67

WLA 10-23-67

test No.	H_T Model	Model Scale	H_T Proto	test No.	H_T Model	Model Scale	H_T Proto
484	.3861	35'	13.51'	516	.6039	35	21.14
485	.5996	"	21.00	517	.7052	"	24.68
486	.5387	"	18.86	518	.8565	"	29.96
487	.6833	"	23.90	519	.7982	"	27.93
488	.7772	"	27.20	520	.758	"	26.53
489	.8836	"	30.94	521	.803	"	28.10
490	.9775	"	34.23	522	.840	"	29.~~57~~40
491	1.0477	"	36.68	523	.890	"	31.15
492	.3490	"	12.22	524	.943	"	33.00
493	.5321	"	18.62	525	.990	"	34.65
494	.6028	"	21.10	526	1.058	"	37.03
495	.6956	"	24.36	527	.797	"	27.90
496	.8039	"	28.14	528	.733	"	25.66
497	.8919	"	31.22	529	.837	"	29.30
498	.9608	"	33.64	530	.901	"	31.54
499	1.0030	"	35.10	531	.954	"	33.39
500	.4720	"	16.52	532	.999	"	34.96
501	.5703	"	19.95	533	.924	"	32.34
502	.6490	"	22.72	534	.856	"	29.96
503	.7086	"	24.82	535	.801	"	28.04
504	.7825	"	27.37	536	.987	"	34.54
505	.8543	"	29.89	542	.856	"	29.96
506	.9183	"	32.13	543	.801	"	28.04
507	.9927	"	34.76	544	.897	"	31.40
508	.3843	"	13.44	545	.946	"	33.11
509	.5707	"	19.98	546	1.000	"	35.00
510	.6404	"	22.40	547	.821	"	28.74
511	.7346	"	25.72	548	.576	"	20.16
512	.7946	"	27.82	549	.626	"	21.91
513	.8594	"	30.06	550	.714	"	24.99
514	.9260	"	32.41				
515	.4792	"	16.76				

Calculation No: CDQ000020080014

Attachment A18-7

Source: Reference A3

Computation of Area, Velocity, Velocity head, and Discharge for One bay. Gate Opening Proto = 29.0486'

COMPUTED WLA DATE 10-31-67

CHECKED BJC DATE 10-3

PJJ 11-1-67

Test No.	H. Proto ft.	H. Model ft.	H. + .580 ft.	Width Model ft.	A model ft.²	Qm 3 bays cfs	V model ft/sec	$\frac{V^2}{2g}$ ft.	$H. + \frac{V^2}{2g}$ Model ft.	$H + \frac{V^2}{2g}$ Proto ft.	Q 1 bay Model	Corr. fact	Q_c 1 bay Model	Q Proto 1 bay
537	48.72	1.392	1.972	4.082	8.050	15.575	1.935	.058	1.450	50.75	5.192	1.001	5.197	37,663
538	48.79	1.394	1.974	"	8.058	15.580	1.933	.058	1.452	50.82	5.193	"	5.198	37,670
539	48.72	1.392	1.972	"	8.050	15.553	1.932	.058	1.450	50.75	5.184	"	5.189	37,605
540	49.07	1.402	1.982	"	8.091	15.564	1.924	.057	1.459	51.06	5.188	"	5.193	37,63
541	49.70	1.420	2.000	"	8.164	15.567	1.907	.057	1.477	51.70	5.189	"	5.194	37,641
551	35.04	1.001	1.581	"	6.454	12.498	1.936	.058	1.059	37.06	4.166	"	4.170	30,220
552	35.07	1.002	1.582	"	6.458	12.574	1.947	.059	1.061	37.14	4.191	"	4.195	30,401
553	35.98	1.028	1.608	"	6.564	12.598	1.919	.057	1.085	37.98	4.199	"	4.203	30,45
554	37.17	1.062	1.642	"	6.703	12.495	1.864	.054	1.116	39.06	4.165	"	4.169	30,213
555	39.20	1.120	1.700	"	6.939	12.561	1.810	.051	1.171	40.98	4.187	"	4.191	30,37
556	41.09	1.174	1.754	"	7.160	12.590	1.758	.048	1.222	42.77	4.197	"	4.201	30,445
557	43.23	1.235	1.815	"	7.409	12.564	1.696	.045	1.280	44.80	4.188	"	4.292	31,104
558	45.29	1.294	1.874	"	7.650	12.540	1.639	.042	1.336	46.76	4.180	"	4.184	30,321
559	35.56	1.016	1.596	"	6.515	12.570	1.929	.058	1.074	37.59	4.190	"	4.194	30,39

Q = 37,643

Q = 30,378

To 603

Computation of Area, Velocity, Velocity head, and Discharge for One bay. Gate Opening Proto = 29.0486'

COMPUTED WLA DATE 10-30-67
CHECKED BJC DATE 10-31-67

Test No.	H. Proto ft.	H. Model ft.	H. + .580 ft.	Width Model ft.	A model ft.²	Qm 3 bays cfs	V model ft/sec	$\frac{V^2}{2g}$ ft.	$H.+\frac{V^2}{2g}$ Model ft.	$H.+\frac{V^2}{2g}$ Proto ft.	Q 1 bay Model	Corr. fact	Q_c 1 bay Model	Q Proto 1 bay
560	35.21	1.006	1.586	4.082	6.474	12.474	1.927	.058	1.064	37.24	4.158	1.001	4.162	30.162
561	48.20	1.377	1.957	"	7.988	12.524	1.568	.038	1.415	49.52	4.175	"	4.179	30.28
562	35.42	1.012	1.592	"	6.499	12.492	1.922	.057	1.069	37.42	4.164	"	4.168	30.20
563	49.60	1.417	1.997	"	8.152	12.543	1.539	.037	1.454	50.89	4.181	"	4.185	30.32
564	38.40	1.097	1.677	"	6.846	13.228	1.932	.058	1.155	40.42	4.409	"	4.413	31,981
565	38.57	1.102	1.682	"	6.866	13.208	1.924	.057	1.159	40.56	4.403	"	4.407	31,93
566	38.71	1.106	1.686	"	6.882	13.211	1.920	.057	1.163	40.70	4.404	"	4.408	31,94
567	38.92	1.112	1.692	"	6.907	13.238	1.917	.057	1.169	40.92	4.413	"	4.417	32,010
568	39.52	1.129	1.709	"	6.976	13.211	1.894	.056	1.185	41.48	4.404	"	4.408	31,94
569	40.11	1.146	1.726	"	7.046	13.225	1.877	.055	1.201	42.04	4.408	"	4.412	31,974
570	41.16	1.176	1.756	"	7.168	13.206	1.842	.053	1.229	43.02	4.402	"	4.406	31,93
571	42.42	1.212	1.792	"	7.315	13.241	1.810	.051	1.263	44.20	4.414	"	4.418	32,01
572	45.04	1.287	1.867	"	7.621	13.257	1.740	.047	1.334	46.69	4.419	"	4.423	32,05
573	48.20	1.377	1.957	"	7.988	13.206	1.652	.042	1.419	49.66	4.402	"	4.406	31,93
574	50.05	1.430	2.010	"	8.205	13.222	1.612	.040	1.470	51.45	4.407	"	4.411	31,96
~~575~~	~~41.86~~	~~1.196~~	~~1.776~~	~~"~~	~~7.250~~	~~13.996~~	~~1.930~~	~~.058~~	~~1.254~~	~~43.87~~	~~4.665~~	~~"~~	~~4.669~~	~~33,83~~
576	42.00	1.200	1.780	"	7.266	13.974	1.923	.057	1.257	44.00	4.658	"	4.663	33,79
577	42.00	1.200	1.780	"	7.266	13.966	1.922	.057	1.257	44.00	4.655	"	4.660	33,77
578	42.00	1.200	1.780	"	7.266	13.999	1.927	.058	1.258	44.03	4.666	"	4.671	33,85
~~579~~	~~42.18~~	~~1.205~~	~~1.785~~	~~"~~	~~7.286~~	~~13.993~~	~~1.920~~	~~.057~~	~~1.262~~	~~44.17~~	~~4.664~~	~~"~~	~~4.668~~	~~33,82~~
580	42.21	1.206	1.786	"	7.290	13.966	1.916	.057	1.263	44.20	4.655	"	4.660	33,77
581	42.56	1.216	1.796	"	7.331	13.966	1.905	.056	1.272	44.52	4.655	"	4.660	33,77
582	43.05	1.230	1.810	"	7.388	13.982	1.892	.056	1.286	45.01	4.661	"	4.666	33,815
583	45.01	1.286	1.866	"	7.617	14.223	1.867	.054	1.340	46.90	4.741	"	4.746	34,39
584	46.27	1.322	1.902	"	7.764	14.349	1.848	.053	1.375	48.12	4.783	"	4.788	34,69
585	47.46	1.356	1.936	"	7.903	14.391	1.821	.052	1.408	49.28	4.797	"	4.802	34,80
586	49.42	1.412	1.992	"	8.131	14.327	1.762	.048	1.460	51.10	4.776	"	4.781	34,64
587	45.40	1.297	1.877	"	7.662	14.798	1.931	.058	1.355	47.42	4.933	"	4.938	35,7
588	45.36	1.296	1.876	"	7.658	14.806	1.933	.058	1.354	47.39	4.935	"	4.940	35,80
589	45.50	1.300	1.880	"	7.674	14.828	1.932	.058	1.358	47.53	4.943	"	4.948	35,85
590	45.88	1.311	1.891	"	7.719	14.811	1.919	.057	1.368	47.88	4.937	"	4.942	35,815

To 551 ↑

Q = 31,972

VOID

Q = 33,795

VOID

Q = 34,635

Q = 35,798

To 595 ↓

Calculation No: CDQ000020080014

Attachment A18-9

Source: Reference A3

Computation of Area, Velocity, Velocity head, and Discharge for One bay. Gate Opening Proto = 29.0486'

COMPUTED WLA DATE 10-31-67

CHECKED BUC DATE 10-31-67

To 587 ↑

Test No.	H. Proto ft.	H. Model ft.	H. + .580 ft.	Width Model ft.	A model ft.²	Qm 3 bays cfs	V model ft/sec	$\frac{V^2}{2g}$ ft.	H. + $\frac{V^2}{2g}$ Model ft.	H. + $\frac{V^2}{2g}$ Proto ft.	Q 1 bay Model	Corr. fact.	Q_c 1 bay Model	Q Proto 1 bay
591	46.24	1.321	1.901	4.082	7.760	14.782	1.905	.056	1.377	48.20	4.927	1.001	4.932	35,742
592	47.28	1.351	1.931	"	7.882	14.803	1.878	.055	1.406	49.21	4.934	"	4.939	35,793
593	49.74	1.421	2.001	"	8.168	14.801	1.812	.051	1.472	51.52	4.934	"	4.939	35,793
594	48.30	1.380	1.960	"	8.001	14.809	1.851	.053	1.433	50.16	4.936	"	4.941	35,807
595	45.46	1.299	1.879	"	7.670	14.798	1.929	.058	1.357	47.50	$4.93\overset{3}{0}$	"	$4.93\overset{8}{5}$	35,78
VOID 596	/	/	/	/	/	/	/	/	/	/	/	/	/	/
597	33.67	.962	1.542	"	6.294	11.614	1.845	.053	1.015	35.52	3.871	1.001	3.875	28,08
598	$\overset{36.61}{37.24}$	1.046	1.626	"	6.637	11.586	1.746	.048	1.094	38.29	3.862	"	3.866	28,01
599	42.91	1.226	1.806	"	7.372	11.625	1.577	.039	1.265	44.28	3.875	"	3.879	28,11
600	46.48	1.328	1.908	"	7.788	11.611	1.491	.035	1.363	47.70	3.870	"	3.874	28,07
601	39.16	1.119	1.699	"	6.935	11.611	1.674	.043	1.162	40.67	3.870	"	3.874	28,07
602	48.34	1.381	1.961	"	8.005	11.611	1.450	.033	1.414	49.49	3.870	"	3.874	28,07
603	31.99	.914	1.494	"	6.098	11.635	1.908	.057	.971	33.98	3.878	"	3.882	28,13
604	31.57	.902	1.482	"	6.050	11.627	1.922	.057	.959	33.56	3.876	"	3.880	28,11
605	31.29	.894	1.474	"	6.017	11.651	1.936	.058	.952	33.32	3.884	"	3.888	28,17
606	31.12	.889	1.469	"	5.996	11.641	1.941	.059	.948	33.18	3.880	"	3.884	28,14
607	36.82	1.052	1.632	"	6.662	8.936	1.341	.028	1.080	37.80	2.979	"	2.982	21,61
608	38.29	1.094	1.674	"	6.833	8.907	1.304	.026	1.120	39.20	2.969	"	2.972	21,53
609	46.88	1.168	1.748	"	7.135	8.907	1.248	.024	1.192	41.72	2.969	"	2.972	21,53
610	42.84	1.224	1.804	"	7.364	8.907	1.210	.023	1.247	43.64	2.969	"	2.972	21,53
611	44.94	1.284	1.864	"	7.609	8.907	1.170	.021	1.305	45.68	2.969	"	2.972	21,53
~~612~~	48.93	1.398	1.978	"	8.074	8.907	1.103	.019	1.417	49.60	2.969	"	2.972	21,53
613	43.92	1.255	1.835	"	7.490	8.877	1.185	.022	1.277	44.70	2.959	"	2.962	21,46
614	47.00	1.343	1.923	"	7.850	8.877	1.131	.020	1.363	47.70	2.959	"	2.962	21,46
615	45.64	1.304	1.884	"	7.690	8.877	1.154	.021	$\overset{325}{1.905}$	$\overset{46.38}{66.68}$	2.959	"	2.962	21,46
616	42.74	1.221	1.801	"	7.352	8.877	1.207	.023	1.244	43.54	2.959	"	2.962	21,46
617	41.06	1.173	1.753	"	7.156	8.877	1.240	.024	1.197	41.90	2.959	"	2.962	21,46
618	38.18	1.091	1.671	"	6.821	8.877	1.301	.026	1.117	39.10	2.959	"	2.962	21,46
619	36.64	1.047	1.627	"	6.641	8.877	1.337	.028	1.075	37.62	2.959	"	2.962	21,46
620	34.58	.988	1.568	"	6.401	8.864	1.385	.030	1.018	35.63	2.955	"	2.958	21,43
621	31.96	.913	1.493	"	6.094	8.877	1.457	.033	.946	33.11	2.959	"	2.962	21,46
622	30.17	.862	1.442	"	5.836	8.877	1.508	.035	.897	31.40	2.959	"	2.962	21,46

Q = 28,072

Q = 28,144

Q = 21,492

To 624 ↓

Calculation No: CDQ000020080014

Attachment A18-10

Source: Reference A3

Computation of Area, Velocity, Velocity head, and Discharge for One bay. Gate Opening Proto = 29.0486

COMPUTED BJC DATE 11-2-67
CHECKED WLA DATE 11-3-67

Test No.	H. Proto ft.	H. Model ft.	H. + .580 ft.	Width Model ft.	A model ft.²	Qm 3 bays cfs	V model ft/sec	$\frac{V^2}{2g}$ ft.	$H.+\frac{V^2}{2g}$ Model ft.	$H.+\frac{V^2}{2g}$ Proto ft.	Q 1 bay Model	Corr. fact	Q_c 1 bay Model	Q Proto 1 bay
623	28.00	.800	1.380	4.082	5.633	8.877	1.576	.03~~8~~9	.83~~8~~9	29.3~~3~~6	2.959	1.001	2.962	21,466
624	26.98	.771	1.351	"	5.515	8.877	1.610	.040	.811	28.38	2.959	"	2.962	21,466
625	38.46	1.099	1.679	"	6.854	5.680	.829	.011	1.110	38.85	1.893	"	1.895	13,733
626	40.18	1.148	1.728	"	7.054	5.680	.805	.010	1.158	40.53	1.893	"	1.895	13,733
627	42.00	1.200	1.780	"	7.266	5.680	.782	.010	1.210	42.35	1.893	"	1.895	13,733
628	44.03	1.258	1.838	"	7.503	5.680	.7~~80~~57	.009	1.26~~8~~7	44.3~~8~~4	1.893	"	1.895	13,733
629	36.33	1.038	1.618	"	6.605	5.680	.860	.012	1.050	36.75	1.893	"	1.895	13,733
630	34.16	.976	1.556	"	6.352	5.680	.894	.012	.988	34.58	1.893	"	1.895	13,733
631	29.82	.852	1.432	"	5.845	5.680	.972	.015	.867	30.34	1.893	"	1.895	13,733
TEST RUN	32.20	.920	1.500	4.082	6.123	12.431	2.030	.064	.984	34.44	4.144	1.001	4.148	30,06
709	41.76	1.193	1.773	4.082	7.237	14.087	1.947	.059	1.252	43.82	4.696	1.001	4.701	34,06
710	41.76	1.193	1.773	"	7.237	14.095	1.948	.059	1.252	43.82	4.698	"	4.703	34,09
711	41.90	1.197	1.777	"	7.254	14.105	1.944	.05~~8~~9	1.25~~5~~6	43.9~~2~~6	4.702	"	4.707	34,11
712	42.46	1.213	1.793	"	7.319	14.111	1.928	.058	1.271	44.48	4.704	"	4.709	34,12
713	43.50	1.243	1.823	"	7.441	14.132	1.899	.056	1.299	45.46	4.711	"	4.716	34,17
714	45.85	1.310	1.890	"	7.715	14.113	1.82~~6~~9	.052	1.362	47.67	4.704	"	4.709	34,12
715	44.94	1.284	1.864	"	7.609	14.111	1.855	.054	1.338	46.83	4.704	"	4.709	34,12
716	43.22	1.235	1.8~~33~~15	"	7.4~~82~~09	14.108	1.~~886~~904	.05~~5~~6	1.29~~0~~1	45.1~~5~~8	4.703	"	4.708	34,11
717	46.94	1.341	1.921	"	7.842	14.127	1.801	.050	1.391	48.68	4.709	"	4.714	34,16
718	48.23	1.378	1.958	"	7.993	14.143	1.769	.049	1.427	49.94	4.714	"	4.719	34,19

Q = 13,733

Q = 34,130

TVA 4232 (WCP-7-50)

Calculation No: CDQ000020080014

Attachment A18-11

Source: Reference A3

Tennessee Valley Authority

Nappe touches bottom of gate

Hydraulic Data Branch
Hydraulic Laboratory Section

Party HMG PJJ

Date 10-25-67
Computed PJJ
Date 10-25-67
Checked PJC
Date 11-11-67

Sheet ____ of ____

Subject Spillway Rating

Project Nickajack

GAGE READINGS

Test No. Test Run

MODEL G.O. 9.9595
PROTO G.O. 29.0484

Time	Rdg. No.	Weir Gage	Gage Reading (R)								
				1		2		3		4	
	1	1.356		1.560		1.559		2.670		1.403	
	2	1.357		1.565		1.555		2.668		1.406	
	3	1.360		1.563		1.553		2.668		1.401	
	4	1.358		1.561		1.552		2.666		1.402	
	5	1.359		1.565		1.561		2.667		1.405	
	6	1.359		1.565		1.561		2.667		1.405	
	7	1.358		1.561		1.553		2.666		1.402	
	8	1.358		1.563		1.553		2.668		1.406	
	9	1.359		1.560		1.550		2.670		1.403	
	10	1.358		1.561		1.552		2.663		1.402	
Sum of Rdgs. (ΣR)											
Average Rdg. (R)		1.3582		1.5624		1.5548		2.6673		1.4035	
Gage Reading at Datum Z(±)		.757		.642		.633		2.232		.961	
(R-Z)		.6012		.9204		.9218		.4353		.4425	
*1/S (R-Z)											
Elev. of Datum (D)											
W. S. Elev. 1/S (R-Z) + D											

4661

$Q = (.6012)^{3/2} \times 2661 = 1243$

Calculation No: CDQ000020080014

Attachment A18-12

Source: Reference A3

Tailwater Heads

G.O. PROTO = 29.0486'

COMPUTED WLA DATE 10-31-67
CHECKED BJC DATE 10-31-67

test No.	H_T Model	Model Scale	H_T Proto	test No.	H_T Model	Model Scale	H_T Proto
537	.644	35	22.54	576	.601	35	21.04
538	.764	"	26.74	577	.452	"	15.82
539	.802	"	28.07	578	.657	"	23.00
540	.880	"	30.80	579	.708	"	24.78
541	.938	"	32.83	580	.758	"	26.53
551	.470	"	16.45	581	.800	"	28.00
552	.605	"	21.18	582	.858	"	30.03
553	.703	"	24.60	583	.932	"	32.62
554	.803	"	28.10	584	.975	"	34.12
555	.899	"	31.46	585	1.018	"	35.63
556	.955	"	33.42	586	1.072	"	37.52
557	1.003	"	35.10	587	.635	"	22.22
558	1.049	"	36.72	588	.714	"	24.99
559	.647	"	22.64	589	.788	"	27.58
560	.642	"	22.47	590	.856	"	29.96
561	1.103	"	38.60	591	.902	"	31.57
562	.669	"	23.42	592	.966	"	33.81
563	1.133	"	39.66	593	1.054	"	36.89
564	.465	"	16.28	594	1.010	"	3535
565	.648	"	22.68	595	.576	"	20.16
566	.694	"	24.29				
567	.739	"	25.86	597	.794	"	27.79
568	.798	"	27.93	598	.888	"	31.08
569	.842	"	29.47	599	1.027	"	35.94
570	.902	"	31.57	600	1.100	"	38.50
571	.948	"	33.18	601	.953	"	33.36
572	1.018	"	35.63	602	1.140	"	39.90
573	1.084	"	37.94	603	.762	"	26.67
574	1.120	"	39.20	604	.717	"	25.10
575	.535	"	18.72	605	$.67\overset{7}{8}$	"	$23.\overset{70}{73}$

Calculation No: CDQ000020080014

Attachment A18-13

Source: Reference A3

Tailwater Heads

G.O. Proto = 29.0486'

COMPUTED BJC DATE 11-2-67

CHECKED PJC DATE 11-2-67

test No.	H_T Model	Model Scale	H_T Proto
606	.628	35	21.98
607	.971	"	33.98
608	1.001	"	35.04
609	1.052	"	36.82
610	1.098	"	38.43
611	1.149	"	40.22
612	1.246	"	43.61
613	1.124	"	39.34
614	1.200	"	42.00
615	1.166	"	40.81
616	1.095	"	38.32
617	1.055	"	36.92
618	.999	"	34.96
619	.966	"	33.81
620	.920	"	32.20
621	.874	"	30.59
622	.818	"	28.63
623	.704	"	24.64
624	.602	"	21.07
625	1.057	"	37.00
626	1.102	"	38.57
627	1.151	"	40.28
628	1.204	"	42.14
629	1.001	"	35.04
630	.948	"	33.18
631	.841	"	29.44

Test No.	H_T Model	Model Scale	H_T Proto
709	.608	35	21.28
710	.650	"	22.75
711	.738	"	25.83
712	.827	"	28.94
713	.906	"	31.71
714	.996	"	34.86
715	.973	"	34.06
716	.889	"	31.12
717	1.026	"	35.91
718	1.060	"	37.10

Calculation No: CDQ000020080014

Attachment A18-14

Source: Reference A3

Computation of Area, Velocity, Velocity head, and Discharge for One bay. Gate Opening Proto = 36.8717'

COMPUTED WLA DATE 11-16-67

CHECKED BJC DATE 11-16-67

Test No.	H_i Proto ft.	H_i Model ft.	H_i + .580 ft.	Width Model ft.	A model ft.^{2}	Qm 3 bays cfs	V model ft/sec	$\frac{V^2}{2g}$ ft.	$H_i+\frac{V^2}{2g}$ Model ft.	$H_i+\frac{V^2}{2g}$ Proto ft.	Q 1 bay Model	Corr. fact	Q_c 1 bay Model	Q Proto 1 bay
632	45.50	1.300	1.880	4.082	7.674	18.738	2.442	.093	1.393	48.76	6.246	1.001	6.252	4530
633	45.64	1.304	1.884	"	7.690	18.776	2.442	.093	1.397	48.90	6.259	"	6.265	4540
634	45.85	1.310	1.890	"	7.715	18.778	2.434	.092	1.402	49.07	6.259	"	6.265	4540
635	46.20	1.320	1.900	"	7.756	18.738	2.416	.091	1.411	49.38	6.246	"	6.252	4530
636	46.72	1.335	1.915	"	7.817	18.736	2.397	.089	1.424	49.84	6.245	"	6.251	4530
637	45.40	1.297	1.877	"	7.662	18.718	2.443	.093	1.390	48.65	6.239	"	6.245	4525
638	45.36	1.296	1.876	"	7.658	18.702	2.442	.093	1.389	48.62	6.234	"	6.240	4522
639	42.91	1.226	1.806	"	7.372	18.254	2.476	.096	1.321	46.27	6.085	"	6.091	4414
640	42.88	1.225	1.805	"	7.368	18.219	2.473	.095	1.320	46.20	6.073	"	6.079	4405
641	43.05	1.230	1.810	"	7.388	18.247	2.470	.095	1.325	46.38	6.082	"	6.088	4412
642	43.36	1.239	1.819	"	7.425	18.227	2.455	.094	1.333	46.66	6.076	"	6.082	4407
643	43.72	1.249	1.829	"	7.466	18.216	2.440	.093	1.342	46.97	6.072	"	6.078	4404
644	44.24	1.264	1.844	"	7.529	18.187	2.416	.091	1.355	47.42	6.062	"	6.068	4397
645	45.18	1.291	1.871	"	7.637	18.137	2.375	.088	1.379	48.28	6.046	"	6.052	4385
646	45.88	1.311	1.891	"	7.719	18.136	2.350	.086	1.397	48.90	6.045	"	6.051	4385
647	46.97	1.342	1.922	"	7.846	18.092	2.306	.083	1.425	49.88	6.031	"	6.037	4375
648	44.28	1.265	1.845	"	7.531	18.463	2.448	.093	1.358	47.53	6.144	"	6.150	4456
649	44.14	1.261	1.841	"	7.516	18.449	2.455	.094	1.355	47.42	6.150	"	6.156	4461
650	44.17	1.262	1.842	"	7.517	18.425	2.450	.093	1.355	47.42	6.142	"	6.148	4455
651	44.28	1.265	1.845	"	7.531	18.427	2.447	.093	1.358	47.53	6.142	"	6.148	4455
652	44.38	1.268	1.848	"	7.544	18.429	2.442	.093	1.361	47.64	6.141	"	6.147	4454
653	44.84	1.281	1.861	"	7.597	18.411	2.423	.091	1.372	48.02	6.137	"	6.143	4451
654	45.22	1.292	1.872	"	7.642	18.422	2.411	.090	1.382	48.37	6.141	"	6.147	4454
655	47.88	1.368	1.948	"	7.952	18.417	2.316	.084	1.452	50.82	6.139	"	6.145	4453
656	46.55	1.330	1.910	"	7.797	18.433	2.364	.087	1.417	49.60	6.144	"	6.150	4456
657	33.92	.969	1.549	"	6.323	13.792	2.180	.074	1.043	36.50	4.594	"	4.598	3332
658	33.95	.970	1.550	"	6.327	13.814	2.183	.074	1.044	36.54	4.605	"	4.610	3340
659	34.09	.974	1.554	"	6.343	13.786	2.173	.073	1.047	36.64	4.595	"	4.600	3333
660	34.54	.987	1.567	"	6.396	13.782	2.155	.072	1.059	37.06	4.591	"	4.596	3335
661	35.63	1.018	1.598	"	6.523	13.753	2.108	.069	1.087	38.04	4.584	"	4.589	3325
662	37.66	1.076	1.656	"	6.760	13.745	2.033	.064	1.140	39.90	4.582	"	4.587	3324
663	41.40	1.183	1.763	"	7.196	13.766	1.913	.057	1.240	43.40	4.589	"	4.594	3329
664	46.34	1.324	1.904	"	7.772	13.758	1.770	.049	1.373	48.06	4.586	"	4.591	3327
665	43.40	1.240	1.820	"	7.429	13.745	1.850	.053	1.293	45.26	4.582	"	4.587	3324

Q = 45,314

Q = 43986

Q = 44556

Q = 33298

Calculation No: CDQ000020080014

Attachment A18-15

Source: Reference A3

Computation of Area, Velocity, Velocity head, and Discharge for One bay Gate Opening Proto = 36.8717'

COMPUTED BJC DATE 11-16-67
CHECKED WLA DATE 11-17-67
LMG 11-17-67

Test No.	H. Proto ft.	H. Model ft.	H. + .580 ft.	Width Model ft.	A model ft.^{2}	Qm 3 bays cfs	V model ft/sec	$\frac{V^2}{2g}$ ft.	$H_1+\frac{V^2}{2g}$ Model ft.	$H_1+\frac{V^2}{2g}$ Proto ft.	Q 1 bay Model	Corr. fact	Q_c 1 bay Model	Q Proto 1 bay
666	37.34	1.067	1.647	4.082	6.723	16.343	2.431	.092	1.159	40.56	5.448	1.001	5.453	39.518
667	37.45	1.070	1.650	"	6.735	16.283 ~~14.38~~	2.418 ~~2.1~~	.091 ~~.073~~	1.161 ~~1.143~~	40.64 ~~40.08~~	5.428 ~~4.863~~	"	5.433 ~~4.866~~	39.32 ~~35.2~~
668	37.45	1.070	1.650	"	6.735	16.348	2.427	.092	1.162	40.67	5.449	"	5.454	39.52
669	37.59	1.074	1.654	"	6.752	16.369	2.424	.091 ~~.098~~	1.165	40.78	5.456	"	5.461	39.57
670	37.80	1.080	1.660	"	6.776	16.321	2.409	.090	1.170	40.95	5.440	"	5.445	39.4
671	38.46	1.099	1.679	"	6.854	16.321	2.381	.088	1.187	41.54	5.440	"	5.445	39.4
672	39.34	1.124	1.704	"	6.956	16.319	2.346	.086	1.210	42.35	5.440	"	5.445	39.4
673	43.92	1.255	1.836	"	7.490	16.345	2.182	.074	1.329	46.52	5.448	"	5.453	39.5
674	46.20	1.320	1.900	"	7.756	16.310	2.103	.069	1.389	48.62	5.437	"	5.442	39.4
675	42.14	1.204	1.784	"	7.282	16.318	2.241	.078	1.282	44.87 ~~45.12~~	5.439	"	5.444	39.45
676	39.97	1.142	1.722	"	7.029	16.348	2.326	.084	1.226	42.91	5.449	"	5.454	39.52
679	39.69	1.134	1.714	"	6.996	18.088	2.585	.104	1.238	43.33	6.029	"	6.035	43.73
680	39.80	1.137	1.717	"	7.009	18.088	2.581	.104	1.241	43.44	6.029	"	6.035	43.73
681	39.72	1.135	1.715	"	7.001	18.071	2.581	.104	1.239	43.36	6.024	"	6.030	43.69
682	39.69	1.134	1.714	"	6.996	18.000	2.573	.103	1.237	43.30	6.000	"	6.006	43.52
683	39.69	1.134	1.714	"	6.996	17.973	2.569	.103	1.237	43.30	5.991	"	5.997	43.4
684	40.00	1.143	1.723	"	7.033 ~~6.992~~	18.000	2.559 ~~2.574~~	.102 ~~.103~~	1.245	43.58	6.000	"	6.006	43.52
685	43.08	1.231	1.811	"	7.392	18.019	2.438	.093 ~~.092~~	1.324	46.34	6.006	"	6.012	43.56
686	44.17	1.262	1.842	"	7.519	17.948	2.387	.089	1.351	47.28	5.983	"	5.989	43.4
687	46.97	1.342	1.922	"	7.846	17.963	2.289 ~~2.290~~	.081 ~~.082~~	1.423	49.80	5.988	"	5.993	43.4
688	45.46	1.299	1.879	"	7.670	17.957	2.341	.085	1.384	48.44	5.986	"	5.992	43.42
689	34.12	.975	1.555	"	6.348	9.342	1.469 ~~1.472~~	.034	1.009	35.32	3.108	"	3.111	22.5
690	36.16	1.033	1.613	"	6.584	9.345	1.419	.031	1.064	37.24	3.115	"	3.118	22.5
691	37.62	1.075	1.655	"	6.756	9.321	1.380	.030	1.105	38.68	3.107	"	3.110	22.53
692	33.67	.962	1.542	"	6.294	9.335	1.483	.034	.996	34.86	3.112	"	3.115	22.57
693	31.54	.901	1.481	"	6.045	9.327	1.543	.037	.938	32.83	3.109	"	3.112	22.5
694	35.63	1.018	1.598	"	6.523	11.992	1.838	.053 ~~.052~~	1.071 ~~1.070~~	37.48	3.997	"	4.001	28.97
695	36.89	1.054	1.634	"	6.670	11.978	1.796	.050	1.104	38.64	3.993	"	3.997	28.96
696	38.82	1.109	1.689	"	6.894	11.984	1.738	.047	1.156	40.46	3.995	"	3.999	28.98
697	34.37	.982	1.562	"	6.376	11.997	1.882	.055	1.037	36.30	3.999	"	4.003	29.010
698	32.69	.934	1.514	"	6.180	11.960	1.935	.058	.992	34.72	3.987	"	3.991	28.9
699	31.74	.907	1.487	"	6.070	11.970	1.972	.060	.967	33.84	3.990	"	3.994	28.9
700	31.40	.897	1.477	"	6.029	11.965	1.984	.061	.958	33.53	3.988	"	3.992	28.9
TEST	40.46	1.156	1.736	"	7.086	18.741	2.646	.109	1.265	44.28	6.247	"	6.253	45.3
[illegible]		[illegible]		"	[illegible]	[illegible]					[illegible]	"	[illegible]	

Q = 39,482

Q = 43,561

Q = 22,561

28,964

Calculation No: CDQ000020080014

Attachment A18-16

Source: Reference A3

Computation of Area, Velocity, Velocity head, and Discharge for One bay. Gate Opening Proto = 36.8717'

COMPUTED Wmb DATE 11-21-67

CHECKED WLA DATE 11-21-67

Test No.	H. Proto ft.	H. Model ft.	H. + .580 ft.	Width Model ft.	A model ft.^{2}	Qm 3 bays cfs	V model ft/sec	$\frac{V^2}{2g}$ ft.	H. + $\frac{V^2}{2g}$ Model ft.	H. + $\frac{V^2}{2g}$ Proto ft.	Q 1 bay Model	Corr. fact	Q_c 1 bay Model	Q Proto 1 bay
768	38.50	1.100	1.680	4.082	6.858	17.122	2.497	.097	1.197	41.90	5.707	1.001	5.713	41402
769	38.61	1.103	1.683	"	6.870	17.086	2.487	.096	1.199	41.97	5.695	"	5.701	41315
770	38.82	1.109	1.689	"	6.894	17.121	2.483	.096	1.205	42.18	5.707	"	5.713	41402
771	38.50	1.100	1.680	"	6.858	17.114	2.495	.097	1.197	41.90	5.705	"	5.711	41388
772	39.34	1.124	1.704	"	6.956	17.151	2.466	.095	1.219	42.66	5.717	"	5.723	41475
773	41.86	1.196	1.776	"	7.250	17.125	2.362	.087	1.283	44.90	5.708	"	5.714	41409
774	43.37	1.239	1.819	"	7.425	17.122	2.306	.083	1.322	46.27	5.707	"	5.713	41402
775	44.52	1.272	1.852	"	7.560	17.098	2.262	.080	1.352	47.32	5.699		5.705	41344
776	36.68	1.048	1.628	"	6.645	15.114	2.274	.080	1.128	39.48	5.038	"	5.043	36,547
777	37.66	1.076	1.656	"	6.760	15.090	2.232	.077	1.153	40.36	5.030	"	5.035	36,489
778	39.66	1.133	1.713	"	6.992	15.106	2.160	.072	1.205	42.18	5.035	"	5.040	36,525
779	40.39	1.154	1.734	"	7.078	15.093	2.132	.071	1.225	42.88	5.031	"	5.036	36,496
780	41.06	1.173	1.753	"	7.156	15.125	2.114	.070	1.243	43.50	5.042	"	5.047	36,576
781	42.63	1.218	1.798	"	7.339	15.050	2.051	.065	1.283	44.90	5.017	"	5.022	36,394
782	41.93	1.198	1.778	"	7.258	15.074	2.077	.067	1.265	44.28	5.025	"	5.030	36,452

Q = 41,392

Q = 36,477

Calculation No: CDQ000020080014

Attachment A18-17

Source: Reference A3

TAILWATER HEADS
G.O. 36.8717' PROTO

COMPUTED HMG DATE 11/16/67
CHECKED BJC DATE 11-16-67

TEST No.	Tw MODEL	x35	Tw PROTO	TEST No.	Tw MODEL	x35	Tw PROTO	TEST No.	Tw MODEL	x35	Tw PROTO
632	.704		24.64	667	.596		20.86	768	.6$\overset{8}{6}$8		24.08 ~~23.3~~
633	.788		27.58	668	.669		23.42	769	.756		26.4
634	.852		29.82	669	.726		25.41	770	.828		28.9
635	.922		32.27	670	.800		28.00	771	.644		22.5
636	.960		33.60	671	.897		31.40	772	.899		31.4
637	.528		18.48	672	.972		34.02	773	.975		34.12
638	.374		13.09	673	1.092		38.22	774	1.024		35.8
639	.352		12.32	674	1.151		40.28	775	1.064		37.24
640	.572		20.02	675	1.043		36.50	776	.838		29.33
641	.702		24.57	676	1.007		35.24	777	.927		32.44
642	.798		27.93	679	.578		20.23	778	1.035		36.22
643	.853		29.86	680	.628		21.98	779	1.050		36.75
644	.915		32.02	681	.665		23.28	780	1.061		37.14
645	.981		34.34	682	.707		24.74	781	1.100		38.50
646	1.018		35.63	683	.768		26.88	782	1.081		37.84
647	1.070		37.45	684	.845		29.58				
648	.584		20.44	685	.920		32.20				
649	.632		22.12	686	.979		34.26				
650	.666		23.31	687	1.099		38.46				
651	.732		25.62	688	1.038		36.33				
652	.785		27.48	689	.940		32.90				
653	.875		30.62	690	1.004		35.14				
654	.918		32.13	691	1.048		36.68				
655	1.078		37.73	692	.925		32.38				
656	1.004		35.14	693	.856		29.96				
657	.347		12.14	694	.954		33.39				
658	.533		18.66	695	1.000		35.00				
659	.668		23.38	696	1.062		37.17				
660	.771		26.98	697	.901		31.54				
661	.873		30.56	698	.796		27.86				
662	.987		34.54	699	.699		24.46				
663	1.103		38.60	700	.599		20.96				
664	1.205		42.18								
665	1.148		40.18								
666	.424		14.84								

