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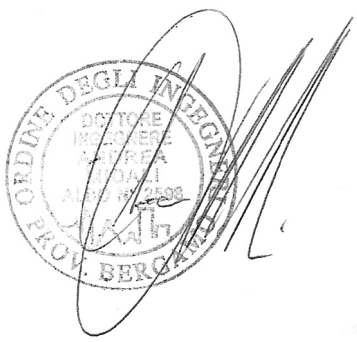
COMMITTENTE
ENERGIA MINERALS ITALIA s.r.l.

ISTANZA DI RINNOVO DELLA CONCESSIONE MINERARIA DENOMINATA "MONICA"

PROGETTO RIFACIMENTO PONTE "EX LAVERIA" IN LOCALITA' RISO

RELAZIONE IDRAULICA



1. PREMESSA

Per incarico di ENERGIA MINERALS ITALIA S.r.l. è stata redatta la seguente relazione per gli interventi di sistemazione del ponte di accesso all'ex impianto laveria sito in località Riso nel comune di Gorno (BG).

Nella presente relazione idraulica, a partire dalla caratterizzazione idrologica generale e di massima dell'area, vengono presi in esame gli aspetti relativi all'interazione tra le opere previste dal progetto e le portate del torrente Riso.

Immagine 01: Inquadramento dell'intervento

2. CARATTERISTICHE DEL TORRENTE RISO

Il Riso è un torrente della provincia di Bergamo. Nasce sulle propaggini del monte Grem, nei pressi del Colle di Zambla, nelle Alpi Orobie e confluisce dopo 7 km da destra nel Serio a Ponte Nossa, in Val Seriana, dopo aver percorso la valle omonima. Il torrente scorre nei comuni di Oneta, Gorno e Ponte Nossa.

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L'asta principale del torrente Riso, che in questo tratto ha un percorso prevalentemente rettilineo, con alveo incassato e nel quale predomina una elevata azione erosiva, sottende un bacino idrografico di 32,4 km2.

La pendenza in prossimità dell'impalcato di attraversamento è assunta nel calcolo pari del 5,2%.

Il letto e le pareti del fiume oggetto di studio sono assunte equivalenti a quelle di torrenti di montagna con letto irregolare e formati da massi per il calcolo della scabrezza secondo il metodo di Strickler.

Il progetto prevede la ricostruzione del ponte esistente senza variazione geometrica della struttura e dei materiali, mantenendo costante l'area di luce libera dell'alveo.

3. STIMA DELLE PORTATE E ALTEZZA CRITICA

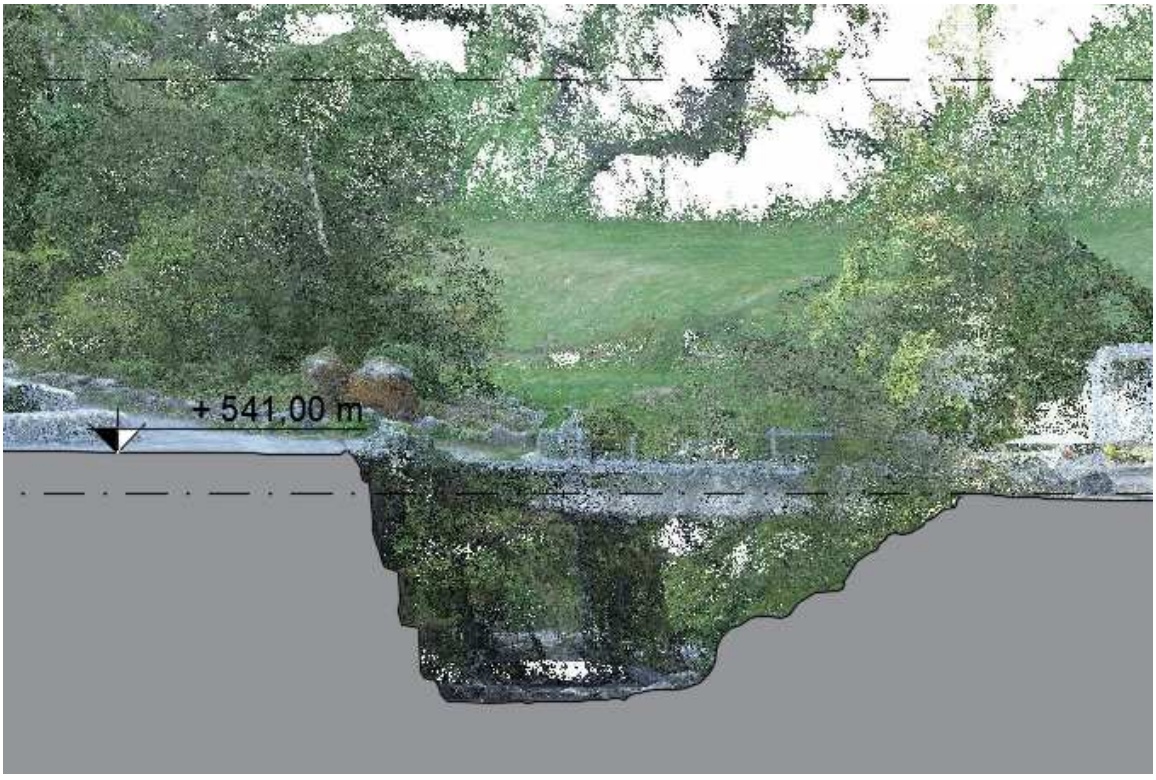

Immagine 02: Sezione in esame

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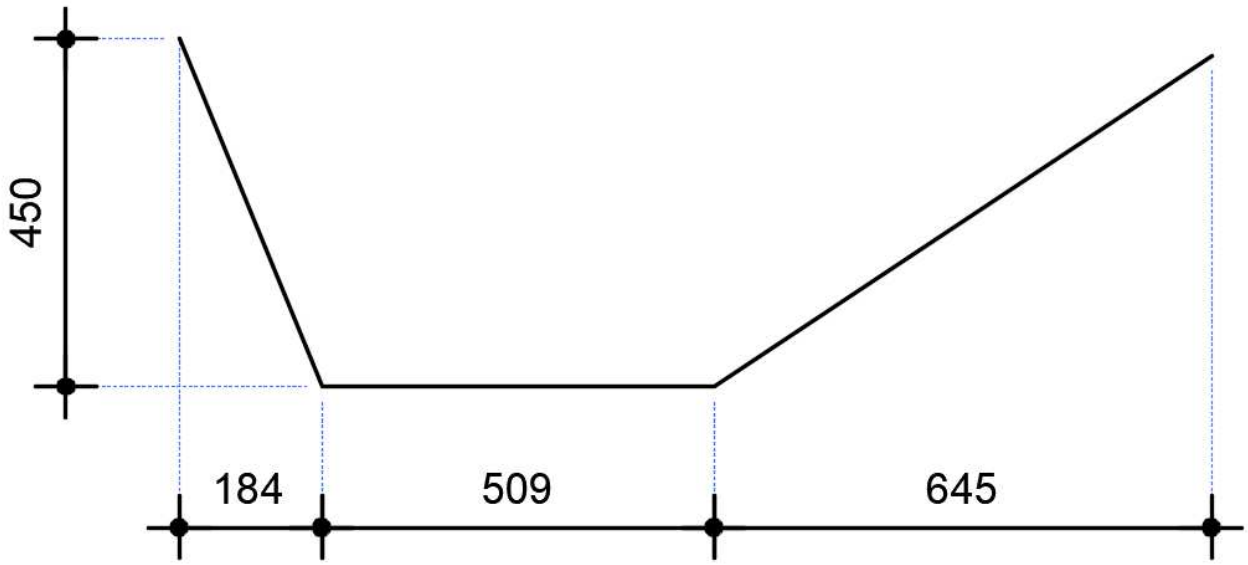

