



VARIANTE AL II REGOLAMENTO URBANISTICO DEL COMUNE DI SESTO FIORENTINO FINALIZZATA ALL'AGGIORNAMENTO DELLE CONDIZIONI IDRAULICHE E A MODIFICHE PUNTUALI DEGLI AMBITI DI TRASFORMAZIONE
STUDIO IDROLOGICO – IDRAULICO



Elaborato n. 1 – Relazione idrologica e idraulica

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ALLEGATO: OUTPUT VERIFICHE IDRAULICHE

Relazione idrologica ed idraulica

Premessa

Il presente documento rappresenta la relazione di accompagnamento dello studio idrologico ed idraulico a supporto della variante al Regolamento Urbanistico del Comune di Sesto Fiorentino; lo studio rappresenta un **approfondimento di maggior dettaglio rispetto al quadro conoscitivo del recente Piano Strutturale Intercomunale dei Comuni di Calenzano e Sesto Fiorentino**, soprattutto per l'area di Osmannoro. Si rimanda comunque allo studio idraulico del PSI per una maggior caratterizzazione e descrizione dell'idrologia e dell'idraulica di tutti i corsi d'acqua non facenti parte del comparto idraulico di Osmannoro.

Nell'ambito della presentazione delle varianti puntuali individuate dai progettisti urbanisti infatti, secondo quanto previsto dal punto 3.6 dell'allegato A del DPGR 53/R sono state predisposte cartografie di maggior dettaglio, che consentono l'individuazione delle situazioni di fattibilità e delle condizioni di attuazione degli interventi, così da permettere una loro agevole traduzione nelle norme tecniche del regolamento urbanistico.

L'aggiornamento di maggior dettaglio del quadro conoscitivo è stato ottenuto grazie ad una serie di incontri tecnici con il Consorzio di Bonifica Medio Valdarno e Genio Civile Valdarno Superiore, promosse anche per integrarsi con gli studi idraulici in itinere dei comuni limitrofi, che hanno portato alla definizione di condizioni al contorno e di input idrologico più precise, come successivamente descritte.

Sulla base delle nuove condizioni al contorno e di input idrologico sono state aggiornati i modelli idrologici ed idraulici del comparto dell'Osmannoro, in modo da definire le classi di pericolosità idraulica ai sensi del 53/R e del PGRA, i battenti idraulici, la velocità e la magnitudo secondo la definizione della L.R. 41/2018. L'aggiornamento della modellistica idraulica ha inoltre tenuto conto di piccole modifiche al LIDAR di zone di recente trasformazione, secondo il materiale ed i rilievi forniti dall'Amministrazione Comunale.

Sulla base degli incontri avuti si è provveduto inoltre ad un editing finale delle cartografie, in modo da post processare i battenti della modellazione idraulica con uno smoothing tale da eliminare isole, pixel isolati o dati da battenti non significativi, minori di 5 cm.

L'aggiornamento del modello idraulico di riferimento del quadro conoscitivo del PSI ha riguardato i seguenti corsi d'acqua:

- Fosso Osmannoro;
- Fosso Nuova Gavine;
- Collettore sinistro di acque basse;
- Collettore principale delle acque basse.

Come detto, per gli altri corsi d'acqua del territorio comunale si rimanda agli studi idraulici allegati al PSI dei Comuni di Calenzano e Sesto Fiorentino. Relativamente alla porzione di territorio del Comune di Sesto Fiorentino dell'Osmannoro, il dato di pericolosità derivante da modellazione idraulica è stato comunque integrato con quello derivante dal PGRA, che prevede un battente di esondazione duecentennale che si attesta a +37.00 m s.l.m. per l'esondazione del Fiume Arno.

1. Aggiornamento analisi idrologica comparto Osmannoro

Come precedentemente accennato, gli incontri con i tecnici del Consorzio di Bonifica Medio Valdarno e Genio Civile Alto Valdarno sono stati finalizzati ad una maggior definizione dei sottobacini idrografici afferenti all'area di Osmannoro, vista l'area particolarmente antropizzata, che ha subito nel tempo numerose modifiche ed urbanizzazioni, che hanno interessato anche il reticolo idrografico.

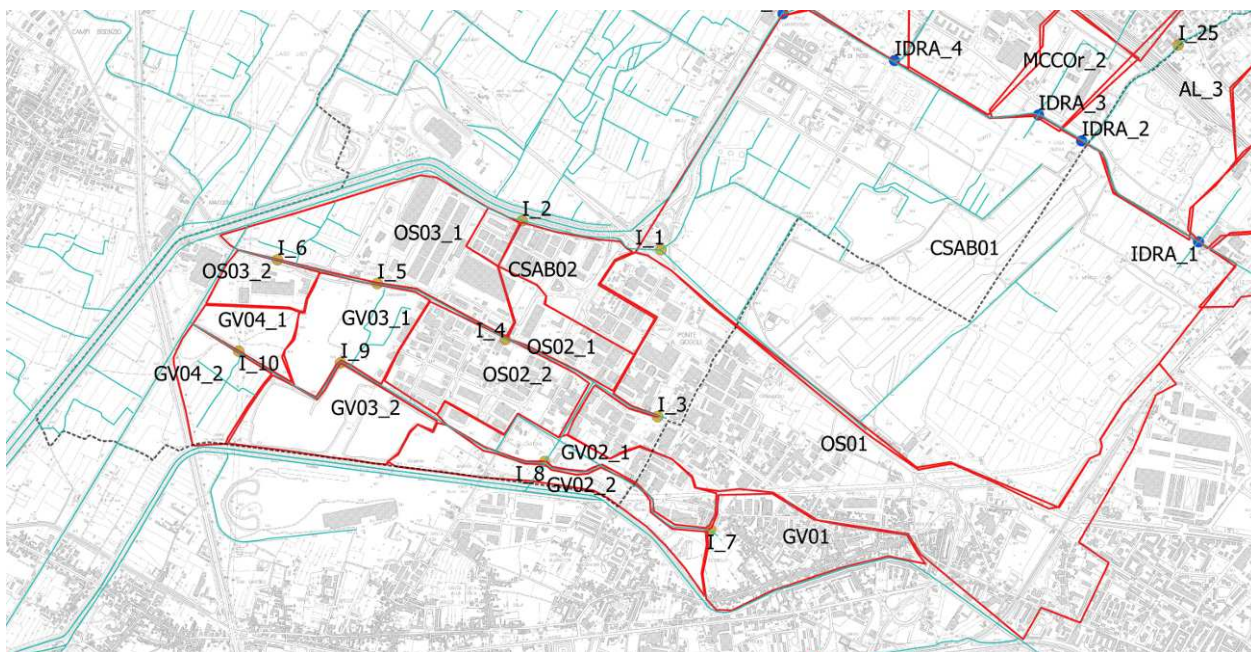


Figura 1 – Schematizzazione in sottobacini del comparto idrologico di Osmannoro

1.1 Pluviometria

L'analisi idrologica è stata condotta tenendo conto delle linee segnalatrici di possibilità pluviometrica (LSPP) aggiornate nel 2012, dall'Università di Firenze (Dipartimento di Ingegneria Civile e Ambientale) nell'ambito dell'accordo di collaborazione con la Regione Toscana di cui alla DGRT 1133/2012. I parametri delle LSPP aggiornate sono disponibili e consultabili al link <http://www.sir.toscana.it/lsp-2012>. Le curve di possibilità pluviometrica definiscono i parametri dell'espressione monomia per l'altezza di precipitazione:

$$h = a t^n$$

dove h è l'altezza di precipitazione espressa in mm, t è la durata di pioggia ed a e n sono i parametri caratteristici delle curve. La stazione pluviometrica più prossima all'area di interesse per il comune di Sesto Fiorentino è quella di Case Passerini (TOS01001225) che presenta i seguenti valori caratteristici di pioggia:

Stazione di Case Passerini		
	a	n
Tr = 200 anni	65.616	0.27248
Tr = 30 anni	44.461	0.25298

Stazione Case Passerini		
Durata pioggia	Tr 30	Tr 200
1 ora	44.46	65.62
2 ore	52.98	79.26
3 ore	58.71	88.51
6 ore	69.96	106.92

E' stato effettuato un confronto utilizzando la spazializzazione dei coefficienti a ed n delle LSPP su griglie di 1 km x 1 km, messo a disposizione dalla Regione Toscana, in modo da fornire un dato puntuale di pioggia per ogni singolo sottobacino, con media pesata delle altezze di pioggia h.

OSMANNORO	H _{tr} pesata			
Tr200	1	2	3	6
media pesata h maglia 1 km x 1 km	66.38	80.12	89.45	107.99
h stazione Case Passerini	65.62	79.26	88.51	106.92
delta h in mm	0.76	0.86	0.94	1.07
Tr30	1	2	3	6
media pesata h maglia 1 km x 1 km	46.48	55.27	61.17	72.73
h stazione Case Passerini	44.46	52.98	58.71	69.96
delta h in mm	2.02	2.29	2.46	2.77

Per ciascun sottobacino per la definizione delle portate di riferimento si è fatto riferimento all'input pluviometrico basato sulla spazializzazione delle piogge sopra riportato.

L'andamento temporale dell'evento pluviometrico è stato schematizzato ricorrendo ad uno ietogramma sintetico, che pur non rappresentando il reale andamento dell'evento di pioggia, introduce, nelle procedure di trasformazione afflussi-deflussi, una variabilità temporale della pioggia in grado di produrre risultati tali da ritenersi cautelativi. Per lo studio in questione, tra gli ietogrammi noti in letteratura, si è deciso di utilizzare lo ietogramma rettangolare ad intensità costante, da considerarsi verosimile per la superficie non particolarmente estesa dei singoli sottobacini analizzati.

1.2 Perdite idrologiche

Per la determinazione dei deflussi netti corrispondenti allo scorrimento superficiale dei bacini si è optato per il metodo CN del SCS.

Il metodo del Curve Number (CN) del Soil Conservation Service si basa sul concetto che il flusso superficiale è nullo fino al raggiungimento di un valore di soglia di infiltrazione iniziale I_a , da letteratura tecnica legata alla capacità di ritenzione potenziale S dalla relazione:

$$I_a = 0.2 \cdot S$$

dove S è definita dall'espressione:

$$S = 25.4 \left(\frac{1000}{CN} - 10 \right) \text{ [mm]}$$

Il parametro adimensionale Runoff Curve Number può variare tra 0 e 100 ed è determinabile mediante apposite tabelle, in funzione della natura del terreno, dal tipo di copertura vegetale, della tessitura del terreno, dell'uso del suolo e del grado di saturazione.

Si è fatto quindi riferimento al gruppo idrologico USDA (A: suoli con deflusso superficiale basso, B: suoli con deflusso superficiale moderatamente basso, C: suoli con deflusso superficiale moderatamente alto, D: suoli con deflusso superficiale alto) grazie alla cartografia resa disponibile dal Geoscopio della Regione Toscana (*Figura 2*).

È stato poi analizzato l'uso del suolo sulla cartografia della Regione Toscana che riporta i valori del codice Corine Land cover, con riferimento alla carta di uso del suolo riferita al 2013.

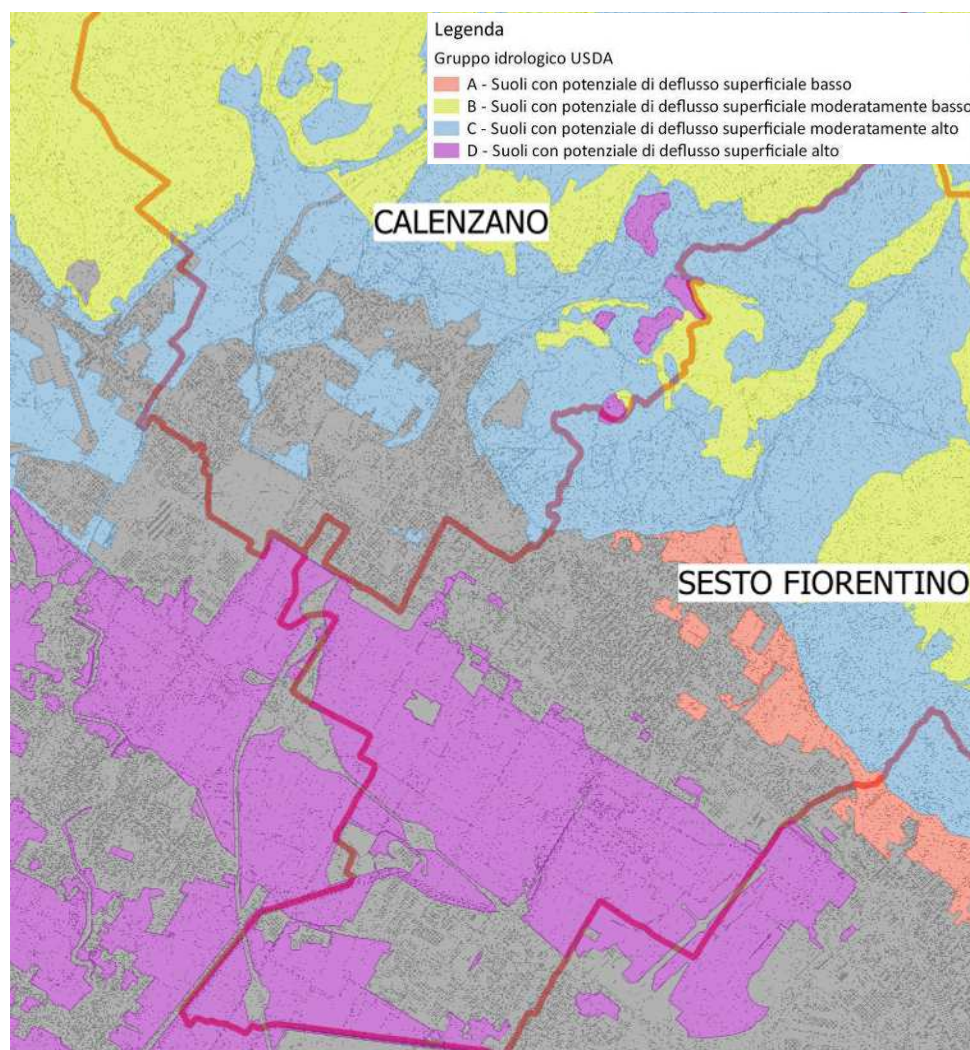


Figura 2 – Carta dei gruppi idrologici (esempio su una porzione di territorio)

Ad ogni codice CORINE è associato un valore di CN, riferito ad una condizione media di umidità del terreno antecedente l'evento di pioggia considerato (AMC II: Antecedent Moisture Condition Classe II). Tale tabella è stata ricavata dal documento “Modellazione idrologica caso pilota. Implementazione modello distribuito per la Toscana MOBIDIC Addendum: Parametrizzazione HMS” del novembre 2014, predisposto nell'ambito dell'Accordo di collaborazione scientifica tra Regione Toscana e Dipartimento di Ingegneria Civile e Ambientale dell'Università degli Studi di Firenze per attività di ricerca per la mitigazione del rischio idraulico nella Regione Toscana.

Codice CORINE	CN(A)	CN (B)	CN (C)	CN (D)
111	89	92	94	95
112	77	85	90	92
121	81	88	91	93
122	98	98	98	98
123	98	98	98	98
124	98	98	98	98
131	76	85	89	91
133	77	86	91	93

Codice CORINE	CN(A)	CN (B)	CN (C)	CN (D)
141	49	69	79	84
142	68	79	86	89
210	61	73	81	84
211	61	73	81	84
212	67	78	85	89
213	62	71	78	81
221	76	85	90	93
222	43	65	76	82
223	43	65	76	82
231	49	69	79	84
241	61	73	81	84
242	61	73	81	84
243	61	73	81	84
244	43	65	76	82
311	36	60	73	79
312	36	60	73	79
313	36	60	73	79
321	49	69	79	84
322	49	69	79	84
323	35	56	70	77
324	35	56	70	77
331	46	65	77	82
332	96	96	96	96
333	63	77	85	88
334	63	77	85	88
335	98	98	98	98
411	98	98	98	98
412	98	98	98	98
421	98	98	98	98
422	98	98	98	98
423	98	98	98	98
511	98	98	98	98
512	98	98	98	98
521	98	98	98	98
522	98	98	98	98
523	98	98	98	98

Tabella 1 –Parametri CN relativi alla classe II di umidità per le quattro classi litologiche e per i vari tipi di uso del suolo. Fonte: Regione Toscana

Per ogni sottobacino il CN è stato calcolato a partire dai gruppi idrologici e dal Corinne Land Cover, procedendo come media pesata areale delle singole aree elementari. La condizione di umidità del suolo fa riferimento alla capacità di filtrazione del suolo, funzione della sua umidità. In particolare, si deve fare riferimento all'ammontare delle piogge nei 5 giorni antecedenti l'evento ed assegnare la condizione AMC secondo la tabella indicata in Tabella 2, riferita alla stagione di riposo (autunno/inverno) o vegetativa (primavera estate).

CLASSE AMC	STAGIONE DI RIPOSO	STAGIONE VEGETATIVA
I	<12.7	<35.5
II	12.7- -28.0	35.5- - 53.3
III	>28	>53.3

Tabella 2 - Condizioni di umidità antecedenti individuate in base alla precipitazione totale nei 5 giorni precedenti (mm)

Fra una classe e l'altra esistono le seguenti relazioni:

$$CN_{III} = \frac{CN_{II}}{0.43 + 0.0057 \cdot CN_{II}}$$

$$CN_I = \frac{CN_{II}}{2.38 + 0.0138 \cdot CN_{II}}$$

A titolo di cautela, per la determinazione delle portate estreme è stato utilizzato il valore del CN III.

1.3 Trasformazione afflussi-deflussi

Come modello di trasformazione afflussi deflussi si è utilizzato l'idrogramma unitario del SCS, calcolando il lag time su tutti i tratti di tipo *reach*, considerando una celerità d'onda di 2.0 m/s. La valutazione del tempo di corrivazione dei singoli sottobacini è stata effettuata mediando i valori che si ottengono da molteplici formulazioni impiegate in letteratura:

- formula di Ventura:

$$T_c = 0.127 \left(\frac{A}{i_B} \right)^{0.5}$$

- formula di Kirpich:

$$T_c = 0.0003257 \frac{L^{0.77}}{i_B^{0.385}}$$

- formula di Pasini:

$$T_c = 0.108 \frac{(AL)^{0.33}}{i^{0.5}}$$

- formula di Pezzoli:

$$T_c = 0.055 \frac{L}{i^{0.5}}$$

- formula di Ferro:

$$T_c = 0.675 A^{0.5}$$

dove A è la superficie del Bacino in km², L la lunghezza dell'asta principale in km, i la pendenza media del corso d'acqua, i_B la pendenza media del bacino. La lag time del bacino, ovvero il tempo di risposta, seguendo il metodo proposto dall'SCS, viene posto pari a 0.6 volte il tempo di corrivazione.

1.4 Sintesi degli studi idrologici pregressi

Nell'ambito della formazione del secondo regolamento urbanistico del Comune di Sesto Fiorentino l'Ing. Davide Settesoldi ha sviluppato lo studio idrologico idraulico, con modello tarato sulla base di un set di eventi reali registrati all'idrometro presente sul Fosso Reale, con pluviometria antecedente all'aggiornamento delle curve di possibilità pluviometrica del 2012.

Corso d'acqua	A bacino	Q30	q30	Q200	q200
Fosso Osmannoro	5.09 km ²	18.28 m ³ /s	3.59 m ³ /s km ²	29.01 m ³ /s	5.69 m ³ /s km ²
Fossa Nuova Gavina	2.48 km ²	11.17 m ³ /s	4.50 m ³ /s km ²	18.41 m ³ /s	7.42 m ³ /s km ²

Tabella 3 –Portate di piena desunte dallo studio idraulico dell'Ing. David Settesoldi per il secondo regolamento urbanistico del Comune di Sesto Fiorentino per i bacini di Osmannoro

1.5 Modello idrologico sviluppato nell'ambito della variante del secondo Regolamento Urbanistico del Comune di Sesto Fiorentino

Per le premesse precedentemente esposte, ovvero per una definizione di maggior dettaglio dei bacini di scolo afferenti all'area di Osmannoro, è stato sviluppato un nuovo modello idrologico tramite in software HEC HMS, con riferimento alle CPP aggiornate al 2012.

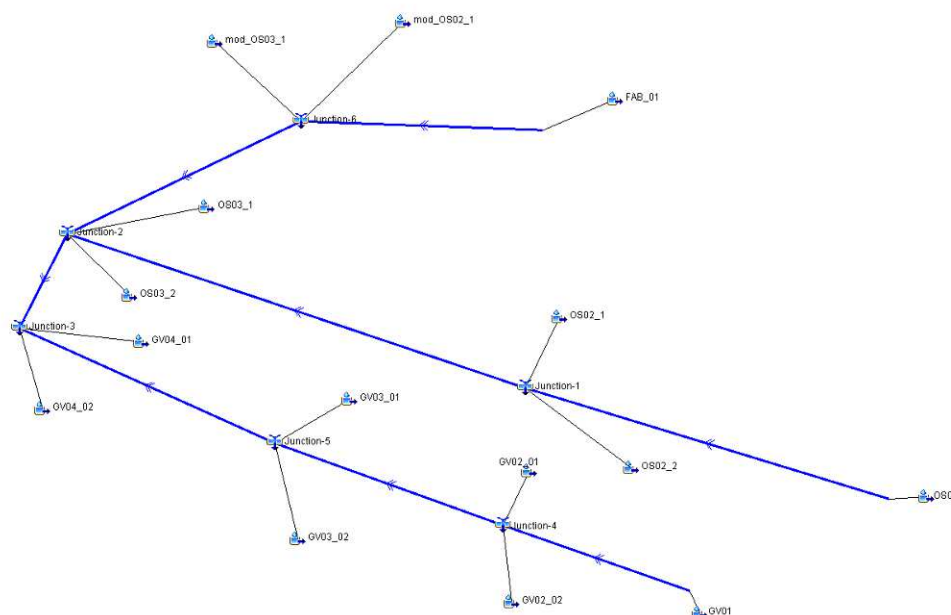


Figura 3 – Modello HEC HMS dei sottobacini afferenti al comparto idraulico di Osmannoro

Il modello idrologico è stato basato sui seguenti presupposti:

- Modello in HMS con il metodo SCS-CN, con verifica di congruenza rispetto allo schema utilizzato dall'Ing. Davide Settesoldi, tarato su eventi pluviometrici reali e portate registrate all'idrometro presente sul Fosso Reale;
- Sottobacini aventi le caratteristiche riportate in *Figura 1* e nelle tavole grafiche allegate;
- Spazializzazione delle portate sulla base della media pesata h su maglia 1 km x 1 km;
- Ietogramma rettangolare ad intensità costante;
- Curve number CN III.

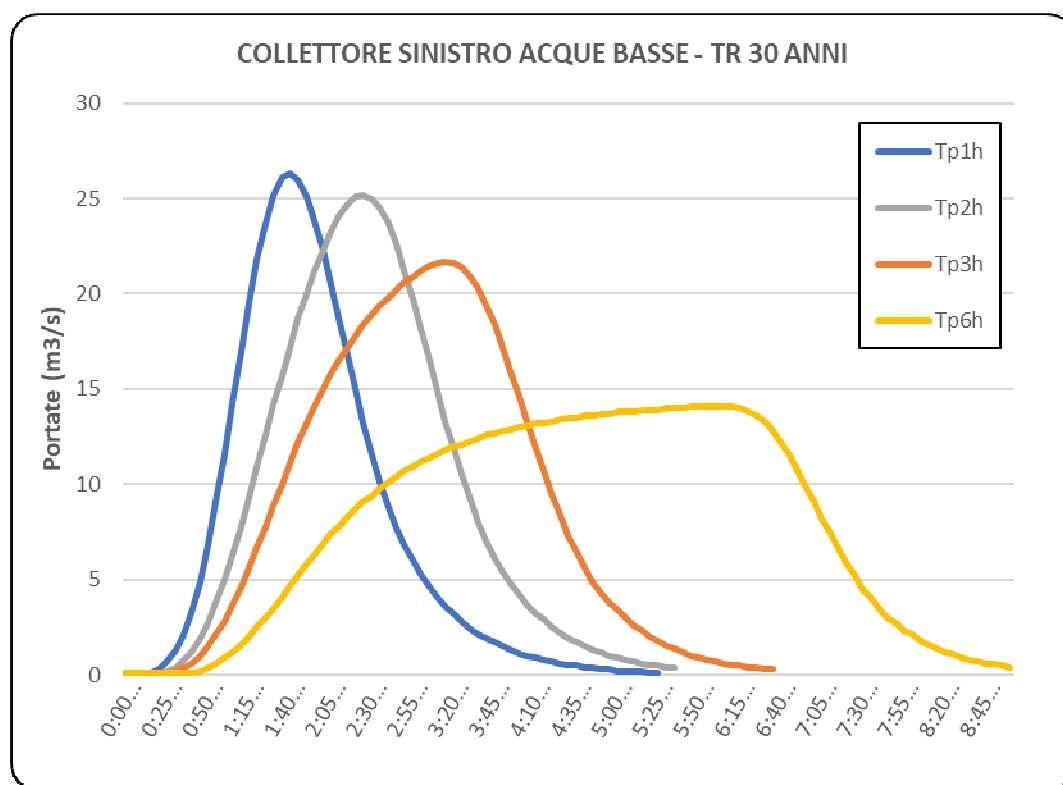


Figura 4 – Idrogrammi di piena Collettore sinistro acque basse per Tr 30 anni, metodo CN del SCS, in testa alla sezione di inizio verifica idraulica

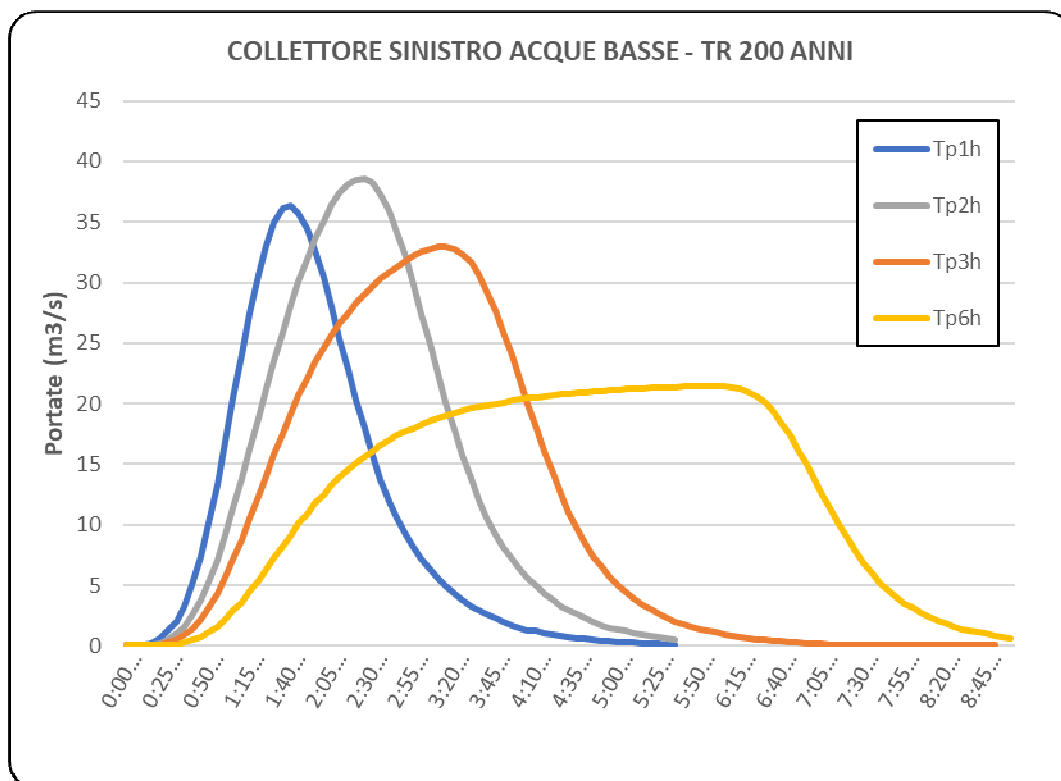


Figura 5 – Idrogrammi di piena Collettore sinistro acque basse per Tr 200 anni, metodo CN del SCS, in testa alla sezione di inizio verifica idraulica

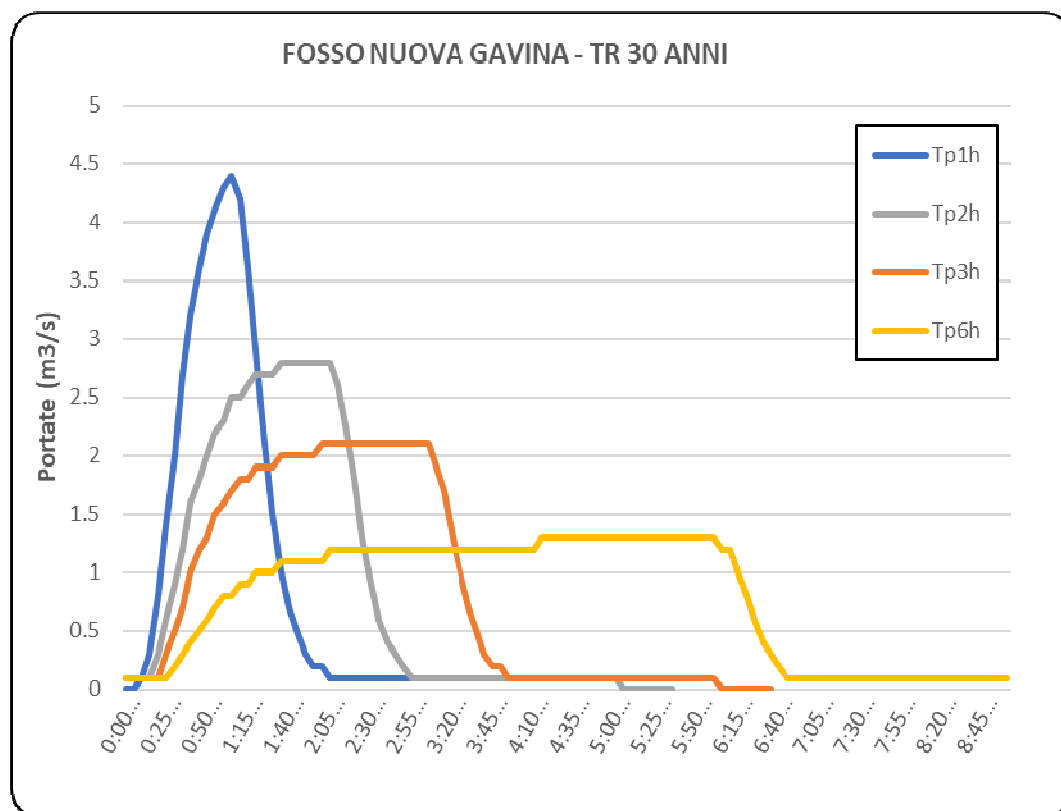


Figura 6 – Idrogrammi di piena Fossa Nuova Gavina per Tr 30 anni, metodo CN del SCS, in testa alla sezione di inizio verifica idraulica

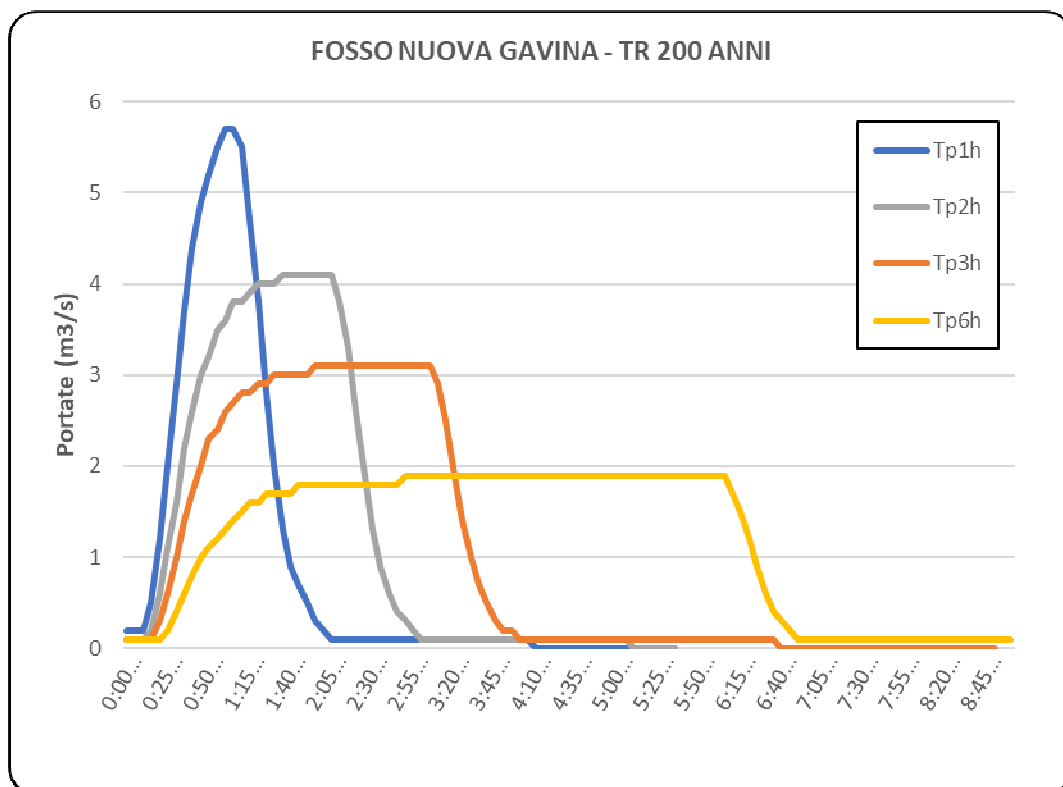


Figura 7 – Idrogrammi di piena Fossa Nuova Gavina per Tr 200 anni, metodo CN del SCS, in testa alla sezione di inizio verifica idraulica

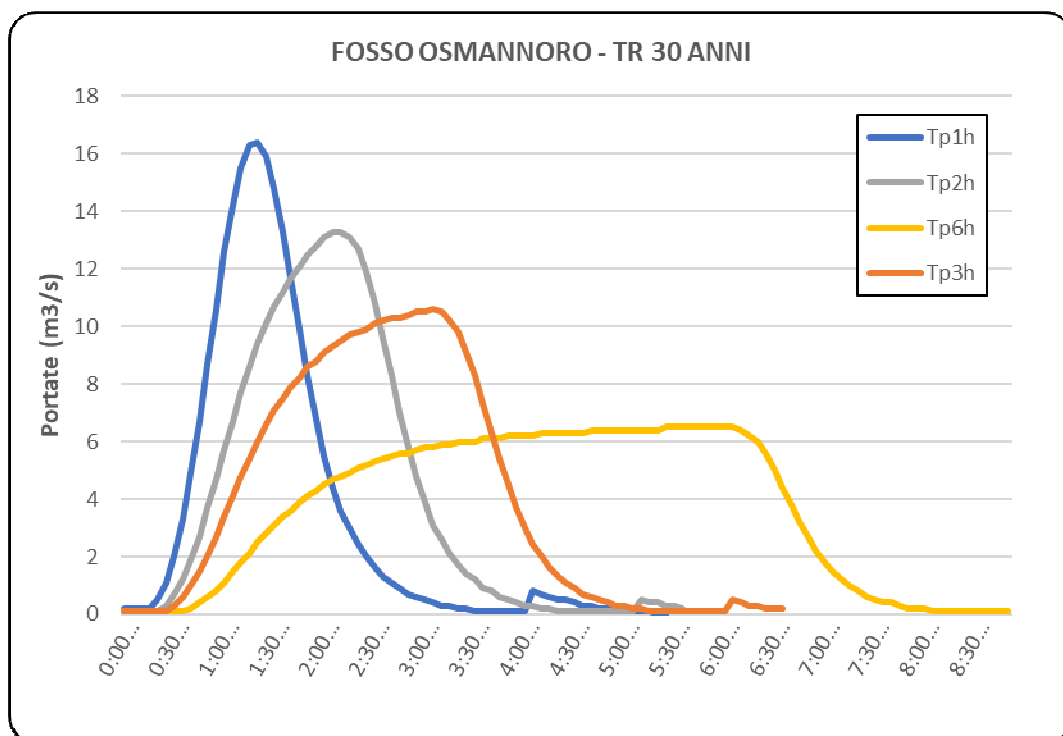


Figura 8 – Idrogrammi di piena Fosso Osmannoro per Tr 30 anni, metodo CN del SCS, in testa alla sezione di inizio verifica idraulica

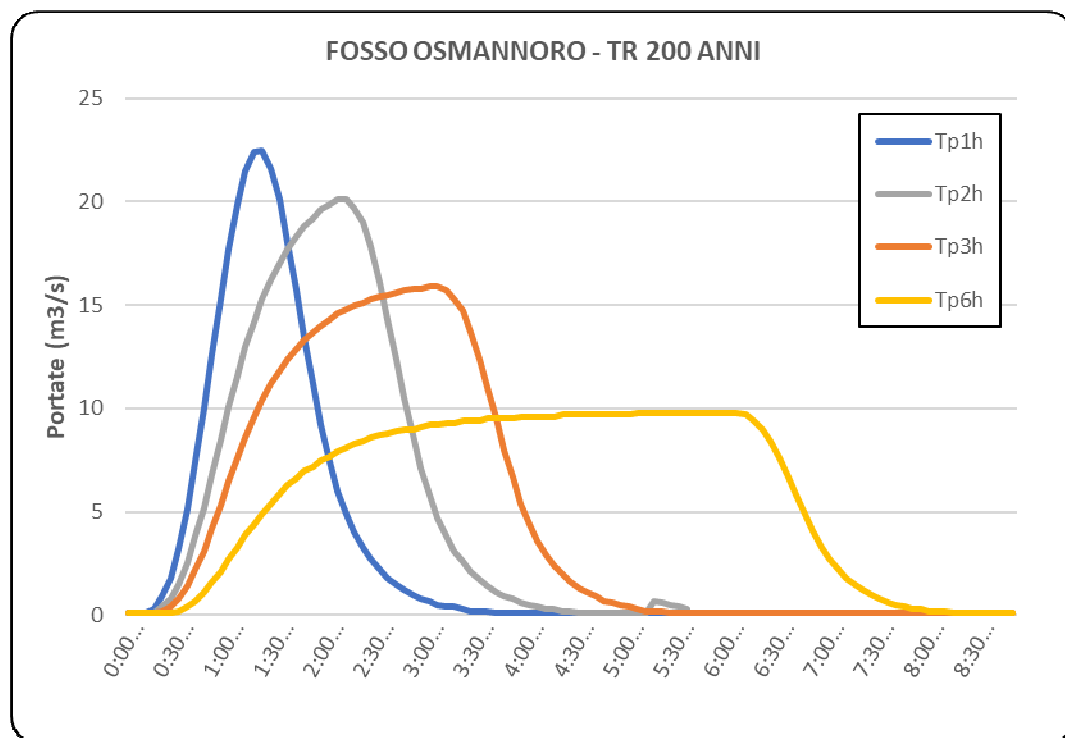


Figura 9 – Idrogrammi di piena Fosso Osmannoro per Tr 200 anni, metodo CN del SCS, in testa alla sezione di inizio verifica idraulica

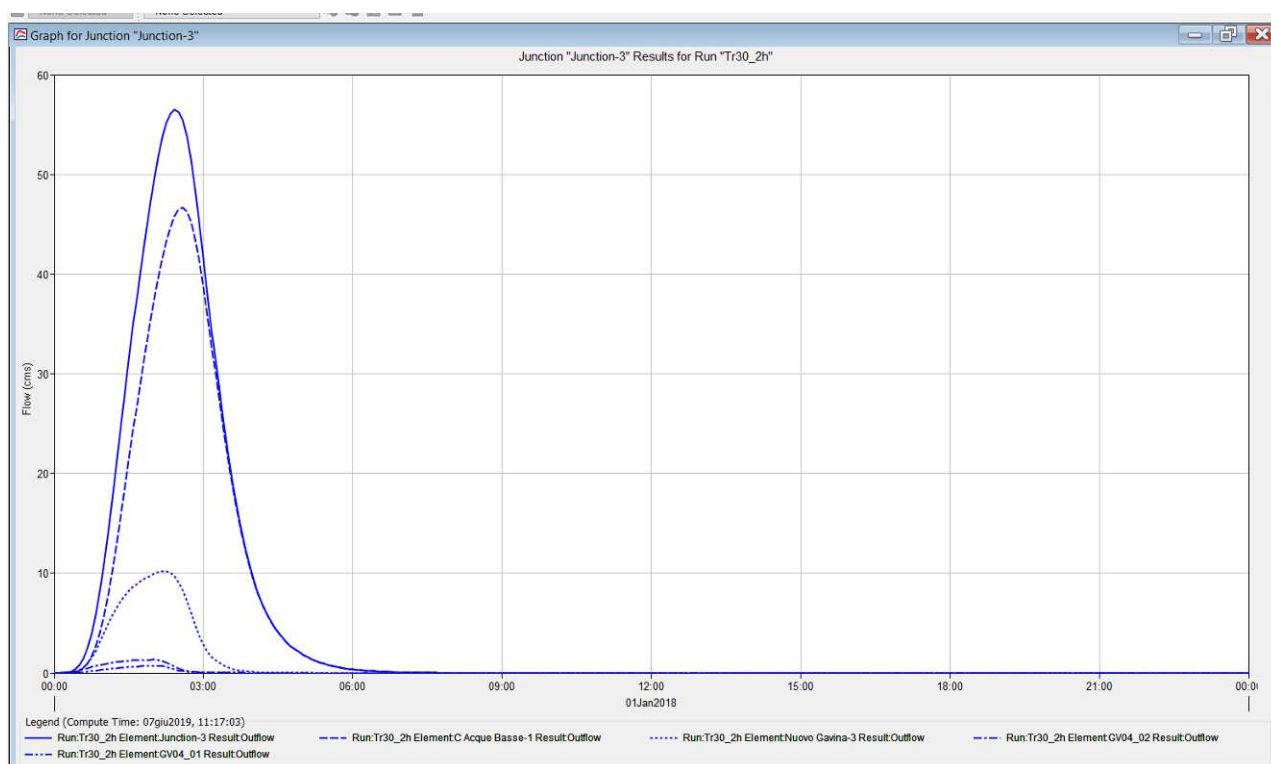


Figura 10 – Idrogrammi di piena del nodo confluenza Fosso Osmannoro, dopo aver ricevuto il collettore sinistro e la Fossa Nuova Gavina per Tr 30 anni

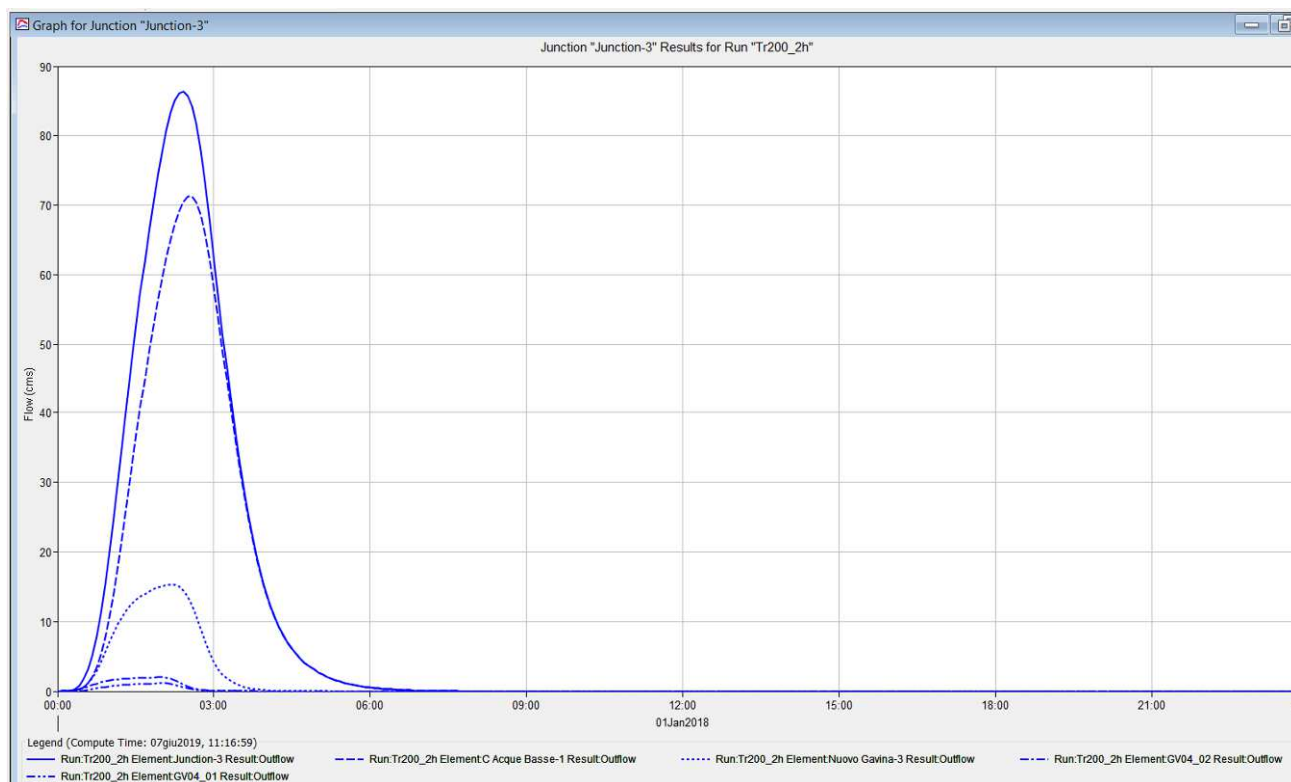


Figura 11 – Idrogrammi di piena del nodo confluenza Fosso Osmannoro, dopo aver ricevuto il collettore sinistro e la Fossa Nuova Gavina per Tr 30 anni

1.6 Condizioni al contorno

Come ricavato dagli incontri con i tecnici del Consorzio di Bonifica Medio Valdarno, per rappresentare realisticamente la dinamica delle acque basse a valle dell'autostrada A1, come condizione al contorno di valle è stato imposto lo "Stage Hydrograph" ovvero l'idrogramma dei livelli del Collettore Principale delle Acque Basse in corrispondenza del tombamento di Via Pistoiese.

Risultano significativi i seguenti livelli:

- Tr 30 anni: +34.00 m.s.l.m.
- Tr 200 anni: +35.00 m.s.l.m.

2. Modellazione idraulica

La modellazione idraulica è stata condotta con uno schema di moto vario unidimensionale per il canale e puramente bidimensionale per la propagazione dei deflussi sul piano campagna.

2.1 Schema di moto vario 1-D accoppiato con schema 2-D tramite HEC-RAS

Le verifiche idrauliche sono state realizzate con un modello accoppiato di tipo monodimensionale all'interno del canale e puramente bidimensionale per la propagazione dei volumi esondati sul piano campagna, implementato con il software HEC RAS 5.0.7, che è un modello fisicamente basato in grado di conservare e distribuire i volumi d'acqua in base all'effettiva morfologia e topografia del territorio analizzato.

Lo schema di moto all'interno del canale è di tipo unidimensionale non stazionario (moto vario), risolto mediante integrazione numerica delle equazioni di De Saint Venant; le arginature od i cigli di sponda sono rappresentati mediante sfioratori longitudinali (*Lateral Structures*) che, nell'evenienza in cui il livello liquido raggiunga la sommità arginale, trasferiscono il volume esondato sul territorio, per la sua propagazione con schema di moto bidimensionale, che è risolto mediante l'integrazione numerica delle equazioni del moto, espressa come equazione dell'onda dinamica completa, e di conservazione del volume:

$$\frac{\partial h}{\partial t} + \frac{\partial h V_x}{\partial x} = i$$

$$S_{fx} = S_{0x} - \frac{\partial h}{\partial x} - \frac{V_x}{g} \frac{\partial V_x}{\partial x} - \frac{1}{g} \frac{\partial V_x}{\partial t}$$

dove:

- h: tirante idrico;
- V_x : componente lungo x della velocità media;
- i: intensità dell'eccesso di pioggia;
- S_{fx} : componente lungo x del gradiente delle perdite di carico per attrito (da equazione di Manning);
- S_{0x} : pendenza del piano campagna.

L'interfaccia 1D-2D è di tipo bidirezionale, ovvero consente la propagazione da e verso il canale, ovviamente in base alle condizioni topografiche e dei livelli idraulici di monte e valle. La costruzione del modello digitale del terreno è realizzata mediante l'utilizzo di punti georeferenziati di coordinate x,y,z a partire dei dati altimetrici Lidar, forniti dal volo della Regione Toscana (anno 2012).

La definizione dei coefficienti di scabrezza è stata fatta distinguendo il moto nei canali e quello nella piana alluvionale. Per quanto riguarda il primo caso si sono assunti i seguenti valori di scabrezza:

Tipologia	Scabrezza n (Manning)
Canale principale in terra	0.03-0.035
Canale artificiale in cls	0.025
Sommità spondale	0.065
Manufatti in cls	0.025

Tabella 4 – Coefficienti di scabrezza utilizzati per lo schema di moto vario

Sempre per quanto riguarda le verifiche in moto vario all'interno del canale principale si sono assunti i seguenti coefficienti di contrazione/espansione:

Tipologia	Coeff. Contrazione	Coeff. Espansione
Variazioni graduali di sezione	0.1	0.3
Brusche variazioni di sezione	0.3	0.5
Ponti e attraversamenti	0.3	0.5

Tabella 5 – Coefficienti di contrazione ed espansione

L'interfaccia 1D-2D è stata simulata mediante *lateral structures* ricalcanti il profilo longitudinale della sommità arginale, con sfioro delle acque con stramazzo direttamente nelle aree 2D, simulato mediante la "Standard Weir Equation" secondo i seguenti coefficienti:

What is being modeled with the Lateral Structure	Description	Range of Weir Coefficients
Levee/Roadway – 3ft or higher above natural ground	Broad crested weir shape, flow over levee/road acts like weir flow	1.5 to 2.6 (2.0 default) SI Units: 0.83 to 1.43
Levee/Roadway – 1 to 3 ft elevated above ground	Broad crested weir shape, flow over levee/road acts like weir flow, but becomes submerged easily.	1.0 to 2.0 SI Units: 0.55 to 1.1
Natural high ground barrier – 1 to 3 ft high	Does not really act like a weir, but water must flow over high ground to get into 2D flow area.	0.5 to 1.0 SI Units: 0.28 to 0.55
Non elevated overbank terrain. Lat Structure not elevated above ground	Overland flow escaping the main river.	0.2 to 0.5 SI Units: 0.11 to 0.28

Tabella 6 – Coefficienti di sfioro laterale

Relativamente alla simulazione degli attraversamenti, oltre ai coefficienti di contrazione ed espansione precedentemente riportati, si specifica che sono stati modellati tramite l'approccio pressure and/or wier, per simularne anche il comportamento in pressione, mediante l'immissione di culvert aventi coefficienti di perdita per ingresso e uscita rispettivamente pari a 0.5 e 1 e Manning pari a 0.02.

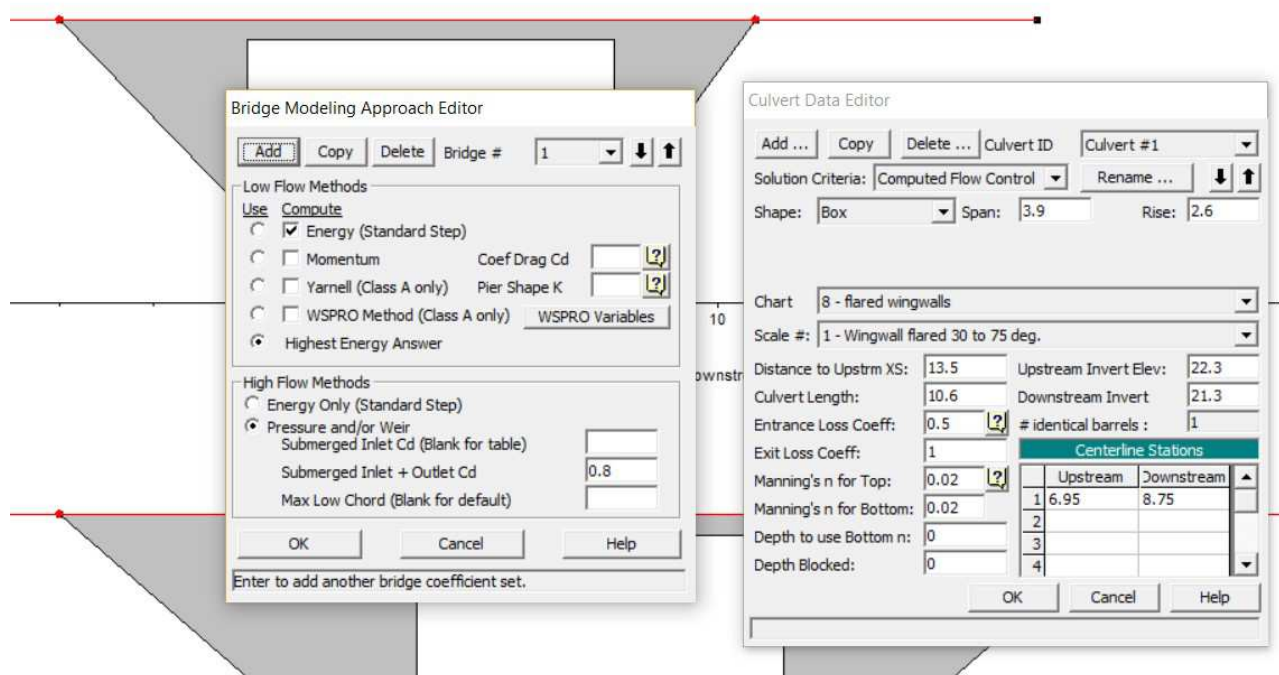


Figura 12 - Modellazione dei ponti e attraversamenti

La definizione dei coefficienti di scabrezza della pianura alluvionale è stata effettuata mediante valori di letteratura associati ai codici di uso del suolo del Land Corine Cover (C.J. van Der Sande et al, *A segmentation and classification approach of IKONOS-2 imagery for land cover mapping to assist flood risk and flood damage assessment*, *International Journal of applied earth observation and geoinformation*, 2003, Lopes et al *Flooding assessment under sea level rise scenarios: Ria de Aveiro case*, *Journal of coastal research*, 2013).

USO DEL SUOLO	Codice CORINE	Manning n
Tessuto Urbano continuo	111	0.20
Tessuto Urbano discontinuo	112	0.09
Aree industriali o commerciali	121	0.14
Reti stradali e ferroviarie e spazi accessori	122	0.07
Aree portuali	123	0.07
Aeroporti	124	0.06
Aree estrattive	131	0.12

USO DEL SUOLO	Codice CORINE	Manning n
Discariche	132	0.04
Cantieri	133	0.06
Aree verdi urbane	141	0.02
Aree ricreative e sportive	142	0.04
Seminativi in aree non irrigue	211	0.08
Seminativi in aree irrigue	212	0.08
Risaie	213	0.04
Vigneti	221	0.12
Frutteti e frutti minori	222	0.12
Oliveti	223	0.12
Prati Stabili	231	0.1
Colture temporanee associate a colture permanenti	241	0.08
Sistemi colturali e particellari complessi	242	0.10
Aree con colture agrarie e spazi naturali importanti	243	0.09
Boschi di latifoglie	311	0.1
Boschi di conifere	312	0.1
Boschi misti	313	0.13
Aree a pascolo naturale e praterie	321	0.11
Brughiere e cespuglieti	322	0.06
Aree a vegetazione sclerofilla	323	0.10
Aree a vegetazione boschiva ed arbustiva in evoluzione	324	0.10
Spiagge, dune e sabbie	331	0.07
Rocce nude, falesie, rupi, affioramenti	332	0.07
Aree con vegetazione rada	333	0.09
Aree percorse da incendi	334	0.07
Paludi interne	411	0.10
Saline	422	0.04
Corsi d'acqua, canali e idrovie	511	0.03
Bacini d'acqua	521	0.03

Tabella 7 – Coefficienti di scabrezza per la propagazione dei volumi esondati sul piano campagna

L'attribuzione dei coefficienti di scabrezza è stata fatta mediante la procedura di Hec Ras "Land Cover to Manning's n" con cui associare a ciascuna cella 2D il corrispettivo codice Corine, e da questo il relativo valore di scabrezza secondo Manning, in modo da descrivere fedelmente le effettive condizioni di deflusso della pianura.

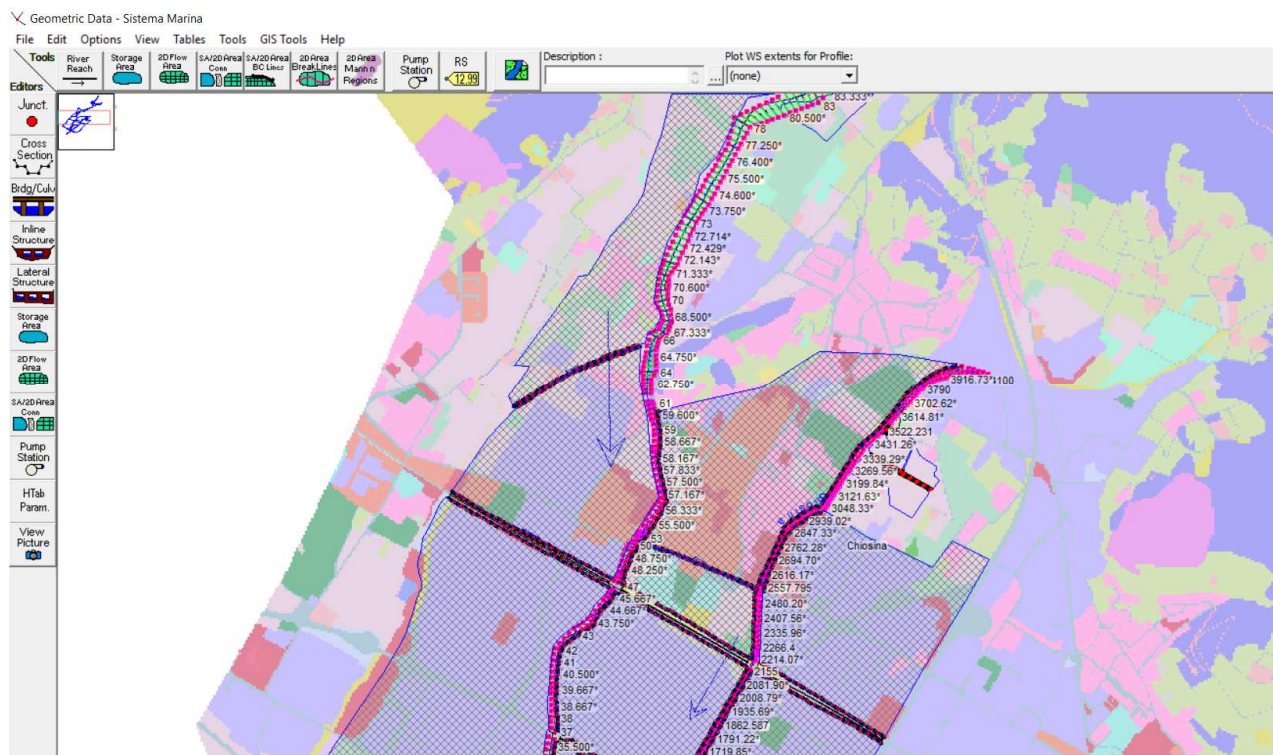


Figura 13 - Esempio di associazione dei valori di scabrezza secondo Manning della pianura tramite il relativo codice Corine effettuato tramite Hec Ras

Tutte le simulazioni sono state condotte con riferimento a tempi di ritorno 30 e 200 anni e tempi di pioggia di 1, 2, 3 e 6 ore. La durata di ogni run di simulazione è stata imposta di 3 ore in più rispetto al tempo di pioggia, in modo da consentire l'effettiva propagazione dei volumi sfiorati sul piano campagna, verificando comunque che al termine della simulazione la propagazione si fosse effettivamente stabilizzata.

2.2 Verifica idraulica Collettore sinistro delle acque basse - Fosso Osmannoro – Fossa Gavina – Collettore principale acque basse

Per definire la pericolosità idraulica della zona di Osmannoro sono state condotte verifiche idrauliche anche sul Collettore sinistro delle acque basse, sul Fosso Osmannoro, sulla Fossa nuova Gavina e sul collettore delle acque basse; il collettore sinistro è stato simulato a partire dallo svincolo autostradale di uscita a Osmannoro, il fosso Osmannoro è stato simulato a partire dalla località Ponte a Giogoli, mentre la Fossa Gavina da Via della Madonna del Terrazzo (sulla base della geometria dei lavori recentemente realizzati), imponendo come input gli idrogrammi di piena precedentemente esposti. Il collettore delle acque basse si origina dalla confluenza di suddetti fossi ed è stato simulato fino a Via Pistoiese (fuori Comune) imponendo comunque come condizione di valle i livelli costanti precedentemente riportati.



Figura 14 – Schematizzazione modello idraulico comparto Osmannoro

Per eventi con Tr 30 anni si riscontrano alcune esondazioni in sinistra del collettore delle acque basse e del Fosso Gavina, così come alcune fuoriuscite in destra e sinistra del Fosso Osmannoro; per eventi con Tr 200 anni le esondazioni si estendono, interessando anche la porzione a valle dell'autostrada A1, che risente delle condizioni dei livelli di valle.



Figura 15 – Risultati verifiche idrauliche Tr 30 anni

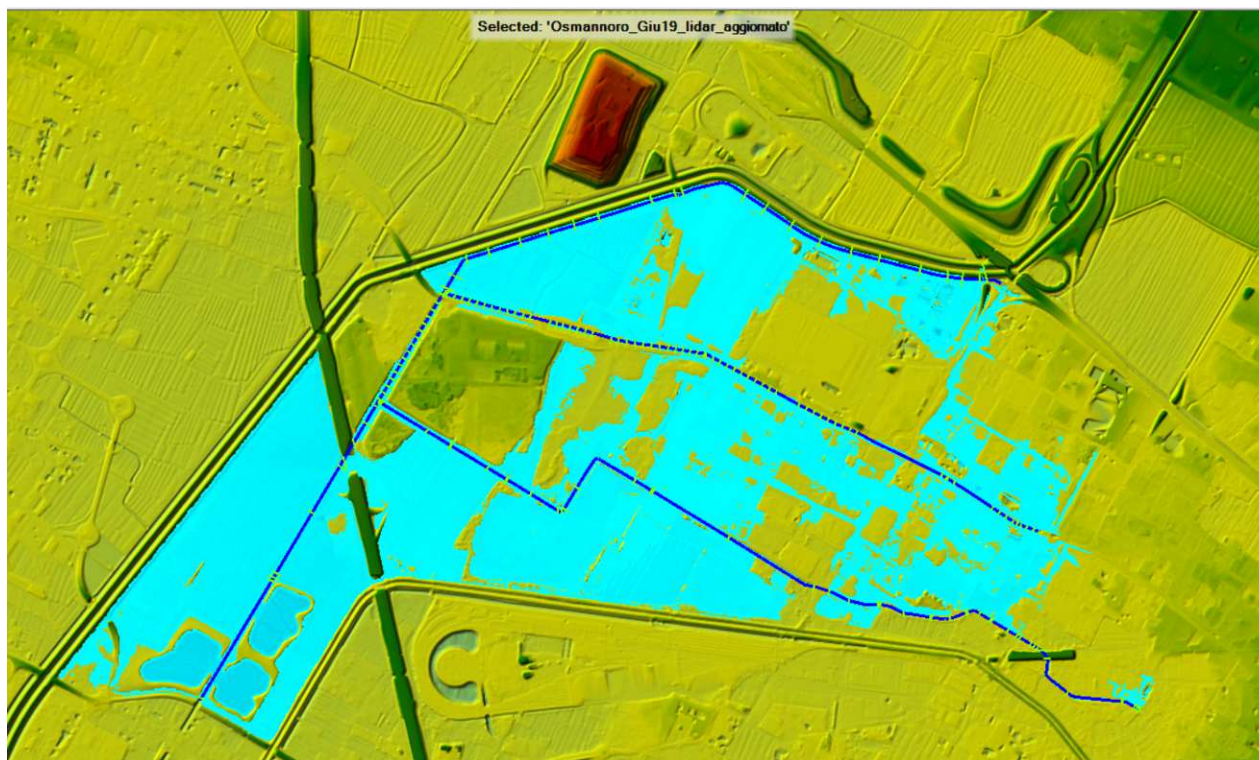


Figura 16 – Risultati verifiche idrauliche Tr 200 anni

In quest'areale oltre ai battenti derivanti dal modello descritto, occorre aggiungere quelli derivanti dalle esondazioni del Fiume Arno per eventi duecentennali che si attestano a 37.00 m s.l.m., come dati forniti dall'Autorità di Distretto appennino settentrionale.

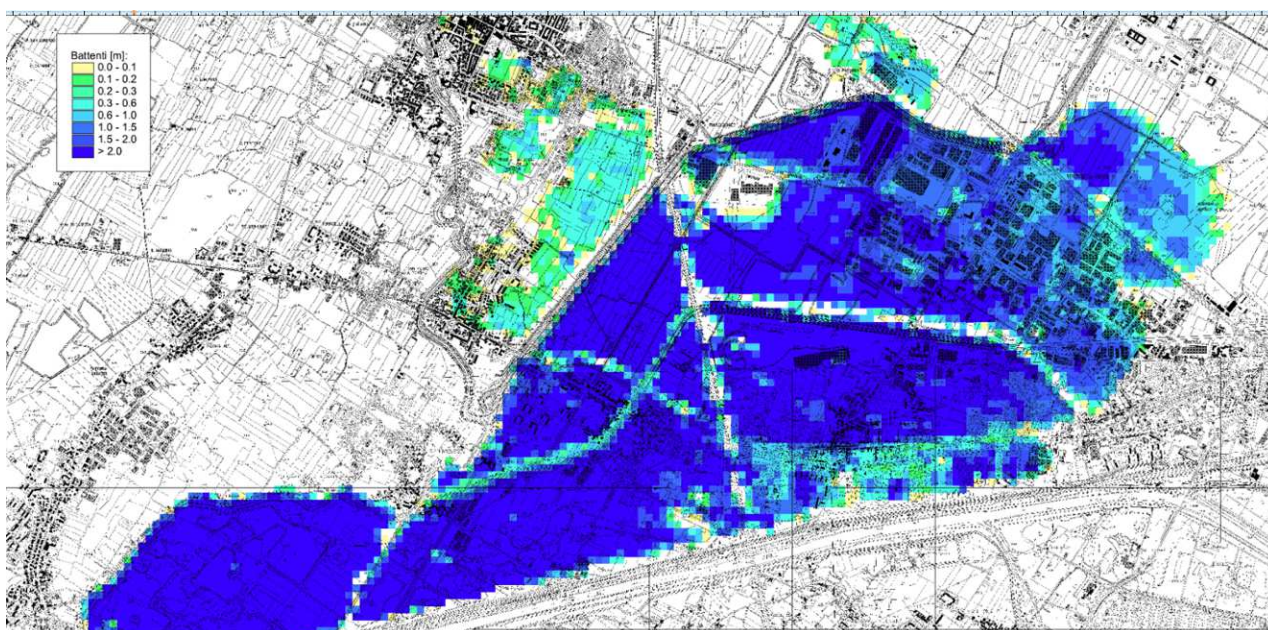


Figura 17 - Battenti di esondazione per il tempo di ritorno di 200 anni (A.R.N.O. Arno River Network Operational model, 2006)

2. Aggiornamento della pericolosità idraulica

Sulla base dei battenti per veri tempi di ritorno e per le varie durate di pioggia ricavati dalle verifiche idrauliche sono state aggiornate le mappe di pericolosità del Comune di Sesto Fiorentino, ai sensi del 53/R/2011 ed ai sensi del P.G.R.A. Distretto Appennino Settentrionale.

La pericolosità idraulica ai sensi del 53/R è stata definita sulla base dei seguenti criteri:

- I.2 aree inondabili con tempi di ritorno maggiori di Tr 200 anni;
- I.3 aree inondabili con tempo di ritorno superiore Tr 30 anni e minore o uguale a Tr 200 anni;
- I.4 aree inondabili con tempo di ritorno inferiore o uguale a Tr 30 anni.

Poiché non si è provveduto ad effettuare simulazioni per eventi con tempo di ritorno cinquecento anni, il limite I.2 è stato desunto dalla pericolosità P1 del PGRA, che viene confermato in questa sede. In analogia a quanto fatto in sede di secondo regolamento urbanistico del Comune di Sesto Fiorentino, sono state introdotte due ulteriori classi:

- I.2* aree di potenziale inefficienza della rete fognaria;
- I.3* aree di potenziale ristagno e/o insufficienza di drenaggio della rete di acque basse.

La pericolosità idraulica ai sensi del P.G.R.A. è stata definita sulla base dei seguenti criteri:

- P1 aree inondabili con tempi di ritorno maggiori di Tr 200 anni;
- P2 aree inondabili con tempo di ritorno superiore Tr 30 anni e minore o uguale a Tr 200 anni;
- P3 aree inondabili con tempo di ritorno inferiore o uguale a Tr 30 anni.

Ai fini della classificazione del territorio sulla base della legge 41/R/2018 si è provveduto a redigere la tavola della magnitudo idraulica, che tiene conto della combinazione dei battenti di esondazione e della velocità di propagazione:

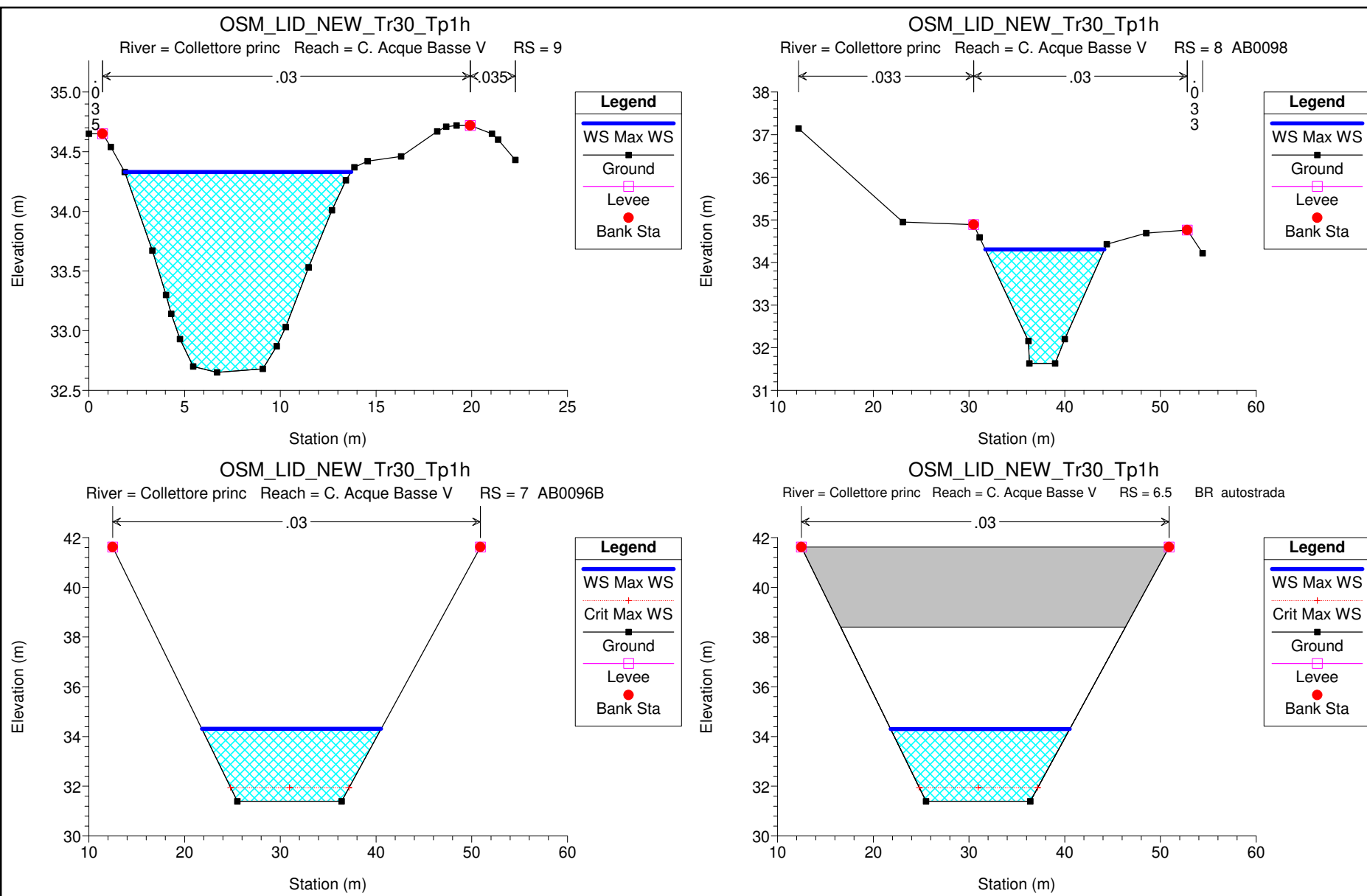
- magnitudo idraulica moderata: valori di battente inferiore o uguale a 0,5 metri e velocità inferiore o uguale a 1 metro per secondo (m/s). Nei casi in cui la velocità non sia determinata, battente uguale o inferiore a 0,3 metri;
- magnitudo idraulica severa: valori di battente inferiore o uguale a 0,5 metri e velocità superiore a 1 metro per secondo (m/s) oppure battente superiore a 0,5 metri e inferiore o uguale a 1 metro e velocità inferiore o uguale a 1 metro per secondo (m/s). Nei casi in cui la velocità non sia determinata, battente superiore a 0,3 metri e inferiore o uguale a 0,5 metri;

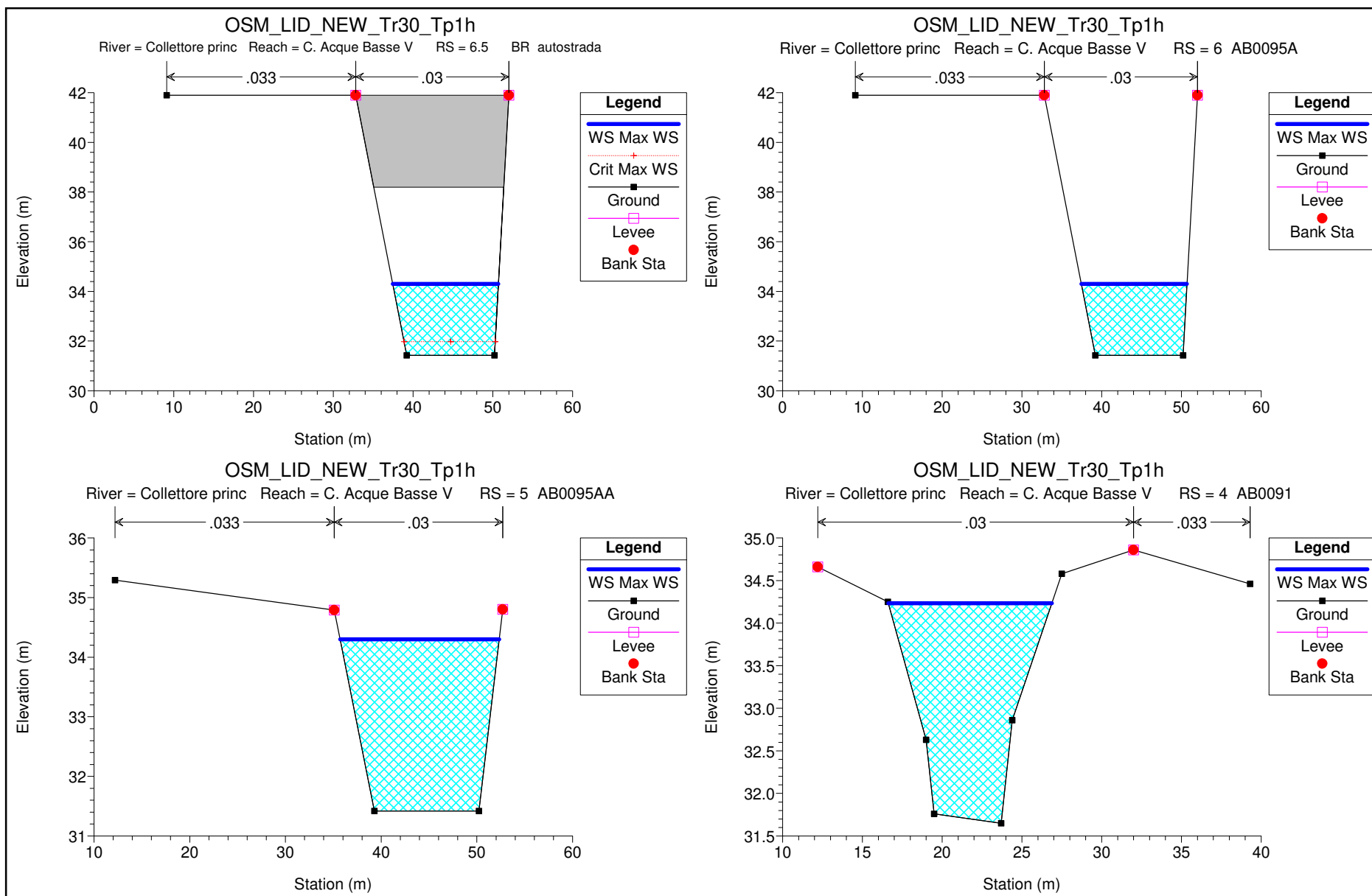
- magnitudo idraulica molto severa: battente superiore a 0,5 metri e inferiore o uguale a 1 metro e velocità superiore a 1 metro per secondo (m/s) oppure battente superiore a 1 metro. Nei casi in cui la velocità non sia determinata battente superiore a 0,5 metri.

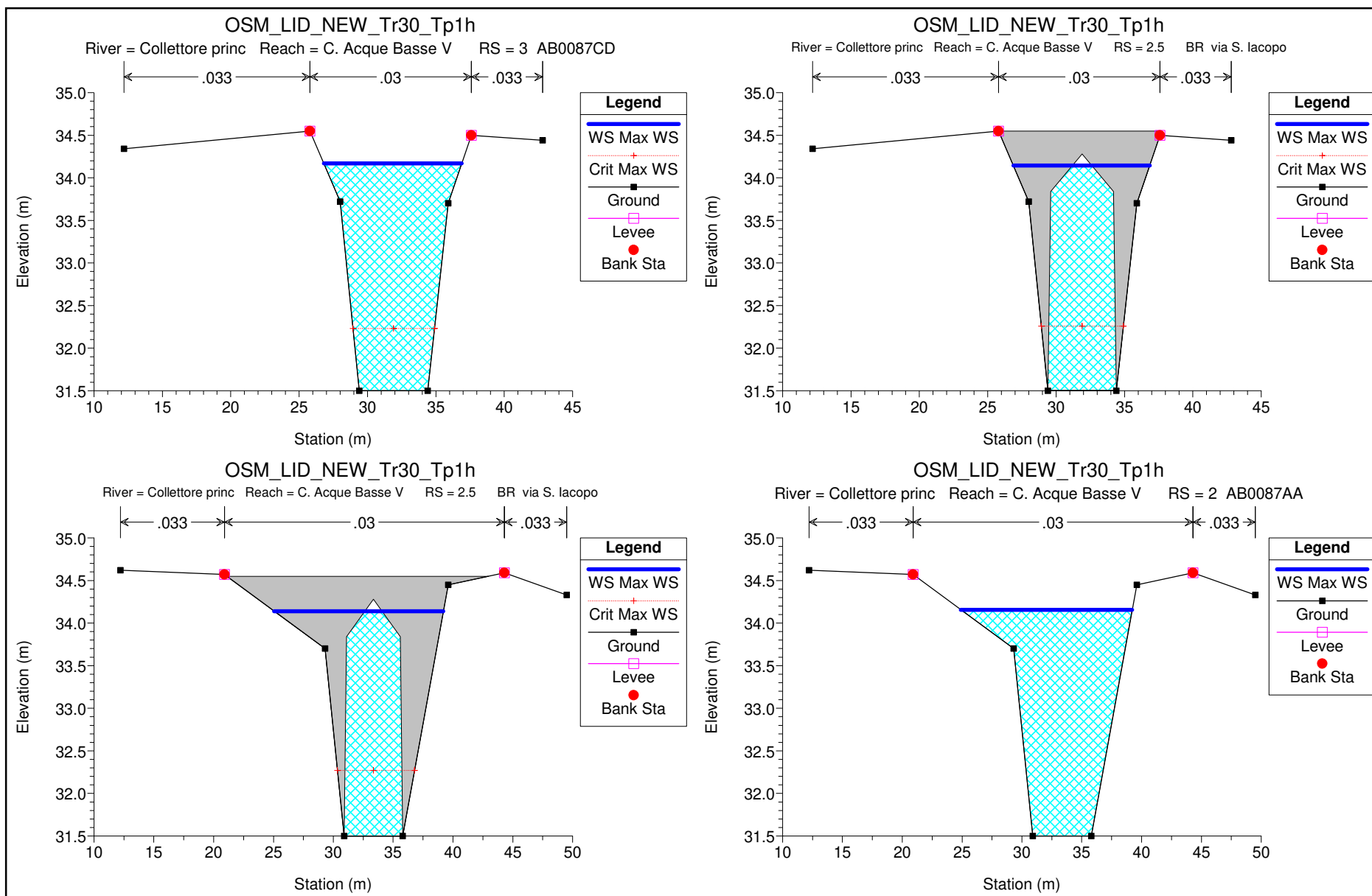
N.B.: Per come è costruito, il modello idraulico, che è basato su LIDAR con maglia 1 x 1 m, restituisce nelle zone di frangia delle aree allagabili una sorta di “sfrangiatura di pixel” con valori di battente molto bassi, dovuto alla tolleranza di calcolo del modello. Per completezza nelle carte dei battenti allegate sono riportati integralmente i risultati dell’output idraulico sotto forma di grid, filtrando i battenti inferiori a 5 cm, in modo da mitigare questo effetto di sfrangiatura. Come concordato con Autorità di Distretto Appennino Settentrionale e Uffici del Genio Civile, nel passaggio da battenti a pericolosità è stato effettuato un processo di “smoothing” del dato, in modo da eliminare pixel distaccati dal corpo delle esondazioni o pixel isolati. Allo stesso modo si è cercato di eliminare “l’effetto isola” all’interno delle aree inondate, salvo veri alti morfologici, al fine di dare un continuum alla forma dell’esondazione, attribuendo pertanto a queste aree la classe di pericolosità dell’area limitrofa. In questo caso, ad un’area a pericolosità idraulica cui non corrisponde un battente reale, si attribuisce un battente convenzionale di 10 cm, per tenere conto dell’eventuale incertezza del modello idraulico utilizzato.

