MANITOBA HYDRO

2012/13 & 2013/14 ELECTRIC GENERAL RATE APPLICATION

PUBLIC UTILITIES BOARD ("PUB") PRE-ASK QUESTIONS OF MANITOBA HYDRO

PUB/MH/PRE-ASK-1

Question:
For Kettle GS, please provide a 20 year spreadsheet comparing, year-by-year, Depreciation Expense by Component (as listed on page 7 of 10 of Appendix 5.7) using ASL and using ELG.

Response:

The following table provides a year-by-year comparison of depreciation expense by component for Kettle Generating Station based on IFF12, calculated using the ASL based depreciation rates shown on page 7 of 10 of Appendix 5.7 as the rates effective April 1, 2011, as compared with the ELG based depreciation rates shown on page 7 of 10 of Appendix 5.7 as the rates effective April 1, 2013.

Please note, the implementation date for the ELG based depreciation rates was deferred to April 1, 2014 subsequent to the filing of Appendix 5.7, reflecting Manitoba Hydro's decision to defer the implementation of IFRS for an additional year. IFF12 reflects the revised implementation date for the ELG based depreciation rates.

MANITOBA HYDRO
KETTLE GENERATING STATION
DEPRECIATION EXPENSE **(000's)**

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Using Current ASL Based Rates										
Dams, Dykes & Weirs	390	390	391	394	397	399	401	401	401	401
Powerhouse	1,273	1,275	1,278	1,290	1,300	1,307	1,312	1,312	1,312	1,312
Spillway	338	338	339	342	344	346	348	348	348	348
Water Control Systems	283	290	301	309	316	332	347	347	347	347
Roads & Site Improvements	12	12	12	13	13	13	13	13	13	13
Turbines & Generators	1,475	1,481	1,501	1,773	1,981	2,260	2,486	2,608	2,731	2,854
Governors & Excitation System	110	113	116	131	139	150	159	159	159	159
A/C Electrical Power Systems	556	743	924	986	994	1,002	1,013	1,013	1,013	1,013
Instrumentation, Control & D/C Systems	636	672	715	744	759	779	799	799	799	799
Auxiliary Station Processes	458	487	506	533	551	570	615	628	642	656
Support Buildings	17	17	18	18	18	18	18	18	18	18
	$ 5,548	$ 5,818	$ 6,101	$ 6,533	$ 6,812	$ 7,176	$ 7,511	$ 7,646	$ 7,783	$ 7,920
Using Proposed ELG Based Rates										
Dams, Dykes & Weirs	356	357	357	360	363	365	366	366	366	366
Powerhouse	1,154	1,156	1,159	1,170	1,179	1,186	1,190	1,190	1,190	1,190
Spillway	327	327	327	330	333	335	336	336	336	336
Water Control Systems	186	190	197	203	208	218	227	227	227	227
Roads & Site Improvements	12	12	12	13	13	13	13	13	13	13
Turbines & Generators	1,290	1,294	1,312	1,549	1,730	1,974	2,170	2,277	2,384	2,492
Governors & Excitation System	78	79	82	92	98	106	112	112	112	112
A/C Electrical Power Systems	524	699	870	928	936	944	954	954	954	954
Instrumentation, Control & D/C Systems	511	540	575	598	610	626	642	642	642	642
Auxiliary Station Processes	403	429	445	469	484	501	541	553	565	577
Support Buildings	15	15	15	15	16	16	16	16	16	16
	$ 4,856	$ 5,098	$ 5,351	$ 5,727	$ 5,970	$ 6,284	$ 6,567	$ 6,686	$ 6,805	$ 6,925
Difference										
Dams, Dykes & Weirs	34	33	34	34	34	34	35	35	35	35
Powerhouse	119	119	119	120	121	121	122	122	122	122
Spillway	11	11	12	12	11	11	12	12	12	12
Water Control Systems	97	100	104	106	108	114	120	120	120	120
Roads & Site Improvements	-	-	-	-	-	-	-	-	-	-
Turbines & Generators	185	187	189	224	251	286	316	331	347	362
Governors & Excitation System	32	34	34	39	41	44	47	47	47	47
A/C Electrical Power Systems	32	44	54	58	58	58	59	59	59	59
Instrumentation, Control & D/C Systems	125	132	140	146	149	153	157	157	157	157
Auxiliary Station Processes	55	58	61	64	67	69	74	75	77	79
Support Buildings	2	2	3	3	2	2	2	2	2	2
	$ 692	$ 720	$ 750	$ 806	$ 842	$ 892	$ 944	$ 960	$ 978	$ 995

MANITOBA HYDRO
KETTLE GENERATING STATION
DEPRECIATION EXPENSE

(000's)

	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Using Current ASL Based Rates										
Dams, Dykes & Weirs	401	401	401	401	401	401	401	401	401	401
Powerhouse	1,312	1,312	1,312	1,312	1,312	1,312	1,312	1,312	1,312	1,312
Spillway	348	348	348	348	348	348	348	348	348	348
Water Control Systems	347	347	347	347	347	347	347	347	347	347
Roads & Site Improvements	14	14	15	16	16	17	18	18	19	20
Turbines & Generators	2,978	3,054	3,063	3,073	3,082	3,092	3,103	3,113	3,124	3,135
Governors & Excitation System	159	159	159	159	159	159	159	159	159	159
A/C Electrical Power Systems	1,013	1,013	1,013	1,013	1,013	1,013	1,013	1,013	1,013	1,013
Instrumentation, Control & D/C Systems	799	799	799	799	799	799	799	799	799	799
Auxiliary Station Processes	670	685	700	715	730	746	762	779	796	813
Support Buildings	18	18	18	18	18	18	18	18	18	18
	$ 8,059	$ 8,150	$ 8,175	$ 8,201	$ 8,225	$ 8,252	$ 8,280	$ 8,307	$ 8,336	$ 8,365
Using Proposed ELG Based Rates										
Dams, Dykes & Weirs	366	366	366	366	366	366	366	366	366	366
Powerhouse	1,190	1,190	1,190	1,190	1,190	1,190	1,190	1,190	1,190	1,190
Spillway	336	336	336	336	336	336	336	336	336	336
Water Control Systems	227	227	227	227	227	227	227	227	227	227
Roads & Site Improvements	14	15	15	16	17	17	18	19	19	20
Turbines & Generators	2,599	2,665	2,674	2,682	2,691	2,699	2,708	2,717	2,727	2,736
Governors & Excitation System	112	112	112	112	112	112	112	112	112	112
A/C Electrical Power Systems	954	954	954	954	954	954	954	954	954	954
Instrumentation, Control & D/C Systems	642	642	642	642	642	642	642	642	642	642
Auxiliary Station Processes	590	603	616	629	643	657	671	685	700	715
Support Buildings	16	16	16	16	16	16	16	16	16	16
	$ 7,046	$ 7,126	$ 7,148	$ 7,170	$ 7,194	$ 7,216	$ 7,240	$ 7,264	$ 7,289	$ 7,314
Difference										
Dams, Dykes & Weirs	35	35	35	35	35	35	35	35	35	35
Powerhouse	122	122	122	122	122	122	122	122	122	122
Spillway	12	12	12	12	12	12	12	12	12	12
Water Control Systems	120	120	120	120	120	120	120	120	120	120
Roads & Site Improvements	-	(1)	-	-	(1)	-	-	(1)	-	-
Turbines & Generators	379	389	389	391	391	393	395	396	397	399
Governors & Excitation System	47	47	47	47	47	47	47	47	47	47
A/C Electrical Power Systems	59	59	59	59	59	59	59	59	59	59
Instrumentation, Control & D/C Systems	157	157	157	157	157	157	157	157	157	157
Auxiliary Station Processes	80	82	84	86	87	89	91	94	96	98
Support Buildings	2	2	2	2	2	2	2	2	2	2
	$ 1,013	$ 1,024	$ 1,027	$ 1,031	$ 1,031	$ 1,036	$ 1,040	$ 1,043	$ 1,047	$ 1,051

MANITOBA HYDRO

2012/13 & 2013/14 ELECTRIC GENERAL RATE APPLICATION

PUBLIC UTILITIES BOARD ("PUB") PRE-ASK QUESTIONS OF MANITOBA HYDRO

PUB/MH/PRE-ASK-2 (Revised)

Question:

For Bipole I and Bipole II, please provide a 20 year spreadsheet comparing, year-by-year, Depreciation Expense by applicable Component (as listed for Transmission and Substation on page 9 of 10 of Appendix 5.7) using ASL and using ELG.

Response:

The following tables provide a 20 year comparison of depreciation expense for the transmission and sub-station components applicable to Bi-Pole I & II based on IFF12, calculated using the ASL based depreciation rates shown on page 9 of 10 of Appendix 5.7 as the rates effective April 1, 2011, as compared with the ELG based depreciation rates shown on page 9 of 10 of Appendix 5.7 as the rates effective April 1, 2013.

Please note, the implementation date for the ELG based depreciation rates was deferred to April 1, 2014 subsequent to the filing of Appendix 5.7, reflecting Manitoba Hydro's decision to defer the implementation of IFRS for an additional year. IFF-12 reflects the revised implementation date for the ELG based depreciation rates.

MANITOBA HYDRO
BI-POLE I & II
DEPRECIATION EXPENSE
CALCULATED USING CURRENT ASL BASED RATES **(000's)**

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
TRANSMISSION										
Roads, Trails & Bridges	16	16	16	16	16	16	16	16	17	17
Metal Towers & Concrete Poles	1,318	1,318	1,319	1,320	1,320	1,321	1,324	1,327	1,347	1,355
Overhead Conductor & Devices	1,298	1,298	1,299	1,300	1,300	1,301	1,303	1,307	1,327	1,335
Non-Refundable Contributions	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Subtotal	$ 2,631	$ 2,631	$ 2,633	$ 2,635	$ 2,635	$ 2,637	$ 2,642	$ 2,649	$ 2,690	$ 2,706
SUBSTATIONS										
Buildings	1,413	1,415	1,415	1,416	1,416	1,419	1,442	1,485	1,521	1,536
Building Renovations	499	510	540	540	540	541	542	543	551	554
Roads, Steel Structures & Civil Site Work	391	391	397	442	470	490	518	526	549	554
Power Transformers	343	343	343	344	344	344	345	346	351	353
Other Transformers	488	488	488	489	490	500	514	691	1,124	1,163
Interrupting Equipment	597	597	597	633	636	641	648	653	674	678
Other Station Equipment	1,600	1,585	1,571	1,573	1,560	1,562	1,571	1,574	1,618	1,615
Electronic Equipment & Batteries	440	420	452	466	450	471	510	510	553	533
Synchronous Condensers & Unit Transformers	1,871	1,835	1,798	1,763	1,727	1,692	1,658	1,625	1,612	1,585
Synchronous Condenser Overhauls	854	935	1,342	2,045	2,779	3,398	3,931	4,423	4,473	4,492
HVDC Convertor Equipment	10,079	10,641	11,074	12,164	12,619	12,663	12,705	12,745	14,019	16,532
HVDC Serialized Equipment	27,094	27,556	28,225	28,673	29,339	28,708	28,632	28,697	29,109	29,263
HVDC Accessory Station Equipment	1,922	2,013	2,248	2,865	3,394	3,886	4,145	4,213	4,272	4,294
HVDC Electronic Equipment & Batteries	832	883	923	929	804	807	1,462	2,789	3,267	3,505
Subtotal	$48,423	$49,612	$51,413	$54,342	$56,568	$57,122	$58,623	$60,820	$63,693	$66,657
TOTAL	$51,054	$52,243	$54,046	$56,977	$59,203	$59,759	$61,265	$63,469	$66,383	$69,363

MANITOBA HYDRO
BI-POLE I & II
DEPRECIATION EXPENSE
CALCULATED USING CURRENT ASL BASED RATES **(000's)**

	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
TRANSMISSION										
Roads, Trails & Bridges	17	17	17	17	17	17	17	17	17	17
Metal Towers & Concrete Poles	1,355	1,355	1,355	1,355	1,355	1,355	1,355	1,355	1,355	1,355
Overhead Conductor & Devices	1,335	1,335	1,335	1,335	1,335	1,335	1,335	1,335	1,335	1,335
Non-Refundable Contributions	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Subtotal	$ 2,706	$ 2,706	$ 2,706	$ 2,706	$ 2,706	$ 2,706	$ 2,706	$ 2,706	$ 2,706	$ 2,706
SUBSTATIONS										
Buildings	1,536	1,536	1,536	1,536	1,536	1,536	1,536	1,536	1,536	1,536
Building Renovations	554	554	554	554	554	554	554	554	439	63
Roads, Steel Structures & Civil Site Work	554	554	554	554	554	554	554	554	554	554
Power Transformers	353	353	353	353	353	353	353	353	353	353
Other Transformers	1,163	1,163	1,163	1,163	1,163	1,163	1,163	1,163	1,163	1,163
Interrupting Equipment	678	678	678	678	678	678	678	678	678	678
Other Station Equipment	1,600	1,585	1,570	1,555	1,541	1,526	1,511	1,496	1,481	1,467
Electronic Equipment & Batteries	505	477	450	422	394	366	339	311	283	256
Synchronous Condensers & Unit Transformers	1,548	1,512	1,475	1,438	1,402	1,365	1,329	1,292	1,256	1,219
Synchronous Condenser Overhauls	4,492	4,492	4,492	4,489	4,483	4,301	3,619	2,920	2,142	1,741
HVDC Convertor Equipment	18,945	21,358	22,765	22,765	22,765	22,765	22,765	22,765	22,765	22,765
HVDC Serialized Equipment	29,263	29,263	29,263	29,263	29,263	29,263	29,263	29,263	29,263	29,263
HVDC Accessory Station Equipment	4,294	4,294	4,294	4,294	4,294	4,294	4,294	4,294	4,294	4,294
HVDC Electronic Equipment & Batteries	3,505	3,505	3,505	3,505	3,505	3,505	3,505	3,505	3,505	3,505
Subtotal	$68,990	$71,324	$72,652	$72,569	$72,485	$72,223	$71,463	$70,684	$69,712	$68,857
TOTAL	$71,696	$74,030	$75,358	$75,275	$75,191	$74,929	$74,169	$73,390	$72,418	$71,563

MANITOBA HYDRO
BI-POLE I & II
DEPRECIATION EXPENSE
CALCULATED USING PROPOSED ELG BASED RATES **(000's)**

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
TRANSMISSION										
Roads, Trails & Bridges	17	17	17	17	17	17	17	17	17	17
Metal Towers & Concrete Poles	1,041	1,041	1,041	1,042	1,042	1,044	1,046	1,048	1,065	1,071
Overhead Conductor & Devices	1,105	1,105	1,106	1,107	1,107	1,108	1,110	1,113	1,130	1,137
Non-Refundable Contributions	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Subtotal	$ 2,162	$ 2,162	$ 2,163	$ 2,165	$ 2,165	$ 2,168	$ 2,172	$ 2,177	$ 2,211	$ 2,224
SUBSTATIONS										
Buildings	1,389	1,391	1,392	1,393	1,393	1,396	1,419	1,462	1,497	1,512
Building Renovations	451	461	488	488	488	489	490	491	499	502
Roads, Steel Structures & Civil Site Work	362	362	368	409	435	454	479	487	509	513
Power Transformers	354	354	354	354	354	355	355	356	362	364
Other Transformers	460	460	460	461	461	471	484	652	1,059	1,096
Interrupting Equipment	572	572	572	607	610	615	621	627	646	651
Other Station Equipment	1,546	1,532	1,518	1,521	1,509	1,511	1,520	1,523	1,565	1,562
Electronic Equipment & Batteries	415	397	427	440	425	445	483	483	523	504
Synchronous Condensers & Unit Transformers	1,829	1,793	1,758	1,724	1,688	1,654	1,621	1,589	1,577	1,550
Synchronous Condenser Overhauls	882	965	1,386	2,112	2,869	3,509	4,060	4,568	4,620	4,638
HVDC Convertor Equipment	7,569	7,991	8,316	9,136	9,478	9,513	9,547	9,579	10,537	12,423
HVDC Serialized Equipment	22,733	23,120	23,683	24,062	24,622	24,096	24,037	24,094	24,443	24,571
HVDC Accessory Station Equipment	1,580	1,655	1,847	2,354	2,789	3,194	3,407	3,463	3,512	3,530
HVDC Electronic Equipment & Batteries	693	736	769	774	670	673	1,219	2,324	2,722	2,920
Subtotal	$40,835	$41,789	$43,338	$45,835	$47,791	$48,375	$49,742	$51,698	$54,071	$56,336
TOTAL	$42,997	$43,951	$45,501	$48,000	$49,956	$50,543	$51,914	$53,875	$56,282	$58,560

MANITOBA HYDRO
BI-POLE I & II
DEPRECIATION EXPENSE
CALCULATED USING PROPOSED ELG BASED RATES **(000's)**

	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
TRANSMISSION										
Roads, Trails & Bridges	17	17	17	17	17	17	17	17	17	17
Metal Towers & Concrete Poles	1,071	1,071	1,071	1,071	1,071	1,071	1,071	1,071	1,071	1,071
Overhead Conductor & Devices	1,137	1,137	1,137	1,137	1,137	1,137	1,137	1,137	1,137	1,137
Non-Refundable Contributions	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Subtotal	$ 2,224	$ 2,224	$ 2,224	$ 2,224	$ 2,224	$ 2,224	$ 2,224	$ 2,224	$ 2,224	$ 2,224
SUBSTATIONS										
Buildings	1,512	1,512	1,512	1,512	1,512	1,512	1,512	1,512	1,512	1,512
Building Renovations	502	502	502	502	502	502	502	502	502	497
Roads, Steel Structures & Civil Site Work	513	513	513	513	513	513	513	513	513	513
Power Transformers	364	364	364	364	364	364	364	364	364	364
Other Transformers	1,096	1,096	1,096	1,096	1,096	1,096	1,096	1,096	1,096	1,096
Interrupting Equipment	651	651	651	651	651	651	651	651	651	651
Other Station Equipment	1,548	1,533	1,519	1,505	1,491	1,476	1,462	1,448	1,433	1,419
Electronic Equipment & Batteries	478	451	425	399	373	347	321	294	268	242
Synchronous Condensers & Unit Transformers	1,514	1,479	1,443	1,407	1,371	1,336	1,300	1,264	1,229	1,193
Synchronous Condenser Overhauls	4,638	4,638	4,638	4,631	4,556	4,156	3,433	2,679	2,028	1,498
HVDC Convertor Equipment	14,234	16,045	17,102	17,102	17,102	17,102	17,102	17,102	17,102	17,102
HVDC Serialized Equipment	24,571	24,571	24,571	24,571	24,571	24,571	24,571	24,571	24,571	24,571
HVDC Accessory Station Equipment	3,530	3,530	3,530	3,530	3,530	3,530	3,530	3,530	3,530	3,530
HVDC Electronic Equipment & Batteries	2,920	2,920	2,920	2,920	2,920	2,920	2,920	2,920	2,920	2,920
Subtotal	$58,071	$59,805	$60,786	$60,703	$60,552	$60,076	$59,277	$58,446	$57,719	$57,108
TOTAL	$60,295	$62,029	$63,010	$62,927	$62,776	$62,300	$61,501	$60,670	$59,943	$59,332

MANITOBA HYDRO
BI-POLE I & II
DEPRECIATION EXPENSE
DIFFERENCE BETWEEN CURRENT ASL AND PROPOSED ELG RATES (000's)

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
TRANSMISSION										
Roads, Trails & Bridges	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	-	-
Metal Towers & Concrete Poles	277	277	278	278	278	277	278	279	282	284
Overhead Conductor & Devices	193	193	193	193	193	193	193	194	197	198
Non-Refundable Contributions	-	-	-	-	-	-	-	-	-	-
Subtotal	$ 469	$ 469	$ 470	$ 470	$ 470	$ 469	$ 470	$ 472	$ 479	$ 482
SUBSTATIONS										
Buildings	24	24	23	23	23	23	23	23	24	24
Building Renovations	48	49	52	52	52	52	52	52	52	52
Roads, Steel Structures & Civil Site Work	29	29	29	33	35	36	39	39	40	41
Power Transformers	(11)	(11)	(11)	(10)	(10)	(11)	(10)	(10)	(11)	(11)
Other Transformers	28	28	28	28	29	29	30	39	65	67
Interrupting Equipment	25	25	25	26	26	26	27	26	28	27
Other Station Equipment	54	53	53	52	51	51	51	51	53	53
Electronic Equipment & Batteries	25	23	25	26	25	26	27	27	30	29
Synchronous Condensers & Unit Transformers	42	42	40	39	39	38	37	36	35	35
Synchronous Condenser Overhauls	(28)	(30)	(44)	(67)	(90)	(111)	(129)	(145)	(147)	(146)
HVDC Convertor Equipment	2,510	2,650	2,758	3,028	3,141	3,150	3,158	3,166	3,482	4,109
HVDC Serialized Equipment	4,361	4,436	4,542	4,611	4,717	4,612	4,595	4,603	4,666	4,692
HVDC Accessory Station Equipment	342	358	401	511	605	692	738	750	760	764
HVDC Electronic Equipment & Batteries	139	147	154	155	134	134	243	465	545	585
Subtotal	$ 7,588	$ 7,823	$ 8,075	$ 8,507	$ 8,777	$ 8,747	$ 8,881	$ 9,122	$ 9,622	$10,321
TOTAL	$ 8,057	$ 8,292	$ 8,545	$ 8,977	$ 9,247	$ 9,216	$ 9,351	$ 9,594	$10,101	$10,803

MANITOBA HYDRO
BI-POLE I & II
DEPRECIATION EXPENSE
DIFFERENCE BETWEEN CURRENT ASL AND PROPOSED ELG RATES **(000's)**

	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
TRANSMISSION										
Roads, Trails & Bridges	-	-	-	-	-	-	-	-	-	-
Metal Towers & Concrete Poles	284	284	284	284	284	284	284	284	284	284
Overhead Conductor & Devices	198	198	198	198	198	198	198	198	198	198
Non-Refundable Contributions	-	-	-	-	-	-	-	-	-	-
Subtotal	$ 482	$ 482	$ 482	$ 482	$ 482	$ 482	$ 482	$ 482	$ 482	$ 482
SUBSTATIONS										
Buildings	24	24	24	24	24	24	24	24	24	24
Building Renovations	52	52	52	52	52	52	52	52	(63)	(434)
Roads, Steel Structures & Civil Site Work	41	41	41	41	41	41	41	41	41	41
Power Transformers	(11)	(11)	(11)	(11)	(11)	(11)	(11)	(11)	(11)	(11)
Other Transformers	67	67	67	67	67	67	67	67	67	67
Interrupting Equipment	27	27	27	27	27	27	27	27	27	27
Other Station Equipment	52	52	51	50	50	50	49	48	48	48
Electronic Equipment & Batteries	27	26	25	23	21	19	18	17	15	14
Synchronous Condensers & Unit Transformers	34	33	32	31	31	29	29	28	27	26
Synchronous Condenser Overhauls	(146)	(146)	(146)	(142)	(73)	145	186	241	114	243
HVDC Convertor Equipment	4,711	5,313	5,663	5,663	5,663	5,663	5,663	5,663	5,663	5,663
HVDC Serialized Equipment	4,692	4,692	4,692	4,692	4,692	4,692	4,692	4,692	4,692	4,692
HVDC Accessory Station Equipment	764	764	764	764	764	764	764	764	764	764
HVDC Electronic Equipment & Batteries	585	585	585	585	585	585	585	585	585	585
Subtotal	$10,919	$11,519	$11,866	$11,866	$11,933	$12,147	$12,186	$12,238	$11,993	$11,749
TOTAL	$11,401	$12,001	$12,348	$12,348	$12,415	$12,629	$12,668	$12,720	$12,475	$12,231

MANITOBA HYDRO

2012/13 & 2013/14 ELECTRIC GENERAL RATE APPLICATION

PUBLIC UTILITIES BOARD ("PUB") PRE-ASK QUESTIONS OF MANITOBA HYDRO

PUB/MH/PRE-ASK-3

Question:
For Kettle GS please provide a 20 year spreadsheet comparing, year-by-year, the expense impact of the Removal of Asset Retirement Costs from Depreciation Expense – (include the proposed capital expenditures on those projects over the next 20 years);

Response:
The following table provides a year-by-year comparison of depreciation expense by component for Kettle Generating Station based on IFF12 including forecast capital expenditures, and represents the difference in depreciation expense when calculated using ELG based depreciation rates with a provision for future asset retirement costs and ELG based depreciation rates without a provision for future asset retirement costs.

KETTLE GENERATING STATION
DEPRECIATION EXPENSE
Impact of Removing the Provision for Future Asset Retirement Costs **(000's)**

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Dams, Dykes & Weirs	(56)	(56)	(56)	(57)	(57)	(57)	(57)	(57)	(57)	(57)
Powerhouse	(192)	(192)	(192)	(194)	(194)	(195)	(195)	(195)	(195)	(195)
Spillway	(67)	(67)	(68)	(68)	(68)	(68)	(69)	(69)	(69)	(69)
Water Control Systems	(117)	(121)	(125)	(128)	(130)	(137)	(144)	(144)	(144)	(144)
Roads & Site Improvements	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Turbines & Generators	(335)	(337)	(341)	(401)	(448)	(511)	(563)	(591)	(619)	(647)
Governors & Excitation System	(40)	(42)	(43)	(48)	(51)	(55)	(58)	(58)	(58)	(58)
A/C Electrical Power Systems	(92)	(124)	(154)	(163)	(164)	(165)	(167)	(167)	(167)	(167)
Instrumentation, Control & D/C Systems	(159)	(168)	(178)	(185)	(189)	(193)	(199)	(199)	(199)	(199)
Auxiliary Station Processes	(93)	(98)	(102)	(107)	(111)	(114)	(123)	(125)	(128)	(131)
Support Buildings	(4)	(5)	(5)	(5)	(4)	(4)	(4)	(4)	(4)	(4)
	$ (1,157)	$ (1,212)	$ (1,266)	$ (1,358)	$ (1,418)	$ (1,501)	$ (1,581)	$ (1,611)	$ (1,642)	$ (1,673)

	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Dams, Dykes & Weirs	(57)	(57)	(57)	(57)	(57)	(57)	(57)	(57)	(57)	(57)
Powerhouse	(195)	(195)	(195)	(195)	(195)	(195)	(195)	(195)	(195)	(195)
Spillway	(69)	(69)	(69)	(69)	(69)	(69)	(69)	(69)	(69)	(69)
Water Control Systems	(144)	(144)	(144)	(144)	(144)	(144)	(144)	(144)	(144)	(144)
Roads & Site Improvements	(2)	(1)	(2)	(2)	(2)	(3)	(2)	(2)	(3)	(3)
Turbines & Generators	(676)	(694)	(695)	(698)	(699)	(702)	(705)	(707)	(709)	(712)
Governors & Excitation System	(58)	(58)	(58)	(58)	(58)	(58)	(58)	(58)	(58)	(58)
A/C Electrical Power Systems	(167)	(167)	(167)	(167)	(167)	(167)	(167)	(167)	(167)	(167)
Instrumentation, Control & D/C Systems	(199)	(199)	(199)	(199)	(199)	(199)	(199)	(199)	(199)	(199)
Auxiliary Station Processes	(134)	(137)	(140)	(143)	(146)	(149)	(152)	(156)	(159)	(163)
Support Buildings	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)
	$ (1,705)	$ (1,725)	$ (1,730)	$ (1,736)	$ (1,740)	$ (1,747)	$ (1,752)	$ (1,758)	$ (1,764)	$ (1,771)

MANITOBA HYDRO

2012/13 & 2013/14 ELECTRIC GENERAL RATE APPLICATION

PUBLIC UTILITIES BOARD ("PUB") PRE-ASK QUESTIONS OF MANITOBA HYDRO

PUB/MH/PRE-ASK-4

Question:

For Brandon Coal GS please provide a spreadsheet for the last 20 years of its intended economic life, showing the impact of the change of methodology where asset retirement costs are removed from Depreciation Expense.

Answer:

The Brandon Unit 5 (Coal) thermal generating station is not impacted by the proposed change in methodology to remove asset retirement costs from depreciation expense. This coal generating station, as a whole, is expected to be retired, and a provision for the cost to decommission the site has been made in the financial statements as an Asset Retirement Obligation, as indicated in Note 15 to the 2011/12 Consolidated Financial Statements. Please refer to Appendix 5.8 – Manitoba Hydro-Electric Board – 61st Annual Report, page 73.

As the expected cost to decommission the Brandon Unit 5 (Coal) plant is covered by an asset retirement obligation, the 2010 Depreciation Study does not include any provision in the depreciation rates for future removal costs under either the current ASL or proposed ELG scenario. Please refer to the Net Salvage column for accounts 1205B – 1205W in Appendix 5.7 – Depreciation Rates & Depreciation Study: page 6 of the attachment to the letter dated January 13, 2012 and page III-9 of the 2010 Depreciation Study.

This treatment is consistent with the approach taken in the 2005 Depreciation Study, where the depreciation rates for Brandon Unit 5 (Coal) did not include any provision for future removal costs as the cost to decommission the plant was covered by an asset retirement obligation. Please refer to the Estimated Net Salvage column for accounts 1411 and 2011, as found in Appendix 24 – Manitoba Hydro's [2005] Depreciation Study, page III-3.

MANITOBA HYDRO

2012/13 & 2013/14 ELECTRIC GENERAL RATE APPLICATION

PUBLIC UTILITIES BOARD ("PUB") PRE-ASK QUESTIONS OF MANITOBA HYDRO

PUB/MH/PRE-ASK-5

Question:
Please confirm that MH's CEF 11-2 calls for capital expenditures relative to the Pointe Du Bois G.S. as follows:

- Spillway $398 M (2011/12 to 2015/16)
- Powerhouse $1538 M (2023/24 to 2031/32)
- Transmission $86 M (201/112 to 2014/15)

Answer:

The CEF11-2 total project costs outlined above are confirmed but note that the amounts for the Spillway and Transmission include historical actual capital expenditures prior to 2011/12. The annual capital expenditures prior to 2011/12 are detailed in PUB/MH PRE-ASK – 20.

It should be noted that the estimated capital costs for the Spillway Replacement Project have been updated to $560 million in CEF12. The increase of $162 million is due to increased costs related to excavation as a result of more detailed site investigations and the decision to maintain the existing spillway capacity, which requires increased river management.

MANITOBA HYDRO

2012/13 & 2013/14 ELECTRIC GENERAL RATE APPLICATION

PUBLIC UTILITIES BOARD ("PUB") PRE-ASK QUESTIONS OF MANITOBA HYDRO

PUB/MH/PRE-ASK-6

Question:
Please confirm that Pointe Du Bois G.S. is the most upstream of MH's Winnipeg River G.S.(s) and that its total flow capacity essentially determines the flood flows that will reach the other 5 downstream G.S.(s).

Answer:

The Pointe du Bois generating station is the most upstream of Manitoba Hydro's Winnipeg River generating stations. Downstream in order of location are Slave Falls, Seven Sisters, McArthur, Great Falls and Pine Falls.

The flow capacity at Pointe du Bois does not determine the flood flows on the Winnipeg River as the station has a relatively small reservoir. As a result the river flow that arrives at the station is passed immediately downstream. This is regardless of whether the water control structures have the required discharge capacity. If river flows exceed the capacity of the spillways the reservoir will surcharge and the structures will be overtopped potentially toppling or bypassing the structures.

The flows that reach the downstream stations are the sum of flows passing Pointe du Bois and water that flows into the Winnipeg River from local tributaries downstream of Pointe du Bois.

MANITOBA HYDRO

2012/13 & 2013/14 ELECTRIC GENERAL RATE APPLICATION

PUBLIC UTILITIES BOARD ("PUB") PRE-ASK QUESTIONS OF MANITOBA HYDRO

PUB/MH/PRE-ASK-7

Question:
Please confirm PdB essentially establishes flow requirements for those downstream G.Ss?

Answer:

As indicated in response to PUB/MH/PRE-ASK-6 Pointe du Bois does not establish flow requirements for the downstream stations.

MANITOBA HYDRO

2012/13 & 2013/14 ELECTRIC GENERAL RATE APPLICATION

PUBLIC UTILITIES BOARD ("PUB") PRE-ASK QUESTIONS OF MANITOBA HYDRO

PUB/MH/PRE-ASK-8

Question:
Please indicate the existing flow capacity of the Pointe Du Bois facility:
- Spillway at full supply level and at overtopping;
- Powerhouse at full supply level and at overtopping;
- Fail-safe emergency spillway (if any);

Answer:

The spillway flow capacity at Pointe du Bois is as follows;
a) With the reservoir at the full supply level (299.1 m) 2,625 m3/s, and
b) With the reservoir at the level at which the water control structures begin to be overtopped (299.72 m) 3,949 m3/s.

The powerhouse flow capacity at Pointe du Bois with all generating units in service is as follows;
a) With the reservoir at the full supply level (299.1 m) 620 m3/s, and
b) With the reservoir at the level at which the water control structures begin to be overtopped (299.72 m) 610 m3/s.

At present the powerhouse flow capacity is considerably less because 9 of the 16 units are out of service and cannot pass any flow. Under inflow design flood conditions it is assumed that the powerhouse is flooded and that the speed-no-load discharge of 200 m3/s will flow through the powerhouse.

There is no fail safe emergency spillway at Pointe du Bois.

MANITOBA HYDRO

2012/13 & 2013/14 ELECTRIC GENERAL RATE APPLICATION

PUBLIC UTILITIES BOARD ("PUB") PRE-ASK QUESTIONS OF MANITOBA HYDRO

PUB/MH/PRE-ASK-9

Question:
Please indicate the Pointe du Bois flood scenarios (flows and water levels) for:

- Original maximum design flow
- Maximum recorded flow
- Probable maximum flood
- MH's new design flood

Answer:

Originally it appears that Pointe du Bois was designed to operate with a forebay level of 298.5 m. This level is not certain due to limited documentation available from over 100 years ago. At this level the spillway and powerhouse flow capacities were about 910 m3/s and 180 m3/s, respectively. Over the years, modifications have been made to the structures and the survey datum for the station has changed to the forebay level and spillway capacity values referred to in PUB/MH/PRE-ASK 8.

The maximum recorded flow at Pointe du Bois was 2,621 m3/s in 1992.

The 1:1000 flood is 4,280 m3/s.

The inflow design flood for Pointe du Bois is 5,040 m3/s. This flood flow was established by Manitoba Hydro based on the 2007 Canadian Dam Safety Guidelines and a detailed consequence evaluation.

The probable maximum flood peak inflow is 6,570 m3/s.

MANITOBA HYDRO

2012/13 & 2013/14 ELECTRIC GENERAL RATE APPLICATION

PUBLIC UTILITIES BOARD ("PUB") PRE-ASK QUESTIONS OF MANITOBA HYDRO

PUB/MH/PRE-ASK-10

Question:
Please indicate Ontario Hydro's design floods and probable maximum flood criteria for their most downstream power stations east of Manitoba border:

- Caribou Falls G.S. (English River)
- Whitedog Falls G.S. (Winnipeg River)

Answer:

Manitoba Hydro is not in a position to provide the requested information from Ontario Power Generation. Ontario Power Generation provided this information to Manitoba Hydro on the basis that it remain confidential and not be released in any form.

MANITOBA HYDRO

2012/13 & 2013/14 ELECTRIC GENERAL RATE APPLICATION

PUBLIC UTILITIES BOARD ("PUB") PRE-ASK QUESTIONS OF MANITOBA HYDRO

PUB/MH/PRE-ASK-11

Question:
Please explain the hydraulic need for the Pointe du Bois spillway and/or powerhouse replacements.

Answer:

The Pointe du Bois generating station must be capable of safely passing the inflow design flood which Manitoba Hydro has determined is 5040 m3/s based upon the 2007 Canadian Dam Safety Guidelines. The current capacity of the spillway at Pointe du Bois is only 2,625 m3/s or 52% of the required capacity.

The existing spillway is comprised of a nearly continuous string of 97 small spill gates on top of a granite ridge running across the river. The available/potential capacity with this configuration of gates is exhausted. A new spillway is required in a different location to achieve the required spillway capacity. No amount of repair of the structures in their original configuration will achieve the required capacity.

In addition there are other considerations that factor into the need to replace the spillway structures. These include the irreparable and poor condition of concrete structures, employee safety, professional responsibility, re-licensing requirements under the Water Power Act and the consequences of failure including the financial and environmental impacts, and loss of public confidence in Manitoba Hydro's ability to maintain dam safety.

MANITOBA HYDRO

2012/13 & 2013/14 ELECTRIC GENERAL RATE APPLICATION

PUBLIC UTILITIES BOARD ("PUB") PRE-ASK QUESTIONS OF MANITOBA HYDRO

PUB/MH/PRE-ASK-12

Question:
Please indicate whether upgrading of Pointe du Bois spillway gates and concrete rehabilitation is a viable alternative to total rebuild of the spillway.

Answer:

No. As indicated in PUB/MH/PRE-ASK-11 the required spill capacity cannot be achieved with the existing configuration even if it were economical to rehabilitate the concrete structures.

MANITOBA HYDRO

2012/13 & 2013/14 ELECTRIC GENERAL RATE APPLICATION

PUBLIC UTILITIES BOARD ("PUB") PRE-ASK QUESTIONS OF MANITOBA HYDRO

PUB/MH/PRE-ASK-13

Question:
Please comment on the interim loss of flow capacity during the spillway rebuilding process.

Answer:

As the new spillway will be built outside the main river channel, its construction will not interfere with the current spillway capacity during the construction period.

MANITOBA HYDRO

2012/13 & 2013/14 ELECTRIC GENERAL RATE APPLICATION

PUBLIC UTILITIES BOARD ("PUB") PRE-ASK QUESTIONS OF MANITOBA HYDRO

PUB/MH/PRE-ASK-14

Question:
Please describe the current physical condition/adequacy of Pointe du Bois:

- Spillway structure and gates
- Main dam and dikes
- Powerhouse turbines and generators

Answer:

The spillway components range in condition from poor (serious deterioration in some portions of structure; function is inadequate) to good (only minor deterioration or defects are evident).

With regard to the main dam and dikes, the components of the east and west concrete gravity dams range in condition from very poor (extensive deterioration; barely functional) to good. The rockfill dam has been upgraded to the required standard.

With regard to the powerhouse turbines and generators, the powerhouse structure is in poor to good condition. However many of the units have failed or are failing. At present only seven of the sixteen units are operating. Only unit 1 is in relatively new condition.

MANITOBA HYDRO

2012/13 & 2013/14 ELECTRIC GENERAL RATE APPLICATION

PUBLIC UTILITIES BOARD ("PUB") PRE-ASK QUESTIONS OF MANITOBA HYDRO

PUB/MH/PRE-ASK-15

Question:

Please explain the extent of concrete deterioration including specific reference to alkali reactivity problems for concrete and reinforcing steel.

Answer:

All of the concrete structures at Pointe du Bois are deteriorating with time, weathering and concrete growth from Alkali Aggregate Reaction (AAR).

AAR is the chemical reaction between the aggregate and the cement in concrete which results in the volume of the concrete very slowly increasing as the reaction proceeds. Symptoms of AAR were first noticed shortly after original construction and continue to be seen today. Over 90 years of AAR has resulted in significant cracking of concrete and misalignment of structures and equipment.

MANITOBA HYDRO

2012/13 & 2013/14 ELECTRIC GENERAL RATE APPLICATION

PUBLIC UTILITIES BOARD ("PUB") PRE-ASK QUESTIONS OF MANITOBA HYDRO

PUB/MH/PRE-ASK-16

Question:

Please indicate whether decommissioning of the facility (powerhouse or spillway) was considered and what costs would have been incurred.

Answer:

Manitoba Hydro has extensively studied decommissioning Pointe du Bois. The decommissioning alternative consisted of depowering the site and rebuilding the spillway.

A new spillway would be required in order to

a) maintain the upstream water regime, and
b) to provide an appropriate control structure to safely manage river flows.

The estimated cost for decommissioning the Pointe du Bois facility at the time the alternative was considered was in the order of $400M.

As described in Manitoba Hydro's response to CAC/MH II-22a), Manitoba Hydro concluded that there were benefits to maintaining the ongoing operation of the powerhouse and has pursued only the Spillway Replacement Project. The decision on long-term operation or replacement of the powerhouse has been deferred to a future date.

MANITOBA HYDRO

2012/13 & 2013/14 ELECTRIC GENERAL RATE APPLICATION

PUBLIC UTILITIES BOARD ("PUB") PRE-ASK QUESTIONS OF MANITOBA HYDRO

PUB/MH/PRE-ASK-17

Question:
Please provide a listing/table of contents/summaries of reports that were prepared (draft as well as final) w.r.t.:

- Dam Safety
- Probable Maximum Flood
- Condition assessments
- Rehabilitation alternatives
- Capital project justification documents

Answer:

Dam Safety, Probable Maximum Flood and Condition Assessments:

Attachment 1: Pointe du Bois Spillway Replacement Incremental Consequence Classification and Selection of Inflow Design Flood

Attachment 2: Pointe du Bois Spillway Replacement Probable Maximum Flood Review

Attachment 3: 2008 Dam Safety Intermediate Inspection Concrete Structures Field Inspection Form

Attachment 4: Pointe du Bois G.S.—2008 Dam Safety Annual Report

Rehabilitation Alternatives:

Please see Manitoba Hydro's response to CAC/MH I-53(a), CAC/MH II-22(a), and PUB/MH PRE-ASK 16.

<u>Capital Project Justifications:</u>

Attachment 5: Pointe du Bois Spillway Replacement Project Capital Project Justification Addendum 5 (September 15, 2010)

Attachment 6: Pointe du Bois Spillway Replacement Project Capital Project Justification Addendum 6 (August 21, 2012)

KGS ACRES
KGS ACRES Ltd
580-500 Portage Avenue, Winnipeg, Manitoba, Canada R3C 3X1
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December 2, 2011
KGS ACRES Project No: 10-0038-01/H-334653

Manitoba Hydro
Winnipeg River Section
Hydro Power Planning Department
Power Projects Development Division
15th Floor, 360 Portage Avenue
Winnipeg, Manitoba
R3C 0G8

Attention: **Mr. R.H. Penner, P.Eng.**
Section Head

Dear Mr. Penner:

Pointe du Bois Spillway Replacement
Incremental Consequence Classification and Selection of Inflow Design Flood
Deliverable No: P-1.3.2.2.0440.1 Rev 0
Manitoba Hydro File 00102-11340-0011_02

Please find enclosed the finalized KGS ACRES memorandum for the Incremental Consequence Classification and Selection of Inflow Design Flood. The memorandum has been revised with Manitoba Hydro's final Quality Review comments and reposted to eRoom and is now considered a final Stage IV product.

Should you have any questions, please contact Dave Brown or the undersigned.

Yours very truly,

for. Dave B. MacMillan, P.Eng.
Project Manager

DBM/sml
Enclosure

KGS ACRES **Office Memorandum**

To	Kevin Sydor, P.Eng.	**Date**	December 2, 2011
		File No.	10-0038-01/H-334653
From	Joe Groeneveld, P.Eng. David S. Brown, P.Eng.	**Cc**	Dave MacMillan, P.Eng. Rick Carson, P.Eng.
Subject	**Pointe du Bois Spillway Replacement Incremental Consequence Classification and Selection of Inflow Design Flood Deliverable No: P-1.3.2.2.0440.1 Rev 0 Manitoba Hydro File 00102-11340-0011_02**		

This memorandum was issued for documentation of Incremental Consequence Classification and Selection of the Inflow Design Flood for the Pointe du Bois Spillway Replacement Project. The information presented may not reflect the final General Arrangement, but was representative on September 24, 2010. Minor alterations of the General Arrangement will not materially affect the conclusions of recommendations of this memo. Refer to the Stage IV Report, Deliverable P-1.3.9.1000.1, Manitoba Hydro file 00102-05500-0001 [Ref 1] for final arrangement details. **This memorandum was previously issued in draft on September 24, 2010.**

1 Summary

The Incremental Consequence Classification (ICC) and Inflow Design Flood (IDF) for the Pointe du Bois Generating Station (GS) have been reviewed and updated based on the 2007 Canadian Dam Association (CDA) Guidelines [Ref 2]. This review builds on earlier studies undertaken by both KGS Group and Acres, and takes into consideration the overall incremental consequence classification of the project, as well as the effects of possible upstream failures on the IDF. In past design studies, the IDF for this project was selected as the Probable Maximum Flood (PMF), in accordance with requirements set out within Manitoba Hydro's draft internal dam safety guideline.

The CDA published new guidelines in 2007 that recommend less stringent flood selection criteria for dams with a "High" ICC. Since that time, Manitoba Hydro has made a decision to put less emphasis on their draft internal guideline, and consider recommendations put forward by the CDA in the 2007 document. This has led to a re-evaluation of the project IDF.

Using the 2007 CDA Guidelines, the project incremental consequence classification was initially selected as "High" based on the economic damage and loss of life estimates provided in previous dam break studies. The IDF was accordingly selected for the Stage IV studies as one third of the way between the 1 in 1 000 year flood and the PMF. The early selection of this flood allowed work on the Stage IV studies to begin.

However, as a part of the Stage IV studies, dam break analyses for the project were updated to reflect i) the project layout for the proposed spillway replacement, and ii) reflect recent bathymetric and topographic information gathered at the site. These updated dam break studies focussed on assessing loss of life (LOL) potential in the local reach between the Slave Falls GS and the Pointe du Bois Project for two (2) potential design flows – one third of the way between the 1 in 1 000 year flood and the PMF, and the PMF. Economic damages, since they were not governing criteria in the earlier studies, were not updated as a part of the current review.

Following completion of the dam break analysis, the incremental consequence classification for the project was updated based on the revised loss of life estimates and the earlier economic losses. The updated dam break analyses confirmed the initial selection of "High" for incremental consequence classification and the project IDF of 5 040 m^3/s.

This document summarizes the results of this re-evaluation, and the proposed selection of the IDF for the Pointe du Bois Spillway Replacement Project.

2 Overview of the Stage IV Preliminary Engineering Process

2.1 General

The Stage IV Engineering Process for the Pointe du Bois Spillway Replacement Project included the input of all primary Manitoba Hydro Stakeholders, each with discrete, responsibilities within the Corporation. To ensure that the requirements of all Stakeholders were adequately addressed, a structured process was adopted for the Stage IV Engineering Studies, which allowed several opportunities for each Stakeholder group to provide input into the design and provide review and commentary on the design progress and deliverables. The Stakeholders who participated in this process and a general description of the progress are provided in this section.

2.2 Stakeholders

The major Stakeholders for the Stage IV Engineering Process were as follows:

- *Hydro Power Planning Department* - responsible for the preliminary engineering phase of the project.
- *Water Resources Engineering Department* - responsible for hydrotechnical studies related to the project.
- *Engineering Services Division* - responsible for corporate technical engineering standards and dam safety aspects of the project.
- *Generation South* - *Winnipeg River Stations and Generation Maintenance Engineering Departments* - responsible for operation & maintenance of the existing facilities at the site, and future operation and maintenance of the project infrastructure.
- *Major Projects Licensing Department* - responsible for environmental studies and licensing of the project.
- *New Generation Construction Division* - responsible for final detailed design and construction of the project.

2.3 Stage IV Engineering Process

As noted above, a structured process was employed that allowed all of the Stakeholders several opportunities to provide input into and contribute to direction of the preliminary design process. This process entailed initial development of draft design criteria (called "Basis of Design") which was intended as a set of requirements and guidelines for the remainder of the design process; the design process itself, during which the design aspects themselves were advanced, reviewed and adapted as necessary; and a final documentation stage where the final outcome of the design process was reported upon in technical memoranda, or "Design Descriptions". The process is graphically illustrated in Appendix A.

3 Background

3.1 General

The Pointe du Bois GS is one of a series of generating stations located along the Winnipeg River. It is located downstream of several other dams including: Ear Falls, Manitou Falls and Caribou Falls on the English River and Whitedog, Kenora and Norman Dams on the Winnipeg River.

The Pointe du Bois GS was acquired by Manitoba Hydro in 2002 with the purchase of Winnipeg Hydro. It is located on the Winnipeg River approximately 160 km northeast of the City of Winnipeg in the Whiteshell Provincial Park. A general location plan is shown in Figure 01. Construction began on the Pointe du Bois GS in 1909 and first power was produced in 1911 with three (3) generating units. Over the period from 1914 to 1926 thirteen (13) additional units were added bringing the plant up to its present day capacity of 78 MW.

The existing structures consist of the West Gravity Dam, the Powerhouse, the East Gravity Dam, a number of spillways and sluiceways, as well as a Rockfill Dam. Despite extensive ongoing maintenance and upgrades over the years, the existing facilities require major repair or replacement to maintain current dam safety standards, provide a safe working environment for staff, and to ensure reliability of power production. Manitoba Hydro has determined that the Corporation’s best use of this resource in the near-term would involve construction of a new Spillway and water retaining structures at the site, while maintaining the existing Powerhouse.

This would involve the replacement of the existing spillways and sluiceways with a new 5-Bay Spillway along the east shoreline of the Winnipeg River (termed the Primary Spillway) and a new 5-Bay Spillway in the middle of the Spillway rapids downstream of the existing spillways and sluiceways (termed the Secondary Spillway). A General Arrangement of the project, at the time of this analysis, is illustrated in Figure 02.

Since the completion of the ICC and selection of the IDF, the General Arrangement changed from that noted above, and described in this memorandum, to include a new 5-Bay Primary Spillway and a new 7-Bay Secondary Spillway. The changes to the general since this task was completed will not materially affect the conclusions of recommendations of this memo. The final General Arrangement is shown in the Stage IV Report [Ref 1].

As part of the new Spillway project, the existing Spillway and sluiceway will be decommissioned to the rollway elevation. Additionally, new Main and West Dams will be constructed immediately downstream of the existing spillways, sluiceways and the East Gravity Dam (EGD).

As part of the current redevelopment plans, the existing Powerhouse will continue to operate and utilize the head of approximately 14 m available between the existing Pointe du Bois forebay and tailrace to produce power. There is some uncertainty at this time as to the continued long-term operation of the Powerhouse; it is possible that it may be decommissioned at some point in the future. The dam breach analyses documented within this memorandum have assumed that the Powerhouse would continue to operate for the foreseeable future. However, it should be noted that the presence (or not) of the Powerhouse would not affect the incremental classification of the structures based on the dam breach analyses, nor would it alter the magnitude of the selected IDF.

Of particular interest to this dam break assessment is the fact that the preferred General Arrangement includes a section of earthen dam between the two (2) new Spillways that may be up to 11 m in height.

Within the first 2 km downstream of the Generating Station there are a number of permanent residences and seasonal cottages, with the majority of the buildings being cottages. Some of these cottages are built to an elevation that would avoid damage from even the worst flood, but there are a number of buildings that would be affected by a breach at Pointe du Bois. There is also some future development planned downstream of the existing cottages. Some of these buildings may be affected in the event of a dam breach.

3.2 Previous Dam Safety Analyses

In the past, various studies have been conducted to investigate dam safety related issues at the Pointe du Bois Generating Station. Three (3) of these studies, which have been briefly summarized below, dealt specifically with the ICC for the project.

3.2.1 Acres International Study (1995)

Acres International Ltd. completed a dam break analysis for Winnipeg Hydro’s Dam Safety Program in August 1995 [Ref 3]. In this report titled, “Report on Hydraulic Studies and Inundation Maps”, a dam breach at Pointe du Bois was investigated as well as a subsequent breach at Slave Falls.

In this study, two (2) scenarios were analyzed including failures during flood events of 2 600 m^3/s and 4 600 m^3/s. Failures were assumed to be a result of overtopping, and in order to ensure a worst case scenario, the spillway bays were assumed to remain open during the formation of the breach. The major results of the study for the reach between Pointe du Bois and Slave Falls are:

- If a breach developed during a 4 600 m^3/s flood event, peak water levels in the developed portion of the reach would be 3.5 to 4.0 m above high water mark (established by the 1992 flood) and 4.5 to 5.0 m above normal water levels.
- If a breach developed during a 2 600 m^3/s flood event, water levels in the developed portion of the reach would be 0.5 to 1.0 m lower than levels associated with a failure during the 4 600 m^3/s flood event.
- Peak breach outflow estimated to be reached within 2 hours of breach initiation for 2 600 m^3/s and within 1.5 to 2 hours for the 4 600 m^3/s flood.

- Ten (10) buildings were flooded between Pointe du Bois and Eight Foot Falls (no information between Eight Foot Falls and Slave Falls).
- No predictions were made for LOL and the dam was not given an ICC.

3.2.2 KGS Group Study (2001)

This report titled, “Pointe du Bois Spillway Capacity Assessment” was completed by KGS Group in March, 2001 [Ref 4]. In this study, flow events discussed in the aforementioned 1995 report were reviewed. Although the same inundation maps were used to assess the ICC of the dam, the return periods were slightly modified.

The major points of the KGS Group study were:

- The IDF was selected as a 1 in 1 000 year flood event in accordance with the 1999 CDA Dam Safety Guidelines.
- The predicted loss of life for a 1 in 1 000 year event was determined to be 1.5 persons.
- The existing Pointe du Bois Dam was given a ICC of “High”
- The cost of damages related to a breach during a 1 in 1 000 year flood event (believed to be representative of a wide range of floods coincident with a dam breach) was $28 million based on breaches at both Pointe du Bois and Slave Falls. The majority of this cost is related to damages to Manitoba Hydro structures and lost power generation.

3.2.3 Acres Manitoba Ltd. Study (2002)

This report entitled, “Pointe du Bois Dam Safety Hydraulic Studies Review” [Ref 5], consists of a review of previous reports. In this study, the flows were also reviewed and updated with new return periods.

The major points of the Acres study were:

- PMF updated from 7 250 m^3/s to 6 570 m^3/s
- 1 in 1 000 year flood event was updated from 4 600 m^3/s to 4 390 m^3/s
- The dam’s incremental consequence classification remained “High”
- The predicted loss of life for a 1 in 1 000 year event was between 3 and 5

- The cost of damages related to a breach during a 1 in 1 000 year flood event (believed to be representative of a wide range of floods coincident with a dam breach) was $73 million based on breaches at both Pointe du Bois and Slave Falls. Again, the majority of this cost is related to damages to Manitoba Hydro structures and lost power generation.

4 Available Data

4.1 Geometric and Hydrometric Data

Data available for use in this update study included the following:

- A HEC-RAS backwater model of the reach from Pointe du Bois to Slave Falls that was developed by Manitoba Hydro as part of the Stage IV Design studies. This model is an updated version of an earlier model of the same reach of the river, used in the previous studies for Pointe du Bois. This updated backwater model consists of a number of cross sections that were developed based on recent bathymetric surveys of the reach carried out by Manitoba Hydro in 2006 and 2007.

- Topographic maps of the river reach. These maps were used to obtain geometric data necessary for estimating the maximum extent of downcutting during the breach as well as to determine the extent of incremental flooding associated with each breach scenario. These maps were developed based on LiDAR surveys taken by Manitoba Hydro in 2007. These maps were also used to show the locations of the affected buildings downstream of the dam.

- Preliminary General Arrangement drawing for the preferred General Arrangement of the Spillway Replacement.

- ***Project stage-storage curves*** - The storage curve for the Pointe du Bois reservoir was developed as part of the 1995 dam break study and was considered to be suitable for application in the current study. As part of the Stage IV Design studies, Manitoba Hydro prepared an updated stage-storage curve, however, this updated curve was not available at the time of this dam breach analysis. As such, the 1995 stage-storage curve for the reservoir, as shown in Figure 03, was used for this study. The updated curves [Ref 6] indicate that storage volumes are approximately equivalent for forebay elevations of El. 296.0 m and greater. For forebay elevations below El. 296.0 m, the 1995 relationship indicates there is a greater storage volume than the updated relationship. Therefore, use of the 1995 curves in the dam breach assessment will provide a slightly conservatively high estimate of breach outflow for the sunny day breach scenario. However, estimates for the IDF scenarios will be unaffected since storage is only released from the upper portion of the reservoir (i.e. above El. 296.0 m) for these flood scenarios.

- Available hydrometric data was collected in the river reach and was used to confirm the calibration of the backwater model developed by Manitoba Hydro. As this model was originally developed in steady state mode, it was necessary to ensure that the model remained valid when used in unsteady state mode. Water surface profiles were recorded and available for 16 different flows ranging from 285 m^3/s to 2 763 m^3/s.

4.2 Summary of Project Hydrology

Hydrological analyses were completed for the Pointe du Bois Project as a part of hydrology review carried out by Manitoba Hydro [Ref 7]. The results of these earlier studies are discussed in detail in other memoranda, but for convenience, key study results have been summarized in Table 4.1 below.

Table 4.1:
Project Hydrology – Pointe du Bois Generating Station

Flood Event	Peak Inflow (m^3/s)
1 in 20 year	2 250 (1)
1 in 100 year	2 900 (1)
1 in 1 000 year	4 280 (1)
PMF Without Upstream Breach	6 570 (2)
PMF With Upstream Breach	9 900 (2)

Notes: (1) Source: Pointe du Bois Spillway Replacement Hydrology Review Memorandum P-1.3.2.2.0420 [Ref 7]
(2) Source: Pointe du Bois Spillway Replacement Probable Maximum Flood Review Memorandum P-1.3.2.2.0430.1 [Ref 8]

It should be noted that two (2) values are provided above for the PMF. There are a number of major dams located upstream of Pointe du Bois that are owned by others. Based on the existing infrastructure at these plants, it is considered likely that some of these structures would be overtopped during a very large flood event such as a PMF. In the previous hydrological studies it was assumed that these structures would not fail during the PMF, but rather that they would either survive the overtopping event, or that appropriate modifications would be made to the project infrastructure (by the dam's Owner) to enable them to safely pass these events.

As a part of subsequent dam safety reviews conducted by others, it was suggested that a separate estimate be made to take into account the effects of upstream dam breaches during a PMF event. The Caribou Falls GS is capable of passing at least a 1 in 1 000 year flood on the English River without failure, but would be overtopped during larger flood events given the station's current discharge capacity. Based on earlier PMF simulations conducted for the Pointe du Bois Project, it is estimated that the block dams associated with the Caribou Falls development could begin to be overtopped for Pointe du Bois flood magnitudes of

between
4 000 m^3/s and 4 700 m^3/s. As such, KGS ACRES assessed this consideration as part of the PMF review [Ref 8]. That analysis indicated that the Pointe du Bois inflows could increase to as much as 9 900 m^3/s should a major dam associated with the Caribou Falls GS fail during passage of the PMF.

5 Dam Break Model

5.1 Description of Model

The HEC-RAS (Version 4.0) software package was used to simulate the dam breach and resulting flood discharges and water levels downstream of the Pointe du Bois project in this study. This program was developed by the USACE Hydrologic Engineering Center, and similarly to other software packages such as DAMBRK and FLDWAV, HEC-RAS offers the ability to simulate unsteady flow conditions due to a dam breach using the former UNET hydrodynamic solver as well as aspects of the NWS DAMBRK and FLDWAV model solvers developed by Danny Fread. The model results have been found to be comparable to the results of the FLDWAV and DAMBRK programs.

Like FLDWAV, the HEC-RAS model utilizes an empirically based methodology to define and control the development of a breach in a dam. Parameters entered by the user include the mode of failure (piping vs. overtopping), the ultimate breach width, the breach bottom elevation, side-slope, and time of formation.

Again, like FLDWAV, HEC-RAS simulates the progression and attenuation of a flood hydrograph using hydraulic flood routing methods. The program solves the equations of unsteady flow to determine water levels and flow rates along a study river reach. The model supports both supercritical and subcritical flow regimes, and automatically calculates the transition between each. The model can assess an entire river system with dams, bridges, flow control structures, and local inflows and outflows that affect the flow conditions. Internal and external boundary conditions are used to simulate a large number of prototype river system arrangements, and the model can accommodate interconnected streamflow networks consisting of multiple tributaries and/or branches.

At each dam site, the model can simulate turbine, spillway, dam overtopping and dam failure outflows. Operating policies can be represented using either time or water level dependent discharge relationships.

The hydraulic character of the river channel is defined by a series of user input cross-sections. These cross-sections can be located strategically along the river channel, and the model is able to create interpolated cross-sections between any two given sections based on a user specified interval. The cross-sectional geometry can be defined by using up to 500 data points per cross-section. This is a distinct advantage compared to the FLDWAV model, which only allows the specification of eight top widths to define a river cross section. The model allows the input of both a main river channel, as well as flood plains on both banks. Off channel storage areas can also be included, as required. These areas can have a significant attenuating effect on the flood wave.

Channel roughness parameters and other minor loss coefficients are selected to account for the effects of channel boundary roughness, meanders, debris and unanticipated obstructions. Roughness values can be varied spatially across a section. This allows the model to best simulate the effect that variations in infrastructure/vegetation might have on the local hydraulic conditions.

Results from the HEC-RAS program can be easily imported and exported into the ESRI ArcGIS program through use of the HEC-GeoRAS add on for ArcGIS or by other means through the use of ArcGIS. This allows model results to be developed from and brought back into a GIS based topographic model of the river valley, and flood lines can then be automatically developed for the reach.

5.2 Model Set-up

The reach being modeled is approximately 10.5 km long and extends from the Pointe du Bois forebay downstream to the Slave Falls GS. The HEC-RAS model used in this assessment was originally developed by Manitoba Hydro to represent steady state hydraulic conditions within the study reach. Subsequently, KGS ACRES obtained the model from Manitoba Hydro, and made various refinements to the model to better serve the objectives of the current study.

Specific features of the model set-up utilized in this study include:

- The model has been converted to run in an unsteady or dynamic mode. Therefore, rather than using the standard step backwater algorithm, all water levels and flows are now computed based on solution of the St. Venant equations of fluid motion.

- The geometric configuration of the channel is represented by a series of fifty-five (55) cross sections, most of which were previously scaled by Manitoba Hydro based on recent bathymetric sounding information. The locations of the cross sections used in the model are shown in Figure 04. KGS ACRES added additional cross-sectional information at two (2) key locations within the channel; at the site of Eight Foot Falls, and at a narrow section of the river located approximately 2.3 km upstream of Slave Falls. Observations taken during past flood events indicate significant head loss can occur across this channel narrowing during large flood events, and therefore additional sections were

- At the upstream end of the model, the stage-storage curve for the reservoir (Figure 03) was linked to the first cross-section. This allowed for the hydraulic conditions of the reservoir to be modeled dynamically without defining the geometry of the reservoir.

- In the HEC-RAS program, a dam is represented as an in-line structure. For this reason it was necessary to define the new Pointe du Bois dam as an internal boundary within the model.

- For all model runs, the inflow hydrograph was specified as the upstream boundary condition. Although it is a dynamic model, the inflow was assumed to be constant for these model simulations. For the calibration runs, the downstream boundary at Slave Falls was set to the observed Slave Falls reservoir level associated with the date of the recorded data used for the calibration events. However, for all dam break runs, the downstream boundary consisted of the Slave Falls rating curve, which considers Slave Falls operating at the FSL of El. 284.62 m. The rating curve utilized was developed during Acres Manitoba's 2002 review of the project, and is shown in Figure 05. It should be noted that this rating curve assumes that all facilities are operational at the Slave Falls facility. At the time this memorandum was finalized Manitoba Hydro has noted that the creek spillway and ice sluiceway are inoperable, and that they may be decommissioned in the future. The implications of this change in discharge capacity at Slave Falls GS are discussed in Section 6.4.5.

As noted above, the model did not extend downstream beyond the Slave Falls GS, but rather this study concentrated on the river reach between the two Generating Stations. This is the reach with the greatest potential for loss of life to occur should a breach develop at Pointe du Bois due to the short warning time available. Effects downstream of Slave Falls consist primarily of economic damages, and these effects were assessed on the basis of past study reports as outlined within Section 7.

5.3 Model Calibration

Upon completion of the model set-up (i.e. modification of the existing backwater model for use in the dam break studies), additional work was undertaken to re-calibrate the numerical model. Re-calibration was necessary given the change in the solution algorithm to that of a dynamic model (i.e. from standard step backwater calculations to solution of the St. Venant equations of fluid flow).

For most of the reach, a Manning's n-value of 0.035 was maintained except at a few strategic locations. At Eight Foot Falls, a value of 0.045 was used and two (2) separate constrictions near the downstream end of the model required artificially high n-values of 0.070. Although it is recognized that values in this upper range do not represent actual roughness in these areas, they were required to indirectly compensate for other hydraulic complexities in this reach of the river, such as the simplification of the complex geometry that exists with the use of only a few cross sections within the model, as well as, any complexities in the bathymetry that was not captured by surveys of the river.

Although data does not exist for flows similar in magnitude to those expected during a dam break, the model was calibrated to recorded water levels along the reach at lower flows. Water level data was available from Manitoba Hydro for flow events ranging from 285 m^3/s to 2 763 m^3/s. Although all available flow events were considered in the calibration, priority was given to matching existing water level data during higher flood flows, that is, for those flows above 2 000 m^3/s. A total of sixteen (16) flows have been used to calibrate and verify the model. The estimated water level profiles compared to the observed data for each of the sixteen flow events are shown in Figures 06 to 21. The match obtained is generally very good, with water levels that are within 0.1 to 0.2 m of the observed levels along the reach.

For comparative purposes, water surface profiles from Manitoba Hydro's Mike21 model are also included on each of the sixteen (16) profile graphs. This two-dimensional model obtains a good match with the historical data, with results similar to the one-dimensional HEC-RAS model.

6 Dam Break Assessment

6.1 Breach Scenarios

The breach analysis was carried out for three (3) flow scenarios. In selecting the flow scenarios, it was considered that, based on the earlier dam break analysis and the 2007 Guidelines, the lowest ICC possible for the project would be "High". Such an ICC would warrant selection of an IDF equal to a flood one third of the way between the 1 in 1 000 year flood and the PMF. The highest ICC that could be considered for the project would be "Extreme", and this would warrant selection of an IDF equal to the PMF. Accordingly, flow scenarios for the dam break analysis were selected which would bracket this range. The scenarios tested included:

- Scenario 1: A sunny day failure with a flow of 1 000 m^3/s and the forebay at El. 299.10 m
- Scenario 2: Flow of 4 800 m^3/s with the forebay at El. 301.30 m
- Scenario 3: PMF of 6 570 m^3/s with forebay at El. 301.30 m

It should be noted that in the above scenarios, a flow of 4 800 m^3/s (Scenario 2) was adopted to represent a flood event that was one third of the way between the 1 in 1 000 year flood and the PMF event. At the time in which these dam break analyses were completed the 1 in 1 000 year flood had a magnitude of 3 920 m^3/s, which resulted in a potential IDF flow of 4 800 m^3/s. Subsequent to the completion of this work, the estimate of the 1 in 1 000 year flood was adjusted to be 4 280 m^3/s [Ref 7], which results in the magnitude of a potential IDF to be 5 040 m^3/s. Given the relatively small difference between these two (2) numbers, the dam break analyses presented within this memorandum have not been updated to reflect the revised hydrological estimate of the 1 in 1 000 year flood.

6.2 Selection of Breach Parameters

Like FLDWAV or DAMBRK, the HEC-RAS model utilizes an empirically based methodology to define and control the development of a breach in a dam. There are several methods which can be used to determine the necessary breach parameters. The parameters that must be selected include:

- Final depth of the breach,
- Ultimate bottom width of the breach,
- Side slope of the breach opening,
- Breach formation time,
- Reservoir elevation at which a breach begins to form ,
- Initial piping elevation.

These parameters are typically selected based on empirical relationships that have been developed based on a review of historical dam failures. Two (2) of the more popular methods for estimating these parameters are briefly described in the following sub-sections.

6.2.1 FERC and Froehlich Methods

Two (2) of the most widely accepted methods for determining breach parameters are the FERC method [Ref 9] and the Froehlich method [Ref 10]. Both of these methods were examined during this study. The FERC method is relatively simplistic, while the Froehlich method consists of a series of empirically based equations that were derived from historical dam failures. One of the major shortfalls of the FERC method is the fact that storage volume is not considered in the calculation of ultimate breach width or the time of failure. Froehlich, on the other hand, attempts to incorporate this into his analysis.

However, one (1) of the potential flaws in Froehlich's methodology is that data from all dam failures was included when the relationships were derived. This includes dams that were not engineered structures and in some cases, were spoil piles of slag and other waste used to impound tailings at mines. Failure of such structures would presumably be rapid.

In spite of their limitations, each of these methodologies was initially applied to predict potential breach dimensions for the Pointe du Bois Project. The worst location for breach formation in the earthen structures was considered to be a point immediately to the west of the Primary Spillway. At this location, the height of the breach would be approximately 9 m when the forebay is at FSL and 11 m when the forebay level is at or above the crest of the dam. Table 6.1 summarizes the estimated breach parameters at the site based on these two (2) methodologies.

Table 6.1:
Breach Parameters estimated by FERC and Froehlich

Methodology and Forebay Level	Average Breach Width (m)	Time of Formation (hrs)	Final Breach Bottom Elevation (m)	Side Slope
FERC Forebay at El. 299.1 m	45	1.0	290	1H:1V
FERC Forebay at El. 301.3 m	55	1.0	290	1H:1V
Froehlich Forebay at El. 299.1 m	132	9.8	290	1H:1V
Froehlich Forebay at El. 301.3 m	148	9.3	290	1H:1V

6.2.2 Alternative Method for Defining Breach Parameters

As discussed in Section 6.2.1 above, both historical methodologies for estimating breach parameters have flaws. In order to improve upon these methods, new breach relationships were recently developed by Hatch in a dam break analysis completed for the Saskatchewan Watershed Authority, Qu'Appelle River Dam [Ref 11]. These new relationships were based on a revised database of dam failures that was screened to include only failures of engineered structures.

These relationships are expected to provide a refinement to the earlier work of Froehlich. The equations developed for determining breach width and time of formation, are as follows:

$$B = 9.43 \cdot V_w^{\ 0.12} \cdot H^{0.64}$$

$$t_f = 0.91 \cdot V_w^{\ 0.17} \cdot H^{0.11}$$

where,

B = Average breach width (metres)

V_w = Reservoir volume at time of failure (millions m^3)

H = Height of final breach (metres)

t_f = Formation time (hours)

All coefficients are empirically derived, and have been developed based on a regression analysis that was originally completed for the Qu'Appelle River study. The application of these equations is shown graphically on Figures 22 and 23. These figures also show how the breach parameters calculated for Pointe du Bois relate to historical data.

Table 6.2 summarizes the calculated parameters based on the dam breach relationships described above. It can be seen from this table that the breach width, which is a function of the reservoir storage and breach depth, only changes with the initial elevation of the forebay. The time of formation varied from 2.96 hrs for failure at the reservoir FSL, to 3.18 hrs for failure at a surcharged reservoir elevation of 301.3 m. In this study a formation time of 3.0 hrs was selected for all of the cases.

Table 6.2:
Adopted Breach Parameters

Scenario	Flow (m^3/s)	Average Breach Width (m)	Forebay Level (m)	Time of Formation (hrs)	Final Breach Bottom Elevation (m)	Side Slope
1	1 000	74	299.1	3	290	1H:1V
2	4 800	87	301.3	3	290	1H:1V
3	6 570	87	301.3	3	290	1H:1V
2 & 3*	n/a	82 (Breach Bottom)	301.3	3	290	2H:1V

* Based on estimated capacity of upstream control

As indicated earlier, the location of the largest potential breach is the earthfill section located between the two (2) new Spillways. Immediately upstream of this earthen embankment, the waterway will be somewhat constricted, given the presence of the old sluiceway rollways and the partially removed rockfill dam. In the event of a failure in the new downstream embankment, the rockfill dam remnant would likely erode down to bedrock, but if the downstream breach became large enough, the control in reservoir outflow could indeed shift from the developing breach to this upstream section. Hydraulic calculations indicate that for the Sunny Day scenario, the control would remain at the downstream breach section, but that for the two failure scenarios involving surcharge of the forebay to El. 301.3 m, the size of the breach would be large enough for control to actually shift to the upstream section. For these scenarios, the ultimate breach size, and outflow capacity were estimated based on the cross-sectional geometry of the bedrock and the partially demolished sluiceway structure at this upstream control section.

Because HEC-RAS is only able to model rectangular or trapezoidal breaches, a composite breach was developed based on the calculated critical flow rating curve for this upstream cross section. The outflow capacity of this composite breach closely compares to the calculated critical flow rating curve, and was ultimately adopted for breach scenarios 2 and 3. It is shown on the last line in Table 6.2.

6.3 Methodology to Estimate Loss of Life

There are a number of methods available to predict the LOL for these types of flood events. For this study, the Graham methodology [Ref 12] was adopted. This methodology was developed by the Dam Safety Office of the USBR in 1999, and has become an industry standard for these types of assessments.

The methodology was developed based on an empirical analysis of historical fatality rates for dam failures and other types of flood events which have occurred within the United States. Graham's methodology involves a multi-step procedure to assess the LOL potential.

Graham provides recommended fatality rates based on a number of factors, including the anticipated severity of the flood, the amount of warning time available, the expected population at risk, and a measure of whether people fully understand the severity of the approaching flood. Once a fatality rate is selected for a flood event, the rate is multiplied by the identified population at risk (PAR) to determine the number of anticipated fatalities. Table 6.3 summarizes the fatality rates provided within Graham's paper.

Table 6.3:
Graham's Coefficients for Determining Loss of Life

Flood Severity	Warning Time (minutes)	Flood Severity Understanding	Fatality Rate (Fraction of people at risk expected to die)	
			Suggested	Suggested Range
High	no warning	n/a	0.75	0.30 to 1.00
	15 to 60	vague	Use the values shown above and apply to the number of people who remain in the dam failure floodplain after warnings are issued. No guidance is provided on how many people will remain in the floodplain.	
		precise		
	>60	vague		
		precise		
Medium	no warning	n/a	0.15	0.03 to 0.35
	15 to 60	vague	0.04	0.01 to 0.08
		precise	0.02	0.005 to 0.04
	>60	vague	0.03	0.005 to 0.06
		precise	0.01	0.002 to 0.02
Low	no warning	n/a	0.01	0.0 to 0.02

	15 to 60	vague	0.007	0.0 to 0.015
		precise	0.002	0.0 to 0.004
	>60	vague	0.0003	0.0 to 0.0006
		precise	0.0002	0.0 to 0.0004

The notion of the loss of a fraction of a life may seem illogical to some. However, the numbers for loss of life that are quoted in the reference documents and in this report should be viewed as indices that represent the level of expected fatalities based on experience with real dam breach events in the past. They can be used to compare, in a relative sense, the LOL potential for a range of dam breach scenarios or for different dams. It does not represent a precise prediction of a loss of a fraction of life in any particular dam breach event.

In assessing the loss of life potential associated with the Pointe du Bois dam break scenarios, the following steps were undertaken:

(a) Estimation of Population at Risk (PAR):

The first step for each scenario involved estimation of the PAR. This required that inundation mapping be developed for each scenario, both with and without a breach in the dam. Maximum water surface profiles were taken from HEC-RAS and imported into a GIS model of the study reach. The GIS model was then able to automatically delineate the flood line associated with each water surface profile (i.e. with and without failure). The area in between the two flood lines represents the area that would be incrementally flooded by the dam breach event. Any buildings in this area were identified and included in the population at risk for each breach scenario. Approximate floor elevations were identified for each affected building based on the available contour mapping.

It was assumed that each identified building would be inhabitable (unless it was known otherwise), and that at the time of failure, each building would house up to three occupants.

(b) Estimation of Flood Severity:

For each affected building, it was also necessary to estimate the expected flood severity. Graham provides some guidance for this in his paper, and subdivides the severity index into three categories:

1. *High Severity* – results in total destruction of any infrastructure downstream of a breached dam, and nothing would remain in the area (trees or homes).

2. *Medium Severity* – the flood wave is of sufficient force to knock affected buildings from their foundations, but does not result in total destruction downstream of the dam. Trees and damaged buildings would remain in the flood plain.

3. *Low Severity* – No buildings are washed off of their foundations.

For the Pointe du Bois project, none of the affected buildings would be classified as a High Severity flood risk. Depending on where the buildings are located, some would be exposed to a Medium Severity flood risk and others to a Low Severity flood risk. In distinguishing between Low and Medium Severity flood, Graham suggests that for any building exposed to flood depths of less than 10 feet, the flood severity would normally be classified as Low. Graham also suggests that exposed buildings could be classified based on the expected DV (Depth*Velocity) factor at the site. Graham recommends using a DV value of 4.6 m^2/s (50 ft^2/s) to distinguish between low and medium flood severity. The USBR also suggests ranking the hazard potential for buildings exposed to flood flows based on the expected depth of flooding and the velocity of flow. Taking this information into consideration, for this study a conservative classification system was adopted based on the following assumptions:

- For buildings exposed to a depth of flooding of less than 3 m (10 ft) and a velocity of flow of less than 0.5 m/s (1.64 ft/s), the flood risk would remain Low.

- For all buildings exposed to flood depths of more than 3 m (10 ft), the flood risk would be Medium regardless of the velocity.

- Whenever the velocity is above 0.5 m/s (1.64 ft/s) and the depth of flooding is above 1 m (3.28 ft), the flood risk would be Medium.

Figure 24 illustrates the final selection criteria for flood risk. Using this chart, the flood risk associated with each affected building was assessed based on the expected depth of flooding and velocity of flow. By using the maps to select the floor elevation of the buildings and extracting the peak water levels from the nearest HEC-RAS cross section, the depth of flooding at each building could be determined. The estimated depth of flooding and maximum calculated flow velocity were then compared to the criteria established on Figure 24 to select the flood severity risk for each individual building.

(c) Understanding of Flood:

The estimated fatality rate for each flood scenario also depends on the perceived understanding of the impending flood event by both the flood issuers and the downstream PAR. For this assessment, it was conservatively assumed that the flood understanding would be vague, meaning that downstream residents would have a general understanding of the flood risk, but may not fully comprehend the true magnitude of the flooding to be expected. It should be noted that this parameter is only considered if the residents have more than 15 minutes of warning time.

(d) Warning Time:

The warning time available to each downstream resident was calculated as the time between the issuance of an initial flood warning by Manitoba Hydro (i.e. either as a siren activated at the plant, or as activation of an automatic telephone warning system, or plant staff notifying downstream residents, etc.), and the time at which flood waters were expected to reach the main floor elevation of the home. It was assumed that a flood warning would be initiated by Manitoba Hydro within an hour of breach initiation for each event. Given the 3-hour breach formation time selected, as noted in Section 6.2.2, this means the water levels between Pointe du Bois and Slave Falls would generally be expected to peak within approximately two
(2) hours of the warning being issued. The warning time available at each building location varied depending on the floor elevation of the building. Buildings which were located higher up on the bank were given longer warning times since it would take longer for the flood waters to reach the main floor of the building.