Computation of Area, Velocity, Velocity head, and Discharge for One bay. Gate Opening Proto = 42.4917'

COMPUTED PJC DATE 11-21-67

CHECKED ____ DATE ____

Q = 48,014

Q = 35,000

Q = 41,544

Test No.	H. Proto ft.	H. Model ft.	H. + 580 ft.	Width Model ft.	A model ft.²	Qm 3 bays cfs	V model ft/sec	$\frac{V^2}{2g}$ ft.	$H.+\frac{V^2}{2g}$ Model ft.	$H.+\frac{V^2}{2g}$ Proto ft.	Q 1 bay Model	Corr. fact.	Q_c 1 bay Model	Q Proto 1 bay 7247
701	41.96	1.199	1.779	4.082	7.262	19.840	2.732	.116	1.315	46.02	6.613	1.001	6.620	47975
702	42.04	1.201	1.781	"	7.270	19.832	2.728	.116	1.317	46.10	6.611	"	6.618	47961
703	42.00	1.200	1.780	"	7.266	19.821	2.728	.116	1.316	46.06	6.607	"	6.614	47932
704	42.07	1.202	1.782	"	7.274	19.848	2.729	.116	1.318	46.13	6.616	"	6.623	47997
705	42.21	1.206	1.786	"	7.290	19.872	2.726	.116	1.322	46.27	6.624	"	6.631	48055
706	42.49	1.214	1.794	"	7.323	19.880	2.715	.115	1.329	46.52	6.627	"	6.634	48077
707	43.19	1.234	1.814	"	7.405	19.867	2.683	.112	1.346	~~43.67~~ 47.11	6.622	"	6.629	48040
708	44.10	1.260	1.840	"	7.511	19.880	2.647	.109	1.369	47.92	6.627	"	6.634	48077
719	34.96	.999	1.579	"	6.445	14.461	2.244	.078	1.077	37.70	4.820	"	4.825	34967
720	35.14	1.004	1.584	"	6.466	14.464	2.237	.078	1.082	37.87	4.821	"	4.826	34974
721	34.93	.998	1.578	"	6.441	14.453	2.244	.078	1.076	37.66	4.818	"	4.823	34952
722	35.67	1.019	1.599	"	6.527	14.456	2.215	.076	1.095	38.32	4.819	"	4.824	34960
723	36.12	1.032	1.612	"	6.580	14.485	2.201	.075	1.107	38.74	4.828	"	4.833	35025
724	36.78	1.051	1.631	"	6.658	14.490	2.176	.074	1.125	39.38	4.830	"	4.835	35039
725	37.70	1.077	1.657	"	6.764	14.472	2.140	.071	1.148	40.18	4.824	"	4.829	34996
726	38.85	1.110	1.690	"	6.899	14.496	2.101	.069	1.179	41.26	4.832	"	4.837	35054
727	40.78	1.165	1.745	"	7.123	14.488	2.034	.064	1.229	43.02	4.829	"	4.834	[illegible]
728	38.61	1.103	1.683	"	6.870	17.210	2.505	.098	1.201	42.04	5.737	"	5.743	41620
729	38.57	1.102	1.682	"	6.866	17.210	2.507	.098	1.200	42.00	5.737	"	5.743	41620
730	38.64	1.104	1.684	"	6.874	17.202	2.502	.097	1.201	42.04	5.734	"	5.740	41598
731	38.82	1.109	1.689	"	6.894	17.170	2.491	.096	1.205	42.18	5.723	"	5.729	41518
732	39.06	1.116	1.696	"	6.923	17.197	2.484	.096	1.212	42.42	5.732	"	5.738	41583
733	39.69	1.134	1.714	"	6.997	17.133	2.449	.093	1.227	42.94	5.711	"	5.717	41431
734	40.64	1.161	1.741	"	7.107	17.131	2.416	.091	1.252	43.82	5.724	"	5.730	41525
735	42.00	1.200	1.780	"	7.266	17.142	2.359	.087	1.287	45.04	5.714	"	5.720	41453
736	VOID													
737	VOID													
738	VOID													
739	45.82	1.309	1.889	"	7.711	22.661	2.939	.134	1.443	50.50	7.554	"	7.562	54802
740	46.06	1.316	1.896	"	7.739	22.567	2.916	.132	1.448	50.68	7.522	"	7.530	54570
741	46.20	1.320	1.900	"	7.756	[illegible]	2.913	.132	1.452	50.82	7.532	"	7.540	54642
742	45.82	1.309	1.889	"	7.711	22.540	2.923	.133	1.442	50.47	7.513	"	7.521	54505

VOID

Calculation No: CDQ000020080014

Attachment A18-20

Source: Reference A3

Computation of Area, Velocity, Velocity head, and Discharge for One bay. Gate Opening Proto = 42.4917

COMPUTED HMG DATE 11-21-67
CHECKED PJC DATE 11-22-67

Test No.	H. Proto ft.	H. Model ft.	H. + .580 ft.	Width Model ft.	A model ft.²	Qm 3 bays cfs	V model ft/sec	$\frac{V^2}{2g}$ ft.	H. + $\frac{V^2}{2g}$ Model ft.	H. + $\frac{V^2}{2g}$ Proto ft.	Q 1 bay Model	Corr. fact.	Q_c 1 bay Model	Q Proto 1 bay
743	45.54	1.301	1.881	4.082	7.678	22.461	2.925	.133	1.434	50.19	7.487	1.001	7.494	5430
744	45.50	1.300	1.880	"	7.674	22.595	2.938	.134	1.434	50.19	7.515	"	7.523	5451
745	45.50	1.300	1.880	"	7.674	22.488	2.930	.134	1.434	50.19	7.496	"	7.503	543
746	45.50	1.300	1.880	"	7.674	22.488	2.930	.134	1.434	50.19	7.496	"	7.503	5437
747	45.57	1.302	1.882	"	7.682	22.461	2.924	.133	1.435	50.22	7.487	"	7.494	54309
748	45.78	1.308	1.888	"	7.707	22.461	2.914	.132	1.440	50.40	7.487	"	7.494	54309
~~749~~	~~48.18~~	~~1.377~~	~~1.957~~		~~8.076~~	~~22.502~~	[illegible]	~~.122~~	~~1.515~~	[illegible]	~~7.501~~	"	~~7.509~~	~~5441~~
750	45.92	1.312	1.892	"	7.723	22.418	2.903	.131	1.443	50.50	7.473	"	7.480	54208
751	46.27	1.322	1.902	"	7.764	22.380	2.883	.129	1.451	50.78	7.460	"	7.467	54113
752	46.48	1.328	1.908	"	7.788	22.413	2.878	.129	1.457	51.00	7.471	"	7.478	54193
753	36.16	1.033	1.613	"	6.584	13.230	2.009	.063	1.096	38.36	4.410	"	4.414	3198
754	37.73	1.078	1.658	"	6.768	13.272	1.961	.060	1.138	39.83	4.424	"	4.428	32090
755	39.48	1.128	1.708	"	6.972	13.259	1.902	.056	1.184	41.44	4.420	"	4.424	32061
756	34.79	.994	1.574	"	6.425	13.278	2.067	.066	1.060	37.10	4.426	"	4.430	32104
757	34.02	.972	1.552	"	6.335	13.254	2.092	.068	1.040	36.40	4.418	"	4.422	32046
758	33.50	.957	1.537	"	6.274	13.248	2.112	.069	1.026	35.91	4.416	"	4.420	32032
759	33.36	.953	1.533	"	6.258	13.270	2.120	.070	1.023	35.81	4.423	"	4.427	32082
760	33.22	.949	1.529	"	6.241	13.262	2.125	.070	1.019	35.66	4.421	"	4.425	32068
761	33.18	.948	1.528	"	6.237	13.259	2.126	.070	1.018	35.63	4.420	"	4.424	32061
762	36.75	1.050	1.630	"	6.654	9.058	1.361	.029	1.079	37.76	3.019	"	3.022	21900
763	37.52	1.072	1.652	"	6.743	9.066	1.345	.028	1.100	38.50	3.022	"	3.025	2192
764	38.32	1.095	1.675	"	6.837	9.071	1.327	.027	1.122	39.27	3.024	"	3.027	21937
765	35.21	1.006	1.586	"	6.474	9.071	1.401	.031	1.037	36.30	3.024	"	3.027	2193
766	32.72	.935	1.515	"	6.184	9.071	1.467	.033	.968	33.88	3.024	"	3.027	21937
767	30.66	.876	1.456	"	5.943	9.050	1.523	.036	.912	31.92	3.017	"	3.020	2188

Q = 54,307

Q = 32,059

Q = 21,920

Calculation No: CDQ000020080014

Attachment A18-21

Source: Reference A3

SHEET ____ OF ____

Tailwater Heads

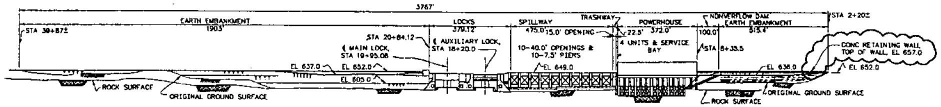
G.O. Proto 42.4917'

Nickajack

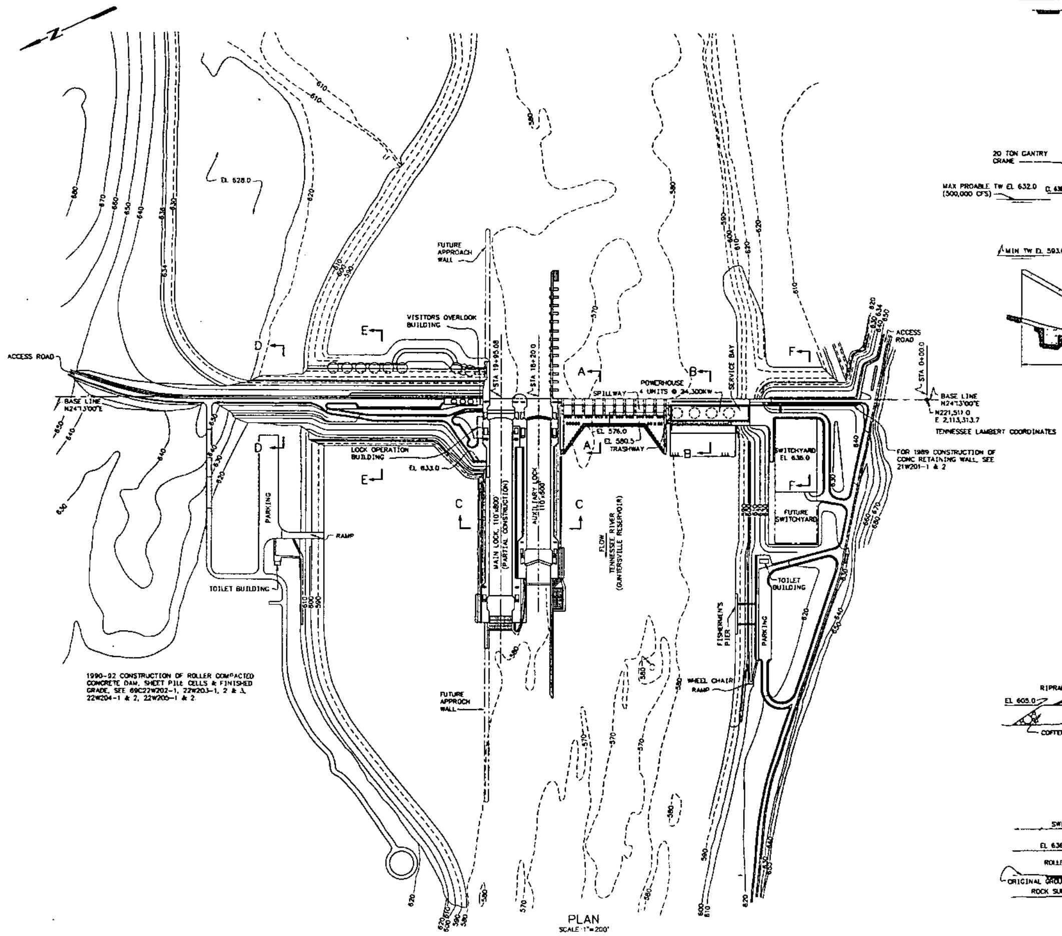
COMPUTED BJC DATE 11-20-67

CHECKED HMcG DATE 11-21-67

Test No.	TW Model	x35	TW Proto	Test No.	TW Model	x35	TW Proto
701	.630		22.05	745	.809		28.32
702	.698		24.43	746	.847		29.64
703	.588		20.58	747	.896		31.36
704	.780		27.30	748	.962		33.67
705	.854		29.89	749	1.002		35.07
706	.922		32.27	750	1.002		35.07
707	.995		34.82	751	1.045		36.58
708	1.069		37.42	752	1.064		37.24
719	.461		16.14	753	.943		33.00
720	.684		23.94	754	1.004		35.14
721	.601		21.04	755	1.064		37.24
722	.802		28.07	756	.853		29.86
723	.844		29.54	757	.773		27.06
724	.902		31.57	758	.700		24.50
725	.962		33.67	759	.654		22.89
726	1.019		35.66	760	.590		20.65
727	1.094		38.29	761	.506		17.71
728	.617		21.60	762	1.024		35.84
729	.541		18.94	763	1.046		36.61
730	.704		24.64	764	1.070		37.45
731	.788		27.58	765	.978		34.23
732	.851		29.78	766	.900		31.50
733	.928		32.48	767	.830		29.05
734	1.000		35.00				
735	1.068		37.38				
~~736~~							
~~737~~							
~~738~~							
739	.862		30.17				
740	.998		34.93				
741	1.012		35.42				
742	.940		32.90				
743	.745		26.08				
744	.698		24.43				



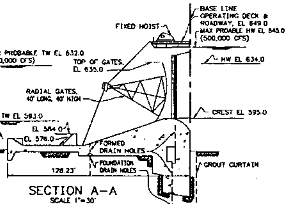
DOWNSTREAM ELEVATION
SCALE 1"=200'



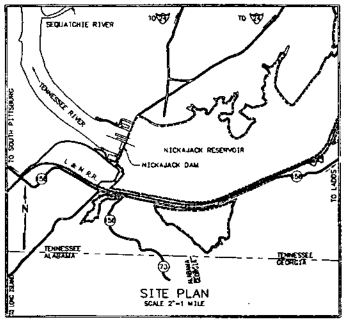
1990-92 CONSTRUCTION OF ROLLER COMPACTED CONCRETE DAM, SHEET PILE CELLS & FINISHED GRADE, SEE 69C22W202-1, 22W203-1, 2 & 3, 22W204-1 & 2, 22W205-1 & 2.

FOR 1989 CONSTRUCTION OF CONC RETAINING WALL, SEE 21W201-1 & 2

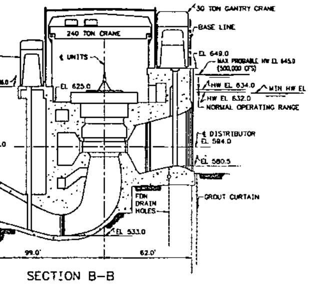
PLAN
SCALE 1"=200'



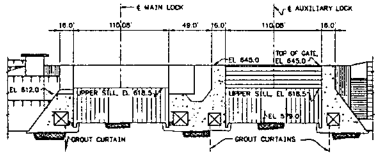
SECTION A-A
SCALE 1"=30'



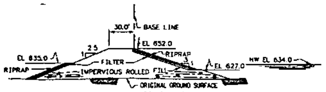
SITE PLAN
SCALE 2"=1 MILE



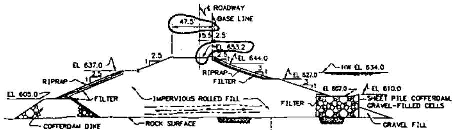
SECTION B-B
SCALE 1"=30'



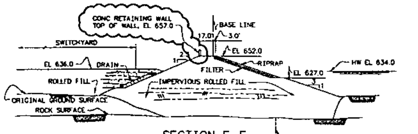
SECTION C-C
SCALE 1"=50'



SECTION D-D
SCALE: 1"=50'



SECTION E-E
SCALE: 1"=50'



SECTION F-F
SCALE: 1"=50'

FOR PROBABLE MAXIMUM FLOOD MODIFICATIONS, SEE DRAWINGS:
21W201-SERIES ----- DAM SAFETY MODIFICATIONS
22W202-SERIES ----- EMBANKMENT MODIFICATIONS
22W203-SERIES ----- EMBANKMENT MODIFICATIONS
22W204-SERIES ----- EMBANKMENT MODIFICATIONS
22W205-SERIES ----- EMBANKMENT MODIFICATIONS

R	JAN 09 2007	---	KGK	LBG	CBO		RWT	MAC			D
R 8	ELECTRONICALLY RESTORED; ADDED PMF INFORMATION										

SCALE: 1"=200' EXCEPT AS NOTED

MAIN DAM WORKS

GENERAL PLAN
ELEVATION & SECTIONS

DESIGNED BY	DRAWN BY	CHECKED BY	SUPERVISED BY	REVISED BY	APPROVED BY	ISSUED BY
	K.N.S.	C.C.T.	T.J.A.	F.P.L.	W.L.B.	W.T.C.

NICKAJACK PROJECT
TENNESSEE VALLEY AUTHORITY
RIVER SYSTEMS OPERATIONS

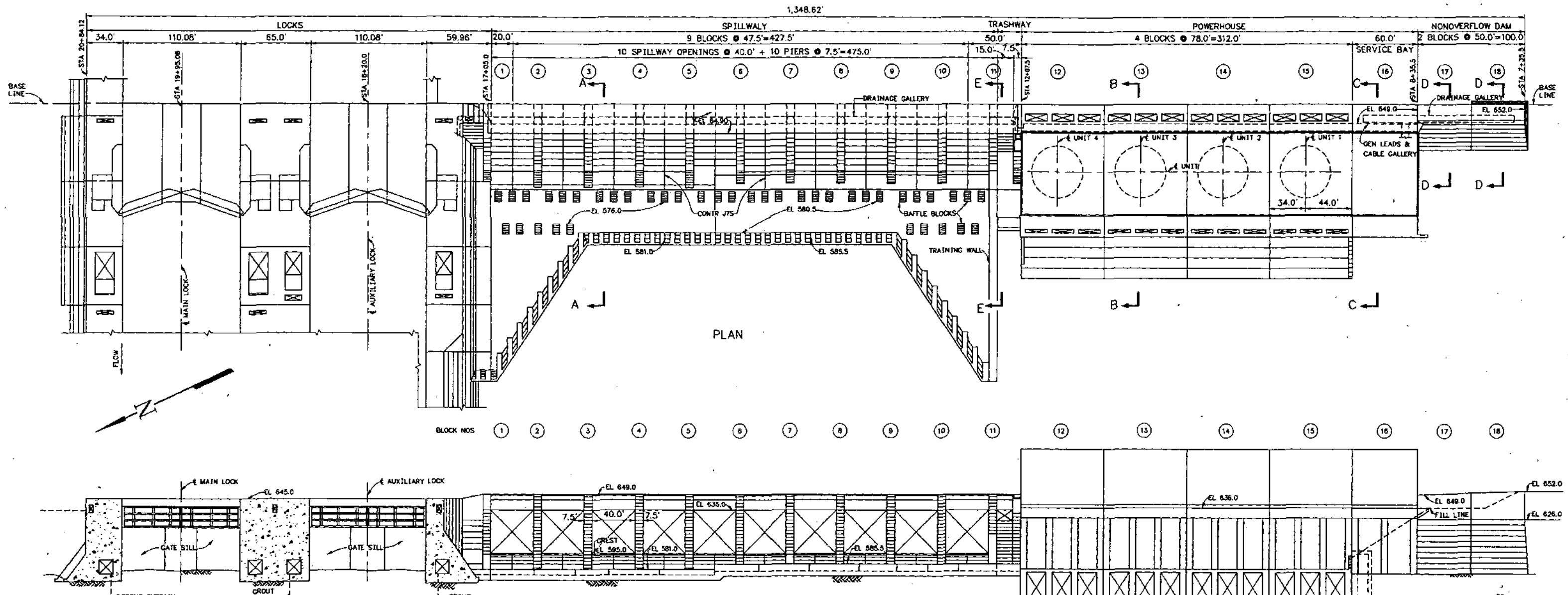
AUTOCAD 2006 | DATE 4-13-64 | 69 | C | 10W200 | R 8

TASK COMPLETED BY: | REV NO.

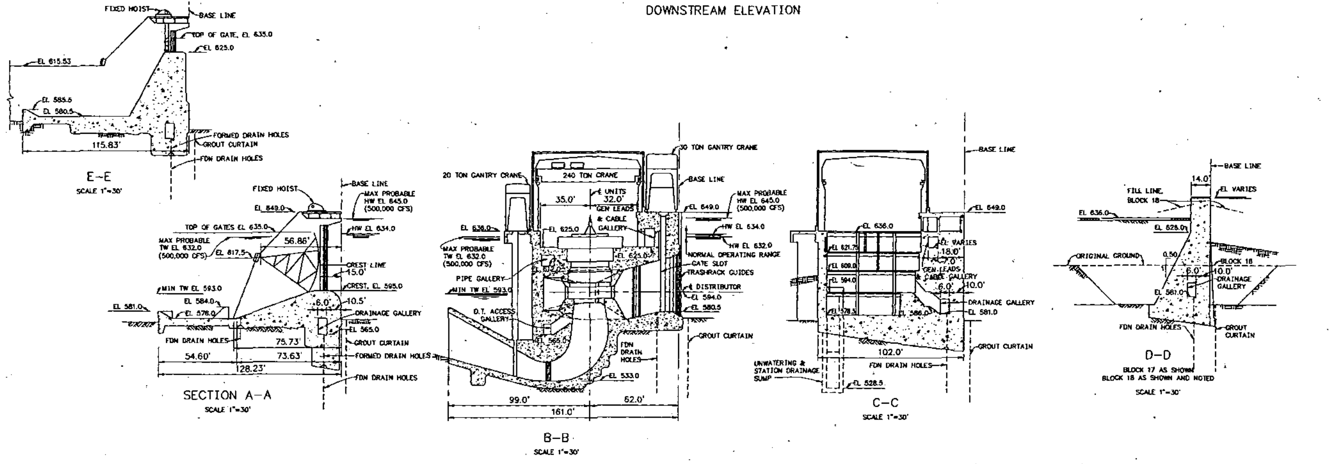
ELECTRONICALLY RESTORED DRAWING
THIS DRAWING HAS BEEN COMPLETELY REDRAWN
AND SUPERSEDES :(10N200 R7)

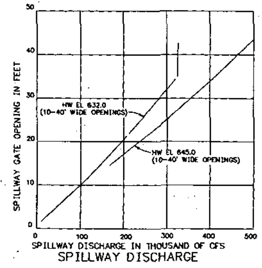
PLOT FACTOR:2400
W_TVA

C.A.D. DRAWING
DO NOT ALTER MANUALLY



DOWNSTREAM ELEVATION





SPILLWAY DISCHARGE

R 6	4/17/01	JKS	SMW	BH	TKM	JEV	JEV	JEV		
REDRAWN TO CAD FORMAT										
REV. NO.	DATE	DSGN	CHKD	CKRD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST

SCALE: 1"=40'-0" EXCEPT AS NOTED

SPILLWAY, POWERHOUSE &
NONOVERFLOW DAM

GENERAL PLAN
ELEVATION & SECTIONS

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
	ETR, CCT	HAM	TJA			

NICKAJACK HYDRO PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING
MF

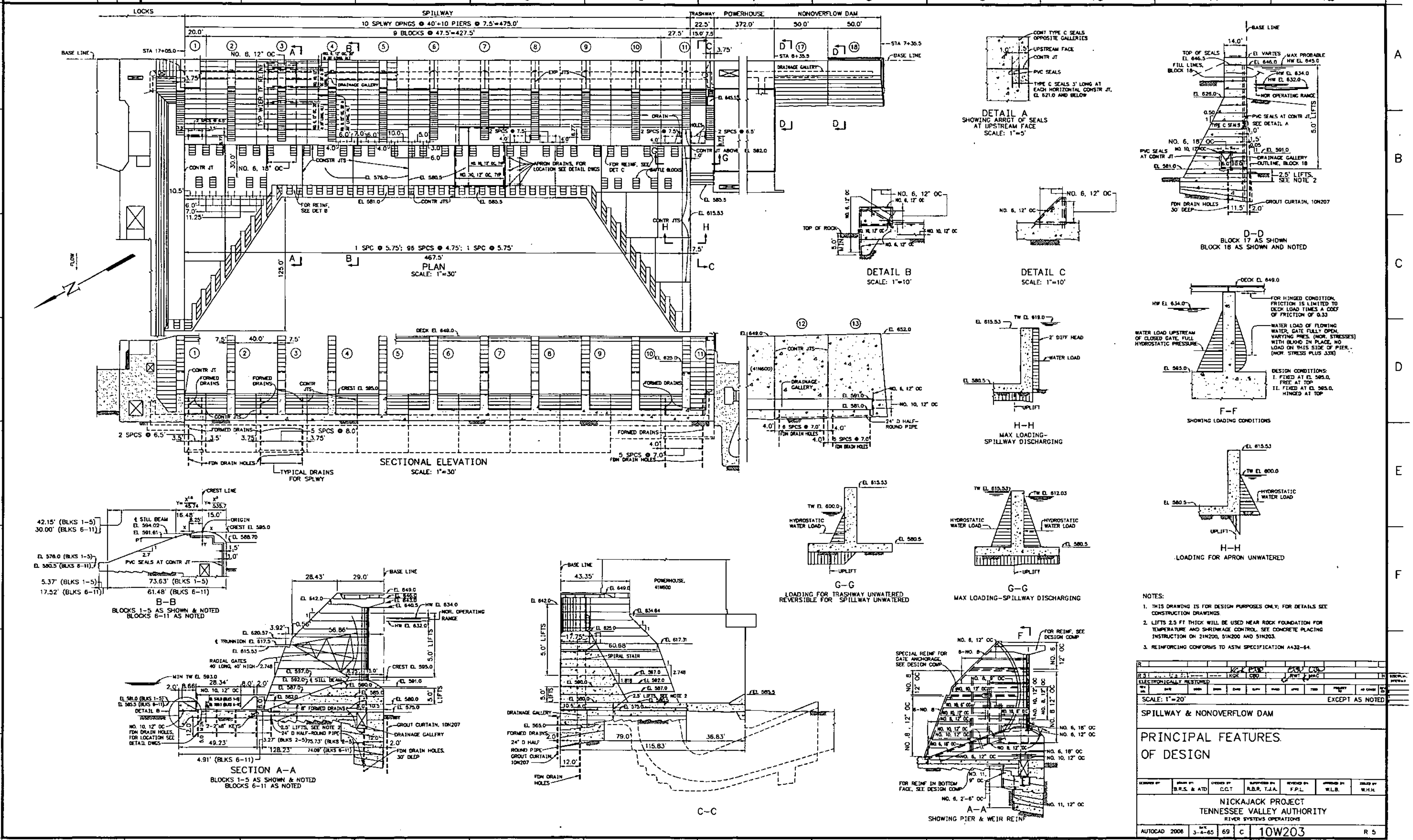
AUTOCAD R14 | DATE 8-20-64 | 69 | C | 10W201 | R 6

ELECTRONICALLY RESTORED DRAWING
THIS DRAWING HAS BEEN COMPLETELY REDRAWN
AND SUPERSEDES : (10N201 R5)

TASK COMPLETED BY: | REV NO.

PLOT FACTOR:480
W_TVA

C.A.D. DRAWING
DO NOT ALTER MANUALLY



NOTES:

1. THIS DRAWING IS FOR DESIGN PURPOSES ONLY; FOR DETAILS SEE CONSTRUCTION DRAWINGS.
2. LIFTS 2.5 FT THICK WILL BE USED NEAR ROCK FOUNDATION FOR TEMPERATURE AND SHRINKAGE CONTROL. SEE CONCRETE PLACING INSTRUCTION ON 21N200, 51N200 AND 51N203.
3. REINFORCING CONFORMS TO ASTM SPECIFICATION A432-64.

R 5 KCK CBO RWT MAC

ELECTRONICALLY RESTORED

SCALE: 1"=20' EXCEPT AS NOTED

SPILLWAY & NONOVERFLOW DAM

PRINCIPAL FEATURES
OF DESIGN

DRAWN BY	CHECKED BY	SUPERVISED BY	REVIEWED BY	APPROVED BY	ISSUED BY
B.R.S. & ATD	C.C.T	R.B.R, T.J.A.	F.P.L.	W.L.B.	W.H.H.

NICKAJACK PROJECT
TENNESSEE VALLEY AUTHORITY
RIVER SYSTEMS OPERATIONS

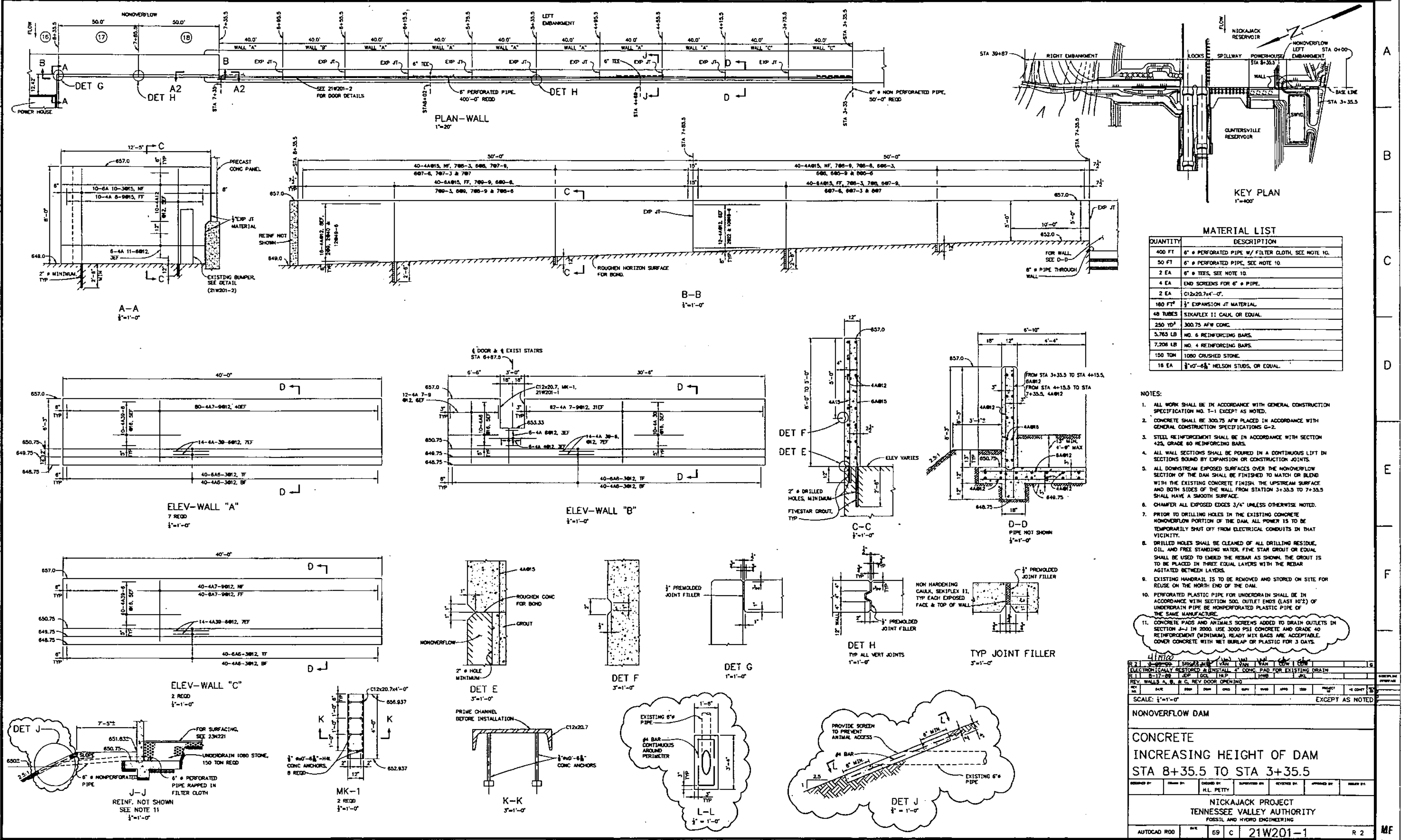
AUTOCAD 2006 | 3-4-65 | 69 | C | 10W203 | R 5

ELECTRONICALLY RESTORED DRAWING
THIS DRAWING HAS BEEN COMPLETELY REDRAWN AND SUPERSEDES : (10N203 R4)

TASK COMPLETED BY: REV NO

PLOT FACTOR:240
W_TVA

C.A.D. DRAWING
DO NOT ALTER MANUALLY



MATERIAL LIST

QUANTITY	DESCRIPTION
400 FT	6" ϕ PERFORATED PIPE W/ FILTER CLOTH, SEE NOTE 10.
50 FT	6" ϕ PERFORATED PIPE, SEE NOTE 10.
2 EA	6" ϕ TEES, SEE NOTE 10.
4 EA	END SCREENS FOR 6" ϕ PIPE.
2 EA	C12x20.7x4'-0".
160 FT²	½" EXPANSION JT MATERIAL.
48 TUBES	SIKAFLEX II CALK. OR EQUAL.
250 YD³	300.75 AFW CONC.
5,763 LB	NO. 6 REINFORCING BARS.
7,206 LB	NO. 4 REINFORCING BARS.
150 TON	1080 CRUSHED STONE.
16 EA	⅜"x0'-6⅝" NELSON STUDS, OR EQUAL.

NOTES:

1. ALL WORK SHALL BE IN ACCORDANCE WITH GENERAL CONSTRUCTION SPECIFICATION NO. T-1 EXCEPT AS NOTED.
2. CONCRETE SHALL BE 300.75 AFW PLACED IN ACCORDANCE WITH GENERAL CONSTRUCTION SPECIFICATIONS G-2.
3. STEEL REINFORCEMENT SHALL BE IN ACCORDANCE WITH SECTION 425, GRADE 60 REINFORCING BARS.
4. ALL WALL SECTIONS SHALL BE POURED IN A CONTINUOUS LIFT IN SECTIONS BOUND BY EXPANSION OR CONSTRUCTION JOINTS.
5. ALL DOWNSTREAM EXPOSED SURFACES OVER THE NONOVERFLOW SECTION OF THE DAM SHALL BE FINISHED TO MATCH OR BLEND WITH THE EXISTING CONCRETE FINISH. THE UPSTREAM SURFACE AND BOTH SIDES OF THE WALL FROM STATION 3+35.5 TO 7+35.5 SHALL HAVE A SMOOTH SURFACE.
6. CHAMFER ALL EXPOSED EDGES 3/4" UNLESS OTHERWISE NOTED.
7. PRIOR TO DRILLING HOLES IN THE EXISTING CONCRETE NONOVERFLOW PORTION OF THE DAM, ALL POWER IS TO BE TEMPORARILY SHUT OFF FROM ELECTRICAL CONDUITS IN THAT VICINITY.
8. DRILLED HOLES SHALL BE CLEANED OF ALL DRILLING RESIDUE, OIL, AND FREE STANDING WATER. FIVE STAR GROUT OR EQUAL SHALL BE USED TO EMBED THE REBAR AS SHOWN. THE GROUT IS TO BE PLACED IN THREE EQUAL LAYERS WITH THE REBAR AGITATED BETWEEN LAYERS.
9. EXISTING HANDRAIL IS TO BE REMOVED AND STORED ON SITE FOR REUSE ON THE NORTH END OF THE DAM.
10. PERFORATED PLASTIC PIPE FOR UNDERDRAIN SHALL BE IN ACCORDANCE WITH SECTION 500. OUTLET ENDS (LAST 10'±) OF UNDERDRAIN PIPE BE NONPERFORATED PLASTIC PIPE OF THE SAME MANUFACTURE.
11. CONCRETE PADS AND ANIMALS SCREENS ADDED TO DRAIN OUTLETS IN SECTION J-J IN 2000. USE 3000 PSI CONCRETE AND GRADE 40 REINFORCEMENT (MINIMUM). READY MIX BAGS ARE ACCEPTABLE. COVER CONCRETE WITH WET BURLAP OR PLASTIC FOR 3 DAYS.