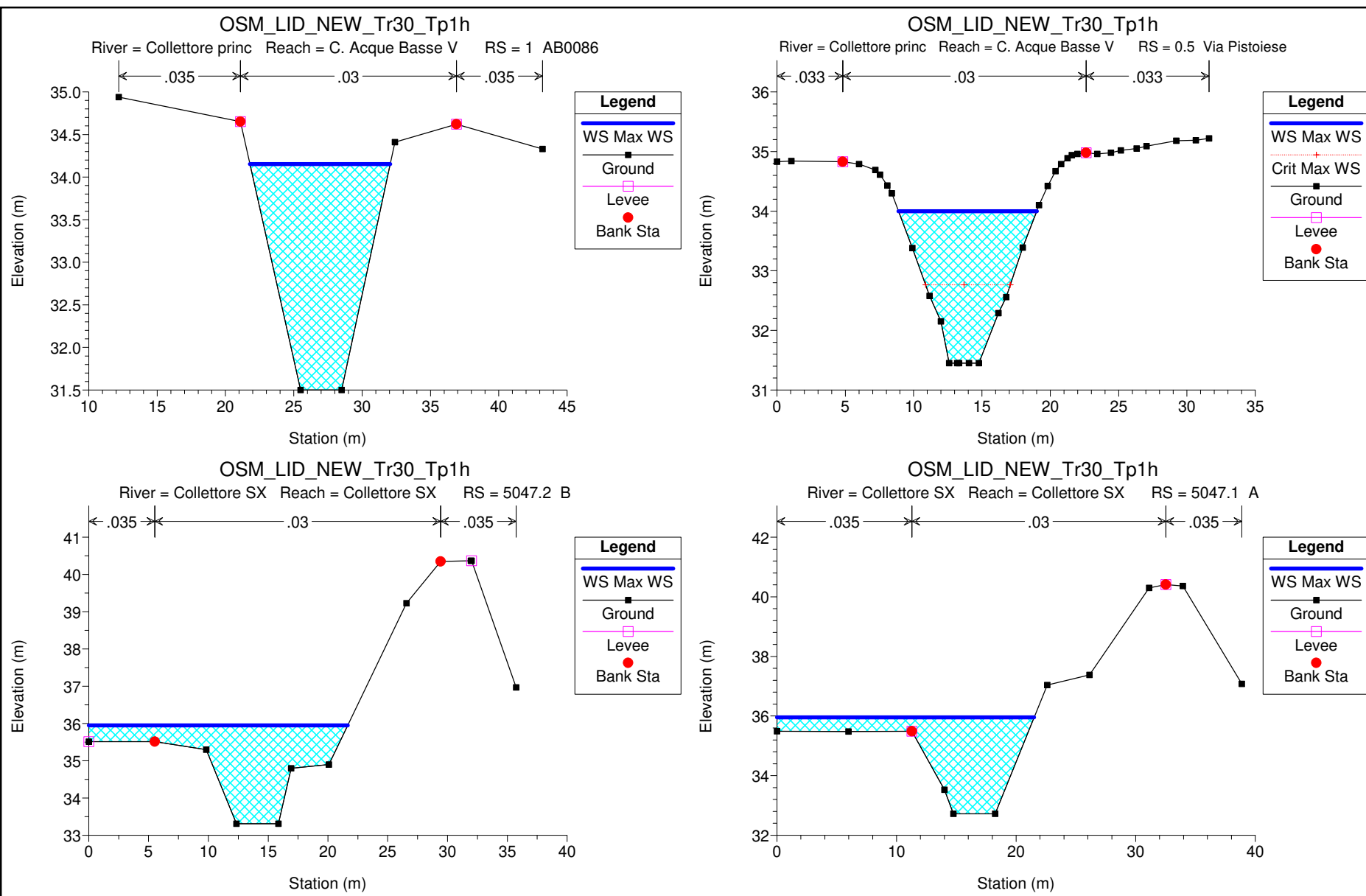
Verifiche idrauliche Tr 30 anni Tp 1h

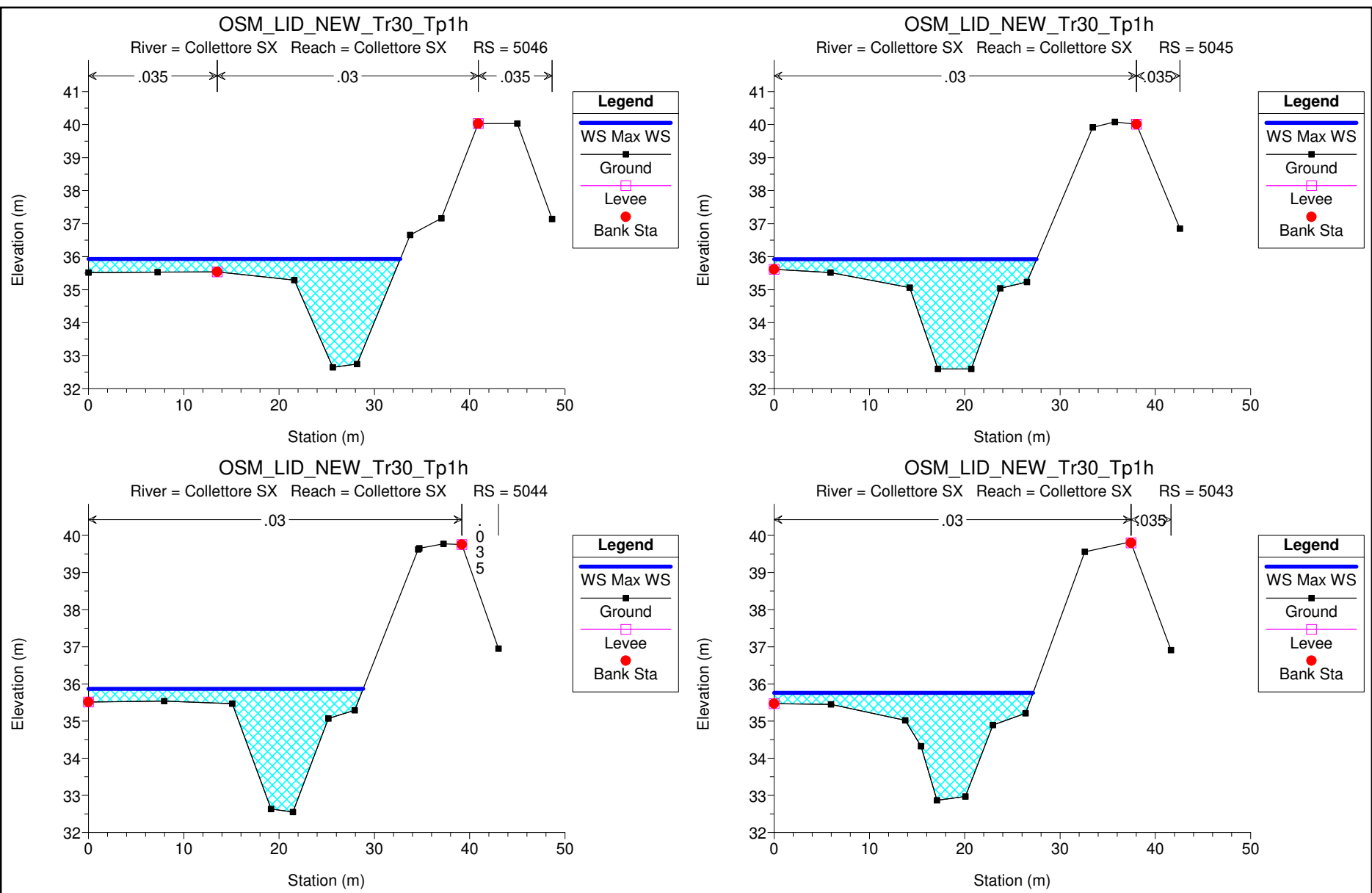
**Collettore sinistro acque basse – Fosso Osmannoro – Fosso Nuova Gavine – Collettore
principale delle acque basse**

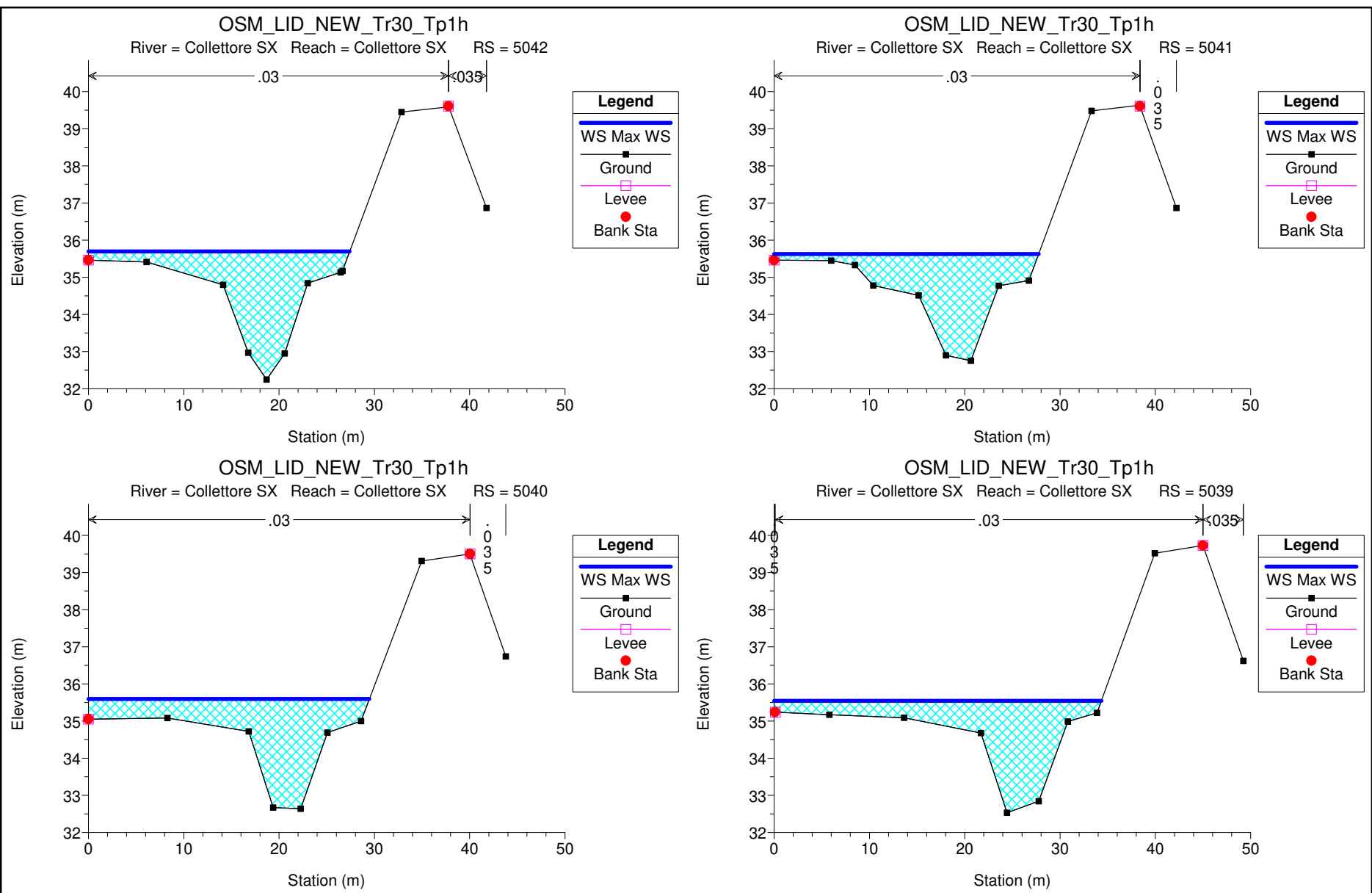


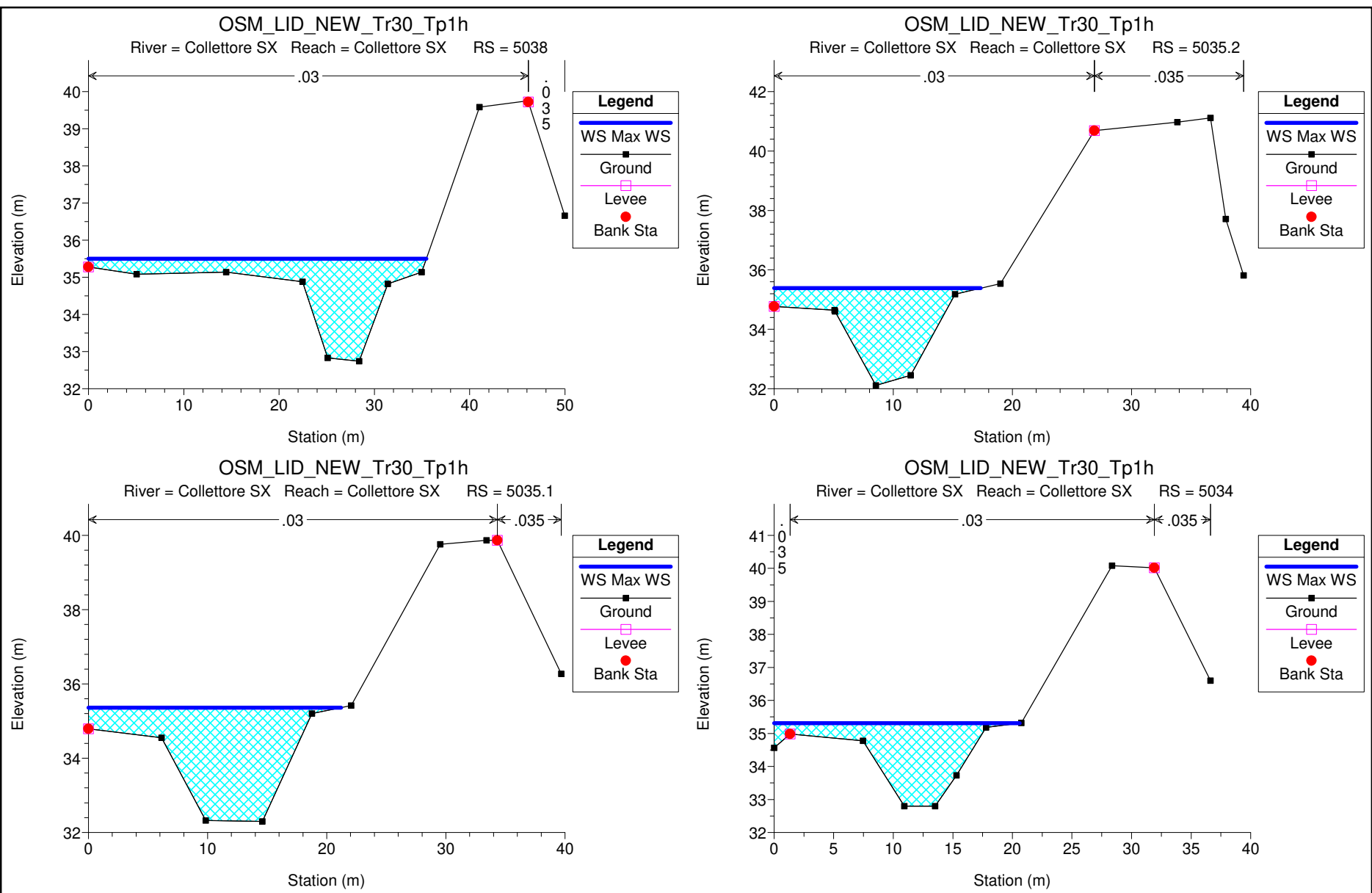


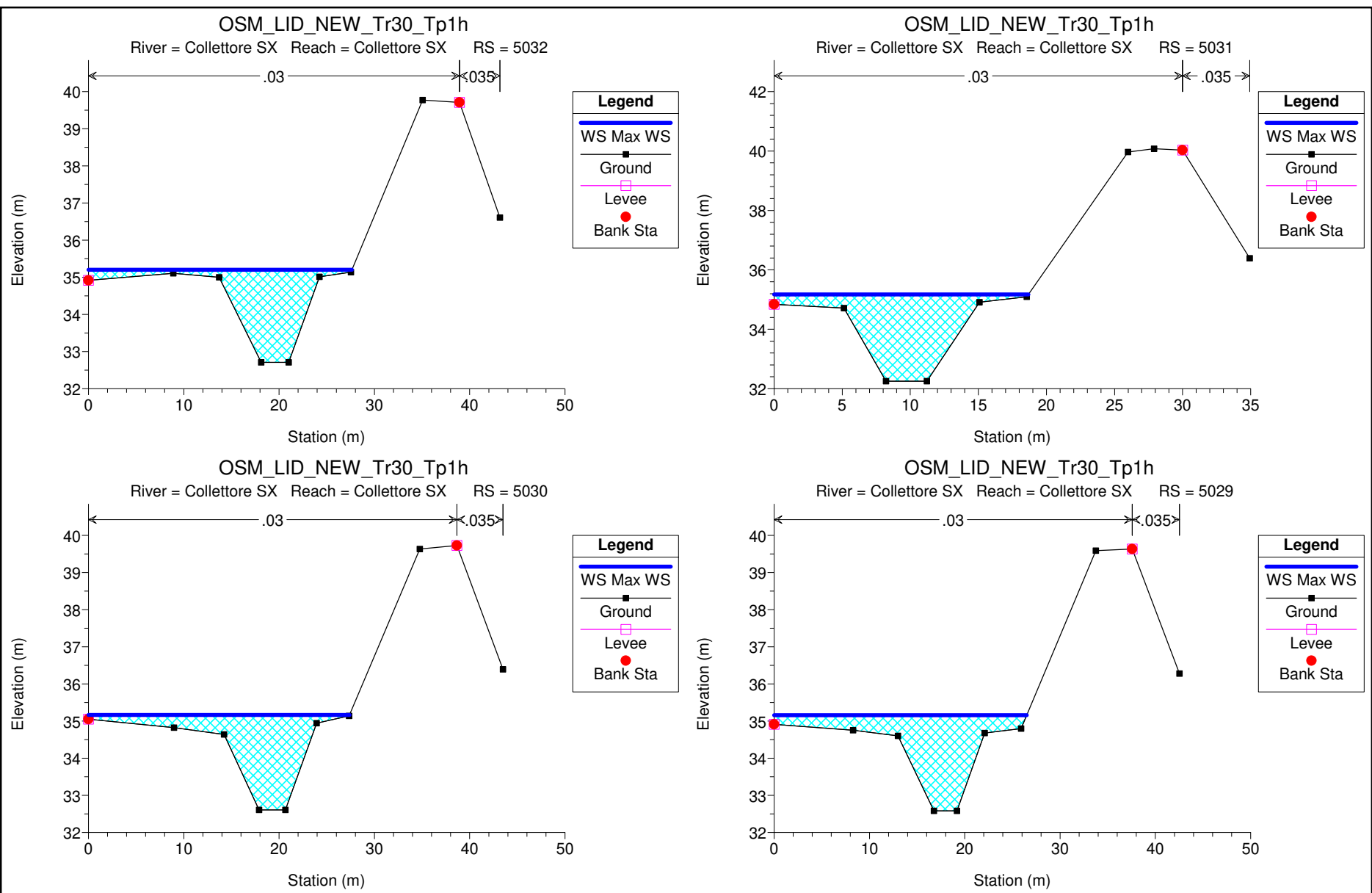


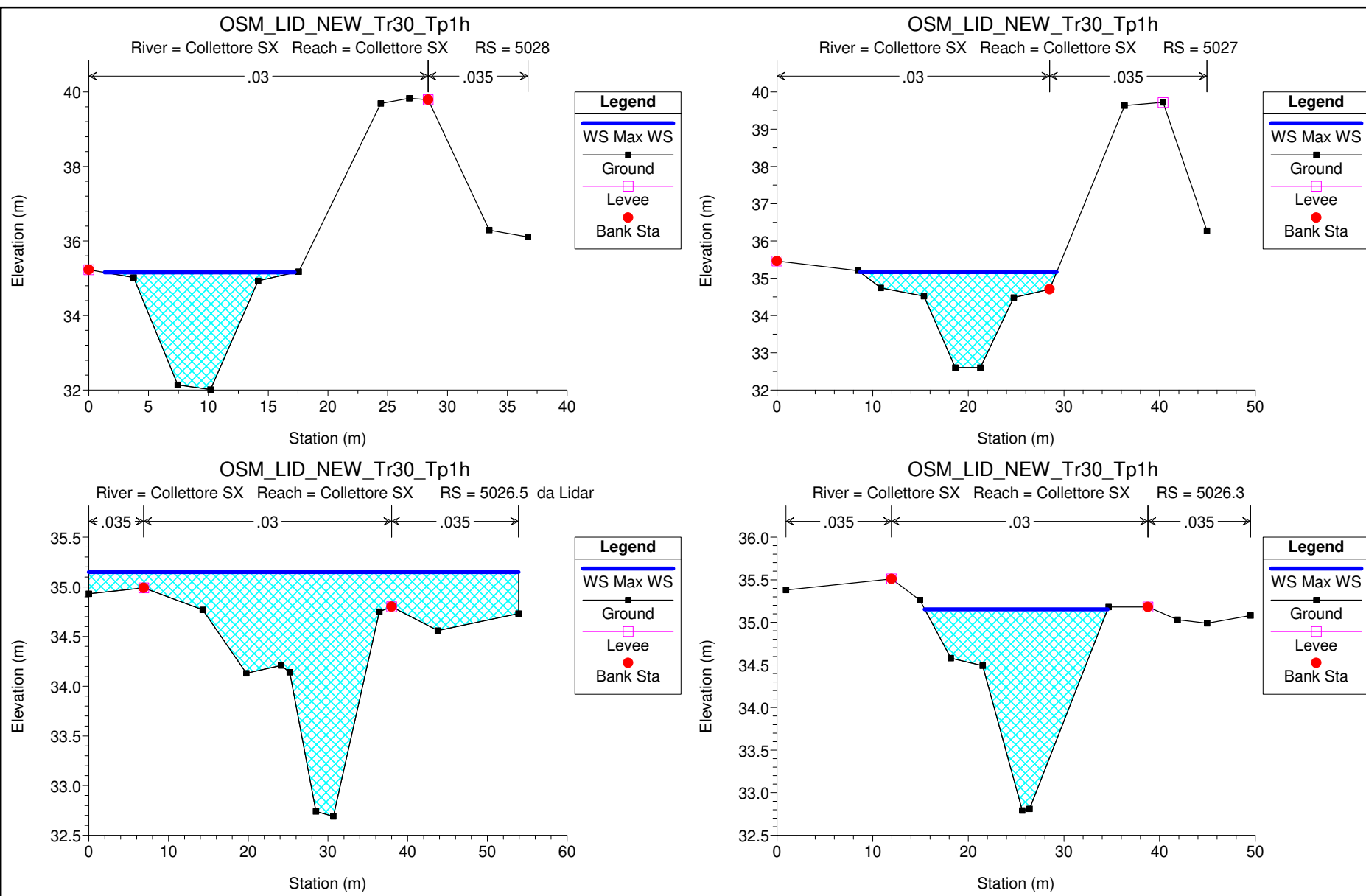


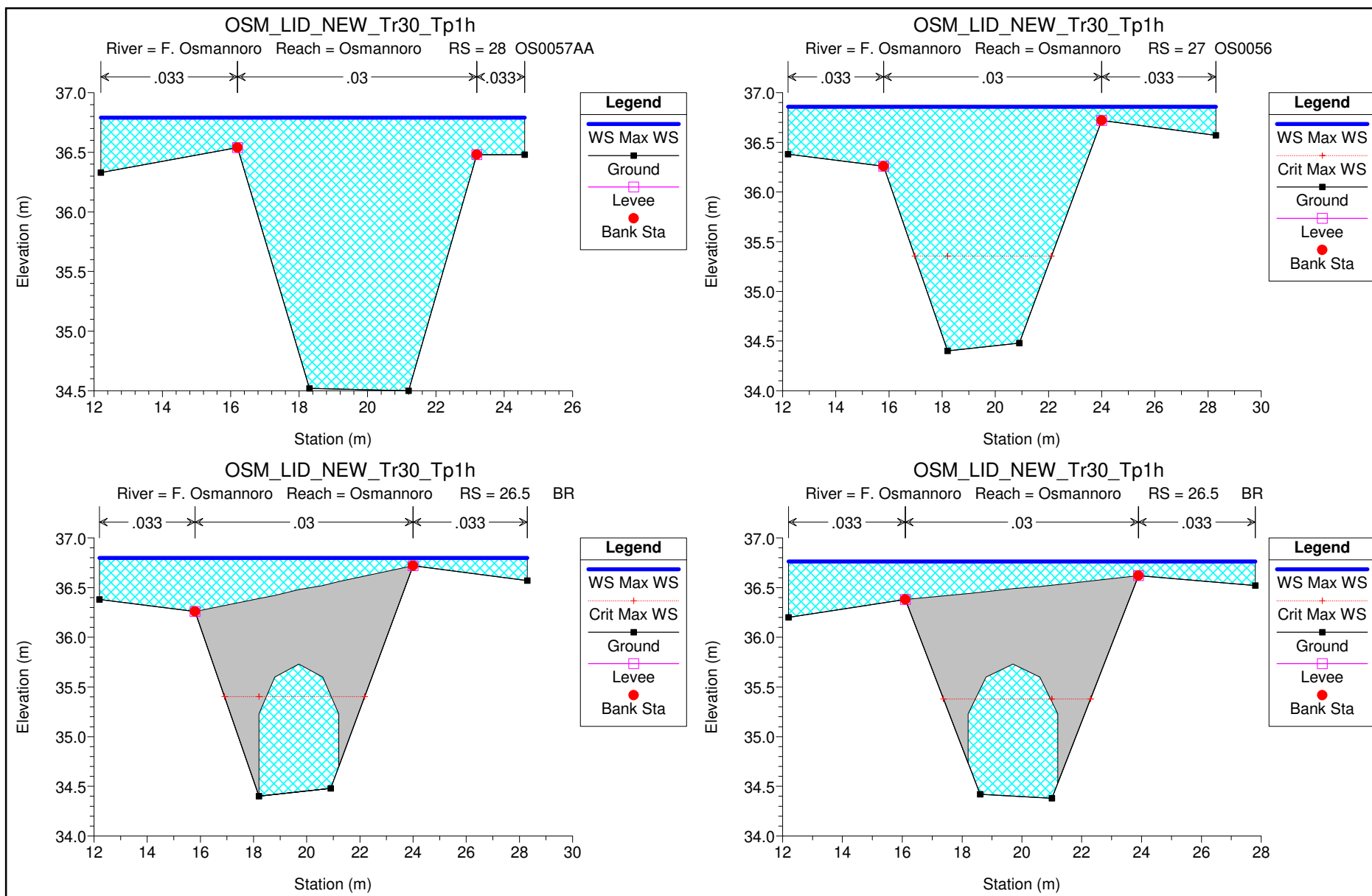


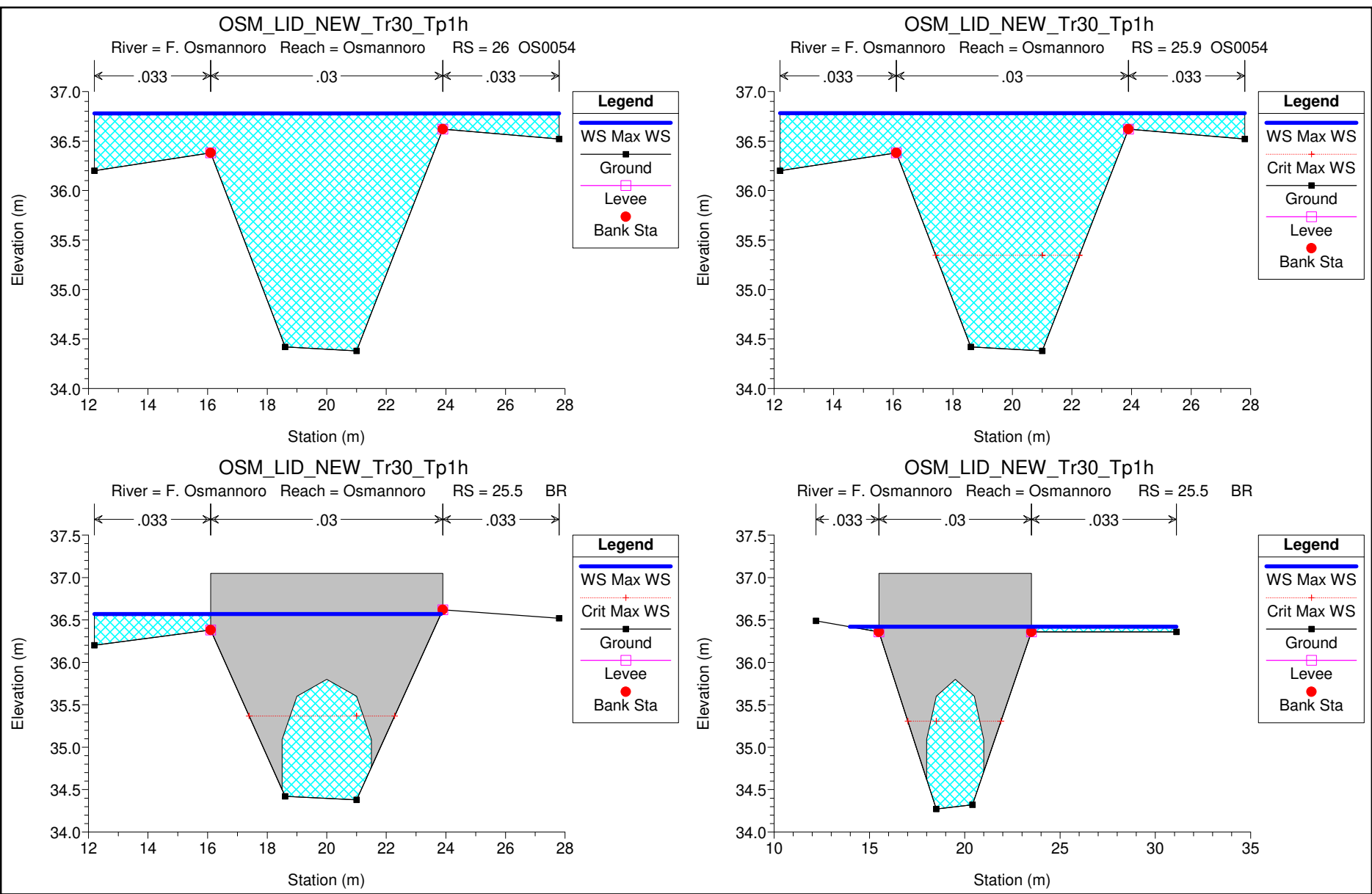


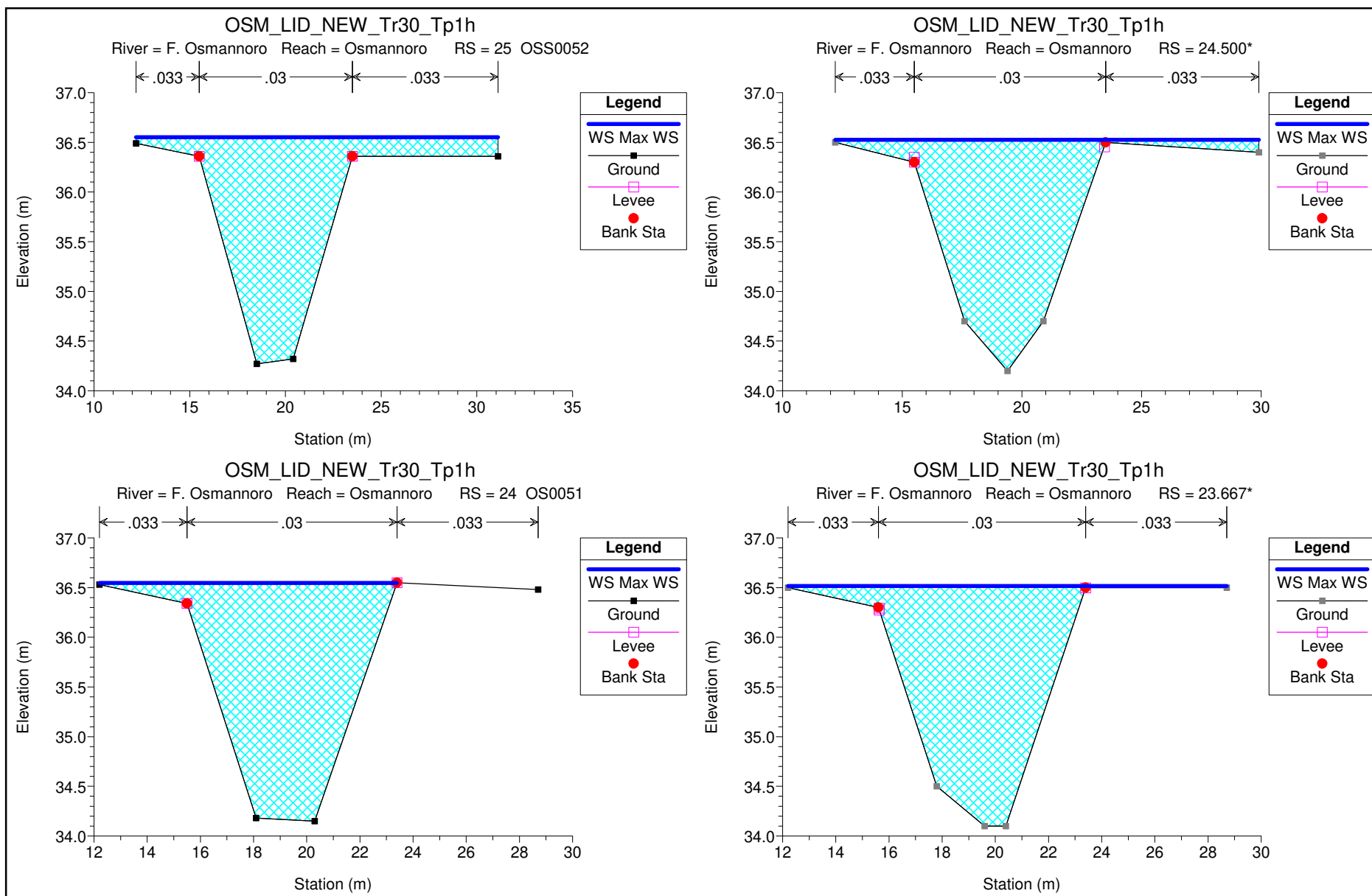


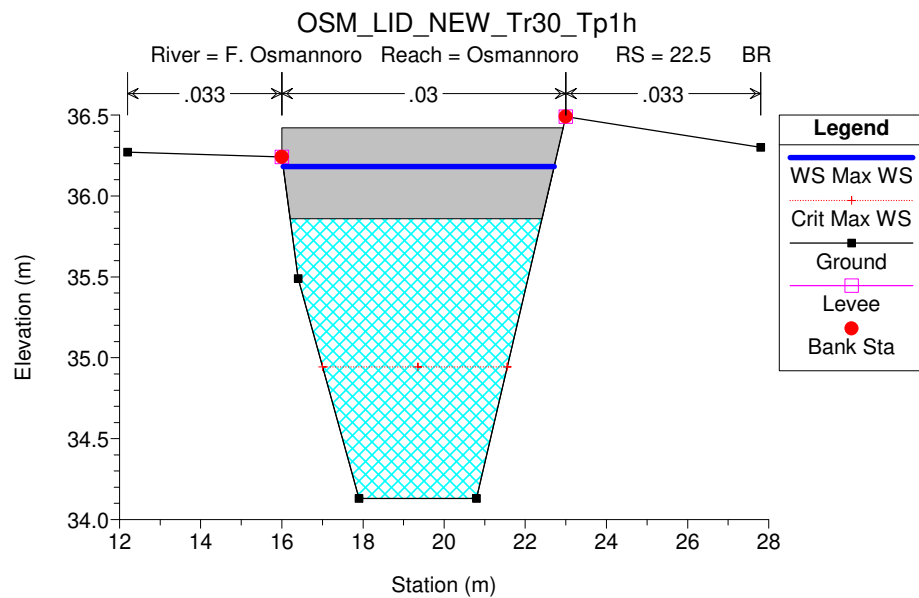
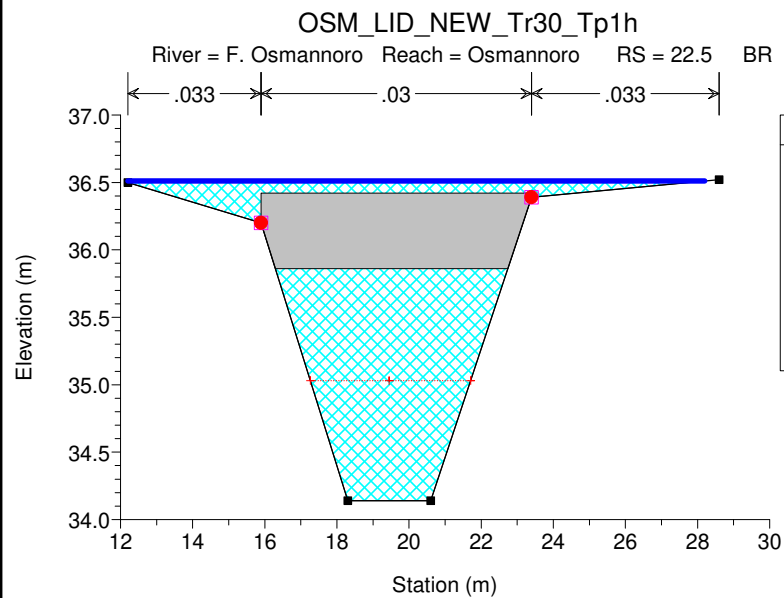
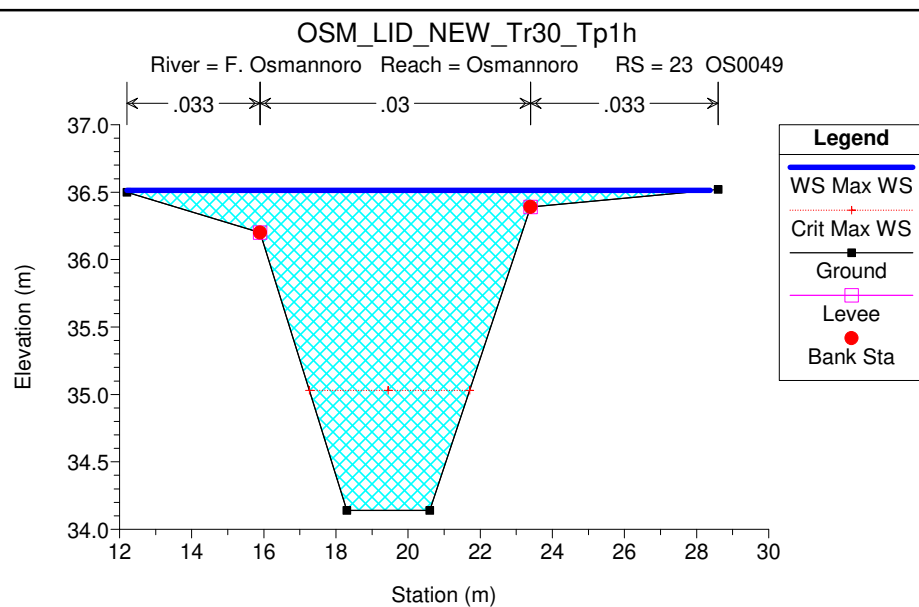
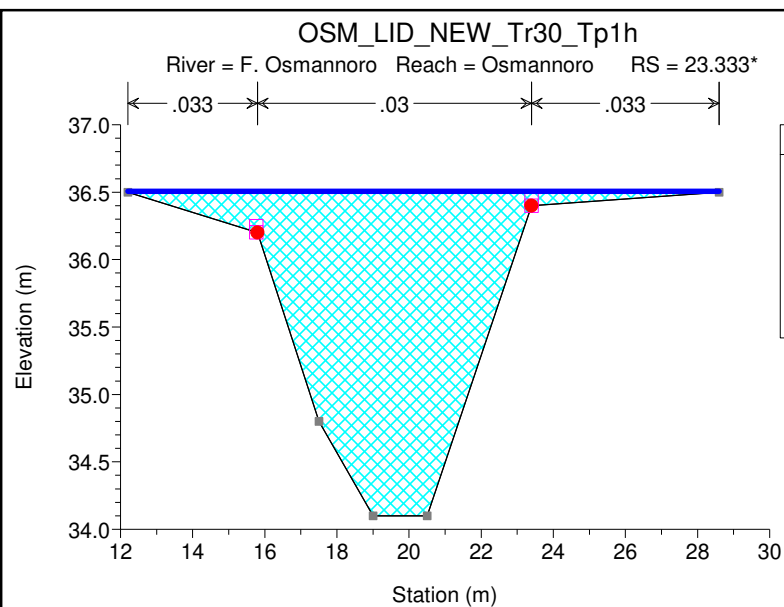