(e) Sensitivity Test:

The assumptions described above represent a “best estimate” of the number of fatalities that could occur should a breach develop in one of the water retaining structures associated with the Pointe du Bois project. To test the sensitivity of the LOL estimates to these assumptions, a second case was considered for each breach scenario that is considered to represent a “worst case” estimate of LOL potential. For this second case, it was assumed that up to four residents would be in each affected house, effectively increasing the PAR by 33 %. In addition, it was assumed that no warning would be available to any of the affected residents. This is considered to be very unrealistic, but was considered in this study for comparative purposes.

6.4 Results of Dam Break Analysis

6.4.1 General

Dam break model simulations were undertaken to estimate the impacts of breach development in the Pointe du Bois earthfill dam for three different scenarios.

- Scenario 1: A sunny day failure with a flow of 1 000 m^3/s and the forebay at El. 299.1 m.
- Scenario 2: Flow of 4 800 m^3/s with the forebay at El. 301.3 m.
- Scenario 3: PMF of 6 570 m^3/s with forebay at El. 301.3 m.

Hydrographs for the breach outflow just downstream of Pointe du Bois and at Slave Falls are shown for all failure scenarios in Figure 25 and 26 respectively, while Figures 27 to 29 provide stage hydrographs expected at key locations downstream of the Pointe du

Bois GS for each scenario. Figures 30 to 32 provide water surface elevation profiles for each scenario that compare the maximum water surface profiles with and without a breach at Pointe du Bois. Inundation mapping has been prepared for all failure scenarios and is shown in Figures 33 to 46. It should be noted for Scenarios 1 and 3, mapping has only been provided for the populated area just downstream of the dam (first 2 sheets). However, for Scenario 2, which is considered to be the most representative scenario for the post redevelopment case, a full suite of maps has been provided extending from the Pointe du Bois Project down to the Slave Falls site.

Key findings from the dam break assessment for each scenario are presented in the following sections.

6.4.2 Scenario 1: Sunny Day Failure

This scenario was assessed to determine the effects should a failure occur in the absence of a significant flood event. Key findings are summarized as follows:

- It was assumed the initial river flow would be 1 000 m^3/s.
- Failure was assumed to occur with forebay at the normal FSL of El. 299.1 m
- Failure was assumed to occur due to piping at El. 290.0 m. (the bottom elevation of the breach).
- It was assumed that the breach would be discovered and that warnings would be given within 1 hour of breach initiation. This is consistent with suggestions made by Graham (1999) given the size of the drainage basin, the presence of operating staff, and close proximity of residents to the dam.
- It was assumed that the Powerhouse and Spillways would initially be passing 1 000 m^3/s, and that this flow would continue throughout the breach event.
- The inundation mapping associated with this scenario is shown in Figures 33 and 34.
- In total, it is estimated that up to six (6) buildings may be impacted by a failure under sunny day conditions.
- Table 6.4 summarizes hydraulic conditions expected at the six (6) building locations. Figure 47 compares the expected velocity and depth at each location with the flood severity criteria developed in Section 6.3. This information was then applied to Graham's equations in order to estimate the loss of life. For a PAR based on three persons per building and a warning time calculated by the rise in water levels, 0 - 1 fatalities may occur.

- For the more conservative case of up to 4 persons per building and no warning time, Graham's equations still indicate that 0 - 1 fatalities may occur.

- The peak flow at Slave Falls is approximately 4 050 m^3/s and although the Spillway may be able to handle flows of this magnitude, without adequate warning, the stop logs may not be removed in time and a breach at Slave Falls may occur. Should the dam breach at Pointe du Bois result in a subsequent breach at Slave Falls, this would result in a small increase in flows and water levels downstream of Slave Falls compared to a case in which Slave Falls did not breach. Because of the small headpond associated with the Slave Falls plant, the expected water level increase due to a domino failure was previously shown to be no more than 0.6 m downstream of Slave Falls, and only 0.3 m at Nutimik Lake (nearest habituated area downstream of Slave Falls) [Ref 3]. This was shown to have no increase to the PAR.

Table 6.4:
Scenario 1 Results

Building #	Floor Elevation (m)	Initial Water Level (m)	Peak Water Level (m)	Depth of Flooding (m)	Peak Velocity (m/s)	Time to Peak (hrs)	Warning Time (hrs)	Severity Index
16	287.00	284.82	287.08	0.08	0.51	2.00	1.93	Low
17	286.75	284.81	287.01	0.26	1.13	2.00	1.76	Low
18	286.75	284.81	287.01	0.26	1.13	2.00	1.76	Low
24	286.00	284.80	286.93	0.93	1.75	2.00	1.13	Low
28	286.00	284.80	286.89	0.89	1.87	2.00	1.15	Low
40	285.00	284.64	285.43	0.43	0.22	2.00	0.91	Low

Notes:
1 The time to peak is defined as the time from breach initiation until the time at which the peak water level is reached at a site
2 The warning time is defined as the time between the issuance of an initial flood warning by Manitoba Hydro at the time at which flood waters were expected to reach the main floor elevation of the home.

6.4.3 Scenario 2: 4,800 m^3/s Failure with Surcharge

This scenario was assessed to determine the effects should an overtopping failure occur during a high flood event. Although it has not yet been finalized, for the purpose of this study, the crest elevation of the dam was assumed to be at El. 300.8 m. The reservoir was allowed to surcharge to El. 301.3 m prior to failure, which would cause down cutting of the earthen structure. Should the actual crest elevation be higher than El. 300.8 m, the results of the dam breach analysis would not be noticeably different than what is outlined within this memorandum. The key findings of the model assessment of this scenario are as follows:

- It was assumed the initial river flow would be 4 800 m^3/s.

- It was assumed that failure would occur with the forebay surcharged to El. 301.3 m.

- Failure was assumed to occur due to overtopping at an El. 301.3 m.

- It was assumed that the breach would be discovered and that warnings would be given within 1-hour of breach initiation. This is consistent with suggestions made by Graham (1999) given the size of the drainage basin, the presence of operating staff, and close proximity of residents to the dam.

- It was assumed that the spillways and powerhouse would be initially passing 4 800 m^3/s with the forebay surcharged to El. 301.3 m. It was also assumed that the spillway bays would not be closed upon initiation of the breach.

- The inundation mapping associated with this scenario is shown in Figures 35 to 44.

- In total, it is estimated that up to twenty-nine (29) buildings may be incrementally impacted by a failure under these conditions.

- Table 6.5 summarizes hydraulic conditions expected at the twenty-nine (29) building locations. Figure 48 compares the expected velocity and depth at each location with the flood severity criteria developed in Section 6.3. This information was then applied to Graham's equations in order to estimate the loss of life. For a PAR based on three persons per building and a warning time calculated by the rise in water levels, up to two (2) fatalities may occur.

- For the more conservative case in which we assume up to four (4) persons per building and no warning time, Graham's equations indicate that up to eight (8) fatalities may occur.

- The peak flow at Slave Falls is 8 900 m^3/s. Under this flow, a subsequent breach at Slave Falls is likely to occur. Although this is approximately 1 200 m^3/s greater than the peak flows predicted in the original analyses, it is judged that this will result in similar impacts below Slave Falls to those described in previous study reports. However, it will result in additional surcharge at the Seven Sisters GS in passing the resulting flood. Although the surcharge is not expected to be sufficient to overtop the dam, it will cause the reservoir levels to encroach on the minimum freeboard allowances established at the dam to protect against wind driven wave events during the passage of large floods.

Table 6.5:
Scenario 2 Results

Building #	Floor Elevation (m)	Initial Water Level (m)	Peak Water Level (m)	Depth of Flooding (m)	Peak Velocity (m/s)	Time to Peak (hrs)	Warning Time (hrs)	Severity Index
6	290.00	287.53	290.30	0.30	1.22	2.00	1.78	Low
7	289.00	287.55	290.35	1.35	0.61	2.00	1.04	Medium
8	288.00	287.55	290.35	2.35	0.61	2.00	0.32	Medium
9	288.00	287.54	290.34	2.34	0.76	2.00	0.33	Medium
10	290.00	287.54	290.34	0.34	0.76	2.00	1.76	Low
13	289.00	287.54	290.32	1.32	0.91	2.00	1.05	Medium
14	288.00	287.54	290.32	2.32	0.91	2.00	0.33	Medium
15	288.00	287.54	290.32	2.32	0.91	2.00	0.33	Medium
19	288.50	287.46	290.19	1.69	1.70	2.00	0.76	Medium
20	289.00	287.46	290.19	1.19	1.70	2.00	1.13	Medium
21	289.00	287.38	290.06	1.06	2.49	2.00	1.21	Medium
22	290.00	287.38	290.06	0.06	2.49	2.00	1.96	Low
23	289.00	287.38	290.06	1.06	2.49	2.00	1.21	Medium
25	289.50	287.35	289.98	0.48	2.88	2.00	1.63	Low
26	289.90	287.35	289.98	0.08	2.88	2.00	1.94	Low
27	288.50	287.33	289.98	1.48	2.88	2.00	0.88	Medium
29	289.90	287.33	289.98	0.08	2.88	2.00	1.94	Low
30	289.00	287.33	290.07	1.07	2.88	2.00	1.22	Medium
31	289.25	287.33	290.07	0.82	2.88	2.00	1.40	Low
32	289.25	287.33	289.98	0.73	2.88	2.00	1.45	Low
33	287.50	287.33	289.98	2.48	2.88	2.00	0.13	Medium
35	288.50	285.94	288.53	0.03	0.47	2.00	1.98	Low
36	288.50	285.94	288.53	0.03	0.47	2.00	1.98	Low
37	288.50	285.94	288.53	0.03	0.47	2.00	1.98	Low
39	287.00	285.94	288.53	1.53	0.44	2.00	0.82	Low
41	288.00	285.94	288.53	0.53	0.44	2.00	1.59	Low
43	288.50	285.94	288.53	0.03	0.48	2.00	1.98	Low
44	287.00	285.94	288.53	1.53	0.48	2.00	0.82	Low
45	288.00	285.94	288.53	0.53	0.48	2.00	1.59	Low

Notes:
1 The time to peak is defined as the time from breach initiation until the time at which the peak water level is reached at a site
2 The warning time is defined as the time between the issuance of an initial flood warning by Manitoba Hydro and the time at which flood waters were expected to reach the main floor elevation of the home.

6.4.4 Scenario 3: PMF Failure

This scenario was assessed to determine the effects should an overtopping failure occur during the PMF Event. Again, although it has not yet been finalized, for the purpose of this study, the crest elevation of the dam was assumed to be at El. 300.8 m. If the dam was to fail due to overtopping it is likely that it would occur near this elevation. However, by allowing the reservoir to surcharge to El. 301.3 m it allows for moderate weir flow over the dam, which would eventually cause downcutting of the earthen structure. The key findings of the model assessment of this scenario are as follows:

- It was assumed the initial river flow would be 6 570 m^3/s.
- It was assumed that failure would occur due to overtopping, with the forebay surcharged to El. 301.3 m.
- It was assumed that the breach would be discovered and that warnings would be given within 1-hour of breach initiation. This is consistent with suggestions made by Graham (1999) given the size of the drainage basin, the presence of operating staff, and close proximity of residents to the dam.
- It was assumed that the structure would be initially passing 6 570 m^3/s with the forebay surcharged to El. 301.3 m. It was also assumed that the Spillway bays would not be closed upon initiation of the breach.
- The inundation mapping associated with this scenario is shown in Figures 45 and 46.
- In total, it is estimated that up to thirty-one (31) buildings may be incrementally impacted by a failure under these conditions.
- Table 6.6 summarizes hydraulic conditions expected at thirty-one (31) building locations. Figure 49 compares the expected velocity and depth at each location with the flood severity criteria developed in Section 6.3. This information was then applied to Graham's equations in order to estimate the LOL. For a PAR based on three persons per building and a warning time calculated by the rise in water levels, up to three (3) fatalities may occur.
- For the more conservative case of up to four (4) persons per building and no warning time, Graham's equations indicate that up to eight (8) fatalities may occur.
- The resulting peak flow at Slave Falls is estimated to be 10 640 m^3/s. Under this flow, a subsequent breach at Slave Falls is likely to occur. As noted in Section 6.4.2, this will result in a small increase in flows and water levels downstream of Slave Falls compared to a case in which Slave Falls did not breach and would not be expected to increase to the PAR.
- The influx of water due to the Pointe du Bois/Slave Falls breach events will result in additional inflow and surcharge at the Seven Sisters GS. Although detailed routing studies were not conducted, it is possible to get a rough estimate of the expected inflow at Seven Sisters by attenuating the peak Slave Falls outflows by a factor similar to that observed in the 1995 studies. Based on this, albeit crude analysis, it is expected that peak levels at Seven Sisters may be at or very near to the crest of the

earthen dykes for this scenario. Depending on the magnitude of any coincident wind events, this may lead to some short term overtopping of these structures. This could potentially lead to a subsequent domino failure of both the Seven Sisters GS and the McArthur GS.

Table 6.6:
Scenario 3 Results

Building #	Floor Elevation (m)	Initial Water Level (m)	Peak Water Level (m)	Depth of Flooding (m)	Peak Velocity (m/s)	Time to Peak (hrs)	Warning Time (hrs)	Severity Index
1	291.00	288.70	291.09	0.09	2.60	2.00	1.92	Low
2	291.00	288.70	291.09	0.09	2.60	2.00	1.92	Low
3	291.00	288.70	291.09	0.09	2.60	2.00	1.92	Low
4	291.00	288.70	291.09	0.09	2.60	2.00	1.92	Low
5	291.00	288.70	291.09	0.09	2.60	2.00	1.92	Low
6	290.00	288.78	291.24	1.24	1.35	2.00	0.99	Medium
7	289.00	288.81	291.29	2.29	0.69	2.00	0.15	Medium
10	290.00	288.80	291.28	1.28	0.86	2.00	0.97	Medium
11	291.00	288.80	291.28	0.28	0.86	2.00	1.77	Low
12	291.00	288.80	291.26	0.26	1.03	2.00	1.79	Low
13	289.00	288.80	291.26	2.26	1.03	2.00	0.16	Medium
20	289.00	288.70	291.12	2.12	1.84	2.00	0.25	Medium
21	289.00	288.60	290.98	1.98	2.65	2.00	0.34	Medium
22	290.00	288.60	290.98	0.98	2.65	2.00	1.18	Medium
23	289.00	288.60	290.98	1.98	2.65	2.00	0.34	Medium
25	289.50	288.51	290.88	1.38	3.13	2.00	0.84	Medium
26	289.90	288.51	290.88	0.98	3.13	2.00	1.17	Low
29	289.90	288.51	290.88	0.98	3.13	2.00	1.17	Low
30	289.00	288.51	290.88	1.88	3.13	2.00	0.41	Medium
31	289.25	288.51	290.88	1.63	3.13	2.00	0.62	Medium
32	289.25	288.51	290.88	1.63	3.13	2.00	0.62	Medium
34	289.00	287.17	289.39	0.39	0.55	2.00	1.65	Low
35	288.50	287.17	289.39	0.89	0.55	2.00	1.20	Low
36	288.50	287.17	289.39	0.89	0.55	2.00	1.20	Low
37	288.75	287.17	289.39	0.64	0.55	2.00	1.42	Low
38	289.00	287.17	289.39	0.39	0.53	2.00	1.65	Low
39	287.50	287.17	289.39	1.89	0.50	2.00	0.30	Medium
41	288.00	287.17	289.39	1.39	0.50	2.00	0.75	Medium
42	289.25	287.17	289.39	0.14	0.55	2.00	1.87	Low
43	288.50	287.17	289.39	0.89	0.55	2.00	1.20	Low
46	289.00	287.17	289.39	0.39	0.62	2.00	1.65	Low

Notes:
1 The time to peak is defined as the time from breach initiation until the time at which the peak water level is reached at a site
2 The warning time is defined as the time between the issuance of an initial flood warning by Manitoba Hydro and the time at which flood waters were expected to reach the main floor elevation of the home.

6.4.5 Sensitivity Analyses

Additional analyses were also undertaken to assess the overall sensitivity of the results to the:

- Selected breach parameters,
- Selected breach location,
- Selected sub-population grouping,

- Slave Falls spillway capacity,
- PAR,
- Warning time.

The results of these sensitivity tests are discussed briefly below.

Breach Parameters

One of the most important parts of a dam break assessment is the selection of an appropriate breach parameter set for a given water retaining structure. To assess the sensitivity of the results to the selected parameter set, a brief sensitivity analysis was conducted. The parameters that were varied during the sensitivity analysis included the initial piping elevation (for sunny day failures), the breach width and the time of failure. Other parameters that were defined by topography or chosen based on the most conservative estimates were not varied.

Possible variations in both the estimated breach width and assumed time of formation were also tested. Using the breach width and time of formation obtained with the alternative method analysis discussed in Section 6.2.2, the breach width was adjusted up and down by 25% and the time of formation from 2 to 4-hours. Note that the currently adopted breach widths for the 4800 m^3/s and PMF scenarios already represent the maximum expected dimensions, since they correspond to the physical flow constraint or control at the upstream section. Therefore the maximum water surface profile remains unchanged as the breach width increases beyond 82 m. The sensitivity test results showed that the downstream water levels are most sensitive to the breach width and it was therefore deemed to be the most important parameter. Although the time of formation is also important, it takes a much larger change to cause the same effects as an adjustment to the breach width. Figures 50 and 51 show the effect of adjusting these parameters for Scenarios 2 and 3. By reducing the breach width, the flows and downstream water levels drop. However, a breach width and formation time of 82 m and 3-hours were considered to be appropriate for this study, and represent a best estimate of what would likely occur.

Breach Location

Consideration was also given to the potential effects if a breach were to develop in another component of the project. Breach development in either the Powerhouse, a section of the East Gravity Wall, or the west embankment would also lead to an uncontrolled release of water from the reservoir. In these instances, under the worst possible scenario (i.e. largest possible breach), the control of outflow from the reservoir would switch relatively quickly from the downstream breach location to a point in the Intake Channel, located near to the existing footbridge. The Intake Channel is quite narrow and relatively shallow in this area. The HEC-RAS model was reconfigured to represent such a failure, and the results indicated peak flow rates for this scenario would be approximately 25% lower than for a breach in the embankment dam between the two (2) Spillways. It was therefore not a governing scenario for IDF selection.

Sub-Population Grouping

The Graham methodology for estimating LOL provides some allowance for the division of the downstream PAR into sub-population groupings. In a USACE publication entitled "Estimating Life Loss for Dam Safety Risk Assessment – A Review and New Approach" [Ref 13], the author states that Graham's model is intended to be applied to relatively homogeneous sub-PAR's, and that the PAR should be subdivided when areas differ significantly in terms of the flood severity, warning time, or flood severity understanding. This flexibility to sub-divide the PAR where appropriate makes the Graham method for LOL estimation superior to earlier methods, like that of DeKay and McClelland, which could not support such a sub-division.

For the Pointe du Bois assessment, the Graham method was applied individually to each affected home to determine LOL potential, and the estimates for each home were then summed to estimate the cumulative number of fatalities expected. Therefore each home essentially acted as a separate sub-PAR. It is unclear from the existing literature if this degree of PAR breakdown is entirely consistent with the PAR breakdown utilized in Graham's own database and analysis. It is quite possible that the sub-PAR's utilized in Graham's database may not have been completely homogeneous in terms of their flood exposure index, or warning time.

To address this potential concern, the Pointe du Bois LOL estimates (best estimate values) were re-assessed based on a much broader sub-population breakdown. For this sensitivity analysis, the PAR downstream of the project was divided into two areas:

1) the reach of river upstream of eight foot falls, and

2) the reach of river downstream of eight foot falls.

For each area, a single flood severity and a single warning time were selected based on the average hydraulic conditions expected in the area. An appropriate fatality rate was then selected and applied for each of the two (2) sub-populations, and the results summed to estimate the total fatality rate. The results of this sensitivity test are summarized in Table 6.7. As shown, the LOL estimates derived based on a technique utilizing only two (2) larger sub-populations are nearly identical to those derived based on a much finer breakdown of the downstream PAR. This is encouraging, and indicates that, for Pointe du Bois at least, assumptions made in the size of the PAR subgroups do not significantly affect the results of the analysis.

Table 6.7:
Sensitivity of Loss of Life Estimate to Sub-Population Grouping

Area	Item	Flood Scenario		
		1	2	3
Upstream Area	No. of homes	5	21	21
	PAR	15	63	63
	Flood severity	Low	Medium	Medium
	Average Warning (hrs)	1.5	1	1
	No. of Fatalities	<1	2.5	2.5
Downstream Area	No. of homes	1	8	10
	PAR	3	24	30
	Flood severity	Low	Low	Low
	Average Warning (hrs)	0.9	1.5	1.2
	No. of Fatalities	<1	0	0
Total Fatalities:		<1	2.5	2.5

Slave Falls Spillway Capacity

As noted in Section 5.2, the rating curve adopted for the Slave Falls GS in this study assumes that all existing discharge facilities are operational, or if they are not, that they will be rehabilitated in the future. Manitoba Hydro has advised the study team that at present, the creek spillway and ice sluiceway are inoperable, and may be decommissioned in the future. The decommissioning of these structures will reduce the overall discharge capacity of the station, and this would result in some additional surcharge upstream of the plant when passing the dam breach flows. Given that flow conditions through Eight Foot Falls are near to critical for these large flows, the reach affected by this additional surcharge would be limited to the area between Eight Foot Falls and the Slave Falls GS. Sensitivity tests indicate that residents immediately downstream of Eight Foot Falls may experience an additional 0.5 m of surcharge at the peak of the breach event (should these structures be decommissioned in the future), and that levels immediately upstream of the Slave Falls GS may increase by approximately 1 m.

To test the potential impacts of this, existing LOL estimates for the project were re-evaluated assuming flood depths in the affected area would increase by these amounts. The resulting loss of life estimates were nearly identical to those calculated previously, indicating the additional surcharge created by the decommissioning of these structures would not adversely affect the consequence rating for the Pointe du Bois Project.

Population at Risk

As noted in Section 6.3, the PAR for the Pointe du Bois Project was estimated based on an assumption that all buildings within the flood inundation zone would be inhabited by an average of three residents. Since many of these dwellings may be seasonal cottages, this estimate may be conservatively high (particularly during the passage of a flood event). To test the sensitivity of estimated fatality rates to this parameter, loss of life estimates for the "best estimate scenario" were recalculated assuming that each building would contain only two residents at the time of failure. The results of this assessment indicate that LOL estimates for the "best estimate" scenario would only change marginally, and would:

- Be unchanged for the sunny day failure (Scenario 1),
- Remain at two (2) fatalities for flood Scenario 2,
- Drop to two (2) fatalities for flood Scenario 3 (from the "best estimate" value of three).

Warning Time

As noted in Section 6.3, it was judged that in the event of a breach event at the project, Manitoba Hydro would be able to issue some form of warning to downstream residents within approximately 1-hour of breach initiation. At present the existing project does not have provision for a warning siren or an automated telephone warning system, and therefore any advance warning would need to be given directly by site staff or other observers. It is possible that under some circumstances, it may take longer than 1-hour to warn downstream residents.

Additional sensitivity tests were, therefore, performed to determine how the "best estimate" fatality estimates may be affected should warning times be reduced. For this case, it was assumed that there would be no warning to downstream residents, but that all other parameters in the assessment would be unchanged. The results of this sensitivity test indicate that LOL estimates for the "best estimate" scenario would change as follows:

- LOL estimates for the sunny day failure (Scenario 1) would be unchanged,
- LOL estimates for flood Scenario 2 would increase to six (6) (from the "best estimate" value of two),
- LOL estimates for flood Scenario 3 would increase to six (6) (from the "best estimate" value of three).

It should be noted that the lack of any warning from either Manitoba Hydro or other observers would double the expected fatality rate at the facility, but would not cause the number of fatalities to exceed ten (10).

7 Incremental Consequence Classification (ICC) Summary

The ICC for the Pointe du Bois Project was selected based on the overall impacts associated with a failure of one (1) of the Project's water retaining structures. These impacts were evaluated under three (3) basic categories – the potential for incremental LOL to occur, the potential for incremental economic damage to occur, and the potential for incremental environmental losses to occur. Loss of life potential has been estimated based on the recent dam break analysis described in Section 6. Potential economic losses have been taken from earlier study reports prepared by KGS Group in 2001 [Ref 4], and Acres in 2002 [Ref 5]. Damage estimates were not revisited in this study as previous estimates were completed recently and the majority of the losses are first party losses related to lost power generation. Considering these results, and current dam safety philosophies, the following observations are offered regarding these impacts arising from a breach event:

Incremental Loss of Life (LOL)

- It was estimated that the LOL, should a breach occur during a sunny day condition, (1 000 m^3/s), would be up to one (1) person. The PAR downstream of the project consisted of approximately six (6) permanent buildings, most of which were located between the Project and Eight Foot Falls.

- It was estimated that the LOL, should a breach occur during a relatively large flood event (4 800 m^3/s), would be approximately two (2) people. Even under a worst case condition, involving a larger number of inhabitants and zero warning time, the LOL estimate was eight (8) persons. The PAR downstream of the project consisted of approximately twenty-nine (29) permanent buildings, most of which were located between the Project and Eight Foot Falls.

- Estimates were also prepared for LOL potential should a structure fail during passage of a much larger flood like that of the PMF. In this case, it was estimated that the LOL due to breach formation would be approximately three (3) people. Even under a worst case condition, involving a larger number of inhabitants and zero warning time, the LOL estimate was eight (8) persons. The PAR downstream of the Project consisted of approximately thirty-one (31) permanent buildings, most of which were located between the Project and Eight Foot Falls.

- Consideration was also given to the effects of upstream breaches, and how they may impact on the LOL potential at Pointe du Bois. As discussed in further detail in Section 8, it is expected that the LOL associated with a failure scenario that includes the impacts of an upstream dam failure would almost certainly be zero, owing to the additional warning time available because of the upstream failure. Breach flows from a Caribou

Falls failure would reach Pointe du Bois in approximately 4.5 hours, and would not peak for almost 60 hours. Therefore, this scenario would not be a governing condition in selecting the incremental consequence classification for the Pointe du Bois facility.

- For each of the scenarios addressed above, the LOL associated with a natural flood (i.e. non-breach) condition would be zero.

Incremental Economic Damages

- Should a breach develop during the passage of a large flood (i.e. exceeding 1 in 1 000 years), some infrastructure downstream of the Pointe du Bois GS would be impacted. These potential impacts would include the flooding of various permanent/seasonal residences, the overtopping and potential failure of the Pinawa Dam and/or the Eleanor Lake Highway, and the overtopping and failure of the Slave Falls GS. The accumulated economic damage was previously estimated to be approximately $78 million (2001$) for such an event. It should be noted that the majority of these damages were generation losses and repair costs to Manitoba Hydro owned infrastructure. Third party losses were considered to be minimal. For this ICC assessment both Manitoba Hydro and third party damages were considered. This is contrary to the 2007 CDA Guidelines, however, it was included as the losses to Manitoba Hydro could be considered as losses to society. Damages associated with a natural flood (i.e. non-breach) would be less than $1 million. It should also be noted that these damage estimates assume the Pointe du Bois Powerhouse would remain operational. As discussed in Section 3.1, there is some uncertainty at this time as to the continued long-term operation of the Powerhouse; it is possible that it may be decommissioned at some point in the future. If it were decommissioned, the damage estimates quoted above would be reduced considerably.

- Should a breach develop at Pointe du Bois during passage of the PMF event, earlier studies indicate it could lead to the incremental failure of the Slave Falls GS. It is likely that the resulting flood wave would cause surcharge of the Seven Sisters forebay to a level that is very near to overtopping the earthen dykes. Under a worst case scenario, this may lead to breach formation in one of these containment dykes, and possible loss of both the Seven Sisters GS and the McArthur GS. The Great Falls and Pine Falls stations, which are also downstream of Pointe du Bois on the Winnipeg River, were not included since their selected IDF's were smaller than the PMF and would be expected to fail during passage of the natural PMF. Therefore, their failure was not considered to be an incremental effect resulting from a failure of Pointe du Bois. In addition, various residences downstream of the plant would be inundated. It was estimated that total economic damages arising from such a scenario would be in the order of $200 million (2001$). It should be noted that the majority of these damages were generation losses and repair costs to Manitoba Hydro owned infrastructure. Third party losses were considered to be minimal. Damages associated with failure of Seven Sisters GS and McArther GS for a natural flood would be in the order of $46 million.

- The above scenario for the PMF event did not consider the economic impact of failure for a case in which upstream breach effects are also included. The inclusion of these effects will serve to increase overall river flows and water levels associated with the PMF event. For this scenario, the additional inflow from an upstream breach would likely be enough to lead to the overtopping and failure of all generating stations on the river. However, under these circumstances all dams downstream of Pointe du Bois would have likely failed due to the sheer magnitude of the PMF inflow (with the upstream Caribou Falls breach), whether the Pointe du Bois dam failed or not. Therefore, their failure should not be considered to be an incremental effect associated with the Pointe du Bois failure. In this case, incremental impacts would be considerably smaller than for a case involving passage of the PMF without upstream breach effects.

Incremental Environmental Losses

Consideration was also given to the types and severity of any environmental impacts that may result in the event of a breach at the Pointe du Bois Project. It is expected that these impacts would primarily be aquatic in nature, since terrestrial impacts are likely to be quite limited. Potential aquatic impacts arising from a breach event at Pointe du Bois for dam breaches could result from:

- Potential exposure to contaminants associated with river bottom sediments downstream of Pointe du Bois GS.

- Any physical changes to overall habitat as a result of potential erosion and sediment deposition.

- Temporary loss of habitat areas upstream of the breached dams as the reservoir is drawn down involuntarily.

Considering the above, and considering that the upstream reservoir would likely be re-impounded within a year, it was judged that any habitat loss would be temporary, as would the impact to local fish populations.

Summary

Based on the 2007 CDA dam classification table, and the impacts summarized above, the Pointe du Bois development would fall under the “High” dam classification. This classification applies to any structure with a permanent PAR downstream, and whose failure may result in a LOL of ten (10) people or less. It is not likely that a failure of any one of the project’s water retaining structures would result in a LOL potential that could exceed ten (10) fatalities. In addition, the estimated economic damage associated with a failure is moderate, and likely would not justify an incremental consequence classification any greater than “High”. Considering the environmental losses, it was judged that the overall impacts of dam failure would result in a temporary loss of habitat that would be restored relatively quickly following re-construction of the dam. Based on these expected losses, the guidelines would suggest that a “High” dam classification also be adopted.

It should be noted that this analysis did not take into consideration any potential future development downstream of the Pointe du Bois Project. It is possible that following the re-development of the facility, there may be increased recreational development in the reach between Eight Foot Falls and the Project either on the west or east bank (this is the area most susceptible incremental flooding during dam break events). Should future development be significant in this area, it may require a future increase in the PAR and project ICC. However, it is not possible at this time to predict the degree of development that may take place. In consultation with Manitoba Hydro, it has been agreed that the current assessment will be made on the basis of existing infrastructure only (including any currently planned subdivisions).

Therefore, the ICC for Pointe du Bois has been selected as “High”.

8 Inflow Design Flood Selection

Based on the consequences of failures, the Pointe du Bois Project does not require the selection of the PMF as the IDF for the project. With a well-organized emergency preparedness plan, sufficient warning could be provided to affected downstream residents to limit LOL potential, particularly under large flood events. The incremental economic damages sustained would also not likely be enough to require selection of the PMF as a design flood for this structure.

Based on the above, the appropriate design flood for the Pointe du Bois Project would fall somewhere between the already identified PMF, and the 1 in 1 000 year flood. Based on the 2007 CDA Guidelines, the IDF for this project should be one third of the way between the 1 in 1 000 year flood and the PMF.

The question arises as to what value of the PMF to use in the upper range of the flood estimate – i.e. one that includes or excludes upstream breach effects. It is our opinion that the upper limit for the flood range should be a PMF that does not include upstream breach effects based on the following considerations:

- The occurrence of an upstream breach would actually serve to reduce the overall ICC for the Pointe du Bois structure. If the IDF at the Pointe du Bois Project is based on an inflow that assumes a breach of a major upstream dam, then the LOL estimate should also be based on that same inflow assumption. Breach flows from a Caribou Falls failure would reach Pointe du Bois in approximately 4.5-hours, and would not peak for almost 60-hours. When calculating LOL, it is a generally accepted practice to ignore populations at least 3-hours downstream of the breach location, because warning time would be sufficient to enable the evacuation of affected areas. Therefore, at Pointe du Bois, it could be said that the LOL would be zero for a case involving a breach of the Caribou Falls GS, since there would be sufficient response time. Incremental economic damage associated with failure of Pointe du Bois, although not a driver in the classification, would also actually likely decrease, since much of the damage sustained by downstream infrastructure would be attributed to the Caribou Falls GS failure rather than the Pointe du Bois GS failure. Given these considerations, one could argue that this scenario is considerably reduced in severity from a case in which it is assumed that upstream dams do not fail. It is, therefore, not the governing condition in assessing the plant's ICC and it would be unreasonable to include additional spill capacity into Pointe du Bois Project for no apparent "benefit" in terms of a reduction in LOL.

- Consideration was also given to the economic value of building additional discharge capacity into the Pointe du Bois Project. Building additional capacity would reduce the overall risk that the project may, at some time, be overtopped and fail. To demonstrate the value of this additional capacity, a cursory analysis was undertaken. For this preliminary assessment, it was assumed that the project IDF would be selected as the 1 000 year flood, and that as a worst case scenario, damages of $200 million would accrue for any flood with a probability of occurrence of 0.001 or less (assuming the Seven Sisters and McArthur structures are damaged by the resultant flood wave). This would result in an annual flood damage of approximately $200,000 per year. The present value of this magnitude of average annual flood damage would be between $4.0 and $5.0 million over the 100-year life of the Project. Comparing this cost to the additional construction cost that would be necessary to enlarge the Spillway structure (estimated to be approximately $10 million for the addition of a single bay), it would appear that the provision of additional capacity is not justified from a purely economic standpoint. This assessment is a "first cut" and should be refined using Manitoba Hydro's own internal guidelines to better assess the economic value of adding capacity.

The appropriate IDF range for the Pointe du Bois development is, therefore, between 5 040 m^3/s (1/3 of the way between the 1 in 1 000 year flood and the PMF) and 6 570 m^3/s (the full PMF). A flow of 5 040 m^3/s would represent the minimum design standard based on the 2007 CDA Guidelines. It also represents the approximate flood event (at Pointe du Bois) that would occur just prior to overtopping and potential failure of one of the components of the Caribou Falls Project. Therefore, the provision of additional Spillway capacity would offer little benefit to the project unless it was sufficient to handle the full breach inflow from an upstream breach. For this reason, it is recommended that this flood (5 040 m^3/s) be adopted as the final design flood for the project.

9 Summary

Investigations have been completed to update the ICC and the selection of the IDF for the Pointe Du Bois Spillway Replacement Project. This study has involved:

- The setup and calibration of a hydrodynamic model using HEC-RAS, based on Manitoba Hydro's steady state backwater model.

- The simulation of dam break scenarios and the preparation of inundation mapping showing the amount of incremental flooding that would result for three failure scenarios:
  - A sunny day failure with a flow of 1 000 m^3/s and the forebay at El. 299.1 m
  - Flow of 4 800 m^3/s with the forebay at El. 301.3 m
  - PMF of 6 570 m^3/s with forebay at El. 301.3 m

- LOL predictions were completed for each of the dam break scenarios. The study results indicate the LOL potential downstream of the project to be as shown in Table 9.1:

Table 9.1:
Loss of Life Summary

Scenario	Loss of Life Potential	
	Best Estimate	Worst Case
1	0-1	0-1
2	2	8
3	4	8

Based on the estimated consequences of failure identified in this study, and the CDA 2007 Guidelines, it is recommended that an ICC of "High" be adopted for this Project. It is also recommended that a flood discharge capacity of 5 040 m^3/s be adopted for the project IDF. This represents a flood that is one third of the way between the 1 in 1 000 year flood and the PMF (no upstream breaches).

10 References

1. KGS ACRES. "Pointe du Bois Spillway Replacement Stage IV Report", Memorandum P-1.3.9.1000.1, Manitoba Hydro File 00102-05500-0001.
2. Canadian Dam Association 2007. "Dam Safety Guidelines".
3. Acres International Ltd., 1995. "Report on Hydraulic Studies and Inundation Maps"
4. KGS Group, 2001. "Pointe du Bois Spillway Capacity Assessment"

5. Acres Manitoba Ltd., 2002. "Pointe du Bois Dam Safety Hydraulic Studies Review"

6. Manitoba Hydro, "Pointe du Bois Spillway Replacement Project Stage IV Studies – Stage Storage Relationship & Flooded Area", Memorandum P-1.3.2.2.0450, Manitoba Hydro File 00102-11400-0064.

7. Manitoba Hydro, "Pointe du Bois Spillway Replacement Project Hydrology Review", Memorandum P-1.3.2.2.0420, Manitoba Hydro File 00102-11300-0005.

8. KGS ACRES. "Pointe du Bois Spillway Replacement Probable Maximum Flood Review", Memorandum P-1.3.2.2.0430.1, Manitoba Hydro File 00102-11340-0010.

9. Federal Energy Regulatory Commission (FERC), 1993. "Engineering Guidelines for the Evaluation of Hydropower Projects" Chapter 4 – Embankment Dams

10. Froehlich, D. C., 1995. "Embankment Dam Breach Parameters Revisited" Proceedings of the 1995 ASCE Conference on Water Resources Engineering

11. Hatch, 2007. "Qu'Appelle River Dam, Dam Break Analysis"

12. Graham, W. J., 1999. "A Procedure for Estimating Loss of Life Caused by Dam Failure"

13. USACE, 2002. "Estimating Life Loss for Dam Safety Risk Assessment – A Review and New Approach".

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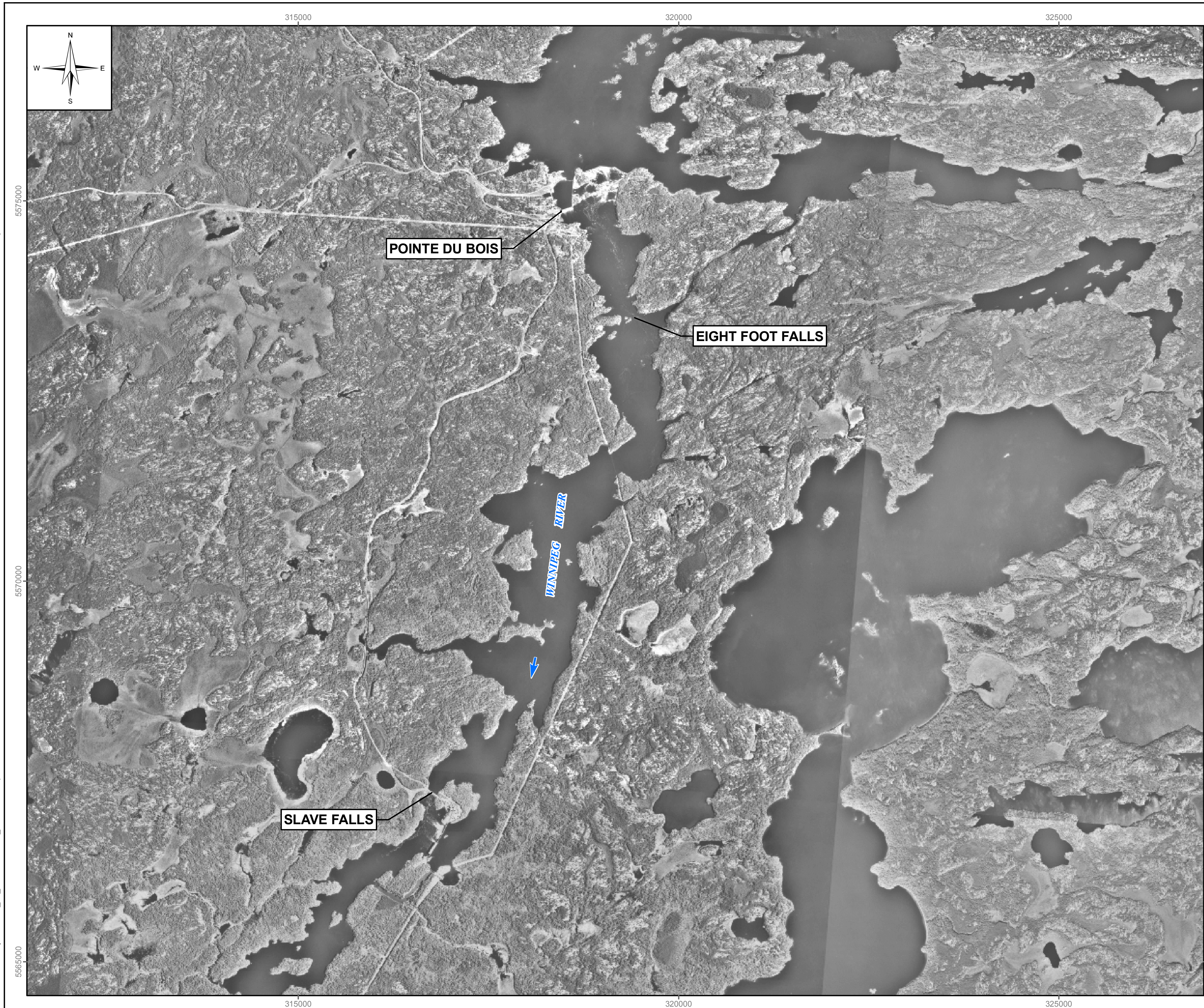
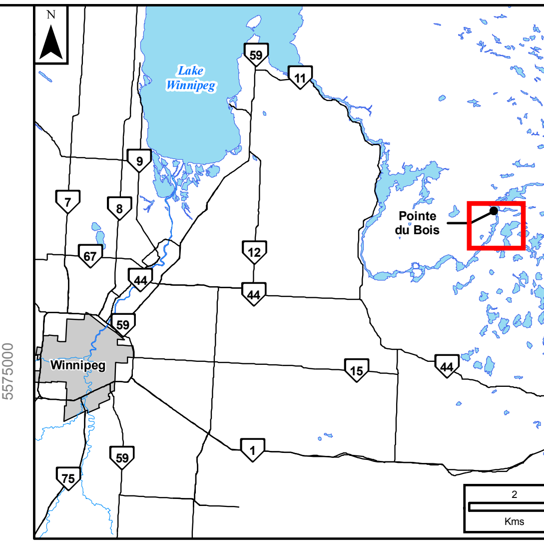
Appendix A
Figures 01 – 51
JLG/DSB/sml

Figures





0 1 2 3
Kilometres

SCALE: 1:50,000 METRIC 11" x 17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 15
Elevations are in metres above sea level (MSL)

ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES

Drawn: EYB
Submitted: DSB

MANITOBA HYDRO

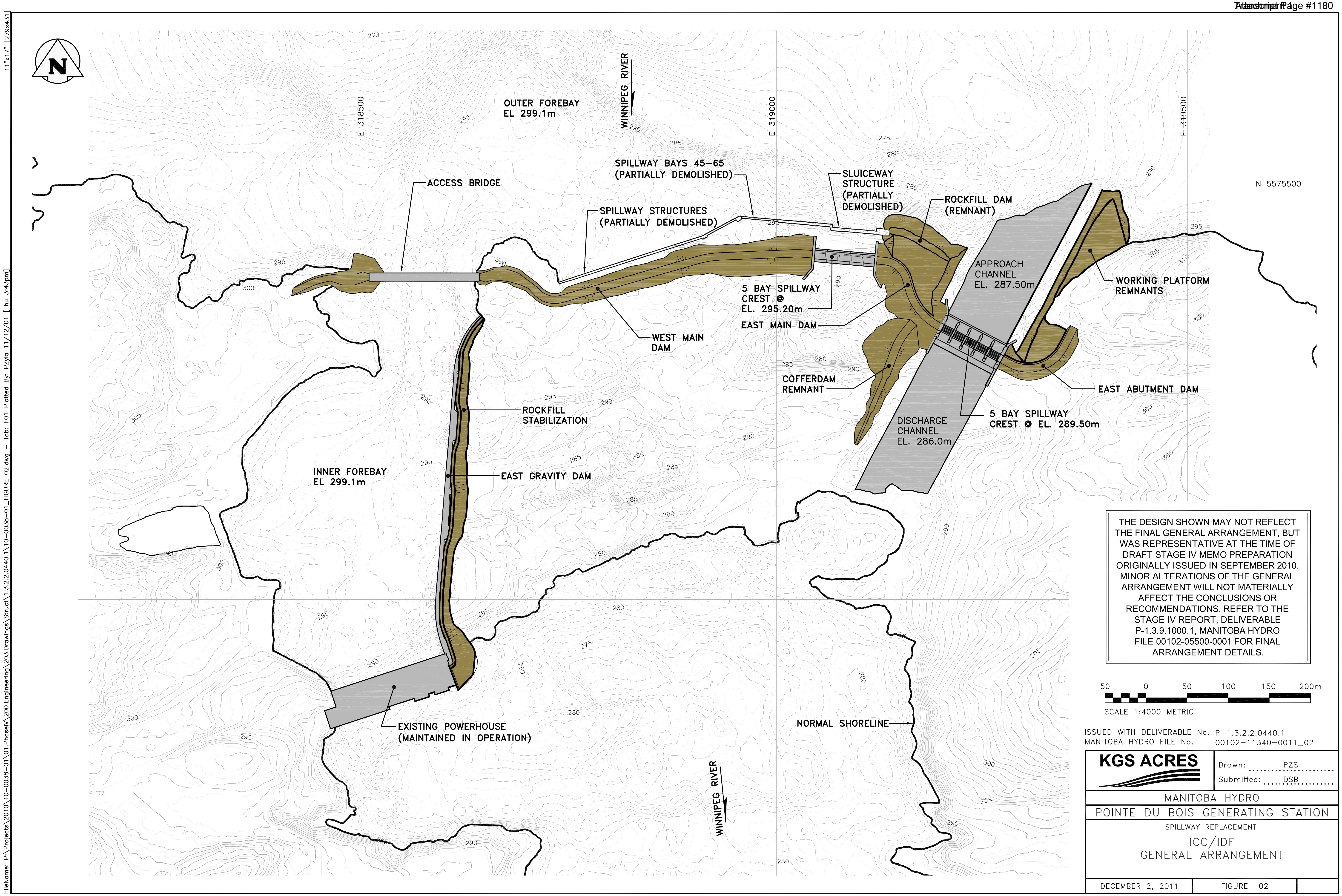
POINTE DU BOIS GENERATING STATION

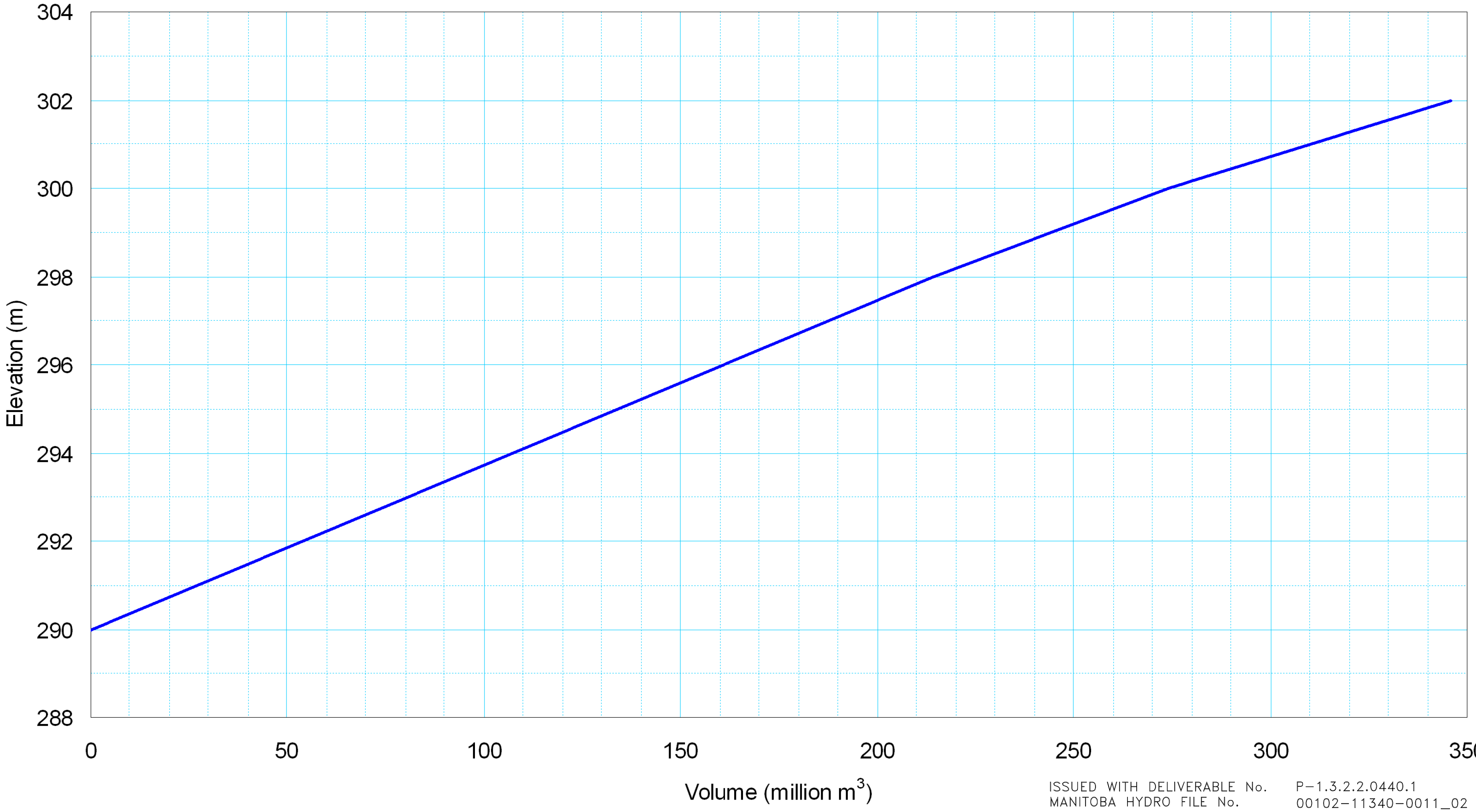
SPILLWAY REPLACEMENT

ICC/IDF
GENERAL LOCATION PLAN
POINTE DU BOIS TO SLAVE FALLS

DECEMBER 2, 2011 | FIGURE 01

Y:\TechData\GIS\Projects\Point_du_bois\Focus\ICC_IDF\MXDs\Replacement\Rev2\FIGURE1.mxd


N
OUTER FOREBAY
EL 299.1m
WINNIPEG RIVER
E 318500
E 319000
E 319500
N 5575500
ACCESS BRIDGE
SPILLWAY BAYS 45–65
(PARTIALLY DEMOLISHED)
SPILLWAY STRUCTURES
(PARTIALLY DEMOLISHED)
SLUICEWAY
STRUCTURE
(PARTIALLY
DEMOLISHED)
ROCKFILL DAM
(REMNANT)
APPROACH
CHANNEL
EL. 287.50m
WORKING PLATFORM
REMNANTS
5 BAY SPILLWAY
CREST @
EL. 295.20m
EAST MAIN DAM
WEST MAIN
DAM
COFFERDAM
REMNANT
EAST ABUTMENT DAM
5 BAY SPILLWAY
CREST @ EL. 289.50m
DISCHARGE
CHANNEL
EL. 286.0m
ROCKFILL
STABILIZATION
INNER FOREBAY
EL 299.1m
EAST GRAVITY DAM
EXISTING POWERHOUSE
(MAINTAINED IN OPERATION)
NORMAL SHORELINE
WINNIPEG RIVER
THE DESIGN SHOWN MAY NOT REFLECT THE FINAL GENERAL ARRANGEMENT, BUT WAS REPRESENTATIVE AT THE TIME OF DRAFT STAGE IV MEMO PREPARATION ORIGINALLY ISSUED IN SEPTEMBER 2010. MINOR ALTERATIONS OF THE GENERAL ARRANGEMENT WILL NOT MATERIALLY AFFECT THE CONCLUSIONS OR RECOMMENDATIONS. REFER TO THE STAGE IV REPORT, DELIVERABLE P-1.3.9.1000.1, MANITOBA HYDRO FILE 00102-05500-0001 FOR FINAL ARRANGEMENT DETAILS.
50 0 50 100 150 200m
SCALE 1:4000 METRIC
ISSUED WITH DELIVERABLE No. P–1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102–11340–0011_02
KGS ACRES
Drawn: PZS
Submitted: DSB
MANITOBA HYDRO
POINTE DU BOIS GENERATING STATION
SPILLWAY REPLACEMENT
ICC/IDF
GENERAL ARRANGEMENT
DECEMBER 2, 2011
FIGURE 02
11"x17" [279x431]



Source: Acres Manitoba Ltd., 1995. "Report on Hydraulic Studies and Inundation Maps"

ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

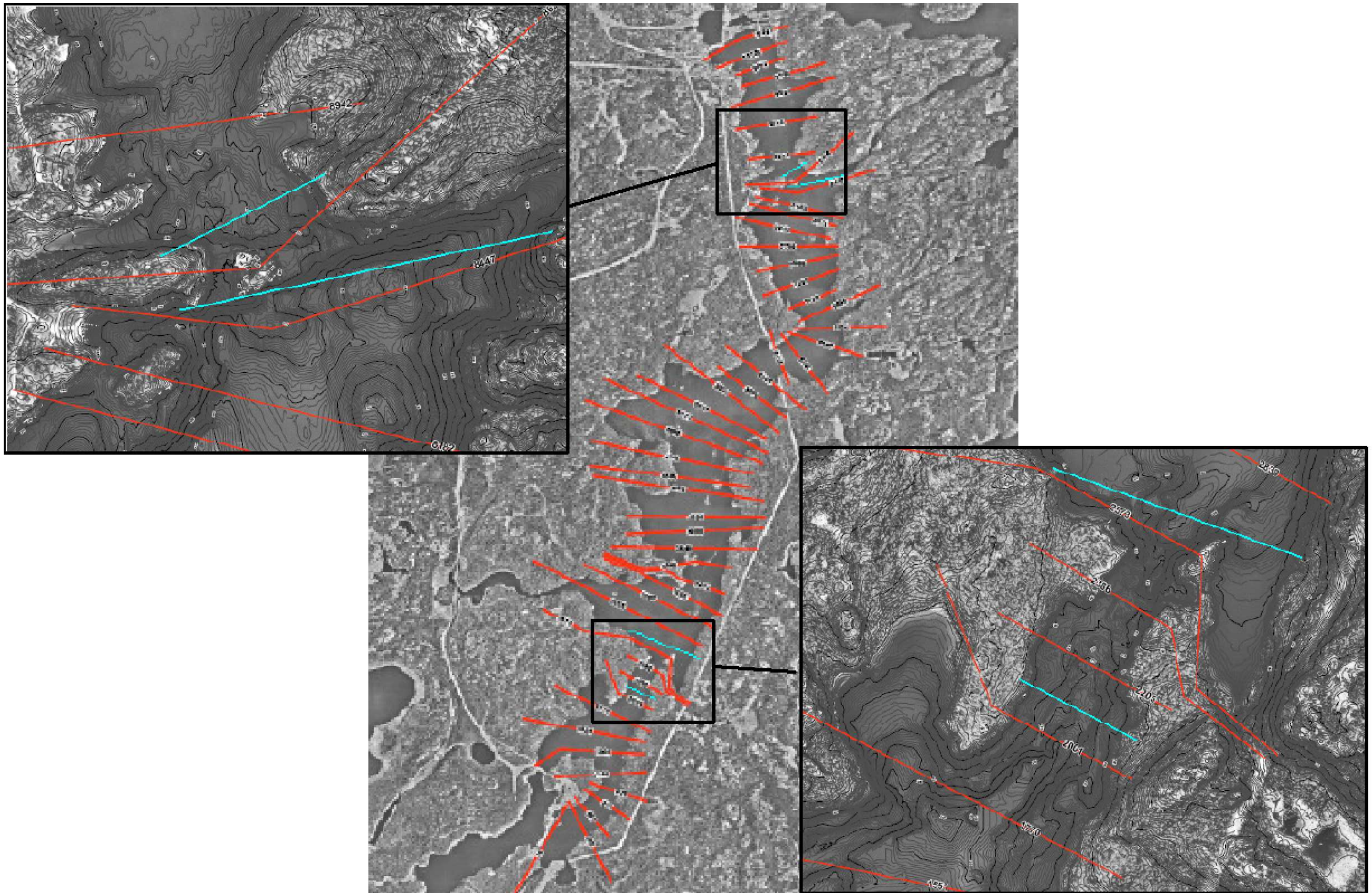
KGS ACRES

Drawn: JKK
Submitted: JLG

MANITOBA HYDRO
POINTE DU BOIS GENERATING STATION
SPILLWAY REPLACEMENT

ICC/IDF
STAGE-STORAGE CURVE
POINTE DU BOIS RESERVOIR

DECEMBER 2, 2011 | FIGURE 03



Red lines denote cross sections previously scaled by Manitoba Hydro
Blue lines denote cross sections added to the model by KGS Acres

ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES

Drawn: JKK
Submitted: JLG

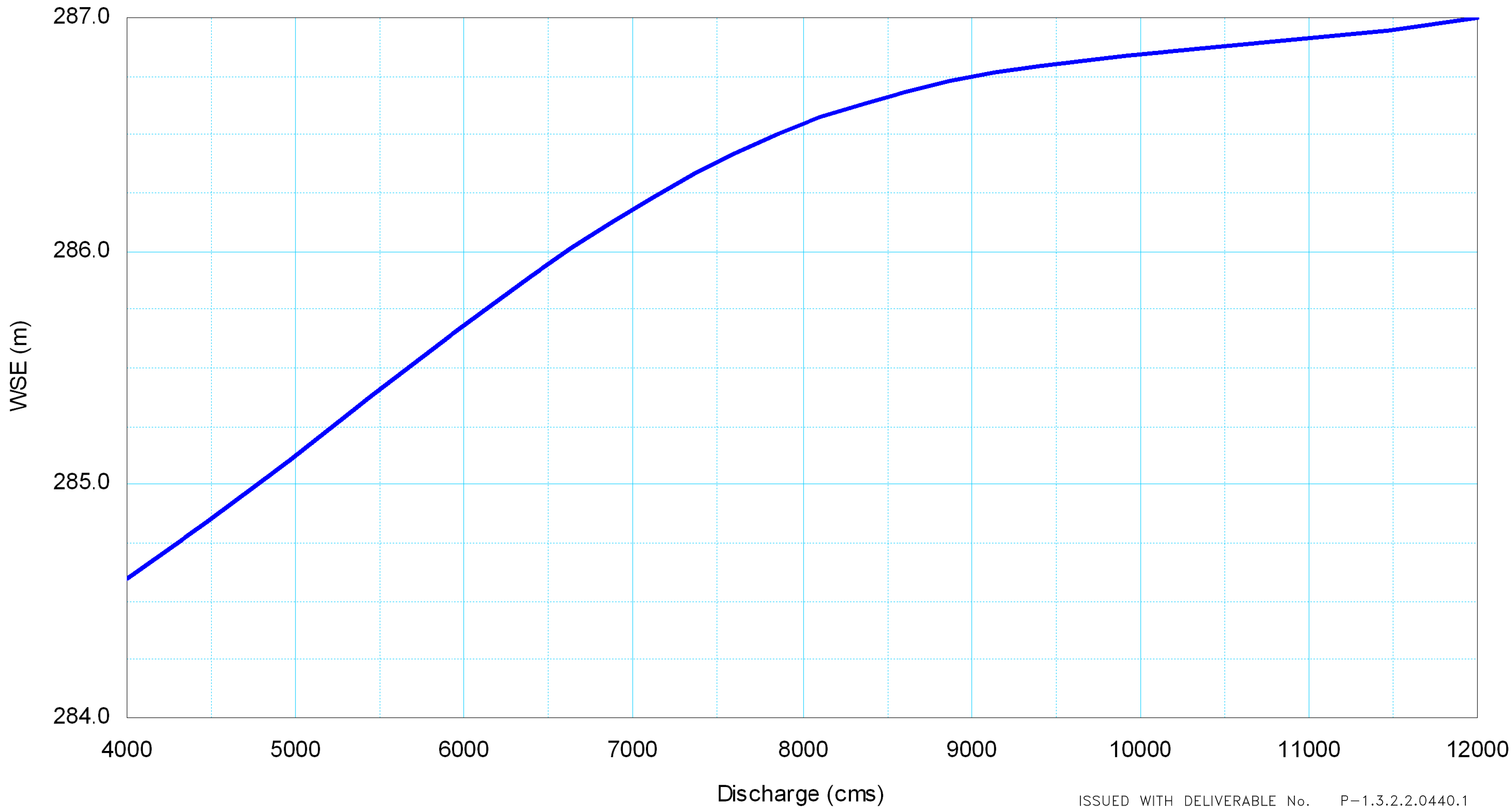
MANITOBA HYDRO

POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT

ICC/IDF
CROSS SECTION LOCATIONS AND
ADDITIONAL CROSS SECTIONS

DECEMBER 2, 2011 | FIGURE 04



Source: Acres Manitoba Ltd., 2002. "Pointe du Bois Dam Safety Hydraulic Studies Review"

ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES

Drawn: JKK
Submitted: JLG

MANITOBA HYDRO

POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT

ICC/IDF
RATING CURVE FOR
SLAVE FALLS RESERVOIR

DECEMBER 2, 2011 | FIGURE 05

FileName: P:\Projects\2010\10-0038-01\01.PhaseIV\200.Engineering\203.Drawings\Struct\1.3.2.2.0440.1\fig05_slaveratingcurve.dwg - Tab: Model   81/2"x11" (216x279)

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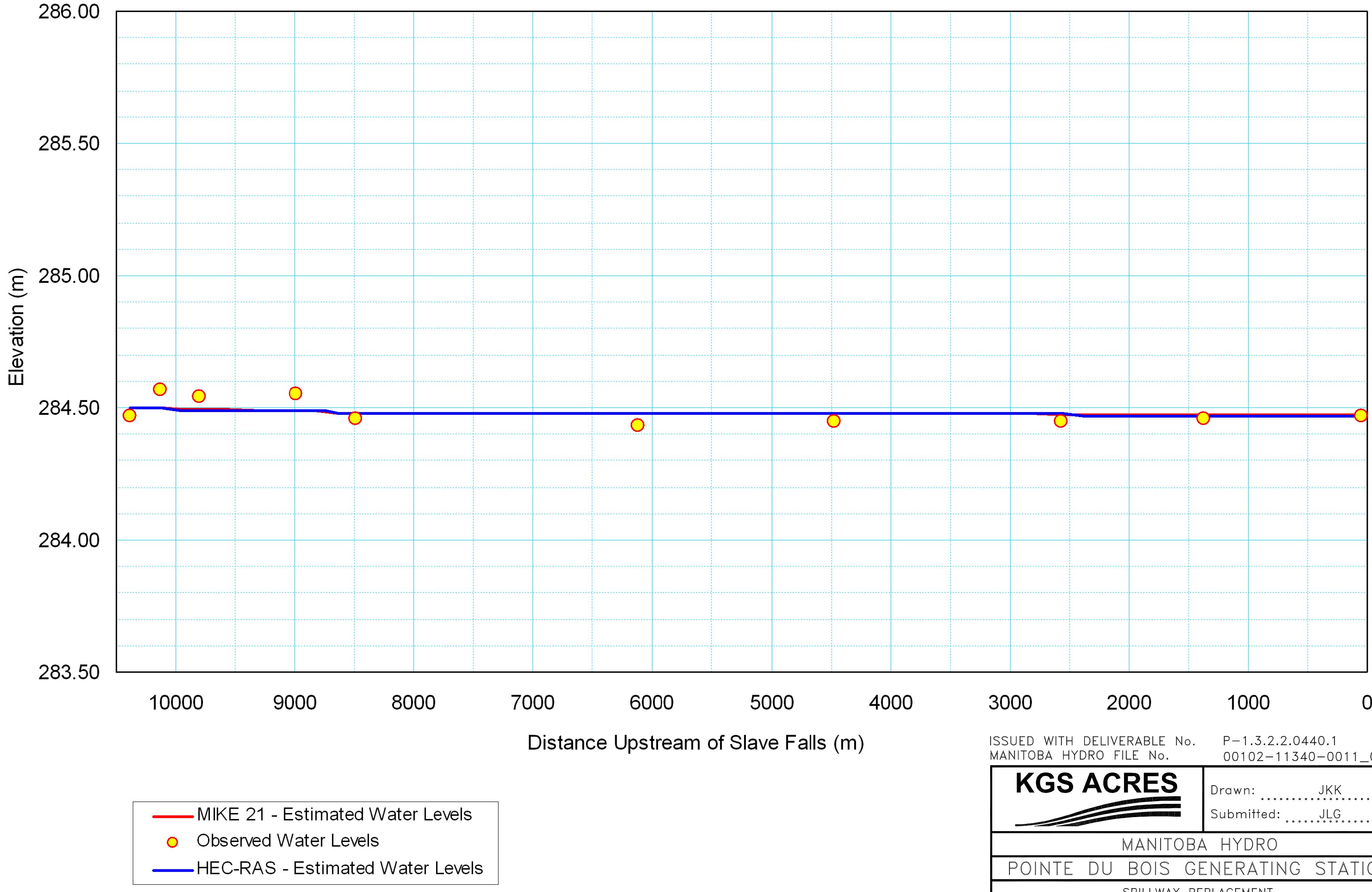


ISSUED WITH DELIVERABLE No. P–1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102–11340–0011_02

KGS ACRES

Drawn: JKK
Submitted: JLG

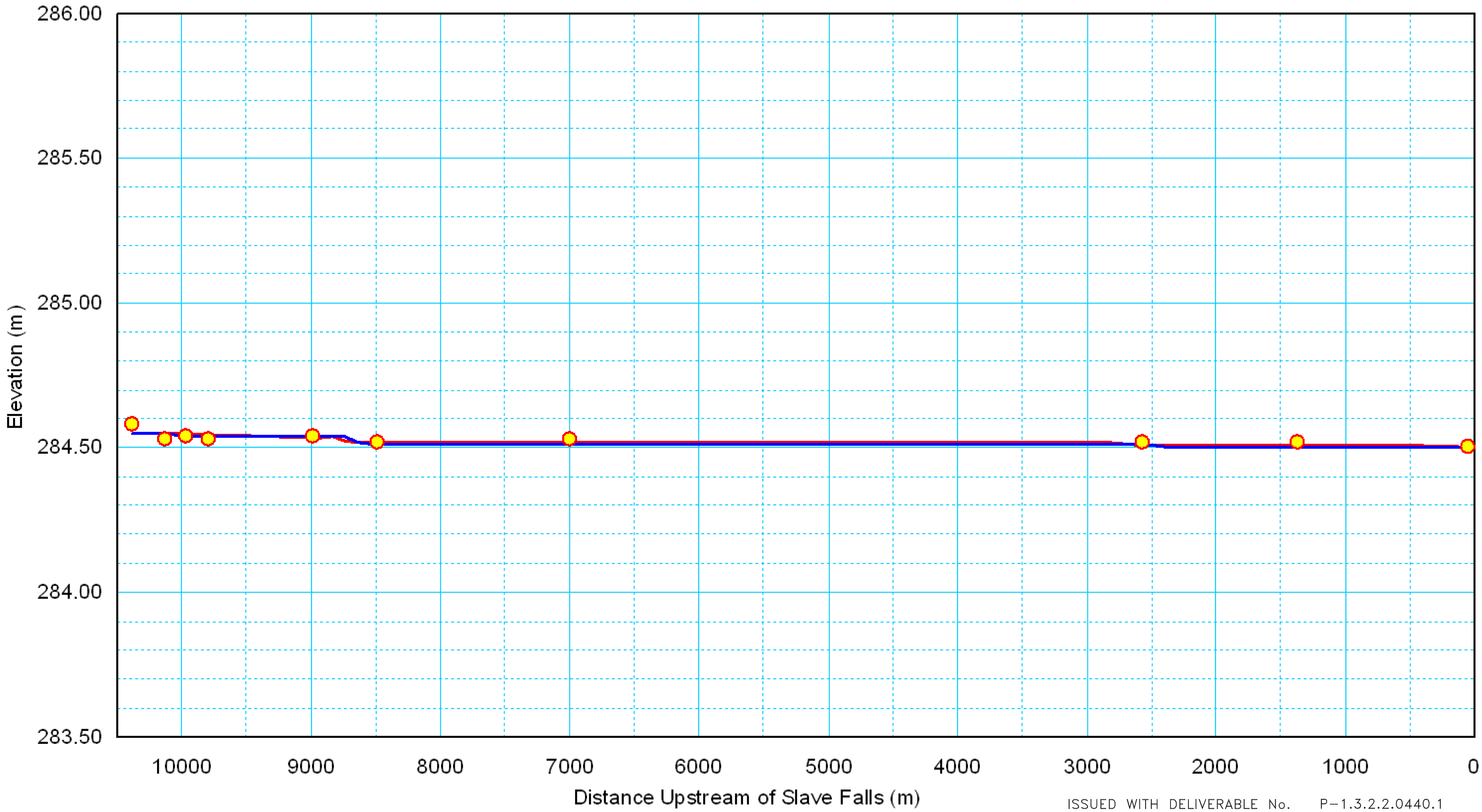
MANITOBA HYDRO

POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT

ICC/IDF
MODEL CALIBRATION
FLOW = 285.8 cms

DECEMBER 2, 2011 | FIGURE 06



MIKE 21 - Estimated Water Levels
Observed Water Levels
HEC-RAS - Estimated Water Levels

ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES

Drawn: JKK
Submitted: JLG

MANITOBA HYDRO
POINTE DU BOIS GENERATING STATION
SPILLWAY REPLACEMENT

ICC/IDF
MODEL CALIBRATION
FLOW = 387.5 cms

DECEMBER 2, 2011 | FIGURE 07

FileName: P:\Projects\2010\10-0038-01\01.PhaseIV\200.Engineering\203.Drawings\Struct\1.3.2.2.0440.1\fig07_profile2.dwg - Tab: Model
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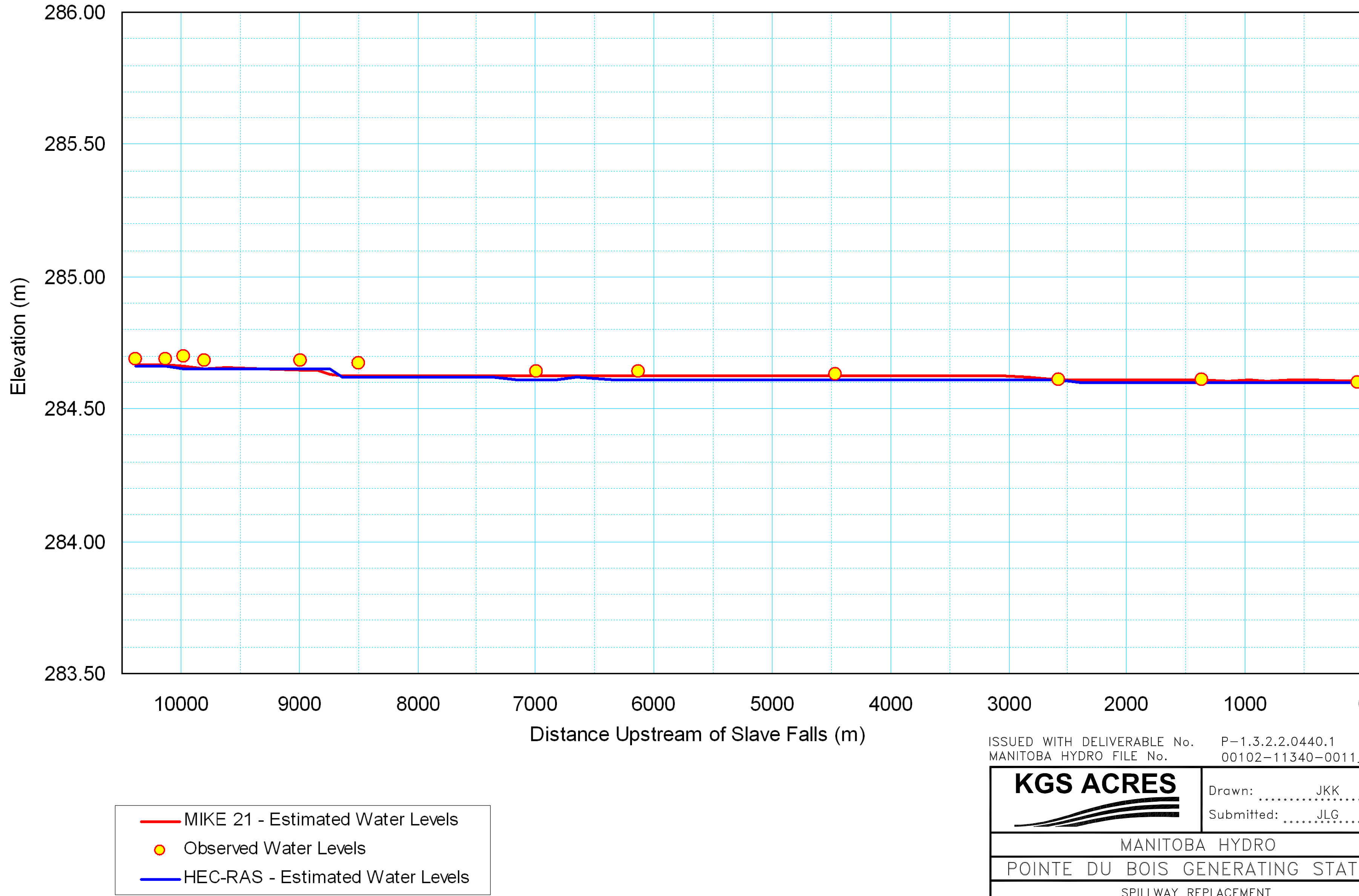

ISSUED WITH DELIVERABLE No. P–1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102–11340–0011_02

KGS ACRES

Drawn: JKK
Submitted: JLG

MANITOBA HYDRO

POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT

ICC/IDF
MODEL CALIBRATION
FLOW = 451.6 cms

DECEMBER 2, 2011 | FIGURE 08

FileName: P:\Projects\2010\10–0038–01\01.PhaseIV\200.Engineering\203.Drawings\Struct\1.3.2.2.0440.1\fig08_profile3.dwg – Tab: Model
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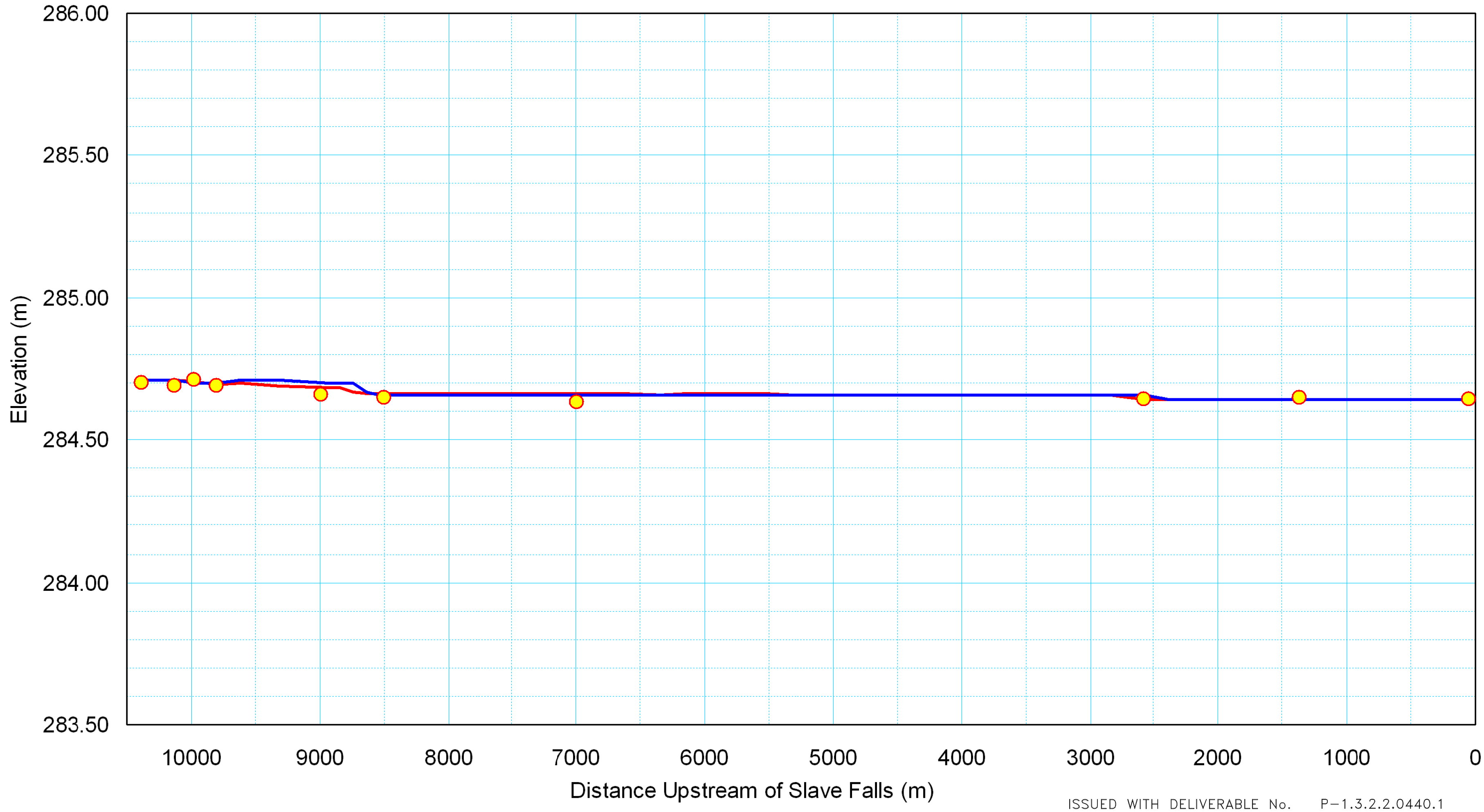


MIKE 21 - Estimated Water Levels
Observed Water Levels
HEC-RAS - Estimated Water Levels

ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES

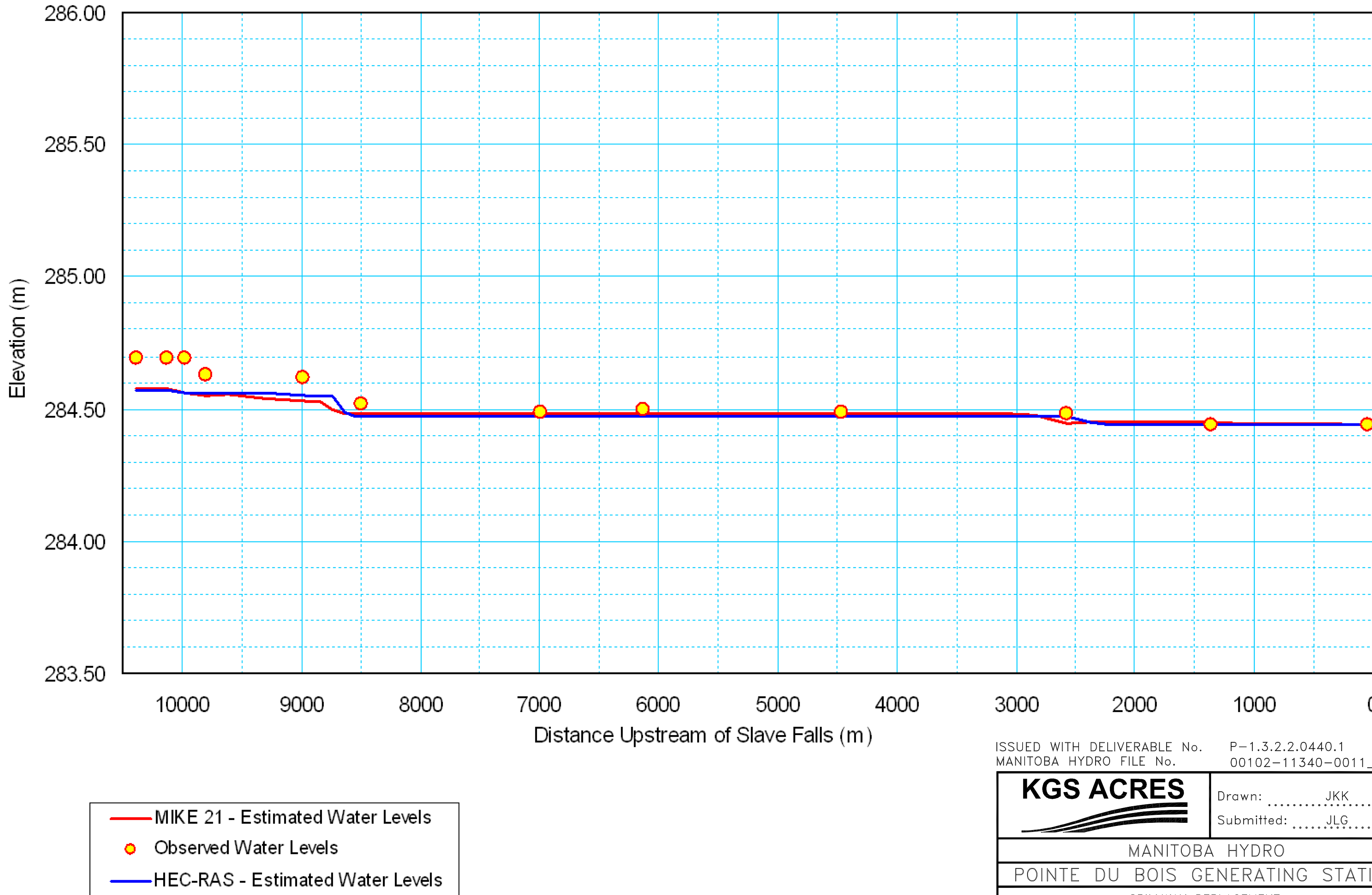
Drawn: JKK
Submitted: JLG

MANITOBA HYDRO
POINTE DU BOIS GENERATING STATION
SPILLWAY REPLACEMENT

ICC/IDF
MODEL CALIBRATION
FLOW = 504.5 cms

DECEMBER 2, 2011 | FIGURE 09

FileName: P:\Projects\2010\10-0038-01\01.PhaseIV\200.Engineering\203.Drawings\Struct\1.3.2.2.0440.1\fig09_profile4.dwg - Tab: Model 81/2"x11" (216x279)



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MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES

Drawn: JKK
Submitted: JLG

MANITOBA HYDRO

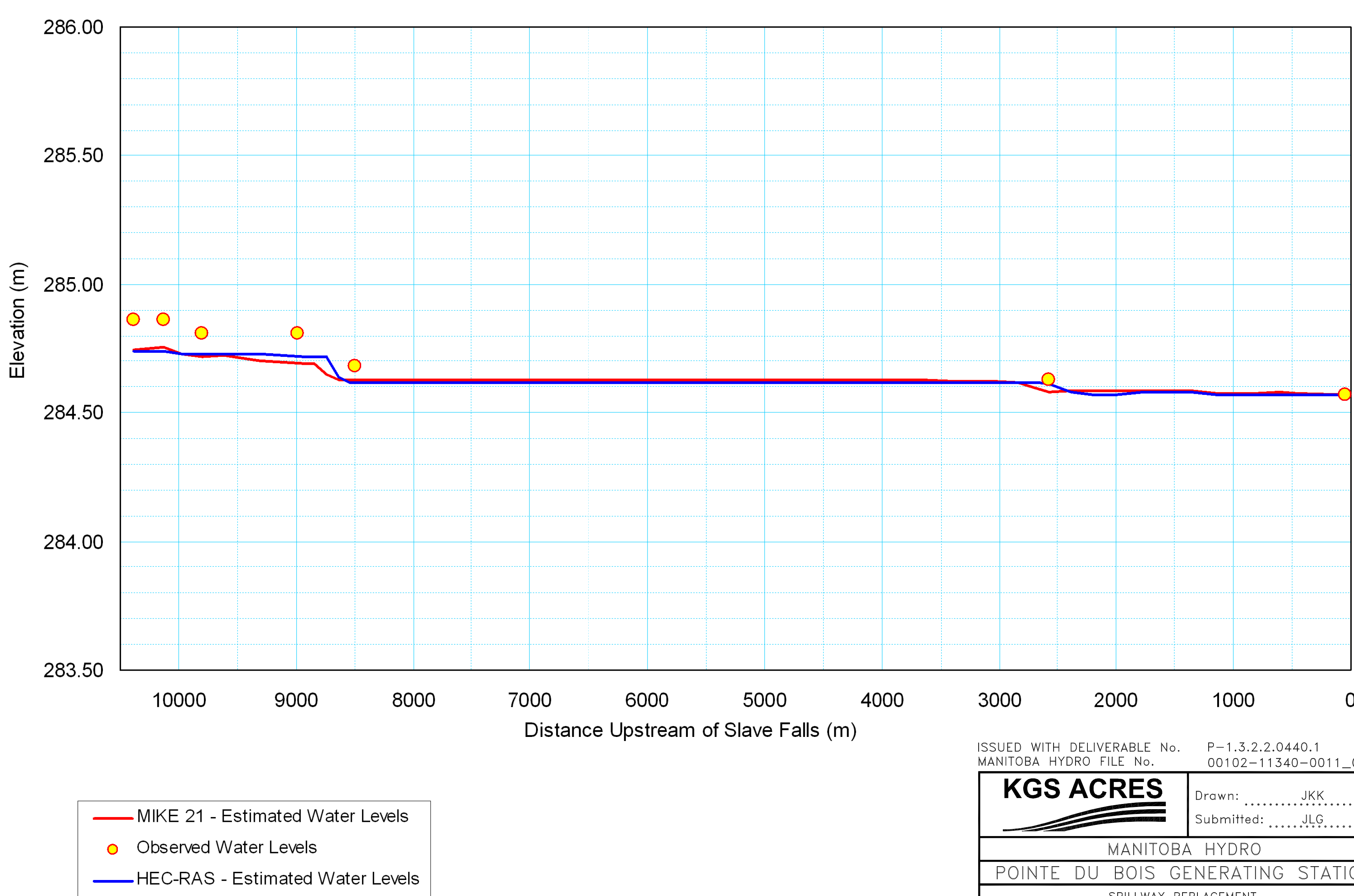
POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT

ICC/IDF
MODEL CALIBRATION
FLOW = 653.4 cms

DECEMBER 2, 2011 | FIGURE 10

FileName: P:\Projects\2010\10-0038-01\01.PhaseIV\200.Engineering\203.Drawings\Struct\1.3.2.2.0440.1\fig10_profile5.dwg - Tab: Model 81/2"x11" (216x279)



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MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES

Drawn: JKK
Submitted: JLG

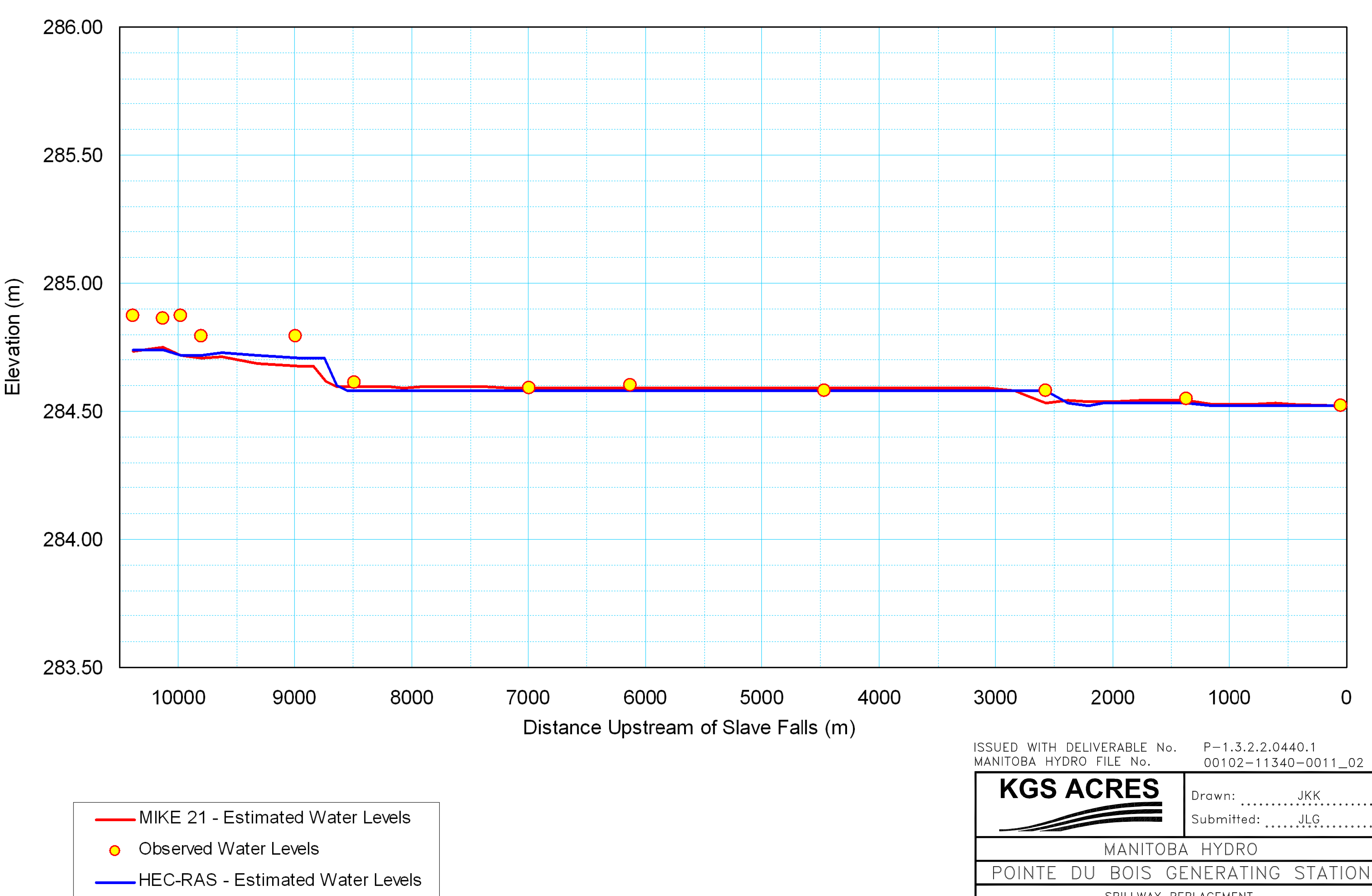
MANITOBA HYDRO

POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT

ICC/IDF
MODEL CALIBRATION
FLOW = 789 cms

DECEMBER 2, 2011 | FIGURE 11



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MANITOBA HYDRO FILE No. 00102–11340–0011_02

KGS ACRES

Drawn: JKK
Submitted: JLG

MANITOBA HYDRO
POINTE DU BOIS GENERATING STATION
SPILLWAY REPLACEMENT

ICC/IDF
MODEL CALIBRATION
FLOW = 875 cms

DECEMBER 2, 2011 | FIGURE 12

FileName: P:\Projects\2010\10–0038–01\01.PhaseIV\200.Engineering\203.Drawings\Struct\1.3.2.2.0440.1\fig12_profile7.dwg – Tab: Model
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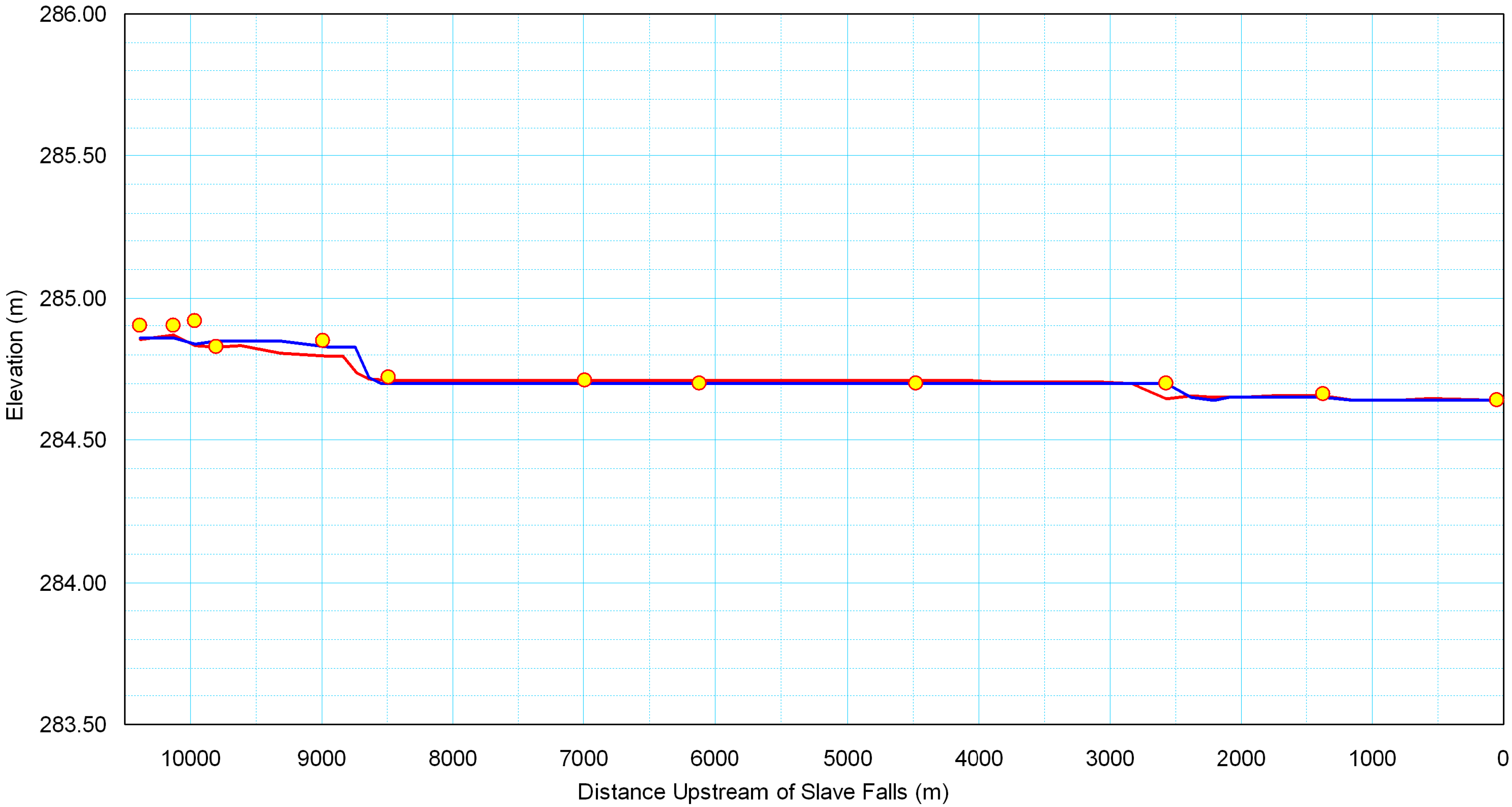


MIKE 21 - Estimated Water Levels
Observed Water Levels
HEC-RAS - Estimated Water Levels

ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

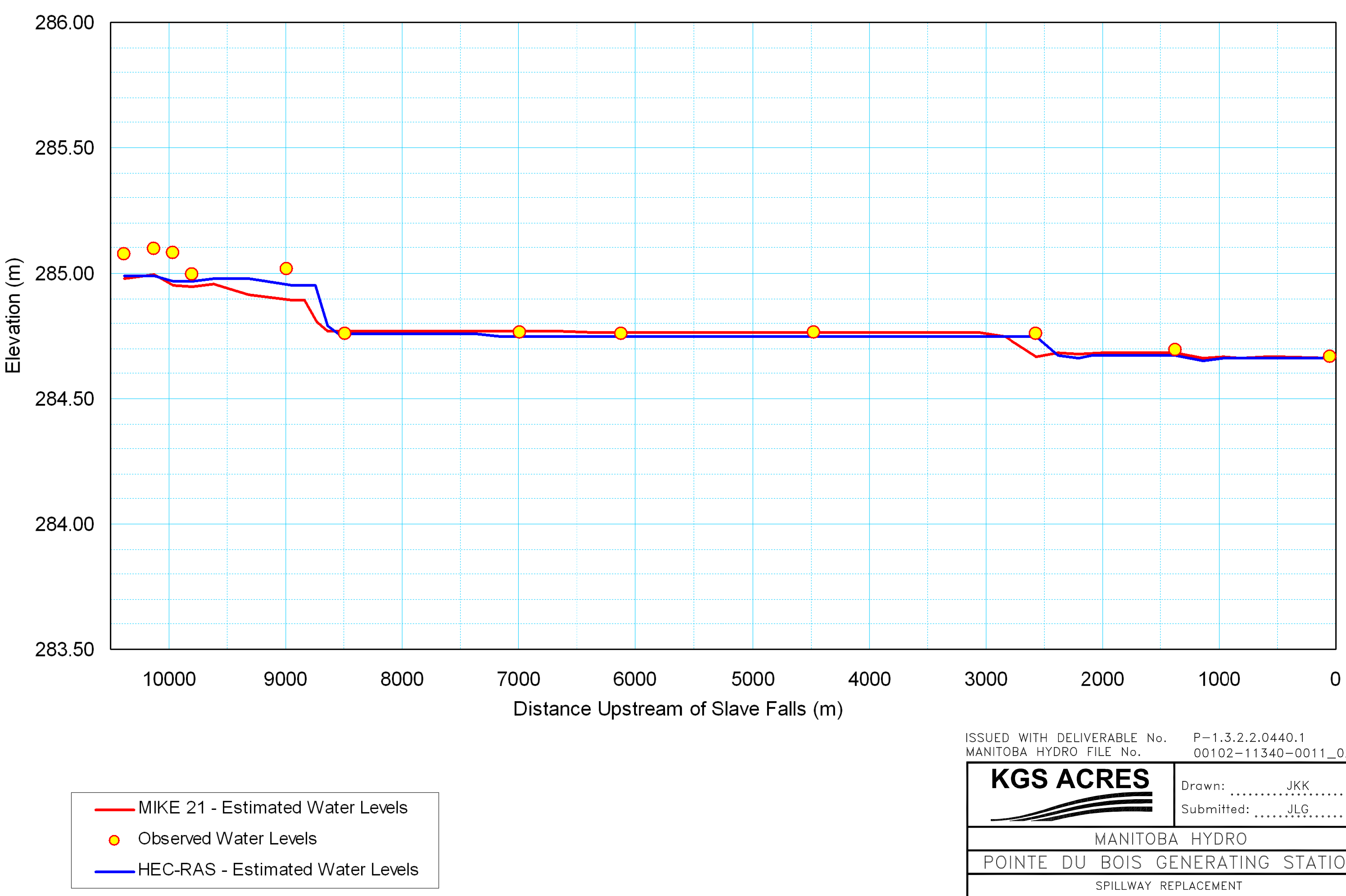
KGS ACRES

Drawn: JKK
Submitted: JLG

MANITOBA HYDRO
POINTE DU BOIS GENERATING STATION
SPILLWAY REPLACEMENT
ICC/IDF
MODEL CALIBRATION
FLOW = 912.6 cms

DECEMBER 2, 2011 | FIGURE 13

FileName: P:\Projects\2010\10-0038-01\01.PhaseIV\200.Engineering\203.Drawings\Struct\1.3.2.2.0440.1\fig13_profile8.dwg - Tab: Model 81/2"x11" (216x279)



ISSUED WITH DELIVERABLE No. P–1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102–11340–0011_02

KGS ACRES

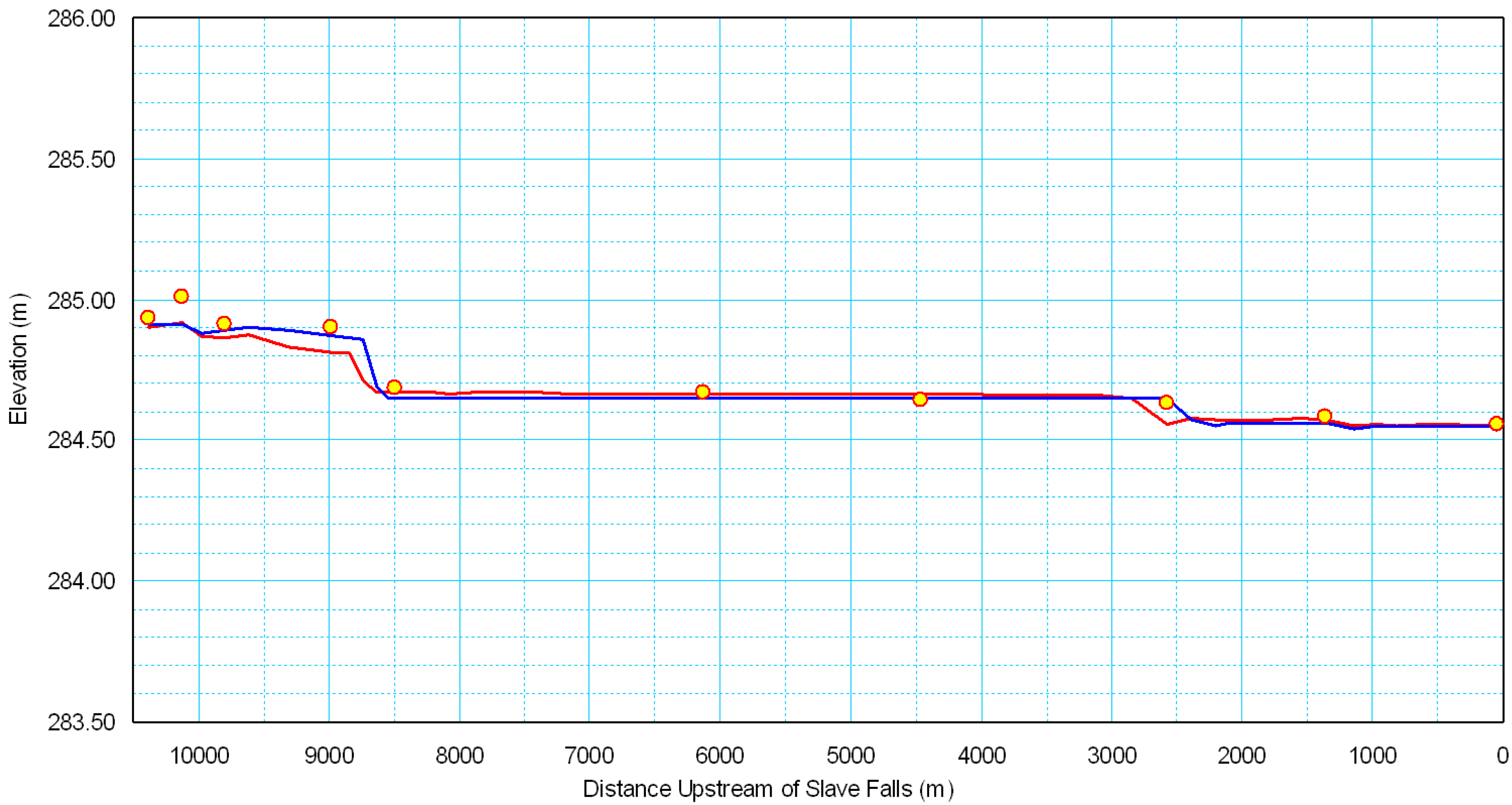
Drawn: JKK
Submitted: JLG

MANITOBA HYDRO
POINTE DU BOIS GENERATING STATION
SPILLWAY REPLACEMENT

ICC/IDF
MODEL CALIBRATION
FLOW = 1141 cms

DECEMBER 2, 2011	FIGURE 14	

FileName: P:\Projects\2010\10-0038-01\01.PhaseIV\200.Engineering\203.Drawings\Struct\1.3.2.2.0440.1\fig14_profile9.dwg – Tab: Model 81/2"x11" (216x279)



MIKE 21 - Estimated Water Levels
Observed Water Levels
HEC-RAS - Estimated Water Levels

ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES

Drawn: JKK
Submitted: JLG

MANITOBA HYDRO

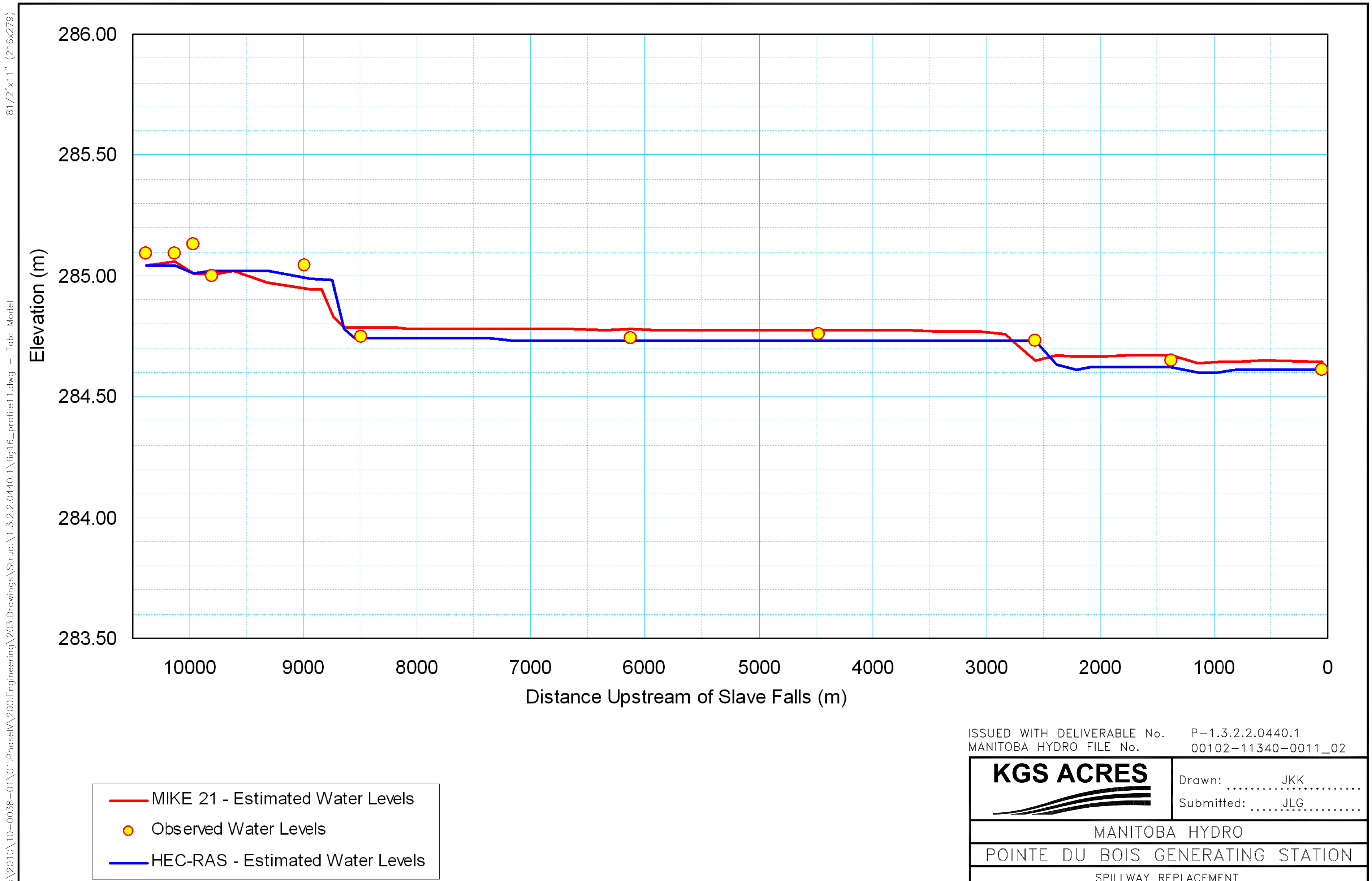
POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT

ICC/IDF
MODEL CALIBRATION
FLOW = 1163 cms

DECEMBER 2, 2011	FIGURE 15	

FileName: P:\Projects\2010\10-0038-01\01.PhaseIV\200.Engineering\203.Drawings\Struct\1.3.2.2.0440.1\fig15_profile10.dwg - Tab: Model
81/2"x11" (216x279)



ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES

Drawn: JKK
Submitted: JLG

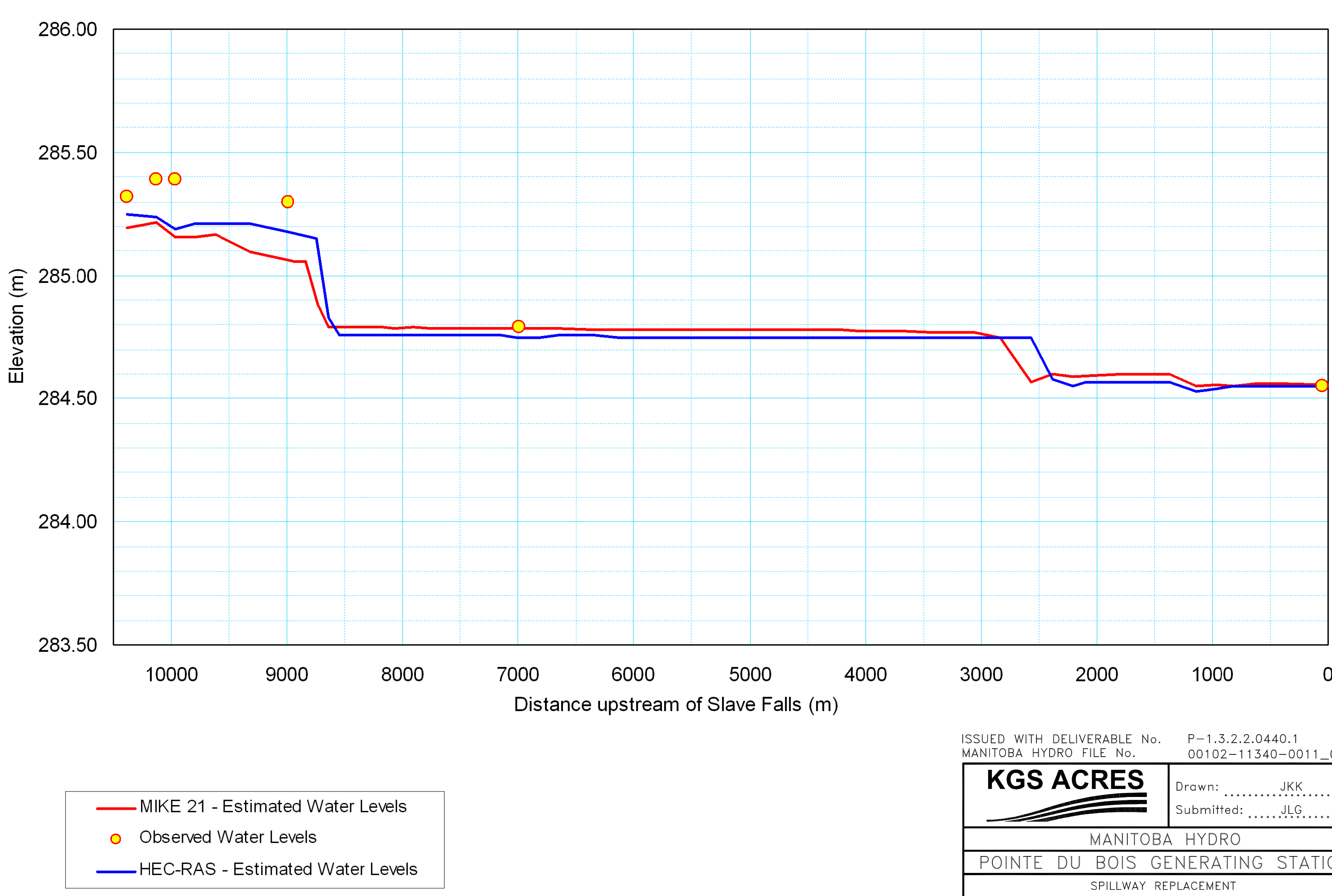
MANITOBA HYDRO

POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT

ICC/IDF
MODEL CALIBRATION
FLOW = 1295 cms

DECEMBER 2, 2011 | FIGURE 16



FileName: P:\Projects\2010\10-0038-01\01.PhaseIV\200.Engineering\203.Drawings\Struct\1.3.2.2.0440.1\fig17_profile12.dwg - Tab: Model 81/2"x11" (216x279)

ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

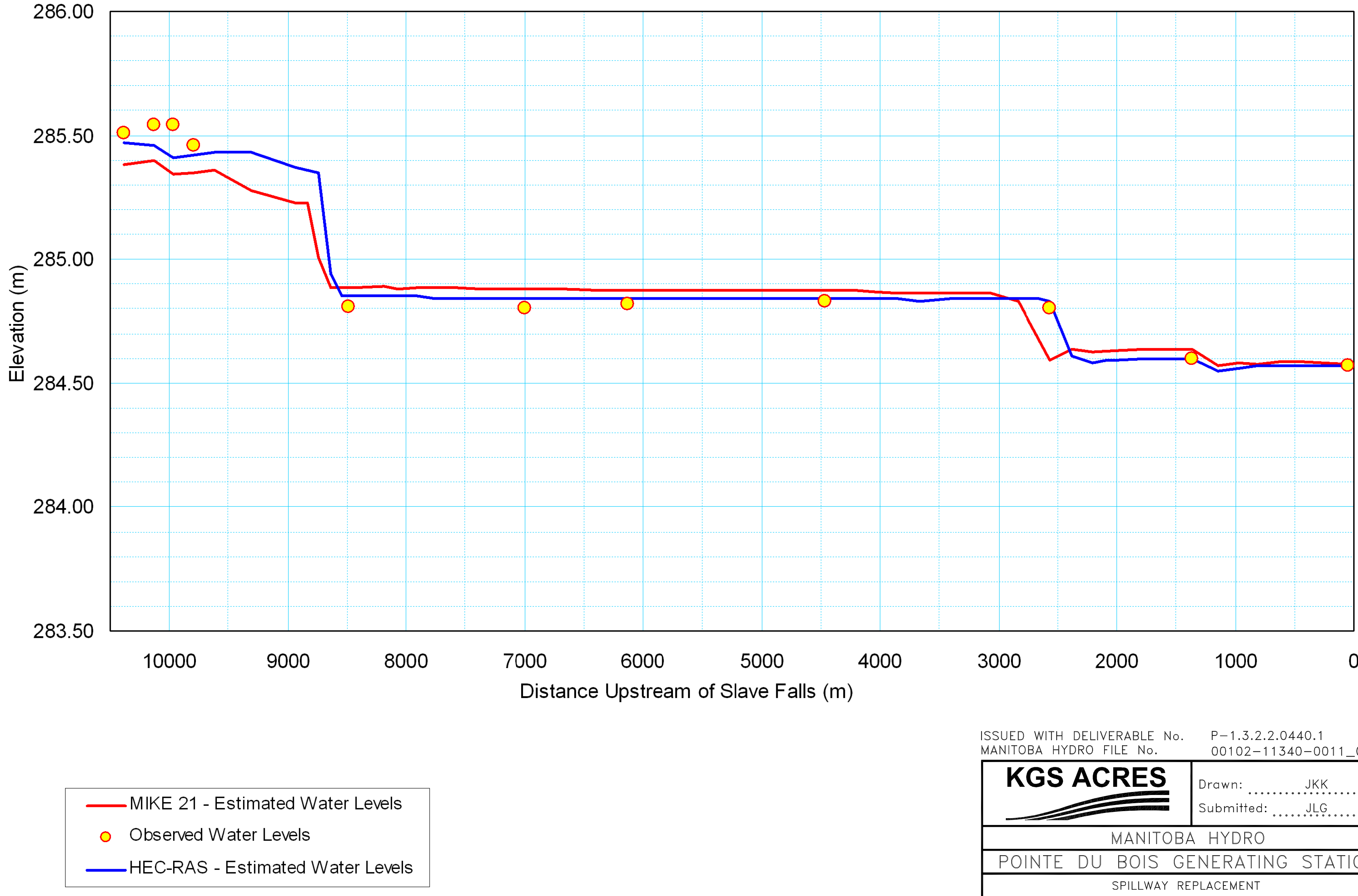
KGS ACRES

Drawn: JKK
Submitted: JLG

MANITOBA HYDRO
POINTE DU BOIS GENERATING STATION
SPILLWAY REPLACEMENT

ICC/IDF
MODEL CALIBRATION
FLOW = 1655 cms

DECEMBER 2, 2011 | FIGURE 17



ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES

Drawn: JKK
Submitted: JLG

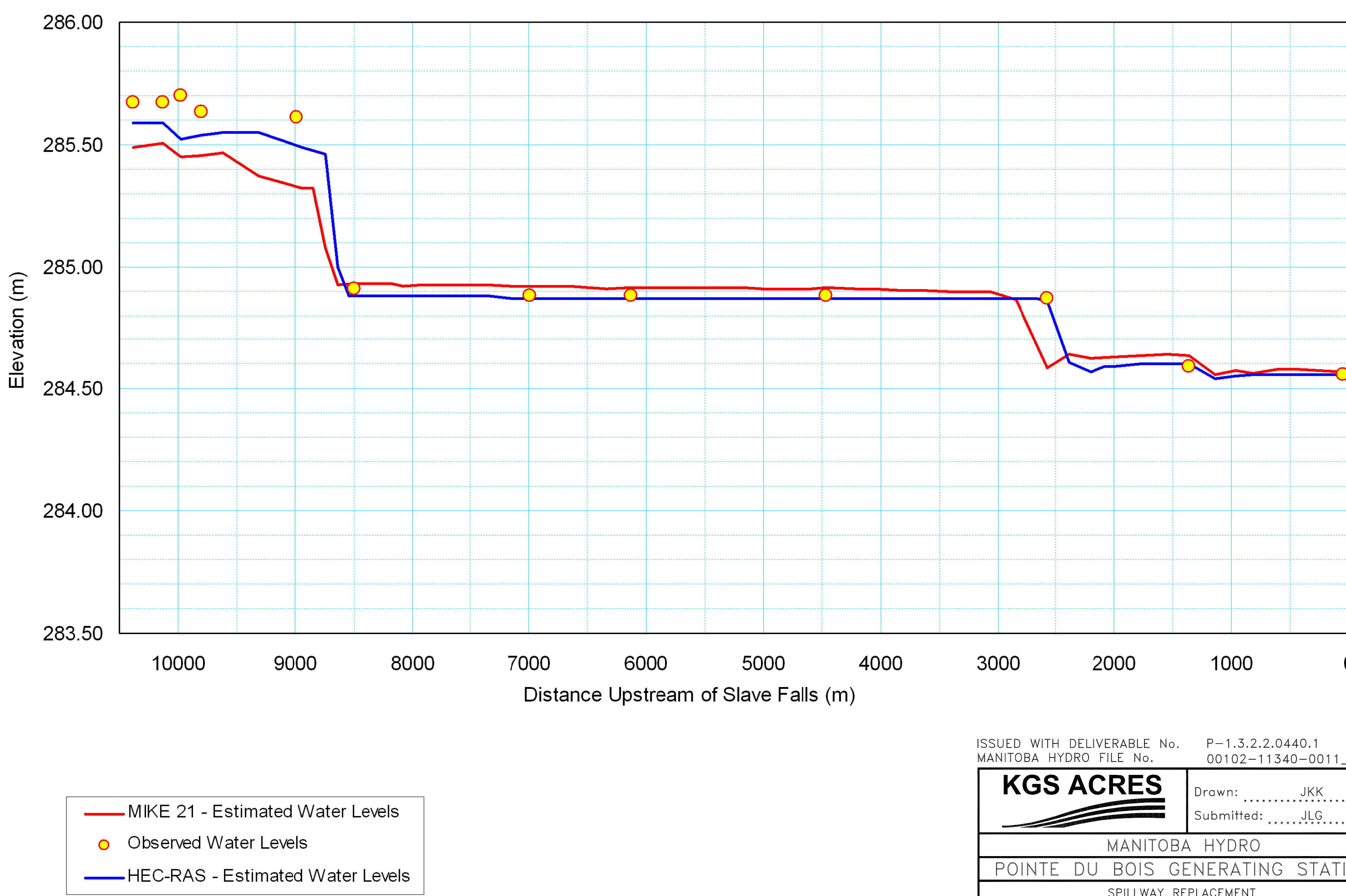
MANITOBA HYDRO

POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT

ICC/IDF
MODEL CALIBRATION
FLOW = 1910 cms

DECEMBER 2, 2011 | FIGURE 18



ISSUED WITH DELIVERABLE No. P–1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102–11340–0011_02

KGS ACRES

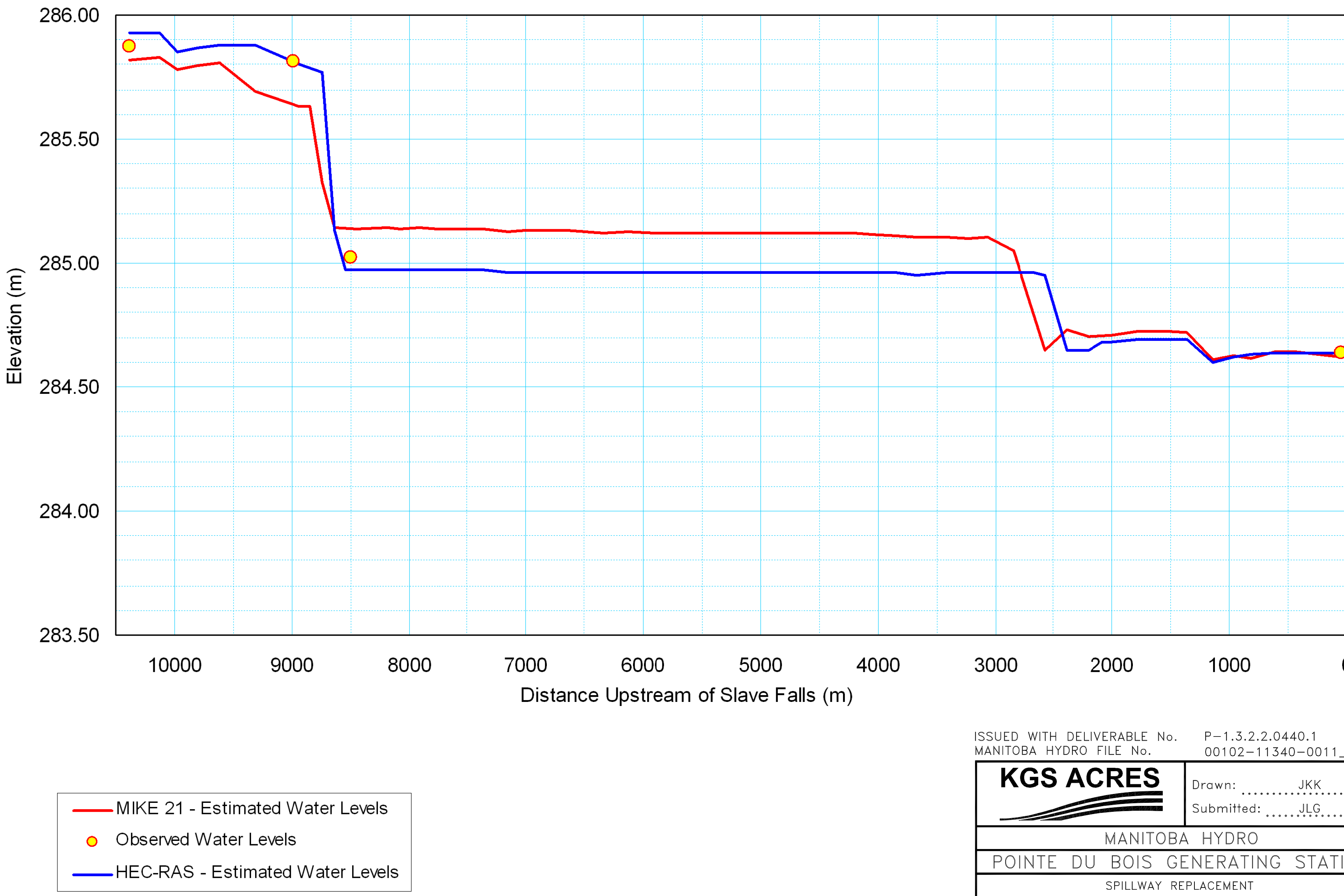
Drawn: JKK
Submitted: JLG

MANITOBA HYDRO
POINTE DU BOIS GENERATING STATION
SPILLWAY REPLACEMENT

ICC/IDF
MODEL CALIBRATION
FLOW = 2061 cms

DECEMBER 2, 2011 | FIGURE 19

FileName: P:\Projects\2010\10-0038-01\01.PhaseIV\200.Engineering\203.Drawings\Struct\1.3.2.2.0440.1\fig19_profile14.dwg – Tab: Model 81/2"x11" (216x279)



ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES

Drawn: JKK
Submitted: JLG

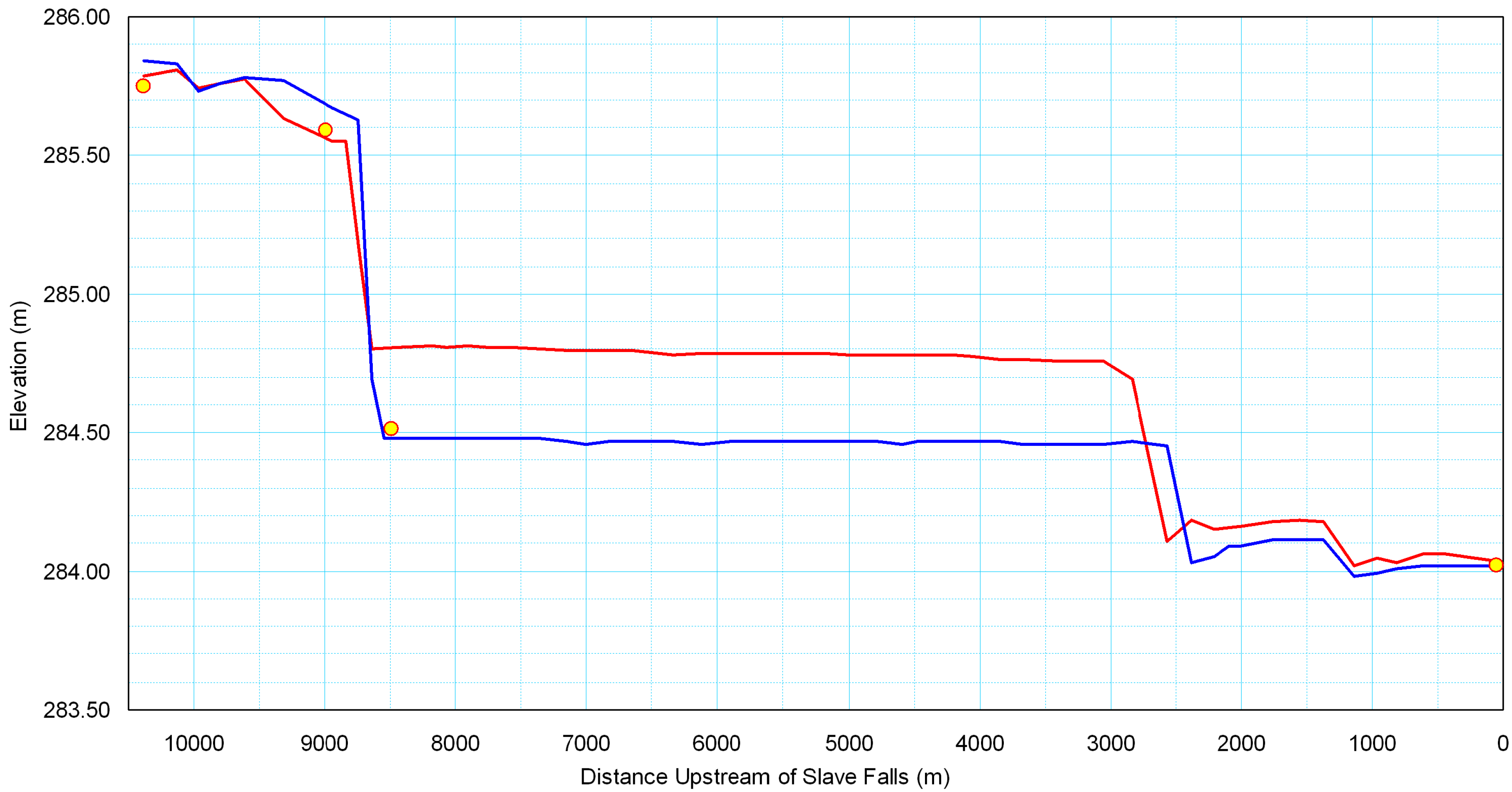
MANITOBA HYDRO

POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT

ICC/IDF
MODEL CALIBRATION
FLOW = 2508 cms

DECEMBER 2, 2011 | FIGURE 20



MIKE 21 - Estimated Water Levels
Observed Water Levels
HEC-RAS - Estimated Water Levels

ISSUED WITH DELIVERABLE No. P–1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102–11340–0011_02

KGS ACRES

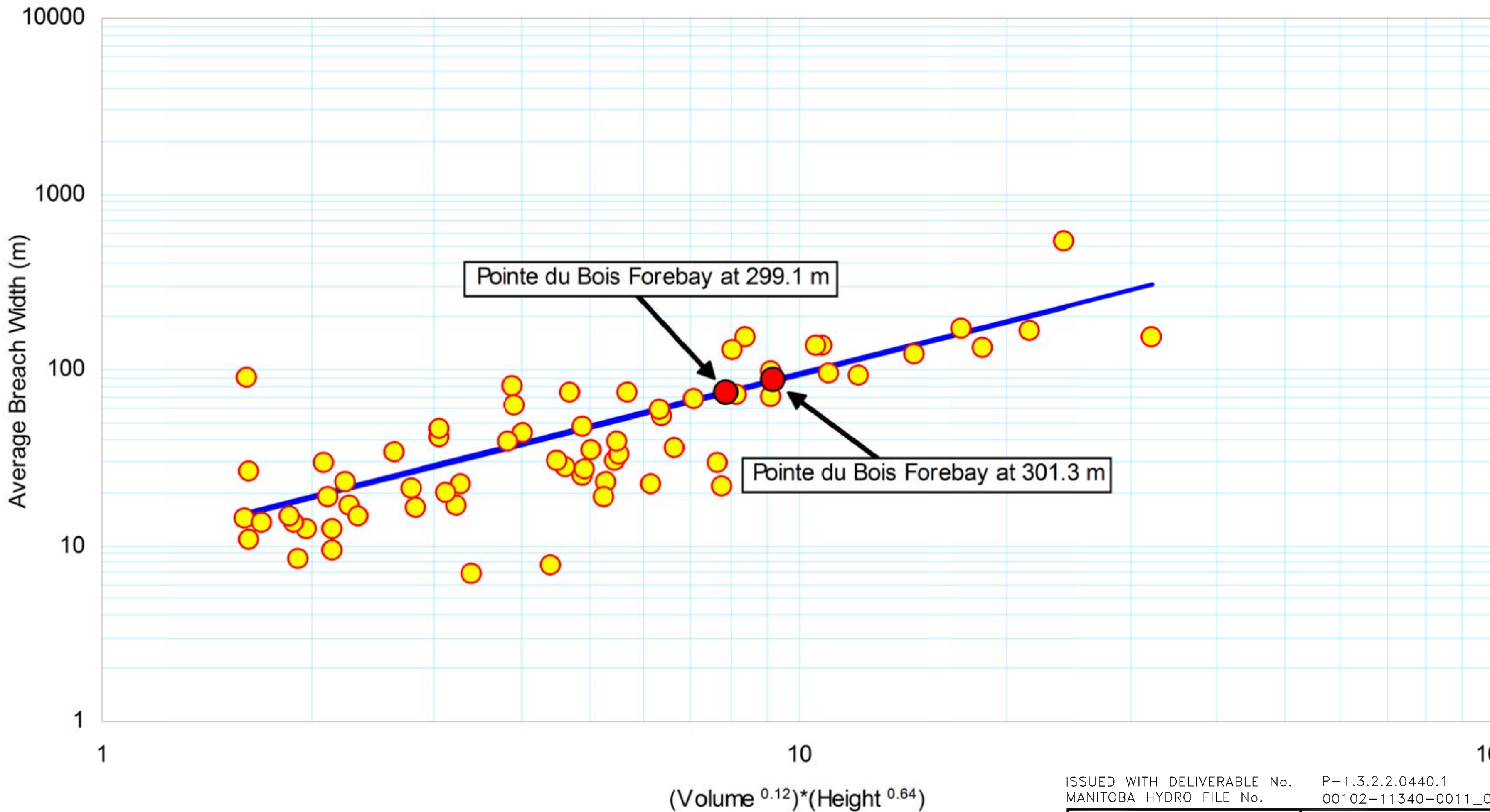
Drawn: JKK
Submitted: JLG

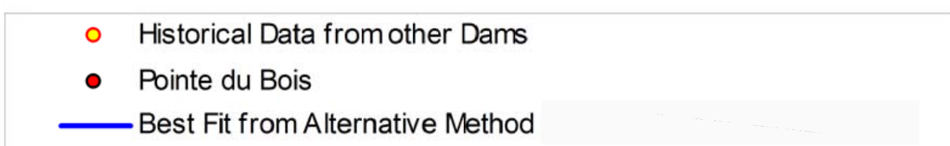
MANITOBA HYDRO
POINTE DU BOIS GENERATING STATION
SPILLWAY REPLACEMENT

ICC/IDF
MODEL CALIBRATION
FLOW = 2763 cms

DECEMBER 2, 2011 | FIGURE 21

FileName: P:\Projects\2010\10-0038-01\01.PhaseIV\200.Engineering\203.Drawings\Struct\1.3.2.2.0440.1\fig21_profile16.dwg – Tab: Model
81/2"x11" (216x279)





ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES

Drawn: JKK
Submitted: JLG

MANITOBA HYDRO

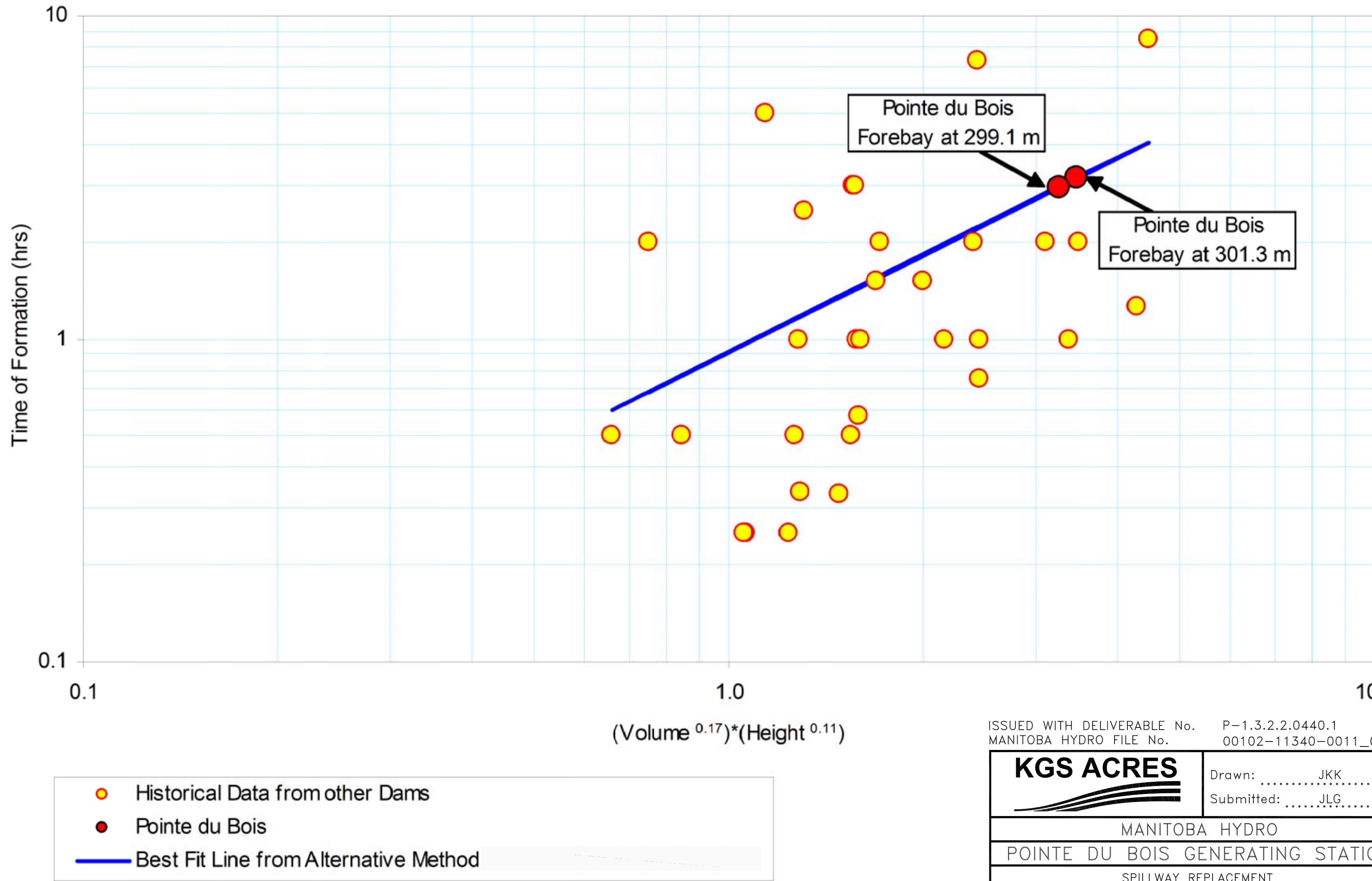
POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT

ICC/IDF
SELECTION OF BREACH PARAMETERS
AVERAGE BREACH WIDTH

DECEMBER 2, 2011 | FIGURE 22

FileName: P:\Projects\2010\10-0038-01\01.PhaseIV\200.Engineering\203.Drawings\Struct\1.3.2.2.0440.1\fig22_breachwidth.dwg – Tab: Model 81/2"x11" (216x279)



ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES

Drawn: JKK
Submitted: JLG

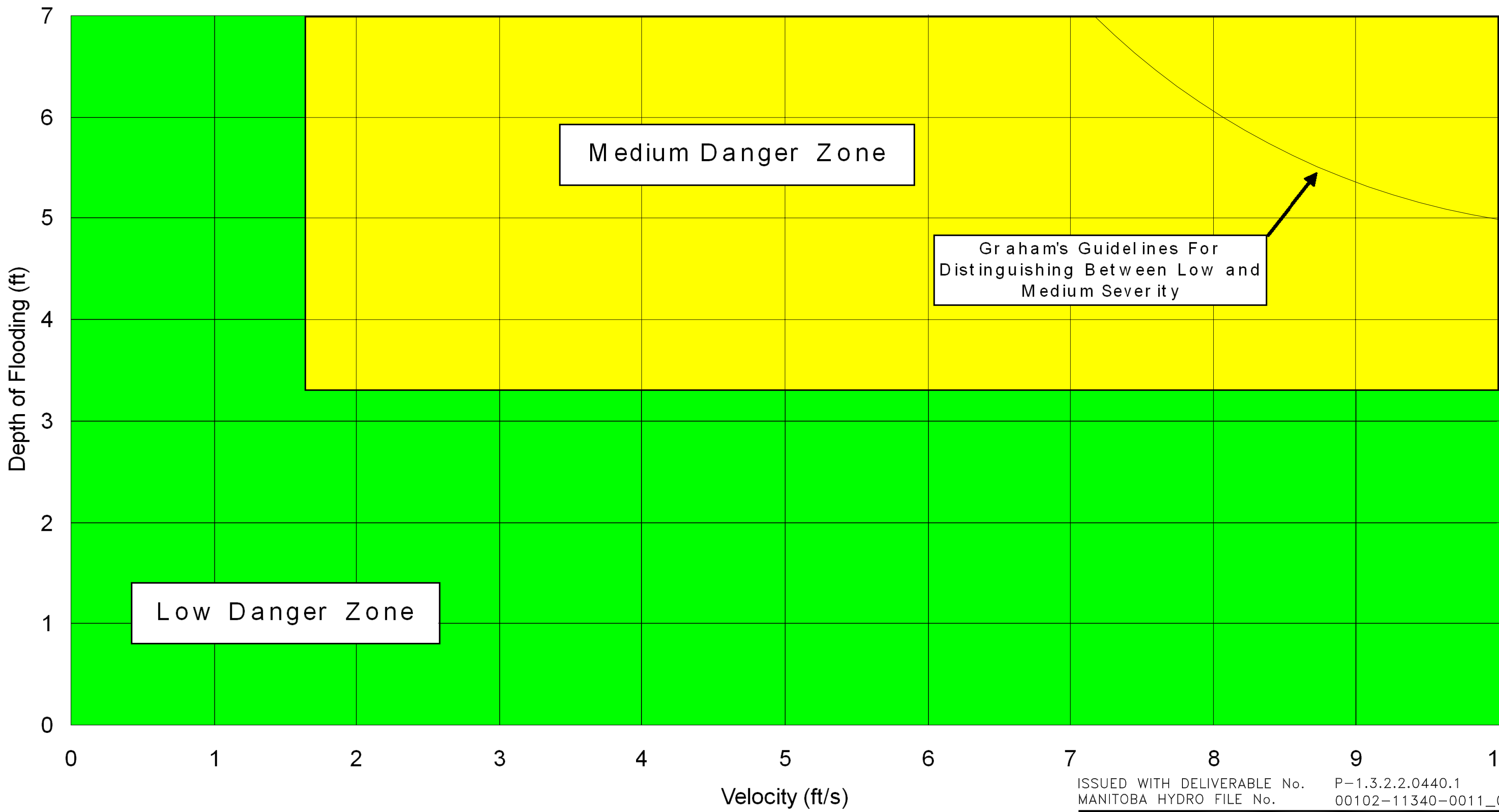
MANITOBA HYDRO

POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT

ICC/IDF
SELECTION OF BREACH PARAMETERS
TIME OF FORMATION

DECEMBER 2, 2011 | FIGURE 23



ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

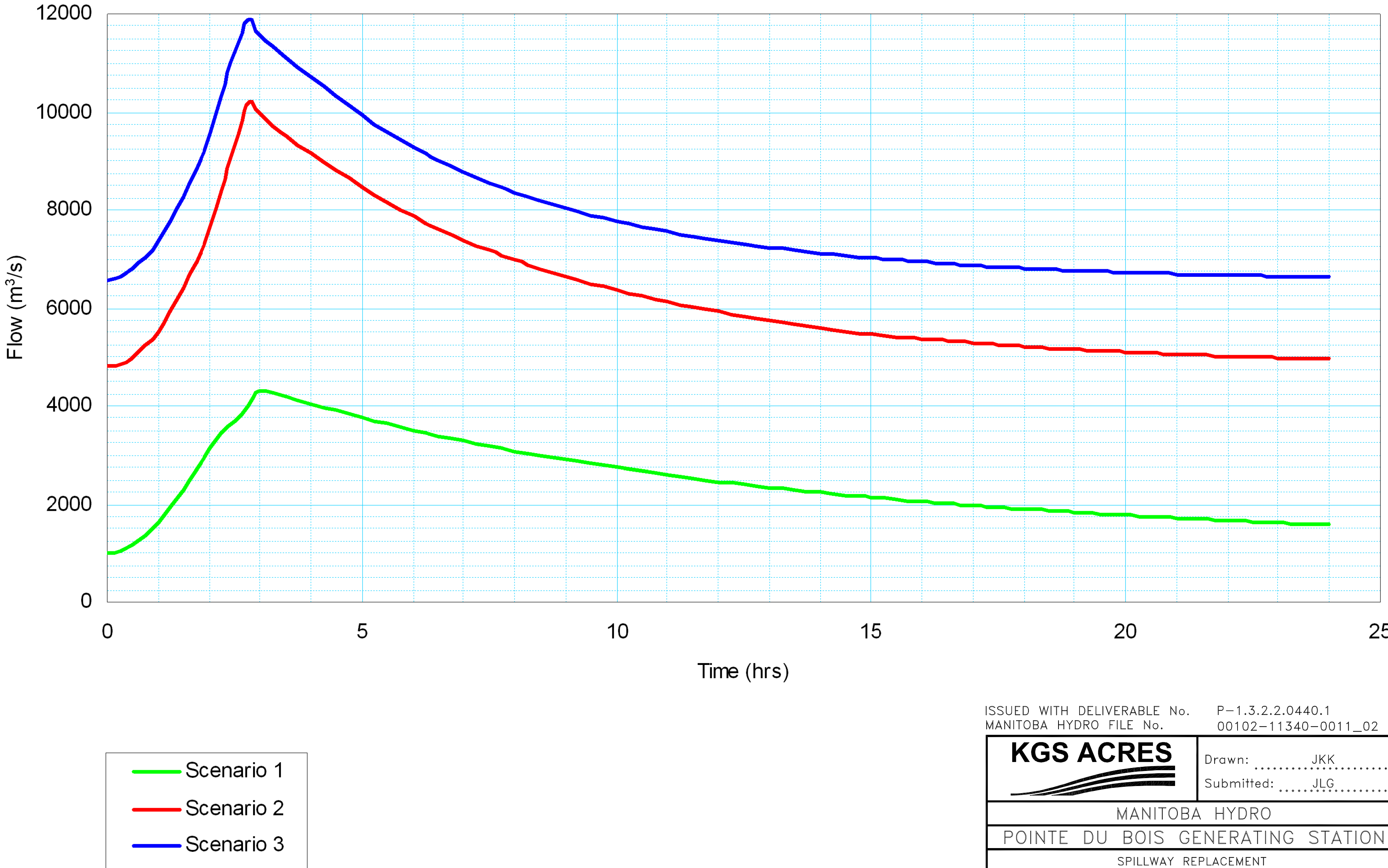
KGS ACRES

Drawn: JKK
Submitted: JLG

MANITOBA HYDRO
POINTE DU BOIS GENERATING STATION
SPILLWAY REPLACEMENT

ICC/IDF
SEVERITY RISK FOR BUILDINGS
ADOPTED VS. GRAHAM'S GUIDELINES

DECEMBER 2, 2011 | FIGURE 24



ISSUED WITH DELIVERABLE No. P–1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102–11340–0011_02

KGS ACRES

Drawn: JKK
Submitted: JLG

MANITOBA HYDRO

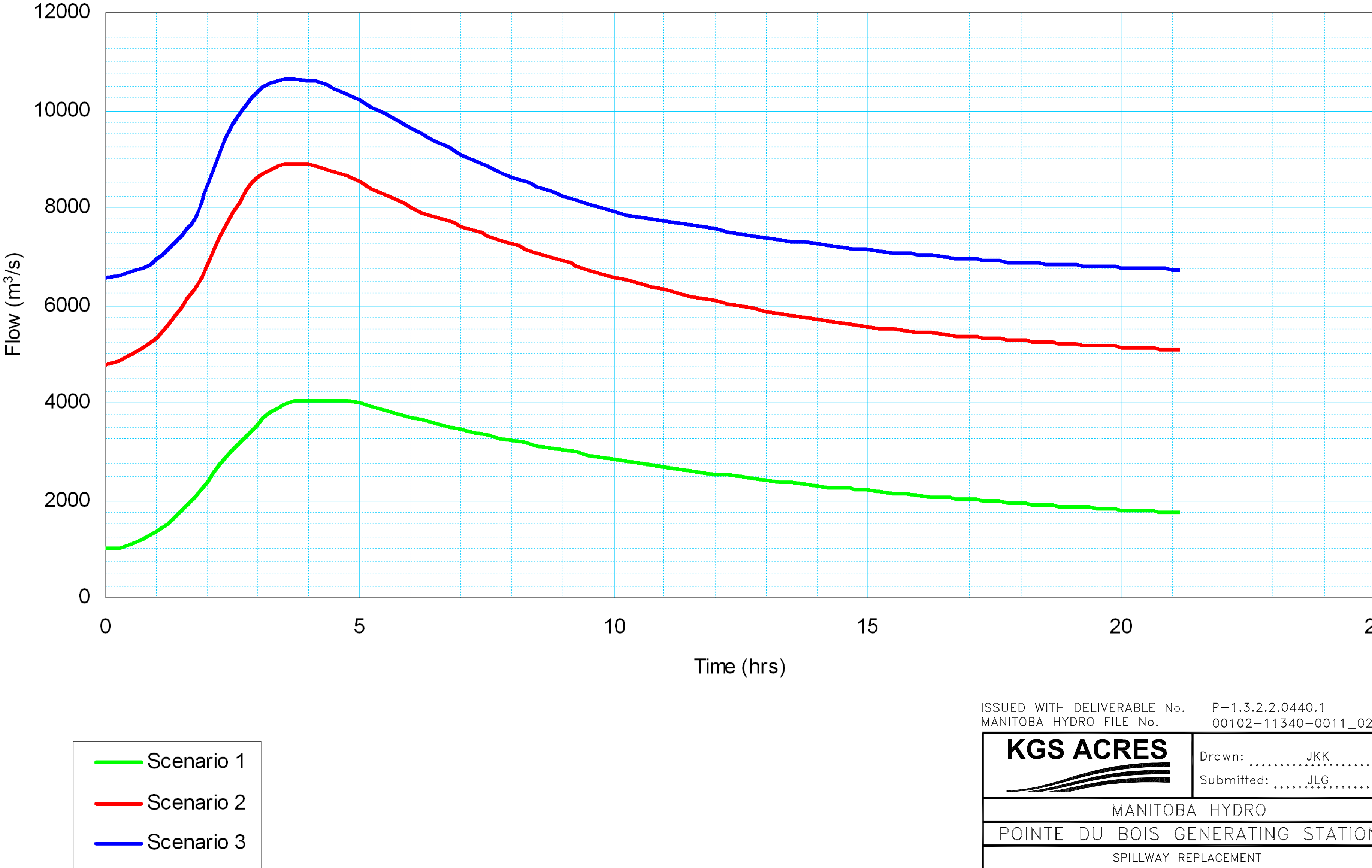
POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT

ICC/IDF
DISCHARGE HYDROGRAPHS
POINTE DU BOIS DAM

DECEMBER 2, 2011 | FIGURE 25

FileName: P:\Projects\2010\10–0038–01\01.PhaseIV\200.Engineering\203.Drawings\Struct\1.3.2.2.0440.1\fig25_pdbhydrographs.dwg – Tab: Model
8 1/2"x11" (216x279)



ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES

Drawn: JKK
Submitted: JLG

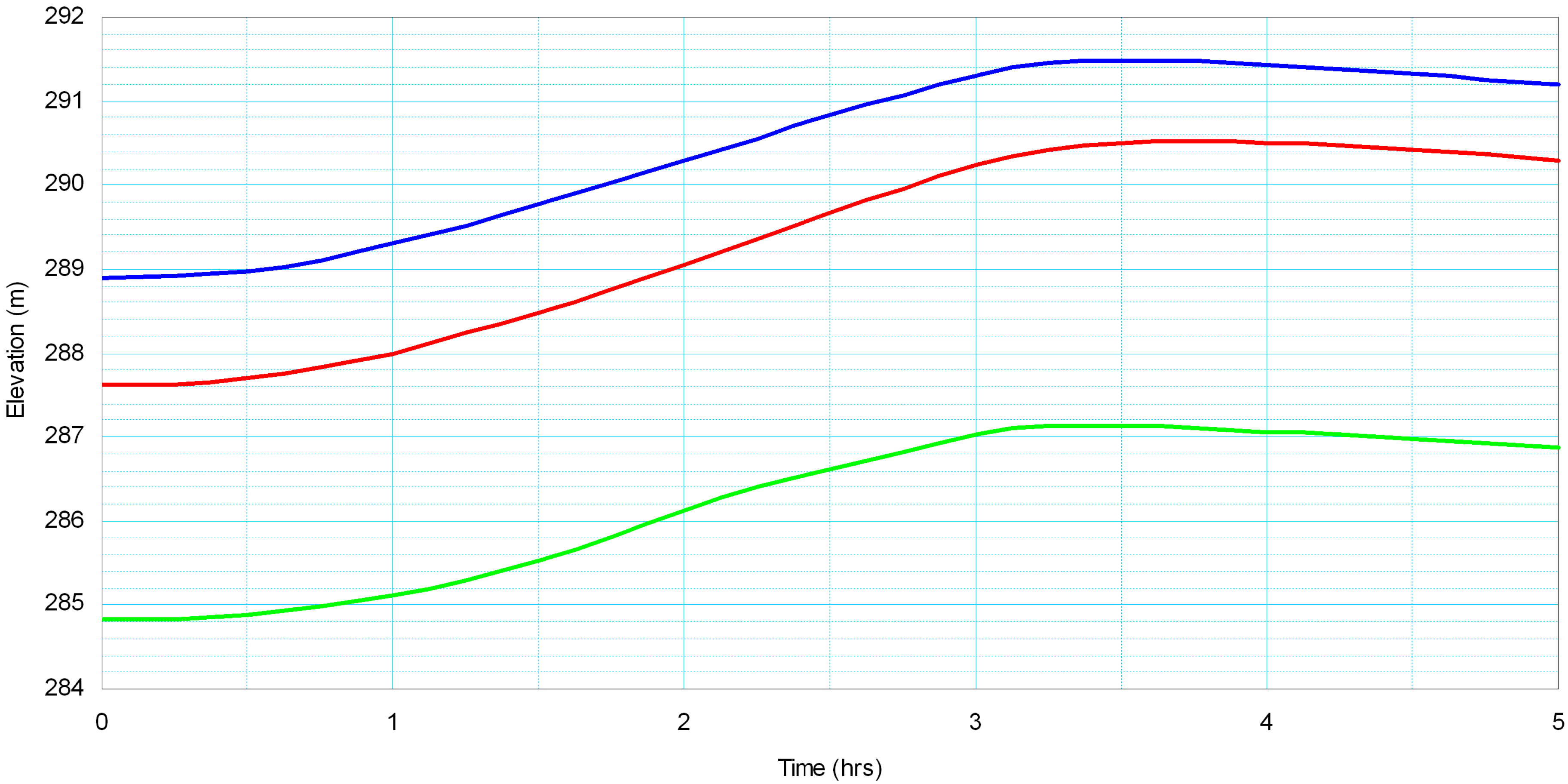
MANITOBA HYDRO

POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT

ICC/IDF
DISCHARGE HYDROGRAPHS
SLAVE FALLS DAM

DECEMBER 2, 2011 | FIGURE 26



ISSUED WITH DELIVERABLE No. P–1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102–11340–0011_02

