

REGIONE PIEMONTE
Provincia di Cuneo
COMUNE DI BARBARESCO

**RICOSTRUZIONE DI SBARRAMENTO FLUVIALE
ESISTENTE AD USO IRRIGUO CON INNALZAMENTO
ABBATTIBILE AD USO IDROELETTRICO E
CENTRALE IN CORPO TRAVERSA**

PROGETTO DEFINITIVO

Elaborato n.

A1-2

"Relazione idrologico idraulica"

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1. PREMESSA

La presente relazione viene redatta dagli scriventi su incarico della società Tanaro Power S.p.A. ed analizza gli aspetti idrologici e idraulici necessari alla valutazione del comportamento del Fiume Tanaro nel Comune di Barbaresco, relativamente alle portate a cui corrispondono i tempi di ritorno tecnici caratteristici dell'idraulica di piena ed alle portate di utilizzo idroelettrico del corso d'acqua.

Il presente progetto prevede la ricostruzione dello sbarramento fluviale di Barbaresco, crollato nel novembre del 2010, ed il ripristino della derivazione del canale irriguo San Marzano (attualmente non operativa in quanto la presa non è fruibile).

Si prevede inoltre la realizzazione, per scopo idroelettrico, di un innalzamento abbattibile al di sopra della traversa e di una centrale in corpo traversa. La nuova traversa fissa avrà la stessa quota in sommità dello sbarramento crollato (148.40 m s.l.m.), mentre lo sbarramento mobile (completamente abbattibile) installato sulla traversa avrà un'altezza pari a 0.8 m; la quota in sommità con lo sbarramento mobile alzato sarà quindi di 149.20 m s.l.m.

La centrale, realizzata in corpo traversa, sarà completamente sommersa.

In caso di portate elevate defluenti nel corso d'acqua (superiori a 300 m³/s), le paratoie costituenti lo sbarramento mobile verranno abbattute; in questo modo sarà possibile ridurre in modo significativo i fenomeni di rigurgito.

La quasi totalità delle opere in progetto è ubicata in comune di Barbaresco, con la sola eccezione dell'edificio costituente la cabina di consegna e di parte del tracciato dell'elettrodotto interrato che sono localizzati in comune di Castagnito.

2. CARATTERISTICHE IDROLOGICHE DEL BACINO DEL FIUME TANARO NELLA SEZIONE DI CHIUSURA

Le caratteristiche idrologiche del bacino del Fiume Tanaro che vengono adottate nei calcoli delle portate idrologiche sono riferite alla sezione di chiusura posta in corrispondenza della sezione di presa.

Corpo idrico	Superficie bacino (km ²)	Quota media (m s.l.m.)
Tanaro	3520	1034

Tab. 2.1 Caratteristiche idrologiche del Fiume Tanaro a Barbaresco, in corrispondenza della sezione di chiusura considerata.

**RICOSTRUZIONE DI SBARRAMENTO FLUVIALE ESISTENTE AD USO IRRIGUO CON INNALZAMENTO
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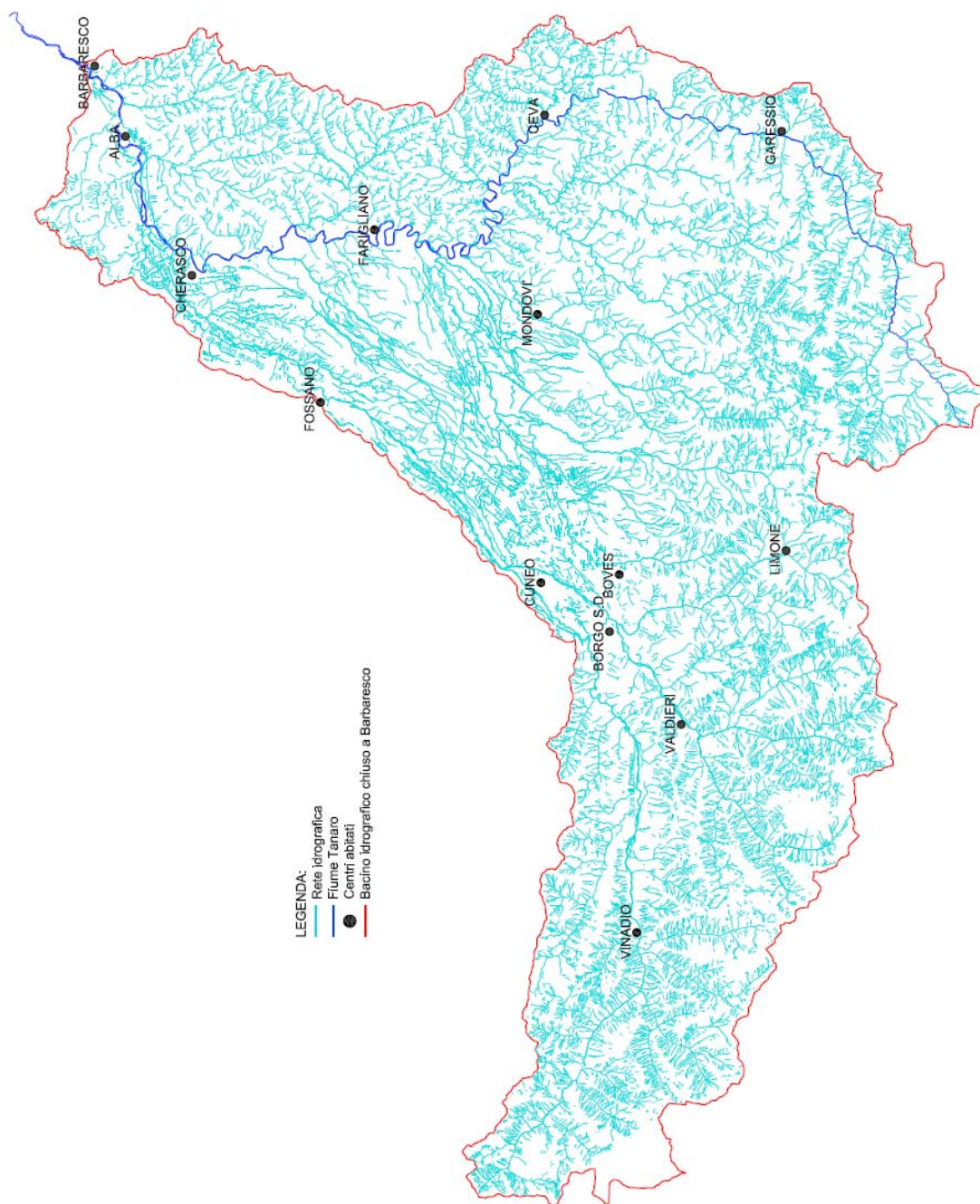


Fig. 2.1 Bacino idrografico del Fiume Tanaro chiuso a Barbaresco, in corrispondenza dello sbarramento in progetto.

3. VALUTAZIONE DELLE PORTATE MASSIME ANNUE AL COLMO

3.1 DIRETTIVA PIENA DI PROGETTO DELL'AUTORITA' DI BACINO DEL FIUME PO

Per la valutazione delle portate di piena a cui corrispondono i tempi di ritorno "tecnici", di 20, 100 e 200 anni, si utilizzano i dati contenuti nel *Piano Stralcio delle Fasce Fluviali* dell'Autorità di Bacino del Fiume Po, riferiti alla sezione di chiusura di Alba che è ubicata circa 6 km a monte della sezione di presa.

Tali valori sono riportati nella seguente tabella

T_{ritorno} (anni)	Q_c (m ³ /s)
20	2050
100	2750
200	3050

Tab3.1.1. Portate al colmo del Fiume Tanaro in corrispondenza della sezione di chiusura di Alba, posta circa 6km a monte rispetto alla sezione di presa.

I valori delle portate di piena che si assumono per la modellizzazione idraulica del tratto di fiume in corrispondenza del sito sono, dunque, quelli derivanti dalla Direttiva Piena di Progetto dell'Autorità di Bacino del Fiume Po in quanto riportate in un documento ufficiale.

4. DESCRIZIONE DEI RILIEVI TOPOGRAFICI UTILIZZATI

Per valutare i livelli raggiunti dall'acqua sulle aree circostanti il corso d'acqua, è condizione essenziale disporre di rilievi topografici dettagliati e sufficientemente estesi.

Anche le batimetrie devono essere, per quanto possibile, accurate.

Il caso in esame richiede una grande mole di rilievi, in quanto si fa riferimento ad un tratto abbastanza considerevole del Fiume.

Si è pertanto utilizzato un accurato rilievo delle sezioni del corso d'acqua di un lungo tratto di fiume e delle aree ad esso circostanti, a valle ed a monte

dell'area oggetto di esame. Inoltre, per l'estensione del modello idraulico-numerico del F. Tanaro nel tratto a monte e a valle della zona oggetto di intervento, sono stati utilizzati rilievi effettuati nell'ambito di studi pregressi e il DTM ICE realizzato nel 2012 con volo laser scanner LIDAR, disponibile sul sito internet della Regione Piemonte. Tale DTM presenta una risoluzione di 5 m e una precisione sulle quote di ± 30 cm.

Il poter disporre di tali rilievi di dettaglio ha permesso di calcolare i livelli idraulici di piena sia nell'alveo sia nelle aree latitanti con una buona attendibilità lungo tutto il tratto d'asta in studio per poter meglio valutare gli effetti dell'opera in progetto sulle sezioni idrauliche in corrispondenza dell'intervento ed a monte e che, in ragione delle caratteristiche idrauliche della corrente, sono influenzate dal medesimo.

5. VALUTAZIONE DEI LIVELLI DI PIENA IN CONDIZIONI DI MOTO PERMANENTE ASSOCIATI AI VALORI DI Q_{cmax} CON I TEMPI DI RITORNO ASSEGNATI

La valutazione dei livelli di piena viene effettuata in moto permanente in quanto questo tipo di moto rappresenta una buona approssimazione del moto che si manifesta negli alvei naturali dei corsi d'acqua.

Con un modello monodimensionale di moto permanente è stato simulato il comportamento idraulico del tratto di Fiume Tanaro compreso tra il centro abitato di Alba e il comune di Neive (località cascina Boschi), per una lunghezza complessiva di circa 10.8 km.

Le simulazioni in moto permanente consentono una rappresentazione dei livelli di piena nelle sezioni del fiume più raffinata di quanto non lo permetta la schematizzazione del moto uniforme nelle singole sezioni dell'alveo, in quanto con esso è possibile calcolare i livelli tenendo in conto anche le altre sezioni di verifica e le singolarità idrauliche che ci possono essere nel tratto considerato.

Il problema del tracciamento del profilo di superficie libera di un corso d'acqua naturale in moto permanente con una data portata Q si risolve con procedimenti di calcolo numerico.

L'operazione richiede preliminarmente un rilievo dettagliato dell'alveo per suddividere il corso d'acqua in tronchi di lunghezza Δs , tali da poter confondere i valori medi della sezione e della velocità in ciascun tronco con i valori ad un estremo. Anche la natura dell'alveo deve conservarsi, entro certi limiti, in ciascun tronco.

Eseguita la suddivisione, è necessario il rilievo dettagliato delle caratteristiche geometriche di tutte le sezioni di separazione dei vari tratti.

Siano (i) e (i+1) due sezioni consecutive, distanti Δx in asse, nella prima delle quali siano note tutte le grandezze idrauliche.

La variazione di carico idraulico ΔH tra le due sezioni si può calcolare mediante la seguente relazione alle differenze finite:

$$\Delta H = -[j]_i \cdot \Delta x$$

Si può ottenere così il carico H_{i+1} della sezione i+1 e conseguentemente il carico piezometrico h_{i+1} , che rappresenta la quota del pelo libero rispetto ad un piano di riferimento orizzontale, risolvendo l'equazione:

$$H_{i+1} = h_{i+1} + \frac{Q^2}{2g \cdot \Omega_{i+1}^2}$$

E' possibile in questo modo ricavare il carico piezometrico della corrente nelle sezioni di rilievo e da questo calcolare le caratteristiche idrauliche che il fiume ha nel tratto in esame.

Questa trattazione teorica relativa ad alvei omogenei è stata generalizzata considerando anche il deflusso golenale che si manifesta per portate al colmo dell'entità di quelle in oggetto.

Per il calcolo dei livelli e delle principali caratteristiche del moto è stato utilizzato il software HEC-RAS sviluppato dall'U.S. Army Corps of Engineers, nella versione 4.1.

Venendo nel dettaglio del modello idraulico-numerico si è compiuta la modellazione del moto permanente del Fiume Tanaro lungo un tratto di asta avente una lunghezza di circa 10.8 km.

Nel modello sono state implementate 47 sezioni del Fiume Tanaro, rappresentative sia dell'alveo che delle zone golenali, come indicato nella planimetria in Allegato.

Le scabrezze adottate hanno un significato globale all'interno della schematizzazione in alveo principale e in aree golenali e sono state dedotte dall'analisi del terreno e dalla letteratura tecnica dalla Direttiva "*Criteria per la valutazione della compatibilità idraulica delle infrastrutture pubbliche e di interesse pubblico all'interno delle fasce A e B*" dell'Autorità di bacino del Fiume Po e cioè:

per l'alveo principale:

n	=0.06 m ^{-1/3} s	secondo Manning
C	= 1/n = 16.67 m ^{1/3} /s	secondo GaucklerStrickler

per le aree golenali:

n	=0.125 m ^{-1/3} s	secondo Manning
C	= 1/n = 8 m ^{1/3} /s	secondo GaucklerStrickler

I valori di scabrezza possono sembrare piuttosto elevati (secondo la definizione di Manning), ma derivano direttamente da operazioni di taratura effettuate con riferimento alle portate di piena del Fiume Tanaro ed eseguite in seguito all'evento alluvionale del 1994.

Da tali studi emerge, infatti, che per portate di piena di notevole entità i coefficienti di scabrezza, intesi nella definizione di Manning, che si osservano sono relativamente elevati. Da quanto sopra, ne deriva che i valori del coefficiente di scabrezza che si calcolano in fase di taratura sono da ritenersi corretti, a condizione di svincolarsi dal significato fisico del coefficiente di scabrezza. In tal modo essi sono da considerarsi come una sorta di

"coefficienti globali" in grado di tenere conto dell'insieme dei complessi fenomeni dissipativi che si verificano durante il passaggio di un evento di piena di notevole importanza.

Occorre, pertanto, considerare alcuni dei meccanismi reali non simulati dal modello che possono aver contribuito a produrre livelli idrici maggiori a parità di portate, e che quindi si traducono in una riduzione del coefficiente c di Strikler rispetto ai valori standard comunemente reperibili in letteratura tecnica.

Questi meccanismi sommariamente sono i seguenti:

- presenza notevolissima di trasporto solido in sospensione, capace di modificare la densità della corrente e di incrementare i meccanismi dissipativi all'interno della massa fluida, indipendentemente dalla scabrezza fisica del contorno bagnato;
- presenza di trasporto solido flottante, soprattutto tronchi d'albero, interferente con le pile dei ponti, con conseguenti temporanei effetti di rigurgito a monte superiori rispetto a quelli desumibili dalla geometria delle pile stesse;
- dinamica fluviale tutt'altro che gradualmente variata, caratterizzata da vorticosità, effetti dovuti alla curvatura dei meandri e irregolarità causate da bruschi restringimenti.

L'elaborazione è stata compiuta partendo da valle e risalendo verso monte; infatti il Fiume Tanaro, nel tratto esaminato e nelle condizioni di piena ipotizzate, è un corso d'acqua a regime fluviale ed il moto dell'acqua avviene in corrente lenta con il profilo liquido che dipende dalle condizioni di valle.

A proposito delle condizioni al contorno del modello, e cioè del livello dell'acqua nella sezione di partenza, si è imposto per le portate di riferimento che tale livello fosse pari a quello di moto uniforme.

Si precisa comunque che l'ipotesi sul livello di partenza, sebbene importante per le caratteristiche del moto nel tratto in studio, non influenza in modo significativo i livelli dell'acqua nel tratto di fiume a ridosso della zona di intervento. Questo perché la sezione di partenza della simulazione idraulica

è relativamente lontana a valle, e sono numerose le sezioni d'alveo frapposte tra essa e quelle che sono significative per lo studio delle aree in oggetto, pertanto in queste condizioni il livello dell'acqua in quella prima sezione ha poca influenza, come si può osservare facilmente facendolo variare all'interno di una tolleranza ragionevole, tale da non cambiare le caratteristiche idrauliche del moto.

La verifica idraulica è stata effettuata con riferimento alle portate di piena più significative, ovvero quelle con tempo di ritorno pari a 20, 100 e 200 anni.

Le simulazioni effettuate devono essere rappresentative delle seguenti tre condizioni:

- scenario 1: situazione attuale (presenza della traversa esistente in buona parte crollata);
- scenario 2: situazione ante crollo del novembre 2010 (presenza della traversa fissa con quota in sommità di 148.40 m s.l.m.);
- scenario 3: situazione di progetto (presenza della traversa ricostruita con innalzamento abbattibile per uso idroelettrico: quota in sommità di 149.20 m s.l.m.).

In questo modo è possibile valutare, con riferimento alla componente idraulica, gli effetti prodotti dalla realizzazione dello sbarramento in progetto.

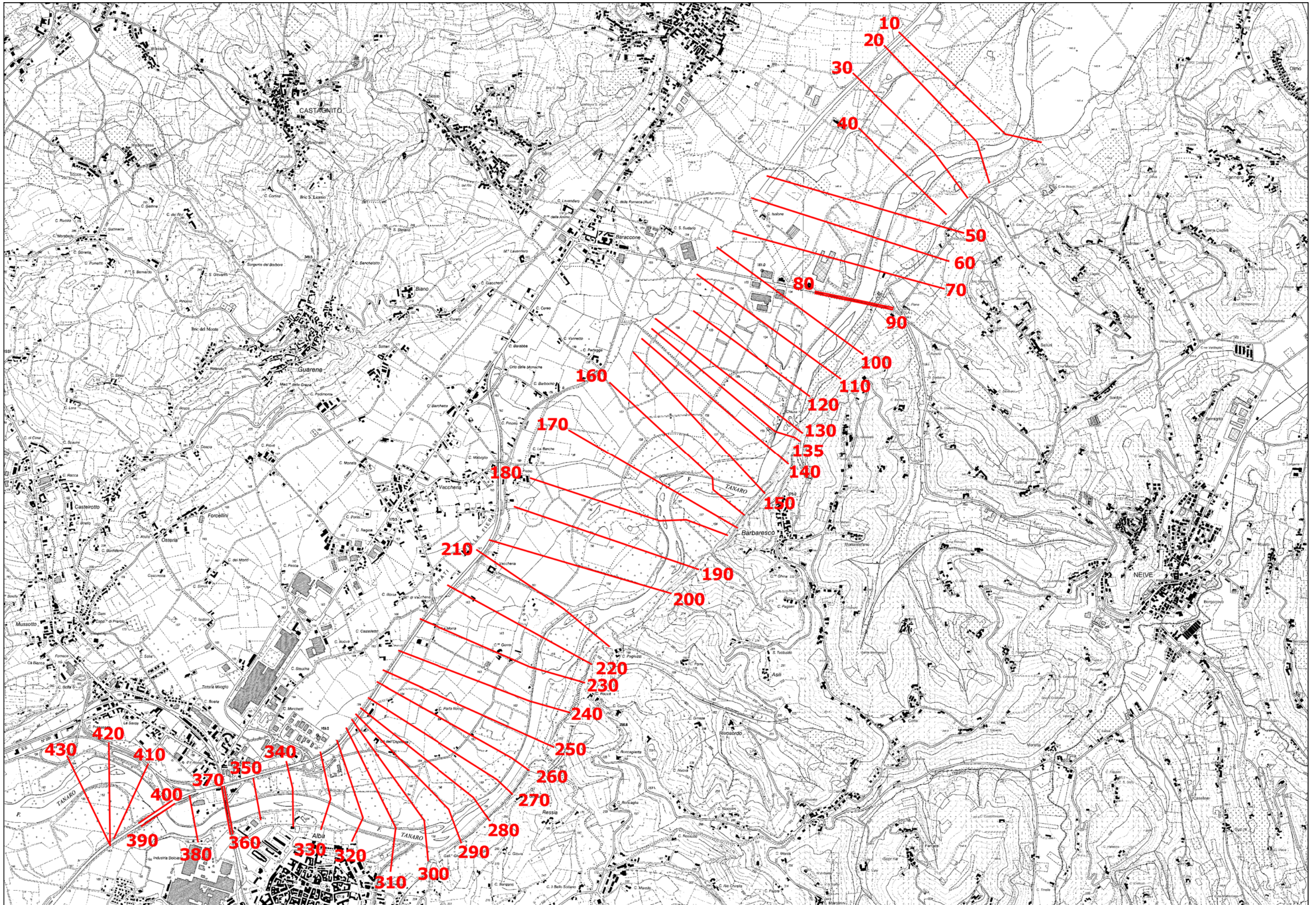
Come più volte ribadito, per portate superiori a 300 m³/s lo sbarramento mobile in progetto verrà completamente abbattuto, ripristinando la quota in sommità di 148.40 m s.l.m.; pertanto, nelle condizioni di piena analizzate, lo scenario 2 e lo scenario 3 sono coincidenti.

I valori numerici delle varie grandezze specificate in legenda, relativi alle portate di verifica, sono riportati nelle seguenti tabelle.

Anche i livelli del pelo libero per le portate considerate sono riportati nelle sezioni schematiche e nel profilo longitudinale allegati nelle pagine seguenti.

LEGENDA

River sta.	=	sezione di calcolo
Q total	=	portata in m ³ /s
Min Ch El	=	quota del fondo alveo in m
W.S. Elev.	=	livello del pelo libero dell'acqua in m
Crit W.S.	=	livello di moto critico dell'acqua in m
E.G. Elev	=	livello energetico globale in m
E.G. Slope	=	pendenza motrice
Vel Chnl	=	velocità nell'alveo in m/s
Flow Area	=	area liquida in m ²
Top Width	=	larghezza sezione liquida in sommità in m
Froude # Chl	=	numero di Froude della corrente in alveo



**SITUAZIONE ATTUALE
SIMULAZIONE 1**

corso d'acqua	portata al colmo Q_c m^3/s	tempo di ritorno anni
Fiume Tanaro	2050	20

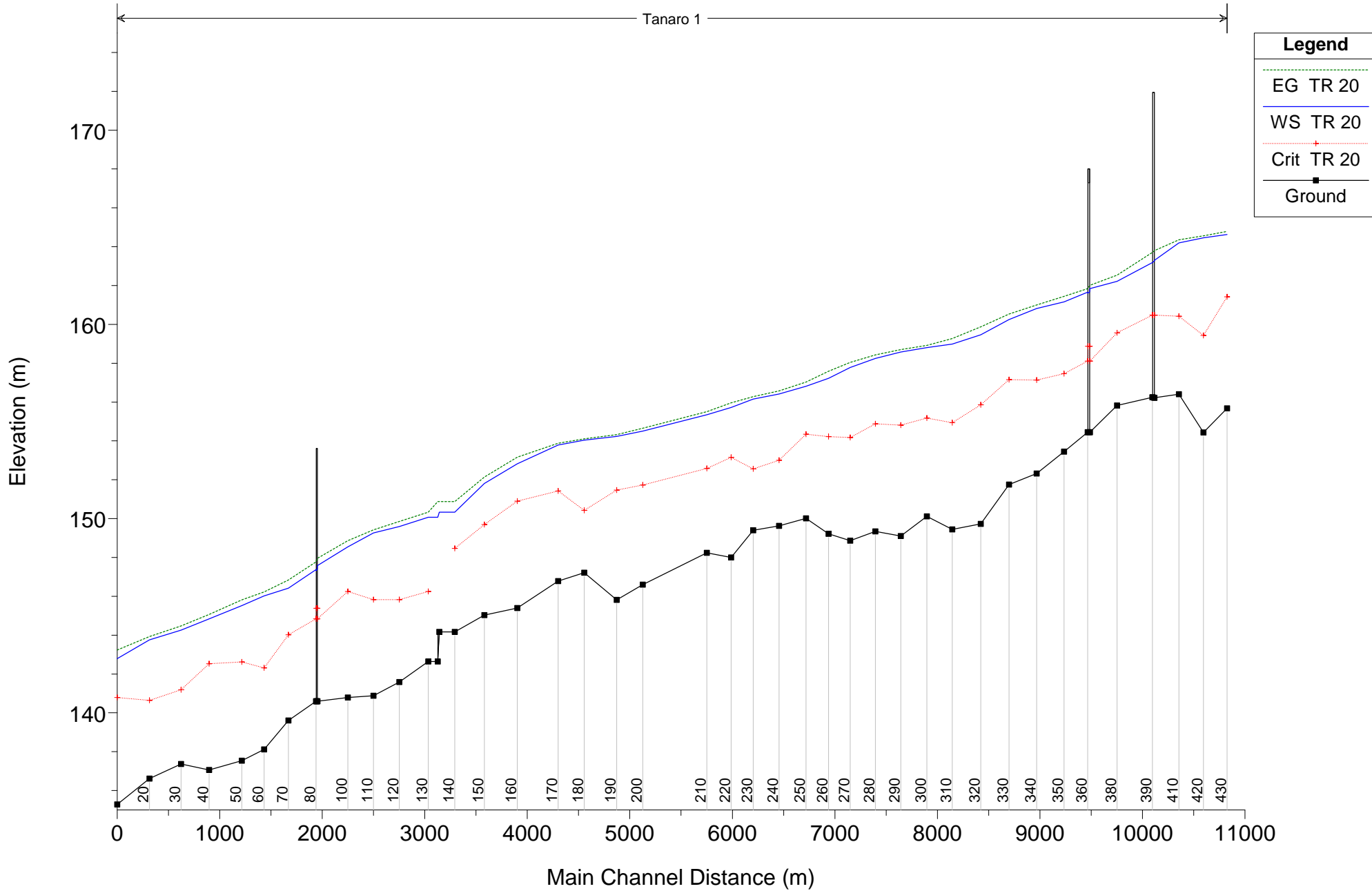
HEC-RAS Plan: Plan 06 River: Tanaro Reach: 1 Profile: TR 20

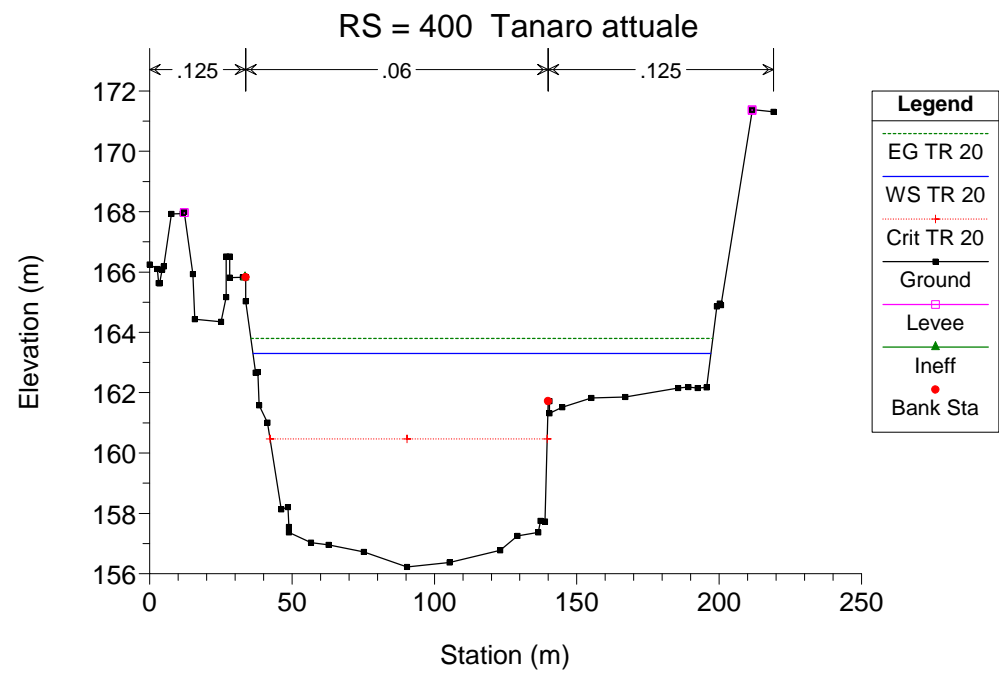
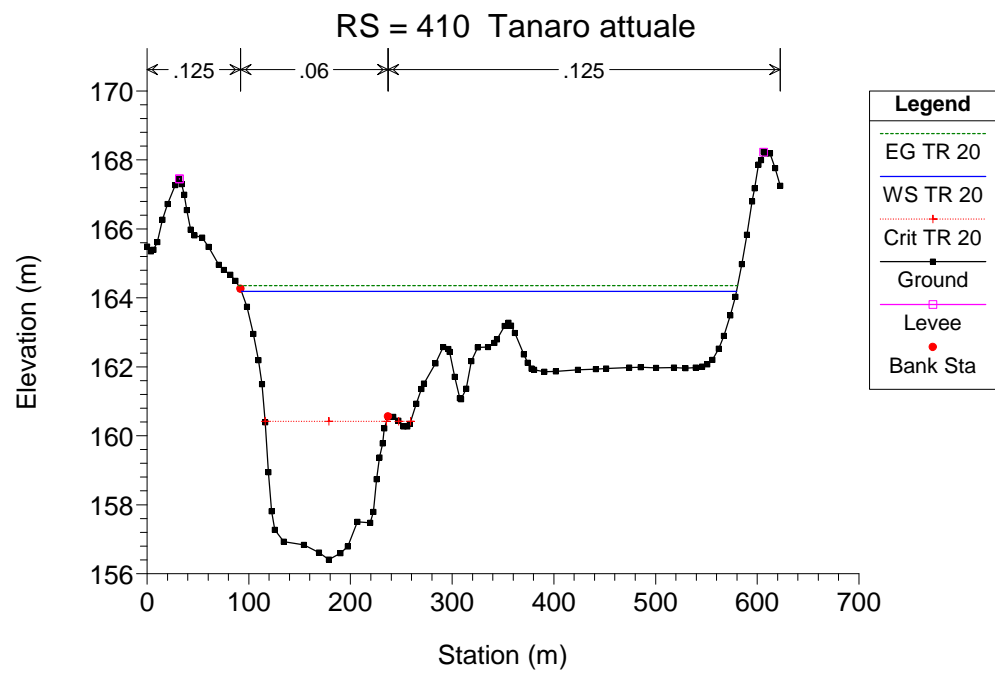
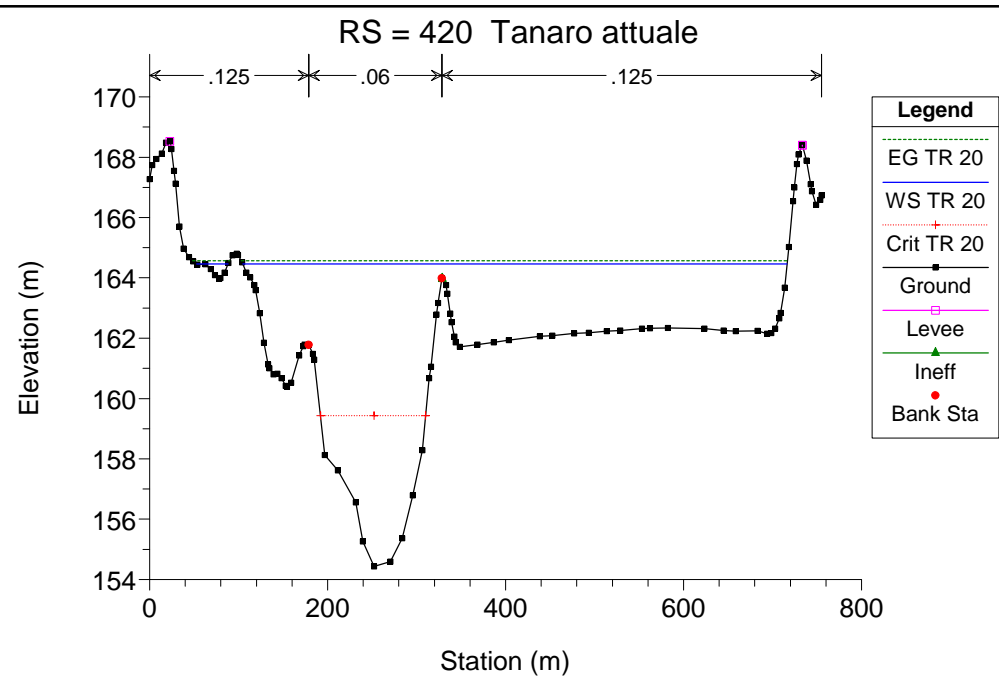
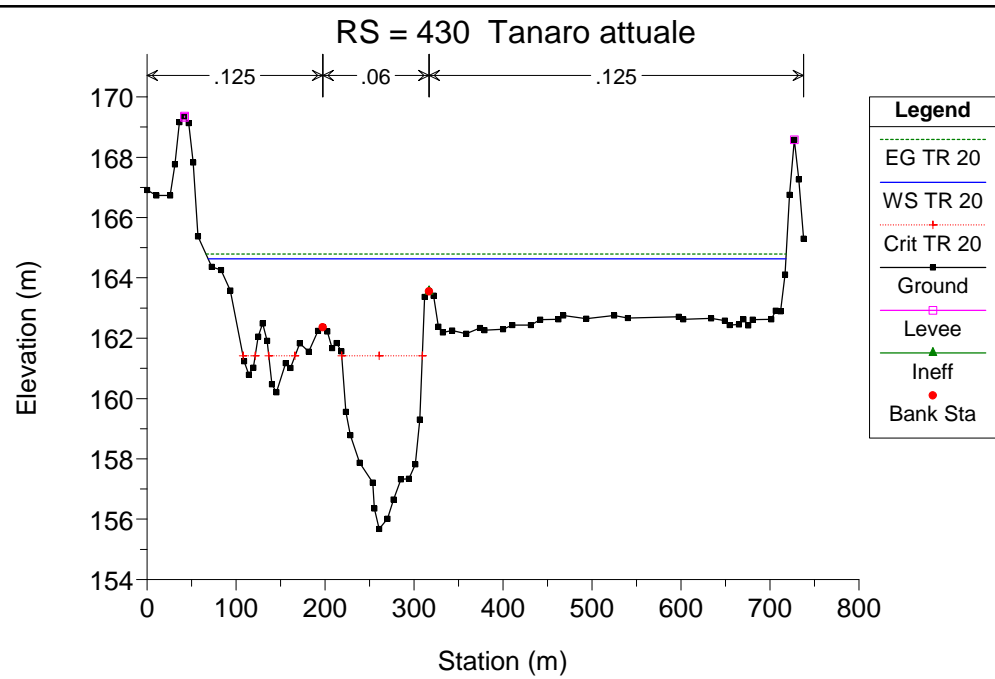
Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
1	430	TR 20	2050.00	155.68	164.63	161.42	164.79	0.001468	2.06	1854.56	649.27	0.27
1	420	TR 20	2050.00	154.44	164.46	159.43	164.56	0.000667	1.57	2129.21	647.18	0.19
1	410	TR 20	2050.00	156.41	164.19	160.42	164.36	0.001294	1.96	1608.89	486.72	0.26
1	400	TR 20	2050.00	156.22	163.30	160.47	163.80	0.003476	3.17	711.40	160.81	0.41
1	395		Bridge									
1	390	TR 20	2050.00	156.25	163.19	160.48	163.71	0.003707	3.24	693.45	160.50	0.42
1	380	TR 20	2050.00	155.82	162.22	159.56	162.54	0.002615	2.50	819.27	159.16	0.35
1	370	TR 20	2050.00	154.45	161.84	158.11	162.01	0.001197	1.81	1129.61	198.29	0.24
1	365		Bridge									
1	360	TR 20	2050.00	154.45	161.66	158.11	161.84	0.001325	1.88	1093.08	197.16	0.25
1	350	TR 20	2050.00	153.45	161.16	157.46	161.45	0.001856	2.37	863.99	143.66	0.31
1	340	TR 20	2050.00	152.32	160.82	157.14	161.00	0.001295	1.89	1084.95	195.64	0.25
1	330	TR 20	2050.00	151.75	160.25	157.15	160.54	0.002273	2.39	870.91	235.85	0.33
1	320	TR 20	2050.00	149.73	159.46	155.86	159.87	0.002470	2.93	953.84	366.63	0.36
1	310	TR 20	2050.00	149.44	158.98	154.93	159.27	0.001777	2.56	1319.82	482.32	0.30
1	300	TR 20	2050.00	150.11	158.81	155.18	158.92	0.000913	1.68	2036.54	630.63	0.22
1	290	TR 20	2050.00	149.10	158.58	154.81	158.70	0.000911	1.57	1684.17	578.96	0.21
1	280	TR 20	2050.00	149.34	158.25	154.88	158.42	0.001411	2.06	1557.15	441.34	0.27
1	270	TR 20	2050.00	148.86	157.79	154.17	158.04	0.001767	2.43	1354.37	453.59	0.30
1	260	TR 20	2050.00	149.22	157.22	154.22	157.59	0.002572	2.84	1007.17	286.65	0.36
1	250	TR 20	2050.00	150.01	156.82	154.35	157.03	0.002251	2.25	1393.82	508.58	0.33
1	240	TR 20	2050.00	149.63	156.42	153.01	156.58	0.001277	1.90	1640.00	735.41	0.25
1	230	TR 20	2050.00	149.40	156.16	152.56	156.28	0.001030	1.66	1653.13	454.78	0.23
1	220	TR 20	2050.00	148.00	155.73	153.15	155.96	0.002078	2.37	1304.74	398.14	0.32
1	210	TR 20	2050.00	148.24	155.34	152.59	155.51	0.001558	1.94	1484.37	543.02	0.27
1	200	TR 20	2050.00	146.60	154.51	151.73	154.65	0.001430	2.04	2215.35	1056.43	0.27
1	190	TR 20	2050.00	145.82	154.23	151.46	154.32	0.001017	1.56	2496.50	1137.37	0.22
1	180	TR 20	2050.00	147.21	154.04	150.42	154.10	0.000601	1.34	3026.64	1302.83	0.18
1	170	TR 20	2050.00	146.78	153.79	151.42	153.89	0.001241	1.55	2368.20	1358.04	0.24
1	160	TR 20	2050.00	145.40	152.82	150.90	153.16	0.003088	2.94	1434.94	1150.04	0.39
1	150	TR 20	2050.00	145.03	151.81	149.69	152.14	0.003507	2.63	1049.00	751.54	0.40
1	140	TR 20	2050.00	144.17	150.33	148.46	150.88	0.005423	3.28	624.61	145.59	0.50
1	135		Inl Struct									
1	130	TR 20	2050.00	142.64	150.06	146.24	150.32	0.001640	2.27	903.48	143.52	0.29
1	120	TR 20	2050.00	141.58	149.58	145.83	149.84	0.001725	2.26	914.30	286.66	0.30
1	110	TR 20	2050.00	140.88	149.24	145.83	149.40	0.001552	1.95	1521.96	460.28	0.27
1	100	TR 20	2050.00	140.79	148.51	146.25	148.84	0.003281	2.52	812.45	321.77	0.39
1	90	TR 20	2050.00	140.59	147.59	144.73	147.95	0.002703	2.65	774.31	146.07	0.36
1	85		Bridge									
1	80	TR 20	2050.00	140.59	147.36	144.73	147.75	0.003081	2.76	742.70	142.73	0.38

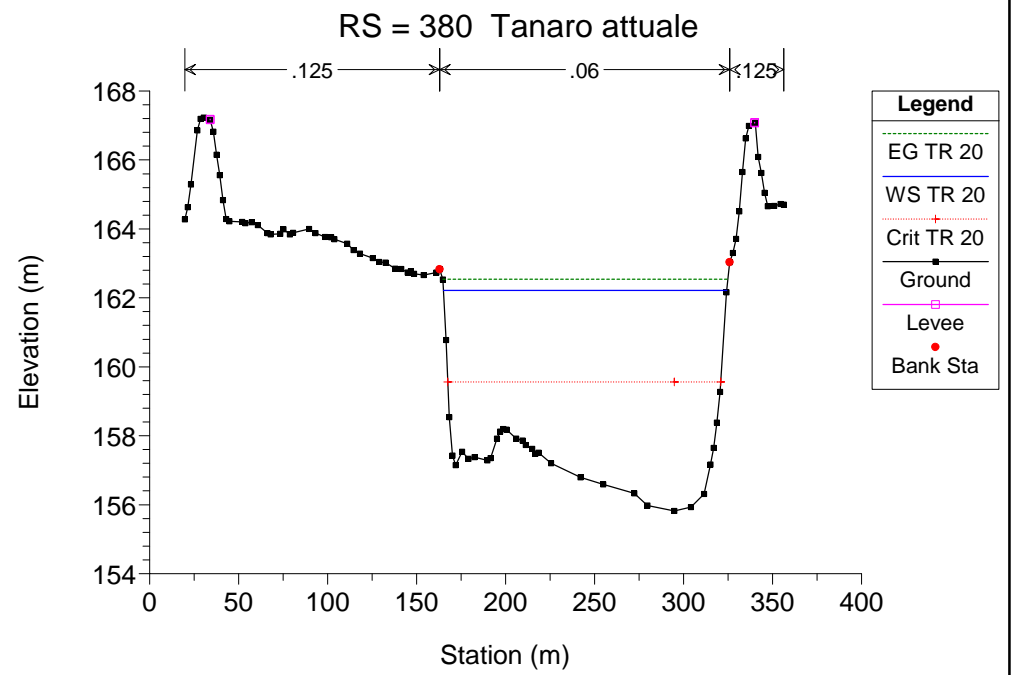
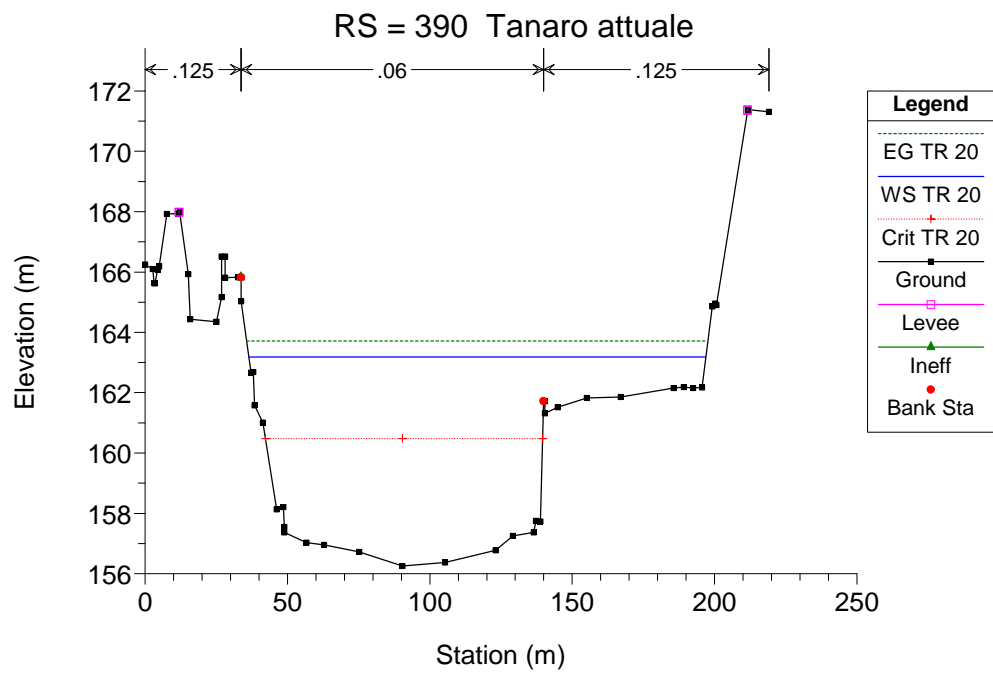
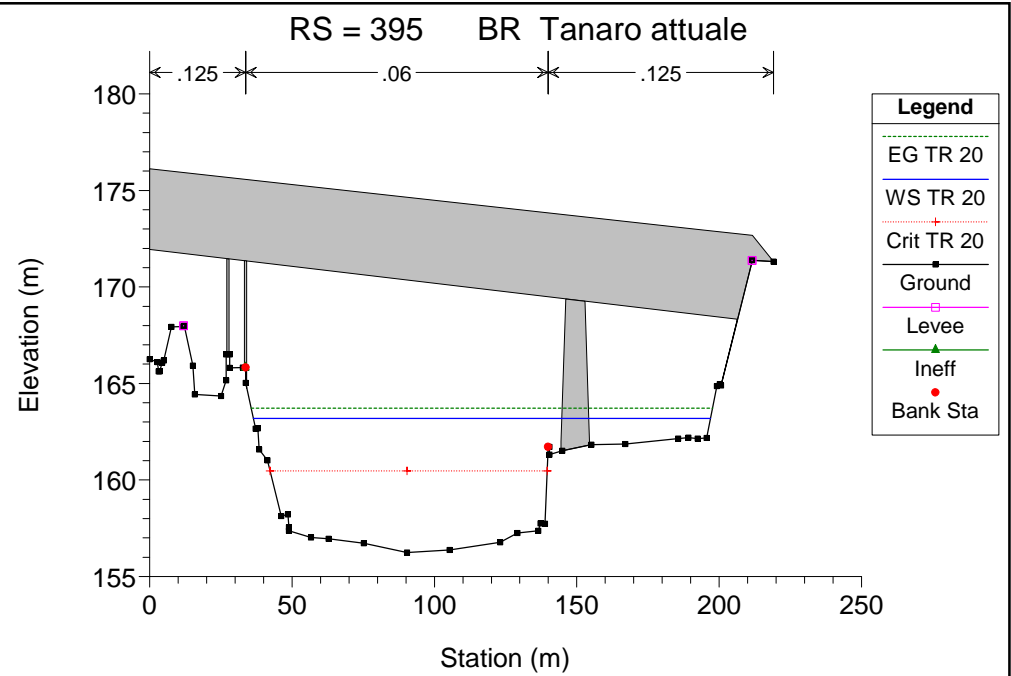
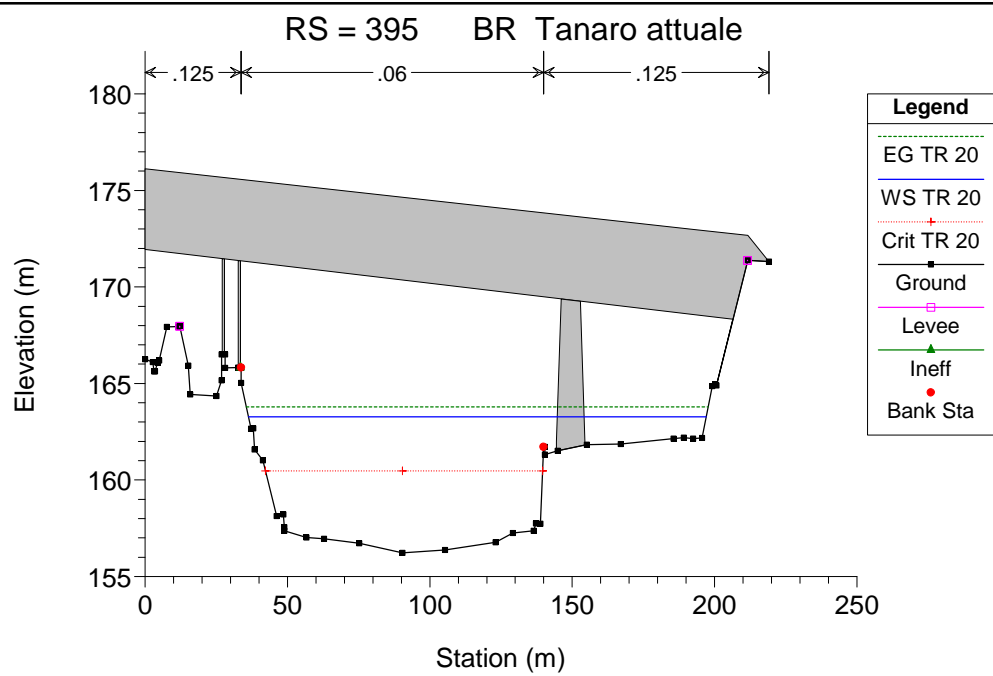
HEC-RAS Plan: Plan 06 River: Tanaro Reach: 1 Profile: TR 20 (Continued)

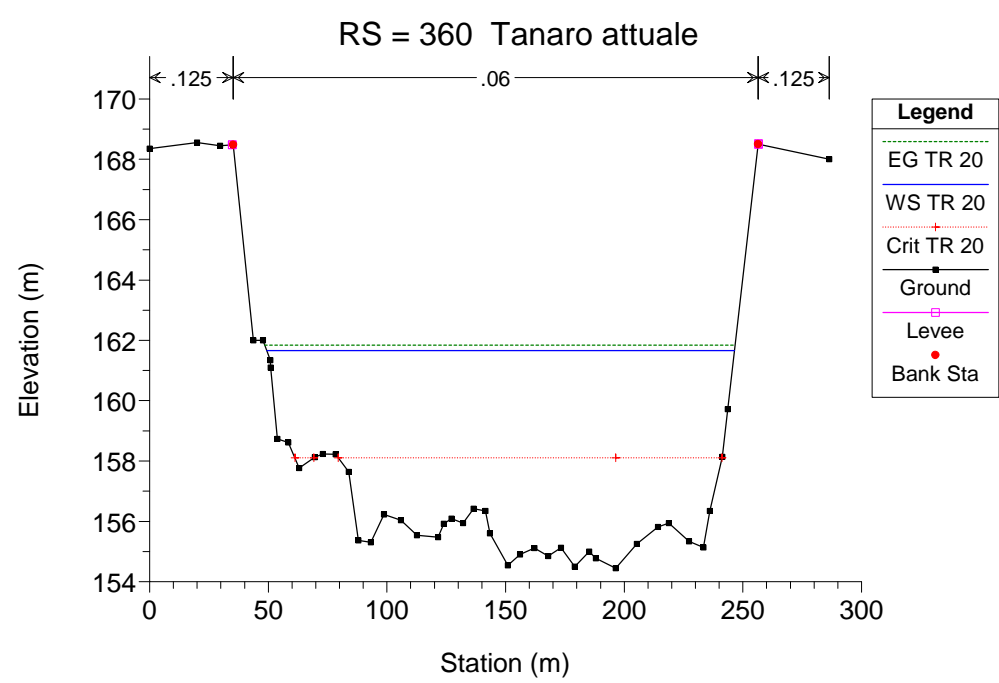
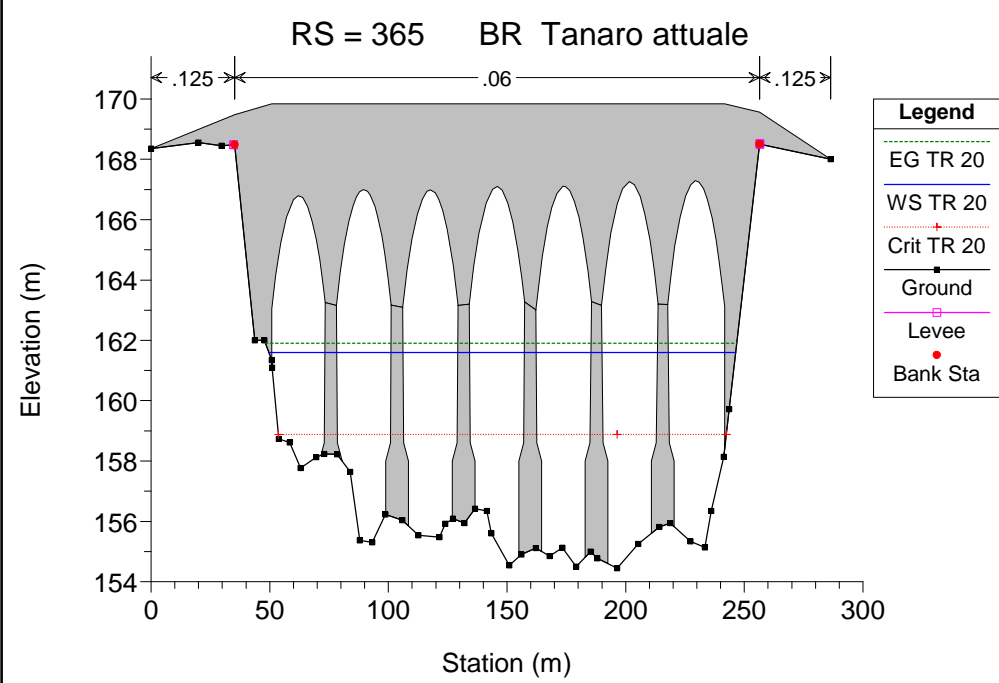
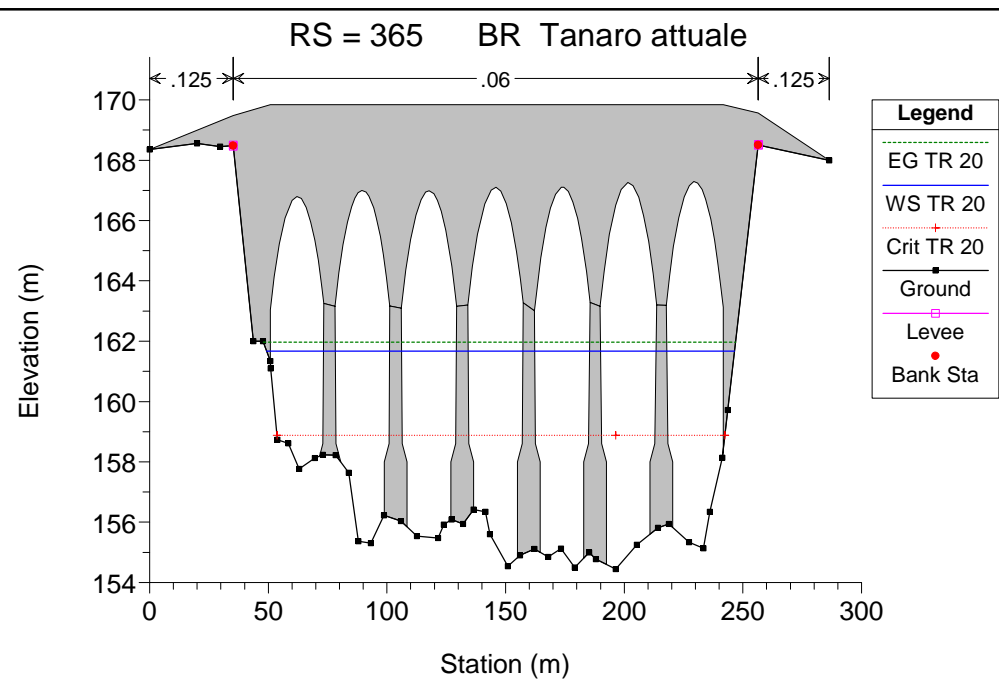
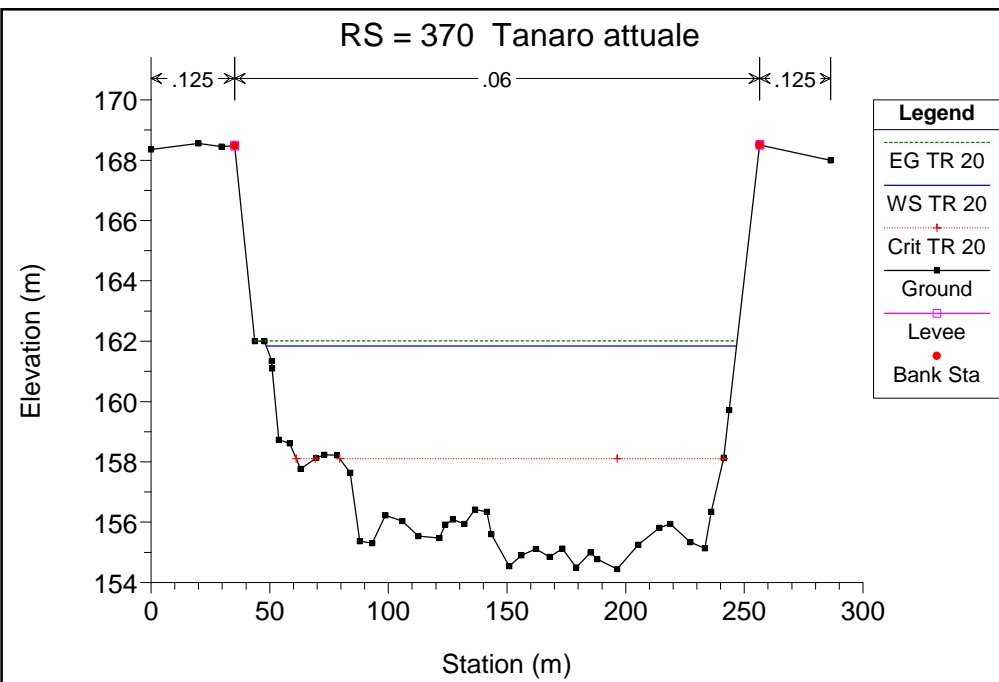
Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
1	70	TR 20	2050.00	139.61	146.42	144.02	146.83	0.003745	2.84	722.77	282.30	0.42
1	60	TR 20	2050.00	138.12	146.02	142.31	146.23	0.001552	2.17	1402.39	539.70	0.28
1	50	TR 20	2050.00	137.54	145.52	142.62	145.81	0.002265	2.55	1169.69	411.90	0.34
1	40	TR 20	2050.00	137.06	144.84	142.53	145.07	0.002439	2.13	961.38	268.40	0.33
1	30	TR 20	2050.00	137.37	144.26	141.18	144.48	0.001906	2.09	980.88	475.93	0.30
1	20	TR 20	2050.00	136.62	143.76	140.64	143.93	0.001535	2.06	1684.57	670.10	0.28
1	10	TR 20	2050.00	135.29	142.79	140.78	143.23	0.004002	3.16	1096.50	620.31	0.44

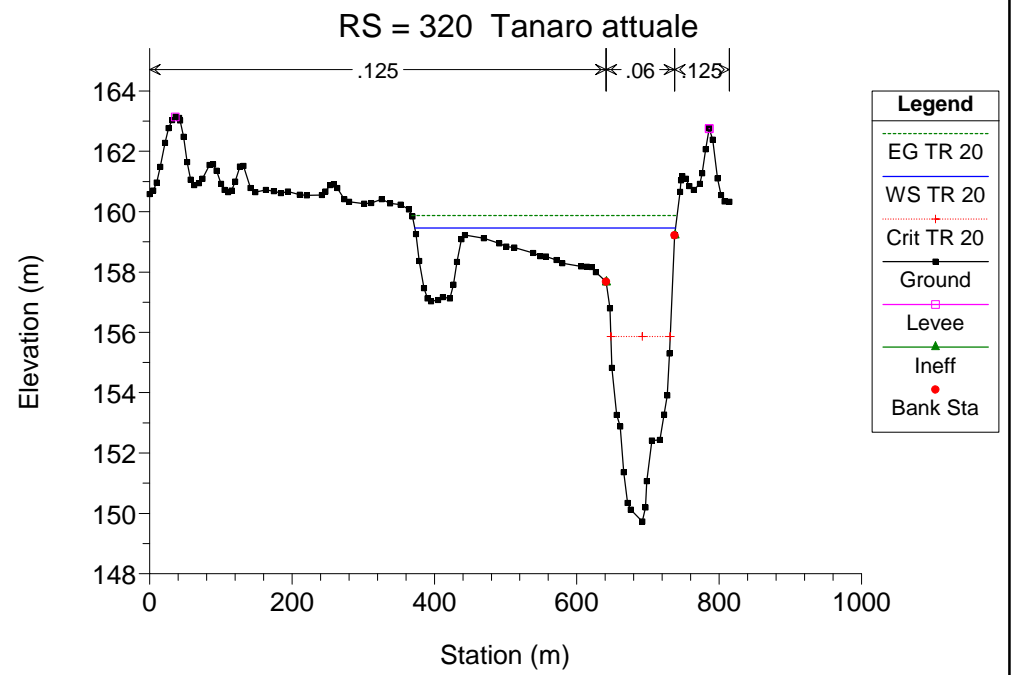
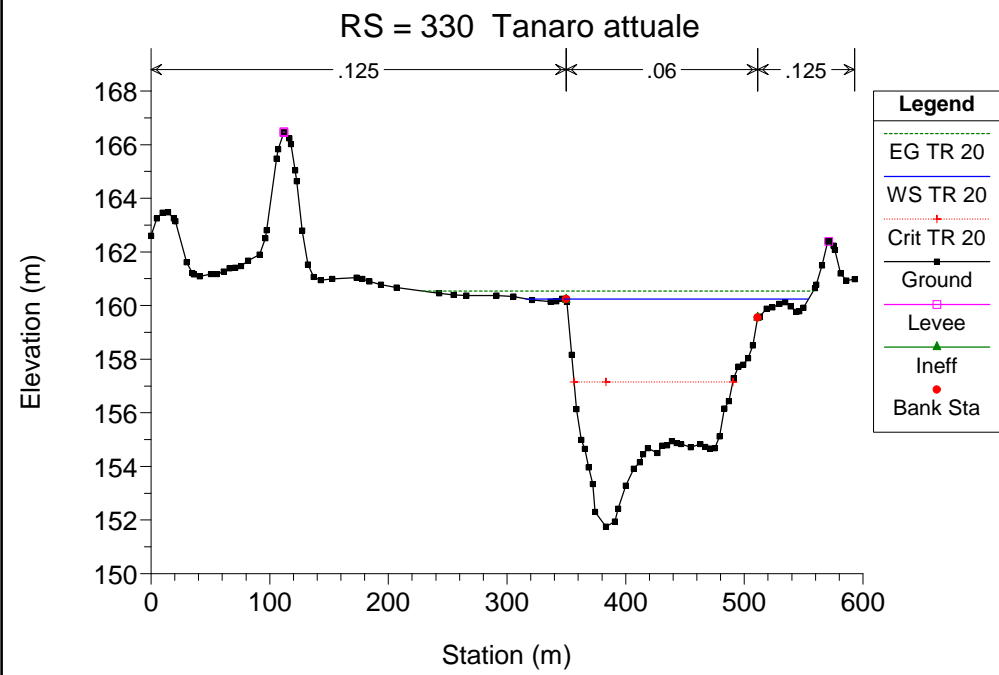
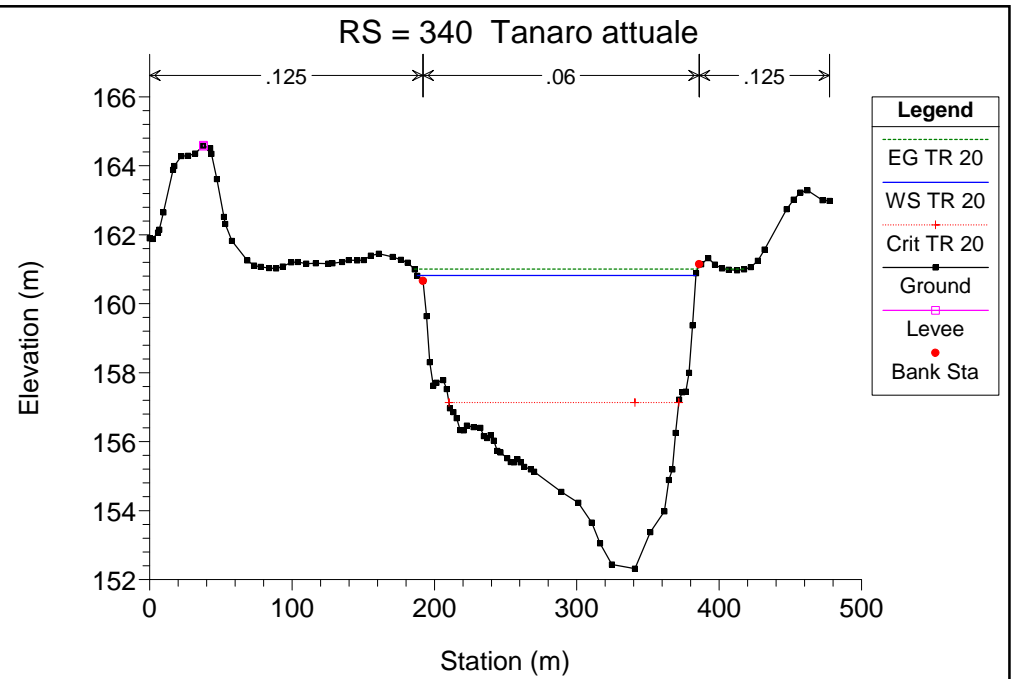
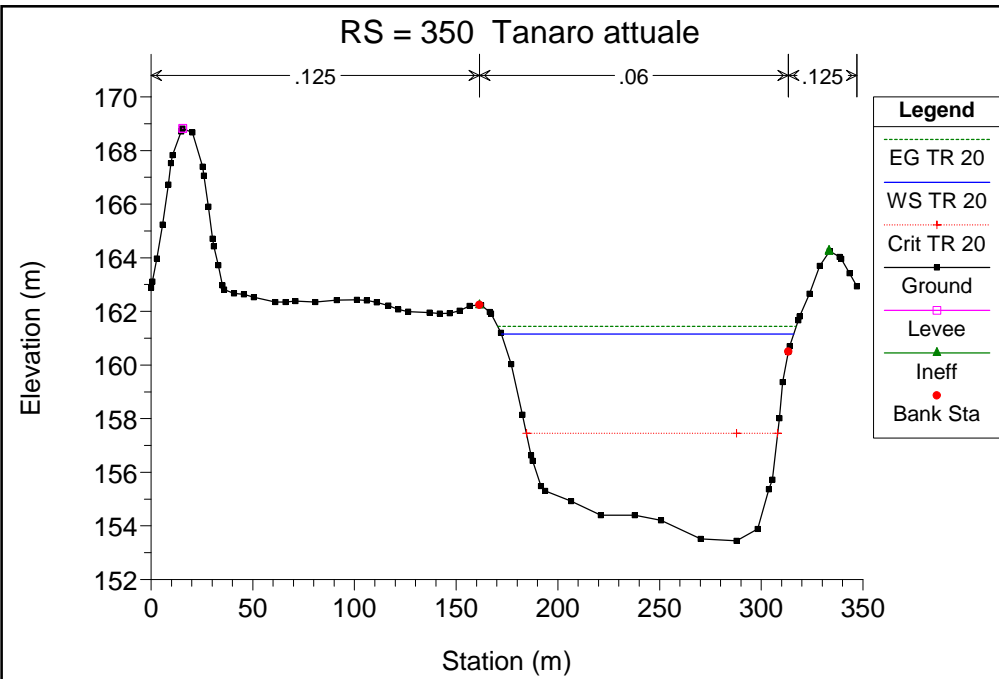
Tanaro attuale

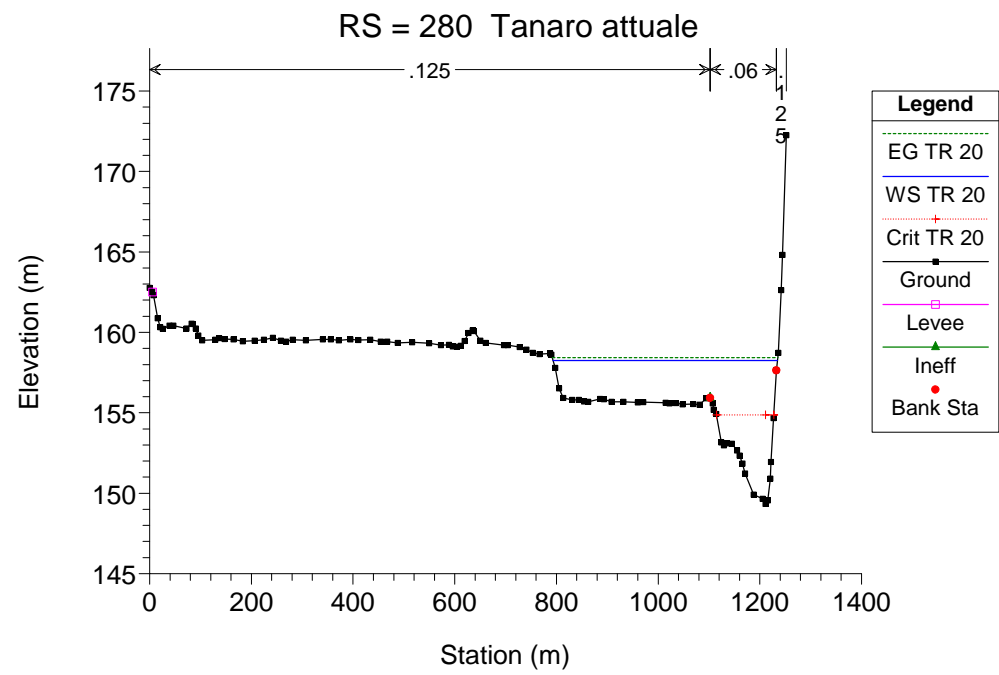
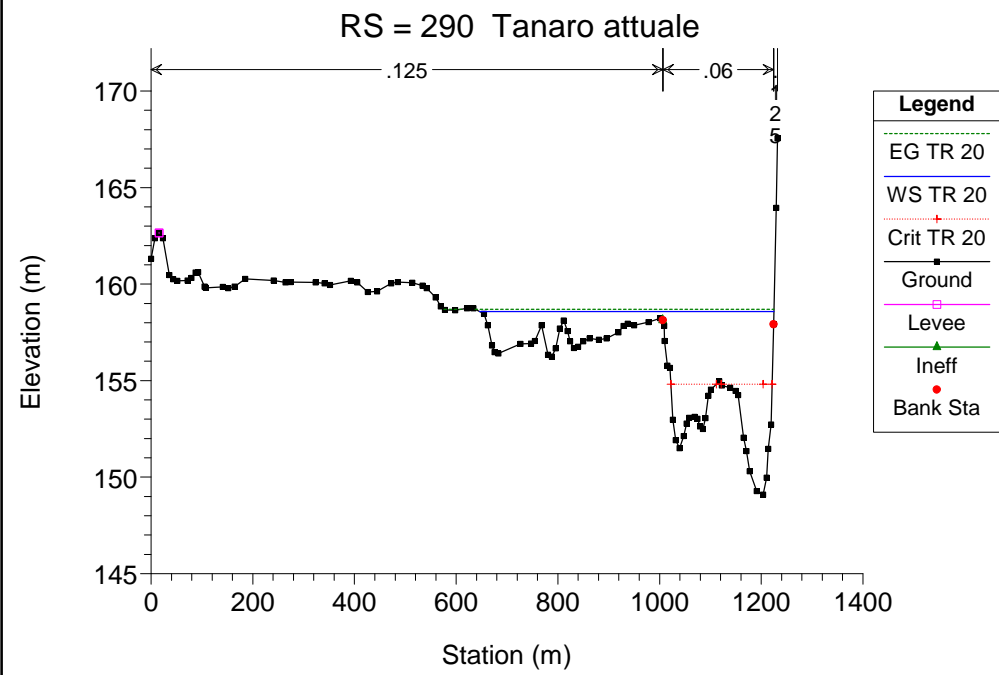
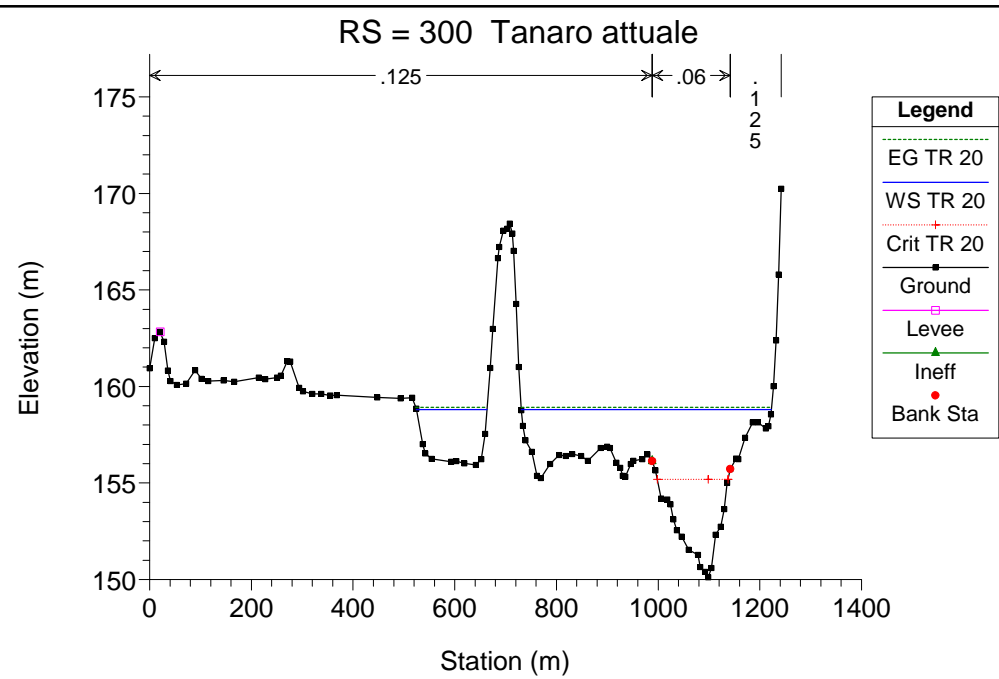
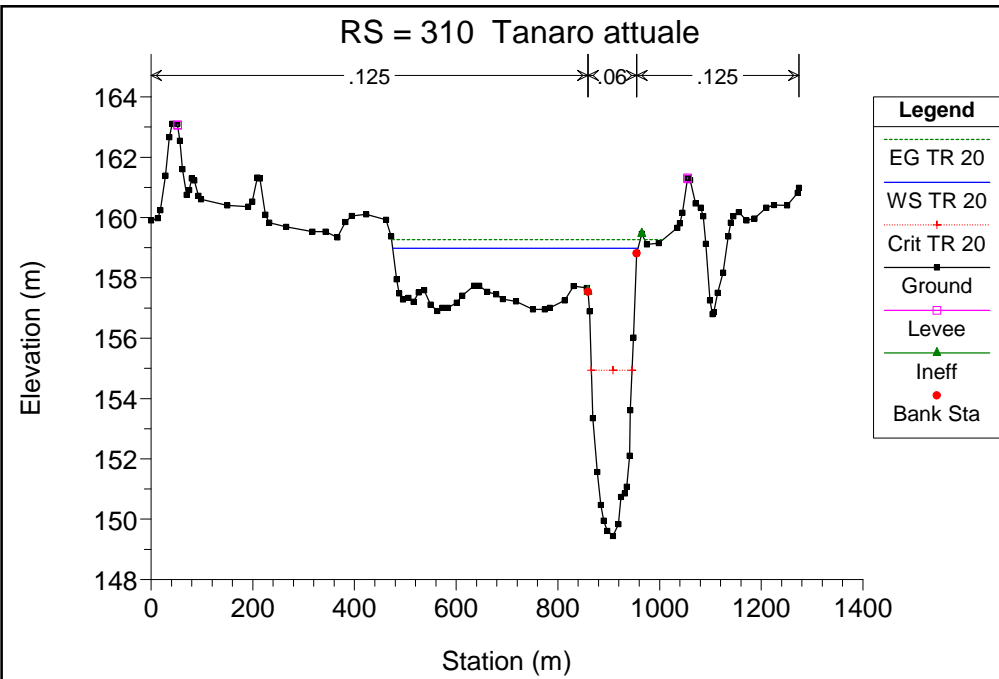


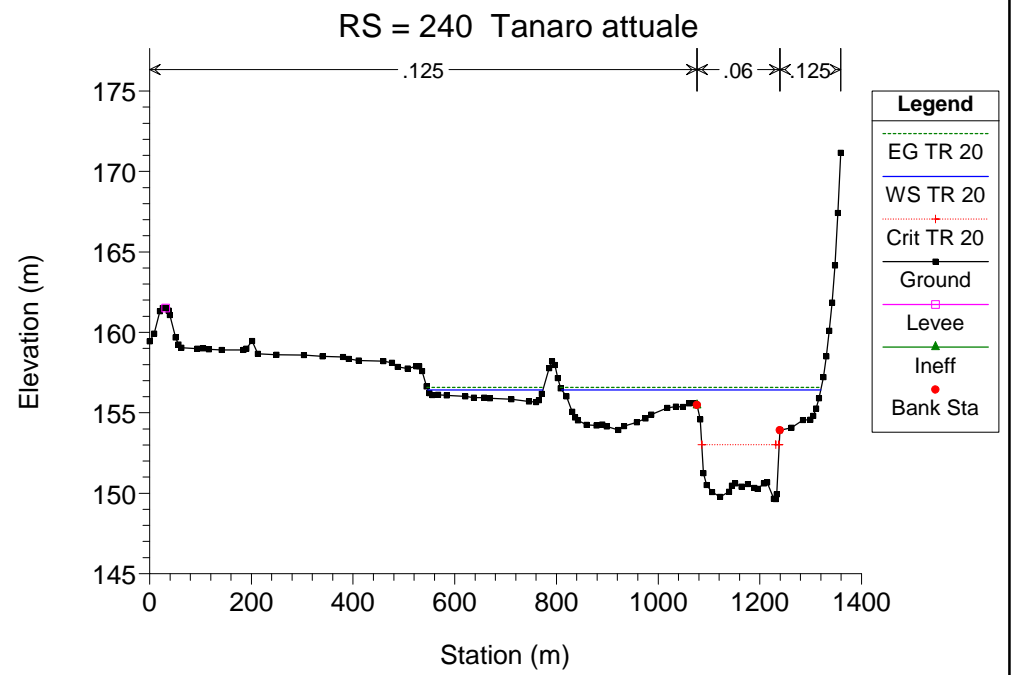
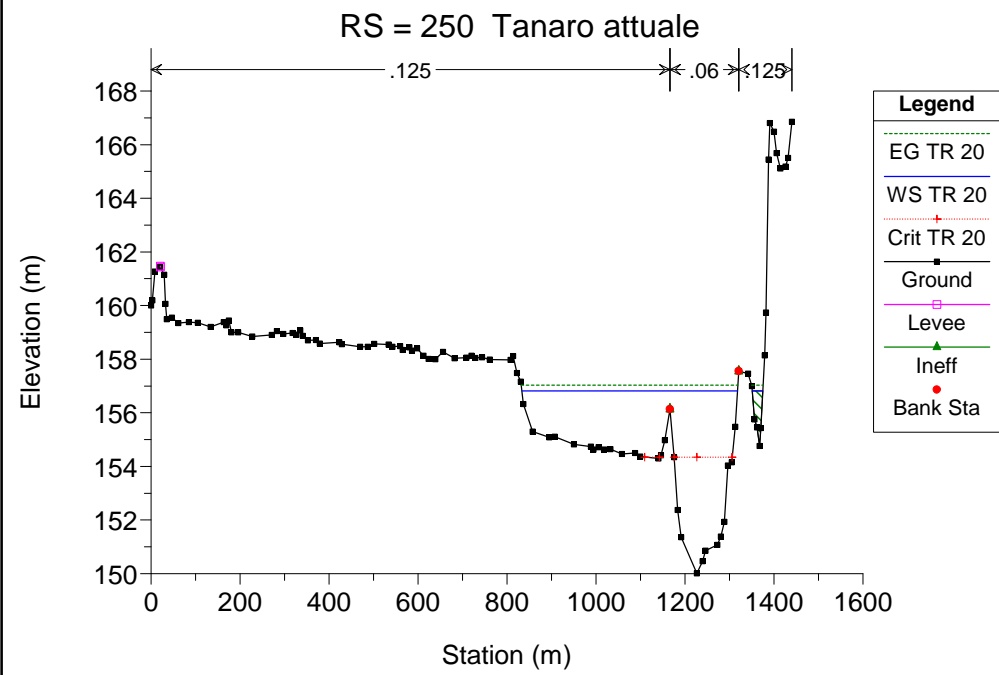
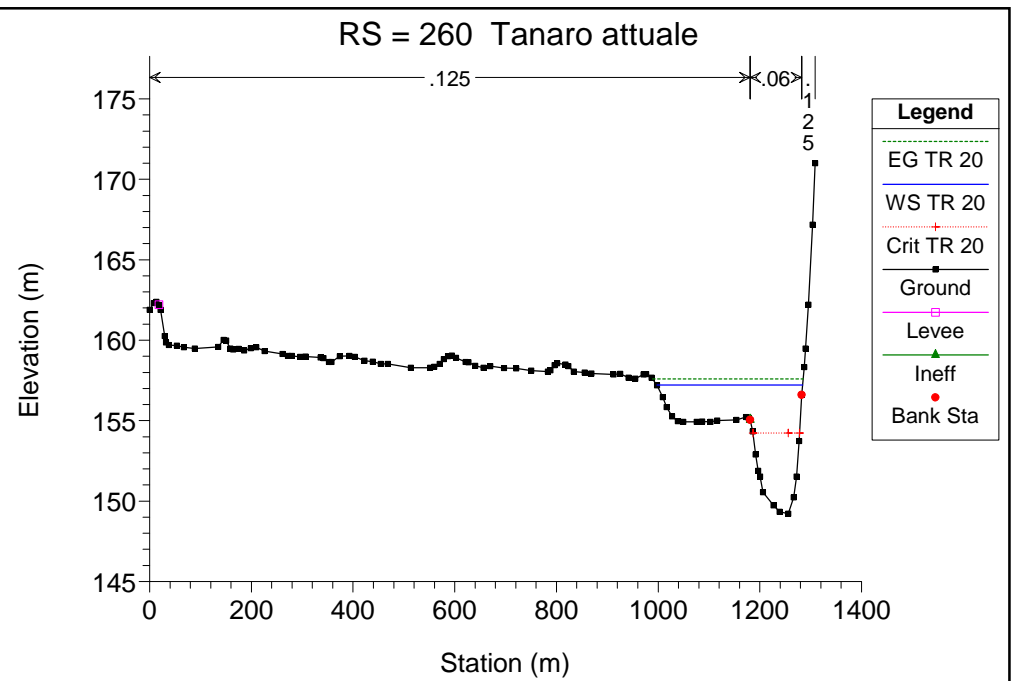
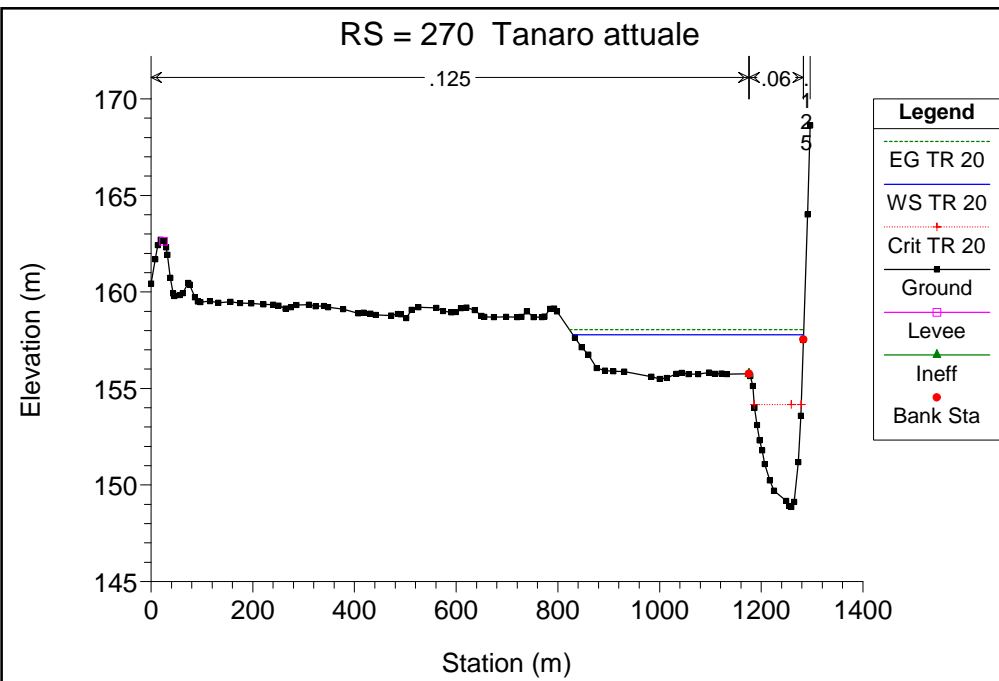


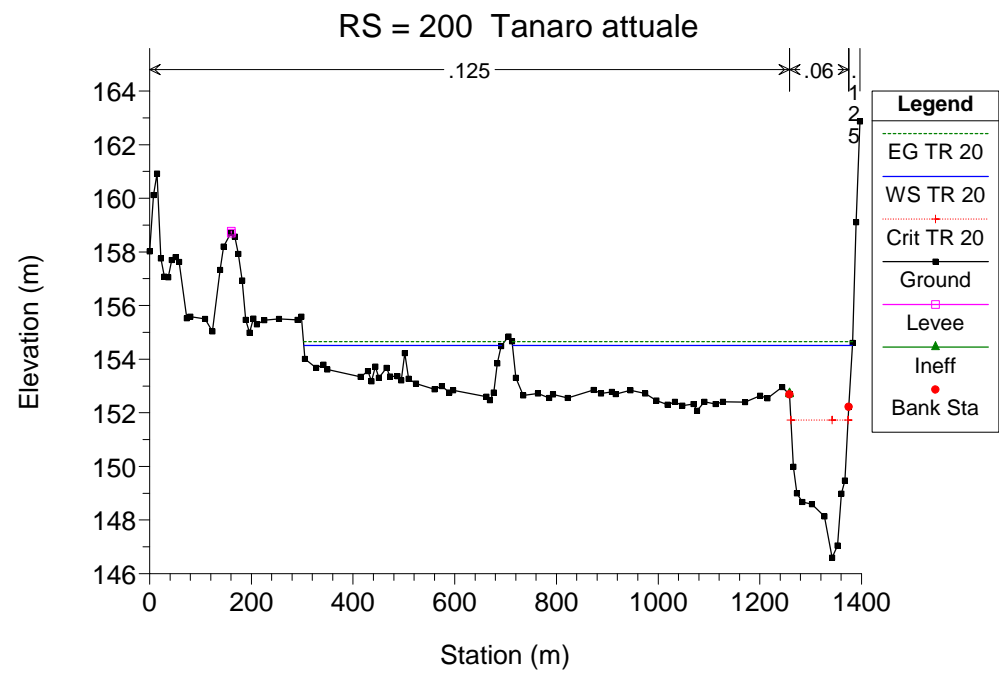
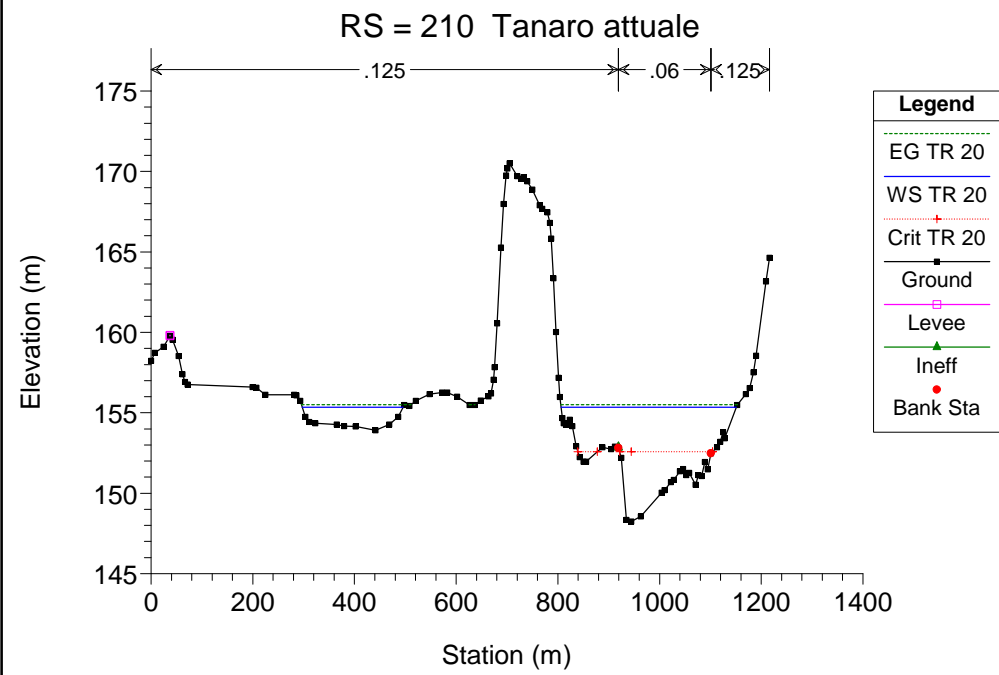
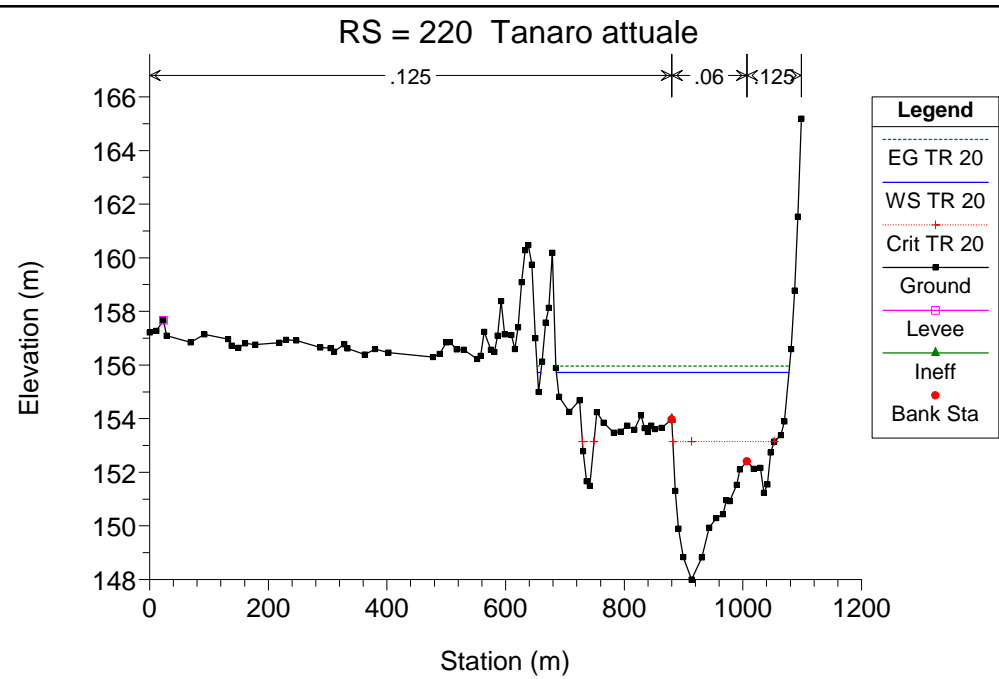
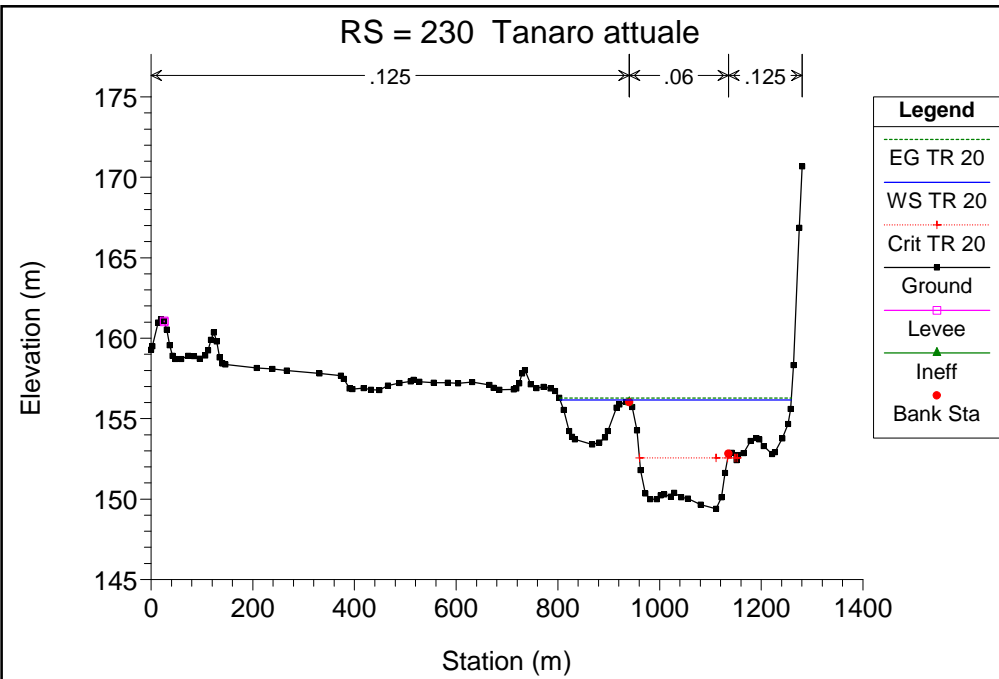


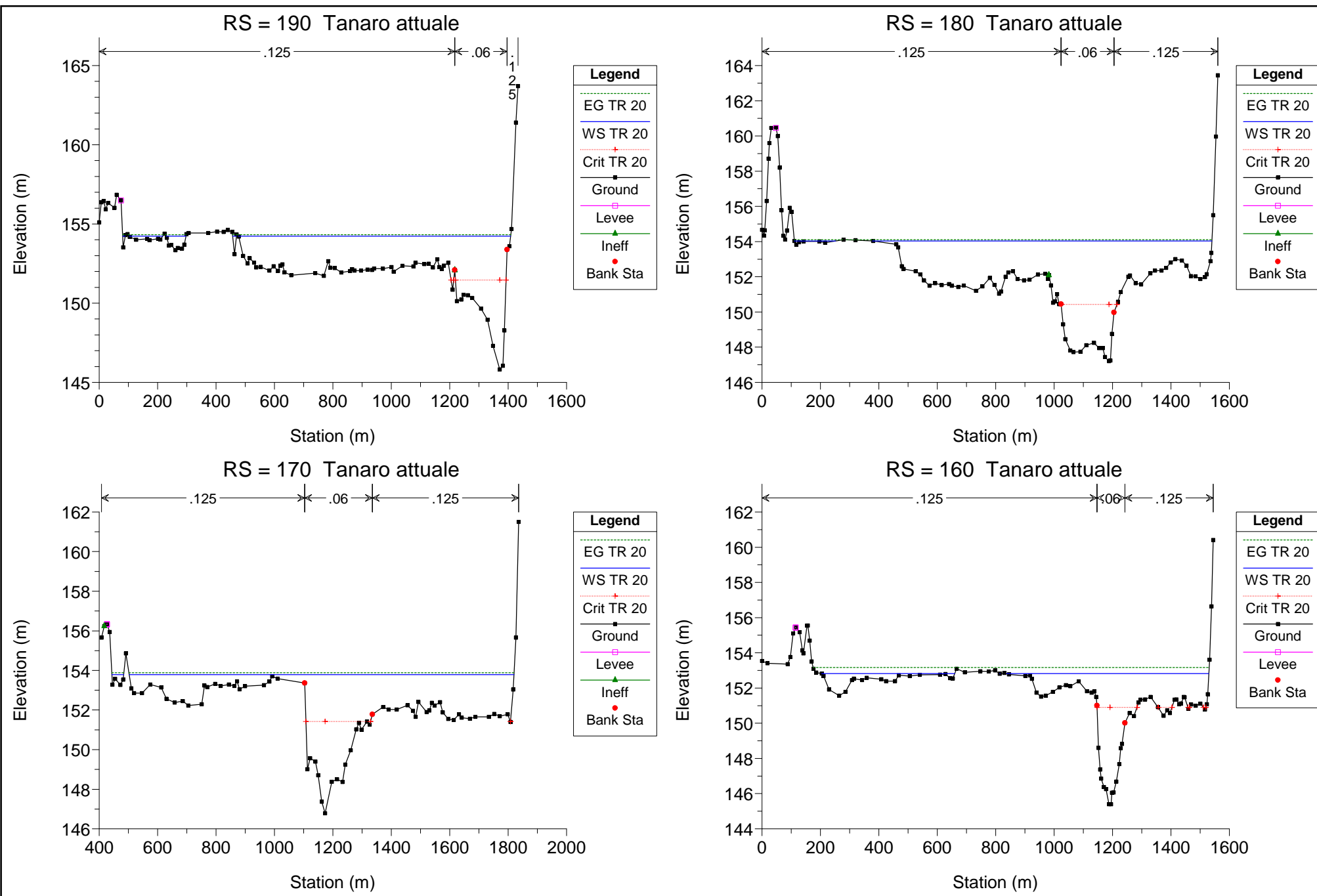


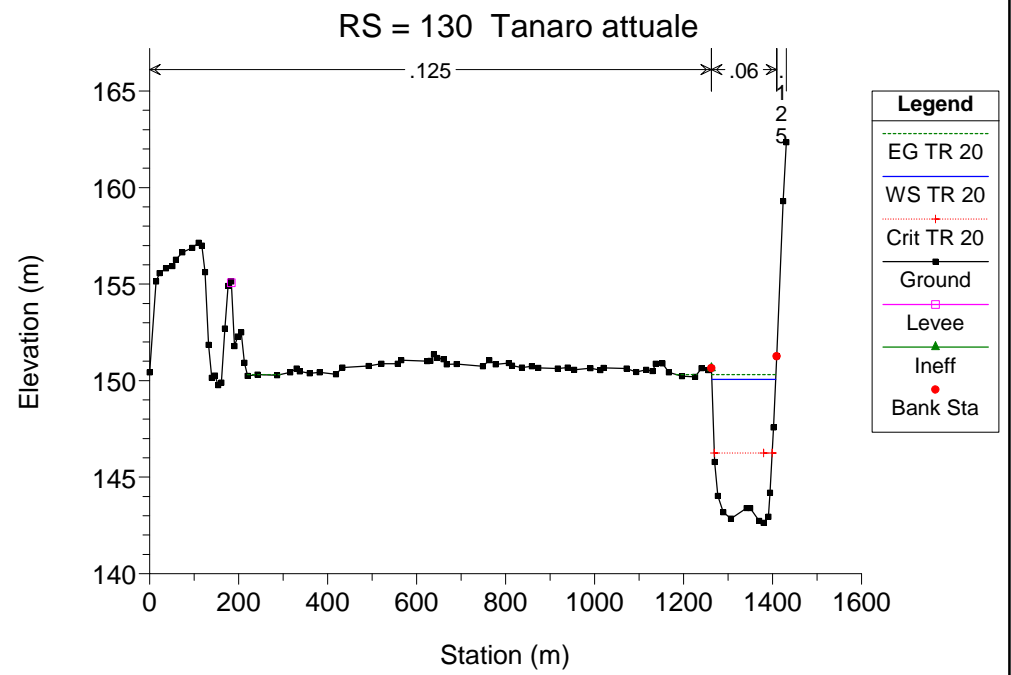
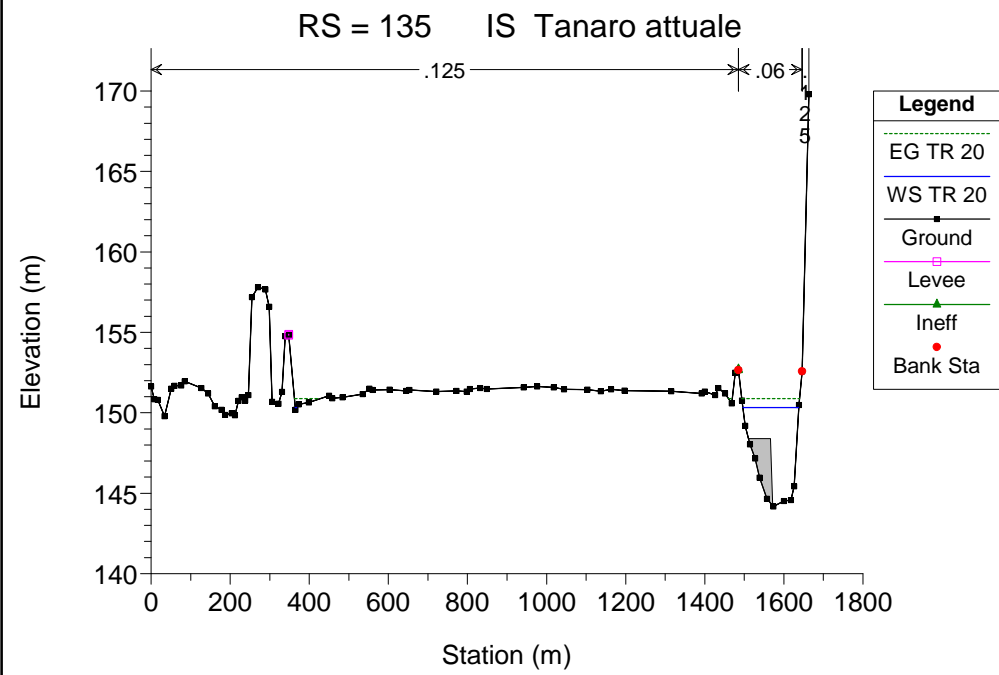
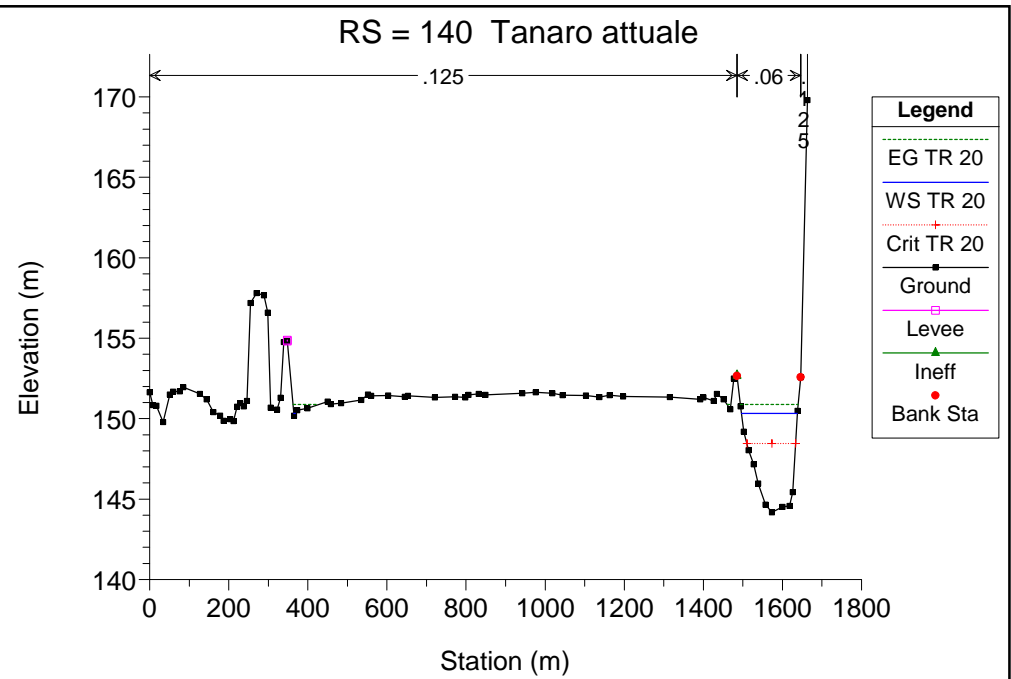
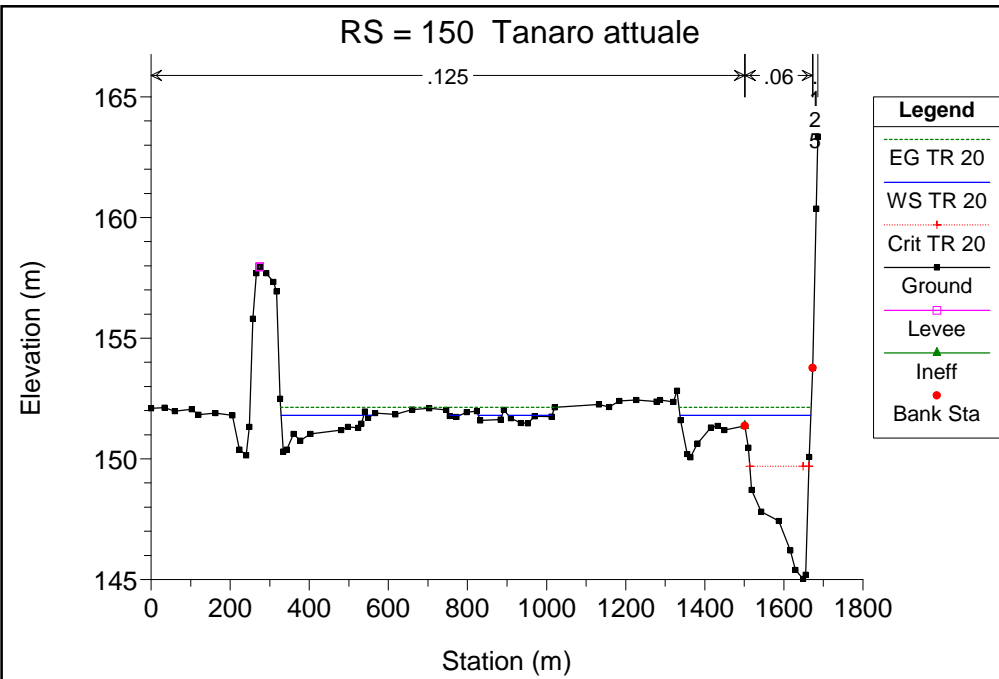


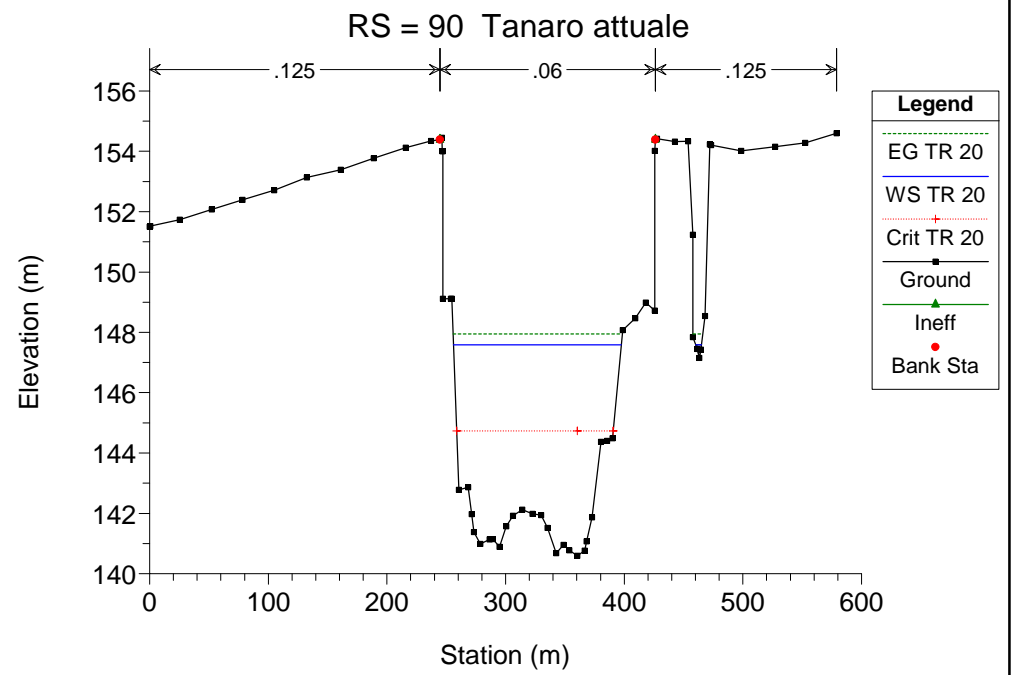
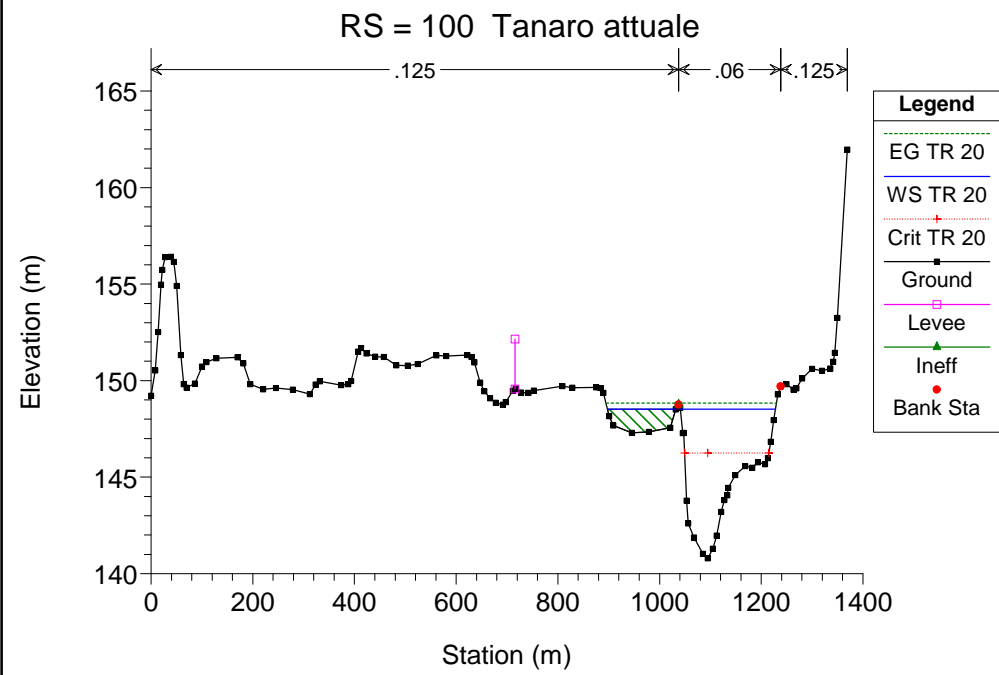
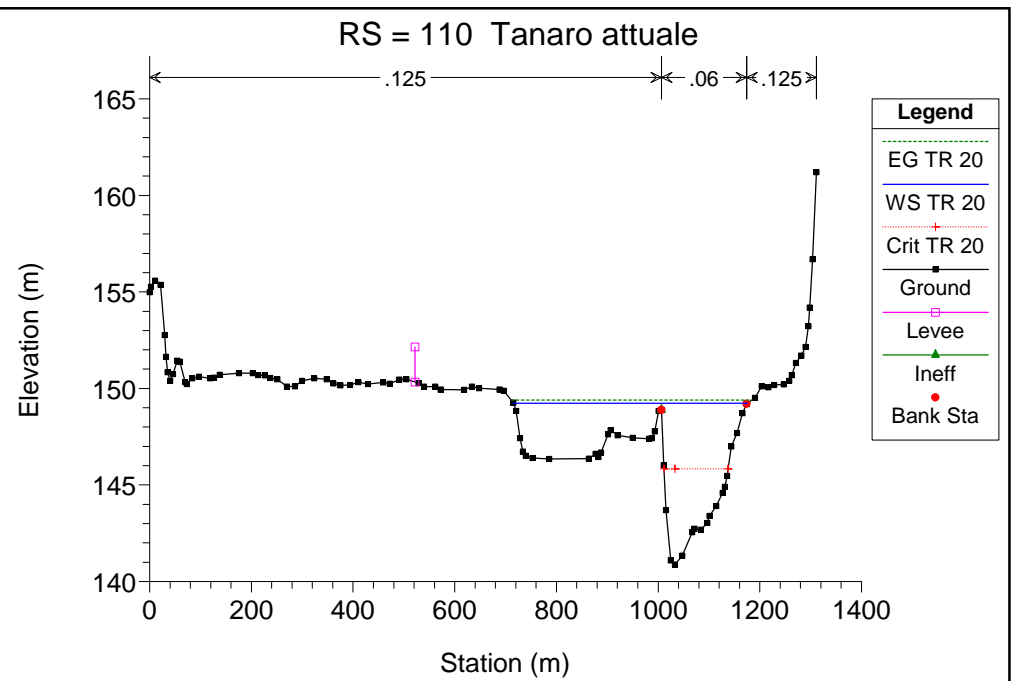
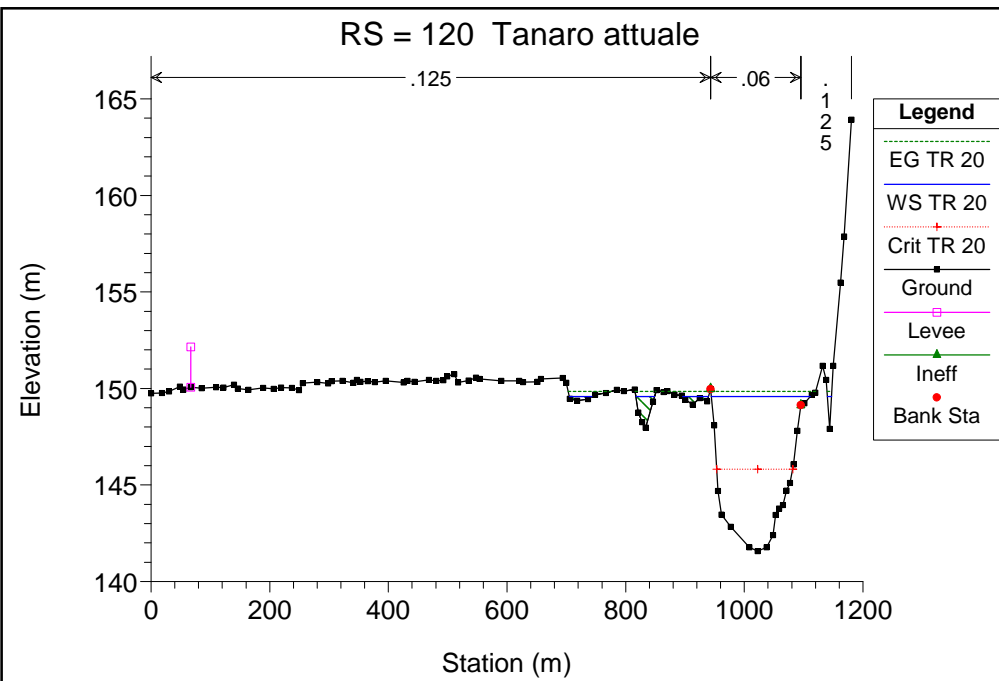


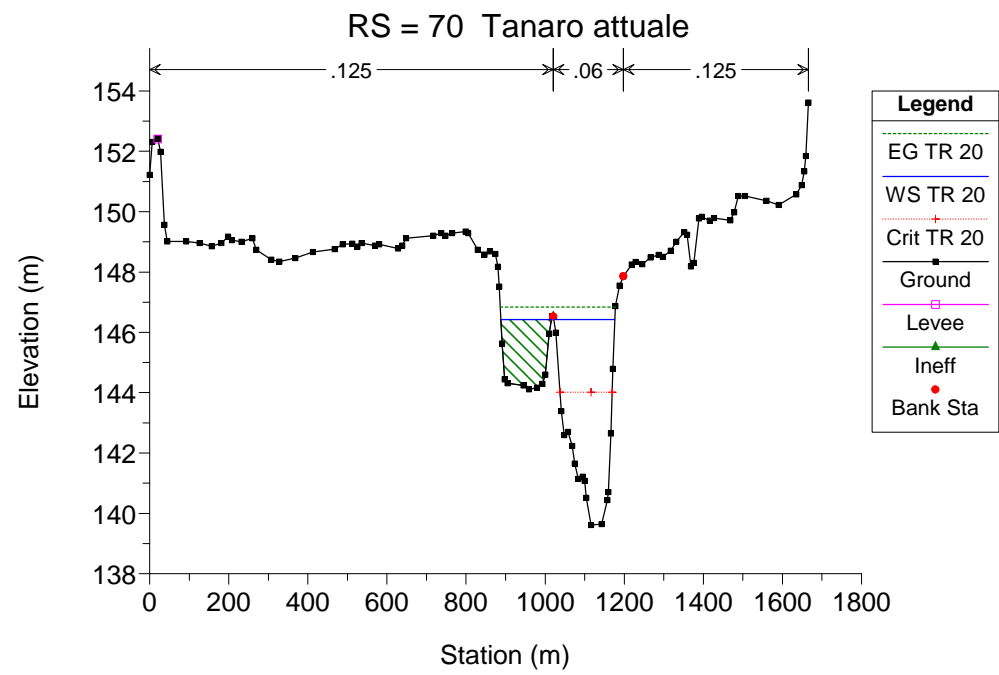
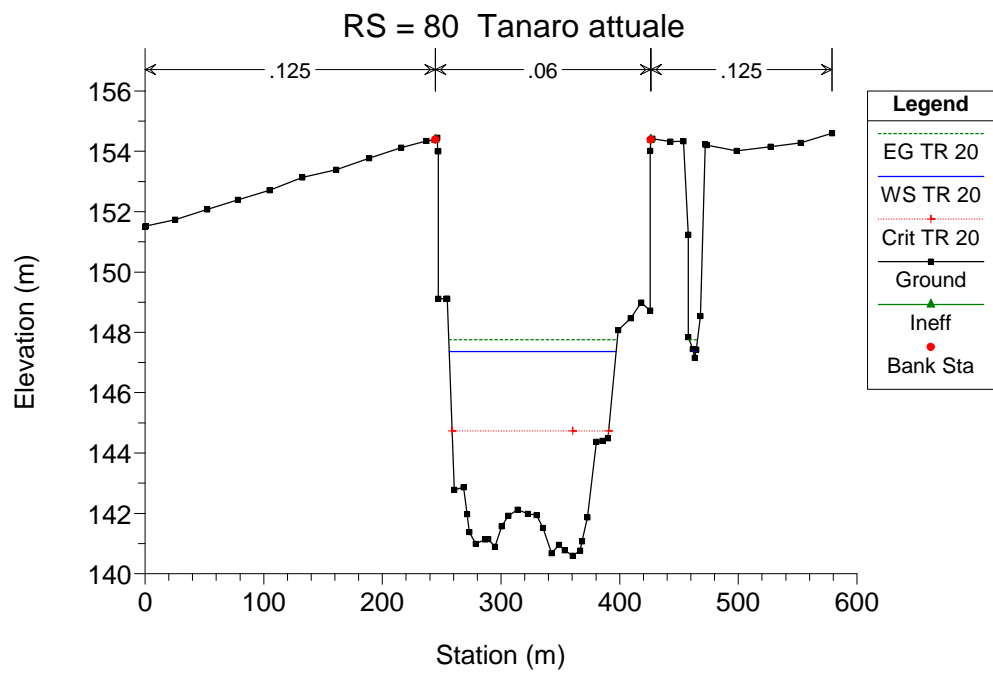
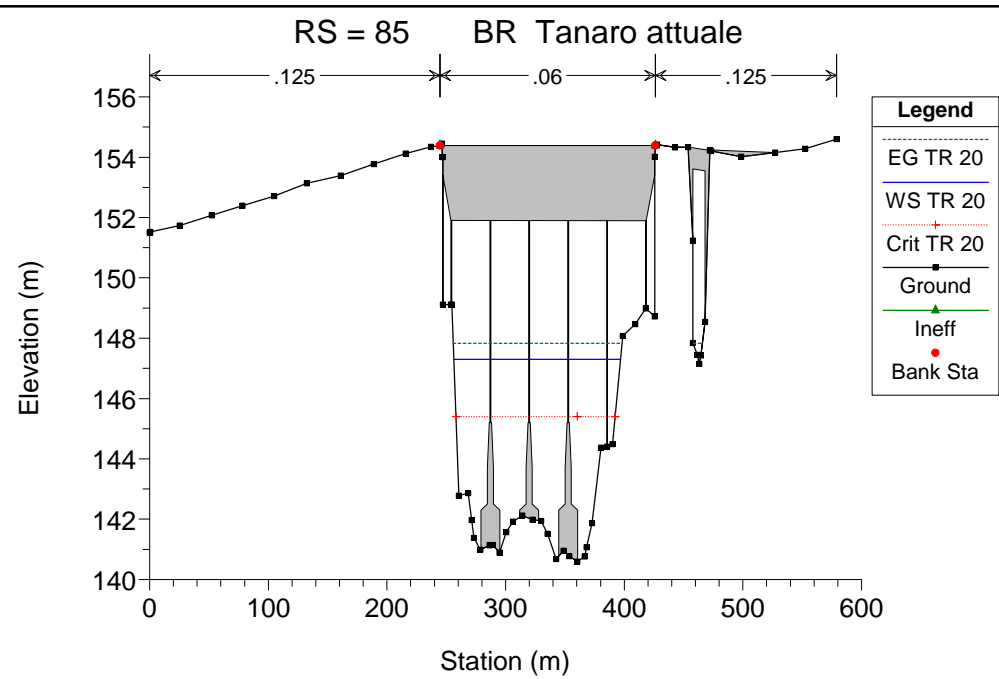
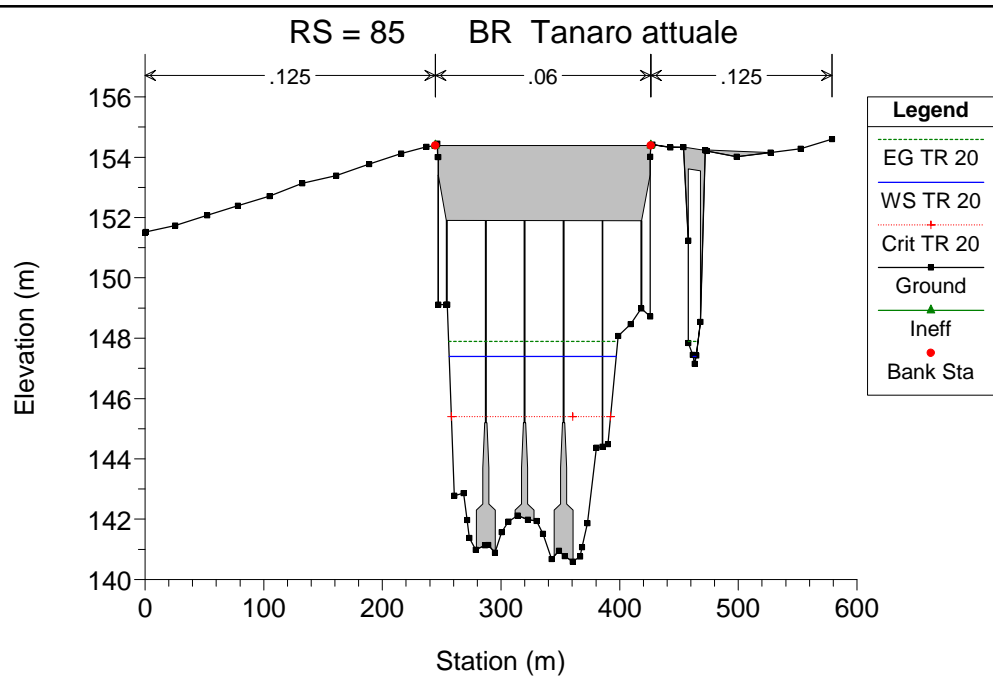


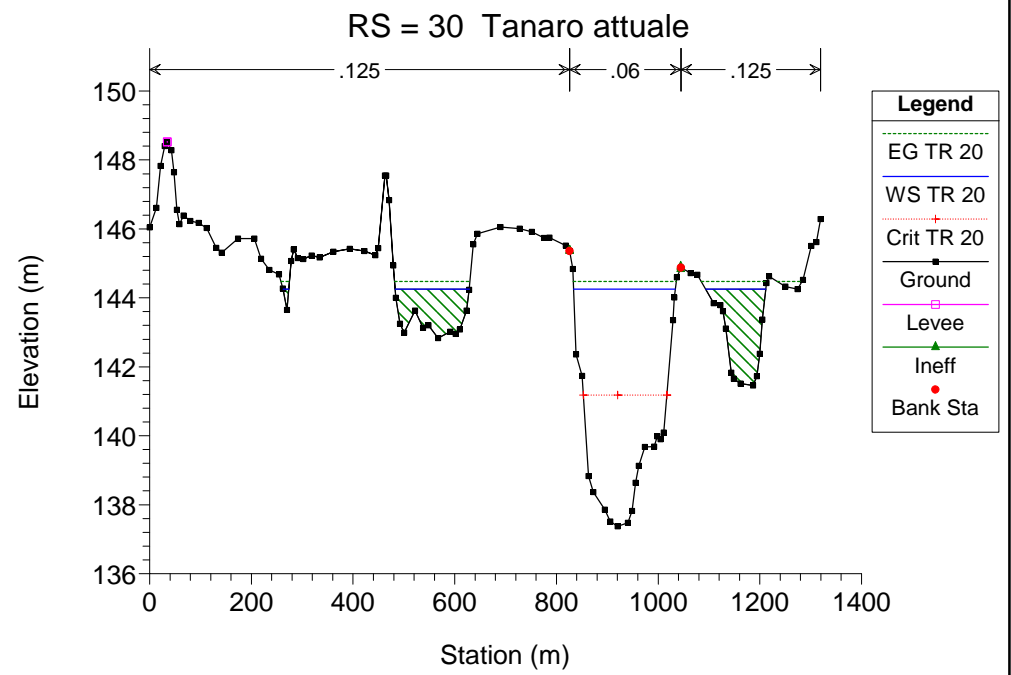
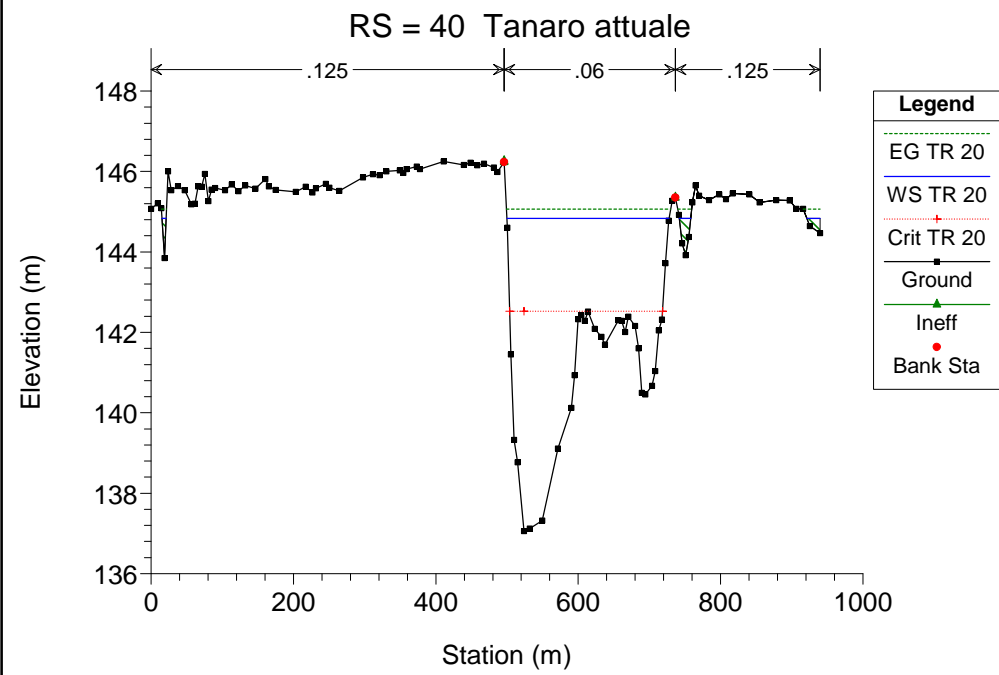
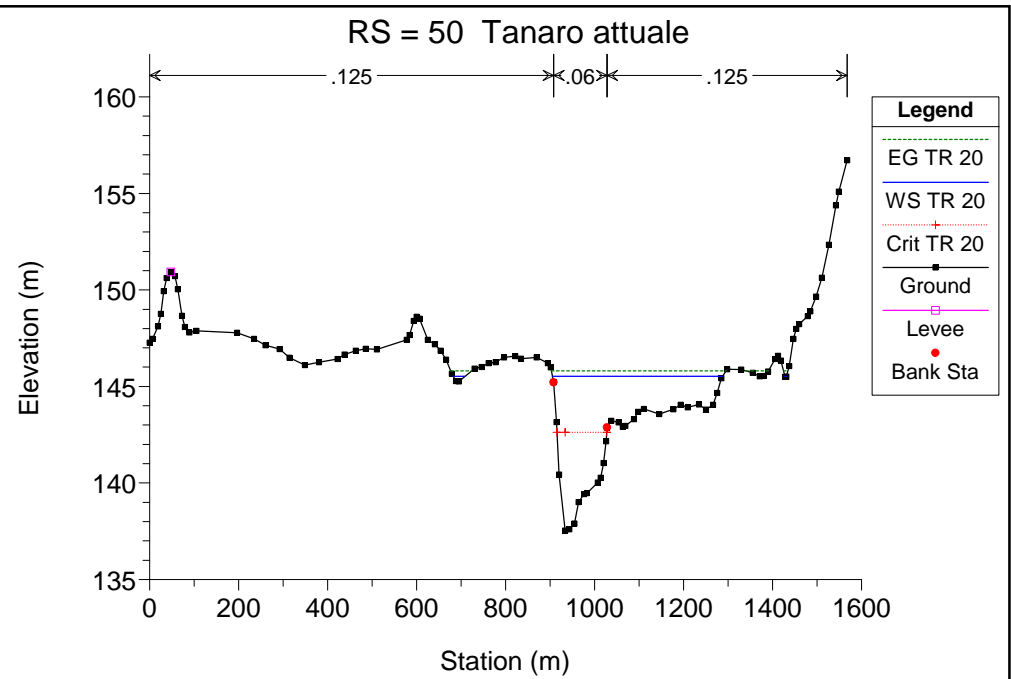
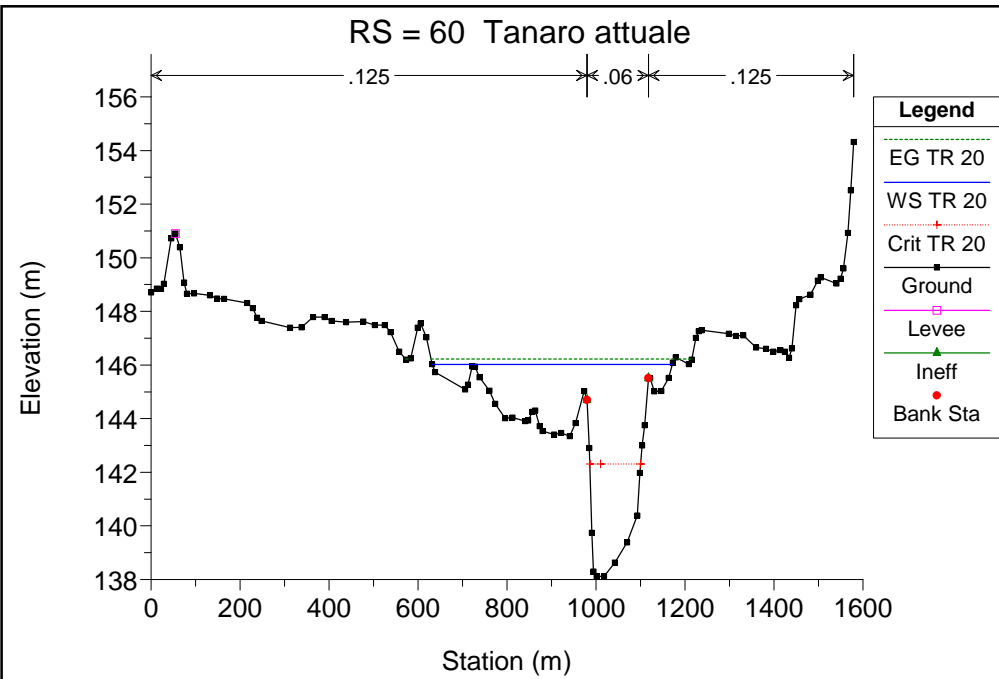


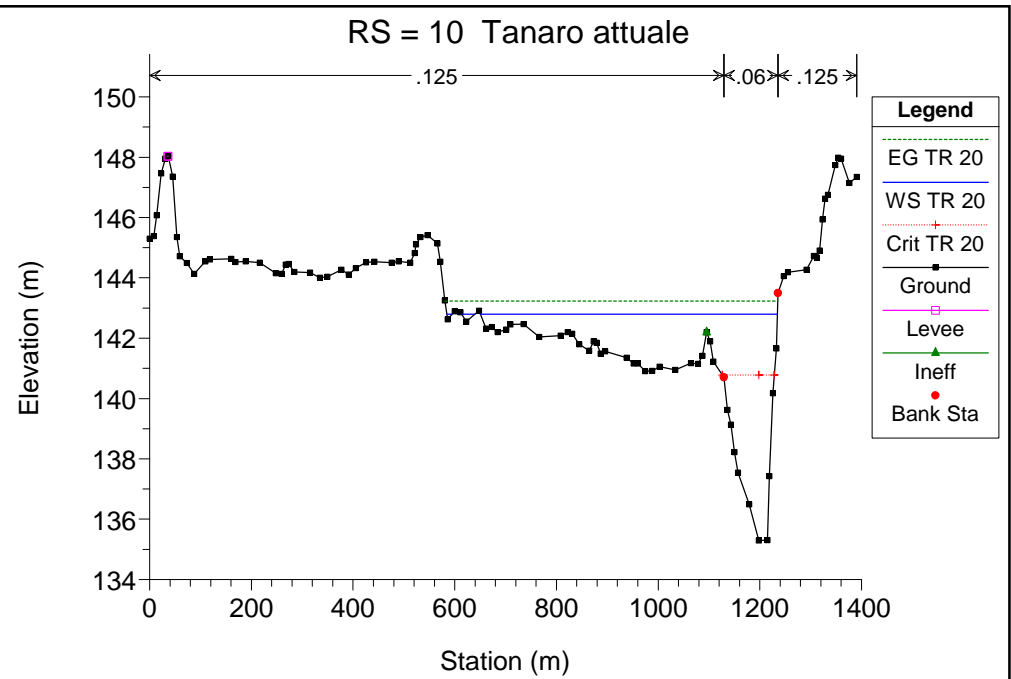
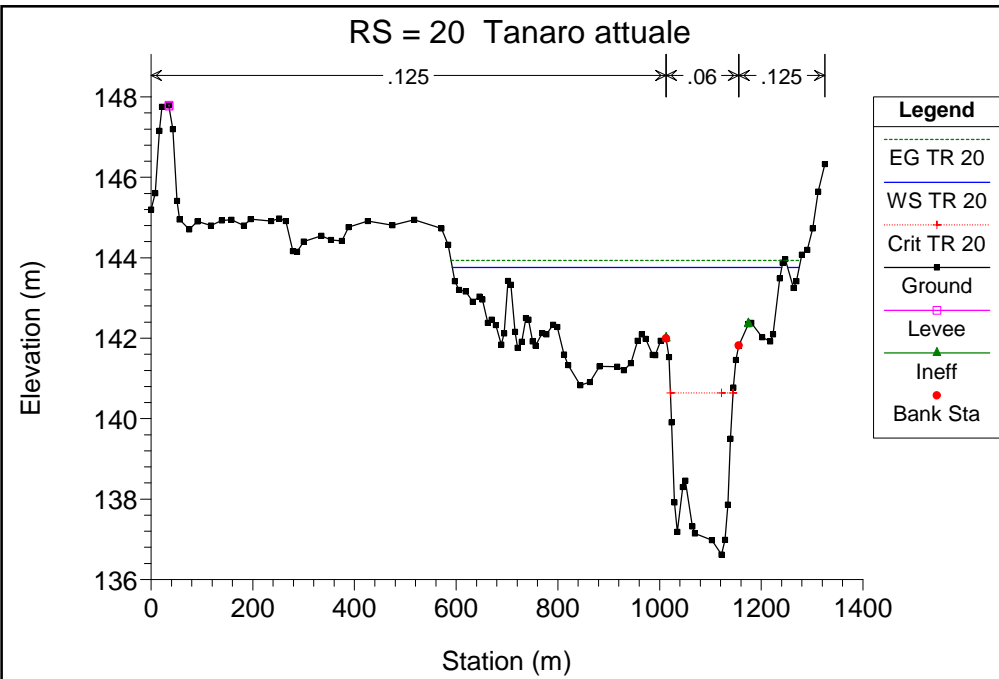












**SITUAZIONE ATTUALE
SIMULAZIONE 2**

corso d'acqua	portata al colmo Q_c m^3/s	tempo di ritorno anni
Fiume Tanaro	2750	100

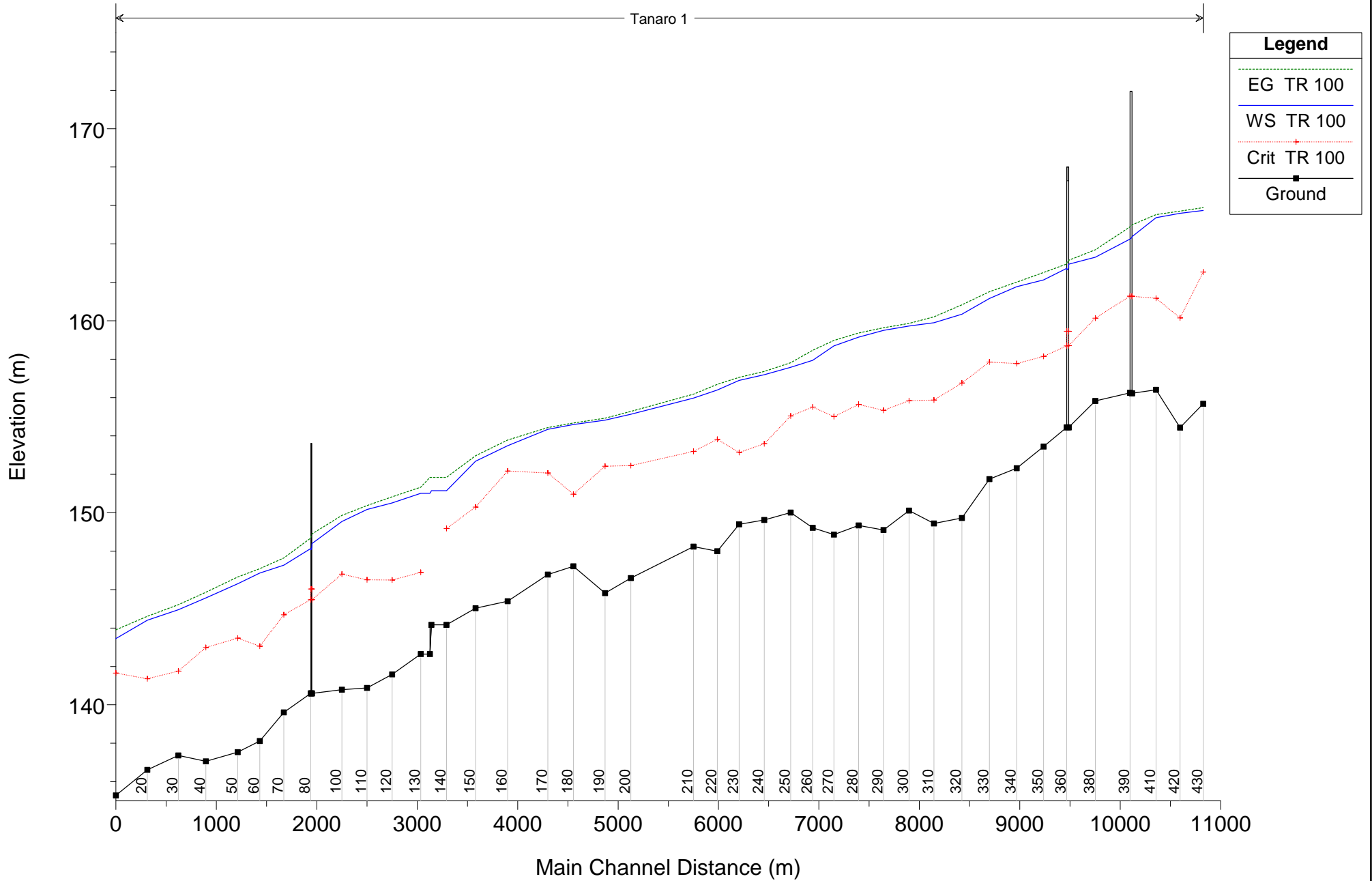
HEC-RAS Plan: Plan 06 River: Tanaro Reach: 1 Profile: TR 100

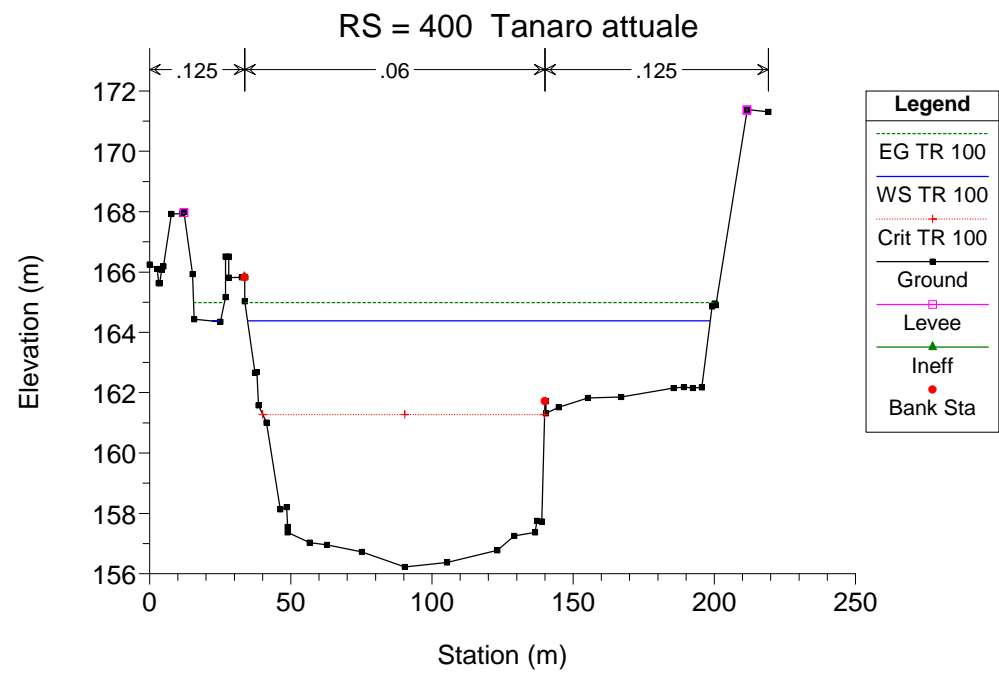
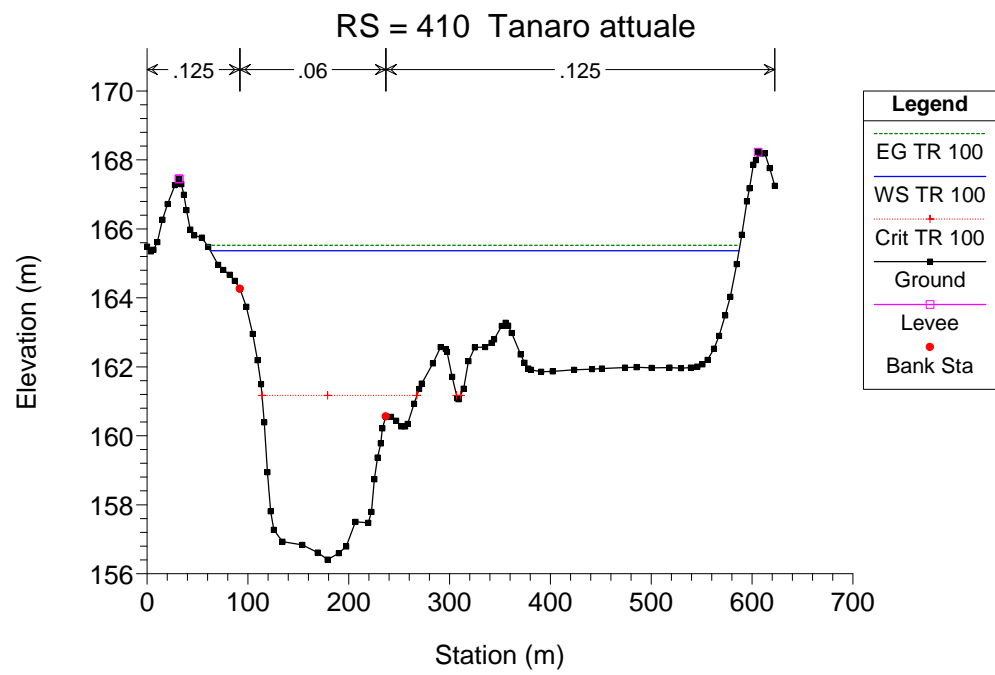
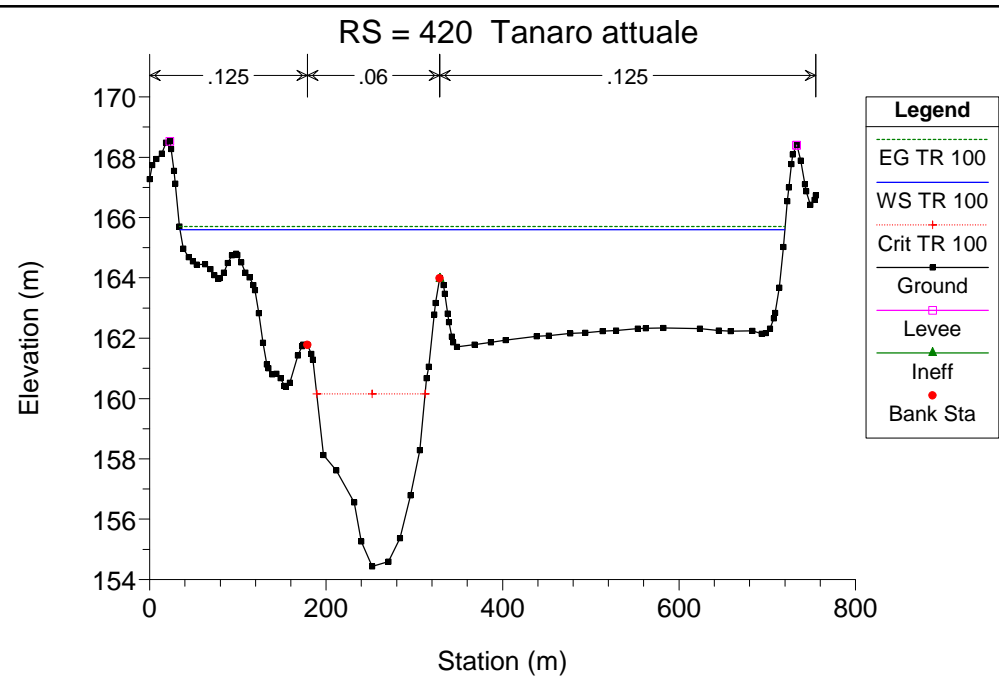
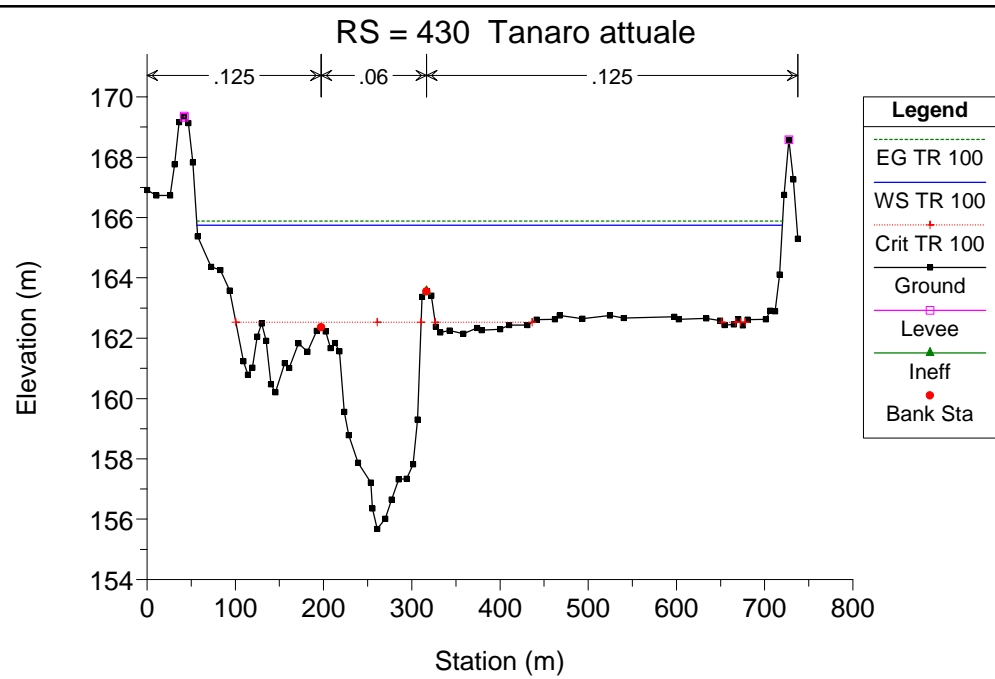
Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
1	430	TR 100	2750.00	155.68	165.75	162.53	165.89	0.001147	2.05	2589.16	663.79	0.25
1	420	TR 100	2750.00	154.44	165.60	160.15	165.70	0.000610	1.66	2896.09	685.69	0.19
1	410	TR 100	2750.00	156.41	165.36	161.17	165.52	0.001081	2.01	2201.54	524.40	0.24
1	400	TR 100	2750.00	156.22	164.38	161.27	164.99	0.003543	3.53	886.96	166.85	0.42
1	395		Bridge									
1	390	TR 100	2750.00	156.25	164.25	161.28	164.89	0.003782	3.61	865.47	163.54	0.44
1	380	TR 100	2750.00	155.82	163.31	160.13	163.70	0.002535	2.76	1014.32	210.52	0.36
1	370	TR 100	2750.00	154.45	162.94	158.70	163.15	0.001244	2.03	1353.33	205.85	0.25
1	365		Bridge									
1	360	TR 100	2750.00	154.45	162.73	158.70	162.95	0.001382	2.10	1309.32	205.25	0.27
1	350	TR 100	2750.00	153.45	162.13	158.14	162.51	0.002182	2.74	1008.51	191.55	0.34
1	340	TR 100	2750.00	152.32	161.77	157.77	162.01	0.001384	2.15	1373.58	375.79	0.27
1	330	TR 100	2750.00	151.75	161.16	157.85	161.52	0.002314	2.69	1188.48	427.09	0.34
1	320	TR 100	2750.00	149.73	160.34	156.76	160.82	0.002628	3.27	1287.36	449.51	0.38
1	310	TR 100	2750.00	149.44	159.90	155.87	160.20	0.001747	2.75	1859.33	733.59	0.31
1	300	TR 100	2750.00	150.11	159.72	155.84	159.86	0.000939	1.87	2669.21	858.10	0.22
1	290	TR 100	2750.00	149.10	159.50	155.33	159.63	0.000886	1.71	2284.17	673.08	0.21
1	280	TR 100	2750.00	149.34	159.15	155.65	159.36	0.001483	2.32	1980.49	534.83	0.28
1	270	TR 100	2750.00	148.86	158.69	155.01	158.97	0.001768	2.65	1774.78	483.42	0.31
1	260	TR 100	2750.00	149.22	157.94	155.50	158.46	0.003210	3.41	1231.14	419.96	0.41
1	250	TR 100	2750.00	150.01	157.58	155.03	157.81	0.002213	2.43	1819.38	556.39	0.33
1	240	TR 100	2750.00	149.63	157.18	153.60	157.36	0.001291	2.08	2214.66	763.19	0.26
1	230	TR 100	2750.00	149.40	156.89	153.15	157.05	0.001147	1.91	1999.73	585.10	0.24
1	220	TR 100	2750.00	148.00	156.40	153.82	156.69	0.002329	2.71	1579.92	483.08	0.35
1	210	TR 100	2750.00	148.24	155.97	153.20	156.18	0.001751	2.22	1860.09	664.48	0.30
1	200	TR 100	2750.00	146.60	155.13	152.46	155.28	0.001442	2.19	2884.22	1086.60	0.27
1	190	TR 100	2750.00	145.82	154.82	152.43	154.93	0.001152	1.79	3237.29	1332.93	0.24
1	180	TR 100	2750.00	147.21	154.60	150.97	154.68	0.000702	1.54	3830.78	1447.85	0.19
1	170	TR 100	2750.00	146.78	154.34	152.07	154.44	0.001228	1.67	3120.38	1371.56	0.24
1	160	TR 100	2750.00	145.40	153.49	152.17	153.78	0.002674	2.94	2323.28	1361.76	0.37
1	150	TR 100	2750.00	145.03	152.69	150.30	152.97	0.002651	2.56	2034.64	1341.25	0.36
1	140	TR 100	2750.00	144.17	151.15	149.18	151.85	0.005831	3.70	743.77	341.89	0.53
1	135		Inl Struct									
1	130	TR 100	2750.00	142.64	151.00	146.90	151.33	0.001803	2.58	1412.76	1089.63	0.31
1	120	TR 100	2750.00	141.58	150.50	146.50	150.82	0.001789	2.52	1465.26	1013.89	0.31
1	110	TR 100	2750.00	140.88	150.15	146.51	150.36	0.001596	2.21	1997.43	689.49	0.28
1	100	TR 100	2750.00	140.79	149.52	146.81	149.84	0.002734	2.56	1289.22	393.01	0.36
1	90	TR 100	2750.00	140.59	148.41	145.37	148.89	0.003350	3.08	892.43	162.06	0.41
1	85		Bridge									
1	80	TR 100	2750.00	140.59	148.12	145.37	148.65	0.003673	3.24	850.04	153.25	0.43

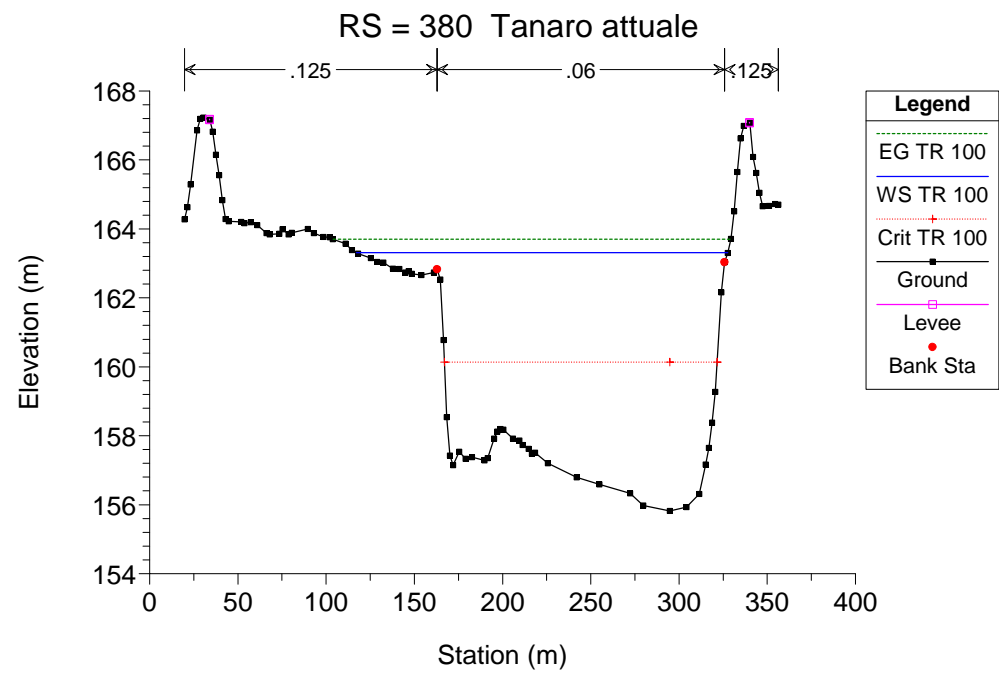
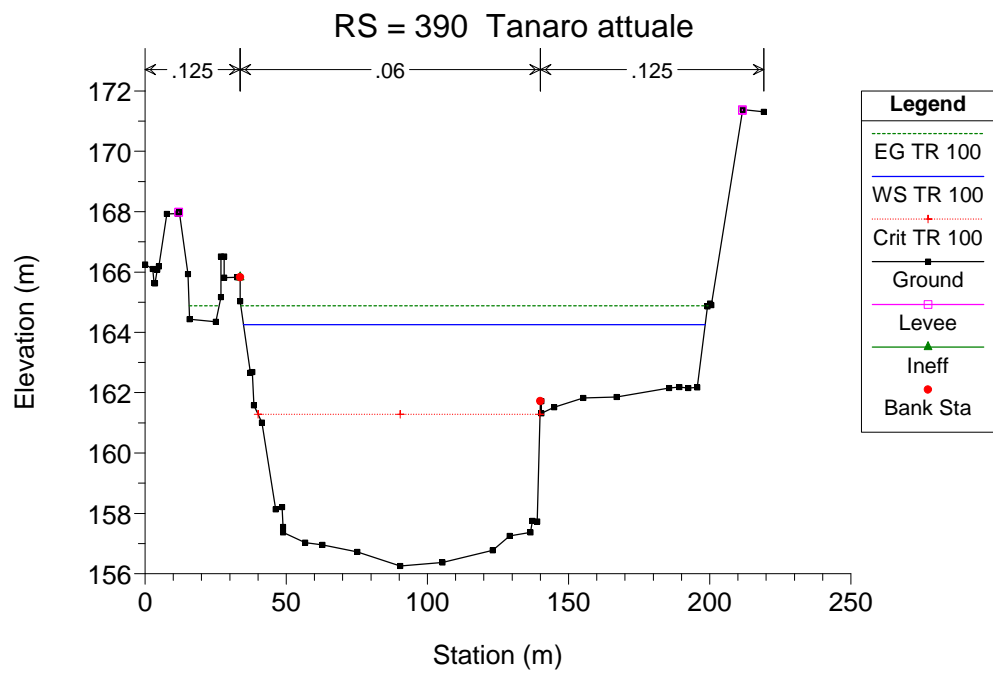
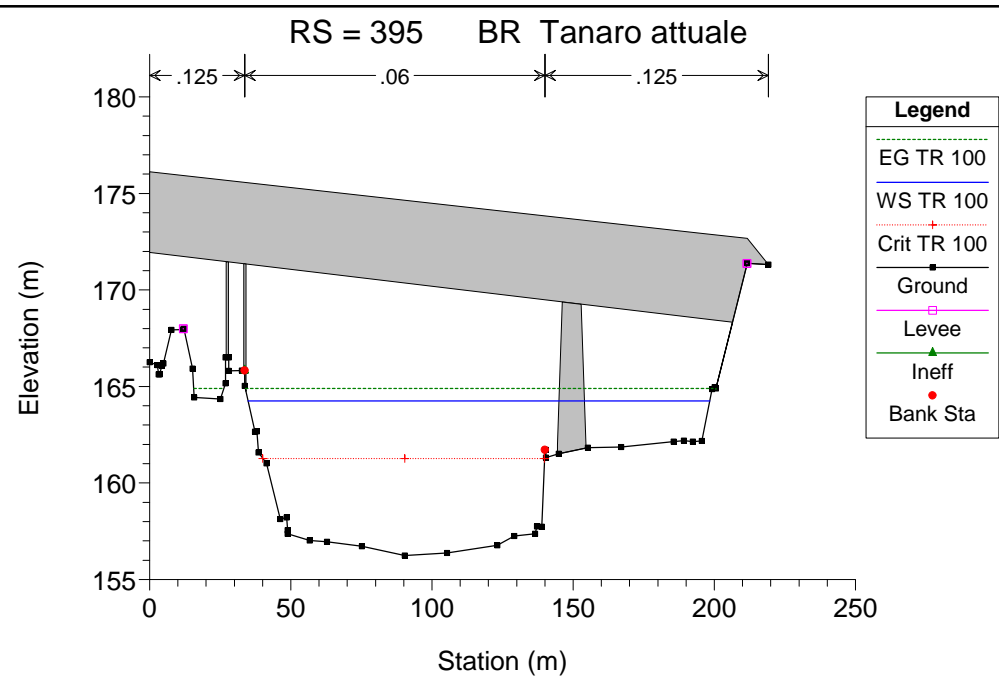
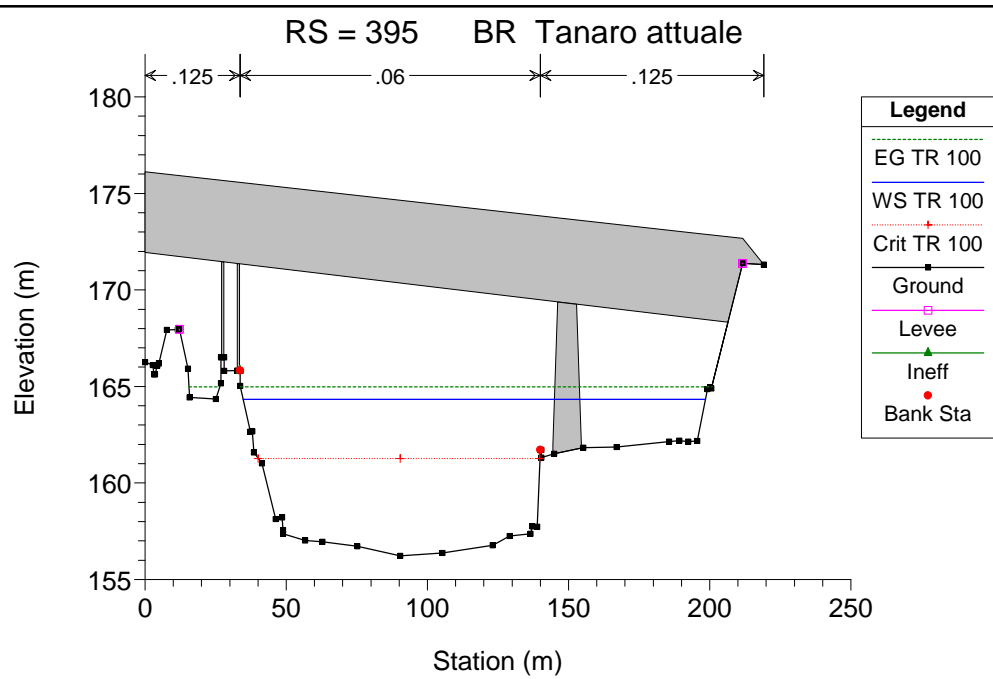
HEC-RAS Plan: Plan 06 River: Tanaro Reach: 1 Profile: TR 100 (Continued)

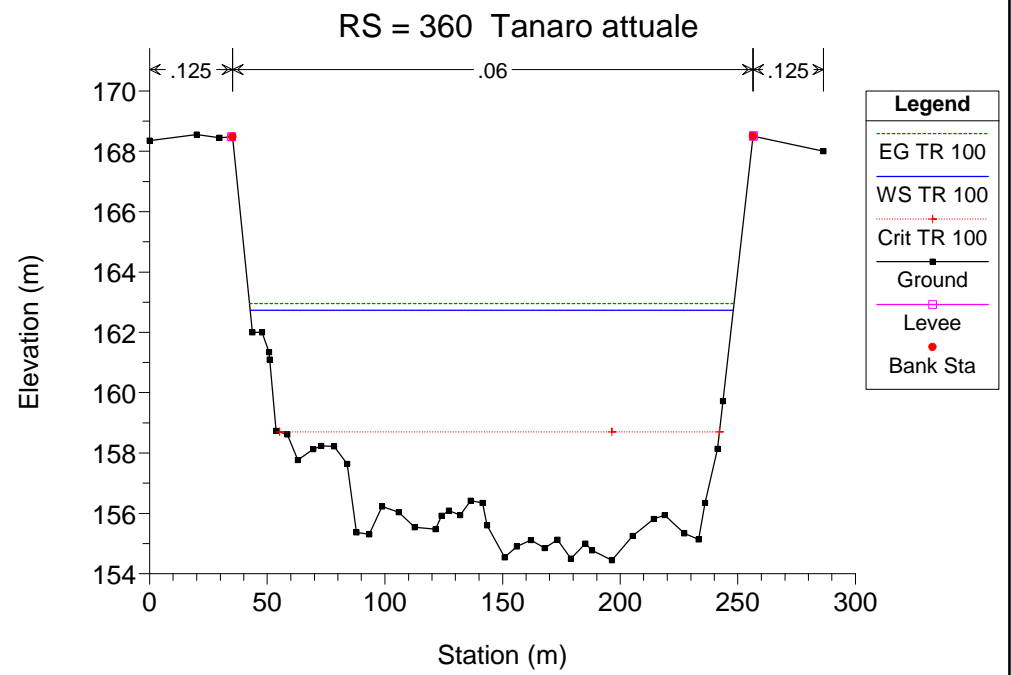
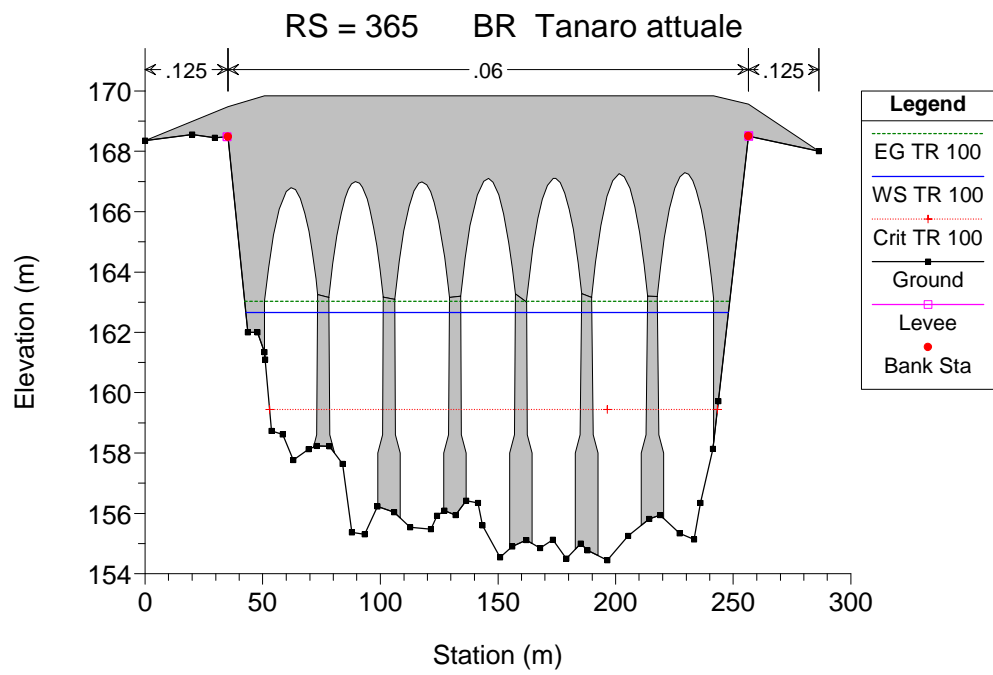
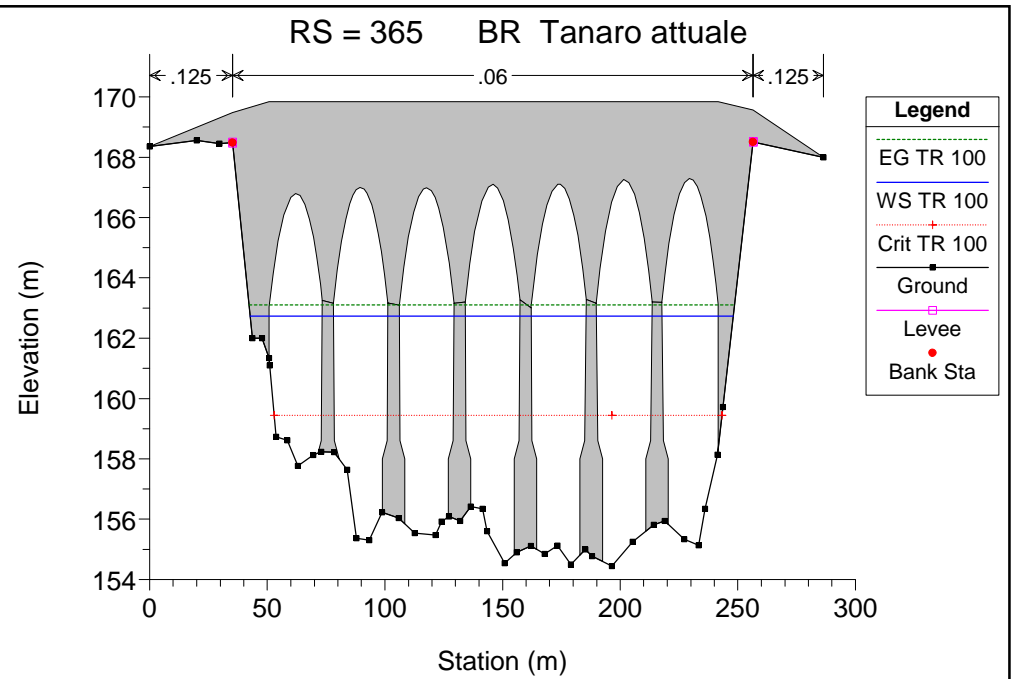
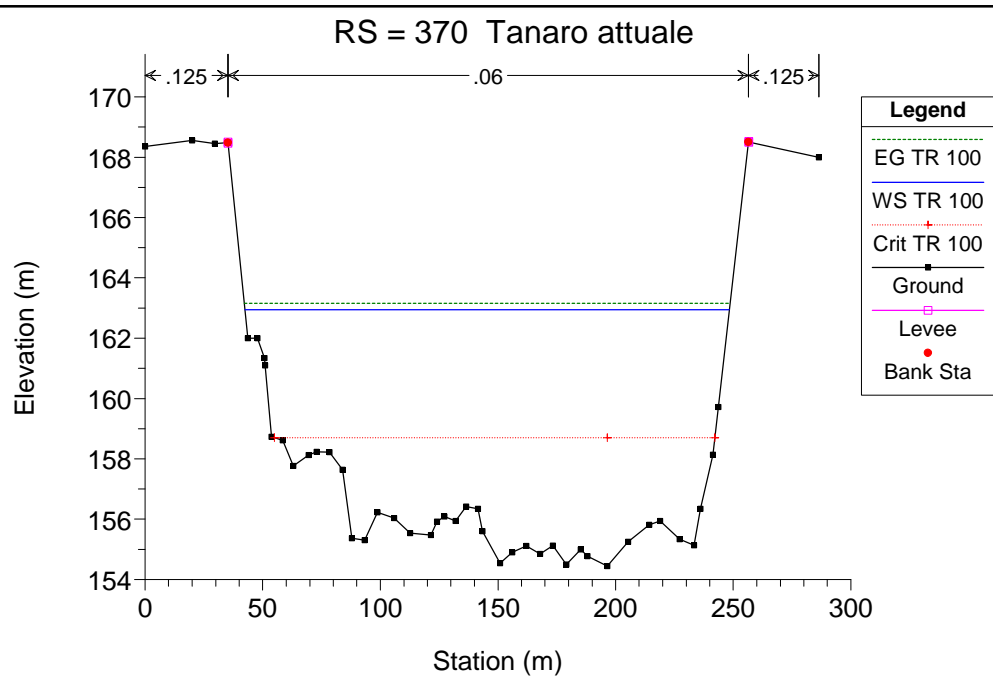
Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
1	70	TR 100	2750.00	139.61	147.28	144.68	147.65	0.003220	2.84	1218.52	298.84	0.40
1	60	TR 100	2750.00	138.12	146.86	143.05	147.09	0.001540	2.35	1941.33	740.77	0.29
1	50	TR 100	2750.00	137.54	146.31	143.47	146.66	0.002427	2.87	1598.63	711.76	0.36
1	40	TR 100	2750.00	137.06	145.57	142.99	145.86	0.002661	2.41	1217.14	582.53	0.35
1	30	TR 100	2750.00	137.37	144.95	141.76	145.21	0.002128	2.31	1457.32	664.24	0.32
1	20	TR 100	2750.00	136.62	144.41	141.35	144.61	0.001661	2.30	2138.86	740.06	0.29
1	10	TR 100	2750.00	135.29	143.45	141.65	143.91	0.004005	3.39	1523.40	656.99	0.45

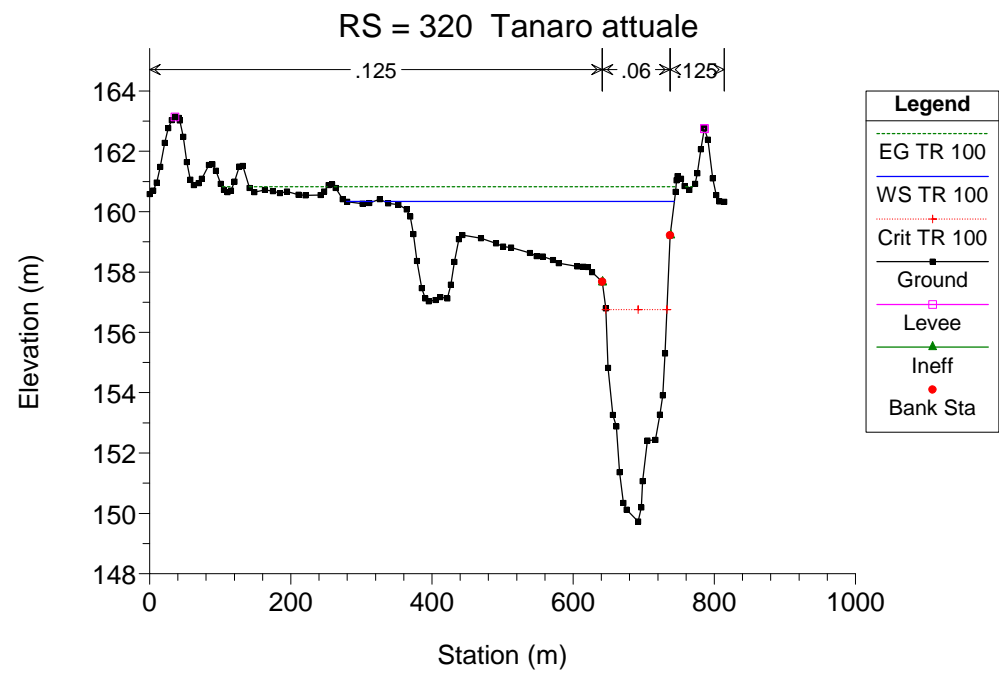
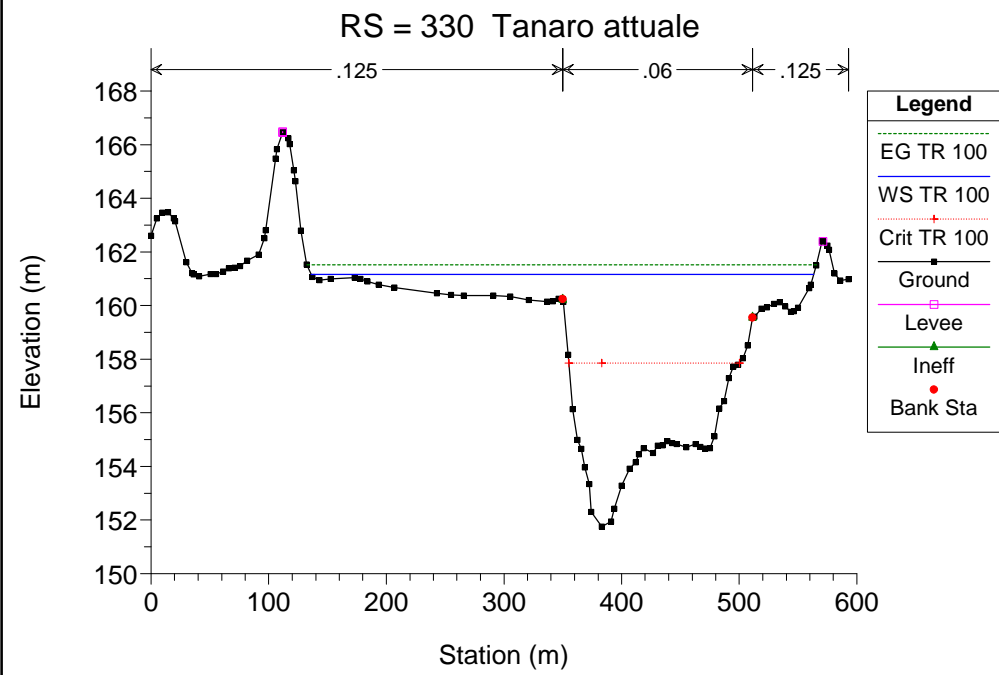
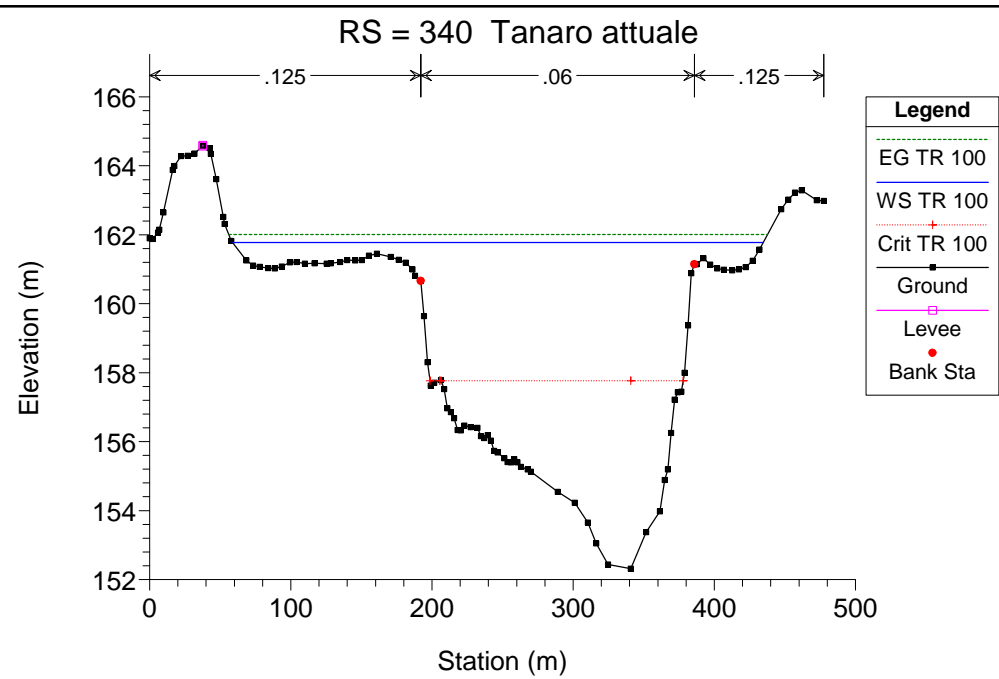
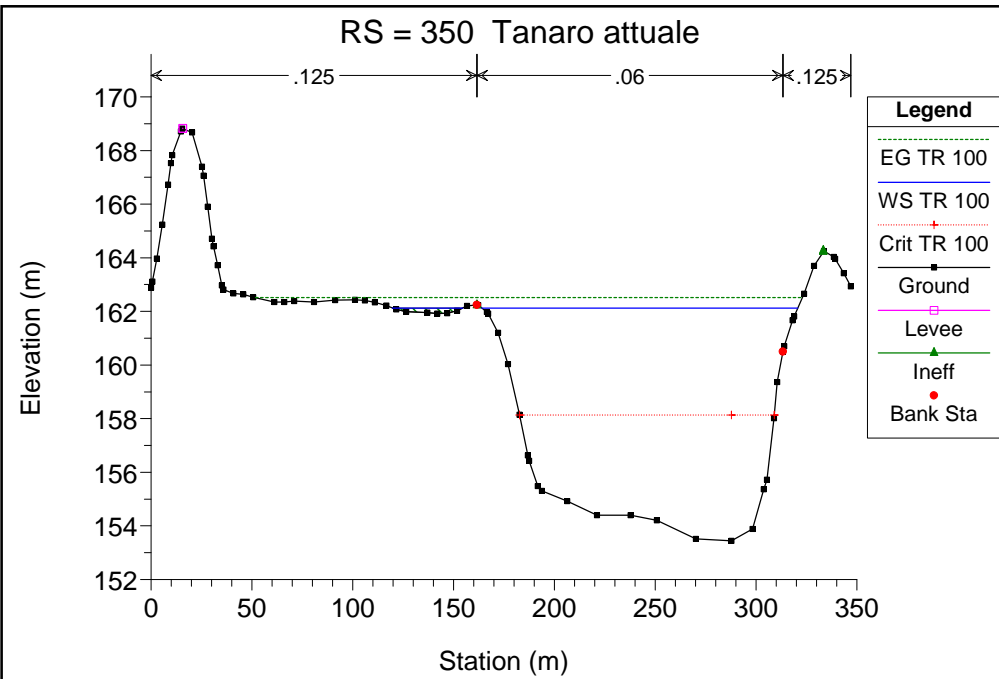
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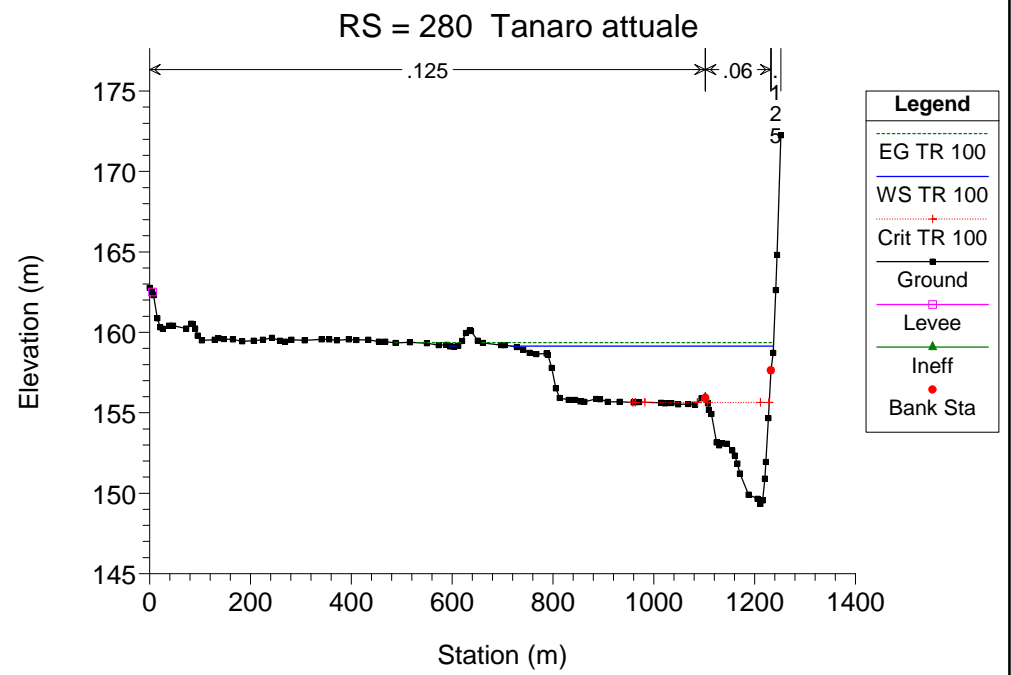
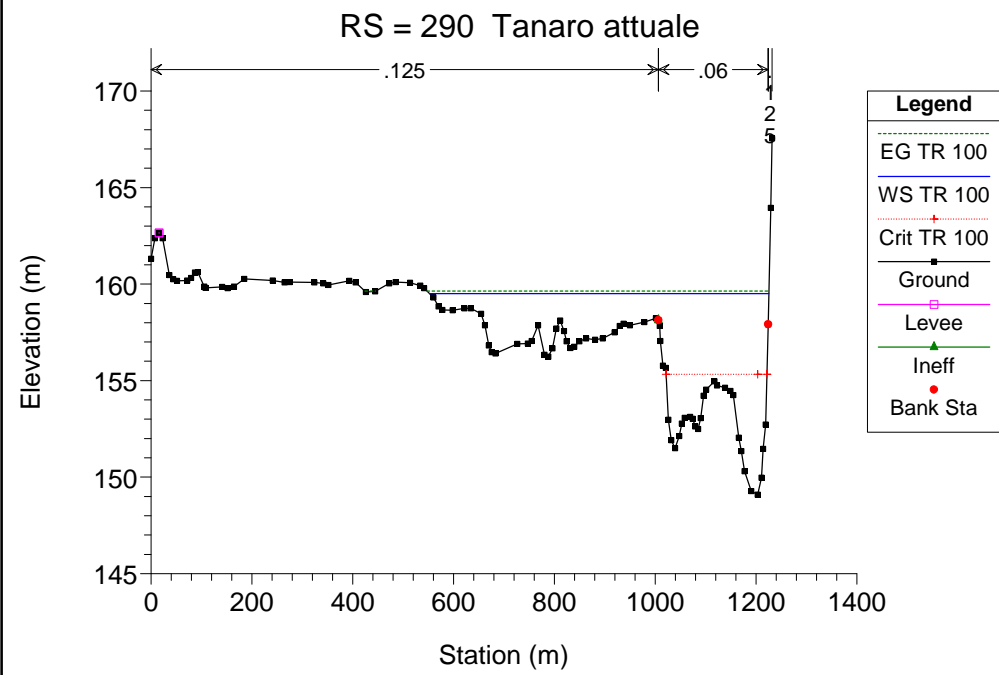
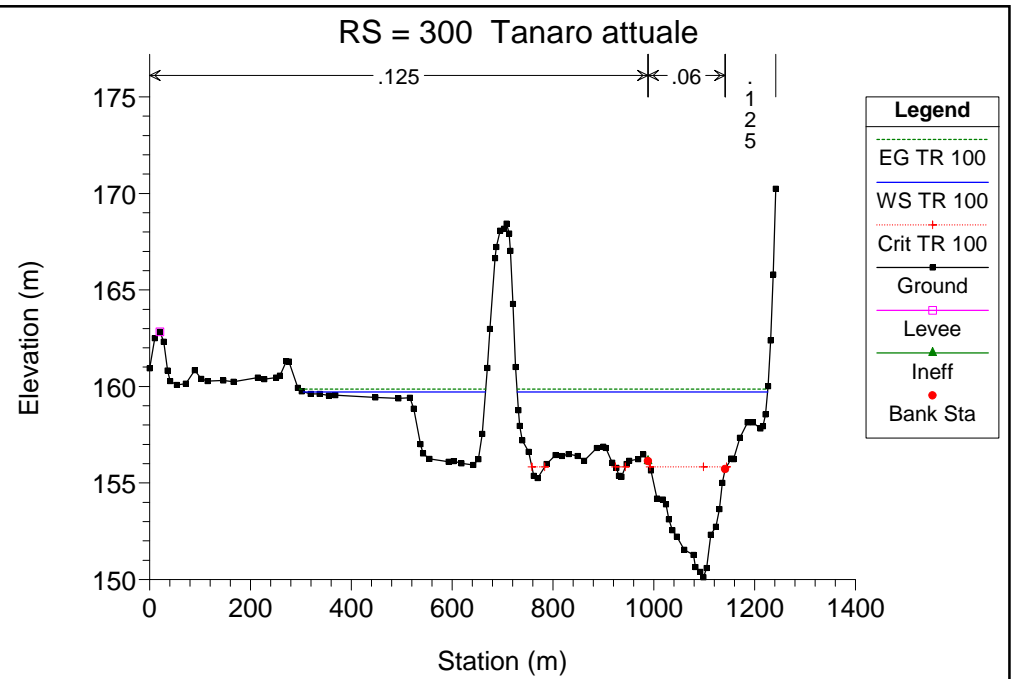
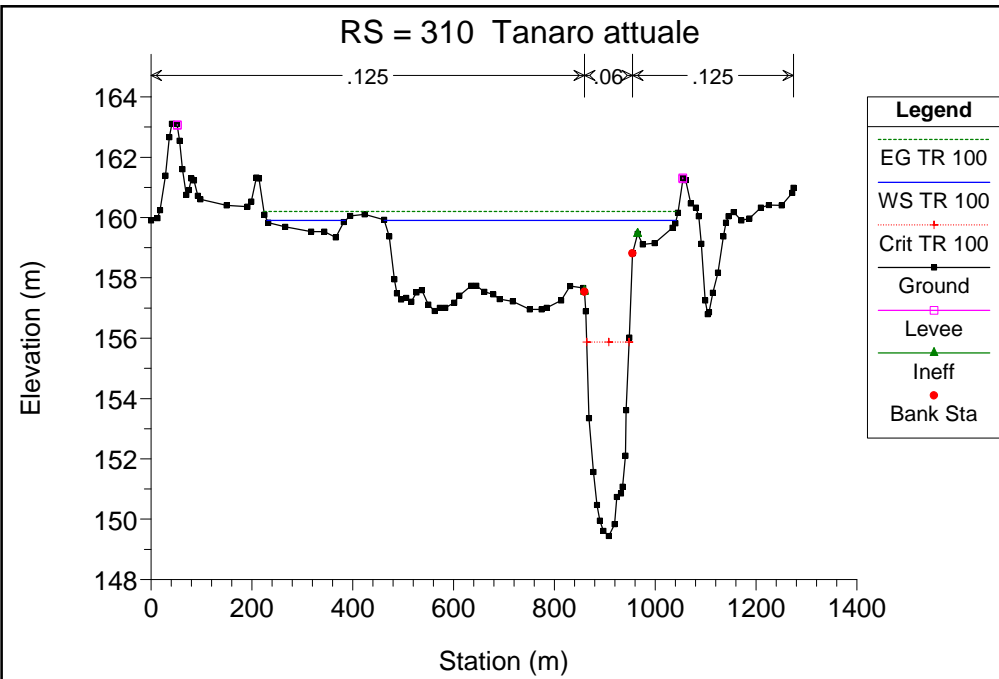


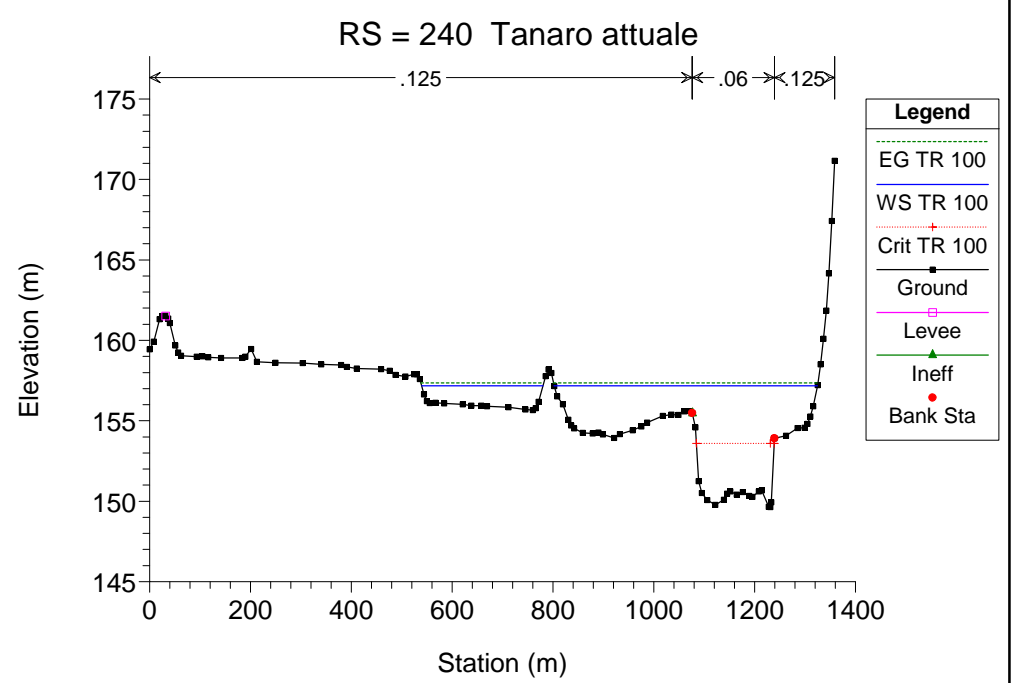
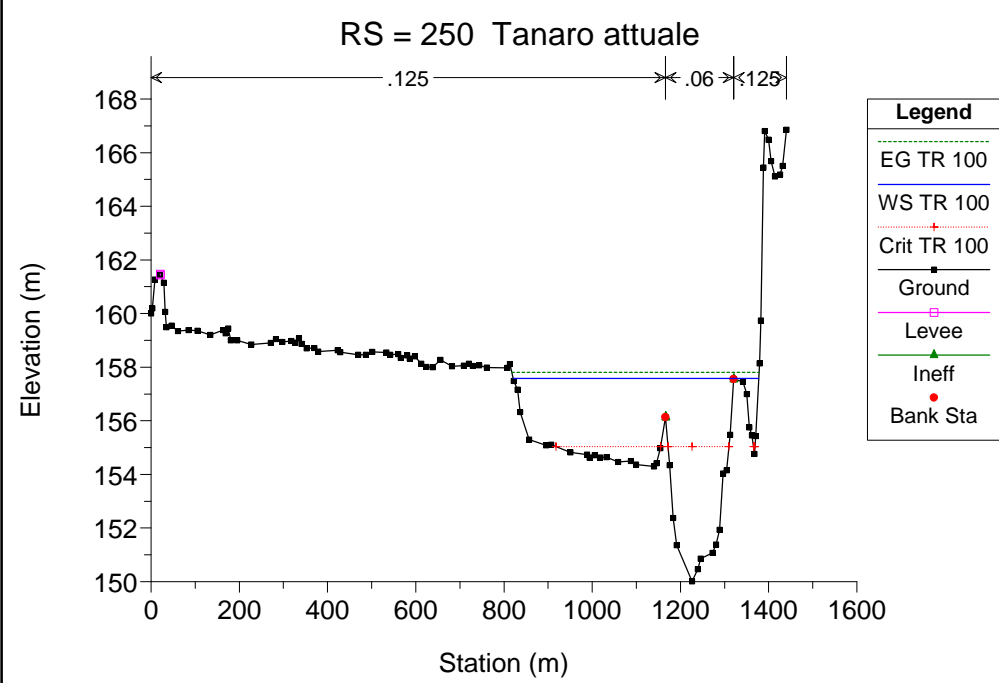
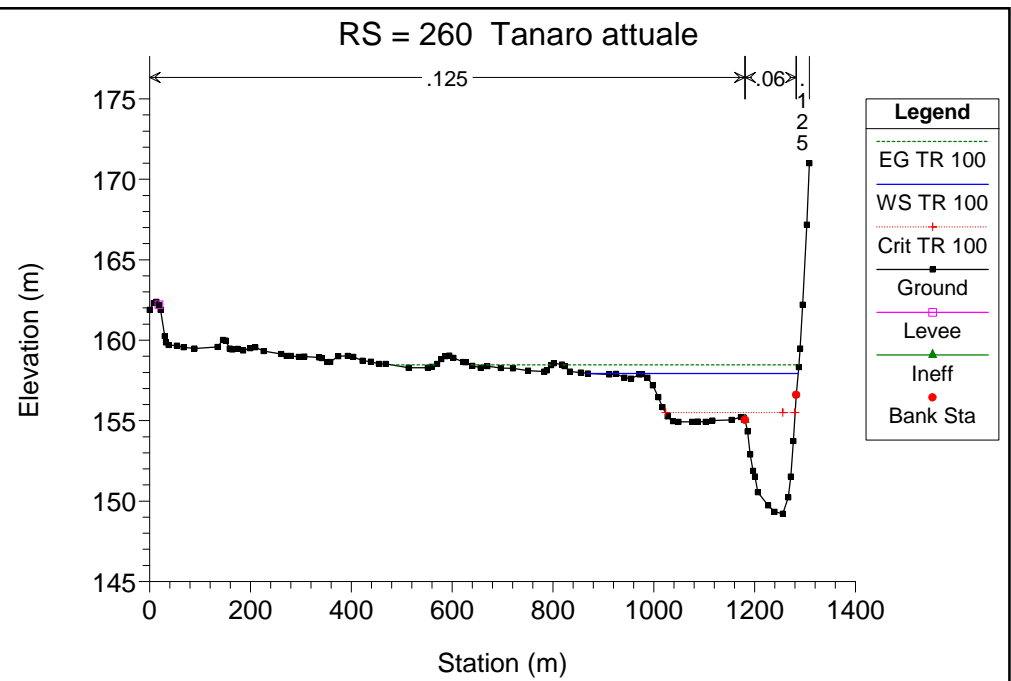
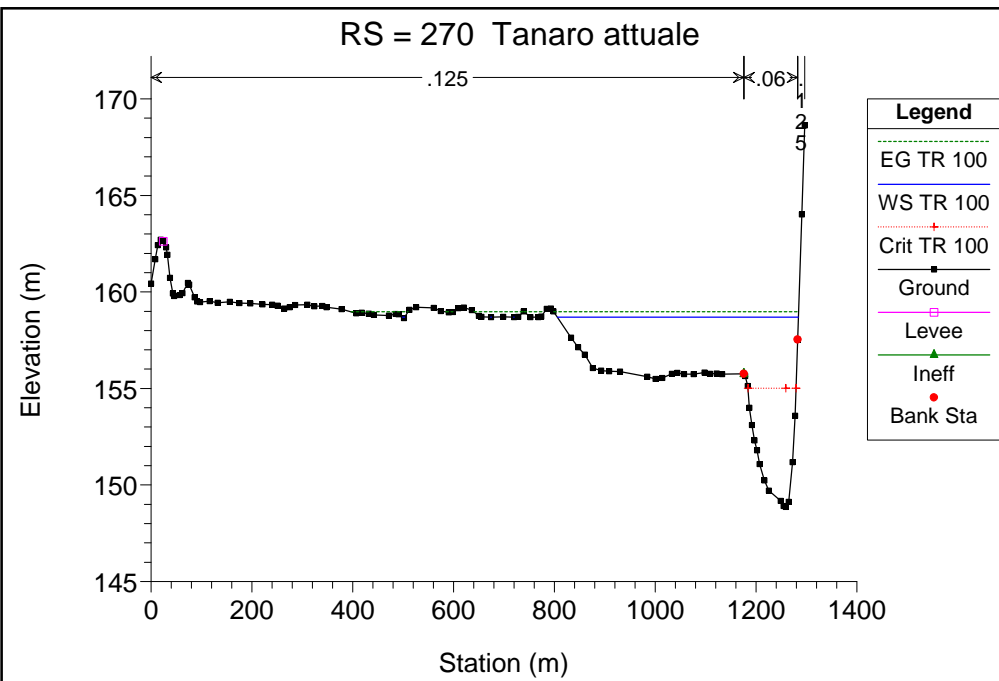


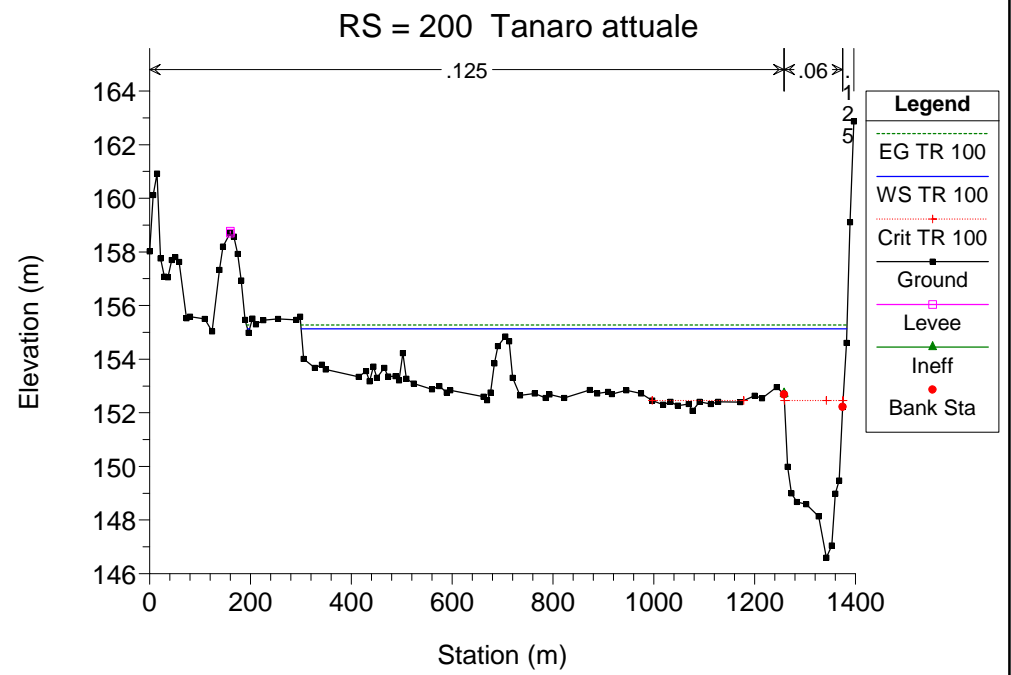
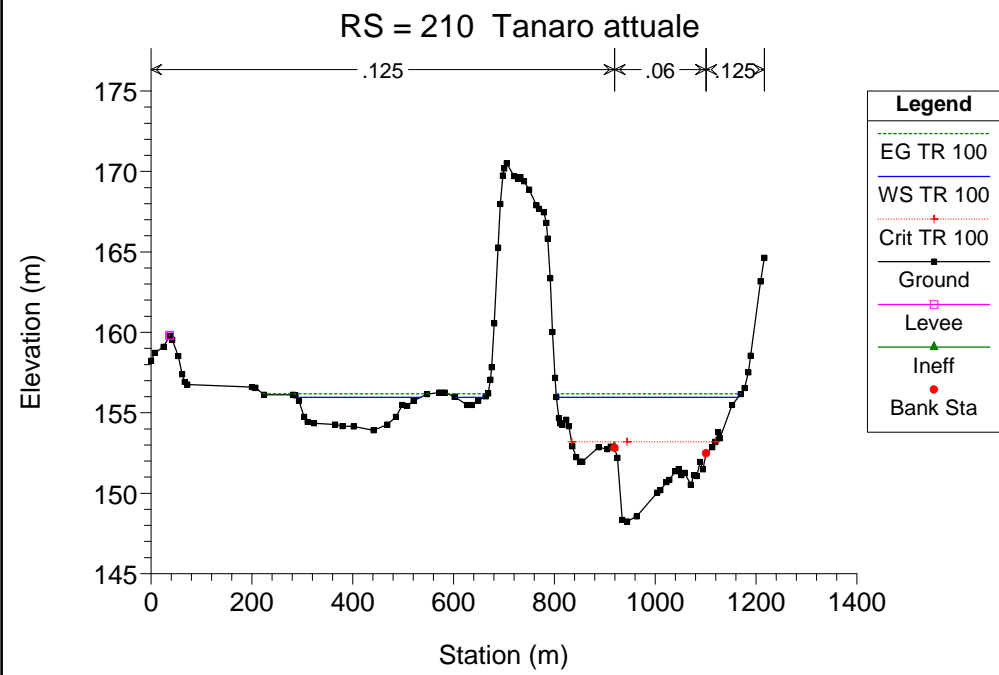
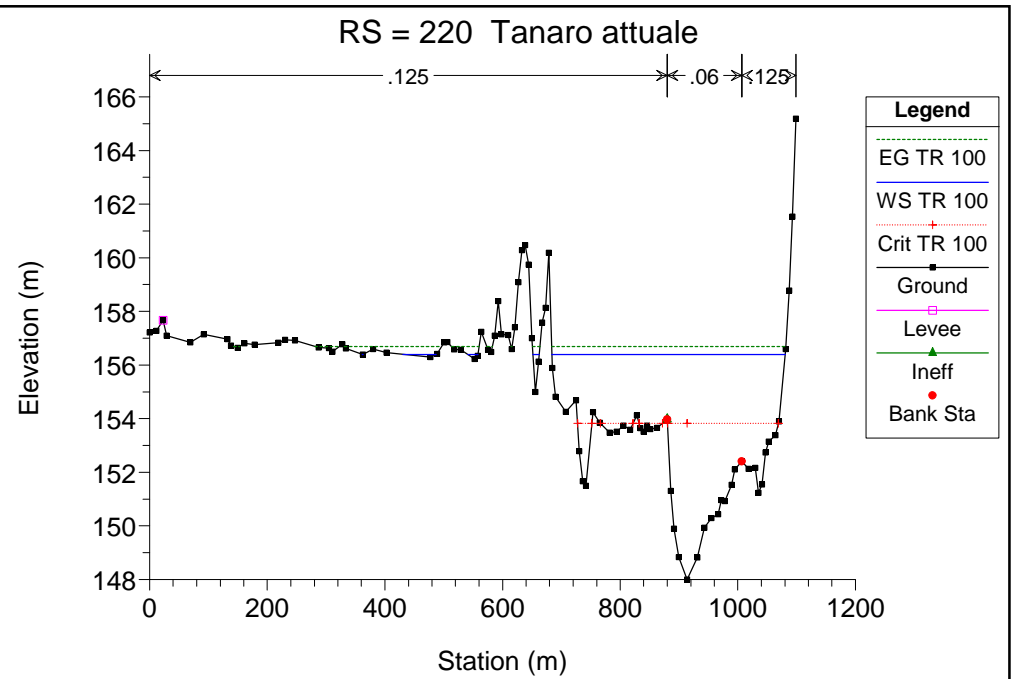
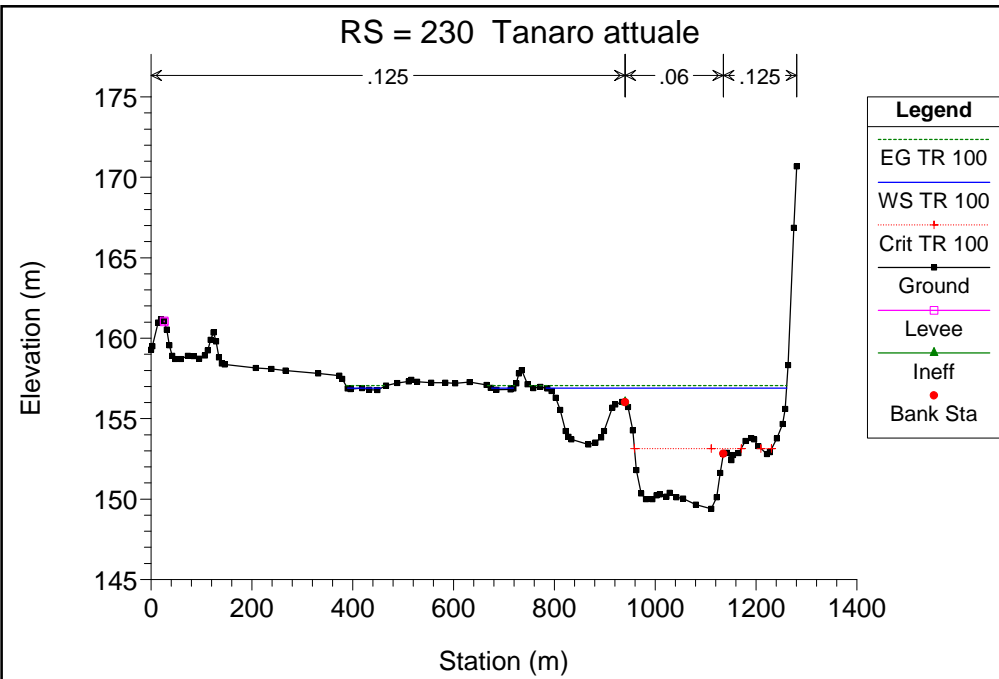


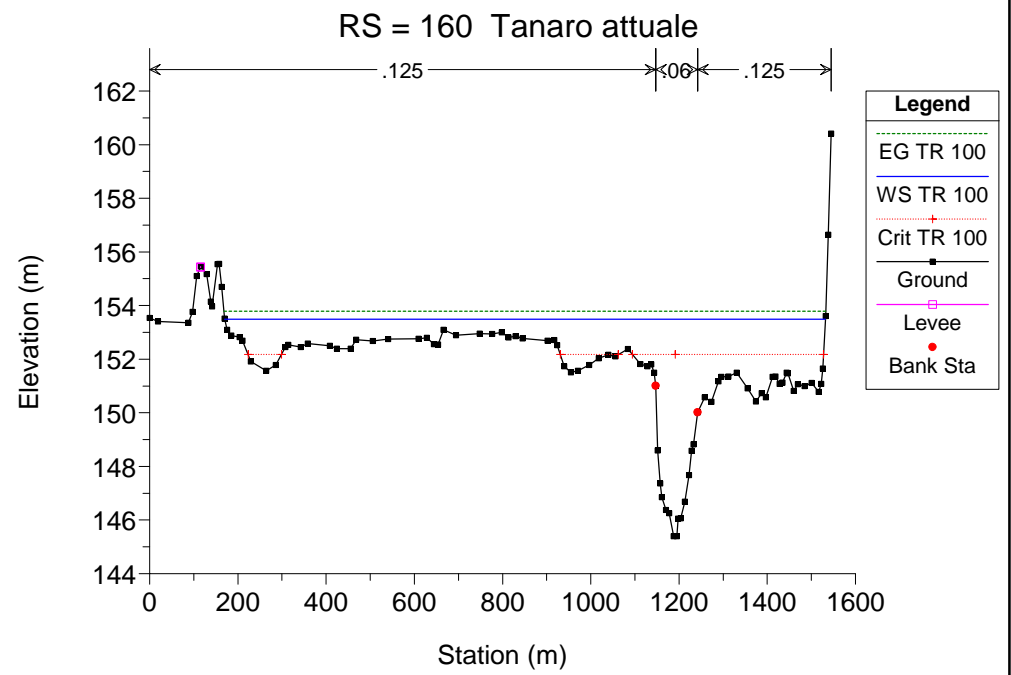
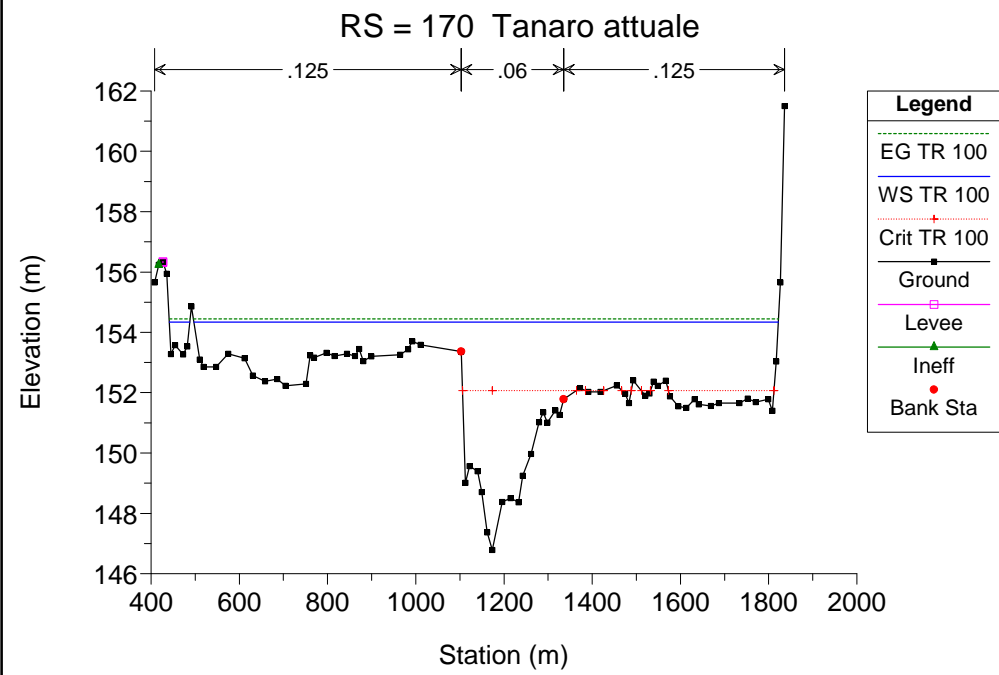
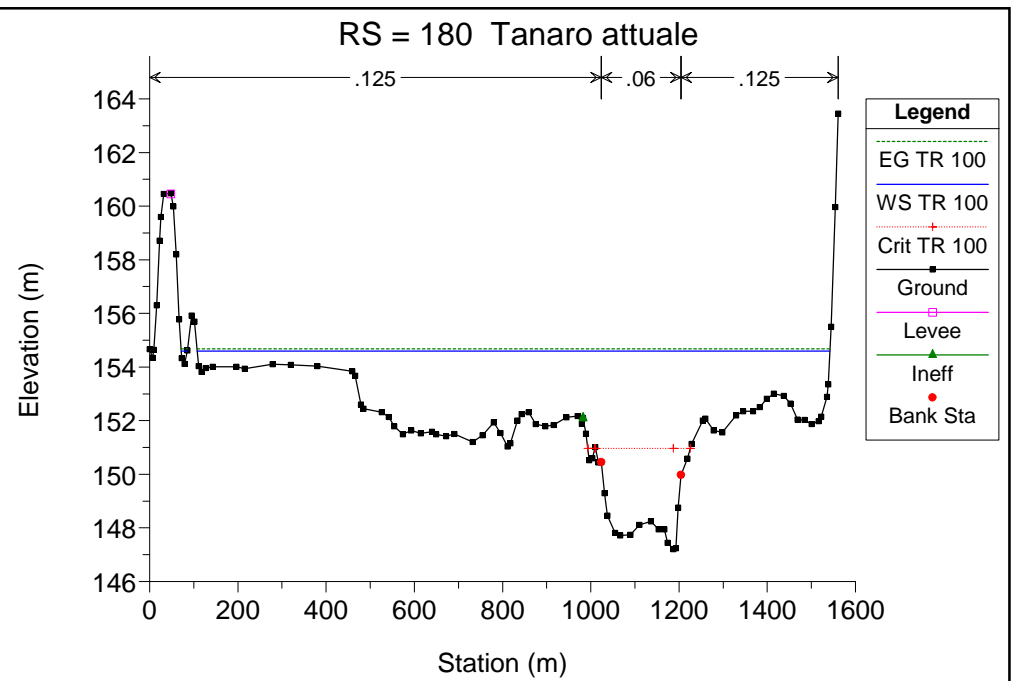
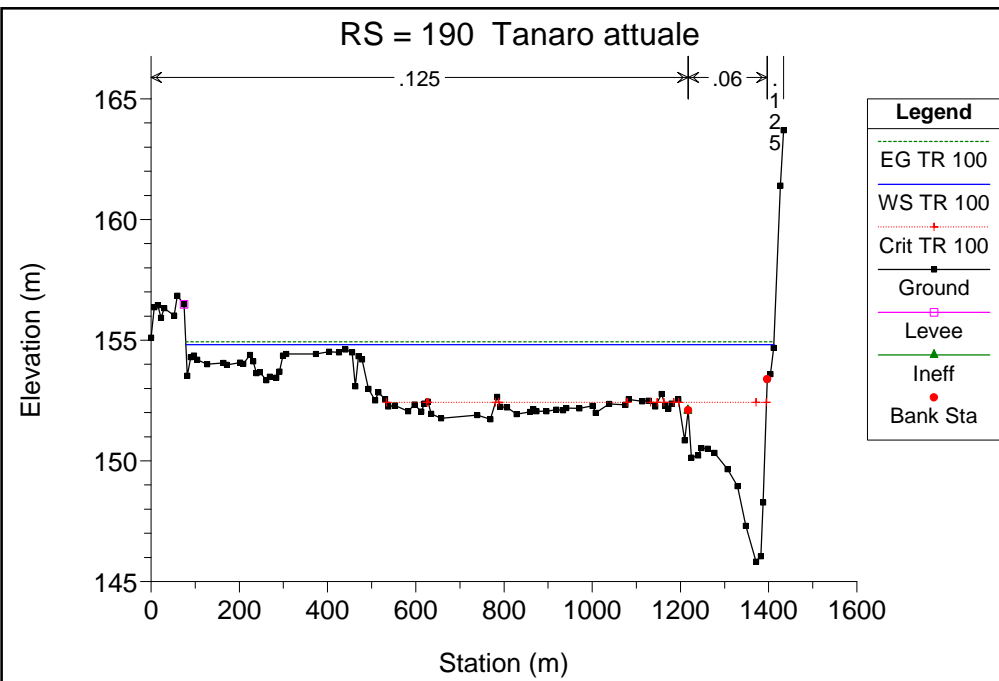


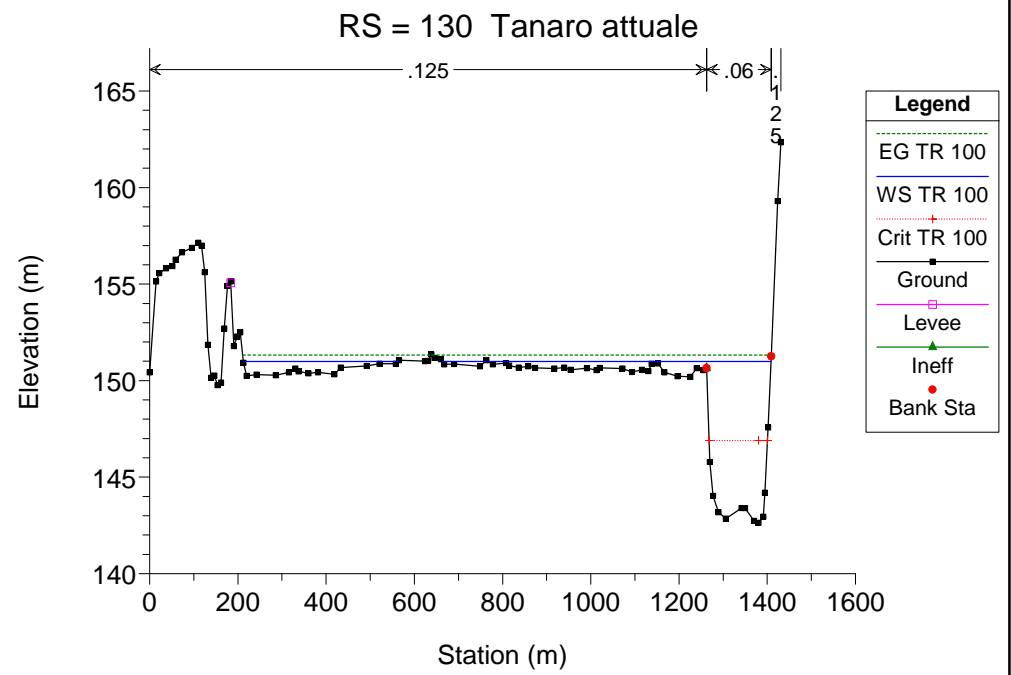
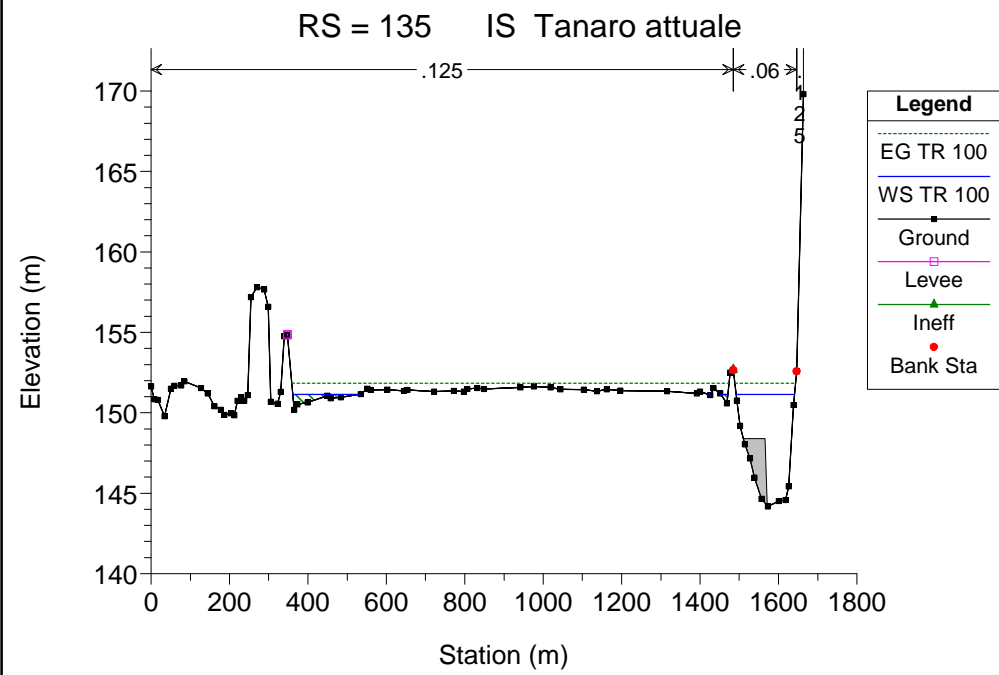
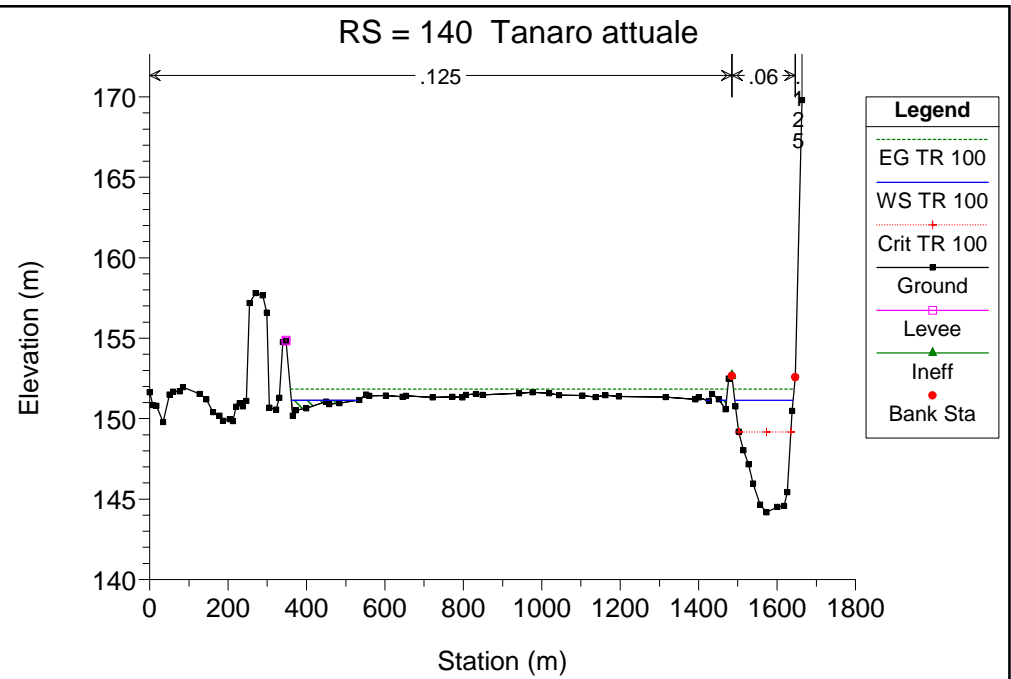
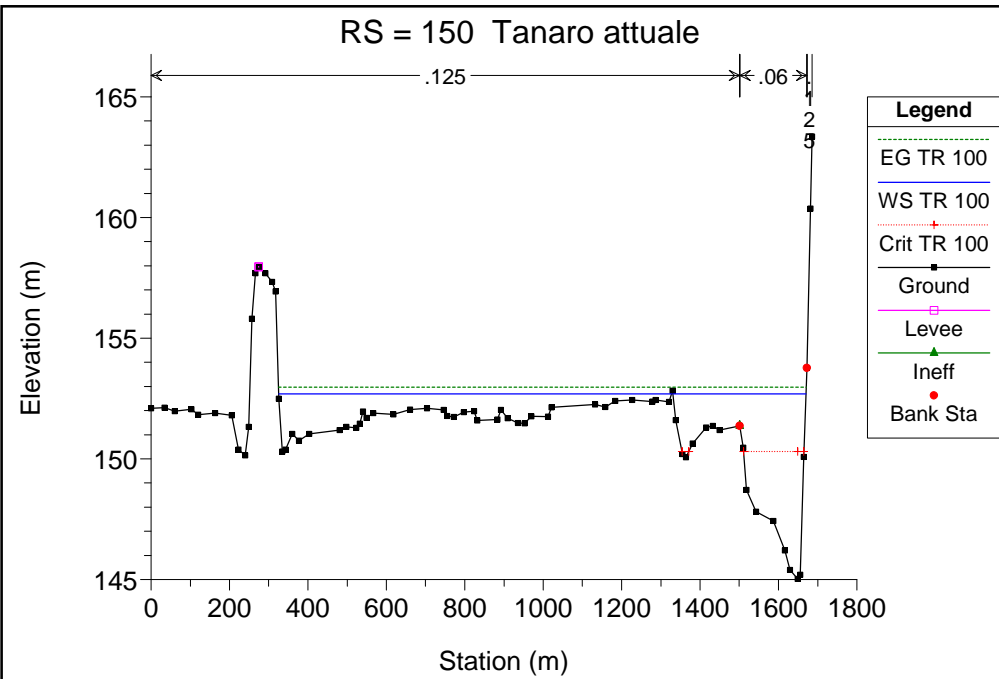


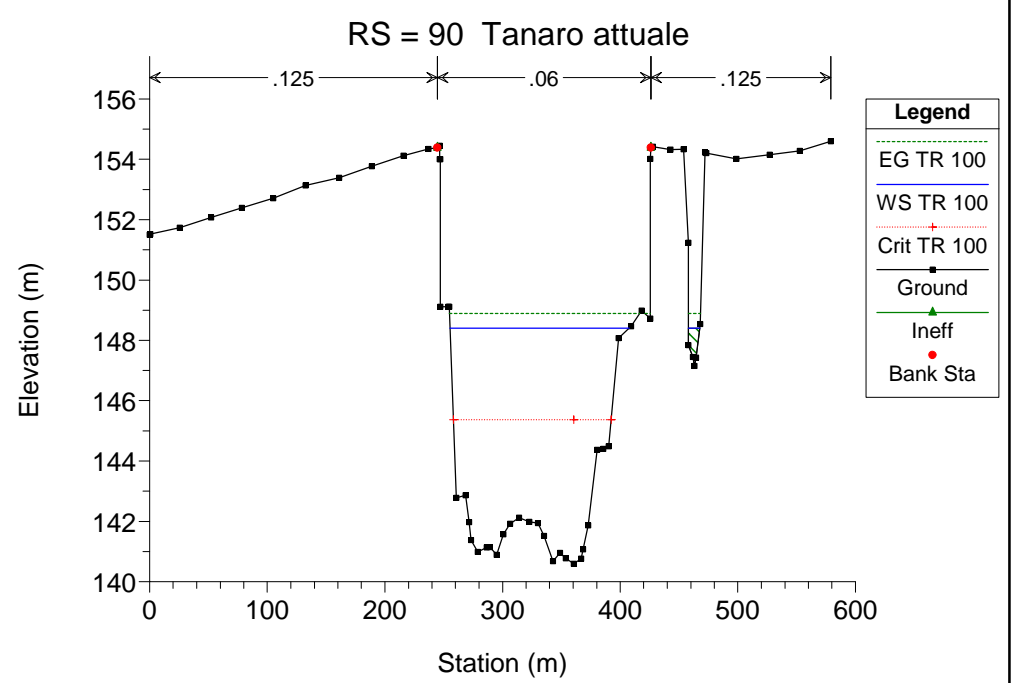
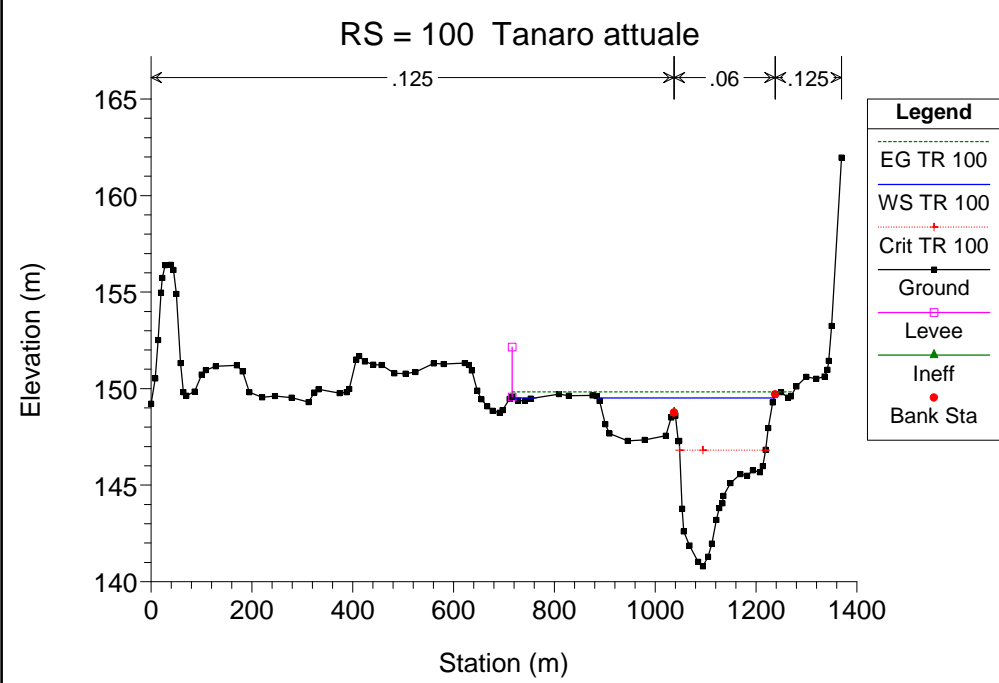
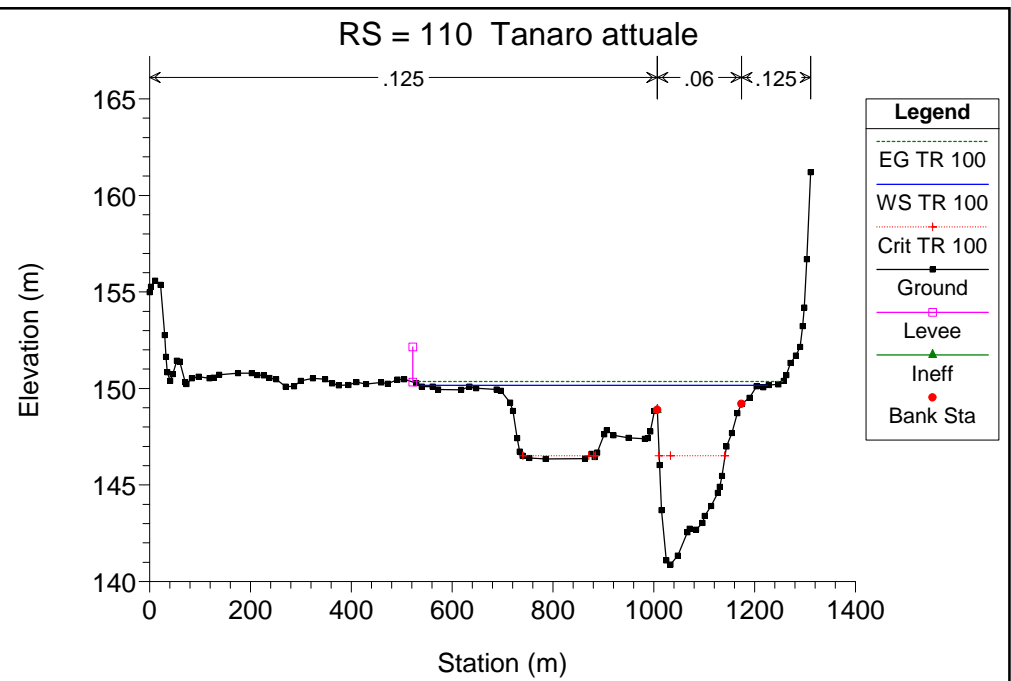
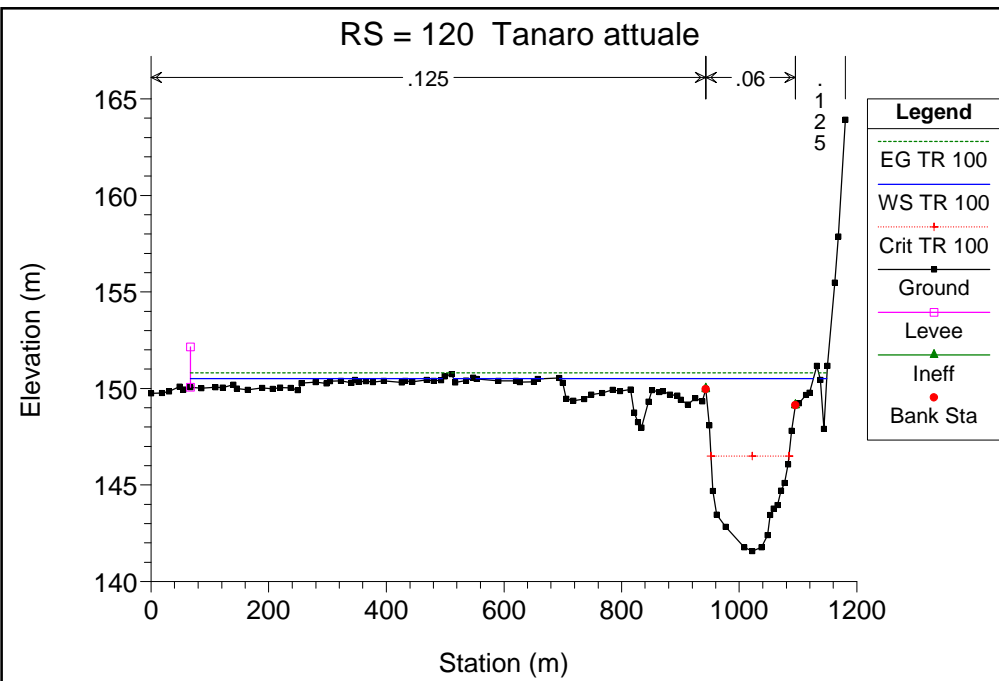