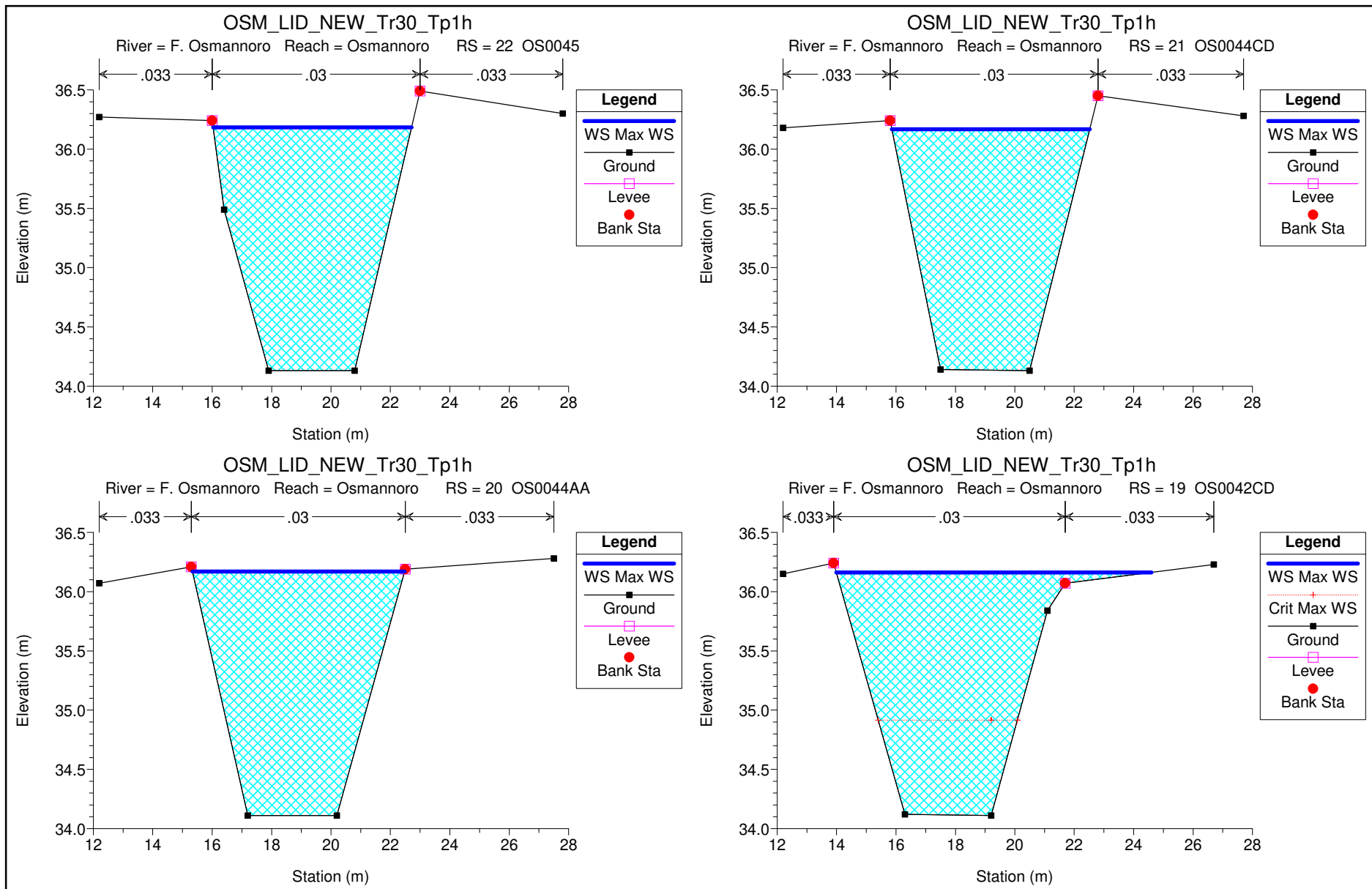


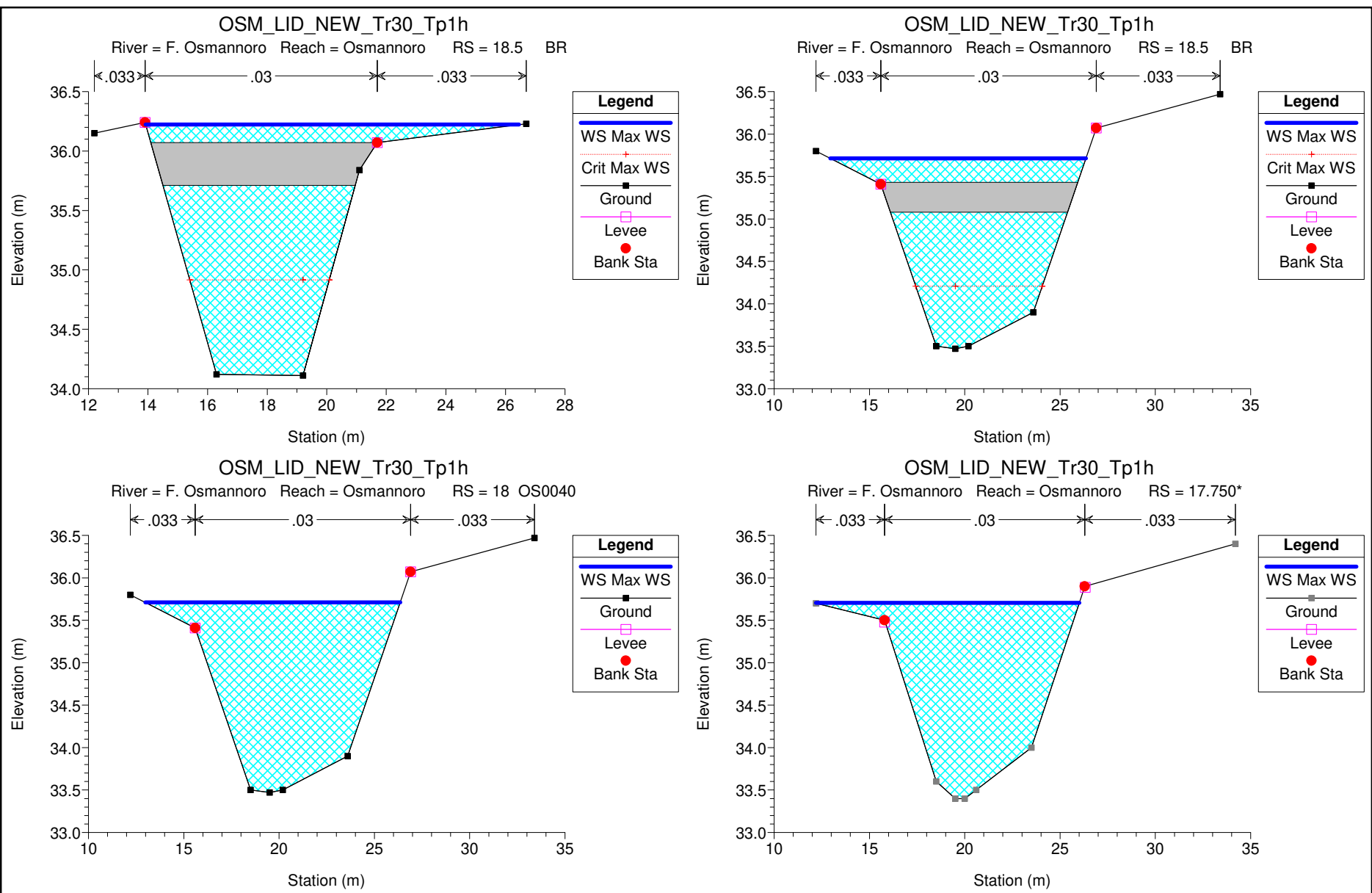


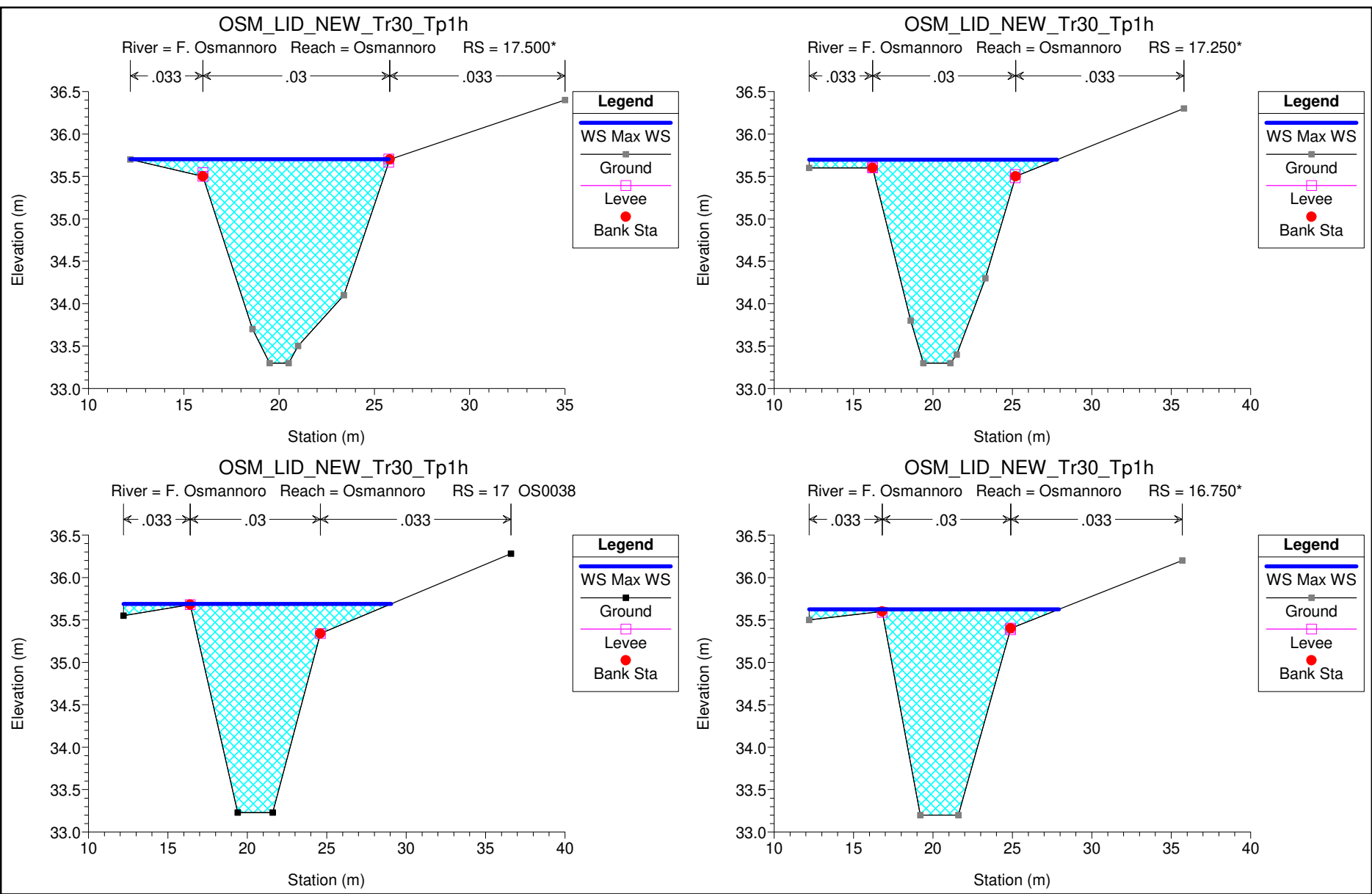


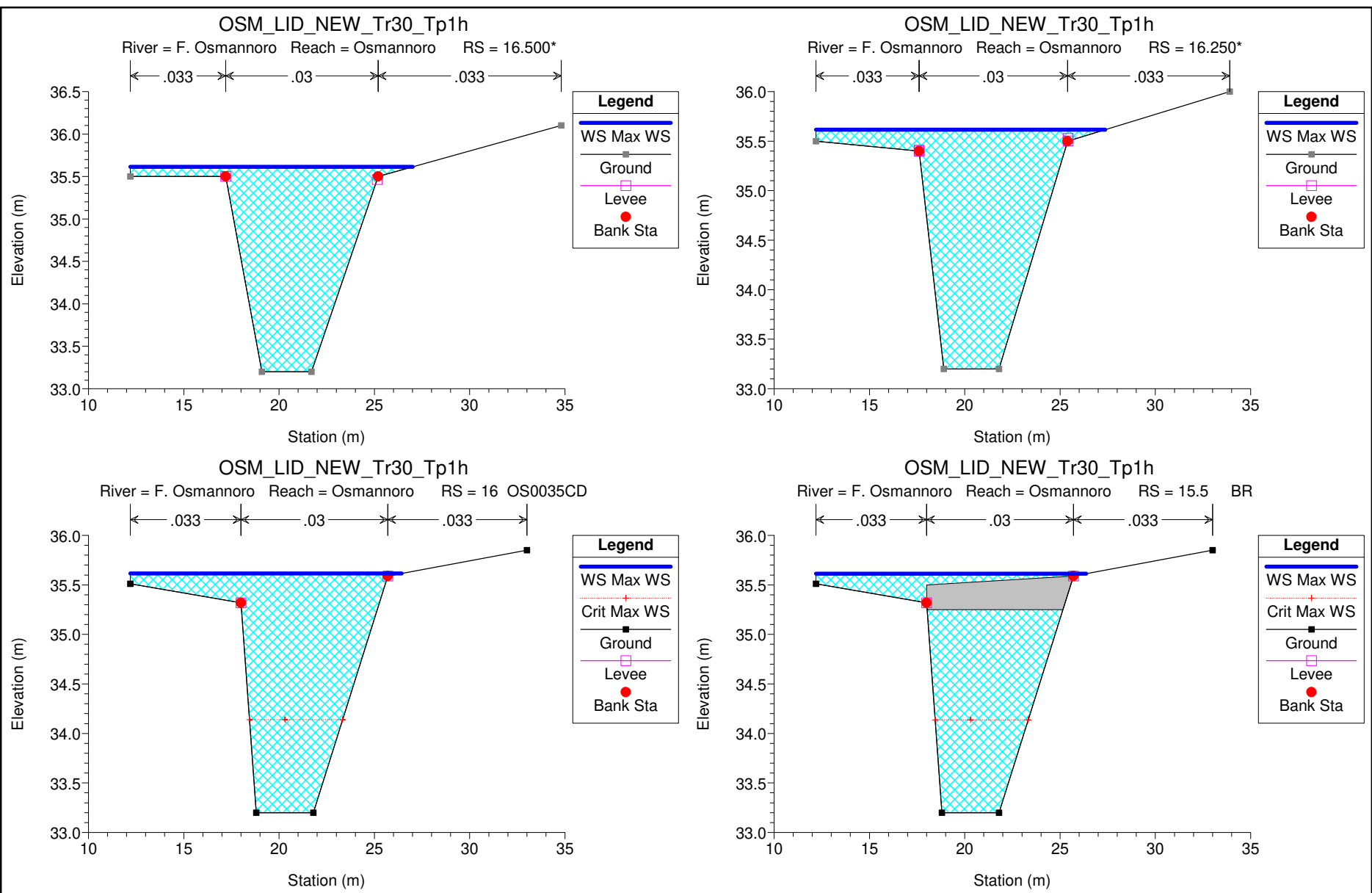


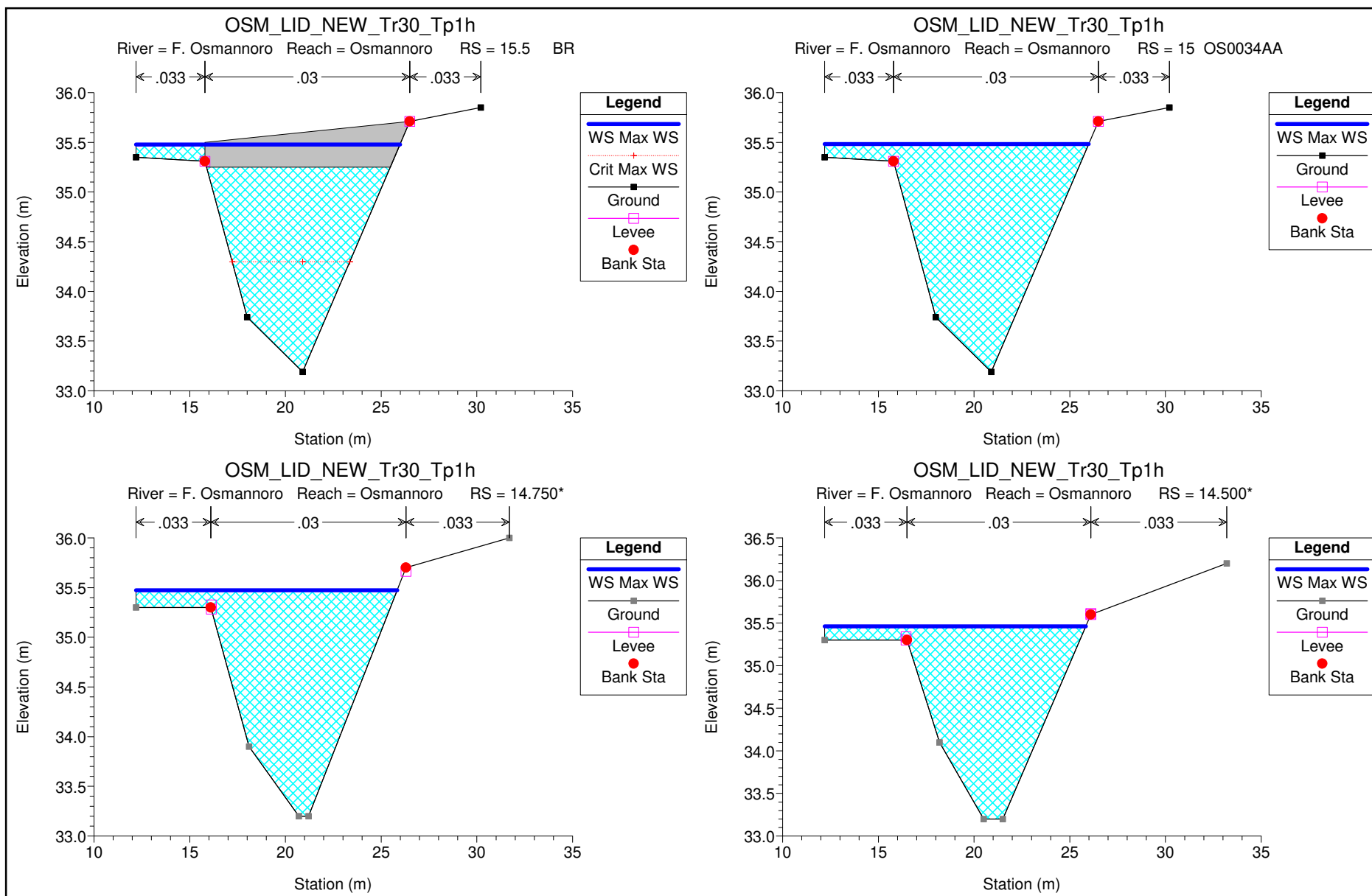


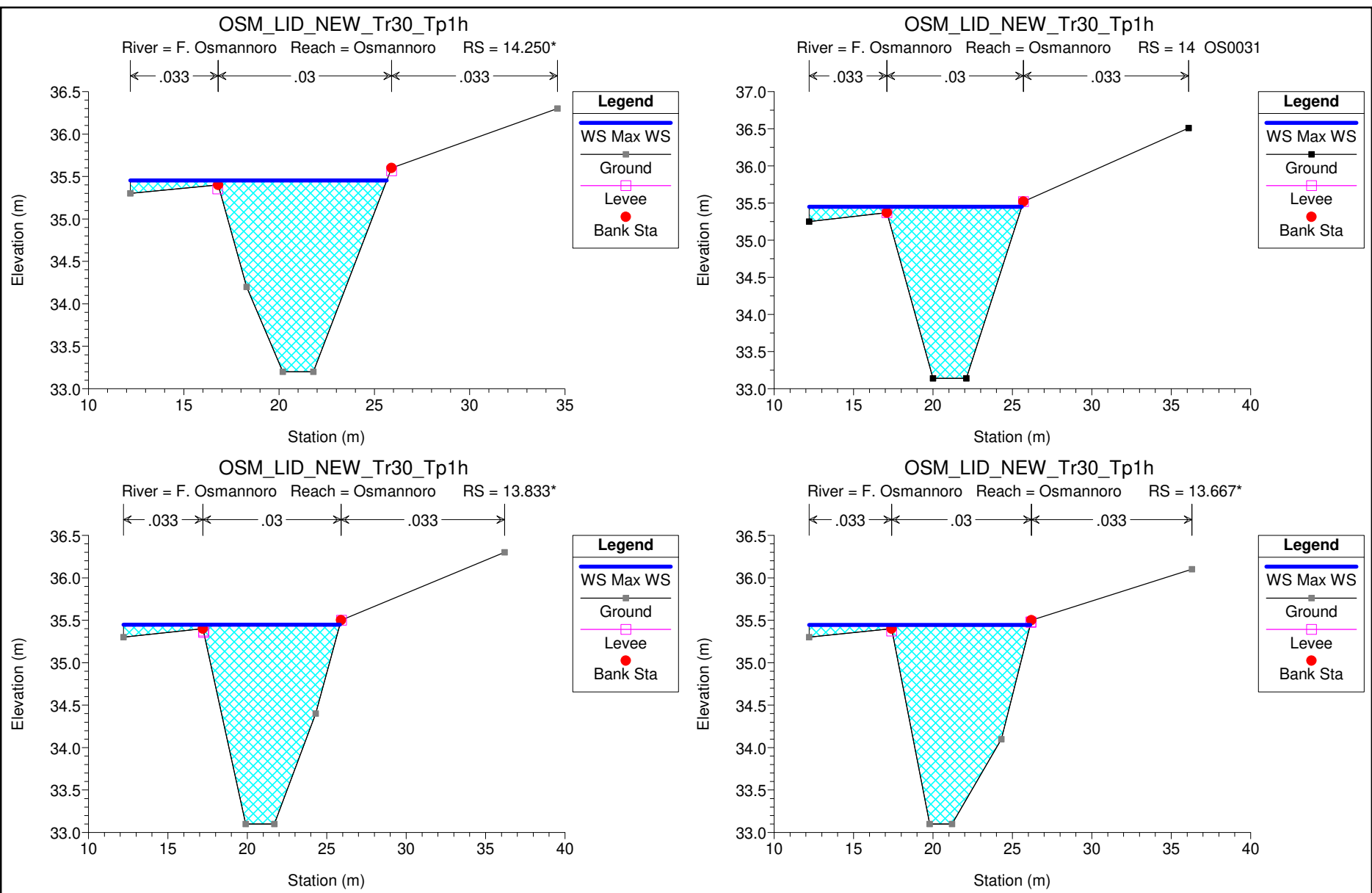


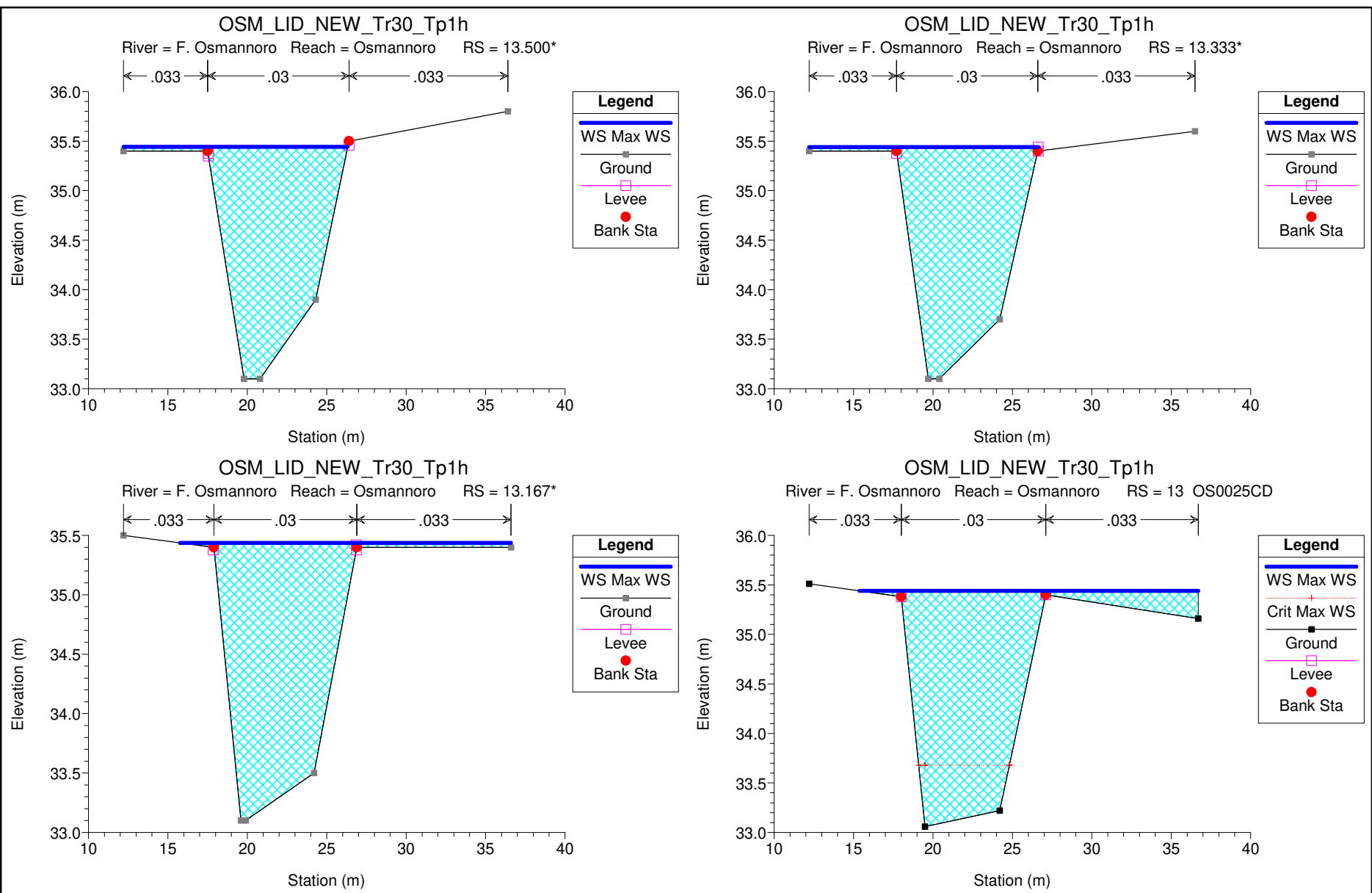


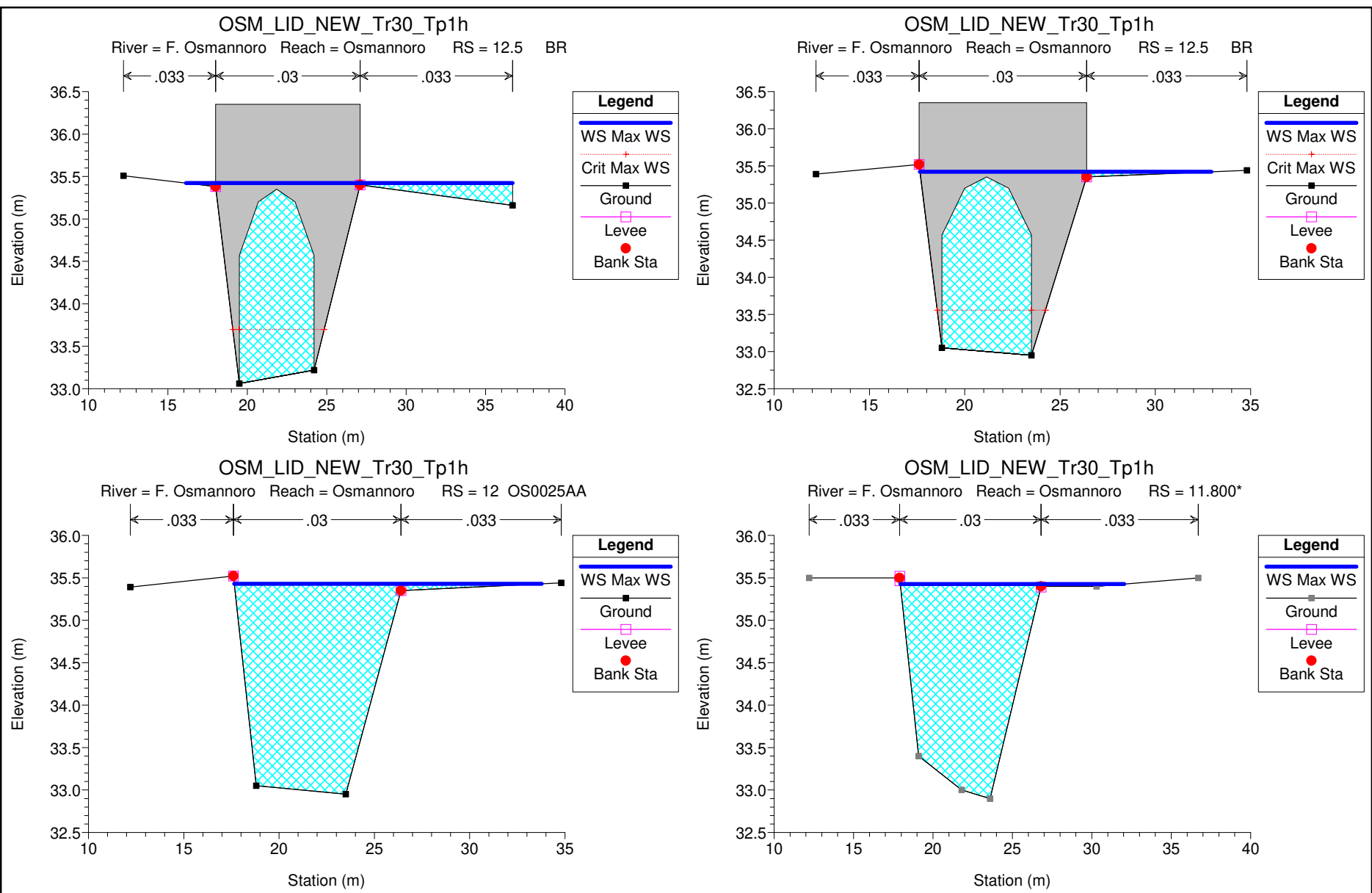


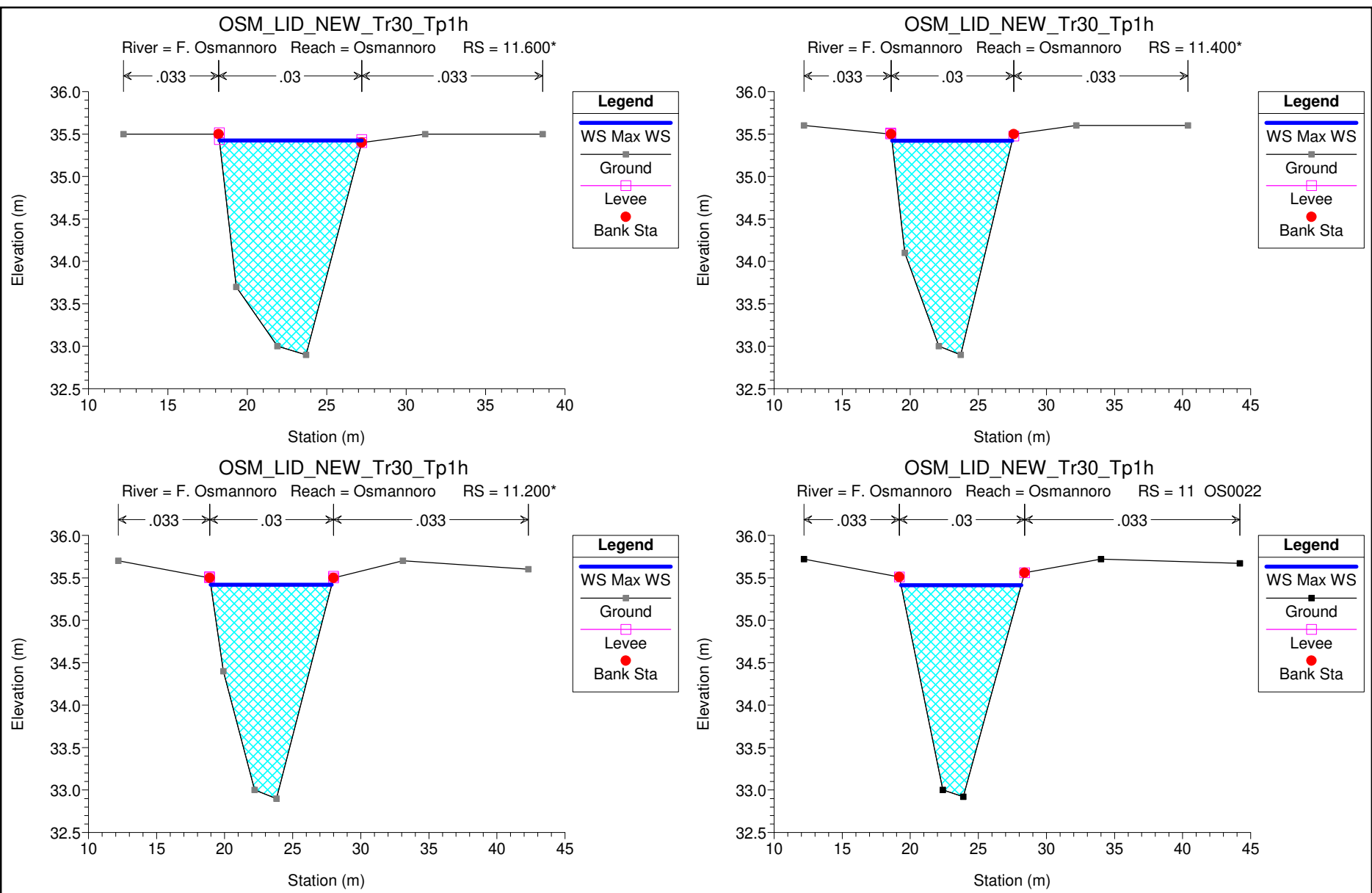


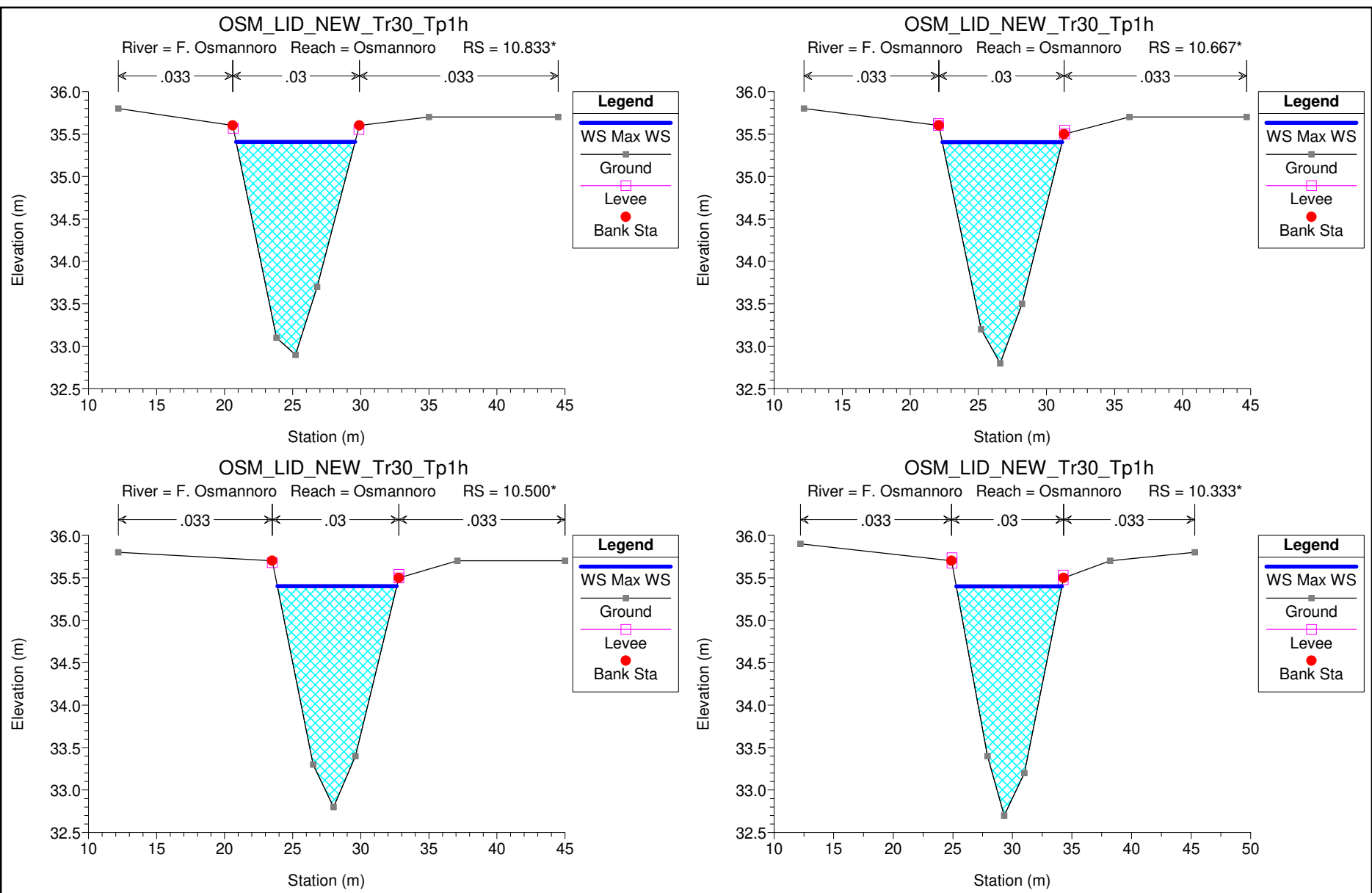


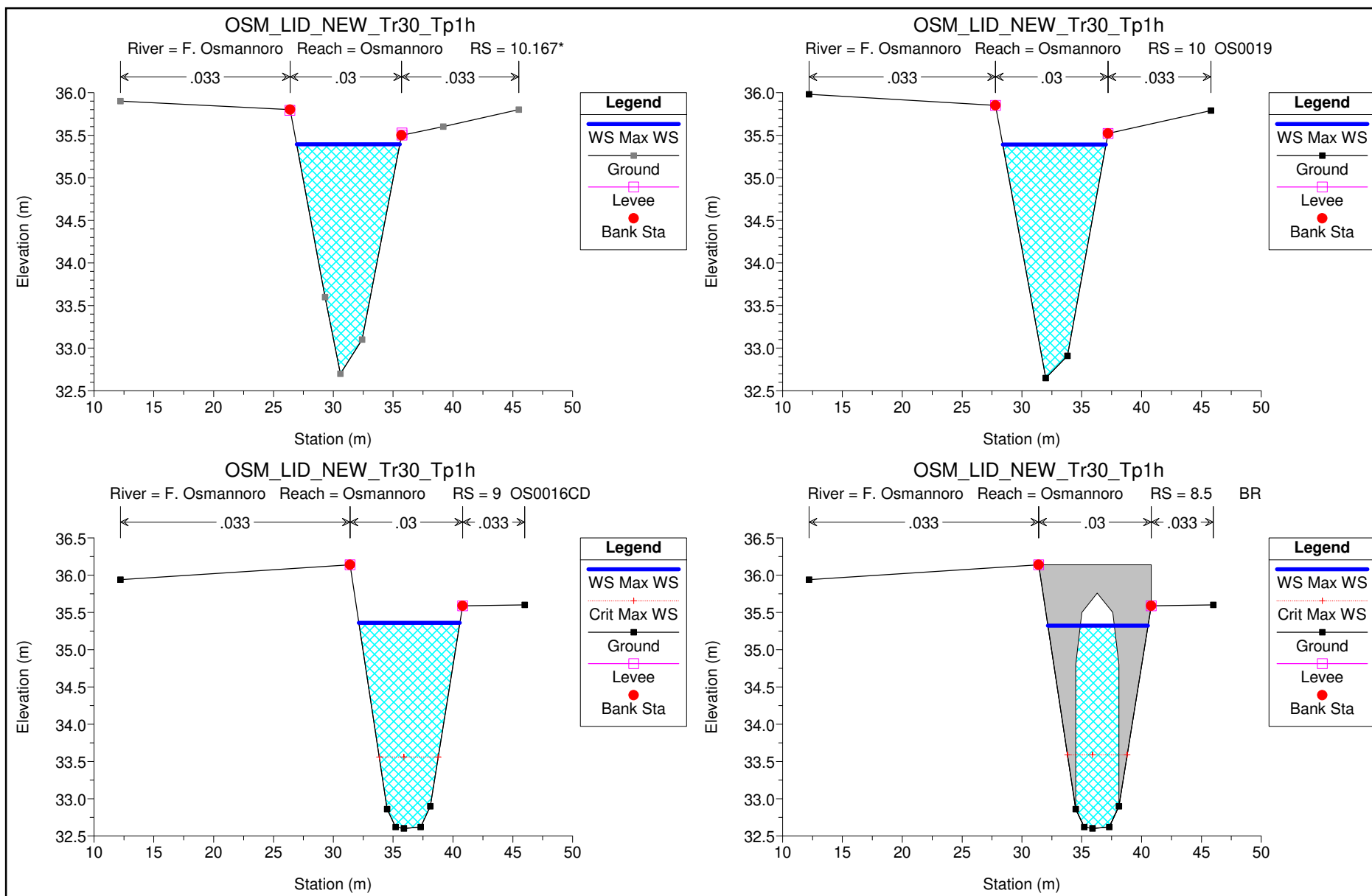


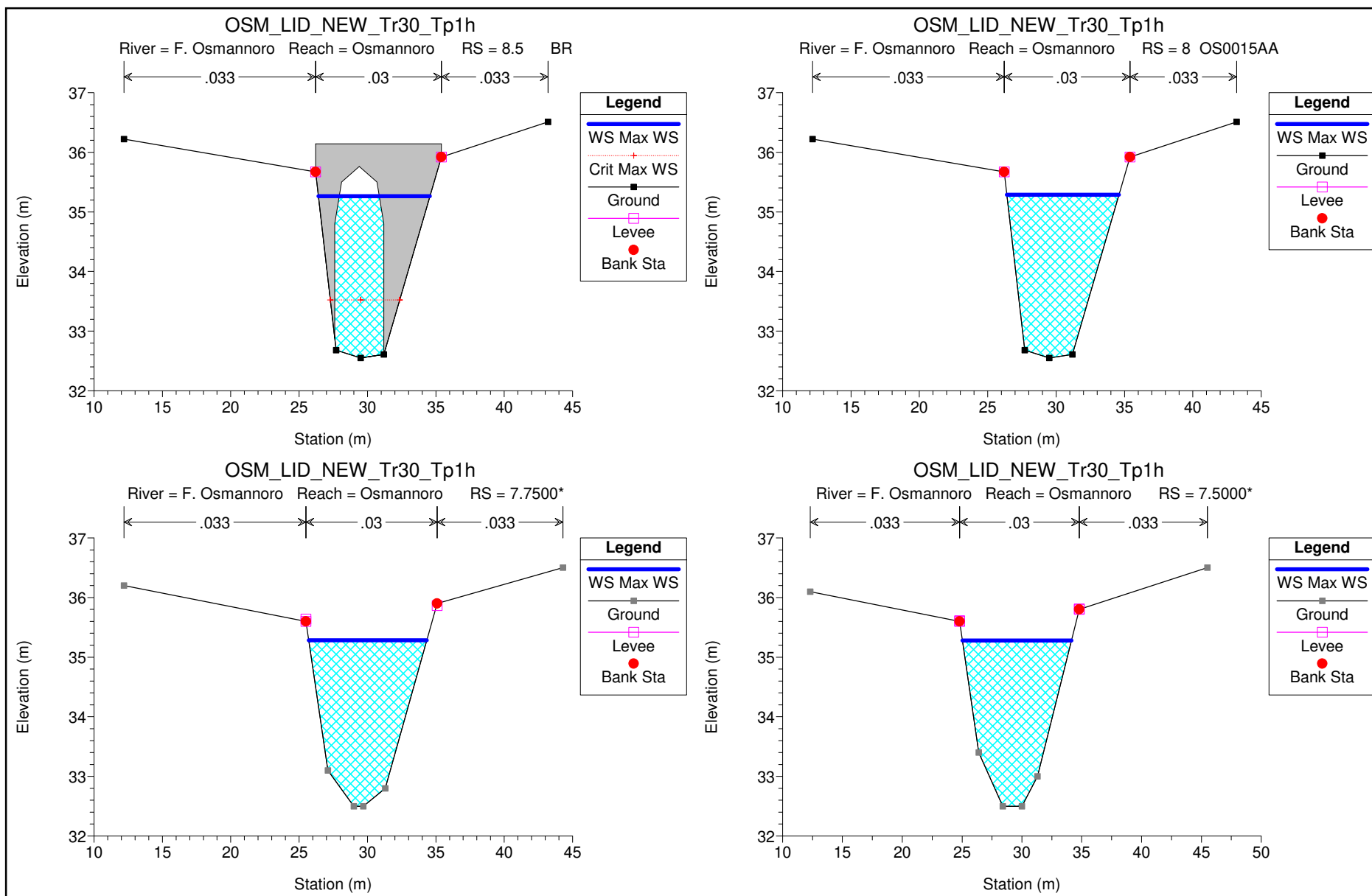


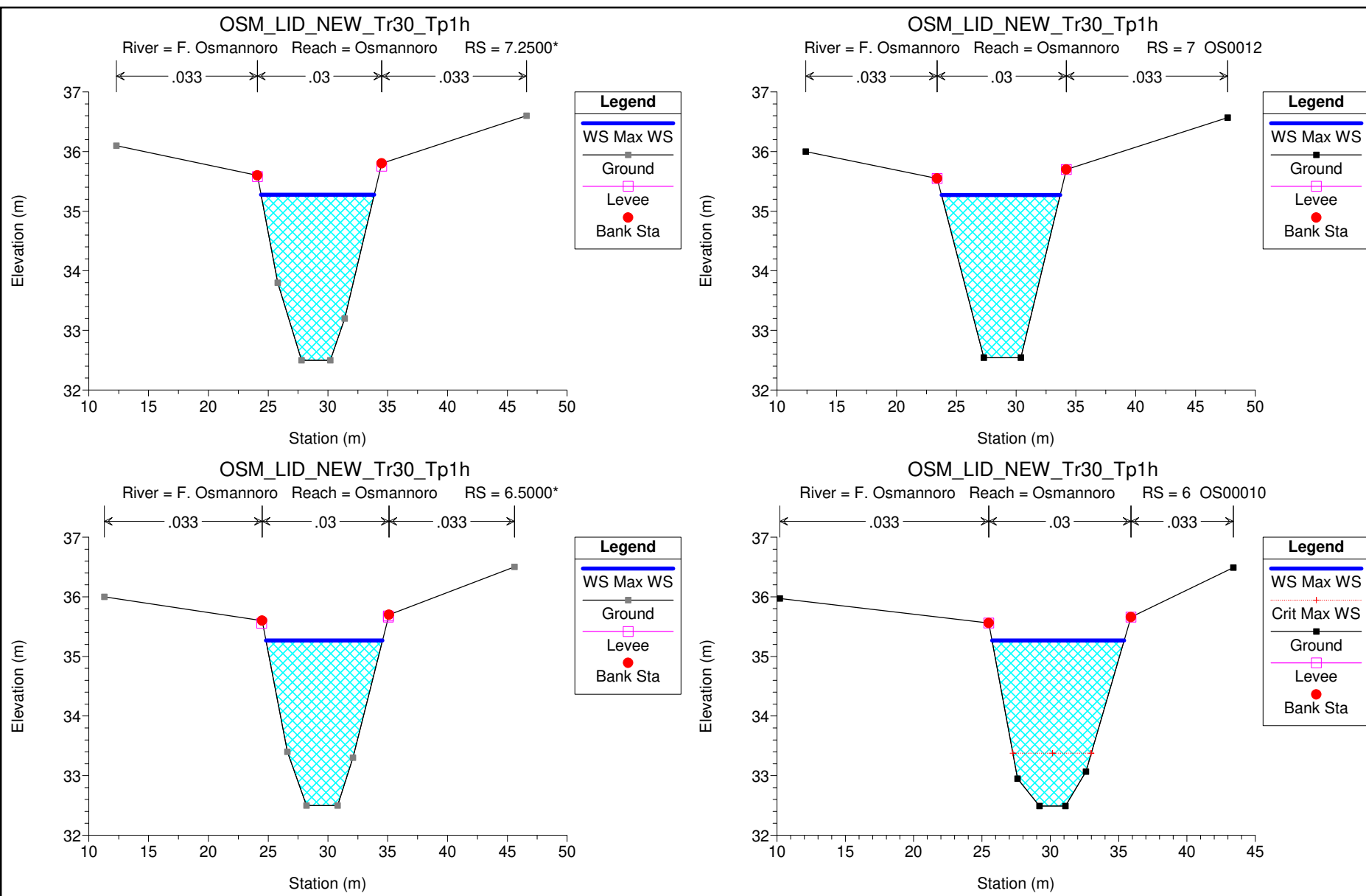


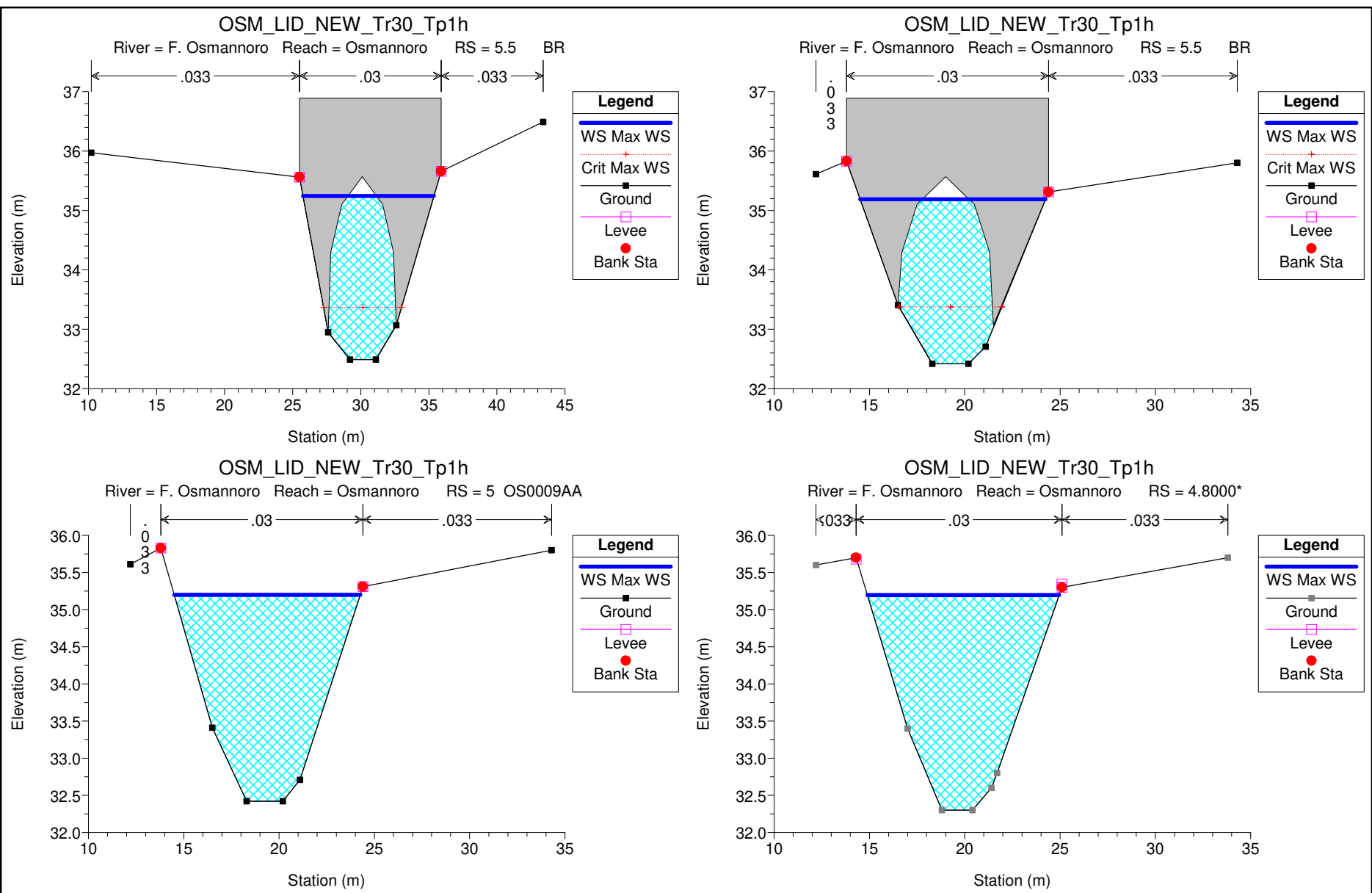


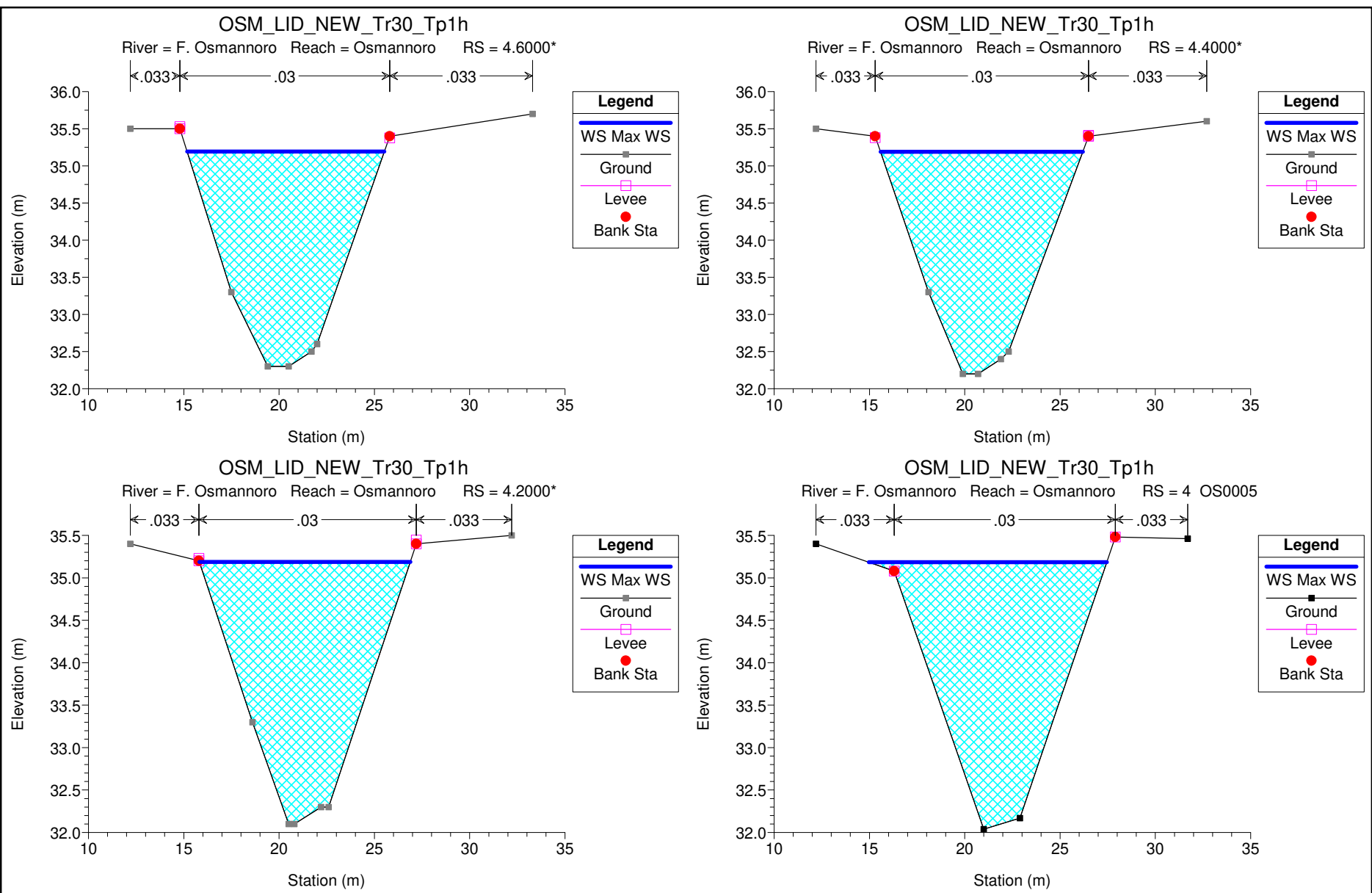


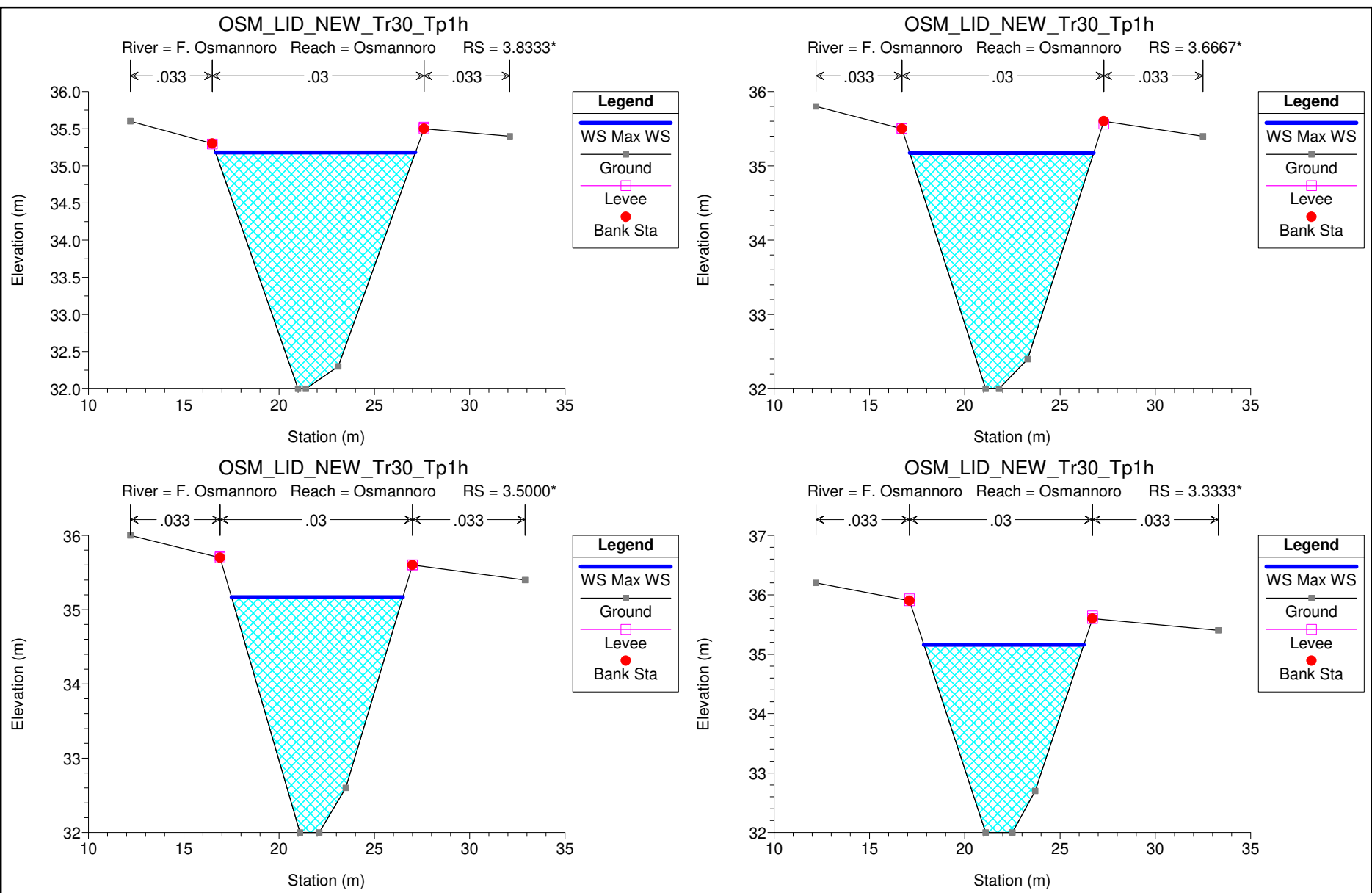


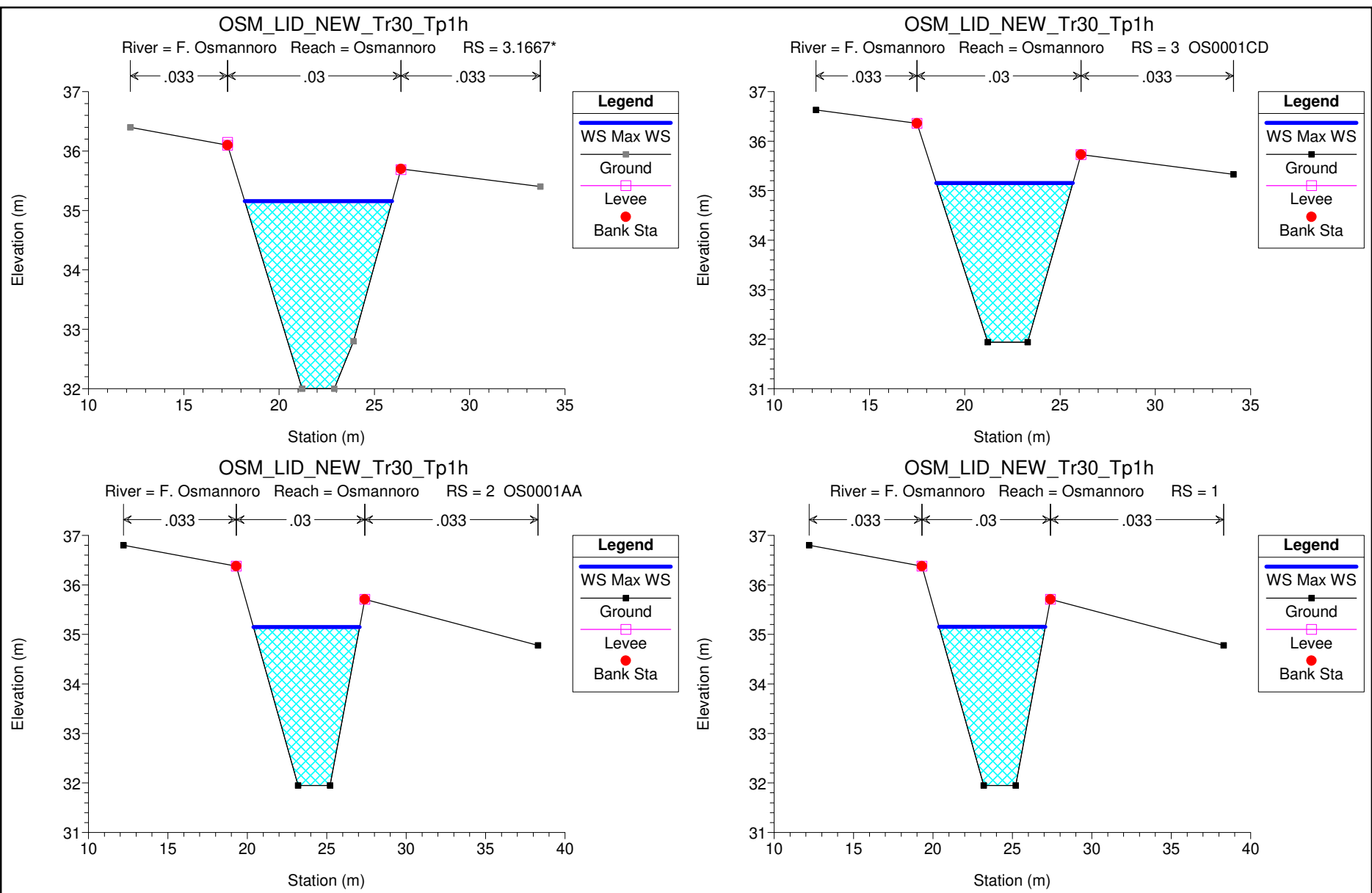


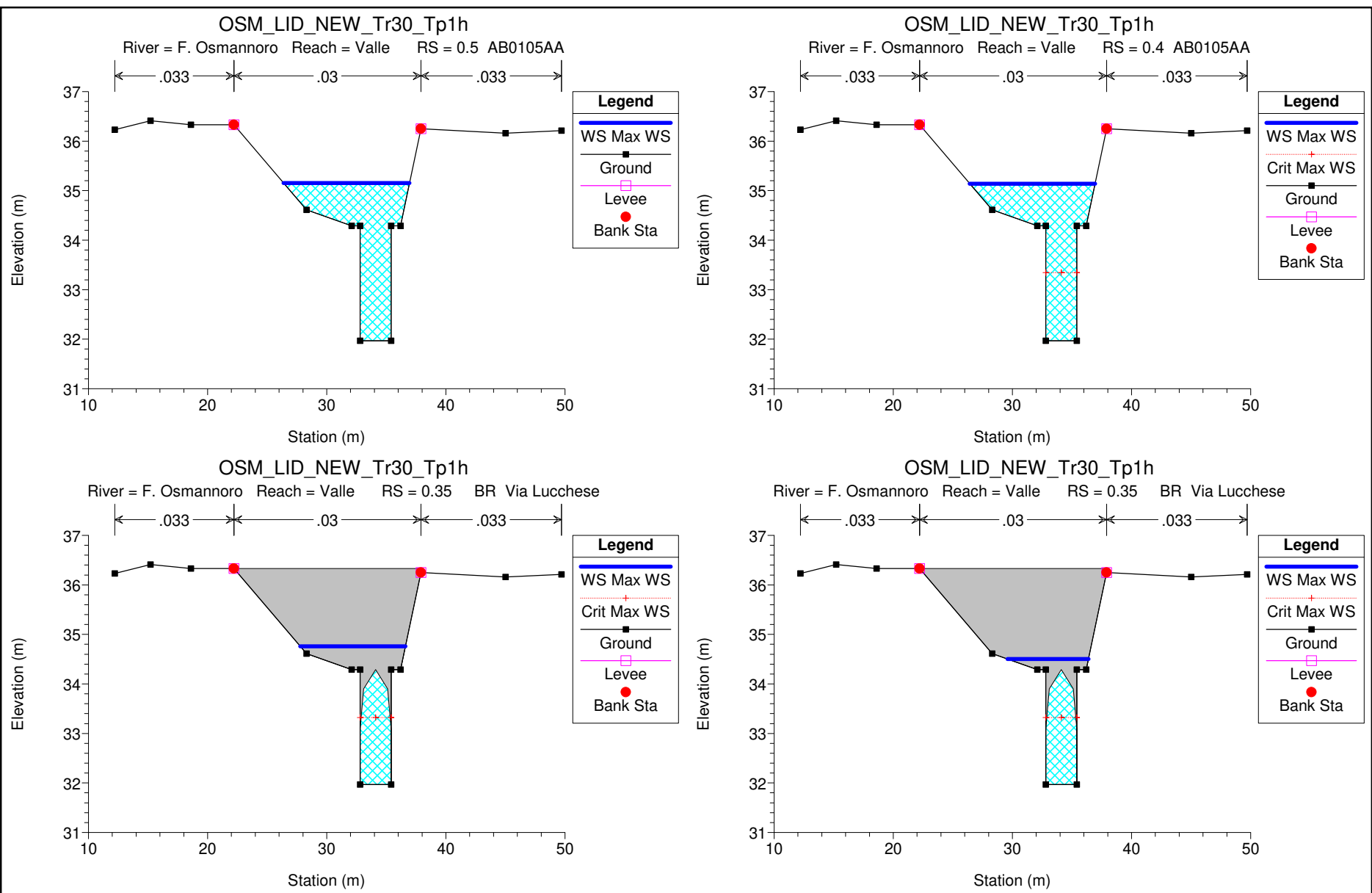


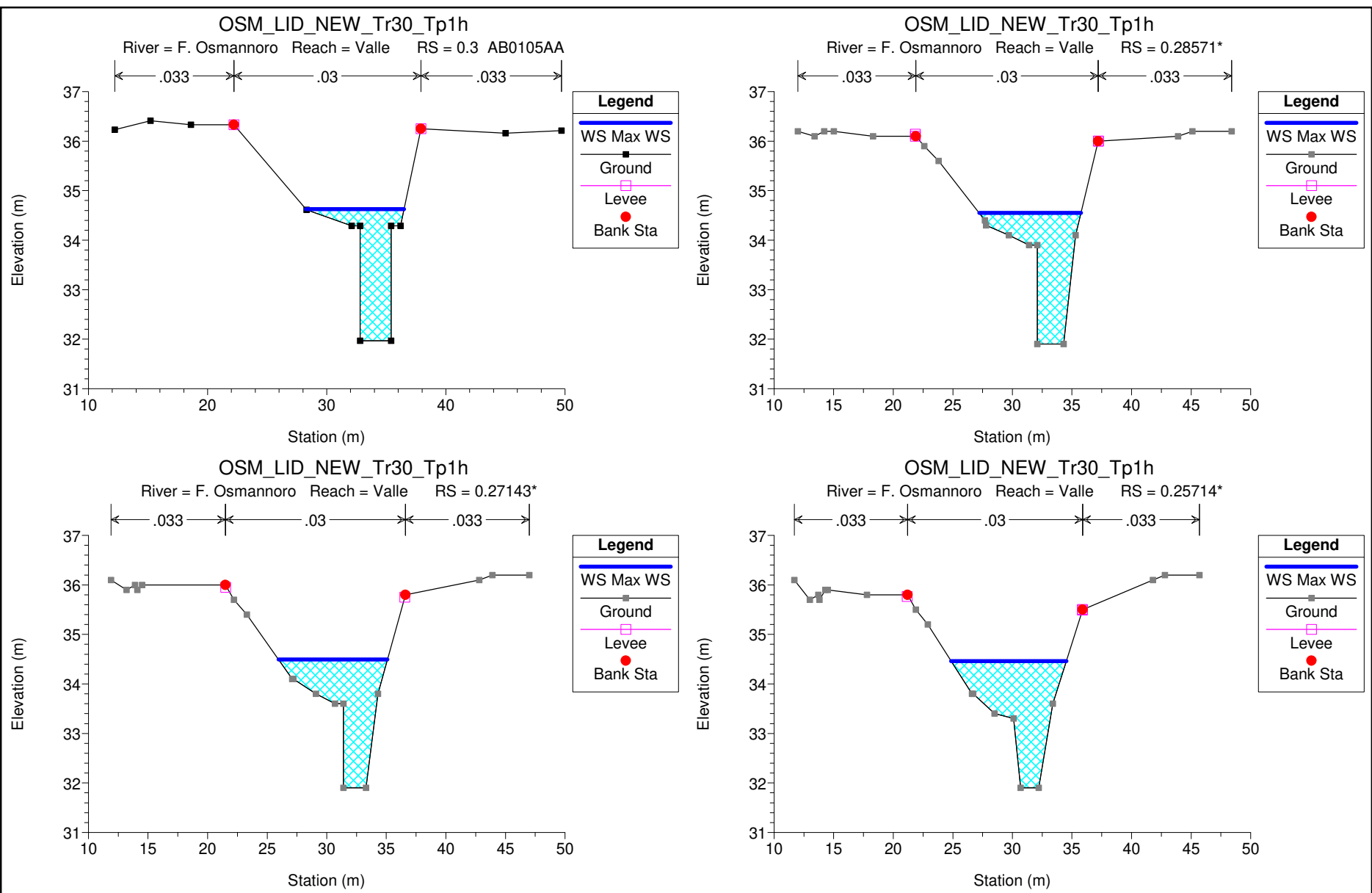


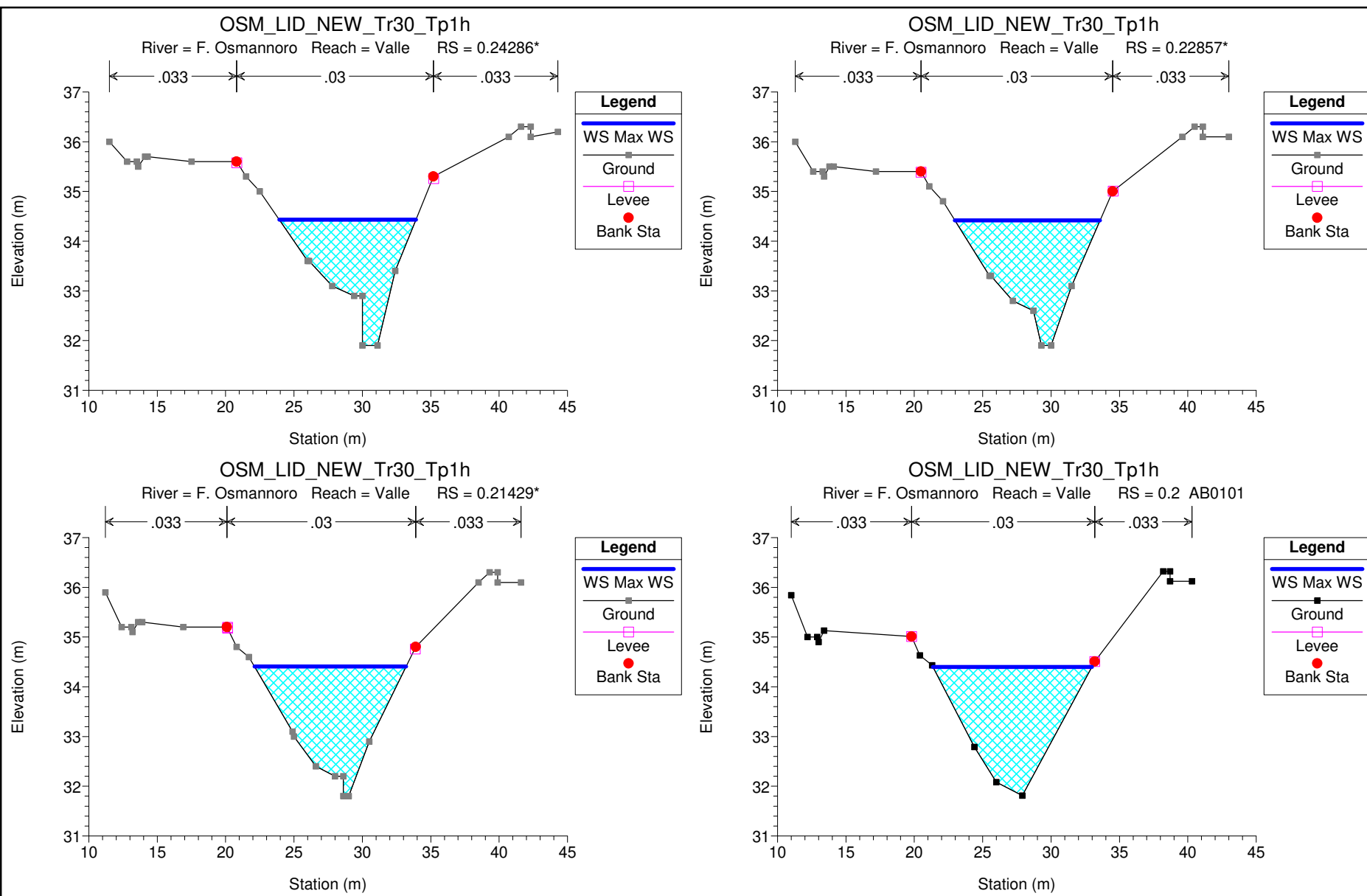


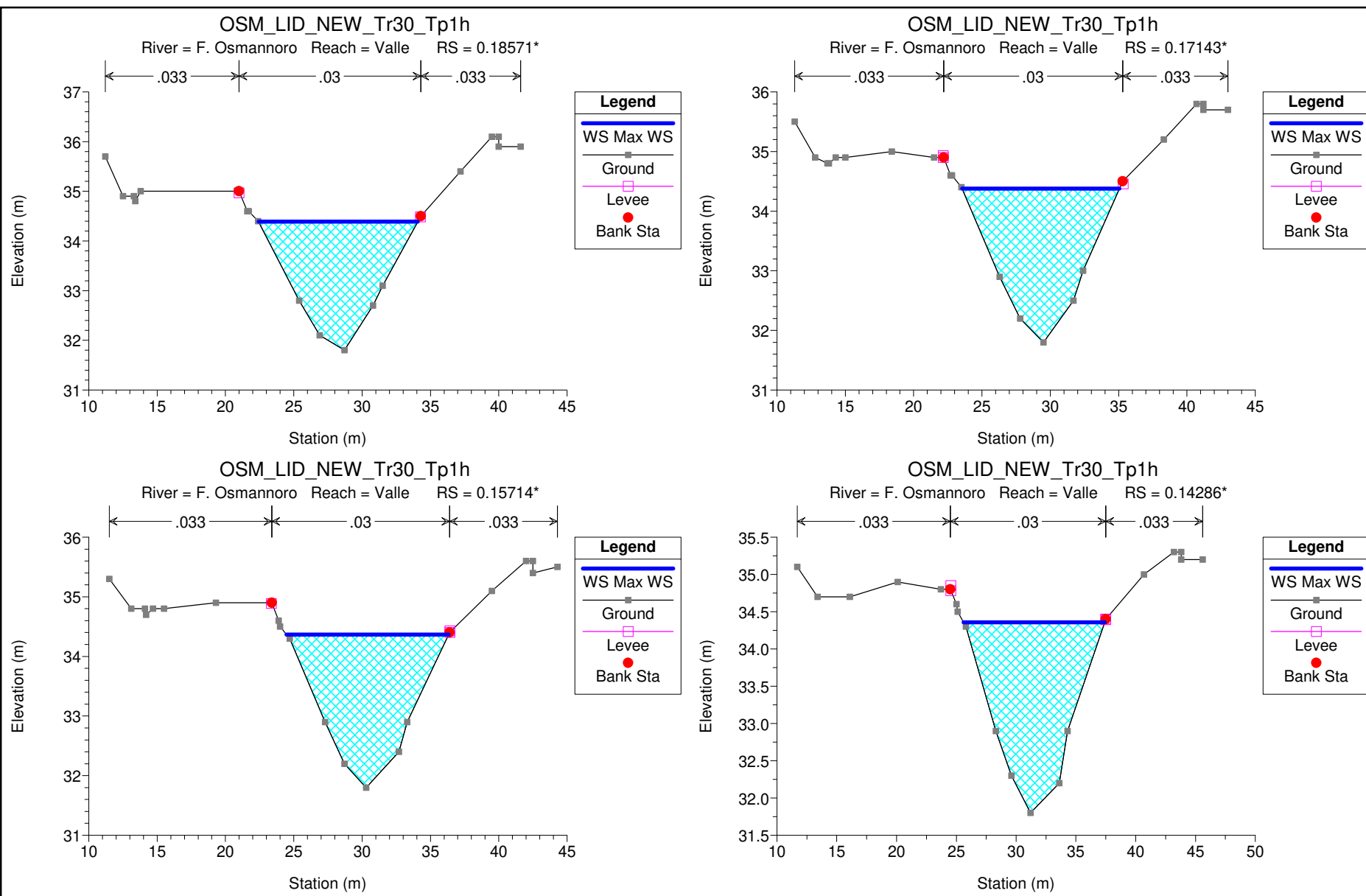


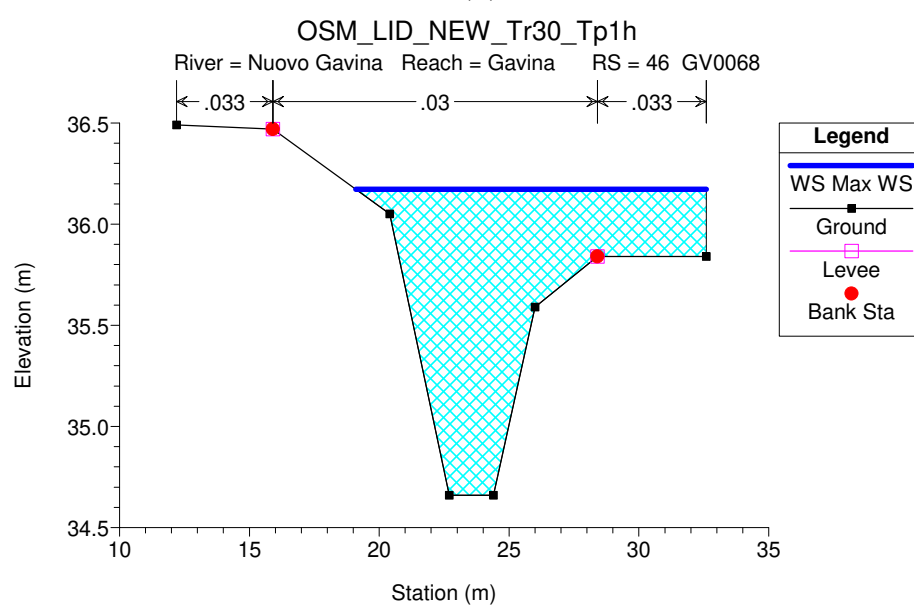
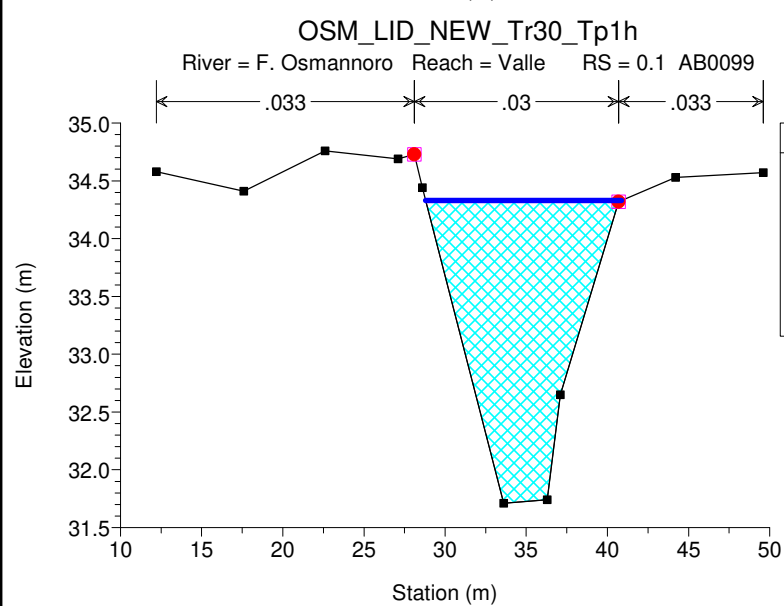
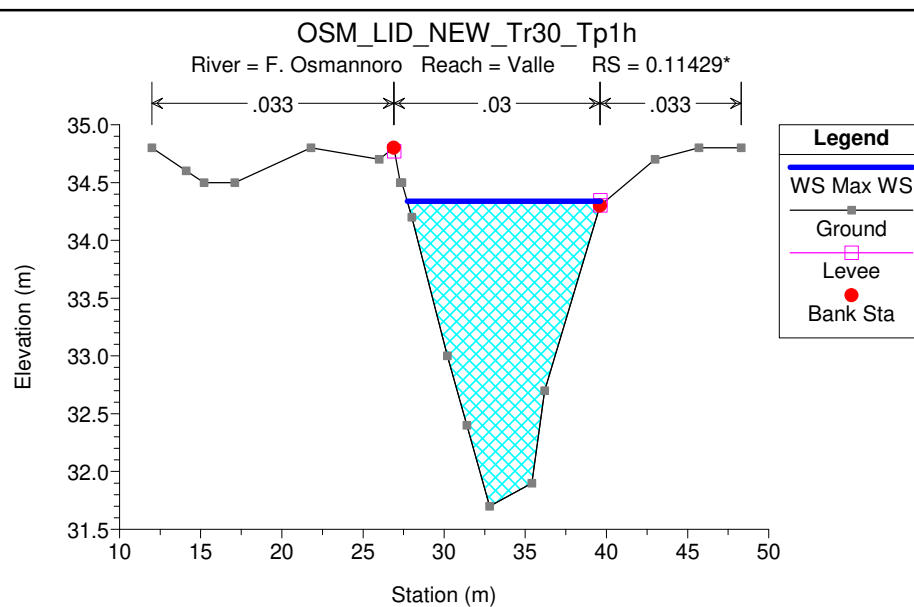
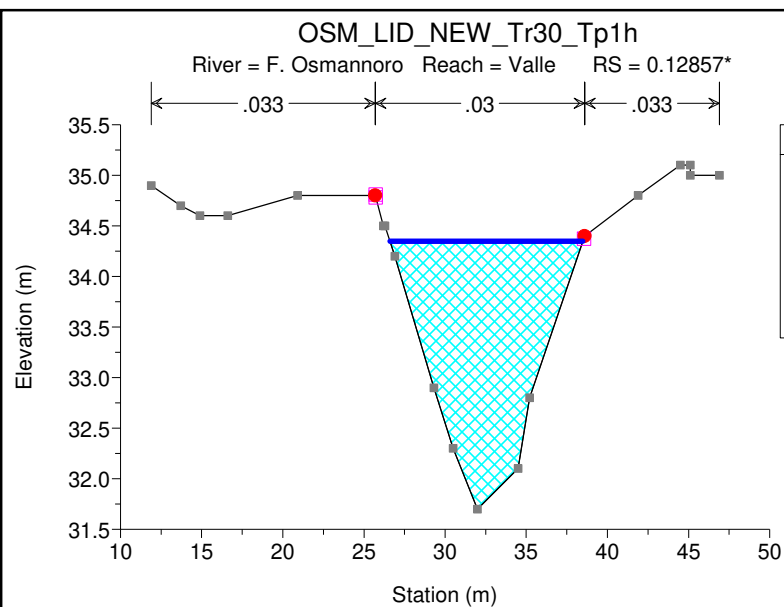


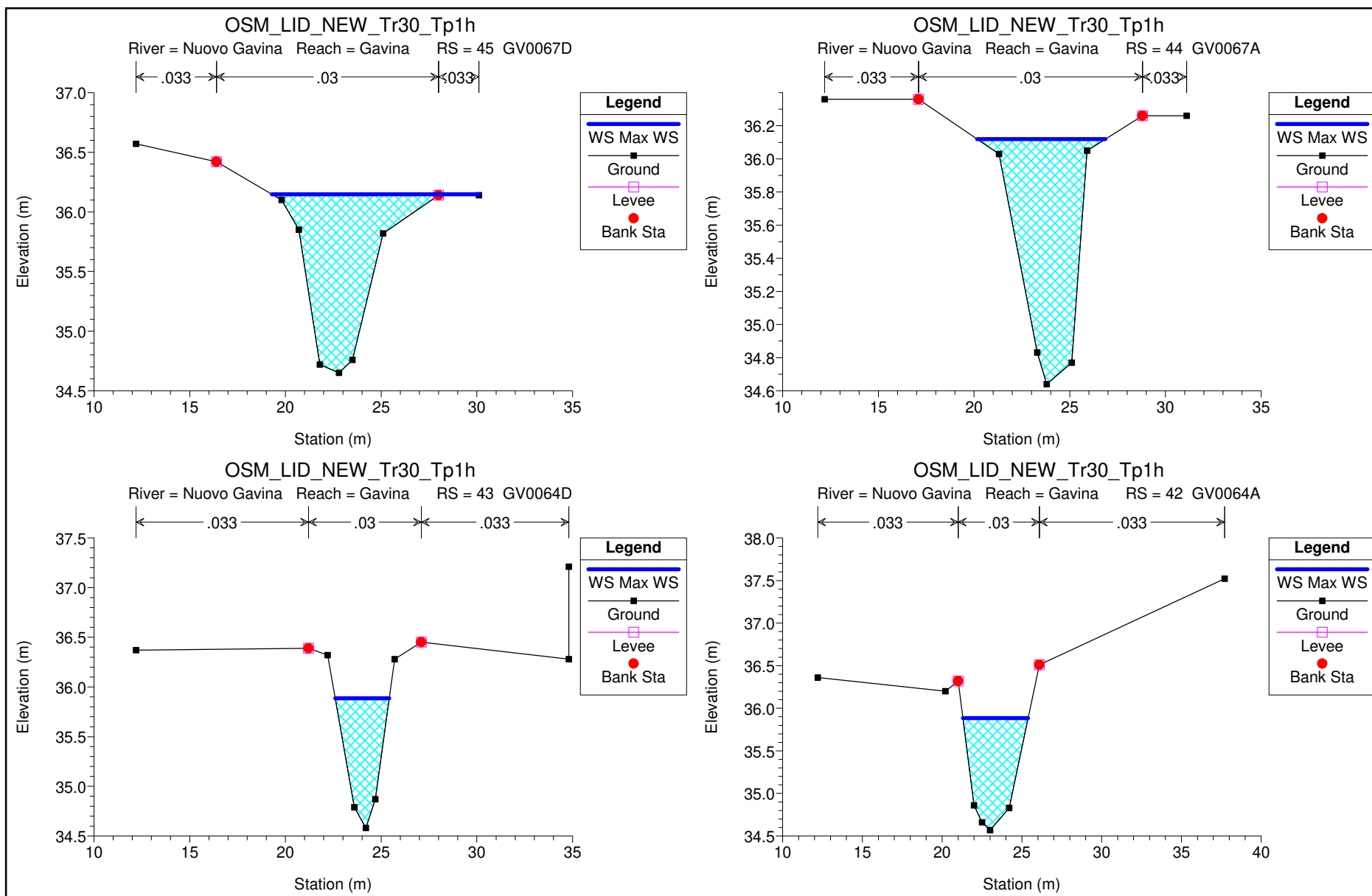


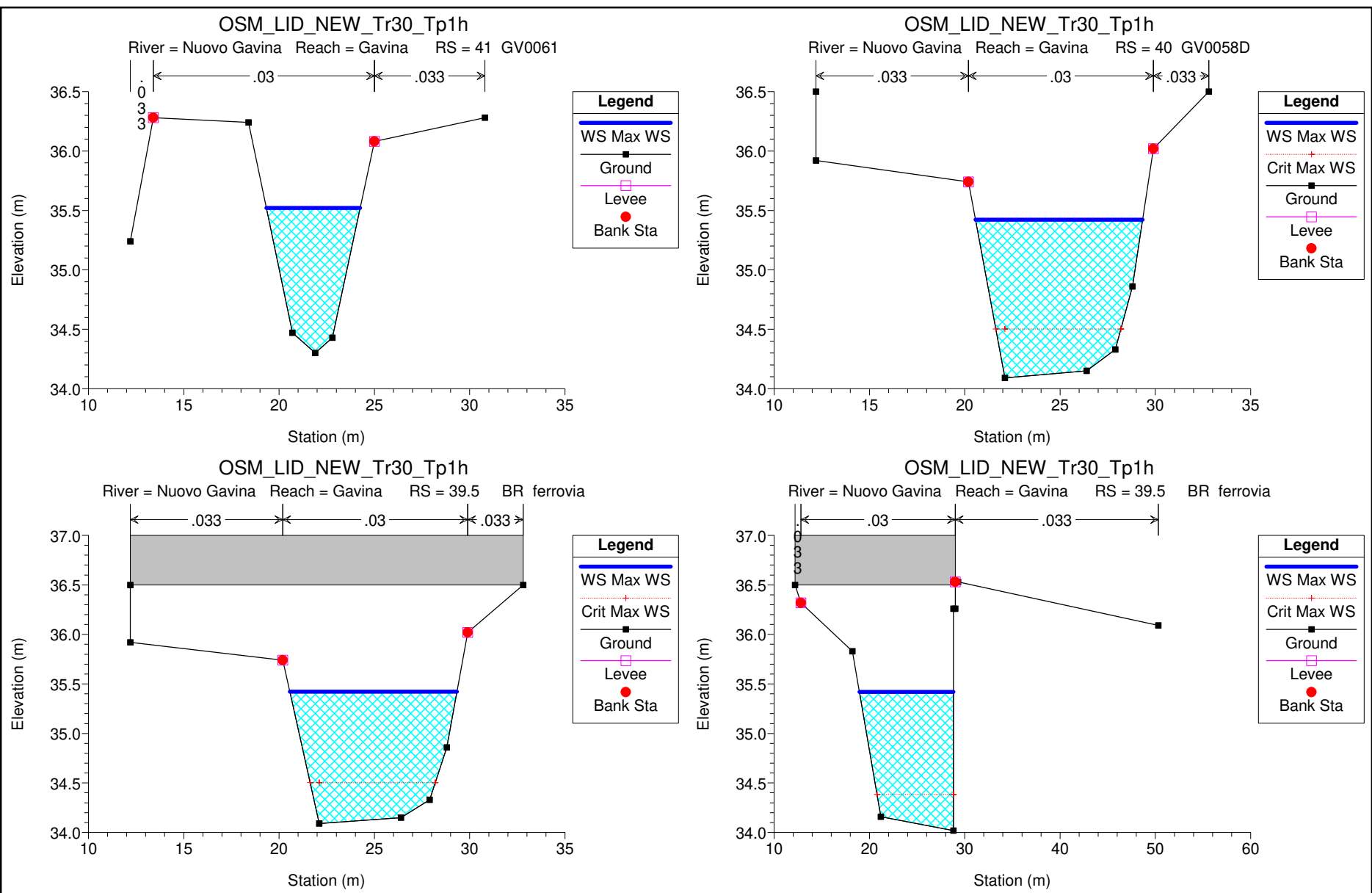


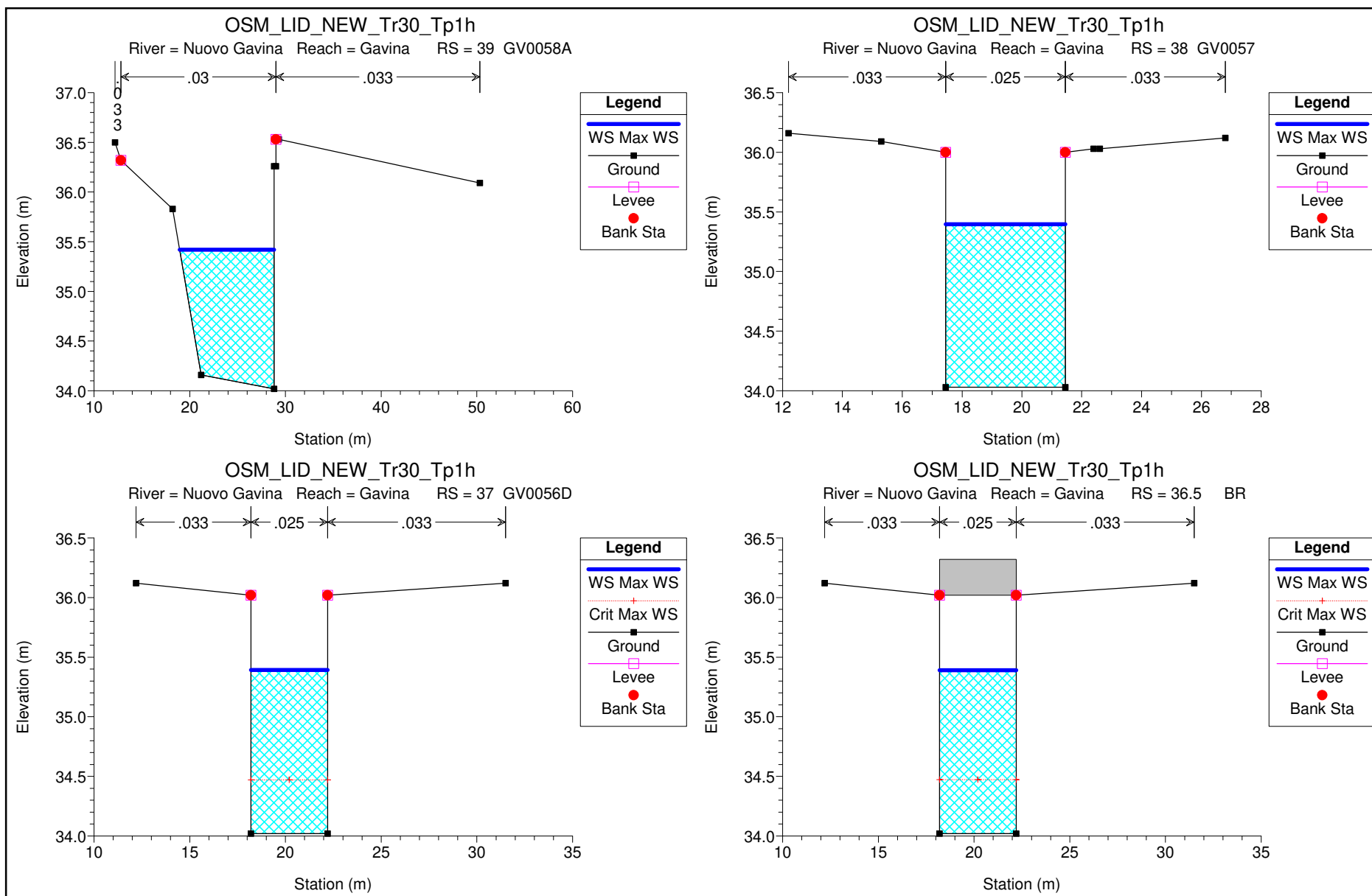


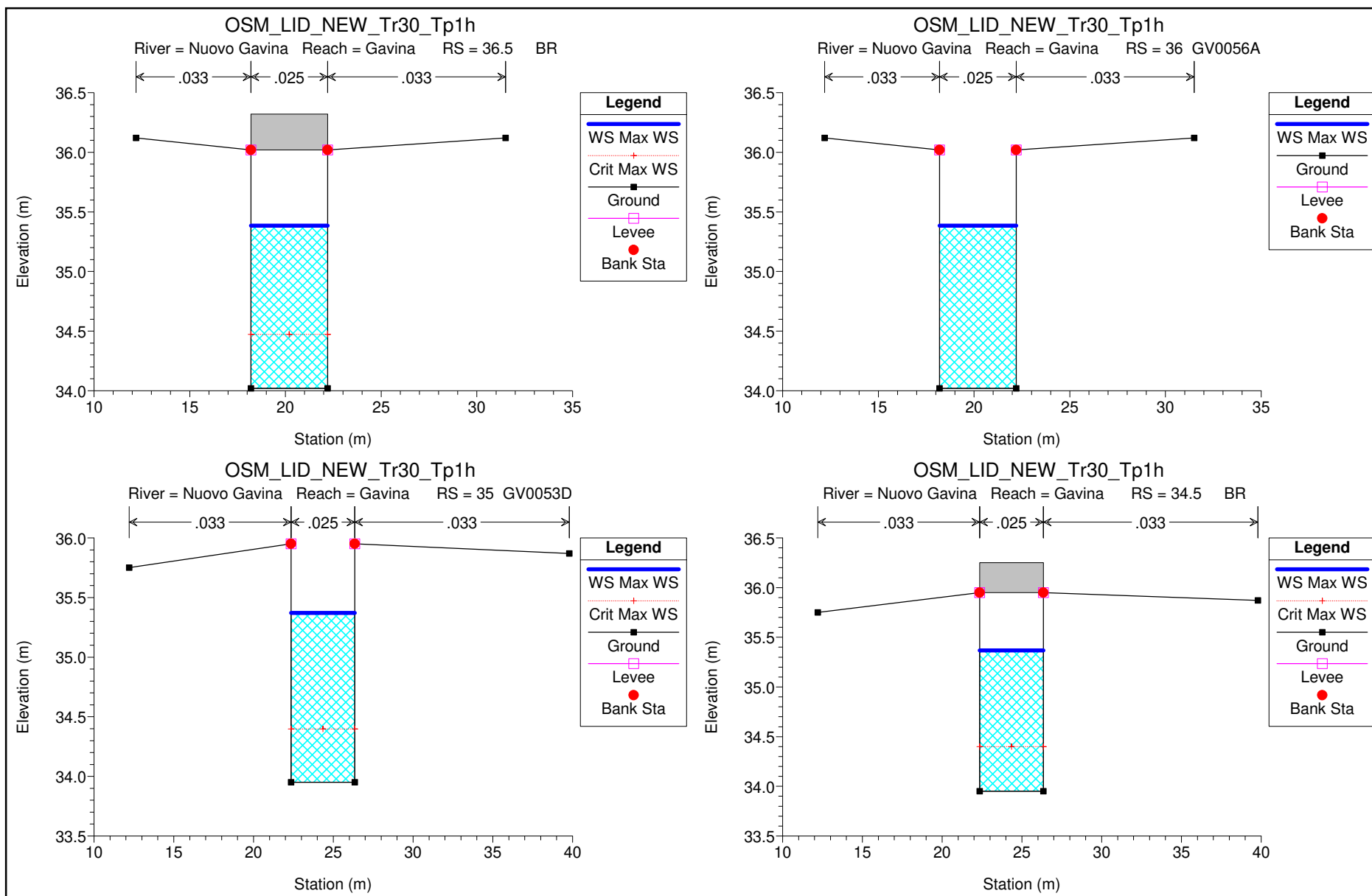


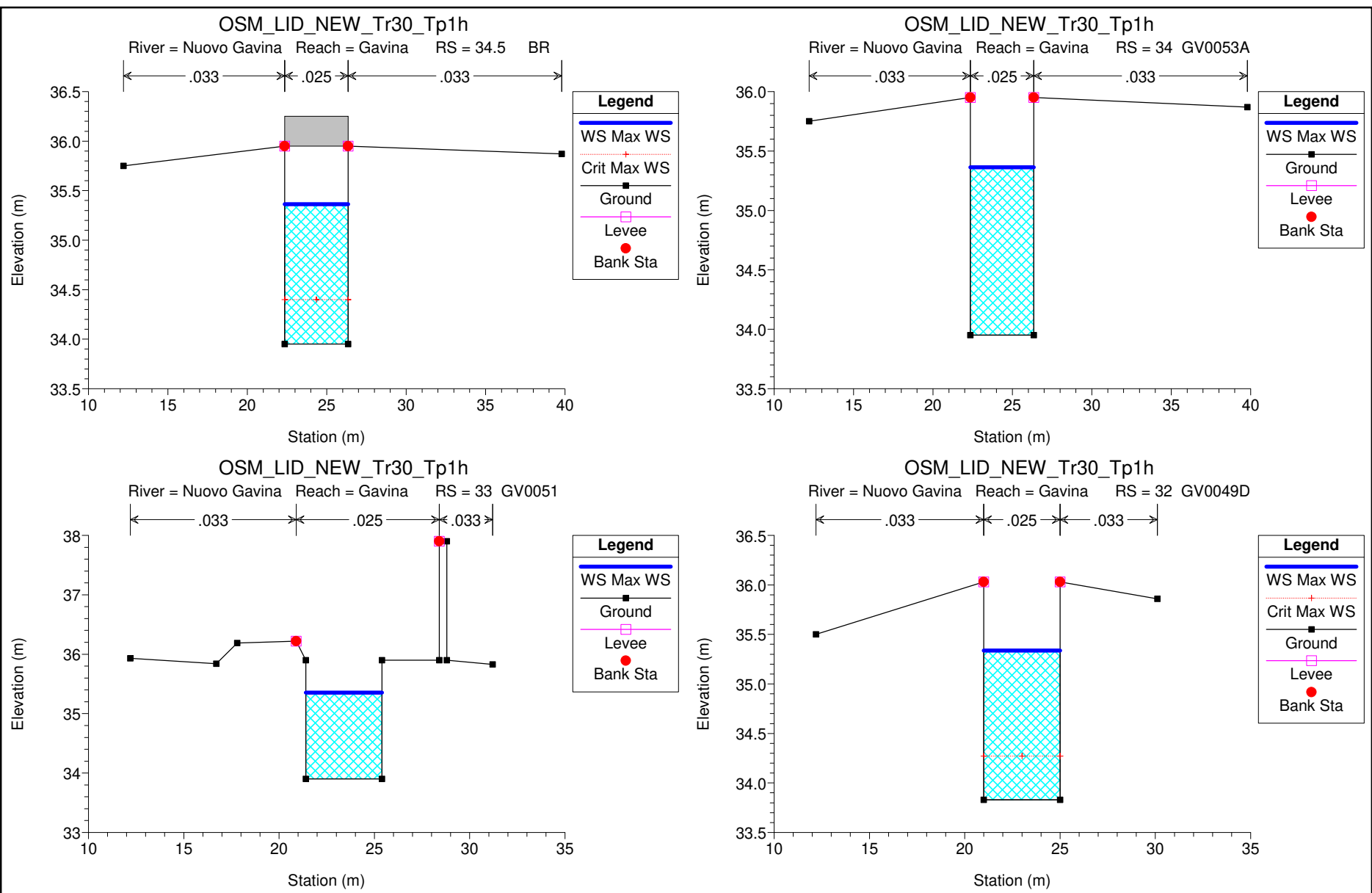


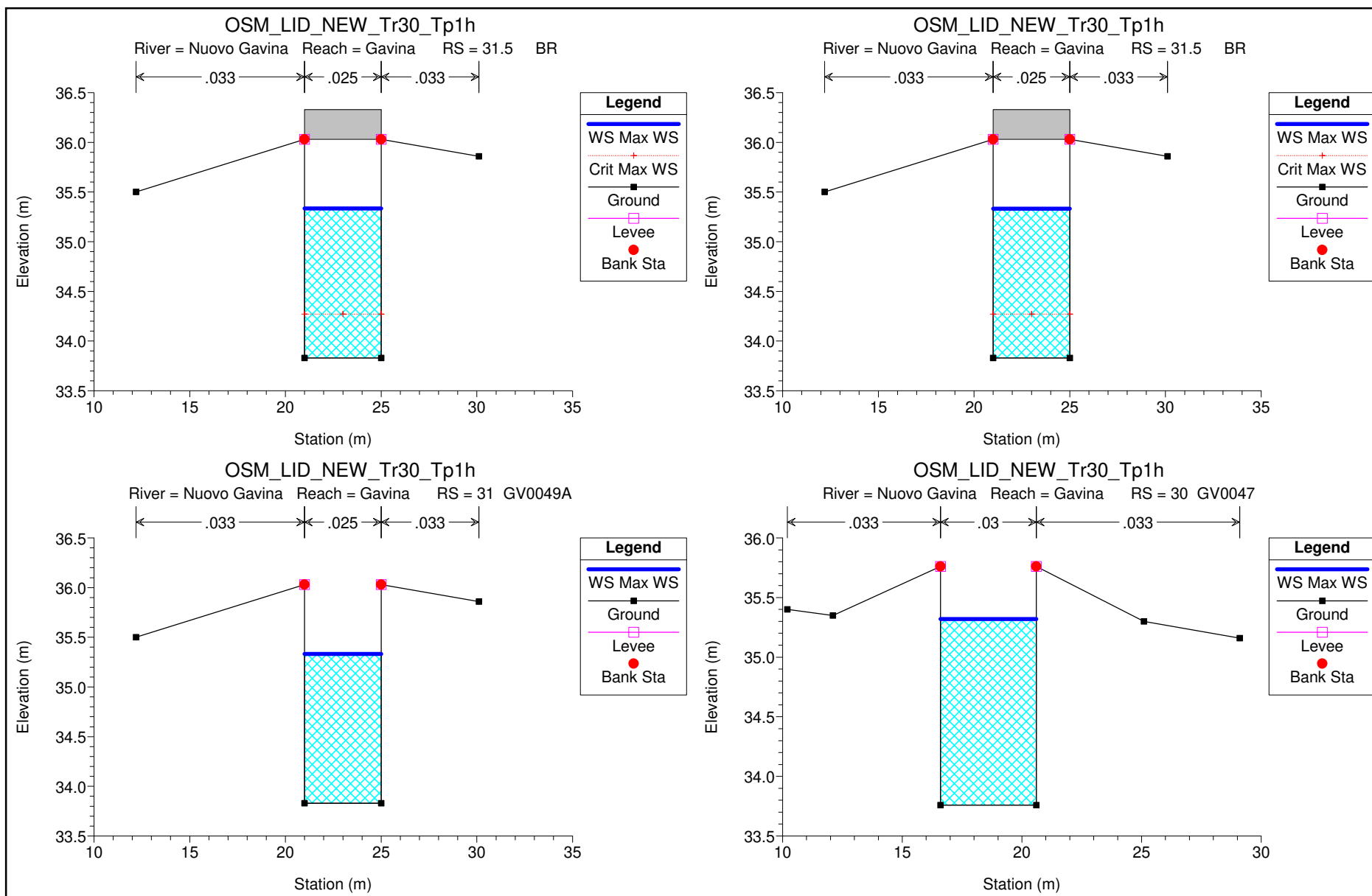


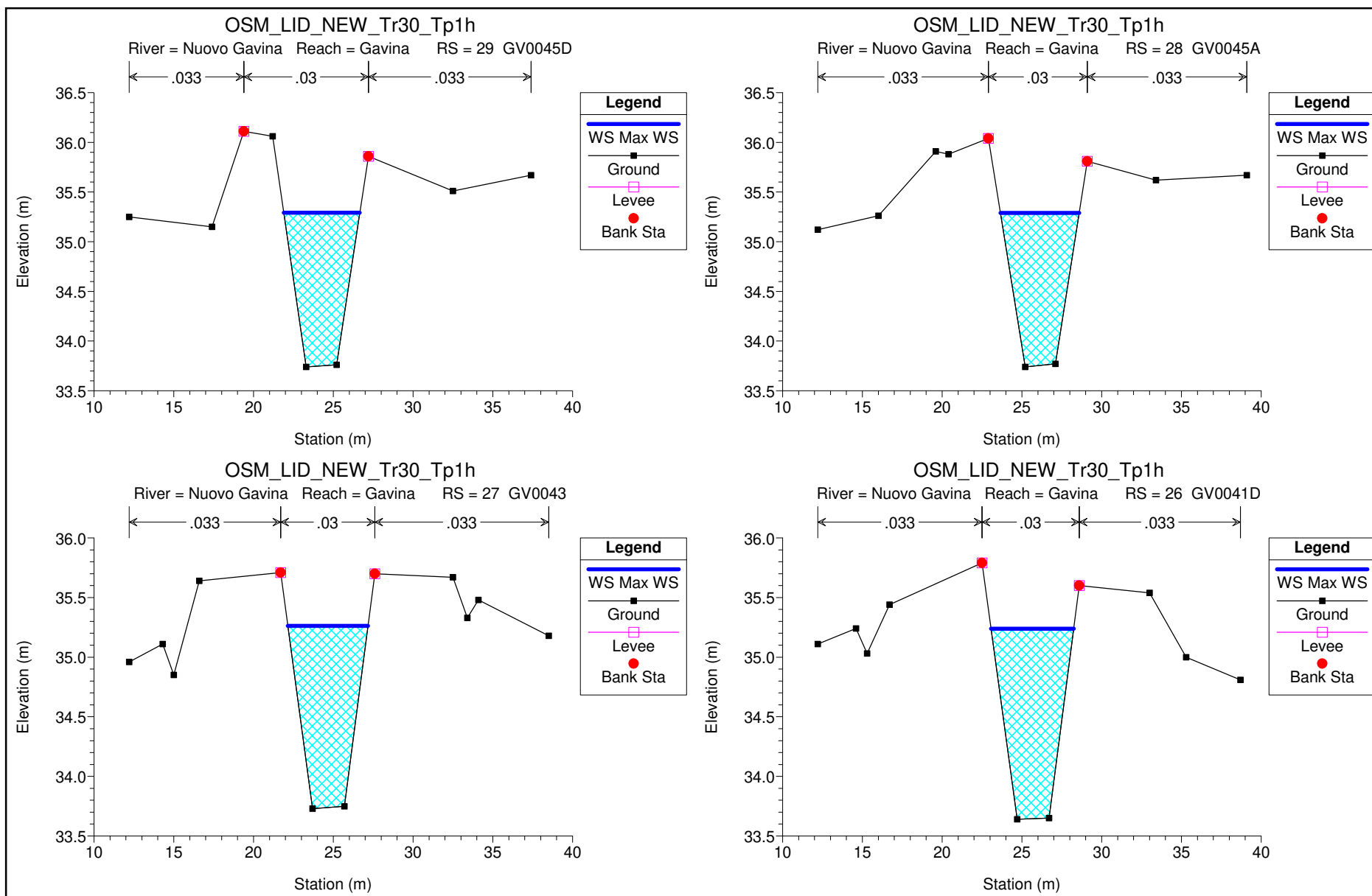


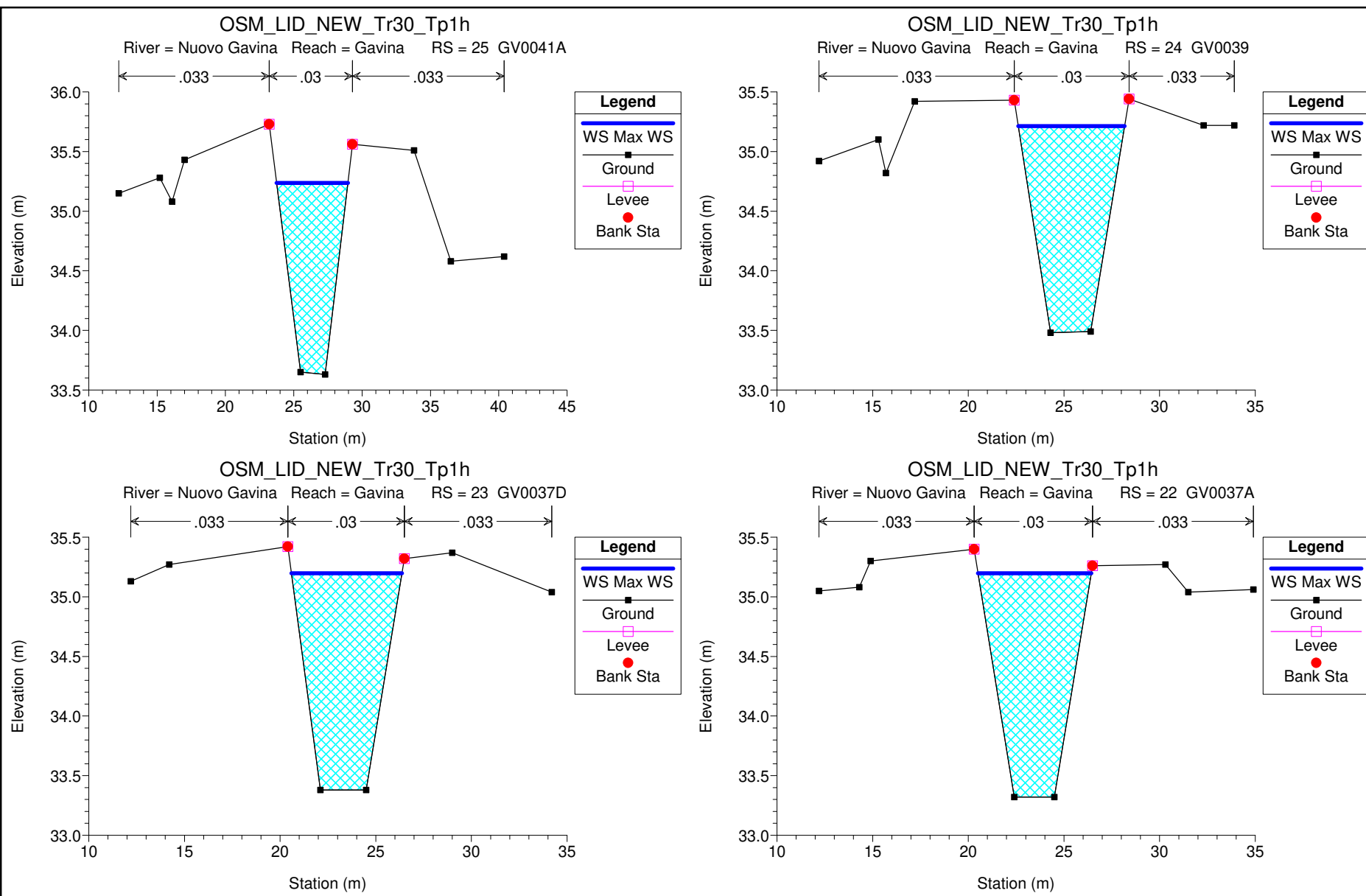


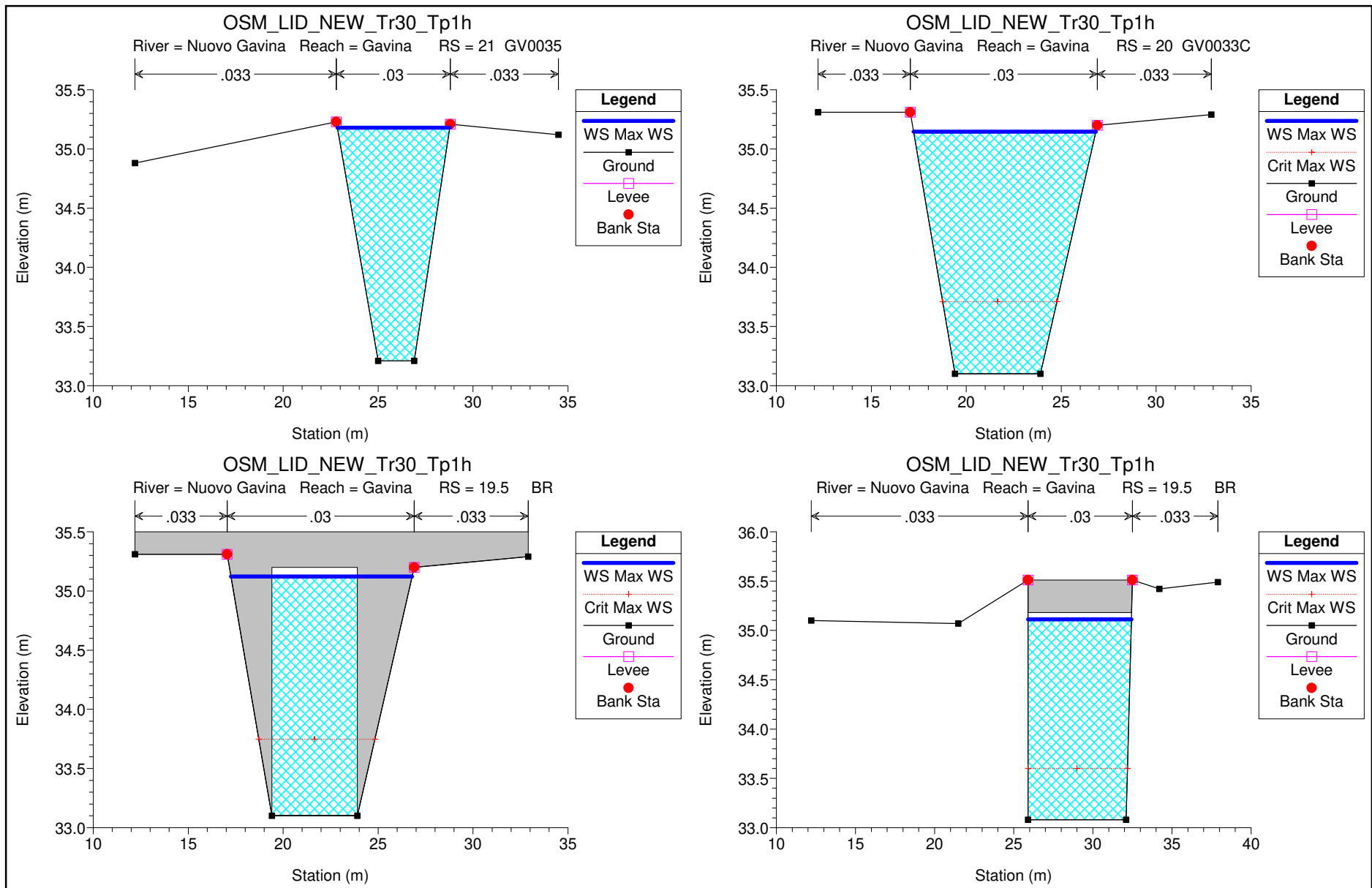


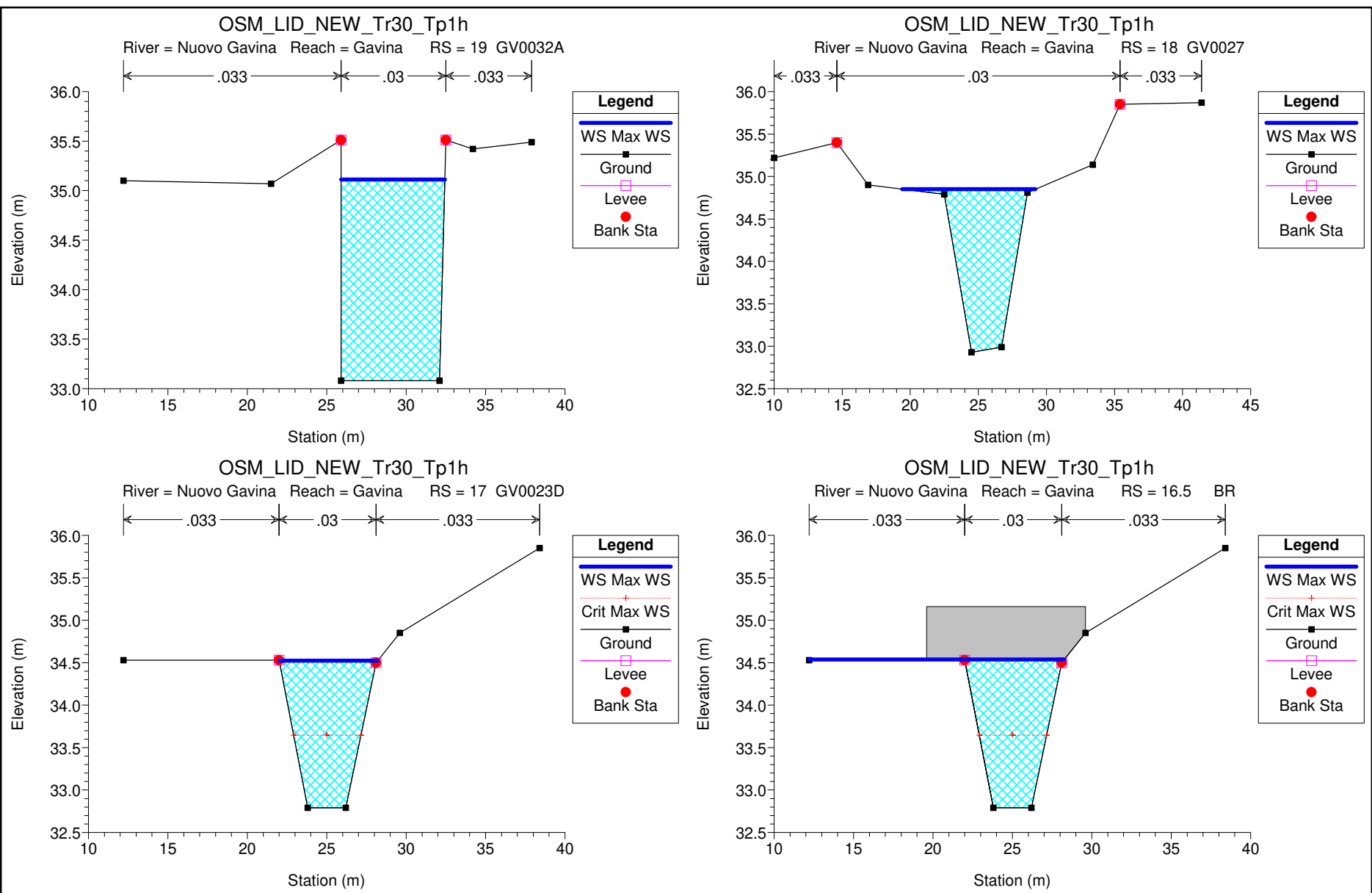


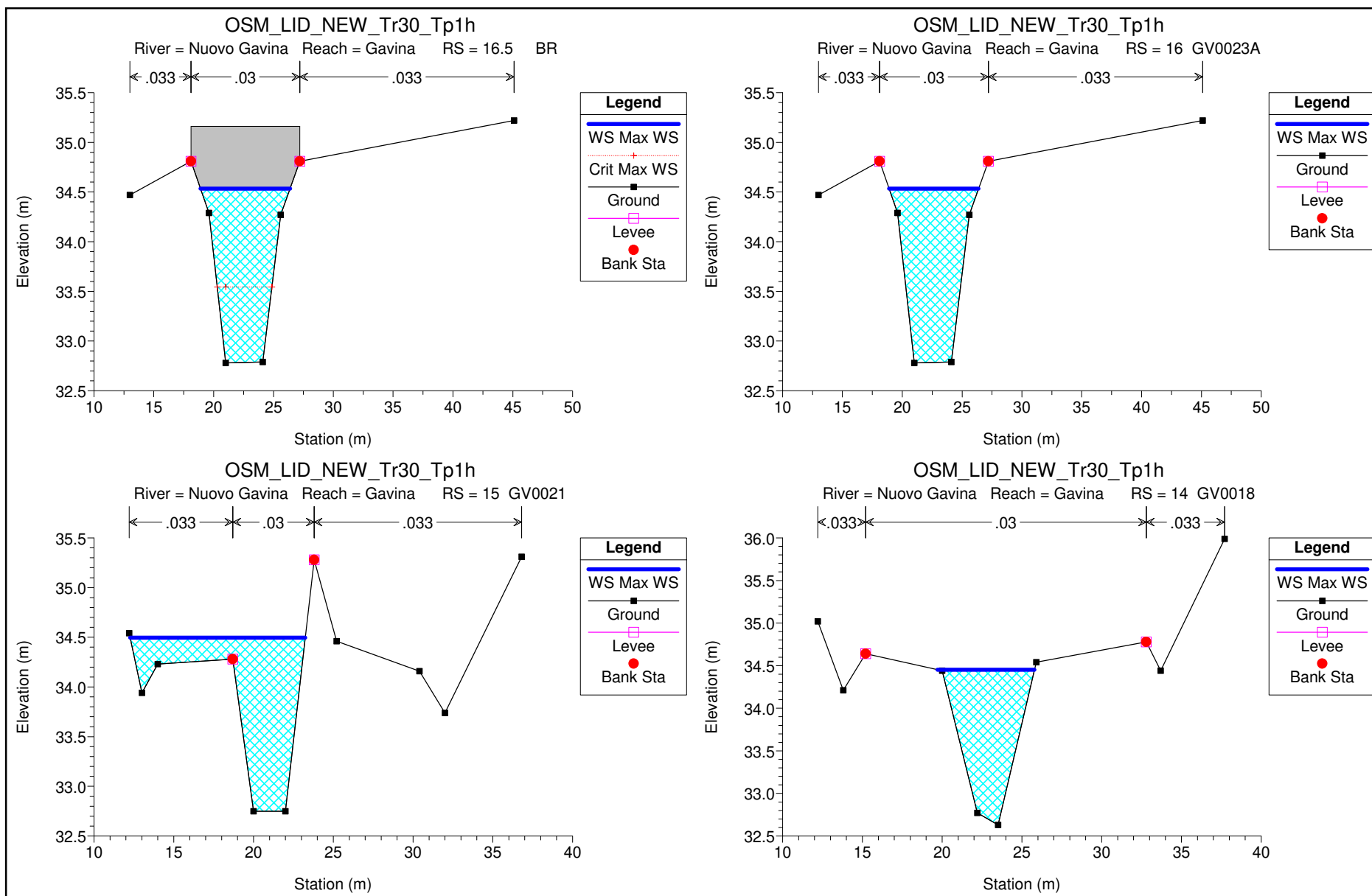


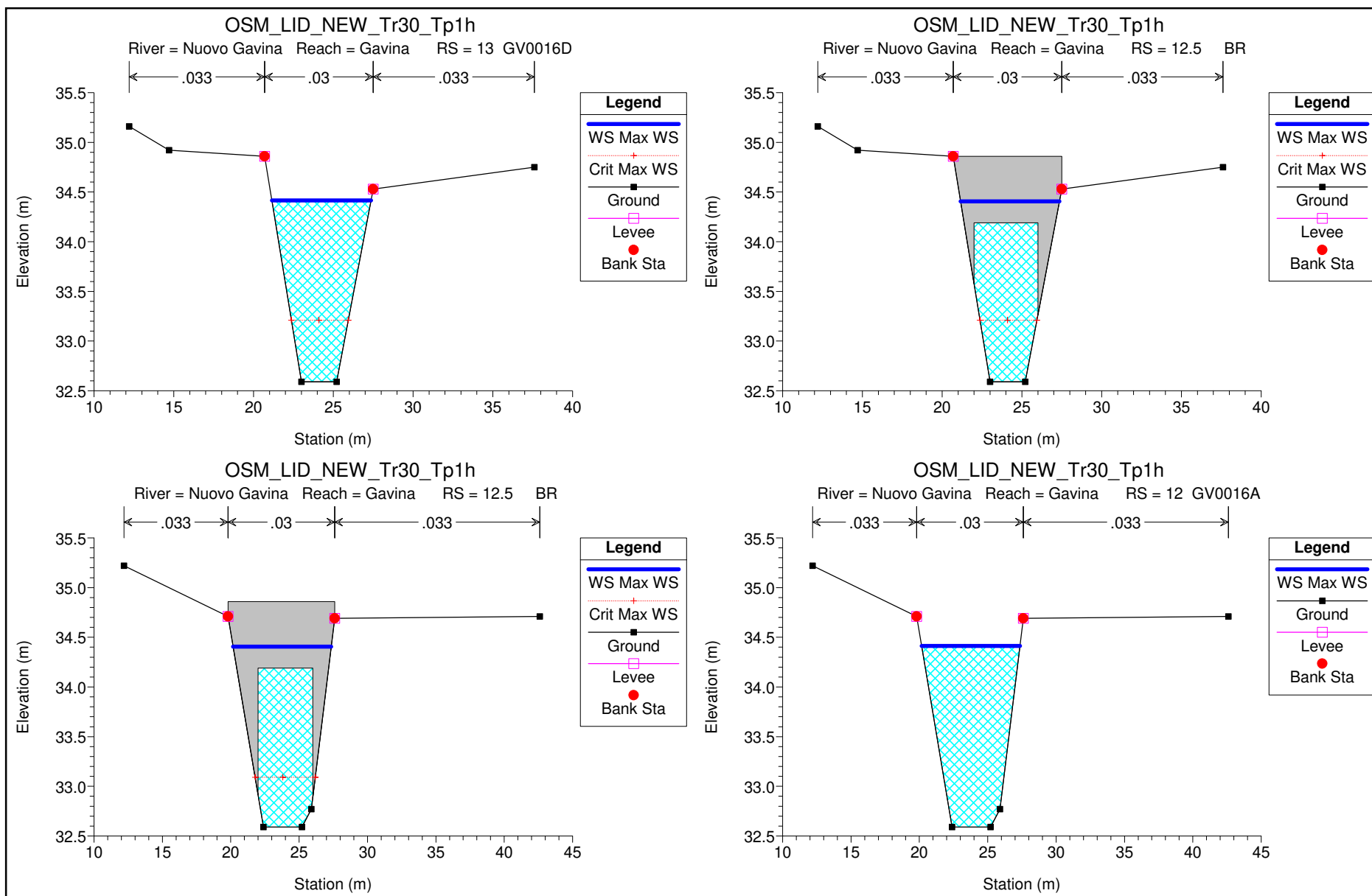


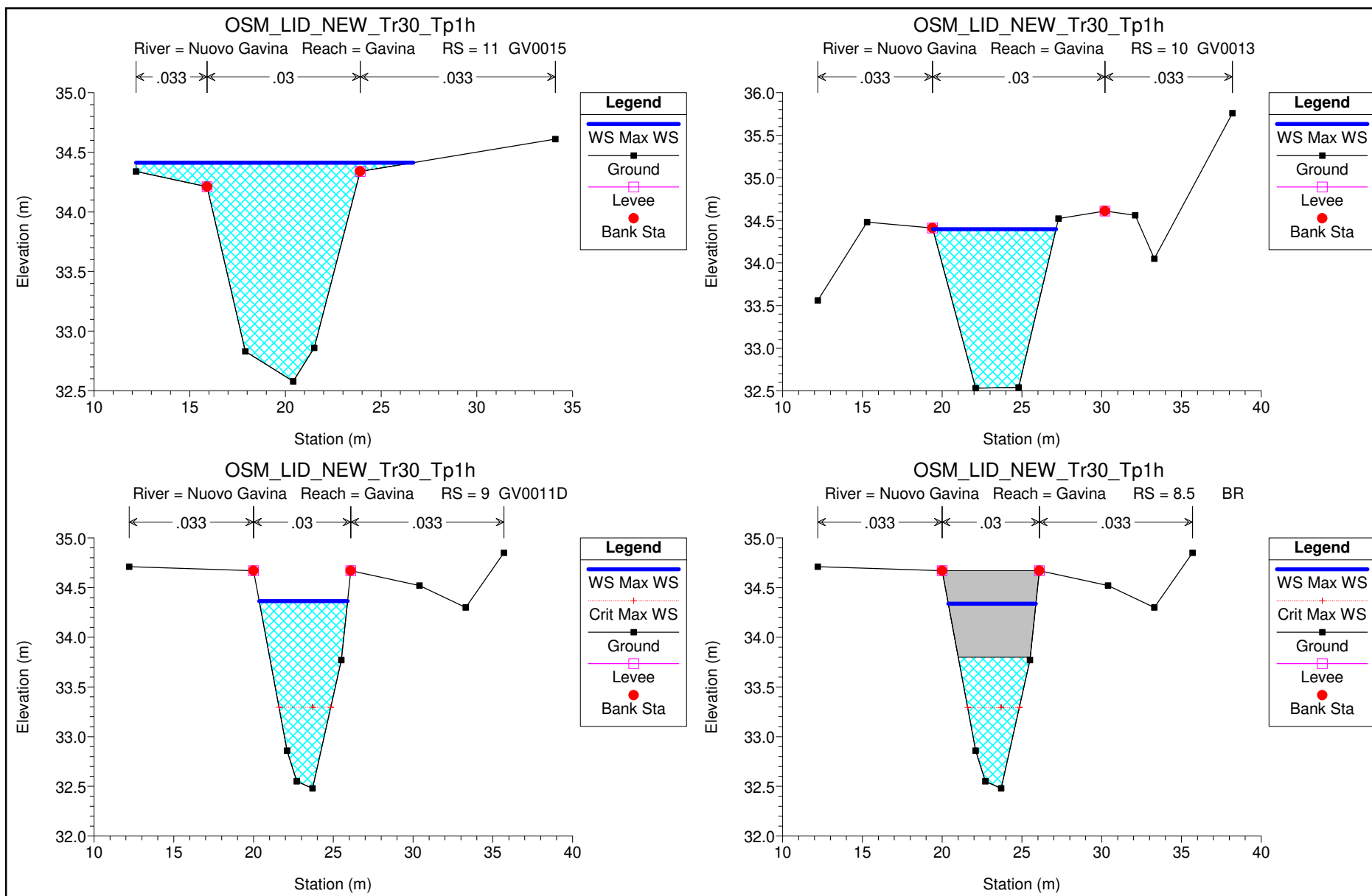


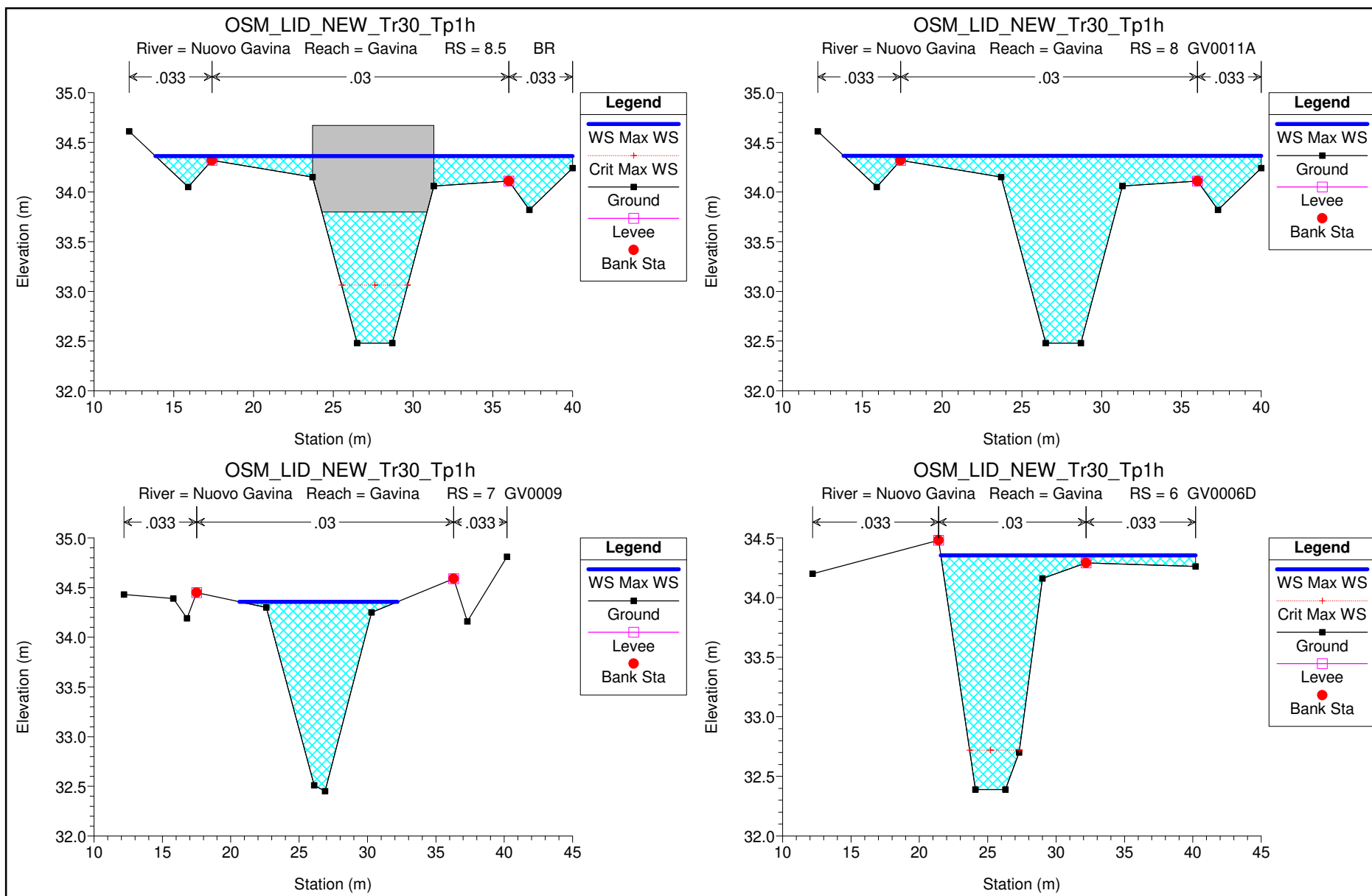


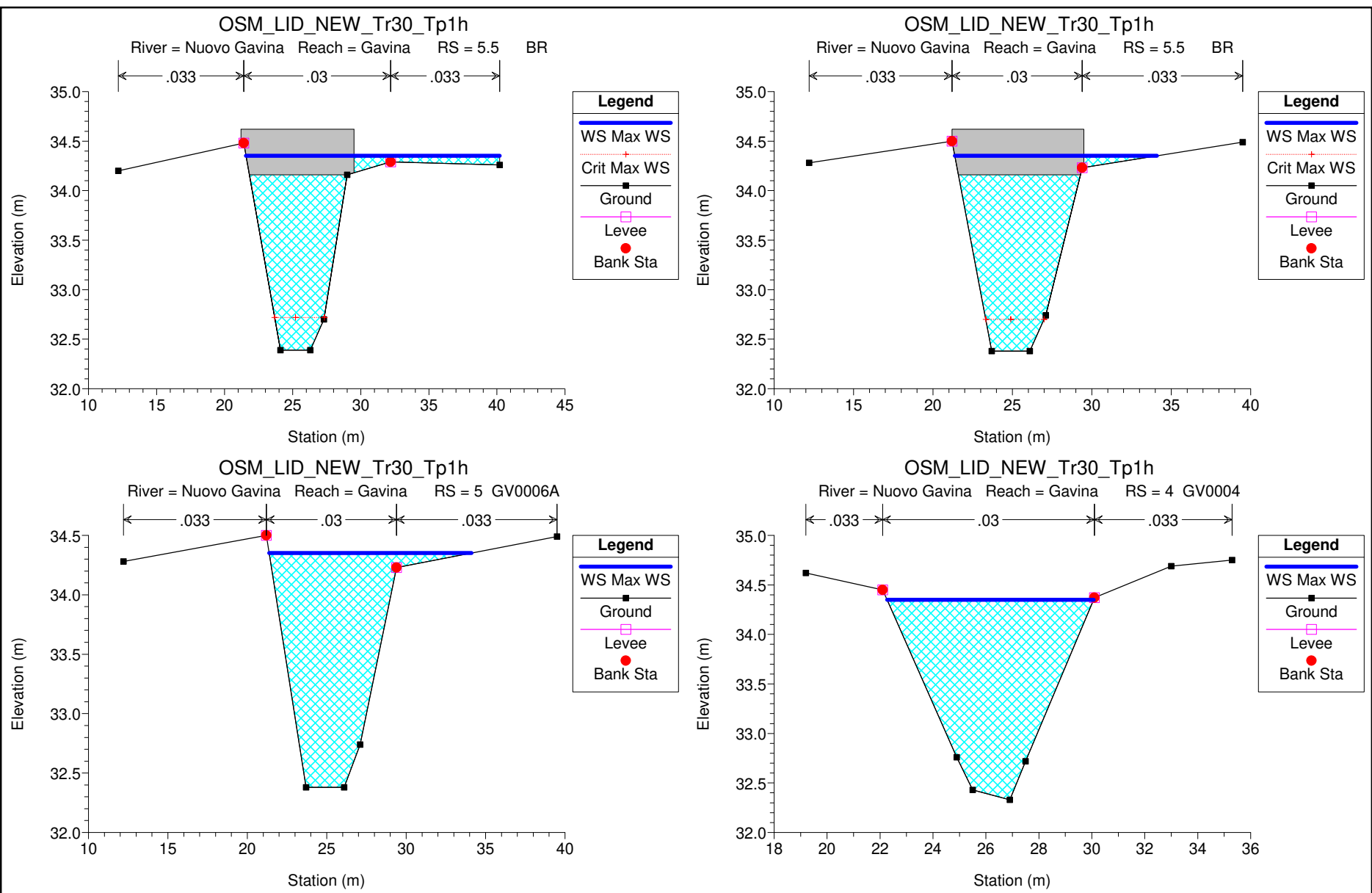


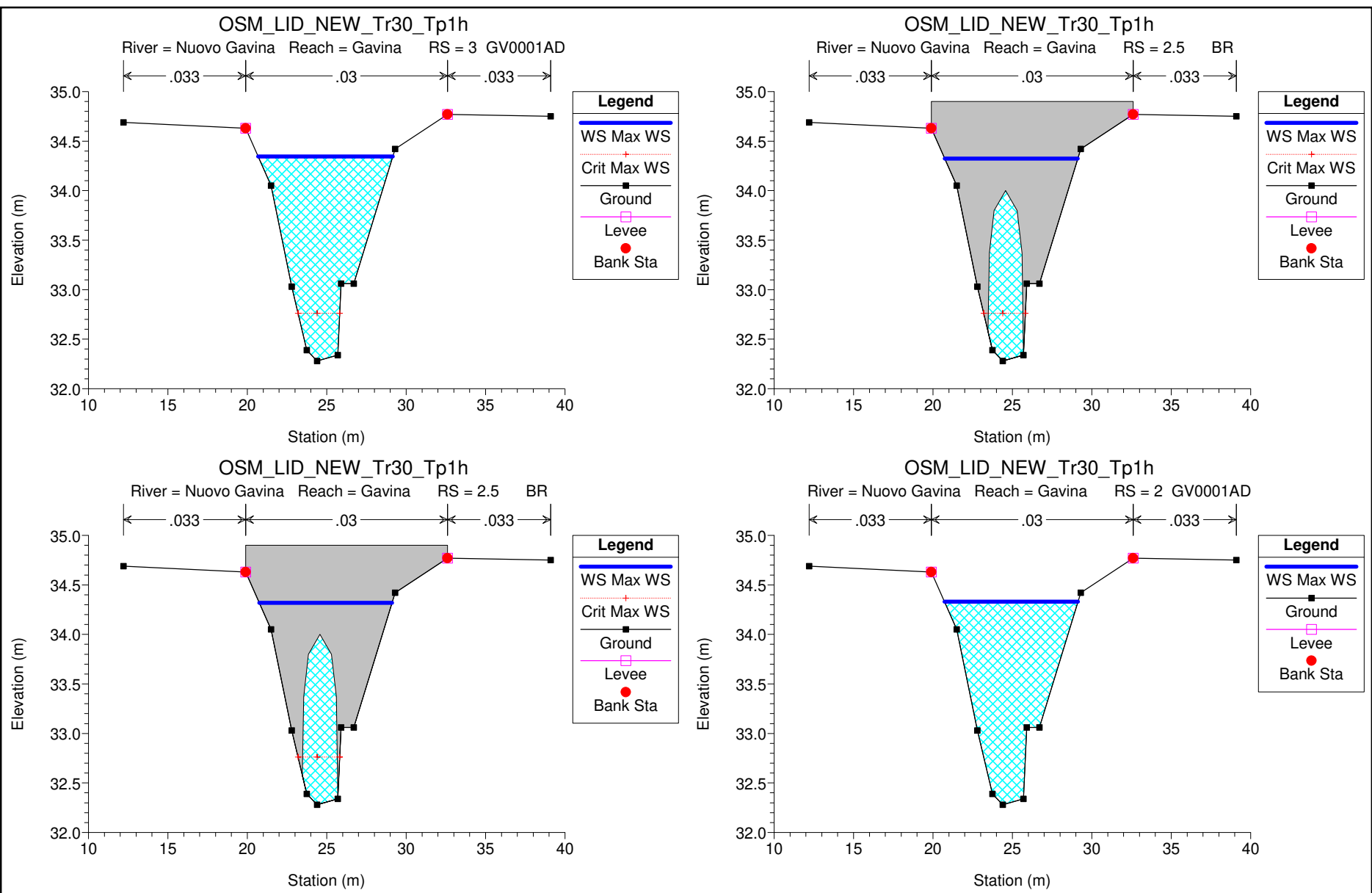






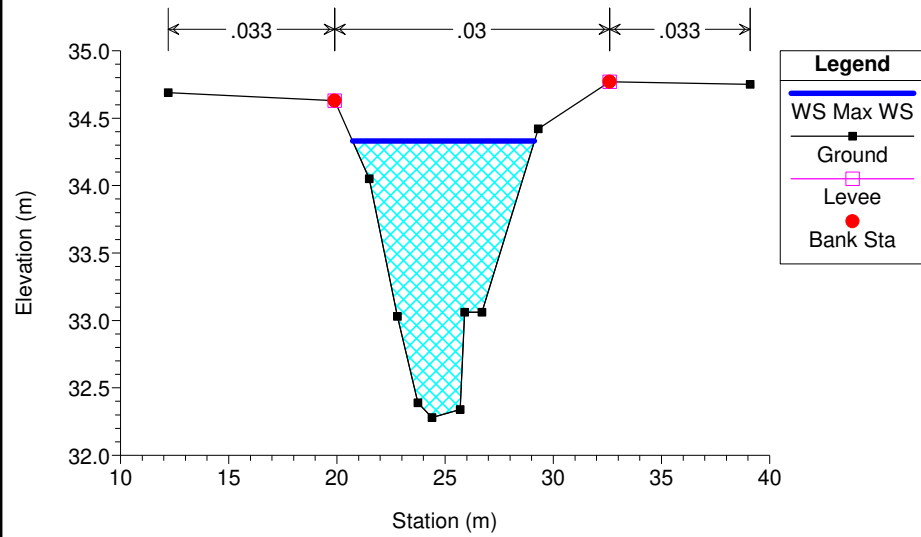






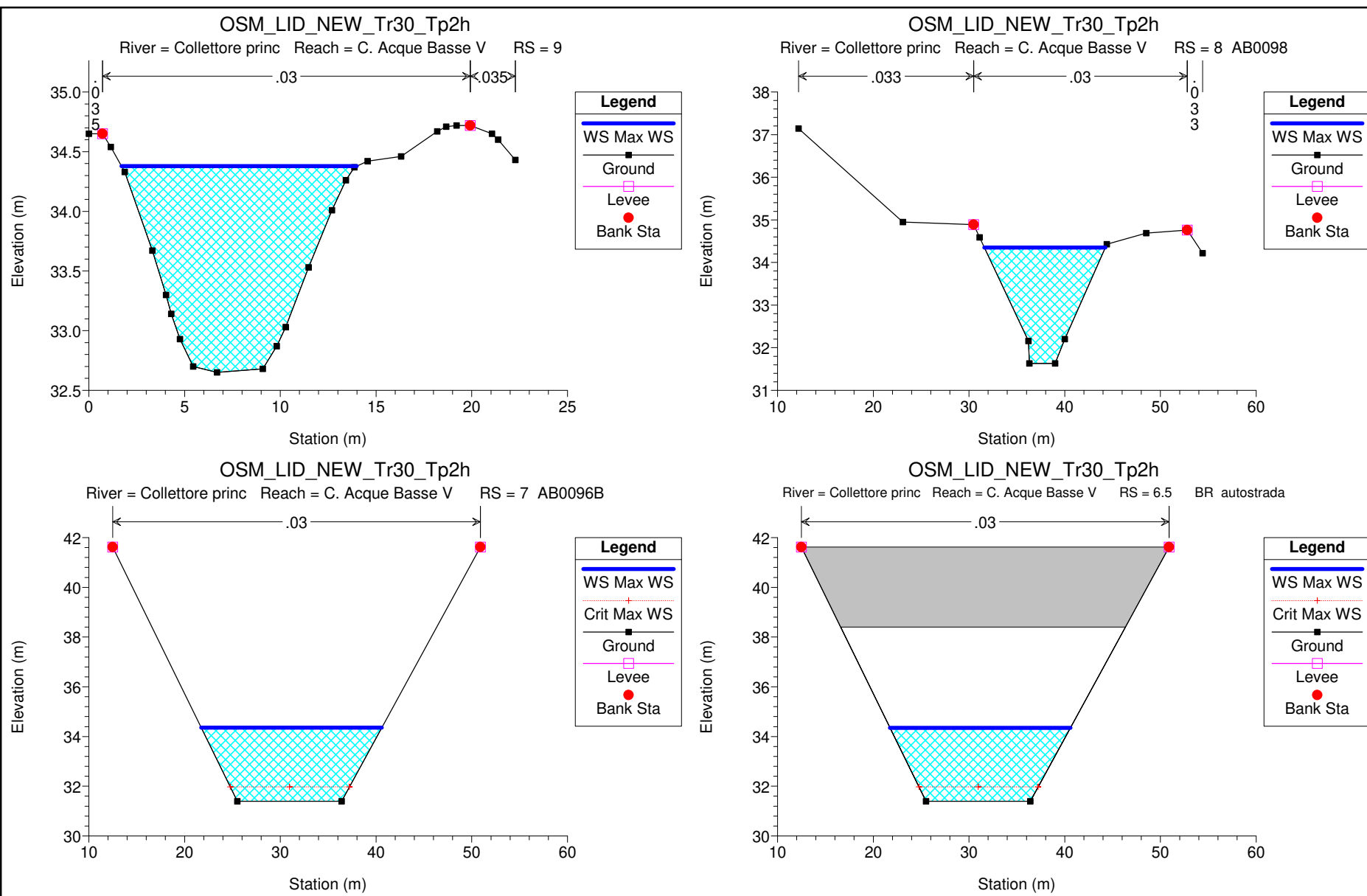
OSM_LID_NEW_Tr30_Tp1h

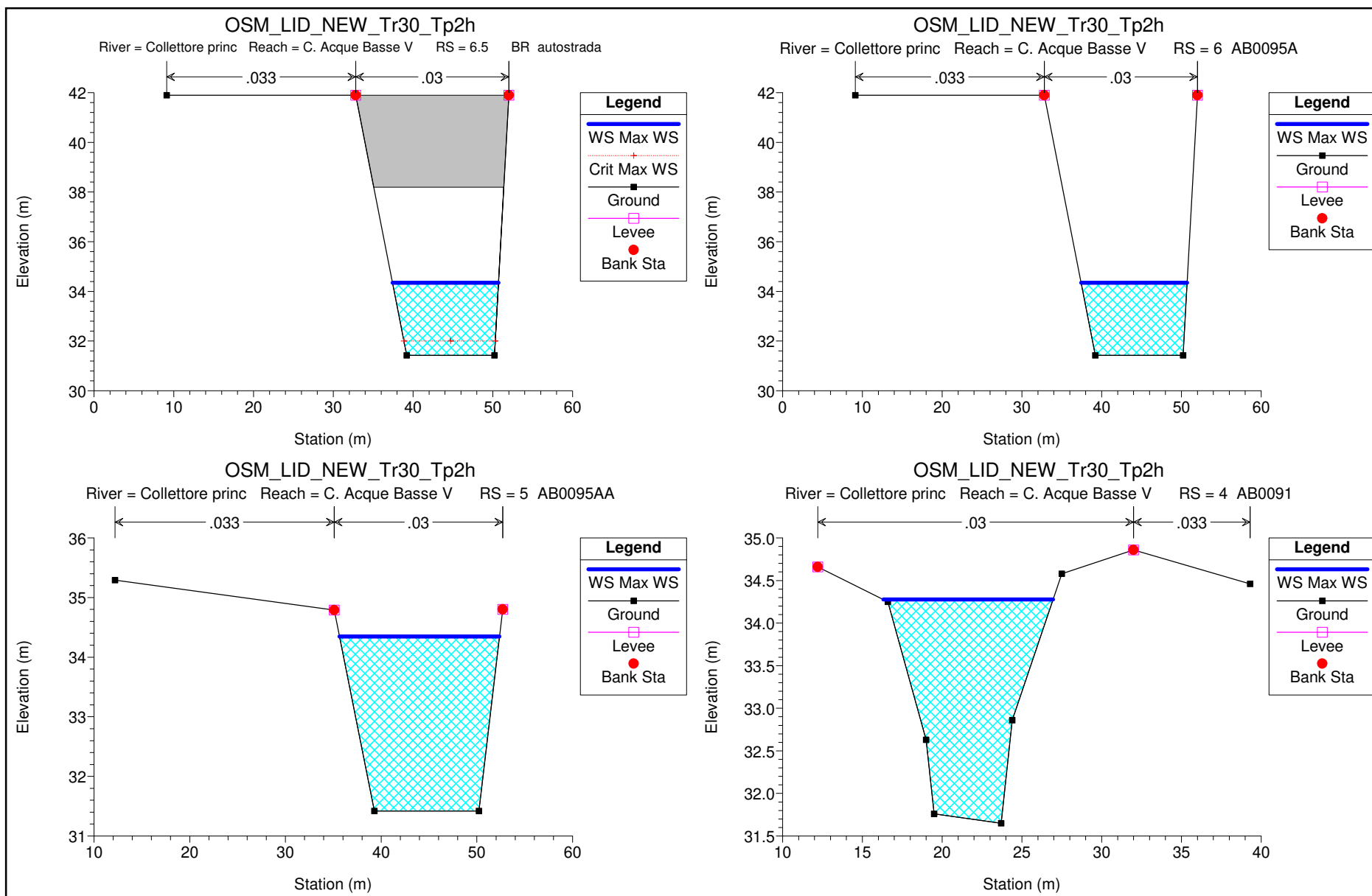
River = Nuovo Gavina Reach = Gavina RS = 1 GV0001AD