4/19/00

R 2	~~3-09-00~~	SRS	VAN	VAN	VAN	CDW	CDW	
ELECTRONICALLY RESTORED & INSTALL 4" CONC. PAD FOR EXISTING DRAIN								
R 1	8-17-89	JDP	GCL	HLP		HWB		JKL
REV. WALLS A, B, & C, REV DOOR OPENING								

SCALE: ¼"=1'-0" EXCEPT AS NOTED

NONOVERFLOW DAM

CONCRETE
INCREASING HEIGHT OF DAM
STA 8+35.5 TO STA 3+35.5

CHECKED BY H.L. PETTY

NICKAJACK PROJECT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD R00 | 69 | C | 21W201-1 | R 2

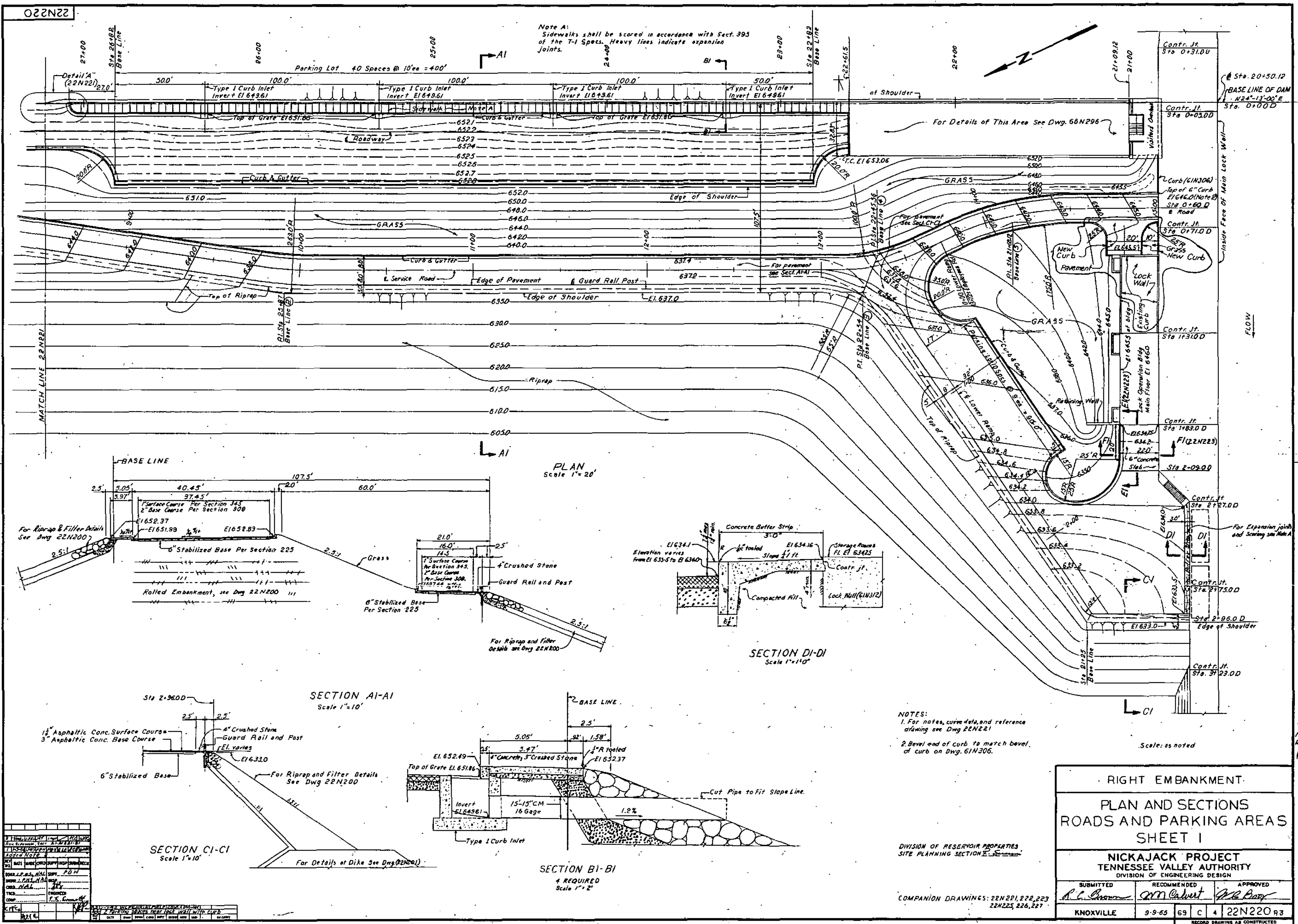
MF

ELECTRONICALLY RESTORED DRAWING
THIS DRAWING HAS BEEN COMPLETELY REDRAWN
AND SUPERSEDES : (21W201-1 R1)

TASK COMPLETED BY:
REV NO.

PLOT FACTOR:48
W_TVA

C.A.D. DRAWING
DO NOT ALTER MANUALLY



Note A:
Sidewalks shall be scored in accordance with Sect. 395 of the T-1 Specs. Heavy lines indicate expansion joints.

NOTES:
1. For notes, curve data, and reference drawing see Dwg 22N221
2. Bevel end of curb to match bevel of curb on Dwg. 61N306.

Scale: as noted

DIVISION OF RESERVOIR PROPERTIES
SITE PLANNING SECTION

COMPANION DRAWINGS: 22N221, 222, 223
22N225, 226, 227

RIGHT EMBANKMENT

PLAN AND SECTIONS
ROADS AND PARKING AREAS
SHEET 1

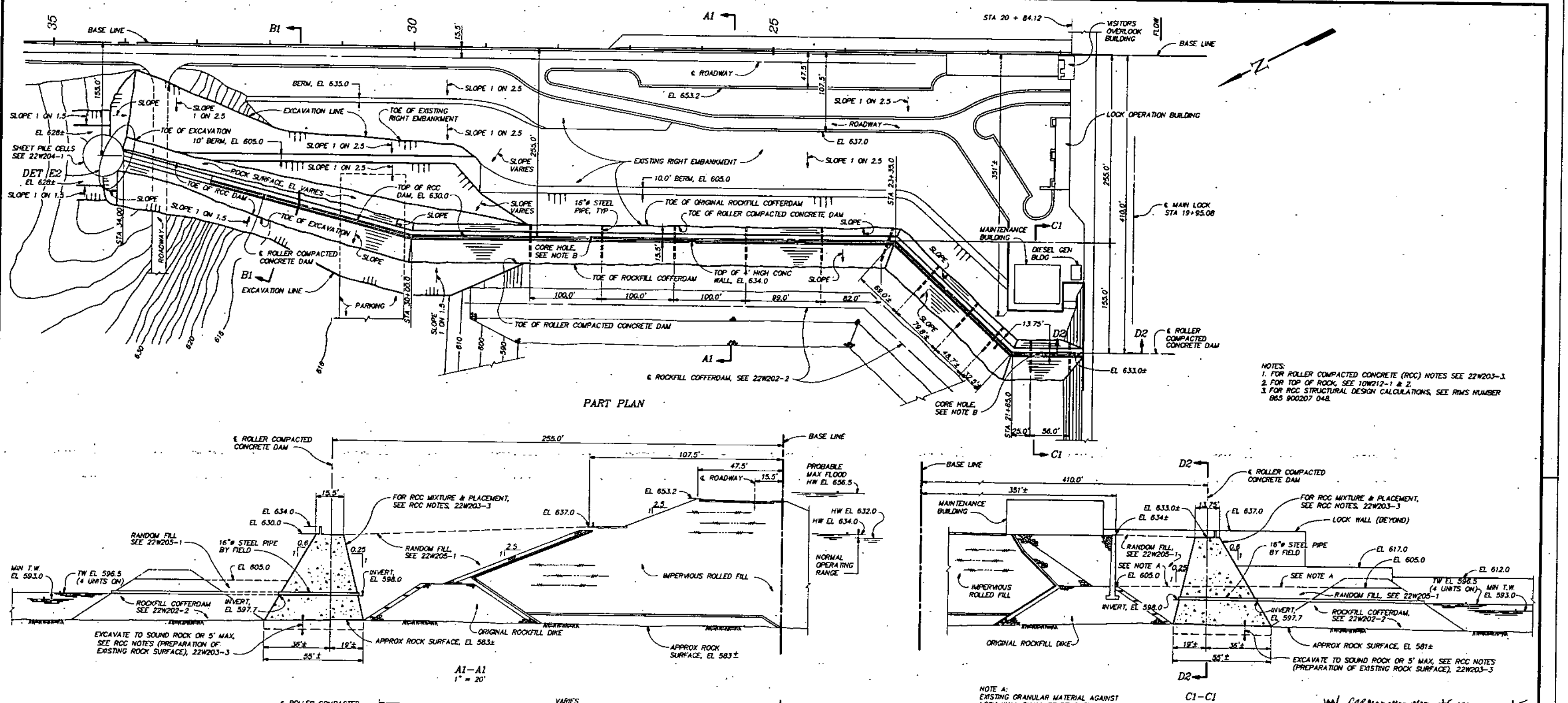
NICKAJACK PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF ENGINEERING DESIGN

SUBMITTED	RECOMMENDED	APPROVED
R. C. Brown	W M Calvert	W. B. Barr

KNOXVILLE	9-9-65	69	C	4	22N220 R3

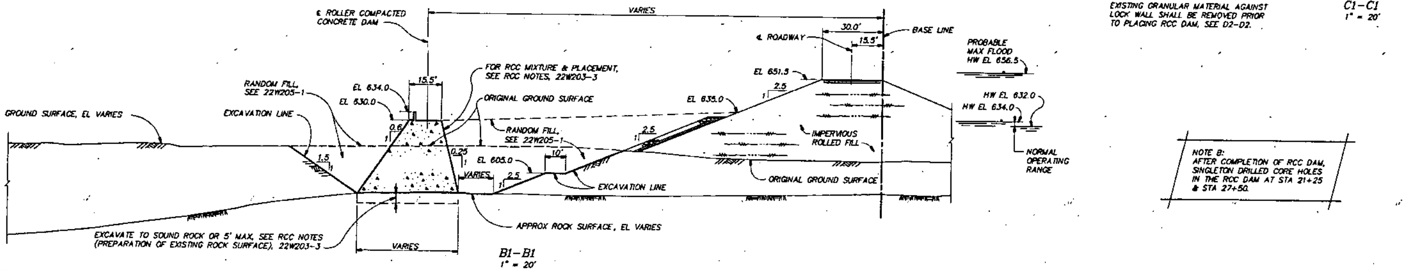
RECORD DRAWING AS CONSTRUCTED
3-7-69

MF
R2
R3



NOTES:
1. FOR ROLLER COMPACTED CONCRETE (RCC) NOTES SEE 22W203-3.
2. FOR TOP OF ROCK, SEE 10W212-1 & 2.
3. FOR RCC STRUCTURAL DESIGN CALCULATIONS, SEE RIMS NUMBER B65 900207 048.

NOTE A:
EXISTING GRANULAR MATERIAL AGAINST LOCK WALL SHALL BE REMOVED PRIOR TO PLACING RCC DAM, SEE D2-D2.



NOTE B:
AFTER COMPLETION OF RCC DAM, SINGLETON DRILLED CORE HOLES IN THE RCC DAM AT STA 21+25 & STA 27+50.

1	10-7-92	VAN	DRC	HAM	HAM	HAM	CDW	JHC		CDW 9-15-92
REVISED DRAWING AS CONSTRUCTED.										
REV NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD		AS CONST

SCALE: 1" = 60' EXCEPT AS NOTED

RIGHT EMBANKMENT
ROLLER COMPACTED CONCRETE DAM

EMBANKMENT MODIFICATIONS PLAN, SECTIONS, & DETAILS

NICKAJACK PROJECT
TENNESSEE VALLEY AUTHORITY

DESIGN		DISCIPLINE INTERFACE		ENGINEERING APPROVAL
DESIGNED V.A. NEWELL	SUPERVISED H.A. MANSON	1	2	C.D. WAGNER
DRAWN D.R. COLLINS				
CHECKED H.A. MANSON	REVIEWED H.A. MANSON	3	4	

ENGINEERING DATE 5-8-90 69 C 22W203-1 R1

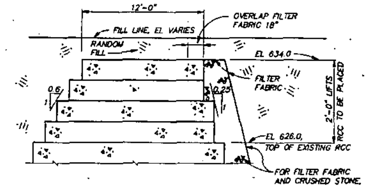
ISSUED BY JAMES H. COULSON

AS CONSTRUCTED

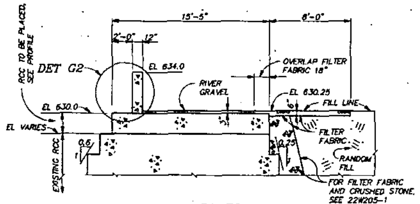
22WDRC3

CAD SYSTEM ORIGINAL
DO NOT CHANGE MANUALLY

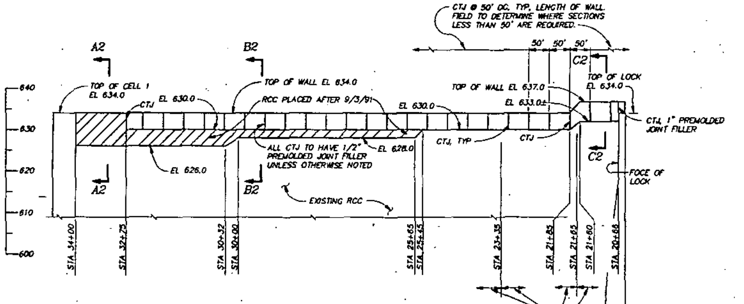
69 | C | 22W203-2



A2-A2
1/4" = 1'-0"

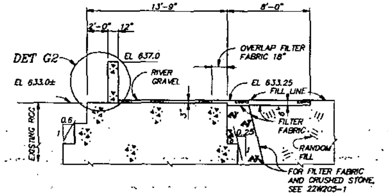


B2-B2
1/4" = 1'-0"

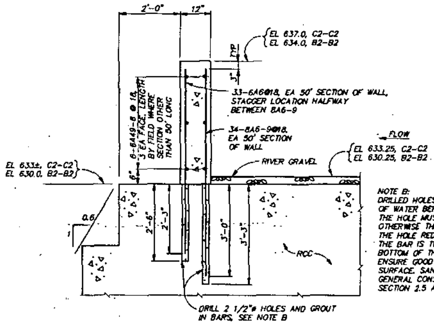


PROFILE – RCC DAM
LOOKING UPSTREAM
1" = 100' HORIZ
1" = 10' VERT

FIELD TO PROVIDE SMOOTH CURVE IN ALIGNMENT OF WALL TO MATCH CURVE IN ALIGNMENT OF RCC DAM

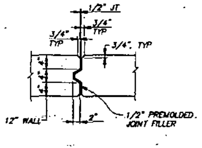


C2-C2
1/4" = 1'-0"

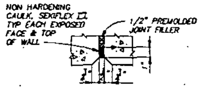


DET G2
3/4" = 1'-0"

NOTE B:
DRILLED HOLES FOR BARS ARE TO BE CLEAN AND FREE OF WATER BEFORE FILLING WITH SAND-CEMENT GROUT. THE HOLE MUST MAINTAIN THE INITIAL GROUT LEVEL. OTHERWISE THE GROUT SHALL BE ALLOWED TO SET, THE HOLE REDRILLED, AND THE PROCEDURE REPEATED. THE BAR IS TO BE FORCED INTO GROUT TO THE BOTTOM OF THE HOLE, THEN SHAKEN AND WORKED TO ENSURE GOOD BOND BETWEEN GROUT, BAR AND DRILLED SURFACE. SAND-CEMENT GROUT SHALL CONFORM TO GENERAL CONSTRUCTION SPECIFICATION G 32, SECTION 2.5 AND G 51.



PLAN-TYP WALL JOINT
1" = 1'-0"

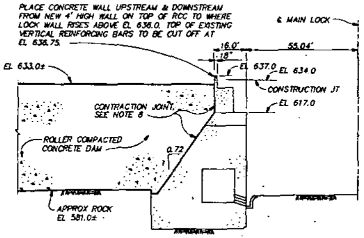


TYP JOINT FILLER
3" = 1'-0"

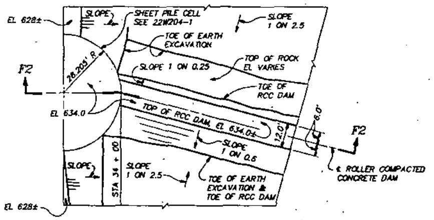
NOTES:

1. CONCRETE SHALL BE PLACED IN ACCORDANCE WITH TVA GENERAL CONSTRUCTION SPECIFICATION NO. G2. CONCRETE SHALL BE CLASS 300.75 AFW. MAXIMUM PLACING TEMPERATURE OF CONCRETE SHALL BE 85' F.
2. FORMWORK SHALL BE IN ACCORDANCE WITH TVA GENERAL CONSTRUCTION SPECIFICATION NO. G8. ALL SURFACES EXPOSED TO THE PUBLIC ACCESS VIEW SHALL HAVE A SMOOTH FORM FINISH.
3. CHAMFER ALL EXPOSED EDGES 3/4" UNLESS OTHERWISE NOTED. CLEAR COVER FROM FACE OF CONCRETE TO NEAREST REINFORCING BAR SHALL BE 2" UNLESS OTHERWISE NOTED. ALL OTHER DIMENSIONS ARE TO THE CENTERLINE OF REINFORCING.
4. WELDING OF OR TO HIGH STRENGTH REINFORCING BARS WITHOUT APPROVAL OF CIVIL ENGINEERING DEPARTMENT – HYDRO SUPPORT GROUP IS PROHIBITED.
5. FOR ROLLER COMPACTED CONCRETE (RCC) NOTES SEE 22W203-3.
6. CONTRACTION JOINT, TREAT ACCORDING TO SECTION 14.5 OF GENERAL CONSTRUCTION SPECIFICATION G2.
7. FOR DESIGN CALCULATIONS, SEE RIMS NUMBER B65 900207 048.

PLACE CONCRETE WALL UPSTREAM & DOWNSTREAM FROM NEW 4' HIGH WALL ON TOP OF RCC TO WHERE LOCK WALL RISES ABOVE EL 636.0. TOP OF EXISTING VERTICAL REINFORCING BARS TO BE CUT OFF AT EL 636.75.

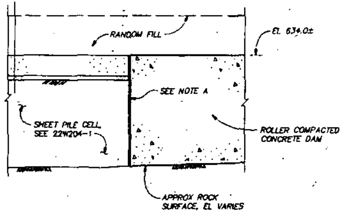


D2-D2 (SH 1)
1" = 20'



DET E2 (SH 1)
1" = 20'

NOTE A:
PRIOR TO PLACING RCC, SURFACE OF STEEL SHEET PILING TO BE CLEANED OF EARTH THROUGH WHICH IT WAS DRIVEN



F2-F2
1" = 10'

VAN DRC HAM HAM HAM CDW JHC cdw

REV NO	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD		AS CONST
2	10-7-92	VAN	DRC	HAM	HAM	HAM	CDW	JHC		CDW 9-15-92
REVISED DRAWING AS CONSTRUCTED.										
1	10-2-91	RLP	GLRH	VAN	HAM	HAM	CDW	JHC		
REMOVED HOLD, ADD CONC WALL, DETAILS & NOTES. MINOR REVISIONS										

2
1
0
KF
R2

SCALE: AS NOTED EXCEPT AS NOTED

RIGHT EMBANKMENT
ROLLER COMPACTED CONCRETE DAM

EMBANKMENT MODIFICATIONS
SECTIONS & DETAILS

NICKAJACK PROJECT
TENNESSEE VALLEY AUTHORITY

DESIGN
DESIGNED V.A. NEWELL
SUPERVISED H.A. MANSON
DRAWN D.B. COLLINS
REVIEWED H.A. MANSON
CHECKED H.A. MANSON

DISCIPLINE INTERFACE
1
2
3
4

ENGINEERING APPROVAL
C.D. WAGNER

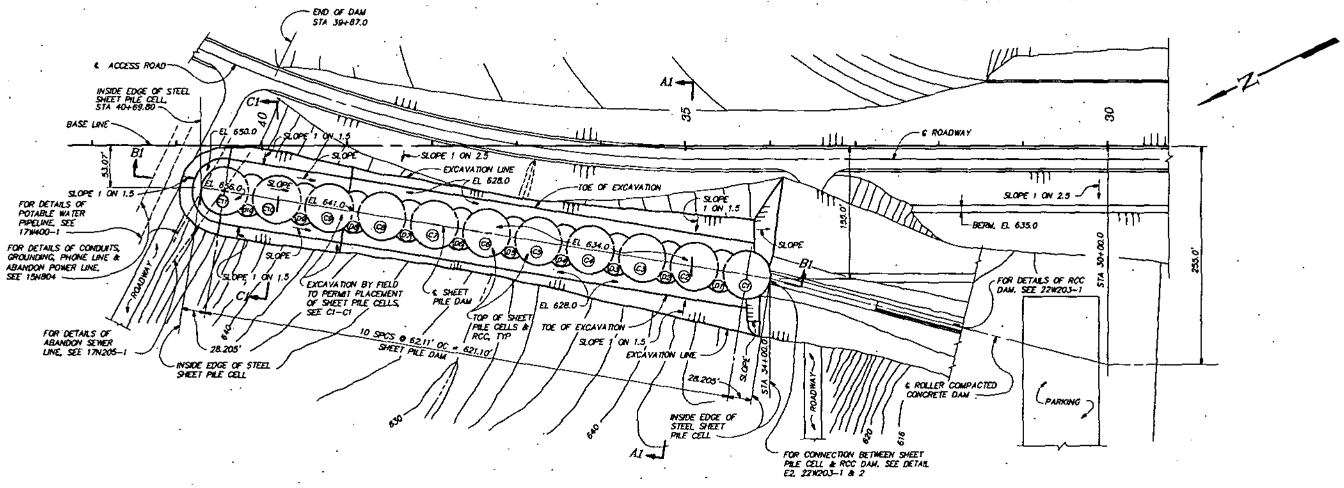
ENGINEERING | DATE 5-8-90 | 69 | C | 22W203-2 | R 2

ISSUED BY JAMES H. COULSON

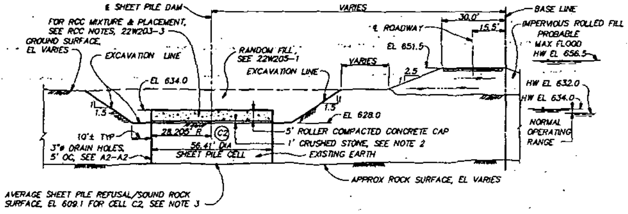
AS CONSTRUCTED

N22W2032

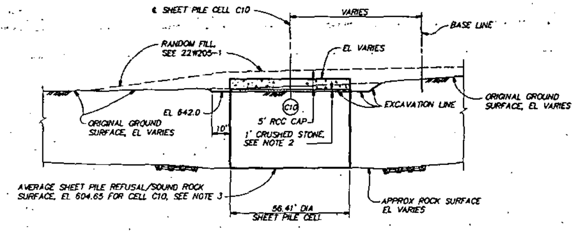
CAD SYSTEM ORIGINAL
DO NOT CHANGE MANUALLY



PART PLAN

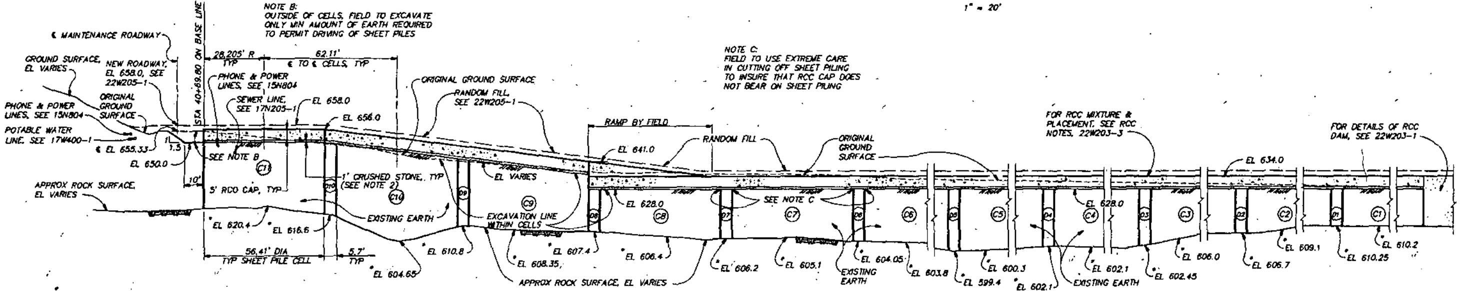


A1–A1
1" = 20'



C1–C1
1" = 20'

NOTES:
1. STEEL SHEET PILE SECTION SHALL BE PS27.5. STEEL T-PILE SECTIONS SHALL BE FT 3100 OR FT 3101.
2. CRUSHED STONE SHALL CONFORM TO SECTION 1032 OF THE NO. T-1 GENERAL CONSTRUCTION SPECIFICATION.
3. FOR FOUNDATION EXPLORATION AND FIELD INFORMATION, SEE RIMS B65 900123 029.
4. FOR SHEET PILE MILL TEST REPORTS, SEE RIMS NUMBER B65 920918 002.
5. FOR SHEET PILE STRUCTURAL DESIGN CALCULATIONS, SEE RIMS NUMBER B65 900207 048.



B1–B1
1" = 20'

		VAN	DRC	HAM	HAM	CDW	CDW	JHC		CDW	
2	10-7-92	VAN	DRC	HAM	HAM	CDW	CDW	JHC		CDW 9-23-92	2
	REVISED DRAWING AS CONSTRUCTED.										
1	11-2-90	VAN	DRC	HAM	HAM	CDW	CDW	JHC			1
	REV PART PLAN, SECTION B1-B1 AND C1-C1										
REV NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD		AS CONST	

SCALE: 1" = 60' EXCEPT AS NOTED 0

RIGHT EMBANKMENT
SHEET PILE DAM

MF: R2

EMBANKMENT MODIFICATIONS
PLAN, SECTIONS
& DETAILS

NICKAJACK PROJECT
TENNESSEE VALLEY AUTHORITY

DESIGN		DISCIPLINE INTERFACE		ENGINEERING APPROVAL
DESIGNED V A NEWELL	SUPERVISED H A MANSON	1 R G JOHNSON	2 C L WIMBERLY	C D WAGNER
DRAWN D R COLLINS	REVIEWED	3	4	
CHECKED H A MANSON				

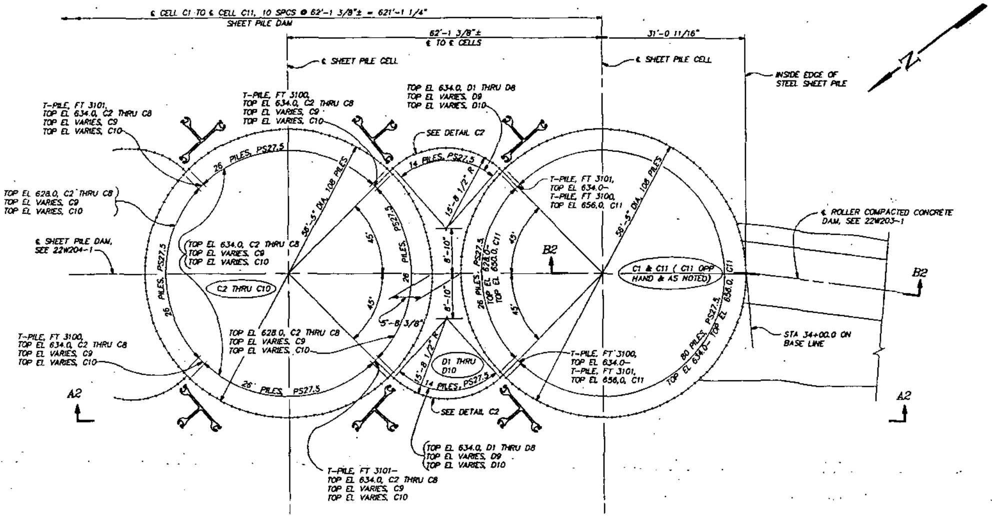
ENGINEERING | DATE 6-7-90 | 69 | C | 22W204-1 | R 2

AS CONSTRUCTED

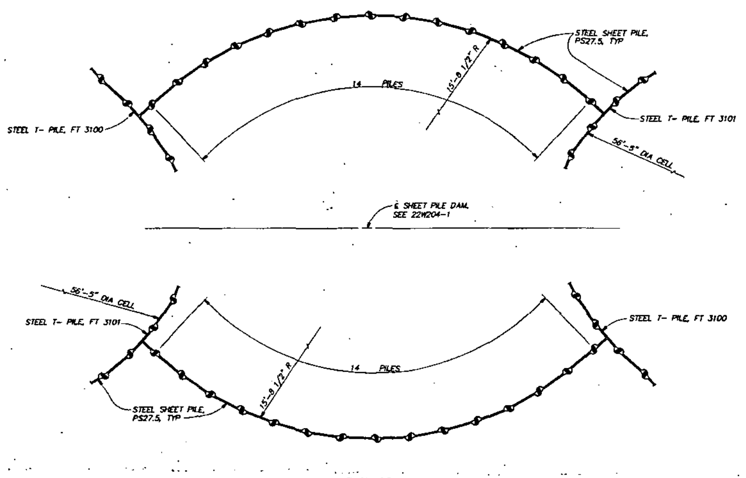
ISSUED BY: JAMES H COULSON

22WDRC4

CAD SYSTEM ORIGINAL
DO NOT CHANGE MANUALLY

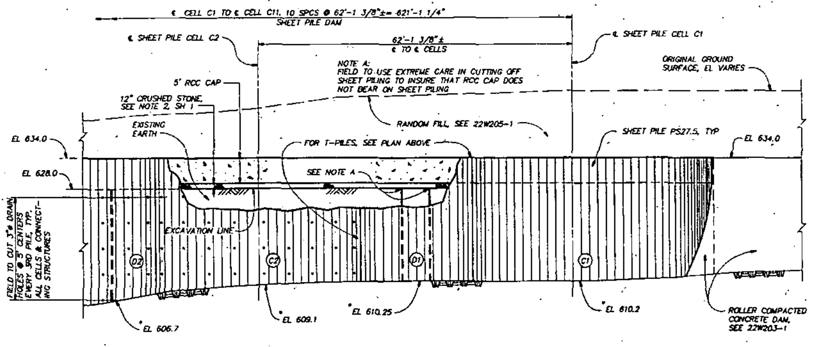


PLAN
SHEET PILE CELLS C1 THRU C11



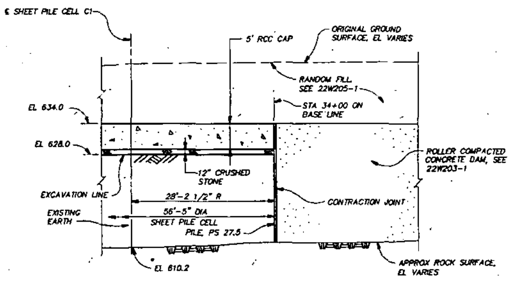
DETAIL C2
SHOWING TYP CONN BETWEEN CELLS
1/2" = 1'-0"

NOTES:
1. FOR LIST SEE 22W204-1.



*AVERAGE SHEET PILE REFUSAL/SOUND ROCK SURFACE PER CELL & DIAPHRAGM, SEE NOTE 3, SH 1

A2–A2
OUTSIDE EARTH REMOVED FOR CLARITY



B2–B2

2	10-7-92	VAN	DRC	HAM	HAM	CDW	CDW	JHC		CDW 9-23-92
	REVISED DRAWING AS CONSTRUCTED.									
1	11-2-90	VAN	DRC	HAM	HAM	CDW	CDW	JHC		
	REV PLAN									
REV NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD		AS CONST

SCALE: 1/8" = 1'-0" EXCEPT AS NOTED

RIGHT EMBANKMENT
SHEET PILE DAM

EMBANKMENT MODIFICATIONS PLAN, SECTIONS & DETAILS

NICKAJACK PROJECT
TENNESSEE VALLEY AUTHORITY

DESIGN		DISCIPLINE INTERFACE		ENGINEERING APPROVAL
DESIGNED V A NEWELL	SUPERVISED	1	2	
DRAWN D R COLLINS	H A MANSON	R G JOHNSON	G L WIMBERLY	C D WAGNER
CHECKED H A MANSON	REVIEWED	3	4	

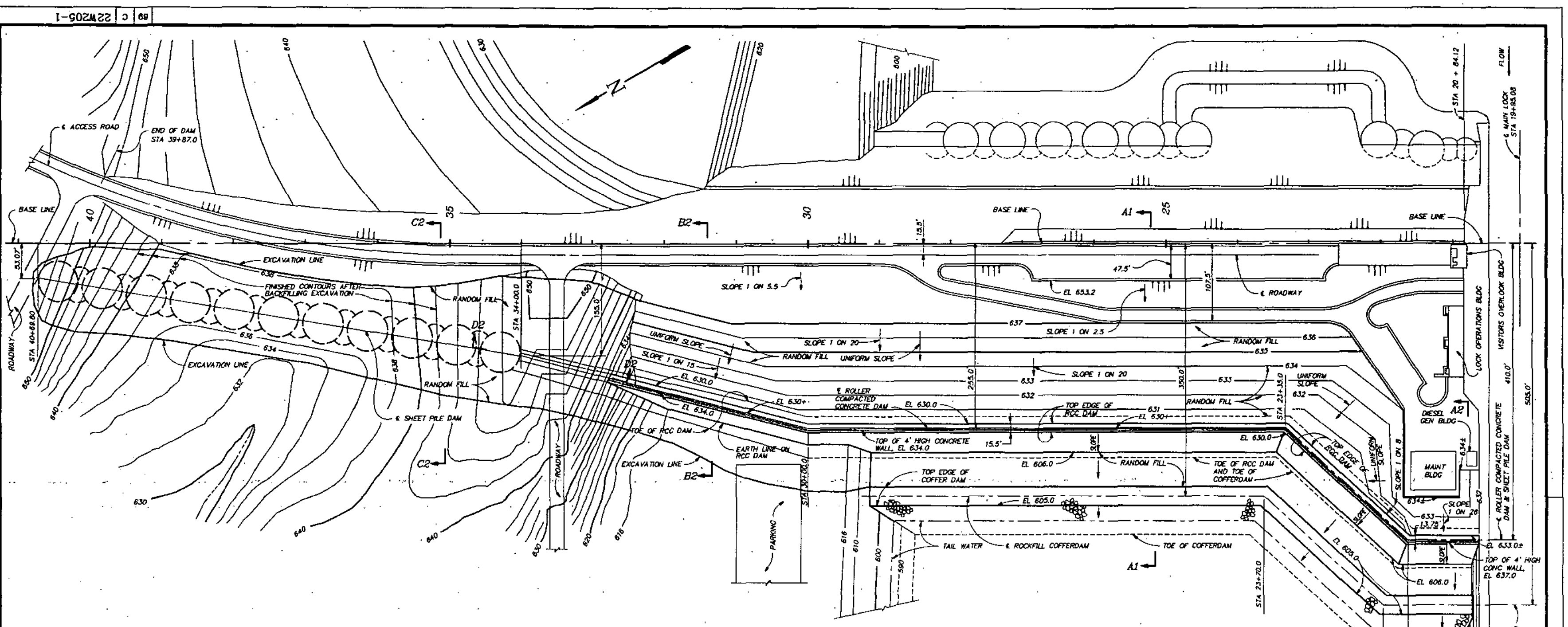
ENGINEERING	DATE 6-7-90	69	C	22W204-2	R 2

ISSUED BY: JAMES H COULSON

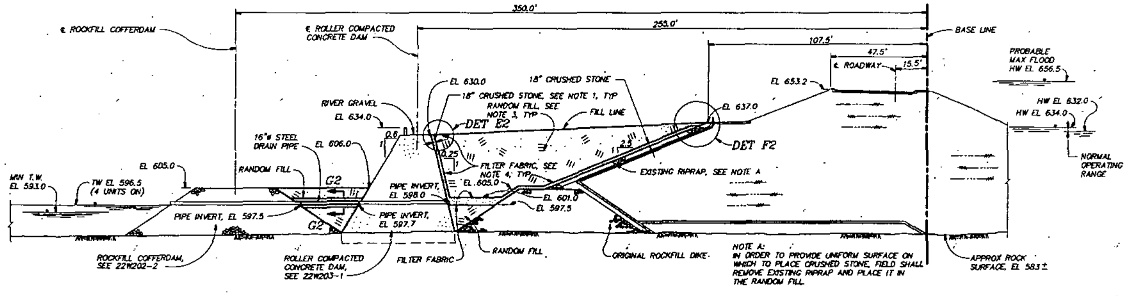
AS CONSTRUCTED:

CAD SYSTEM ORIGINAL
DO NOT CHANGE MANUALLY

22WDRC5



PLAN



NOTE A:
IN ORDER TO PROVIDE UNIFORM SURFACE ON WHICH TO PLACE CRUSHED STONE, FIELD SHALL REMOVE EXISTING RIPRAP AND PLACE IT IN THE RANDOM FILL.

A1–A1
1" = 20'

NOTES:
1. FOR NOTES SEE 22W205-2.