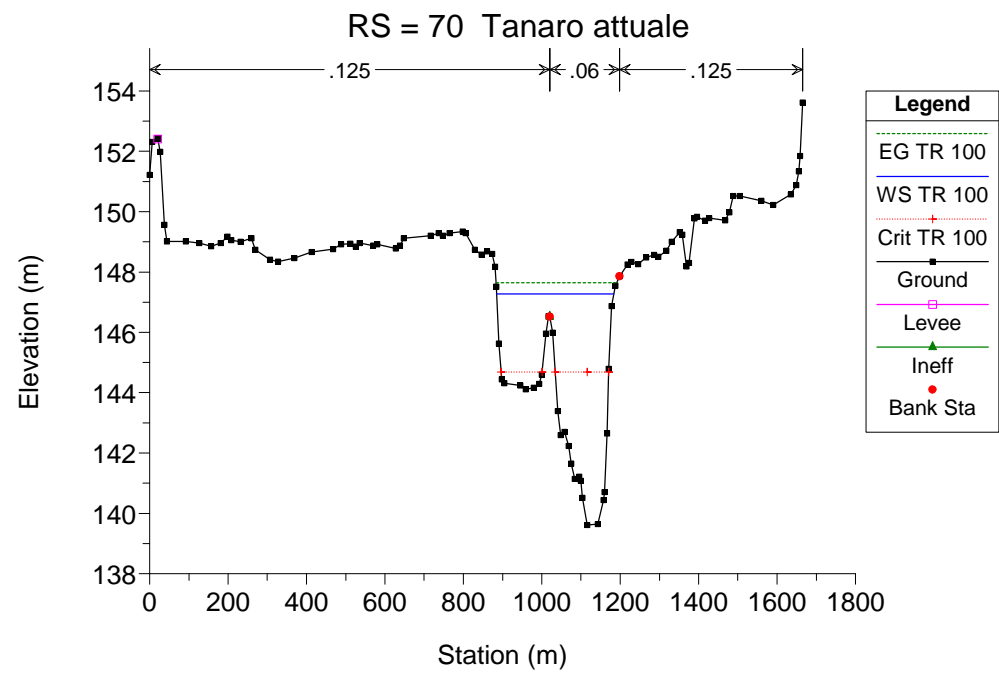
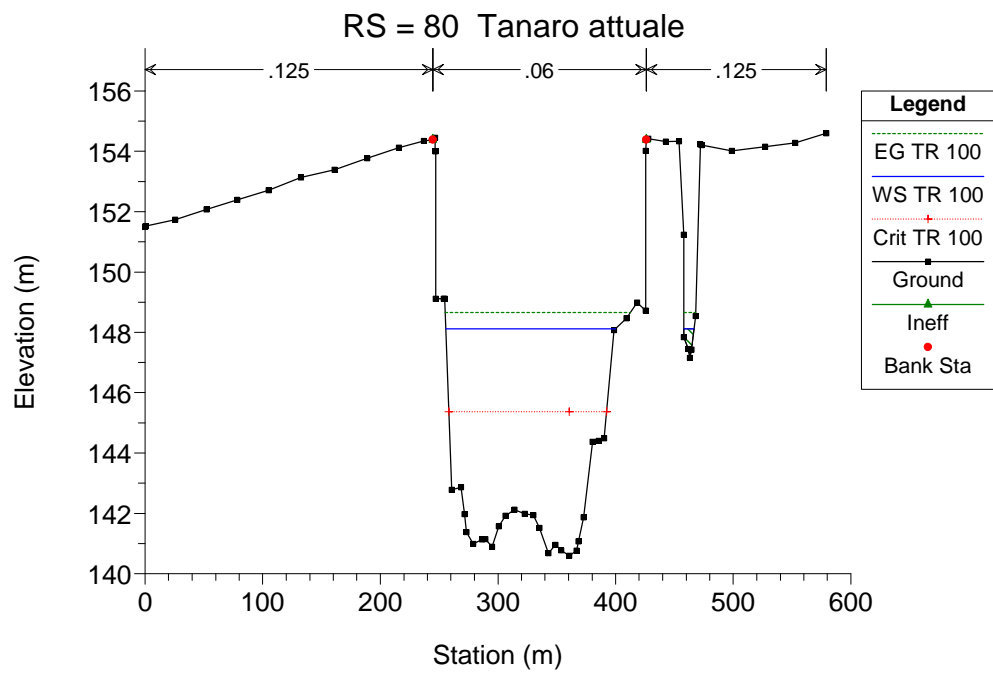
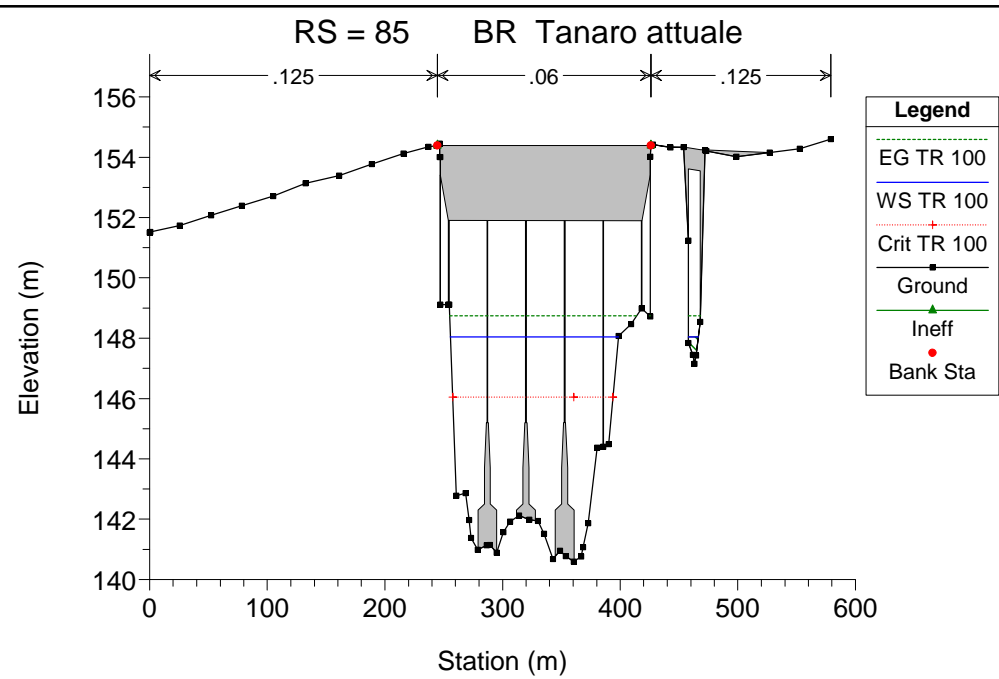
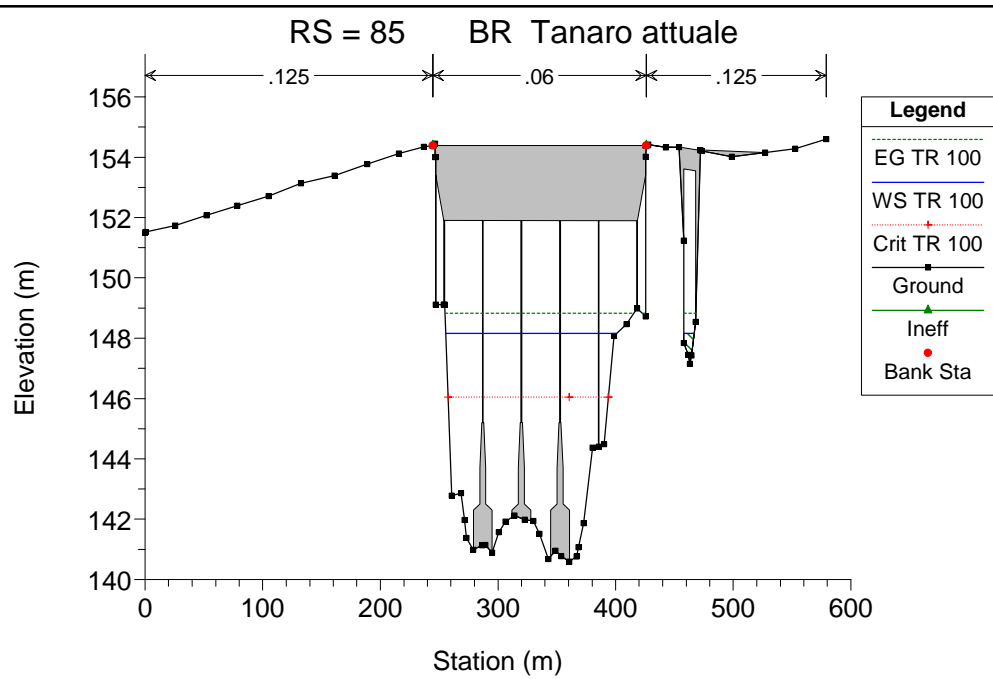


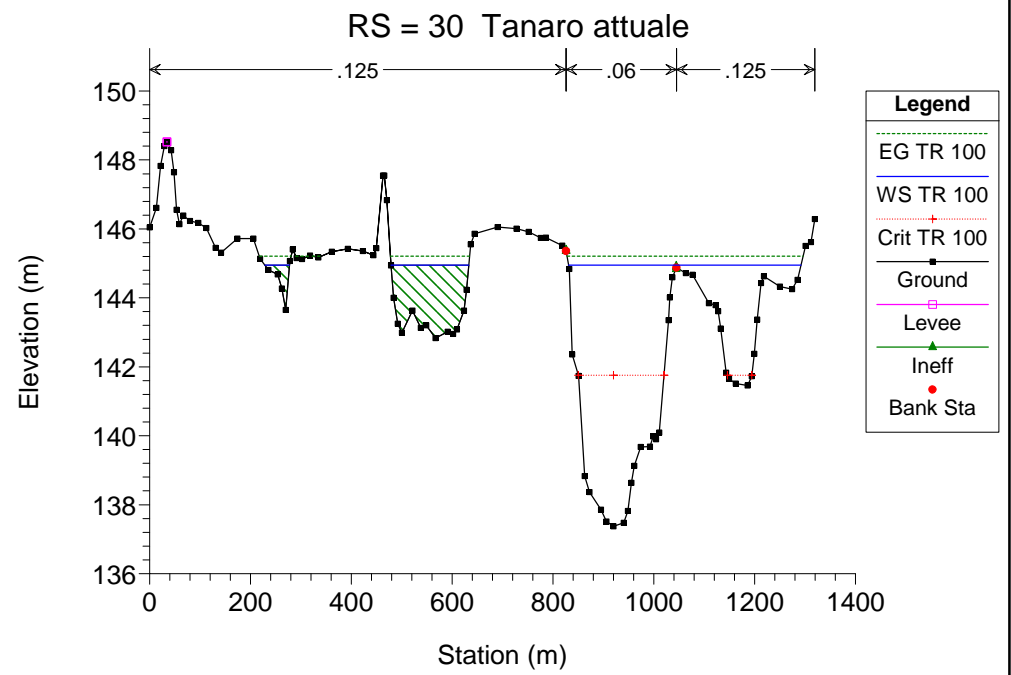
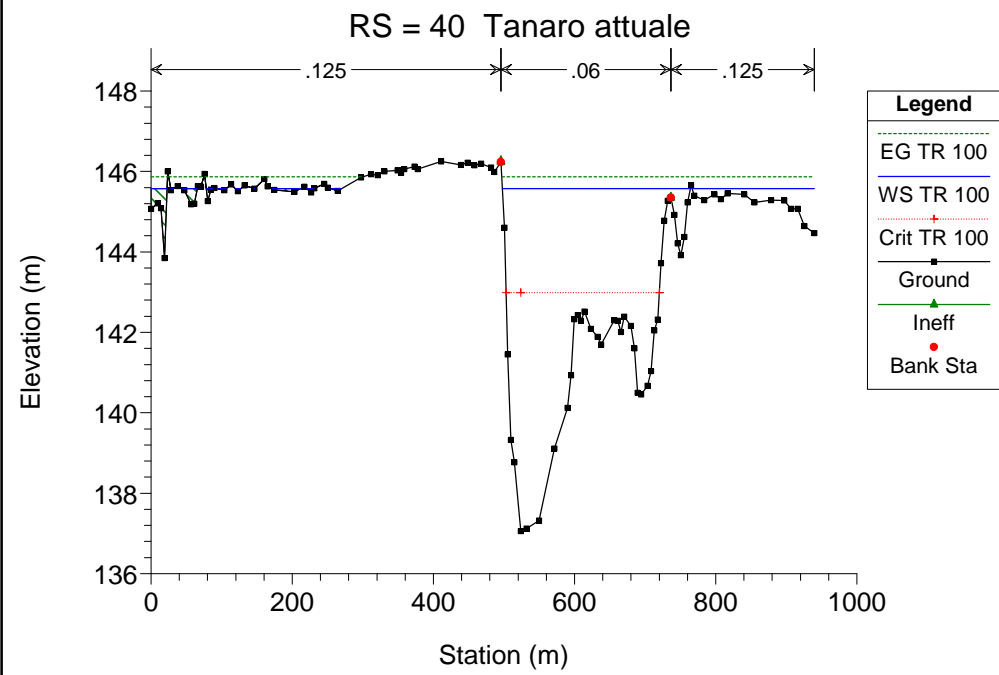
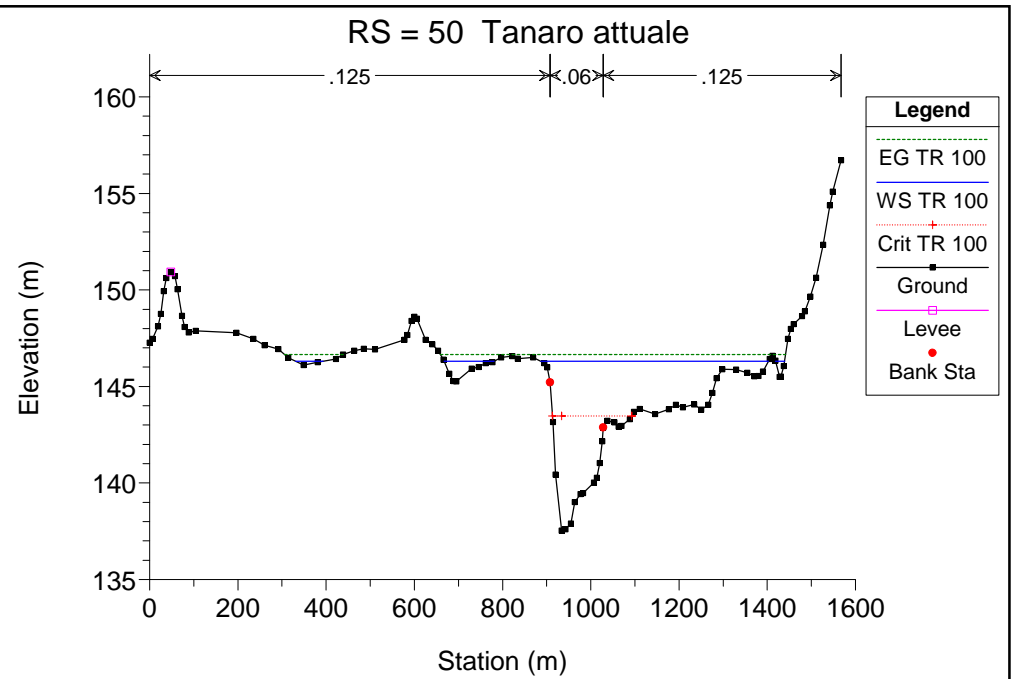
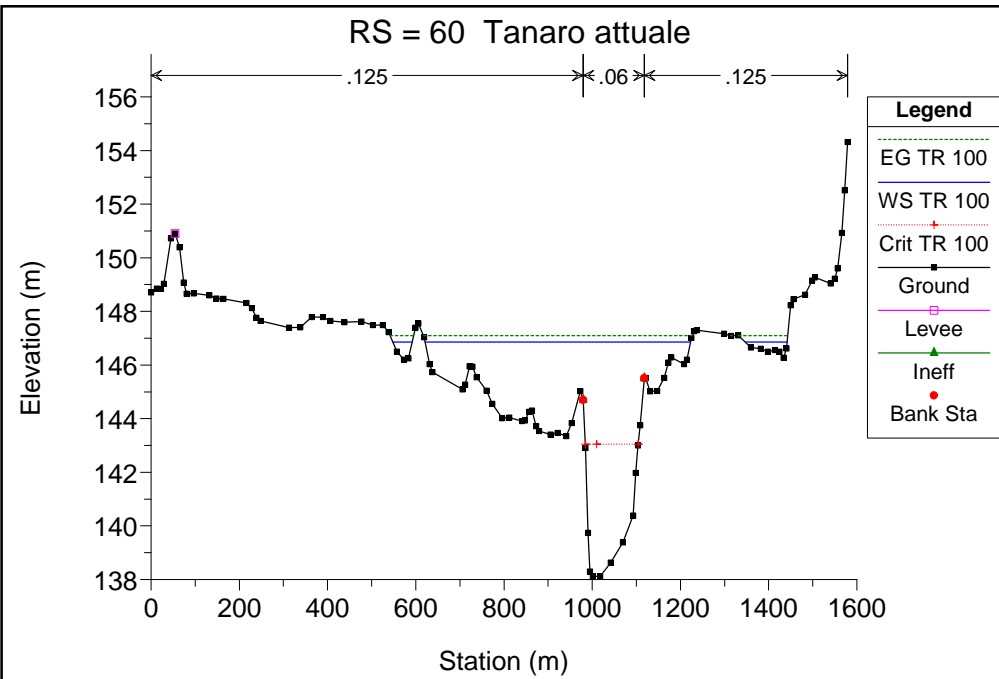


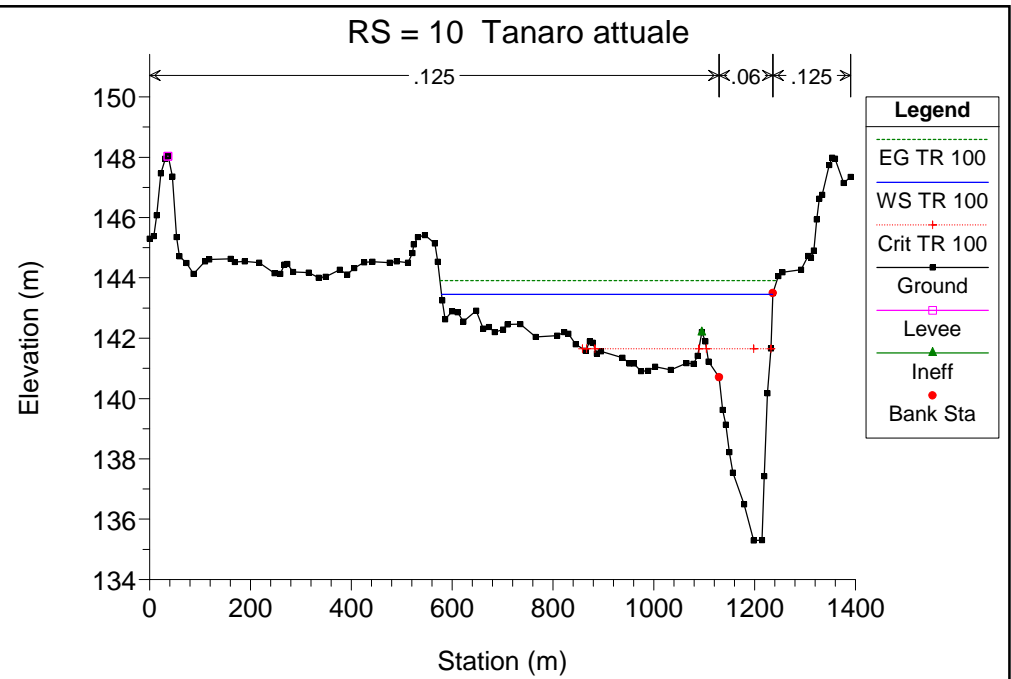
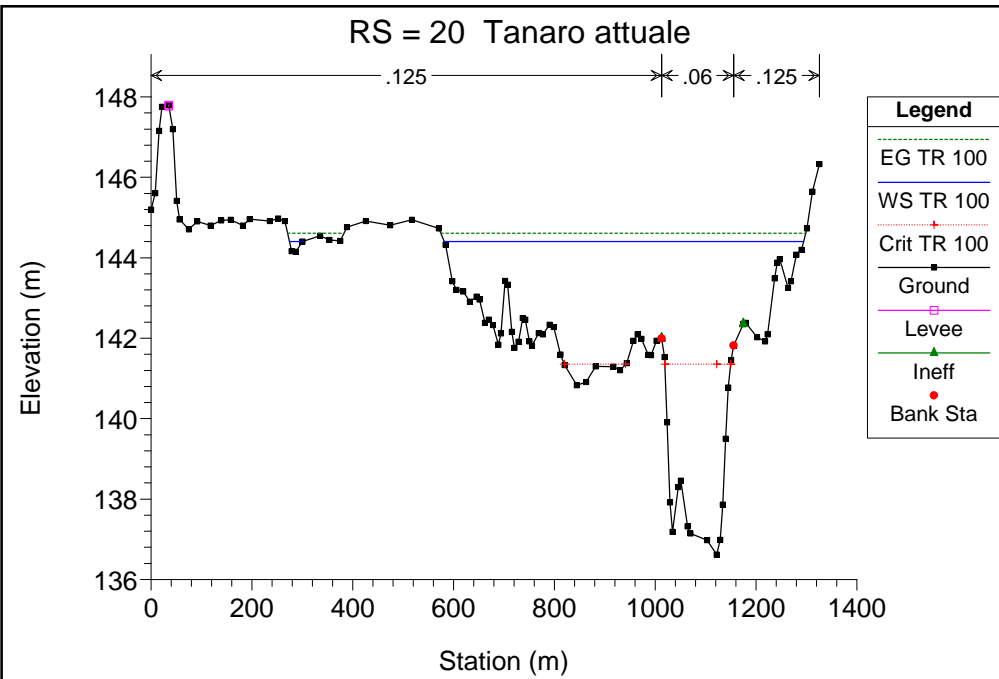












**SITUAZIONE ATTUALE
SIMULAZIONE 3**

corso d'acqua	portata al colmo Q_c m^3/s	tempo di ritorno anni
Fiume Tanaro	3050	200

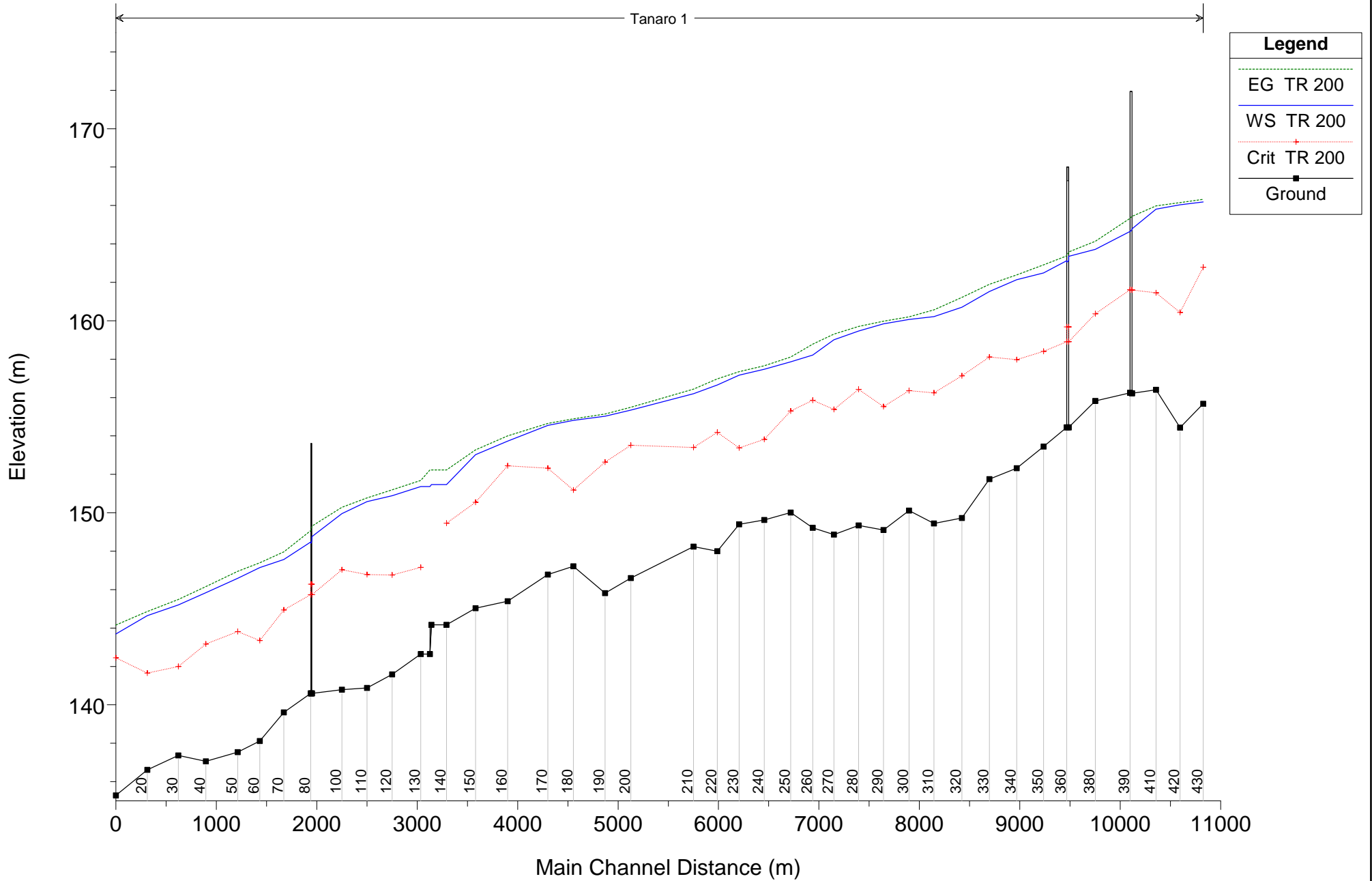
HEC-RAS Plan: Plan 06 River: Tanaro Reach: 1 Profile: TR 200

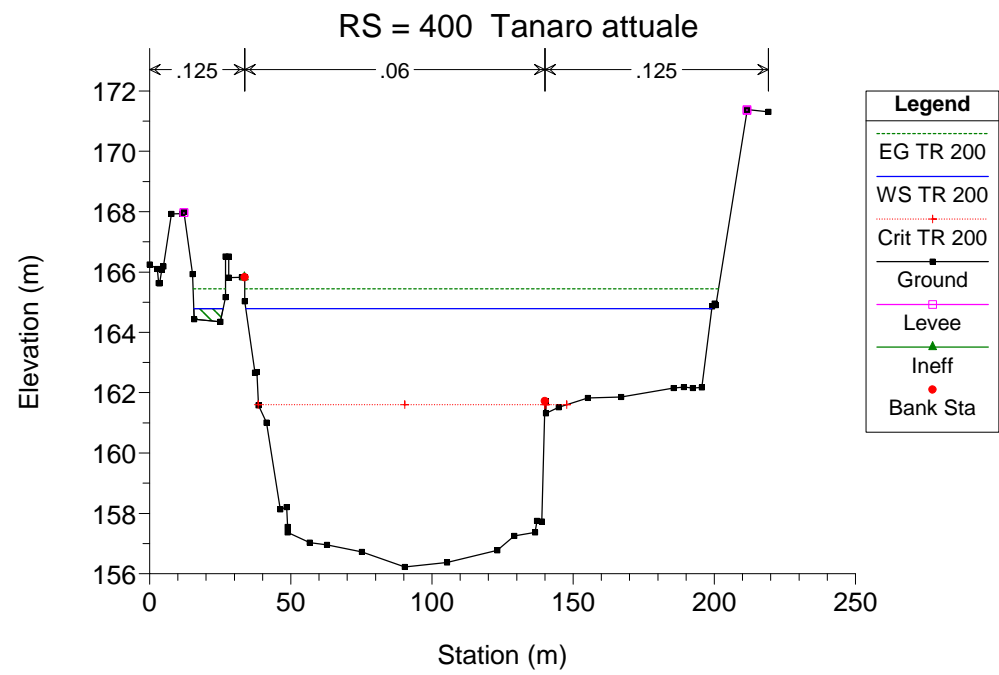
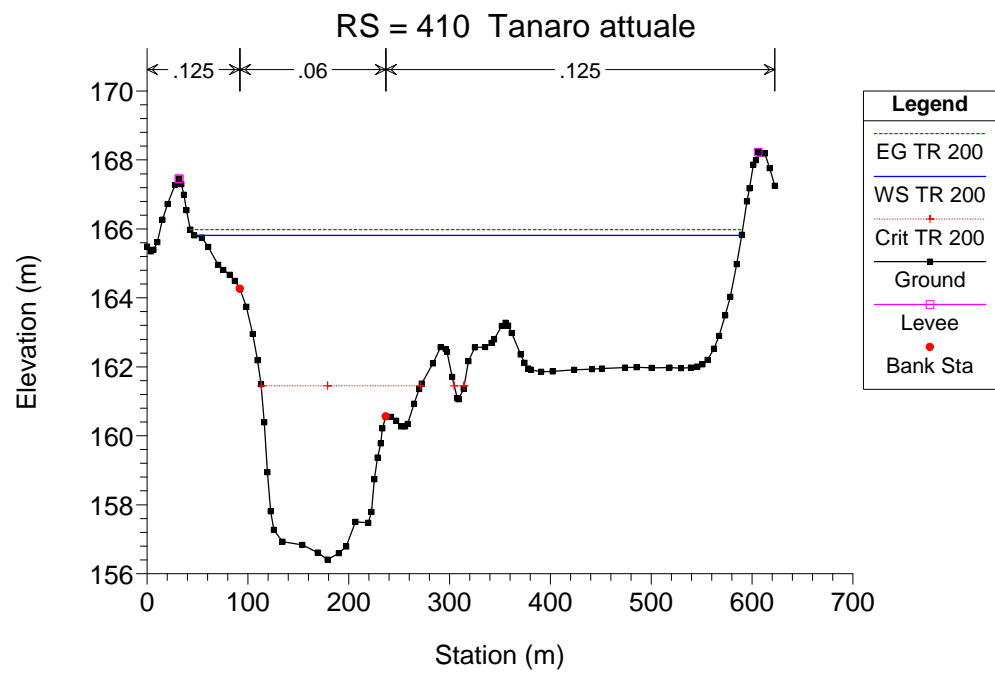
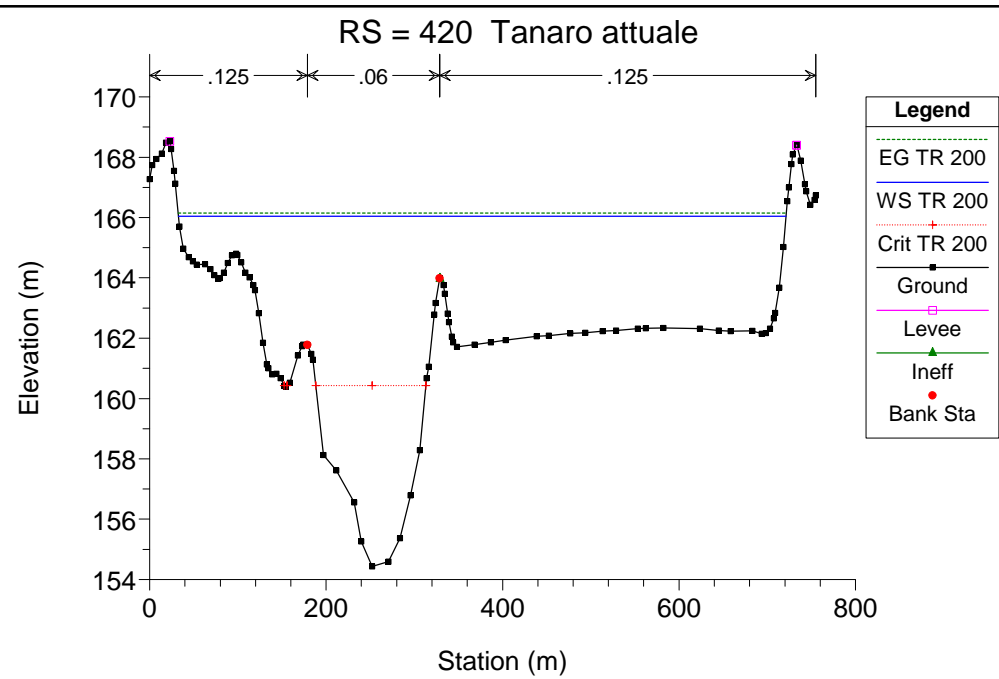
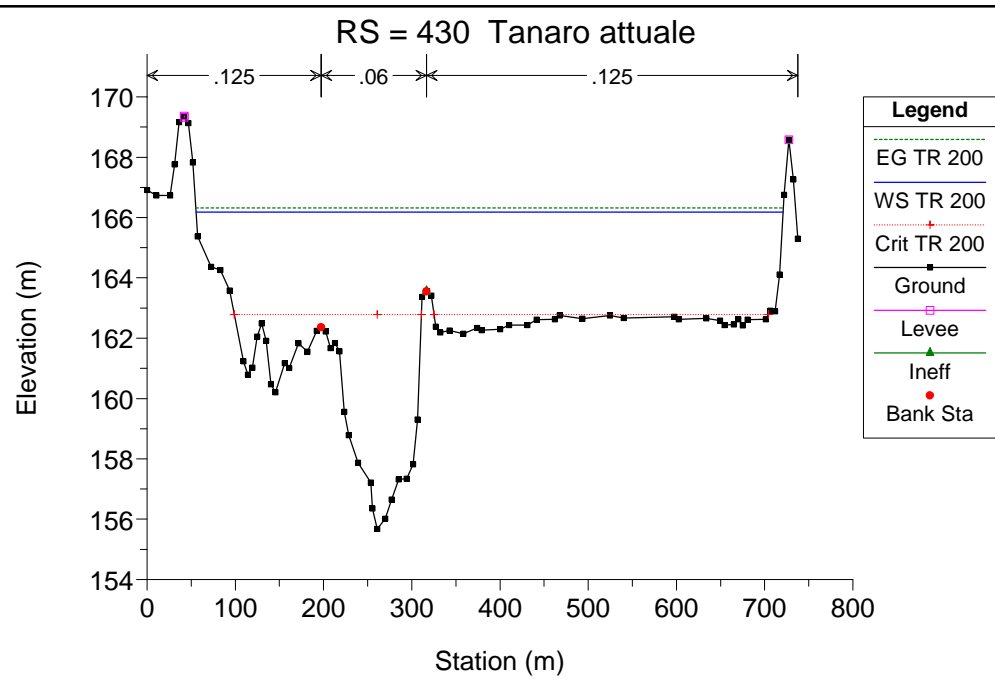
Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
1	430	TR 200	3050.00	155.68	166.18	162.79	166.32	0.001060	2.05	2879.18	665.58	0.24
1	420	TR 200	3050.00	154.44	166.04	160.43	166.15	0.000587	1.69	3200.98	688.79	0.18
1	410	TR 200	3050.00	156.41	165.82	161.45	165.98	0.001023	2.04	2441.66	543.30	0.24
1	400	TR 200	3050.00	156.22	164.79	161.61	165.44	0.003589	3.67	954.14	175.43	0.43
1	395		Bridge									
1	390	TR 200	3050.00	156.25	164.65	161.61	165.33	0.003835	3.75	930.92	174.67	0.44
1	380	TR 200	3050.00	155.82	163.72	160.36	164.14	0.002497	2.86	1103.57	226.25	0.36
1	370	TR 200	3050.00	154.45	163.36	158.91	163.59	0.001258	2.12	1438.99	207.00	0.26
1	365		Bridge									
1	360	TR 200	3050.00	154.45	163.13	158.91	163.37	0.001400	2.19	1391.40	206.36	0.27
1	350	TR 200	3050.00	153.45	162.49	158.40	162.91	0.002286	2.88	1094.50	270.07	0.35
1	340	TR 200	3050.00	152.32	162.14	157.98	162.39	0.001397	2.24	1513.06	384.70	0.27
1	330	TR 200	3050.00	151.75	161.53	158.11	161.90	0.002270	2.76	1347.75	433.38	0.34
1	320	TR 200	3050.00	149.73	160.70	157.14	161.21	0.002662	3.39	1465.66	581.57	0.38
1	310	TR 200	3050.00	149.44	160.22	156.24	160.56	0.001906	2.94	2107.79	821.93	0.32
1	300	TR 200	3050.00	150.11	160.06	156.36	160.20	0.000919	1.91	2964.55	873.63	0.22
1	290	TR 200	3050.00	149.10	159.84	155.53	159.98	0.000881	1.77	2523.33	770.26	0.21
1	280	TR 200	3050.00	149.34	159.46	156.43	159.70	0.001553	2.44	2184.51	781.09	0.29
1	270	TR 200	3050.00	148.86	159.01	155.38	159.30	0.001792	2.74	1985.04	774.43	0.31
1	260	TR 200	3050.00	149.22	158.21	155.86	158.78	0.003356	3.58	1358.82	519.00	0.42
1	250	TR 200	3050.00	150.01	157.86	155.31	158.11	0.002195	2.51	1980.16	561.31	0.33
1	240	TR 200	3050.00	149.63	157.48	153.83	157.66	0.001293	2.14	2438.57	771.72	0.26
1	230	TR 200	3050.00	149.40	157.17	153.38	157.34	0.001202	2.01	2176.67	684.36	0.25
1	220	TR 200	3050.00	148.00	156.65	154.19	156.97	0.002418	2.83	1725.43	663.22	0.36
1	210	TR 200	3050.00	148.24	156.20	153.41	156.43	0.001859	2.35	2023.04	784.36	0.31
1	200	TR 200	3050.00	146.60	155.34	153.52	155.50	0.001466	2.25	3119.02	1099.95	0.28
1	190	TR 200	3050.00	145.82	155.03	152.64	155.14	0.001159	1.83	3520.07	1333.93	0.24
1	180	TR 200	3050.00	147.21	154.81	151.18	154.89	0.000723	1.60	4135.11	1452.26	0.20
1	170	TR 200	3050.00	146.78	154.55	152.32	154.65	0.001233	1.72	3400.41	1376.56	0.24
1	160	TR 200	3050.00	145.40	153.74	152.44	154.01	0.002522	2.93	2659.67	1363.97	0.36
1	150	TR 200	3050.00	145.03	153.03	150.54	153.27	0.002302	2.48	2490.65	1346.24	0.34
1	140	TR 200	3050.00	144.17	151.47	149.45	152.23	0.005967	3.85	791.85	1020.54	0.54
1	135		Inl Struct									
1	130	TR 200	3050.00	142.64	151.36	147.16	151.68	0.001743	2.61	1835.08	1198.59	0.31
1	120	TR 200	3050.00	141.58	150.88	146.76	151.19	0.001720	2.56	1865.89	1077.38	0.30
1	110	TR 200	3050.00	140.88	150.56	146.78	150.76	0.001470	2.21	2292.19	738.68	0.28
1	100	TR 200	3050.00	140.79	149.93	147.04	150.26	0.002630	2.62	1499.38	560.27	0.36
1	90	TR 200	3050.00	140.59	148.77	145.63	149.30	0.003607	3.21	949.70	171.38	0.42
1	85		Bridge									
1	80	TR 200	3050.00	140.59	148.46	145.63	149.05	0.004045	3.38	901.06	163.80	0.45

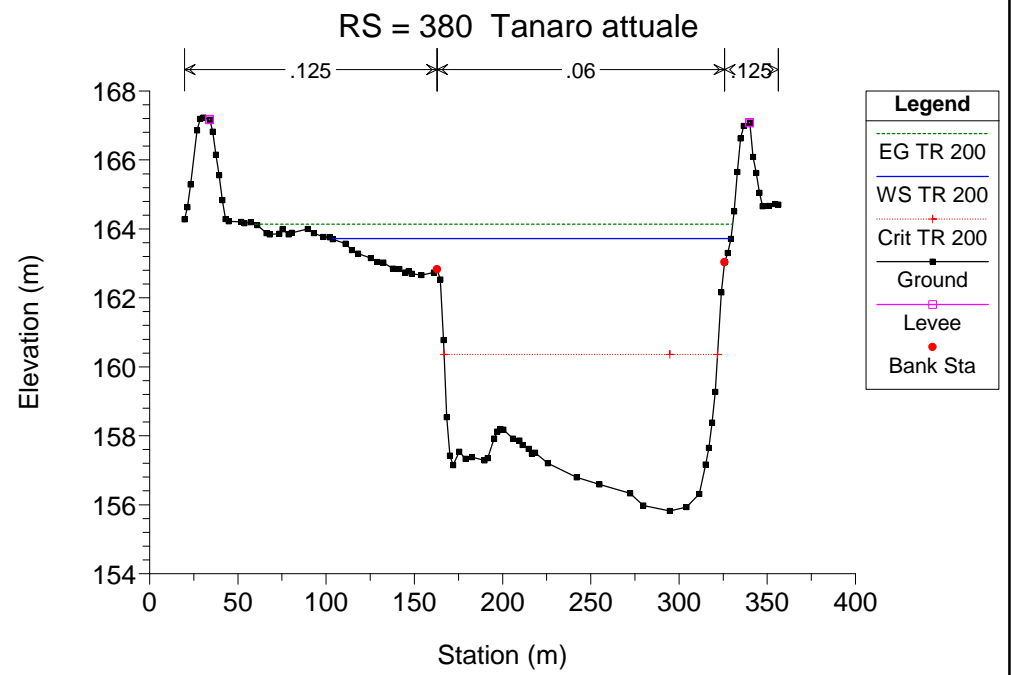
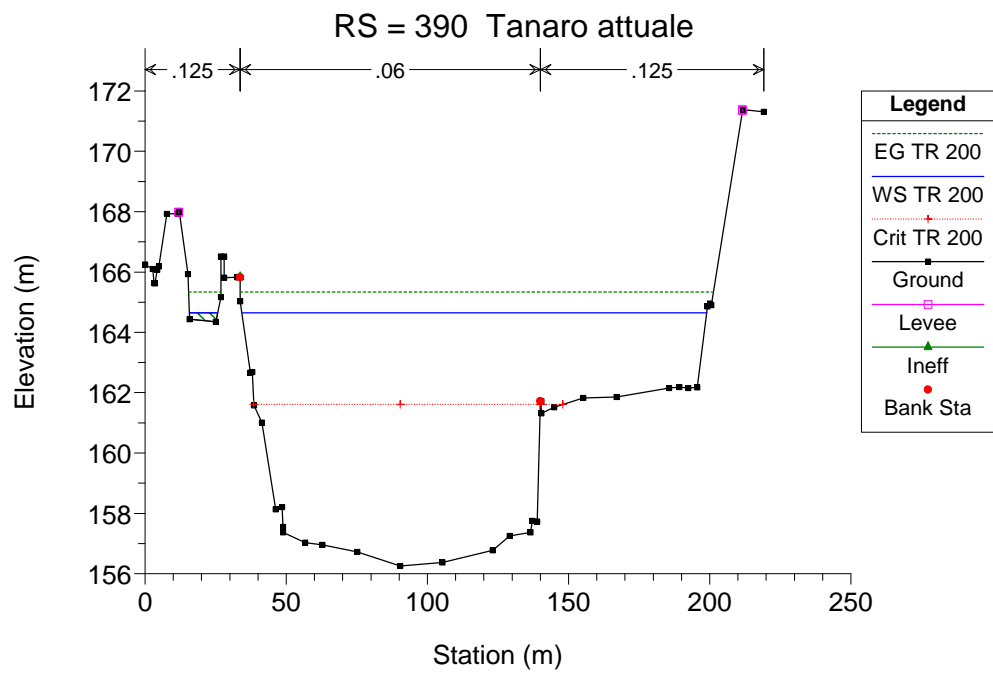
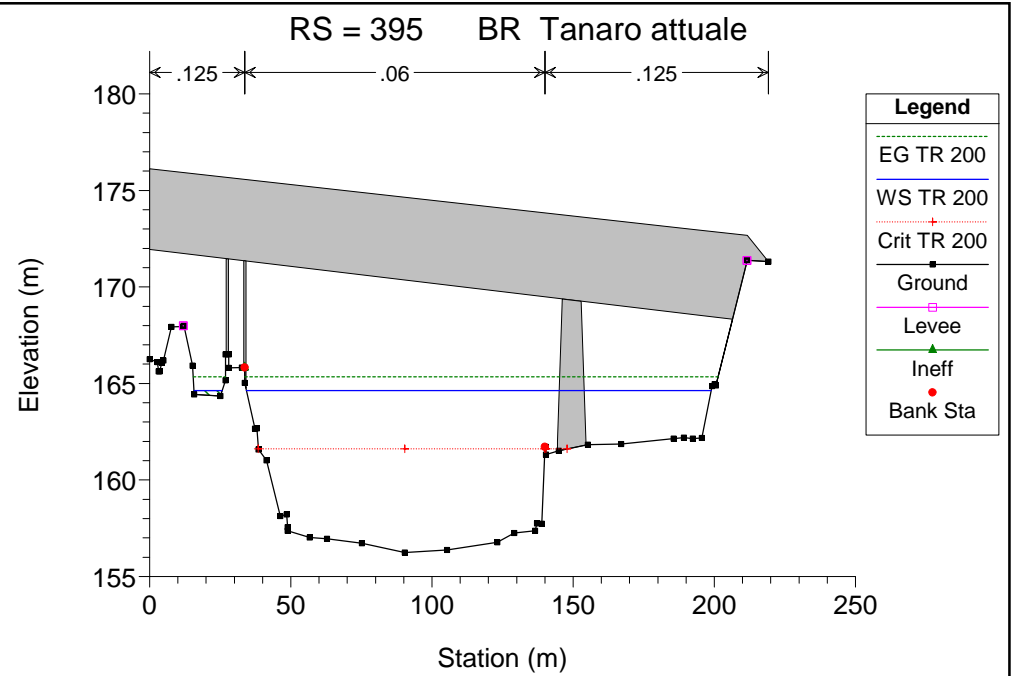
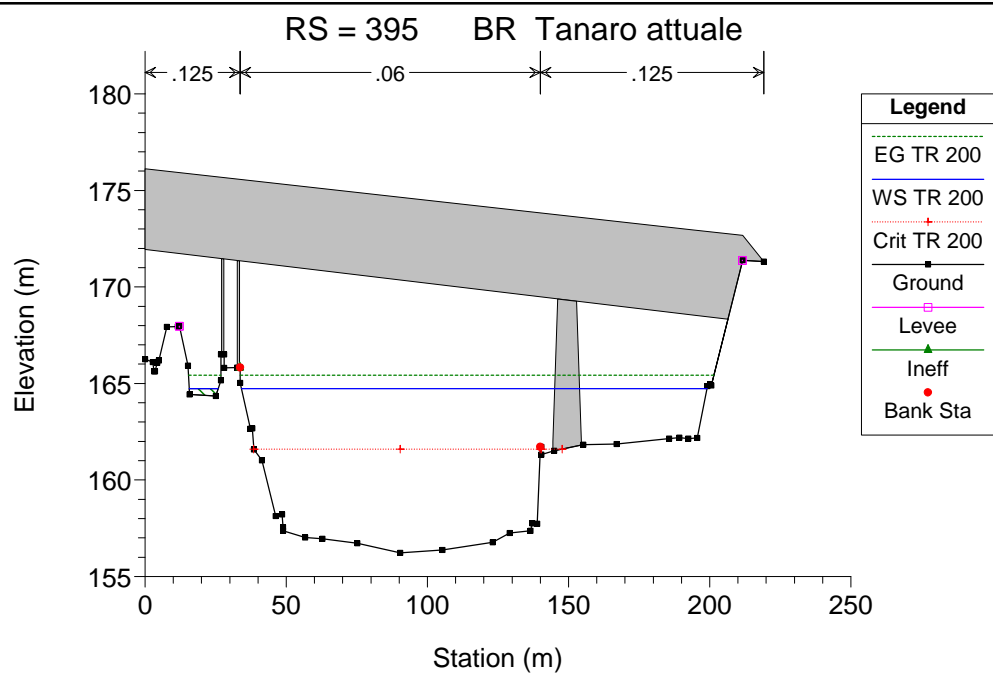
HEC-RAS Plan: Plan 06 River: Tanaro Reach: 1 Profile: TR 200 (Continued)

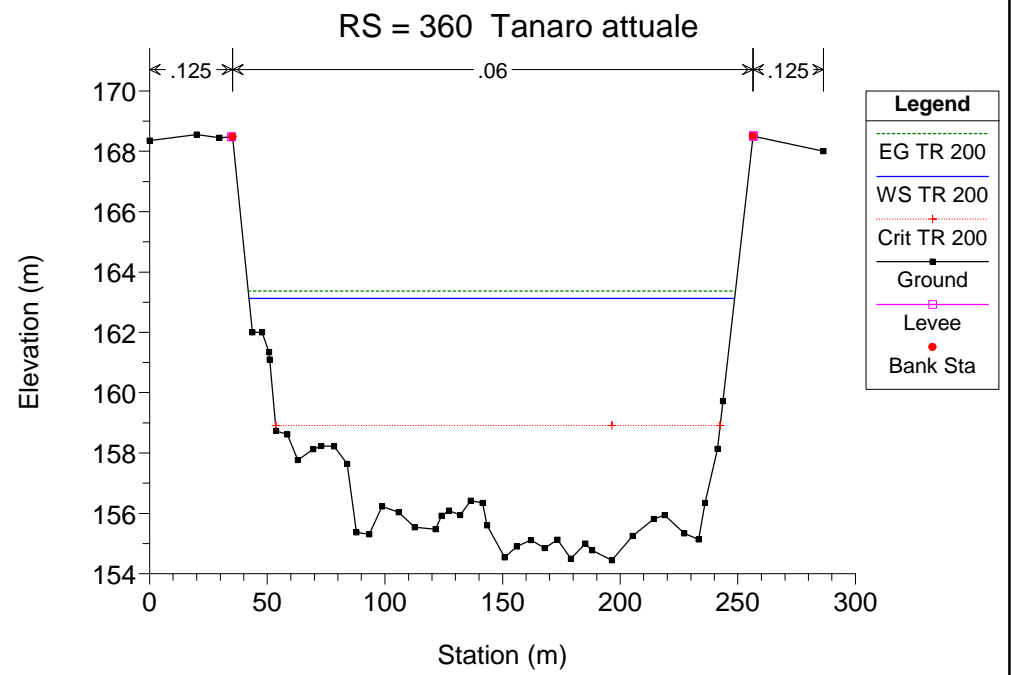
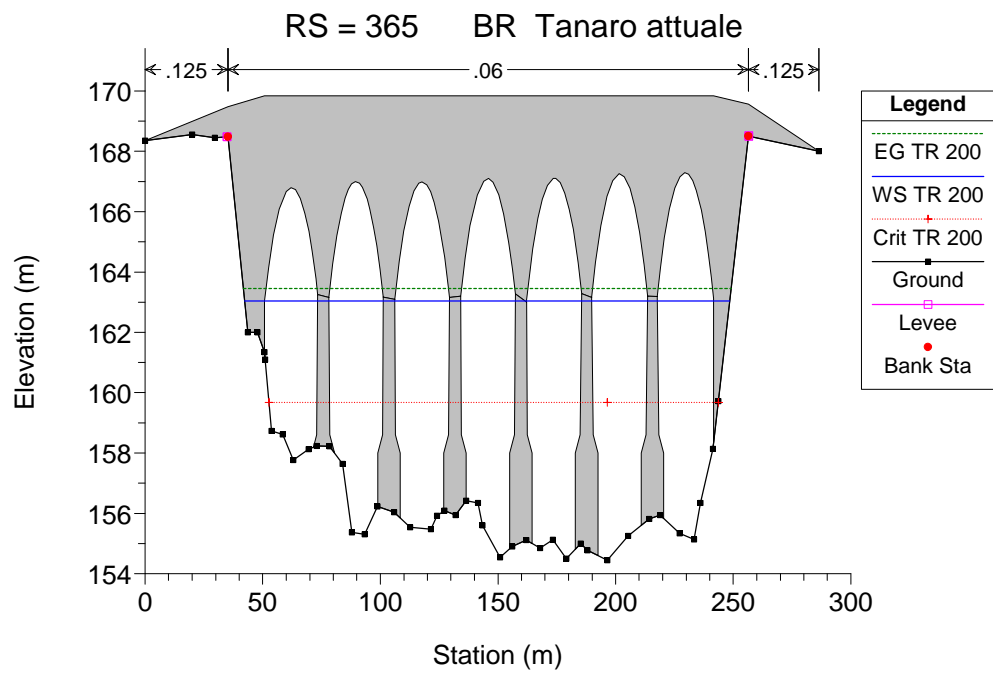
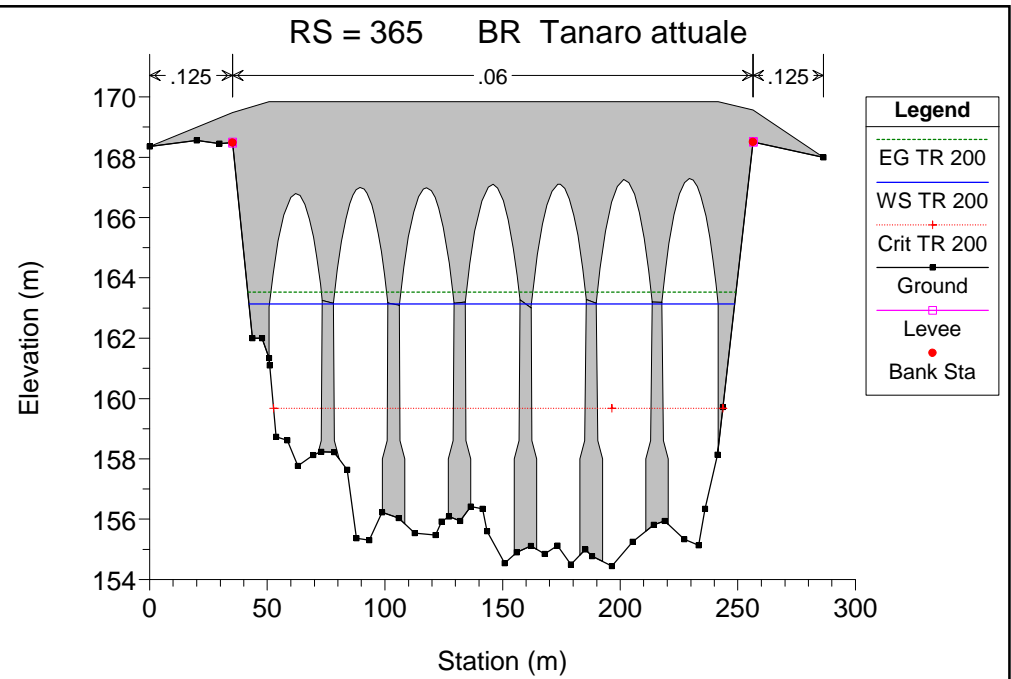
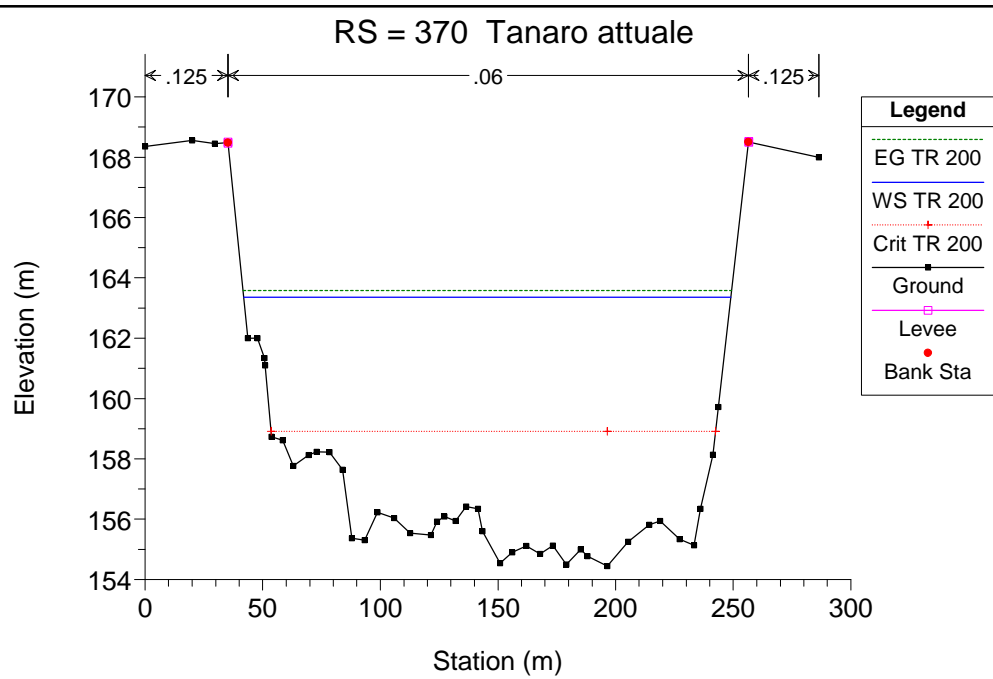
Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
1	70	TR 200	3050.00	139.61	147.57	144.94	147.96	0.003351	2.95	1306.12	304.63	0.41
1	60	TR 200	3050.00	138.12	147.15	143.35	147.39	0.001561	2.44	2161.93	808.92	0.29
1	50	TR 200	3050.00	137.54	146.58	143.82	146.95	0.002450	2.96	1823.04	903.93	0.36
1	40	TR 200	3050.00	137.06	145.84	143.17	146.16	0.002700	2.51	1335.66	734.96	0.36
1	30	TR 200	3050.00	137.37	145.20	141.99	145.48	0.002222	2.42	1574.30	727.26	0.33
1	20	TR 200	3050.00	136.62	144.64	141.66	144.86	0.001718	2.40	2328.51	839.27	0.30
1	10	TR 200	3050.00	135.29	143.69	142.45	144.15	0.004002	3.48	1679.28	662.46	0.45

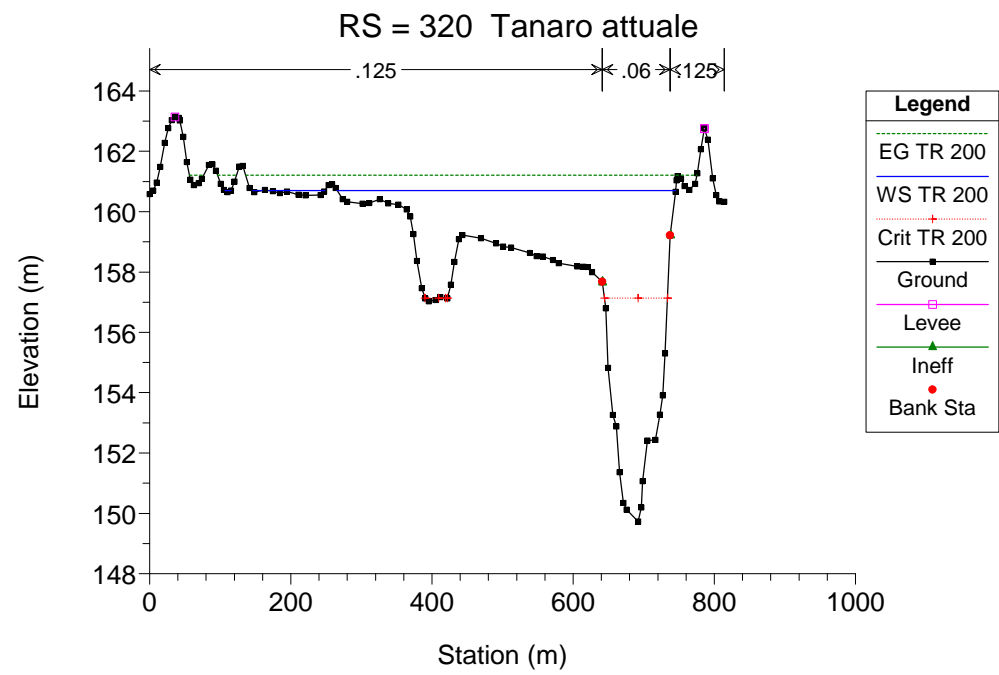
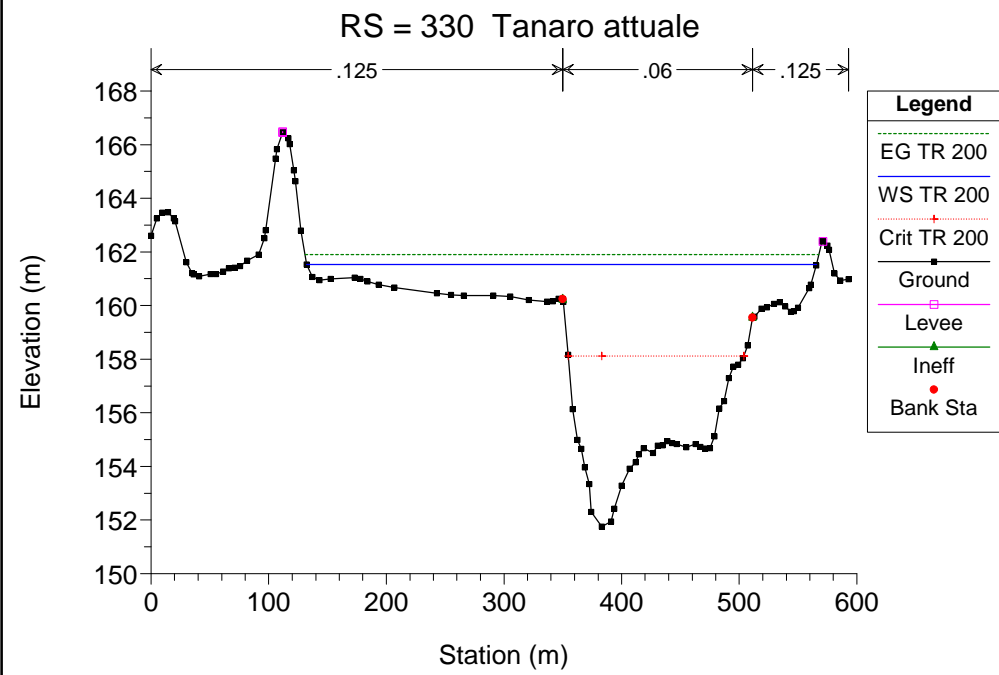
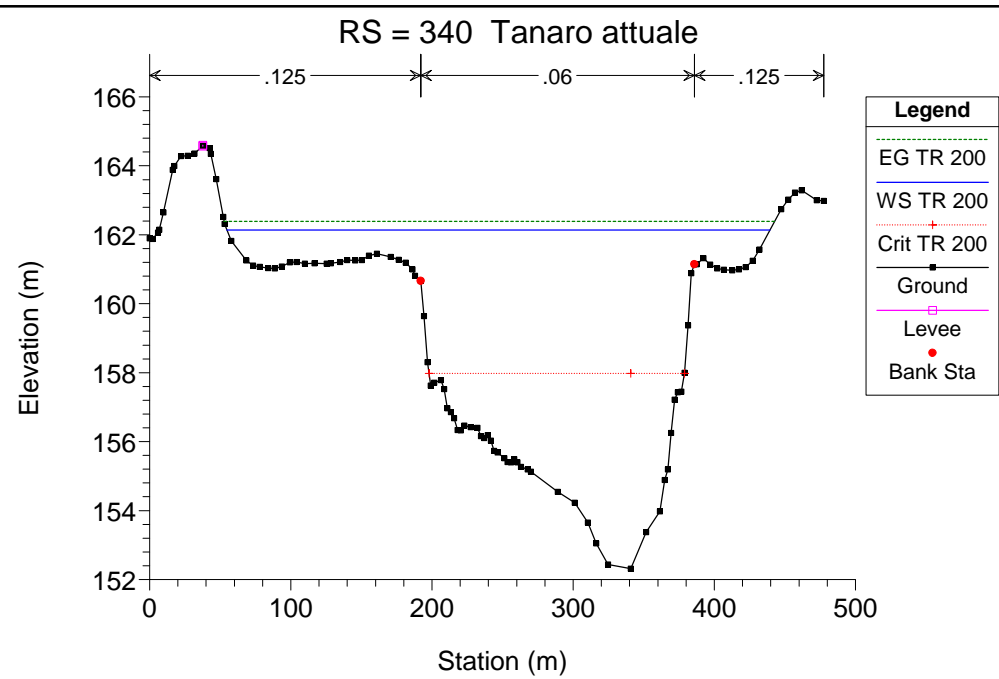
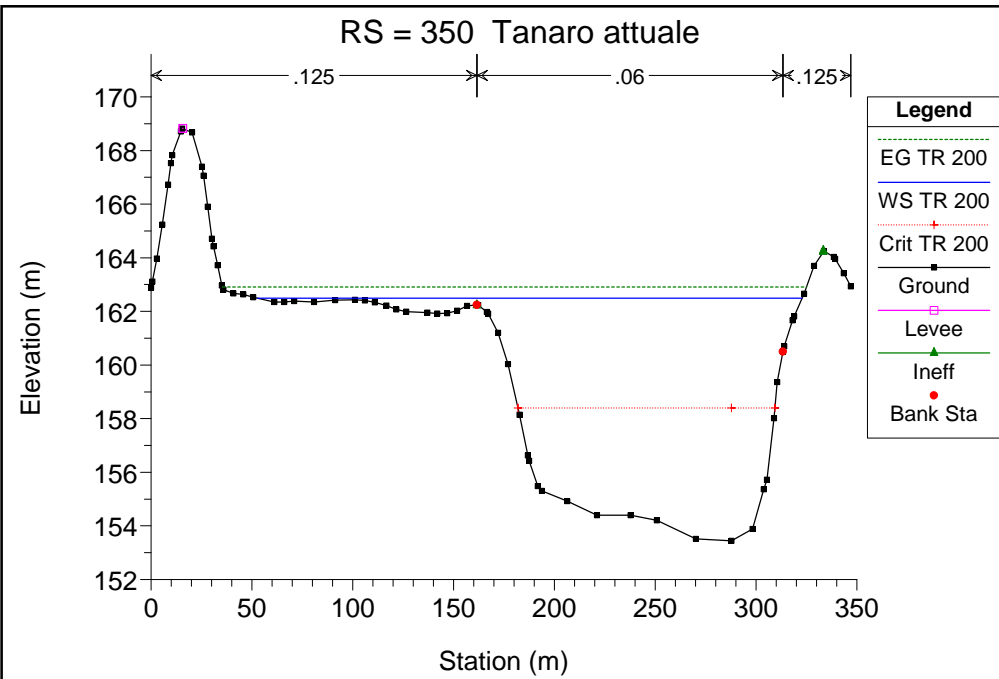
Tanaro attuale

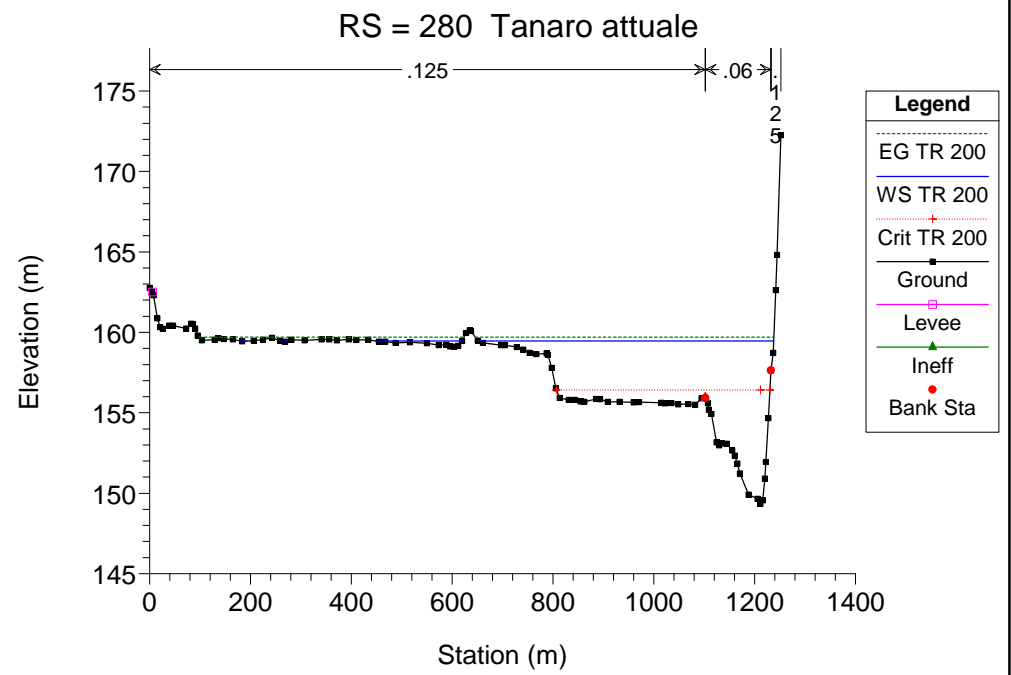
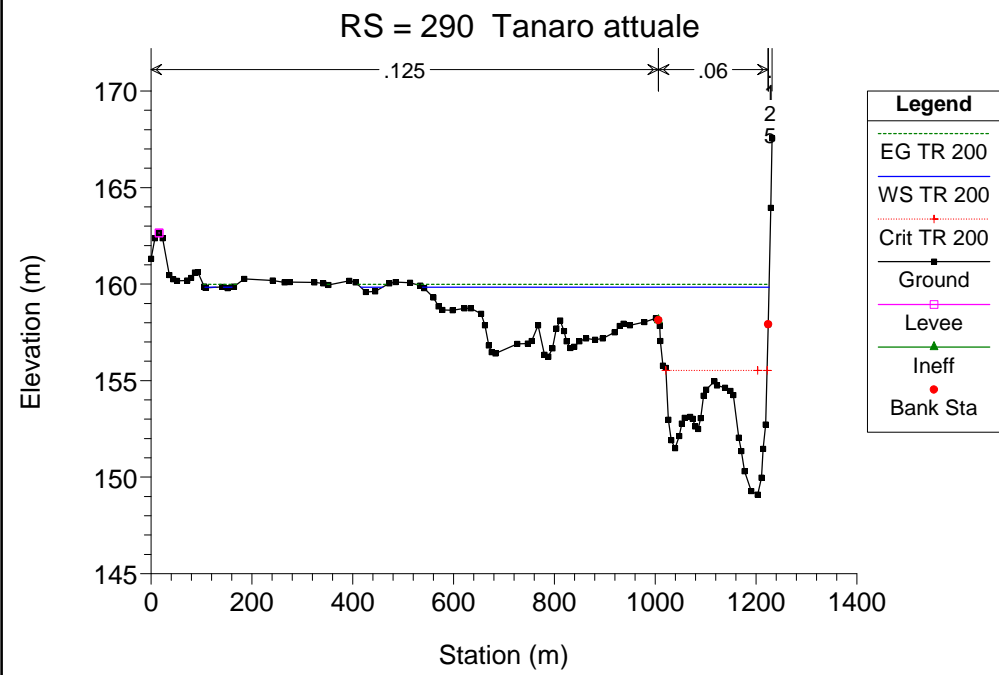
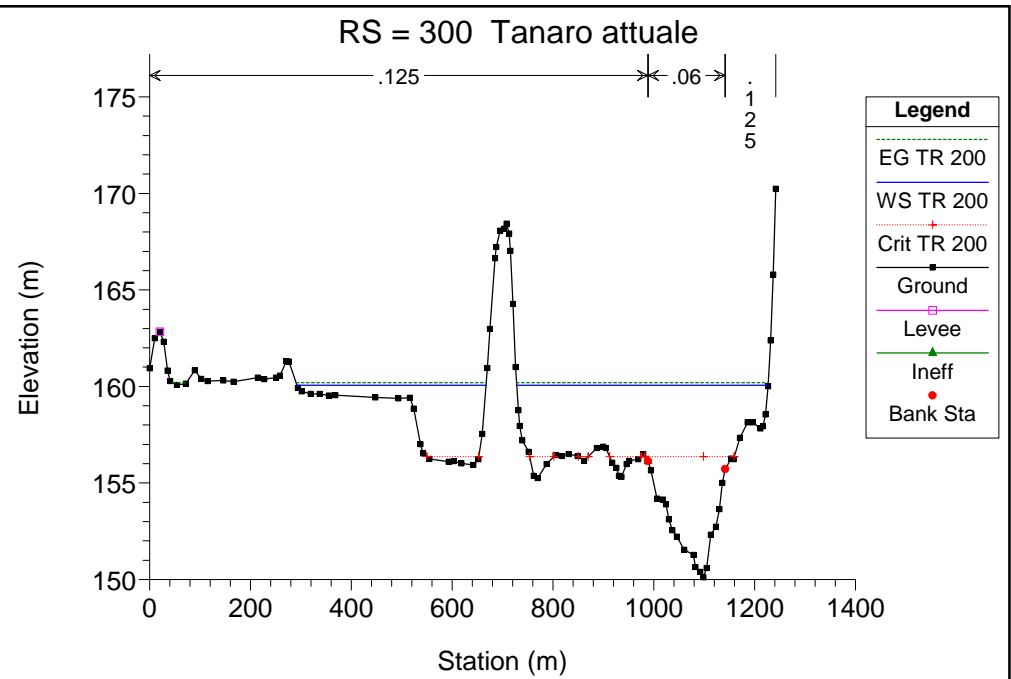
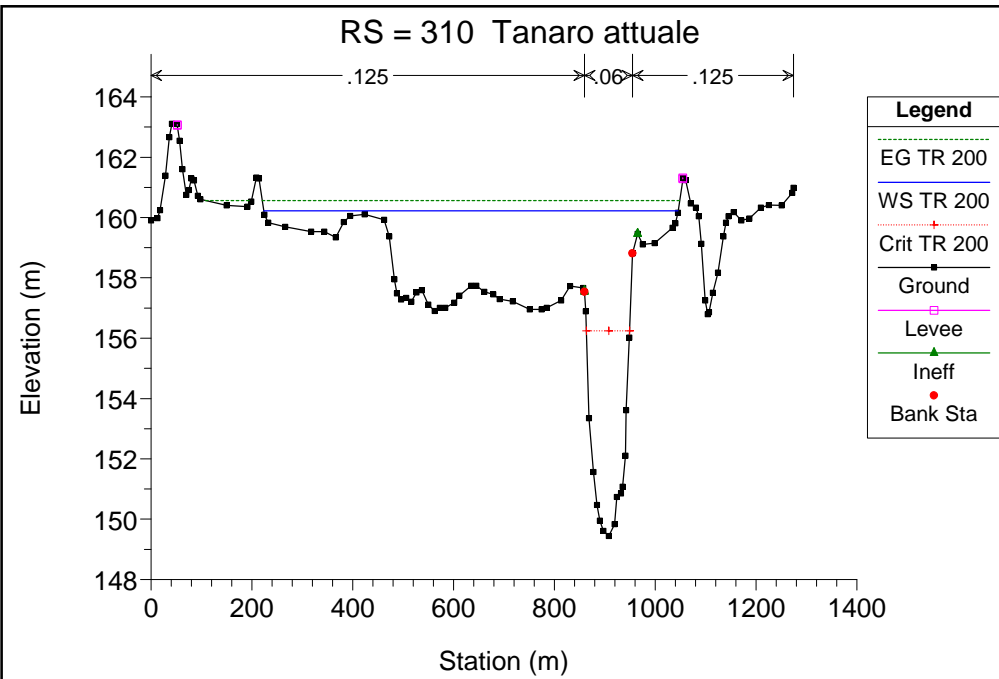


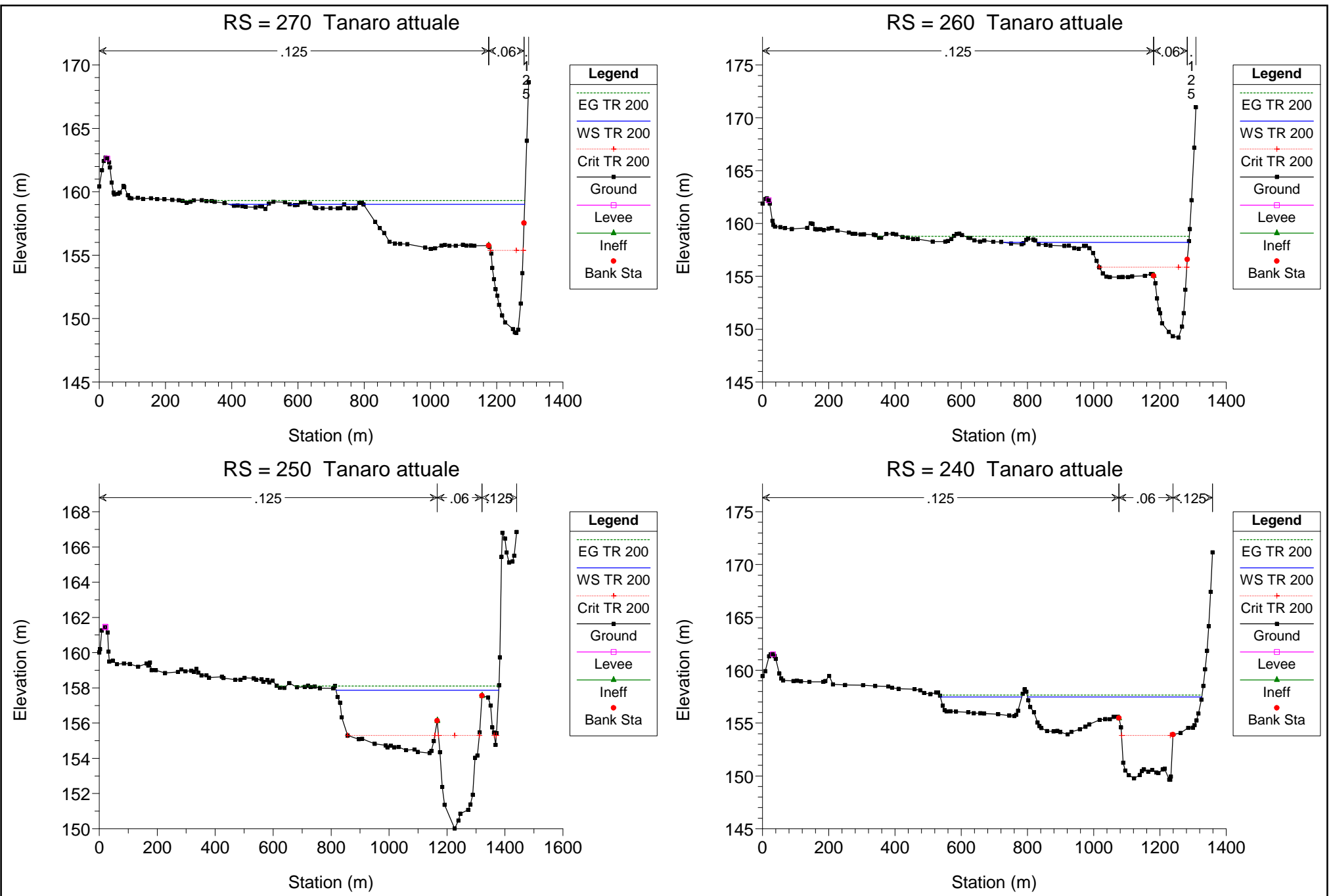


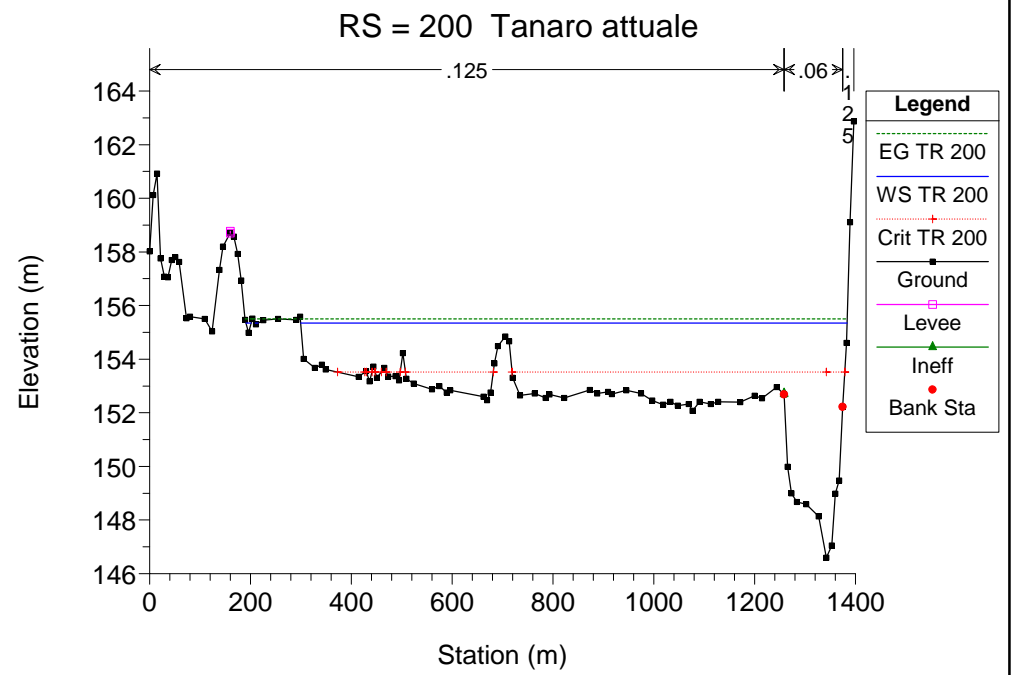
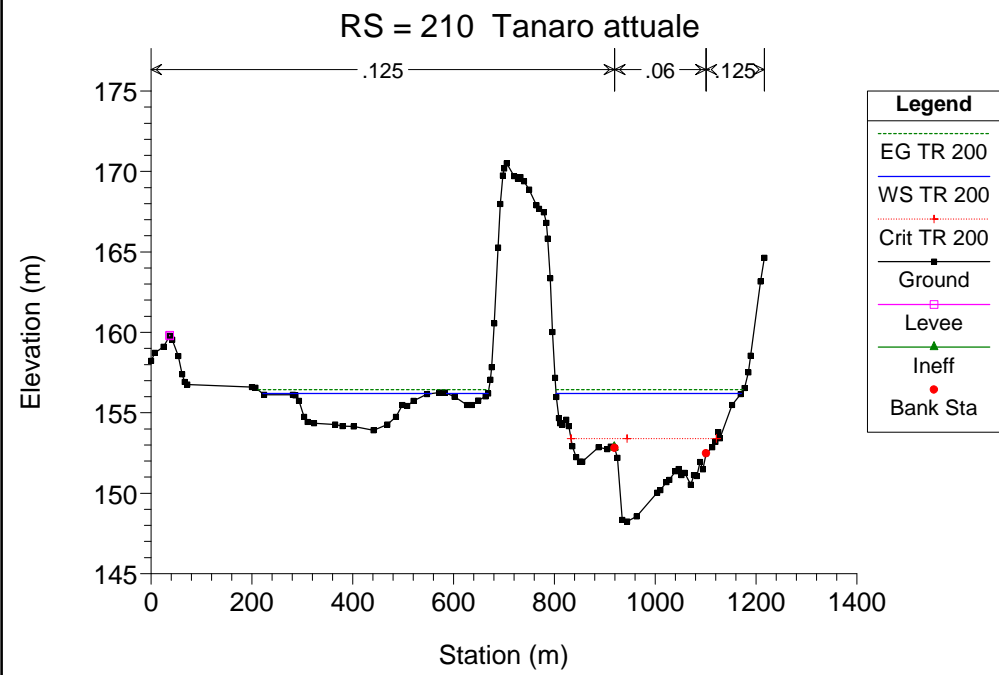
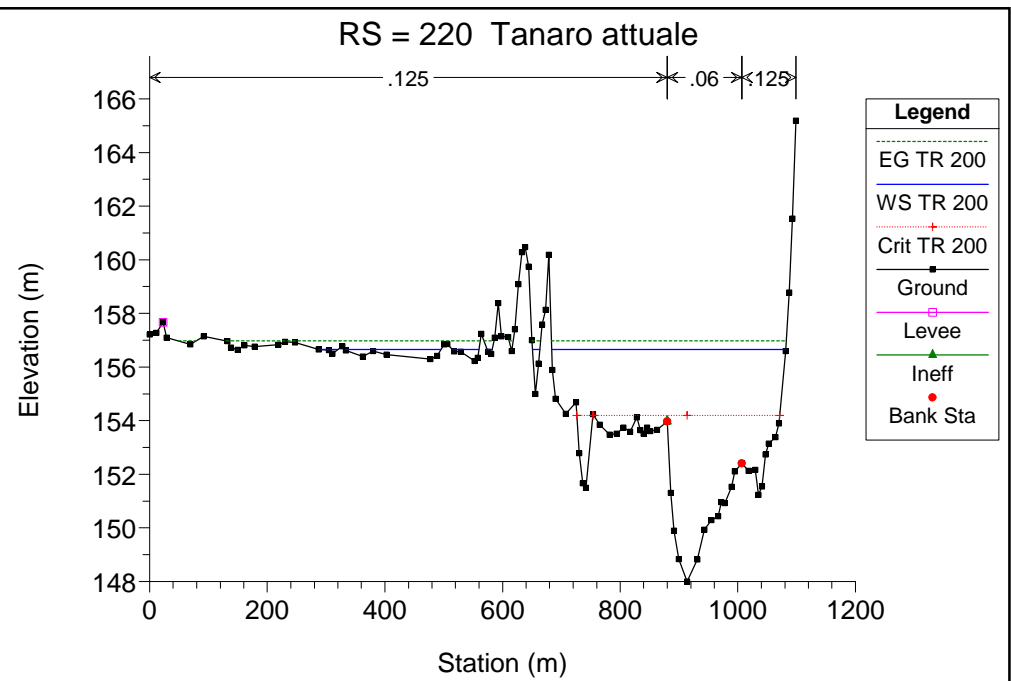
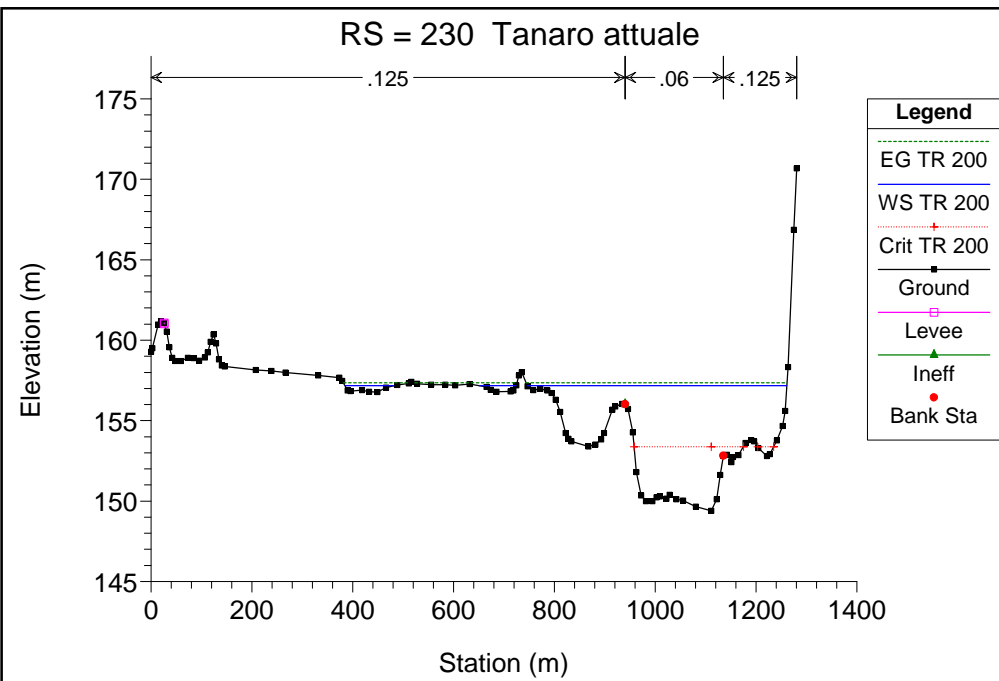


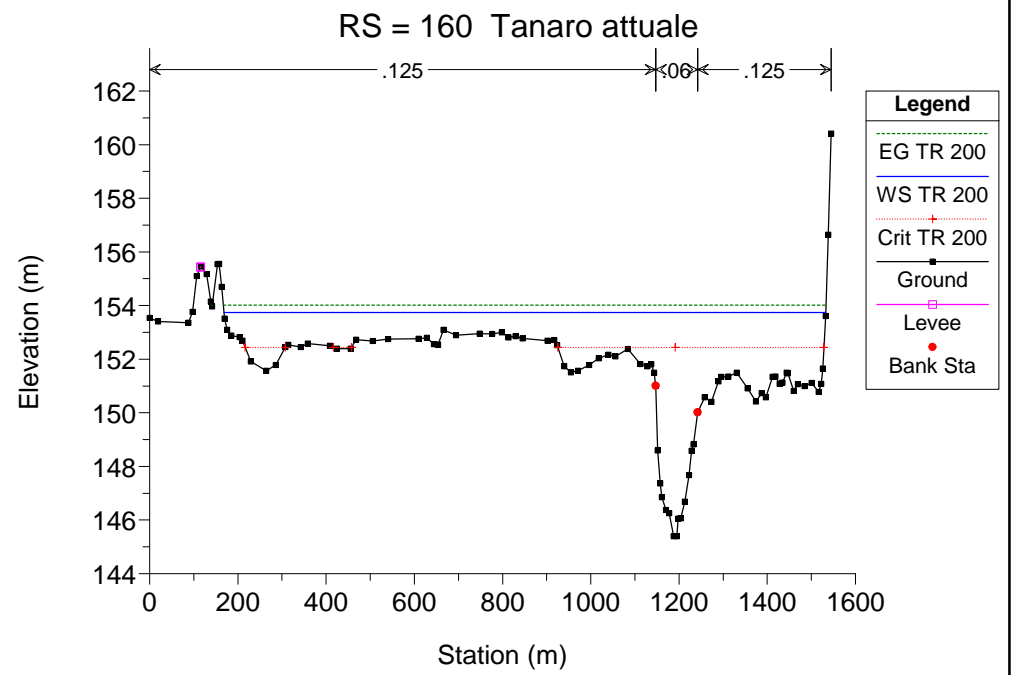
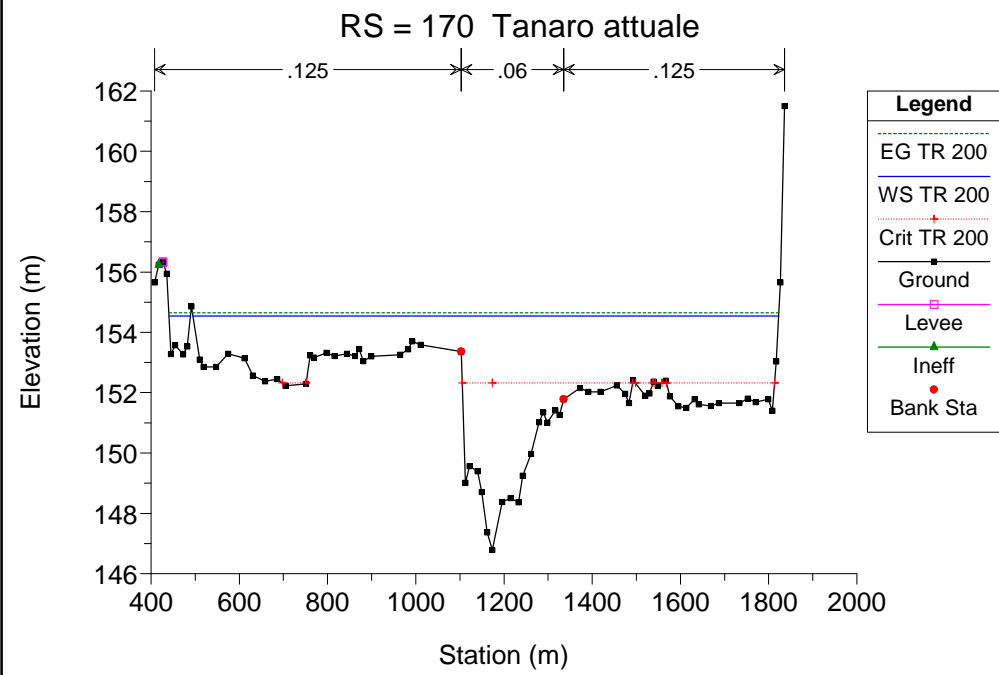
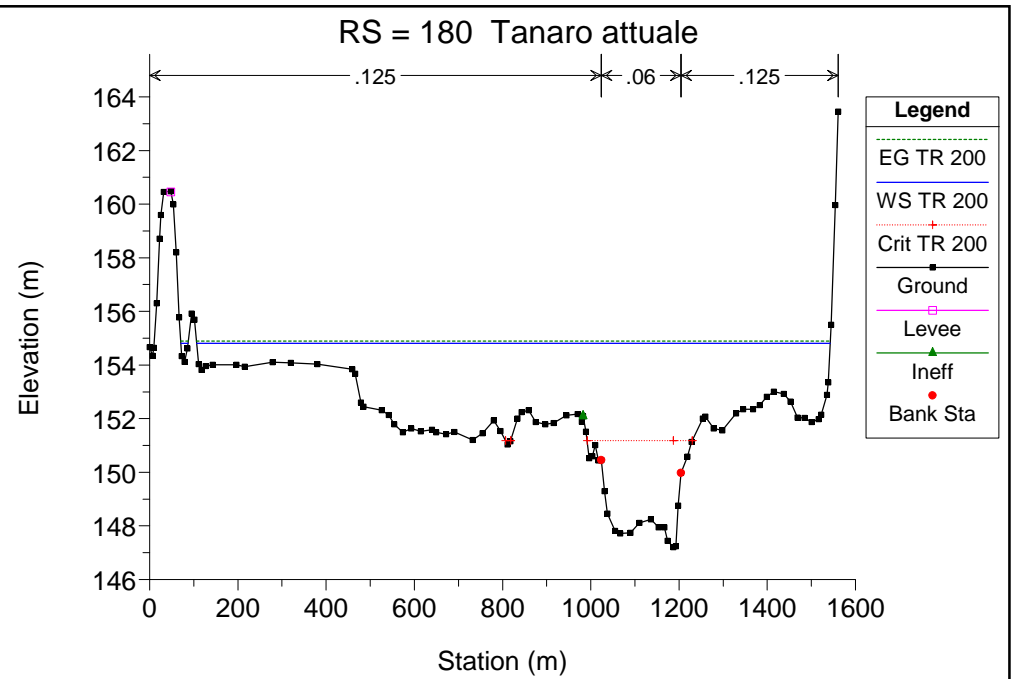
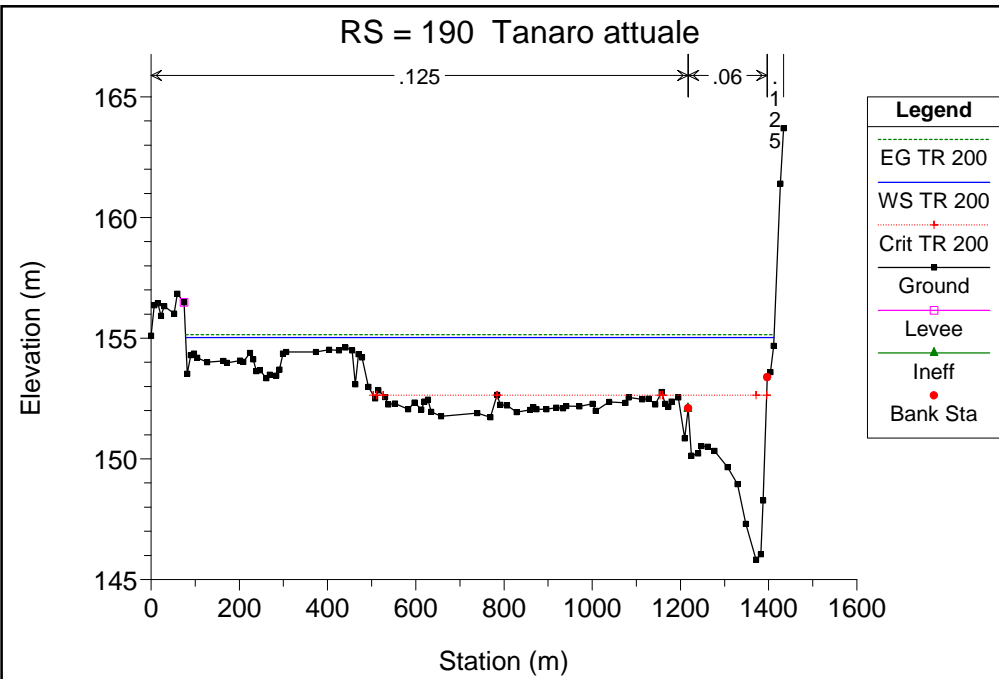


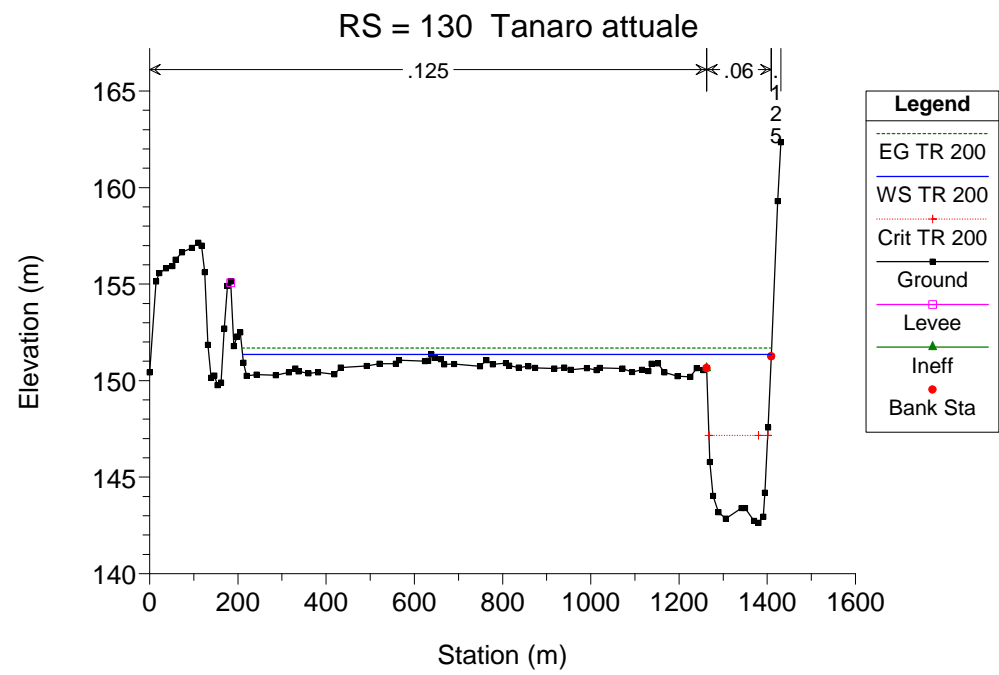
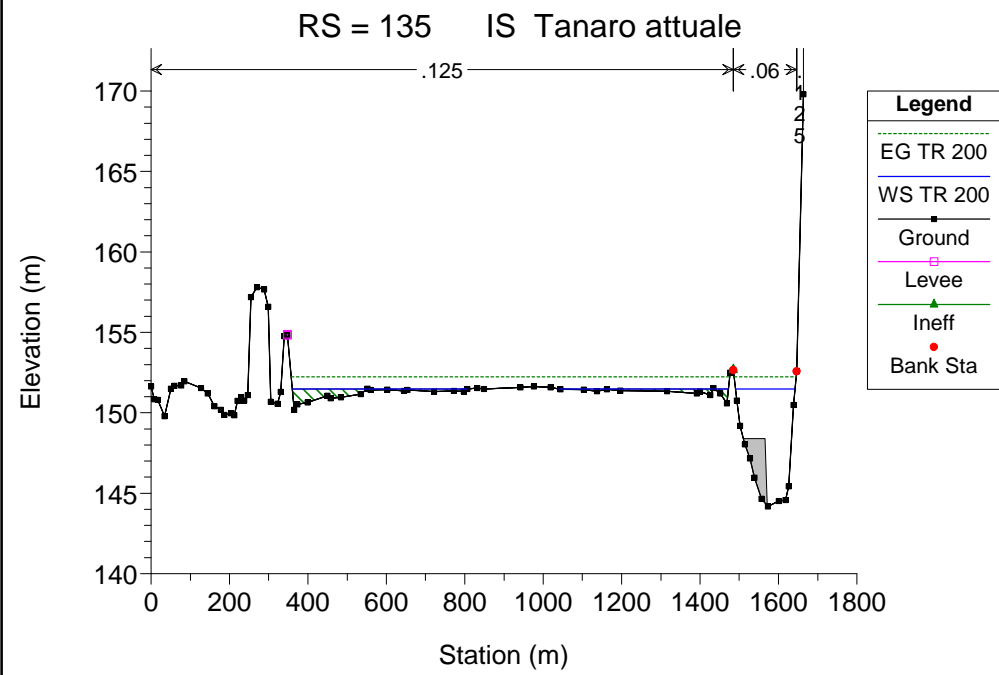
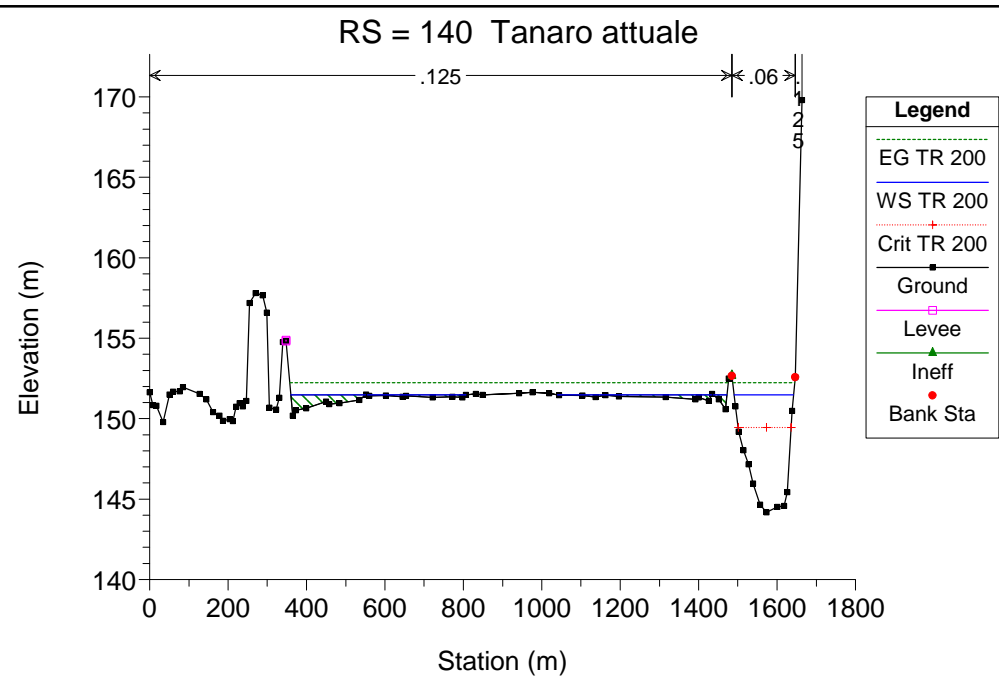
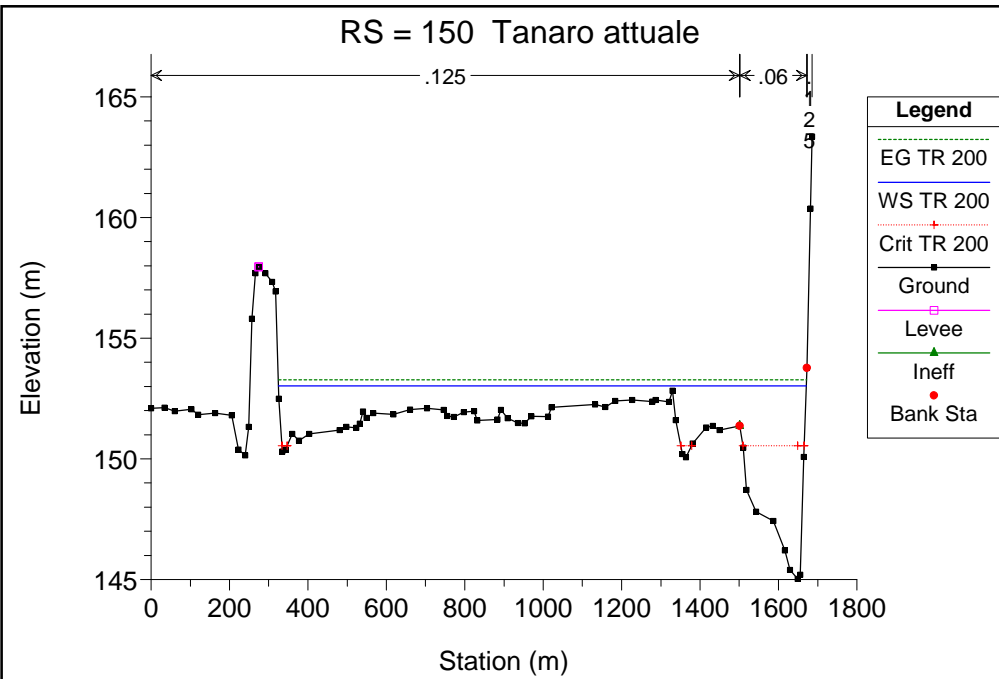


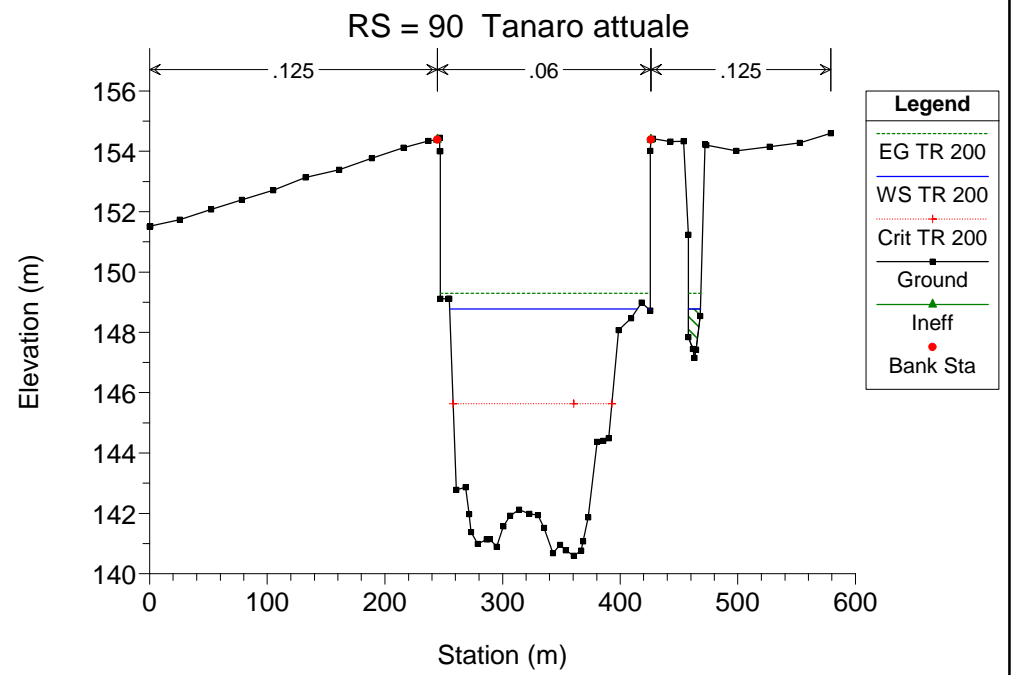
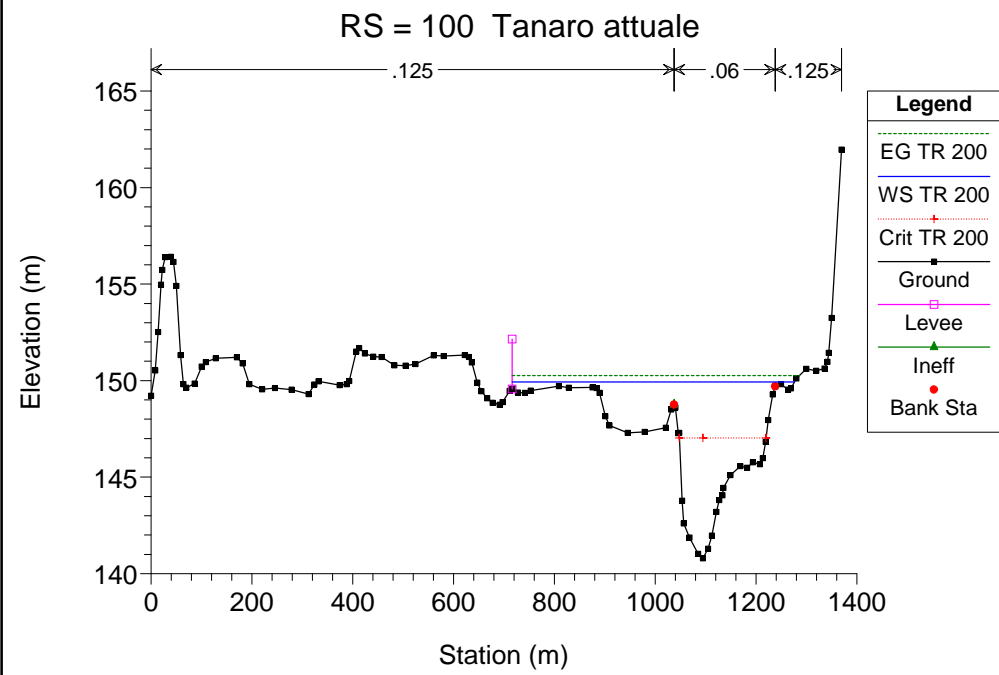
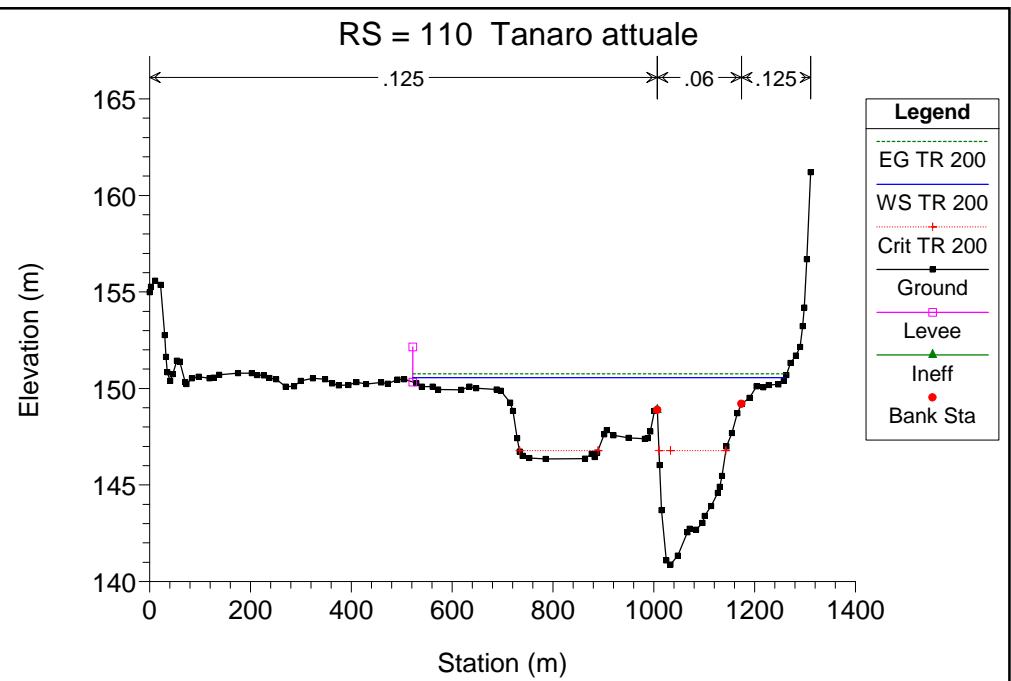
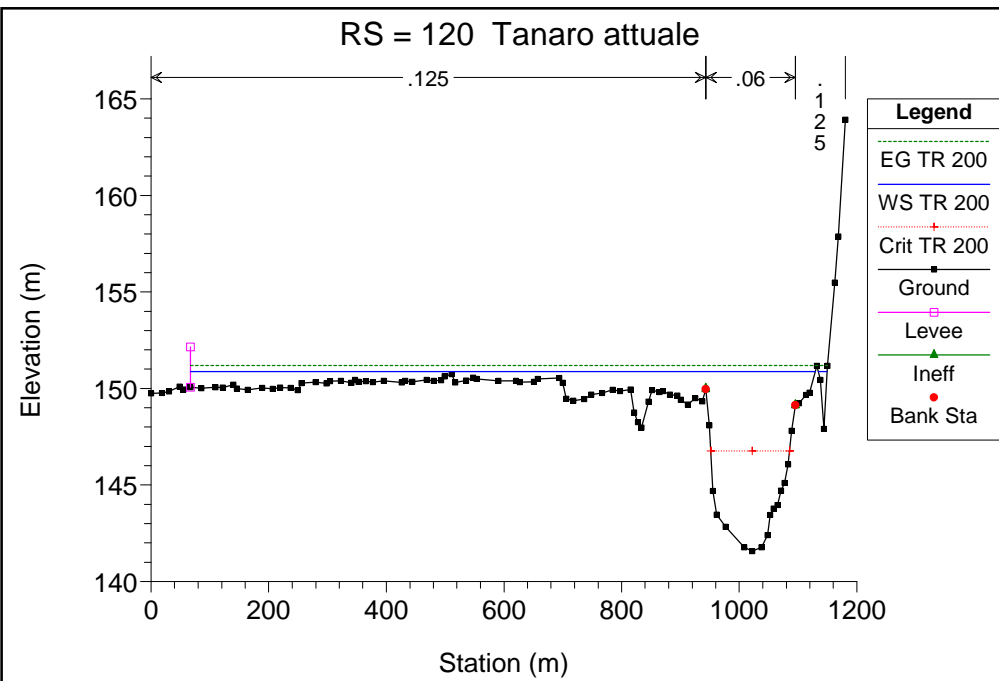


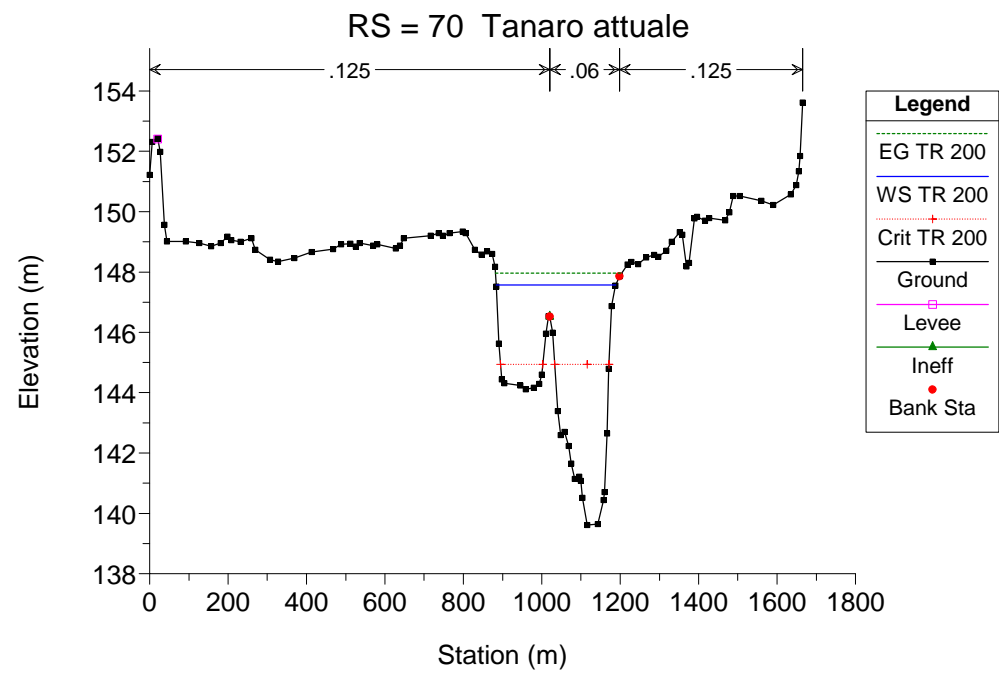
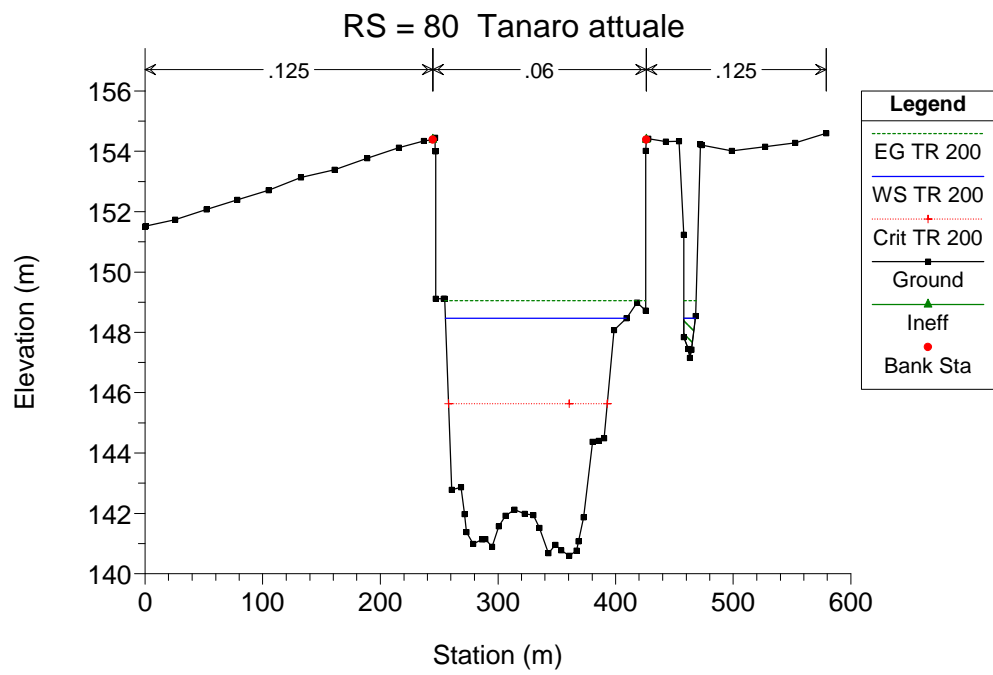
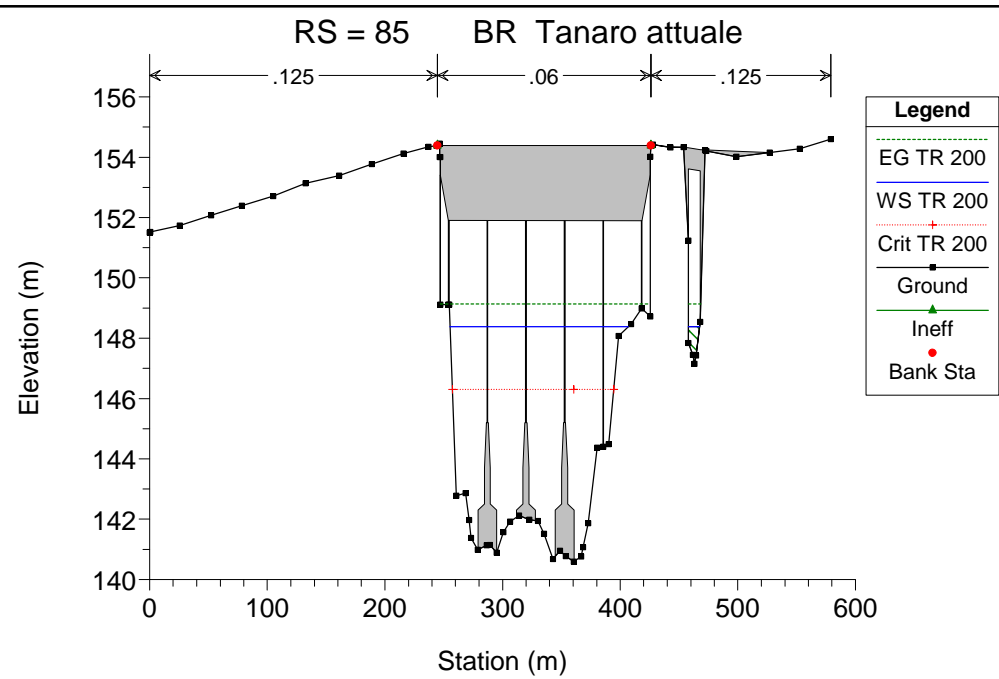
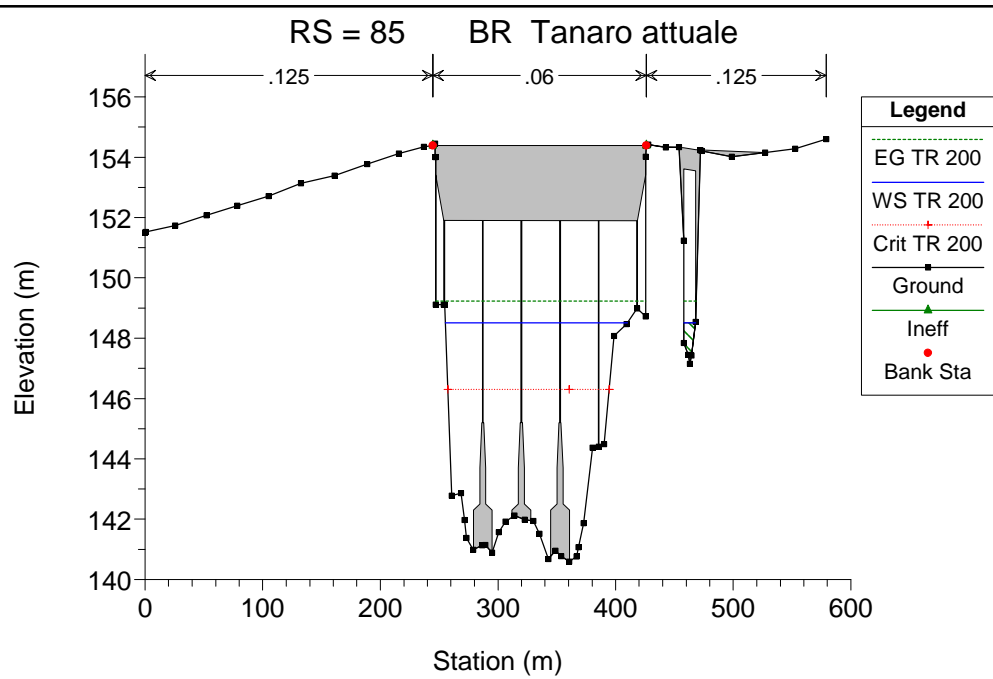


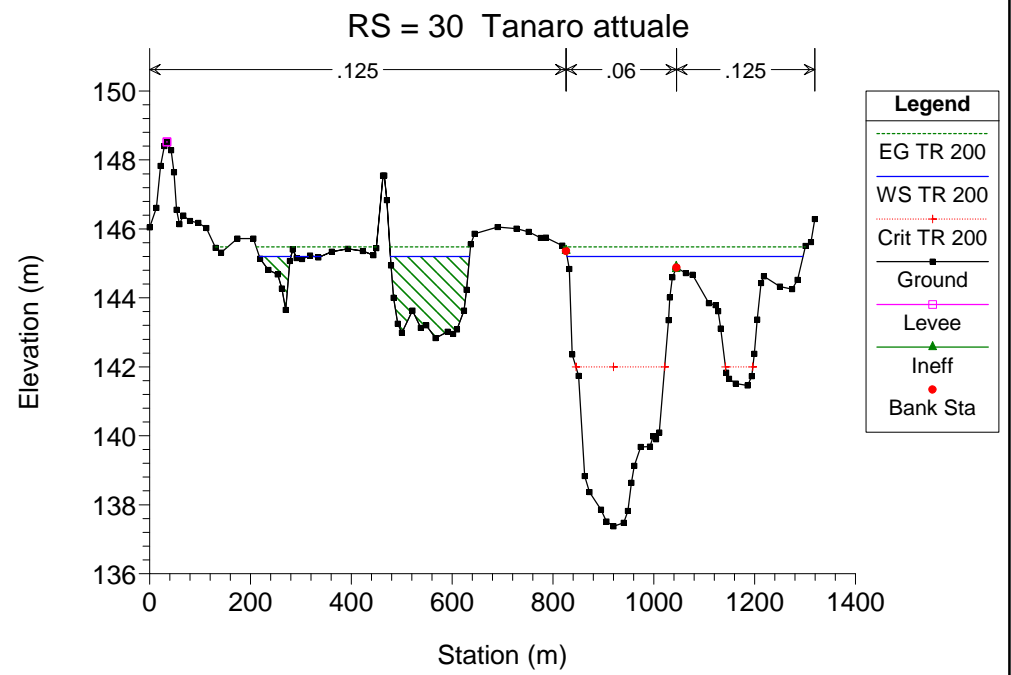
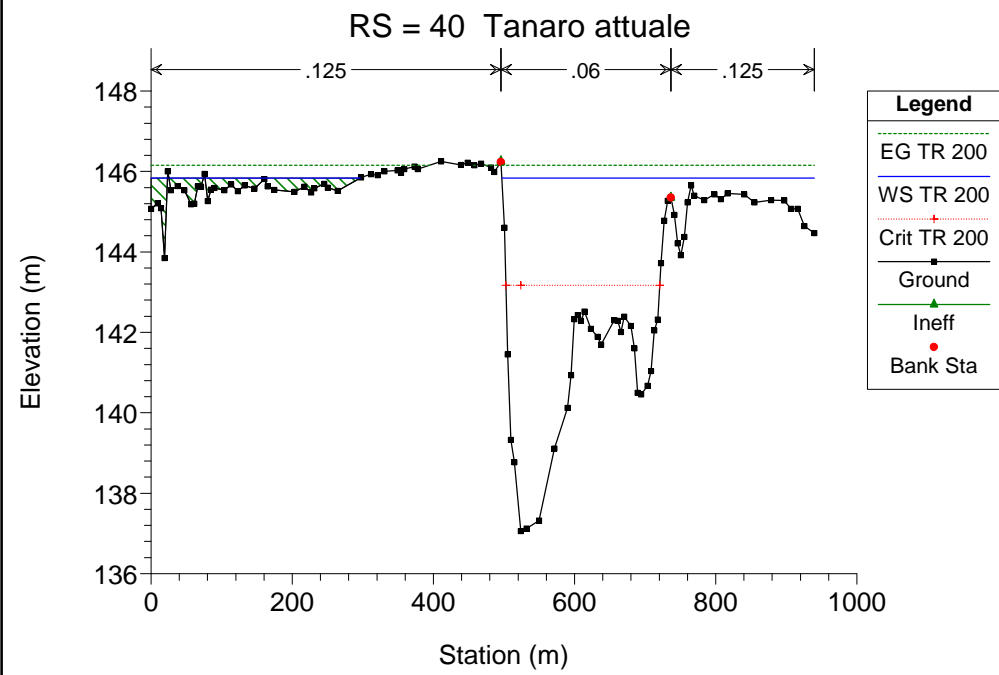
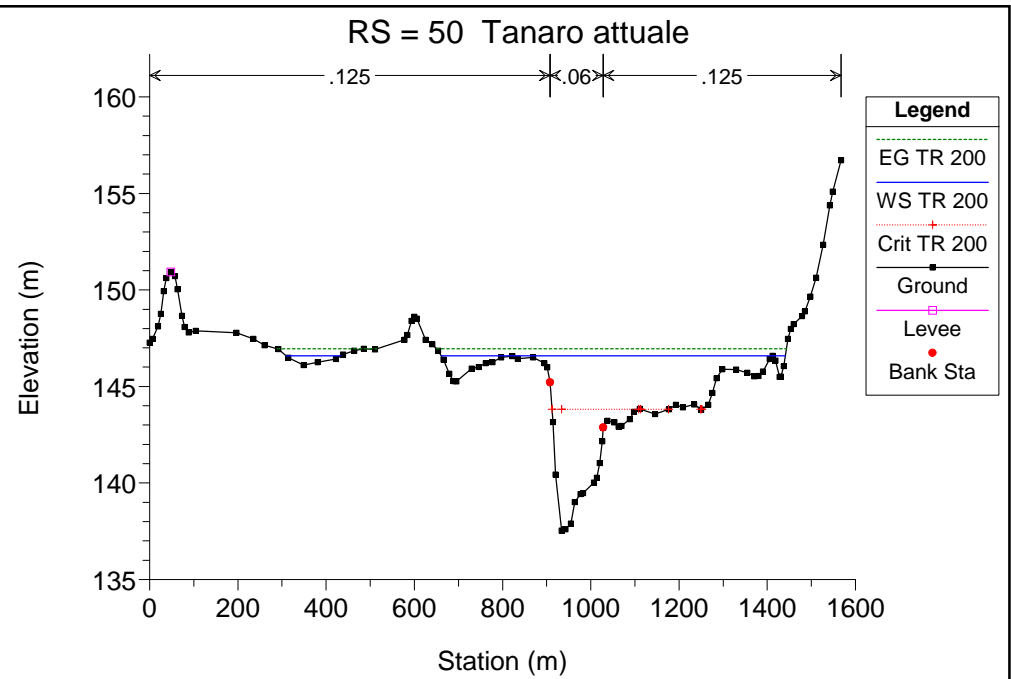
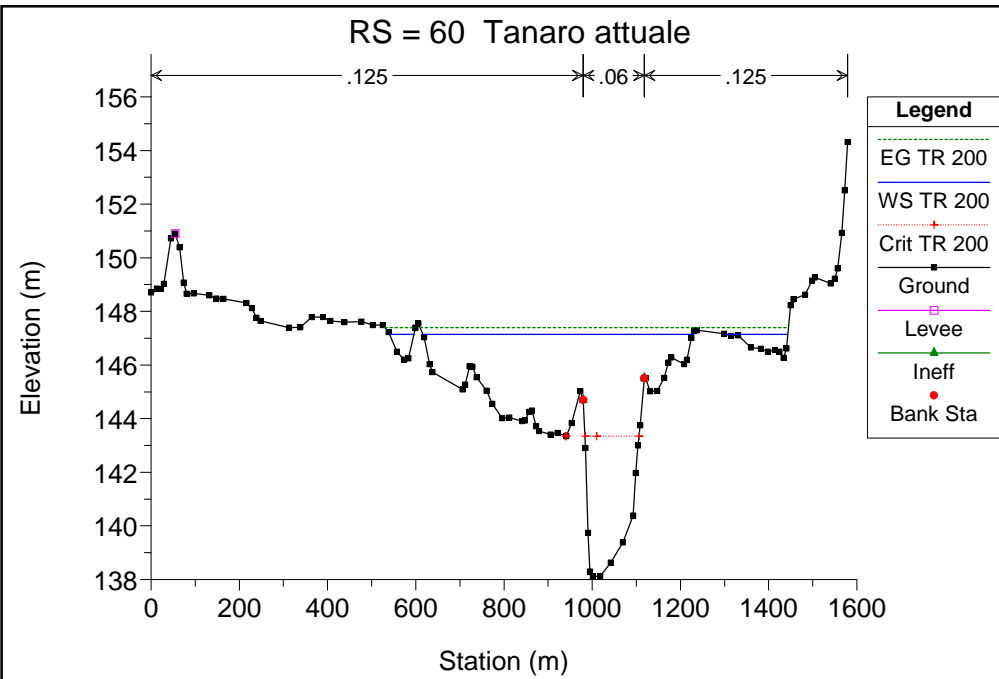


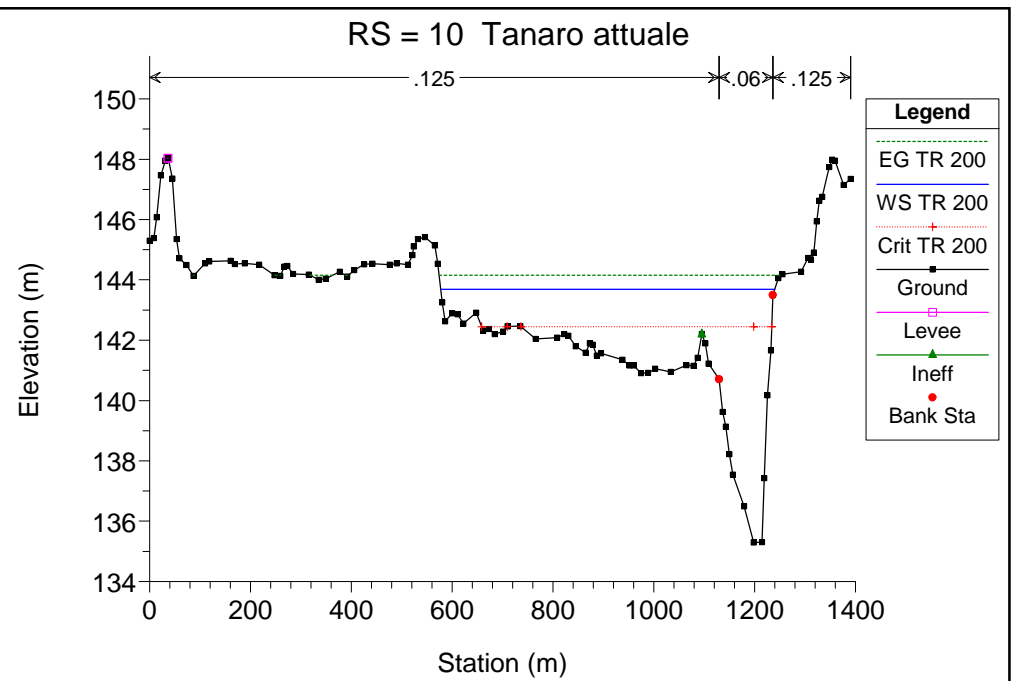
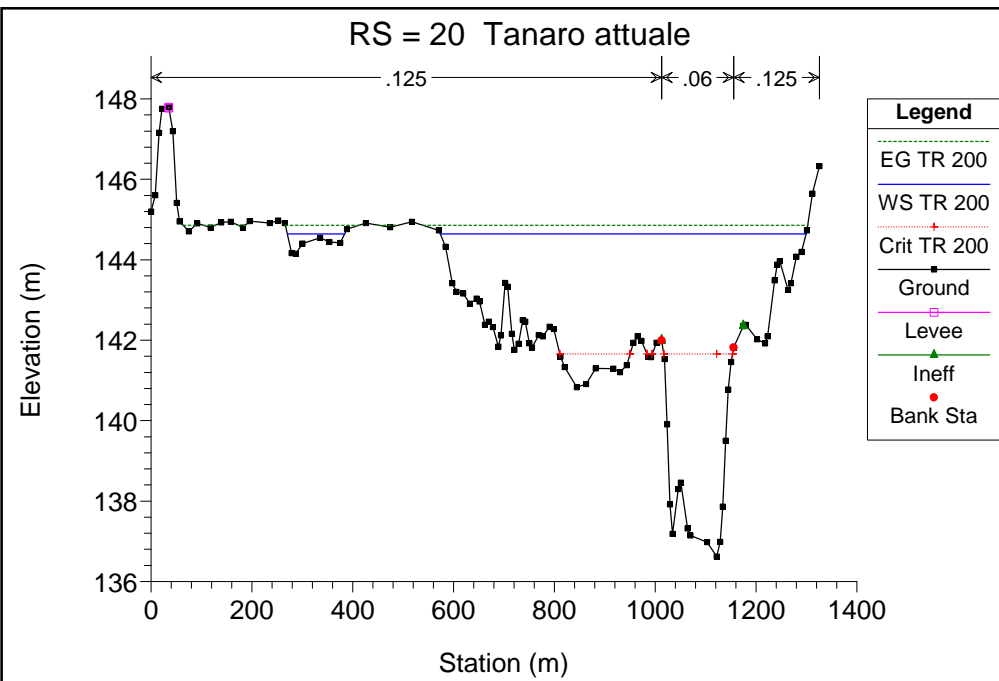












SITUAZIONE DI PROGETTO
(coincidente con situazione ante crollo 2010)
SIMULAZIONE 4

corso d'acqua	portata al colmo Q_c m^3/s	tempo di ritorno anni
Fiume Tanaro	2050	20

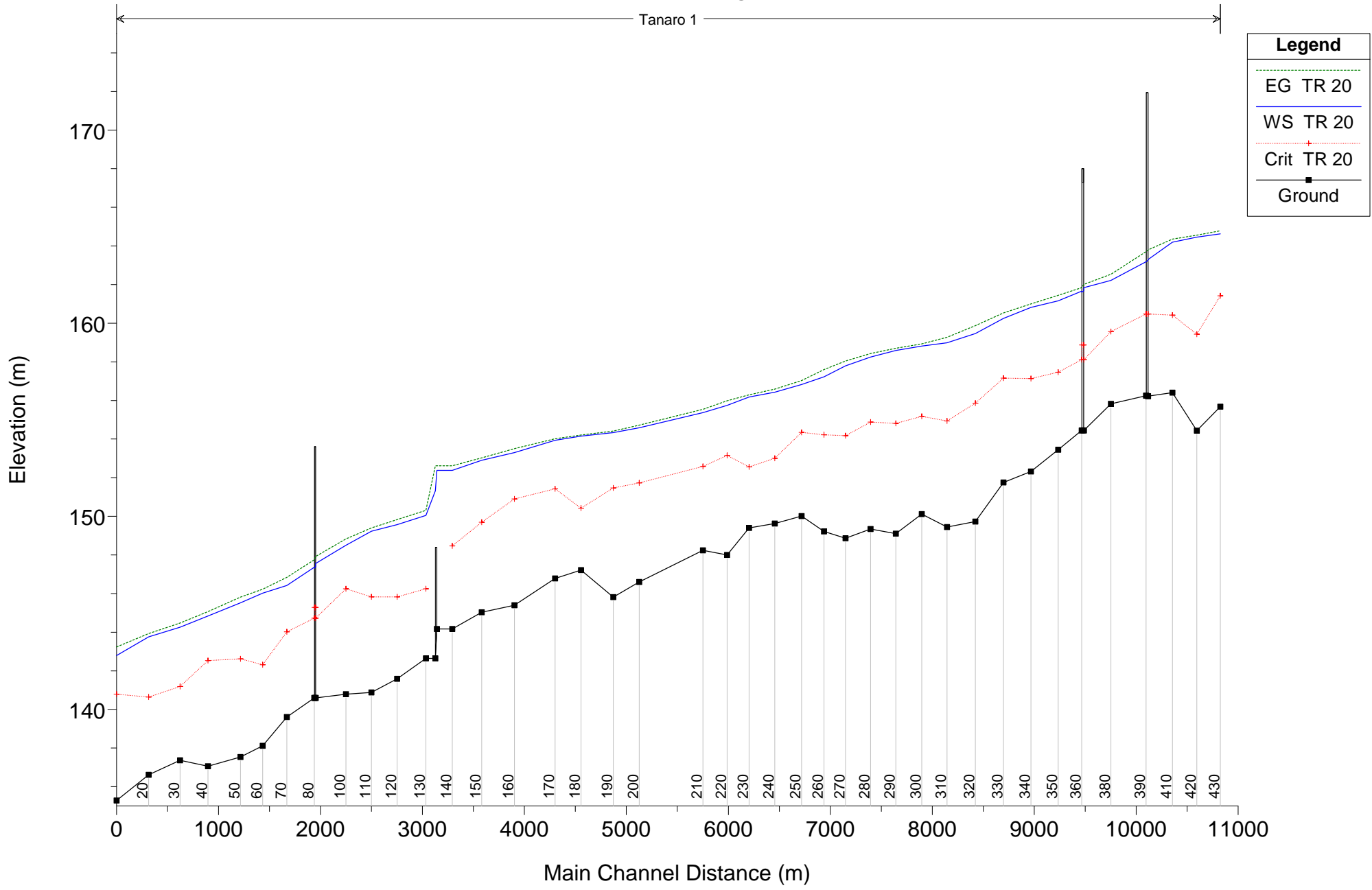
HEC-RAS Plan: Plan 06 River: Tanaro Reach: 1 Profile: TR 20

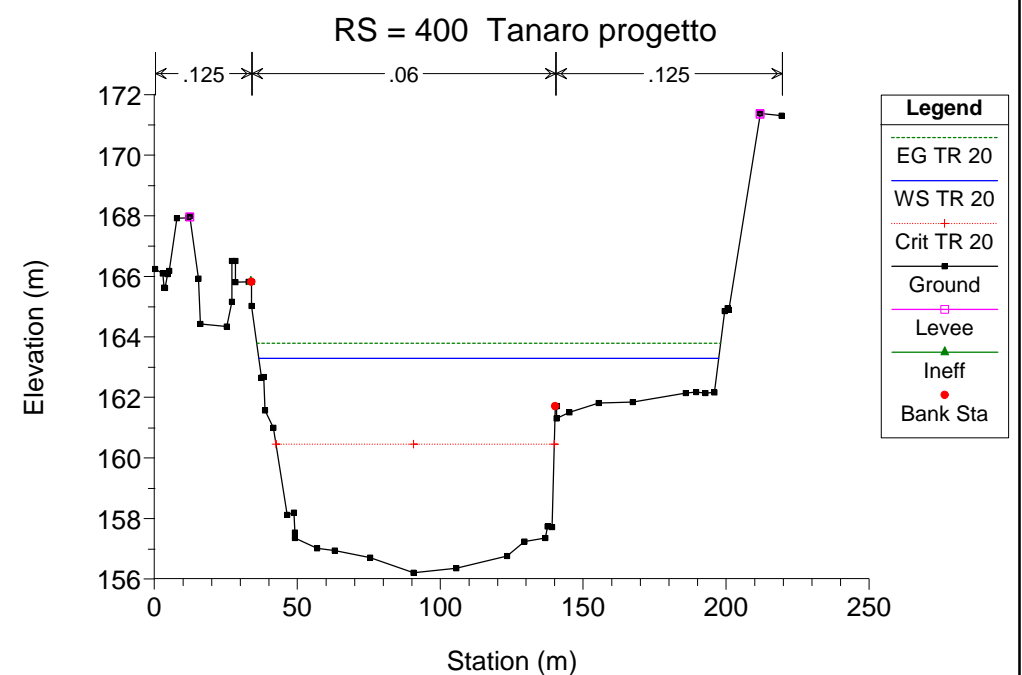
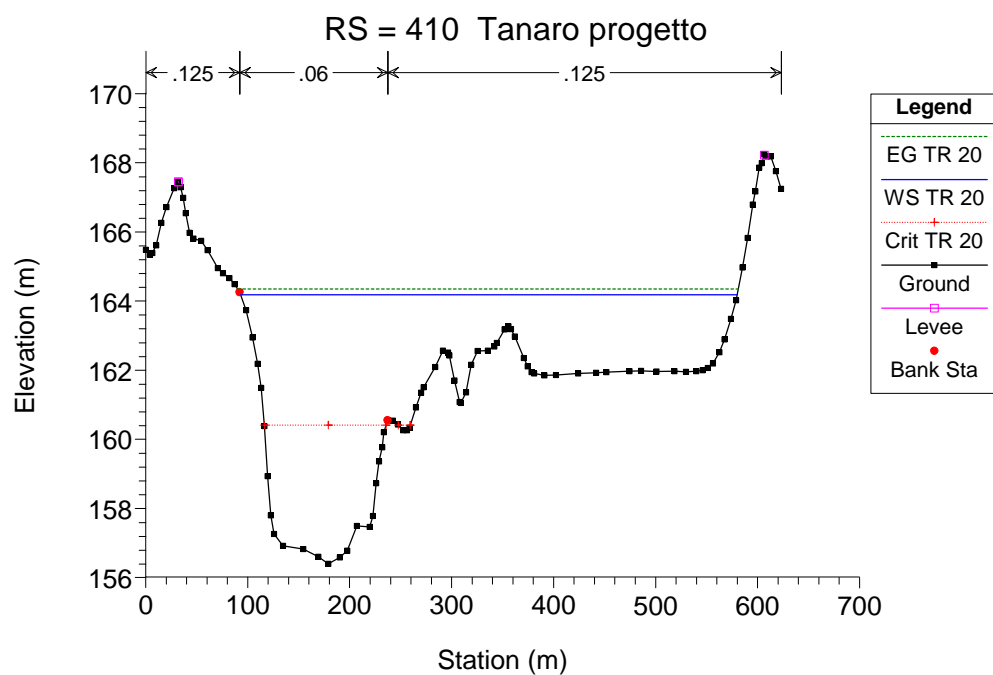
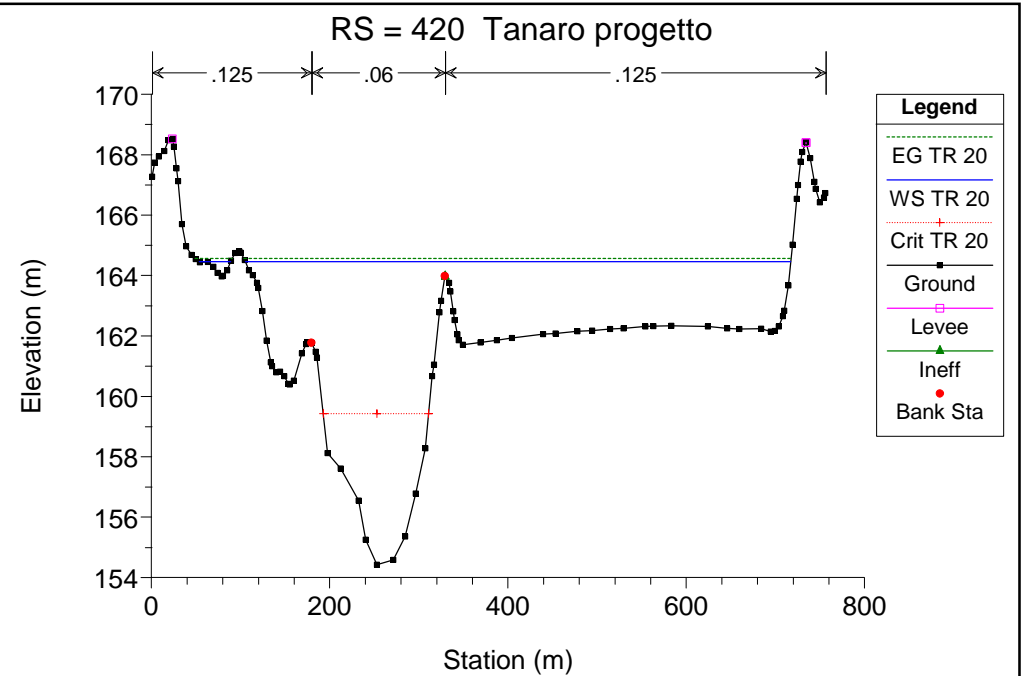
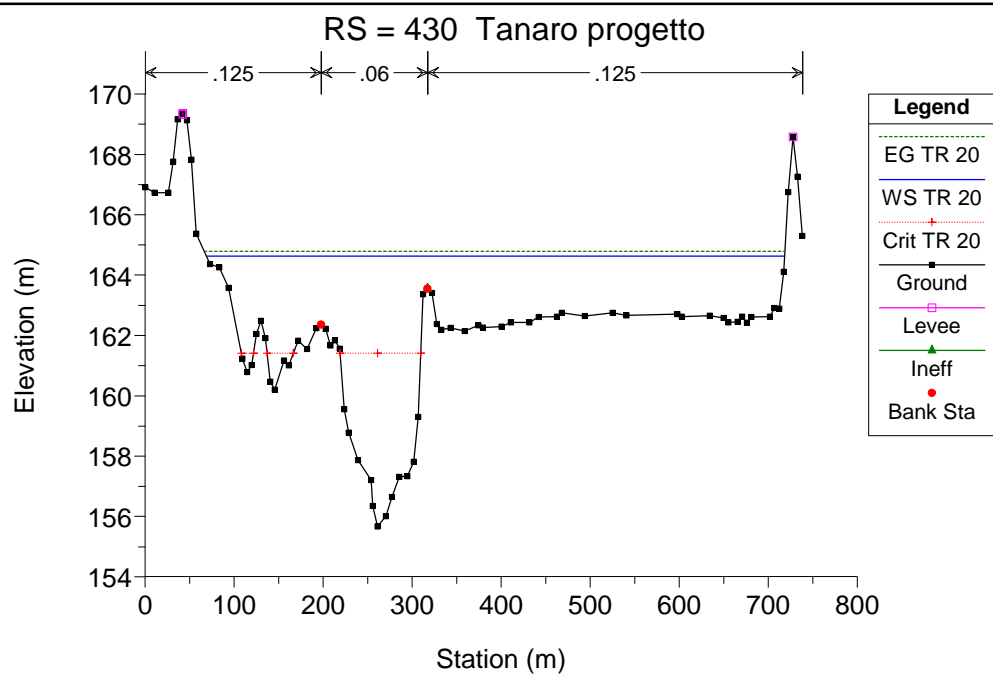
Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
1	430	TR 20	2050.00	155.68	164.63	161.42	164.79	0.001468	2.06	1854.56	649.27	0.27
1	420	TR 20	2050.00	154.44	164.46	159.43	164.56	0.000667	1.57	2129.21	647.18	0.19
1	410	TR 20	2050.00	156.41	164.19	160.42	164.36	0.001294	1.96	1608.89	486.72	0.26
1	400	TR 20	2050.00	156.22	163.30	160.47	163.80	0.003476	3.17	711.40	160.81	0.41
1	395		Bridge									
1	390	TR 20	2050.00	156.25	163.19	160.48	163.71	0.003707	3.24	693.46	160.50	0.42
1	380	TR 20	2050.00	155.82	162.22	159.56	162.54	0.002615	2.50	819.30	159.16	0.35
1	370	TR 20	2050.00	154.45	161.84	158.11	162.01	0.001197	1.81	1129.65	198.29	0.24
1	365		Bridge									
1	360	TR 20	2050.00	154.45	161.66	158.11	161.84	0.001325	1.88	1093.12	197.16	0.25
1	350	TR 20	2050.00	153.45	161.16	157.46	161.45	0.001856	2.37	864.03	143.66	0.31
1	340	TR 20	2050.00	152.32	160.82	157.14	161.00	0.001295	1.89	1085.01	195.64	0.25
1	330	TR 20	2050.00	151.75	160.25	157.15	160.54	0.002273	2.39	871.02	236.11	0.33
1	320	TR 20	2050.00	149.73	159.46	155.86	159.87	0.002469	2.93	954.18	366.64	0.36
1	310	TR 20	2050.00	149.44	158.99	154.93	159.27	0.001776	2.56	1320.50	482.36	0.30
1	300	TR 20	2050.00	150.11	158.81	155.18	158.92	0.000912	1.68	2037.59	630.66	0.22
1	290	TR 20	2050.00	149.10	158.58	154.81	158.70	0.000909	1.57	1685.32	579.11	0.21
1	280	TR 20	2050.00	149.34	158.25	154.88	158.43	0.001408	2.06	1558.27	441.38	0.27
1	270	TR 20	2050.00	148.86	157.79	154.17	158.04	0.001763	2.43	1356.04	453.69	0.30
1	260	TR 20	2050.00	149.22	157.23	154.22	157.59	0.002563	2.84	1008.75	286.79	0.36
1	250	TR 20	2050.00	150.01	156.82	154.35	157.04	0.002235	2.25	1397.94	508.74	0.33
1	240	TR 20	2050.00	149.63	156.43	153.01	156.59	0.001265	1.90	1649.02	736.04	0.25
1	230	TR 20	2050.00	149.40	156.17	152.56	156.30	0.001019	1.66	1659.90	454.98	0.23
1	220	TR 20	2050.00	148.00	155.75	153.15	155.98	0.002047	2.36	1313.00	398.50	0.32
1	210	TR 20	2050.00	148.24	155.37	152.59	155.54	0.001522	1.93	1500.23	544.25	0.27
1	200	TR 20	2050.00	146.60	154.59	151.73	154.72	0.001319	1.97	2301.44	1060.77	0.26
1	190	TR 20	2050.00	145.82	154.34	151.46	154.42	0.000920	1.50	2618.17	1163.84	0.21
1	180	TR 20	2050.00	147.21	154.15	150.42	154.21	0.000586	1.34	3180.89	1431.49	0.17
1	170	TR 20	2050.00	146.78	153.93	151.42	154.02	0.001053	1.46	2564.85	1361.59	0.22
1	160	TR 20	2050.00	145.40	153.29	150.90	153.50	0.001846	2.39	2057.95	1358.22	0.31
1	150	TR 20	2050.00	145.03	152.90	149.69	153.03	0.001184	1.76	2324.51	1345.72	0.24
1	140	TR 20	2050.00	144.17	152.37	148.46	152.62	0.001673	2.20	932.25	1278.39	0.29
1	135		Inl Struct									
1	130	TR 20	2050.00	142.64	150.05	146.24	150.31	0.001645	2.27	902.70	143.51	0.29
1	120	TR 20	2050.00	141.58	149.57	145.83	149.83	0.001731	2.27	913.06	285.61	0.30
1	110	TR 20	2050.00	140.88	149.23	145.83	149.39	0.001563	1.96	1517.54	459.67	0.27
1	100	TR 20	2050.00	140.79	148.50	146.25	148.83	0.003318	2.53	809.40	321.16	0.39
1	90	TR 20	2050.00	140.59	147.56	144.73	147.92	0.002753	2.66	769.82	145.55	0.36
1	85		Bridge									
1	80	TR 20	2050.00	140.59	147.36	144.73	147.75	0.003081	2.76	742.70	142.73	0.38

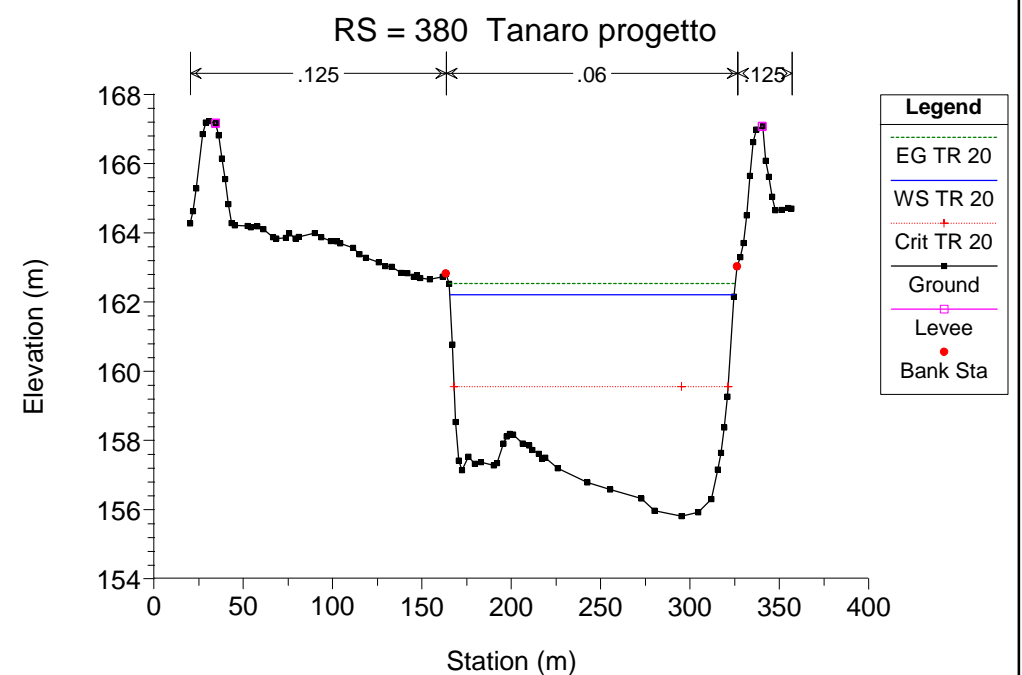
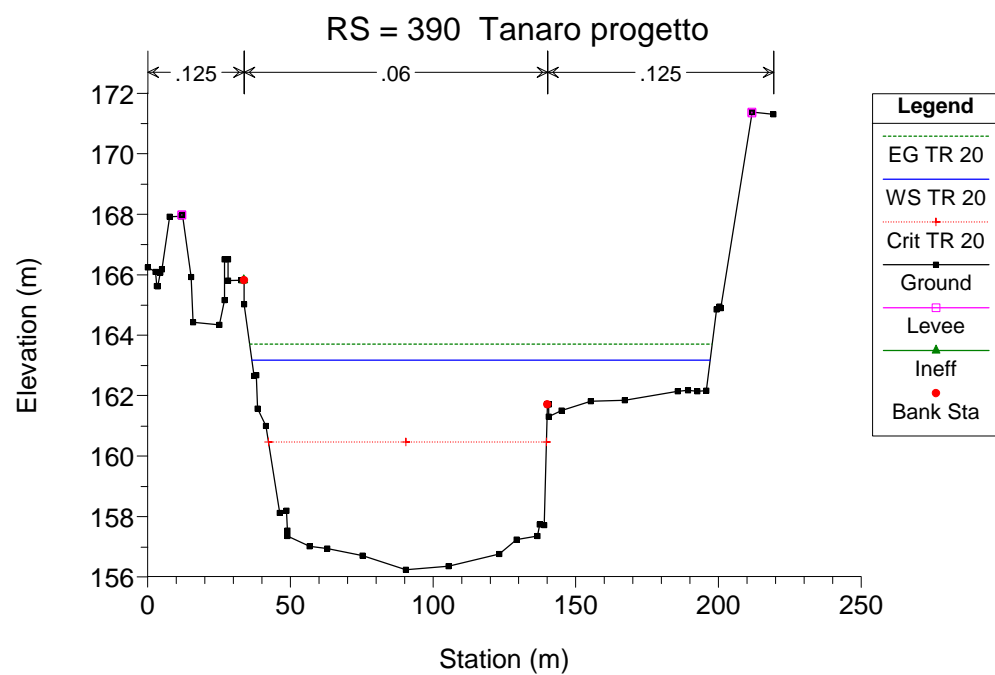
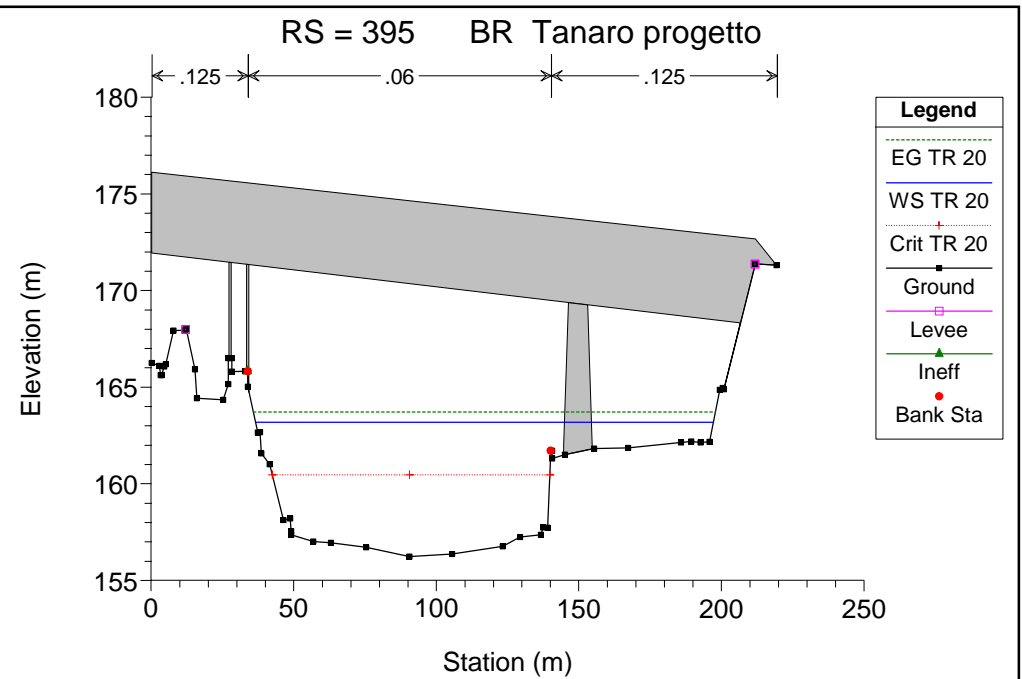
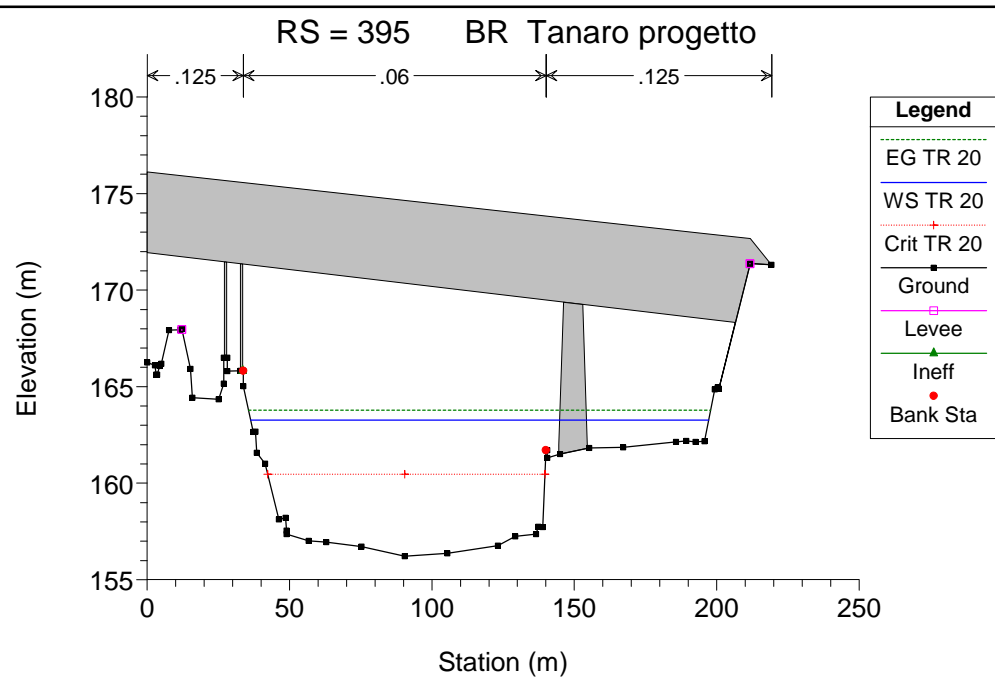
HEC-RAS Plan: Plan 06 River: Tanaro Reach: 1 Profile: TR 20 (Continued)

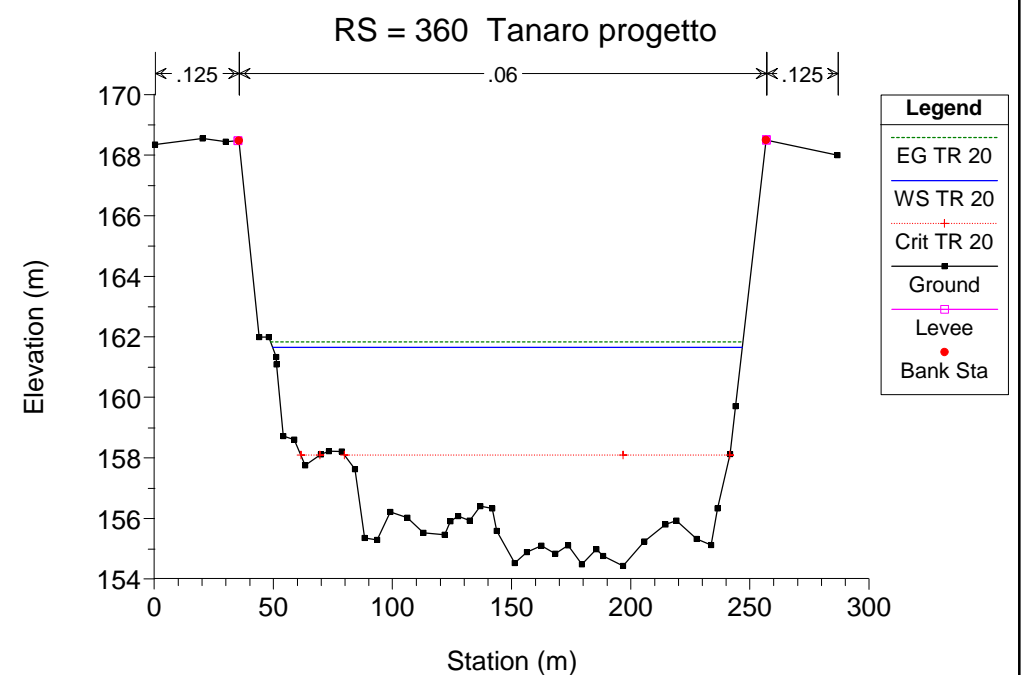
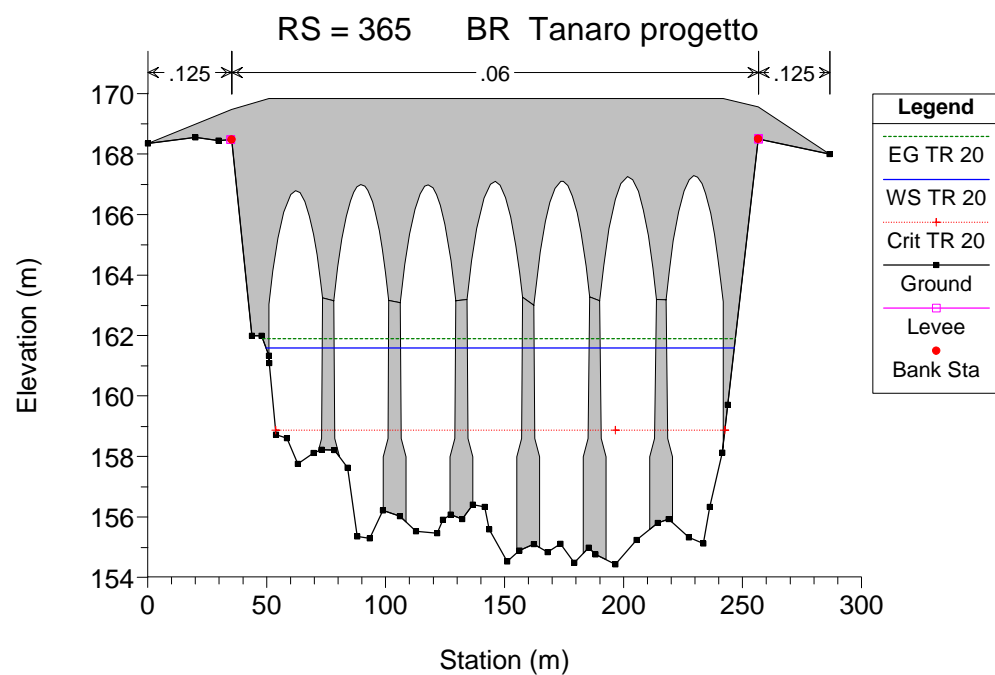
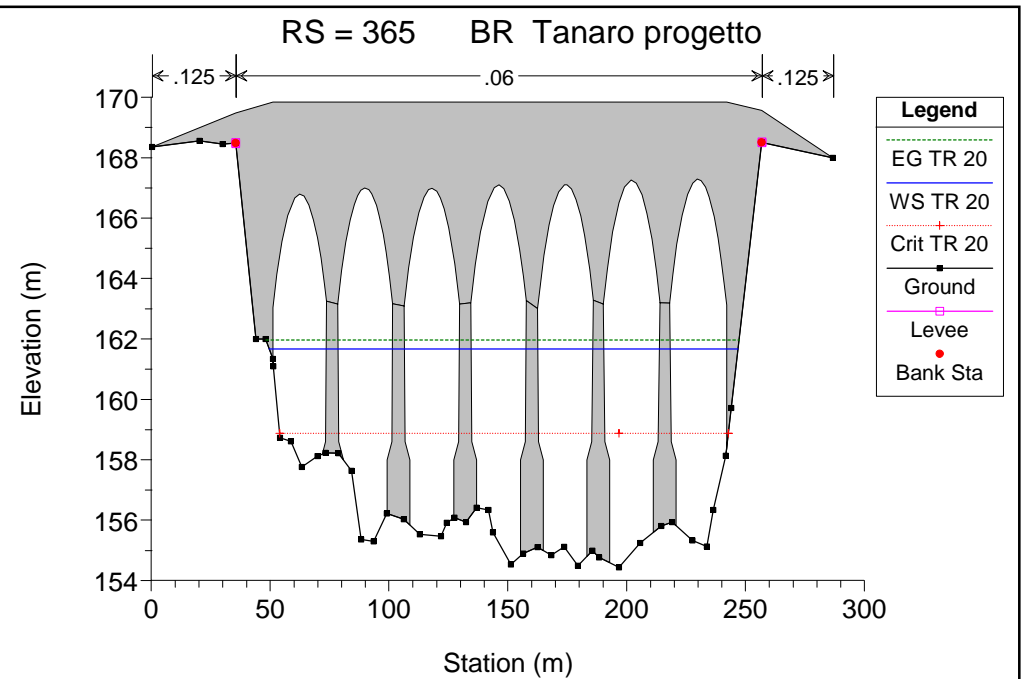
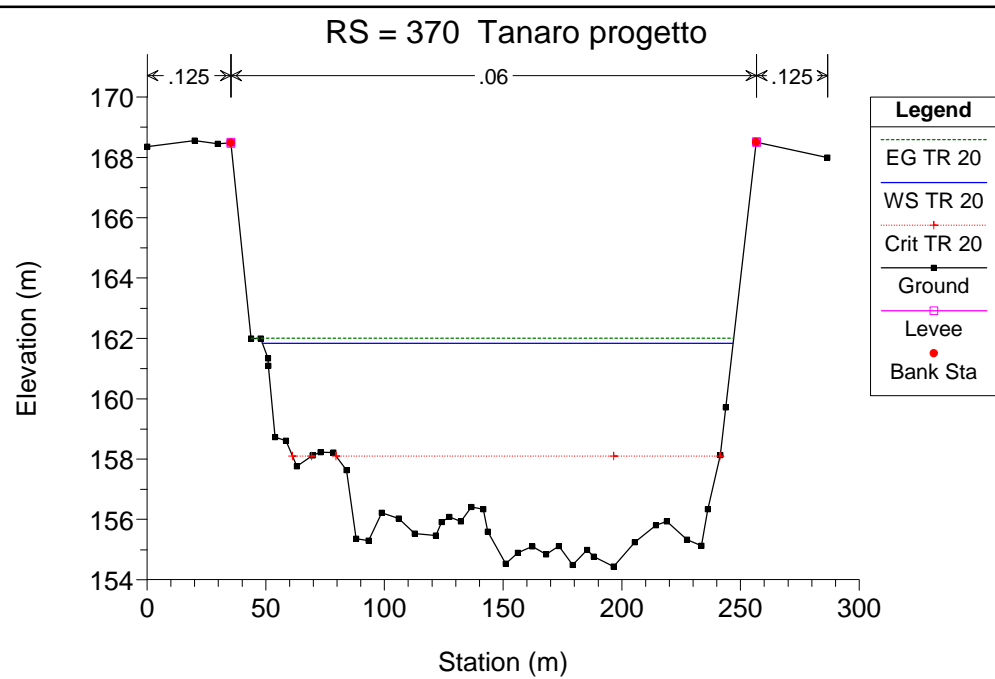
Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
1	70	TR 20	2050.00	139.61	146.42	144.02	146.83	0.003745	2.84	722.77	282.30	0.42
1	60	TR 20	2050.00	138.12	146.02	142.31	146.23	0.001552	2.17	1402.39	539.70	0.28
1	50	TR 20	2050.00	137.54	145.52	142.62	145.81	0.002265	2.55	1169.69	411.90	0.34
1	40	TR 20	2050.00	137.06	144.84	142.53	145.07	0.002439	2.13	961.38	268.40	0.33
1	30	TR 20	2050.00	137.37	144.26	141.18	144.48	0.001906	2.09	980.88	475.93	0.30
1	20	TR 20	2050.00	136.62	143.76	140.64	143.93	0.001535	2.06	1684.57	670.10	0.28
1	10	TR 20	2050.00	135.29	142.79	140.78	143.23	0.004002	3.16	1096.50	620.31	0.44

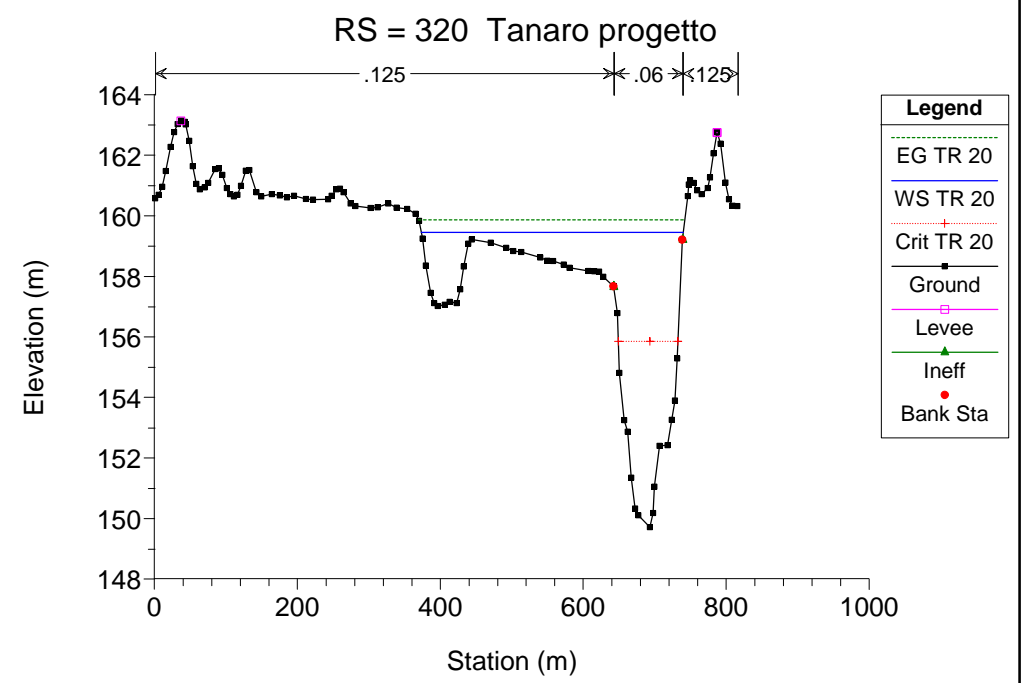
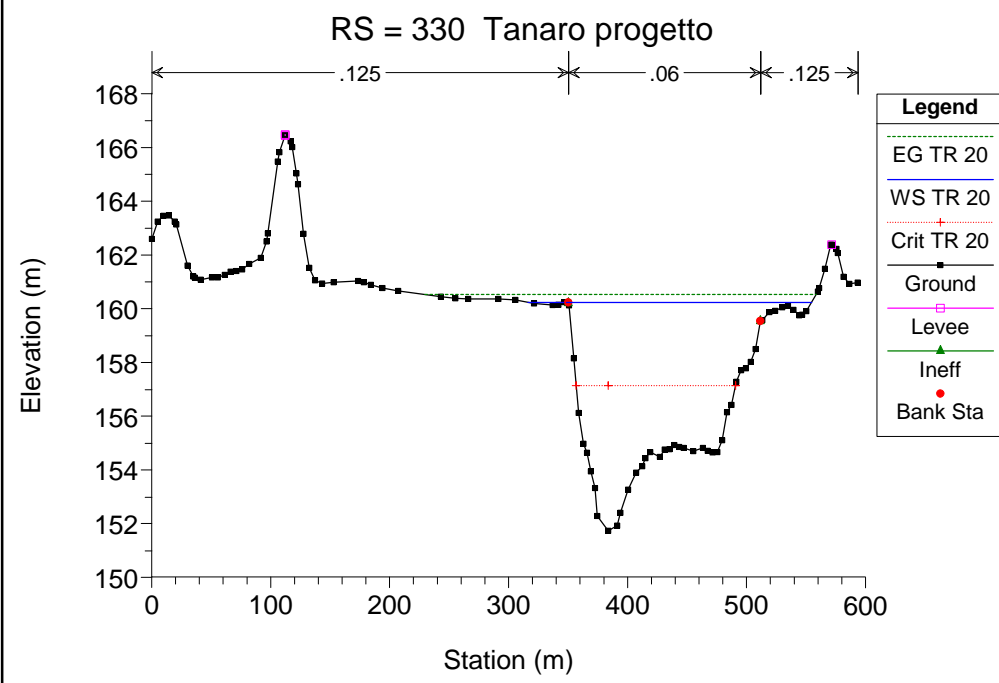
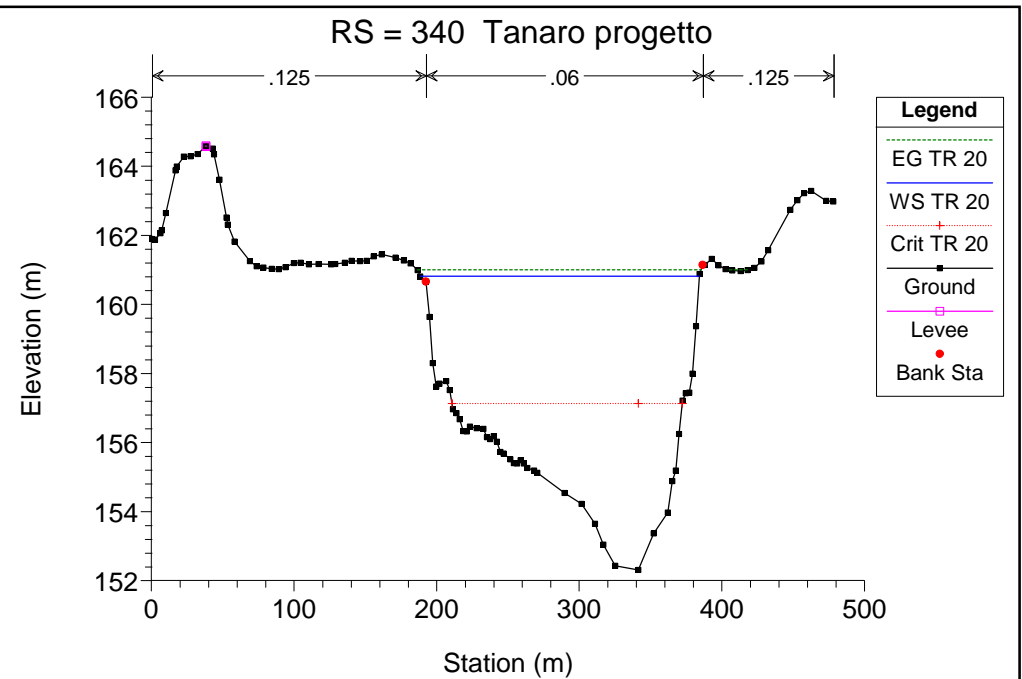
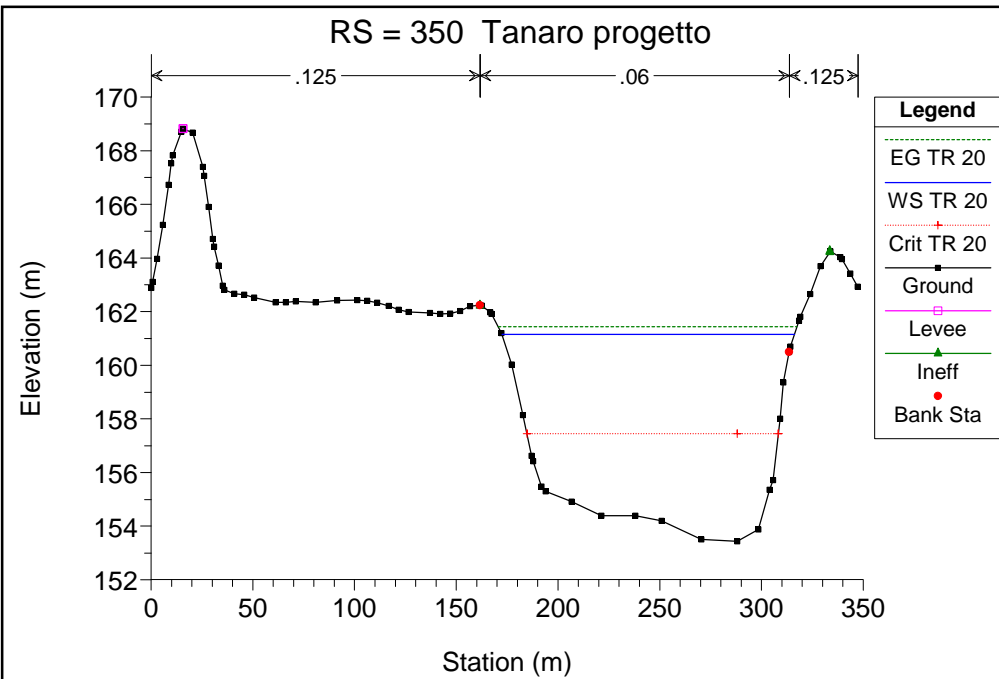
Tanaro progetto

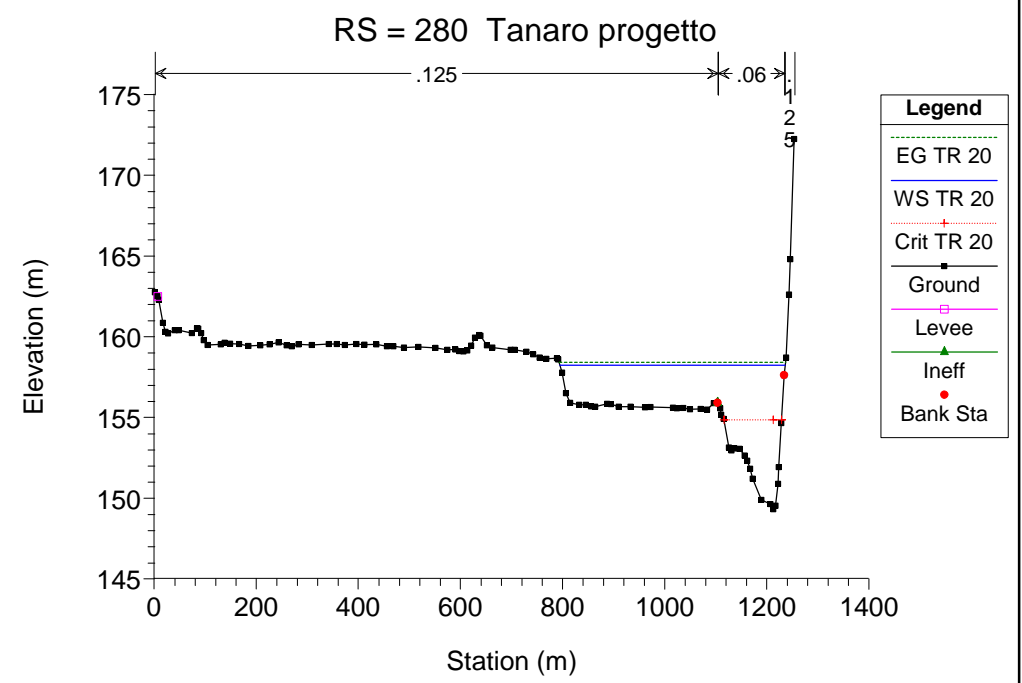
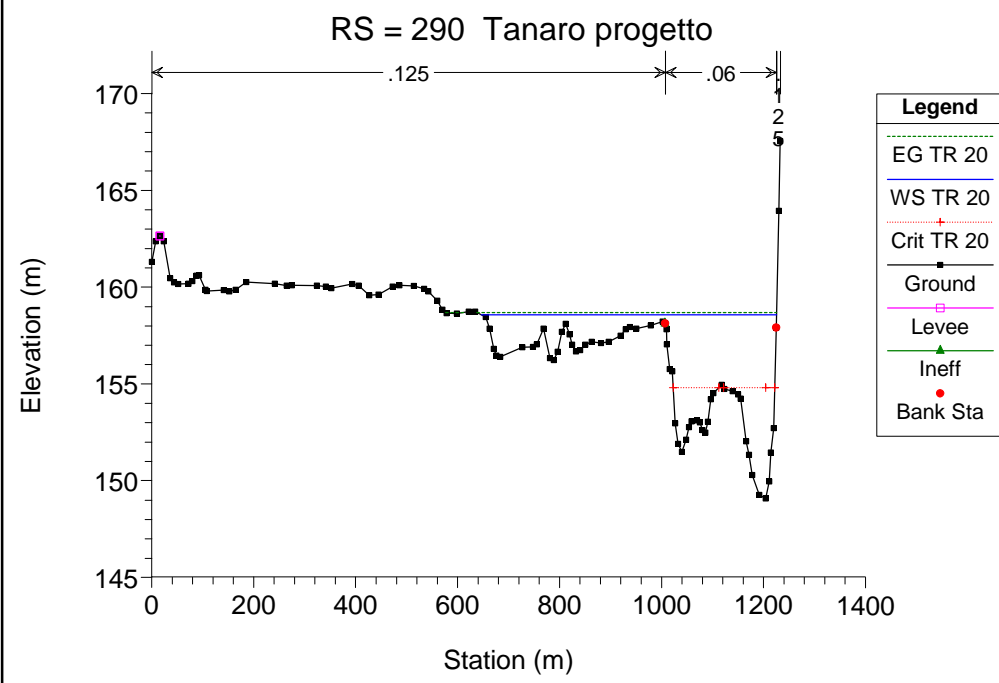
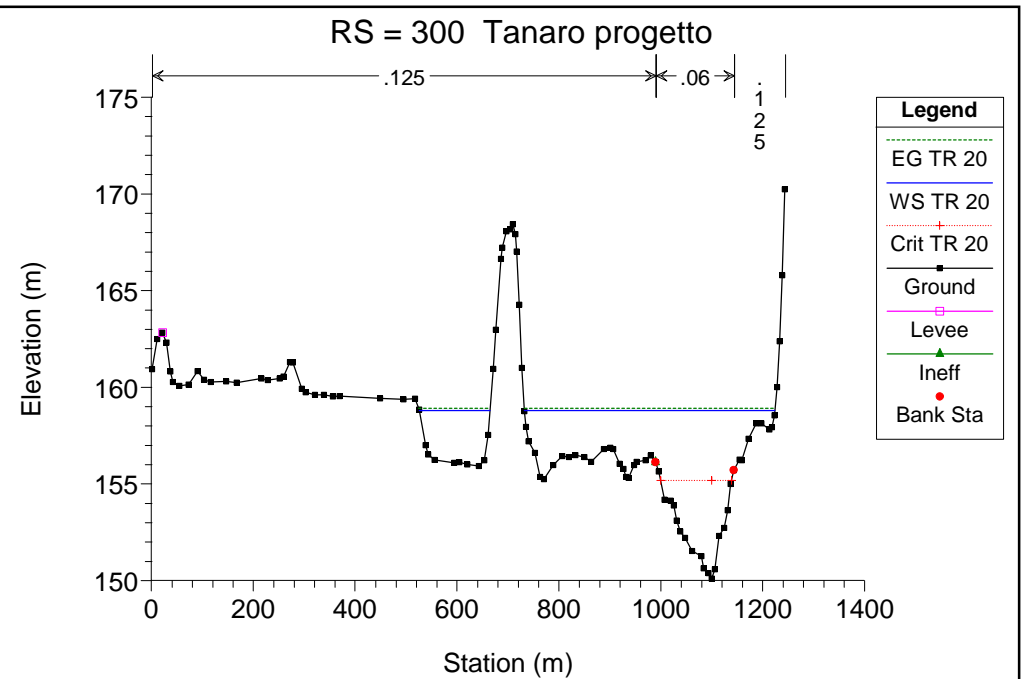
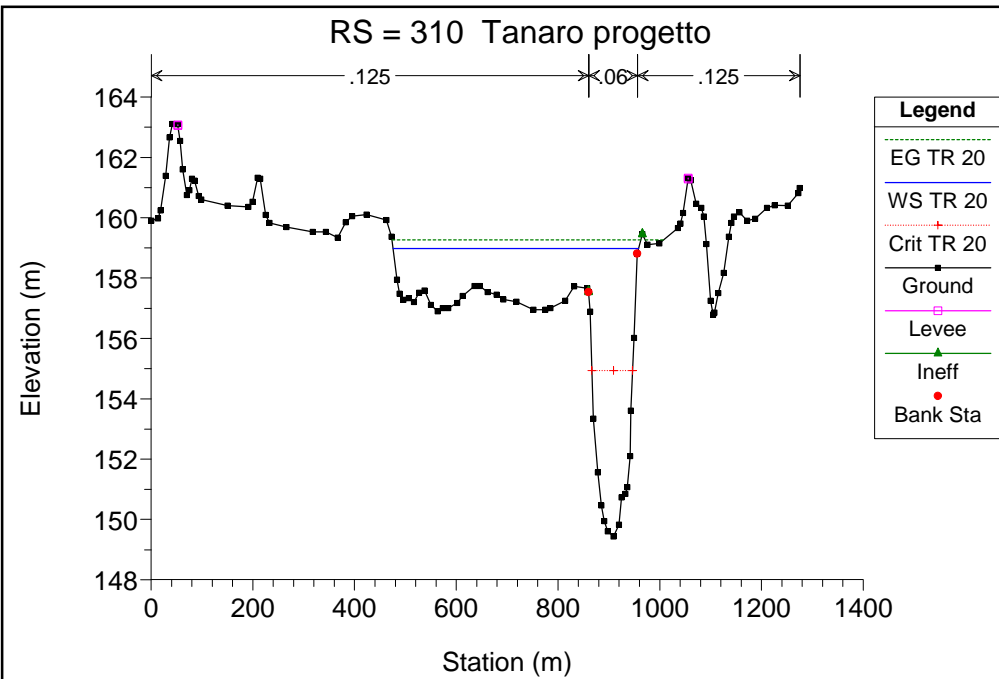


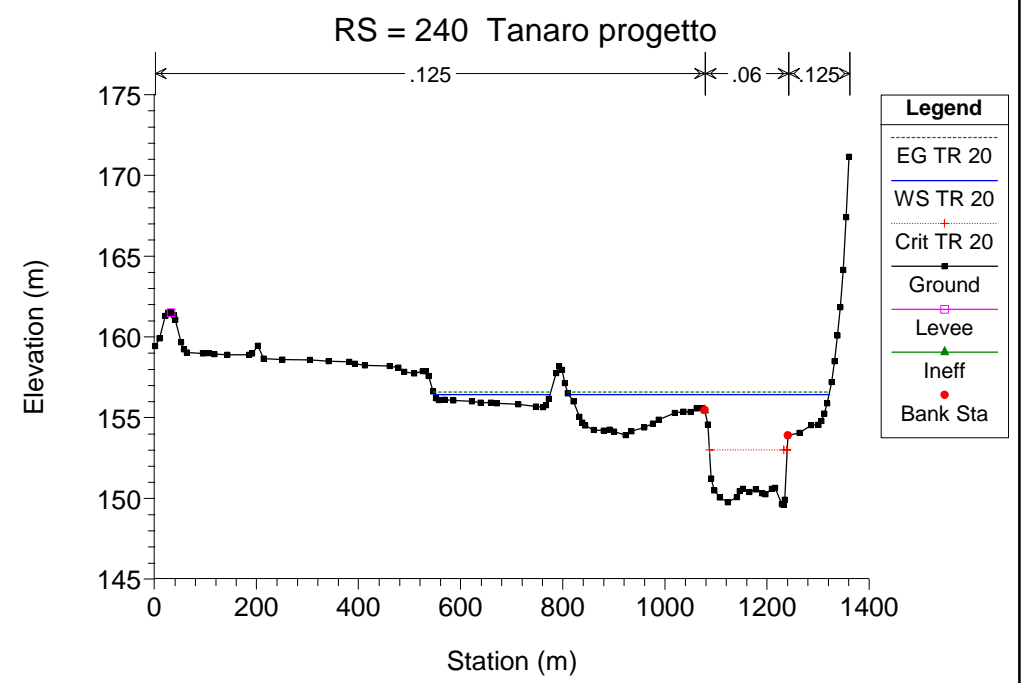
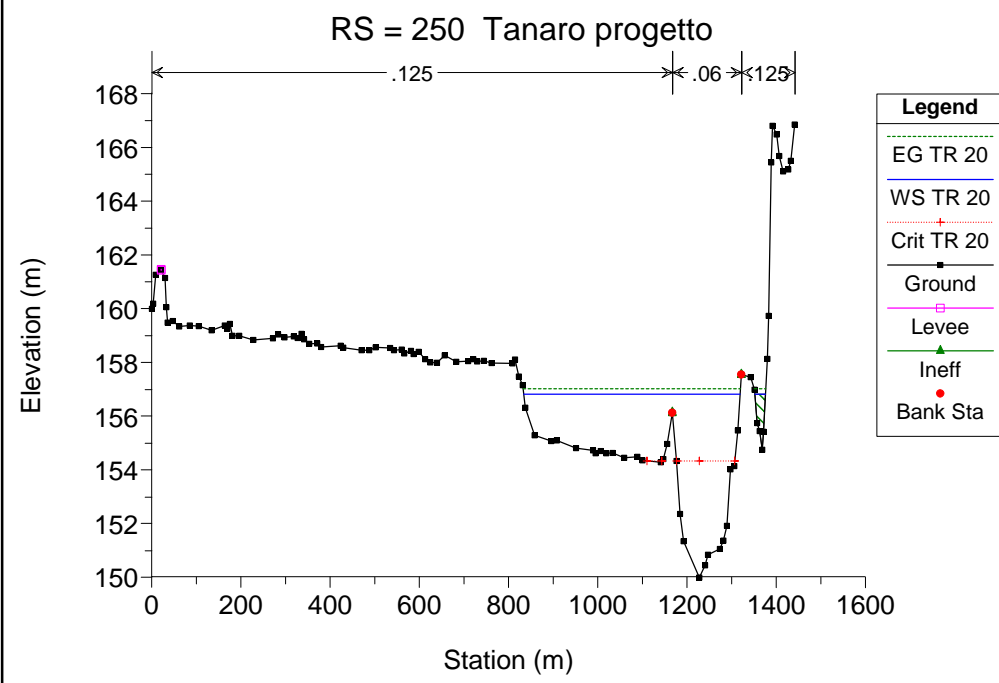
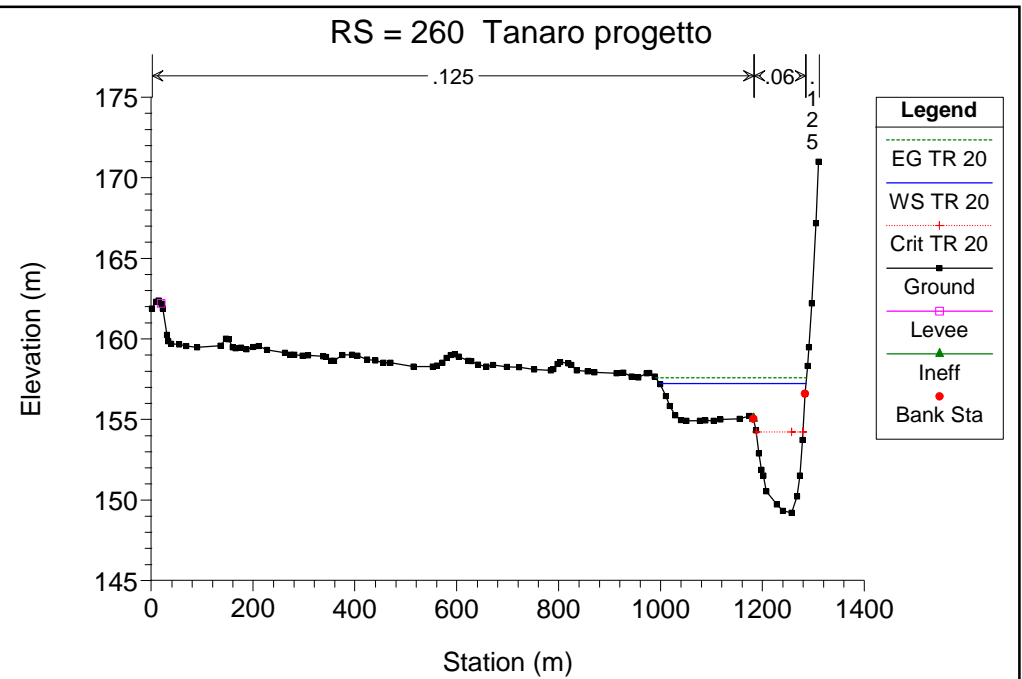
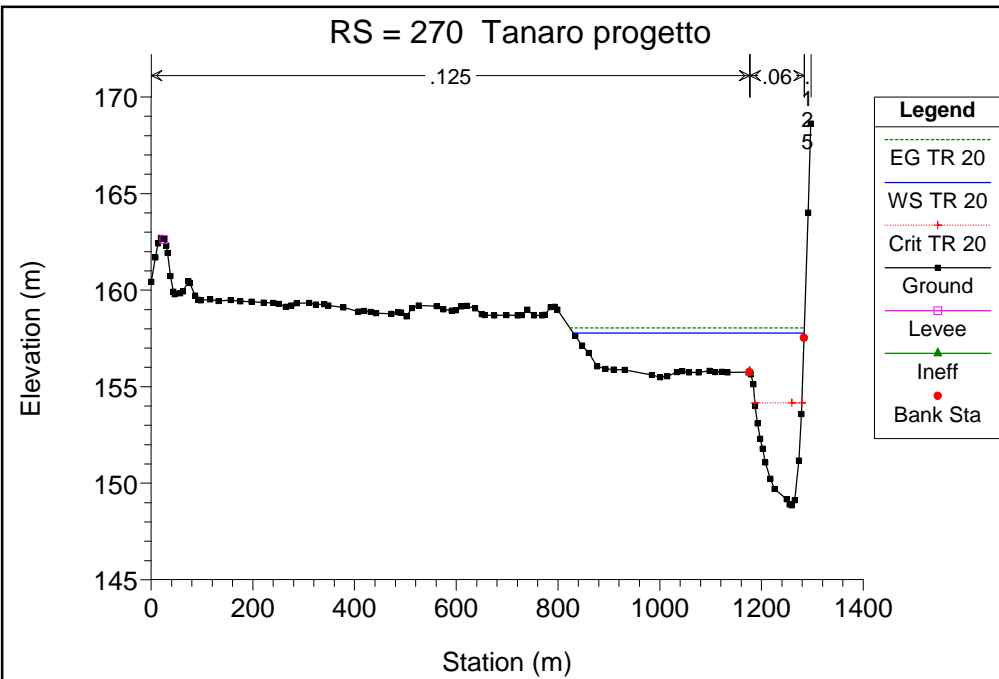


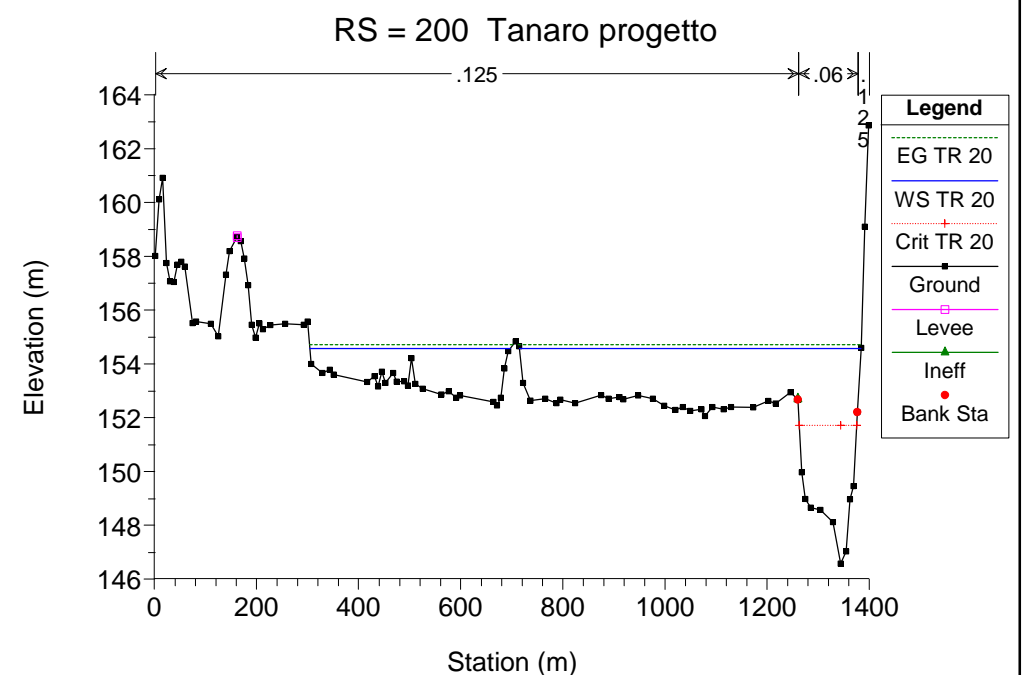
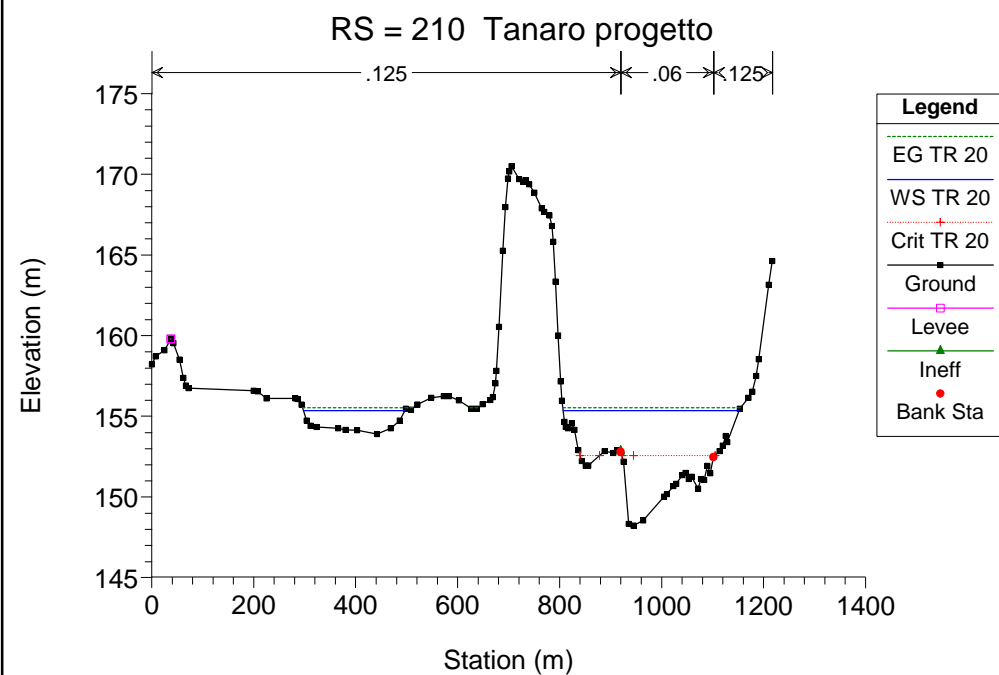
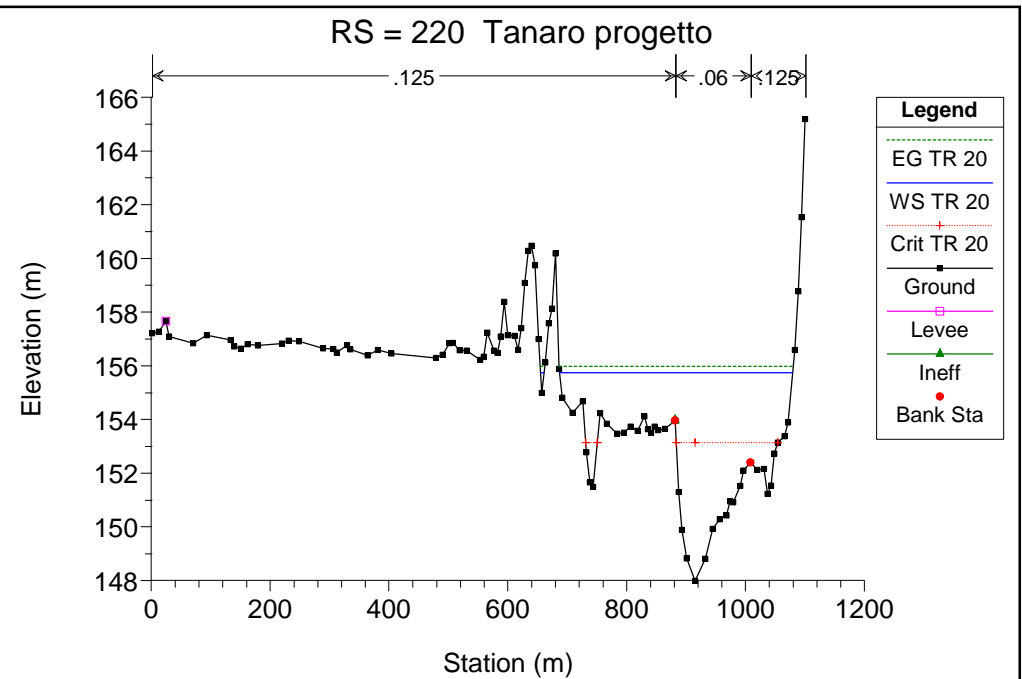
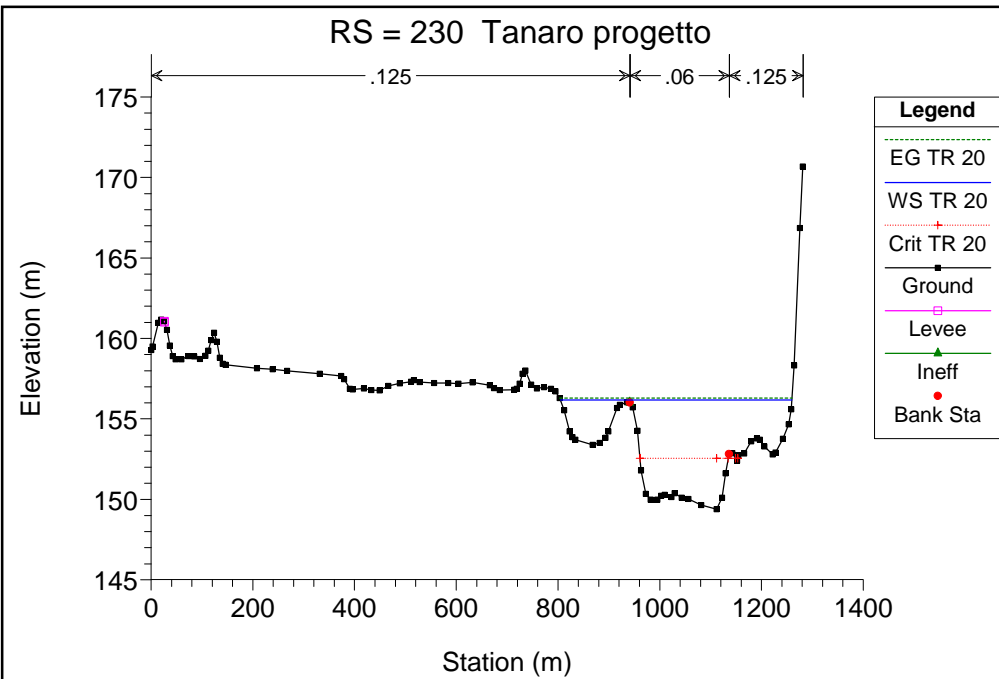


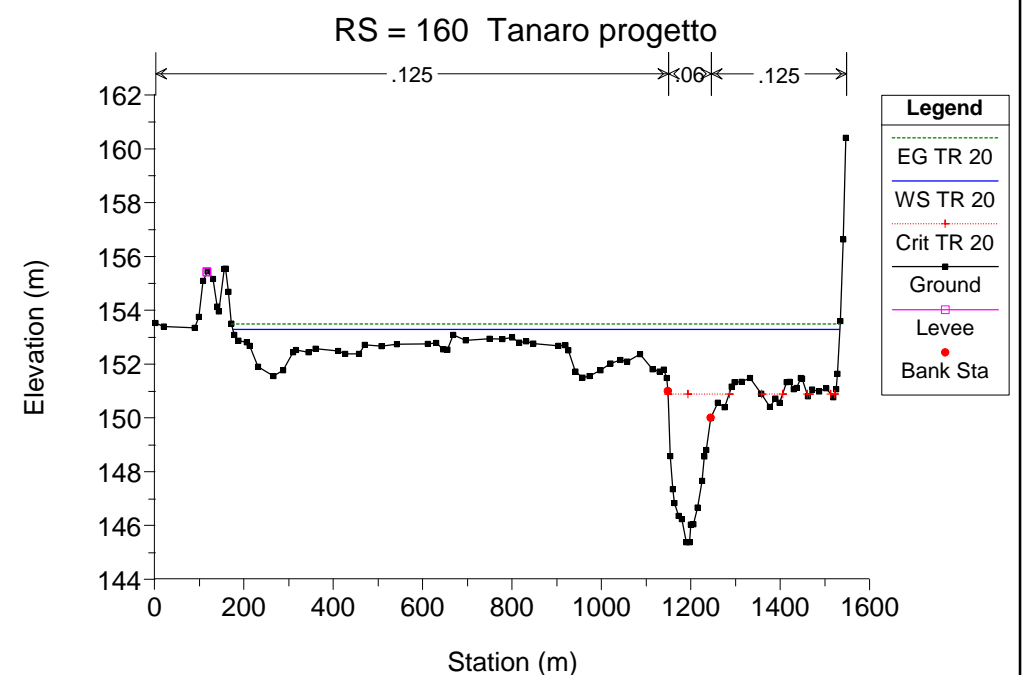
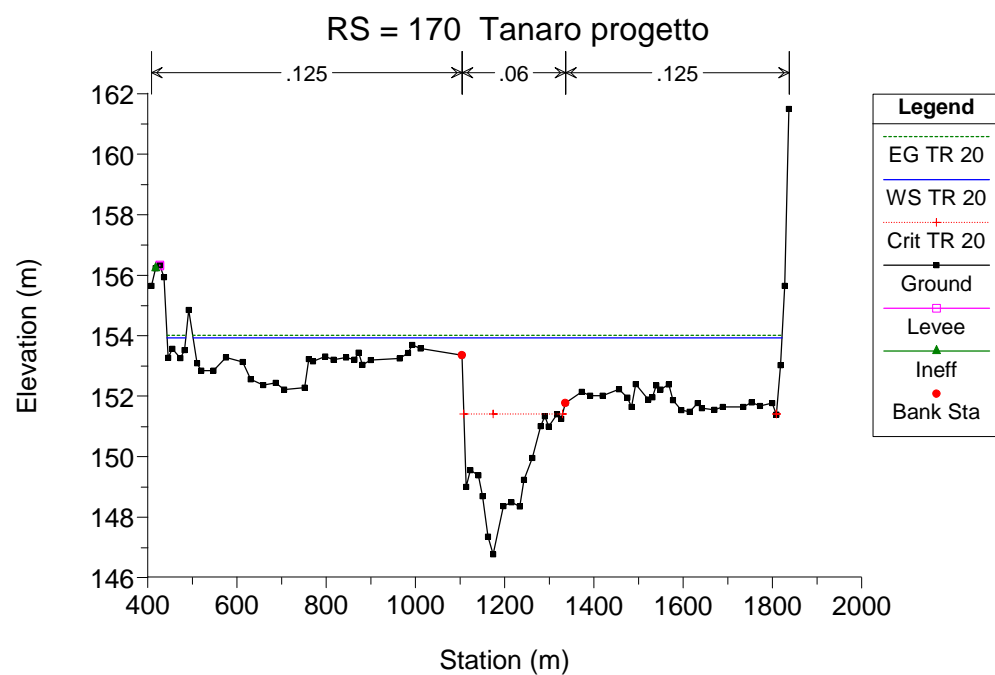
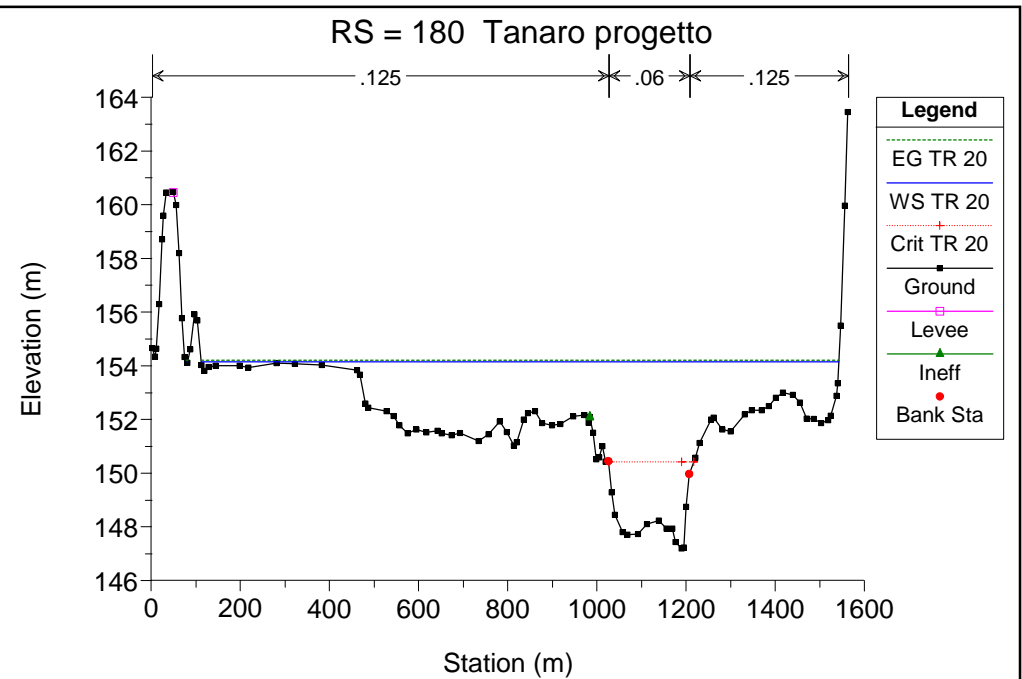
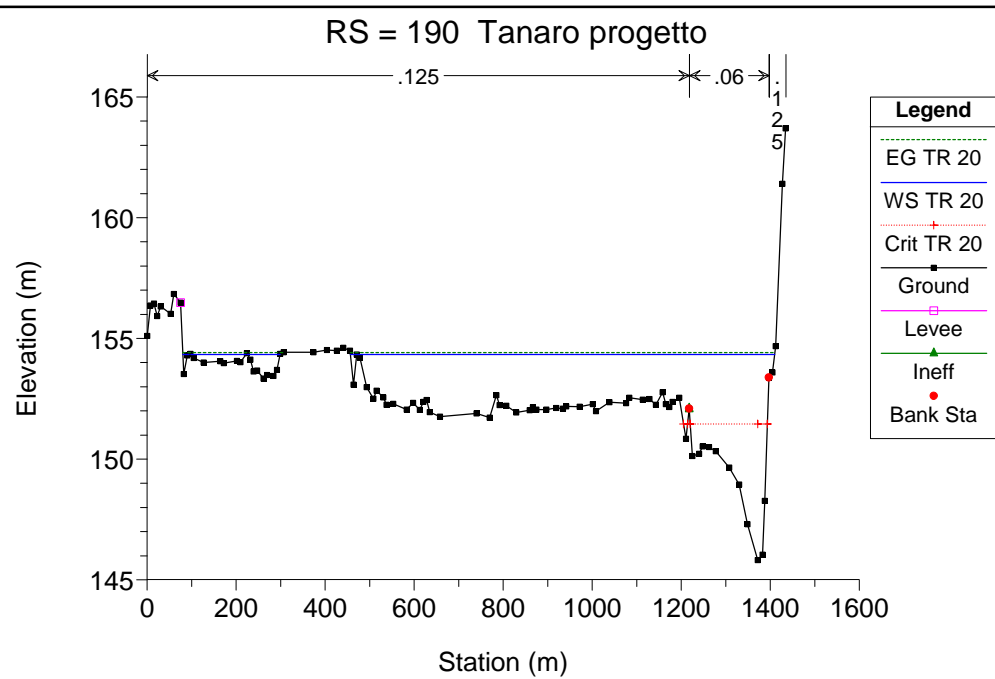


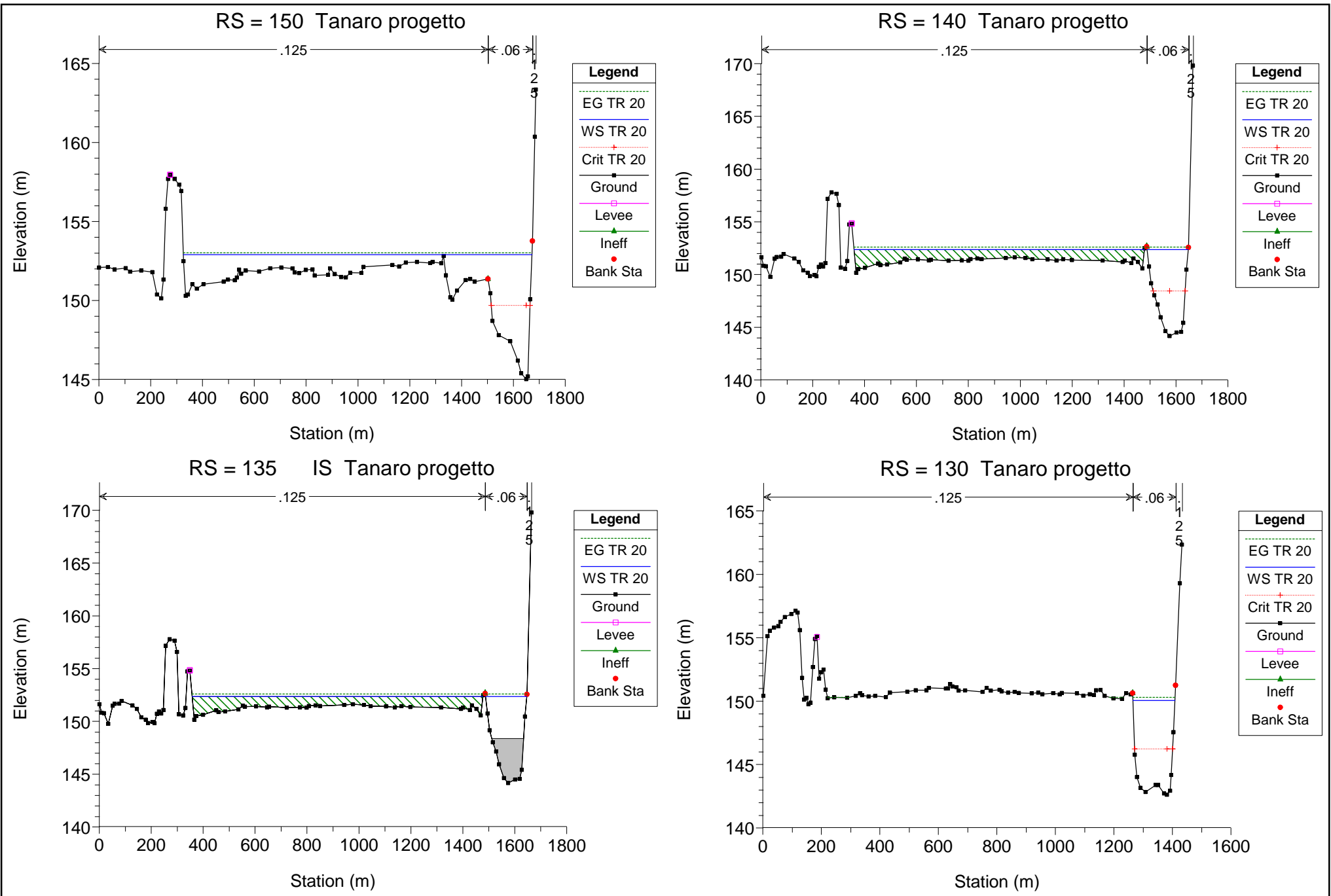


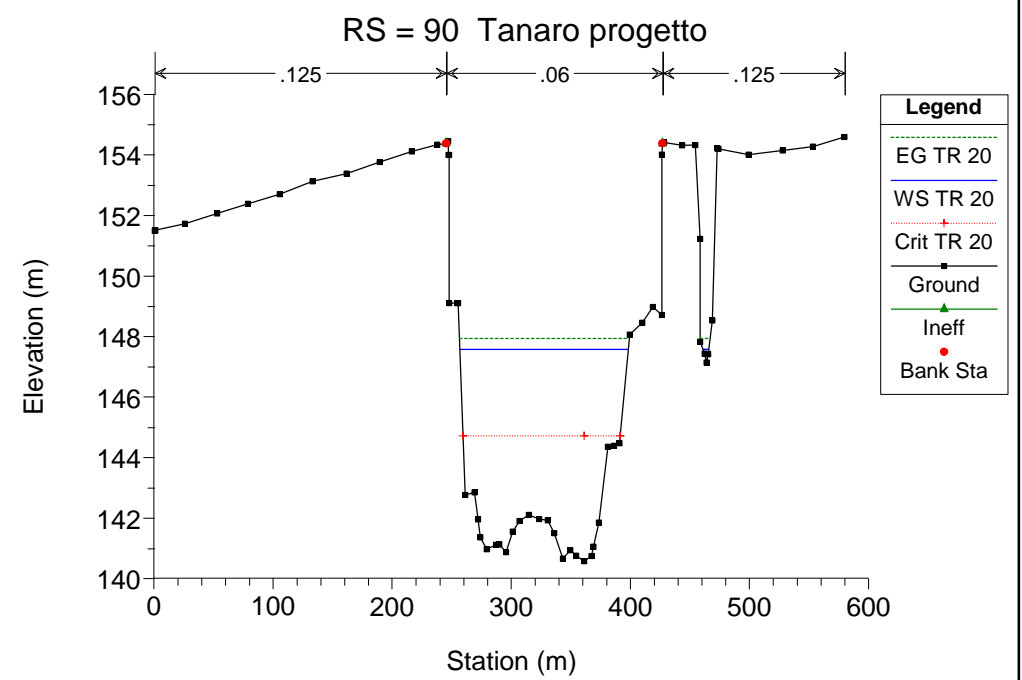
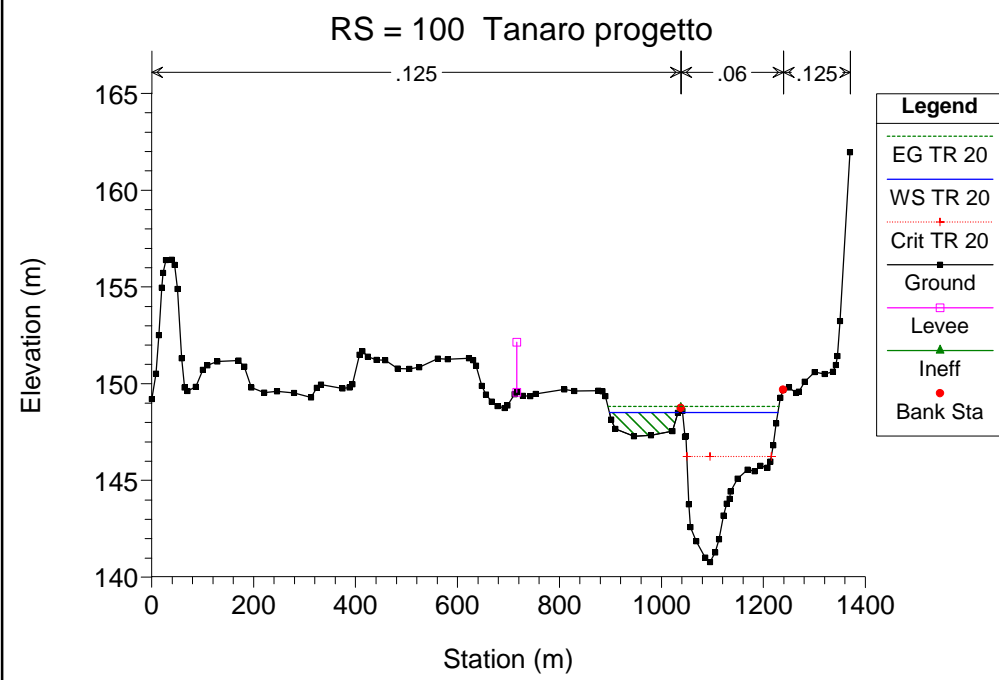
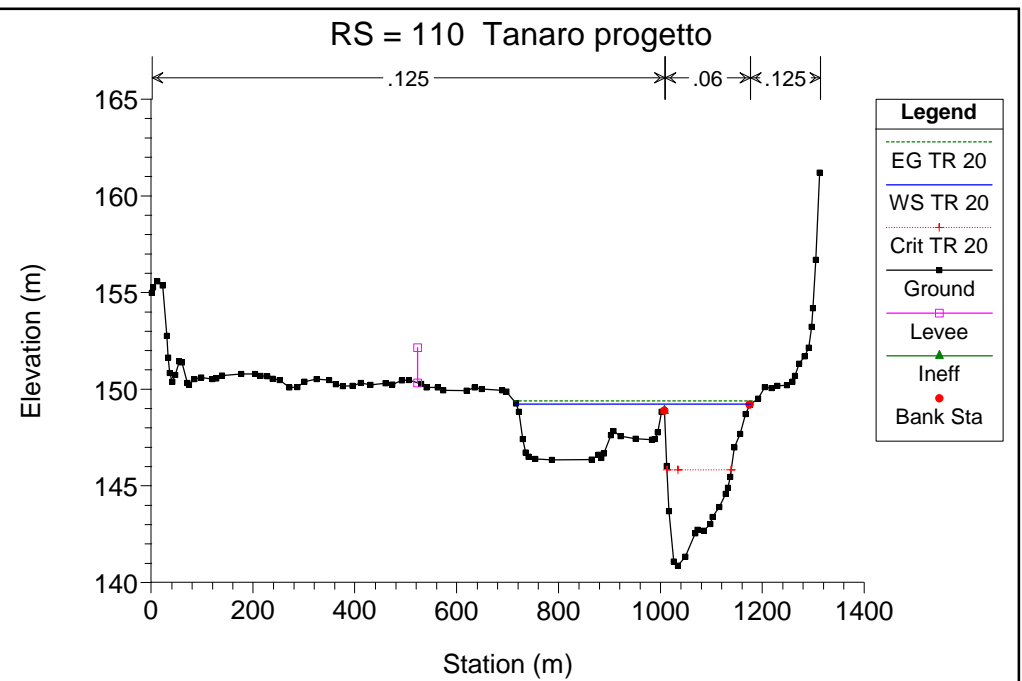
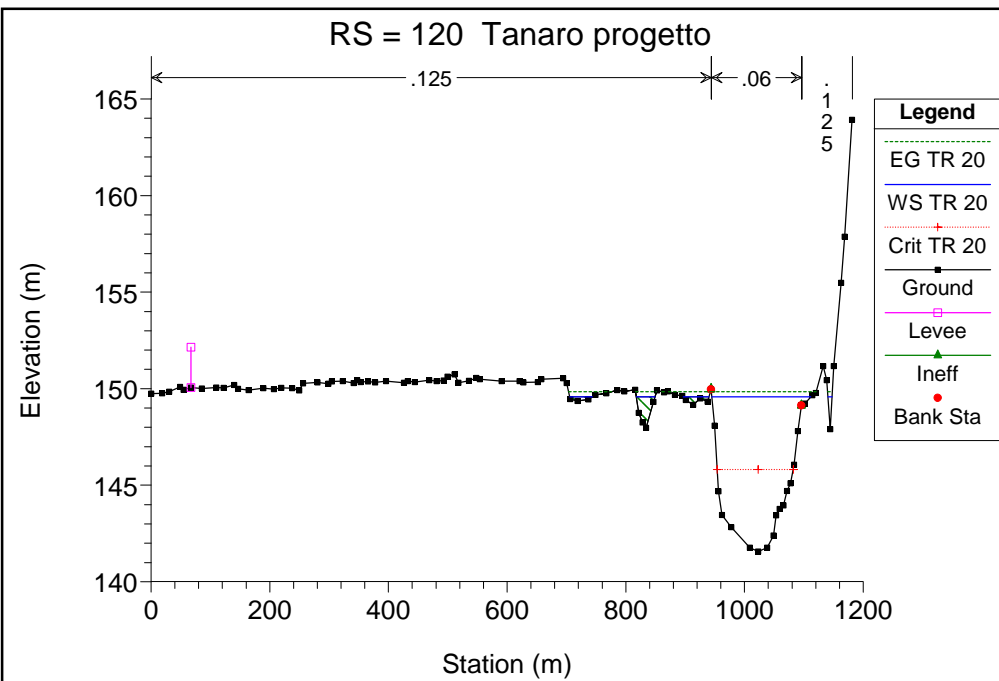