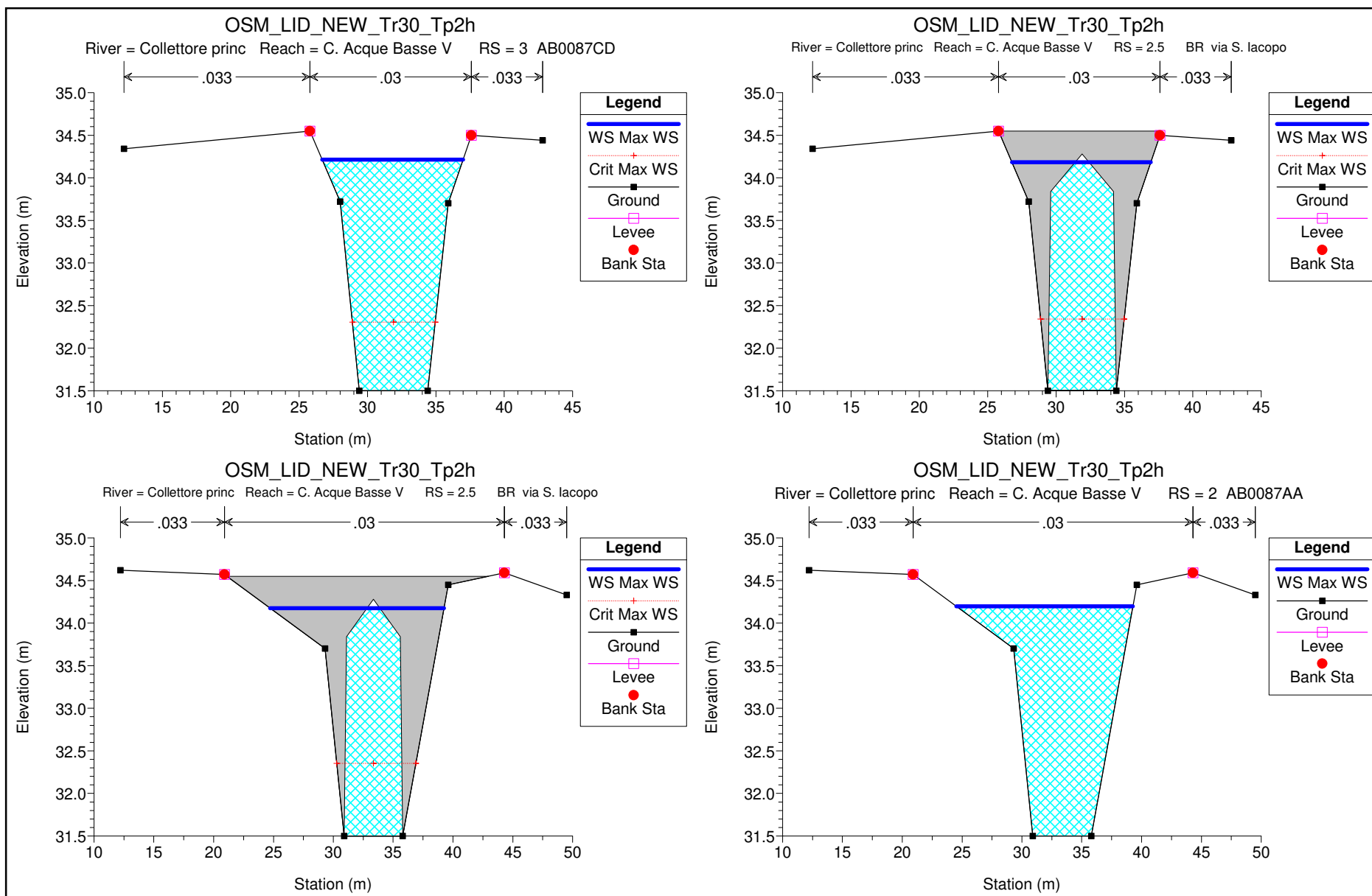


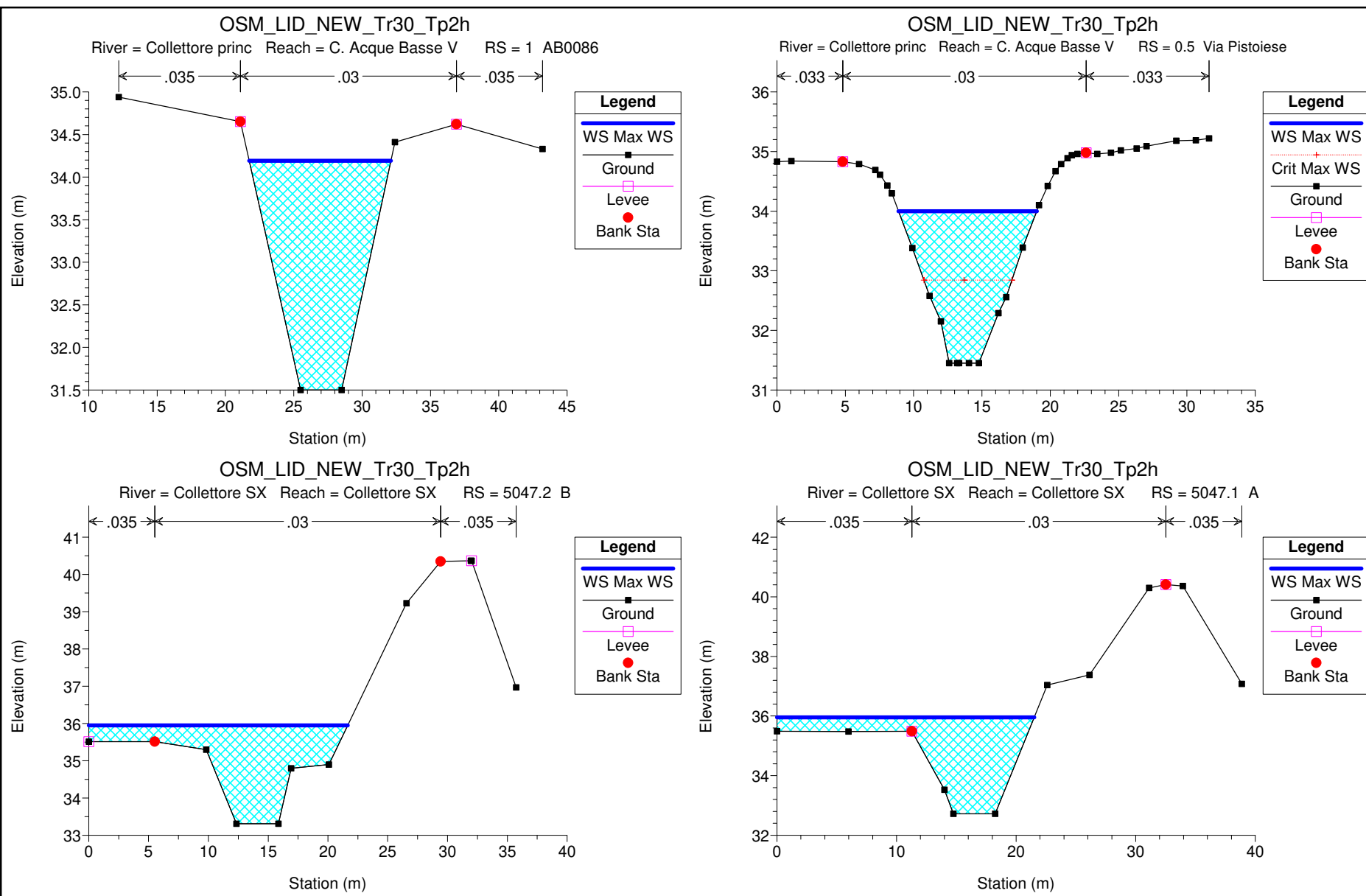
Verifiche idrauliche Tr 30 anni Tp 2h

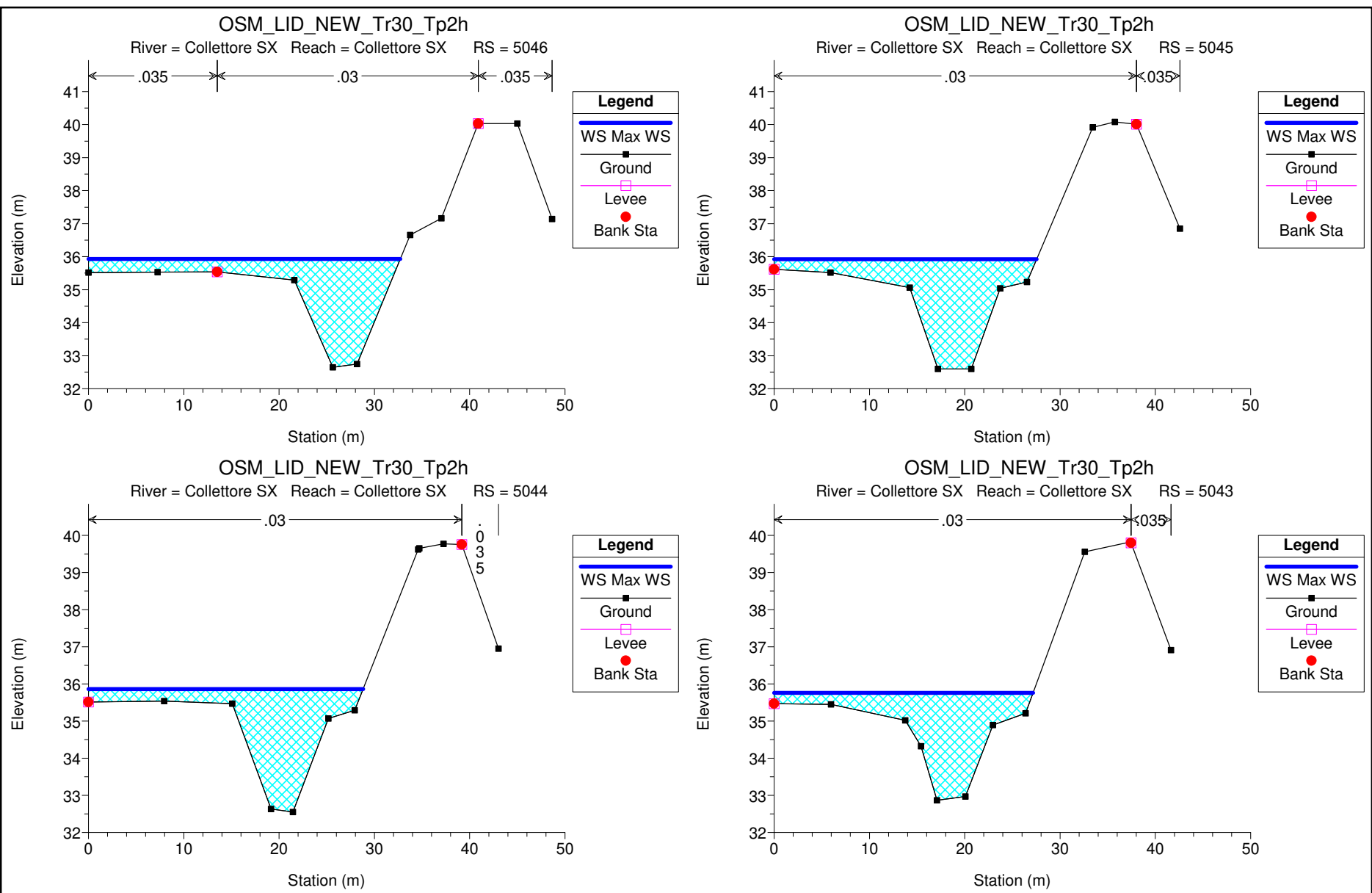
**Collettore sinistro acque basse – Fosso Osmannoro – Fosso Nuova Gavine – Collettore
principale delle acque basse**

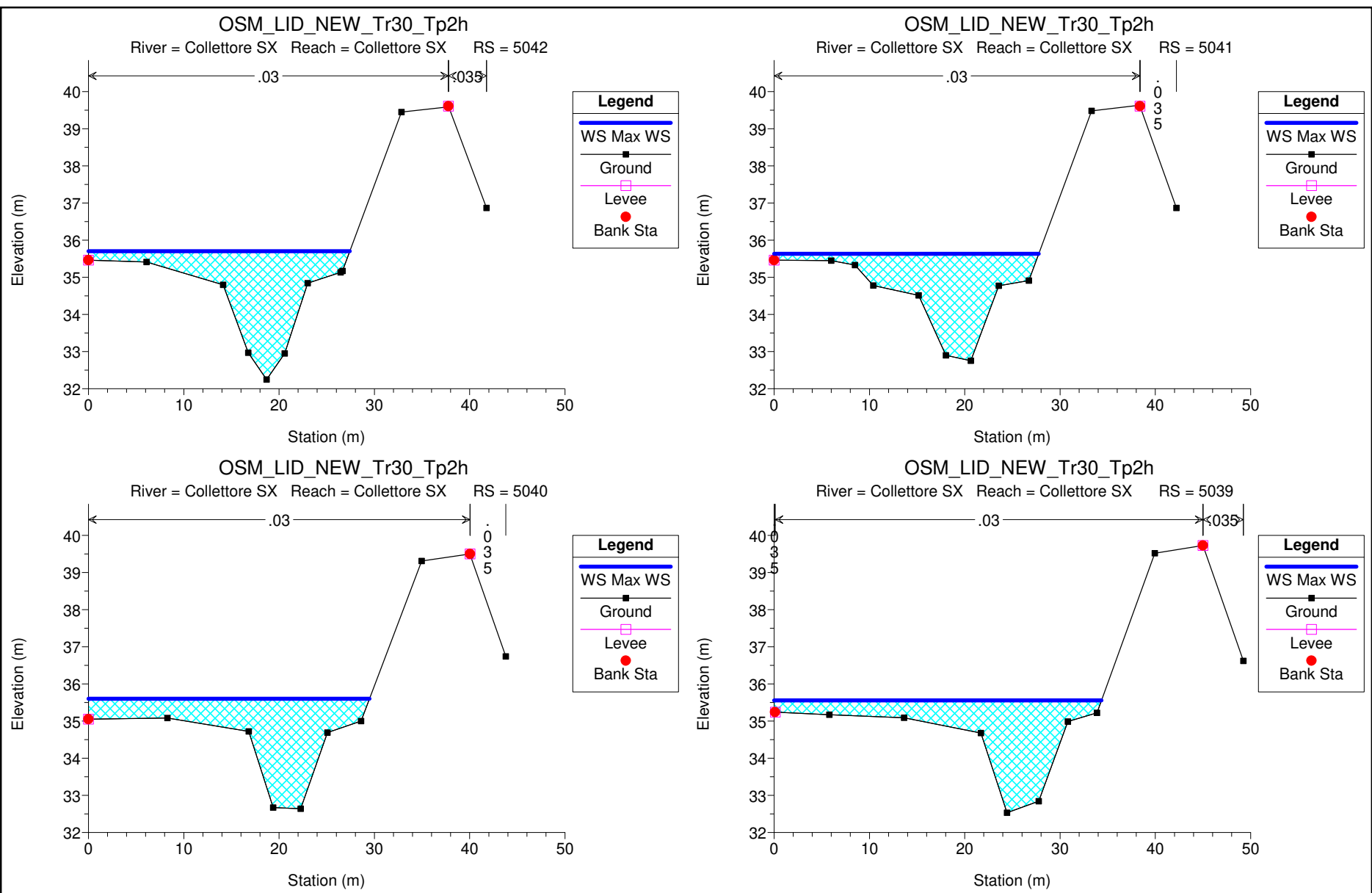


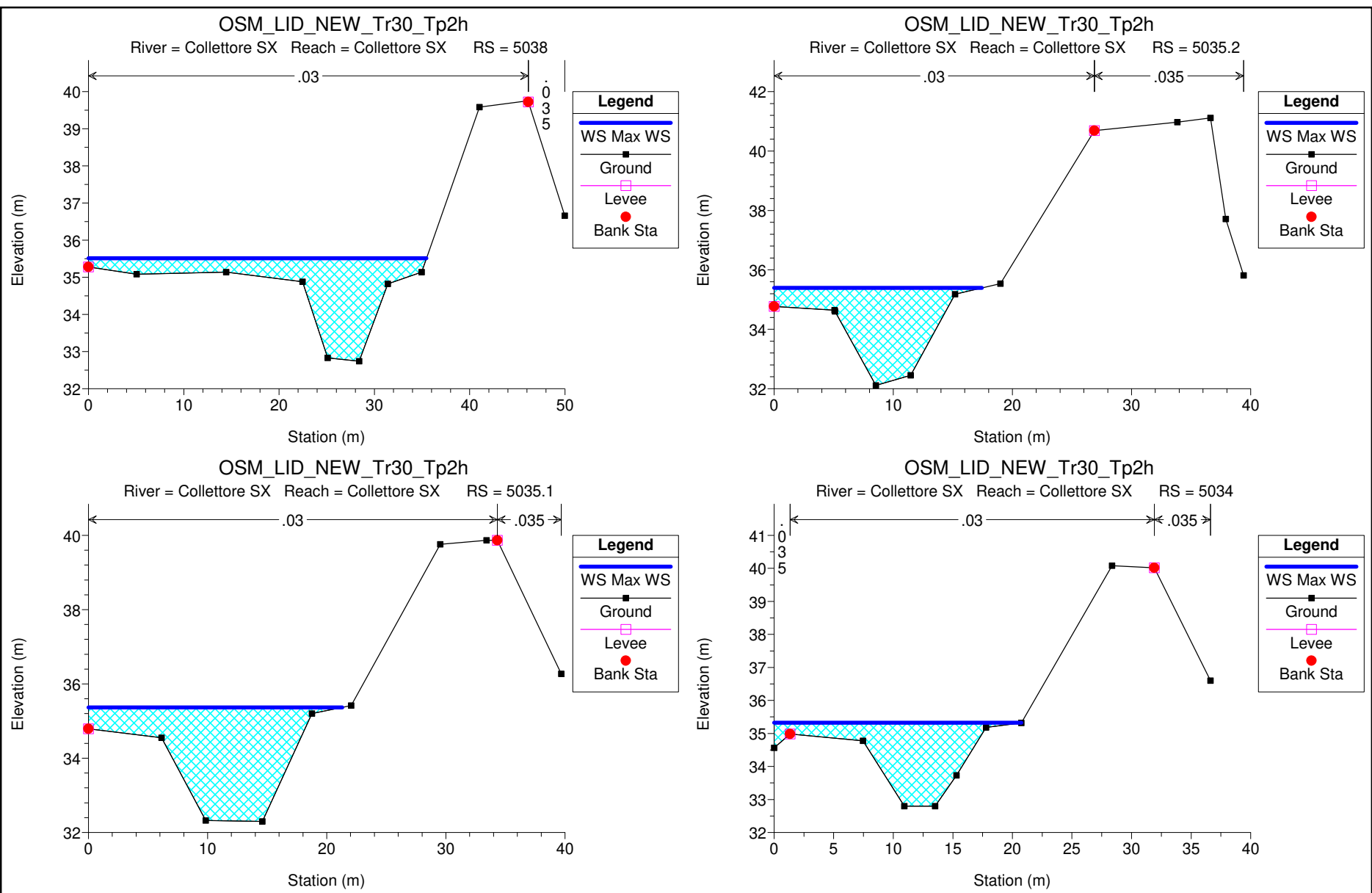


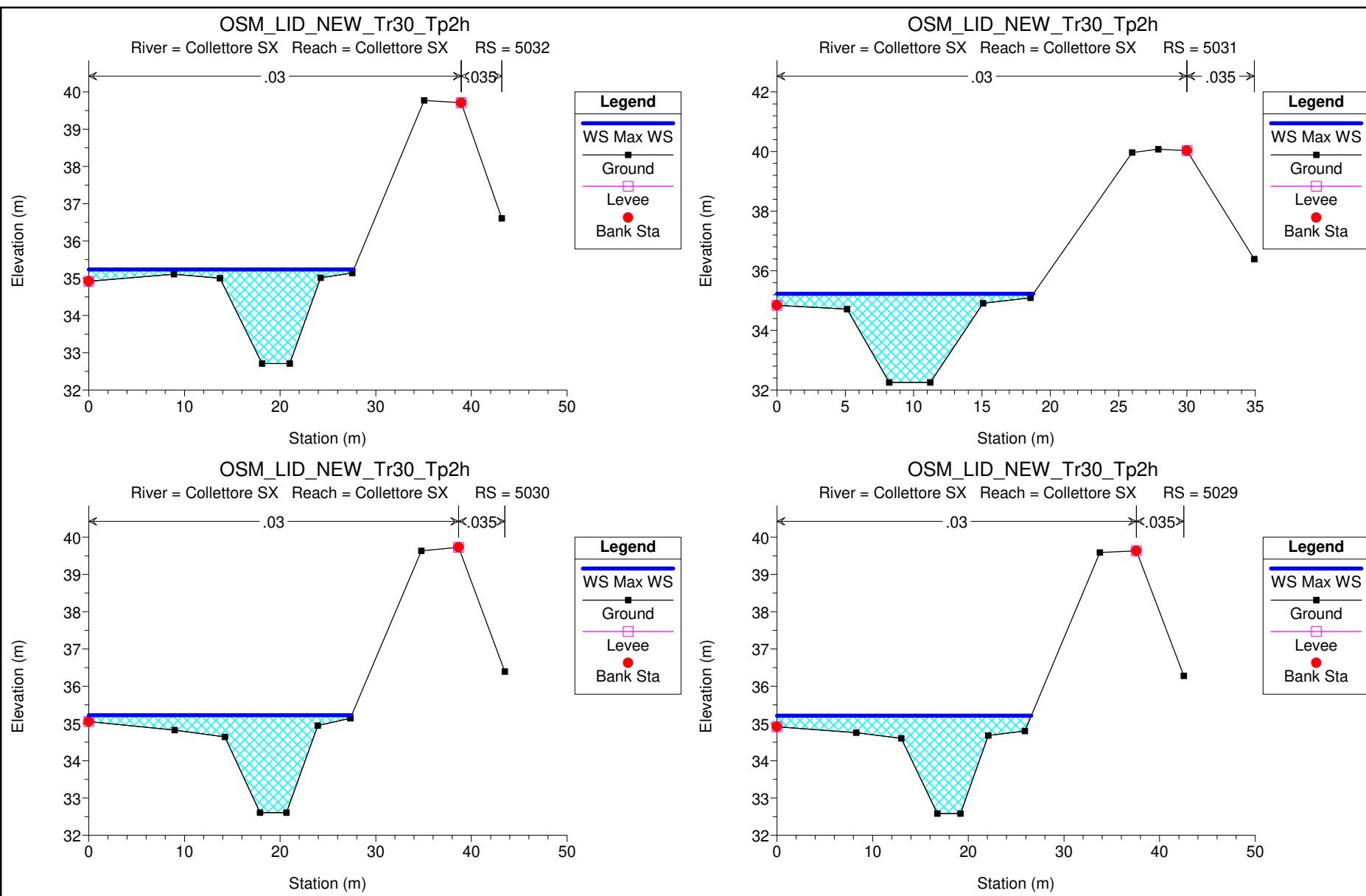


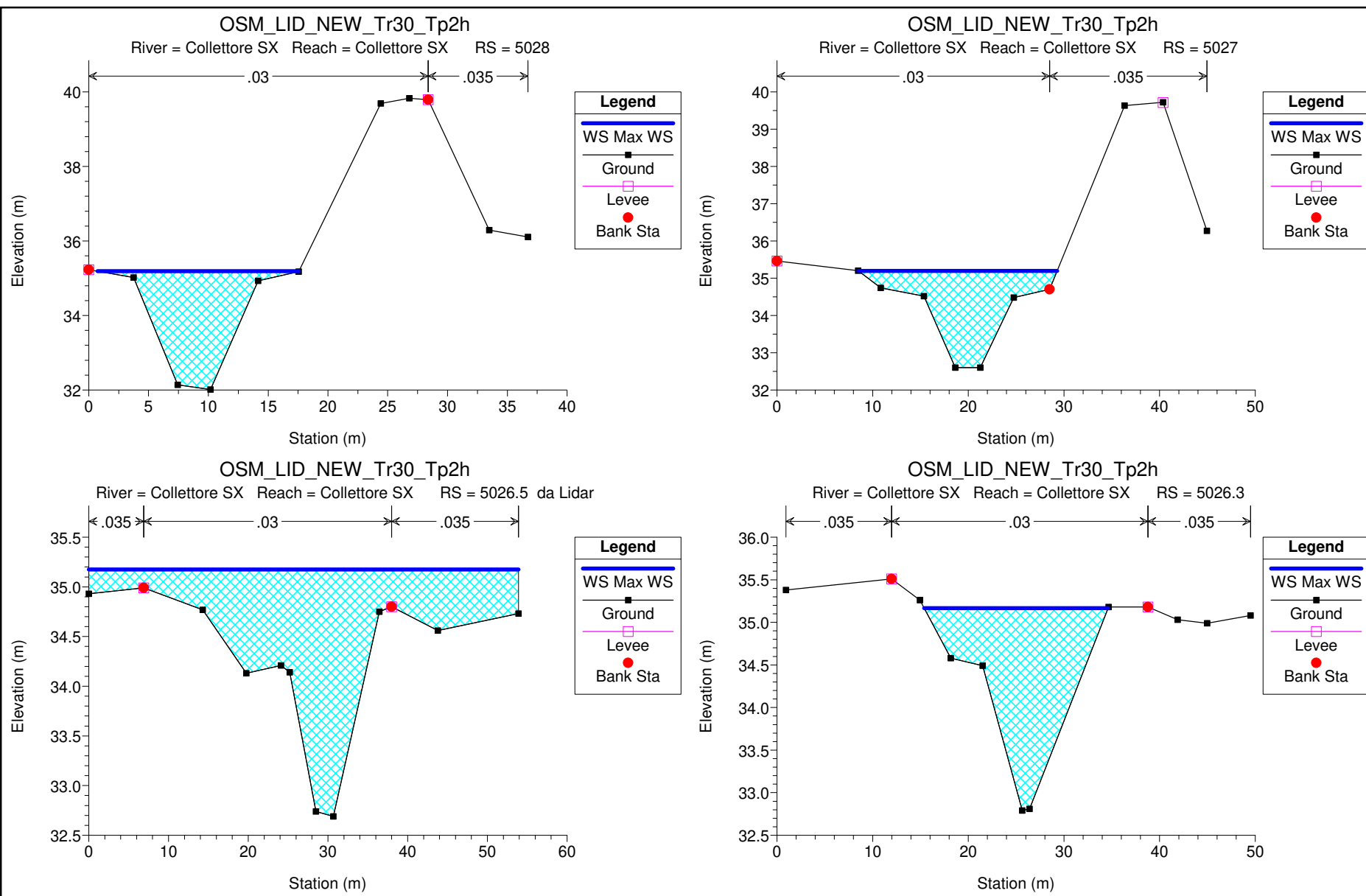


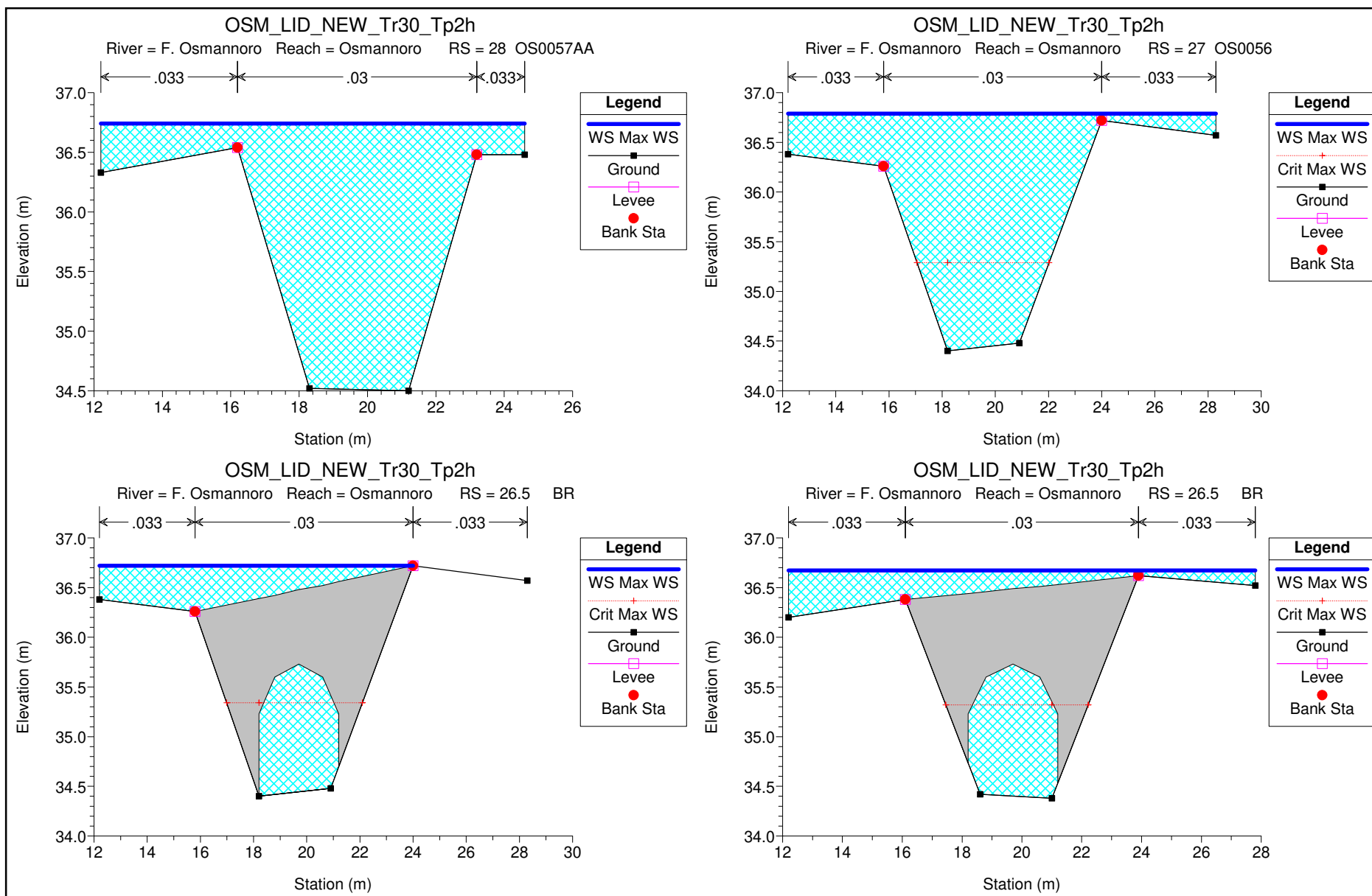


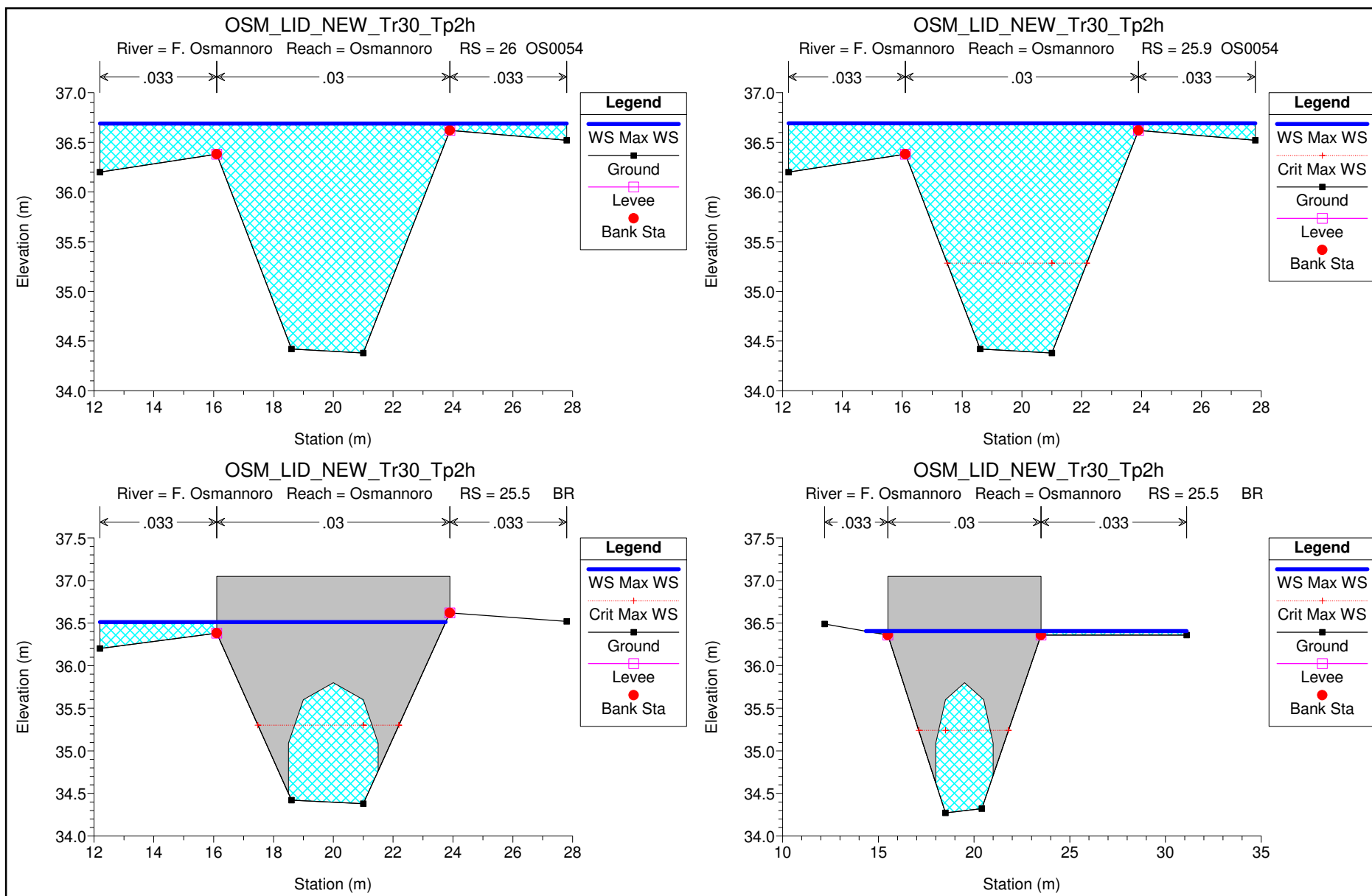


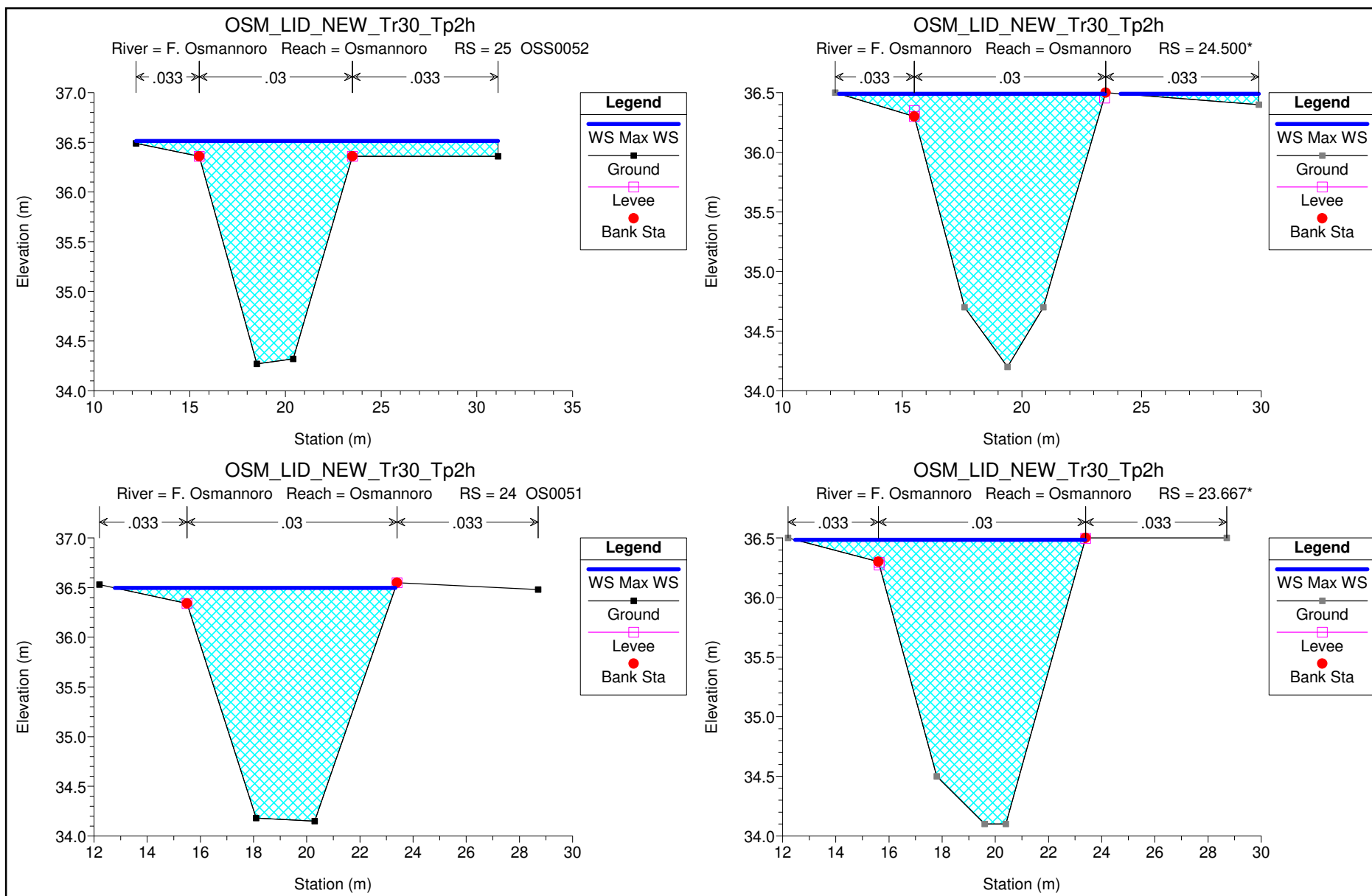


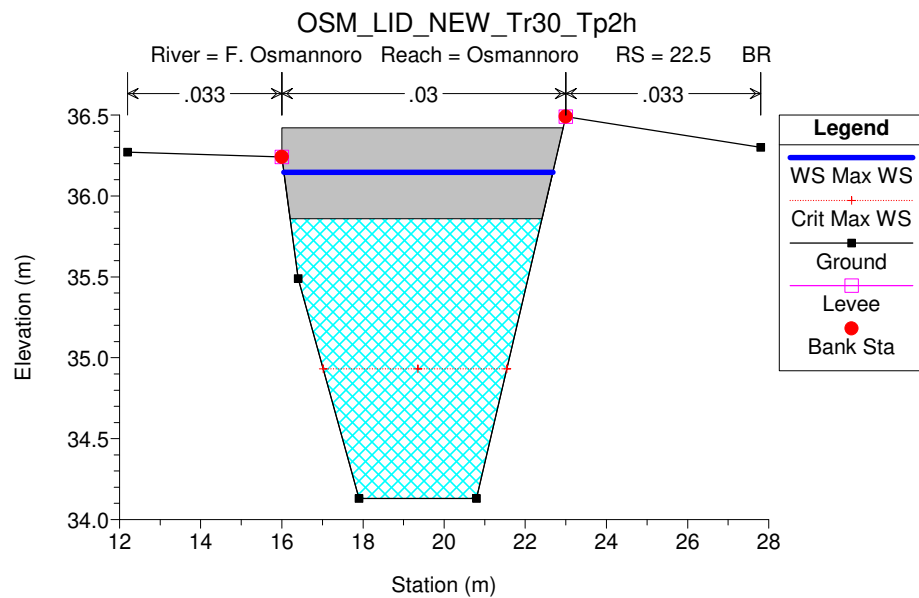
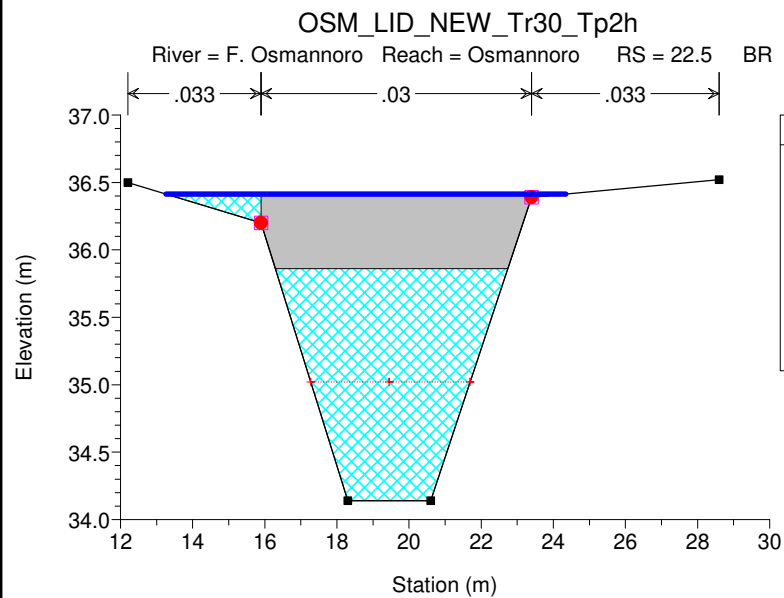
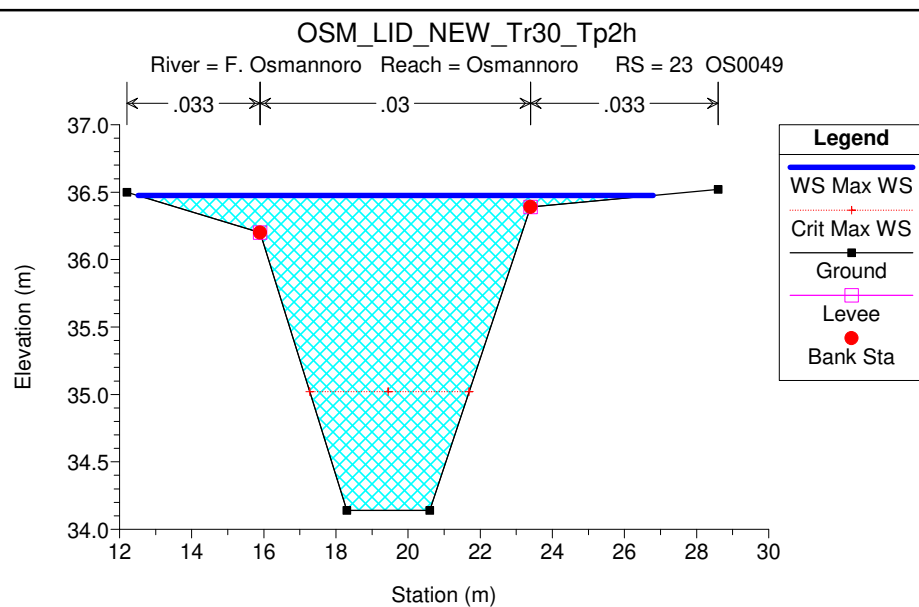
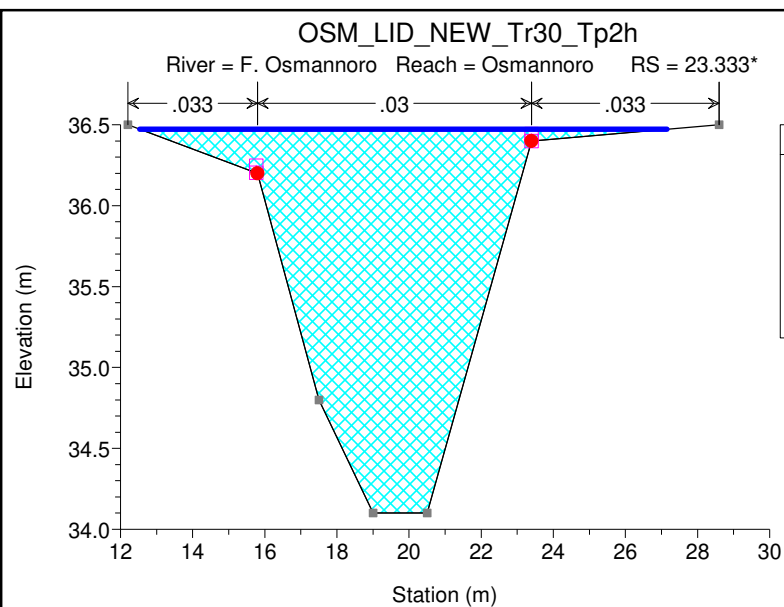