Immagine 03: Sezione trapezia alveo in esame

Noti i valori pluviometrici dell'area è possibile valutare la portata di massima piena del torrente Riso. Le formule empiriche adottate ed i metodi statistici forniscono mediamente un valore di portata di massima piena pari a 200m3/sec, con tempi di ritorno di 100 anni.

Dati:

Pendenza Alveo: 5,2%

Portata: 200 mc/sec

Scabrezza (Strickler): 17 (Torrenti di montagna con letto irregolare e formato da grossi massi)

Altezza libera alveo (hl): 4,50 m

Area luce libera alveo (Al): 42,11 mq

Il calcolo della portata di piena di assegnato tempo di ritorno può quindi essere effettuato o mediante uso delle formule empiriche esistenti in letteratura, o attraverso l'analisi della pluviometria della zona e la successiva applicazione di un modello di trasformazione afflussi-deflussi.

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Valore delle portate

h (m)	Q(mc/s)	V (m/s)	A (mq)	L (m)	C (m)	R (m)	Qk (m/s)
0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
0,010	0,009	0,179	0,051	5,121	5,130	0,010	0,016
0,020	0,029	0,284	0,102	5,142	5,161	0,020	0,045
0,030	0,057	0,371	0,154	5,163	5,191	0,030	0,083
0,040	0,092	0,449	0,206	5,184	5,222	0,039	0,128
0,050	0,134	0,519	0,258	5,205	5,252	0,049	0,179
0,060	0,181	0,585	0,310	5,226	5,283	0,059	0,236
0,070	0,234	0,647	0,362	5,247	5,313	0,068	0,298
0,080	0,293	0,705	0,415	5,268	5,344	0,078	0,364
0,090	0,356	0,761	0,468	5,289	5,374	0,087	0,435
0,100	0,424	0,814	0,520	5,310	5,405	0,096	0,510
0,110	0,497	0,866	0,574	5,331	5,435	0,106	0,589
0,120	0,574	0,915	0,627	5,352	5,466	0,115	0,672
0,130	0,656	0,963	0,681	5,373	5,496	0,124	0,759
0,140	0,742	1,010	0,735	5,394	5,527	0,133	0,849
0,150	0,832	1,055	0,789	5,415	5,557	0,142	0,942
0,160	0,926	1,098	0,843	5,436	5,588	0,151	1,039
0,170	1,024	1,141	0,897	5,457	5,618	0,160	1,139
0,180	1,126	1,183	0,952	5,478	5,649	0,169	1,243
0,190	1,232	1,223	1,007	5,499	5,679	0,177	1,349
0,200	1,341	1,263	1,062	5,520	5,710	0,186	1,459
0,210	1,455	1,302	1,117	5,541	5,740	0,195	1,571
0,220	1,572	1,340	1,173	5,562	5,771	0,203	1,686
0,230	1,692	1,377	1,229	5,583	5,801	0,212	1,805
0,240	1,816	1,414	1,284	5,604	5,832	0,220	1,926
0,250	1,943	1,450	1,341	5,625	5,862	0,229	2,049
0,260	2,074	1,485	1,397	5,646	5,893	0,237	2,176
0,270	2,209	1,519	1,454	5,667	5,923	0,245	2,305
0,280	2,346	1,553	1,510	5,688	5,954	0,254	2,437
0,290	2,487	1,587	1,567	5,709	5,984	0,262	2,572
0,300	2,631	1,620	1,625	5,730	6,015	0,270	2,709
0,310	2,779	1,652	1,682	5,751	6,045	0,278	2,848
0,320	2,929	1,684	1,740	5,772	6,076	0,286	2,990
0,330	3,083	1,715	1,797	5,793	6,106	0,294	3,135
0,340	3,240	1,746	1,855	5,814	6,137	0,302	3,282

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0,350	3,400	1,777	1,914	5,835	6,167	0,310	3,432
0,360	3,563	1,807	1,972	5,856	6,198	0,318	3,584
0,370	3,729	1,836	2,031	5,877	6,228	0,326	3,738
0,380	3,899	1,866	2,090	5,898	6,259	0,334	3,895
0,390	4,071	1,895	2,149	5,919	6,289	0,342	4,054
0,400	4,246	1,923	2,208	5,940	6,320	0,349	4,216
0,410	4,424	1,951	2,268	5,961	6,350	0,357	4,379
0,420	4,605	1,979	2,327	5,982	6,381	0,365	4,545
0,430	4,789	2,006	2,387	6,003	6,411	0,372	4,714
0,440	4,976	2,033	2,447	6,024	6,442	0,380	4,885
0,450	5,166	2,060	2,508	6,045	6,472	0,387	5,058
0,460	5,359	2,087	2,568	6,066	6,503	0,395	5,233
0,470	5,555	2,113	2,629	6,087	6,533	0,402	5,410
0,480	5,753	2,139	2,690	6,108	6,564	0,410	5,590
0,490	5,955	2,164	2,751	6,129	6,594	0,417	5,772
0,500	6,159	2,190	2,812	6,150	6,625	0,425	5,956
0,510	6,366	2,215	2,874	6,171	6,655	0,432	6,142
0,520	6,575	2,240	2,936	6,192	6,686	0,439	6,331
0,530	6,788	2,264	2,998	6,213	6,716	0,446	6,521
0,540	7,003	2,289	3,060	6,234	6,747	0,454	6,714
0,550	7,221	2,313	3,123	6,255	6,777	0,461	6,909
0,560	7,442	2,336	3,185	6,276	6,808	0,468	7,106
0,570	7,666	2,360	3,248	6,297	6,838	0,475	7,305
0,580	7,892	2,383	3,311	6,318	6,869	0,482	7,507
0,590	8,121	2,407	3,375	6,339	6,899	0,489	7,710
0,600	8,353	2,429	3,438	6,360	6,930	0,496	7,915
0,610	8,587	2,452	3,502	6,381	6,960	0,503	8,123
0,620	8,824	2,475	3,566	6,402	6,991	0,510	8,333
0,630	9,064	2,497	3,630	6,423	7,021	0,517	8,545
0,640	9,306	2,519	3,694	6,444	7,052	0,524	8,758
0,650	9,551	2,541	3,759	6,465	7,082	0,531	8,974
0,660	9,799	2,563	3,823	6,486	7,113	0,538	9,192
0,670	10,049	2,584	3,888	6,507	7,143	0,544	9,412
0,680	10,302	2,606	3,954	6,528	7,174	0,551	9,635
0,690	10,558	2,627	4,019	6,549	7,204	0,558	9,859
0,700	10,816	2,648	4,084	6,570	7,235	0,565	10,085
0,710	11,077	2,669	4,150	6,591	7,265	0,571	10,313
0,720	11,341	2,690	4,216	6,612	7,296	0,578	10,543
0,730	11,607	2,710	4,283	6,633	7,326	0,585	10,776
0,740	11,875	2,731	4,349	6,654	7,357	0,591	11,010
0,750	12,147	2,751	4,416	6,675	7,387	0,598	11,246
0,760	12,421	2,771	4,482	6,696	7,417	0,604	11,485