KGS ACRES

Drawn: JKK
Submitted: JLG

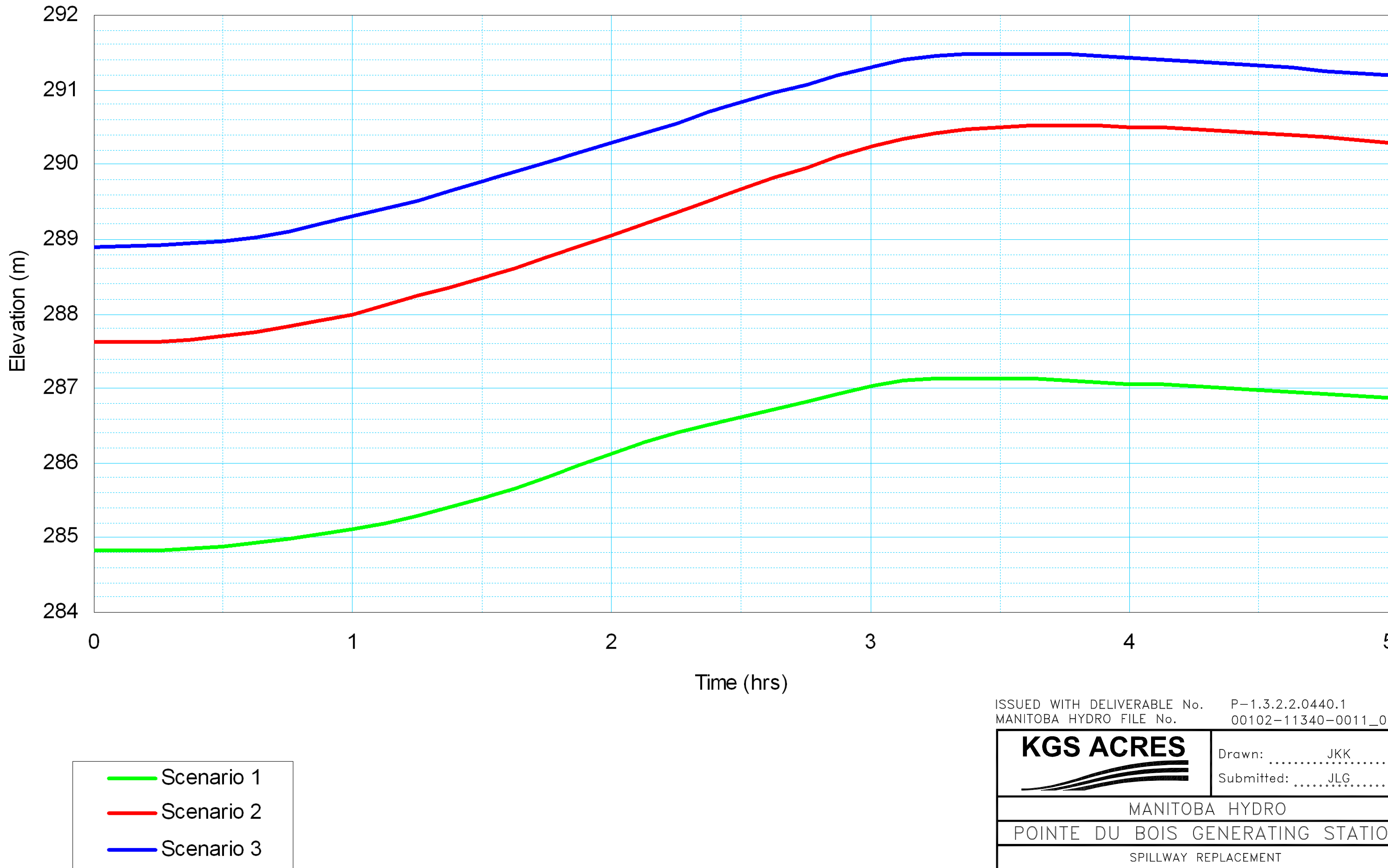
MANITOBA HYDRO

POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT

ICC/IDF
STAGE–TIME CURVES
POINTE DU BOIS TAILRACE

DECEMBER 2, 2011 | FIGURE 27



ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES

Drawn: JKK
Submitted: JLG

MANITOBA HYDRO

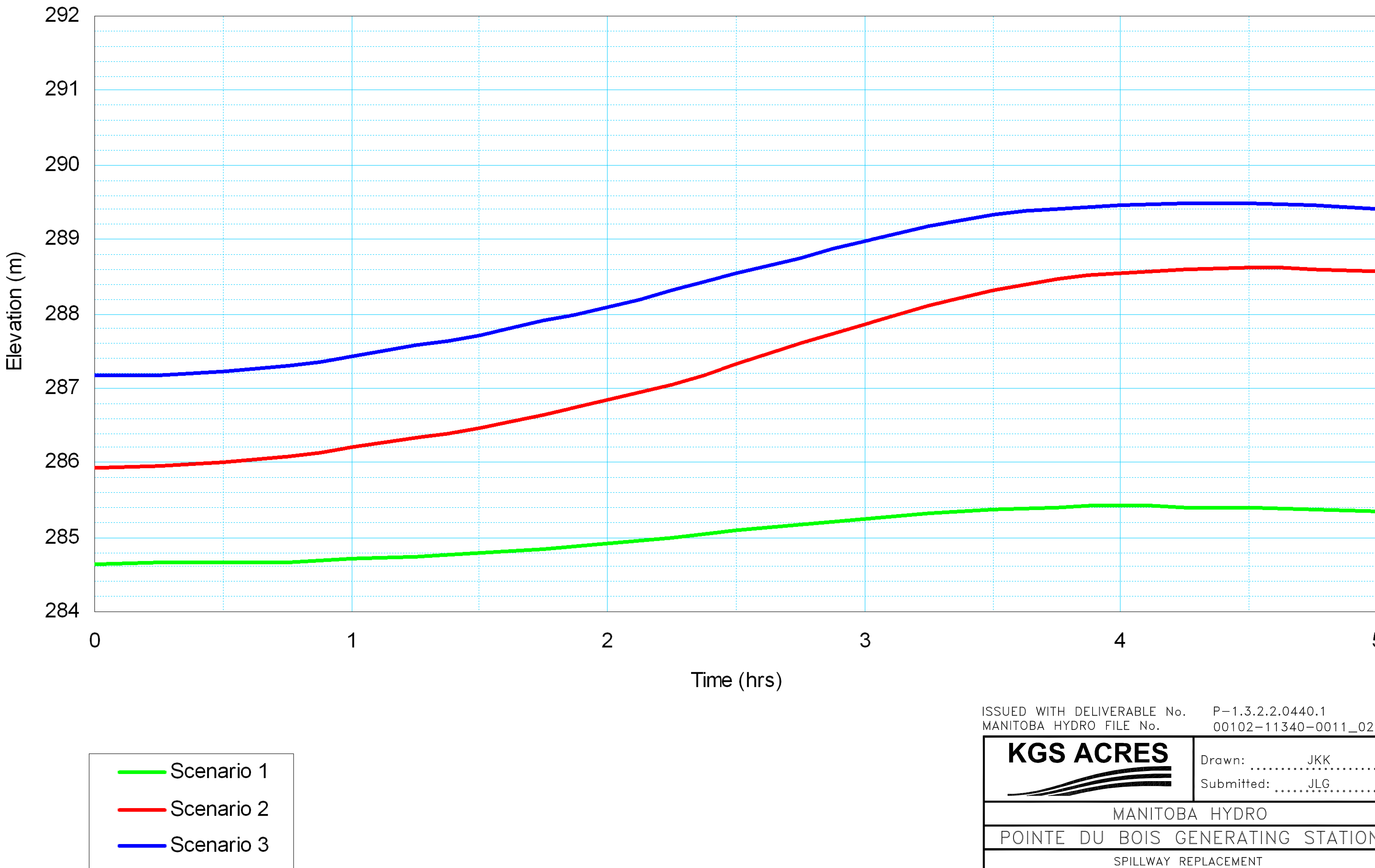
POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT

ICC/IDF
STAGE-TIME CURVES
JUST U/S OF 8 FOOT FALLS

DECEMBER 2, 2011 | FIGURE 28

FileName: P:\Projects\2010\10-0038-01\01.PhaseIV\200.Engineering\203.Drawings\Struct\1.3.2.2.0440.1\fig28_stgtimeus8ff.dwg - Tab: Model 81/2"x11" (216x279)



ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES

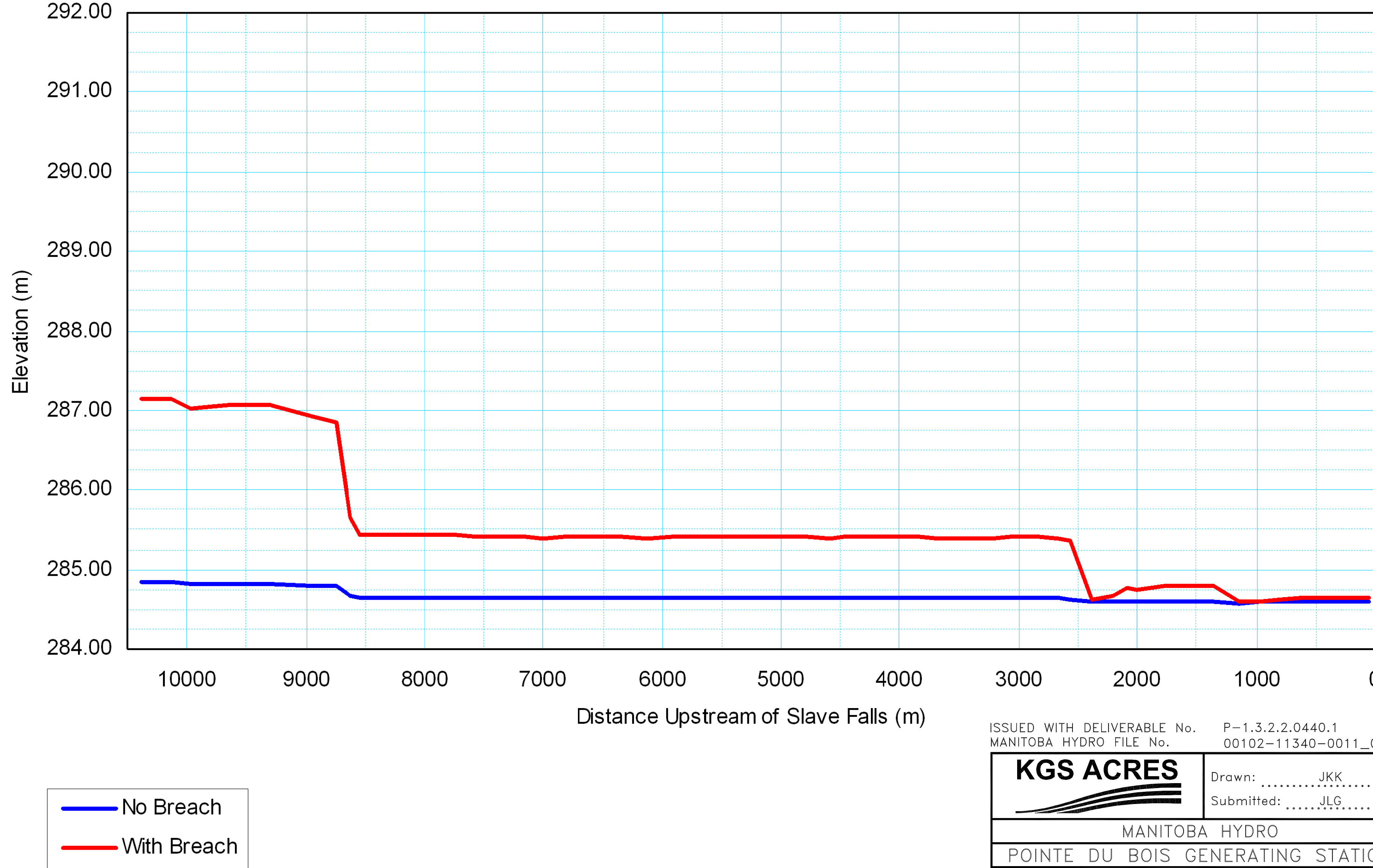
Drawn: JKK
Submitted: JLG

MANITOBA HYDRO
POINTE DU BOIS GENERATING STATION
SPILLWAY REPLACEMENT

ICC/IDF
STAGE-TIME CURVES
JUST D/S OF 8 FOOT FALLS

DECEMBER 2, 2011 | FIGURE 29

FileName: P:\Projects\2010\10-0038-01\01.PhaseIV\200.Engineering\203.Drawings\Struct\1.3.2.2.0440.1\fig29_stgtimeds8ff.dwg - Tab: Model 81/2"x11" (216x279)



ISSUED WITH DELIVERABLE No. P–1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102–11340–0011_02

KGS ACRES

Drawn: JKK
Submitted: JLG

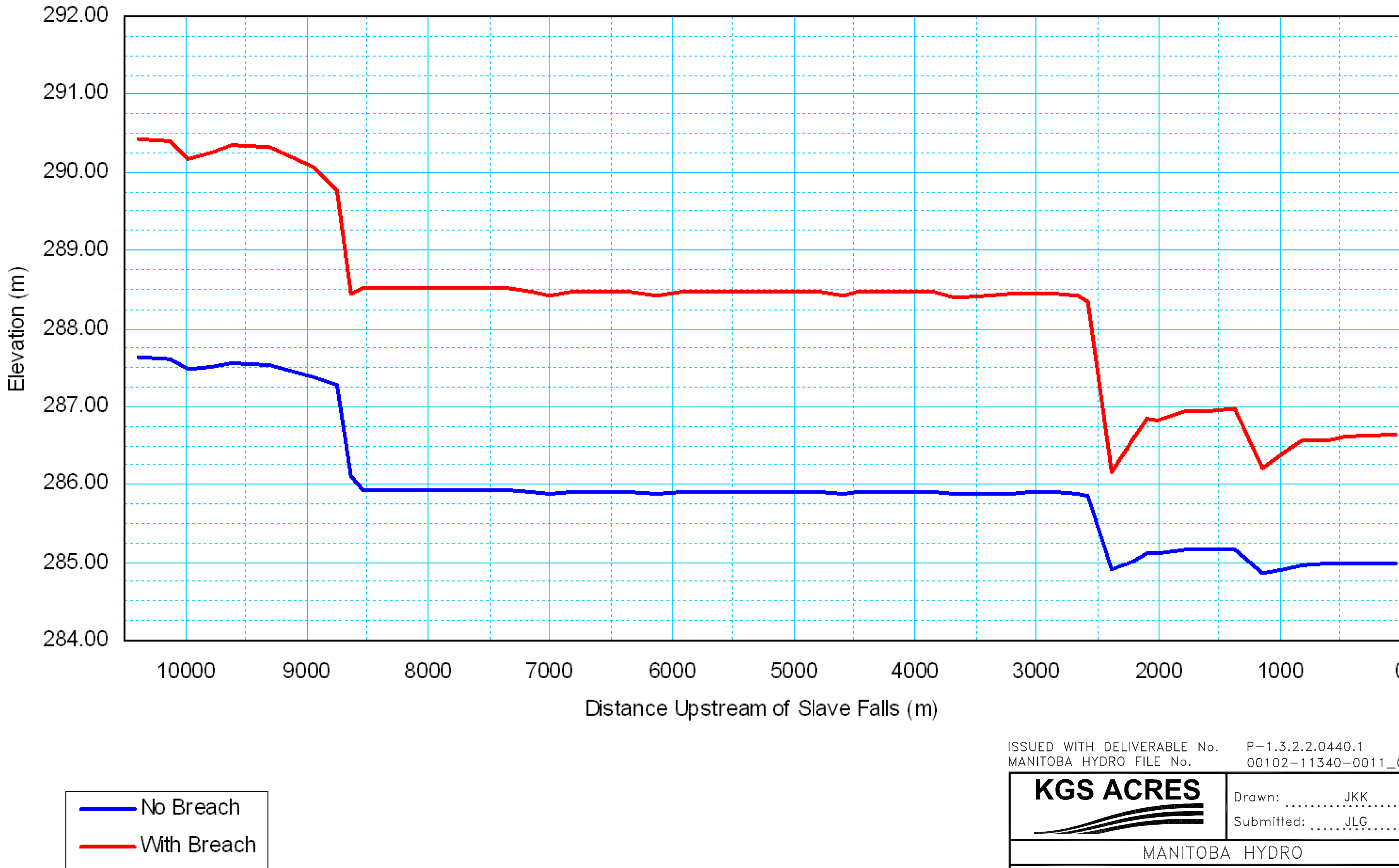
MANITOBA HYDRO

POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT

ICC/IDF
MAXIMUM WATER SURFACE PROFILE
BREACH SCENARIO 1

DECEMBER 2, 2011	FIGURE 30



ISSUED WITH DELIVERABLE No. P–1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102–11340–0011_02

KGS ACRES

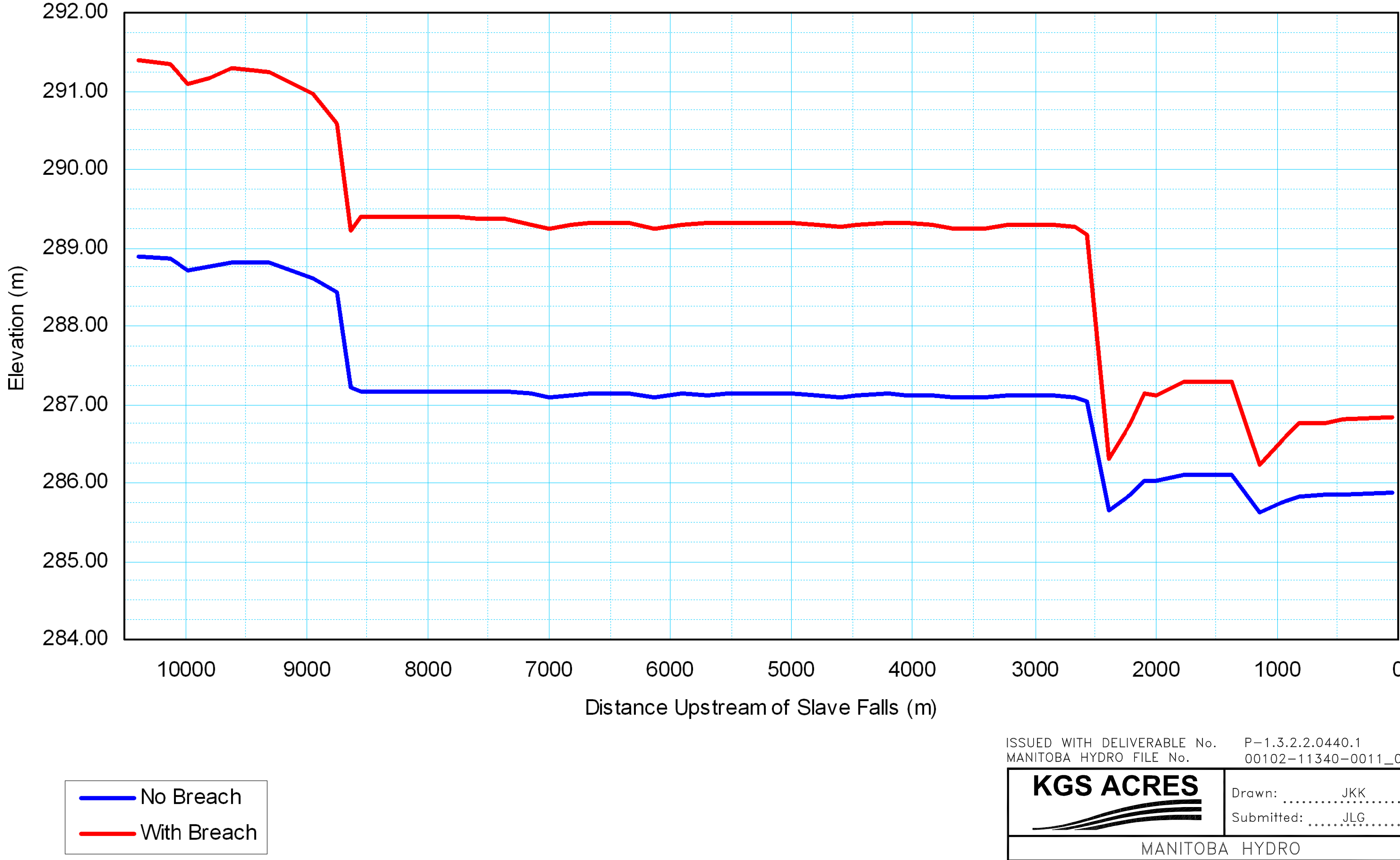
Drawn: JKK
Submitted: JLG

MANITOBA HYDRO
POINTE DU BOIS GENERATING STATION
SPILLWAY REPLACEMENT

ICC/IDF
MAXIMUM WATER SURFACE PROFILE
BREACH SCENARIO 2

DECEMBER 2, 2011 | FIGURE 31

FileName: P:\Projects\2010\10–0038–01\01.PhaseIV\200.Engineering\203.Drawings\Struct\1.3.2.2.0440.1\fig31_breach4800.dwg – Tab: Model 81/2"x11" (216x279)



ISSUED WITH DELIVERABLE No. P–1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102–11340–0011_02

KGS ACRES

Drawn: JKK
Submitted: JLG

MANITOBA HYDRO
POINTE DU BOIS GENERATING STATION
SPILLWAY REPLACEMENT
ICC/IDF
MAXIMUM WATER SURFACE PROFILE
BREACH SCENARIO 3

DECEMBER 2, 2011 | FIGURE 32

FileName: P:\Projects\2010\10-0038-01\01.PhaseIV\200.Engineering\203.Drawings\Struct\1.3.2.2.0440.1\fig32_breach6570.dwg – Tab: Model
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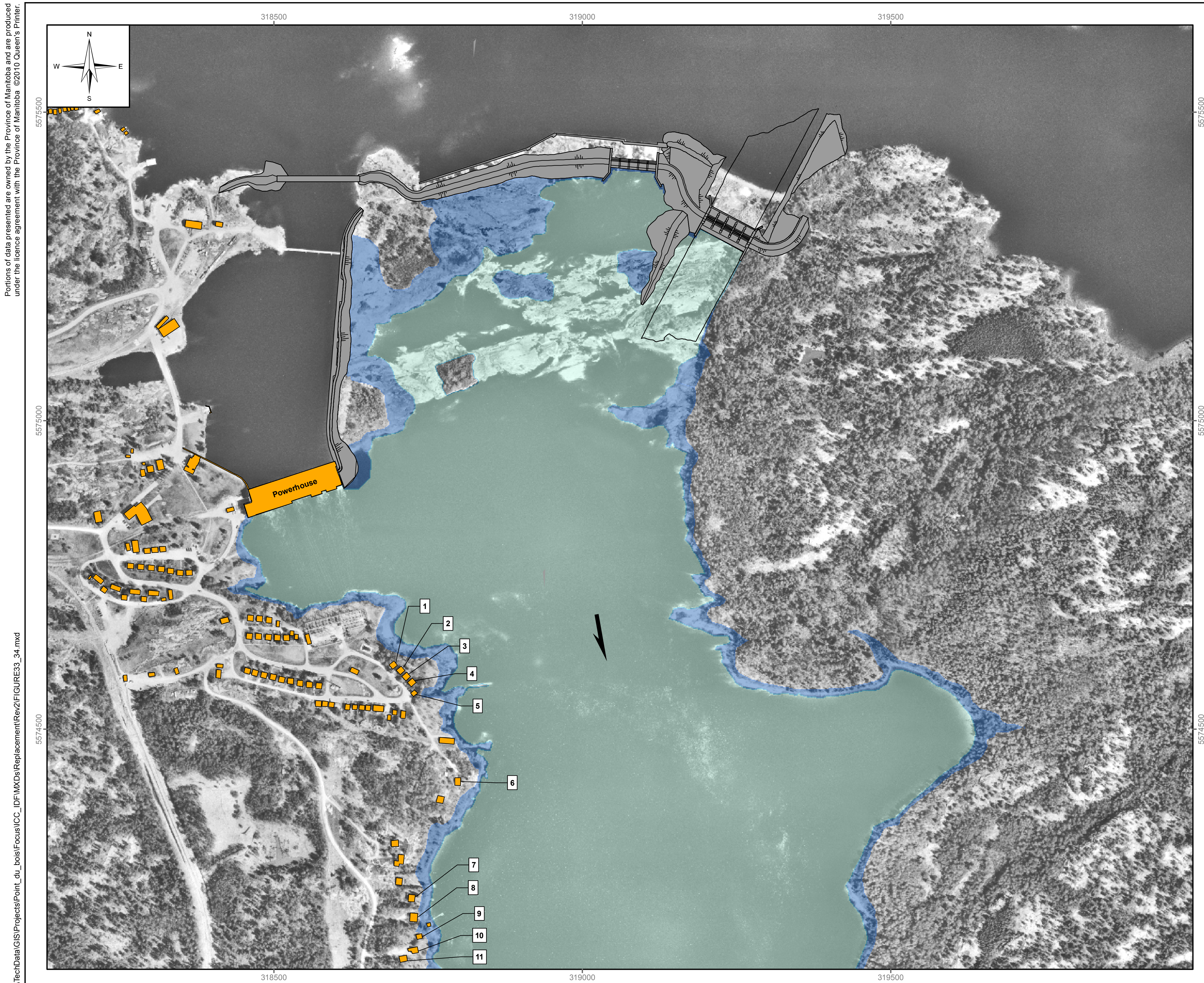
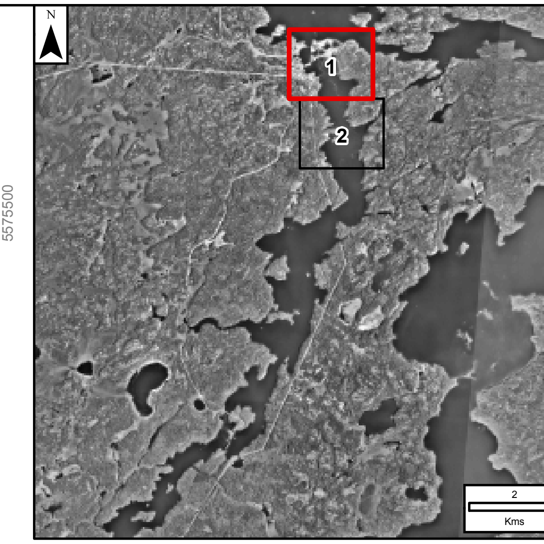




Legend

- Existing Cottage Lot Subdivision
- Building
- Preferred General Arrangement
- Flooded Area Non-Breach Conditions
- Flooded Area Breach Conditions
- 19 Building Prone to Incremental Flooding

THE DESIGN SHOWN MAY NOT REFLECT THE FINAL GENERAL ARRANGEMENT, BUT WAS REPRESENTATIVE AT THE TIME OF DRAFT STAGE IV MEMO PREPARATION ORIGINALLY ISSUED IN SEPTEMBER 2010. MINOR ALTERATIONS OF THE GENERAL ARRANGEMENT WILL NOT MATERIALLY AFFECT THE CONCLUSIONS OR RECOMMENDATIONS. REFER TO THE STAGE IV REPORT, DELIVERABLE P-1.3.9.1000.1, MANITOBA HYDRO FILE 00102-05500-0001 FOR FINAL ARRANGEMENT DETAILS.

0 50 100 150 200 250 300 350

Metres

SCALE: 1:6,000 METRIC 11" x 17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 15
Elevations are in metres above sea level (MSL)

ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES

Drawn: EYB
Submitted: DSB

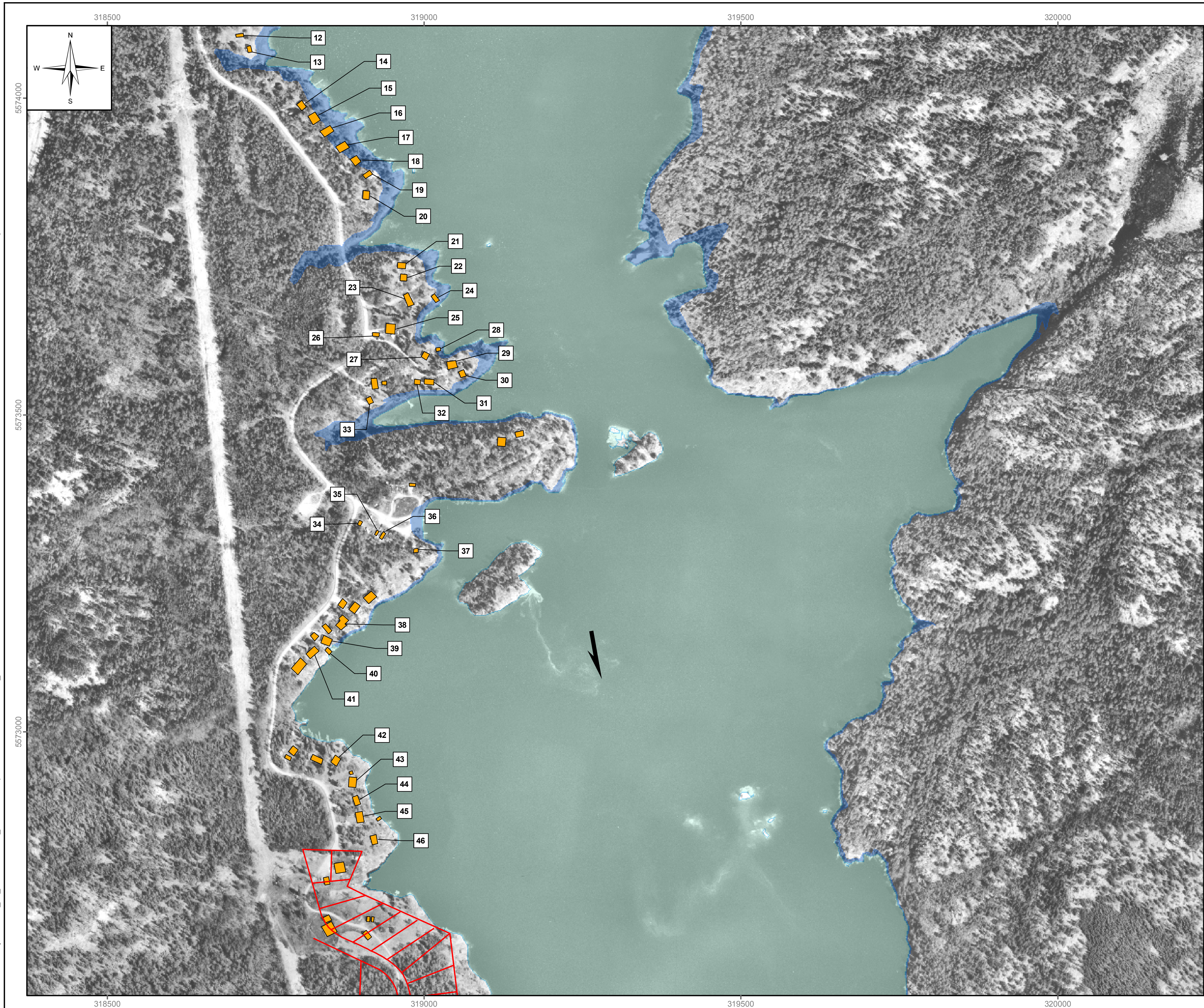
MANITOBA HYDRO

POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT

ICC/IDF
INUNDATED AREA FOR DAM BREACH
SCENARIO 1 (SUNNY DAY FAILURE)

DECEMBER 2, 2011 | FIGURE 33



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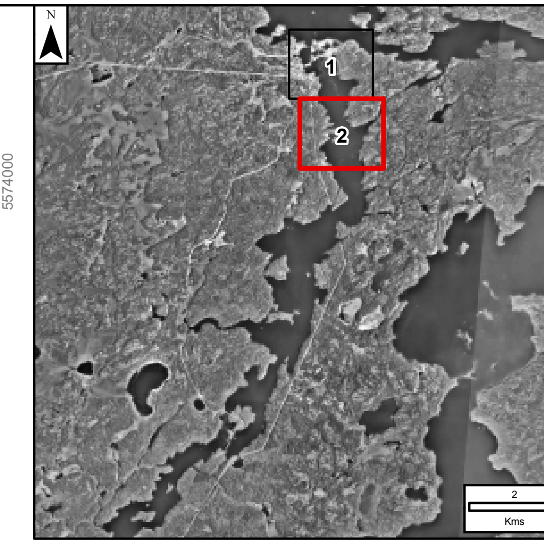
Y:\TechData\GIS\Projects\Point_du_bois\Focus\ICC_IDF\MXDs\Replacement\Rev2\FIGURE33_34.mxd



Legend

- Existing Cottage Lot Subdivision
- Building
- Preferred General Arrangement
- Flooded Area Non-Breach Conditions
- Flooded Area Breach Conditions
- 19 Building Prone to Incremental Flooding

0 50 100 150 200 250 300 350
Metres

SCALE: 1:6,000 METRIC 11" x 17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 15
Elevations are in metres above sea level (MSL)

ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES

Drawn: EYB
Submitted: DSB

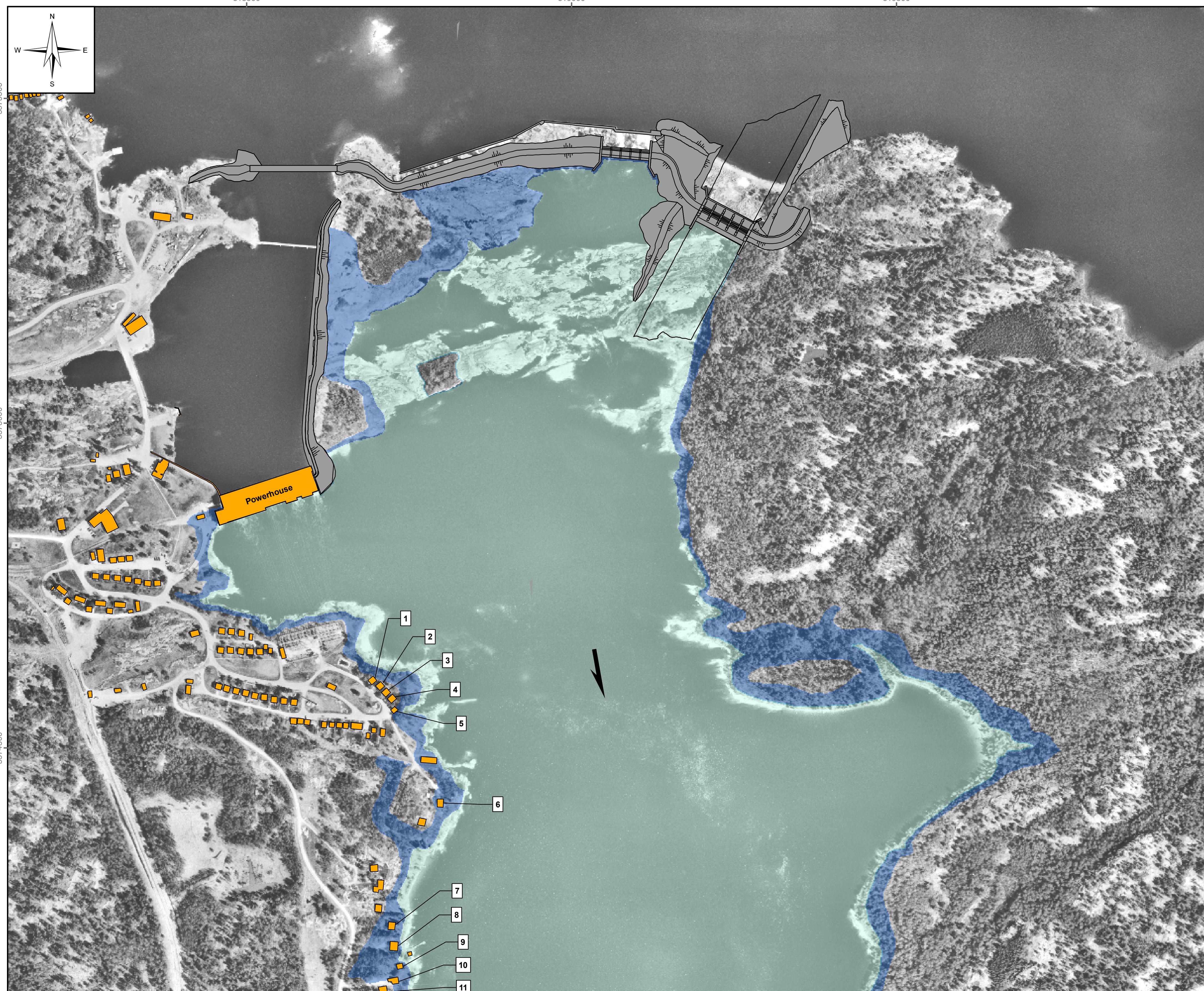
MANITOBA HYDRO
POINTE DU BOIS GENERATING STATION

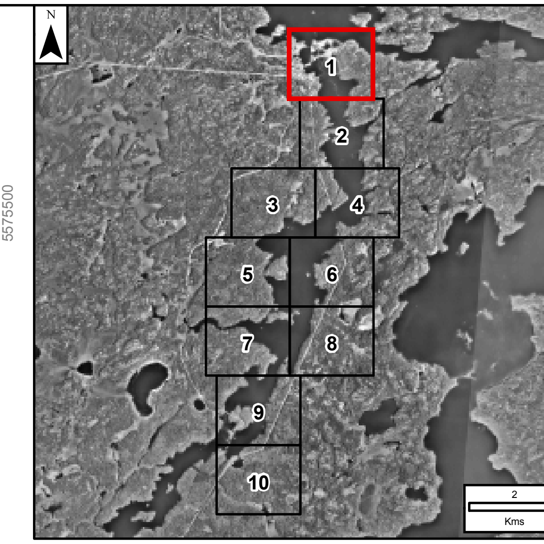
SPILLWAY REPLACEMENT

ICC/IDF
INUNDATED AREA FOR DAM BREACH
SCENARIO 1 (SUNNY DAY FAILURE)

DECEMBER 2, 2011 | FIGURE 34

Y:\TechData\GIS\Projects\Point_du_bois\Focus\ICC_IDF\MXDs\Replacement\Rev2\FIGURE35_TO_44.mxd





Legend

- Existing Cottage Lot Subdivision
- Building
- Preferred General Arrangement
- Flooded Area Non-Breach Conditions
- Flooded Area Breach Conditions
- 19 Building Prone to Incremental Flooding

THE DESIGN SHOWN MAY NOT REFLECT THE FINAL GENERAL ARRANGEMENT, BUT WAS REPRESENTATIVE AT THE TIME OF DRAFT STAGE IV MEMO PREPARATION ORIGINALLY ISSUED IN SEPTEMBER 2010. MINOR ALTERATIONS OF THE GENERAL ARRANGEMENT WILL NOT MATERIALLY AFFECT THE CONCLUSIONS OR RECOMMENDATIONS. REFER TO THE STAGE IV REPORT, DELIVERABLE P-1.3.9.1000.1, MANITOBA HYDRO FILE 00102-05500-0001 FOR FINAL ARRANGEMENT DETAILS.

0 50 100 150 200 250 300 350
Metres

SCALE: 1:6,000 METRIC 11" x 17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 15
Elevations are in metres above sea level (MSL)

ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES

Drawn: EYB
Submitted: DSB

MANITOBA HYDRO

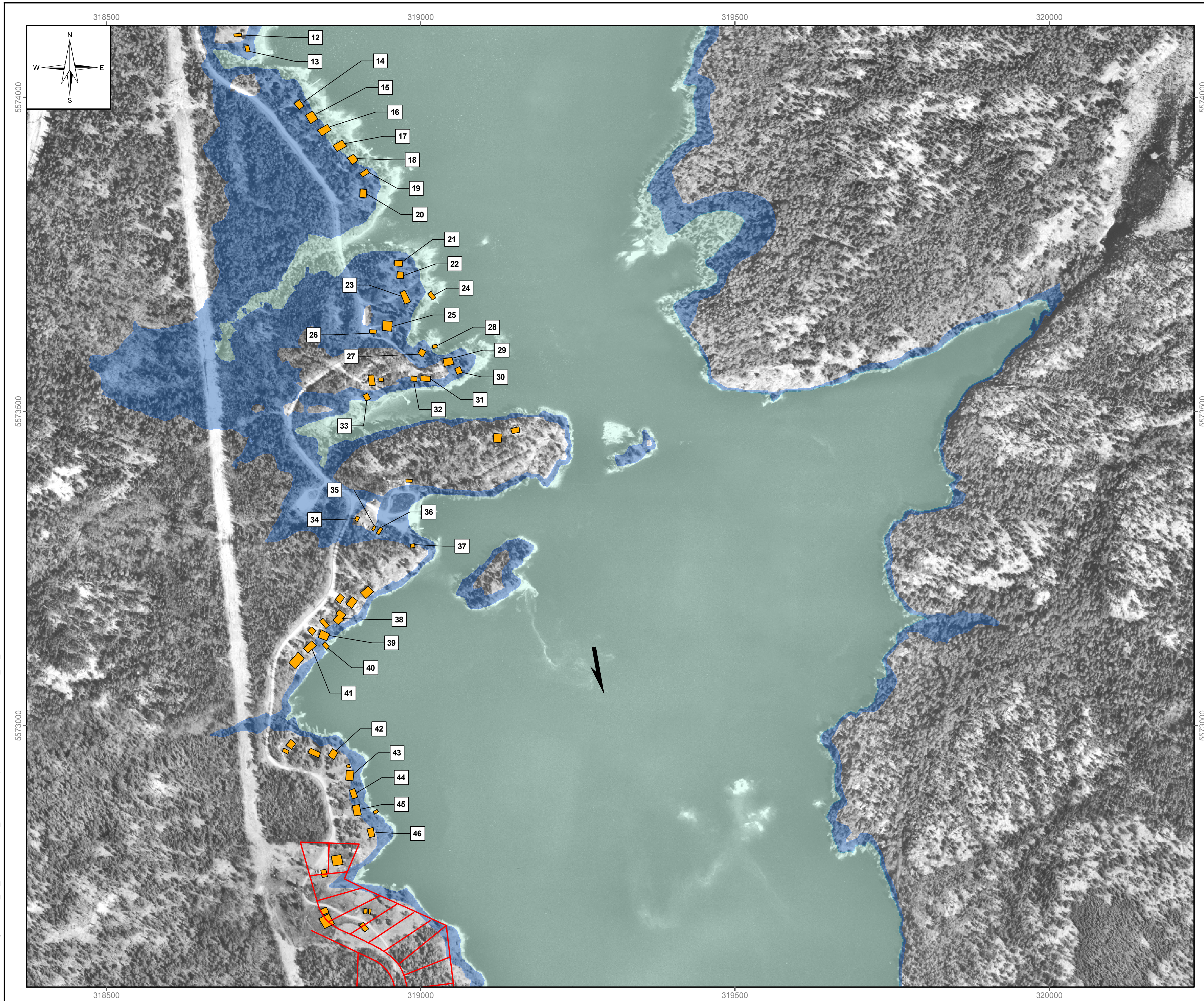
POINTE DU BOIS GENERATING STATION

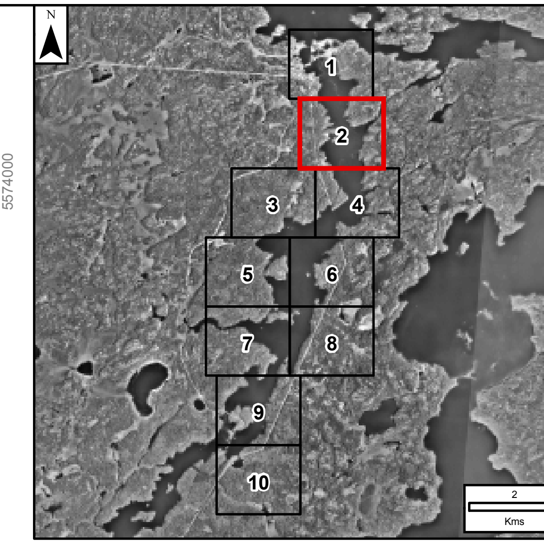
SPILLWAY REPLACEMENT

ICC/IDF
INUNDATED AREA FOR DAM BREACH
SCENARIO 2 (4800 CMS FAILURE)

DECEMBER 2, 2011 | FIGURE 35

Y:\TechData\GIS\Projects\Point_du_bois\Focus\ICC_IDF\MXDs\Replacement\Rev2\FIGURE35_TO_44.mxd





Legend

- Existing Cottage Lot Subdivision
- Building
- Preferred General Arrangement
- Flooded Area Non-Breach Conditions
- Flooded Area Breach Conditions
- 19 Building Prone to Incremental Flooding

0 50 100 150 200 250 300 350
Metres

SCALE: 1:6,000 METRIC 11" x 17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 15
Elevations are in metres above sea level (MSL)

ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES

Drawn: EYB
Submitted: DSB

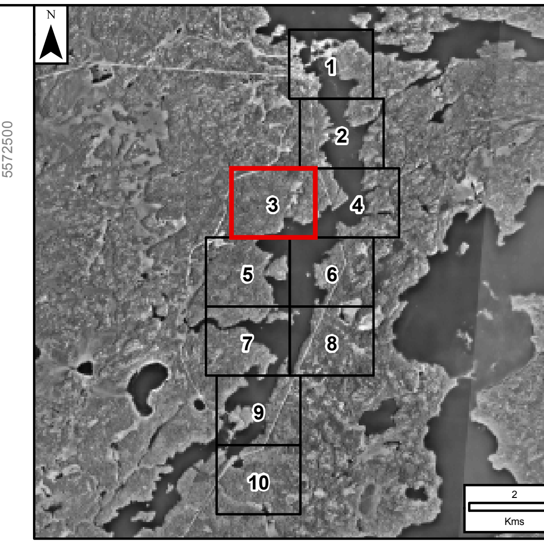
MANITOBA HYDRO
POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT

ICC/IDF
INUNDATED AREA FOR DAM BREACH
SCENARIO 2 (4800 CMS FAILURE)

DECEMBER 2, 2011 | FIGURE 36

Y:\TechData\GIS\Projects\Point_du_bois\Focus\ICC_IDF\MXDs\Replacement\Rev2\FIGURE35_TO_44.mxd



Legend

- Existing Cottage Lot Subdivision
- Building
- Preferred General Arrangement
- Flooded Area Non-Breach Conditions
- Flooded Area Breach Conditions
- 19 Building Prone to Incremental Flooding

0 50 100 150 200 250 300 350
Metres

SCALE: 1:6,000 METRIC 11" x 17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 15
Elevations are in metres above sea level (MSL)

ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES

Drawn: EYB
Submitted: DSB

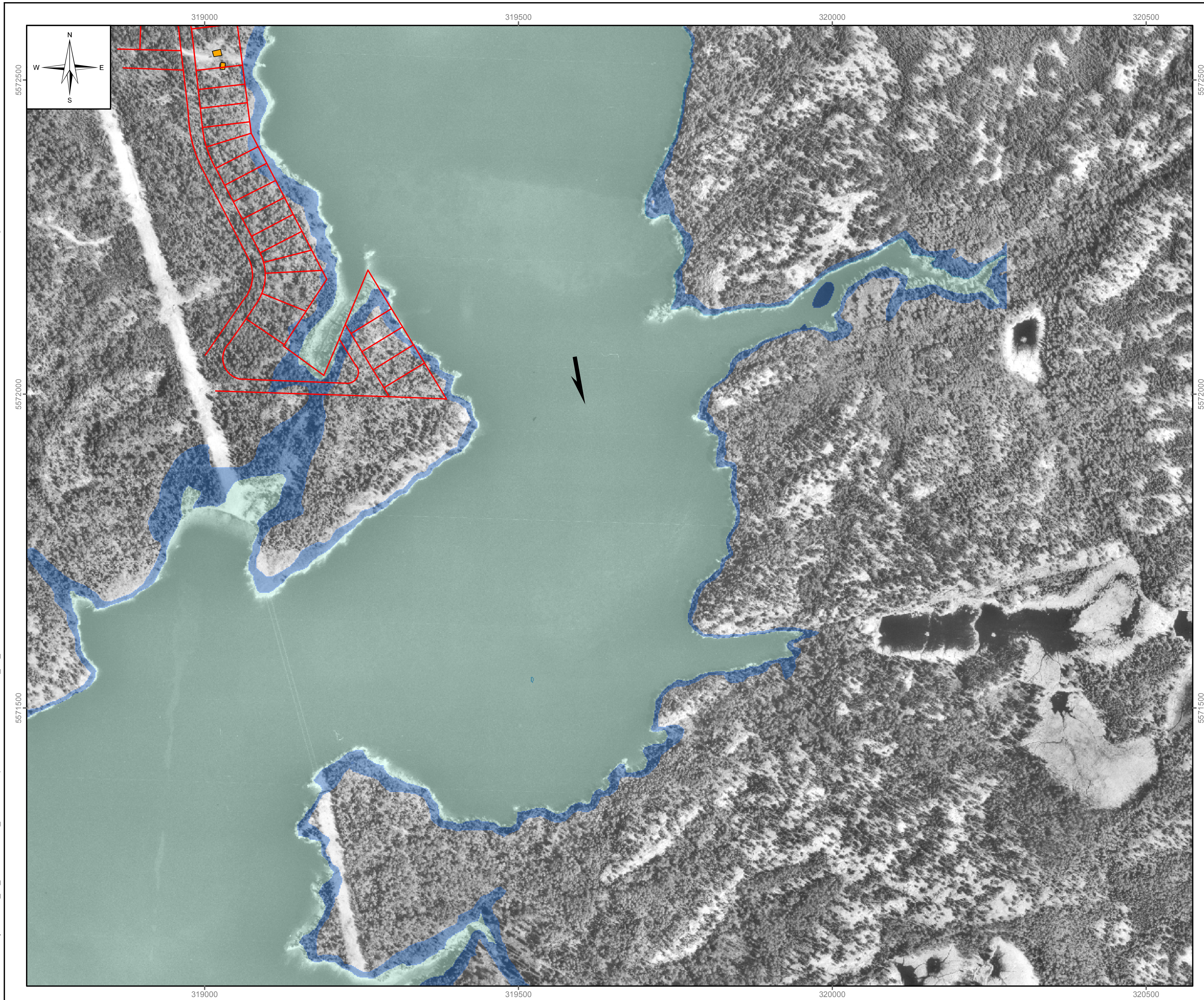
MANITOBA HYDRO

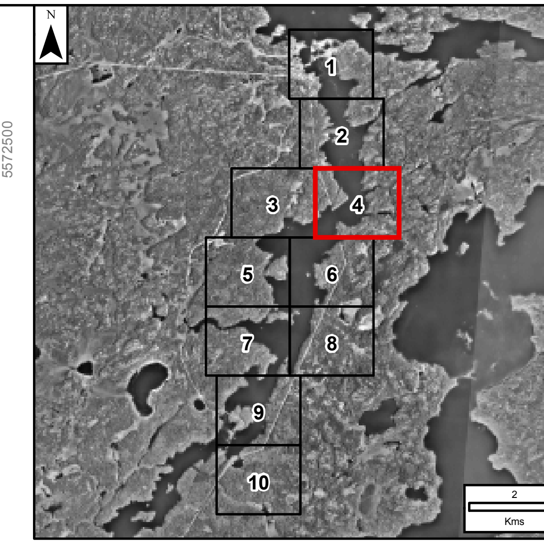
POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT

ICC/IDF
INUNDATED AREA FOR DAM BREACH
SCENARIO 2 (4800 CMS FAILURE)

DECEMBER 2, 2011 | FIGURE 37





Legend

- Existing Cottage Lot Subdivision
- Building
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- Flooded Area Non-Breach Conditions
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- 19 Building Prone to Incremental Flooding

0 50 100 150 200 250 300 350
Metres

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ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES

Drawn: EYB
Submitted: DSB

MANITOBA HYDRO

POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT

ICC/IDF
INUNDATED AREA FOR DAM BREACH
SCENARIO 2 (4800 CMS FAILURE)

DECEMBER 2, 2011 | FIGURE 38

Y:\TechData\GIS\Projects\Point_du_bois\Focus\ICC_IDF\MXDs\Replacement\Rev2\FIGURE35_TO_44.mxd

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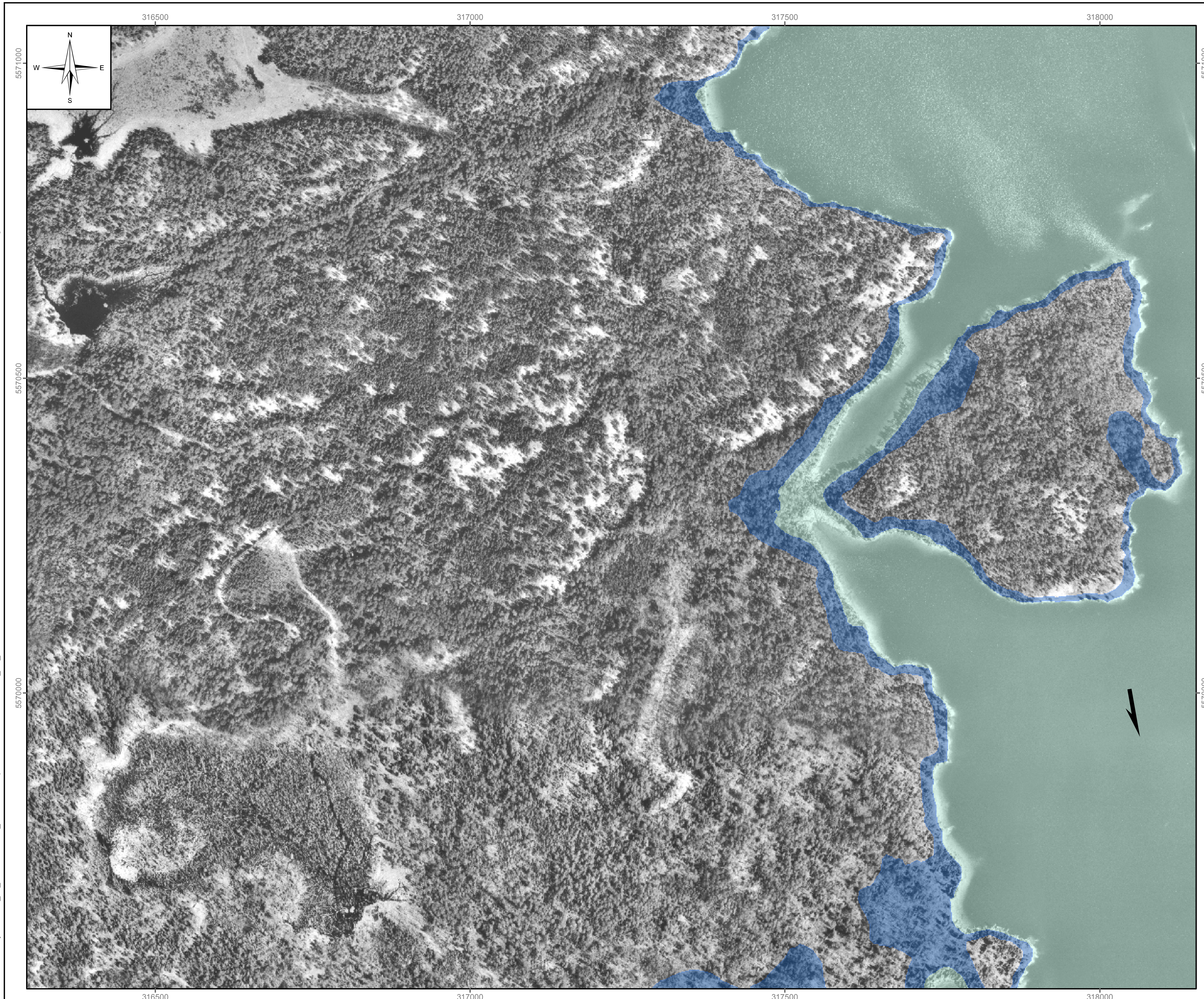

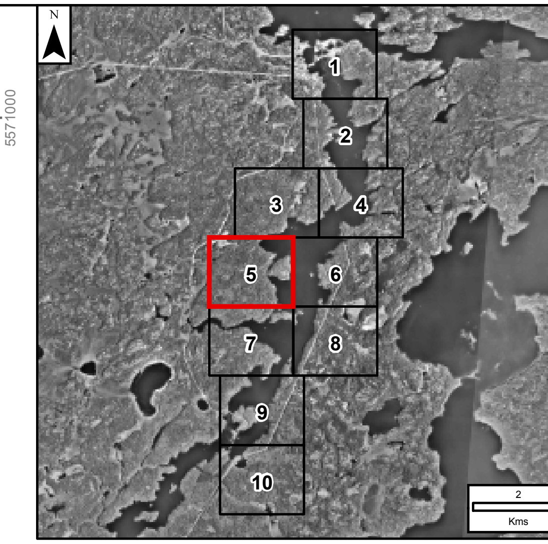

Legend

- Existing Cottage Lot Subdivision
- Building
- Preferred General Arrangement
- Flooded Area Non-Breach Conditions
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- 19 Building Prone to Incremental Flooding

0 50 100 150 200 250 300 350
Metres

SCALE: 1:6,000 METRIC 11" x 17"

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Transverse Mercator Projection, NAD 1983, Zone 15
Elevations are in metres above sea level (MSL)

ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

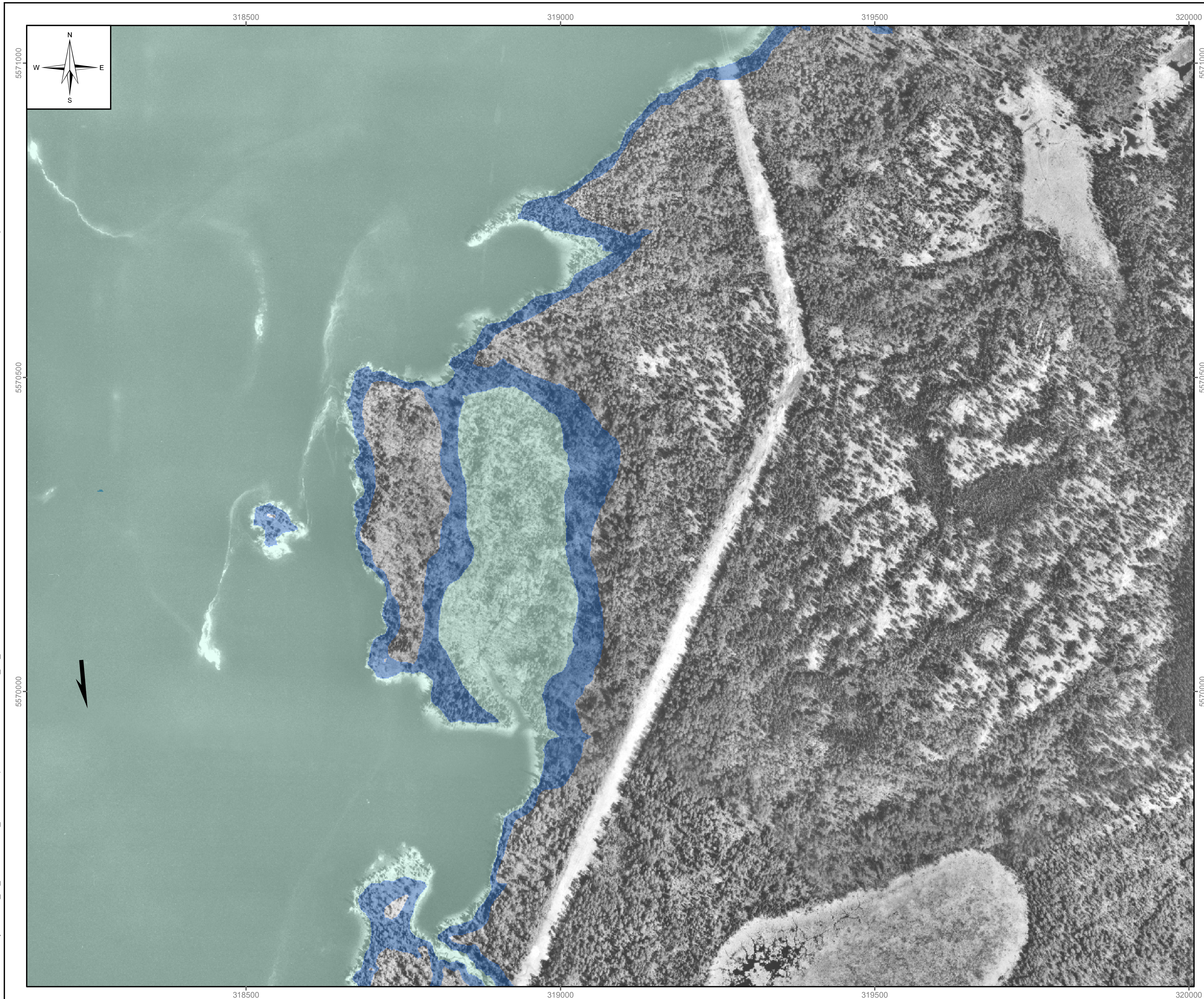
KGS ACRES

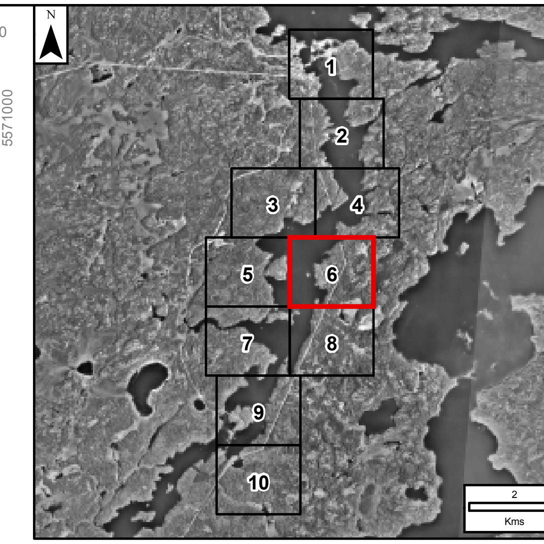
Drawn: EYB
Submitted: DSB

MANITOBA HYDRO
POINTE DU BOIS GENERATING STATION
SPILLWAY REPLACEMENT
ICC/IDF
INUNDATED AREA FOR DAM BREACH
SCENARIO 2 (4800 CMS FAILURE)

DECEMBER 2, 2011 | FIGURE 39

Y:\TechData\GIS\Projects\Point_du_bois\Focus\ICC_IDF\MXDs\Replacement\Rev2\FIGURE35_TO_44.mxd





Legend

- Existing Cottage Lot Subdivision
- Building
- Preferred General Arrangement
- Flooded Area Non-Breach Conditions
- Flooded Area Breach Conditions
- 19 Building Prone to Incremental Flooding

0 50 100 150 200 250 300 350
Metres

SCALE: 1:6,000 METRIC 11" x 17"

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Transverse Mercator Projection, NAD 1983, Zone 15
Elevations are in metres above sea level (MSL)

ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES

Drawn: EYB
Submitted: DSB

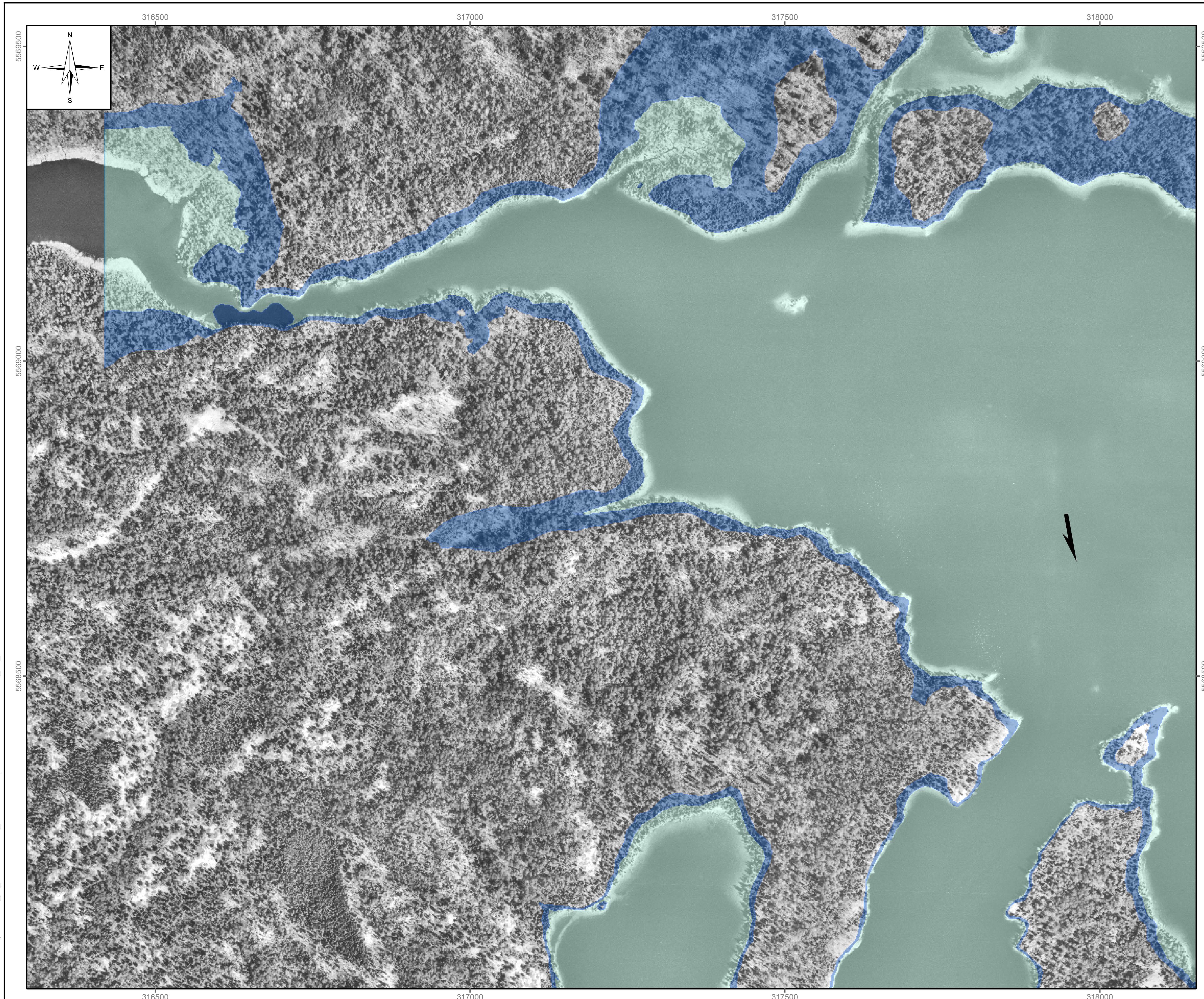
MANITOBA HYDRO

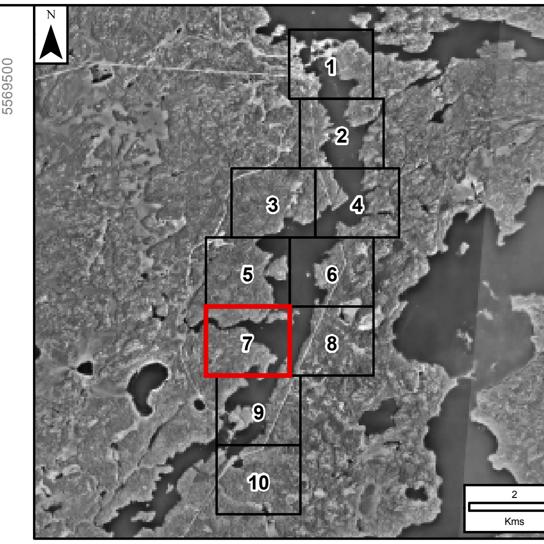
POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT

ICC/IDF
INUNDATED AREA FOR DAM BREACH
SCENARIO 2 (4800 CMS FAILURE)

DECEMBER 2, 2011 | FIGURE 40





Legend

- Existing Cottage Lot Subdivision
- Building
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- Flooded Area Non-Breach Conditions
- Flooded Area Breach Conditions
- 19 Building Prone to Incremental Flooding

0 50 100 150 200 250 300 350
Metres

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Elevations are in metres above sea level (MSL)

ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES

Drawn: EYB
Submitted: DSB

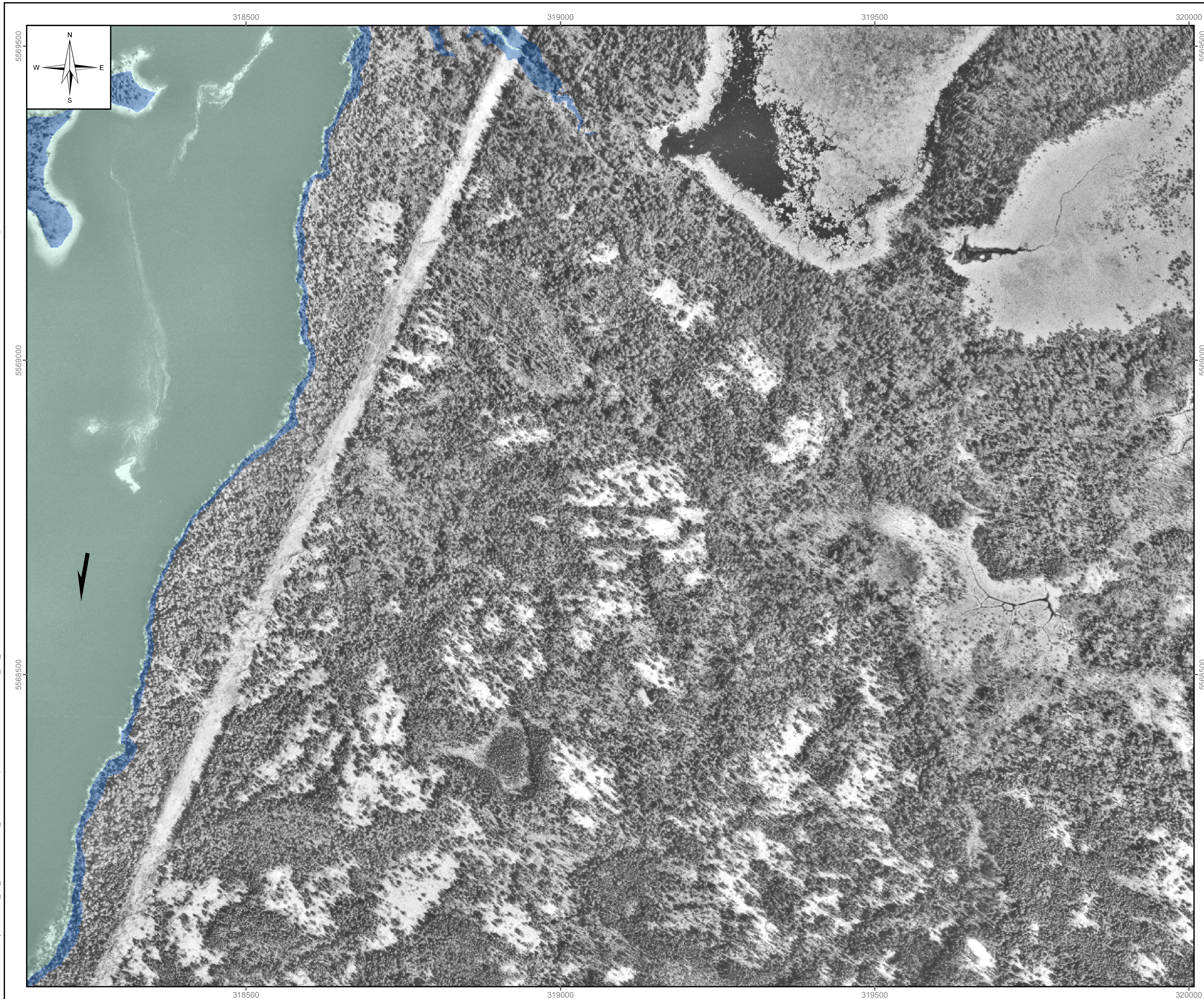
MANITOBA HYDRO
POINTE DU BOIS GENERATING STATION

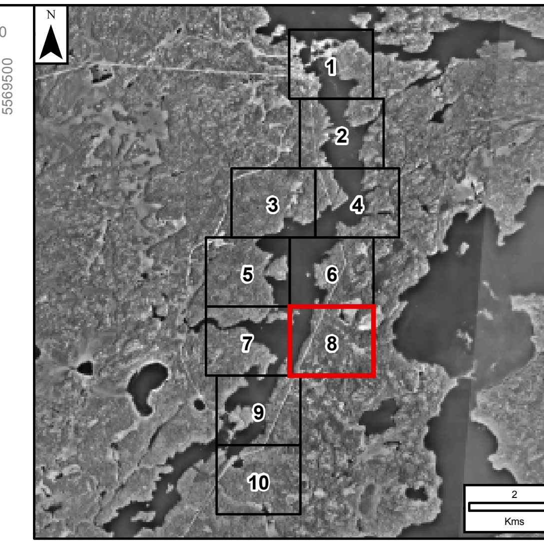
SPILLWAY REPLACEMENT

ICC/IDF
INUNDATED AREA FOR DAM BREACH
SCENARIO 2 (4800 CMS FAILURE)

DECEMBER 2, 2011 | FIGURE 41

Y:\TechData\GIS\Projects\Point_du_bois\Focus\ICC_IDF\MXDs\Replacement\Rev2\FIGURE35_TO_44.mxd





Legend

- Existing Cottage Lot Subdivision
- Building
- Preferred General Arrangement
- Flooded Area Non-Breach Conditions
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Metres

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ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES

Drawn: EYB
Submitted: DSB

MANITOBA HYDRO
POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT

ICC/IDF
INUNDATED AREA FOR DAM BREACH
SCENARIO 2 (4800 CMS FAILURE)

DECEMBER 2, 2011 | FIGURE 42

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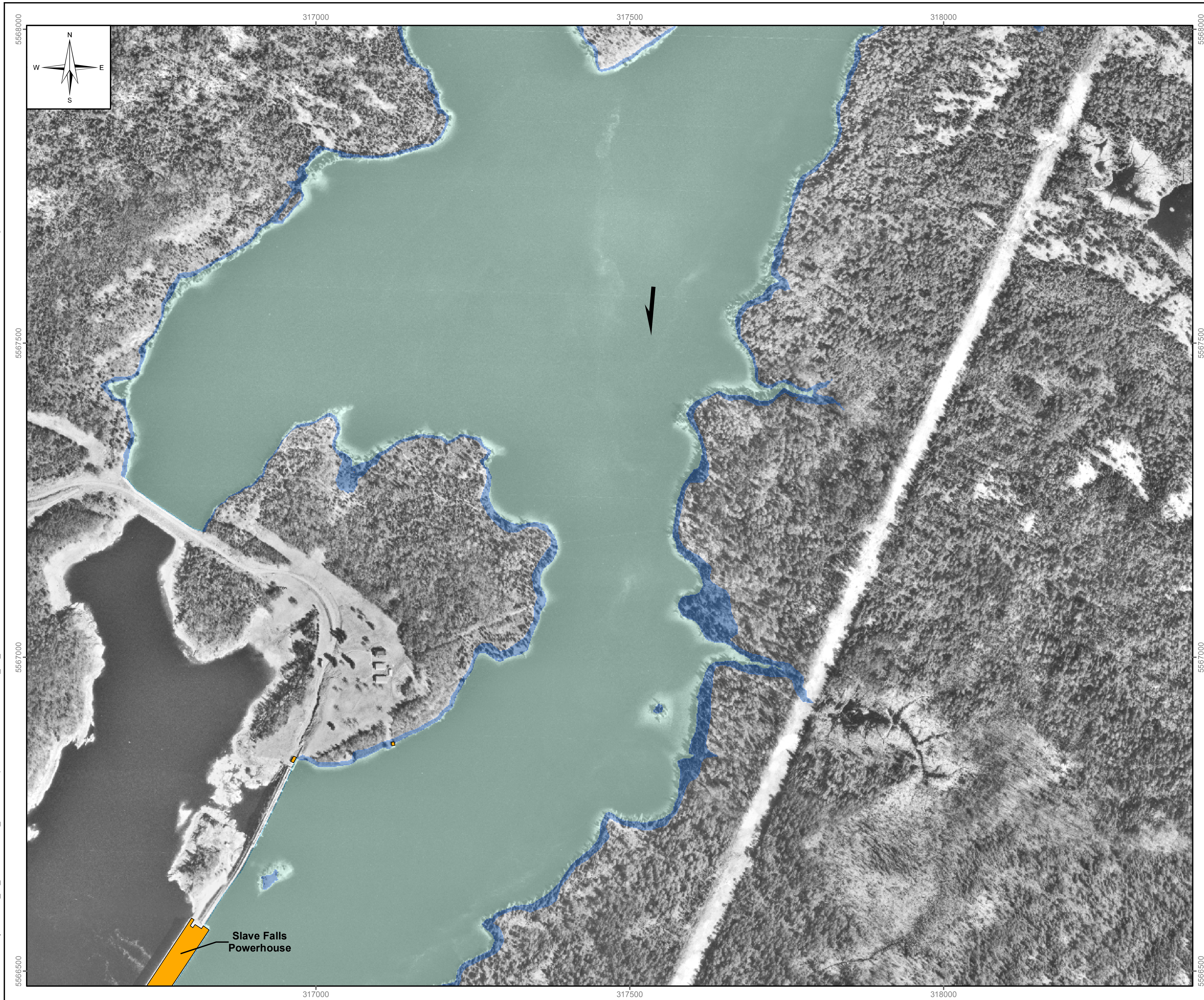

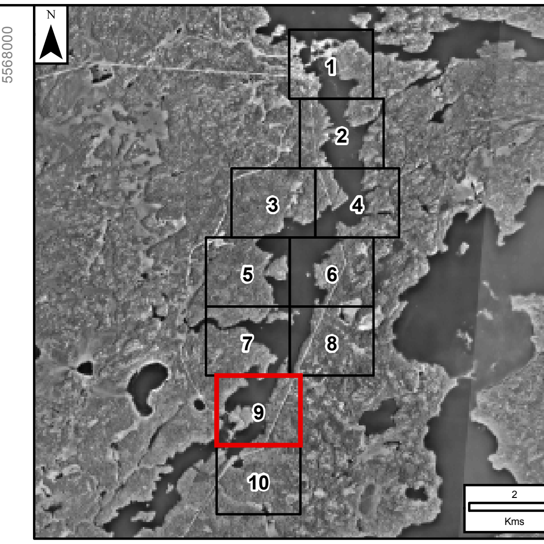

Legend

- Existing Cottage Lot Subdivision
- Building
- Preferred General Arrangement
- Flooded Area Non-Breach Conditions
- Flooded Area Breach Conditions
- 19 Building Prone to Incremental Flooding

0 50 100 150 200 250 300 350
Metres

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Transverse Mercator Projection, NAD 1983, Zone 15
Elevations are in metres above sea level (MSL)

ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES

Drawn: EYB
Submitted: DSB

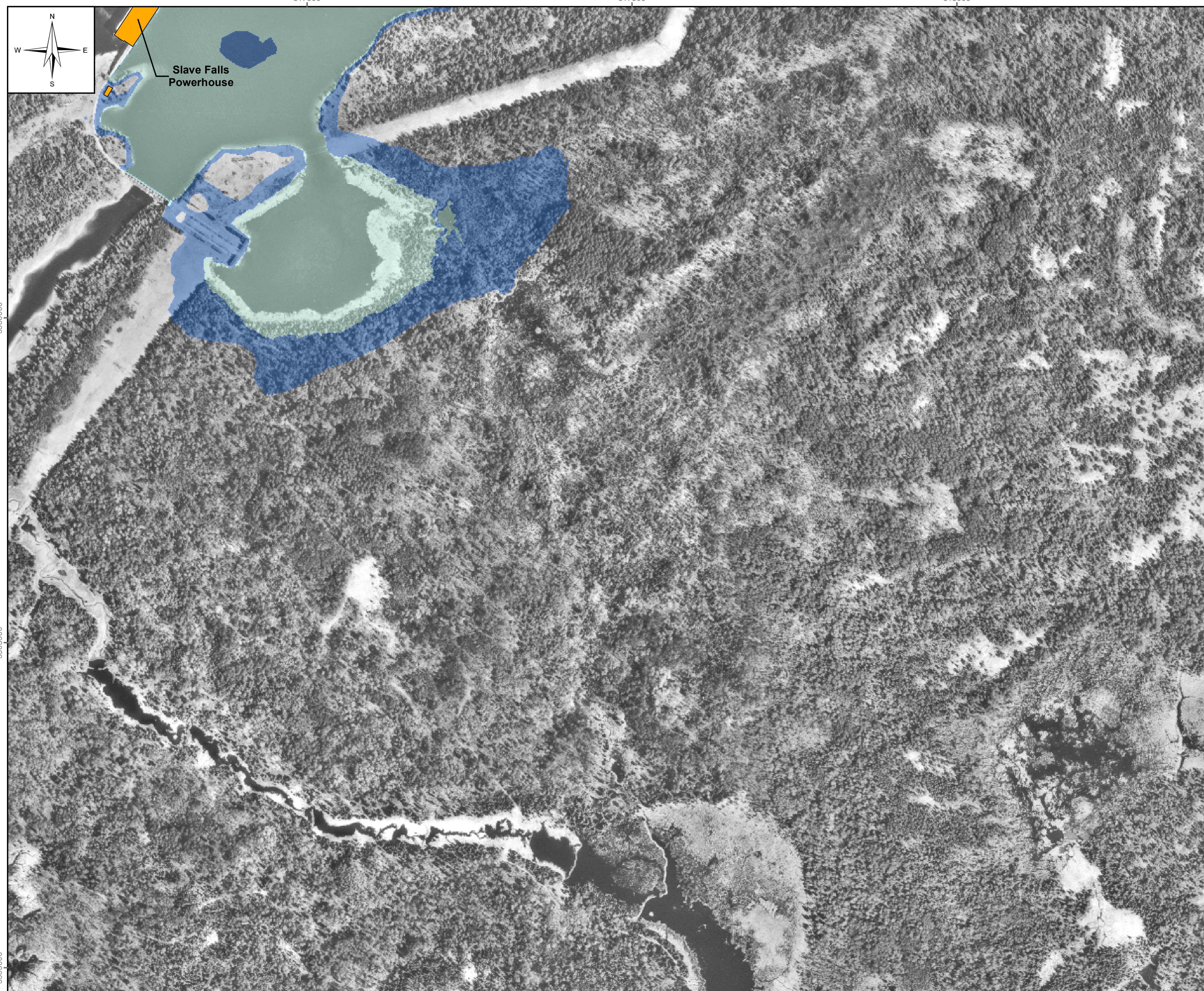
MANITOBA HYDRO

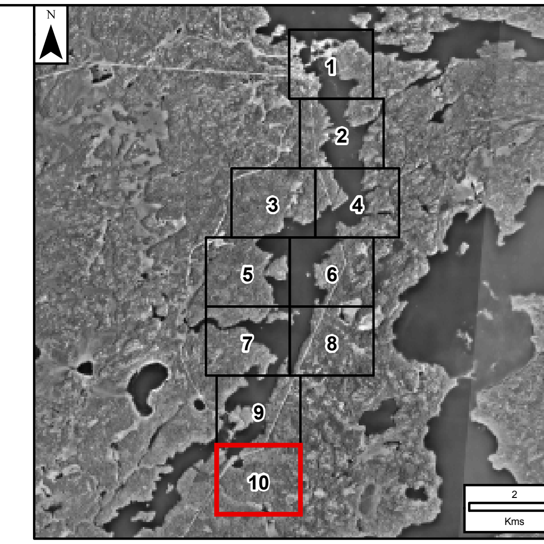
POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT

ICC/IDF
INUNDATED AREA FOR DAM BREACH
SCENARIO 2 (4800 CMS FAILURE)

DECEMBER 2, 2011 | FIGURE 43





Legend

- Existing Cottage Lot Subdivision
- Building
- Preferred General Arrangement
- Flooded Area Non-Breach Conditions
- Flooded Area Breach Conditions
- 19 Building Prone to Incremental Flooding

0 50 100 150 200 250 300 350
Metres

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Transverse Mercator Projection, NAD 1983, Zone 15
Elevations are in metres above sea level (MSL)

ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES

Drawn: EYB
Submitted: DSB

MANITOBA HYDRO
POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT

ICC/IDF
INUNDATED AREA FOR DAM BREACH
SCENARIO 2 (4800 CMS FAILURE)

DECEMBER 2, 2011 | FIGURE 44

Y:\TechData\GIS\Projects\Point_du_bois\Focus\ICC_IDF\MXDs\Replacement\Rev2\FIGURE35_TO_44.mxd

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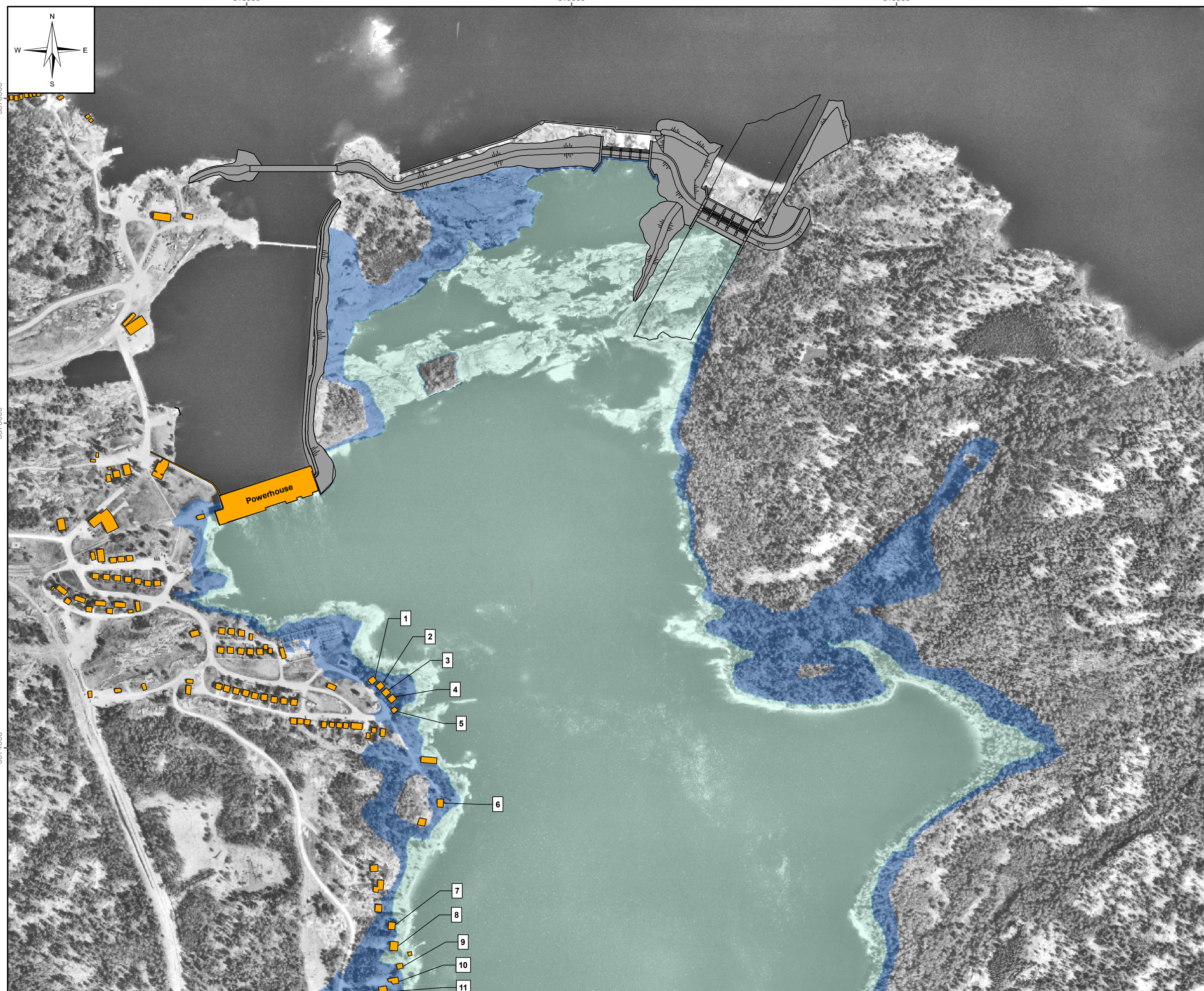
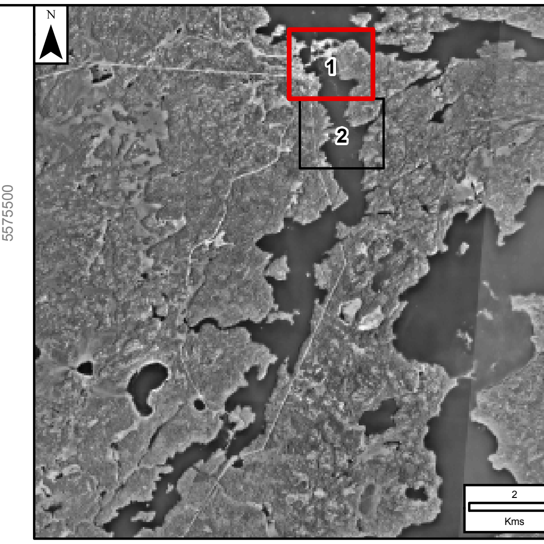
Transcript Page #1180





Legend

- Existing Cottage Lot Subdivision
- Building
- Preferred General Arrangement
- Flooded Area Non-Breach Conditions
- Flooded Area Breach Conditions
- 19 Building Prone to Incremental Flooding

THE DESIGN SHOWN MAY NOT REFLECT THE FINAL GENERAL ARRANGEMENT, BUT WAS REPRESENTATIVE AT THE TIME OF DRAFT STAGE IV MEMO PREPARATION ORIGINALLY ISSUED IN SEPTEMBER 2010. MINOR ALTERATIONS OF THE GENERAL ARRANGEMENT WILL NOT MATERIALLY AFFECT THE CONCLUSIONS OR RECOMMENDATIONS. REFER TO THE STAGE IV REPORT, DELIVERABLE P-1.3.9.1000.1, MANITOBA HYDRO FILE 00102-05500-0001 FOR FINAL ARRANGEMENT DETAILS.