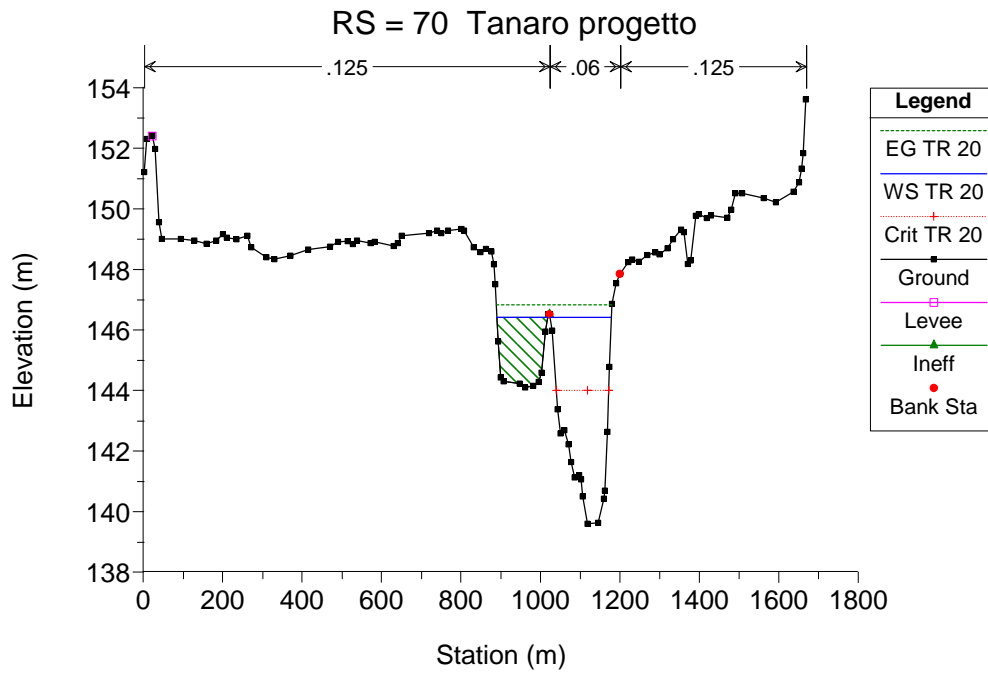
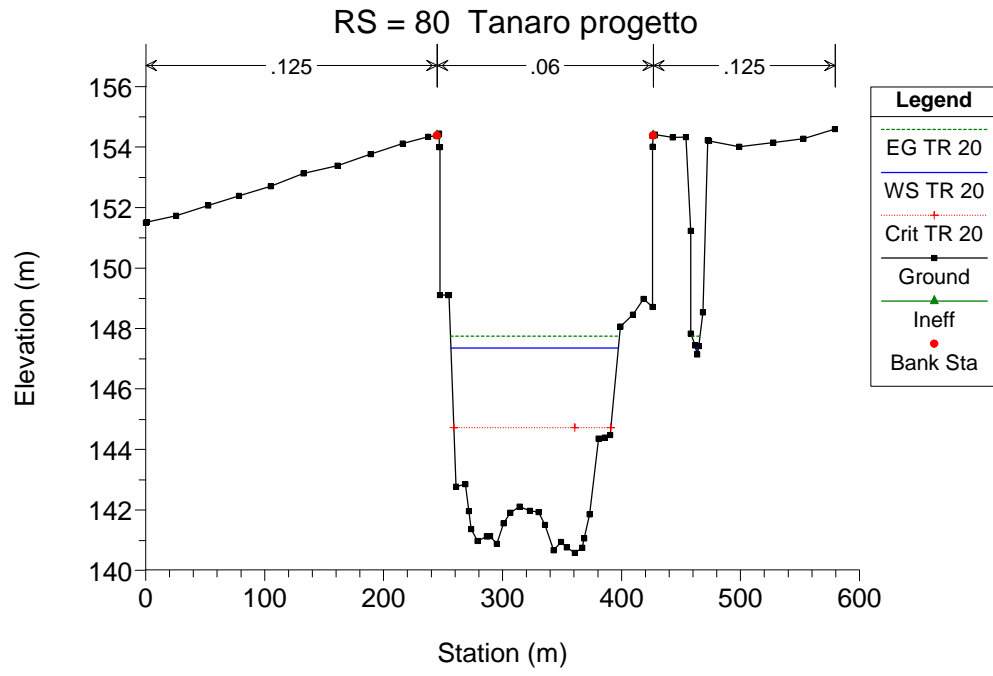
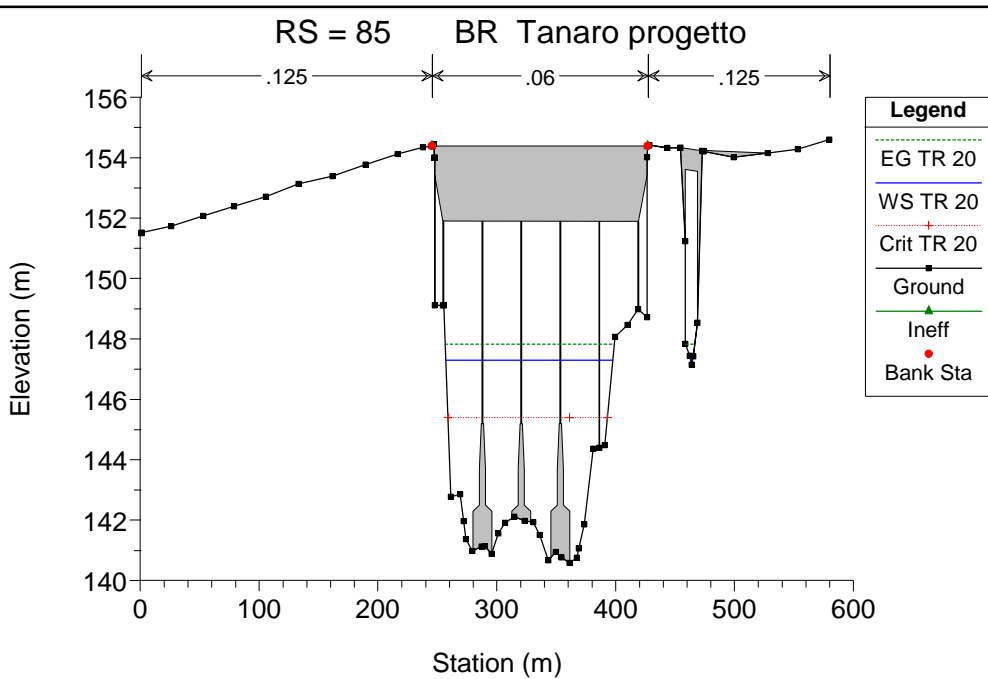
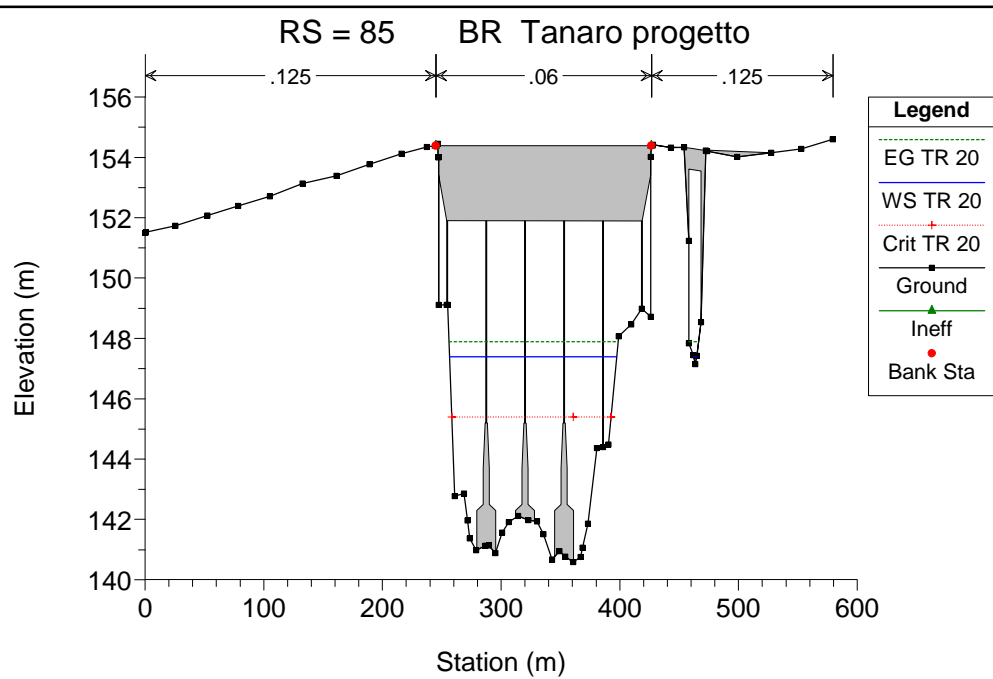


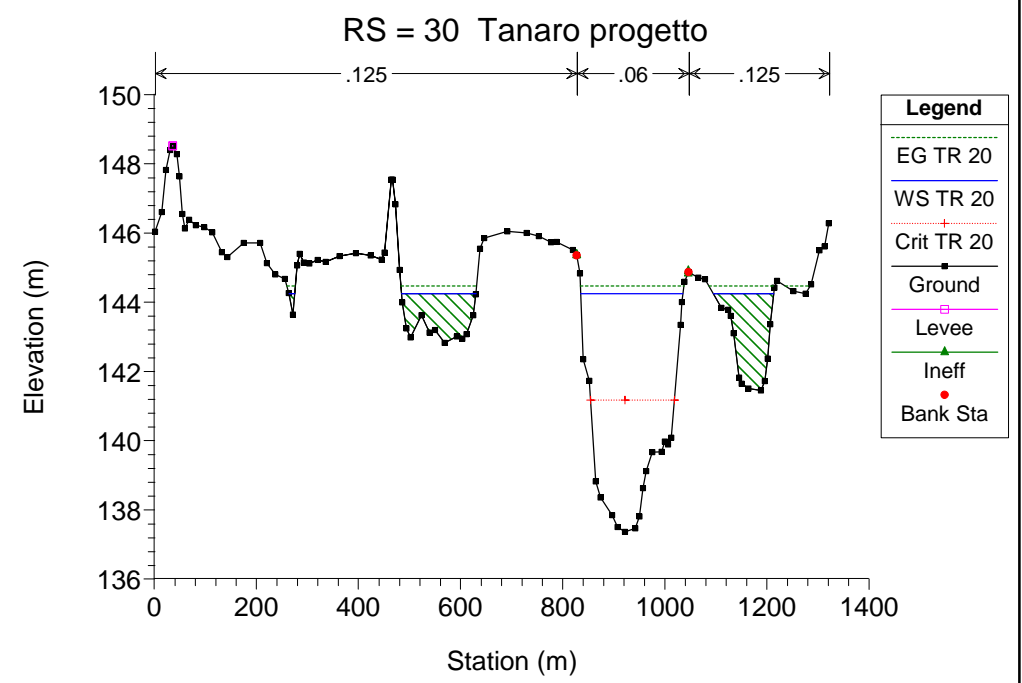
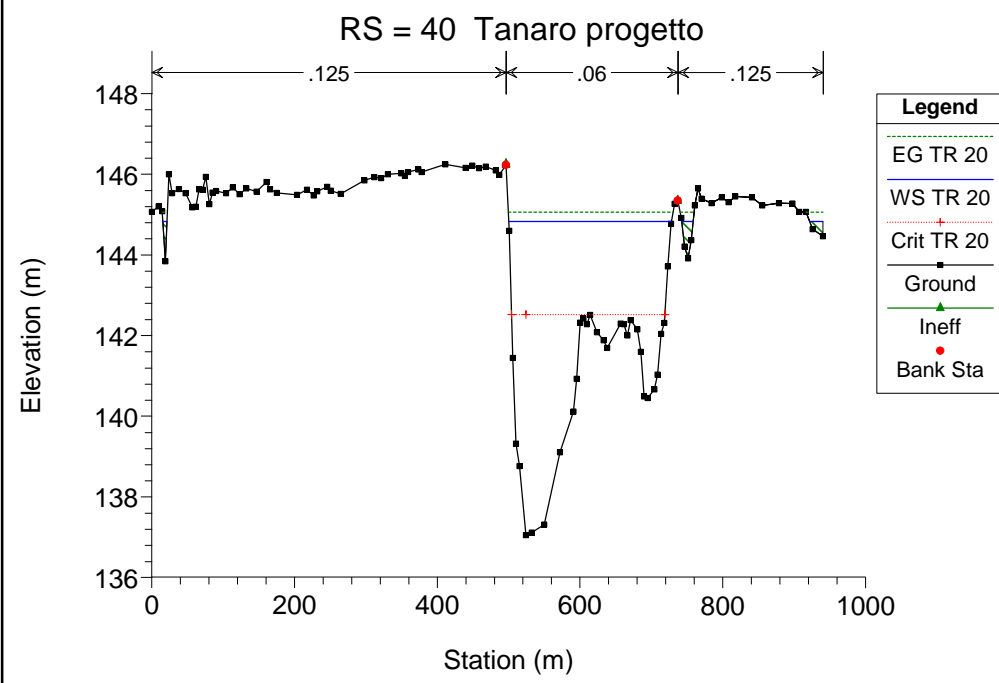
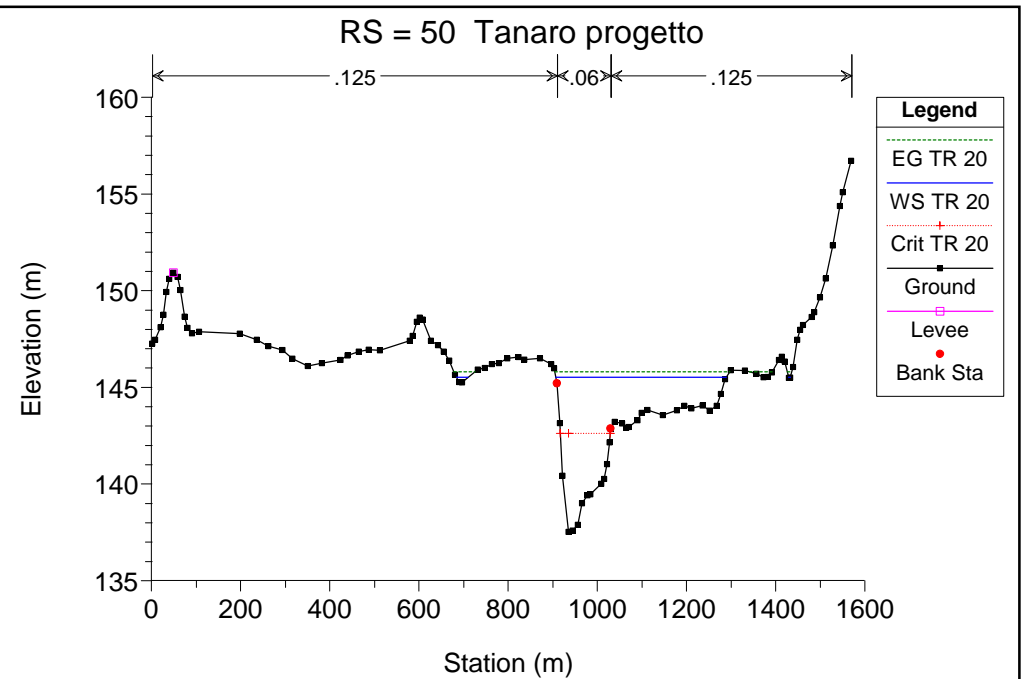
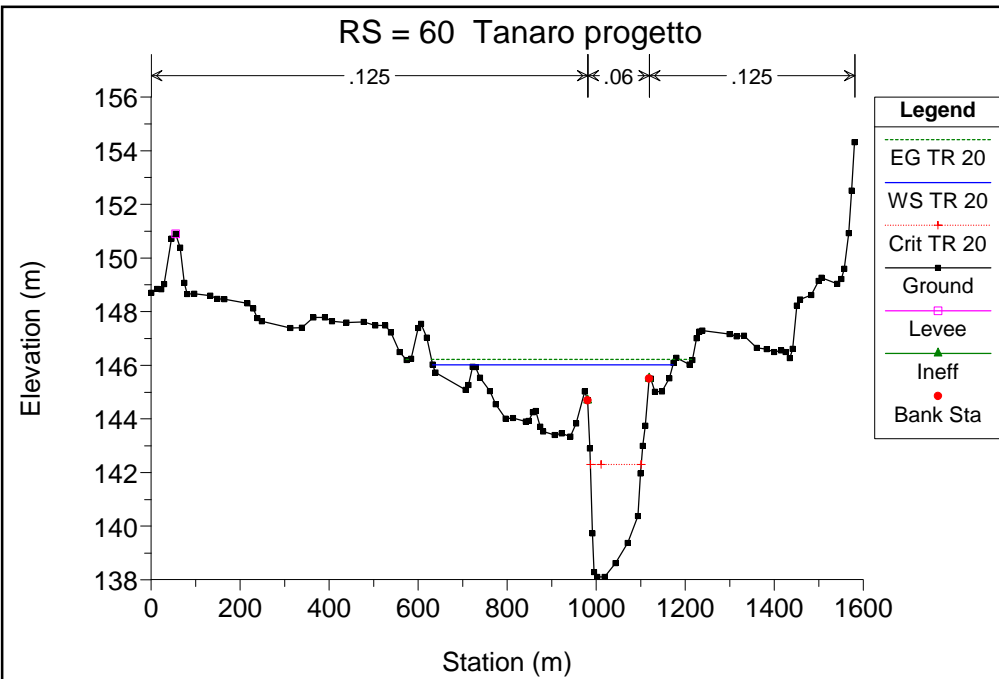




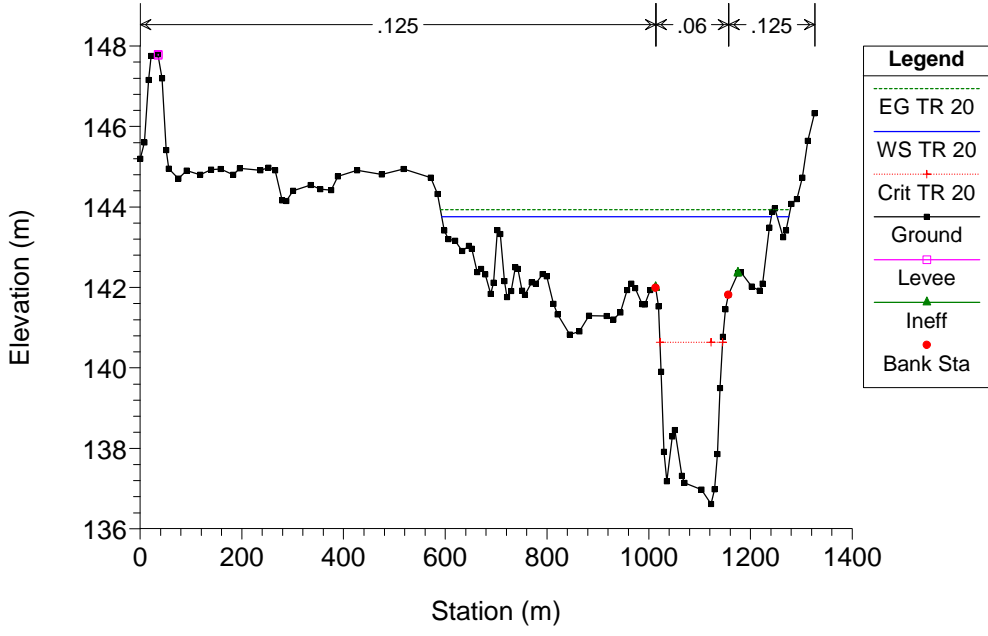




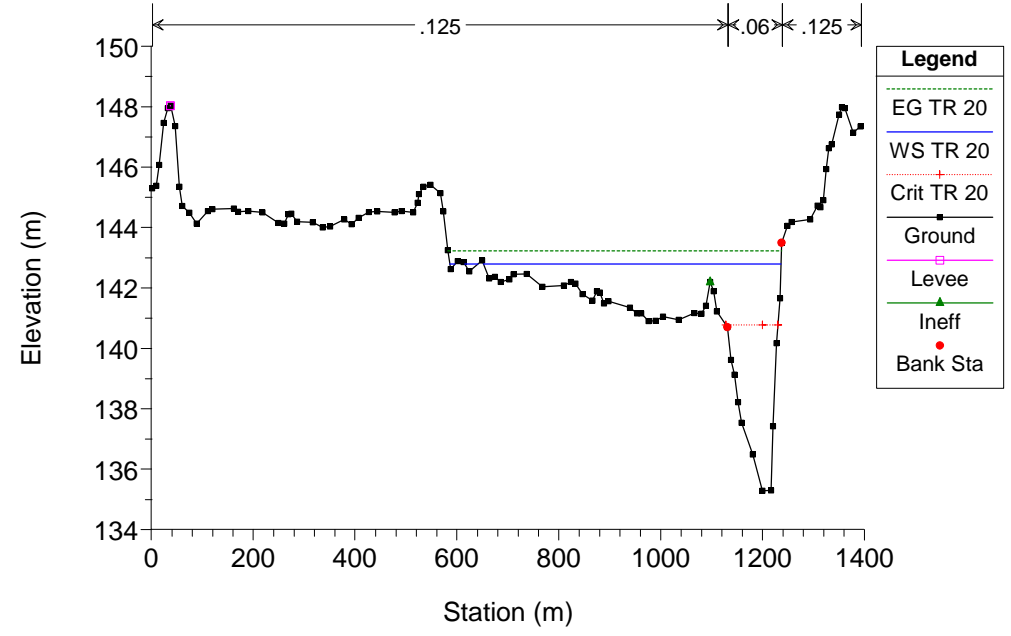




RS = 20 Tanaro progetto



RS = 10 Tanaro progetto



SITUAZIONE DI PROGETTO
(coincidente con situazione ante crollo 2010)
SIMULAZIONE 5

corso d'acqua	portata al colmo Q_c m^3/s	tempo di ritorno anni
Fiume Tanaro	2750	100

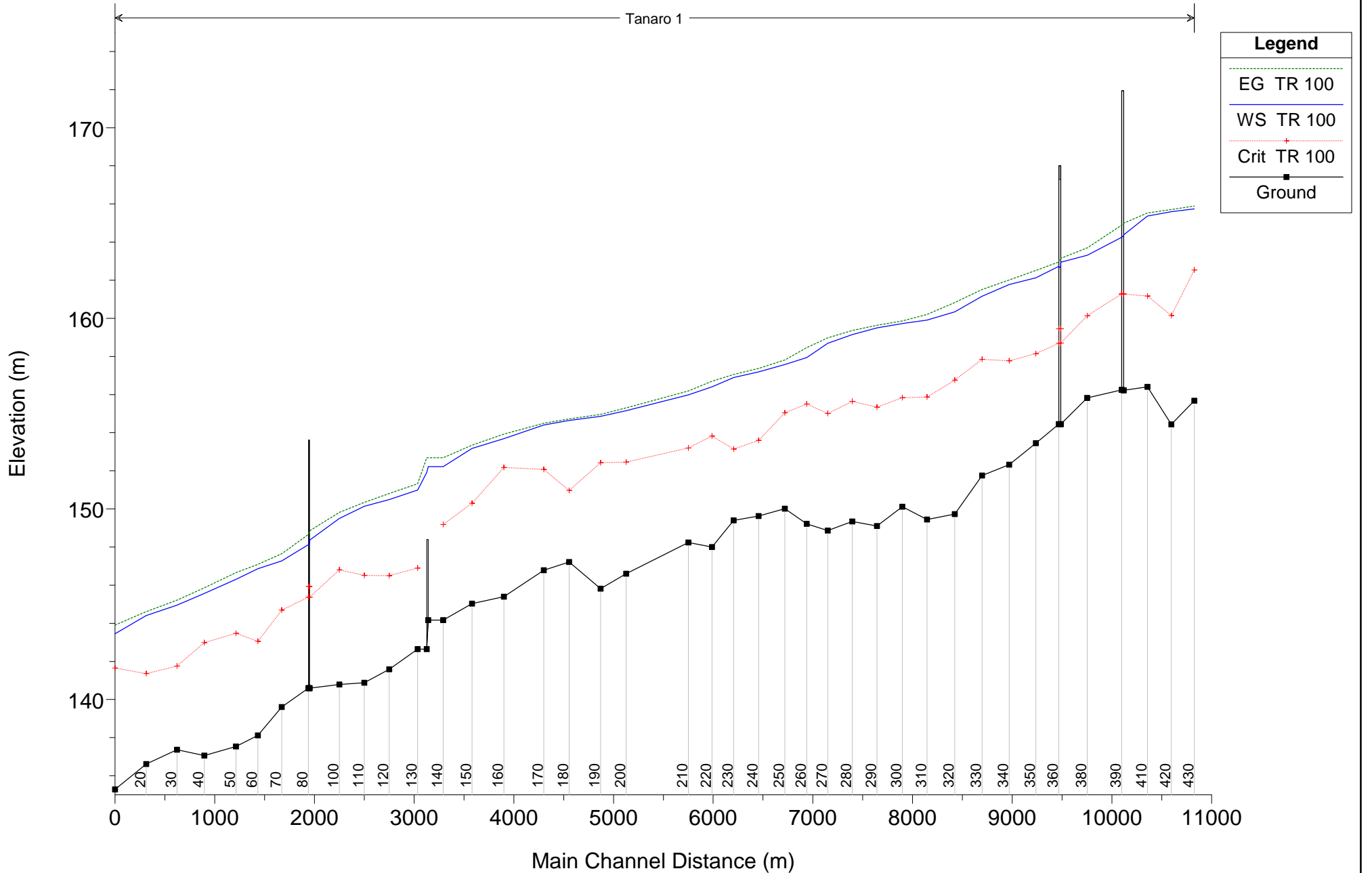
HEC-RAS Plan: Plan 06 River: Tanaro Reach: 1 Profile: TR 100

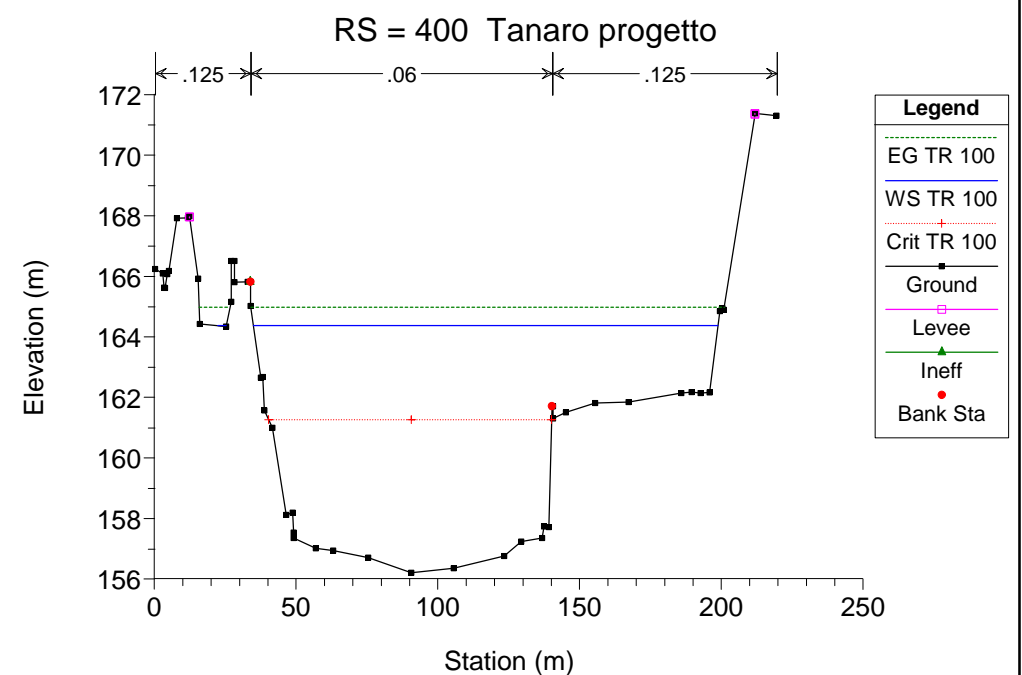
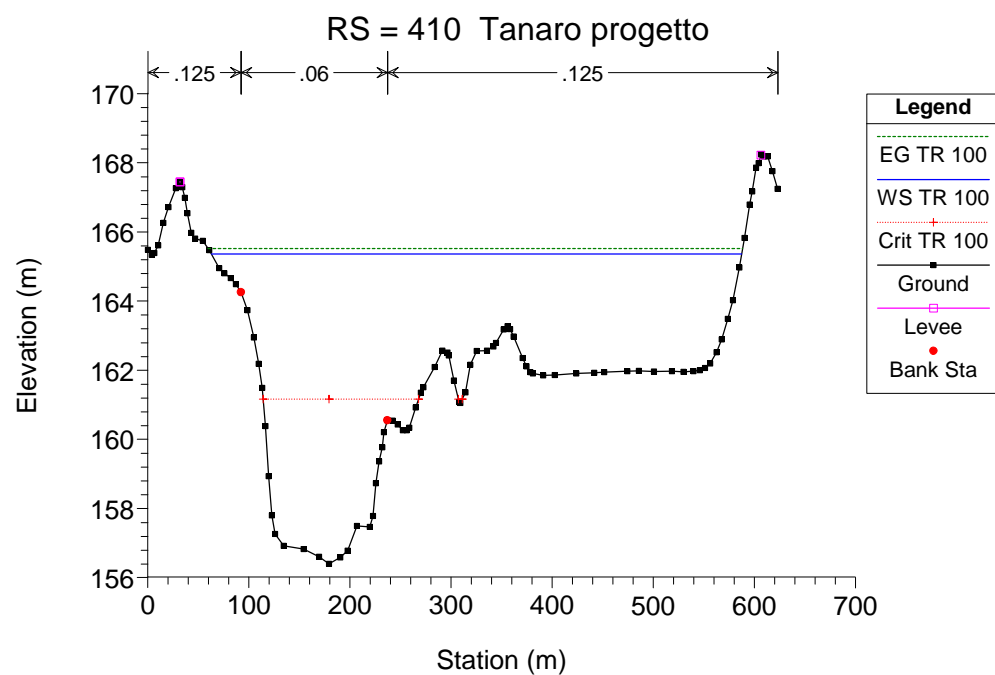
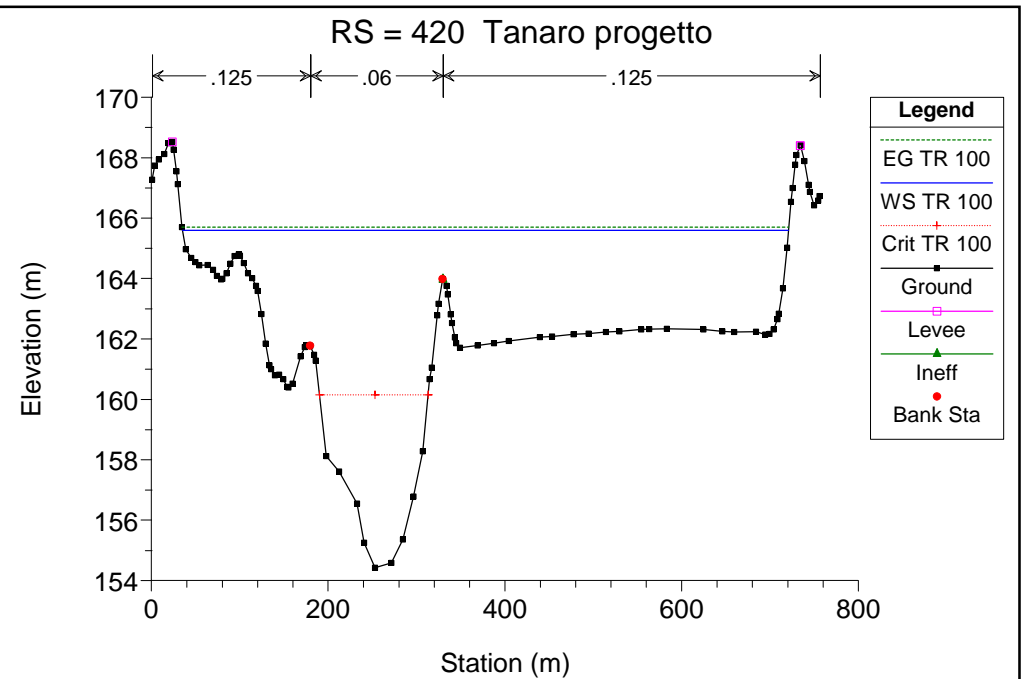
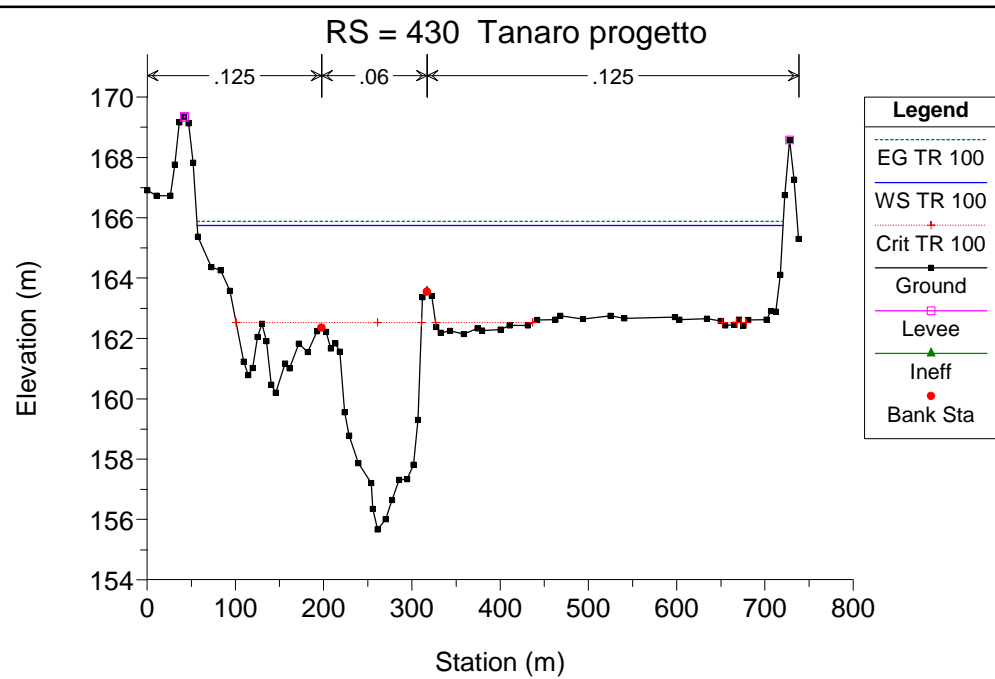
Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
1	430	TR 100	2750.00	155.68	165.75	162.53	165.89	0.001147	2.05	2589.16	663.79	0.25
1	420	TR 100	2750.00	154.44	165.60	160.15	165.70	0.000610	1.66	2896.09	685.69	0.19
1	410	TR 100	2750.00	156.41	165.36	161.17	165.52	0.001081	2.01	2201.54	524.40	0.24
1	400	TR 100	2750.00	156.22	164.38	161.27	164.99	0.003543	3.53	886.96	166.85	0.42
1	395		Bridge									
1	390	TR 100	2750.00	156.25	164.25	161.28	164.89	0.003782	3.61	865.47	163.54	0.44
1	380	TR 100	2750.00	155.82	163.31	160.13	163.70	0.002535	2.76	1014.33	210.52	0.36
1	370	TR 100	2750.00	154.45	162.94	158.70	163.15	0.001244	2.03	1353.34	205.85	0.25
1	365		Bridge									
1	360	TR 100	2750.00	154.45	162.73	158.70	162.95	0.001382	2.10	1309.34	205.25	0.27
1	350	TR 100	2750.00	153.45	162.13	158.14	162.51	0.002182	2.74	1008.53	191.56	0.34
1	340	TR 100	2750.00	152.32	161.77	157.77	162.01	0.001384	2.15	1373.64	375.80	0.27
1	330	TR 100	2750.00	151.75	161.16	157.85	161.52	0.002313	2.69	1188.58	427.09	0.34
1	320	TR 100	2750.00	149.73	160.34	156.76	160.83	0.002627	3.27	1287.56	449.64	0.38
1	310	TR 100	2750.00	149.44	159.90	155.87	160.20	0.001747	2.75	1859.78	733.67	0.31
1	300	TR 100	2750.00	150.11	159.72	155.84	159.86	0.000938	1.87	2669.81	858.20	0.22
1	290	TR 100	2750.00	149.10	159.50	155.33	159.64	0.000885	1.71	2284.73	673.11	0.21
1	280	TR 100	2750.00	149.34	159.15	155.65	159.36	0.001482	2.32	1981.03	535.23	0.28
1	270	TR 100	2750.00	148.86	158.69	155.01	158.97	0.001767	2.65	1775.46	489.83	0.31
1	260	TR 100	2750.00	149.22	157.94	155.50	158.46	0.003206	3.41	1232.06	420.41	0.41
1	250	TR 100	2750.00	150.01	157.58	155.03	157.81	0.002207	2.43	1821.19	556.45	0.33
1	240	TR 100	2750.00	149.63	157.19	153.60	157.37	0.001286	2.07	2218.15	763.34	0.26
1	230	TR 100	2750.00	149.40	156.90	153.15	157.06	0.001143	1.91	2002.89	588.84	0.24
1	220	TR 100	2750.00	148.00	156.40	153.82	156.70	0.002317	2.70	1583.64	489.40	0.35
1	210	TR 100	2750.00	148.24	155.98	153.20	156.19	0.001738	2.22	1867.32	666.87	0.30
1	200	TR 100	2750.00	146.60	155.16	152.46	155.30	0.001406	2.17	2915.09	1087.62	0.27
1	190	TR 100	2750.00	145.82	154.86	152.43	154.97	0.001109	1.76	3289.34	1333.11	0.24
1	180	TR 100	2750.00	147.21	154.65	150.97	154.73	0.000673	1.52	3901.34	1448.97	0.19
1	170	TR 100	2750.00	146.78	154.40	152.07	154.50	0.001153	1.63	3206.07	1373.09	0.23
1	160	TR 100	2750.00	145.40	153.69	152.17	153.92	0.002151	2.69	2598.17	1363.64	0.34
1	150	TR 100	2750.00	145.03	153.18	150.30	153.35	0.001609	2.11	2689.29	1346.87	0.28
1	140	TR 100	2750.00	144.17	152.22	149.18	152.69	0.003252	3.03	907.96	1275.84	0.40
1	135		Inl Struct									
1	130	TR 100	2750.00	142.64	150.99	146.90	151.32	0.001812	2.58	1404.78	1088.16	0.31
1	120	TR 100	2750.00	141.58	150.49	146.50	150.81	0.001802	2.53	1454.46	1003.33	0.31
1	110	TR 100	2750.00	140.88	150.14	146.51	150.35	0.001612	2.22	1987.57	687.19	0.29
1	100	TR 100	2750.00	140.79	149.50	146.81	149.82	0.002773	2.57	1280.43	385.47	0.36
1	90	TR 100	2750.00	140.59	148.37	145.37	148.86	0.003393	3.10	886.56	160.87	0.41
1	85		Bridge									
1	80	TR 100	2750.00	140.59	148.12	145.37	148.65	0.003673	3.24	850.04	153.25	0.43

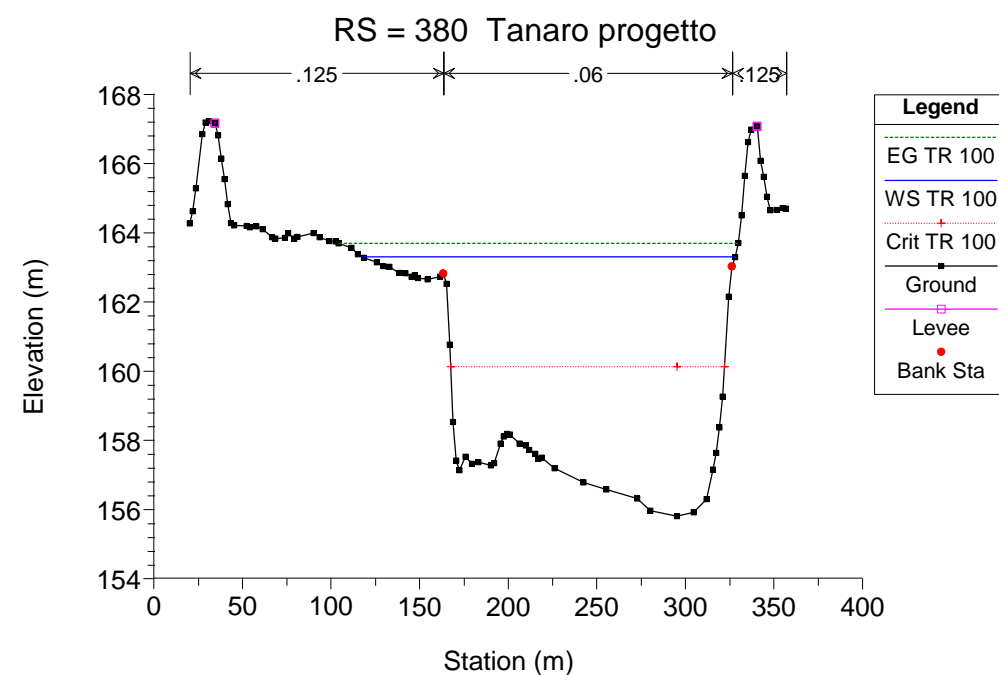
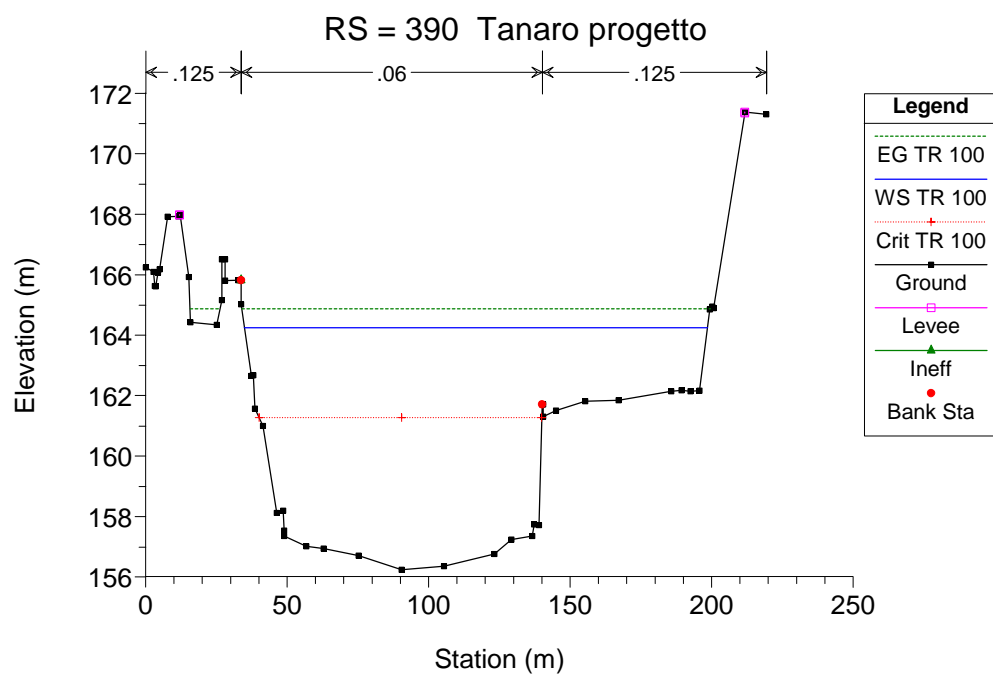
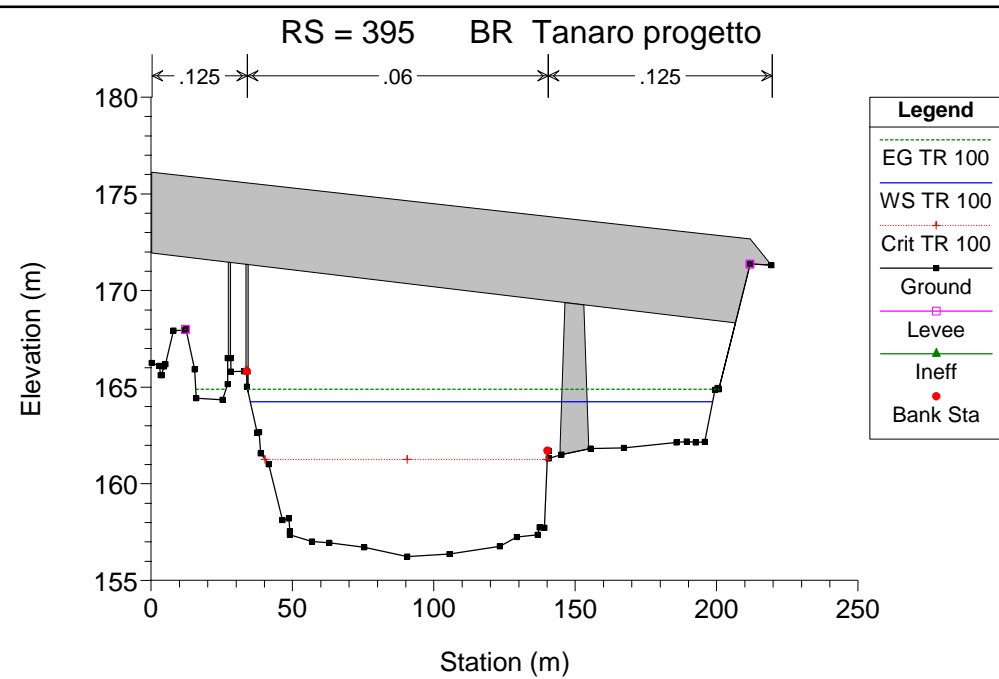
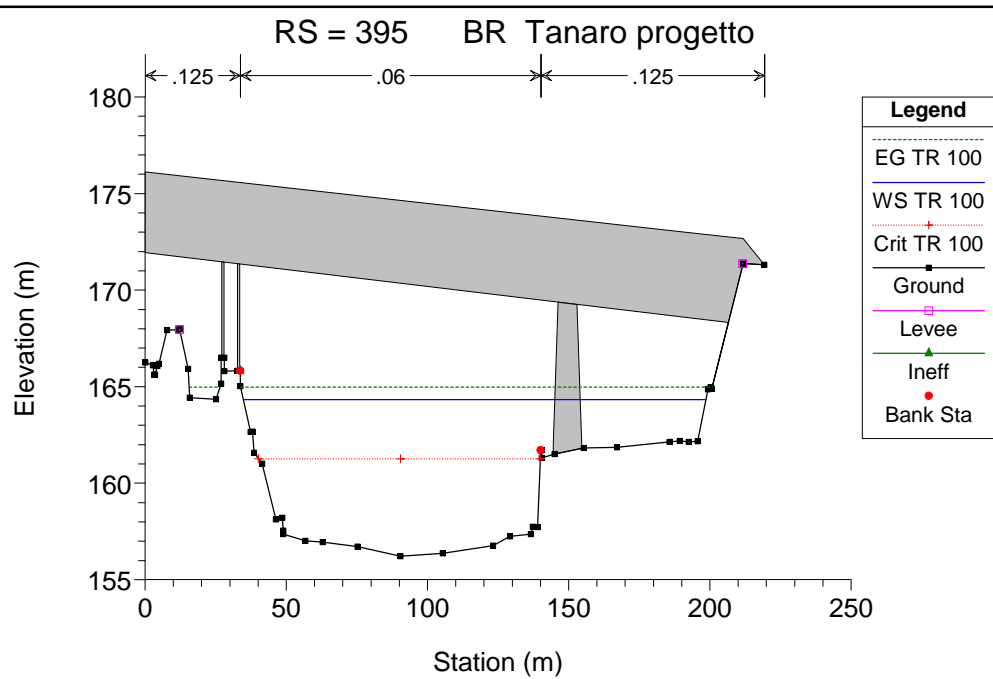
HEC-RAS Plan: Plan 06 River: Tanaro Reach: 1 Profile: TR 100 (Continued)

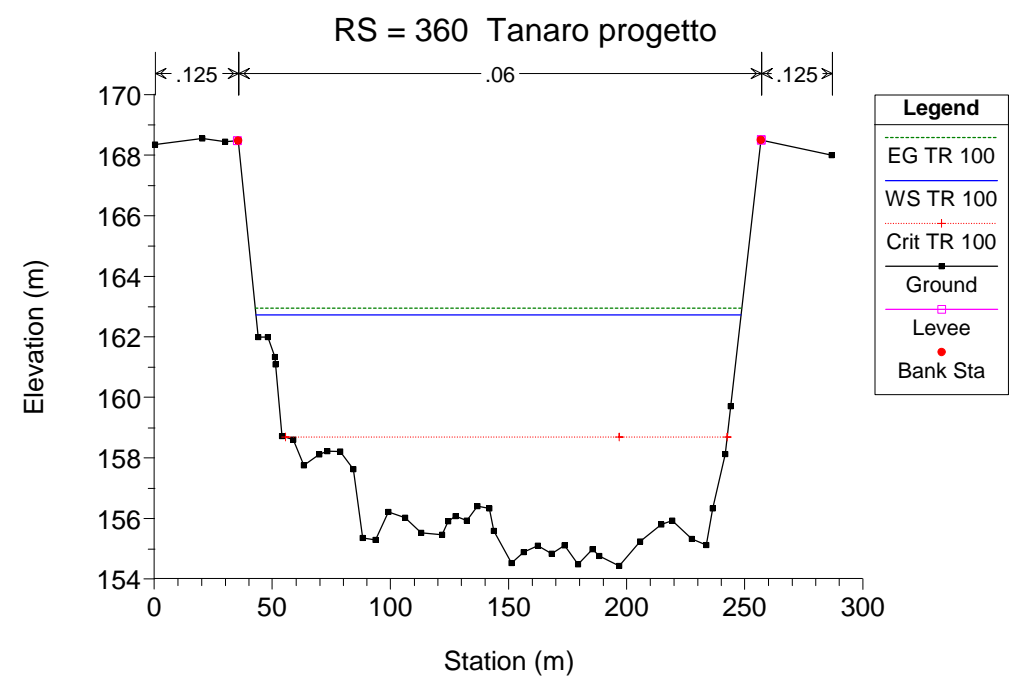
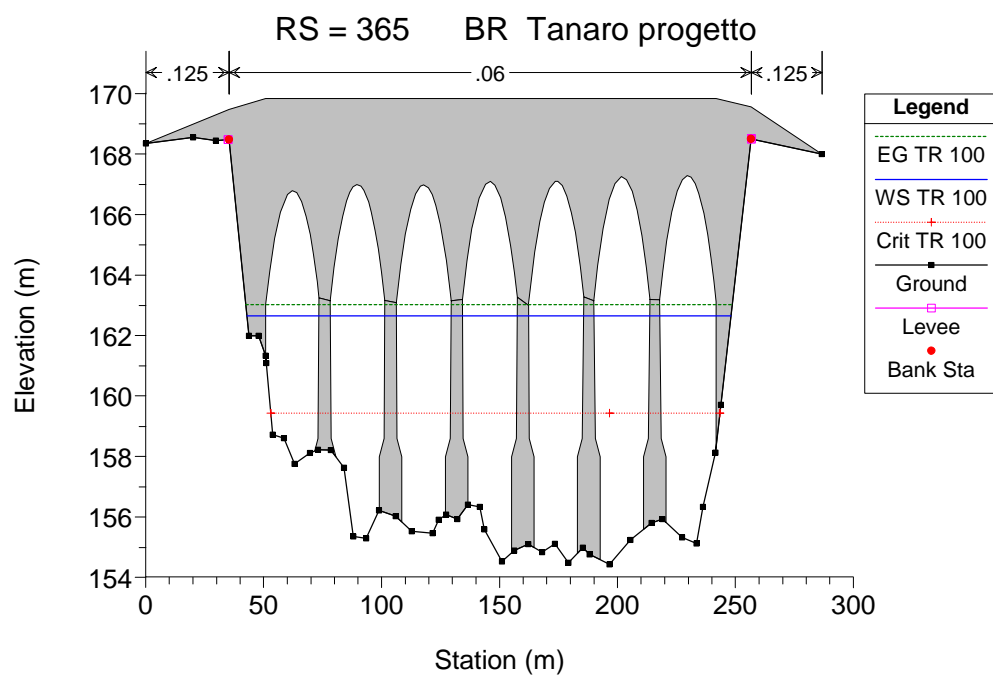
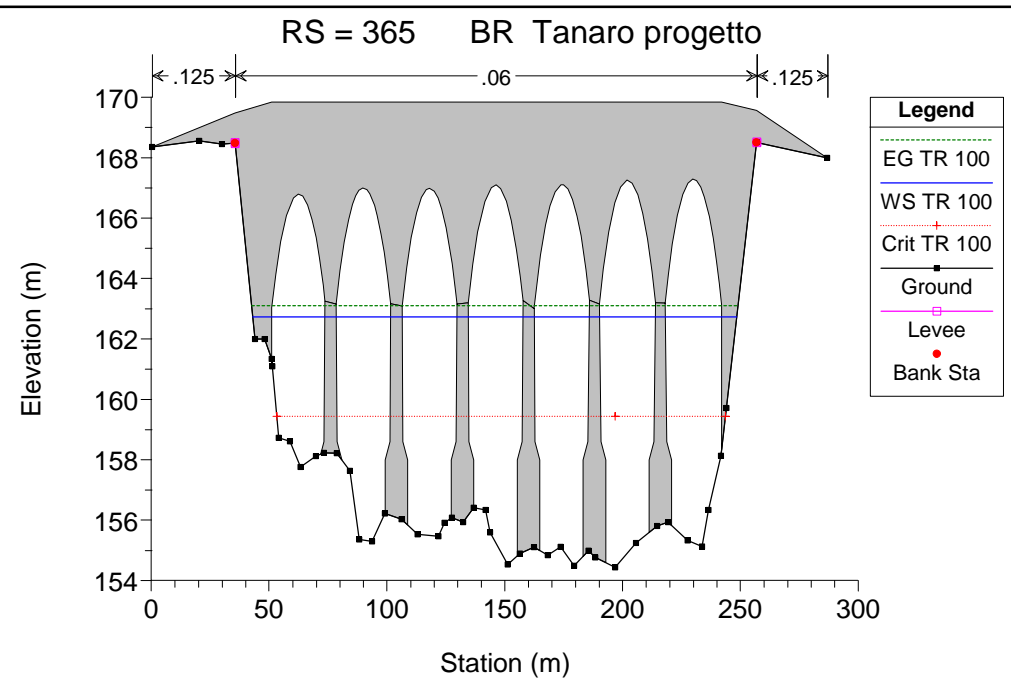
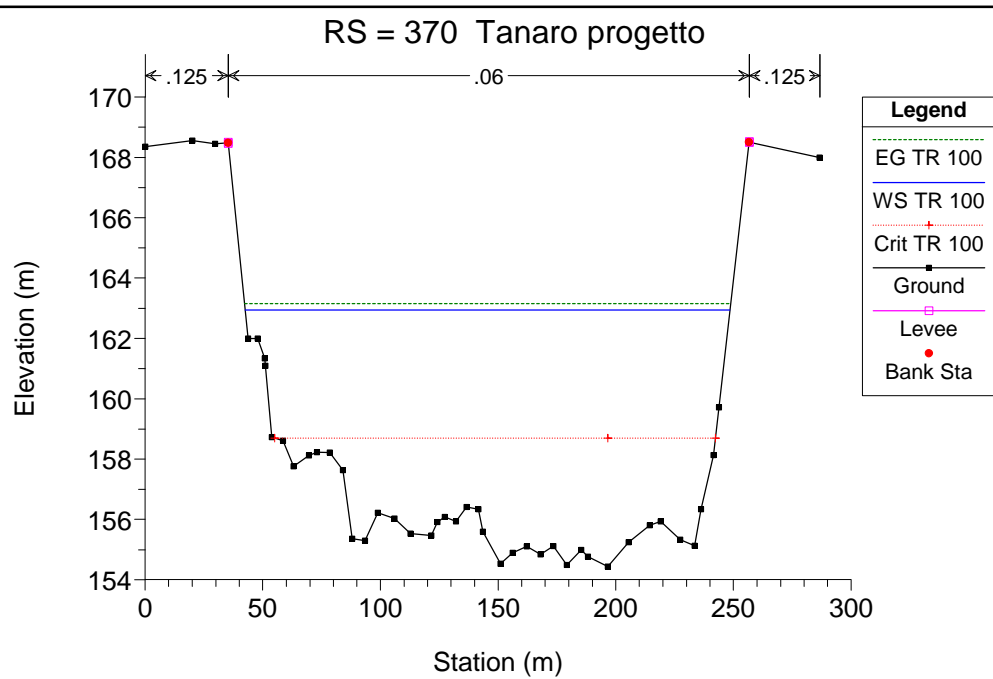
Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
1	70	TR 100	2750.00	139.61	147.28	144.68	147.65	0.003220	2.84	1218.52	298.84	0.40
1	60	TR 100	2750.00	138.12	146.86	143.05	147.09	0.001540	2.35	1941.33	740.77	0.29
1	50	TR 100	2750.00	137.54	146.31	143.47	146.66	0.002427	2.87	1598.63	711.76	0.36
1	40	TR 100	2750.00	137.06	145.57	142.99	145.86	0.002661	2.41	1217.14	582.53	0.35
1	30	TR 100	2750.00	137.37	144.95	141.76	145.21	0.002128	2.31	1457.32	664.24	0.32
1	20	TR 100	2750.00	136.62	144.41	141.35	144.61	0.001661	2.30	2138.86	740.06	0.29
1	10	TR 100	2750.00	135.29	143.45	141.65	143.91	0.004005	3.39	1523.40	656.99	0.45

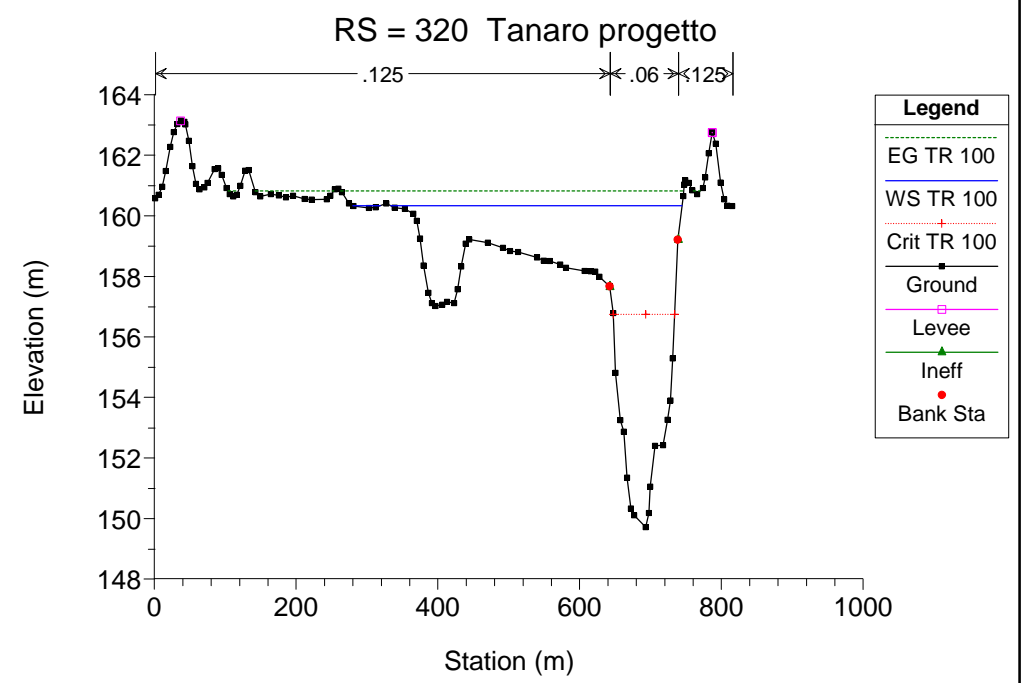
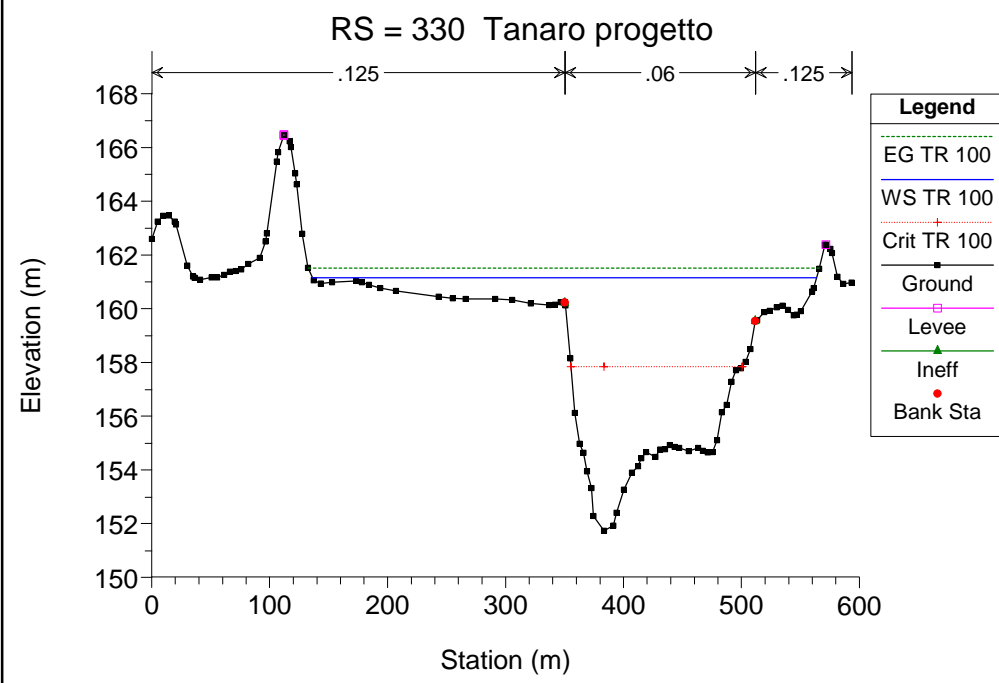
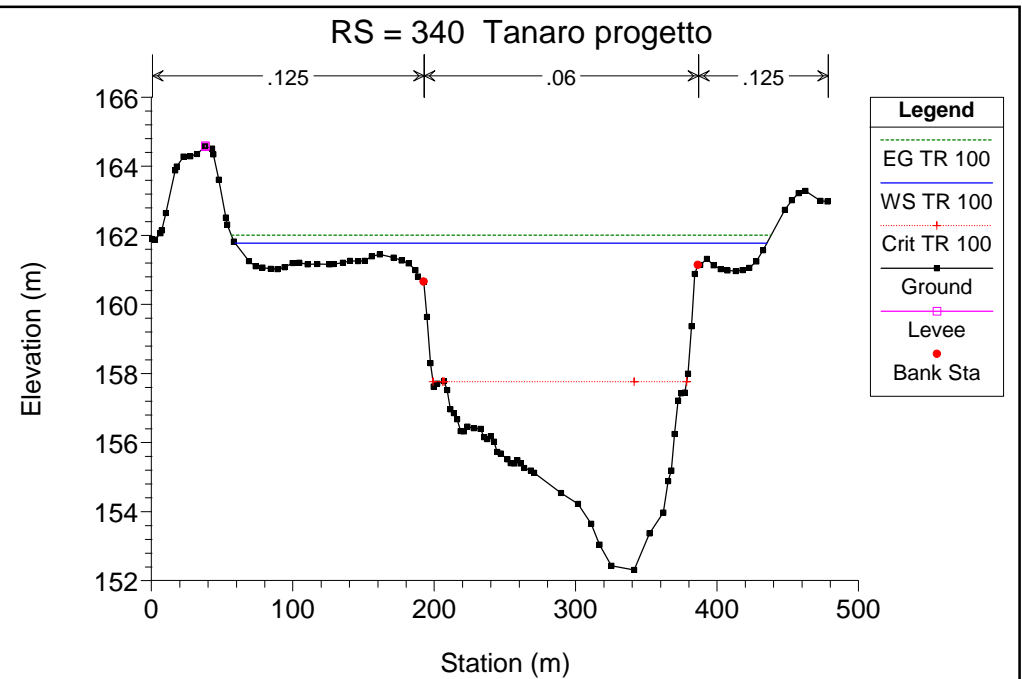
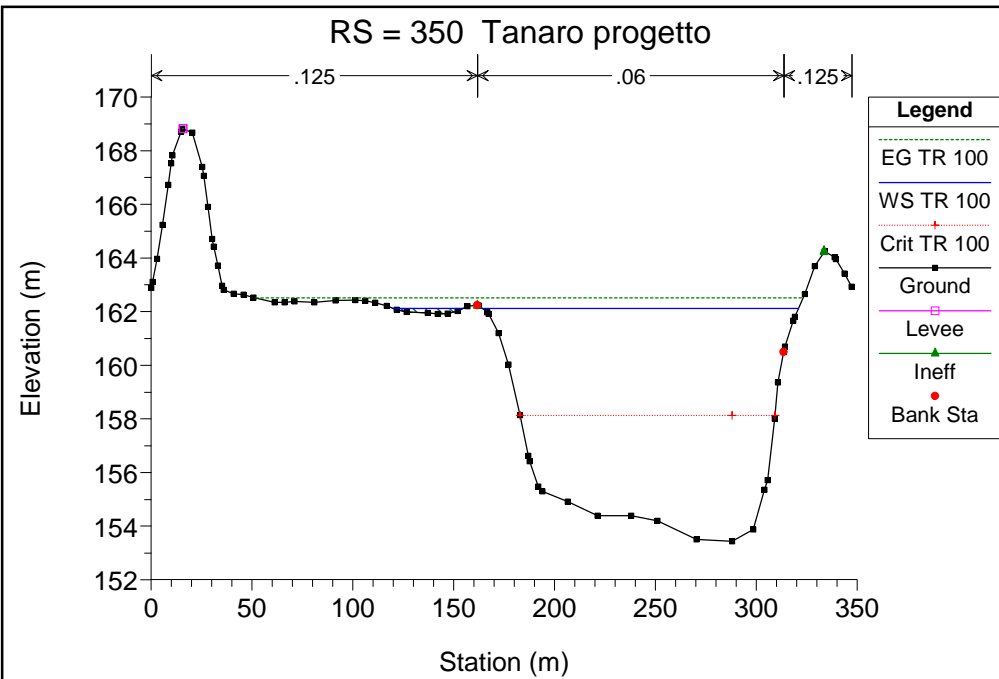
Tanaro progetto

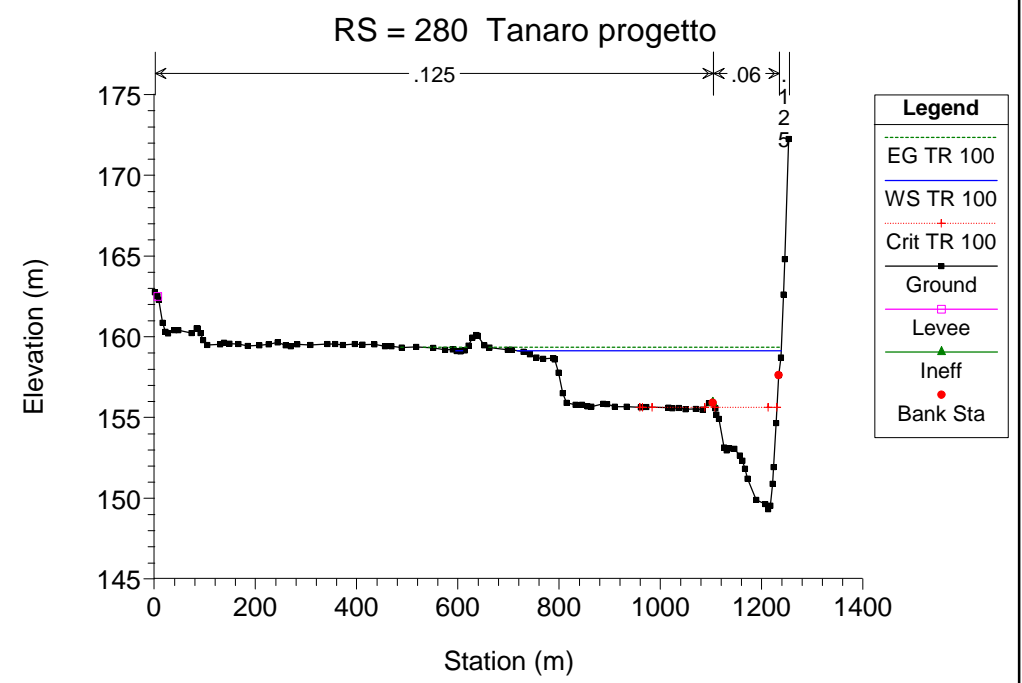
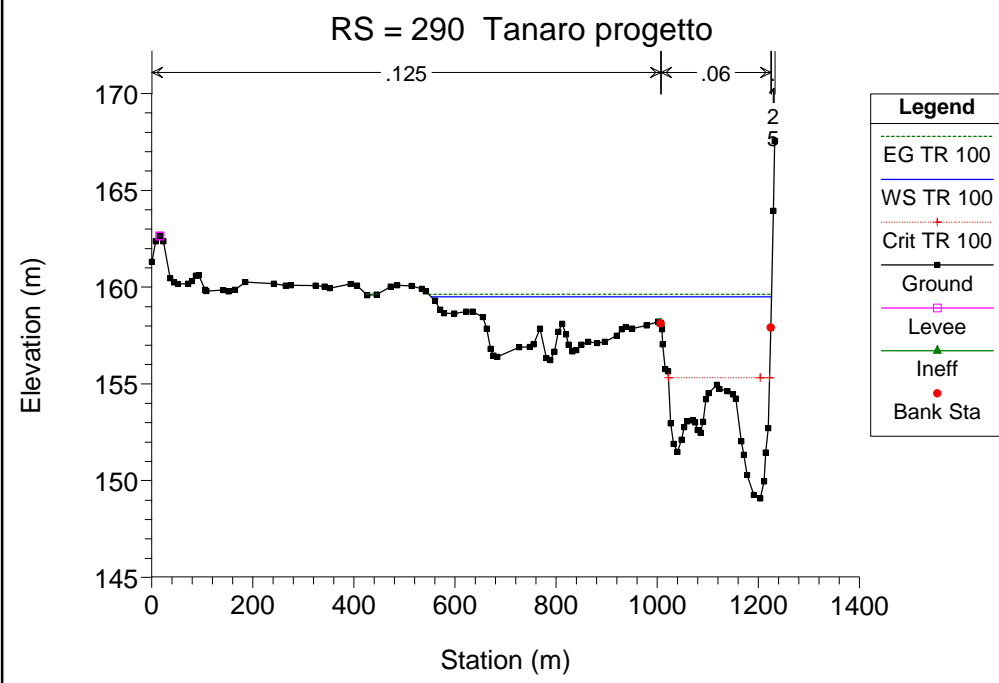
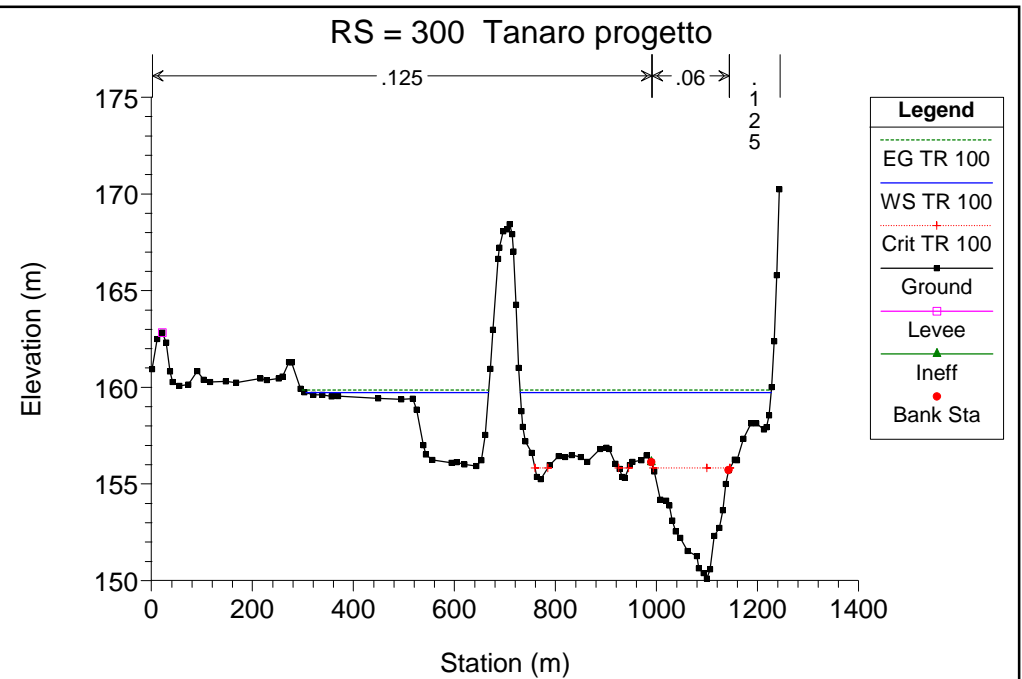
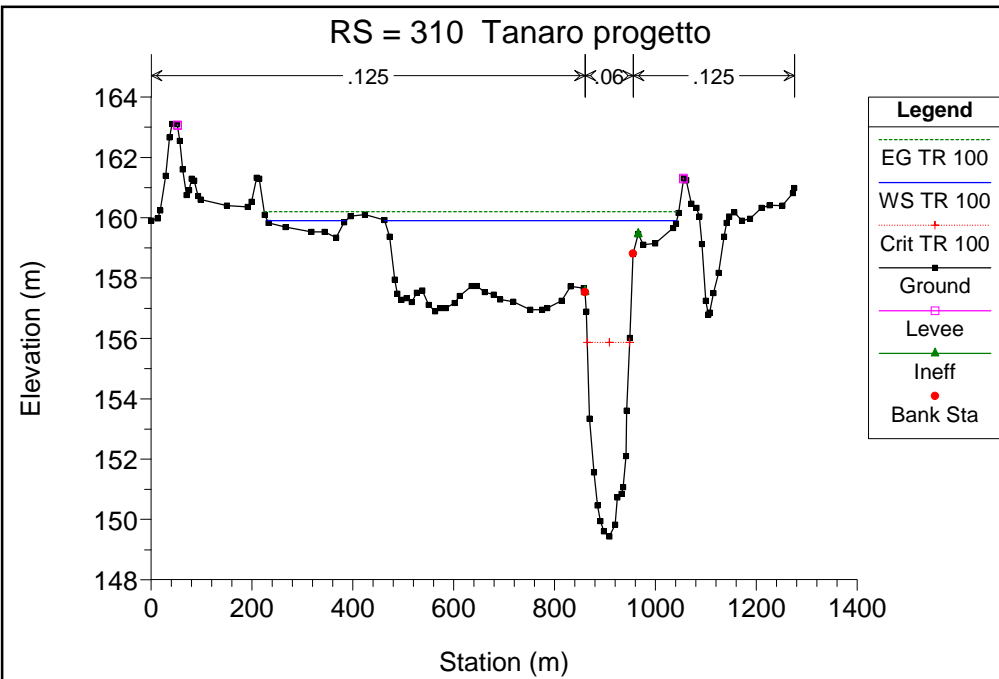


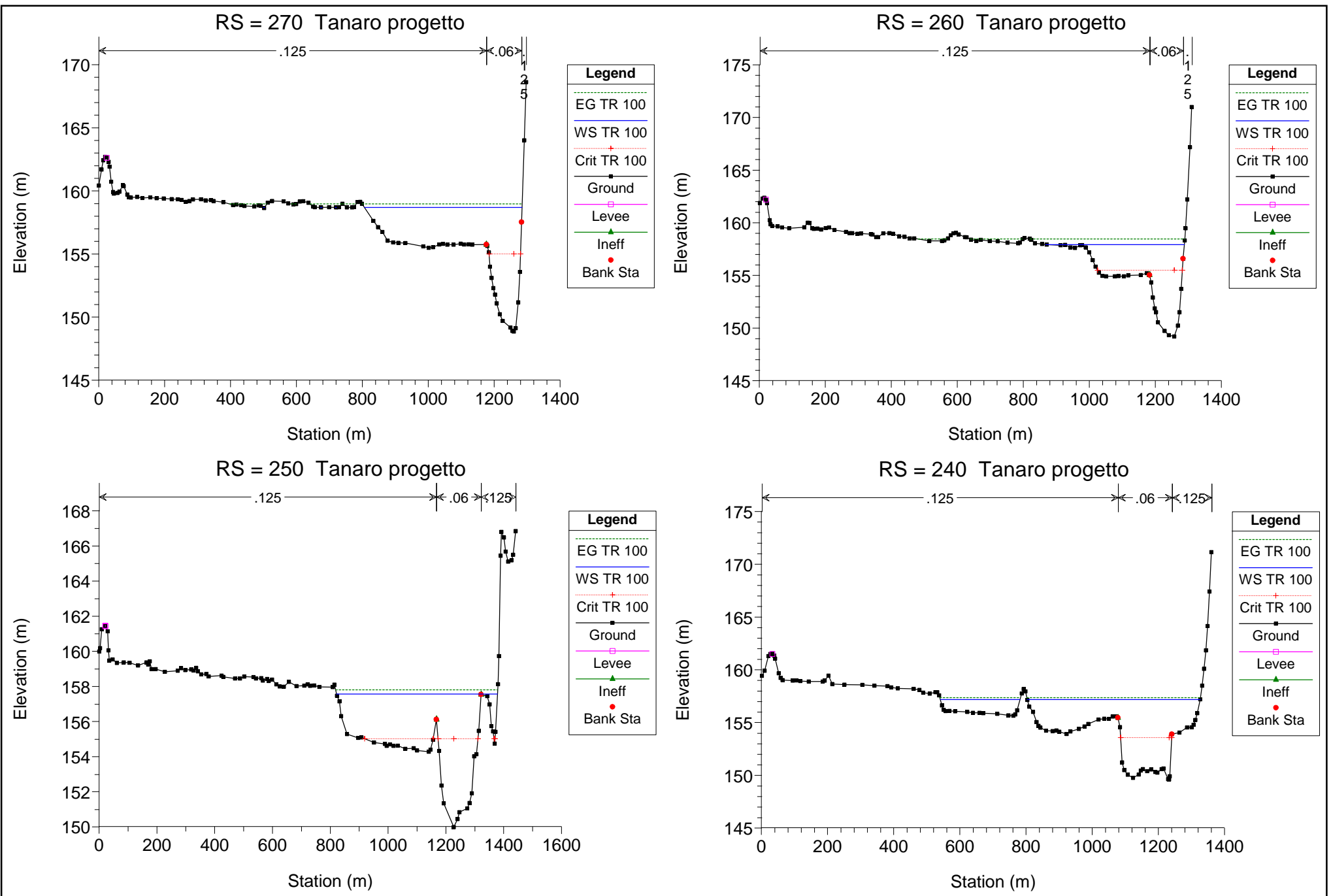


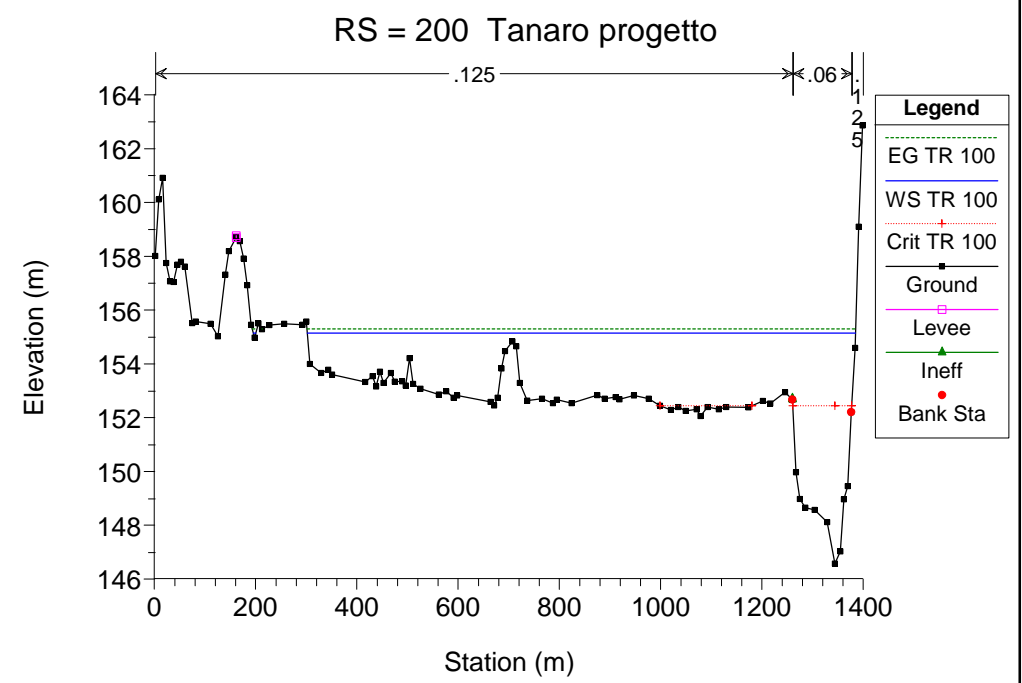
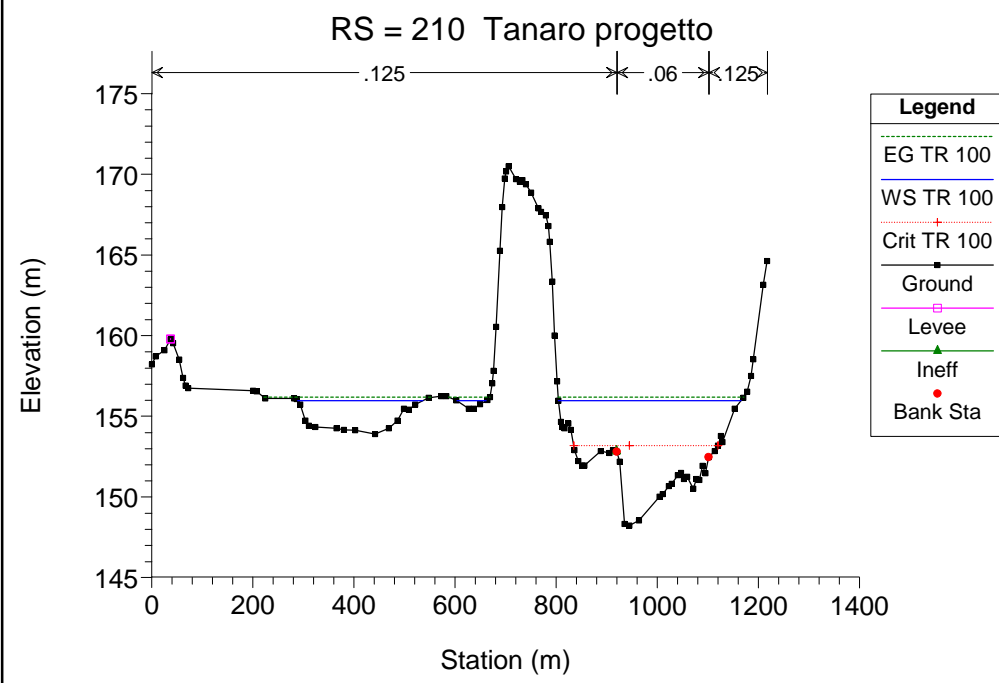
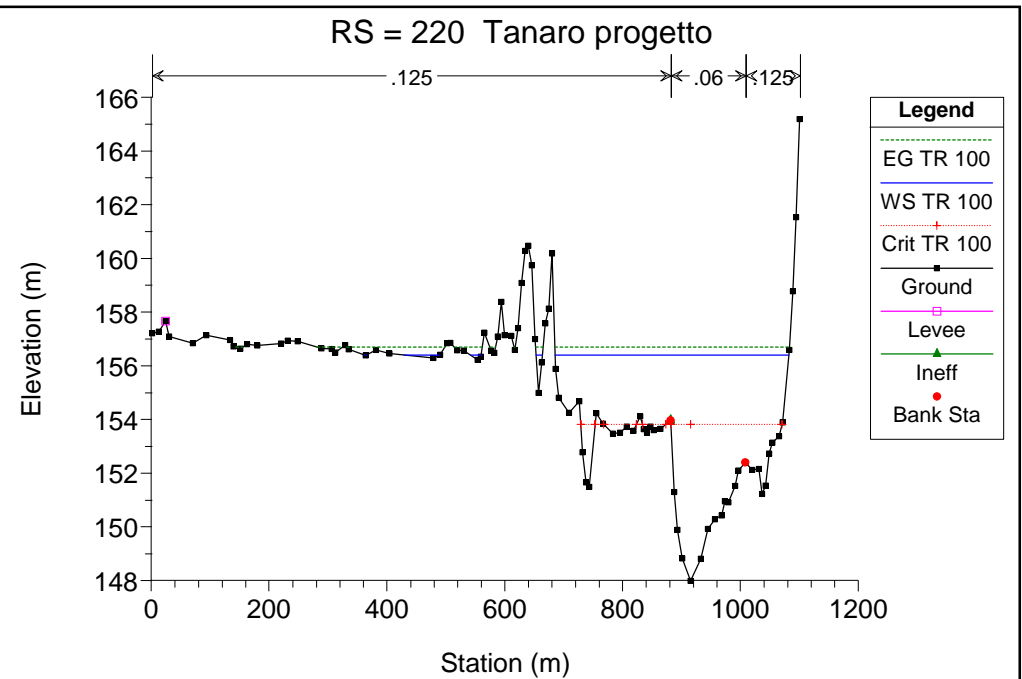
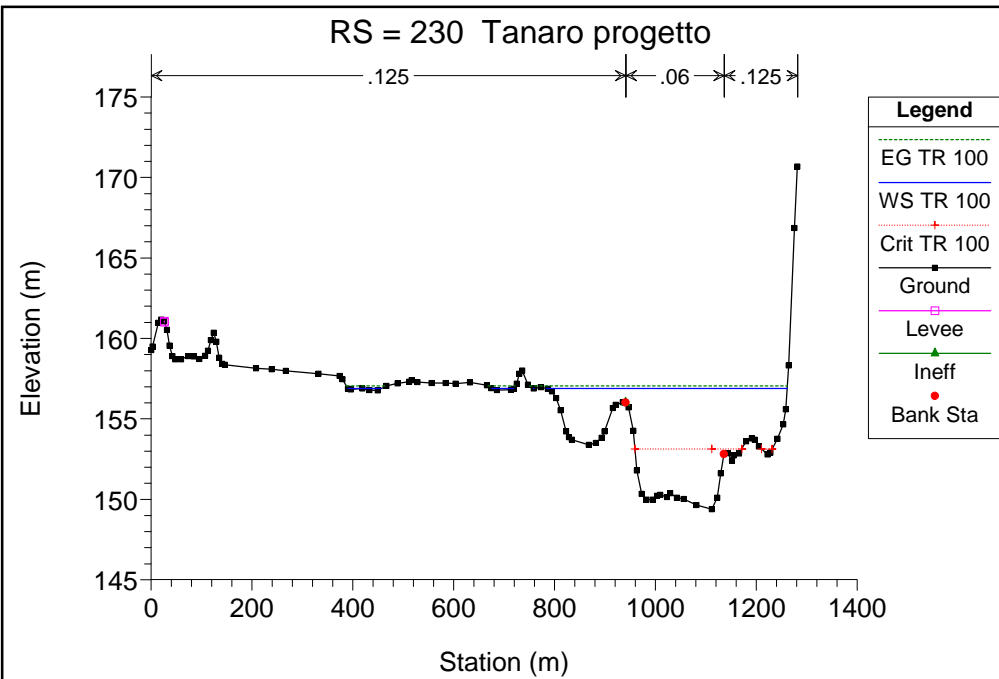


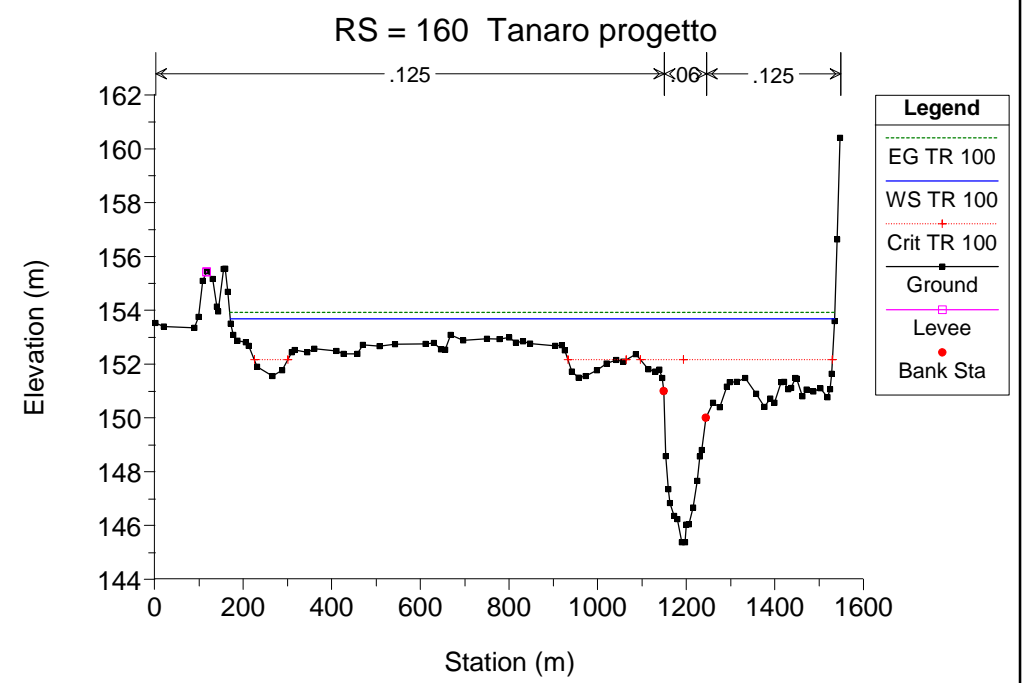
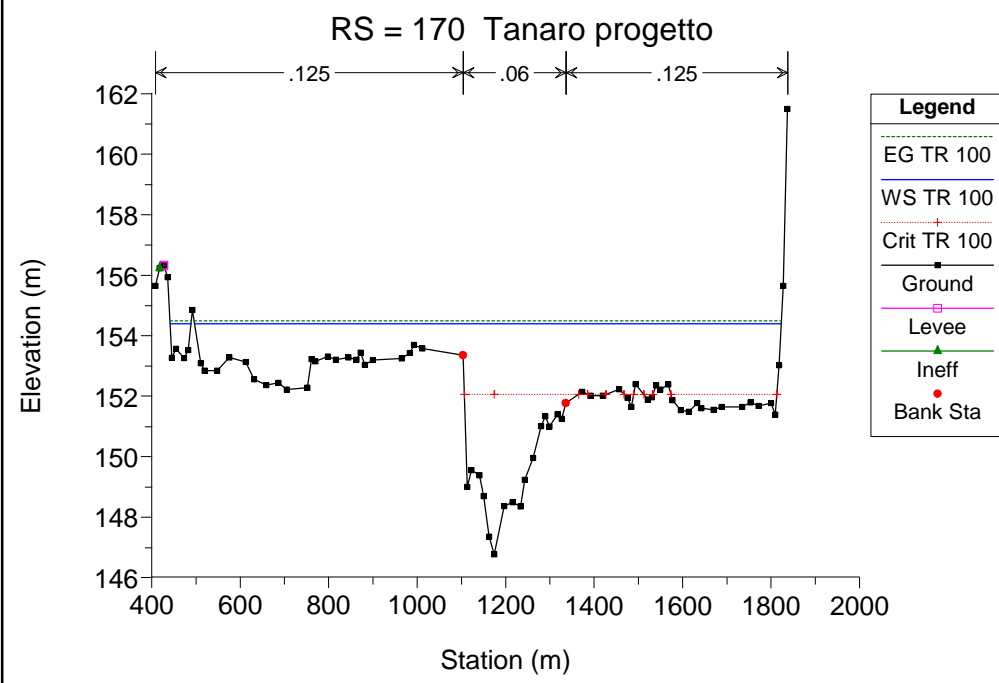
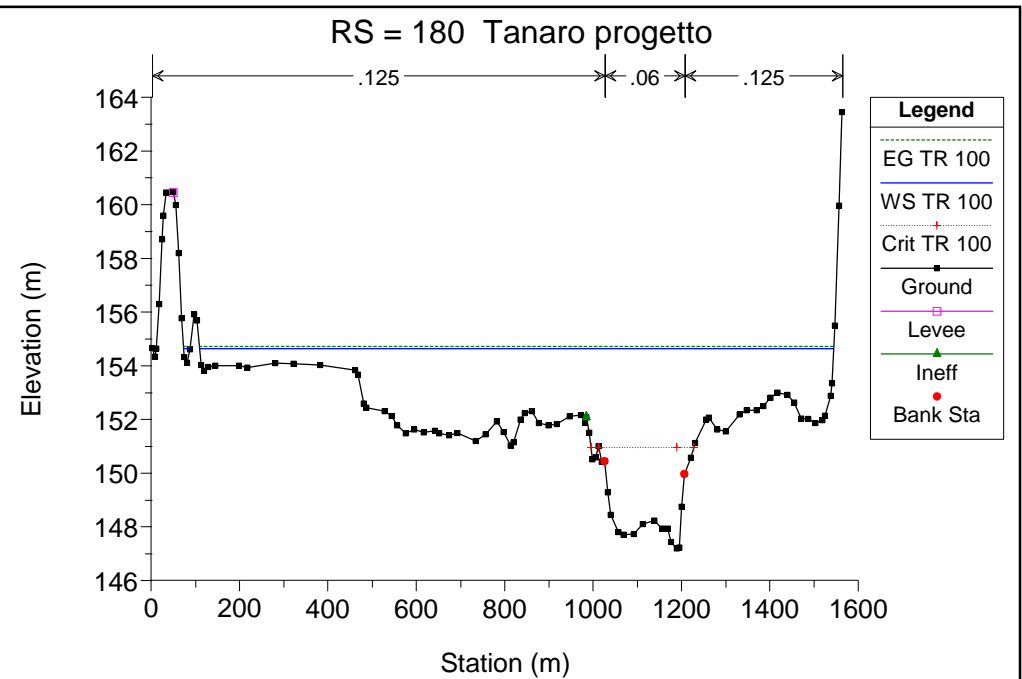
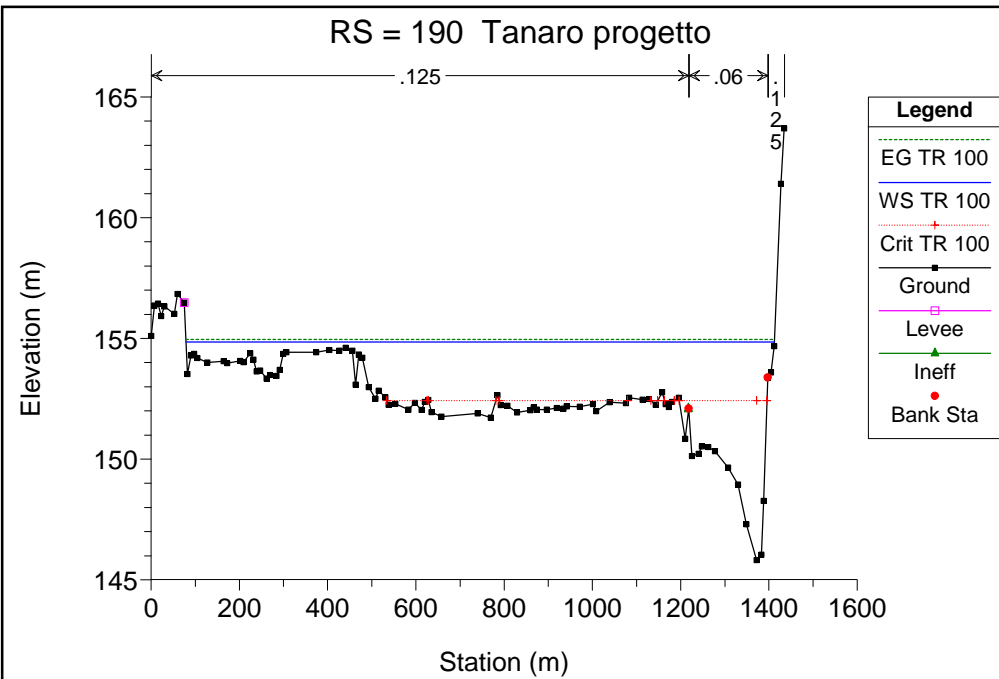


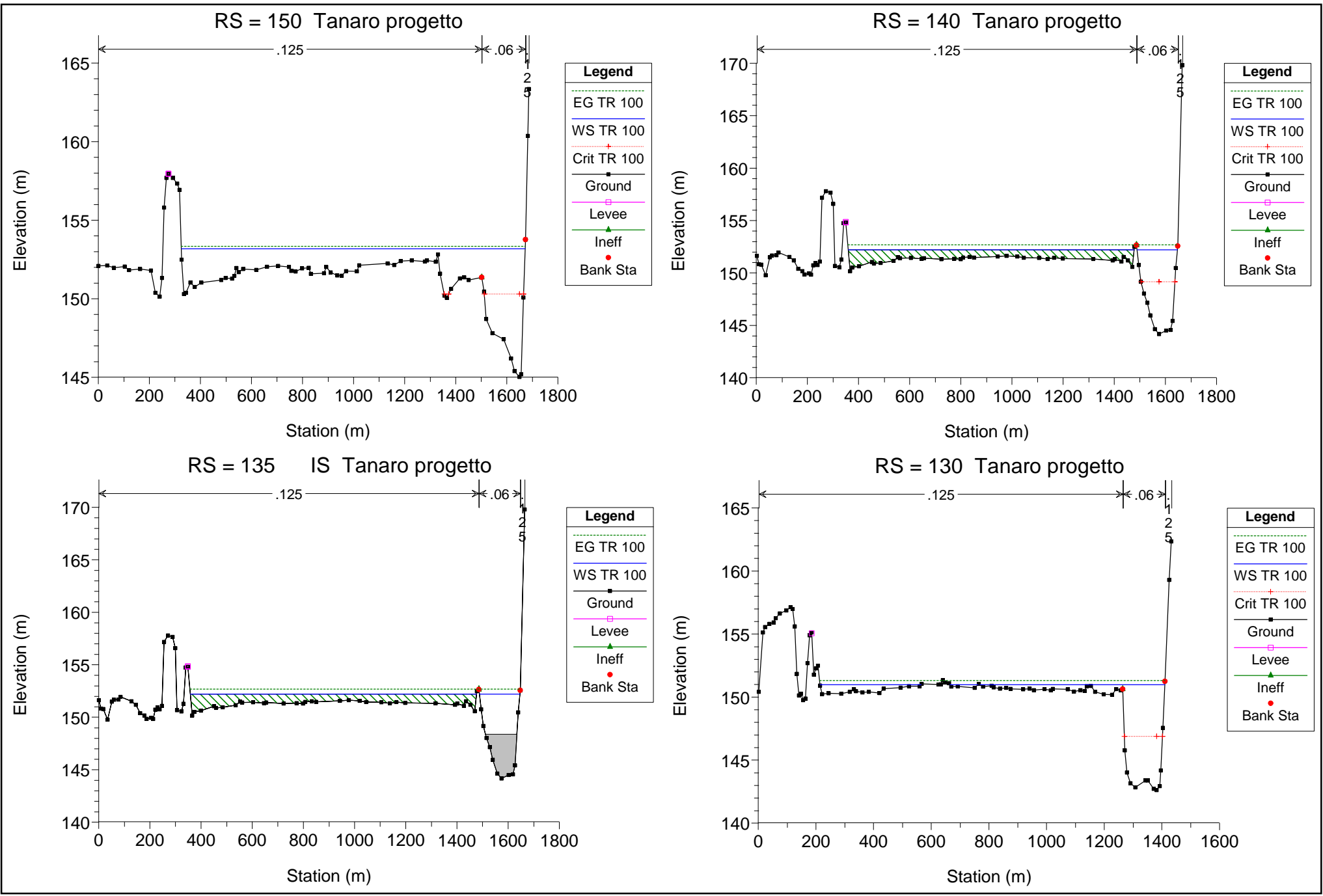


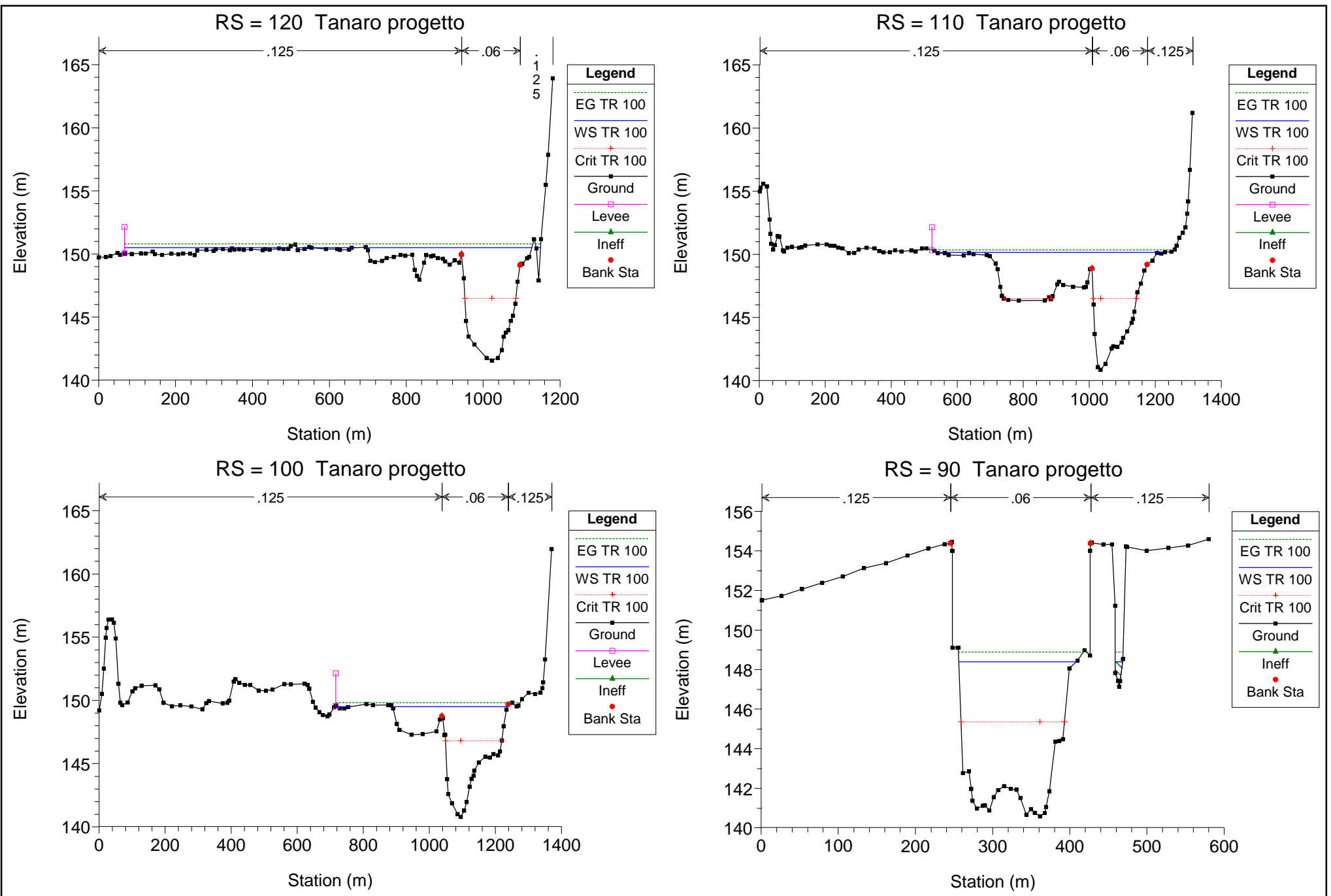


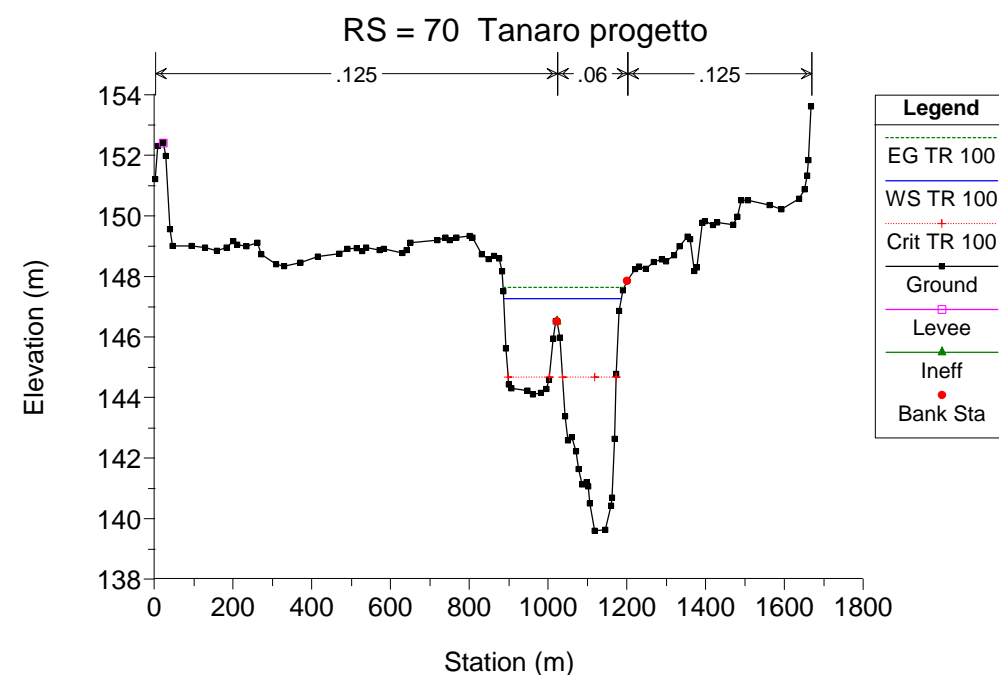
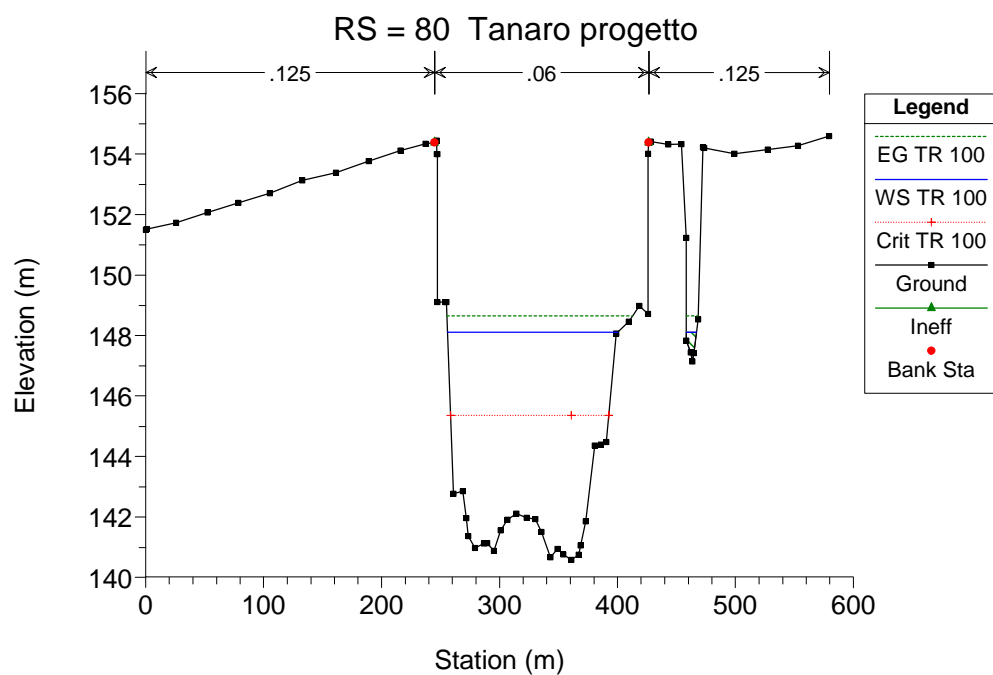
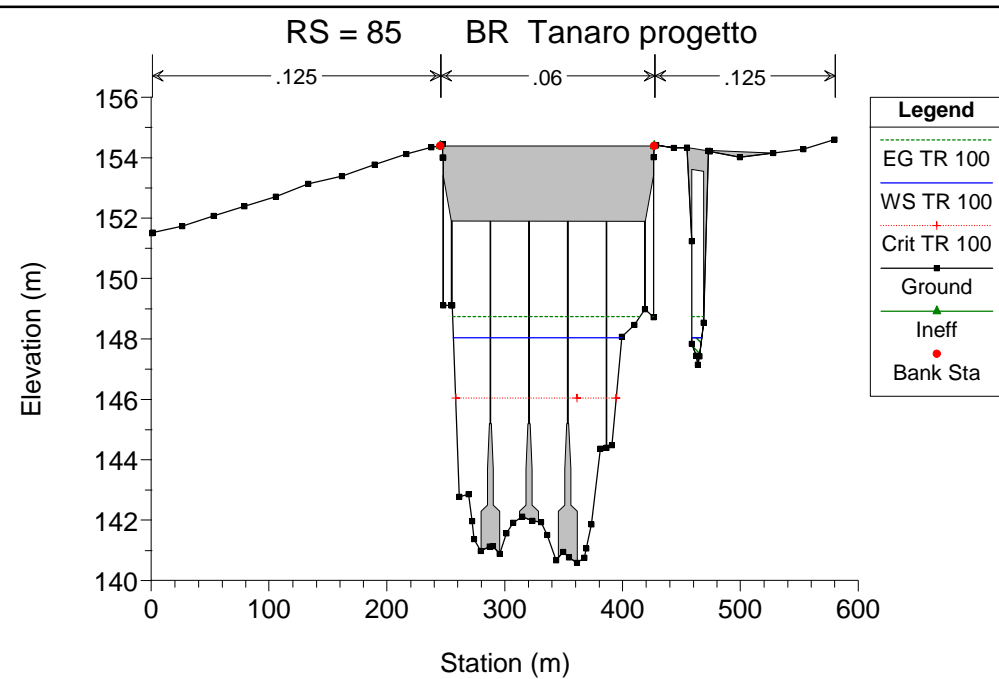
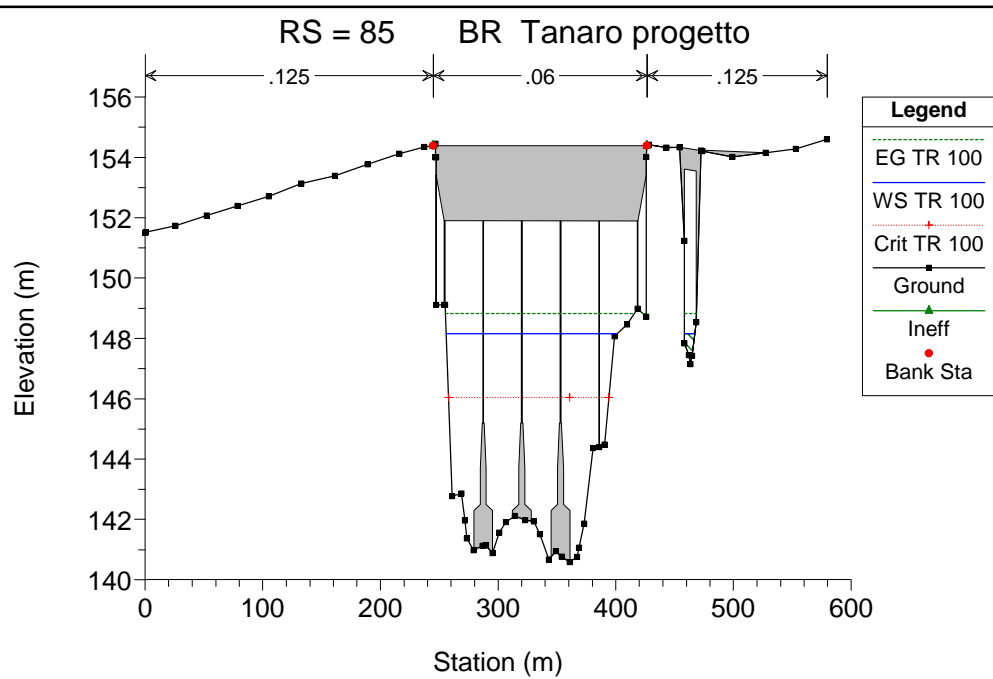


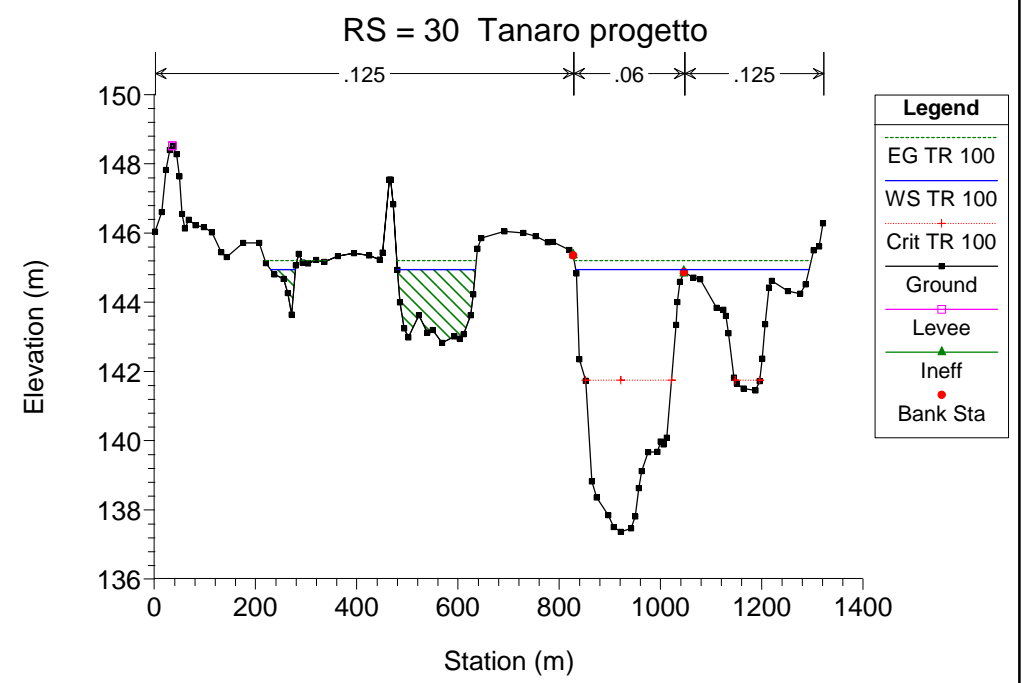
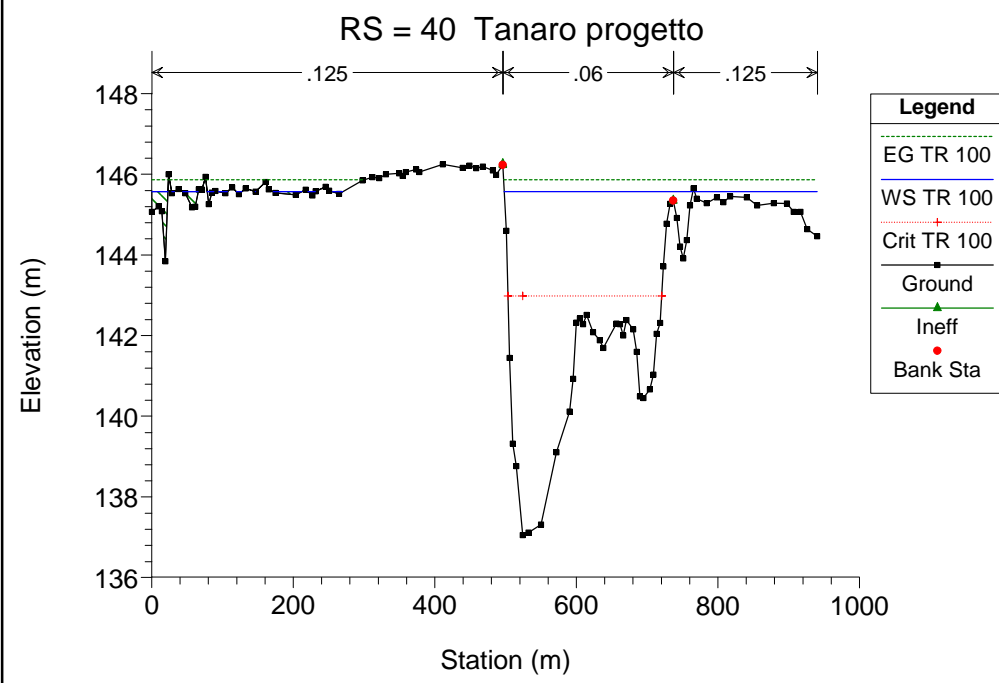
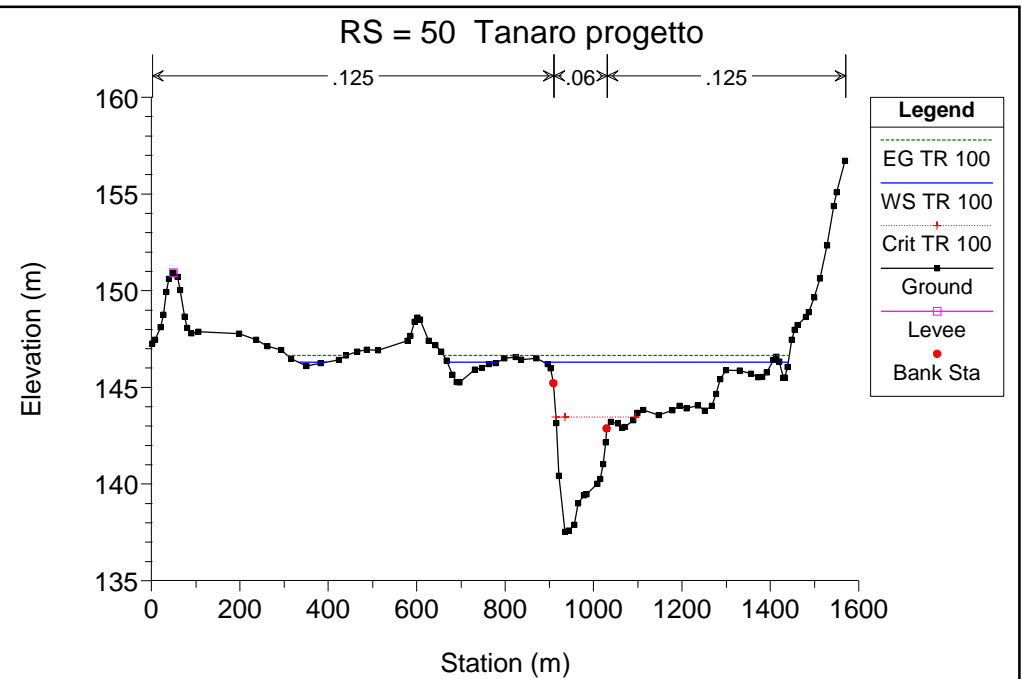
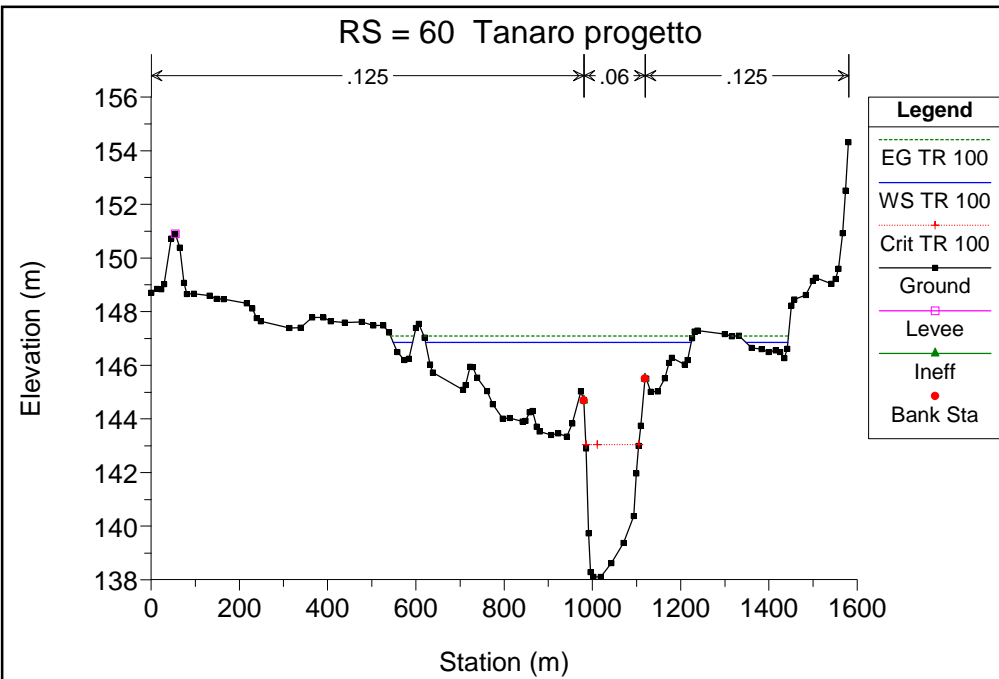




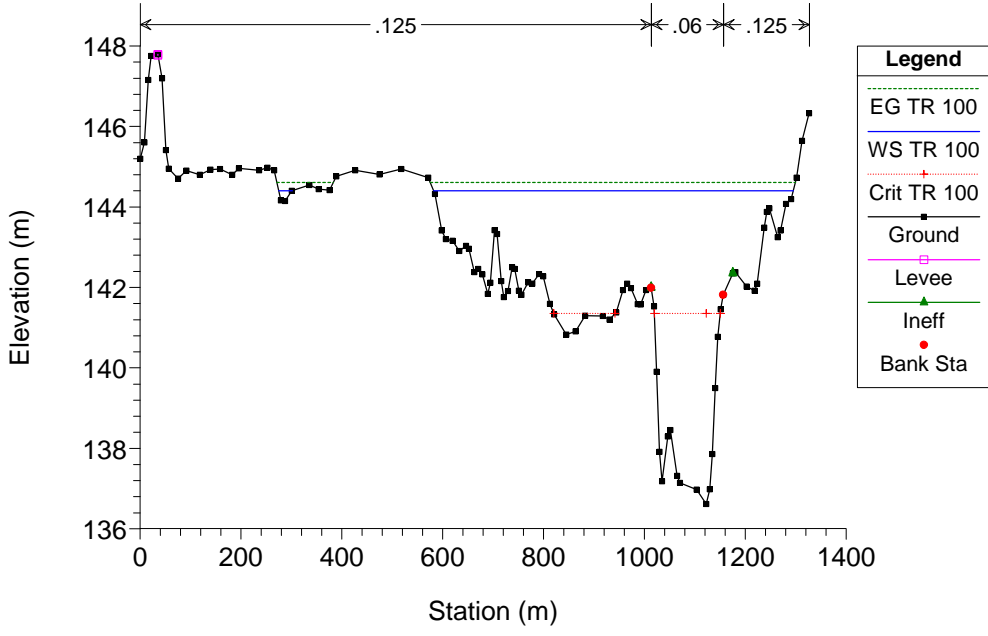




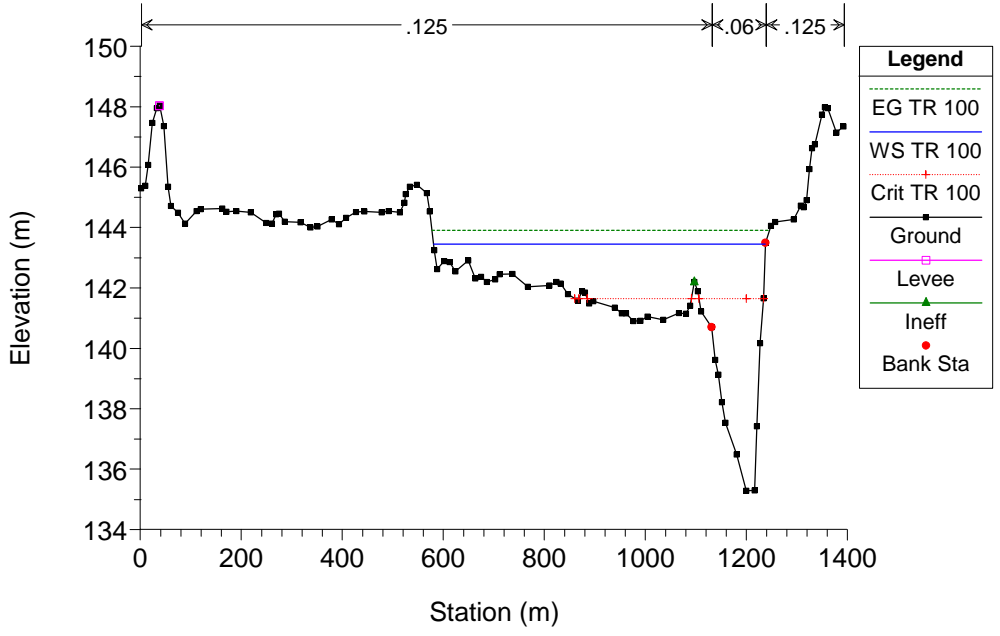




RS = 20 Tanaro progetto



RS = 10 Tanaro progetto



SITUAZIONE DI PROGETTO
(coincidente con situazione ante crollo 2010)
SIMULAZIONE 6

corso d'acqua	portata al colmo Q_c m^3/s	tempo di ritorno anni
Fiume Tanaro	3050	200

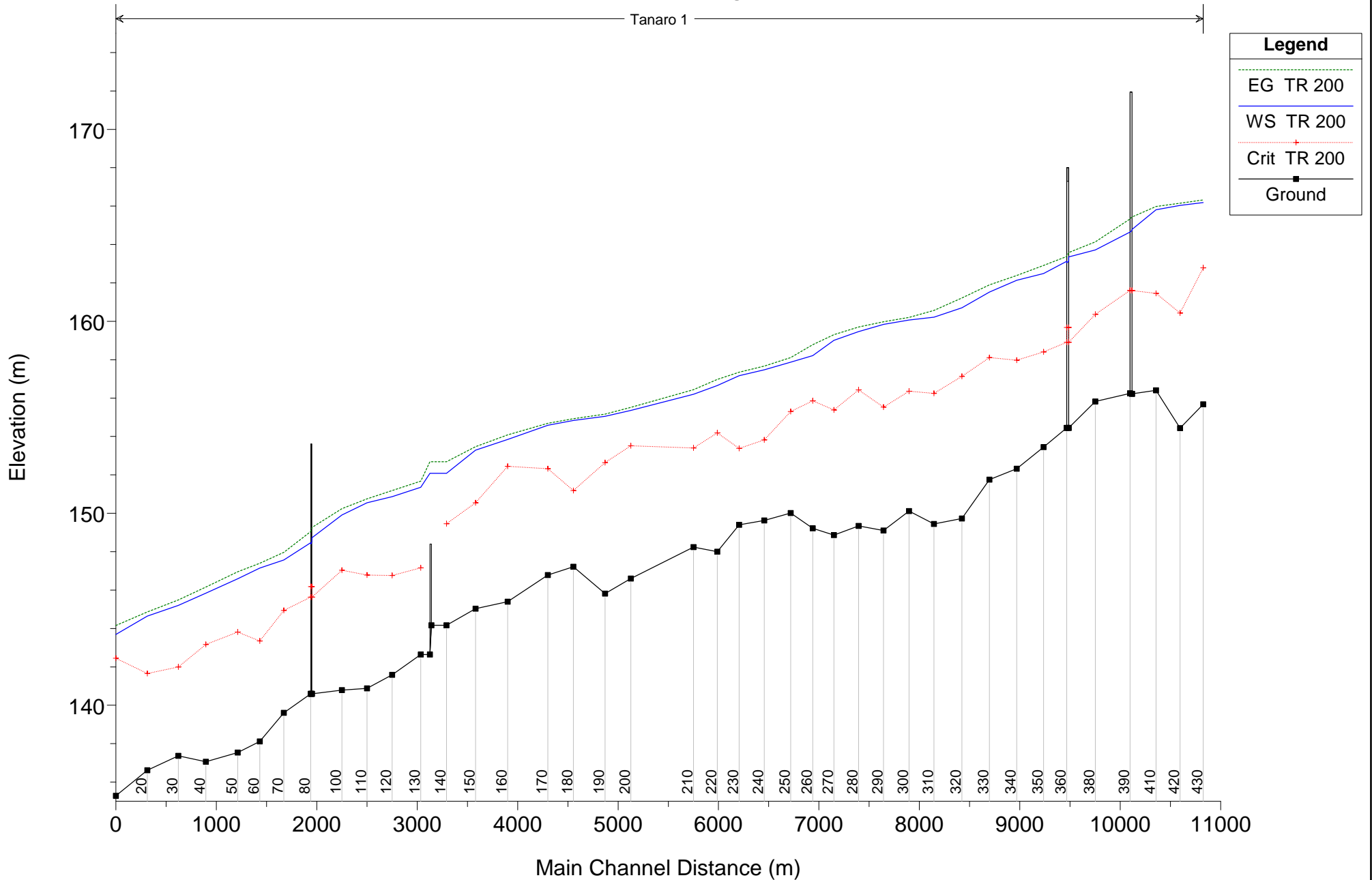
HEC-RAS Plan: Plan 06 River: Tanaro Reach: 1 Profile: TR 200

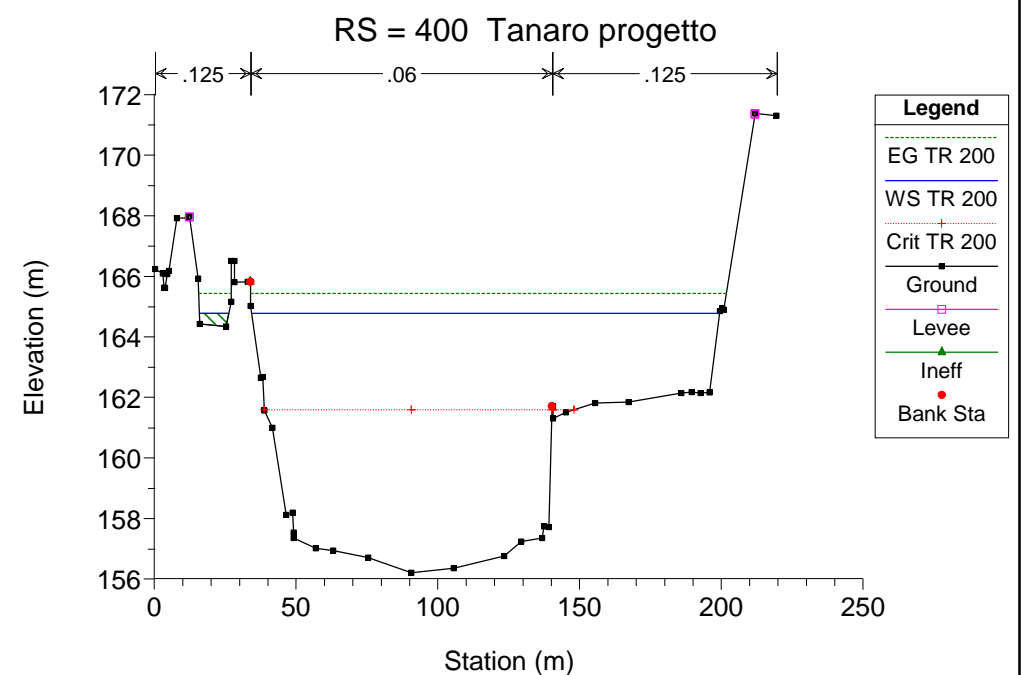
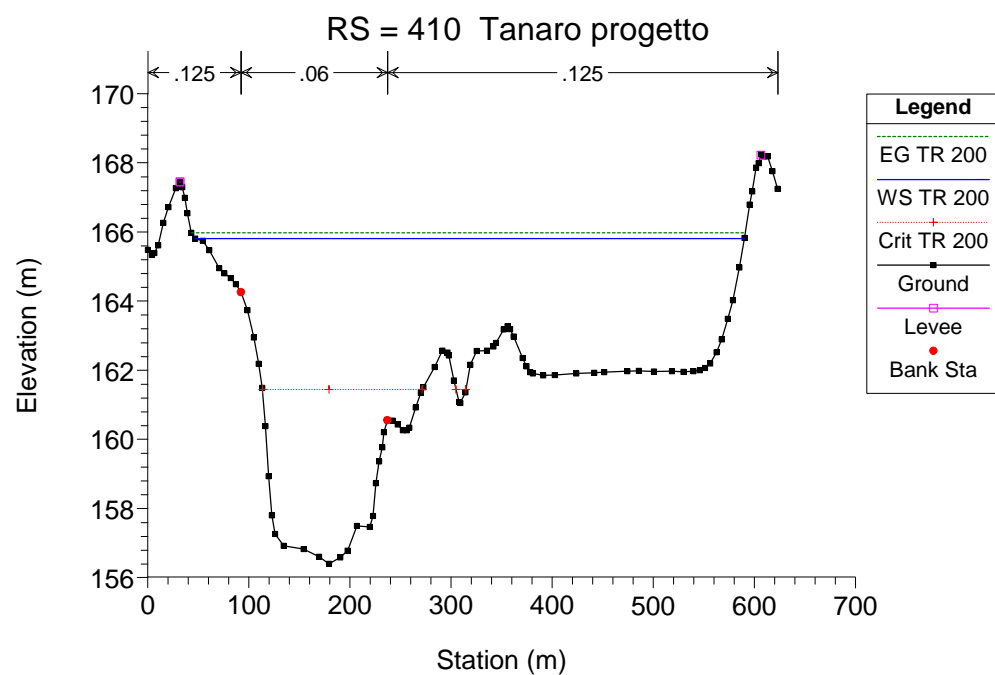
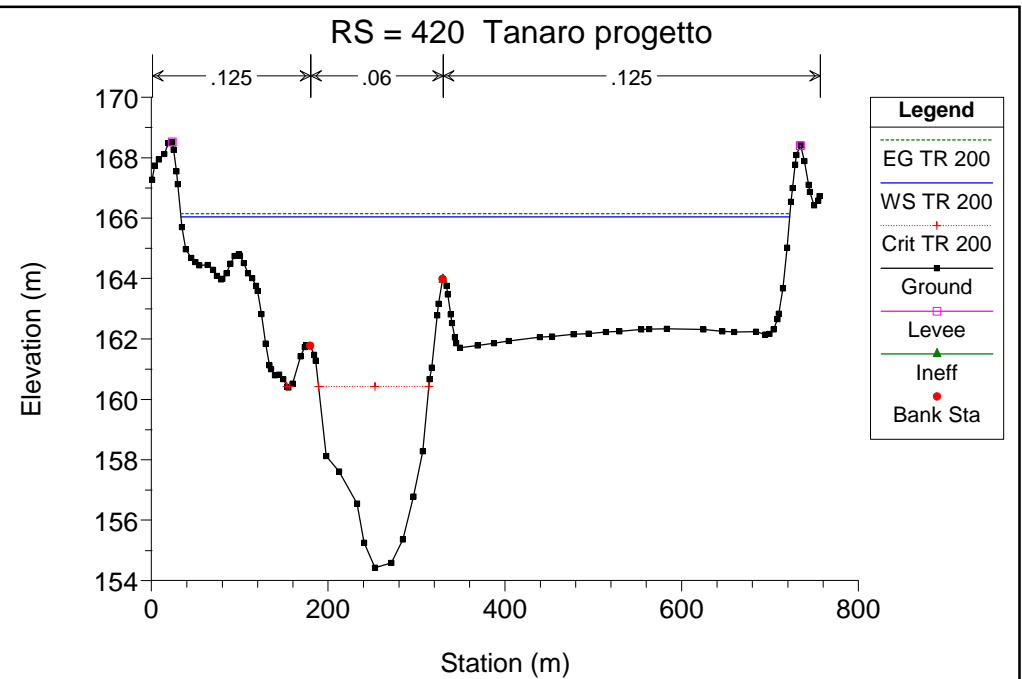
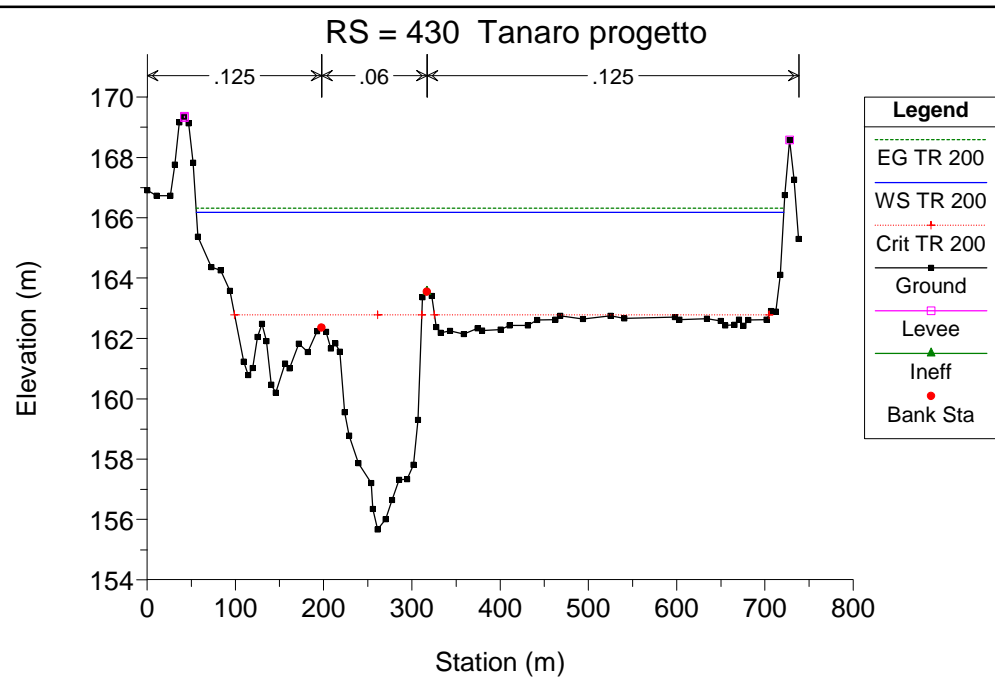
Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
1	430	TR 200	3050.00	155.68	166.18	162.79	166.32	0.001060	2.05	2879.18	665.58	0.24
1	420	TR 200	3050.00	154.44	166.04	160.43	166.15	0.000587	1.69	3200.98	688.79	0.18
1	410	TR 200	3050.00	156.41	165.82	161.45	165.98	0.001023	2.04	2441.66	543.30	0.24
1	400	TR 200	3050.00	156.22	164.79	161.61	165.44	0.003589	3.67	954.14	175.43	0.43
1	395		Bridge									
1	390	TR 200	3050.00	156.25	164.65	161.61	165.33	0.003835	3.75	930.92	174.67	0.44
1	380	TR 200	3050.00	155.82	163.72	160.36	164.14	0.002497	2.86	1103.57	226.25	0.36
1	370	TR 200	3050.00	154.45	163.36	158.91	163.59	0.001258	2.12	1438.99	207.00	0.26
1	365		Bridge									
1	360	TR 200	3050.00	154.45	163.13	158.91	163.37	0.001400	2.19	1391.40	206.36	0.27
1	350	TR 200	3050.00	153.45	162.49	158.40	162.91	0.002286	2.88	1094.50	270.07	0.35
1	340	TR 200	3050.00	152.32	162.14	157.98	162.39	0.001397	2.24	1513.07	384.70	0.27
1	330	TR 200	3050.00	151.75	161.53	158.11	161.90	0.002270	2.76	1347.78	433.38	0.34
1	320	TR 200	3050.00	149.73	160.70	157.14	161.21	0.002661	3.39	1465.76	581.70	0.38
1	310	TR 200	3050.00	149.44	160.22	156.24	160.56	0.001906	2.94	2108.03	821.94	0.32
1	300	TR 200	3050.00	150.11	160.06	156.36	160.20	0.000918	1.91	2964.84	873.64	0.22
1	290	TR 200	3050.00	149.10	159.84	155.53	159.98	0.000881	1.77	2523.65	770.74	0.21
1	280	TR 200	3050.00	149.34	159.46	156.43	159.70	0.001552	2.44	2184.90	781.75	0.29
1	270	TR 200	3050.00	148.86	159.01	155.38	159.30	0.001791	2.74	1985.59	774.84	0.31
1	260	TR 200	3050.00	149.22	158.21	155.86	158.78	0.003353	3.58	1359.53	519.36	0.42
1	250	TR 200	3050.00	150.01	157.87	155.31	158.11	0.002192	2.51	1981.25	561.34	0.33
1	240	TR 200	3050.00	149.63	157.48	153.83	157.66	0.001291	2.14	2440.64	771.80	0.26
1	230	TR 200	3050.00	149.40	157.17	153.38	157.35	0.001199	2.01	2178.89	685.60	0.25
1	220	TR 200	3050.00	148.00	156.66	154.19	156.97	0.002410	2.83	1728.57	665.95	0.35
1	210	TR 200	3050.00	148.24	156.20	153.41	156.44	0.001850	2.35	2028.33	786.95	0.31
1	200	TR 200	3050.00	146.60	155.36	153.52	155.51	0.001444	2.24	3137.92	1102.82	0.28
1	190	TR 200	3050.00	145.82	155.06	152.64	155.17	0.001134	1.82	3551.25	1334.04	0.24
1	180	TR 200	3050.00	147.21	154.84	151.18	154.92	0.000706	1.58	4177.24	1452.85	0.19
1	170	TR 200	3050.00	146.78	154.58	152.32	154.68	0.001190	1.70	3451.52	1377.47	0.24
1	160	TR 200	3050.00	145.40	153.85	152.44	154.09	0.002246	2.80	2811.57	1364.80	0.34
1	150	TR 200	3050.00	145.03	153.29	150.54	153.47	0.001773	2.24	2837.62	1347.34	0.30
1	140	TR 200	3050.00	144.17	152.09	149.45	152.69	0.004282	3.44	886.98	1273.62	0.46
1	135		Inl Struct									
1	130	TR 200	3050.00	142.64	151.35	147.16	151.68	0.001752	2.62	1825.97	1198.54	0.31
1	120	TR 200	3050.00	141.58	150.87	146.76	151.18	0.001734	2.57	1853.50	1077.16	0.31
1	110	TR 200	3050.00	140.88	150.55	146.78	150.75	0.001486	2.22	2281.19	738.41	0.28
1	100	TR 200	3050.00	140.79	149.91	147.04	150.24	0.002679	2.64	1485.45	559.72	0.36
1	90	TR 200	3050.00	140.59	148.73	145.63	149.27	0.003634	3.23	943.21	169.49	0.42
1	85		Bridge									
1	80	TR 200	3050.00	140.59	148.46	145.63	149.05	0.004045	3.38	901.06	163.80	0.45

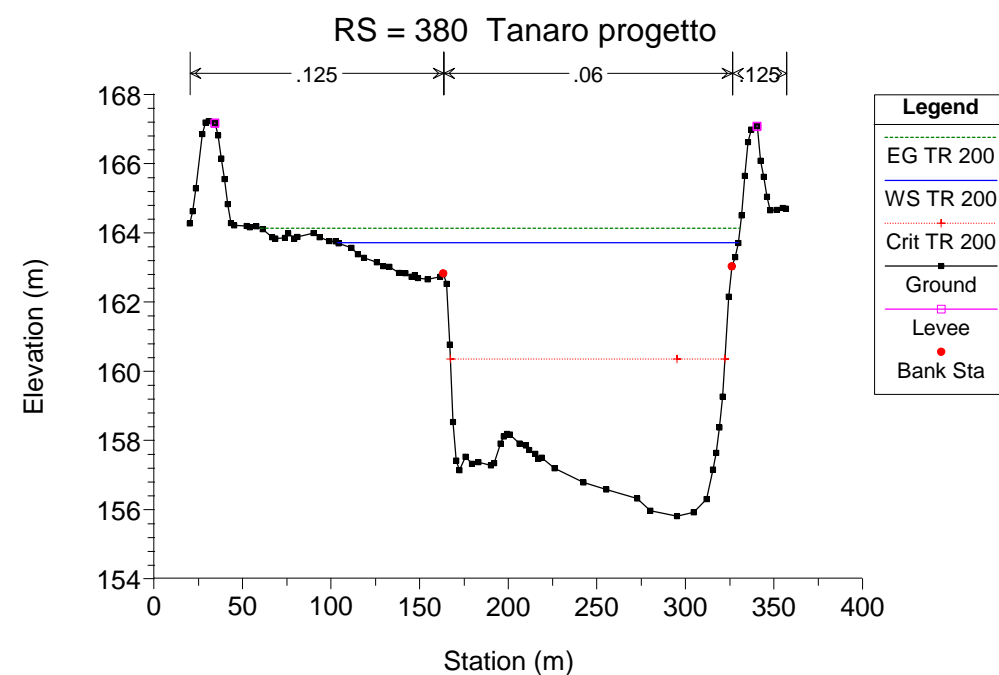
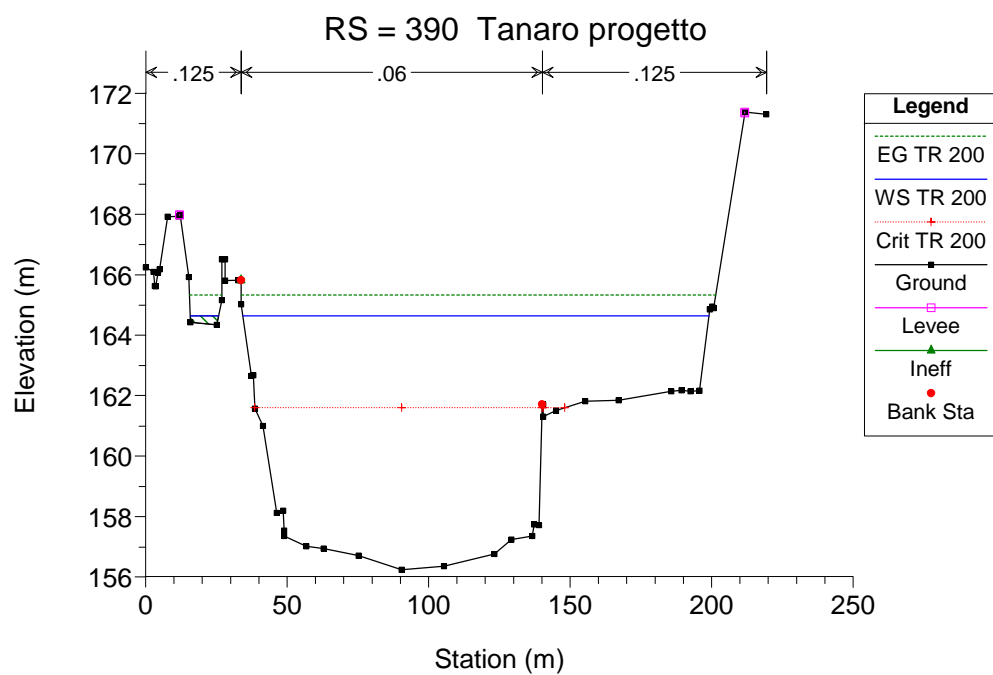
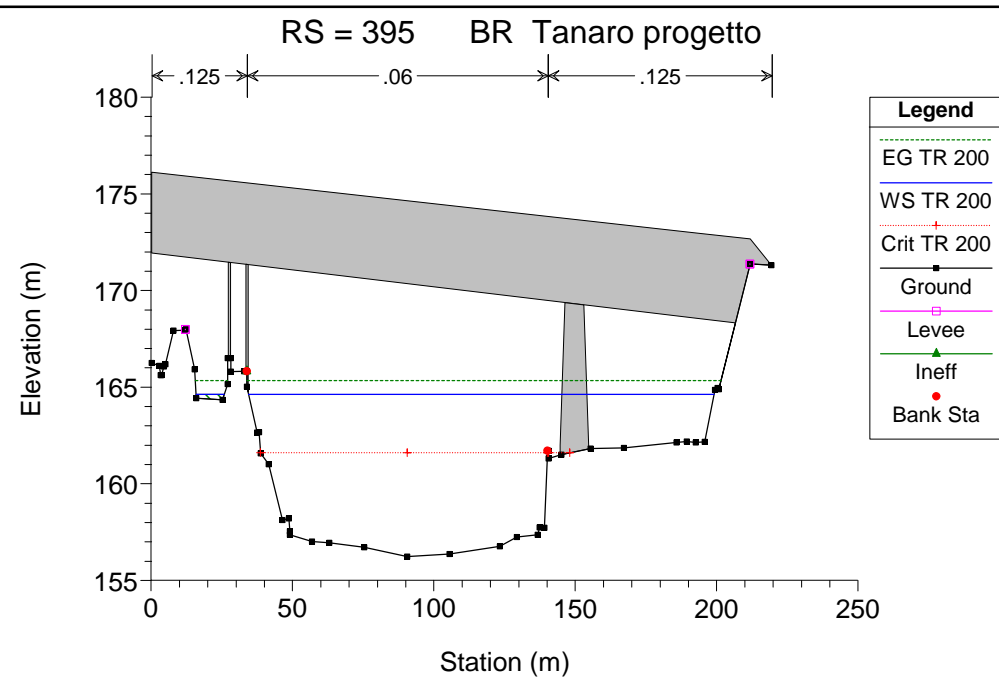
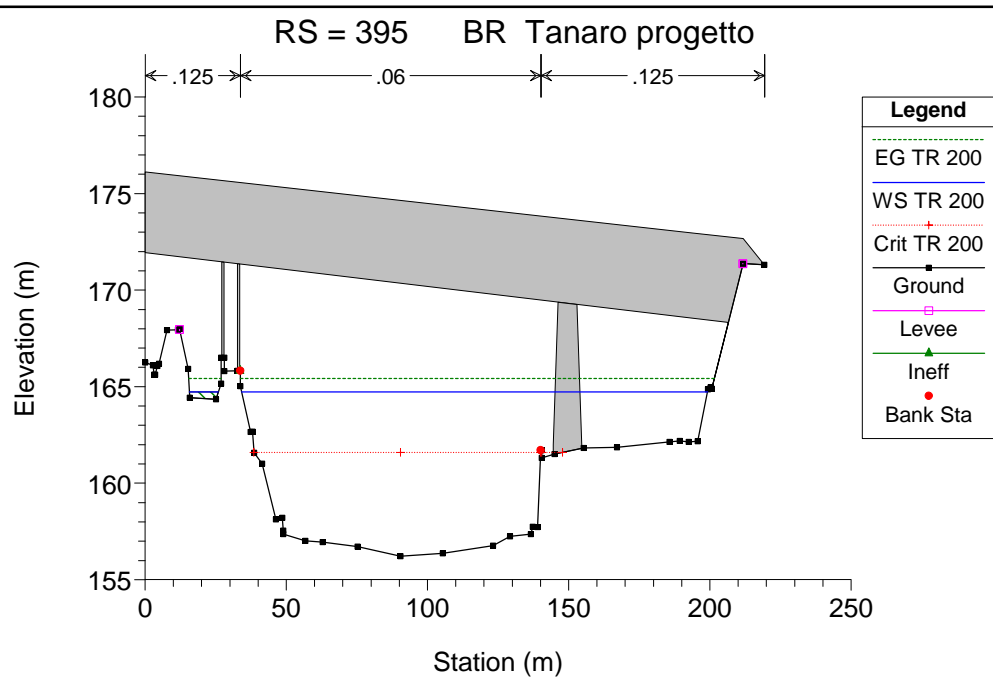
HEC-RAS Plan: Plan 06 River: Tanaro Reach: 1 Profile: TR 200 (Continued)

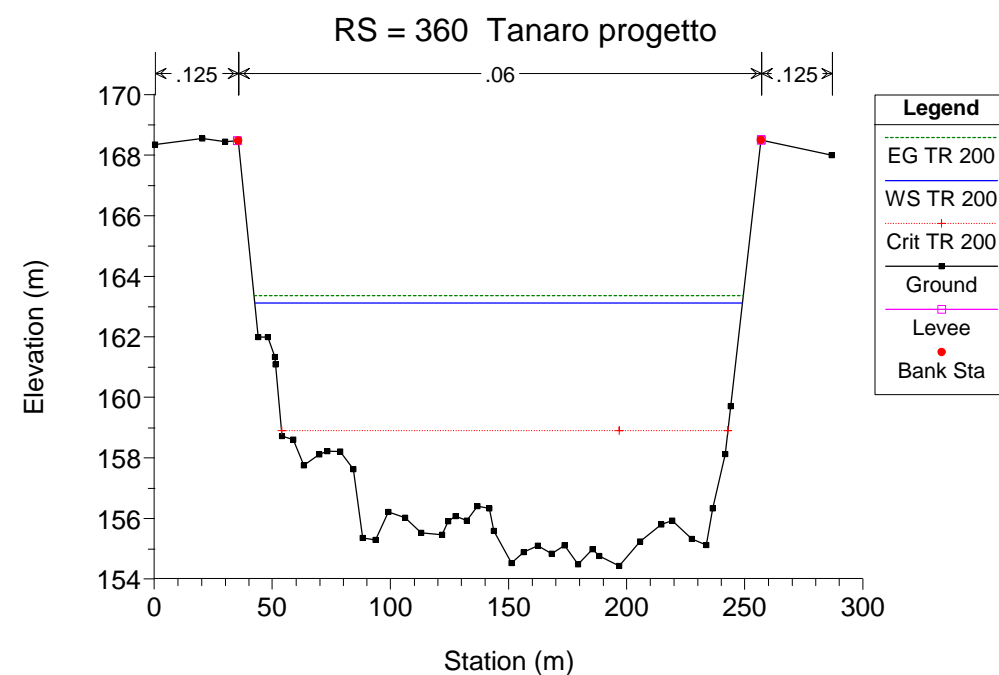
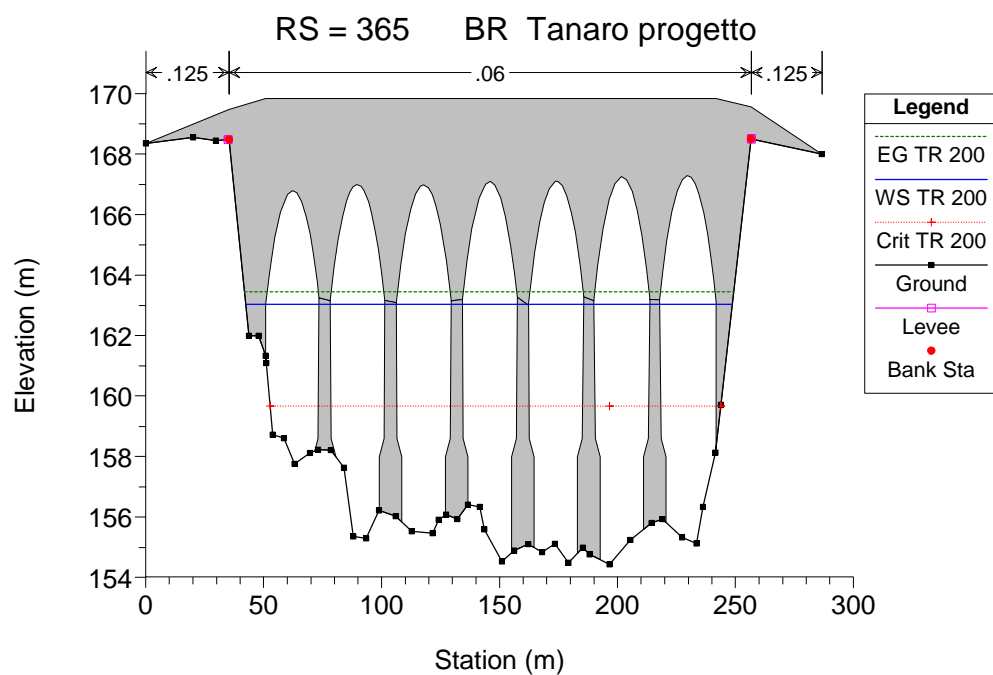
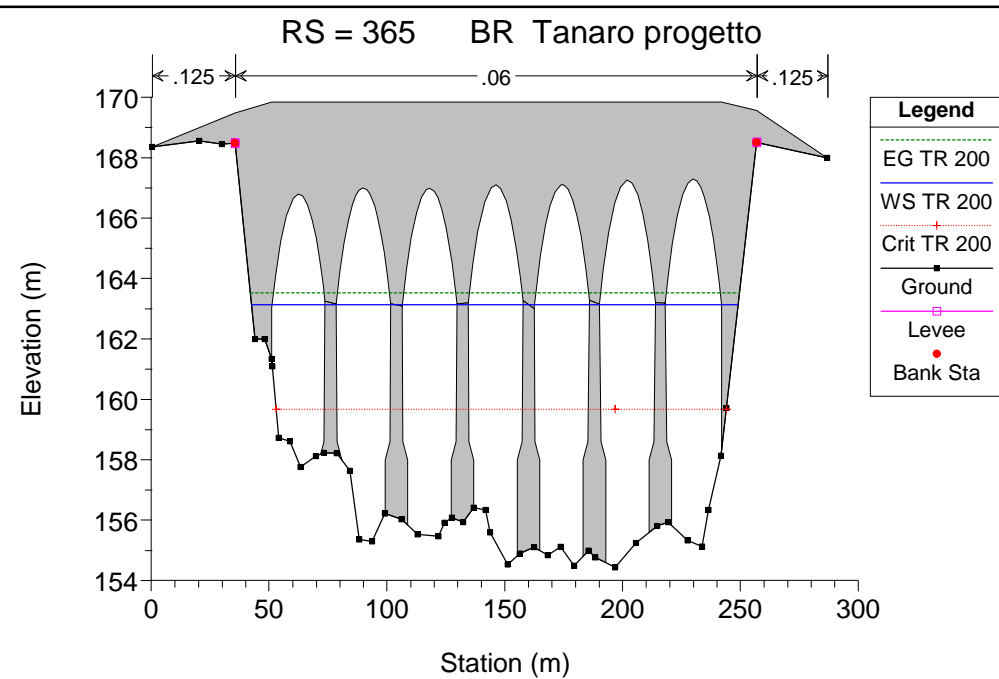
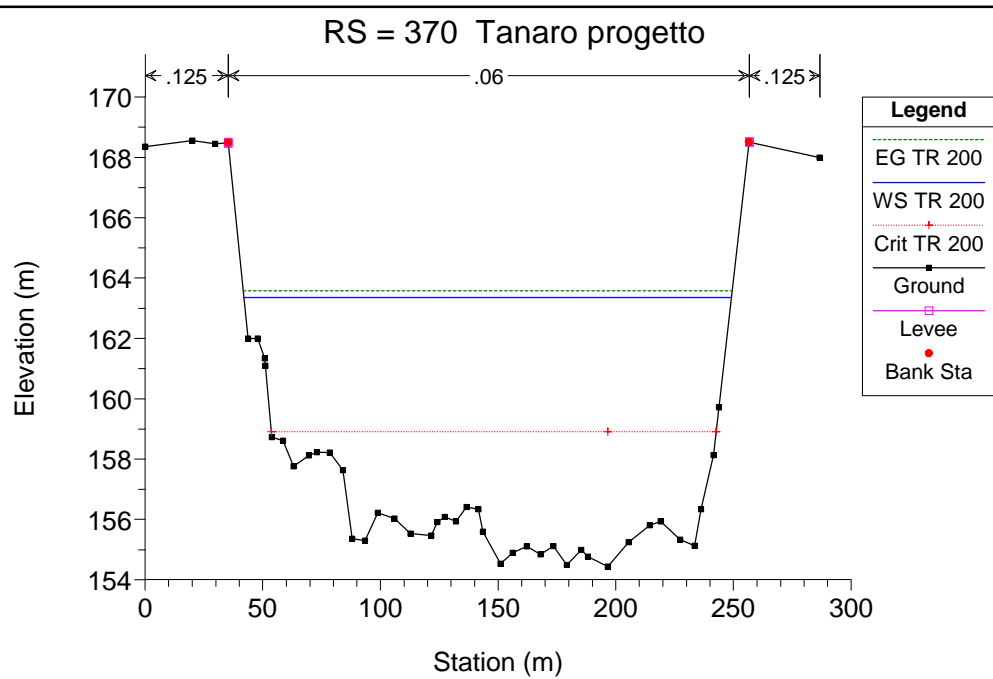
Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
1	70	TR 200	3050.00	139.61	147.57	144.94	147.96	0.003351	2.95	1306.12	304.63	0.41
1	60	TR 200	3050.00	138.12	147.15	143.35	147.39	0.001561	2.44	2161.93	808.92	0.29
1	50	TR 200	3050.00	137.54	146.58	143.82	146.95	0.002450	2.96	1823.04	903.93	0.36
1	40	TR 200	3050.00	137.06	145.84	143.17	146.16	0.002700	2.51	1335.66	734.96	0.36
1	30	TR 200	3050.00	137.37	145.20	141.99	145.48	0.002222	2.42	1574.30	727.26	0.33
1	20	TR 200	3050.00	136.62	144.64	141.66	144.86	0.001718	2.40	2328.51	839.27	0.30
1	10	TR 200	3050.00	135.29	143.69	142.45	144.15	0.004002	3.48	1679.28	662.46	0.45

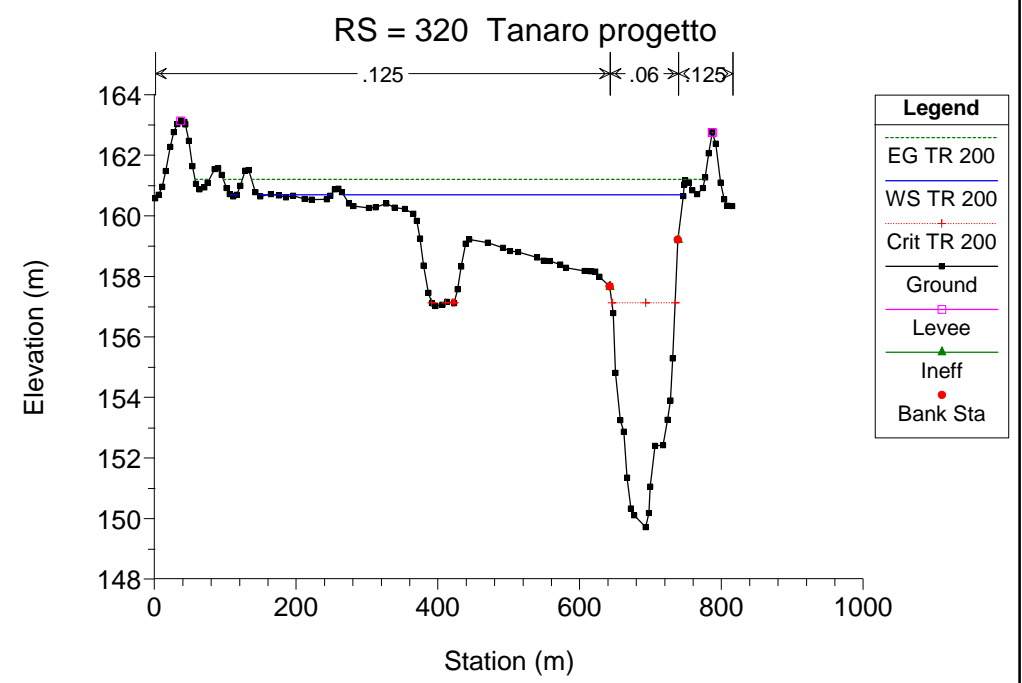
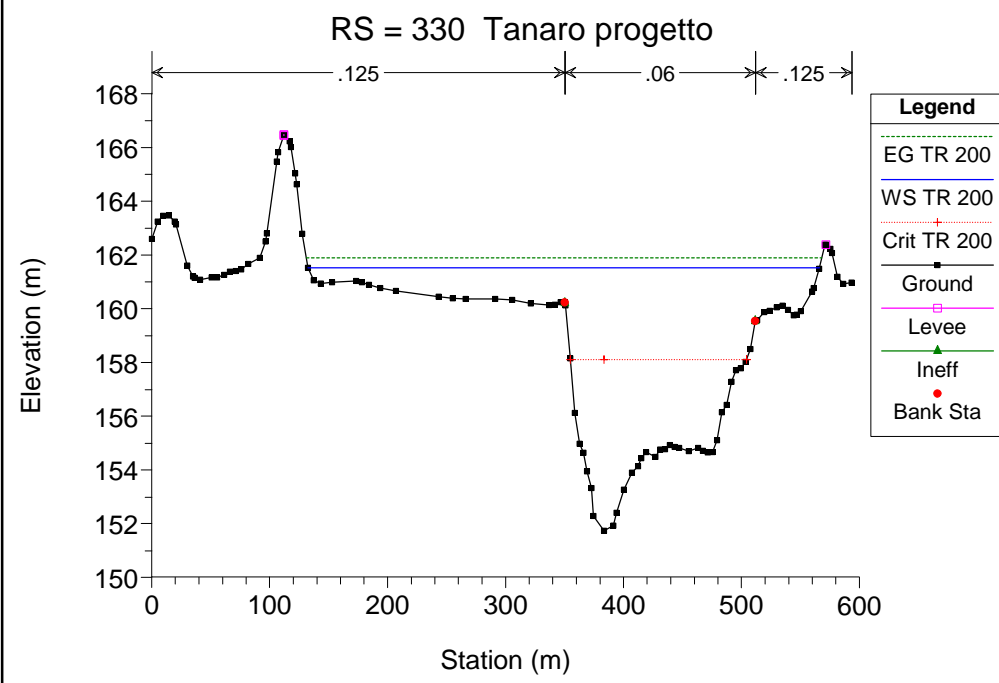
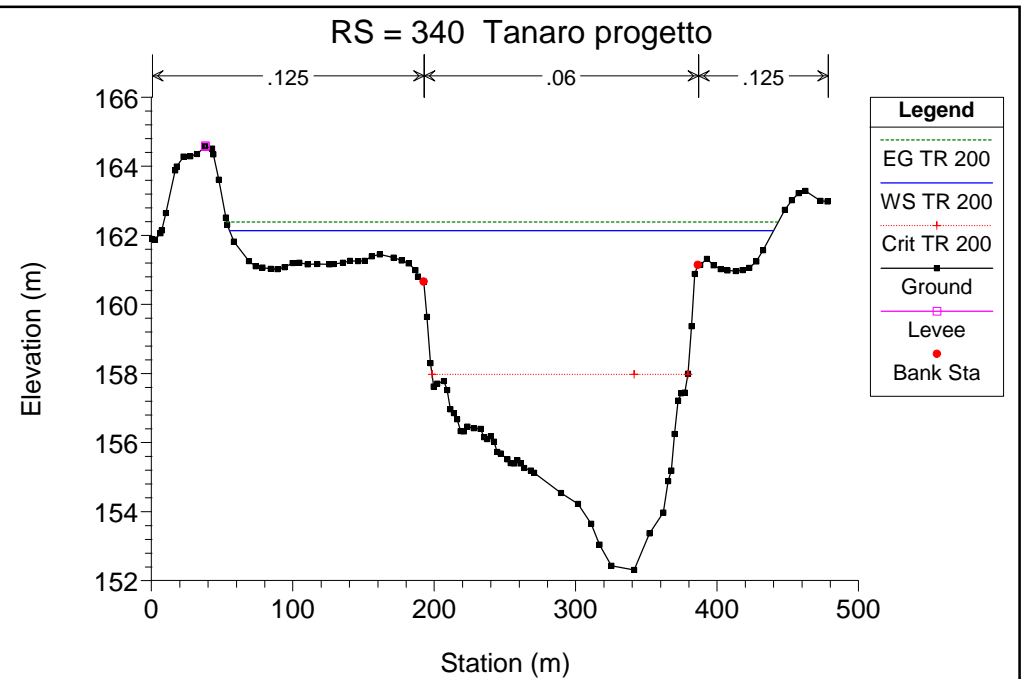
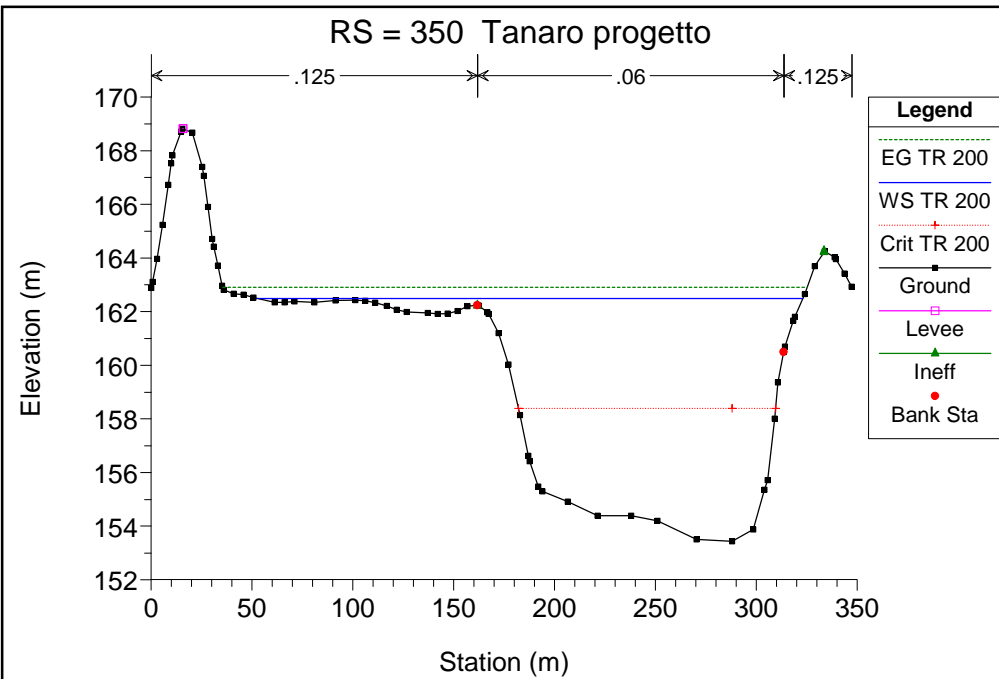
Tanaro progetto

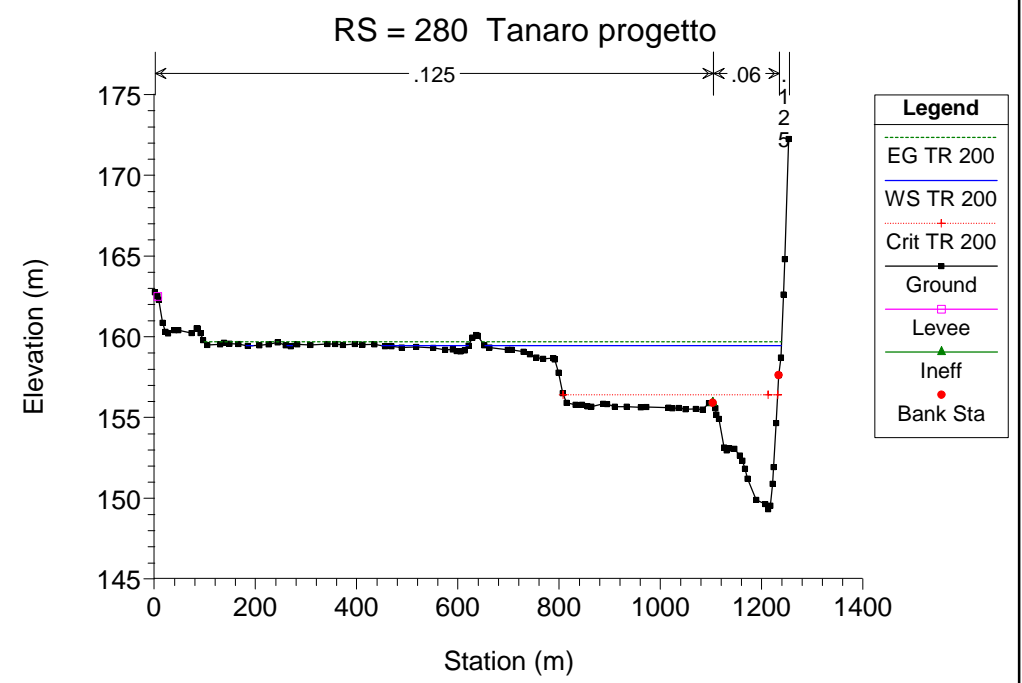
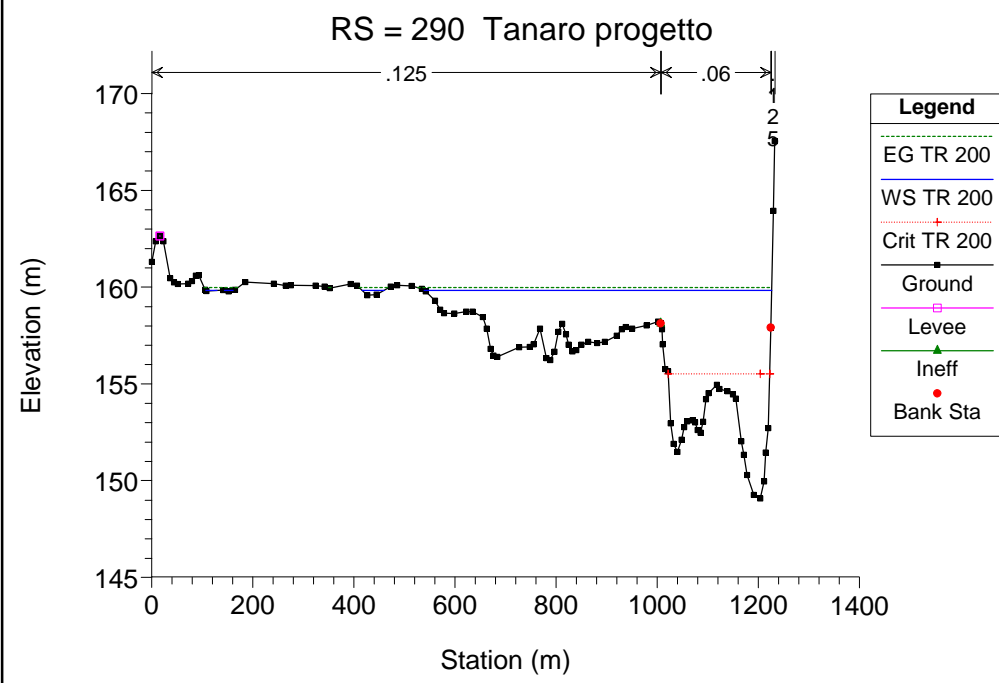
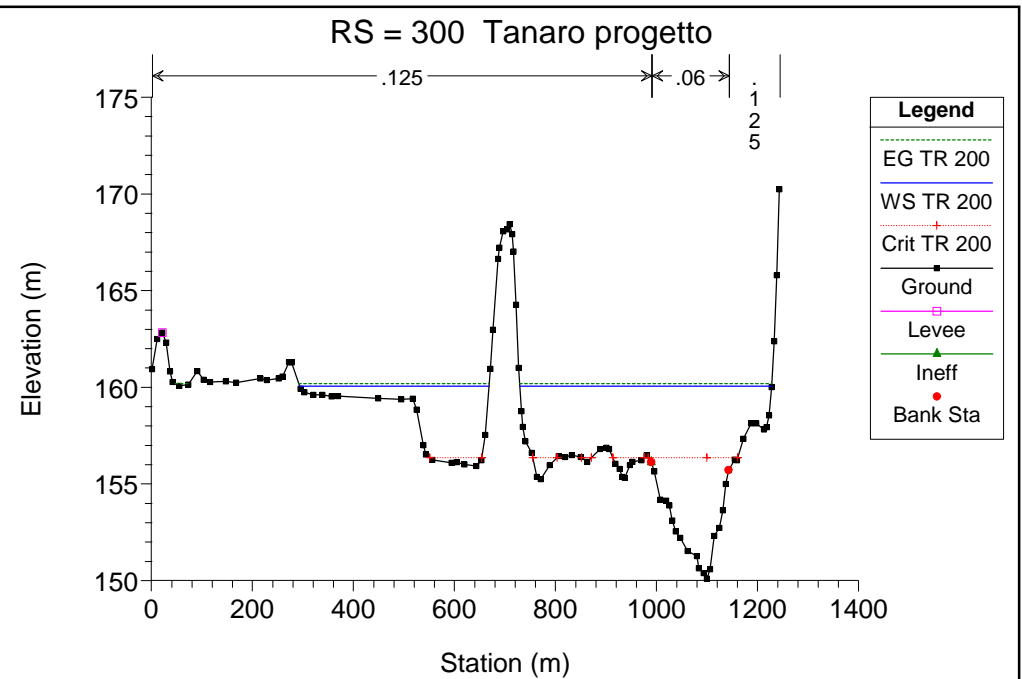
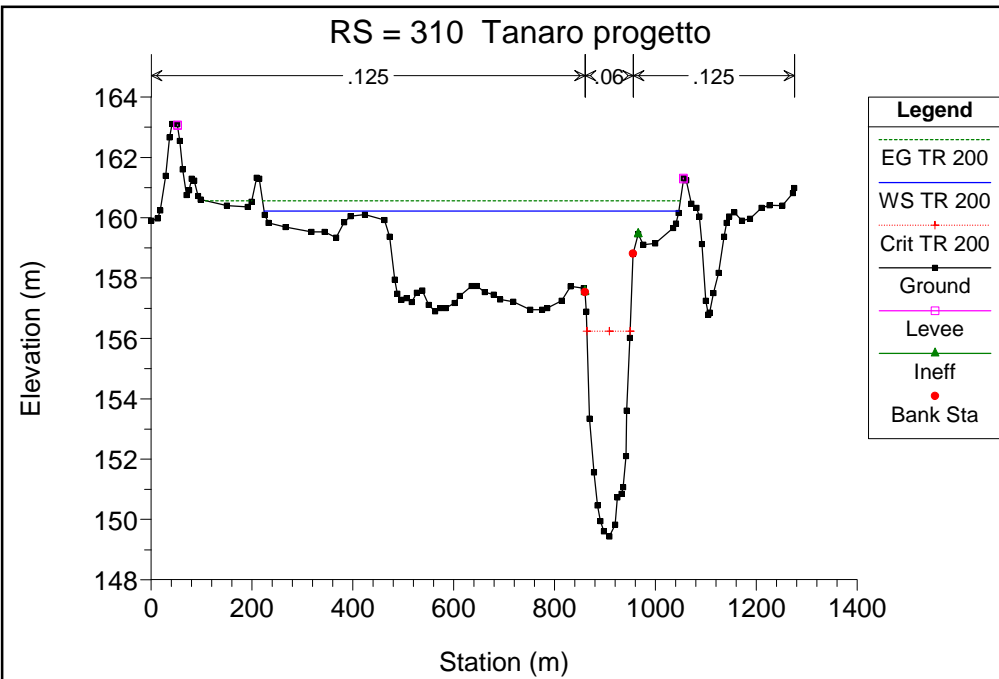


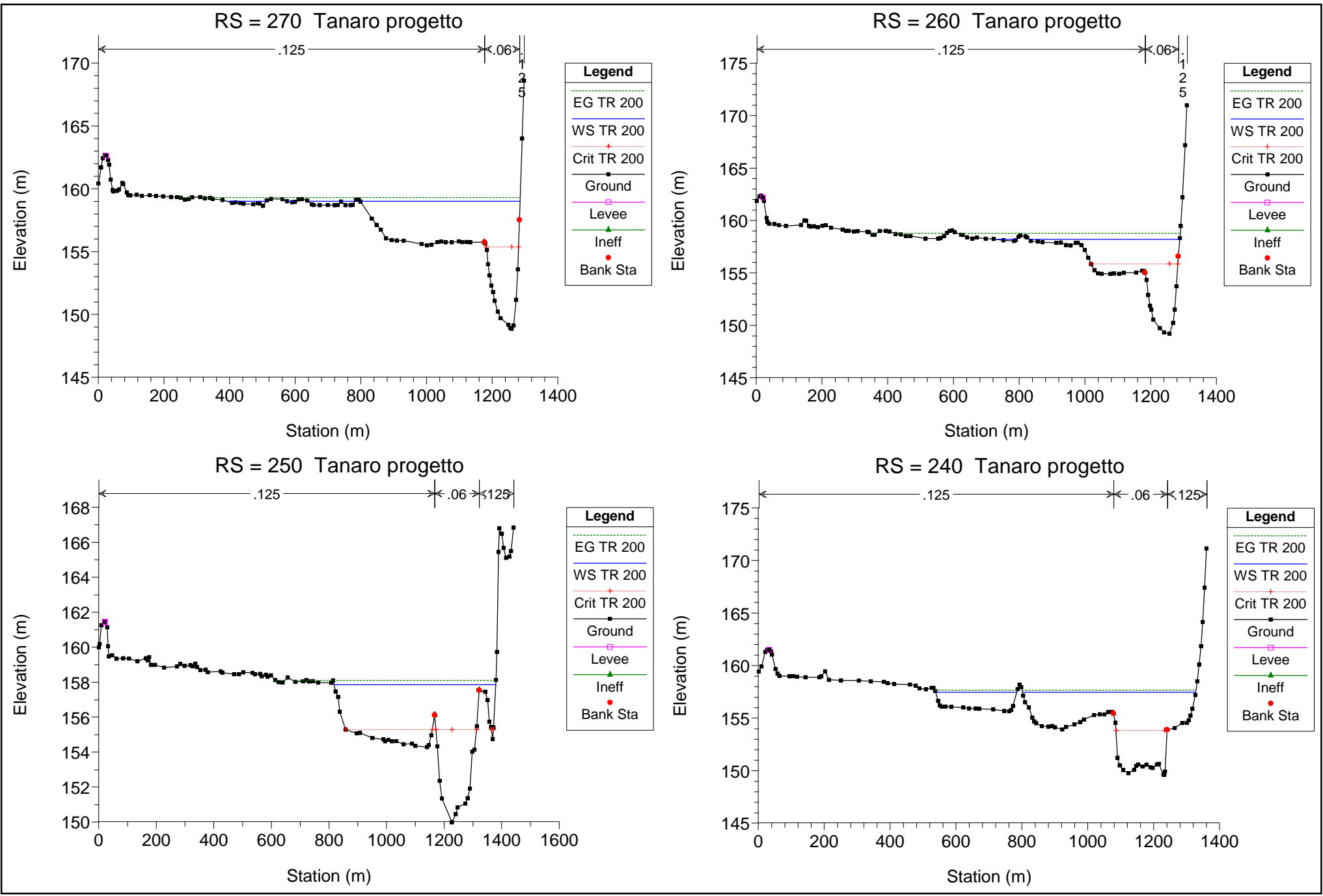


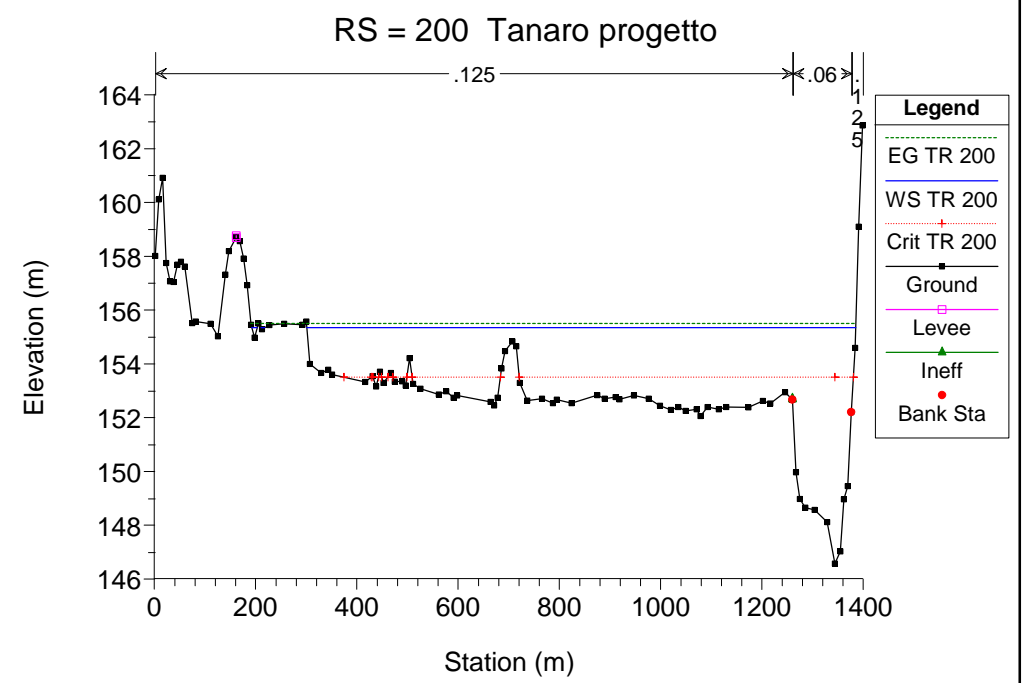
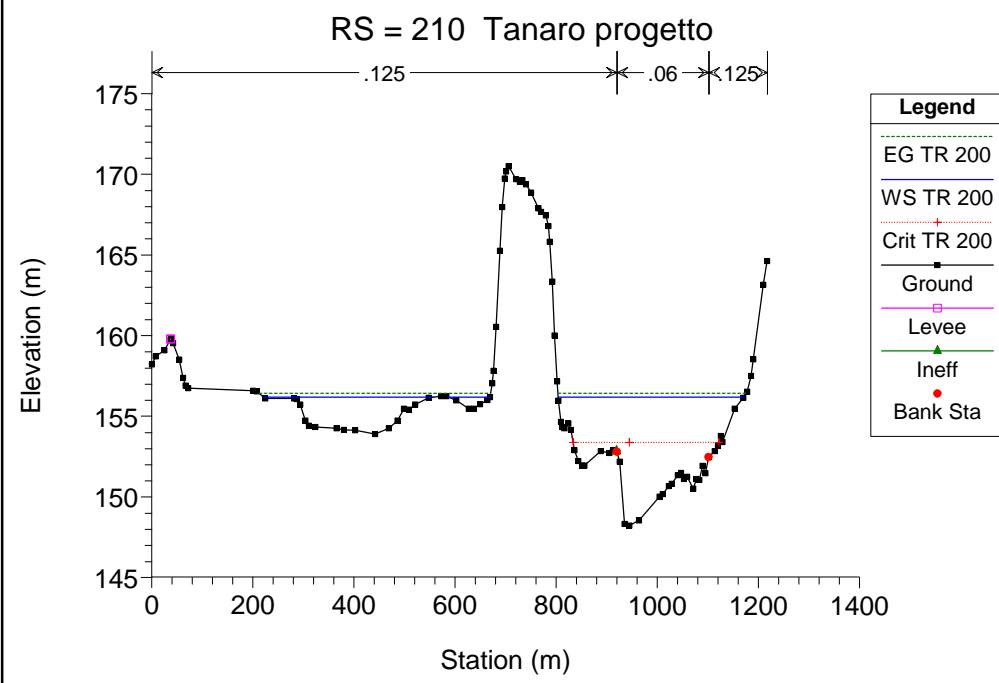
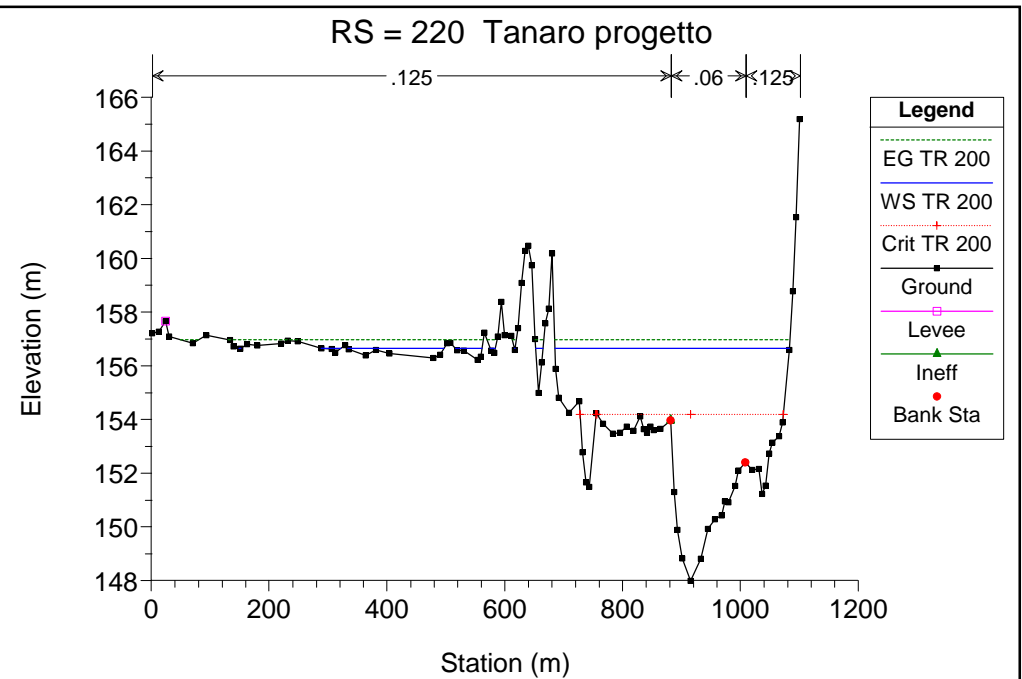
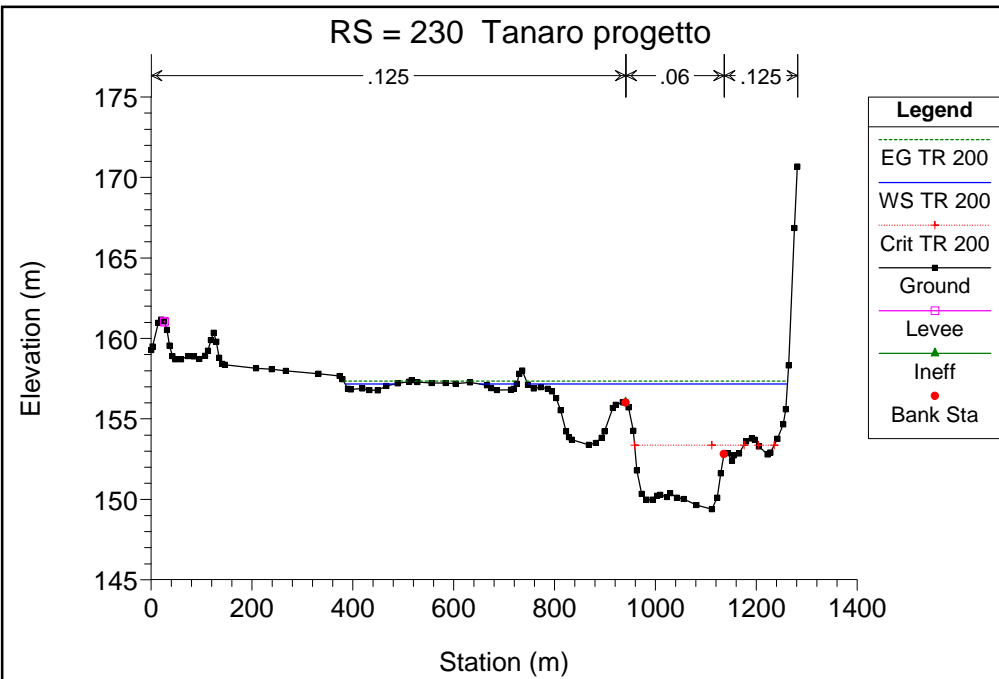


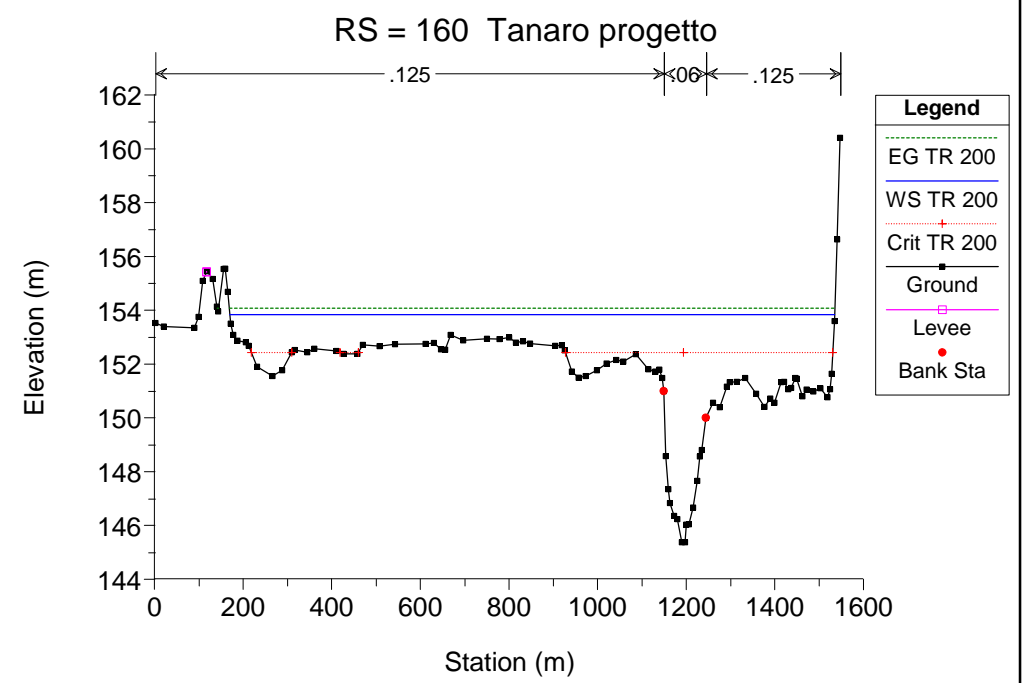
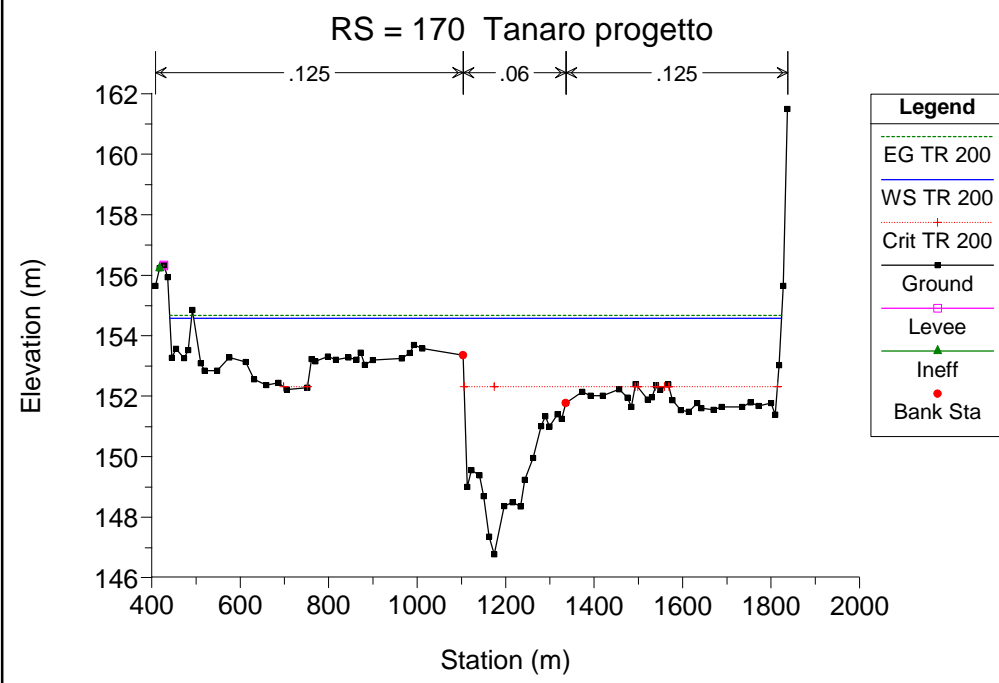
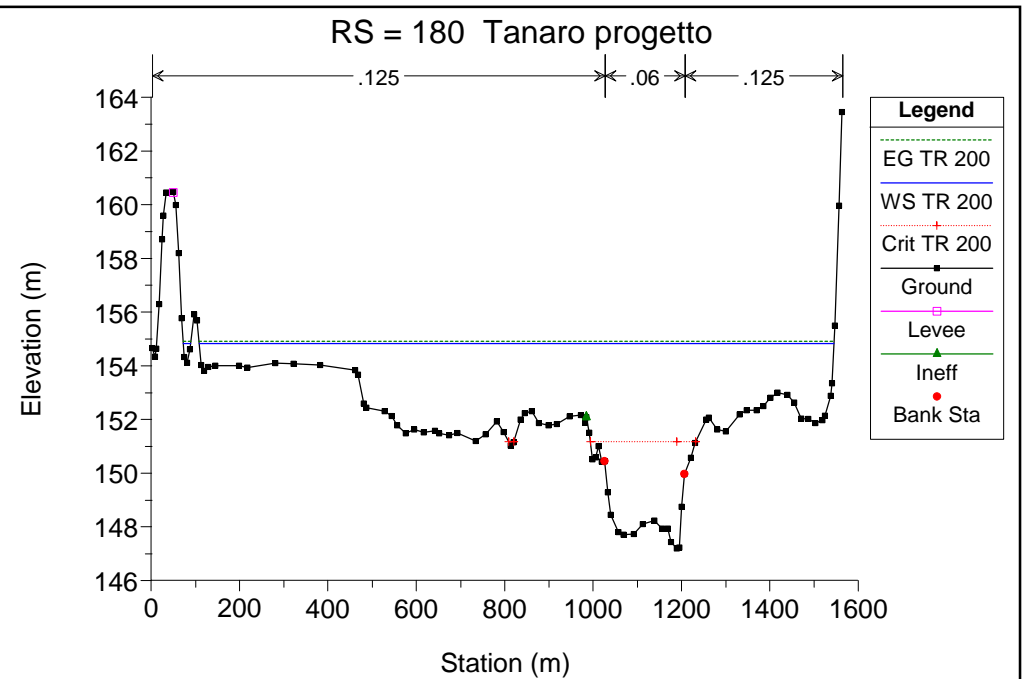
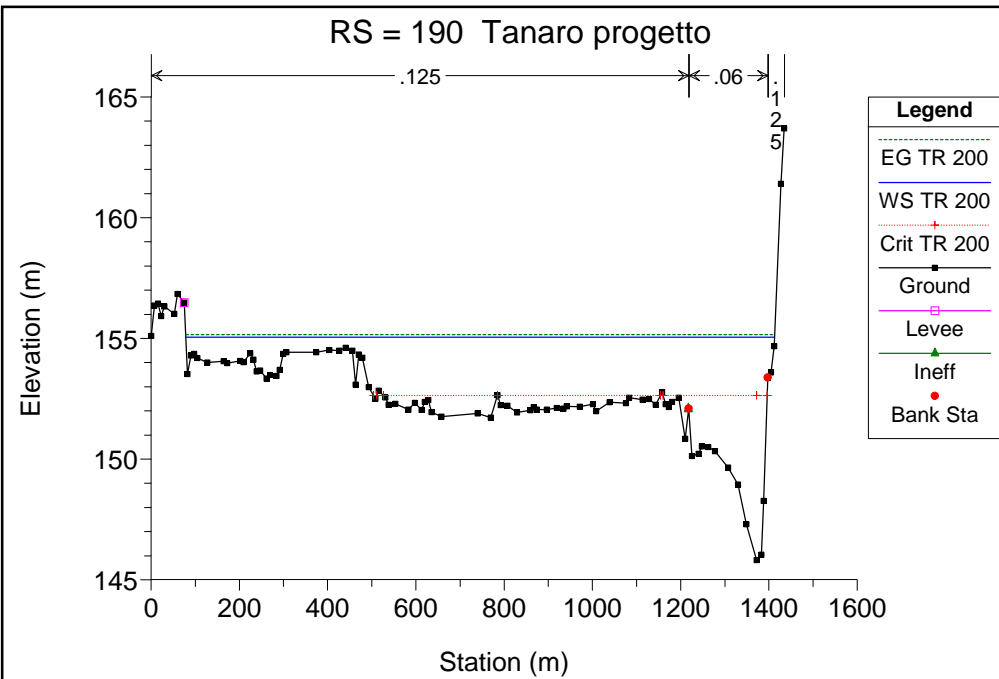


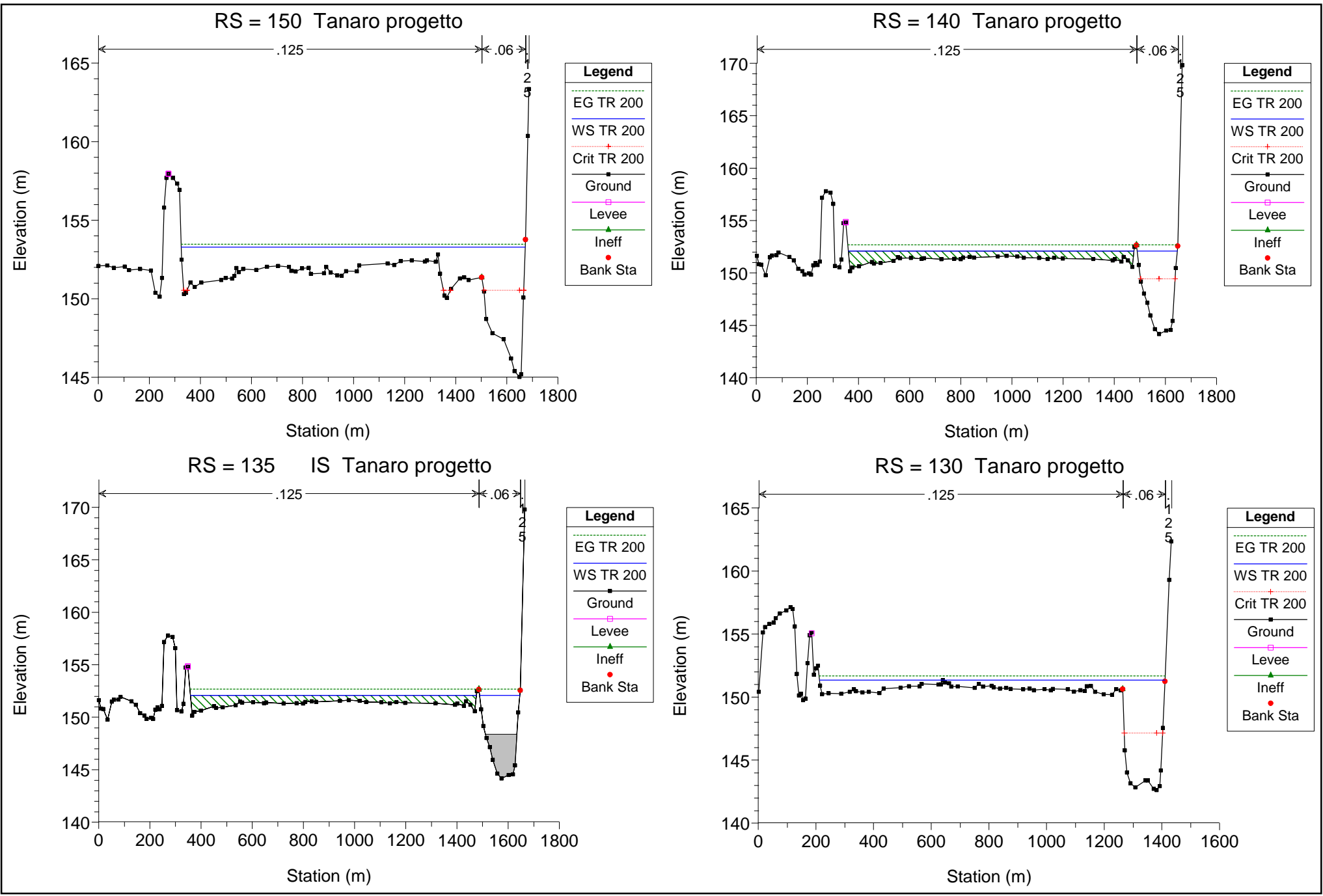


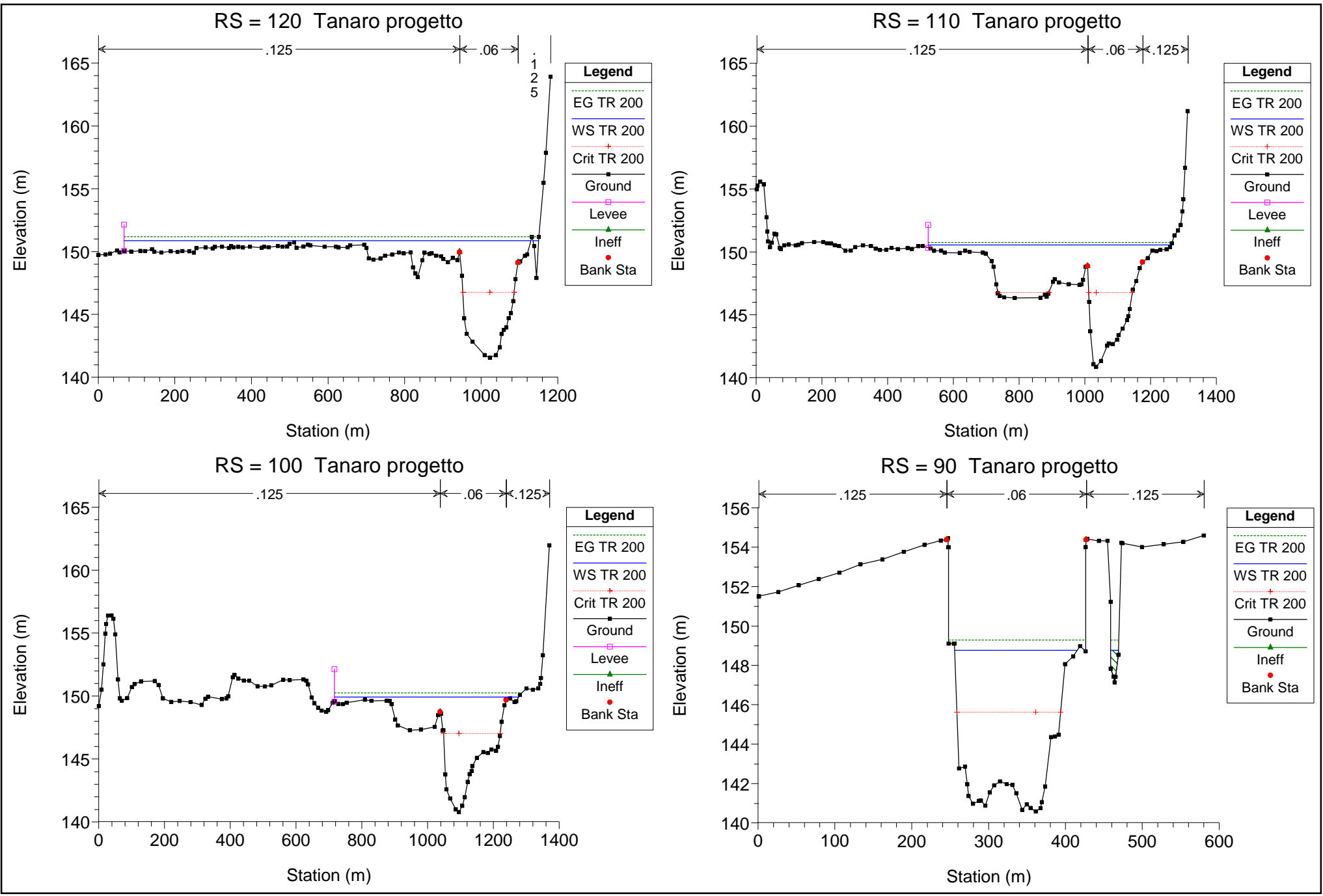


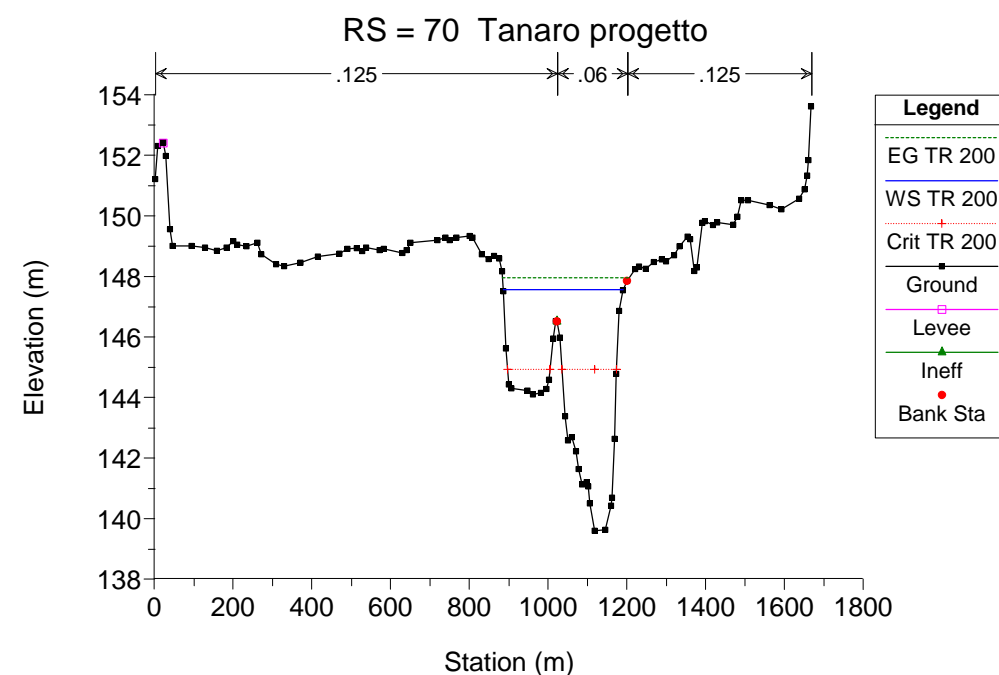
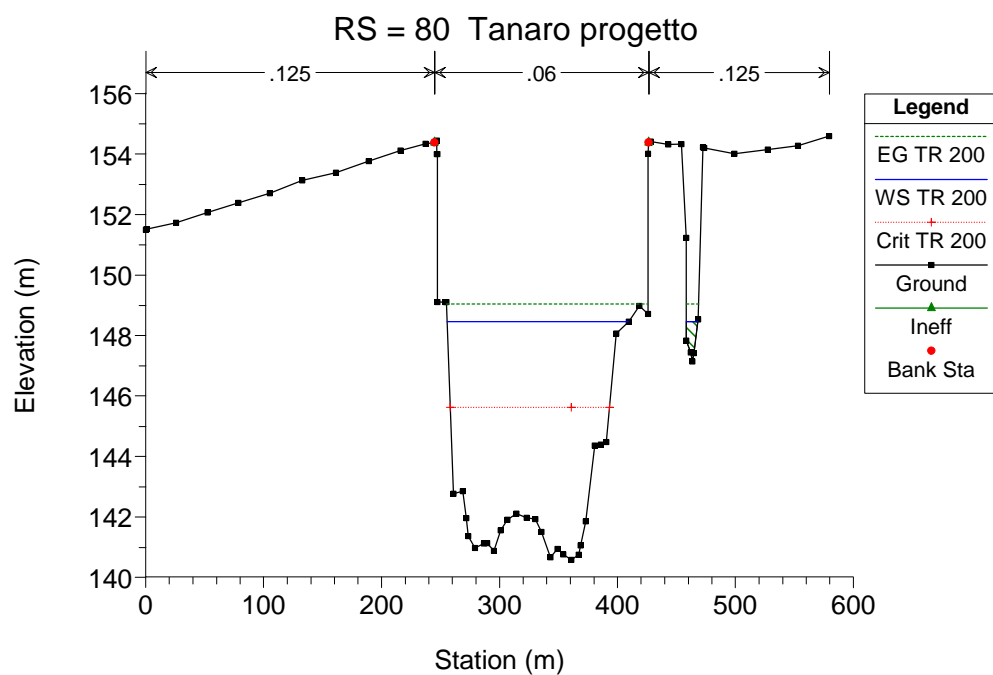
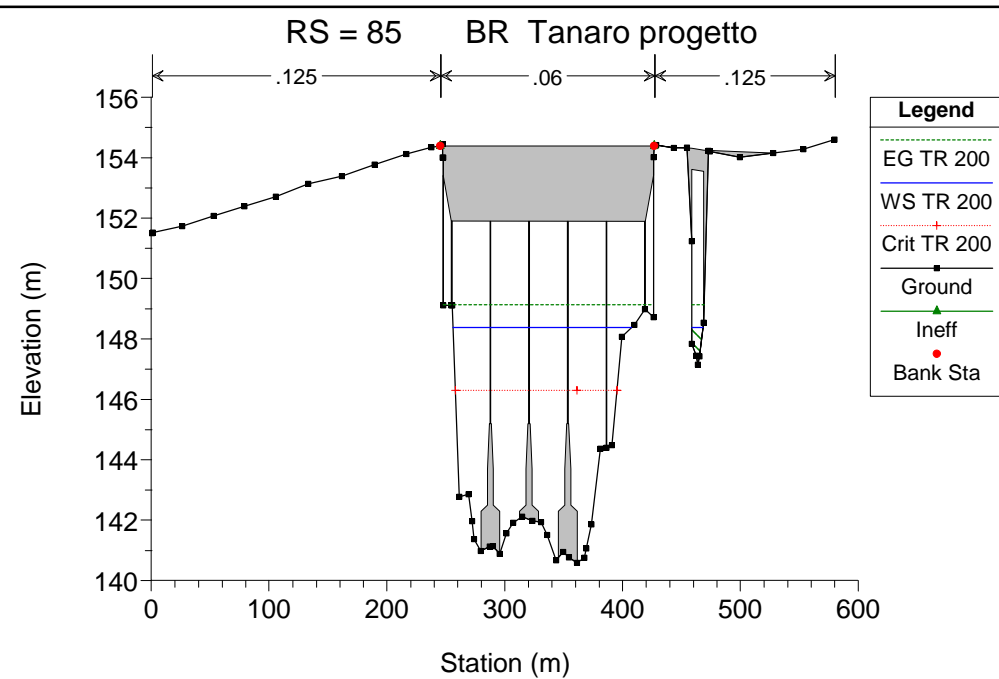
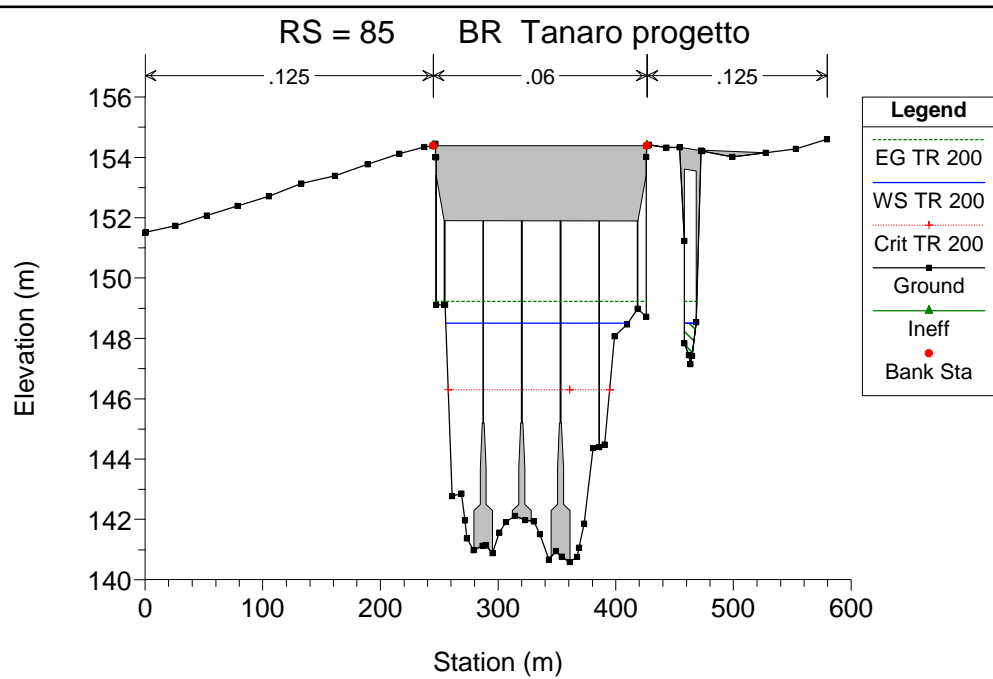


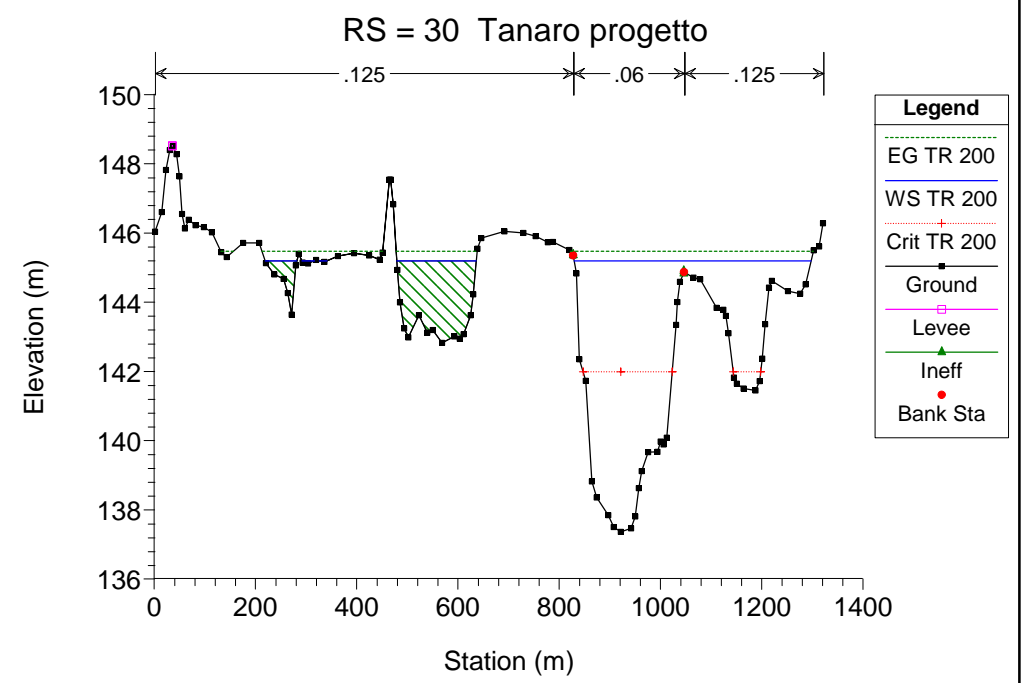
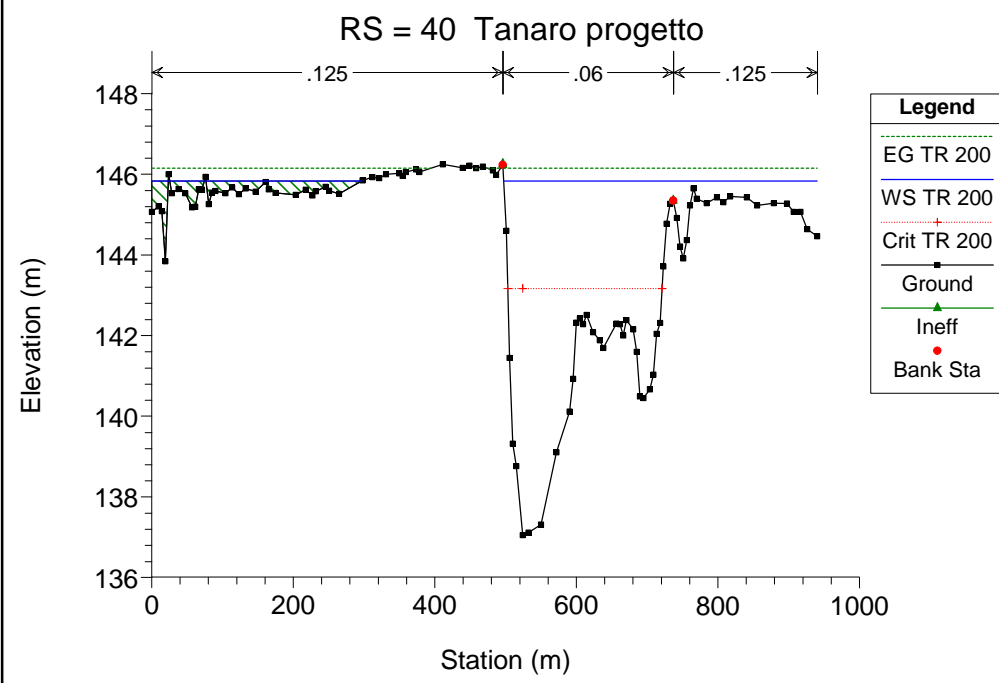
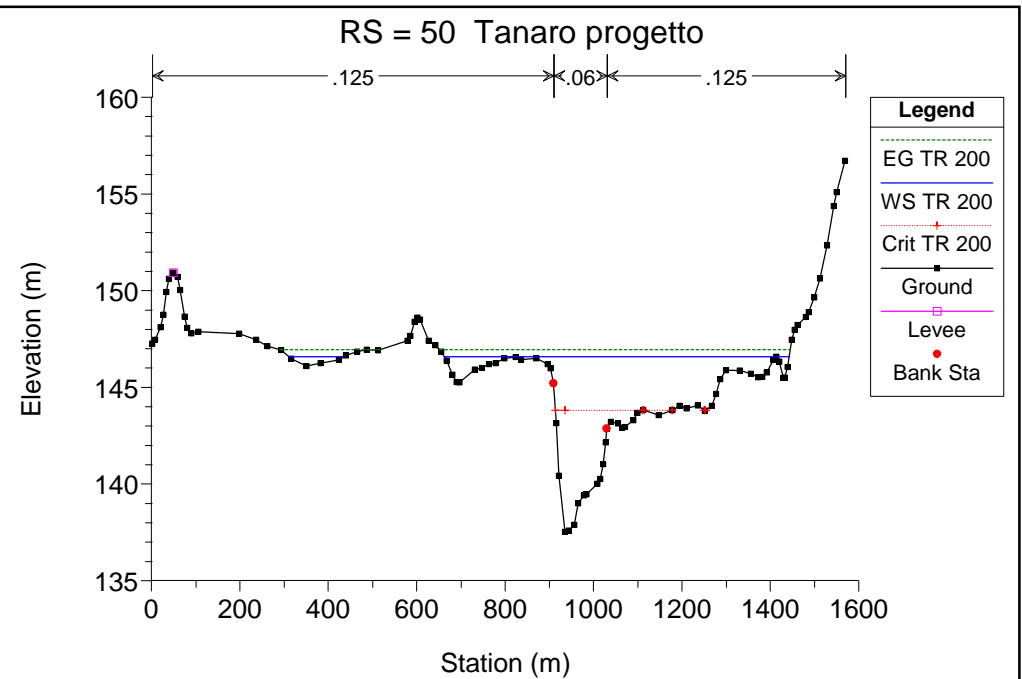
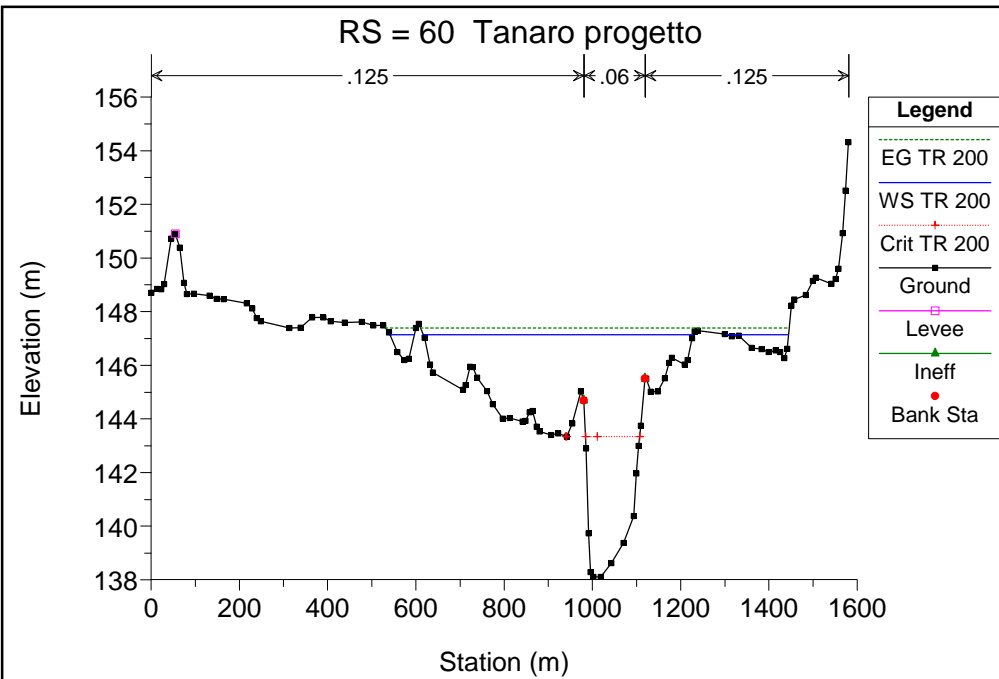




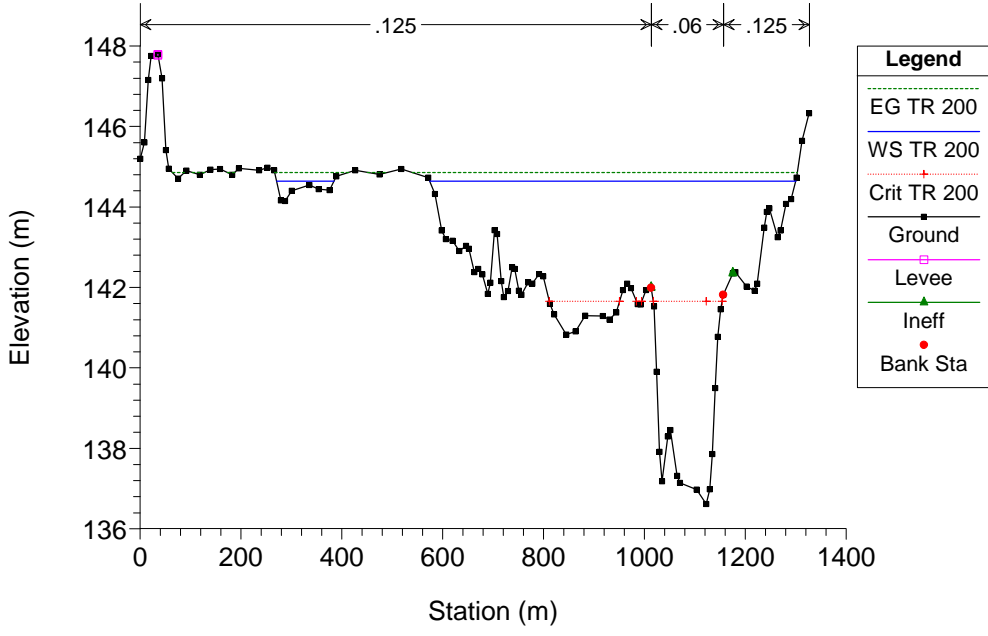




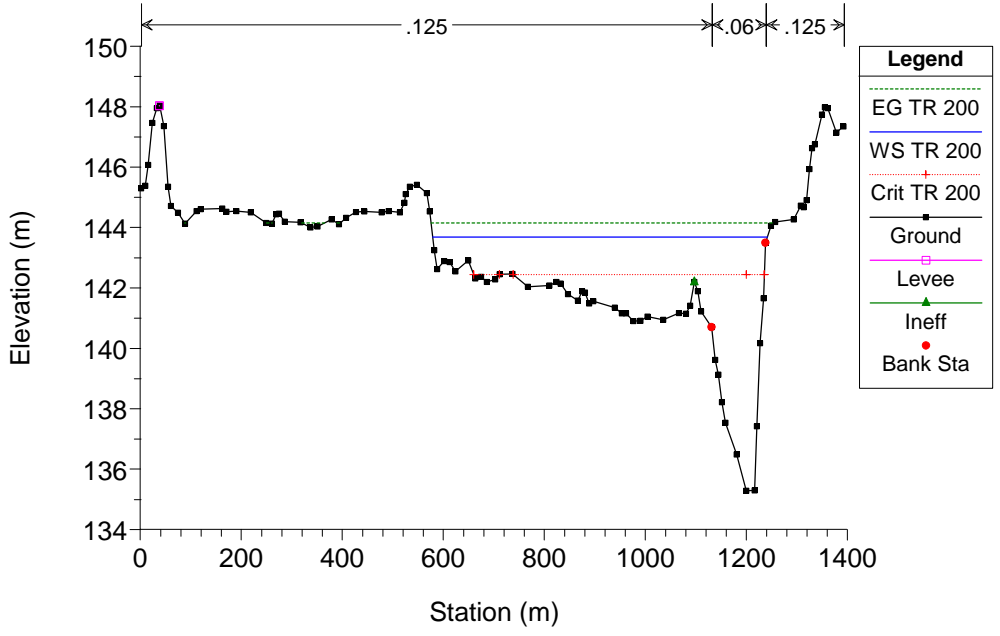




RS = 20 Tanaro progetto



RS = 10 Tanaro progetto



6. COMMENTO AI RISULTATI IDRAULICI

L'esame dei risultati del calcolo dei livelli idrici associati alle portate di piena con i tempi di ritorno tecnici del Fiume Tanaro (Tab. 6.1÷ Tab. 6.3) rileva che i livelli di piena in presenza dell'opera in progetto, nella zona immediatamente a monte della traversa, sono superiori a quelli attuali. L'incremento è di circa 2 m per la portata con tempo di ritorno di 20 anni, circa 1 m per la T_R 100 anni e circa 0.6 m per la T_R 200 anni. L'aumento dei livelli di piena è legato al fatto che la traversa esistente è, in buona parte, crollata; pertanto, anche se lo sbarramento in progetto presenta una quota in sommità identica a quello dello sbarramento esistente (in condizioni di piena, infatti, lo sbarramento mobile è abbassato), è inevitabile che quest'ultimo determini un incremento dei livelli in quanto esso occupa l'intera sezione trasversale. Tuttavia, è opportuno evidenziare come l'incremento dei livelli idrici in condizioni di piena conseguente alla realizzazione dello sbarramento in progetto, non modifichi le aree inondabili dal F. Tanaro che, nelle condizioni di progetto, risultano sostanzialmente coincidenti con quelle rappresentative della situazione attuale.