REV NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD		AS CONST
2	10-7-92	VAN	DRC	HAM	HAM	HAM	CDW	JHC		CDW 8-15-92
	REVISED DRAWING AS CONSTRUCTED									
1	10-18-91	VAN	GLRH	HAM	HAM	HAM	CDW	JHC		
	REV PLAN AND A1-A1									

SCALE: 1" = 60' EXCEPT AS NOTED

RIGHT EMBANKMENT
FINISHED GRADING

EMBANKMENT MODIFICATIONS
PLAN, SECTIONS AND DETAILS

NICKAJACK PROJECT
TENNESSEE VALLEY AUTHORITY

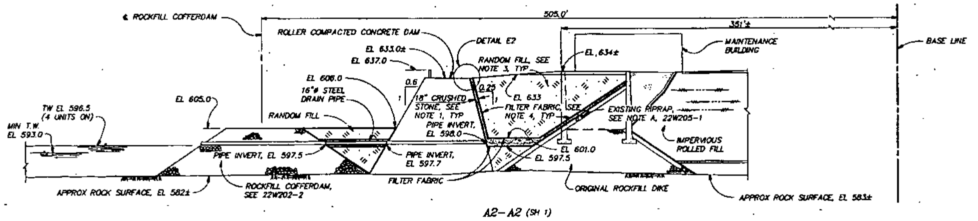
DESIGN		DISCIPLINE INTERFACE		ENGINEERING APPROVAL
DESIGNED V.A. NEWELL	SUPERVISED H.A. MANSON	1	2	C.D. WAGNER
DRAWN D.B. COLLINS CHECKED H.A. MANSON	REVIEWED C.D. WAGNER	3	4	

ENGINEERING DATE 10-30-90 | 69 | C | 22W205-1 | R 2

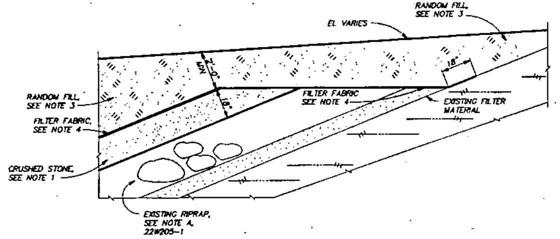
AS CONSTRUCTED:

ISSUED BY: JAMES H. COULSON

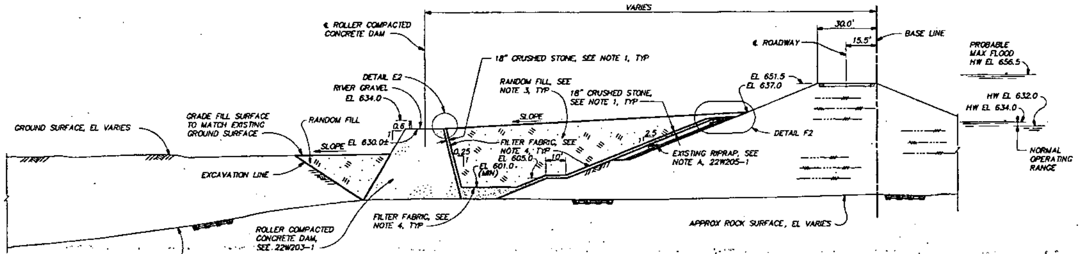
CAD SYSTEM ORIGINAL
DO NOT CHANGE MANUALLY



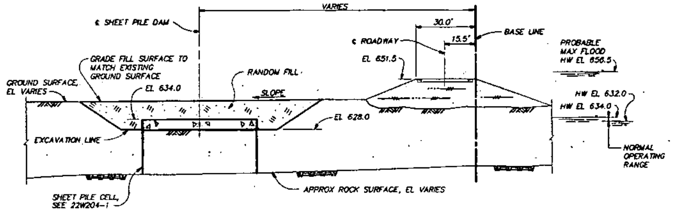
A2–A2 (SH 1)



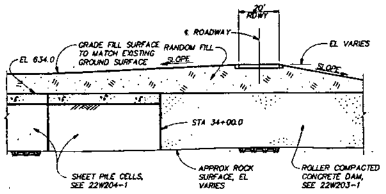
DETAIL F2
½" = 1'-0"



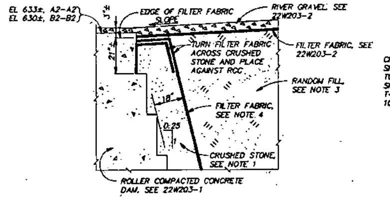
B2–B2 (SH 1)



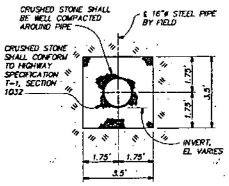
C2–C2 (SH 1)



D2–D2 (SH 1)



DETAIL E2
½" = 1'-0"



G2–G2 (SH 1)
½" = 1'-0"

NOTES:

1. CRUSHED STONE FOR DRAINAGE SYSTEM SHALL CONFORM TO HIGHWAY SPECIFICATION T-1, SECTION 1081.
2. ALL EARTHWORK SHALL BE IN ACCORDANCE WITH TVA CONSTRUCTION SPECIFICATION G-9.
3. RANDOM FILL MATERIAL MAY CONSIST OF FINE GRAIN SOILS; SANDY SOILS; OR GRAVELLY SOILS BLENDED WITH SAND, CLAY OR SILT. ORGANIC MATERIAL SUCH AS HUMUS, ROOTS, ETC. IS NOT PERMITTED. EXISTING RIPRAP REMOVED FROM THE DAM SURFACE MAY BE PLACED IN THE RANDOM FILL PROVIDED LARGER STONES ARE PLACED SO THAT THEY ARE TOTALLY SURROUNDED BY FINER GRAINED MATERIAL AND NO VOIDS ARE CREATED IN THE FILL. RANDOM FILL SHALL BE PLACED IN 8" LAYERS AND THOROUGHLY COMPACTED. NO MOISTURE CONTROL IS REQUIRED IN THE RANDOM FILL. A MINIMUM 12" THICK LAYER OF FINE GRAINED SOILS SHALL BE PLACED AND COMPACTED ON TOP OF THE RANDOM FILL TO PERMIT GRASSING AND TO PREVENT EROSION OF THE SANDY MATERIALS.
4. FILTER FABRIC SHALL BE INSTALLED IN ACCORDANCE WITH HIGHWAY SPECIFICATION T-1, SECTION 571. THE STRIPS OF FABRIC SHALL BE PLACED TO PROVIDE A MINIMUM WIDTH OF OVERLAP OF 18" FOR EACH JOINT. THE WORK SHALL BE SCHEDULED SO THAT THE COVERING OF THE FABRIC WITH A LAYER OF RANDOM FILL IS ACCOMPLISHED WITHIN 14 DAYS AFTER PLACEMENT OF THE FABRIC. SHOULD THE FABRIC BE DAMAGED DURING CONSTRUCTION, THE DAMAGED SECTION SHALL BE REPAIRED BY OVERLAYING THE DAMAGED SECTION WITH A PIECE OF FABRIC THAT IS LARGE ENOUGH TO COVER THE DAMAGED AREA AND TO MEET THE OVERLAP REQUIREMENT.
5. FILTER FABRIC SHALL BE PHILLIPS 66 SUPAC 12NP (NONWOVEN), OR EQUIVALENT.

REV NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD			AS CONST
2	10-7-92	VAN	DRC	HAM	HAM	HAM	CDW	JHC		CDW 9-15-92
	REVISED DRAWING AS CONSTRUCTED.									
1	10-18-91	VAN	GLRH	HAM	HAM	HAM	CDW	JHC		
	REV A2-A2, B2-B2, DET E2 AND DET F2									

SCALE: 1" = 20' EXCEPT AS NOTED

RIGHT EMBANKMENT
FINISHED GRADING

EMBANKMENT MODIFICATIONS
SECTIONS & DETAILS

NICKAJACK PROJECT
TENNESSEE VALLEY AUTHORITY

DESIGN		DISCIPLINE INTERFACE		ENGINEERING APPROVAL
DESIGNED V.A. NEWELL	SUPERVISED H.A. MANSON	1	2	C.D. WAGNER
DRAWN D.R. COLLINS				
CHECKED H.A. MANSON	REVIEWED C.D. WAGNER	3	4	

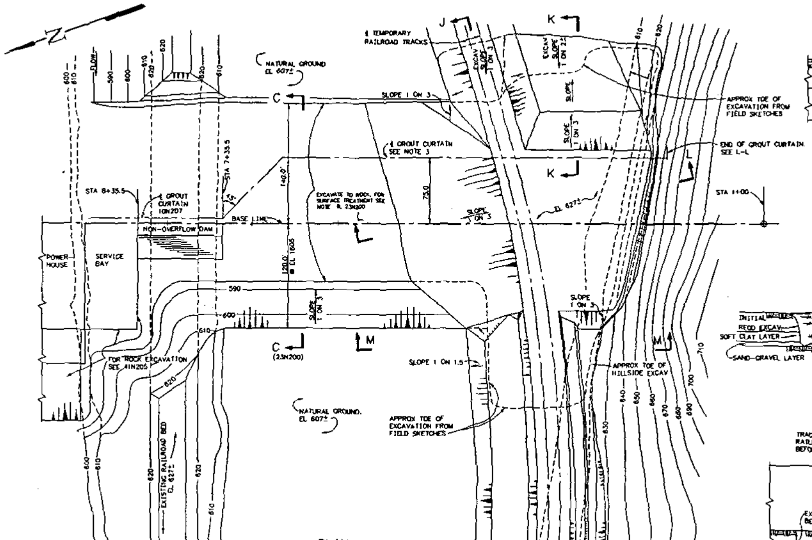
ENGINEERING DATE 10-30-90 | 69 | C | 22W205-2 | R 2

AS CONSTRUCTED:

ISSUED BY JAMES H. COULSON

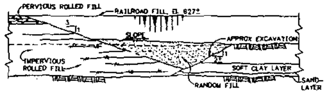
K22W2052

CAD SYSTEM ORIGINAL
DO NOT CHANGE MANUALLY



PLAN

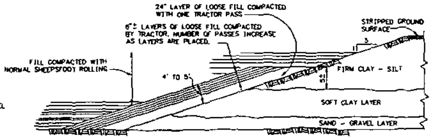
SHOWING EXCAVATION & TEMPORARY-RAILROAD FILL



K – K

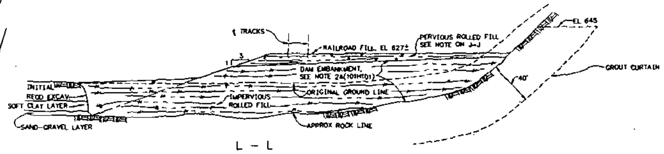
SHOWING INITIAL EXCAV & TEMPORARY-RAILROAD FILL

SCALE 1"=30'



FILL PLACEMENT ON SOFT CLAY LAYER

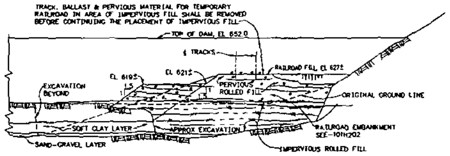
SCALE 1"=10'



L – L

SHOWING INITIAL EXCAV & TEMPORARY-RAILROAD FILL

SCALE 1"=30'



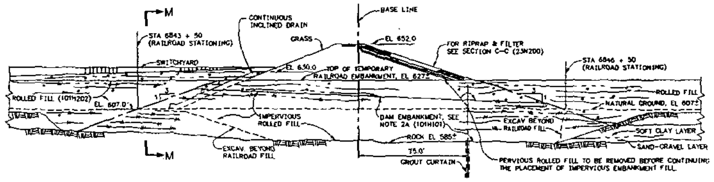
M – M

SHOWING INITIAL EXCAV & TEMPORARY-RAILROAD FILL

SCALE 1"=30'

NOTES:

1. FOR GENERAL NOTES SEE 23W200.
2. THE INITIAL EXCAVATION SHOWN WAS DONE IN THE SUMMER AND FALL OF 1964 FOR CONSTRUCTION OF THAT PORTION OF THE EMBANKMENT FOR THE TEMPORARY RAILROAD LYING WITHIN THE LIMITS OF THE EARTH DAM. THE EXCAVATION WAS NECESSARY BECAUSE ROUGH EXCAVATION HAD REMOVED EARTH ABOVE THE SOFT CLAY LAYER AND FILL COULD NOT BE COMPACTED ON THE SOFT MATERIAL.
3. A GROUT CURTAIN SHALL BE PROVIDED AT THE LOCATION SHOWN ON PLAN AND SECTION L-L IN ACCORDANCE WITH GENERAL CONSTRUCTION SPECIFICATION G-26. FOR GROUTING RECORD SEE FIELD OFFICE DRAWING 69-PC-4-10K10174.



SECTION J–J

SCALE 1"= 30'

COMPANION DRAWING: 23W200

R 3	3-10-97	CEC	JMR	SRK	TKM	JEV	JEV	JEV		
REDRAWN TO CAD FORMAT										

SCALE: 1"=50' EXCEPT AS NOTED

LEFT EMBANKMENT

PLAN, SECTIONS & DETAILS
SHEET – 2

DESIGNED BY	DRAWN BY	CHECKED BY	SUPERVISED BY	REVIEWED BY	APPROVED BY	ISSUED BY
CBP	CBP & JRB	DPW	HD		WCB	

NICKAJACK HYDRO PROJECT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

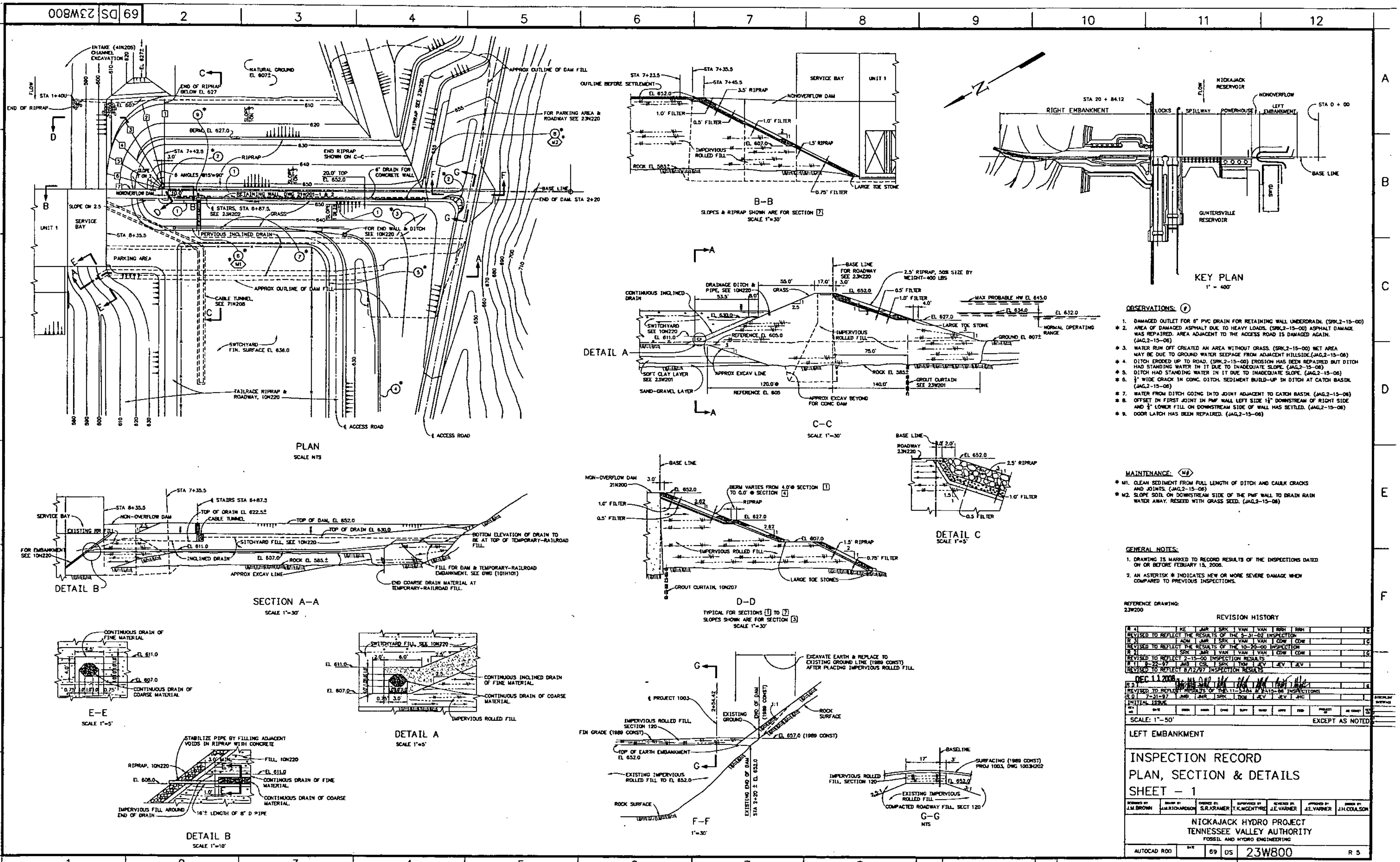
AUTOCAD R12 | 10-4-65 | 69 | C | 23W201 | R 3

ELECTRONICALLY RESTORED DRAWING
THIS DRAWING HAS BEEN COMPLETELY REDRAWN
AND SUPERSEDES :(23N201, R2)

PLOT FACTOR:600
W_TVA

C.A.D. DRAWING
DO NOT ALTER MANUALLY

MF
R3



OBSERVATIONS: (#)

1. DAMAGED OUTLET FOR 6" PVC DRAIN FOR RETAINING WALL UNDERDRAIN. (SRK,2-15-00)
* 2. AREA OF DAMAGED ASPHALT DUE TO HEAVY LOADS. (SRK,2-15-00) ASPHALT DAMAGE WAS REPAIRED. AREA ADJACENT TO THE ACCESS ROAD IS DAMAGED AGAIN. (JAG,2-15-06)
* 3. WATER RUN OFF CREATED AN AREA WITHOUT GRASS. (SRK,2-15-00) WET AREA MAY BE DUE TO GROUND WATER SEEPAGE FROM ADJACENT HILLSIDE.(JAG,2-15-06)
* 4. DITCH ERODED UP TO ROAD. (SRK,2-15-00) EROSION HAS BEEN REPAIRED BUT DITCH HAD STANDING WATER IN IT DUE TO INADEQUATE SLOPE. (JAG,2-15-06)
* 5. DITCH HAD STANDING WATER IN IT DUE TO INADEQUATE SLOPE. (JAG,2-15-06)
* 6. $\frac{1}{2}$" WIDE CRACK IN CONC. DITCH. SEDIMENT BUILD-UP IN DITCH AT CATCH BASIN. (JAG,2-15-06)
* 7. WATER FROM DITCH GOING INTO JOINT ADJACENT TO CATCH BASIN. (JAG,2-15-06)
* 8. OFFSET IN FIRST JOINT IN PMF WALL LEFT SIDE 1$\frac{1}{2}$" DOWNSTREAM OF RIGHT SIDE AND $\frac{1}{2}$" LOWER FILL ON DOWNSTREAM SIDE OF WALL HAS SETTLED. (JAG,2-15-06)
* 9. DOOR LATCH HAS BEEN REPAIRED. (JAG,2-15-06)

MAINTENANCE: ⟨M#⟩

* M1. CLEAN SEDIMENT FROM FULL LENGTH OF DITCH AND CAULK CRACKS AND JOINTS. (JAG,2-15-06)
* M2. SLOPE SOIL ON DOWNSTREAM SIDE OF THE PMF WALL TO DRAIN RAIN WATER AWAY. RESEED WITH GRASS SEED. (JAG,2-15-06)

GENERAL NOTES:

1. DRAWING IS MARKED TO RECORD RESULTS OF THE INSPECTIONS DATED ON OR BEFORE FEBUARY 15, 2006.
2. AN ASTERISK * INDICATES NEW OR MORE SEVERE DAMAGE WHEN COMPARED TO PREVIOUS INSPECTIONS.

REFERENCE DRAWING:
23W200

REVISION HISTORY

R 4		KE	JMR	SRK	VAN	VAN	RRH	RRH			C
REVISED TO REFLECT THE RESULTS OF THE 5-31-02 INSPECTION											
R 3		ADM	JMR	SRK	VAN	VAN	CDW	CDW			C
REVISED TO REFLECT THE RESULTS OF THE 10-20-00 INSPECTION											
R 2		SRK	JMR	VAN	VAN	VAN	CDW	CDW			C
REVISED TO REFLECT 2-15-00 INSPECTION RESULTS											
R 1	9-22-97	JMB	CSL	SRK	TKM	JEV	JEV	JEV			
REVISED TO REFLECT 8/12/97 INSPECTION RESULTS											
R 5	DEC 11 2006										C
REVISED TO REFLECT RESULTS OF THE 11-5-04 & 2-15-06 INSPECTIONS											
R 0	7-31-97	JMB	JMR	SRK	TKM	JEV	JEV	JHC			
INITIAL ISSUE											

SCALE: 1"-50' EXCEPT AS NOTED

LEFT EMBANKMENT

INSPECTION RECORD
PLAN, SECTION & DETAILS
SHEET - 1

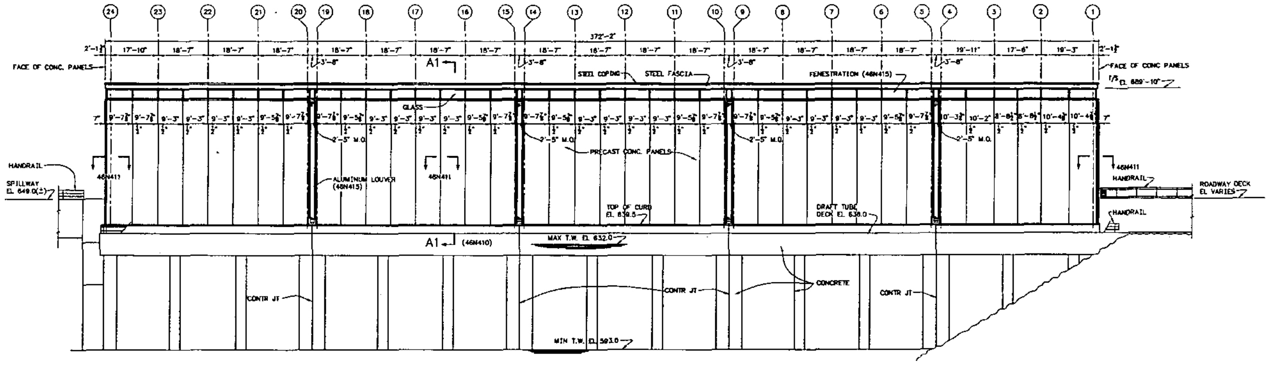
DESIGNED BY	DRAWN BY	CHECKED BY	SUPERVISED BY	REVIEWED BY	APPROVED BY	ISSUED BY
J.M.BROWN	J.M.RICHARDSON	S.R.KRAMER	T.K.MCENTYRE	J.E.VARNER	J.E.VARNER	J.H.COULSON

NICKAJACK HYDRO PROJECT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

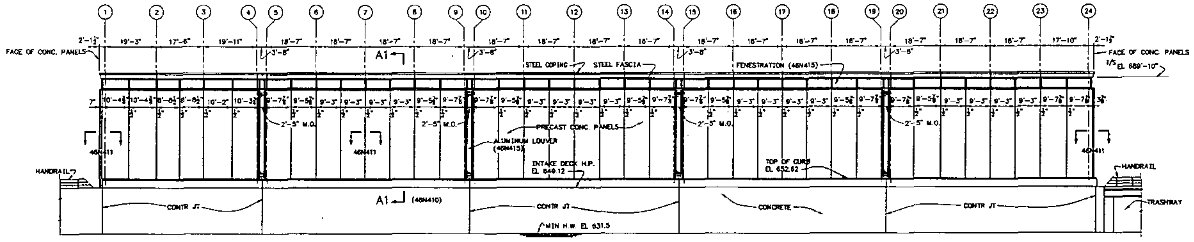
AUTOCAD R00 | DATE | 69 | DS | 23W800 | R 5

PLOT FACTOR:600
W_TVA

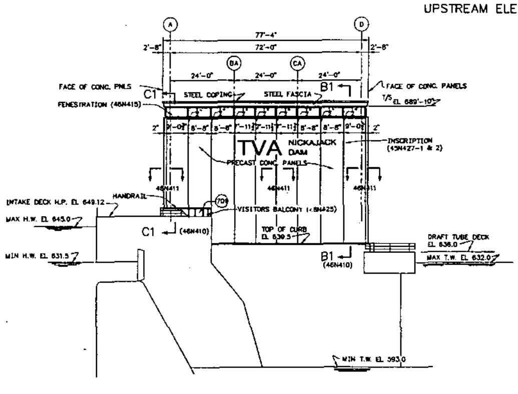
C.A.D. DRAWING
DO NOT ALTER MANUALLY



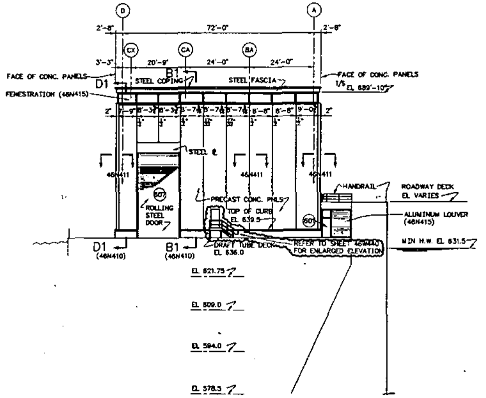
DOWNSTREAM ELEVATION



UPSTREAM ELEVATION



NORTH ELEVATION



SOUTH ELEVATION

NOTES:
FOR SECTIONS & DETAILS SEE 46N410, 411.
DIMENSIONS SHOWN ON ELEVATIONS ARE EXACT PANEL DIMENSIONS.

R											
		PDR	BLK	HYW	MSM		CCM	MAC			
R 5	OCT 1 9 2005	PDH	BLK	HYW	MSM	N/A	CCM	MAC	KY0058	—	D
DCN NJH-05-30: REVISED FOR LIFE SAFETY CIVIL/ARCH MODIFICATIONS											

SCALE: $\frac{1}{16}$"=1'-0" EXCEPT AS NOTED

POWERHOUSE

ARCHITECTURAL
ELEVATIONS

NICKAJACK HYDRO PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD R2000 | 10-19-65 | 69 | A | 46W401 | R 5

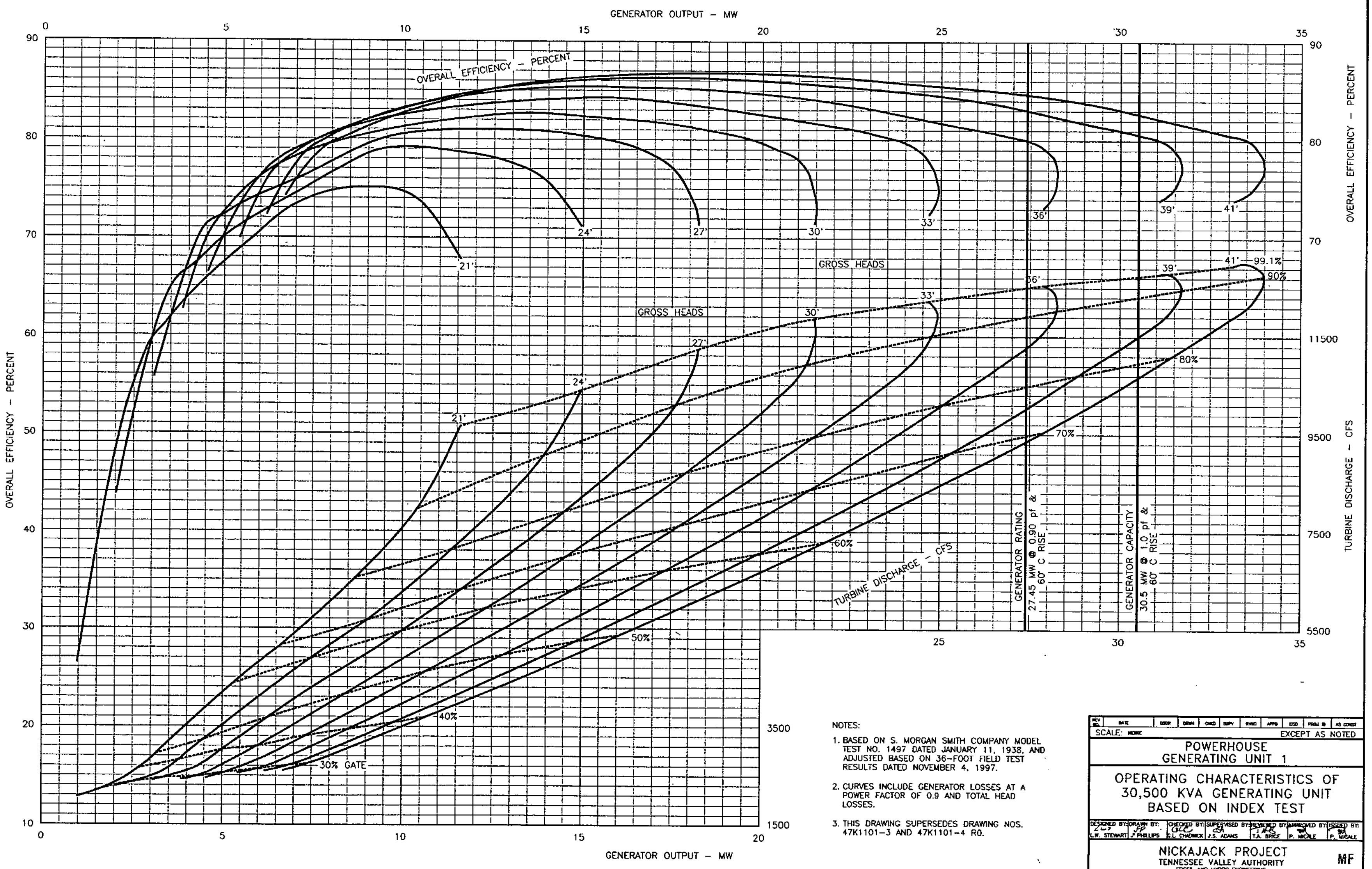
MESA ASSOCIATES, INC.
TASK COMPLETED BY:
5
REV NO.

ELECTRONICALLY RESTORED DRAWING
THIS DRAWING HAS BEEN COMPLETELY REDRAWN
AND SUPERSEDES :(46N401 R4)

PLOT FACTOR:192
W_TVA

C.A.D. DRAWING
DO NOT ALTER MANUALLY

69 | M | 47K1102-1



NOTES:

1. BASED ON S. MORGAN SMITH COMPANY MODEL TEST NO. 1497 DATED JANUARY 11, 1938, AND ADJUSTED BASED ON 36-FOOT FIELD TEST RESULTS DATED NOVEMBER 4, 1997.
2. CURVES INCLUDE GENERATOR LOSSES AT A POWER FACTOR OF 0.9 AND TOTAL HEAD LOSSES.
3. THIS DRAWING SUPERSEDES DRAWING NOS. 47K1101-3 AND 47K1101-4 R0.

REV NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJ ID	AS CONST

SCALE: NONE EXCEPT AS NOTED

POWERHOUSE
GENERATING UNIT 1

OPERATING CHARACTERISTICS OF
30,500 KVA GENERATING UNIT
BASED ON INDEX TEST

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
L.W. STEWART	J. PHILLIPS	C.L. CHADWICK	J.S. ADAMS	T.A. BRICE	P. MICALE	P. MICALE

NICKAJACK PROJECT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING
MF

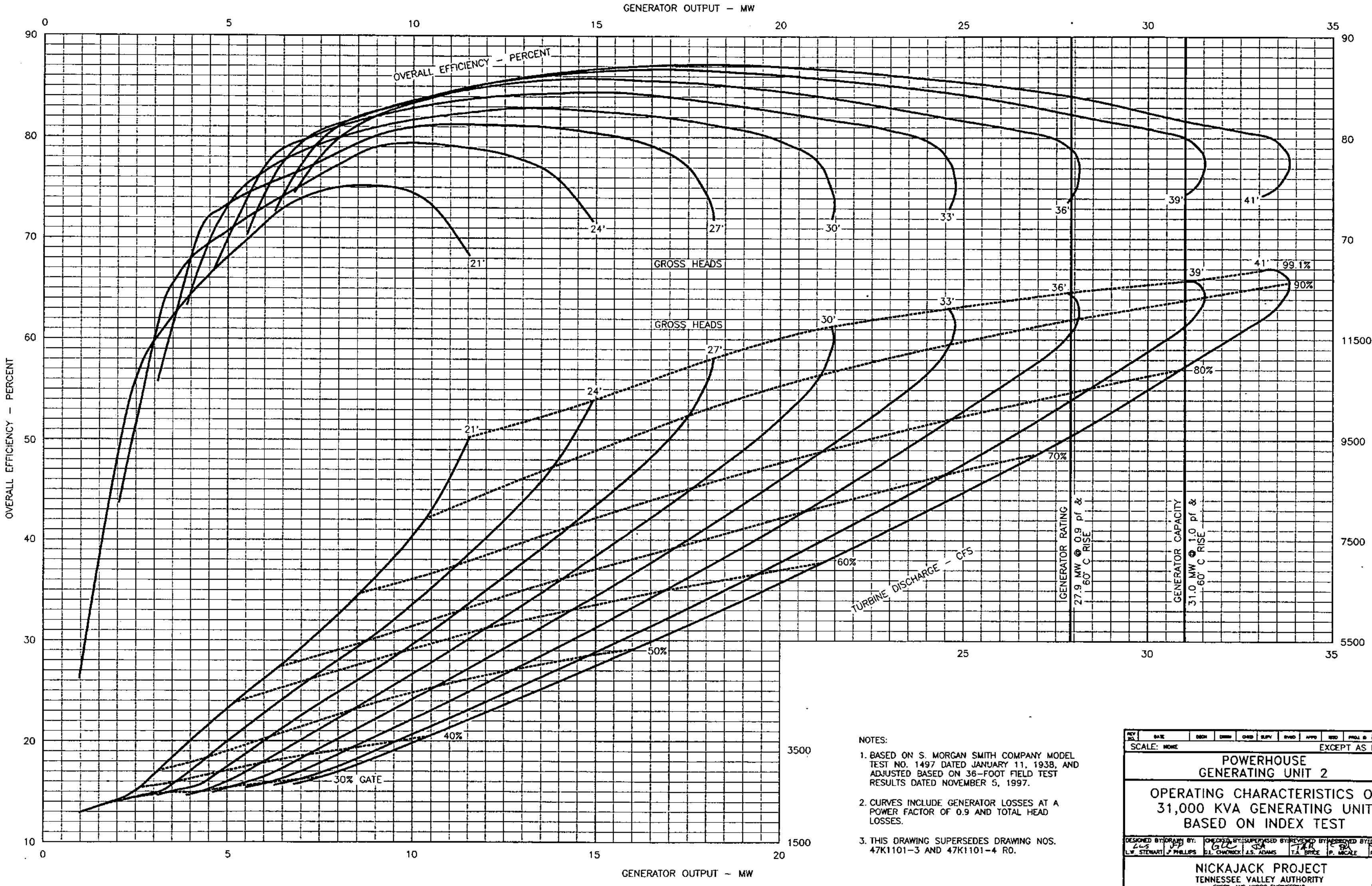
AUTOCAD R12 | DATE 12/15/00 | 69 | M | 47K1102-1 R0

ISSUED BY: PMicale

CAD SYSTEM DRAWING
DO NOT ALTER MANUALLY

DRAWING PLOT FACTOR: 1=1
INSERTED DRAWING: X=1,Y=1.34

69 | M | 47K1102-2



NOTES:

1. BASED ON S. MORGAN SMITH COMPANY MODEL TEST NO. 1497 DATED JANUARY 11, 1938, AND ADJUSTED BASED ON 36–FOOT FIELD TEST RESULTS DATED NOVEMBER 5, 1997.
2. CURVES INCLUDE GENERATOR LOSSES AT A POWER FACTOR OF 0.9 AND TOTAL HEAD LOSSES.
3. THIS DRAWING SUPERSEDES DRAWING NOS. 47K1101–3 AND 47K1101–4 R0.