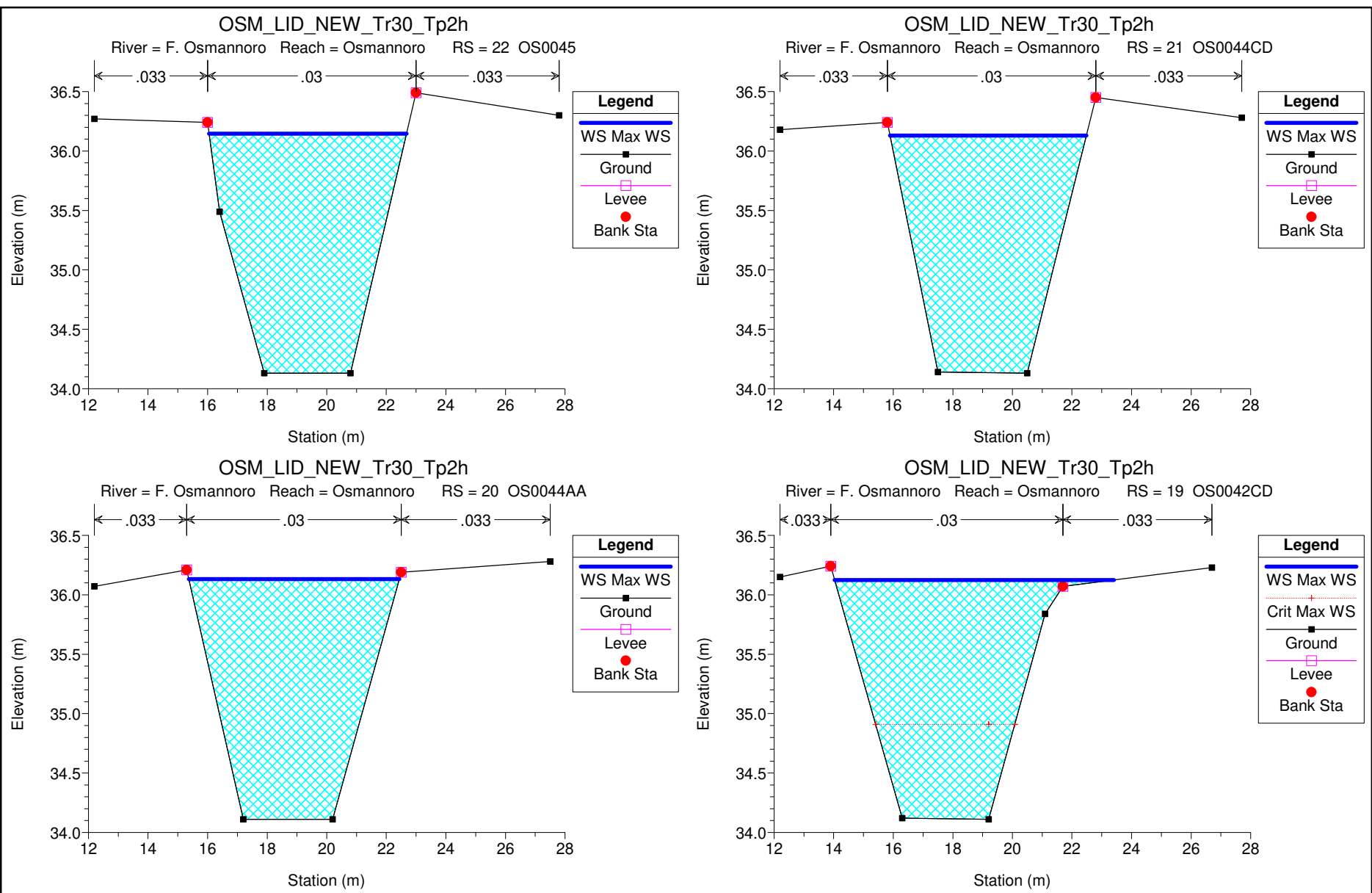


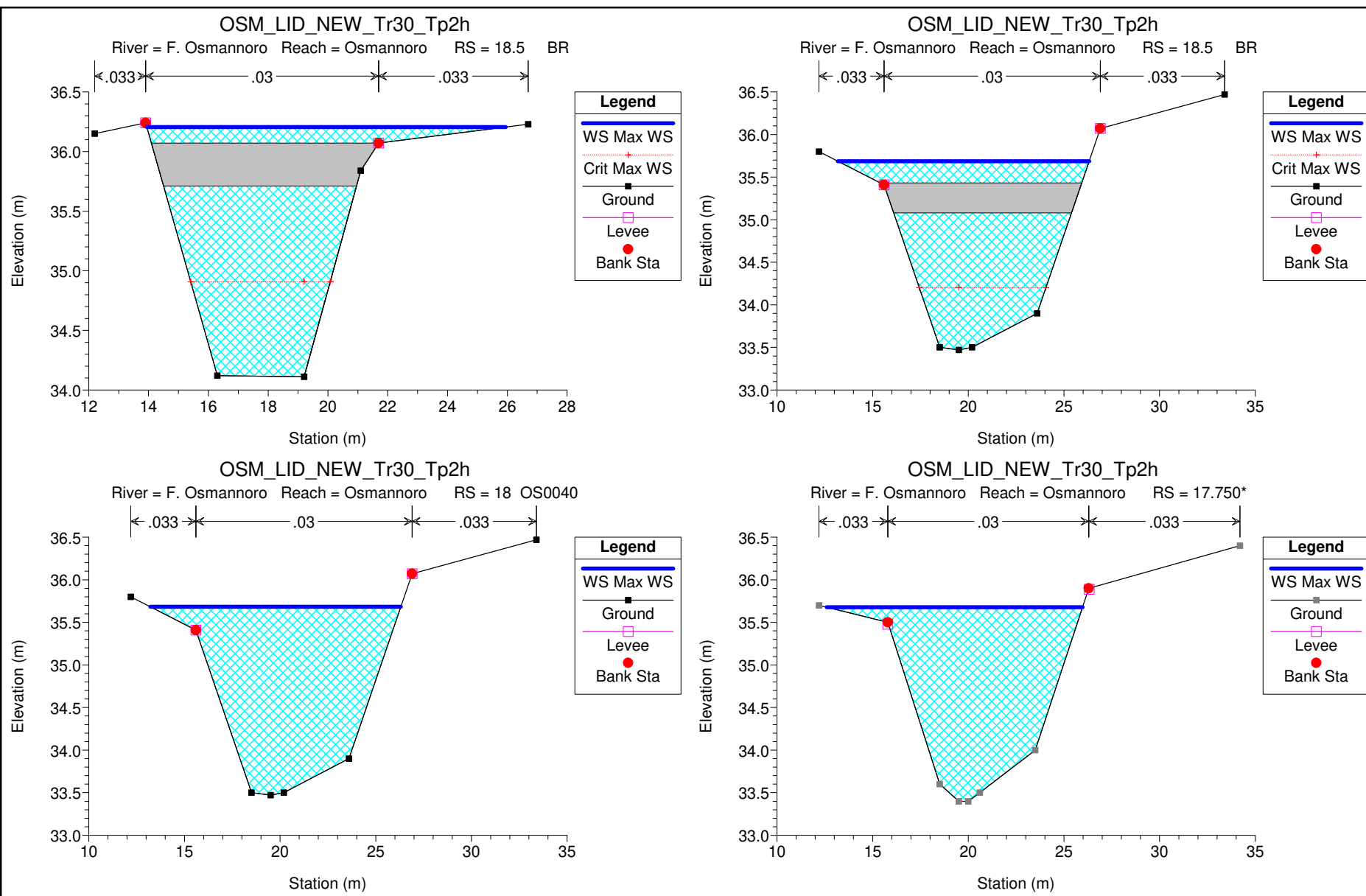


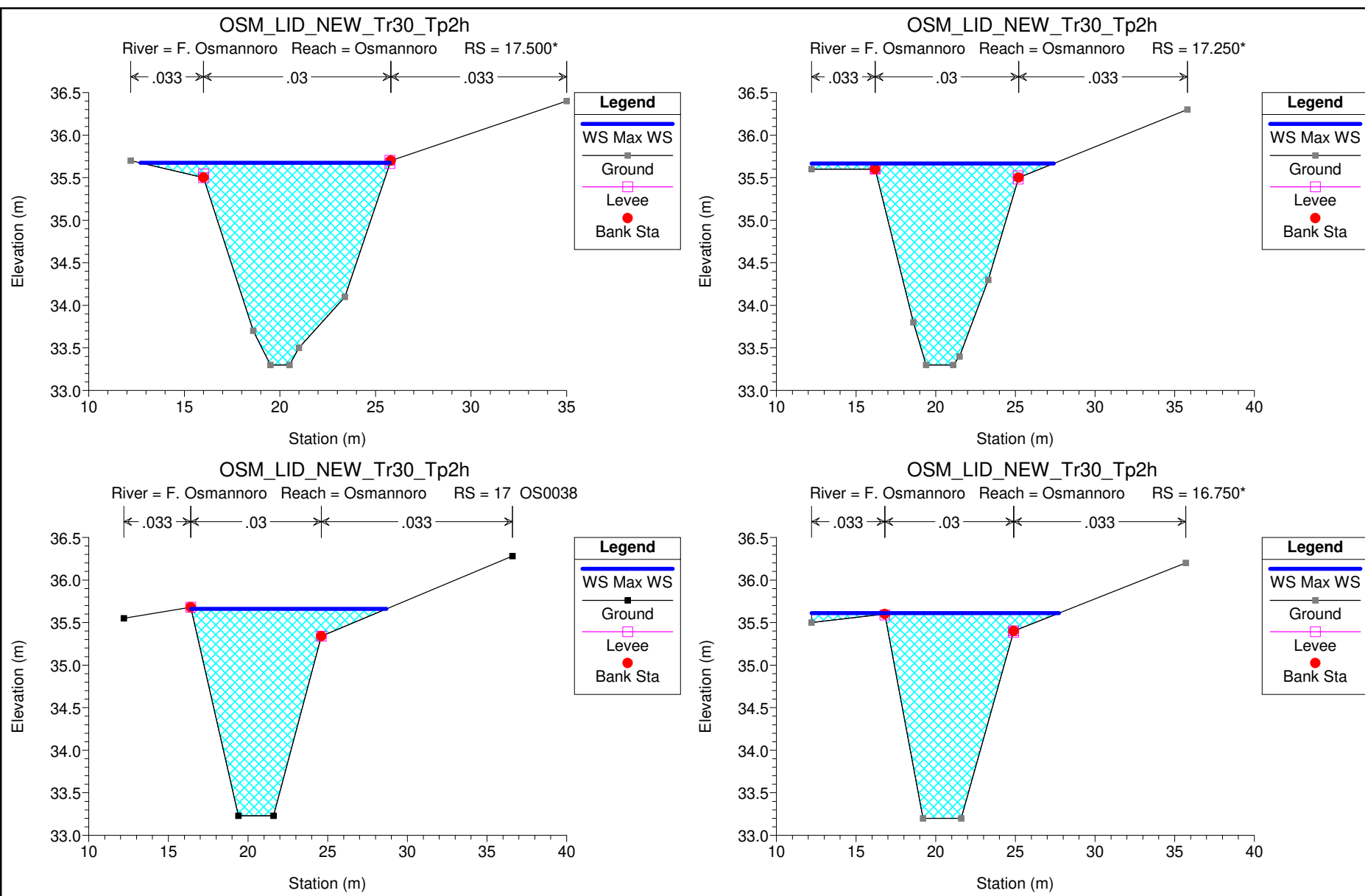


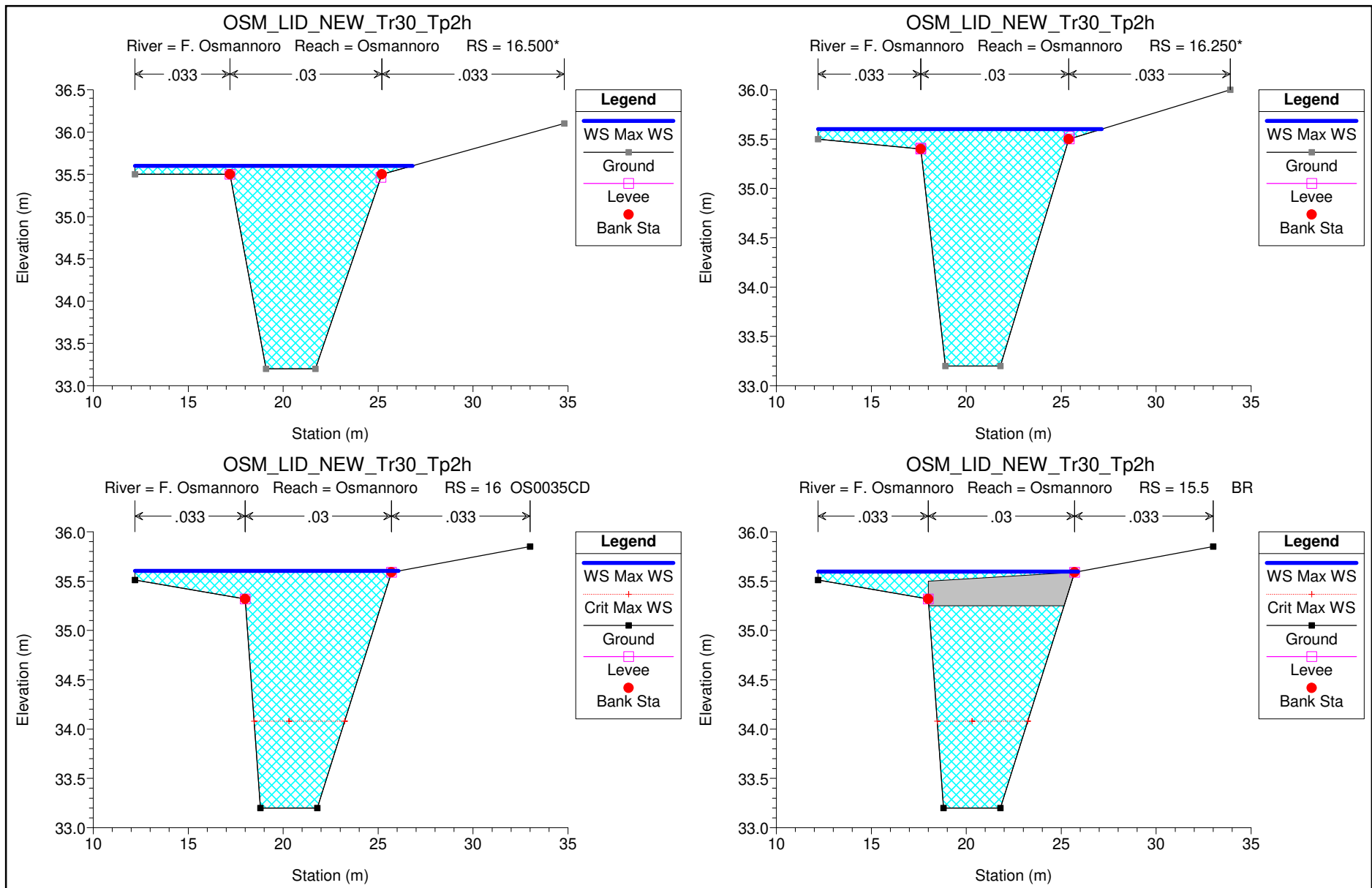


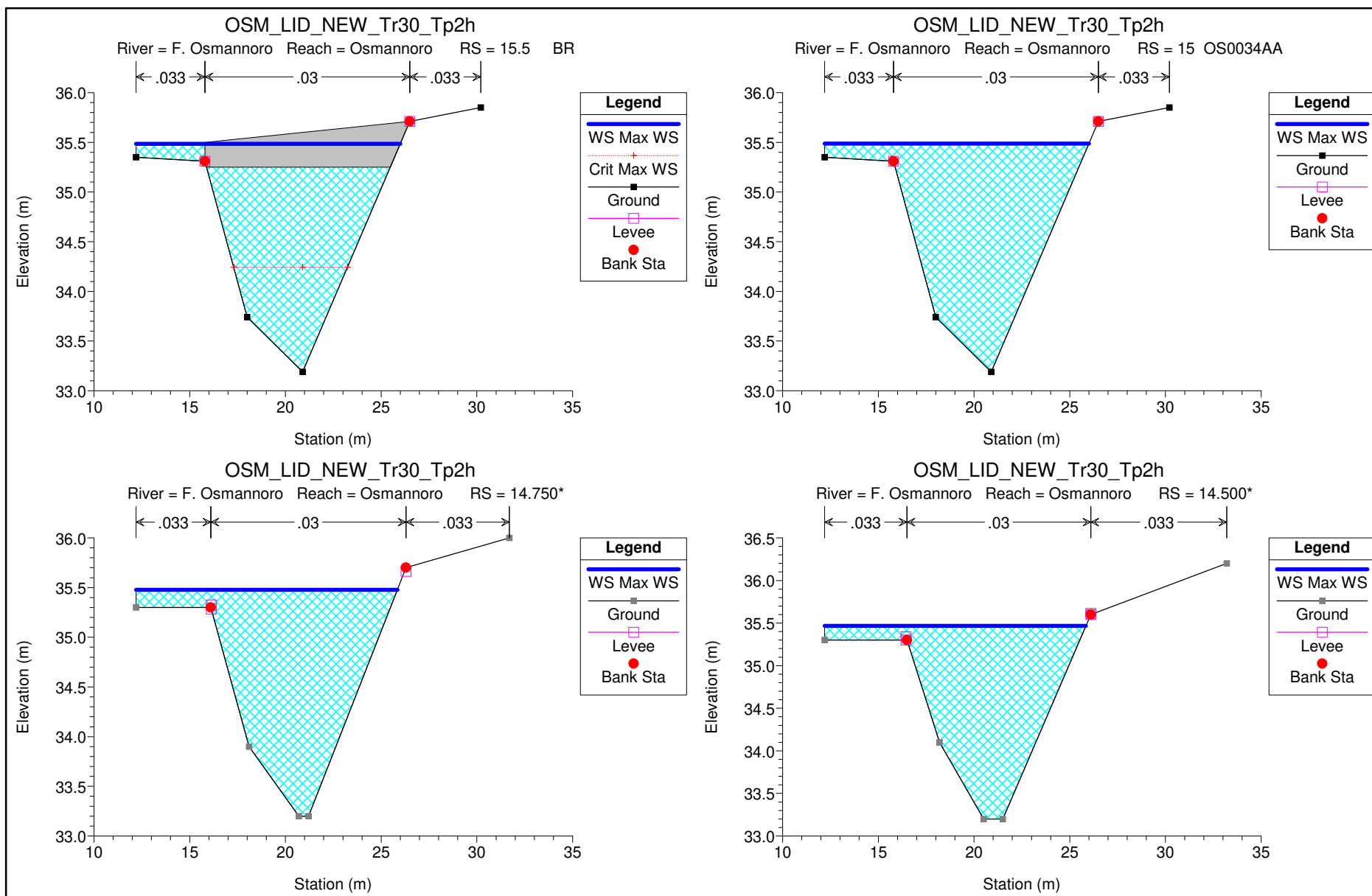


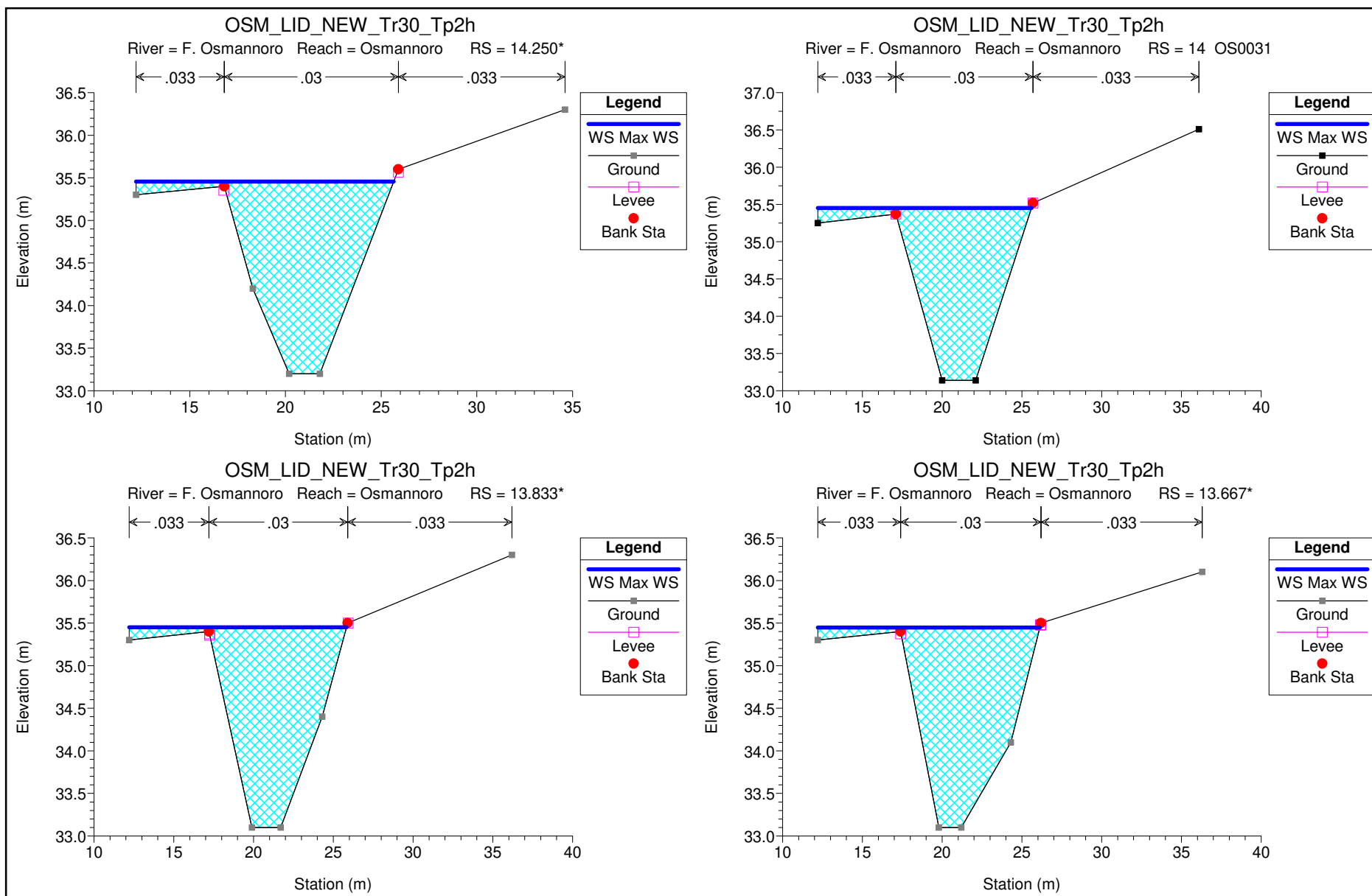


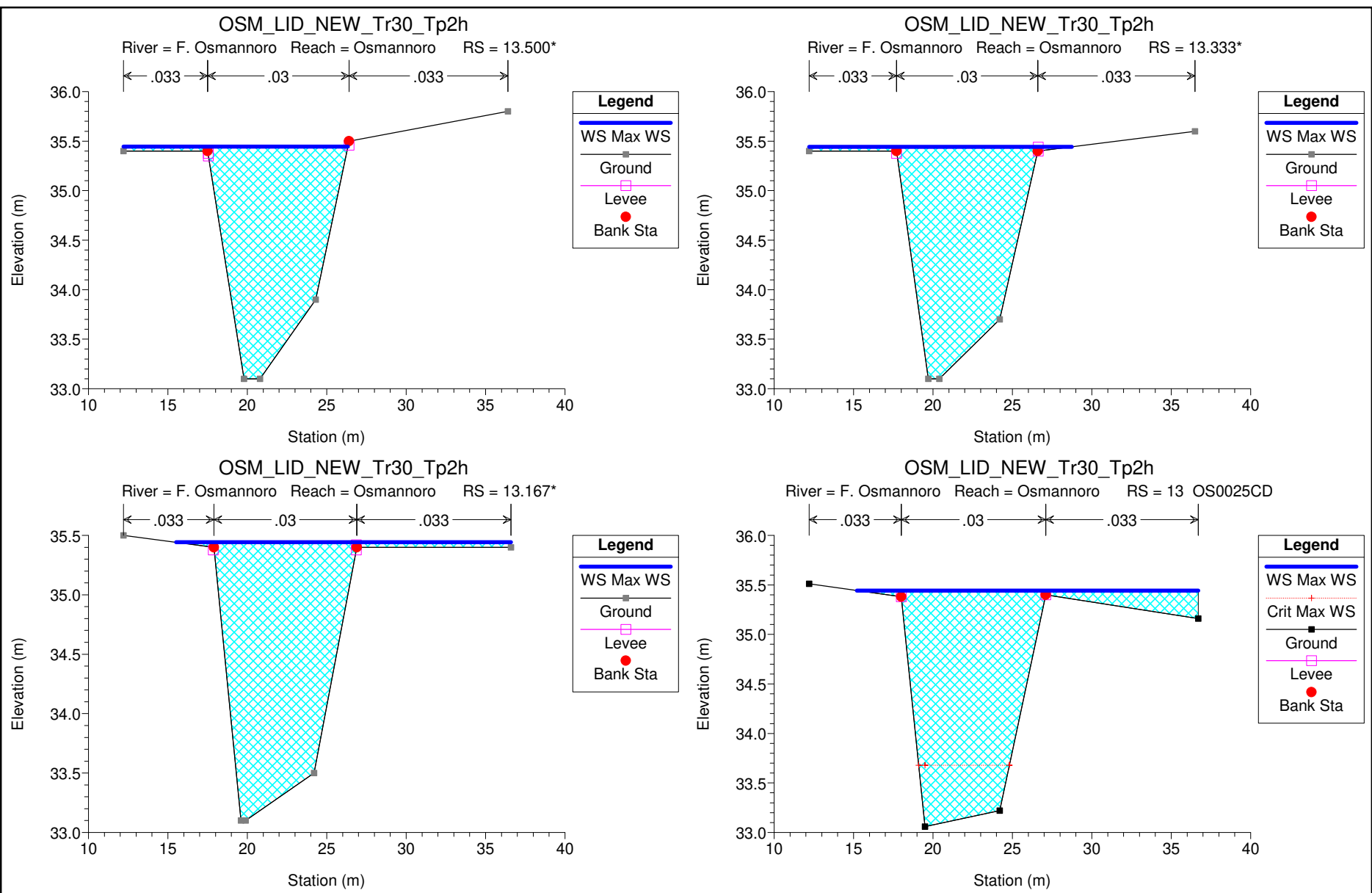


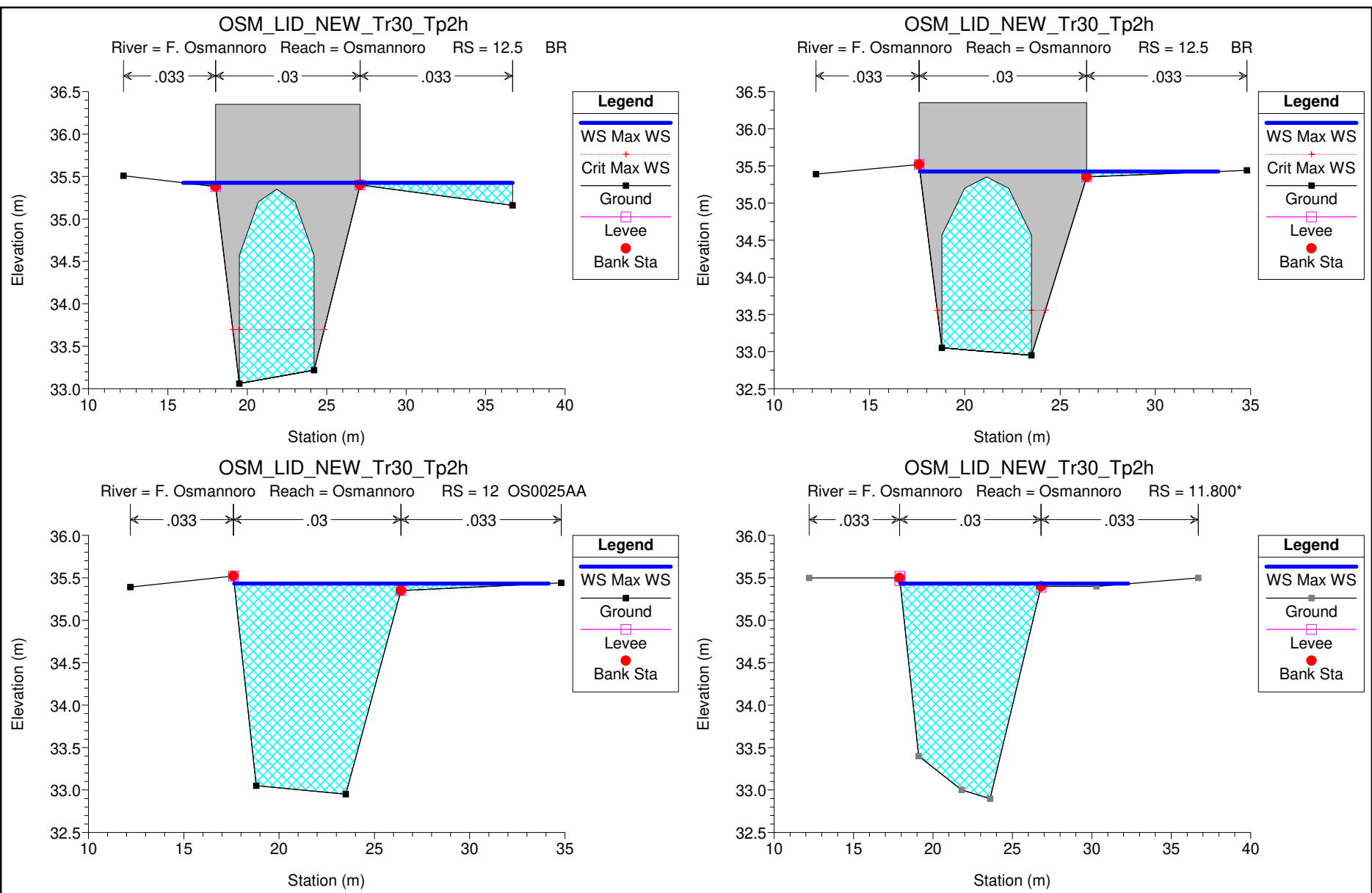


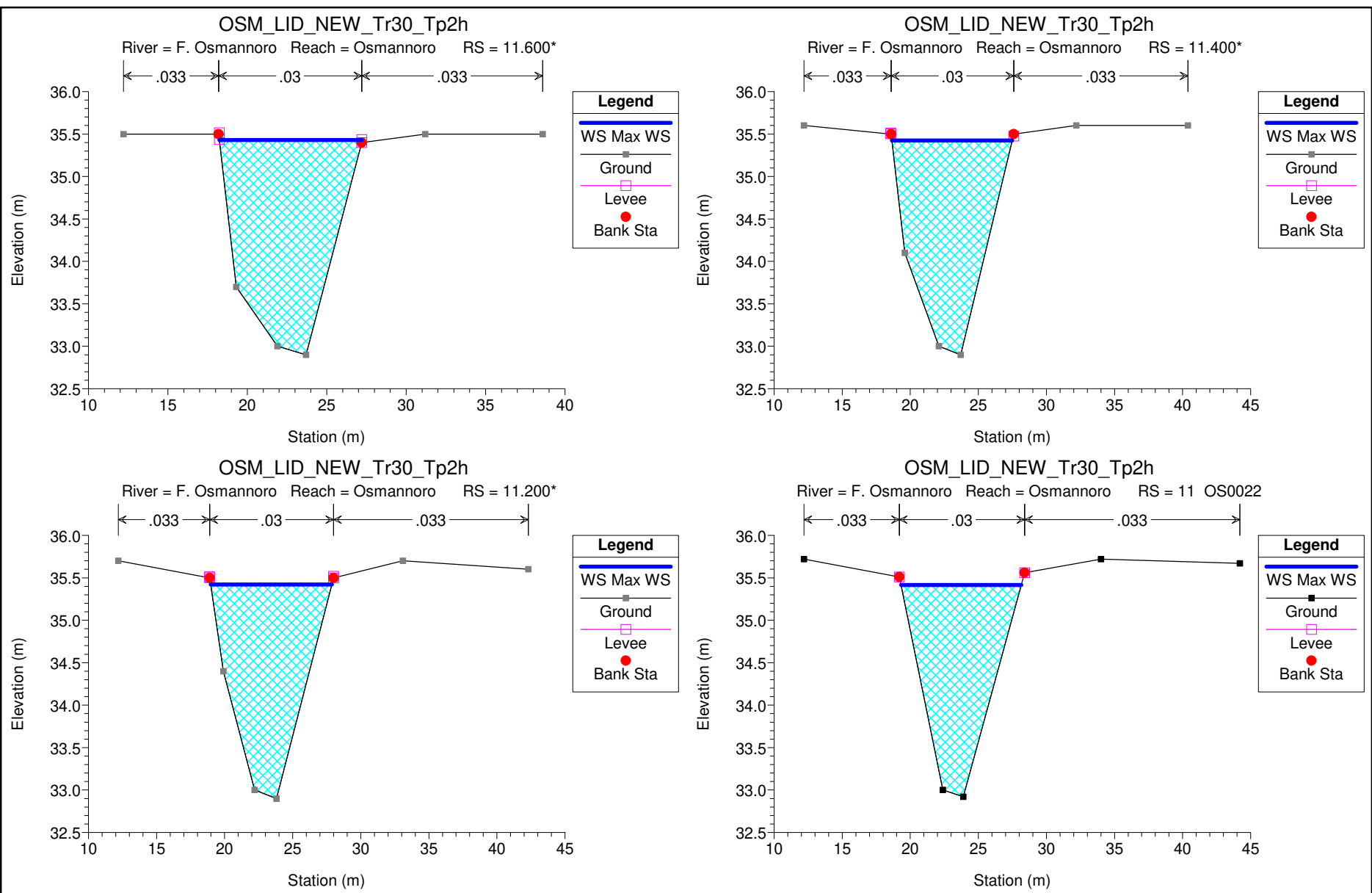


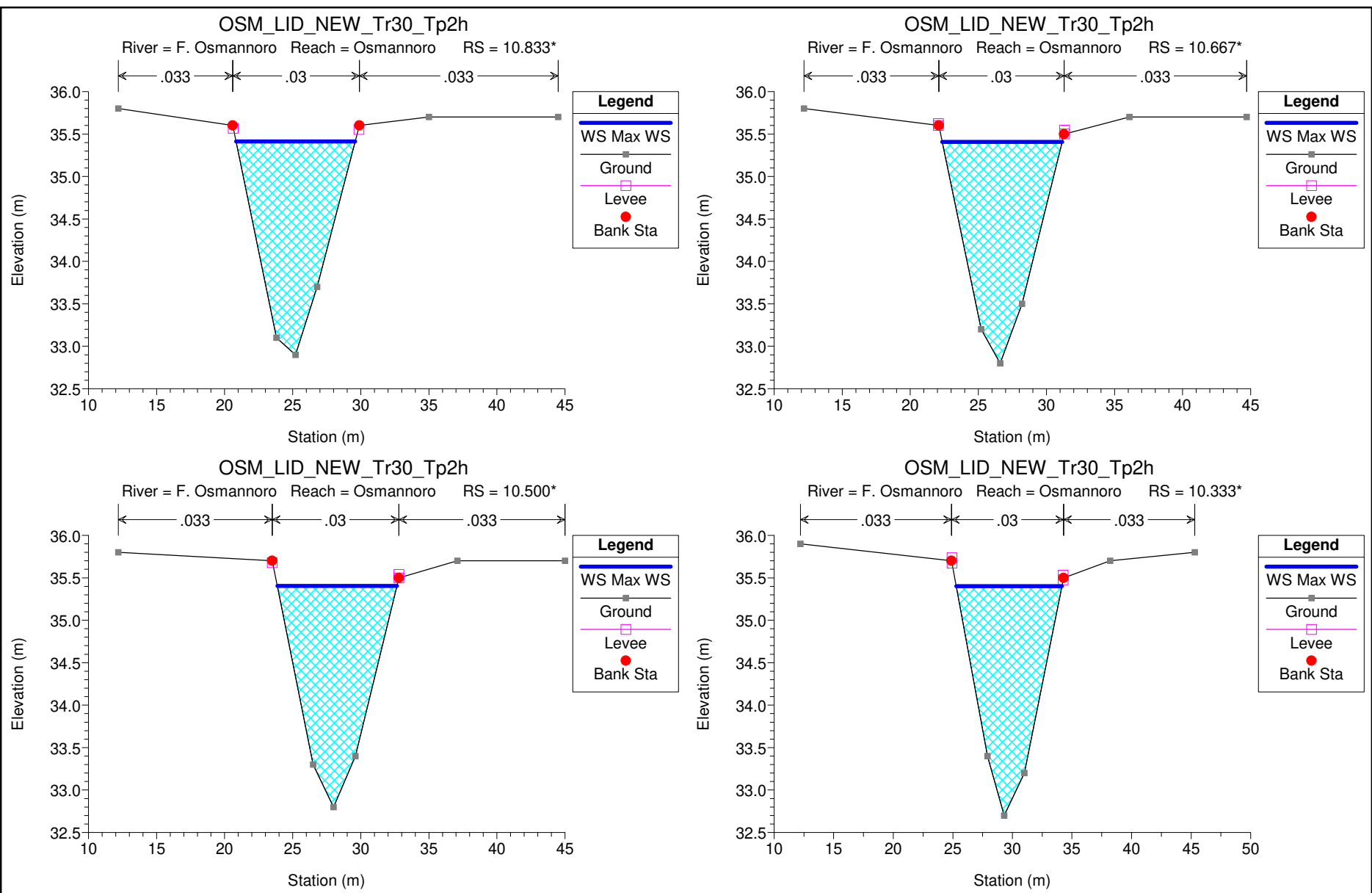


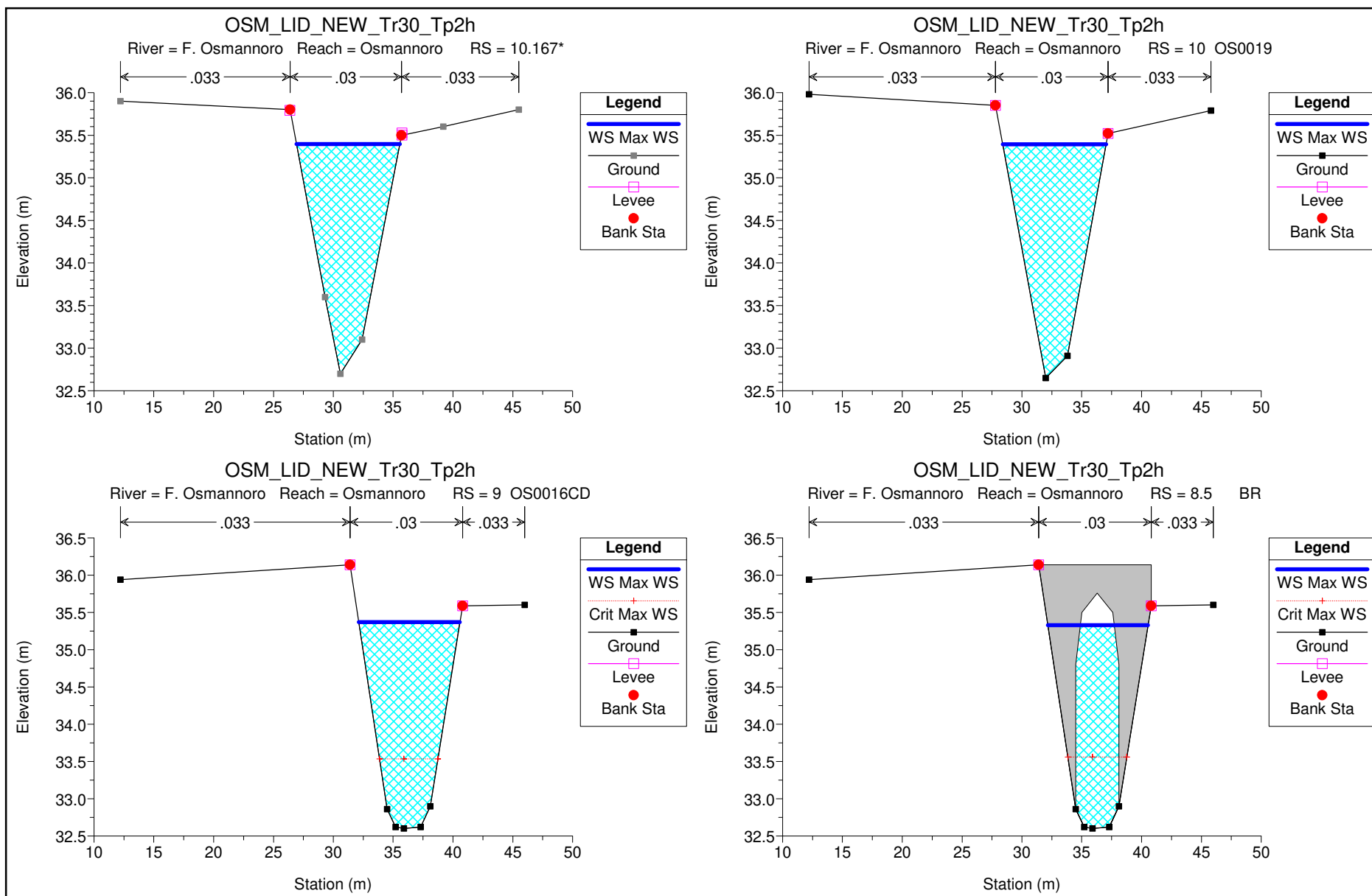


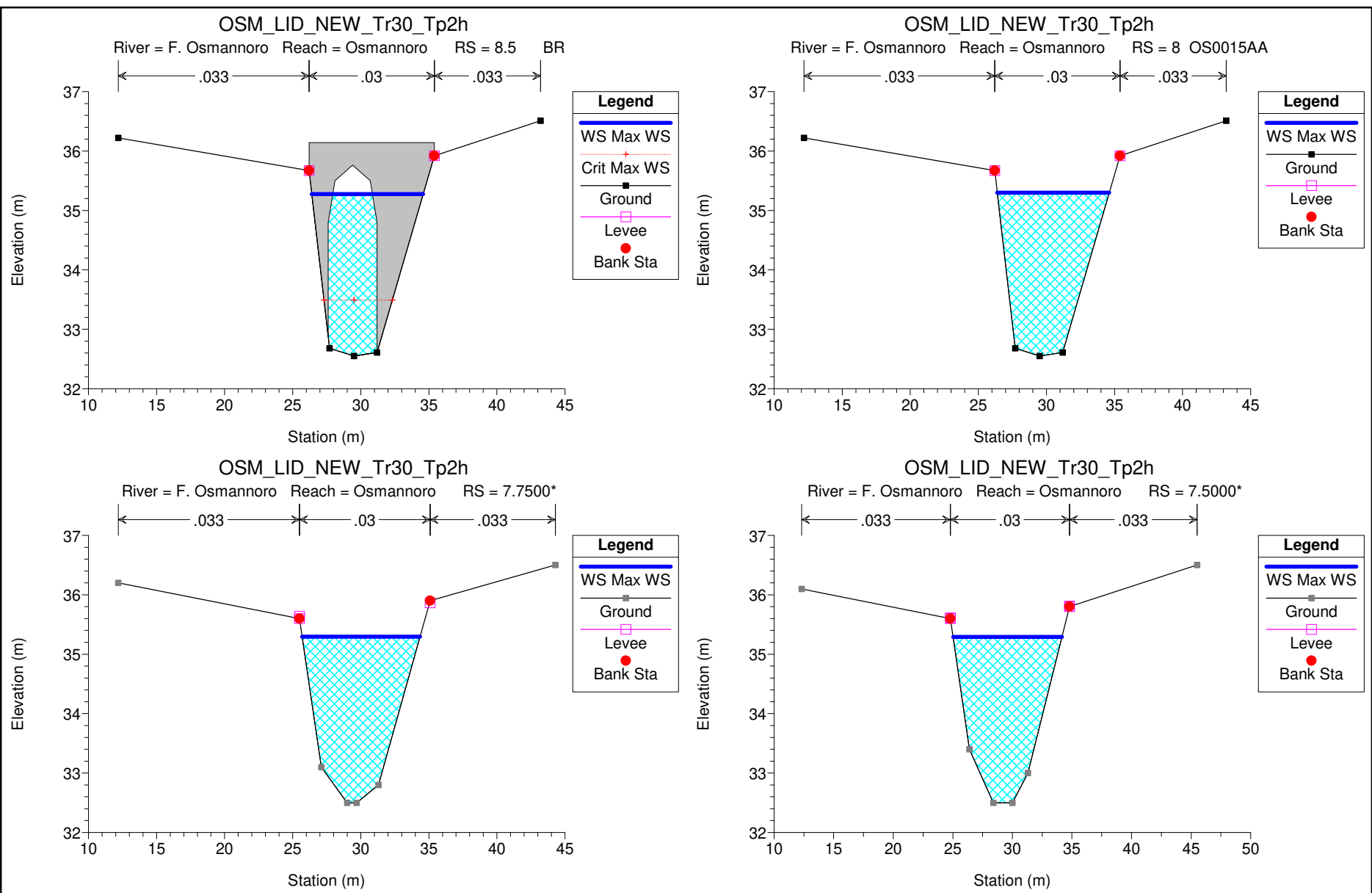


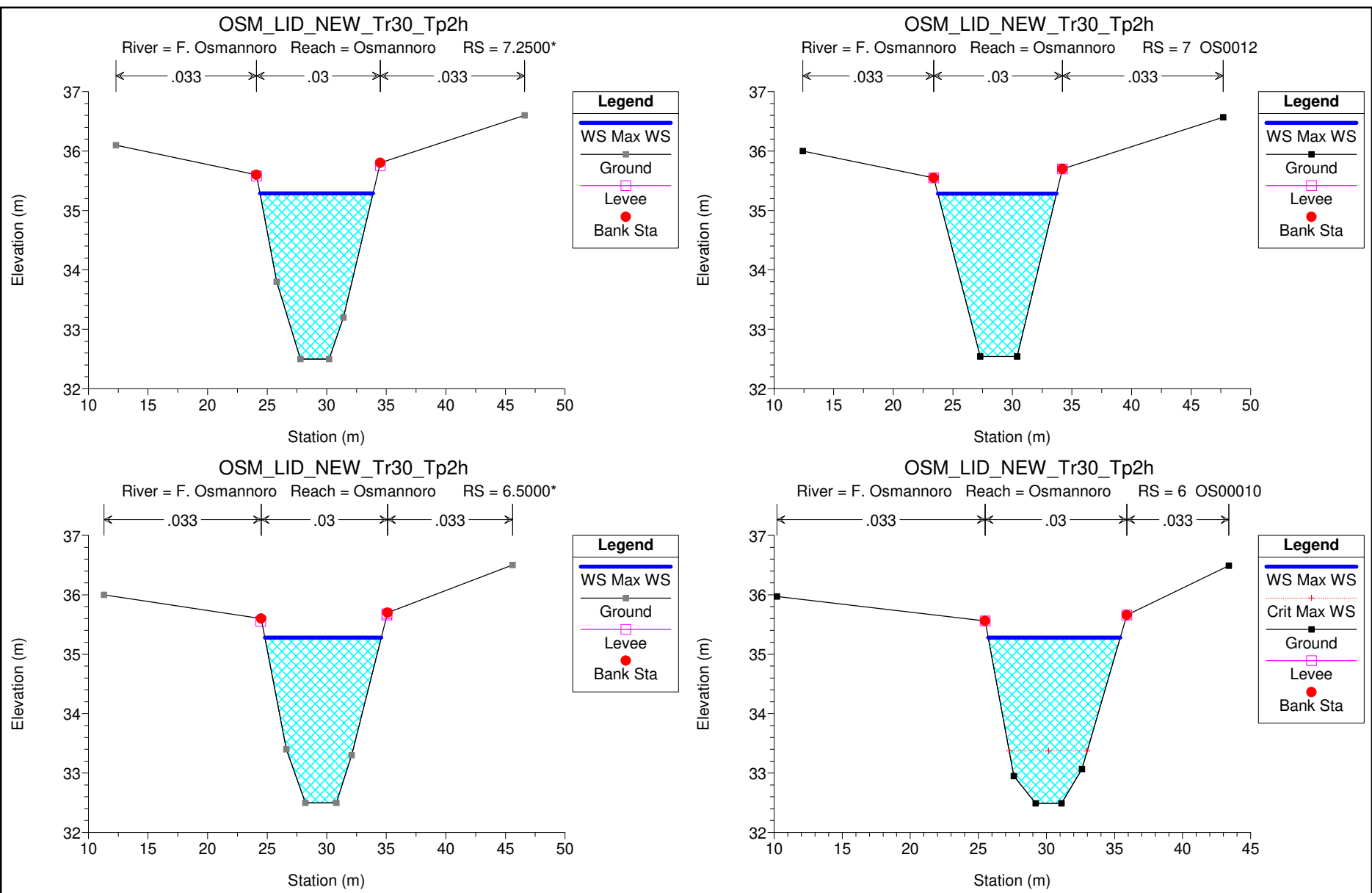


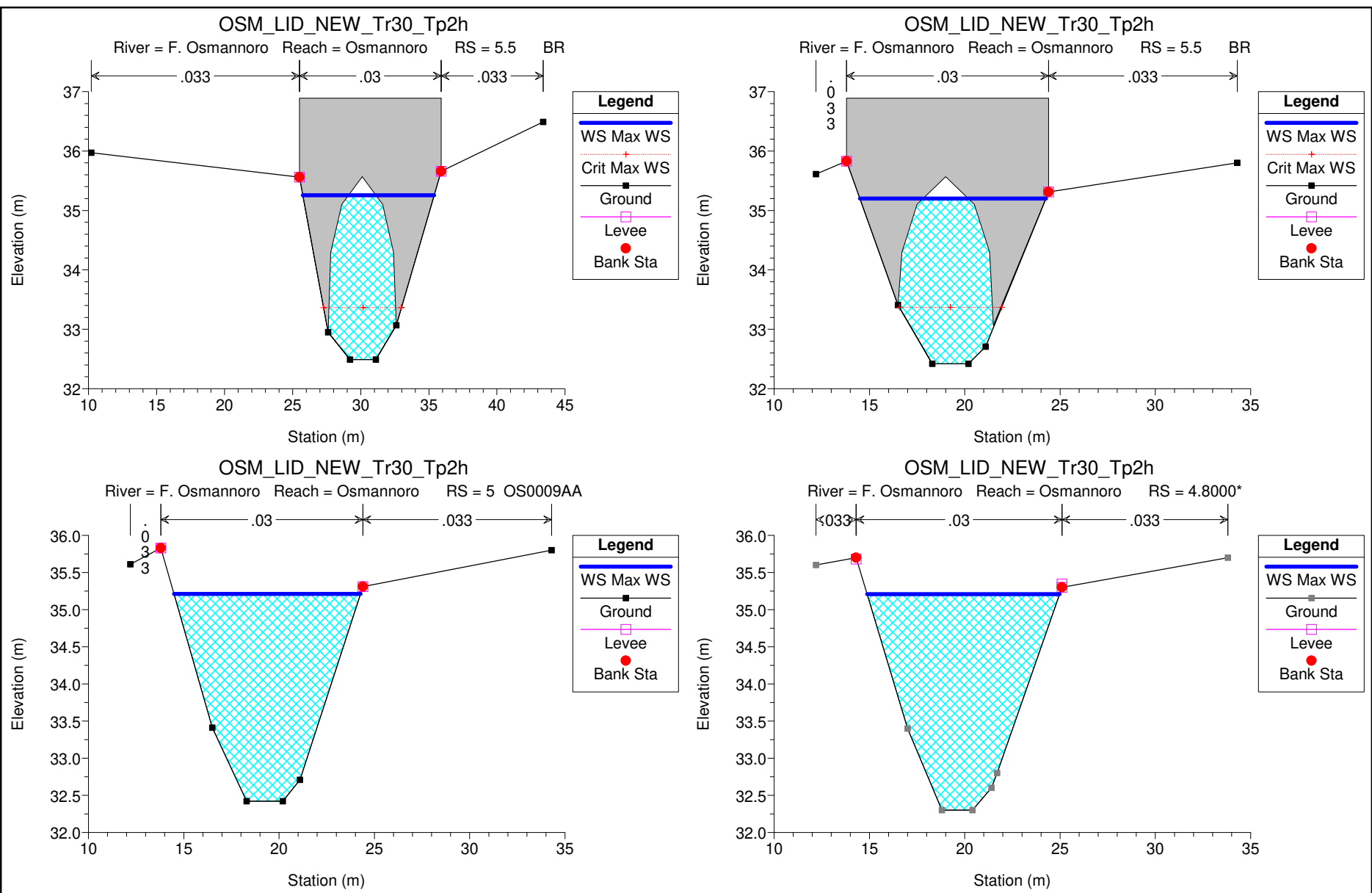


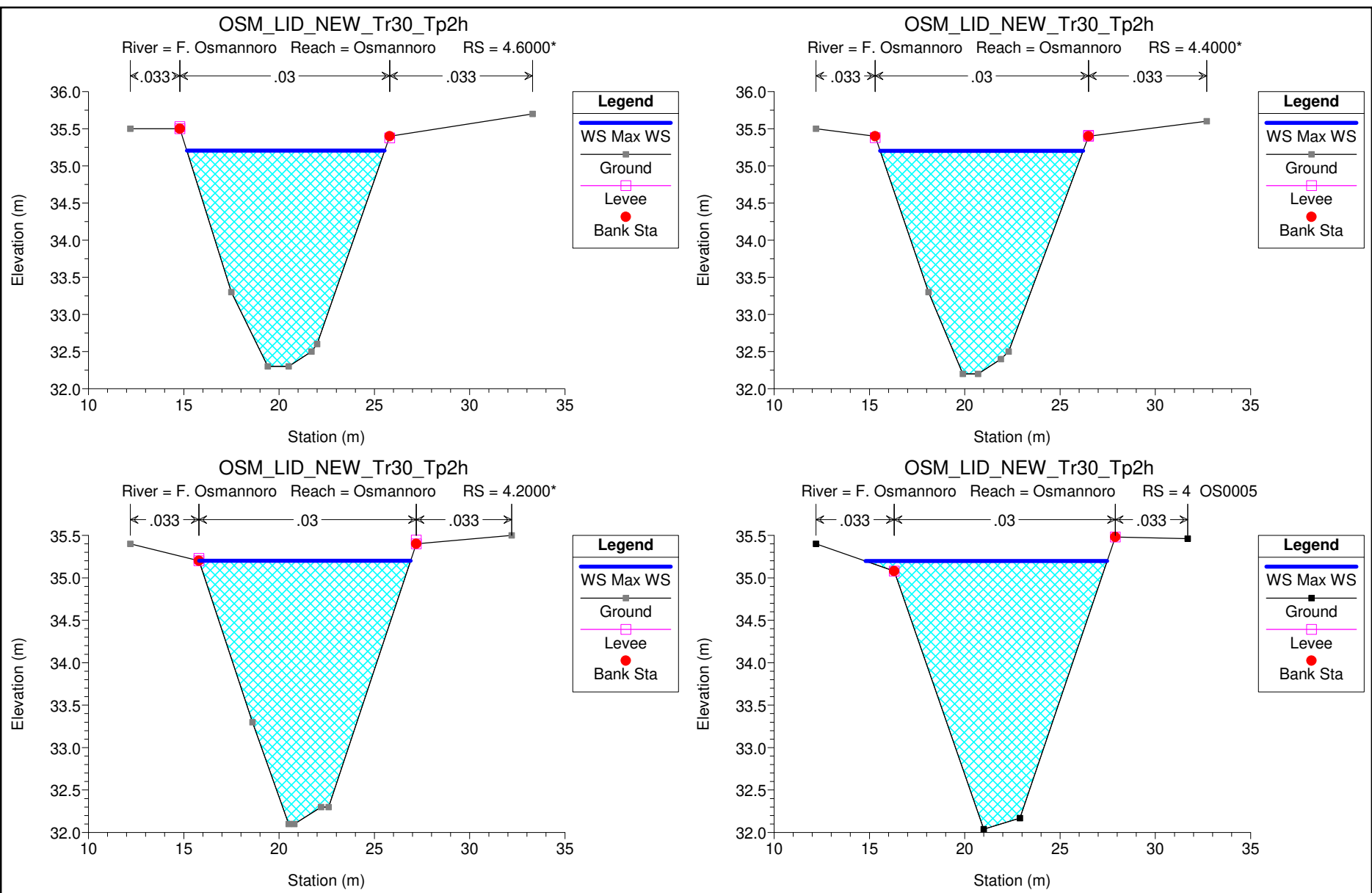


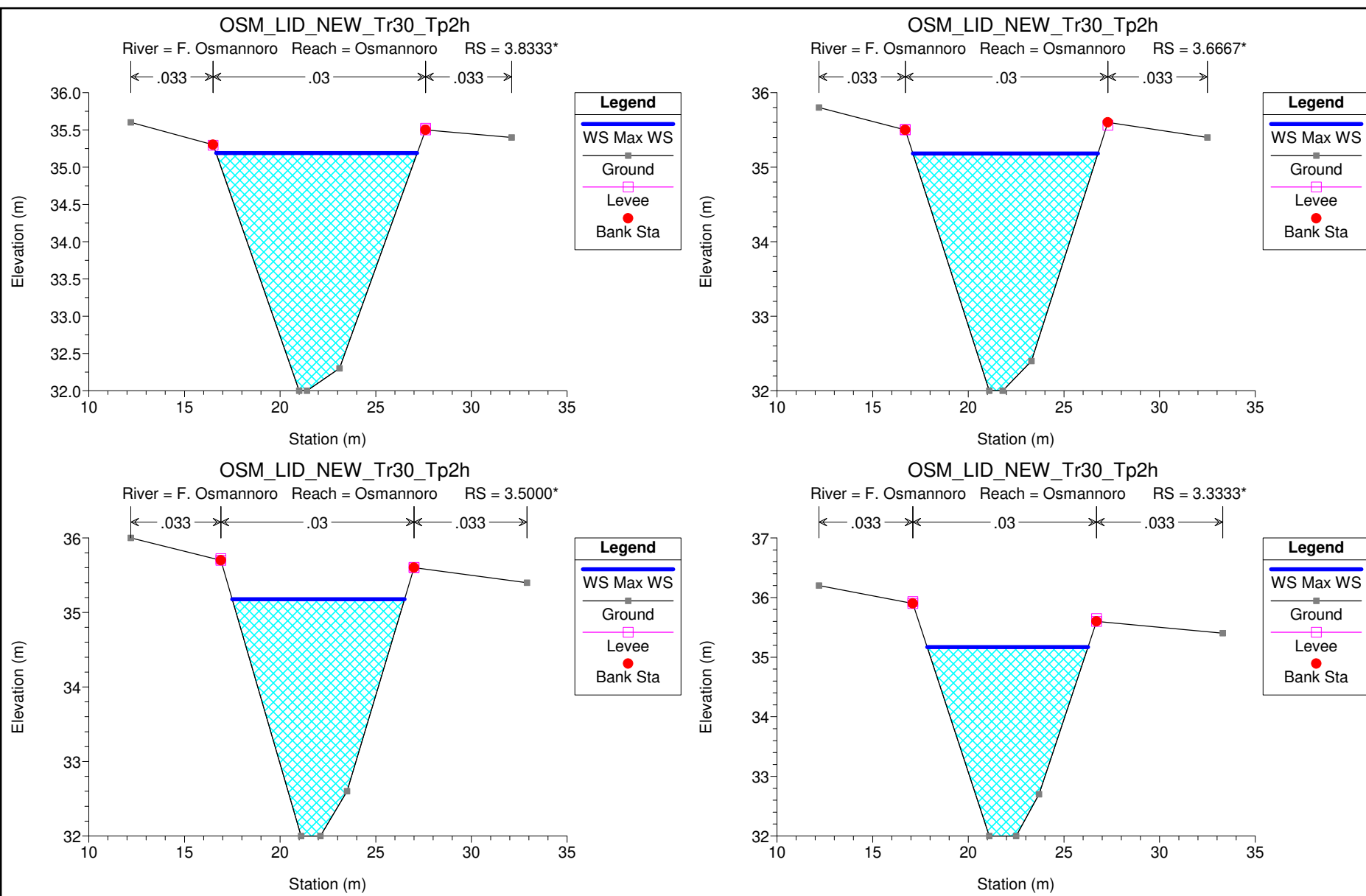


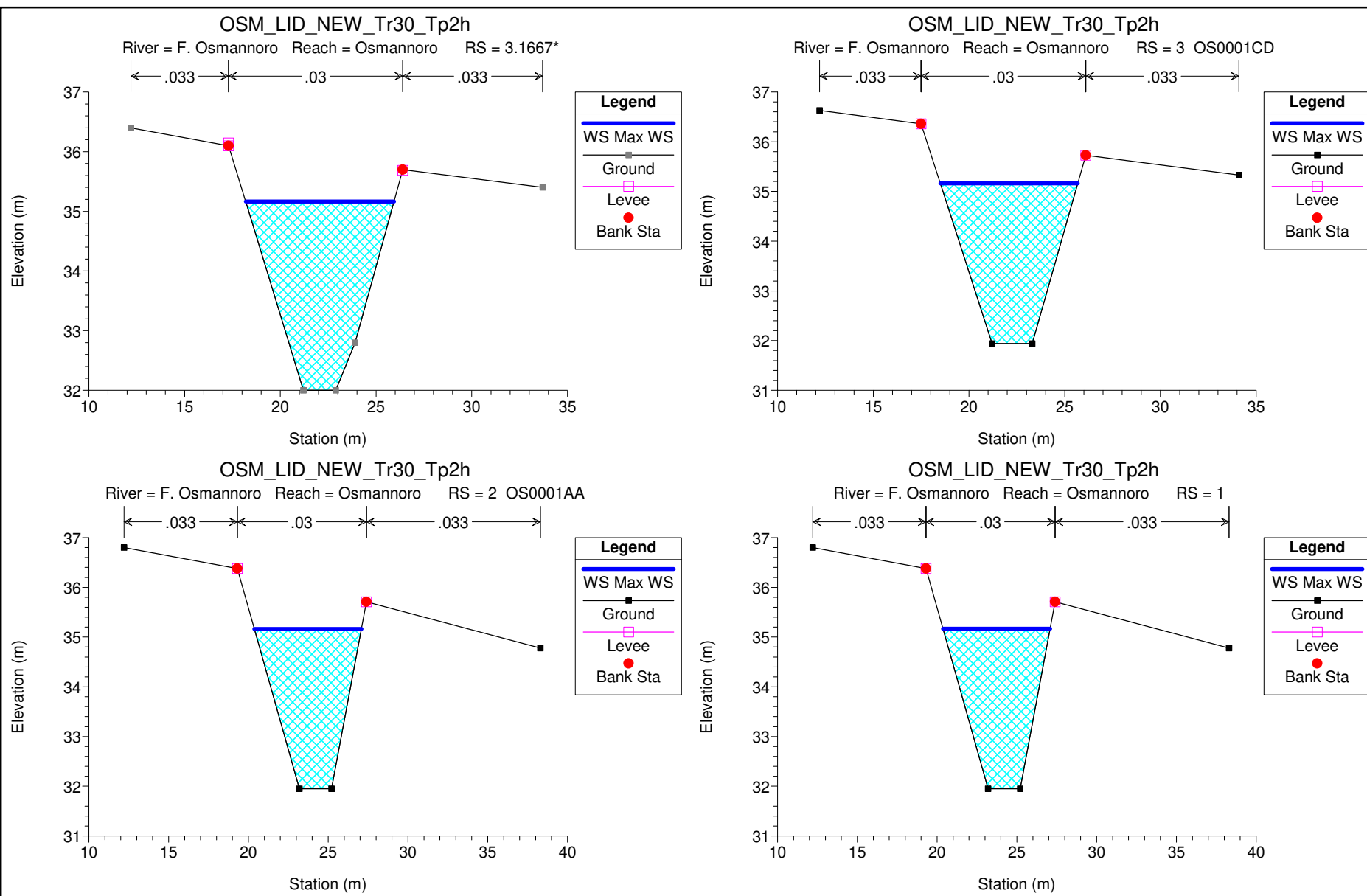


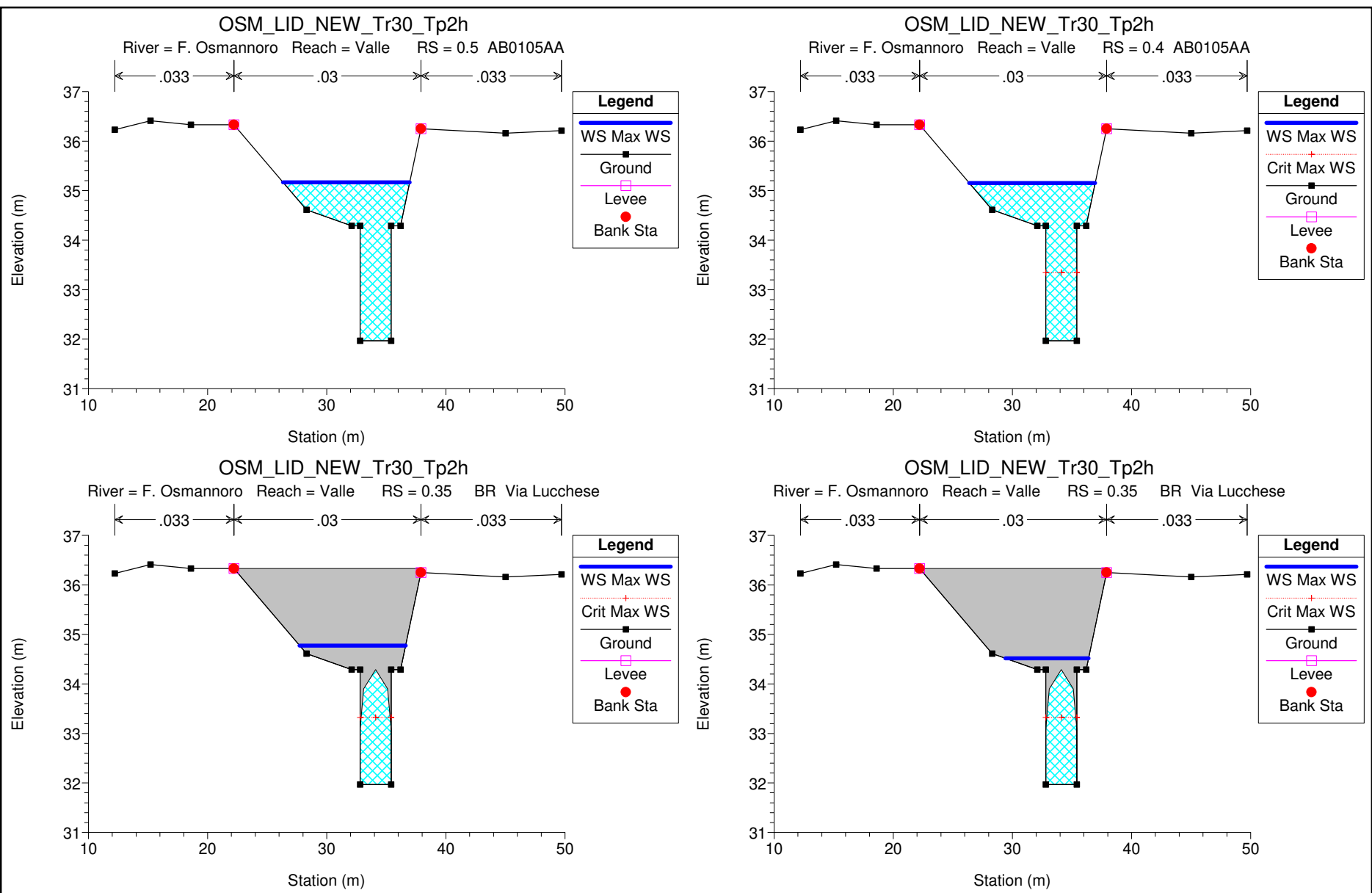


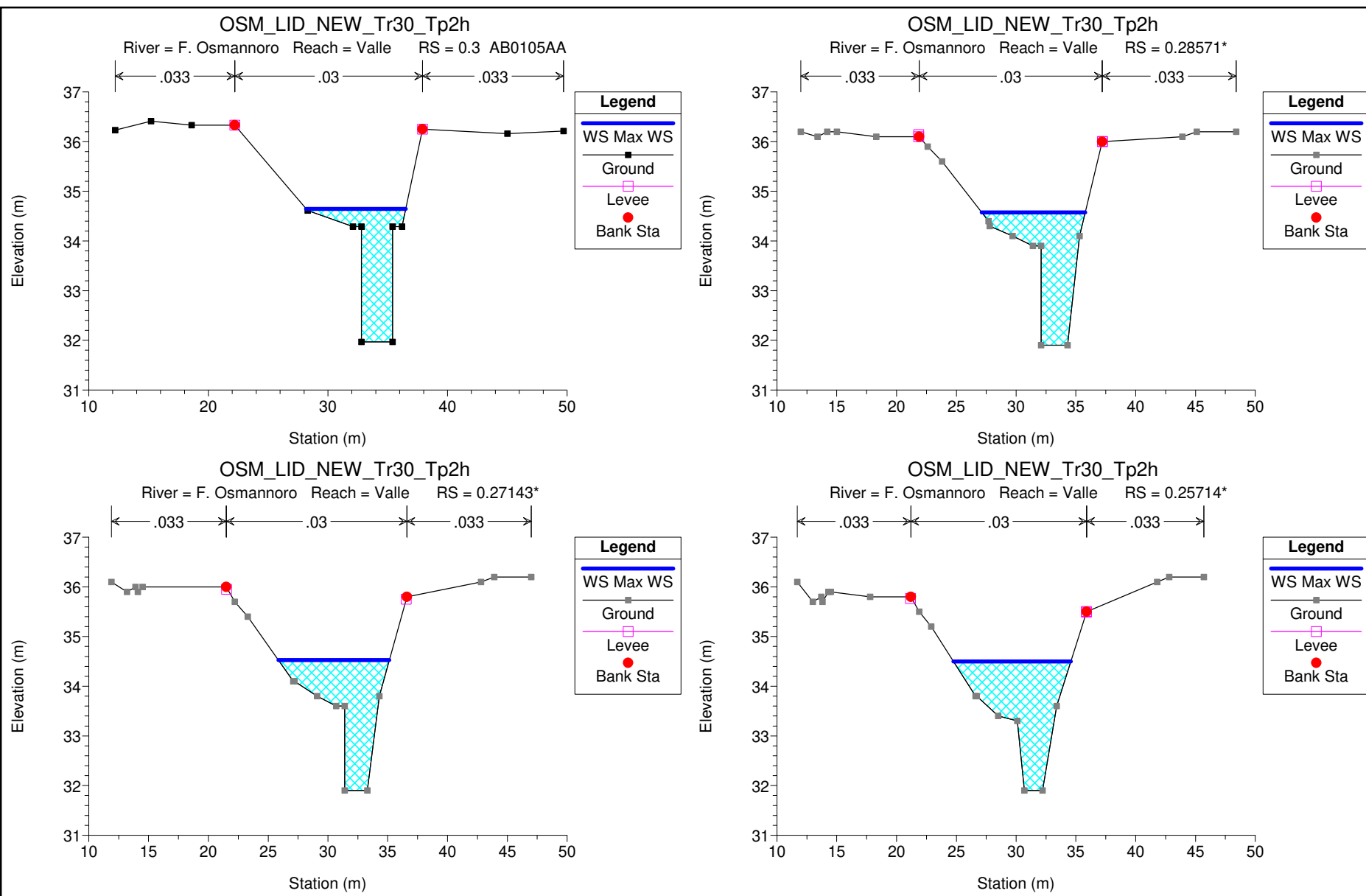


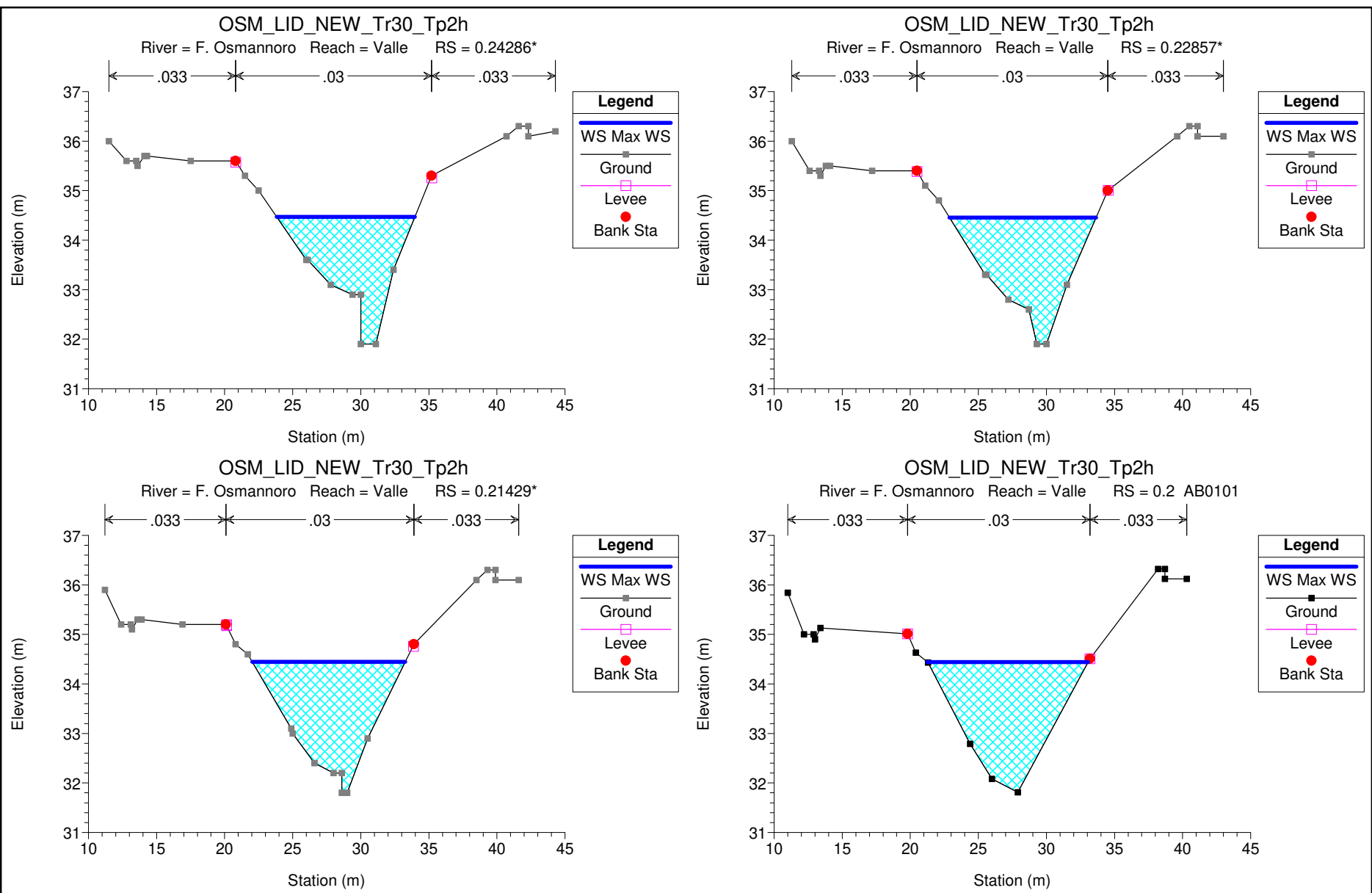


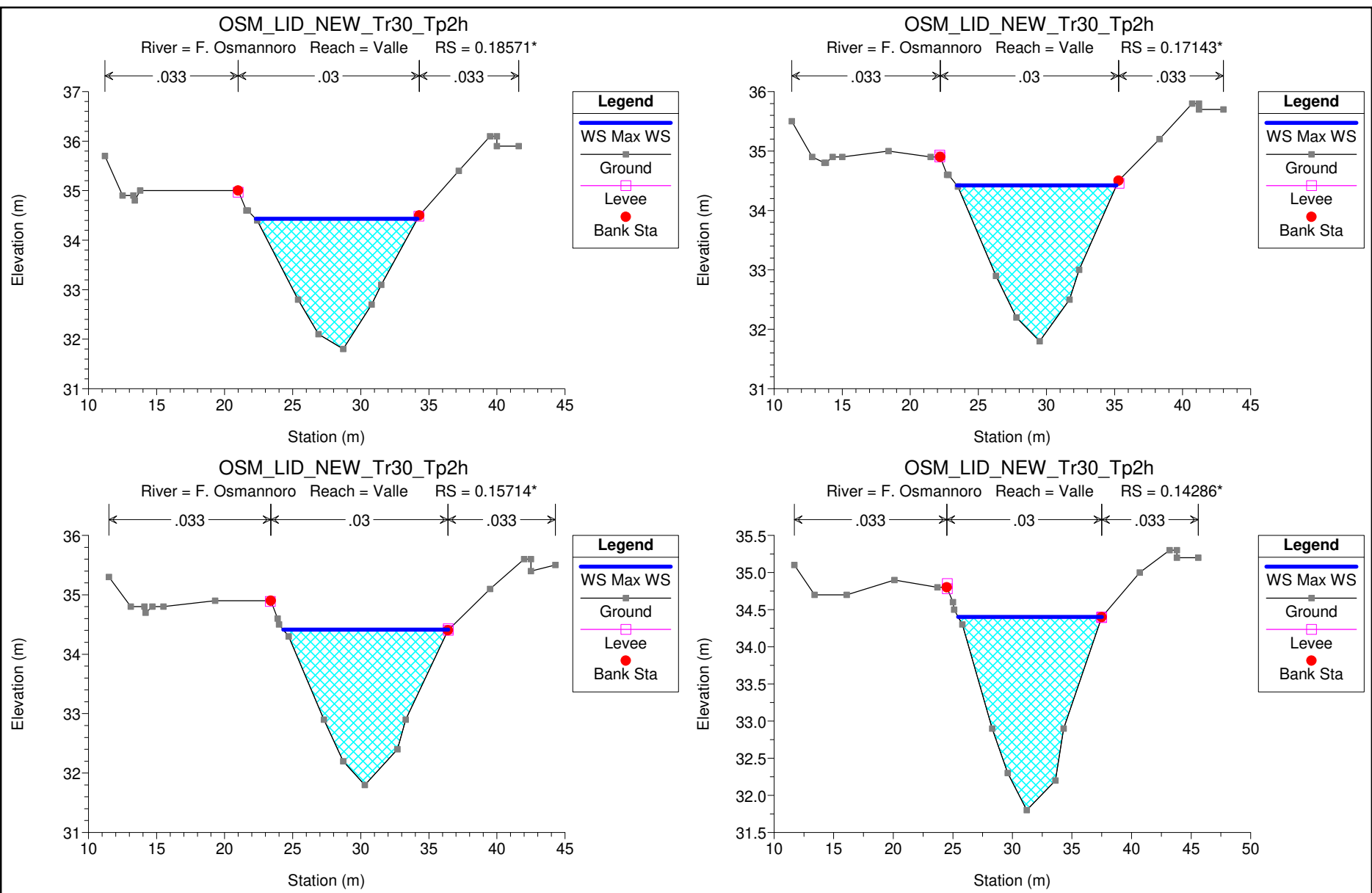


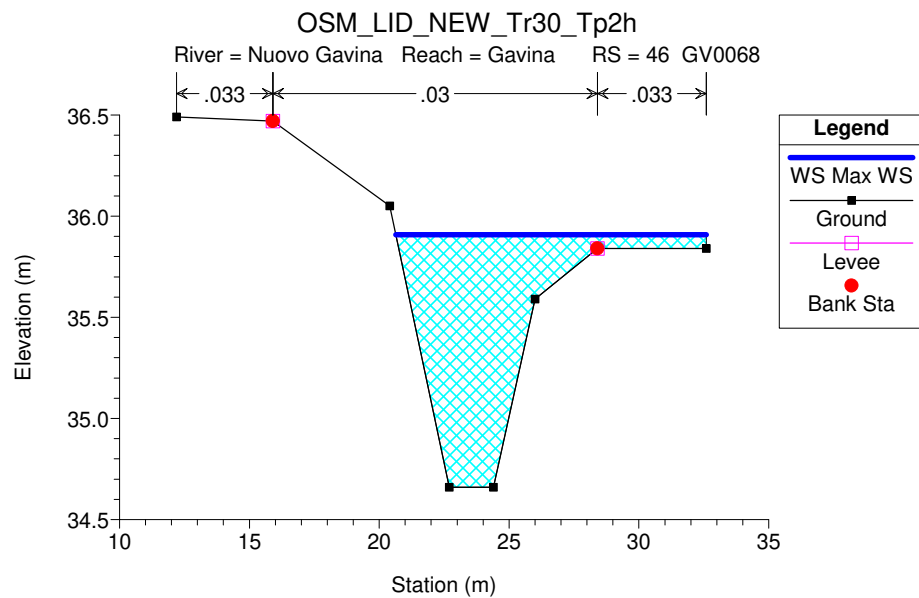
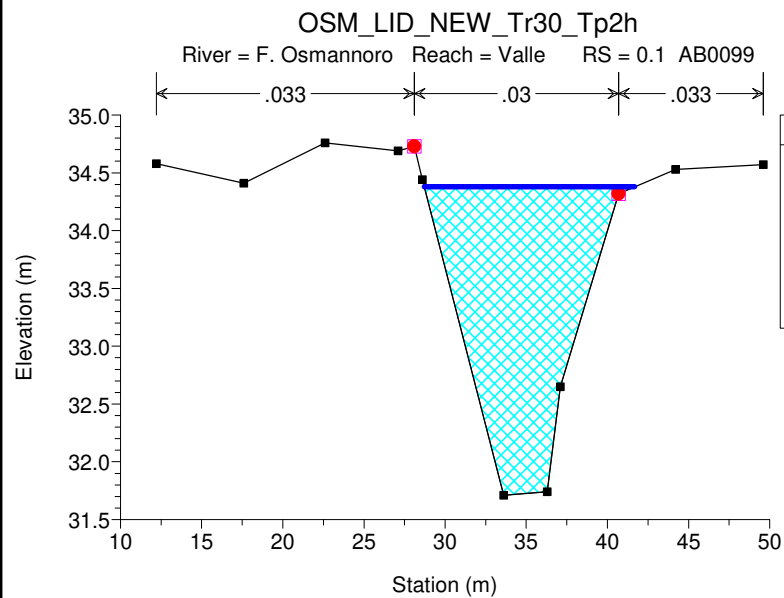
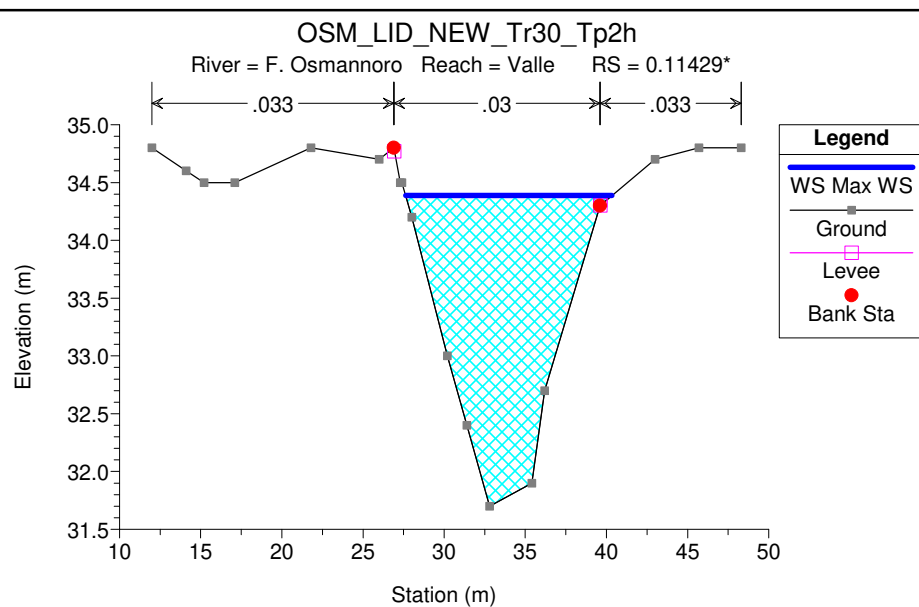
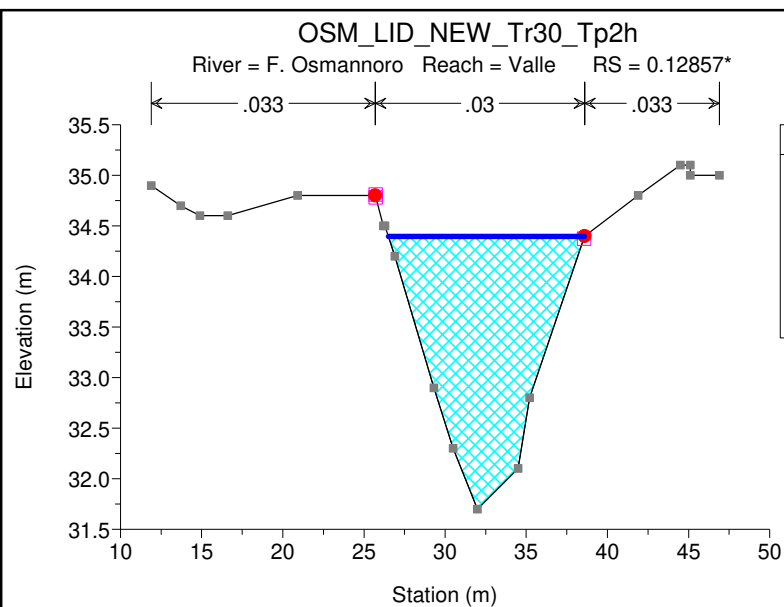


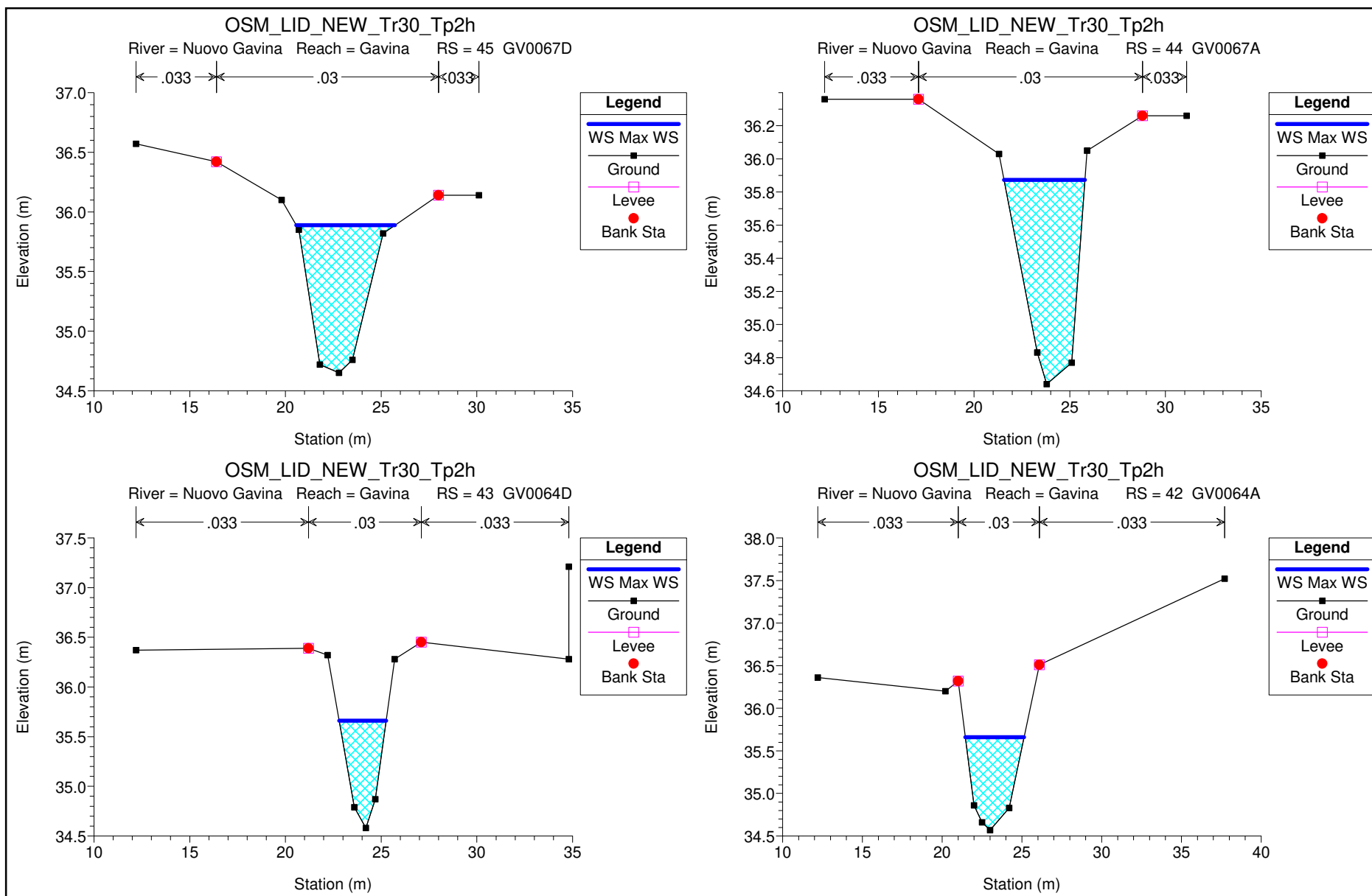


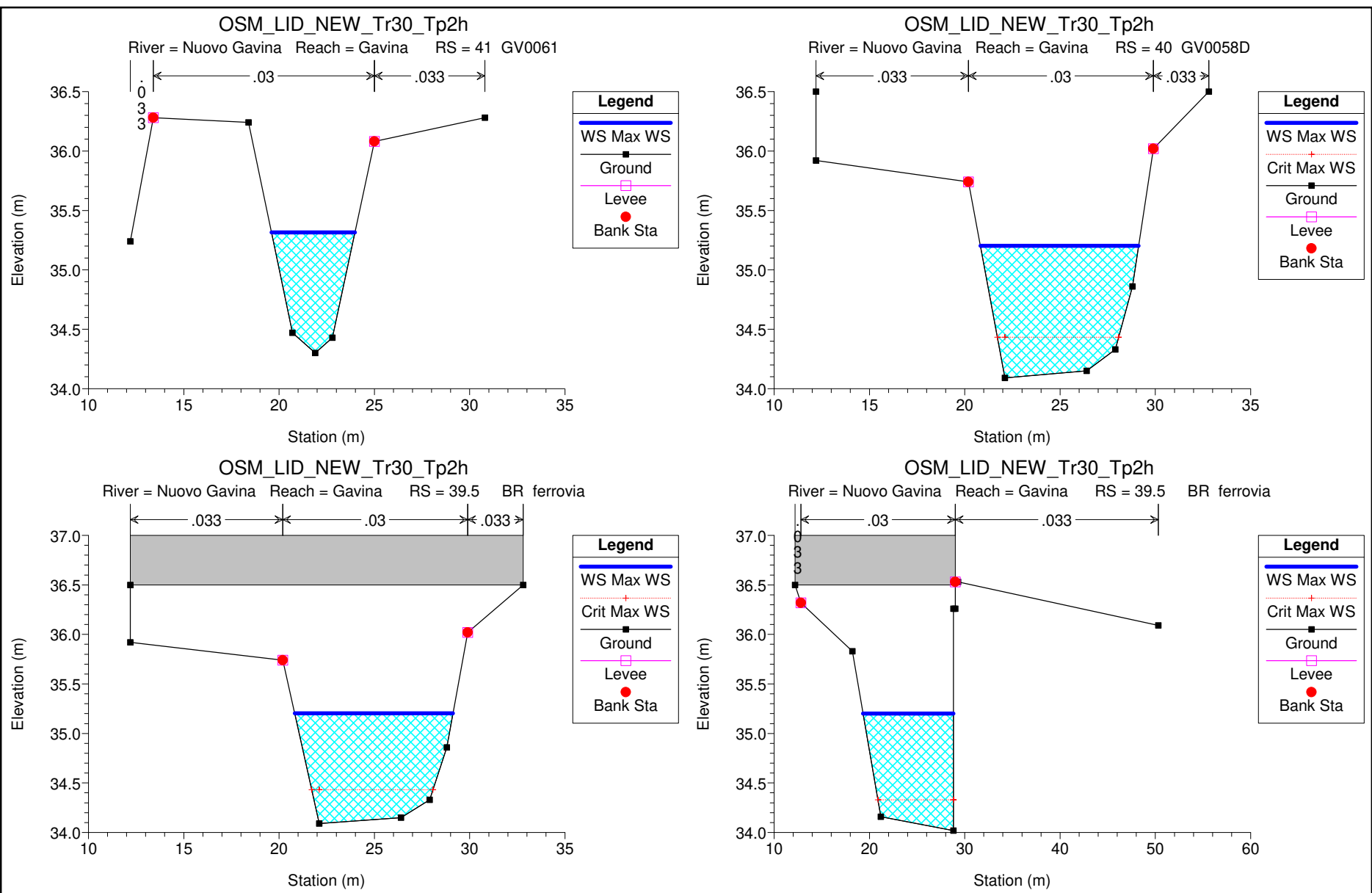


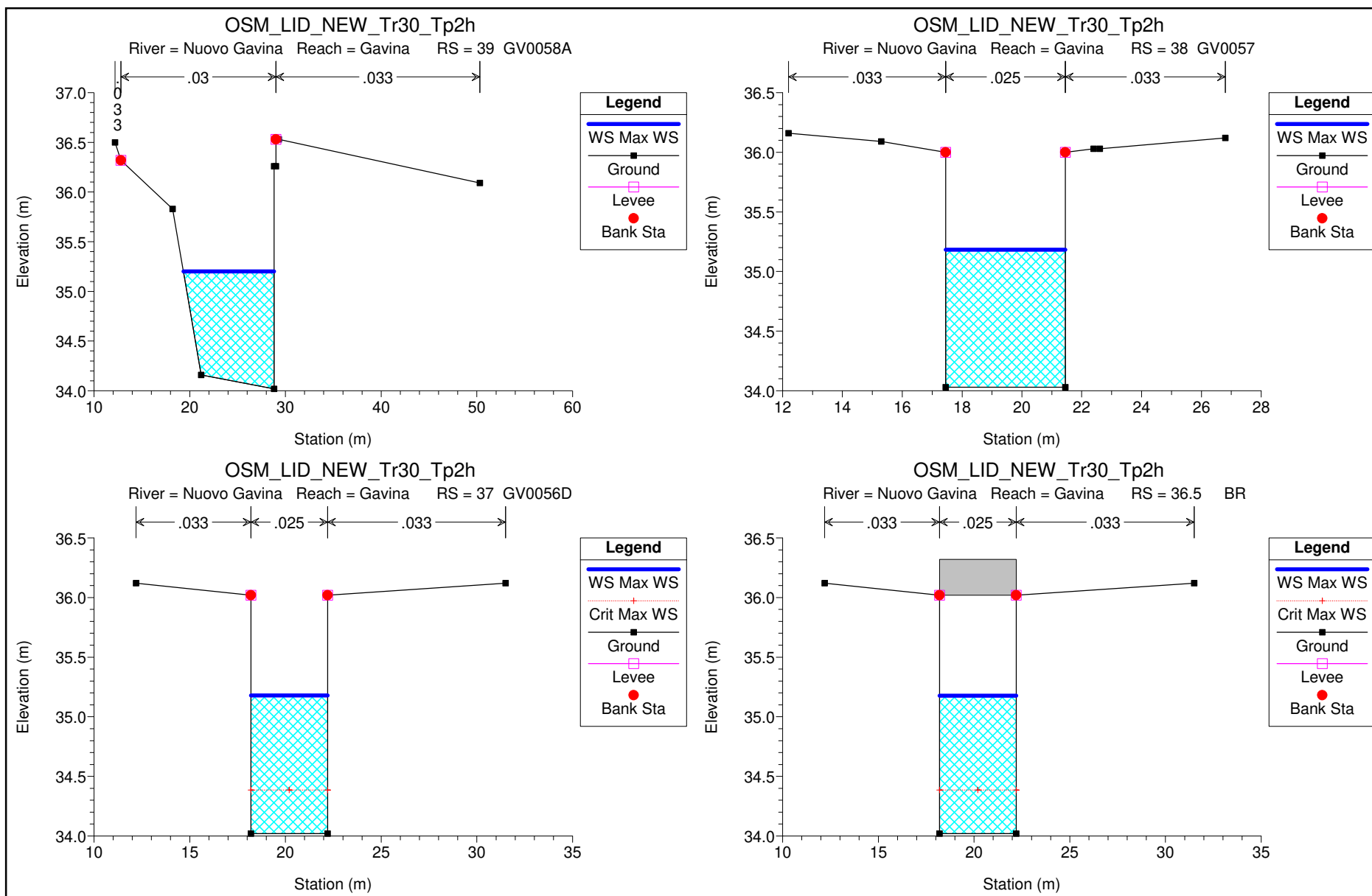


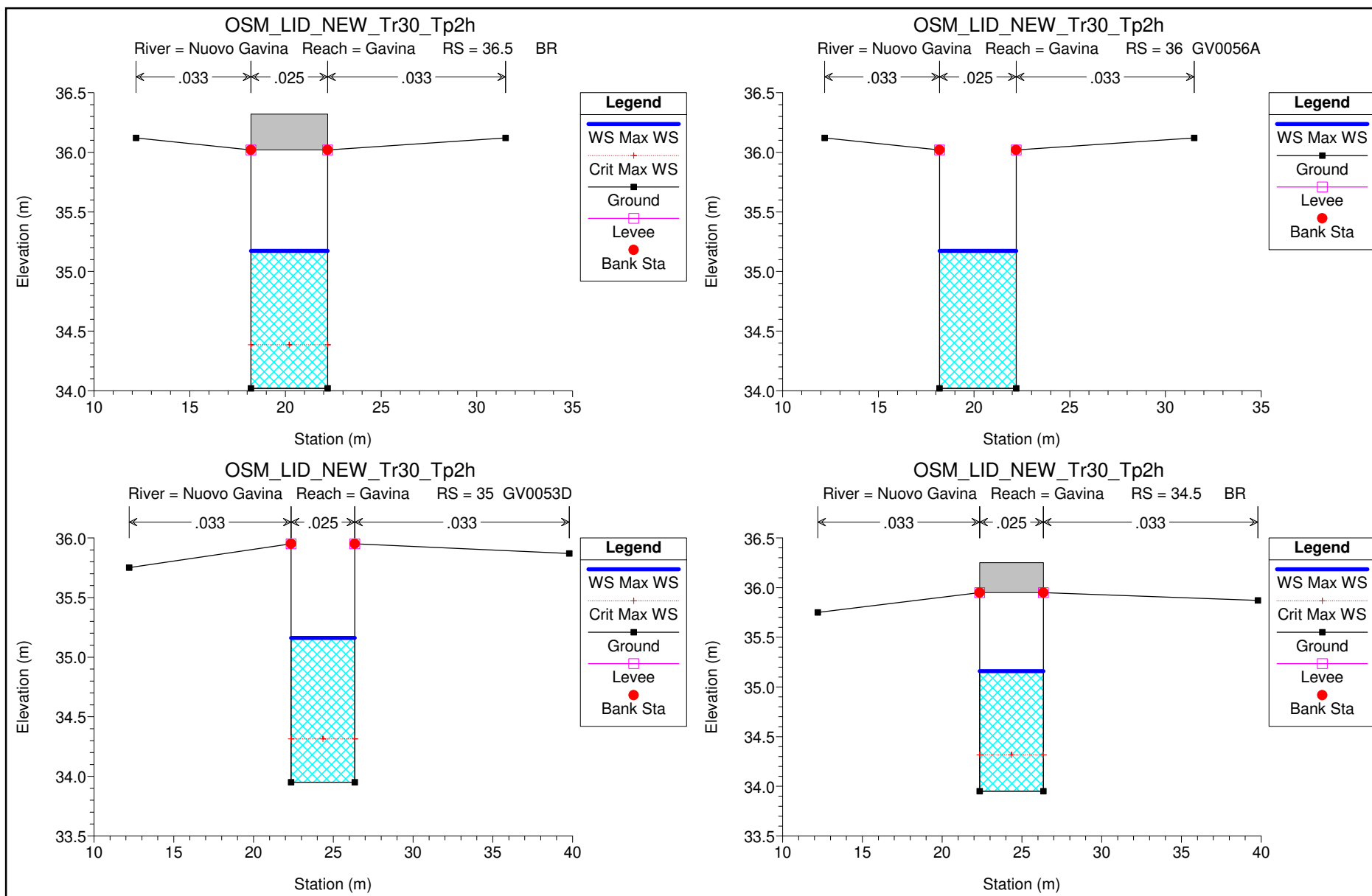


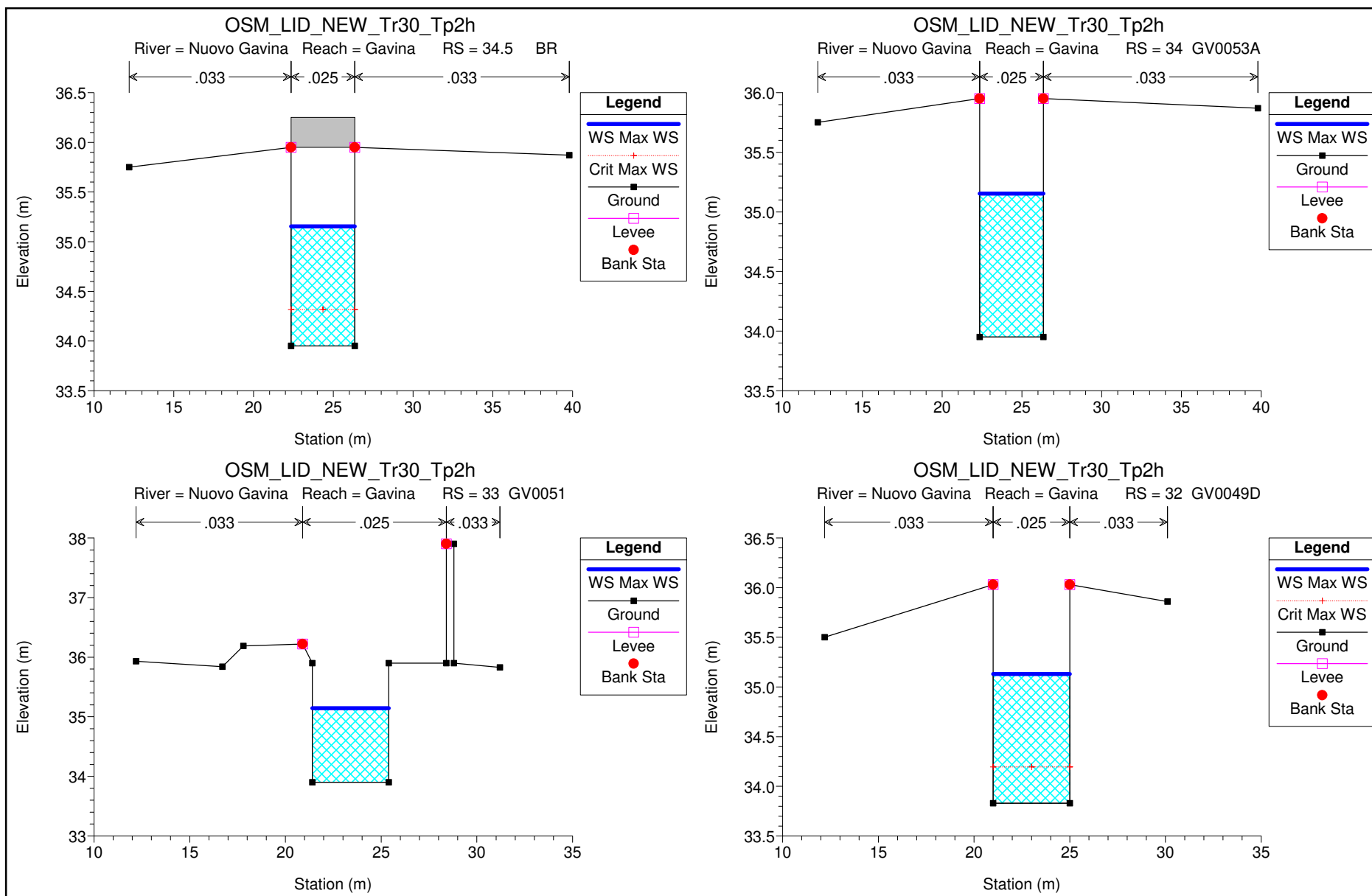


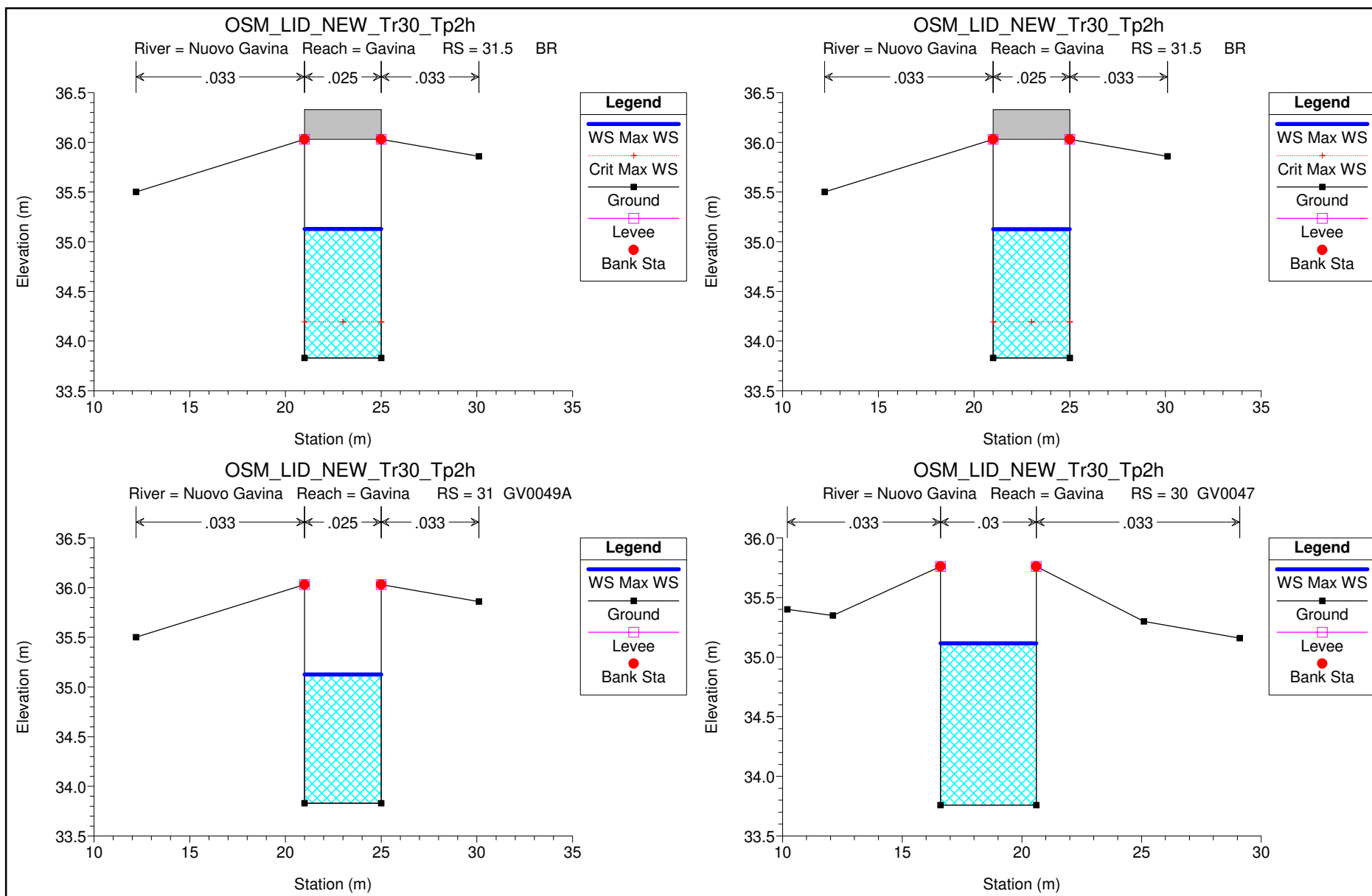


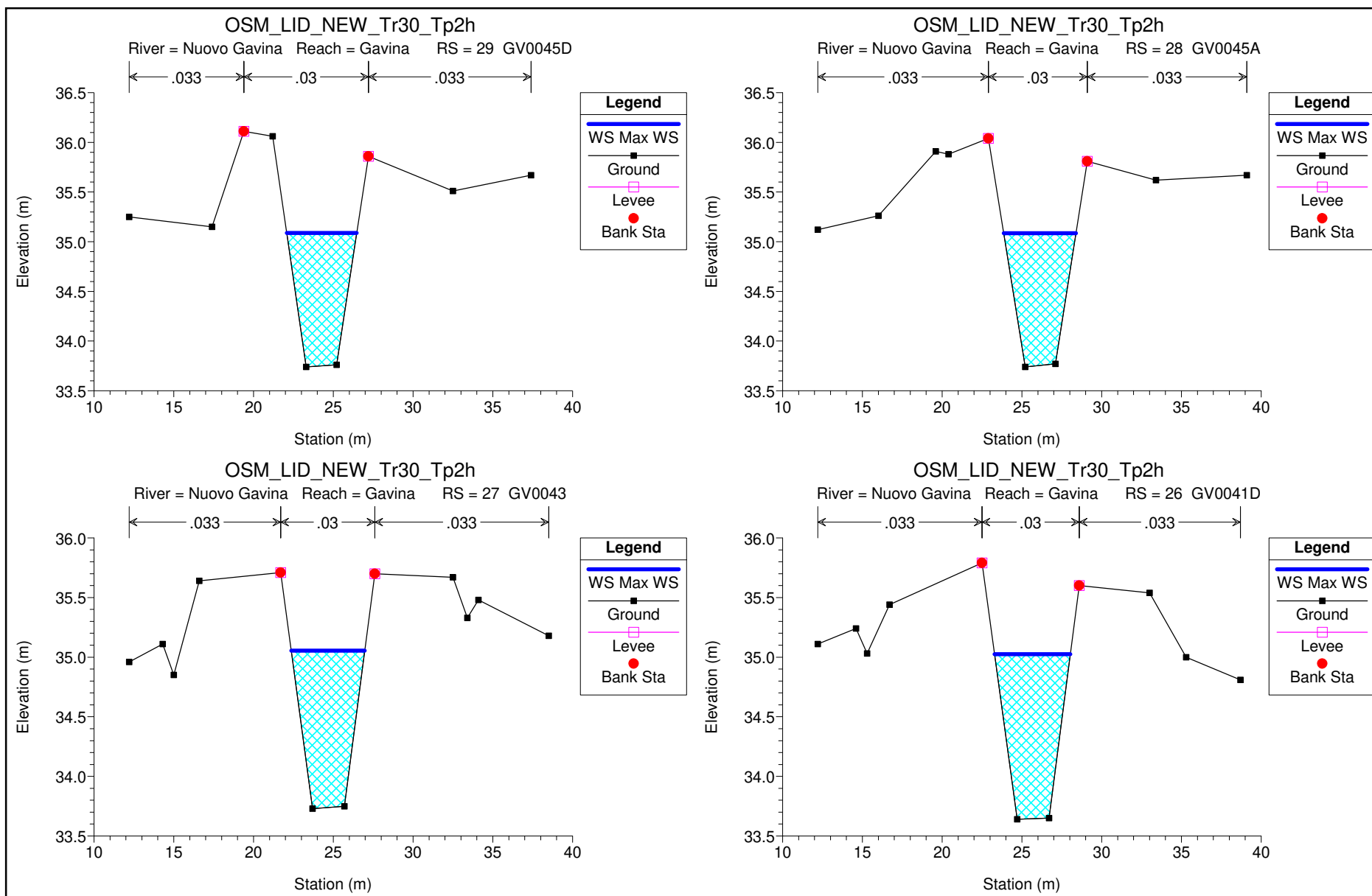


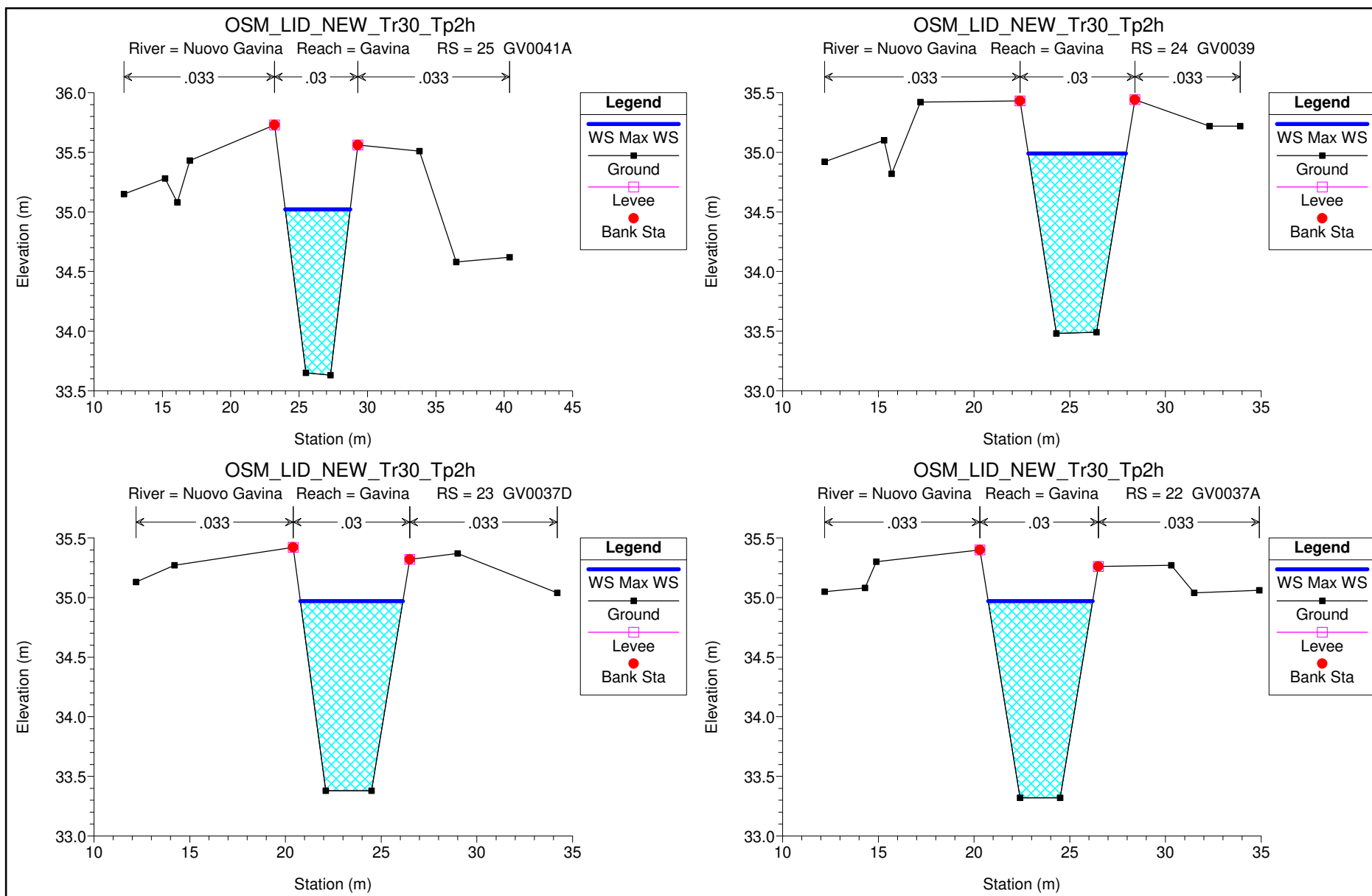


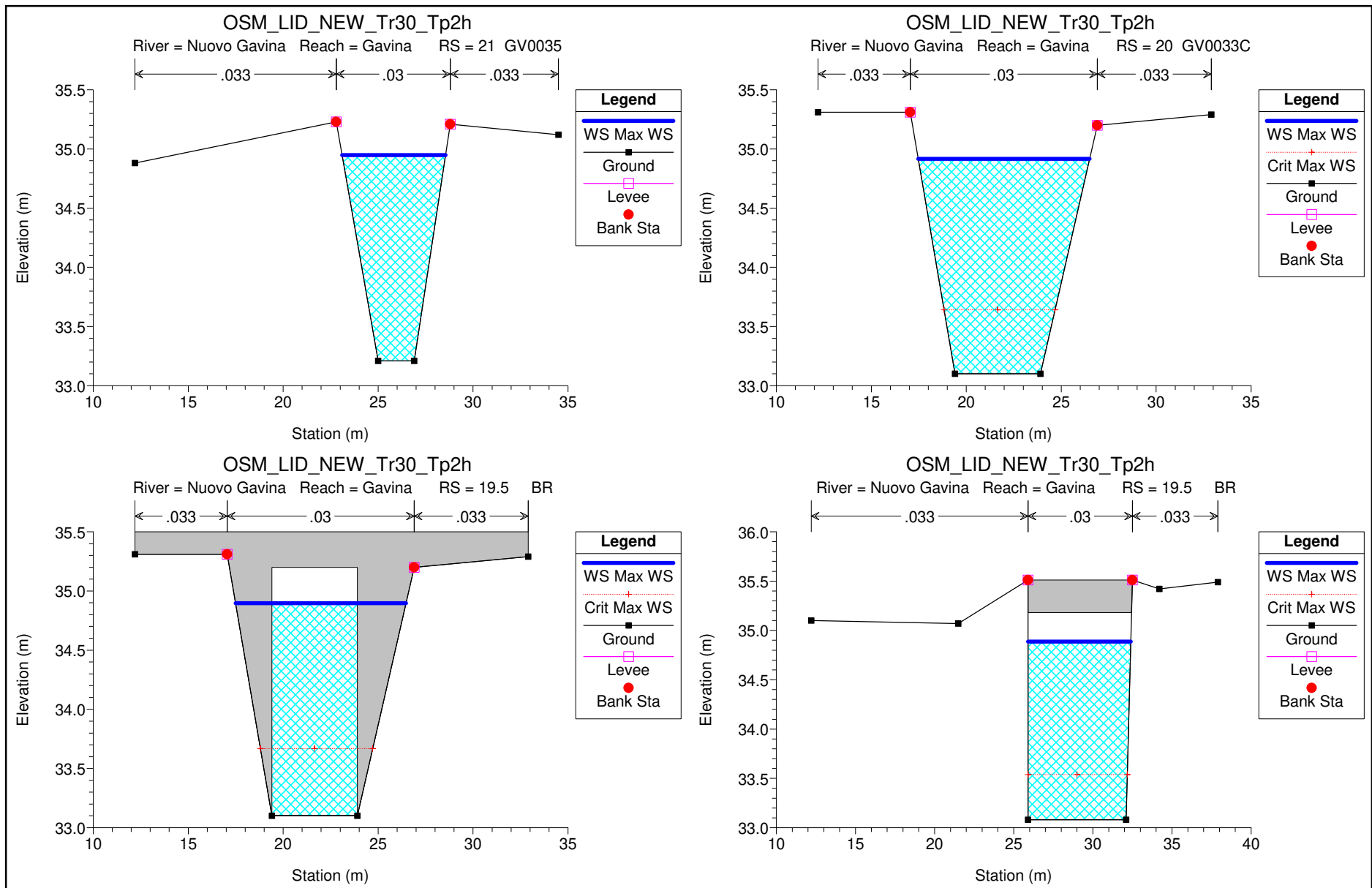


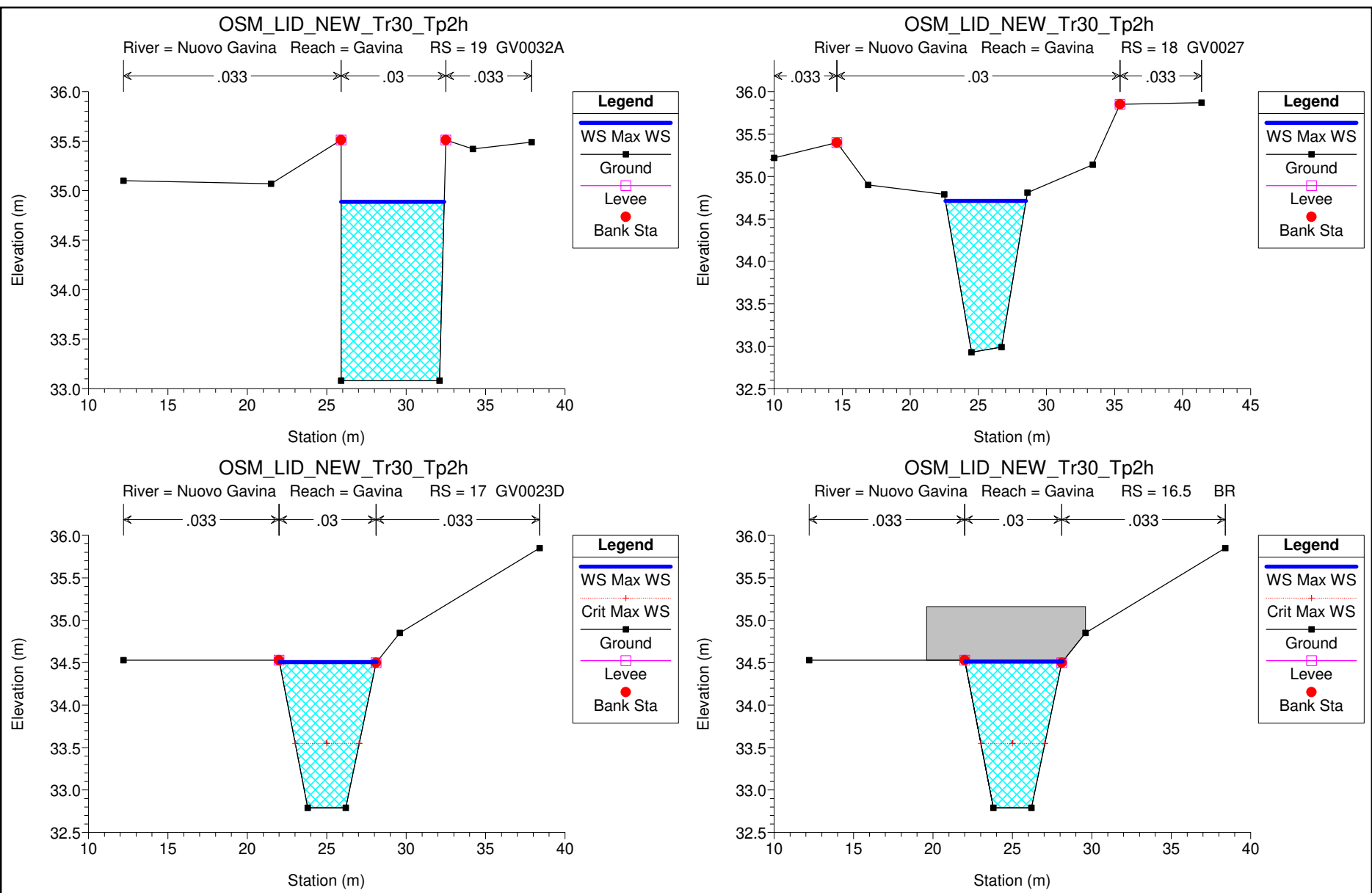


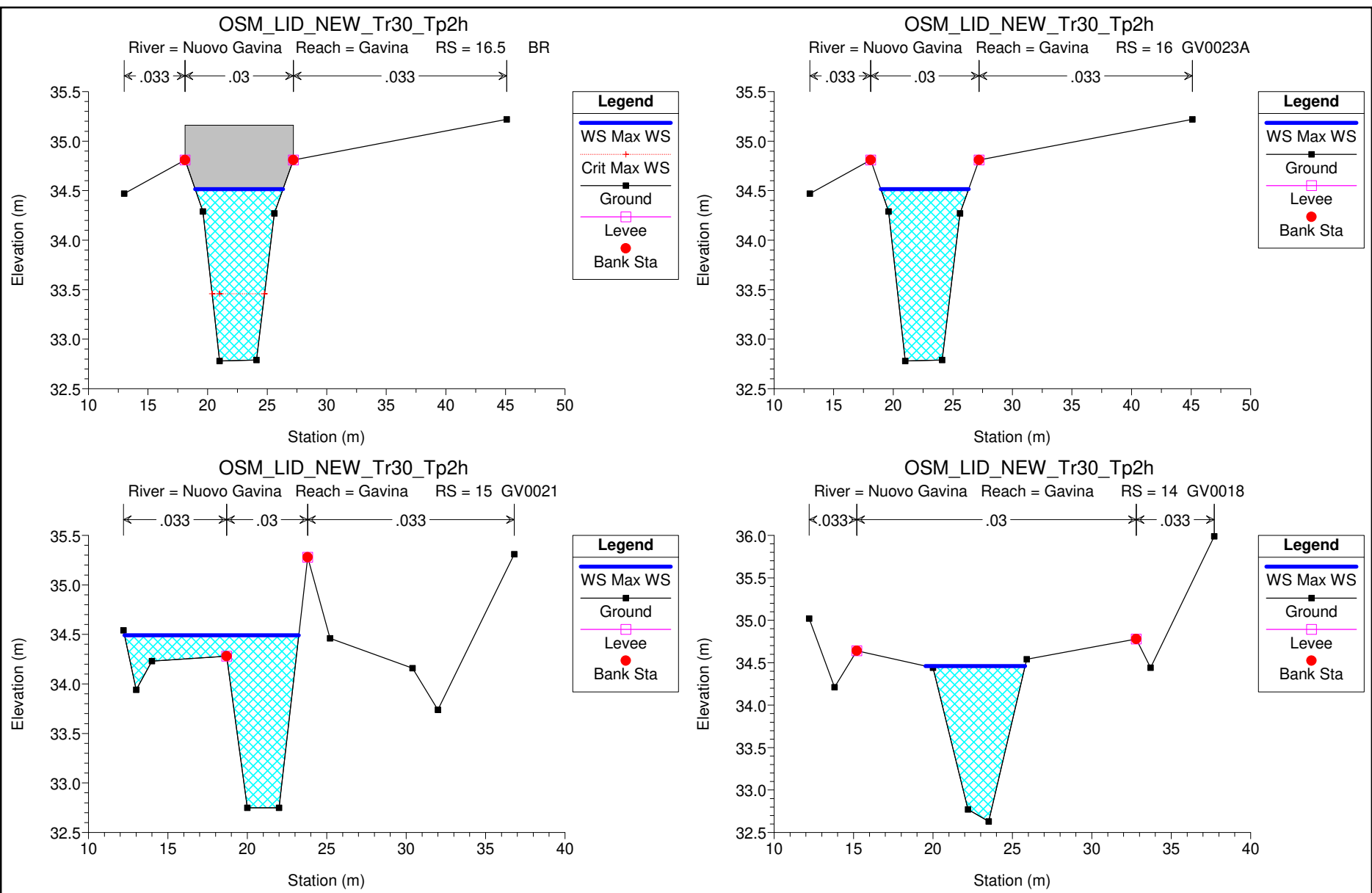


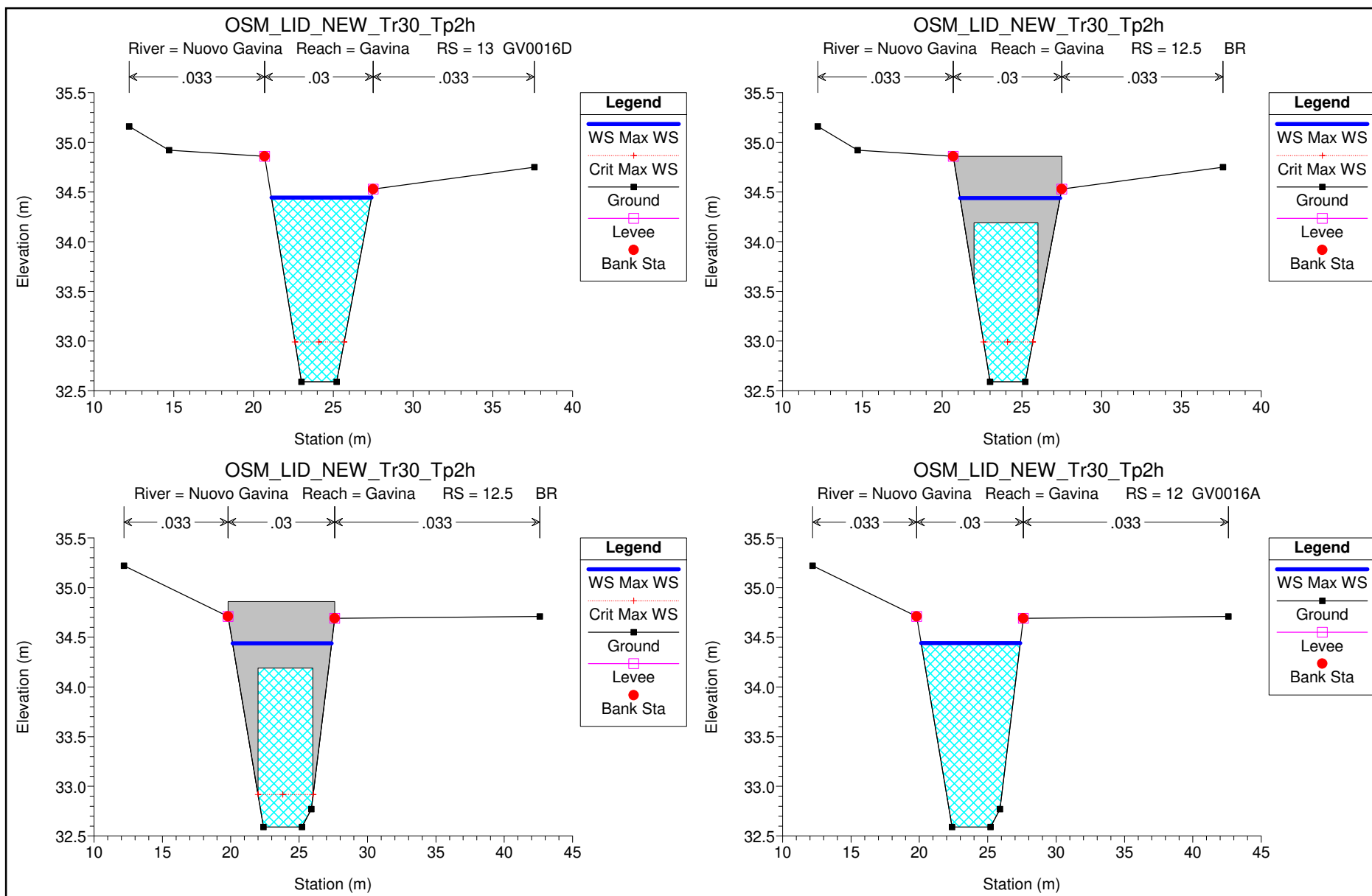


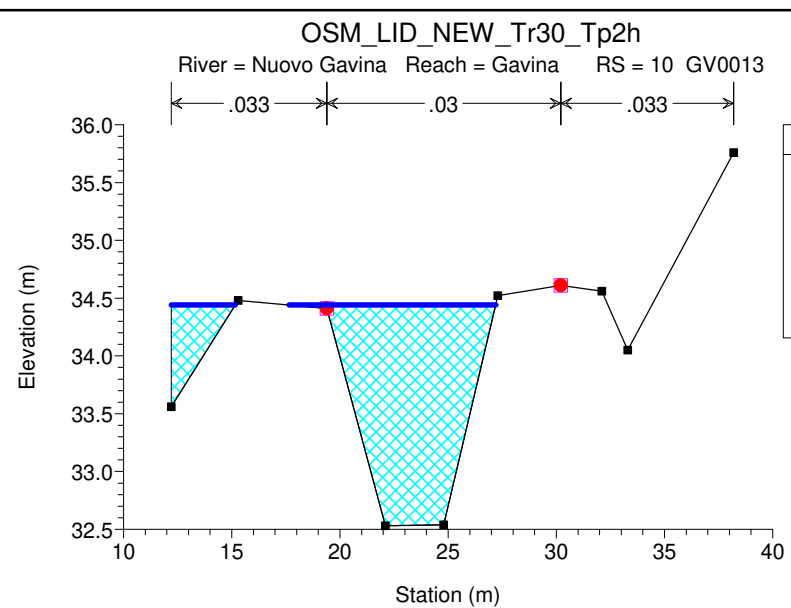
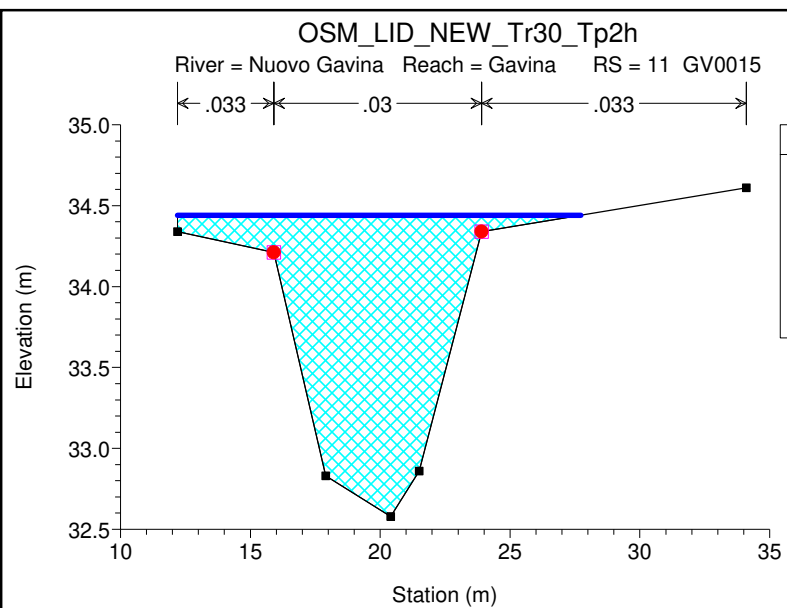