**Fig.6.1 Foto aerea della zona di interesse. Si evidenzia la presenza della traversa in buona parte crollata. Il crollo dell'opera è avvenuto nel novembre 2010.
(Fonte Google Earth, 2013)**

Per quanto concerne le velocità in alveo si evidenzia, nella zona immediatamente a monte dello sbarramento, una riduzione rispetto alla situazione attuale. Il decremento è di circa 1 m/s per la portata con tempo di ritorno di 20 anni, circa 0.6 m/s per la T_R 100 anni e circa 0.4 m/s per la T_R 200 anni.

Lo scenario di progetto, nelle condizioni di piena considerate (T_R pari a 20, 100 e 200 anni), è sostanzialmente analogo a quello precedente al crollo della traversa avvenuto nel novembre 2010. Per portate superiori a 300 m³/s, infatti, lo sbarramento mobile viene abbassato; in tali condizioni la quota in sommità della traversa è di 148.40 m s.l.m. ed è quindi coincidente con quella della traversa esistente crollata nel 2010.

A proposito delle azioni temporanee che ci possono essere nel transitorio della realizzazione dell'opera si ritiene che, in queste condizioni, ci sia un incremento del trasporto solido, di fondo e in sospensione, dovuto essenzialmente all'inevitabile transito dei mezzi d'opera in alveo ed ai lavori e scavi connessi.

Tale problema sarà minimizzato dalla realizzazione immediatamente a valle dei lavori di una tura in materiale incoerente con funzioni di filtro.

Qualora si presentassero in alveo condizioni idrologiche critiche, tale manufatto di sbarramento temporaneo sarebbe rapidamente asportato dalle acque in crescita eliminando, quindi, la sua interazione con il regime idraulico del corso d'acqua prima del manifestarsi del colmo di piena.

Inoltre, in considerazione dell'entità delle variazioni che esso determina in relazione alle modalità specifiche di propagazione delle medesime, si ritiene che si tratti unicamente di un impatto locale.

Nelle seguenti tabelle si riporta un confronto tra situazione attuale e situazione di progetto con riferimento alle principali grandezze idrauliche (livello del pelo libero e velocità in alveo).

**RICOSTRUZIONE DI SBARRAMENTO FLUVIALE ESISTENTE AD USO IRRIGUO CON INNALZAMENTO
ABBATTIBILE AD USO IDROELETTRICO E CENTRALE IN CORPO TRAVERSA**

TR = 20 anni						
Sez	Livello [m s.l.m.]			Velocità [m/s]		
	Attuale	Progetto	Δ	Attuale	Progetto	Δ
430	164.63	164.63	0.00	2.06	2.06	0.00
420	164.46	164.46	0.00	1.57	1.57	0.00
410	164.19	164.19	0.00	1.96	1.96	0.00
400	163.30	163.30	0.00	3.17	3.17	0.00
390	163.19	163.19	0.00	3.24	3.24	0.00
380	162.22	162.22	0.00	2.50	2.50	0.00
370	161.84	161.84	0.00	1.81	1.81	0.00
360	161.66	161.66	0.00	1.88	1.88	0.00
350	161.16	161.16	0.00	2.37	2.37	0.00
340	160.82	160.82	0.00	1.89	1.89	0.00
330	160.25	160.25	0.00	2.39	2.39	0.00
320	159.46	159.46	0.00	2.93	2.93	0.00
310	158.98	158.99	0.01	2.56	2.56	0.00
300	158.81	158.81	0.00	1.68	1.68	0.00
290	158.58	158.58	0.00	1.57	1.57	0.00
280	158.25	158.25	0.00	2.06	2.06	0.00
270	157.79	157.79	0.00	2.43	2.43	0.00
260	157.22	157.23	0.01	2.84	2.84	0.00
250	156.82	156.82	0.00	2.25	2.25	0.00
240	156.42	156.43	0.01	1.90	1.90	0.00
230	156.16	156.17	0.01	1.66	1.66	0.00
220	155.73	155.75	0.02	2.37	2.36	-0.01
210	155.34	155.37	0.03	1.94	1.93	-0.01
200	154.51	154.59	0.08	2.04	1.97	-0.07
190	154.23	154.34	0.11	1.56	1.50	-0.06
180	154.04	154.15	0.11	1.34	1.34	0.00
170	153.79	153.94	0.15	1.55	1.46	-0.09
160	152.82	153.29	0.47	2.94	2.39	-0.55
150	151.81	152.91	1.10	2.63	1.76	-0.87
140	150.33	152.37	2.04	3.28	2.20	-1.08
130	150.06	150.06	0.00	2.27	2.27	0.00
120	149.58	149.58	0.00	2.26	2.26	0.00
110	149.24	149.24	0.00	1.95	1.95	0.00
100	148.51	148.51	0.00	2.52	2.52	0.00
90	147.59	147.59	0.00	2.65	2.65	0.00
80	147.36	147.36	0.00	2.76	2.76	0.00
70	146.42	146.42	0.00	2.84	2.84	0.00
60	146.02	146.02	0.00	2.17	2.17	0.00
50	145.52	145.52	0.00	2.55	2.55	0.00
40	144.84	144.84	0.00	2.13	2.13	0.00
30	144.26	144.26	0.00	2.09	2.09	0.00
20	143.76	143.76	0.00	2.06	2.06	0.00
10	142.79	142.79	0.00	3.16	3.16	0.00

Tab 6.1 Confronto livelli e velocità in alveo situazione attuale – progetto ($T_R=20$ anni)

**RICOSTRUZIONE DI SBARRAMENTO FLUVIALE ESISTENTE AD USO IRRIGUO CON INNALZAMENTO
ABBATTIBILE AD USO IDROELETTRICO E CENTRALE IN CORPO TRAVERSA**

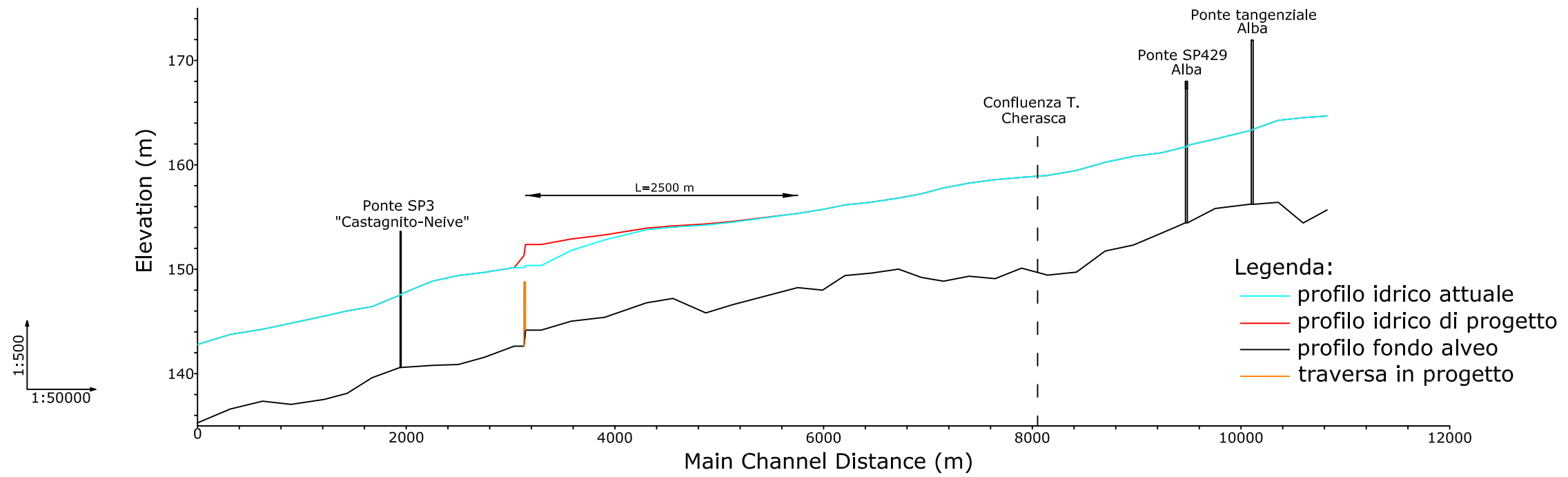
TR = 100 anni						
Sez	Livello [m s.l.m.]			Velocità [m/s]		
	Attuale	Progetto	Δ	Attuale	Progetto	Δ
430	165.75	165.75	0.00	2.05	2.05	0.00
420	165.60	165.60	0.00	1.66	1.66	0.00
410	165.36	165.36	0.00	2.01	2.01	0.00
400	164.38	164.38	0.00	3.53	3.53	0.00
390	164.25	164.25	0.00	3.61	3.61	0.00
380	163.31	163.31	0.00	2.76	2.76	0.00
370	162.94	162.94	0.00	2.03	2.03	0.00
360	162.73	162.73	0.00	2.10	2.10	0.00
350	162.13	162.13	0.00	2.74	2.74	0.00
340	161.77	161.77	0.00	2.15	2.15	0.00
330	161.16	161.16	0.00	2.69	2.69	0.00
320	160.34	160.34	0.00	3.27	3.27	0.00
310	159.90	159.90	0.00	2.75	2.75	0.00
300	159.72	159.72	0.00	1.87	1.87	0.00
290	159.50	159.50	0.00	1.71	1.71	0.00
280	159.15	159.15	0.00	2.32	2.32	0.00
270	158.69	158.69	0.00	2.65	2.65	0.00
260	157.94	157.94	0.00	3.41	3.41	0.00
250	157.58	157.58	0.00	2.43	2.43	0.00
240	157.18	157.19	0.01	2.08	2.07	-0.01
230	156.89	156.90	0.01	1.91	1.91	0.00
220	156.40	156.40	0.00	2.71	2.70	-0.01
210	155.97	155.98	0.01	2.22	2.22	0.00
200	155.13	155.16	0.03	2.19	2.17	-0.02
190	154.82	154.86	0.04	1.79	1.76	-0.03
180	154.60	154.65	0.05	1.54	1.52	-0.02
170	154.34	154.40	0.06	1.67	1.63	-0.04
160	153.49	153.69	0.20	2.94	2.69	-0.25
150	152.69	153.18	0.49	2.56	2.11	-0.45
140	151.15	152.22	1.07	3.70	3.03	-0.67
130	151.00	151.00	0.00	2.58	2.58	0.00
120	150.50	150.50	0.00	2.52	2.52	0.00
110	150.15	150.15	0.00	2.21	2.21	0.00
100	149.52	149.52	0.00	2.56	2.56	0.00
90	148.41	148.41	0.00	3.08	3.08	0.00
80	148.12	148.12	0.00	3.24	3.24	0.00
70	147.28	147.28	0.00	2.84	2.84	0.00
60	146.86	146.86	0.00	2.35	2.35	0.00
50	146.31	146.31	0.00	2.87	2.87	0.00
40	145.57	145.57	0.00	2.41	2.41	0.00
30	144.95	144.95	0.00	2.31	2.31	0.00
20	144.41	144.41	0.00	2.30	2.30	0.00
10	143.45	143.45	0.00	3.39	3.39	0.00

Tab 6.2 Confronto livelli e velocità in alveo situazione attuale – progetto ($T_R=100$ anni)

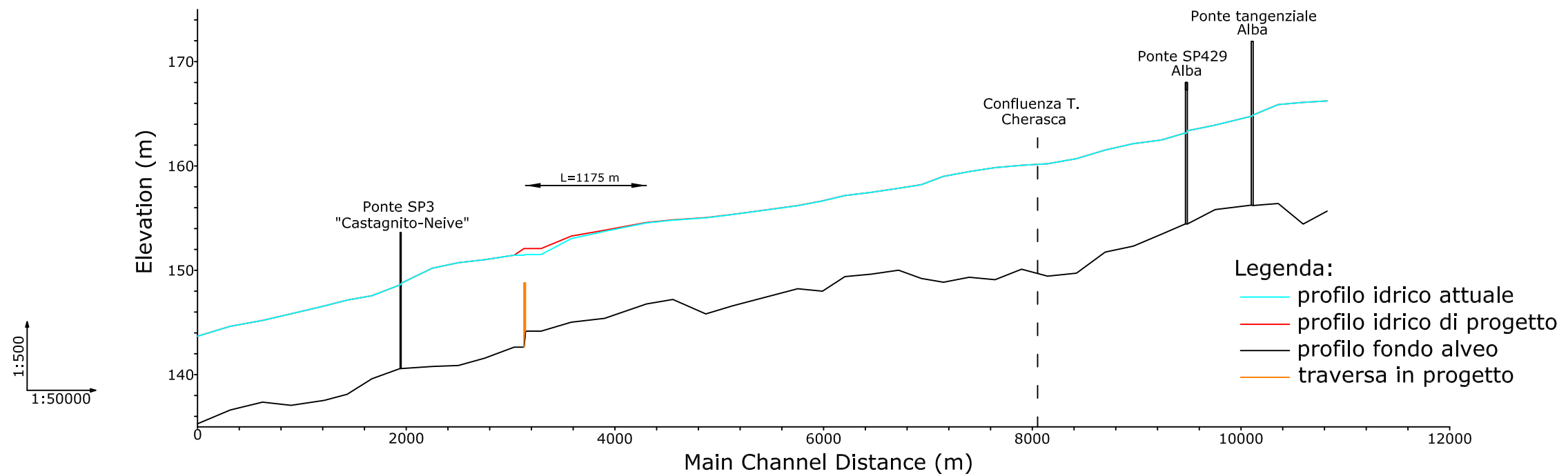
TR = 200 anni						
Sez	Livello [m s.l.m.]			Velocità [m/s]		
	Attuale	Progetto	Δ	Attuale	Progetto	Δ
430	166.18	166.18	0.00	2.05	2.05	0.00
420	166.04	166.04	0.00	1.69	1.69	0.00
410	165.82	165.82	0.00	2.04	2.04	0.00
400	164.79	164.79	0.00	3.67	3.67	0.00
390	164.65	164.65	0.00	3.75	3.75	0.00
380	163.72	163.72	0.00	2.86	2.86	0.00
370	163.36	163.36	0.00	2.12	2.12	0.00
360	163.13	163.13	0.00	2.19	2.19	0.00
350	162.49	162.49	0.00	2.88	2.88	0.00
340	162.14	162.14	0.00	2.24	2.24	0.00
330	161.53	161.53	0.00	2.76	2.76	0.00
320	160.70	160.70	0.00	3.39	3.39	0.00
310	160.22	160.22	0.00	2.94	2.94	0.00
300	160.06	160.06	0.00	1.91	1.91	0.00
290	159.84	159.84	0.00	1.77	1.77	0.00
280	159.46	159.46	0.00	2.44	2.44	0.00
270	159.01	159.01	0.00	2.74	2.74	0.00
260	158.21	158.21	0.00	3.58	3.58	0.00
250	157.86	157.87	0.01	2.51	2.51	0.00
240	157.48	157.48	0.00	2.14	2.14	0.00
230	157.17	157.17	0.00	2.01	2.01	0.00
220	156.65	156.66	0.01	2.83	2.83	0.00
210	156.20	156.20	0.00	2.35	2.35	0.00
200	155.34	155.36	0.02	2.25	2.24	-0.01
190	155.03	155.06	0.03	1.83	1.82	-0.01
180	154.81	154.84	0.03	1.60	1.58	-0.02
170	154.55	154.58	0.03	1.72	1.70	-0.02
160	153.74	153.85	0.11	2.93	2.80	-0.13
150	153.03	153.29	0.26	2.48	2.24	-0.24
140	151.47	152.09	0.62	3.85	3.44	-0.41
130	151.36	151.36	0.00	2.61	2.61	0.00
120	150.88	150.88	0.00	2.56	2.56	0.00
110	150.56	150.56	0.00	2.21	2.21	0.00
100	149.93	149.93	0.00	2.62	2.62	0.00
90	148.77	148.77	0.00	3.21	3.21	0.00
80	148.46	148.46	0.00	3.38	3.38	0.00
70	147.57	147.57	0.00	2.95	2.95	0.00
60	147.15	147.15	0.00	2.44	2.44	0.00
50	146.58	146.58	0.00	2.96	2.96	0.00
40	145.84	145.84	0.00	2.51	2.51	0.00
30	145.20	145.20	0.00	2.42	2.42	0.00
20	144.64	144.64	0.00	2.40	2.40	0.00
10	143.69	143.69	0.00	3.48	3.48	0.00

Tab 6.3 Confronto livelli e velocità in alveo situazione attuale – progetto ($T_R=200$ anni)

Confronto profili idrici attuale-progetto
 $Q=2050 \text{ m}^3/\text{s}$ (TR20 anni; sbarramento mobile abbassato)



Confronto profili idrici attuale-progetto
 $Q=3050 \text{ m}^3/\text{s}$ (TR200 anni; sbarramento mobile abbassato)



7. VALUTAZIONE DEI LIVELLI IN ALVEO IN CONDIZIONI DI ESERCIZIO CON LE PORTATE DELLA CURVA DI DURATA.

Per valutare i livelli idrici in alveo e le principali grandezze idrauliche in condizioni di esercizio sono state effettuate delle simulazioni idraulico-numeriche sia nella condizione attuale che in quella di progetto.

La metodologia di calcolo adottata è la stessa descritta nel capitolo precedente per la valutazione dei livelli idrici del Fiume Tanaro in condizioni di piena; il software utilizzato è sempre HEC-RAS nella versione 4.1.

Nel periodo irriguo, quando le portate in alveo sono inferiori a $9.2 \text{ m}^3/\text{s}$ non viene effettuata alcuna derivazione né per fini irrigui, né per fini idroelettrici, mentre per portate in arrivo comprese tra $9.2 \text{ m}^3/\text{s}$ e $10.3 \text{ m}^3/\text{s}$ si procede alla derivazione della sola portata irrigua del canale San Marzano pari a $0.70 \text{ m}^3/\text{s}$. Quando le portate in alveo sono comprese tra $10.3 \text{ m}^3/\text{s}$ e $300 \text{ m}^3/\text{s}$ si procede anche alla derivazione ad uso idroelettrico con portate turbinate variabili tra 6.6 e $100 \text{ m}^3/\text{s}$. Nel periodo non irriguo la derivazione ad uso idroelettrico viene effettuata quando le portate in alveo sono comprese tra $9.6 \text{ m}^3/\text{s}$ e $300 \text{ m}^3/\text{s}$, con portate turbinate variabili tra 6.6 e $100 \text{ m}^3/\text{s}$.

Alla portata minima di funzionamento dell'impianto idroelettrico pari a $6.6 \text{ m}^3/\text{s}$ corrisponde, infatti, in periodo non irriguo, la portata naturale in alveo di $9.6 \text{ m}^3/\text{s}$, data dalla somma della portata minima di funzionamento dell'impianto ($6.6 \text{ m}^3/\text{s}$), della portata Q_{PAI} rilasciata nella scala di rimonta della fauna ittica ($1.8 \text{ m}^3/\text{s}$) e della portata rilasciata sulla traversa per costituire il "velo scenico" ($1.2 \text{ m}^3/\text{s}$). Alla portata massima di funzionamento dell'impianto ($100 \text{ m}^3/\text{s}$), sempre in periodo non irriguo, corrispondono portate naturali in alveo variabili tra $103 \text{ m}^3/\text{s}$ (portata massima di funzionamento dell'impianto pari a $100 \text{ m}^3/\text{s}$ + portata Q_{PAI} rilasciata nella scala di rimonta della fauna ittica pari a $1.8 \text{ m}^3/\text{s}$ + portata rilasciata sulla traversa per costituire il "velo scenico" pari a $1.2 \text{ m}^3/\text{s}$) e $300 \text{ m}^3/\text{s}$.

L'impianto non è in funzione per portate superiori ai $300 \text{ m}^3/\text{s}$; in tali condizioni le paratoie costituenti lo sbarramento mobile vengono completamente abbattute ripristinando una quota in sommità della traversa di

148.40 m s.l.m.; in questo modo è possibile limitare i fenomeni di rigurgito in condizioni di piena.

Le simulazioni effettuate sono rappresentative delle seguenti tre condizioni:

- scenario 1: situazione attuale (presenza della traversa esistente in buona parte crollata);
- scenario 2: situazione ante crollo del novembre 2010 (presenza della traversa fissa con quota in sommità di 148.40 m s.l.m.);
- scenario 3: situazione di progetto (presenza della traversa ricostruita con innalzamento abbattibile per uso idroelettrico: quota in sommità di 149.20 m s.l.m.).

In questo modo è possibile valutare le variazioni delle principali grandezze idrauliche imputabili alla realizzazione dello sbarramento in progetto rispetto alla situazione attuale e alla situazione precedente il crollo del 2010.

Le portate in alveo utilizzate nelle simulazioni sono le seguenti:

9.2 m³/s, 9.6 m³/s; 10.3 m³/s, 15 m³/s, 20 m³/s, 30 m³/s, 40 m³/s, 50 m³/s, 60 m³/s, 80 m³/s, 100 m³/s, 120 m³/s, 140 m³/s, 160 m³/s, 180 m³/s, 200 m³/s, 220 m³/s, 240 m³/s, 260 m³/s, 280 m³/s, 300 m³/s.

Nel seguito si riportano i risultati completi delle simulazioni relative alla portata minima superata la quale è possibile effettuare la derivazione per solo scopo irriguo (9.2 m³/s in alveo e 0.7 m³/s derivati), per la portata minima di funzionamento dell'impianto idroelettrico (9.6 m³/s in alveo e 6.6 m³/s turbinati), e per la portata massima di funzionamento dell'impianto (300 m³/s in alveo e 100 m³/s turbinati).

Per i valori intermedi di portata si riportano i livelli idrici immediatamente a monte e immediatamente a valle della traversa.

LEGENDA

River sta.	=	sezione di calcolo
Q total	=	portata in m ³ /s
Min Ch El	=	quota del fondo alveo in m
W.S. Elev.	=	livello del pelo libero dell'acqua in m
Crit W.S.	=	livello di moto critico dell'acqua in m
E.G. Elev	=	livello energetico globale in m
E.G. Slope	=	pendenza motrice
Vel Chnl	=	velocità nell'alveo in m/s
Flow Area	=	area liquida in m ²
Top Width	=	larghezza sezione liquida in sommità in m
Froude # Chl	=	numero di Froude della corrente in alveo

**SITUAZIONE ATTUALE
(CON SBARRAMENTO DIVELTO)
SIMULAZIONE 7**

Corso d'acqua	PortataQ m³/s	Portata
Fiume Tanaro	9.2 (in alveo) 0.7 (derivati per alimentazione canale)	Minima per la derivazione ad uso irriguo

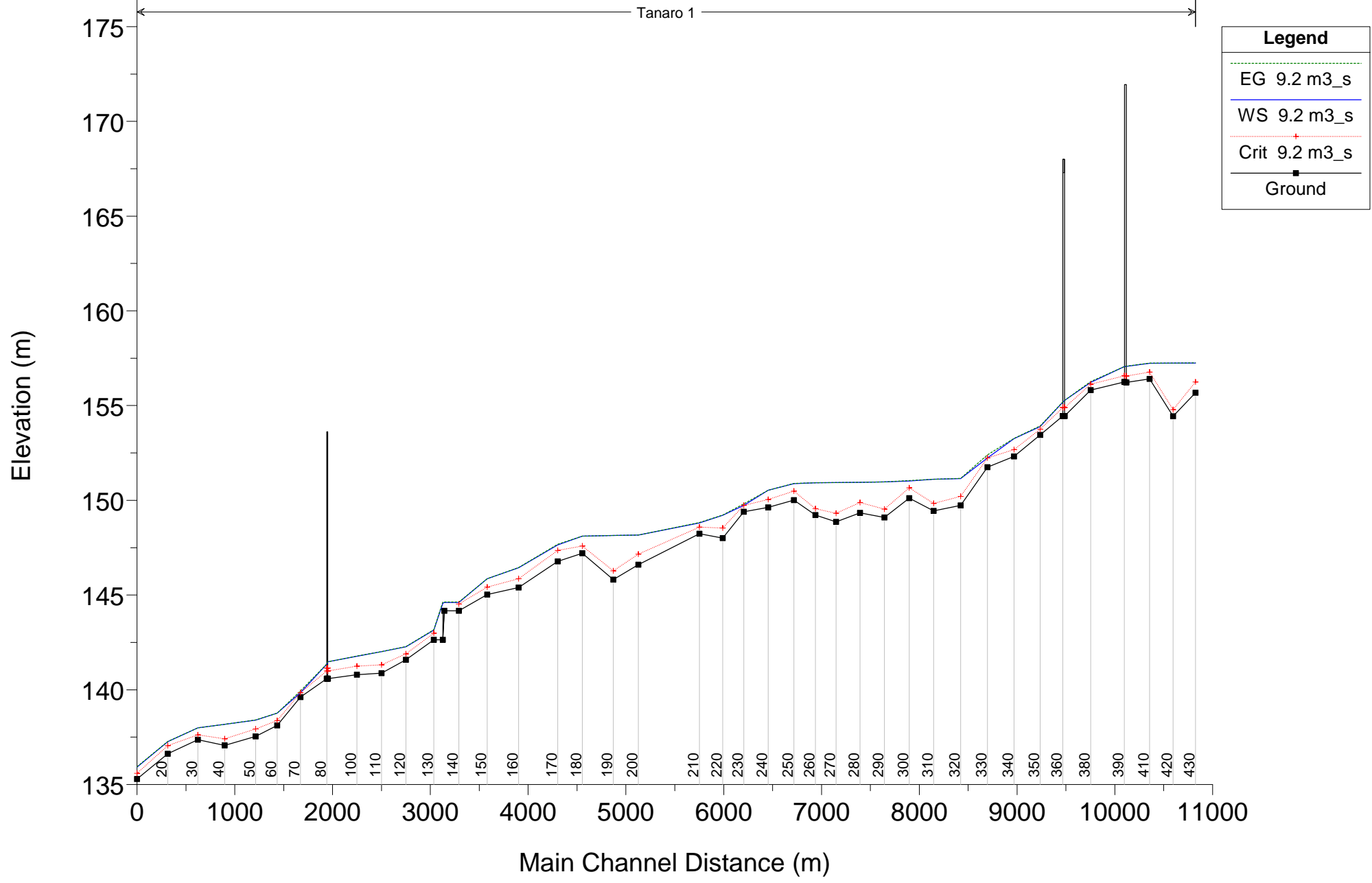
HEC-RAS Plan: Plan 06 River: Tanaro Reach: 1 Profile: 9.2 m3_s

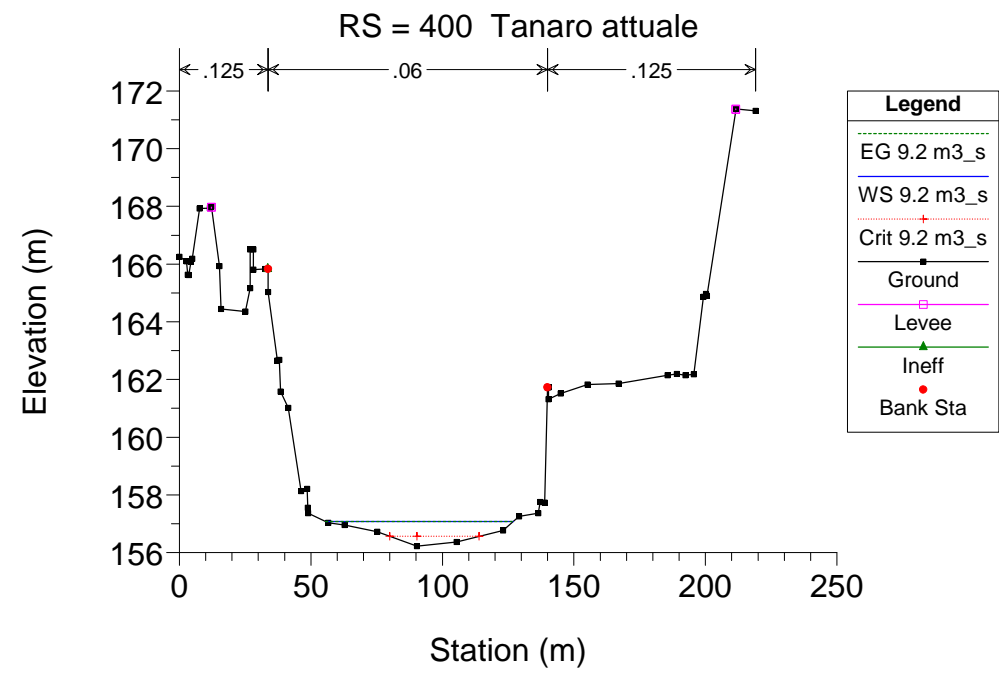
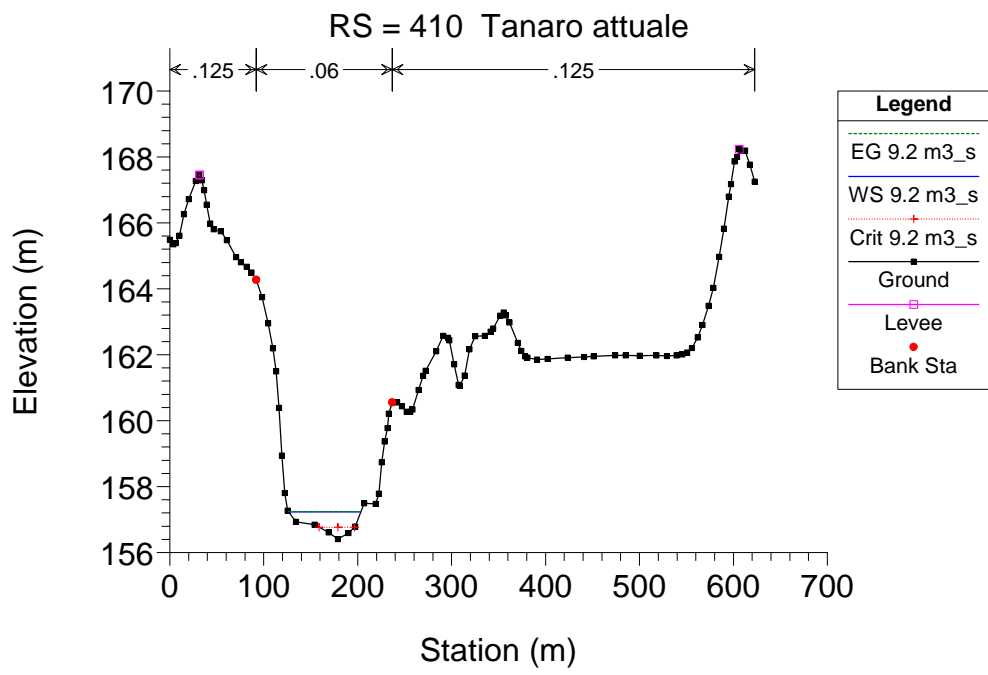
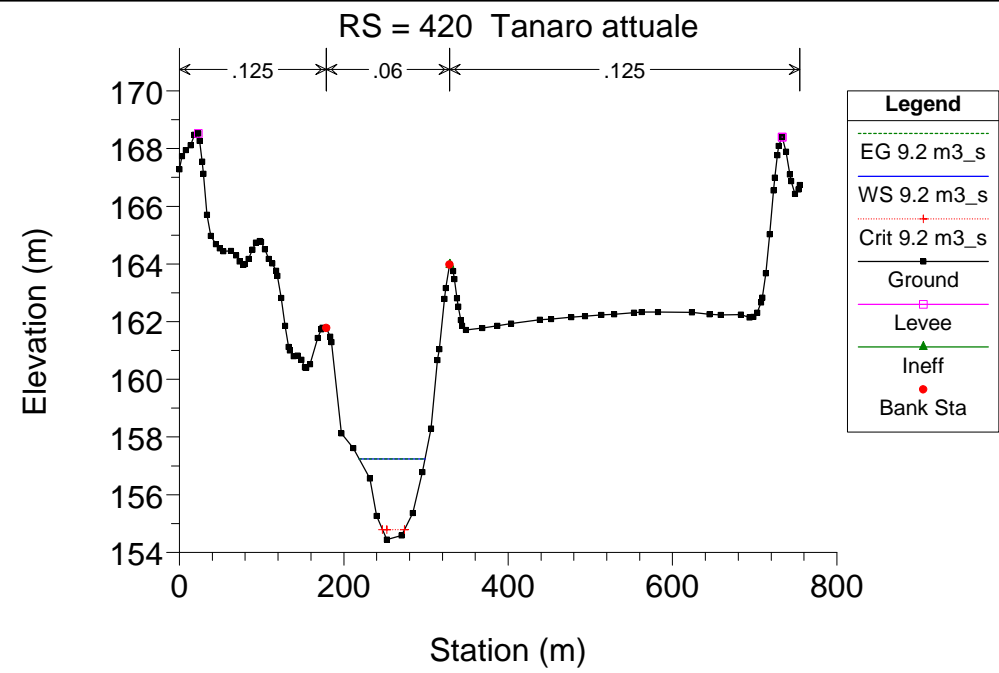
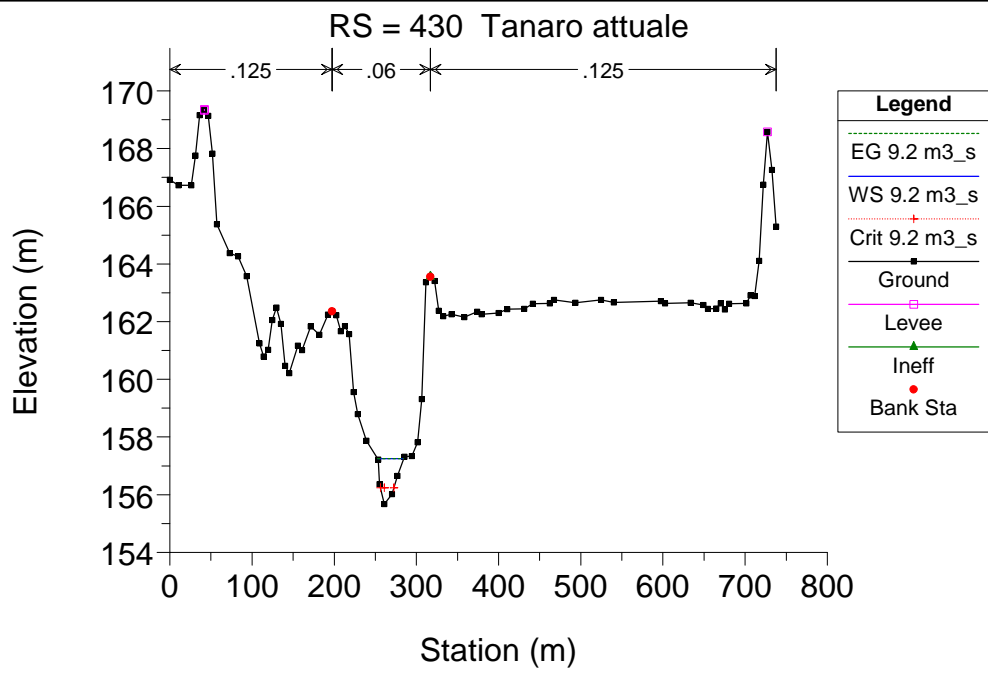
Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
1	430	9.2 m3_s	9.20	155.68	157.25	156.24	157.25	0.000404	0.32	29.11	31.49	0.10
1	420	9.2 m3_s	9.20	154.44	157.24	154.79	157.24	0.000007	0.07	139.73	80.30	0.02
1	410	9.2 m3_s	9.20	156.41	157.23	156.77	157.24	0.000621	0.25	36.43	76.80	0.12
1	400	9.2 m3_s	9.20	156.22	157.07	156.56	157.08	0.000717	0.27	33.87	71.30	0.13
1	395		Bridge									
1	390	9.2 m3_s	9.20	156.25	157.06	156.58	157.06	0.000832	0.28	32.29	70.73	0.13
1	380	9.2 m3_s	9.20	155.82	156.23	156.13	156.27	0.018007	0.95	9.73	35.39	0.58
1	370	9.2 m3_s	9.20	154.45	155.27	154.89	155.27	0.001540	0.36	25.82	64.02	0.18
1	365		Bridge									
1	360	9.2 m3_s	9.20	154.45	155.17	154.89	155.19	0.003172	0.46	20.16	59.26	0.25
1	350	9.2 m3_s	9.20	153.45	153.89	153.75	153.93	0.011398	0.80	11.56	38.64	0.46
1	340	9.2 m3_s	9.20	152.32	153.26	152.68	153.27	0.001030	0.40	23.19	36.23	0.16
1	330	9.2 m3_s	9.20	151.75	152.24	152.24	152.39	0.053312	1.73	5.32	17.59	1.00
1	320	9.2 m3_s	9.20	149.73	151.15	150.21	151.16	0.000300	0.29	31.95	31.81	0.09
1	310	9.2 m3_s	9.20	149.44	151.11	149.84	151.11	0.000094	0.16	56.26	55.02	0.05
1	300	9.2 m3_s	9.20	150.11	151.02	150.66	151.04	0.003056	0.62	14.84	26.77	0.27
1	290	9.2 m3_s	9.20	149.10	150.97	149.53	150.98	0.000082	0.18	51.44	39.61	0.05
1	280	9.2 m3_s	9.20	149.34	150.95	149.88	150.95	0.000146	0.20	45.91	46.11	0.06
1	270	9.2 m3_s	9.20	148.86	150.93	149.31	150.93	0.000030	0.11	83.58	63.04	0.03
1	260	9.2 m3_s	9.20	149.22	150.93	149.56	150.93	0.000045	0.12	75.31	65.31	0.04
1	250	9.2 m3_s	9.20	150.01	150.88	150.48	150.89	0.002401	0.47	19.54	44.59	0.23
1	240	9.2 m3_s	9.20	149.63	150.53	150.05	150.53	0.000881	0.24	38.30	112.94	0.13
1	230	9.2 m3_s	9.20	149.40	149.73	149.73	149.82	0.063297	1.31	7.00	39.90	1.00
1	220	9.2 m3_s	9.20	148.00	149.21	148.54	149.22	0.000722	0.35	26.44	38.54	0.13
1	210	9.2 m3_s	9.20	148.24	148.81	148.59	148.83	0.006317	0.69	13.42	35.98	0.36
1	200	9.2 m3_s	9.20	146.60	148.16	147.16	148.17	0.000416	0.32	28.80	31.41	0.11
1	190	9.2 m3_s	9.20	145.82	148.14	146.28	148.14	0.000040	0.13	69.08	48.11	0.04
1	180	9.2 m3_s	9.20	147.21	148.10	147.59	148.11	0.000795	0.23	39.61	113.77	0.13
1	170	9.2 m3_s	9.20	146.78	147.65	147.36	147.68	0.005664	0.75	12.22	26.20	0.35
1	160	9.2 m3_s	9.20	145.40	146.44	145.86	146.45	0.001910	0.46	20.20	40.74	0.21
1	150	9.2 m3_s	9.20	145.03	145.85	145.42	145.87	0.001754	0.47	19.44	34.64	0.20
1	140	9.2 m3_s	9.20	144.17	144.60	144.52	144.64	0.021240	0.81	11.37	59.17	0.59
1	135		Inl Struct									
1	130	9.2 m3_s	9.20	142.64	143.15	142.99	143.17	0.007604	0.56	16.42	68.50	0.37
1	120	9.2 m3_s	9.20	141.58	142.27	141.89	142.27	0.001709	0.40	23.09	52.48	0.19
1	110	9.2 m3_s	9.20	140.88	142.01	141.32	142.01	0.000696	0.35	26.15	36.39	0.13
1	100	9.2 m3_s	9.20	140.79	141.77	141.25	141.78	0.001327	0.41	22.36	40.01	0.18
1	90	9.2 m3_s	9.20	140.59	141.48	140.99	141.49	0.000752	0.29	31.60	61.97	0.13
1	85		Bridge									
1	80	9.2 m3_s	9.20	140.59	141.35	140.99	141.36	0.001779	0.39	23.81	58.28	0.19

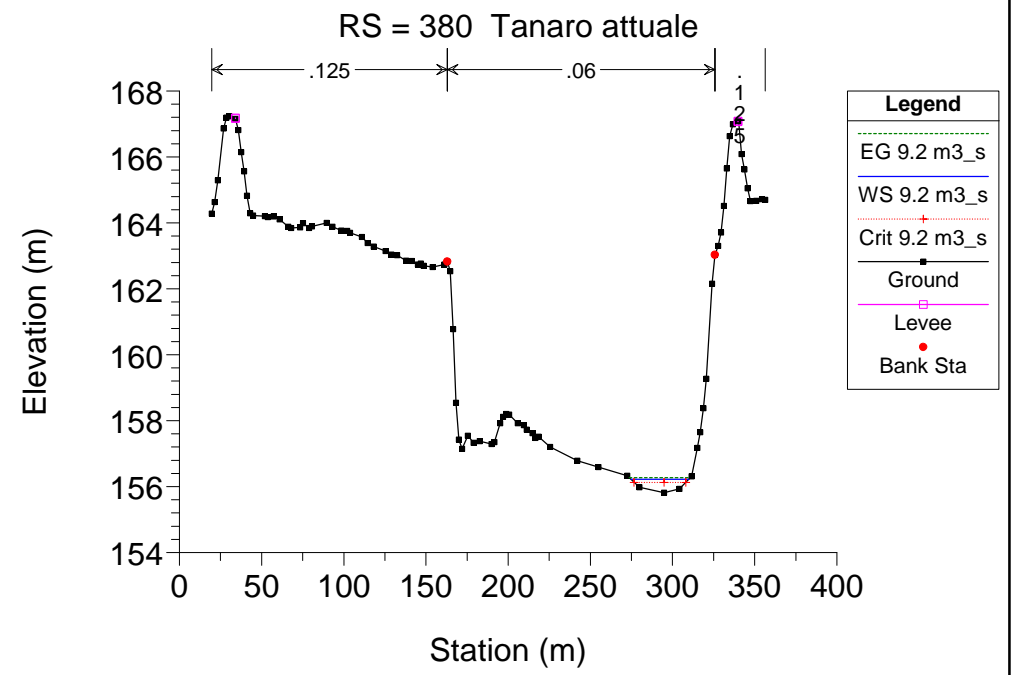
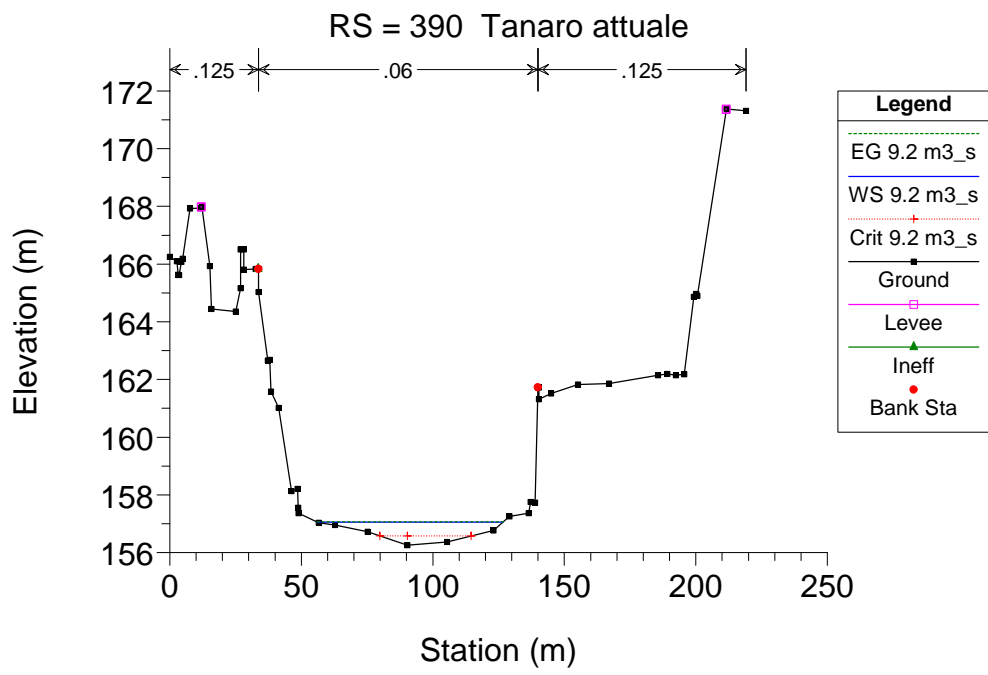
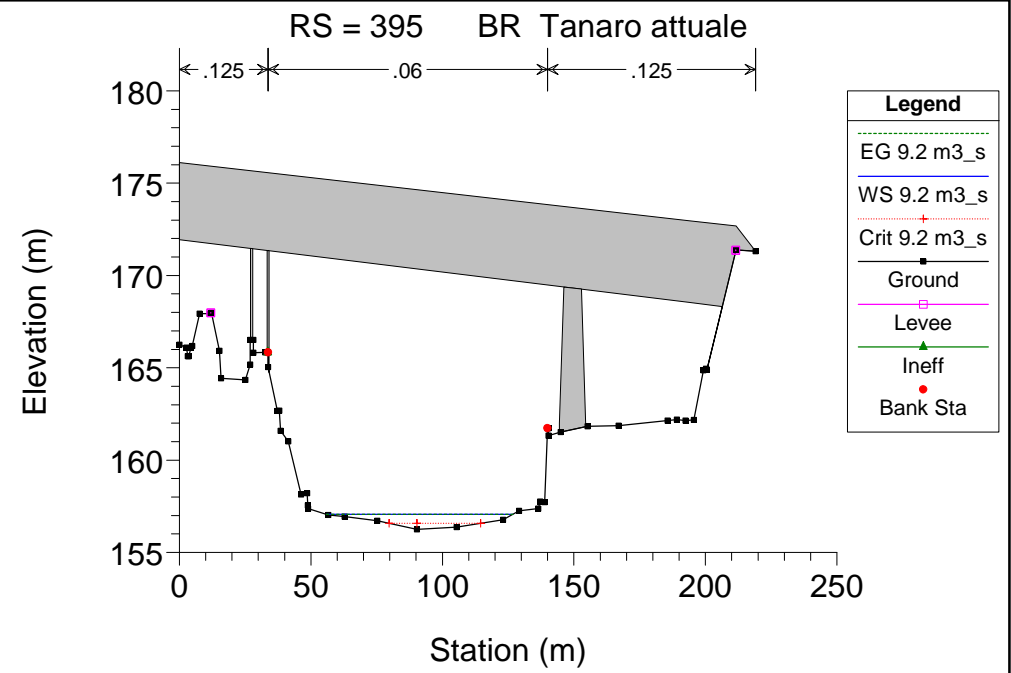
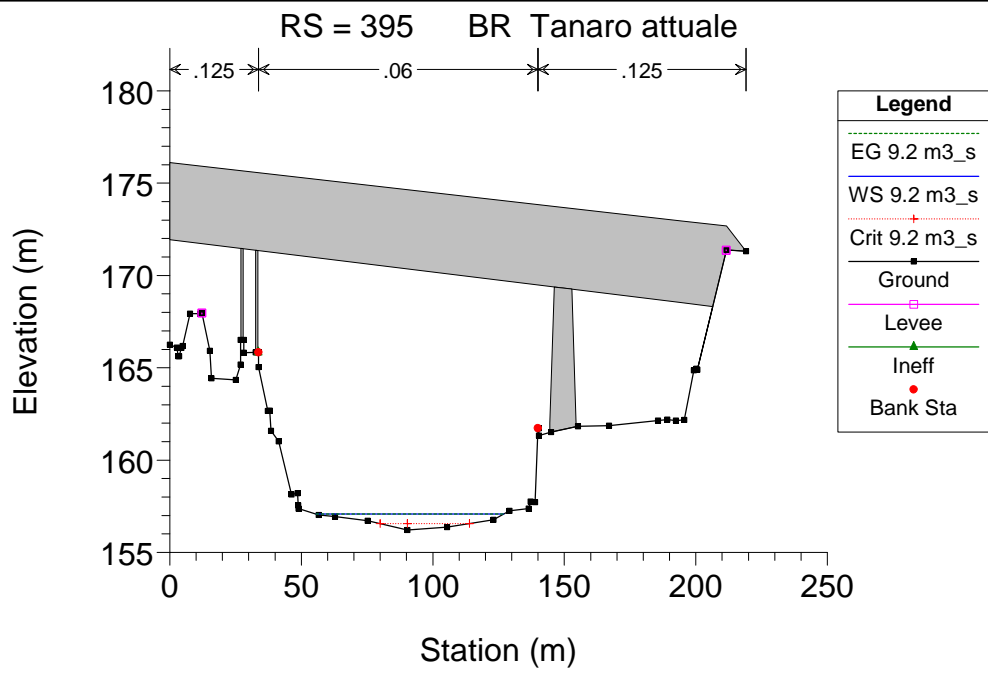
HEC-RAS Plan: Plan 06 River: Tanaro Reach: 1 Profile: 9.2 m3_s (Continued)

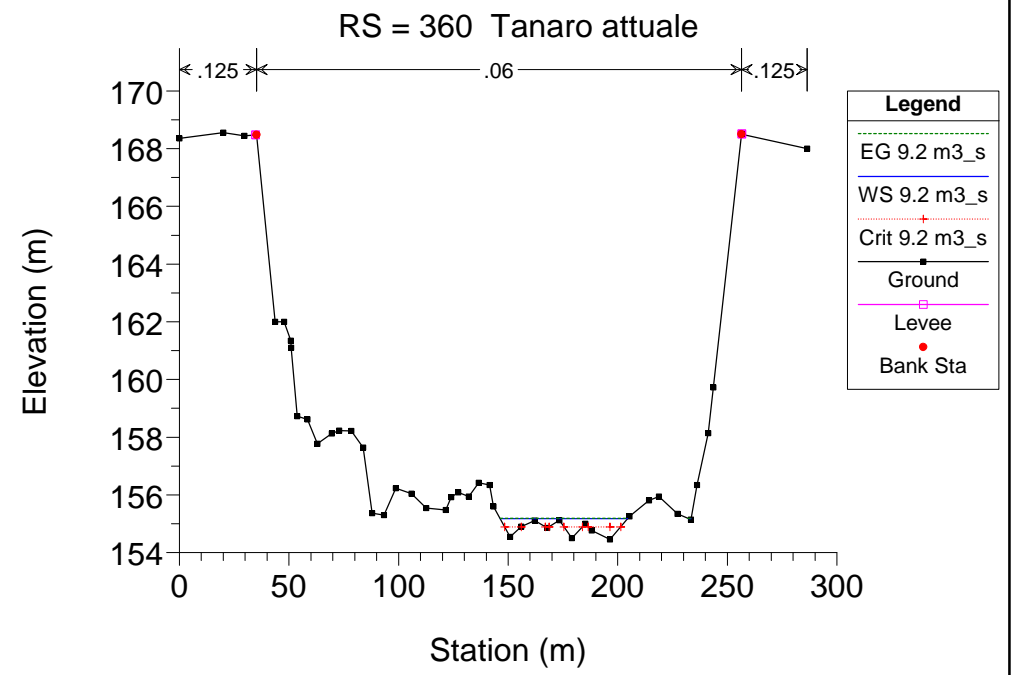
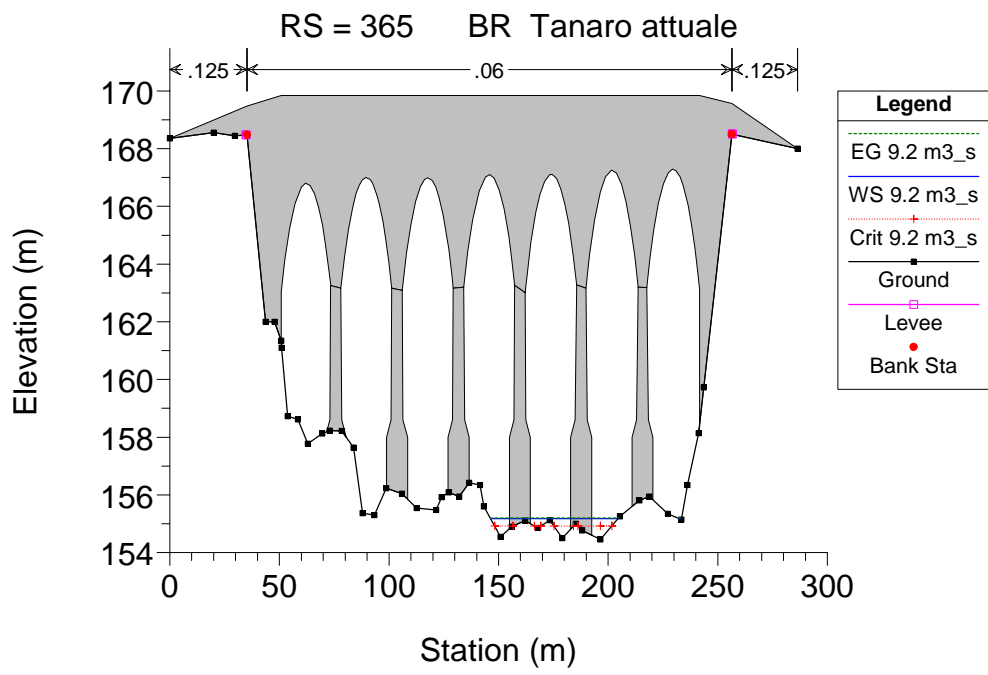
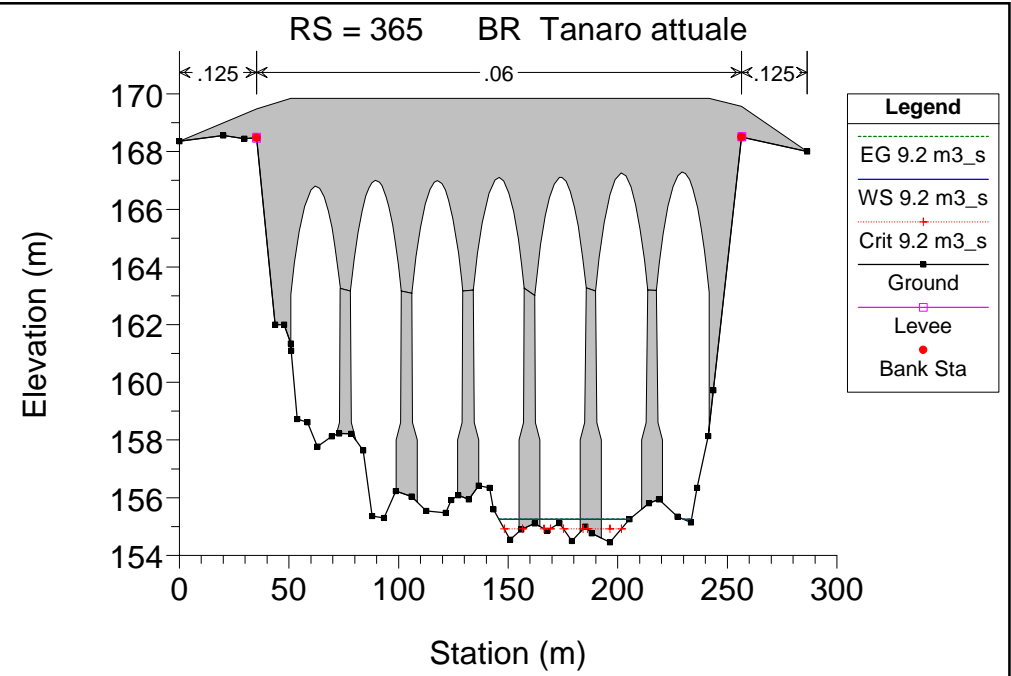
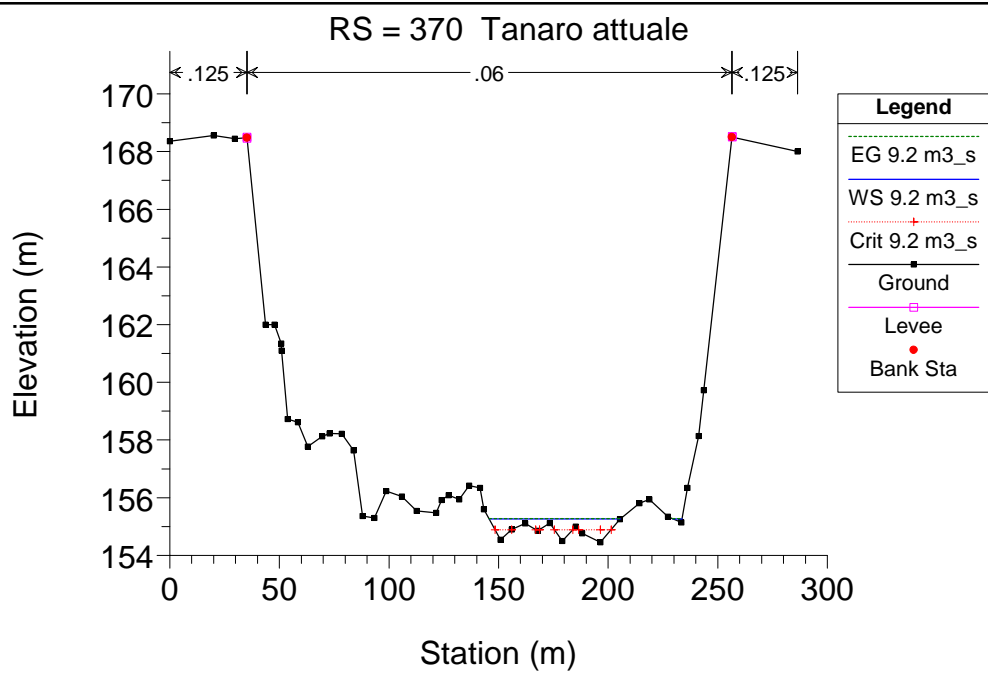
Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
1	70	9.2 m3_s	9.20	139.61	139.84	139.84	139.94	0.059664	1.38	6.68	33.96	0.99
1	60	9.2 m3_s	9.20	138.12	138.76	138.37	138.77	0.001462	0.38	24.45	53.79	0.18
1	50	9.2 m3_s	9.20	137.54	138.39	137.94	138.41	0.001875	0.52	17.70	28.84	0.21
1	40	9.2 m3_s	9.20	137.06	138.17	137.41	138.17	0.000378	0.28	33.27	42.03	0.10
1	30	9.2 m3_s	9.20	137.37	137.99	137.62	137.99	0.001434	0.36	25.84	60.94	0.17
1	20	9.2 m3_s	9.20	136.62	137.26	137.05	137.27	0.004519	0.49	18.88	65.75	0.29
1	10	9.2 m3_s	9.20	135.29	135.91	135.59	135.94	0.004001	0.66	13.93	27.90	0.30

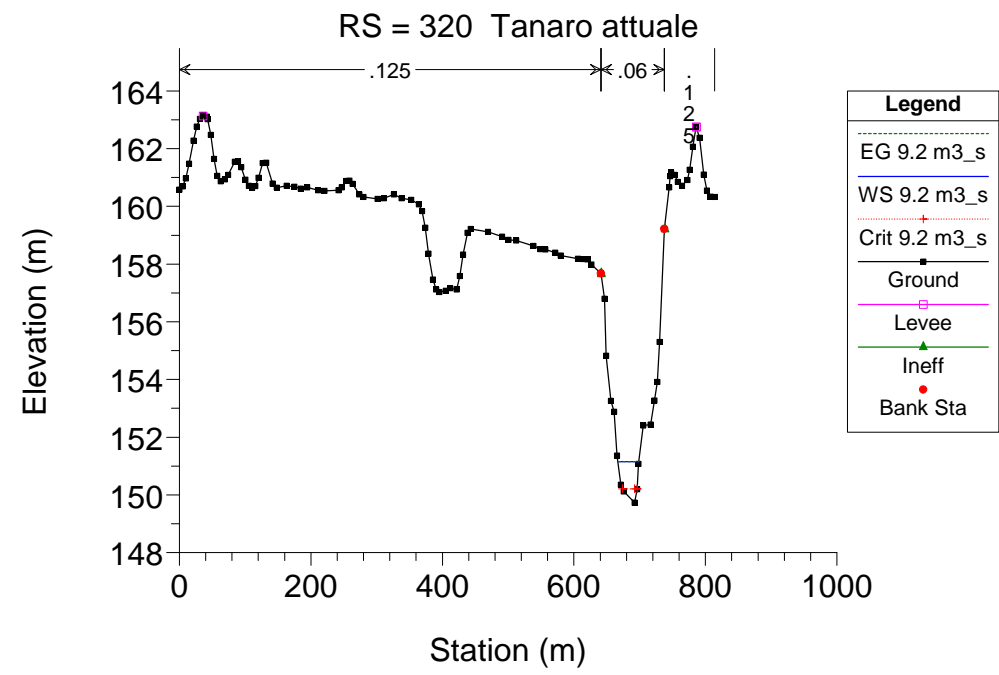
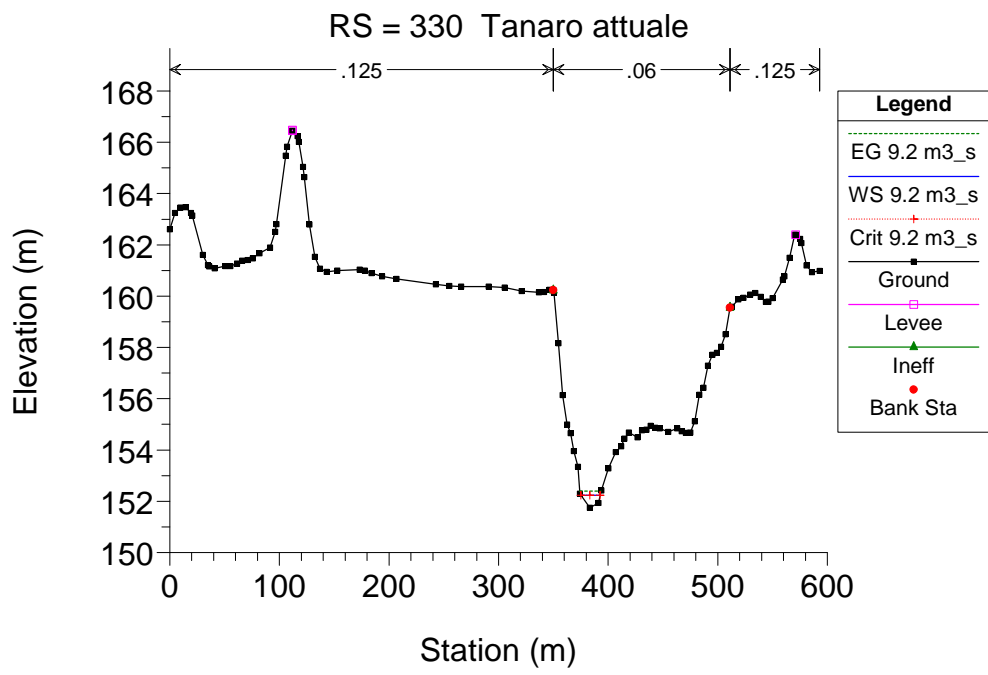
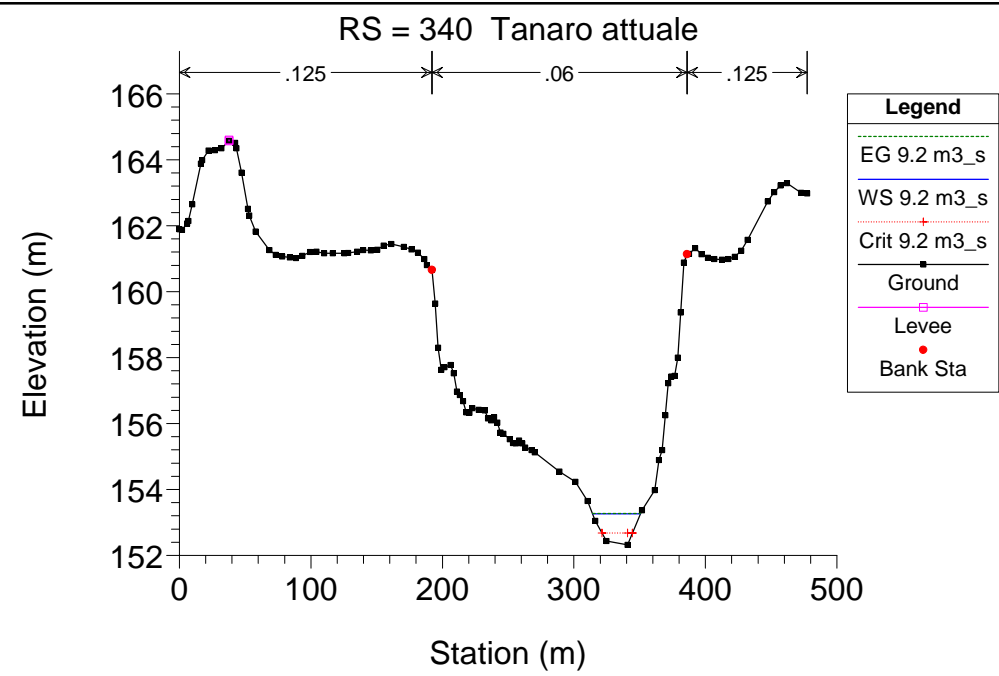
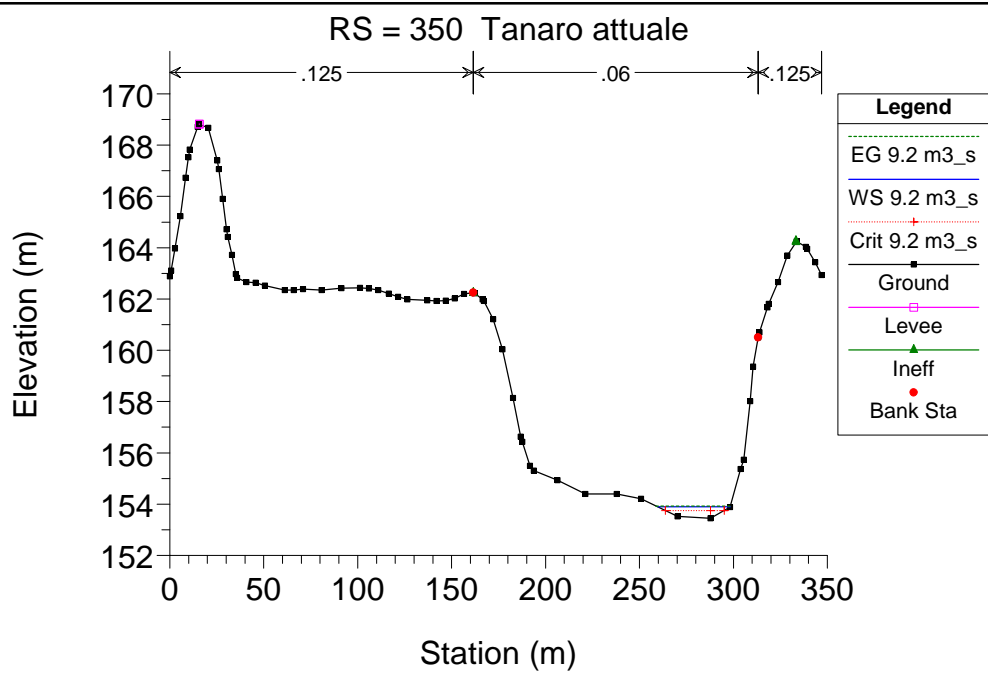
Tanaro attuale

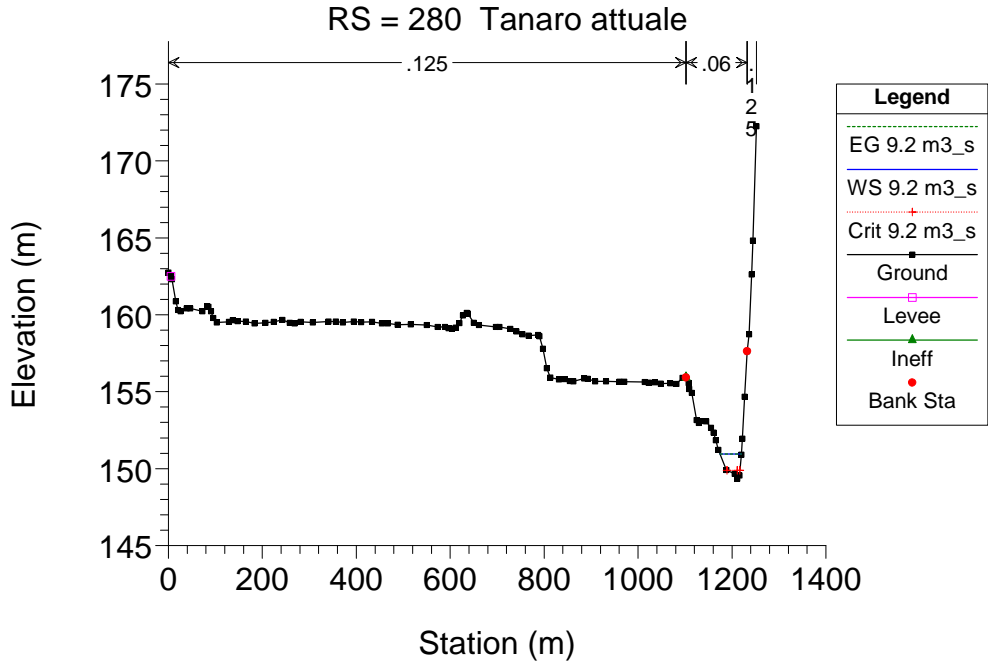
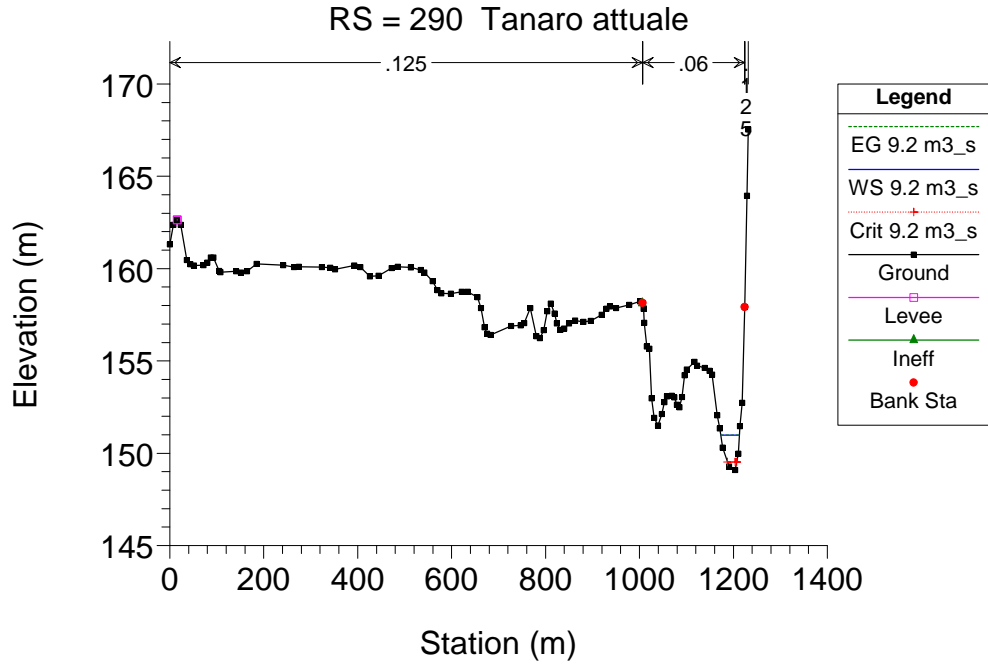
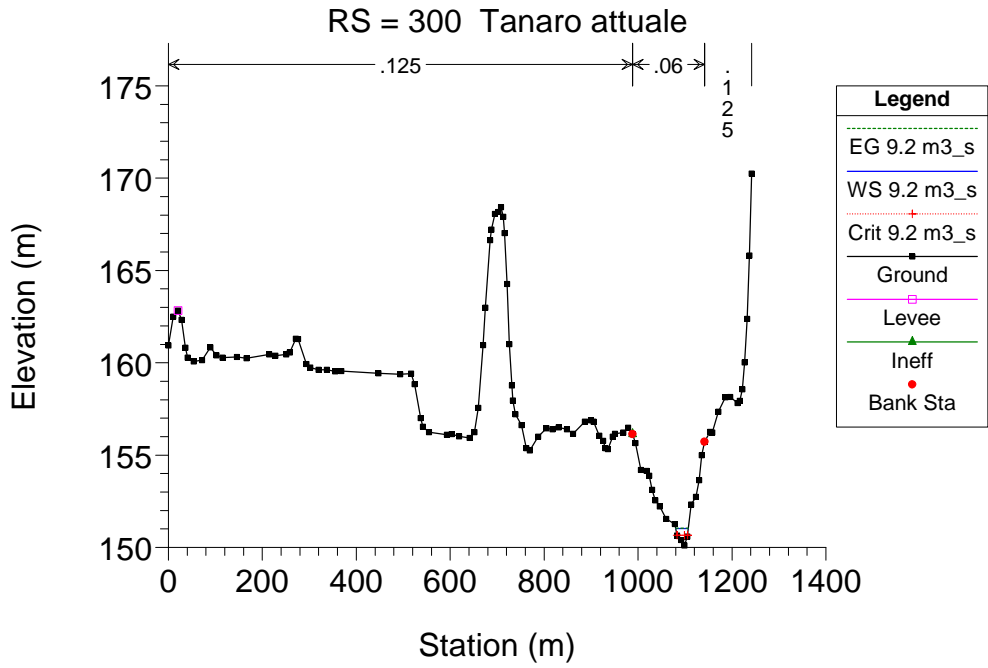
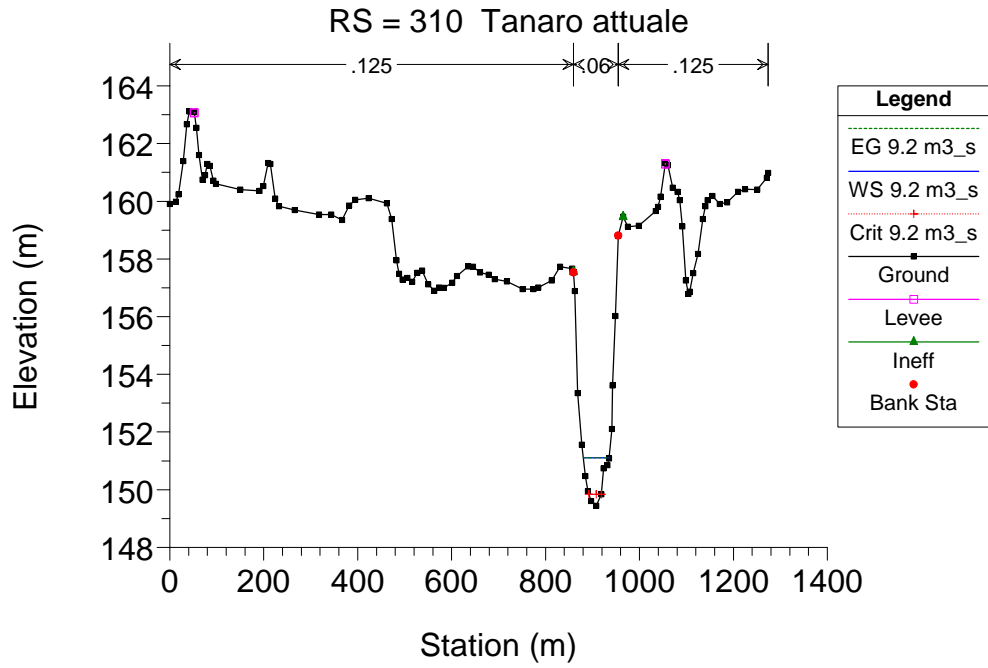


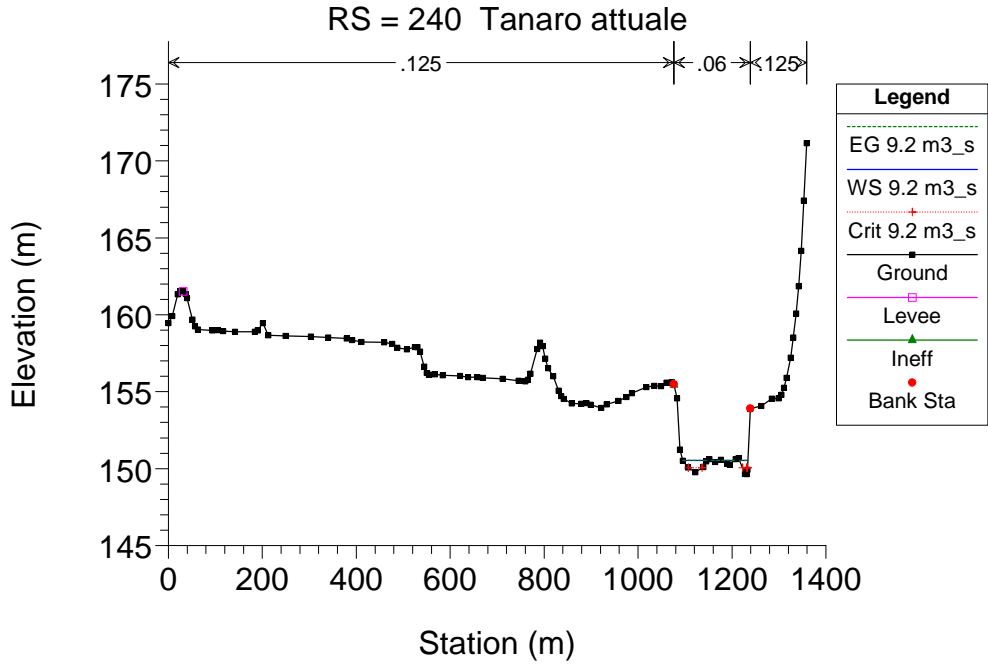
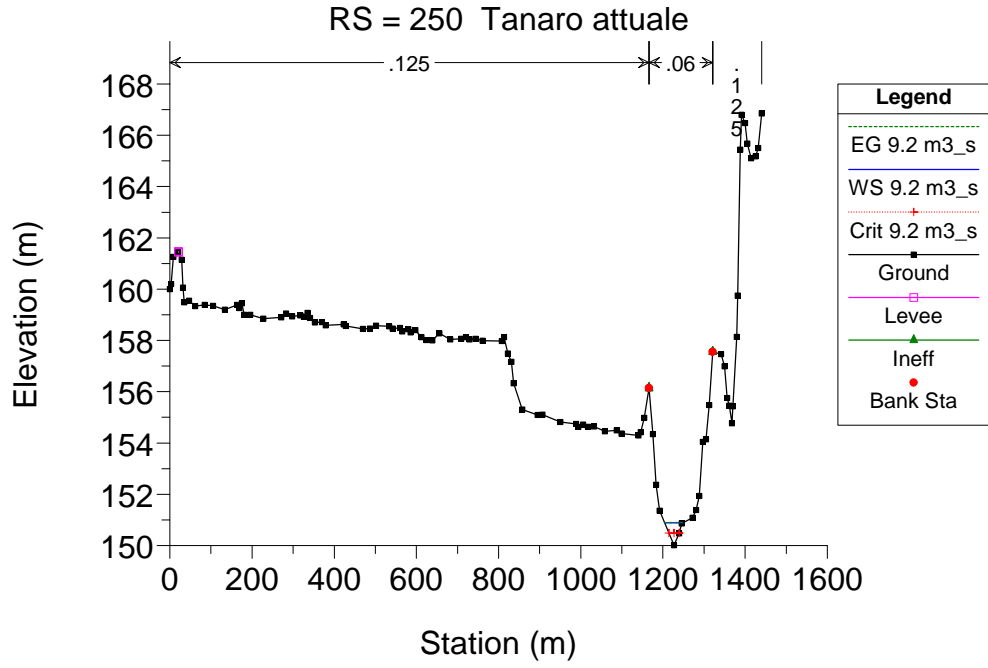
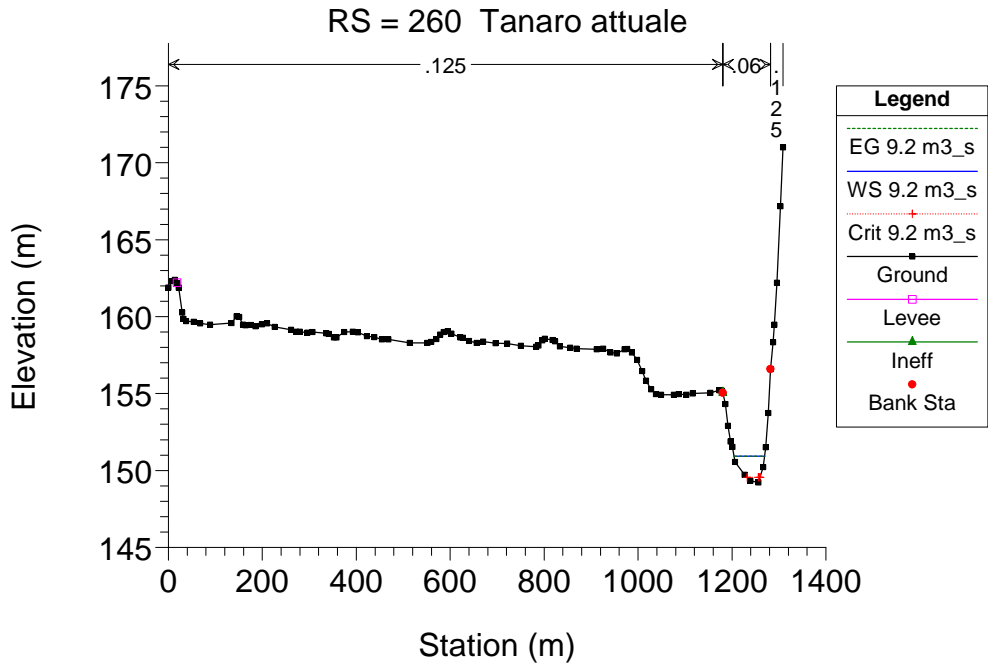
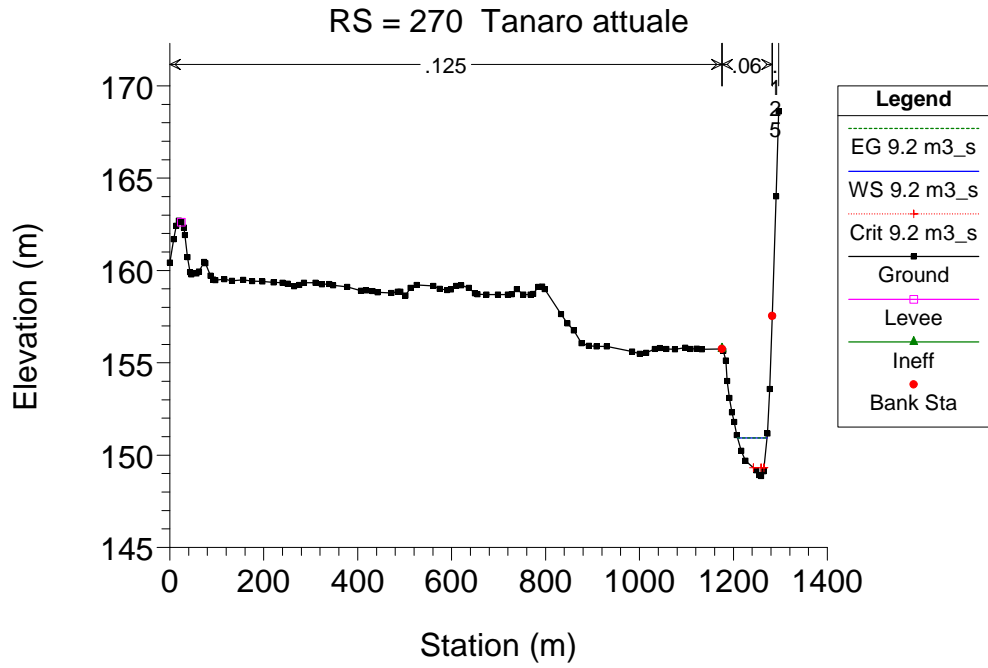


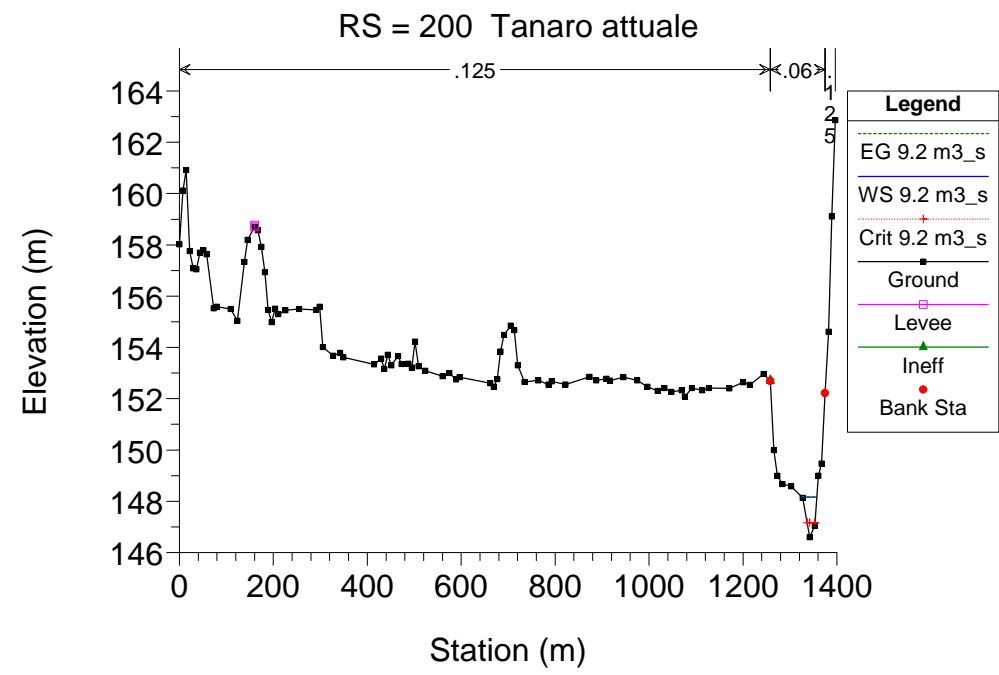
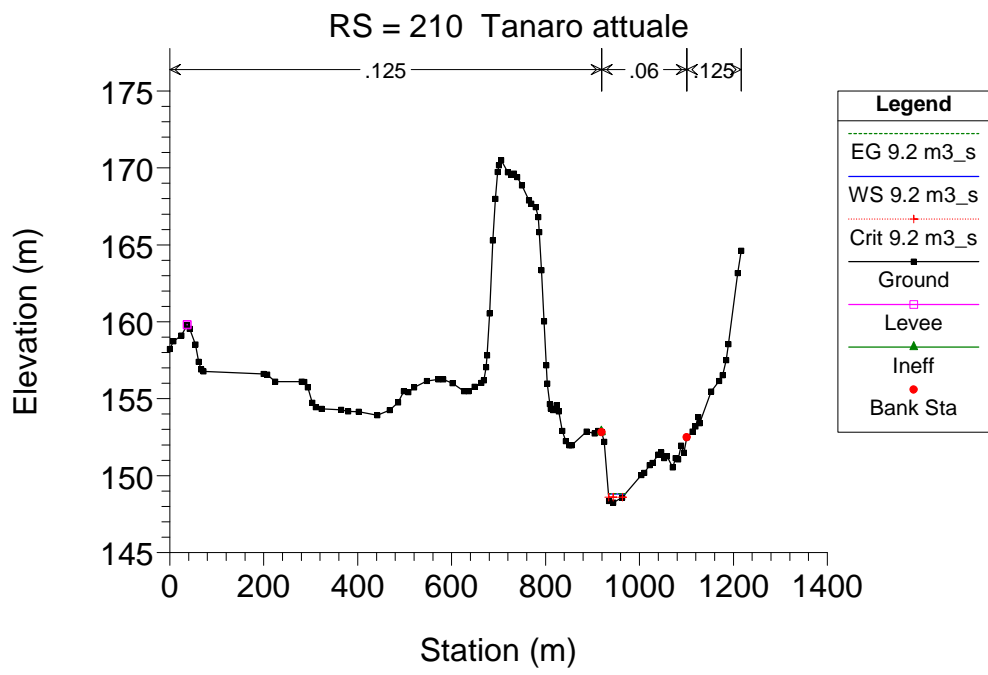
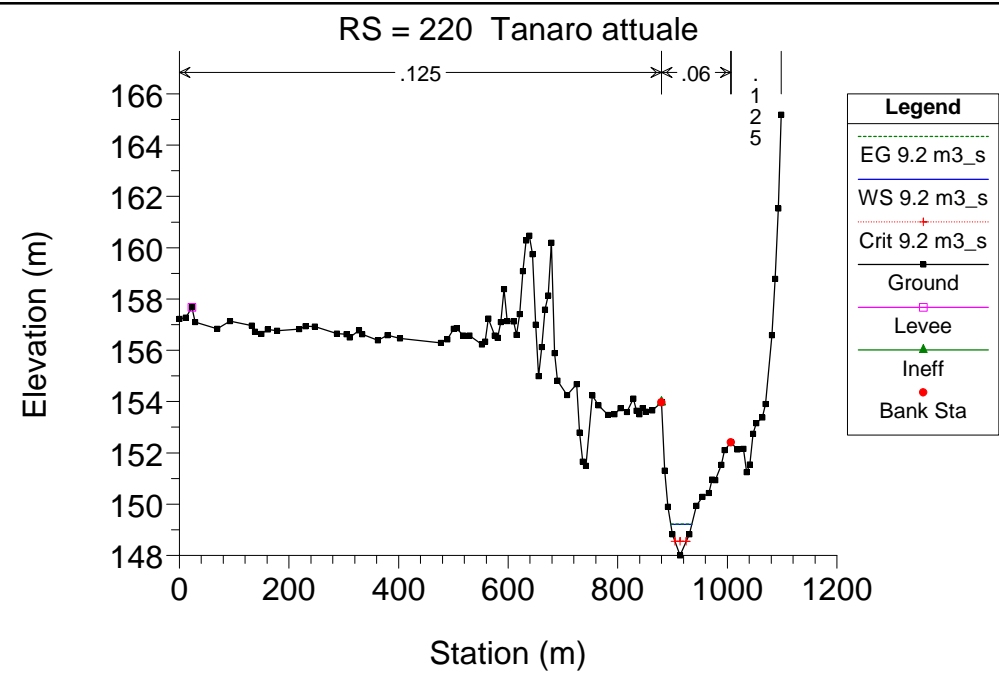
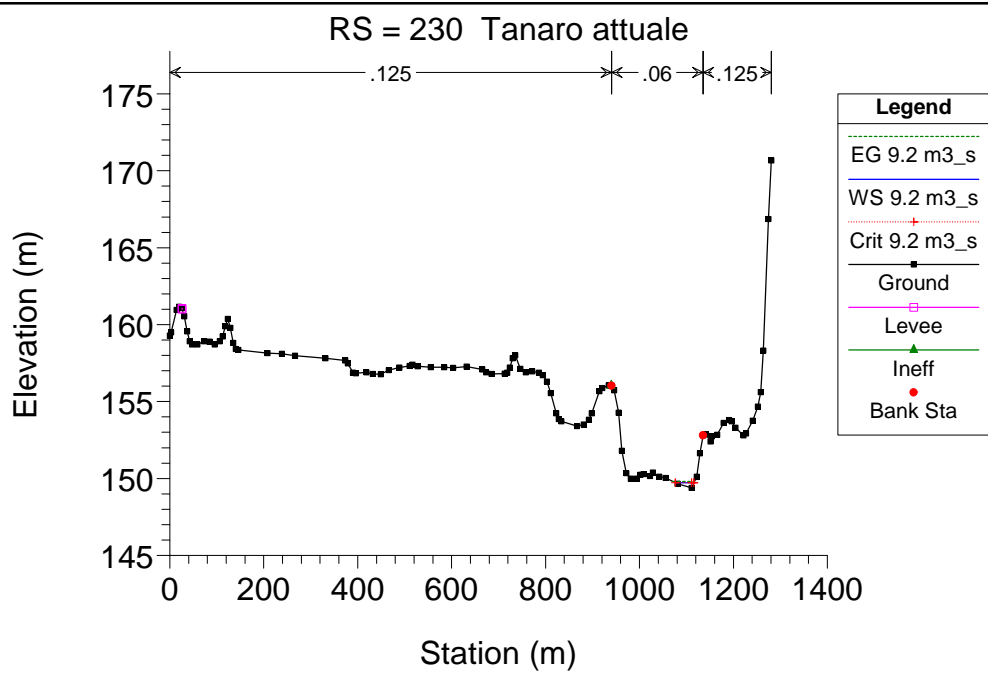


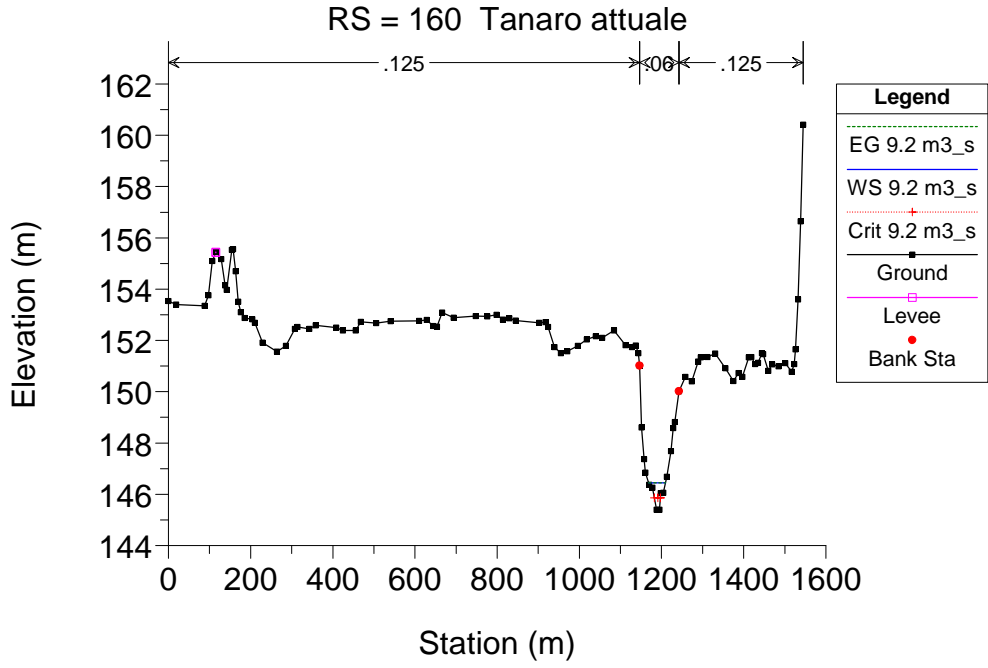
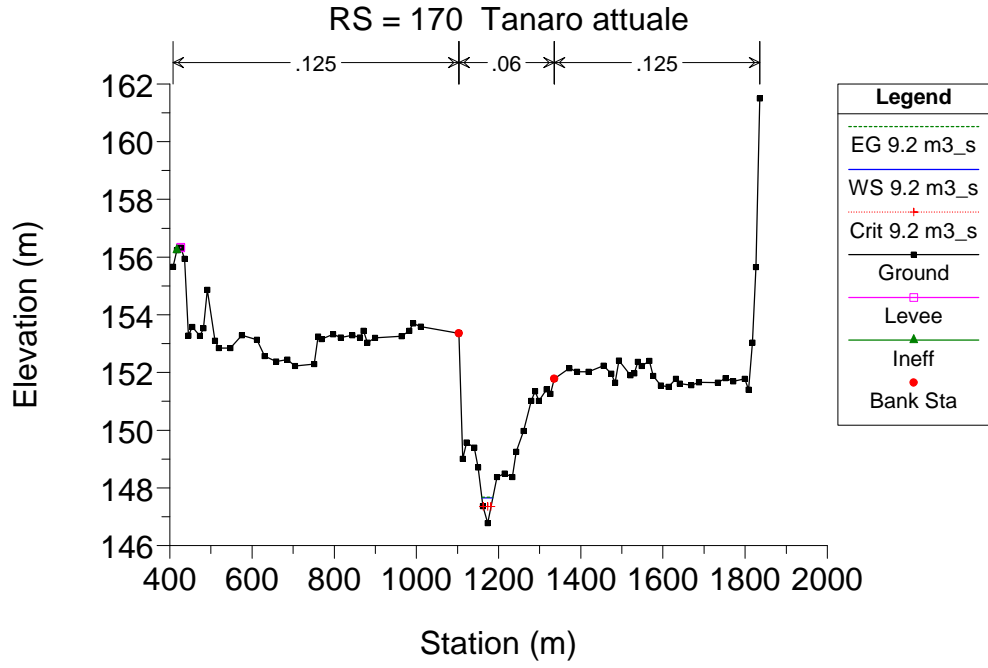
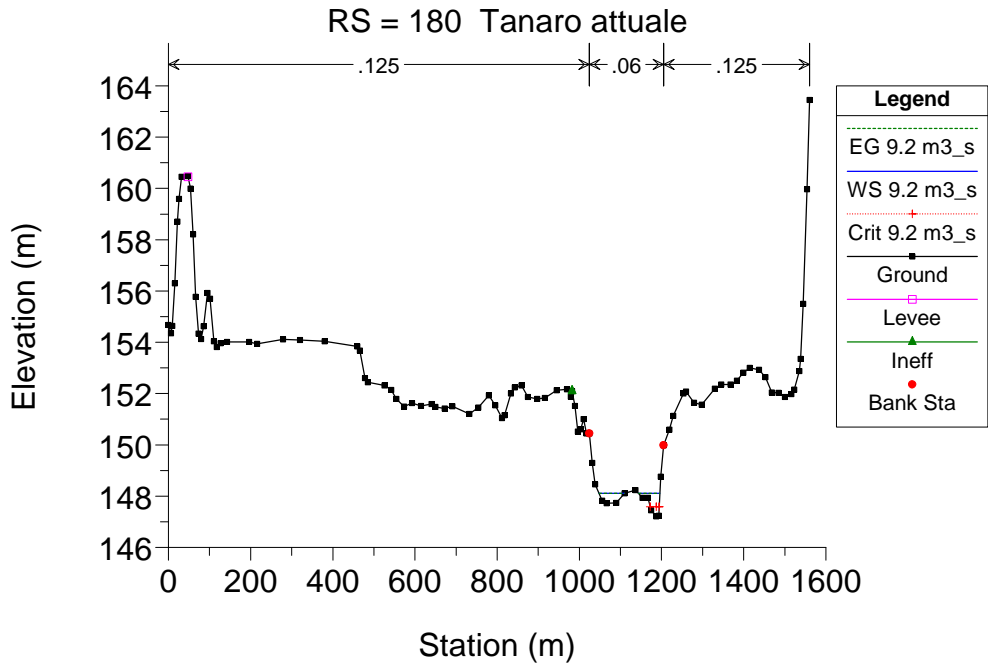
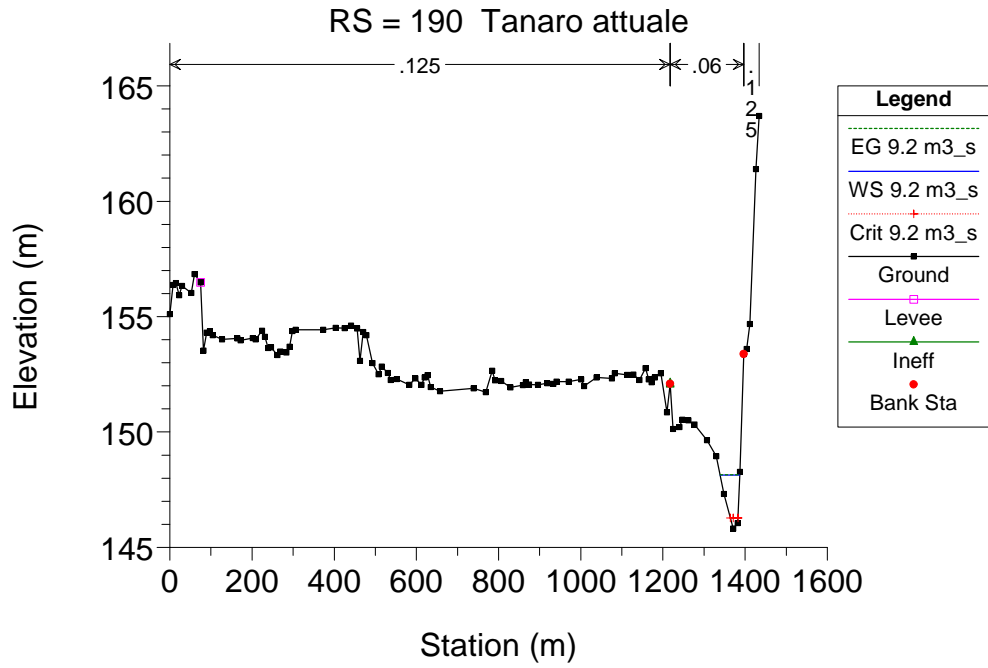


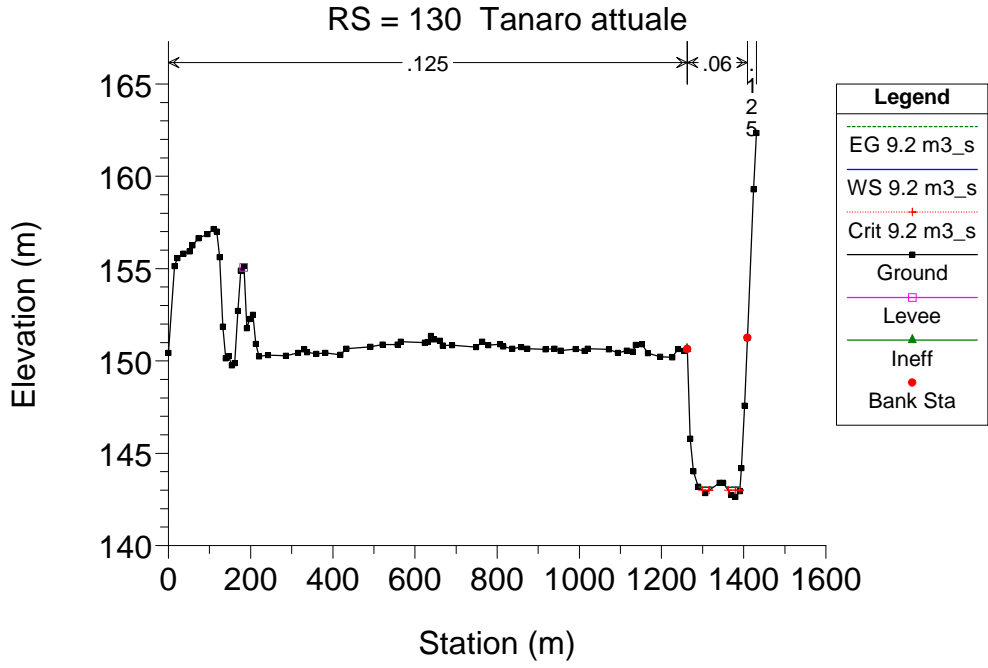
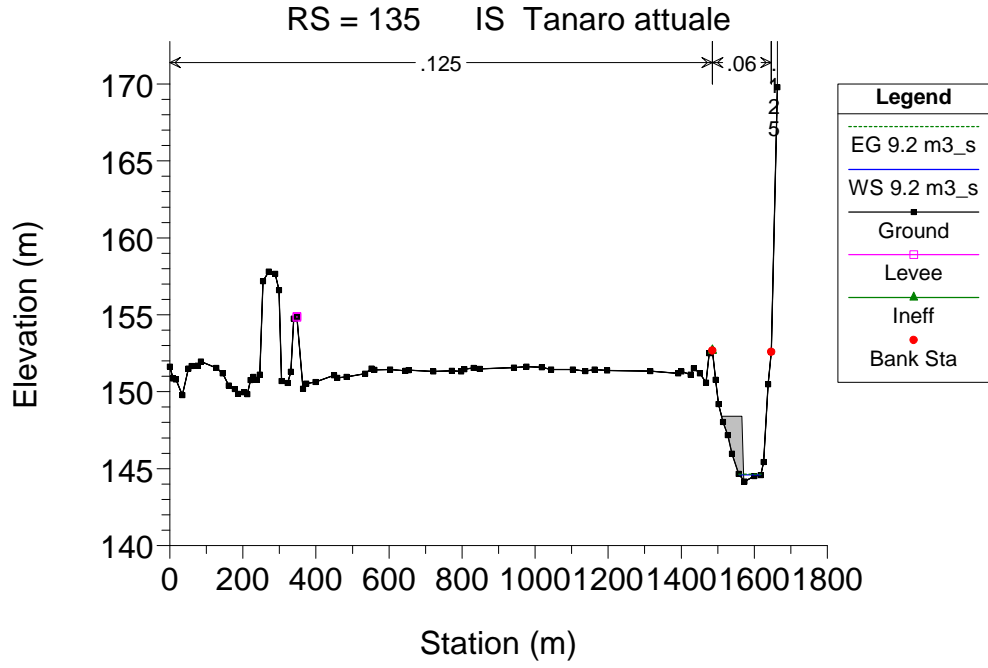
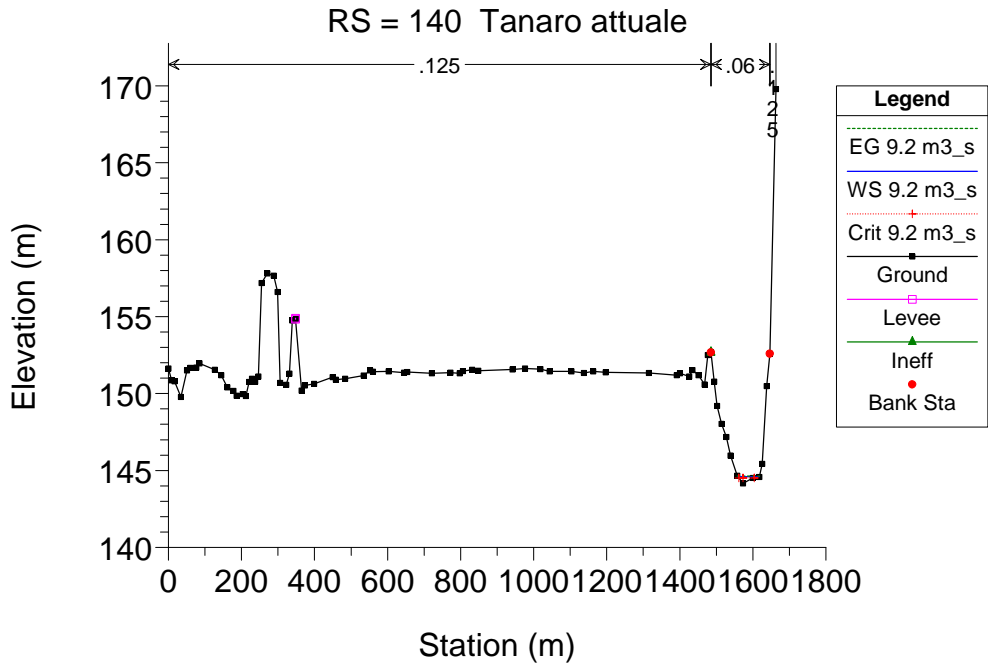
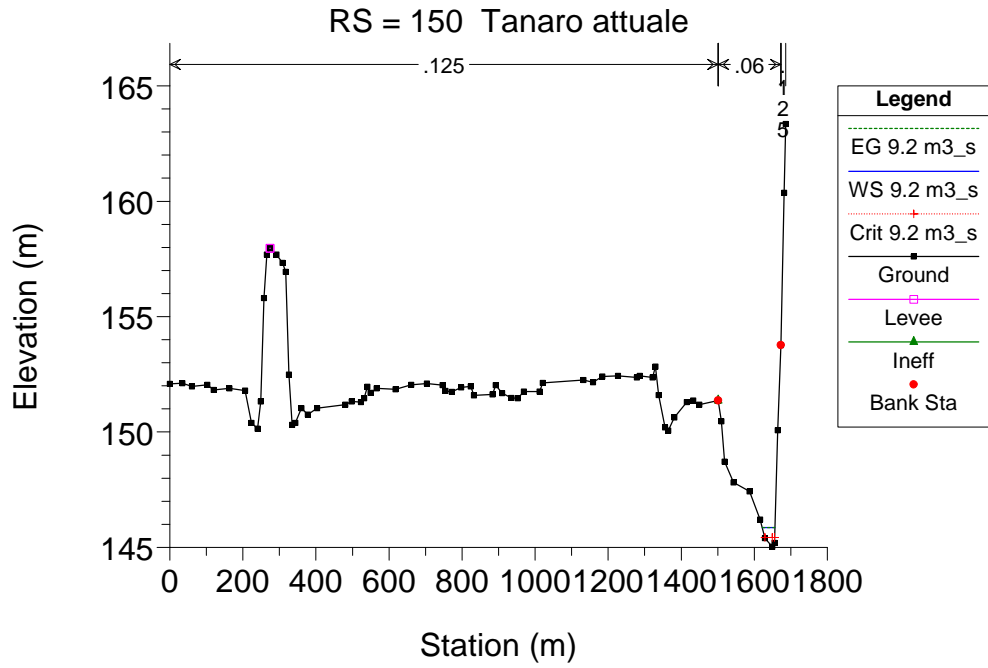


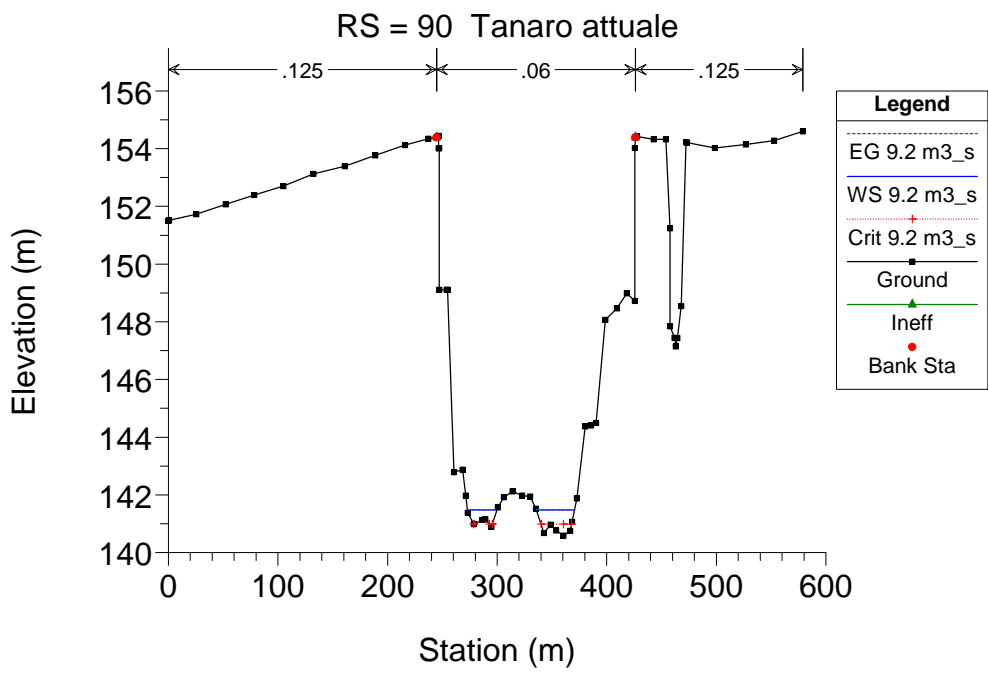
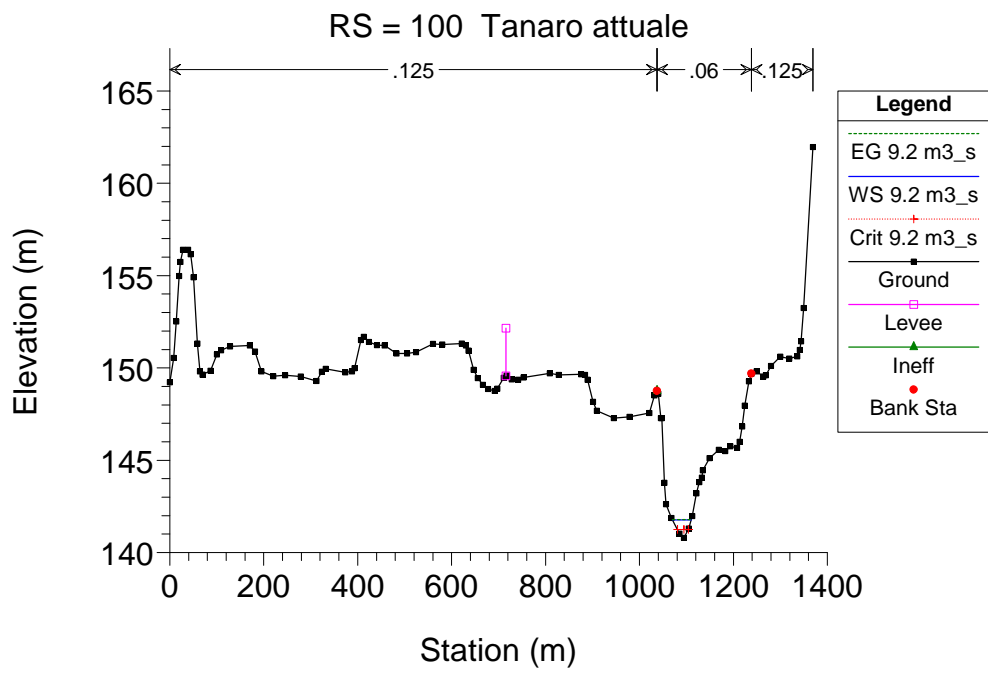
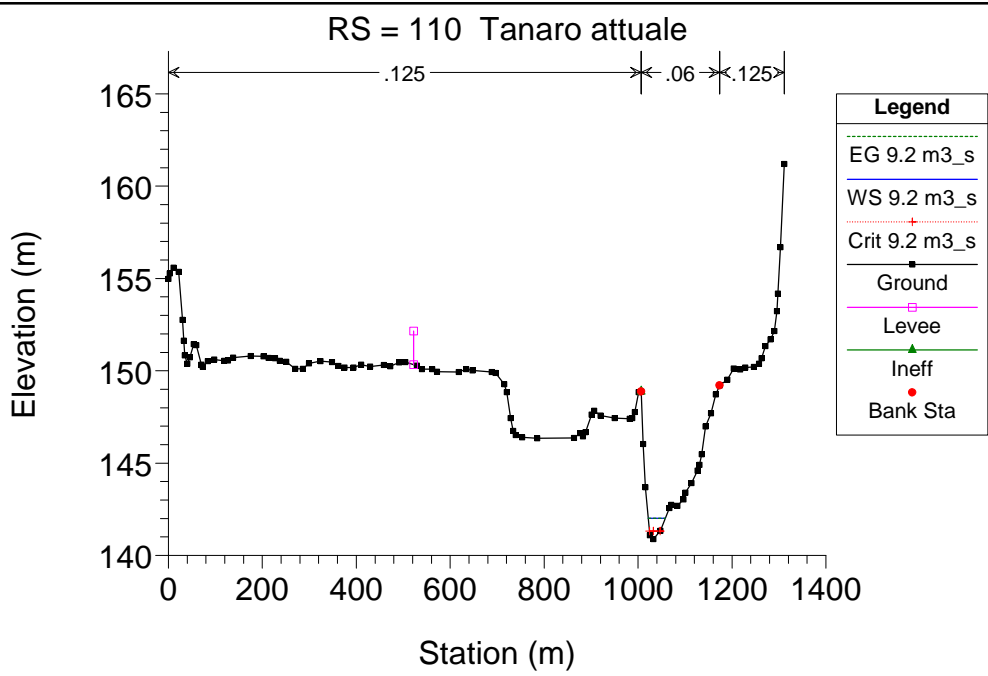
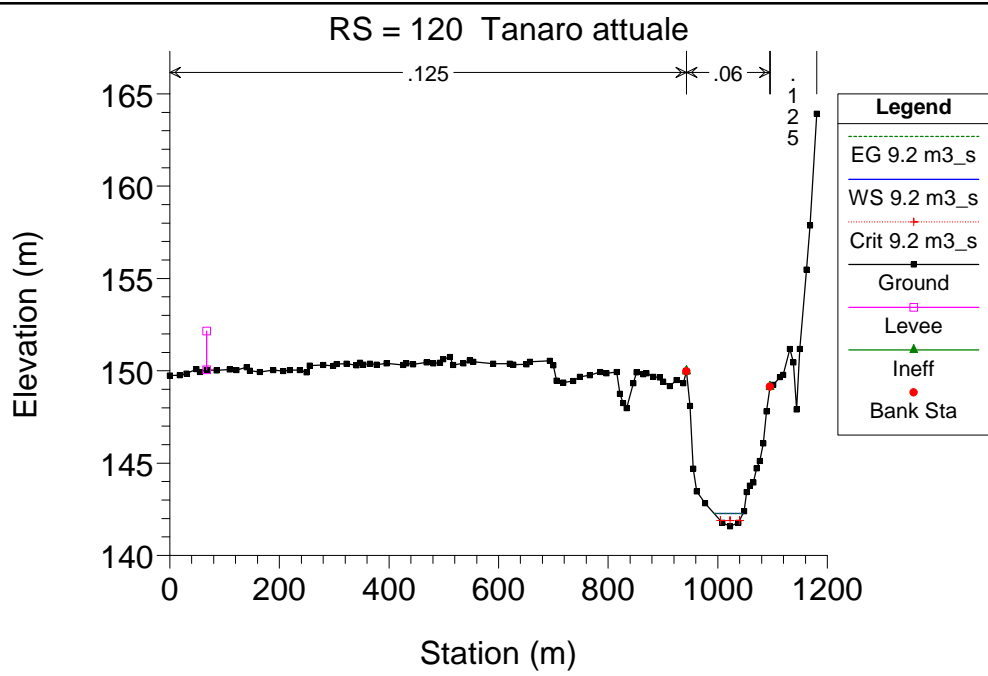


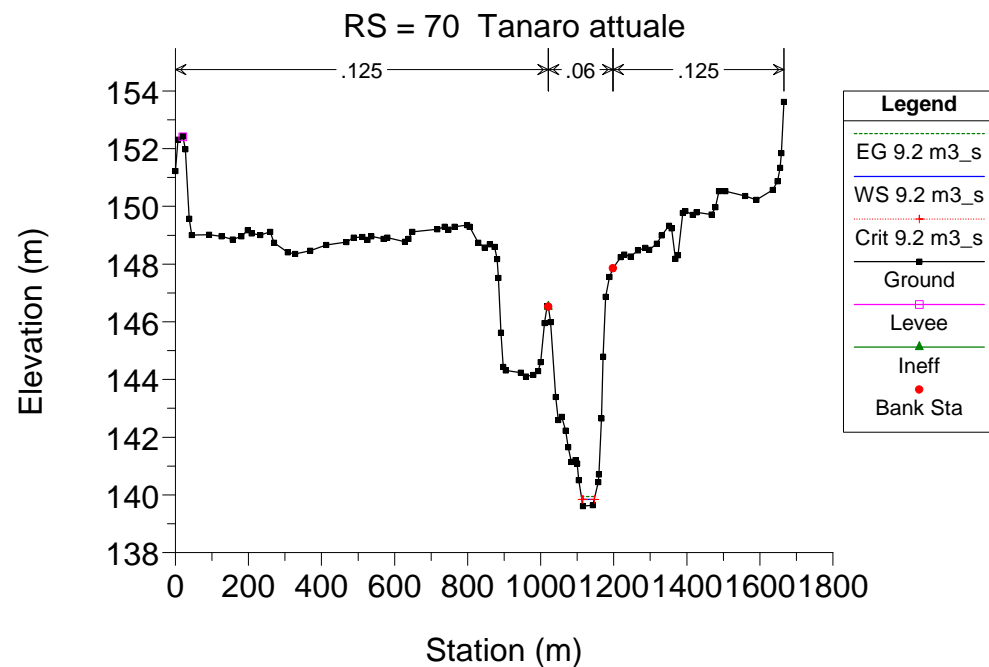
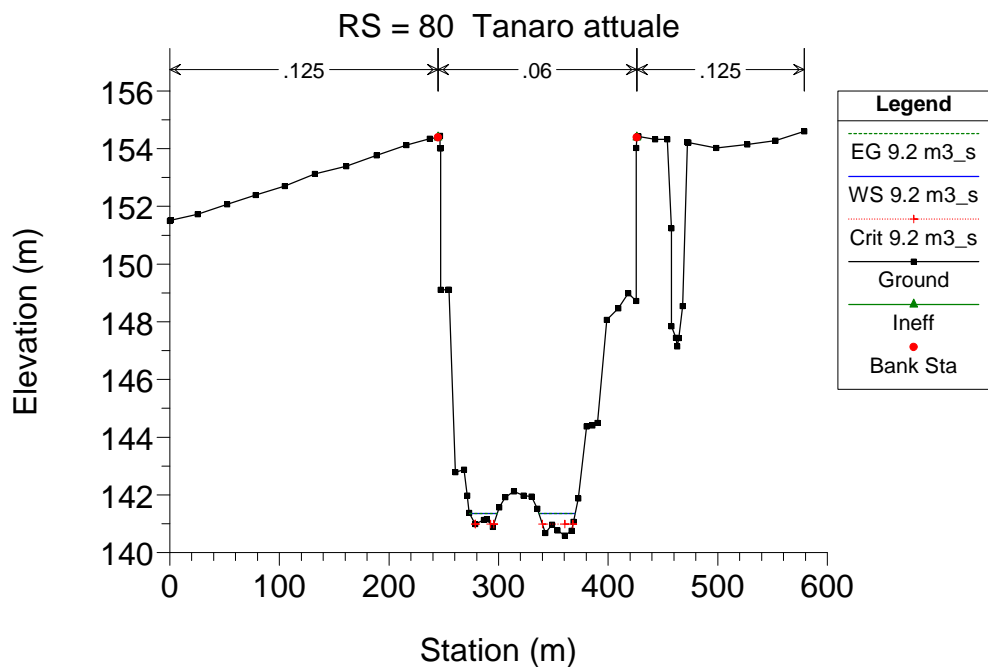
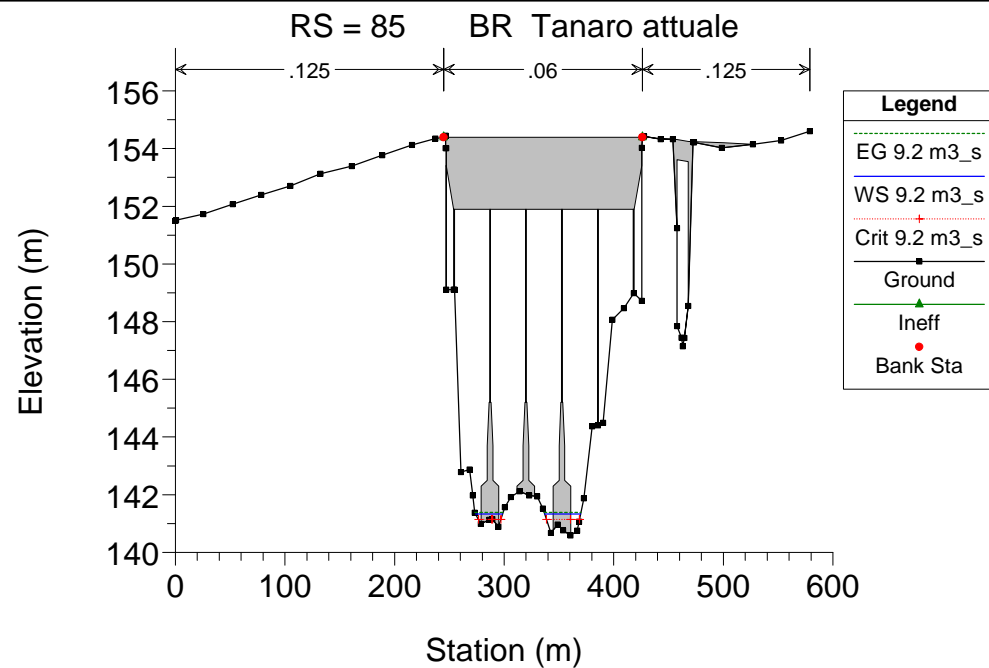
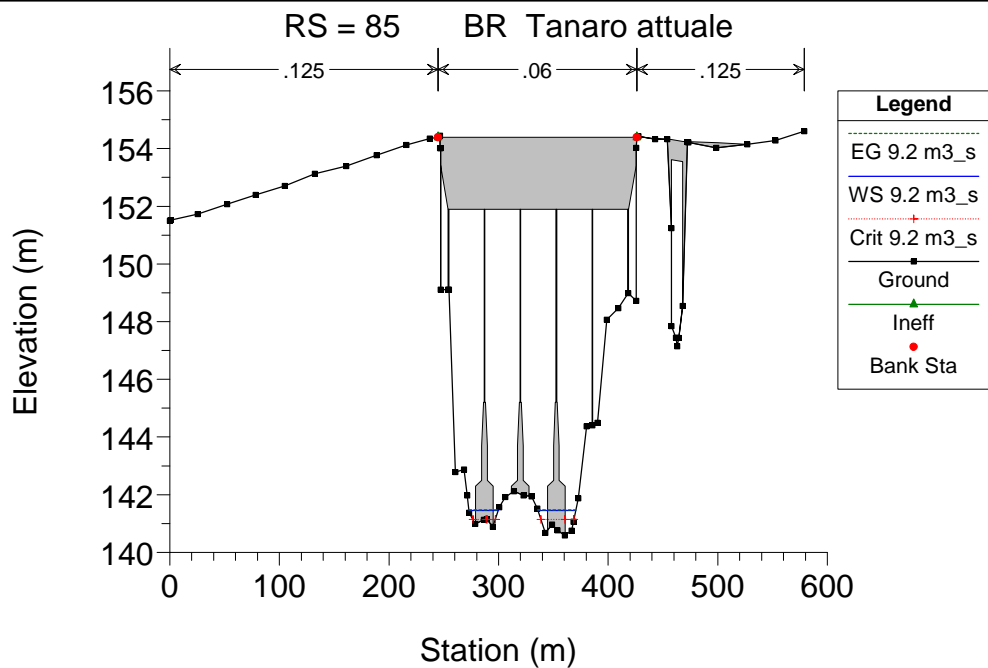


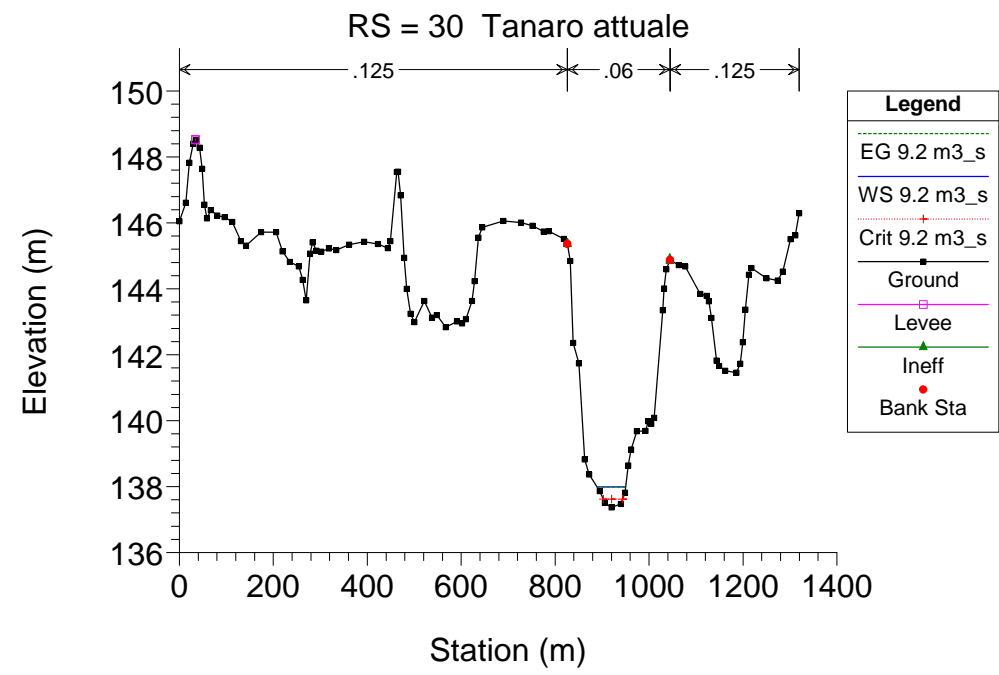
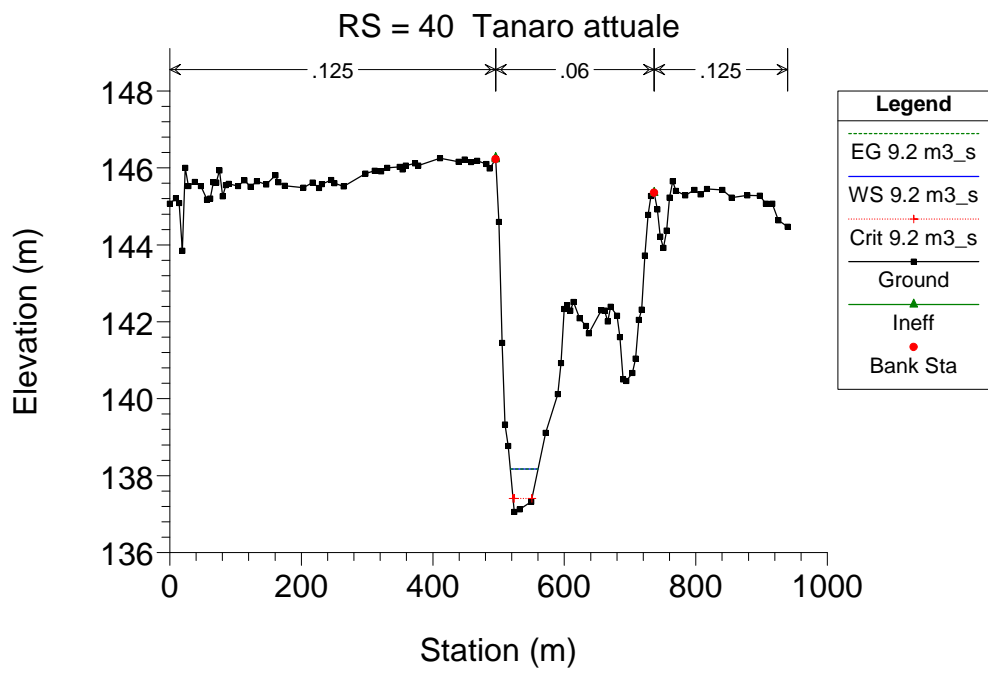
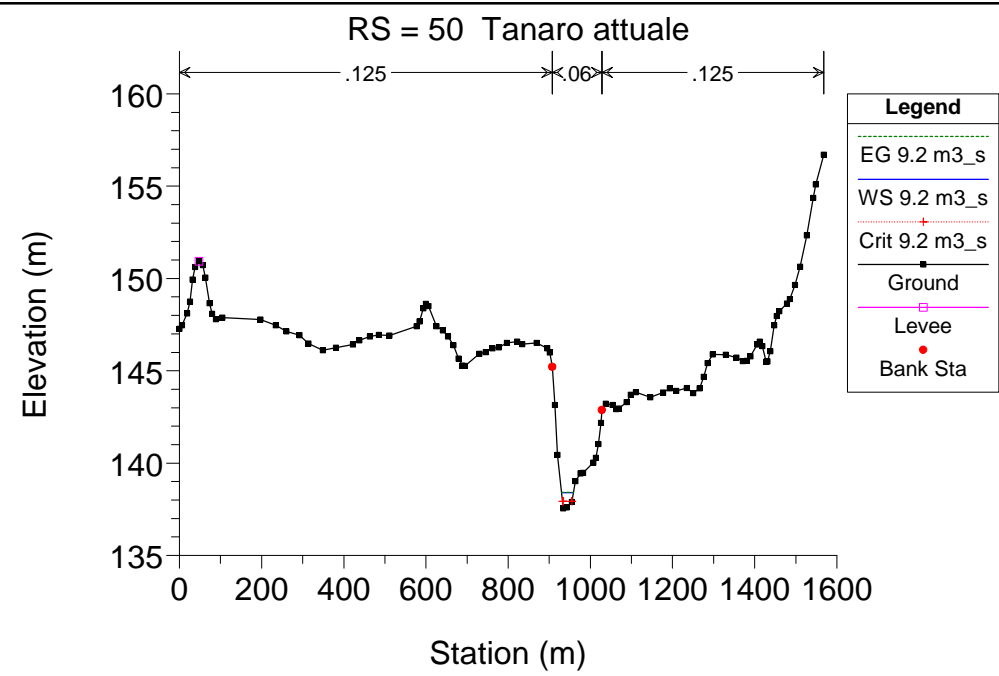
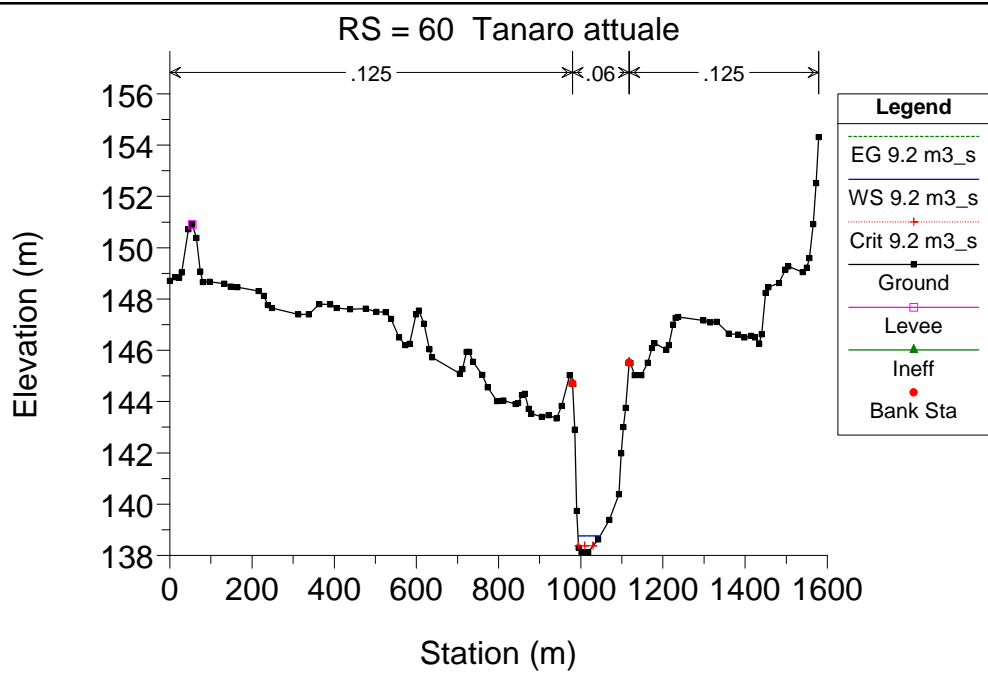


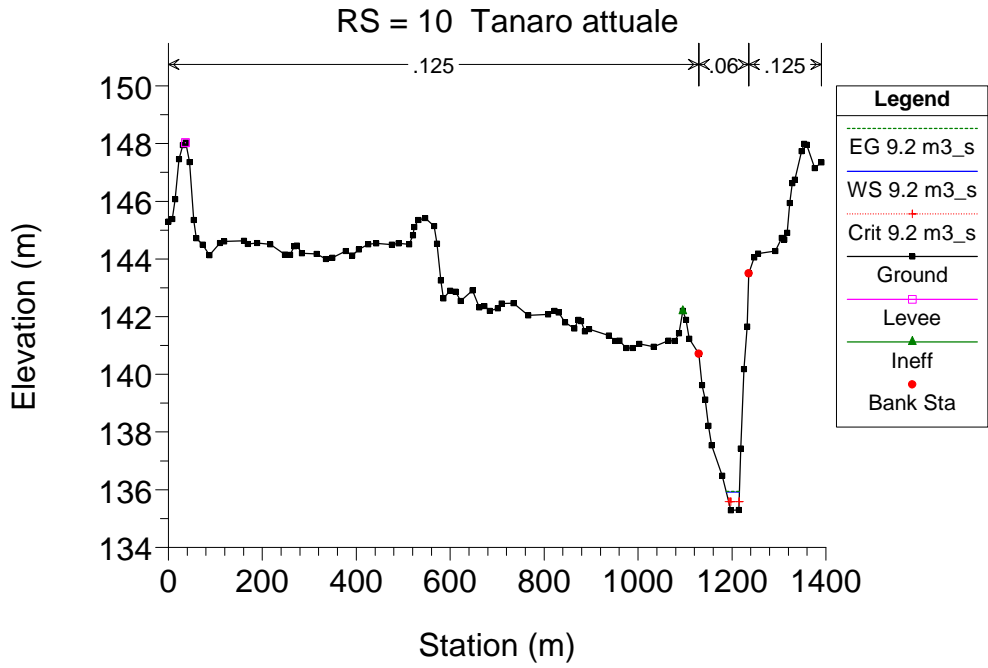
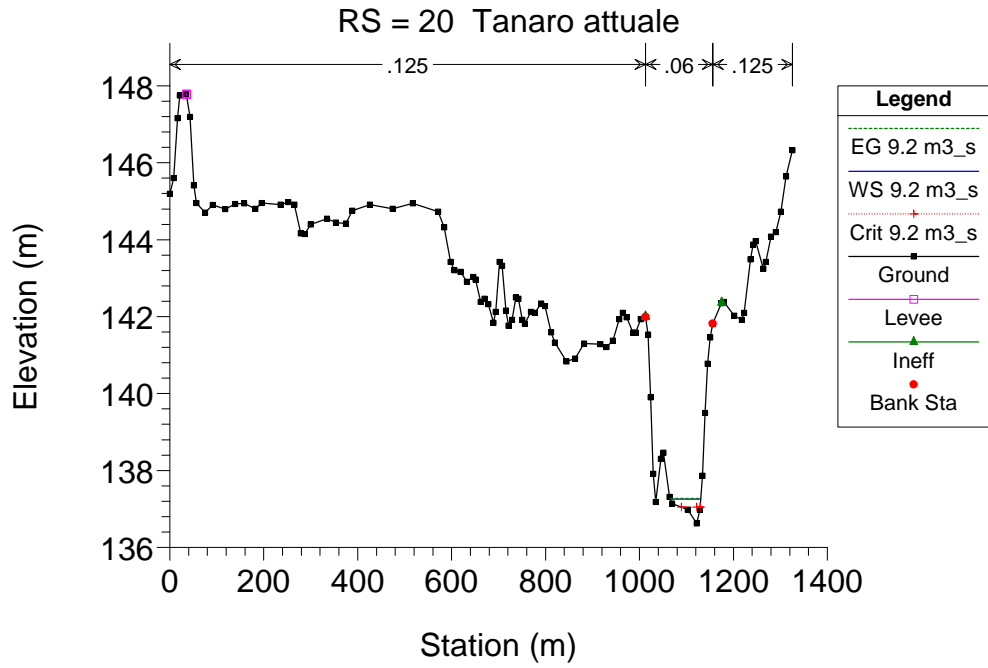












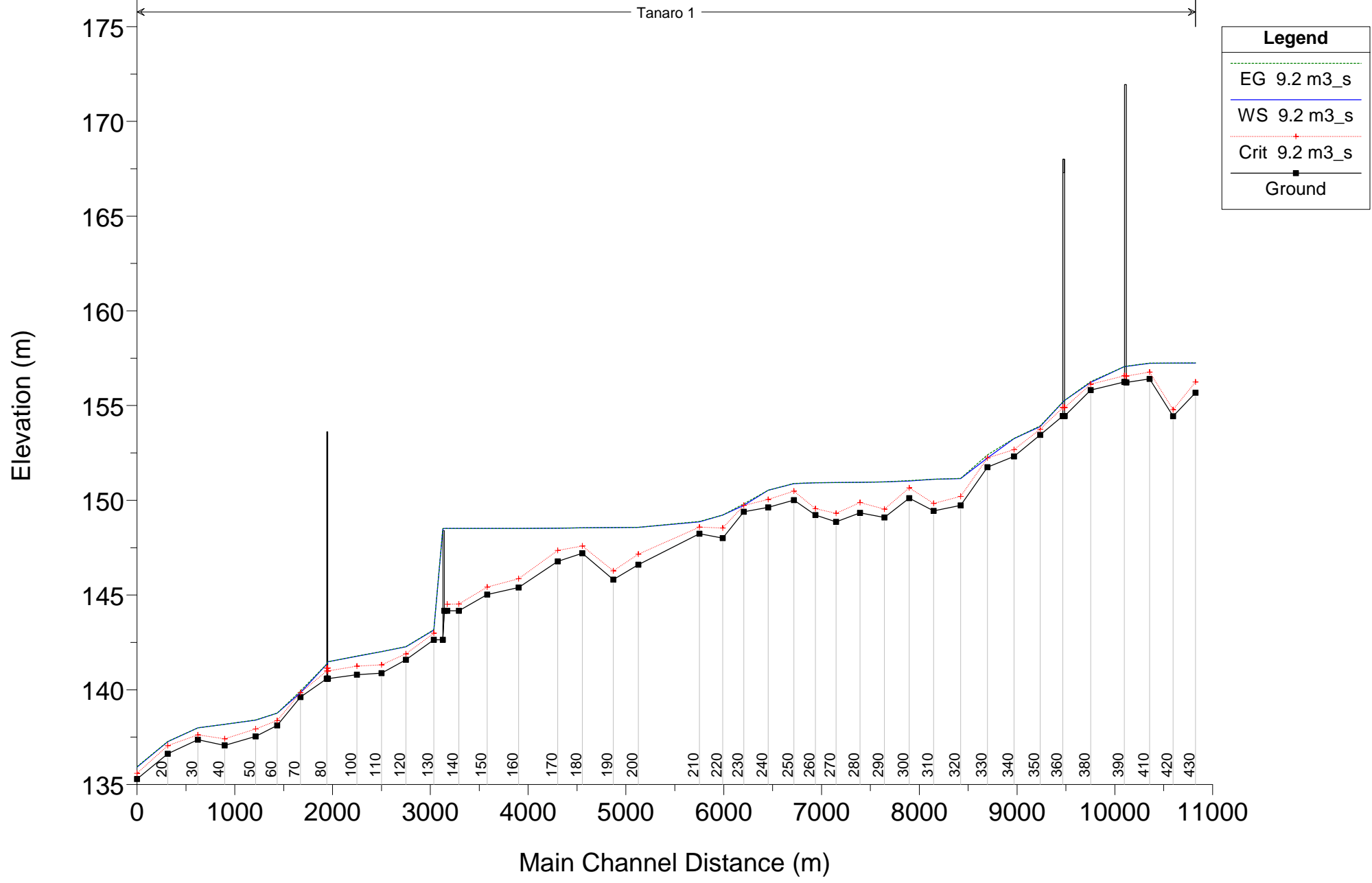
SITUAZIONE ANTE CROLLO DEL 2010**SIMULAZIONE 8**

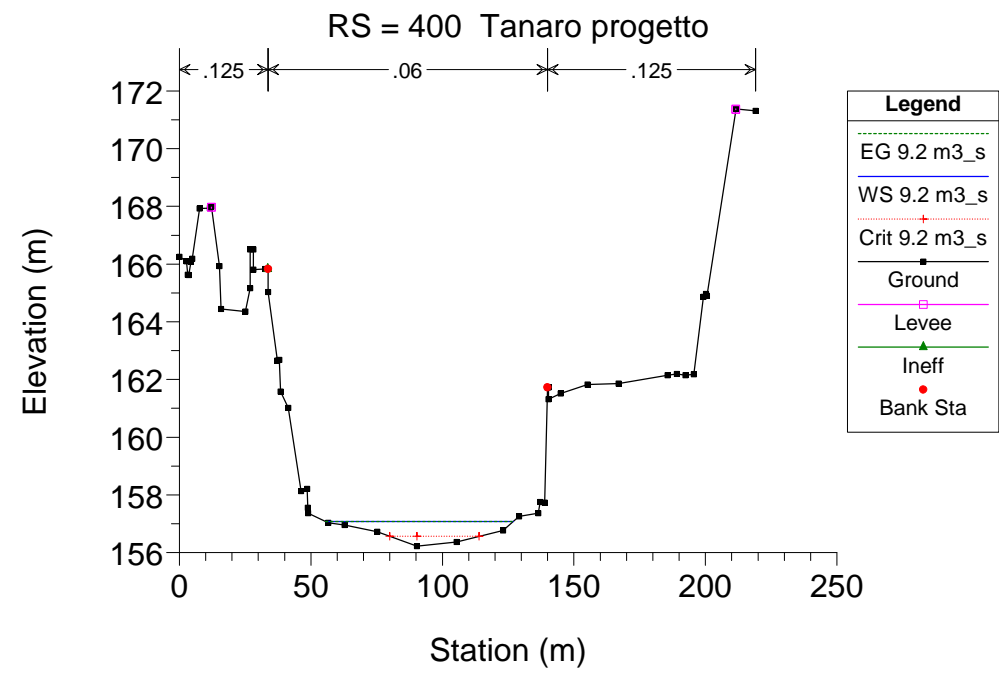
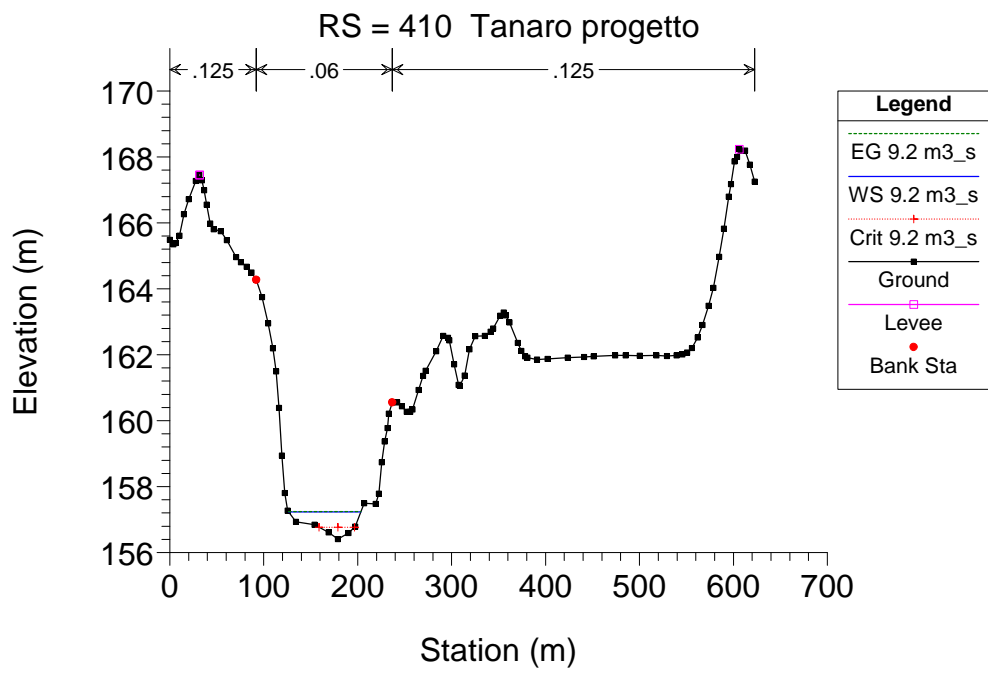
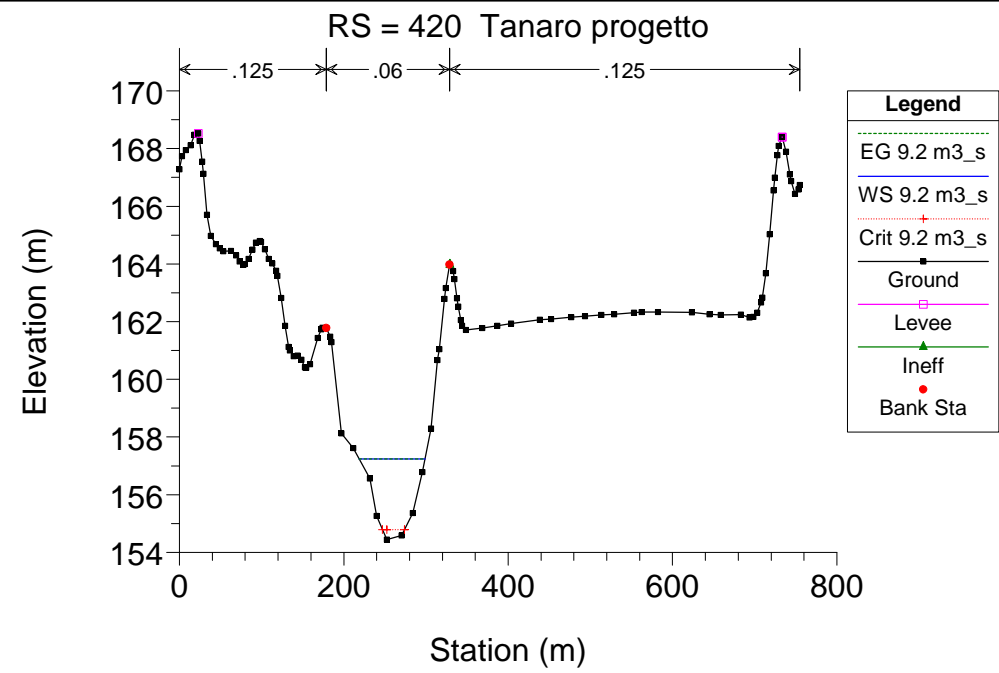
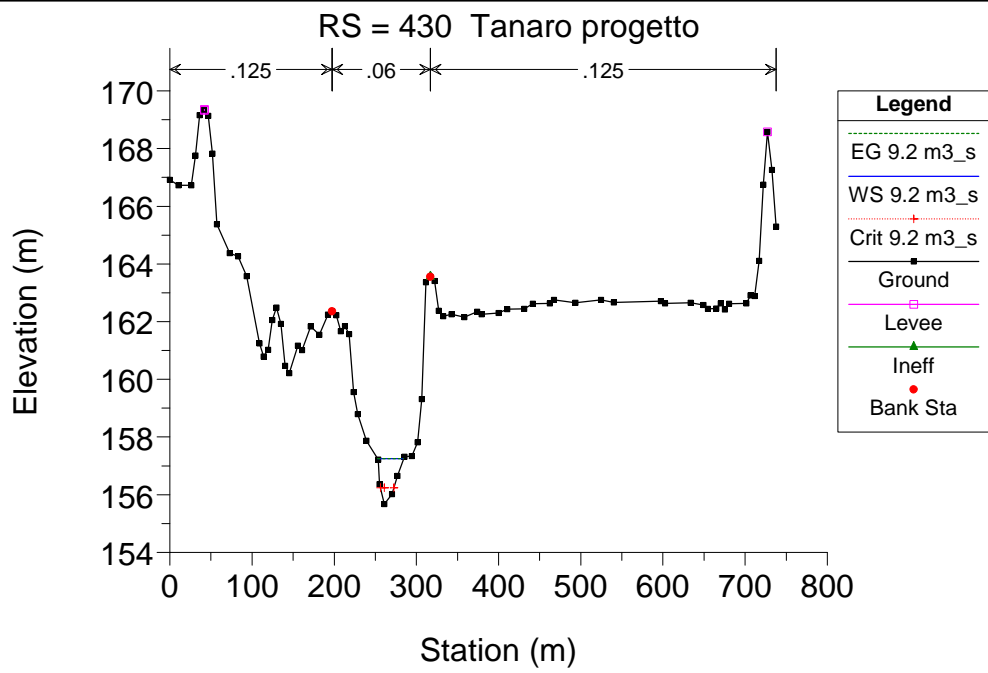
Corso d'acqua	Portata Q m³/s	Portata
Fiume Tanaro	9.2 (in alveo) 0.7 (derivati per alimentazione canale)	Minima per la derivazione ad uso irriguo

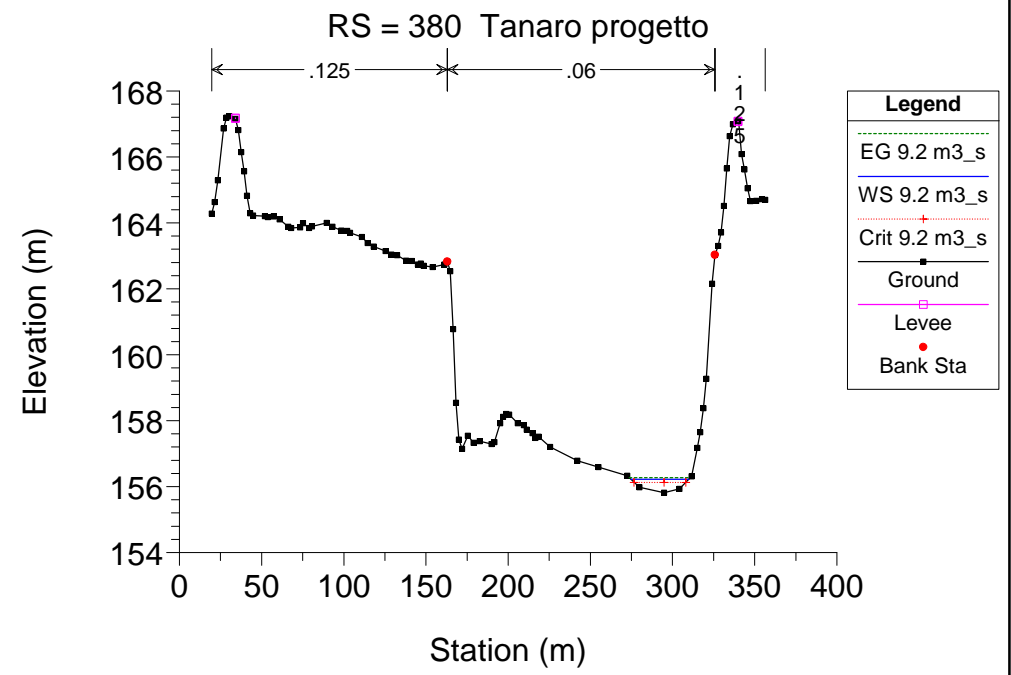
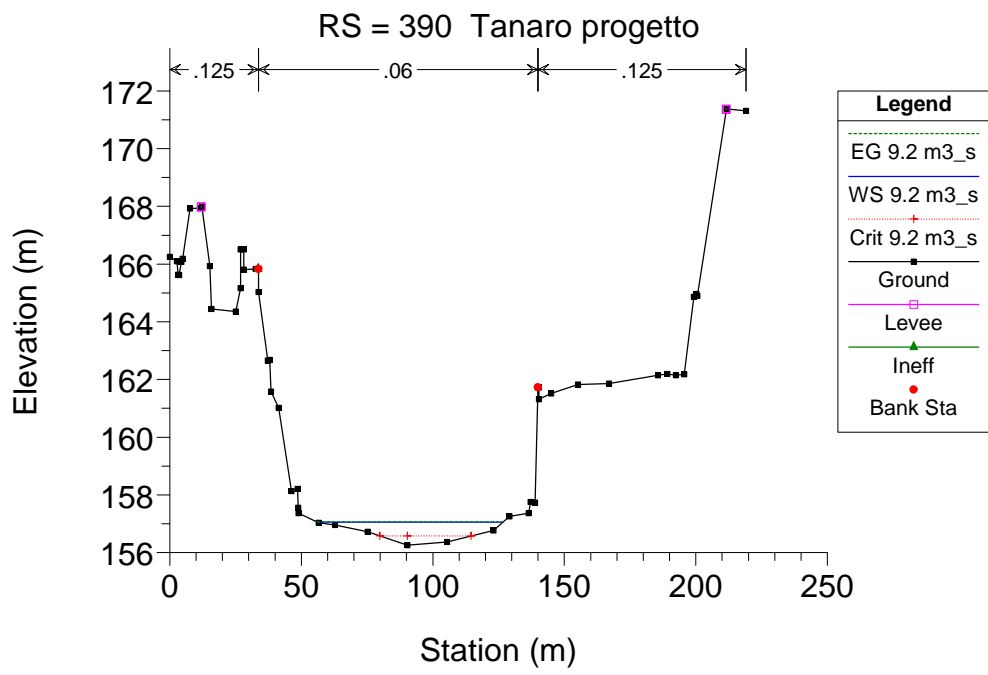
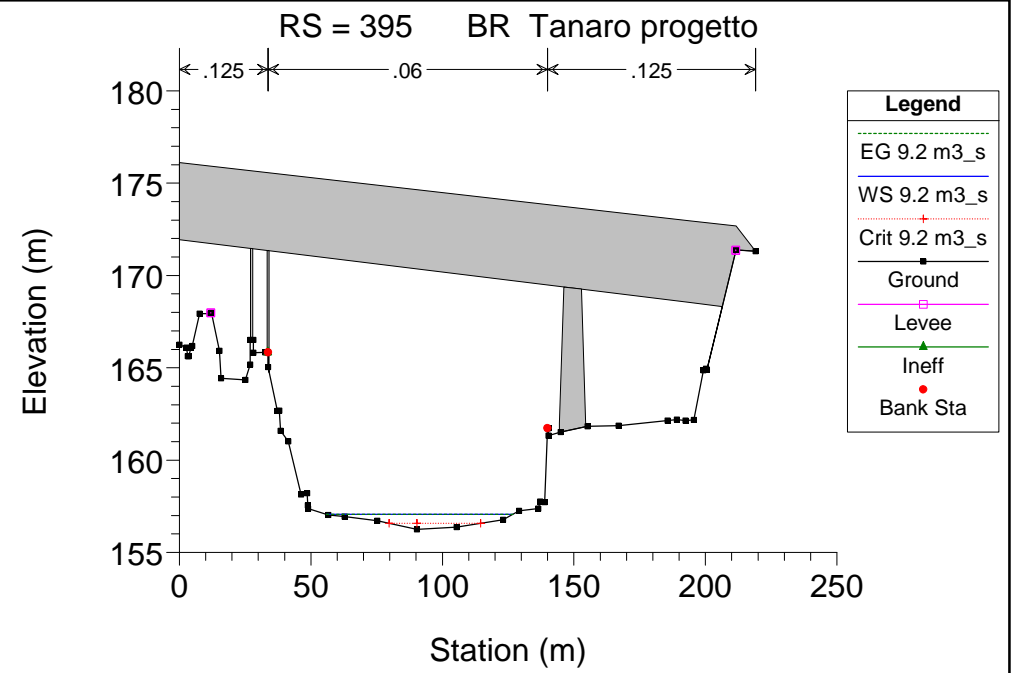
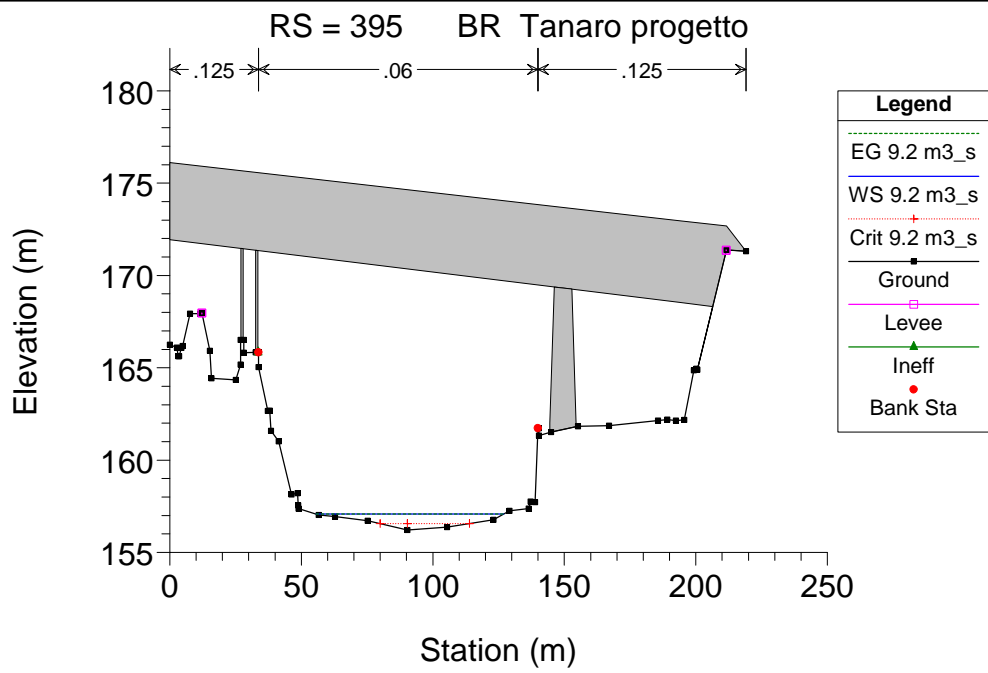
HEC-RAS Plan: Plan 06 River: Tanaro Reach: 1 Profile: 9.2 m3_s (Continued)

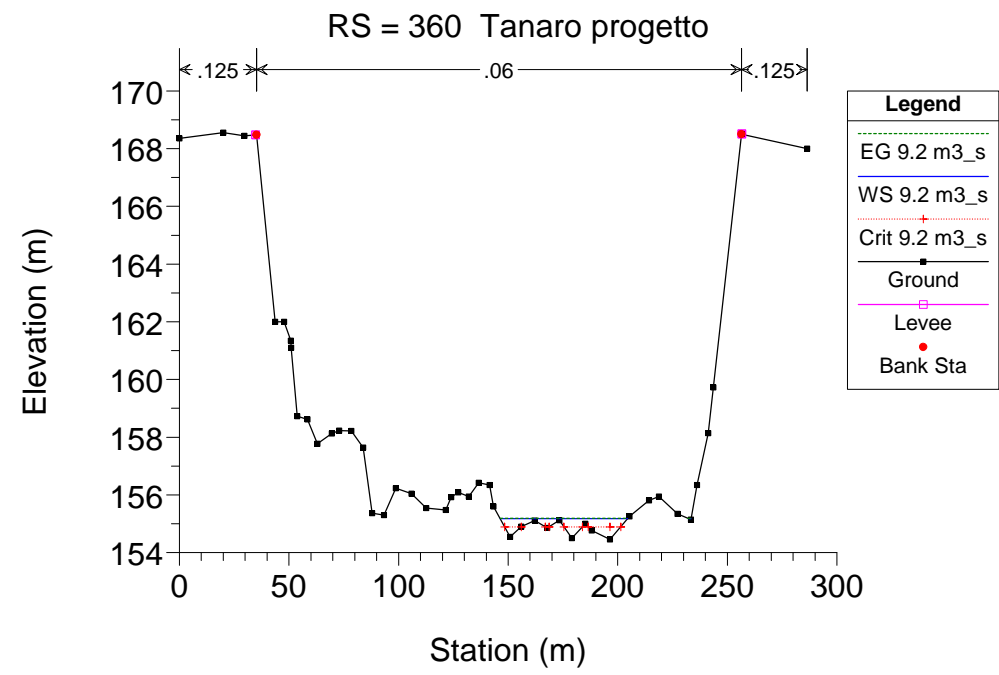
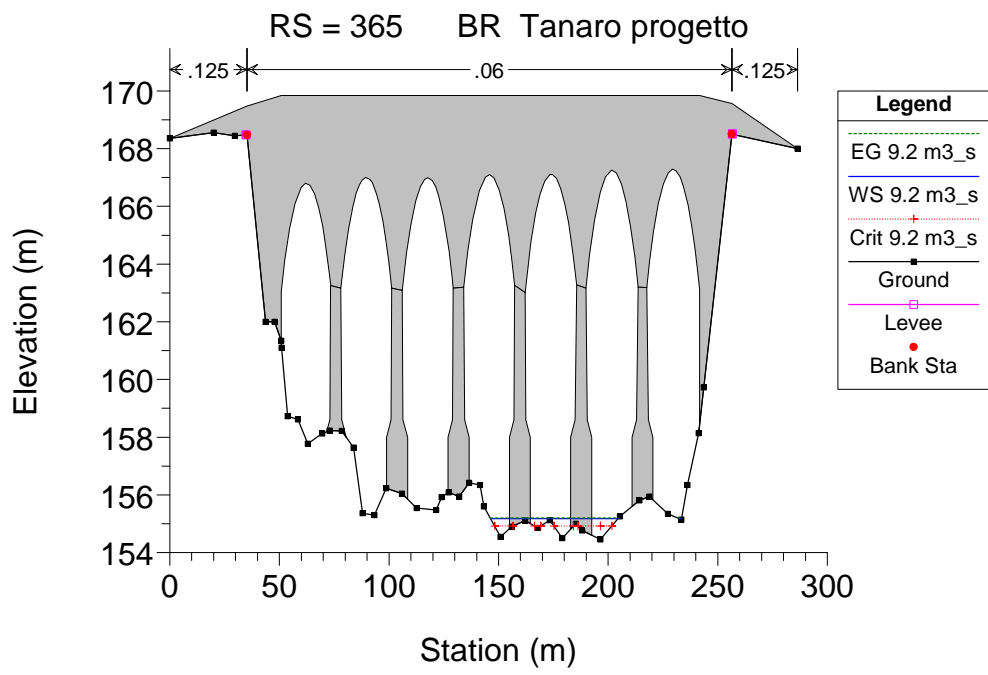
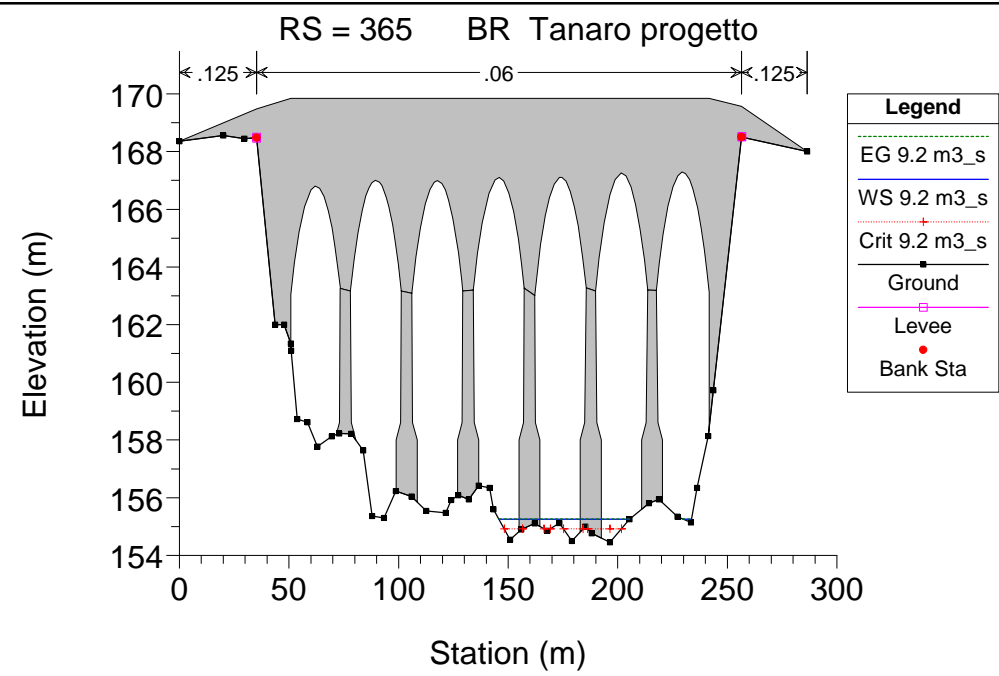
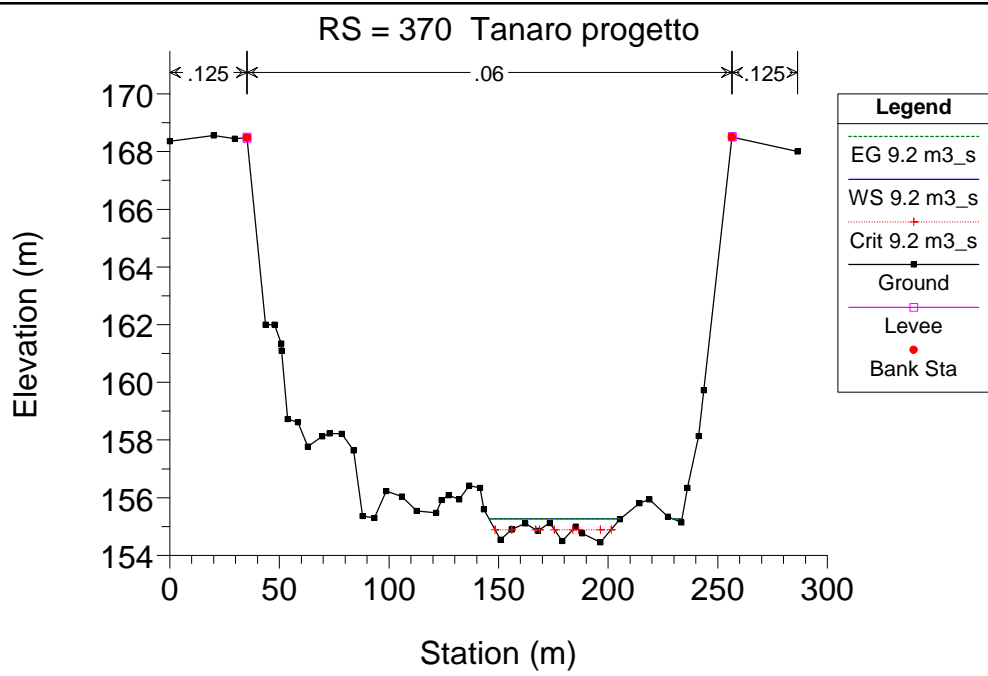
Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
1	80	9.2 m3_s	9.20	140.59	141.35	140.99	141.36	0.001779	0.39	23.81	58.28	0.19
1	70	9.2 m3_s	9.20	139.61	139.84	139.84	139.94	0.059664	1.38	6.68	33.96	0.99
1	60	9.2 m3_s	9.20	138.12	138.76	138.37	138.77	0.001462	0.38	24.45	53.79	0.18
1	50	9.2 m3_s	9.20	137.54	138.39	137.94	138.41	0.001875	0.52	17.70	28.84	0.21
1	40	9.2 m3_s	9.20	137.06	138.17	137.41	138.17	0.000378	0.28	33.27	42.03	0.10
1	30	9.2 m3_s	9.20	137.37	137.99	137.62	137.99	0.001434	0.36	25.84	60.94	0.17
1	20	9.2 m3_s	9.20	136.62	137.26	137.05	137.27	0.004519	0.49	18.88	65.75	0.29
1	10	9.2 m3_s	9.20	135.29	135.91	135.59	135.94	0.004001	0.66	13.93	27.90	0.30

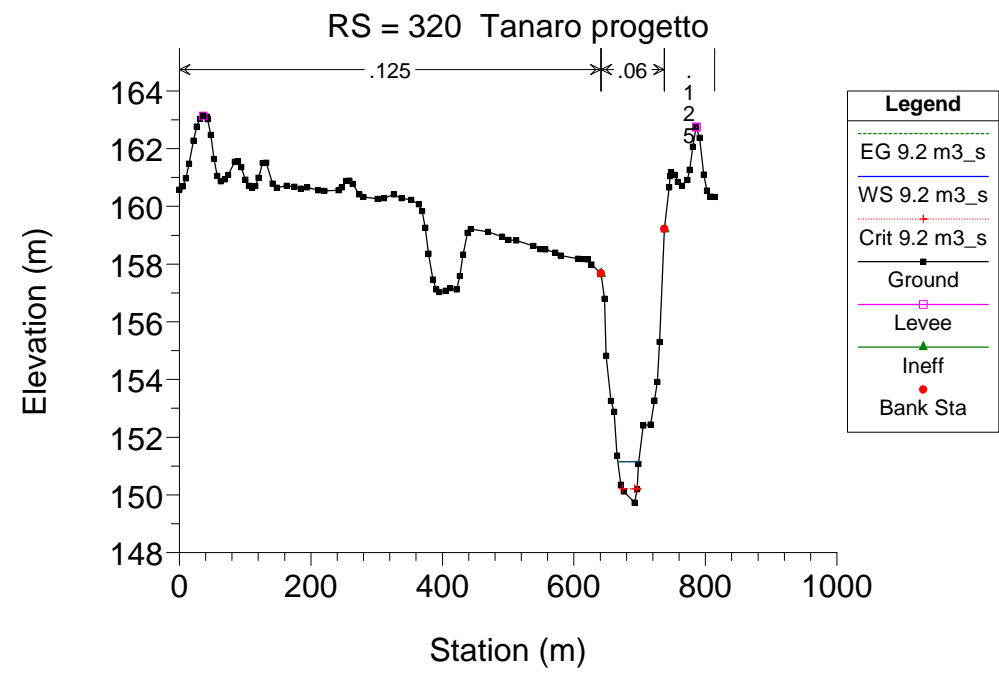
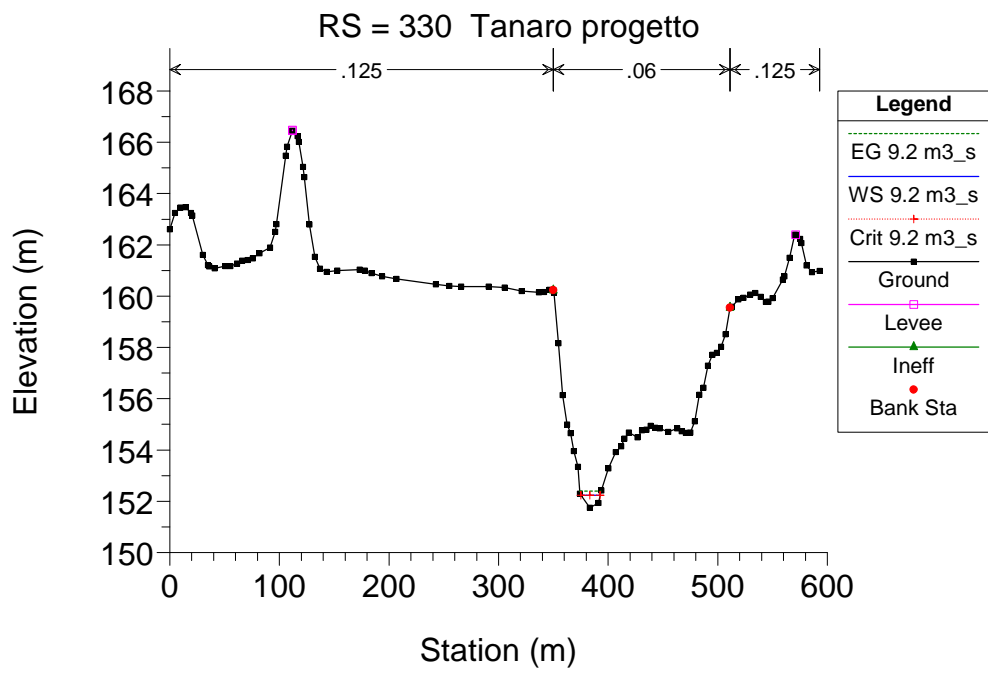
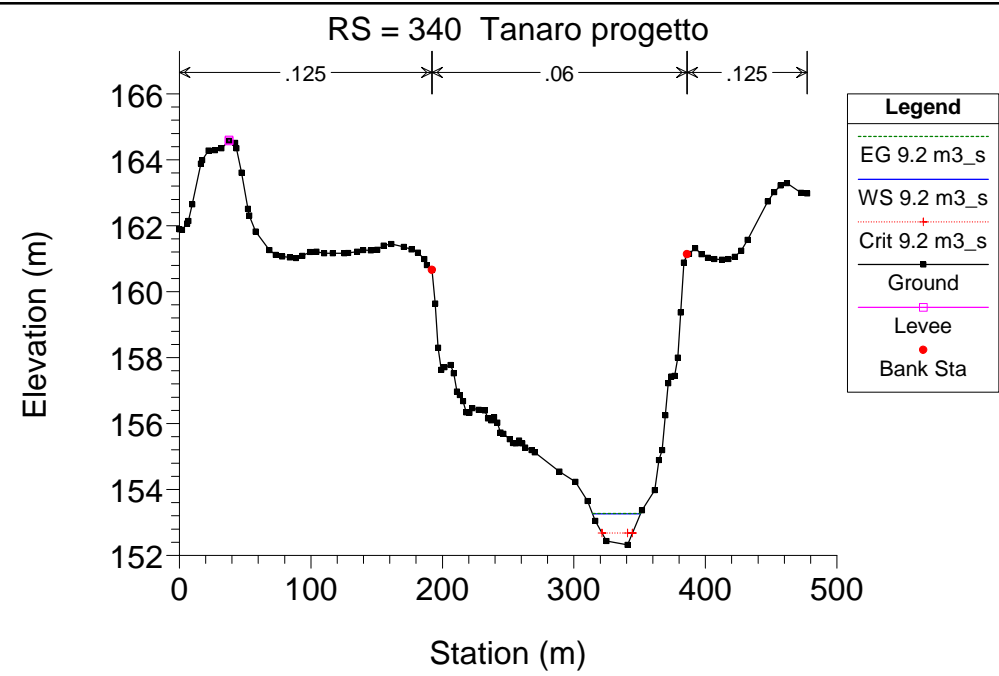
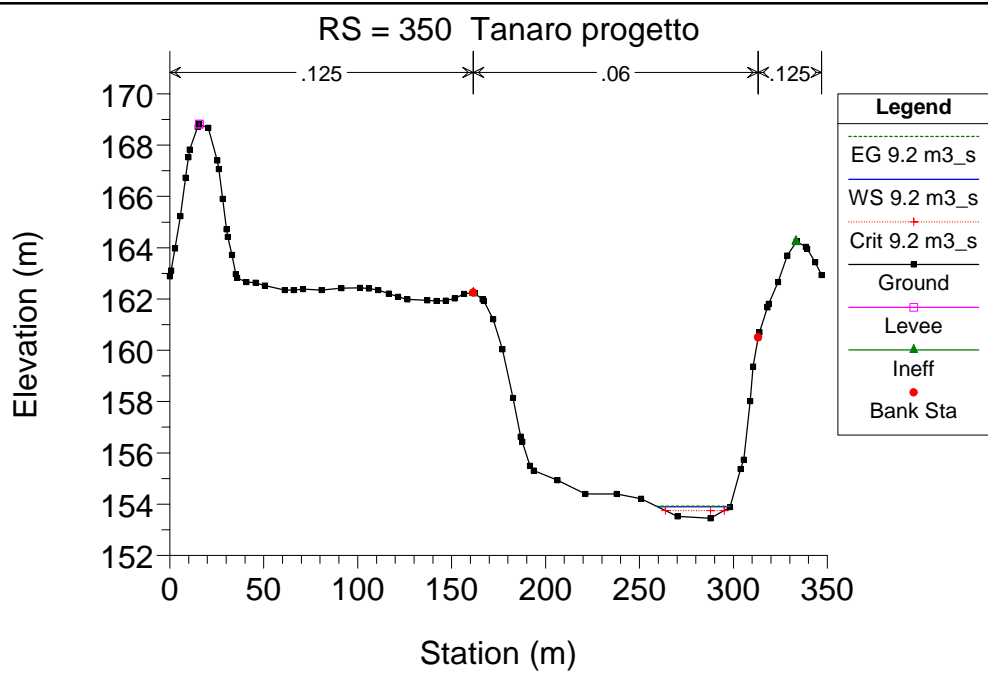
Tanaro progetto

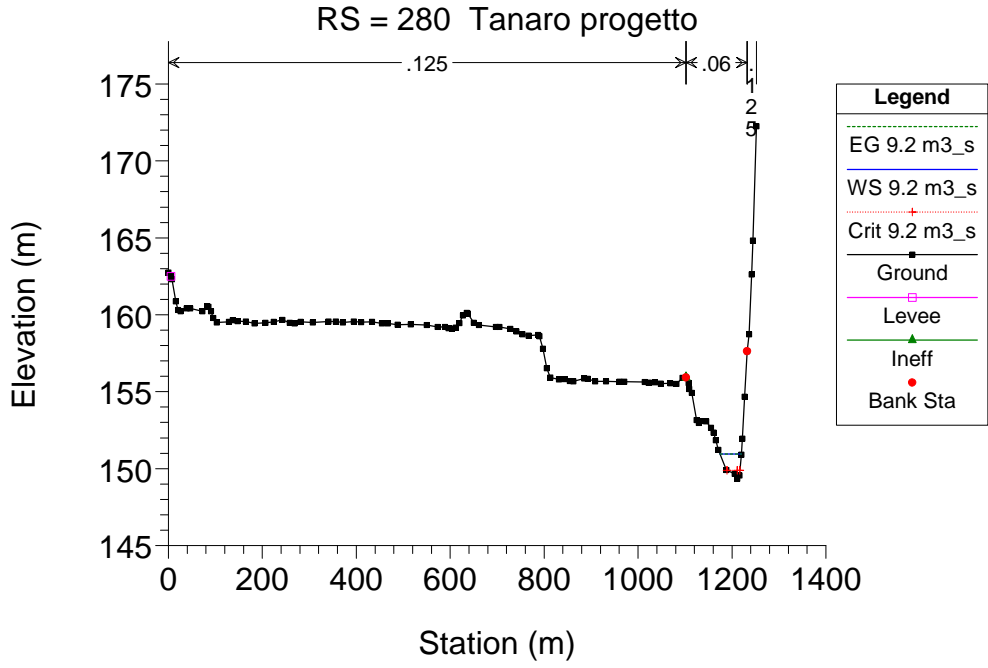
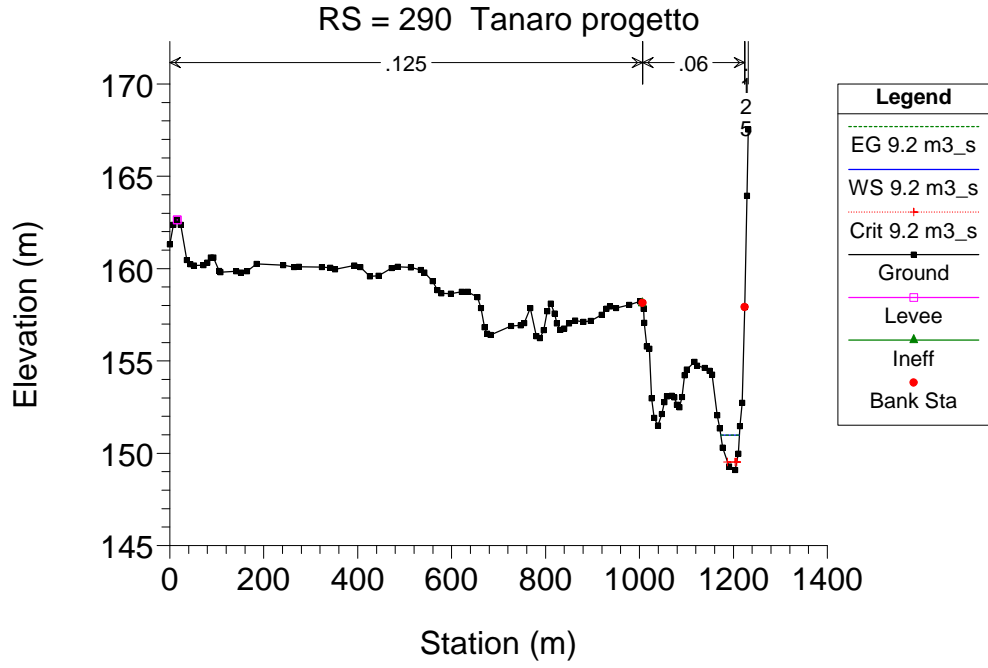
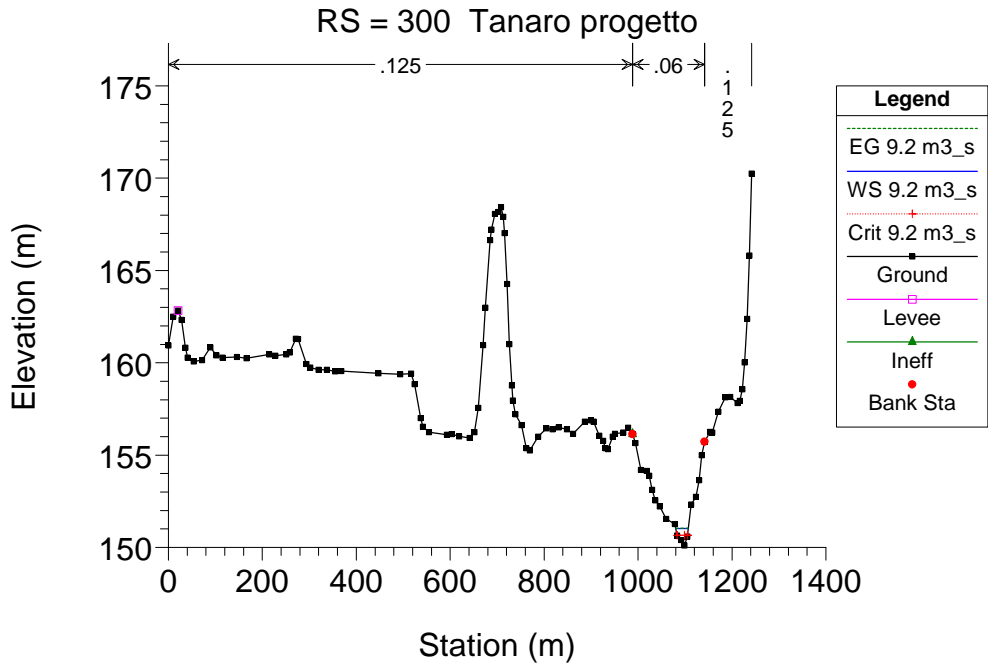
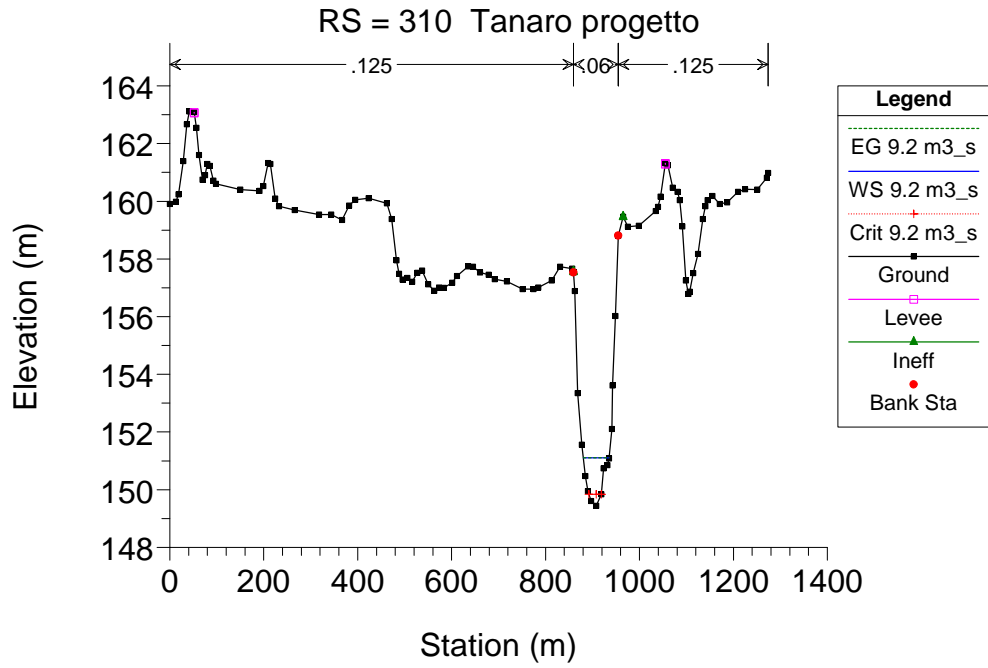


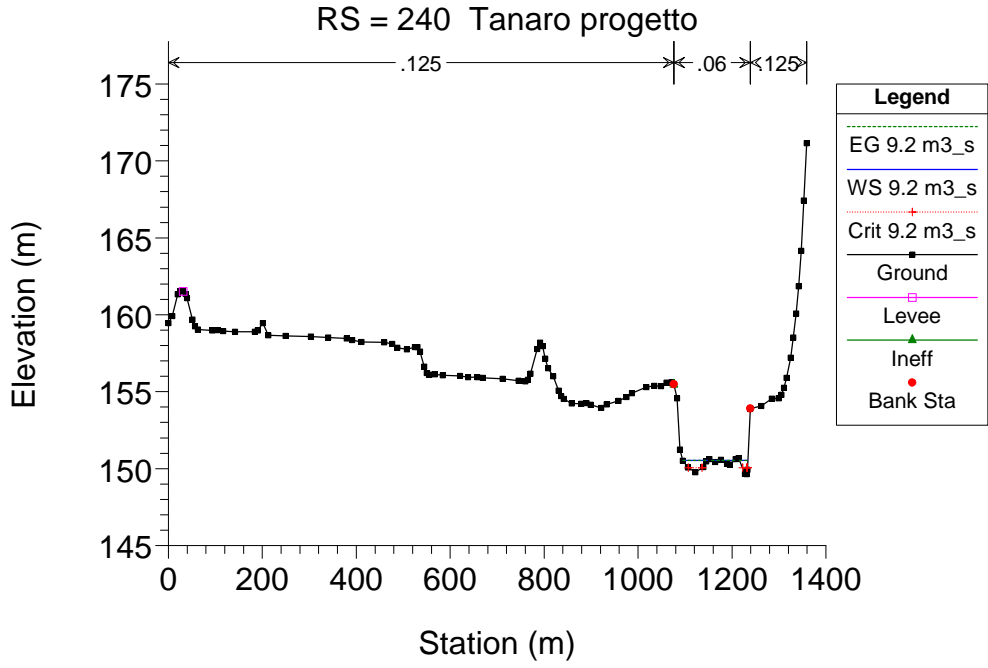
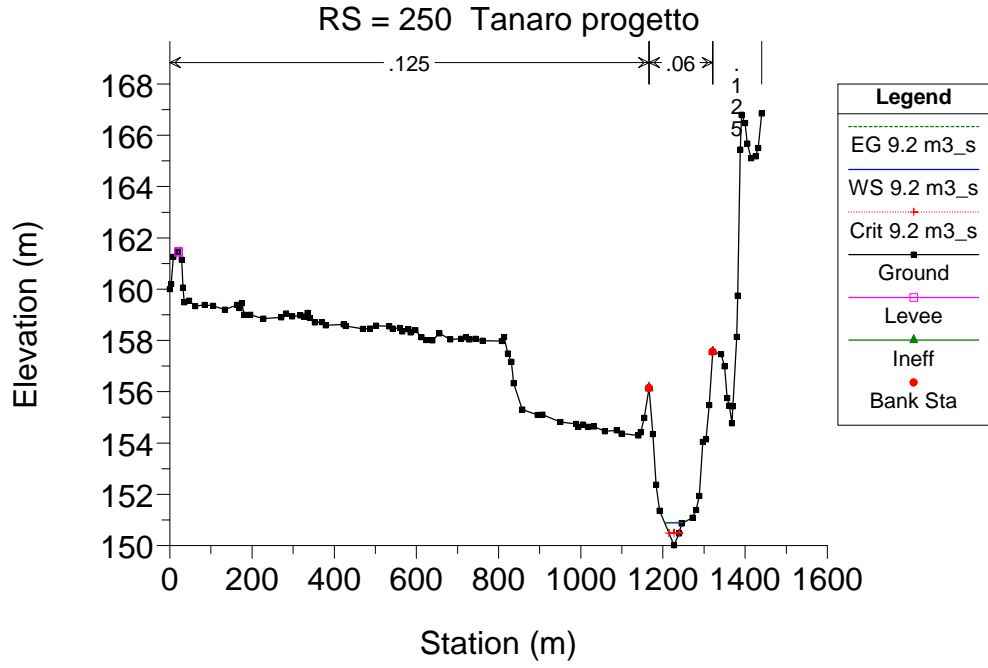
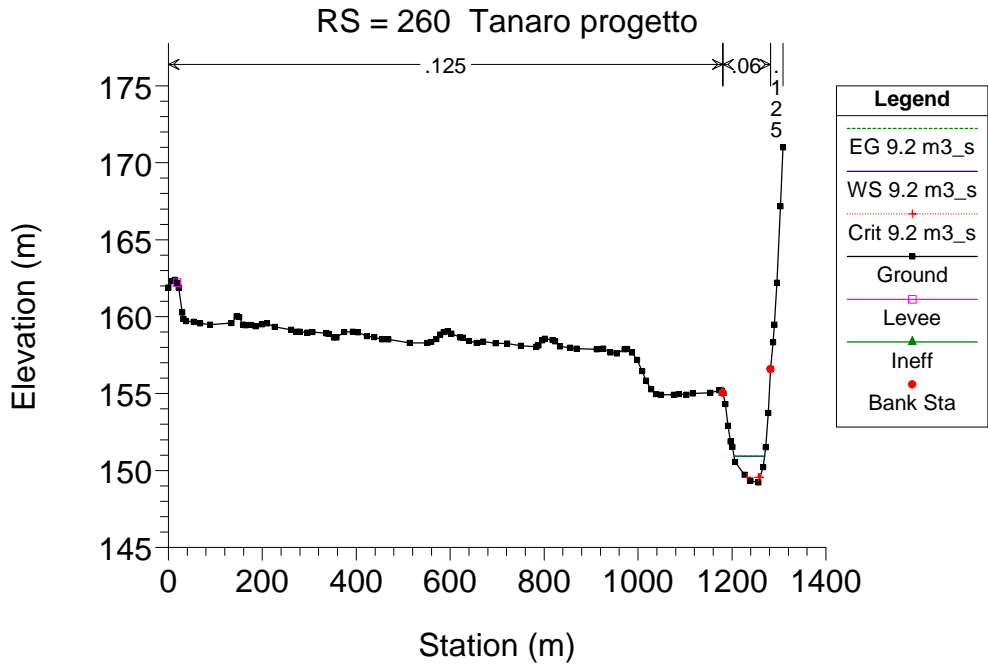
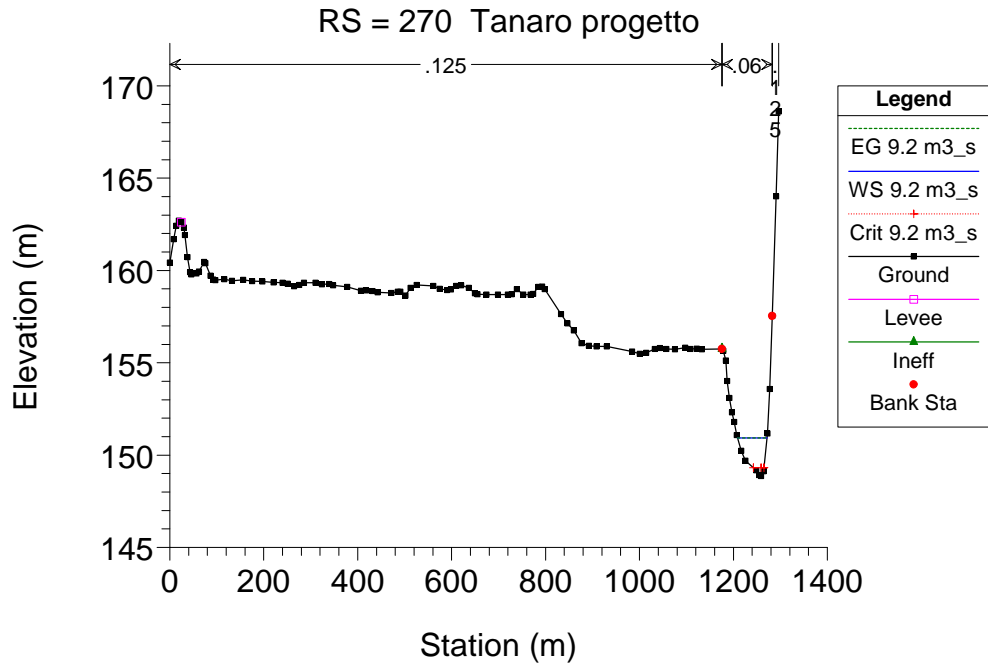


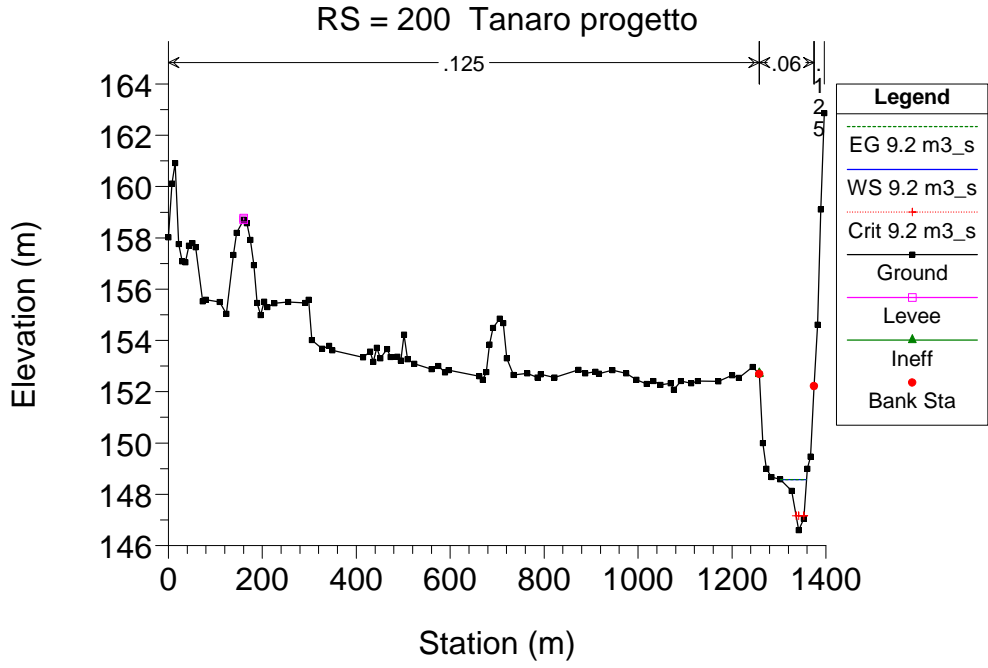
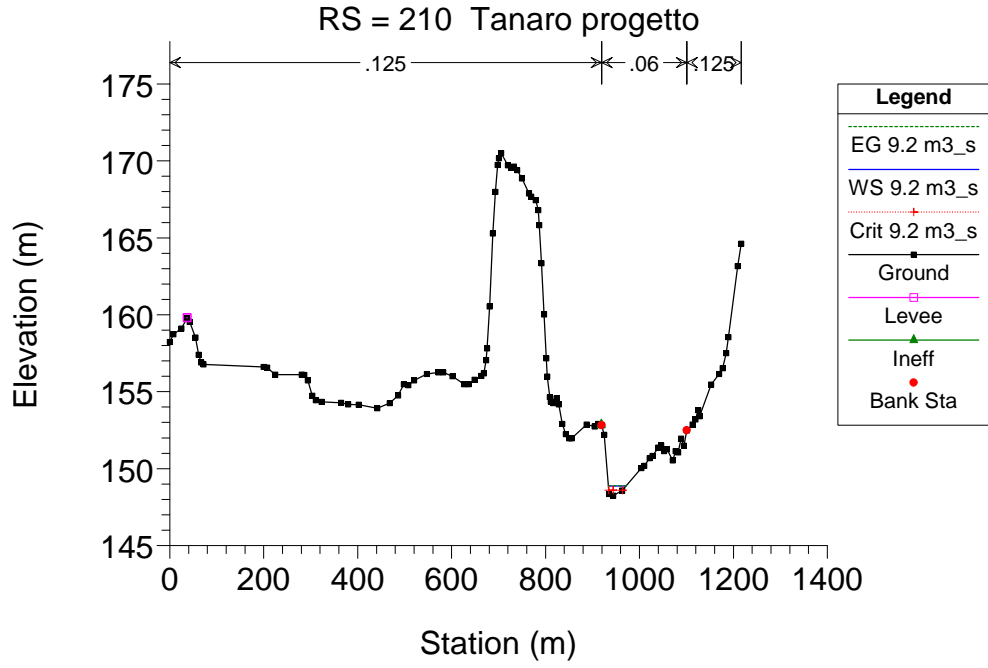
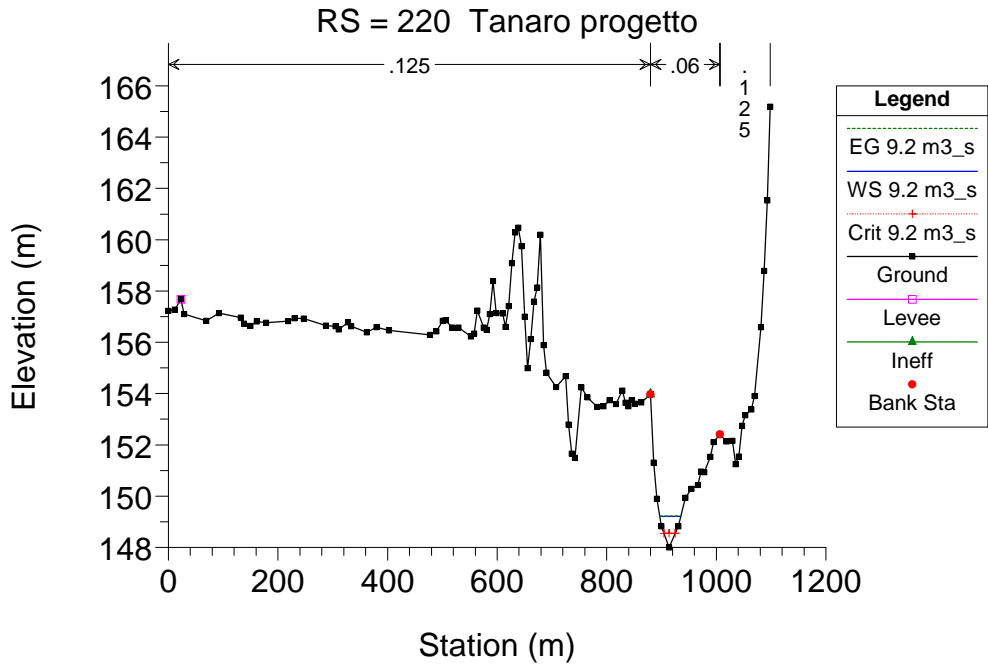
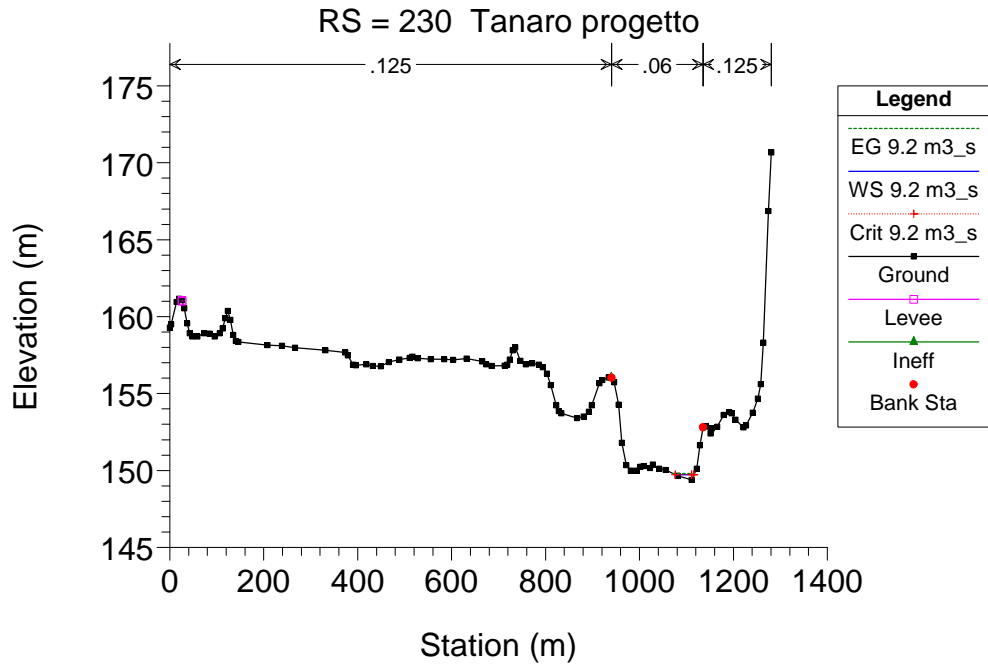


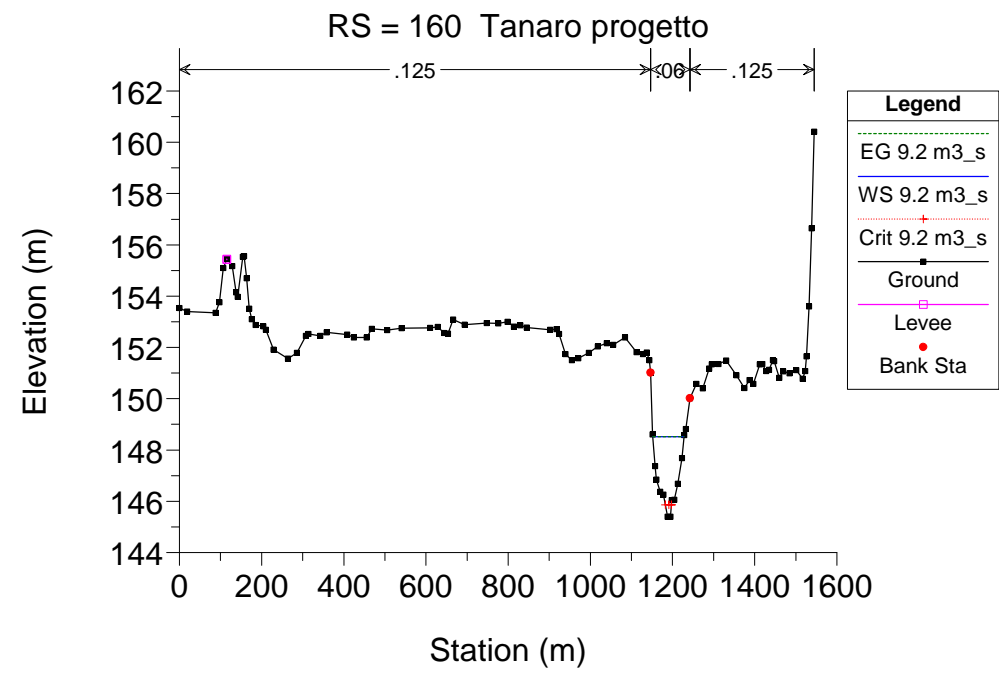
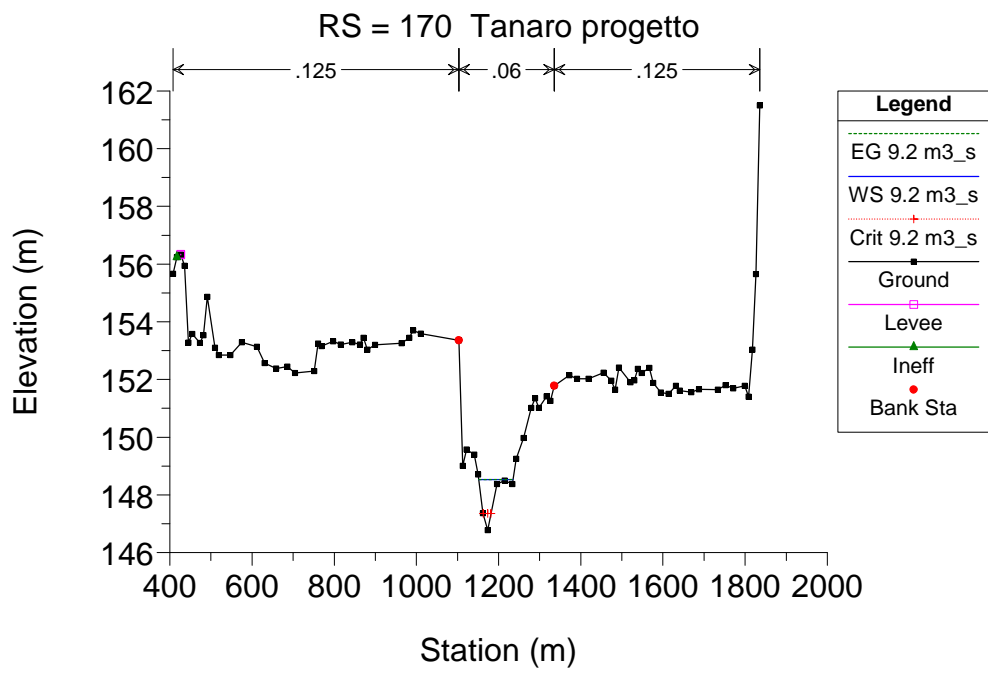
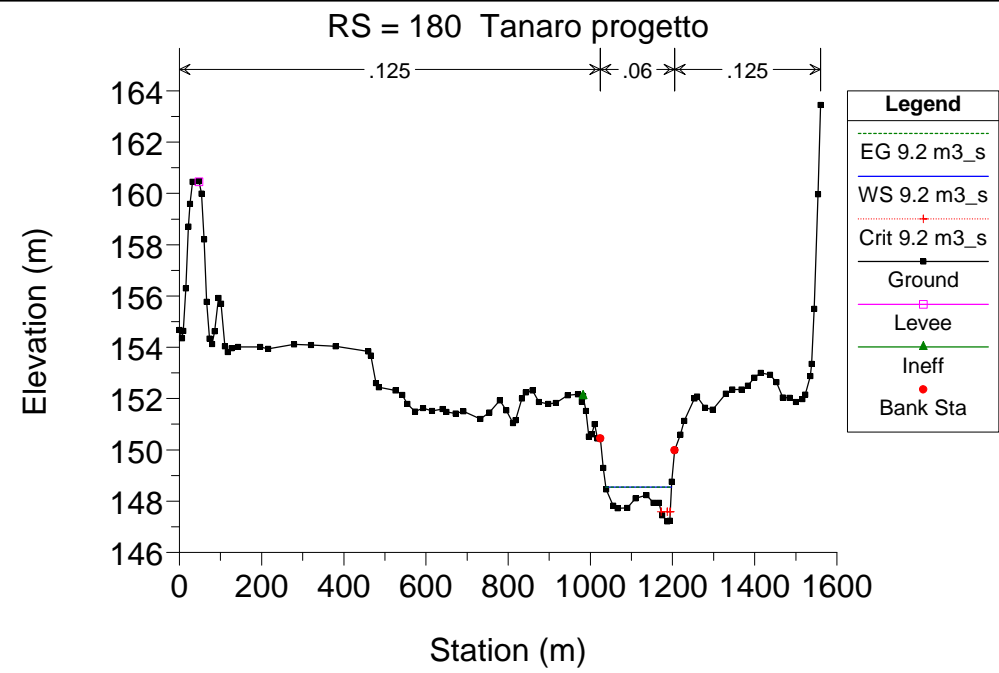
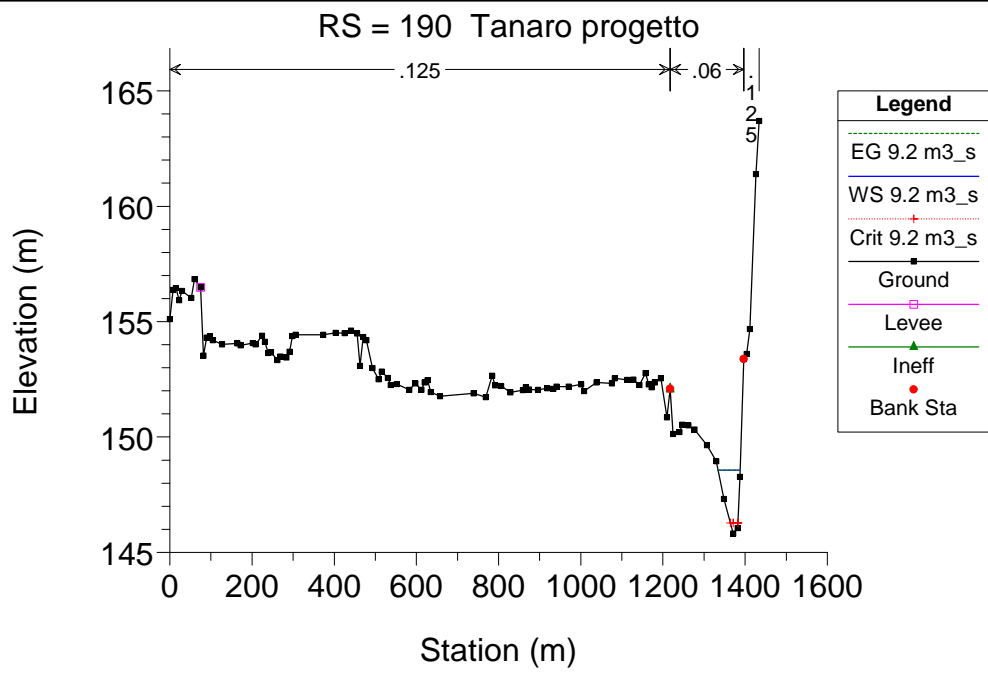


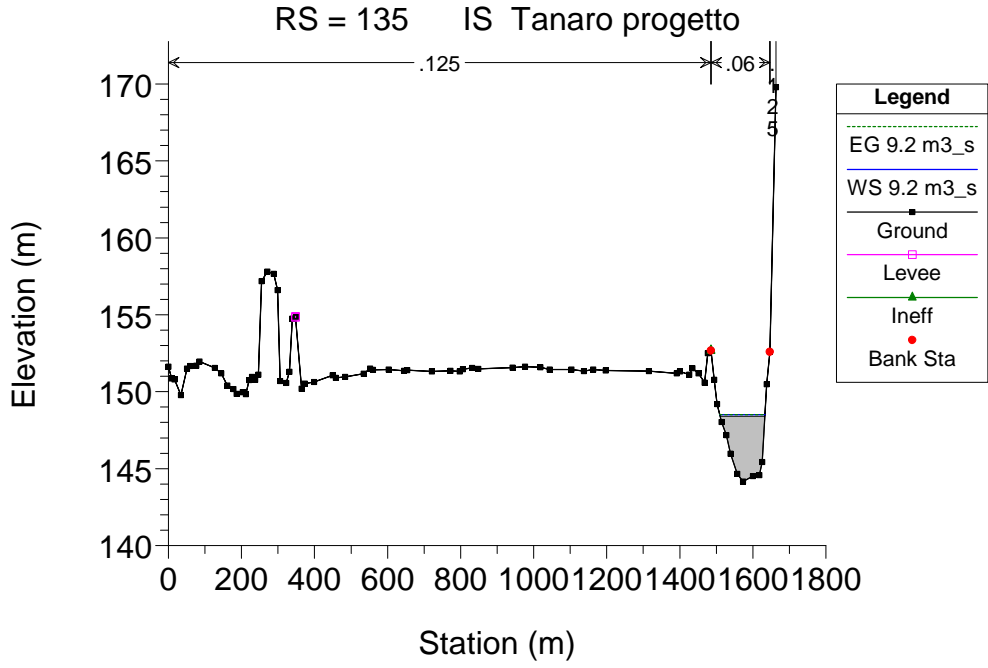
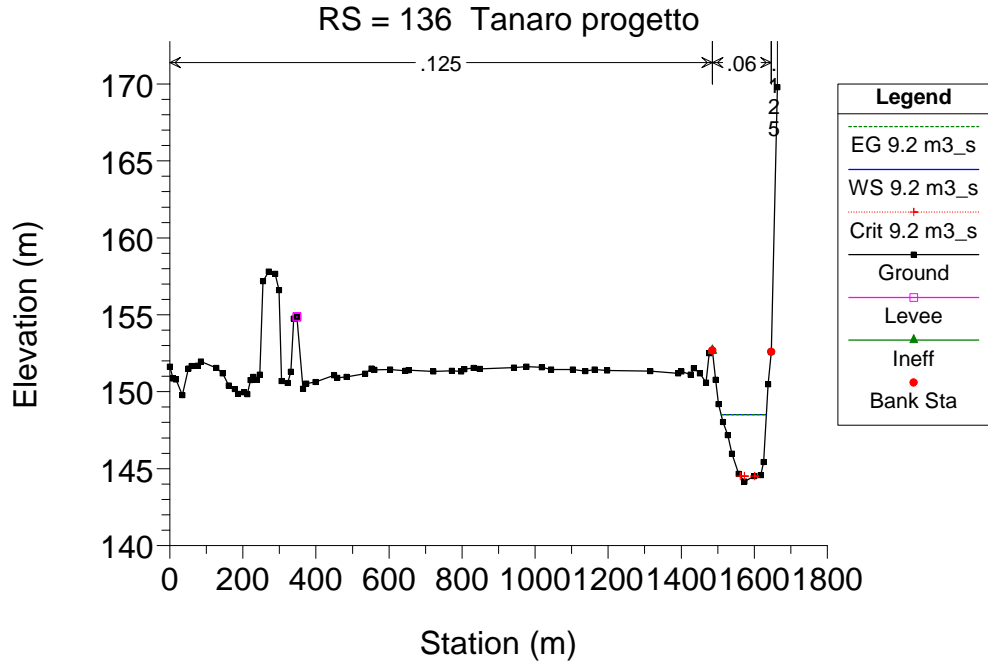
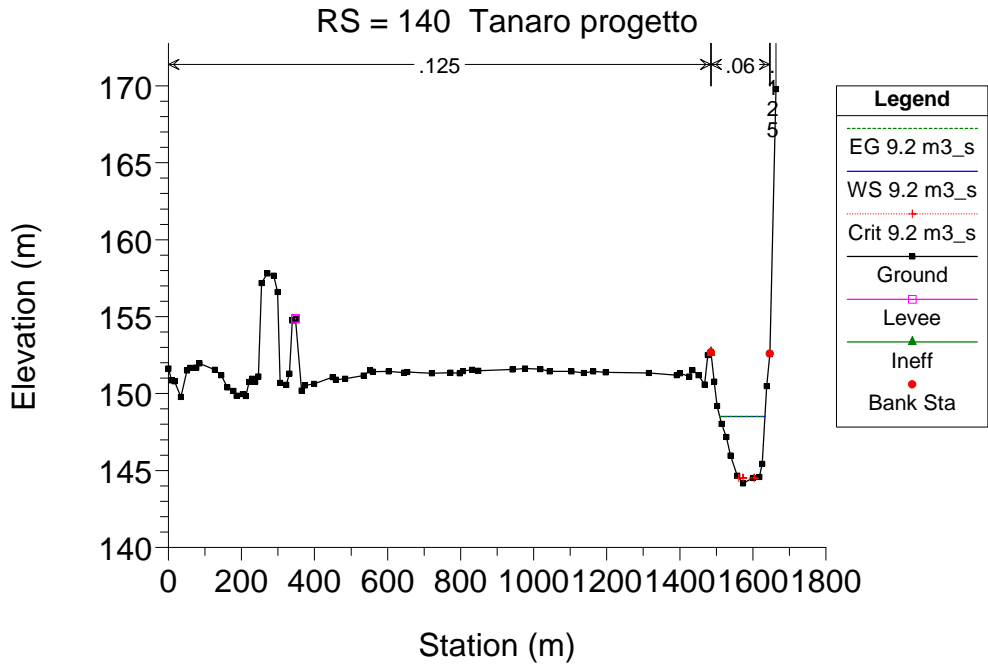
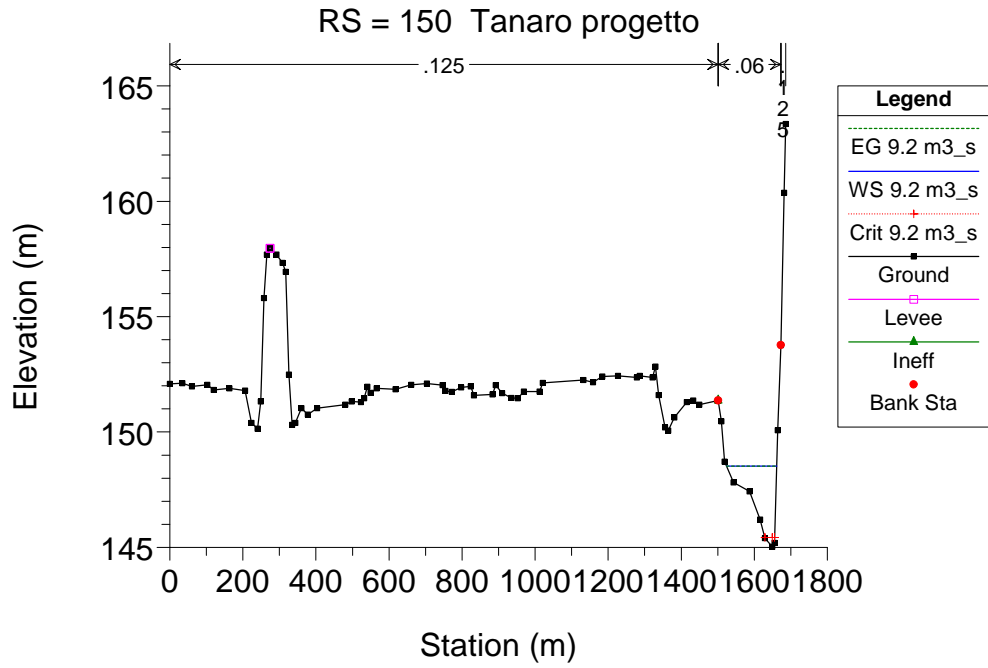