0 50 100 150 200 250 300 350
Metres

SCALE: 1:6,000 METRIC 11" x 17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 15
Elevations are in metres above sea level (MSL)

ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES

Drawn: EYB
Submitted: DSB

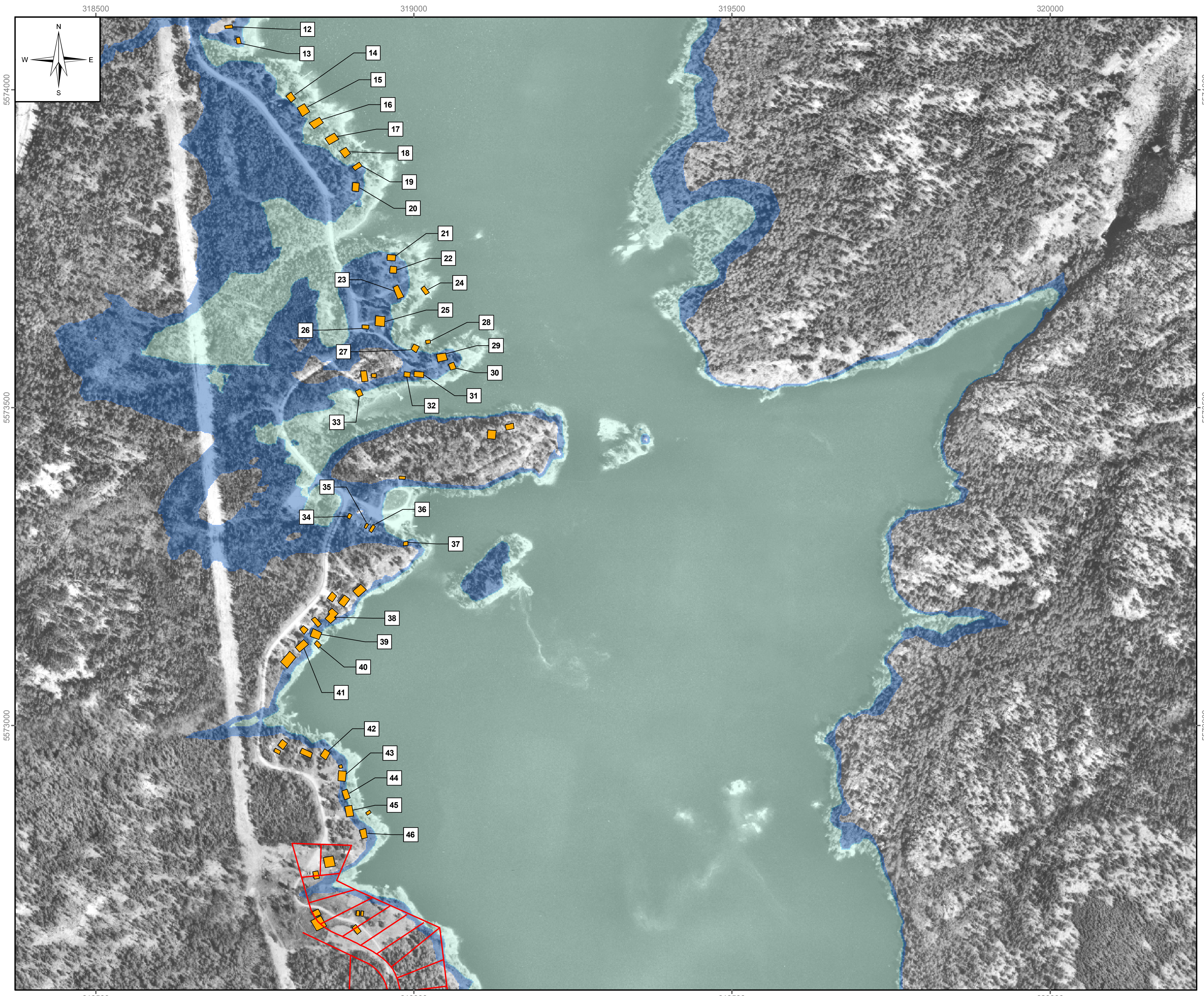
MANITOBA HYDRO
POINTE DU BOIS GENERATING STATION

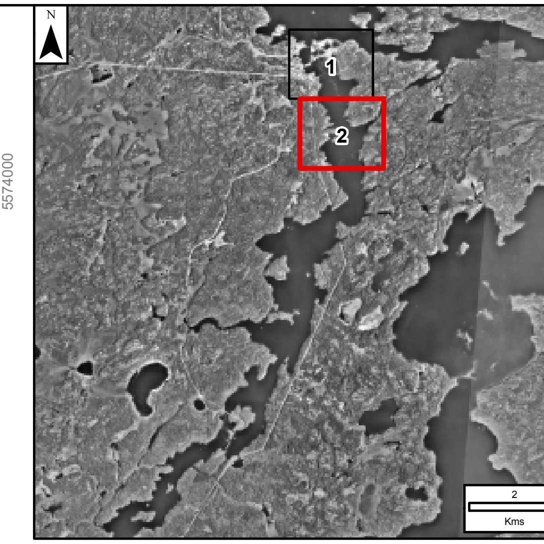
SPILLWAY REPLACEMENT

ICC/IDF
INUNDATED AREA FOR DAM BREACH
SCENARIO 3 (PMF FAILURE)

DECEMBER 2, 2011 | FIGURE 45

Y:\TechData\GIS\Projects\Point_du_bois\Focus\ICC_IDF\MXDs\Replacement\Rev2\FIGURE45_46.mxd





Legend

- Existing Cottage Lot Subdivision
- Building
- Preferred General Arrangement
- Flooded Area Non-Breach Conditions
- Flooded Area Breach Conditions
- 19 Building Prone to Incremental Flooding

0 50 100 150 200 250 300 350
Metres

SCALE: 1:6,000 METRIC 11" x 17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 15
Elevations are in metres above sea level (MSL)

ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES

Drawn: EYB
Submitted: DSB

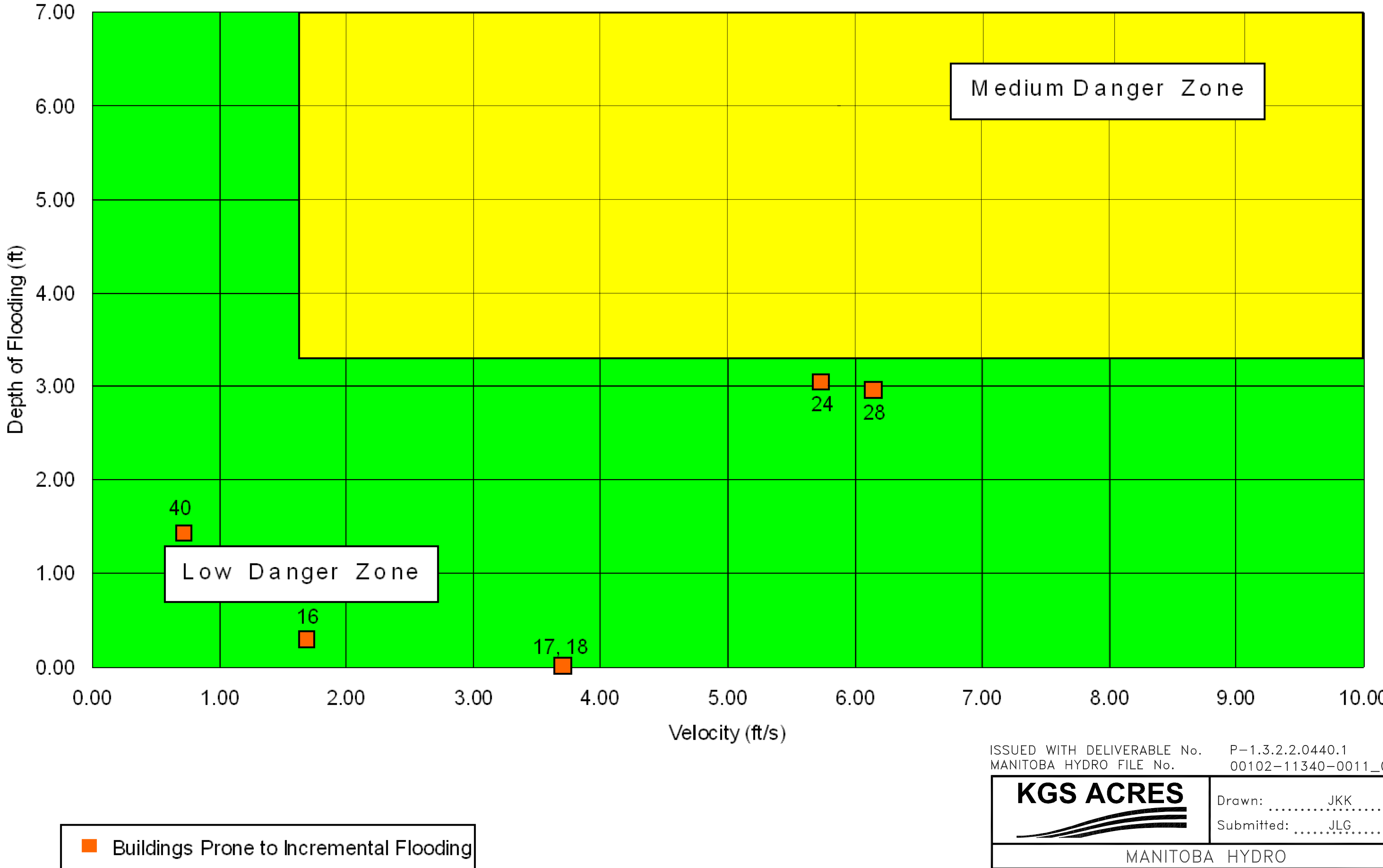
MANITOBA HYDRO
POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT

ICC/IDF
INUNDATED AREA FOR DAM BREACH
SCENARIO 3 (PMF FAILURE)

DECEMBER 2, 2011 | FIGURE 46

Y:\TechData\GIS\Projects\Point_du_bois\Focus\ICC_IDF\MXDs\Replacement\Rev2\FIGURE45_46.mxd



ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES	Drawn: JKK Submitted: JLG

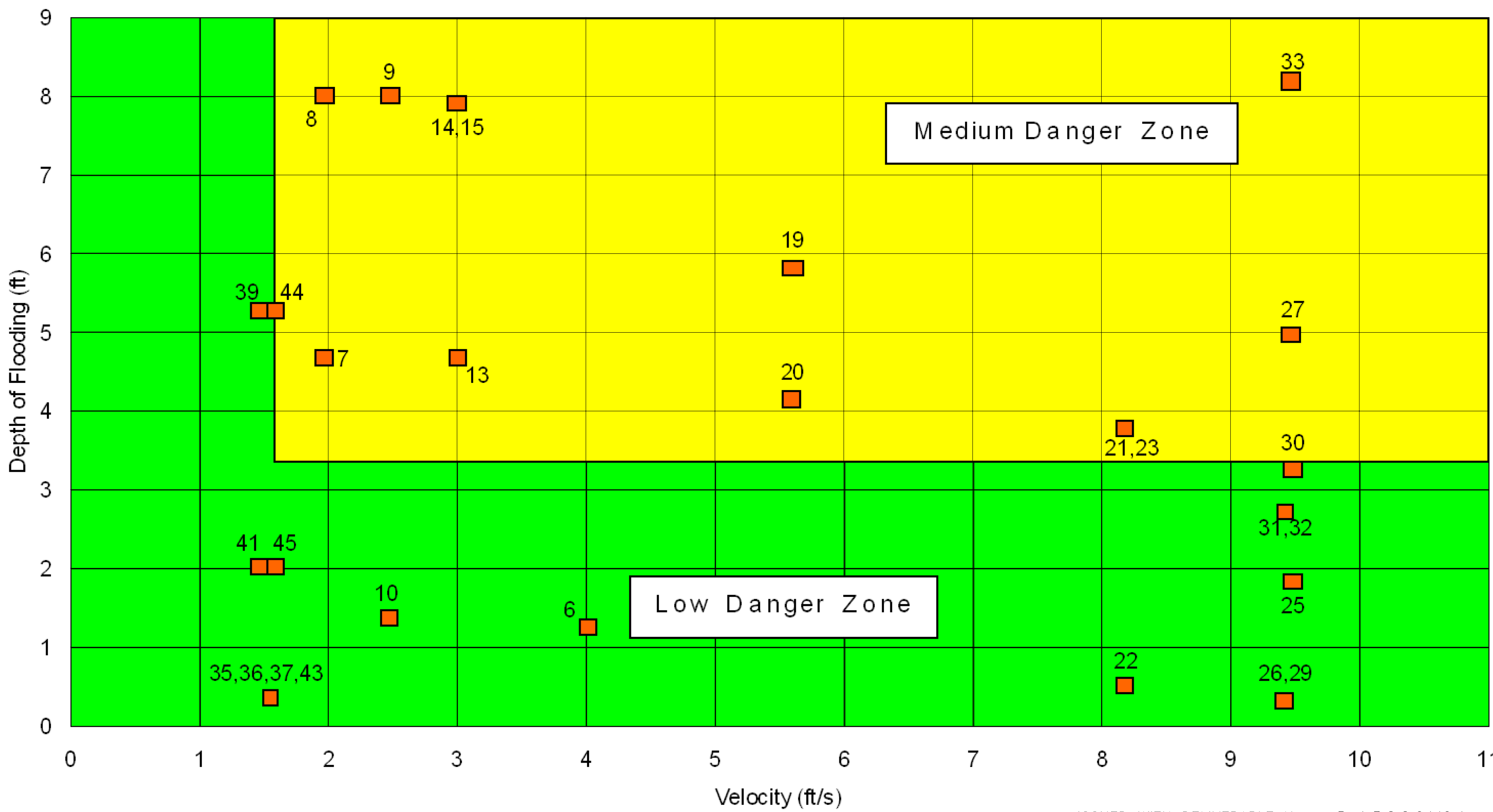
MANITOBA HYDRO

POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT

ICC/IDF
SEVERITY RISK FOR BUILDINGS
BREACH SCENARIO 1

DECEMBER 2, 2011	FIGURE 47	



Buildings Prone to Incremental Flooding

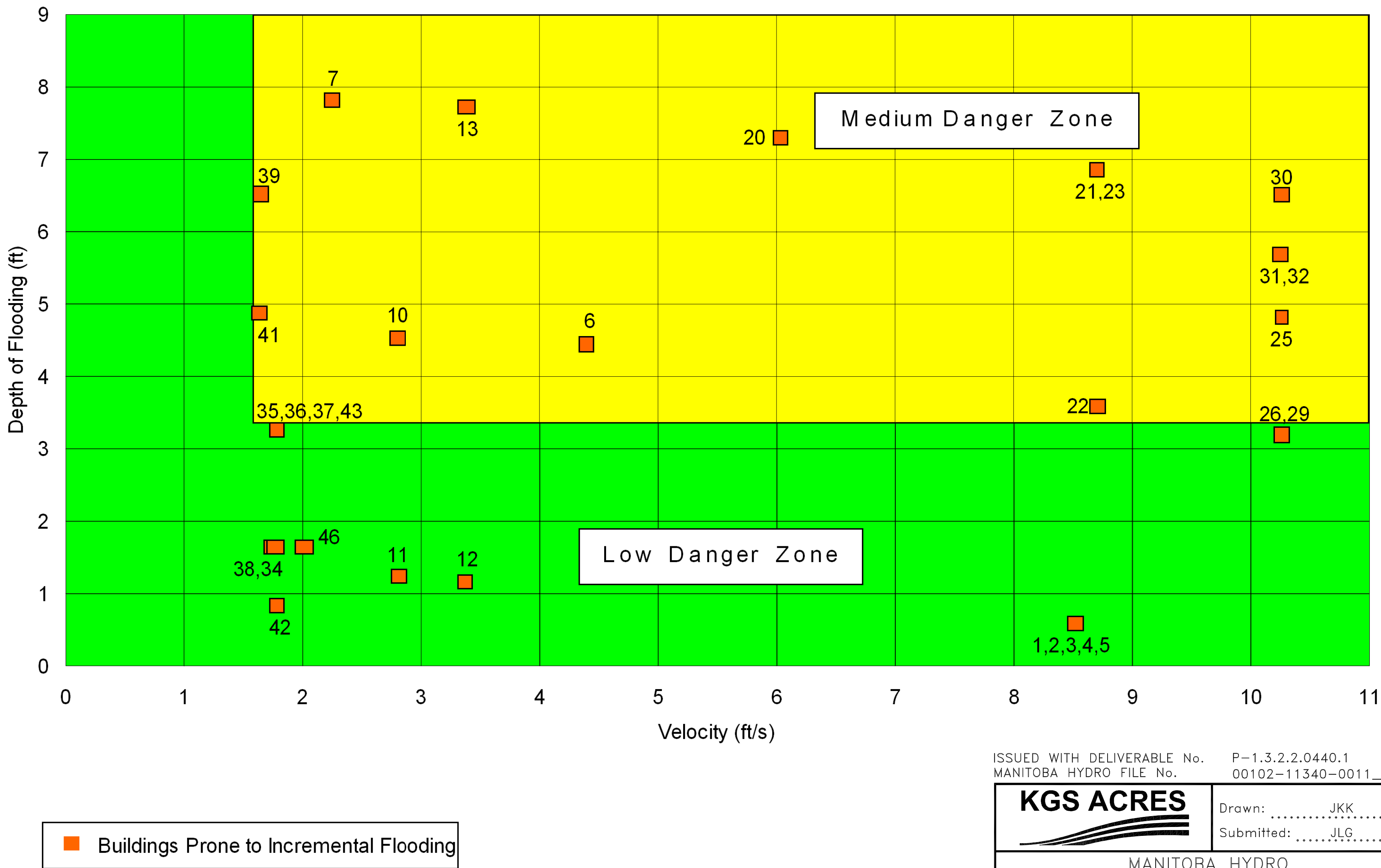
ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES

Drawn: JKK
Submitted: JLG

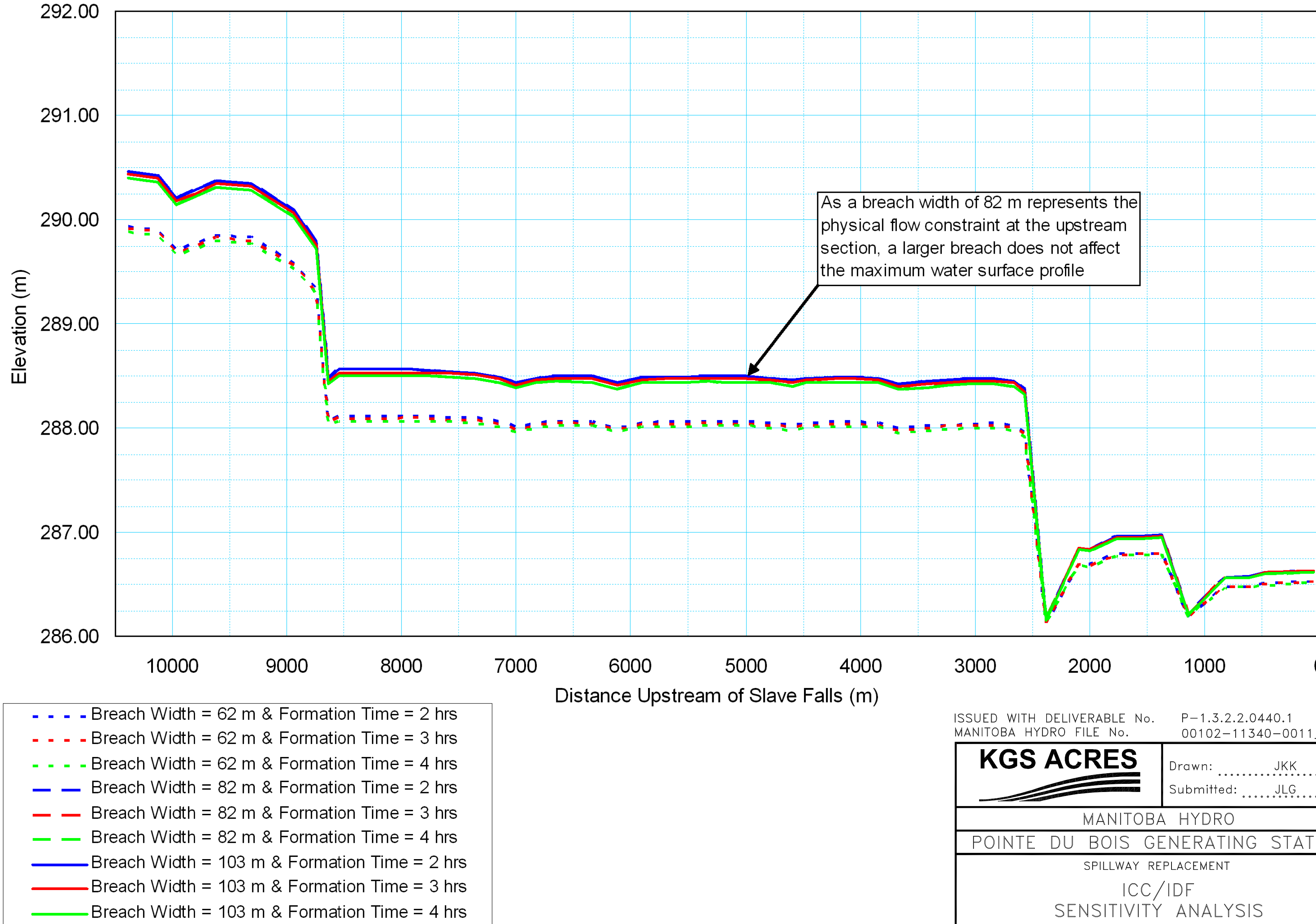
MANITOBA HYDRO
POINTE DU BOIS GENERATING STATION
SPILLWAY REPLACEMENT
ICC/IDF
SEVERITY RISK FOR BUILDINGS
BREACH SCENARIO 2

DECEMBER 2, 2011 | FIGURE 48



ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES	Drawn: JKK Submitted: JLG
MANITOBA HYDRO	
POINTE DU BOIS GENERATING STATION	
SPILLWAY REPLACEMENT ICC/IDF SEVERITY RISK FOR BUILDINGS BREACH SCENARIO 3	
DECEMBER 2, 2011	FIGURE 49



ISSUED WITH DELIVERABLE No. P-1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102-11340-0011_02

KGS ACRES

Drawn: JKK
Submitted: JLG

MANITOBA HYDRO

POINTE DU BOIS GENERATING STATION

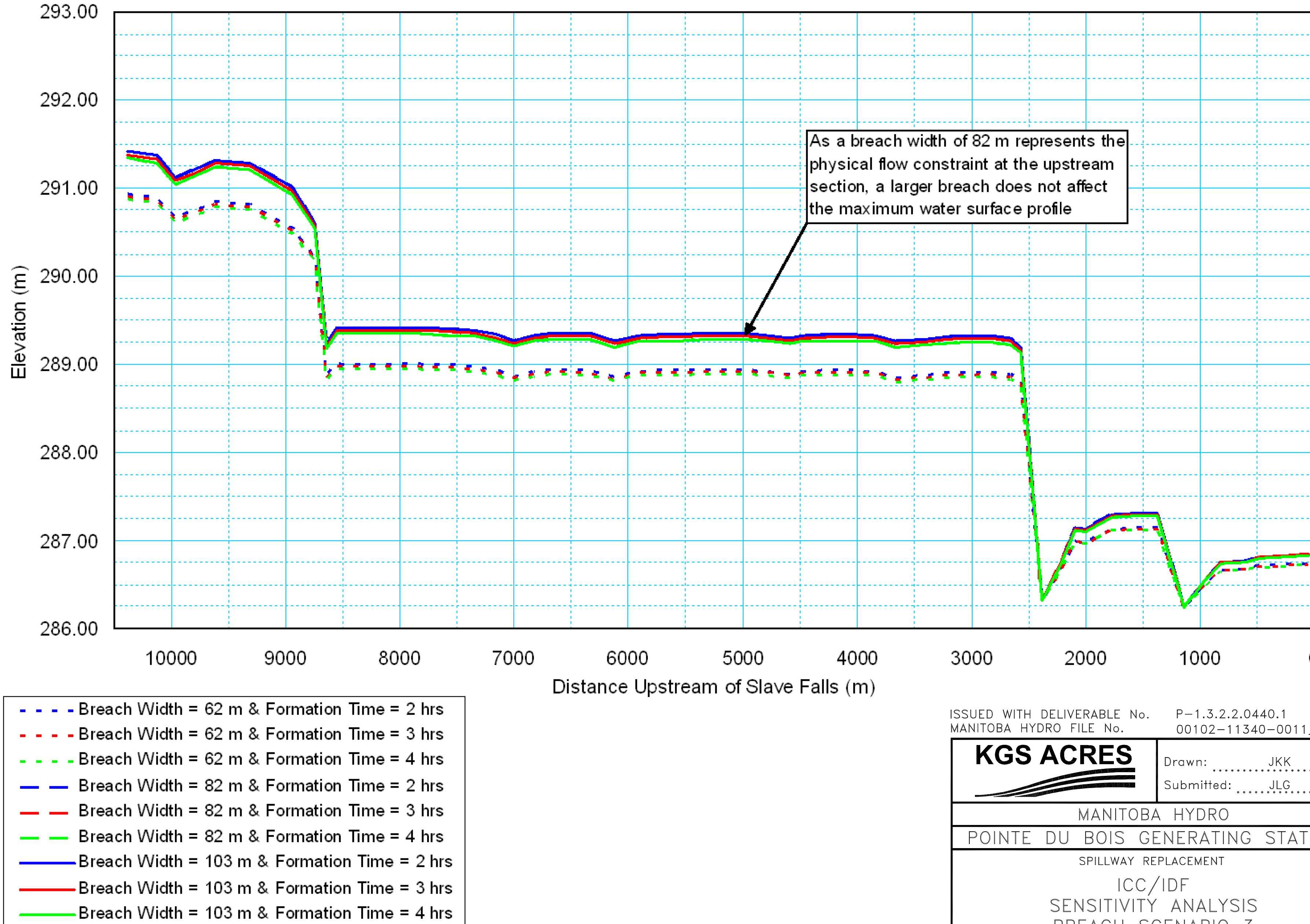
SPILLWAY REPLACEMENT

ICC/IDF
SENSITIVITY ANALYSIS
BREACH SCENARIO 2

DECEMBER 2, 2011 | FIGURE 50

FileName: P:\Projects\2010\10-0038-01\01.PhaseIV\200.Engineering\203.Drawings\Struct\1.3.2.2.0440.1\fig50_sensitivity4800.dwg – Tab: Model

81/2"x11" (216x279)



ISSUED WITH DELIVERABLE No. P–1.3.2.2.0440.1
MANITOBA HYDRO FILE No. 00102–11340–0011_02

KGS ACRES

Drawn: JKK
Submitted: JLG

MANITOBA HYDRO
POINTE DU BOIS GENERATING STATION
SPILLWAY REPLACEMENT
ICC/IDF
SENSITIVITY ANALYSIS
BREACH SCENARIO 3

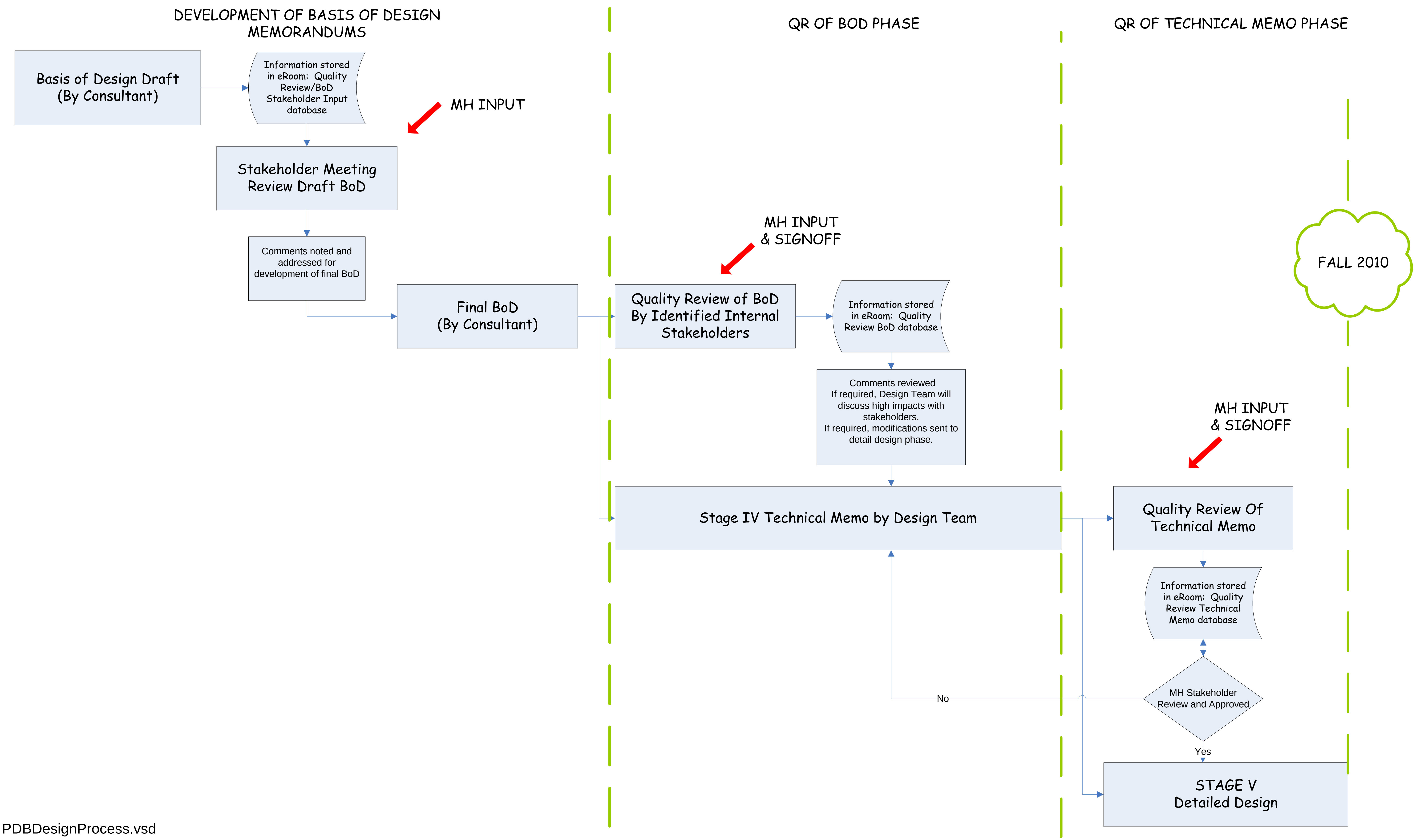
DECEMBER 2, 2011 | FIGURE 51

FileName: P:\Projects\2010\10-0038-01\01.PhaseIV\200.Engineering\203.Drawings\Struct\1.3.2.2.0440.1\fig51_sensitivity6570.dwg – Tab: Model 81/2"x11" (216x279)

Appendix A

Stage IV Design & Quality Review Process

Pointe du Bois
Stage IV Design & Quality Review Process



KGS ACRES

KGS ACRES Ltd
580-500 Portage Avenue, Winnipeg, Manitoba, Canada R3C 3X1
Tel: 204-786-8751 • Fax: 204-786-2242 • www.kgsacres.com

November 25, 2011
KGS ACRES Project No: 10-0038-01/H-334653

Manitoba Hydro
Winnipeg River Section
Hydro Power Planning Department
Power Projects Development Division
15th Floor, 360 Portage Avenue
Winnipeg, Manitoba
R3C 0G8

Attention: Mr. R.H. Penner, P.Eng.
Section Head

Dear Mr. Penner:

Pointe du Bois Spillway Replacement
Probable Maximum Flood Review
Deliverable No: P-1.3.2.2.0430.1 Rev 0
Manitoba Hydro File 00102-11340-0010_01

Please find enclosed the finalized KGS ACRES memorandum for the Probable Maximum Flood Review that has been adopted at Pointe du Bois. The memorandum has been revised with Manitoba Hydro's final Quality Review comments and reposted to eRoom and is now considered a final Stage IV product.

Should you have any questions, please contact Dave Brown or the undersigned.

Yours very truly,

for Dave B. MacMillan, P.Eng.
Project Manager

DBM/sml
Enclosure

KGS ACRES

Office Memorandum

To	Kevin Sydor, P.Eng.	**Date**	November 25, 2011
		File No.	10-0038-01/H-334653
From	David S. Brown, P.Eng. Brian Bodnaruk, P.Eng. Joe Groeneveld, P.Eng.	**cc**	Dave MacMillan, P.Eng.

Subject **Pointe du Bois Spillway Replacement**
Probable Maximum Flood Review
Deliverable P-1.3.2.2.0430.1 Rev 0
Manitoba Hydro File 00102-11340-0010_01

1 Summary

The Probable Maximum Flood (PMF) hydrograph for the Pointe du Bois Generating Station was first estimated in 1995 and is presented in the report entitled "Winnipeg Hydro Dam Safety Program Report on Hydraulic Studies and Inundation Maps", Acres 1995. An update to this study was completed in 2002 and presented in the report entitled "Pointe du Bois Dam Safety Hydraulic Studies Review", Acres 2002. This study shows that the PMF event at the Pointe du Bois and Slave Falls GS would result from a spring scenario, generated by the combined melt of a large snowpack and a spring Probable Maximum Precipitation (PMP) event. The peak flood estimate at Pointe du Bois was 6 570 m^3/s.

As part of the work for the Pointe du Bois Modernization Project, a review of the magnitude of the PMF was carried out, which included a review of the methods used in the derivation of the PMP and PMF. The review was undertaken with particular reference to the following:

- The principles and procedures outlined in the 2007 Canadian Dam Association (CDA) Dam Safety Guidelines;
- Guidelines presented by industry experts and leading authorities in PMF derivation retained by Alberta Transportation (2004);
- Report on PMP in Boreal Regions by the Canadian Electrical Association (1995);
- Report on PMF in Boreal Regions by the Canadian Electrical Association (1995); and
- World Meteorological Organization Manual for Estimation of PMP (1973).

As part of the review, the final value for the PMF was compared to PMF estimates produced on other Canadian rivers.

This memorandum documents the findings of the review of the existing study reports that defined the derivation of the PMF and comments on the procedures and applicability of the final PMF that has been adopted at Pointe du Bois.

Two magnitudes of the PMF have been determined as part of this work and are presented below.

- The PMF with a magnitude of 6 570 m^3/s as estimated by Acres in 1995, and
- A PMF with a magnitude of 9 900 m^3/s, which includes a breach at Caribou GS at the time of the flood.

2 Overview of the Stage IV Preliminary Engineering Process

2.1 General

The Stage IV engineering process for the Pointe du Bois Spillway Replacement Project included the input of all primary Manitoba Hydro Stakeholders, each with discrete, responsibilities within the Corporation. To ensure that the requirements of all Stakeholders were adequately addressed, a structured process was adopted for the Stage IV Engineering Studies, which allowed several opportunities for each Stakeholder group to provide input into the design and provide review and commentary on the design progress and deliverables. The stakeholders who participated in this process and a general description of the progress are provided in this section.

2.2 Stakeholders

The major Stakeholders for the Stage IV engineering process were as follows;

- *Hydro Power Planning Department* - responsible for the preliminary engineering phase of the project
- *Water Resources Engineering Department* - responsible for hydrotechnical studies related to the project
- *Engineering Services Division* - responsible for corporate technical engineering standards and dam safety aspects of the project

- *Generation South - Winnipeg River Stations and Generation Maintenance Engineering Departments* - responsible for operation & maintenance of the existing facilities at the site, and future operation and maintenance of the project infrastructure

- *Major Projects Licensing Department* - responsible for environmental studies and licensing of the project

- *New Generation Construction Division* - responsible for final detailed design and construction of the project

2.3 Stage IV Engineering Process

As noted above, a structured process was employed that allowed all of the Stakeholders several opportunities to provide input into and contribute to direction of the preliminary design process. This process entailed initial development of draft design criteria (called "Basis of Design") which was intended as a set of requirements and guidelines for the remainder of the design process; the design process itself, during which the design aspects themselves were advanced, reviewed and adapted as necessary; and a final documentation stage where the final outcome of the design process was reported upon in technical memoranda, or "Design Descriptions". The process is graphically illustrated in Appendix A.

3 Review of Probable Maximum Precipitation

The PMP procedures conducted by Acres Manitoba Ltd. (2002) followed procedures outlined in the 1995 issue of the CDA Dam Safety Guidelines. Since the estimation of the PMF in 1999, the CDA has reviewed and published a revised set of Dam Safety Guidelines in October of 2007. A review of the 2007 Dam Safety Guidelines showed that the procedures used to estimate the PMF are also consistent with these new guidelines.

Acres International (2006) assessed a number of rainfall / snowmelt combinations that could produce large floods on the Winnipeg River basin. These combinations include:

- A spring event involving the melt of maximized end-of-winter snowpack and moderately large spring rainstorm

- A spring event involving the melt of a moderately large end-of-winter snowpack followed by a maximized spring rainstorm.

- A summer event involving a maximized summer rainstorm falling on a wet basin.

PMP estimates based on all three of these combinations were used in a runoff model to derive the Winnipeg River PMF. The methods used to estimate the maximized snowpack accumulation and the maximized rainstorm are outlined below.

3.1 Probable Maximum Snowpack Accumulation (PMSA)

Acres International estimated the maximized end-of-winter snowpack based on the partial season method, using a partial season duration of one month. Other methods for estimating the Probable Maximum Snowpack Accumulation (PMSA), not used by Acres Wardrop (1995) include the statistical method and the snowfall maximization method. The statistical method requires that a standard frequency analysis be conducted on the available snow cover data/records at a site. The PMSA is then selected based on the results of this frequency assessment (e.g. selection of the 1 in 1000 year end-of-winter snowpack water equivalent). The snowfall maximization method involves reviewing the historical snowfall records and selecting one or two candidate years that exhibit the greatest snowfall accumulation. For each candidate year, each recorded snowstorm is maximized, as long as it is considered as an individual event based on its storm dynamics. The total accumulation over the winter is then the summation of all the maximized snowstorms. The snowfall maximization of each winter storm requires considerable effort and requires a significant amount of data such as upper air data, which is not generally available except for the most recent years. Although this method for estimating PMSA is recommended by the Canadian Electrical Association (CEA 1995), it is a bit impractical, and is not universally accepted in the industry due the extremely low probability associated with the maximization of a significant number of individual storms in the PMSA event.

The partial season method used by Acres Wardrop (1995) is an accepted industry standard for estimating the PMSA. The final PMSA value however varies with the length of the partial season, with higher values corresponding to the shorter partial seasons. The PMSA computed by Acres Wardrop (1995) using the one-month partial season essentially stacks the highest observed monthly snowpack water equivalents for the period of record in a back to back manner. The PMSA determined by Acres Wardrop (1995) will produce an acceptably high estimate of the PMSA for the maximized snowpack that KGS ACRES considers acceptable for analysis of the Winnipeg River PMF.

3.2 Rain Storm Maximization

Maximized rain storms for the summer and spring PMP estimates are typically determined from following two methods:

- using generalized PMP maps applicable to the drainage basin, and
- using storm maximization and transposition, which is referred to as the rational method as developed by the World Meterological Organization (WMO), 1973.

Since there are no generalized PMP maps available that are specifically related to the Winnipeg River Basin, this method is considered to be inferior to the rational method. Generalized PMP estimated for the Winnipeg River Basin could have been made by extrapolating information from the generalized PMP maps prepared for the United States for areas east of the 105th meridian (Hansen et al. 1982), but this would have required extrapolation of charts that exist only to the US–Canada border.

Acres Wardrop (1995) used the traditional approach of storm maximization and transposition for the estimate of the PMP. This method is regarded as an appropriate method, especially if site specific generalized PMP mapping is not available. It is also considered to be an industry standard approach applied to determine the PMP for large basins, provided suitable large storms have been recorded and cover the watershed under review. Since there were a number of candidate storms available for maximization for the Winnipeg River, the rational method used by Acres Wardrop (1995) is considered to be superior approach.

For the Winnipeg River PMP, the largest historical storms observed in the area of the Winnipeg River basin were transposed and maximized on the basis of maximum moisture for the time of the year. The storm identified as ONT-09-41, centered in Sioux Lookout, Ontario with rainfall occurring during the period from September 18-22, 1941, was shown to have the greatest basin average depth of precipitation when maximized. This storm was used to produce both a spring snowmelt and maximized rainfall scenario and a summer maximized rainfall scenario for determining the PMF. Figures 01 and 02 illustrate the ONT-09-41 storm, maximized for moisture inflow and positioned over the basin for the spring and summer PMP rainstorms, respectively.

The summer PMP required that the ONT-09-41 storm be transposed to the Winnipeg River basin and maximized for the date of occurrence and for the summer season based on maximum moisture inflow. Surface observed dew point temperatures were used to scale the observed storm to the mid-July maximized storm precipitable water using the design charts in the WMO, 1973 manual. For the summer PMP, the date of the storm needed to be moved by approximately two (2) months to the mid-July date. The WMO guidelines suggest that there are limitations on seasonal maximization due to seasonal variations in storm structure. The WMO recommends that storms be maximized on the basis of the maximized due points within fifteen (15) days of the storm. The method does allow for longer durations provided that meteorological studies show that similar atmospheric conditions that produced the storm could have also occurred at the earlier period.

Maximizing the storm for the mid-July period summer PMP as done by Acres Wardrop (1995) is slightly longer time shift than recommended, however, it is considered to be acceptable, given that there are a limited number of storms available for review. Time shifting the storm to the April period used in the spring PMP, however, is normally considered to be well beyond the accepted limits for seasonal adjustment for maximizing a September storm. Although, the time adjustment for spring PMP derivation is often not strictly applied, since there are not many storms available for analysis in the spring period. The reduction in the storm precipitable water using the seasonal variation in inflow dew points to the spring period is considered to be acceptable for the Winnipeg River PMP.

Acceptance of the spring PMP maximization using the September storm was also supported by the review of the PMP by Atmospheric Environment Service (AES) in 1994 for the Acres Wardrop (1995) PMF estimate.

Subsequent to the 2002 49^{th} Parallel Storm, Acres International (2006) reviewed the development of the PMP to determine if the PMP should be revised for the Winnipeg River based on the 2002 storm. This storm, which occurred from June 8 to June 11 of 2002, was the largest rainstorm that was observed in the area. The maximum rainfall for the centre of the storm over a drainage area of 100 km^2 produced 360 mm of rain. The corresponding rainfall depth over 10,000 km^2 and 100,000 km^2 was also the highest on record at average rainfall depths of 284 mm and 159 mm.

Figure 03 shows a comparison of the rainfall depth-area relationships for the ONT-09-41 and the June 2002 49^{th} Parallel Storms. The maximized depth for the June 2002 storm is 15% to 20% greater than the ONT-09-41 storm for areas up to 25,000 km^2, but is approximately 10% greater for a basin area of 100,000 km^2. The drainage area for the Winnipeg River basin is 135,500 km^2. However, when the two storms are transposed and positioned over the Winnipeg River basin to maximize the runoff volume over the critical lower portion of the basin, the maximized precipitation on the Winnipeg River basin is greatest for the ONT-09-41 storm. The rainfall volume for the ONT-09-41 storm is 25,900 million m^3 compared to 21,750 million m^3 for the June 2002 storm. Although the June 2002 storm is shown to have basin rainfall depths that are approximately 15% to 20% greater than the ONT-09-41 storm, the isohyethal pattern for the June 2002 storm was shown to be more elongated. As a result, it does not fit the shape of the Winnipeg River and therefore a greater percentage of the rain falls outside of the Winnipeg River Basin.

KGS ACRES supports the conclusion by Acres International (2006) that the ONT-09-41 storm be used as the governing storm for determining the spring and summer PMP for the Winnipeg River at Pointe du Bois. As well, KGS ACRES supports the methods that were used by Acres International (2006) to estimate the PMP.

4 Probable Maximum Flood

4.1 Introduction

The PMF estimate was determined by Acres Wardrop (1995) using acceptable rainfall-runoff models to translate the PMP to flood runoff. These included a combination of the SSARR hydrologic model to determine runoff and the DAMBRK hydrodynamic routing model to route the runoff hydrographs though the Winnipeg River system. These methods are accepted as appropriate model for the determination of the PMF.

The final estimate of the PMF involves judgement and uncertainty in the various parameters and the combinations of these parameters. The uncertainty in the derivation of the PMF includes:

- The estimate of the rainfall and snowpack depth and the spatial and temporal distribution.
- Temperature sequences used in the melting of the end of winter snowpack.
- Antecedent basin conditions prior to the critical precipitation event.
- The representation of the basin as a series of river and lake storage elements.
- Model parameters and calibration.

Some of the factors vary according to the season and the severity of the flood scenario. For a PMF to be considered as a reasonable estimate of the probable maximum, the principal storm is typically assumed as the maximum probable event, other factors should be assumed severe but not necessarily extreme.

The PMF study by Acres Wardrop (1995) was reviewed in this regard to insure that the PMF estimate is considered to be a reasonable estimate of the probable maximum and not the highest possible value.

4.2 PMF Based on ONT-09-41 Rainstorm

The ONT-09-41 rainstorm, maximized for the spring and summer periods, as discussed in Section 3, and shown in Figures 01 and 02, was translated to runoff using the SSARR hydrological model. The following conditions were assumed for the PMF derivation:

- The Lake St Joseph basin was not modeled hydrologically. Rather the Lake St Joseph Diversion flows were set equal to the maximum mean monthly discharges on record for each month of the PMF simulation.
- The reservoir levels at Norman Dam (Lake of the Woods), Manitou Falls, Ear Falls, Caribou Falls, Whitedog and Pointe du Bois were assumed to be operated at the summer Full Supply Level (FSL) at the PMF. The reservoirs were assumed to surcharge as required to pass the PMF inflow. The dams upstream of Pointe du Bois were assumed not to fail during the passage of the PMF.
- Water levels on uncontrolled lakes in the basin were assumed to be at the 1 in 10 year level at the end of winter for the spring PMF to represent the carry over effect of the previous year high flow year. The same conditions were assumed for the summer PMF

condition to represent the lake levels resulting from a 1 in 100 year rainstorm prior to the PMF.

- Base flow conditions on the rivers were assumed at the highest recorded mean monthly discharge at the time of the PMF.
- Powerhouse discharges were assumed at speed-no-load.
- The basin soil conditions were assumed to be near saturation at the time of the PMF. For the spring PMF, this condition would be representative of the frozen soils at the time of the basin snowmelt. The antecedent soil moisture for the summer PMF was determined by applying the 1 in 100 year rainstorm prior to the PMP with the resulting soil moisture conditions used as the initial soil moisture for the SSARR model simulations.
- The snow water equivalent for the end of winter snowpack for the spring PMP combined with melt of the end-of-season snowpack was assumed as the basin average 1 in 100 year value of 180 mm. The PMF based on a maximized end-of winter snowpack combined with a severe rainfall event (1 in 100 year spring rainstorm) was shown to be less severe in terms of maximum flood runoff. The partial season method of snowfall accumulation was used for determining the maximized snowpack.
- Since temperature sequences during the snowmelt period and the maximized PMP rainfall depth vary with time, a number of different times were assumed for the spring PMP. Maximum runoff was computed with the spring PMP assumed to occur on April 19th.
- The temporal distribution of the PMP was based on the observed rainfall pattern for Sioux Lookout, Ontario, the location of the centre of the ONT-09-41 rainstorm.
- The governing position for the storm on the Winnipeg River Basin was that shown on Figures 01 and 02.

As noted above, the Winnipeg River PMF was initially determined using the SSARR model to compute runoff hydrographs resulting from the PMP. The results of the SSARR hydrological model runs for the PMSA PMF and spring and summer PMP scenarios resulted in computed peak PMF discharges at Pointe du Bois of 6 800 m^3/s, 7 250 m^3/s and 6,850 m^3/s, respectively. On this basis, the spring PMP scenario was selected to be the governing scenario for determining the PMF for Winnipeg River at Pointe du Bois. The SSARR model setup and calibration used for the PMF assessment is described in detail in the Acres Wardrop (1995) report.

The final PMF discharge at Pointe du Bois was determined using the US National Weather Service DAMBRK hydrodynamic model. This was done since the SSARR river routing procedures are simple storage routing methods that require observed hydrographs to determine time of storage parameters for the river reaches and is considered to be inferior to hydrodynamic routing methods. The DAMBRK model is a hydrodynamic model originally developed to model the movement of a flood wave down a river system resulting from a dam failure. This model allows for a more accurate solution of the water level through channel constrictions such as the reach upstream from the Manitou Falls Generating Station, between Caribou Falls and the Manitou Falls GS and the river reach from Caribou Falls to Lamprey Falls near Pointe du Bois. This model was used in place of the SSARR model to assess the movement of the flood wave down the main stem river reaches.

The DAMBRK model was run for only the governing spring condition as identified by the SSARR model. The individual sub-basin runoff hydrographs developed using the SSARR model were input to the DAMBRK river routing model. These hydrographs represent tributary runoff to the main stem of the river. The peak discharge for the PMF at Pointe du Bois was estimated as 6 570 m^3/s using the DAMBRK model as compared to the previous estimate of 7 250 m^3/s using the SSARR model. The final estimate of the PMF was therefore considered to be 6 570 m^3/s.

4.3 PMF Based on June 2002 Rainstorm

The SSARR model that was used for the spring ONT-09-41 PMF scenario was used to determine the PMF discharge based on a new PMP event that was derived from the June 2002 storm. All model parameters were unchanged for this scenario, except that the rainfall input was modified to reflect the new PMP event. The revised model results showed that the PMP based on the June 2002 rainstorm produced a PMF peak flow value of 6 240 m^3/s which is less than PMF peak flow of 6 570 m^3/s for the ONT-09-41 based PMP. The computed peak discharge at Pointe du Bois for the summer PMF scenario computed with the June 2002 maximized rainstorm is 4 800 m^3/s.

4.4 Pointe du Bois PMF Hydrograph

As noted above, peak discharge for the Winnipeg River at Pointe du Bois PMF was adopted as 6 570 m^3/s. The flood hydrograph illustrating that has been defined for the PMF is shown on Figure 04. The PMF hydrograph was developed using the DAMBRK hydrodynamic routing model to route the tributary flows down the main stem rivers in the Winnipeg River basin.

4.5 Consideration of Upstream Breach on Magnitude of PMF

There are a number of major dams located upstream of Pointe du Bois. Based on the existing infrastructure at these plants, it is considered likely that some of these structures would be overtopped during a very large flood event such as a PMF. In the previous hydrological studies it was assumed that these structures would not fail during the PMF, but rather that they would either survive the overtopping event, or that appropriate modifications would be made to the project infrastructure (by the dam's owner) to enable them to safely pass these events.

As a part of subsequent dam safety reviews conducted by others, it was suggested that a separate estimate be made to take into account the effects of upstream dam breaches during a PMF event. In response to this request, additional model simulations were conducted to assess the impact an upstream breach would have on peak inflows to the Pointe du Bois during passage of the PMF event. The hydrodynamic dam breach model that was setup and used in the previous studies (as described in Section 4.2), was remobilized and modified to simulate an upstream failure.

To do this, the existing DAMBRK models were modified to allow the formation of an upstream breach. Because all of the upstream dams were already included in the original model setup, modifying the models to include a possible upstream dam failure was accomplished by simply modifying breach parameters for these dams.

Of the dams located upstream of Pointe du Bois, the most critical for a breach that would affect Pointe du Bois is Caribou Falls, located on the English River just above its confluence with the Winnipeg River. A failure of this dam formed the primary focus for this assessment. It was assumed that a breach would form in the most critical embankment dam (Block Dam 2) during the PMF once it had been overtopped by approximately 0.3 m.

Other structures located upstream of Pointe du Bois were not expected to have a significant impact should they breach. For example, under large flood events friction losses within the Whitedog Generating Station reservoir cause it to essentially become a "run of river" station, and there is little storage that can actually be released in the event of failure. Likewise, a breach in the Norman Dam would not result in an uncontrolled release of water, since the upstream river channel (located between Lake of the Woods and the project) would control outflow from Lake of the Woods. A similar hydraulic restriction exists upstream of the Manitou Generating Station, limiting the possible release of water from Pakwash Lake. Finally, the Ear Falls Dam, located above the Manitou Falls Dam, is a relatively low head structure. The magnitude of uncontrolled breach flows associated with a dam break event at this location are therefore considerably smaller than those associated with a breach event at the Caribou Falls Generating Station.

Two model simulations were conducted based on failure of the Caribou Falls Generating Station during a large flood event. Each is briefly described below:

Scenario 1: Failure of the Caribou Falls Dam during the Pointe du Bois PMF – For this scenario, it was assumed that the Caribou Falls Dam would fail during passage of the Pointe du Bois PMF. It should be noted that the storm position assumed for this PMF event is unchanged from that used and adopted in the original PMF studies for Pointe du Bois (as opposed to the storm position adopted for a Caribou Falls PMF event). In routing this flood, it was assumed that the reservoir level for the Caribou Falls Dam would initially be at the normal FSL, and that spillway capacity would be mobilized as necessary to prevent the level from exceeding FSL. Once the capacity of the spillway at FSL is reached, the reservoir would begin to surcharge, eventually leading to overtopping of the dam. It was assumed that the dam would not fail until overtopped by at least 0.3 m. Once this occurred, it was assumed that a breach would form in Block Dam 2, which is the largest/highest earthen structure. The results for this simulation are summarized in Figure 05. These results indicate that this failure would generate a peak inflow to the Pointe du Bois site of 9 900 m^3/s. This is approximately 3 300 m^3/s larger than the "no-failure" Pointe du Bois PMF estimate of 6 570 m^3/s.

Scenario 2: Failure of the Caribou Falls Dam during a more Moderate Flood Event – In this scenario, it was assumed that the dam would fail during a flood that was just large enough to cause the overtopping of Block Dam 2. This was considered to be significant since it is the point in the flood frequency regime in which the risk of breach formation at Caribou Falls begins to increase significantly. This would occur under approximately a 1 in 10,000 year flood at Pointe du Bois, based on the storm position adopted in the PMF study. For this scenario, PMF inflow hydrographs were scaled down such that the highest water level reached on Umfreville Lake (the Caribou Falls GS Forebay) would nominally overtop the crest of the dam. It was assumed that Block Dam 2 would fail under this scenario. Figure 06 illustrates that the peak flow reached at Pointe du Bois would be approximately 8 600 m^3/s. This is approximately 3 300 to 3 400 m^3/s larger than the "no failure" scenario for Pointe du Bois during passage of the 1 in 10,000 year flood.

The governing flow case for each of the two scenarios outlined above would be Scenario 1, which indicates that should a breach form at the Caribou Falls GS during passage of the PMF, the peak discharge at Pointe du Bois would be as high as 9 900 m^3/s.

5 Discussion of Winnipeg River PMF Estimate

The PMF estimate for the Winnipeg River described above has been developed based on sound engineering analysis and has been reviewed and updated periodically. Following the completion of the original study in 1992, the PMF estimates were independently reviewed by

Klohn-Crippen during the Seven Sisters GS Dam Safety Review (DSR) in 1998. Additional sensitivity studies have been undertaken since then to update estimates and address any issues identified in these past DSR's.

To provide further review, as a part of this assessment the methodology, described in the previous sub-sections, used in the selection of the PMP and the determination of the PMF discharge were compared to methods used by other authorities and agencies. One such report prepared for Alberta Transportation (2004) is a compendium of methods developed by a panel of experts from across Canada. This document includes input from a number of practitioners involved in meteorology, extreme flood analysis and the design of water management projects. The key recommendations from this report for extreme flood determination were compared to methods used by Acres International (2002) for the Winnipeg River PMF analysis without the inclusion of an upstream dam breach.

The methods used in the Winnipeg River PMF determination follow the key guidelines from the Alberta Transportation document, including the use of antecedent rainstorm prior to the PMP, initial soil moisture levels, and initial snowpack water equivalent coincident with the spring PMP. Long term average lake levels were recommended for natural lake elevations at the start of the antecedent condition with FSL levels on regulated reservoirs. The 1 in 10 year level on natural lakes with FSL on regulated reservoirs was used for the Winnipeg River PMF. The recommended approach for the determination of the PMP was to use generalized PMP mapping to estimate the PMP, if the maps exist and to use the rational method of storm maximization and transposition as the alternative if site specific PMP maps are not available. As discussed in Section 3.0, the WMO rational method was used for the Winnipeg River PMP in the absence of site specific generalized PMP mapping.

When compared with the estimate of the 1 in 10,000 year flood, (Figure 07) the PMF, as estimated to be 6 570 m^3/s, is shown to be approximately 1.23 times larger. The ratio for other PMF estimates is typically in the range of 1.5 to 2.0. The computed ratio for the Winnipeg River falls below the typical range. Lower ratios are, however, typical of streams having significant lake and reservoir storage, which tends to limit maximum flows due to a large amount of storage attenuation. For comparison, the ratio of the PMF to the 1 in 10,000 year flood for the Saskatchewan River at the E.B. Campbell Dam is 1.43.

Another procedure for evaluating the validity of the PMF is to compare the unit discharge associated with peak flows on the Winnipeg River with those of other river basins located within Canada. This method is referred to as the Creager method. The Creager diagram, presented in Watt's book "Hydrology of Floods in Canada" summarizes a database of "unusual flood discharges" that have been compiled for a number of rivers. The Creager equation, used to provide a regression fit to the data, relates the expected unit peak flow on a basin, in $m^3/s/km^2$, to the basin area. The coefficient "C" in the Creager equation typically varies depending on the productivity of the basin. Basins that are flashy and respond quickly, such as mountain streams, will generally have a higher C value, whereas basins that are not as quick to respond which have significant storage or draining flatter prairie regions will have lower C values.

Figure 08 has been prepared in the Creager format to summarize extreme flood flows expected or observed on a number of Canadian river basins. The unit discharge for the Winnipeg River PMF is 0.048 $m^3/s/km^2$, which lies below the extreme range of historical Canadian floods, as shown on Figure 08. The attenuation of the runoff by the numerous lakes and reservoirs in the Winnipeg River watershed is a major factor in the lower unit runoff rate. When compared to other estimates of PMF, the Winnipeg River PMF estimate is considered to be a reasonable estimate.

The PMF for the Winnipeg River at Pointe du Bois is based on the maximum runoff for the lower Winnipeg River downstream from the Manitoba-Ontario boundary as a result of a storm positioned over the lower portion of the English River basin and the Winnipeg River. The computed PMF discharges on the English River at the dams at the Ear Falls, Manitou, and Caribou Falls GS, have been based on a different storm positioning from that used for the Winnipeg River at Pointe du Bois. The PMF discharges at each of the English River dams exceed the total spill capacity at each of the three locations (Acres Manitoba 2002) and overtopping of the dams at each location would occur with a potential to fail during the separate PMF events. However, it is unlikely that coincident floods on the Winnipeg River system upstream of Lake of the Woods and the development of the PMF on the lower basin would result in failure of any structures on the upper Winnipeg River system. This is due to the fact that maximum flows on the lower Winnipeg River require that the PMP storm be positioned over the lower reaches of the English River and Winnipeg River basins with relatively little falling on the upper Winnipeg River basin.

As a final perspective on the Winnipeg River PMF, the assumptions used in the development of the PMF have been compared to those used by other agencies that have conducted PMF analyses and which have been documented. These agencies include Alberta Transportation (AT), U.S. Army Corps of Engineers (USACE), the American Nuclear Standard (ANS), the Tennessee Valley Authority (TVA), the Soil Conservation Service (SCS), the U.S. Bureau of Reclamation (USBR), the U.S. Weather Bureau (USWB), the Canadian Dam Association (CDA), and BC Hydro. The assumed values for the model parameters and assumptions used in the derivation of the Winnipeg River PMF are compared to those used by other agencies as shown in Table 1.

Table 1:
Pointe du Bois Spillway Replacement
Probable Maximum Flood Review
Comparison of Assumptions used in the Derivation of the PMF

PMF Component	Parameters Used by the Various Agencies	Parameters used in PMF for the Winnipeg River
Principal Storm	Probable Maximum Precipitation – AT Probable Maximum Precipitation – CDA Probable Maximum Precipitation – USWB USBR Probable Maximum Storm – USBR	Probable Maximum Precipitation
Antecedent Condition	1% probability snowpack with wet antecedent conditions at PMP – AT Snowmelt of 100 Yr. Snow Accumulation – CDA 40 Percent of PMP – ANS Standard Project Flood 5 days prior – USACE 1% chance flood peaking in reservoir 10 days prior – SCS 15 to 20% of PMP depending on watershed size and location – TVA 1% flood (100 year) - USBR 0.1% probability snow pack (1000 yr) – BC Hydro	1% probability snow pack with wet antecedent soil condition at PMP
Loss Rates or Initial Moisture Condition	Minimum Loss Rate from saturated soil following snowmelt – AT Observed During Maximum Flood – CDA Median Soil Moisture – ANS Minimum Infiltration – USACE Curve Number for Antecedent Moisture Condition II – SCS Median values observed prior to recorded storms – TVA Minimum Retention Loss Rates – USBR As determined by calibrated SSARR model – BC Hydro	Minimum loss rates consistent with saturated soil as determined by SSARR model
Rainfall Time Distribution	Largest Increment Placed in Centre of Storm – AT Distribution of Candidate Storm – CDA Most Critical possible for Region – ANS Sequence that gives maximum Peak flow – USACE Average Mass Curve – SCS, TVA Avg. Mass Curve with Critical Arrangement of 6 hr rainfall – USBR Distribution of PMP Candidate Storm – BC Hydro	Based on Distribution of PMP Candidate Storm
Initial Reservoir Condition	Full Supply Level – AT Upper Level of Operating Rule – ANS Top of Conservation Pool or one-half Flood Control Storage – USACE 1% chance Flood Peaking 10 days Prior – SCS Median at Start of Storm Sequence – TVA Full Supply Level – BC Hydro	Full Supply Level

Source: "Realistic Assessment of Maximum Flood Potentials" by D.W. Newton (TVA), A.S.C.E. Journal of Hydraulic Engineering, Vol. 109, No. 6, June 1983

6 Conclusions

Based on KGS ACRES review of the Winnipeg River PMF at Pointe du Bois, the following conclusions are made:

- The methodologies used to estimate both the probable PMP and the PMF follow the recommendations of the various guidelines.

- KGS ACRES considers the methodologies and assumptions that were used to determine the PMP and PMF as acceptable for the Winnipeg River at Pointe du Bois. This finding is consistent with that of other independent reviews.
- When compared to other extreme historical Canadian floods, the unit discharge of the Winnipeg River PMF without an upstream dam breach included is shown to be a reasonable estimate for Pointe du Bois.
- The PMF estimate was based on the assumption that the upstream structures on the Winnipeg and English River systems would likely not fail during the PMF. An estimate of a PMF that includes an upstream dam breach has also been made.
- Two magnitudes of the PMF have been determined and are presented below.
    - The PMF with a magnitude of 6 570 m^3/s as estimated by Acres in 1995, and
    - A PMF with a magnitude of 9 900 m^3/s, which includes a breach at Caribou GS at the time of the flood.

7 References

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12) World Meteorological Organization, 1973, "Manual for Estimation of Probable Maximum Precipitation".

13) Watt, W.E. et al, 1989, "Hydrology of Floods in Canada"

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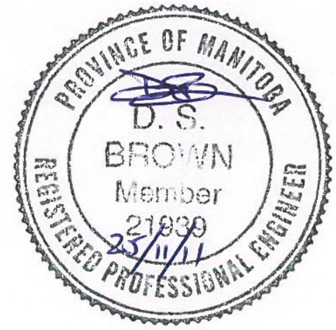
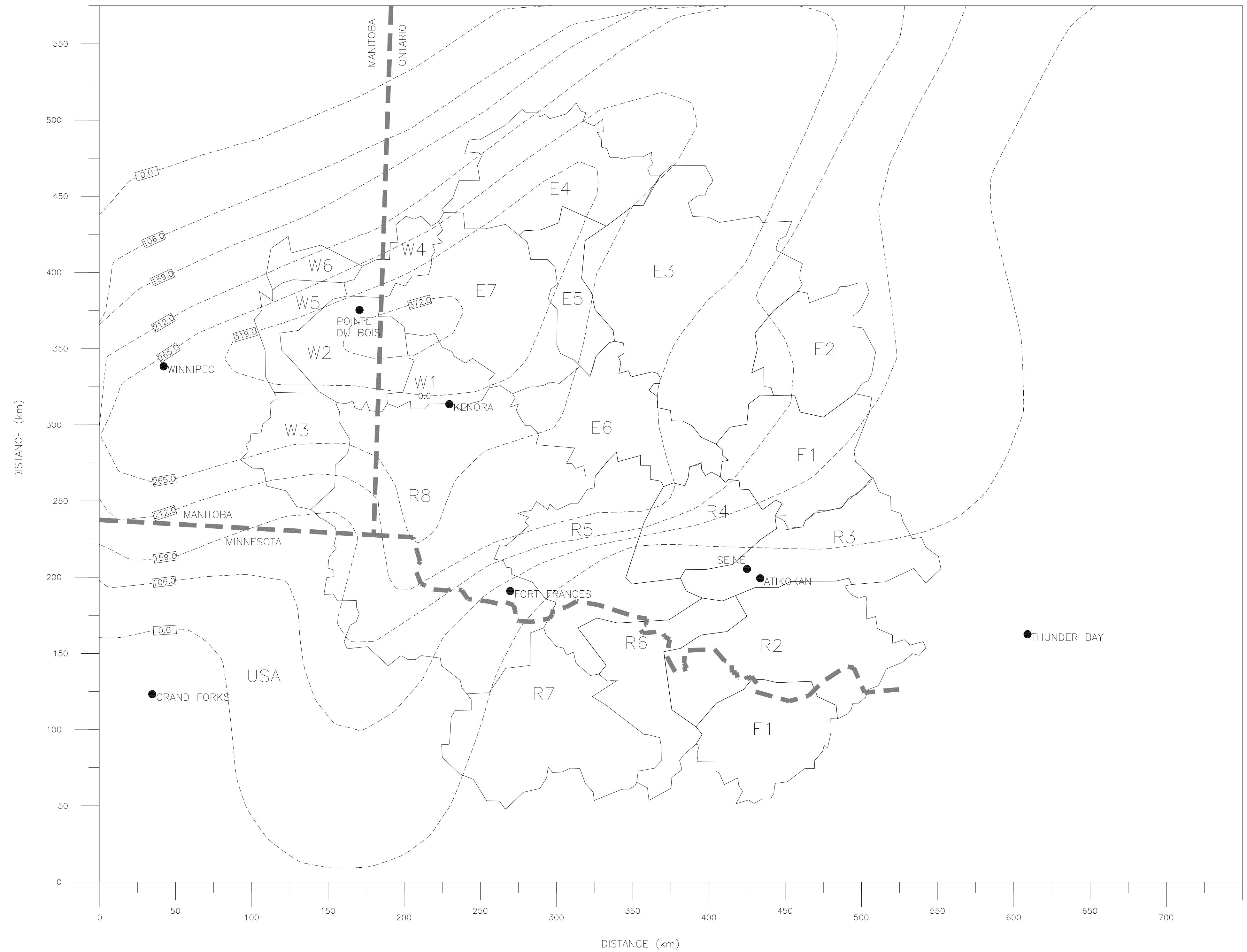


Figures 01 - 08
Appendix A

DSB/sml

Figures



NOTE:
1. RAINFALL DEPTHS ARE IN MILLIMETRES.

