

1 Q. **Reference: Application, Schedule 1: Upgrade Report – Penstock 1 Life Extension – Bay**
2 **d'Espoir, Page 14, lines 24-25 and Page 15, lines 6-8.**

3 Hydro anticipates that the new 17-foot diameter penstock section will have an
4 operational life of 80–100 years.

5 and,

6 By implementing a planned refurbishment and following operational and
7 maintenance guidelines, Hydro anticipates these sections of penstock would
8 have an operational life of 30–50 years.

9 **a)** What is the inspection and recoating regime for the new 17-foot diameter section of
10 penstock to achieve the 80-100 year life? Furthermore, what is the lifecycle cost for this
11 inspection and recoating regime over its 80-100 year life?

12 **b)** The existing 17-foot diameter penstock section had a service life of approximately 55 years.
13 Please elaborate on why Hydro would anticipate: (i) the 17-foot diameter replacement
14 section will have a service life of 80-100 years; and (ii) the 13.5 and 15-foot diameter
15 sections can be extended to an operational life of 30 to 50 years.

16 **c)** Given Hydro's experience to date with the 13.5 and 15-foot diameter penstock sections,
17 would Hydro anticipate an operational life to be closer to 30 years or 50 years?

18

19

20 **A. a)** The inspection regime proposed by the consultant for Option 3 recommends annual
21 inspections for the first 2 years following refurbishment to verify the performance of the
22 coating and welds. Commencing in Year 3, inspections should occur every 3 to 5 years to
23 assess the coating condition and welds throughout the life of the penstock. Newfoundland
24 and Labrador Hydro's ("Hydro") operations staff will continue to complete preventive
25 maintenance checks on an annual basis.

26 Kleinschmidt estimates that a penstock interior coating system would require replacement
27 after 15 to 20 years depending on the surface preparation and service life of the product.

1 With the execution strategy outlined in the proposal, the first coating for the new 17-foot
 2 diameter section will primarily be applied in the shop on new steel; this coating would be
 3 expected to last 20 years. After the initial 20 years, the recoating will require surface
 4 cleaning and a field applied coating system, which is estimated to last approximately
 5 15 years. It is assumed that a recoating regime every 15 years will continue thereafter.

6 The estimated lifecycle cost for the inspection and recoating regime for the 17-foot
 7 penstock section over the 100-year life is shown in Table 1.

Table 1: Lifecycle Cost for Inspection and Coating^{1,2}

Year	Cost 1 ³ Hydro PM ⁴ Checks	Cost 2 ⁵ Weld Inspection	Cost 3 ⁶ Coating Inspection	Cost 4 ⁷ Recoating
2021	-	-	-	-
2022	-	-	-	-
2023	-	-	-	-
2024	-	-	-	-
2025	-	-	-	-
2026	11,416	91,326	34,247	-
2027	11,732	93,854	35,195	-
2028	12,057	-	-	-
2029	12,390	-	-	-
2030	12,734	-	-	-
2031	13,086	104,689	39,258	-
2032	13,448	-	-	-
2033	13,821	-	-	-
2034	14,204	-	-	-
2035	14,597	116,774	43,790	-
2036	15,001	-	-	-
2037	15,416	-	-	-
2038	15,843	-	-	-
2039	16,282	130,255	48,846	-
2040	16,733	-	-	-

¹ Total nominal cost in 2021 dollars.

² Dollar values in Table 1 account for escalation based on Hydro’s Corporate Planning Assumptions.

³ Hydro’s preventive maintenance checks estimated at approximately \$10,000 per year.

⁴ Preventive maintenance (“PM”).

⁵ Annual third-party weld inspection cost is estimated at \$80,000 per year.

⁶ Annual third-party coating inspection cost is estimated at \$30,000 per year.

⁷ Recoating costs are based on Kleinschmidt’s AACE Class 4 Capital Cost Estimate provided in “Application for Approval of Capital Expenditures for Section Replacement and Weld Refurbishment for Bay d’Espoir Hydroelectric Generating Facility Penstock 1,” Newfoundland and Labrador Hydro, December 7, 2022, sch. 1, app. K.

Year	Cost 1 ³ Hydro PM ⁴ Checks	Cost 2 ⁵ Weld Inspection	Cost 3 ⁶ Coating Inspection	Cost 4 ⁷ Recoating
2041	17,196	-	-	-
2042	17,672	-	-	-
2043	18,161	145,292	54,484	-
2044	18,664	-	-	-
2045	19,181	-	-	10,274,591
2046	19,712	-	59,137	-
2047	20,258	162,065	60,774	-
2048	20,819	-	-	-
2049	21,395	-	-	-
2050	21,988	-	-	-
2051	22,597	180,774	67,790	-
2052	23,222	-	-	-
2053	23,865	-	-	-
2054	24,526	-	-	-
2055	25,205	201,642	75,616	-
2056	25,903	-	-	-
2057	26,620	-	-	-
2058	27,358	-	-	-
2059	28,115	224,920	84,345	-
2060	28,894	-	-	15,257,414
2061	29,694	-	89,081	-
2062	30,516	-	91,547	-
2063	31,361	250,885	94,082	-
2064	32,229	-	-	-
2065	33,121	-	-	-
2066	34,039	-	-	-
2067	34,981	279,848	104,943	-
2068	35,950	-	-	-
2069	36,945	-	-	-
2070	37,968	-	-	-
2071	39,019	312,154	117,058	-
2072	40,100	-	-	-
2073	41,210	-	-	-
2074	42,351	-	-	-
2075	43,524	348,190	-	22,656,735
2076	44,729	-	134,186	-
2077	45,967	-	137,902	-
2078	47,240	-	-	-
2079	48,548	388,385	145,644	-