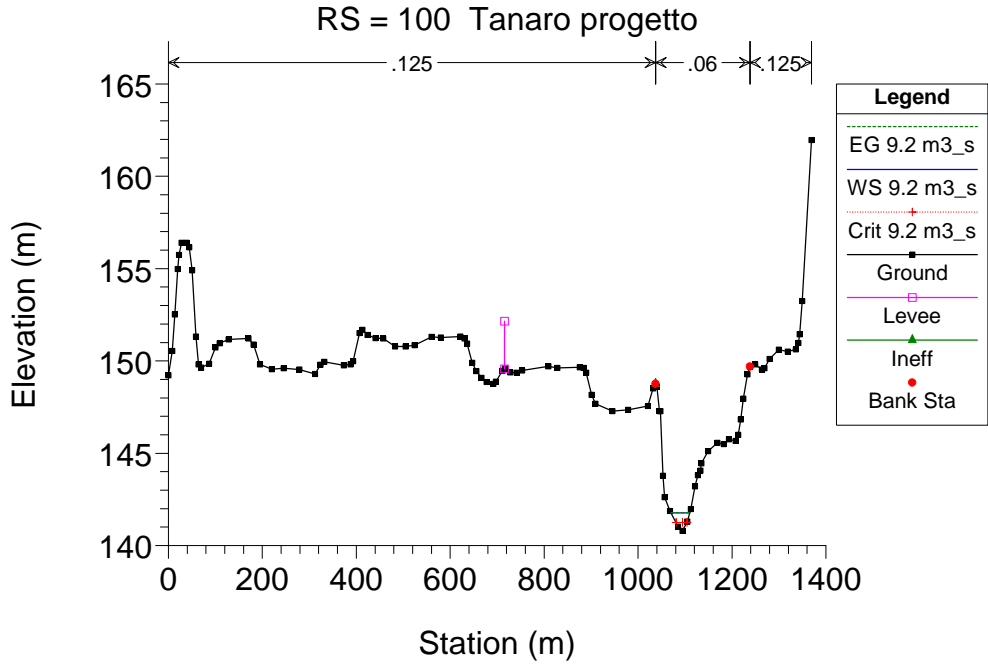
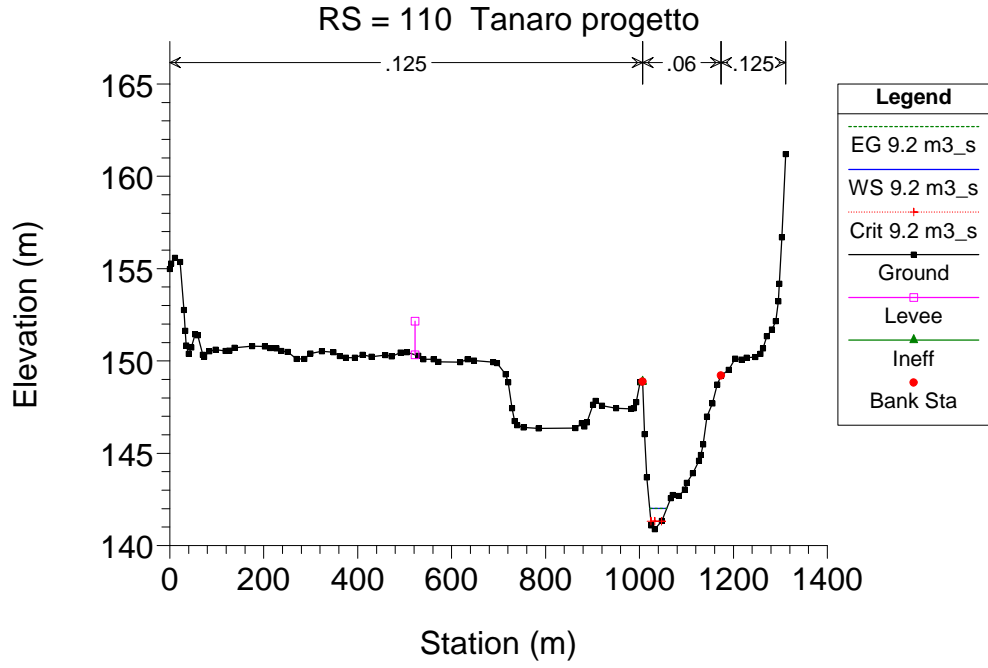
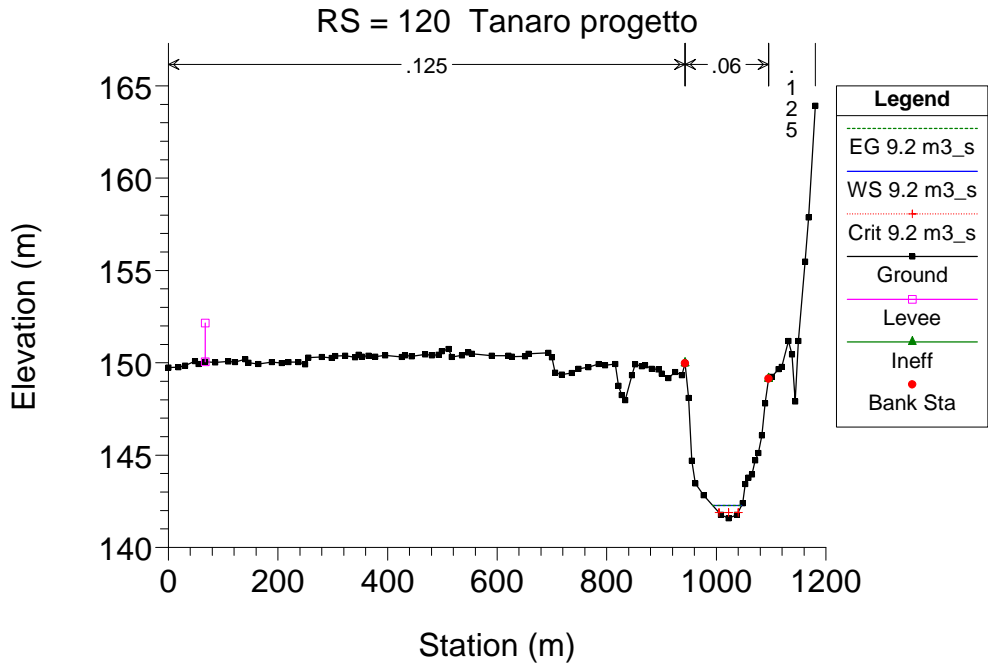
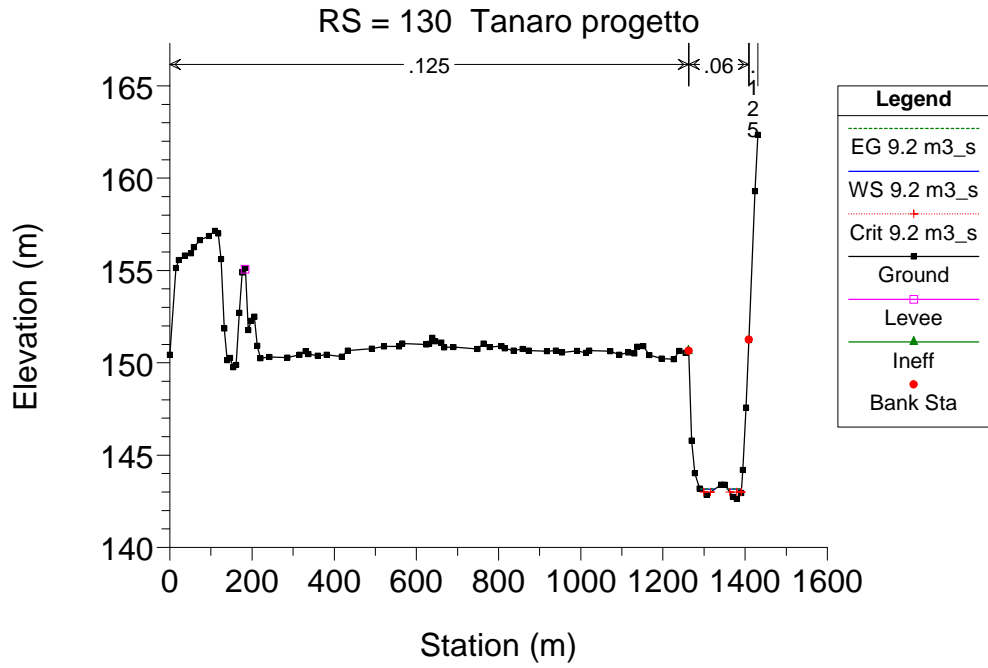


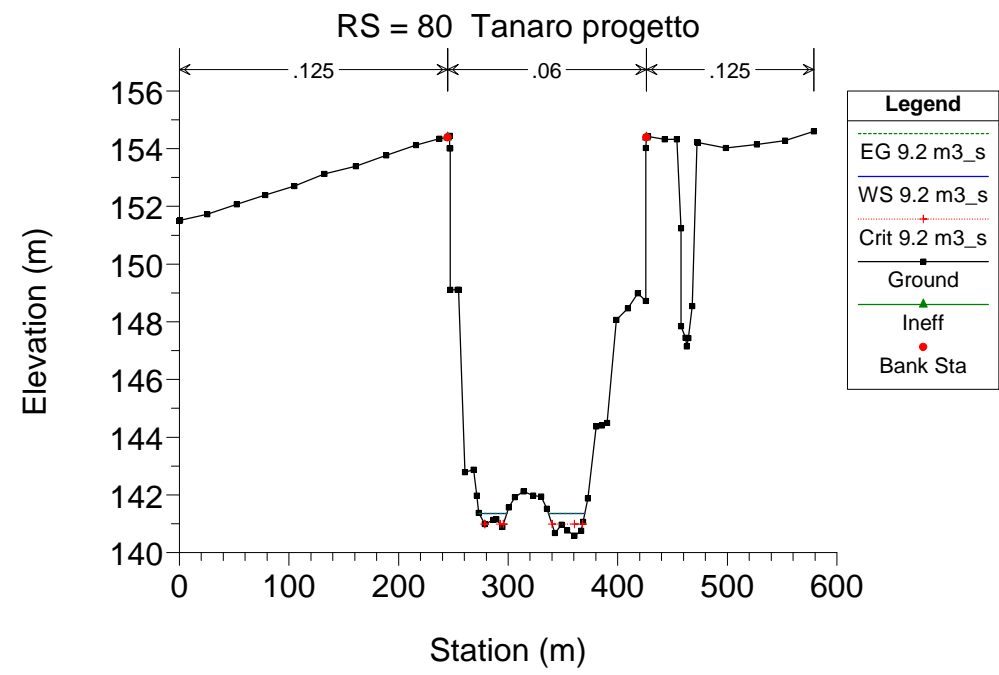
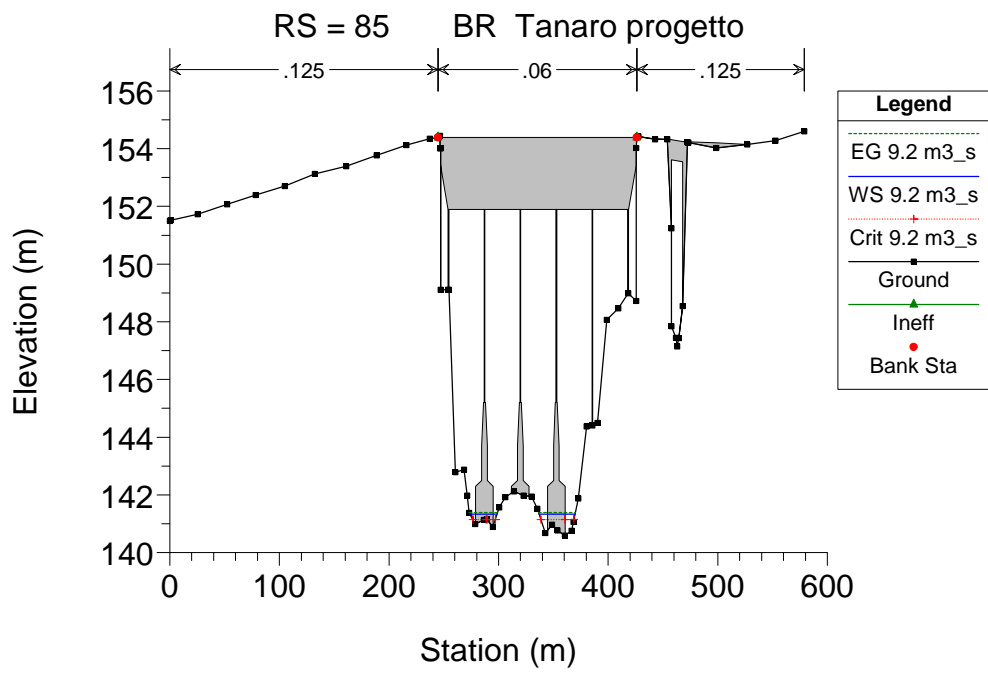
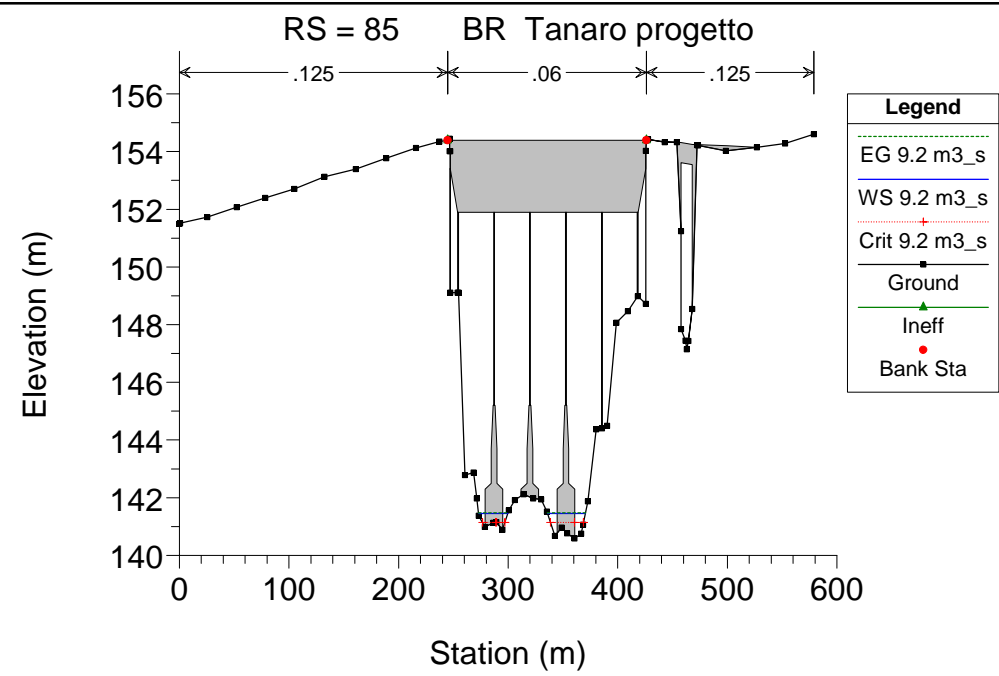
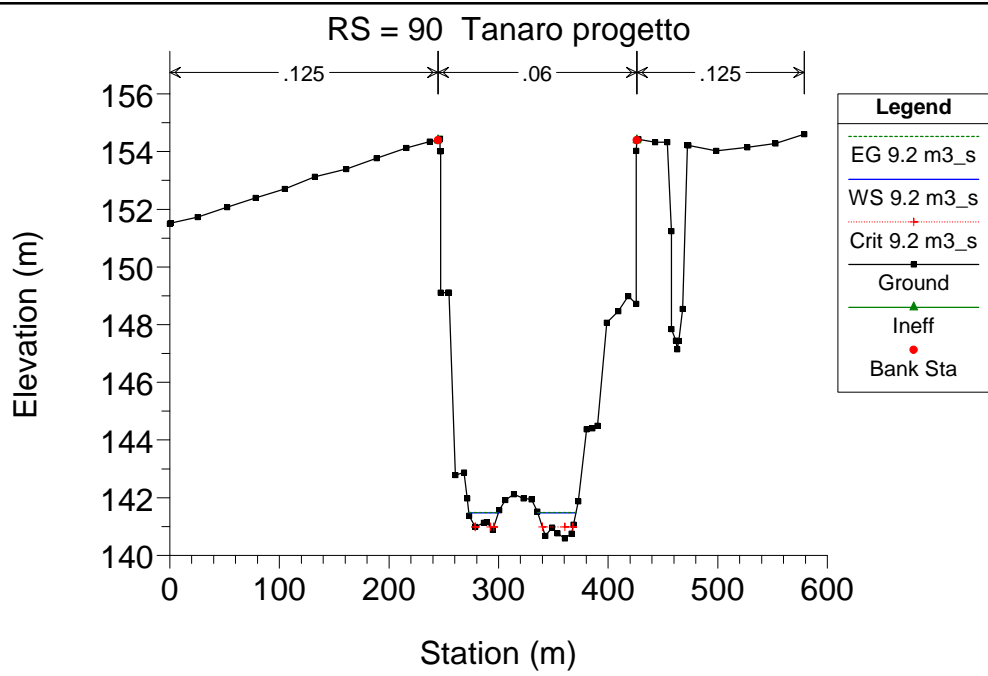


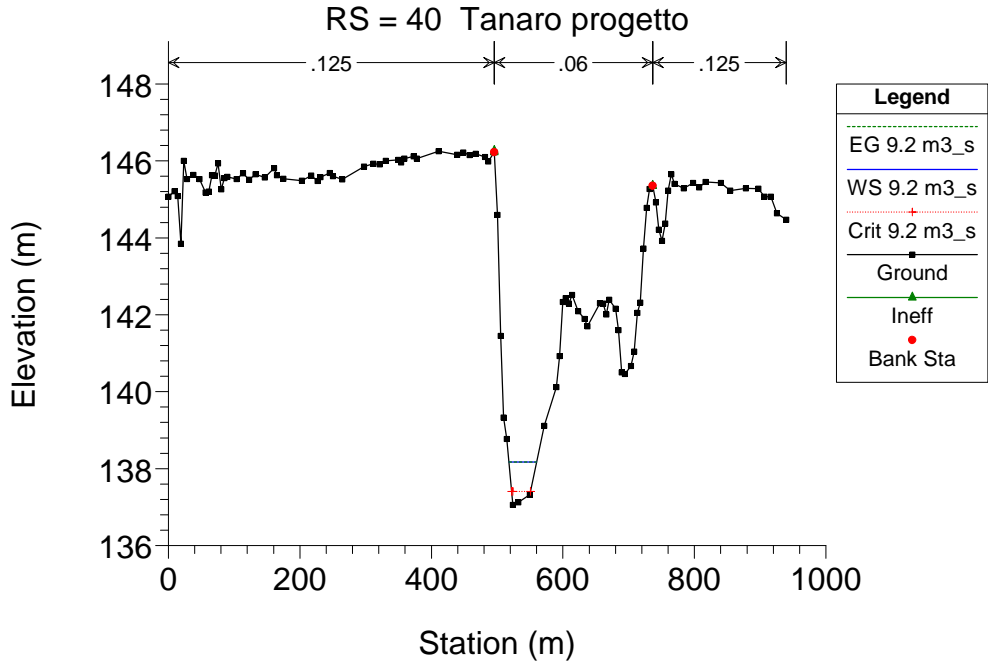
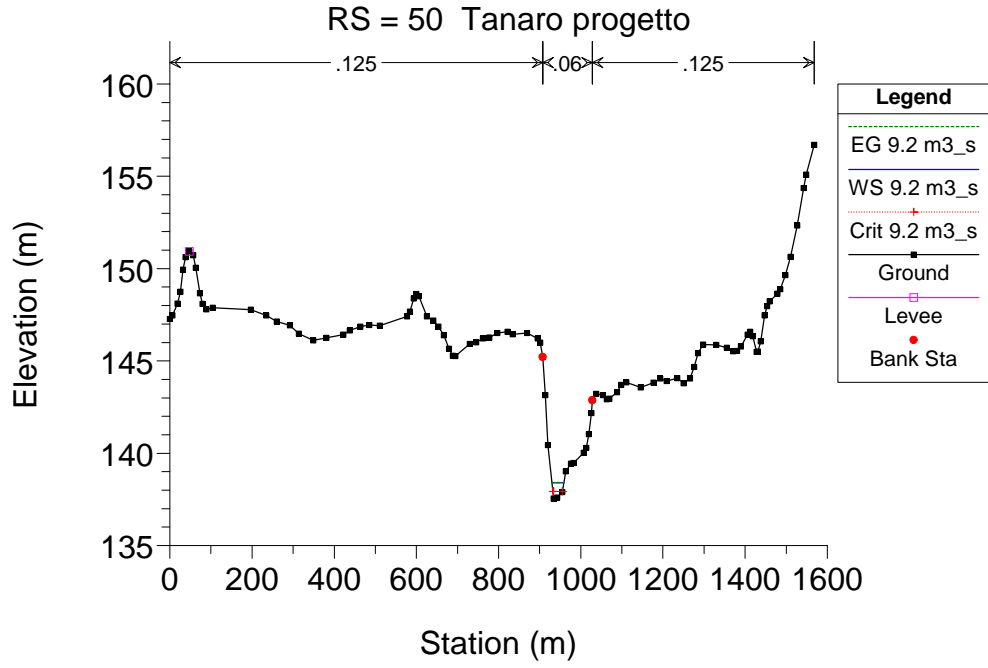
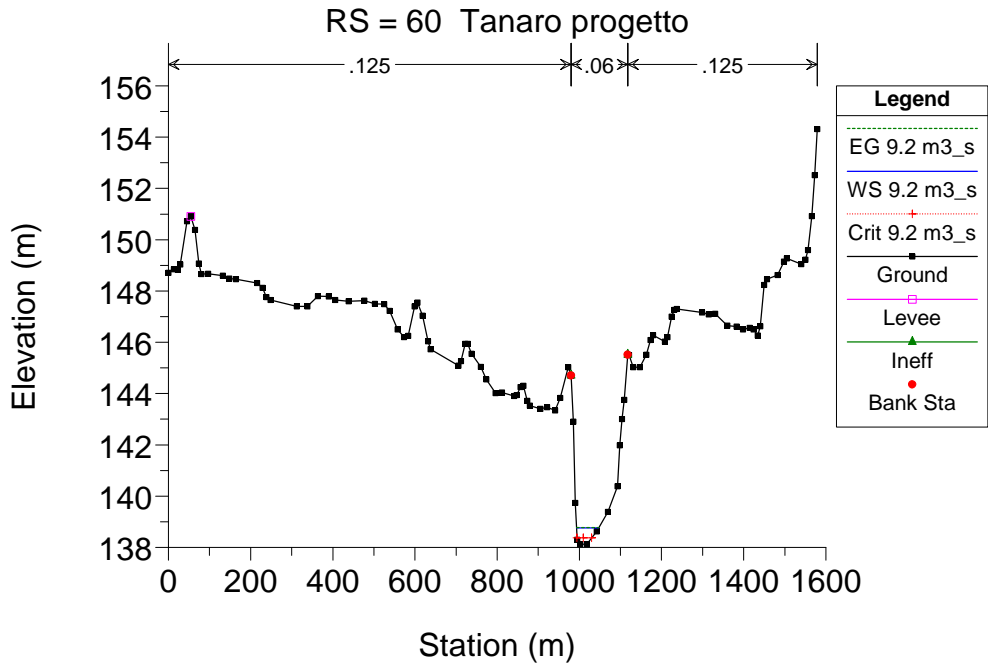
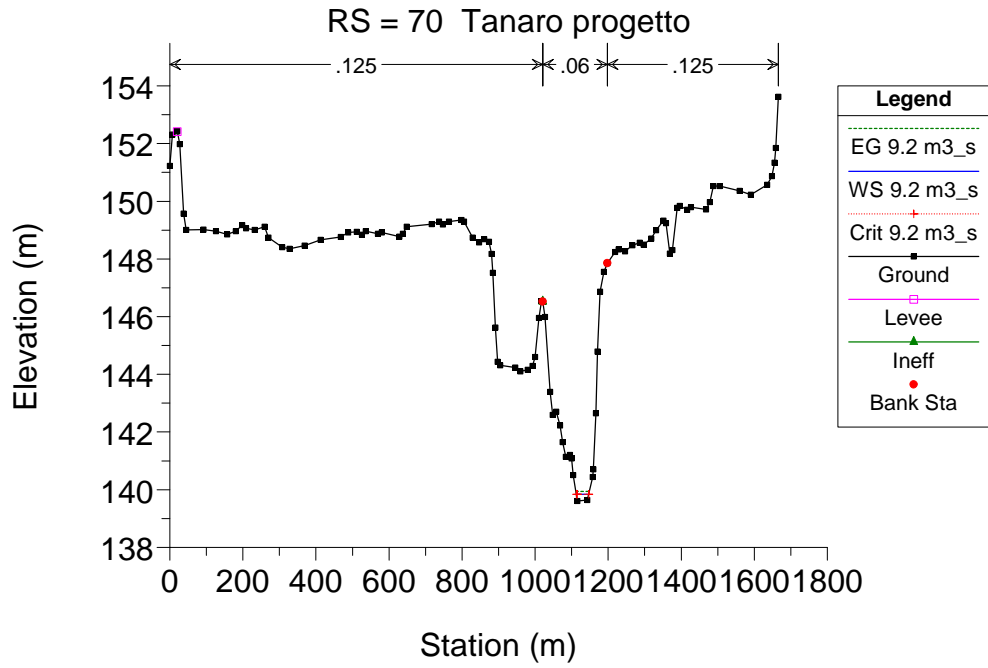


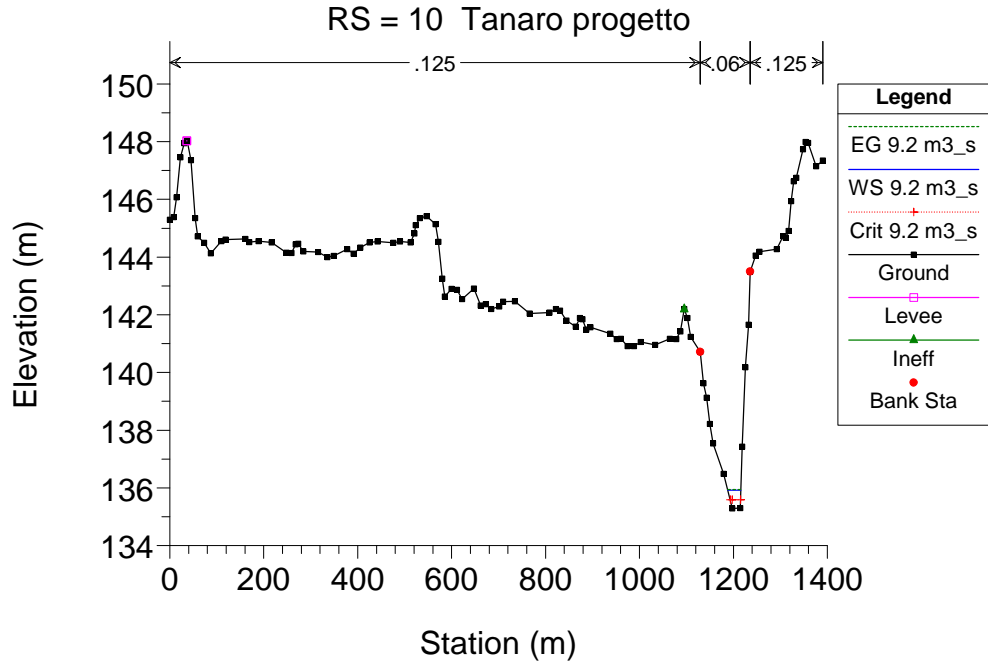
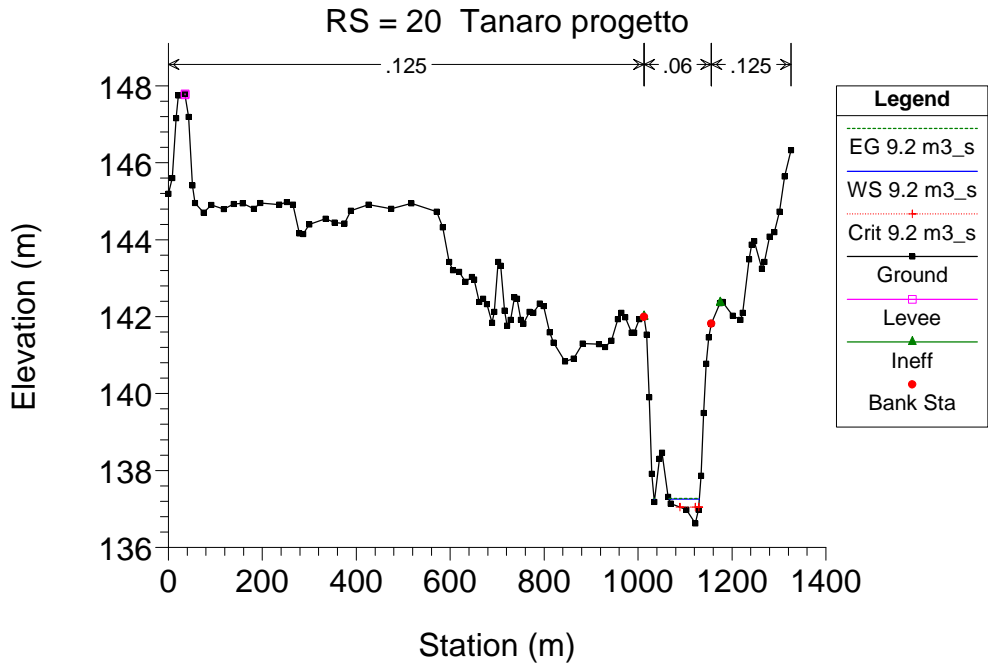
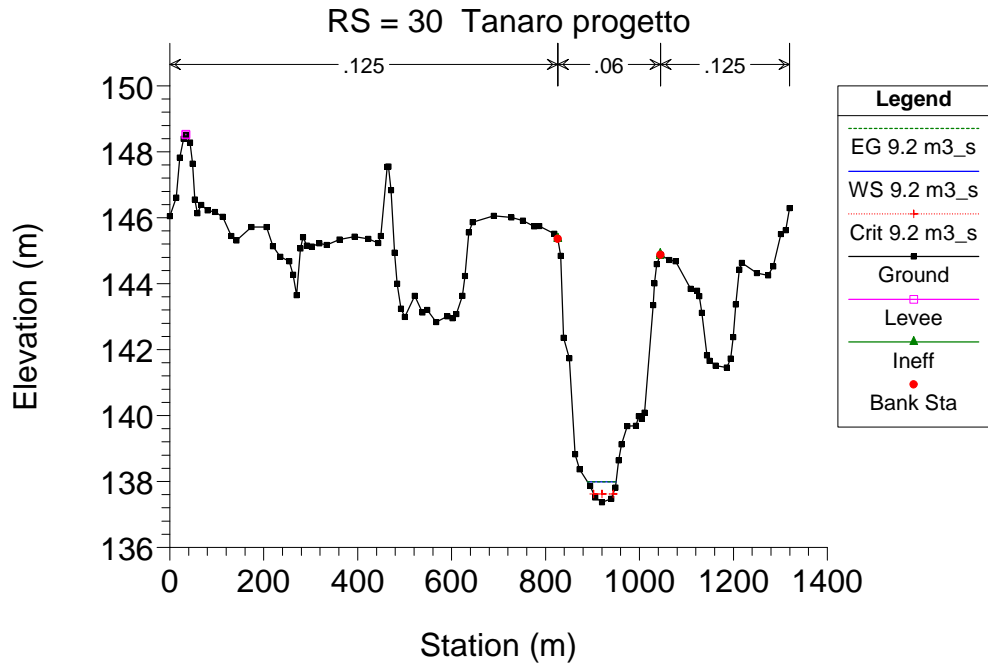












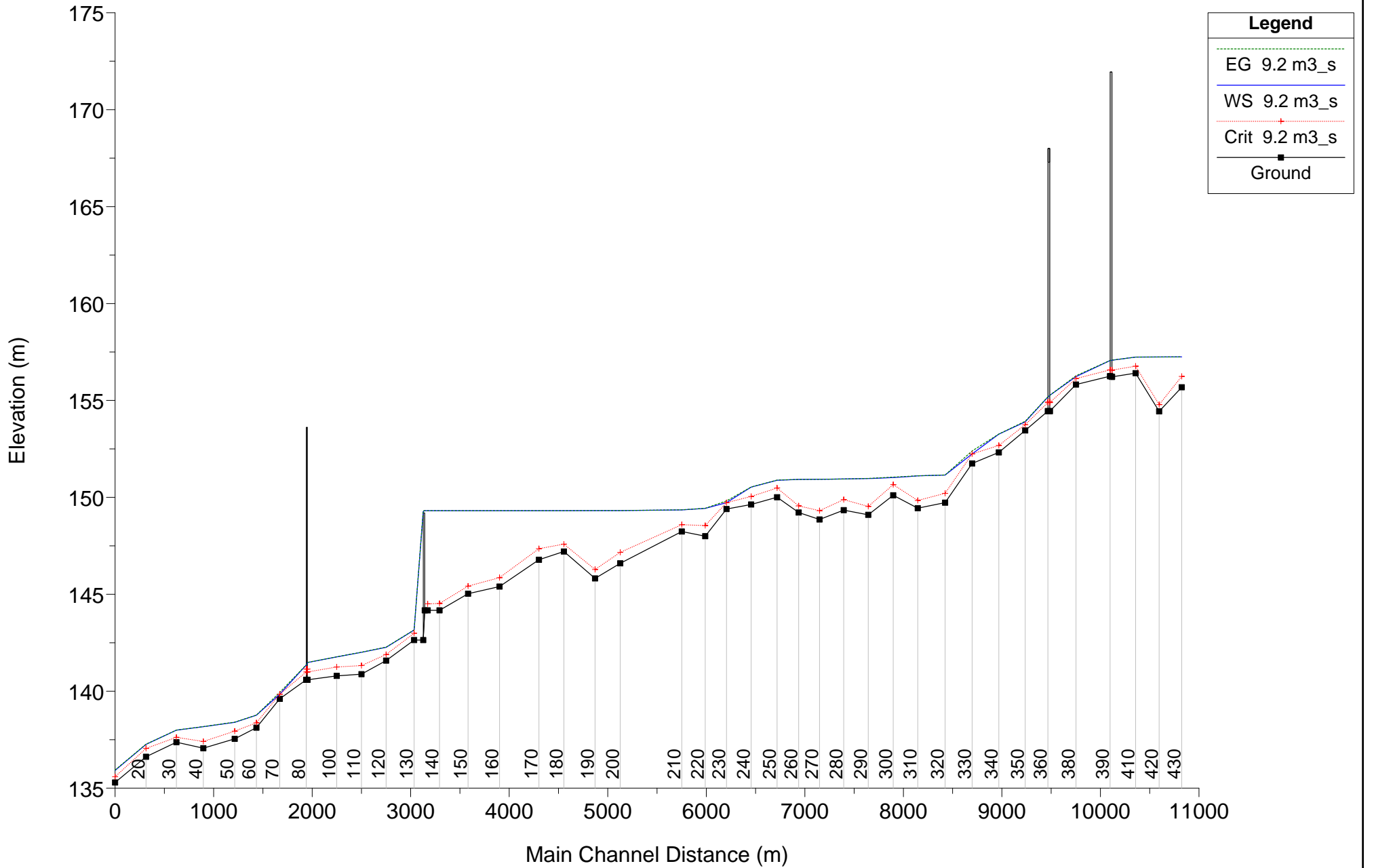
**SITUAZIONE DI PROGETTO (CON SBARRAMENTO MOBILE ALZATO)
SIMULAZIONE 9**

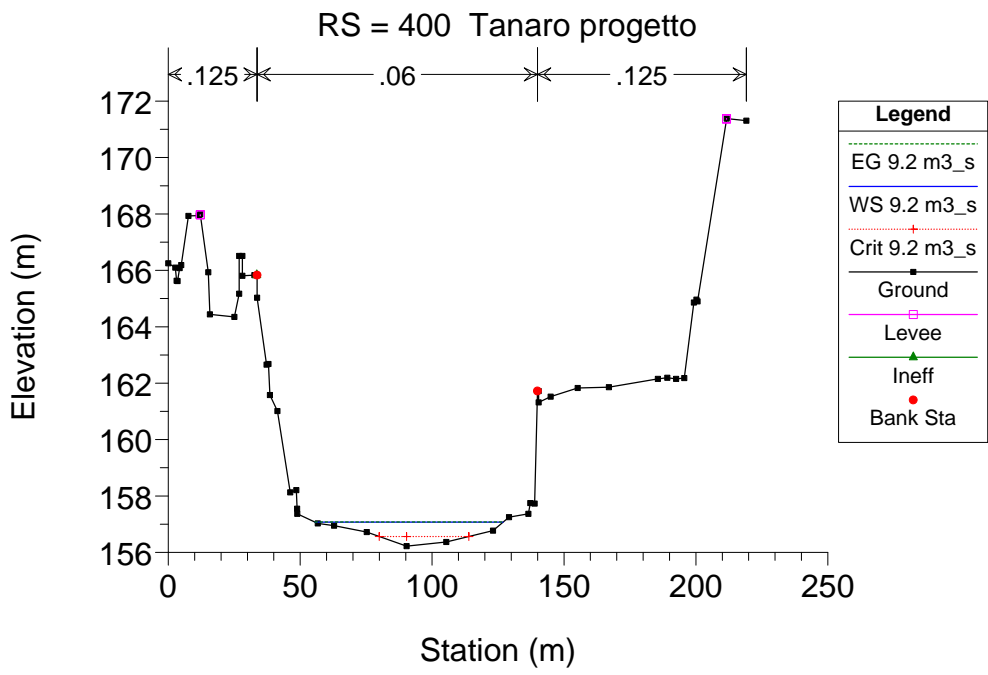
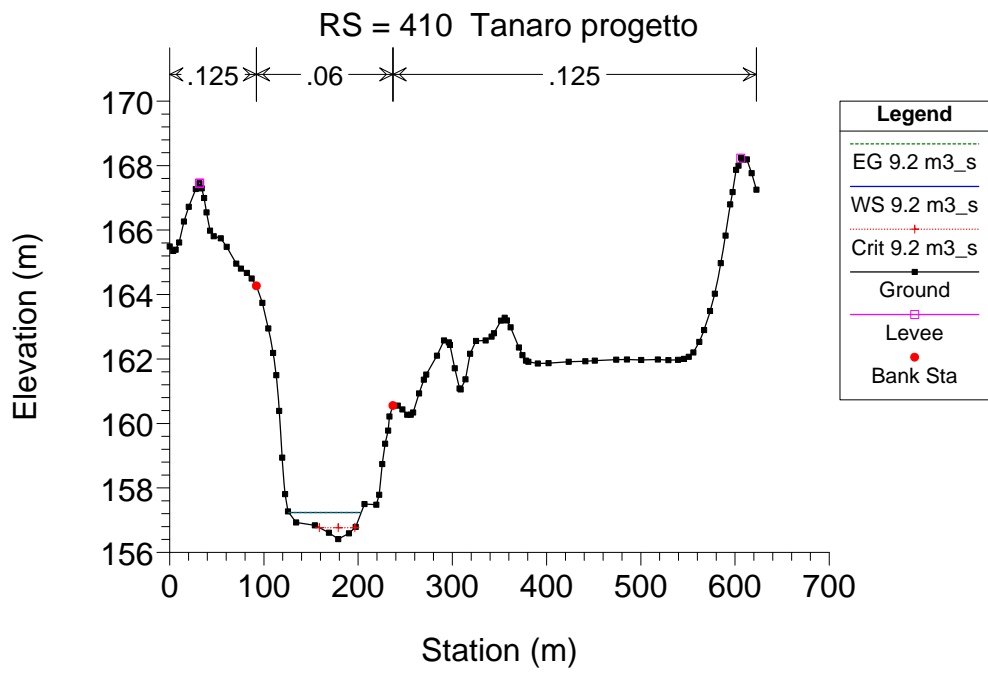
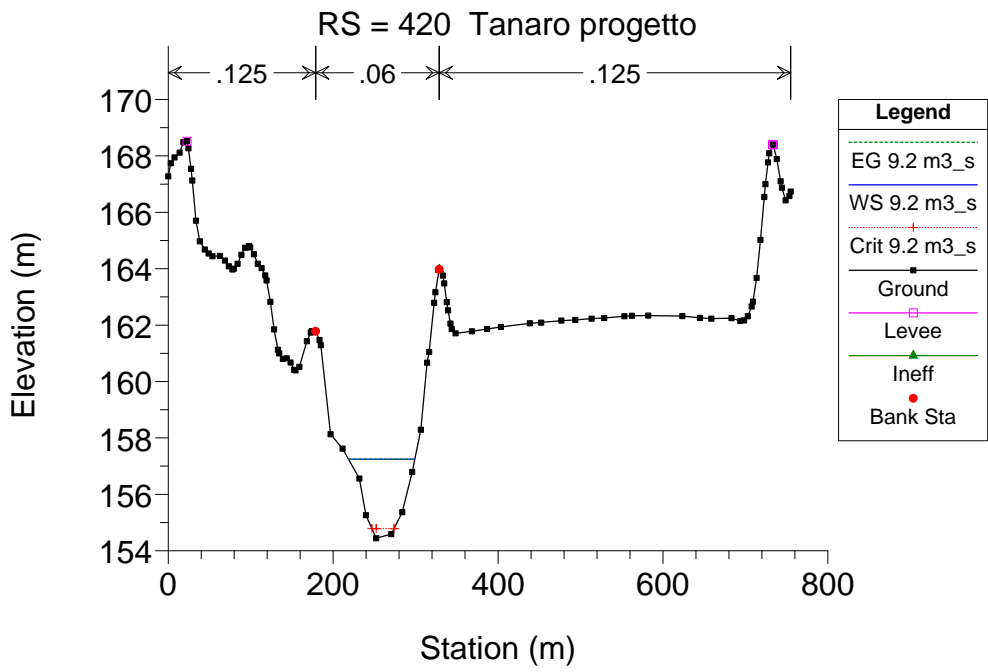
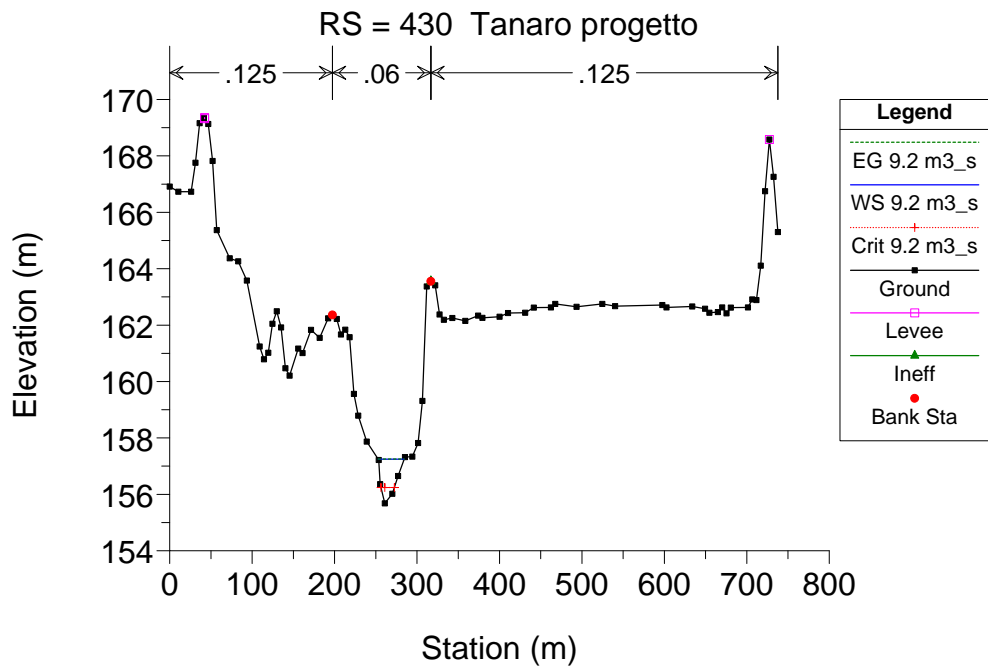
Corso d'acqua	Portata Q m³/s	Portata
Fiume Tanaro	9.2 (in alveo) 0.7 (derivati per alimentazione canale)	Minima per la derivazione ad uso irriguo

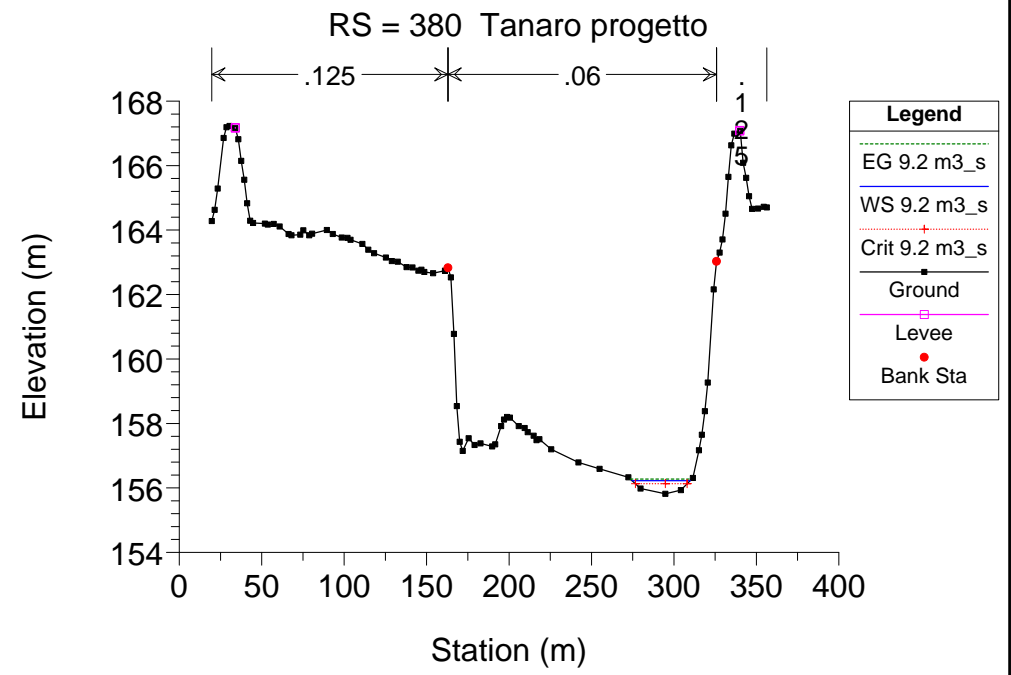
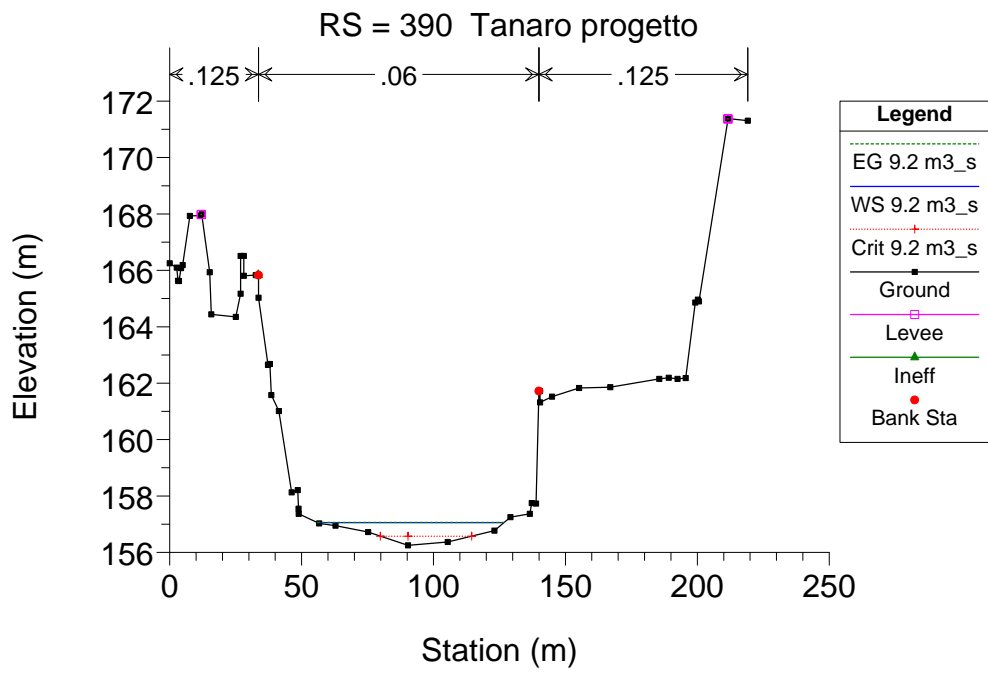
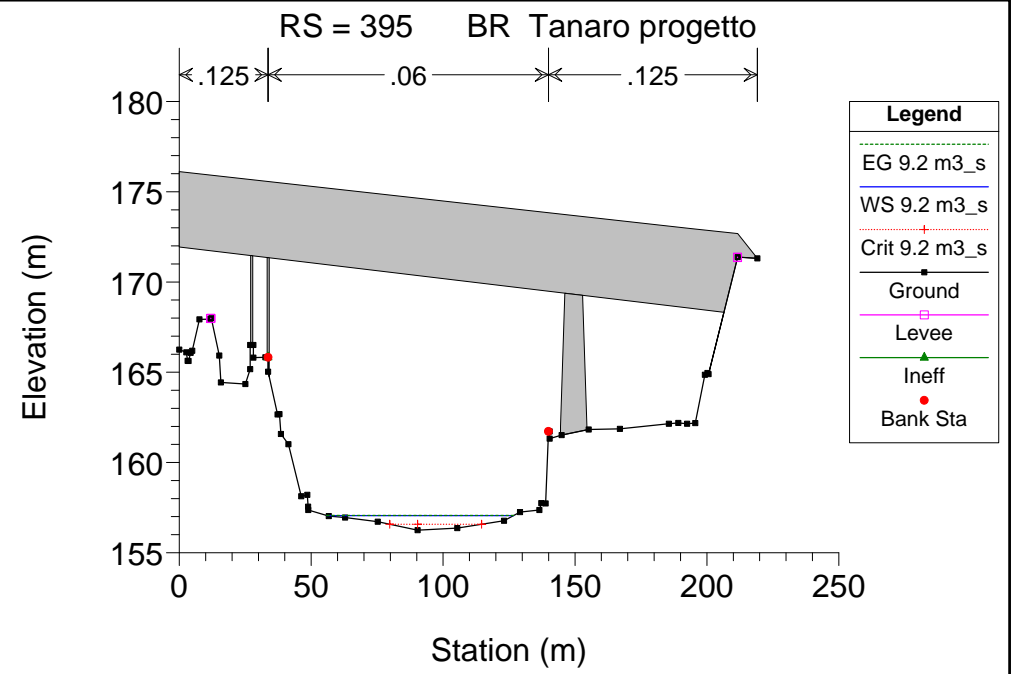
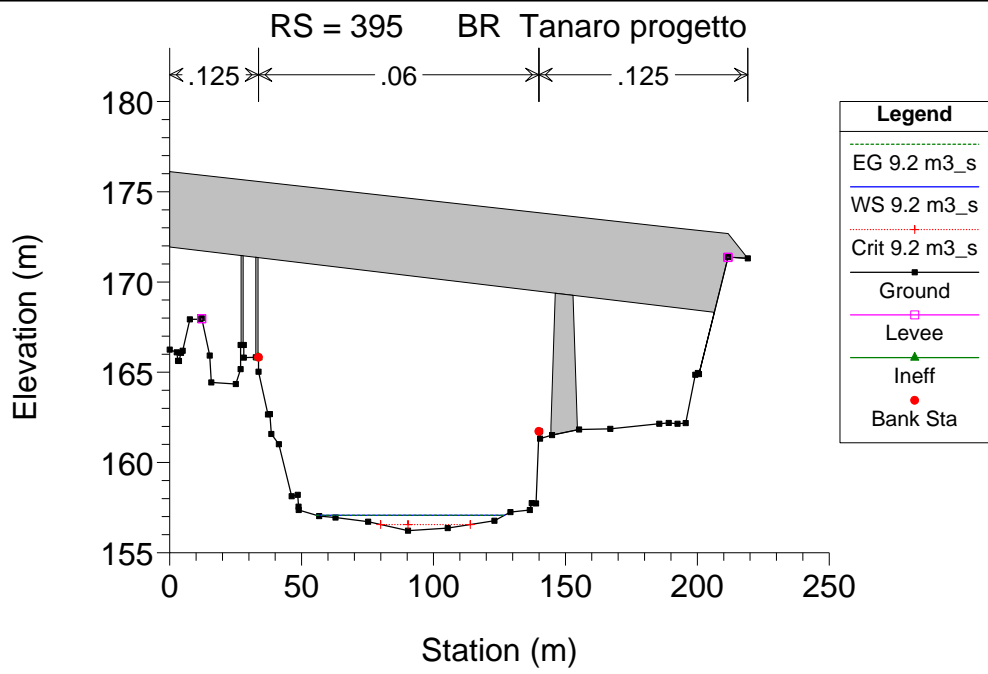
HEC-RAS Plan: Plan 06 River: Tanaro Reach: 1 Profile: 9.2 m3_s (Continued)

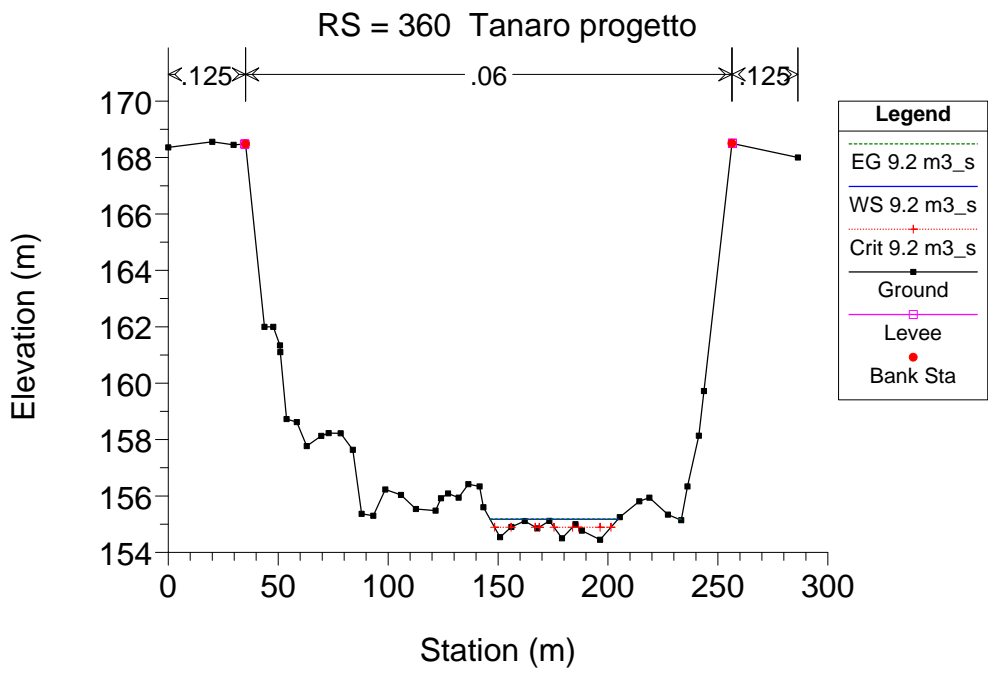
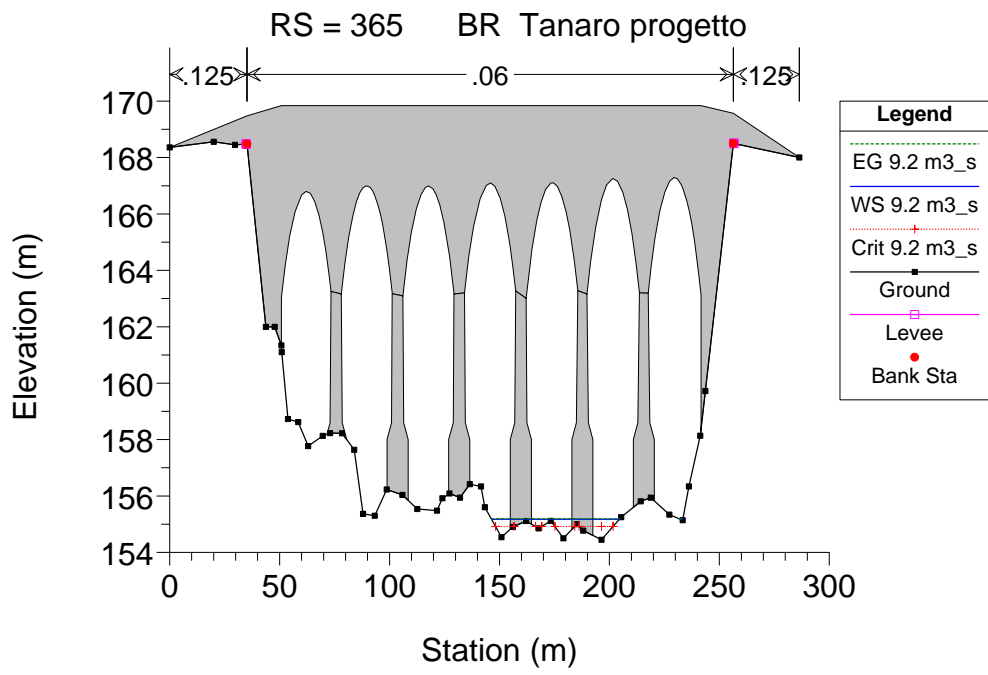
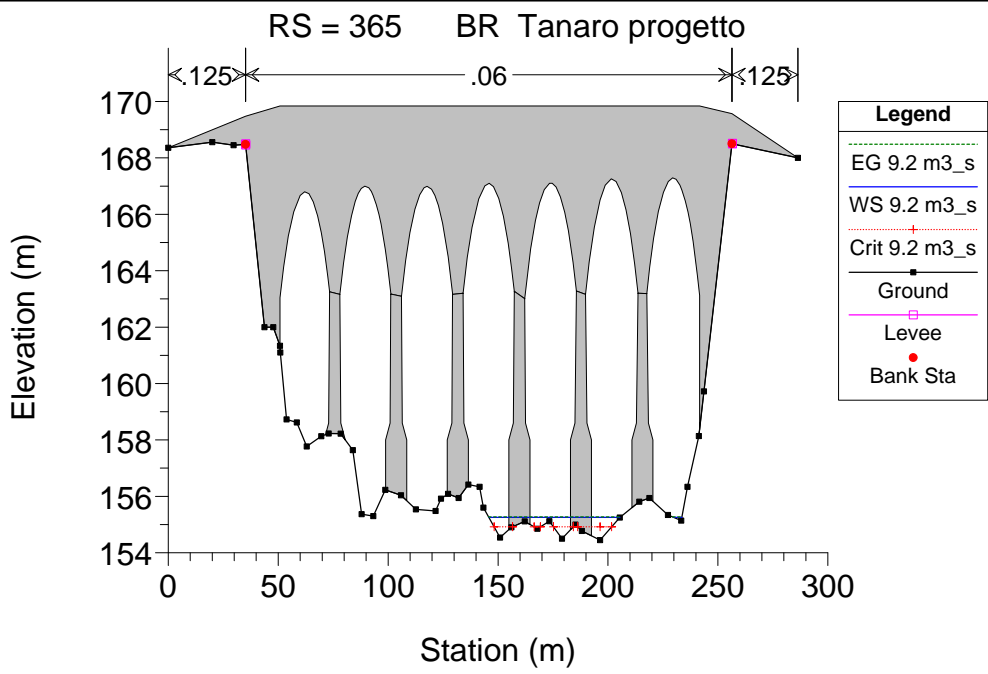
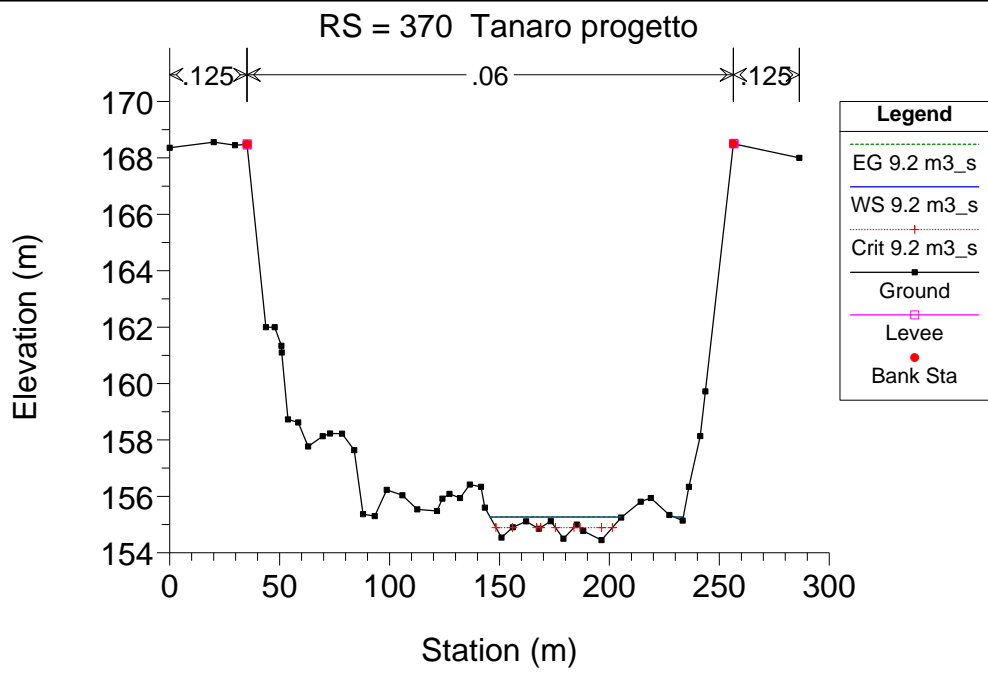
Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
1	80	9.2 m3_s	8.50	140.59	141.33	140.98	141.34	0.001766	0.38	22.64	57.53	0.19
1	70	9.2 m3_s	8.50	139.61	139.83	139.83	139.92	0.060997	1.35	6.30	33.61	0.99
1	60	9.2 m3_s	8.50	138.12	138.73	138.36	138.74	0.001498	0.37	22.95	52.69	0.18
1	50	9.2 m3_s	8.50	137.54	138.36	137.92	138.37	0.001905	0.51	16.70	28.39	0.21
1	40	9.2 m3_s	8.50	137.06	138.14	137.39	138.15	0.000357	0.26	32.11	41.54	0.10
1	30	9.2 m3_s	8.50	137.37	137.97	137.61	137.97	0.001401	0.34	24.64	59.90	0.17
1	20	9.2 m3_s	8.50	136.62	137.24	137.04	137.25	0.004595	0.48	17.82	64.87	0.29
1	10	9.2 m3_s	8.50	135.29	135.89	135.57	135.91	0.004002	0.64	13.19	27.43	0.30

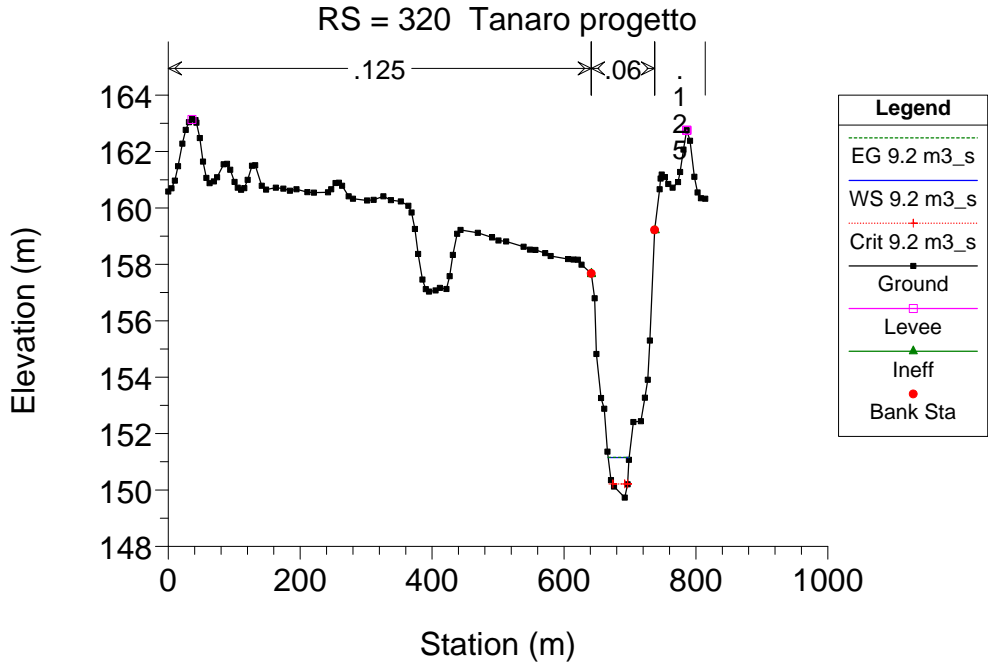
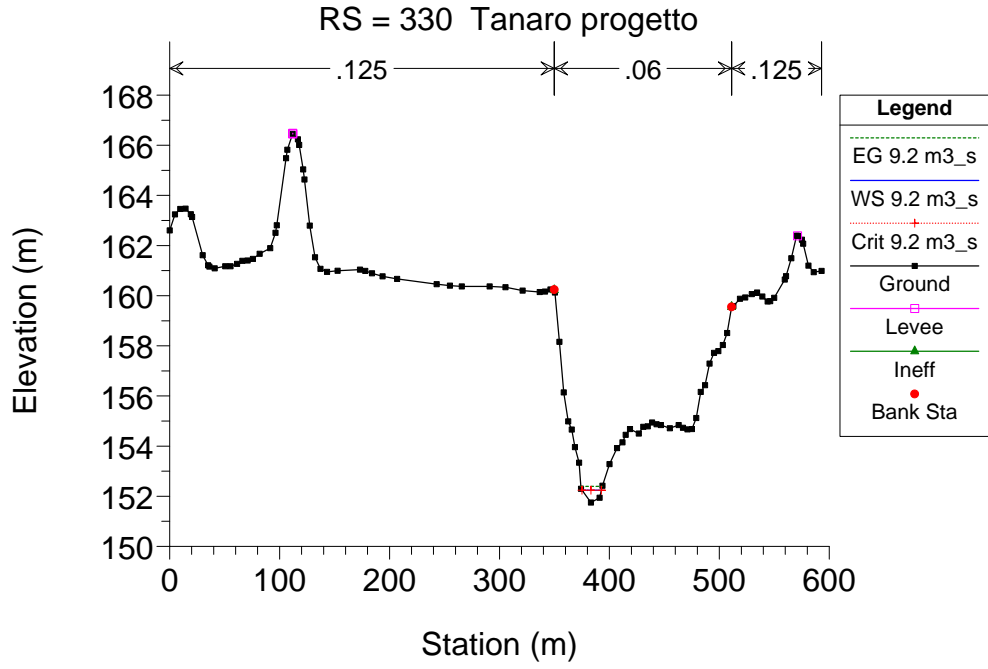
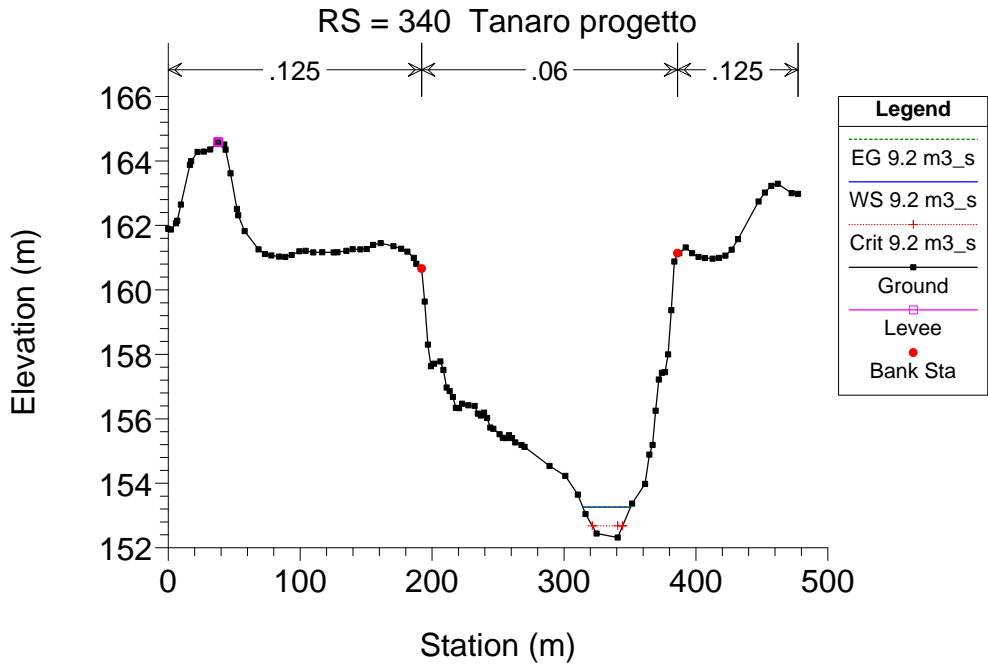
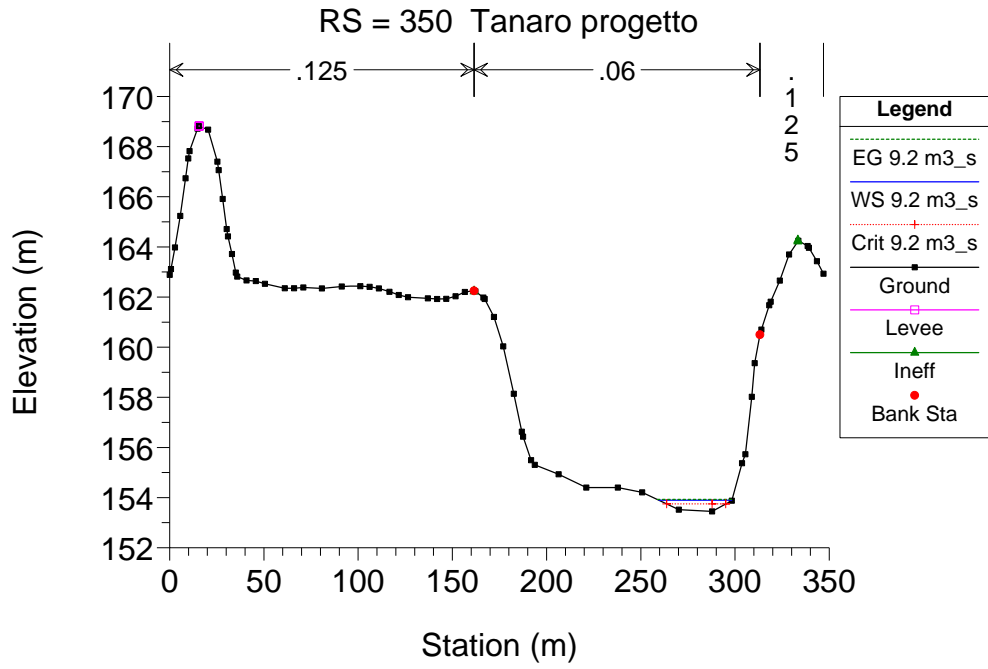
Tanaro progetto

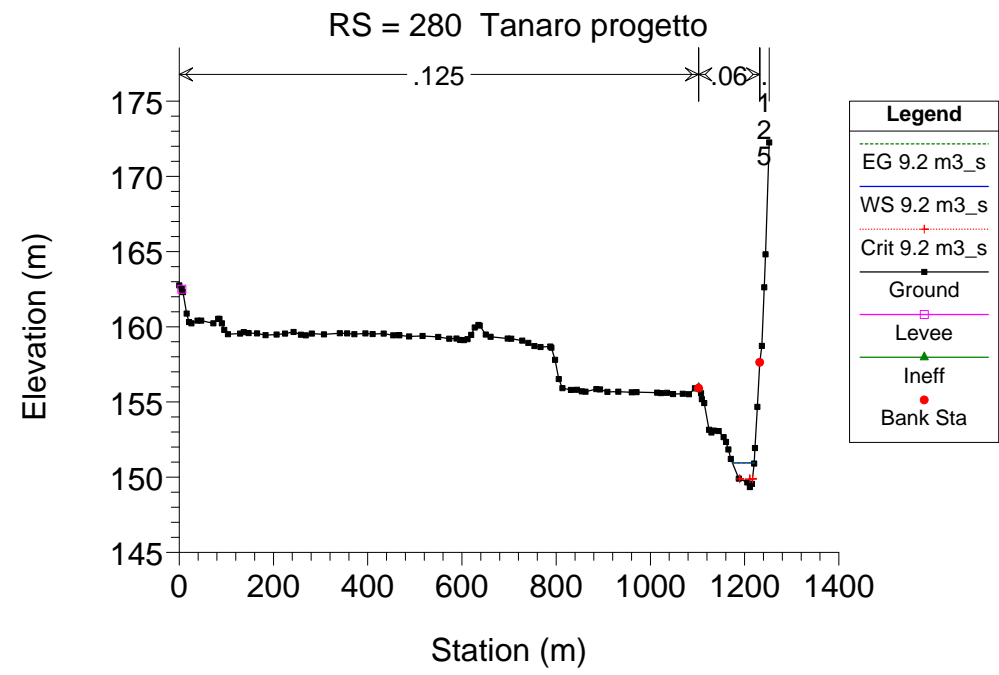
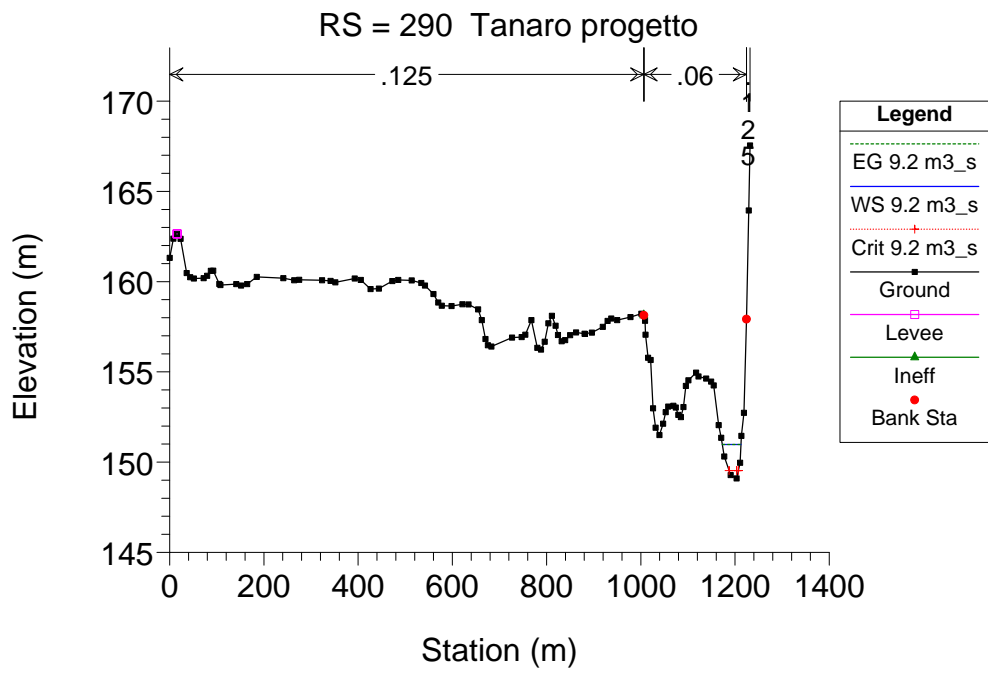
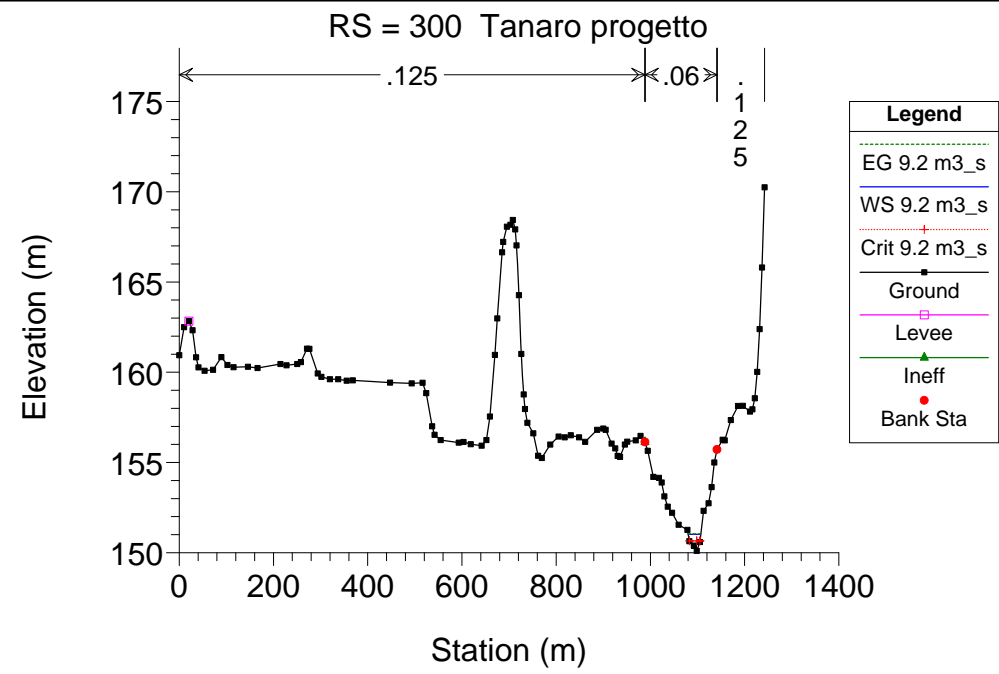
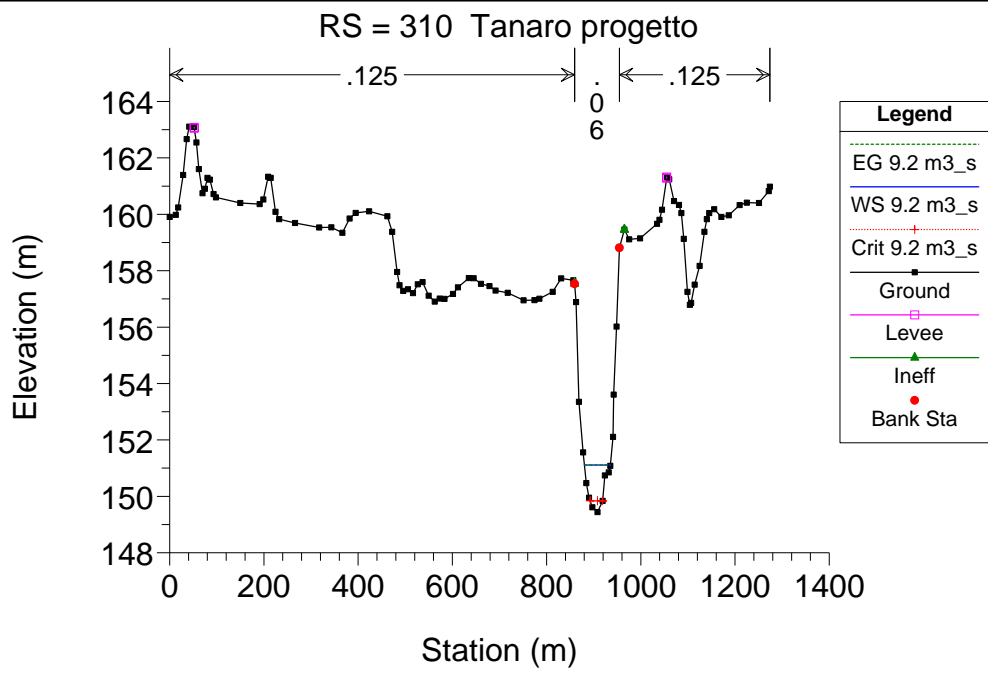


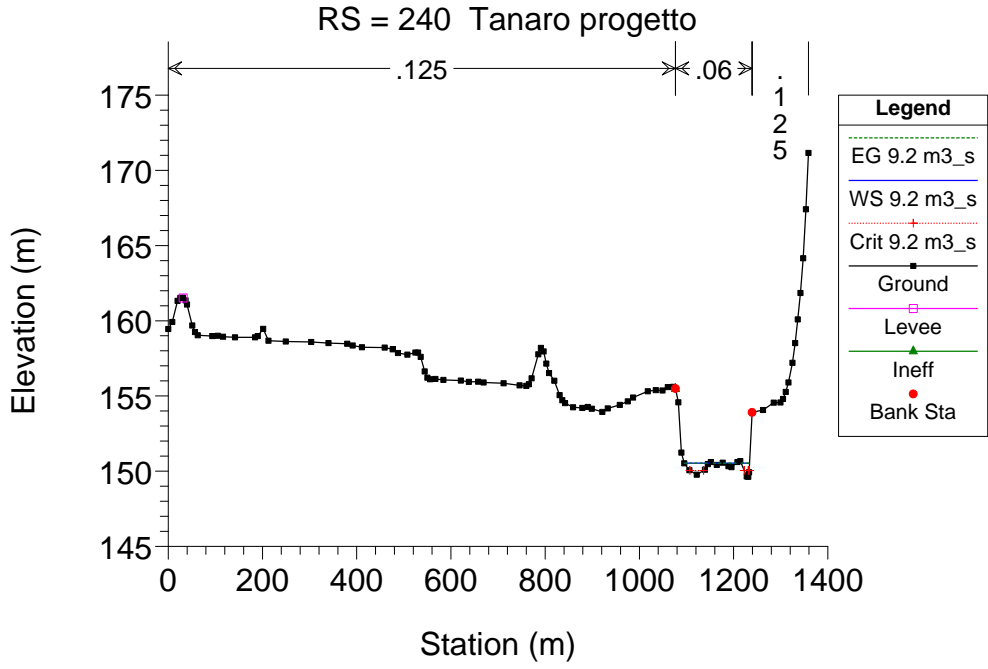
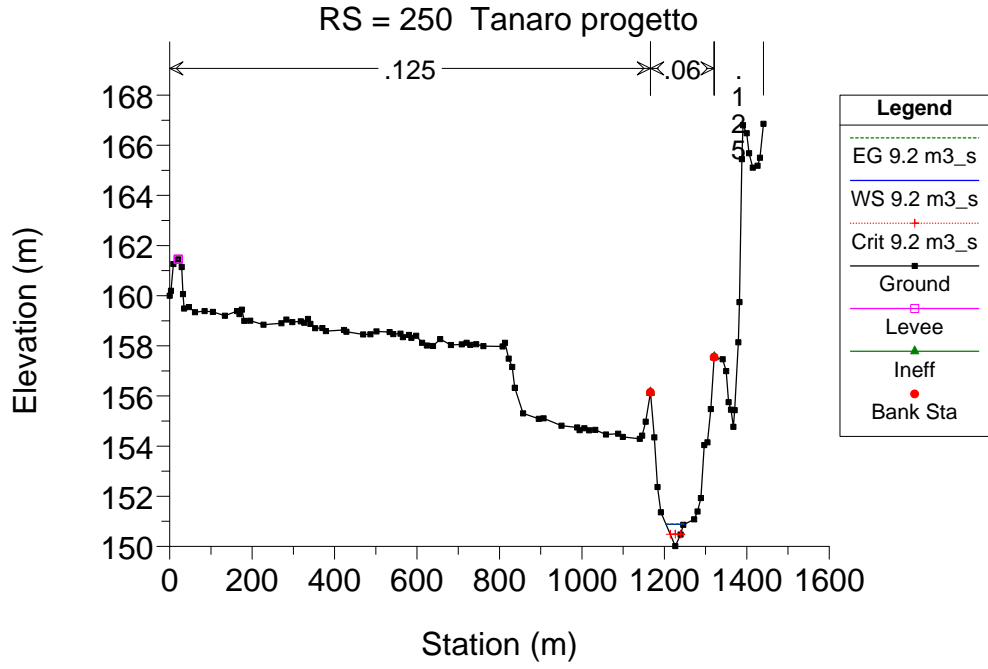
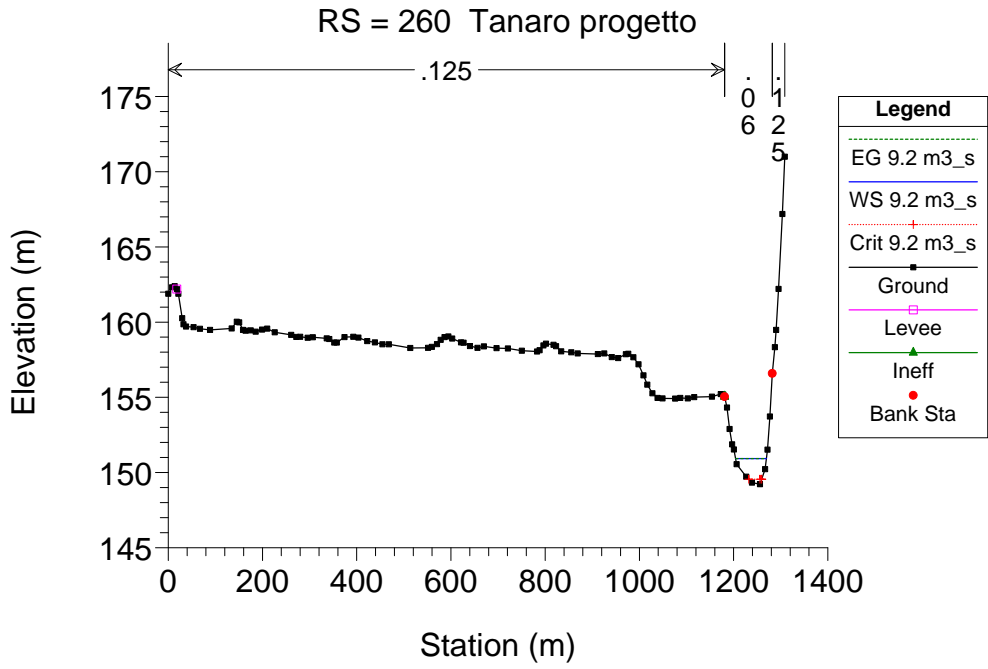
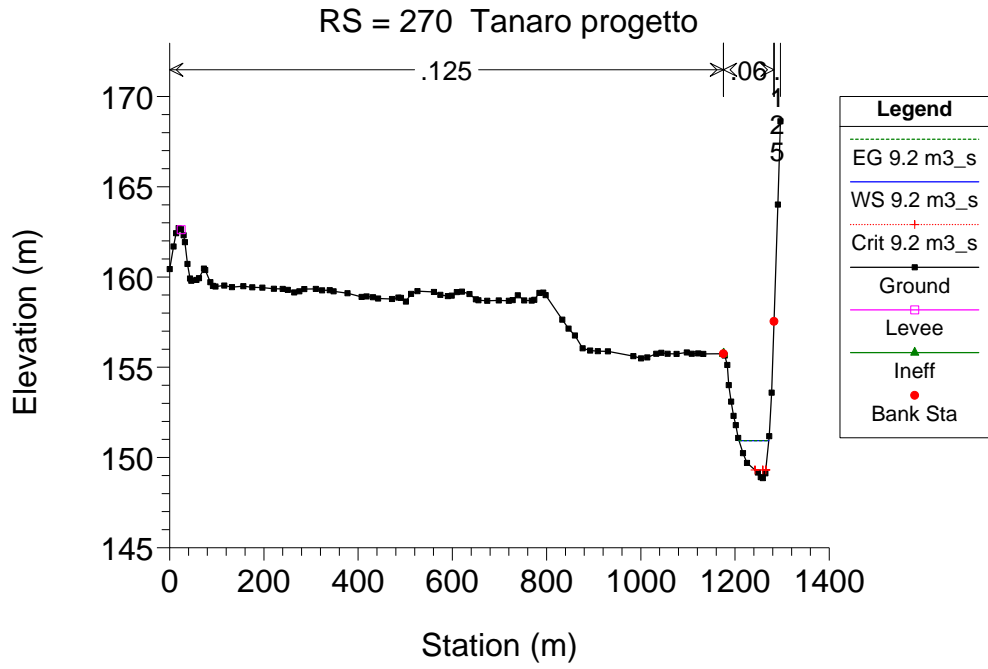


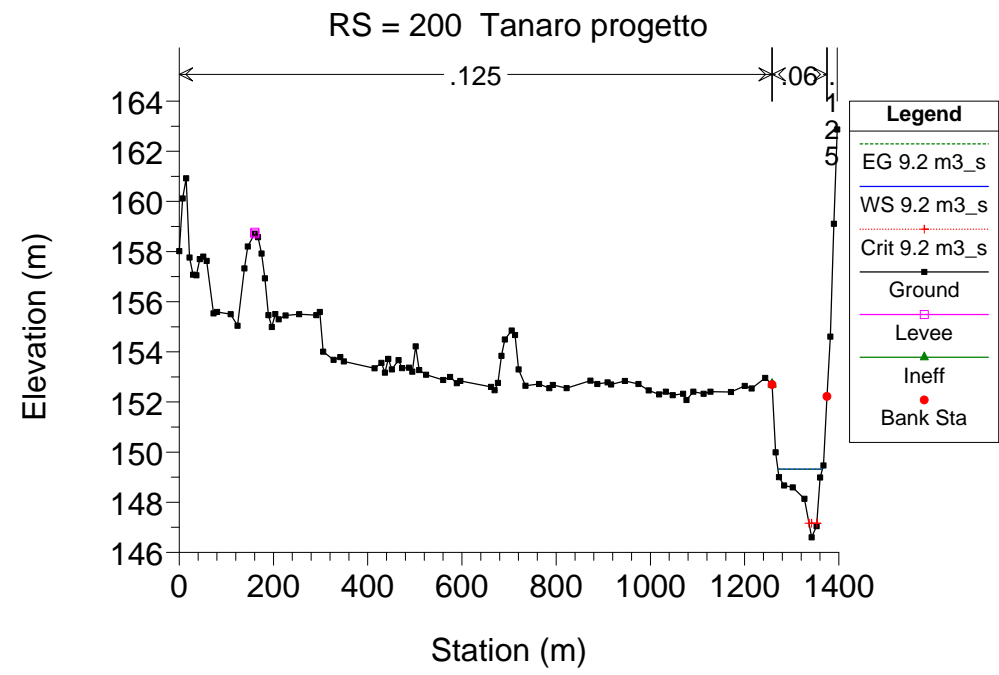
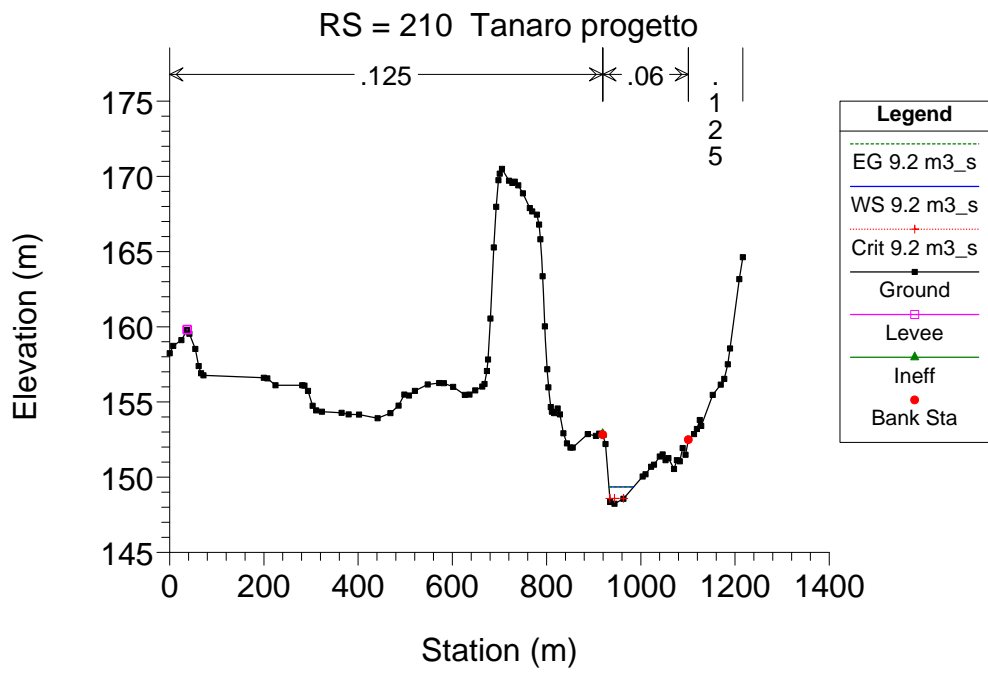
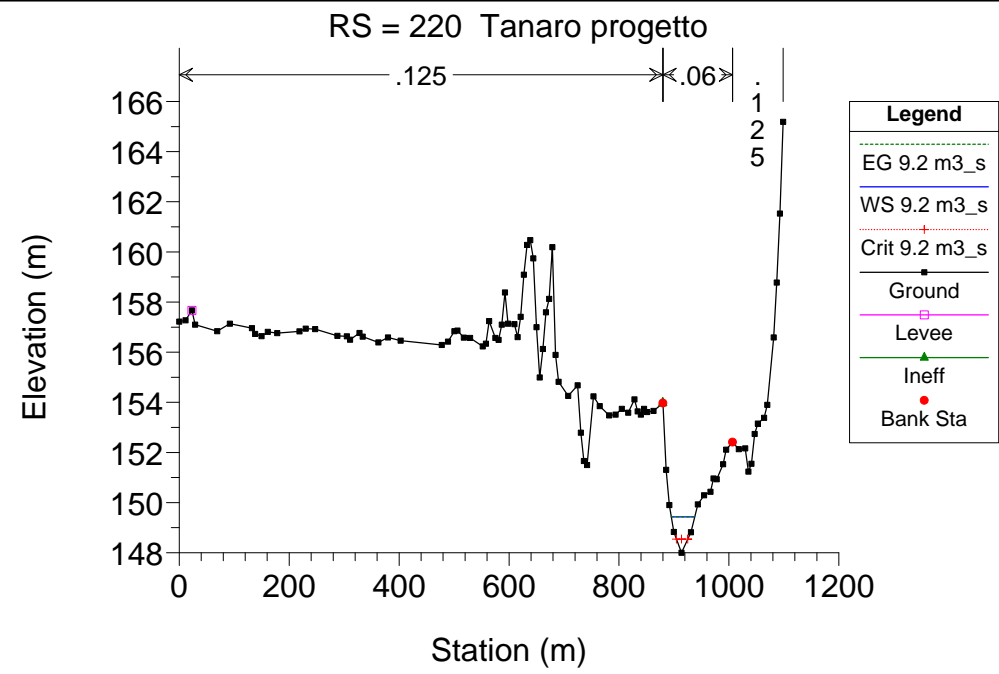
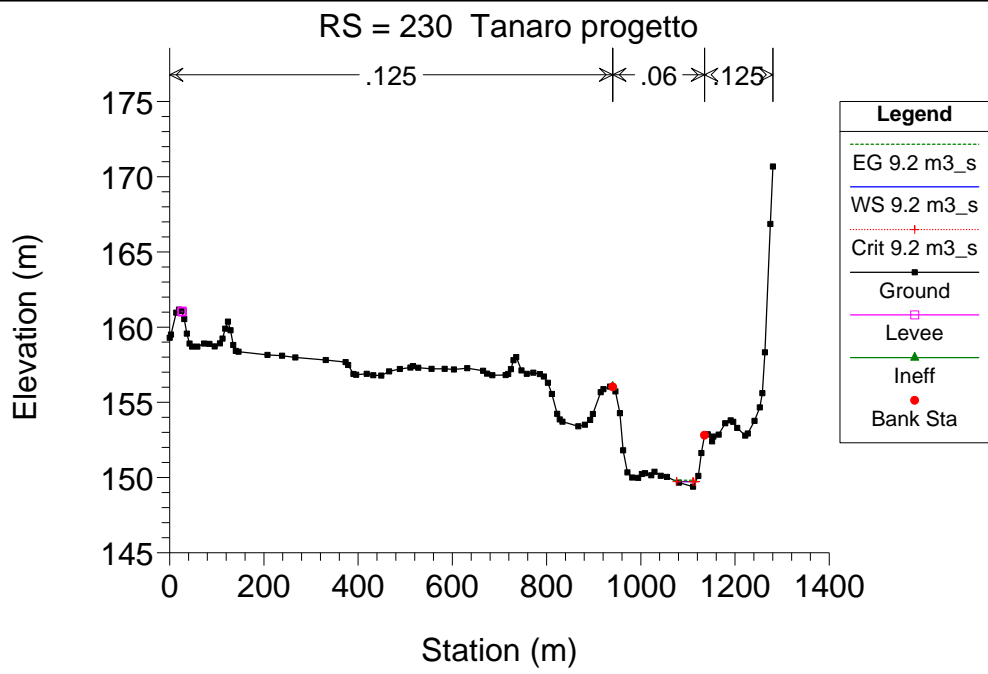


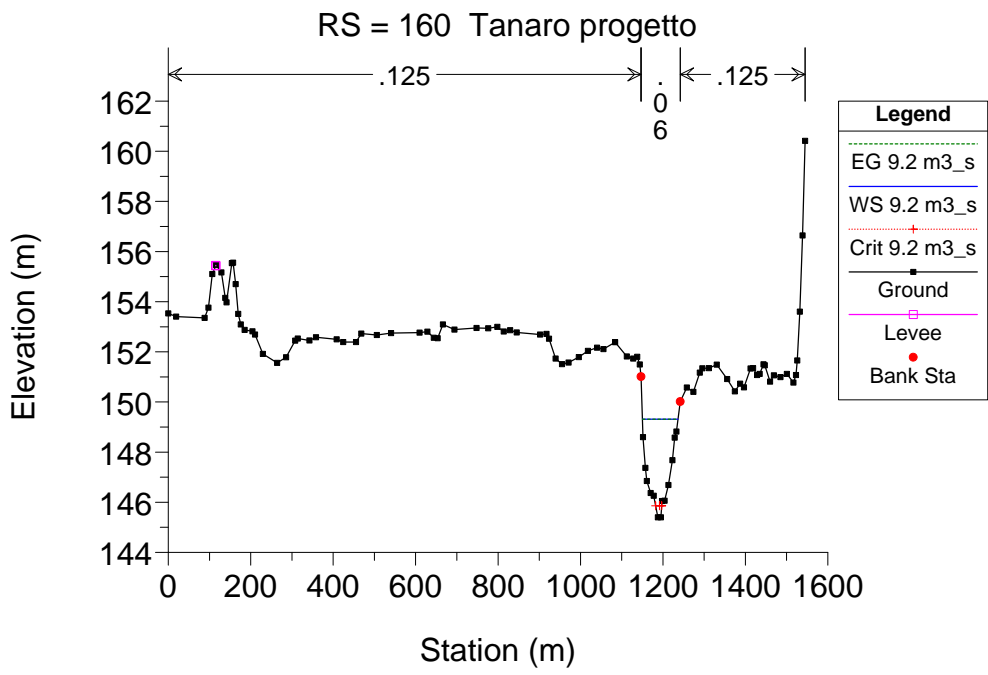
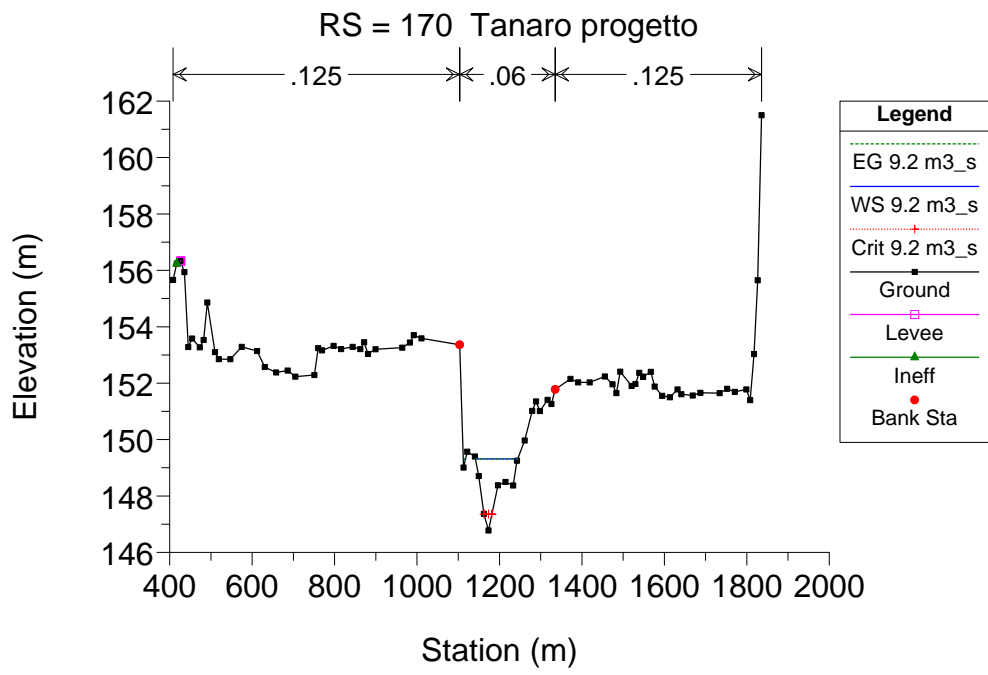
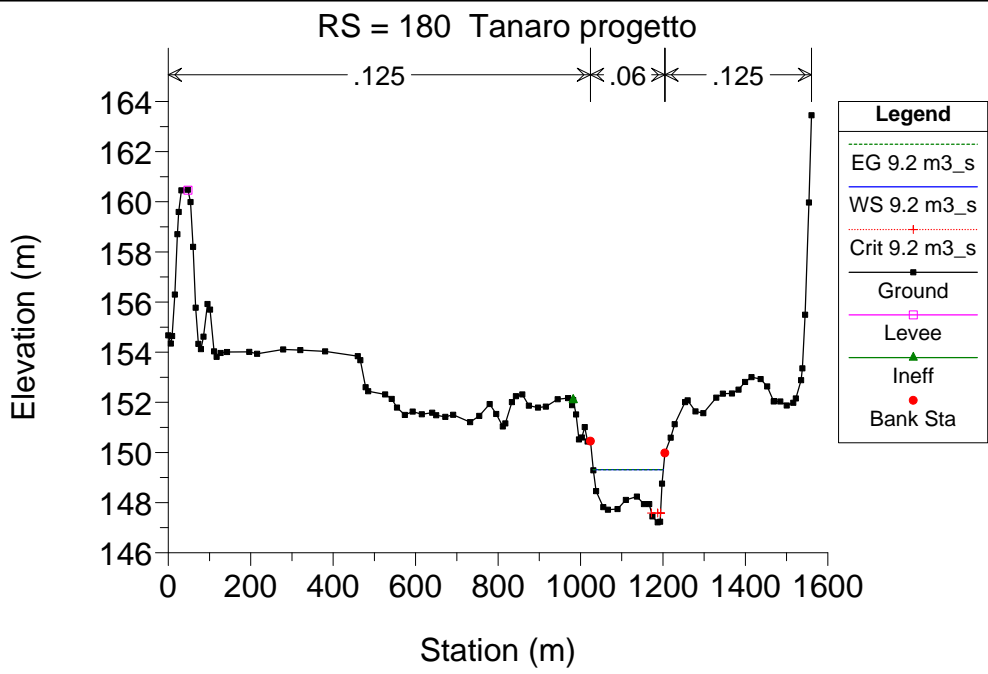
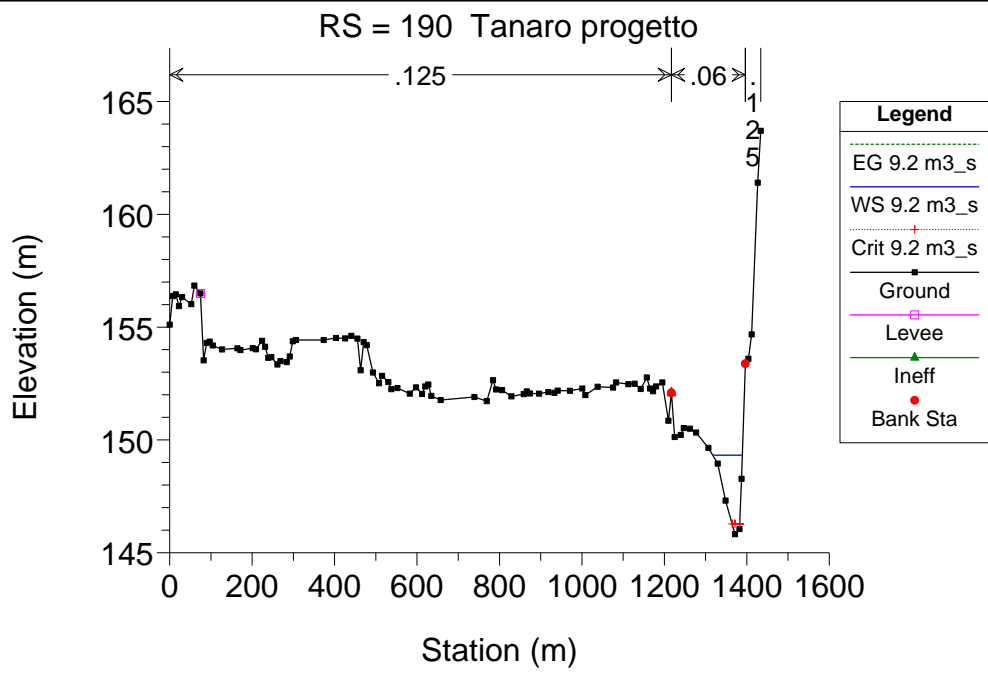


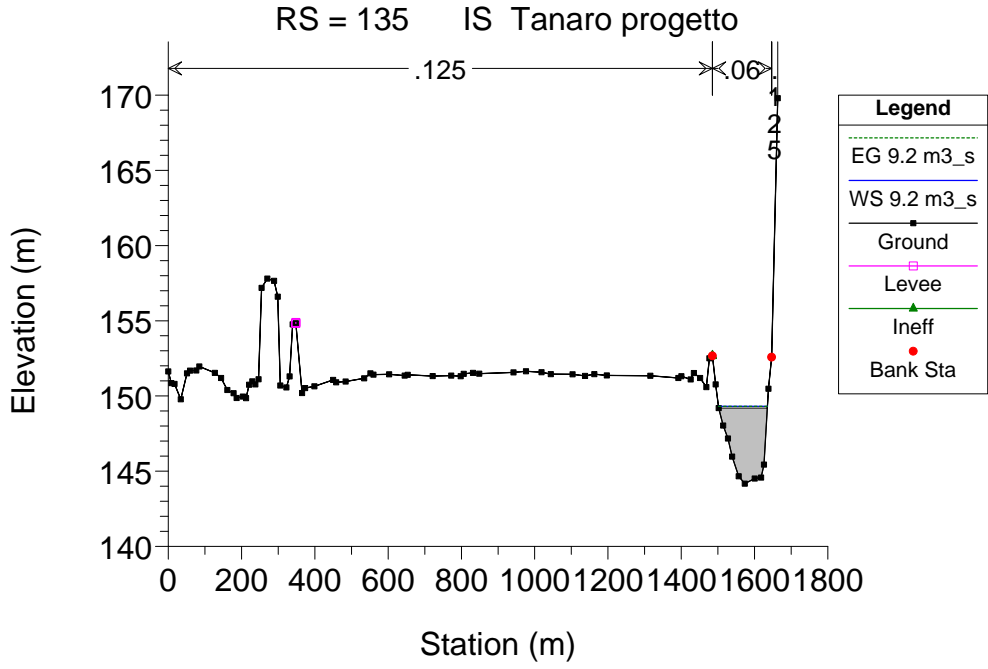
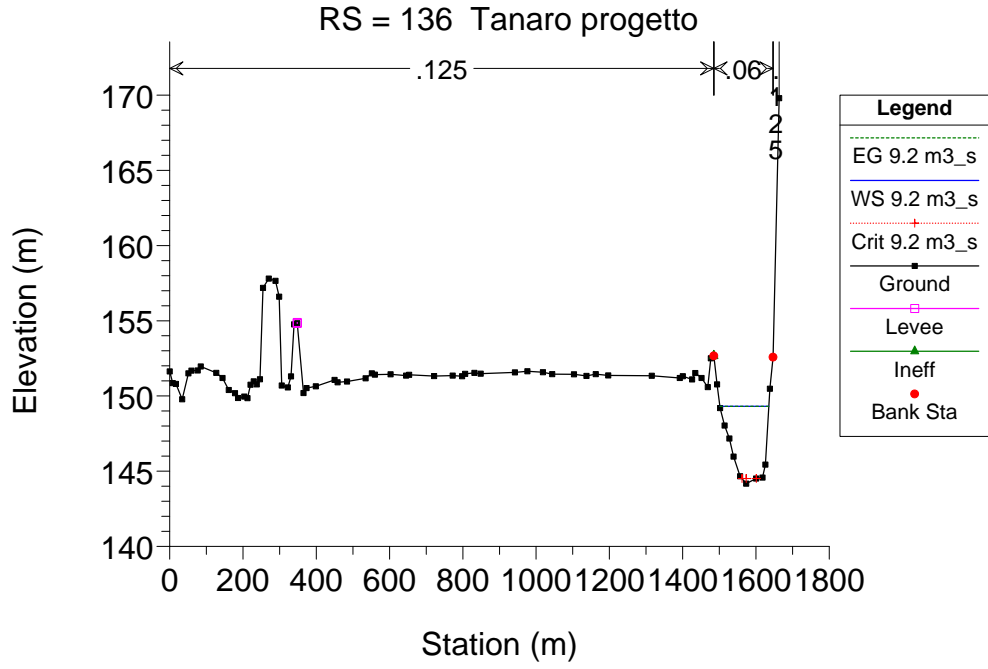
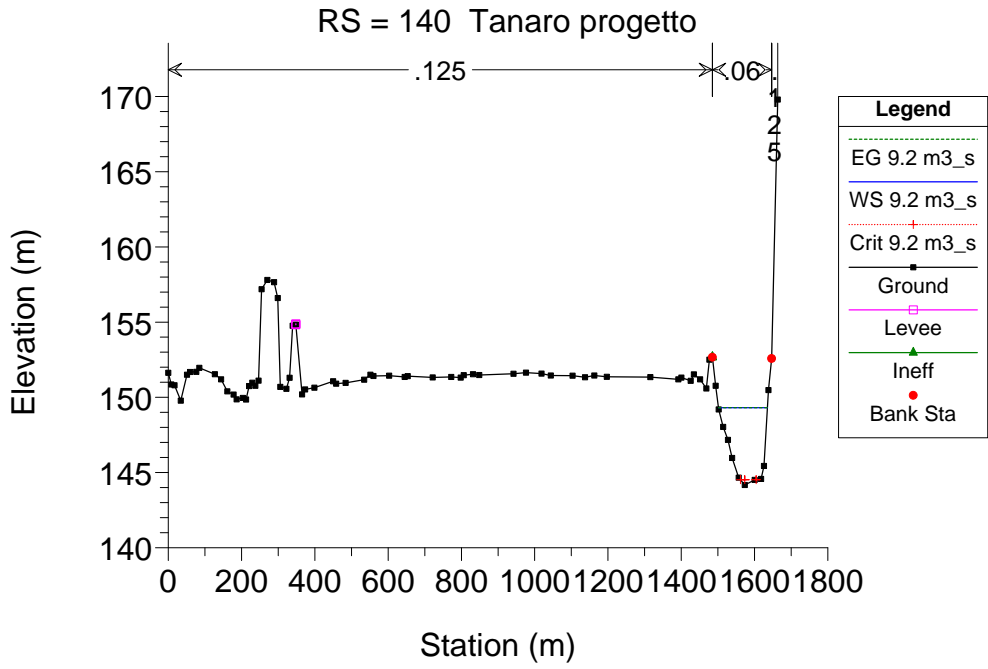
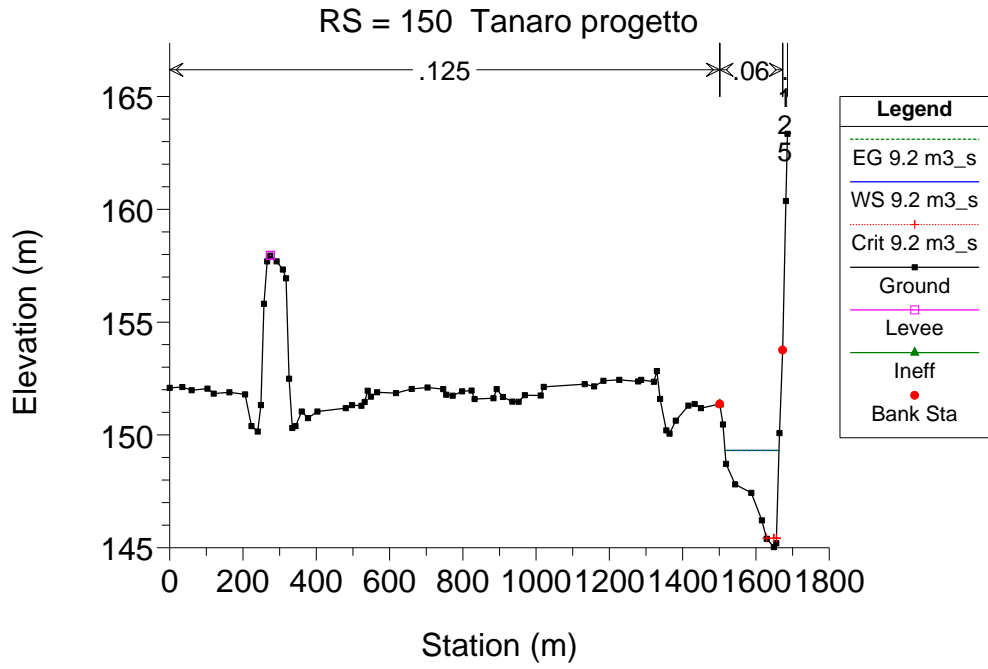


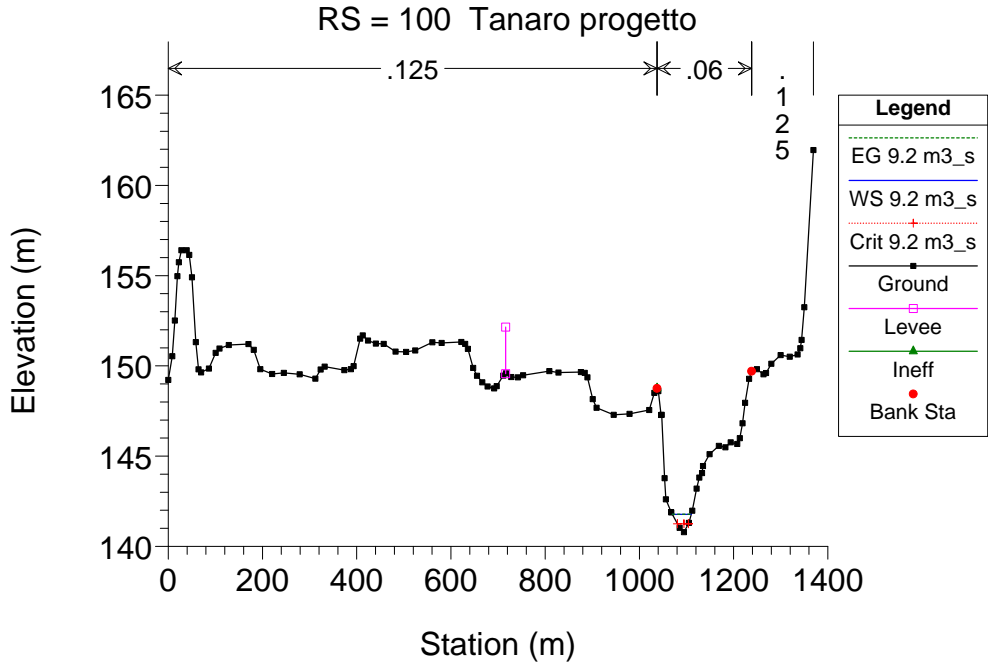
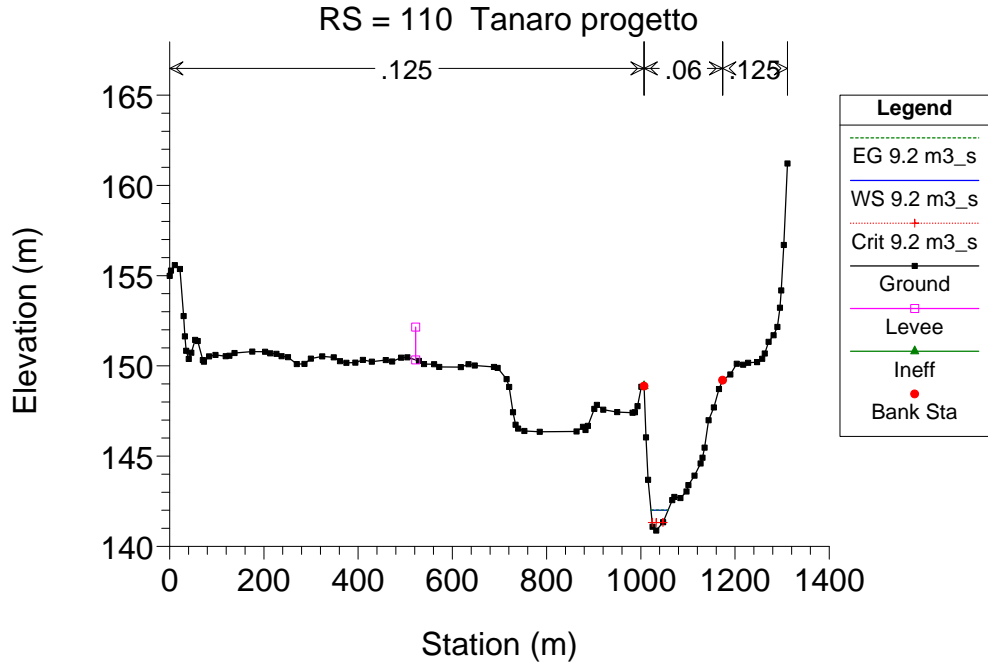
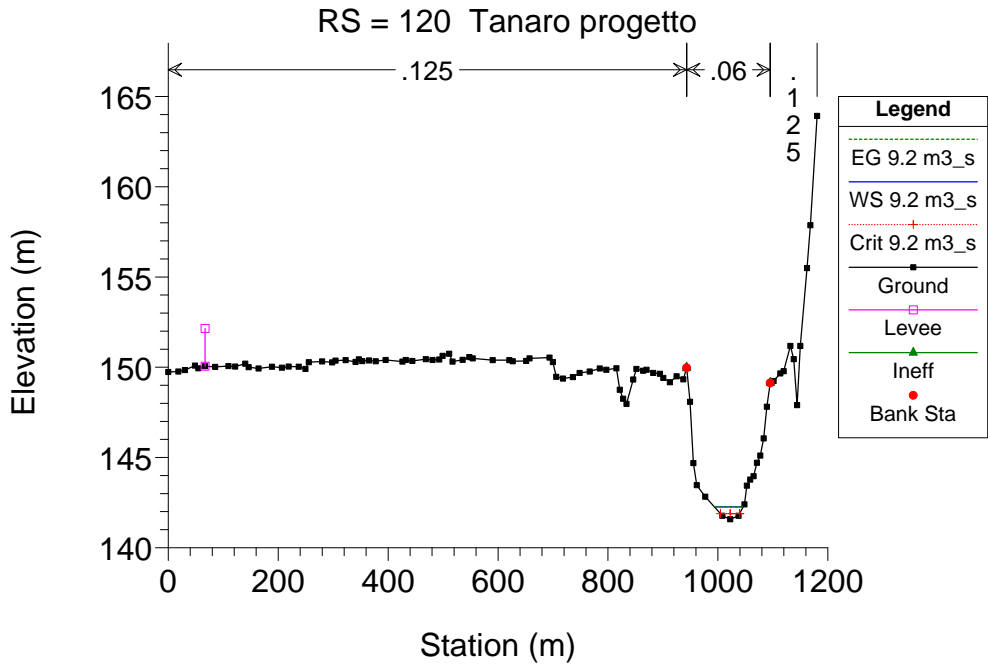
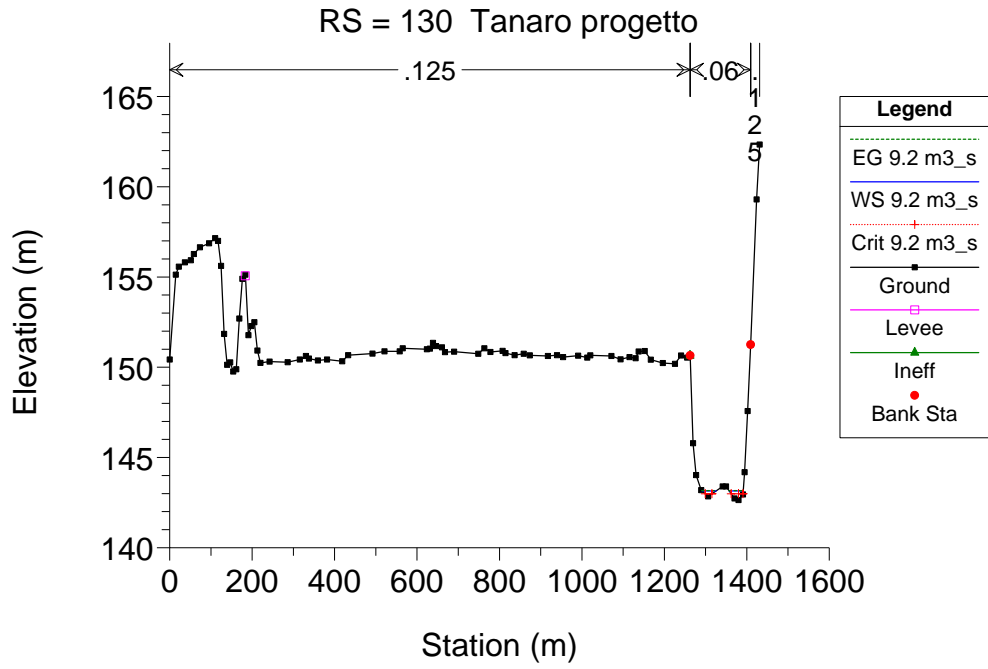


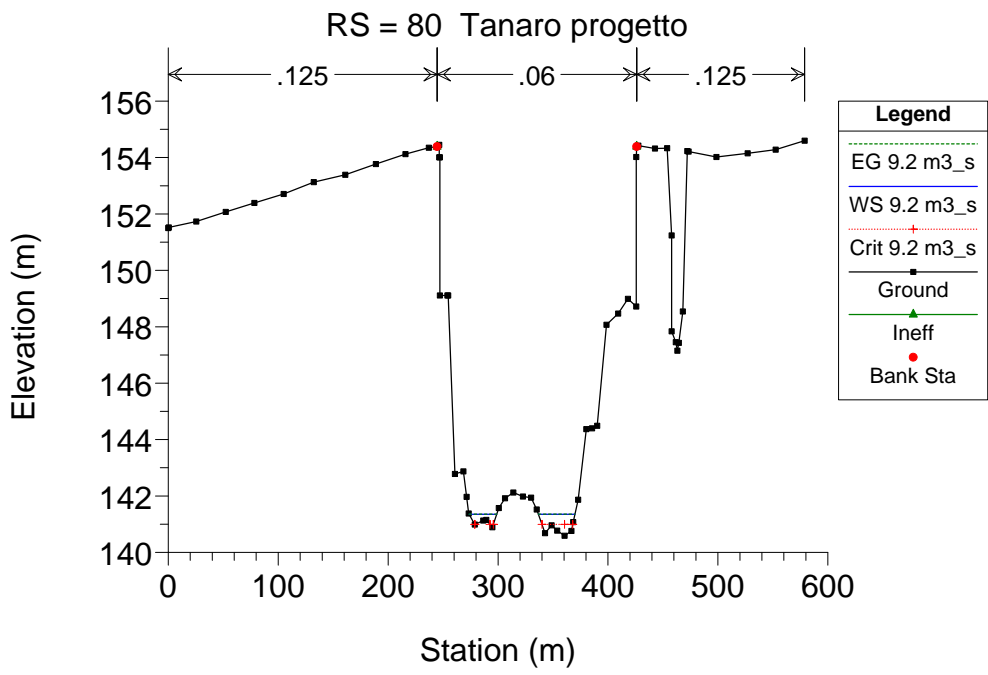
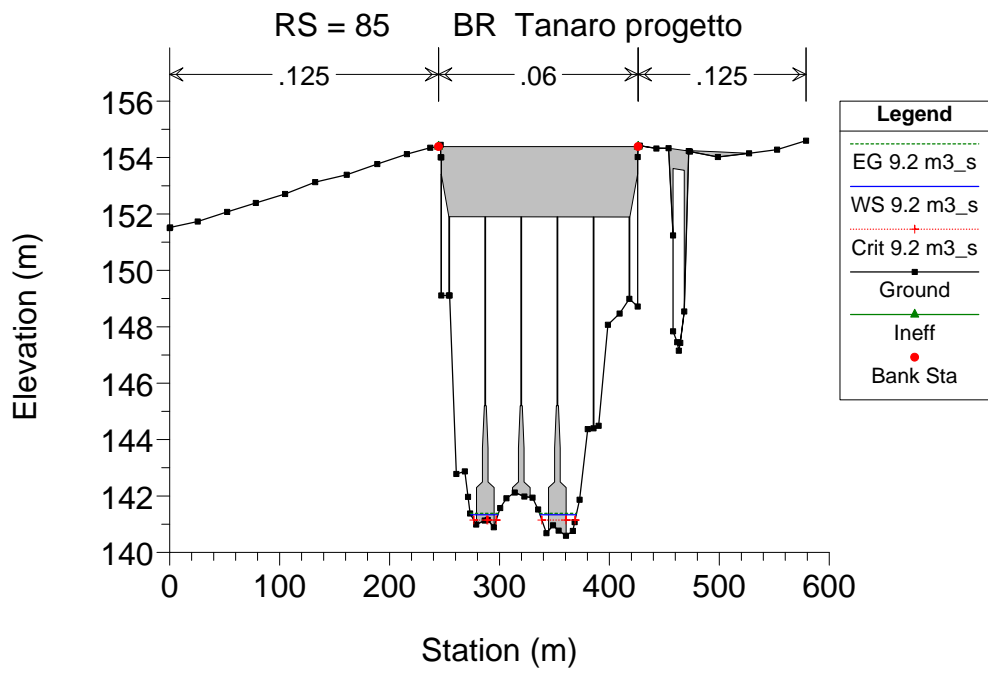
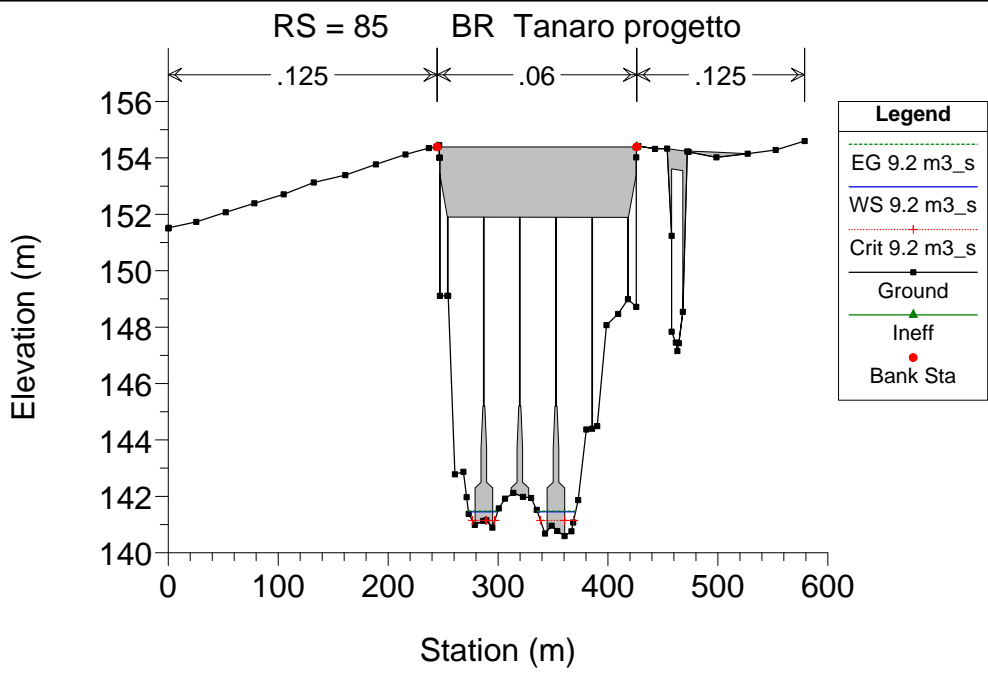
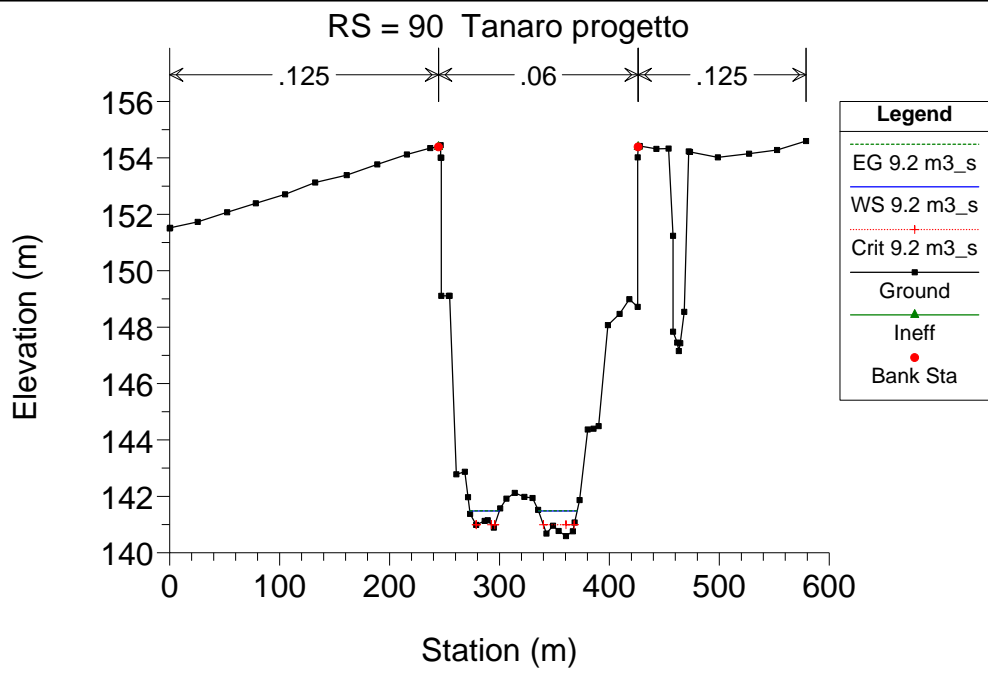


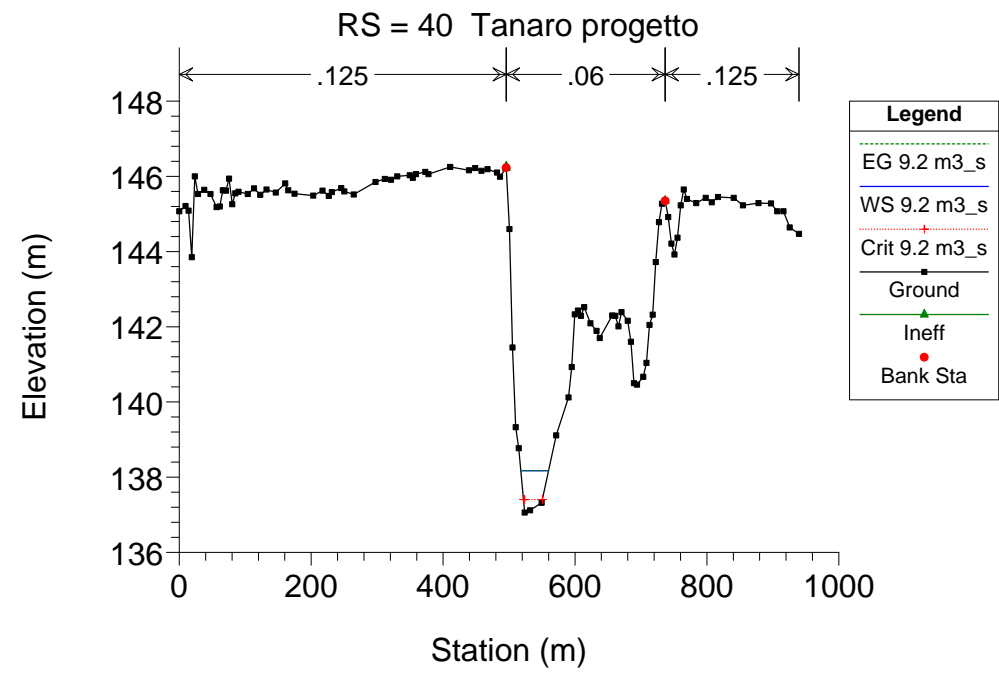
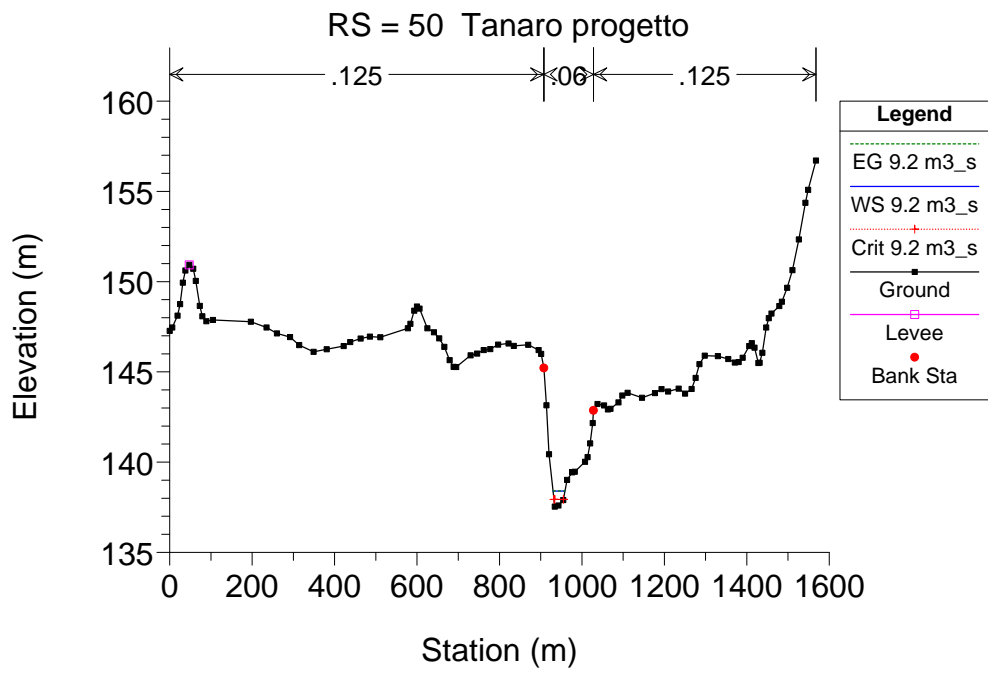
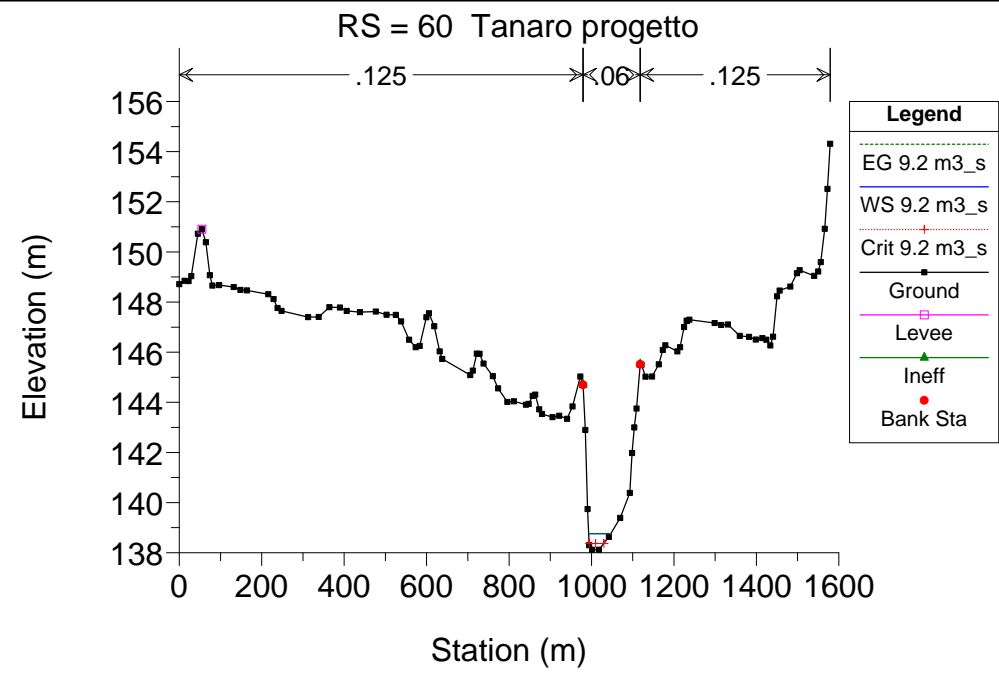
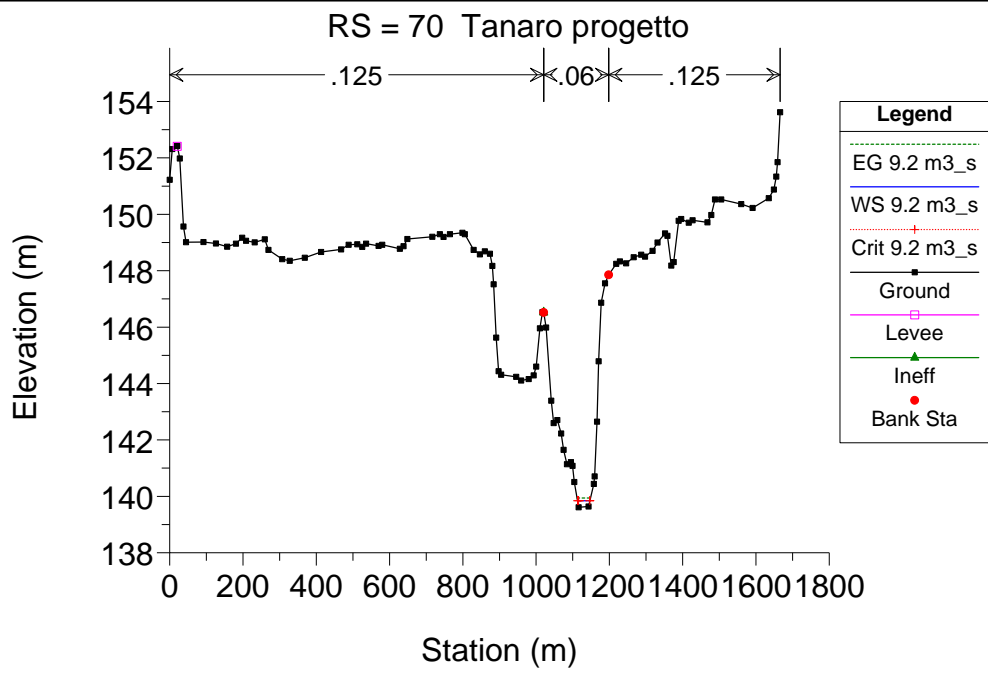


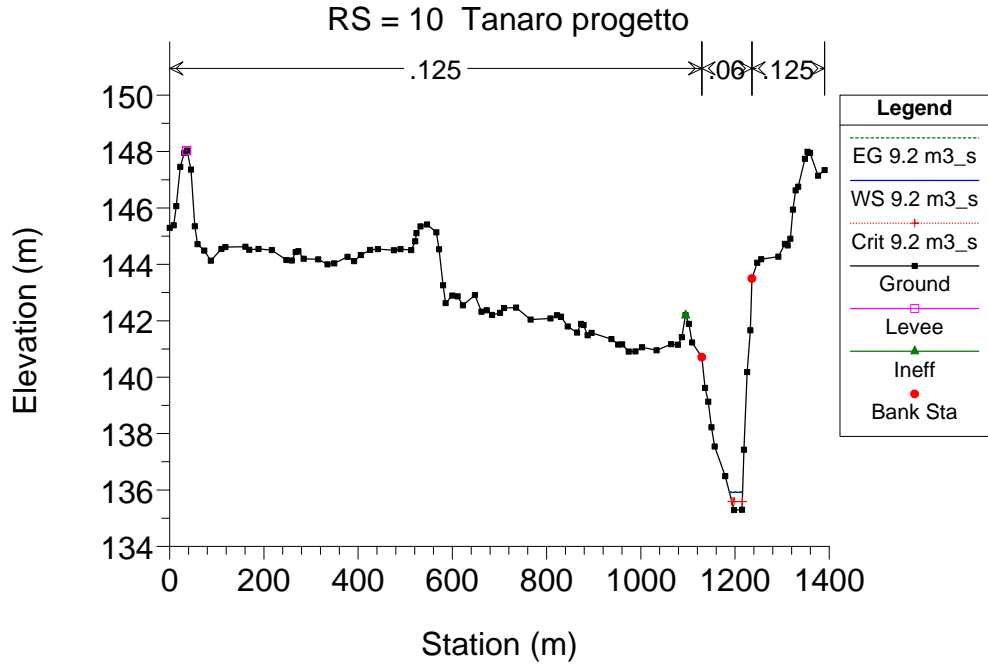
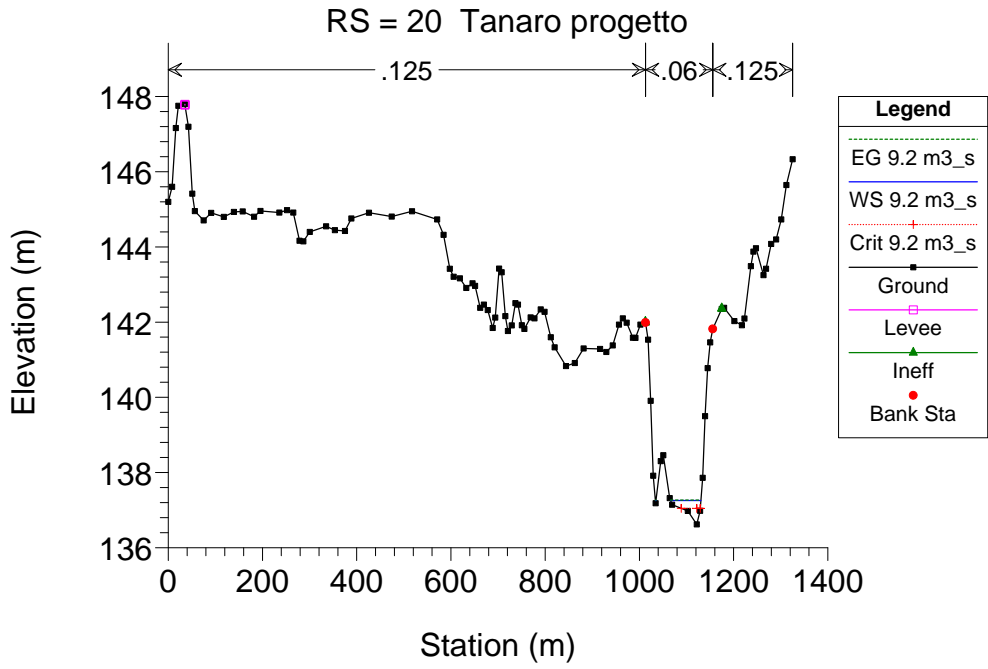
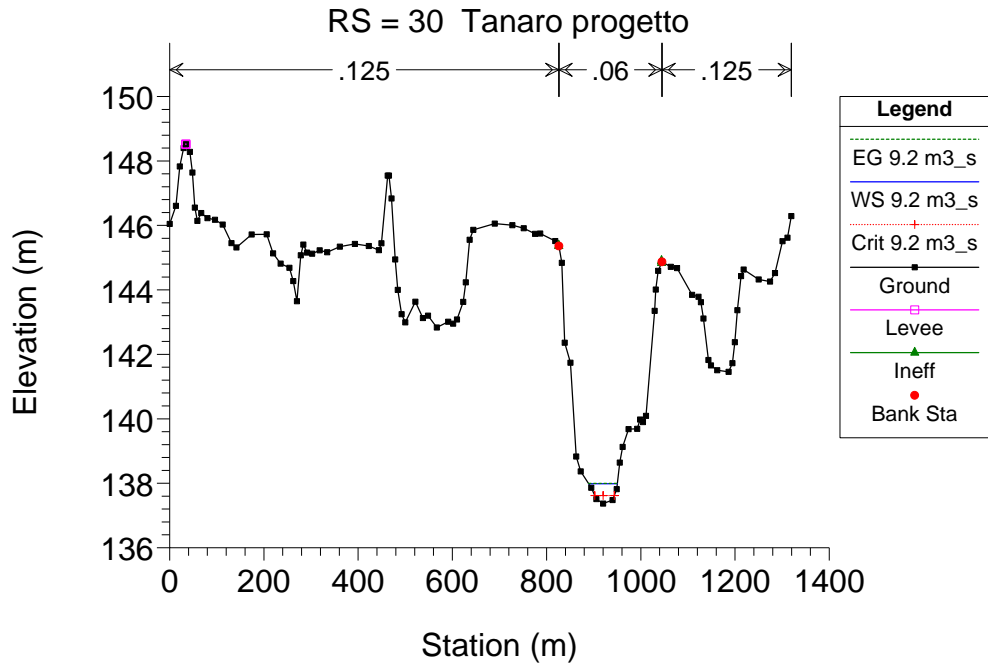












**SITUAZIONE ATTUALE (CON SBARRAMENTO DIVELTO)
SIMULAZIONE 10**

Corso d'acqua	Portata al colmo Q_c m^3/s	Portata
Fiume Tanaro	9.6 (in alveo) 6.6 (turbinati)	Minima di funzionamento dell'impianto idroelettrico

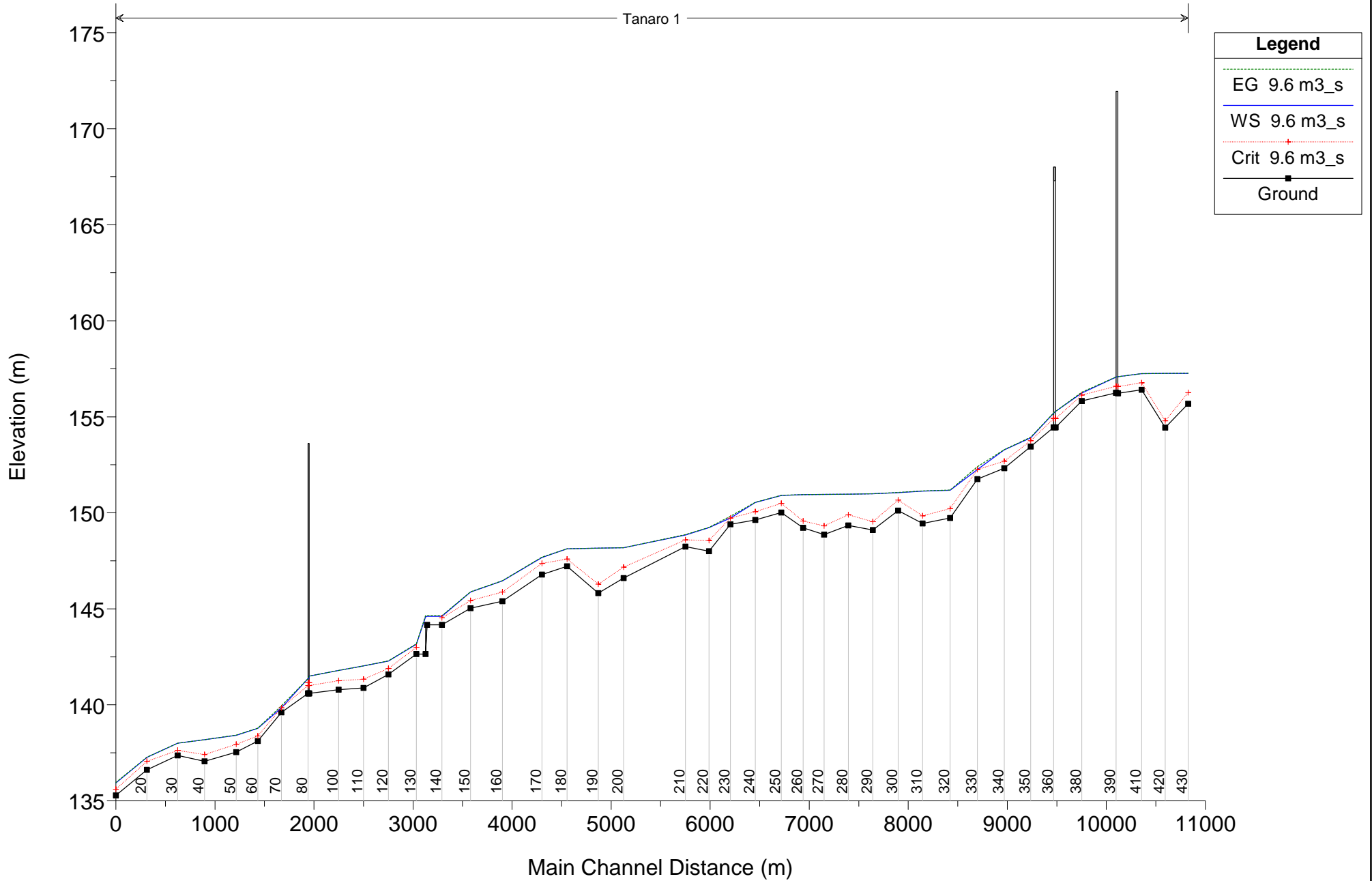
HEC-RAS Plan: Plan 06 River: Tanaro Reach: 1 Profile: 9.6 m3_s

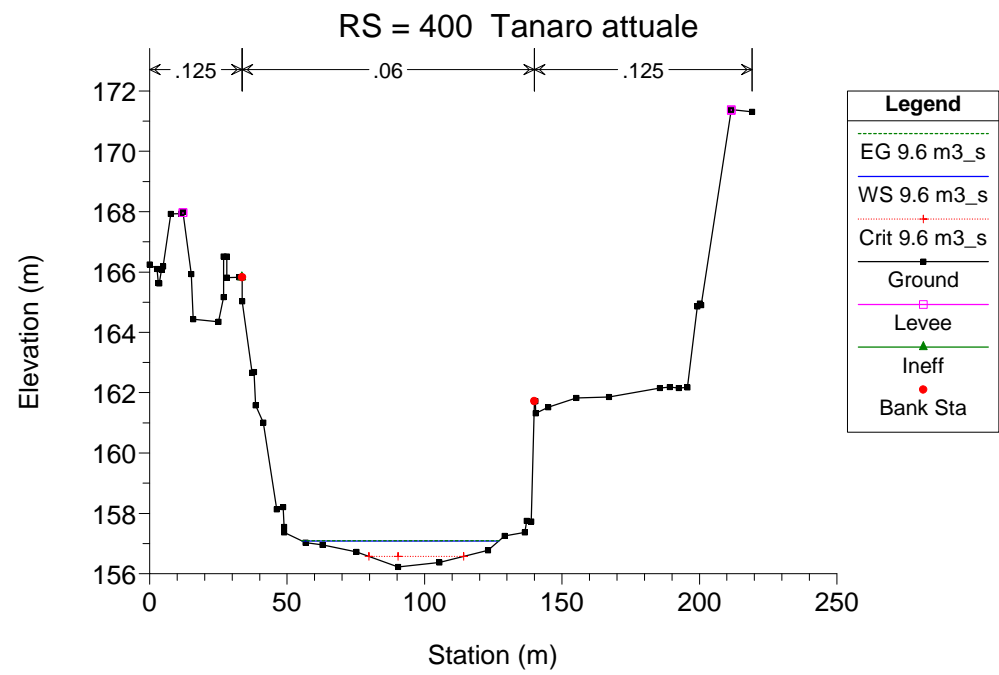
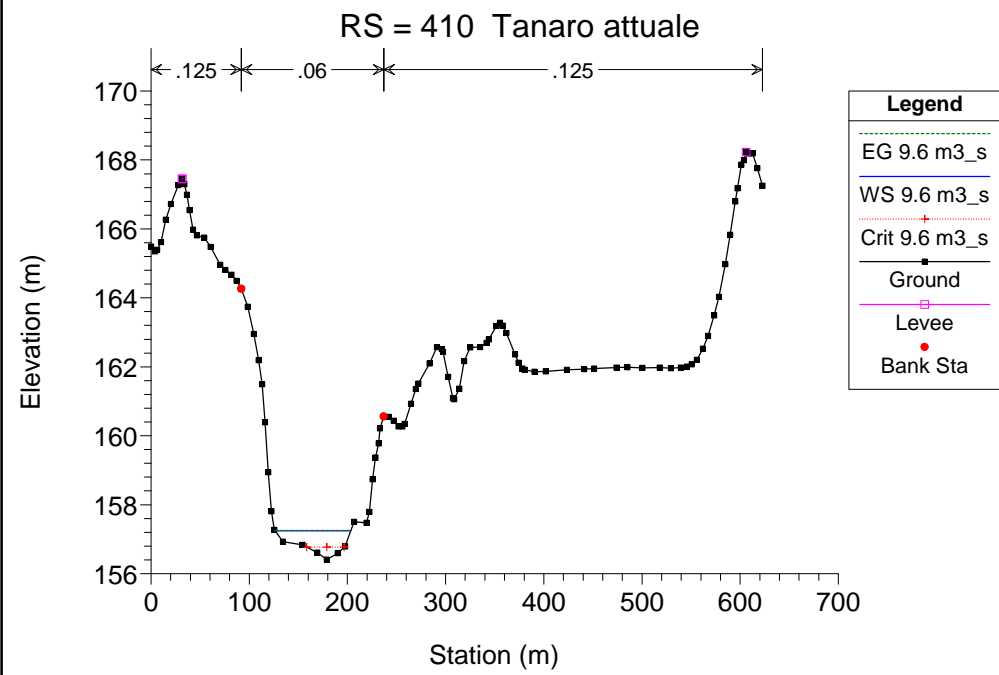
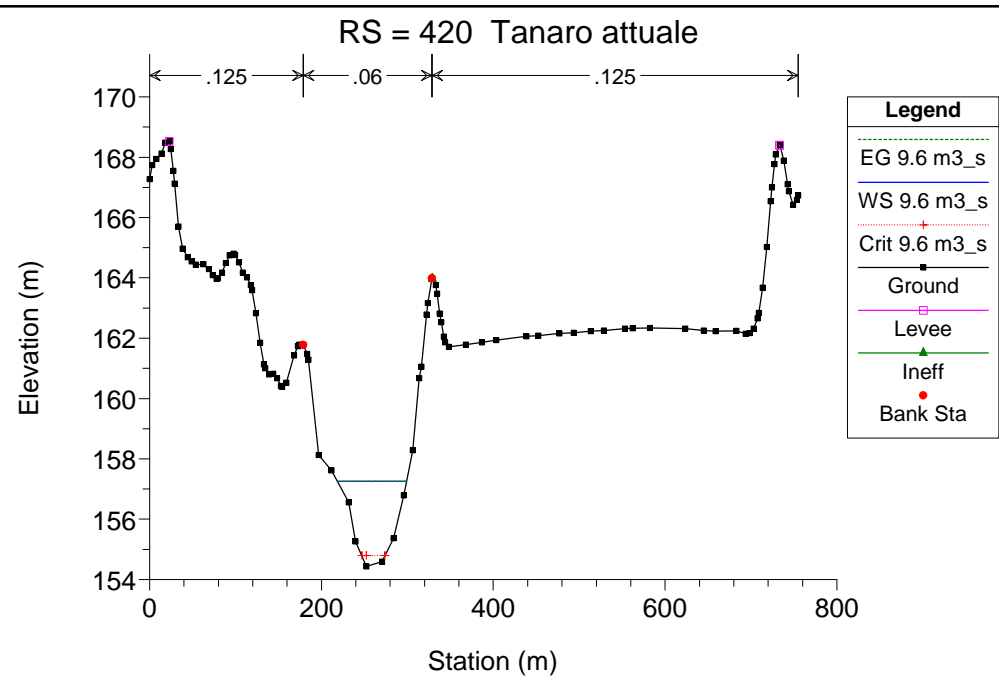
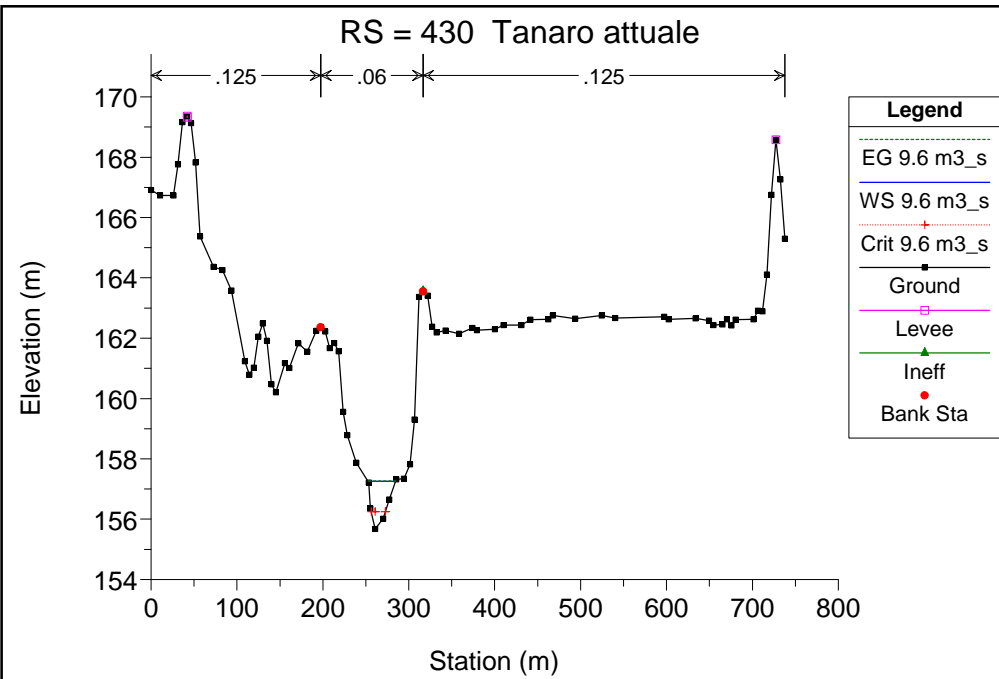
Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
1	430	9.6 m3_s	9.60	155.68	157.26	156.25	157.26	0.000428	0.33	29.53	31.96	0.11
1	420	9.6 m3_s	9.60	154.44	157.26	154.79	157.26	0.000008	0.07	140.80	80.64	0.02
1	410	9.6 m3_s	9.60	156.41	157.25	156.77	157.25	0.000624	0.26	37.42	77.30	0.12
1	400	9.6 m3_s	9.60	156.22	157.09	156.57	157.09	0.000726	0.28	34.69	71.71	0.13
1	395		Bridge									
1	390	9.6 m3_s	9.60	156.25	157.07	156.58	157.07	0.000841	0.29	33.10	71.14	0.14
1	380	9.6 m3_s	9.60	155.82	156.24	156.14	156.28	0.017376	0.95	10.14	35.86	0.57
1	370	9.6 m3_s	9.60	154.45	155.28	154.90	155.28	0.001558	0.36	26.49	64.60	0.18
1	365		Bridge									
1	360	9.6 m3_s	9.60	154.45	155.18	154.90	155.19	0.003234	0.47	20.61	59.65	0.25
1	350	9.6 m3_s	9.60	153.45	153.91	153.75	153.94	0.010801	0.79	12.11	39.09	0.45
1	340	9.6 m3_s	9.60	152.32	153.28	152.69	153.28	0.001040	0.40	23.81	36.58	0.16
1	330	9.6 m3_s	9.60	151.75	152.25	152.25	152.41	0.051843	1.73	5.53	17.86	0.99
1	320	9.6 m3_s	9.60	149.73	151.17	150.22	151.18	0.000306	0.29	32.69	32.05	0.09
1	310	9.6 m3_s	9.60	149.44	151.13	149.84	151.13	0.000096	0.17	57.50	55.29	0.05
1	300	9.6 m3_s	9.60	150.11	151.04	150.66	151.06	0.002963	0.62	15.42	27.02	0.26
1	290	9.6 m3_s	9.60	149.10	150.99	149.54	151.00	0.000086	0.18	52.23	39.77	0.05
1	280	9.6 m3_s	9.60	149.34	150.97	149.89	150.97	0.000151	0.21	46.79	46.39	0.07
1	270	9.6 m3_s	9.60	148.86	150.95	149.32	150.95	0.000032	0.11	84.74	63.33	0.03
1	260	9.6 m3_s	9.60	149.22	150.94	149.57	150.94	0.000046	0.13	76.49	65.50	0.04
1	250	9.6 m3_s	9.60	150.01	150.90	150.49	150.91	0.002469	0.47	20.31	47.08	0.23
1	240	9.6 m3_s	9.60	149.63	150.54	150.06	150.54	0.000888	0.24	39.73	116.75	0.13
1	230	9.6 m3_s	9.60	149.40	149.73	149.73	149.82	0.062762	1.33	7.24	40.38	1.00
1	220	9.6 m3_s	9.60	148.00	149.23	148.56	149.24	0.000733	0.35	27.09	38.86	0.14
1	210	9.6 m3_s	9.60	148.24	148.84	148.60	148.86	0.005440	0.66	14.55	36.92	0.34
1	200	9.6 m3_s	9.60	146.60	148.18	147.17	148.18	0.000444	0.33	29.36	32.43	0.11
1	190	9.6 m3_s	9.60	145.82	148.16	146.29	148.16	0.000042	0.14	69.86	48.33	0.04
1	180	9.6 m3_s	9.60	147.21	148.12	147.60	148.12	0.000784	0.23	41.31	117.32	0.13
1	170	9.6 m3_s	9.60	146.78	147.66	147.36	147.69	0.005684	0.76	12.58	26.53	0.35
1	160	9.6 m3_s	9.60	145.40	146.46	145.87	146.47	0.001900	0.46	20.87	41.29	0.21
1	150	9.6 m3_s	9.60	145.03	145.87	145.43	145.88	0.001778	0.48	19.92	34.89	0.20
1	140	9.6 m3_s	9.60	144.17	144.61	144.53	144.64	0.020759	0.82	11.77	59.45	0.59
1	135		Inl Struct									
1	130	9.6 m3_s	9.60	142.64	143.16	143.00	143.17	0.007688	0.57	16.88	69.49	0.37
1	120	9.6 m3_s	9.60	141.58	142.28	141.90	142.29	0.001662	0.40	24.04	53.31	0.19
1	110	9.6 m3_s	9.60	140.88	142.03	141.33	142.03	0.000706	0.36	26.82	36.75	0.13
1	100	9.6 m3_s	9.60	140.79	141.79	141.26	141.79	0.001339	0.42	22.98	40.49	0.18
1	90	9.6 m3_s	9.60	140.59	141.49	141.00	141.50	0.000757	0.30	32.43	62.32	0.13
1	85		Bridge									
1	80	9.6 m3_s	9.60	140.59	141.36	141.00	141.37	0.001777	0.39	24.51	58.73	0.19

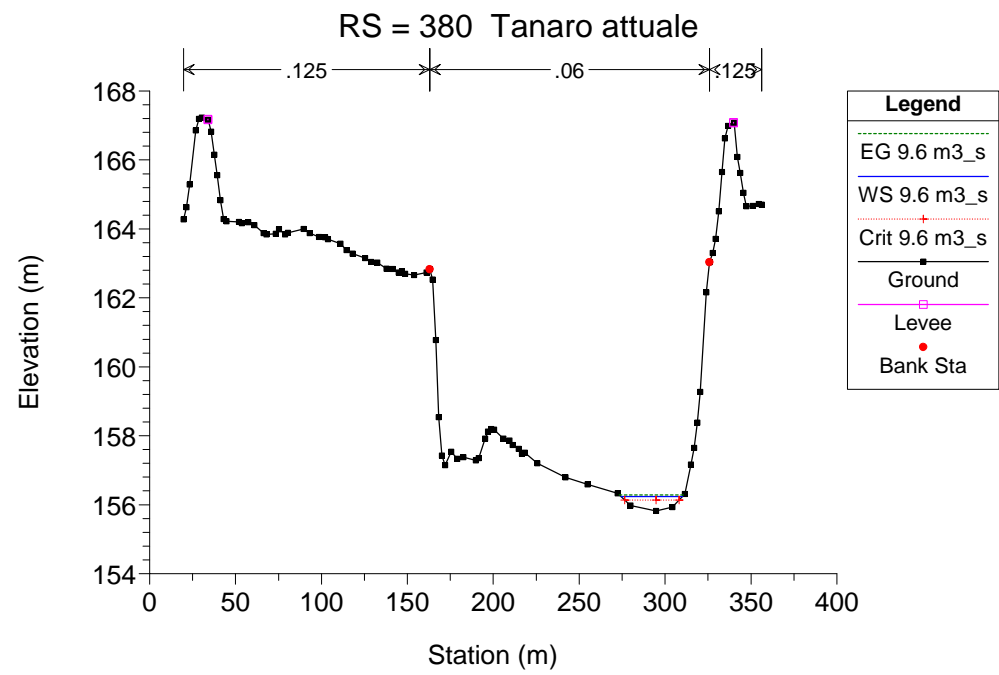
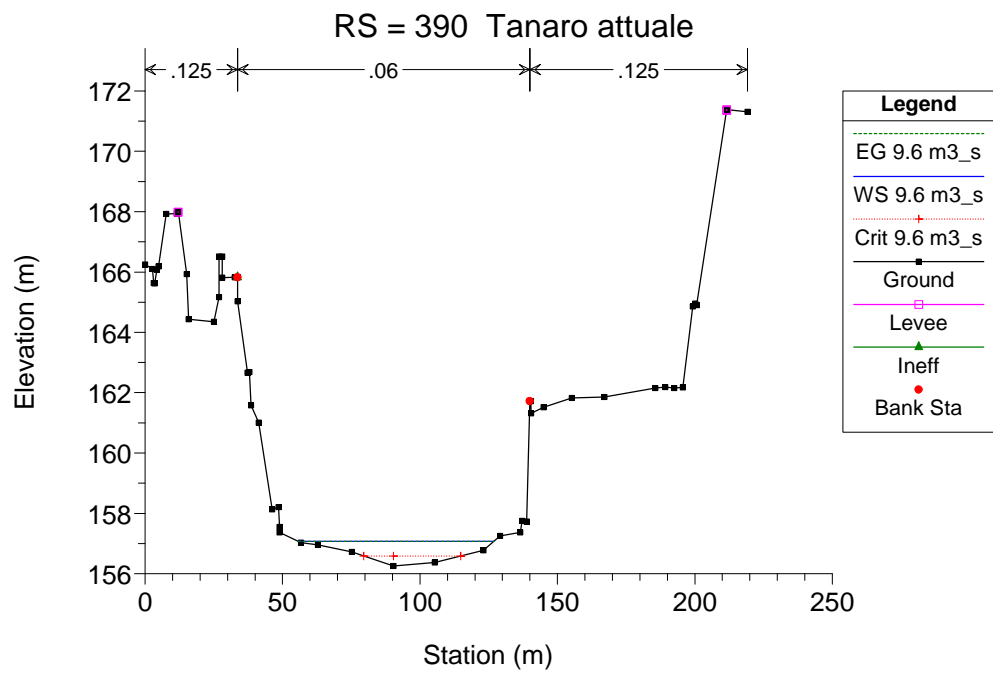
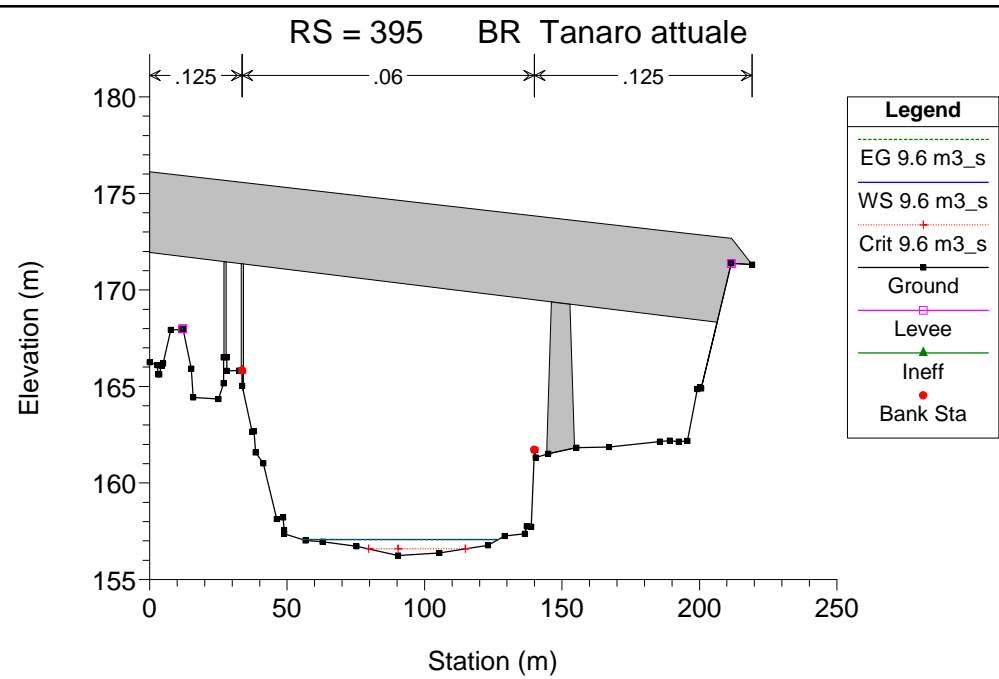
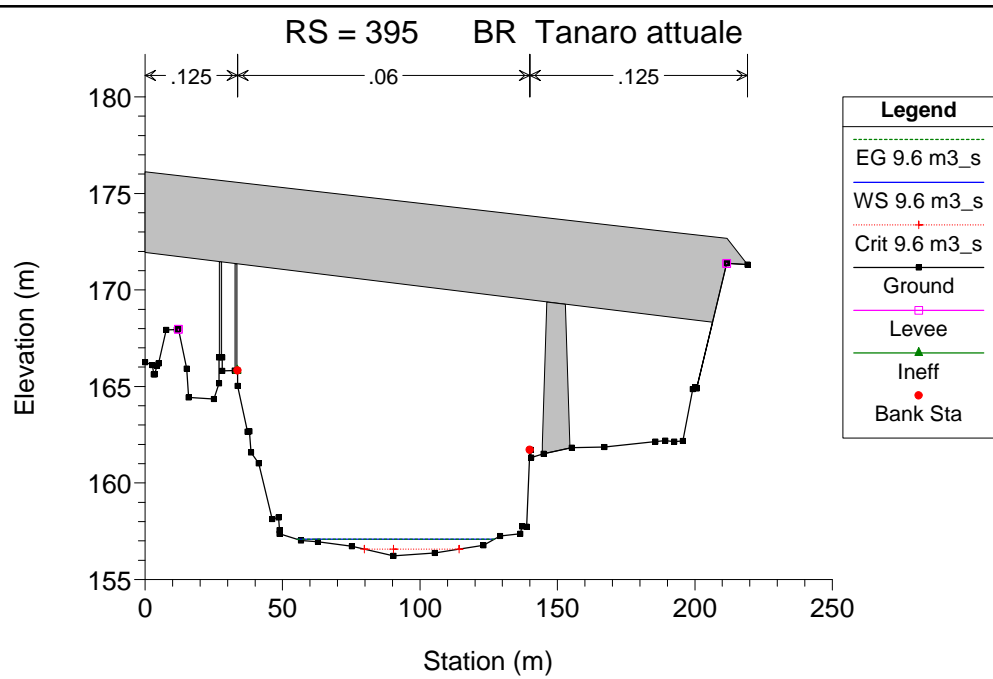
HEC-RAS Plan: Plan 06 River: Tanaro Reach: 1 Profile: 9.6 m3_s (Continued)

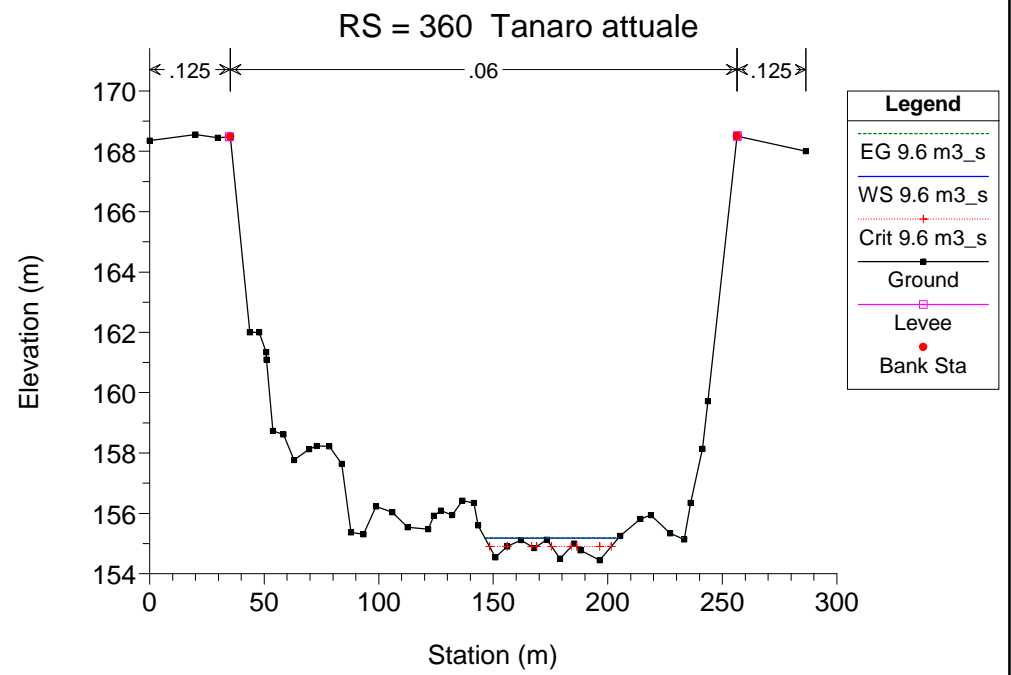
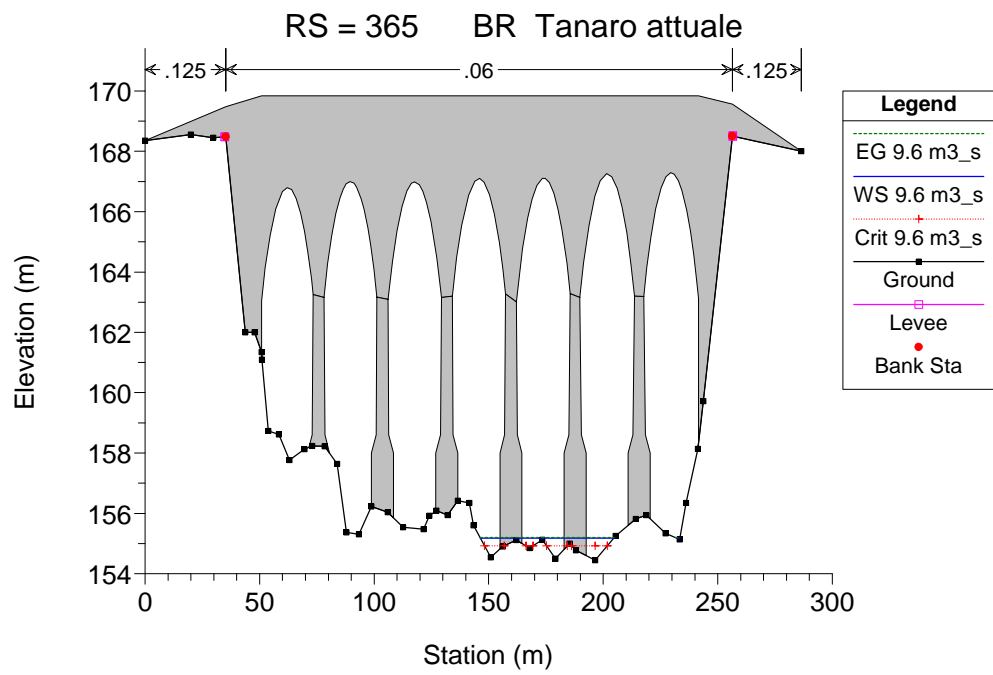
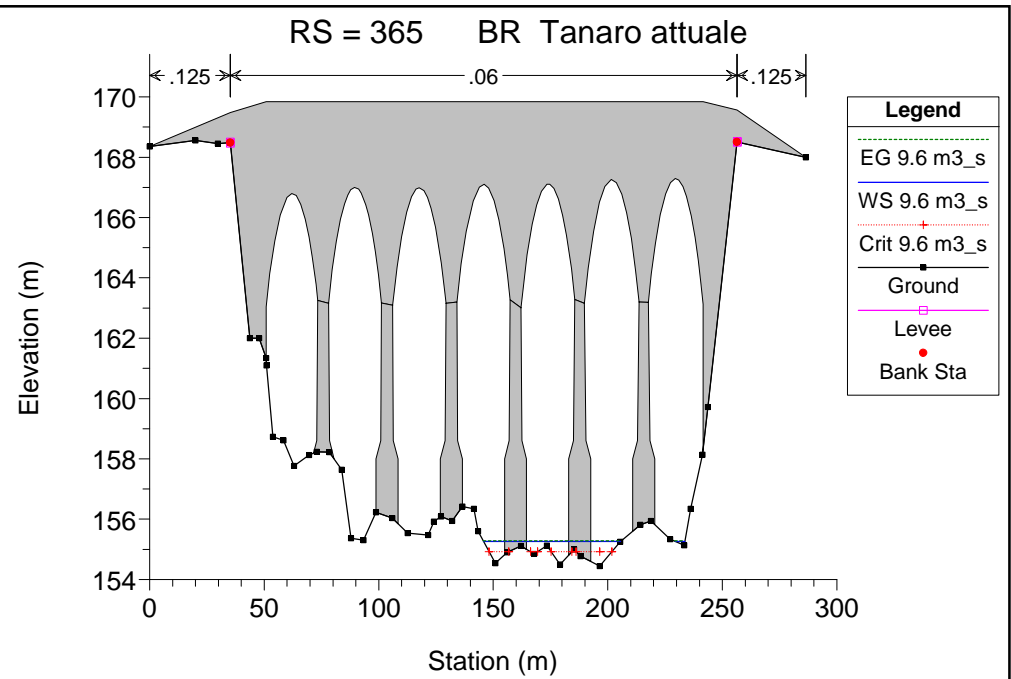
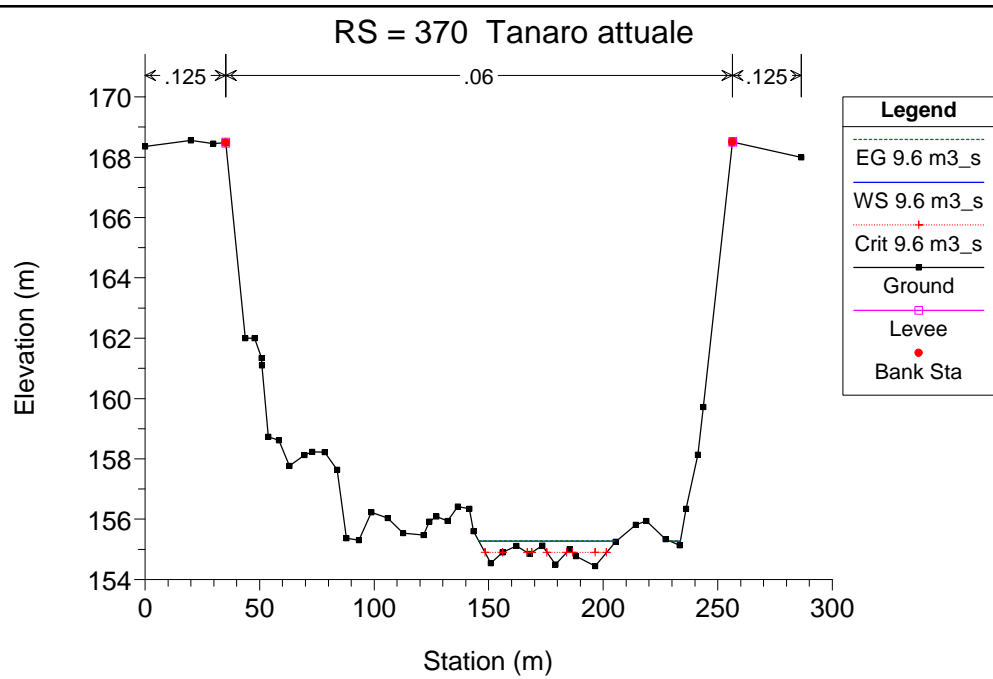
Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
1	70	9.6 m3_s	9.60	139.61	139.85	139.85	139.95	0.061207	1.41	6.81	34.08	1.01
1	60	9.6 m3_s	9.60	138.12	138.78	138.38	138.79	0.001440	0.38	25.31	54.41	0.18
1	50	9.6 m3_s	9.60	137.54	138.41	137.94	138.43	0.001860	0.53	18.27	29.09	0.21
1	40	9.6 m3_s	9.60	137.06	138.19	137.41	138.19	0.000389	0.28	33.93	42.30	0.10
1	30	9.6 m3_s	9.60	137.37	138.00	137.63	138.01	0.001445	0.36	26.55	61.55	0.18
1	20	9.6 m3_s	9.60	136.62	137.27	137.06	137.28	0.004463	0.49	19.50	66.26	0.29
1	10	9.6 m3_s	9.60	135.29	135.93	135.60	135.95	0.004001	0.67	14.34	28.15	0.30

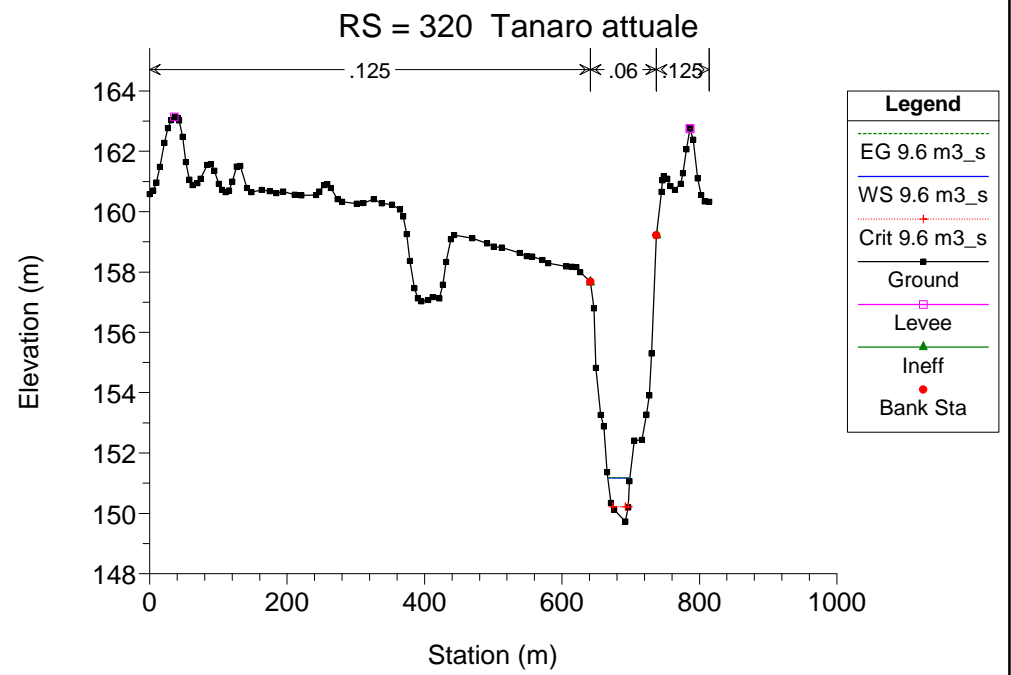
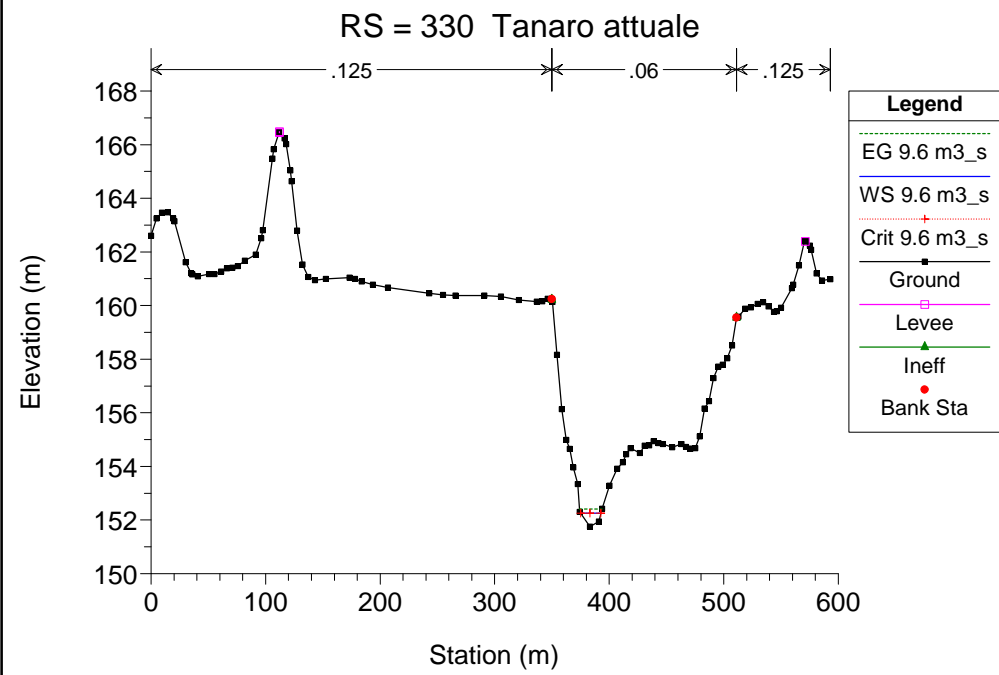
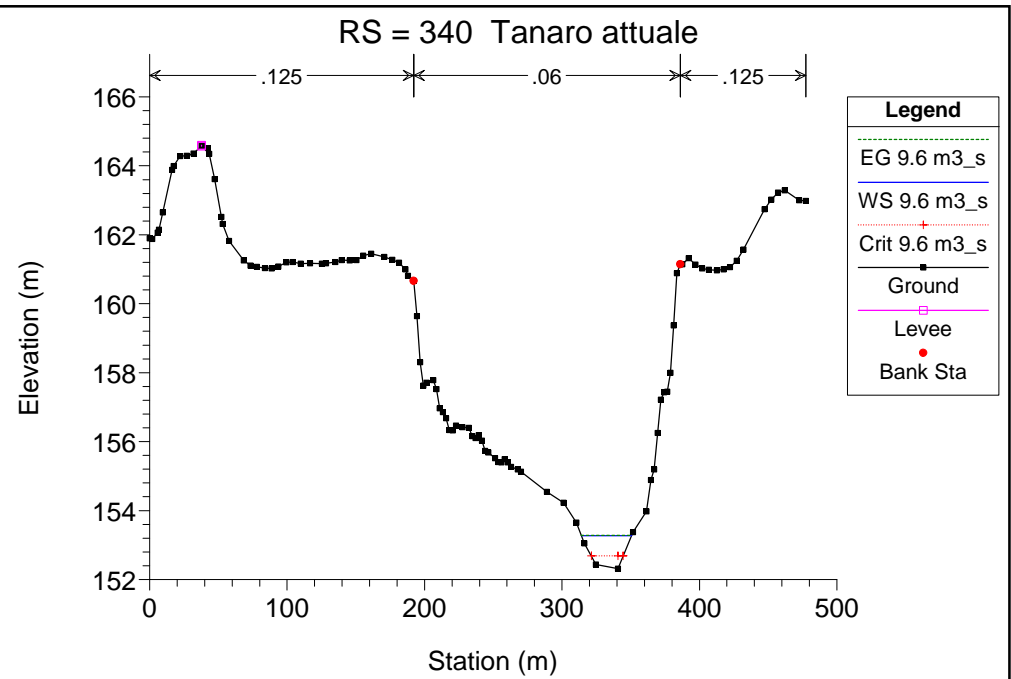
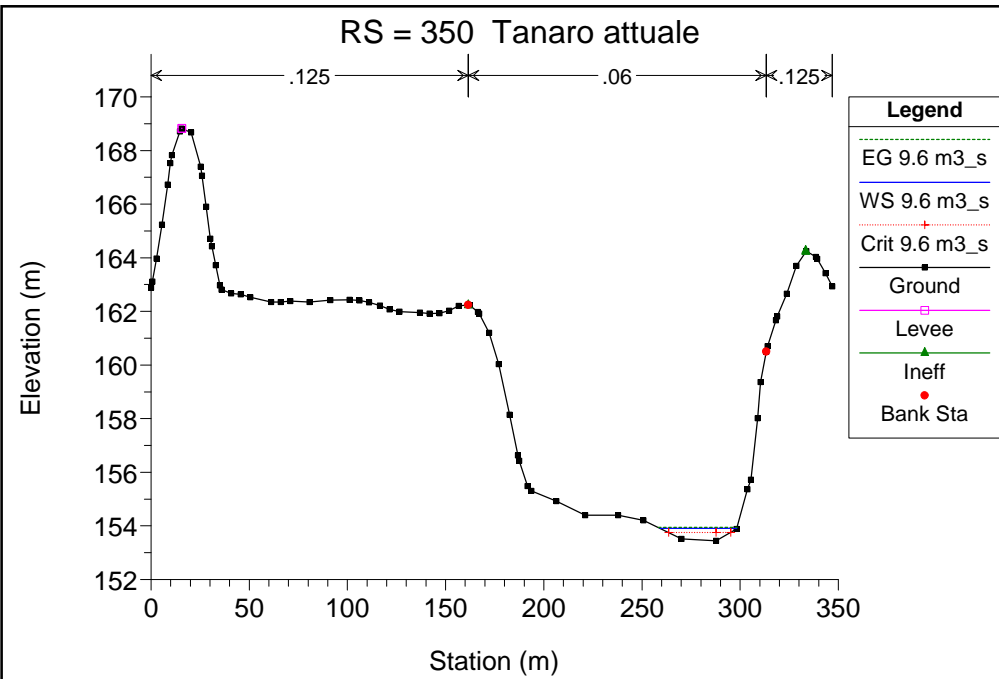
Tanaro attuale

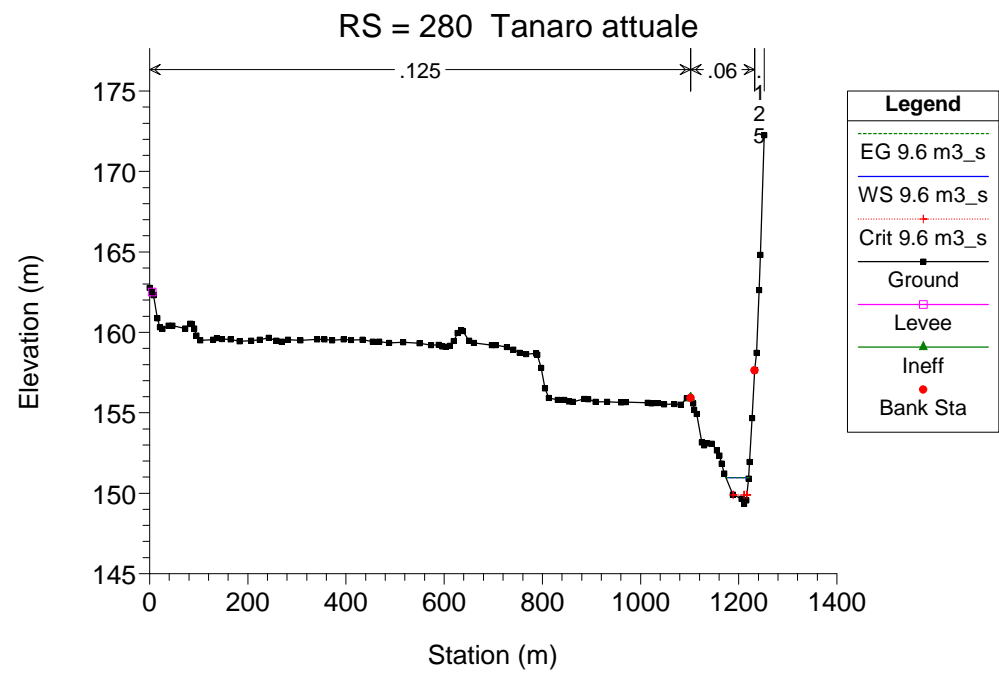
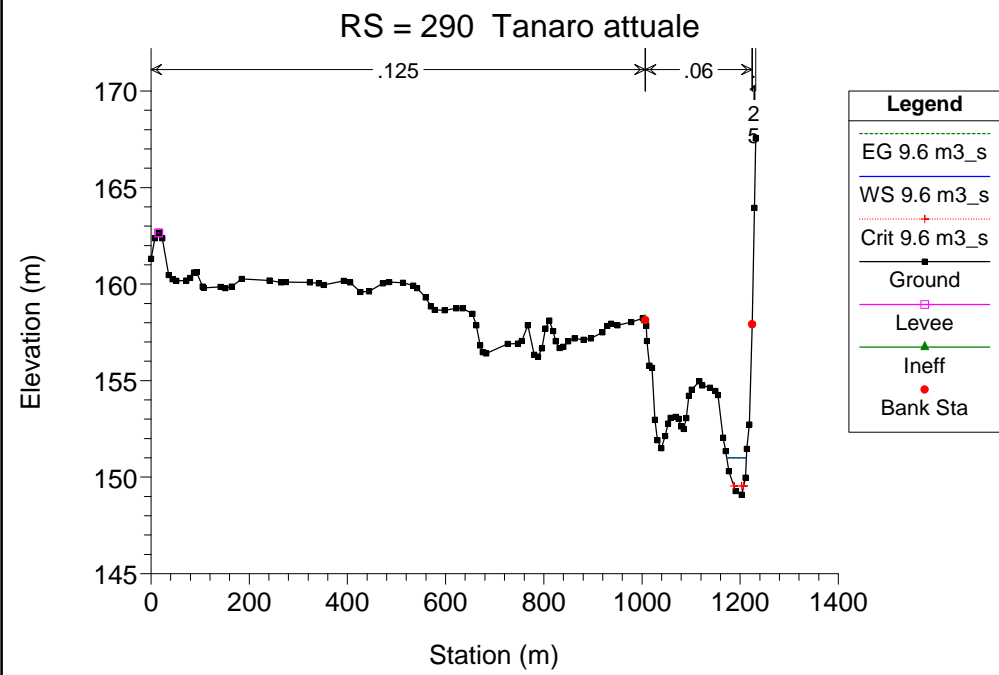
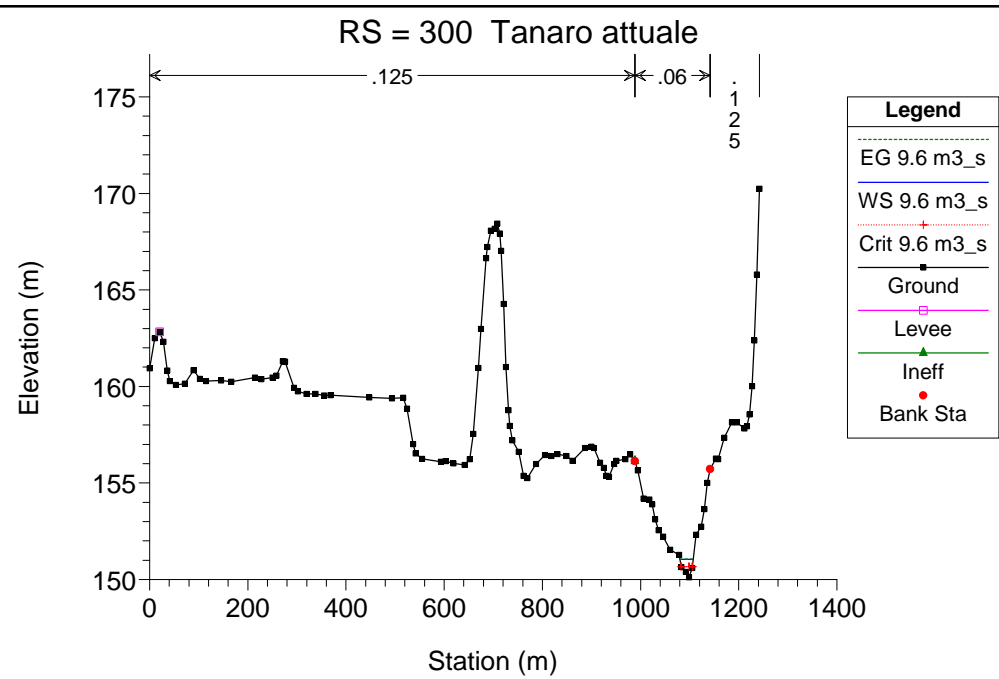
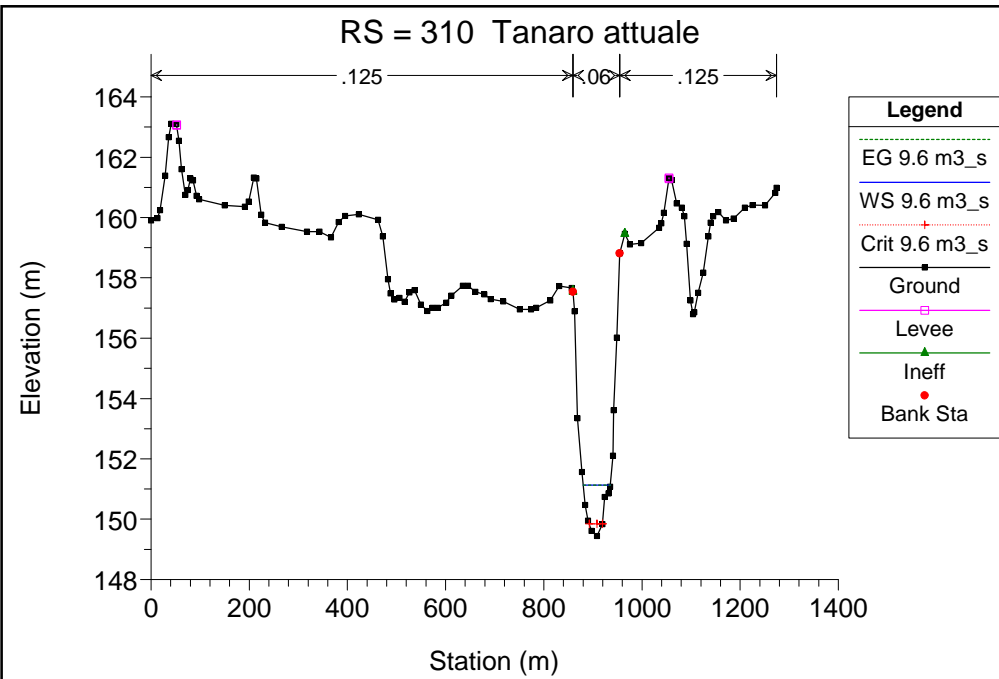


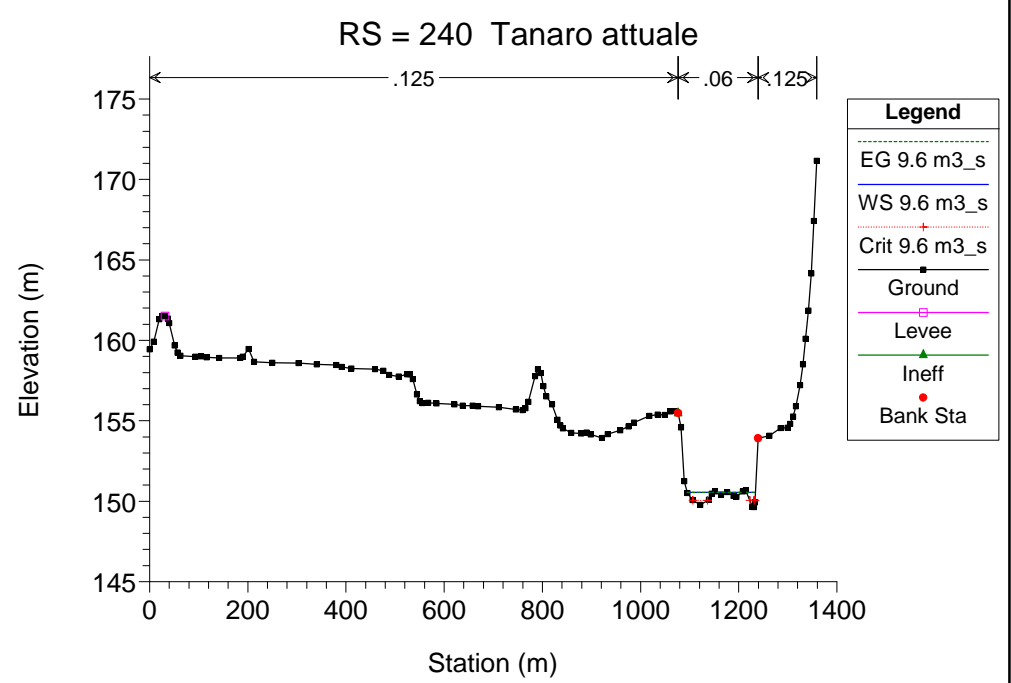
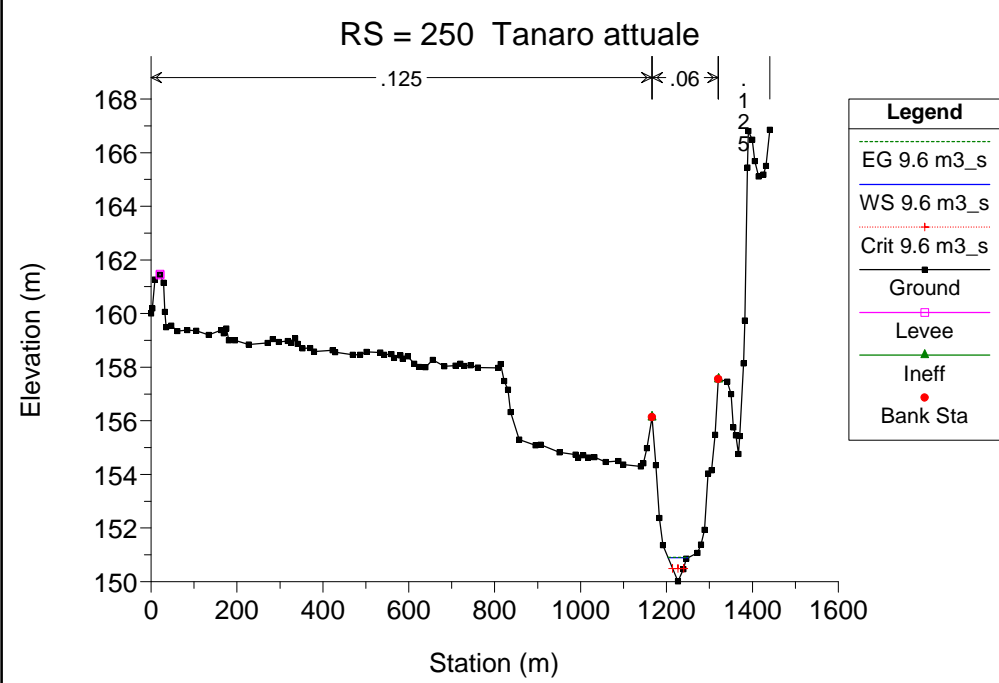
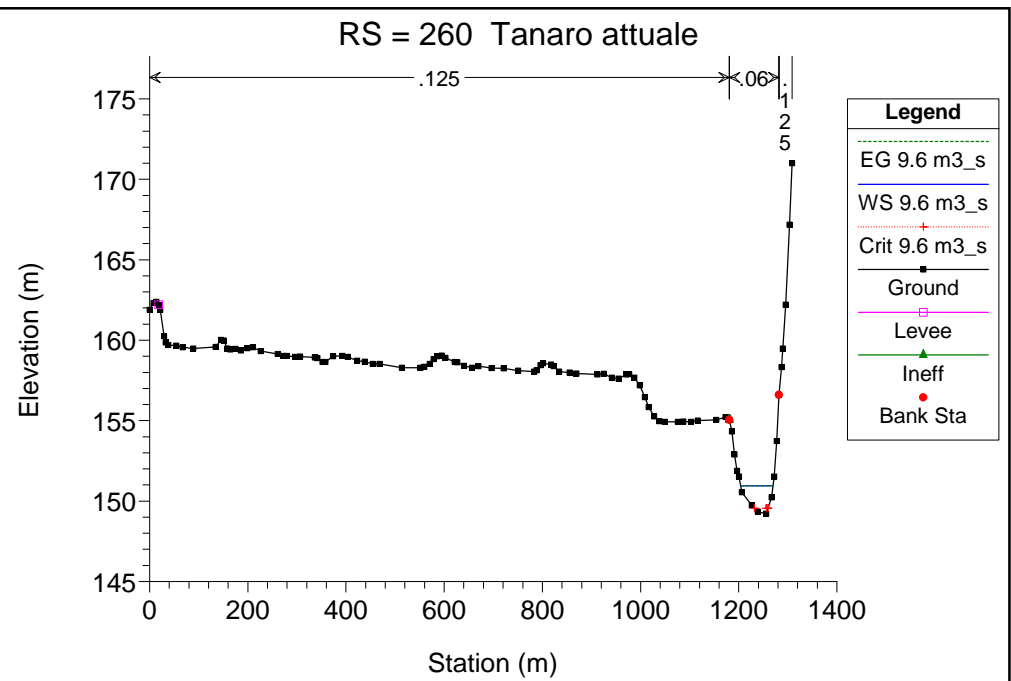
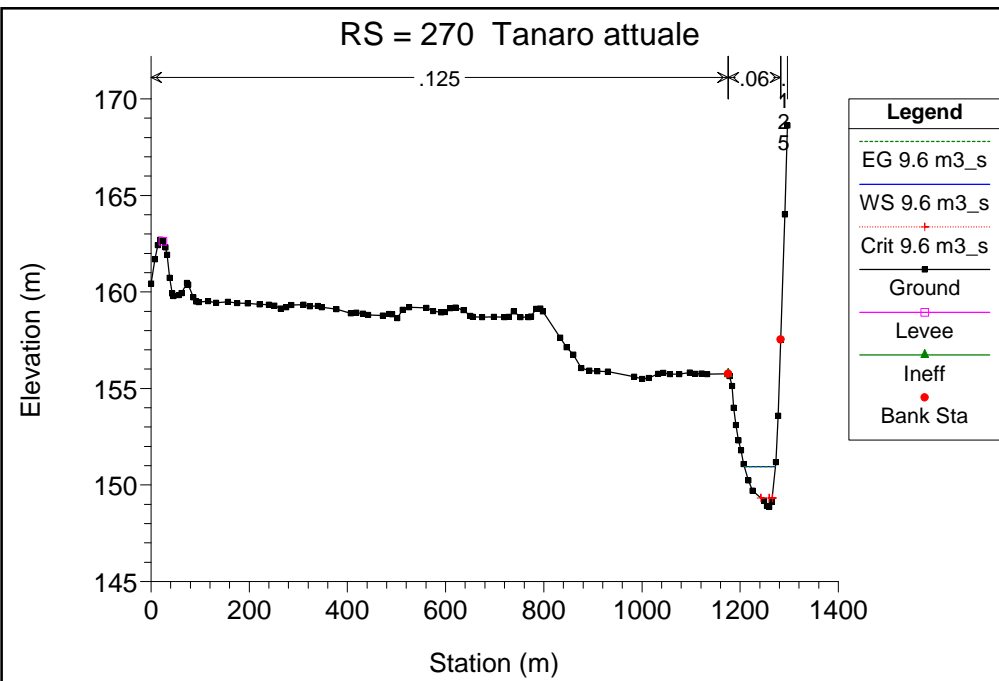


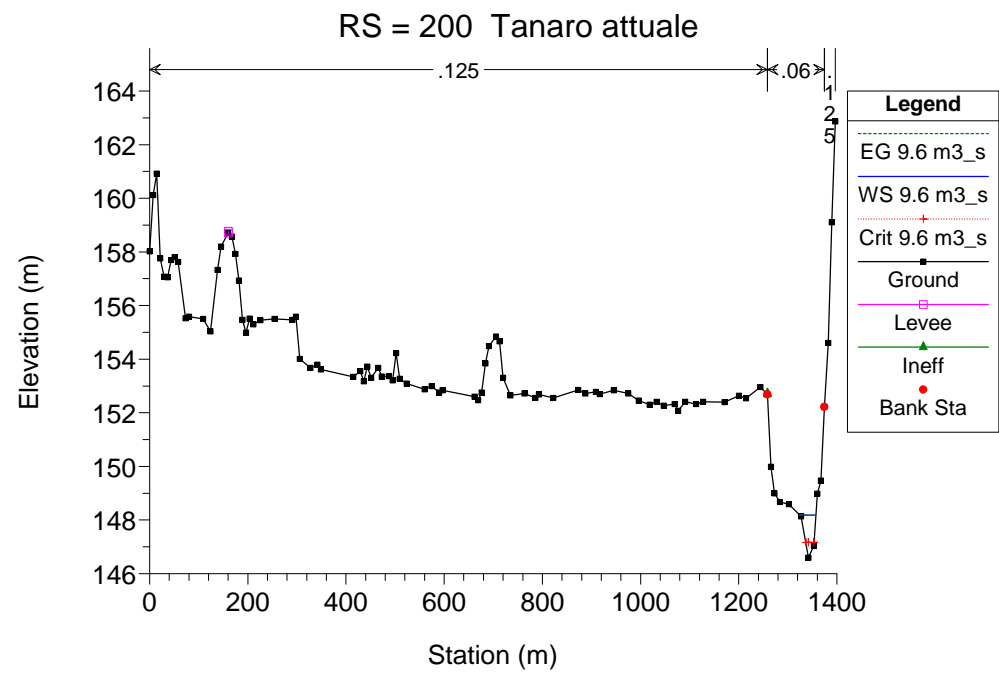
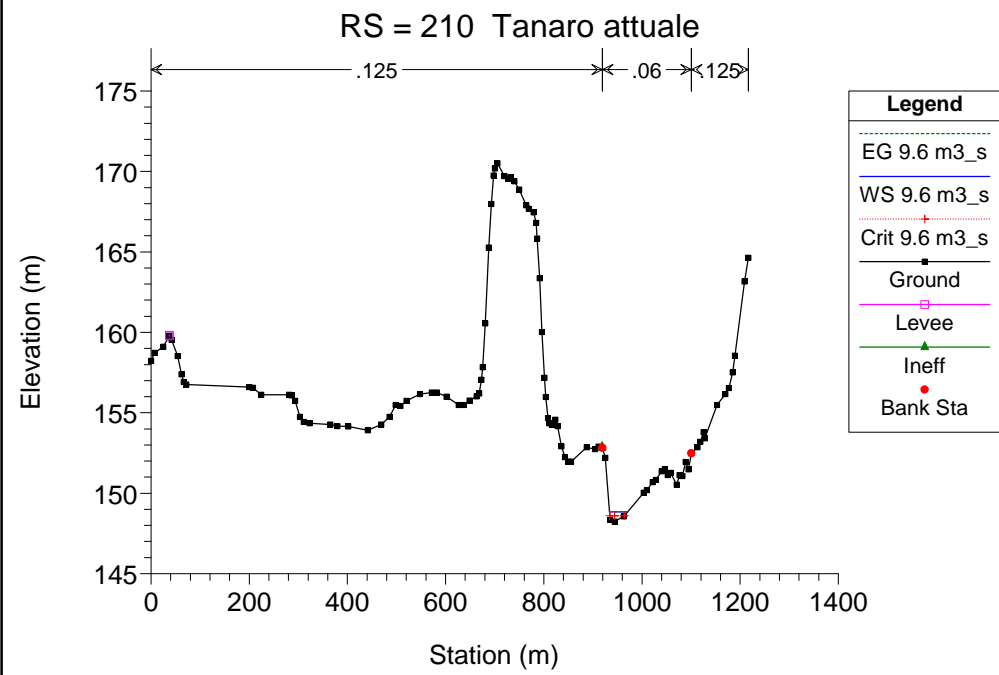
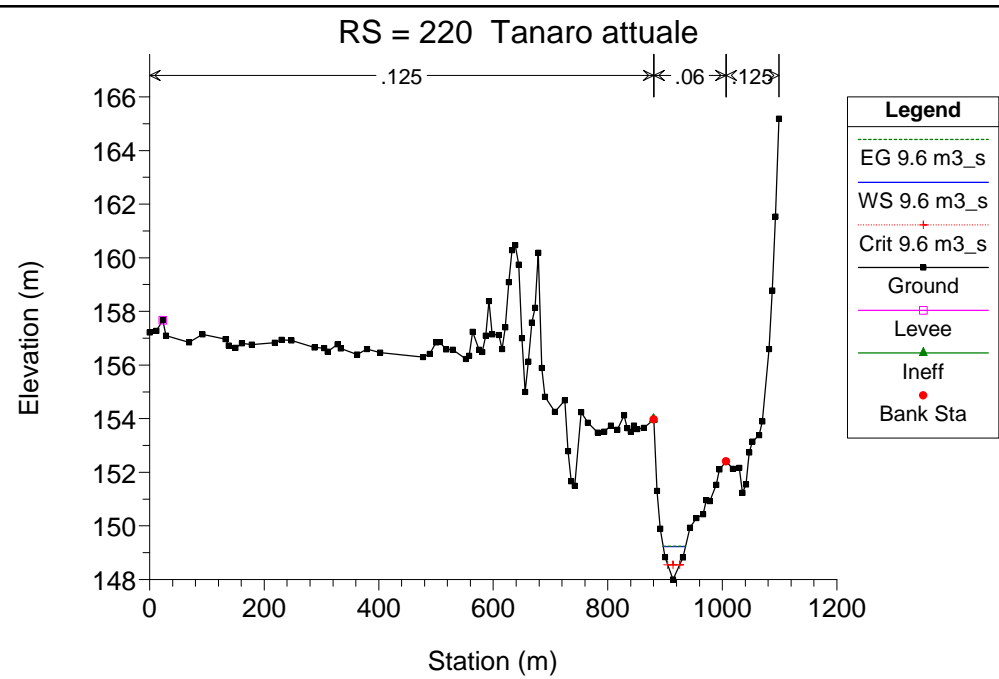
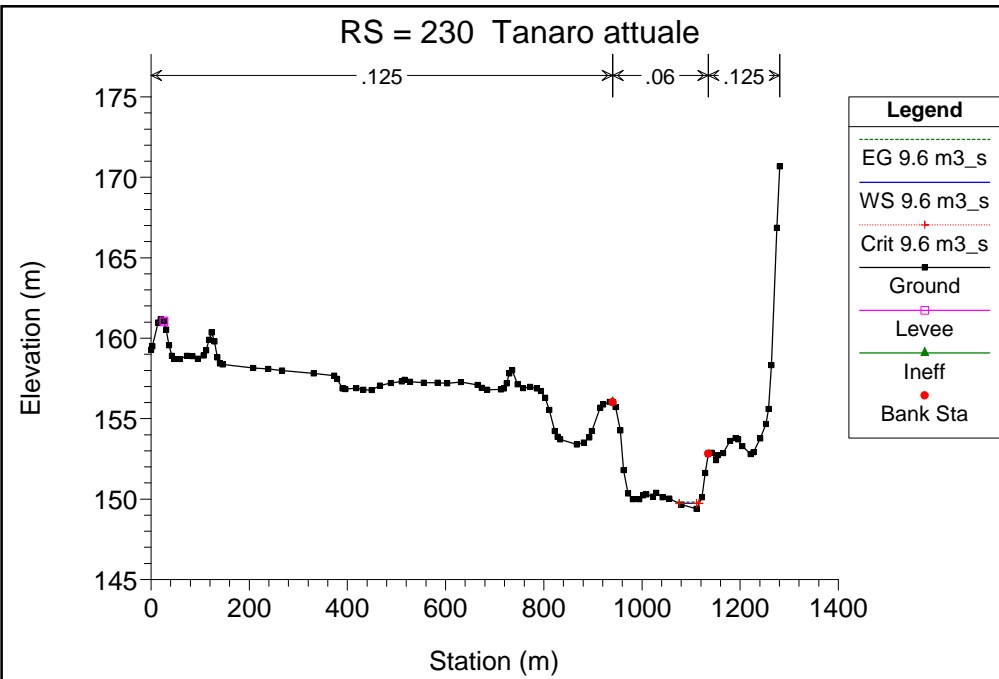


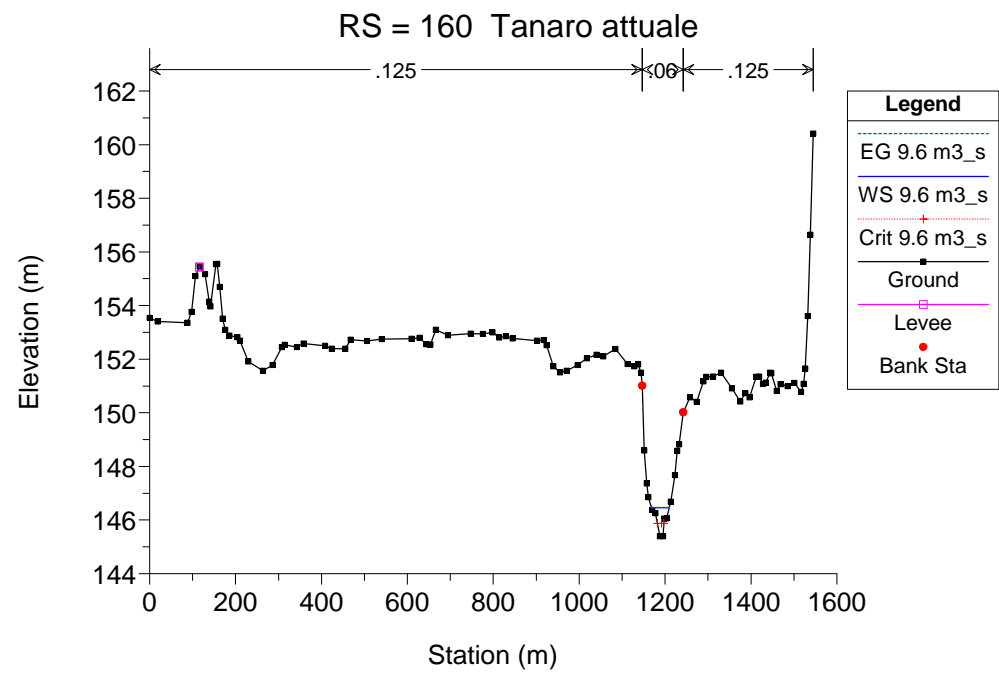
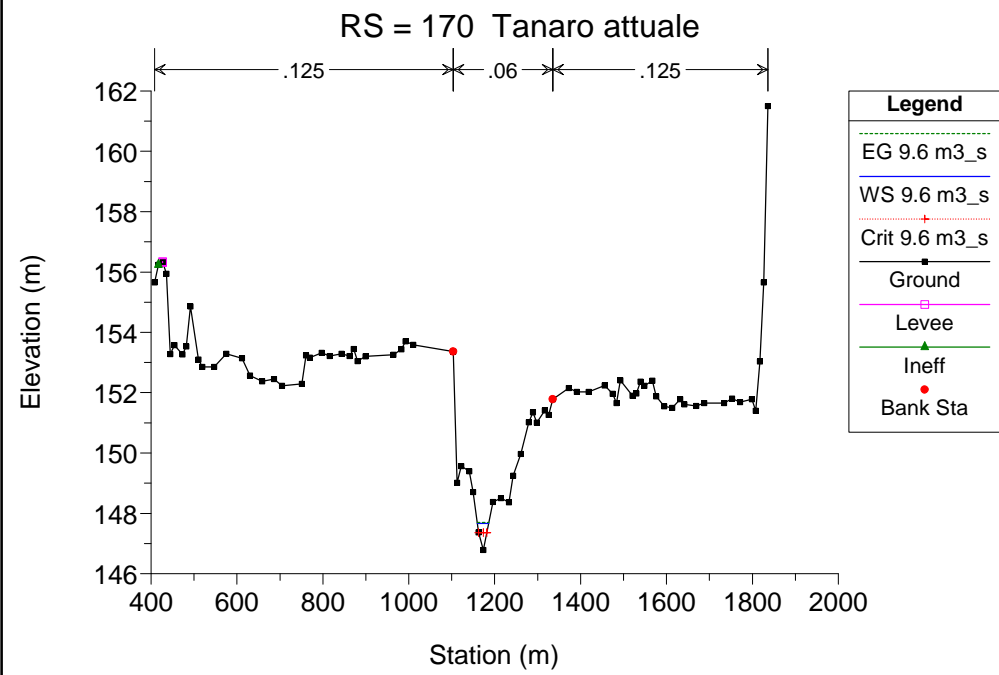
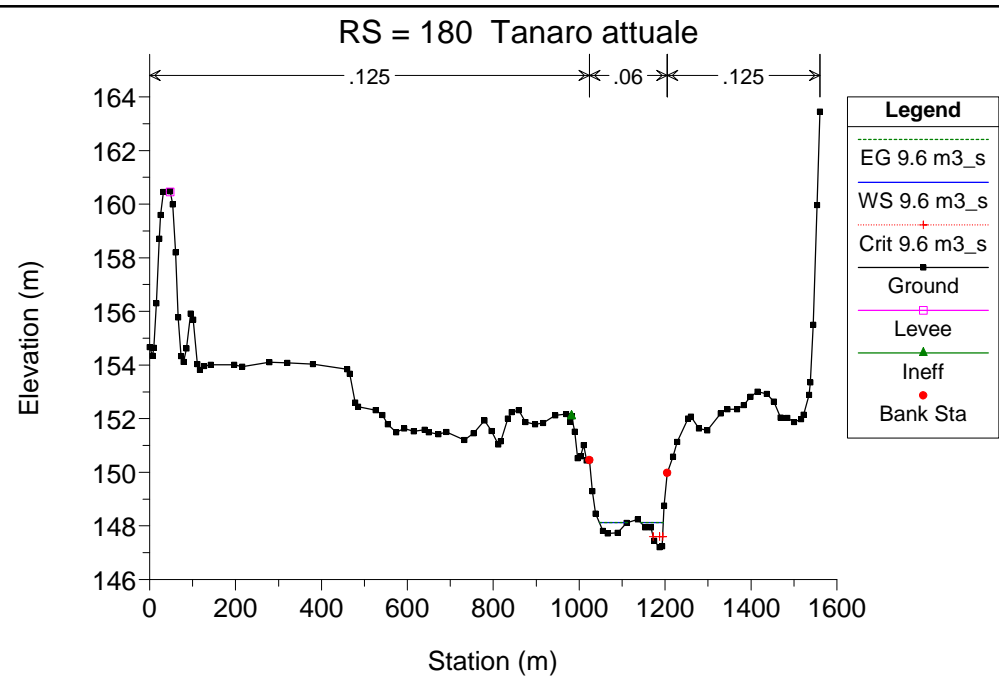
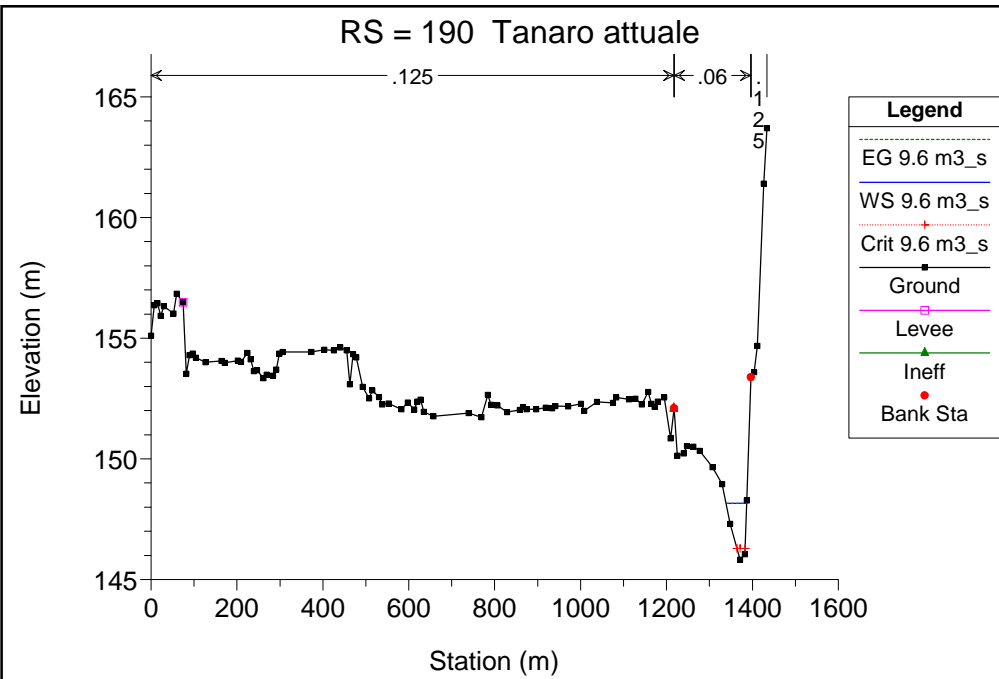


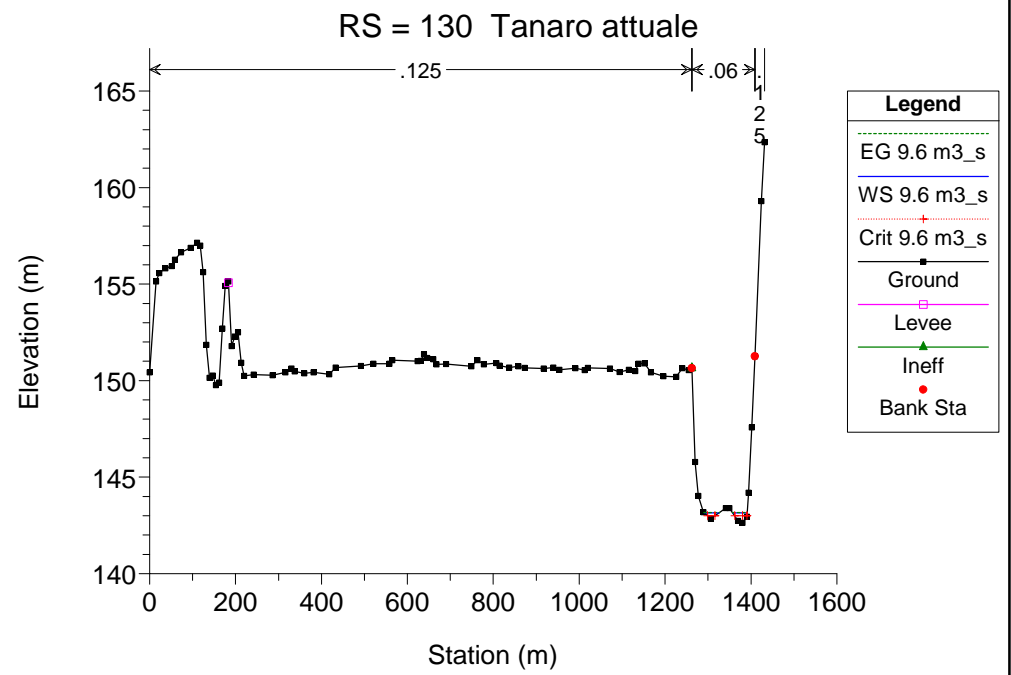
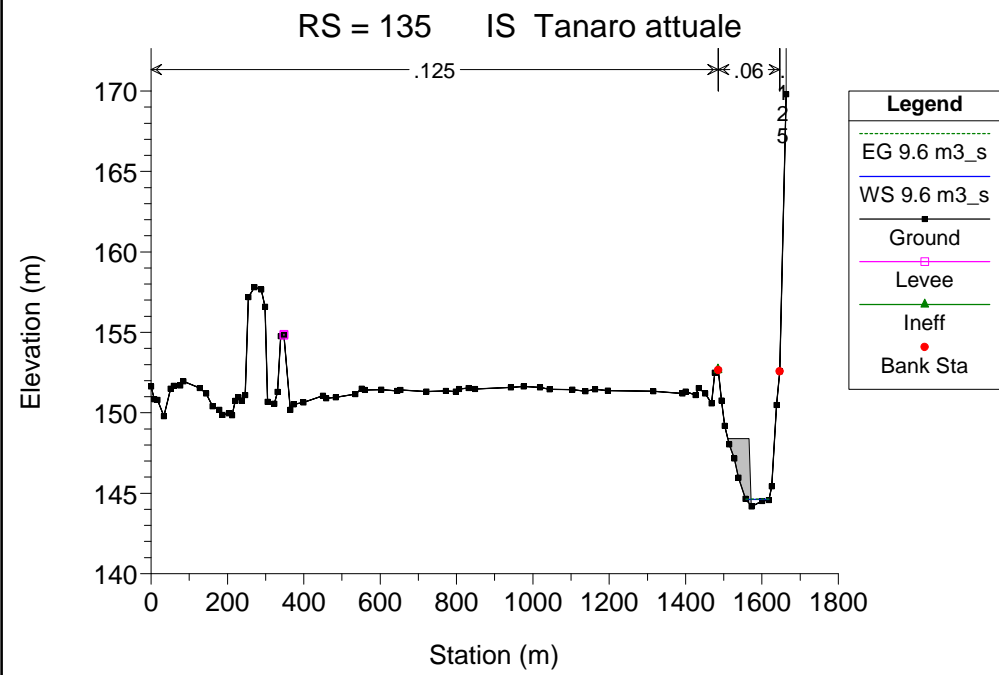
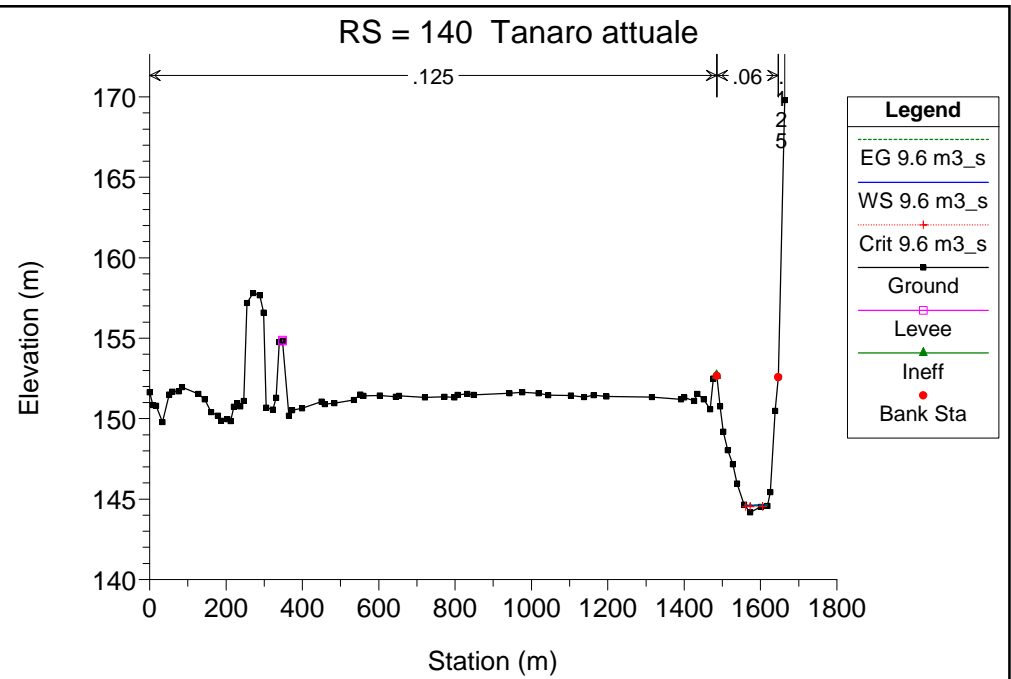
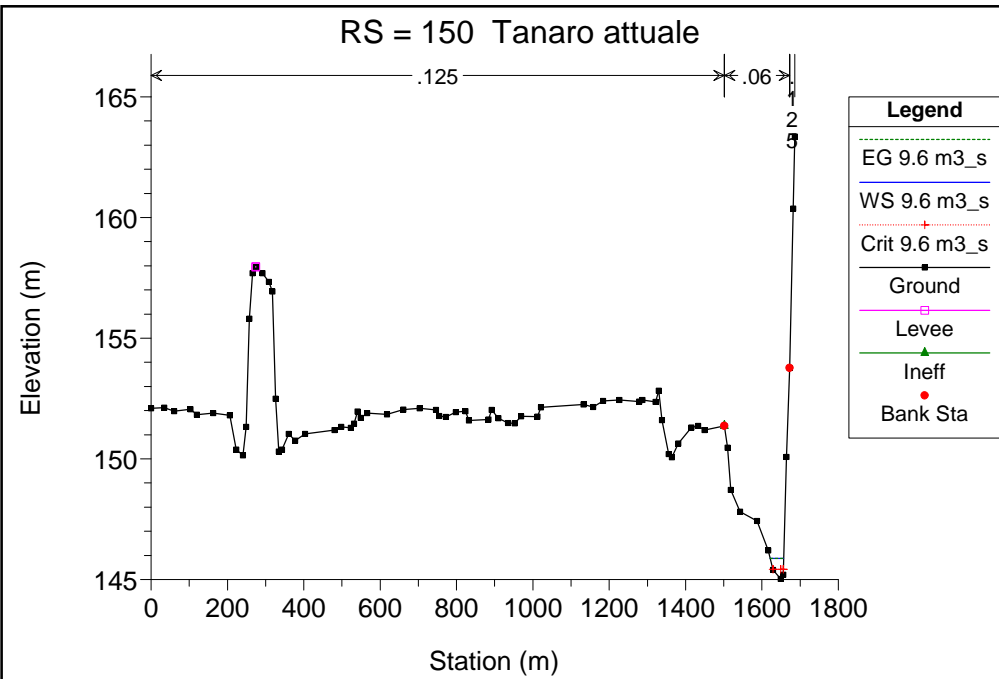