REV NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJ ID	AS CONST

SCALE: NONE EXCEPT AS NOTED

POWERHOUSE
GENERATING UNIT 2

OPERATING CHARACTERISTICS OF
31,000 KVA GENERATING UNIT
BASED ON INDEX TEST

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
LWS L.W. STEWART	JP J PHILLIPS	GLC G.L. CHADWICK	JSA J.S. ADAMS	TAB T.A. BRICE	PM P. MICALE	PM P. MICALE

NICKAJACK PROJECT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING
MF

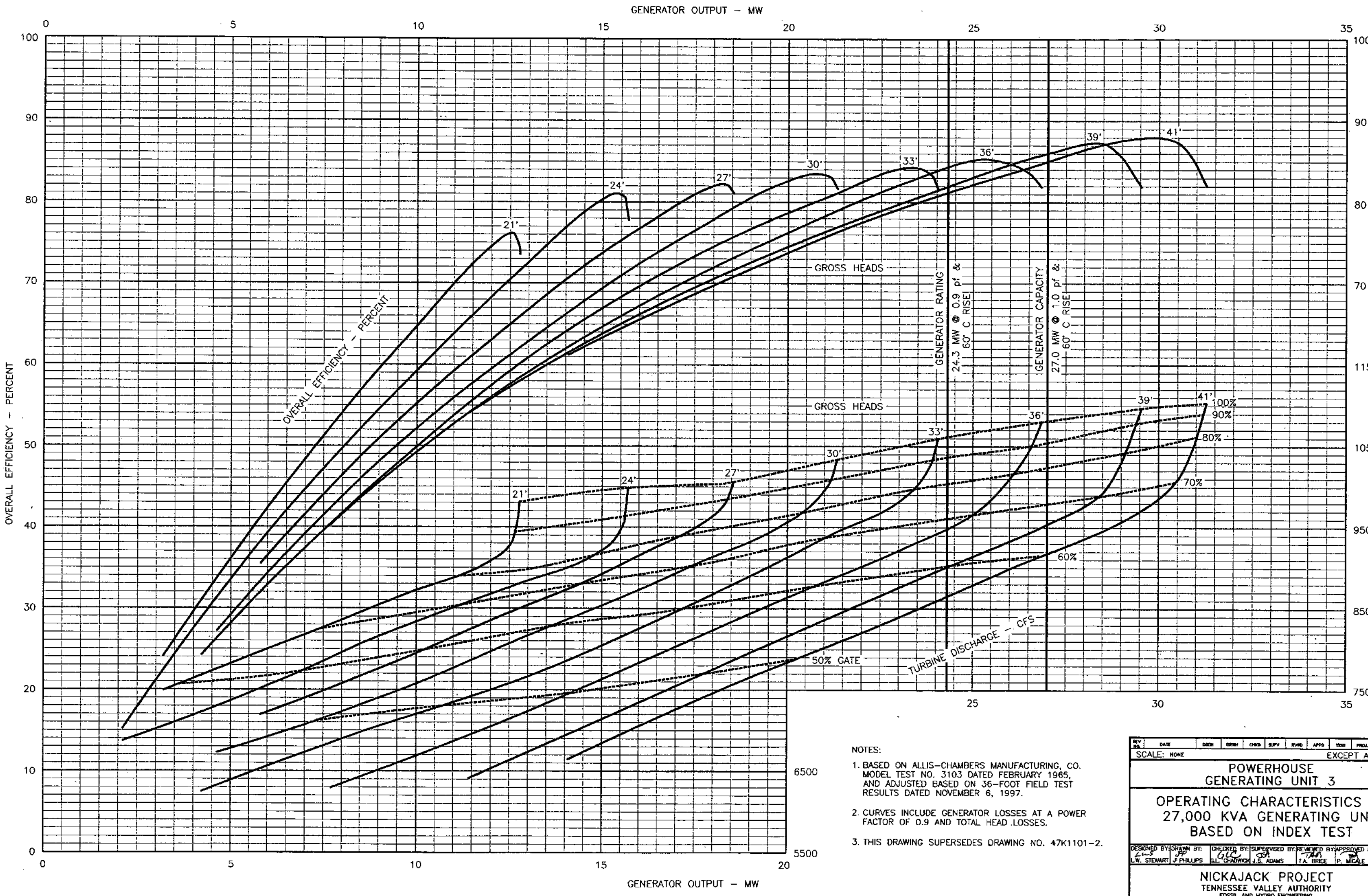
AUTOCAD R12	DATE ~~10/10/00~~ 1/5/01	69	M		47K1102–2	R0

ISSUED BY: PMicale

CAD SYSTEM DRAWING
DO NOT ALTER MANUALLY

DRAWING PLOT FACTOR: 1=1
INSERTED DRAWING: X=1,Y=1.08

69 M 47K1102-3



NOTES:

1. BASED ON ALLIS-CHAMBERS MANUFACTURING, CO. MODEL TEST NO. 3103 DATED FEBRUARY 1965, AND ADJUSTED BASED ON 36-FOOT FIELD TEST RESULTS DATED NOVEMBER 6, 1997.
2. CURVES INCLUDE GENERATOR LOSSES AT A POWER FACTOR OF 0.9 AND TOTAL HEAD .LOSSES.
3. THIS DRAWING SUPERSEDES DRAWING NO. 47K1101-2.

REV NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	TESD	PROJ. ID	AS CONST

SCALE: NONE EXCEPT AS NOTED

POWERHOUSE
GENERATING UNIT 3

OPERATING CHARACTERISTICS OF
27,000 KVA GENERATING UNIT
BASED ON INDEX TEST

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
LWS L.W. STEWART	JP J. PHILLIPS	GLC G.L. CHADWICK	JSA J.S. ADAMS	TAB T.A. BRICE	P. MICALE	P. MICALE

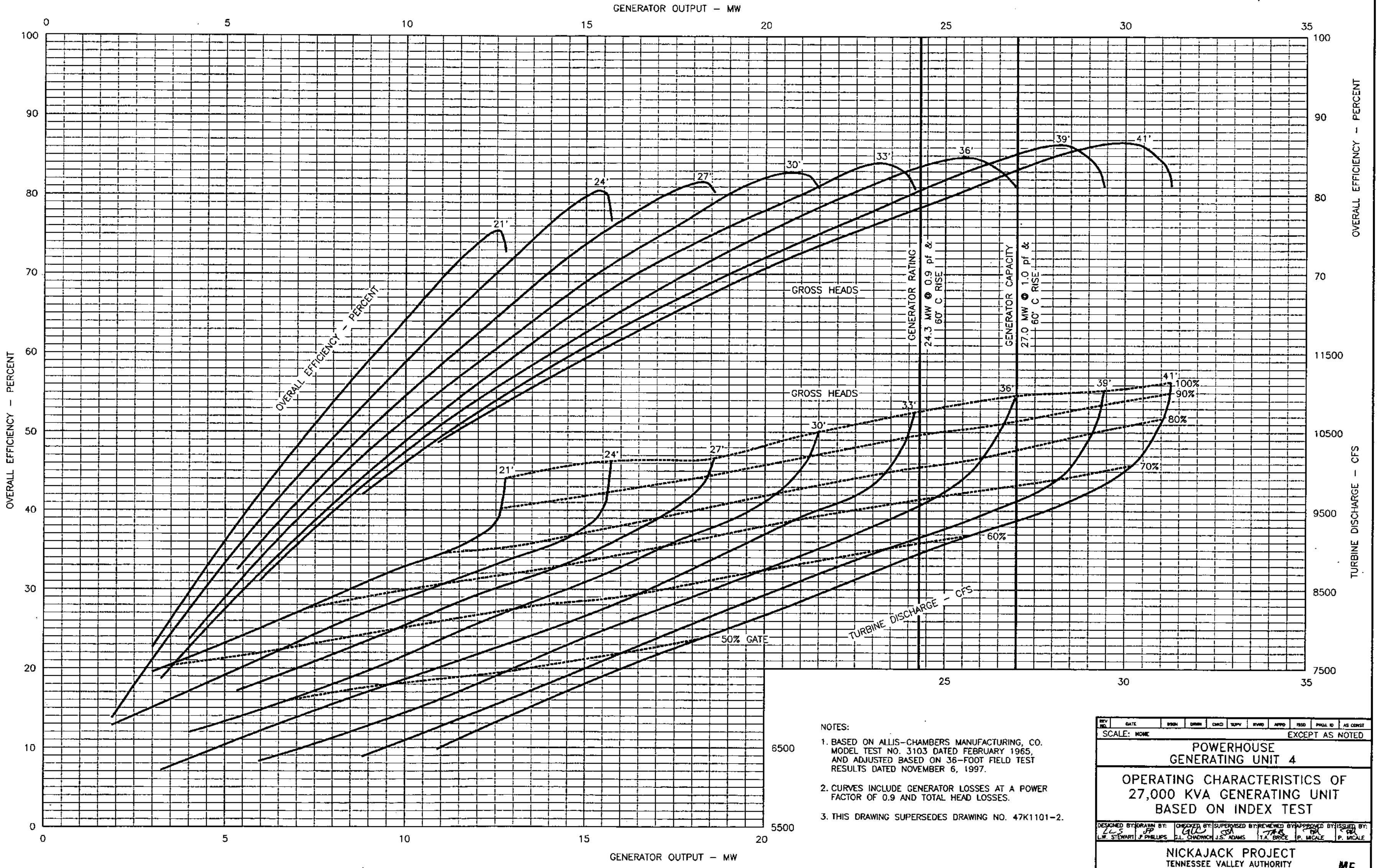
NICKAJACK PROJECT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING
MF

AUTOCAD R12	DATE ~~10/2/00~~	69	M		47K1102-3	R0

ISSUED BY: PMicale

CAD SYSTEM DRAWING
DO NOT ALTER MANUALLY

DRAWING PLOT FACTOR: 1=1
INSERTED DRAWING: X=1,Y=1



NOTES:

1. BASED ON ALLIS–CHAMBERS MANUFACTURING, CO. MODEL TEST NO. 3103 DATED FEBRUARY 1965, AND ADJUSTED BASED ON 36–FOOT FIELD TEST RESULTS DATED NOVEMBER 6, 1997.
2. CURVES INCLUDE GENERATOR LOSSES AT A POWER FACTOR OF 0.9 AND TOTAL HEAD LOSSES.
3. THIS DRAWING SUPERSEDES DRAWING NO. 47K1101–2.

REV NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJ. ID	AS CONST

SCALE: NONE EXCEPT AS NOTED

POWERHOUSE
GENERATING UNIT 4

OPERATING CHARACTERISTICS OF
27,000 KVA GENERATING UNIT
BASED ON INDEX TEST

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
LWS L.W. STEWART	JP J PHILLIPS	GLC G.L. CHADWICK	JSA J.S. ADAMS	TAB T.A. BRICE	PM P. MICALE	PM P. MICALE

NICKAJACK PROJECT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING
MF

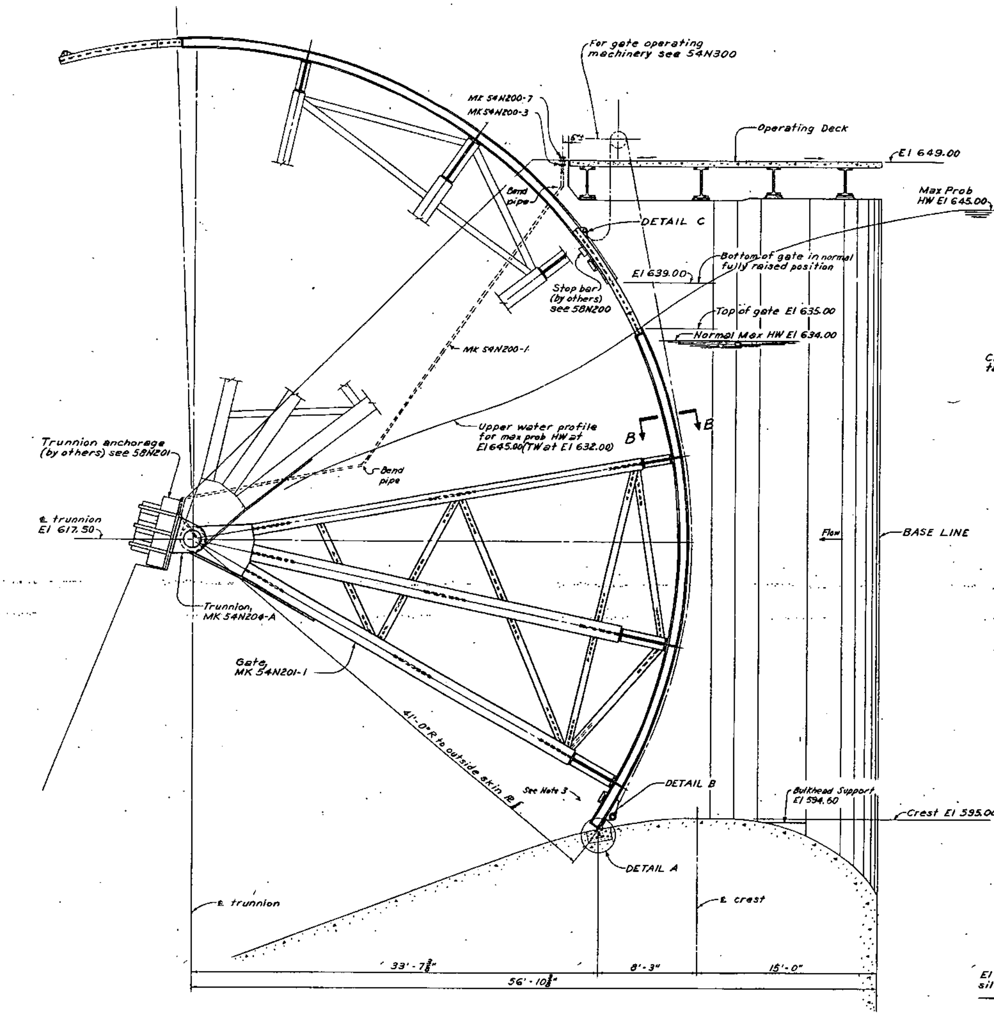
AUTOCAD R12	DATE [illegible]	69	M		47K1102–4	R0

ISSUED BY: PMicale

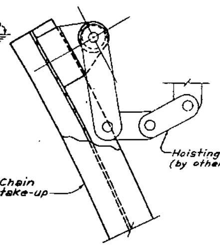
CAD SYSTEM DRAWING
DO NOT ALTER MANUALLY

DRAWING PLOT FACTOR: 1=1
INSERTED DRAWING: X=1,Y=1

54N200

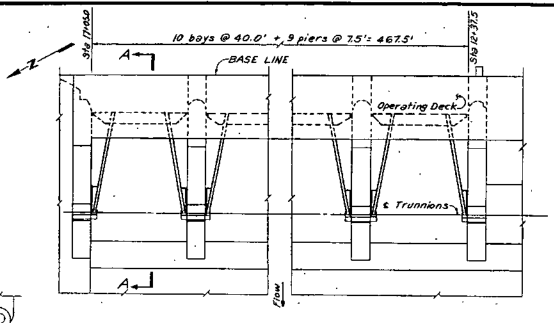


SECTION A-A



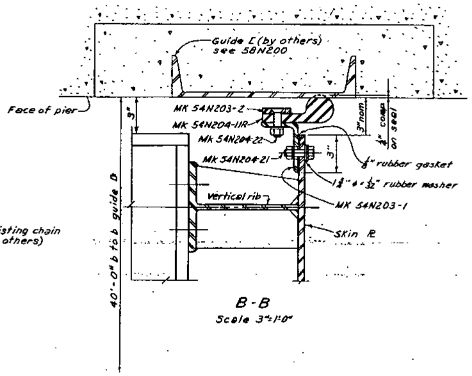
DETAIL C

Scale 1½"=1'-0"



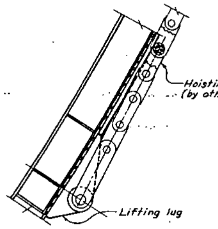
KEY PLAN

Scale 1"=20'



B-B

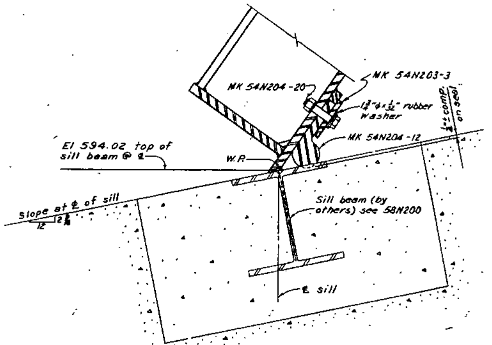
Scale 3"=1'-0"



DETAIL B

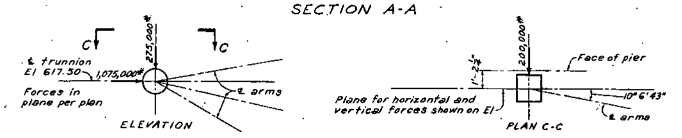
Scale 1½"=1'-0"

NOTES
1. Lubrication piping & fittings, MKs 54N200-1 thru 7, by TVA Field per Bill of Material 54BM200
2. For mfr's details of gates refer to Lakeside Bridge & Steel Co file, TVA Contract No 65C52-62892
3. For additional bracing on gate No 5 (with No 1 at North end of spillway) see Field dwg 54K10286 R1



DETAIL A

Scale 3"=1'-0"



TRUNNION LOADING DIAGRAM

MAX LOADS FOR ONE TRUNNION
OCCURS WITH MAX HW AND GATE SLIGHTLY OPEN

Scale ¼"=1'-0"
Except as Noted

SPILLWAY

RADIAL GATES ARRANGEMENT

NICKAJACK PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF ENGINEERING DESIGN

SUBMITTED S. Kesler
RECOMMENDED B. Titus
APPROVED W. L. Boop

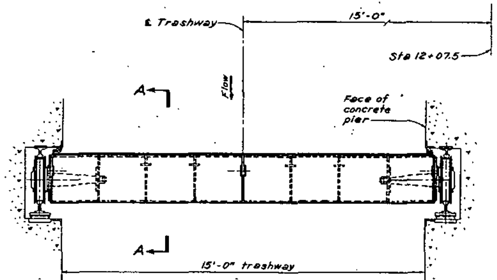
KNOXVILLE | 3-17-65 | 69 | SH 4 | 54N200 R1

RECORD DRAWING AS CONSTRUCTED 3-14-69

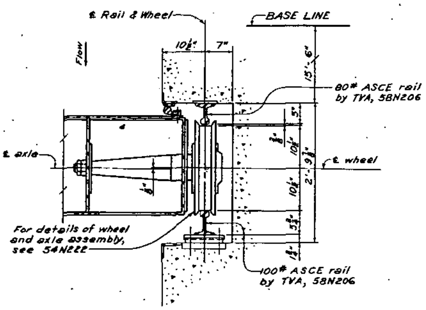
DSGN GBC
DRWN BGR
CHKD JAK
TRCD
COMP
SUPV RRD 3-4-65
INSP
DRAWN FOR

MF
Ro4
R1

54N220

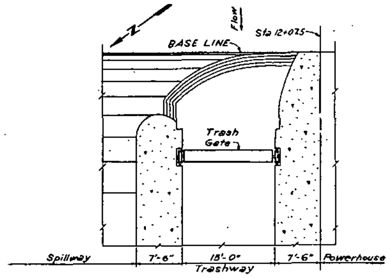


SECTIONAL PLAN



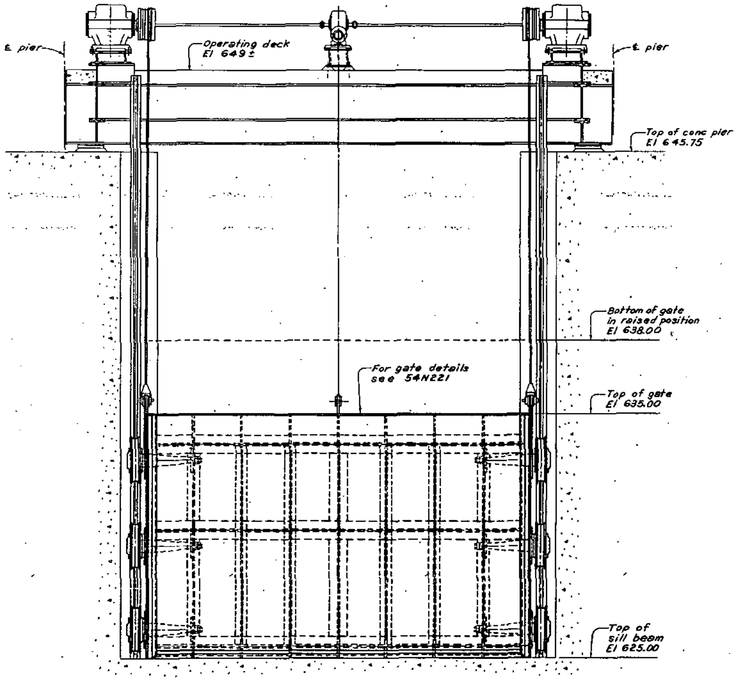
TYPICAL SECTION THRU SLOT

Scale 1"=1'-0"

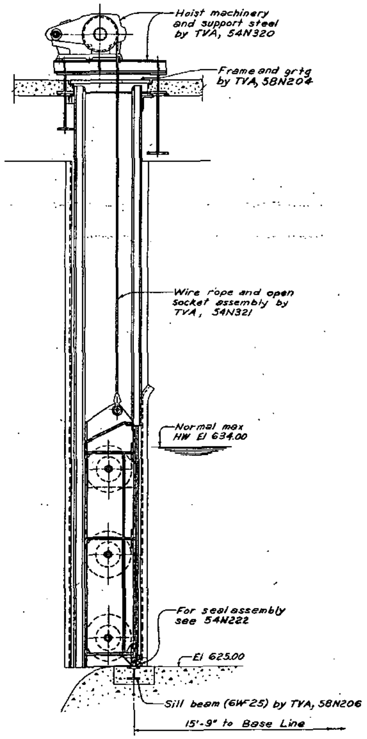


KEY PLAN

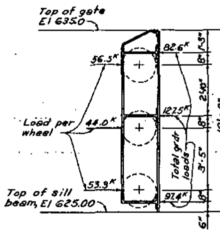
Scale ⅛"=1'-0"



UPSTREAM ELEVATION

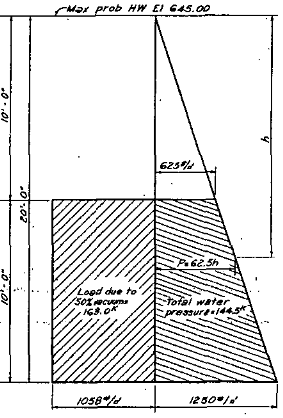


SECTION A-A



LOADING DIAGRAM

Scale ⅜"=1'-0"



PRESSURE DIAGRAM

Scale 1"=500#/□'

For mfr's details refer to Lakeside Bridge & Steel Co. file, TVA Contract No. 66C52-90101.

Scale ½"=1'-0"
Except as noted

TRASHWAY

TRASH GATE
ARRANGEMENT

NICKAJACK PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF ENGINEERING DESIGN

SUBMITTED	RECOMMENDED	APPROVED
	S. Keeler	W. L. Boor

KNOXVILLE	6-16-65	69	H	4	54N220R1

RECORD DRAWING AS CONSTRUCTED
3-14-69

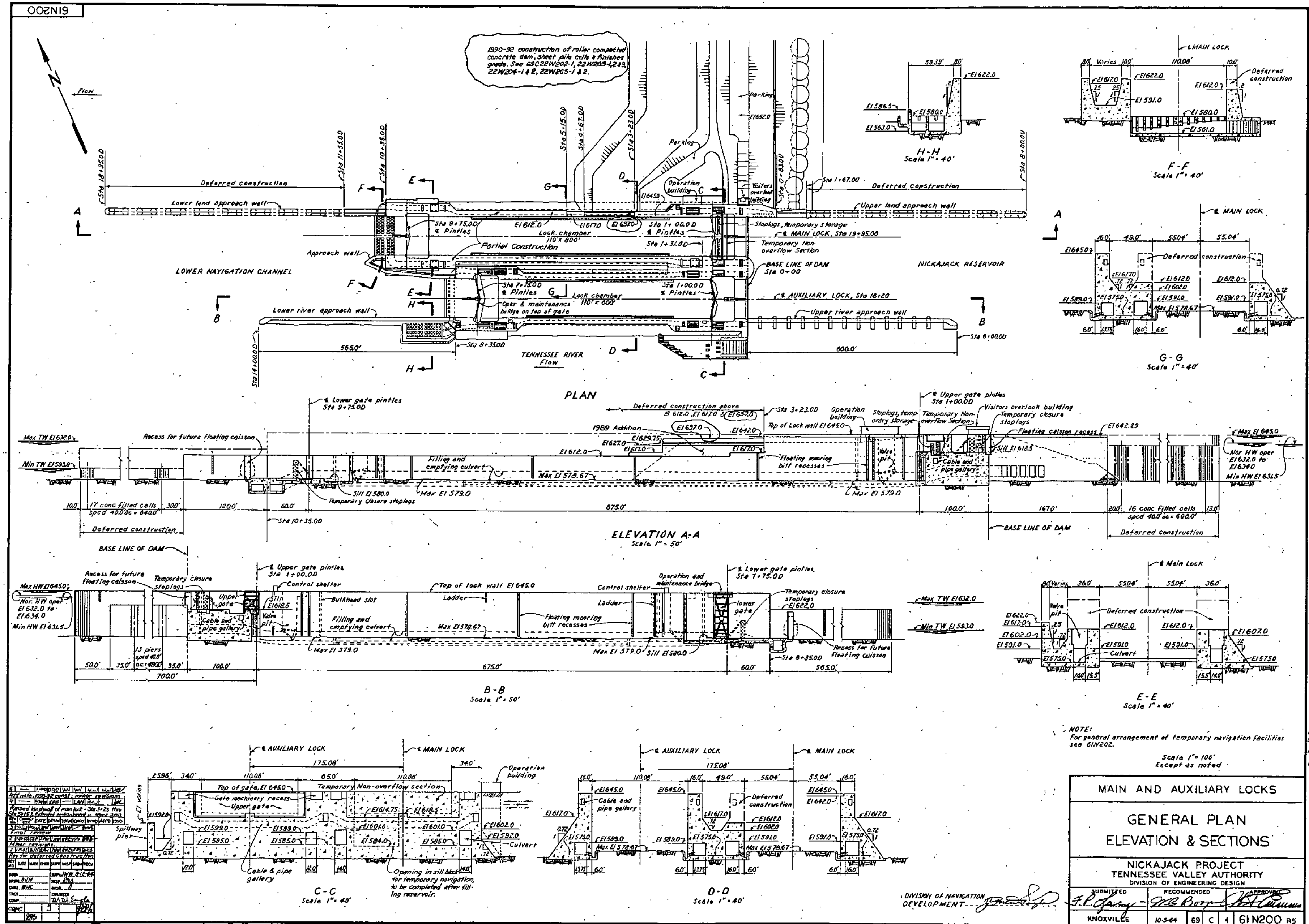
REV NO.	DATE	MADE	CHKD	SUPV	INSP	[illegible]	[illegible]
1	3-14-69	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]

Piers changed in Key Plan

DSGN JAK
DRWN BGR 4-65
CKD WMB
TRCD
COMP
SUPV
INSP
ENGINEER
[illegible]

① ② ③ ④ ⑤ ⑥

MF
RD



NOTE:
For general arrangement of temporary navigation facilities see 61N202.

Scale 1" = 100'
Except as noted

MAIN AND AUXILIARY LOCKS

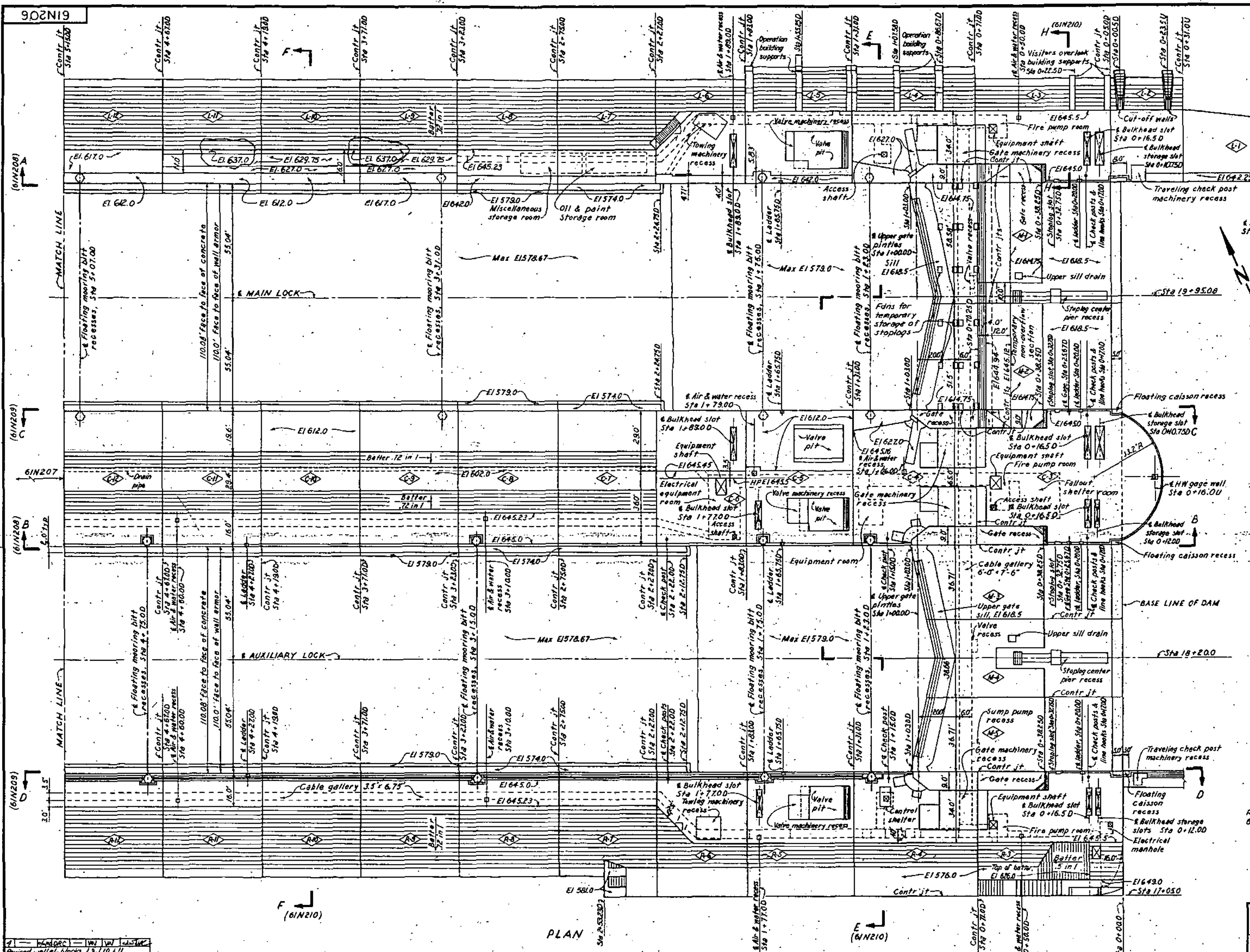
GENERAL PLAN
ELEVATION & SECTIONS

NICKAJACK PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF ENGINEERING DESIGN

SUBMITTED	RECOMMENDED	APPROVED
F. P. Lacy	M. B. Boop	

KNOXVILLE	10-5-64	69	C	4	61N200 R5

RECORD DRAWING AS CONSTRUCTED
5-24-68



REFERENCE DRAWING:
61BM206 .... BILL OF MATERIAL

COMPANION DRAWINGS: 61N207, 208, 209, & 210.

Scale 1" = 20'

MAIN AND AUXILIARY LOCKS

CONCRETE
PLAN-CHAMBER WALLS UPPER END
STA 1+67.0U TO STA 5+15.0D

NICKAJACK PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF ENGINEERING DESIGN

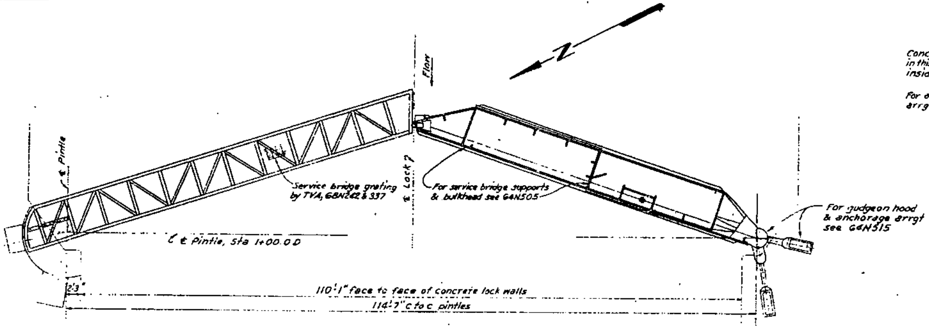
SUBMITTED	RECOMMENDED	APPROVED
W. W. Engle	F. P. Falcy	M. B. Bix
KNOXVILLE	5-12-65	69 C 4 61N206 R4

RECORD DRAWING AS CONSTRUCTED
5-24-68

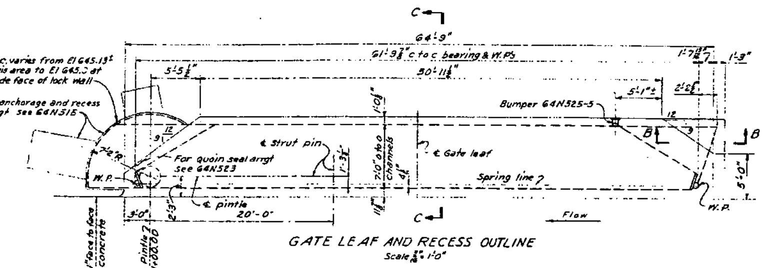
MF
R1
R2
R3
R4

Revised wall el - blocks L-3, L-10, & L-11
Revised land wall of main lock - blocks L-9 thru L-12
Final review

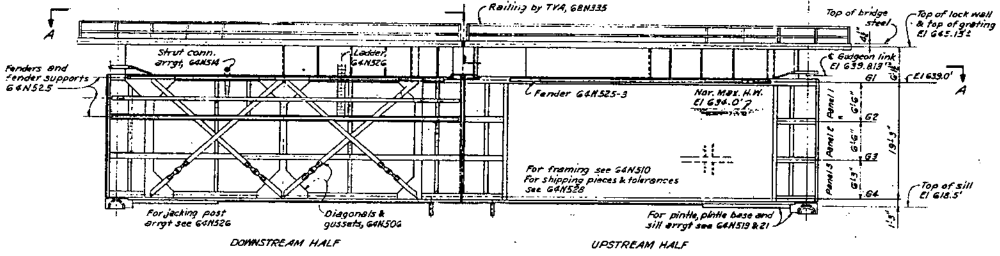
64N504



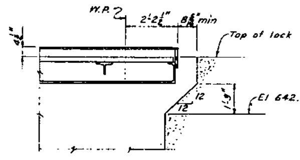
PLAN A-A



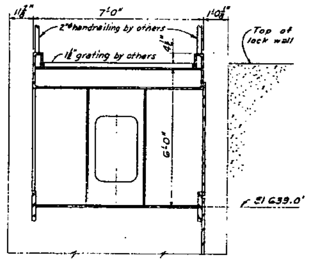
GATE LEAF AND RECESS OUTLINE
Scale 3/16" = 1'-0"



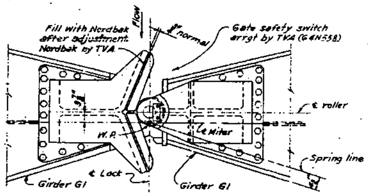
ELEVATION



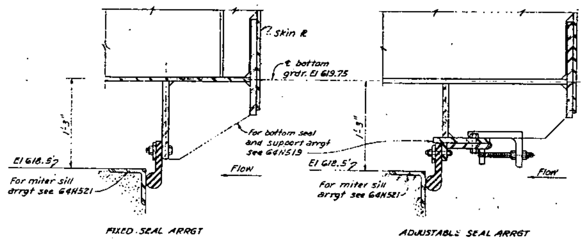
B-B
Scale 1/4" = 1'-0"



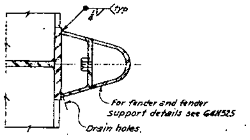
C-C
Scale 1/4" = 1'-0"



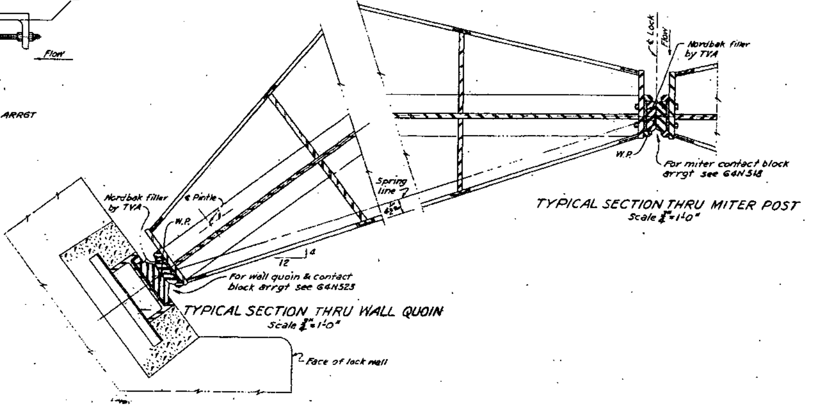
MITERING DEVICE
For details see 64N518
Scale 3/4" = 1'-0"



TYPICAL SECTIONS THRU BOTTOM SEAL
Scale 1 1/2" = 1'-0"



TYPICAL SECTION THRU FENDERS
Scale 1 1/2" = 1'-0"



TYPICAL SECTION THRU WALL QUOIN
Scale 3/4" = 1'-0"

TYPICAL SECTION THRU MITER POST
Scale 3/4" = 1'-0"

MFR. NOTES:
Numbers shown as required on all detail drawings are total for upper and lower gates, 4 leaves.
Machine tolerances, except as otherwise shown or noted on detail drawings, shall not exceed ± 1/64.
All threads to be American Standard coarse thread series, class 2A fit for bolts and class 2B fit for nuts, unless otherwise noted.
All bolt heads and nuts to be American Standard, semi-finished, regular, hexagon, unless otherwise noted.
For general arrangement of lower gate see 64N507

FIELD NOTES:
Downstream fenders to be installed before final adjustment of diagonals.
Drill 1" Φ drain hole at low point in each panel of horizontal girders after final gate leaf assembly.
For limits on use of upper gate bridge see 64N505.

For mfr's details refer to Lakeside Bridge & Steel Co file TVA contract 66C52-90057.

MF
R1

Scale 1/8" = 1'-0"
Except as noted.