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0,770	12,697	2,791	4,550	6,717	7,448	0,611	11,725
0,780	12,976	2,811	4,617	6,738	7,478	0,617	11,967
0,790	13,258	2,830	4,684	6,759	7,509	0,624	12,212
0,800	13,542	2,850	4,752	6,780	7,539	0,630	12,458
0,810	13,829	2,869	4,820	6,801	7,570	0,637	12,706
0,820	14,118	2,888	4,888	6,822	7,600	0,643	12,957
0,830	14,410	2,907	4,956	6,843	7,631	0,650	13,209
0,840	14,705	2,926	5,025	6,864	7,661	0,656	13,463
0,850	15,002	2,945	5,094	6,885	7,692	0,662	13,719
0,860	15,301	2,964	5,163	6,906	7,722	0,669	13,978
0,870	15,603	2,982	5,232	6,927	7,753	0,675	14,238
0,880	15,908	3,001	5,301	6,948	7,783	0,681	14,500
0,890	16,215	3,019	5,371	6,969	7,814	0,687	14,764
0,900	16,525	3,037	5,440	6,990	7,844	0,694	15,030
0,910	16,837	3,055	5,511	7,011	7,875	0,700	15,298
0,920	17,152	3,073	5,581	7,032	7,905	0,706	15,568
0,930	17,470	3,091	5,651	7,053	7,936	0,712	15,840
0,940	17,789	3,109	5,722	7,074	7,966	0,718	16,114
0,950	18,112	3,127	5,793	7,095	7,997	0,724	16,390
0,960	18,437	3,144	5,864	7,116	8,027	0,730	16,668
0,970	18,764	3,162	5,935	7,137	8,058	0,737	16,948
0,980	19,094	3,179	6,006	7,158	8,088	0,743	17,230
0,990	19,427	3,196	6,078	7,179	8,119	0,749	17,513
1,000	19,762	3,213	6,150	7,200	8,149	0,755	17,799
1,010	20,099	3,230	6,222	7,221	8,180	0,761	18,086
1,020	20,439	3,247	6,294	7,242	8,210	0,767	18,376
1,030	20,782	3,264	6,367	7,263	8,241	0,773	18,667
1,040	21,127	3,281	6,440	7,284	8,271	0,779	18,961
1,050	21,475	3,297	6,513	7,305	8,302	0,784	19,256
1,060	21,825	3,314	6,586	7,326	8,332	0,790	19,553
1,070	22,178	3,330	6,659	7,347	8,363	0,796	19,853
1,080	22,533	3,347	6,733	7,368	8,393	0,802	20,154
1,090	22,890	3,363	6,807	7,389	8,424	0,808	20,457
1,100	23,251	3,379	6,880	7,410	8,454	0,814	20,762
1,110	23,613	3,395	6,955	7,431	8,485	0,820	21,069
1,120	23,978	3,411	7,029	7,452	8,515	0,825	21,378
1,130	24,346	3,427	7,104	7,473	8,546	0,831	21,688
1,140	24,716	3,443	7,179	7,494	8,576	0,837	22,001
1,150	25,089	3,459	7,254	7,515	8,607	0,843	22,316
1,160	25,464	3,475	7,329	7,536	8,637	0,849	22,632
1,170	25,842	3,490	7,404	7,557	8,668	0,854	22,951
1,180	26,222	3,506	7,480	7,578	8,698	0,860	23,271

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1,190	26,605	3,521	7,556	7,599	8,729	0,866	23,594
1,200	26,990	3,536	7,632	7,620	8,759	0,871	23,918
1,210	27,378	3,552	7,708	7,641	8,790	0,877	24,244
1,220	27,768	3,567	7,785	7,662	8,820	0,883	24,572
1,230	28,161	3,582	7,862	7,683	8,851	0,888	24,902
1,240	28,556	3,597	7,938	7,704	8,881	0,894	25,234
1,250	28,954	3,612	8,016	7,725	8,912	0,899	25,568
1,260	29,354	3,627	8,093	7,746	8,942	0,905	25,904
1,270	29,757	3,642	8,171	7,767	8,973	0,911	26,242
1,280	30,162	3,657	8,248	7,788	9,003	0,916	26,582
1,290	30,570	3,671	8,326	7,809	9,034	0,922	26,923
1,300	30,980	3,686	8,404	7,830	9,064	0,927	27,267
1,310	31,393	3,701	8,483	7,851	9,095	0,933	27,612
1,320	31,808	3,715	8,562	7,872	9,125	0,938	27,959
1,330	32,226	3,730	8,640	7,893	9,156	0,944	28,309
1,340	32,647	3,744	8,719	7,914	9,186	0,949	28,660
1,350	33,069	3,758	8,799	7,935	9,217	0,955	29,013
1,360	33,495	3,773	8,878	7,956	9,247	0,960	29,368
1,370	33,923	3,787	8,958	7,977	9,278	0,966	29,725
1,380	34,353	3,801	9,038	7,998	9,308	0,971	30,084
1,390	34,786	3,815	9,118	8,019	9,339	0,976	30,445
1,400	35,222	3,829	9,198	8,040	9,369	0,982	30,808
1,410	35,659	3,843	9,278	8,061	9,400	0,987	31,172
1,420	36,100	3,857	9,359	8,082	9,430	0,992	31,539
1,430	36,543	3,871	9,440	8,103	9,461	0,998	31,907
1,440	36,988	3,885	9,521	8,124	9,491	1,003	32,278
1,450	37,436	3,899	9,603	8,145	9,522	1,009	32,650
1,460	37,887	3,912	9,684	8,166	9,552	1,014	33,024
1,470	38,340	3,926	9,766	8,187	9,583	1,019	33,401
1,480	38,796	3,939	9,848	8,208	9,613	1,024	33,779
1,490	39,254	3,953	9,930	8,229	9,644	1,030	34,159
1,500	39,715	3,967	10,012	8,250	9,674	1,035	34,541
1,510	40,178	3,980	10,095	8,271	9,705	1,040	34,925
1,520	40,644	3,993	10,178	8,292	9,735	1,045	35,311
1,530	41,112	4,007	10,261	8,313	9,765	1,051	35,698
1,540	41,583	4,020	10,344	8,334	9,796	1,056	36,088
1,550	42,056	4,033	10,428	8,355	9,826	1,061	36,480
1,560	42,532	4,046	10,511	8,376	9,857	1,066	36,873
1,570	43,010	4,059	10,595	8,397	9,887	1,072	37,269
1,580	43,491	4,073	10,679	8,418	9,918	1,077	37,666
1,590	43,975	4,086	10,764	8,439	9,948	1,082	38,065
1,600	44,461	4,099	10,848	8,460	9,979	1,087	38,467