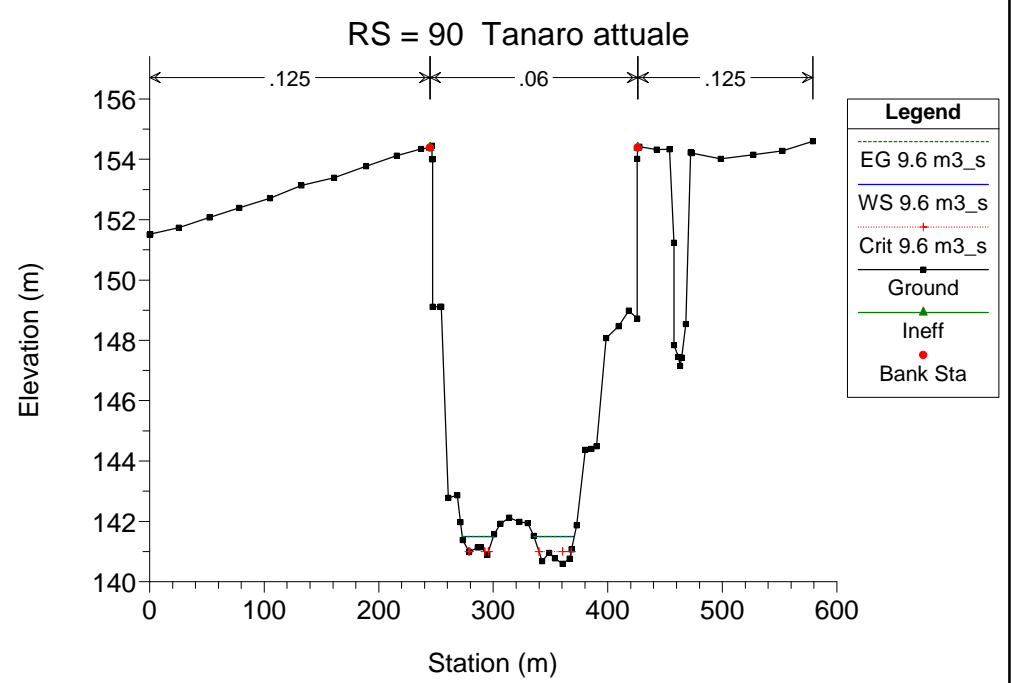
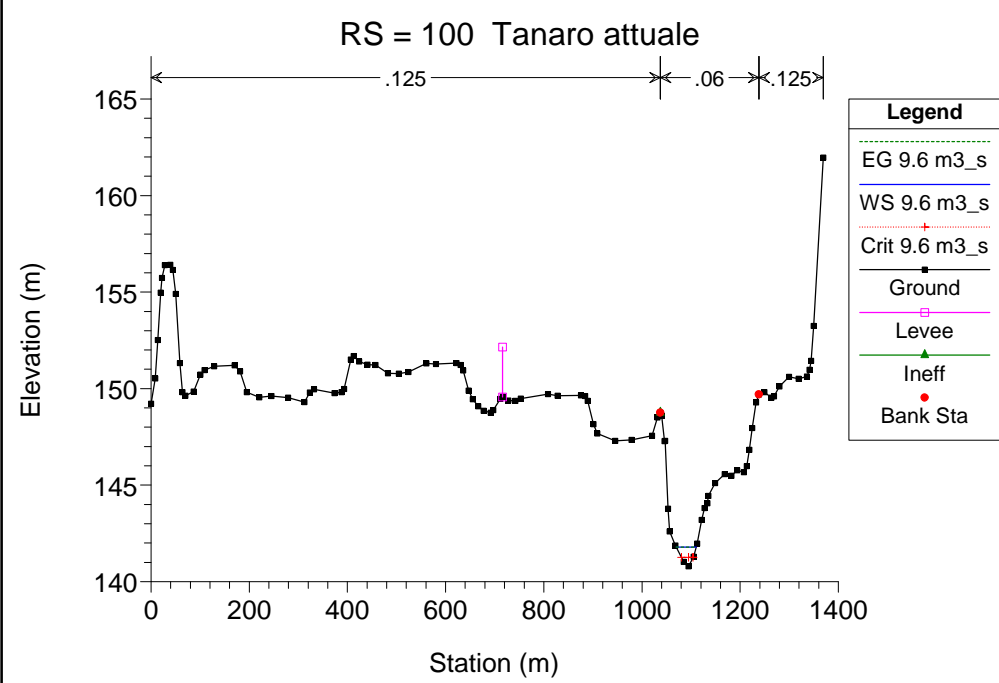
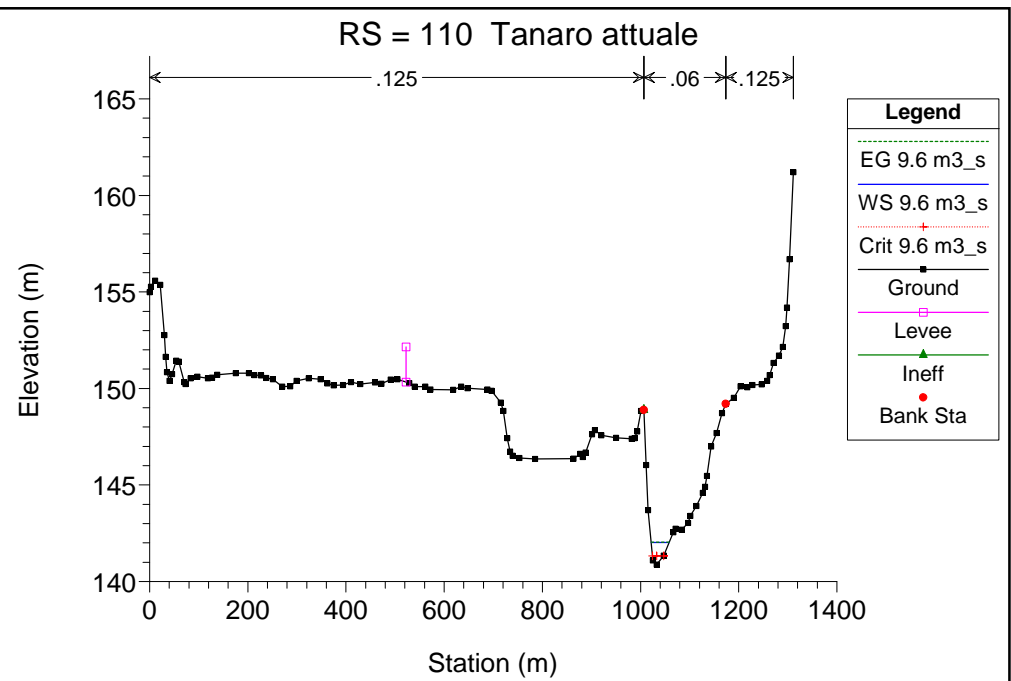
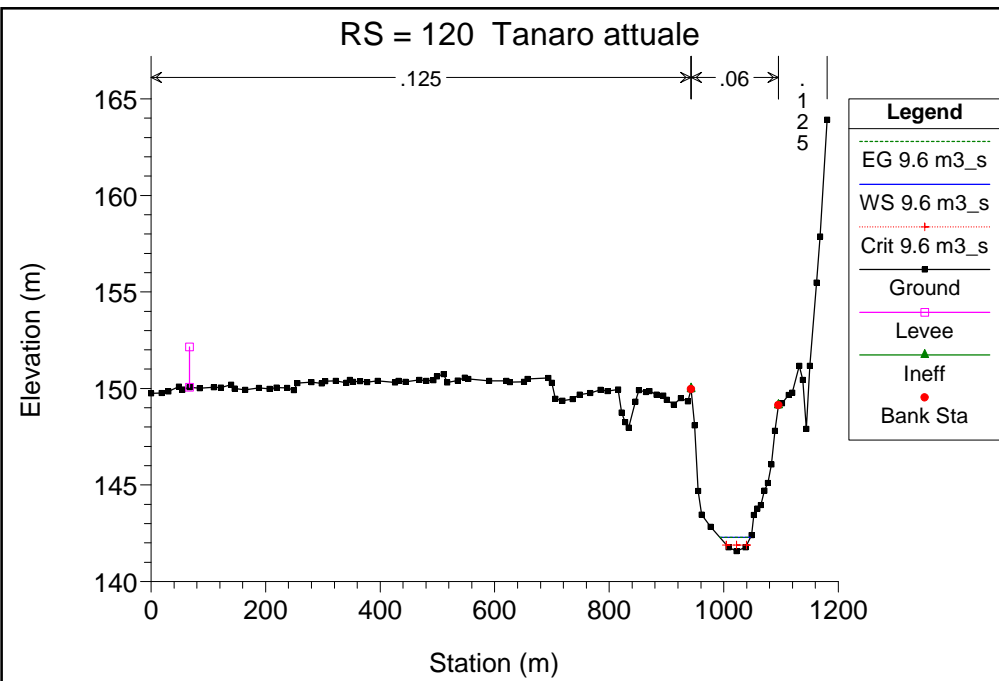


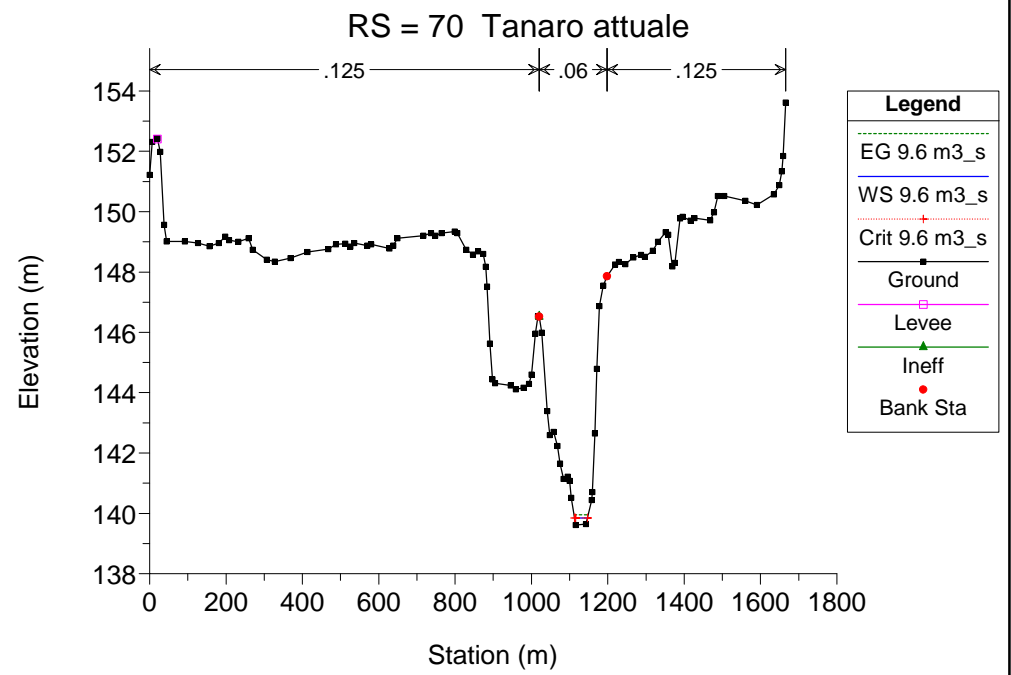
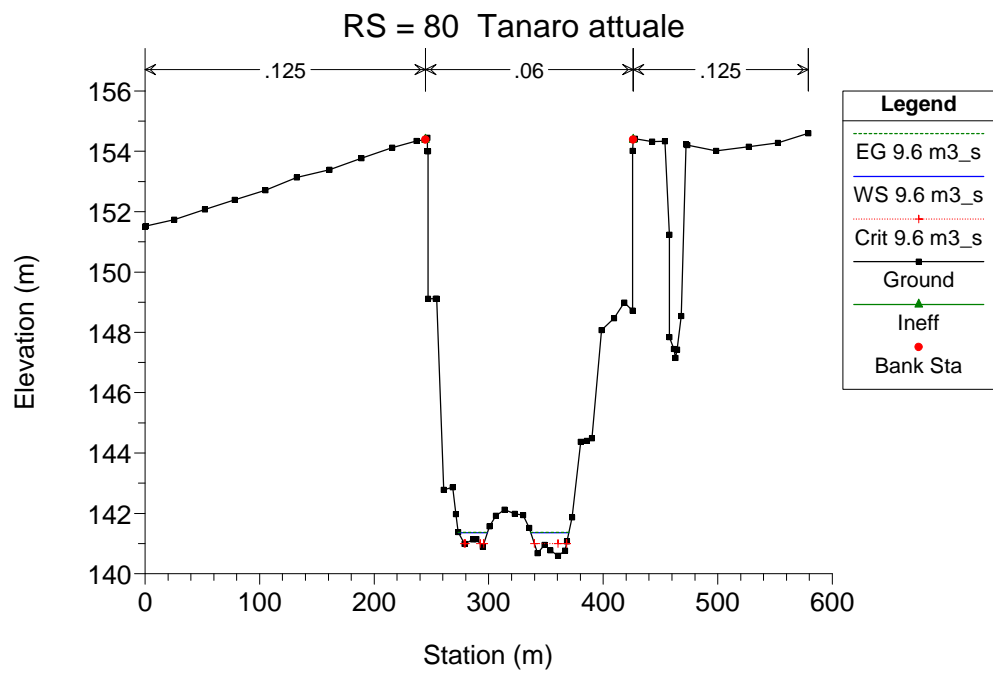
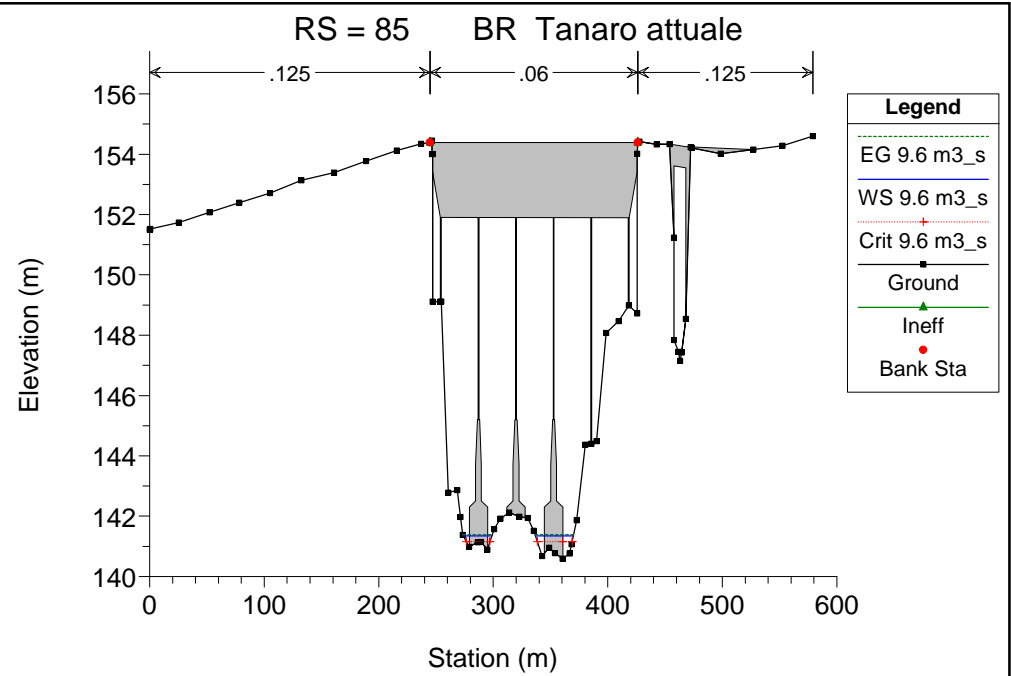
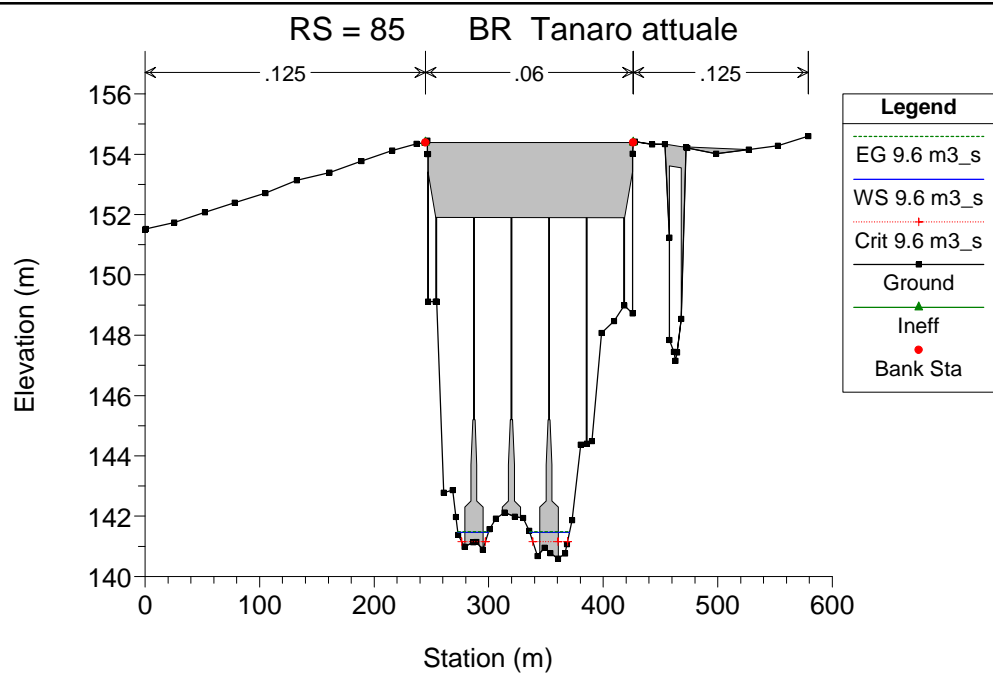


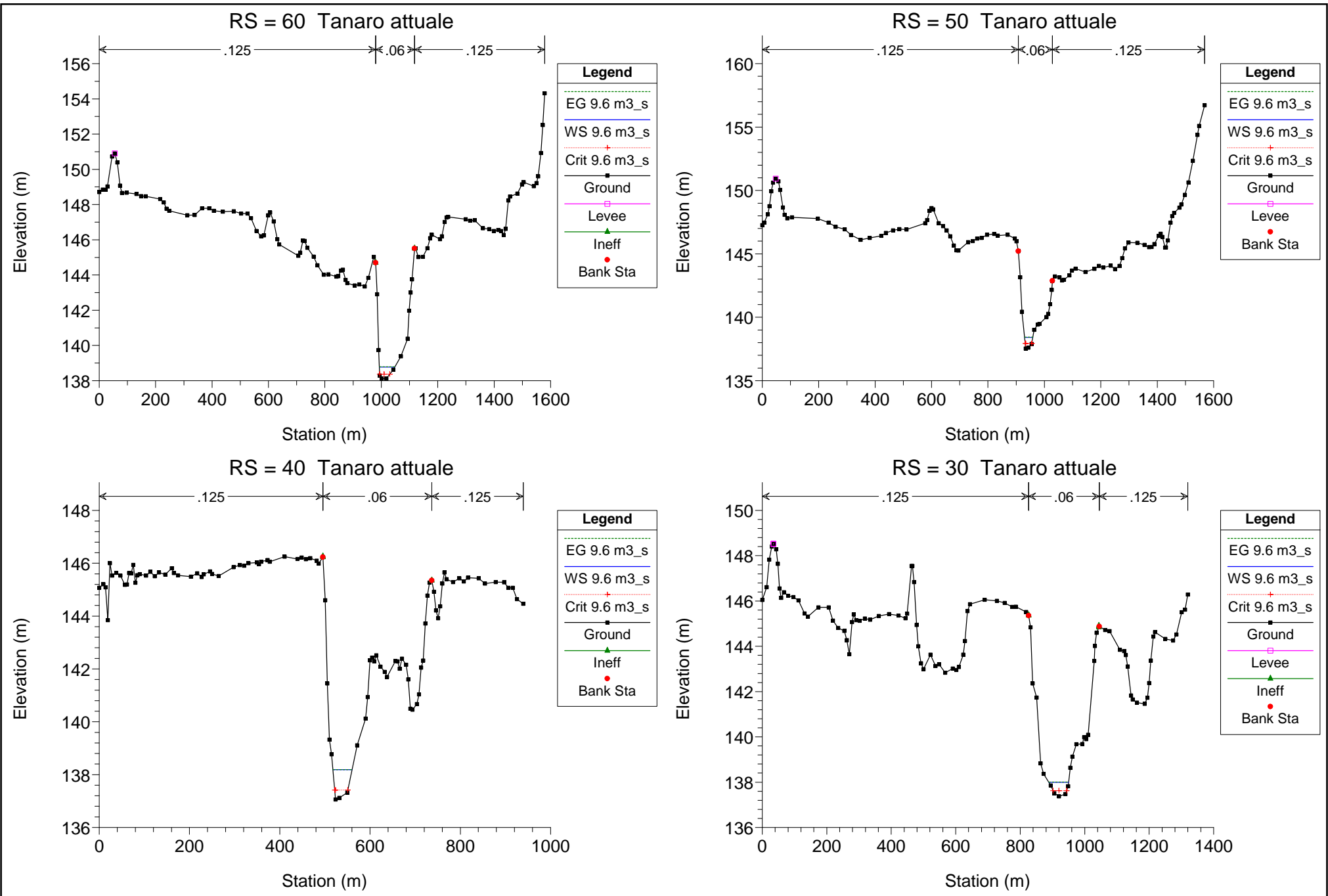


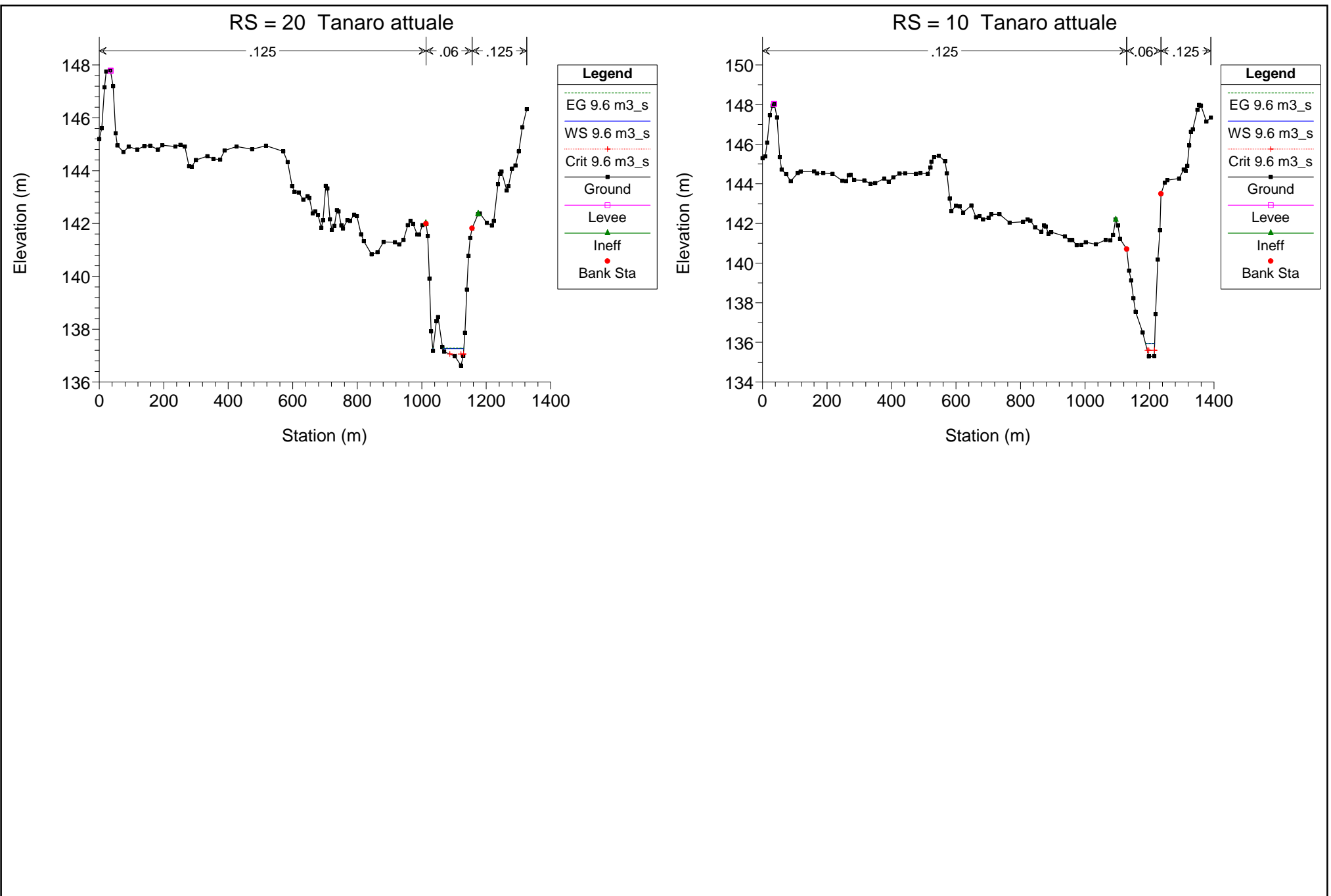












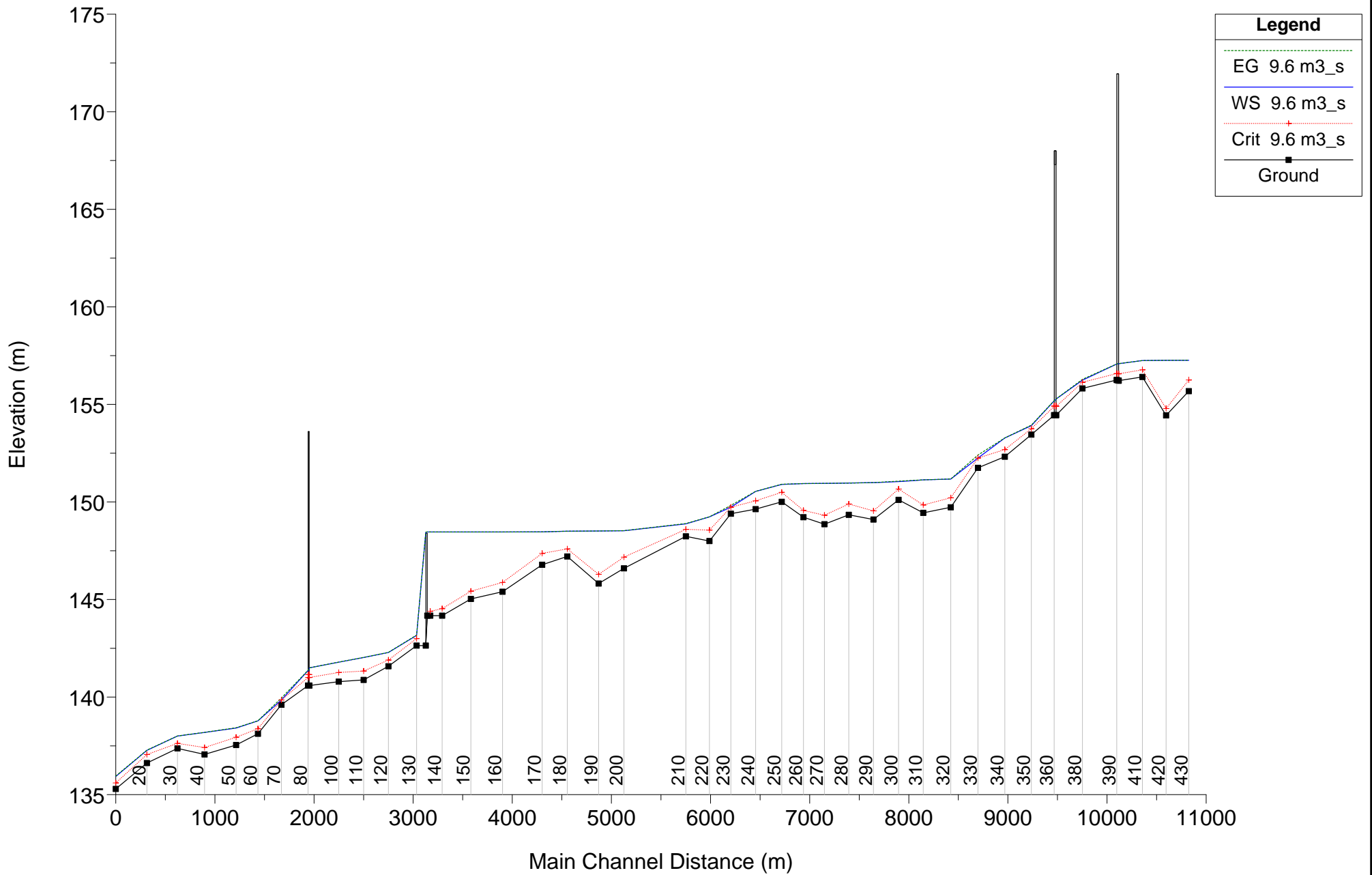
**SITUAZIONE ANTE CROLLO DEL 2010
SIMULAZIONE 11**

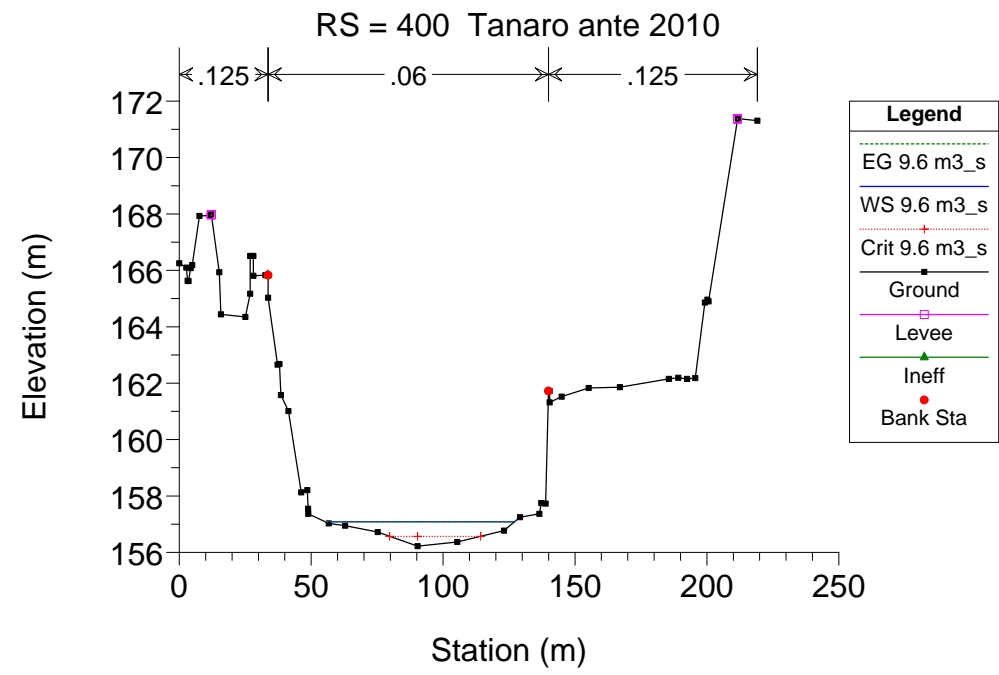
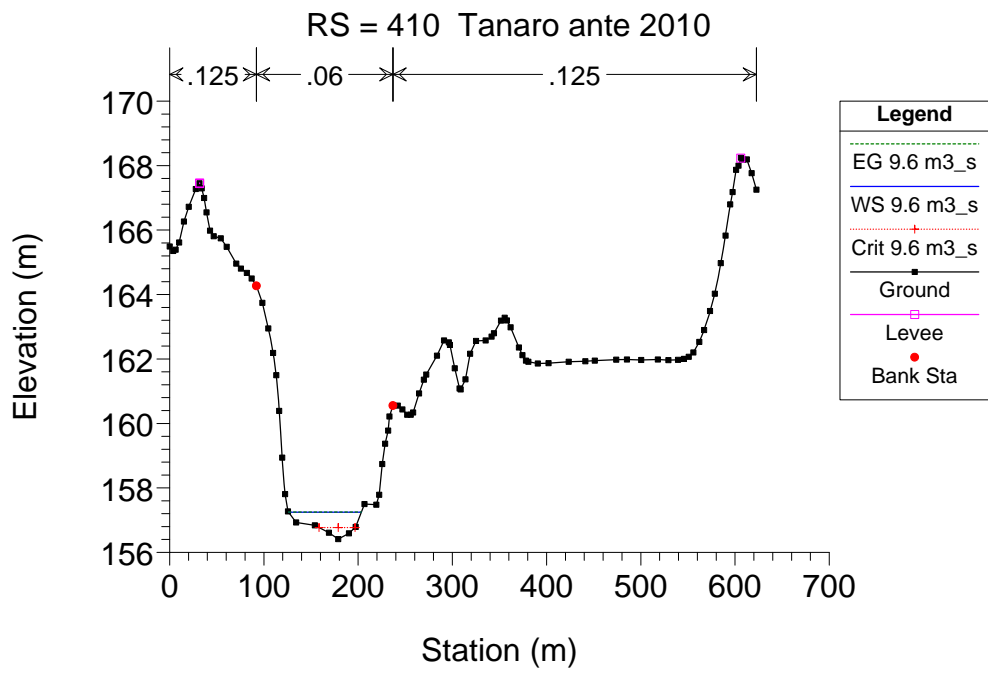
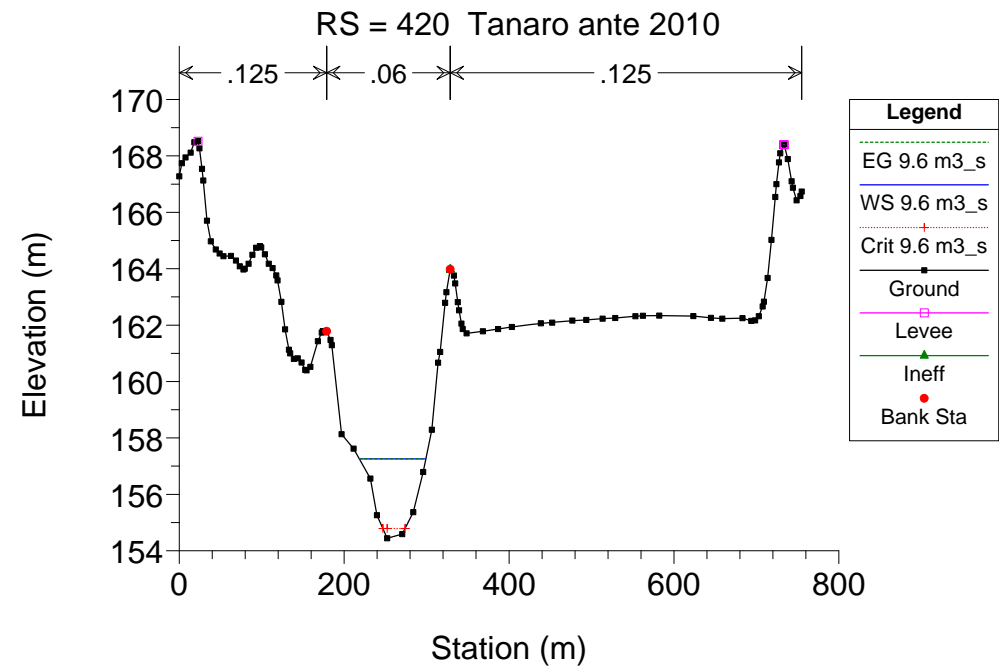
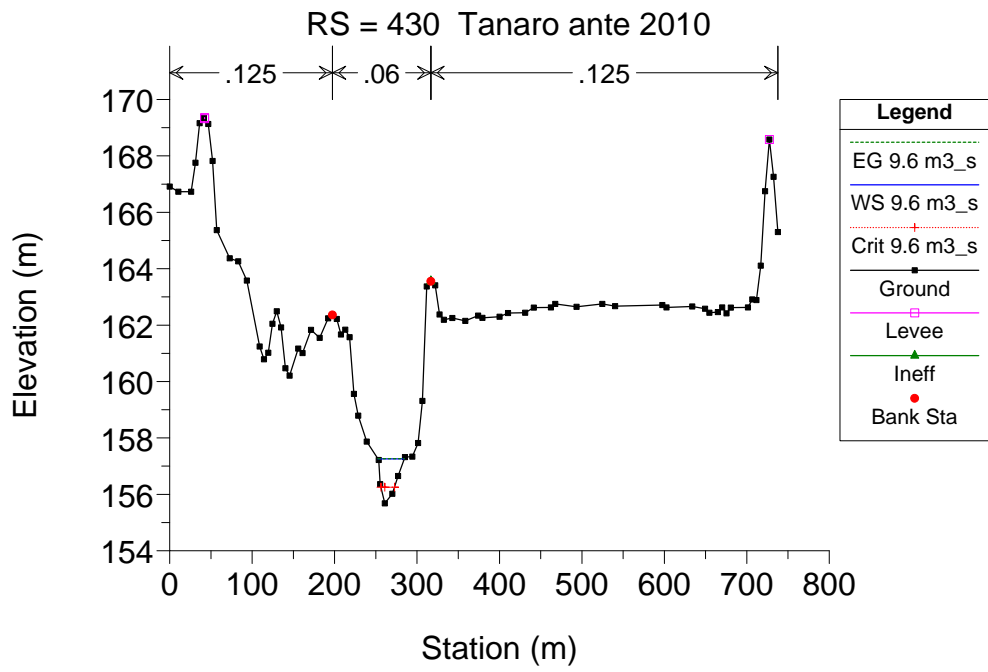
Corso d'acqua	Portata Q m³/s	Portata
Fiume Tanaro	9.6 (in alveo) 6.6 (turbinati)	Minima di funzionamento dell'impianto idroelettrico

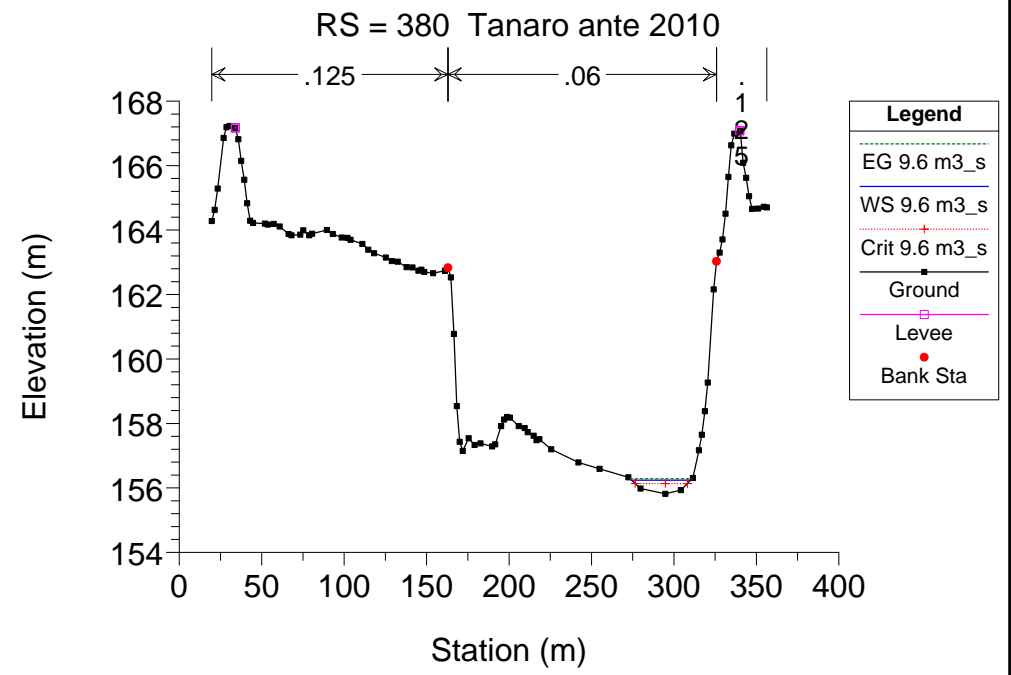
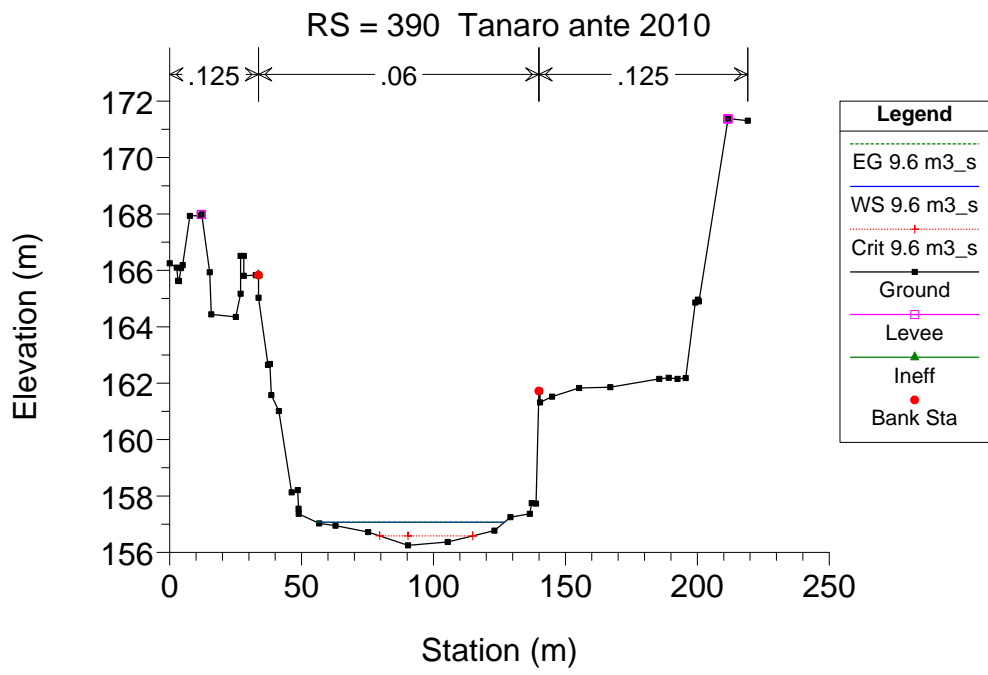
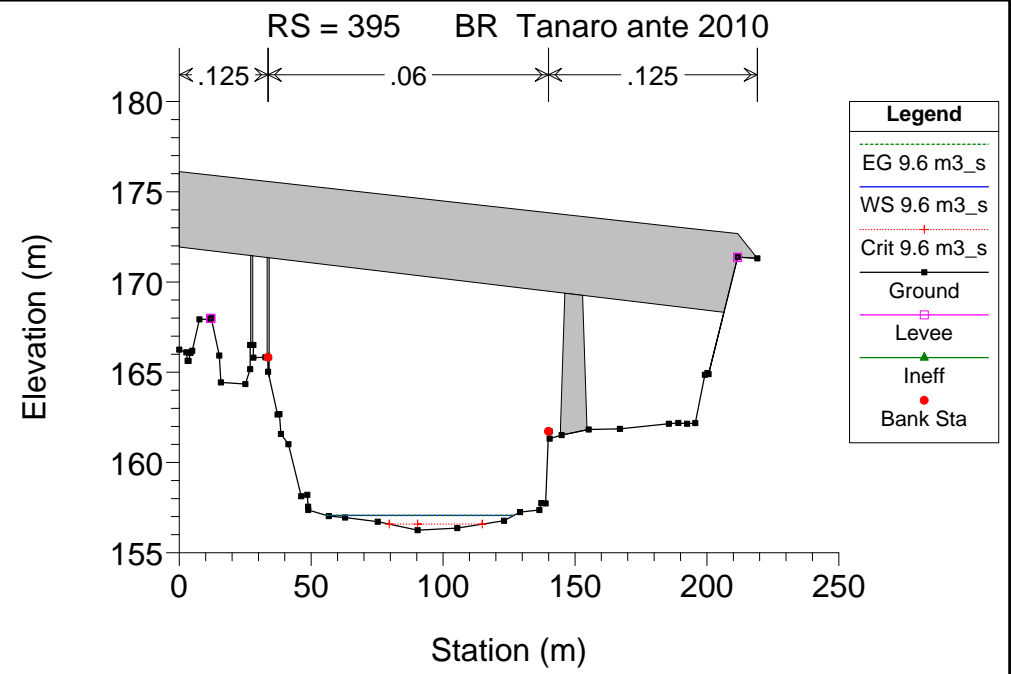
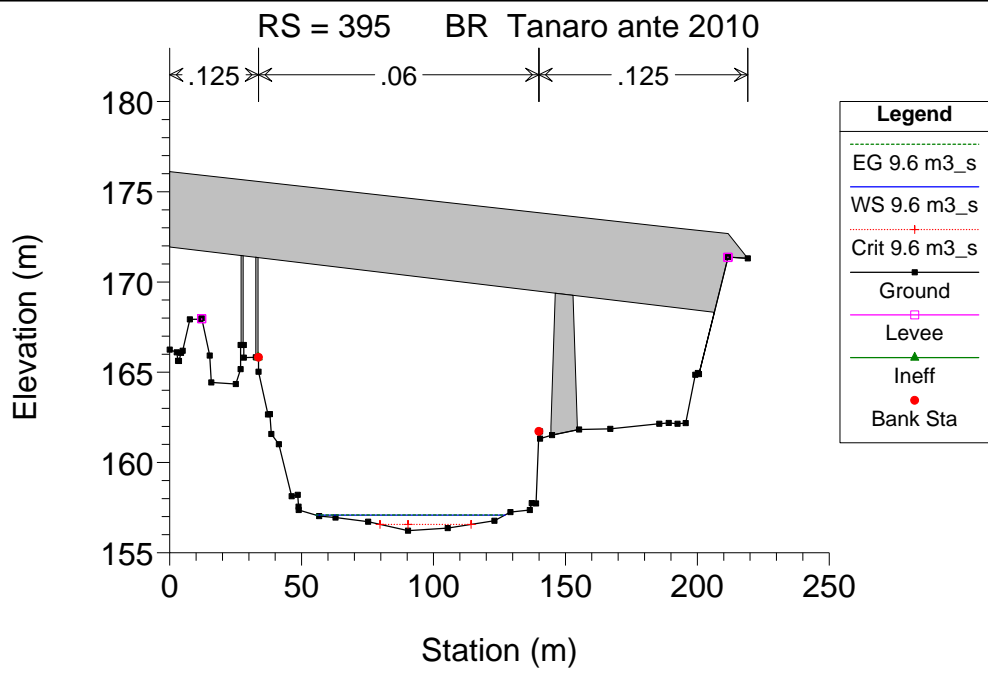
HEC-RAS Plan: Plan 06 River: Tanaro Reach: 1 Profile: 9.6 m3_s (Continued)

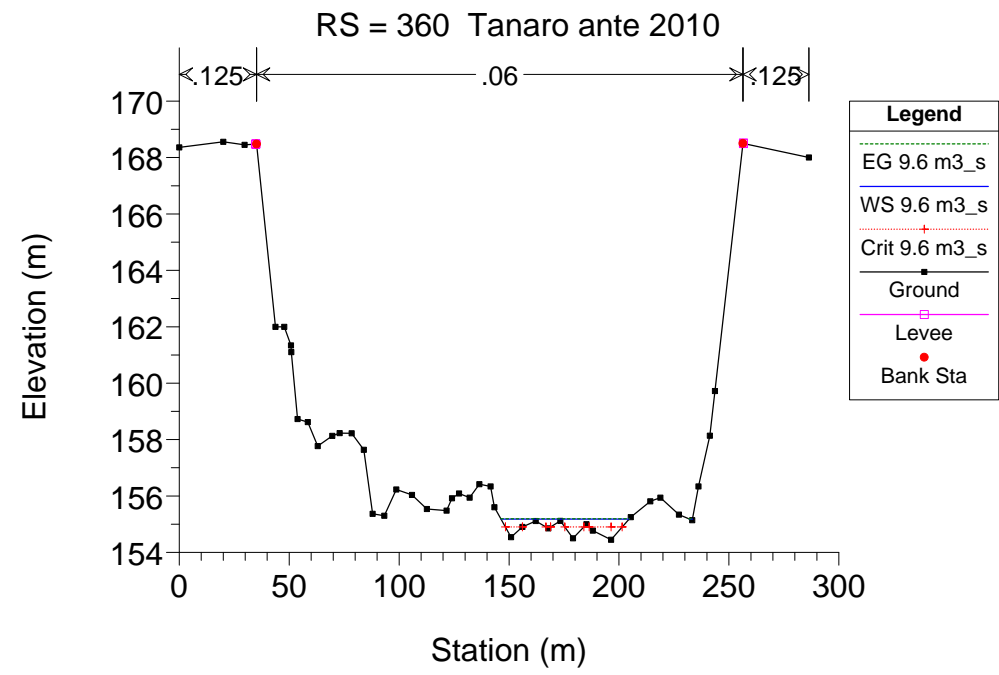
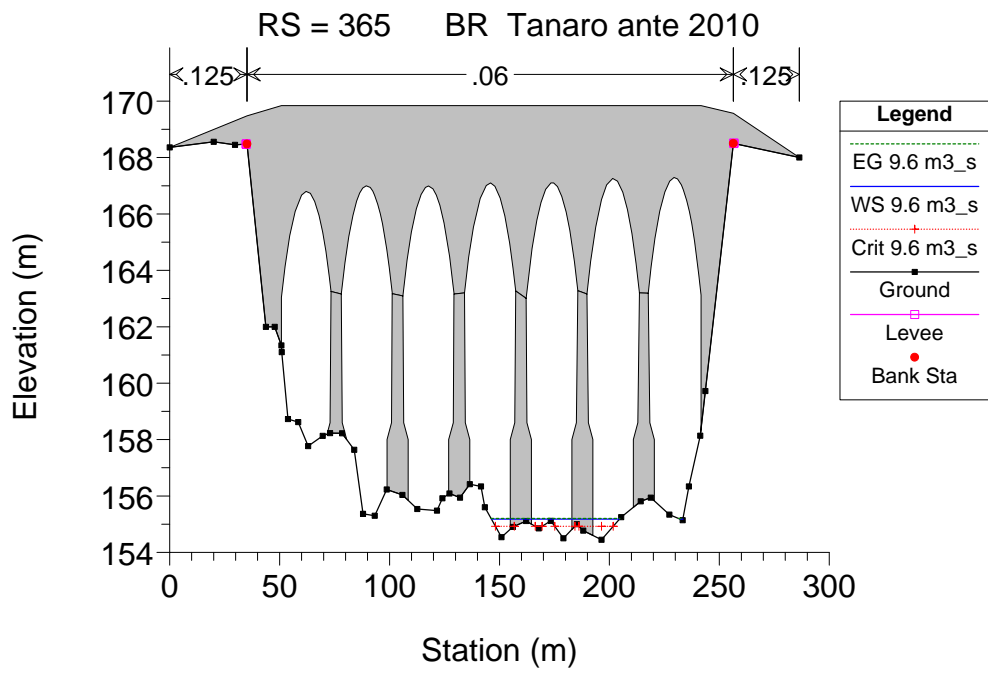
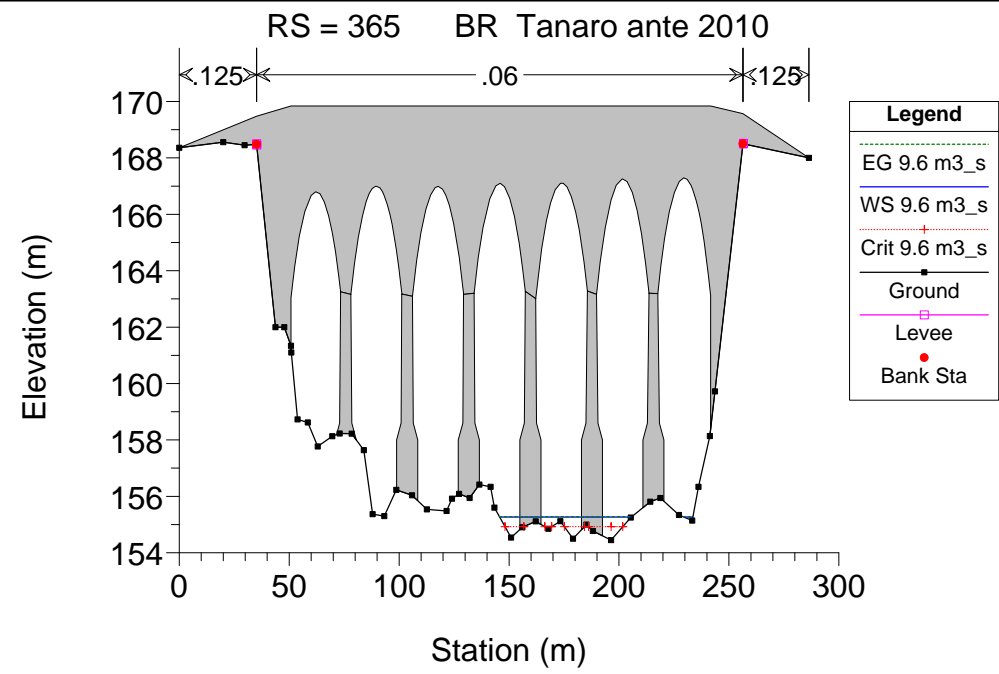
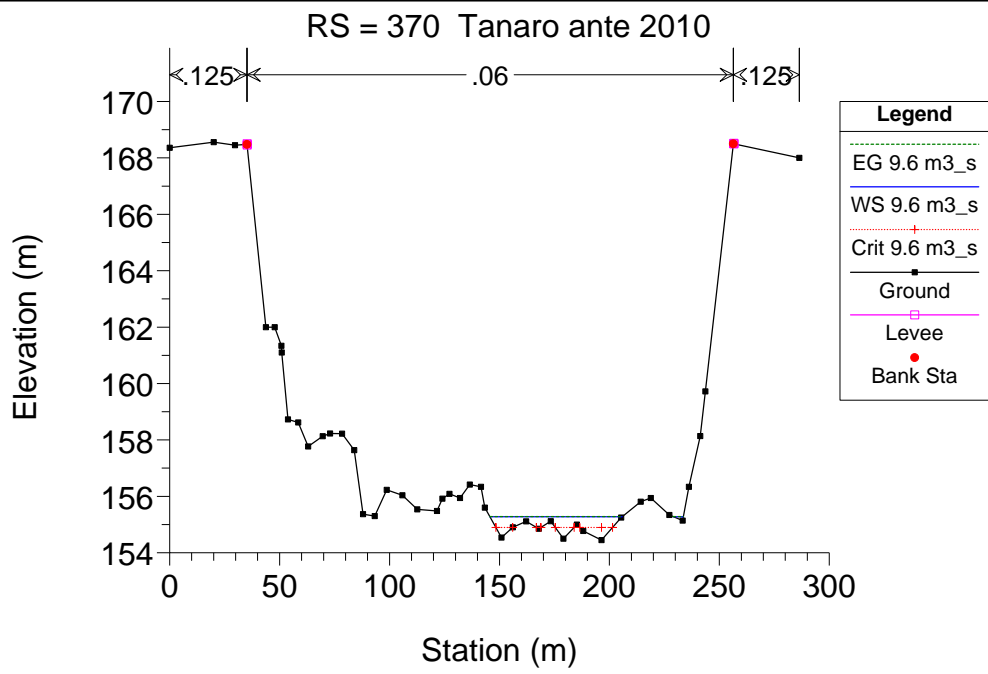
Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
1	80	9.6 m3_s	9.60	140.59	141.36	141.00	141.37	0.001777	0.39	24.51	58.73	0.19
1	70	9.6 m3_s	9.60	139.61	139.85	139.85	139.95	0.061207	1.41	6.81	34.08	1.01
1	60	9.6 m3_s	9.60	138.12	138.78	138.38	138.79	0.001440	0.38	25.31	54.41	0.18
1	50	9.6 m3_s	9.60	137.54	138.41	137.94	138.43	0.001860	0.53	18.27	29.09	0.21
1	40	9.6 m3_s	9.60	137.06	138.19	137.41	138.19	0.000389	0.28	33.93	42.30	0.10
1	30	9.6 m3_s	9.60	137.37	138.00	137.63	138.01	0.001445	0.36	26.55	61.55	0.18
1	20	9.6 m3_s	9.60	136.62	137.27	137.06	137.28	0.004463	0.49	19.50	66.26	0.29
1	10	9.6 m3_s	9.60	135.29	135.93	135.60	135.95	0.004001	0.67	14.34	28.15	0.30

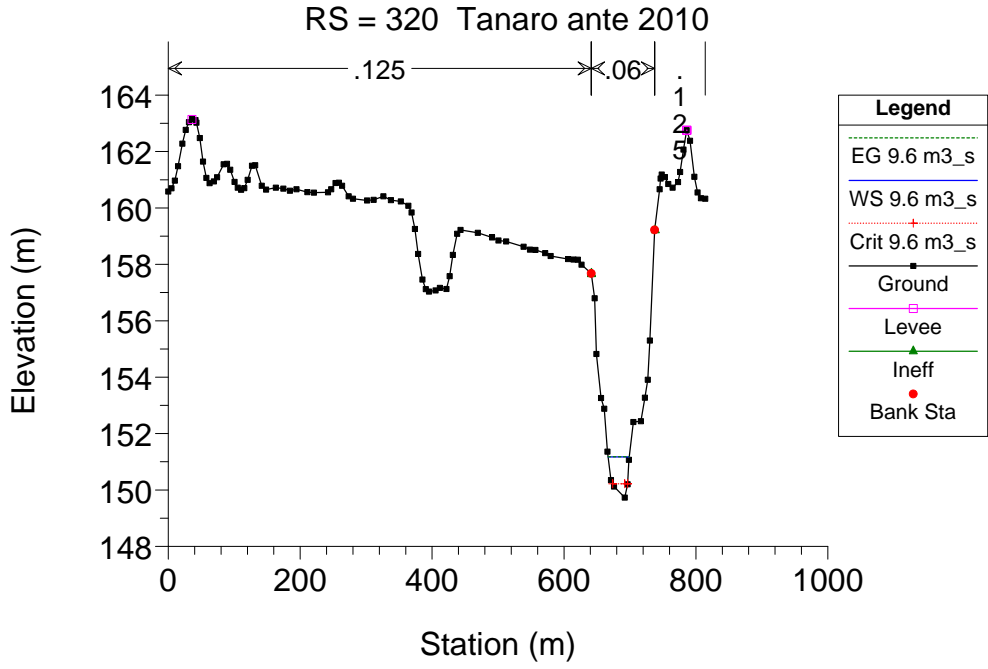
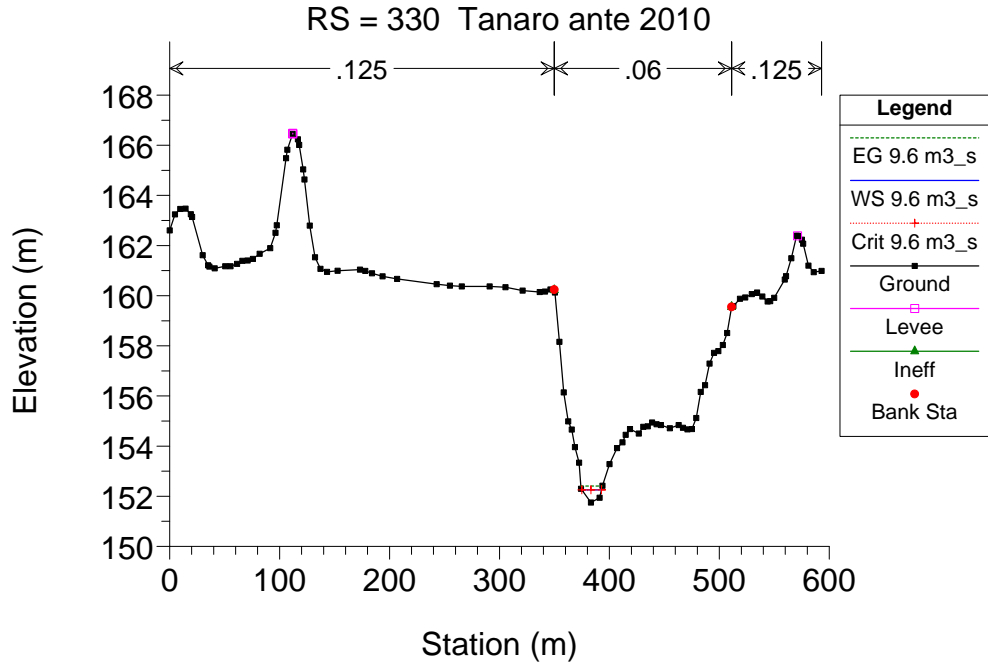
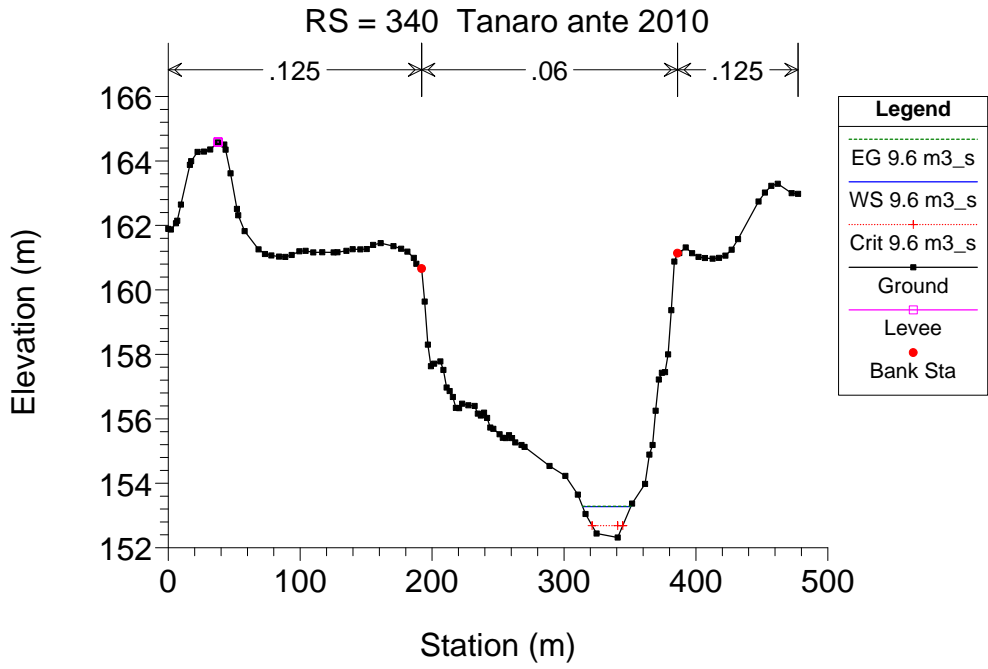
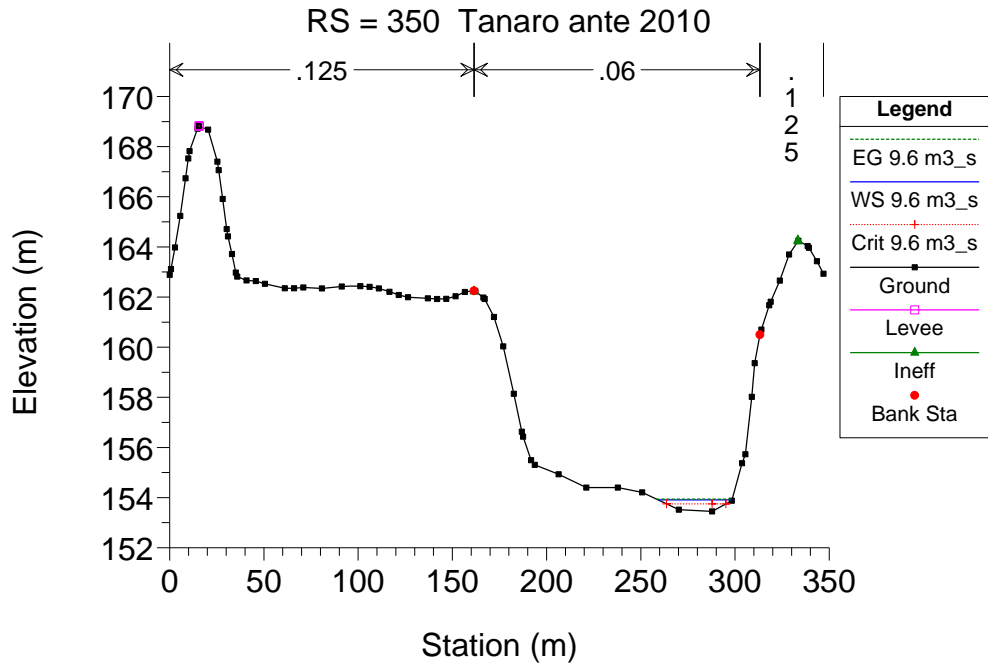
Tanaro ante 2010

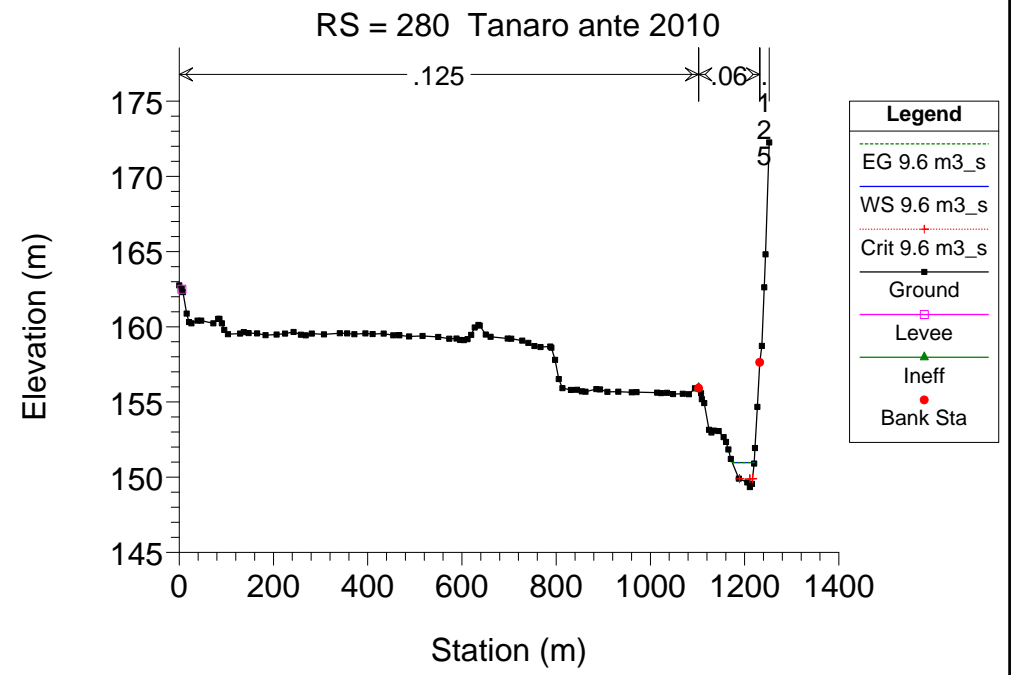
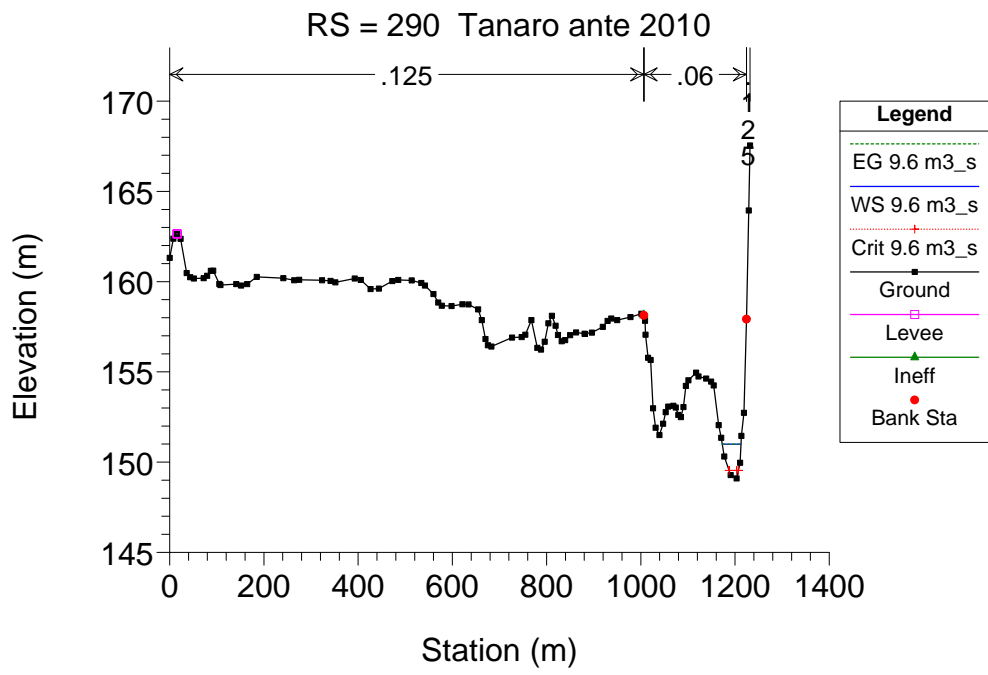
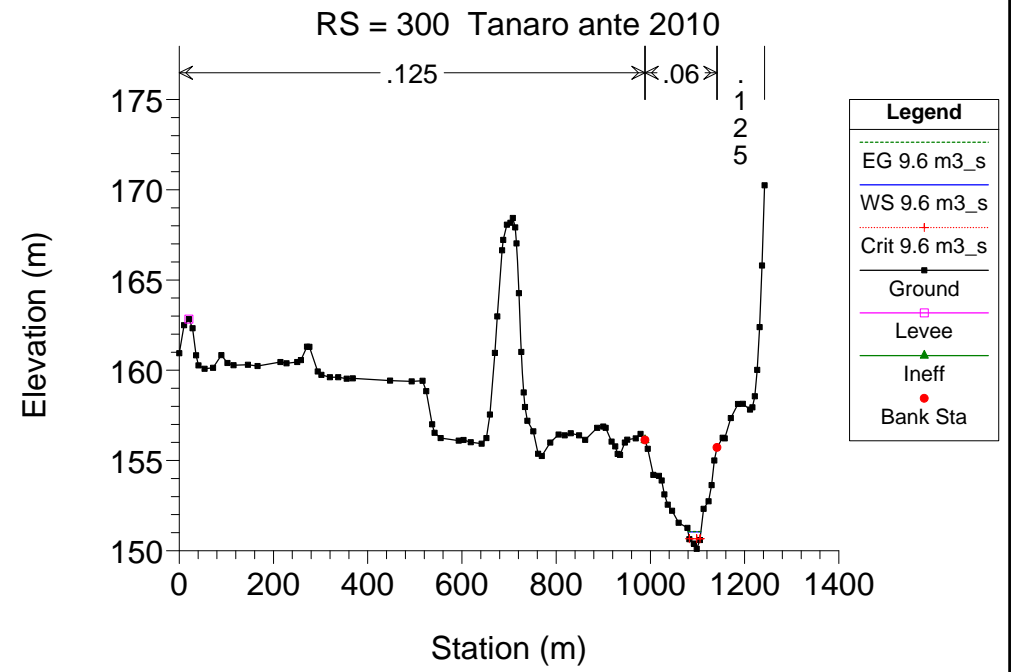
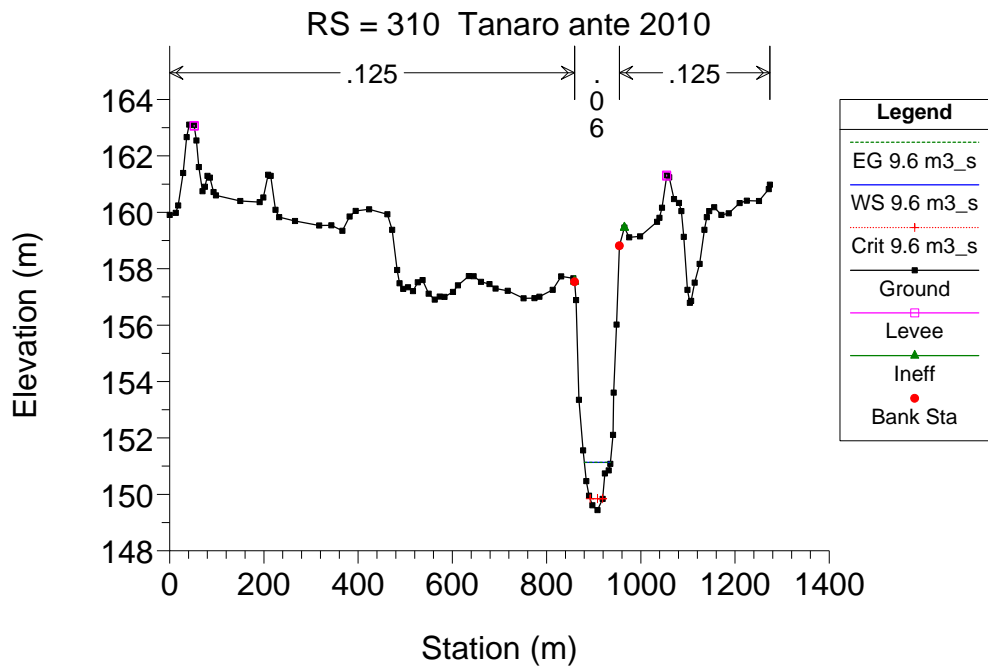


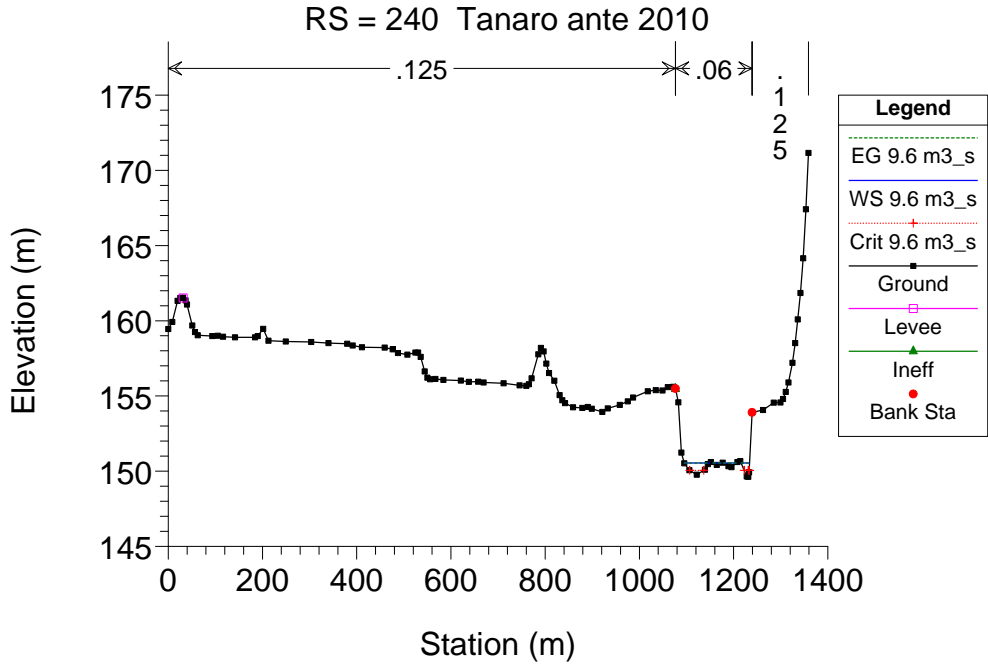
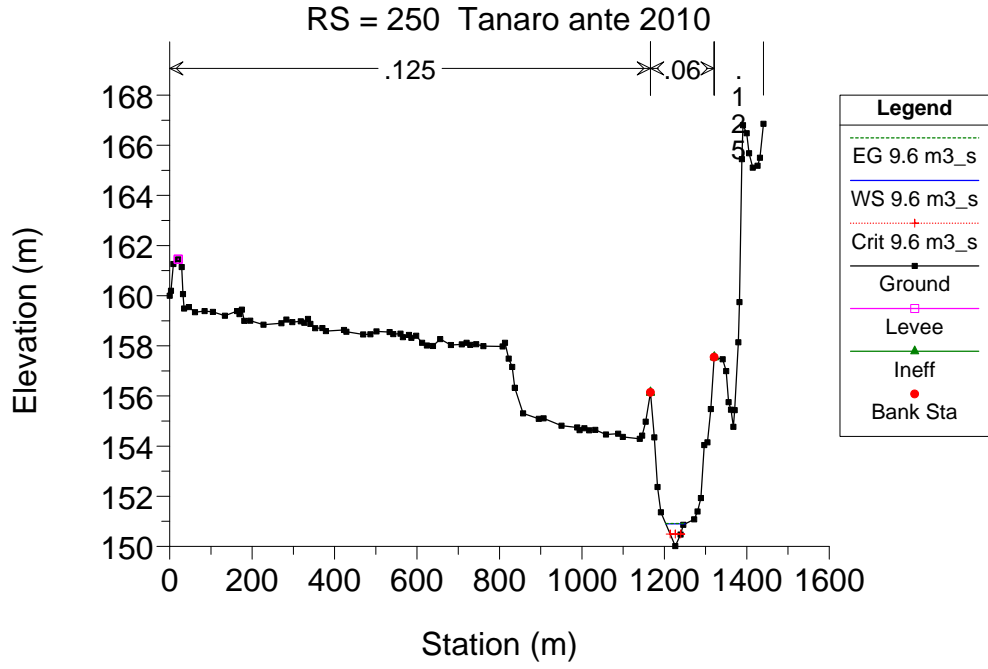
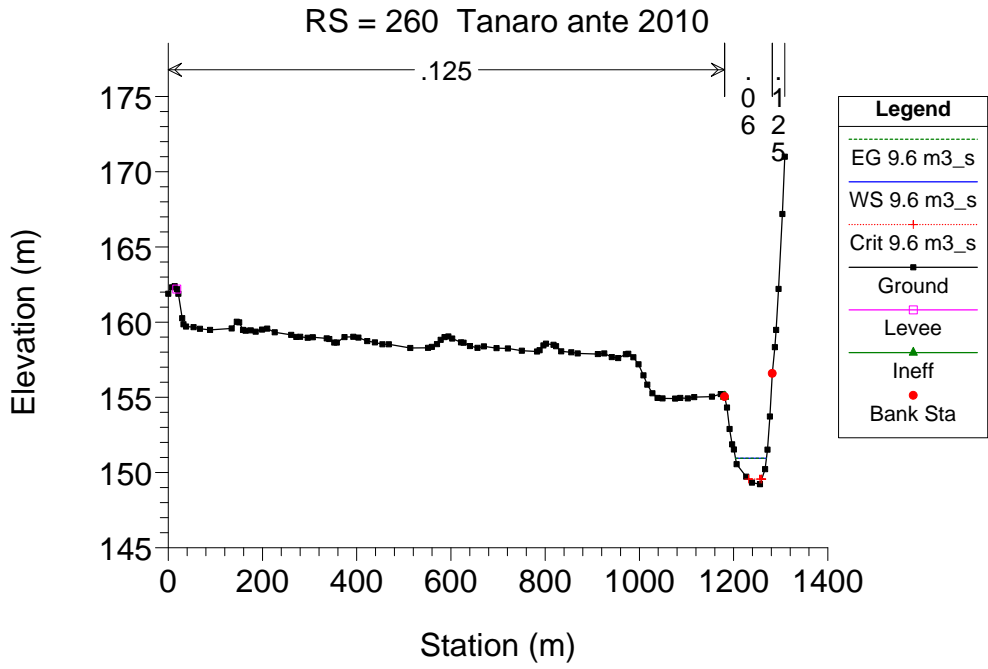
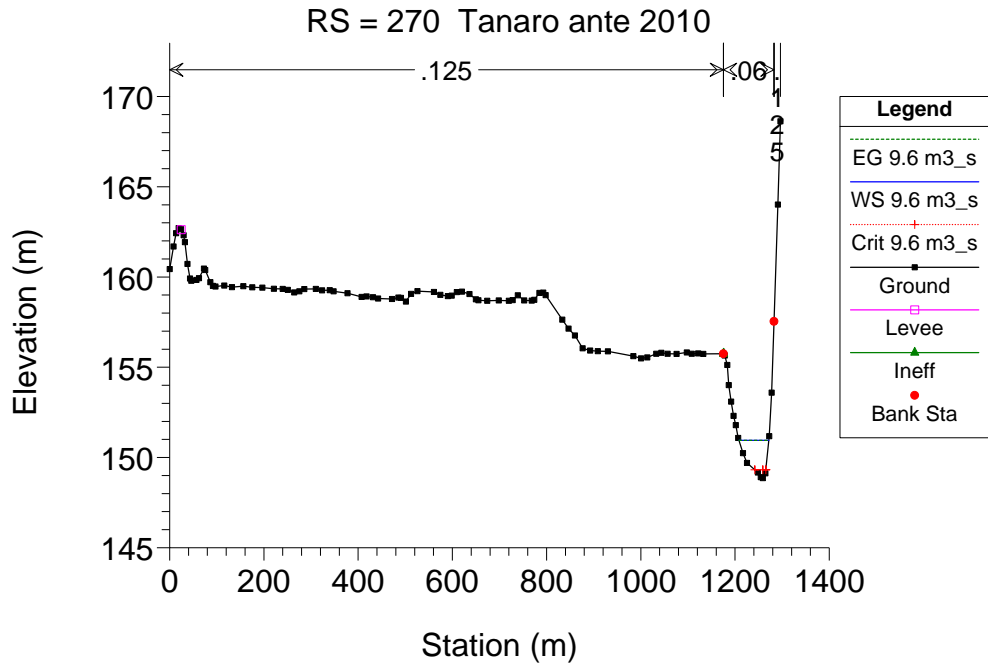


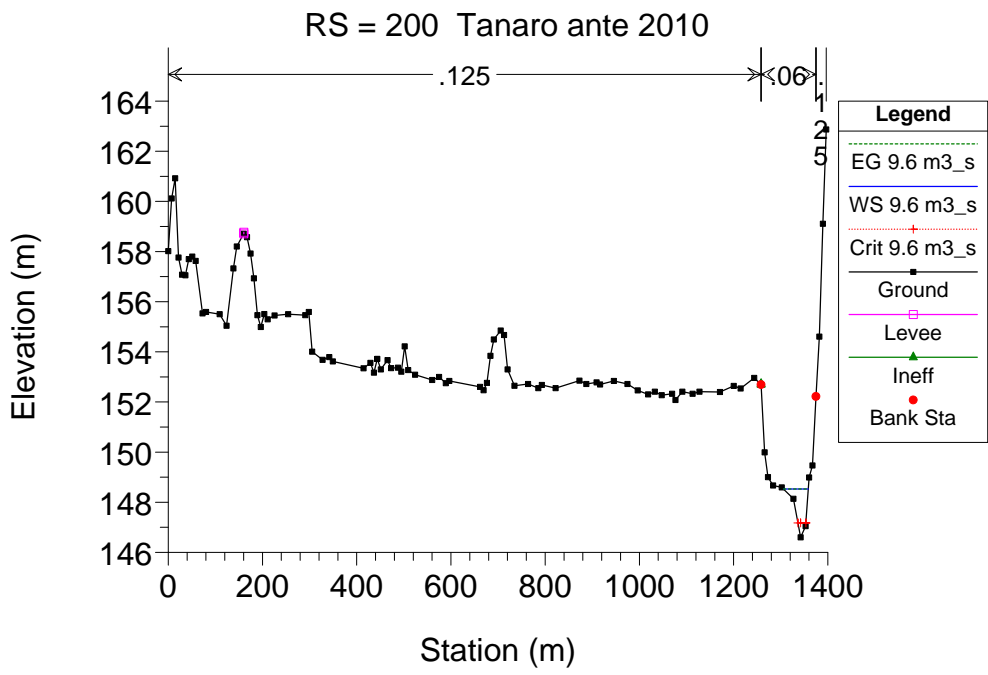
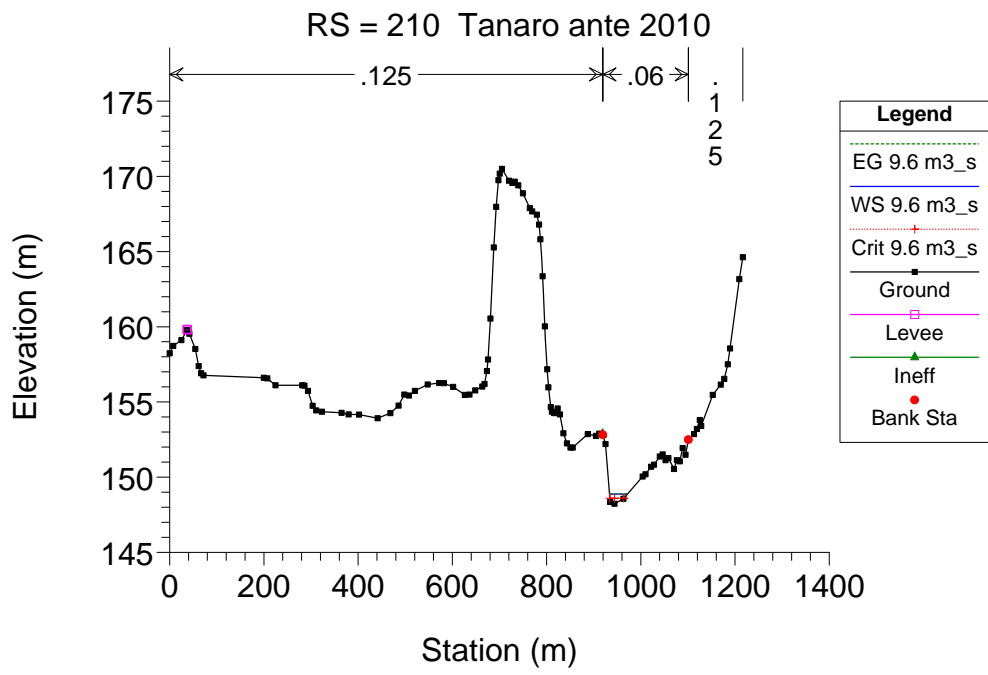
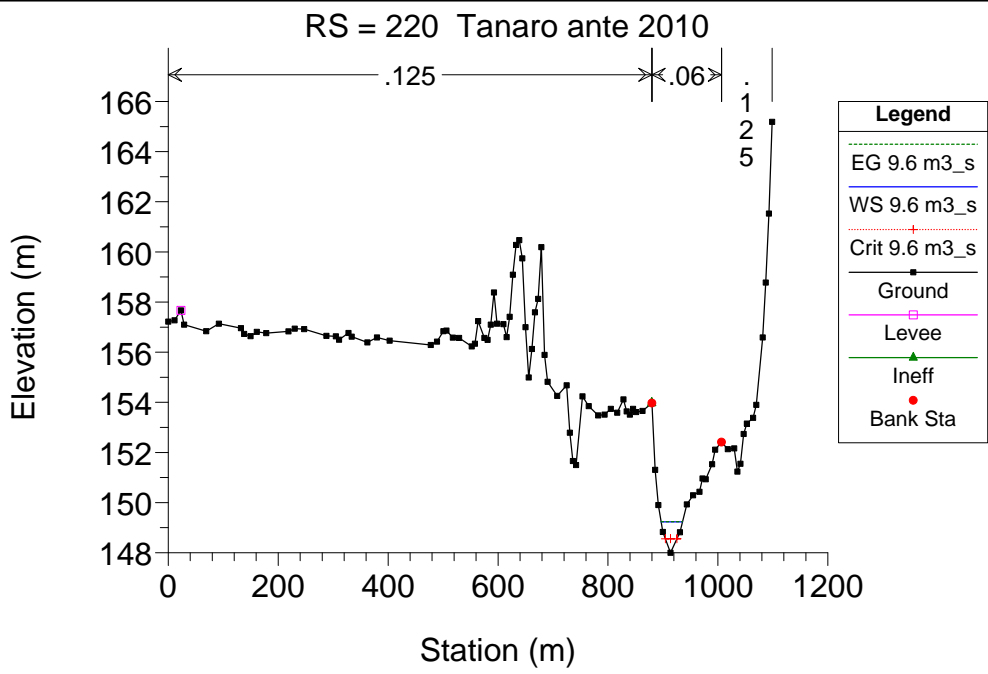
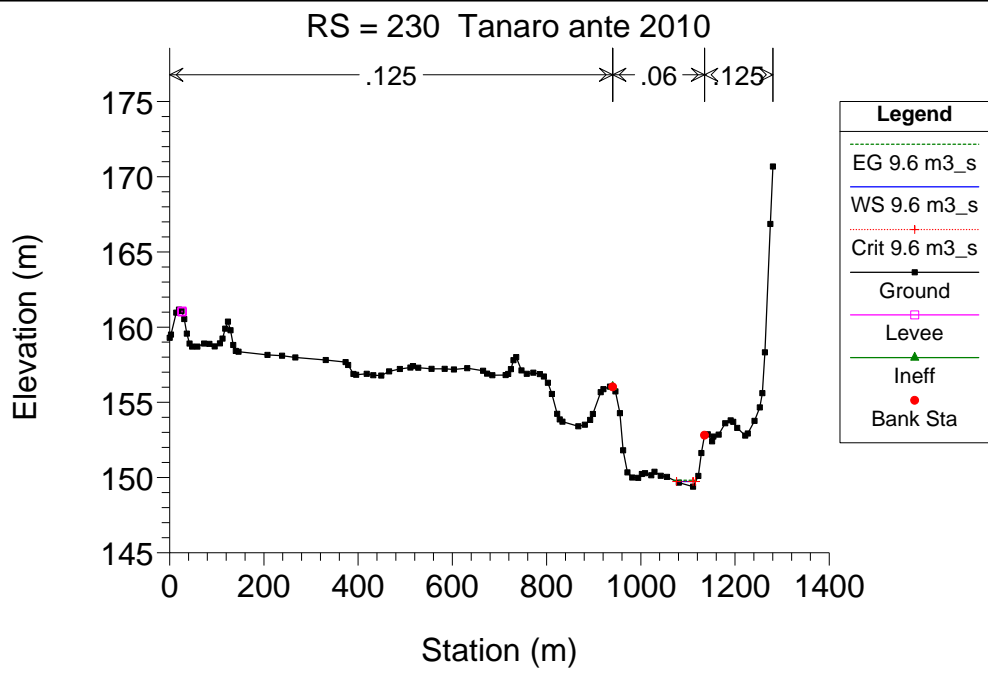


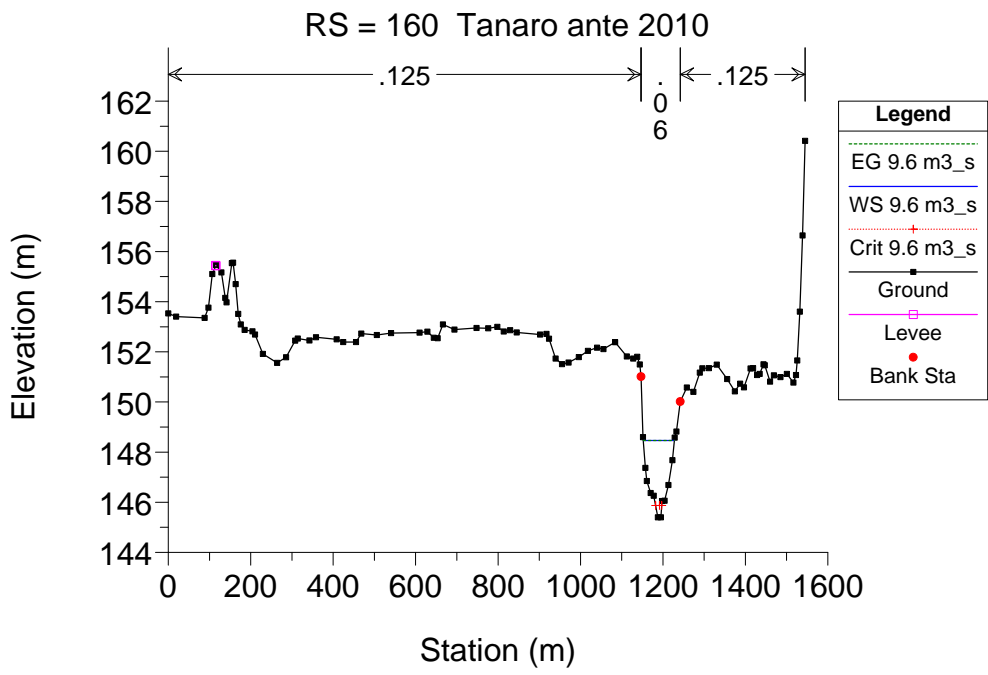
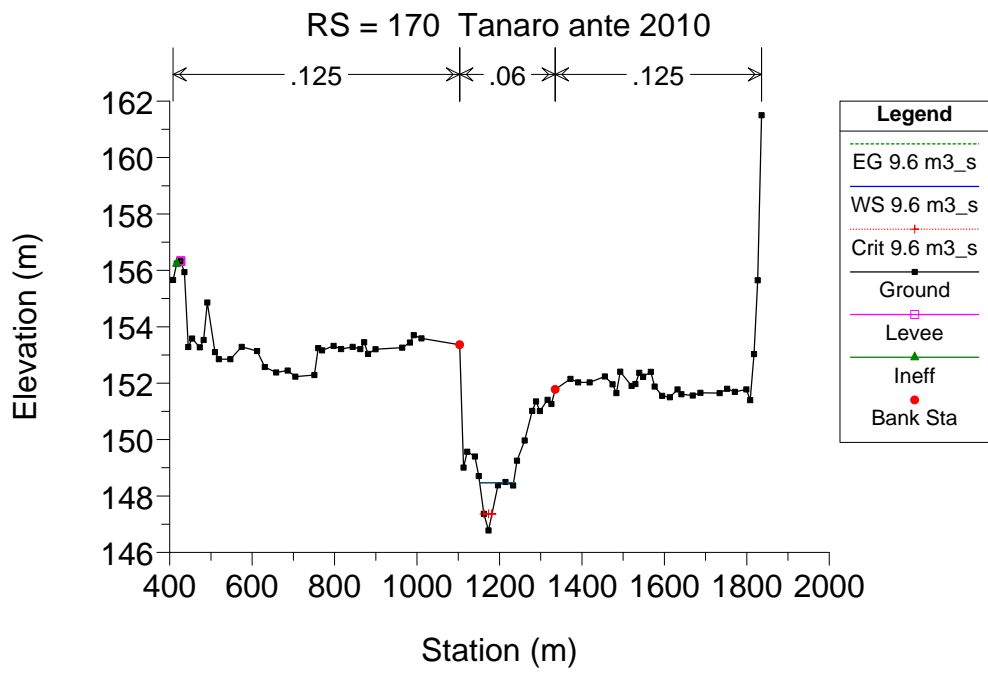
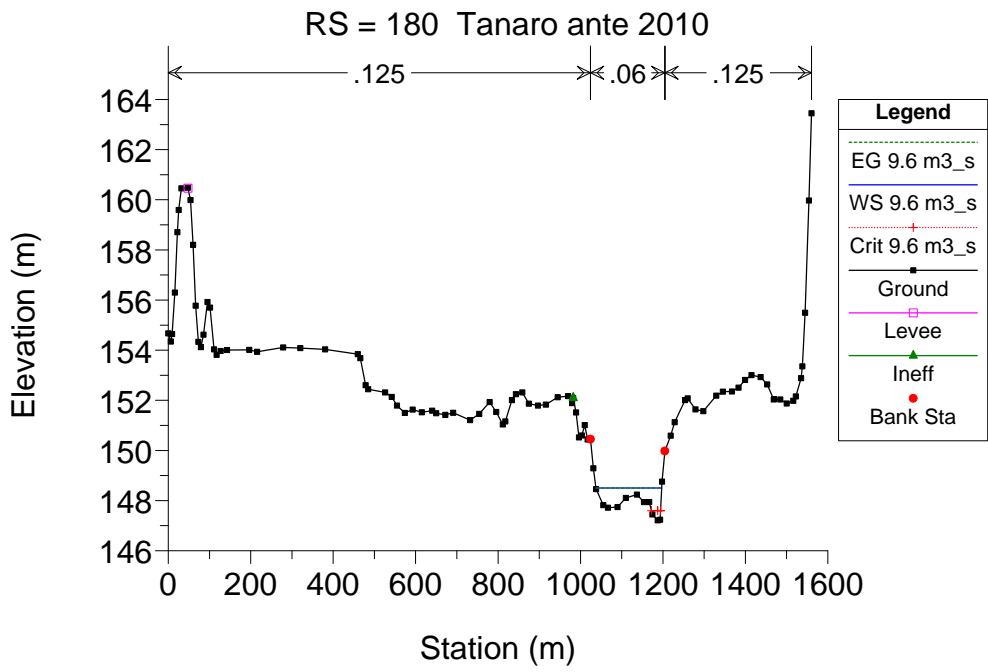
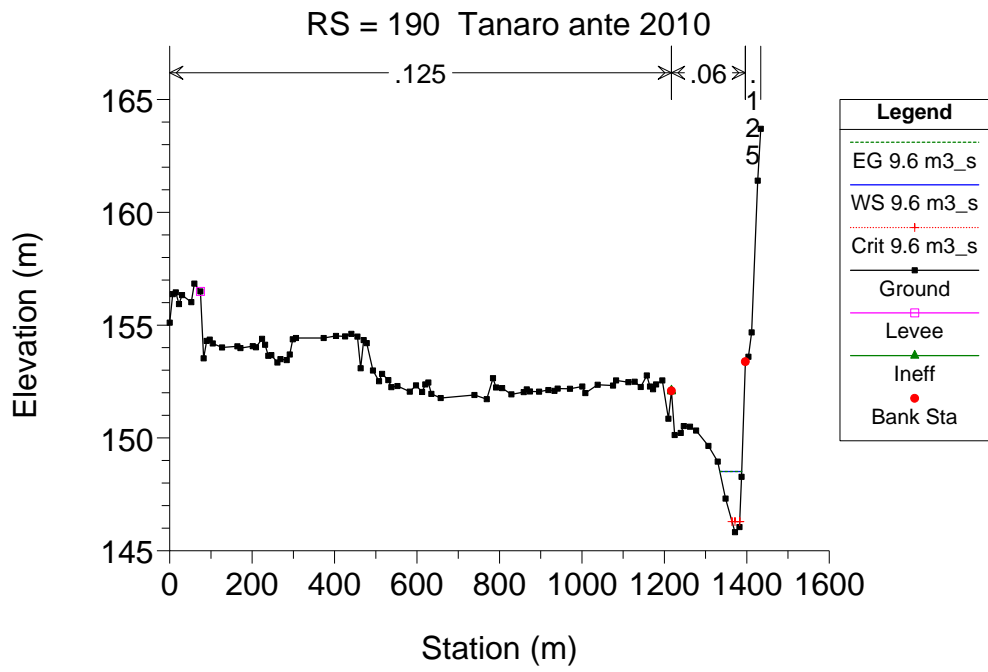


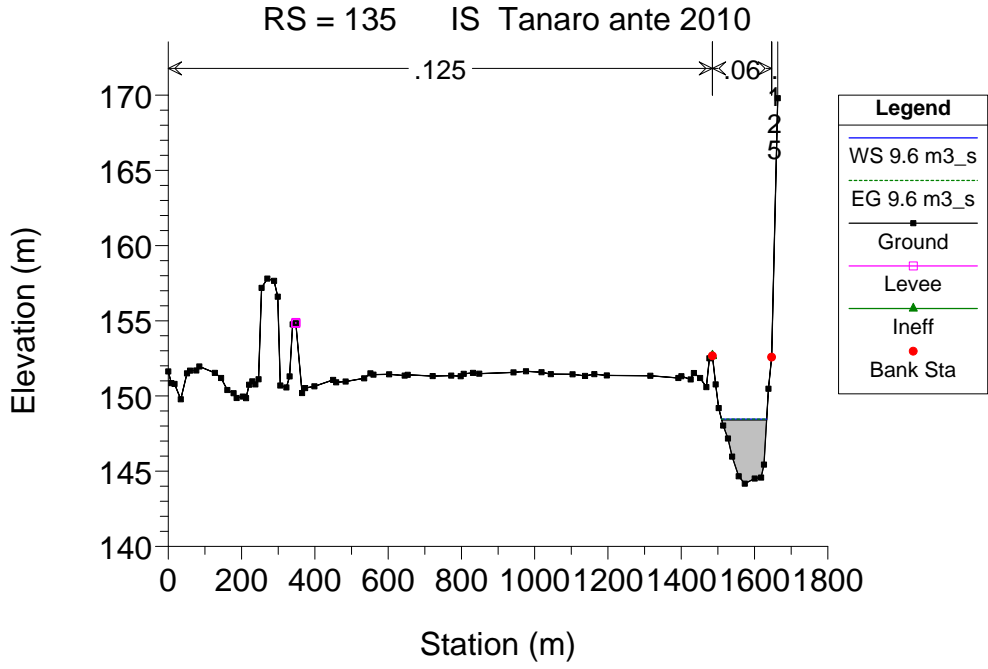
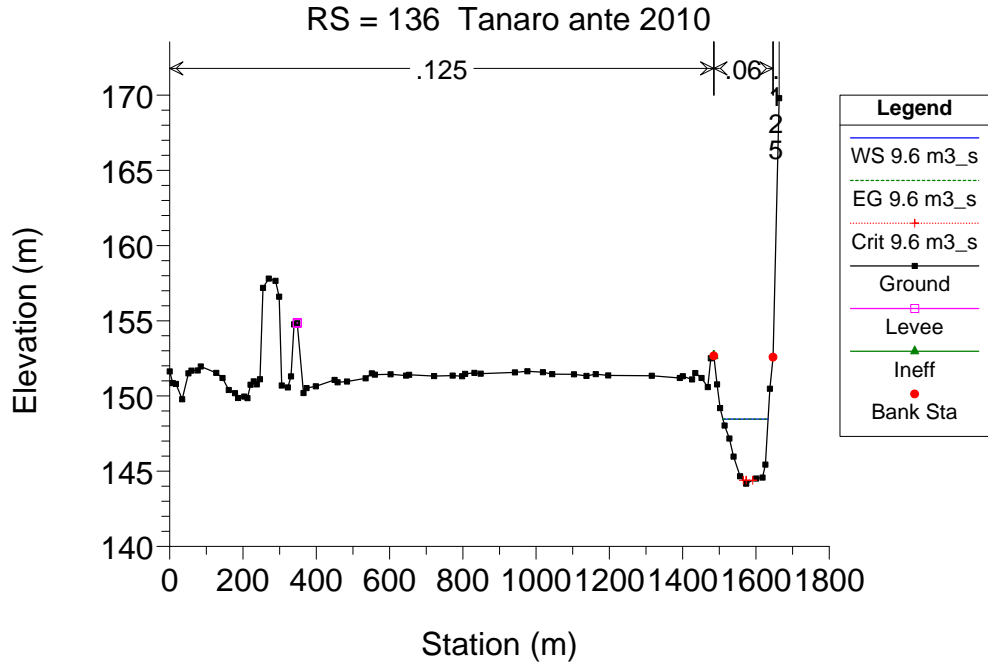
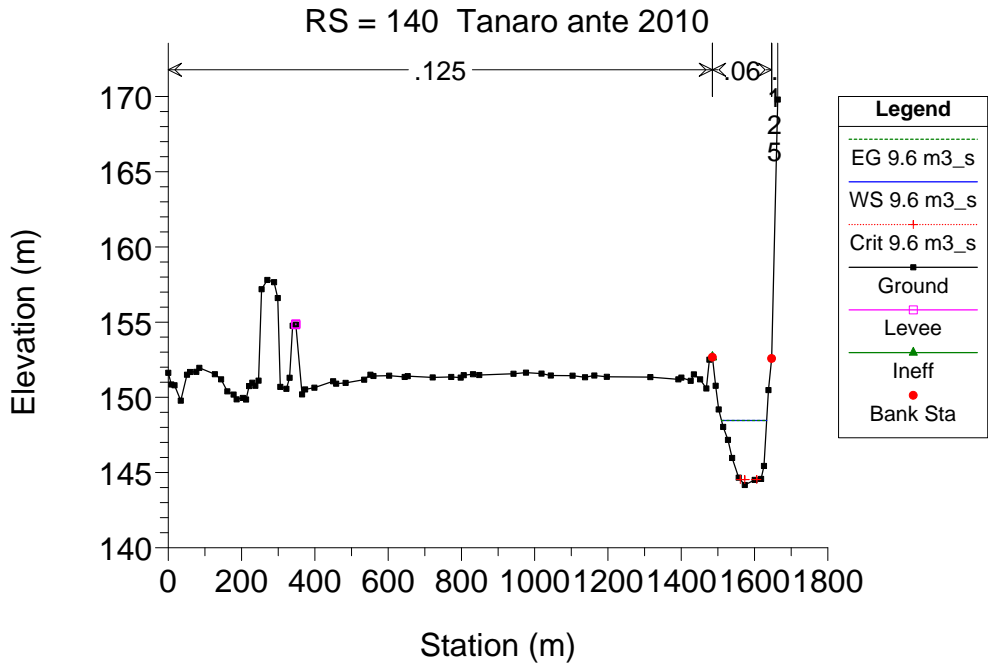
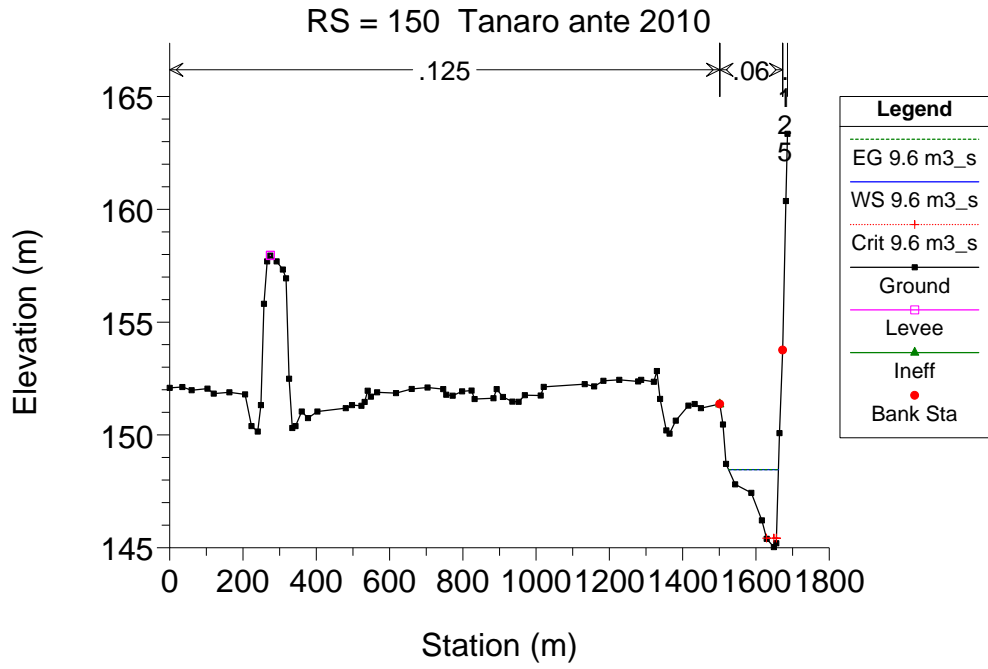


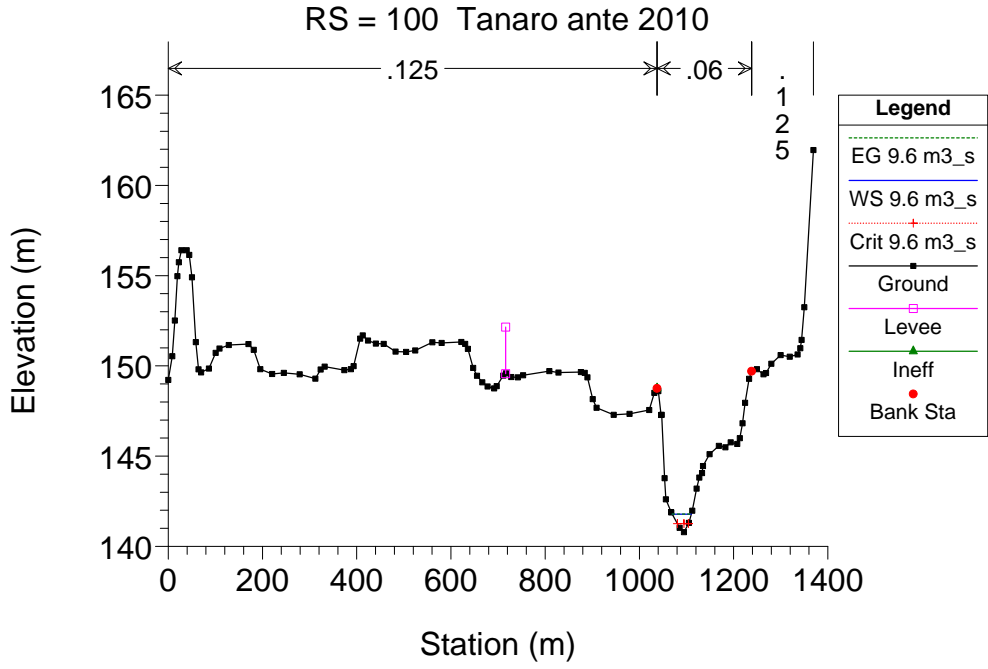
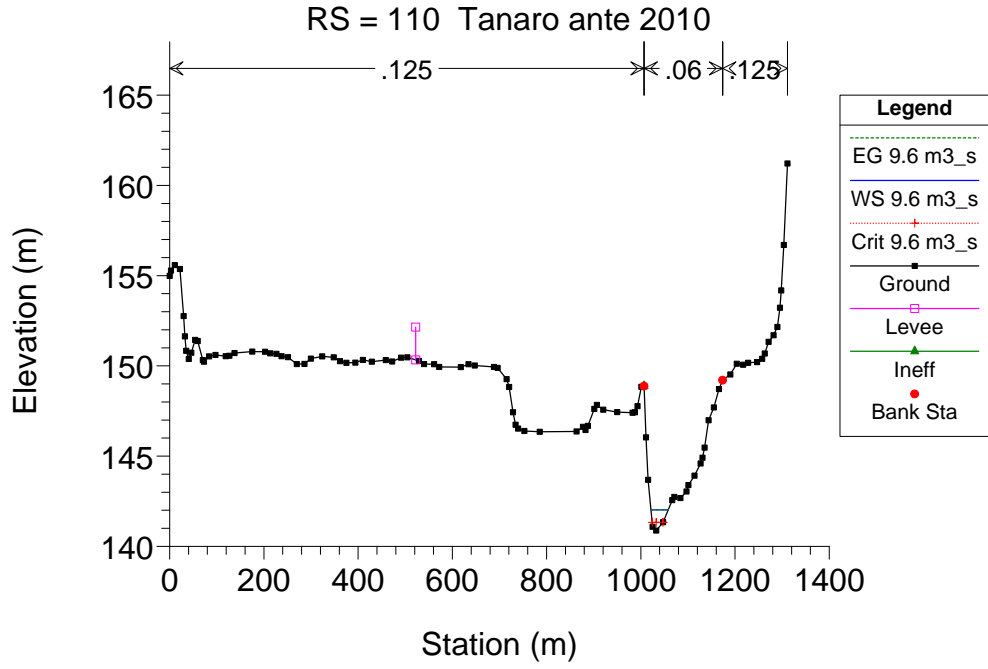
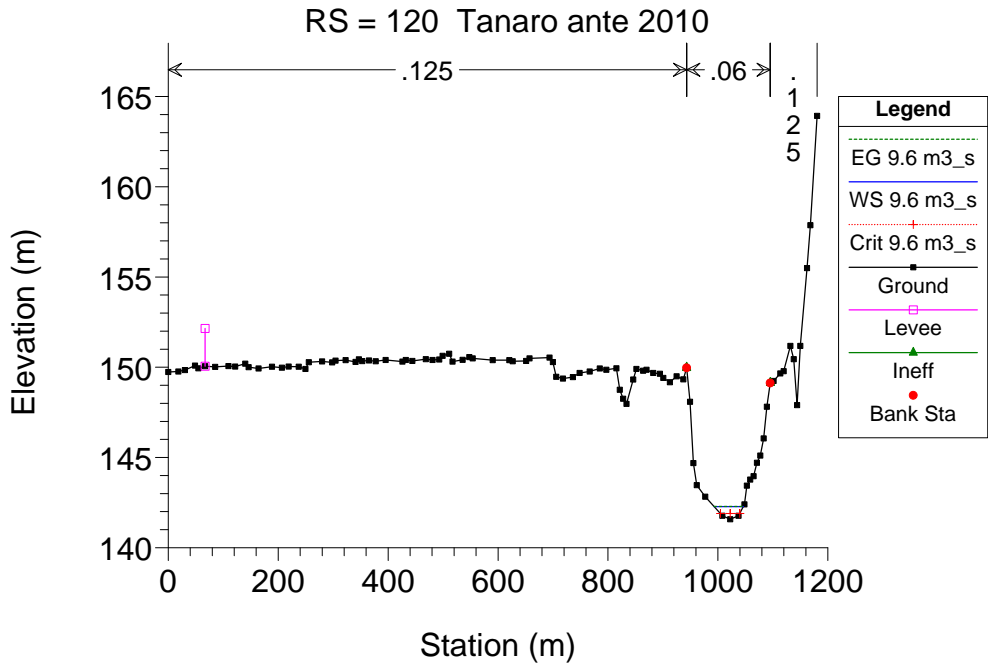
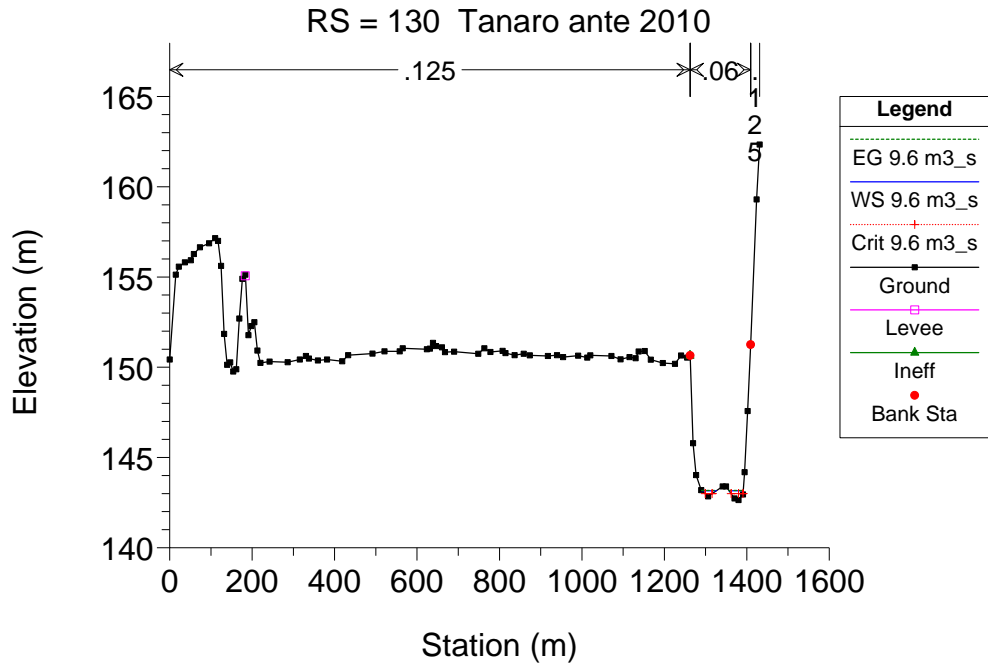


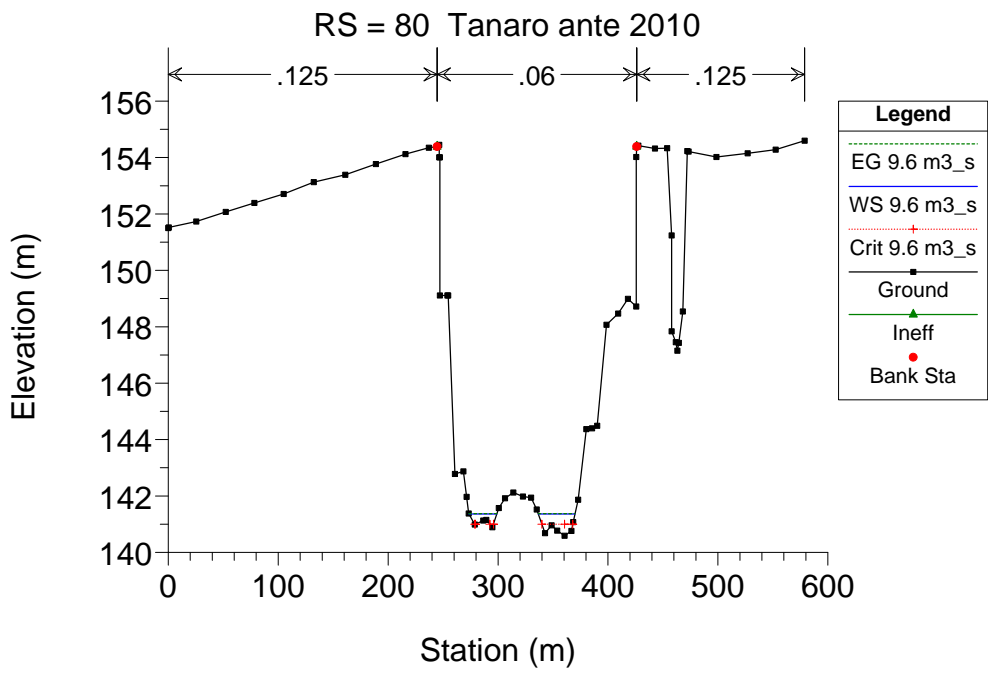
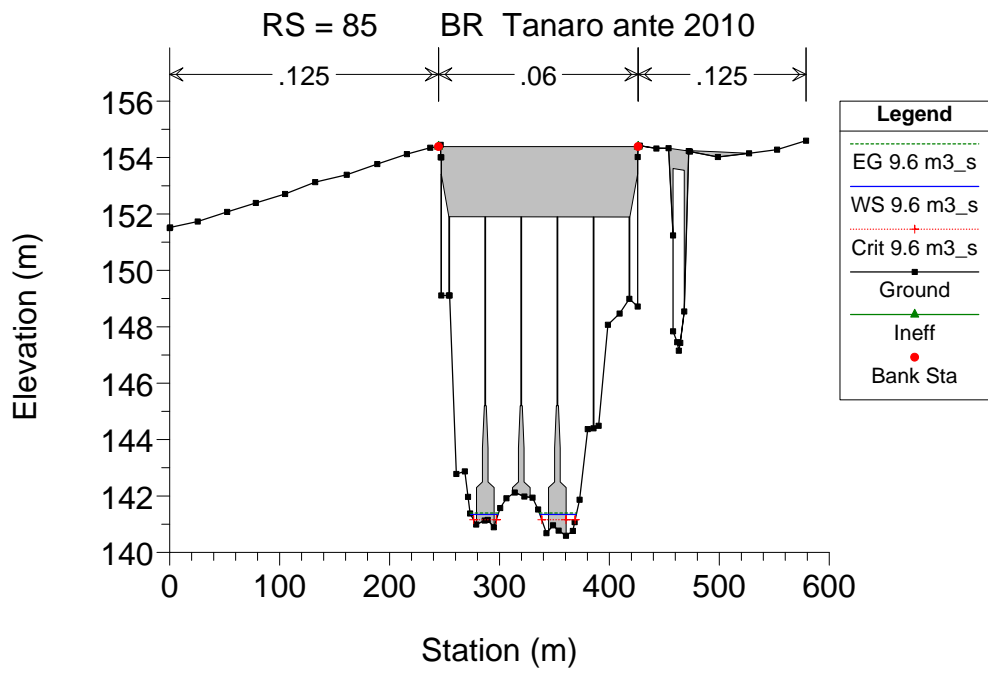
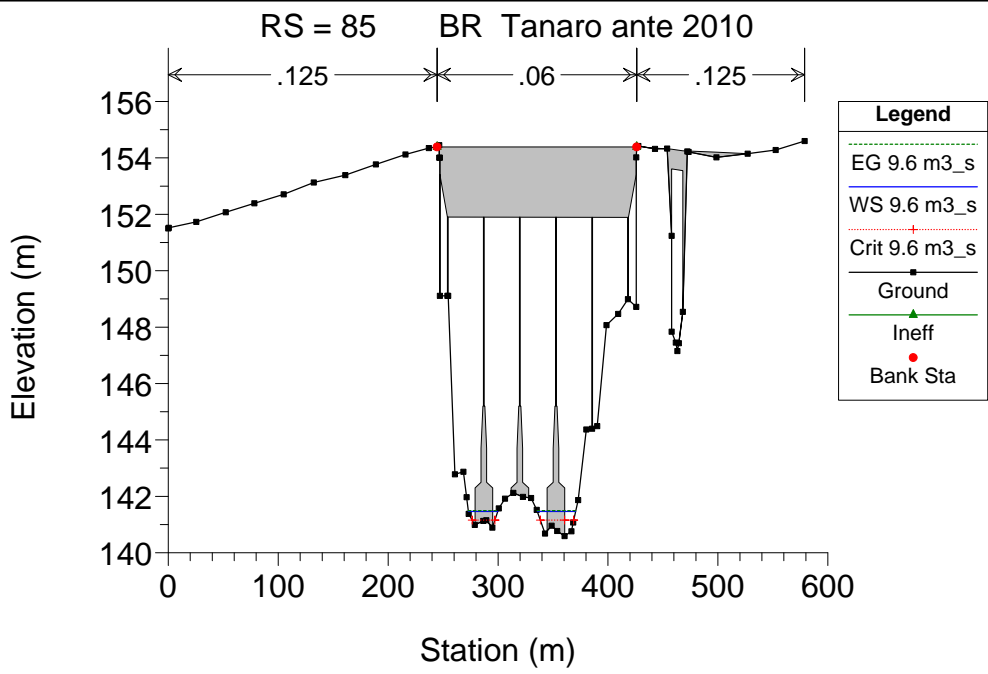
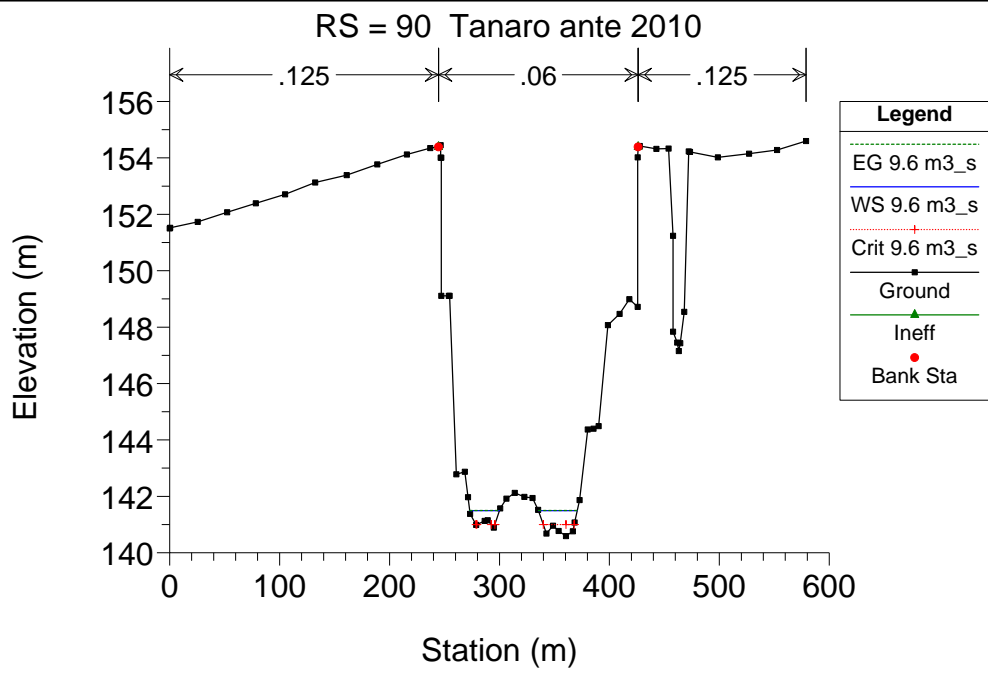


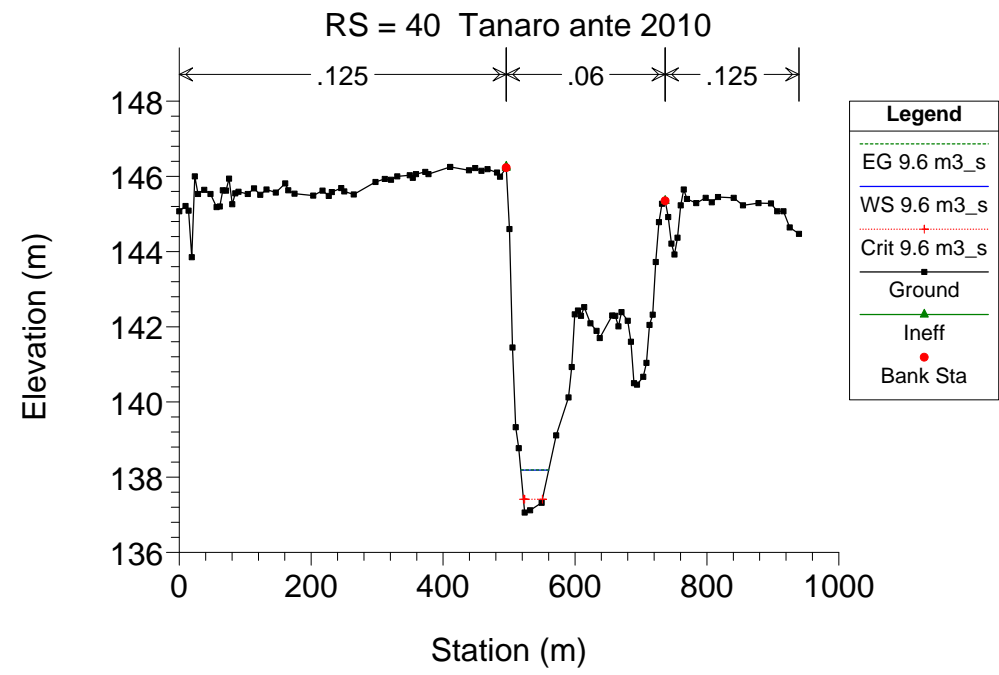
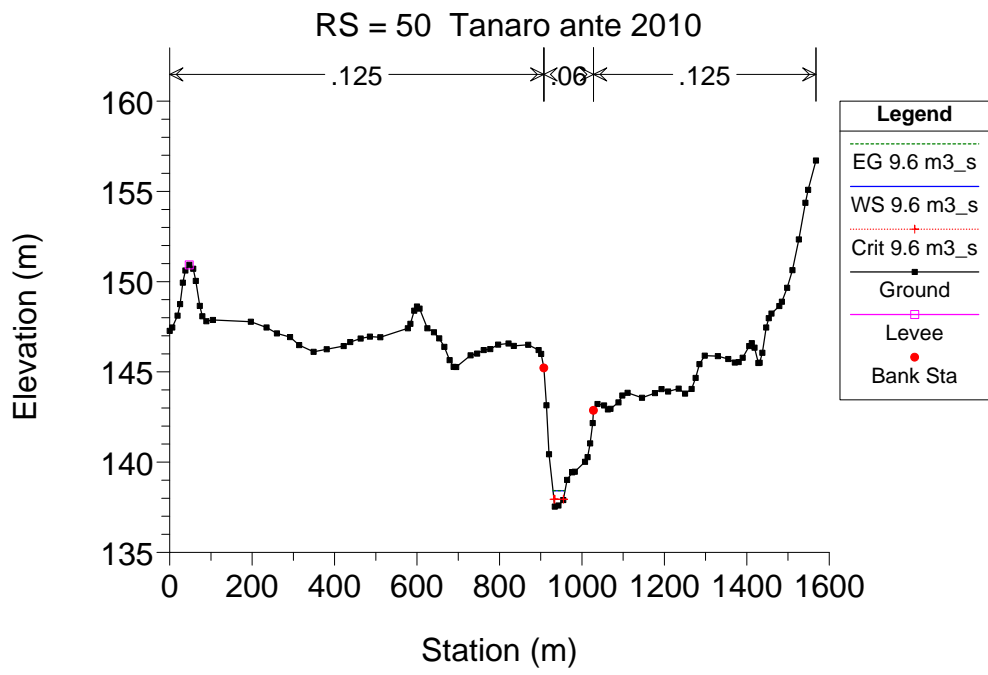
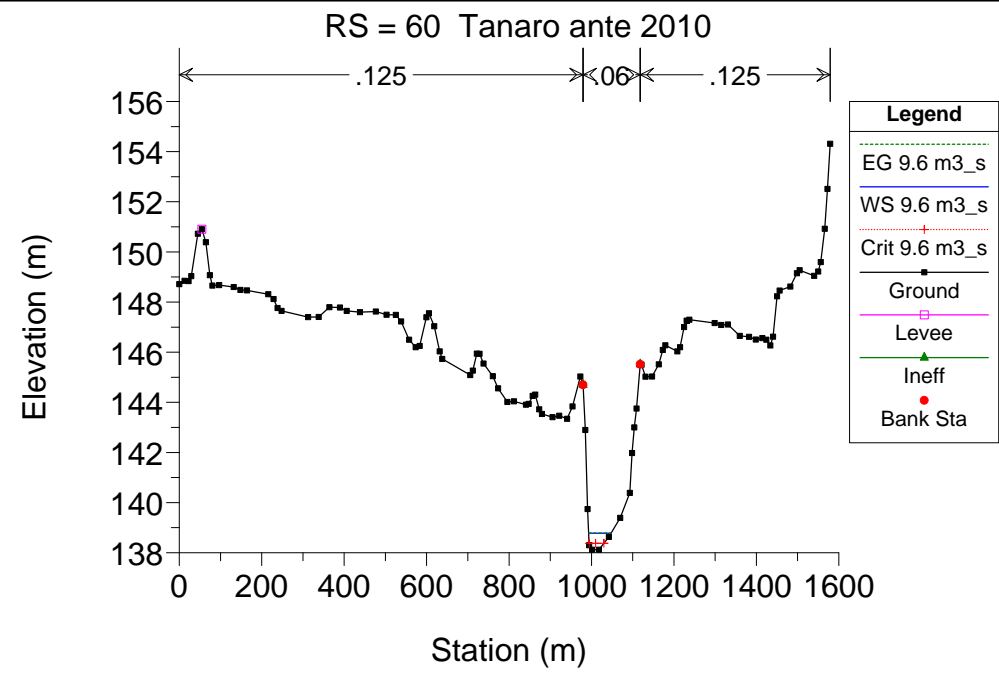
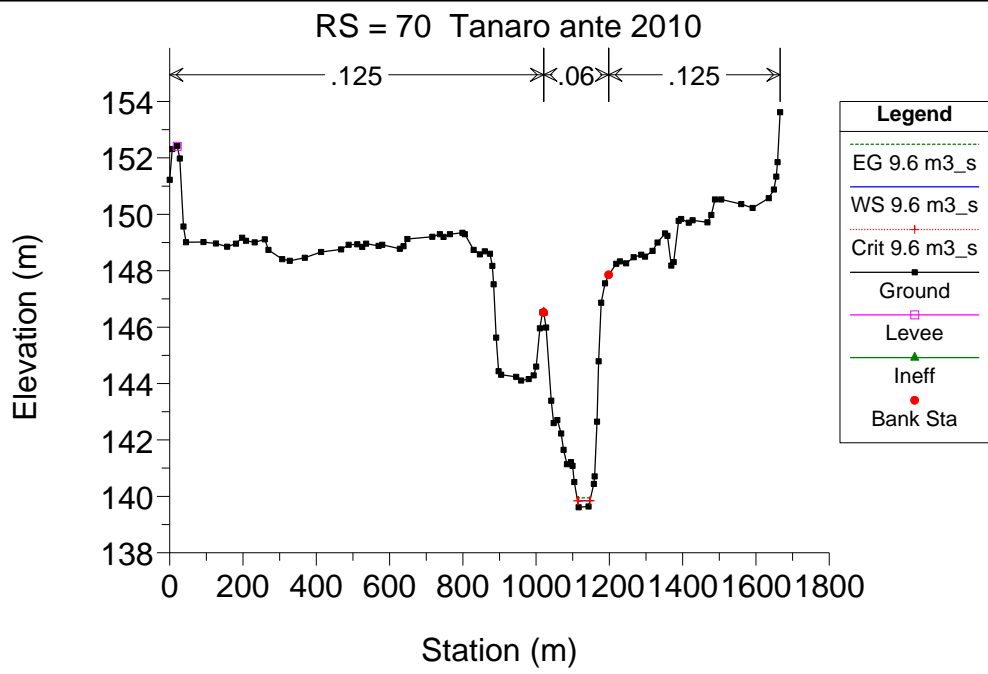


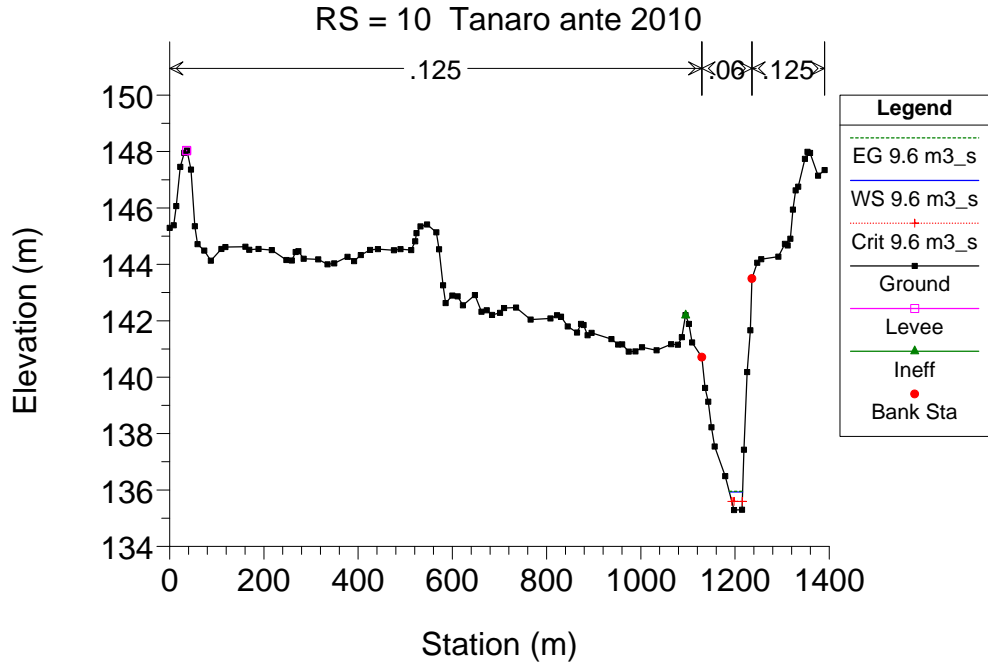
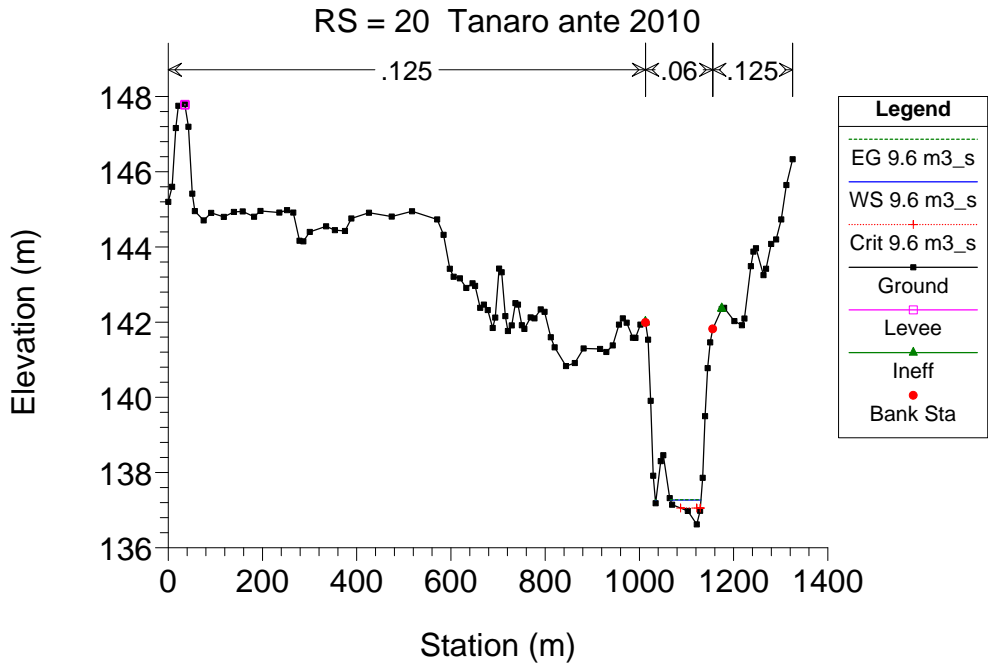
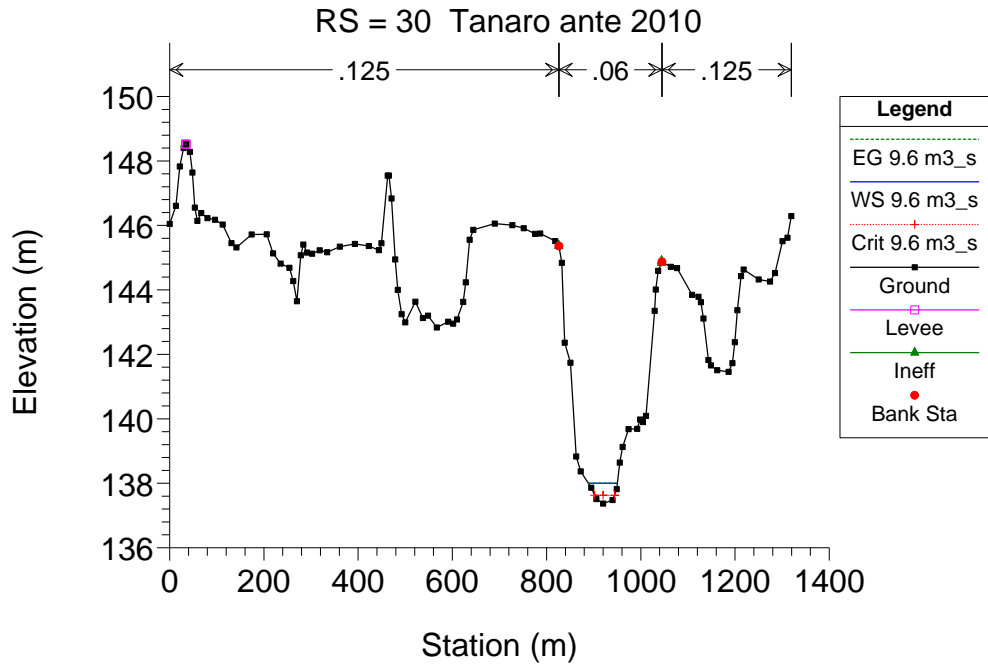












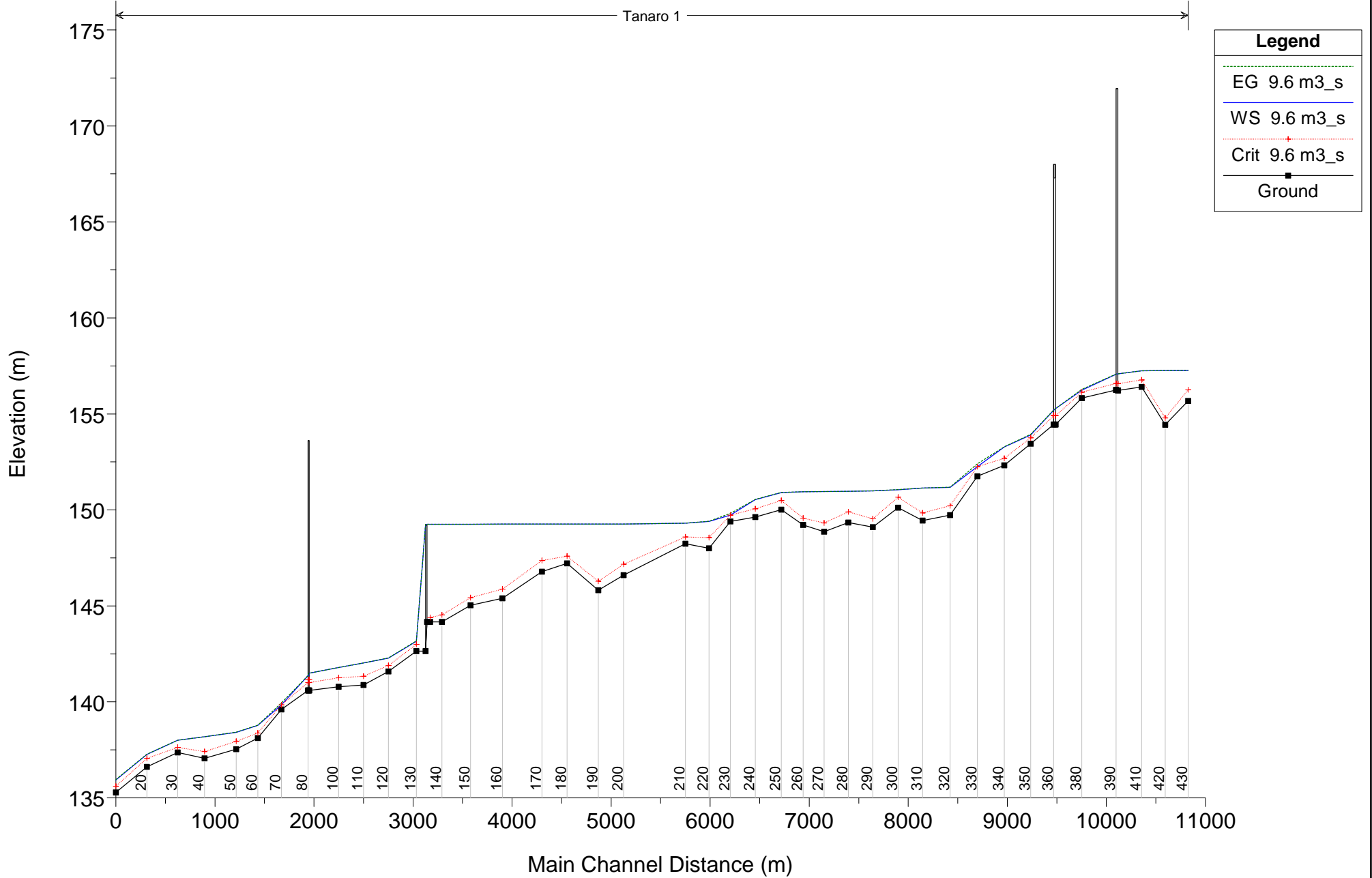
**SITUAZIONE DI PROGETTO (CON SBARRAMENTO MOBILE ALZATO)
SIMULAZIONE 12**

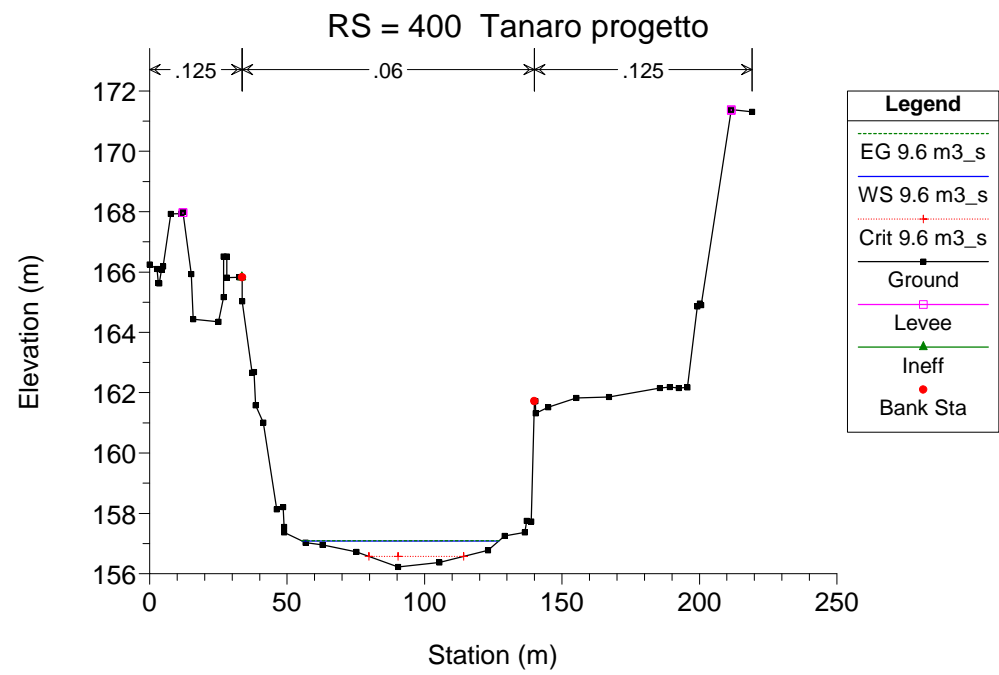
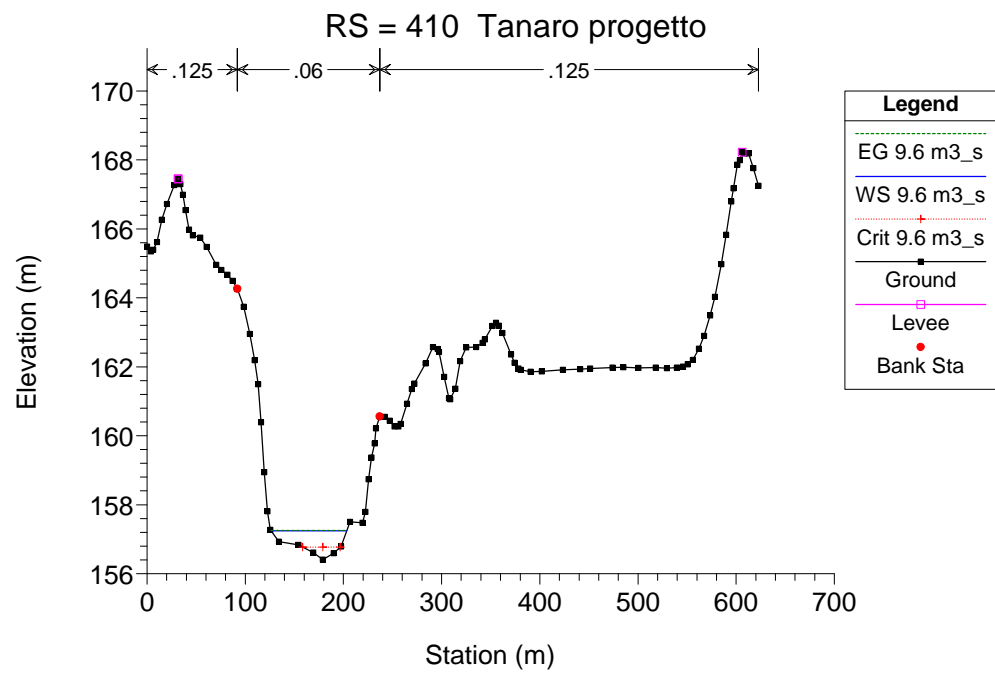
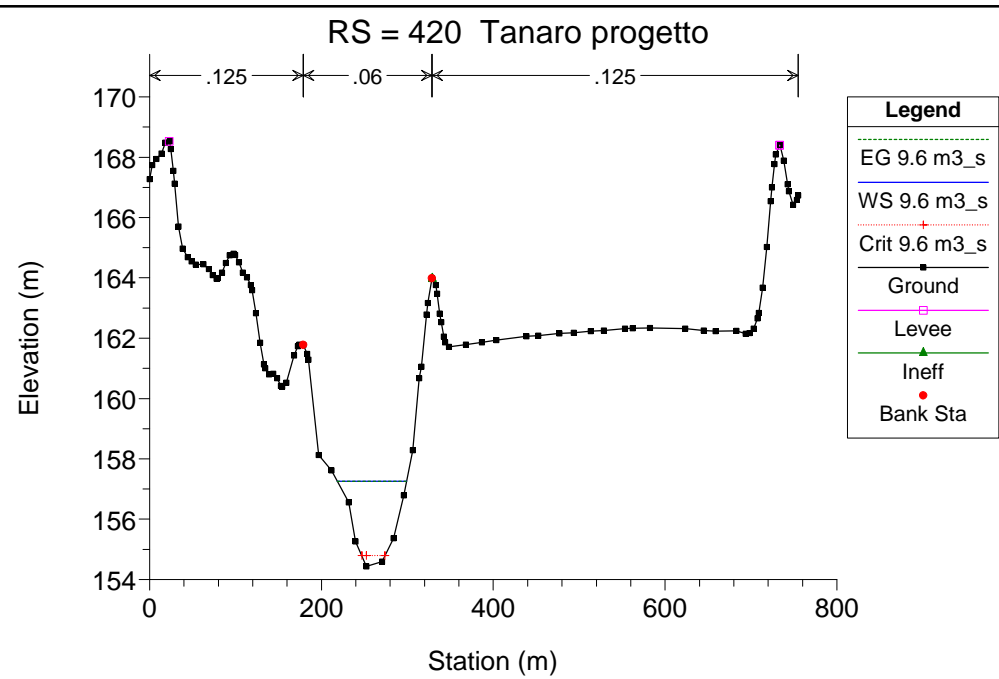
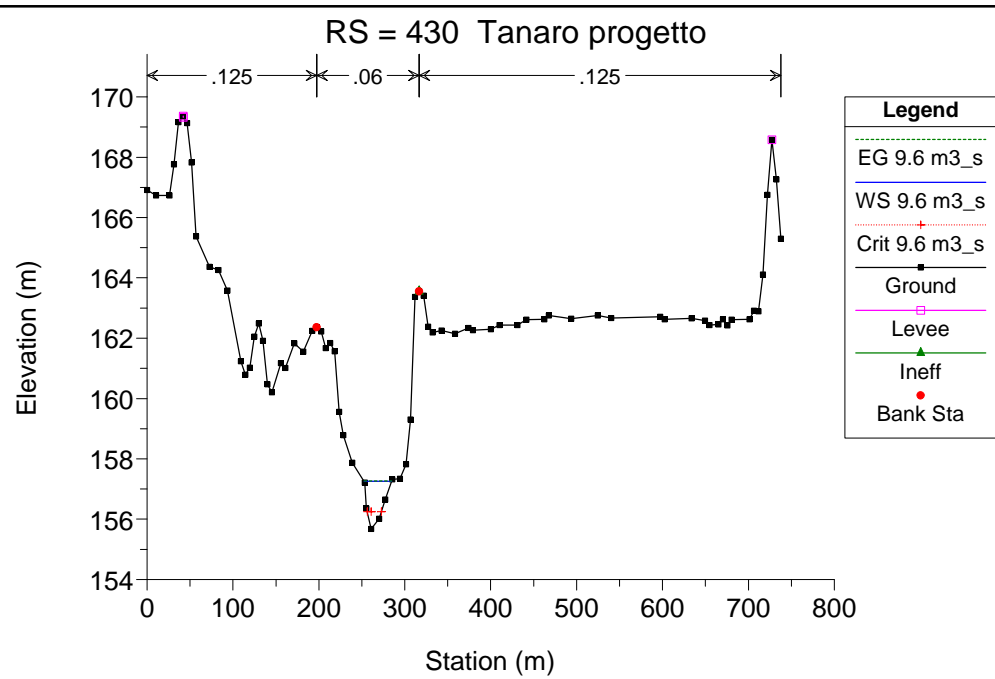
Corso d'acqua	Portata Q m³/s	Portata
Fiume Tanaro	9.6 (in alveo) 6.6 (turbinati)	Minima di funzionamento dell'impianto idroelettrico

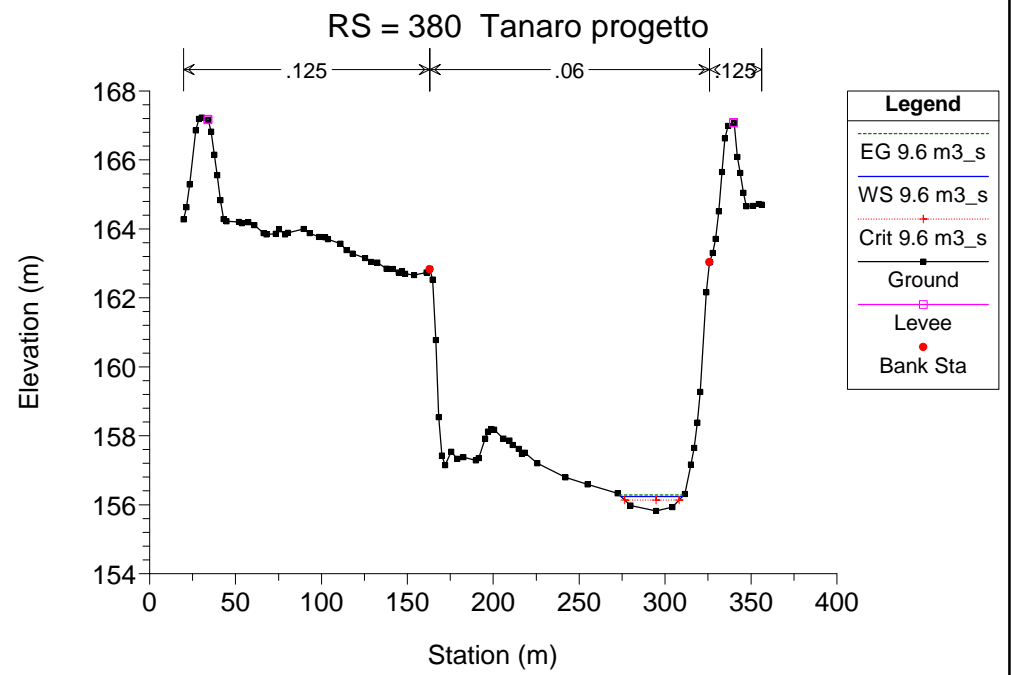
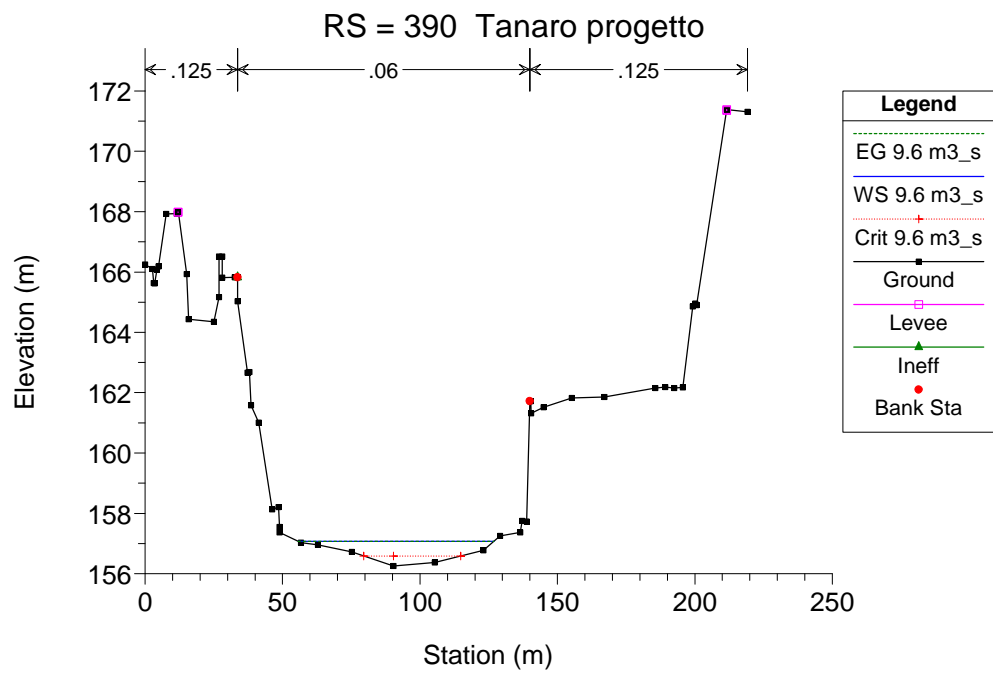
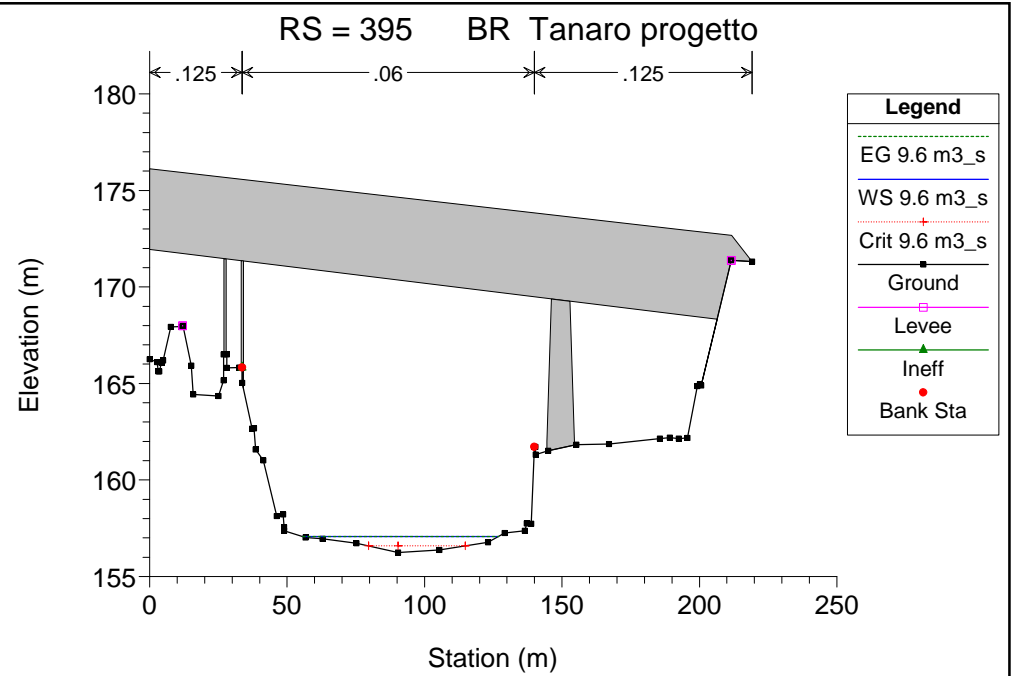
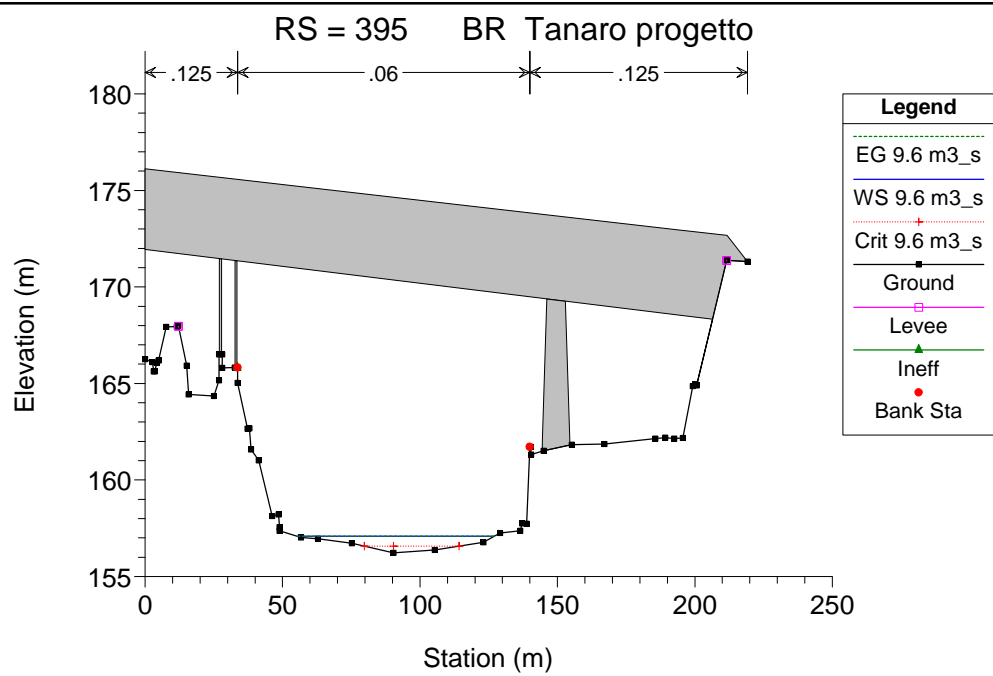
HEC-RAS Plan: Plan 06 River: Tanaro Reach: 1 Profile: 9.6 m3_s (Continued)

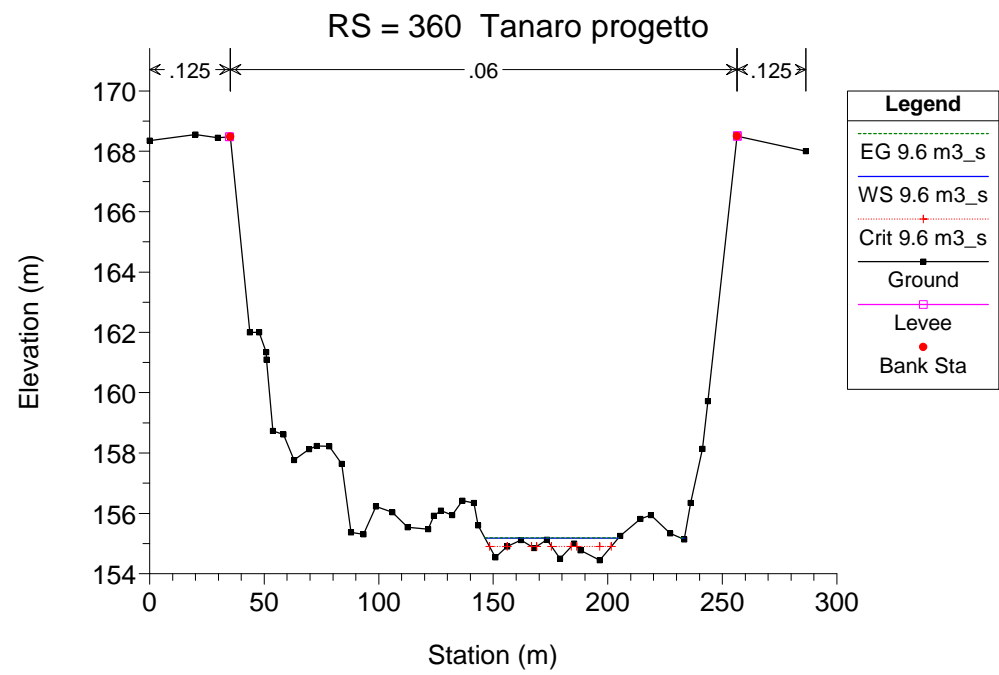
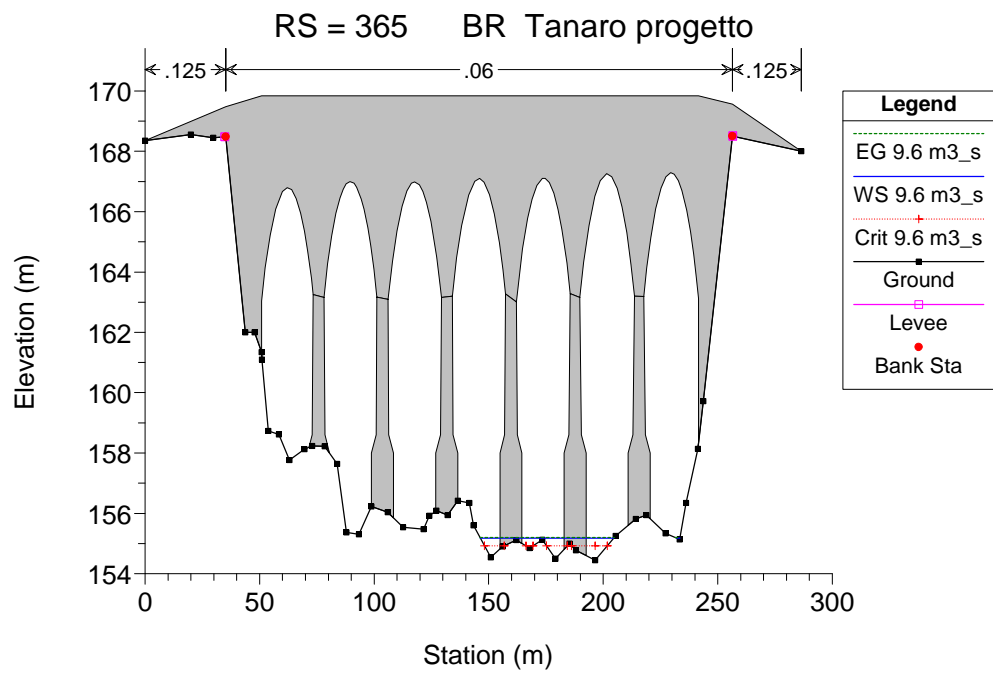
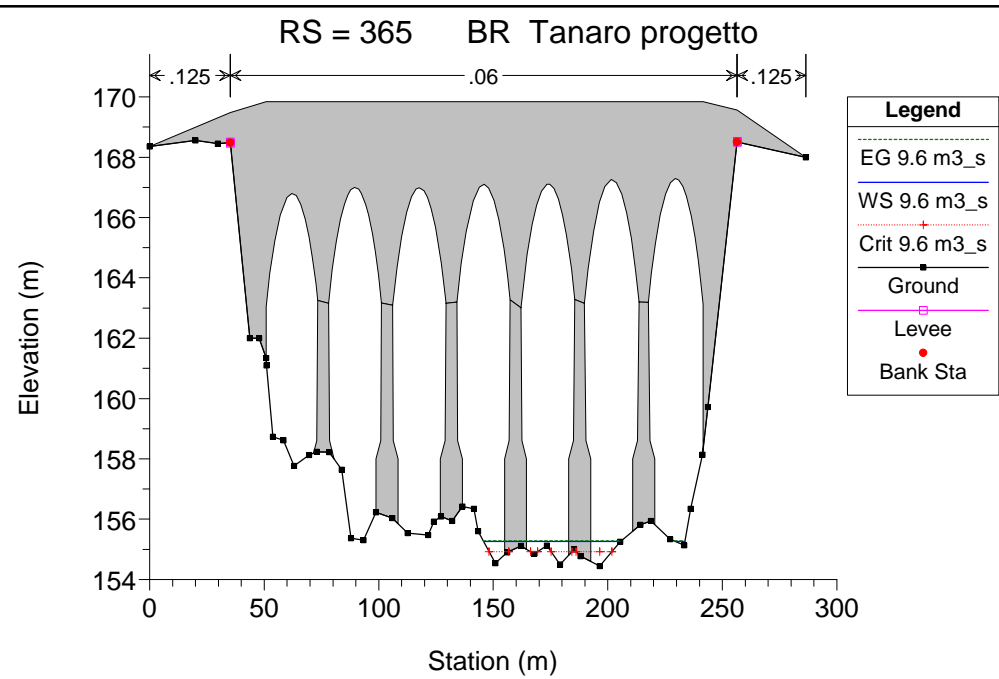
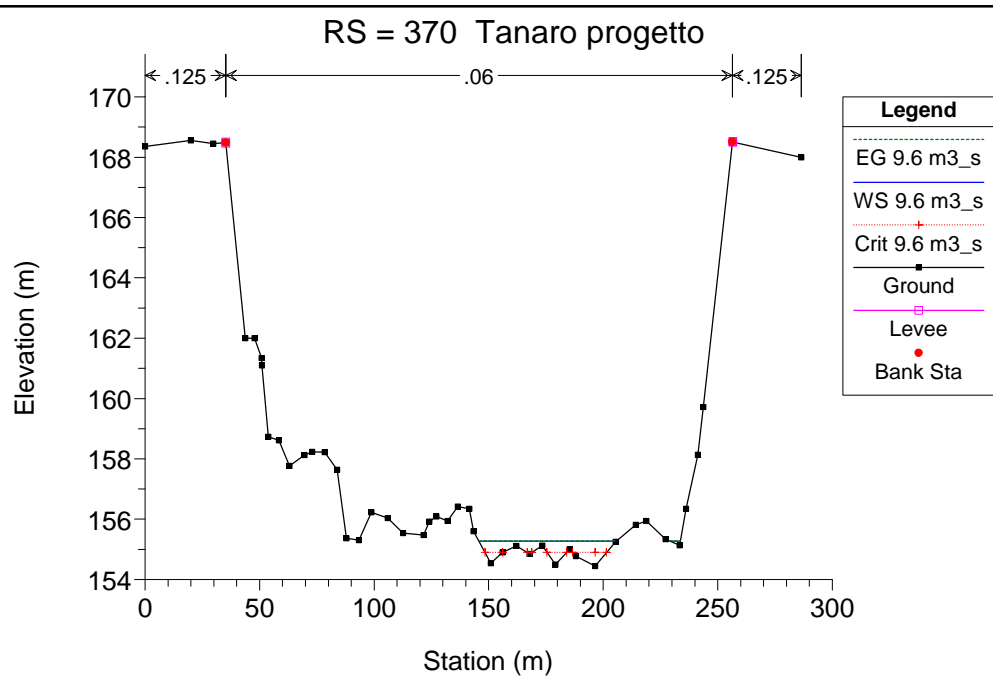
Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
1	80	9.6 m3_s	9.60	140.59	141.36	141.00	141.37	0.001777	0.39	24.51	58.73	0.19
1	70	9.6 m3_s	9.60	139.61	139.85	139.85	139.95	0.061207	1.41	6.81	34.08	1.01
1	60	9.6 m3_s	9.60	138.12	138.78	138.38	138.79	0.001440	0.38	25.31	54.41	0.18
1	50	9.6 m3_s	9.60	137.54	138.41	137.94	138.43	0.001860	0.53	18.27	29.09	0.21
1	40	9.6 m3_s	9.60	137.06	138.19	137.41	138.19	0.000389	0.28	33.93	42.30	0.10
1	30	9.6 m3_s	9.60	137.37	138.00	137.63	138.01	0.001445	0.36	26.55	61.55	0.18
1	20	9.6 m3_s	9.60	136.62	137.27	137.06	137.28	0.004463	0.49	19.50	66.26	0.29
1	10	9.6 m3_s	9.60	135.29	135.93	135.60	135.95	0.004001	0.67	14.34	28.15	0.30

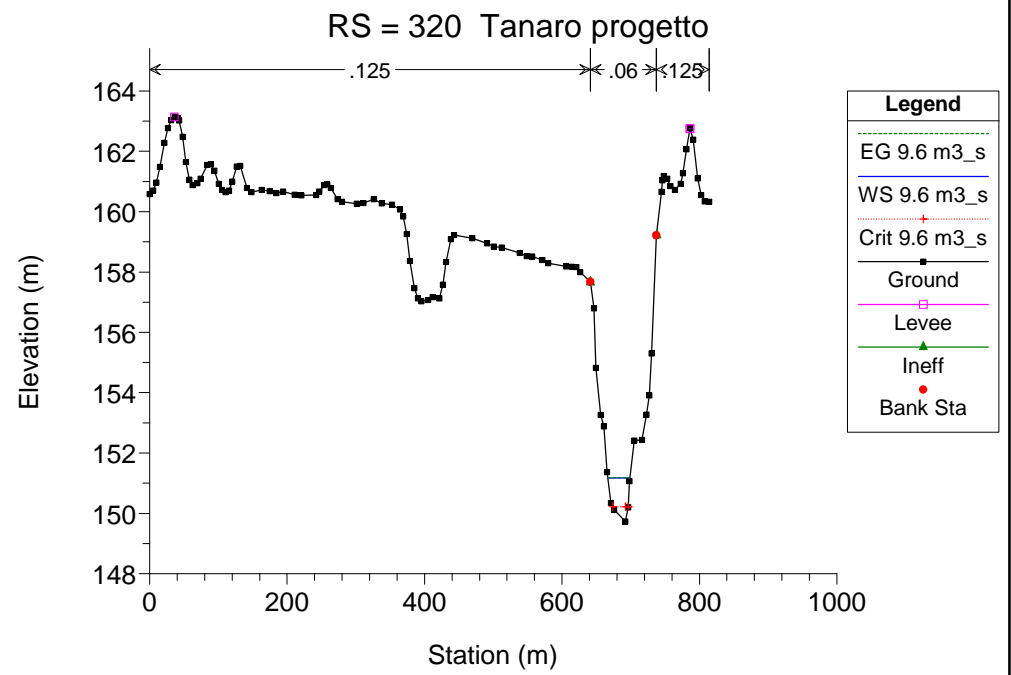
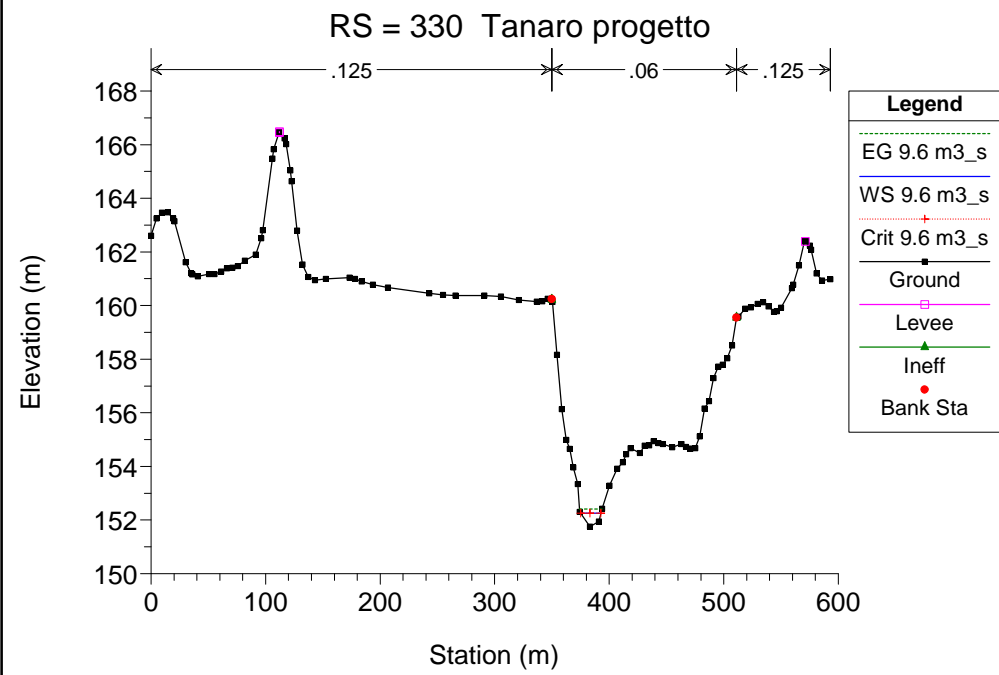
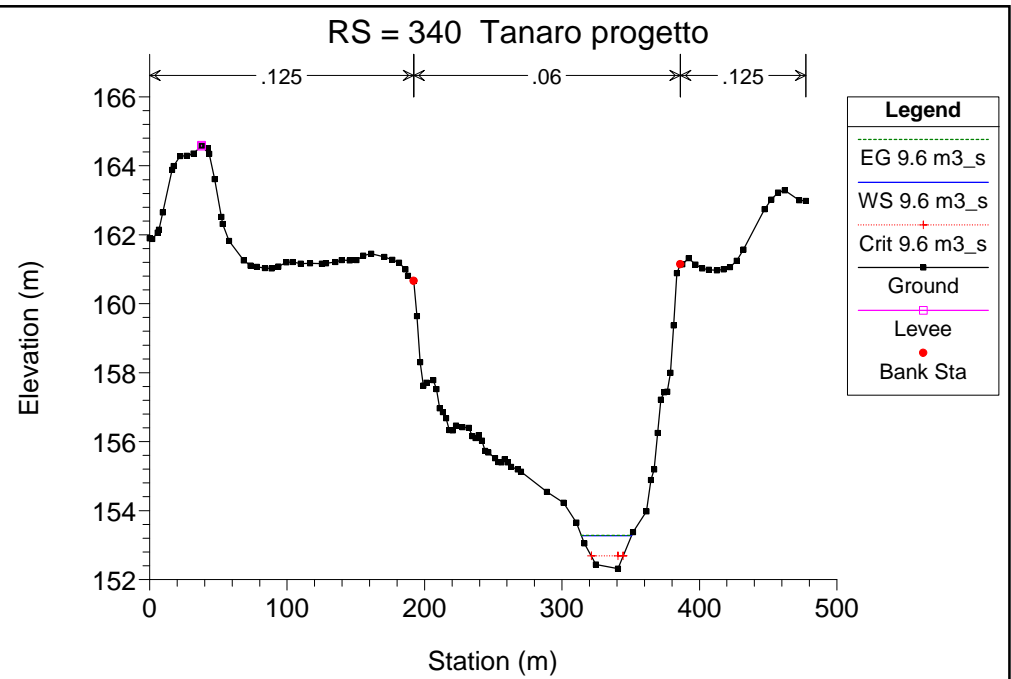
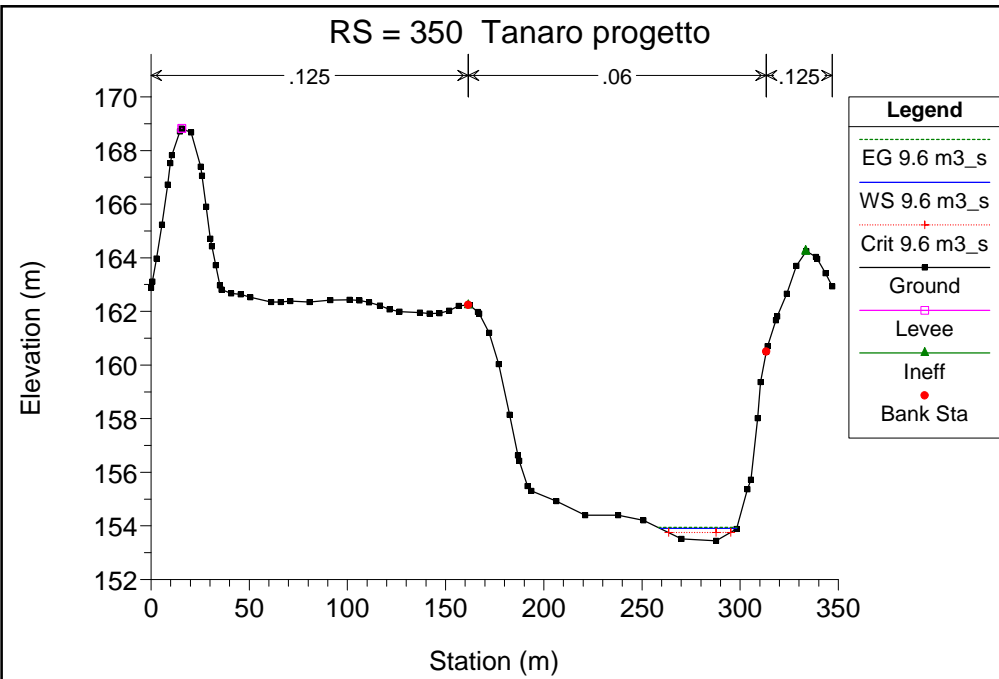
Tanaro progetto

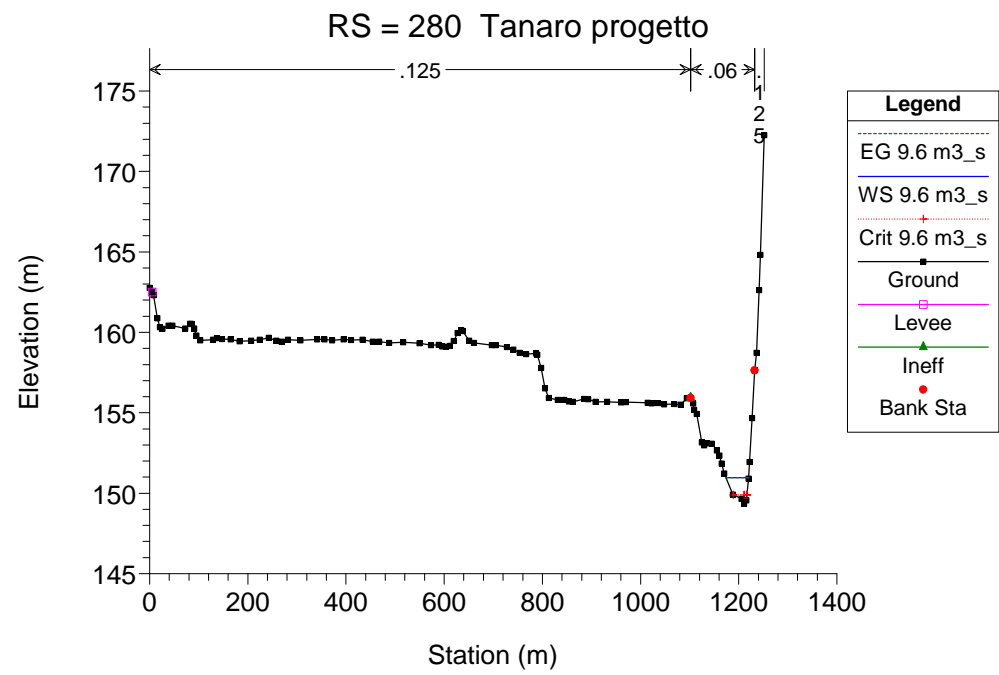
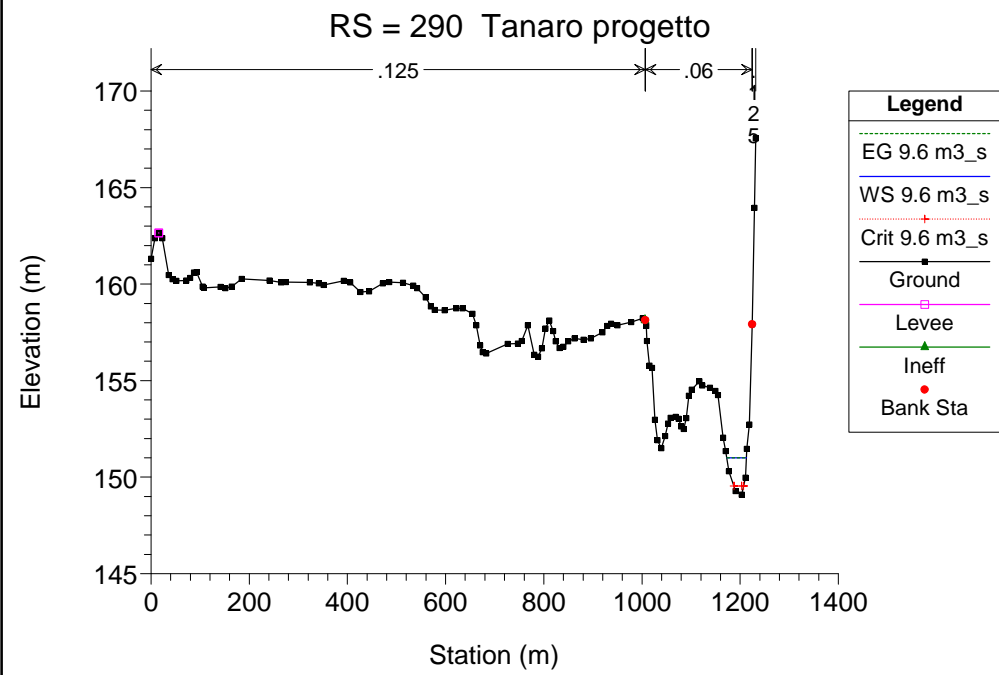
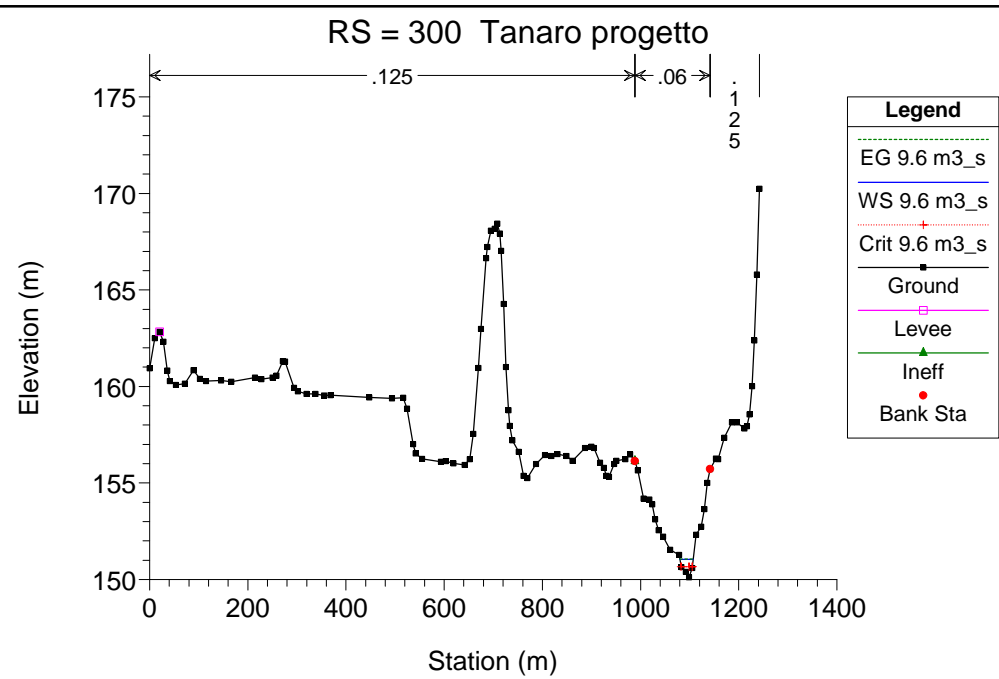
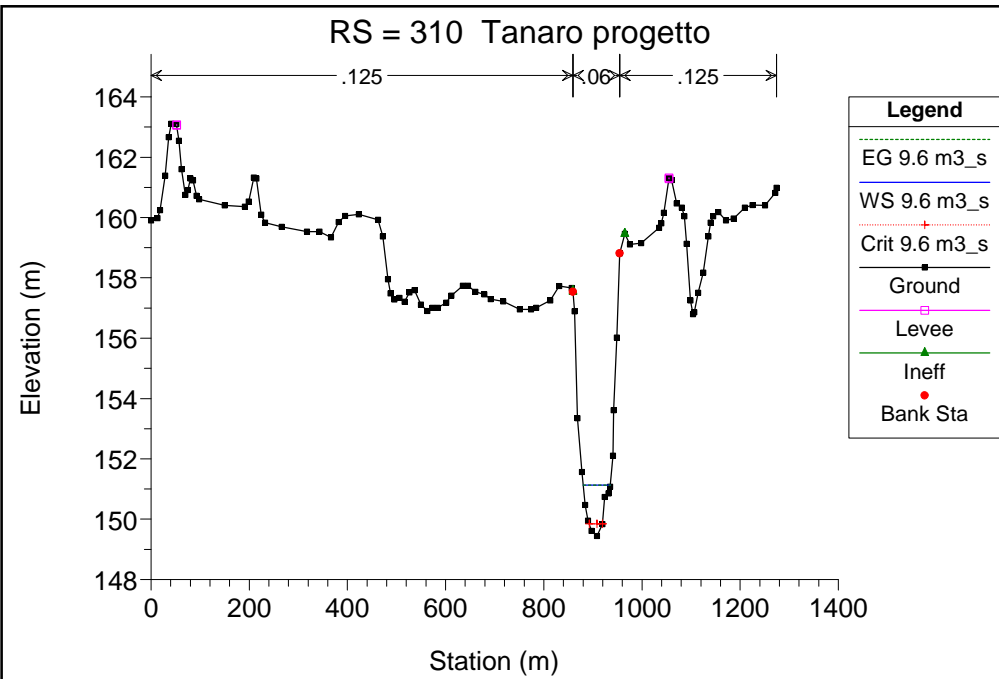


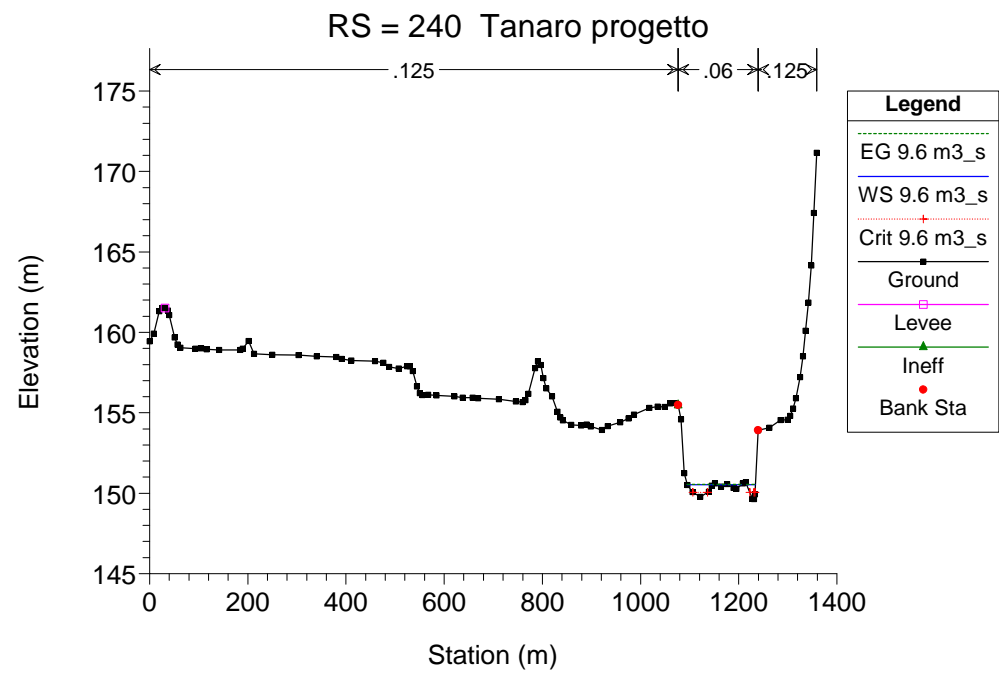
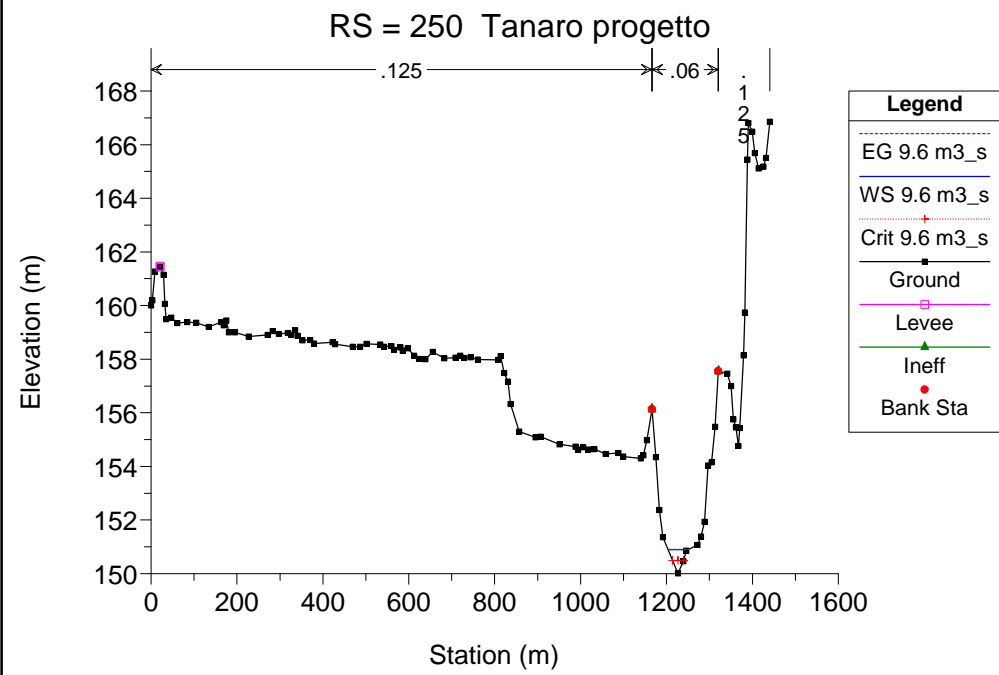
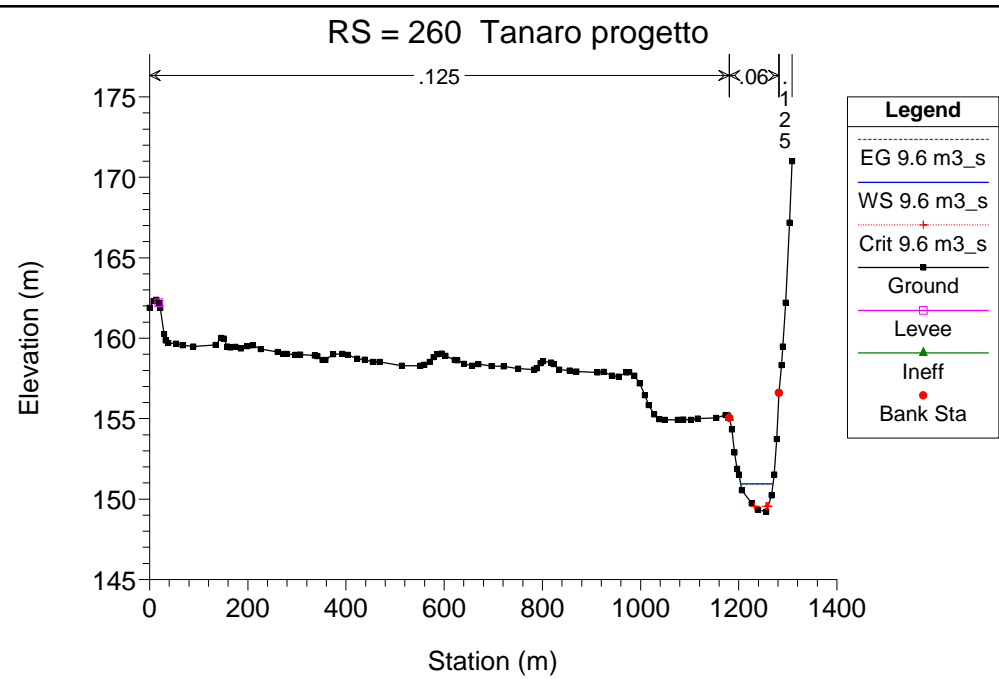
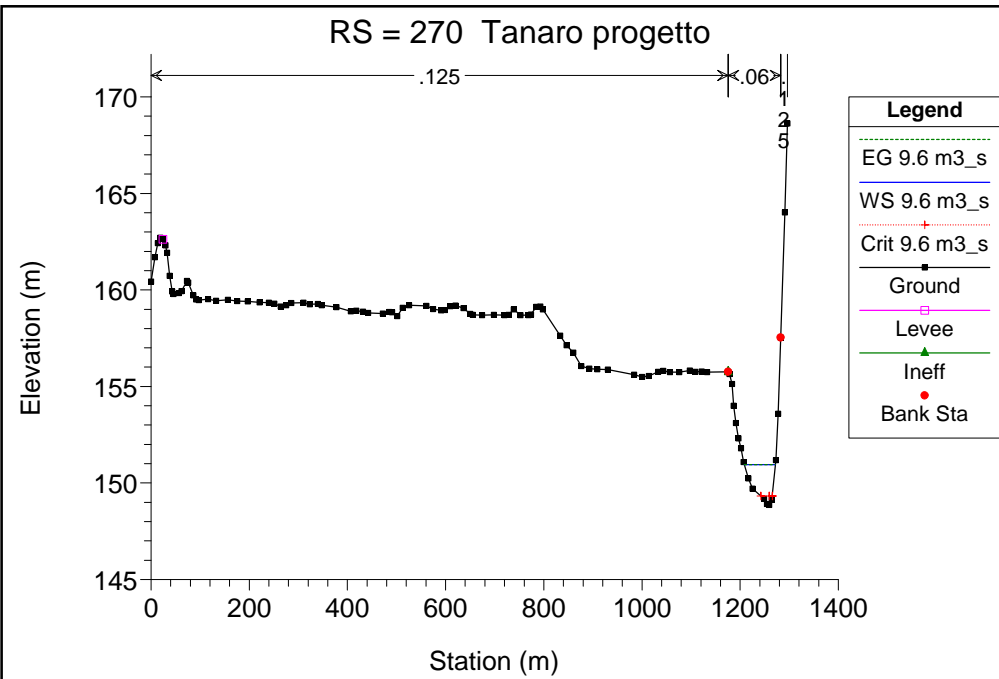


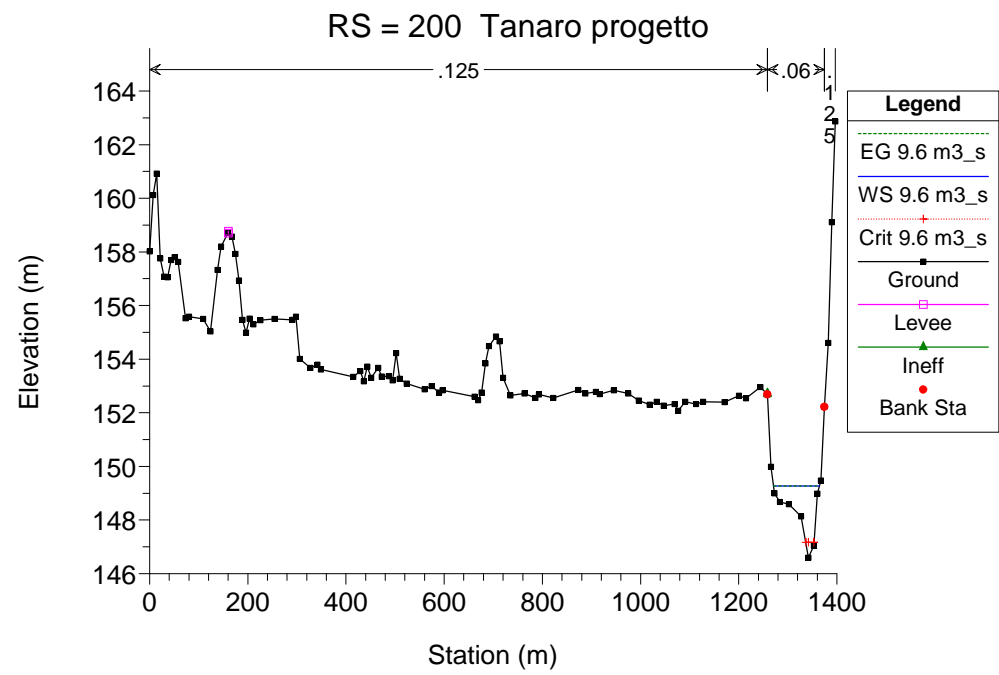
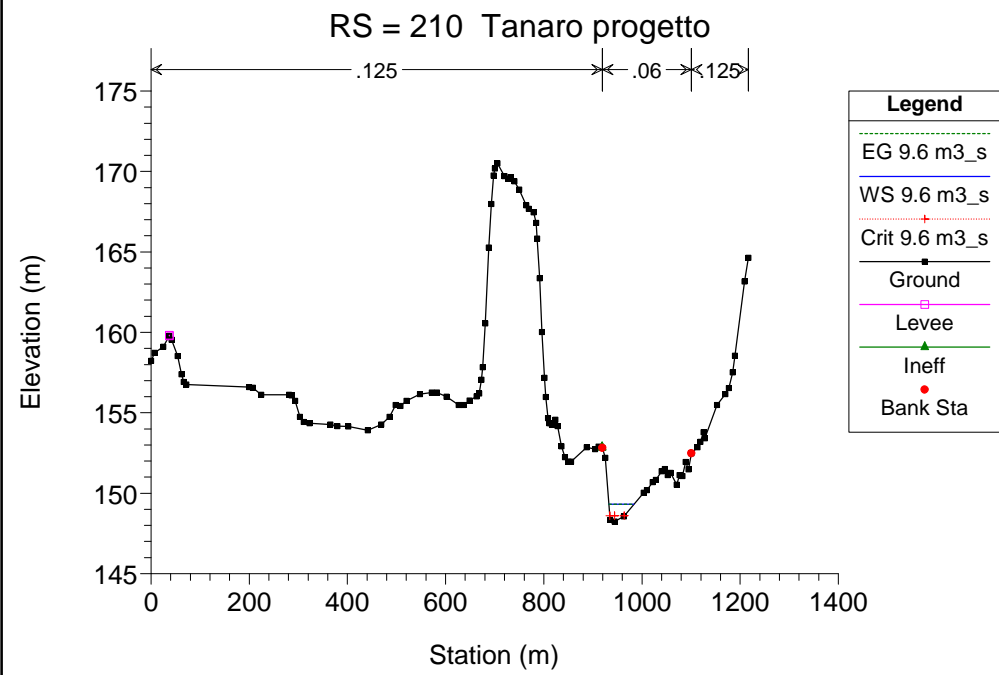
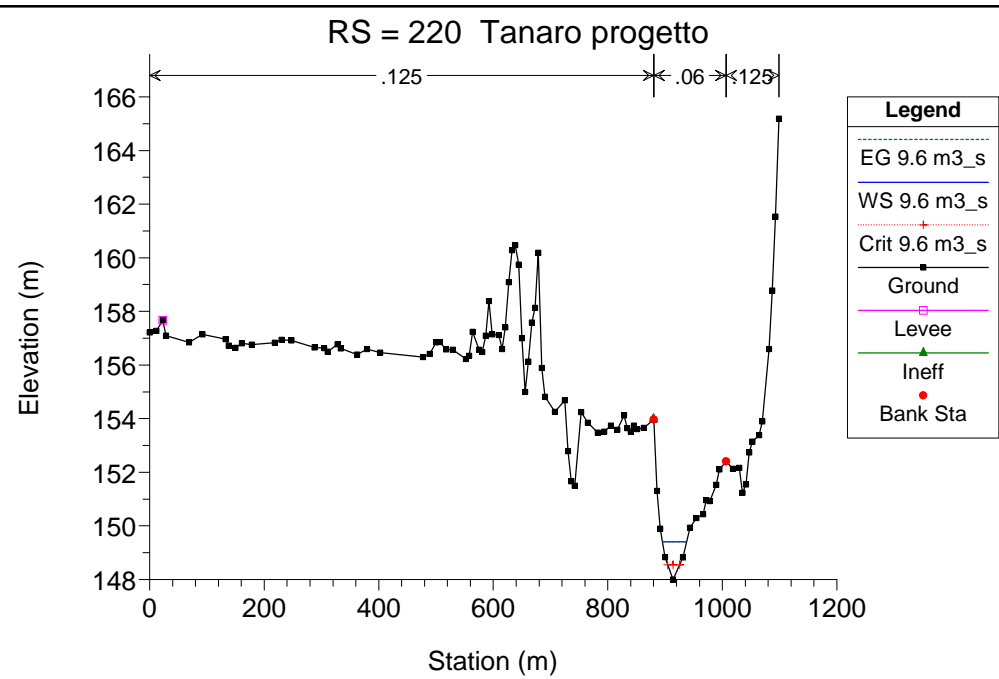
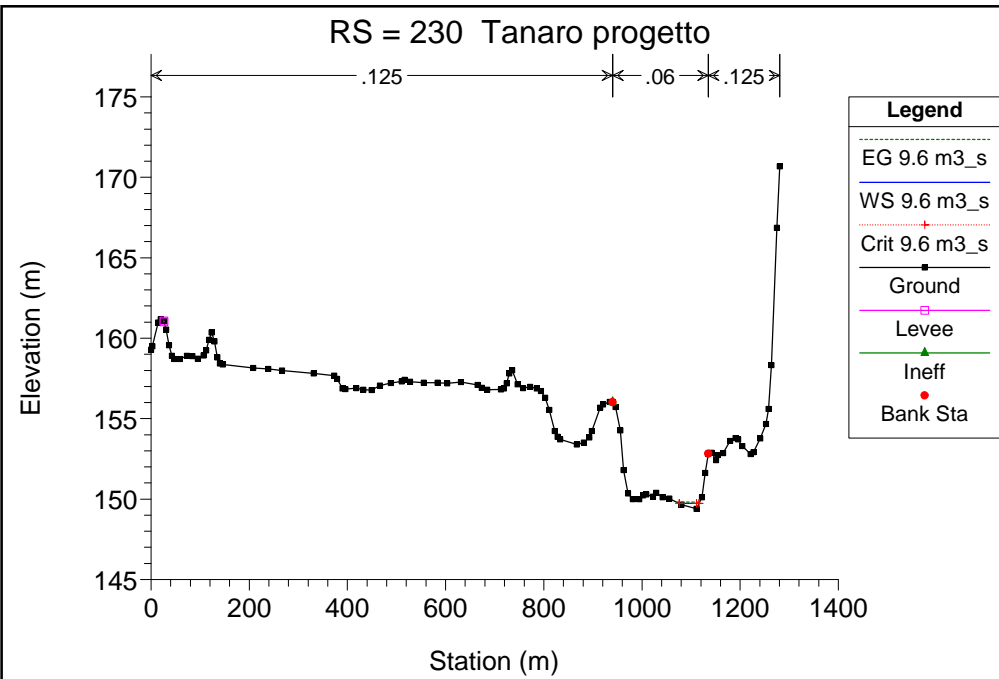


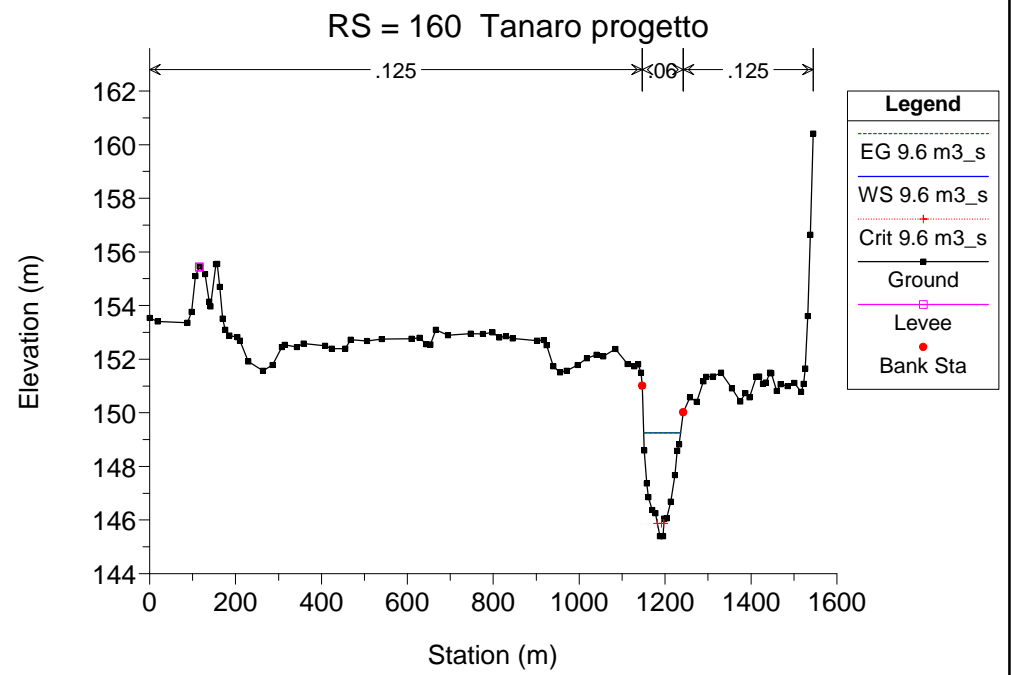
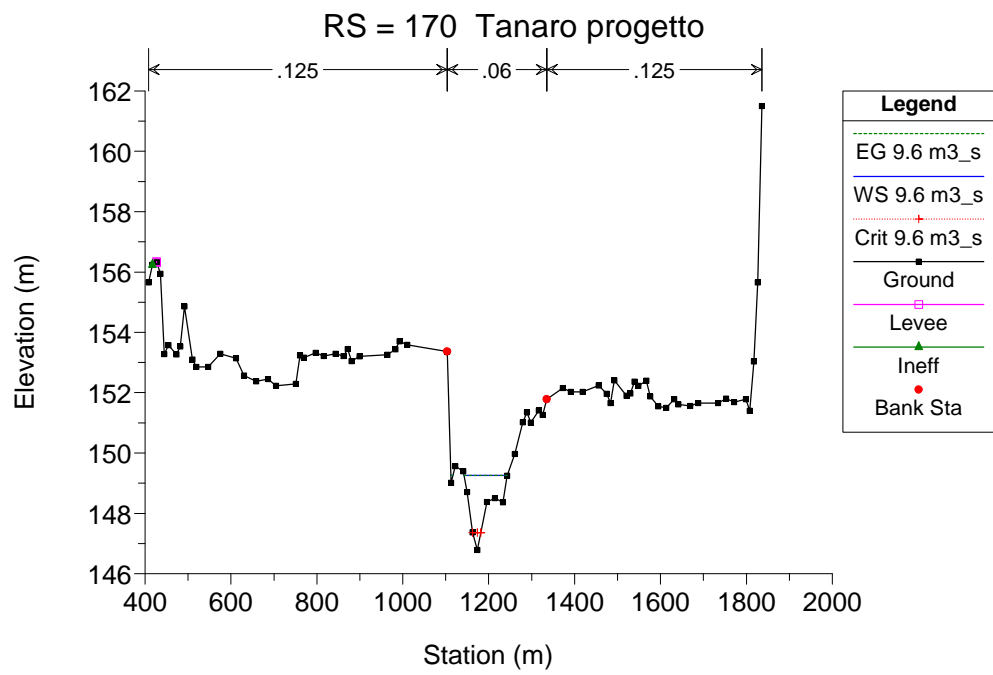
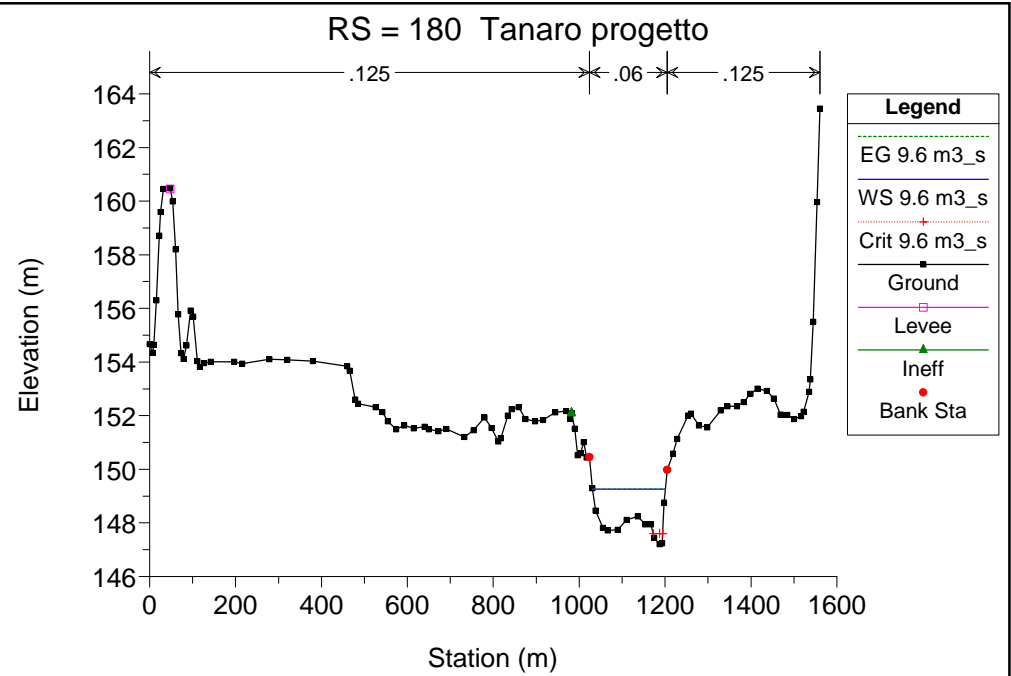
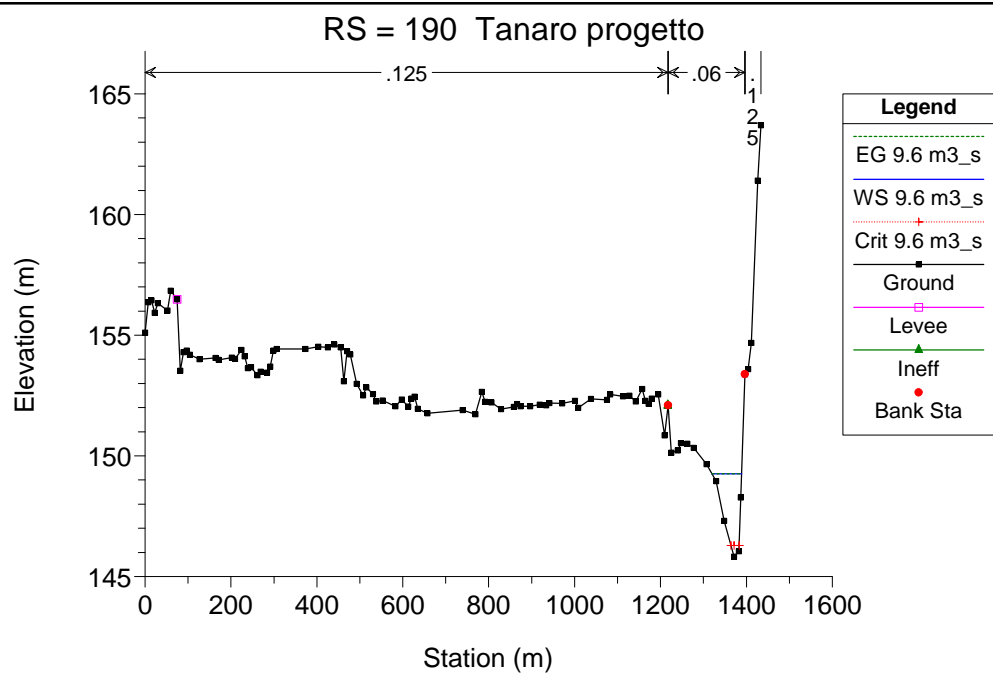


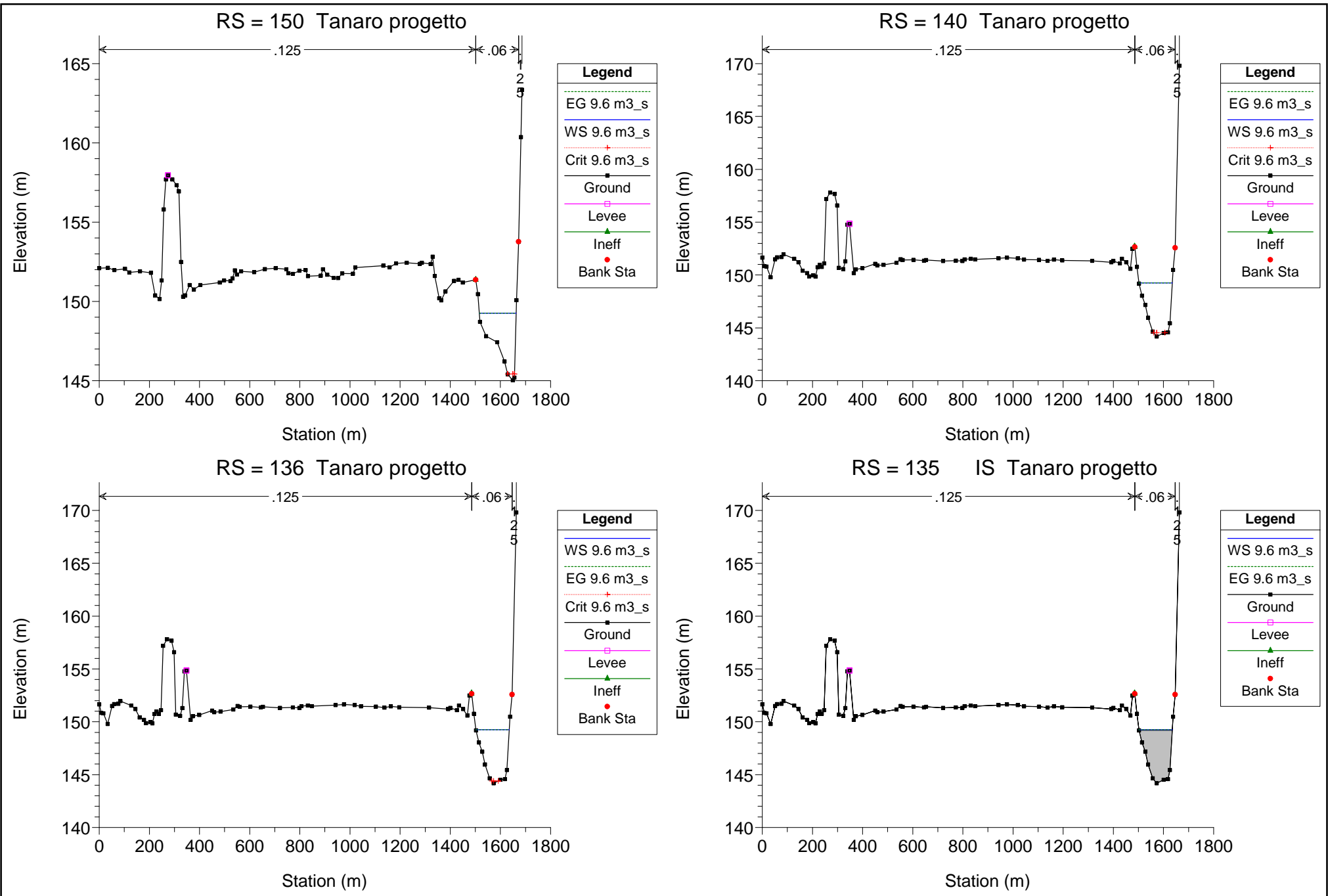


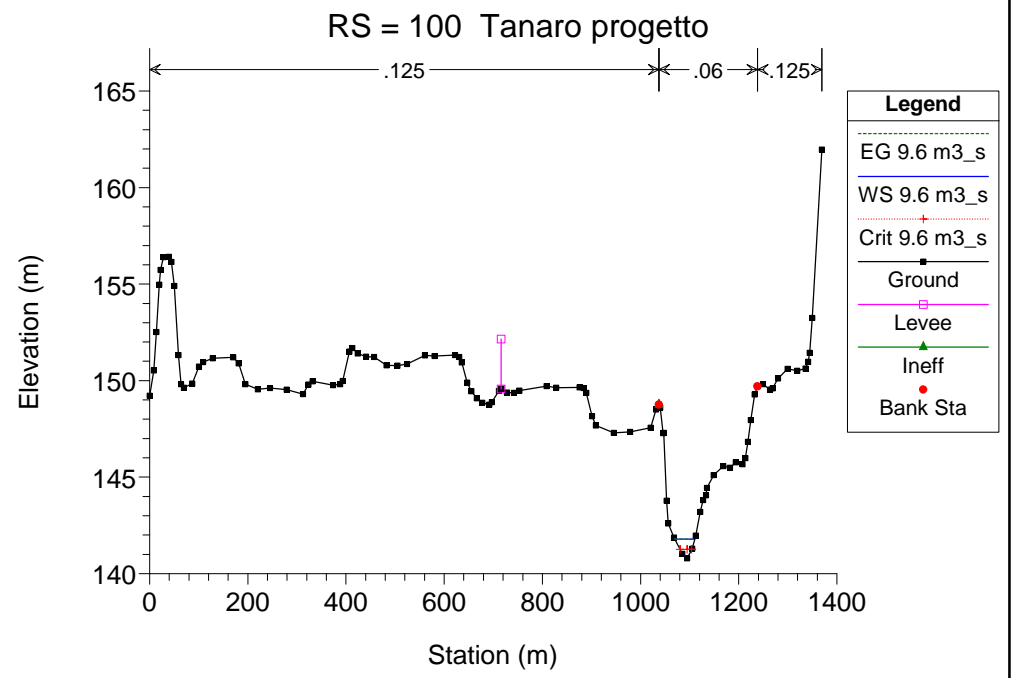
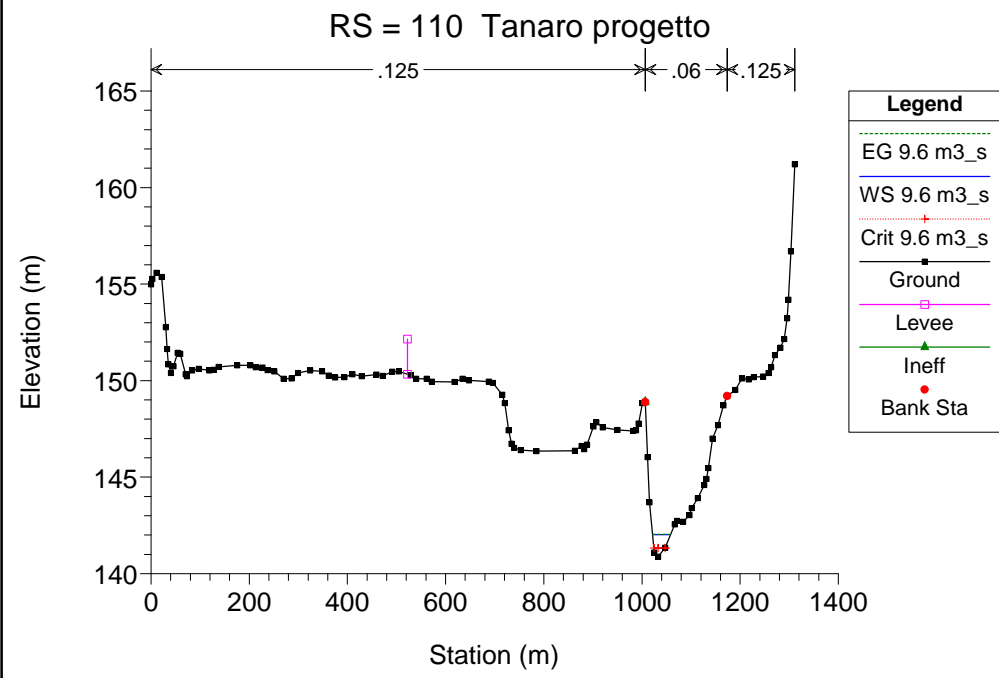
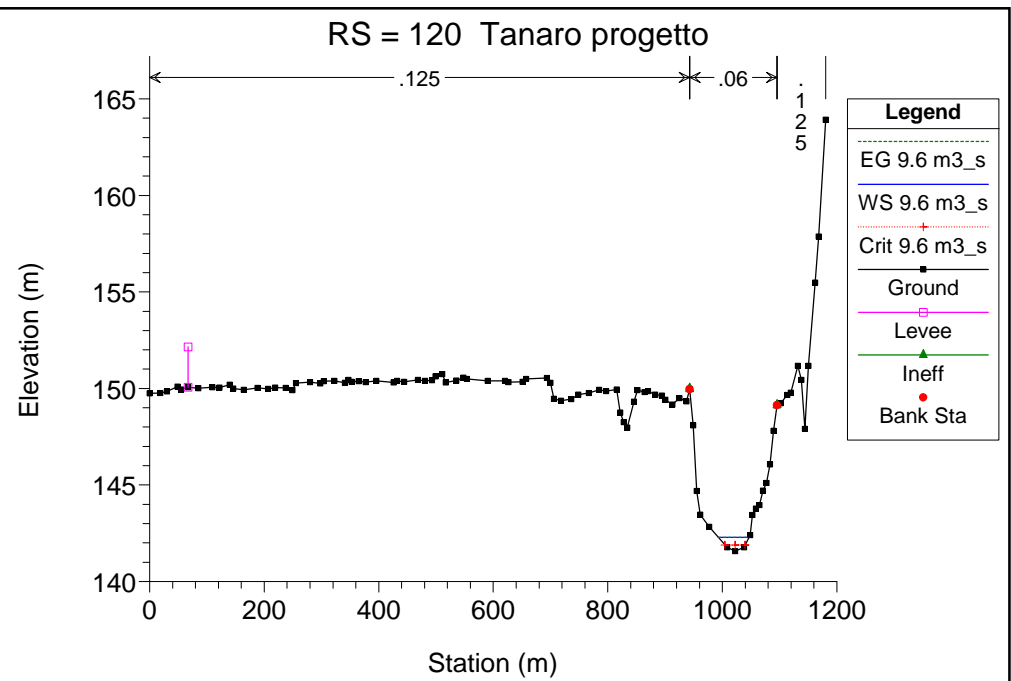
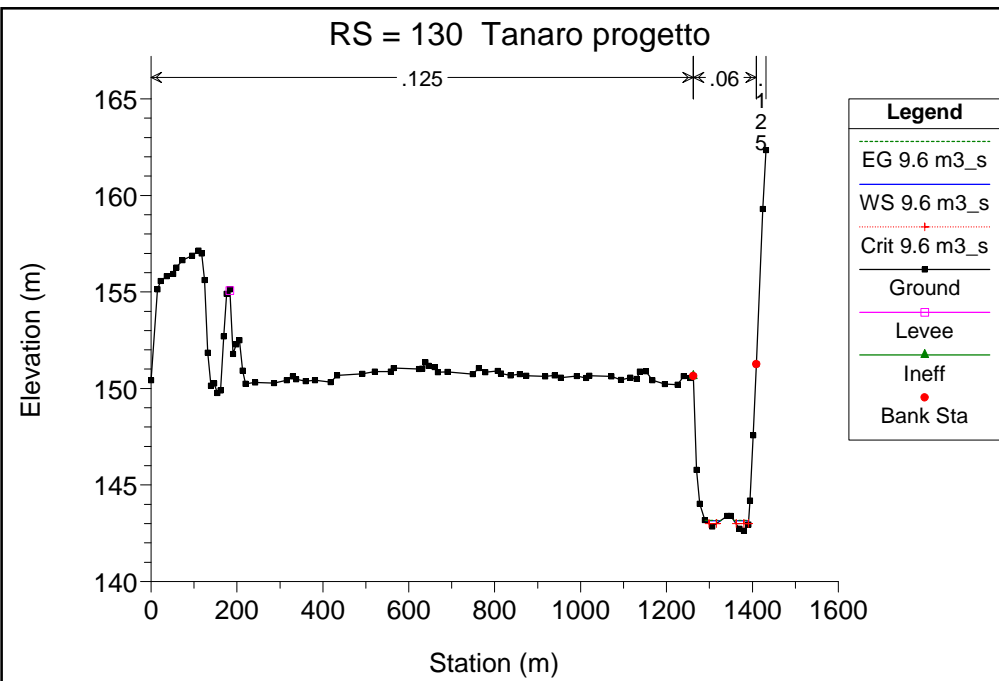