1	5-9-67	BJC	[illegible]	[illegible]		[illegible]	[illegible]
Rubber fenders removed, metal fenders add.							
REV NO	DATE	MADE	CHKD	SUPV	INSP	SUBMITTED	RECM

DSGN
DRWN HLW
CHKD
TRCD
COMP
SUPV
INSP
ENGINEER

AUXILIARY LOCK

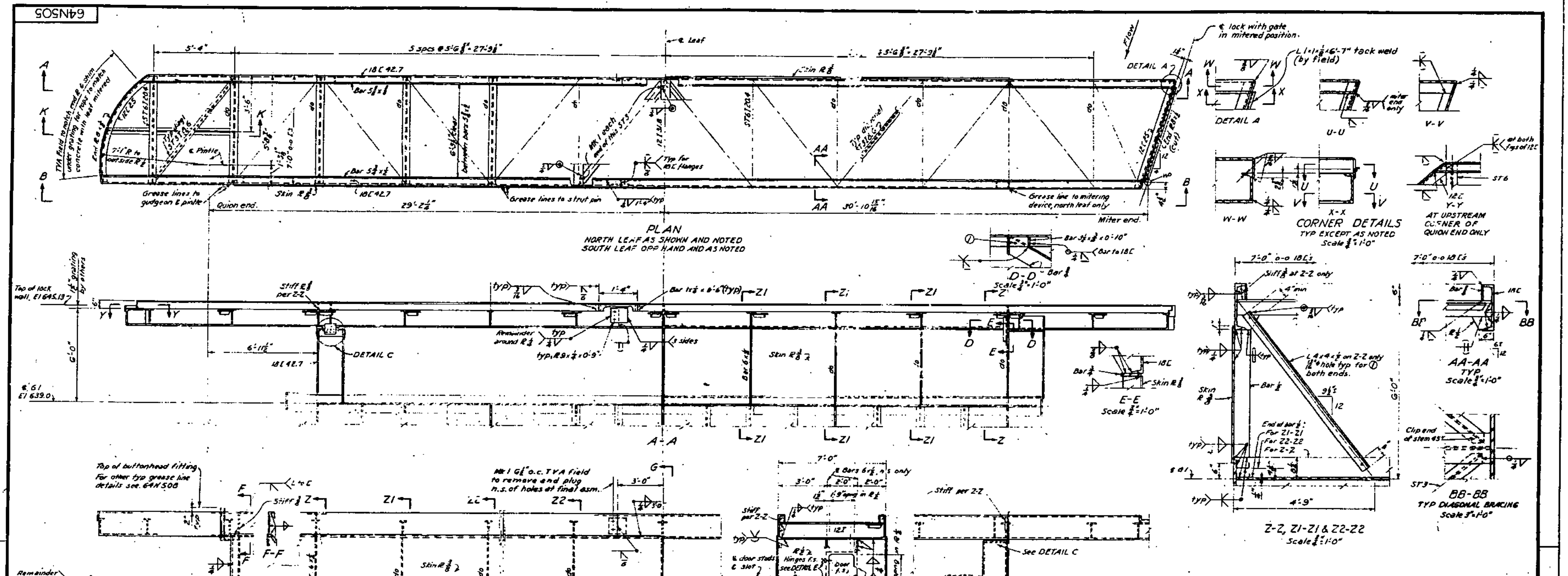
UPPER GATE
GENERAL ARRANGEMENT

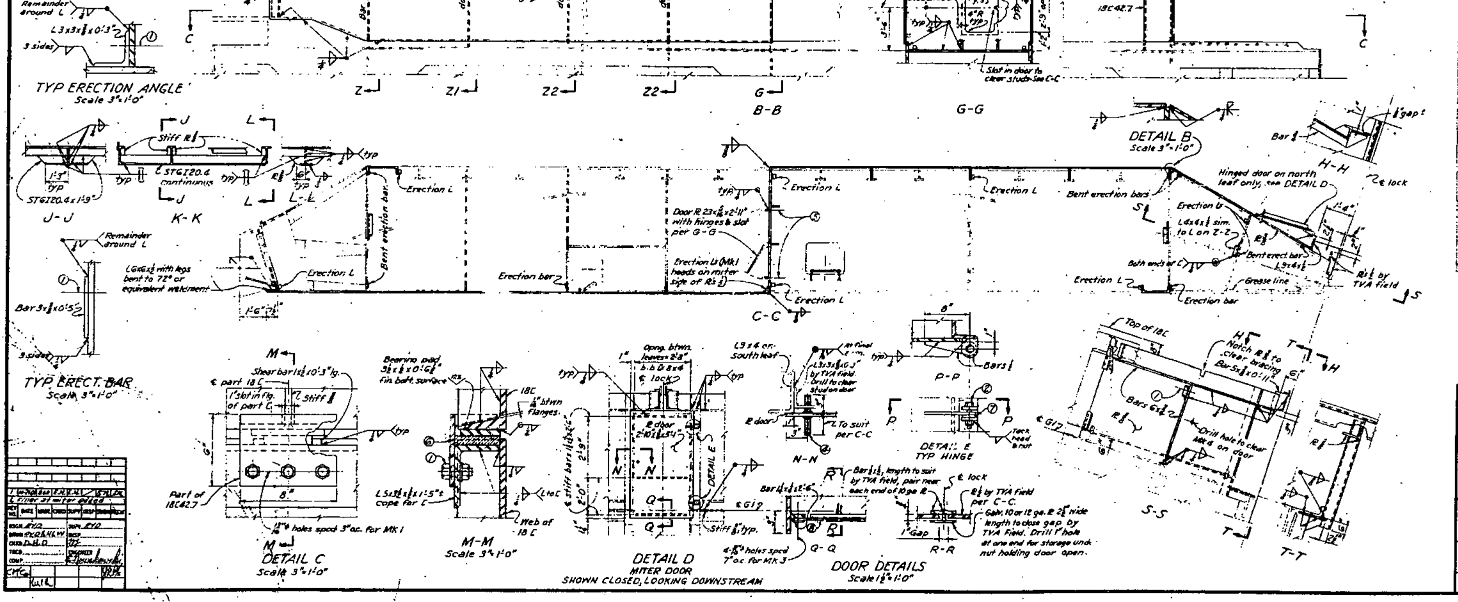
NICKAJACK PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF ENGINEERING DESIGN

SUBMITTED	RECOMMENDED	APPROVED
S. Kuhn		W. C. Boy

KNOXVILLE | 5-14-65 | 69 | SH | 4 | 64N504 R1

RECORD DRAWING AS CONSTRUCTED
5-17-68





MFR NOTES:
STRUCTURAL STEEL TO BE ASTM A36 EXCEPT AS OTHERWISE NOTED.
ALL MARK NUMBERS TO HAVE PREFIX 64N505 UNLESS OTHERWISE NOTED.
MARK 1: 3/4" D X 1-3/4" HEX HEAD BOLT, NUT, AND LW, ASTM A307 70 REQD + 3 EXTRA.
MARK 2: 3/4" D X 3-1/2" HEX HEAD BOLT, NUT, AND LW, ASTM A320, TYPE B8F, ANNEALED - 6 REQD.
MARK 3: 1/2" D X 1-3/4" HEX HEAD BOLT, NUT, AND LW, ASTM A307 4 REQD.
MARK 4: 3/4" D STUD, LENGTH TO SUIT, NAVAL BRASS NUT, AND W, ASTM A320, TYPE B8F, ANNEALED - 1 REQD.
MARK 5: 3/4" D STUD, LENGTH TO SUIT, NAVAL BRASS NUT, AND W, ASTM A320, TYPE B8F, ANNEALED - 4 REQD.
MARK 6: 3-3/4" X 3/4" X 0'-6" BEARING PAD, LUBRITE, OR EQUAL - 4 REQD.
MARK 7: ±2" O.D. X 13/16" I.D. X 1/4" THICK WASHER, BRONZE - 6 REQD.
MARK 8: 3" X 1/4" X 2'-8" RUBBER BELTING AS COMMERCIALLY AVAILABLE - 1 REQD.

FIELD NOTES:
WITH THE GATES MITERED, AFTER FINAL ALIGNMENT FURNISH BARS TO SUIT AND TACK WELD TO THE END PLATES ON MITER END OF BRIDGE TO CLOSE THE GAP BETWEEN LEAVES TO 1" MIN, AND 1-1/2" MAX.
FURNISH ITEMS CALLED FOR IN SECTIONS C-C, N-N, Q-Q, AND R-R.

DESIGN LOADS:
MAXIMUM UNIFORM LIVE LOAD TO BE 50 PSF.
MAXIMUM CONCENTRATED LIVE LOADS TO BE FROM A FULLY LOADED 3-WHEELED SERVICE CART - 2000 LB TOTAL.

For mtr's details refer to Lakeside Bridge & Steel Co file TVA Contract 66C52-90057.

Scale ⅜"=1'-0"
Except as noted.

AUXILIARY LOCK

UPPER GATE
BRIDGE AND BULKHEAD

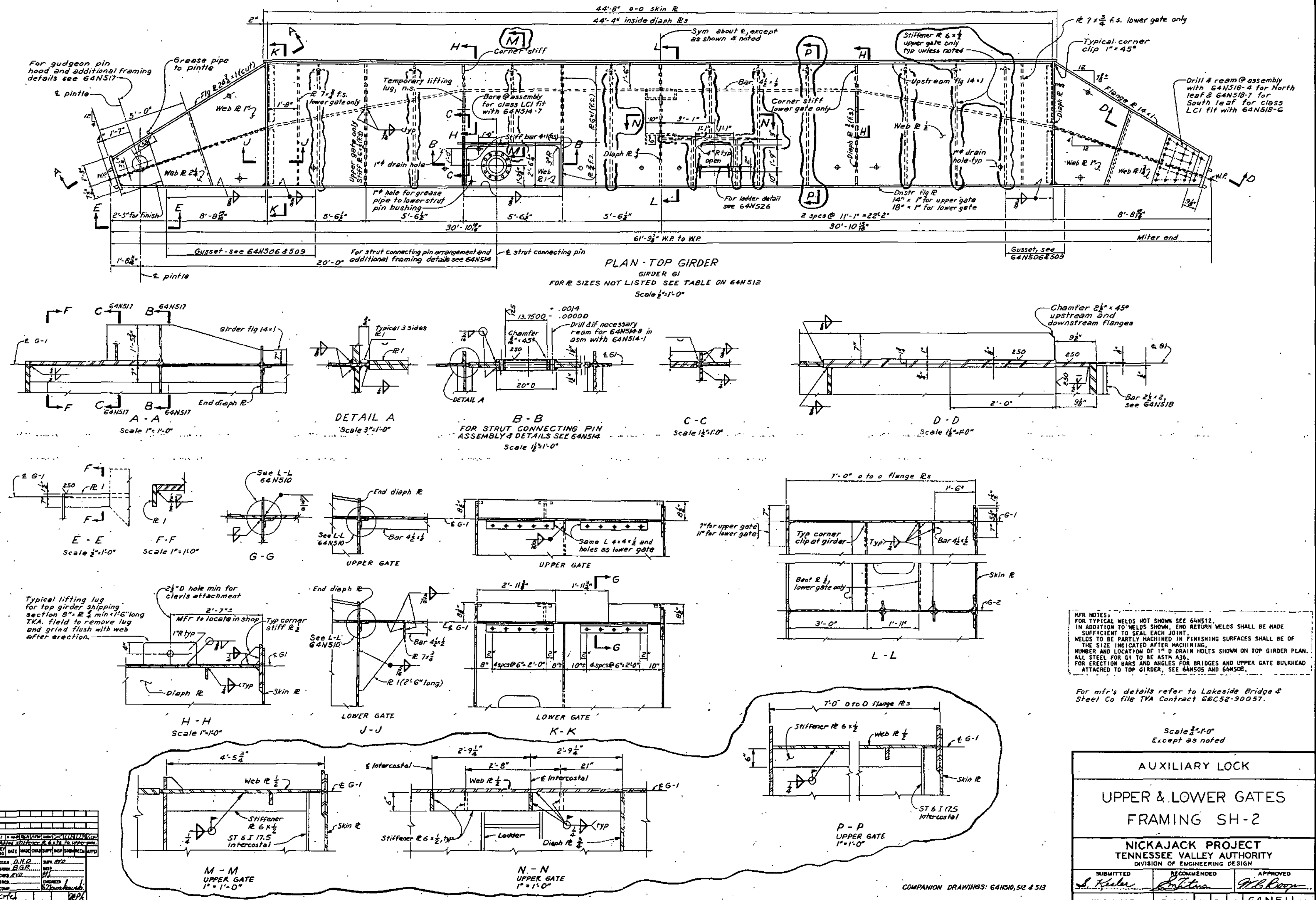
NICKAJACK PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF ENGINEERING DESIGN

SUBMITTED	RECOMMENDED	APPROVED
S. Keeler	L. Titus	J. B. Roy

KNOXVILLE	5-14-65	69	SH	4	64N505 R1

RECORD DRAWING AS CONSTRUCTED 5-17-68 · 10-2-69

MF 120 D1



MFR NOTES;
FOR TYPICAL WELDS NOT SHOWN SEE 64N512.
IN ADDITION TO WELDS SHOWN, END RETURN WELDS SHALL BE MADE SUFFICIENT TO SEAL EACH JOINT.
WELDS TO BE PARTLY MACHINED IN FINISHING SURFACES SHALL BE OF THE SIZE INDICATED AFTER MACHINING.
NUMBER AND LOCATION OF 1" D DRAIN HOLES SHOWN ON TOP GIRDER PLAN.
ALL STEEL FOR G1 TO BE ASTM A36.
FOR ERECTION BARS AND ANGLES FOR BRIDGES AND UPPER GATE BULKHEAD ATTACHED TO TOP GIRDER, SEE 64N505 AND 64N508.

For mfr's details refer to Lakeside Bridge & Steel Co file TVA Contract 66C52-90057.

Scale 3/4" = 1'-0"
Except as noted

COMPANION DRAWINGS: 64N510, 512 & 513

AUXILIARY LOCK

UPPER & LOWER GATES
FRAMING SH-2

NICKAJACK PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF ENGINEERING DESIGN

SUBMITTED	RECOMMENDED	APPROVED
S. Keeler		

KNOXVILLE 5-14-65 69 SH 4 64N511 R1

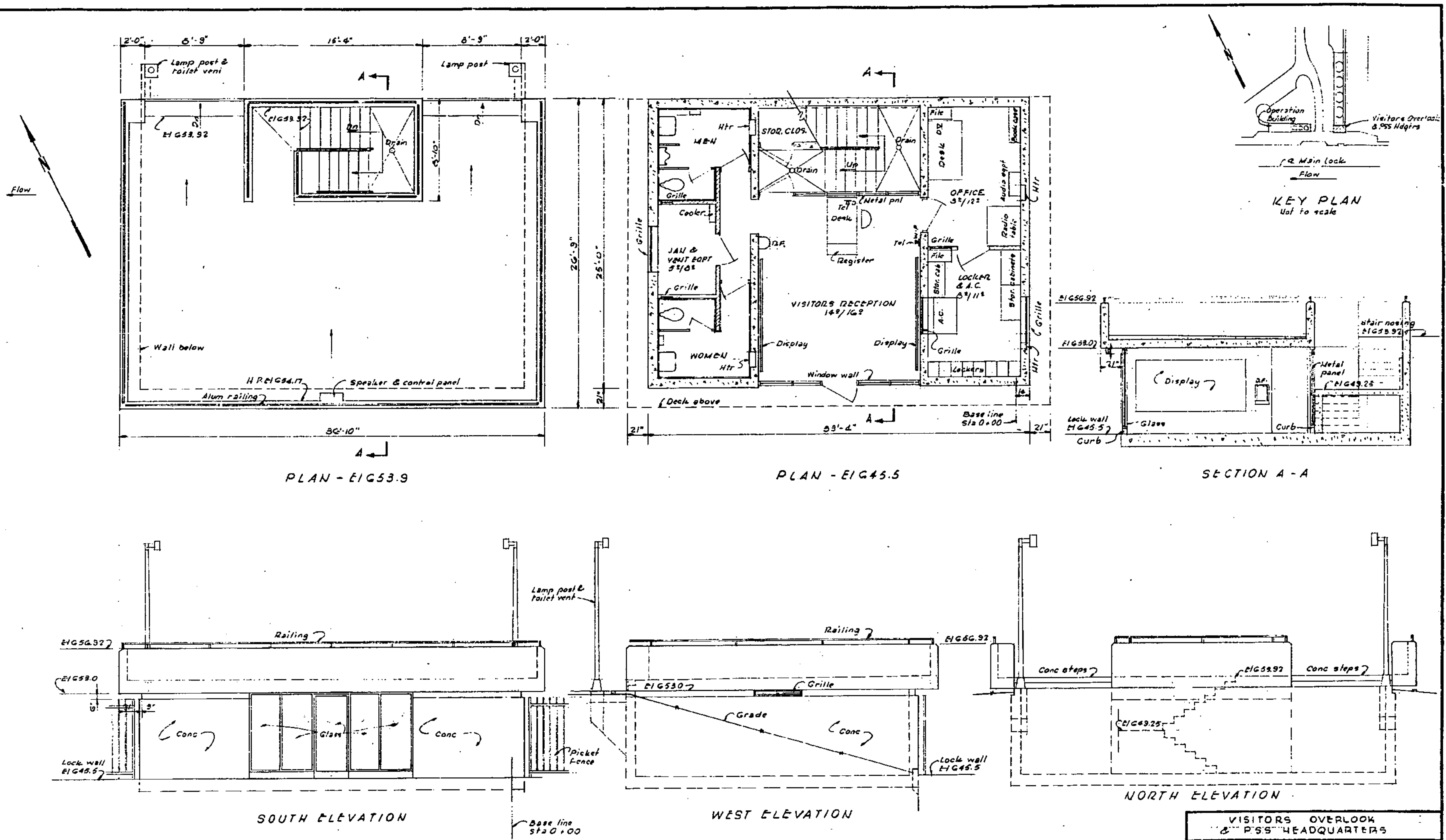
RECORD DRAWING AS CONSTRUCTED 5-17-68

REV NO	DATE	MADE	CHKD	SUPV	INSP	SUBM	RECM	APPD
1	[illegible]	[illegible]	[illegible]	[illegible]		LLB	LLB	[illegible]

Added stiffener ℞ 6 × 1/2 to upper gate.

DSGN D.H.Q.
DRWN BGR
CHKD RVD
TRCD
COMP
SUPV RVD
INSP
ENGINEER

CMG



VISITORS OVERLOOK
& PSS HEADQUARTERS

ARCHITECTURAL
PLANS, ELEVATIONS, SECTION
PRINCIPAL DESIGN FEATURES

NICKAJACK PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF ENGINEERING DESIGN

SUBMITTED	RECOMMENDED	APPROVED
R. H. Owens		J. R. Parish

KNOXVILLE	7-3-67	69	A	4	66K101R0

RECORD DRAWING AS CONSTRUCTED

Scale ¼" = 1'-0"

REV NO.	DATE	MADE	CHKD	SUPV	INSP	SUBM	RECM

DSGN
DRWN RHS
CHKD HO
TRCD
COMP
SUPV
DE: RRR
ENGINEER

Cull		JTL		RHR

RB

3. Free earth support analyses which compensate for toe fixity by including a bending moment reduction factor are liable to be misleading; fixed earth support methods should always be used.

4. Design analyses should be suitable for practical design use. In view of the approximations involved in "idealizing" geologic sections and assessing soil properties, design computations should not depend on arithmetical accuracy to several decimal places.

AMERICAN SOCIETY OF CIVIL ENGINEERS
Founded November 5, 1852
TRANSACTIONS

Paper No. 2677 Vol. 119, 1954

RATING CURVES FOR FLOW OVER DRUM GATES

BY JOSEPH N. BRADLEY,[1] A. M. ASCE

WITH DISCUSSION BY MESSRS. GUIDO WYSS; SAM SHULITS; BOB BUEHLER; F. B. CAMPBELL AND A. A. MCCOOL; AND JOSEPH N. BRADLEY

SYNOPSIS

With water becoming more valuable in the western states each year, there is an increasing demand for better methods of measurement and additional rating structures. This condition applies not only to the requirements for main canals and laterals of irrigation works but also to the regulation and measurement of flow at dams. In fact, the need has reached the point at which operators are desirous of metering the flow at nearly all control devices in irrigation systems, and in other water supply or control systems.

The primary purpose of this paper is to point out that there are numerous control structures in existence that will serve a dual purpose—that of a metering station as well as that of a regulating device. Examples of such structures include spillways, with or without gates; outlet works for dams using gates or valves; and canal regulating structures using gates. With the accumulation of information from hydraulic model studies made by the Bureau of Reclamation (USBR), United States Department of the Interior, it is now possible to prepare reasonably accurate rating curves for many such structures without the construction of models and without access to the prototypes. The method is especially useful for the rating of existing structures. This paper describes the method as it applies to the rating of drum gates and the paper is concluded with an engineering example. The method is also applicable to the rating of the Volet gate used in France, the bascule gate manufactured in the United States, and others in which the sector of a circle is hinged at or near the crest of a spillway.

NOTE.—Published, essentially as printed here, in February, 1953, as *Proceedings-Separate No. 169*. Positions and titles given are those in effect when the paper or discussion was received for publication.

[1] Hydr. Engr., Bureau of Reclamation, U. S. Dept. of the Interior, Denver, Colo.

INTRODUCTION

The drum gate is a type of gate that floats in a chamber and is buoyed into position by regulating the water level in that chamber. A medium-sized gate of this type is shown in Fig. 1. To use drum gates as metering devices, it is essential that each gate be equipped with an accurate position indicator. This indicator may consist of an arm or pointer connected directly to one of the gate pins, and is usually located inside an adjacent pier. The scale, which commonly indicates "position of high point of gate," may be a cast-metal arc mounted on the wall under the pointer, or a scale painted on the wall.

This paper presents a method of computing rating curves for all positions of the gate with an accuracy comparable to that which can be obtained from an average current-meter traverse of the river. The information required for rating a drum gate consists of the over-all dimensions of the gate and overflow crest, the information contained in this paper, and the coefficient of discharge for any appreciable head on the spillway with the gate in the completely lowered position. Should the coefficient data be lacking, the coefficient of discharge for the designed head can be estimated for nearly any overflow section by a method previously published.[2]

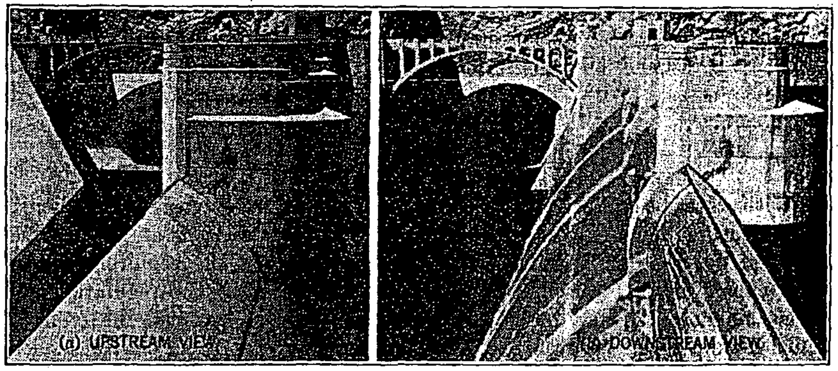


FIG. 1.—DRUM GATE, 100 FT BY 16 FT, AT HOOVER DAM (ARIZONA-NEVADA)

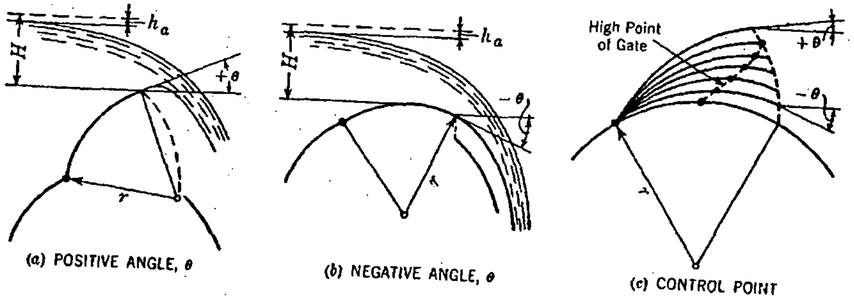
The method of rating described here is not intended to replace the measurements taken at river gaging stations. However, it has the following advantages: (1) The gates can be set in a few minutes to pass a desired discharge and (2) in time of flood, the gaging station may be out of order but the gate calibration is as accurate as usual. The flood that passed over Grand Coulee Dam (Washington) in 1948 is an example. The river gage, in the pier of a bridge downstream, was in error because of a drawdown in the water surface, adjacent to the pier, at the higher flows. Current-meter measurements were also attempted during the flood, but the swiftness of the current and other difficulties rendered these only partially successful. As a result, the discharge at the peak of the flood, which was finally estimated as 638,000

sec-ft, is questionable. Measurement of the flow over the drum gates, which is now possible, would have afforded a continuous record and one that would be as accurate for floods as for normal flows.

CHARACTERISTICS OF THE DRUM GATE

As a measuring device, the drum gate resembles a sharp-crested weir with a curved upstream face over the greater part of its travel. With an adequate positioning indicator, the drum gate can serve as a very satisfactory metering device.

When the drum gate simulates a sharp-crested weir—that is, when a line drawn tangent to the downstream lip of the gate makes a positive angle with the horizontal, as in Fig. 2(a), four principal factors are involved. These factors are H, the total head above the high point of the gate; θ, the angle made by a line drawn tangent to the downstream lip of the gate and the horizontal; r, the radius of the gate or an equivalent radius, should the curvature of the gate involve a parabola; and C_q, the coefficient of discharge in $Q = C_q L H^{3/2}$, in which Q is the discharge in second-feet, and L is the length of the gate.



(a) POSITIVE ANGLE, θ

(b) NEGATIVE ANGLE, θ

(c) CONTROL POINT

FIG. 2.—DRUM-GATE POSITIONS

The depth of approach was not included as a variable because drum-gate installations studied were for medium and high dams at which approach effects were negligible. When the approach depth, measured below the high point of the gate, is equal to or greater than twice the head on the gate, it has been shown[3] that a further increase in approach depth produces very little increase in the coefficient of discharge. Most drum-gate installations satisfy this condition, especially when the gate is in a raised position. Therefore, with adequate approach depth the four variables H, θ, r, and C_q completely define the flow over this type of gate for positive angles of θ, Fig. 2(a).

For negative values of θ, Fig. 2(b), the downstream lip of the gate no longer controls the flow. Rather, the control point shifts upstream to the vicinity of the high point of the gate for each setting as illustrated in Fig. 2(c), and flow conditions gradually approach those of the free crest (as the gate is lowered). Although other factors enter the problem, the similitude also holds for this case down to an angle of approximately −15°.

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[2] "Discha[illegible]oefficients for Irregular Overfall Spillway Sections," by J. N. Bradley, *Engineering Monograph N*[illegible] Bureau of Reclamation, U. S. Dept. of the Interior, Denver, Colo., March, 1952.

[3] "Studies of Crests for Overfall Dams," *Bulletin No. 3*, Pt. VI, Boulder Canyon Final Reports, Bureau of Reclamation, U. S. Dept. of the Interior, Denver, Colo., 1948.

SOURCES OF INFORMATION

The data for this drum-gate study were obtained from hydraulic models of various sizes and scales. The experiments were performed over a period of about eighteen years. The spillway drum gates tested, the principal dimensions of each, the model scale, the laboratory where the tests were conducted, and other information are given in Table 1. Gates for the first three dams listed in the table—Grand Coulee Dam (Washington), Bhakra Dam (India), and Shasta Dam (California)—are identical except for the length and number. The models of each were tested at different times by different personnel. The results of the tests are nearly identical, which fact indicates the consistency possible in this type of test. Although identical gates are of value in indicating the consistency of results, test results on dissimilar gates are desirable because they can give assurance that all factors involved in the establishment of similitude have been considered. The study includes only eleven gates (Table 1), but the dimensions of these vary over a fairly wide range, and the consistency indicated in compiling the results was quite satisfactory.

TABLE 1.—PRINCIPAL DIMENSIONS OF DRUM GATES TESTED

Dam	No. of gates	Length of gate, in ft	Height of gate, in ft	Radius of gate, in ft	Approach depth, in ft	Maximum head on crest,[a] in ft	Model scale	Hydraulic laboratory
Grand Coulee (Washington)	11	135	28	66.25	360	31.65	1:30	Fort Collins (Colo.)
Bhakra (India)	2	135	28	66.25	410	28	1:80	Customhouse (Denver, Colo.)
Shasta (California)	3	110	28	66.25	460	28	1:68	Customhouse
Hamilton (Texas)	1	300	28	74.17	50	32	1:30	Fort Collins
Hoover, Shape 4-M3[b] (Ariz.-Nev.)	4	100	16	26.8	50	26.6	1:20	Montrose, Colo.
Hoover, Shape 8-M5[b] (Ariz.-Nev.)	4	100	16	36.0	50	26.6	1:20	Montrose
Hoover, Shape 7-C4[b] (Ariz.-Nev.)	4	100	16	26.0	50	26.6	1:60	Fort Collins
Friant (California)	3	100	18	47.0	140	19.0	1:25	Fort Collins
Norris (Tennessee)	3	100	14	34.0	200	27.0	1:72	Fort Collins
Madden (Canal Zone)	4	100	18	30.0	120	30.0	1:72	Fort Collins
Capilano (British Columbia)	1	70	23	71.0	200	23.0	1:60	Denver Federal Center

[a] Gate down. [b] Refers to the shape of the spillway cross section.

Cross sections of representative examples of the spillway overflow sections and drum gates listed in Table 1 are shown in Fig. 3. For Hoover Dam, Shape 4-M3 is shown. The data relating the coefficient, C_q, to the head for the model drum gates tested are tabulated in Table 2.

RESULTS OF BAZIN ON STRAIGHT INCLINED WEIRS

The straight inclined weir is comparable to a drum gate, having infinite radius, thus the results of Bazin serve as an introduction to this study.

Bazin, in his classical experiments, studied inclined sharp-crested weirs.[4] The angle of the weir was varied in increments from 14° to 90° with the horizontal, and each weir was 3.7 ft high (vertical dimension). The head on the crest of the weirs ranged from 0.32 ft to 1.48 ft. The results, presented in Fig. 4, show θ plotted against the Bazin coefficient, C_b (in the formula, $Q = C_b\, L\, h \sqrt{2\, g\, h}$), in which h does not include the velocity head of approach (h_a). The angle θ is also plotted with respect to C_q (in the expression, $Q = C_q\, L\, H^{3/2}$) in which H is the total head. This latter expression will be used throughout the paper.

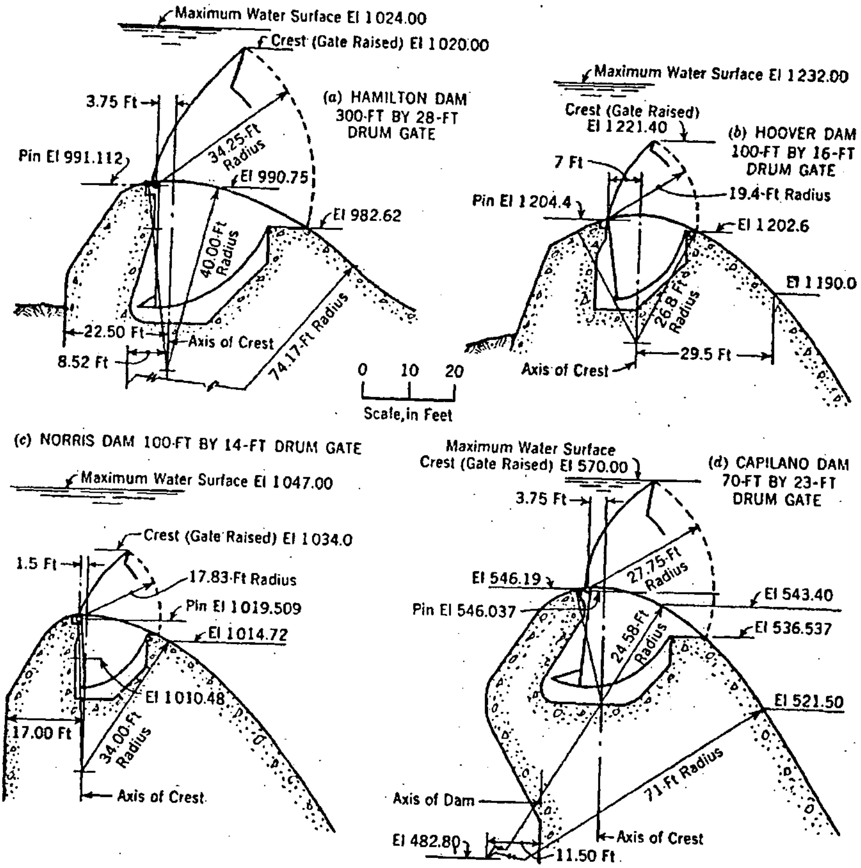

FIG. 3.—EXAMPLES OF DRUM-GATE CROSS SECTIONS

By reference to Fig. 4 it can be observed (1) that the coefficient, C_q, varies only slightly with the observed head on the weir, (2) that there is a rather

---

[4] "Recent Experiments on the Flow of Water over Weirs," by H. Bazin, *Annales des Ponts et Chaussées*, October, 1888. (Translation by Arthur Marichal and John C. Trautwine, Jr., *Proceedings*, Engineers' Club of Philadelphia, Pa., Vol. IX, No. 4, 1892, p. 316.)

TABLE 2.—DRUM-GATE COEFFICIENTS[a]

GRAND COULEE DAM (Washington)		BHAKRA DAM (India)		SHASTA DAM (California)		HAMILTON DAM (Texas)	
Reservoir elevation, in feet	Coefficient, C_q	Reservoir elevation, in feet	Coefficient, C_q	Reservoir elevation, in feet	Coefficient, C_q	Total head on gate, in feet	Coefficient, C_q
GATE ELEVATION[b] 1260.0		GATE ELEVATION[b] 1552.0		GATE ELEVATION[b] 1037.0		GATE ELEVATION[b] 992.0	
1295	3.920	1580	3.680	1075	3.895	35	3.710
1290	3.842	1575	3.645	1070	3.835	30	3.645
1285	3.745	1570	3.550	1065	3.760	25	3.580
1280	3.635	1565	3.420	1060	3.675	20	3.500
1275	3.510	1560	3.275	1055	3.575	15	3.400
1270	3.352	1555	3.120	1050	3.465	10	3.290
1265	3.220			1045	3.335	5	3.160
GATE ELEVATION 1263.51		GATE ELEVATION 1557.0		GATE ELEVATION 1039.0		GATE ELEVATION 995.52	
1295	3.530	1580	3.430	1075	3.637	30	3.400
1290	3.442	1575	3.380	1070	3.565	25	3.310
1285	3.360	1570	3.295	1065	3.490	20	3.223
1280	3.280	1565	3.170	1060	3.417	15	3.150
1275	3.220	1560	3.040	1055	3.340	10	3.085
1270	3.182			1050	3.250	5	3.010
GATE ELEVATION 1267.02		GATE ELEVATION 1562.0		GATE ELEVATION 1041.0		GATE ELEVATION 999.0	
1295	3.530	1580	3.550	1075	3.550	25	3.450
1290	3.457	1576	3.355	1070	3.494	20	3.390
1285	3.380	1572	3.290	1065	3.432	15	3.300
1280	3.300	1568	3.345	1060	3.365	10	3.195
1275	3.213	1564	3.465	1055	3.290	5	3.080
1270	3.120						
GATE ELEVATION 1270.48		GATE ELEVATION 1567.0		GATE ELEVATION 1045.0		GATE ELEVATION 1006.0	
1295	3.600	1580	3.665	1075	3.637	18	3.640
1290	3.530	1577	3.650	1070	3.565	15	3.635
1285	3.462	1573	3.600	1065	3.490	12	3.605
1280	3.410	1570	3.535	1060	3.415	9	3.560
1275	3.375			1055	3.330	6	3.505
				1050	3.220		
GATE ELEVATION 1274.01		GATE ELEVATION 1572.0		GATE ELEVATION 1050.0		GATE ELEVATION 1013.0	
1300	3.725	1580	3.780	1075	3.717	12	3.718
1295	3.695	1579	3.755	1070	3.670	10	3.690
1290	3.662	1578	3.690	1065	3.615	8	3.645
1285	3.630	1577	3.500	1060	3.560	6	3.595
1280	3.600	1576	3.150	1055	3.495	4	3.530
GATE ELEVATION 1277.50				GATE ELEVATION 1055.0		GATE ELEVATION 1020.0	
1295	3.750			1075	3.854	6	3.630
1290	3.738			1070	3.827	5	3.610
1285	3.740			1065	3.800	4	3.540
1280	3.765			1060	3.780	3.5	3.400
				1055	3.763		
GATE ELEVATION 1281.02				GATE ELEVATION 1060.0			
1295	3.730			1075	3.645		
1292	3.708			1072	3.683		
1288	3.705			1069	3.740		
1285	3.725			1066	3.815		
				1063	3.920		
GATE ELEVATION 1284.50				GATE ELEVATION 1065.0			
1300	3.840			1076	3.810		
1296	3.830			1074	3.865		
1292	3.875			1072	3.910		
1288	3.950			1070	3.950		
GATE ELEVATION 1288.0							
1296	3.750						
1294	3.720						
1292	3.670						
1290	3.580						

Coordinates of curves prepared by plotting original data. [b] Gate down.