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1,610	44,949	4,111	10,933	8,481	10,009	1,092	38,870
1,620	45,440	4,124	11,018	8,502	10,040	1,097	39,275
1,630	45,934	4,137	11,103	8,523	10,070	1,103	39,682
1,640	46,430	4,150	11,188	8,544	10,101	1,108	40,091
1,650	46,929	4,163	11,274	8,565	10,131	1,113	40,502
1,660	47,430	4,175	11,359	8,586	10,162	1,118	40,915
1,670	47,934	4,188	11,445	8,607	10,192	1,123	41,330
1,680	48,441	4,201	11,532	8,628	10,223	1,128	41,747
1,690	48,950	4,213	11,618	8,649	10,253	1,133	42,165
1,700	49,461	4,226	11,704	8,670	10,284	1,138	42,586
1,710	49,976	4,238	11,791	8,691	10,314	1,143	43,008
1,720	50,492	4,251	11,878	8,712	10,345	1,148	43,433
1,730	51,012	4,263	11,966	8,733	10,375	1,153	43,859
1,740	51,533	4,276	12,053	8,754	10,406	1,158	44,288
1,750	52,058	4,288	12,141	8,775	10,436	1,163	44,718
1,760	52,585	4,300	12,228	8,796	10,467	1,168	45,150
1,770	53,114	4,312	12,317	8,817	10,497	1,173	45,585
1,780	53,647	4,325	12,405	8,838	10,528	1,178	46,021
1,790	54,181	4,337	12,493	8,859	10,558	1,183	46,459
1,800	54,719	4,349	12,582	8,880	10,589	1,188	46,899
1,810	55,258	4,361	12,671	8,901	10,619	1,193	47,341
1,820	55,801	4,373	12,760	8,922	10,650	1,198	47,785
1,830	56,346	4,385	12,849	8,943	10,680	1,203	48,231
1,840	56,894	4,397	12,939	8,964	10,711	1,208	48,679
1,850	57,444	4,409	13,029	8,985	10,741	1,213	49,129
1,860	57,997	4,421	13,119	9,006	10,772	1,218	49,580
1,870	58,552	4,433	13,209	9,027	10,802	1,223	50,034
1,880	59,110	4,445	13,299	9,048	10,833	1,228	50,490
1,890	59,671	4,456	13,390	9,069	10,863	1,233	50,947
1,900	60,234	4,468	13,480	9,090	10,894	1,237	51,407
1,910	60,800	4,480	13,571	9,111	10,924	1,242	51,869
1,920	61,368	4,492	13,663	9,132	10,955	1,247	52,332
1,930	61,939	4,503	13,754	9,153	10,985	1,252	52,798
1,940	62,513	4,515	13,846	9,174	11,016	1,257	53,265
1,950	63,089	4,527	13,938	9,195	11,046	1,262	53,734
1,960	63,668	4,538	14,030	9,216	11,077	1,267	54,206
1,970	64,250	4,550	14,122	9,237	11,107	1,271	54,679
1,980	64,834	4,561	14,214	9,258	11,138	1,276	55,154
1,990	65,421	4,573	14,307	9,279	11,168	1,281	55,632
2,000	66,010	4,584	14,400	9,300	11,199	1,286	56,111
2,010	66,602	4,595	14,493	9,321	11,229	1,291	56,592
2,020	67,197	4,607	14,586	9,342	11,260	1,295	57,075

DOTT. ING. ANDREA MIDALI
via Crescenzi, 65/A – 24123 Bergamo
Tel. 035.224488

2,030	67,794	4,618	14,680	9,363	11,290	1,300	57,561
2,040	68,394	4,629	14,774	9,384	11,321	1,305	58,048
2,050	68,996	4,641	14,868	9,405	11,351	1,310	58,537
2,060	69,602	4,652	14,962	9,426	11,382	1,315	59,028
2,070	70,209	4,663	15,056	9,447	11,412	1,319	59,521
2,080	70,820	4,674	15,151	9,468	11,443	1,324	60,016
2,090	71,433	4,686	15,245	9,489	11,473	1,329	60,513
2,100	72,049	4,697	15,340	9,510	11,504	1,334	61,012
2,110	72,667	4,708	15,436	9,531	11,534	1,338	61,513
2,120	73,288	4,719	15,531	9,552	11,565	1,343	62,016
2,130	73,912	4,730	15,627	9,573	11,595	1,348	62,521
2,140	74,538	4,741	15,723	9,594	11,626	1,352	63,028
2,150	75,167	4,752	15,819	9,615	11,656	1,357	63,537
2,160	75,799	4,763	15,915	9,636	11,687	1,362	64,047
2,170	76,433	4,774	16,011	9,657	11,717	1,366	64,560
2,180	77,071	4,785	16,108	9,678	11,748	1,371	65,075
2,190	77,710	4,795	16,205	9,699	11,778	1,376	65,592
2,200	78,353	4,806	16,302	9,720	11,809	1,381	66,111
2,210	78,998	4,817	16,399	9,741	11,839	1,385	66,632
2,220	79,645	4,828	16,497	9,762	11,870	1,390	67,155
2,230	80,296	4,839	16,595	9,783	11,900	1,394	67,680
2,240	80,949	4,849	16,692	9,804	11,931	1,399	68,206
2,250	81,605	4,860	16,791	9,825	11,961	1,404	68,735
2,260	82,263	4,871	16,889	9,846	11,992	1,408	69,266
2,270	82,925	4,881	16,988	9,867	12,022	1,413	69,799
2,280	83,588	4,892	17,086	9,888	12,052	1,418	70,334
2,290	84,255	4,903	17,185	9,909	12,083	1,422	70,871
2,300	84,924	4,913	17,284	9,930	12,113	1,427	71,410
2,310	85,596	4,924	17,384	9,951	12,144	1,431	71,950
2,320	86,271	4,934	17,484	9,972	12,174	1,436	72,493
2,330	86,948	4,945	17,583	9,993	12,205	1,441	73,038
2,340	87,628	4,955	17,683	10,014	12,235	1,445	73,585
2,350	88,311	4,966	17,784	10,035	12,266	1,450	74,134
2,360	88,997	4,976	17,884	10,056	12,296	1,454	74,685
2,370	89,685	4,987	17,985	10,077	12,327	1,459	75,238
2,380	90,376	4,997	18,086	10,098	12,357	1,464	75,793
2,390	91,070	5,007	18,187	10,119	12,388	1,468	76,350
2,400	91,766	5,018	18,288	10,140	12,418	1,473	76,909
2,410	92,465	5,028	18,389	10,161	12,449	1,477	77,470
2,420	93,167	5,038	18,491	10,182	12,479	1,482	78,033
2,430	93,872	5,049	18,593	10,203	12,510	1,486	78,598
2,440	94,579	5,059	18,695	10,224	12,540	1,491	79,165