0 30 60 90 120 150km

ISSUED WITH DELIVERABLE No. P-1.3.2.2.0430.1
MANITOBA HYDRO FILE No. 00102-11340-0010_01

KGS ACRES

Drawn: PNT
Submitted: DSB

MANITOBA HYDRO
POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT
PROBABLE MAXIMUM FLOOD REVIEW
ONT-09-41 PMP STORM
ISOHYETS SPRING PMP

NOVEMBER 25, 2011 | FIGURE 01

11"x17"

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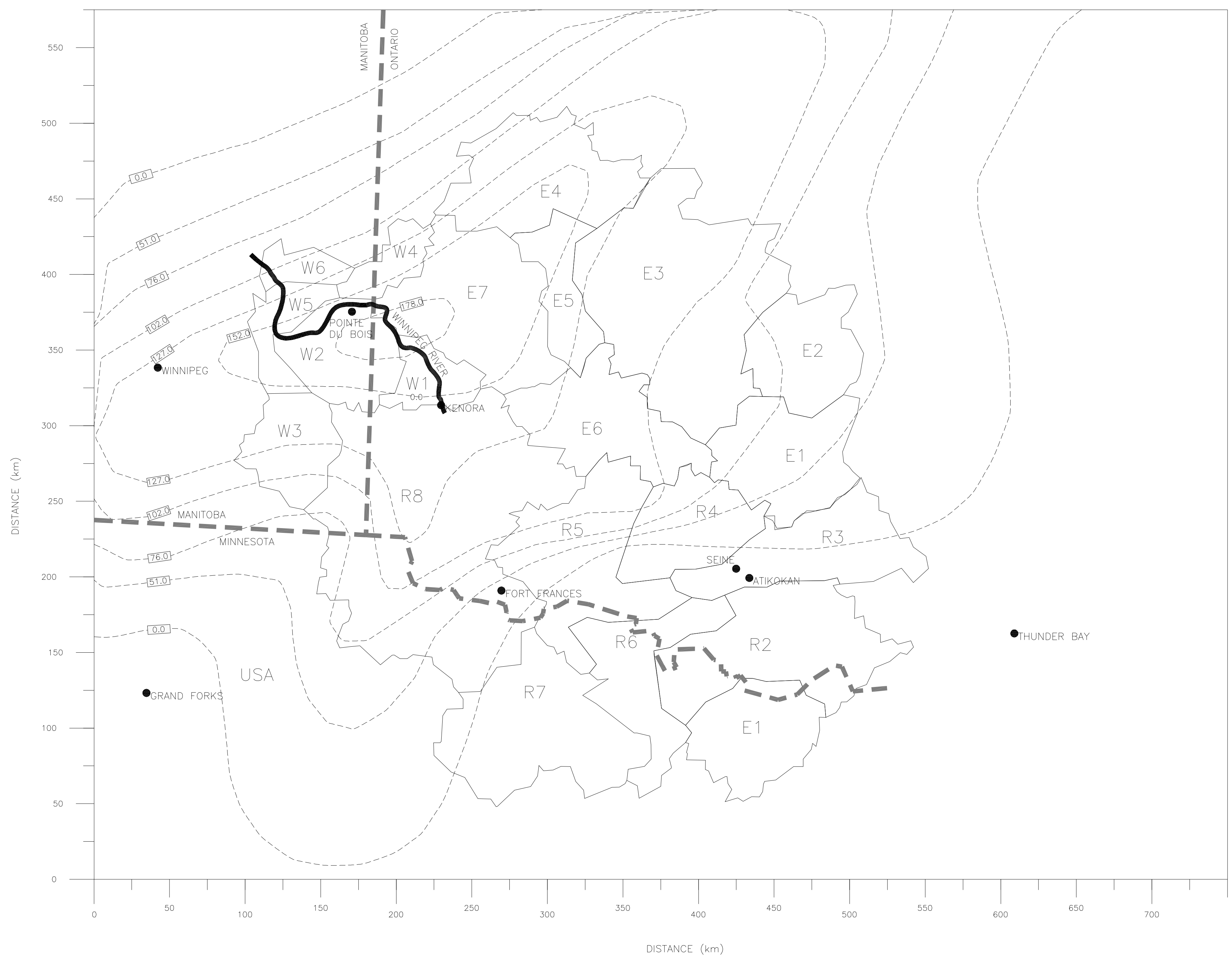

NOTE:
1. RAINFALL DEPTHS ARE IN MILLIMETRES.

0 30 60 90 120 150km

ISSUED WITH DELIVERABLE No. P-1.3.2.2.0430.1
MANITOBA HYDRO FILE No. 00102-11340-0010_01

KGS ACRES

Drawn: PNT
Submitted: DSB

MANITOBA HYDRO

POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT

PROBABLE MAXIMUM FLOOD REVIEW
ONT-91-41 PMP STORM
ISOHYETS SUMMER PMP

NOVEMBER 25, 2011 | FIGURE 02

FileName: P:\Projects\2010\10-0038-01\01.PhaseV\200.Engineering\203.Drawings\Struct\1.3.2.1.0390.1\1.3.2.2.0430.1\10-0038-01-Figure 02_R01.dwg – Tab: Layout 1 Plotted By: JRemillard 11/11/22 [Tue 9:54am]

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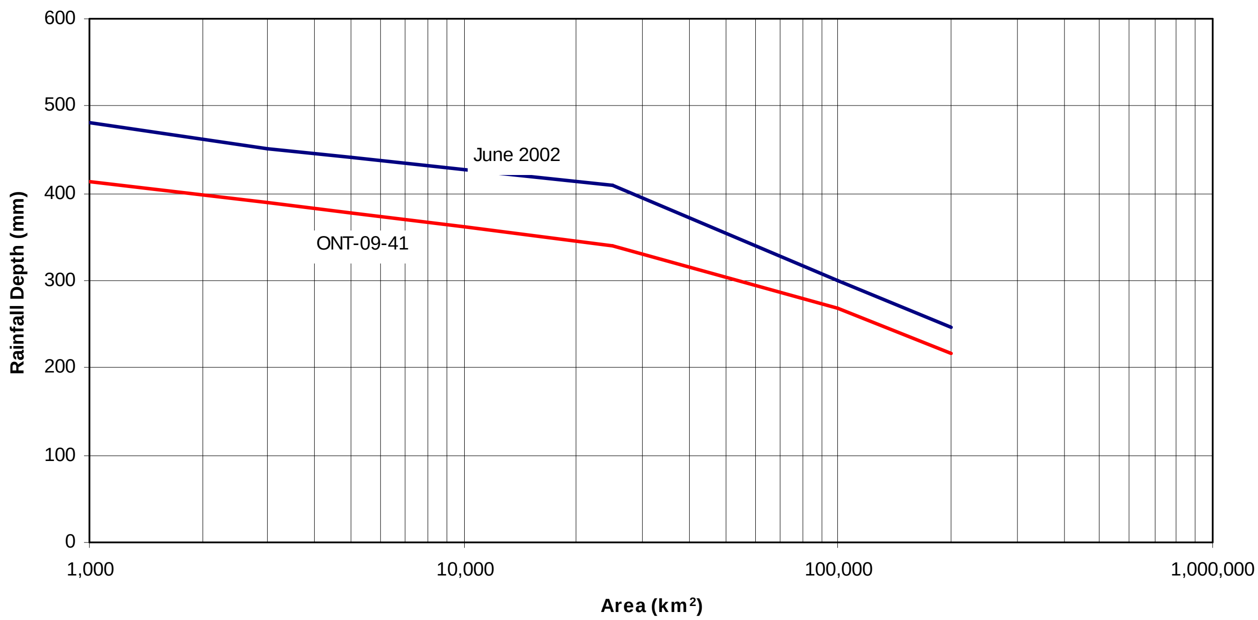

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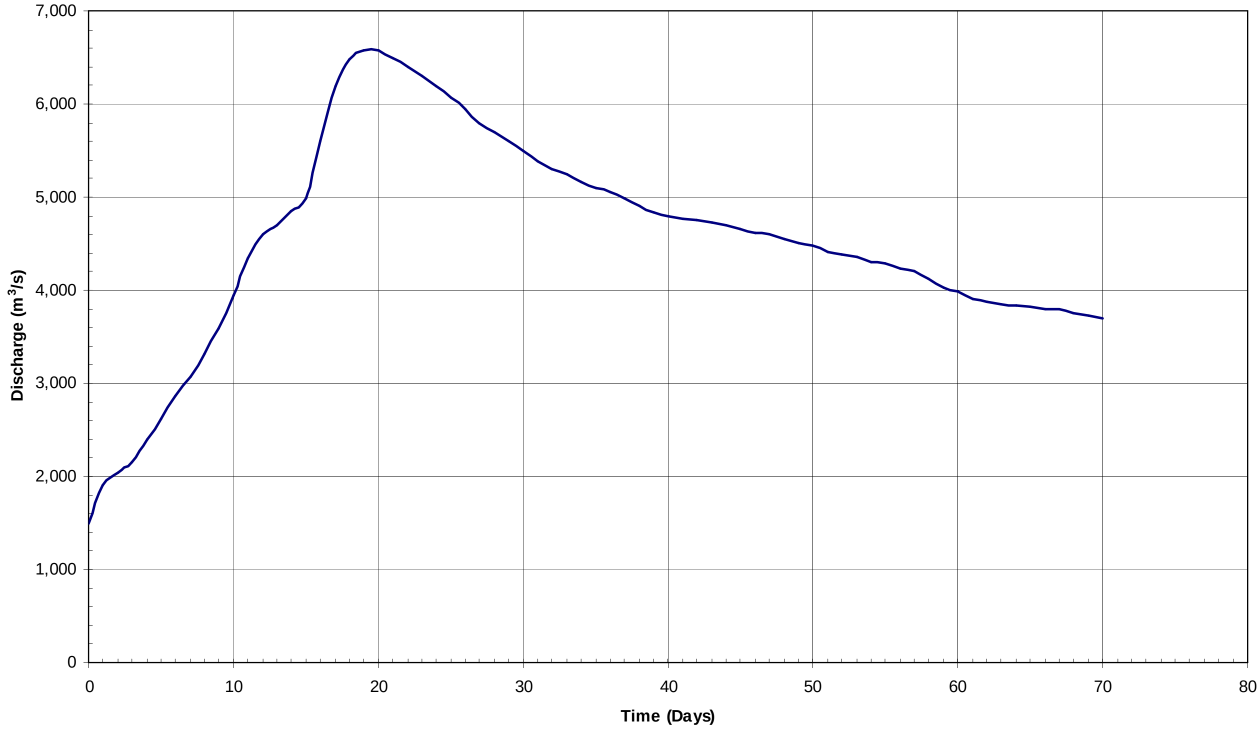
KGS ACRES	Drawn: PNT Submitted: DSB
MANITOBA HYDRO	
POINTE DU BOIS GENERATING STATION	
SPILLWAY REPLACEMENT DEPTH AREA CURVE JUNE 2002 AND ONT-09-41 STORMS	
NOVEMBER 25, 2011	FIGURE 03



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KGS ACRES

Drawn: PNT
Submitted: DSB

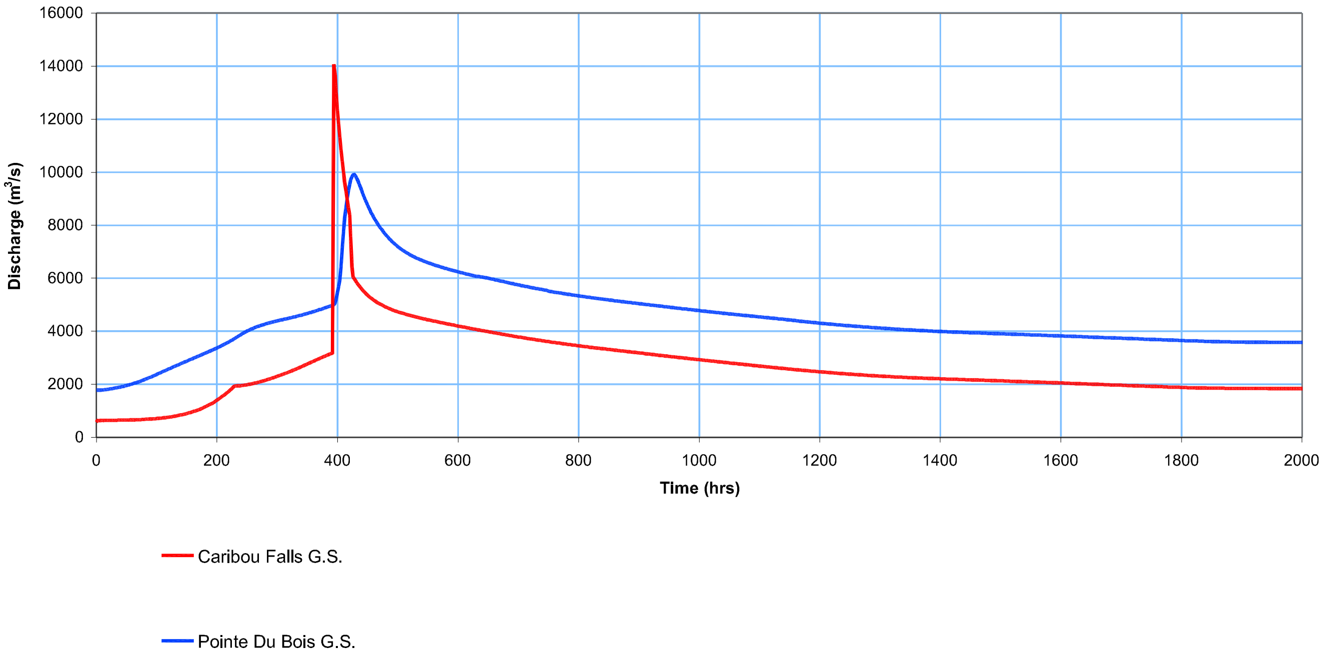
MANITOBA HYDRO

POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT

PROBABLE MAXIMUM FLOOD REVIEW
PROBABLE MAXIMUM FLOOD HYDROGRAPH

NOVEMBER 25, 2011 | FIGURE 04



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MANITOBA HYDRO FILE No. 00102-11340-0010_01

KGS ACRES	Drawn: PNT Submitted: DSB

MANITOBA HYDRO

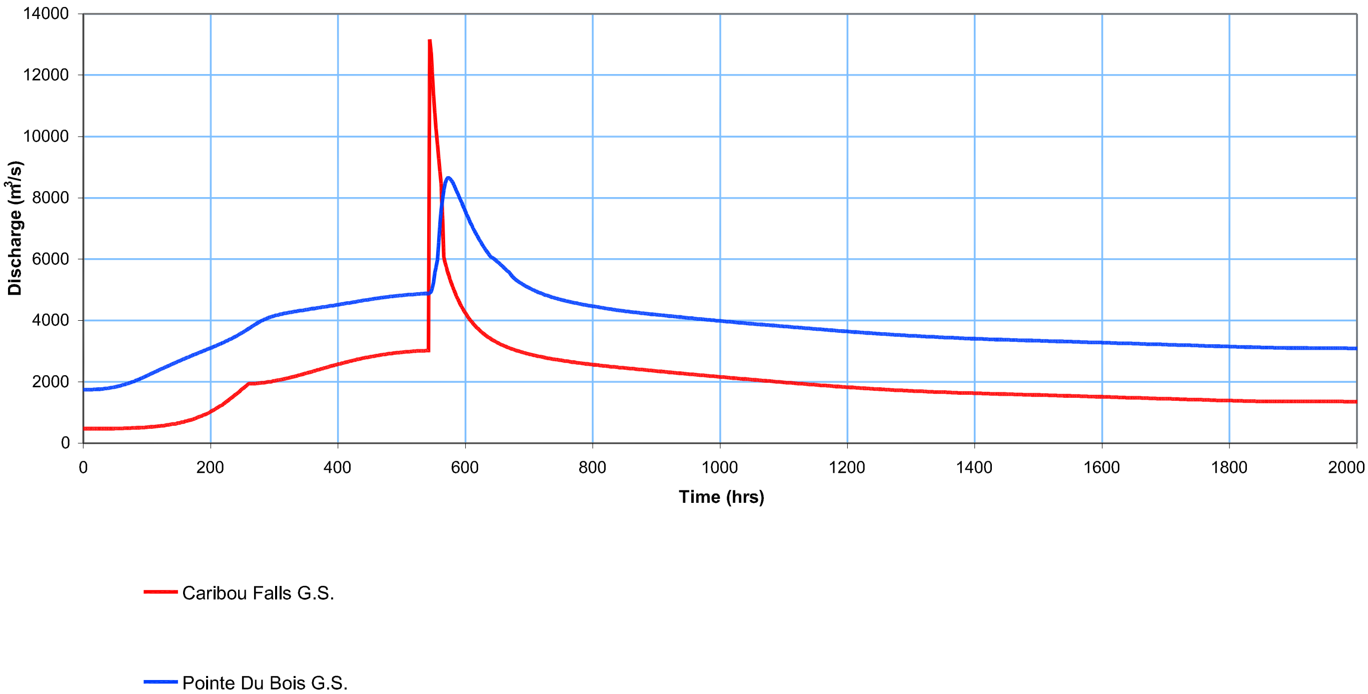
POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT

CARIBOU FALLS FAILURE DURING POINTE DU BOIS PMF DISCHARGE HYDROGRAPH

NOVEMBER 25, 2011	FIGURE 05

Exhibit #MH-ASK-17
Transcript Page #1180



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MANITOBA HYDRO FILE No. 00102–11340–0010_01

KGS ACRES

Drawn: PNT
Submitted: DSB

MANITOBA HYDRO

POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT

CARIBOU FALLS FAILURE
INCIPIENT OVERTOPPING
DISCHARGE HYDROGRAPH

NOVEMBER 25, 2011 | FIGURE 06

8 1/2"x11"
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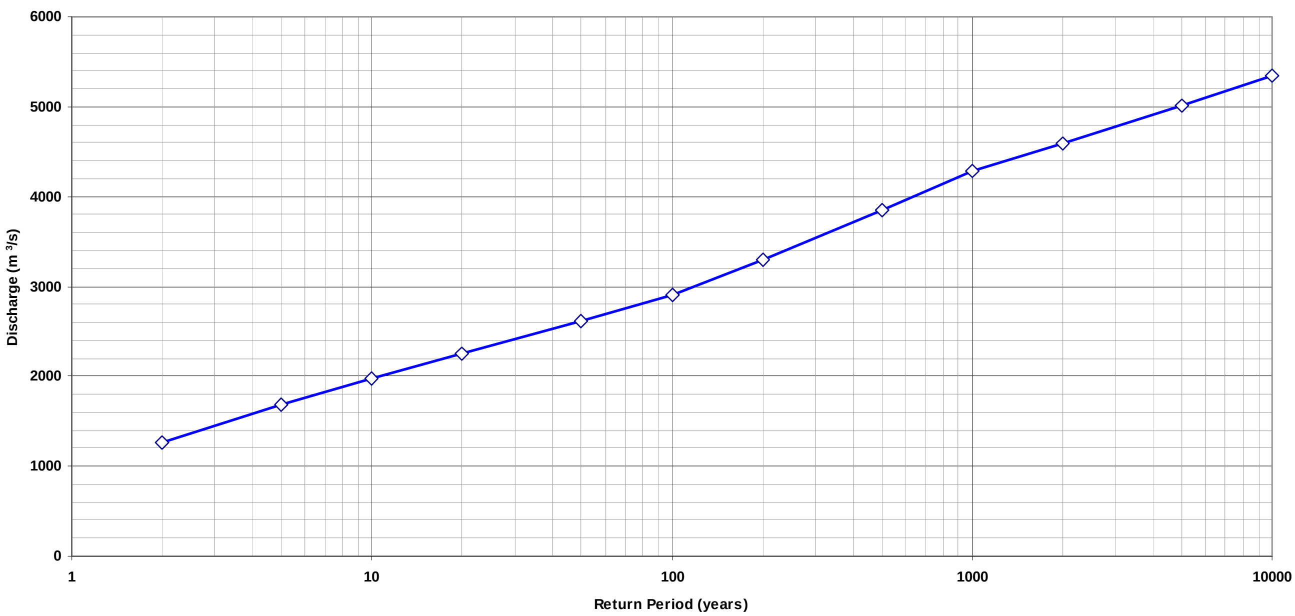


Source:
Manitoba Hydro
Pointe du Bois Generating Station Hydrology Review
P-1.3.2.2.0420

ISSUED WITH DELIVERABLE No. P-1.3.2.2.0430.1
MANITOBA HYDRO FILE No. 00102-11340-0010_01

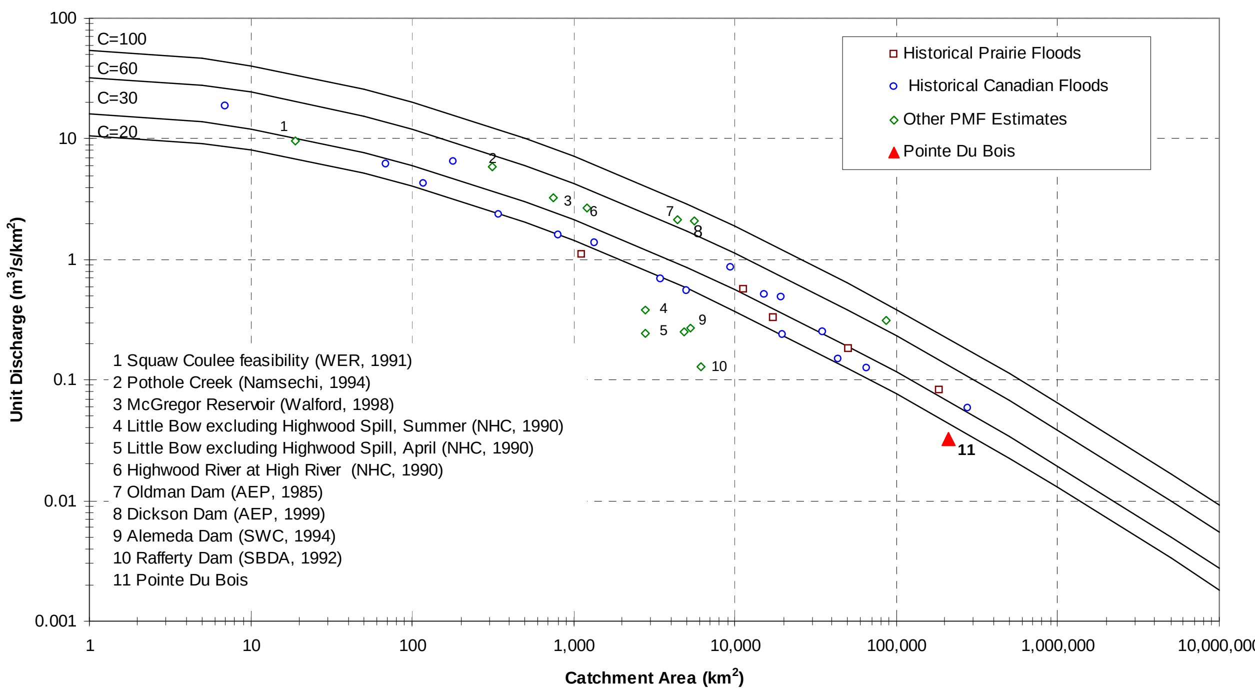
KGS ACRES

Drawn: PNT
Submitted: DSB

MANITOBA HYDRO
POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT
PROBABLE MAXIMUM FLOOD REVIEW
ANNUAL FREQUENCY CURVE

NOVEMBER 25, 2011 | FIGURE 07



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MANITOBA HYDRO

POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT

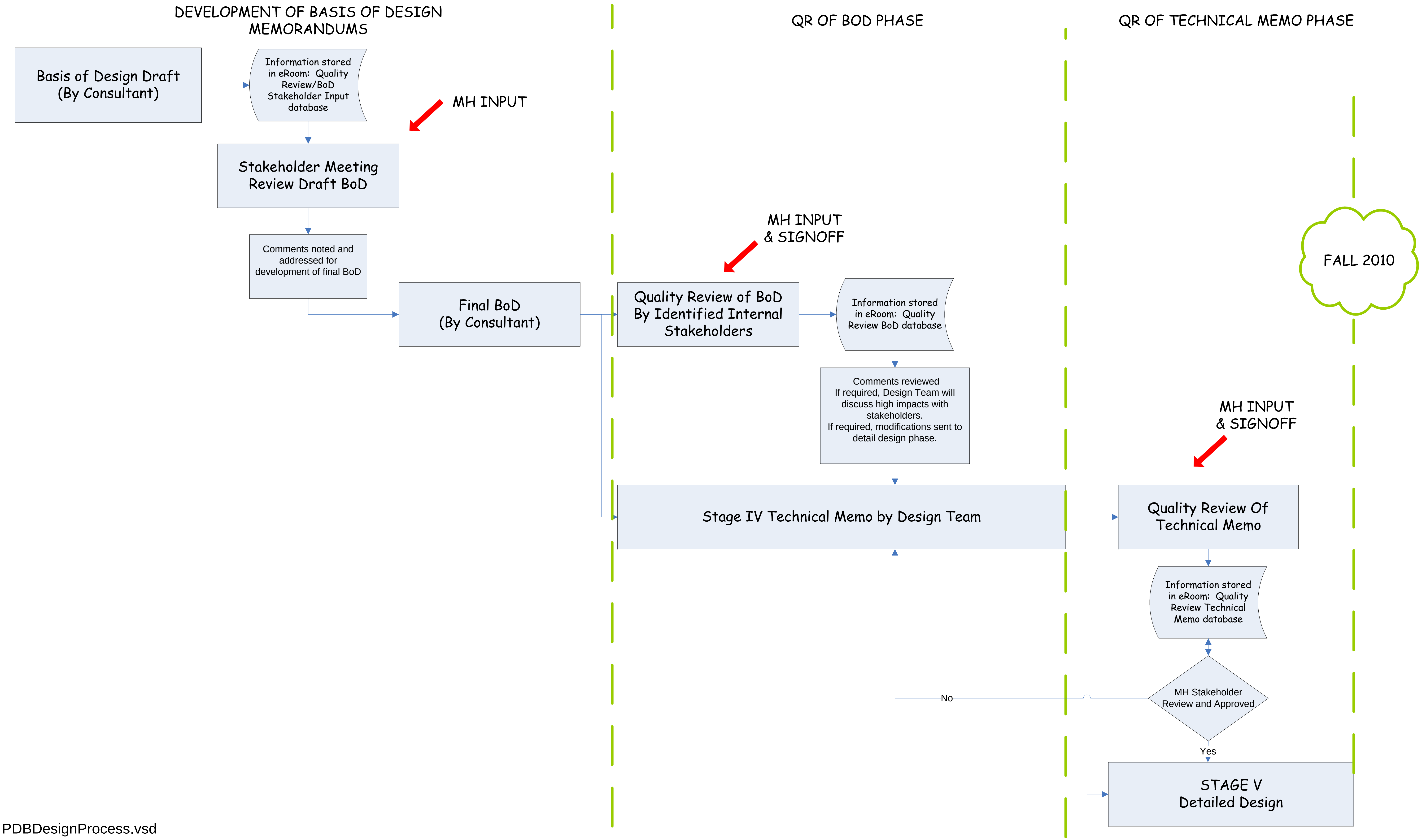
PROBABLE MAXIMUM FLOOD REVIEW
PMF COMPARISON

NOVEMBER 25, 2011	FIGURE 08	

Appendix A

Stage IV Design & Quality Review Process

Pointe du Bois
Stage IV Design & Quality Review Process



Seven Sisters Generating Station

2008 Dam Safety Intermediate Inspection
Concrete Structures
Field Inspection Form

Objectives:

1. To carry out a cursory civil inspection of the powerhouse, spillway and appurtenant concrete structures, identifying the present condition, changes in conditions, deterioration and/or damage to items on the checklist below. Conditions are described with terminology consistent with the U.S. Army Corps of Engineers *"REMR Condition Indexing Scale"* as follows:

Condition Range	Definition
E - G	Condition is within the range of *Excellent* to *Good* ***Excellent:*** no noticeable defects; some aging or wear may be visible. ***Good:*** only minor deterioration or defects are evident.
F - M	Condition is within the range of *Fair* to *Marginal* ***Fair:*** some deterioration or defects are evident; function is not significantly affected. ***Marginal:*** moderate deterioration; function is still adequate.
P - VP - F	Condition is within the range of *Poor* to *Very Poor* to *Failed* ***Poor:*** serious deterioration in some portions of structure; function is inadequate. ***Very Poor:*** extensive deterioration; barely functional. ***Failed:*** no longer functions; general or complete failure of a major component.
N/I	Not Inspected

2. To update and prioritize deficiencies on the *Generation South 2008 Concrete Structures and Gates Maintenance Deficiencies Planner (MDP) and the Generation South Dam Safety Structural Deficiencies (DSSD) list.*
3. To identify needs for more detailed inspections, assessments and/or repairs as condition(s) might warrant.

Item	Condition				Remarks
	E-G	F-M	P-VP-F	N/I	
1. Access and Security					
(a) south approach					
- access road (condition)	✓				
- guardrails	✓				
- signing	✓	✓			No load restriction signage
- gate, lock, fences	✓				
- bridge deck	✓				
- handrails	✓				
- expansion joints	✓				
- bridge piers/abutment	✓	✓			A medium vertical crack on the north abutment, spalling to 50 mm deep on the downstream of north abutment (no change) and a spall at fill line of north pier (300 mm x 900 mm x 50 mm deep) are evident.
- bearing pads	✓				
(b) north approach					
- access road (condition)	✓				
- guardrails	✓				
- gates, locks				✓	
(c) tailrace					
- access road	✓				
- gates, locks, fences	✓				
- signing	✓				
- guardrails (north)	✓				
- parking lot					Paved in 2006

Item	Condition				Remarks
	E-G	F-M	P-VP-F	N/I	
2. North Non-Overflow Dam					
(a) upstream face	✓				
(b) deck (concrete)	✓				Slight spalling
- joint seals	✓				Concrete edge damage, spalling along construction joint and sealant lifted on construction joint near upstream rail (Photo 1).
- handrails	✓				
- stoplog hoist & rails	✓			✓	Rails appear good. Stoplog hoist was not inspected.
- timber deck		✓	✓		Some of the timbers along rails are badly weathered
(c) downstream face	✓				Minor seasonal leakage through centre joint
3. Intake Powerhouse Exterior					
(a) upstream face (concrete)	✓	✓			Horizontal cracking of the gunite and Thorotop HCR overlay is offset up to 40 mm at unit 3. Thorotop HCR overlay is spalled between unit 1 and 2 (Photo 2). Concrete spall 100 mm x 25 mm x 25 mm deep at units 5/6 (Photo 3).
- frost protection	✓				
(b) deck (concrete)	✓				Concrete spall/about to spall at unit 2 (Photo 4).
- joint seals	✓	✓			Intake 6 centerline joint seal (evazote) is fair only.
- handrails	✓				Slight damage to chainlink fence
- rails	✓				
(c) superstructure					
- upstream wall (gate room)	✓				Concrete is cracked and spalled below window at unit 6.
- upstream wall (high tension)	✓				
- south elevation	✓				
- north elevation	✓				Very slight flow at relief pipe, joint along relief pipe is dam
- downstream wall (generator floor)	✓				Some hairline cracks
- downstream wall (high tension)	✓				
(d) roofs					
- gate room	✓				Exposed roofing material in north and south ends, gravel blown into northwest corner of roof (Photo 5).
- high tension	✓				Ponded water on roof due to recent rain
- generator	✓				Ponded water on roof due to recent rain (inspected from high tension roof)
(e) tailrace deck (concrete)	✓				Some minor cracking
- downstream crane rail bear	✓	✓			Some cracking and blistering in the membrane is evident at unit 6 end
- access well covers	✓				
- stoplog opening covers (steel)	✓				
- joint seals	✓				
- handrails	✓				
- stoplogs				✓	Not inspected for structural defects.
- gantry crane & rails	✓			✓	Hairline pattern cracking is evident in areas of the upstream crane rail beam concrete. The gantry crane was not inspected.
- north retaining wall		✓	✓		Conditions appear unchanged (on MDP)
(f) tailrace below deck	✓				Cracks and seasonal leakage on downstream wall and pier faces. Crack with calcite buildup is evident downstream of powerhouse wall at unit 6 below deck (Photo 6).

Item	Condition				Remarks
	E-G	F-M	P-VP-F	N/I	
4. Intake-Powerhouse Interior					
(a) el. 905.5' gate room (general)	✓				Staining and cracking are evident along the underside of roof at north and south ends. New grating on south opening at unit 6. Secondary concrete damaged at unit 6 gate cover. Vertical cracking below windows is typical.
- covers	✓				Some cracking and edge spalling. Covers spalled on north openings at units 2 and 4. Secondary concrete is damaged from concrete cover removal at unit 6. New grating has been installed on south opening unit 6.
- intake gates	✓				Not inspected for structural defects
- intake stoplogs				✓	In storage
(b) stairwell - south end	✓				Minor cracking
(c) stairwell - north end	✓				Some cracking and spalling
(d) el. 966.5' high tension floor	✓				Areas of seasonal leakage are evident on downstream wall (likely from windows). Most interior columns have horizontal cracks.
(e) el. 943.0' switching floor	✓				Cracks on upstream wall remain unchanged.
(f) el. 919.0' breaker floor	✓				Most interior columns have horizontal cracks (unchanged). Hairline to medium cracking is evident along walls.
(g) el. 884.0' transformer floor	✓				Transformer three has clay tile removed to seal crack at upstream wall.
(h) el. 874.0' upstream galleries	✓				Hairline to wide cracking on downstream wall of downstream gallery. Minor leakage through upstream wall, damp in three areas.
(i) el. 865.0' generator floor	✓				Seasonal leakage is evident at service bay and intake 6 upstream columns. No evidence of further movement in the floor crack at the south end. Tiles are cracked between units 2 and 3.
(j) generator sole plates, units 1-6	✓				
(k) el. 853.0' turbine access floor	✓				Surface damage is evident along the upstream wall of unit 3 from seasonal leakage & floor paint at unit 1 is peeled; no change (typical at most units). Leakage through horizontal crack at units 5/6 during inspection (Photo 7).
(l) turbine pits, units 1 - 6	✓				Minor seasonal leakage (typical); units 2 (Photo 8) and 6, are the most severe with surface deterioration along the south wall and at stairs due to leakage. Slight leakage was noted through cracks in unit 2.
(m) el. 846.0' service bay floor	✓				Active seasonal leakage on upstream and south walls (no change
- oil room	✓				Upstream, south, and north walls are wet from leakage, which appears to have increased from last inspection. Piezometer is at 0.243 m and the pressure relief drain is dripping.
- oil/water separation system concrete sump				✓	Last inspected in 2006
5. North Spillway					
(a) upstream face & pier noses	✓				Some hairline pattern cracking through Thorotop HCR coating at piers 2, 4, 5, 6, 8, 9, 10, 13 and 14. Visible crack up to 6 mm wide on pier 5 nose (Photo 9).
(b) deck (concrete)	✓				A few minor membrane failures are evident at piers 3, 5, 7, 9, 11, between bays 13/14, 15 and parking area.
- joint seals	✓				
- rout & seal	✓				
- handrails	✓				
- covers	✓				
- crane rails	✓				
- bearing assemblies				✓	
(c) underside of parking deck	✓	✓			The wide cracking on the north and south walls remains unchanged. Joint at back wall and deck has seasonal leakage; damp during inspection.

Item	Condition E-G	F-M	P-VP-F	N/I	Remarks
(d) piers - downstream of stoplogs	✓	✓			Piers 1, 2, 3, 4 & 6 were reconstructed in the 1980's and are in good condition. The remaining piers consist of original concrete with a gunite overlay and are in fair condition with the exception of piers 5 and 11, which are in marginal condition.
(e) rollways - concrete	✓				
- joint seals				✓	
(f) stoplogs					Bays 11, 14 and 15 have steel stoplogs; Stoplogs stored on deck
- leakage past	✓	✓			Leakage is evident past stoplogs in bays 4 and 5.
6. Sluiceway					
(a) upstream face	✓				The overlay on the upstream beam at the north sluiceway pier is cracked and debonded.
(b) deck (concrete)	✓				Few areas of minor membrane failures
- joint seals	✓				
- rout & seal	✓				
- gates, locks, fencing	✓				
- covers	✓				
- crane rails	✓				
- handrails	✓				
- bearing assemblies				✓	
(c) hoist superstructure	✓				Clean and dry
(d) piers	✓				Some leakage is evident through gunite on the north and south piers. Ectoflex over cracks on the upstream end of the south pier is cracked and about to spall.
(e) rollways				✓	Spilling through sluiceway bays
(f) training wall				✓	Underwater
(g) gates		✓			Cladding on the sluiceway gates was repaired in the fall of 2005. Leakage problems from the downstream cladding is still evident.
(h) bedrock at toe				✓	
(i) stoplogs	✓				Not inspected for structural defects
7. South Spillway					
(a) upstream face & pier noses	✓				Some cracking through the Thorotop HCR coating near the joints is typical.
(b) deck (concrete)	✓				Few areas of minor membrane failures at piers 17, 19 , 21, 23, 25 (Photo 10) and 27.
- joint seals	✓				
- rout & seal	✓				
- handrails	✓				
- crane rails	✓				
- bearing assemblies				✓	
(c) downstream face, deck, & piers	✓				Stoplog follower docking station at bay 26
(d) rollways - concrete	✓				Crack at cleanout between piers 20 and 21
- joint seals	✓				
(e) south retaining wall	✓	✓			Surface deterioration has increased slightly with one area about to spall.
(f) stoplogs	✓				Bays 18, 23, 25 and 26 have steel stoplogs. Stoplogs being stored on deck.
- leakage past	✓		✓		Slight leakage in bays 17 and 27; leakage in bays 18, 20, 22, 23 and 24
(g) bedrock at toe	✓				
8. South Non-Overflow Dam					
(a) upstream face	✓				Slight concrete spalling at water level
(b) deck (concrete)		✓			Upstream end of deck is badly deteriorated at the surface (not a concern). Crack has mirrored through the membrane.
- handrails	✓				Minor coating failure

Item	Condition E-G	Condition F-M	Condition P-VP-F	Condition N/I	Remarks
- joints		✓			No sealant - minor concrete edge damage. Concrete spalling at south en joints at the water level.
(c) downstream face	✓				Seasonal leakage and calciteis evident along crack at el. 895' of north block. Slope downstream of non-overflow dam is dry.
(d) access gate (to south dyke)	✓				

POINTE DU BOIS GENERATING STATION

DAM SAFETY 2008

ANNUAL REPORT

Civil Engineering Department

Report #ESD09-11

Manitoba Hydro

MANITOBA HYDRO
INTEROFFICE MEMORANDUM

FROM	K.S.G. Halayko Dam Safety Section Head Civil Engineering Department Engineering Services Division Power Supply	**TO**	L. Officer Civil Section Head Generation Maintenance Engineering Generation South Power Supply

DATE 2009 07 31

FILE 00102-09100

SUBJECT **POINTE DU BOIS G.S. – 2008 DAM SAFETY ANNUAL REPORT**

Attached please find the 2008 Dam Safety Annual Report for the Pointe du Bois Generating Station. The report documents key findings from Dam Safety Program activities in calendar year 2008 as well as other related dam safety considerations for the plant. The report is available electronically at:

http://coil.hydro.mb.ca/civileng/damsafety/reference/00102-Pointe-du-Bois/Annual-Dam-Safety/2008_PDB_Dam_Safety_Annual_Report.pdf

ld/PDB-CoverMemo.doc

Att.

cc.	H.J. Clouston (E)*	G.J. Fergusson	Dam Safety Section Files
	R.R. Raban (E)	P. Softley	Records Management
	A.L. Driver (E)	N.G. Read (E)	Library

* (E) = Electronic copy

Pointe du Bois Generating Station

2008 Dam Safety Annual Report

Prepared by:	*L.C. Dueck*
Contributions from:	*E.R. Chambers (Geotechnical)* C.E.T.
	G.E. Ferguson (Structural) C.E.T.
	D.J. Danielson (Hydrotechnical) P.Eng.
	M.R. Klein (Emergency Preparedness) P.Eng.
Approved by:	*K.S.G. Halayko* P.Eng.
	A.L. Driver P. ENG.
Noted by:	*R.R. Raban*

Date:	2009 07 31
Report No.:	ESD09-11
File No.:	00102-09100

Distribution:

H.J. Clouston (E)*	G.J. Fergusson	Dam Safety Section Files
R.R. Raban (E)	P. Softley	Records Management
A.L. Driver (E)	N.G. Read (E)	Library

Notes

EXECUTIVE SUMMARY

The overall conditions of the water retaining structures at Pointe du Bois range from poor to excellent. The rockfill dam is the only embankment structure at Pointe and it is assessed to be in excellent condition. The concrete structures exhibit varying degrees of concrete deterioration and are assessed to be in poor to marginal condition.

The most prominent dam safety related concern for Pointe du Bois is the deficiency in spill capacity and slow response time to significantly adjust spill. Both issues will be addressed through modernization of the spillway. In the mean time, measures are being taken to improve spill response time and reliability. In 2008 a backup steam generator was ordered to allow for more reliable winter operation of spillways.

There was one notable dam safety-related event in 2008. The hoist for the 5-bay sluiceway was not operable for a couple of days due to an electronics failure in extremely cold weather. Approximately two-thirds of routine inspections planned for the year were completed. The emergency preparedness plan remains in draft and plans are to issue it in late 2009.

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Remedial Work - Construction Summary
Drawing

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INTRODUCTION

The major Dam Safety Program activities that took place at Pointe du Bois during the 2008 calendar year are documented in this report. Results of condition assessments of the structures based on surveillance (visual inspection), monitoring (instrumentation data review), and analysis are described in the report. In addition, there are sections covering other dam safety related activities such as emergency preparedness, notable events, and training.

The data in this report has been compiled from various contributors within the Civil Engineering Department, Engineering Services Division. The Dam Safety Section would like to acknowledge the assistance of all of these individuals, and also the Pointe du Bois site staff for their assistance with the 2008 inspections.

Notes

NOTABLE EVENTS

There was one notable event in 2008 at the Pointe du Bois Generating Station.

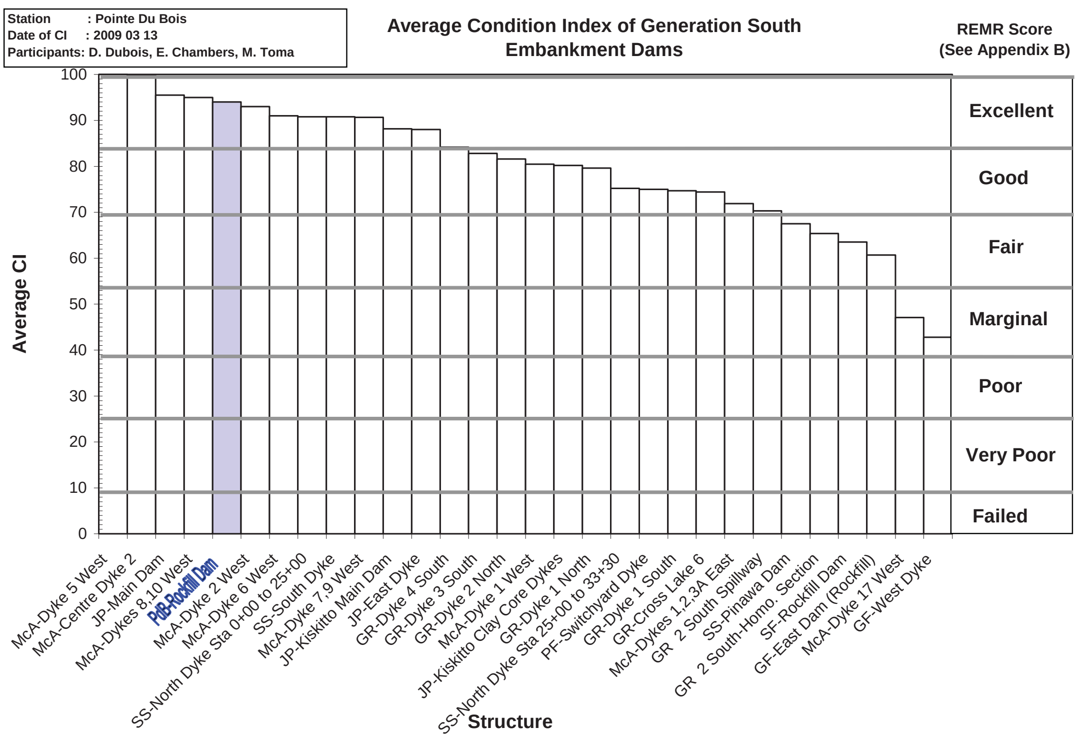
The event occurred on December 17th, 2008. The utility crew was contacted by the station operator to perform water control requirements at the 5 bay sluiceway. The hoist for the sluiceway, however, was not operable due to extremely cold weather which caused the electronics in the main electrical panel to fail. Supplemental heat was added and within a couple of days the system was working again. This event is summarized in the Dam Safety Emergency Incident Report in Appendix G.

Notes

CONDITION OF GEOTECHNICAL STRUCTURES

The rockfill dam at Pointe du Bois is assessed to be in excellent condition. The reason for the improved rating from 2007 is that the freeboard deficiency (0.07m) is less than previously thought; the result of applying the 2007 CDA guidelines recommended changes in the calculation of the inflow design flood. No remedial projects are planned and regular surveillance and monitoring activities will continue. Details of the geotechnical structures are included in Appendix B.

The condition of the Pointe du Bois rockfill dam is shown relative other Generation South structures in the following graph:



Inspections will continue. A summer of 2008's inspection activities is provided below:

Embankment Dam/Inspection Type	No. of Inspections Required	No. of Inspections Performed	Remarks
Rockfill			
Routine	24	18	
Intermediate	1	1	

Routine inspections were performed by site staff. Intermediate inspections were performed by Civil Engineering Department staff. A history of inspections and inspection guidelines for both concrete and geotechnical structures are included in Appendices B and D, respectively.

Notes

CONDITION OF CONCRETE STRUCTURES

Overall, the concrete structures at Pointe Du Bois remain in poor to marginal condition with no significant changes in 2008.

All of the concrete structures at Pointe Du Bois are in the "High" incremental consequence category as shown in Appendix A.

Condition Assessment

The 2008 assessment of concrete structures at Pointe Du Bois was based on:

- routine inspections by site staff,
- the annual summer intermediate inspection,
- the winter, spring and fall intermediate inspections,
- a photo log of the east and west gravity structures,
- the underwater inspection of the west gravity dam,
- a stability analysis of the west gravity dam, and
- studies conducted by the Operations Support Group (OSG).

The history of inspections conducted by the Dam Safety Section is shown in Appendix D and the suggested inspection frequency for concrete structures at Pointe Du Bois is outlined in Appendix E.

In 2008, site staff completed seven of the twelve required routine inspections. Copies of the summer intermediate, three follow-up emails on the intermediate inspections, as well as the summary of concrete inspections since 2005 for Pointe Du Bois are located in Appendix C.

With the powerhouse shut down temporarily for other studies, we conducted an underwater inspection of the west gravity dam. Our major objective was to determine quantity and locations of leakage through joints and cracks in the concrete and at the concrete-bedrock interface. Our findings indicated no leakage through vertical joints or through cracks in the concrete. Only slight leakage was detected sporadically along the concrete-bedrock interface. An inspection drawing of the west gravity dam and an email from V. Yereniuk to L. Officer providing details of the inspection is included in Appendix C.

A stability assessment of the west gravity dam was completed by the Civil Engineering Department in 2008. The assessment found that the west gravity dam does not meet current CDA guidelines. The main conclusion was that the structure is stable for load cases up to insipient overtopping with the downstream clay fill intact, but is unstable if the fill was washed away. The report is available electronically on the coil server, with the following address:

http://coil.hydro.mb.ca/civileng/damsafety/reference/

Notes

In 2007, a program was established for monitoring the east and west gravity structures. The comprehensive photo log of the east and west gravity structures compiled in 2008 indicates a slight increase in concrete spalling and some new leakage on the downstream side of the east gravity structure. For a link to the comprehensive photo log refer to email from M. Klein to D. Lemke dated 08 07 30 located in Appendix C.

Also in 2008, a seismic test program was conducted at Pointe du Bois. All of the structures adjacent to the testing area showed no change in observed conditions and all peak particle velocity readings measured on the structures were below the imposed limit of 10 mm/sec. For more information on the seismic test program please see report from V. Yereniuk to J. Wortley dated 08 03 18 located in Appendix C. Civil Engineering staff performed load cell readings on the east gravity dam and the readings indicate that the anchors are performing well. Readings were taken at strategic times during the seismic test program in March, 2008 and again in June. We have recommended that the load cell readings be taken at a minimum of twice a year.

Dam Safety/Maintenance Deficiencies

Dam safety and maintenance deficiencies at Pointe du Bois are currently determined by condition assessments (CA) of the structures and if required, repairs or improvements are recommended. As of 2007, dam safety, maintenance and operational issues at Pointe du Bois have been discussed and assessed by the OSG, which is comprised of plant and engineering staff. Deficiencies are then prioritized and addressed based on the group's findings. Included in Appendix C is a document from D. Lemke to R. McKinnon dated 2008 06 12 on the OSG findings of conditions at the east and west gravity dams and abutments.

Structural Deficiencies

A list of dam safety structural deficiencies for all of Generation South's generating stations, except Pointe du Bois and Slave Falls, has been compiled and the deficiencies have been prioritized. The list, however, does not include these two stations, because of ongoing assessments and studies, including the work of the OSG.

Notes

HYDROTECHNICAL CONSIDERATIONS

Inflow Design Flood

A review of past hydraulic studies in 2002 suggested that an inflow design flood (IDF) of as much as 5,080 m^3/s may be appropriate for Pointe du Bois Generating Station. A review of the new 2007 CDA dam safety guidelines suggests the IDF should be 1/3 of the way between a 1:1,000 year flood and the Probable Maximum Flood (PMF). The peak discharge during a flood of that frequency is about 4,800 m^3/s. Allowing for speed-no-load discharge and drawdown between the outer and inner forebays, the peak water level during this IDF would marginally exceed the crest elevation of the West Gravity Dam, even without wind effect. The outer forebay level would marginally exceed the outer concrete structure deck elevation and, including wind effect, could also overtop the Rockfill Dam. These capacity estimates assume the spillway gates are completely removed from the checks in order to prevent orifice flow during high water levels which could cause decreased capacity.

The plan to achieve adequate discharge capacity is the modernization project, which will include new spillway bays. While the discharge capacities of spillway bays 48 to 65 were increased during rehabilitation projects in 1998 and 2002, no other capacity increases are planned to precede the modernization.

Deficiency Studies

The two biggest hydrotechnical concerns regarding operation of the Pointe du Bois G.S. are the lack of spill capacity and the slow response time to mobilize significant spill.

As mentioned above, Pointe du Bois is deficient in its ability to pass floods. The existing structures can pass about 2,850 m^3/s with the reservoir at its normal operating limit of 299.1 m and the powerhouse at speed-no-load. Spill records are not directly determined from gate operations but are calculated from total flow and reservoir level changes at Slave Falls Generating Station (G.S.) and powerhouse flow at Pointe du Bois G.S. Water Resource Engineering and Development Department used a flow-record adjustment provided by Civil Engineering to update the flood frequency analysis at Pointe du Bois, which relies on the long historical record at Slave Falls. This updated analysis was released in their 2008 report, “Pointe du Bois Generating Station Hydrology Review”, (March 2008). The flood frequencies shown in the total discharge charts reflect this updated frequency analysis.

The flow change response time issue is partially addressed with rehabilitated spillway bays from 45 to 65 (45-53 new in 2003 and 54-65 new in 1999). The crest elevation for spillway bays from 48 to 65 were lowered in order to increase their spill capacity. In 2007 these bays received new one-piece gates and a new hoist as well. A new spill operation sequence was developed and issued in 2007 addressing different spill operating sequences for summer and winter seasons. It is important to address the steaming capacity at the site in order to allow reliable winter gate operation. Plans for the addition of a back-up steam generator were initiated in 2007 with anticipated delivery in early 2009.

Notes

Hydrotechnical Surveillance

The Dam Safety Section inspected the hydraulic conditions on July 8 as part of the concrete structures intermediate inspection. Conditions were generally satisfactory, except for severe leakage at many spillway and sluiceway bays, excessive debris in front of many of the generating units, stoplog damage in bay 112 and trash rack damage at units 6 and 9. None of these problems are considered dam safety issues.

At the time of the inspection, thirteen of the sixteen generating units were operating and there was significant spill. The observed hydraulic conditions are summarized in the field inspection forms located in Appendix F.

The hydraulic operating records are provided in Appendix F. These records include historical and 2008 forebay levels, tailrace levels, total discharge, and spill. Spill was required throughout 2008 and the maximum daily average total flow and spill were 1,642 m^3/s and 2,286 m^3/s, respectively. Maximum flows occurred at the end of July and the peak total flow has a return period of just over 20 years.

Notes

EMERGENCY PREPAREDNESS PLAN

The Pointe du Bois Emergency Preparedness Plan (EPP) continued to be under development in 2008 to accommodate the completion of the new 3 level Dam Safety Emergency Classification and Response Guide. The guide was finalized at the end of 2008 and will be issued early in 2009. The Pointe du Bois EPP will also be finalized, reviewed and issued in 2009. New notification charts were drafted in 2008 for all Manitoba Hydro's EPPs following the template established for the Pointe du Bois EPP and will be reviewed with each respective site prior to issuing.

In order to improve assessments and to learn from any dam safety related emergencies that may occur, a Dam Safety Emergency Incident Report form was drafted as a template for site to use to document the incident.

OPERATION, MAINTENANCE AND SURVEILLANCE MANUAL

At present an Operation, Maintenance and Surveillance (OMS) Manual does not exist for Slave Falls. Bradley Hay has filled the newly created position of Operations and Maintenance Officer in the Dam Safety Section as of February 2009. He has been tasked with creating the OMS manual, with an expected completion date of August 2010.

The current versions of the EPP and the draft OMS Manual for all other stations are available on the Manitoba Hydro intranet via the following link:

http://coil.hydro.mb.ca/civileng/damsafety/reference/

DAM SAFETY TRAINING

There were no dam safety related training courses delivered to Winnipeg River staff in 2008. The following dam safety training courses are available from the Dam Safety section upon request:

- Dam Safety General Awareness (for all)
- Emergency Preparedness (for operators, supervisors, management)
- Routine Inspection Training (for utility staff, supervisors)

A dam safety tabletop exercise that involved a breach of McArthur Dyke 17W was conducted on January 9 at Pinewood Lodge in the Whiteshell Provincial Park as part of a two-day Manitoba Emergency Management Course. Participants included Manitoba Hydro staff from the Winnipeg River plants, authorities from the local municipalities, the RCMP, Fire Department, and Manitoba Conservation.

Appendix A

Incremental Consequence Categories

Pointe Du Bois Generating Station

MANITOBA HYDRO-ADOPTED STRUCTURE INCREMENTAL CONSEQUENCE CATEGORIES

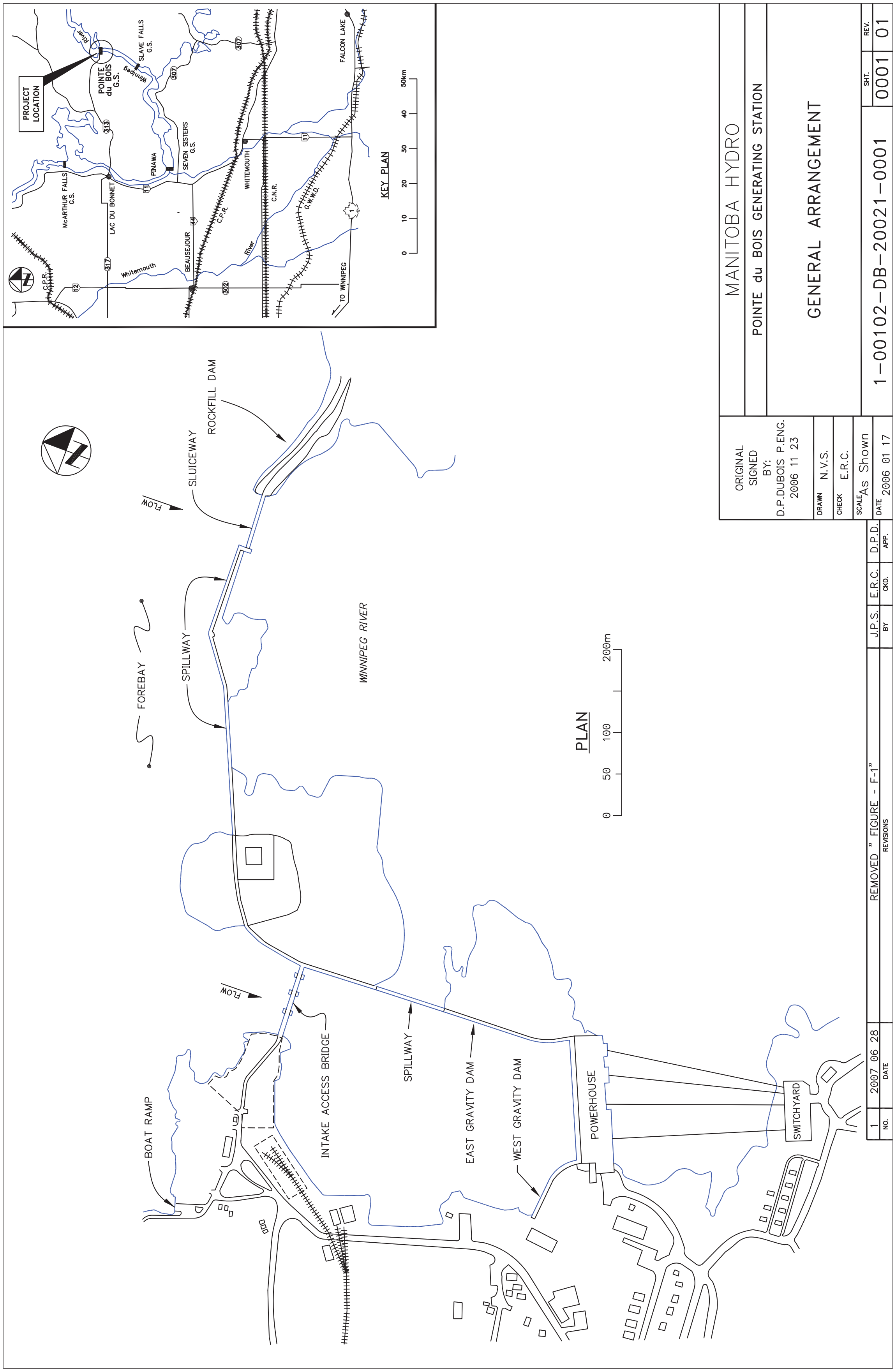
As of December 2003

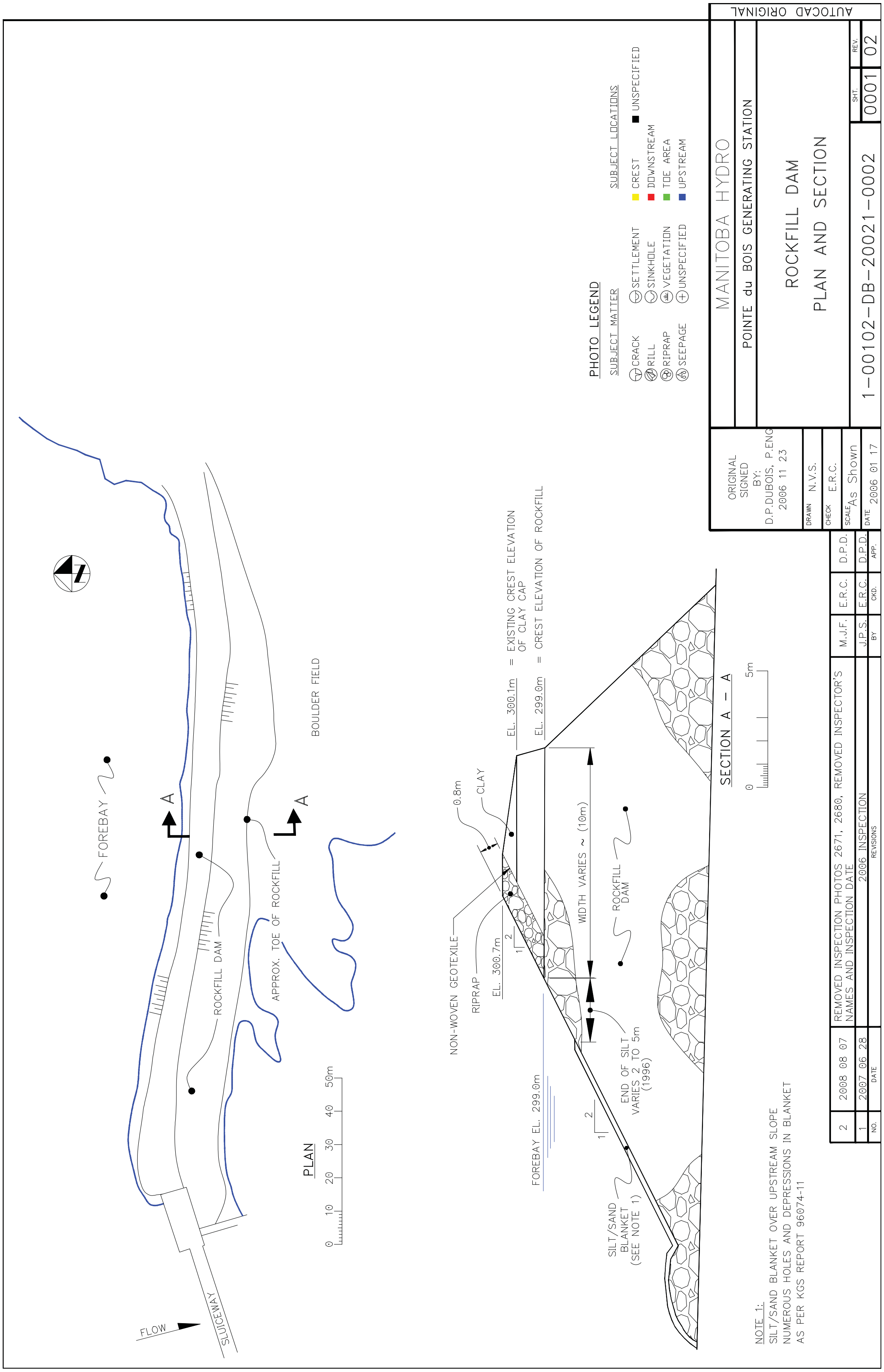
Note : Adopted incremental consequence categories for individual structures are subject to change with approval of a Corporate standard for evaluation of incremental consequences of failure.

Name of Dam Plant Abbreviation - Dam	**Type of Dam**	**Initial In-Service Date** Year	**MH Adopted Incremental Consequence Category**
PdBGS-West Gravity Dam	Concrete Gravity	1911	High
PdBGS-Intake & Powerhouse	Concrete Gravity	1911	High
PdBGS-East Gravity Dam Blocks 1-12	Concrete Gravity	1911	High
PdBGS-Spillway Bays 121-133	Concrete Gravity	1911	High
PdBGS-East Gravity Dam Blocks 13-19	Concrete Gravity	1911	High
PdBGS-Curved Spillway Bays 101-114	Concrete Gravity	1911	High
PdBGS-Spillway Bays 1-35	Concrete Gravity	1911	High
PdBGS-Spillway Bays 36-44	Concrete Gravity	1911	High
PdBGS-Spillway Bays 45-65	Concrete Gravity	1911	High
PdBGS-Sluiceway Bays 1-5	Concrete Gravity	1911	High
PdBGS-Rock Filled Dam	Rockfill	1911	High

Appendix B

Geotechnical Structures Documentation


PROJECT LOCATION
POINTE du BOIS G.S.
SLAVE FALLS G.S.
SEVEN SISTERS G.S.
McARTHUR FALLS G.S.
PINAWA
LAC DU BONNET
WHITEMOUTH
BEAUSEJOUR
FALCON LAKE
TO WINNIPEG
C.P.R.
C.N.R.
G.W.W.D.
Whitemouth
River
Winnipeg
KEY PLAN
0 10 20 30 40 50km
ROCKFILL DAM
SLUICEWAY
SPILLWAY
FOREBAY
FLOW
WINNIPEG RIVER
PLAN
0 50 100 200m
INTAKE ACCESS BRIDGE
EAST GRAVITY DAM
WEST GRAVITY DAM
POWERHOUSE
SWITCHYARD
BOAT RAMP
MANITOBA HYDRO
POINTE du BOIS GENERATING STATION
GENERAL ARRANGEMENT
1-00102-DB-20021-0001
SHT. 0001
REV. 01
ORIGINAL SIGNED BY: D.P.DUBOIS P.ENG. 2006 11 23
DRAWN N.V.S.
CHECK E.R.C.
SCALE As Shown
DATE 2006 01 17
1 2007 06 28 REMOVED " FIGURE - F-1" J.P.S. E.R.C. D.P.D.
NO. DATE REVISIONS BY CKD. APP.


AUTOCAD ORIGINAL
MANITOBA HYDRO
POINTE du BOIS GENERATING STATION
ROCKFILL DAM
PLAN AND SECTION
1-00102-DB-20021-0002
SHT. 0001
REV. 02
ORIGINAL SIGNED BY: D.P.DUBOIS, P.ENG 2006 11 23
DRAWN N.V.S.
CHECK E.R.C.
SCALE As Shown
DATE 2006 01 17
2 | 2008 08 07 | REMOVED INSPECTION PHOTOS 2671, 2680, REMOVED INSPECTOR'S NAMES AND INSPECTION DATE | M.J.F. | E.R.C. | D.P.D.
1 | 2007 06 28 | 2006 INSPECTION | J.P.S. | E.R.C. | D.P.D.
NO. DATE REVISIONS BY CKD. APP.
PHOTO LEGEND
SUBJECT MATTER
CRACK
RILL
RIPRAP
SEEPAGE
SETTLEMENT
SINKHOLE
VEGETATION
UNSPECIFIED
SUBJECT LOCATIONS
CREST
DOWNSTREAM
TOE AREA
UPSTREAM
UNSPECIFIED
FOREBAY
A
A
ROCKFILL DAM
APPROX. TOE OF ROCKFILL
BOULDER FIELD
FLOW
SLUICEWAY
PLAN
0 10 20 30 40 50m
EL. 300.1m = EXISTING CREST ELEVATION OF CLAY CAP
EL. 299.0m = CREST ELEVATION OF ROCKFILL
0.8m
CLAY
NON-WOVEN GEOTEXTILE
RIPRAP
EL. 300.7m
WIDTH VARIES ~ (10m)
ROCKFILL DAM
END OF SILT VARIES 2 TO 5m (1996)
FOREBAY EL. 299.0m
SILT/SAND BLANKET (SEE NOTE 1)
SECTION A - A
0 5m
NOTE 1:
SILT/SAND BLANKET OVER UPSTREAM SLOPE
NUMEROUS HOLES AND DEPRESSIONS IN BLANKET
AS PER KGS REPORT 96074-11

Manitoba Hydro Dam Safety Program

INSPECTION HISTORY
POINTE DU BOIS GS

Routine Inspections

YEAR	STRUCTURE	RECOMMENDED	RECEIVED	COMMENTS
2005	Rockfill Dam	52	22	
2006	Rockfill Dam	52	34	
2007	Rockfill Dam	24	28	
2008	Rockfill Dam	24	18	

Intermediate Inspections

YEAR	STRUCTURE	RECOMMENDED	RECEIVED	COMMENTS
2005	Rockfill Dam	1	1	
2006	Rockfill Dam	1	1	
2007	Rockfill Dam	1	1	
2008	Rockfill Dam	1	1	

Cursory Inspections

YEAR	STRUCTURE	RECOMMENDED	RECEIVED	COMMENTS
2005	Rockfill Dam	1	1	
2006	Rockfill Dam	1	1	

Unscheduled Inspection

YEAR	STRUCTURE	RECOMMENDED	RECEIVED	COMMENTS
2005	Rockfill Dam	As necessary	1	

Dubois, Denis

From:	Chambers, Ed
Sent:	Friday, September 26, 2008 3:32 PM
To:	Officer, Larry
Cc:	Dubois, Denis; Yim, Keysoon; Mymryk, Matthew; Halayko, Krista; Klein, Marno; Softley, Paul; Fergusson, Garth; Kraeker, Vincent; Richards, Scott
Subject:	2008 Pointe du Bois Dam Safety Intermediate Inspection Of Rockfill Dam

Hi Larry

We have completed our 2008 Dam Safety Intermediate Inspection for Pointe du Bois Generating Station rockfill dam Sept. 25

Based on our inspection the structure is in good condition unchanged from the previous year.

A comprehensive condition assessment will be completed and reported in the 2008 Dam Safety Annual Report (DSAR).

If you have any questions regarding the inspection please let me know.

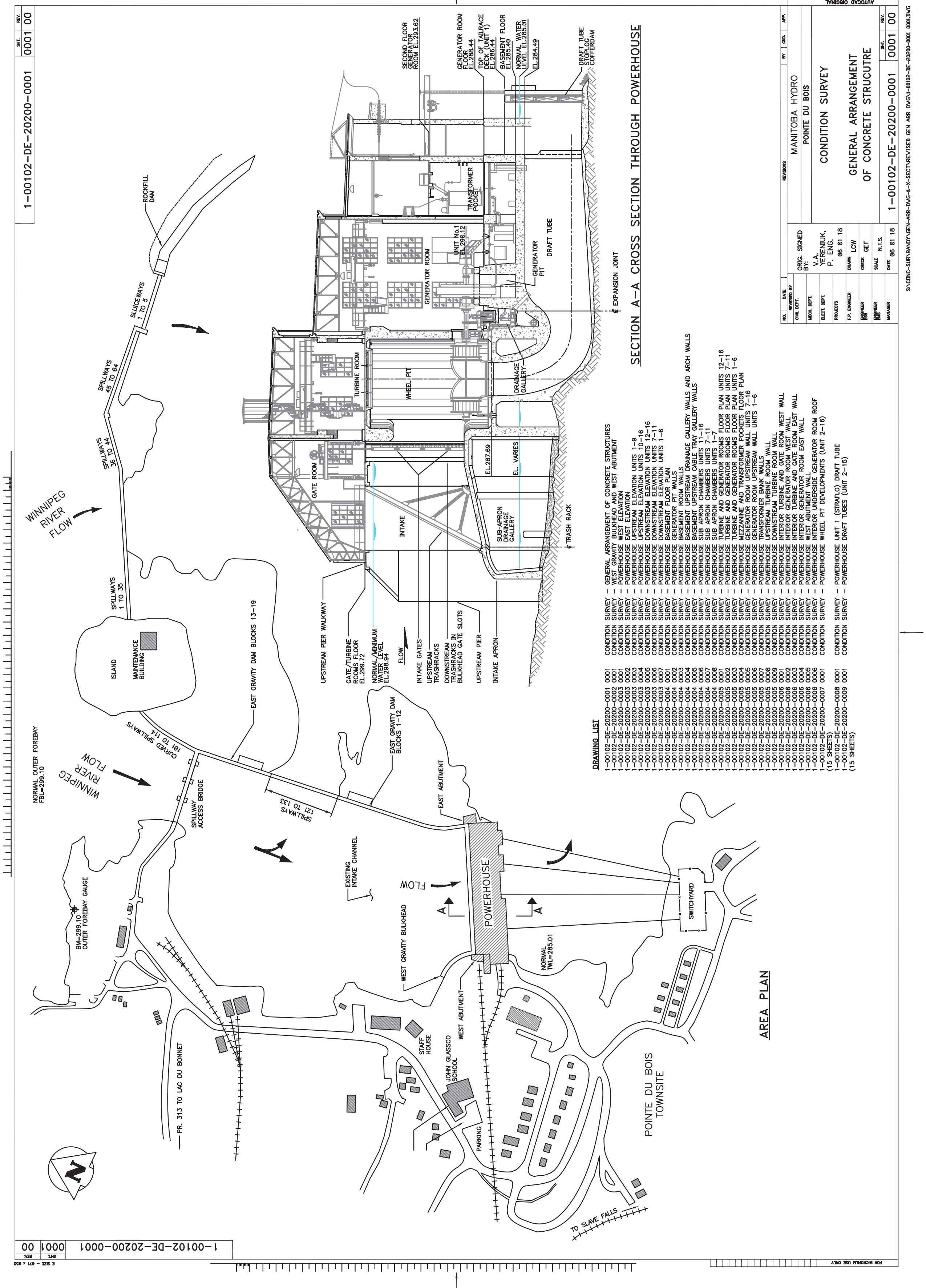
Regards

Ed

Ed Chambers, C.E.T.
Dam Safety Section
Civil Engineering Department
Engineering Services Division
Manitoba Hydro
phone (204) 477-7310
fax (204) 477-7189
e-mail erchambers@hydro.mb.ca

Appendix C

Concrete Structures Documentation


1-00102-DE-20200-0001
SECTION A-A CROSS SECTION THROUGH POWERHOUSE
AREA PLAN
POWERHOUSE
SWITCHYARD
WINNIPEG RIVER FLOW
ISLAND
MAINTENANCE BUILDING
ROCKFILL DAM
SLUICEWAYS 1 TO 5
SPILLWAYS 45 TO 64
SPILLWAYS 36 TO 44
SPILLWAYS 1 TO 35
EAST GRAVITY DAM BLOCKS 13-19
EAST GRAVITY DAM BLOCKS 1-12
CURVED SPILLWAYS 101 TO 114
SPILLWAYS 121 TO 133
SPILLWAY ACCESS BRIDGE
EAST ABUTMENT
WEST ABUTMENT
WEST GRAVITY BULKHEAD
EXISTING INTAKE CHANNEL
NORMAL OUTER FOREBAY FBL=299.10
BM=299.10 OUTER FOREBAY GAUGE
NORMAL TWL=285.01
STAFF HOUSE
JOHN GLASSCO SCHOOL
PARKING
POINTE DU BOIS TOWNSITE
PR. 313 TO LAC DU BONNET
TO SLAVE FALLS
GATE ROOM
TURBINE ROOM
GENERATOR ROOM
WHEEL PIT
INTAKE
DRAFT TUBE
GENERATOR PIT
TRANSFORMER POCKET
DRAINAGE GALLERY
SUB-APRON DRAINAGE GALLERY
EXPANSION JOINT
TRASH RACK
UPSTREAM PIER WALKWAY
GATE/TURBINE ROOMS FLOOR EL.299.72
NORMAL/MINIMUM WATER LEVEL EL.298.94
INTAKE GATES
UPSTREAM TRASHRACKS
DOWNSTREAM TRASHRACKS IN BULKHEAD GATE SLOTS
UPSTREAM PIER
INTAKE APRON
SECOND FLOOR GENERATOR ROOM EL.293.62
GENERATOR ROOM FLOOR EL.288.44
TOP OF TAILRACE DECK (UNIT 1) EL.286.44
BASEMENT FLOOR EL.285.49
NORMAL WATER LEVEL EL.285.01
EL.284.49
DRAFT TUBE STOPLOG COFFERDAM
EL.287.69
EL. VARIES
DRAWING LIST
MANITOBA HYDRO
POINTE DU BOIS
CONDITION SURVEY
GENERAL ARRANGEMENT OF CONCRETE STRUCUTRE
ORIG. SIGNED BY: V.A. YERENIUK, P. ENG. 06 01 18
DRAWN LCW
CHECK GEF
SCALE N.T.S.
DATE 06 01 18
AUTOCAD ORIGINAL
FOR MICROFILM USE ONLY

Manitoba Hydro Dam Safety Program

SUMMARY OF CONCRETE STRUCTURE INSPECTIONS SINCE 2005
POINT DU BOIS

Routine Inspection

YEAR	RECOMMENDED	RECEIVED	COMMENTS
2005	12	6	
2006	12	8	Kick plates added to handrails on spillways and gravity structures
2007	12	6	Stoplogs were being replaced in Spillway (Bays 45-65) in Sept.
2008	12	7	

Intermediate Inspection

YEAR	RECOMMENDED	COMPLETED	COMMENTS
2005	1	1	
2006	2	2	Inspection frequency increased from 1 per year to 4 per year.
2007	4	4	Took a photo log of upstream and downstream faces of the east and west gravity structures during fall inspection.
2008	4	4	Took a photo log of upstream and downstream faces of the east and west gravity structures during fall inspection.

Condition Survey Inspection

YEAR	STRUCTURE	PROPOSED INSPECTIONS	COMPLETED	COMMENTS
2005	Unit 15 Turbine Base	1	1	
	2005 Powerhouse Study	1	1	
	Wheel Pit 13	1	1	
2006	Unit 4 Wheel Pit	1	1	
	Rockfill Dam Diving	1	1	
	Spillway Access Bridge Piers - Divers	1	1	
2007	Unit 4 throat ring and turbine base	1	1	
	Unit 10 throat ring and turbine base	1	1	
2008	Unit 11 wheel pit	1	1	
	West Gravity Dam Diving	1	1	

Manitoba Hydro Dam Safety Program

2008 Dam Safety Intermediate Inspection
Concrete Structures
- Summary -

Plant:		Date of this inspection:
Pointe du Bois Generating Station		July 08, 2008
Forebay Elev: **Inner:** 298.85m **Outer:** 299.06m	**Tailrace Elev:** 285.67m	**Date of previous inspection:** July 04, 2007

Inspection personnel:

R.E. McMahon & J.N. Hoplock

Key Observations:

In 2008, the Dam Safety Section performed four intermediate inspections (spring, summer, fall and winter). The information shown in this report is from the summer inspection, as conditions during the other inspections changed minimally.

For monitoring conditions of the east and west gravity dams, we have compiled detailed photo logs of these structures for the past two years. We noted a slight increase in concrete spalling and some new leakage on the downstream side of the east gravity structure in 2008.

Upstream and downstream retaining walls at curved spillway bay 101 have moved inwards and the wide vertical crack in the downstream wall is offset 25 mm.

Deck joint seal at spillway bay 128 is gone and the deck on the north side spillway 128 joint is offset 20 mm on the downstream face (ice-jacked). Pier concrete below deck is spalled.

Brush and vegetation along the downstream toe of the east gravity dam blocks 1-12 has been cleared.

Stoplogs are damaged in the curved spillway bay 112; due to high ice flow in spring, as noted during the spring inspection. Damage appears to have worsened slightly and leakage has increased.

Recommendations:

A prioritized list of outstanding deficiencies for Generation South are included in the 2008 Concrete Structures and Gates Maintenance Deficiencies Planner (MDP). However, it does not include Pointe Du Bois because of other ongoing assessments of the structures at Pointe Du Bois. The repair recommendations as well as the inspection drawings have been and will continue to be presented in condition assessment and interim reports.

It would be difficult to spill water through curved spillway bay 101 without complete failure of the upstream and downstream retaining walls.

Reference Materials:

2008 field inspection form and photographs

Signature of Inspectors:	Signature of Concrete Engineer:
Randy McMahon	[signature]

Pointe du Bois Generating Station

2008 Dam Safety Intermediate Inspection
Concrete Structures
Field Inspection Form

Objectives:

1. To carry out a cursory civil inspection of the powerhouse, spillway and appurtenant concrete structures, identifying the present condition, changes in conditions, deterioration and/or damage to items on the checklist below. Conditions are described with terminology consistent with the U.S. Army Corps of Engineers "*REMR Condition Indexing Scale"* as follows:

Condition Range	Definition
E - G	Condition is within the range of *Excellent* to *Good* ***Excellent:*** no noticeable defects; some aging or wear may be visible. ***Good:*** only minor deterioration or defects are evident.
F - M	Condition is within the range of *Fair* to *Marginal* ***Fair:*** some deterioration or defects are evident; function is not significantly affected. ***Marginal:*** moderate deterioration; function is still adequate.
P - VP - F	Condition is within the range of *Poor* to *Very Poor* to *Failed* ***Poor:*** serious deterioration in some portions of structure; function is inadequate. ***Very Poor:*** extensive deterioration; barely functional. ***Failed:*** no longer functions; general or complete failure of a major component.
N/I	Not Inspected

2. To update and prioritize deficiencies on the *Generation South 2008 Concrete Structures and Gates Maintenance Deficiencies Planner (MDP) and the Generation South Dam Safety Structural Deficiencies (DSSD) list.*
3. To identify needs for more detailed inspections, assessments and/or repairs as condition(s) might warrant.