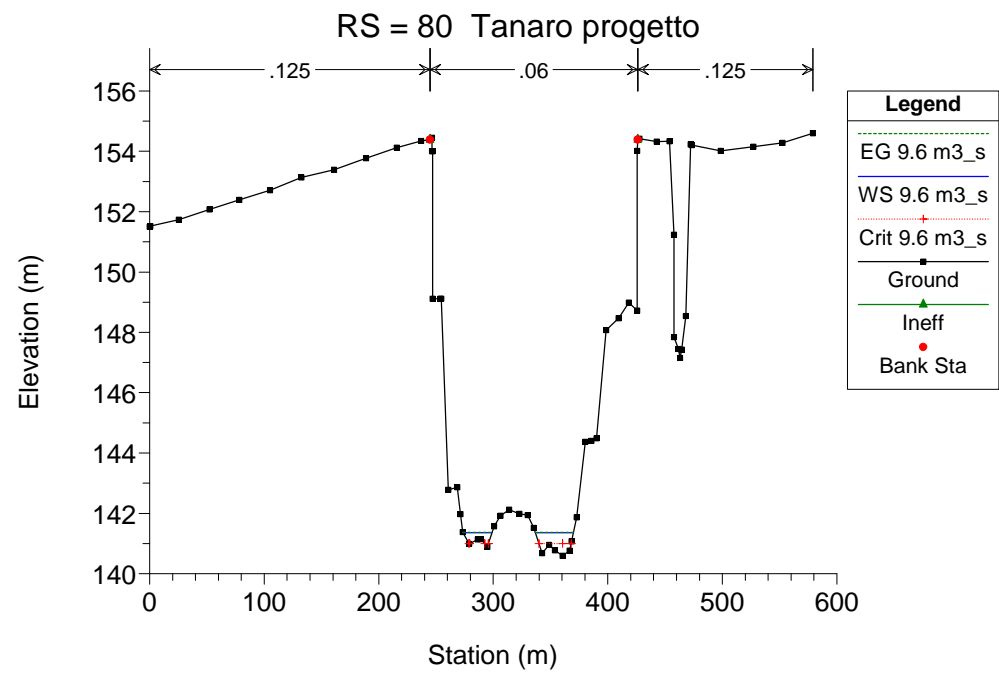
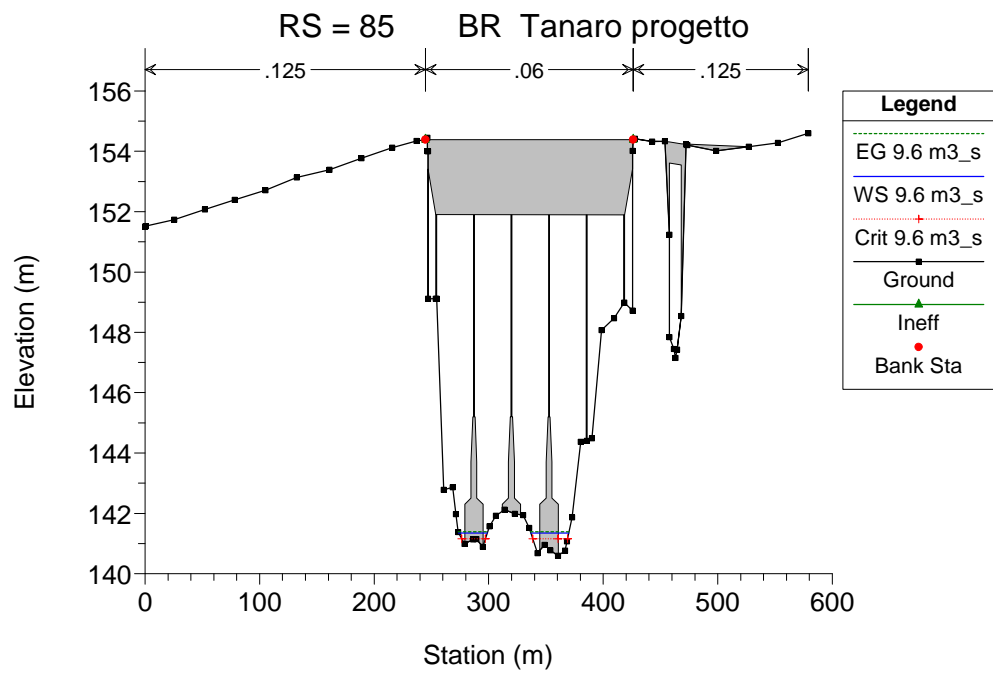
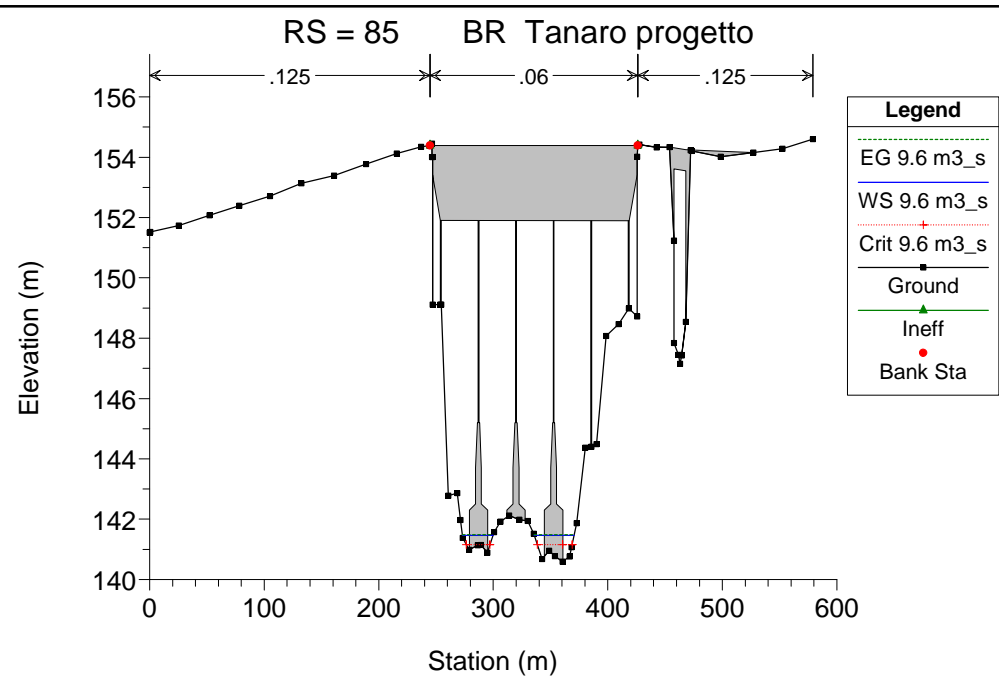
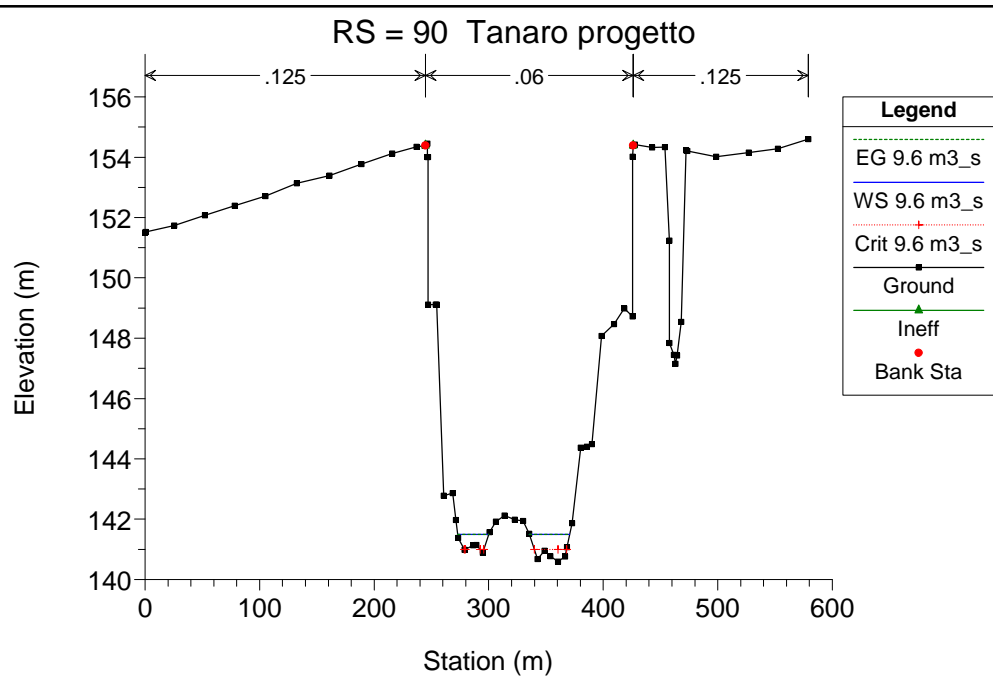


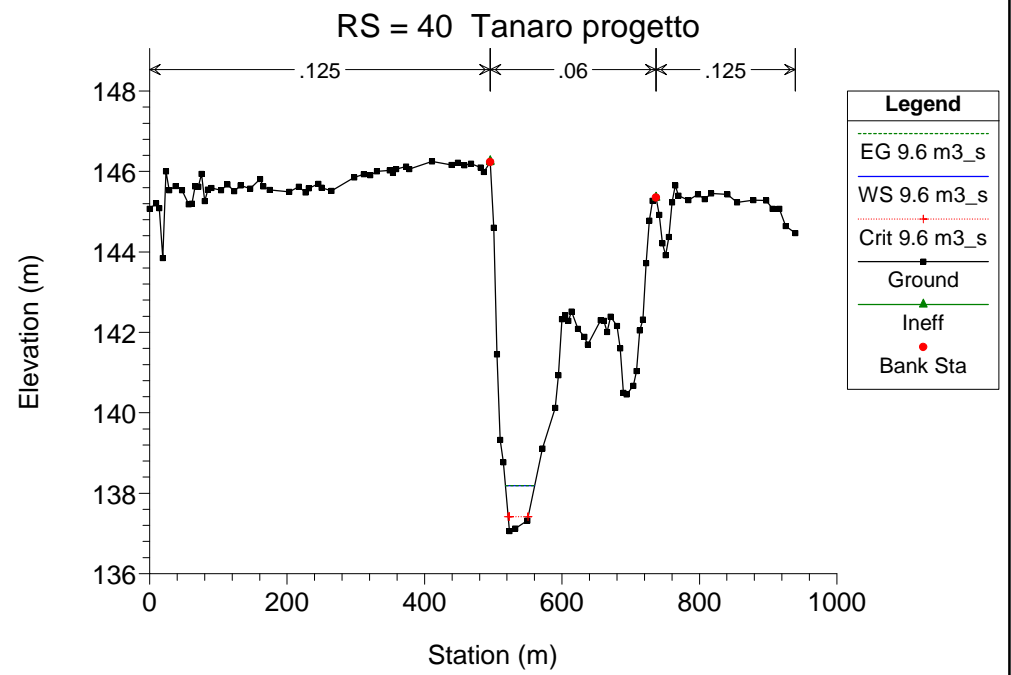
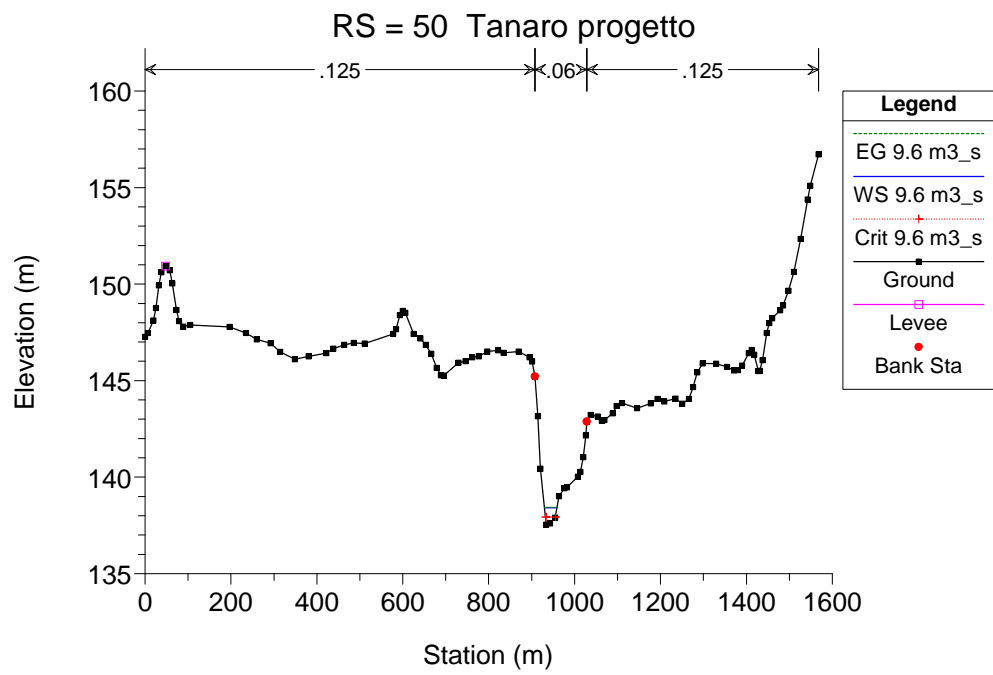
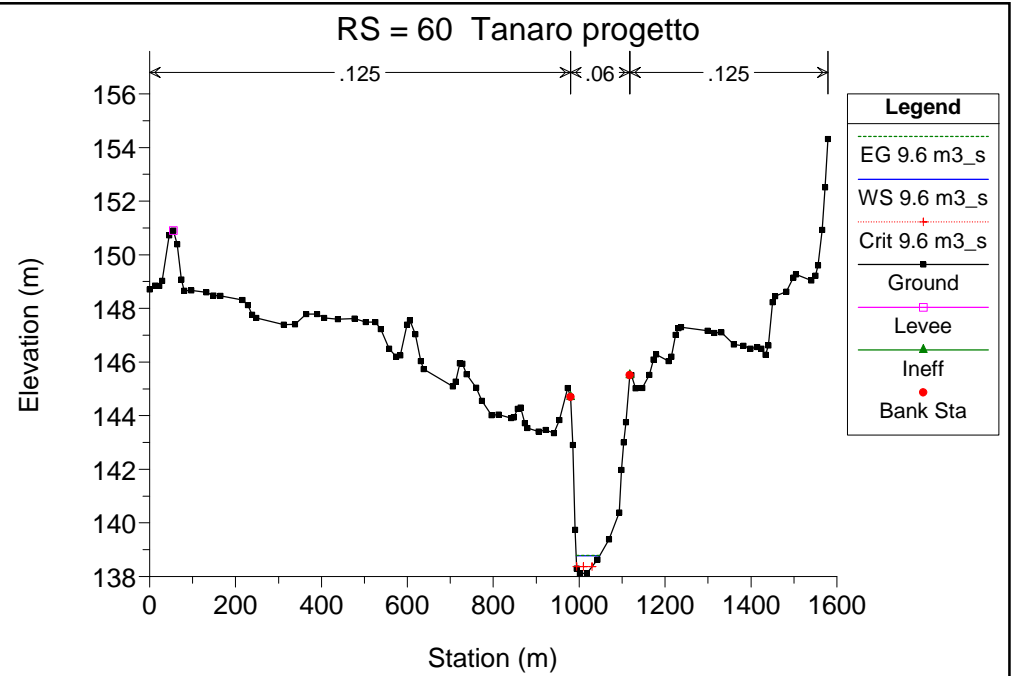
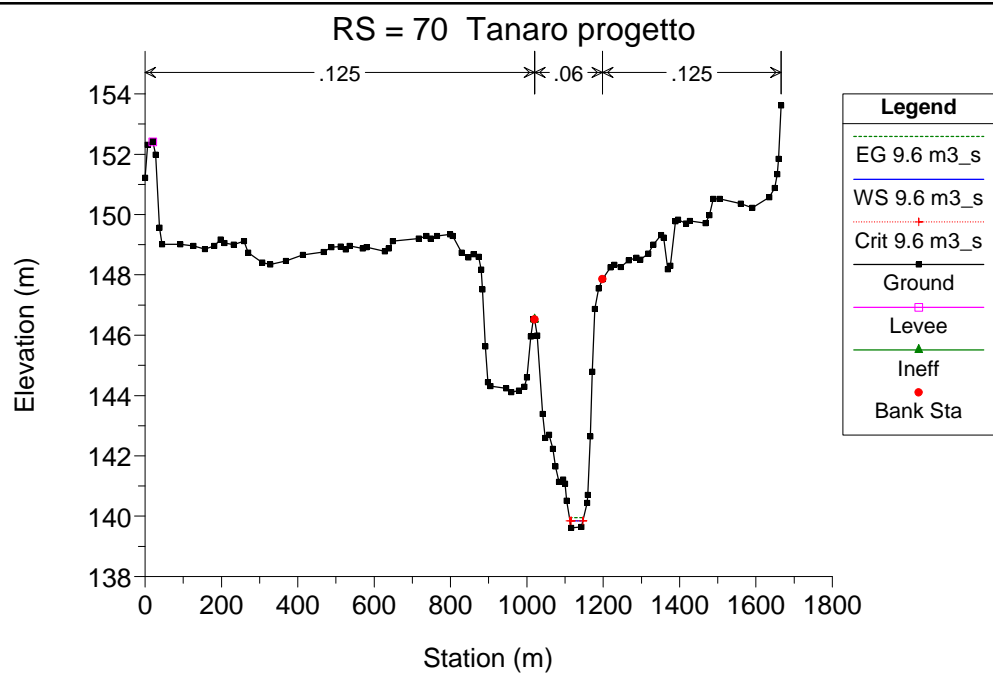


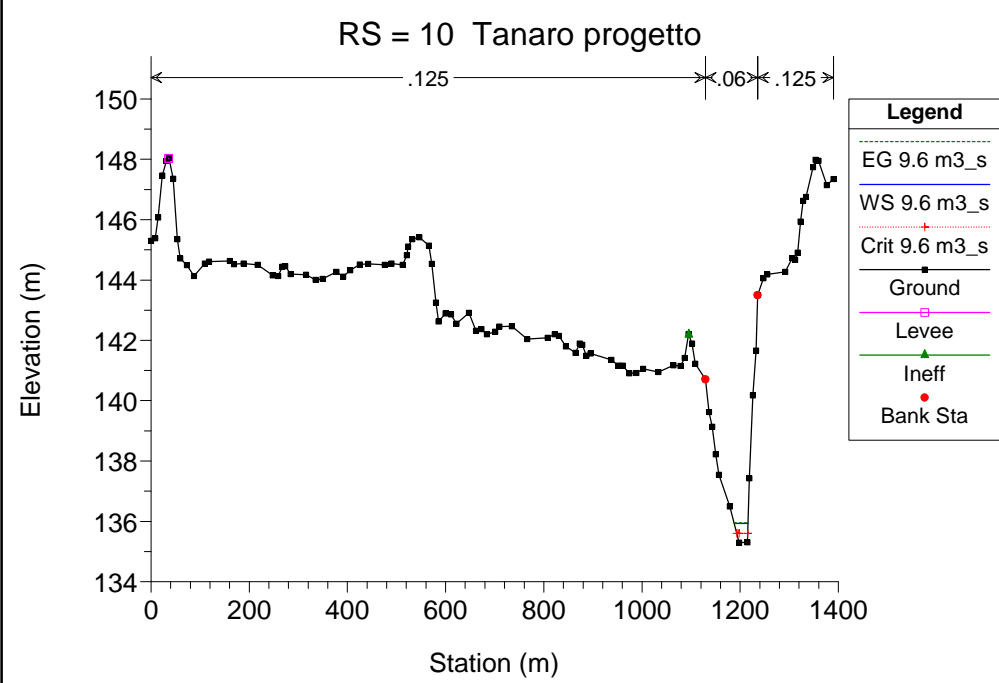
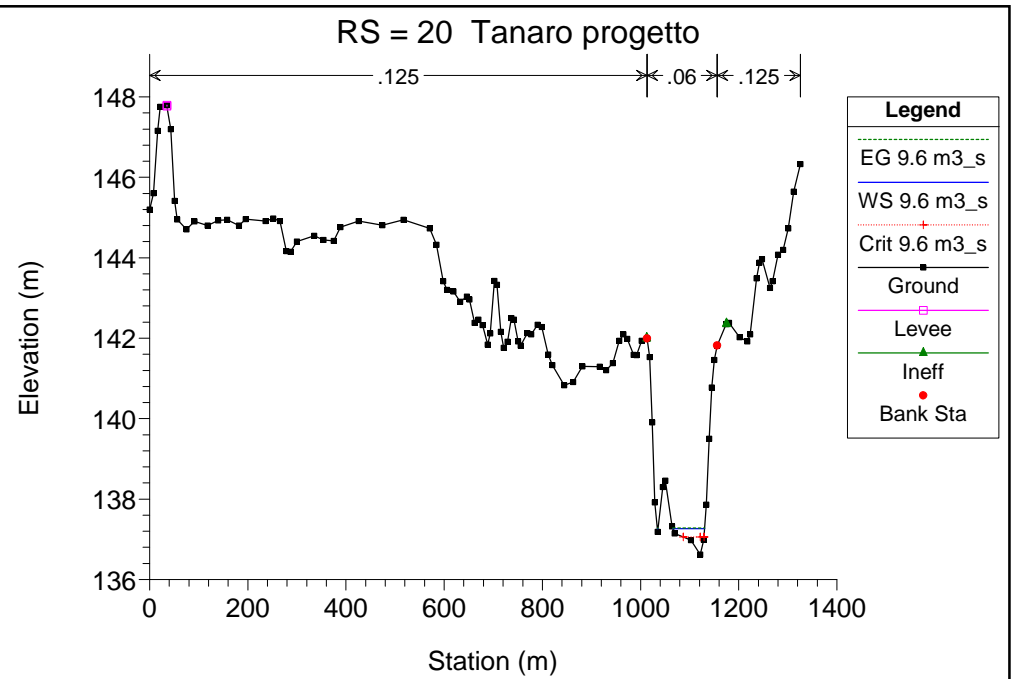
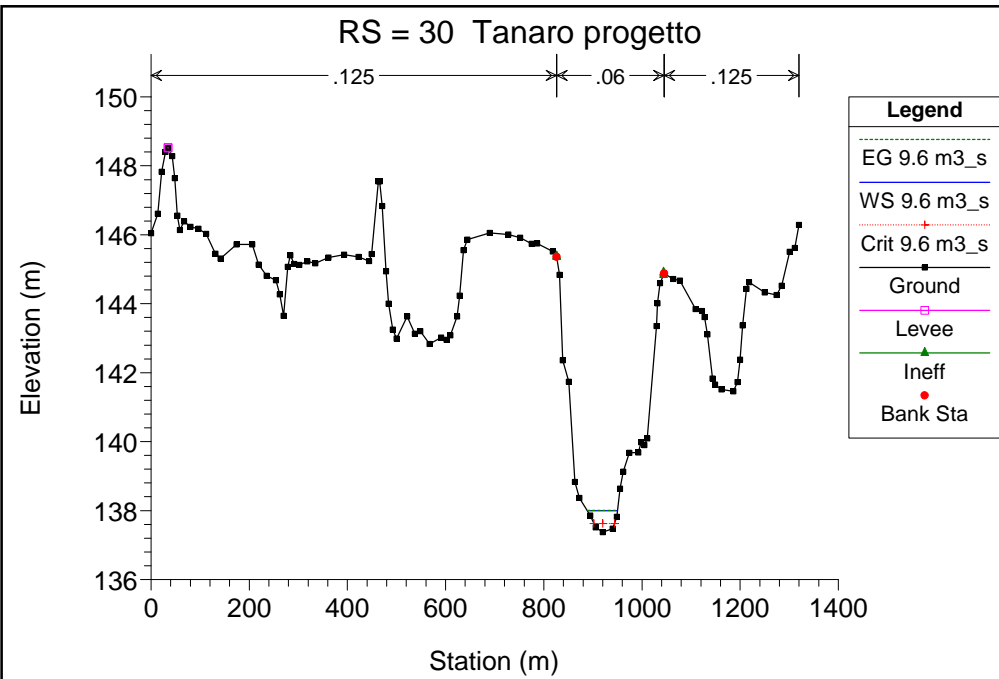












**SITUAZIONE ATTUALE (CON SBARRAMENTO DIVELTO)
SIMULAZIONE 13**

Corso d'acqua	Portata Q m³/s	Portata
Fiume Tanaro	300 (in alveo) 100 (turbinati)	Massima di funzionamento dell'impianto idroelettrico

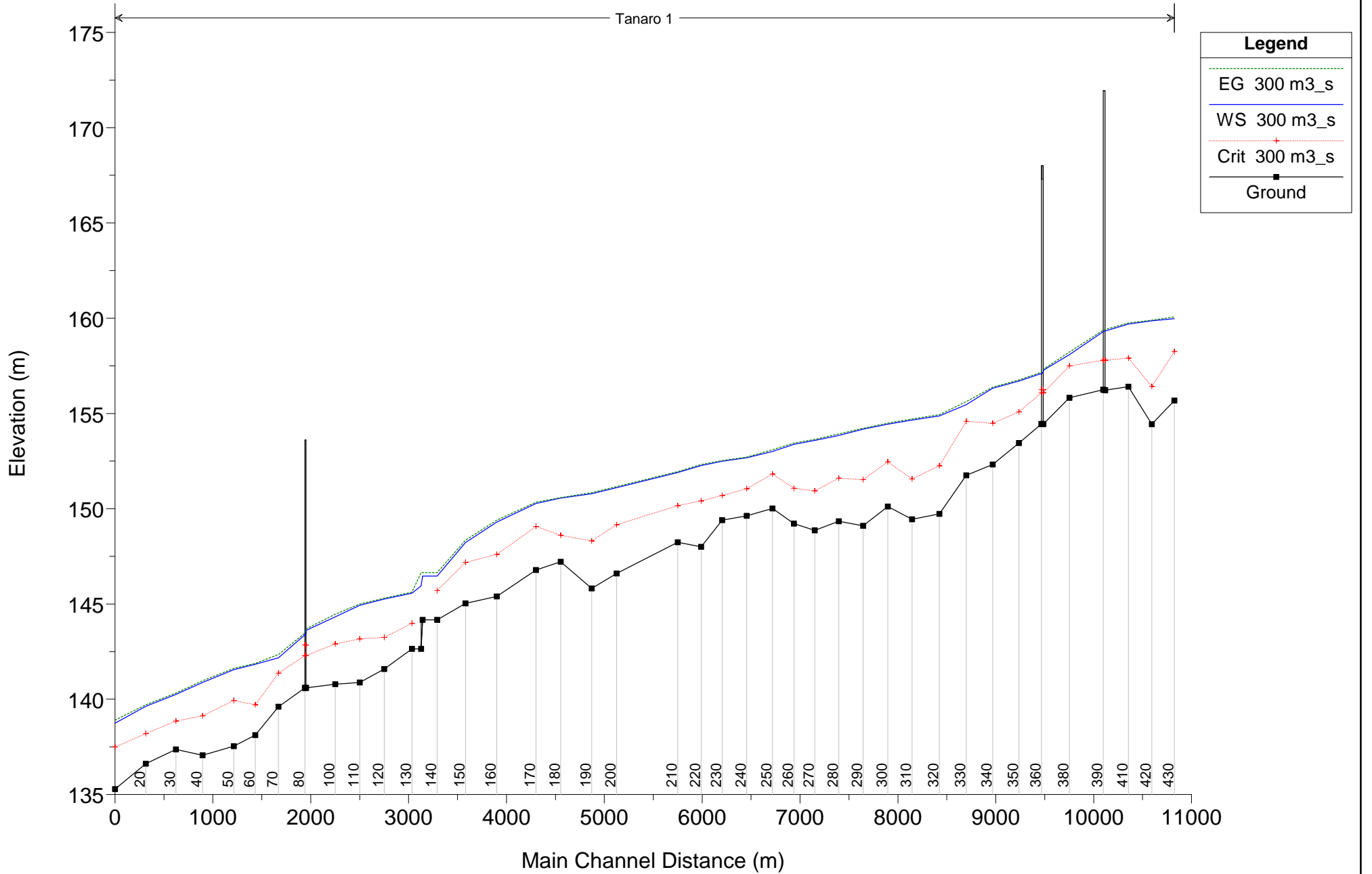
HEC-RAS Plan: Plan 06 River: Tanaro Reach: 1 Profile: 300 m3_s

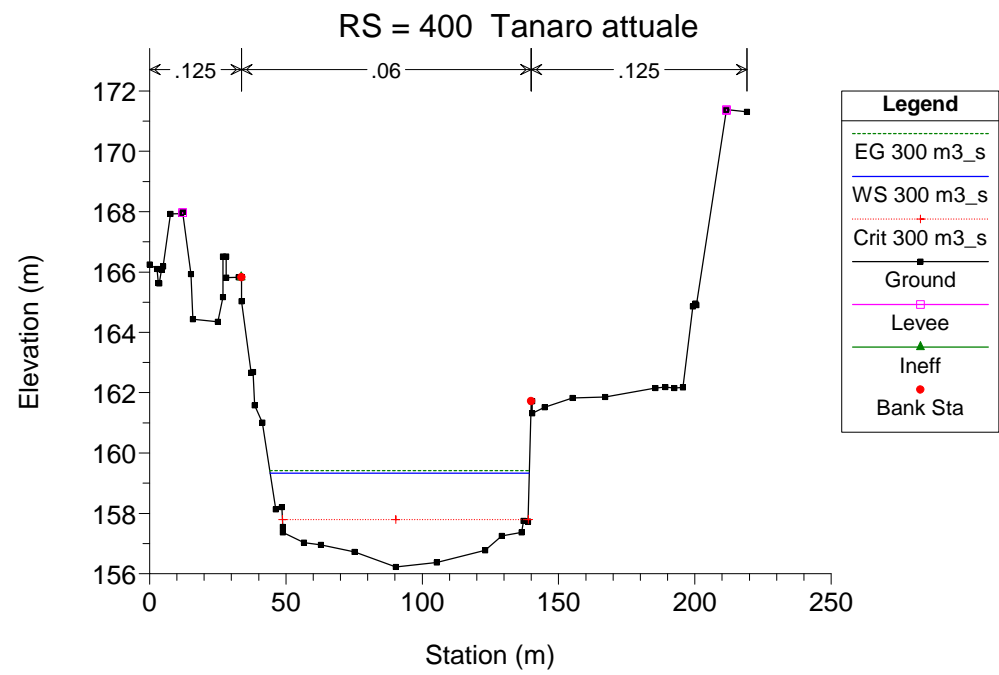
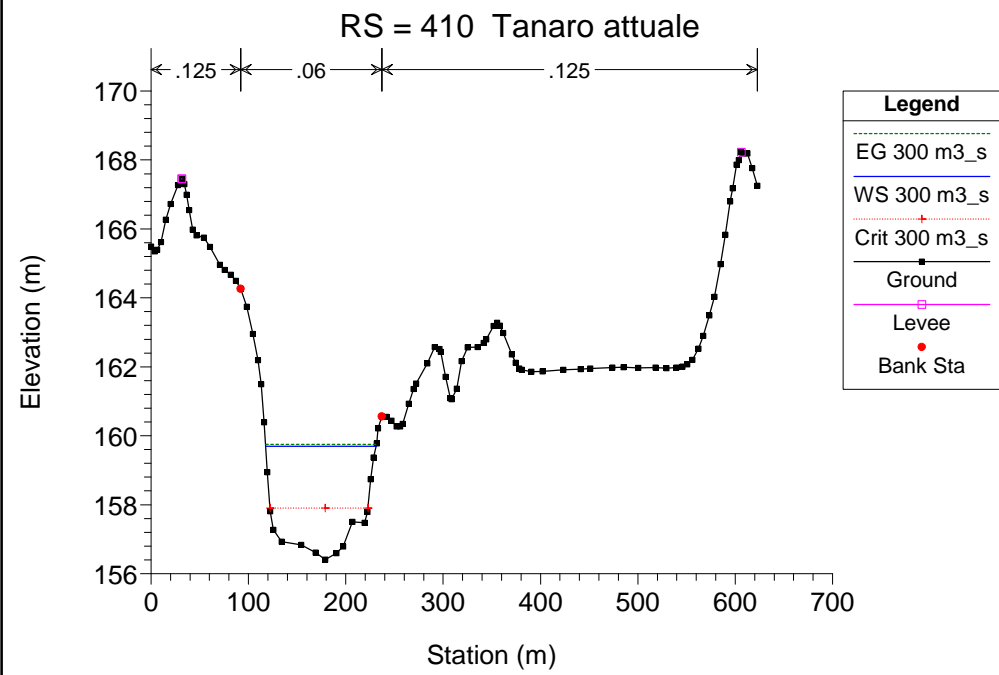
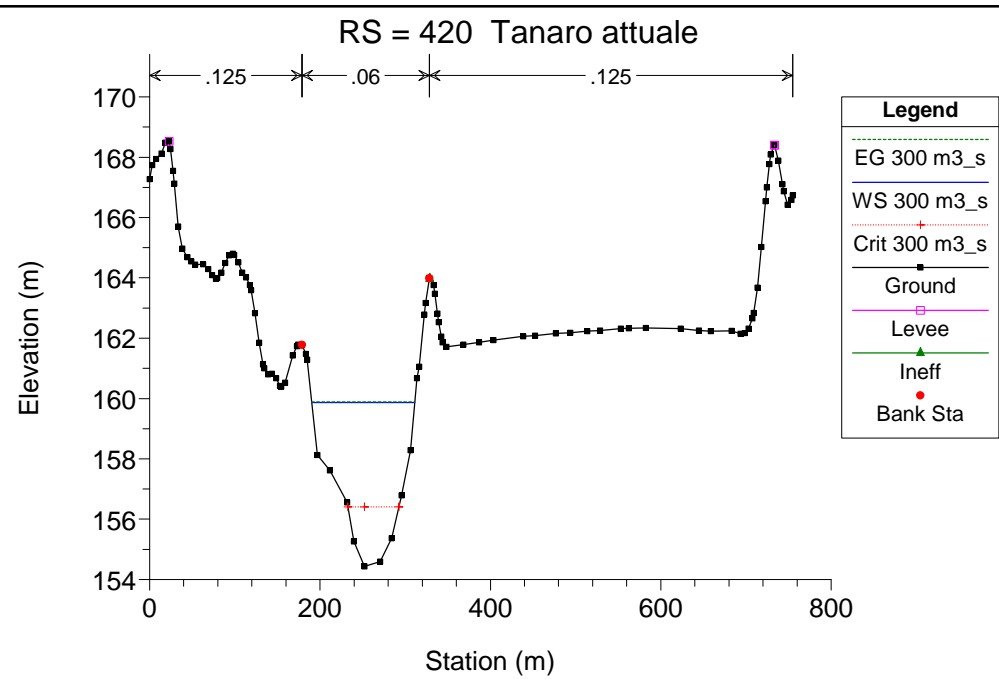
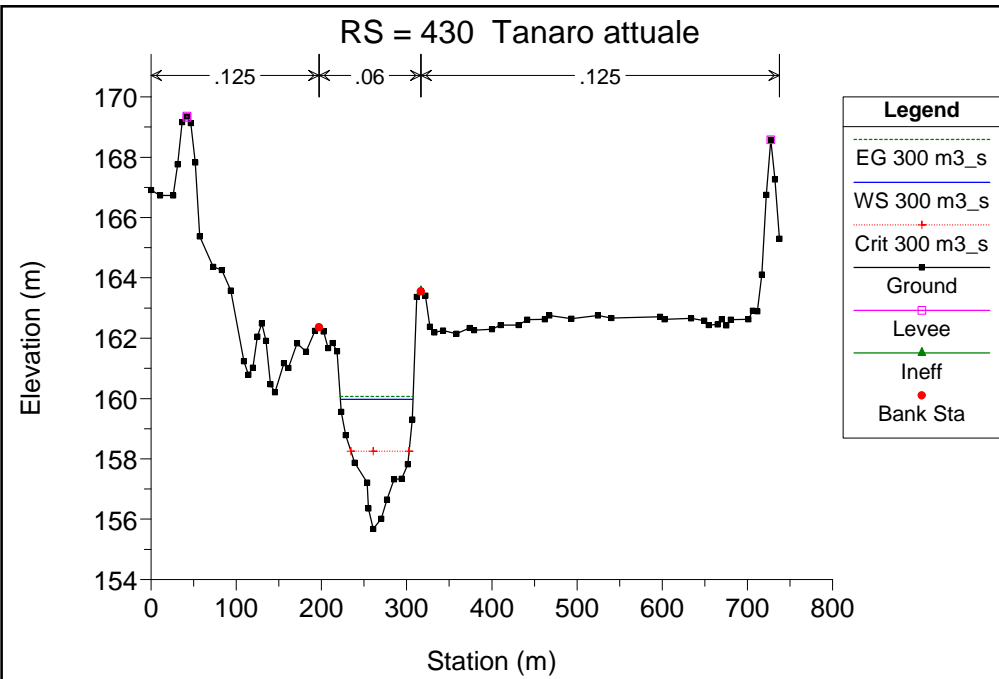
Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
1	430	300 m3_s	300.00	155.68	159.98	158.25	160.07	0.001887	1.36	220.91	85.05	0.27
1	420	300 m3_s	300.00	154.44	159.87	156.41	159.89	0.000347	0.71	421.96	120.99	0.12
1	410	300 m3_s	300.00	156.41	159.70	157.90	159.75	0.001133	1.04	288.31	113.45	0.21
1	400	300 m3_s	300.00	156.22	159.33	157.79	159.41	0.001756	1.26	237.22	95.09	0.26
1	395		Bridge									
1	390	300 m3_s	300.00	156.25	159.29	157.79	159.37	0.001862	1.29	232.97	95.01	0.26
1	380	300 m3_s	300.00	155.82	158.08	157.50	158.22	0.007307	1.66	180.70	143.05	0.47
1	370	300 m3_s	300.00	154.45	157.27	156.09	157.33	0.001788	1.05	284.70	154.28	0.25
1	365		Bridge									
1	360	300 m3_s	300.00	154.45	157.10	156.08	157.17	0.002478	1.16	257.57	153.46	0.29
1	350	300 m3_s	300.00	153.45	156.70	155.09	156.76	0.001310	1.06	282.55	120.27	0.22
1	340	300 m3_s	300.00	152.32	156.33	154.48	156.38	0.001498	1.05	285.44	136.65	0.23
1	330	300 m3_s	300.00	151.75	155.46	154.59	155.62	0.006915	1.75	171.10	119.47	0.47
1	320	300 m3_s	300.00	149.73	154.87	152.25	154.94	0.001182	1.21	248.50	80.04	0.22
1	310	300 m3_s	300.00	149.44	154.66	151.56	154.71	0.000602	0.99	303.13	78.79	0.16
1	300	300 m3_s	300.00	150.11	154.44	152.46	154.50	0.001297	1.03	291.26	129.04	0.22
1	290	300 m3_s	300.00	149.10	154.18	151.53	154.22	0.000907	0.90	334.02	137.33	0.18
1	280	300 m3_s	300.00	149.34	153.85	151.61	153.92	0.001603	1.19	252.59	105.18	0.24
1	270	300 m3_s	300.00	148.86	153.59	150.93	153.64	0.000830	1.04	287.46	88.64	0.18
1	260	300 m3_s	300.00	149.22	153.38	151.07	153.44	0.001057	1.13	264.75	86.71	0.21
1	250	300 m3_s	300.00	150.01	153.00	151.82	153.09	0.002625	1.35	222.36	111.62	0.31
1	240	300 m3_s	300.00	149.63	152.67	151.04	152.71	0.000866	0.86	350.69	151.01	0.18
1	230	300 m3_s	300.00	149.40	152.50	150.69	152.52	0.000617	0.73	409.36	175.53	0.15
1	220	300 m3_s	300.00	148.00	152.26	150.41	152.32	0.001490	1.11	279.07	160.87	0.23
1	210	300 m3_s	300.00	148.24	151.90	150.16	151.95	0.001622	0.98	304.79	170.75	0.24
1	200	300 m3_s	300.00	146.60	151.11	149.16	151.16	0.001007	1.02	294.39	109.18	0.20
1	190	300 m3_s	300.00	145.82	150.79	148.31	150.84	0.001625	0.99	304.04	169.50	0.24
1	180	300 m3_s	300.00	147.21	150.56	148.60	150.58	0.000469	0.66	456.39	205.78	0.13
1	170	300 m3_s	300.00	146.78	150.27	149.07	150.34	0.002580	1.17	255.80	156.34	0.29
1	160	300 m3_s	300.00	145.40	149.30	147.60	149.40	0.002149	1.41	213.30	86.19	0.29
1	150	300 m3_s	300.00	145.03	148.23	147.18	148.35	0.005494	1.59	189.13	129.15	0.42
1	140	300 m3_s	300.00	144.17	146.47	145.71	146.65	0.006322	1.88	159.65	94.21	0.46
1	135		Inl Struct									
1	130	300 m3_s	300.00	142.64	145.57	143.98	145.62	0.001216	1.02	295.10	126.85	0.21
1	120	300 m3_s	300.00	141.58	145.26	143.25	145.31	0.001012	0.97	308.45	123.66	0.20
1	110	300 m3_s	300.00	140.88	144.93	143.16	145.00	0.001518	1.12	268.44	118.10	0.24
1	100	300 m3_s	300.00	140.79	144.33	142.91	144.46	0.003143	1.61	186.63	82.09	0.34
1	90	300 m3_s	300.00	140.59	143.61	142.29	143.69	0.002045	1.22	245.80	118.16	0.27
1	85		Bridge									
1	80	300 m3_s	300.00	140.59	143.38	142.29	143.48	0.002975	1.37	218.89	117.25	0.32

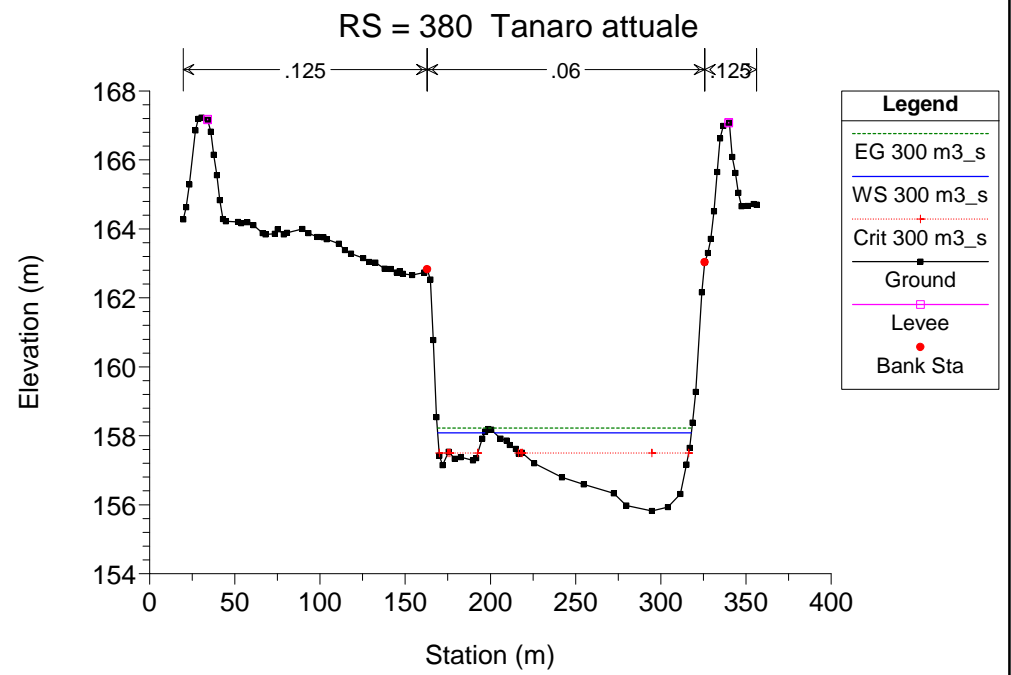
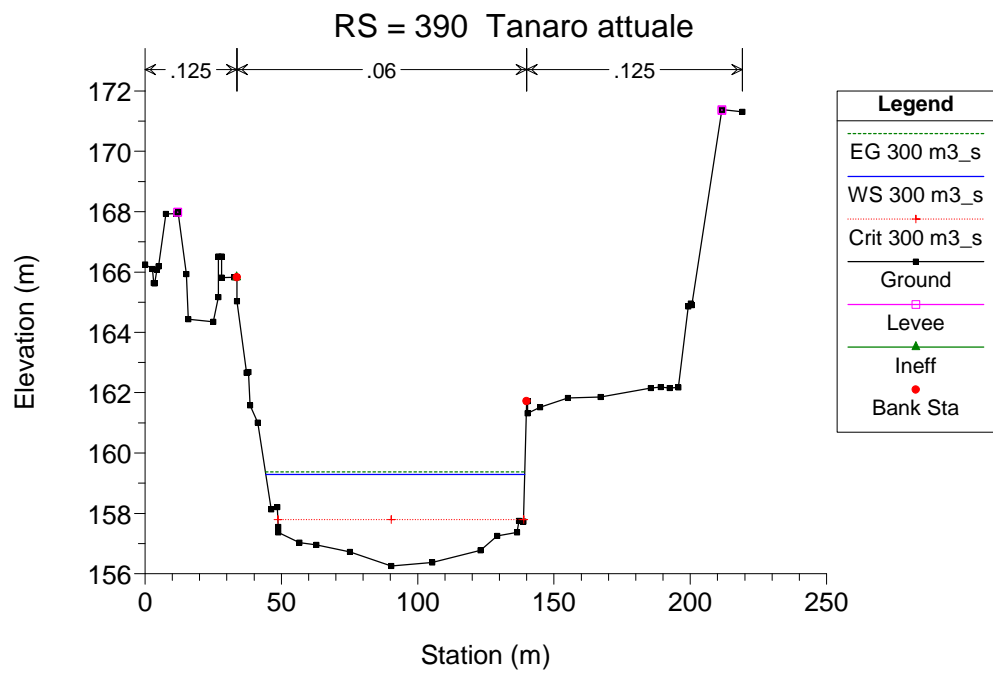
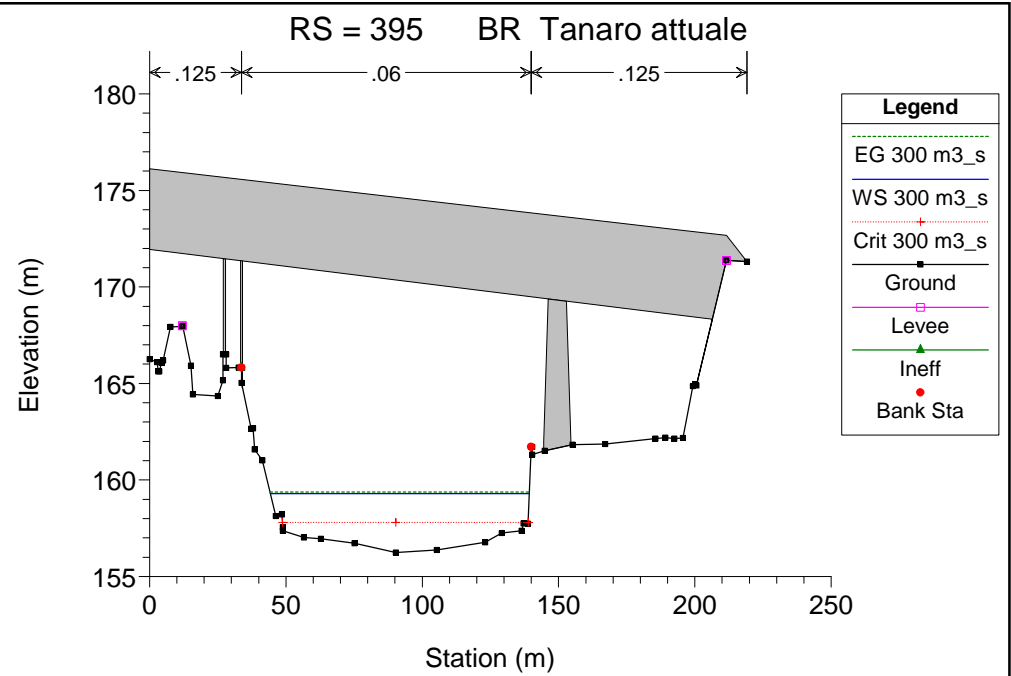
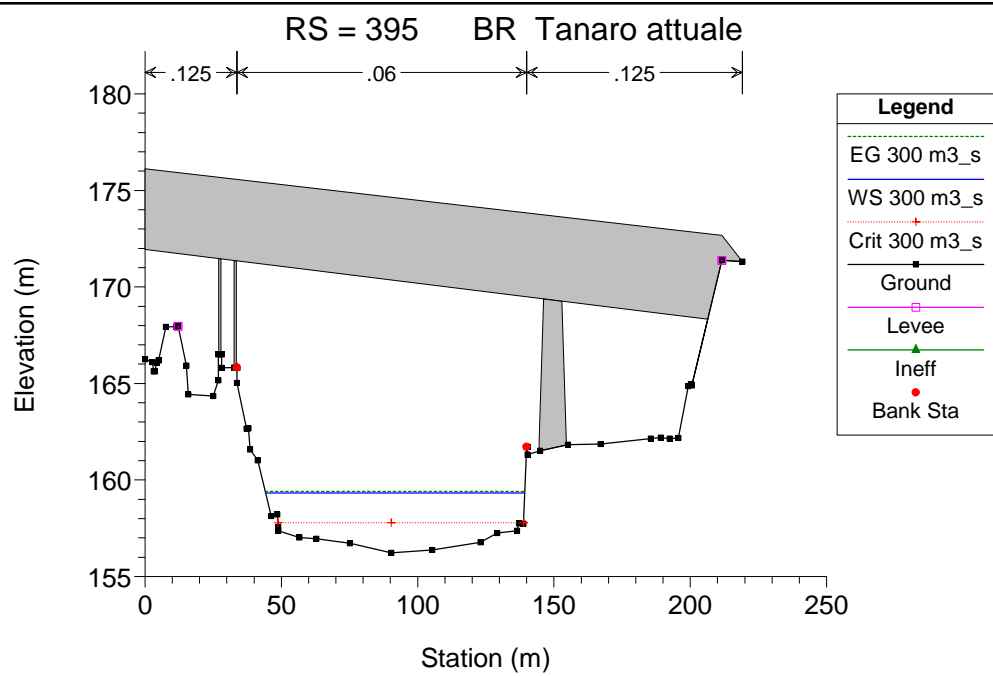
HEC-RAS Plan: Plan 06 River: Tanaro Reach: 1 Profile: 300 m3_s (Continued)

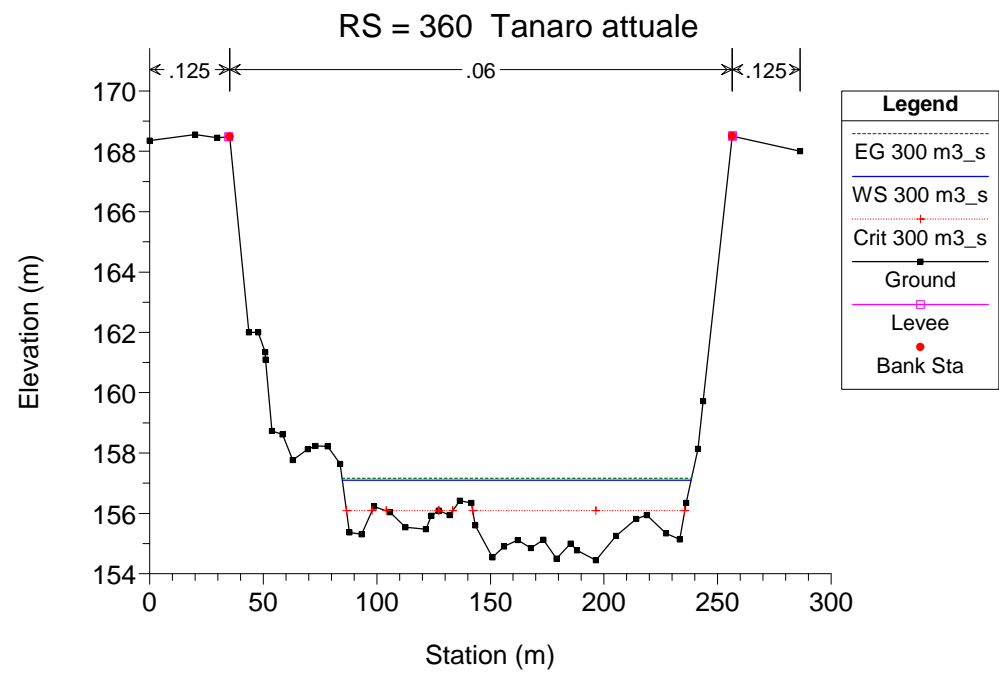
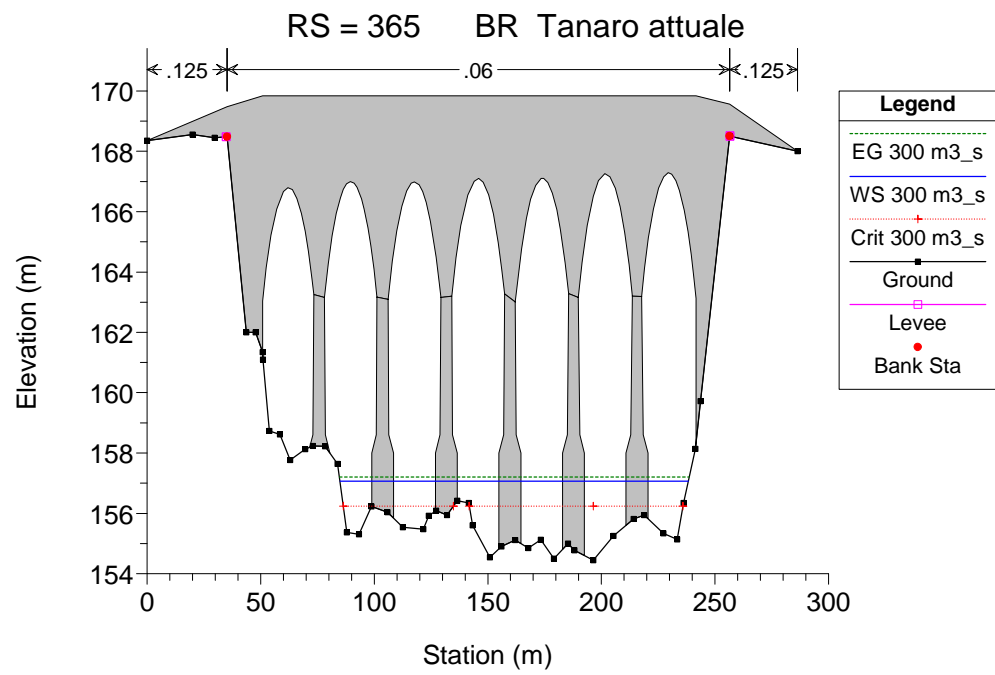
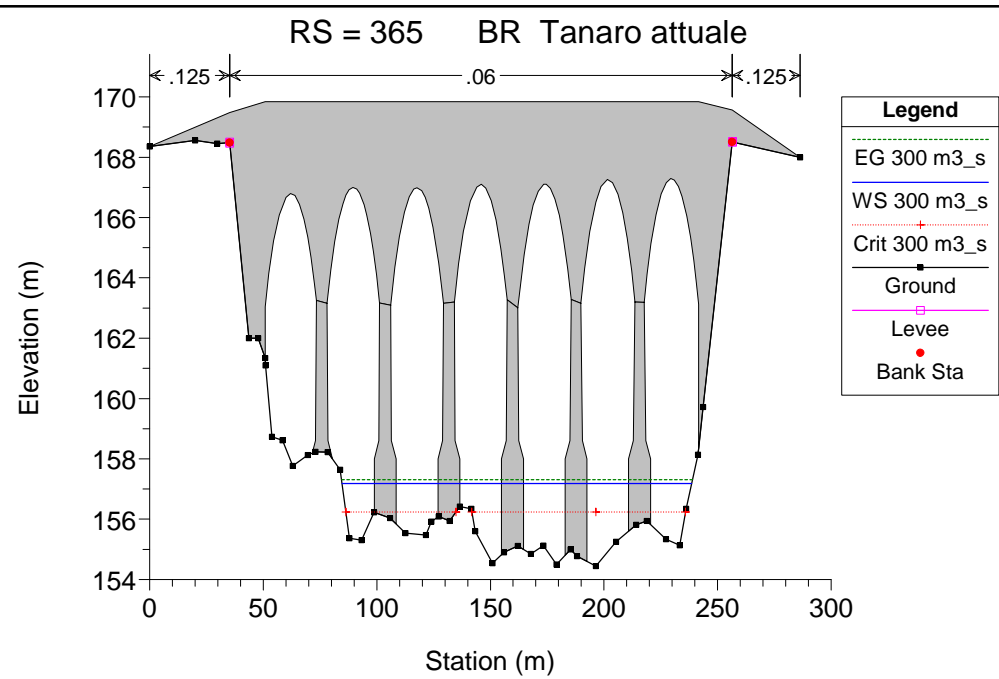
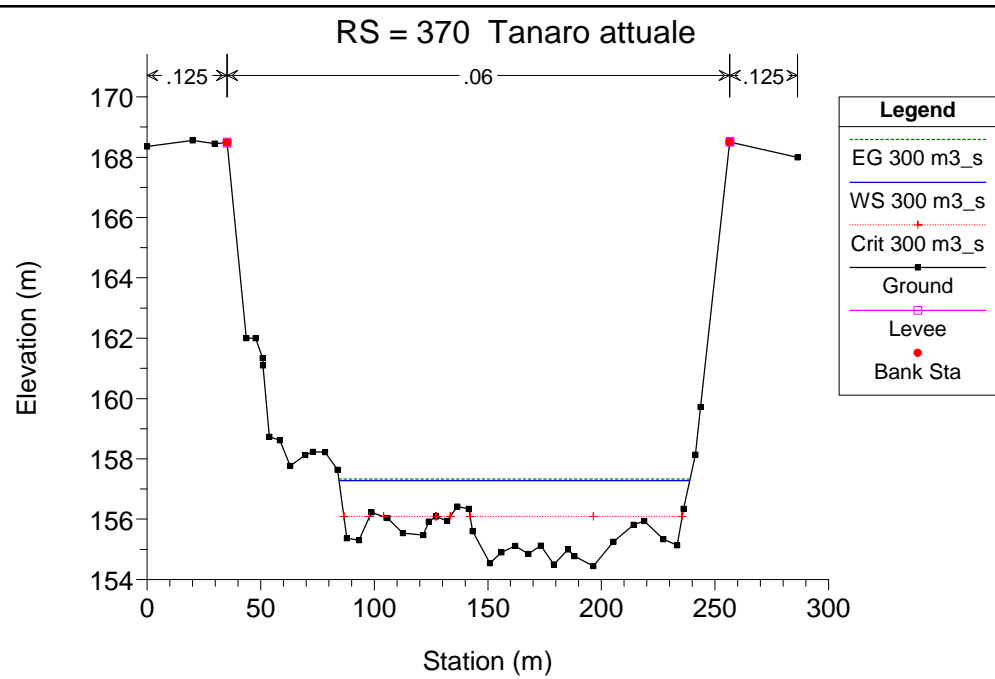
Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
1	70	300 m3_s	300.00	139.61	142.17	141.37	142.35	0.006051	1.84	162.81	95.73	0.45
1	60	300 m3_s	300.00	138.12	141.84	139.71	141.88	0.000849	0.96	312.09	110.96	0.18
1	50	300 m3_s	300.00	137.54	141.55	139.93	141.62	0.001712	1.21	246.99	104.93	0.25
1	40	300 m3_s	300.00	137.06	140.88	139.13	140.97	0.002465	1.35	222.83	106.64	0.30
1	30	300 m3_s	300.00	137.37	140.25	138.86	140.32	0.002277	1.13	264.36	154.78	0.28
1	20	300 m3_s	300.00	136.62	139.63	138.19	139.70	0.001753	1.18	254.96	115.63	0.25
1	10	300 m3_s	300.00	135.29	138.74	137.49	138.90	0.004001	1.78	168.56	75.91	0.38

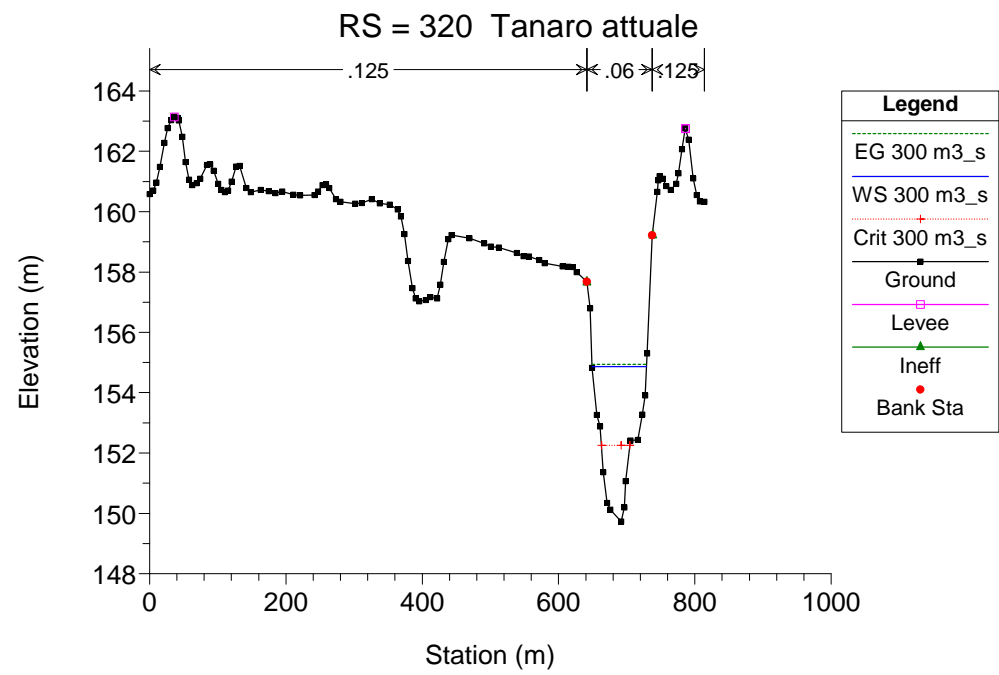
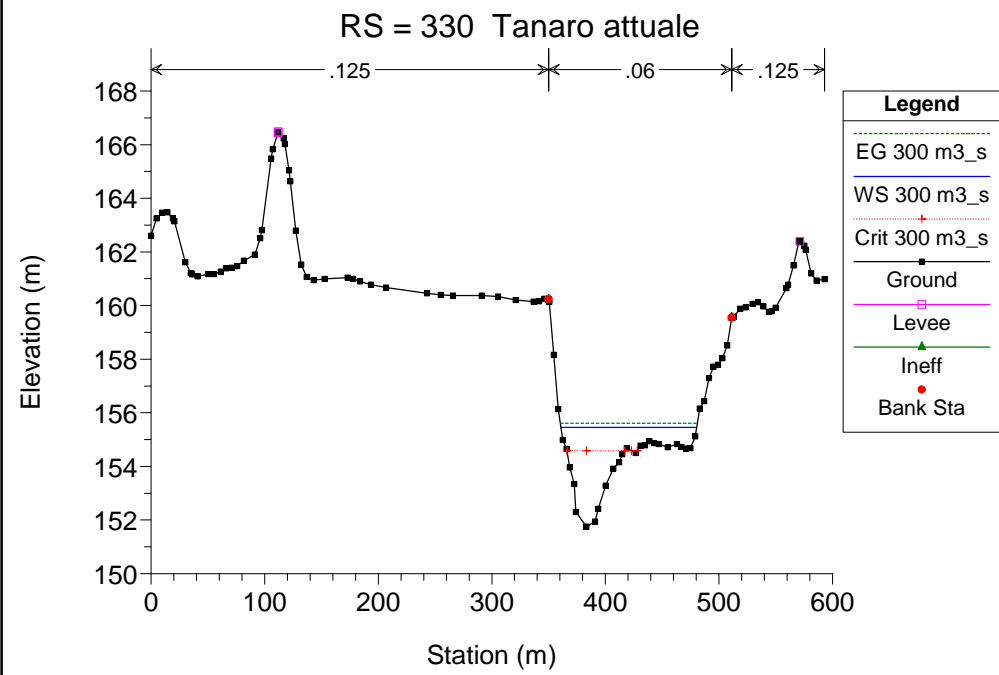
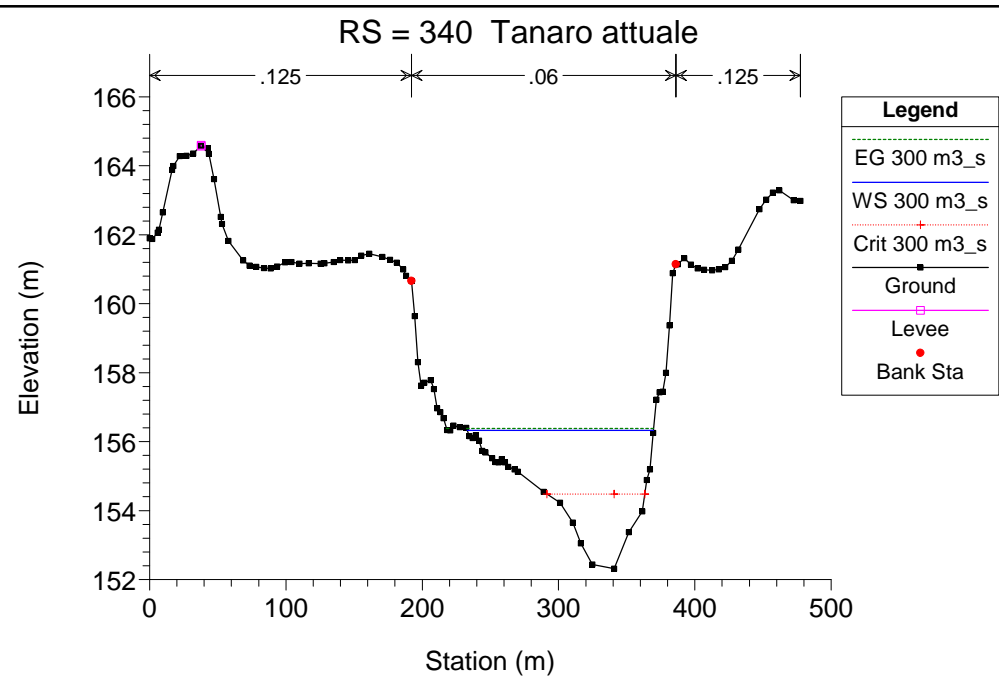
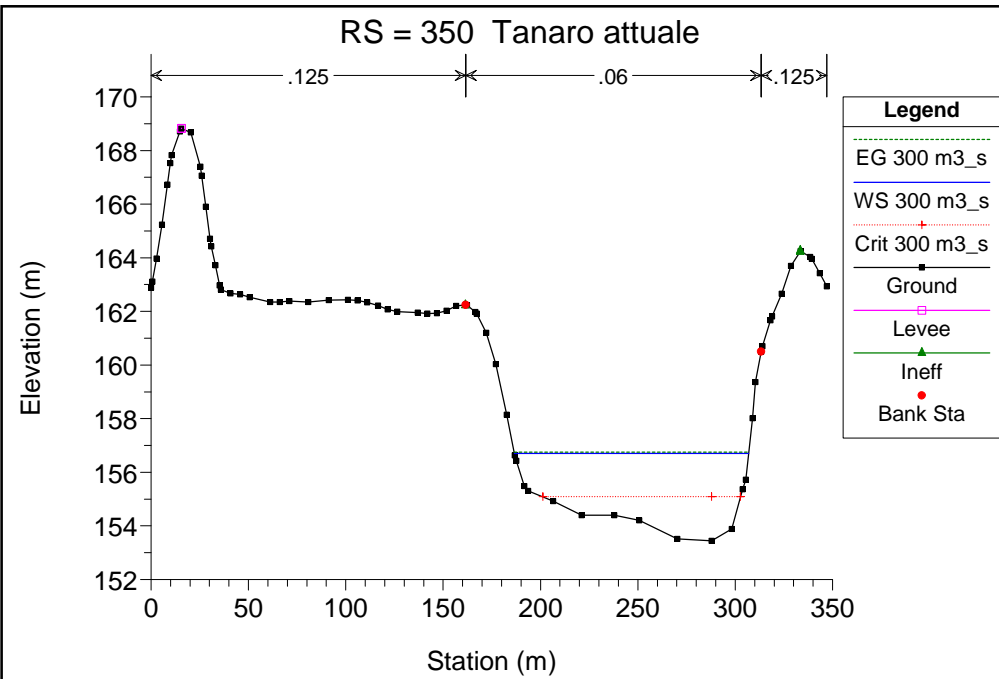
Tanaro attuale

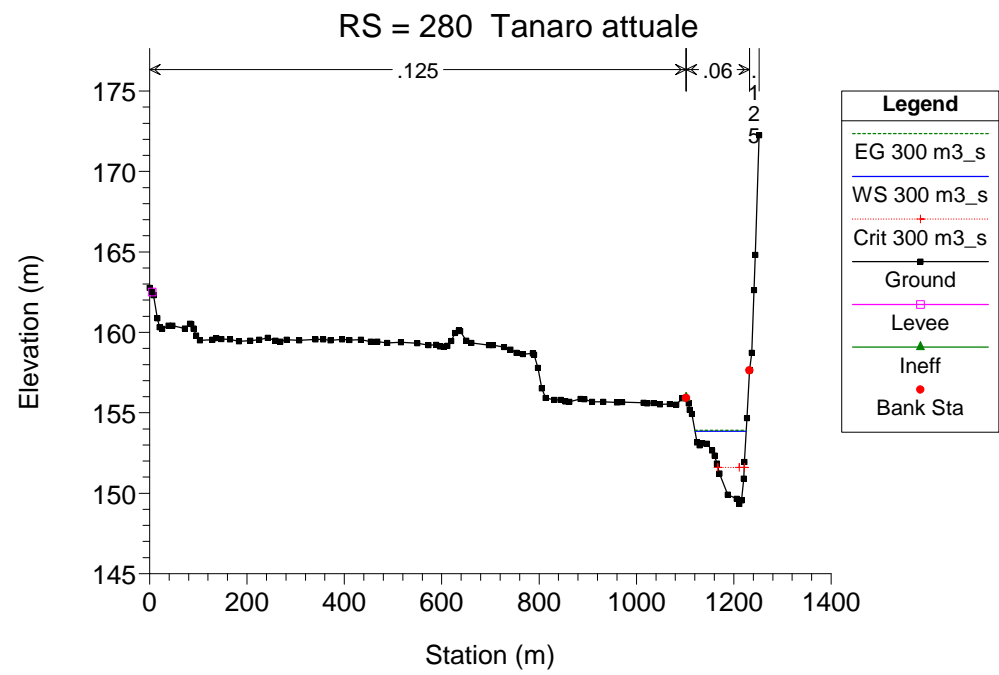
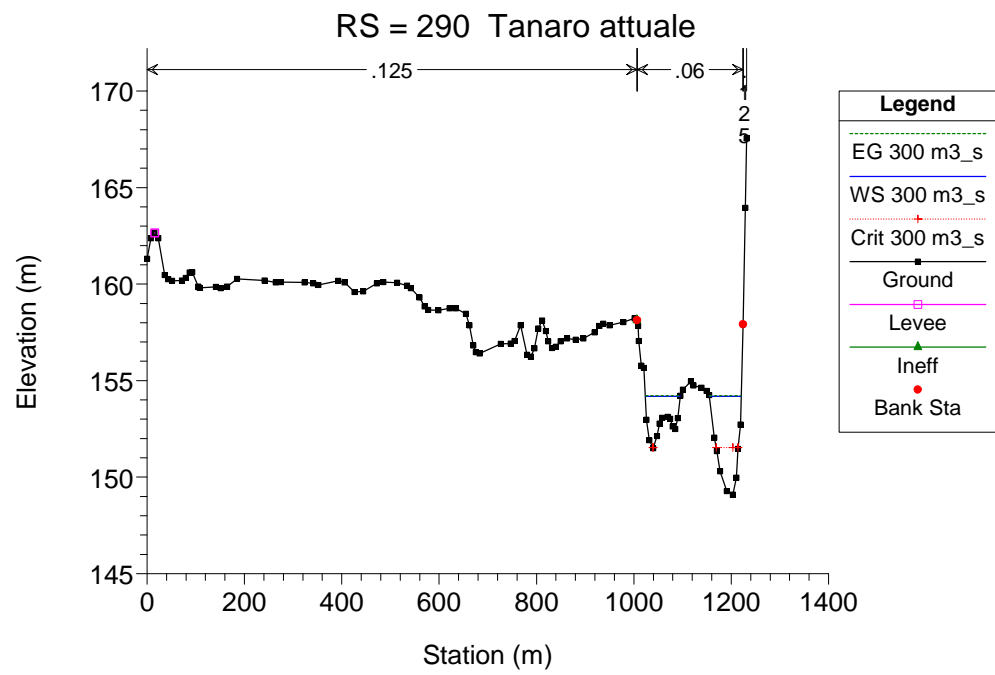
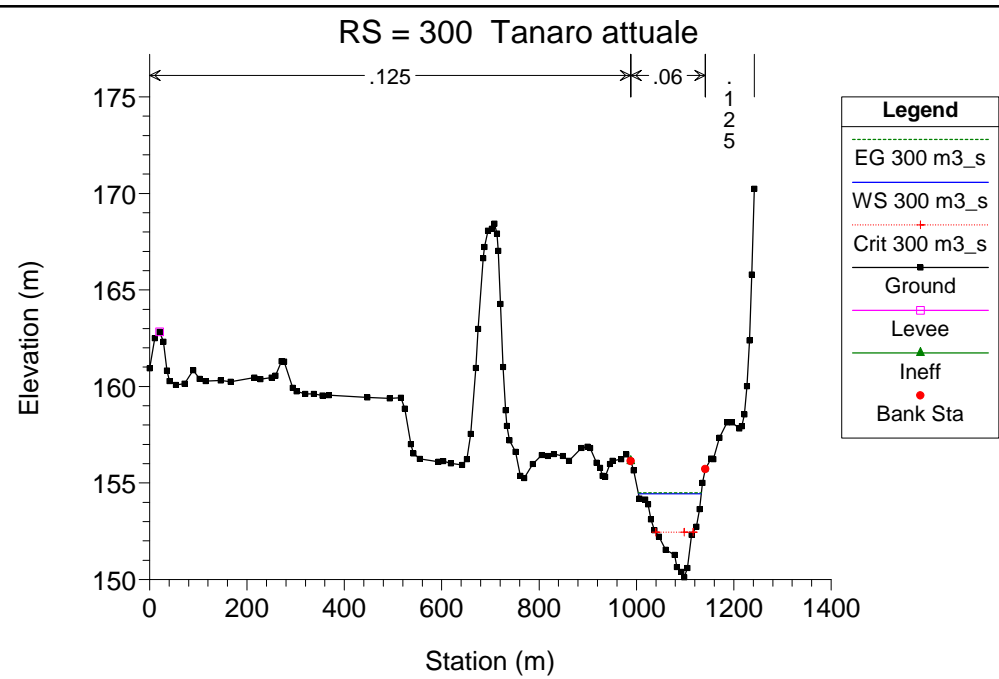
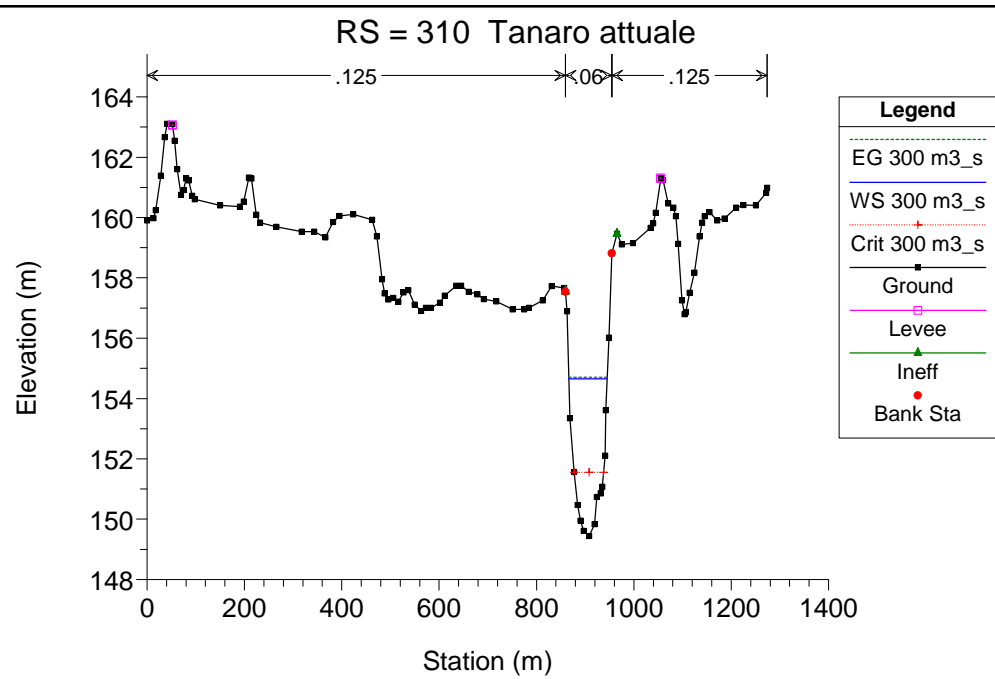


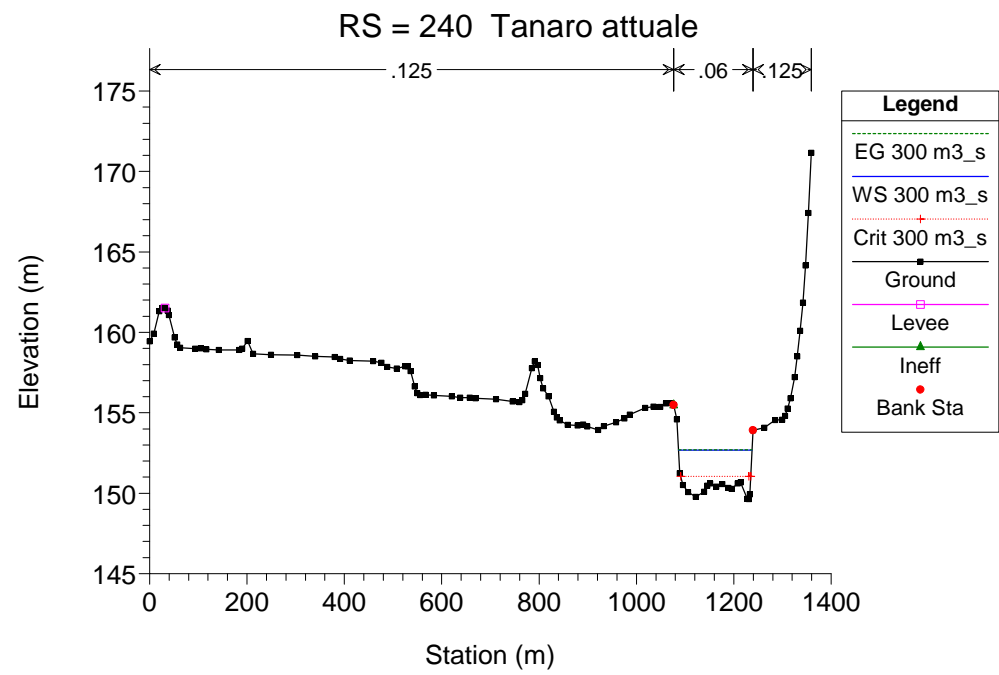
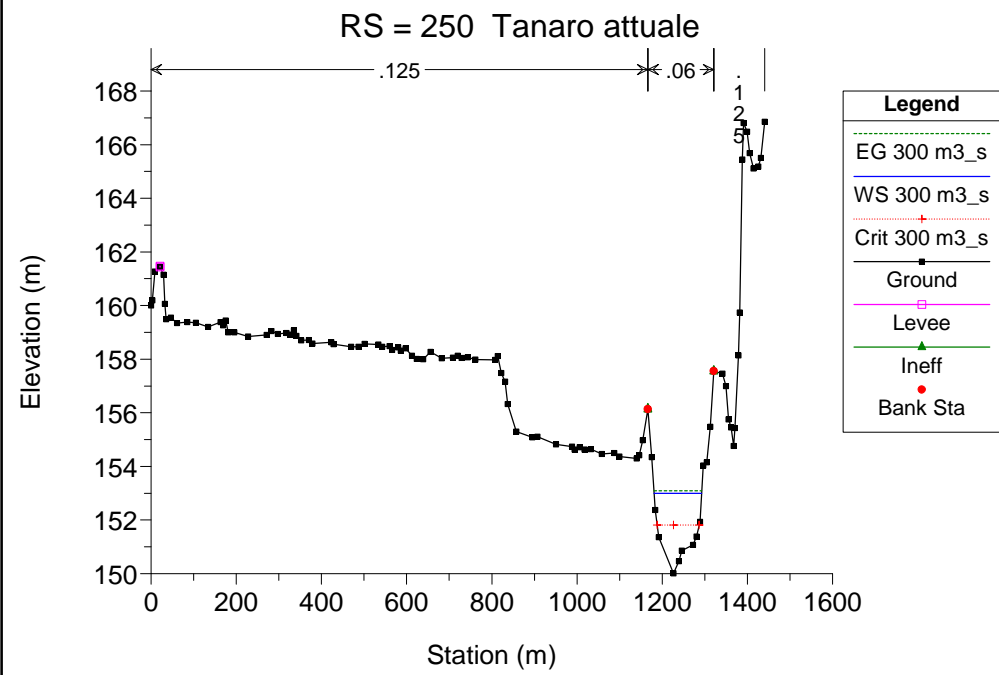
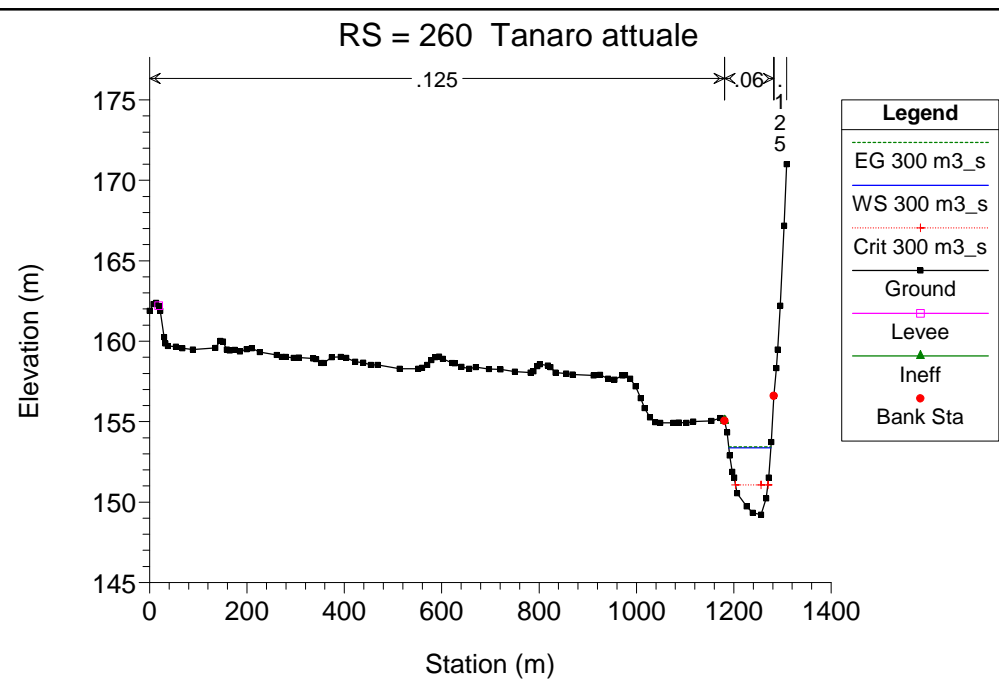
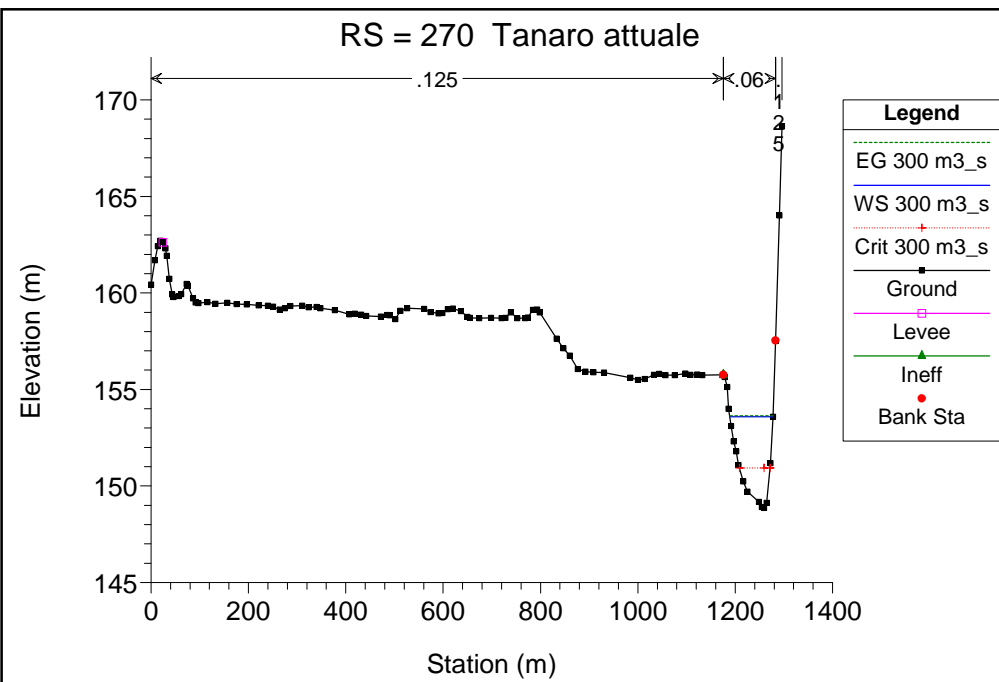


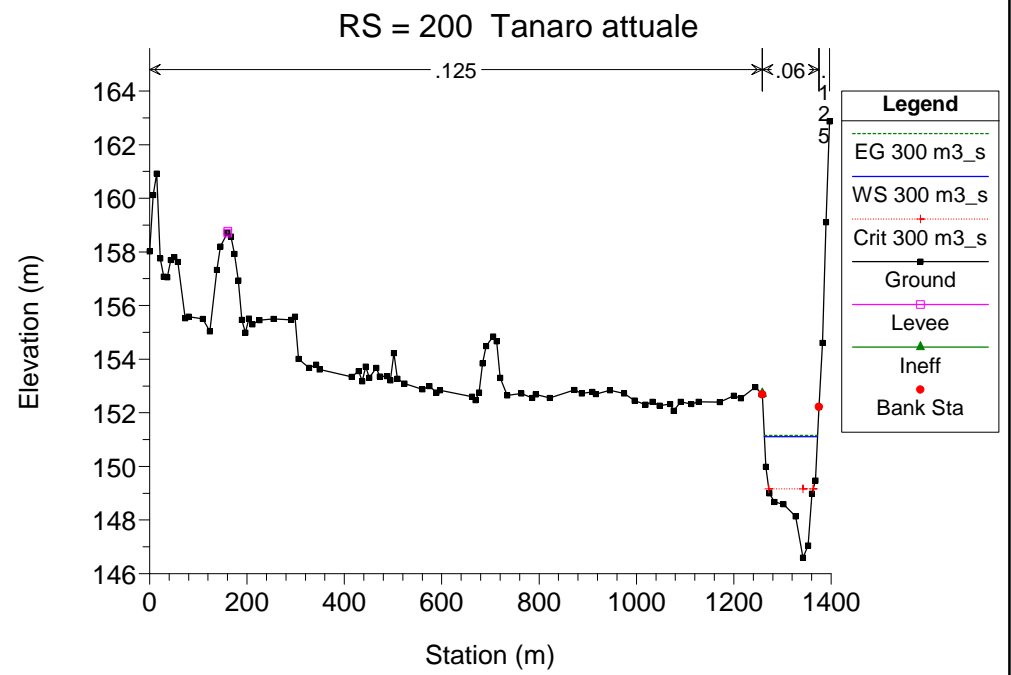
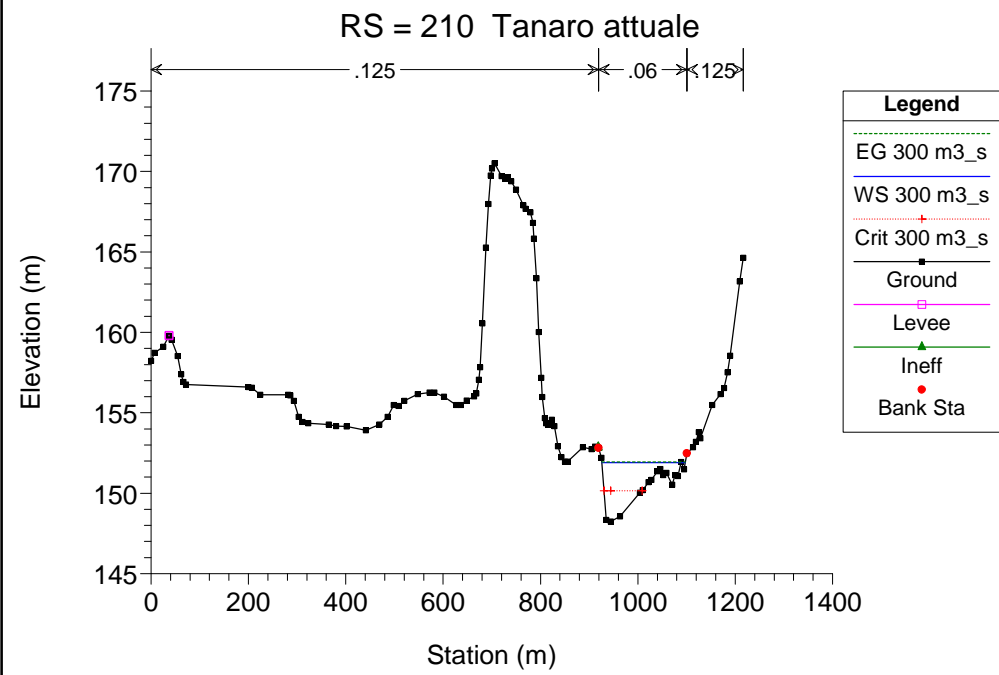
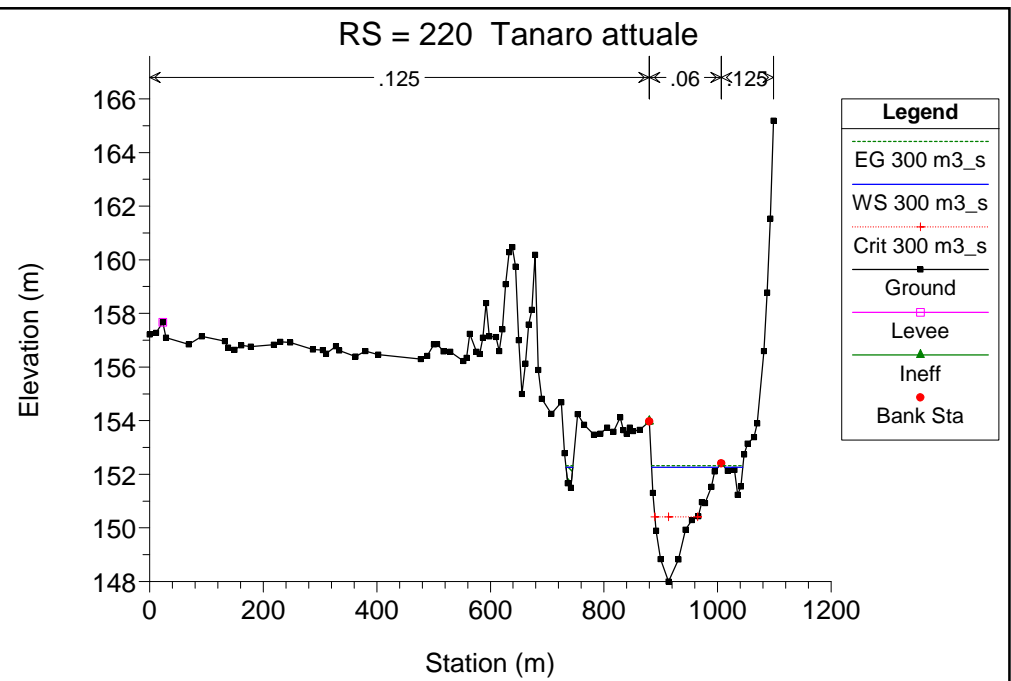
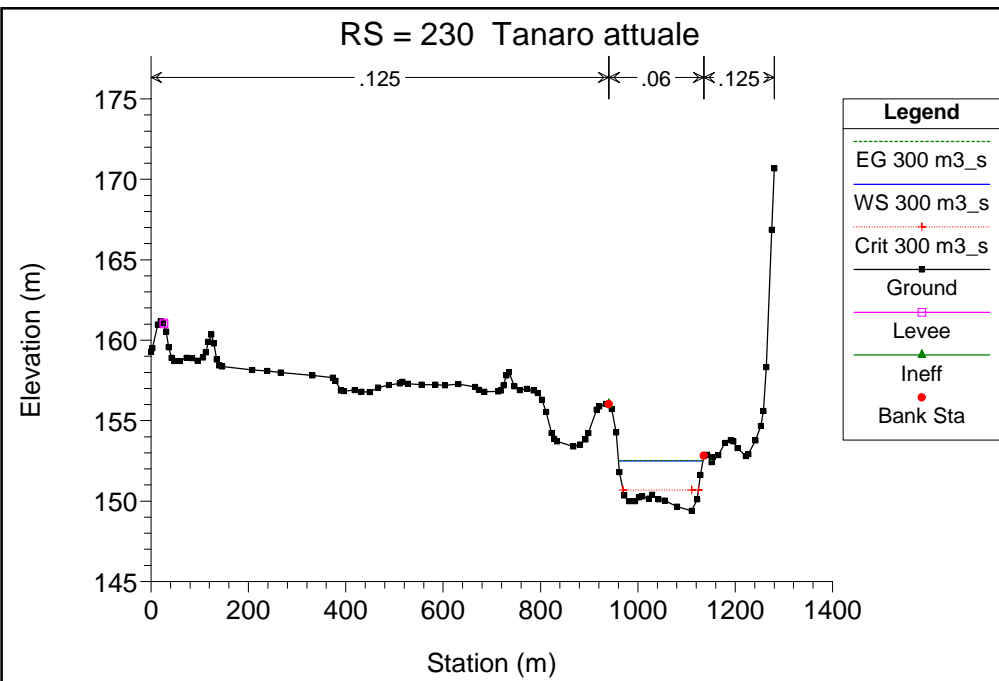


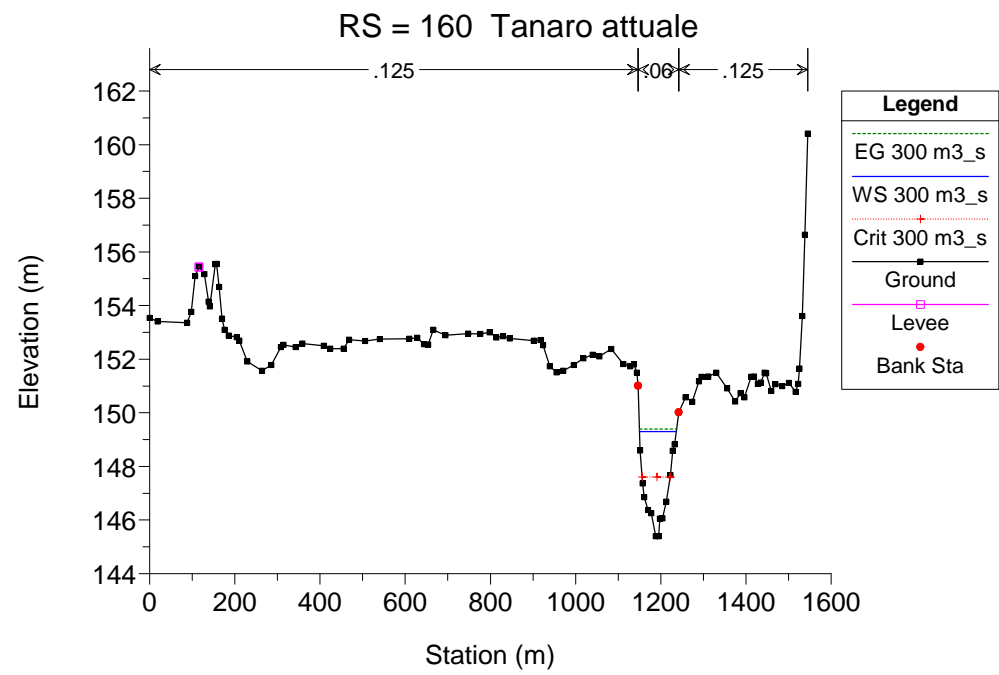
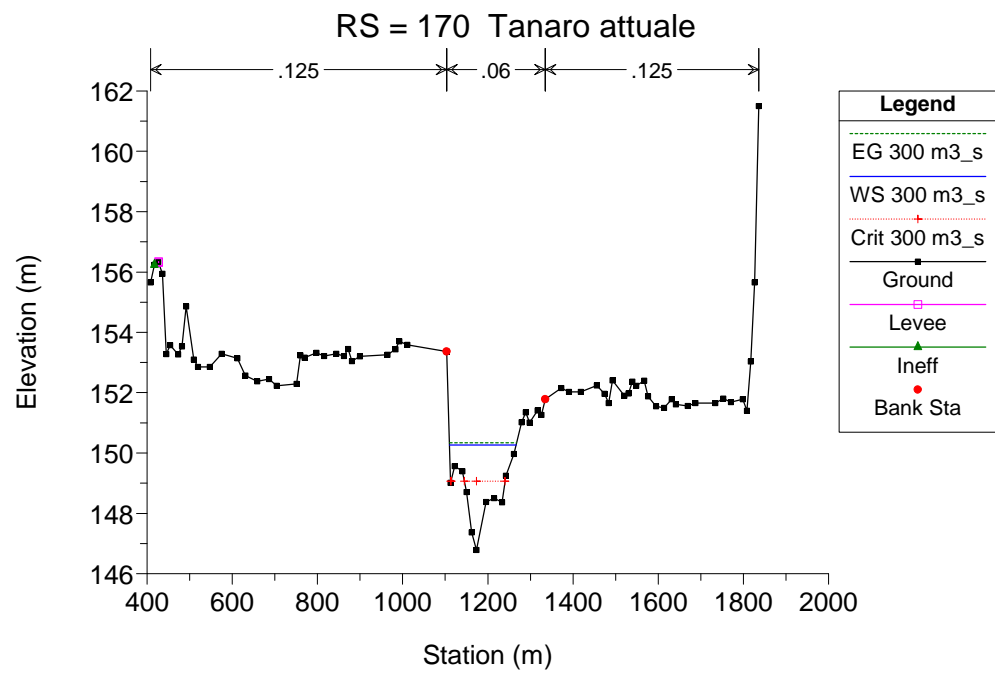
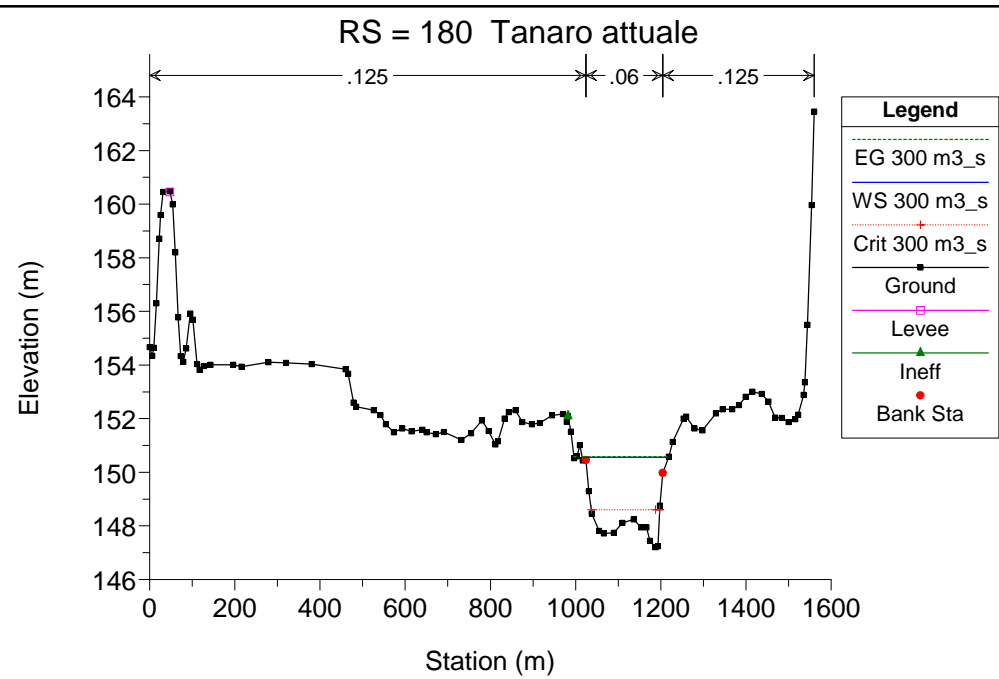
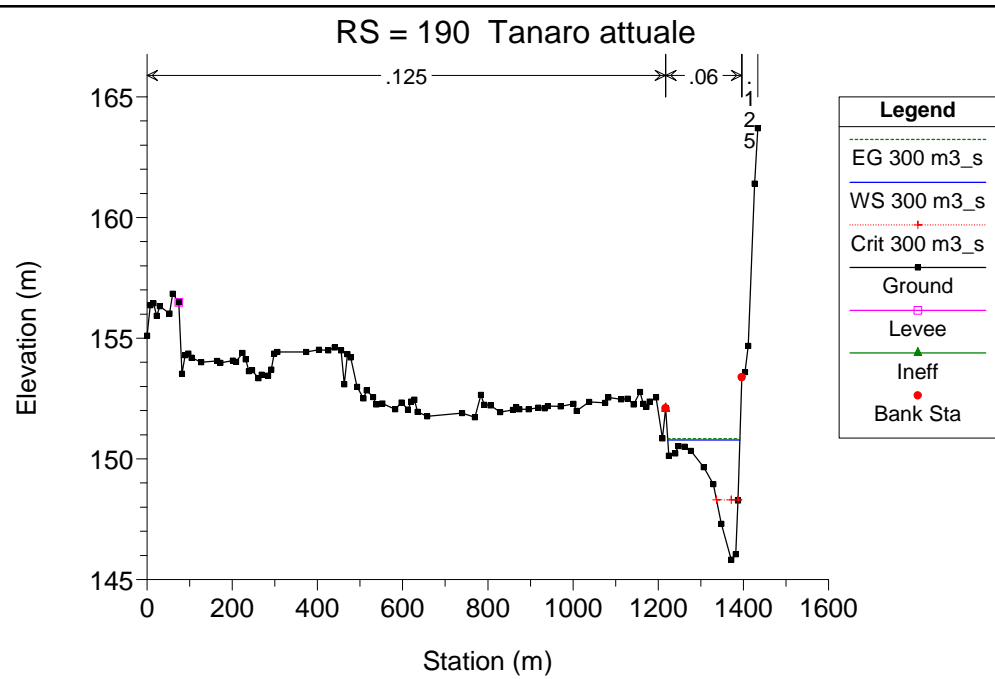


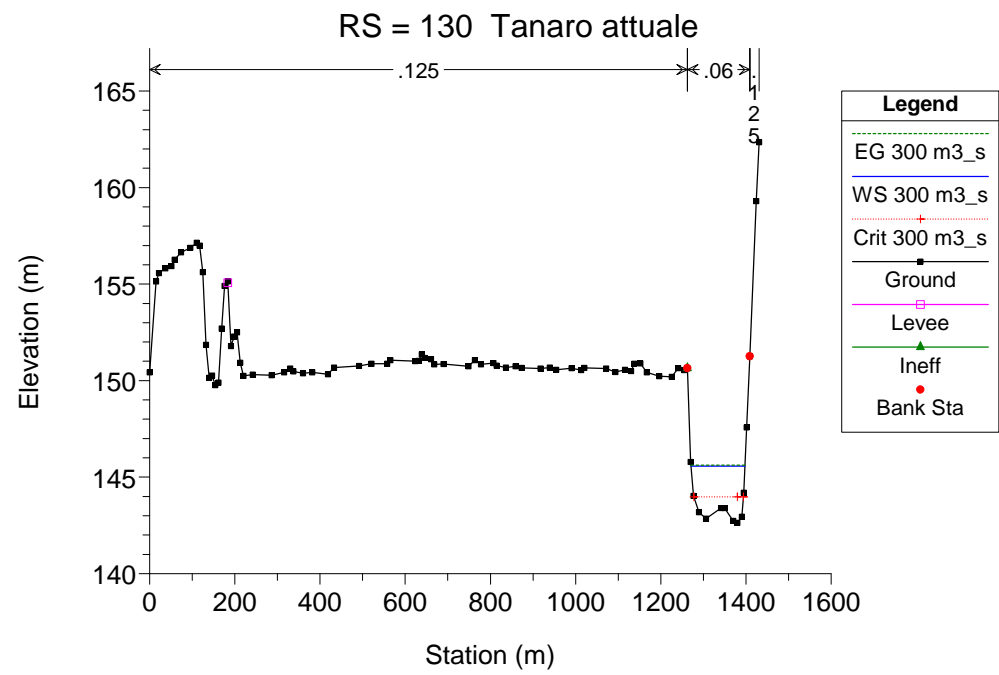
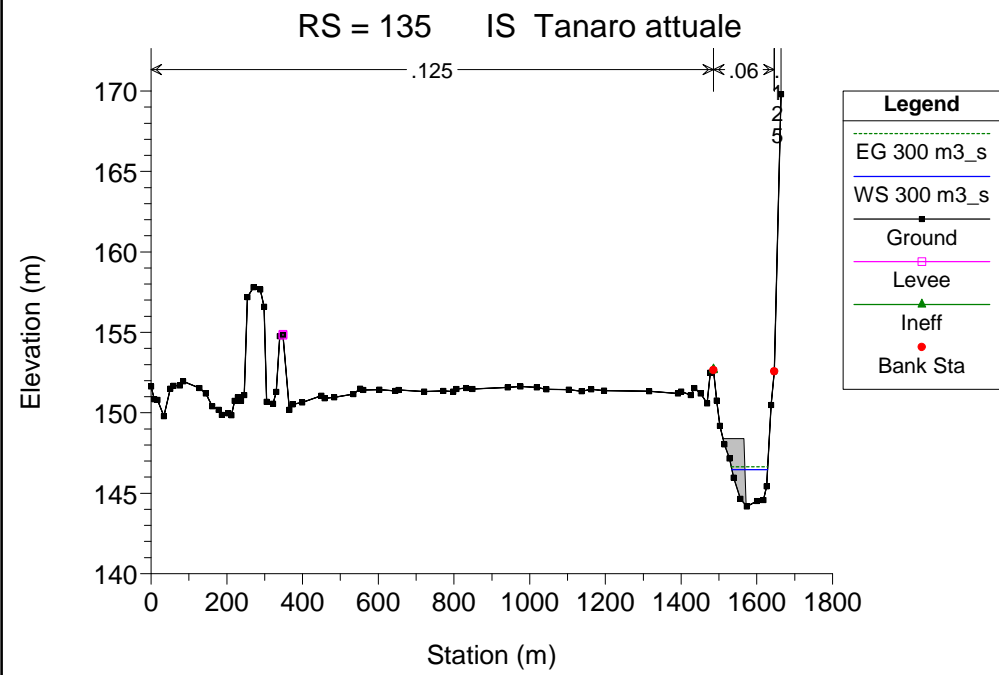
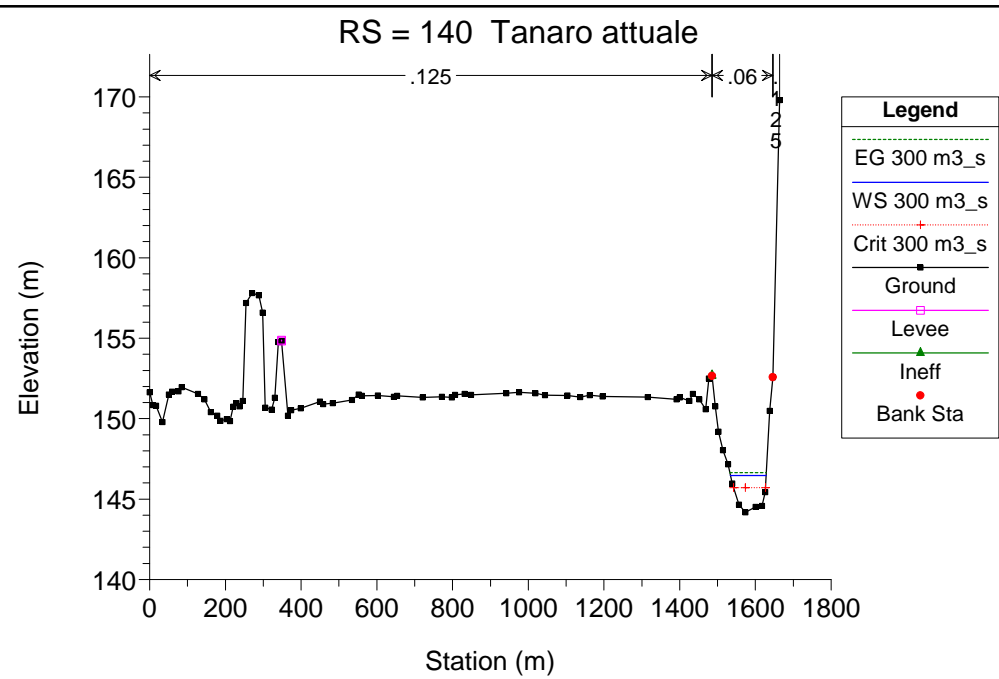
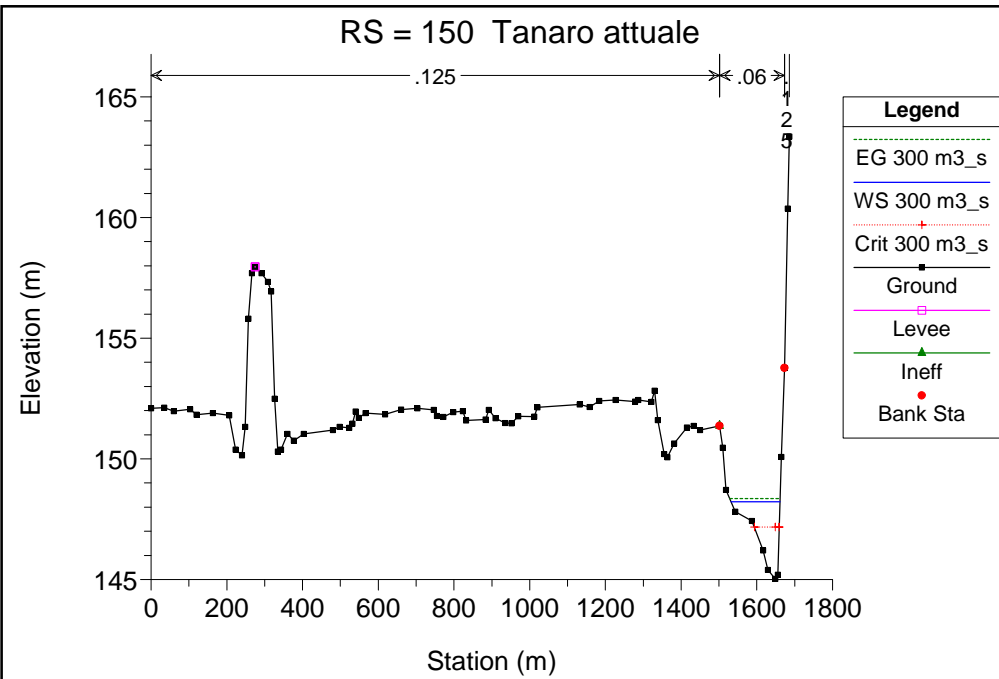


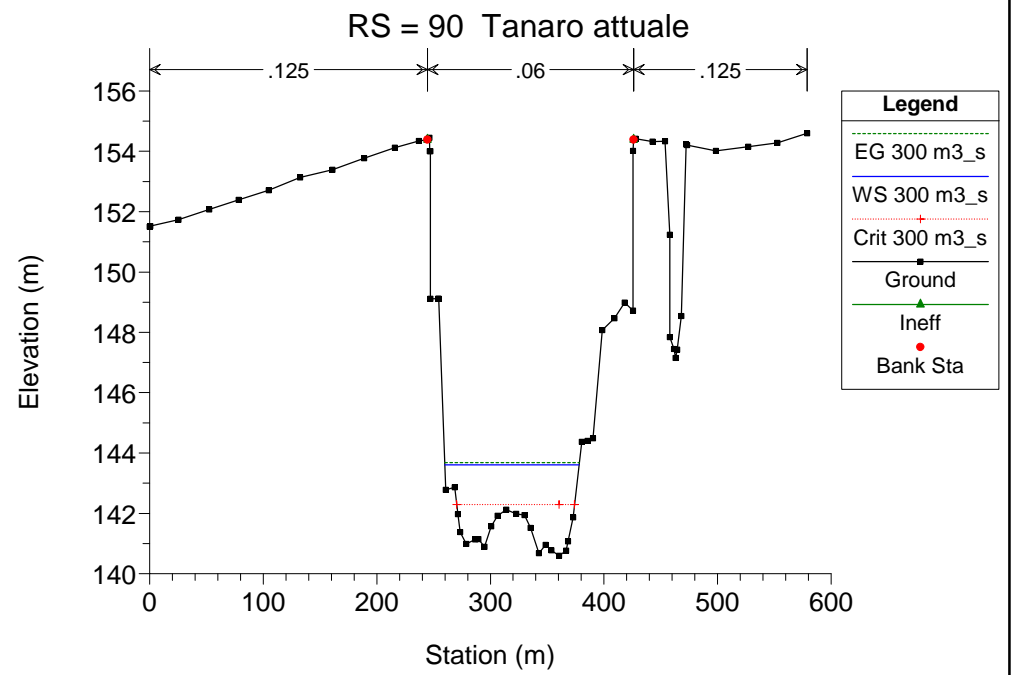
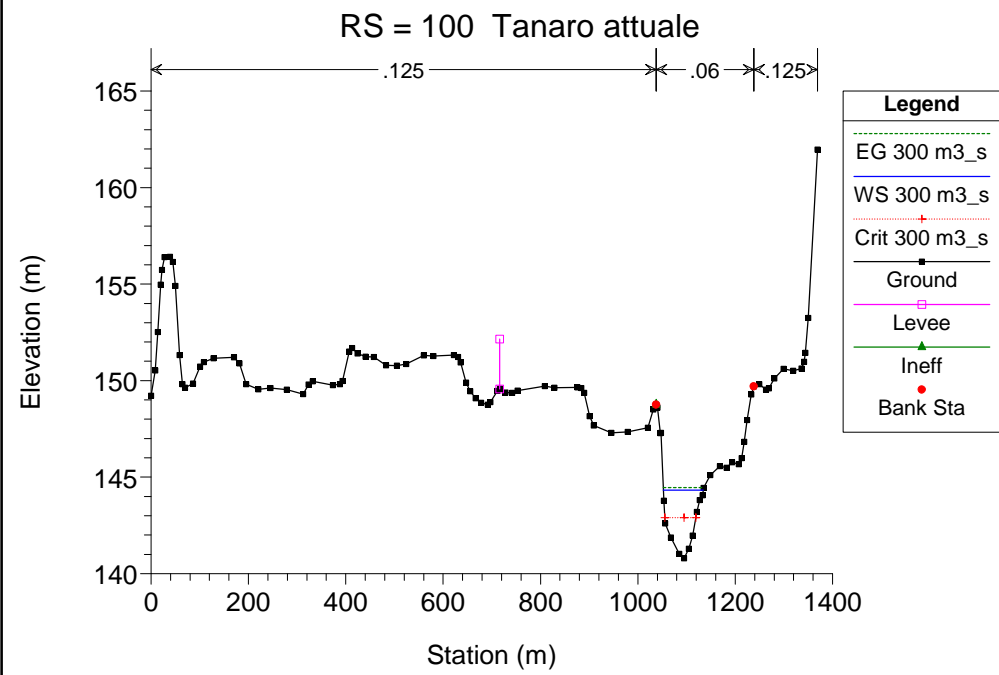
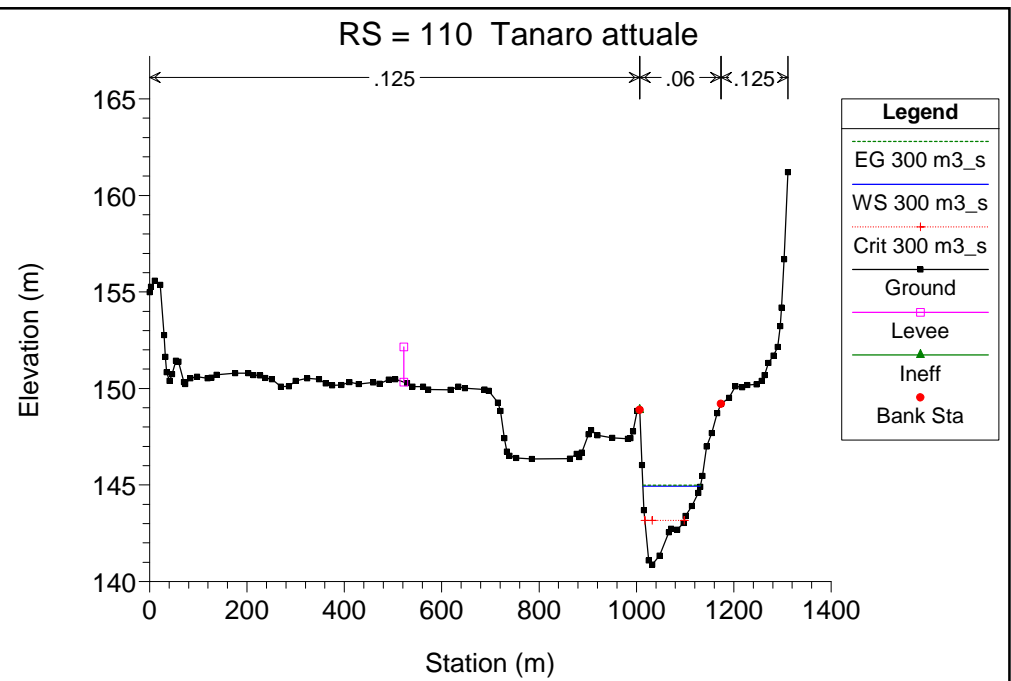
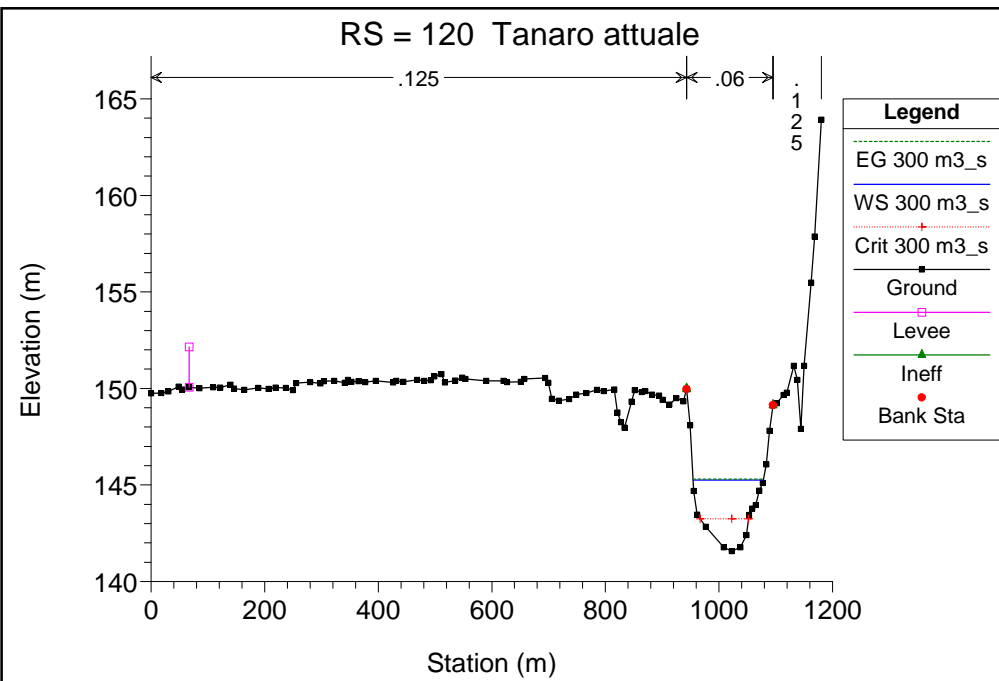


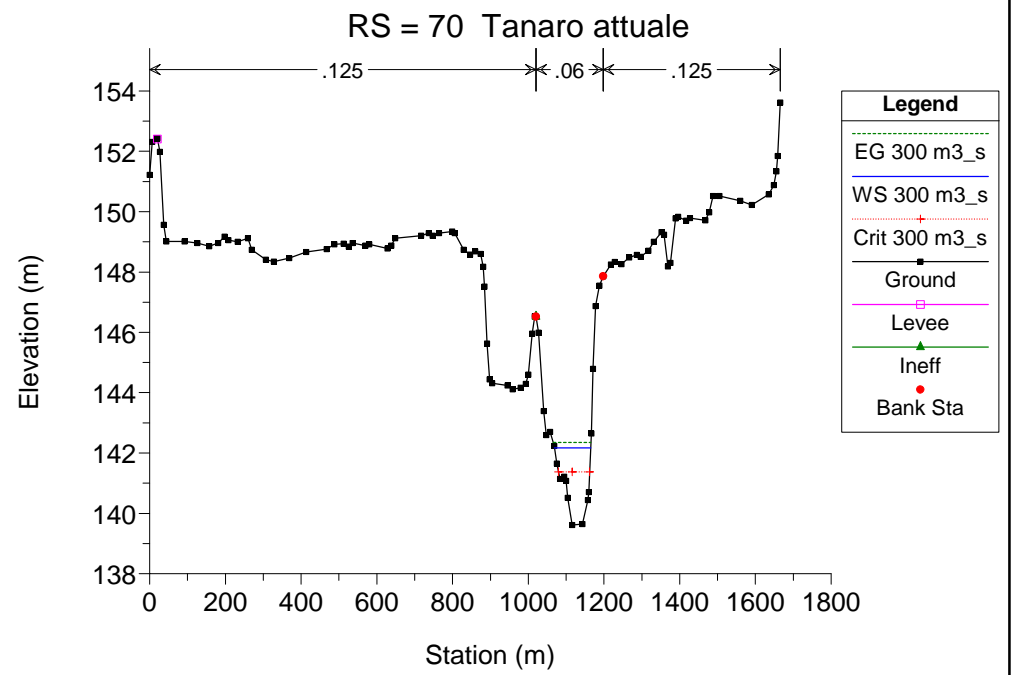
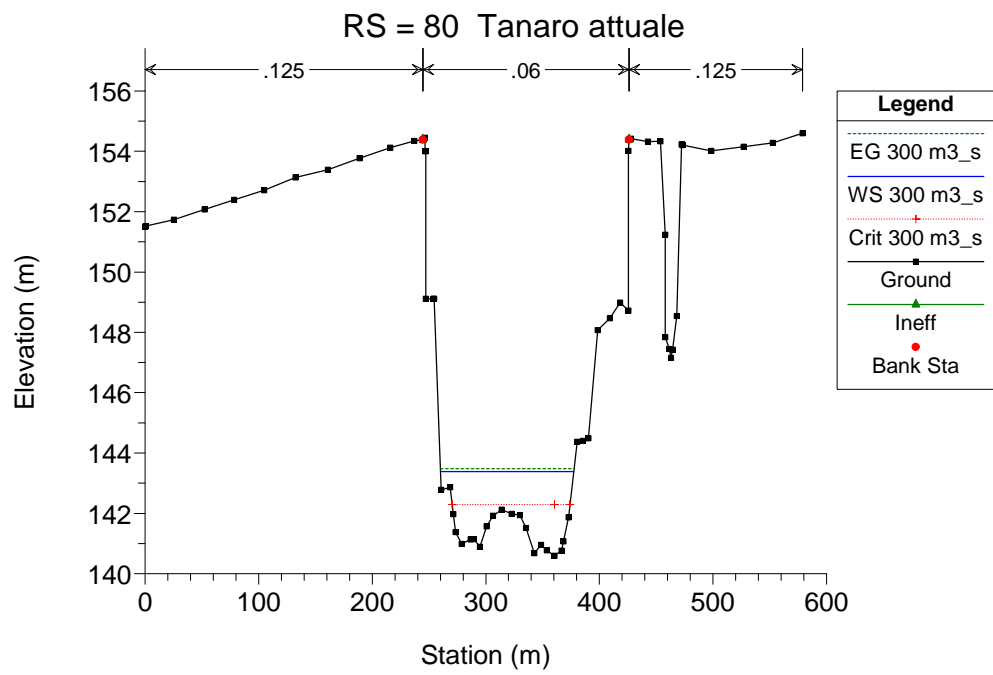
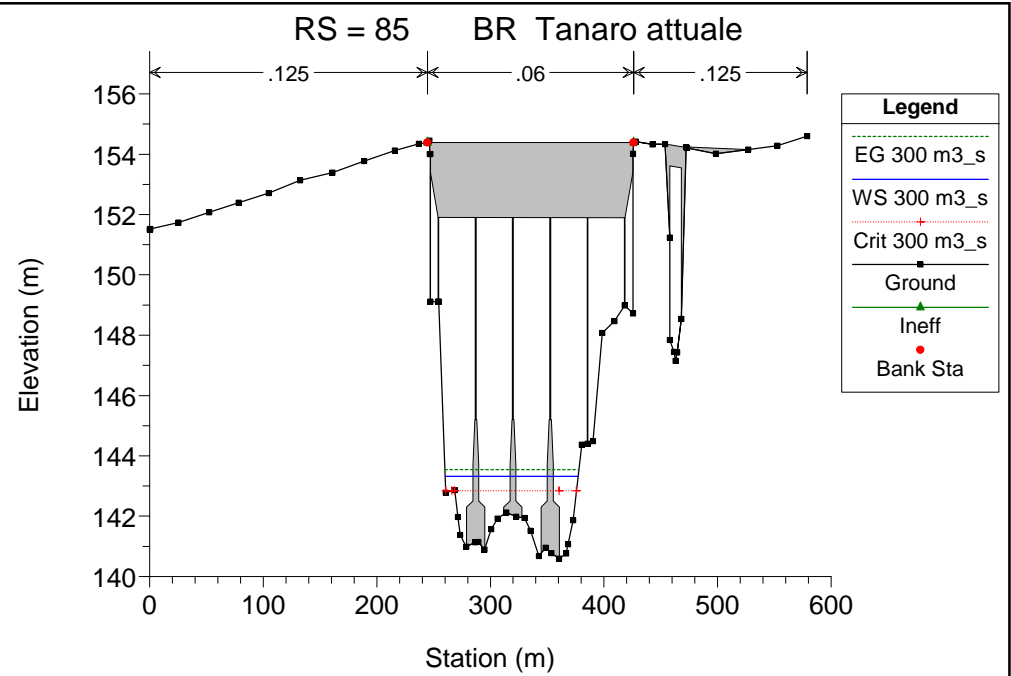
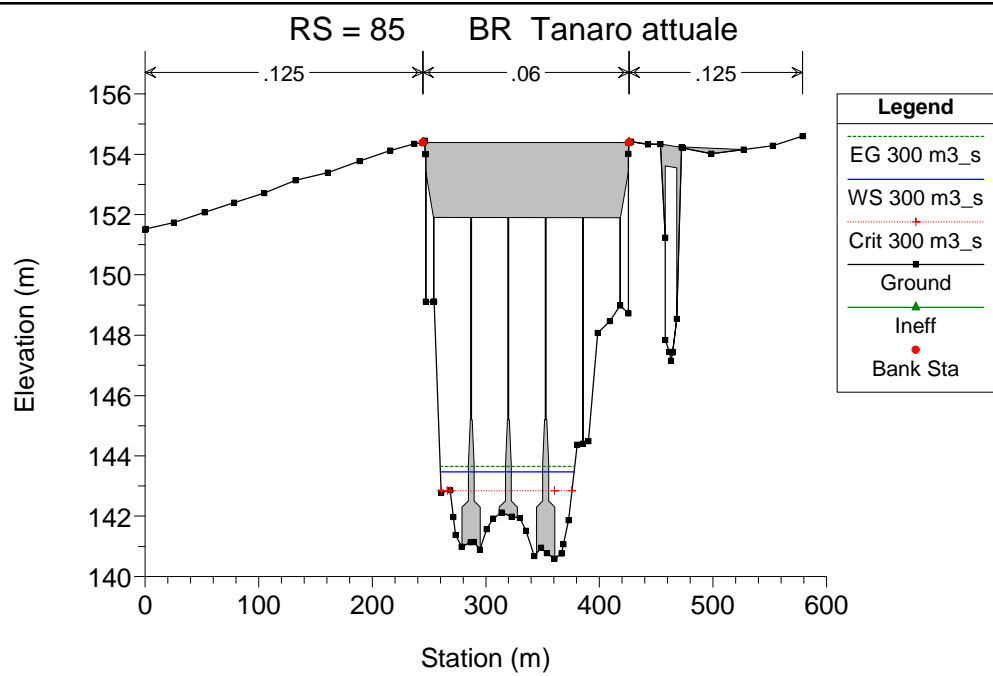


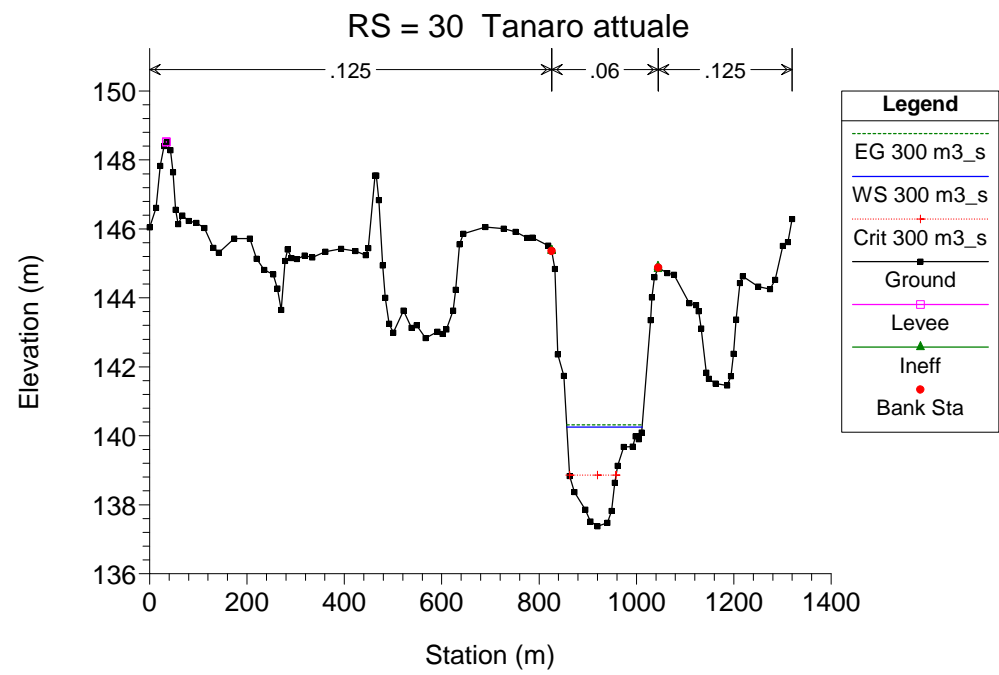
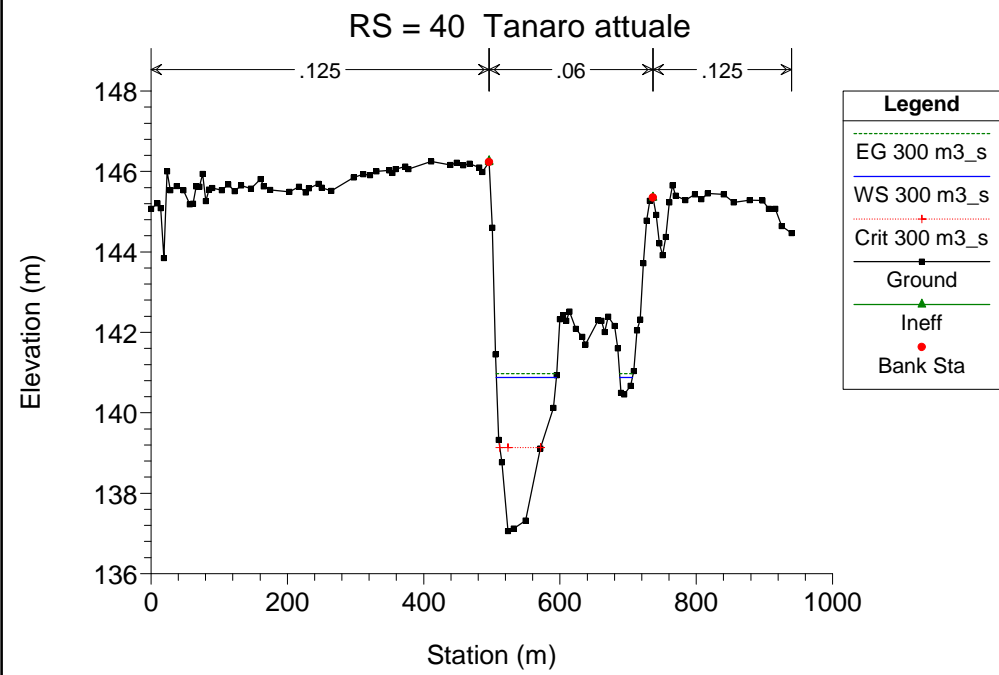
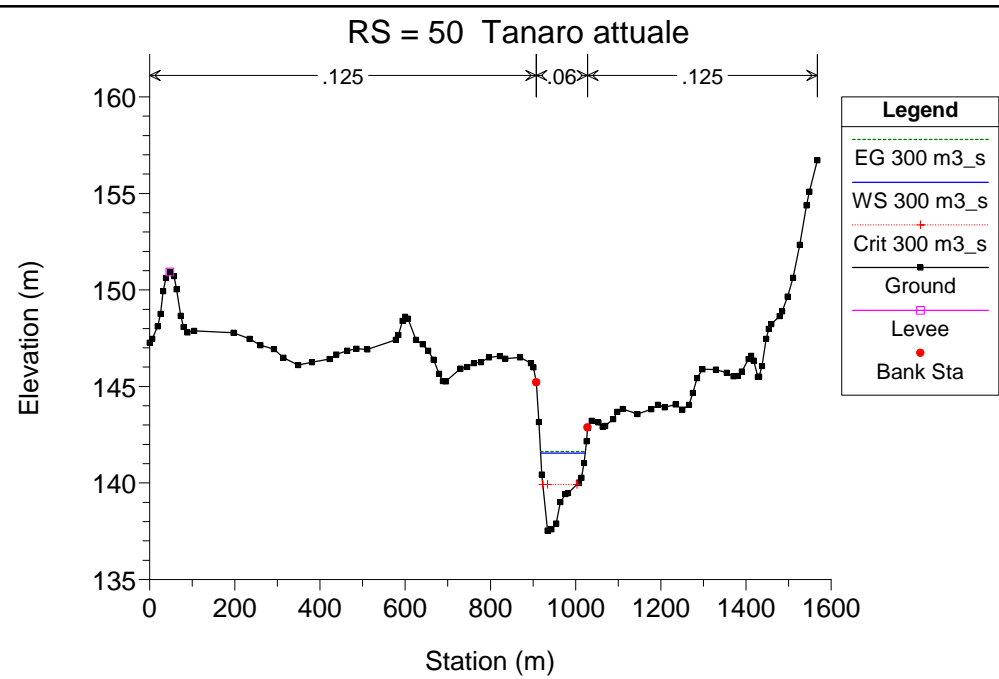
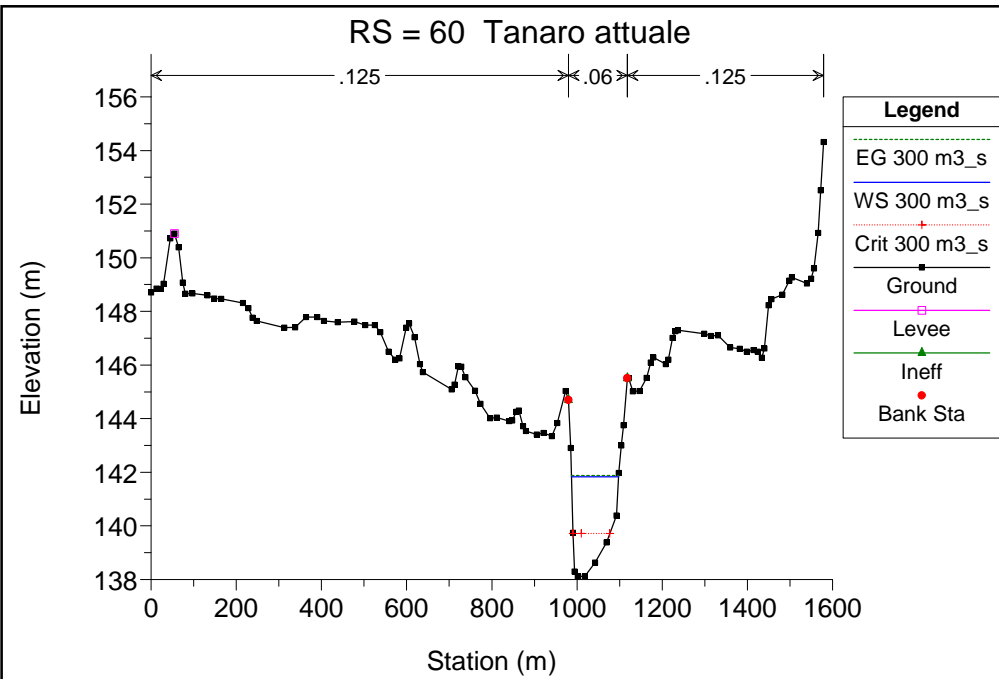


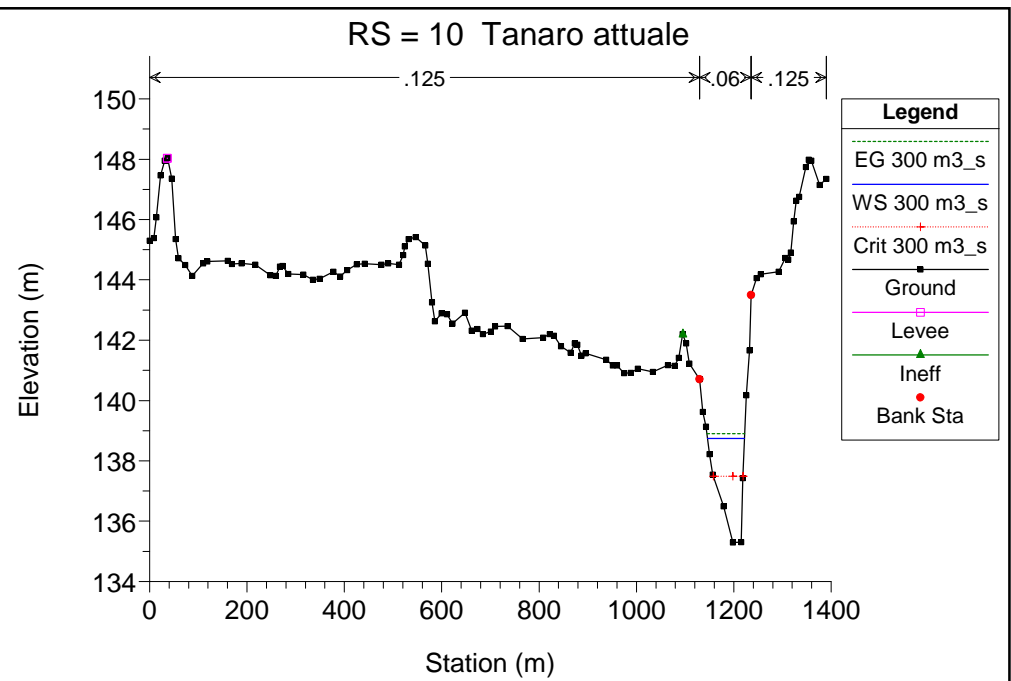
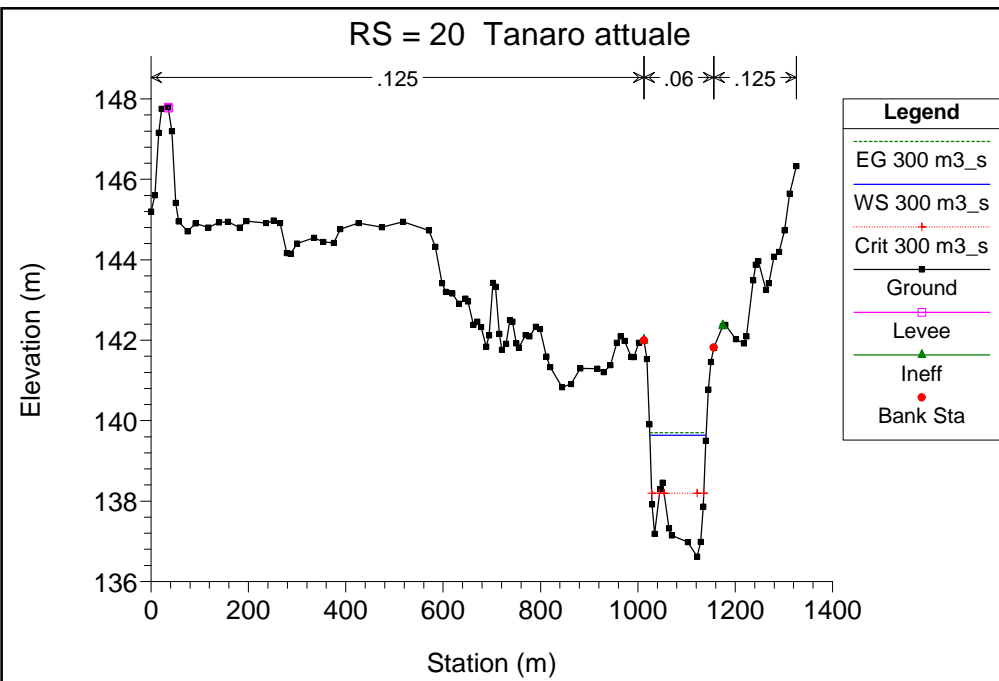












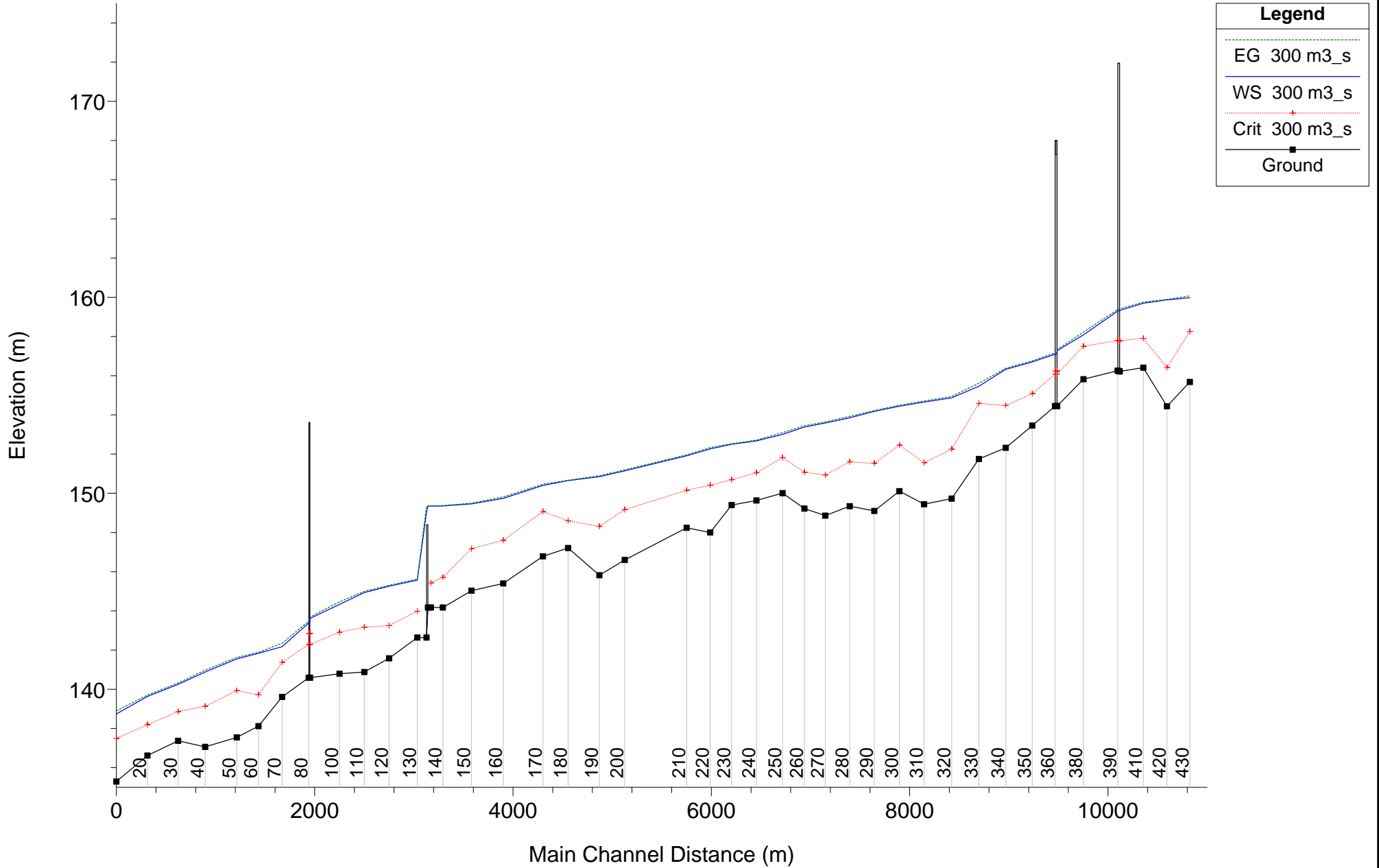
**SITUAZIONE ANTE CROLLO DEL 2010
SIMULAZIONE 14**

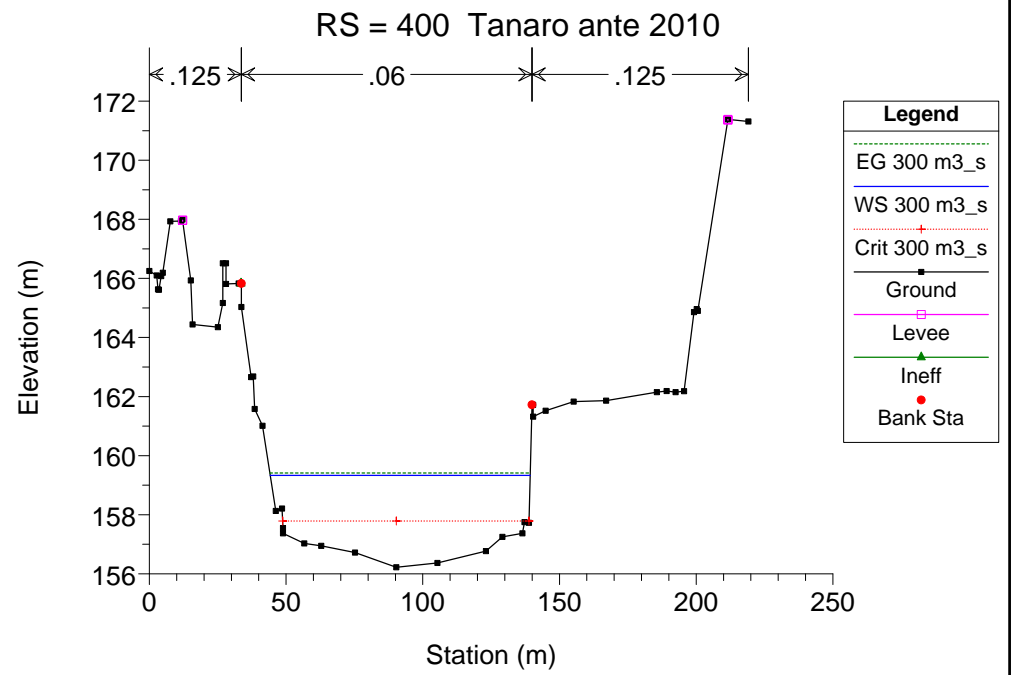
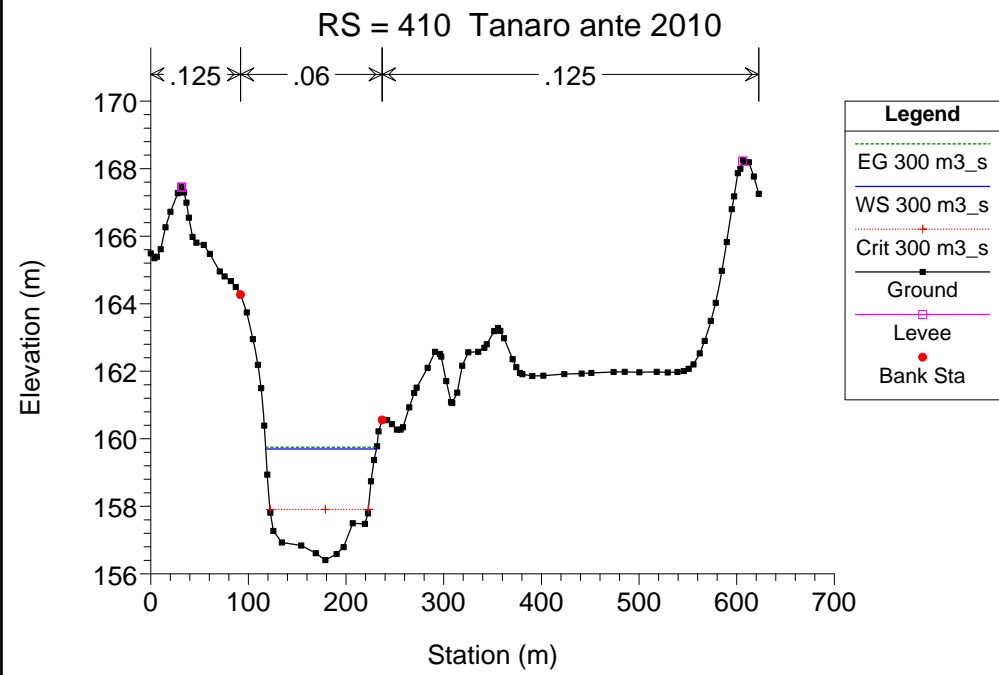
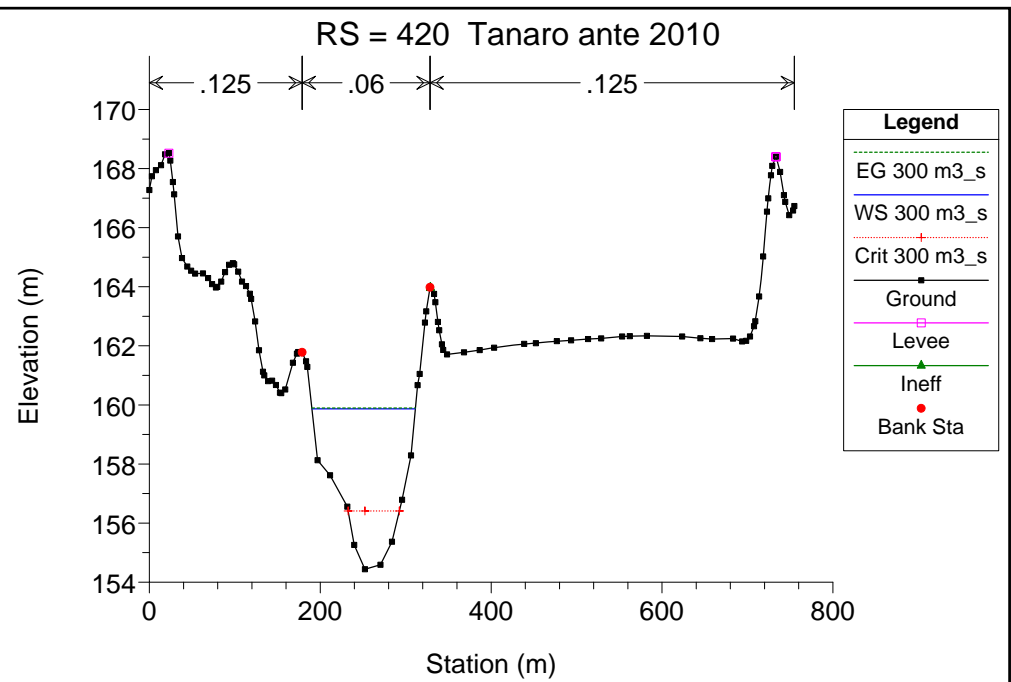
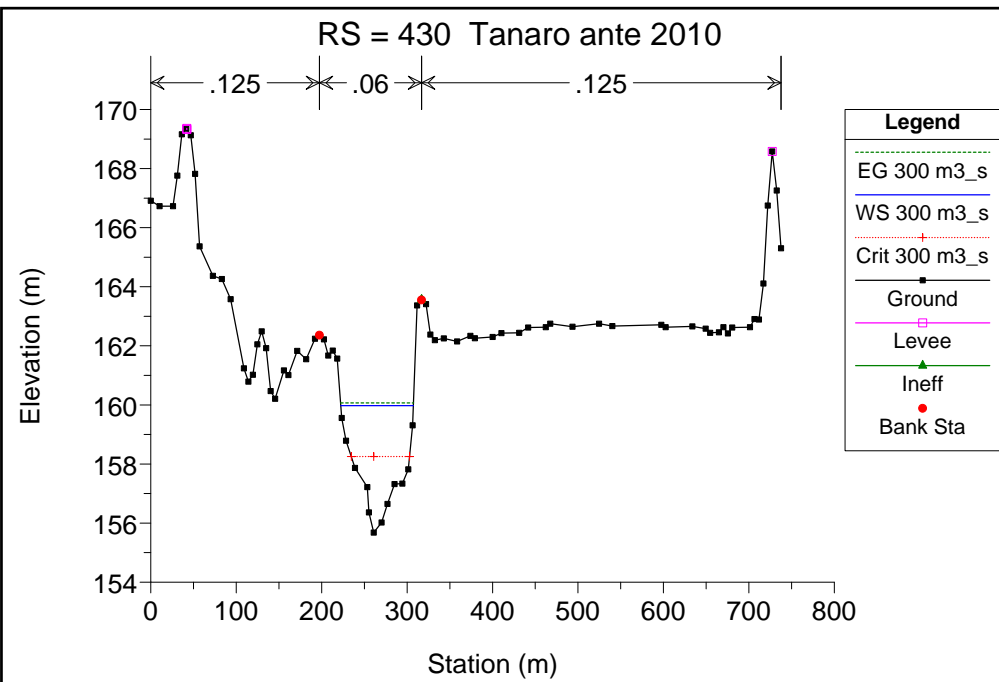
Corso d'acqua	Portata Q m³/s	Portata
Fiume Tanaro	300 (in alveo) 100 (turbinati)	Massima di funzionamento dell'impianto idroelettrico

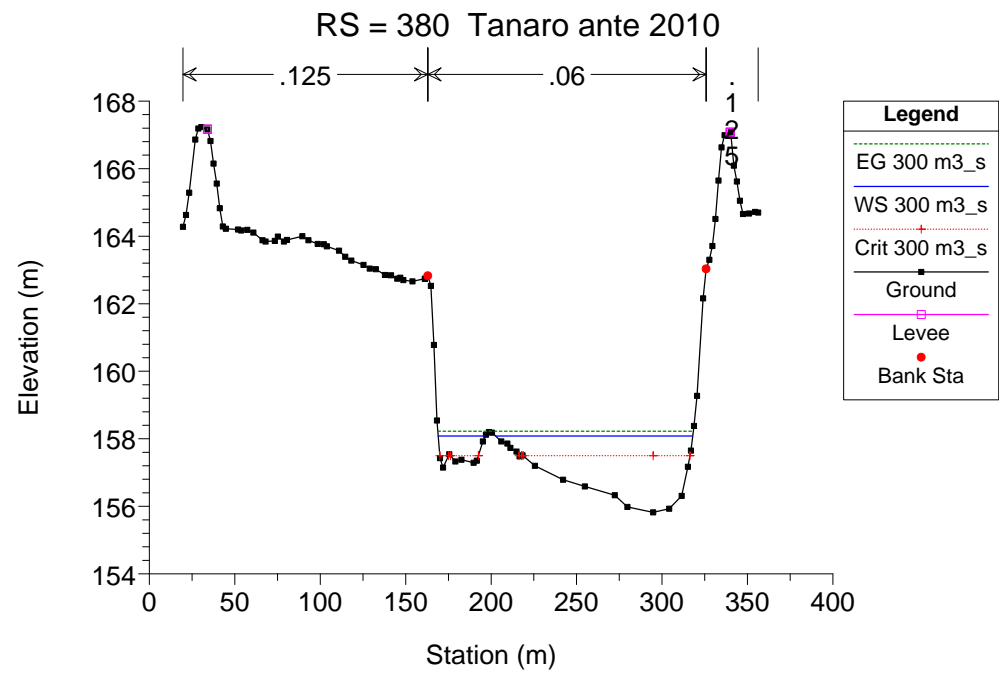
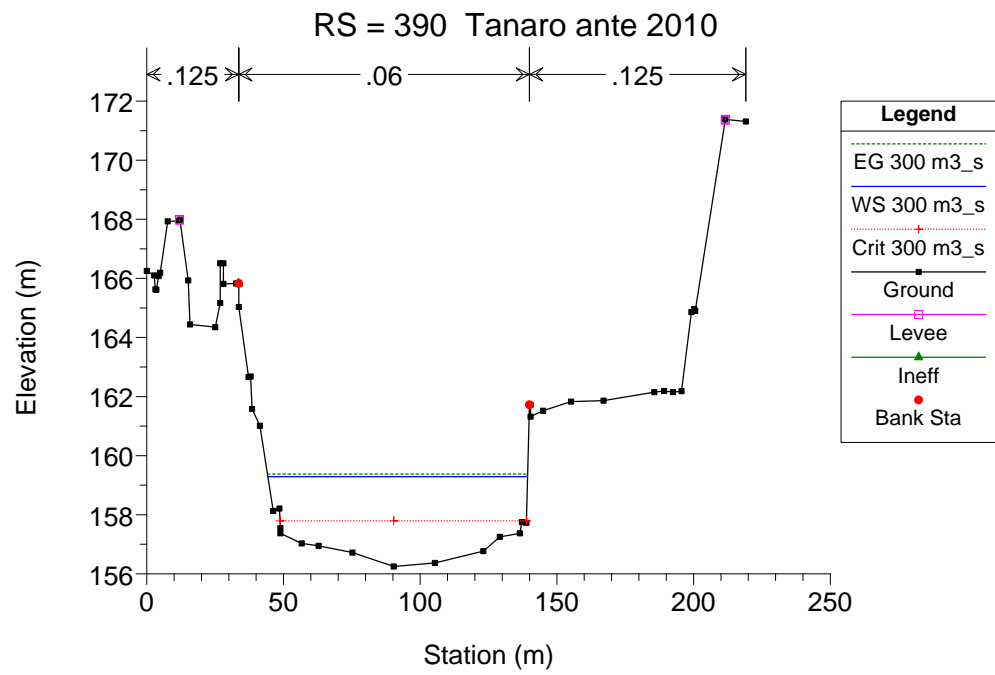
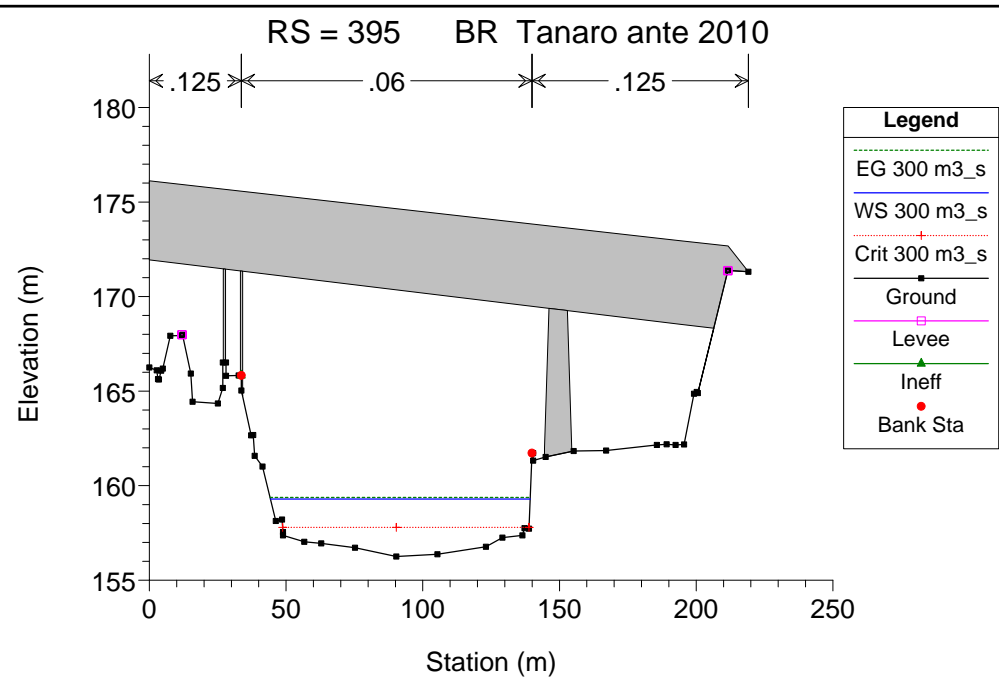
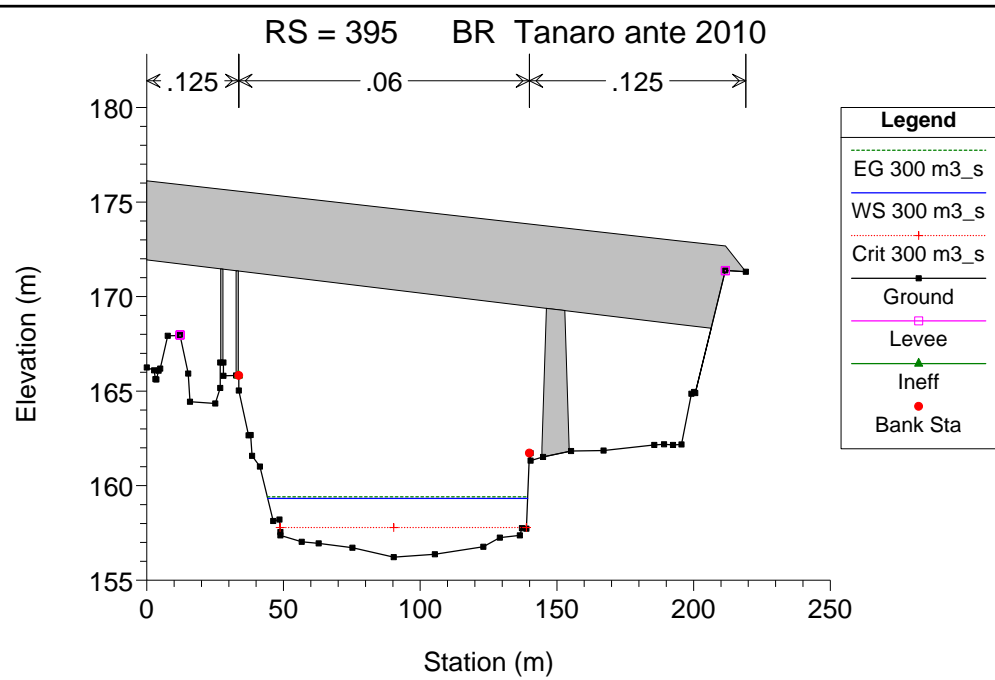
HEC-RAS Plan: Plan 06 River: Tanaro Reach: 1 Profile: 300 m3_s (Continued)

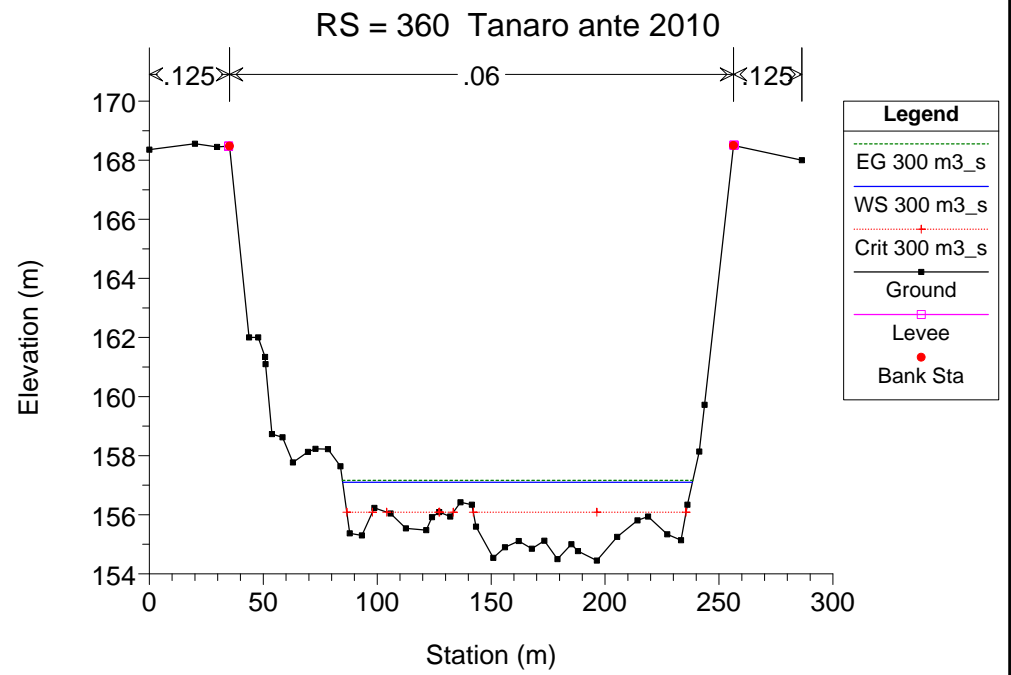
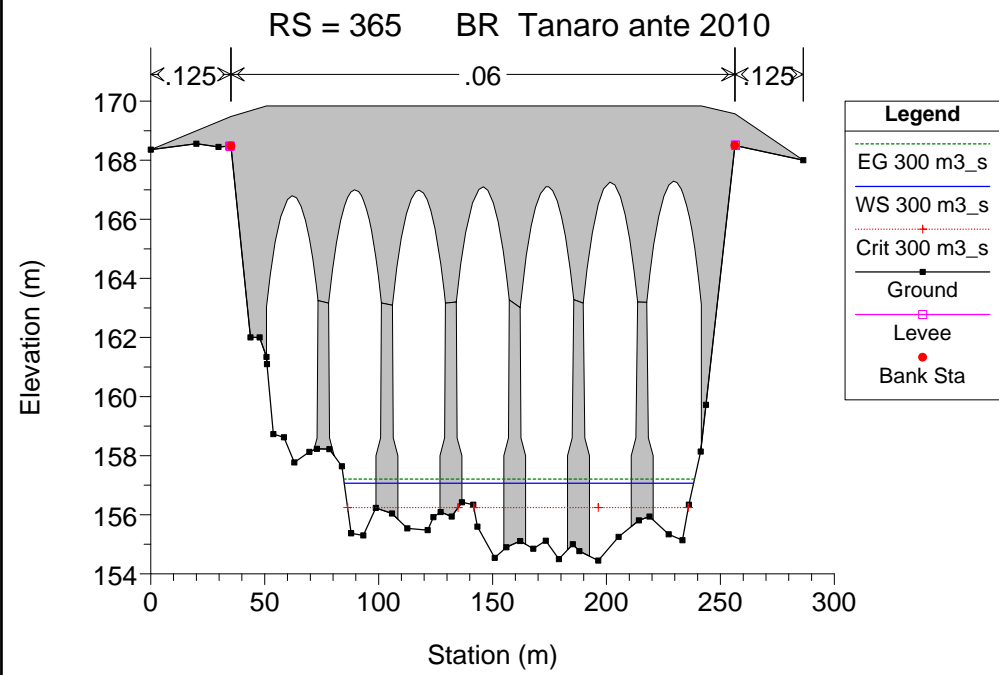
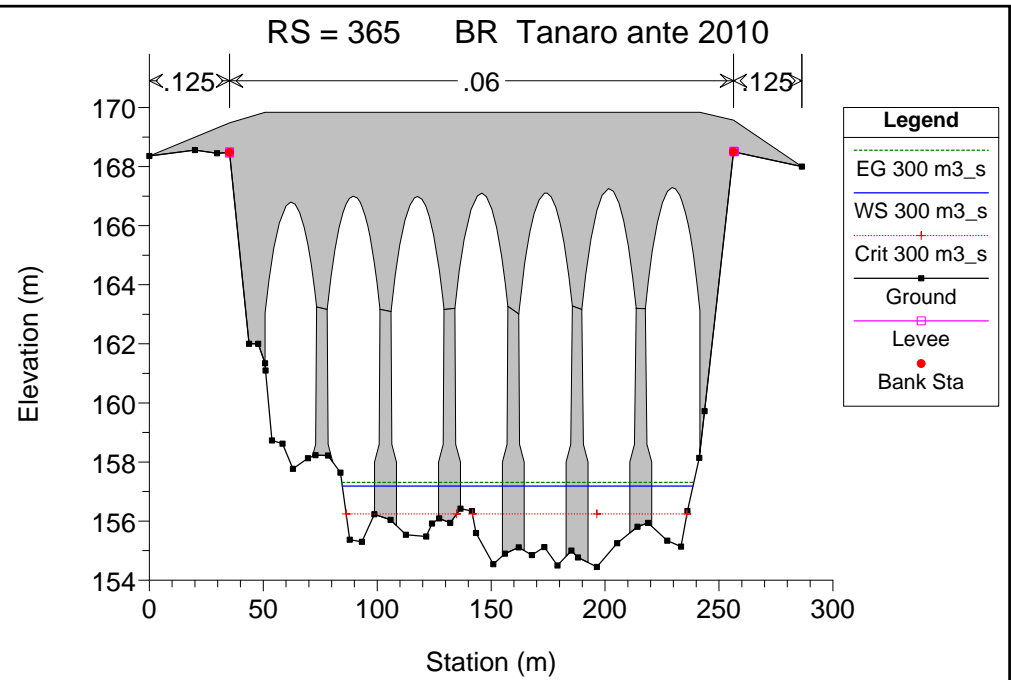
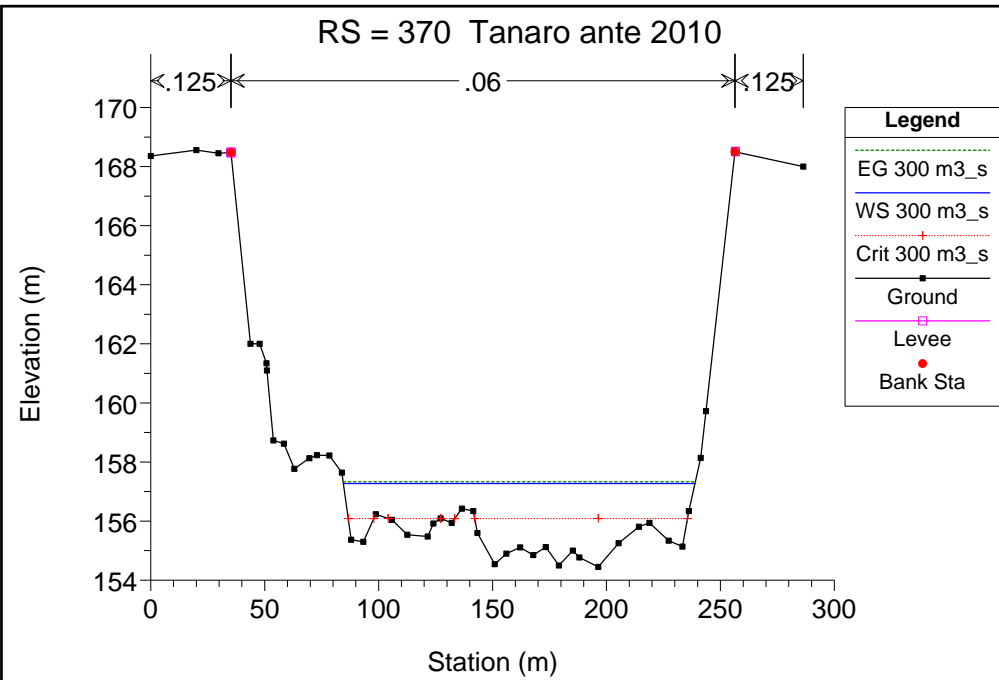
Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
1	80	300 m3_s	300.00	140.59	143.38	142.29	143.48	0.002975	1.37	218.89	117.25	0.32
1	70	300 m3_s	300.00	139.61	142.17	141.37	142.35	0.006051	1.84	162.81	95.73	0.45
1	60	300 m3_s	300.00	138.12	141.84	139.71	141.88	0.000849	0.96	312.09	110.96	0.18
1	50	300 m3_s	300.00	137.54	141.55	139.93	141.62	0.001712	1.21	246.99	104.93	0.25
1	40	300 m3_s	300.00	137.06	140.88	139.13	140.97	0.002465	1.35	222.83	106.64	0.30
1	30	300 m3_s	300.00	137.37	140.25	138.86	140.32	0.002277	1.13	264.36	154.78	0.28
1	20	300 m3_s	300.00	136.62	139.63	138.19	139.70	0.001753	1.18	254.96	115.63	0.25
1	10	300 m3_s	300.00	135.29	138.74	137.49	138.90	0.004001	1.78	168.56	75.91	0.38

Tanaro ante 2010

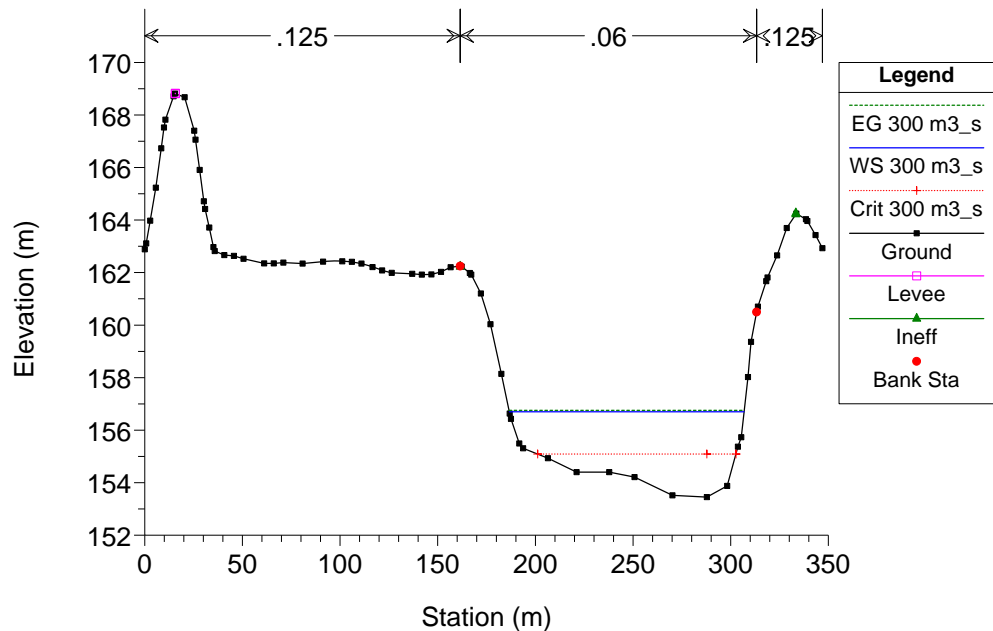




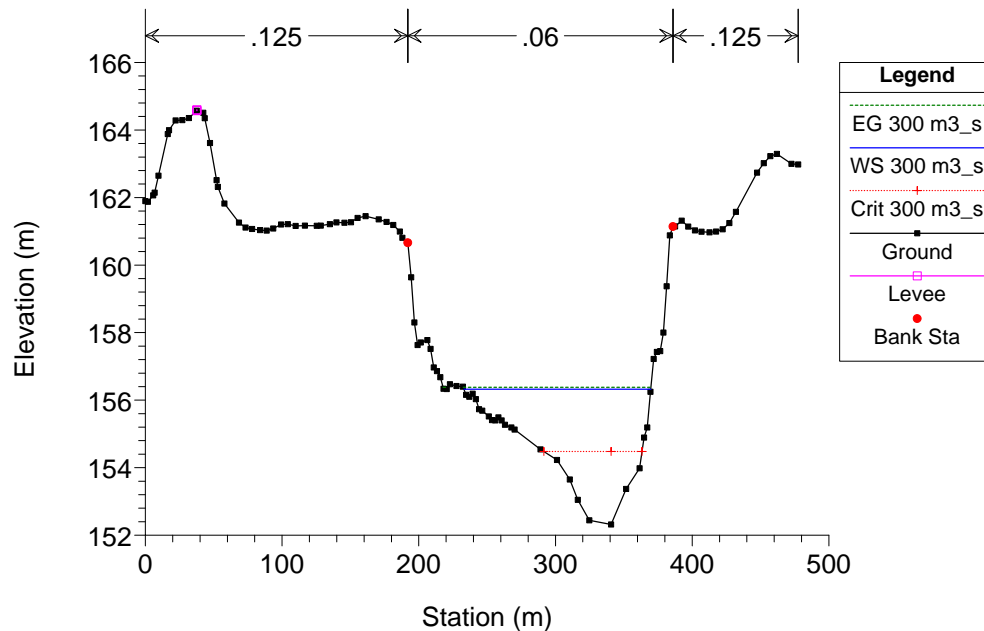




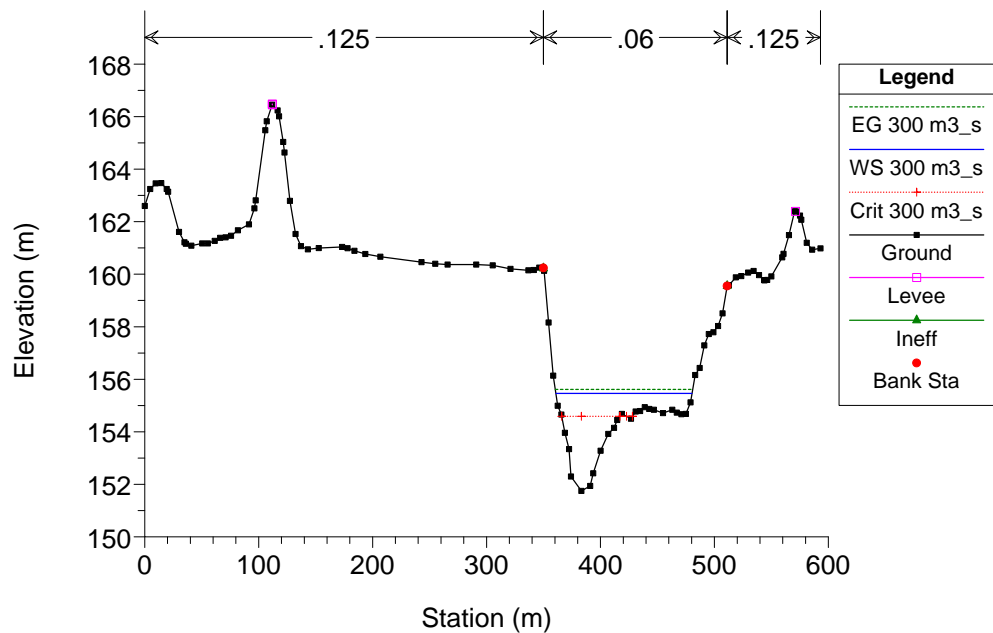
RS = 350 Tanaro ante 2010



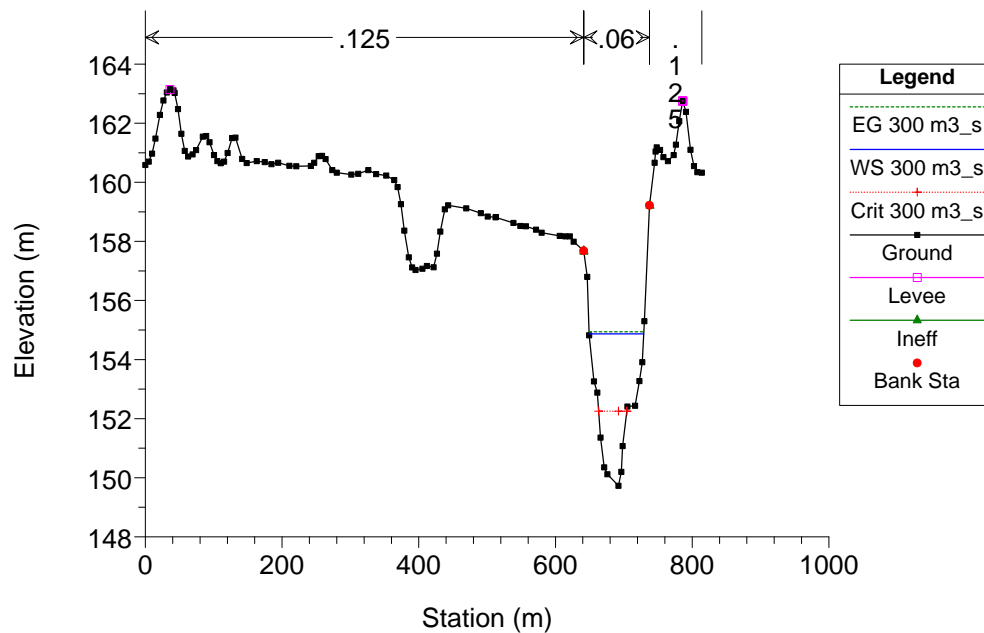
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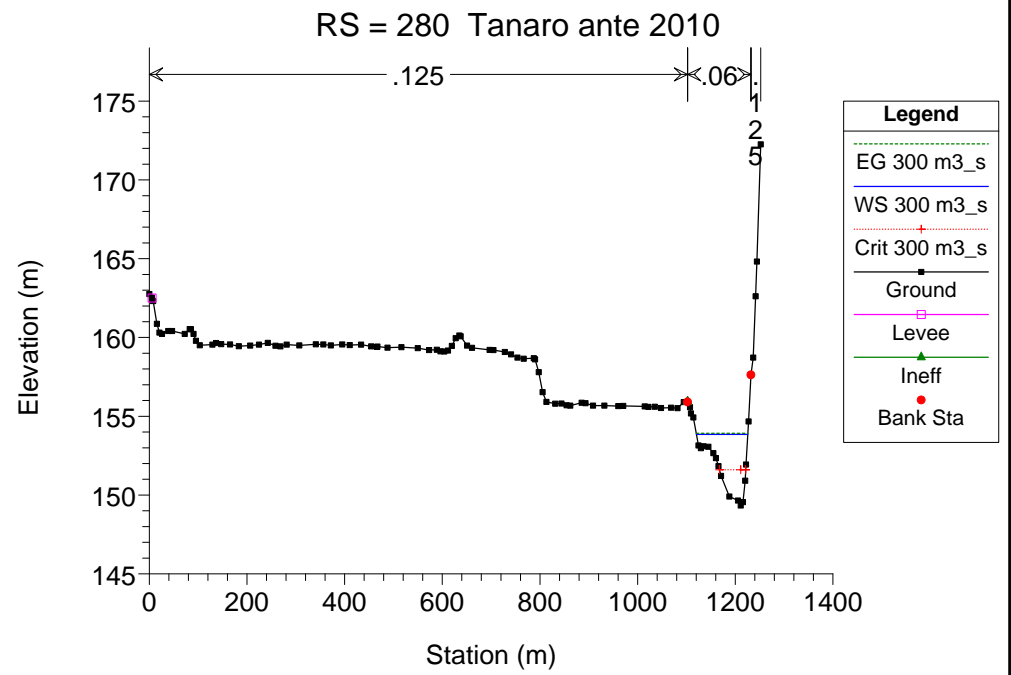
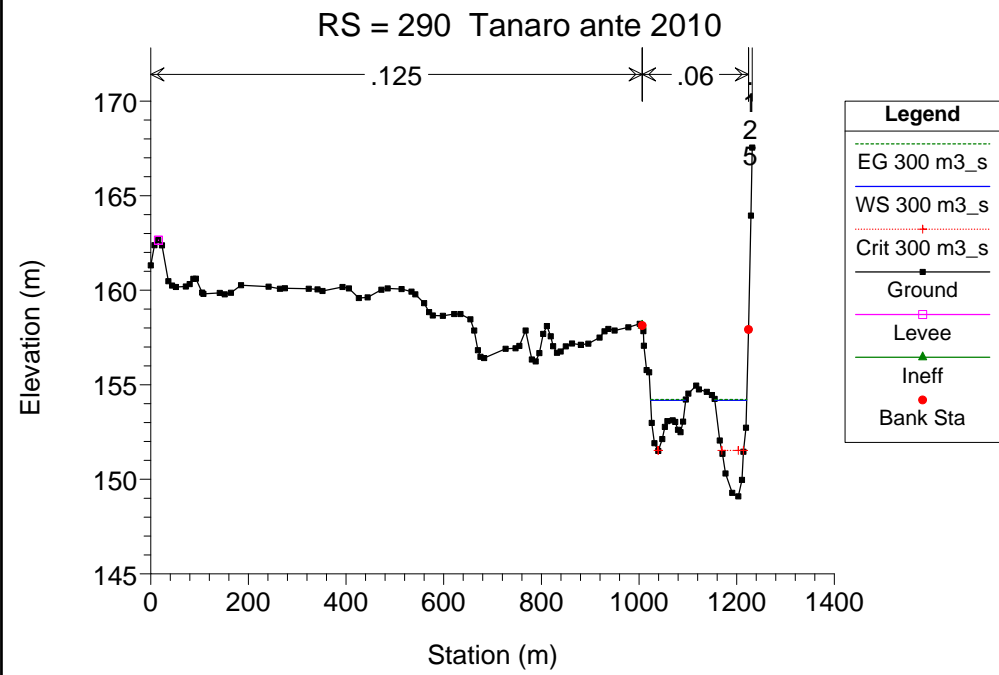
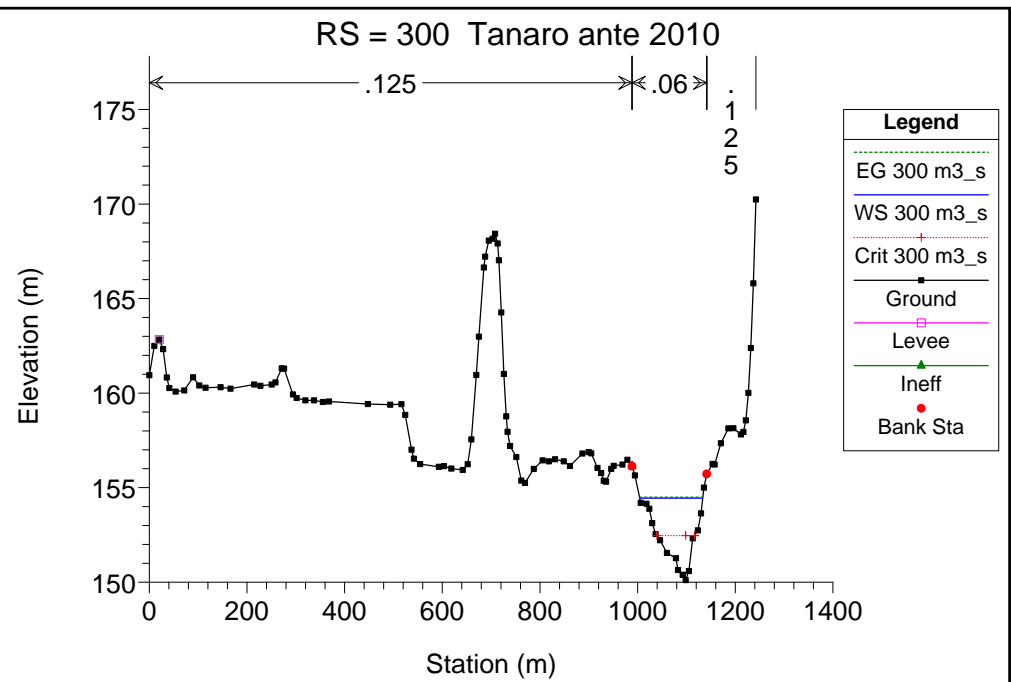
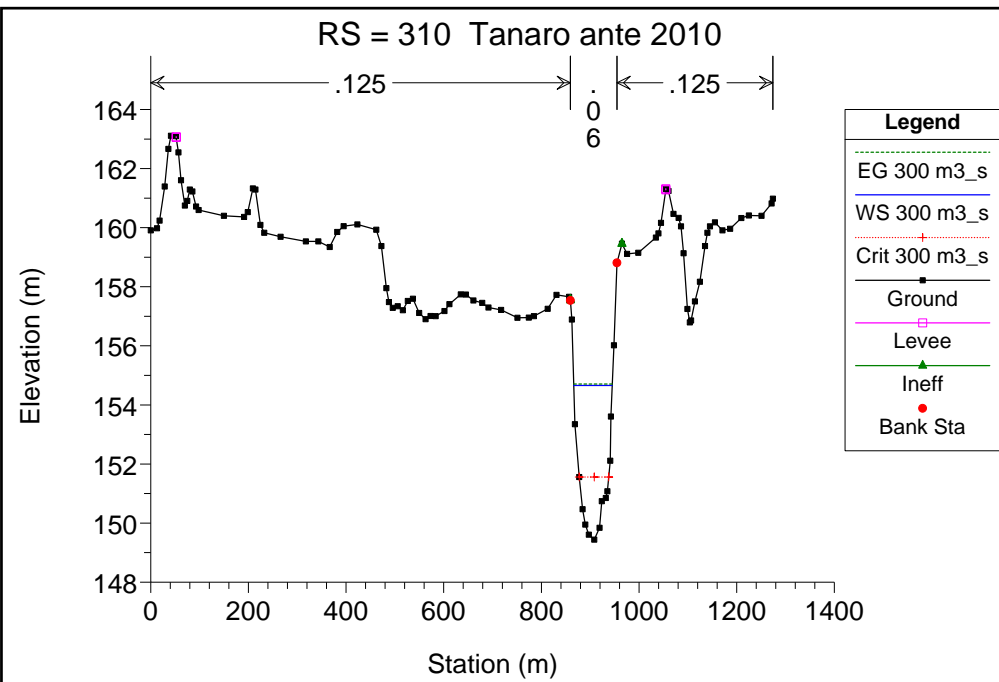


RS = 330 Tanaro ante 2010

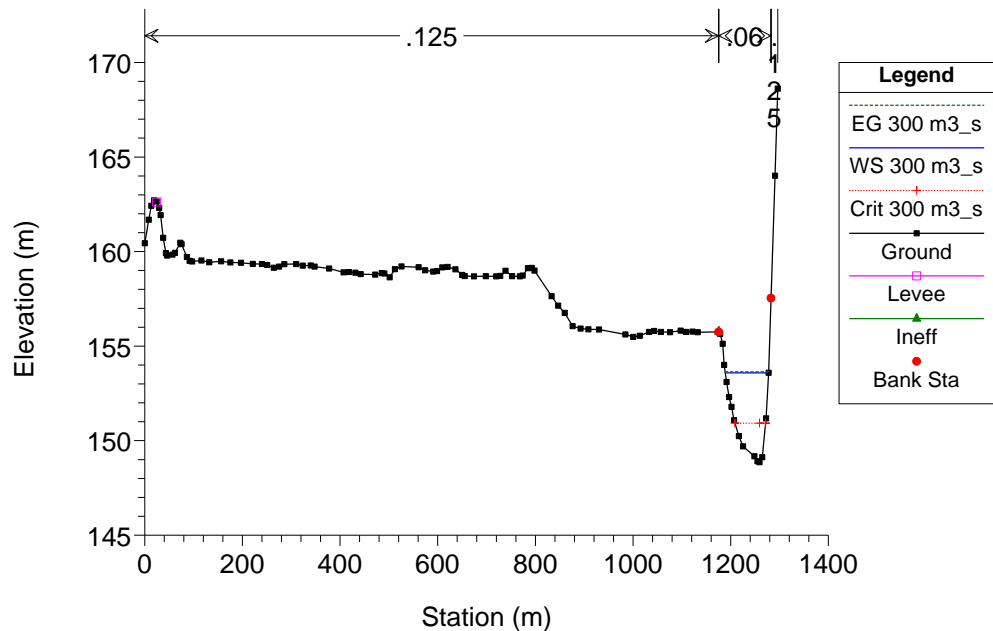


RS = 320 Tanaro ante 2010

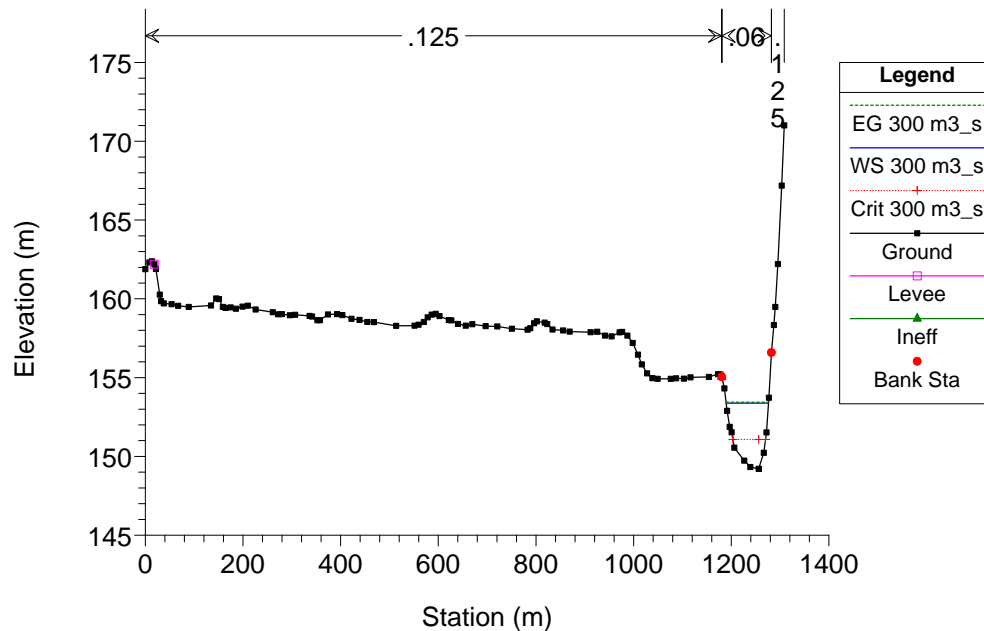




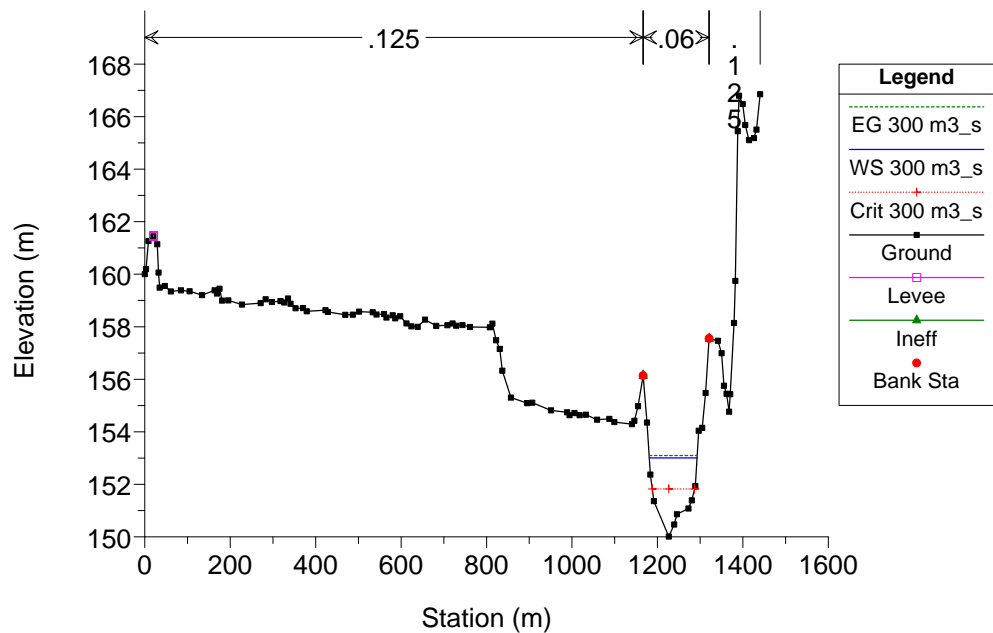
RS = 270 Tanaro ante 2010



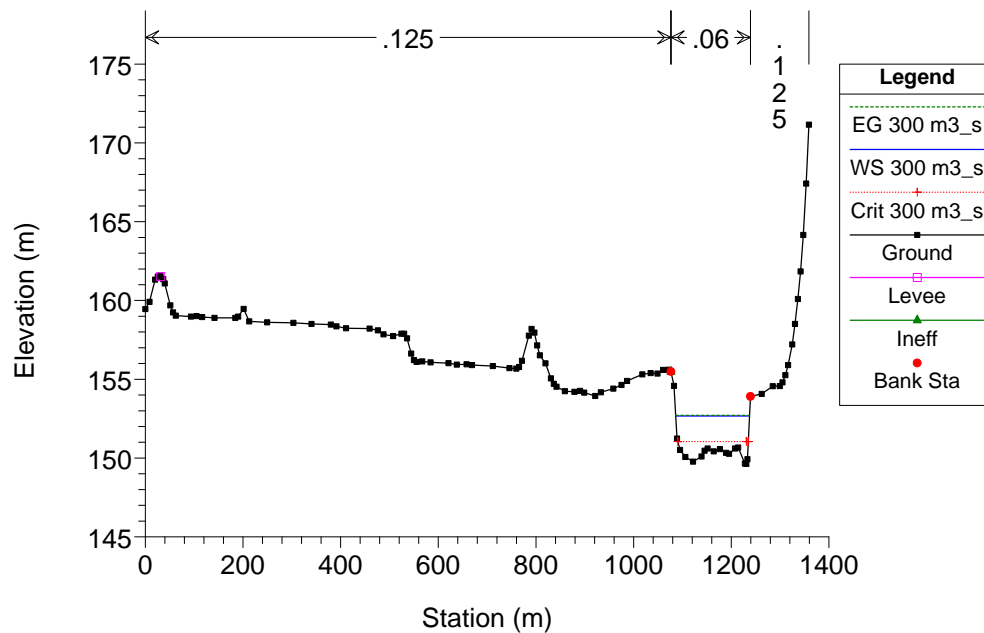
RS = 260 Tanaro ante 2010

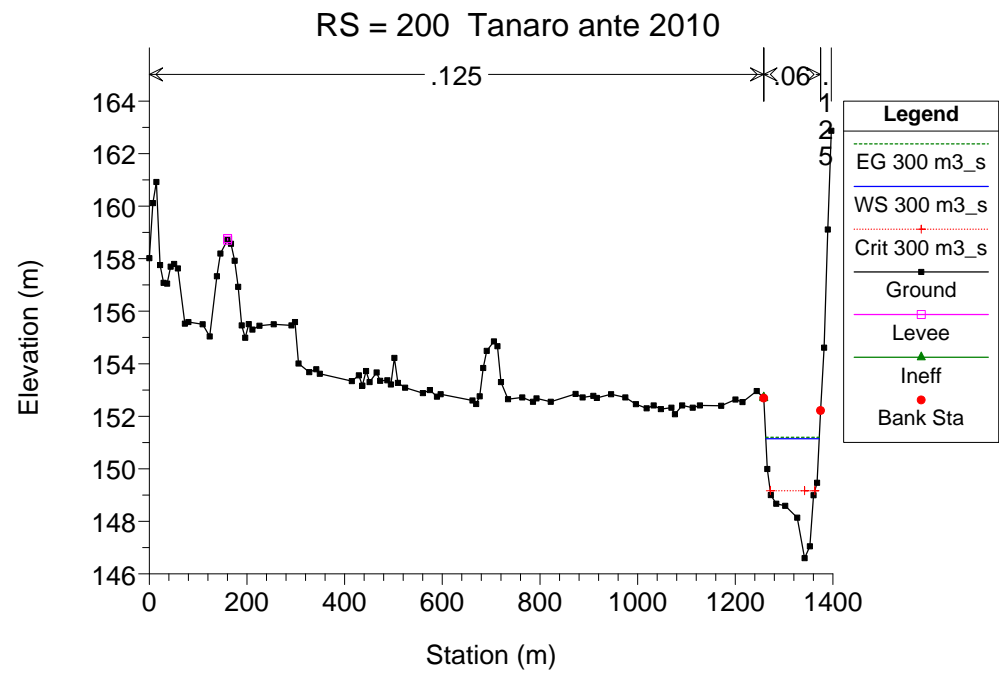
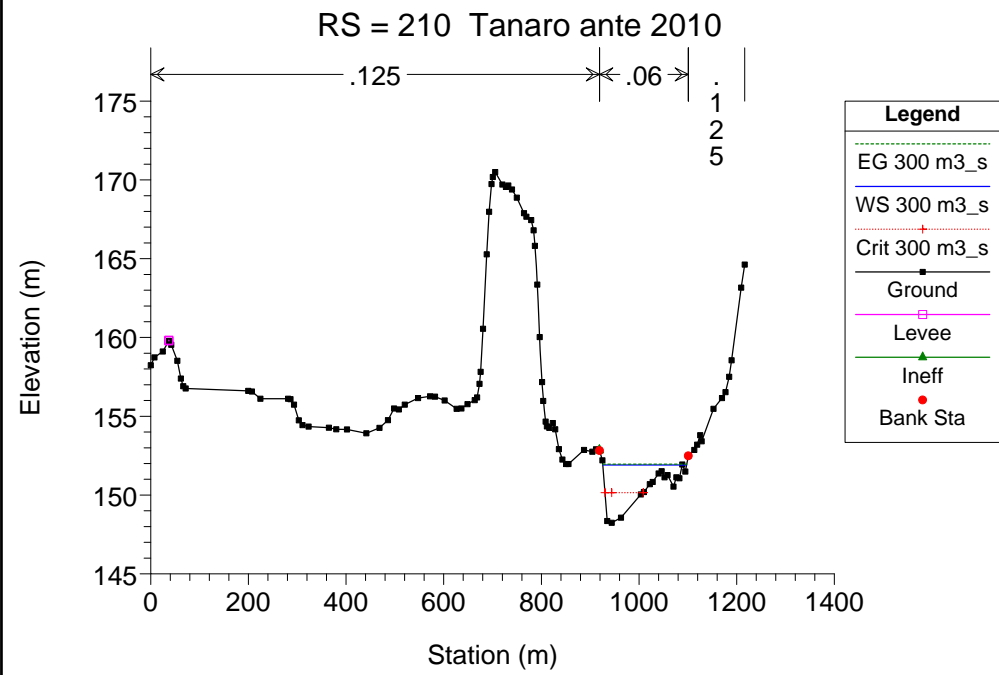
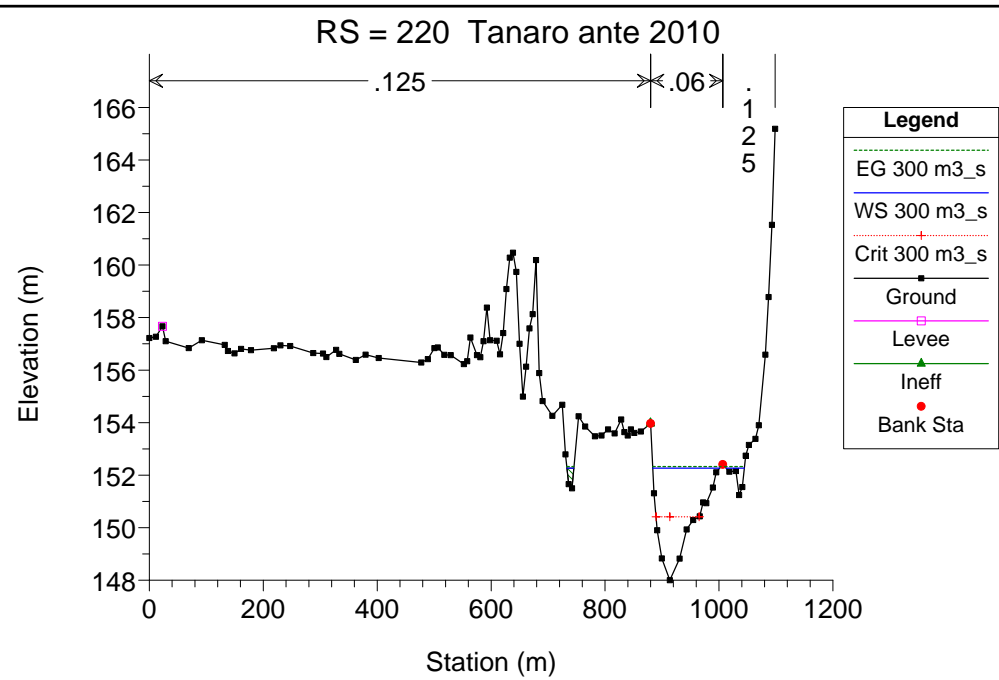
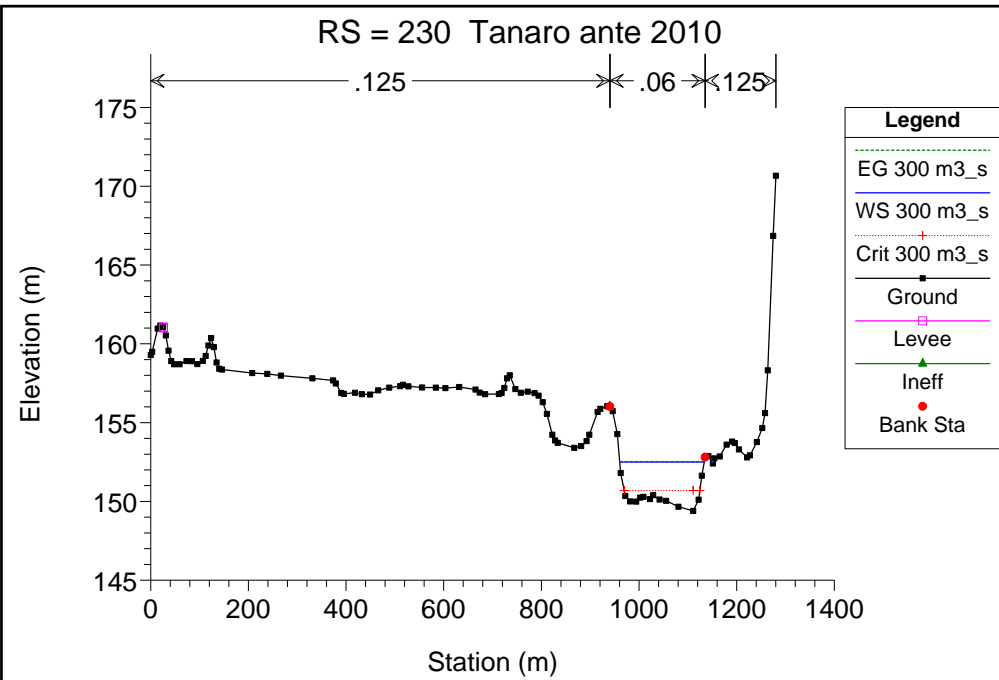


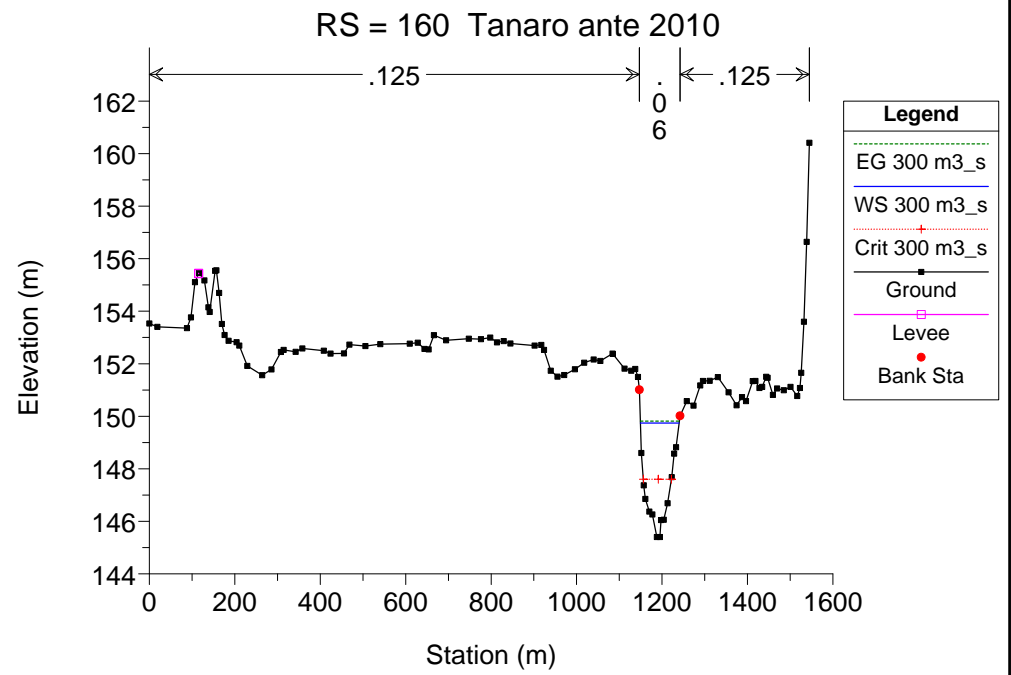
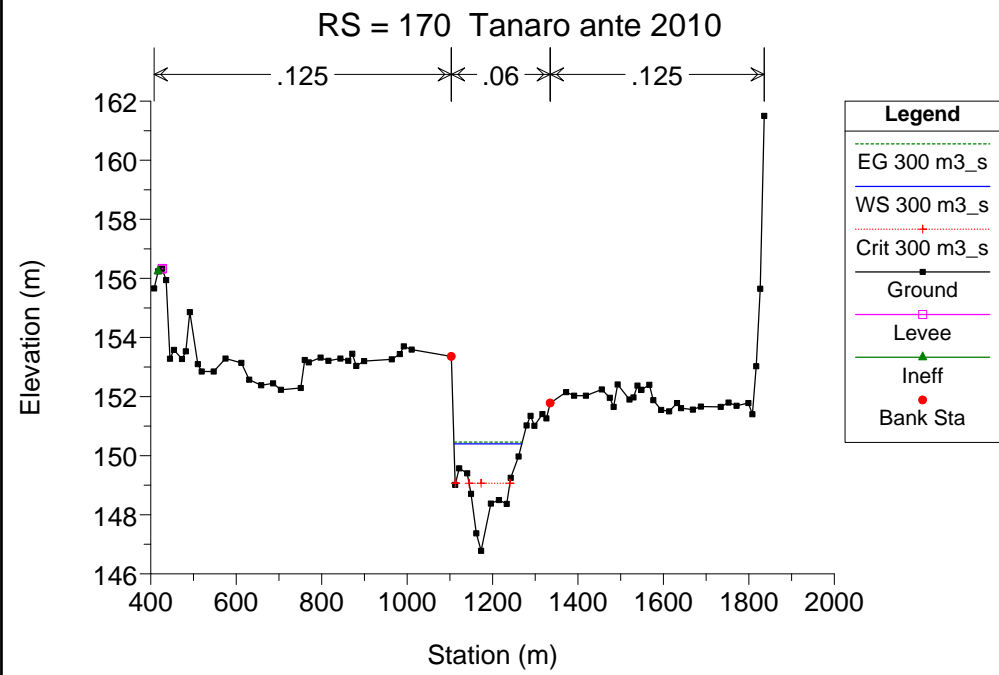
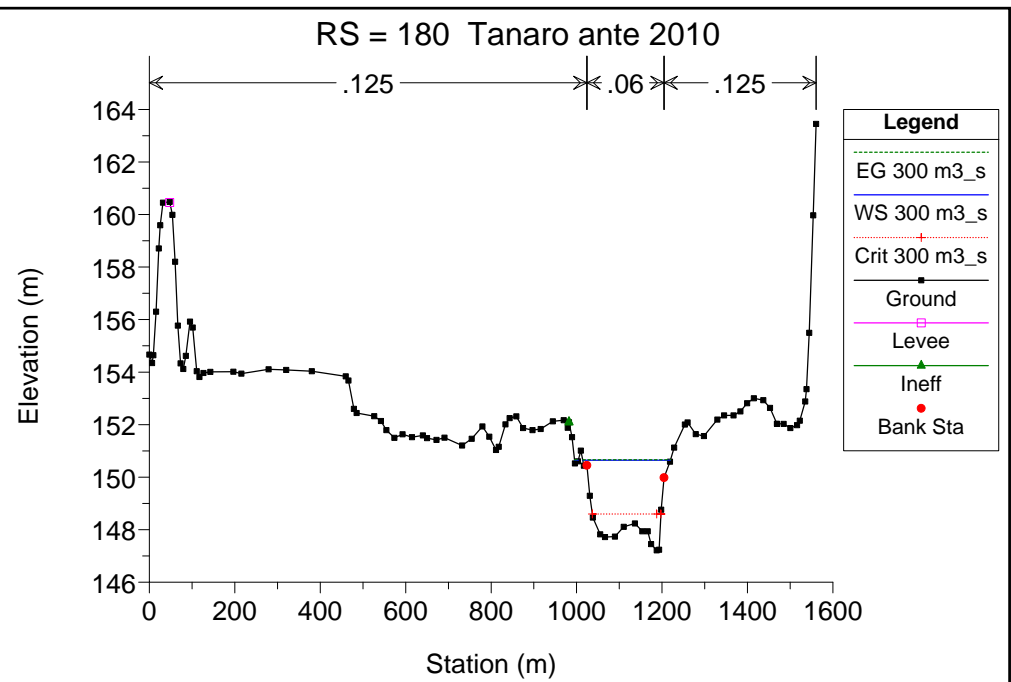
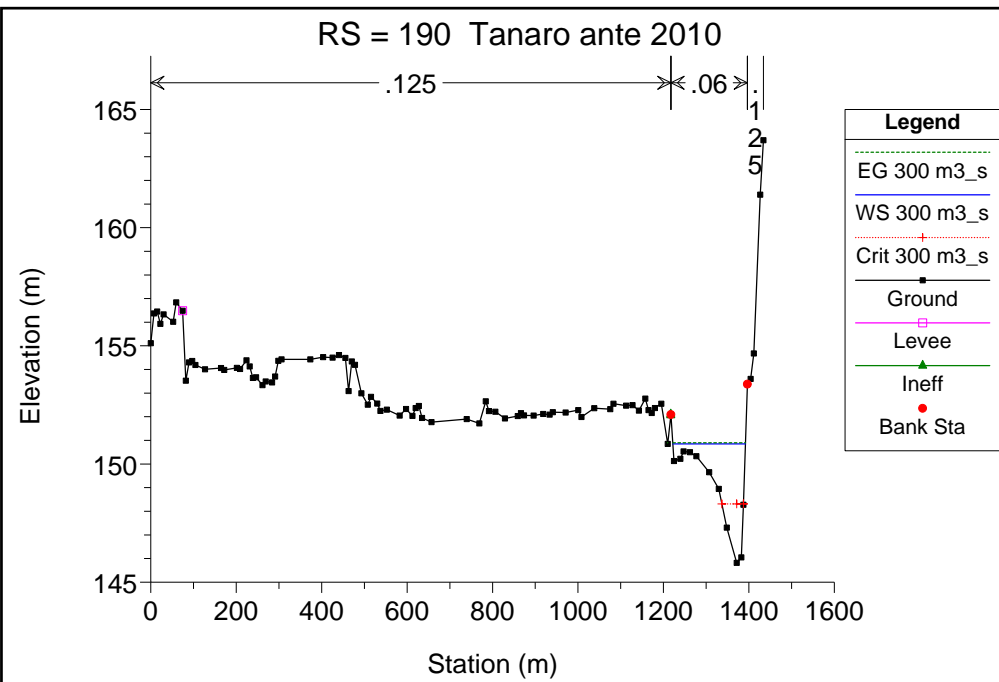
RS = 250 Tanaro ante 2010

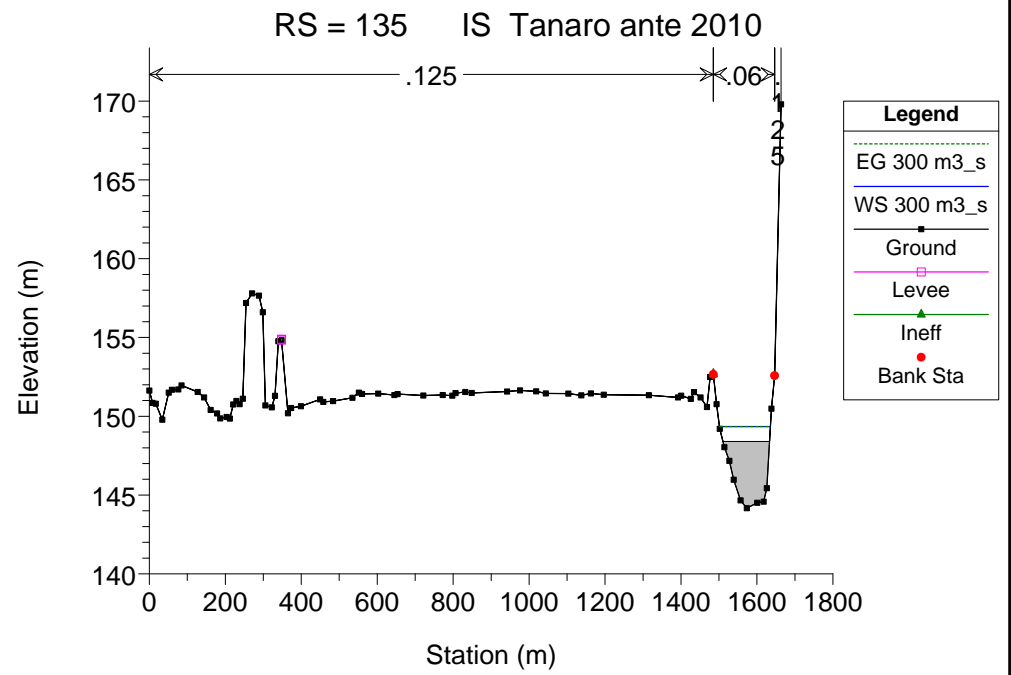
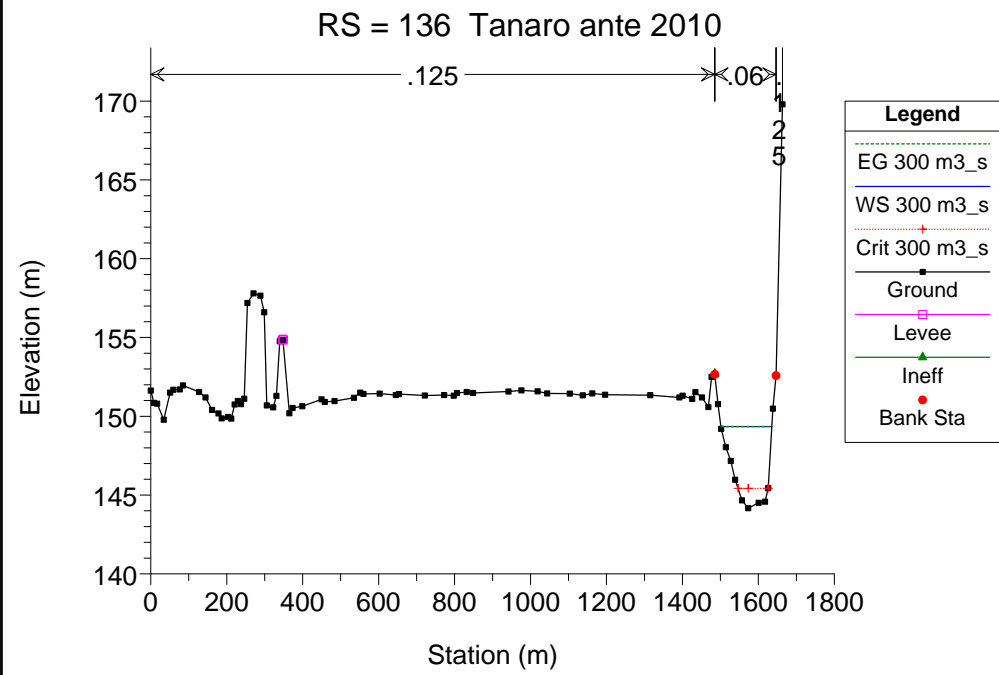
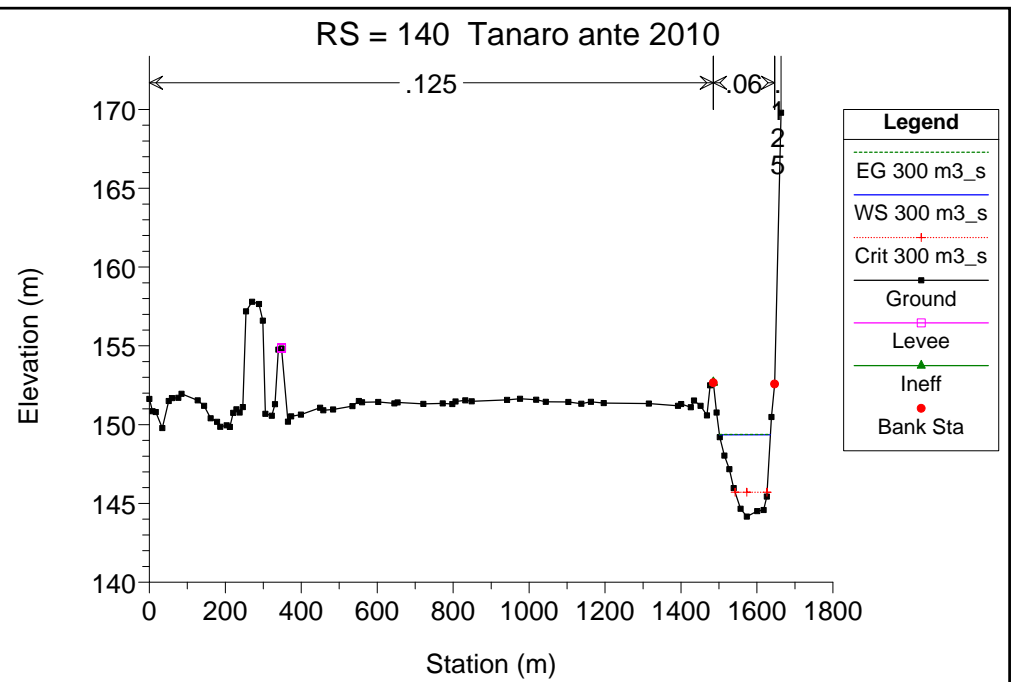
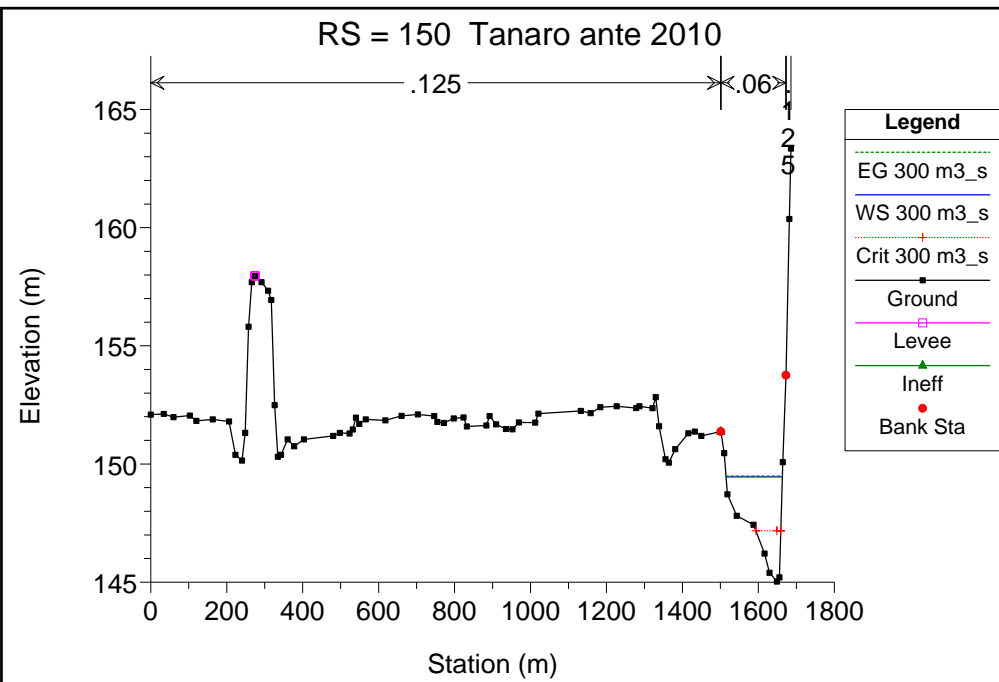


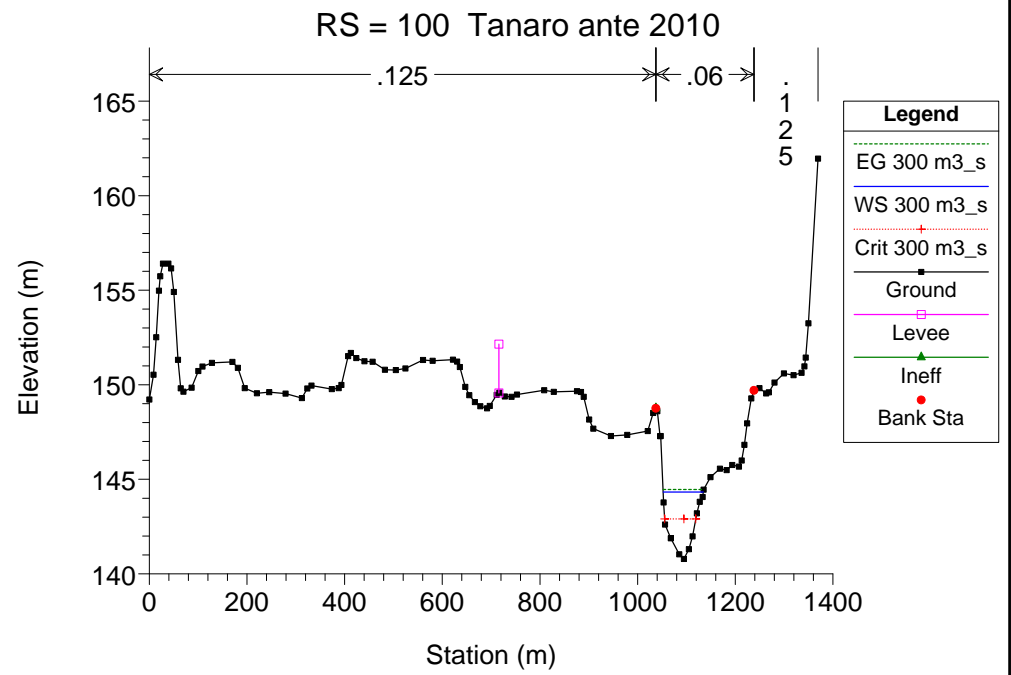
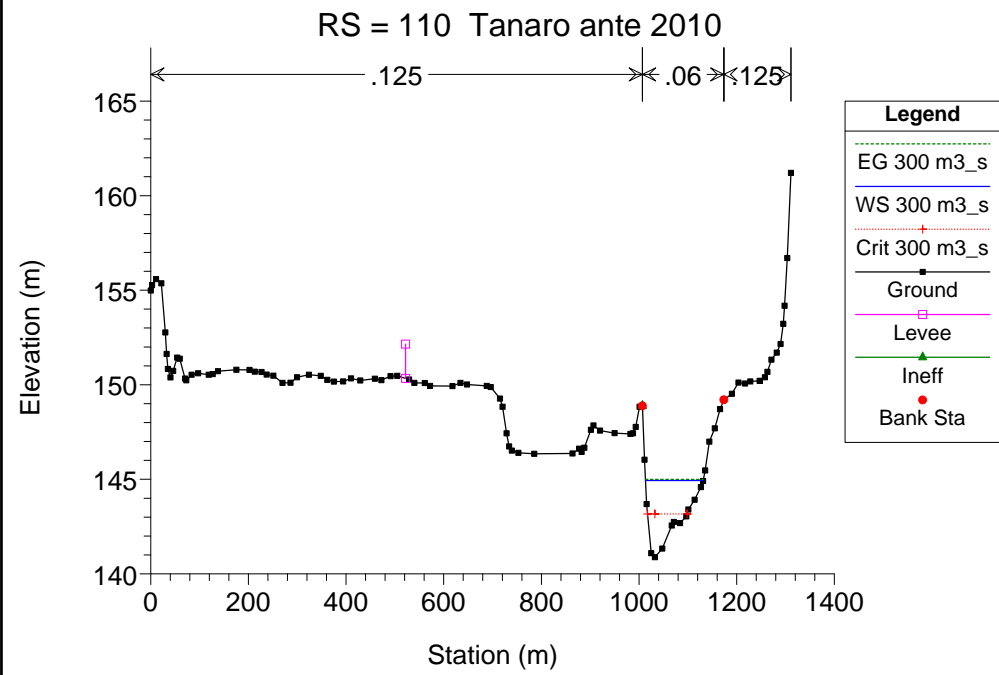
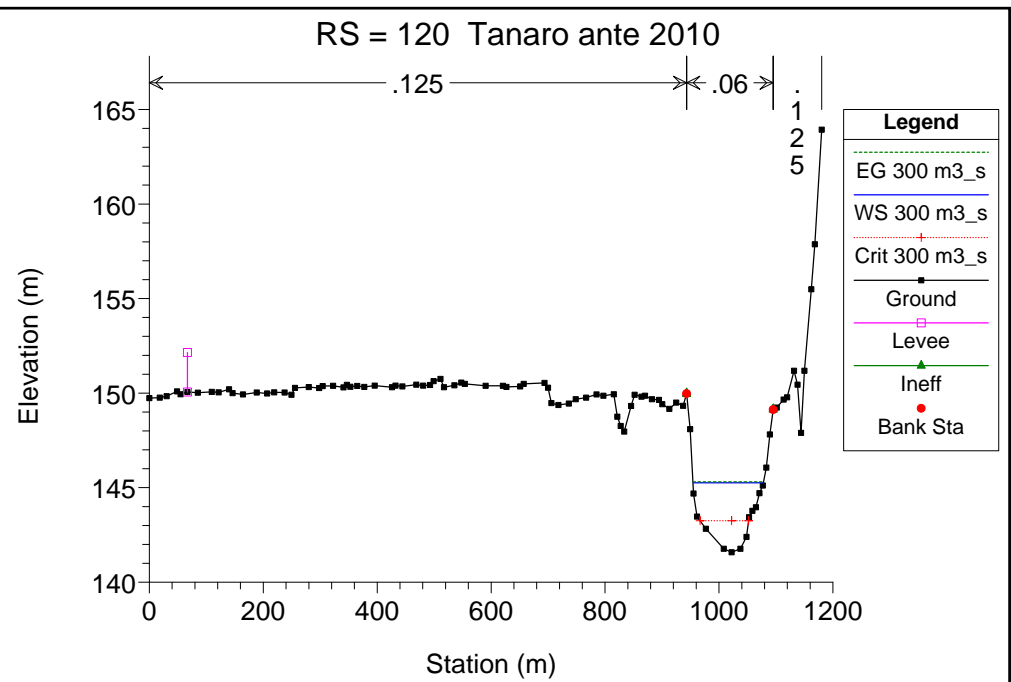
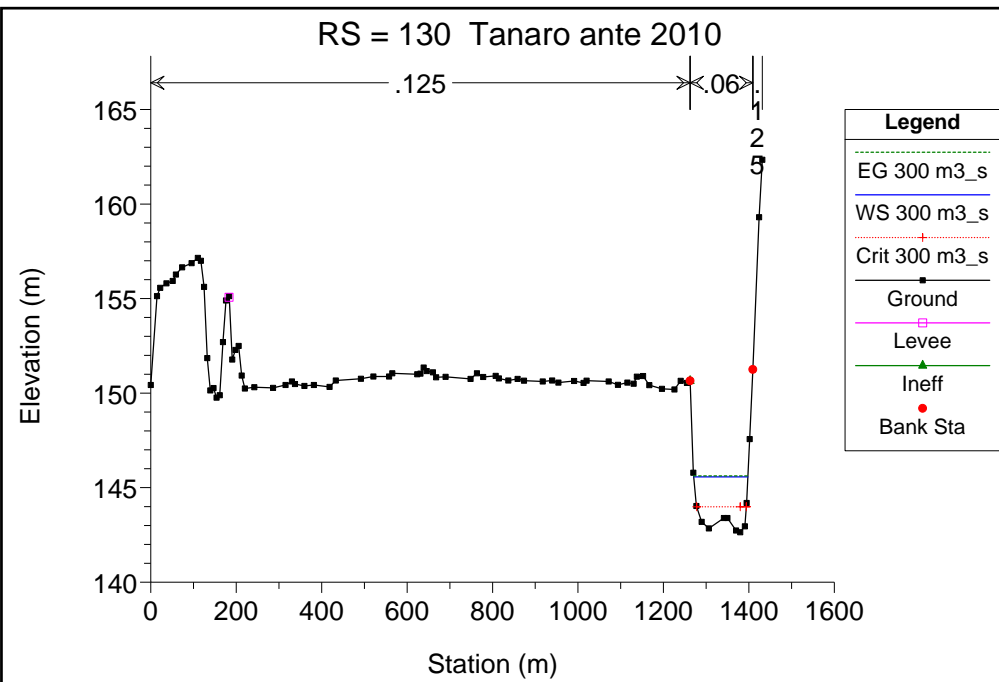
RS = 240 Tanaro ante 2010