DOTT. ING. ANDREA MIDALI
via Crescenzi, 65/A – 24123 Bergamo
Tel. 035.224488

2,450	95,289	5,069	18,798	10,245	12,571	1,495	79,734
2,460	96,002	5,079	18,900	10,266	12,601	1,500	80,305
2,470	96,718	5,090	19,003	10,287	12,632	1,504	80,878
2,480	97,436	5,100	19,106	10,308	12,662	1,509	81,454
2,490	98,157	5,110	19,209	10,329	12,693	1,513	82,031
2,500	98,881	5,120	19,312	10,350	12,723	1,518	82,610
2,510	99,608	5,130	19,416	10,371	12,754	1,522	83,191
2,520	100,337	5,140	19,520	10,392	12,784	1,527	83,775
2,530	101,069	5,150	19,624	10,413	12,815	1,531	84,360
2,540	101,804	5,160	19,728	10,434	12,845	1,536	84,947
2,550	102,542	5,170	19,833	10,455	12,876	1,540	85,537
2,560	103,282	5,180	19,937	10,476	12,906	1,545	86,128
2,570	104,025	5,190	20,042	10,497	12,937	1,549	86,722
2,580	104,771	5,200	20,147	10,518	12,967	1,554	87,318
2,590	105,520	5,210	20,252	10,539	12,998	1,558	87,915
2,600	106,272	5,220	20,358	10,560	13,028	1,563	88,515
2,610	107,026	5,230	20,464	10,581	13,059	1,567	89,117
2,620	107,783	5,240	20,570	10,602	13,089	1,571	89,720
2,630	108,543	5,250	20,676	10,623	13,120	1,576	90,326
2,640	109,306	5,260	20,782	10,644	13,150	1,580	90,934
2,650	110,071	5,269	20,889	10,665	13,181	1,585	91,544
2,660	110,839	5,279	20,995	10,686	13,211	1,589	92,156
2,670	111,610	5,289	21,102	10,707	13,242	1,594	92,770
2,680	112,384	5,299	21,210	10,728	13,272	1,598	93,386
2,690	113,161	5,309	21,317	10,749	13,303	1,602	94,004
2,700	113,940	5,318	21,424	10,770	13,333	1,607	94,624
2,710	114,723	5,328	21,532	10,791	13,364	1,611	95,247
2,720	115,508	5,338	21,640	10,812	13,394	1,616	95,871
2,730	116,296	5,347	21,749	10,833	13,425	1,620	96,498
2,740	117,087	5,357	21,857	10,854	13,455	1,624	97,126
2,750	117,880	5,367	21,966	10,875	13,486	1,629	97,757
2,760	118,677	5,376	22,074	10,896	13,516	1,633	98,389
2,770	119,476	5,386	22,184	10,917	13,547	1,638	99,024
2,780	120,278	5,395	22,293	10,938	13,577	1,642	99,661
2,790	121,083	5,405	22,402	10,959	13,608	1,646	100,300
2,800	121,890	5,414	22,512	10,980	13,638	1,651	100,941
2,810	122,701	5,424	22,622	11,001	13,669	1,655	101,584
2,820	123,514	5,434	22,732	11,022	13,699	1,659	102,229
2,830	124,331	5,443	22,842	11,043	13,730	1,664	102,876
2,840	125,150	5,452	22,953	11,064	13,760	1,668	103,525
2,850	125,972	5,462	23,064	11,085	13,791	1,672	104,176
2,860	126,797	5,471	23,175	11,106	13,821	1,677	104,830

DOTT. ING. ANDREA MIDALI
via Crescenzi, 65/A – 24123 Bergamo
Tel. 035.224488

2,870	127,624	5,481	23,286	11,127	13,852	1,681	105,485
2,880	128,455	5,490	23,397	11,148	13,882	1,685	106,143
2,890	129,288	5,500	23,509	11,169	13,913	1,690	106,803
2,900	130,125	5,509	23,620	11,190	13,943	1,694	107,464
2,910	130,964	5,518	23,732	11,211	13,974	1,698	108,128
2,920	131,806	5,528	23,845	11,232	14,004	1,703	108,794
2,930	132,651	5,537	23,957	11,253	14,035	1,707	109,462
2,940	133,498	5,546	24,070	11,274	14,065	1,711	110,132
2,950	134,349	5,556	24,183	11,295	14,096	1,716	110,805
2,960	135,203	5,565	24,296	11,316	14,126	1,720	111,479
2,970	136,059	5,574	24,409	11,337	14,157	1,724	112,155
2,980	136,918	5,583	24,522	11,358	14,187	1,729	112,834
2,990	137,780	5,593	24,636	11,379	14,218	1,733	113,515
3,000	138,645	5,602	24,750	11,400	14,248	1,737	114,197
3,010	139,513	5,611	24,864	11,421	14,279	1,741	114,882
3,020	140,384	5,620	24,978	11,442	14,309	1,746	115,569
3,030	141,258	5,629	25,093	11,463	14,340	1,750	116,258
3,040	142,135	5,639	25,208	11,484	14,370	1,754	116,949
3,050	143,014	5,648	25,323	11,505	14,400	1,758	117,643
3,060	143,897	5,657	25,438	11,526	14,431	1,763	118,338
3,070	144,782	5,666	25,553	11,547	14,461	1,767	119,036
3,080	145,671	5,675	25,669	11,568	14,492	1,771	119,735
3,090	146,562	5,684	25,784	11,589	14,522	1,775	120,437
3,100	147,456	5,693	25,900	11,610	14,553	1,780	121,141
3,110	148,353	5,702	26,017	11,631	14,583	1,784	121,847
3,120	149,253	5,711	26,133	11,652	14,614	1,788	122,555
3,130	150,156	5,720	26,250	11,673	14,644	1,792	123,266
3,140	151,062	5,729	26,367	11,694	14,675	1,797	123,978
3,150	151,971	5,738	26,484	11,715	14,705	1,801	124,693
3,160	152,883	5,747	26,601	11,736	14,736	1,805	125,409
3,170	153,798	5,756	26,718	11,757	14,766	1,809	126,128
3,180	154,715	5,765	26,836	11,778	14,797	1,814	126,849
3,190	155,636	5,774	26,954	11,799	14,827	1,818	127,572
3,200	156,559	5,783	27,072	11,820	14,858	1,822	128,297
3,210	157,486	5,792	27,190	11,841	14,888	1,826	129,025
3,220	158,415	5,801	27,309	11,862	14,919	1,830	129,754
3,230	159,348	5,810	27,428	11,883	14,949	1,835	130,486
3,240	160,283	5,819	27,546	11,904	14,980	1,839	131,219
3,250	161,222	5,828	27,666	11,925	15,010	1,843	131,955
3,260	162,163	5,836	27,785	11,946	15,041	1,847	132,693
3,270	163,107	5,845	27,905	11,967	15,071	1,851	133,434
3,280	164,055	5,854	28,024	11,988	15,102	1,856	134,176