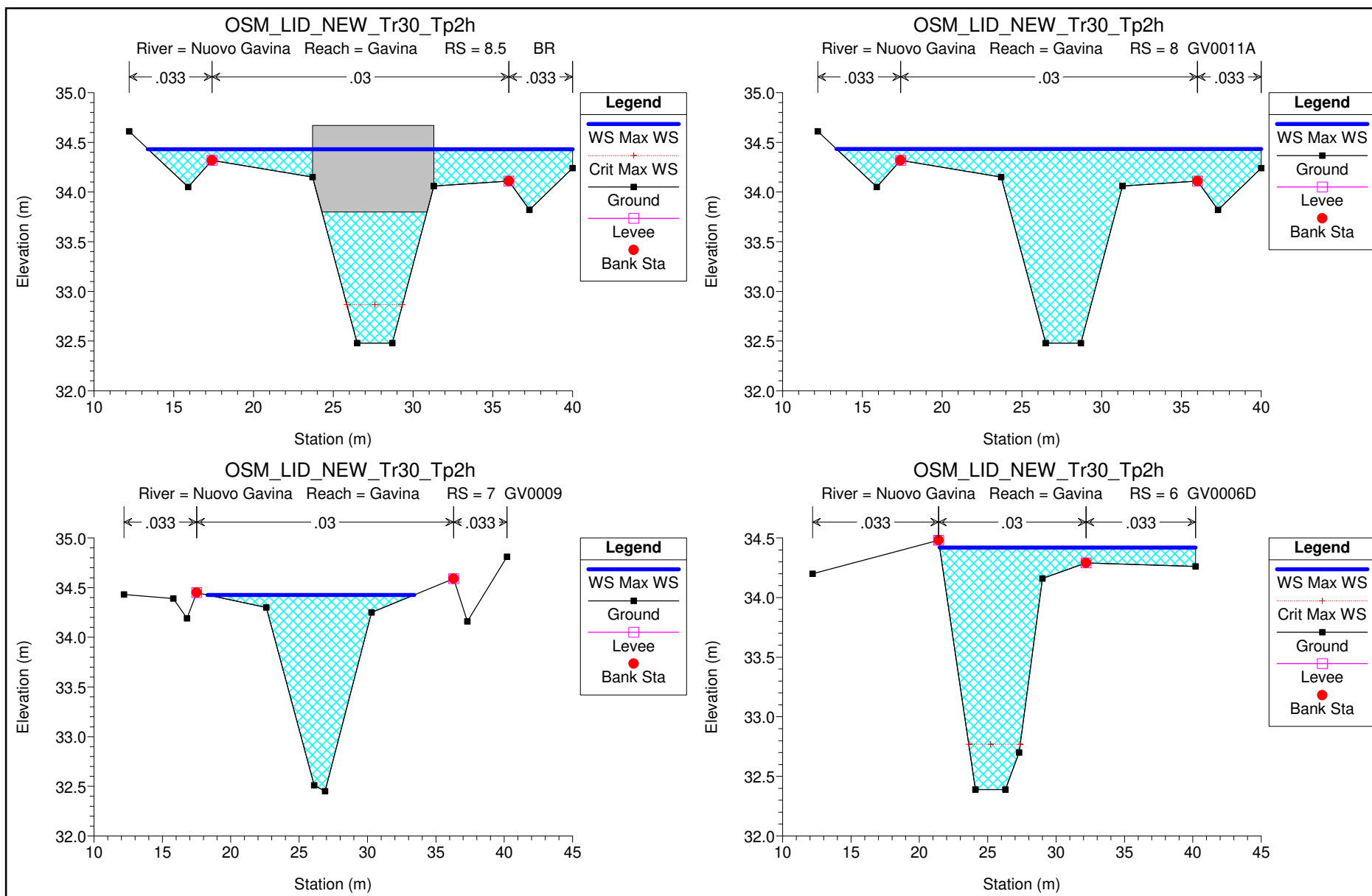


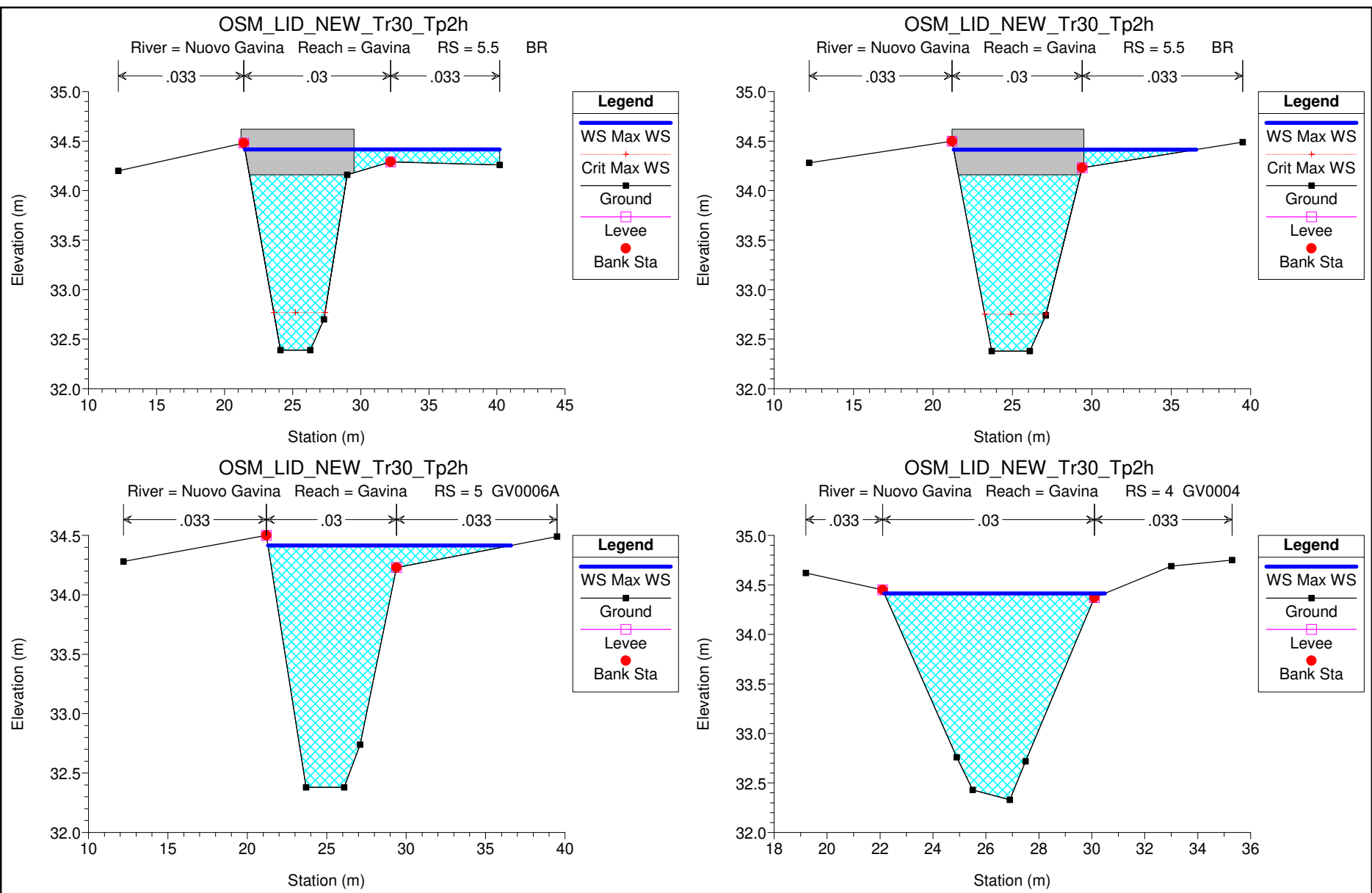


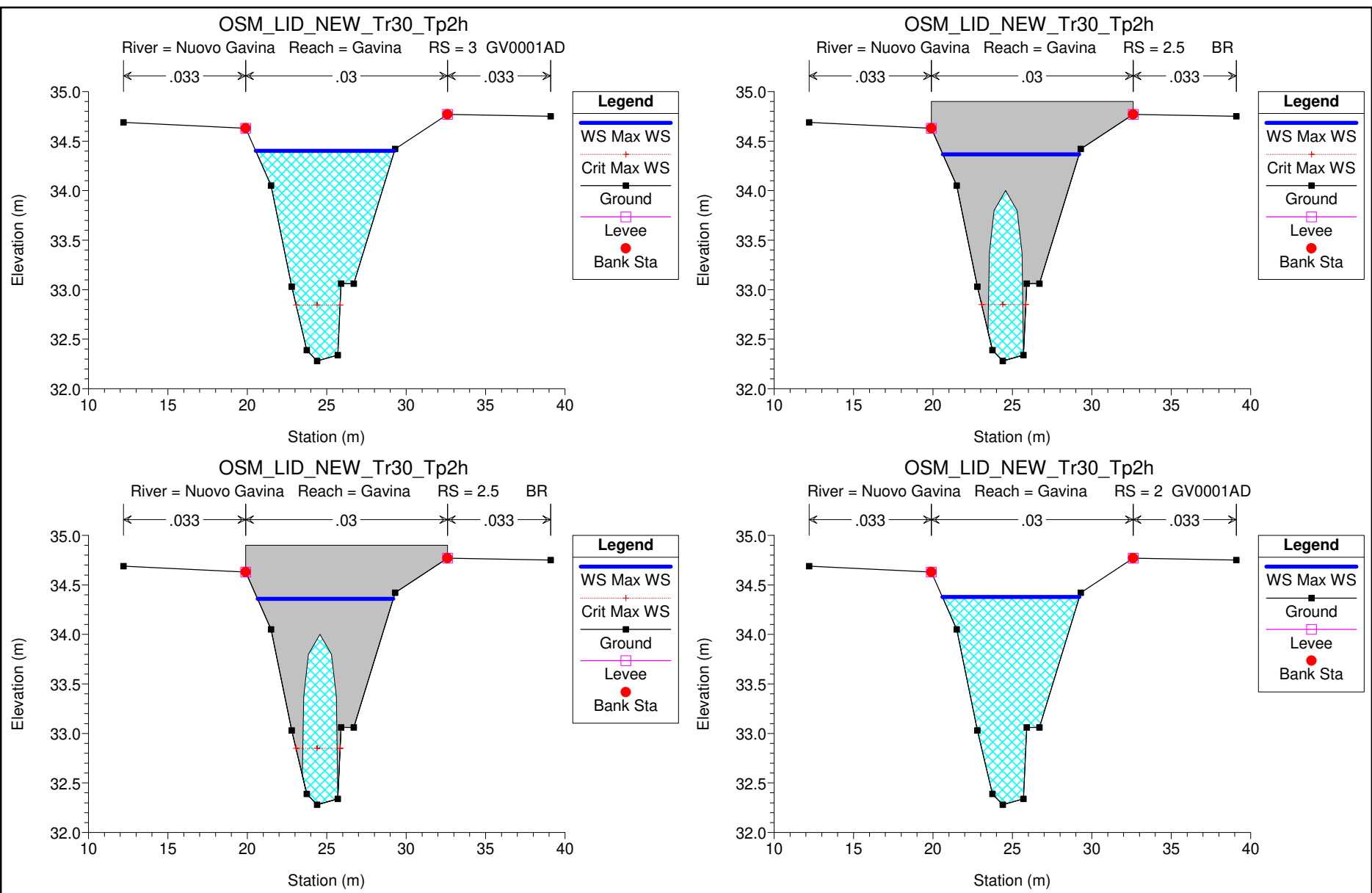






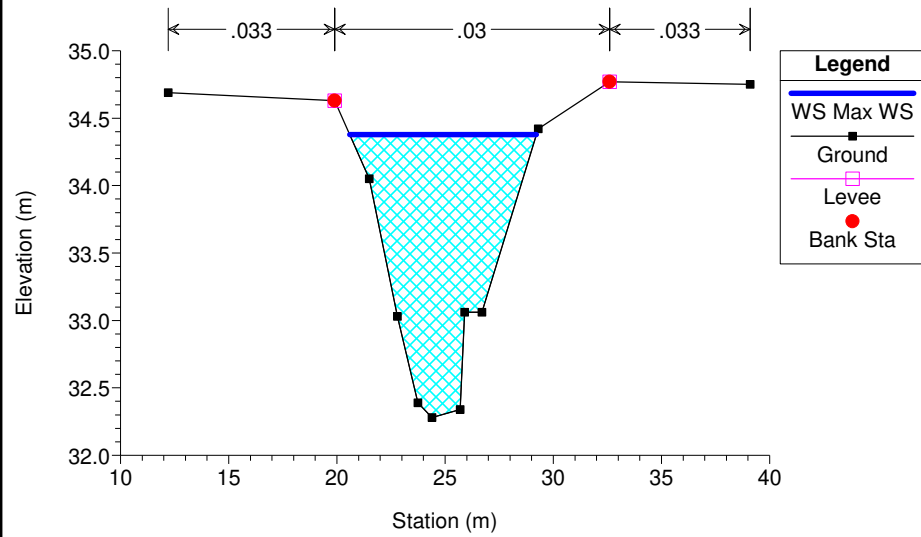






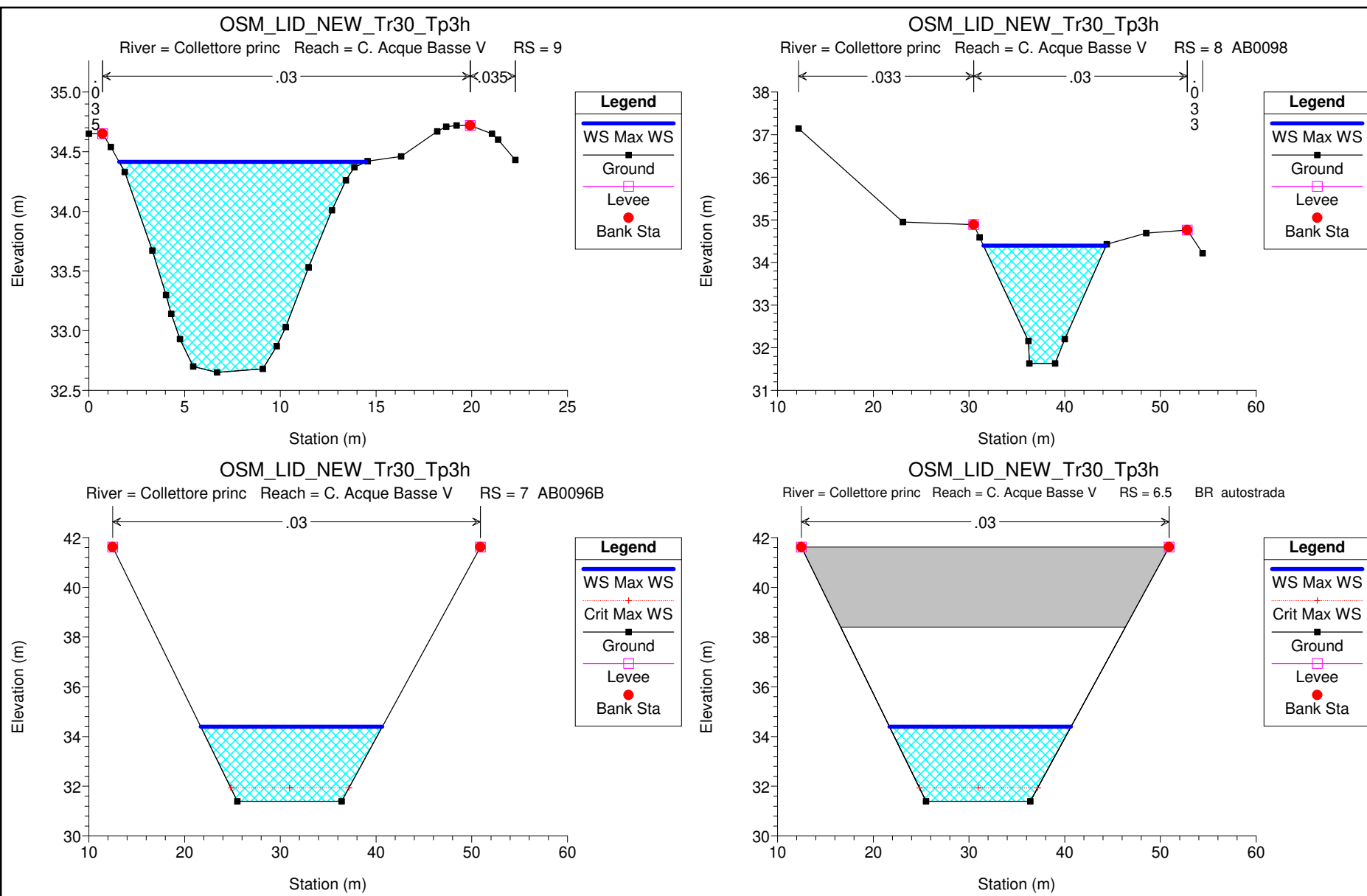
OSM_LID_NEW_Tr30_Tp2h

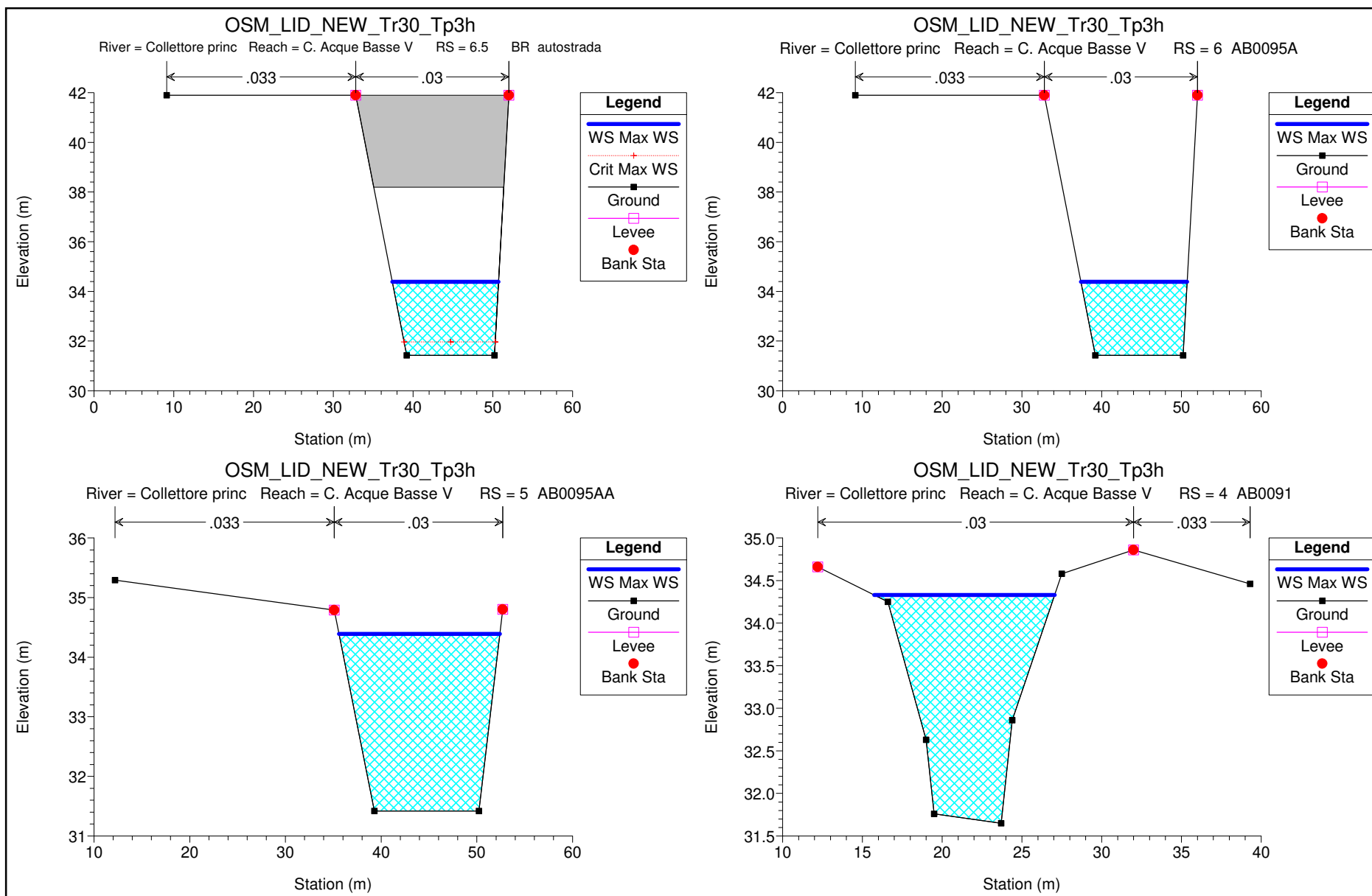
River = Nuovo Gavina Reach = Gavina RS = 1 GV0001AD

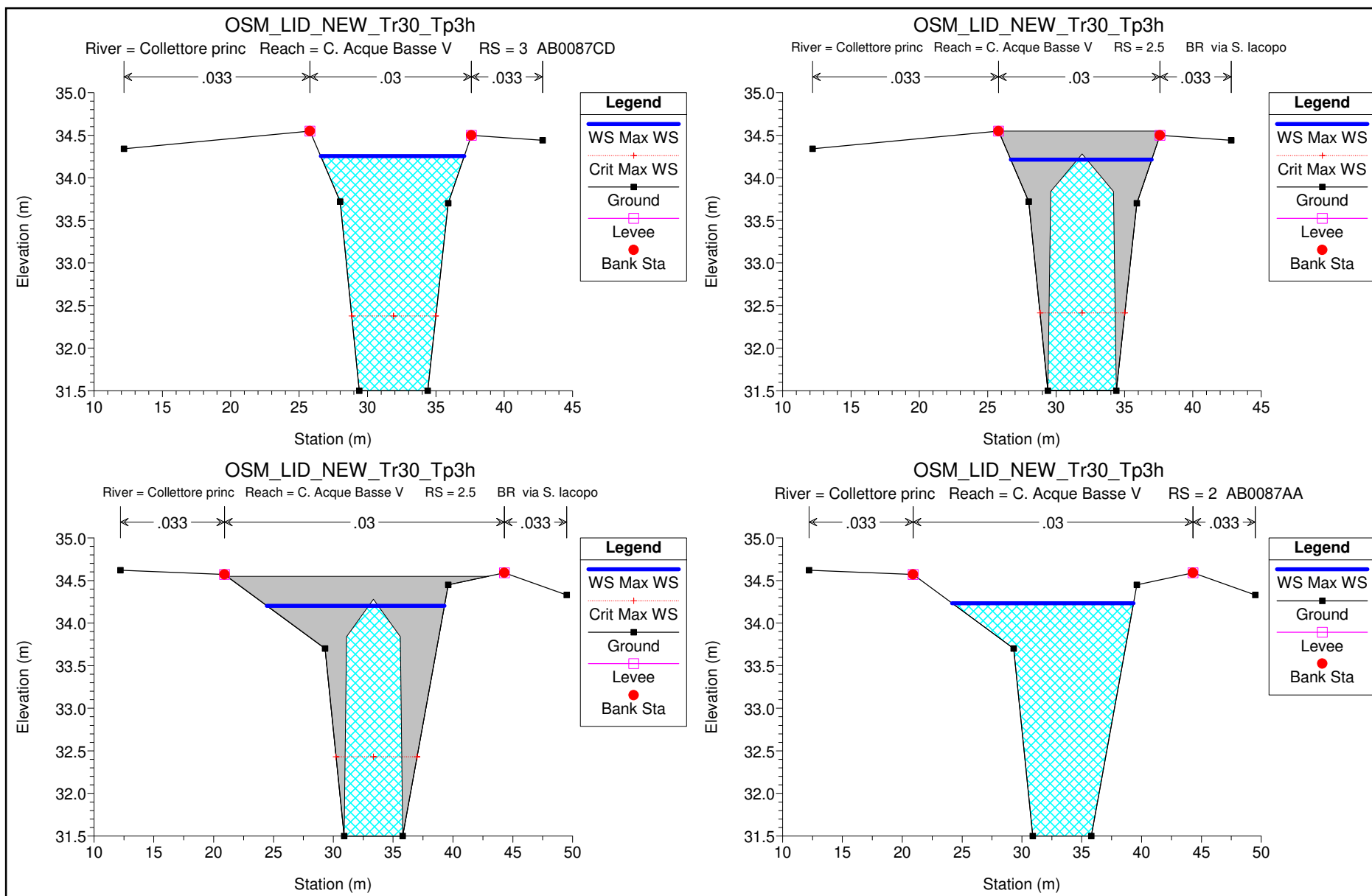


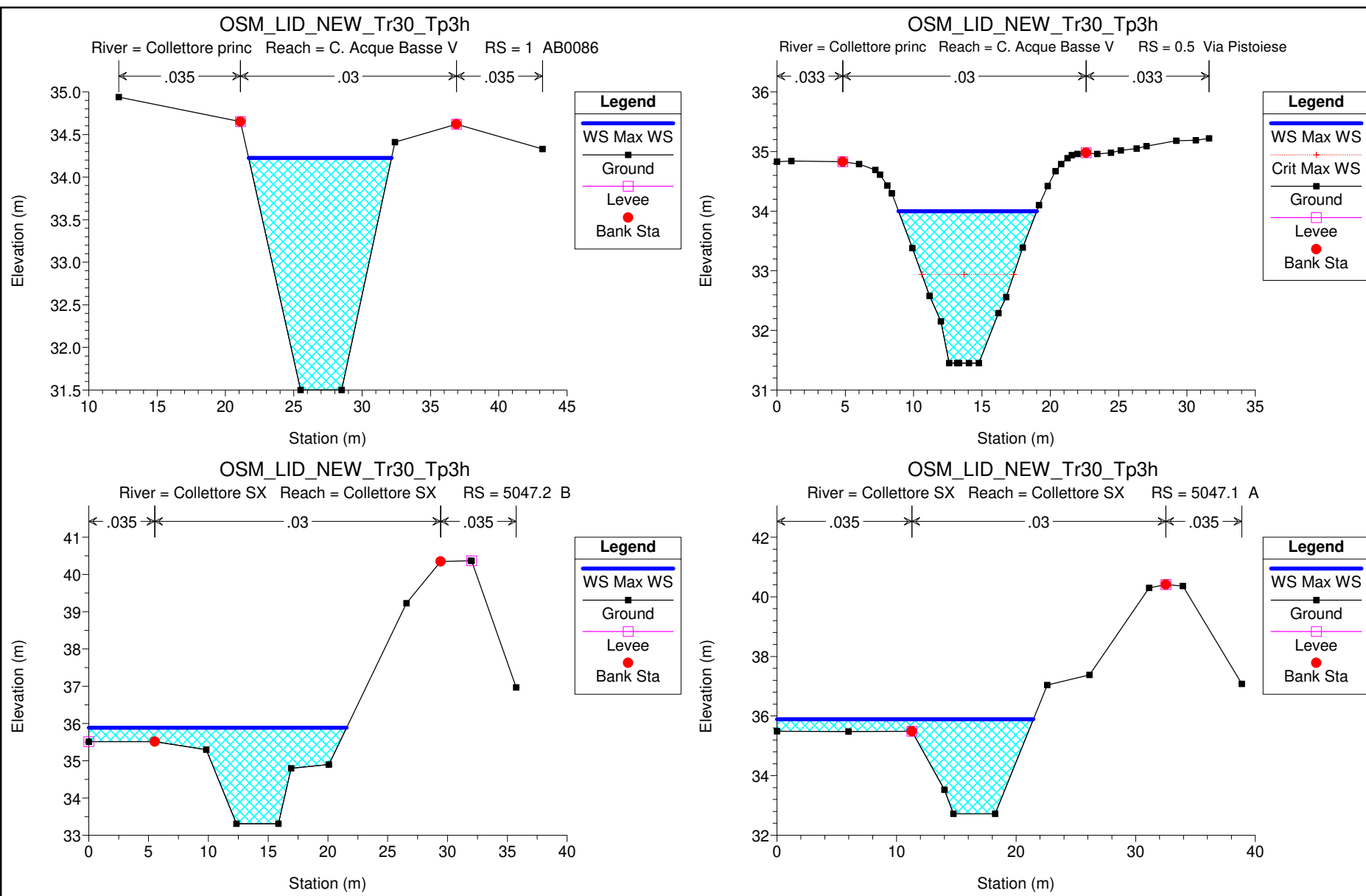
Verifiche idrauliche Tr 30 anni Tp 3h

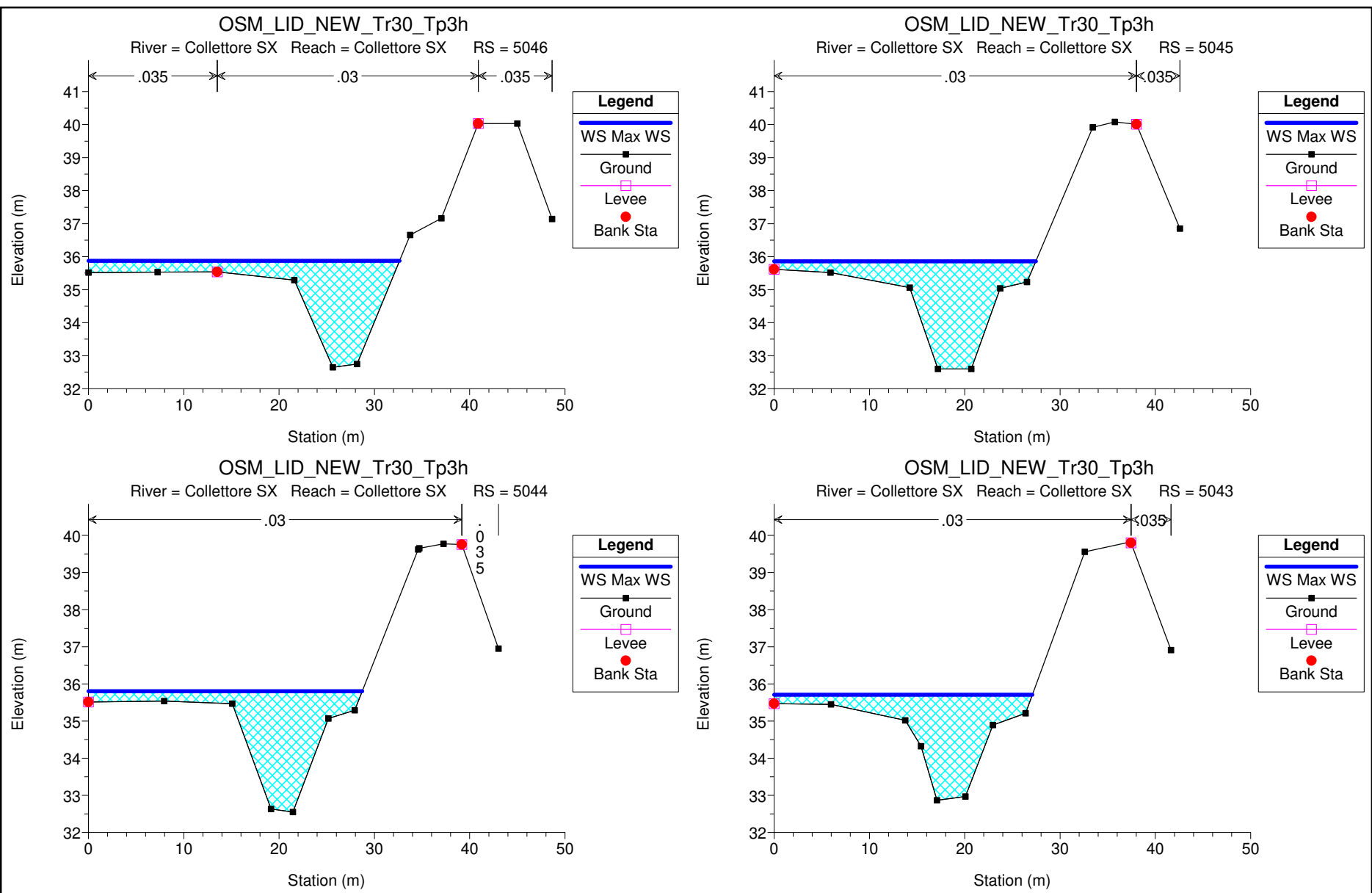
**Collettore sinistro acque basse – Fosso Osmannoro – Fosso Nuova Gavine – Collettore
principale delle acque basse**

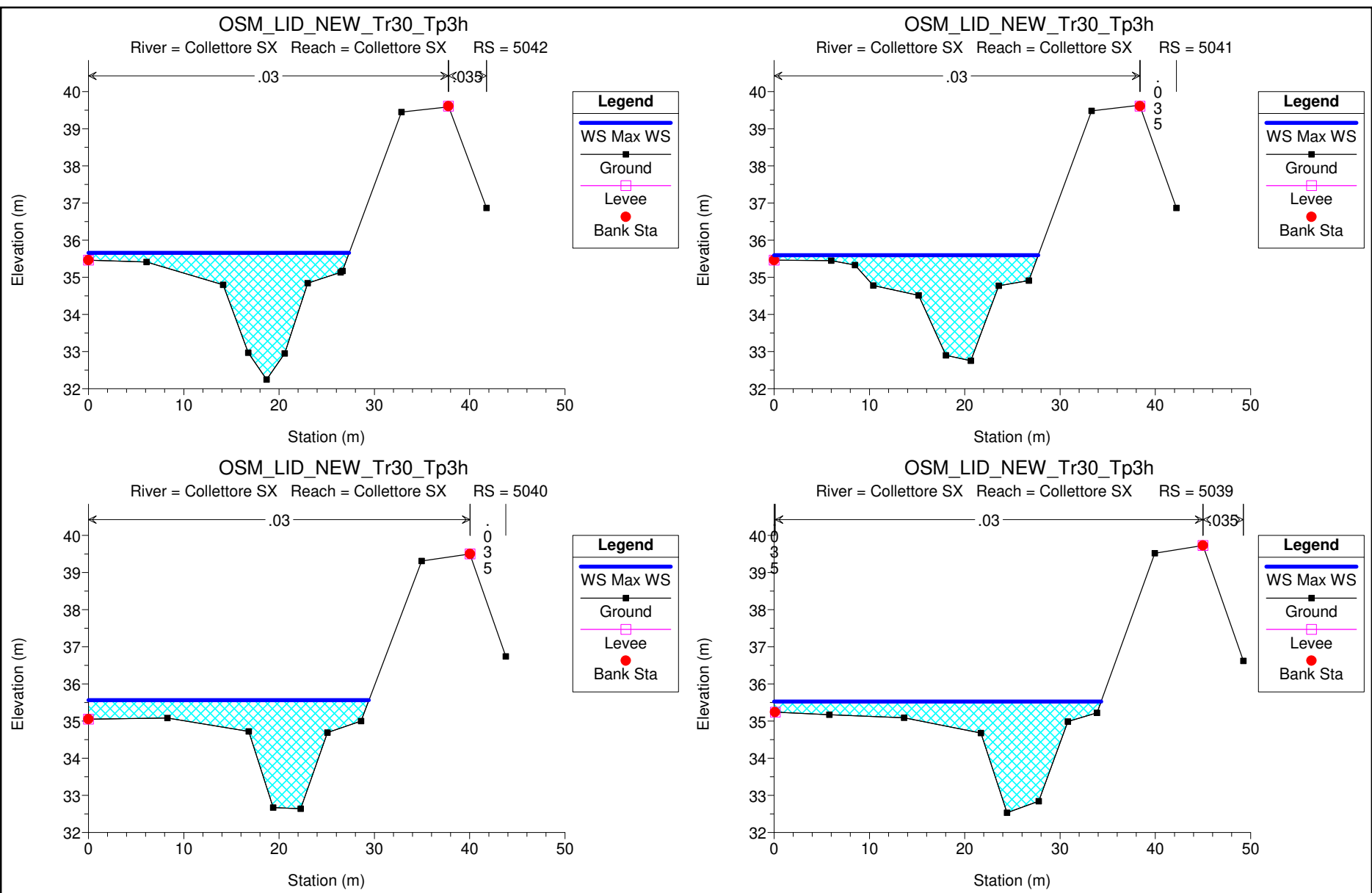


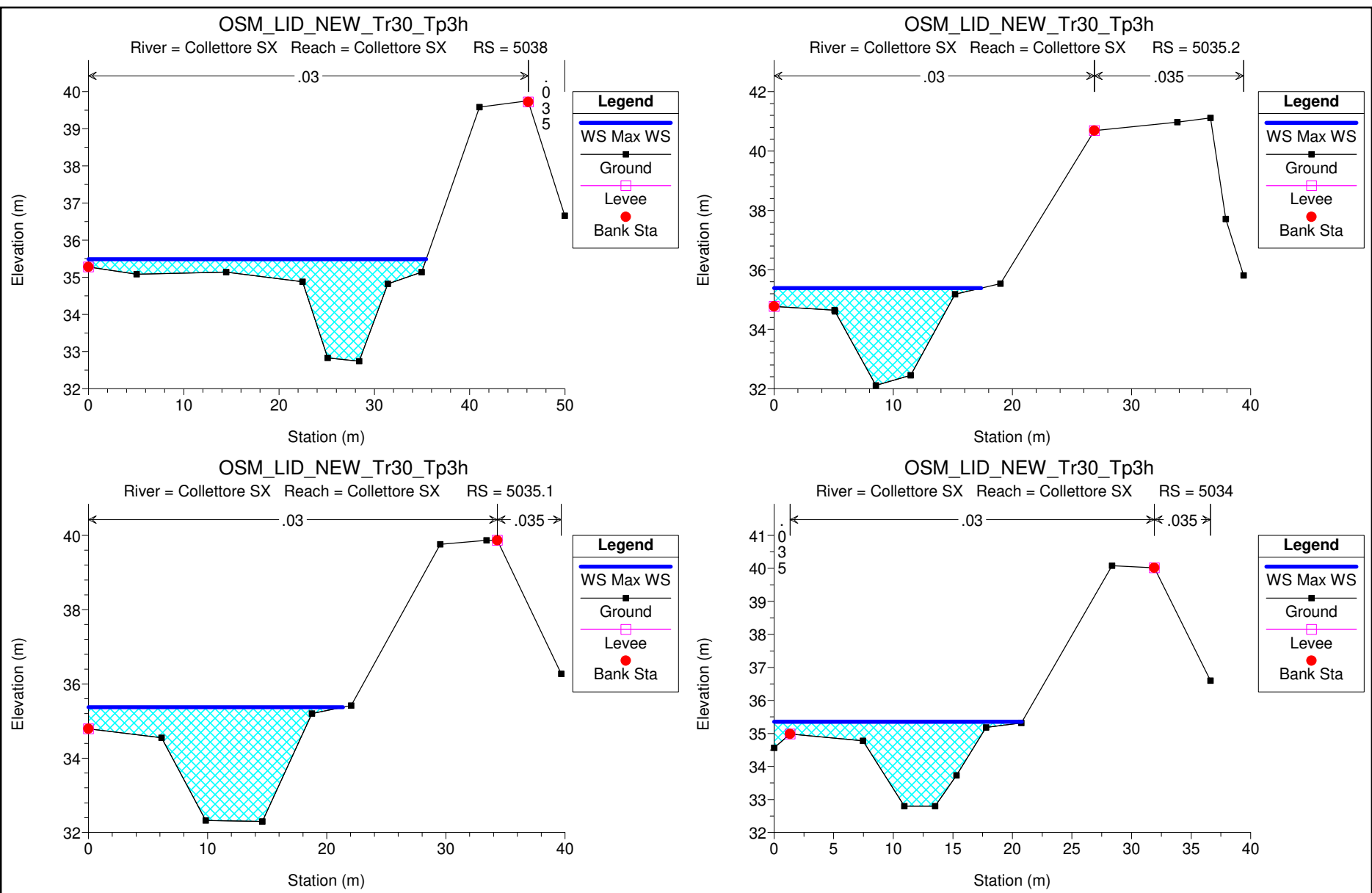


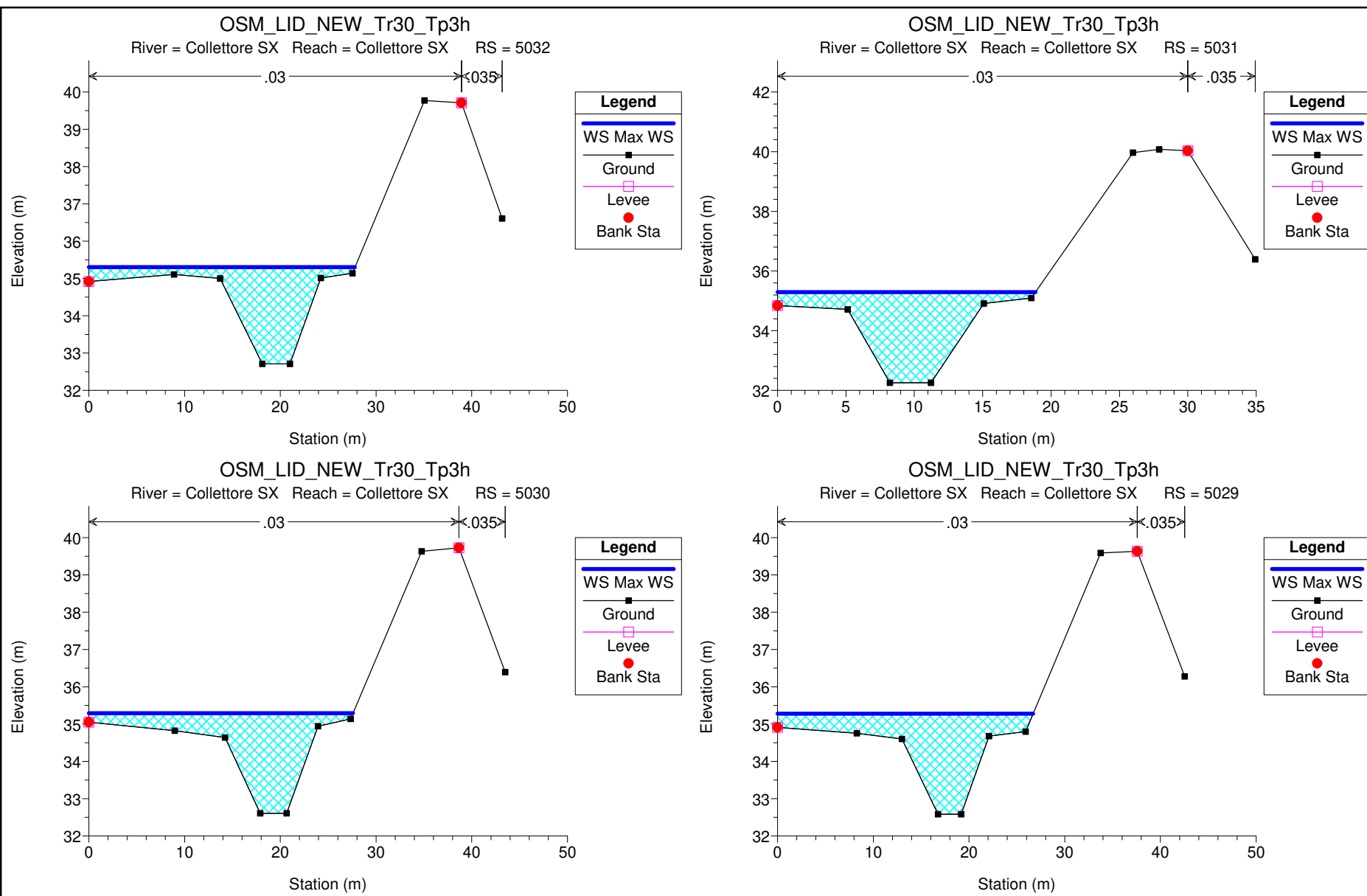


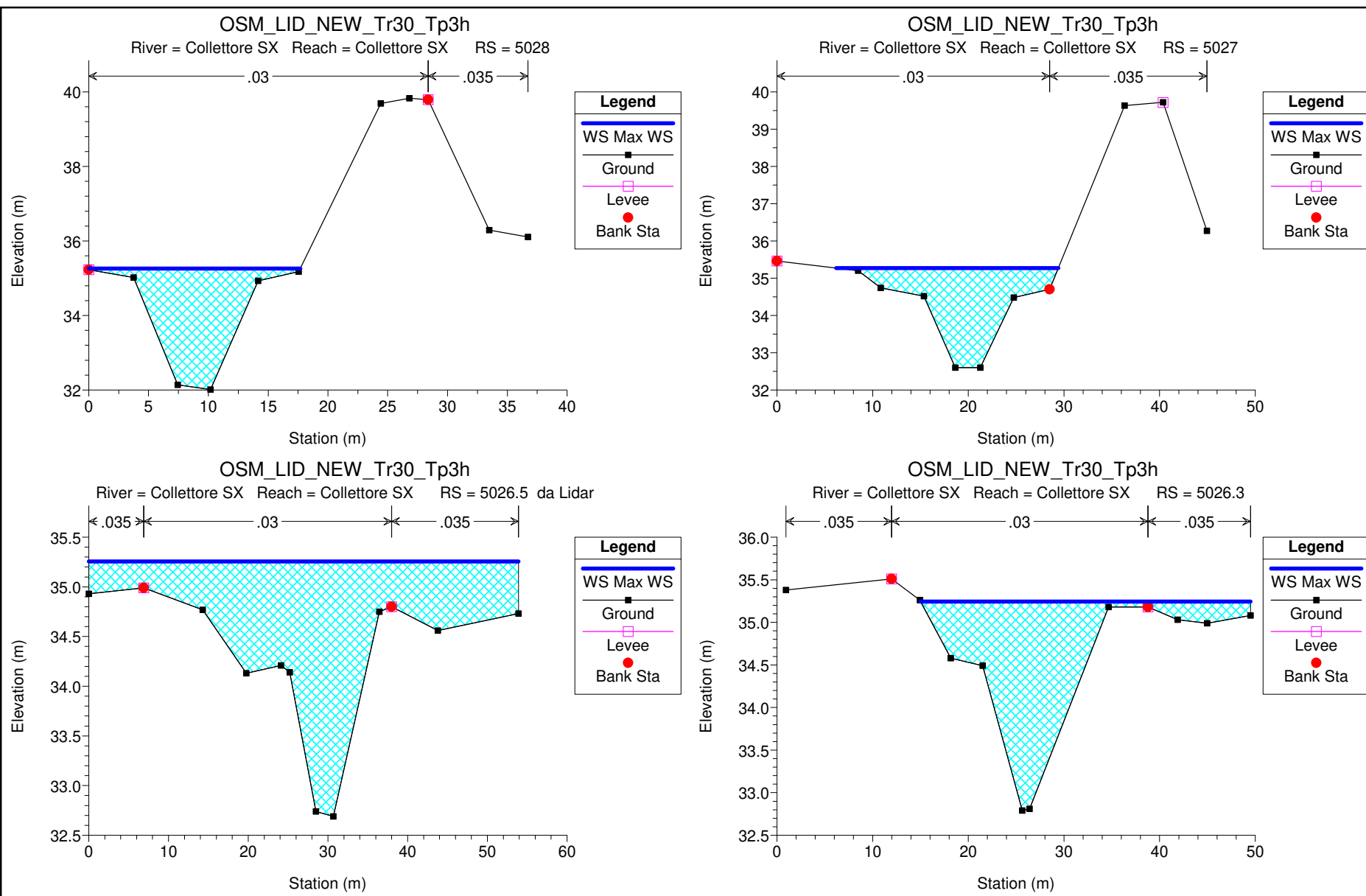


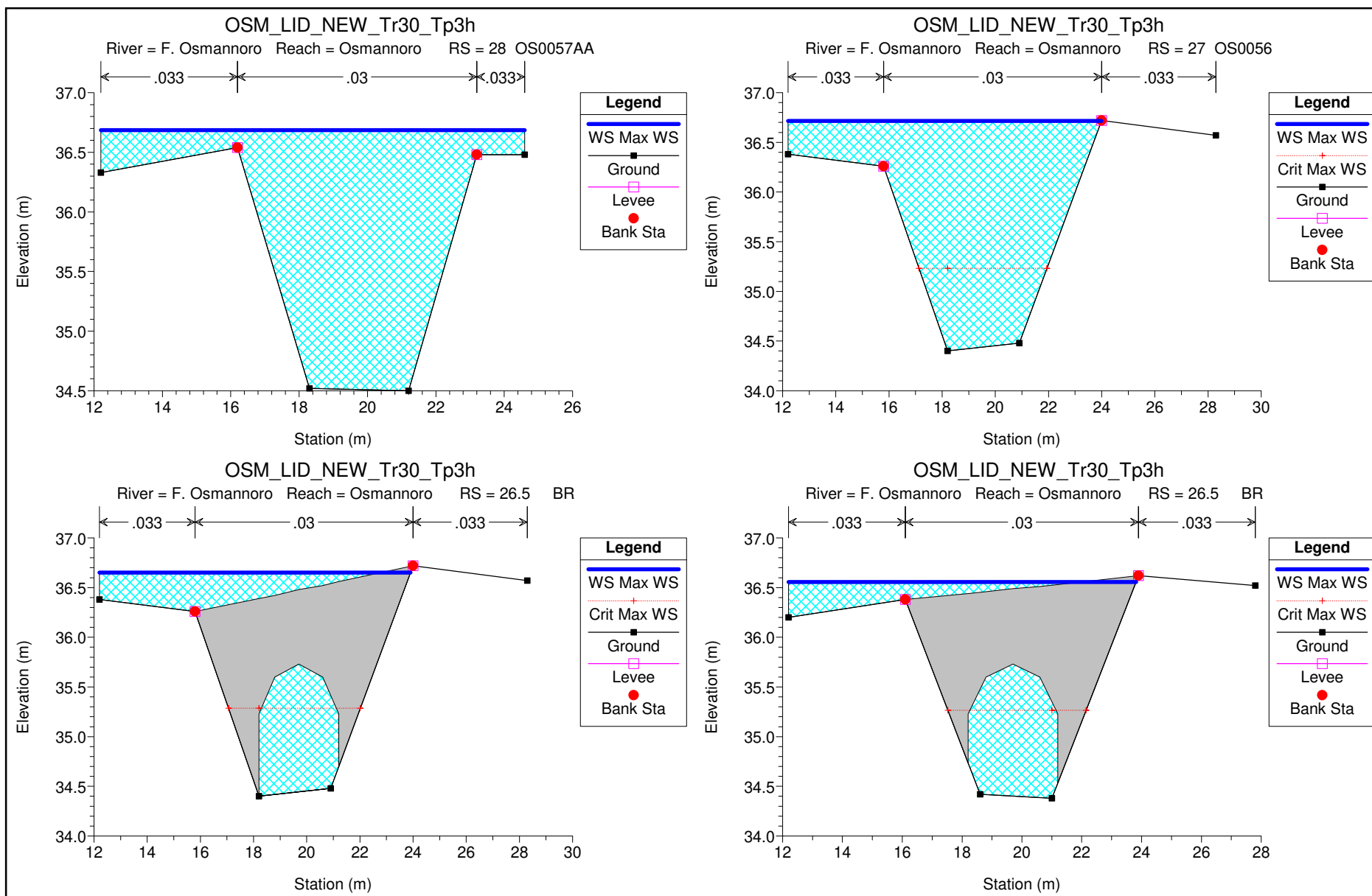


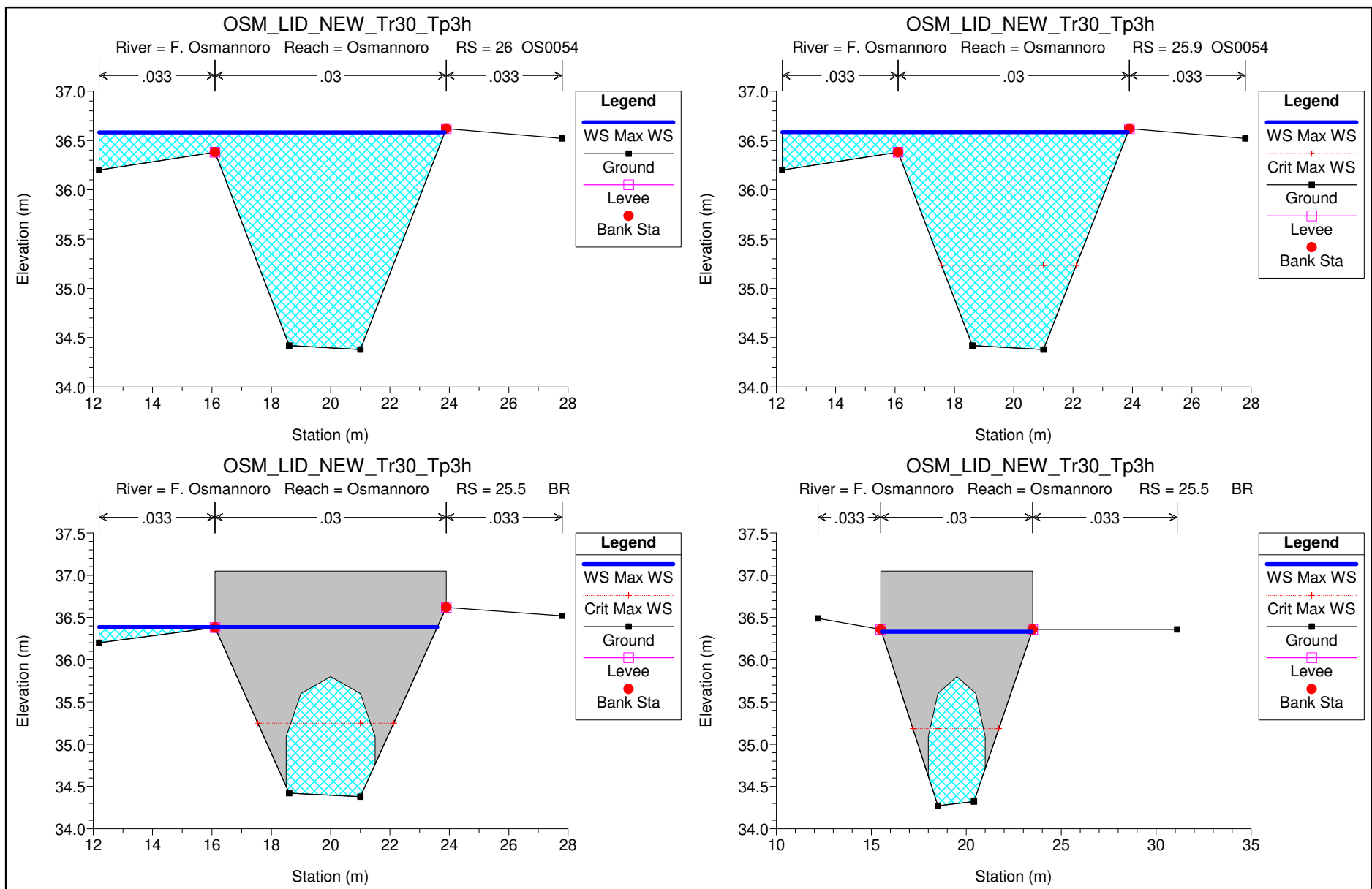


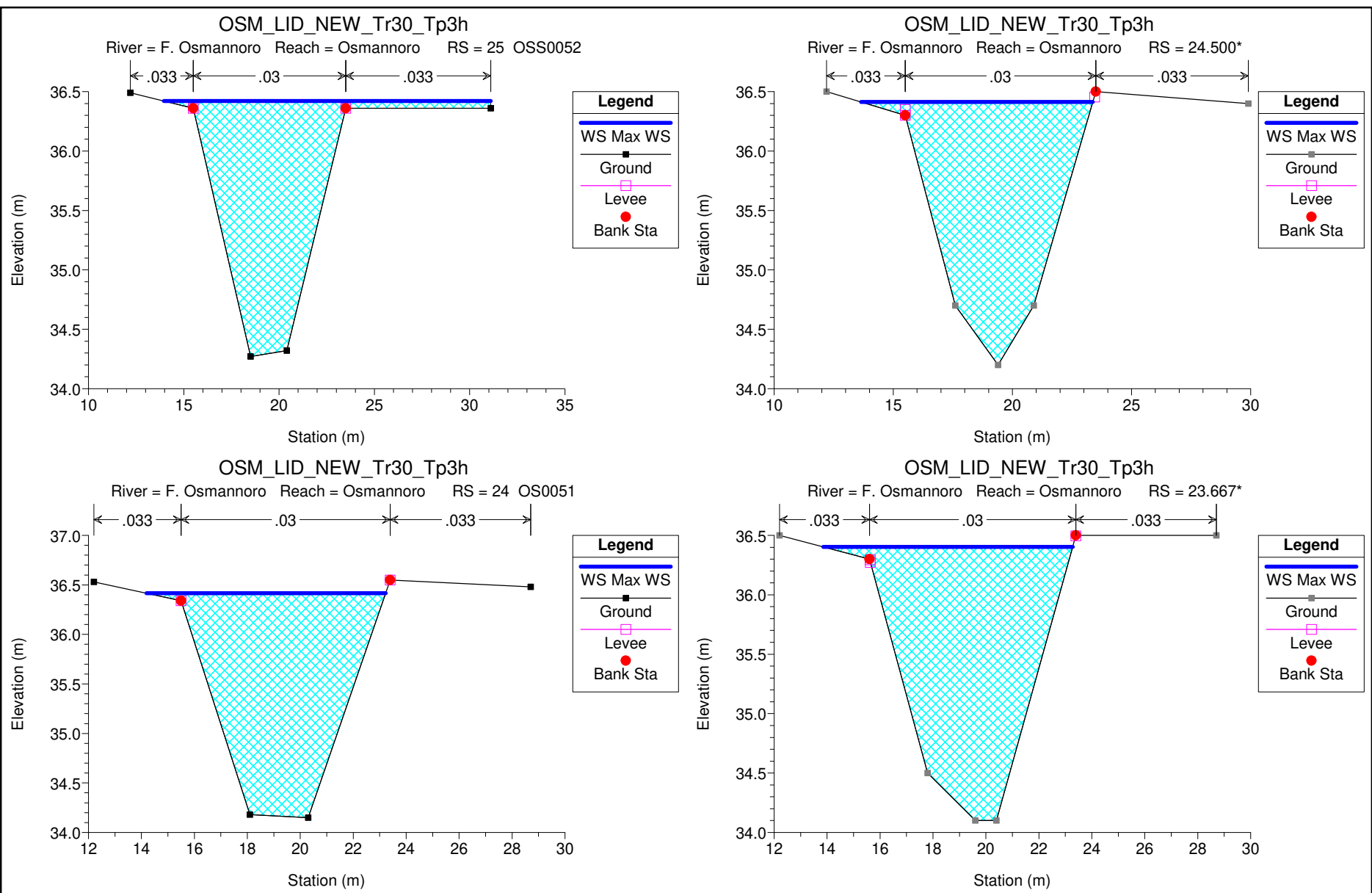


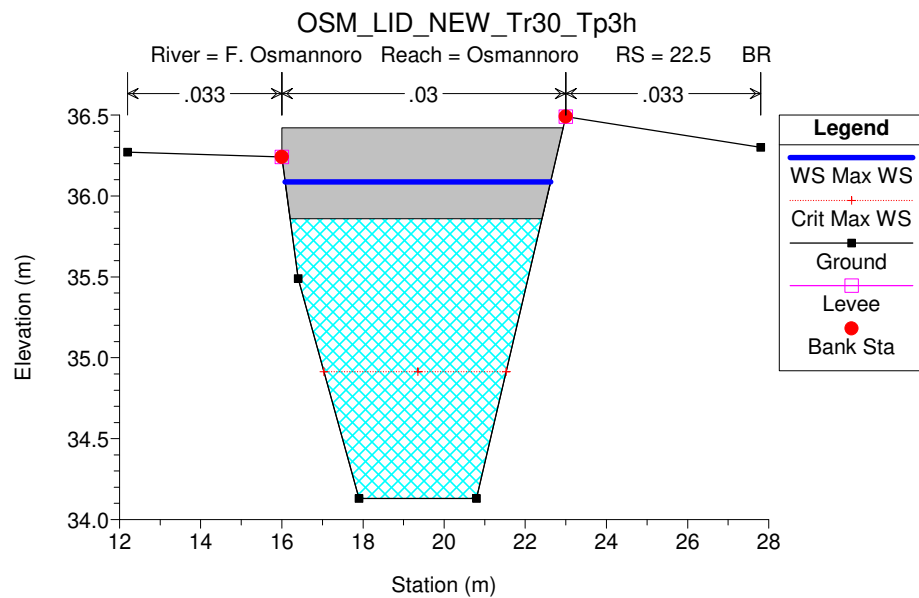
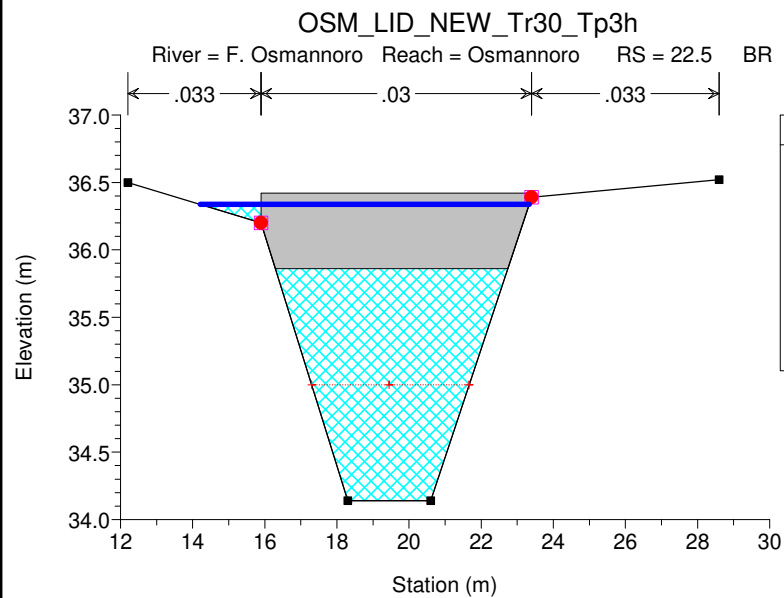
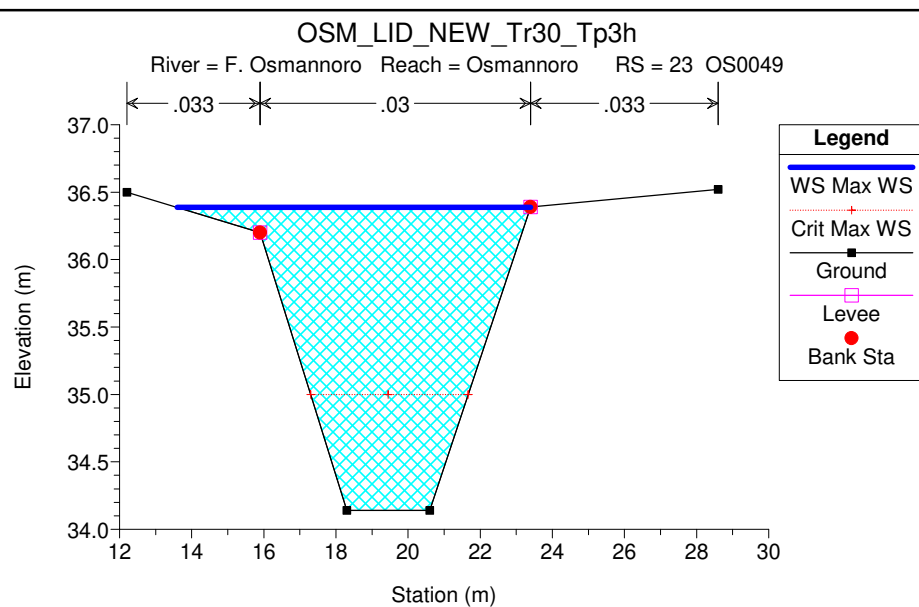
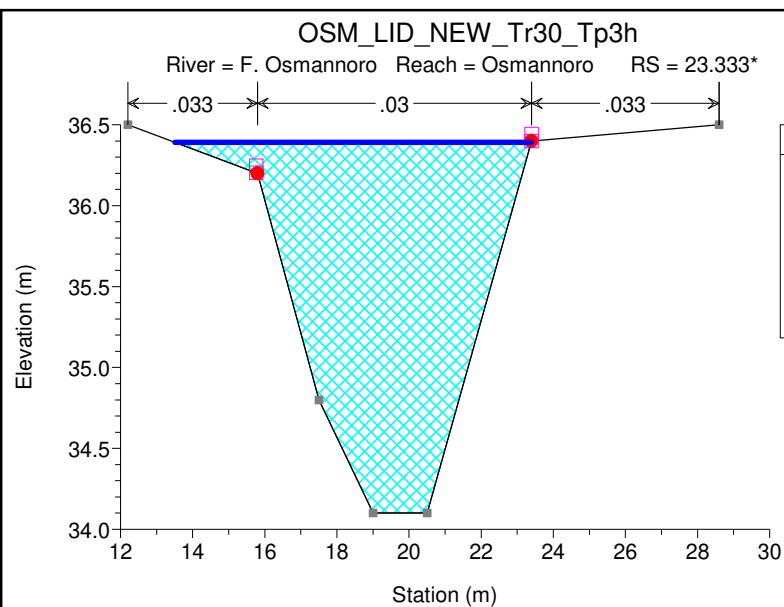