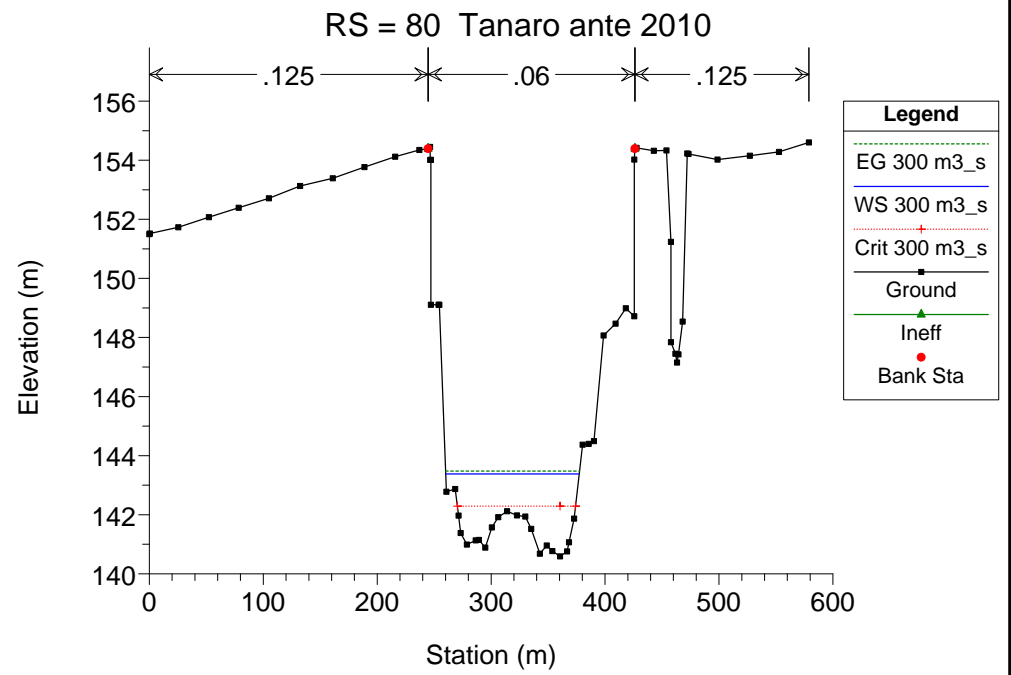
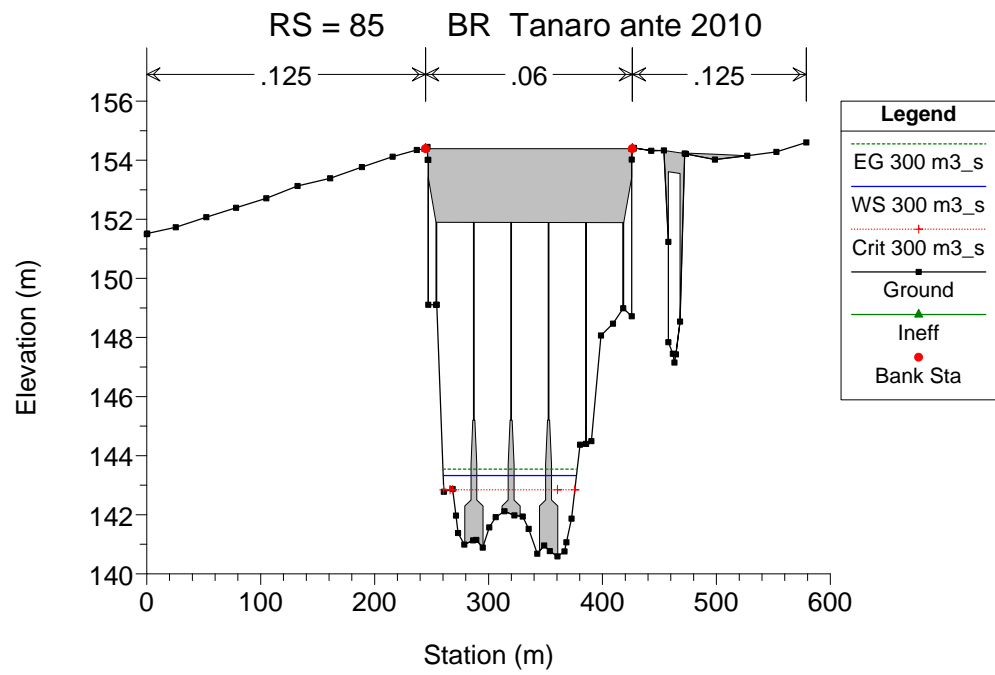
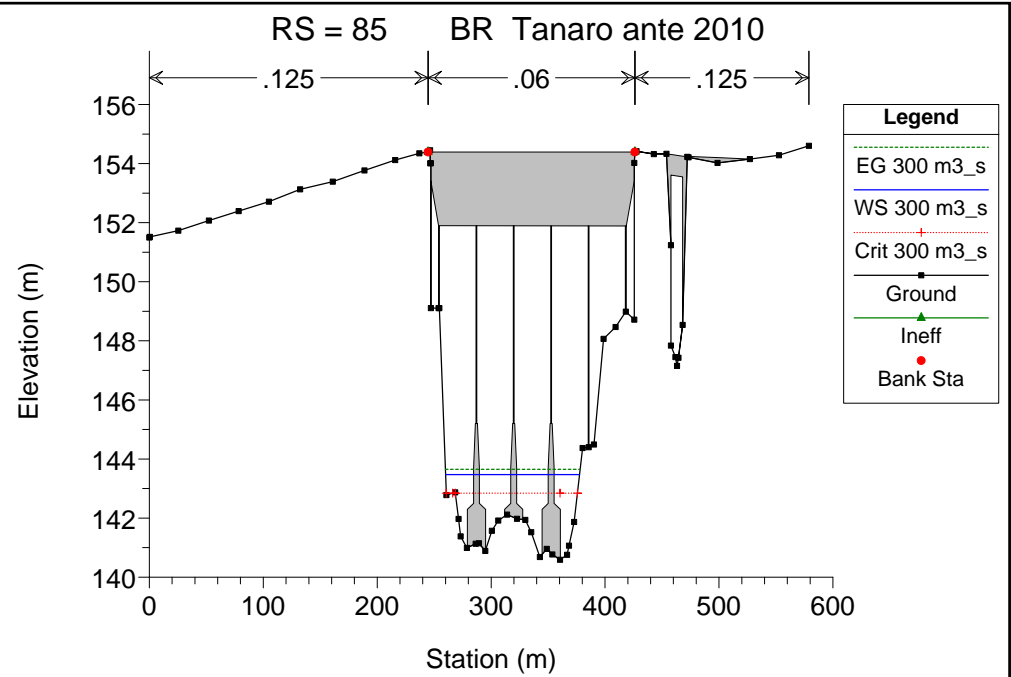
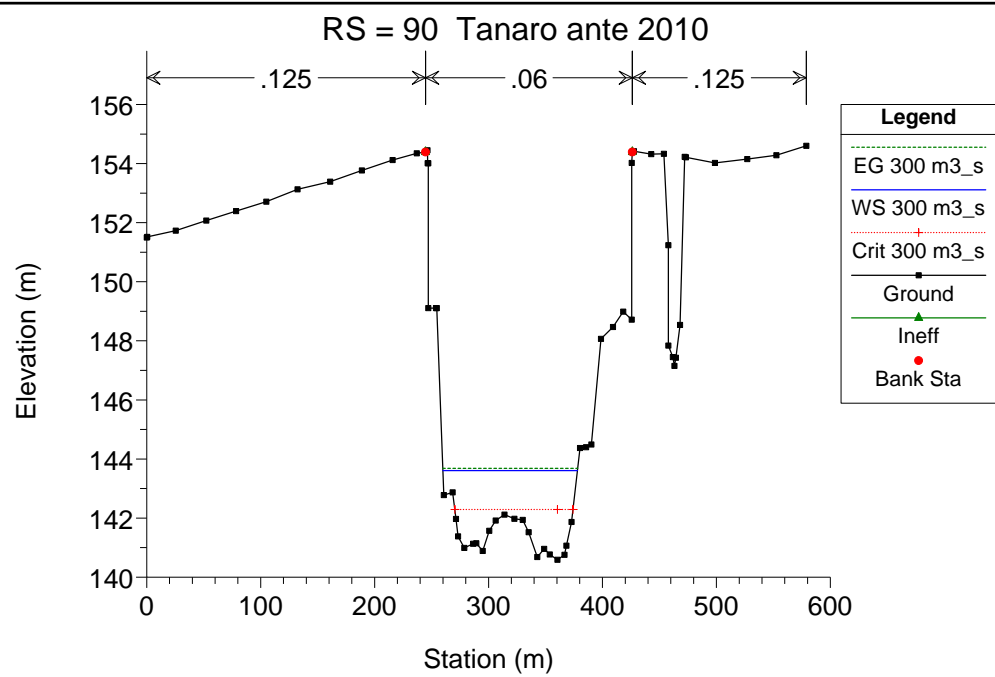


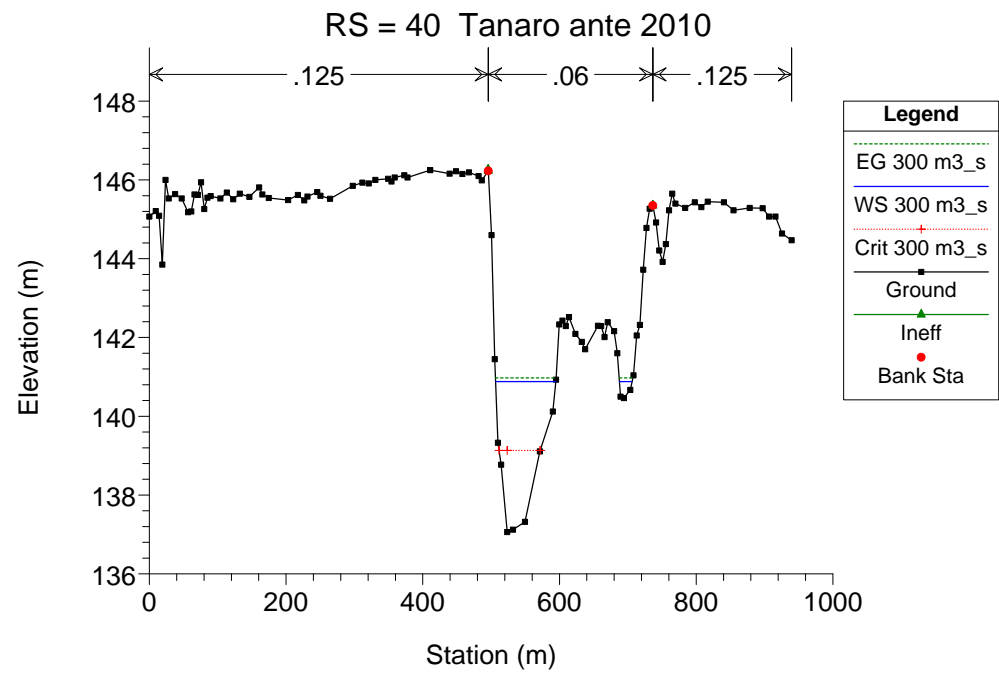
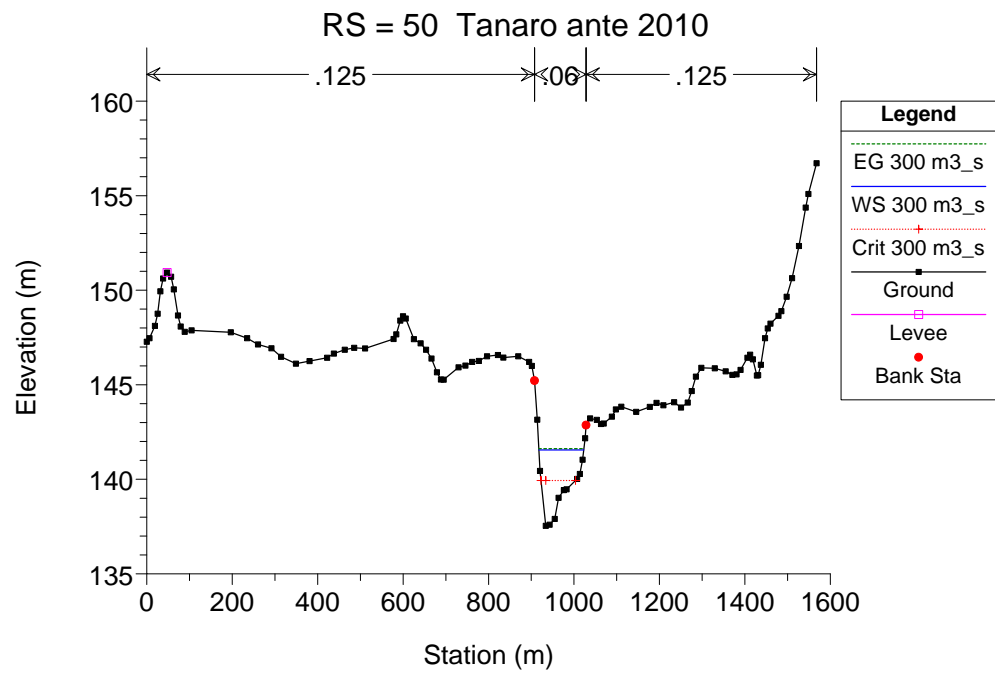
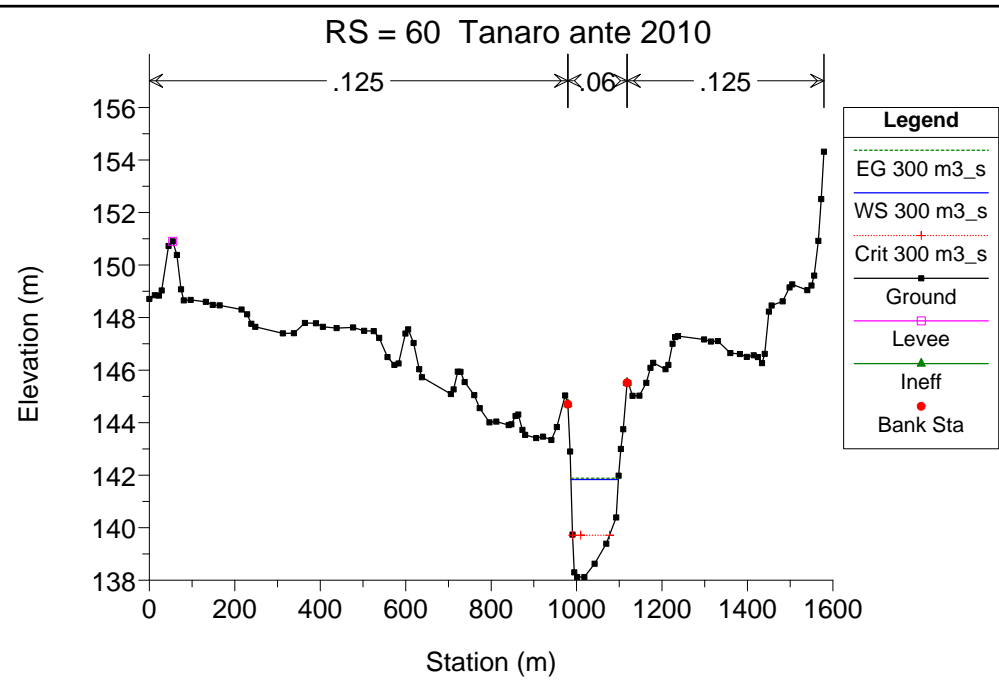
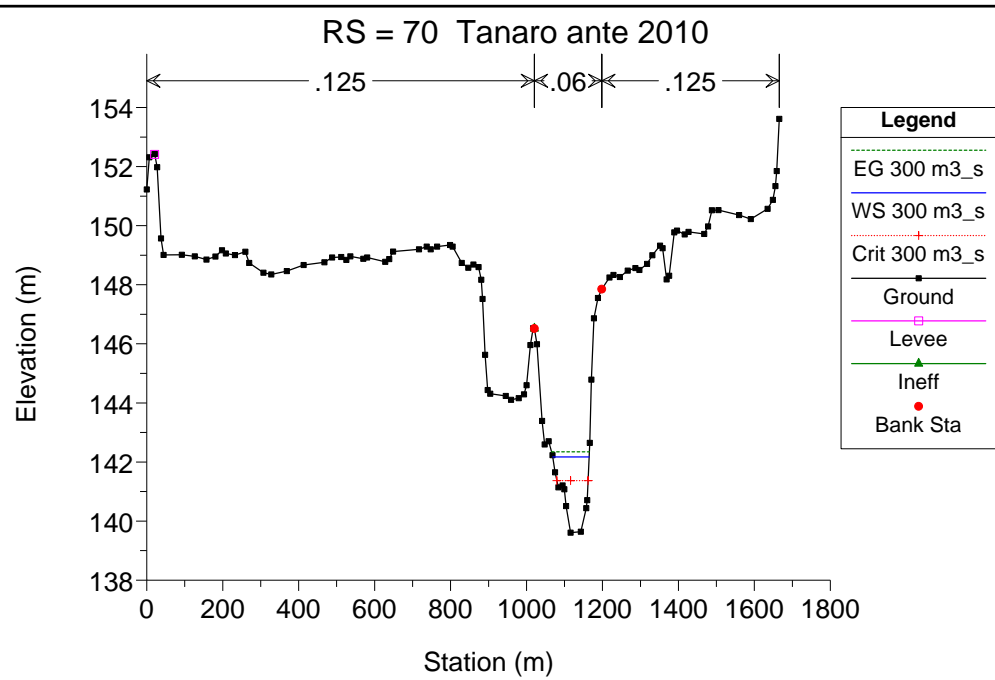


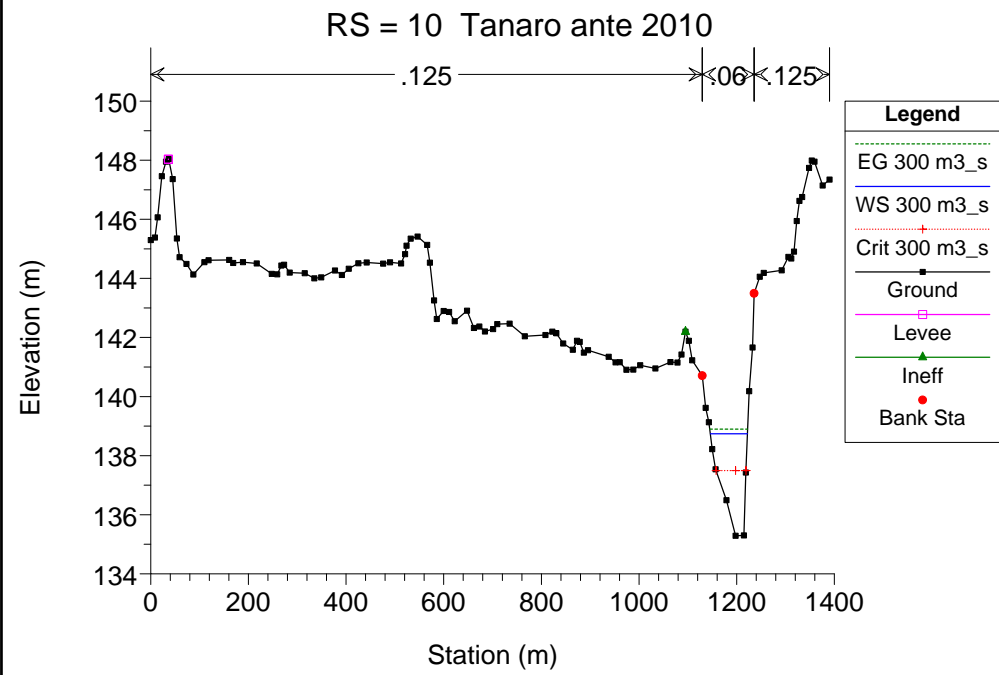
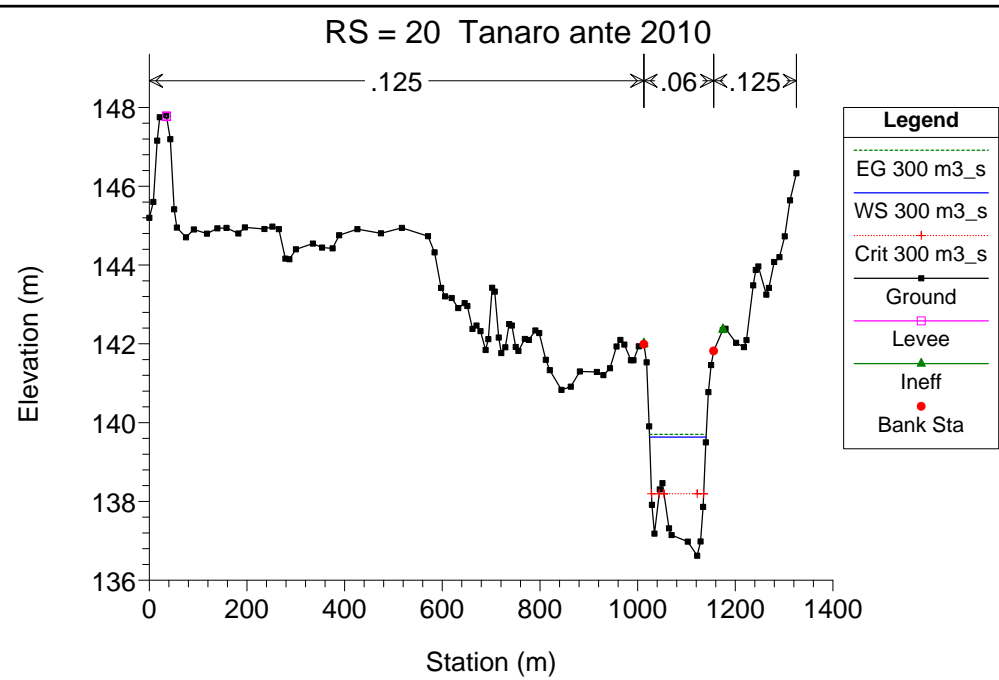
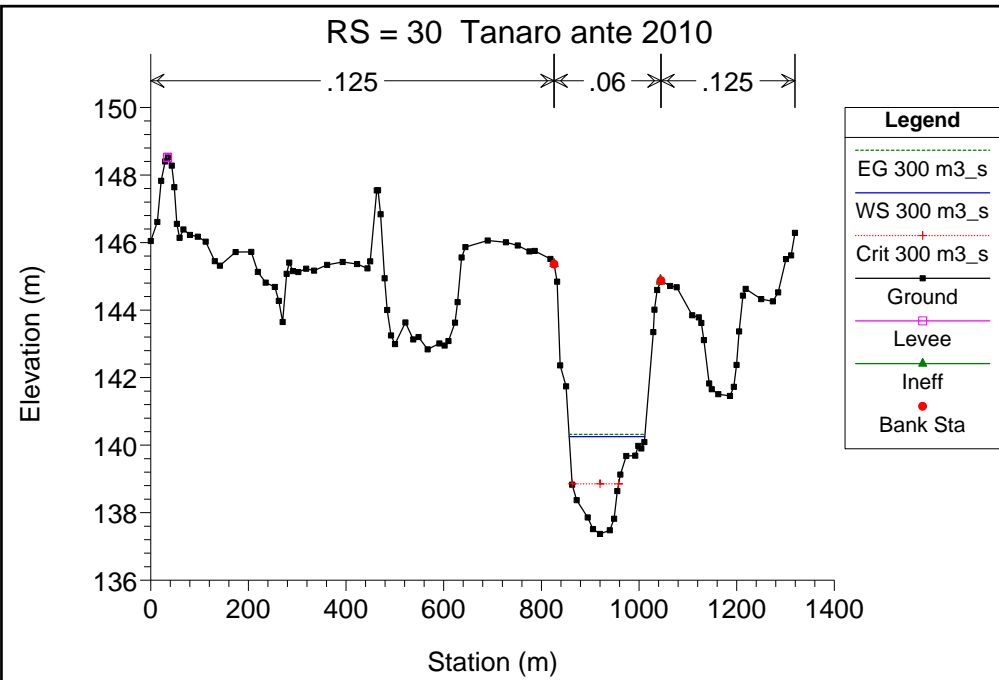












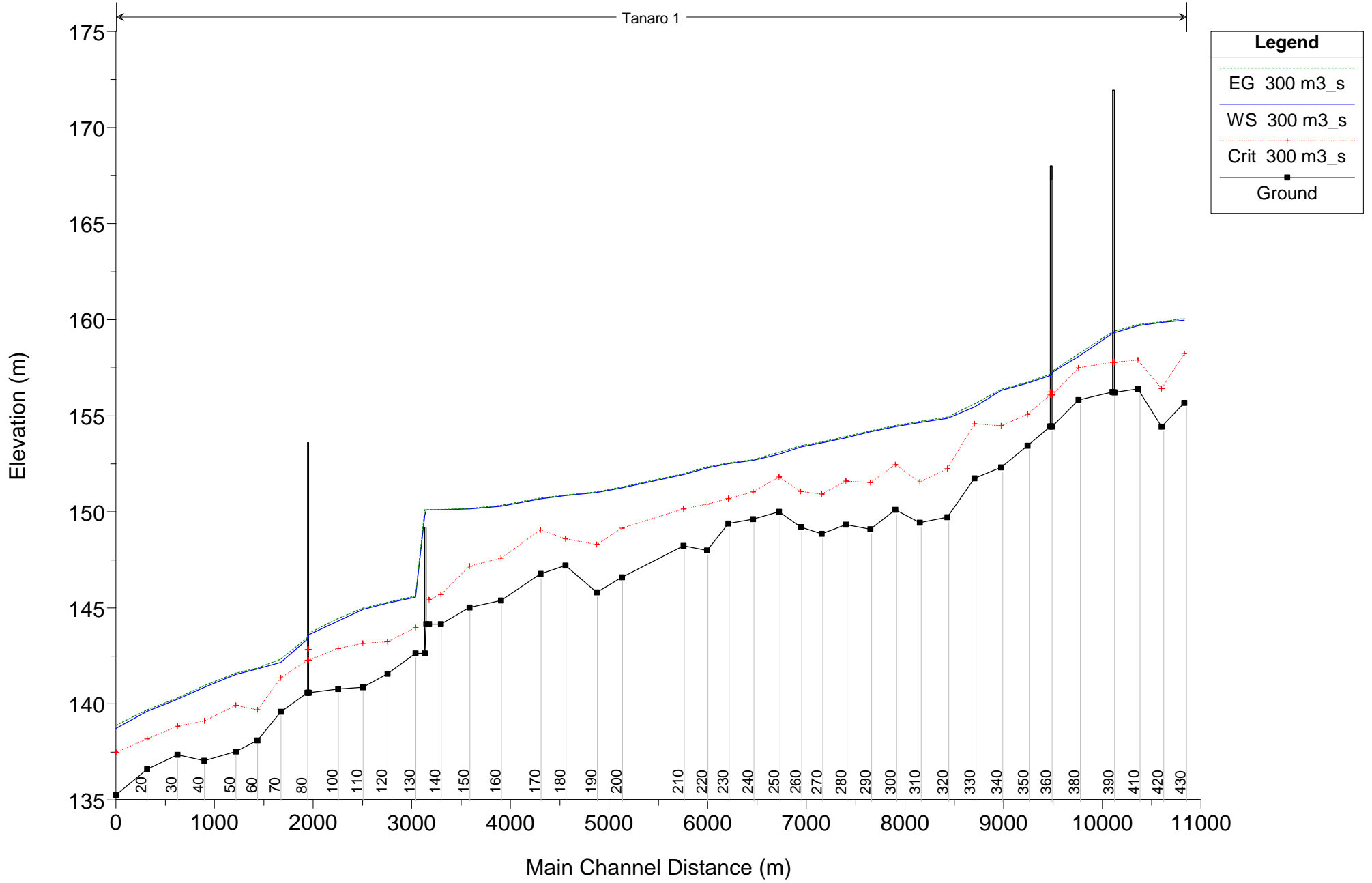
**SITUAZIONE DI PROGETTO (CON SBARRAMENTO MOBILE ALZATO)
SIMULAZIONE 15**

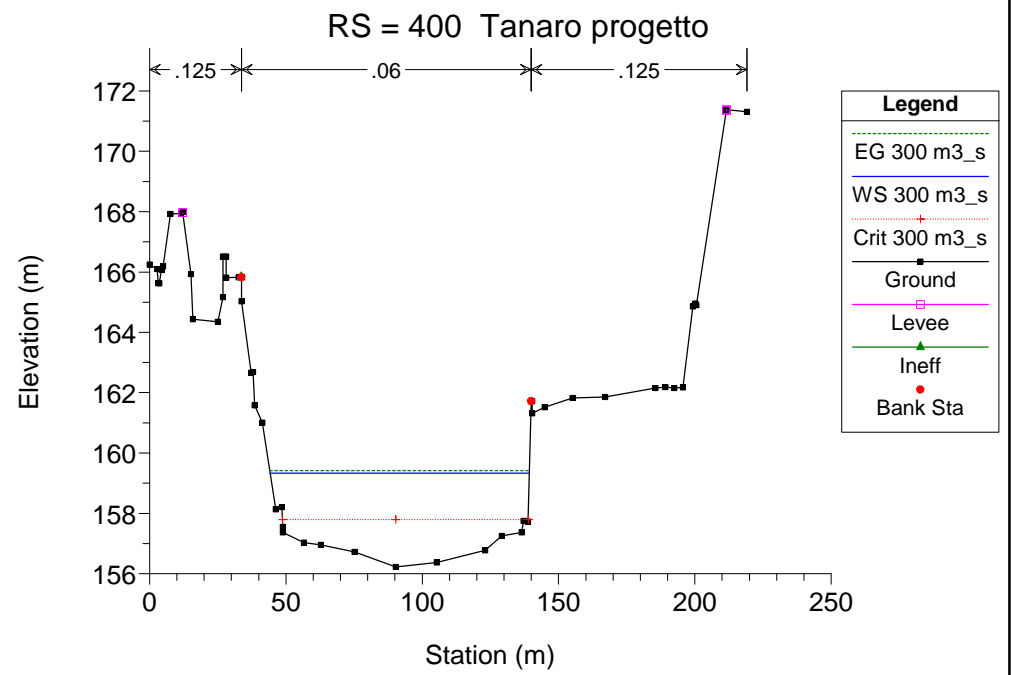
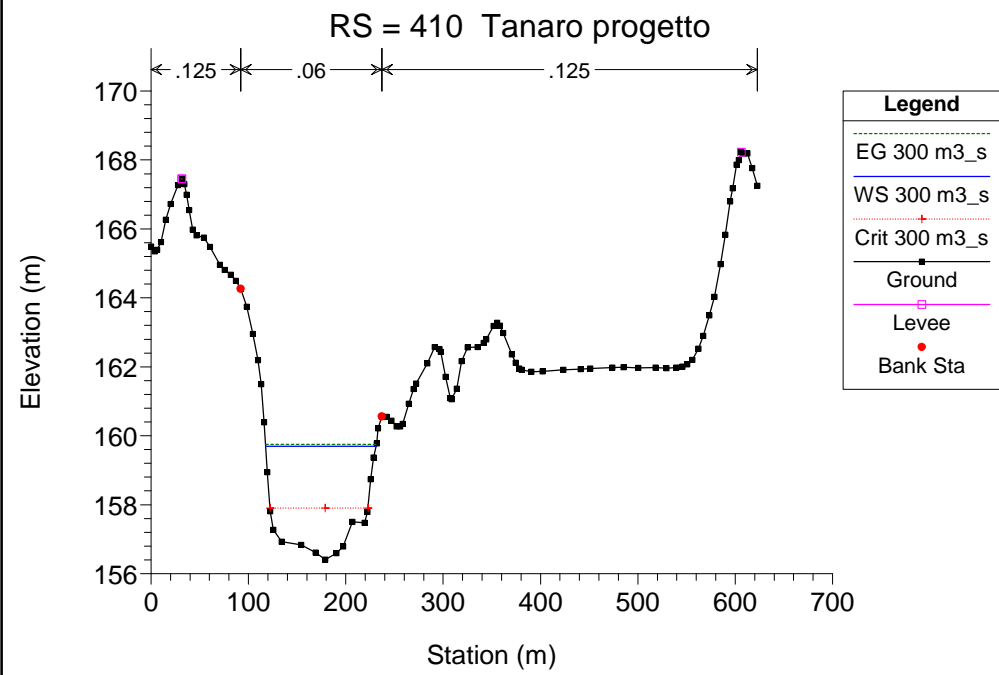
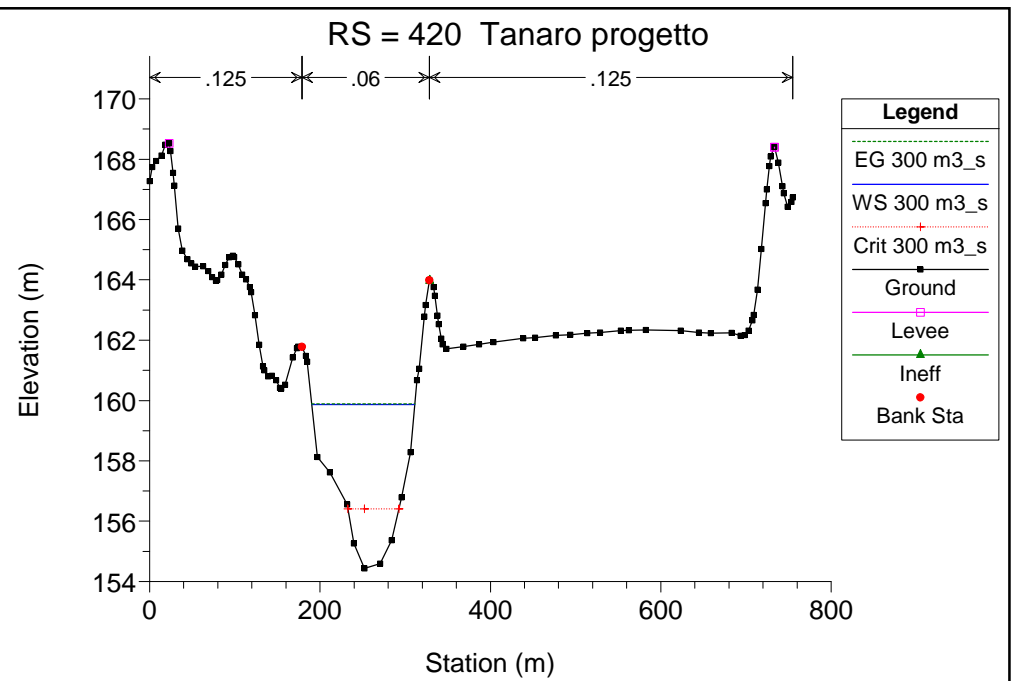
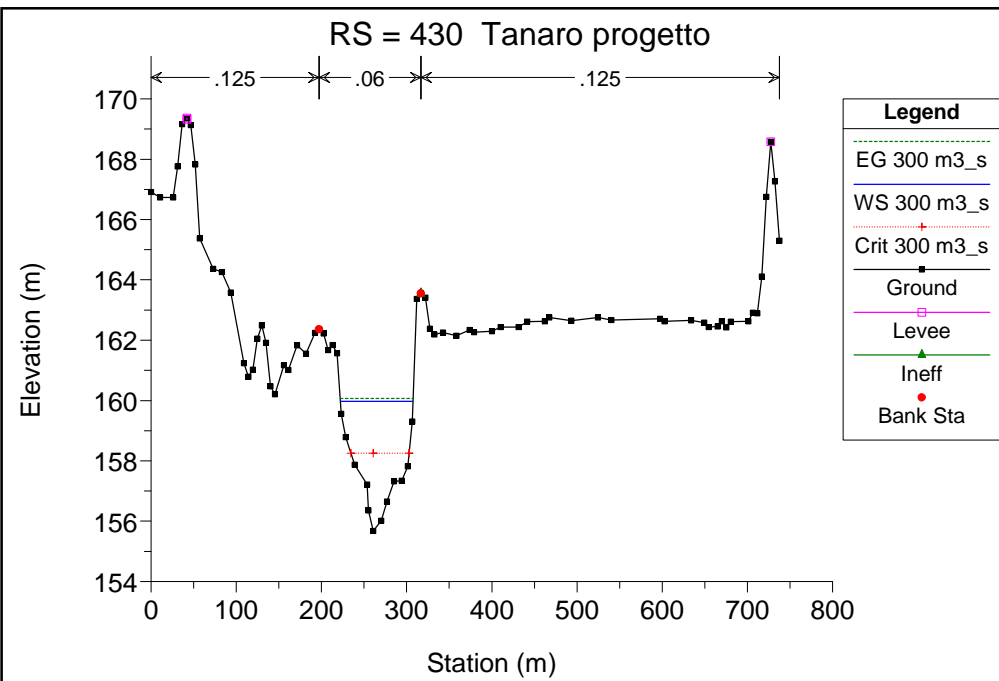
Corso d'acqua	Portata Q m³/s	Portata
Fiume Tanaro	300 (in alveo) 100 (turbinati)	Massima di funzionamento dell'impianto idroelettrico

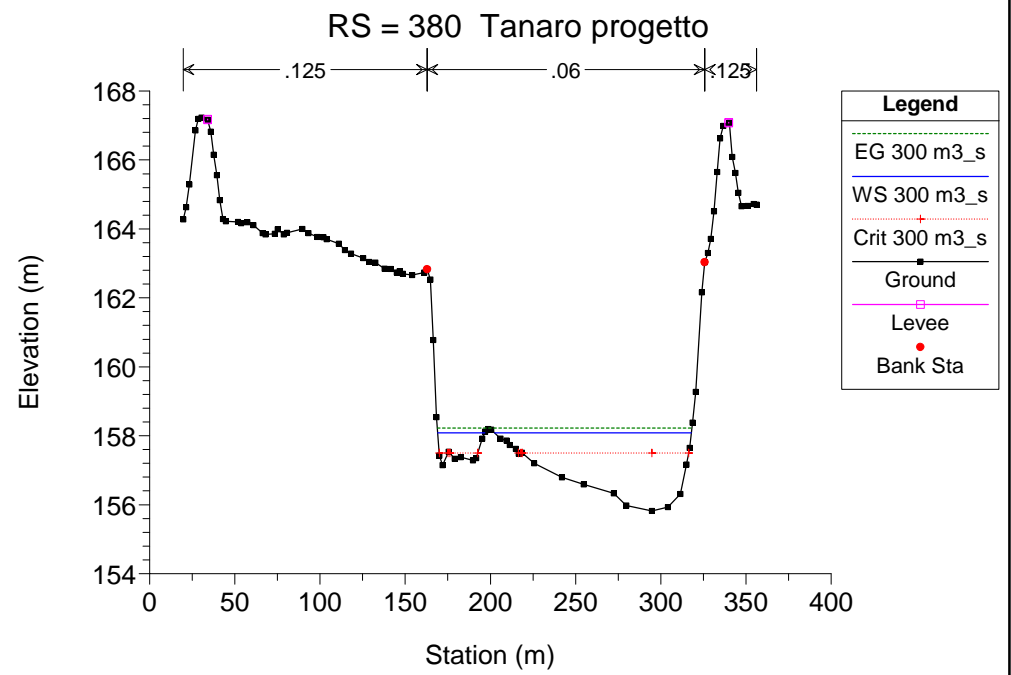
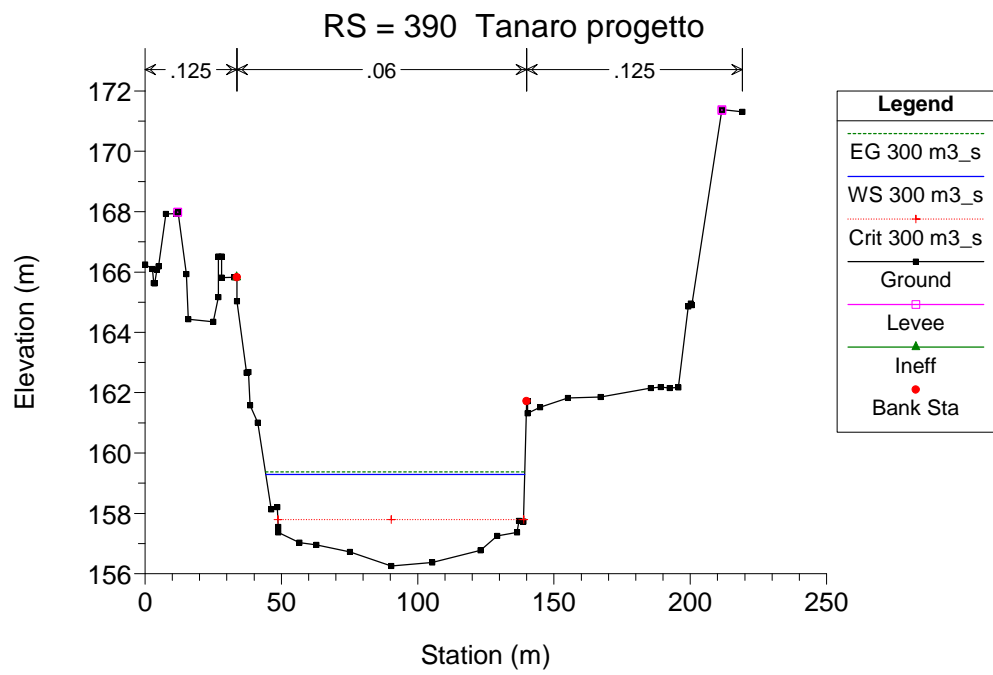
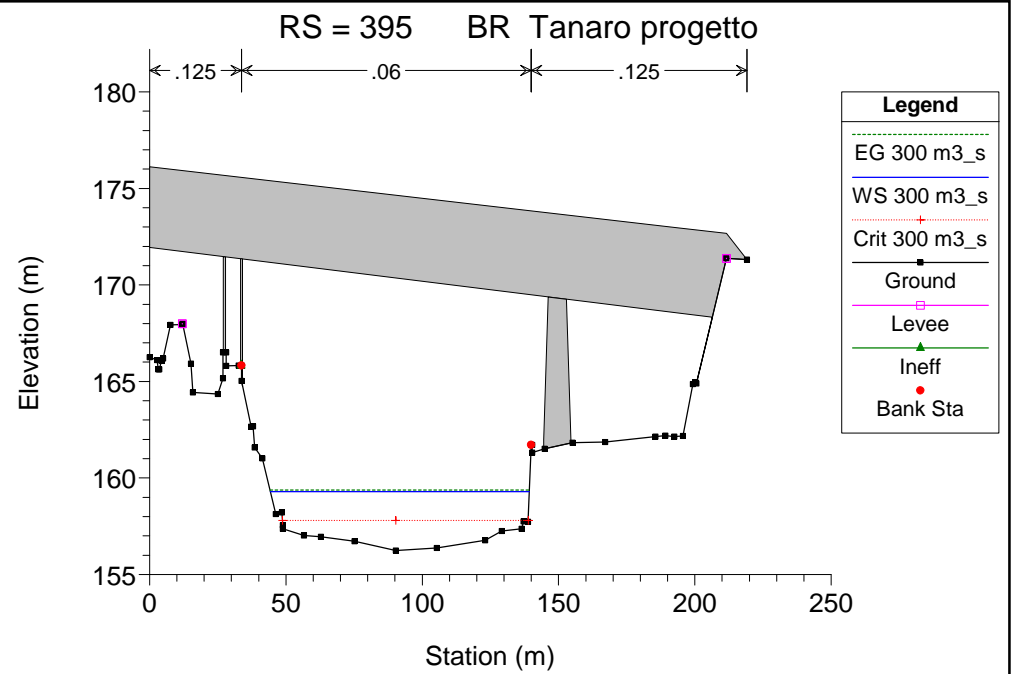
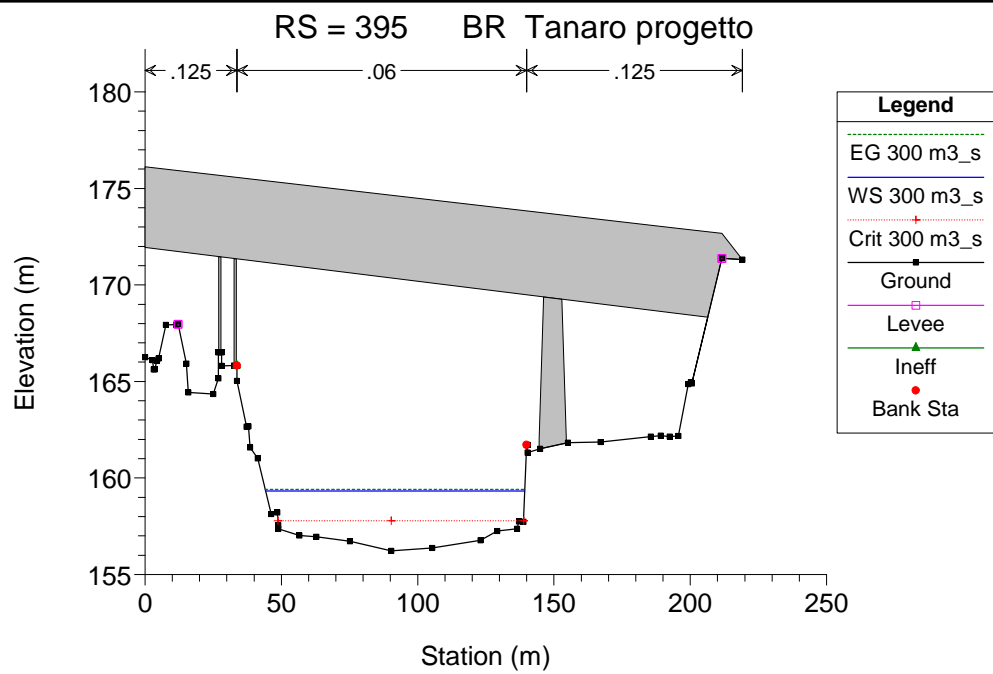
HEC-RAS Plan: Plan 06 River: Tanaro Reach: 1 Profile: 300 m3_s (Continued)

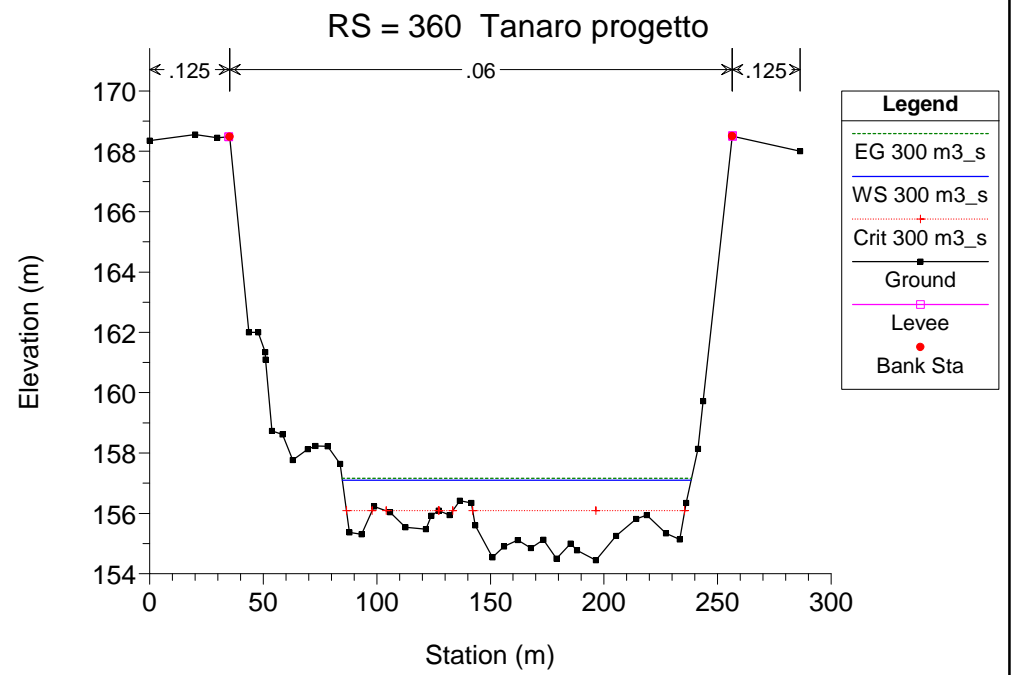
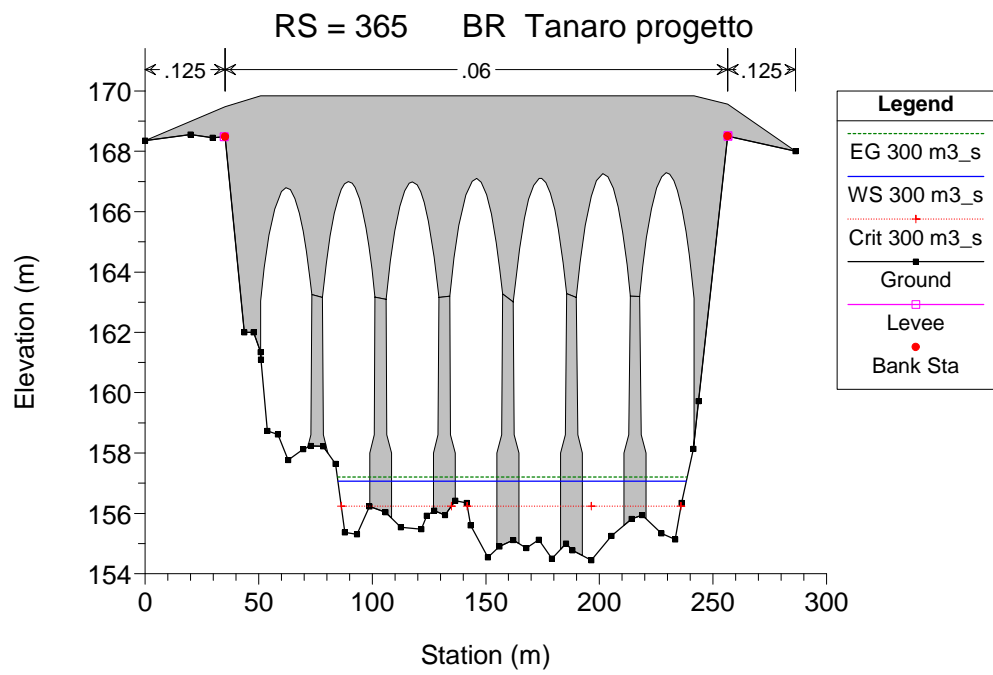
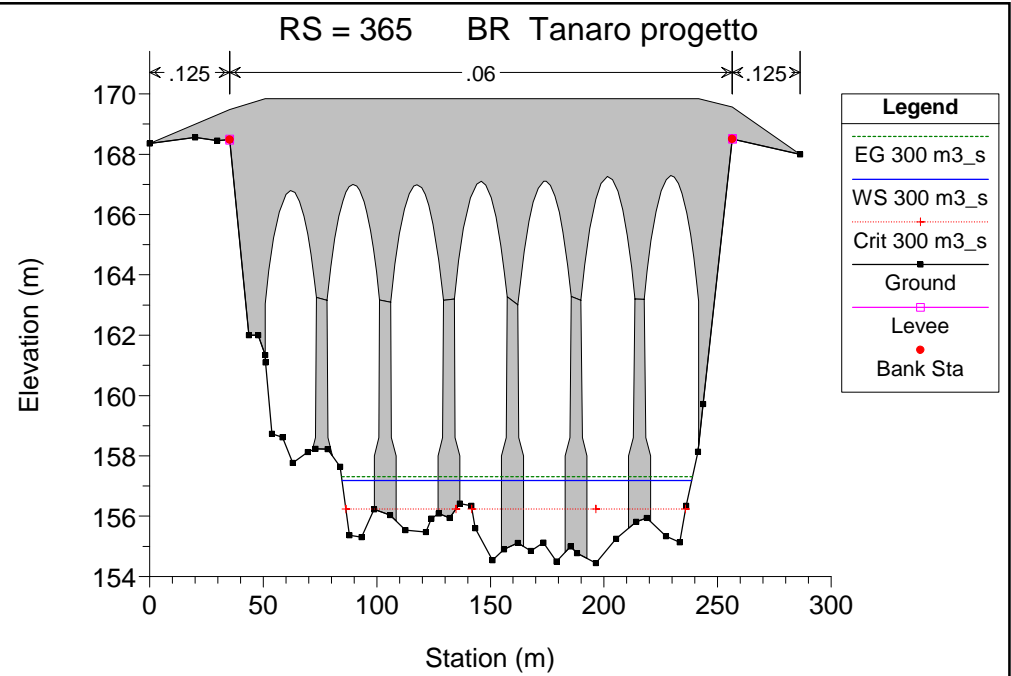
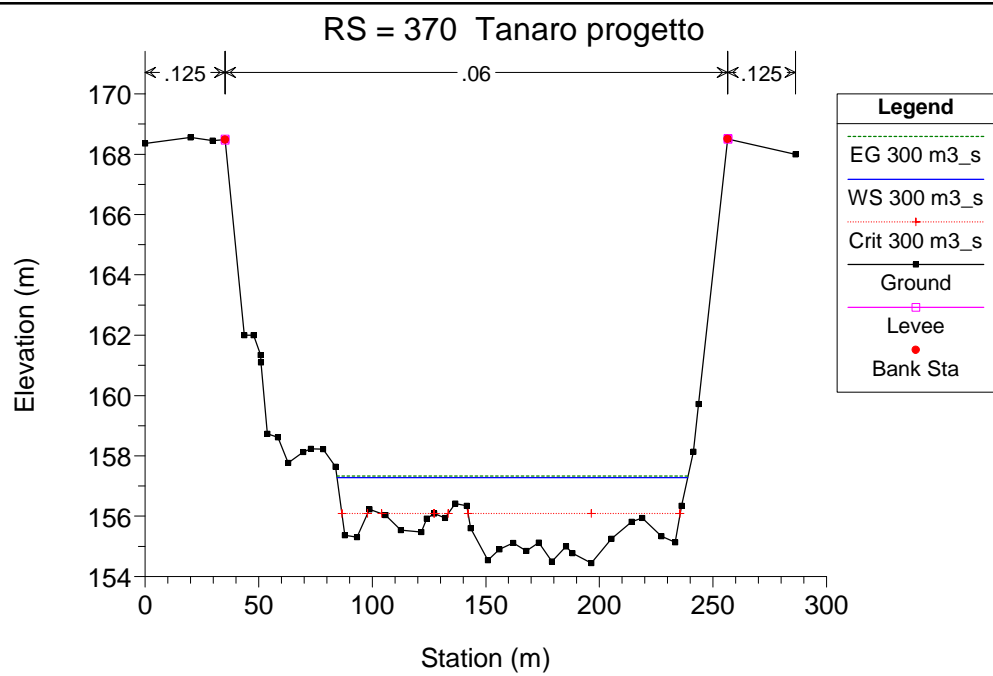
Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
1	80	300 m3_s	300.00	140.59	143.38	142.29	143.48	0.002975	1.37	218.89	117.25	0.32
1	70	300 m3_s	300.00	139.61	142.17	141.37	142.35	0.006051	1.84	162.81	95.73	0.45
1	60	300 m3_s	300.00	138.12	141.84	139.71	141.88	0.000849	0.96	312.09	110.96	0.18
1	50	300 m3_s	300.00	137.54	141.55	139.93	141.62	0.001712	1.21	246.99	104.93	0.25
1	40	300 m3_s	300.00	137.06	140.88	139.13	140.97	0.002465	1.35	222.83	106.64	0.30
1	30	300 m3_s	300.00	137.37	140.25	138.86	140.32	0.002277	1.13	264.36	154.78	0.28
1	20	300 m3_s	300.00	136.62	139.63	138.19	139.70	0.001753	1.18	254.96	115.63	0.25
1	10	300 m3_s	300.00	135.29	138.74	137.49	138.90	0.004001	1.78	168.56	75.91	0.38

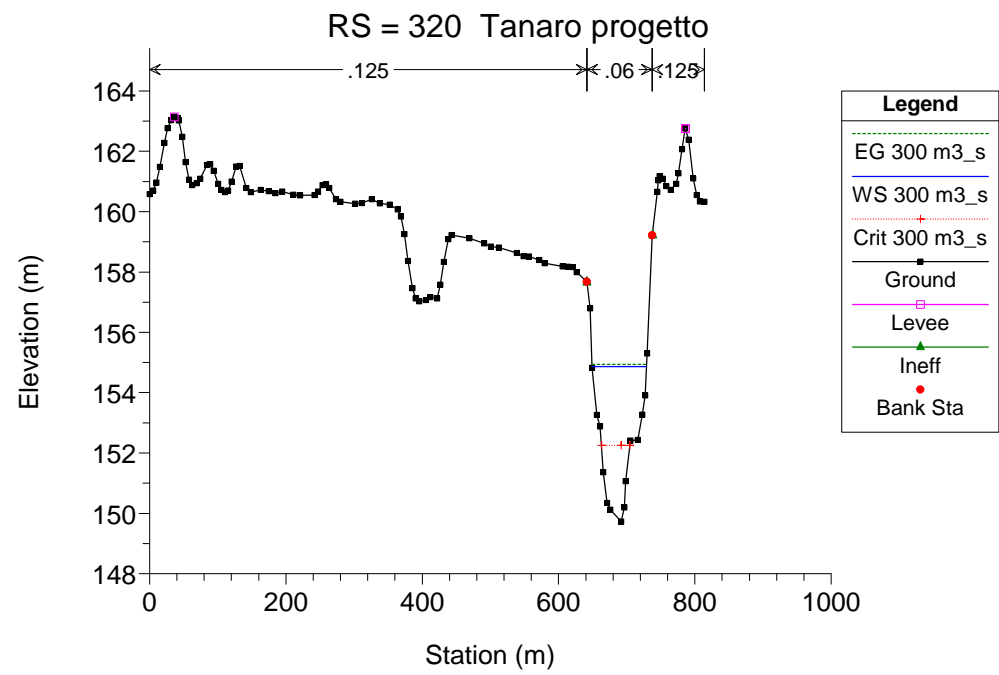
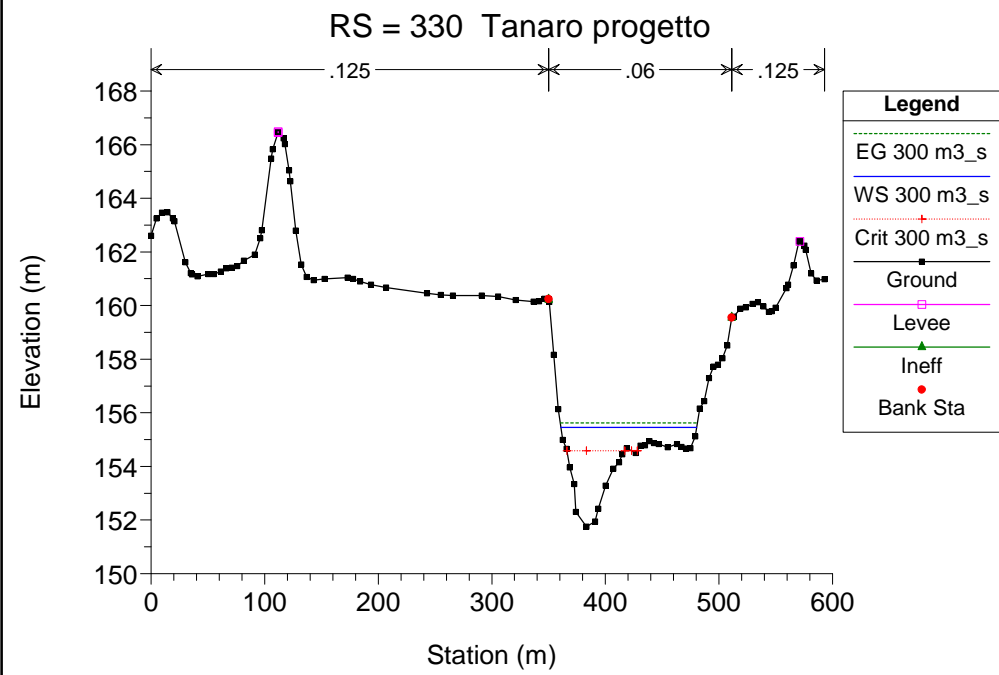
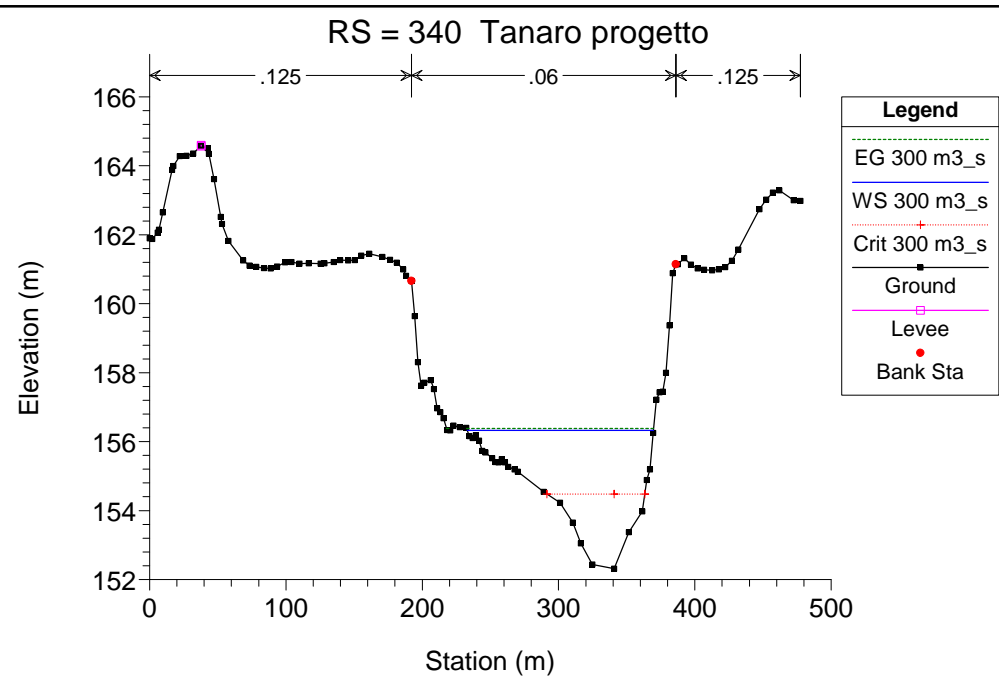
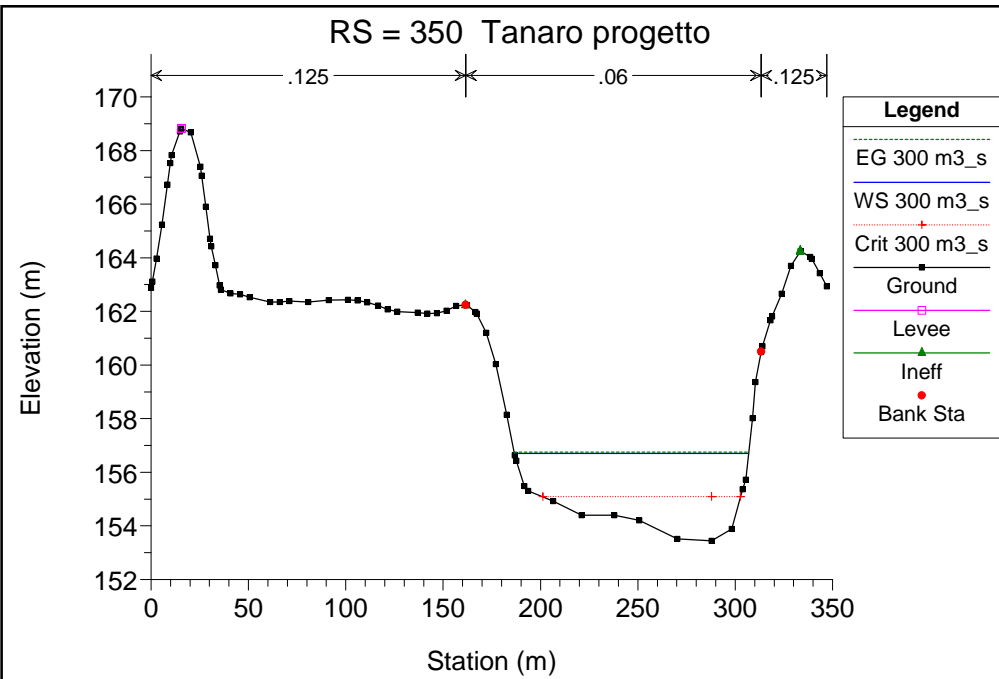
Tanaro progetto

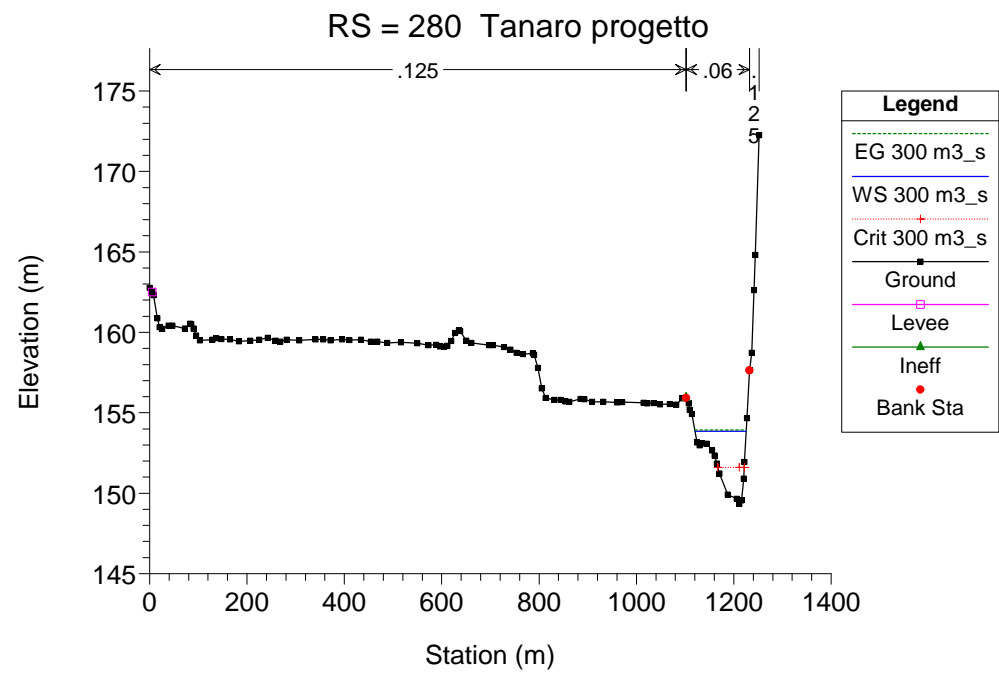
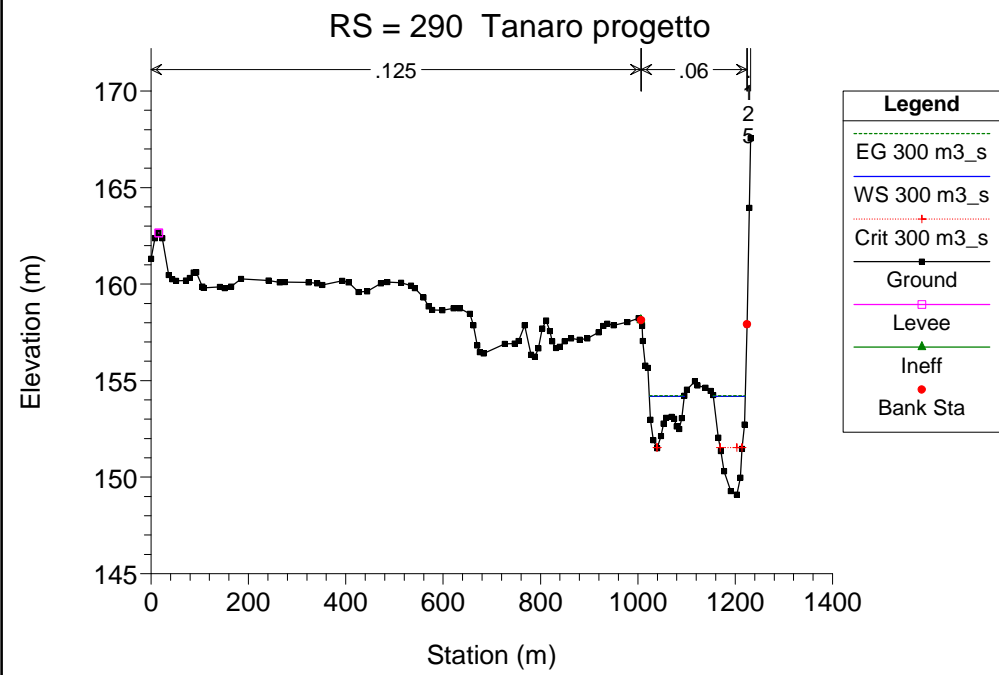
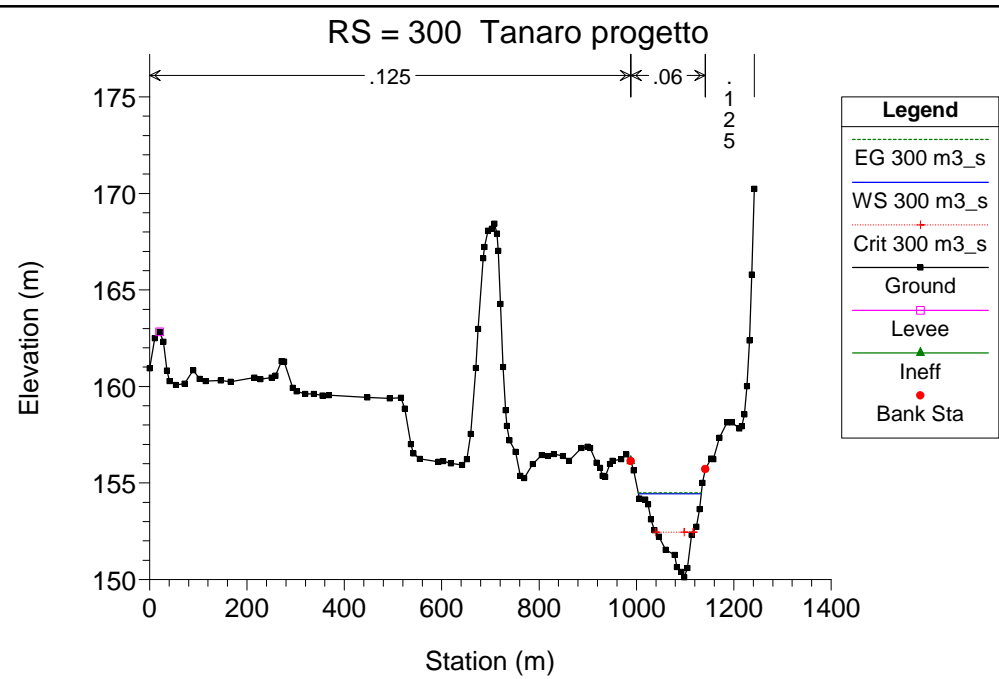
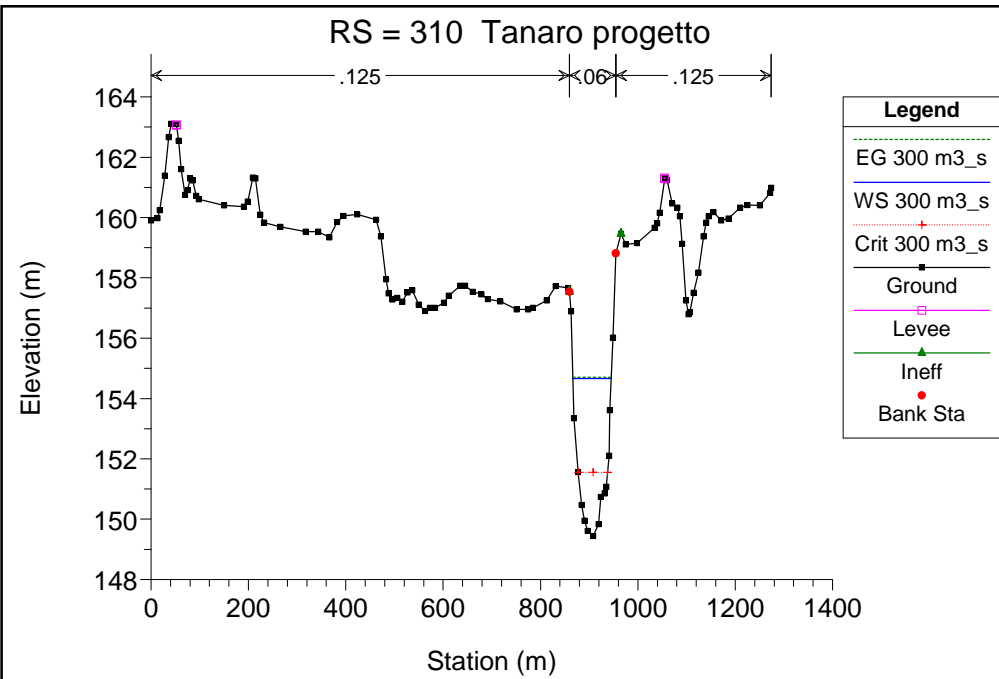


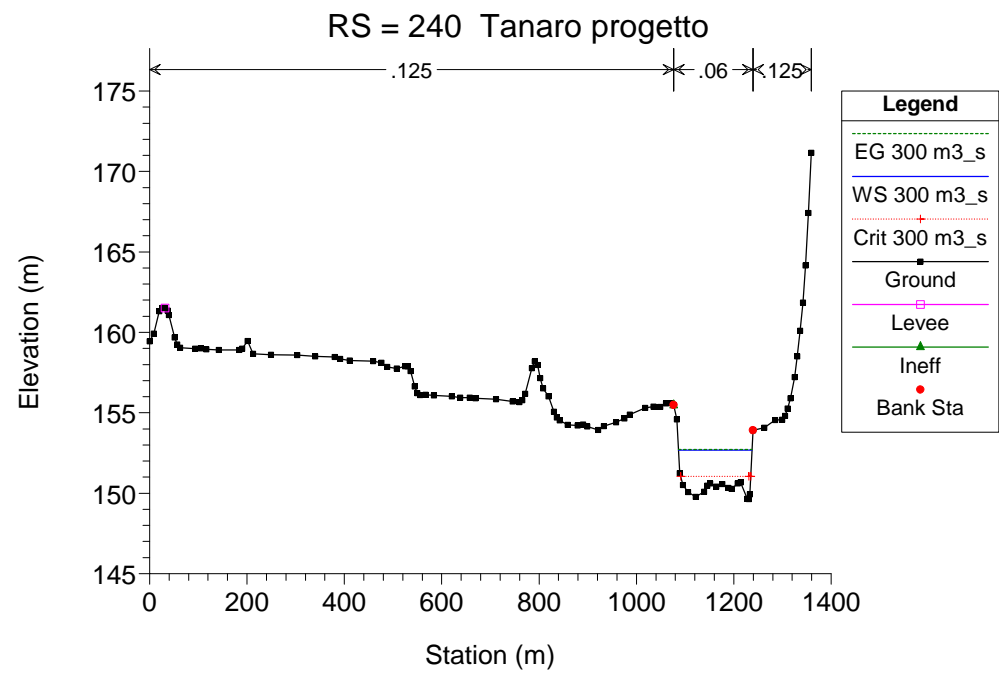
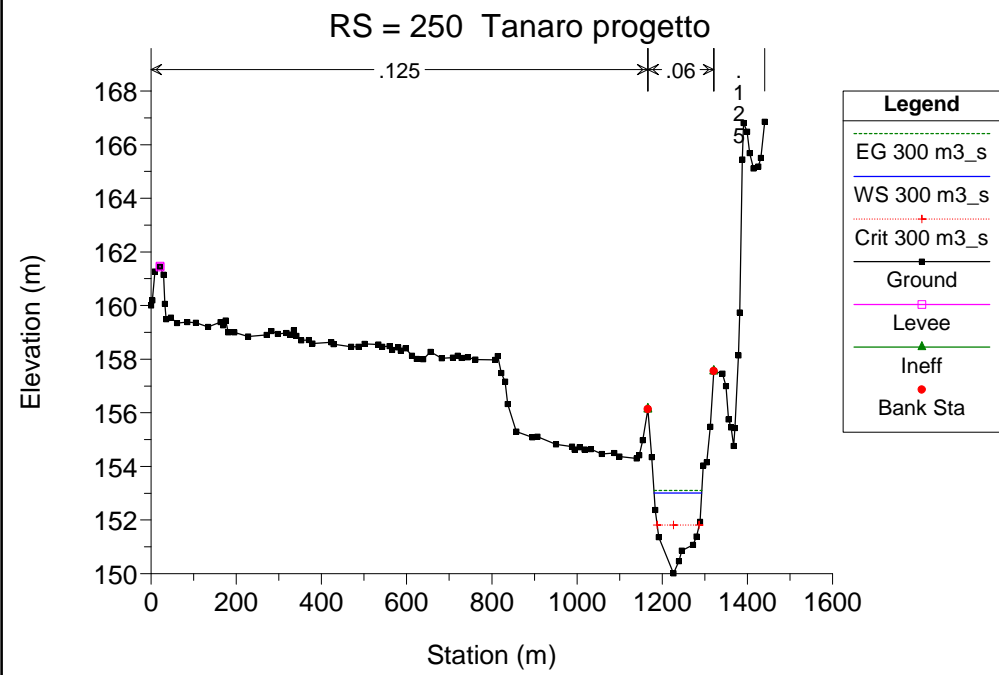
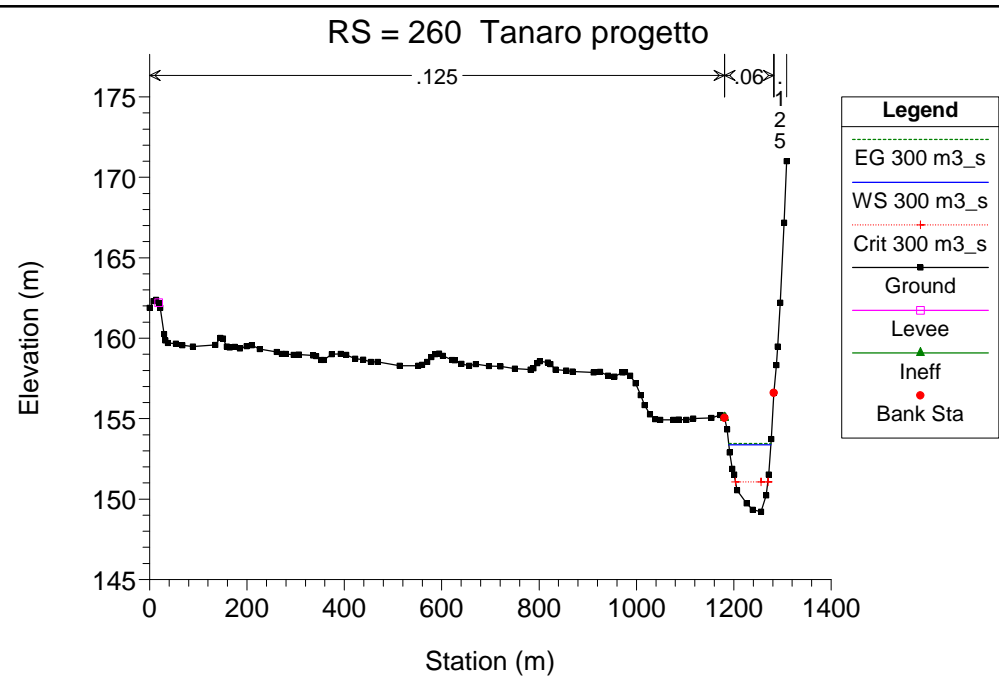
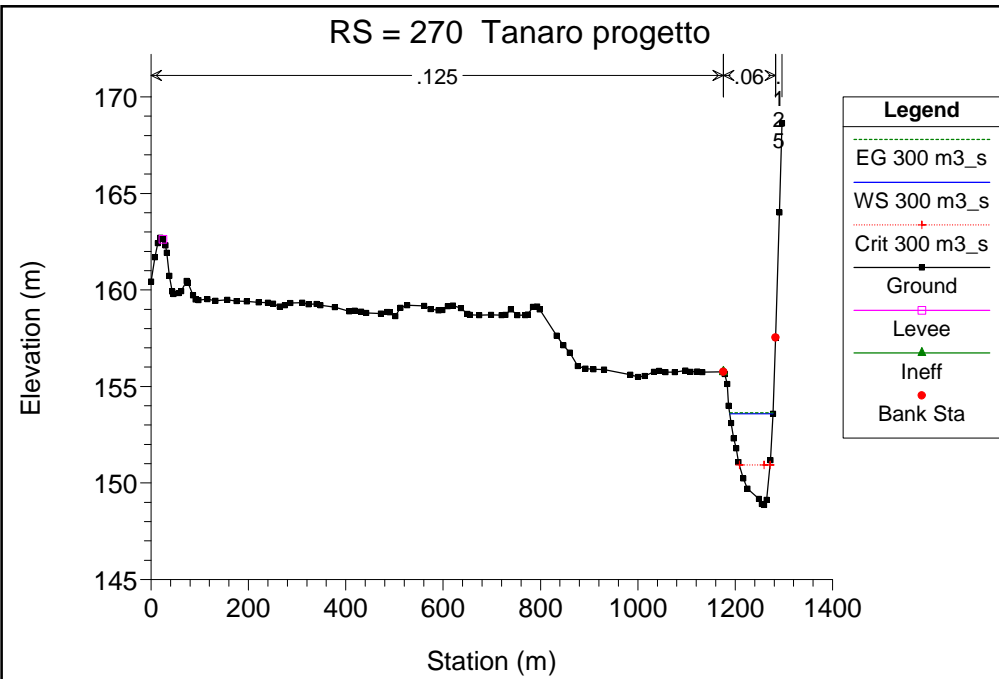


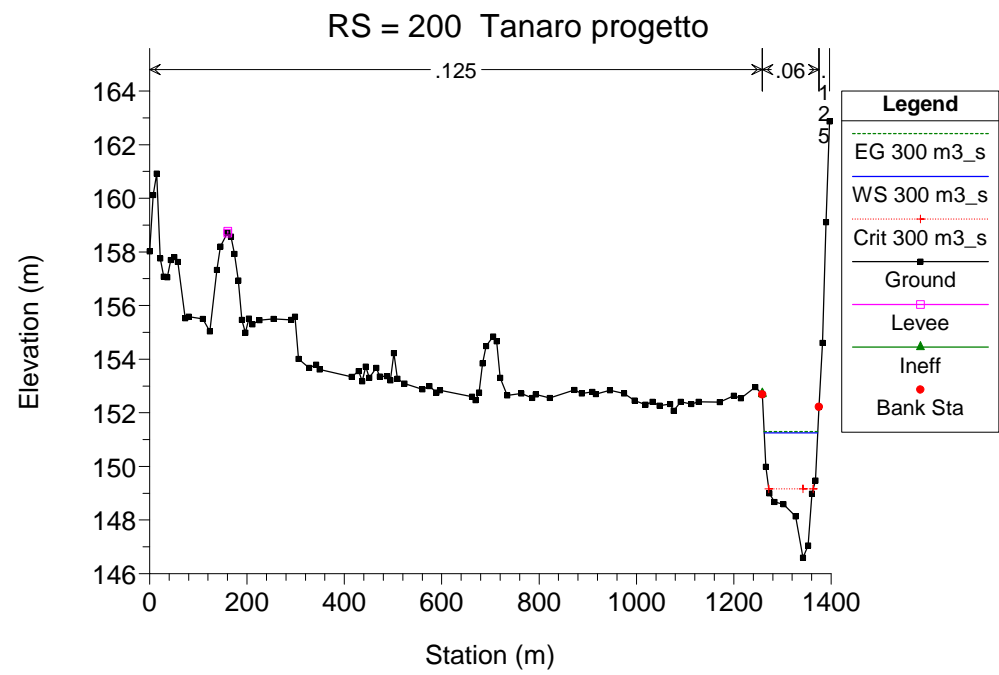
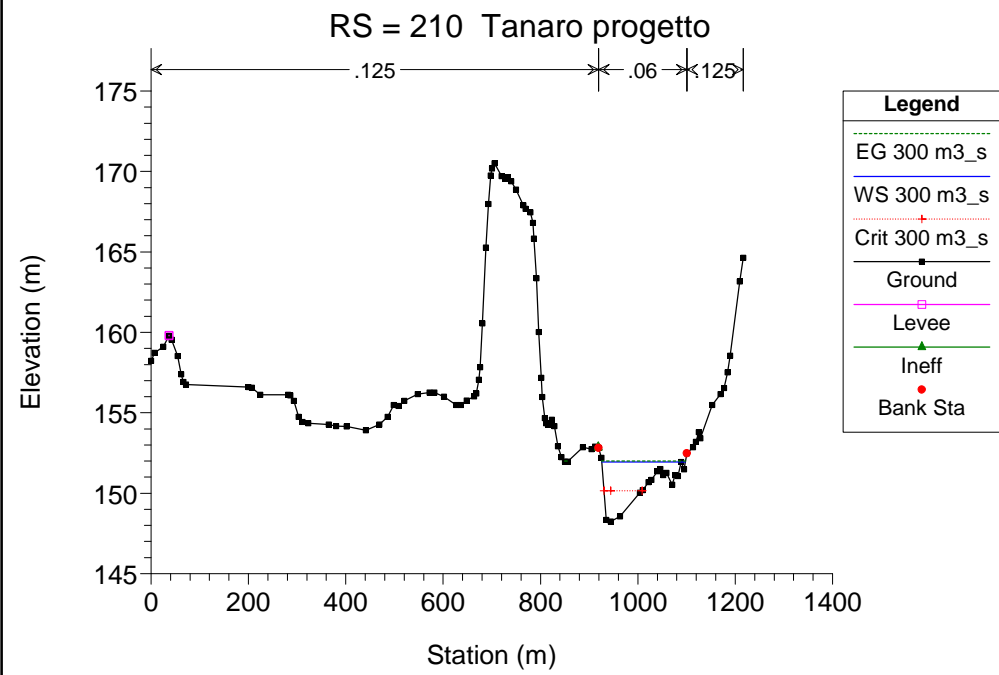
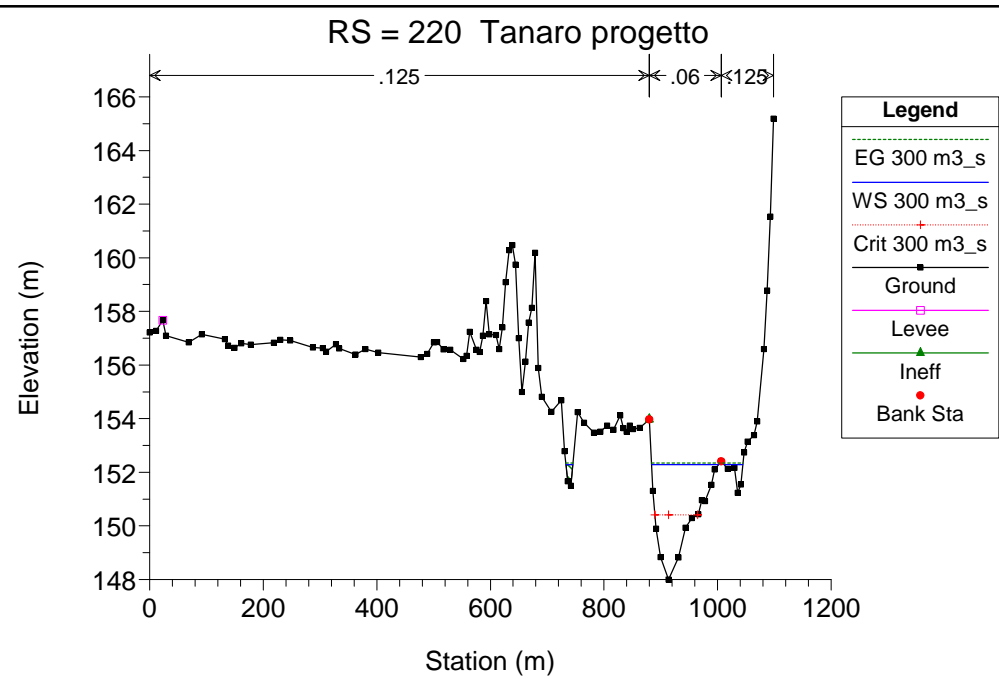
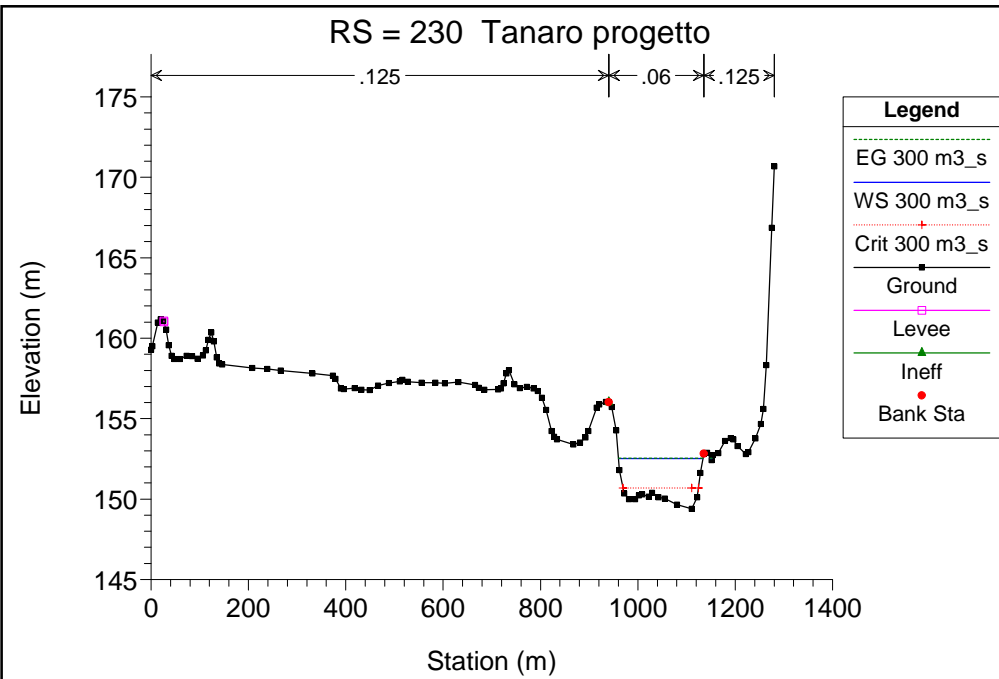


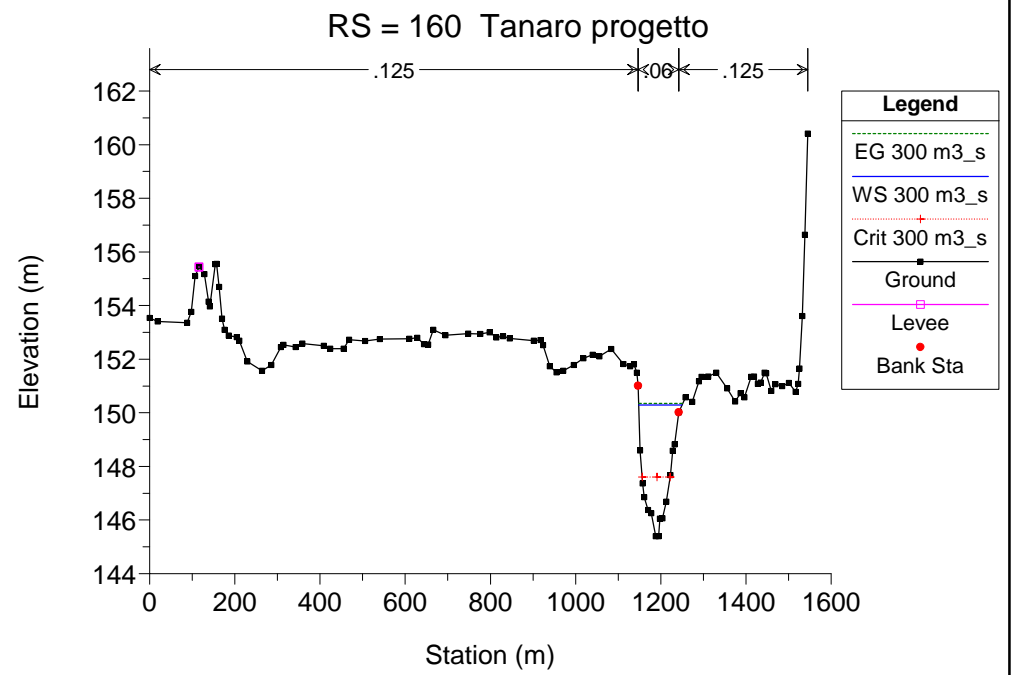
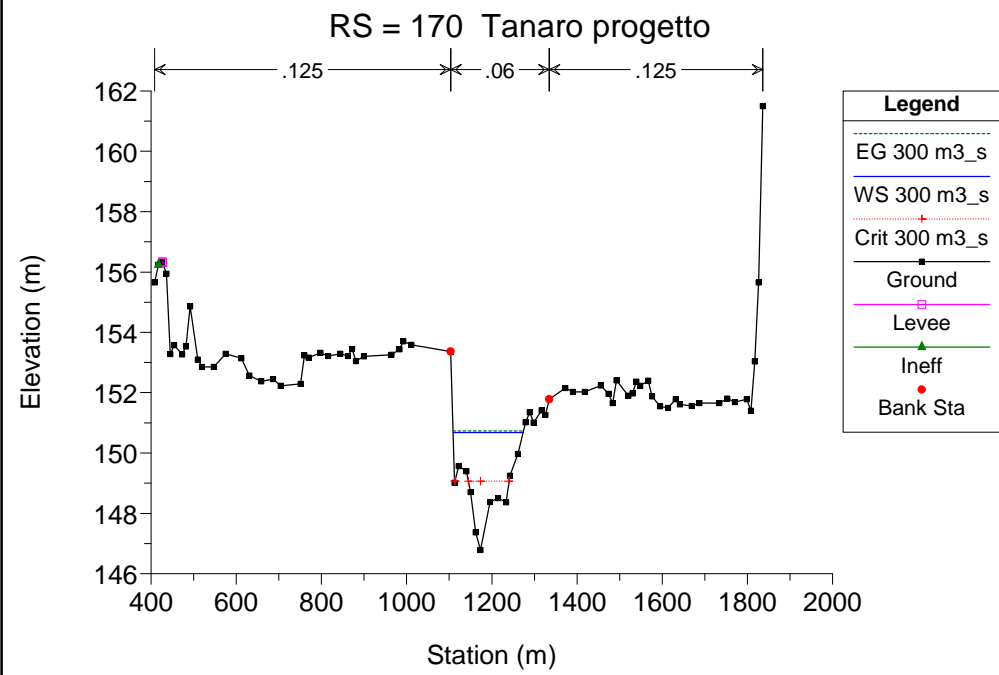
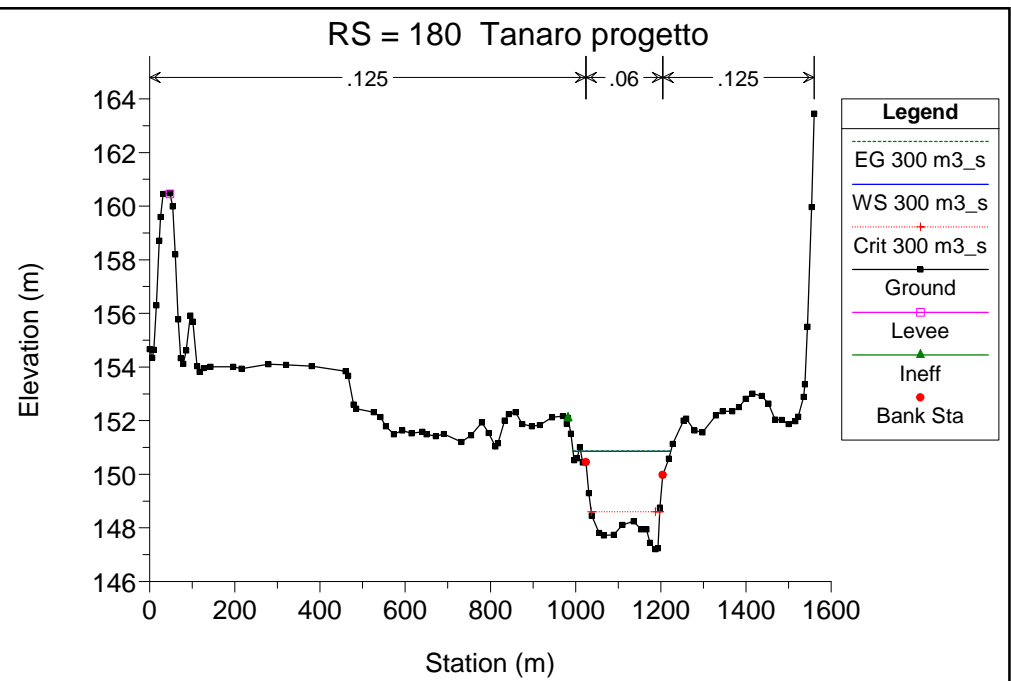
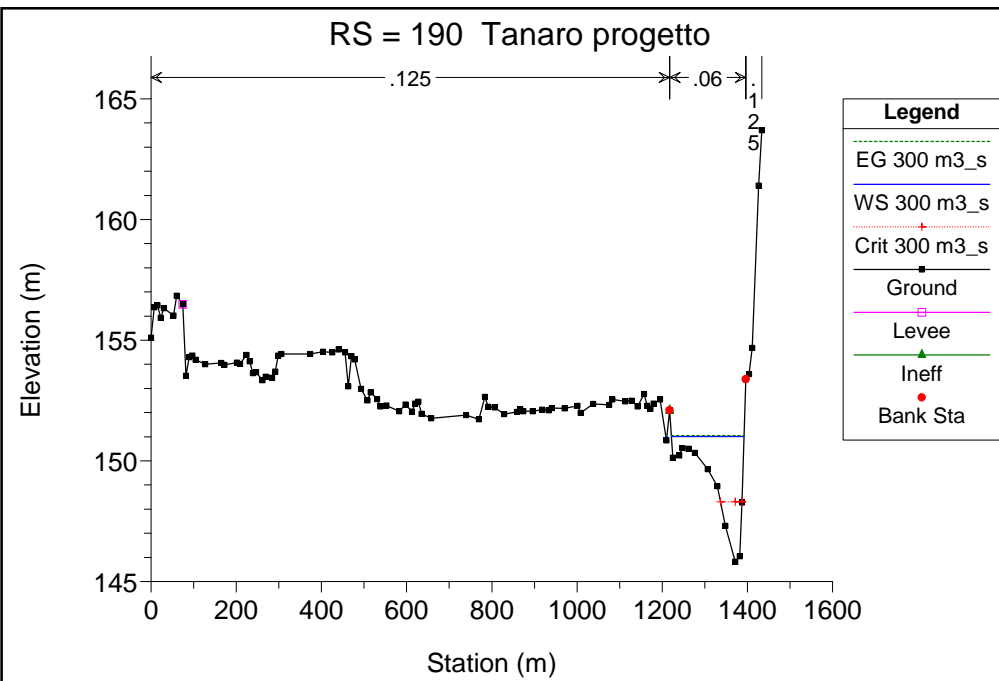


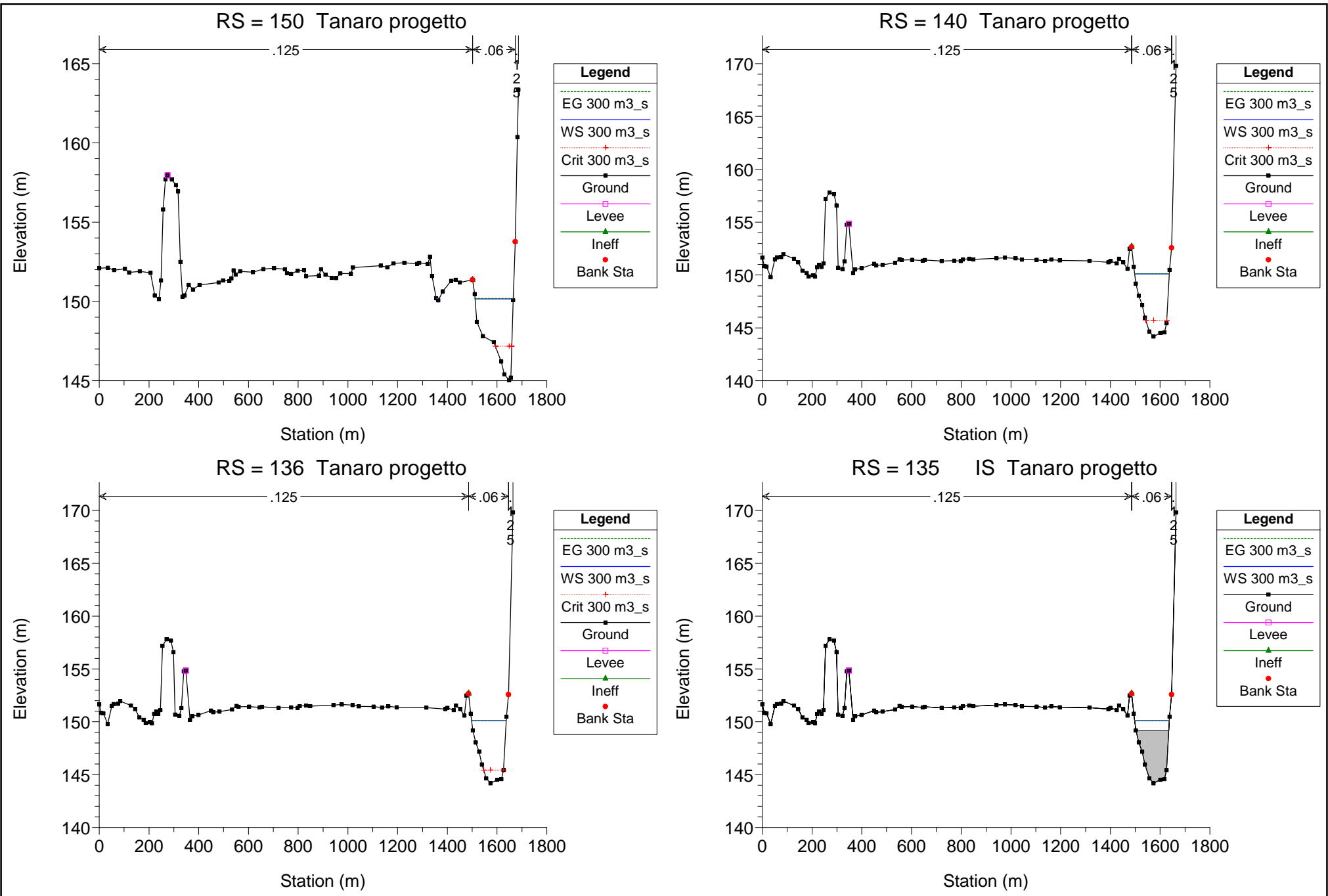


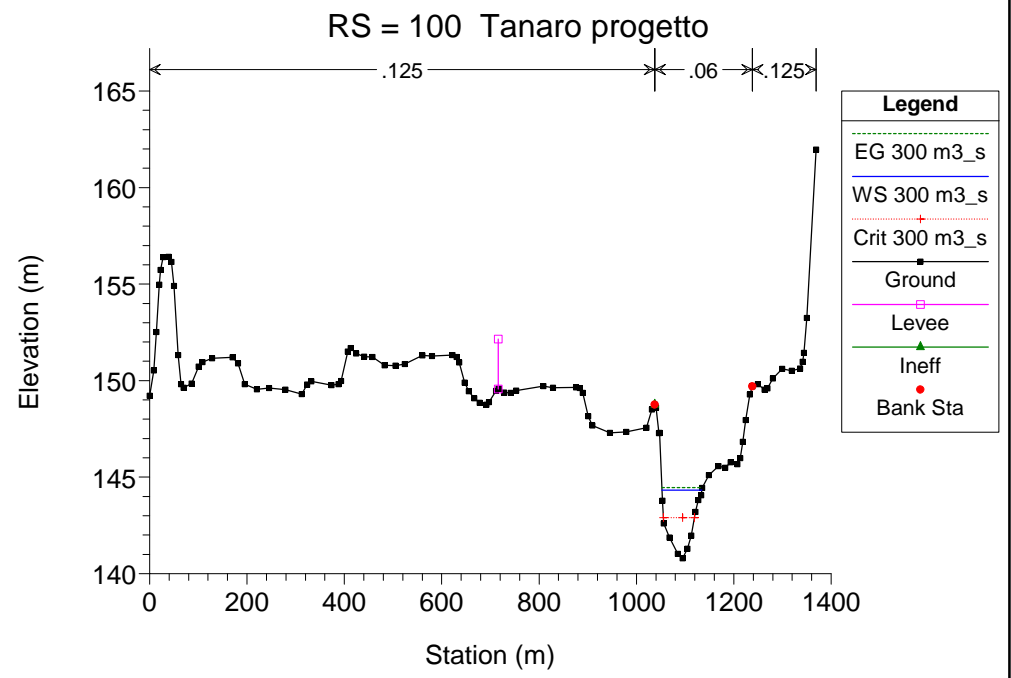
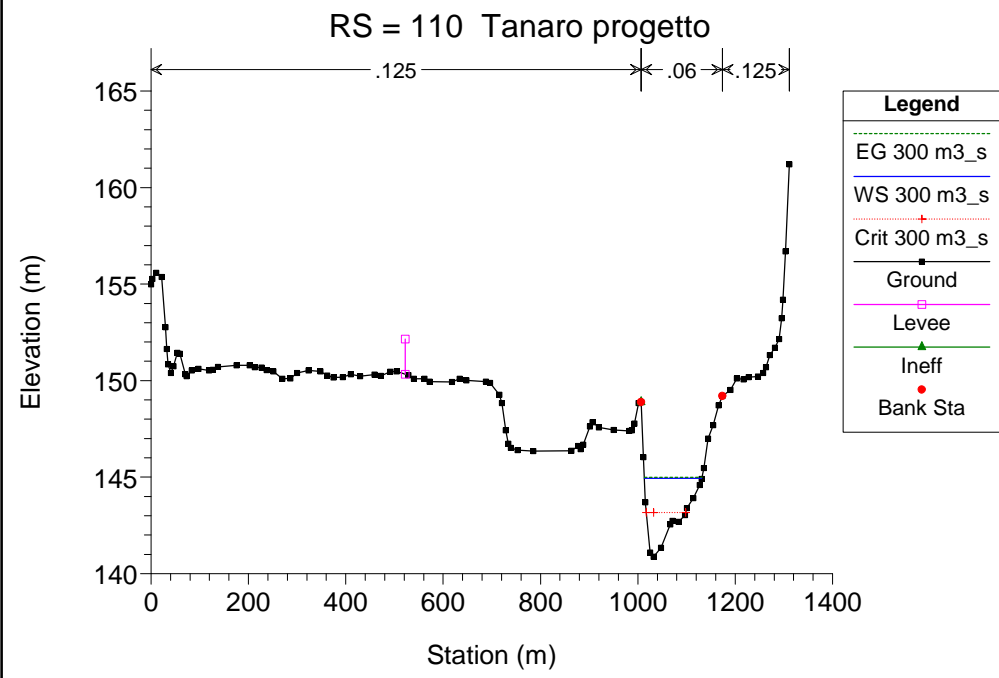
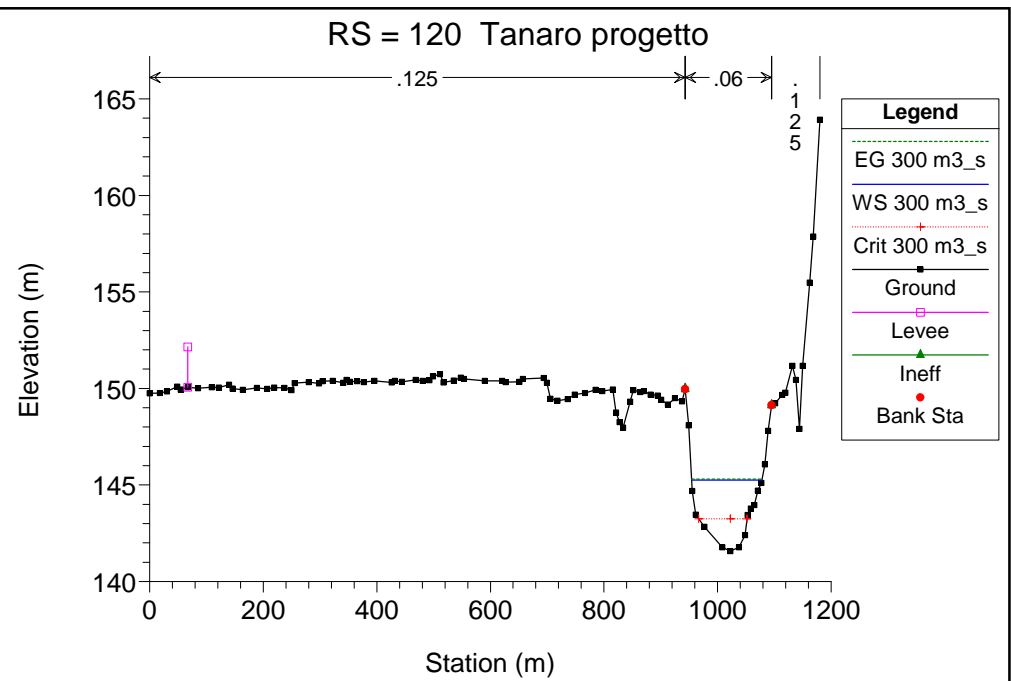
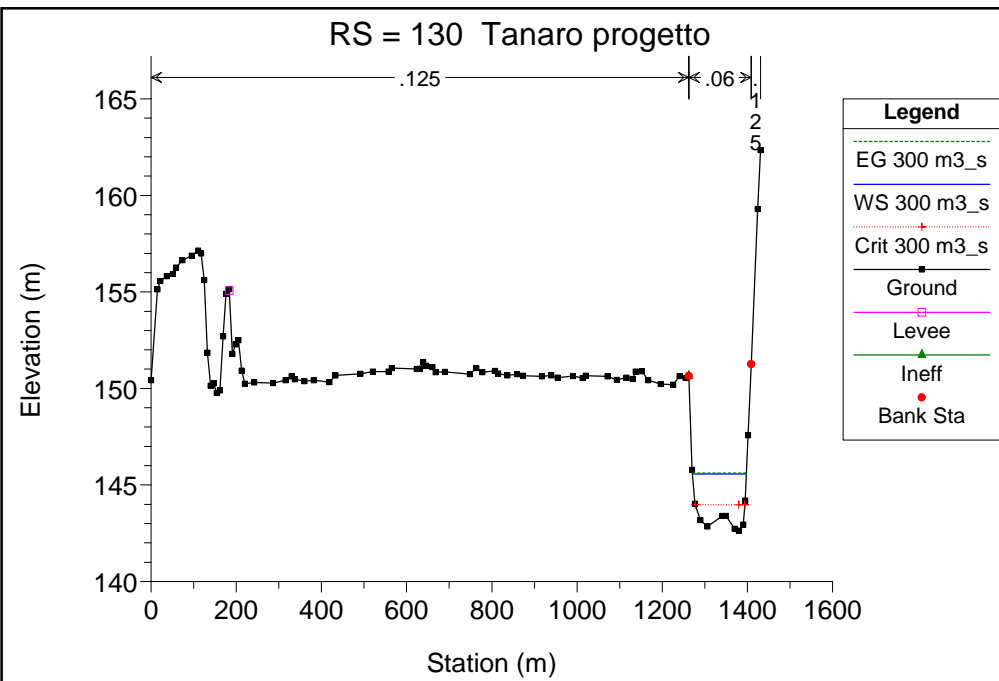


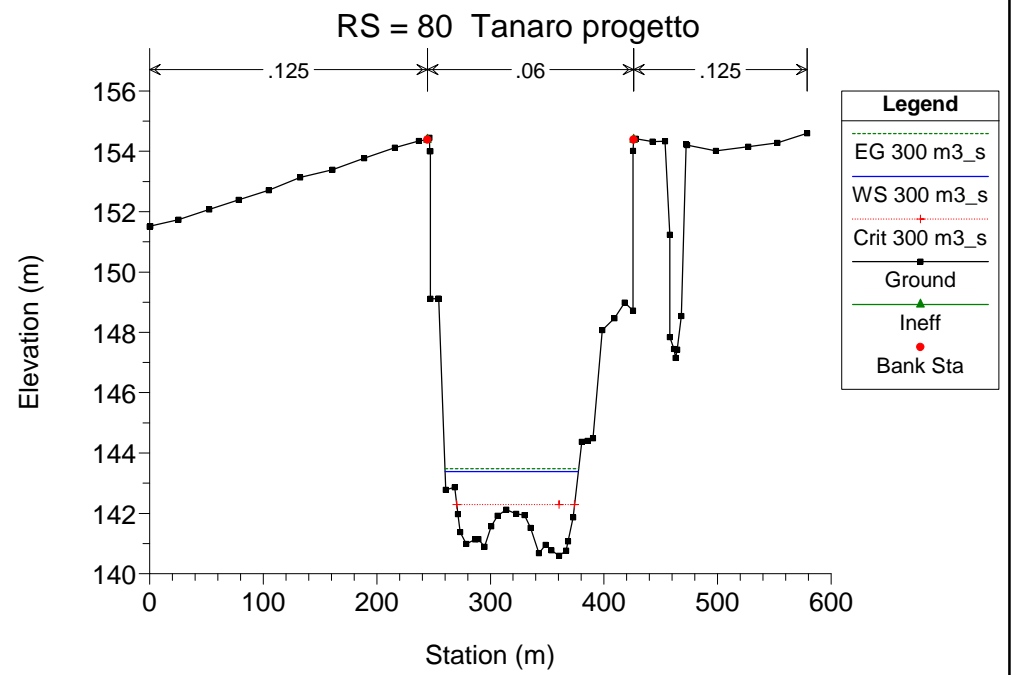
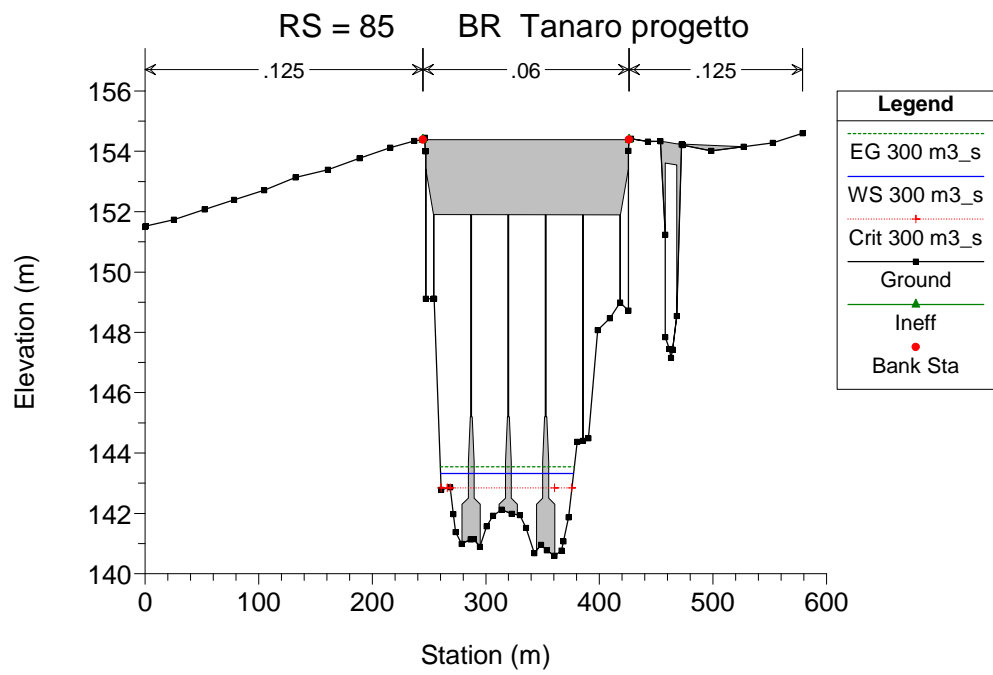
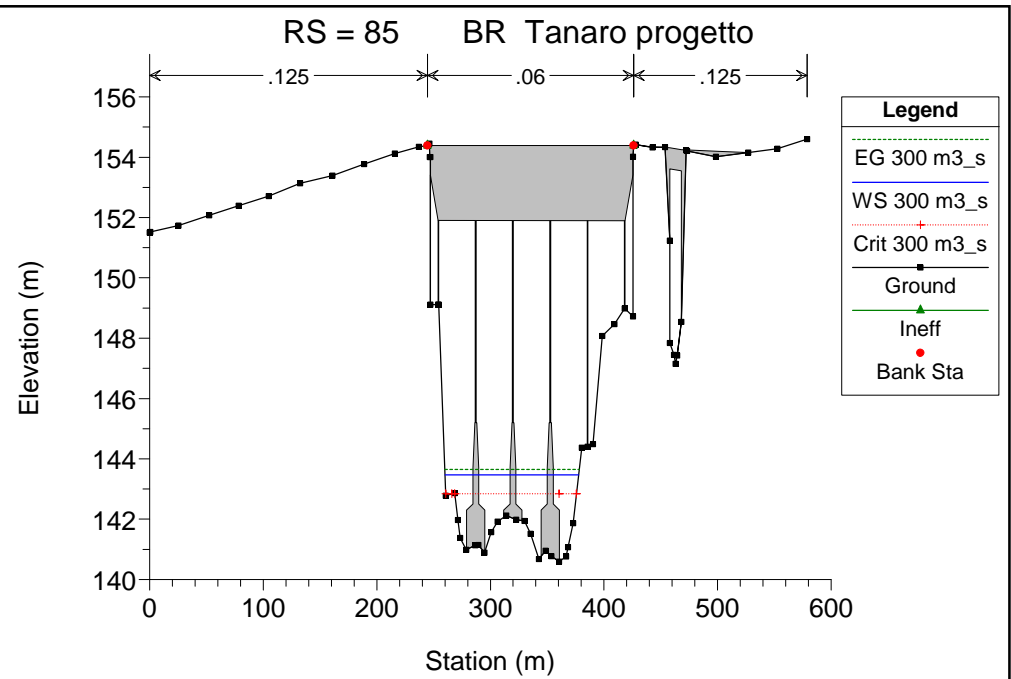
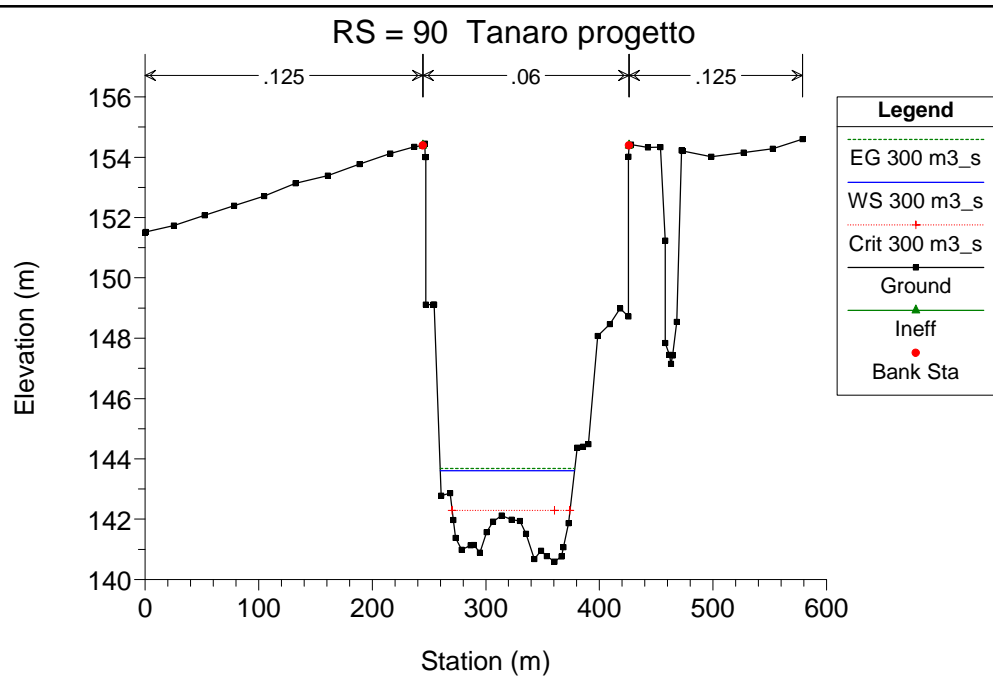


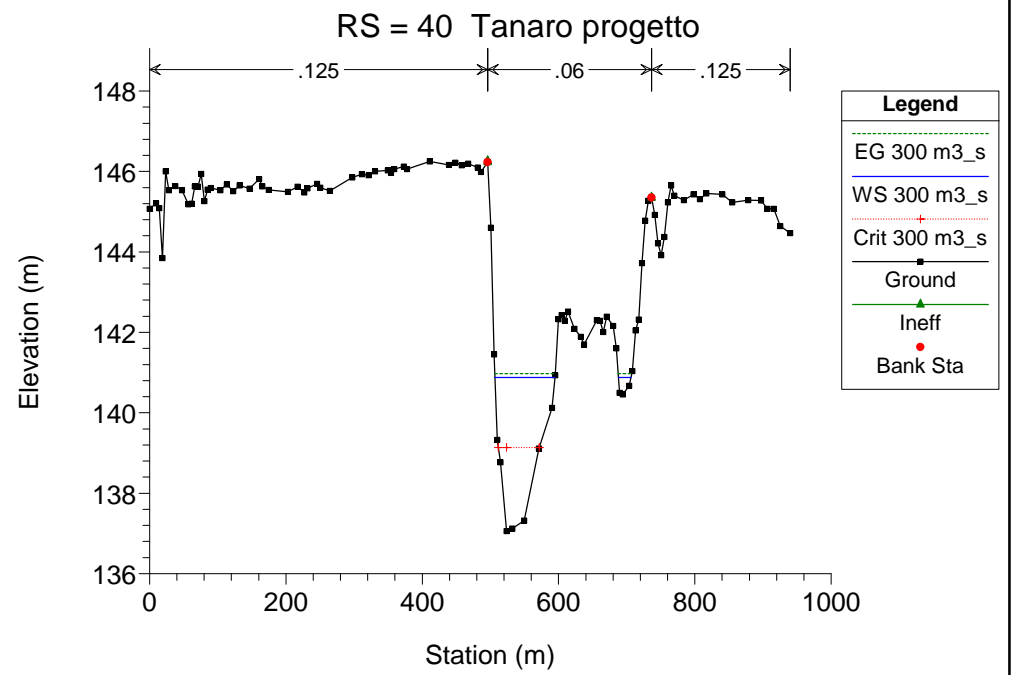
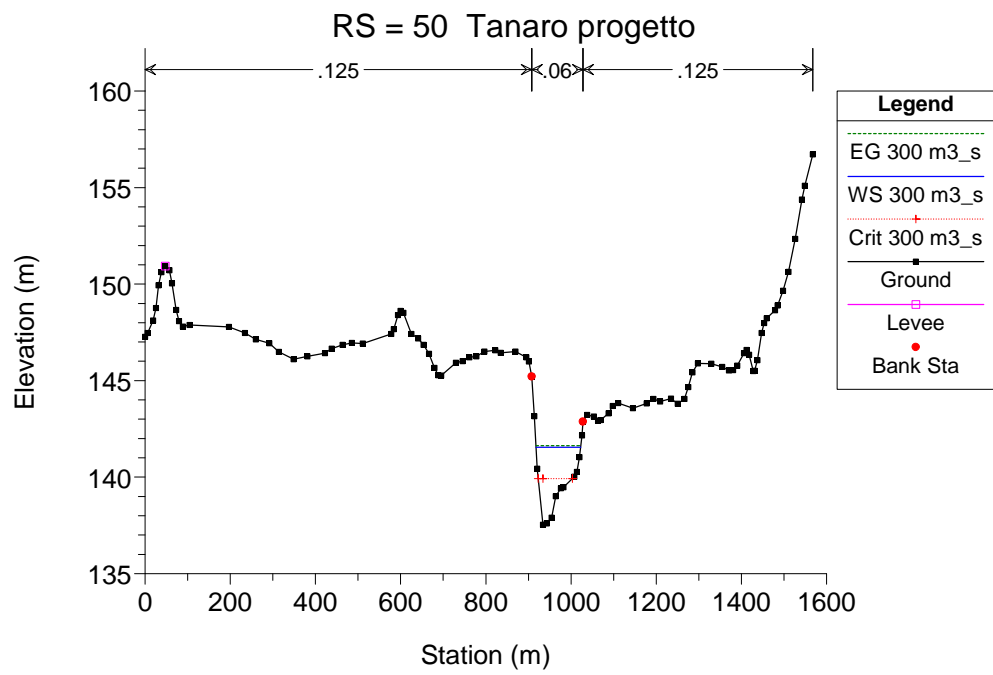
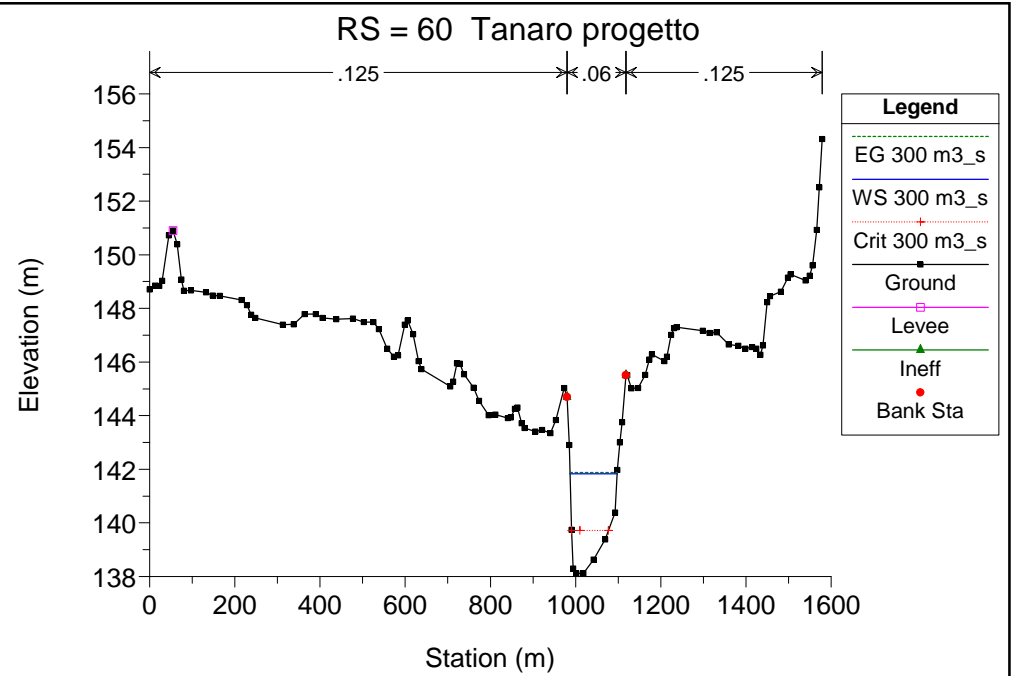
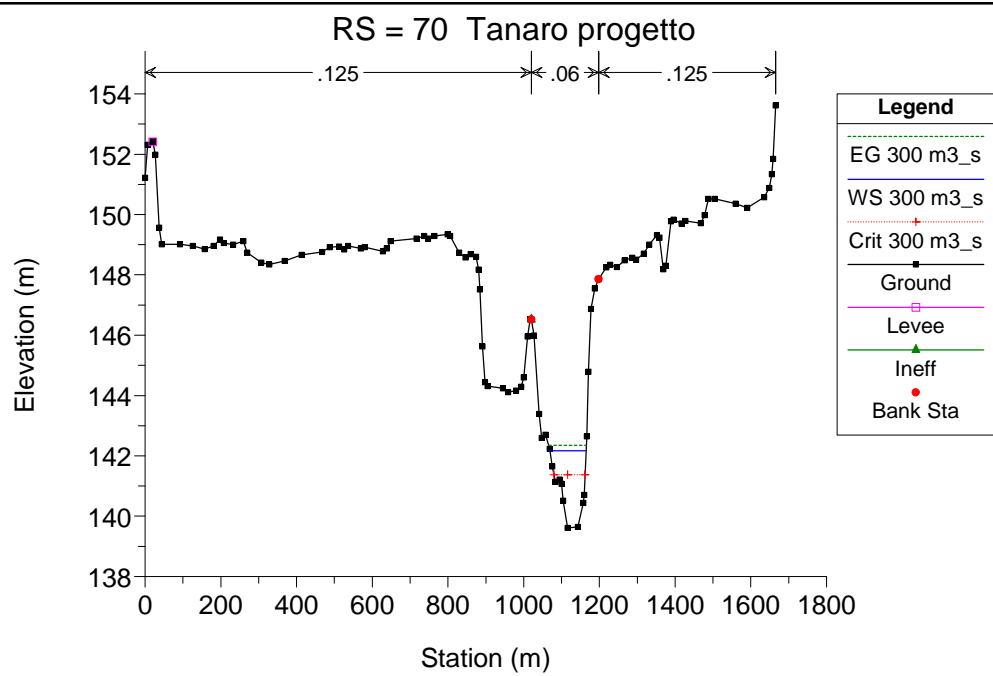


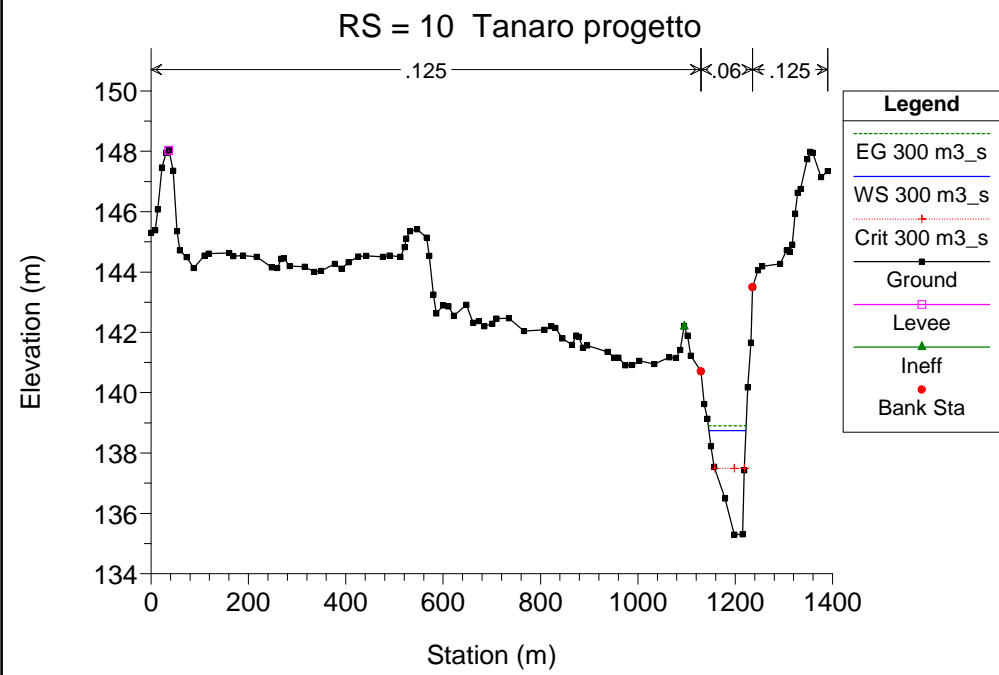
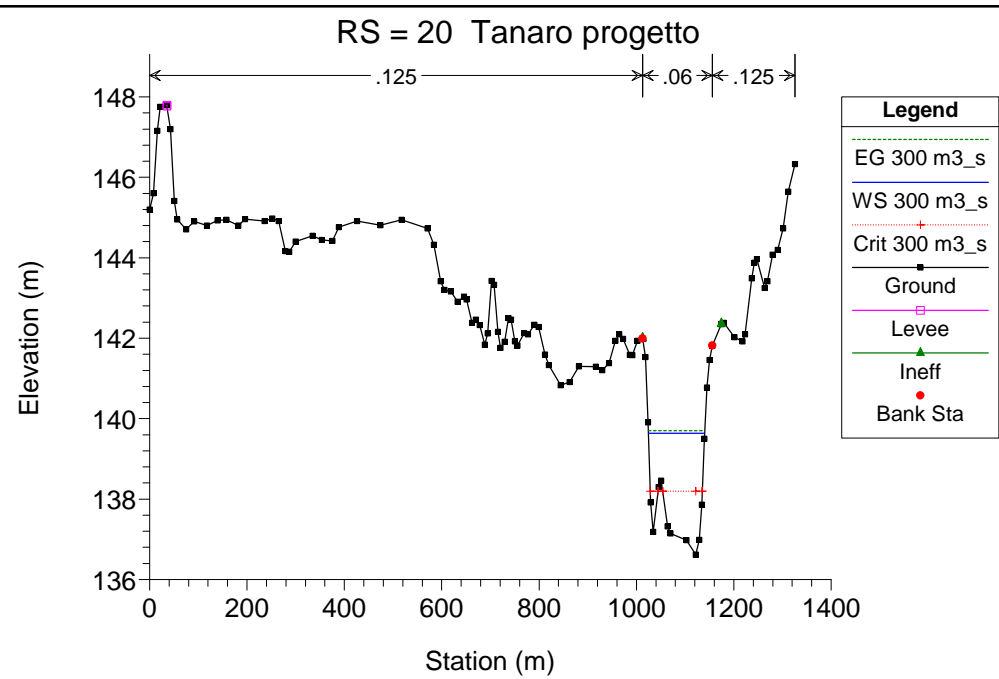
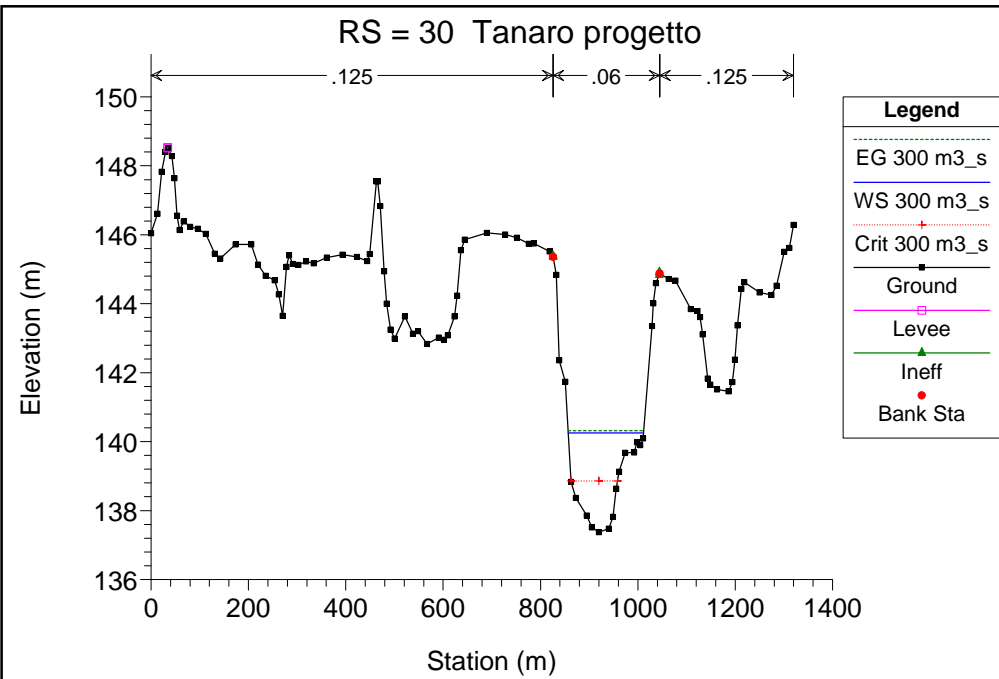












Nella tabella seguente si riportano i livelli a monte della traversa in progetto in corrispondenza dell'ingresso del canale di presa ed a valle in corrispondenza della sezione di restituzione, per le portate di funzionamento della centrale idroelettrica.

Portata [m ³ /s]	Livello monte traversa [m s.l.m]	Livello nella sezione di scarico [m s.l.m]
9.6	149.26	143.14
10.3	149.26	143.16
15	149.26	143.21
20	149.26	143.28
30	149.26	143.44
40	149.26	143.59
50	149.26	143.73
60	149.26	143.87
80	149.26	144.10
100	149.26	144.31
120	149.40	144.49
140	149.51	144.65
160	149.61	144.81
180	149.70	144.95
200	149.77	145.09
220	149.85	145.22
240	149.92	145.34
260	149.98	145.46
280	150.05	145.57
300	150.11	145.68

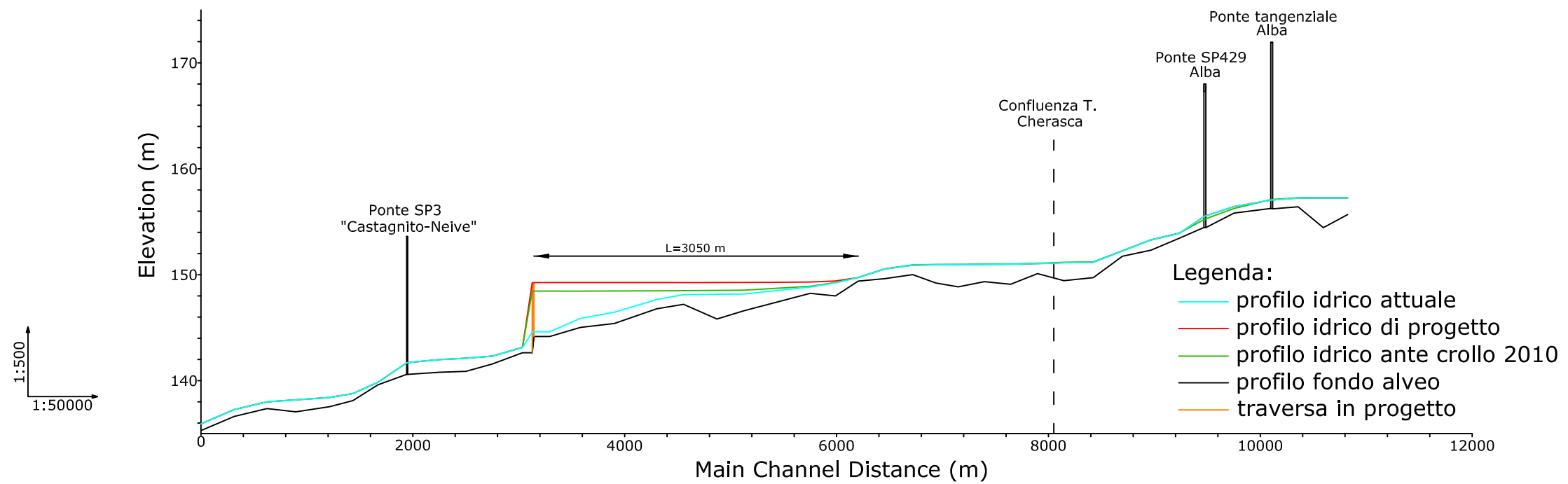
Tab. 7.1. Livelli a monte e a valle della traversa corrispondenti alle portate di funzionamento dell'impianto idroelettrico.

Dalle simulazioni idrauliche eseguite è possibile stimare una lunghezza massima del rigurgito provocato dalla traversa (con sbarramento mobile alzato) pari a circa 3050 m. Tale rigurgito si spinge al massimo fino a 1850 m a valle della confluenza con il torrente Cherasca.

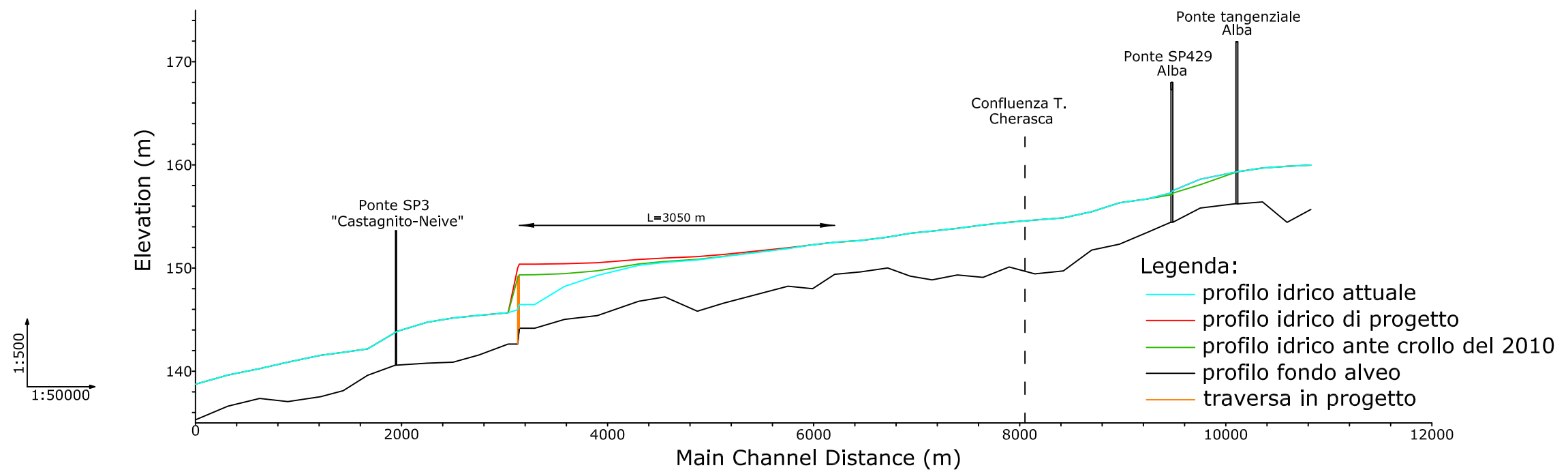
I livelli di rigurgito corrispondenti al range di operatività dell'impianto idroelettrico (portate in alveo comprese tra 9.6 e 300 m³/s), sono sempre ampiamente contenuti all'interno dell'alveo inciso del Fiume Tanaro.

Nella pagina seguente si riportano i profili di rigurgito con riferimento alle portate minima e massima di funzionamento dell'impianto.

Confronto profili idrici attuale-progetto
 $Q=9.6 \text{ m}^3/\text{s}$ (portata minima di funzionamento dell'impianto idroelettrico)



Confronto profili idrici attuale-progetto
 $Q=300 \text{ m}^3/\text{s}$ (portata massima di funzionamento dell'impianto idroelettrico)



8. VALUTAZIONE DEL VOLUME INVASATO

Quando l'impianto idroelettrico è in funzione la presenza della traversa fissa sormontata dallo sbarramento mobile determina il massimo rigurgito verso monte, per un'estensione pari a circa 3050 m.

Con riferimento alla minima portata di funzionamento dell'impianto (9.6 m³/s in alveo e 6.6 m³/s turbinati), l'innalzamento massimo del pelo libero rispetto alla situazione precedente al crollo del 2010 (rappresentativa di un utilizzo della derivazione per soli fini irrigui) è pari a 0.80 m, mentre l'innalzamento rispetto alla situazione attuale (con sbarramento divelto) è di 4.65 m.

Se si analizza invece la massima portata di funzionamento dell'impianto (300 m³/s in alveo e 100 m³/s turbinati), l'innalzamento massimo del pelo libero rispetto alla situazione precedente al crollo del 2010 (rappresentativa di un utilizzo della derivazione per soli fini irrigui) è pari a 0.76 m, mentre l'innalzamento rispetto alla situazione attuale è di 3.64 m.

I livelli di rigurgito associati alle portate di funzionamento dell'impianto sono sempre ampiamente contenuti all'interno dell'alveo inciso del Fiume Tanaro.

Con riferimento alla minima portata di funzionamento dell'impianto (9.6 m³/s in alveo e 6.6 m³/s turbinati), il volume massimo invasato a monte della traversa in progetto con sbarramento mobile alzato, per effetto del rigurgito provocato dall'opera stessa, rispetto alla situazione attuale, è pari a circa 447'000 m³; il volume massimo invasato a monte della traversa in progetto con sbarramento mobile abbassato, per effetto del rigurgito provocato dall'opera stessa, rispetto alla situazione attuale, è invece pari a circa 251'000 m³. L'incremento di volume invasato per scopo idroelettrico rispetto a quello invasato per il solo fine irriguo è quindi di 196'000 m³.

Analizzando invece la massima portata di funzionamento dell'impianto (300 m³/s in alveo e 100 m³/s turbinati), si osserva che il volume massimo invasato a monte della traversa in progetto con sbarramento mobile alzato, per effetto del rigurgito provocato dall'opera stessa, rispetto alla situazione attuale, è pari a circa 312'000 m³; il volume massimo invasato a monte della traversa in progetto con sbarramento mobile abbassato, per effetto del

rigurgito provocato dall'opera stessa, rispetto alla situazione attuale, è invece pari a circa 183'000 m³. L'incremento di volume invasato per scopo idroelettrico rispetto a quello invasato per il solo fine irriguo è quindi di 129'000 m³.

9. DIMENSIONAMENTO VASCA DI DISSIPAZIONE

Immediatamente a valle del corpo traversa al fine di evitare problemi legati all'erosione e lo scalzamento della traversa, come già avvenuto a seguito degli eventi alluvionali del 2010 (che hanno determinato il crollo di buona parte dello sbarramento), è prevista la realizzazione di una vasca di dissipazione con sistemazione del fondo in massi cementati.

Il calcolo idraulico del bacino di dissipazione si opera utilizzando la teoria del risalto idraulico (Bidone) applicando la conservazione dell'energia fra sezioni di monte (sezione 0) e di valle (sezione 1) del paramento inclinato della traversa. Trascurando le resistenze passive si ha:

$$y_0 + \frac{Q^2}{2g\Omega_0^2} = y_1 + \frac{Q^2}{2g\Omega_1^2 l_b^2}$$

dove con y_0 si intende il dislivello tra il pelo libero di monte e il fondo del bacino (sezione 0 a monte della traversa), y_1 l'altezza del pelo libero dal fondo del bacino (nella sezione 1 all'interno del bacino) e Ω_0 l'area della sezione bagnata nella sezione 0 e l_b la larghezza del bacino di dissipazione.

Da cui nota la profondità y_1 è possibile valutare la profondità coniugata dalla teoria del risalto che vale nella sezione a valle del dissipatore, mediante la seguente equazione

$$\frac{y_2}{y_1} = \frac{1}{2} \sqrt{1 + 8 \cdot Fr_1^2} - 1$$

dove il numero di Froude è determinato mediante la relazione:

$$Fr_1 = \frac{Q}{B y_1 g \sqrt{y_1}}$$

Infine si determina la soglia terminale della vasca di dissipazione a mediante la relazione :

$$\alpha = (y_2 - y_3) + \frac{Q^2}{2gB^2} \left(\frac{1}{y_2^3} + \frac{1}{y_3^3} \right)$$

dove y_3 è l'altezza dell'acqua a valle della vasca, pari all'altezza di moto uniforme (se l'alveo a valle è a debole pendenza), della corrente nella sezione 1 o all'altezza critica se l'alveo a valle è a forte pendenza.

Il procedimento sopra descritto risulta iterativo di complessa risoluzione; pertanto esso è stato risolto in per tentativi portando il risalto a ridosso del paramento inclinato della traversa.

La lunghezza del dissipatore, valutata come 6 volte l'altezza y_2 , consente il mantenimento del risalto nella vasca di dissipazione ed è pari a circa 15 m, mentre l'altezza del dente di valle è di circa 1.37 m, rispetto all'asse di posa dei massi di rivestimento.

Tale dimensionamento è stato successivamente verificato mediante la realizzazione di un modello in HEC-RAS di cui si riportano sinteticamente i risultati

Metodo di calcolo

Il programma di simulazione utilizzato HEC-RAS 4.1.0 permette, tramite l'utilizzo di una procedura di calcolo iterativa, la risoluzione delle equazioni che descrivono il moto permanente gradualmente vario (moto di una corrente a pelo libero costante nel tempo, con variazioni graduali di sezione ed eventualmente di direzione). La simulazione dei flussi permette di analizzare la capacità dei corsi d'acqua (rischi di esondazioni) e lo studio d'impatto a seguito di modificazioni delle condizioni al contorno (tipo l'inserimento di ponti, sbarramenti ecc.). I calcoli dei flussi in moto gradualmente vario sono basati sull'equazione di Bernoulli; le perdite di carico sono valutate con l'equazione di Manning - Strickler per il termine di scabrezza, e da coefficienti di contrazione ed espansione. Nel caso di moti bruscamente vari l'equazione utilizzata è quella della quantità di moto; quest'ultima è applicata nei restringimenti e in particolari casi come il passaggio della corrente in presenza di pile di ponti o nelle confluenze.

La risoluzione di queste equazioni necessita la conoscenza della geometria del corso d'acqua, delle caratteristiche di rugosità e della portata del flusso;

le condizioni al contorno non ricavabili direttamente per mancanza di dati rilevati direttamente, vengono calcolate dal programma a partire dalla profondità critica.

I dati necessari all'esecuzione della procedura di calcolo sono i seguenti:

- geometria delle sezioni, espressa mediante coppie di coordinate (progressiva, quota) distanza tra la sezione ennesima e quella successiva;
- coefficiente di scabrezza n di Manning, in particolare i valori adottati nel presente studio sono i seguenti:
 - o $0.125 \text{ m}^{-1/3}\text{s}$ per il fondo alveo,
 - o $0.125 \text{ m}^{-1/3}\text{s}$ per le aree golenali caratterizzate da vegetazione prativa,
 - o $0.060 \text{ m}^{-1/3}\text{s}$ per la traversa.
- coefficienti di contrazione-espansione dell'alveo nel tratto compreso tra la sezione ennesima e quella successiva.

Nelle simulazioni è stato imposto al modello una condizione di moto uniforme con pendenza al fondo di 0.004% a valle e 0.004% a monte.

Risultati verifica dissipatore

Al fine di tenere in considerazione la presenza dei massi cementanti si è valutata un scabrezza equivalente di Manning pari a $0.06 \text{ m}^{-1/3}\text{s}$.

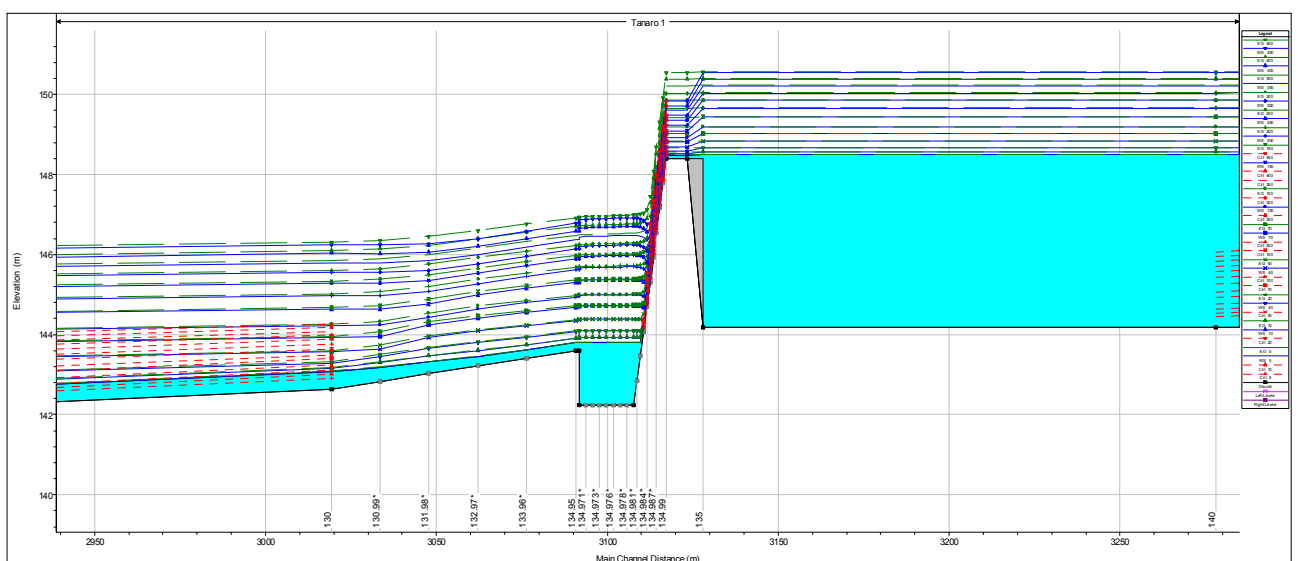


Fig. 8.1 valutazione della posizione del risalto idraulico con differenti portate.

La tabella seguente illustra la valutazione dei livelli e delle portate rispettivamente nelle sezioni 0 (134.99), sez.1 (134.98), sez 2. (134.97) e sez.3 (134.96) sopra riportate nel dimensionamento teorico del dissipatore a risalto idraulico

Reac h	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
1	134.99	5	5	148.4	148.47	148.47	148.51	0.37091	0.84	5.99	84.2	1
1	134.99	10	10	148.4	148.51	148.51	148.57	0.31778	1.05	9.51	84.2	1
1	134.99	20	20	148.4	148.58	148.58	148.67	0.28243	1.34	14.94	84.2	1.01
1	134.99	40	40	148.4	148.68	148.68	148.83	0.23786	1.68	23.86	84.2	1.01
1	134.99	70	70	148.4	148.81	148.81	149.02	0.2117	2.02	34.61	84.2	1.01
1	134.99	100	100	148.4	148.92	148.92	149.19	0.19554	2.28	43.94	84.2	1.01
1	134.99	150	150	148.4	149.08	149.08	149.43	0.17964	2.6	57.58	84.2	1.01
1	134.99	200	200	148.4	149.23	149.23	149.65	0.16906	2.87	69.78	84.2	1
1	134.99	250	250	148.4	149.36	149.36	149.85	0.16146	3.09	80.96	84.2	1.01
1	134.99	300	300	148.4	149.49	149.49	150.03	0.15572	3.28	91.44	84.2	1
1	134.99	350	350	148.4	149.6	149.6	150.21	0.15083	3.45	101.35	84.2	1
1	134.99	400	400	148.4	149.72	149.72	150.38	0.14728	3.61	110.75	84.2	1.01
1	134.99	450	450	148.4	149.83	149.83	150.54	0.14154	3.74	120.41	85.52	1
1	134.99	TR 20	2050	148.4	152.02		152.19	0.0205	2.63	1503.81	1548.61	0.44
1	134.99	TR 100	2750	148.4	152.27		152.44	0.0195	2.68	1898.33	1554.11	0.43
1	134.99	TR 200	3050	148.4	152.49		152.62	0.01497	2.43	2234.27	1558.78	0.38

Reac h	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
1	134.98	5	5	142.23	143.81		143.81	1.3E-05	0.04	133.28	84.2	0.01
1	134.98	10	10	142.23	143.92		143.92	0.00004	0.07	142.62	84.2	0.02
1	134.98	20	20	142.23	144.1		144.1	0.00012	0.13	157.68	84.2	0.03
1	134.98	40	40	142.23	144.39		144.39	0.00029	0.22	181.76	84.2	0.05
1	134.98	70	70	142.23	144.73		144.73	0.00055	0.33	210.32	84.2	0.07
1	134.98	100	100	142.23	145		145.01	0.00081	0.43	232.91	84.2	0.08
1	134.98	150	150	142.23	145.38		145.39	0.0012	0.57	265.06	84.2	0.1
1	134.98	200	200	142.23	145.7		145.72	0.00154	0.68	291.98	84.2	0.12
1	134.98	250	250	142.23	145.99		146.02	0.00188	0.79	316.29	84.2	0.13
1	134.98	300	300	142.23	146.25		146.29	0.00217	0.89	338.13	84.2	0.14
1	134.98	350	350	142.23	146.49		146.53	0.00244	0.98	358.28	84.2	0.15
1	134.98	400	400	142.23	146.71		146.77	0.0027	1.06	377.32	84.2	0.16
1	134.98	450	450	142.23	146.92		146.99	0.00296	1.14	395.22	84.2	0.17
1	134.98	TR 20	2050	142.23	150.9		151.27	0.00817	2.72	863.02	367.97	0.29
1	134.98	TR 100	2750	142.23	152.04		152.28	0.00584	2.5	2050.06	1548.99	0.25
1	134.98	TR 200	3050	142.23	152.32		152.51	0.00514	2.38	2484.08	1555.04	0.24

**RICOSTRUZIONE DI SBARRAMENTO FLUVIALE ESISTENTE AD USO IRRIGUO CON INNALZAMENTO
ABBATTIBILE AD USO IDROELETTRICO E CENTRALE IN CORPO TRAVERSA**

Reac h	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
1	134.97	5	5	142.23	143.81		143.81	1.3E-05	0.04	133.26	84.2	0.01
1	134.97	10	10	142.23	143.92		143.92	0.00004	0.07	142.57	84.2	0.02
1	134.97	20	20	142.23	144.1		144.1	0.00012	0.13	157.52	84.2	0.03
1	134.97	40	40	142.23	144.38		144.39	0.00029	0.22	181.36	84.2	0.05
1	134.97	70	70	142.23	144.72		144.72	0.00055	0.33	209.57	84.2	0.07
1	134.97	100	100	142.23	144.98		144.99	0.00082	0.43	231.81	84.2	0.08
1	134.97	150	150	142.23	145.36		145.38	0.00121	0.57	263.41	84.2	0.1
1	134.97	200	200	142.23	145.67		145.7	0.00158	0.69	289.85	84.2	0.12
1	134.97	250	250	142.23	145.96		145.99	0.00193	0.8	313.68	84.2	0.13
1	134.97	300	300	142.23	146.21		146.25	0.00224	0.9	335.1	84.2	0.14
1	134.97	350	350	142.23	146.44		146.49	0.00252	0.99	354.86	84.2	0.15
1	134.97	400	400	142.23	146.67		146.72	0.0028	1.07	373.51	84.2	0.16
1	134.97	450	450	142.23	146.87		146.94	0.00307	1.15	391.04	84.2	0.17
1	134.97	TR 20	2050	142.23	150.74		151.13	0.00889	2.8	808.44	309.18	0.31
1	134.97	TR 100	2750	142.23	151.87		152.18	0.00706	2.71	1797.78	1533.77	0.28
1	134.97	TR 200	3050	142.23	152.19		152.43	0.00597	2.55	2288.4	1552.31	0.26
Reac h	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
1	134.96	5	5	143.6	143.81		143.81	0.01031	0.29	17.53	84.2	0.2
1	134.96	10	10	143.6	143.92		143.92	0.01039	0.38	26.56	84.2	0.21
1	134.96	20	20	143.6	144.09		144.1	0.00976	0.49	41.12	84.2	0.22
1	134.96	40	40	143.6	144.37		144.38	0.00885	0.62	64.41	84.2	0.23
1	134.96	70	70	143.6	144.69		144.72	0.00826	0.76	92	84.2	0.23
1	134.96	100	100	143.6	144.95		144.99	0.00846	0.88	113.67	84.2	0.24
1	134.96	150	150	143.6	145.32		145.37	0.00866	1.04	144.5	84.2	0.25
1	134.96	200	200	143.6	145.62		145.69	0.00891	1.17	170.22	84.2	0.26
1	134.96	250	250	143.6	145.9		145.98	0.00925	1.29	193.43	84.2	0.27
1	134.96	300	300	143.6	146.14		146.24	0.0095	1.4	214.27	84.2	0.28
1	134.96	350	350	143.6	146.37		146.49	0.00978	1.5	233.48	84.2	0.29
1	134.96	400	400	143.6	146.59		146.72	0.01003	1.59	251.64	84.2	0.29
1	134.96	450	450	143.6	146.79		146.93	0.0103	1.67	268.69	84.2	0.3
1	134.96	TR 20	2050	143.6	150.5		151.11	0.01754	3.49	628.31	227.82	0.42
1	134.96	TR 100	2750	143.6	151.69	148.37	152.16	0.01293	3.33	1405.12	1497.26	0.37
1	134.96	TR 200	3050	143.6	152.14		152.42	0.00867	2.83	2100.81	1551.3	0.31

10. VERIFICA AL SIFONAMENTO

Per sifonamento si intende la rimozione da parte del moto di filtrazione delle particelle più piccole del terreno di appoggio della traversa, con la conseguente formazione di una zona a permeabilità maggiore che agisce da richiamo di acqua con conseguente aumento della velocità di filtrazione che diventa capace di erodere e trasportare via le particelle più grandi del terreno creando veri e propri canali. Il processo di erosione e trasporto del materiale si amplifica determinando il collasso della parte sovrastante.

Utilizzando come verifica la legge di Lane:

$$H_m - H_v < \Delta H = i \cdot \left(\frac{1}{3} L_o + L_v \right)$$

dove:

H_m = livello idrico a monte della traversa;

H_v = livello idrico a valle della traversa;

L_o = lunghezza dei tratti orizzontali di contatto platea-terreno;

L_v = lunghezza dei tratti verticali di contatto platea-terreno;

i = coefficiente empirico relativo al tipo di terreno comprensivo di fattore di sicurezza.

Con riferimento alla figura 10.1 si ha:

$$L_o = l_1 + l_2 + l_3 = 31m$$

$$L_v = h_1 + h_2 + h_3 + h_4 = 7.7m$$

Assumendo il parametro empirico relativo all'argilla compatta ($i = 0,556$) si ottiene il seguente risultato:

$$\Delta H = 0.556 \cdot \left(\frac{1}{3} L_o + L_v \right) = 10.03m$$

Tale condizione è sempre verificata, anche nelle condizioni più critiche, ossia nei periodi di magra, quando si ha il massimo dislivello di pelo libero tra monte e valle della traversa.

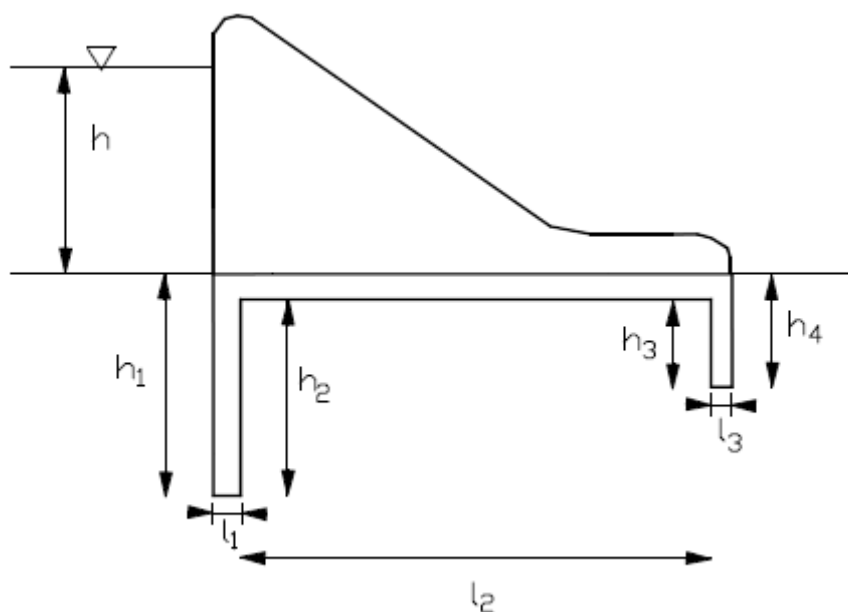


Fig. 10.1. Schema grafico per l'applicazione del criterio di Lane.

11. VERIFICA DEGLI EFFETTI DELL'ONDA DI PIENA CONSEGUENTE AL CROLLO DELLA TRAVERSA FLUVIALE

Si compie la verifica degli effetti dell'onda di piena che si determinerebbe nell'ipotesi che si verifichi il crollo pressoché totale della traversa fluviale in progetto.

11.1. SCELTA DELLE PORTATE DI VERIFICA

Si assumono come portate di verifica le seguenti portate: portata minima di funzionamento dell'impianto idroelettrico (9.6 m³/s in arrivo, 6.6 m³/s derivati), portata massima di funzionamento dell'impianto idroelettrico (300 m³/s in arrivo, 100 m³/s derivati) e portata con tempo di ritorno 200 anni (pari a 3050 m³/s).

11.2. CARATTERISTICHE DELL'ONDA DI PIENA CONSEGUENTE AL COLLASSO DELLO SBARRAMENTO

La Circolare Ministero dei Lavori Pubblici 4 dicembre 1987 prescrive la determinazione delle caratteristiche dell'onda di piena conseguente ad un ipotetico collasso dello sbarramento e l'individuazione delle aree soggette ad allagamento ai fini della protezione civile.

Le modalità di generazione di un onda di piena conseguente alla rottura dello sbarramento sono complesse.

Le cause che innescano la rottura possono essere eventi di piena, fessurazioni, sismi e queste possono dar luogo a tracimazione o sifonamento che generalmente comportano la distruzione del manufatto.

11.2.1 Stima delle caratteristiche della breccia della diga

Durante i primi anni 80' sia il US Army Corps of Engineers (COE) e il National Weather Service (NWS) hanno pubblicato delle linee guida in cui si indicavano delle raccomandazioni per i parametri della breccia.

DAM TYPE	BREACH WIDTH	SIDE SLOPE OF BREACH	FAILURE TIME
EARTHFILL DAM	0.5 TO 3.0 DAM HEIGHTS	VERTICAL TO 1:1	0.5 To 4.0 HRS (COE) 0.1 To 2.0 HRS (NWS)
CONCRETE GRAVITY DAM	INTEGER MULTIPLE OF MONOLITH WIDTHS	VERTICAL	0.1 TO 0.5 HRS
CONCRETE ARCH DAM	ENTIRE VALLEY WIDTH	VALLEY WALL	0 TO 0.1 HRS

Tab. 11.2.1.1 valori raccomandati per le caratteristiche della breccia

In base alla casistica analizzata si sono ipotizzate le caratteristiche idrauliche del fenomeno di rottura del manufatto che è un tipico fenomeno di moto vario.

Le caratteristiche dell'onda di piena conseguente al collasso dello sbarramento sono valutate mediante il software HEC RAS v. 4.1, uno tra i codici di calcolo più utilizzati per le valutazioni del collasso delle dighe tramite

l'uso della teoria idrodinamica per stimare la formazione e la propagazione dell'onda di piena. Tale software permette di analizzare regimi di flusso sub-critici, super-critici e misti.

Si prende in esame un tratto di fiume che si sviluppa da circa 7.5 km a monte della traversa a circa 11 km a valle della stessa.

Nell'ambito di tale distanza si manifestano sostanzialmente gli effetti dell'onda di piena generata dal crollo per le portate di verifica ed al termine del medesimo questa è ormai quasi completamente laminata.

Inoltre si valutano gli idrogrammi di piena in sezioni significative all'interno del tratto in studio per individuare le aree che possono essere soggette ad allagamento ai fini della Protezione Civile.

11.3 TEMPO DI ROTTURA DELLO SBARRAMENTO

Si suppone che la rottura dello sbarramento avvenga repentinamente in quanto tale è la condizione peggiore che si possa verificare.

La durata del fenomeno di crollo che si assume, in considerazione sia delle dimensioni del medesimo sia del bacino di invaso, è 18 secondi, ovvero circa 0.005 ore.

11.4 CALCOLI DELLE CARATTERISTICHE DELL'ONDA DI PIENA

Si riportano di seguito i risultati dei calcoli e gli idrogrammi di piena relativi ai livelli ed alle portate conseguenti ad un ipotetico collasso dello sbarramento.

Si riportano nel seguito le principali caratteristiche idrologiche delle onde di piena nelle seguenti sezioni:

- sezione immediatamente a monte della traversa;
- sezione immediatamente a valle della traversa;
- ponte della SP3 Castagnito-Neive;
- ponte della SS231 di Govone.

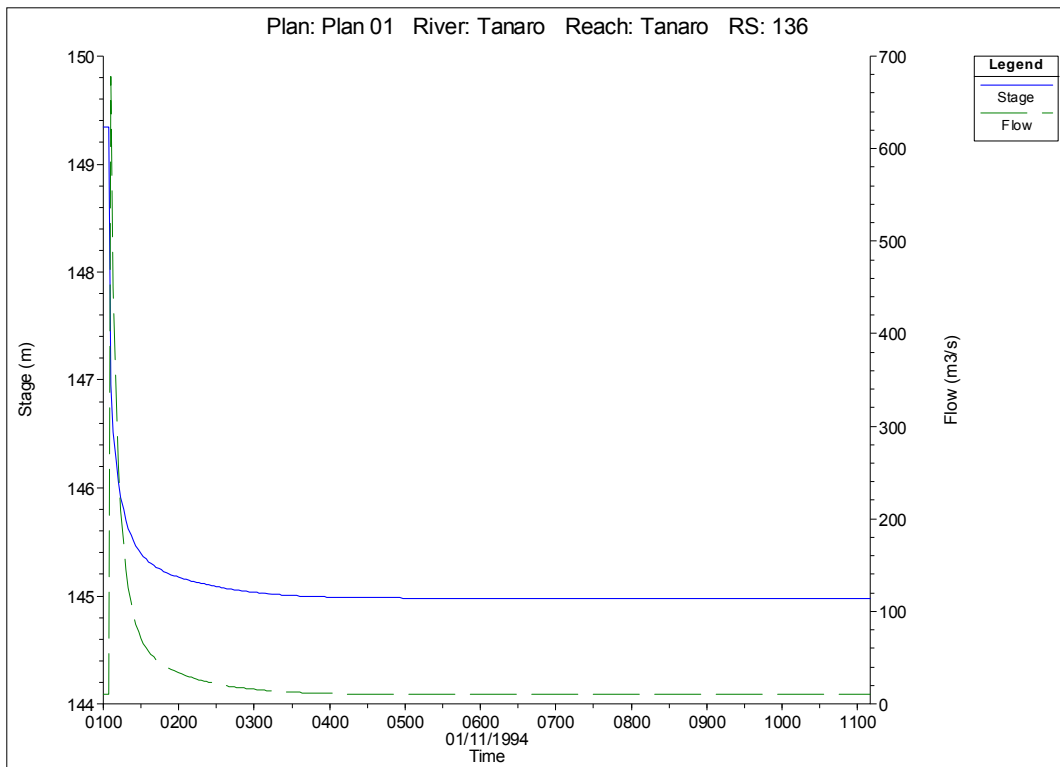
Il collasso dello sbarramento è stato analizzato nelle seguenti condizioni:

A) $Q = 9.6 \text{ m}^3/\text{s}$ – TRAVERSA ALLA MASSIMA QUOTA DI PROGETTO

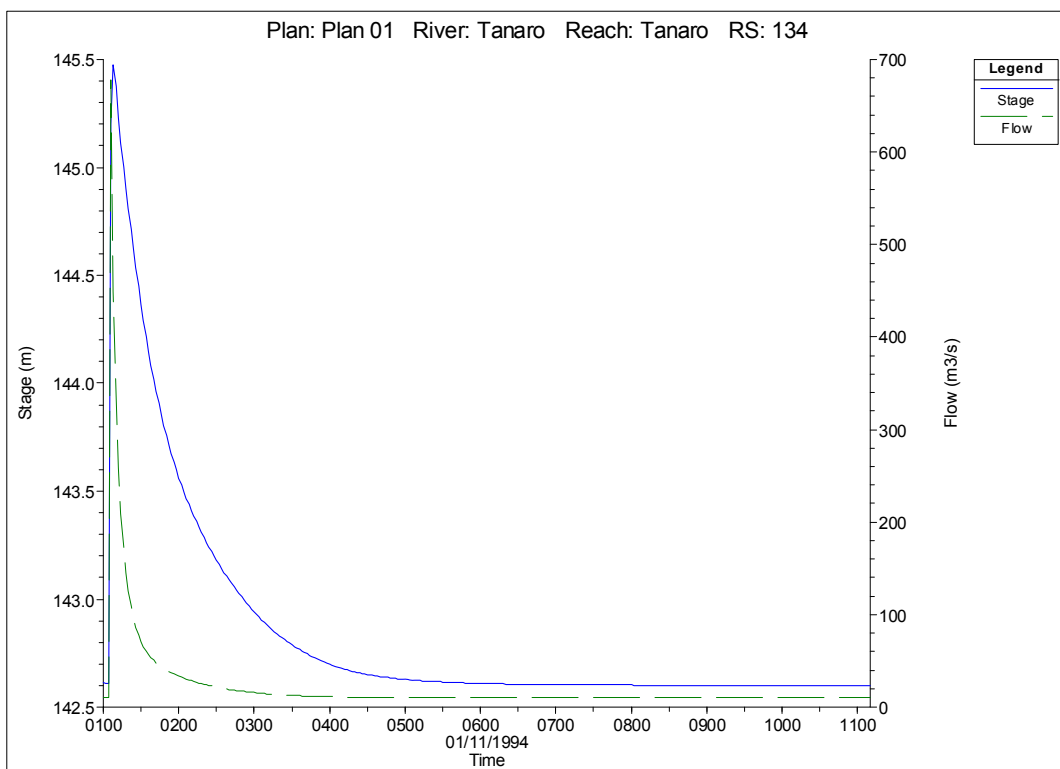
B) $Q = 300 \text{ m}^3/\text{s}$ - TRAVERSA ALLA MASSIMA QUOTA DI PROGETTO

C) $Q = 3050 \text{ m}^3/\text{s}$ (TR200) - TRAVERSA ALLA MASSIMA QUOTA DI PROGETTO

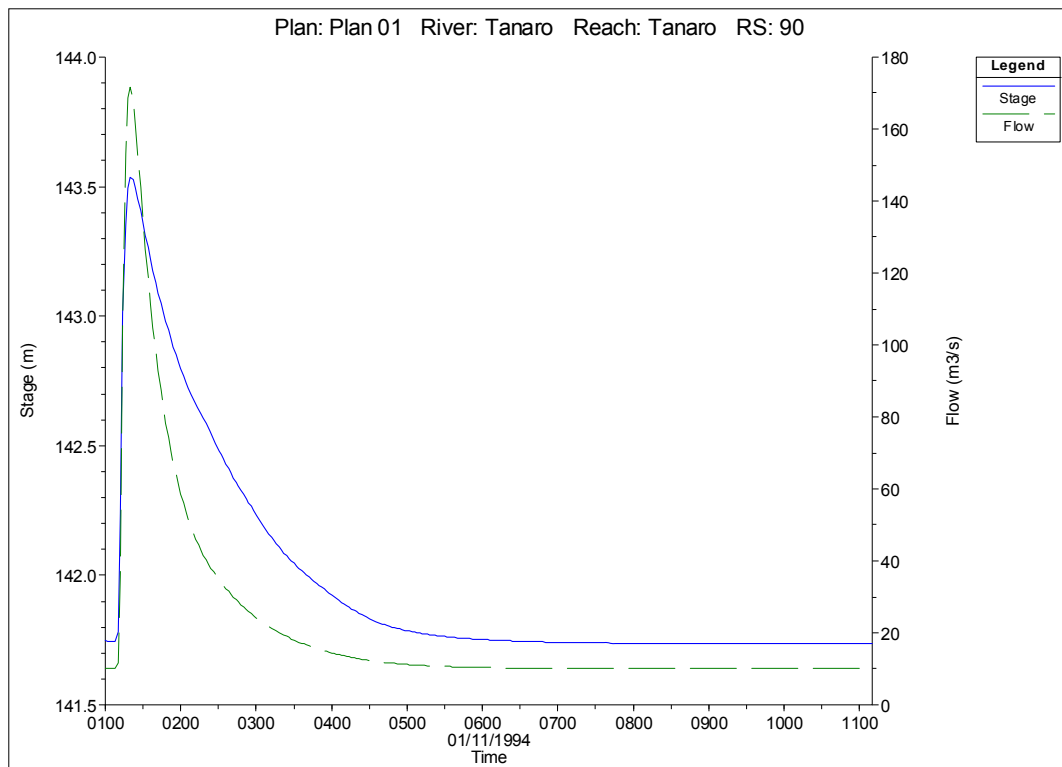
A) $Q = 9.6 \text{ m}^3/\text{s}$ - TRAVERSA ALLA MASSIMA QUOTA DI PROGETTO



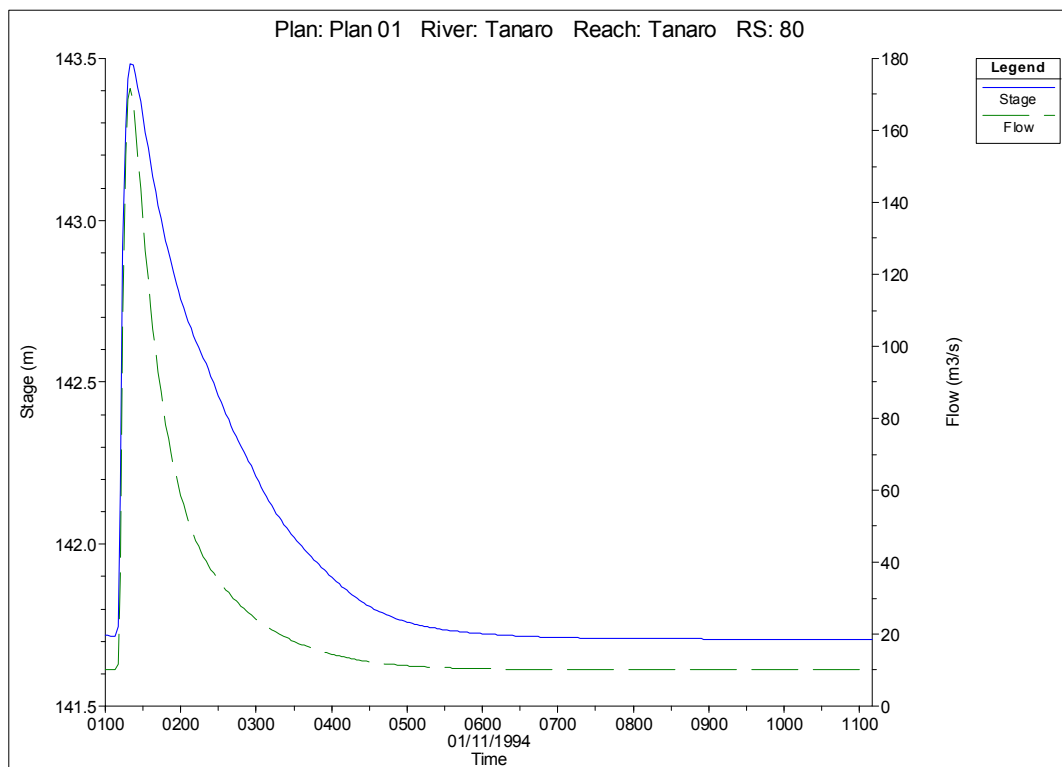
sezione immediatamente a monte della traversa in progetto



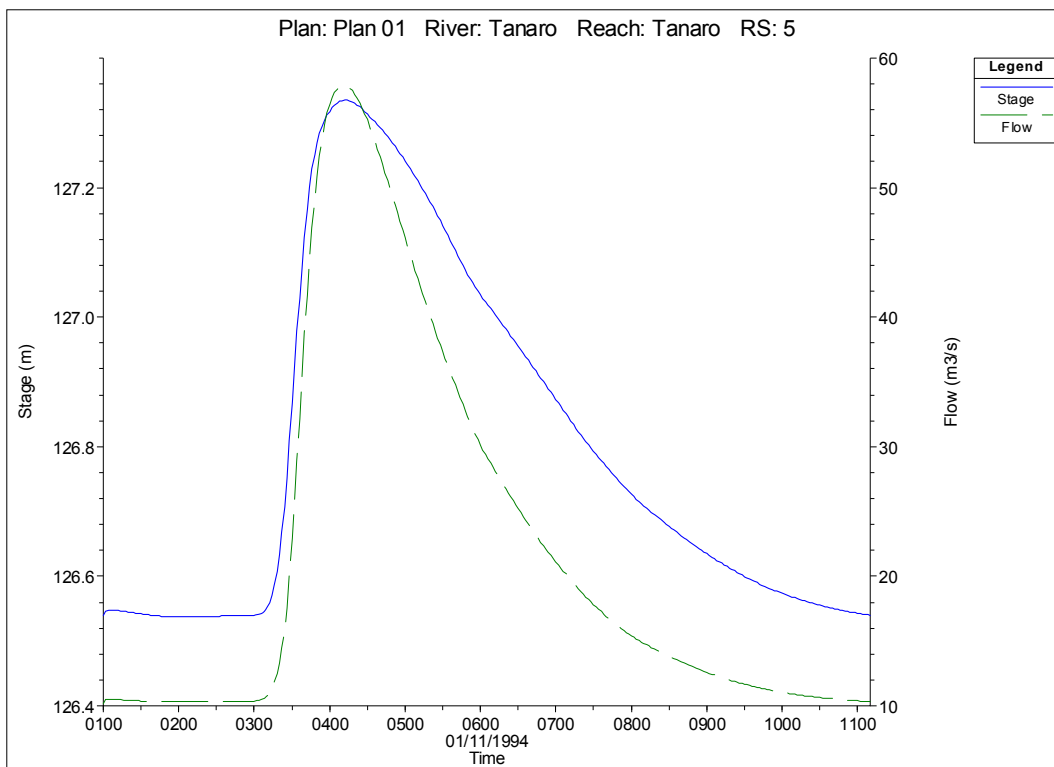
sezione immediatamente a valle della traversa in progetto



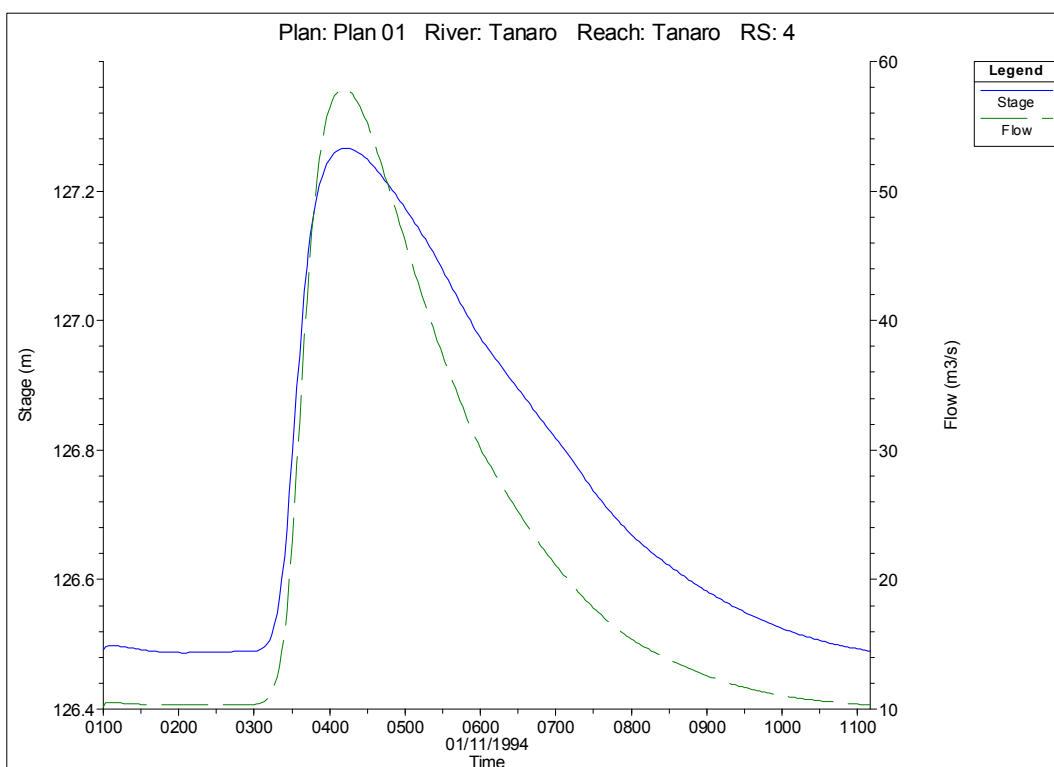
sezione immediatamente a monte del ponte della SP3 Castagnito-Neive.



sezione immediatamente a valle del ponte della SP3 Castagnito-Neive

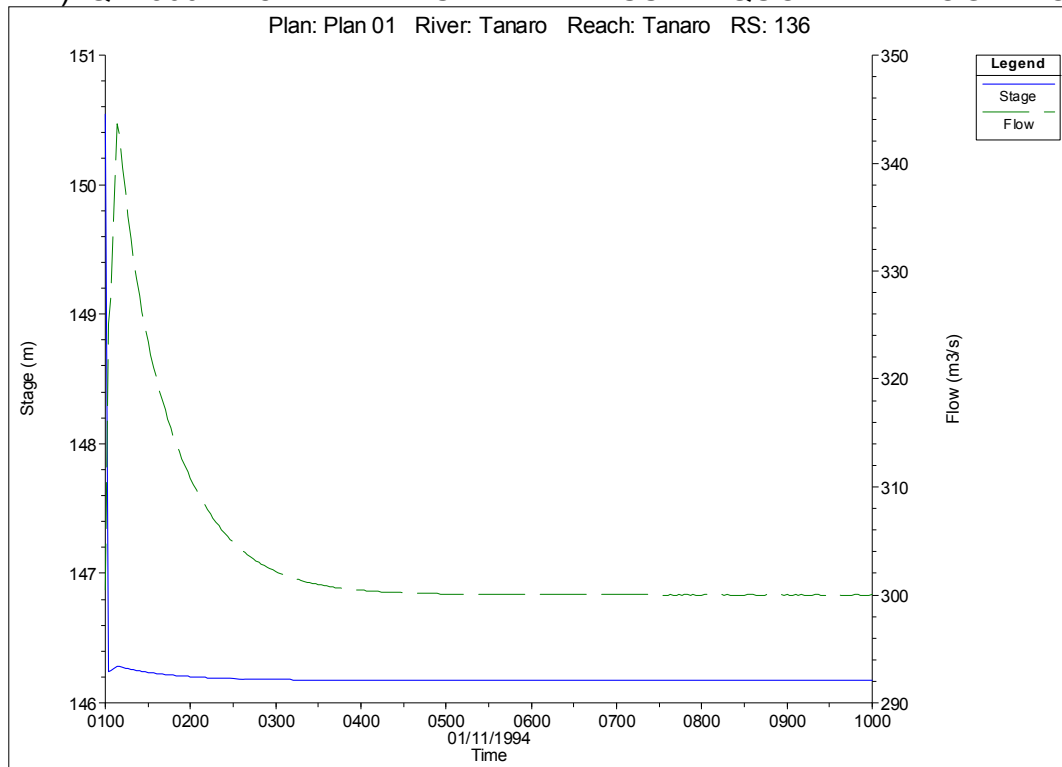


sezione immediatamente a monte del ponte della SS231 di Govone.

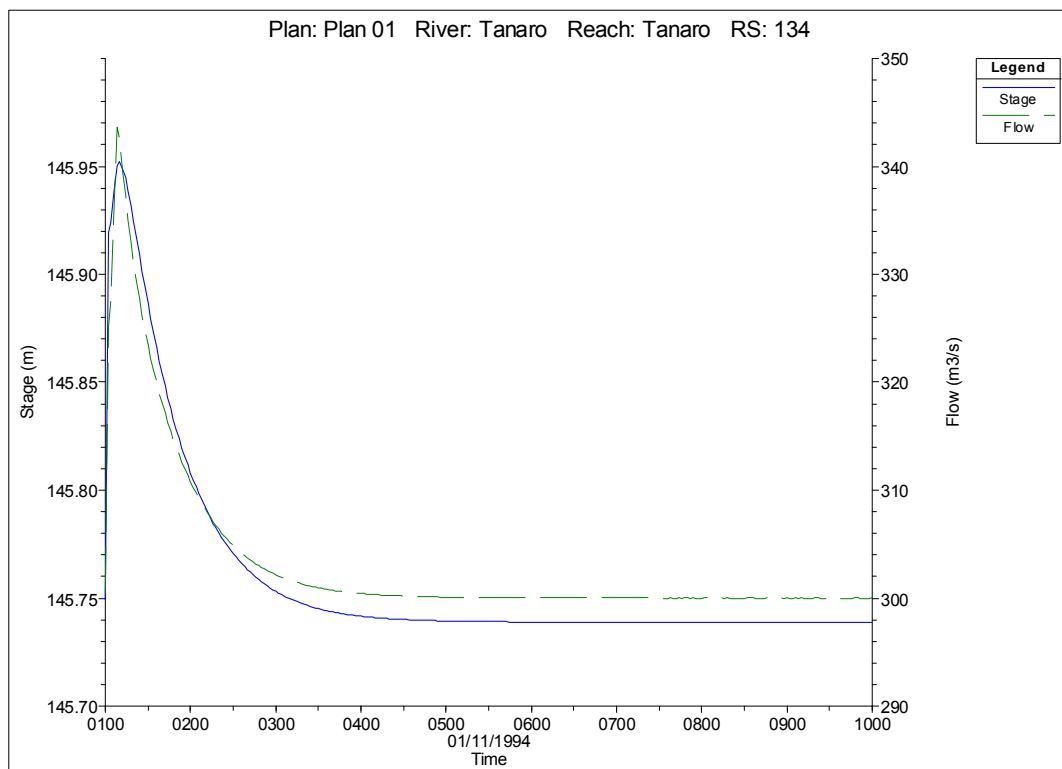


sezione immediatamente a valle del ponte della SS231 di Govone.

B) $Q = 300 \text{ m}^3/\text{s}$ - TRAVERSA ALLA MASSIMA QUOTA DI PROGETTO

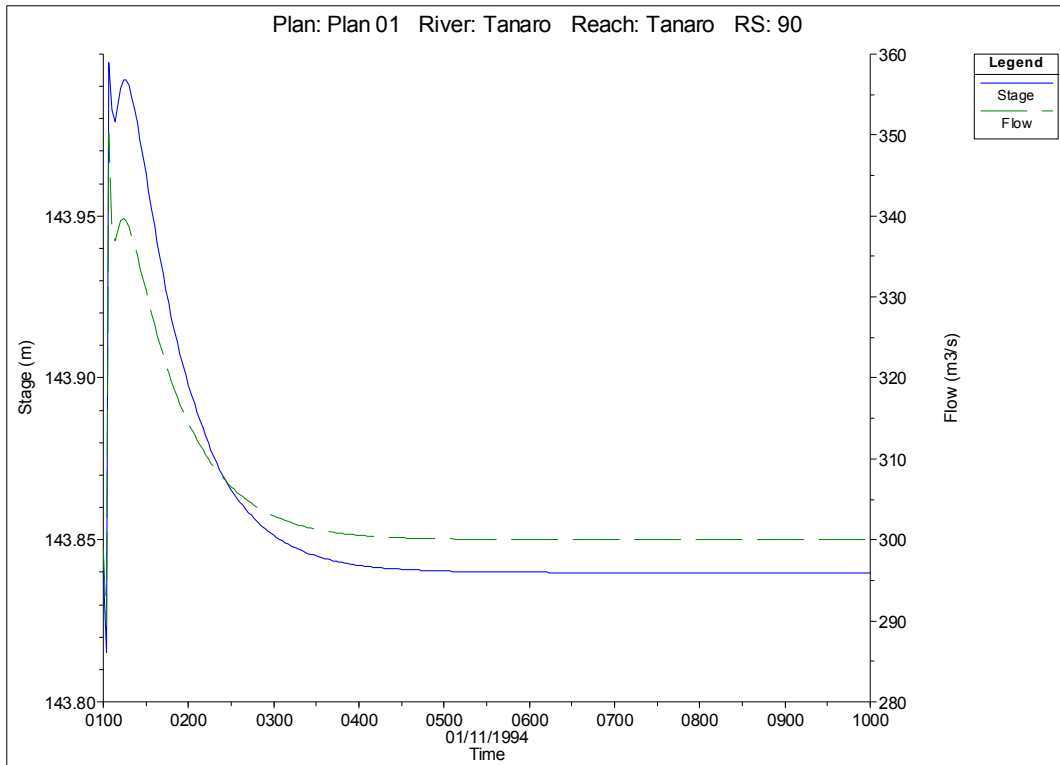


sezione immediatamente a monte della traversa in progetto

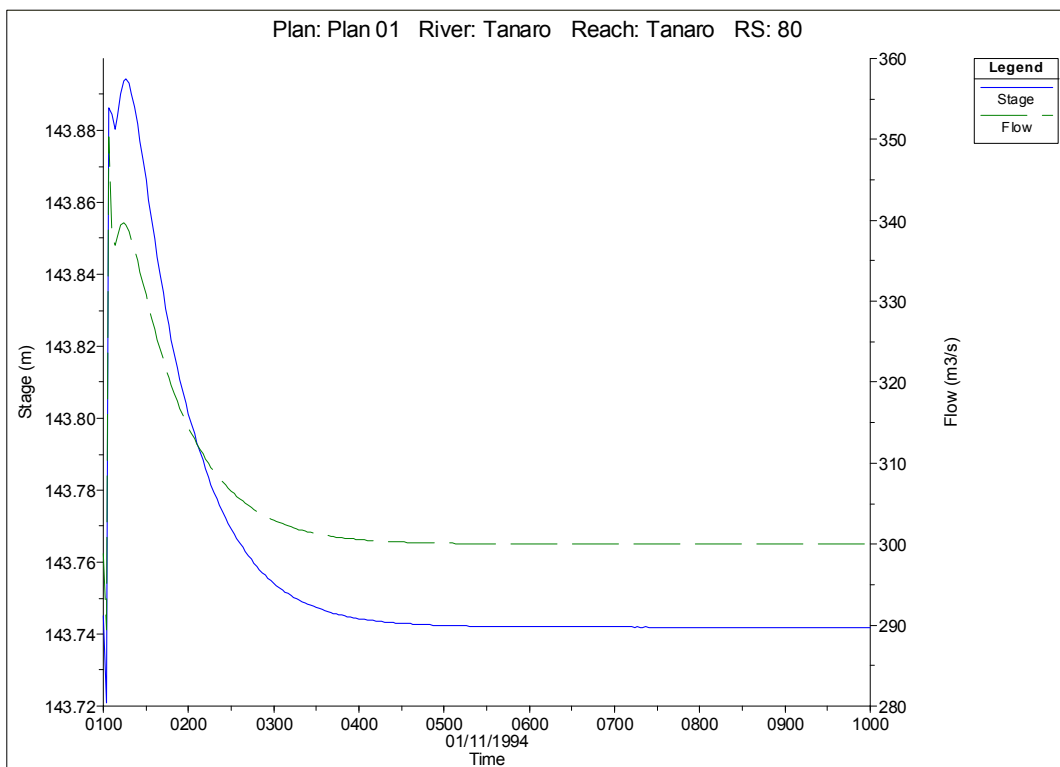


sezione immediatamente a valle della traversa in progetto

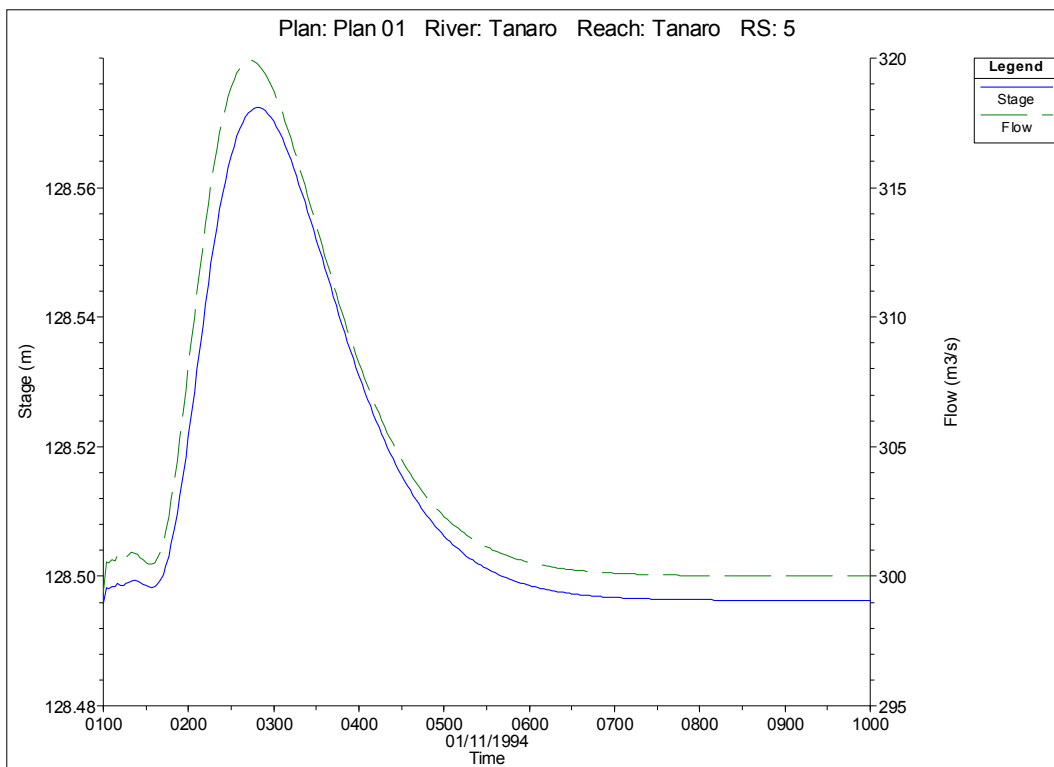
**RICOSTRUZIONE DI SBARRAMENTO FLUVIALE ESISTENTE AD USO IRRIGUO CON INNALZAMENTO
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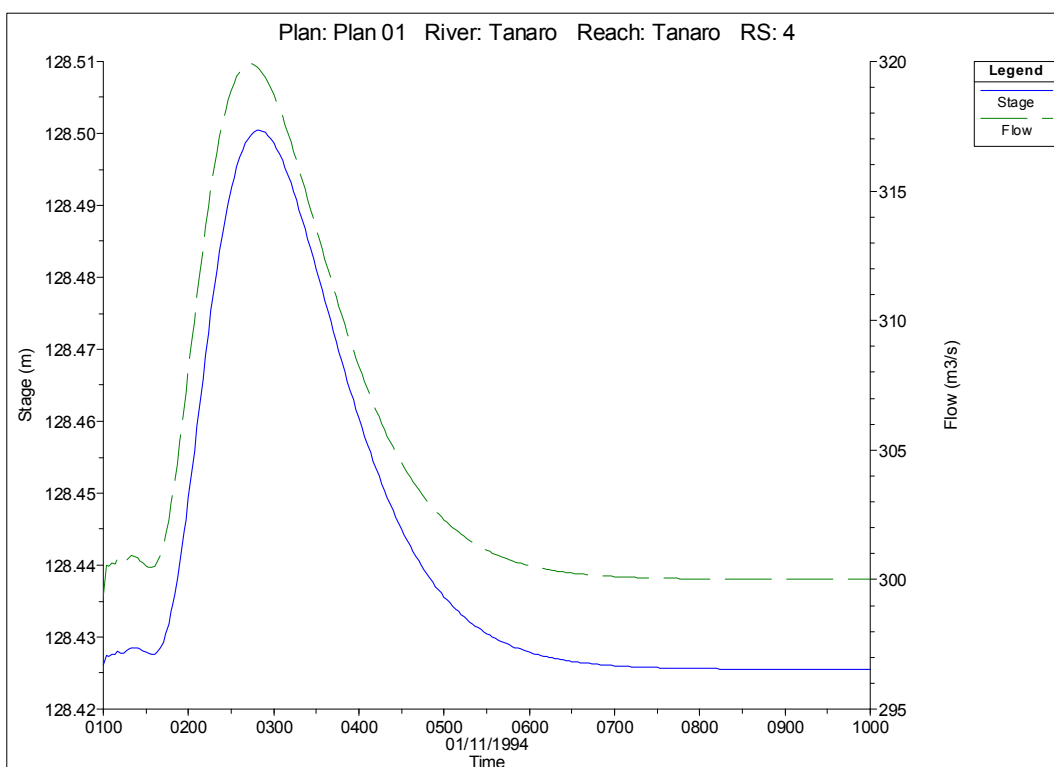
sezione immediatamente a monte del ponte della SP3 Castagnito-Neive



sezione immediatamente a valle del ponte della SP3 Castagnito-Neive

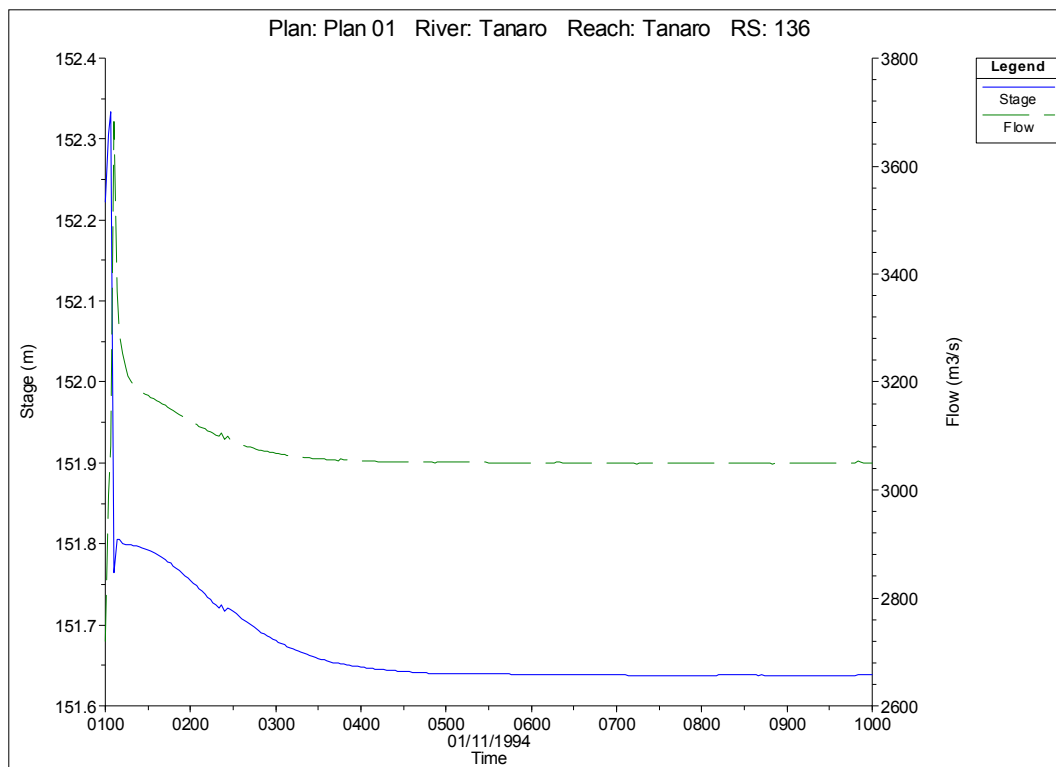


sezione immediatamente a monte del ponte della SS231 di Govone.

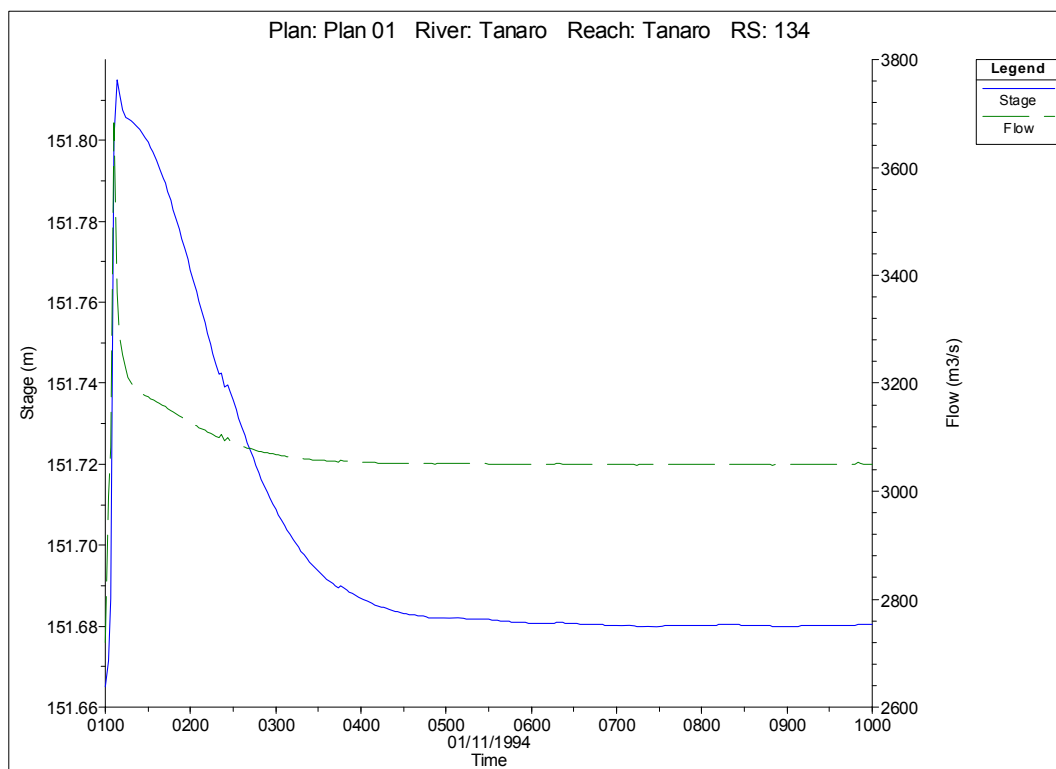


sezione immediatamente a valle del ponte della SS231 di Govone.

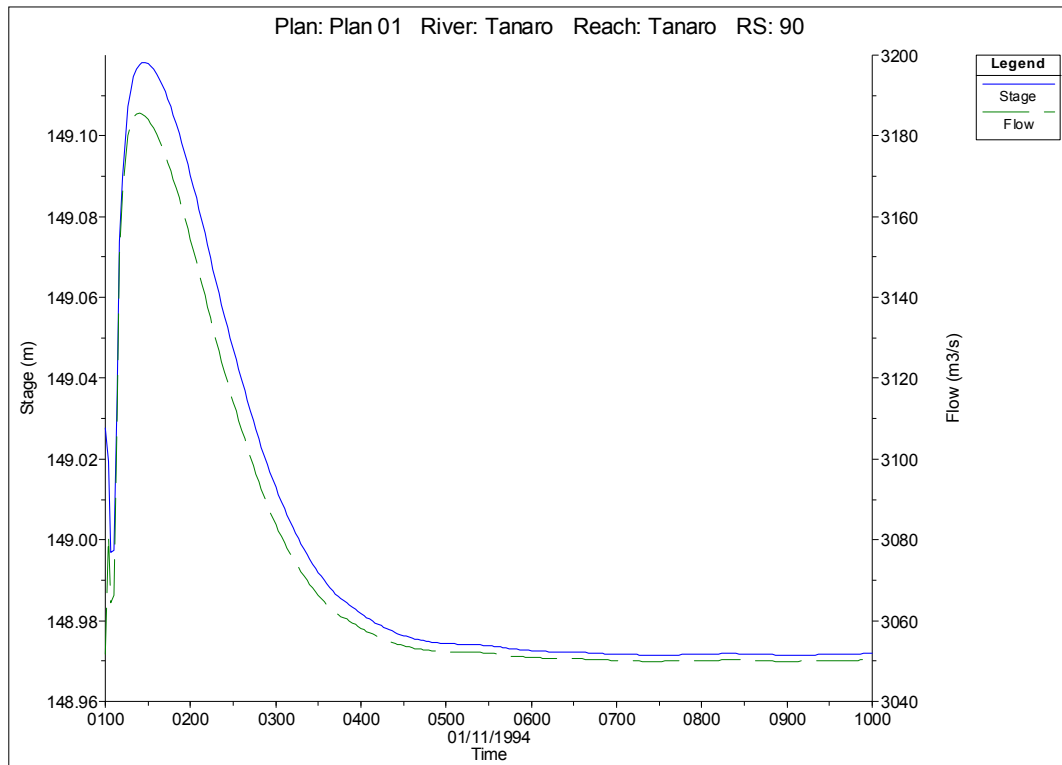
C) $Q = 3050 \text{ m}^3/\text{s}$ - TRAVERSA ALLA MASSIMA QUOTA DI PROGETTO



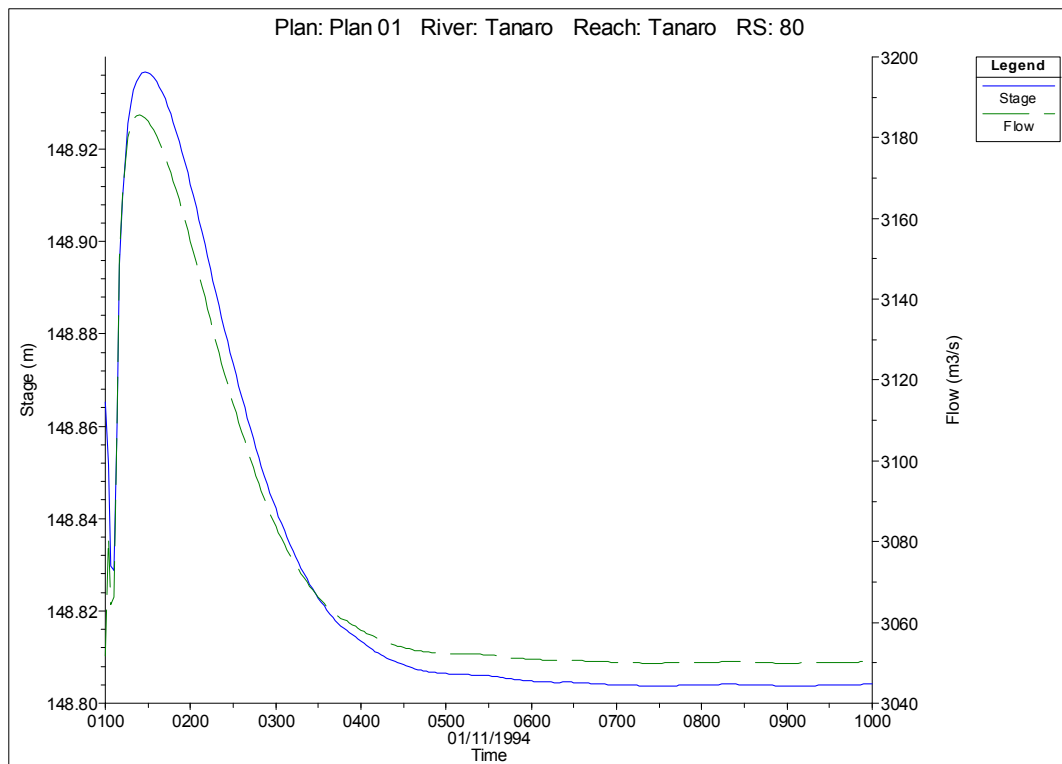
sezione immediatamente a monte della traversa in progetto



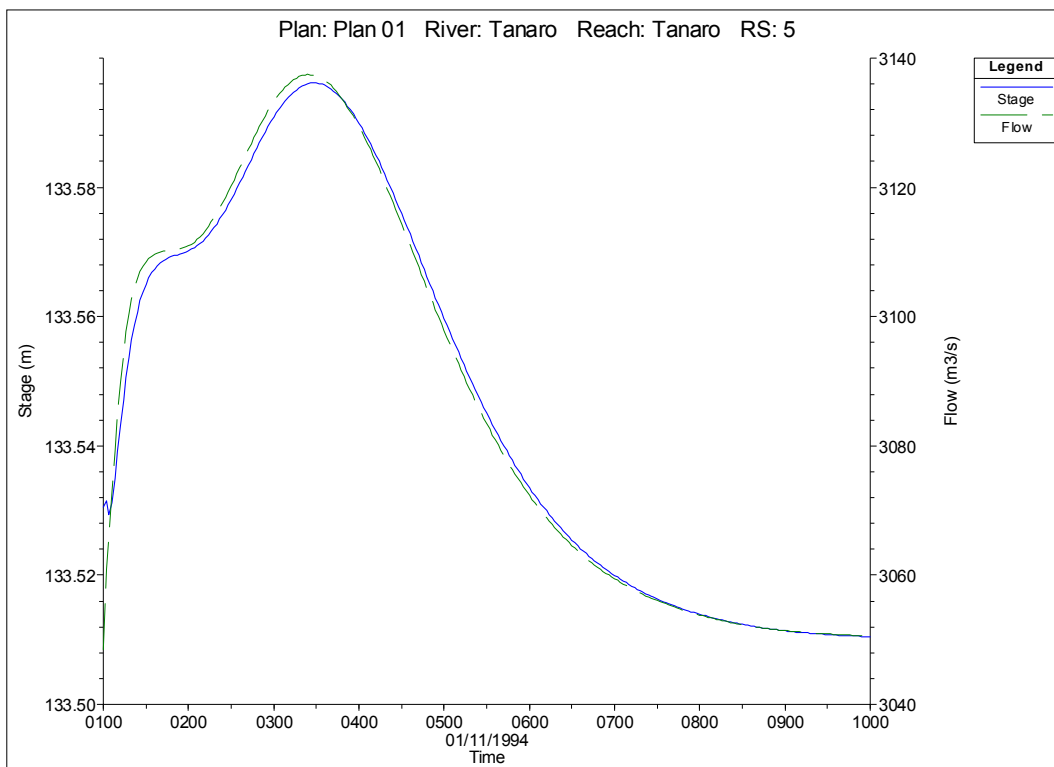
sezione immediatamente a valle della traversa in progetto



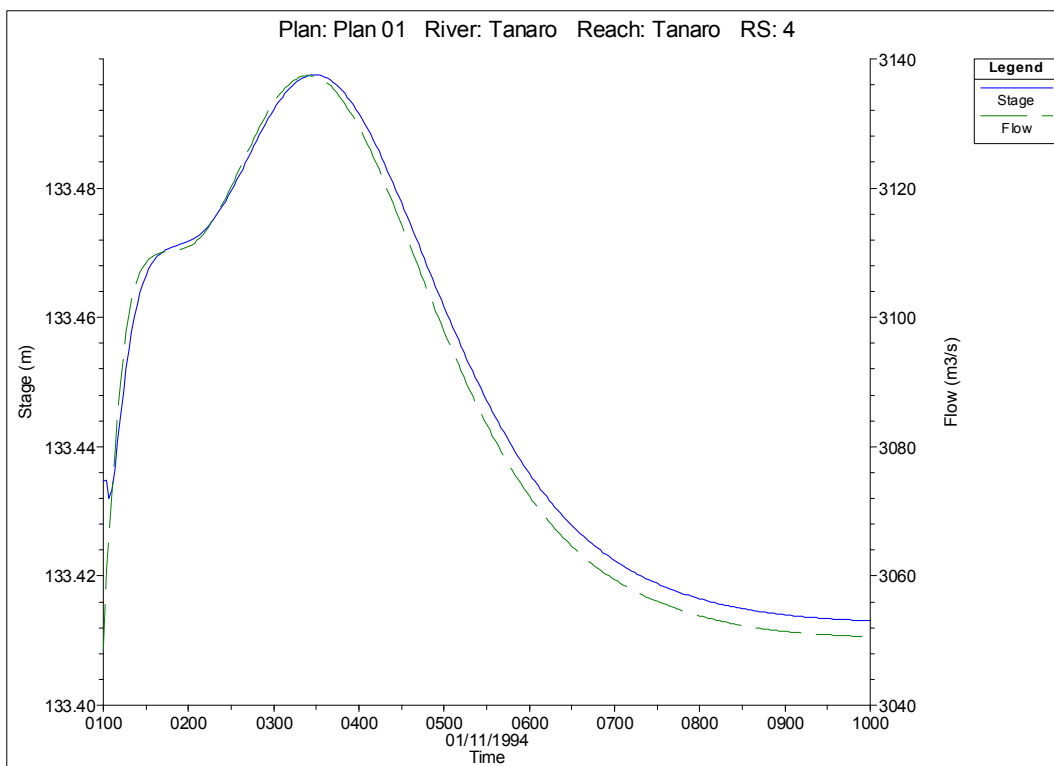
sezione immediatamente a monte del ponte della SP3 Castagnito-Neive.



sezione immediatamente a valle del ponte della SP3 Castagnito-Neive



sezione immediatamente a monte del ponte della SS231 di Govone.



sezione immediatamente a valle del ponte della SS231 di Govone.

11.5. COMMENTO AI RISULTATI IDRAULICI OTTENUTI

L'esame dei risultati idraulici rivela che l'onda di piena conseguente all'ipotetico crollo dello sbarramento transita piuttosto velocemente verso valle con innalzamenti massimi del corso d'acqua che, nel tratto immediatamente a valle dello sbarramento raggiungono i seguenti valori massimi: 2.9 m per la portata pari a $9.6 \text{ m}^3/\text{s}$, 1.0 m per la portata pari a $300 \text{ m}^3/\text{s}$ e di 0.15 m per la portata duecentennale (pari a $3050 \text{ m}^3/\text{s}$).

Con riferimento alle portate di $300 \text{ m}^3/\text{s}$ e $3050 \text{ m}^3/\text{s}$ si osserva che tale innalzamento si lamina quasi completamente nella sezione 3, ubicata circa 1200 m a valle del ponte di Govone; infatti il sovrizzo del pelo libero generato dall'onda di piena conseguente al dam break è pari a 10 cm per la portata pari a $300 \text{ m}^3/\text{s}$ e a 8 cm per la portata pari a $3050 \text{ m}^3/\text{s}$. Se si analizza il crollo con riferimento alla portata di $9.6 \text{ m}^3/\text{s}$ l'innalzamento è maggiore e pari a 88 cm.

Le simulazioni mostrano anche che l'onda di piena impiega circa 15 minuti per raggiungere la sezione 90 nel caso di portata pari a $9.6 \text{ m}^3/\text{s}$, circa 10 minuti nel caso di portata pari a $300 \text{ m}^3/\text{s}$ e circa di 20 minuti nel caso di portata pari a $3050 \text{ m}^3/\text{s}$.

11.6 VALUTAZIONE DELLE AREE INONDABILI DALL'ONDA DI PIENA DIPENDENTE DAL COLLASSO DEL MANUFATTO DI SBARRAMENTO

Si compie la valutazione dell'esondabilità del Fiume Tanaro conseguente al crollo della traversa in progetto.

A tal fine si riportano le quote delle sponde dell'alveo inciso nel tratto a valle della traversa e le quote massime dei livelli idraulici conseguenti al crollo per le portate di verifica pari a $9.6 \text{ m}^3/\text{s}$, $300 \text{ m}^3/\text{s}$ e $3050 \text{ m}^3/\text{s}$.

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sezione	quota sponda sinistra	quota sponda destra	livello massimo con $Q = 9.6 \text{ m}^3/\text{s}$	incremento massimo con $Q = 9.6 \text{ m}^3/\text{s}$	livello massimo con $Q = 300 \text{ m}^3/\text{s}$	incremento massimo con $Q = 300 \text{ m}^3/\text{s}$
	(m s.l.m.)	(m s.l.m.)	(m s.l.m.)	(m s.l.m.)	(m s.l.m.)	(m)
430	161.57	163.37	157.31	0.00	160.11	0.00
420	161.48	163.98	157.29	0.00	159.93	0.00
410	164.27	160.56	157.26	0.00	159.73	0.00
400	165.83	161.72	157.06	0.00	159.38	0.00
Bridge						
390	165.83	161.72	157.04	0.00	159.34	0.00
380	162.83	163.03	156.62	0.00	158.72	0.01
370	168.48	168.5	155.62	0.01	157.76	0.01
Bridge						
360	168.48	168.5	155.55	0.01	157.61	0.00
350	161.92	161.67	154.06	0.00	156.84	0.00
340	160.66	160.88	153.22	0.00	156.52	0.00
330	160.24	159.55	152.54	0.01	155.67	0.00
320	157.68	161.18	151.38	0.00	154.95	0.01
310	157.66	158.81	151.34	0.00	154.73	0.00
300	156.48	156.26	151.23	0.00	154.51	0.01
290	158.22	157.92	151.13	0.00	154.26	0.00
280	155.92	154.67	151.1	0.00	153.95	0.00
270	155.75	157.54	151.09	0.00	153.69	0.00
260	155.19	156.59	151.08	0.00	153.51	0.01
250	156.14	157.55	151.01	0.00	153.15	0.00
240	155.49	153.91	150.52	0.00	152.83	0.02
230	156.02	152.81	149.97	0.02	152.69	0.02
220	153.97	153.9	149.53	0.03	152.47	0.05
210	154.57	155.48	149.42	0.01	152.19	0.09
200	152.69	152.22	149.36	0.00	151.73	0.23
190	152.55	153.38	149.35	0.00	151.64	0.31
180	152.09	152.01	149.35	0.00	151.54	0.35
170	153.36	151.35	149.35	0.00	151.51	0.47
160	151.81	150.58	149.34	0.00	151.51	0.74
136	152.66	152.58	149.34	0.00	150.54	0.00
Inline S.						
134	152.66	152.58	145.48	2.87	146.77	1.02
130	149.97	149.13	144.8	2.42	145.88	0.39
110	148.88	149.2	144.52	2.30	145.54	0.28
100	148.75	149.7	144.11	1.98	145.07	0.21
90	154.45	154.39	143.54	1.79	144	0.16
Bridge						
80	154.45	154.39	143.49	1.77	143.89	0.14
70	146.52	146.87	141.47	1.39	142.57	0.16
60	145.03	145.51	140.74	1.94	142.05	0.16
50	146	143.22	140.46	1.97	141.74	0.15

sezione	quota sponda sinistra	quota sponda destra	livello massimo con Q = 9.6 m ³ /s	incremento massimo con Q = 9.6 m ³ /s	livello massimo con Q = 300 m ³ /s	incremento massimo con Q = 300 m ³ /s
40	146.23	145.27	139.76	1.55	141.09	0.14
30	145.52	144.87	139.24	1.26	140.61	0.16
20	141.99	141.82	138.63	1.28	140.22	0.18
10	142.2	143.49	137.81	1.69	139.79	0.18
9	141.89	142.32	135.2	1.08	136.35	0.12
8	136.92	138.13	132.87	1.25	134.32	0.13
7	138.09	136.75	131.5	0.96	133.65	0.14
6	135.55	135.29	129.19	1.22	131.5	0.10
5	138.81	138.73	127.33	0.79	128.57	0.07
Bridge						
4	138.81	138.73	127.27	0.78	128.5	0.07
3	128.92	127.57	124.68	0.88	126.57	0.10

Tab. 11.6.1 livelli idrici conseguenti al crollo della traversa per le portate di verifica di 9.6 m³/s e 300 m³/s.

sezione	quota sponda sinistra	quota sponda destra	livello massimo con Q = 3050 m ³ /s	incremento massimo con Q = 3050 m ³ /s
	(m s.l.m.)	(m s.l.m.)	(m s.l.m.)	(m)
430	161.57	163.37	166.19	0.00
420	161.48	163.98	166.03	0.00
410	164.27	160.56	165.8	0.00
400	165.83	161.72	164.92	0.01
Bridge				
390	165.83	161.72	164.77	0.00
380	162.83	163.03	163.9	0.03
370	168.48	168.5	163.36	0.02
Bridge				
360	168.48	168.5	163.18	0.02
350	161.92	161.67	162.53	0.00
340	160.66	160.88	162.2	0.00
330	160.24	159.55	161.63	0.01
320	157.68	161.18	160.85	0.05
310	157.66	158.81	160.31	0.02
300	156.48	156.26	160.13	0.00
290	158.22	157.92	159.89	0.00
280	155.92	154.67	159.53	0.00
270	155.75	157.54	159.04	0.00
260	155.19	156.59	158.33	0.03
250	156.14	157.55	157.96	0.03
240	155.49	153.91	157.47	0.03

sezione	quota sponda sinistra	quota sponda destra	livello massimo con Q = 3050 m ³ /s	incremento massimo con Q = 3050 m ³ /s
230	156.02	152.81	157.11	0.01
220	153.97	153.9	156.69	0.01
210	154.57	155.48	156.31	0.01
200	152.69	152.22	155.48	0.03
190	152.55	153.38	155.18	0.00
180	152.09	152.01	154.99	0.00
170	153.36	151.35	154.73	0.00
160	151.81	150.58	154.23	0.00
136	152.66	152.58	152.34	0.12
Bridge				
134	152.66	152.58	151.82	0.15
130	149.97	149.13	151.25	0.1
110	148.88	149.2	150.95	0.1
100	148.75	149.7	150.53	0.11
90	154.45	154.39	149.12	0.09
Bridge				
80	154.45	154.39	148.94	0.07
70	146.52	146.87	147.76	0.04
60	145.03	145.51	147.29	0.04
50	146	143.22	146.77	0.06
40	146.23	145.27	146.08	0.03
30	145.52	144.87	145.61	0.03
20	141.99	141.82	145.12	0.06
10	142.2	143.49	144.64	0.02
9	141.89	142.32	141.68	0.05
8	136.92	138.13	139.92	0.04
7	138.09	136.75	139.15	0.00
6	135.55	135.29	137	0.05
5	138.81	138.73	133.6	0.07
Bridge				
4	138.81	138.73	133.5	0.07
3	128.92	127.57	130.91	0.08

Tab. 11.6.2 livelli idrici conseguenti al crollo della traversa per la portate di verifica di 3050 m³/s (T_R = 200 anni).

Si osserva che i livelli idrici relativi alle portate di 9.6 m³/s e 300 m³/s sono sempre ampiamente inferiori rispetto alla quota delle sponde dell'alveo inciso e pertanto, per i primi due scenari presi in esame, non si originano effetti idraulici significativi.

La simulazione relativa alla portata con tempo di ritorno di 200 anni (pari a $3050 \text{ m}^3/\text{s}$) evidenzia come i livelli idrici in caso di crollo della traversa siano superiori alla quota delle sponde. Occorre però osservare, come mostrato dalle simulazioni precedentemente riportate, che anche nella situazione attuale la portata duecentennale non è contenuta in alveo. Gli incrementi di livello derivanti dal crollo della traversa rispetto sia alla situazione attuale che a quella di progetto sono comunque contenuti. Inoltre è bene precisare che la simulazione relativa al crollo della traversa con la portata duecentennale è stata effettuata nelle condizioni più sfavorevoli; si è infatti considerato lo sbarramento mobile alzato anche se, come più volte ribadito, esso viene abbassato una volta che la portata in alveo supera i $300 \text{ m}^3/\text{s}$.