DOTT. ING. ANDREA MIDALI
via Crescenzi, 65/A – 24123 Bergamo
Tel. 035.224488

3,290	165,005	5,863	28,144	12,009	15,132	1,860	134,920
3,300	165,958	5,872	28,264	12,030	15,163	1,864	135,667
3,310	166,914	5,880	28,385	12,051	15,193	1,868	136,416
3,320	167,874	5,889	28,505	12,072	15,224	1,872	137,167
3,330	168,836	5,898	28,626	12,093	15,254	1,877	137,920
3,340	169,801	5,907	28,747	12,114	15,285	1,881	138,675
3,350	170,769	5,915	28,869	12,135	15,315	1,885	139,433
3,360	171,741	5,924	28,990	12,156	15,346	1,889	140,192
3,370	172,715	5,933	29,112	12,177	15,376	1,893	140,954
3,380	173,692	5,942	29,234	12,198	15,407	1,897	141,718
3,390	174,672	5,950	29,356	12,219	15,437	1,902	142,484
3,400	175,656	5,959	29,478	12,240	15,468	1,906	143,252
3,410	176,642	5,968	29,600	12,261	15,498	1,910	144,023
3,420	177,631	5,976	29,723	12,282	15,529	1,914	144,795
3,430	178,623	5,985	29,846	12,303	15,559	1,918	145,570
3,440	179,619	5,993	29,969	12,324	15,590	1,922	146,347
3,450	180,617	6,002	30,093	12,345	15,620	1,927	147,126
3,460	181,618	6,011	30,216	12,366	15,651	1,931	147,907
3,470	182,623	6,019	30,340	12,387	15,681	1,935	148,691
3,480	183,630	6,028	30,464	12,408	15,712	1,939	149,477
3,490	184,641	6,036	30,588	12,429	15,742	1,943	150,264
3,500	185,654	6,045	30,712	12,450	15,773	1,947	151,054
3,510	186,671	6,053	30,837	12,471	15,803	1,951	151,847
3,520	187,690	6,062	30,962	12,492	15,834	1,955	152,641
3,530	188,713	6,070	31,087	12,513	15,864	1,960	153,438
3,540	189,739	6,079	31,212	12,534	15,895	1,964	154,236
3,550	190,767	6,087	31,338	12,555	15,925	1,968	155,037
3,560	191,799	6,096	31,463	12,576	15,956	1,972	155,840
3,570	192,834	6,104	31,589	12,597	15,986	1,976	156,646
3,580	193,872	6,113	31,715	12,618	16,017	1,980	157,453
3,590	194,913	6,121	31,841	12,639	16,047	1,984	158,263
3,600	195,957	6,130	31,968	12,660	16,078	1,988	159,075
3,610	197,004	6,138	32,095	12,681	16,108	1,992	159,889
3,620	198,055	6,147	32,222	12,702	16,139	1,997	160,705
3,630	199,108	6,155	32,349	12,723	16,169	2,001	161,524
3,640	200,164	6,163	32,476	12,744	16,200	2,005	162,345
3,650	201,224	6,172	32,604	12,765	16,230	2,009	163,168
3,660	202,286	6,180	32,731	12,786	16,261	2,013	163,993
3,670	203,352	6,189	32,859	12,807	16,291	2,017	164,820
3,680	204,421	6,197	32,987	12,828	16,322	2,021	165,650
3,690	205,492	6,205	33,116	12,849	16,352	2,025	166,481
3,700	206,567	6,214	33,244	12,870	16,383	2,029	167,315

DOTT. ING. ANDREA MIDALI
via Crescenzi, 65/A – 24123 Bergamo
Tel. 035.224488

3,710	207,645	6,222	33,373	12,891	16,413	2,033	168,152
3,720	208,727	6,230	33,502	12,912	16,444	2,037	168,990
3,730	209,811	6,239	33,632	12,933	16,474	2,041	169,831
3,740	210,898	6,247	33,761	12,954	16,505	2,046	170,673
3,750	211,989	6,255	33,891	12,975	16,535	2,050	171,519
3,760	213,082	6,263	34,020	12,996	16,566	2,054	172,366
3,770	214,179	6,272	34,151	13,017	16,596	2,058	173,215
3,780	215,279	6,280	34,281	13,038	16,627	2,062	174,067
3,790	216,382	6,288	34,411	13,059	16,657	2,066	174,921
3,800	217,488	6,296	34,542	13,080	16,687	2,070	175,777
3,810	218,597	6,305	34,673	13,101	16,718	2,074	176,636
3,820	219,709	6,313	34,804	13,122	16,748	2,078	177,496
3,830	220,825	6,321	34,935	13,143	16,779	2,082	178,359
3,840	221,944	6,329	35,067	13,164	16,809	2,086	179,224
3,850	223,065	6,337	35,199	13,185	16,840	2,090	180,092
3,860	224,190	6,346	35,331	13,206	16,870	2,094	180,961
3,870	225,318	6,354	35,463	13,227	16,901	2,098	181,833
3,880	226,450	6,362	35,595	13,248	16,931	2,102	182,707
3,890	227,584	6,370	35,728	13,269	16,962	2,106	183,584
3,900	228,721	6,378	35,860	13,290	16,992	2,110	184,462
3,910	229,862	6,386	35,993	13,311	17,023	2,114	185,343
3,920	231,006	6,394	36,127	13,332	17,053	2,118	186,226
3,930	232,153	6,402	36,260	13,353	17,084	2,122	187,111
3,940	233,303	6,411	36,394	13,374	17,114	2,126	187,999
3,950	234,457	6,419	36,528	13,395	17,145	2,131	188,889
3,960	235,613	6,427	36,662	13,416	17,175	2,135	189,781
3,970	236,773	6,435	36,796	13,437	17,206	2,139	190,675
3,980	237,936	6,443	36,930	13,458	17,236	2,143	191,572
3,990	239,102	6,451	37,065	13,479	17,267	2,147	192,471
4,000	240,271	6,459	37,200	13,500	17,297	2,151	193,372
4,010	241,444	6,467	37,335	13,521	17,328	2,155	194,275
4,020	242,619	6,475	37,470	13,542	17,358	2,159	195,181
4,030	243,798	6,483	37,606	13,563	17,389	2,163	196,089
4,040	244,980	6,491	37,742	13,584	17,419	2,167	196,999
4,050	246,166	6,499	37,878	13,605	17,450	2,171	197,911
4,060	247,354	6,507	38,014	13,626	17,480	2,175	198,826
4,070	248,546	6,515	38,150	13,647	17,511	2,179	199,743
4,080	249,741	6,523	38,287	13,668	17,541	2,183	200,662
4,090	250,939	6,531	38,423	13,689	17,572	2,187	201,584
4,100	252,140	6,539	38,560	13,710	17,602	2,191	202,507
4,110	253,345	6,547	38,698	13,731	17,633	2,195	203,434
4,120	254,552	6,555	38,835	13,752	17,663	2,199	204,362