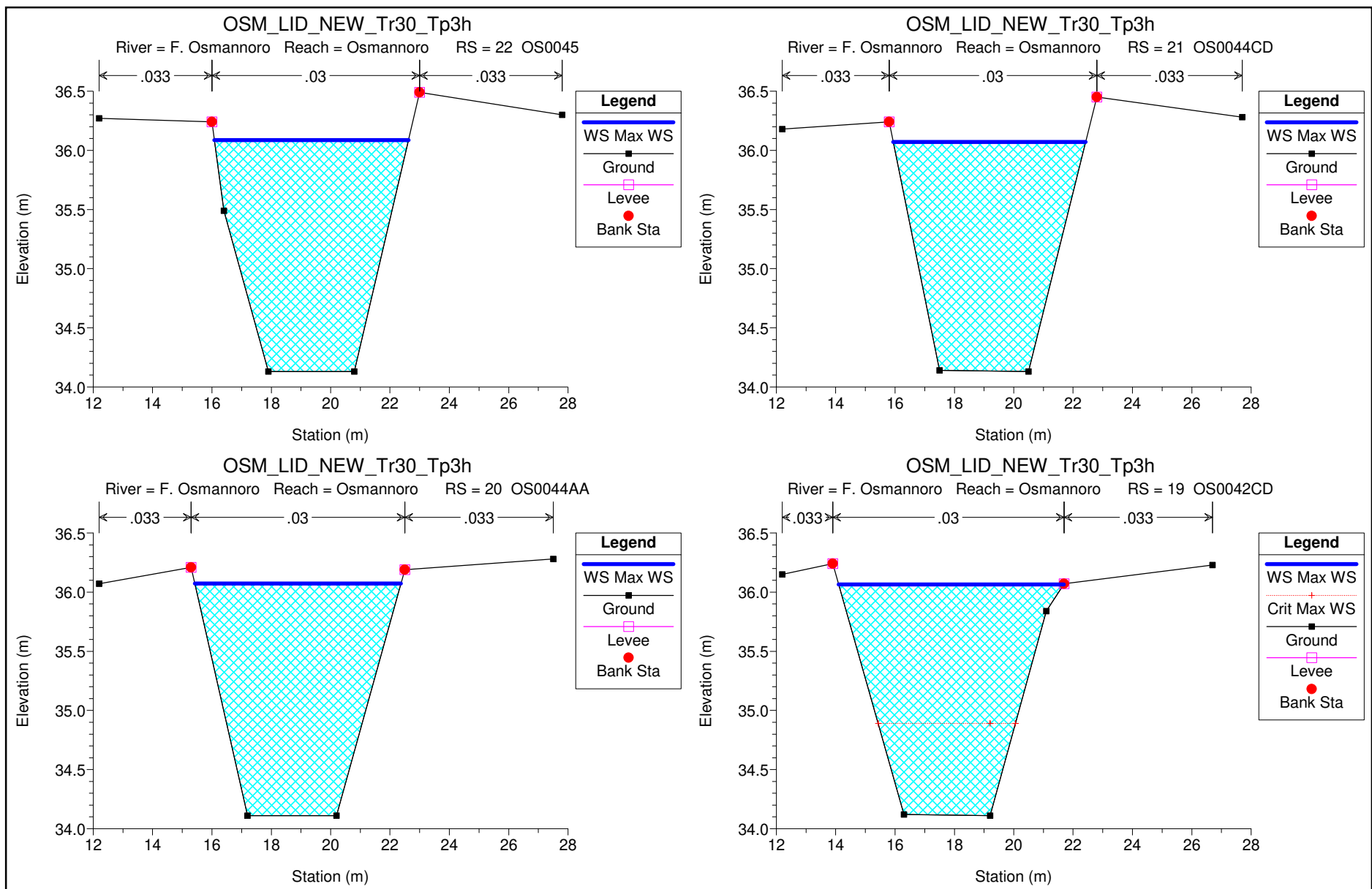


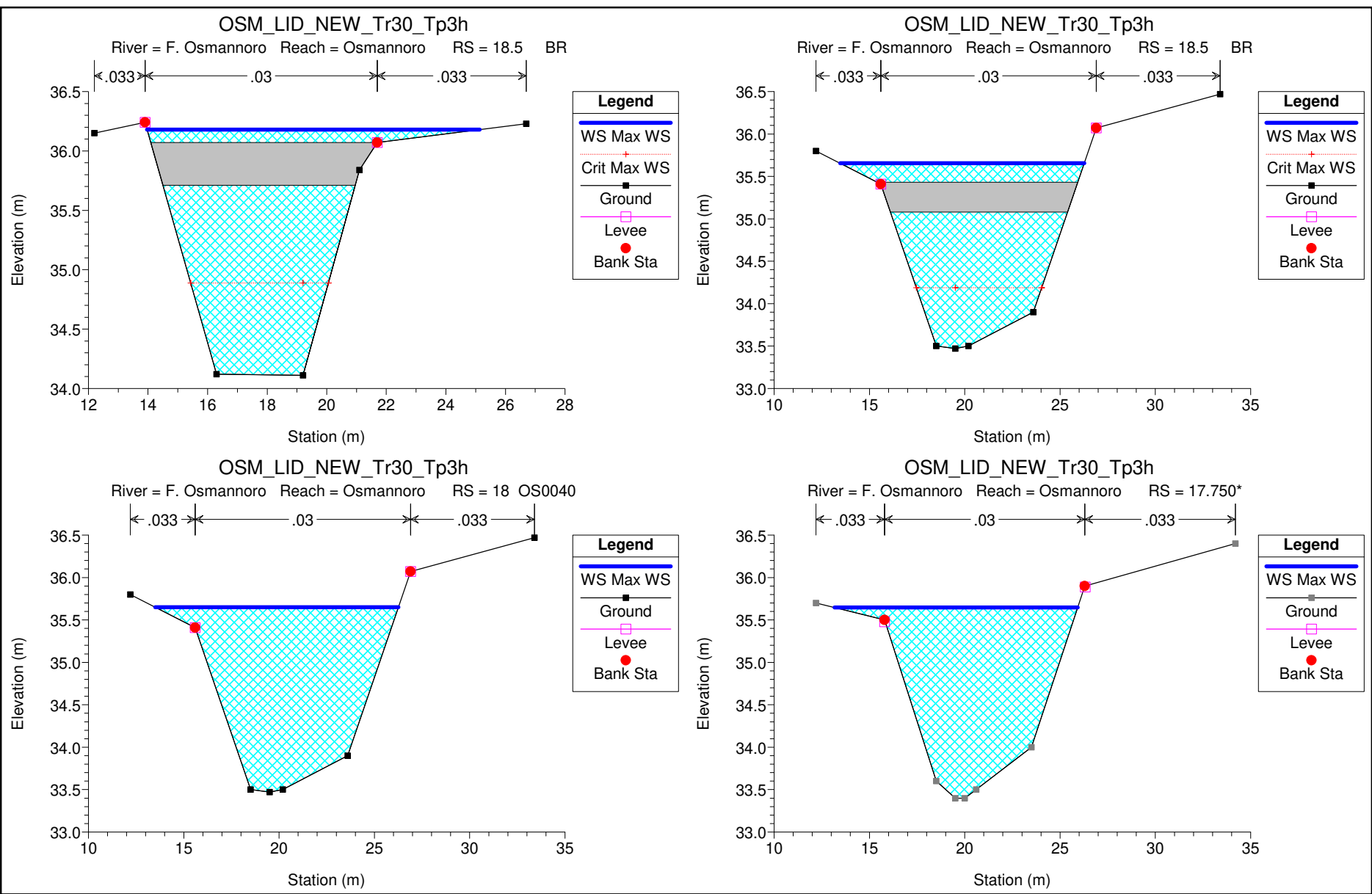


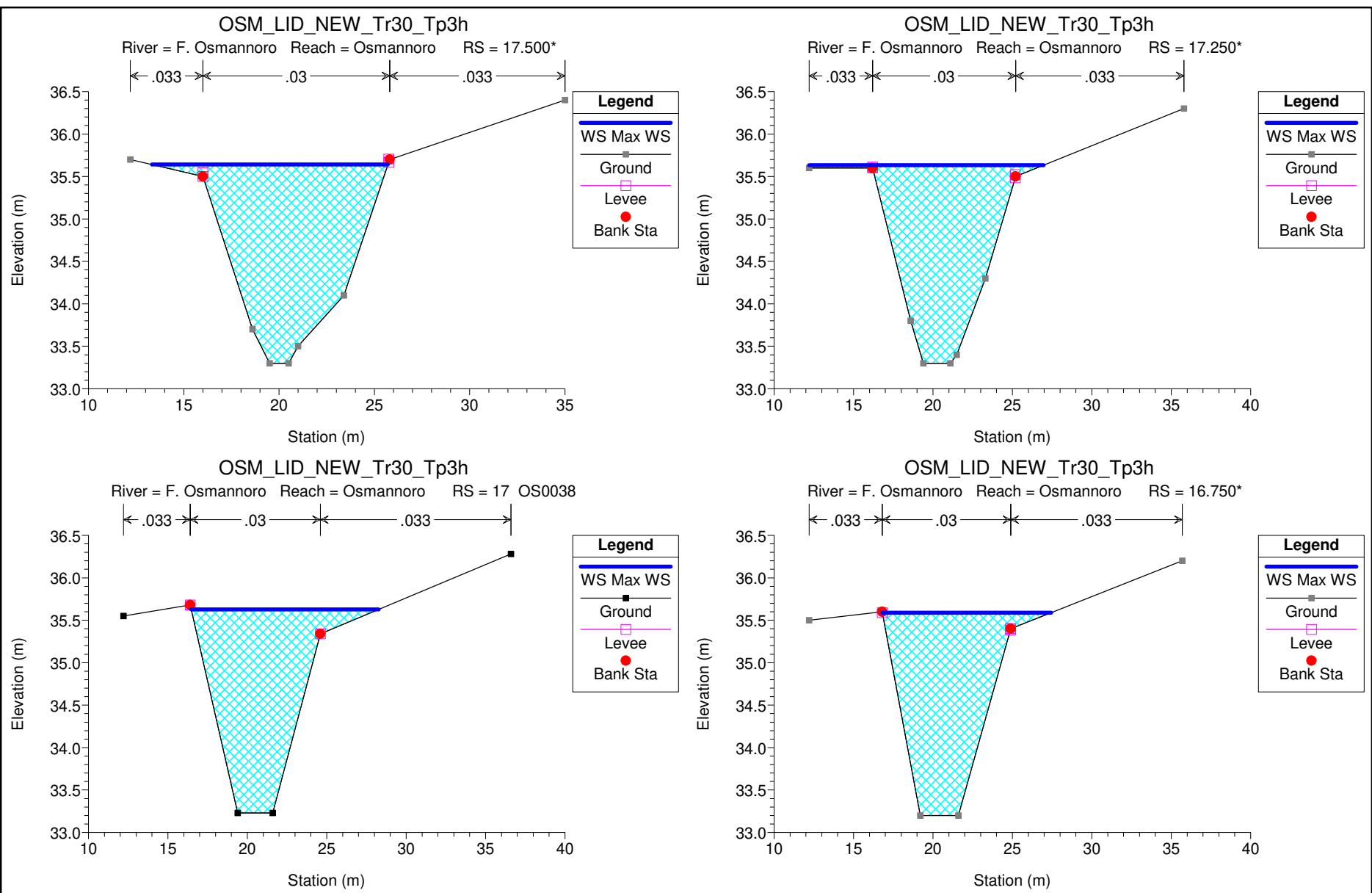


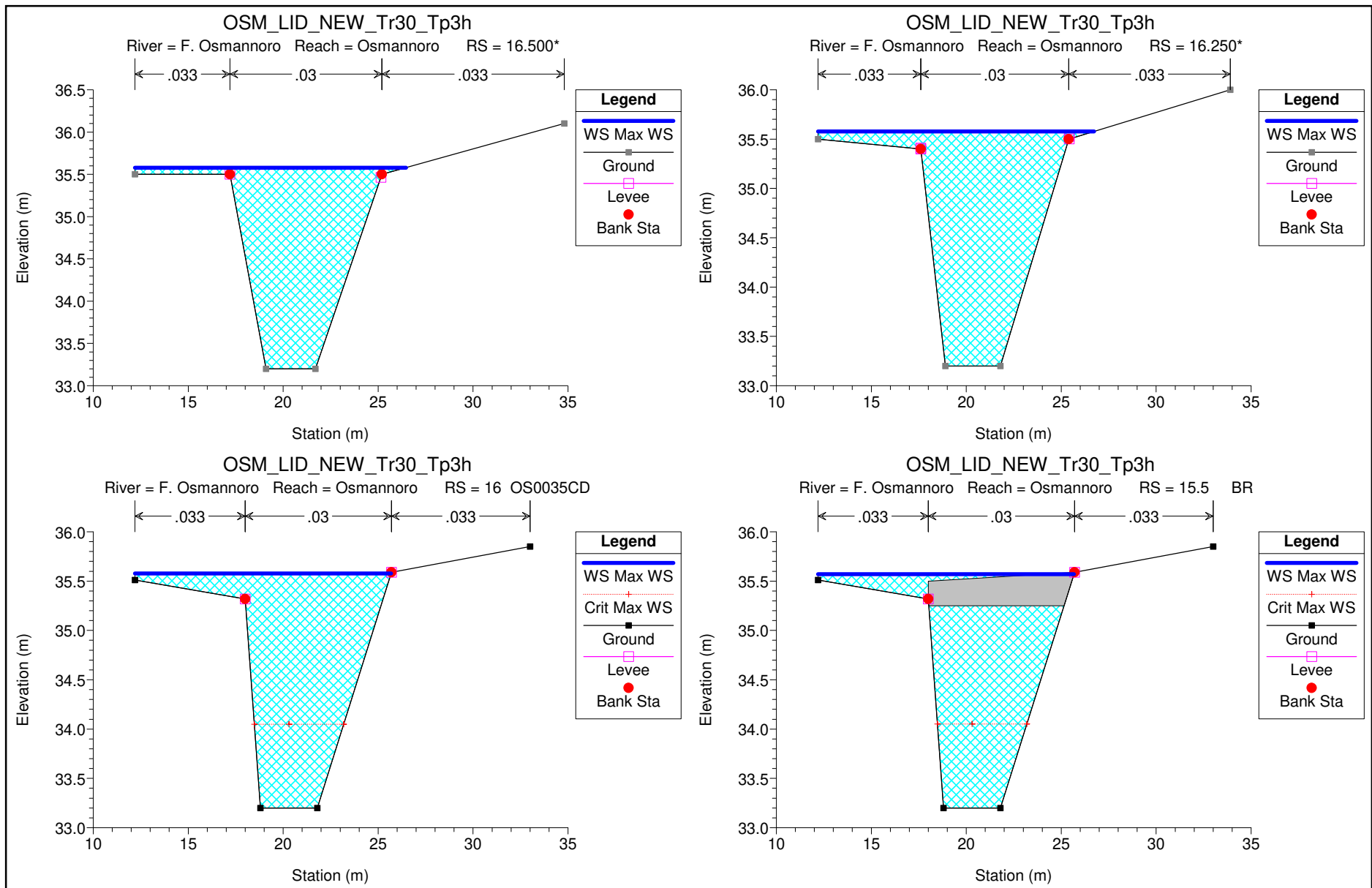


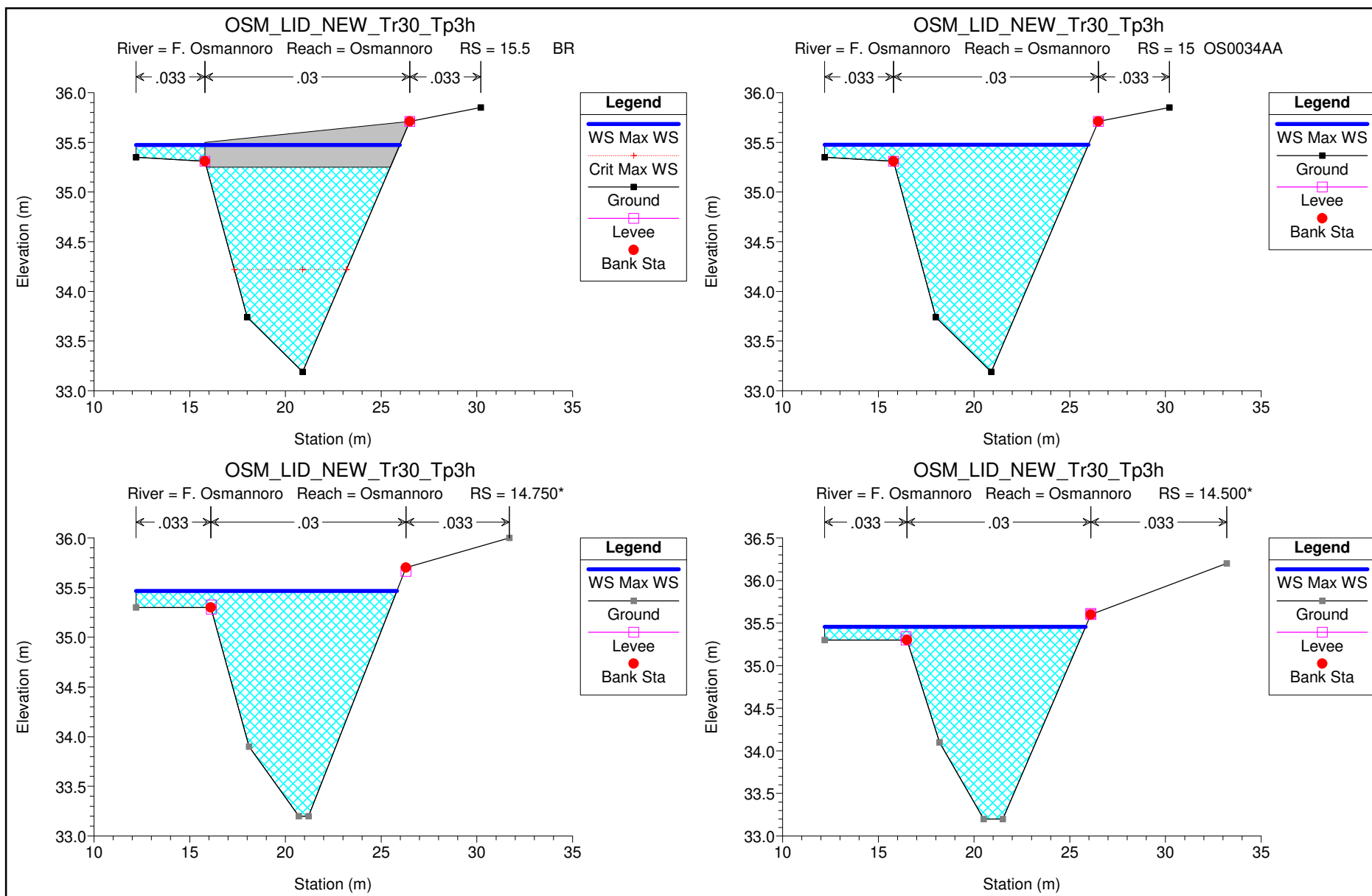


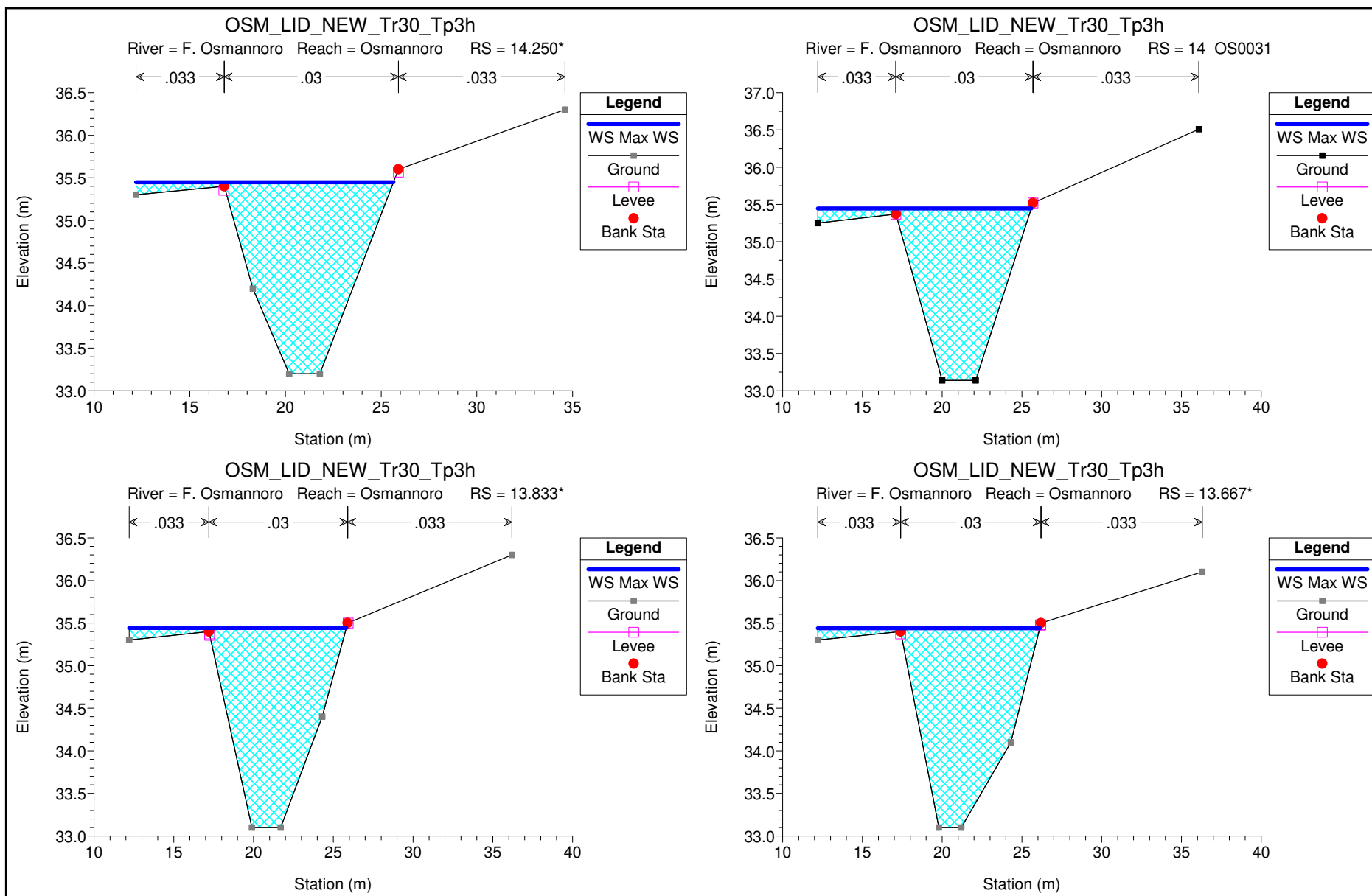


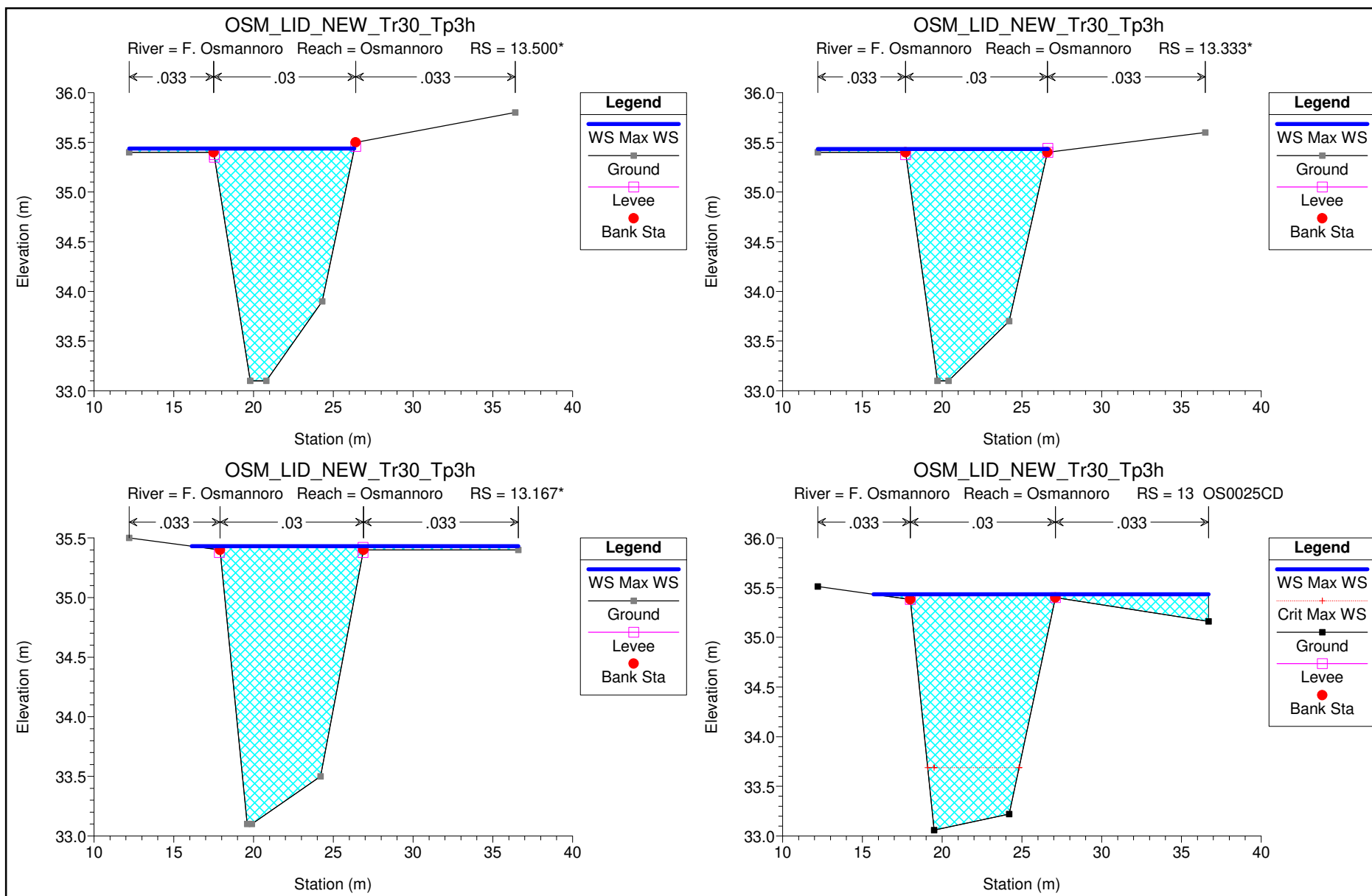


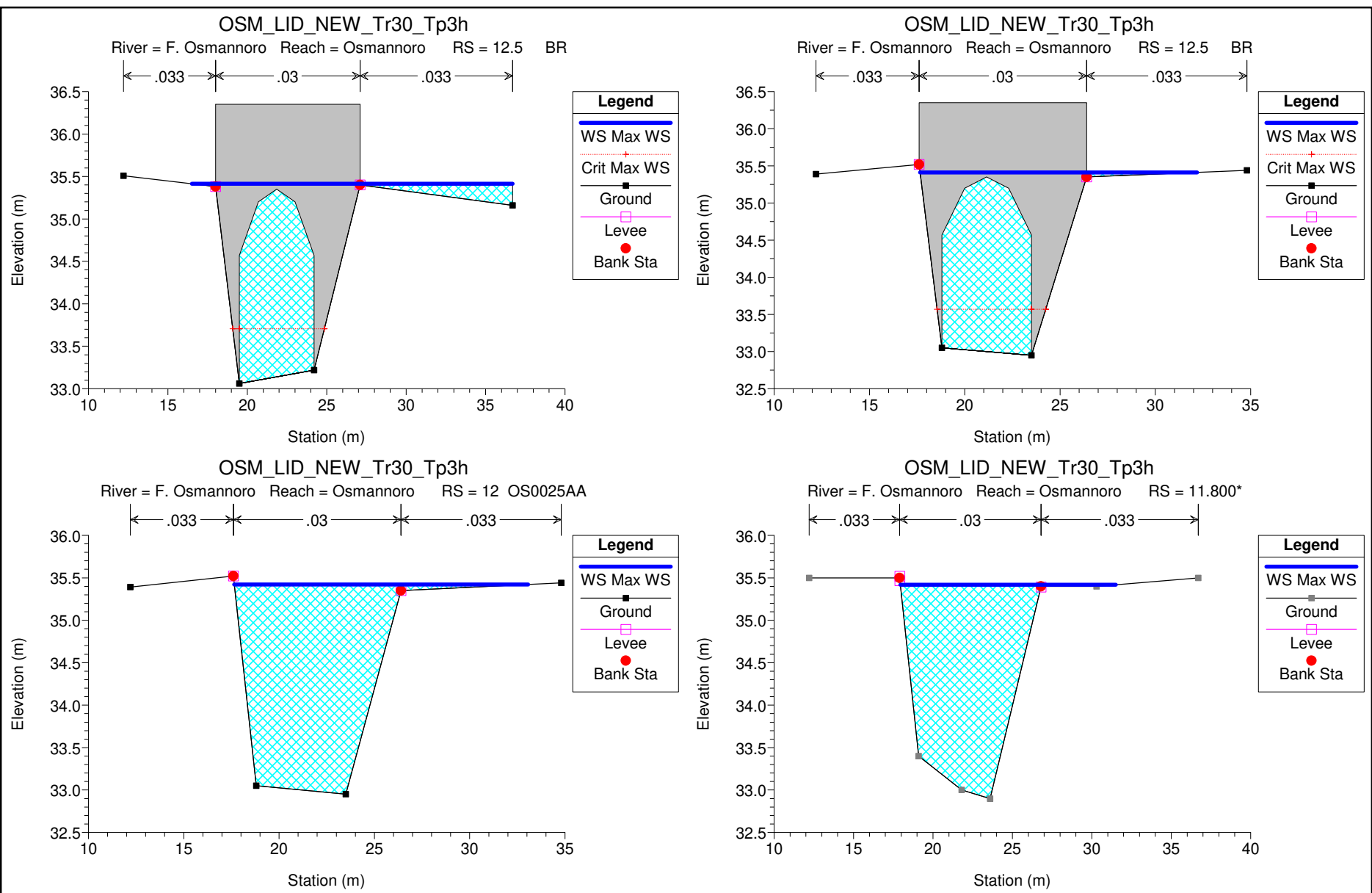


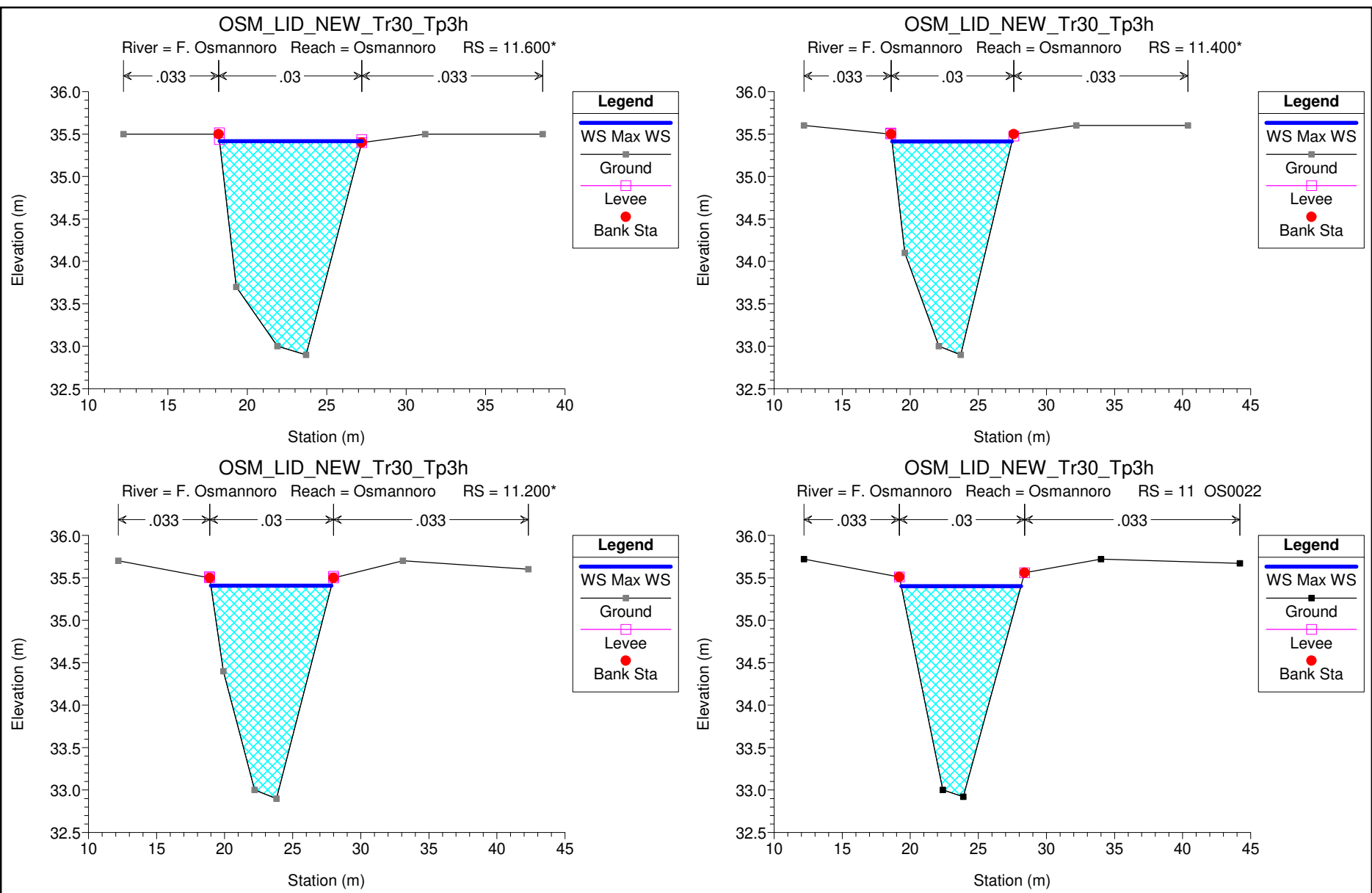


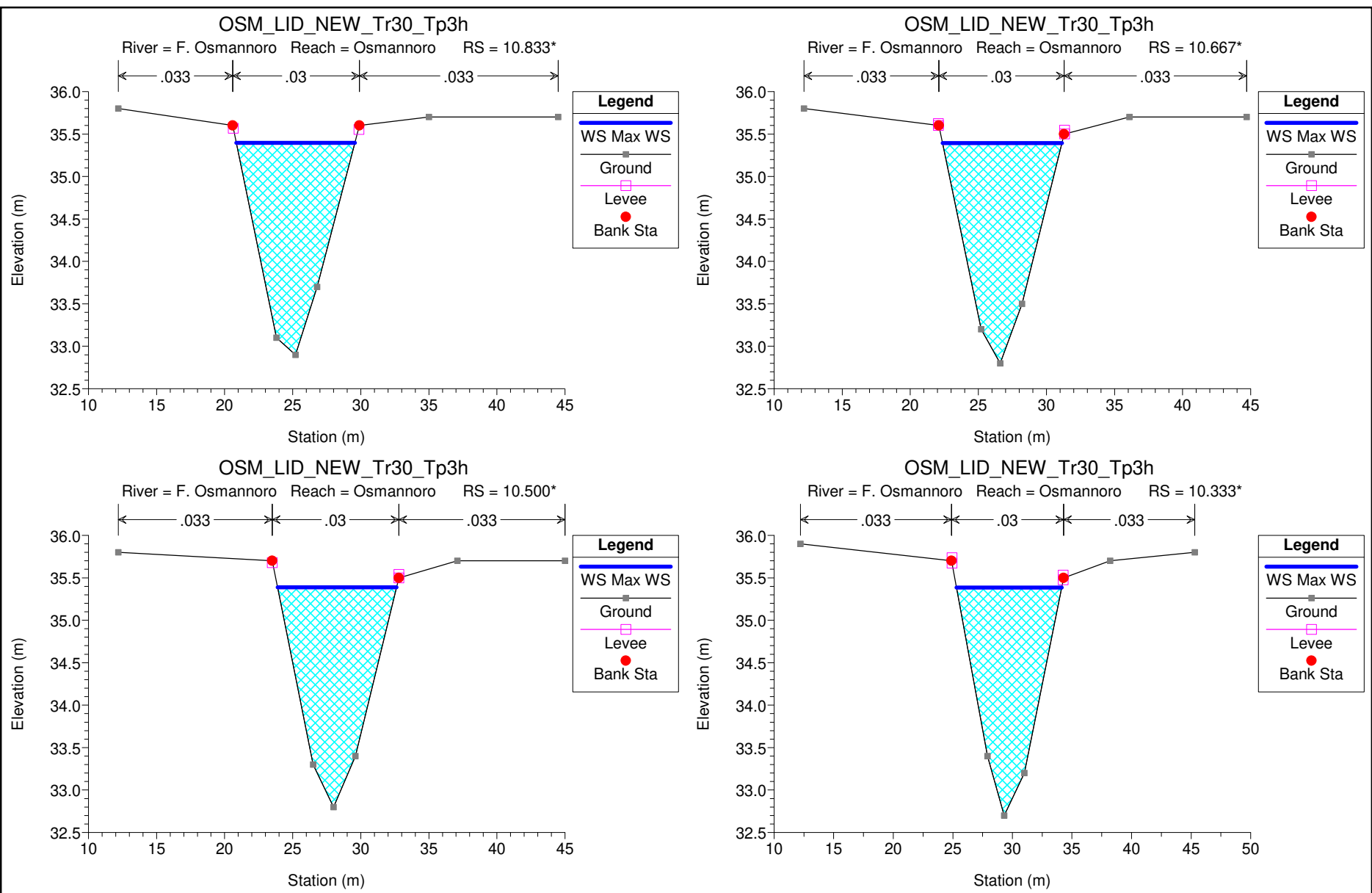


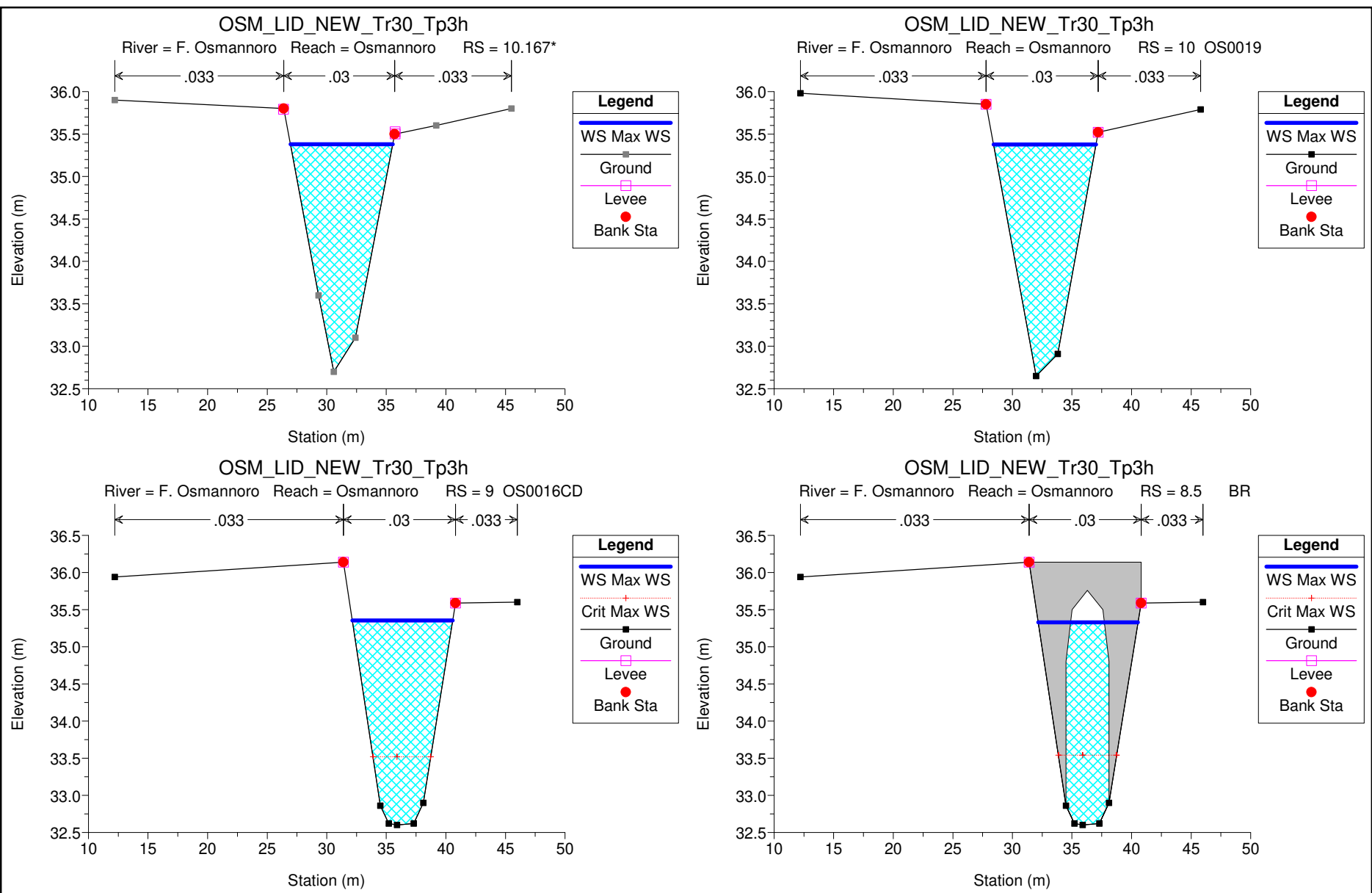


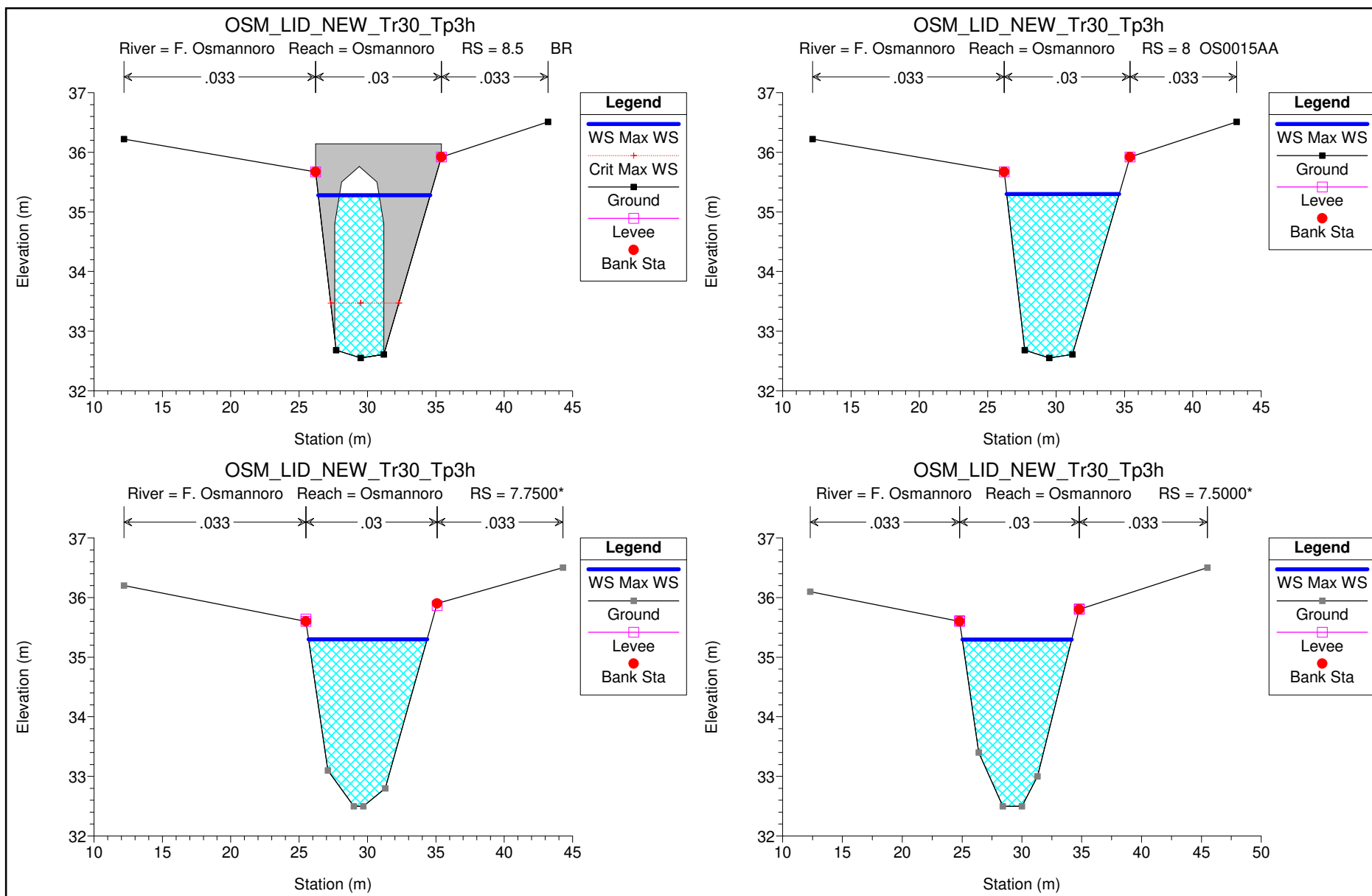


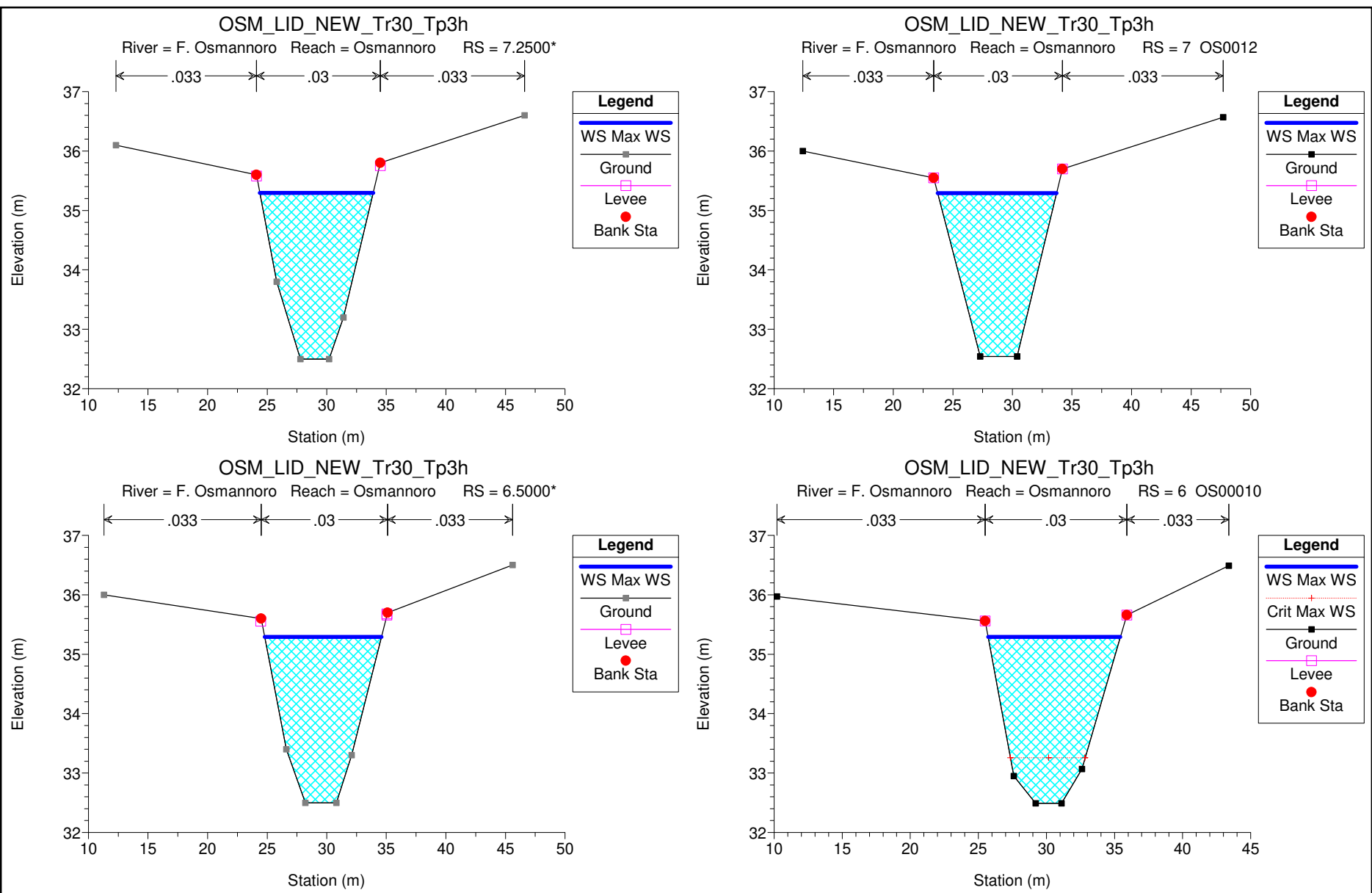


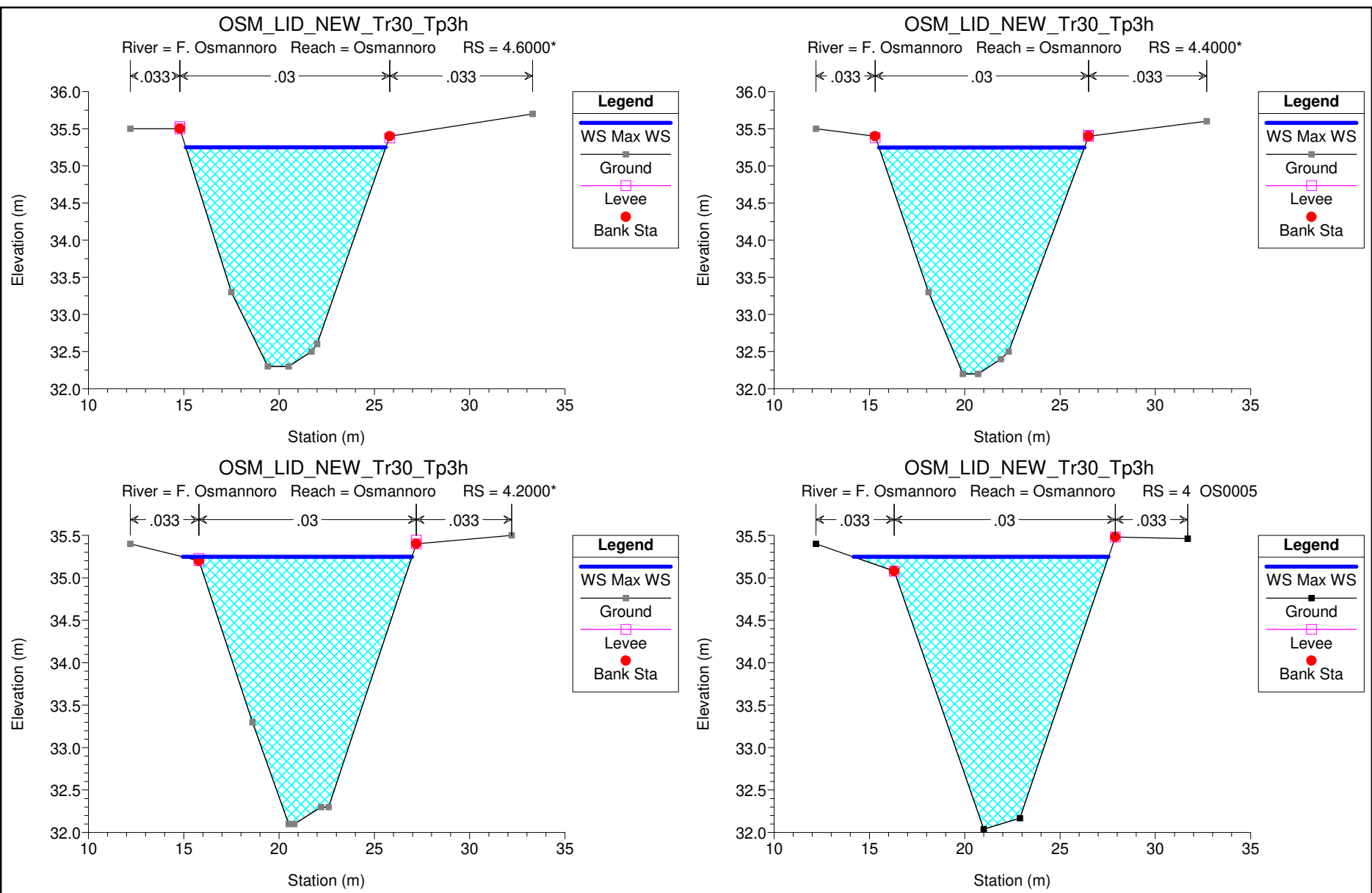


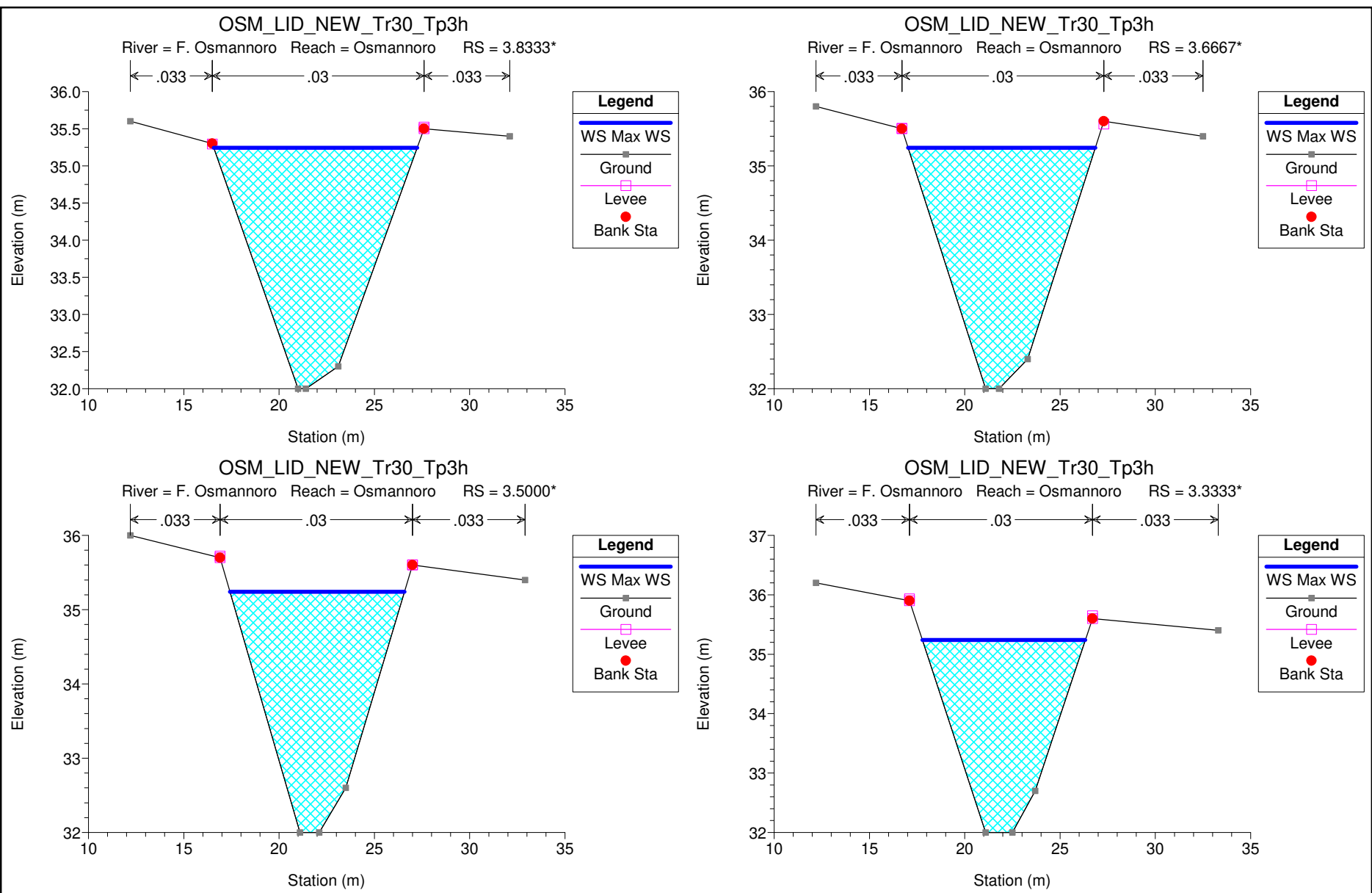


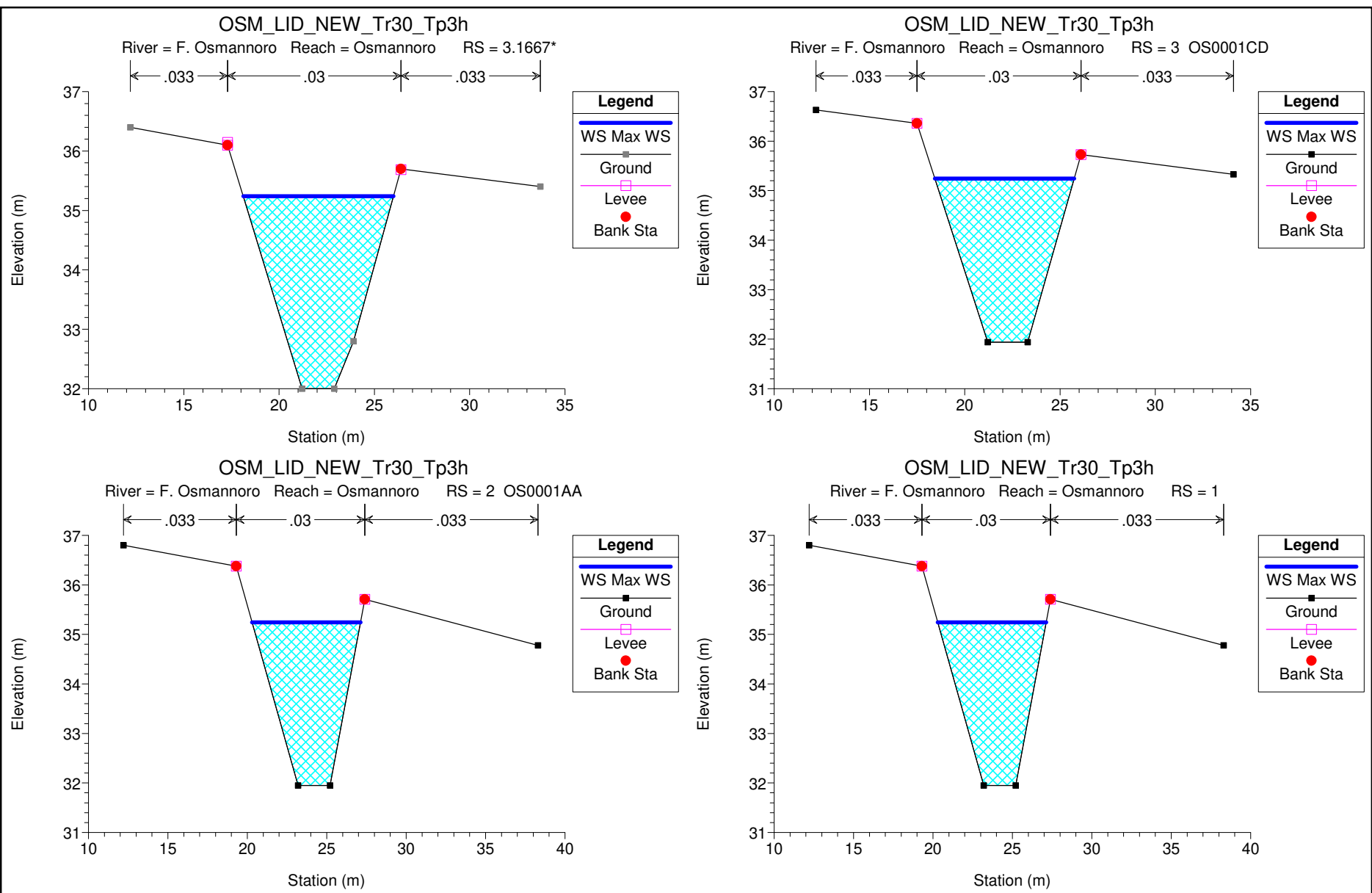


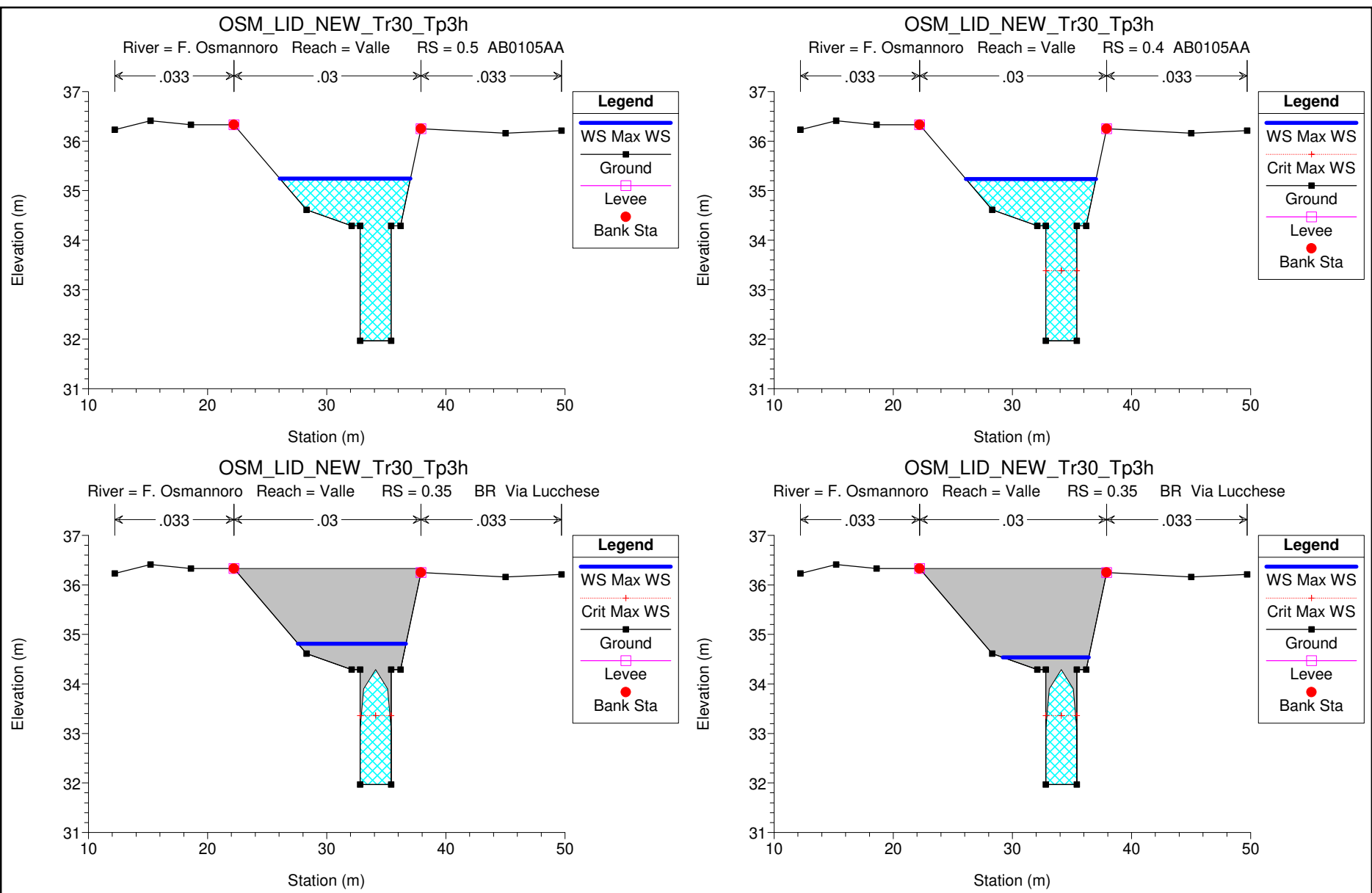


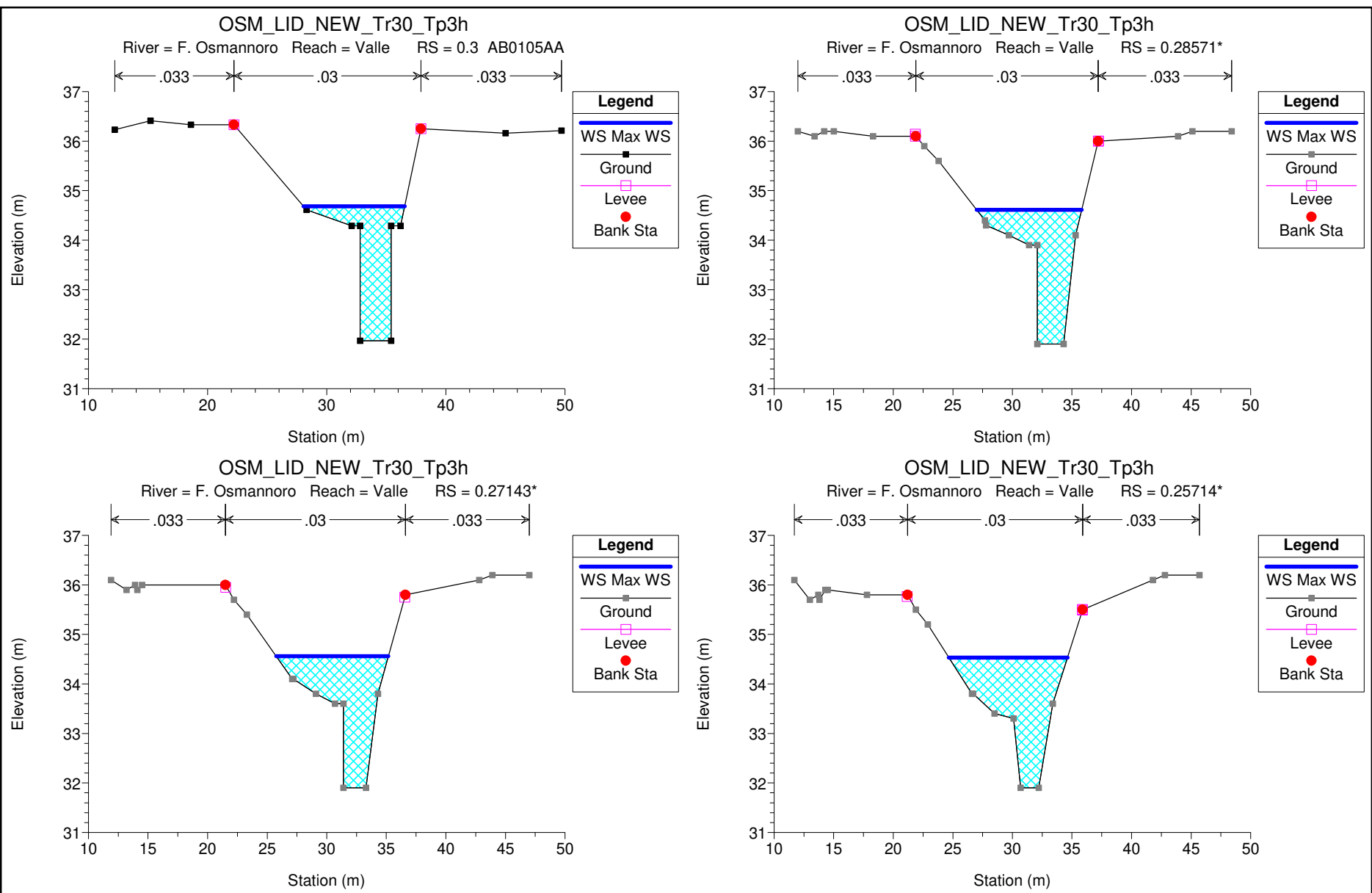


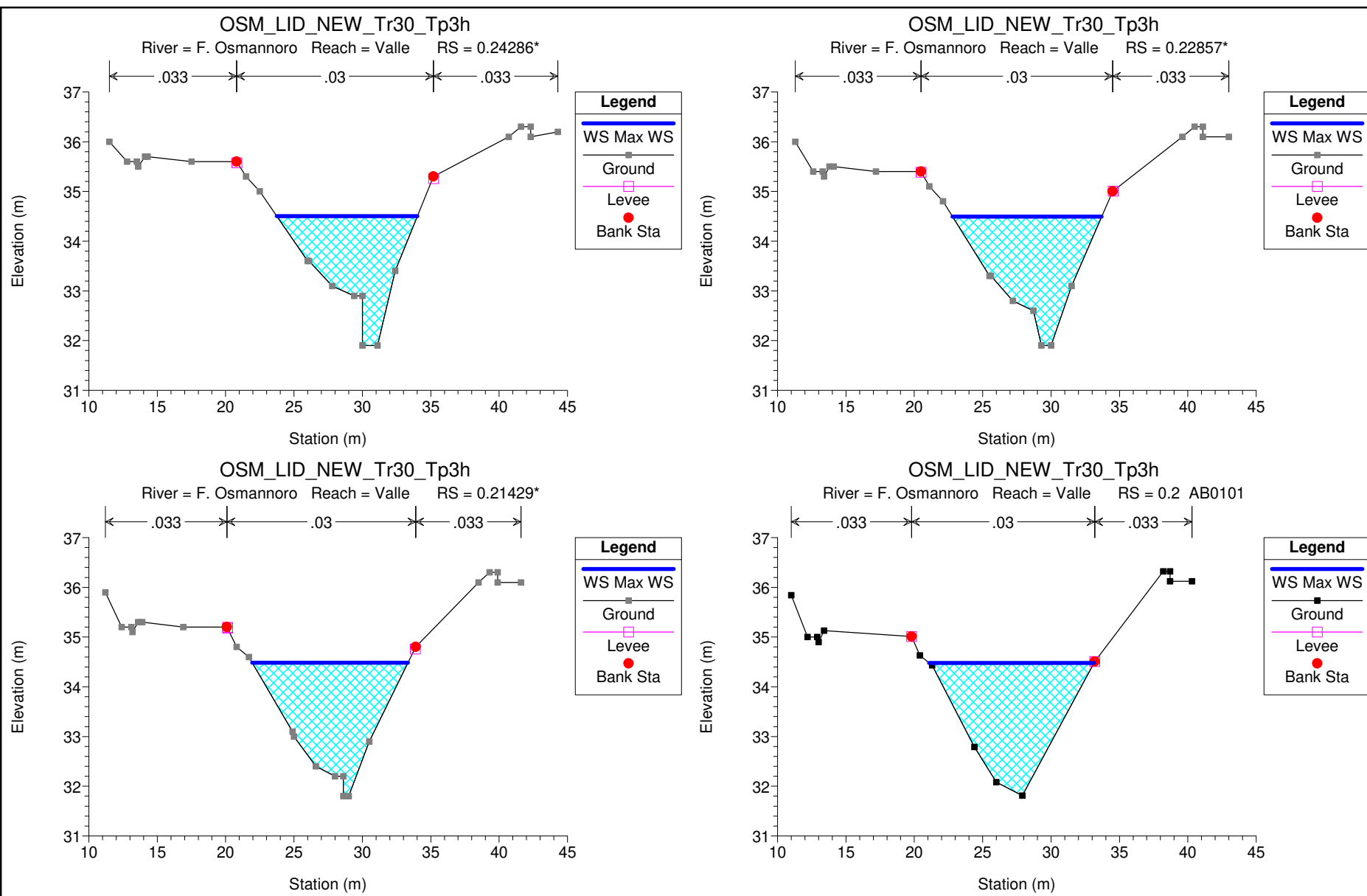


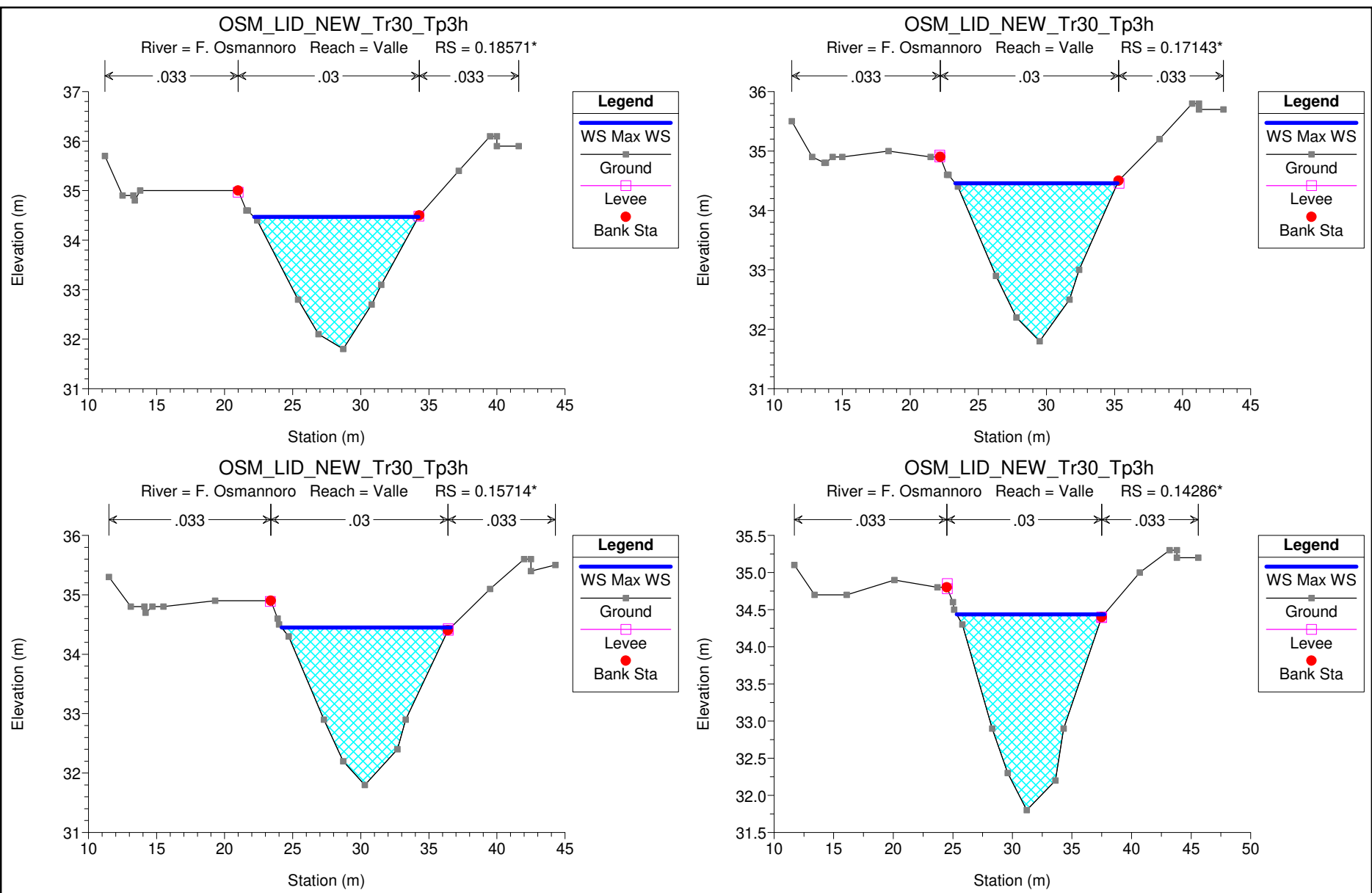


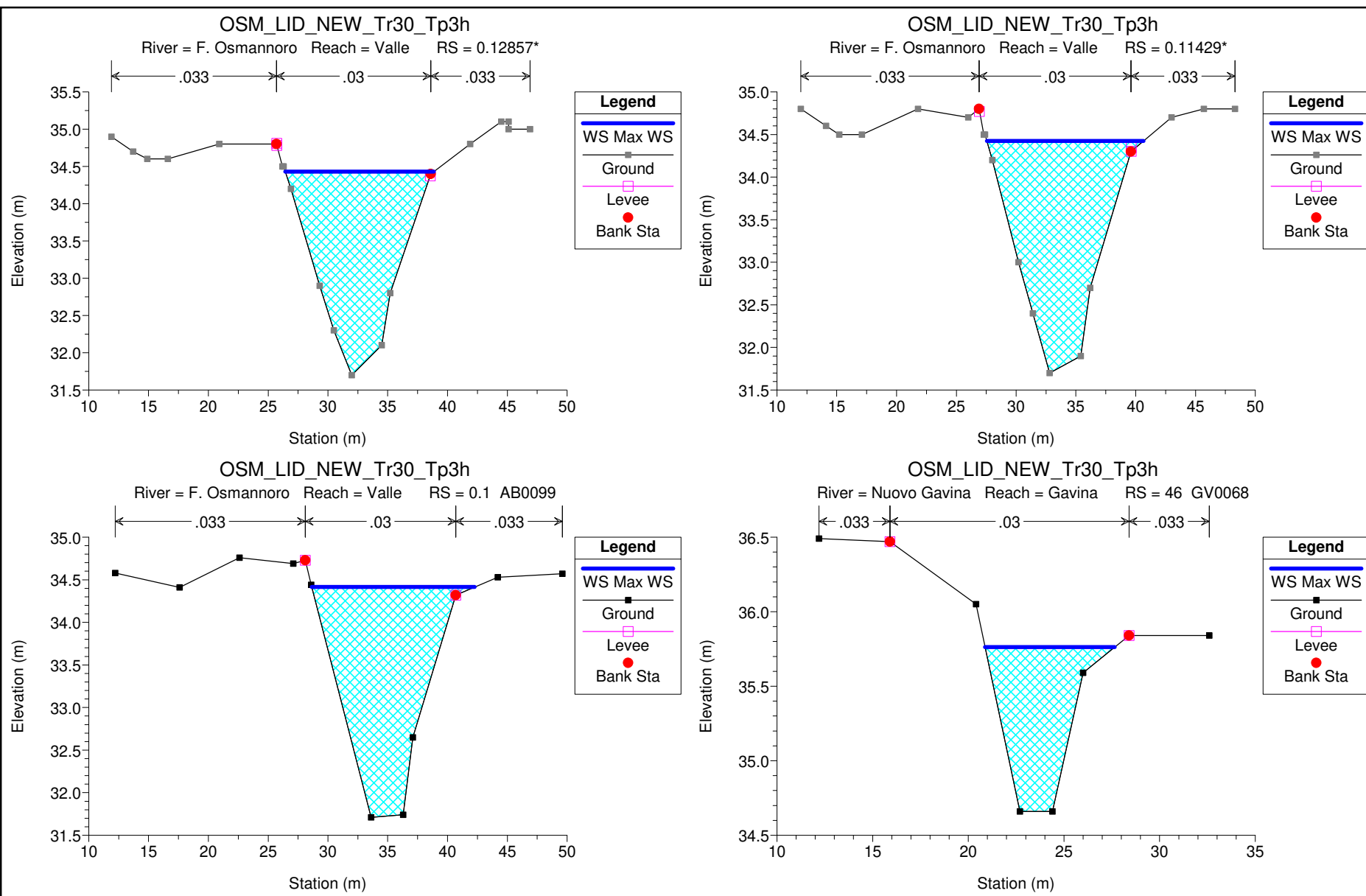


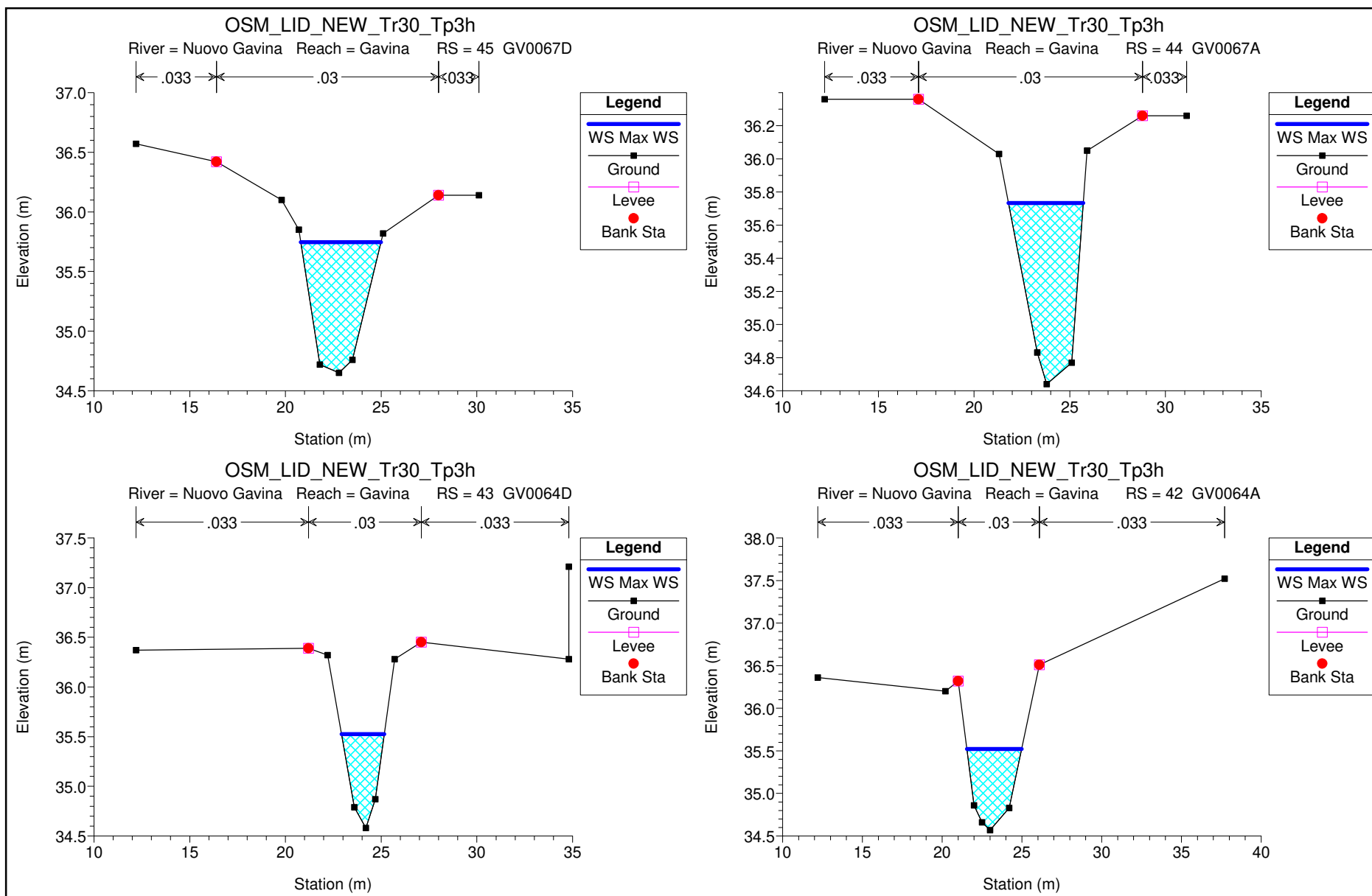


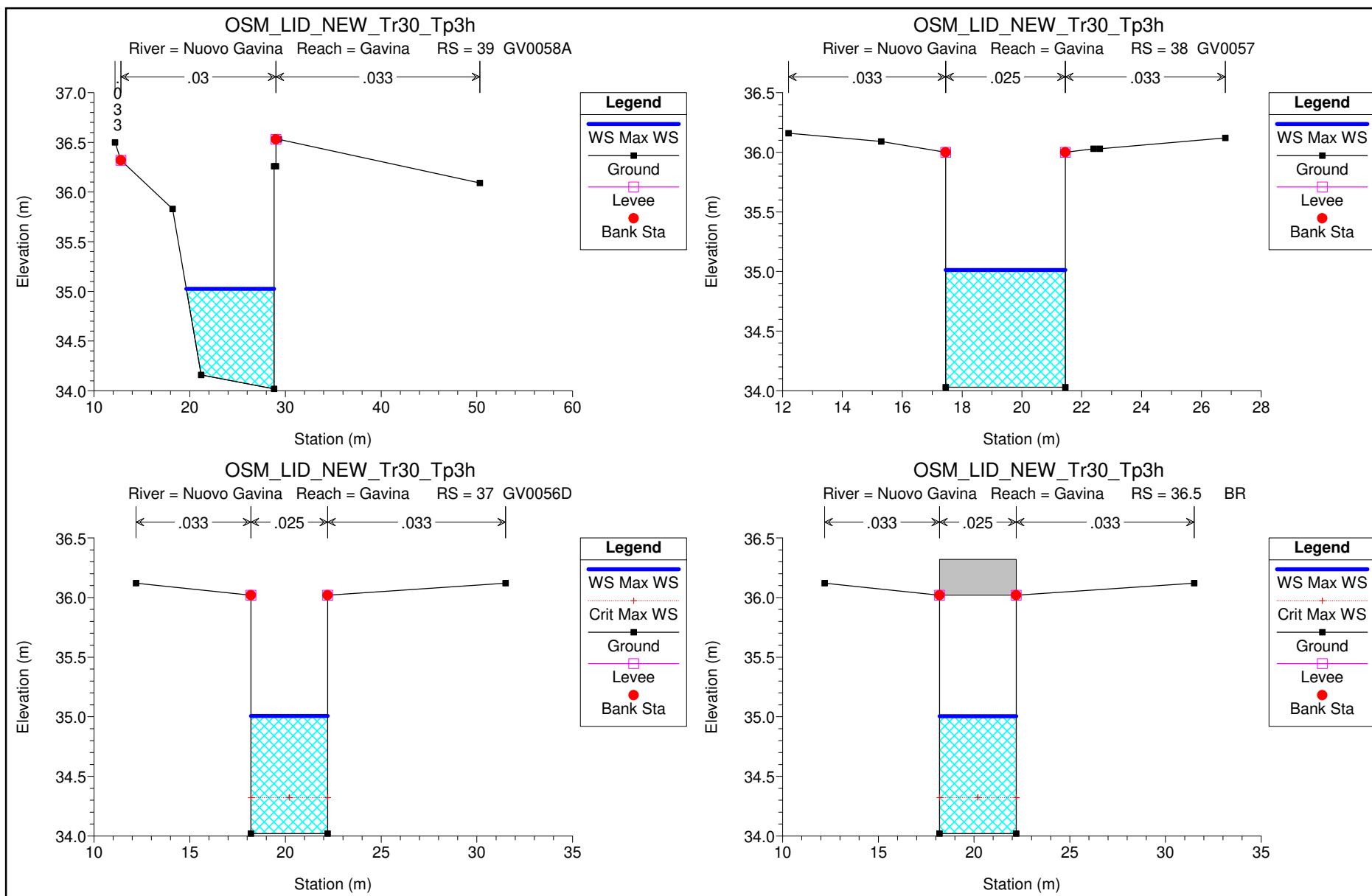


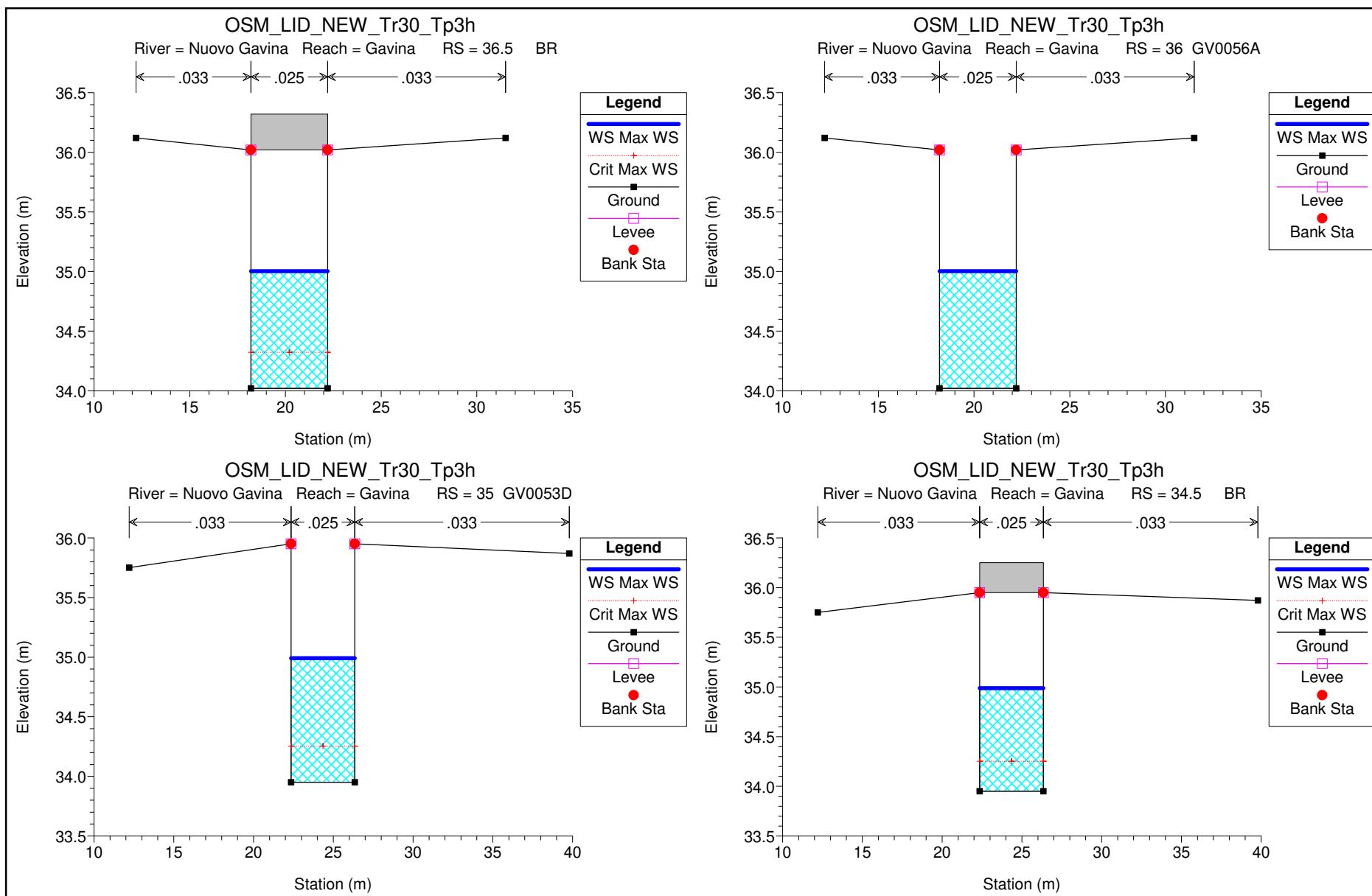


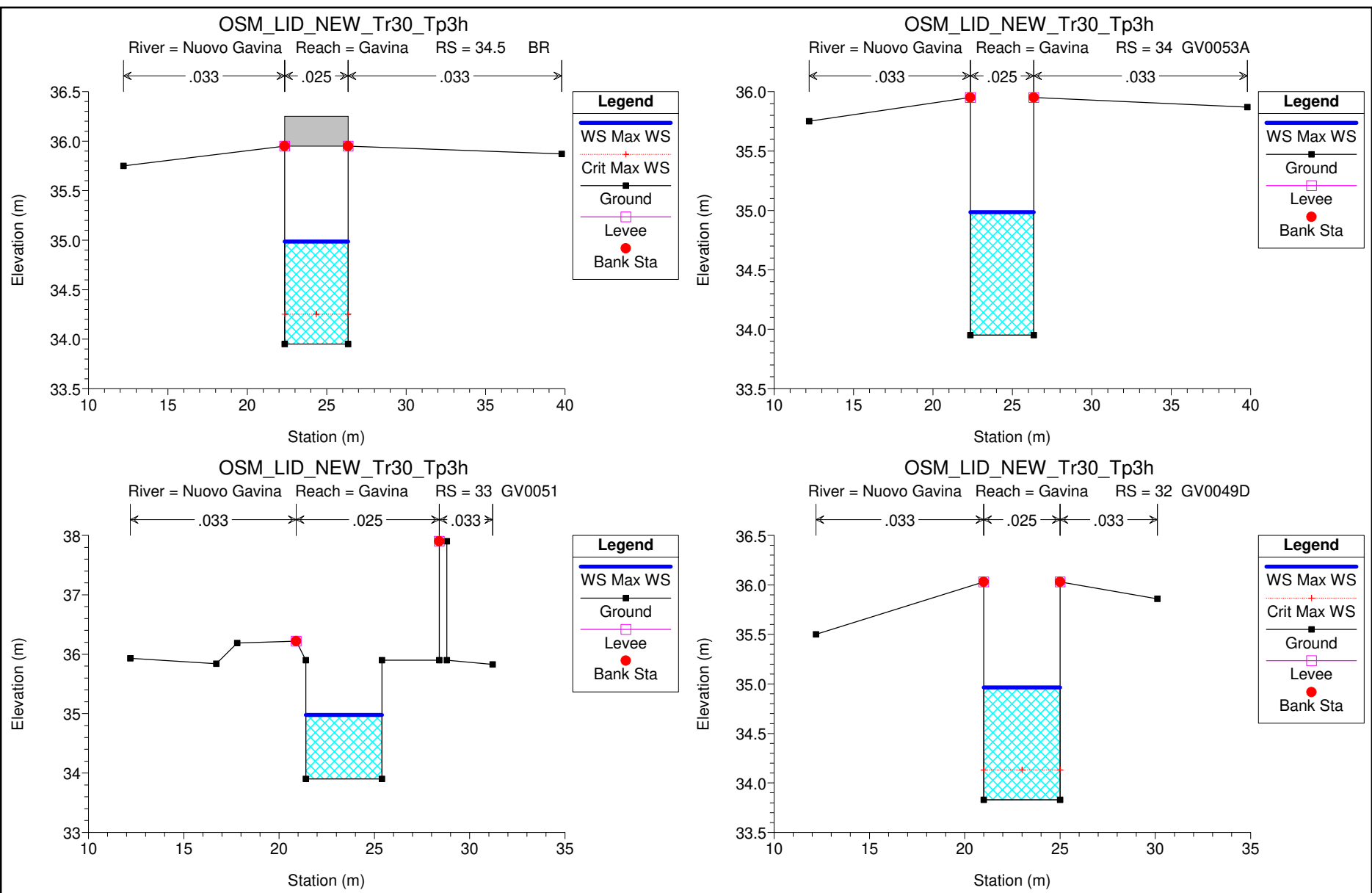


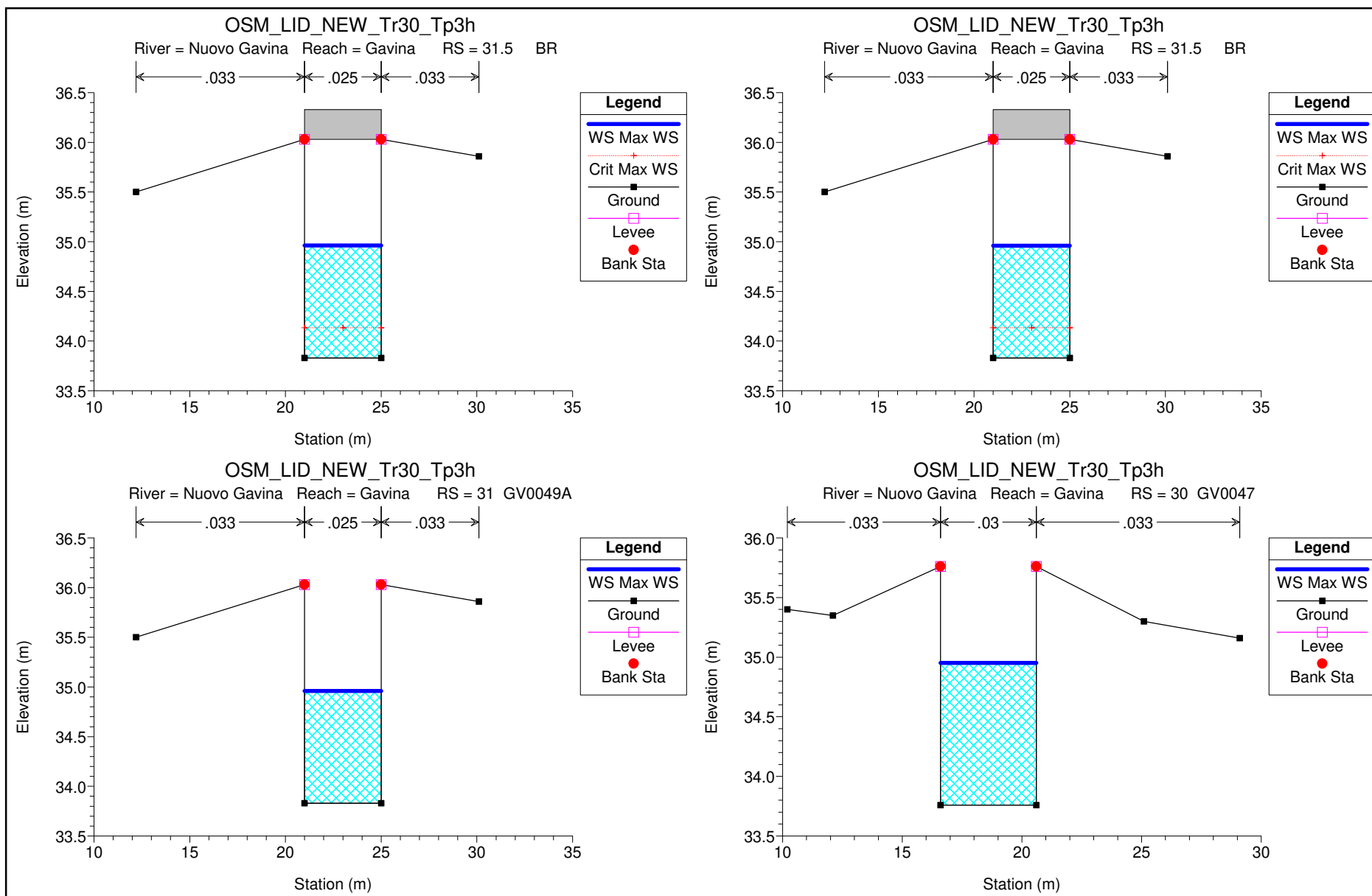


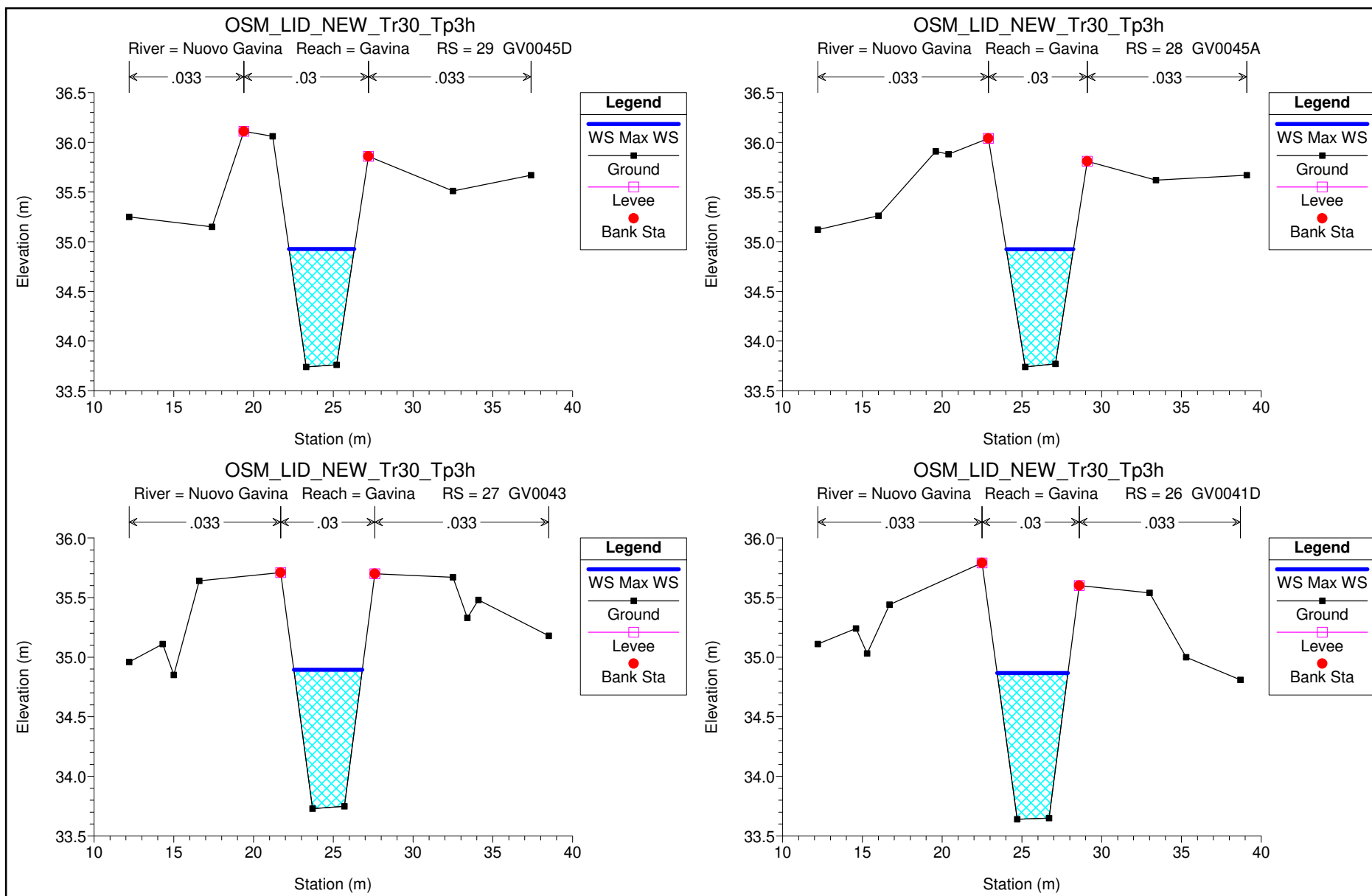


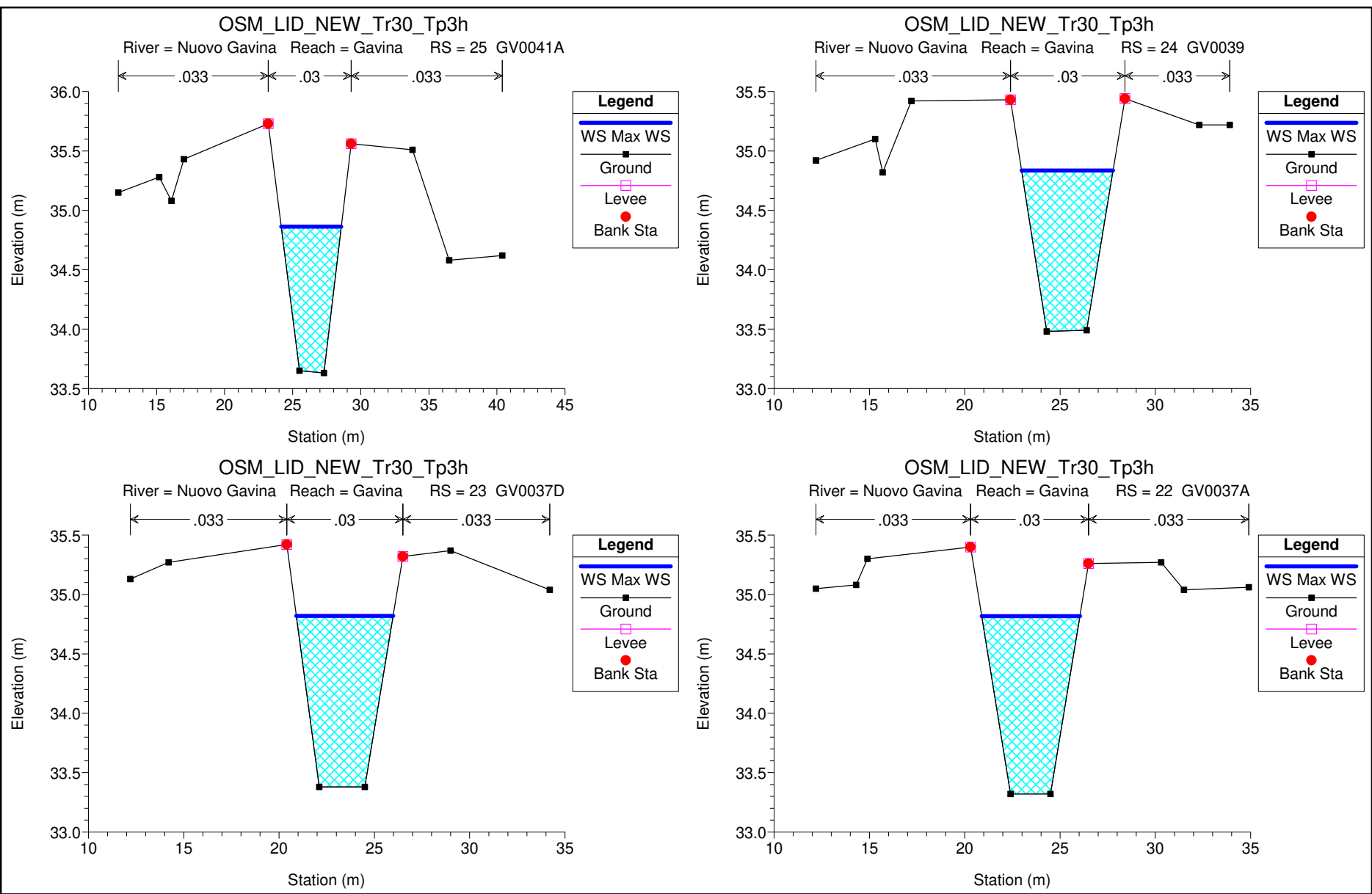


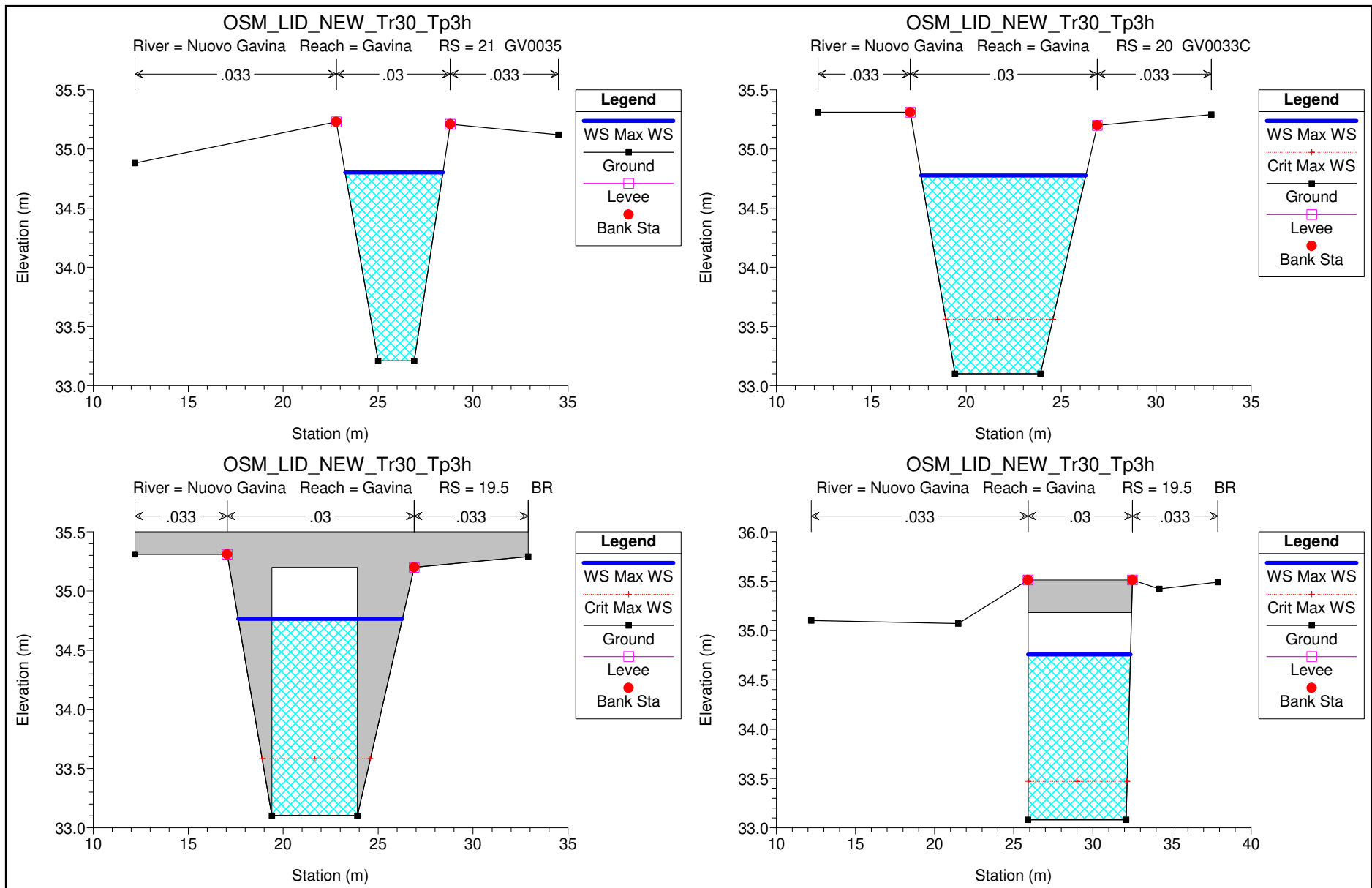


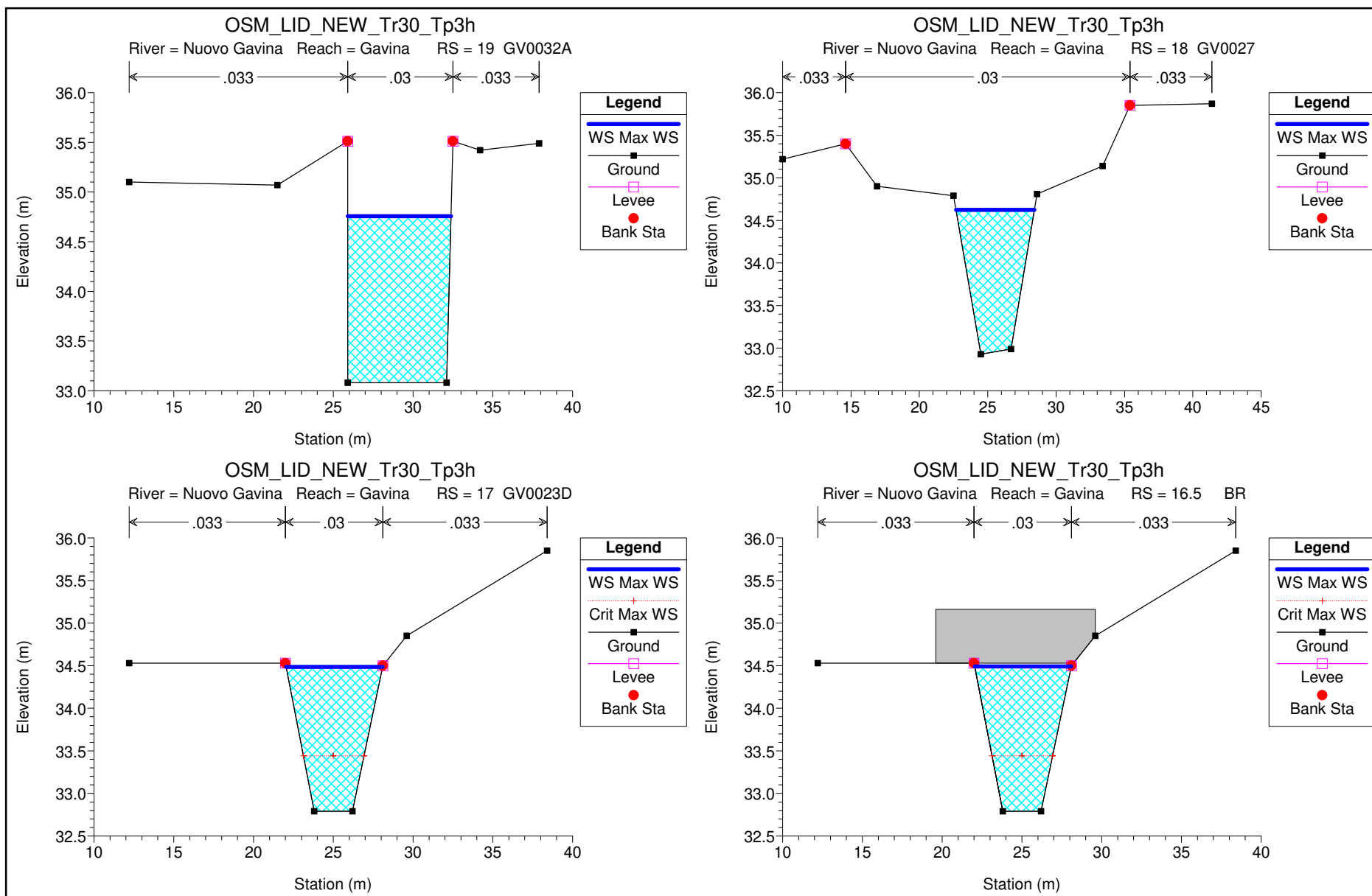


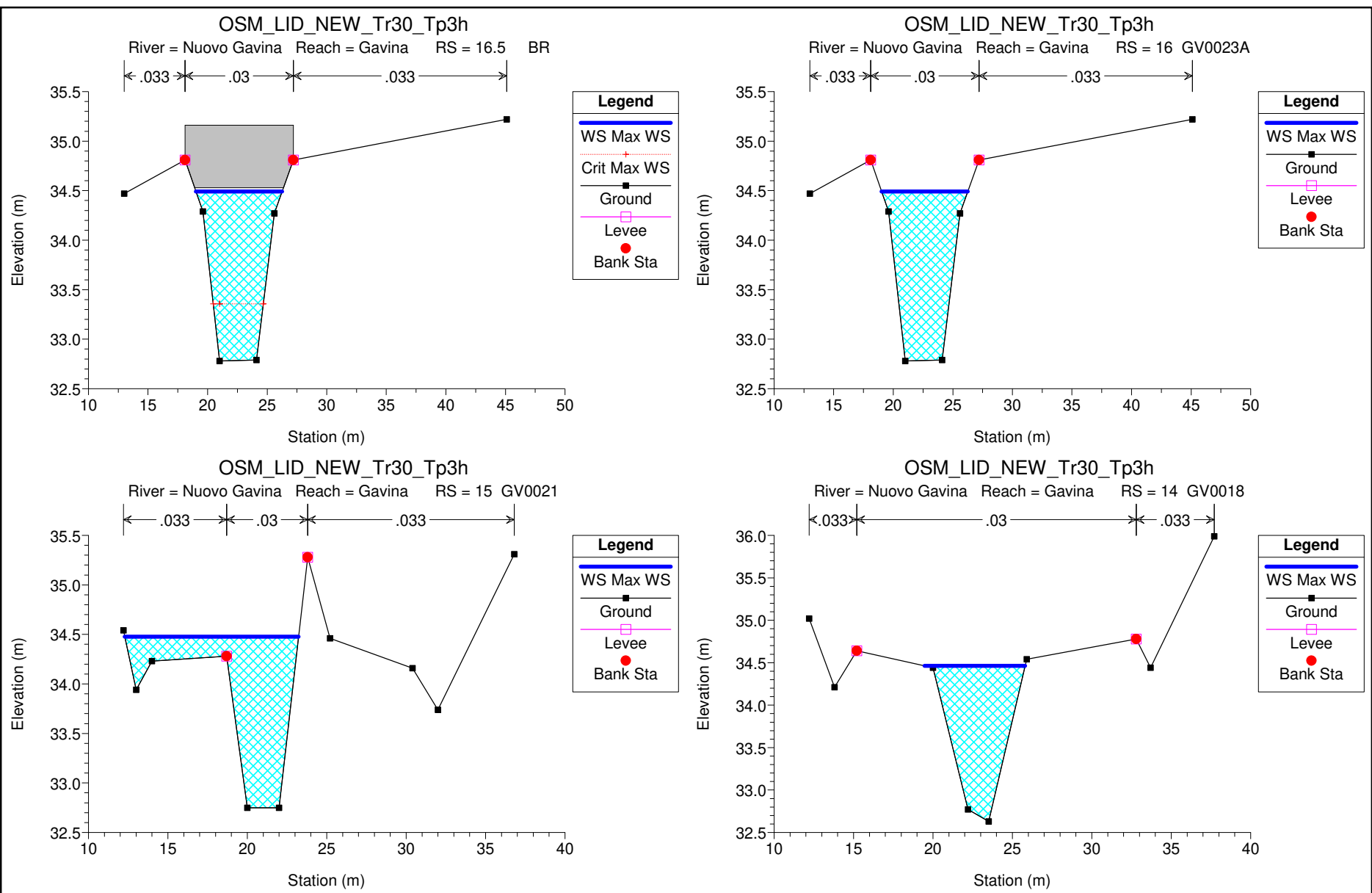


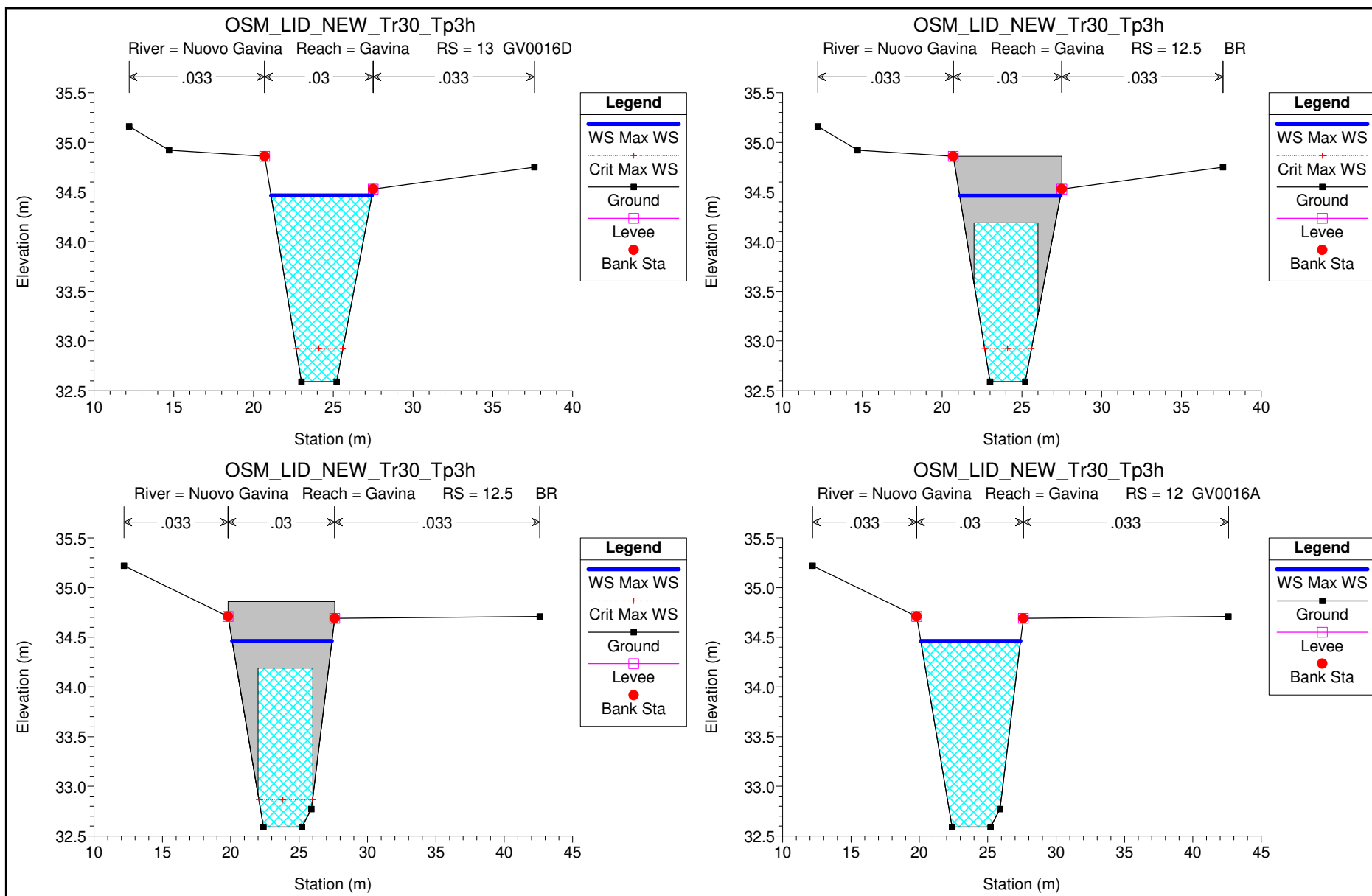