Item	Condition				Remarks
	E-G	F-M	P-VP-F	N/I	
1. Access and Security					
(a) access roads	✓				
(b) guardrails (downstream of powerhouse)	✓				
(c) fences and signage	✓				
2. West Gravity Bulkhead					
(a) deck		✓			Badly cracked
(b) handrails	✓				New kick plate installed in 2006 on upstream and downstream.
(c) upstream face			✓		Extensive erosion at water level to 300 mm deep (Photo 1).
(d) downstream face		✓	✓		Concrete is cracked, spalled/about to spall and leakage is evident.
3. Powerhouse Intake					
(a) superstructure					
- downstream	✓	✓			Areas of freeze-thaw deterioration to 150 mm deep at water level (Not visible due to high water levels).
- upstream (metal cladding)	✓				
- piers	✓	✓			Badly deteriorated with vegetation
- west elevation		✓			Concrete is cracked with some spalling and minor leakage is evident through cracks.
- east elevation	✓	✓			Concrete is spalled with some leakage and vegetation below the curtain wall. Vertical joint below the walkway is about to spall.

Item	Condition E-G	Condition F-M	Condition P-VP-F	Condition N/I	Remarks
- curtain wall			✓		Hairline cracking is evident throughout and the joint between the curtain wall & the intake wall is open up to 25 mm near the top. Spall in the wall above the walkway (wire mesh exposed).
(b) west abutment			✓		Cracked and spalled with slight leakage
(c) intake ice piers			✓		Cracking and spalling has increased at the water level (Photo 2). Vegetation is growing out of the cracks in the piers on the east side.
(d) intake walkway			✓		Cracking and spalling has increased at the top of the intake piers; no handrail.
(e) east abutment			✓		Downstream face is badly deteriorated - cracked, spalled, leakage, and vegetation.
4. Powerhouse Interior					
(a) generator floor (el. 946.33')					
- upstream brick wall		✓			Brick wall is cracked and slight leakage is evident behind the upstream wall at units 3, 5, 6, 10, 13 and 15 (damp). Bricks have been removed at units 14-16. Wall at units 14-16 were injection grouted (polyurethane).
- floor		✓			Full depth, medium - wide cracks slightly spalled between units is typical.
- roof		✓			Areas of plaster have fallen off; debonding is likely from leakage in roof. Leakage is evident in the area of units 1, 3, 4, 8/ 9 (active leak) and 10 / 11.
- downstream wall		✓			Medium - wide cracking
(b) basement floor (el. 936.35')					
basement drainage gallery					
- upstream wall		✓			Medium - wide cracking and calcite build-up is typical. Slight leakage is evident at unit 6.
- floor		✓			Medium - wide cracking is typical with concrete spalling to 25 mm deep at units 4 and 6. Approximately 40 mm of water on the floor due to high tail water (Photo 3). Water coming up through cracks in floor; typical (Photo 4).
- ceiling		✓			Medium - wide cracking
generator pits					
- interior walls		✓			Medium - wide cracking (units 7, 9 and 16 are the most severe) with slight concrete spalling at units 13 and 16.
- floor		✓			Fine - medium cracking (unit 16 is the worst) with slight concrete spalling at unit 2.
- exterior walls		✓			Medium - wide cracking
cable tray gallery					
- floor		✓			Medium - wide cracking
- ceiling		✓			Medium - wide cracking
- downstream wall (arch wall)		✓			Medium - wide cracking
downstream basement room					
- upstream wall (arch wall)		✓			Medium - wide cracking
- floor		✓			Medium - wide cracking
- ceiling		✓			Medium - wide cracking
- downstream wall		✓			Medium - wide cracking
basement storage area/rooms					
- upstream and side wall		✓			Medium - wide cracking is typical with some offset to 25 mm.
- floor		✓			Some spalling and medium - wide cracking (water spewing from crack) is evident.
- ceiling		✓			Medium - wide cracking
- downstream wall		✓			Medium - wide cracking
(c) turbine room (el. 983.33')					
- downstream wall	✓	✓			Medium - wide cracking

Item	Condition: E-G	F-M	P-VP-F	N/I	Remarks
- floor	✓	✓			Some spalling and medium - wide cracking
- ceiling	✓	✓			Spalling along cracks and joints. Slight leakage from crack at unit 2.
- upstream wall	✓				Medium - wide cracking and 1 large spall at unit 11.
- end walls	✓				East wall exhibits wide cracking.
- wheel pit covers	✓				Some cracking and edge spalling
(d) gate room (el. 983.33')					
- upstream cladding	✓				
- handrails (chain)	✓				New handrail installed at all units in 2006.
- rails for hoist	✓				
- hoist	✓				Appears good, not inspected for structural defects.
- trash racks				✓	Concrete spalling at trash rack I-beams is typical. Considerable accumulation of debris was evident upstream at units 1 and 12-16. Slight debris upstream at units 2, 3 and 5-10. Damaged trash racks upstream of unit 6 and 9 (Photo 5).
- ceiling	✓				
- floor		✓			Some cracking and spalling
- metal covers	✓				Metal grating covers at units 2-6, 8-11 and 13-15.
- wood covers		✓			Damaged wood cover uptream of unit 12 (Photo 6).
- downstream wall		✓			Medium - wide cracking
(e) oil/water separator					To be inspected every 5 years. Last inspected in 2006.
5. East Gravity Dam Blocks 1-12					
(a) deck		✓			Cracked & spalled with some hollow areas
(b) handrails	✓				
(c) upstream face			✓		Badly deteriorated; concrete is spalled to 300 mm deep and more is about to spall.
(c) downstream face			✓		Badly deteriorated; concrete is spalled, cracked and leakage is evident through cracks. Concrete continues to spall (Photo 7). Brush and vegetation along the downstream toe was cleared in June 2008. Spalling has increased at north end.
(d) downstream gravity block (2002 const.)	✓				
6. Spillway (Bays 121 to 133)					
(a) deck		✓			Deck joint seal at spillway bay 128 is gone and the north side of the deck joint is offset 20 mm on the downstream face (ice-jacked). Pier concrete below deck is spalled.
- metal covers		✓			
(b) handrails	✓				
(c) piers		✓			Concrete is spalled at south face of spillway pier 128.
(d) rollways		✓	✓		Concrete is spalled/eroded and rebar is exposed.
(e) leakage		✓	✓		Considerable leakage in most bays, except bay 128. Bay 133 has the most leakage. Site has indicated that the stoplogs have been sealed with cinders, during station outage; which has reduced leakage.
(f) stoplogs		✓	✓		Leakage between stoplogs in most bays. Not inspected for structural defects.
7. East Gravity Dam Blocks 13-19					
(a) deck		✓			Cracked & spalled with some hollow areas
(b) handrails	✓				
(c) upstream face			✓		Badly deteriorated; spalled and about to spall up to 300 mm deep.

Item	Condition				Remarks
	E-G	F-M	P-VP-F	N/I	
(c) downstream face			✓		Badly deteriorated; spalled, cracked and leakage through cracks. Wire mesh reinforcing exposed. Concrete spall and leakage at block 19; concrete is offset to 75 mm (Photos 9 & 10).
(d) gravity structure (2002 construction)	✓				Water flowing from north end drain (10 Lpm) and water flowing from south end drain (15 Lpm).
8. Spillway Access Bridge					
(a) deck (wood timbers)		✓			
(b) handrails	✓				
(c) piers			✓		Concrete is badly deteriorated on all three piers at the water level; however, supports have been strengthened and anchored (2004).
(d) abutments		✓			Concrete deteriorated at water level
9. Abandoned waste chute					
(a) deck		✓			Cracking and spalling
(b) handrails	✓				
(c) piers		✓			Concrete is badly deteriorated (cracked, spalled, & eroded). In 2004, piers were stabilized by anchoring into bedrock.
(d) upstream		✓			
(e) downstream			✓		Concrete is deteriorated (cracked & spalled).
10. Curved Spillway (Bays 101 to 114)					
(a) deck	✓				
- metal covers	✓				
(b) handrails	✓				Kick plate installed in fall of 2005.
(c) piers	✓				
(d) rollways	✓	✓			Rollways 109 & 114 were repaired in 2004.
(e) leakage		✓			
(f) stoplogs	✓				Stoplogs are damaged in the curved spillway bay 112, due to high ice flow in spring, as noted during the spring inspection. Damage appears to have increased slightly and leakage increased (Photos 11 & 12).
(h) crane rails	✓				
(i) retaining walls			✓		Upstream and downstream retaining walls are cracked and leaning inward.
11. Spillway (Bays 1 to 35)					
(a) deck	✓	✓			Minor spalling and slight scaling along joints.
- metal covers	✓				
(b) handrails	✓				
(c) piers		✓	✓		Piers 1-25 exhibit slight to severe scaling with slight erosion in bay 25. Piers 26-29 are eroded to 150 mm deep. Piers 30-35 are deteriorated at the downstream corners with rebar exposed. Leakage around gate checks at east pier in bay 26 and 27 and around gate check at west pier of bay 29.
(d) rollways	✓		✓		In bays 16-28, concrete erosion at sills is evident (not visible due to spilling.
(e) leakage	✓	✓			Excessive leakage in bays 27, 29, and 30-33. Spilling in bays 15-17, 19-26, 28, 34 and 35.
(f) stoplogs	✓			✓	Not inspected for structural defects.
(g) crane rails	✓	✓			One section is loose.
12. Spillway (Bays 36 to 44)					
(a) deck	✓				

Item	Condition				Remarks
	E-G	F-M	P-VP-F	N/I	
- steel covers	✓				
(b) handrails	✓				
(c) piers	✓				
(d) rollways	✓	✓			New sill beams and concrete were placed in bays 36 and 44. The remaining rollways remain in fair condition.
(e) leakage	✓				
(f) stoplogs	✓				Not inspected for structural defects.
(g) stoplog hoist building (Bay 36)	✓				
(h) crane rails	✓				
(i) hoist					Damaged during high winds (Photo 8), repaired in fall of 2008
13. Spillway (Bays 45 to 65) Spillway bays 45-53 were new in 2003 & bays 54-65 were new in 1999.					
(a) deck	✓				
- metal covers	✓				
(b) handrails	✓				
(c) piers	✓				
(d) rollways	✓			✓	
(e) leakage	✓		✓		Excessive leakage at bays 48, 49 and 58. Spilling in bays 50, 52-57 and 59.
(f) stoplogs				✓	New stoplogs installed in bays 45-53 in 2003.
(i) crane rails	✓				
14. Sluiceway (Bays 1 to 5)					
(a) deck		✓			Cracked with minor spalling
- metal covers	✓				Metal covers installed in 2006
(b) crane rails	✓	✓			South side of crane rail beam exhibits some freeze-thaw damage.
(c) piers		✓	✓		In 2004 sluiceway pier 1, which was badly cracked & spalled was repaired by anchoring and replacing the beam seat.
(d) rollways				✓	Not inspected due to spilling in bays 2 and 4. Excessive leakage in bays 1, 3, and 5.
(e) leakage past		✓			Excessive leakage at bays with stoplogs installed.
(f) stoplogs				✓	Stoplogs in bays 2 and 4 are scheduled to be replaced in 2007.
(h) parapet walls		✓	✓		Concrete deterioration (cracked, spalled and rebar exposed) is ongoing.
- crane rails	✓				
(i) crane	✓				New in 2006
15. Sluice Log Run		✓			
16. Switchyard					
(a) gates and fencing	✓				
(b) foundations	✓				

Photo 1: Extensive concrete freeze-thaw deterioration at water level on west gravity dam.

Photo 2: Freeze-thaw deterioration at water level on the intake piers

Photo 3: Approximately 40 mm of water on the basement floor due to high tail water.

Photo 4: Water coming up through cracks in basement floor; typical.

Photo 5: Damaged trash racks and slight debris upstream of unit 6 and 9 .

Photo 6: Damaged wood cover in the intake gate room, upstream of unit 12.

Photo 7: Concrete spalls along downstream north end of east gravity dam; leakage is evident through cracks (typical).

Photo 8: Hoist at spillway bay 36, was damaged in high winds.

Photos 9 & 10: Concrete spall and leakage at block 19; concrete is offset to 75 mm.

Photos 11 & 12: Stoplogs are damaged in the curved spillway bay 112, due to high ice flow in spring, as noted during the spring inspection. Damage and leakage appears to have increased.

Hi Barry, Garth

Randy McMahon and Jessica Hoplock (Dam Safety summer student) completed the Pointe spring intermediate inspection of concrete structures. Changes identified since our winter inspection include:

- the stoplogs in bay 112 of the curved spillway have been recently damaged (presumably by ice flows) and will require replacement and
- the downstream end of the log run wall has broken away this past winter. The log run has been abandoned and is neither a dam safety or a maintenance concern.

Please refer to Randy's email for more details.

Regards

Glenn

From: McMahon, Randy
Sent: Wednesday, April 30, 2008 11:54 AM
To: Ferguson, Glenn
Subject: Pointe Du Bois Spring Intermediate Inspection

On April 29, 2008 Jessica Hoplock, Duane Kabaluk (from site) and I performed our Spring Intermediate Inspection at Pointe Du Bois. There was no significant change in conditions, with the exception of four severely damaged stop logs in curved spillway bay 112. Duane indicated that the stop logs were not damaged two weeks ago and were most likely damaged from large ice flows observed the previous week. Please see attached photos.

P4290012.JPG (729 KB) P4290014.JPG (703 KB) P4290029.JPG (694 KB)

We also noticed a large piece of concrete broken off of the downstream concrete wall between the abandoned log sluice and the rockfill dam. I have attached a photo, but this is not a Dam Safety concern.

P4290024.JPG (701 KB)

We compared photos of the concrete offset at the construction joints on the decks at the East Gravity Dam and West Gravity Bulkhead taken from site personnel in April 2008 with photos previously taken by D.S. section personnel and concluded there was no significant change in conditions. We do appreciate the site staff's diligence in their observations and taking photos and encourage them to continue this practice.

Regards

Randy

From: Ferguson, Glenn
Sent: Friday, September 12, 2008 3:37 PM
To: Officer, Larry
Cc: Fergusson, Garth; Ritchie, Rodney; McMahon, Randy; Hoplock, Jessica; Halayko, Krista
Subject: Slave Falls and Pointe Dam Safety Intermediate Inpections

Hi Larry

No new dam safety deficiencies were identified during our intermediate inspection of concrete structures at Slave and Pointe this summer; however, some maintenance deficiencies were noted. One maintenance item - deterioration of the brick facade on the upstream powerhouse wall at Slave Falls should be investigated in more detail. This is not a new item (reported by site staff during routine inspections) but conditions have been getting progressively worse. I have included photos showing current conditions.

Please refer to the below email from Randy McMahon for further information.

Regards

Glenn

Glenn Ferguson C.E.T.
Surveillance, Concrete Structures
Dam Safety Section
Civil Engineering Department
Manitoba Hydro
Ph: (204) 474-4501

Glenn,

Jessica and I recently completed the DS Intermediate Inspections at Slave Falls and Pointe du Bois on July 7 & 8, 2008 respectively. We also photographed the upstream, downstream and deck joints of the East and West Gravity Dams at Pointe. Some observations we made during our inspection are as follows:

Slave Falls

Rockfill Dam

* Increased spalling (up to 30" wide) and exposed rebar at water level along fourth joint south of north tangent on upstream.

7-Bay Sluiceway

* Concrete spalling and exposed rebar on upstream deck face at bay 6

* Concrete continues to spall on downstream face of piers 2 & 4

28-Bay Spillway

* Concrete cracking and spalling /about to spall on piers 7, 10 and 19 appears worse.

* Concrete spalling (with exposed rebar) has increased on the underside of deck. Exposed rebar and pipe in bay 26 and at pier 7 north face are the worst.

* Joint at pier 13 south face and underside of deck is spalled and open to 3/4"

Powerhouse

* Brick facing spalled off at south end and at unit 6. The spalling has occurred on the eighth row from the top and there appears to be a metal plate behind the brick facing at that level. This item has been previously indentified by site staff during their routine inspections.

* Roof leak in generator floor between units 7 and 8 and in gate room above beams at units 1-3 south opening.

South N.O.D.

* Sloughing of trees at the point upstream of the South N.O.D. continues.

Creek Spillway

* Considerable leakage throughout, bays 4, 11 and 18 are the worst. Water continues to flow between the sill and stoplog in bays 2, 4 and 6; and is now flowing behind metal stoplog gain in bays 4 and 6.

Pointe du Bois

With the high water, site was spilling through spillway bays 6-11, 13-28, 30-35, 47, 49-52, 56-65 and sluiceway bays 2-4.

Spillway(s)

* The new spillway hydraulic hoist was damaged

* Damaged stoplogs in bays 17 and 22 were repaired

* Stoplogs are damaged in the curved spillway bay 112, due to high ice flow in spring, as noted during the spring inspection.

East Gravity Dam

* Increased concrete spalling and new leakage on the downstream side of blocks 13-19 and increased spalling on downstream side of blocks 1-12 (first noted by site during routine inspections)

* Site continues to clear brush and vegetation along the downstream toe of the east gravity dam blocks 1-12 which makes inspecting and photographing much easier.

Powerhouse

* There was 1-2" of water in areas of the basement floor due to high tailwater

* A few active leaks were noted in the generator and gate room roofs

* Trash racks in the gate room upstream of units 6 & 9 were damaged (this was noted during our spring inspection)

From: Ferguson, Glenn
Sent: Thursday, October 16, 2008 2:49 PM
To: Fergusson, Garth; Officer, Larry
Cc: Richards, Scott; Halayko, Krista; Yereniuk, Val; McMahon, Randy
Subject: Pointe du Bois Fall Dam Safety Intermediate Inspection

Hi Garth & Larry

On October 15, 2008, Randy McMahon, Don Seaton (from site) and I conducted the Fall Dam Safety Intermediate Inspection of the concrete structures at Pointe. No significant changes in conditions were identified since our previous spring and summer inspections.

The following are key observations made during our inspection:

- Provisions were being made to replace the broken stoplogs at bay 112 of the curved spillway.
- Electrical work was being performed on the gate heat for hydraulic gate 30.
- Leakage, particularly below the bottom log in bays 4 and 10 has increased considerably since the spring (April 29) inspection. Site was spilling extensively in this area at the time of the summer (July 9) inspection.
- The bottom log in spillway bay 11 is split.

The fall intermediate inspection along with the spring, summer and winter inspections will be reported in the Pointe du Bois 2008 Dam Safety Annual Report early next year. If you have further questions, please do not hesitate to call.

Regards
Glenn

Glenn Ferguson C.E.T.
Surveillance, Concrete Structures
Dam Safety Section
Civil Engineering Department
Manitoba Hydro
Ph: (204) 474-4501

D1910

MANITOBA HYDRO

INTEROFFICE MEMORANDUM

FROM Val Yereniuk, P.Eng
Structural Engineer
Civil Engineering Department
Engineering Services
Power Supply

TO Joel Wortley, P.Eng
Department Manager
Civil Engineering Department
Engineering Services
Power Supply

DATE 2008 03 18

FILE CED-00102-0013-001

SUBJECT **POINTE DU BOIS SEISMIC TEST PROGRAM - SURVEILLANCE RESULTS**

The seismic test program at Pointe du Bois was conducted on March 4-7, 2008. All of the structures adjacent to the testing area showed no change in observed conditions and all peak particle velocity readings measured on the structures were below the imposed limit of 10 mm/sec.

Background

A seismic test program was conducted in early March to help in planning the production blasting for the Pointe du Bois redevelopment. Prior to the initiation of the program, Generation South requested the expertise of the Civil Engineering Department to determine the peak particle velocity limits for the structures adjacent to the blasting. Due to the age and condition of the structures, particularly the east gravity dam, a peak particle velocity limit of 10 mm/sec at the structures was recommended.

In addition to the vibration limits imposed on the testing program, representatives from the Civil Engineering Department would be on site to monitor the condition of the structures adjacent to the seismic test area.

Surveillance

Val Yereniuk and Mike Toma from the Civil Engineering Department were on site during the seismic test program to monitor any changes in the conditions of the existing structures. During the seismic program, nine blasts were conducted at three locations.

The structures adjacent to the test area were visually inspected and the seismographs measuring peak particle velocity were manually read after each blast. All of the visual inspections conducted during the program found no visual change in any conditions of the structures and the maximum peak particle velocity measured on the structures was below 9 mm/sec.

PUB/MH I/PRE-18
Attachment 4

In addition to the visual inspections, the three operating load cells that measure tension in the post-tensioned anchors in the east gravity dam were read on four occasions. The load cell readings indicated that there were no changes in the anchor loads.

Recommendations
No immediate action pertaining to the seismic test program is required. The Civil Engineering Department will continue to monitor all structures at Pointe du Bois and report on conditions according to the latest version of the Manitoba Hydro Dam Safety Surveillance Inspection Guidelines for Concrete and Embankment Structures.

VAY/vay/PdB-Seismic Test Program.doc

cc. D.E. Lemke
K.S. Halayko

From: Yereniuk, Val
Sent: Wednesday, June 04, 2008 3:51 PM
To: Officer, Larry
Cc: Fergusson, Garth; Spangelo, Don; Halayko, Krista; Ferguson, Glenn; Dubois, Denis; Chambers, Ed
Subject: Pointe du Bois West Gravity Dam Underwater Inspection

On June 3, 2008, we completed the underwater inspection of the west abutment and west gravity dam at Pointe du Bois.

The inspection found a series of horizontal cracks that ran the length of the structure. Some of the cracks as well as the bedrock-concrete contact had been previously grouted (not sure exactly when), but the existing grout is in poor condition. The cracks likely follow original pour joints and do not show any indication of differential movement. There was no leakage detected at any of the cracks or at the vertical joints between blocks; however, very slight leakage was detected sporadically along the concrete-bedrock contact at the base of the structure.

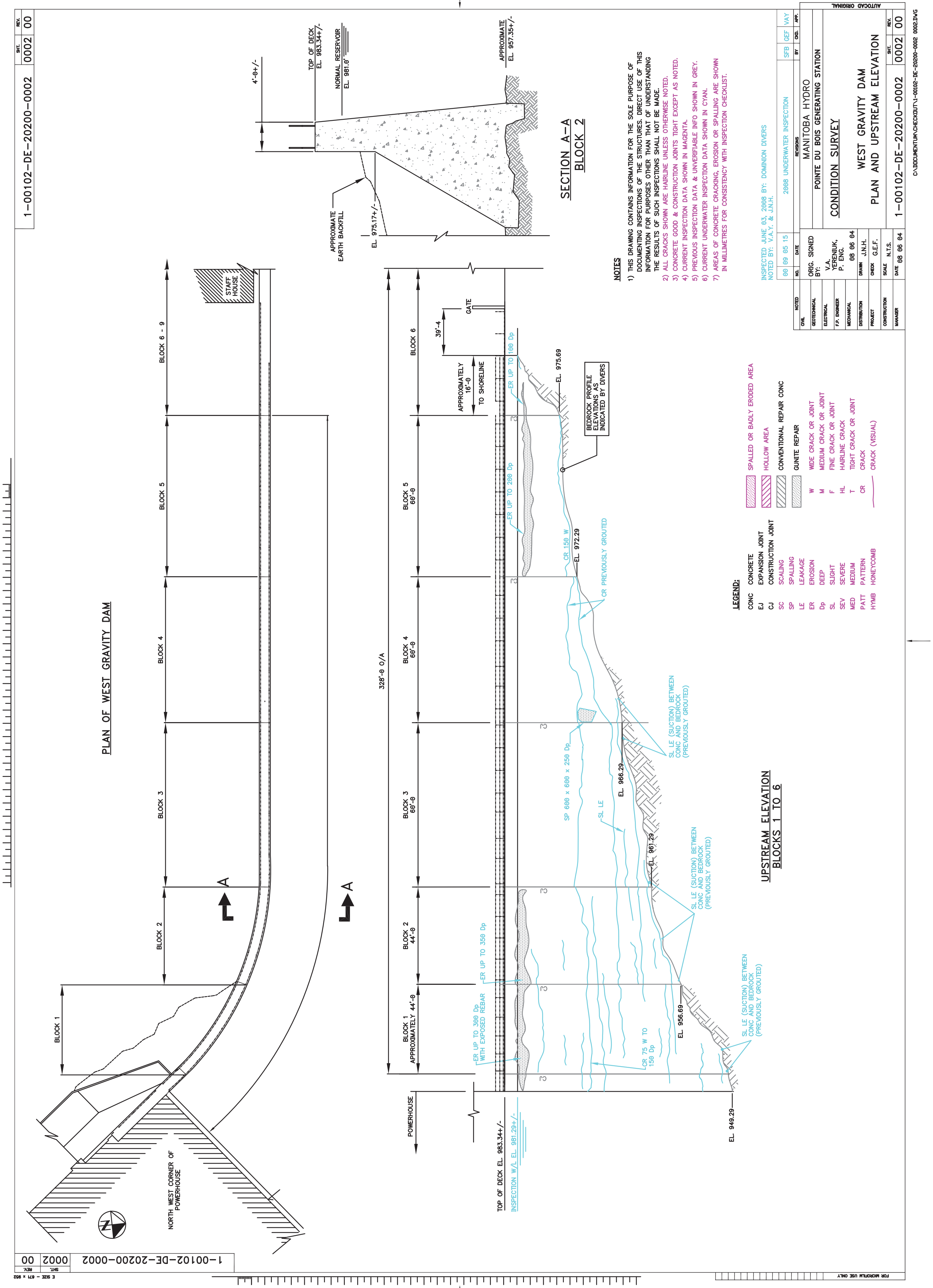
In addition, there was severe freeze-thaw erosion observed just below the water line. The erosion was up to 350 mm deep with exposed rebar, and was most severe on the curved section of the dam, adjacent to the powerhouse.

At this time we recommend continuing with the current inspection program and continuing to monitor the leakage through the west gravity dam during the routine and intermediate inspections. A detailed inspection drawing documenting the conditions observed during the June 3, 2008 inspection will be issued as part of the 2008 Pointe du Bois Dam Safety Annual Report.

If you have any questions or comments please let me know.

Regards,

Val Yereniuk, P.Eng.
Structural Engineer
Civil Engineering Department
Manitoba Hydro
204.477.7134
vayereniuk@hydro.mb.ca


1-00102-DE-20200-0002
SHT. 0002
REV. 00
PLAN OF WEST GRAVITY DAM
BLOCK 1
BLOCK 2
BLOCK 3
BLOCK 4
BLOCK 5
BLOCK 6 - 9
STAFF HOUSE
NORTH WEST CORNER OF POWERHOUSE
A
SECTION A-A
BLOCK 2
TOP OF DECK EL. 983.34+/-
NORMAL RESERVOIR EL. 981.0
4'-0+/-
APPROXIMATE EARTH BACKFILL
EL. 975.17+/-
APPROXIMATE EL. 957.35+/-
UPSTREAM ELEVATION
BLOCKS 1 TO 6
328'-0 O/A
BLOCK 1 APPROXIMATELY 44'-0
BLOCK 2 44'-0
BLOCK 3 60'-0
BLOCK 4 60'-0
BLOCK 5 60'-0
BLOCK 6
39'-4
GATE
APPROXIMATELY 16'-0 TO SHORELINE
POWERHOUSE
TOP OF DECK EL. 983.34+/-
INSPECTION W/L EL. 981.29+/-
EL. 949.29
EL. 956.69
EL. 961.29
EL. 966.29
EL. 972.29
EL. 975.69
BEDROCK PROFILE ELEVATIONS AS INDICATED BY DIVERS
ER UP TO 300 Dp WITH EXPOSED REBAR
ER UP TO 350 Dp
ER UP TO 200 Dp
ER UP TO 100 Dp
CR 75 W TO 150 Dp
CR 150 W
CR PREVIOUSLY GROUTED
SP 600 x 600 x 250 Dp
SL LE
SL LE (SUCTION) BETWEEN CONC AND BEDROCK (PREVIOUSLY GROUTED)
CJ
NOTES
1) THIS DRAWING CONTAINS INFORMATION FOR THE SOLE PURPOSE OF DOCUMENTING INSPECTIONS OF THE STRUCTURES. DIRECT USE OF THIS INFORMATION FOR PURPOSES OTHER THAN THAT OF UNDERSTANDING THE RESULTS OF SUCH INSPECTIONS SHALL NOT BE MADE.
2) ALL CRACKS SHOWN ARE HAIRLINE UNLESS OTHERWISE NOTED.
3) CONCRETE GOOD & CONSTRUCTION JOINTS TIGHT EXCEPT AS NOTED.
4) CURRENT INSPECTION DATA SHOWN IN MAGENTA.
5) PREVIOUS INSPECTION DATA & UNVERIFIABLE INFO SHOWN IN GREY.
6) CURRENT UNDERWATER INSPECTION DATA SHOWN IN CYAN.
7) AREAS OF CONCRETE CRACKING, EROSION OR SPALLING ARE SHOWN IN MILLIMETRES FOR CONSISTENCY WITH INSPECTION CHECKLIST.
LEGEND:
CONC CONCRETE
EJ EXPANSION JOINT
CJ CONSTRUCTION JOINT
SC SCALING
SP SPALLING
LE LEAKAGE
ER EROSION
Dp DEEP
SL SLIGHT
SEV SEVERE
MED MEDIUM
PATT PATTERN
HYMB HONEYCOMB
SPALLED OR BADLY ERODED AREA
HOLLOW AREA
CONVENTIONAL REPAIR CONC
GUNITE REPAIR
W WIDE CRACK OR JOINT
M MEDIUM CRACK OR JOINT
F FINE CRACK OR JOINT
HL HAIRLINE CRACK
T TIGHT CRACK OR JOINT
CR CRACK
CRACK (VISUAL)
INSPECTED JUNE 03, 2008 BY: DOMINION DIVERS
NOTED BY: V.A.Y. & J.N.H.
08 09 05 15 2008 UNDERWATER INSPECTION SFB GEF VAY
MANITOBA HYDRO
POINTE DU BOIS GENERATING STATION
CONDITION SURVEY
WEST GRAVITY DAM
PLAN AND UPSTREAM ELEVATION
ORIG. SIGNED BY: V.A. YERENIUK, P. ENG.
08 06 04
DRAWN J.N.H.
CHECK G.E.F.
SCALE N.T.S.
DATE 08 06 04
AUTOCAD ORIGINAL
FOR MICROFILM USE ONLY
E SIZE - 671 x 952

Civil Engineering Department - Dam Safety Section

POINTE DU BOIS GENERATING STATION - EAST GRAVITY DAM PHOTO LOG

Condition Legend
NC = No change since previous inspection
C = Change (deterioration, increased leakage, or signs of movement since previous inspection)

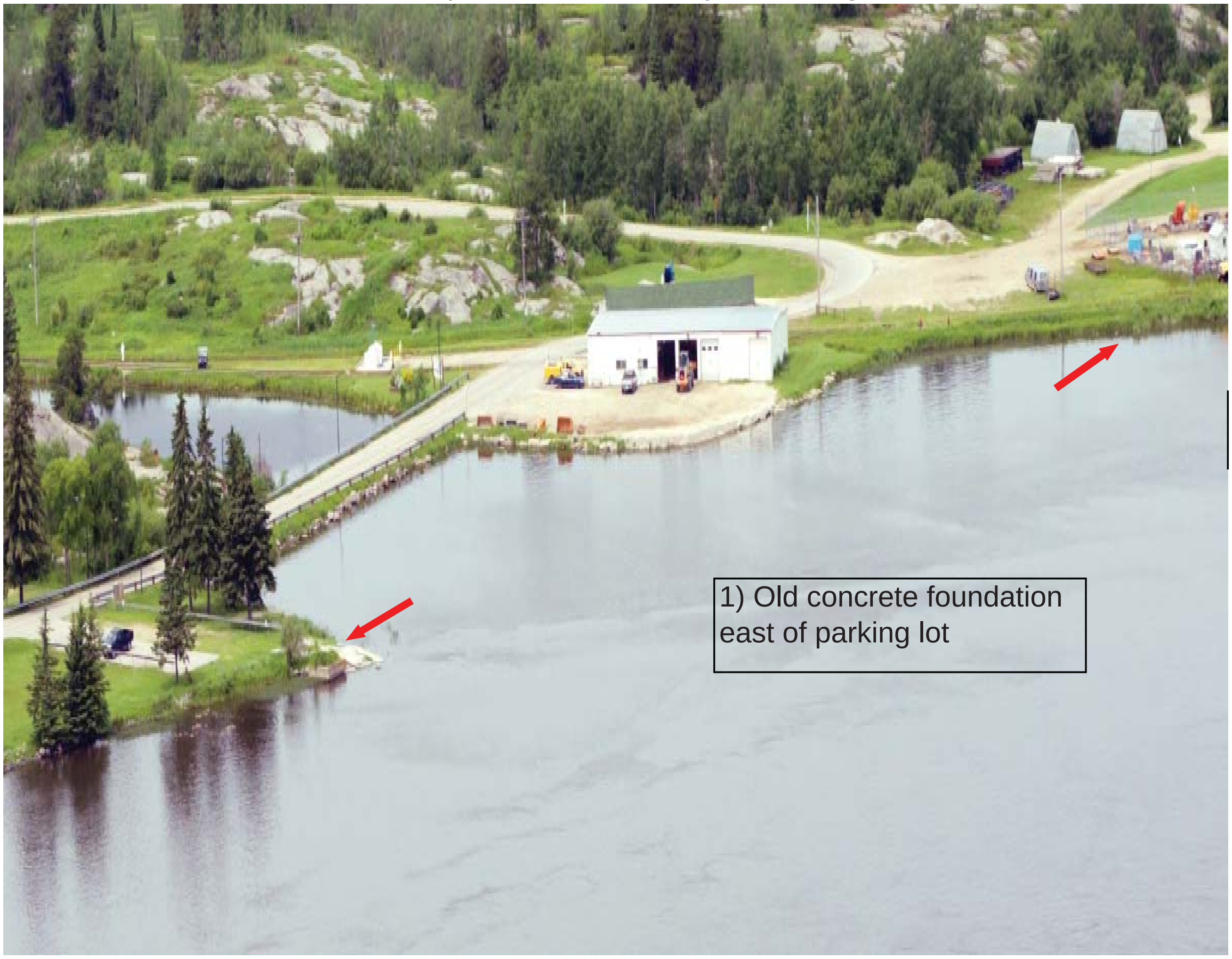
Inspection Dates:	October 11, 2007 & July 8, 2008
2007 Forebay Level:	298.87 m (inner)
2008 Forebay Level:	298.85 m (inner) 299.06 m (outer)

Structure	2007	2008	Photo Description	Condition	Comments
Upstream, Blocks 1-12	P 017.jpg	IMG_1445.JPG	Block 1	NC	
	P 018.jpg	IMG_1446.JPG	Block 2	C	Surface spalling has increased slightly
	P 019.jpg	IMG_1447.JPG	Block 3	C	Surface spalling has increased slightly
	P 020.jpg P 021.jpg	IMG_1448.JPG	Block 4	NC	
	P 022.jpg	IMG_1449.JPG	Block 5	NC	
	P 023.jpg	IMG_1450.JPG	Block 6	NC	
	P 024.jpg	IMG_1451.JPG	Block 7	NC	
	P 025.jpg	IMG_1452.JPG	Block 8	NC	
	P 026.jpg	IMG_1453.JPG	Block 9	NC	
	P 027.jpg	IMG_1454.JPG	Block 10	NC	
	P 027.jpg	IMG_1455.JPG	Block 11	NC	
	P 028.jpg	IMG_1456.JPG	Block 12	NC	
Spillway Bays 121-133	P 029.jpg P 030.jpg	IMG_1457.JPG	Bays 130-133	NC	
	P 031.jpg	IMG_1458.JPG	Bays 127-131	NC	
	P 032.jpg	IMG_1459.JPG	Bays 124-128	NC	
	P 033.jpg	IMG_1460.JPG	Bays 121-124	NC	
	P 057.jpg	IMG_1461.JPG	Bays 132-133	NC	
	P 056.jpg	IMG_1462.JPG	Bays 129-131	NC	
	P 055.jpg	IMG_1463.JPG	Bays 126-128	NC	
	P 054.jpg	IMG_1464.JPG	Bays 123-126	NC	
	P 053.jpg	IMG_1465.JPG	Bays 121-123	NC	
Upstream, Blocks 13-19	P 053.jpg	IMG_1466.JPG	Block 13	NC	
	P 052.jpg	IMG_1467.JPG	Block 13-14	NC	
	P 051.jpg	IMG_1468.JPG	Block 14-15	NC	
	P 050.jpg	IMG_1469.JPG	Block 15-16	NC	
	P 049.jpg	IMG_1470.JPG	Block 16	NC	
	P 048.jpg	IMG_1471.JPG	Block 16-17	C	Surface spalling has increased slightly at joint
	P 048.jpg	IMG_1472.JPG	Block 17-18	NC	
	P 047.jpg	IMG_1473.JPG	Block 18	NC	
	P 046.jpg	IMG_1474.JPG	Block 19	NC	
Deck Joints		IMG_1475.JPG	1st joint d/s of access bridge		Photos of deck joints were not taken in 2007
		IMG_1476.JPG	Crack parallel with d/s face before joint 2		
		IMG_1477.JPG	2nd joint		
		IMG_1478.JPG	3rd joint		
		IMG_1479.JPG	4th joint		
		IMG_1480.JPG	5th joint		
		IMG_1481.JPG	6th joint		
		IMG_1482.JPG	7th joint		

Structure	2007	2008	Photo Description	Condition	Comments
Deck Joints		IMG_1483.JPG	8th joint		
		IMG_1484.JPG	9th joint		
		IMG_1485.JPG	10th joint, btw spillway bays 122 & 123		
		IMG_1486.JPG	11th joint, btw spillway bays 125 & 126		
		IMG_1487.JPG	12th joint, btw spillway bays 128 & 129		
		IMG_1488.JPG	13th joint, btw spillway bays 131 & 132		
		IMG_1489.JPG	14th joint, d/s of spillway bay 133		
		IMG_1490.JPG	15th joint, d/s of rails		
		IMG_1491.JPG	16th joint, d/s end of gravity structure		
		IMG_1492.JPG	17th joint, joint covered by repair		Photos of deck joints were not taken in 2007
		IMG_1493.JPG	18th joint		
		IMG_1494.JPG	19th joint, joint covered by repair		
		IMG_1495.JPG	20th joint		
		IMG_1496.JPG	21th joint		
		IMG_1497.JPG	22th joint		
		IMG_1498.JPG	23th joint		
		IMG_1499.JPG	24th joint		
		IMG_1500.JPG	25th joint		
		IMG_1501.JPG	26th joint		
Downstream, Blocks 1-12	P 068.jpg	IMG_1502.JPG	East Abutment	NC	
	P 069.jpg	IMG_1503.JPG	Block 1-2	C	Increased leakage
	P 070.jpg	IMG_1504.JPG	Blocks 2-3	C	Increased leakage
	P 071.jpg	IMG_1505.JPG	Blocks 2-3	C	Increased leakage
	P 072.jpg	IMG_1506.JPG	Block 3	NC	
	P 073.jpg	IMG_1507.JPG	Block 3	NC	
	P 074.jpg	IMG_1508.JPG	Block 4	NC	
	P 076.jpg	IMG_1509.JPG	Block 5	NC	
	P 077.jpg	IMG_1510.JPG	Blocks 5-6	C	Surface spalling has increased slightly
	P 078.jpg	IMG_1511.JPG	Block 7	C	Increased leakage
		IMG_1512.JPG	Blocks 7-8	NC	
	P 079.jpg	IMG_1513.JPG	Block 8	NC	
	P 080.jpg	IMG_1514.JPG	Block 9	NC	
	P 081.jpg	IMG_1515.JPG	Block 10	C	Surface spalling has increased slightly
	P 083.jpg	IMG_1517.JPG	Blocks 11-12 (south east gravity dam buttress)	NC	
Spillway Bays 121-133	P 084.jpg	IMG_1518.JPG		NC	
	P 085.jpg	IMG_1519.JPG		NC	
Downstream, Blocks 13-19	P 106.jpg	IMG_1520.JPG	Block 19	NC	
	P 105.jpg	IMG_1521.JPG	Block 18	NC	
	P 103.jpg	IMG_1522.JPG	Block 17	NC	
	P 103.jpg	IMG_1523.JPG	Block 16	NC	
	P 102.jpg	IMG_1525.JPG	Block 15 (north east gravity dam buttress)	NC	
	P 101.jpg	IMG_1526.JPG	Block 14	NC	
	P 100.jpg	IMG_1527.JPG	Block 13	NC	
Spillway Bays 121-133	P 107.jpg	IMG_1528.JPG		NC	
	P 107.jpg	IMG_1529.JPG		NC	
	P 107.jpg	IMG_1530.JPG		NC	

Camera Location Plan

For Upstream East Gravity Photo Log



Manitoba Hydro

Civil Engineering Department - Dam Safety Section

POINTE DU BOIS GENERATING STATION - WEST GRAVITY DAM PHOTO LOG

Condition Legend
NC = No change since previous inspection
C = Change (deterioration, increased leakage, or signs of movement since previous inspection)

Inspection Dates: October 11, 2007 & July 8, 2008
2007 Forebay Level: 298.87 m (inner)
2008 Forebay Level: 298.85 m (inner) 299.06 m (outer)

Structure	2007	2008	Photo Description	Condition	Comments
Upstream View	P 061.jpg	IMG_001.JPG		NC	
	P 061.jpg	IMG_002.JPG		NC	
	P 062.jpg	IMG_003.JPG		C	Surface spalling has increased slightly
	P 062.jpg	IMG_004.JPG		NC	
	P 063.jpg	IMG_005.JPG		NC	
	P 064.jpg	IMG_006.JPG		NC	
	P 065.jpg	IMG_007.JPG		NC	
	P 065.jpg	IMG_008.JPG		NC	
	P 066.jpg	IMG_009.JPG		NC	
	P 067.jpg	IMG_010.JPG		NC	
Deck Joints		IMG_011.JPG	Crack u/s of handrail		
		IMG_012.JPG	1st joint		
		IMG_013.JPG	Crack		
		IMG_014.JPG	2nd joint		
		IMG_015.JPG	3rd joint		Photos of deck joints were not taken in 2007
		IMG_016.JPG	Crack		
		IMG_017.JPG	4th joint		
		IMG_018.JPG	5th joint		
		IMG_019.JPG	6th joint		
		IMG_020.JPG	7th joint d/s of powerhouse		
Downstream View		IMG_021.JPG		NC	
	P 126.jpg	IMG_022.JPG		NC	
		IMG_023.JPG		NC	
	P 125.jpg	IMG_024.JPG		NC	
		IMG_025.JPG		NC	
	P 124.jpg	IMG_026.JPG		C	Spalling at handrail embedment has increased
		IMG_027.JPG		NC	
		IMG_028.JPG		NC	

From: Klein, Marno

Sent: Wednesday, July 30, 2008 9:35 AM

To: Lemke, Dennis

Cc: Ferguson, Glenn; Halayko, Krista; McMahon, Randy

Subject: Pointe du Bois OSG - EGD & WGD Benchmark Photos

The dam safety section has completed a database of benchmark photos to monitor alignment of the PdB EGD & WGD. The photos were taken July 8, 2008 by Randy McMahon and Jessica Hoplock. The information is being stored in the following directory and will be part of the concrete intermediate inspections: S:\Dam_Safety-New-Filing-system\00102-PdBGS\Concrete Structures\20010-Concrete Surveillance\20011-Intermediate Inspections\2008\Gravity Dam Photo Log- 2008

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E1910

MANITOBA HYDRO

INTEROFFICE MEMORANDUM

FROM D.E. Lemke, P. Eng.
Section Head, Hydrotechnical Engineering
Civil Engineering Department
Engineering Services Division

TO R.G. McKinnon, Manager
Winnipeg River Generating Stations
N. G. Read, Manager
Generation Maintenance Engineering
Generation South Division

DATE 2008 06 26

FILE 00102-21410

SUBJECT **POINTE DU BOIS – DAM SAFETY OPERATIONS SUPPORT GROUP CONDITION OF EAST AND WEST GRAVITY DAMS AND ABUTMENTS**

The Pointe du Bois Dam Safety Operations Support Group (OSG) investigated the condition and stability of the concrete gravity structures adjacent to the powerhouse. Based on existing conditions, at this time major rehabilitation work to the east gravity structures (including access improvements) is not recommended prior to modernization. The west gravity dam is stable under normal conditions, but some additional analysis is being done to determine if there are cost-effective risk reduction measures that can be taken to mitigate unusual loadings. The impact of modernization construction activities on the structures is beyond the scope of the OSG and should be considered by the modernization design team.

The OSG was initiated in October, 2006. Since that time, the work of the group has included assessments of past studies, a Failure Modes and Effects Analysis, and new concrete condition and stability analyses. At the present time, the structures meet CDA global stability criteria and the condition of the structures has been found to be adequate for the interim period prior to modernization due to past anchoring and buttressing work. The structures continue to be monitored for surface condition, alignments, anchor loads, and seepage so that possible changes to the condition will be detected. Work has also been done to improve the reliability of maintaining reservoir control to limit unusual loadings on the structures. Spillway and sluiceway hoist systems have been replaced or upgraded and spillway bay operating sequences have been developed. Work is underway to improve the ability to mobilize spill during winter conditions by providing redundancy and improvements in the steam generating/delivery system and investigating the benefits of providing agitators upstream of the sluiceway bays to reduce upstream ice.

While present conditions do not warrant major rehabilitation prior to modernization, overall the station does not meet Manitoba Hydro’s standards for dam safety. Therefore, operating the structures in the present condition for the interim period does present some risks, but these are kept low if the period of exposure remains relatively small with an assumed modernization in-service date between 2015 to 2018. Major repair work to the east gravity dam would have a high cost and could take a long time to implement, which would decrease the risk reduction benefits prior to modernization.

With no recommended major rehabilitation to the east gravity dam at this time, the group believes that there is insufficient justification to advance the construction of a temporary access bridge across the inner forebay. The bridge itself would not prevent any future instability of the structures, but may reduce the duration of possible emergency actions such as lowering the forebay or dewatering the inner forebay if problems do arise.

Some study is still required to assess whether there are justifiable options for improving the stability of the west gravity dam given its reliance on the downstream fill that could be eroded if the dam is overtopped. The easy access to this structure would allow quicker and less costly improvements compared to the east gravity dam.

The assessment provided herein is based on existing conditions, which may change in the interim period before modernization. Generation South and Engineering Services continue to monitor and study the structures, and justifiable actions to reduce risk and will be proposed as they are identified.

The following sections provide some detail of considerations that lead to the general assessment above.

Failure Modes & Effects Analysis - Primary Failure Modes

Manitoba Hydro performed a Failure Modes & Effects Analysis (FMEA) in February 2007 to identify, describe, and classify potential failure modes and to suggest risk reduction measures. The only failure mode that was categorized in the highest level of concern was a potential failure of the west gravity dam if it is overtopped due to a rising forebay resulting from a prolonged station load rejection. This failure mode was considered to be more likely to occur in the winter when spillway gates are frozen and therefore harder to operate. A thorough stability analysis of the west gravity dam had not been conducted prior to the FMEA.

Due to the extensive analysis and rehabilitation completed on the east gravity dam over the years, none of the failure modes for this structure were categorized in the highest level of concern. The main vulnerability is a horizontal joint between the original dam concrete and the upper portion of the existing configuration that was added in 1911, soon after initial construction. A failure of this upper portion is not likely to result in a release of water that exceeds capacity of the powerhouse, and therefore the downstream flows could likely be controlled by reducing plant discharge. A deep sliding failure of the east gravity dam would have more significant consequences that could not be mitigated entirely through a reduction in powerhouse outflow. This type of failure is less likely since the structure currently meets CDA criteria for global stability and there is little history of this type of failure worldwide. In addition, if a block of the dam were to fail it would likely hang up with adjacent blocks instead of completely moving downstream, thereby limiting the amount of water released.

Condition of Structures

In early 2007, Civil Engineering conducted a structural assessment of the east and west gravity dams and abutments based on previous work to clarify the known condition of the structures. The report summarized the findings of any stability analyses and remedial measures, visual inspections and materials investigations completed on the structures[1]. While the condition of the concrete in the east gravity dam has been a concern, the Civil Engineering Department found little change in the condition of the gravity dams and abutments over the last five years of inspections.

In the summer of 2007, Civil Engineering conducted a concrete coring program that included a series of eight diamond drill core holes in the east gravity dam and two holes in the west gravity dam. The cores were analyzed by Manitoba Hydro, Crosier-Kilgour, and Wiss, Janney, Elstner Associates of Illinois. It was determined that, while there are fractures present in the concrete, particularly at the joint between the original concrete and the top block that was added in 1911, there were no significant voids detected. Continued deterioration of the dam due to Alkali Aggregate Reactivity (AAR) is not expected to be significant. It was concluded that the concrete for the gravity structures will perform as required until modernization (assumed ISD between 2015 and 2018), based on the condition of the concrete that was analyzed and the remedial work that has been done to date[2].

Stability of Structures

The structural assessment conducted by Civil Engineering in early 2007 included a review of the latest stability analyses. The review concluded that the global stability of the east gravity dam and abutment and west abutment meet CDA standards, but that insufficient information was available to assess the stability of the west gravity dam.

In 2008, Civil Engineering performed a stability assessment of the west gravity dam[3]. The analysis concluded that the stability of the structure is dependant on the clay fill that is located on the downstream side of the dam. The dam satisfies CDA stability criteria if the fill is present, but if the dam were to be overtopped the fill would be washed away and the dam could become unstable. The OSG is looking at the possible benefits of protecting the downstream clay fill, or possibly anchoring the structure. Unlike the east gravity dam, access to the west gravity dam is good and would not cause schedule delays if work is required.

The 2002 anchoring program for the east gravity dam was designed with load cells and strain gauges installed on four sets of adjacent anchors to provide redundant load monitoring. In 2007, the load cells were read and the readings were found to be close to the

[1] Pointe du Bois Generating Station East and West Gravity Dams and Abutments 2007 Structural Assessment, Civil Engineering Department, File CED-00102-0004-0001, Report No. ESD07-24, June 2007.
[2] Pointe du Bois Generating Station East and West Gravity Dams 2007 Concrete Coring Program Results, Civil Engineering Department, File CED-00102-21000, Report No. ESD08-07, June 2008.
[3] Pointe du Bois Generating Station West Gravity Dam Stability Assessment, Civil Engineering Department, File CED-00102-0008-001, Report No. ESD07-38, March 2008.

PUB/MH II-1-8
Attachment 4

lock-off loads[4]. This indicates that the anchors in the east gravity dam are performing well, and have the required design loads to meet the stability safety factors outlined in the CDA Dam Safety Guidelines. Periodic, continued monitoring of the loads was recommended and has been added to the instrumentation surveillance schedules.

Risks

As noted in a previous memorandum on the risks of a sliding ISD for the modernization project, hydroelectric generating stations cannot be operated without some risk[5]. Given its condition and design, Pointe du Bois carries greater risk than other generating stations in the Manitoba Hydro system, and this is the primary justification for modernization.

The FMEA provided confidence that failures of the gravity structures would not likely result in the catastrophic consequences that were identified by dam breach studies performed in the 1990's. While there is confidence, there is no guarantee that a gravity structure will not fail to a greater extent than presently assumed. A catastrophic failure could result in loss of life and cascading effects downstream. The OSG has assumed that a non-catastrophic release of reservoir water through a partial breach of a gravity dam would be a reasonable acceptable risk given:

- the subjectively-assessed low likelihood of occurrence based on condition assessments and stability analyses,
- the short remaining life of the existing structures (assuming an ISD of about 2015), and
- the high costs of temporary remedial measures.

However, even partial loss of control may result in intangible consequences such as damage to corporate reputation, future licensing initiatives, or possible advancement of provincial dam safety regulations. The OSG recognizes that it does not have the authority to establish the acceptable corporate limits to these or any other types of significant risk.

Risk Reduction

The OSG has assessed the risk reduction measures identified during the FMEA and is taking action where deemed appropriate. Some of these measures are related to improving monitoring (e.g., monitoring of anchor loads) to increase the probability of detecting problems prior to a failure. Efforts have also been directed towards minimizing the potential for forebay surcharge or overtopping conditions that lead to the most critical FMEA failure modes. This work is primarily related to spillway/sluiceway hoist and gate operating improvements. Some additional analysis is required to determine if there is justification to ensure the stability of the west gravity dam.

[4] Pointe Du Bois - East Gravity Dam - Load Cell Readings, Memorandum from V. Yereniuk to B. Warner, File CED-00102-0010-001, 2007 10 31.
[5] Pointe Du Bois – Dam Safety Operations Support Group - Implications of a Delayed In-Service Date Beyond 2015, Memorandum from D.E. Lemke to J. Wortley, File 00102-05000, 2008 05 06.

Some risk reduction could be achieved by advancing the construction of an access bridge across the intake channel that will be required for the modernization project. However, the benefits would likely not be a reduction in the probability of a failure occurring. The potential benefits would rather be a reduction in lost generation if the reservoir has to be lowered or the inner forebay closed-off, if that becomes a requirement due to the detection of unsafe conditions with the east gravity dam.

Original signed and sealed by D.E. Lemke, P.Eng.

DEL/del/20080626rm-PB-OSG-GravityDams.doc

c: J.J.C. Wortley
Operations Support Group: G.J. Fergusson
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Appendix D

History of Dam Safety Surveillance Inspections

Pointe du Bois Generating Station
2008 History of Inspections
Dam Safety Surveillance

Inspections	Dams & Dykes	Concrete Structures	Remarks
Geotechnical Structures			
DS Intermediate (since 2003)		✓	Annual
Cursory Inspection (since 2003)		✓	Annual
Underwater Inspection (since 2003)		2006	Rockfill Dam
Hydrotechnical			
DS Intermediate (since 2003)		✓	Annual
Concrete Structures			
DS Intermediate (2003-2006)		✓	Annual
DS Intermediate (since July 2006)		✓	Annual
Condition Surveys		2005	Powerhouse study
Visual Inspection			
Underwater Inspection		2005	Intake sub-apron chambers, west abutment
		2006	Spillway access bridge piers
		2008	West Gravity Dam

Legend	
Gates	
E	Exterior of gate inspected
M	Gate embedments inspected
R	Rehabilitation
Sluiceway Concretes	
R	Rollway only (gate down)
D	Diving inspection
G	Gate gains only (stoplogs in)
P	Partial
Unit Concretes/TEP	
TR	Throat ring
TB	Turbine base

Inspections	Unit/Sluiceway Openings																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Hse Un1	Hse Un
	Year Inspected	Year Inspected	Year Inspected	Year Inspected	Year Inspected	Year Inspected	Year Inspected	Year Inspected	Year Inspected	Year Inspected	Year Inspected	Year Inspected	Year Inspected	Year Inspected	Year Inspected	Year Inspected	Year Inspected	Year Inspected
Sluiceway Gates																		
Sluiceway Concretes																		
Intake Bulkhead Gates																		
Intake Gain Concretes (by divers or camera)	2003	2003	2003	2003	2003	2003	2003	2003	2003	2003			2003	2003	2003		2003	2003
Wheel Pits			2003	2004 2007 TR-TB	2004	2004			2004	2007 TR-TB	2003		2003 2005			2003		
Draft Tubes (all but unit 1 inspected by divers)	2003			2005											2005	2005		

RED items reflect activities taking place in 2008

Revised November 29, 2008

Appendix E

Dam Safety Program Inspection Guidelines

MANITOBA HYDRO DAM SAFETY

SURVEILLANCE INSPECTION GUIDELINES FOR

CONCRETE AND EMBANKMENT STRUCTURES

EFFECTIVE 2008 01 01 to 2008 12 31

LIST OF CONTENTS

MANITOBA HYDRO DAM SAFETY SURVEILLANCE INSPECTION GUIDELINES FOR CONCRETE AND EMBANKMENT STRUCTURES

Effective 2008 01 01 to 2008 12 31

Recommended by: *G.E. Ferguson* C.E.T.
E.R. Chambers C.E.T.

Approved by: *T.J. Armstrong*

PROVINCE OF MANITOBA
2008 01 07
T J
ARMSTRONG
REGISTERED PROFESSIONAL ENGINEER

Date: January, 2008

Document No.: DSP-STD-04-01

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MANITOBA HYDRO'S DAM SAFETY SURVEILLANCE INSPECTION GUIDELINES FOR CONCRETE AND EMBANKMENT STRUCTURES

These guidelines, which were adopted in December, 2004, must be reviewed annually by the Dam Safety Section and updated if necessary, to reflect the ongoing developments in the dam safety industry, and within Manitoba Hydro. The guidelines must also take into account future hydro development and ensure a dam safety process is in place during and following construction.

1. Purpose

Corporate Policy G303 states that Manitoba Hydro conducts a Dam Safety Program that ensures its dams are constructed, operated and maintained in a safe manner. This program is based on the Canadian Dam Association (CDA) "Dam Safety Guidelines".

The objectives of the surveillance program are to detect changes in the condition of dams and to ensure that timely remedial measures are initiated as appropriate. The Dam Safety Program (DSP) includes: surveillance inspections, monitoring, analysis, testing, evaluations and reporting.

A surveillance program consisting of regular inspections, reporting and recommendations for maintenance of dams was initiated by the Geotechnical Department in 1974 and it was formally approved in 1979 (Report No. G.P.D. 42-C1 Safety Surveillance and Repair of Hydraulic Structures) to cover all the hydraulic structures owned by Manitoba Hydro. This program has since been expanded to a comprehensive DSP and the Dam Safety Section has determined there is a need for formal inspection guidelines which are aligned with the CDA Dam Safety Guidelines.

2. CDA Requirements for Inspection Guidelines

According to the CDA 2007 Dam Safety Guidelines, Section 3.6 the inspection guidelines should identify the types of inspections to be carried out, the purpose for each type of inspection, frequency of inspections, type of items to be inspected, and required documentation and follow-up. Section 3.6.3, dam instrumentation, is not included in this document. A policy for dam safety instrumentation is currently being developed.

3. Frequency of Inspections - Development of the Inspection Frequency Table

The inspection frequency table in these guidelines is based on:

- the Risk and Hazard Potential Classification for Manitoba Hydro concrete and embankment dams, 2002 version. The Dam Classification used in the 2002 Risk and Hazard Potential Classification for Manitoba Hydro concrete and embankment dams is based on the January 1999 CDA Guidelines. The dam classification table was revised in the 2007 CDA Guidelines and Manitoba

Hydro's risk and hazard ratings are scheduled to be reviewed and updated in 2008, based on the new dam classifications.

- the average condition index of the structure and
- the judgment of the personnel charged with the responsibility of maintaining a current and effective dam safety surveillance program for Manitoba Hydro's water retaining structures.

3.1 Manitoba Hydro's Risk and Hazard Potential Classification was developed in 2000 following the establishment of the Dam Safety Section within the Civil Engineering Department. The classification provides a ratings index of our dams and can be utilized as a guide for Dam Safety planning and scheduling. It is based on the Hydro Quebec rating system, but has been adopted to suit the inventory of structures and conditions prevalent in the Manitoba Hydro system. Inputs for the Risk and Hazard Classification include: type of dam, type of foundation, dam height, storage capacity, siesmicity, age of dam, flood discharge reliability, physical condition of dam, and consequence classification.

3.2 Condition indexing was implemented in 2001 for Manitoba Hydro embankment structures. It was developed jointly by Hydro Quebec and the U.S. Army Corps of Engineers to assist in allocating maintenance dollars for their dams in a more efficient manner. Condition indexing uses a failure mode based systematic approach to highlight the strengths and weaknesses of each component of an embankment structure. An overall average condition index (CI) for the structure is also determined. The average CI is the value that is used in the Dam Safety Inspection Guidelines.

3.3 The final input used in developing and updating the inspection frequency table is the judgment of personnel responsible for ensuring that surveillance of Manitoba Hydro concrete and embankment dams is in accordance with the CDA Dam Safety Guidelines. This is to include input from all Manitoba Hydro personnel who are knowledgeable of the structures.

4. Qualifications and Training of Inspectors

Certified Engineering Technologists (C.E.T.) and Professional Engineers (P.Eng.) are the two professional groups that must be responsible for the dam safety inspections. Both professions must have the appropriate academic background with specialized training and experience in dam safety inspections. The two professional groups may delegate staff other than C.E.T. or P.Eng. to perform the inspections.

Manitoba Hydro's corporate policy, G303, for dam safety is based on the Canadian Dam Associations Guidelines. Basing corporate policy on third party regulation avoids conflict of interest and omissions of enforcement that can happen when standards are set and measured internally.

The Dam Safety Section is accountable to provide site staff with Introduction to Surveillance to conduct routine inspections at their station.

5. Manitoba Hydro Dam Safety Inspections

Inspections 5.2 to 5.7 must follow the Engineering Services Division Business Process Management System (BPMS) for condition assessment (see http://hal/sites/EngineeringServices/ProcessManagement2/Approved/BPMS%20Matrix.htm# for details). If during any inspection a change in condition is discovered and considered to be significant, the levels of concern as described in the Emergency Preparedness Plan Dam Safety Emergency Classification and Response Guide must be followed with appropriate response, notification, and closure (Appendix C).

5.1 **Routine Inspections** shall be carried out by trained site staff as part of their maintenance activities. The routine inspection is intended as a general inspection that looks for obvious changes in condition of the concrete and embankment structures. Of particular significance are occurrences or noted changes in leakage, erosion, sinkholes, seepage, slope slumping or sliding, settlement, displacements or cracking of structural components and clogging of relief drains. Depending on the structure, the inspection frequency varies from a bi-weekly to a semi-annual basis throughout the entire year (see the attached inspection frequency table). If a structure is inaccessible and personal safety is at risk, an inspection report should be issued stating reasons for not conducting the inspection. The Dam Safety Section shall provide site staff with a checklist of items to be inspected. The checklist is to be filled out and the original is to be filed at site. Copies shall be forwarded to the Dam Safety Coordinator for that site and the Dam Safety Engineer in Winnipeg. These copies of the routine inspection reports submitted to the Dam Safety Engineer must be reviewed by the appropriate qualified Dam Safety Section staff prior to filing.

5.2 **Intermediate Inspections** shall be performed by the appropriate representatives in the Civil Engineering Department under the direction of the Dam Safety Engineer. These inspections are intended as a more formal inspection where the condition of the structure is evaluated and recommendations are made as necessary. Conditions are described with terminology consistent with the U.S. Army Corps of Engineers “REMR Condition Indexing Scale.” Condition Index data, checklists, photos, and drawings are to be included in the intermediate inspection report. The recommendation for further assessments, studies, increased surveillance, proposed instrumentation installations or repair, along with cost estimates, are to be input in the station’s Dam Safety Deficiencies Priorization Planners (spillway gates, concrete and embankments structures) and are to be reviewed by Generation North and Generation South. The Deficiency Planners and the intermediate inspection reports shall form part of the station dam safety annual report. The frequency for conducting intermediate inspections is summarized on the inspection frequency table.

5.3 Condition Indexing Inspections shall be performed by the condition indexing group for embankment structures. The group will consist of a panel of experts on embankment structures from the Civil Engineering Department. The inspection is intended to refresh the group's knowledge on the unique features of the structure immediately prior to the formal condition index session. The frequency of the inspections will be determined by significant change in condition of the structure such as remedial work or by a refinement in the condition index methodology. The output for the condition indexing will be included in the station dam safety annual report.

5.4 Unscheduled Inspections shall be performed by the appropriate representatives in the Civil Engineering Department under the direction of the Dam Safety Engineer. These inspections are not scheduled in advance; rather their timing may be the result of observations of unusual cracking, settlements, changes in seepage, etc. Unscheduled inspections must also be performed following unusual events such as wind storms, floods or earthquakes. The findings from the inspection shall be issued in a timely manner (email) and included in the station dam safety annual report.

5.5 Condition Surveys of Concrete Structures shall be performed by the appropriate representatives in the Civil Engineering Department under the direction of the Dam Safety Engineer. The purpose of the condition survey program is to ensure that the conditions of all concrete structures (above and below water) at generating stations and control structures are determined and updated on a regularly scheduled basis. Conditions are described with terminology consistent with the U.S. Army Corps of Engineers "REMR Condition Indexing Scale." Details from the inspections shall be shown on dam safety inspection drawings and shall be reported along with inspection photographs in the station dam safety annual report. Recommendations for structural assessments or remedial work may be realized as a result of the condition survey inspections and these items shall then be entered on the Deficiency Planners for that station. The frequency of the condition surveys ranges from 12 to 18 years and is shown on the inspection frequency table.

Inspections of spillway bays (gates, embedments, and concrete) and powerhouse water passages (intake gates, gains, scroll cases and draft tubes) also form part of the condition survey program; however, the inspection frequency for these structures does not follow the condition survey schedule. The frequency of spillway opening inspections ranges from 6 to 10 years based on usage and condition. As for the powerhouse units, they are to be inspected during major plant outages for maintenance and the inspections generally will run on a 10 to 12 year cycle. The inspection data shall form part of the station dam safety annual report and should include drawings, photographs, condition index sheets, and repair recommendations, where necessary. The deficiencies requiring repairs shall then be entered on the Dam Safety Deficiencies Prioritization Planners.

5.6 **Winter Inspections** shall be performed on an annual basis by the appropriate representatives in the Civil Engineering Department under the direction of the Dam Safety Engineer. Winter inspections are limited to the six plants on the Winnipeg River, because of the age and condition of some of the structures. The intake-powerhouse, spillway and appurtenant structures are to be inspected during the winter months to observe seasonal changes in behavior of the concrete structures. Of particular note is change in leakage through the structures, ice buildup and new cracking and spalling in the concrete structures. Findings from the winter inspection are to be reported in the station dam safety annual report.

5.7 **Cursory Inspections** of embankment structures in the marginal condition range shall be performed by the appropriate representatives in the Civil Engineering Department under the direction of the Dam Safety Engineer. It is intended to supplement the intermediate inspection by determining if any change has occurred since the previous intermediate inspection. If the average condition index is above the marginal range, but a specific component of the structure has scored low, judgment shall be used in determining if a cursory inspection is to be conducted. The report will be included in the station dam safety annual report.

5.8 **Dam Safety Review Inspections** are carried out in accordance with the CDA 2007 Dam Safety Guidelines, Section 5.4.2.

Zone	Condition Index	Condition Description	Recommended Action
1	85 to 100	Excellent: No noticeable defects. Some ageing or wear may be visible.	Immediate action is not required.
	70 to 84	Good: Only minor deterioration or defects are evident.	
2	55 to 69	Fair: Some deterioration or defects are evident, but function is not significantly affected.	Economic analysis of repair alternatives is recommended to determine appropriate action.
	40 to 54	Marginal: Moderate deterioration. Function is still adequate.	
3	25 to 39	Poor: Serious deterioration in at least some portions of the structure. Function is inadequate.	Detailed evaluation is required to determine the need for repair, rehabilitation, or reconstruction. Safety evaluation is recommended.
	10 to 24	Very Poor: Extensive deterioration. Barely functional.	
	0 to 9	Failed: No longer functions. General failure or complete failure of a major structural component.	

Manitoba Hydro's Inspection Guidelines

Type of Dam	Category	Risk & Hazard Score	Routine Frequency	Intermediate Frequency	DSR Frequency	Condition Survey Frequency
Earthfill	1	> 150	2 per month	Annual	6-7 years	N/A
	2	76 - 150	monthly	Annual	6-7 years	N/A
	3	0 - 75	2 per year	1 - 2 years	6-7 years	N/A
	4	N/A	1 per year, report and photo plate	as required based on routine inspection report		
Concrete	Special	> 75	monthly	4 per year	12-18 years	6-7 years
	1	> 75	1 per 2 months	Annual	6-7 years	12-18 years
	2	0 - 75	2 per year	1 - 2 years	6-7 years	18 years

Note: above inspections to be supplemented by cursory, winter and unscheduled inspections

Name of Facility	Name of Dam	Dam I.D.	Type of Dam	Average condition index score description based on the REMR scale	RISK & HAZARD SCORE	Inspection Category	Frequency
Pointe Du Bois G.S.	West Gravity Bulkhead	PdBGS-01	Concrete Gravity		***196.0***	special	As per inspection frequency guidelines
Pointe Du Bois G.S.	Intake Powerhouse	PdBGS-02	Concrete Gravity		***225.0***	special	As per inspection frequency guidelines
Pointe Du Bois G.S.	East Gravity Dam Blocks 1-12	PdBGS-03	Concrete Gravity		***210.0***	special	As per inspection frequency guidelines
Pointe Du Bois G.S.	Spillway Bays 121-133	PdBGS-04	Concrete Gravity		***210.0***	special	As per inspection frequency guidelines
Pointe Du Bois G.S.	East Gravity Dam Blocks 13-19	PdBGS-05	Concrete Gravity		***210.0***	special	As per inspection frequency guidelines
Pointe Du Bois G.S.	Curved Spillway Bays 101-114	PdBGS-06	Concrete Gravity		***140.0***	special	As per inspection frequency guidelines
Pointe Du Bois G.S.	Spillway Bays 1-35	PdBGS-07	Concrete Gravity		***140.0***	special	As per inspection frequency guidelines
Pointe Du Bois G.S.	Spillway Bays 36-44	PdBGS-08	Concrete Gravity		***140.0***	special	As per inspection frequency guidelines
Pointe Du Bois G.S.	Spillway Bays 45-65	PdBGS-09	Concrete Gravity		***156.0***	special	As per inspection frequency guidelines
Pointe Du Bois G.S.	Sluiceway Bays 1-5	PdBGS-10	Concrete Gravity		***168.0***	special	As per inspection frequency guidelines
Pointe Du Bois G.S.	Rockfill Dam	PdBGS-11	Rockfill	***74.0***	***168.0***	1	As per inspection frequency guidelines.

Exhibit #MH-18
Attachment 4

APPENDIX A

ORIGINAL SIGNING PAGE

Manitoba Hydro **dam safety program**	**Document Number:** DSP-STD-04-01 **File Number:** 00100-20010/20020	**Page:** 1 of 1
TITLE: **MANITOBA HYDRO'S DAM SAFETY SURVEILLANCE INSPECTION GUIDELINES FOR CONCRETE AND EMBANKMENT STRUCTURES**	**Effective Date:** 2005 01 01	**Revision:** R1

PURPOSE
Document prepared for use in the Dam Safety Program.

AUTHORIZATION		
Approved By:	T.J. Armstrong – Mgr. Civil Engineering	Date: 2005 01 27
Approved By:	G.E. Schellenberg Dam Safety Engineer Section Head – Dam Safety	Date: 05.01.27
Recommended By:	G.E. Ferguson E.R. Chambers Dam Safety Surveillance	Date: Jan. 27, 2005

ACCOUNTABLE DIVISION	SUBJECT MATTER EXPERTS
Engineering Services Division	G.E. Ferguson E.R.Chambers - Dam Safety

OTHER INFORMATION
This document was formulated based on the Canadian Dam Association *Dam Safety Guidelines* January 1999.

DOCUMENT HISTORY	
Revision History	See attached log

APPENDIX B

CHANGE RECORD SHEET

ENGINEERING SERVICES DIVISION
CIVIL ENGINEERING DEPARTMENT
DAM SAFETY SECTION

CHANGE RECORD SHEET

Revision	Change	By	Date	Approval
1 Inspection frequency table	Category 4 has been added for non-water retaining structures (freeboard). **Reason for change:** To further refine the guidelines, and to reflect realistic practice, an inspection frequency category 4 has been added. Regardless of the Risk and Hazard score, routine inspections will be carried out at a frequency of 1/year and the report will include a photo plate. Intermediate inspections will be performed as required based on the findings of the routine inspections.	ERC	2006 03 10	TJA
2 Inspection frequency table	We have revised the inspection frequency for the Jenpeg east dyke from a category 1 to a category 2. **Reason for change:** Recent inspections have indicated no new evidence of internal erosion and all repairs are performing well. A classical failure due to piping is very unlikely (Ref: Jenpeg 2004 DSAR Appendix E – Misc. docs. East Dyke collapsibility testing of embankment's sand core). A weir has been installed that measures seepage at the repaired internal erosion locations.	ERC	2006 03 10	TJA
3 Inspection frequency table	We have confirmed the name of The Kiskitto Lake Outlet Structure with the site. **Reason for change:** There were many names for this one structure. The site agreed that the name for the structure should be Kiskitto Lake Outlet Structure (Ref: S/Dam Safety/00198/JPGS/concrete or getoechnical surveillance e-mail form Ron Sveinson).	GEF	2006 03 10	TJA
4 Inspection frequency table	We have confirmed the names of Pointe Du Bois and Slave Falls concrete and embankment structures. **Reason for change:** Many names were being used for the same structures. The names have now been confirmed (Ref: drawings Pointe Du Bois 1-00102-DE-20200-0001 Slave Falls 1-00104-DE-20200-0001).	GEF	2006 03 10	TJA

Revision	Change	By	Date	Approval
5 Section 5.5 Condition Survey of Concrete Structures	We have changed the method of reporting the condition survey of concrete structures. **Reason for change:** In the past, we reported condition survey results in a stand-alone report, often after a number of years. Now, inspection information will be included in the Dam Safety Annual Report for the calendar year.	GEF	2006 03 10	TJA
6 Inspection frequency table	We have included a riprap inspection frequency (once every two years) for main dam north, main dam south, and saddle dam at Kettle. **Reason for change:** Main dam north, main dam south, and saddle dam all have ballast blocks on the crest to increase freeboard. The blocks make visual inspections difficult. Inspecting the riprap by boat on a two year frequency will be sufficient to ensure the riprap is performing. After a wind storm the riprap must be inspected by boat by Generation North Civil Maintenance staff to determine if damage has occurred.	ERC	2006 03 10	TJA
7 Section 4. Qualifications and Training of Inspectors	We have included the words *"specialized training"* for qualifications of inspection staff. **Reason for change:** Colleges and universities in Canada do not have dam safety training as part of their curriculum. Dam safety is a specialized discipline of engineering requiring additional formal training.	GEF ERC	2006 03 10	TJA
8 Section 5. Manitoba Hydro Dam Safety Inspections	Inspections 5.2 to 5.7must follow Engineering Services Division Business Process Management System (BPMS) For Condition Assessment. **Reason for Change:** To ensure inspections are performed consistently amongst inspection staff, this process must be followed.	GEF ERC	2006 03 17	TJA
9 Inspection frequency table	Category Special has been added for all concrete structures at Pointe Du Bois. **Reason for change:** As a result of a recommendation made by The Pointe Du Bois Operational Support Group, four intermediate inspections per year shall be performed by the Dam Safety Section.	GEF	2007 03 14	TJA
10 Inspection frequency table	We have revised the inspection frequency for the Pointe Du Bois rockfill dam from one routine inspection per week to a category 1 (two per month). **Reason for change:** The geotechnical concerns regarding the condition and the rationale behind the function of the upstream seal were lessened due to the findings of the 2006 diving inspection as well as the 2007 FMEA.	ERC	2007 03 14	TJA

Revision	Change	By	Date	Approval
11 Inspection frequency table	Average condition index scored for high consequence classification embankment structures for Generation South. **Reason for change:** Condition Indexing was carried out and scores were updated.	ERC	2007 03 14	TJA
12 Inspection frequency table	Jenpeg Kiskitto dykes four series have been changed from a category 3 to 4. **Reason for change:** These dykes are not retaining forebay and are considered to be secondary structures.	ERC	2007 03 14	TJA
13 Inspection frequency table	We have changed the inspection frequency for embankment structures at Kelsey **Reason for change:** To reflect realistic practice and due to the isolation of the structures all forebay retaining embankment structures will be inspected at a category 1 frequency.	ERC	2007 03 14	TJA
14 Inspection frequency table	We have changed the inspection frequency to a Category 1 for all concrete structures at Limestone. **Reason for change:** To reflect realistic practice.	GEF	2007 03 14	TJA
15 Inspection frequency table	We have changed the inspection frequency to a Category 1 for all concrete and embankment structures at Laurie River No 1 & 2. **Reason for change:** To reflect realistic practice and due to the isolation of the structures.	GEF ERC	2007 03 14	TJA
16 Inspection frequency table	Category Other was included for Loon structures and the Kamachawie weir. **Reason for Change:** To reflect realistic practice, routine inspections will not be required for these structures. The Dam Safety Section will inspect these structures during intermediate inspection.	GEF ERC	2007 03 14	TJA

Revision	Change	By	Date	Approval
17 Section 5. Manitoba Hydro Dam Safety Inspections	We have added the levels of concern to the text for all inspections and included a copy of the EPP Dam Safety Emergency Classification and Response Guide (draft) in Appendix C. **Reason for Change:** The levels of concern as described in the EPP Dam Safety Emergency Classification and Response Guide must be followed with appropriate response, notification, and closure.	GEF ERC	2007 12 07	TJA
18 Section 2. CDA Requirements for Inspection Guidelines	We have changed the wording in section 2. **Reason for Change:** To reflect the new 2007 Dam Safety Guidelines.	GEF ERC	2007 12 07	TJA
19 Section 3. Frequency of Inspections	We have indicated that the risk and hazard ratings used will be based on the CDA 1999 Dam Safety Guidelines Dam Classification table until they have been reviewed and updated in 2008. **Reason for Change:** To reflect the new CDA 2007 Dam Safety Guidelines.	GEF ERC	2007 12 07	TJA
20 Section 5.5 Condition Survey of Concrete Structures	Section 5.5 was reworded. **Reason for Change:** To reflect the new 2007 Dam Safety Guidelines and to explain the purpose of the condition survey program.	GEF	2007 12 07	TJA

Revision	Change	By	Date	Approval
21 Section 5.2 & 5.5 Manitoba Hydro Dam Safety Inspections	The Deficiency Economic Worksheet Planner (DEWP) has been discontinued. Concrete and embankment dam safety deficiencies are included on the Dam Safety Deficiencies Prioritization Planner. **Reason for Change:** To provide Generation North and South with a priority ranking of dam safety deficiencies.	GEF ERC	2007 12 07	TJA
22 Inspection frequency table	Average condition index scored for high consequence classification embankment structures for Generation South and Generation North. **Reason for change:** Condition Indexing was carried out and scores were updated.	ERC	2007 12 07	TJA
23 Inspection frequency table	Meter flow downstream of Pinawa annually to determine if discharge is changing. The Senior Earth Structures Engineer is responsible for ensuring this work is carried out. **Reason for change:** High importance score generated in Condition Indexing - Priority Ranking of Monitoring Activities and Devices.	ERC	2007 12 07	TJA
24 Section 4. Qualifications and Training of Inspectors	We have renamed Type 2a training (Introduction to Surveillance) to Introduction to Surveillance. **Reason for change:** To clarify the type of training referred to in this document and to customize specific types delivered by Manitoba Hydro's Dam Safety Section.	GEF ERC	2007 12 07	TJA
25 Section 5.8 Dam Safety Review Inspections	We have removed the reference to the Dam Safety Management Document DSP-PGM-03-01 section 2.5 which expands on this type of inspection. **Reason for Change:** The 2007 Dam Safety Guidelines outlines how to carry out this type of inspection in Section 5.4.2.	GEF ERC	2007 12 07	TJA

APPENDIX C

DAM SAFETY EMERGENCY CLASSIFICATION AND RESPONSE GUIDE 2008

Manitoba Hydro Dam Safety Program

DAM SAFETY
EMERGENCY CLASSIFICATION AND RESPONSE GUIDE

2008

Refer to Emergency Preparedness Plans (EPP) for Specific Details

Manitoba Hydro

(*This material is taken from the Pointe du Bois Emergency Preparedness Plan)*

Definitions

Dam Breach or Failure - the collapse or failure of an impoundment structure (dam or dyke) that results in the large, rapidly increasing, uncontrolled release of impounded water from the reservoir causing incremental downstream flooding with potential impact on life, property and/or the environment.