DOTT. ING. ANDREA MIDALI
via Crescenzi, 65/A – 24123 Bergamo
Tel. 035.224488

4,130	255,763	6,563	38,973	13,773	17,694	2,203	205,293
4,140	256,978	6,571	39,111	13,794	17,724	2,207	206,225
4,150	258,195	6,578	39,249	13,815	17,755	2,211	207,161
4,160	259,416	6,586	39,387	13,836	17,785	2,215	208,098
4,170	260,640	6,594	39,525	13,857	17,816	2,219	209,038
4,180	261,867	6,602	39,664	13,878	17,846	2,223	209,980
4,190	263,097	6,610	39,803	13,899	17,877	2,227	210,924
4,200	264,331	6,618	39,942	13,920	17,907	2,230	211,871
4,210	265,568	6,626	40,081	13,941	17,938	2,234	212,820
4,220	266,808	6,634	40,221	13,962	17,968	2,238	213,771
4,230	268,052	6,641	40,361	13,983	17,999	2,242	214,725
4,240	269,298	6,649	40,501	14,004	18,029	2,246	215,680
4,250	270,548	6,657	40,641	14,025	18,060	2,250	216,639
4,260	271,802	6,665	40,781	14,046	18,090	2,254	217,599
4,270	273,058	6,673	40,922	14,067	18,121	2,258	218,562
4,280	274,318	6,681	41,062	14,088	18,151	2,262	219,527
4,290	275,581	6,688	41,203	14,109	18,182	2,266	220,494
4,300	276,847	6,696	41,345	14,130	18,212	2,270	221,464
4,310	278,117	6,704	41,486	14,151	18,243	2,274	222,435
4,320	279,389	6,712	41,628	14,172	18,273	2,278	223,410
4,330	280,666	6,719	41,769	14,193	18,304	2,282	224,386
4,340	281,945	6,727	41,911	14,214	18,334	2,286	225,365
4,350	283,228	6,735	42,054	14,235	18,365	2,290	226,346
4,360	284,514	6,743	42,196	14,256	18,395	2,294	227,330
4,370	285,803	6,750	42,339	14,277	18,426	2,298	228,316
4,380	287,096	6,758	42,482	14,298	18,456	2,302	229,304
4,390	288,392	6,766	42,625	14,319	18,487	2,306	230,294
4,400	289,691	6,774	42,768	14,340	18,517	2,310	231,287
4,410	290,993	6,781	42,912	14,361	18,548	2,314	232,282
4,420	292,299	6,789	43,055	14,382	18,578	2,318	233,279
4,430	293,608	6,797	43,199	14,403	18,609	2,321	234,279
4,440	294,921	6,804	43,343	14,424	18,639	2,325	235,281
4,450	296,237	6,812	43,488	14,445	18,670	2,329	236,285
4,460	297,556	6,820	43,632	14,466	18,700	2,333	237,292
4,470	298,878	6,827	43,777	14,487	18,731	2,337	238,301
4,480	300,204	6,835	43,922	14,508	18,761	2,341	239,313
4,490	301,533	6,843	44,067	14,529	18,792	2,345	240,326

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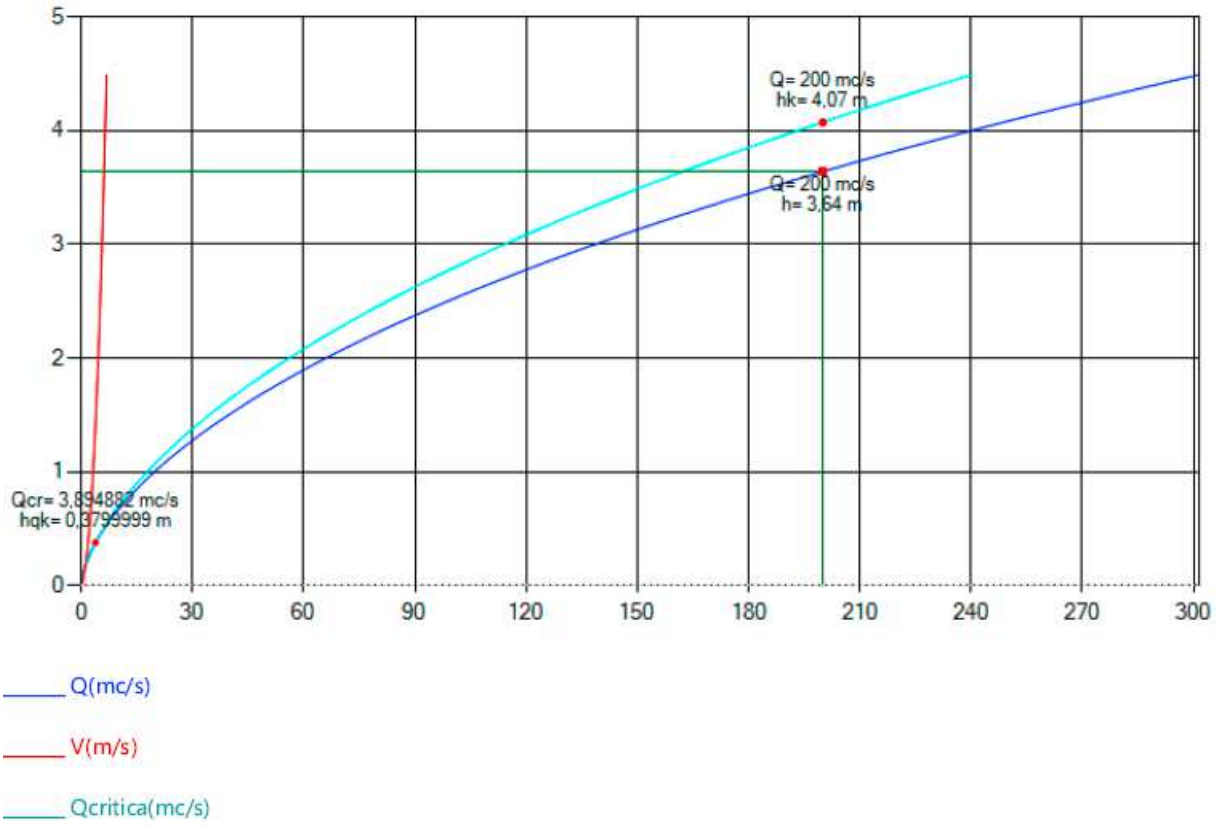