Year	Cost 1 ³ Hydro PM ⁴ Checks	Cost 2 ⁵ Weld Inspection	Cost 3 ⁶ Coating Inspection	Cost 4 ⁷ Recoating
2080	49,892	-	-	-
2081	51,274	-	-	-
2082	52,694	-	-	-
2083	54,153	433,221	162,458	-
2084	55,652	-	-	-
2085	57,193	-	-	-
2086	58,777	-	-	-
2087	60,404	483,233	181,212	-
2088	62,077	-	-	-
2089	63,795	-	-	-
2090	65,562	-	-	33,644,472
2091	67,377	539,018	202,132	-
2092	69,243	-	207,728	-
2093	71,160	-	-	-
2094	73,130	-	-	-
2095	75,155	601,243	225,466	-
2096	77,236	-	-	-
2097	79,375	-	-	-
2098	81,573	-	-	-
2099	83,831	670,651	251,494	-
2100	86,153	-	-	-
2101	88,538	-	-	-
2102	90,990	-	-	-
2103	93,509	748,072	280,527	-
2104	96,098	-	-	-
2105	98,759	-	-	49,960,883
2106	101,494	-	304,481	-
2107	104,304	834,431	312,911	-
2108	107,192	-	-	-
2109	110,160	-	-	-
2110	113,210	-	-	-
2111	116,345	930,759	349,034	-
2112	119,566	-	-	-
2113	122,877	-	-	-
2114	126,279	-	-	-
2115	129,776	1,038,207	389,328	-
2116	133,369	-	-	-
2117	137,062	-	-	-
2118	140,857	-	-	-

Year	Cost 1 ³ Hydro PM ⁴ Checks	Cost 2 ⁵ Weld Inspection	Cost 3 ⁶ Coating Inspection	Cost 4 ⁷ Recoating
2119	144,757	1,158,059	434,272	-
2120	148,766	-	-	74,190,192
2121	152,885	-	458,654	-
2122	157,118	-	471,354	-
2123	161,468	1,291,747	-	-
2124	165,939	-	-	-
2125	170,534	-	-	-

1 **b)** It is important to note that the issues identified with the existing 17-foot diameter section of
2 the penstock, such as peaking along the longitudinal welds, will be addressed with the new
3 17-foot diameter section. The resulting 55-year service life of the existing 17-foot diameter
4 section is not representative of the entire penstock, nor steel penstocks in general.

5 **i.** In the absence of an authoritative engineering guideline on penstock service life
6 estimation, a combination of existing literature and input from Hydro's consultants
7 was used to arrive at the estimate of an 80- to 100-year service life. Notably, ASCE
8 Steel Penstocks; Manuals and Report on Engineering Practice No. 79 states, "Steel
9 penstocks are highly durable structures, as evidenced by numerous penstocks more
10 than 80 years old still in operation."⁸ Additionally, conditions specific to the Bay
11 d'Espoir Hydroelectric Generating Facility were taken into account, e.g., site water
12 chemistry, lack of significant exterior corrosion on the existing penstocks, buried
13 penstock exposure, minimal sediment in the water, and a lack of observed
14 deterioration in the existing penstocks due to water velocity or cavitation. Based
15 upon this, a service life in the range of 80 to 100 years with a steel penstock
16 designed to current standards, supported by an inspection and maintenance
17 program, is appropriate. The future maintenance program assumes the regular
18 inspection of the penstock interior protective coating and the reapplication of this
19 coating as warranted.

20 **ii.** Given the information noted herein and the current condition and design stresses of
21 the existing 13.5- and 15-foot diameter sections of the penstock, this operation life

⁸ American Society of Civil Engineers. (2012). ASCE Manuals and Reports on Engineering Practice No. 79, *Steel Penstocks* (2nd ed.), c. 17, p. 182.

1 extension has been estimated. The future maintenance program assumes the
2 regular inspection of the penstock interior protective coating and the reapplication
3 of this coating as warranted.

4 **c)** The estimated 30- to 50-year range is viewed as reasonable, as outlined in part b of this
5 response. Hydro is not able to provide a more specific estimate within this range at this
6 time.