Dam Safety Concern - an observation, discovery or diagnosis of a condition or event that conceivably has the potential to develop into a dam safety emergency or breach scenario given enough time and no intervention. A dam safety concern in itself poses no immediate threat to either the public, property or dam integrity. Such a condition might warrant increased monitoring, further analysis, testing, or maintenance work. Examples of dam safety concerns include:

- signs of settlement, cracking, new seepage, deflection, unusual instrument readings in water retaining structures.
- deterioration in performance of equipment or components (electrical or mechanical) which could affect the station's ability for flow control.
- an unusual event such as a severe wind or rain storm. This would trigger an unscheduled inspection of the structures to see if there is any damage. High winds may cause wave overtopping leading to possible deterioration in the condition of dams or dykes. Significant rain storms may lead to increase river flows or cause erosion.
- a developing flood event. Factors that can contribute to a possible flood include snowfall amounts and snowmelt rates, precipitation, ambient moisture conditions, and ambient and upstream river flow conditions. Contact Manitoba Hydro Hydraulic Operations Department for further information on potential flood conditions.

The condition or event causing the dam safety concern is then assessed using the emergency classification and response guide (see Figure 1 and following section) to determine if it should be classified as an emergency or remain a concern.

Dam Safety Emergency - a condition or event which develops naturally or unexpectedly, endangers the integrity of the dam or flow control equipment, and has the potential to develop into a dam failure situation resulting in possible loss of life, property and/or environmental damages, and requires immediate action (also see Emergency Classification definition below)

Failure Mode - is a descriptor of how the components or a system of components of a dam can breach or fail. Some general modes of failure for embankment and concrete dams are:

- overtopping during severe flood conditions. Also can be caused by insufficient or reduced flow capacity (i.e., debris blockage)
- internal erosion or "piping" - flow through the dam or foundation causing erosion and internal failure
- mass movement or slope instability (i.e., upstream or downstream slide)
- sliding of concrete dam section along a construction joint, crack or foundation
- overturning of concrete structure due to excessive loading
- spillway or gate failure (i.e., structural, electrical or mechanical)

Note: A dam breach can occur under normal or extreme flow conditions and it could also occur during the winter.

Potential Breach - any condition that poses an immediate threat to the safety of the dam.

Emergency Classification - the more refined classification of a dam safety emergency according to severity, urgency and response (see Figure 1). Three levels are used, as described in the following section, and as listed below in order of increasing severity:

- Level 1 **-** Hazardous condition or incident; no immediate threat to dam's integrity.
- Level 2 **-** Potential failure situation developing.
- Level 3 **-** Failure imminent or has occurred.

Dam Safety Advisory - a warning or notice issued to the local civil authorities of a Level 1 or Level 2 Dam Safety Emergency. A Level 1 Advisory is issued to the authorities if a hazardous condition or incident endangers life or property but has no immediate threat to the dam's integrity (i.e., unusually high flows or spills). A Level 2 Advisory is issued if a potential dam failure situation is developing and is intended to provide early warning to the authorities and place them on stand-by in the event that the condition escalates to Level 3.

Emergency Notification - the corresponding degree of internal and external notification by the site staff for each emergency level (see Figure 1). The notification chart is included in the EPP. The general notifications for each level of emergency are:

- Level 1 (Hazardous condition or incident) **-** initiate internal notification. If the condition endangers life or property, then initiate external notification by issuing a Level 1 Advisory, as appropriate.
- Level 2 (Potential failure situation developing) **-** initiate internal and external notification by issuing a Level 2 Dam Safety Advisory to put local authorities on standby.
- Level 3 (Failure imminent or has occurred) **-** fully activate the EPP by notifying the local authorities of a Level 3 emergency.

LEVEL	DESCRIPTION OF CONDITION OR EVENT[1]	MANITOBA HYDRO'S RESPONSE	MANITOBA HYDRO'S NOTIFICATION
LEVEL 1 (HAZARDOUS CONDITION OR INCIDENT)	• Damaged or malfunctioning flow control equipment or components causing loss of flow control where timely and appropriate response is readily available • Deficiency in water retention structure requires non-critical repair (confirmed by Engineer) • Unusual flood event threatening public safety or may cause some flooding of developments, but not immediately threatening dam integrity. • Facility at maximum discharge capacity • Threat of sabotage or vandalism	**CL1. Local resources and normal support (including local police, fire fighters)[2]** • Maintain flow control and carry out repair or actions to mitigate emergency. • Increase level of monitoring. • If timely response is not readily available, elevate to Level 2 emergency	• Initiate internal notification • If there are public safety concerns or there is the potential for flooding of some developments, issue a Level 1 Advisory to local authorities as appropriate (see Notification Chart, Fig. 2)
LEVEL 2 (POTENTIAL FAILURE SITUATION DEVELOPING)	• Damaged or malfunctioning flow control equipment or component causing loss of flow control where timely and appropriate response is not certain or may be delayed due to distance or adverse conditions • Deficiency in water retention structure requires prompt emergency repair (confirmed by Engineer) • Deficiency or condition of abnormal feature is deteriorating at an accelerated rate (e.g. leakage flow is increasing and more turbid, continuous deflection or settlement of dam, sinkhole growing) • Unusual flood event causes water level license limits (i.e., absolute maximum forebay level) or safe channel capacity to be exceeded and threatens dam integrity • Breach of an upstream dam • Act of sabotage or vandalism affecting capability for flow control or water retention	**CL2. Engage normal corporate resources (including municipal & provincial agencies, contractors, etc.)[2]** • Establish local Level 2 EOC, if required • Carry out emergency repair (coordinated by Dam Safety section head or delegate) • Take appropriate actions to maintain or regain flow control and mitigate damages	• Initiate both internal and external notifications - issuing Level 2 Dam Safety Advisory (see Notification Chart, Fig. 2) • Local Authorities on standby • Provide frequent status updates via EOC.
LEVEL 3 (FAILURE IMMINENT OR HAS OCCURRED)	• Deficiency or condition of abnormal feature is initiating a dam failure • Dam overtopping is imminent or occurring • Failure of dam is probably unavoidable or has occurred.	**CL3. If required, engage external resources (i.e., military, federal agencies)[2]** • As possible, carry out activities or operations to mitigate consequences of failure, considering safety of staff & crews (coordinated by plant manager or delegate) • Establish Corporate Level 3 EOC.	• Fully activate EPP – notify local authority (see Notification Chart, Fig. 2) • Provide frequent status updates via EOC.

1. The list shows sample descriptions of various hydrologic and other events or conditions as a guide to help assess severity and urgency.
2. Reference Manitoba Hydro Corporate Emergency Levels: CL1 = Corporate Level 1; CL2 = Corporate Level 2; CL3 = Corporate Level 3.

DAM SAFETY EMERGENCY CLASSIFICATION AND RESPONSE GUIDE
FIGURE 1

Verification and Reporting of Dam Safety Concern or Emergency

In any emergency, time is of the essence. It is important that reporting and verification be done carefully and accurately but at the same time, as quickly as possible.

First indications of a dam safety concern or emergency can come from numerous sources including routine inspections by Manitoba Hydro staff, instrumentation readings or alarms, observations from the public or as a result of severe weather conditions.

The station operator is responsible to determine whether the information provided is sufficient to warrant activating the EPP. The station operator may dispatch staff to make an immediate on-site inspection or other visual confirmation. Remote cameras, instrumentation readings or alarms may also assist the Operator in verifying verbal reports. **Attempted inspection activity should consider staff safety and activities should be deferred until practical, if attempts at site access place staff at risk.** The condition or event is evaluated and classified according to the emergency classification and response guide provided in Figure 1 and further described in the following section.

All reports or observations of potential dam safety concerns that have not yet been classified as a dam safety emergency should immediately be reported to the appropriate supervisor or manager and they in turn shall contact the Dam Safety Section Head. This contact would determine what follow-up activity, if any, is required. Station staff shall seriously consider any report or indicators of dam safety concerns.

Dam Safety Emergency Classification

Dam safety emergencies are classified according to increasing levels severity, urgency and response, as detailed in Figure 1. This section describes types of conditions or events that categorize three emergency levels ranging from the lowest (Level 1), which represents a hazardous condition or a non-failure emergency, to the highest (Level 3), which represents a dam breach is imminent or has occurred. Certain conditions or deficiencies require confirmation by an Engineer to evaluate the emergency level and develop an appropriate response and notification. Manitoba Hydro's notification and response may vary depending on the level of emergency and each particular situation, and is described in the EPP.

There may be some instances where a condition or event do not constitute an emergency (i.e., have no immediate threat to either the public or to dam safety) but still raise concerns. These may include indicators of conditions or events that might eventually develop into a dam safety emergency or breach scenario given enough time and no intervention. Such a condition might only warrant increased monitoring, further analysis, testing, or minor repair or maintenance. This condition or event is referred to as a **dam safety concern** (see definition in previous section).

NOTE: Although the emergency levels are described in this EPP by increasing order of severity, conditions may be such that the assigned emergency level may advance directly from Level 1 to Level 3 necessitating activation of the EPP.

Level 1 - Hazardous Condition or Incident

A Level 1 emergency is essentially an emergency condition or situation at the station or dam that could eventually lead to a dam failure if not addressed appropriately but can be resolved with normal local resources. It may also represent a condition or event that threatens public safety or developments (such as high river flows), but does not pose an immediate threat to the dam's integrity. A Level 1 emergency can include the following conditions:

- o Damaged or malfunctioning flow control equipment or components causing loss of flow control where timely and appropriate response is readily available. The intent is to emphasize the heightened level of alert at the plant, and the importance of timely and appropriate response. However, there is no immediate threat to the public.

- Deficiency in water retention structure requires non-critical repair (confirmed by Engineer). The intent is that although the deficiency is not posing any immediate danger to the function of the dam, it should be addressed as soon as possible to prevent the situation from getting worse. Possible deficiencies may include dyke settlement, erosion, cracking, leaking or seepage, poor rip rap protection. There is no immediate threat to the public.
- Unusual flood event threatening public safety or is likely to cause some flooding of developments, but not immediately threatening dam integrity. Manitoba Hydro Public Affairs would issue public safety warning to media (alternatively, may be issued by Manitoba Water Stewardship).
- Facility at maximum discharge capacity. This situation poses an increased risk of surcharging the forebay if unit outages occur or if spill is reduced by debris blockage.
- Threat of sabotage. Any communicated threat of sabotage would require increased security and state of alert. The Corporate Security group should be notified, if they are not already aware of the threat.

If the situation is resolved, it may still be considered a dam safety concern in the case where follow-up investigations or monitoring are warranted. Or the situation is closed and no longer considered a dam safety emergency or concern.

Level 2 - Potential Failure Situation Developing

A Level 2 emergency is a condition or event that has the potential for or indications of a failure situation developing if timely and appropriate response is not activated. This level requires issuing a dam safety advisory to local civil authorities, establishing a local EOC, and may require engaging normal corporate resources including contractors, municipal and provincial agencies, and mutual aid partners. A Level 2 emergency can include the following conditions:

- Damaged or malfunctioning flow control equipment or component causing loss of flow control where timely and appropriate response is not certain or may be delayed due to distance or adverse conditions. Delay in restoration results in forebay surcharging above the normal maximum level (license limits).
- Deficiency in water retention structure requires prompt emergency repair (confirmed and coordinated by Engineer). The intent is that the deficiency is showing signs of developing and poses significant danger to the function of the dam, if it is not addressed immediately. Examples include increasing and more turbid seepage flows, serious concerns over sinkhole development, continuous deflection or settlement of dam, erosion, instability, cracking, or riprap loss.
- Unusual flood event causes water level license limits, absolute maximum forebay level, or safe channel capacity to be exceeded and may threaten dam integrity. The forebay level is increasing with limited capability for regaining control.
- Breach of an upstream dam. The ability for Pointe du Bois to adequately pass increased flows caused by an upstream breach is very limited due to the large number of spillway gates and the significant labor involved in opening them. Timely response depends on the distance and size of the upstream breach (flood wave travel time), the existing river flow conditions, staffing, and existing working conditions (weather or darkness).
- Act of sabotage or vandalism affecting capability for flow control or water retention. Obviously, if the act of sabotage or vandalism causes a dam failure, the situation is classified as a Level 3 emergency.

If the situation is stabilized, the emergency level may be lowered to Level 1 where the problem can be properly addressed at a more suitable time and with continued monitoring. The emergency classification may be removed and the condition reduced to a dam safety concern in the case where only follow-up investigations or monitoring are warranted. And if the situation is fully resolved, it is closed and no longer considered a dam safety emergency or concern.

<u>Level 3 - Failure is Imminent or Has Occurred</u>

A Level 3 emergency is a condition where the dam or structure is showing signs of imminent failure or overtopping (i.e. failure is probably unavoidable) or the failure is in process or has already occurred. In any case, it requires activating the EPP. This condition may warrant a Manitoba Hydro Corporate Level 3 response which could engage external resources such as the military, federal agencies or agencies from other provinces. A Level 3 emergency can include of the following conditions:

- Deficiency or condition of abnormal feature is deteriorating at an accelerated rate (e.g. leakage flow is increasing and more turbid, continuous deflection or settlement of dam, sinkhole growing) and initiating a dam failure.
- Water level is increasing or decreasing rapidly.
- Dam overtopping is imminent or occurring. This includes overtopping of concrete structures.
- High probability of dam failure (confirmed by Engineer).

If for some reason the dam did not fail, Manitoba Hydro will conduct a full investigation into the condition of the dam once it is safe to do so and advance any repairs, rehabilitation, cleanup, as required. If the dam did fail, Manitoba Hydro will proceed with a recovery and clean-up program once it is safe to do so.

Notification

The Notification Chart in the EPP contains important contact information for who is to be notified, the recommended order of notification (shown by the numbering 1, 2, 3 etc.) and who is responsible for the notification. If any individual or agency responsible for making further notifications cannot be reached, **the initiating caller is responsible for making these further notifications.**

<u>Level 1 - No Notification Required</u>
If a situation or condition is classified as a Level 1 Emergency - hazardous condition or incident (as per Figure 1), it is not considered to pose an immediate threat to the dam integrity and does not require activation of the EPP. However, appropriate internal notification should be made to report a potential deficiency or condition, as described previously.

Manitoba Hydro may issue appropriate external notification at Level 1 to give early warning of hazardous conditions such as unusually high flows or spills that may threaten public safety or cause flooding of developments.

<u>Level 2 - Issue Dam Safety Advisory</u>
If the condition is classified as a Level 2 Emergency - potential failure situation developing (as per Figure 1), the standby supervisor or manager would initiate internal notification using the Notification Chart and issue a "Level 2 Dam Safety Advisory" to the local civil authority. The advisory identifies the nature of the emergency or concern and Manitoba Hydro's proposed response. The manager or his designate may set up an emergency operating center, if required, but will maintain open communication with the local civil authority until the concern is resolved.

<u>Level 3 - Activate the EPP</u>
When a dam failure is imminent or has been confirmed (Level 3), the station operator would **activate the EPP by initiating notification** to the local civil authorities and internal contacts as outlined in the Notification Chart in the EPP.

Emergency Response

After initiating appropriate notification, as described in the previous section, Manitoba Hydro plant staff will focus their energies primarily on the measures needed to deal with the emergency situation, according to the emergency level shown in Figure 1. Brief descriptions of types of emergency response by Manitoba Hydro are provided below for each emergency level (see section "Dam Safety Emergency Classification" for detailed descriptions of the conditions or events for each emergency level).

Warning and evacuation of the public will be directed by the appropriate local civil authorities. These agencies have their own response obligations which have been developed with input from the EMO. They also have the responsibility to be familiar with the EPP.

Response to Level 1 - Hazardous Condition or Incident

For a situation where some part of the flow control equipment or components are damaged or malfunction causing loss of flow control and where timely and appropriate response is readily available, plant staff will attempt to maintain flow control by alternate means (i.e., plant or spill operations) and repair or restore the affected equipment or system. If timely response is not readily available, the emergency is elevated to Level 2.

For a non-critical deficiency in a water retention structure (dam or dyke), Manitoba Hydro will carry out repairs as soon as they can be arranged. The situation may warrant an increased degree of monitoring, a heightened state of alert and/or further analysis. Again, the condition is not immediately threatening the dam integrity.

In the case of an unusual flood event, Manitoba Hydro will continue to operate the plants according to operating procedures. Several of Manitoba Hydro's hydro plants and control structures are considered to be "run-of-river" which means that they have limited storage capacity and essentially pass all water coming from upstream.

In the case of a threat of sabotage, Manitoba Hydro will activate appropriate security measures according to Corporate Policy G45. This may include heightened security and/or contacting the RCMP to provide additional security at site.

Response to Level 2 - Potential Failure Situation Developing

Manitoba Hydro will issue a "Dam Safety Advisory" to the local authorities to inform them of the potential concern and Hydro's proposed action to remedy it. This emergency level will usually warrant Manitoba Hydro establishing a local Emergency Operation Center (EOC). The station manager or designate will establish the EOC at a designated location and call together the EOC Support Team[1].

For a situation where some part of the flow control equipment or components are damaged or malfunctioning and where timely and appropriate response is not certain or may be delayed due to distance or adverse conditions, plant staff will attempt to take appropriate actions as deemed safe to regain flow control and mitigate damages.

For a deficiency in the water retention structure that requires prompt emergency repair, Manitoba Hydro will carry out or coordinate such repairs (to be coordinated by the Dam Safety Section head or delegate in cooperation with the site staff and other engineering groups).

In the case of a breach of an upstream dam, engineering support may be required to assess the timing of the flood wave and risk to the dam. If it is concluded that there is a high probability the flood wave would overtop any of the water retaining structures due to insufficient capacity to pass the predicted flow, then the emergency is elevated to Level 3.

In the case of an act of sabotage or vandalism, staff must report such acts to Manitoba Hydro's Corporate Security. Site staff will attempt to address any damages provided it is safe to do so.

[1] Refer to Manitoba Hydro Corporate Emergency Preparedness Plan, Section 7.14C

Manitoba Hydro will continue to monitor and attempt to resolve the situation for a Level 2 emergency, providing frequent updates to local authorities, and if conditions deteriorate and failure is deemed to be imminent, the emergency is elevated to Level 3.

Response to Level 3 - Failure is Imminent or Has Occurred

Manitoba Hydro will activate the EPP by initiating notification to the local civil authorities and internal contacts as outlined in the Notification Chart in the EPP. Manitoba Hydro will also, carry out or continue to carry out emergency repair or operations to mitigate the consequences of failure, considering safety of staff & crews. An emergency response plan at site provides staff with further details of key actions to be taken in the event of a dam breach.

For the situation where the repairs are not resolving the deficiency and where the condition is deteriorating at an accelerated rate, where dam overtopping is imminent, or where there is a high probability of dam failure, staff or contractors will only attempt to continue repairs or operations as deemed safe. The station manager or designate will have established an EOC at the designated location and a corporate EOC may be established in Winnipeg, as needed. Manitoba Hydro will continue to monitor the situation and provide frequent updates to local authorities.

If the failure of the dam is discovered as already in progress or has already occurred, Manitoba Hydro will, along with notification, ensure the safety of site staff and crews, and as possible and safe, carry out any activities to mitigate the consequences of failure and monitor the situation.

Manitoba Hydro's emergency response may also include checking on areas of concern at the station and initiate appropriate actions with regard to such items as:

- temporary power
- portable emergency lighting
- alternate access provisions
- equipment sources and construction material stockpiles
- alternate communication arrangements

Appendix F

Hydrotechnical Documentation

Pointe du Bois Generating Station

2008 Dam Safety Intermediate Inspection
Hydraulic Conditions
Field Inspection Form

Objectives:

1. To carry out a cursory inspection of hydraulic conditions for the powerhouse, spillway and appurtenant structures, identifying the present condition and/or changes in conditions to items on the checklist below. Conditions are described with terminology as follows:

Condition Range	Definition
E - G	Condition is within the range of *Excellent* to *Good* ***Excellent to Good*** - No significant defects observed.
F - M	Condition is within the range of *Fair* to *Marginal* ***Fair to Marginal*** - Will fulfill intended purpose. Further monitoring, study or maintenance may be required.
P - VP - F	Condition is within the range of *Poor* to *Very Poor* to *Failed* ***Poor - Very Poor*:** May not fulfill intended purpose. ***Failed:*** Will not fulfill intended purpose.
N/I	Not Inspected

2. To identify needs for more detailed inspections, assessments and/or repairs as condition(s) might warrant.

Item	Condition				Remarks
	E-G	F-M	P-VP-F	N/I	
1. Hydraulic Conditions					**Inspected by:** R.E.M. & J.N.H. **Date:** July 08, 2008 **Forebay Level: Inner:** 298.85 m **Outer:** 299.06 m **Tailrace Level:** 285.67 m **Weather:** Windy, light rain and cool, 11^{o} C **Spillway Gates Open:** 6-11, 13-28, 30-35, 47, 49-52, 56-65 and sluiceway bays 2-4 **Total Spill:** 1340 cms **Units Operating:** All units except 4, 8 and 11
(a) powerhouse intake					
- accumulation or obstruction by debris or ice	✓	✓			Slight debris upstream at units 2, 3, 5-10. Considerable debris upstream at units 1and 12-16. Damaged trashracks at units 6 and 9 (Photo 2).
- eddies, vortices, cross waves, erosion-deposition & tailwater submergence effects	✓				
(b) powerhouse tailrace					(Photo 3)
- obstruction by debris or ice or vegetation	✓				
- eddies, vortices, cross waves, erosion-deposition & tailwater submergence effects	✓				
(c) spillway (bays 121 to 133)					Severe leakage at bays 124, 125, and 127-133. Slight leakage at bays 121 and 123. No leakage at bays 122 and 126.
- obstruction by debris or ice or vegetation	✓				
- eddies, vortices, cross waves, erosion-deposition & tailwater submergence effects	✓				
(d) curved spillway (bays 101 to 114)					Severe leakage in bay 112, due to damaged stoplogs (Photo 4).
- obstruction by debris or ice or vegetation	✓				

Item	Condition				Remarks
	E-G	F-M	P-VP-F	N/I	
- eddies, vortices, cross waves, erosion-deposition & tailwater submergence effects					
(e) spillway (bays 1 to 35)					Spilling in bays 6-11, 13-28 and 30-35.
- obstruction by debris or ice or vegetation	✓				
- eddies, vortices, cross waves, erosion-deposition & tailwater submergence effects	✓				
(f) spillway (bays 36 to 44)					Not spilling
- obstruction by debris or ice or vegetation	✓				
- eddies, vortices, cross waves, erosion-deposition & tailwater submergence effects	✓				
(g) spillway (bays 45 to 65)					Spilling in bays 47, 49-52 and 56-65 (Photo 5).
- obstruction by debris or ice or vegetation	✓				
- eddies, vortices, cross waves, erosion-deposition & tailwater submergence effects	✓				
(h) sluiceway (bays 1 to 5)					Spilling in bays 2, 3, and 4 (Photo 6). Excessive leakage through logs in bays 1 and 5. Backflow into bay 1.
- obstruction by debris or ice or vegetation	✓				
- eddies, vortices, cross waves, erosion-deposition & tailwater submergence effects	✓				
- sluiceway gates (noise or vibrations for open or moving gates)	✓				

Photo 1: General downstream view of spillways and sluiceways.

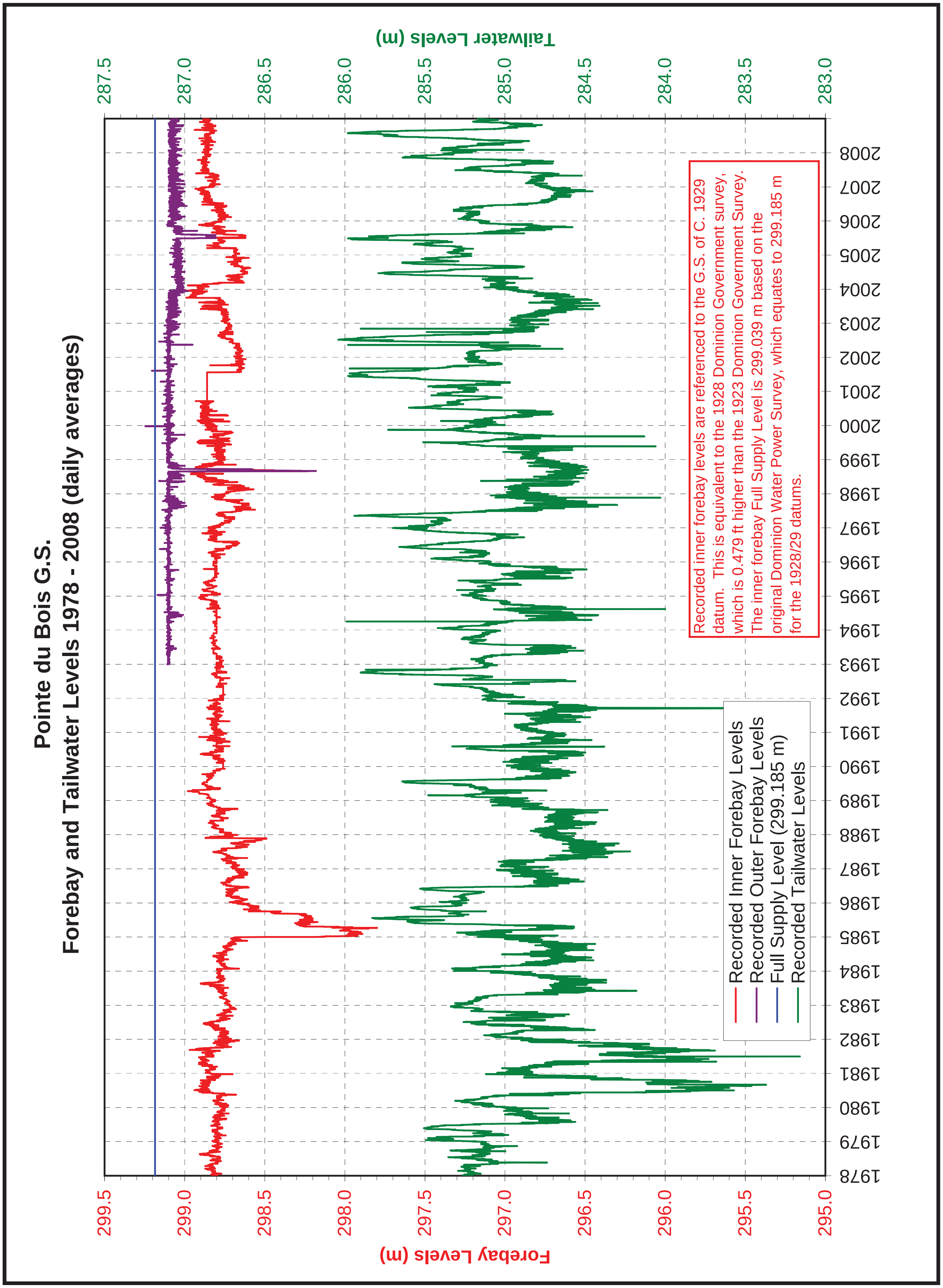
Photo 2: Damaged trashrack and debris upstream of unit 6.

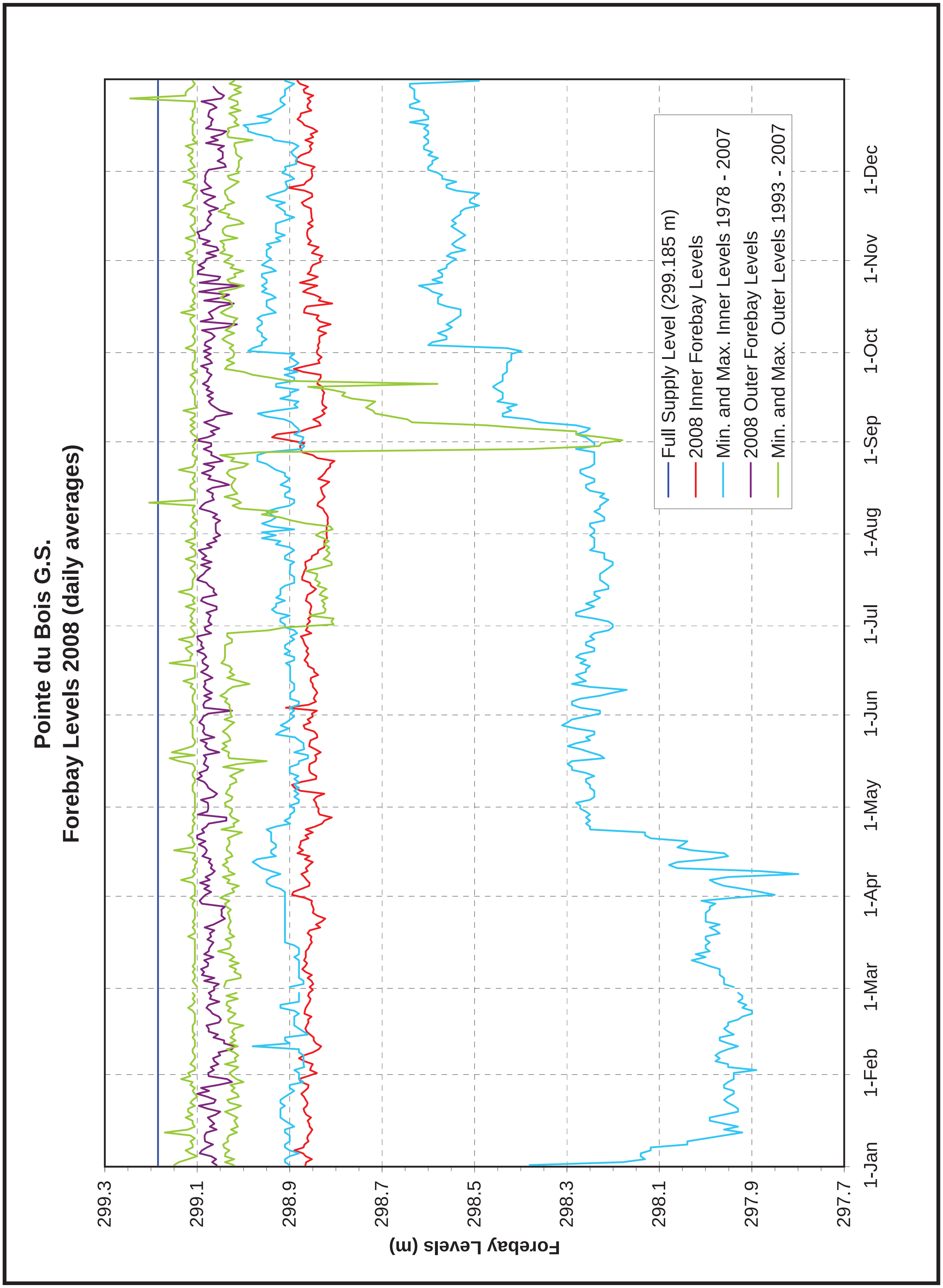
Photo 3: Turbulence at powerhouse tailrace

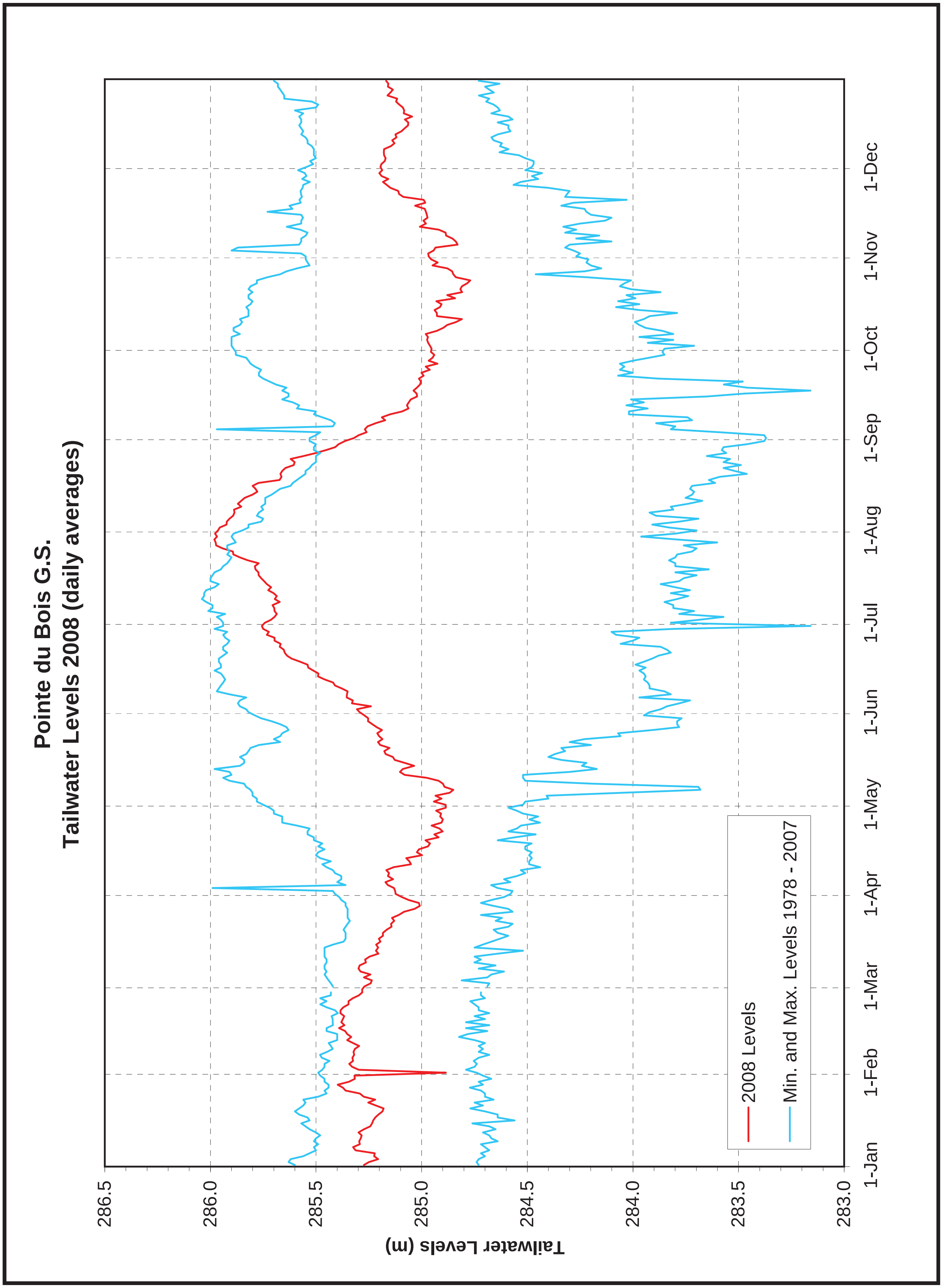
Photo 4: Stoplogs are damaged in the curved spillway bay 112.

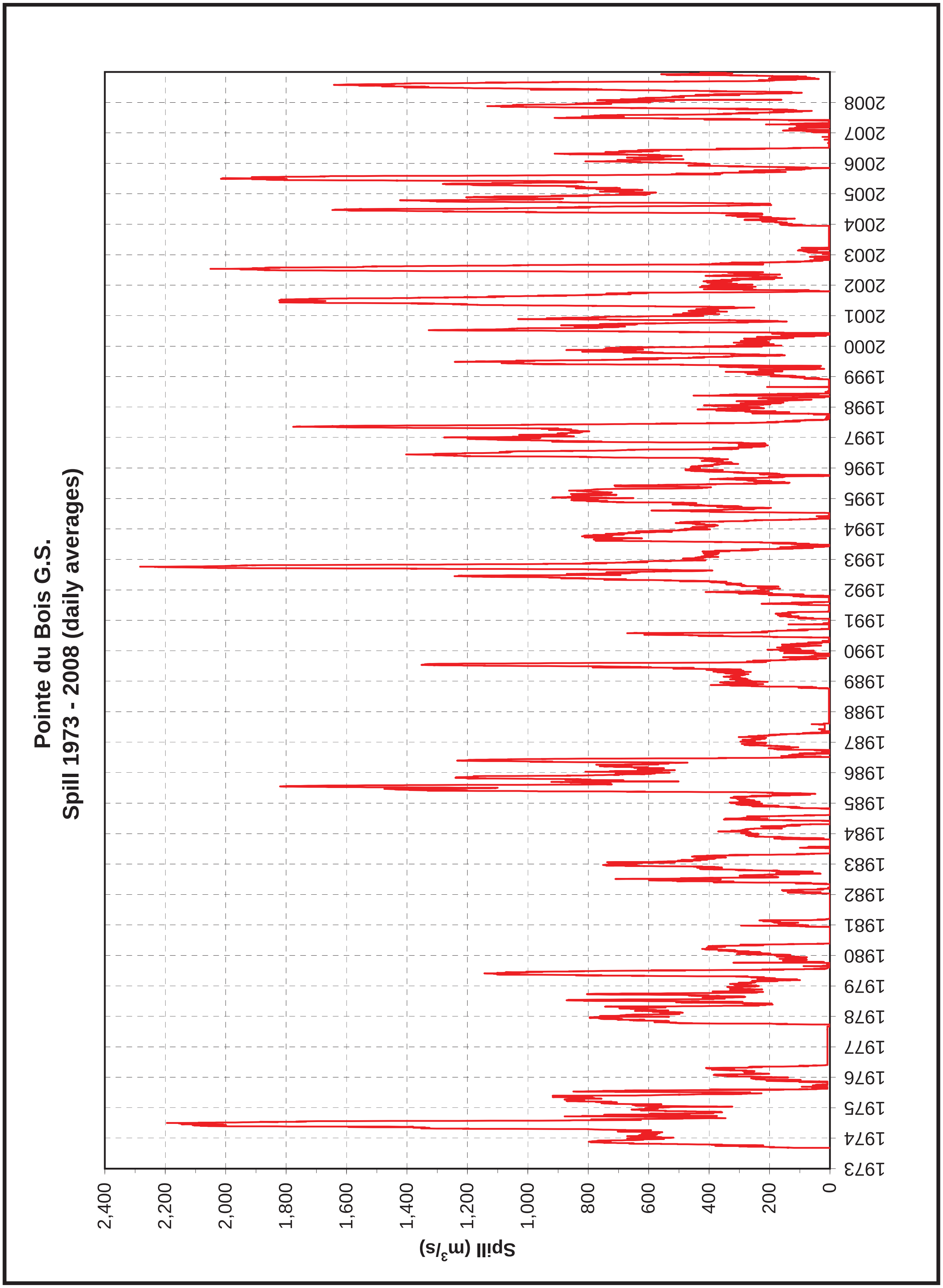
Photo 5: Turbulence downstream of spillway bays 45 - 65; spilling through bays 47, 49-52 and 56-65.

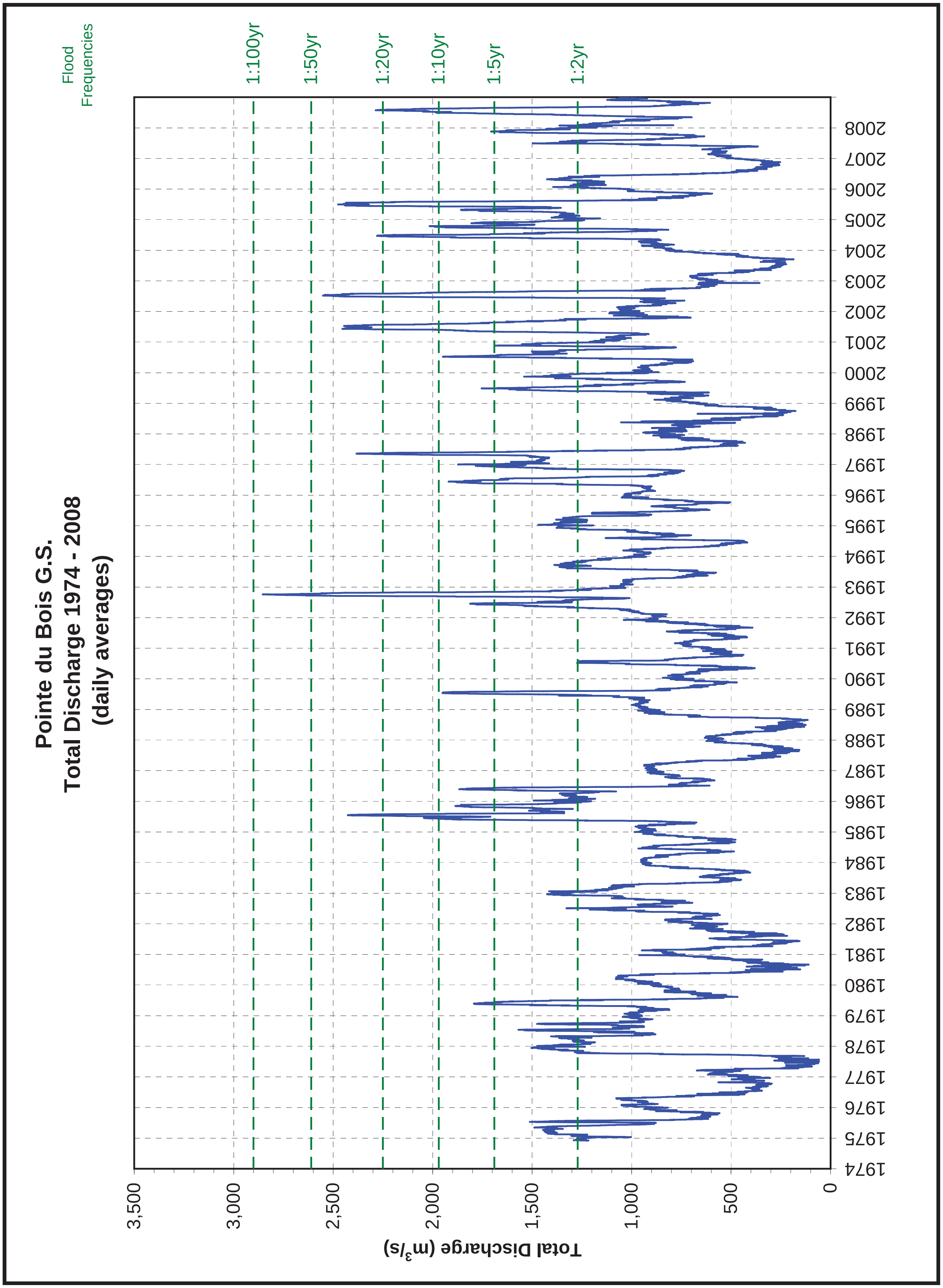
Photo 6: Upstream sluiceway, spilling through openings 2, 3 and 4.


Pointe du Bois G.S.
Forebay and Tailwater Levels 1978 - 2008 (daily averages)
Forebay Levels (m)
Tailwater Levels (m)
299.5
299.0
298.5
298.0
297.5
297.0
296.5
296.0
295.5
295.0
287.5
287.0
286.5
286.0
285.5
285.0
284.5
284.0
283.5
283.0
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Recorded Inner Forebay Levels
Recorded Outer Forebay Levels
Full Supply Level (299.185 m)
Recorded Tailwater Levels
Recorded inner forebay levels are referenced to the G.S. of C. 1929 datum. This is equivalent to the 1928 Dominion Government survey, which is 0.479 ft higher than the 1923 Dominion Government Survey. The inner forebay Full Supply Level is 299.039 m based on the original Dominion Water Power Survey, which equates to 299.185 m for the 1928/29 datums.


Pointe du Bois G.S.
Forebay Levels 2008 (daily averages)
Forebay Levels (m)
299.3
299.1
298.9
298.7
298.5
298.3
298.1
297.9
297.7
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
Full Supply Level (299.185 m)
2008 Inner Forebay Levels
Min. and Max. Inner Levels 1978 - 2007
2008 Outer Forebay Levels
Min. and Max. Outer Levels 1993 - 2007


Pointe du Bois G.S.
Tailwater Levels 2008 (daily averages)
Tailwater Levels (m)
286.5
286.0
285.5
285.0
284.5
284.0
283.5
283.0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
2008 Levels
Min. and Max. Levels 1978 - 2007


Pointe du Bois G.S.
Spill 1973 - 2008 (daily averages)
Spill (m^3/s)
2,400
2,200
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008


Pointe du Bois G.S.
Total Discharge 1974 - 2008
(daily averages)
Flood Frequencies
1:100yr
1:50yr
1:20yr
1:10yr
1:5yr
1:2yr
Total Discharge (m³/s)
0
500
1,000
1,500
2,000
2,500
3,000
3,500
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
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2001
2002
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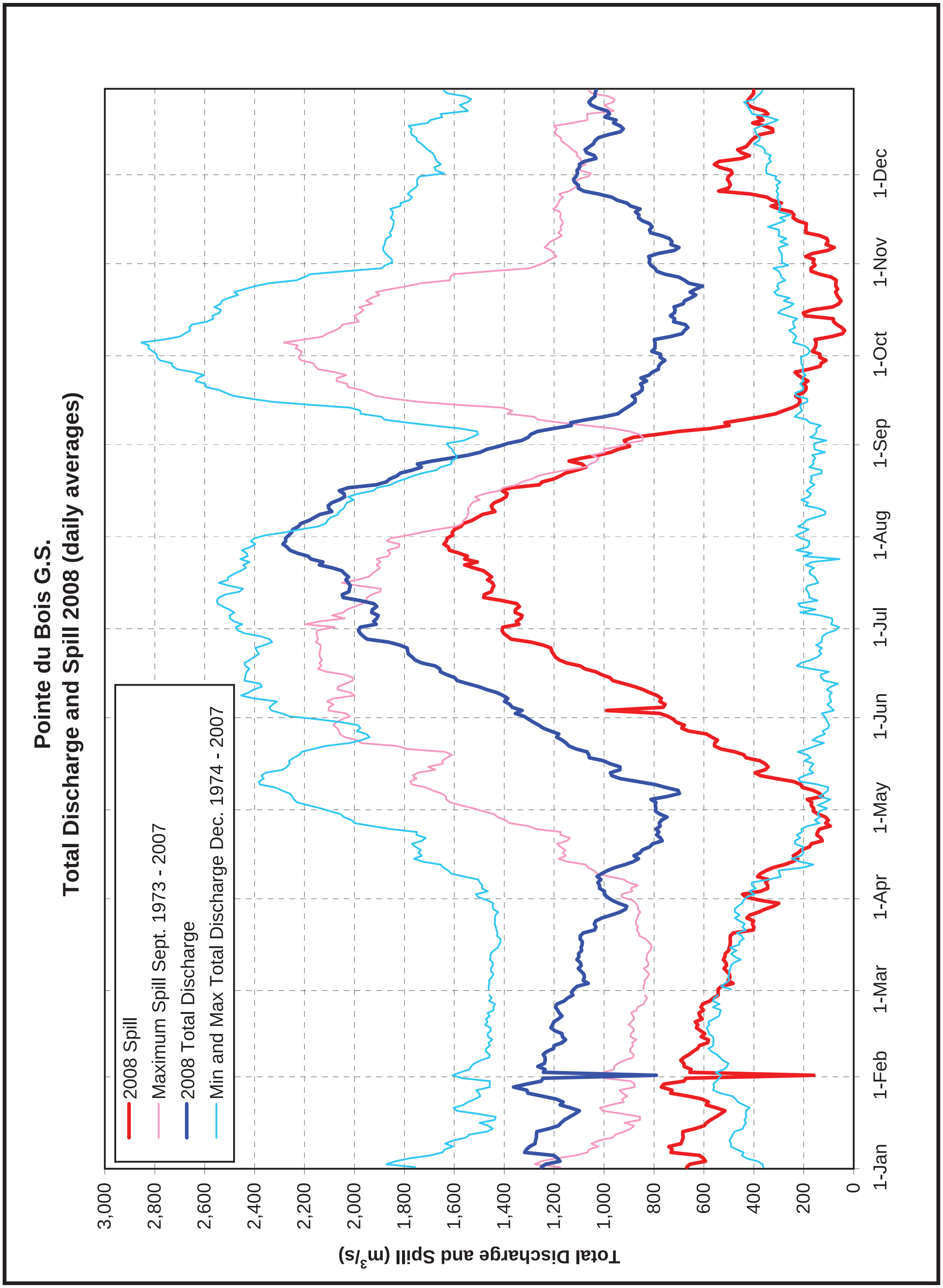
2004
2005
2006
2007
2008


Pointe du Bois G.S.
Total Discharge and Spill 2008 (daily averages)
2008 Spill
Maximum Spill Sept. 1973 - 2007
2008 Total Discharge
Min and Max Total Discharge Dec. 1974 - 2007
Total Discharge and Spill (m³/s)
3,000
2,800
2,600
2,400
2,200
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec

Appendix G

Notable Events - Key Documents

Dam Safety Emergency Incident Report

(*to be completed following the termination of the emergency*)

Station/Dam name: **Pointe du Bois Spillway - Sluice Hoist**

Classification of Incident (check one): Level 1 ☑ Level 2 ☐ Level 3 ☐

General description of the incident (date, time, weather, structure affected):

December 17th, 08:00 am, -30 C, 5 Bay Sluiceway.

The Utility Crew was contacted to perform water control requirements by the Station Operator. Once they had steam and were preparing the work area, it became apparent that the hoist would not operate. The controls were not working as the electronics in the Main Electrical panel were not working. The Lead notified his Supervisor and the Utility Supervisor contacted the Electrical Supervisor to investigate the failure of the hoist. Supplemental heat was add and with the extra heat in the panel within a couple of days and the system was working again.

For Level 1 or 2, include an explanation of why the incident was assessed as a Level 1 or 2 emergency and also a description of how this incident might have led to a dam failure.

It was assessed as a Level 1 based on Equipment Failure. This incident may have led to a dam failure based on the inability to pass water down stream in an emergency. This remained a level 1 concern because the situation was addressed by site staff and resources.

Based on the Winter Spill Operating Guidelines, the Hydraulic gates are to be operated first, then Gates 1 to 29 and then the 5 Bay Sluiceway under the normal controlled operating conditions. In an emergency then staff would then be able open the small water control gates quicker.

Actions/repairs taken including notifications:

It was determined that the Electrical panel was frozen, so a small forced air car heater was installed to assist the strip heater.

Extent of impact or damages:

- to the structure(s): None that has been identified to date.

Incident Report (continued)

- to operations
  - Initial reservoir elevation: 299.068 m Time: 01:00
  - Maximum reservoir elevation: 299.076 m Time: 16:00
  - Final reservoir elevation: 299.072 m Time: 24:00
  - Effects on plant operations: No direct effects other then the inability to pass water.

- to impacted area (damages to property, development, injuries, loss of life)

  None that have been reported to date.

Possible cause(s):

Insufficient designed heat capability, additional heat was added temporarily which resolved the problem. The long term strategy is to continue with the supplemental heat.

Other data and comments:

None

Observer's name and telephone number: Nelson Lamont - Utility Lead, 884- 3113
(*person who made initial discovery of the incident*)

Report Prepared by: Scott Richards

ATTACHMENTS ☐

Please submit completed form to:
Dam Safety Section,
Civil Engineering Dept., ESD
1100 Waverley St.
Attention: Krista Halayko, Section Head

Page 2 of 2

MANITOBA HYDRO
CAPITAL PROJECT JUSTIFICATION ADDENDUM

Project Name

Pointe du Bois - Spillway Replacement Project

Recommendation

To increase the budget to $398 million as reflected in the current project cost estimate.

Project Scope

Pointe du Bois Modernization Project will now take the form of a new spillway and new concrete and earth dams. With this change in the scope of the project, the name has been changed to the Pointe du Bois Spillway Replacement Project. There are no plans to rebuild the powerhouse at this time. The existing powerhouse will continue to operate with on-going activities to maintain safety and reliability. With these improvements, modern dam safety guidelines will be addressed.

The current estimate is based upon conceptual design. A first principal cost estimate will be conducted when engineering has progressed sufficiently (fall of 2010).

It is also noted that a new secondary spillway has recently been included in the project scope and will replace the activities currently in the estimate for rehabilitation of Bays 45 to 65. This is expected to result in an increase of approximately $3.0 Million in the upcoming estimate. Further design work is required on the secondary spillway prior to including in the estimate.

Background

Pointe du Bois is the oldest operating generating station in Manitoba, with much of the original equipment still in service. First power was achieved in 1911 and the last unit was placed in service in 1926. The station does not have adequate spillway capacity to meet current dam safety guidelines. A new spillway is required to meet these guidelines.

The $318 million estimate in the addendum #4 was a preliminary estimate based on earlier work and was a placeholder for the spillway replacement project in CEF 09. The estimate has been updated to reflect progressed design work and current market conditions. The inclusion of a Management Reserve is not considered necessary at this time to cover possible costs of identified items or activities that are currently excluded from the defined scope of work. Attached in Appendix I is a list of those identified, potential items.

The cost for the ongoing activities to maintain safety and reliability at the powerhouse are not part of this project and are not included in this estimate.

JUSTIFICATION—BUSINESS CASE ANALYSIS (SUMMARY):

Justification and Link to Corporate/Business Unit Goals
The scope of modernization at Pointe du Bois was re-evaluated due to increased construction costs. The evaluation included a review of qualitative considerations, safety requirements, and economic information related to the various Pointe du Bois Modernization alternatives. Replacing the spillway and extending the life of the existing powerhouse is the least cost alternative to addressing the safety concerns at Pointe du Bois.

ANALYSIS OF ALTERNATIVES:

Economic Analysis		
Discount Rate	6.1%	

Recommended Option	NPV Benefits/(Costs)
Pointe du Bois - Spillway Replacement Project	-$270 M.

Other Alternatives Considered	NPV Benefits (Costs)

Risk Analysis -
No change.

Total Budget -

The impact on annual budget requirements is as follows (in thousands of dollars):

Fiscal Year	Previous CPJ / CPJ Addendum	This CPJ Addendum	Increase (Decrease)
Prev. Actuals	$ 4,420	$ 4,420	$ -
2007/08	$ 9,312	$ 9,313	$ 1
2008/09	$ 13,346	$ 13,346	$ -
2009/10	$ 13,754	$ 10,639	$ (3,115)
2010/11	$ 14,849	$ 18,569	$ 3,720
2011/12	$ 15,498	$ 24,402	$ 8,904
2012/13	$ 53,002	$ 92,675	$ 39,673
2013/14	$ 83,086	$ 103,619	$ 20,533
2014/15	$ 110,731	$ 89,248	$ (21,483)
2015/16	$ -	$ 31,536	$ 31,536
2016/17	$ -	$ 454	$ 454
2017/18	$ -	$ -	$ -
Total	$ 317,998	$ 398,221	$ 80,223

Proposed Schedule

Primary spillway to be in service in November 2014.
Main Dam complete in July 2015

Related Projects

Pointe Du Bois Generating Station - Safety Upgrades
BUDGET $:$49,996,000 (Total Net Cost)

Reference Documents

Internal draft report dated May 6, 2005 and titled "Pointe du Bois Long-Term Planning Options".
2005/06 Power Resource Plan report PPD #05/05.
Executive Committee Recommendation for the Rebuild Option (May 2007)

Manitoba Hydro Board Recommendation to proceed with filing of EAPF (June 2007)

"Pointe du Bois, Updated Economic Analysis", July 9, 2008. Memo from W. Girling, System Capability Engineer, RPMA to T. Miles, Manager, RPMA.

Briefing Note: Pointe du Bois Interim In Service Date, July 23,2008. *Pointe du Bois Advisory Committee*, Power Supply.

Memorandum: "Pointe du Bois Spillway Replacement Project - ISD 2014 NOVEMBER - Cost Estimate Update & Cash Flow (March 2010), File: 00102-04220-003 I_00

Reference Documents
Appendix I: "Pointe du Bois Spillway Replacement Project"- Management Reserve (2010)

MANITOBA HYDRO
CAPITAL PROJECT JUSTIFICATION ADDENDUM

Project Name

Pointe du Bois - Spillway Replacement Project

Recommendation

To revise the project arrangement and increase the overall budget by $161 Million for a revised total budget of $560 Million.

Project Scope

The following is a summary of the proposed changes in scope required to mitigate Corporate Dam Safety risk:

SCOPE	ESTIMATE
Finalized arrangement at the conclusion of Stage IV engineering	$ 79 M
Increase in general civil contract due to design quantity growth, increased river management and a longer schedule.	$143 M
Revised configuration reduces quantities, schedule and risk.	$ -61 M
Total	$161 M

Background

Pointe du Bois was first placed into service in 1911. The facility does not have the spillway capacity to comply with current dam safety guidelines. A new spillway is required to meet these guidelines. An provincial environment act licence has been issued and federal authorizations are pending. Numerous infrastructure contracts have been awarded and construction activities are underway. The spillway gate contract has been awarded and a limited scope of work has been awarded to the general civil contractor to maintain the earliest in-service date.

The $398 Million estimate in addendum #5 was based on conceptual designs that included re-use of existing spillway bays 45 to 65 and the east gravity dam. Further investigation into stability and operational concerns related to these structures concluded that long term use was not recommended. A secondary spillway, an additional earthfill dam and rehabilitation of the east and west powerhouse abutments were added to the project scope resulting in a $79 Million increase to the project estimate at the conclusion of the Stage IV process.

At the conclusion of the first phase of the Integrated Design Build (IDB) process the real price cost estimate prepared by the general civil contractor represented a further increase to the project estimate of $143 Million. The increase was a result of design quantity growth, increased river management and dewatering costs, a longer schedule and reduced productivity assumptions.

The IDB team developed and assessed options to reduce the project cost incorporating the knowledge gained through the process. The team concluded that constructing a single spillway on the east bank of the existing spillway shelf would reduce the project estimate by $61 Million through reductions in quantities, schedule, construction risk and environmental risk.

Background
Proceeding with the revised configuration requires a provincial and federal alteration process, a revision to the spillway gate contract and additional engineering. All these aspects have been included in the revised project estimate.

JUSTIFICATION—BUSINESS CASE ANALYSIS (SUMMARY):

Justification and Link to Corporate/Business Unit Goals
The project is required to mitigate Corporate dam safety risk. Even though this addendum represents a $161 Million increase to the project budget and represents the most economical means of addressing the Corporate need.

ANALYSIS OF ALTERNATIVES:

Economic Analysis		
Discount Rate	5.75%	

Recommended Option	NPV Benefits/(Costs)

Other Alternatives Considered	NPV Benefits (Costs)

Risk Analysis -
The schedule that the estimate is based on assumed receiving all regulatory authorizations by November 2012 and on an aggressive supply and construction schedule. Delays in receiving authorizations, receiving materials on site or during construction amounting to more than 2 months will result in a year delay of the in-service date. This delay would add approximately $25 Million to the project budget primarily due to additional project indirects and interest and escalation. This value has not been added to the project estimate. Should this occur the project will request the additional funding.

Total Budget -

The impact on annual budget requirements is as follows (in thousands of dollars):

Fiscal Year	Previous CPJ / CPJ Addendum	This CPJ Addendum	Increase (Decrease)
Prev. Actuals	$ 37,718	$ 37,718	$ -
2010/11	$ 18,569	$ 15,253	$ (3,316)
2011/12	$ 24,402	$ 24,880	$ 478
2012/13	$ 92,675	$ 150,008	$ 57,333
2013/14	$ 103,619	$ 248,470	$144,851
2014/15	$ 89,248	$ 80,974	$ (8,274)
2015/16	$ 31,536	$ 2,306	$ (29,230)
2016/17	$ 454	$ -	$ (454)
Total	$ 398,221	$ 559,609	$161,388

Proposed Schedule

Spillway structure in service March 2014.
Main dam in service October 2014.
Site rehabilitation complete October 2015.

Related Projects

Pointe du Bois Generating Station – Vehicle Access Bridge – Completed

Reference Documents

Internal draft report dated May 6, 2005 and titled “Pointe du Bois Long-Term Planning Options”.
2005/06 Power Resource Plan report PPD #05/05.
Executive Committee Recommendation for the Rebuild Option (May 2007)

Manitoba Hydro Board Recommendation to proceed with filing of EAPF (June 2007)

“Pointe du Bois, Updated Economic Analysis”, July 9, 2008. Memo from W. Girling, System Capability Engineer, RPMA to T. Miles, Manager, RPMA.

Briefing Note: Pointe du Bois Interim In Service Date, July 23,2008. *Pointe du Bois Advisory Committee*, Power Supply.

“Updated PdB Project Contingency for CEF12 Capital Cost Update”, July 27, 2012. Memo from A. Fogg, Risk Management Engineer, PSD to B. Nazar, Manager, Pointe Du Bois Spillway Construction

Memorandum: “245725-0125 July 2012 Cost Estimate Update”

MANITOBA HYDRO

2012/13 & 2013/14 ELECTRIC GENERAL RATE APPLICATION

PUBLIC UTILITIES BOARD ("PUB") PRE-ASK QUESTIONS OF MANITOBA HYDRO

PUB/MH/PRE-ASK-19

Question:
Please indicate the expected increased annual revenue stream to offset the powerhouse, spillway and transmission upgrades in-service annual costs.

Answer:

The spillway and transmission upgrade projects enable the existing Pointe du Bois Generating Station to continue to operate at or near current capacity until approximately 2030/31. There is no additional energy or capacity associated with these projects, and consequently, no increased annual revenue stream attributed to these projects. For planning purposes, Manitoba Hydro has assumed the powerhouse is rebuilt in 2030/31 with an estimated increase of 43 MW and 150 GW.h over the existing plant ratings. These resources would contribute to Manitoba Hydro's overall ability to meet energy and capacity requirements and any energy and capacity in excess of committed demand would be available for export.

MANITOBA HYDRO

2012/13 & 2013/14 ELECTRIC GENERAL RATE APPLICATION

PUBLIC UTILITIES BOARD ("PUB") PRE-ASK QUESTIONS OF MANITOBA HYDRO

PUB/MH/PRE-ASK-20

Question:
Please confirm the annual capital expenditures for the overall project is as follows in the table below:

Pointe Du Bois Expenditures Prior to 2015/16

	Spillway ($M)	Transmission	Powerhouse
2010/11	53.0	25.7	
11/12	41.1	14.5	
12/13	113.6	11.1	
13/14	100.4	18.2	
14/15	77.1	16.4	
15/16	13.0		
Subtotal	398.2	85.9	nil
Total	398.2	85.9	1538.2

Answer:

Capital expenditures prior to 2011/12 were incurred over a number of fiscal years. The following table has been revised to show the actual historical spending in the year in which it occurs and the forecast spending as reflected in CEF12.

Pointe Du Bois Expenditures Prior to 2015/16

	Spillway ($M)	Transmission	Powerhouse
2006/07 Act.	4.4	0.2	
07/08	9.3	0.8	
08/09	13.3	1.7	
09/10	10.6	6.0	
10/11	15.3	17.0	
11/12	24.9	15.7	
12/13 Fcst.	150.0	10.2	
13/14	248.5	14.2	
14/15	81.0	20.0	
15/16	2.3		
Expenditures to 15/16	559.6	85.9	nil
Total Project Cost	559.6	85.9	1538.2

MANITOBA HYDRO

2012/13 & 2013/14 ELECTRIC GENERAL RATE APPLICATION

PUBLIC UTILITIES BOARD ("PUB") PRE-ASK QUESTIONS OF MANITOBA HYDRO

PUB/MH/PRE-ASK-21

Transcript Page 1012 "To decommission the powerhouse would be a relatively minor undertaking….and …it's not a significant amount of money".

Question:

a) Please confirm that MH's filings of December 14/12 did not include any decommissioning scenarios for Pointe du Bois generation and spillway facilities.

b) Please provide all relevant reports/studies/cost estimates for Pointe du Bois regarding:
   - Potential decommissioning of power house
   - Potential decommissioning of spillway
   - Rehabilitation of powerhouse
   - Rehabilitation of spillway
   - Replacement of powerhouse
   - Replacement of spillway

c) Please define MH's current estimates of construction and environmental mitigation costs for each item in (b).

Response:

a) MH's response to PUB/MH Pre-Ask-16 provides information on a decommissioning alternative. The response states that the estimated cost for decommissioning the Pointe du Bois facility at the time the alternative was considered was in the order of $400M. It should be noted that the portion of this estimate that relates to decommissioning of the existing powerhouse at Pointe du Bois is approximately $20M and includes approximately $4.5M for a cut-off dam in the intake channel required to maintain the water regime. The estimate for decommissioning of the powerhouse did not include removing the powerhouse concrete below the generator floor and returning the site to the state of nature.

b) Manitoba Hydro has made the decision to proceed with the Spillway Replacement Project and the decision for rebuilding the powerhouse has been deferred. Manitoba Hydro engaged in an extensive process encompassing assessment, planning, evaluation, design, consultation and obtaining required environmental and regulatory authorizations prior to making the decision to proceed with the Spillway Replacement Project, as described below.

Following the acquisition of Pointe du Bois in 2002, Manitoba Hydro assessed long term planning options for the Pointe du Bois Generating Station. It was determined that despite extensive repairs and upgrades over the years, major repair or replacement was required to maintain public and dam safety, provide a safer work environment for staff and ensure reliable power production. In 2005, alternatives for Pointe du Bois modernization were determined to be as follows:

- Rebuild - A new 120 MW powerhouse, spillway and dam would be constructed.
- Renovate - The existing powerhouse would be renovated, and its capacity would be upgraded to 120 MW and a new spillway would be constructed.
- Repair - The existing powerhouse would be repaired and capacity would be upgraded to 85 MW and a new spillway would be constructed.

A preliminary review determined that the preferred alternative for modernization was the rebuilding. This was based on a wide range of factors including engineering, economic, environmental and socio-economic considerations.

In Early 2006, a pre-commitment consultation process was carried out prior to the final selection of a modernization alternative. The pre-commitment consultation process consisted of the following initiatives:

- Communication with government
- Meetings with federal and provincial regulators.
- Public open houses in Pointe du Bois, Lac du Bonnet, and Winnipeg to present information on the modernization alternatives and solicit public comments, interests and concerns. While there were concerns regarding the environment, water levels, public disturbance during construction, and employment opportunities, the need to modernize Pointe du Bois was recognized, and the rebuild alternative was widely regarded as the best alternative for modernization.
- Meetings were also held with Sagkeeng First Nation and Manitoba Métis Federation. Information was shared on Pointe du Bois modernization and comments, interests and

concerns with respect to the project were gathered. Key concerns included respect for Aboriginal and Treaty rights, meaningful consultation, participation in project studies, and sharing in project benefits, along with potential impacts on the environment, resource use and traditional use of lands.

Following the pre-commitment consultation process, the rebuild alternative was selected for modernization.

In 2009 as a result of the change in the economic climate and rising construction costs, the scope of modernization was reduced to a project that would undertake the necessary work to meet Canadian Dam Safety Guidelines. A decision was made that the Pointe du Bois project would take the form of a new spillway and new concrete and earth dams. The powerhouse would continue to operate with on-going activities to maintain safety and reliability.

An Environmental Act Proposal Form (EAPF) for the Pointe du Bois Spillway Replacement Project was submitted to Manitoba Conservation in mid-2010. Manitoba Hydro held Public Open Houses at Pointe du Bois and Winnipeg in November 2010 to share information on the revised project and the environmental assessment. No major concerns were noted.

In early summer 2011, the Environmental Impact Statement (EIS) and the Navigable Waters Protection Act (NWPA) applications were filed for the Pointe du Bois Spillway Replacement Project. The project underwent a cooperative environmental assessment between Canada and Manitoba, with Manitoba taking lead. Site development started in January 2012 following receipt of the Provincial Environment Act Licence. Federal authorization (DFO) was received in December 2012. The Environment Act Licence was issued by Manitoba Conservation on January 6, 2013.

Construction of the Spillway Replacement Project commenced upon receipt of the Environment Act Licence on January 6, 2013.

As stated in Manitoba Hydro’s response to CAC/MH I-70 a), Tab 6 of Manitoba Hydro’s Application summarizes the Capital Expenditure Forecast (CEF11), a copy of which is included as Appendix 6.1. Page 17 of CEF11 provides a description Pointe du Bois Spillway Replacement project to be undertaken, and the justification and cost for the project.

As stated on page 11 of Manitoba Hydro's 2010/11 Power Resource Plan provided as Attachment 2 of the Electric Rate Application:

> "The 2009/10 Power Resource Plan assumed that the Pointe du Bois Generating Station would be redeveloped at a higher capability than the existing facility with first power in 2016/17. Due to increased capital cost a decision was made to reduce the scope of the Pointe du Bois Modernization Project and it will now take the form of a new spillway and new concrete and earth dams (Spillway Replacement Project). For the 2010/11 Power Resource Plan the Pointe du Bois powerhouse is assumed to be rebuilt with an increase of 43 MW and 150 GW.h, similar to the 2009/10 Power Resource Plan, but with first power in 2030/31 instead of 2016/17. Until Pointe du Bois is rebuilt, it is assumed to continue to operate with ongoing maintenance."

The Spillway Replacement Project was selected as it allows for a reduction in short term capital requirements, the deferral of any costs related to decommissioning or rebuilding the powerhouse, and revenues from the existing station to be maintained. Additionally this alternative provides flexibility in relation to the life of the powerhouse and the potential future replacement or decommissioning of the powerhouse.

c) Please see Manitoba Hydro's response to PUB/MH/PRE-ASK-21 a) and b). Manitoba Hydro has made the decision to proceed with the Spillway Replacement Project and the decision for rebuilding the powerhouse has been deferred. As a matter of efficiency, Manitoba Hydro maintains current estimates only for the selected alternative once a decision has been made.

MANITOBA HYDRO

2012/13 & 2013/14 ELECTRIC GENERAL RATE APPLICATION

PUBLIC UTILITIES BOARD ("PUB") PRE-ASK QUESTIONS OF MANITOBA HYDRO

PUB/MH/PRE-ASK-22

PUB/MH Pre-Ask 8 through Pre-Ask 12 and Pre-Ask 17

Question:

a) Please confirm the following hydraulic flow relationship as summarized from Pre-Ask responses.

	Reservoir Levels (m)	Spillway (cms)	Powerhouse (cms)	Total (cms)
Original Design	**298.5**	**910**	**180**	**1090**
Existing	**299.1 (FSL)** **299.72 (overtopping)**	**2625** **3949**	**620** **610** **200 (7/16 units operating)**	**3245** **4559** **4149**
Maximum Recorded Flood				**2621**
1000 Year Flood				**4280**
Inflow Design Flood		**?**	**?**	**5040**
Maximum Probable Flood				**6570**
Ontario (Caribou Falls)				**4000 to 4700**

b) Please confirm that MH intends to design a new spillway facility to accommodate the following flows at over-topping:

- 4440 cms (if the powerhouse is rebuilt in 2031/32)
  or
- 5040 cms (if powerhouse is not rebuilt)

c) Please confirm that a rehabilitated existing spillway would accommodate:

- 80% of the inflow design flood at over-topping (without powerhouse flows)
- 90% of the inflow design flood at over-topping (with rebuilt powerhouse flows)

d) Please indicate the flood flows at full-supply level and at over-topping that can be accommodated at:

- Slave Falls G.S.
- Seven Sisters G.S.
- McArthur G.S.
- Great Falls G.S.
- Pine Falls G.S.

e) Please provide a comparison of flood flow profiles at Slave Falls and Seven Sisters for a rebuilt Point du Bois and rebuilt spillway vs existing (breached).

f) With respect to the Slave Falls G.S., please confirm that MH is considering permanently decommissioning the Creek spillway and the ice sluice components of the station site; and indicate what flows the Slave Falls G.S. would then accommodate at over-topping.

g) Please indicate whether the existing spillway and/or powerhouse gate controls at Pointe du Bois could be removed to provide a free-flow reservoir operation without demolition of physical structures.

h) Please provide a series of Pointe du Bois flow hydrographs depicting the anticipated:

- Inflow design flood (if Pointe du Bois were decommissioned and/or removed)
- Input design flood (with the proposed new spillway)
- Additional outflow from the Pointe du Bois reservoir during the existing facility dam breach period under the inflow design flood.

Response:

a) In regards to the flow conditions described in the table provided in the question:

- Original Design: The values in the table are consistent with our estimate of capacities for an early configuration of the site.

- Existing Conditions: These values are correct, however it should be noted that the flows of 620 cms and 610 cms are *estimates* of the full capacity of the powerhouse with all 16 units in operation. The 200 cms flow is a speed-no-load estimate of the full capacity of the powerhouse with all 16 units in operation.

- Maximum Recorded Flood: The value of 2621 cms represents the maximum recorded flood to date.

- 1000 Year Flood: The value of 4280 cms is Manitoba Hydro's most recent estimate for a 1000 year flood.

- Inflow Design Flood: The value of 5040 cms is Manitoba Hydro's most recent estimate for an inflow design flood. No powerhouse capacity would be relied upon for passage of the inflow design flood because of the uncertainty with respect to continued operation of certain powerhouse units.

- Probable Maximum Flood: The value of 6570 cms is Manitoba Hydro's most recent estimate for probable maximum flood.

- Ontario (Caribou Falls): Manitoba Hydro is not in a position to specify design information pertaining to Caribou Falls. Inquiries should be made to Ontario Power Generation. The values listed in the table above appear to be based on a misinterpretation of information previously provided by Manitoba Hydro. The range of 4,000-4,700 cms reflects the magnitude of flows anticipated at Pointe du Bois GS when the block dams at Caribou Falls would experience incipient overtopping.

b) The new spillway required will be designed to pass 5,040 cms (bullet 2) without exceeding the design surcharge level of 299.7m. With respect to the first scenario, a spillway designed to 4,440 cms was not considered by Manitoba Hydro as it would not be consistent with Canadian Dam Safety Guidelines.

c) Following Canadian Dam Association (CDA) Dam Safety Guidelines, the Inflow Design Flood (IDF) was determined to be 5,040 cms. Having a spillway sized to pass less than the Project IDF would be unsafe. Manitoba Hydro has undertaken the necessary studies to determine the "safe flood capacity" of the project, such that it will be consistent with CDA Dam Safety Guidelines.

Response to parts (d), (e), and (f):

Manitoba Hydro has undertaken the necessary studies to determine the "safe flood capacity" of the project, such that it will be consistent with CDA dam safety guidelines. Manitoba Hydro's process of determining the project IDF is through the assessment of consequences resulting from dam failure. For a given flood event, consequences considered include the population at risk, the expected loss of life, impacts to the environment and cultural values, and infrastructure and economic losses. Impacts are evaluated at the project site, as well as upstream and downstream. In this case, Pointe du Bois would be the project site and impacts to the generating stations on the Winnipeg River upstream and downstream of Pointe du Bois would have been evaluated.

g) Removal of the existing spillway and powerhouse gate controls would cause unacceptable changes to the water regime, environment (fish and fish habitat), environment, and resulting impacts to cottager, businesses, and recreational users of the area in the Provincial Park. This option was not considered.

h) The inflow design flood is not affected by the general arrangement at the site. Given the minimal storage effects from surcharging of the forebay during IDF, the outflow hydrographs for the first two scenarios would be the same with a peak outflow of 5 040cms. Total peak outflows from Pointe du Bois during a breach of the generating station would be in the order of 8 000cms to 10 000cms.

MANITOBA HYDRO

2012/13 & 2013/14 ELECTRIC GENERAL RATE APPLICATION

PUBLIC UTILITIES BOARD ("PUB") PRE-ASK QUESTIONS OF MANITOBA HYDRO

PUB/MH/PRE-ASK-23

Question:

a) Please provide project descriptions and project capital costs and average hydraulic generation outputs going forward for the following scenarios:
- New spillway circa 2014/15 designed for 5040 cms (existing powerhouse rehabilitated to 2031/32 and then decommissioned);
- New spillway circa 2014/15 designed for 4440 cms (existing powerhouse rehabilitated to 2031/32 and then rebuilt to provide at least 600 cms);
- Rehabilitated existing spillway in service to 2031/32 and decommissioned at same time as the powerhouse;
- Existing spillway and powerhouse decommissioned circa 2014/15;

b) Please indicate the on-going average unit costs per kWh of Pointe du Bois energy generated for each of the above scenarios. (assume no internally generated funds are used)

CEF 12		
Spillway	$ 560M	2015 in-service
Transmission	$ 86M	2015 in-service
Powerhouse Rehab	$ 183M	2022 in-service
Powerhouse Rebuild	$ 1,538M	2032 in-service
	$ 2,367M	

Response:

a) Manitoba Hydro does not have information available on any of the scenarios described in part a) of this question.

Regarding the first two scenarios described in part a) of this question, Manitoba Hydro has deferred the decision on the future of the Pointe du Bois powerhouse and will undertake studies as to its future at the appropriate time. In addition, with respect to the second scenario, a spillway designed to 4440 cms was not considered by Manitoba Hydro as it would not be consistent with Canadian Dam Safety Guidelines.

Regarding the third scenario described in part a) of this question, Manitoba Hydro did not consider rehabilitating the existing spillway as doing so would not be consistent with Canadian Dam Safety Guidelines.

Regarding the fourth scenario described in part a) of this question, Manitoba Hydro did not consider decommissioning the existing spillway as Manitoba Hydro has an obligation to maintain the water regime in order to avoid unacceptable changes to the environment, eco-systems, and resulting impacts to cottagers, businesses and recreational users of the area.

b) Please see Manitoba Hydro's response to part a) of this question. Please note that the average unit cost per kWh has been verbally provided for the Powerhouse Rebuild, based on the CEF12 estimated costs, during this General Rate Application Hearing.