TABLE 2.[a]—(*Continued*)

FRIANT DAM (California)		NORRIS DAM (Tennessee)		MADDEN DAM (Canal Zone)		CAPILANO DAM (British Columbia)	
Reservoir elevation, in feet	Coefficient, C_q	Reservoir elevation, in feet	Coefficient, C_q	Total head on gate, in feet	Coefficient, C_q	Reservoir elevation, in feet	Coefficient, C_q
GATE ELEVATION[b] 560.0		GATE ELEVATION[b] 1020.0		GATE ELEVATION[b] 232.0		GATE ELEVATION[b] 547.0	
580	3.650	1055	3.915	35	3.900	580	3.775
577	3.625	1050	3.845	30	3.770	575	3.705
574	3.550	1045	3.765	25	3.660	570	3.625
571	3.460	1040	3.670	20	3.560	565	3.530
568	3.340	1035	3.550	15	3.460	560	3.415
565	3.175	1030	3.390	10	3.365	555	3.250
562	2.965	1025	3.125	5	3.280		
GATE ELEVATION 561.5		GATE ELEVATION 1022.0		GATE ELEVATION 236.0		GATE ELEVATION 555.4	
580	3.340	1055	3.785	30	3.810	580	3.615
577	3.300	1050	3.725	25	3.750	577	3.580
574	3.250	1045	3.655	20	3.675	574	3.540
571	3.200	1040	3.570	15	3.590	571	3.485
568	3.125	1035	3.460	10	3.500	568	3.420
564	2.950	1030	3.300	5	3.410	565	3.320
		1025	3.000				
GATE ELEVATION 563.0		GATE ELEVATION 1024.0		GATE ELEVATION 240.0		GATE ELEVATION 561.1	
580	3.320	1055	3.760	30	3.960	583	3.560
577	3.280	1050	3.720	25	3.890	580	3.530
574	3.240	1045	3.670	20	3.835	577	3.490
571	3.175	1040	3.605	15	3.800	574	3.435
568	3.080	1035	3.520	10	3.775	571	3.355
565	2.960	1030	3.380	5	3.740	568	3.130
		1025	3.000				
GATE ELEVATION 566.0		GATE ELEVATION 1026.0		GATE ELEVATION 245.0		GATE ELEVATION 568.5	
580	3.450	1055	3.835	25	3.900	583	3.785
577	3.410	1050	3.810	20	3.900	580	3.850
574	3.340	1045	3.780	15	3.890	577	3.890
571	3.240	1040	3.740	10	3.910	574	3.925
568	3.085	1035	3.685	5	3.935		
		1030	3.580				
GATE ELEVATION 569.0		GATE ELEVATION 1028.0		GATE ELEVATION 250.0			
580	3.625	1055	3.890	20	3.750		
578	3.605	1050	3.880	15	3.780		
576	3.575	1045	3.865	10	3.860		
574	3.550	1040	3.845	5	3.980		
572	3.500	1035	3.815				
570	3.400	1030	3.745				
GATE ELEVATION 572.0		GATE ELEVATION 1030.0					
580	3.725	1055	3.890				
578	3.720	1050	3.890				
576	3.680	1045	3.885				
574	3.620	1040	3.880				
		1035	3.875				
GATE ELEVATION 573.0		GATE ELEVATION 1032.0					
580	3.760	1055	3.870				
578	3.760	1050	3.875				
576	3.765	1045	3.880				
575	3.780	1040	3.895				
574	3.900	1035	3.920				
GATE ELEVATION 575.0		GATE ELEVATION 1034.0					
580	3.780	1055	3.815				
578	3.790	1050	3.835				
577	3.840	1045	3.855				
576	3.950	1040	3.885				
		1036	3.945				

[a] Coordinates of curves prepared by plotting original data. [b] Gate down.

TABLE 2.[a]—(*Continued*)

HOOVER DAM (Arizona-Nevada) SHAPE 4-M3		HOOVER DAM (Arizona-Nevada) SHAPE 8-M5		HOOVER DAM (Arizona-Nevada) SHAPE 7-C4	
Total head on gate, in feet	Coefficient, C_q	Total head on gate, in feet	Coefficient, C_q	Total head on gate, in feet	Coefficient, C_q
GATE ELEVATION[b] 1205.4		GATE ELEVATION[b] 1205.4		GATE ELEVATION[b] 1205.4	
26	3.670	28	3.735	26	3.665
22	3.605	25	3.705	22	3.615
18	3.540	20	3.650	18	3.540
14	3.472	15	3.565	14	3.450
10	3.405	10	3.460	10	3.360
6	3.338	5	3.335	6	3.200
GATE ELEVATION 1209.4		GATE ELEVATION 1209.4		GATE ELEVATION 1209.0	
20	3.675	24	3.590	23	3.725
17	3.645	20	3.540	19	3.650
14	3.615	16	3.492	15	3.580
11	3.585	12	3.428	11	3.508
8	3.555	8	3.330	7	3.415
GATE ELEVATION 1213.4		GATE ELEVATION 1213.4		GATE ELEVATION 1213.0	
20	3.880	20	3.765	19	3.800
17	3.875	16	3.765	16	3.845
14	3.875	12	3.725	13	3.825
11	3.870	8	3.668	10	3.750
8	3.870	4	3.600	7	3.640
GATE ELEVATION 1217.4		GATE ELEVATION 1217.4		GATE ELEVATION 1217.0	
14	3.960	15	3.900	15	3.960
12	3.980	12	3.890	13	3.930
10	4.010	9	3.900	11	3.935
8	4.075	6	3.930	9	3.970
				7	4.020
GATE ELEVATION 1221.4		GATE ELEVATION 1221.4		GATE ELEVATION 1221.4	
10	3.890	11	3.830	14	3.815
8	3.930	9	3.840	12	3.820
6	4.020	7	3.875	10	3.823
5	4.100	5	3.935	8	3.825

[a] Coordinates of curves prepared by plotting original data. [b] Gate down.

sharp reversal in the curve when the angle θ approaches 28°, and (3) that the coefficient of discharge is a maximum at this angle. As the angle θ is increased from 28° to 90°, contraction of the jet gradually reduces the coefficient to approximately 3.33, which occurs when the weir is vertical. As θ is decreased from 28° to 0° the coefficient is gradually reduced—either by approach conditions, friction, or both—to that for a broad-crested weir, which may be some value between 2.8 and 3.1. As the principal difference between the drum gate and the straight inclined weir lies in the curvature of the gate, the trends for the two should be similar.

An inconsistency exists in Fig. 4—namely, the coefficient of discharge for a vertical sharp-crested weir should approximate 3.33, but Fig. 4 shows that Bazin obtained 3.45. This conclusion is supported by the fact that the USBR, Ernest W. Schoder, M.ASCE, and Kenneth B. Turner,[5] and others have not

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[5] "Precise Weir Measurements," by Ernest W. Schoder and Kenneth B. Turner, *Transactions*, ASCE, Vol. 93, 1929, p. 999.

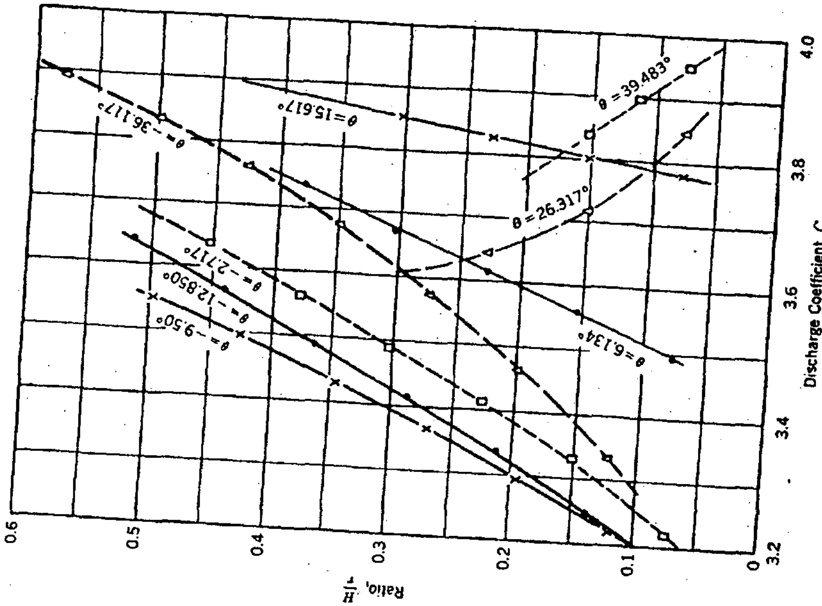


FIG. 5.—DIMENSIONLESS PLOTTING OF DATA FROM MODEL OF SHASTA DAM DRUM GATE

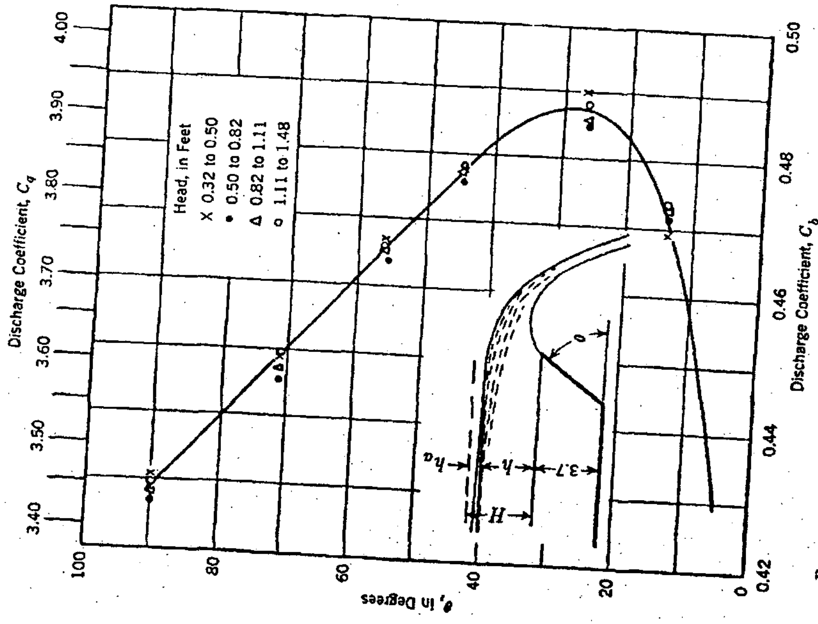


FIG. 4.—RESULTS OF BAZIN'S EXPERIMENTS ON SLOPING WEIRS

been able to check the discharge measurements of Bazin. However, the actual values are not so important for the case at hand as is the significance of the trend.

METHOD OF COMBINING TEST RESULTS

The method for combining results from the eleven drum gates tested (Table 2) consisted of first plotting the coefficient of discharge data separately for each gate as illustrated by the sheet for the Shasta Dam gate (Fig. 5). With the coefficient of discharge as the abscissa and H/r as the ordinate, each curve in Fig. 5 represents a different gate angle θ, which the tangent to the downstre[illegible]ip of the gate makes with the horizontal. In all cases, H is the total head, including the velocity head of approach, measured above the high point of the gate, and r is the radius of the gate. In Fig. 5, C_q is based on the relationship, $Q = C_q L H^{3/2}$. For positive values of θ, the head was measured above the lip of the gate, whereas for negative angles it was observed above the high point, or crest, of the gate proper. The method of measuring the head is illustrated in Fig. 2.

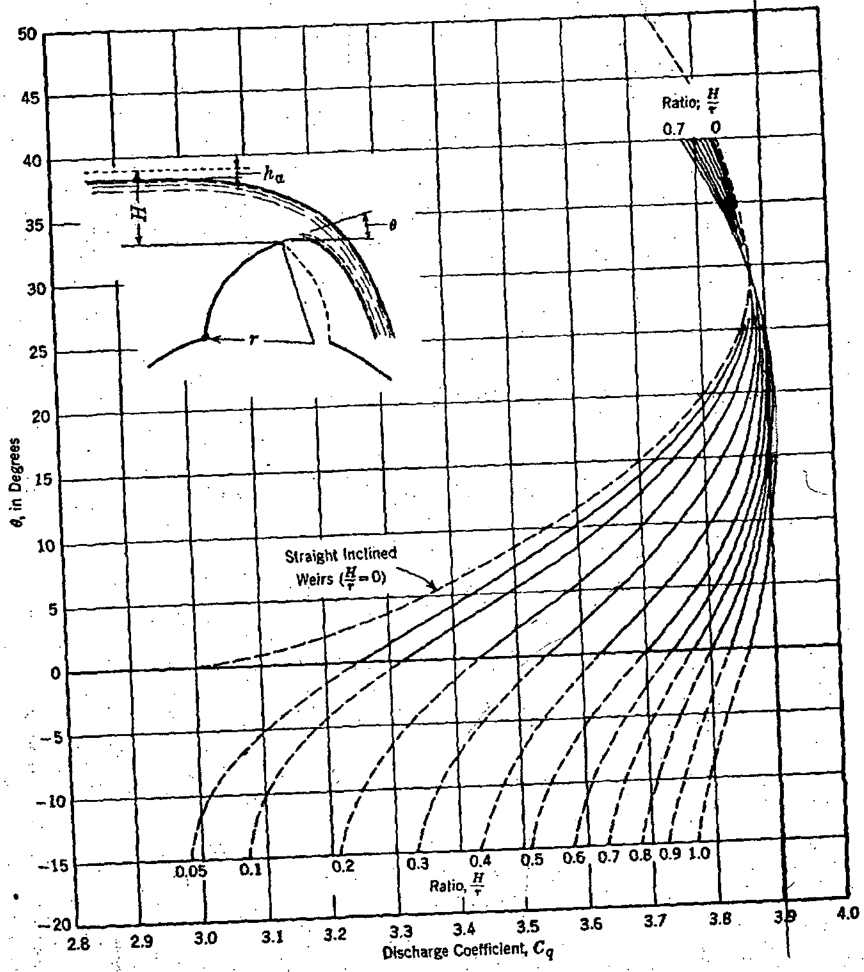


FIG. 6.—GENERAL CURVES FOR THE DETERMINATION OF DISCHARGE COEFFICIENTS

Upon completion of a similar set of curves for each gate tested, the eleven sets of curves were replotted and combined into the chart exhibited as Fig. 6. The results from the various gates showed good general agreement; and the curves in Fig. 6 constitute the general experimental information needed for determining the discharge coefficients for gates in raised or partly raised positions. The supporting points are not shown in Fig. 6, but the individual information for each gate is listed in Table 2.

ANALYSIS OF TEST RESULTS

The curves in Fig. 6 show a tendency toward reversal, similar to that exhibited by the Bazin curve in Fig. 4, but the points of inflection vary from $\theta = 20°$ to $\theta = 30°$, depending on the value of H/r. Fig. 4 showed the coefficients to vary only slightly with the head, but in this case the coefficients definitely vary with the head.

A matter of significance is the reversal of the (H/r)-order which occurs at 29° (Fig. 6). The coefficient of discharge has but one value, 3.88, when θ approximates 29°; thus, it is insensitive to both the radius and the head on the gate for this angle. The curve for $H/r = 0$ approximates a drum gate of infinite radius and was obtained from the data of Bazin (Fig. 4) by applying a uniform adjustment.

As stated previously, similitude is valid for small negative angles of θ, as well as for positive angles up to 90°; thus, the curves in Fig. 6 are shown and recommended for use down to $\theta = -15°$. As the gate is lowered beyond this angle, the curves double back and converge, finally terminating in the free flow coefficient.

The discharge coefficients in the region between $\theta = -15°$ and the gate completely down are determined by graphical interpolation. Interpolation is accomplished by plotting head-discharge curves for several gate angles between $-15°$ and the maximum positive angle. Also the head-discharge curve is plotted for the free crest. This information is then cross-plotted to obtain values in the transition zone. The method will be explained in the example that follows. It will be discovered that negative angles greater than $-15°$ (with the exception of the free crest) are not particularly important from an operator's standpoint, as a change in gate position has little effect on the discharge in this range.

It must be assumed that the coefficient of discharge is known for at least one value of the head on the free crest (gate completely down) for the particular spillway under consideration. With the coefficient known for one or more heads, the complete coefficient curve for the free crest can be plotted by consulting Fig. 7, in which H_o and C_o are the designed head and the coefficient for the designed head, respectively. This chart was reproduced from a previous publication[2] and represents a curve well supported by tests of some fifty overfall spillway crests having wide variation in shape and operating conditions.

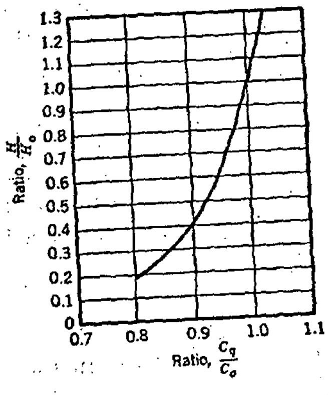


FIG. 7.—COEFFICIENTS OF DISCHARGE FOR OTHER THAN THE DESIGNED HEAD

APPLICATION OF RESULTS

From the plan and section of the Black Canyon Diversion Dam (Idaho), shown in Figs. 8 and 9, assume that it becomes necessary to compute and construct a rating curve for one drum gate for each 0.5 ft of gate elevation. The scale on the gate position indicator is calibrated to show the elevation of the high point of the gate, and the gate has a constant radius of 21.0 ft. The gate is 64 ft long. The coefficient of discharge for the free crest is $C_o = 3.48$ for the designed head (H_o) of 14.5 ft.

With the coefficient of discharge known for free flow at the designed head, the entire free-flow coefficient curve can be established by consulting Fig. 7. The free-flow coefficient curve for Black Canyon Dam spillway (for which $H_o = 14.5$ ft and $C_o = 3.48$) is constructed by arbitrarily assuming several values of H/H_o and reading the corresponding values of C/C_o from Fig. 7. The method is illustrated in Table 3, and the head-coefficient curve for free flow (gate down), obtained in this manner, is shown in Fig. 10.

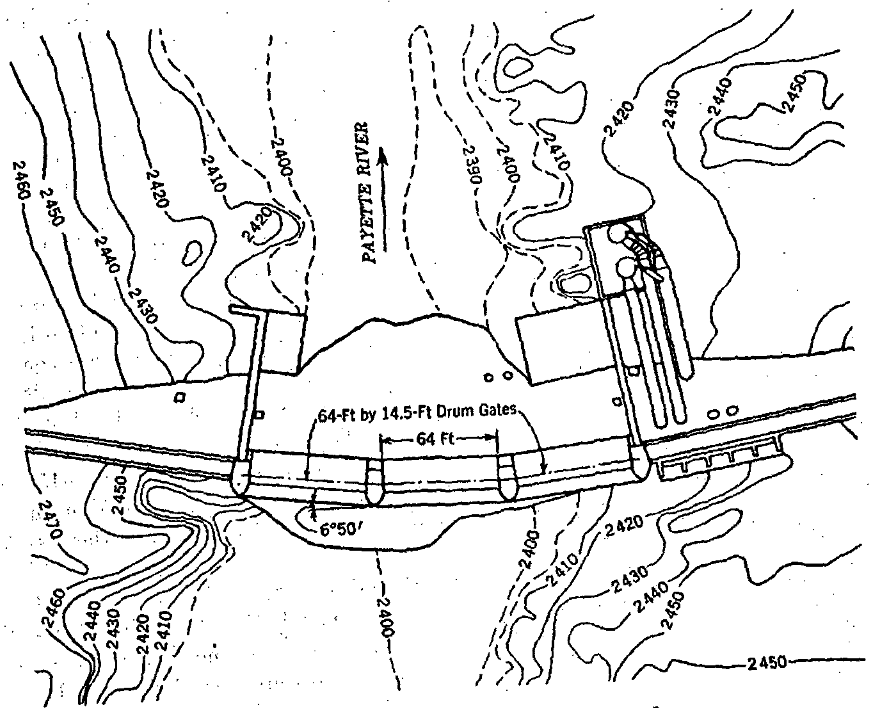


FIG. 8.—PLAN OF BLACK CANYON DIVERSION DAM IN IDAHO

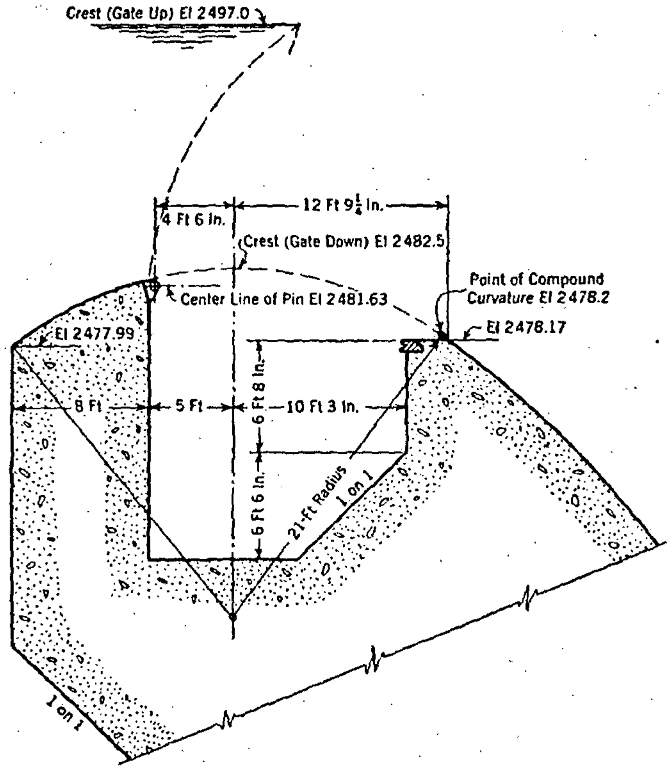


FIG. 9.—SPILLWAY CREST DETAIL, BLACK CANYON DAM IN IDAHO

TABLE 3.—HEAD AND DISCHARGE COMPUTATIONS FOR A FREE CREST (BLACK CANYON DAM IN IDAHO)

Total head, H, in ft (1)	Reservoir elevation, in ft (2)	Ratio,[a] H/H_o (3)	Ratio,[b] C_e/C_o (4)	Coefficient, C_e (5)	Q, in cu ft per sec[c] (6)
17	2499.5	1.172	1.020	3.55	15,950
16	2498.5	1.104	1.012	3.52	14,420
14.5	2497.0	1.0	1.0	3.48	12,296
12	2494.5	0.827	0.980	3.41	9,072
10	2492.5	0.690	0.960	3.34	6,759
8	2490.5	0.552	0.940	3.27	4,736
6	2488.5	0.414	0.905	3.135	2,949
4	2486.5	0.276	0.850	2.957	1,514
3	2485.5	0.207	0.815	2.835	943
2	2484.5	0.138	0.760	2.042	478

[a] $H_o = 14.5$ ft. [b] $C_o = 3.48$. [c] The discharge for one gate: $Q = C_e L H^{\frac{3}{2}}$, in which $L = 64.0$ ft.

Before considering the rating of the spillway with gates in raised positions, it is necessary to construct a diagram such as that shown in Fig. 11 to relate gate elevation to the angle θ for the Black Canyon Dam gate. The tabulation in Fig. 11 shows the angle θ for corresponding elevations of the downstream lip of the gate at intervals of 2 ft.

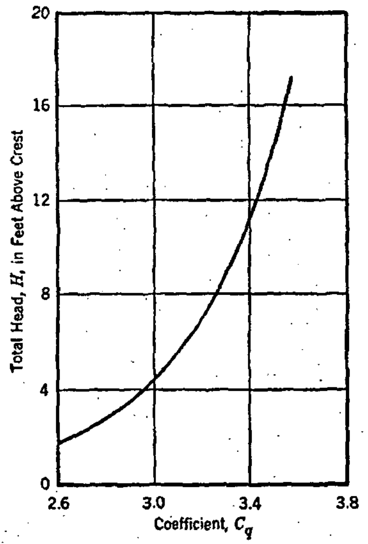


FIG. 10.—HEAD-COEFFICIENT CURVE, BLACK CANYON DAM, IN IDAHO

Beginning with the maximum positive angle of the gate, which is 34.883°, the computations may be begun by choosing a representative number of reservoir elevations as indicated in Col. 2, Table 4. The difference between the reservoir elevation and the high point of the gate (which is the downstream lip in this case) constitutes the total head on the gate, and values of head are recorded in Col. 3. Col. 4 shows these same heads divided by the radius of the gate, which is 21.0 ft.

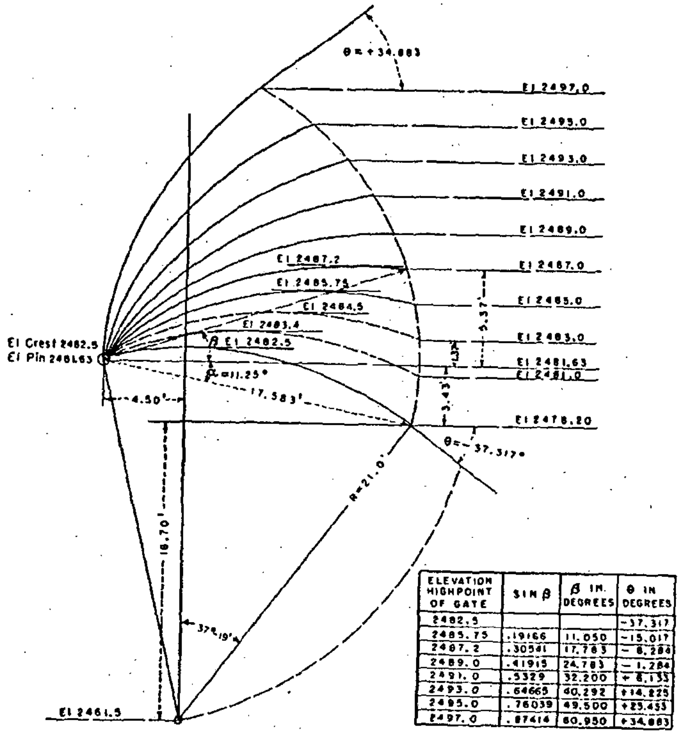
Entering the curves in Fig. 6 with the values in Col. 4, Table 4, for $\theta = +34.883°$, the discharge coefficients, listed in Col. 5 of the set of computations designated "A," are obtained. The remainder of the procedure outlined in Cols. 6 and 7, Table 4, consists of computing the discharge for one gate from the expression, $Q = C_q L H^{\frac{3}{2}}$. A similar procedure of computation is repeated for other positive angles of θ as in sets B, C, and D of Table 4.

As the angle θ is given negative values, the procedure for determining the discharge remains the same for angles between 0 and −15°, except that the head on the gate is measured above the high point rather than above the lip. Discharge computations for negative angles of the gate down to −15.017° are tabulated in E, F, and G of Table 4.

Plotting values of discharge, reservoir elevation, and gate elevation from Table 4 results in the seven curves in Fig. 12 for which the points are denoted by circles. The extreme lower curve, on which the points are identified by x-marks, represents the discharge of the free crest with the gate completely down. The latter values were obtained from Table 3.

The discharge values shown in Fig. 12 are for one gate only. When more than one gate is in operation, the discharges from the separate gates may be totaled providing the gates are each raised the same amount. The experimental models contained from one to four gates (with the exception of that of Grand Coulee Dam, which contained eleven) so a reasonable allowance for pier effect on the discharge is already present in the results.

The intervals between the eight curves identified by points (Fig. 12) are too great for rating purposes, especially the gap between gate elevations, 2485.75 ft and 2482.5 ft. This is remedied by cross-plotting the eight curves for various constant values of the discharge as shown in Fig. 13. Fortunately, the result is a straight-line variation for any constant value of discharge. The lines in Fig. 13 are not quite parallel and there is no assurance that they will be straight for every drum gate. Nevertheless, this will not detract appreciably from the accuracy obtained. Interpolated information from Fig. 13 is then utilized to construct the additional curves in Fig. 12. If all curves are considered, Fig. 12 shows the completed rating for the Black Canyon Dam spillway for 0.5-ft gate intervals. For intermediate values, straight-line interpolation is permissible.



ELEVATION HIGHPOINT OF GATE	SIN β	β IN DEGREES	θ IN DEGREES
2482.5			−37.317
2485.75	.19166	11.050	−15.017
2487.2	.30541	17.783	− 8.284
2489.0	.41915	24.783	− 1.284
2491.0	.5329	32.200	+ 6.133
2493.0	.64665	40.292	+14.225
2495.0	.76039	49.500	+23.433
2497.0	.87414	60.950	+34.883

FIG. 11.—RELATIONSHIP OF GATE ELEVATION TO ANGLE θ

CONCLUSIONS

This paper has demonstrated how an existing control structure, such as the Black Canyon Dam spillway, can also serve as a rating station. The accuracy of rating curves obtained by the method is estimated to approach that of an average current-meter traverse of the river providing that (1) the gate position indicators are made as large as possible and are accurately calibrated, (2) the reservoir gage can be read to within 0.05 ft, (3) nearly atmospheric pressure exists under the sheet of water after it springs from the gate, and (4) all gates are set at approximately the same elevation.

TABLE 4.—HEAD AND DISCHARGE COMPUTATIONS FOR DRUM GATES IN RAISED POSITIONS

Set	Reservoir elevation, in ft	H, in ft[a]	Ratio, $\frac{H}{r}$	Coefficients, C_q	$H^{3/2}$, in ft	Q, in cu ft per sec[b]
(1)	(2)	(3)	(4)	(5)	(6)	(7)
GATE ELEVATION 2497.0; $\theta = +34.88°$						
A	2498.0	1	0.048	3.86	1	247
	2499.0	2	0.095	3.86	2.828	699
	2500.0	3	0.143	3.86	5.196	1.283
GATE ELEVATION 2495.0; $\theta = +23.43°$						
B	2496.0	1	0.048	3.85	1	246
	2497.0	2	0.095	3.86	2.828	698
	2498.0	3	0.143	3.87	5.196	1,284
	2499.0	4	0.190	3.87	8.00	1,979
	2500.0	5	0.238	3.88	11.18	2,770
GATE ELEVATION 2493.0; $\theta = +14.22°$						
C	2494.0	1	0.048	3.69	1	236
	2495.0	2	0.095	3.73	2.828	675
	2496.0	3	0.143	3.75	5.196	1,247
	2498.0	5	0.238	3.80	11.18	2,719
	2500.0	7	0.333	3.84	18.52	4,552
GATE ELEVATION 2491.0; $\theta = +6.13°$						
D	2492.0	1	0.048	3.47	1	222
	2493.0	2	0.095	3.51	2.828	635
	2494.0	3	0.143	3.57	5.196	1,187
	2496.0	5	0.235	3.63	11.18	2,597
	2498.0	7	0.333	3.70	18.52	4,386
	2500.0	9	0.429	3.77	27.00	6,515
GATE ELEVATION 2489.0; $\theta = -1.28°$						
E	2490.0	1	0.048	3.21	1	205
	2491.0	2	0.095	3.28	2.828	594
	2492.0	3	0.143	3.34	5.196	1,111
	2494.0	5	0.238	3.45	11.18	2,469
	2496.0	7	0.333	3.545	18.52	4,202
	2498.0	9	0.429	3.63	27.00	6.273
	2500.0	11	0.524	3.695	36.48	8.627
GATE ELEVATION 2487.2; $\theta = -8.28°$						
F	2488.0	0.8	0.038	3.02	0.716	138
	2489.0	1.8	0.086	3.10	2.415	479
	2490.0	2.8	0.133	3.17	4.685	950
	2492.0	4.8	0.229	3.31	10.52	2,229
	2494.0	6.8	0.324	3.43	17.73	3.892
	2496.0	8.8	0.419	3.51	26.10	5.863
	2498.0	10.8	0.515	3.58	35.49	8.131
	2500.0	12.8	0.610	3.635	45.79	10,653
GATE ELEVATION 2485.75; $\theta = -15.02°$						
G	2487.0	1.25	0.060	3.00	1.398	268
	2488.0	2.25	0.107	3.07	3.375	663
	2489.0	3.25	0.155	3.15	5.850	1,181
	2491.0	5.25	0.250	3.275	12.03	2,522
	2493.0	7.25	0.345	3.375	19.52	4,216
	2495.0	9.25	0.440	3.465	28.13	6,238
	2497.0	11.25	0.536	3.54	37.73	8,548
	2499.0	13.25	0.631	3.595	48.23	11,097

[a] H is the total head on the gate. [b] The discharge for one gate: $Q = C_q L H^{3/2}$.

In connection with provision (3), the blunt piers on the Black Canyon Dam spillway, Figs. 8 and 9, provide effective aeration under the overfalling sheet of water for all but very small heads with gate completely raised. In the case of provision (4), uniform operation of the gates is also most desirable from the standpoint of stilling basin operation for minimum erosion downstream.

Discharge measurements on the prototype are desirable whenever possible as a check on the accuracy of the foregoing method. Sufficient observations should be taken, however, to establish the fact that the prototype information is consistent and reliable.

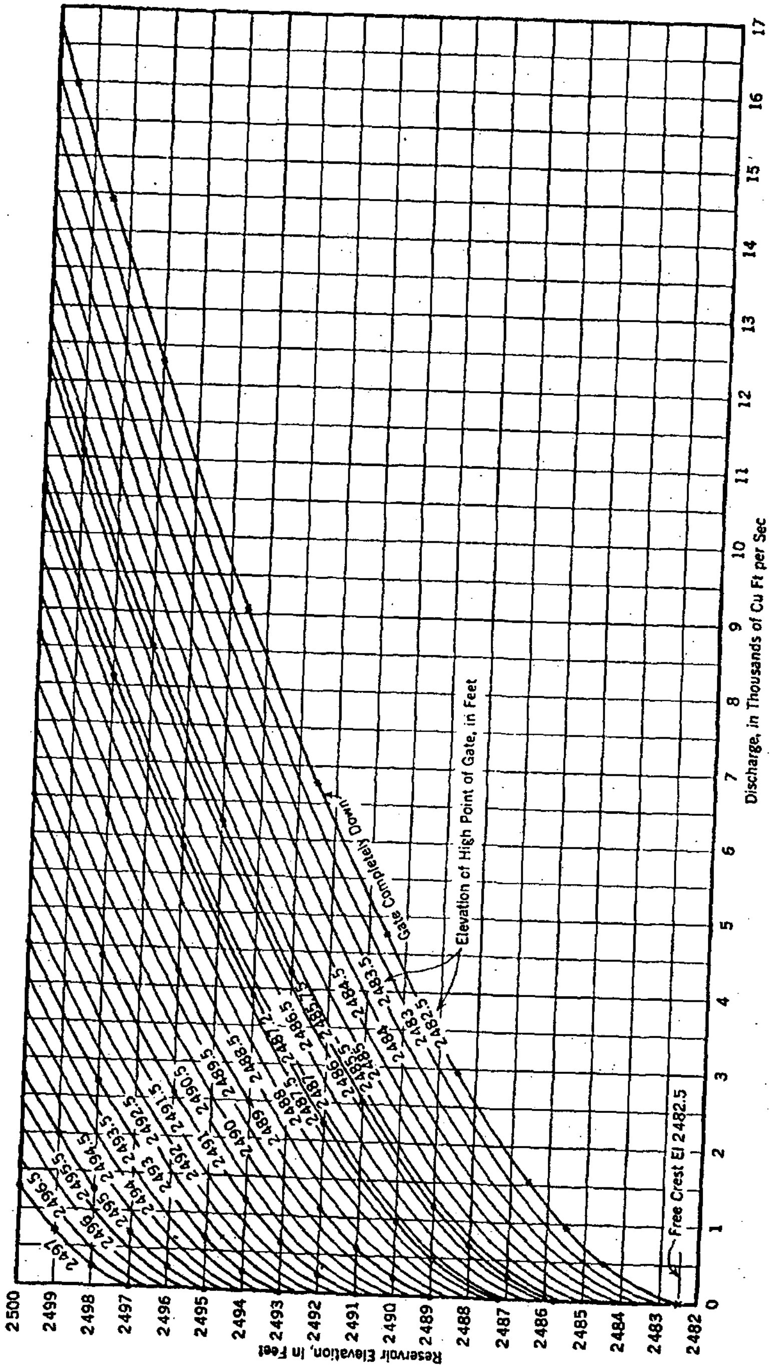


FIG. 12.—RATING CURVES FOR BLACK CANYON DAM DRUM-GATE SPILLWAY IN IDAHO

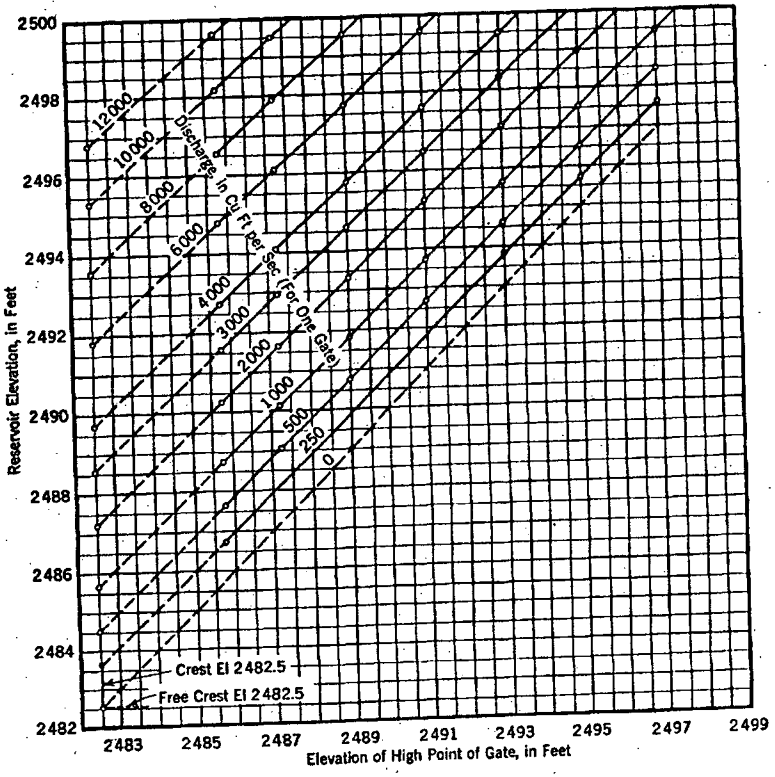


Fig. 13.—Cross-Plotted Initial Rating Curves, Black Canyon Dam in Idaho

Acknowledgments

The writer wishes to thank C. E. Blee, M. ASCE, chief engineer of the Tennessee Valley Authority for the use of the data on the Norris Dam Spillway; Hal Birkeland, M. ASCE, of the International Engineering Corporation, for obtaining permission to include the Bhakra and Capilano Dam spillways in the paper; and the chief engineer of the Panama Canal for use of the data on the Madden Dam spillway. The writer is also grateful to the Bureau of Reclamation for the use of the remainder of the experimental information. He also wishes to thank his engineering associates, H. M. Martin, M. ASCE, D. J. Hebert, and A. J. Peterka, A. M. ASCE, for their most helpful comments and suggestions.