Immagine 04: Valori di altezza critica e portata

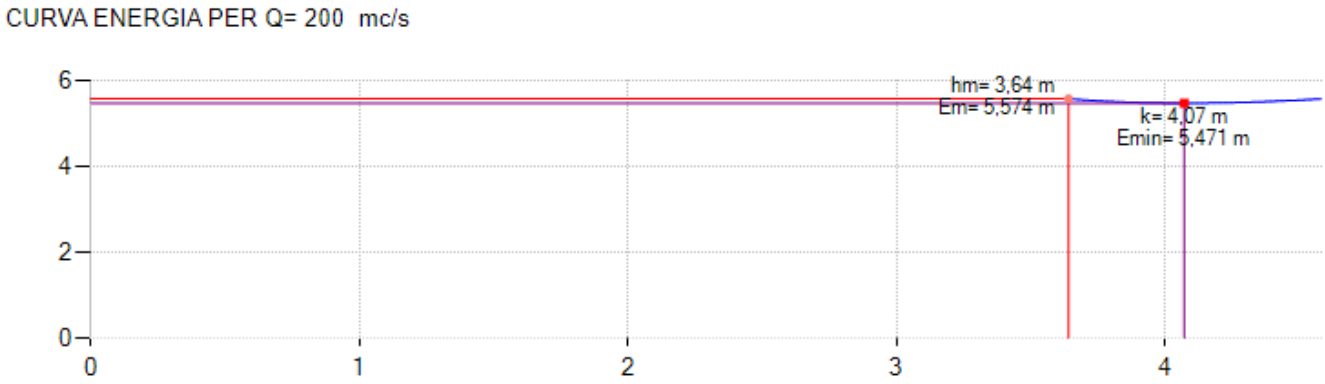

Immagine 05: Curva dell'energia

SEZIONE SUFFICIENTE CON FRANCO IDRAULICO: 0,86 m

Altezza di moto uniforme (h): 3,64 m

Area Bagnata (A): *32,48 mq* ***< Area luce libera alveo (Al):*** *42,11 mq*

Contorno Bagnato (C): 16,2 m

Velocità: 6,163442 m/s

altezza critica (hk): *4,07 m* ***< altezza libera alveo (hl) =*** *4,50 m*

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4. IMPALCATO DI ATTRAVERSAMENTO FLUVIALE

Attualmente il ponte si distacca dalla via pubblica per raggiungere il sito produttivo secondo orientamento obliquo rispetto all'andamento fluviale. Realizzato in cemento armato gettato in opera, esso ha luce netta di mt. 14.60 e altezza dal pelo libero dell'acqua mt. 5.40 dal piano stradale.

La struttura consta di travi ribassate in cemento armato, ad armatura lenta irrimediabilmente danneggiata dall'esposizione agli agenti atmosferici e all'azione antropica. Le travi ribassate hanno sezione cm. 25x90h con sovrastante soletta piena dello spessore di cm. 20. La sede stradale ha una larghezza utile di mt. 3,50 a senso unico alternato. Sono visibili all'intradosso distacchi del copriferro, espulsione dell'acciaio d'armatura, fenomeni importanti e diffusi di carbonatazione e di ossidazione.

L'epoca di costruzione è quella dell'originario sfruttamento minerario. Di conseguenza, sia l'aumento delle portate attualmente necessarie per garantire ai mezzi pesanti il transito; sia lo stato di grave ammaloramento strutturale rendono consigliabile la demolizione del manufatto e la sua ricostruzione secondo le vigenti norme.

Stante i vincoli plano-altimetrici determinati dagli esistenti accessi, si prevede che il rifacimento dell'impalcato di attraversamento non modifichi la sezione idraulica utile allo smaltimento dell'ondata di piena con tempo di ritorno previsto. La struttura sommariamente dovrà prevedere nuove fondazioni indipendenti dagli attuali argini in cemento armato (senza restringimento del corso, pertanto realizzate a monte degli attuali appoggi) e impalcato del tipo misto con travi prefabbricate e sovrastante soletta autoportante in prefabbricato e getto in opera; le travi a seconda del calcolo in acciaio ovvero cemento armato precompresso.

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5. CONCLUSIONI

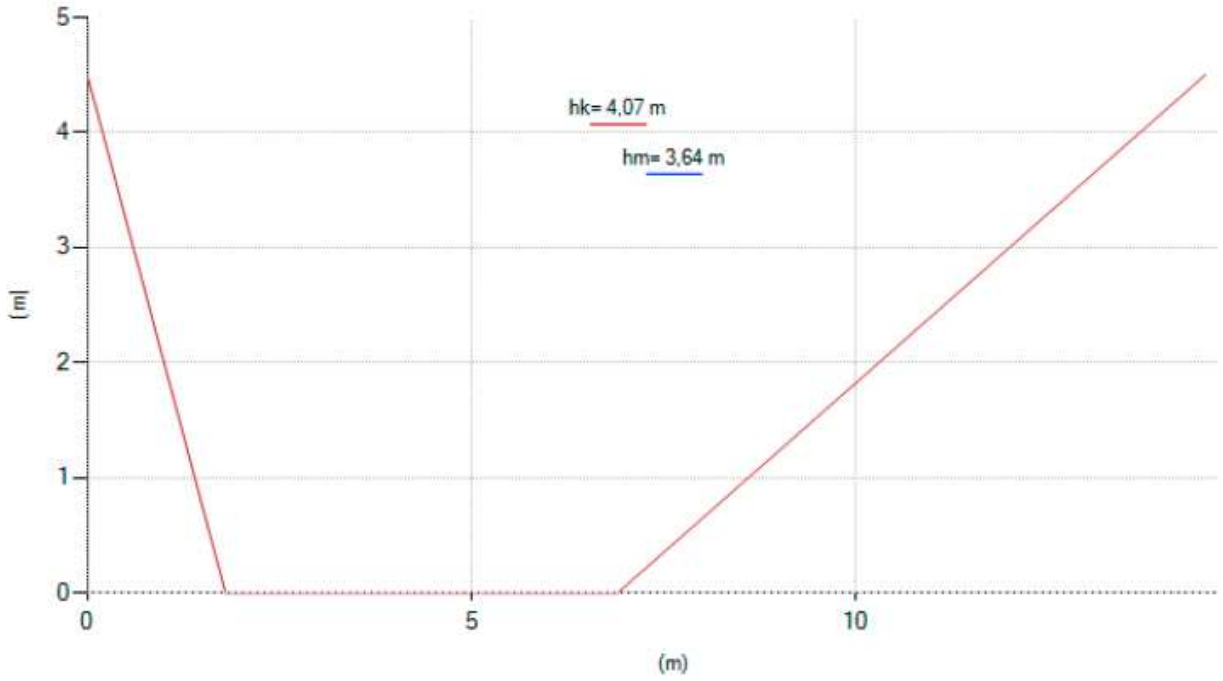

Immagine 05: Valori di altezza media (blu) e critica (rosso) delle portate

Da quanto sopra esposto, si rileva che la sezione idraulica esistente in corrispondenza dell'impalcato da ponte di attraversamento fluviale, allo stato di fatto coincidente con quello di progetto per futura demolizione e ricostruzione secondo caratteristiche geometriche analoghe alle attuali, risulta superiore alla sezione idraulica calcolata necessaria allo smaltimento della portata critica.

Bergamo, agosto 2021

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