DISCUSSION

Guido Wyss[6].—The information presented by Mr. Bradley is of utmost value for determining the quantities of discharge over drum gates under various heads for any gate position. This information will permit operators in the field to adjust the gate position from corresponding chart values in such a manner as to obtain the desired flow. The use of drum gates as an actual metering device for spillway quantity discharges is unique and the results obtained are more practicable and reliable than those obtained by stream gaging, especially when this gaging is conducted during periods of high floods.

It would have been interesting if the author had presented an investigation of the flow, profiles of the upper and lower nappe surfaces, as well as the actual water pressures on the upstream plate of the drum gate by use of charts. This would afford an opportunity to obtain the true loading conditions on the gate during the cycle of operation from fully-raised gate to fully-lowered gate. This information would be important in the determination of the buoyancy and loading criteria of the gate structure.

Sam Shulits,[7] M. ASCE.—An outstanding contribution to the design and operation of drum gates has been presented in this report of the author's work at the USBR. The paper and its complement[2] fill a great need.

Since 1928, when the Freeman Scholarships were established, there has been a tremendous development of hydraulic model research in the laboratories of the United States. Although these laboratories are unexcelled in size and quality, many hydraulic engineers have pondered the procession of models (spillways, stilling pools, and river reaches) in the period from 1928 to 1953 with few, if any, summaries or proposals for design to reduce the dependence on models. In Mr. Bradley's work there is strong evidence that the laboratories will produce correlations and syntheses—not more models.

When it is realized that many of the most famous and productive laboratories in the United States did not exist prior to 1928, the lack of correlation and synthesis for general use is understandable. The hope is that other works of similar quality will be added to engineering literature.

Bob Buehler,[8] A. M. ASCE.—An interesting and clever use of data has resulted in a method by which records of gate settings at dams can be made a substitute for missing stream-flow records and can be used to augment existing records. The construction of a dam and reservoir often floods an established stream gage. Unless the gage is replaced below the dam or upstream from the reservoir, subsequent stream flow usually is not accurately known. Sometimes a series of dams (each causing the water to back up to the dam above) prevents continuing established gages at the strategic points where they had been

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located. The less accurate—and more costly—slope stations are not completely satisfactory alternatives to the single-line rating stations.

If the spillway of a dam can be rated with an accuracy comparable to the accuracy obtainable with a gage (as demonstrated by Mr. Bradley for certain spillway types), and if allowance is made for flow through other water outlets such as turbines, locks, and sluices, the structure is then superior in some respects to the gage. For example, the rating of the dam should be permanent, whereas the rating of a gage usually requires frequent checking.

Mr. Bradley's method for rating drum gates not only allows records for ordinary stream flow to be supplemented, but also probably gives a more accurate determination of extreme flood rates than do most gages. He has made an important contribution to the planning and design of drum-gated structures.

The author has presented a method for rating a spillway at all heads provided the coefficient for one appreciable head is known. He also states that a coefficient for the designed head can be estimated for most spillways by a method previously published.[2] The writer, on the other hand, offers a method by which an ogee spillway can be rated, provided its profile shape is known. The method is based on an equation derived by R. N. Brudenell, A. M. ASCE, incidental to studies made on radial gates.[9] Mr. Brudenell's equation is

$$Q = \frac{3.97\ L\ H^{1.62}}{H^{0.12}{}_{D}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

in which Q is the spillway discharge, in cubic feet per second; L denotes the length of the spillway, in feet; H is the total head on the spillway crest, in feet; and H_D represents the design head in feet. The design head is that head which produces a standard lower nappe that agrees closely with the spillway profile.

TABLE 5.—FREE DISCHARGES FOR BLACK CANYON DAM IN IDAHO

Total head, in feet	Discharge, in cubic feet per second[a]	USING EQ. 1		USING FIG. 14	
		Discharge, in cubic feet per second	Difference, in percent	Discharge, in cubic feet per second	Difference, in percent
(1)	(2)	(3)	(4)	(5)	(6)
17	15,950	15,847	−0.65	15,910	−0.25
16	14,420	1,4363	−0.39	14,421	−0.01
14.5[b]	12,296	12,247[c]	−0.40	12,296	0
12	9,072	9,013	−0.65	9,049	−0.25
10	6,759	6,708	−0.75	6,735	−0.36
8	4,736	4,673	−1.33	4,692	−0.93
6	2,949	2,932	−0.58	2,944	−0.20
4	1,514	1,521	+0.46	1,527	+0.86
3	943	954	+1.17	958	+1.59
2	478	494	+3.35	496	+3.76

[a] From Col. 6, Table 3. [b] Head at which C_q = 3.48. [c] C_q would be 3.466 for this discharge.

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[9] "Flow over Rounded Crests," by R. N. Brudenell, *Engineering News-Record*, July 18, 1935, p. 95.

Eq. 1 was intended to be used with heads greater than $H_D/4$, although the equation has been found to agree closely with model data for somewhat lower heads. Without knowing any coefficients, Eq. 1 gives discharges that agree closely with those obtained by Mr. Bradley for Black Canyon Dam. In the case of Black Canyon Dam, Mr. Bradley used one known coefficient and the curve of Fig. 7. Free-flow discharges computed by the two methods are shown in Cols. 2 and 3, Table 5. The procedure by which Eq. 1 was applied will be described subsequently.

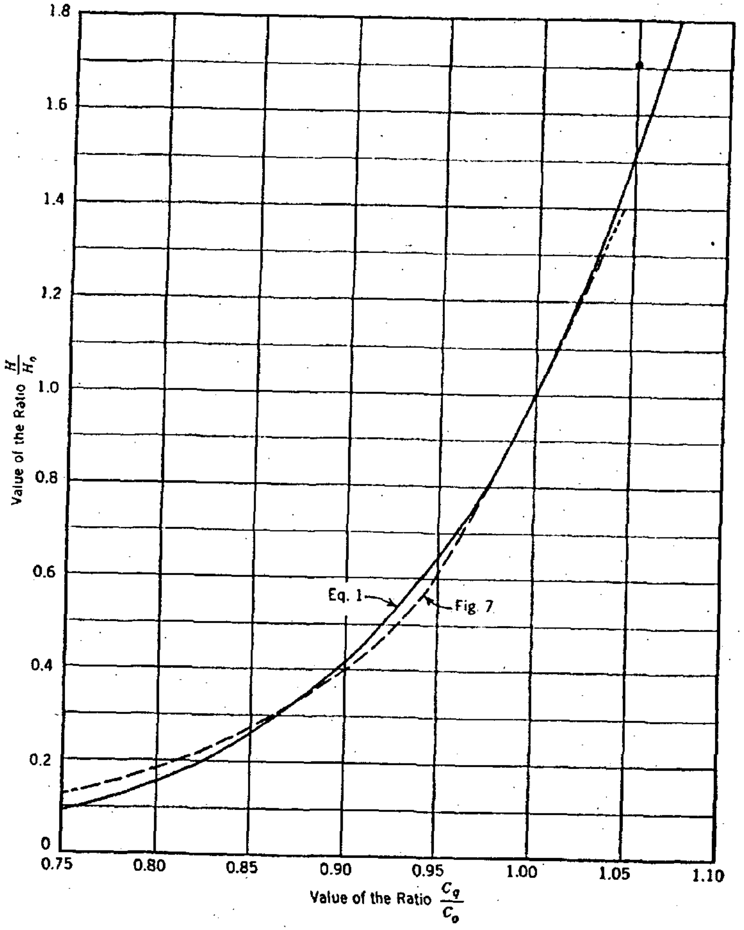

FIG. 14.—COMPARISON OF VALUES OBTAINED FROM FIG. 7 AND EQ. 1

It is assumed that in choosing Black Canyon Dam for his example, the author knew that his method would yield discharges close to known values. The good agreement for all except the low heads shows that, in this example, Eq. 1 (using only the shape of the spillway) also produces suitable results.

This good agreement suggests, too, that there must be a close relationship between the curve in Fig. 7 and a similar curve that can be derived from Eq. 1. To examine the relationship, theoretical discharge coefficients were computed by using

$$Q = C_q\, L\, H^{3/2} \qquad (2)$$

and Eq. 1, from which

$$C_q = \frac{3.97\ H^{1.62}}{H^{0.12}{}_D\ H^{3/2}} \qquad (3)$$

The design head, H_D, was found (by a method to be described subsequently) to be 45 ft for Black Canyon Dam, and this value was used in making the test. Thus, for $H_D = 45$ ft,

$$C_q = \frac{2.5143\ H^{1.62}}{H^{3/2}} \qquad (4)$$

For several assumed values of total head, H, varying from 2 ft to 58.5 ft, corresponding C_q-values were computed. The resulting C_q of 3.97 for a head of 45 ft (H_o) was taken arbitrarily as the known coefficient, C_o. Then the (H/H_o) -ratios and the (C_q/C_o)-ratios were computed for all other heads in the assumed range. The resulting curve is the solid line in Fig. 14. The dashed curve is from Fig. 7. The agreement is close—as expected. Still using H_D equal to 45 ft, the remainder of the process was repeated using the coefficient for the 25-ft head as C_o, and then using the coefficient for the 12-ft head as C_o. There was no discernible difference in the curves resulting from the three separate selections. A similar procedure, using H_D equal to 20 ft in Eq. 1, also showed no differences from Fig. 14. It can probably be proved that there should be no difference.

The curve derived from Eq. 1 then was applied to the Black Canyon Dam spillway, assuming (as did the author) that the coefficient is 3.48 at a 14.5-ft head. The resultant free discharges are shown in Col. 5, Table 5.

The free-flow coefficients in Table 2 invite further comparisons with Eq. 1 for the four projects for which spillway profiles are given in Fig. 3. It should be remembered that this comparison tests the use of only the spillway shape as a guide to free discharge for the entire range of heads. Col. 4, Table 6, shows that for appreciable heads the maximum error in the four cases is approximately 2% (Hamilton Dam). Observed coefficients in model tests often scatter as much.

The same coefficients permit testing the curve in Fig. 7 for all eleven spillways. This test is not as severe, however, because it is necessary to assume one known coefficient at which head agreement becomes perfect. At near-by higher and lower heads, large divergences would not be expected. Col. 6, Table 6, shows that for appreciable heads the maximum error is slightly greater than 2% (Hoover Dam, shape 8-M5). The base coefficient selected to obtain C_q from the (C_q/C_o)-ratios is designated by a footnote for each project. These arbitrary selections were made for medium high heads.

The solid-line curve in Fig. 14 also was tested in this manner. The same coefficient at each project was assumed to be known as when the curve in Fig. 7 was tested. Col. 8, Table 6, shows that for appreciable heads the maximum error is slightly more than 2% (Madden Dam).

These comparisons show that the direct application of Eq. 1, Fig. 7 (or Fig. 14) (derived from Eq. 1), all give highly accurate free-flow spillway dis-

TABLE 6.—COMPARISON OF FREE-FLOW SPILLWAY COEFFICIENTS

Total head, in feet	Coefficient obtained from model test	USING EQ. 1		USING FIG. 7		USING FIG. 14	
		C_q	Difference, in percent	C_q	Difference, in percent	C_q	Difference, in percent
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GRAND COULEE DAM (WASHINGTON)							
35	3.920			3.914	− 0.15	3.902	−0.46
30	3.842			3.831	− 0.29	3.827	−0.39
25	3.745			3.745ᵃ	0	3.745ᵃ	0
20	3.635			3.655	+ 0.55	3.651	+0.44
15	3.510			3.550	+ 1.14	3.524	+0.40
10	3.352			3.370	+ 0.54	3.356	+0.12
5	3.220			3.138	− 2.54	3.168	−1.62
BHAKRA DAM (INDIA)							
28	3.680			3.736	+ 1.52	3.732	+1.41
23	3.645			3.645ᵃ	0	3.645ᵃ	0
18	3.550			3.547	− 0.08	3.543	−0.20
13	3.420			3.434	+ 0.41	3.404	−0.47
8	3.275			3.215	− 1.83	3.208	−2.04
3	3.120			2.748	−11.92	2.854	−8.53
SHASTA DAM (CALIFORNIA)							
38	3.895			3.910	+ 0.39	3.899	+0.10
33	3.835			3.839	+ 0.10	3.831	−0.10
28	3.760			3.760ᵃ	0	3.760ᵃ	0
23	3.675			3.677	+ 0.05	3.674	−0.03
18	3.575			3.591	+ 0.45	3.568	−0.20
13	3.465			3.455	− 0.29	3.429	−1.04
8	3.335			3.215	− 3.60	3.230	−3.15
HAMILTON DAM (TEXAS) H_D = 52 FT							
35	3.710	3.785	+2.02	3.741	+ 0.84	3.730	+0.54
30	3.645	3.716	+1.95	3.662	+ 0.47	3.659	+0.38
25	3.580	3.635	+1.54	3.580ᵃ	0	3.580ᵃ	0
20	3.500	3.539	+1.11	3.494	− 0.17	3.490	−0.29
15	3.400	3.420	+0.59	3.394	− 0.18	3.369	−0.91
10	3.290	3.258	−0.97	3.222	− 2.07	3.208	−2.50
5	3.160	2.997	−5.16	3.000	− 5.06	3.029	−4.14
FRIANT DAM (CALIFORNIA)							
20	3.650			3.717	+ 1.84	3.706	+1.53
17	3.625			3.639	+ 0.39	3.632	+0.19
14	3.550			3.550ᵃ	0	3.550ᵃ	0
11	3.460			3.458	− 0.06	3.452	−0.23
8	3.340			3.348	+ 0.24	3.319	−0.63
5	3.175			3.142	− 1.04	3.131	−1.38
2	2.965			2.723	− 8.15	2.812	−5.16

ᵃ Coefficient assumed to be known.

TABLE 6.—(*Continued*)

Total head, in feet (1)	Coefficient obtained from model test (2)	Using Eq. 1		Using Fig. 7		Using Fig. 14	
		C_e (3)	Difference, in percent (4)	C_e (5)	Difference, in percent (6)	C_e (7)	Difference, in percent (8)
NORRIS DAM (TENNESSEE) H_D = 35 FT							
35	3.915	3.969	+1.38	3.934	+ 0.49	3.923	+0.20
30	3.845	3.897	+1.35	3.852	+ 0.18	3.848	+0.08
25	3.765	3.812	+1.25	3.765[a]	0	3.765[a]	0
20	3.670	3.711	+1.12	3.675	+ 0.14	3.671	+0.03
15	3.550	3.586	+1.01	3.569	+ 0.53	3.543	−0.20
10	3.390	3.416	+0.77	3.388	− 0.06	3.373	−0.50
5	3.125	3.143	+0.58	3.155	+ 0.96	3.185	+1.92
MADDEN DAM (CANAL ZONE)							
35	3.900			3.825	− 1.92	3.814	−2.20
30	3.770			3.744	− 0.69	3.740	−0.80
25	3.660			3.660[a]	0	3.660[a]	0
20	3.560			3.572	+ 0.34	3.568	+0.22
15	3.460			3.470	+ 0.29	3.444	−0.46
10	3.365			3.294	− 2.11	3.279	−2.55
5	3.280			3.067	− 6.49	3.096	−5.61
CAPILANO DAM (BRITISH COLUMBIA) H_D = 48 FT							
33	3.775	3.797	+0.58	3.783	+ 0.21	3.775	0
28	3.705	3.720	+0.40	3.705[a]	0	3.705[a]	0
23	3.625	3.634	+0.25	3.623	− 0.05	3.620	−0.14
18	3.530	3.529	−0.03	3.538	+ 0.23	3.516	−0.40
13	3.415	3.394	−0.62	3.405	− 0.29	3.379	−1.05
8	3.250	3.201	−1.51	3.168	− 2.52	3.183	−2.06
HOOVER DAM (ARIZONA-NEVADA) SHAPE 4-M3, H_D = 50 FT							
26	3.670	3.670	0	3.681	+ 0.30	3.677	+0.19
22	3.605	3.597	−0.22	3.605[a]	0	3.605[a]	0
18	3.540	3.512	−0.79	3.526	− 0.40	3.522	−0.51
14	3.472	3.408	−1.84	3.439	− 0.95	3.414	−1.67
10	3.405	3.273	−3.88	3.306	− 2.91	3.280	−3.67
6	3.338	3.077	−7.82	3.064	− 8.21	3.082	−7.67
HOOVER DAM SHAPE 8-M5							
28	3.735			3.814	+ 2.12	3.800	+1.74
25	3.705			3.752	+ 1.27	3.749	+1.19
20	3.650			3.650[a]	0	3.650[a]	0
15	3.565			3.537	− 0.78	3.530	−0.98
10	3.460			3.387	− 2.11	3.358	−2.94
5	3.335			3.059	− 8.28	3.088	−7.41
HOOVER DAM SHAPE 7-C4							
26	3.665			3.691	+ 0.71	3.687	+0.60
22	3.615			3.615[a]	0	3.615[a]	0
18	3.540			3.535	− 0.14	3.532	−0.23
14	3.450			3.449	− 0.03	3.423	−0.78
10	3.360			3.315	− 1.34	3.290	−2.08
6	3.200			3.073	− 3.97	3.091	−3.41

charges for ogee dams at all but low heads. Eq. 1, applied directly to the spillway shape, has the advantage that no coefficients need be known or estimated in advance.

The comparisons in Table 6 show a tendency toward errors of some importance at low heads when Eq. 1 or its companion curve in Fig. 14 is used, as well as when Fig. 7 is used. In most cases the errors are negative. These errors are of little concern in planning the safety of a structure against extreme floods, or in considering most other operations such as emptying the reservoir. The errors nonetheless affect the analytical rating of drum gates in the lowered or slightly raised positions. The free-flow coefficients help to determine the direction of the general curves at the large negative angles shown in Fig. 6. Free discharges form the base curve of the rating curves in Fig. 12 and help define the curvature of the low ends of the cross-plot curves in Fig. 13. Low to ordinary heads, corresponding to normal stream flow, can exist for a large part of the time at dams whose reservoir capacities are small. Further study of data for low heads might lead to valuable refinements.

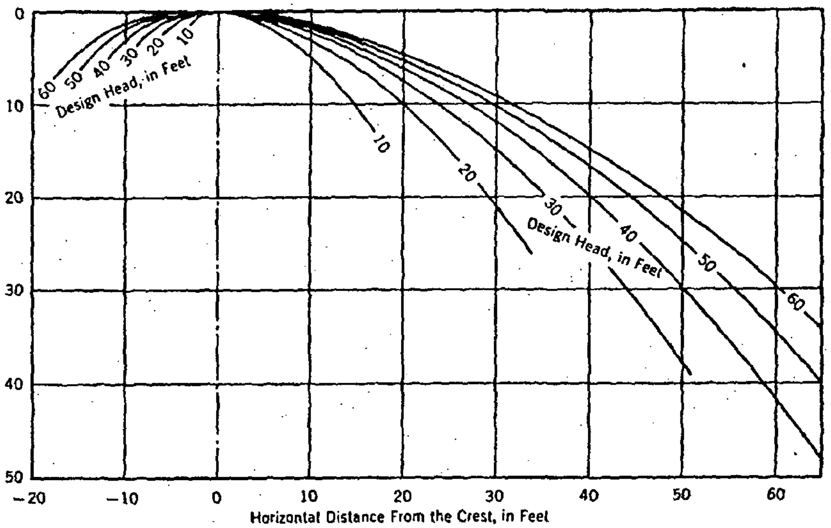

FIG. 15.—STANDARD SPILLWAY SHAPES

Application of Eq. 1.—Since the factor H_D in Eq. 1 represents the head at which a standard lower nappe shape is a reasonable approximation of the spillway shape (as designed or built), it is only necessary to find this head to apply the formula. Spillway coordinates for a standard crest having a vertical upstream face have been used to find this head.[10] These coordinates are shown in Table 7. The last column in Table 7 refers the horizontal (x) coordinates to the spillway crest because this form is the simplest to apply. In Table 7, y is the distance below the crest elevation.

Using these dimensionless coordinates, standard spillway shapes were plotted (Fig. 15) for values of H_D from 10 ft to 60 ft. In Fig. 15 negative

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[10] "Hydroelectric Handbook," by William P. Creager and Joel D. Justin, John Wiley & Sons, Inc., New York, N. Y., 2d Ed., 1950, p. 362.

horizontal distances indicate the distance upstream from the crest. The spillway shape as designed or built is then drawn on transparent paper. This paper is laid over Fig. 15, and the value of H_D which gives the best fit is selected. In deciding the best fit it may be found that the profile upstream from the crest indicates one value and the downstream profile indicates a different value. The higher of the two indicated values of H_D should be used. For example, the shape of Black Canyon Dam spillway upstream from the crest indicated a value of approximately 45 ft for H_D. The downstream shape indicated a value of approximately 25 ft. The larger value was used.

TABLE 7.—COORDINATES OF A STANDARD SPILLWAY CREST

Value of $\frac{x}{H_D}$	Value of $\frac{y}{H_D}$	Value of $\frac{x}{H_D}$ referred to crest
0	0.126	−0.3
0.1	0.036	−0.2
0.2	0.007	−0.1
0.3	0	0
0.4	0.007	0.1
0.6	0.063	0.3
0.8	0.153	0.5
1.0	0.267	0.7
1.2	0.410	0.9
1.4	0.590	1.1
1.7	0.920	1.4
2.0	1.31	1.7

The determination of the H_D-value which gives a reasonable fit requires a certain amount of judgment. When the profile upstream from the crest is the criterion, the lip of the dam will sometimes be the determinant. Sometimes, however, the lip droops sharply downward and indicates a lower value than other parts of the upstream profile. When the downstream shape is the criterion, good results have been obtained by assigning a value of H_D based on the average fit in the zone between points on the spillway where tangents range from 20° to 35° from the horizontal. The exact value of H_D is not too important. Since it enters Eq. 1 in the 0.12 power, a difference of 10% in its value affects the discharge by only 1.15%.

The writer's application of Eq. 1 has been limited to fairly high dams. Although the total head used in Eq. 1 should include the approach velocity, the accuracy of Eq. 1 when used for low dams, where approach velocity is large, has not been tested.

So far as is known, the application of standard nappe shapes (for which discharge coefficients are known) to actual spillways on a basis of reasonable best fit was first suggested by W. M. Borlund.[11] Mr. Borlund used a curve of observed C_q-value plotted against H/H_o. In 1942, C. E. Kindsvater, M. ASCE, suggested a similar procedure in which the curve of C_q versus H/H_o was derived from Eq. 1. Mr. Kindsvater's work (not published) should give results comparable to those obtained herein.

The material presented is regarded as an excellent check on that part of Mr. Bradley's work which relates to free discharge over an ogee spillway.

F. B. CAMPBELL,[12] M. ASCE, AND A. A. McCOOL,[13] J. M. ASCE.—The experimental data on discharge coefficients for flow over drum gates are a welcome addition to the published information on flow over spillways, or the observation and recording of the flow of streams. A paper by Robert E. Horton has been a guide for the estimation of flows over spillways since its publication.[14] The basic information for the discharge over curved crests which fit the under side of a nappe from a sharp-crested weir can be deduced from investigations made by Bazin,[15,16] although the published record of these experiments has not been generally available to engineers in the United States. The investigations conducted by the USBR (proposed by E. W. Lane, M. ASCE) embraced and extended the scope of Bazin's work which is often used as the basis for overflow spillway shapes.[3] Although good estimates for discharge over free-overflow crests can be accomplished rather simply, the problem becomes complicated when flow through partly opened crest gates is involved.

The commonly used types of crest gates are vertical lift gates, tainter or radial gates, and drum gates. The coefficient for a partly opened vertical lift gate depends on the location of the plane of the skin plate or lip with respect to the axis of the curved crest. The discharge coefficient for tainter gates is affected by the radius of the skin plate, the elevation of the trunnion with respect to the crest, and the location of the gate seat with respect to the axis as well as the crest curvature. To complicate any investigations further, observers define the gate opening variously as (1) the length of the arc from the gate seat to the gate lip, (2) the vertical distance from the lip to the face, and (3) the distance from the lip to the face measured normal to the face. The last method is believed to give the proper dimension, whereas the foregoing considerations are geometrical. The effective head for a partly opened vertical lift or tainter gate depends on the pressures on the face of the concrete and the pressures within the issuing jet. The author has given a good outline of the geometrical variables and the head-measurement method for analyzing partly raised drum gates.

The drum gate has the very attractive feature of requiring no mechanical hoisting equipment for operation. Many of the dams constructed by the USBR have spillways controlled by drum gates. For example the Arrowrock Dam in Idaho (constructed in 1915) and the Tieton Dam in Washington (constructed in 1925) are both equipped with drum gates. B. F. Thomas and D. A. Watt credit H. M. Crittenden with the design of what is apparently the first drum gate.[17] The gates were installed in Dam No. 1 on the Osage River in Missouri in 1911. However, the refinements of the modern drum gate have been developed principally by the USBR.

The discharge coefficients presented by the author are based on model studies. There should be opportunity to check the coefficients for relatively low heads with partly raised gates in the prototype by current-meter measure-

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[11] "Flow over Rounded Crest Weirs," by W. M. Borlund, thesis presented to the University of Colorado, at Boulder, Colo., in 1938, in partial fulfilment of the requirement for the degree of Master of Science.

[12] Chf. Hydr. Engr., Analysis Branch, Corps of Engrs., U. S. Waterways Experiment Station, Vicksburg, Miss.

[13] Hydr. [illegible] U. S. Waterways Experiment Station, Vicksburg, Miss.

[14] "Weir Experiments, Coefficients and Formulas," by Robert E. Horton, *Water Supply and Irrigation Paper No. 200*, Coast and Geodetic Survey, U. S. Dept. of Commerce, Washington, D. C., 1907 (revision of Paper No. 150).

[15] "Recent Experiments on the Flow of Water over Weirs," by H. Bazin, *Annales des Ponts et Chaussées*, October, 1888. (Translation by Arthur Marichal and John C. Trautwine, Jr., *Proceedings*, Engineers' Club of Philadelphia, Pa., Vol. VII, No. 5, 1890, p. 259.)

[16] *Ibid.*, Vol. IX, No. 3, 1892, p. 231.

[17] "The Improvement of Rivers," by B. F. Thomas and D. A. Watt, John Wiley & Sons, Inc., New York, N. Y., 2d Ed., 1913.

ments. Only on rare occasions with large floods is it possible to verify the coefficients for high prototype heads over the drum gates in the lowered position. The author's mention of the failure to obtain discharge measurements during the 1948 flood over the Grand Coulee Dam spillway emphasizes the importance of this condition. The writers have studied the basic data for high heads over the drum gate in the lowered position.

It becomes evident from a study of Table 2 that the ratio of gate radius to maximum head has a wide range. The writers use the ratio r/H_D, in which H_D is the design head for the spillway. This is the inverse of the ratio used by Mr. Bradley, used so that circular arcs can be traced on dimensionless profiles of x/H_D and y/H_D.

A comparison has been made of the coefficients for various (r/H_D)-values with the gate down. Only the high-overflow sections with negligible velocity of approach were selected from Table 2 for a study of discharge coefficients. Table 8 shows the value of the discharge coefficients for the condition when the drum gate is down. The percentage difference of the coefficient from that of the Madden Dam coefficient is also shown. It is expected that the accuracy of the discharge measurements and thus the coefficient of discharge is less than 1%.

TABLE 8.—COMPARISON OF DISCHARGE COEFFICIENT WITH THE GATE DOWN

Dam	Radius of gate, in feet[a]	Maximum head on crest, in feet[a]	Ratio, $\frac{r}{H_D}$	Coefficient,[b] C_e	Difference, in percent, from Madden Dam
Madden (Canal Zone)	30.0	30.0	1.00	3.77	0.0
Norris (Tennessee)	34.0	27.0	1.26	3.80	0.8
Grand Coulee (Washington)	66.2	31.6	2.09	3.87	2.6
Shasta (California)	66.2	28.0	2.37	3.76	−0.3
Friant (California)	47.0	19.0	2.47	3.64	−3.5
Capilano (British Columbia)	71.0	23.0	3.08	3.62	−4.0

[a] From Table 1. [b] From Table 2.

The dams for which the data are listed in Table 8 are in the approximate chronological order of the time of their design conception.

Because of the increase in the ratio of r/H_D (Table 8), it is of interest to plot the profile for the lower surface of the nappe from a sharp-crested weir with an approach slope of 2 on 3 in terms of x/H_D and y/H_D and to superimpose on it the arcs of circles with radii of r/H_D equal to 1, 2, and 3, as is done in Fig. 16. The center of the radius is located on the axis of the crest. It can be seen that the arc represented by r/H_D equal to 1 is a fair approximation of the true nappe shape. The arcs of r/H_D equal to 2 and 3 indicate a very flat curvature in comparison to the shape of the nappe.

One is tempted to assume, for a crest with a ratio $r/H_D = 3$, that the coefficient would be that for one third the design head of a crest with $4/H_D = 1$. Model studies for Madden Dam reported by Richard R. Randolph, Jr.,[18] indicate that the coefficient for such a condition is approximately 3.40. Such a coefficient is not in agreement with that for Capilano Dam with r/H_D equal to 3.62 at full head. The lack of agreement does not necessarily vitiate the initial assumption. The difference in the coefficient may be caused by the difference in shape of the two crests upstream from the circular arc. Furthermore, the scale ratio of the Madden Dam model was only 1:78, and a 10-ft prototype head would be 0.128 ft on the model, which is near the lower limit of reliability for conformity of the discharge coefficient.

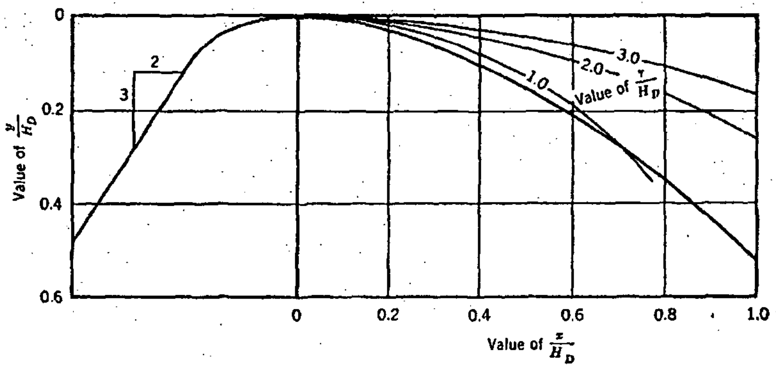

FIG. 16.—LOWER SURFACE OF NAPPE FROM SLOPING WEIR COMPARED WITH CIRCULAR ARCS

JOSEPH N. BRADLEY,[19] A.M. ASCE.—Mr. Shulits' statements regarding the lack of correlation in laboratory studies are well founded, and the writer is in complete agreement with his views.

Mr. Buehler's analysis for the determination of the designed head, H_D, for overflow sections formed by a single radius, or for a shape that conforms closely to a single radius, gives satisfactory results. The comparison of discharge coefficients for free flow over various dams, using Eq. 3 with the method offered in the paper, is gratifying. Mr. Buehler's method certainly has merit because following the determination of H_D, coefficients of discharge can be computed directly for all heads.

Messrs. Campbell and McCool undertook to show that a definite relationship exists between the coefficient of discharge at the designed head and the ratio r/H_D for overflow shapes. This relationship is valid if the overflow shape can be approximated by an arc of a single radius and if the approach conditions are favorable—that is, if the approach depth below the crest is at least twice H_D. This method results in a coefficient of discharge for the designed head only. When overflow sections are encountered where a single radius does not approximate the overflow shape, or when the approach conditions are unusual, an engineering monograph[7] may prove helpful.

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[18] "Hydraulic Tests on the Spillway of the Madden Dam," by Richard R. Randolph, Jr., *Transactions*, ASCE, Vol. 103, 1938, p. 1091.

[19] Hydr. Engr., Bureau of Reclamation, U. S. Dept. of the Interior, Denver, Colo.

Mr. Wyss suggested that pressures and water surfaces for drum gates at various positions and reservoir levels would be useful to designers in computing gate loadings. A limited amount of information is available, and this will be presented.

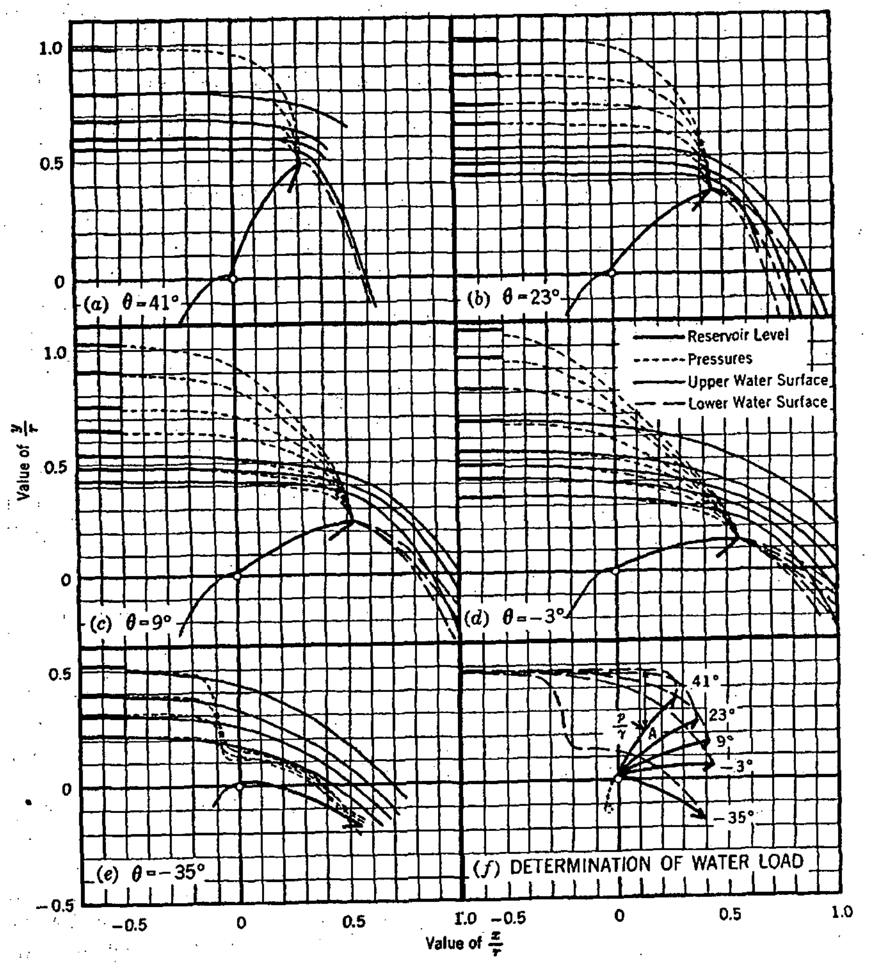

FIG. 17.—PRESSURE AND WATER-SURFACE PROFILES

Because there was good correlation among the discharge coefficients, it was reasoned that the pressures and related flow patterns would also be well correlated through the same variables.

Pressures and water-surface profiles are plotted in dimensionless coordinates (in terms of the radius of the gate) in Fig. 17. Five positions of the gate are shown for various reservoir levels producing flow over the gate. Pressures and water surfaces are shown for some levels whereas only pressures are available for others. The broken lines represent pressure, measured vertically, for the reservoir levels indicated at the left of the charts. Upper water-surface profiles are shown by solid lines, and lower water-surface profiles are identified by dash lines. The charts represent a composite, in graphical form, of information from model tests performed on the Grand Coulee, Hamilton, Norris, Friant, and Hoover dams.

To determine graphically the most adverse water load on a particular gate, it is necessary to investigate the pressures for several gate positions. Assuming that the first position is $\theta = 41°$, the gate is drawn in this position on a piece of transparent paper to the same scale as that used in Fig. 17. The maximum expected reservoir is indicated for this gate position on the left side of the transparent sheet.

The transparent sheet is then placed over Fig. 17(*a*), disregarding the origin of coordinates, and matching only the downstream tips of the two gates. The downstream part of all drum gates, regardless of size or radius, will coincide for any given value of θ. The height of the gate, or length of arc, can be expected to vary; this will have a negligible effect on pressures or water-surface profiles in the majority of cases. Should the gate under investigation differ from the height shown in Fig. 17(*a*), a small increase or decrease in the approach-depth results.

Beginning with the chosen reservoir level, the pressure curve is traced from Fig. 17(*a*) onto the transparent paper. It may be necessary to interpolate between two of the pressure curves. The result will be similar to that shown in Fig. 17(*f*).

A similar procedure is then followed for gate positions of 23°, 9°, −3°, and −35°, utilizing Figs. 17(*b*), 17(*c*), 17(*d*), and 17(*e*), respectively. The result is a composite plot similar to that shown in Fig. 17(*f*). It should be noted that the pressures shown for negative angles of the gate are not as reliable as those for positive angles. Fortunately, the greater water loads occur for positive angles.

Water loads can be determined by scaling the pressures vertically over the gate as indicated by point A in Fig. 17(*f*). If a gate angle other than those shown is desired, interpolation can be made directly on the sheet corresponding to Fig. 17(*f*). Following the establishment of the maximum-pressure curve, values of x/r and y/r are scaled from the sheet corresponding to Fig. 17(*f*) and are transferred to dimensional values by multiplying by r. Should water-surface profiles be desired, the same method of tracing and scaling can be used.