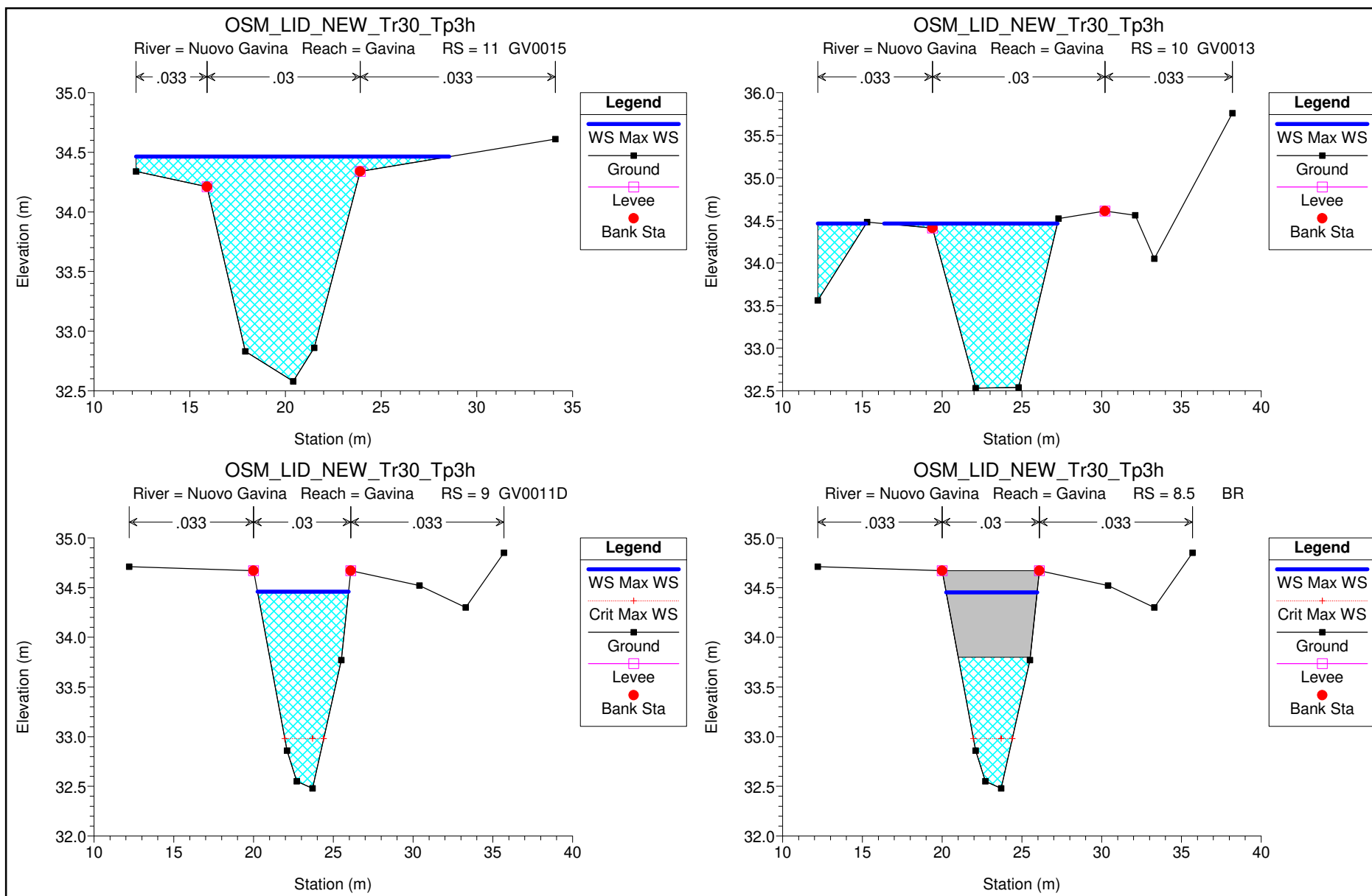


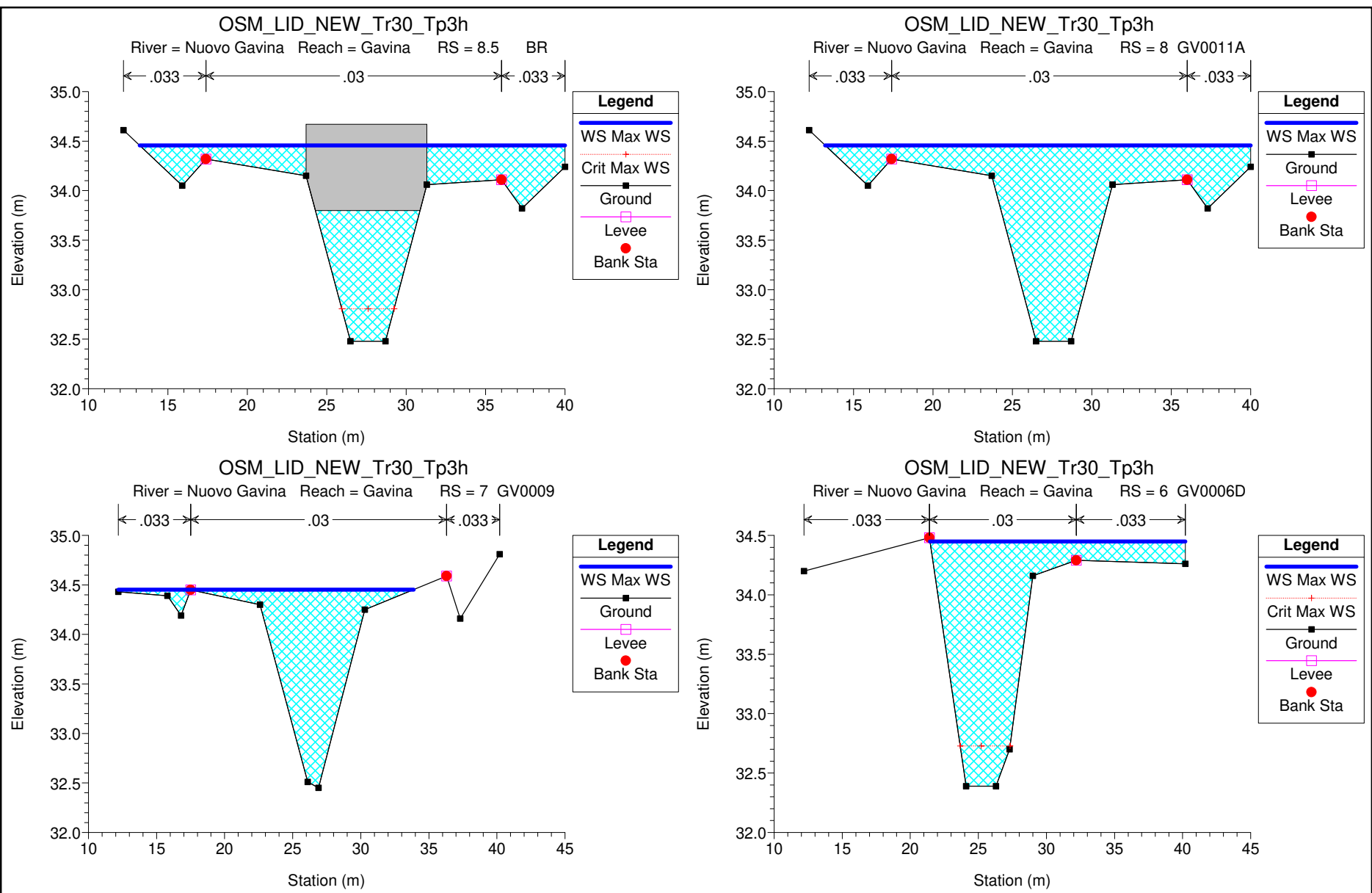


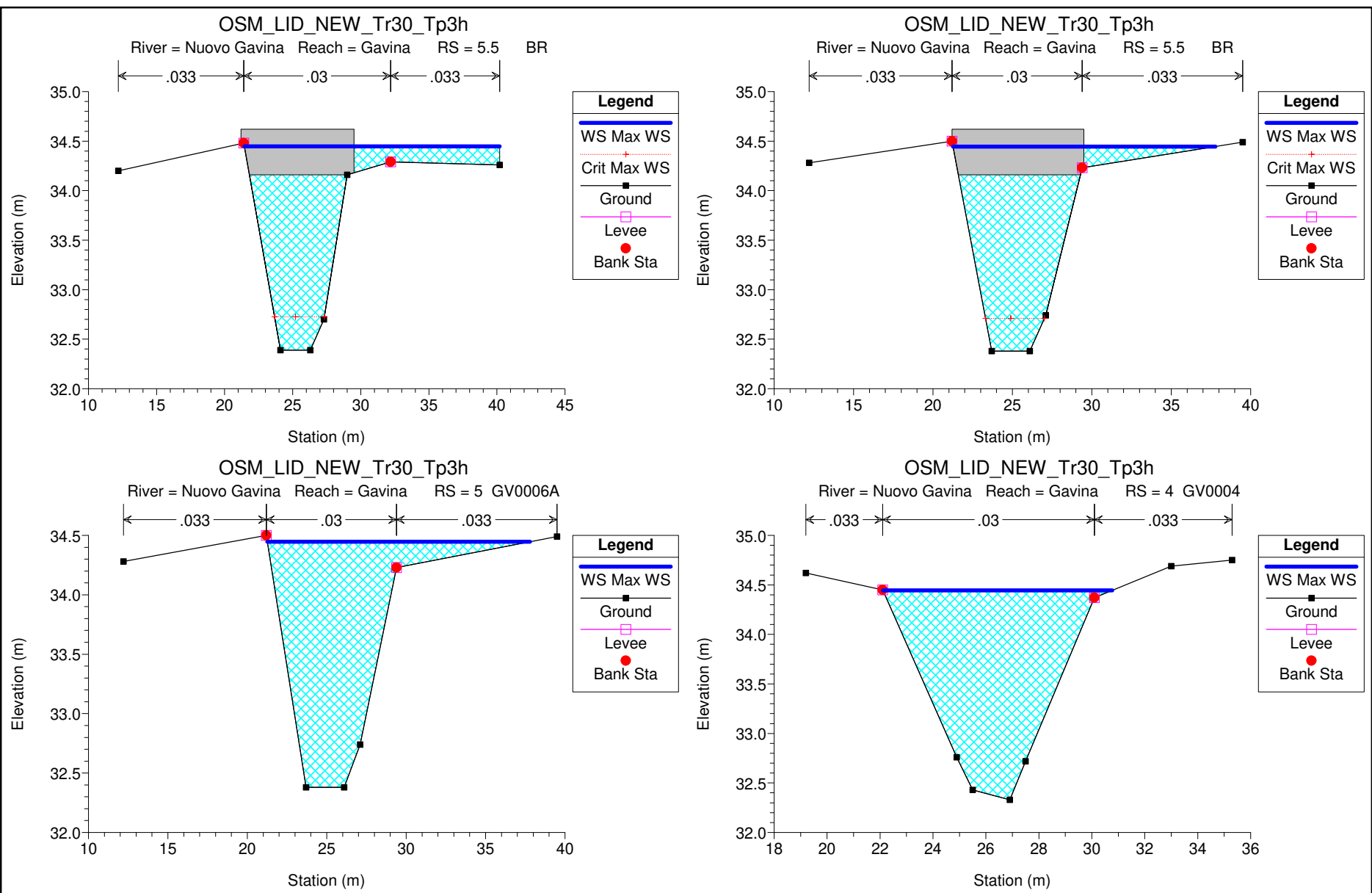


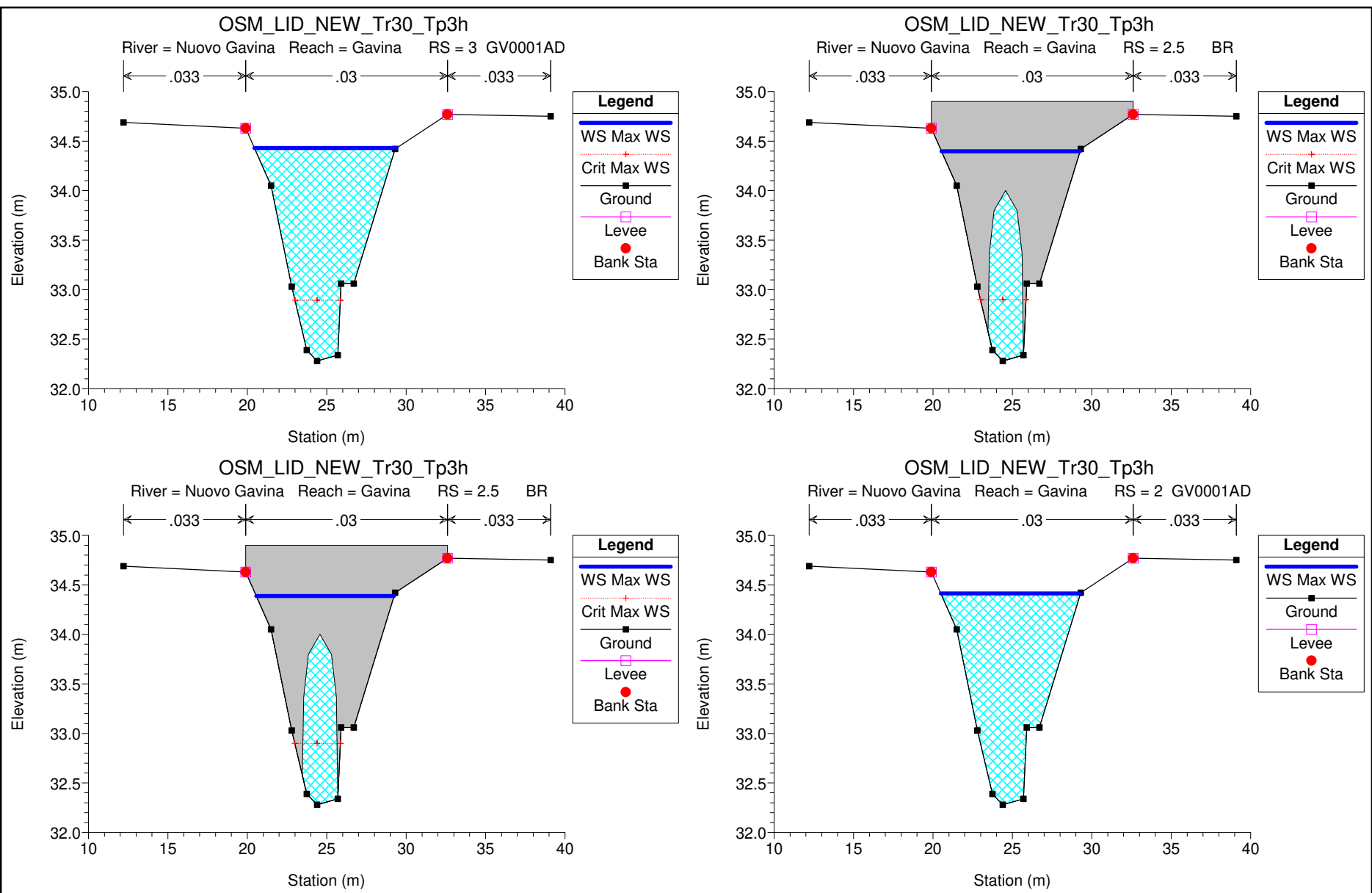






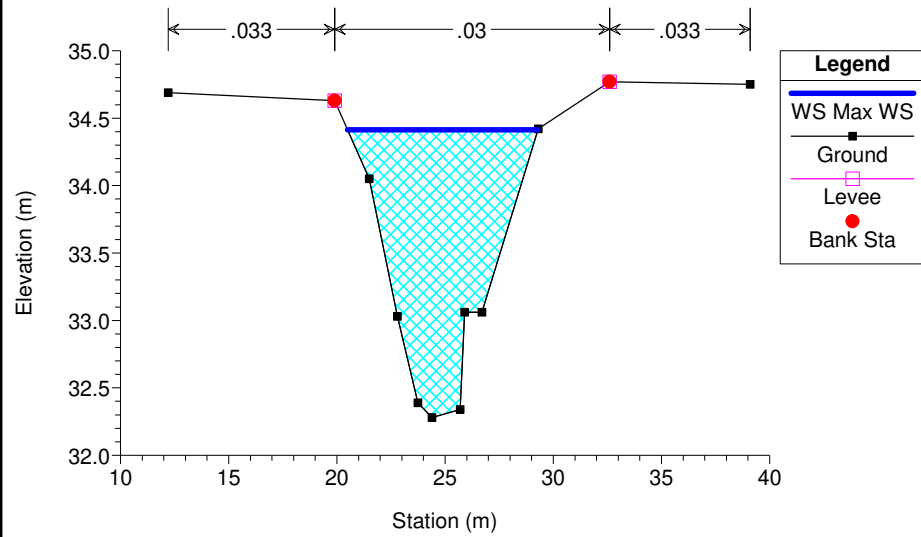






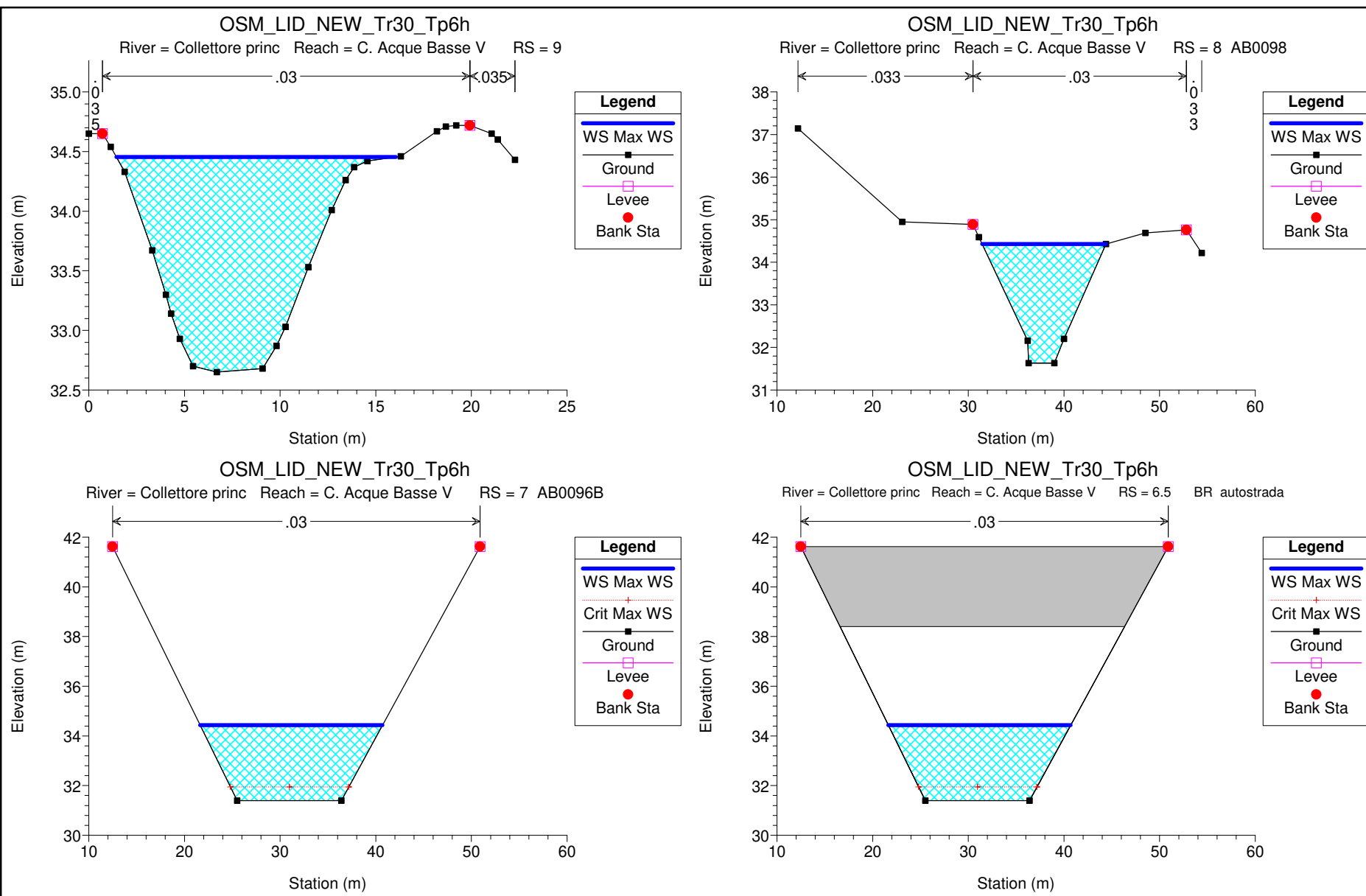
OSM_LID_NEW_Tr30_Tp3h

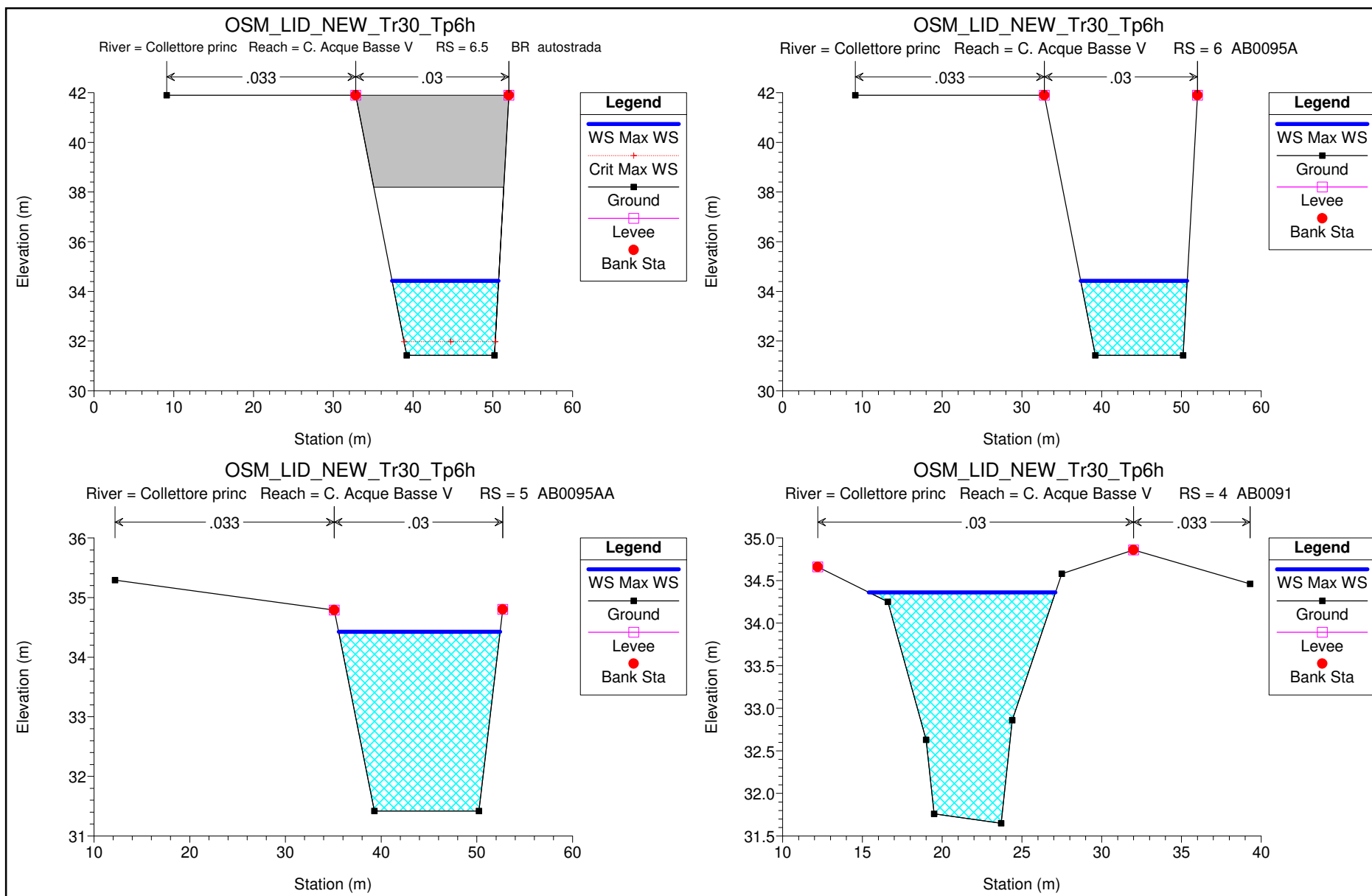
River = Nuovo Gavina Reach = Gavina RS = 1 GV0001AD

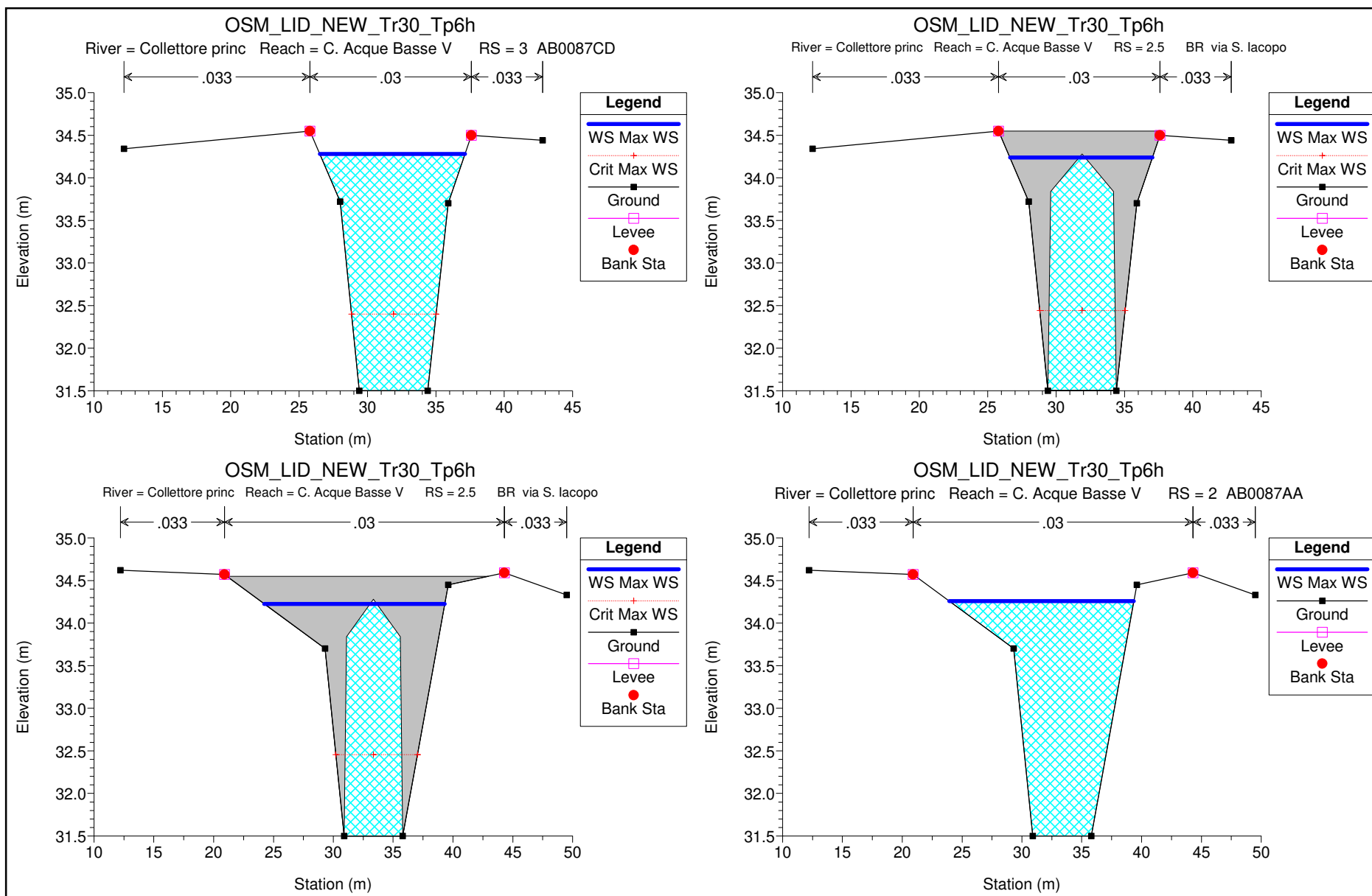


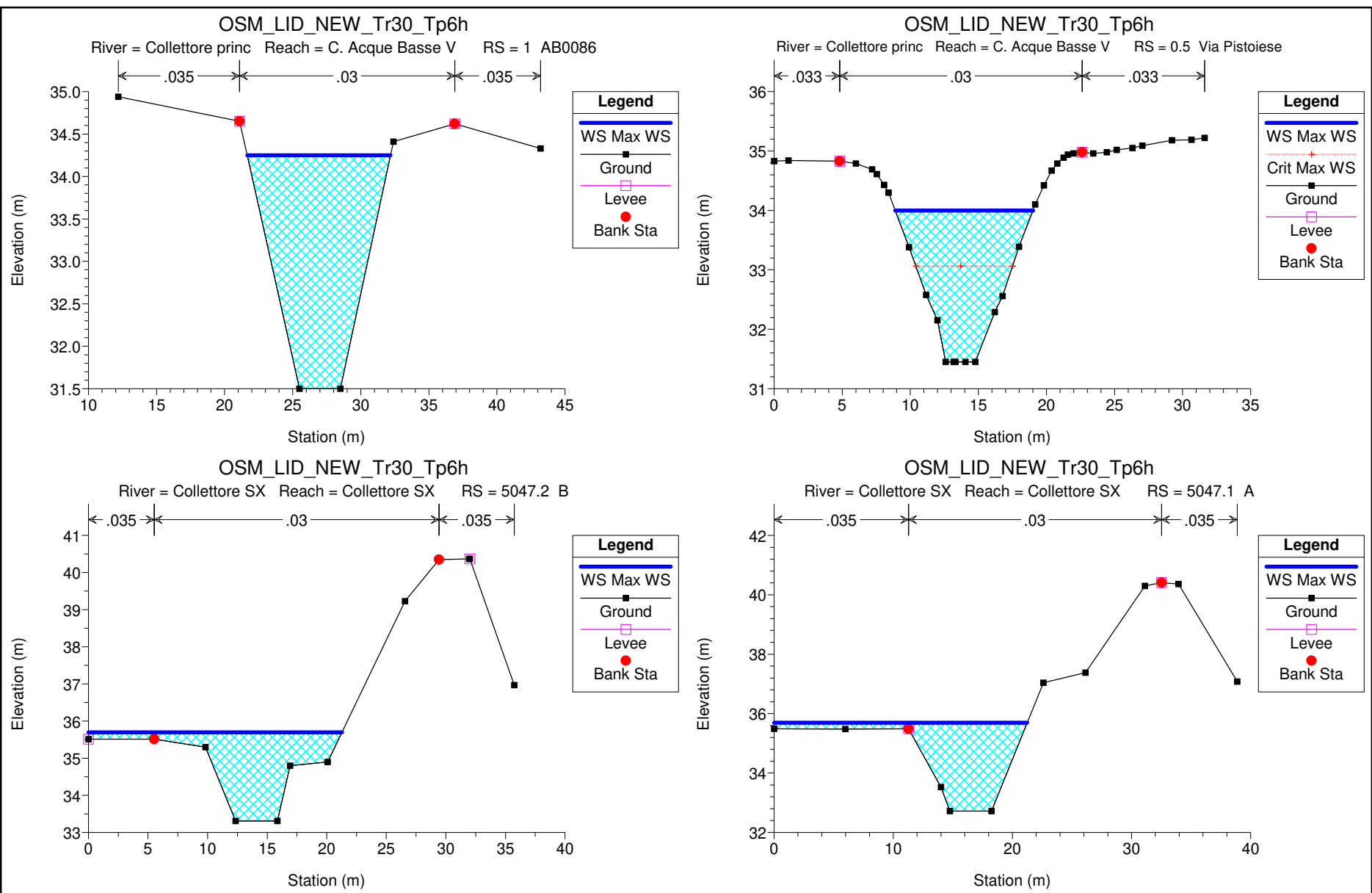
Verifiche idrauliche Tr 30 anni Tp 6h

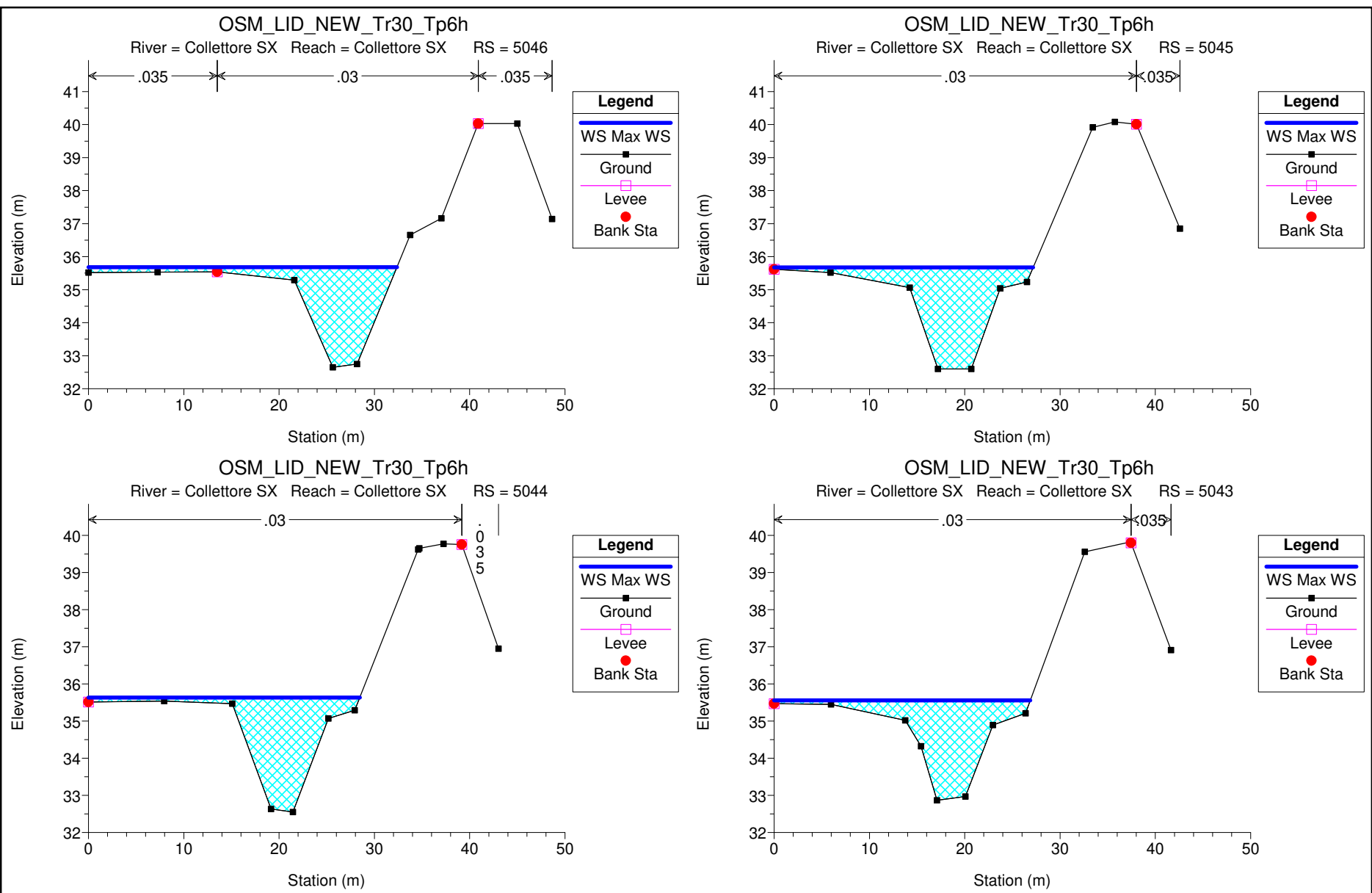
**Collettore sinistro acque basse – Fosso Osmannoro – Fosso Nuova Gavine – Collettore
principale delle acque basse**

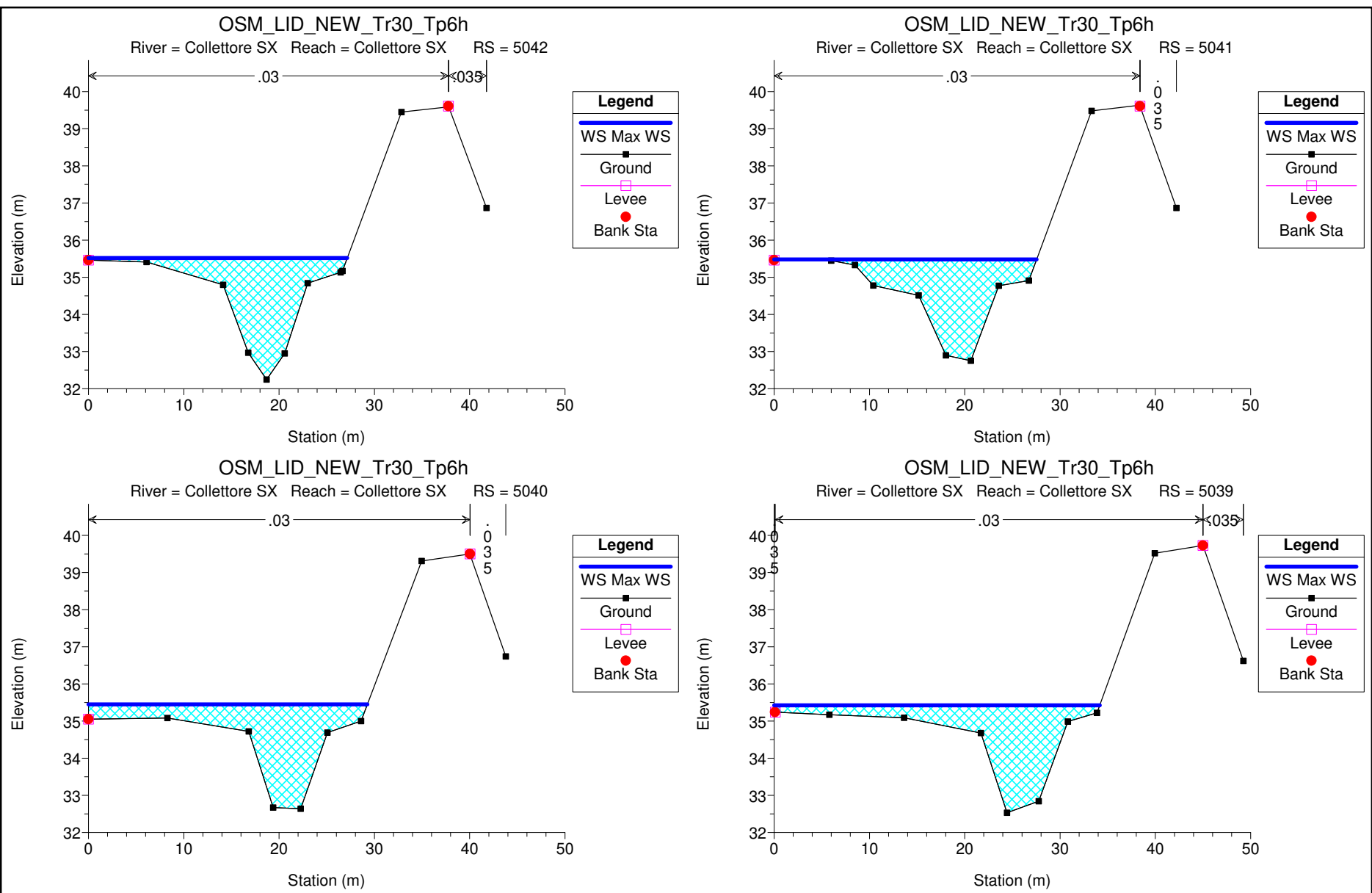


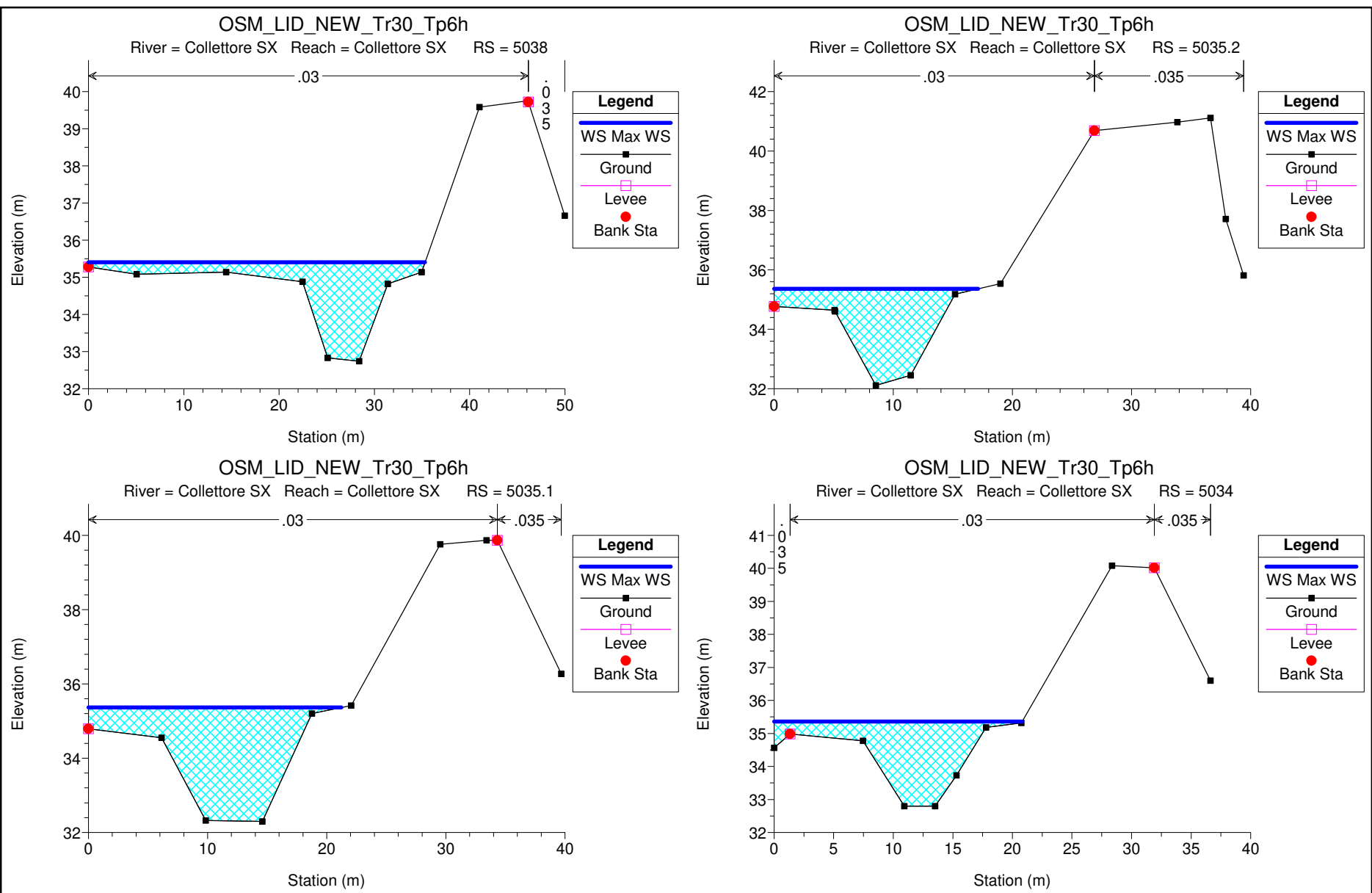


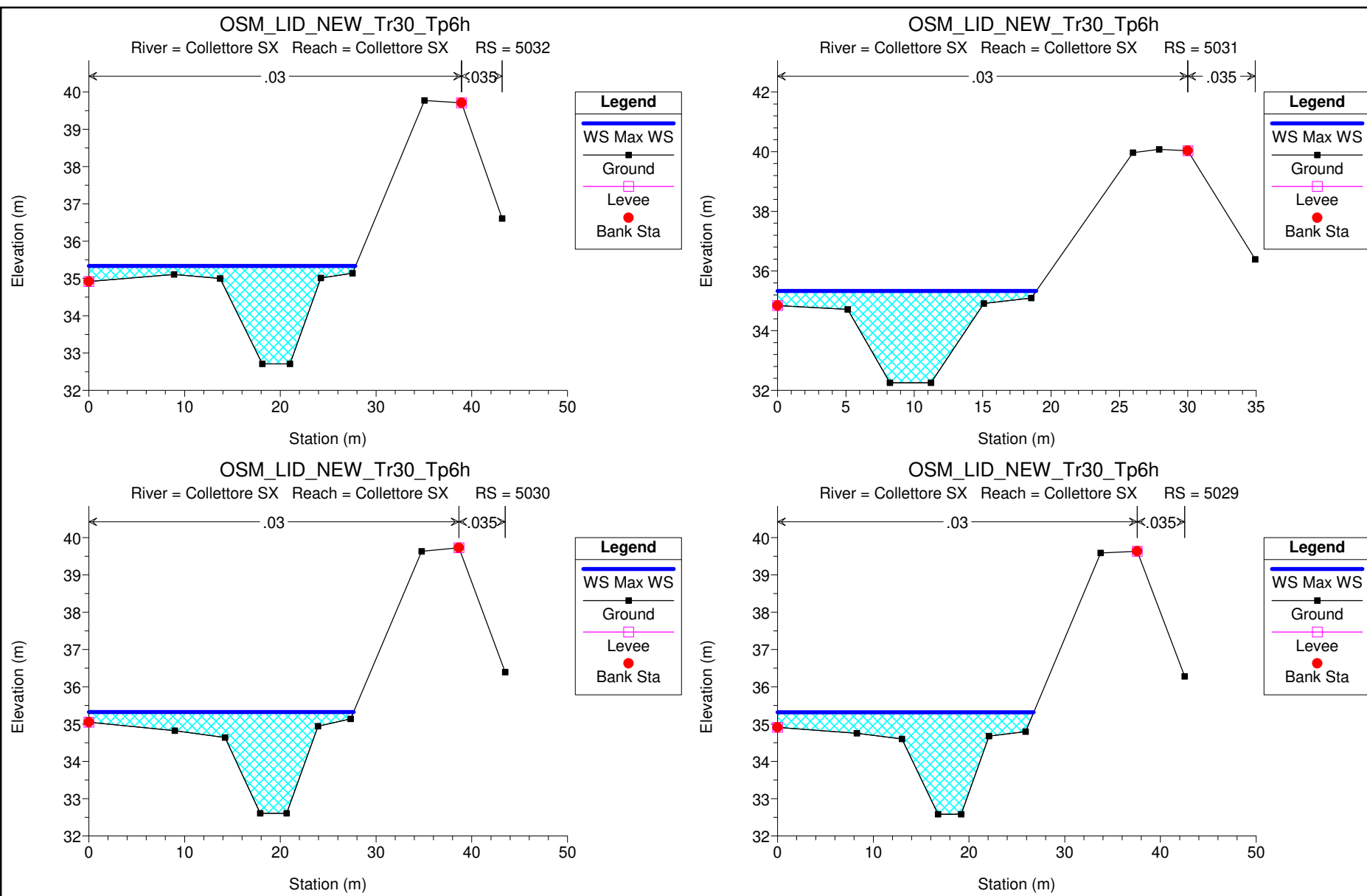


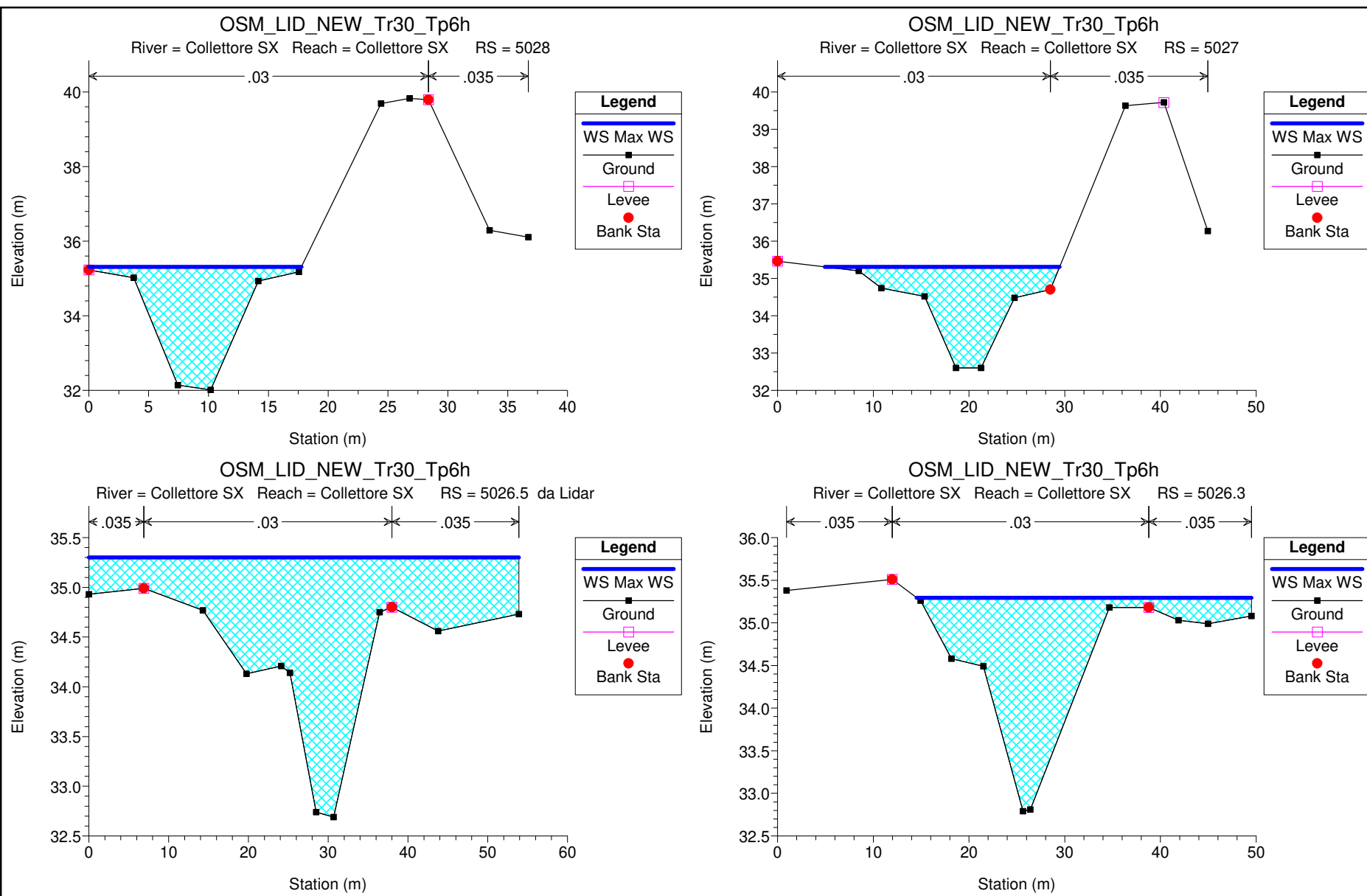


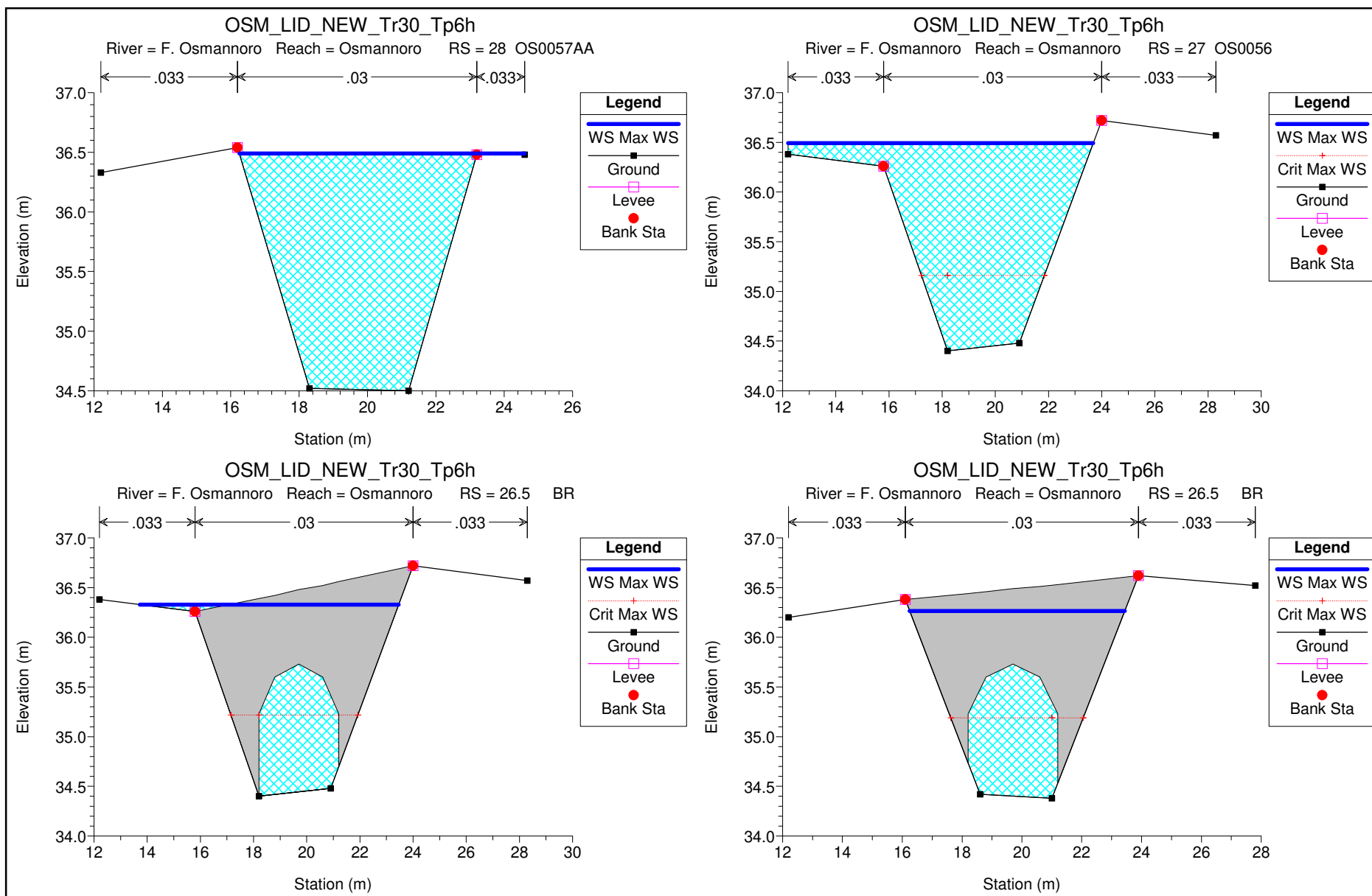


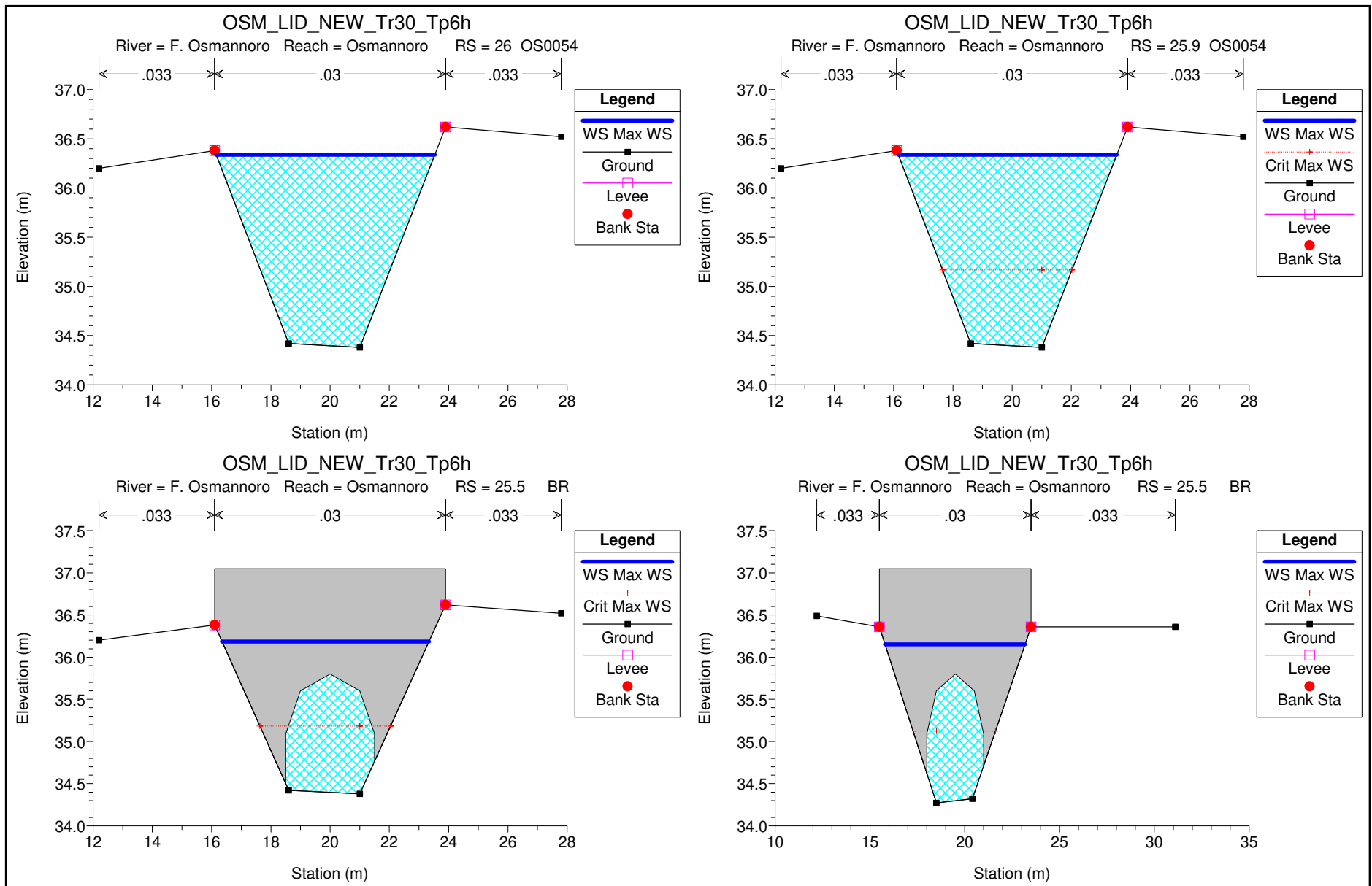


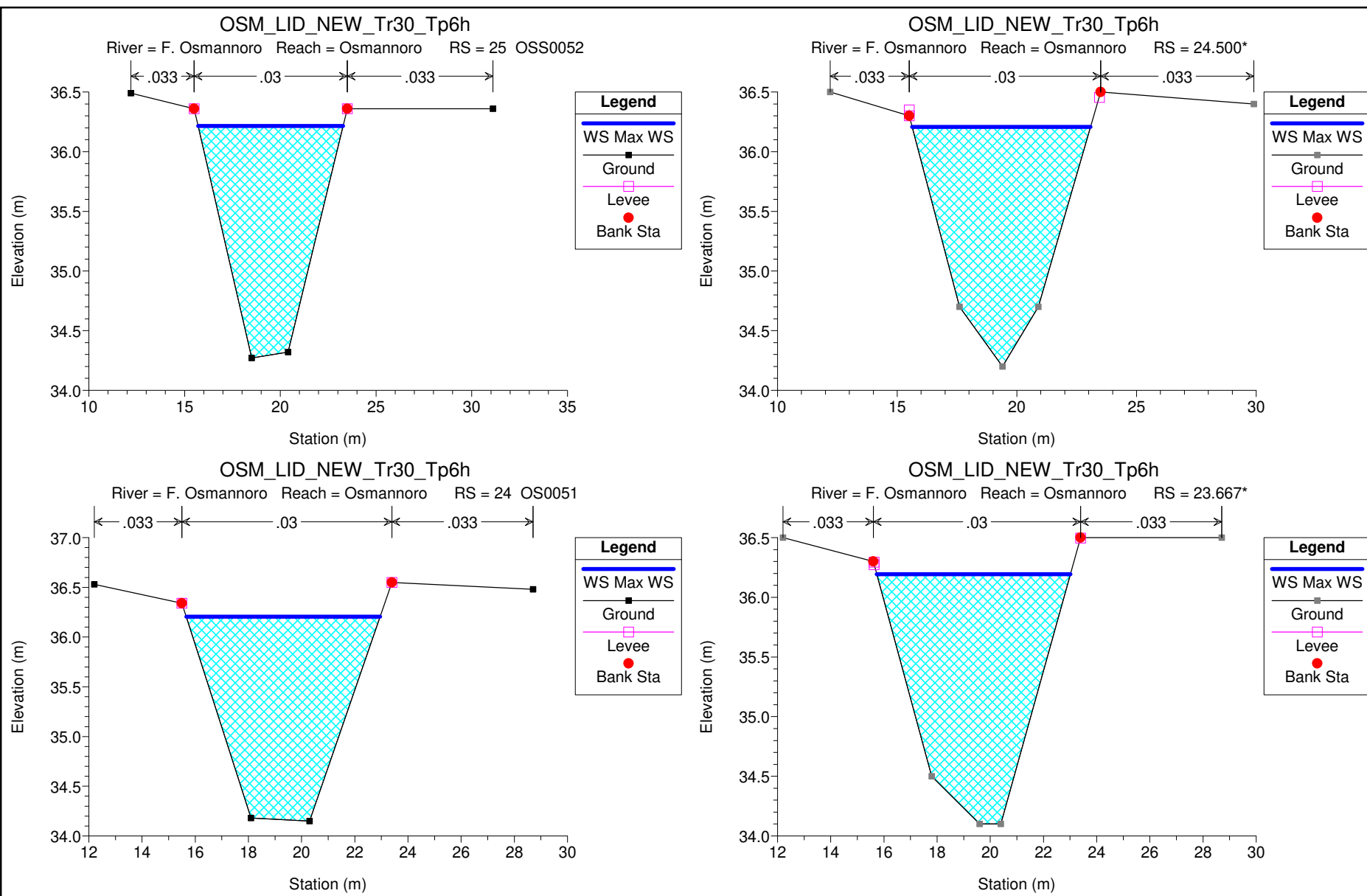


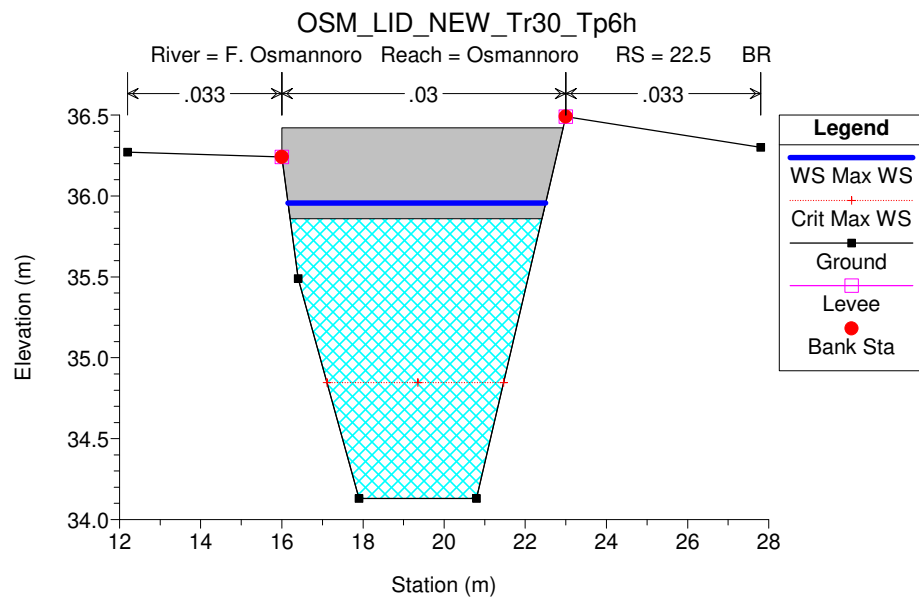
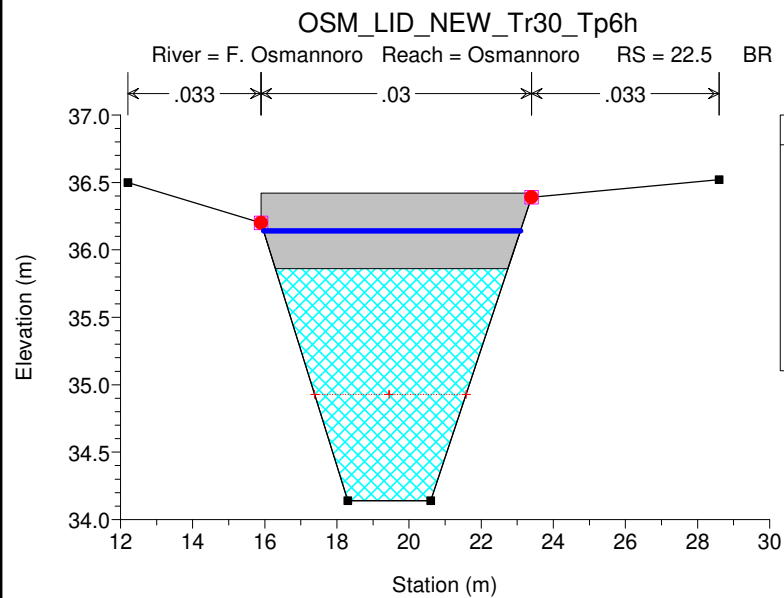
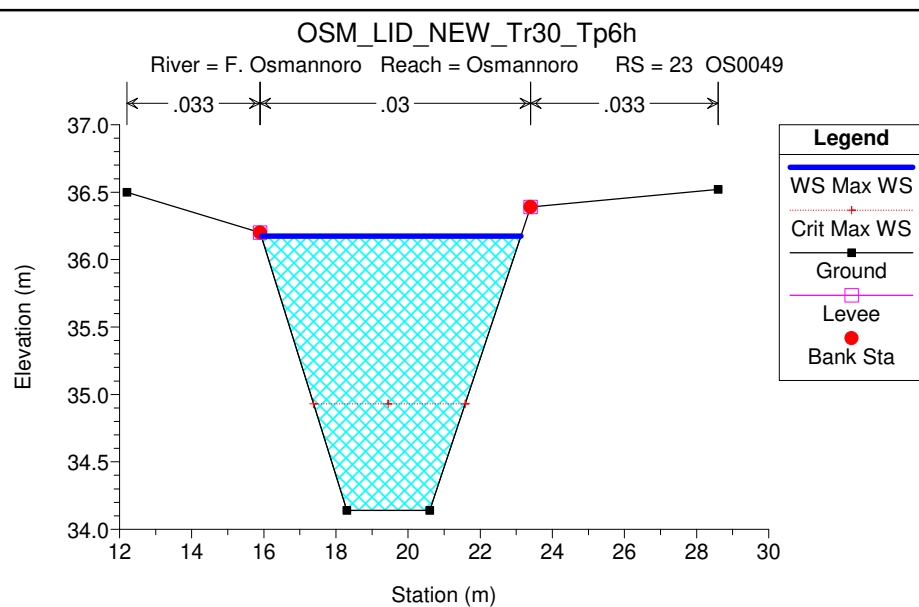
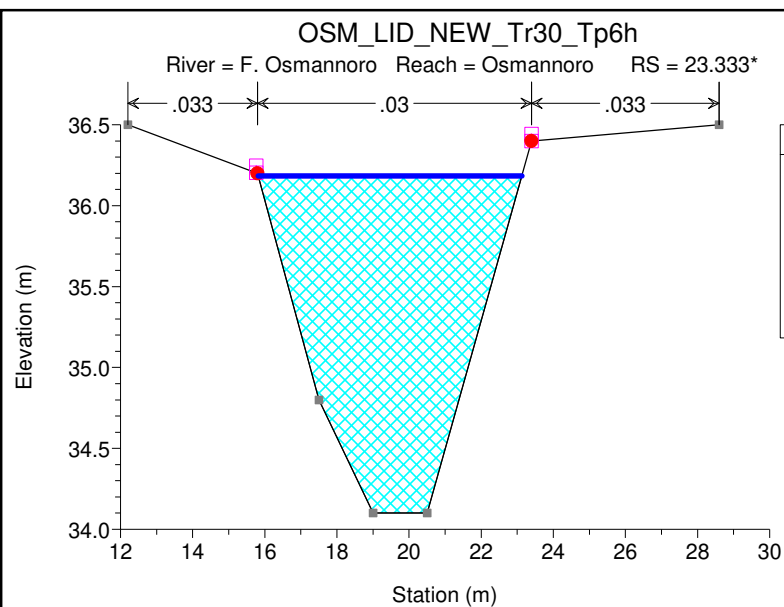


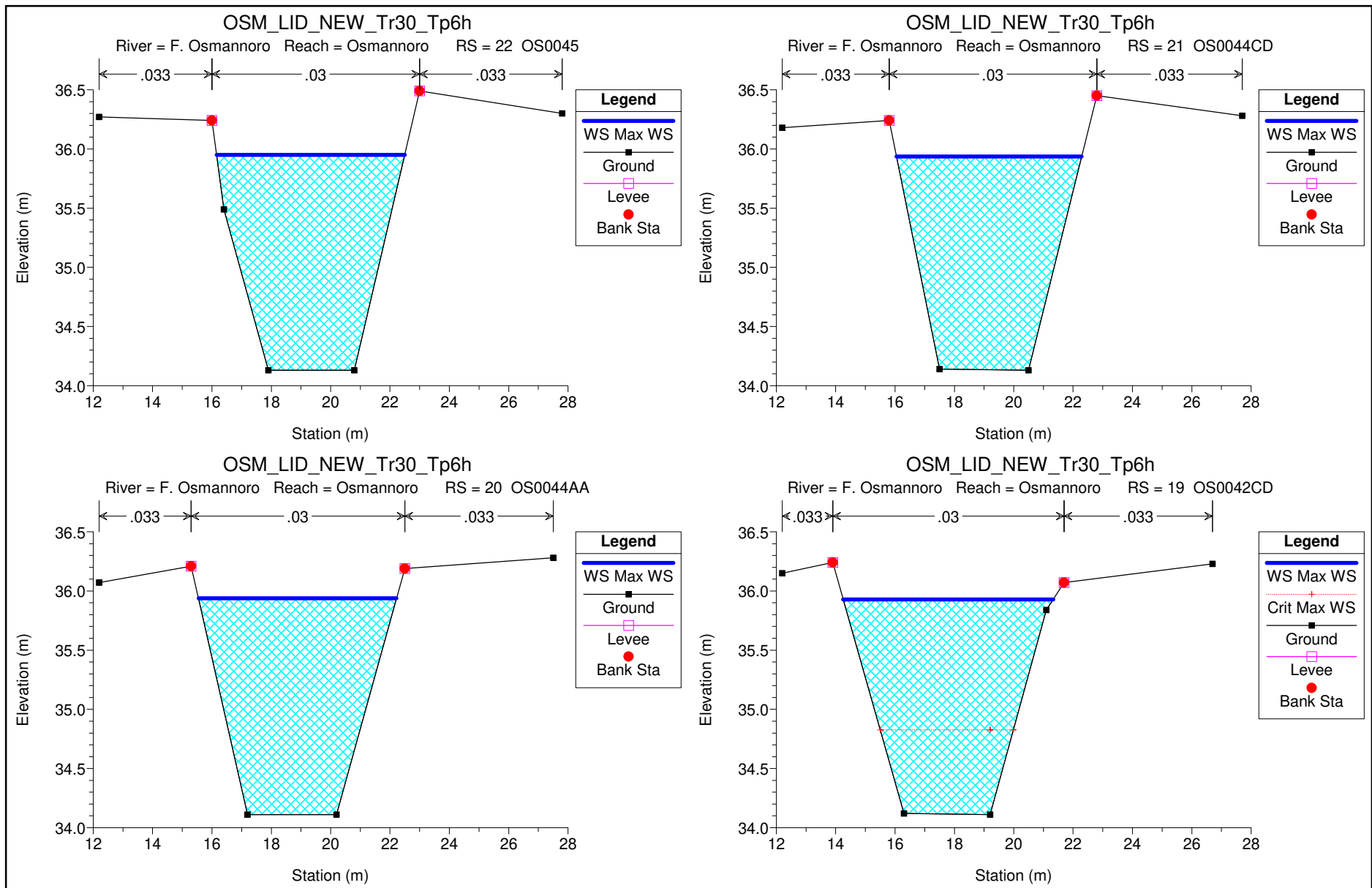


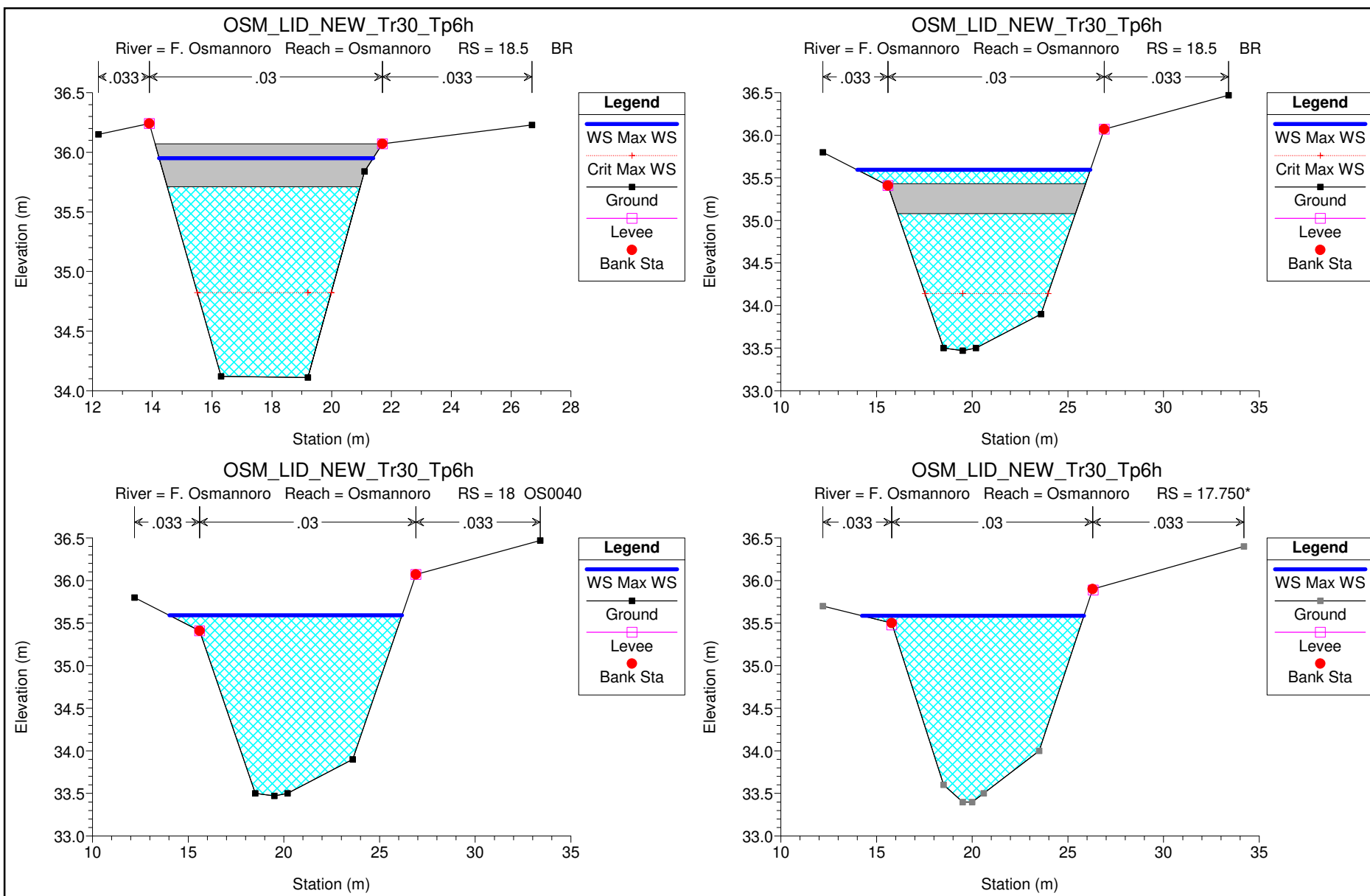


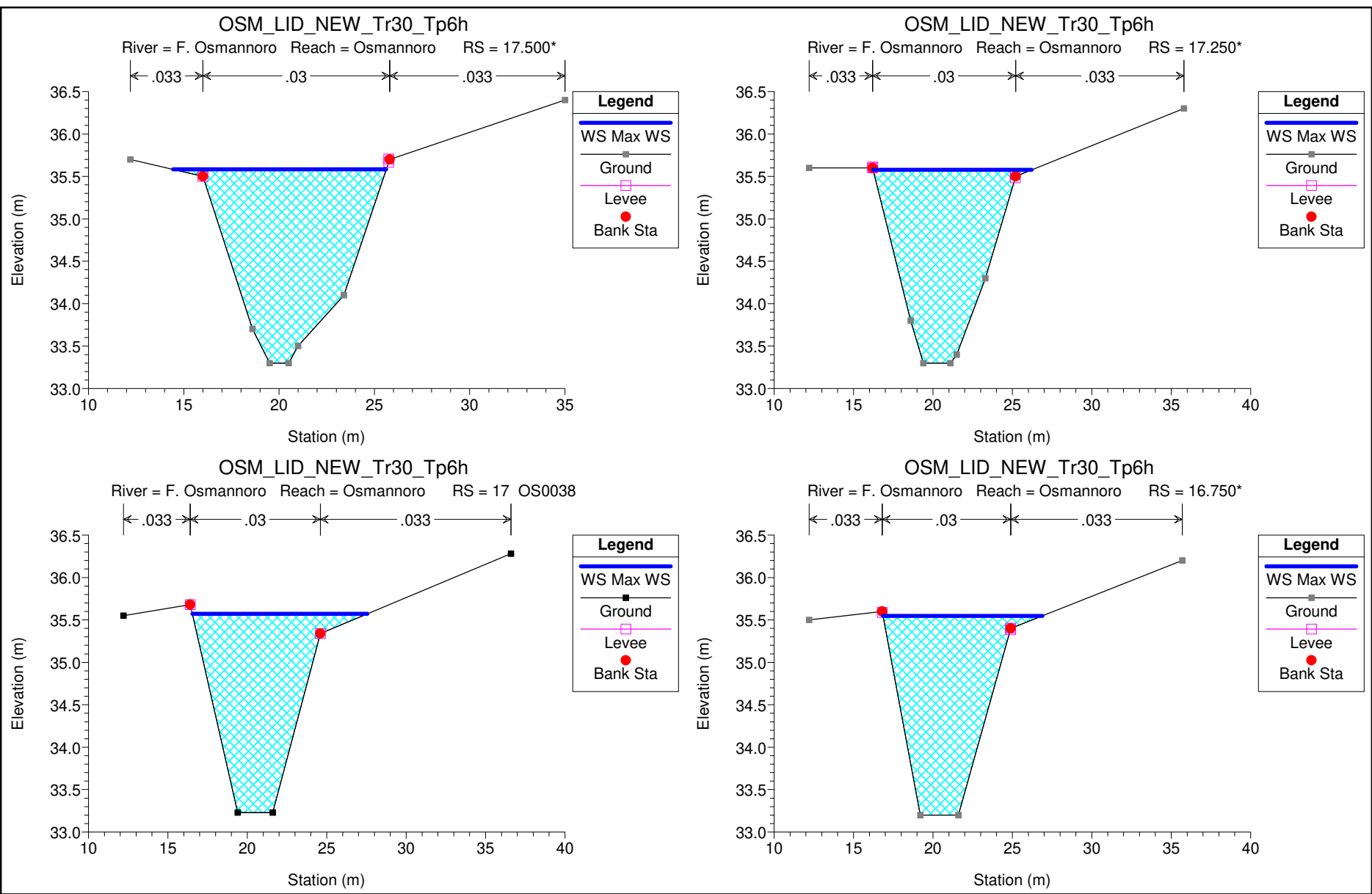


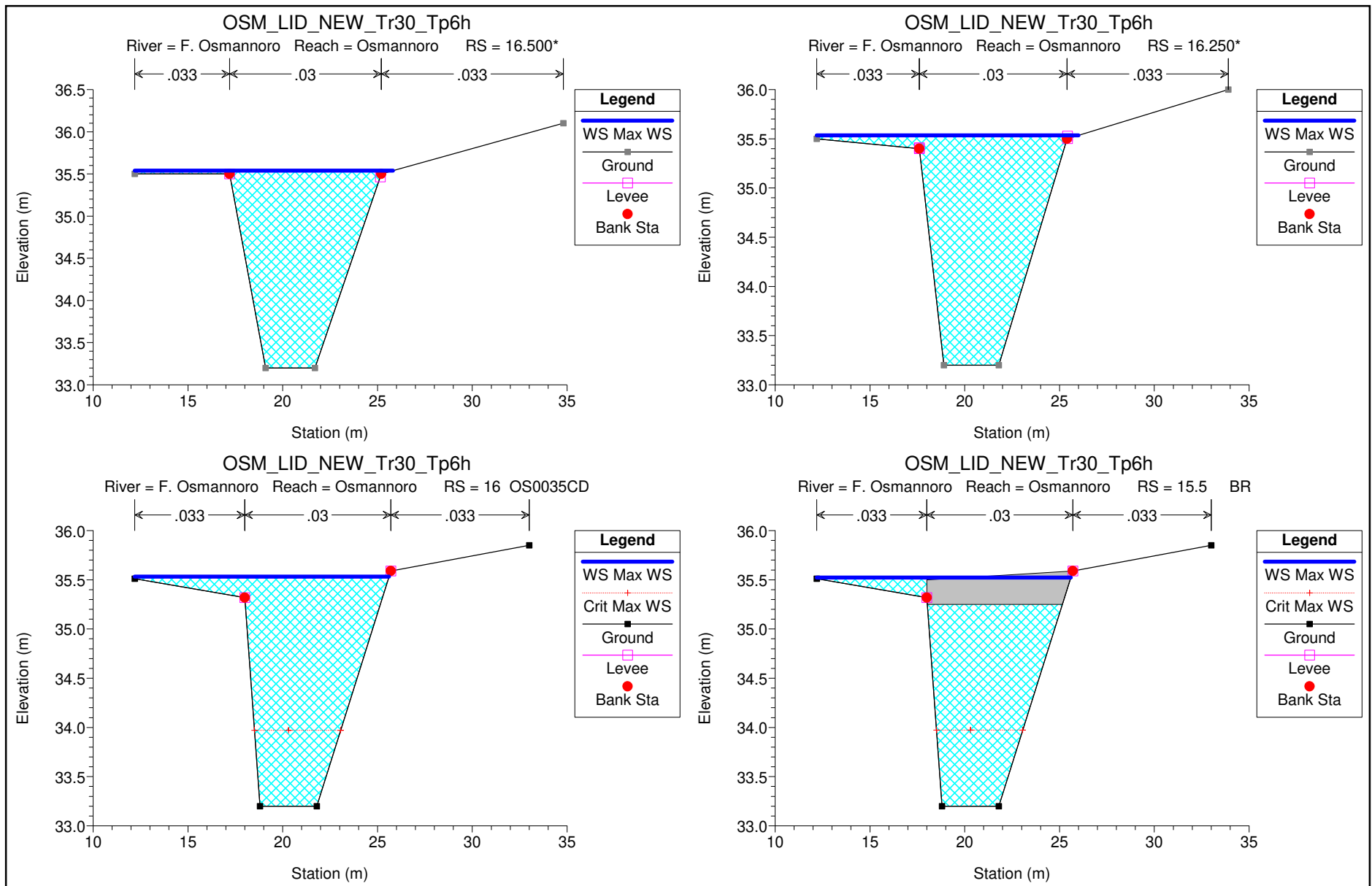


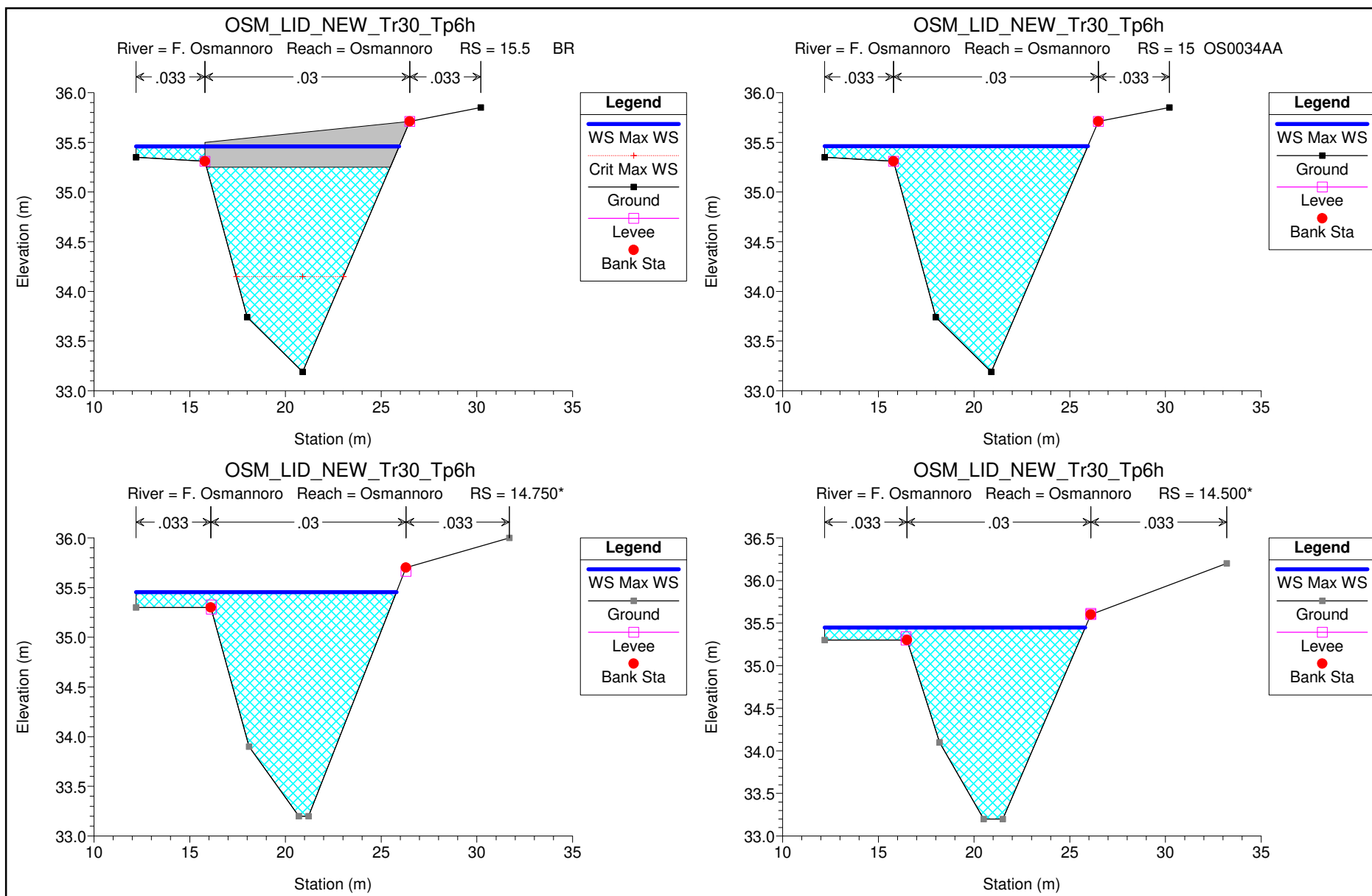


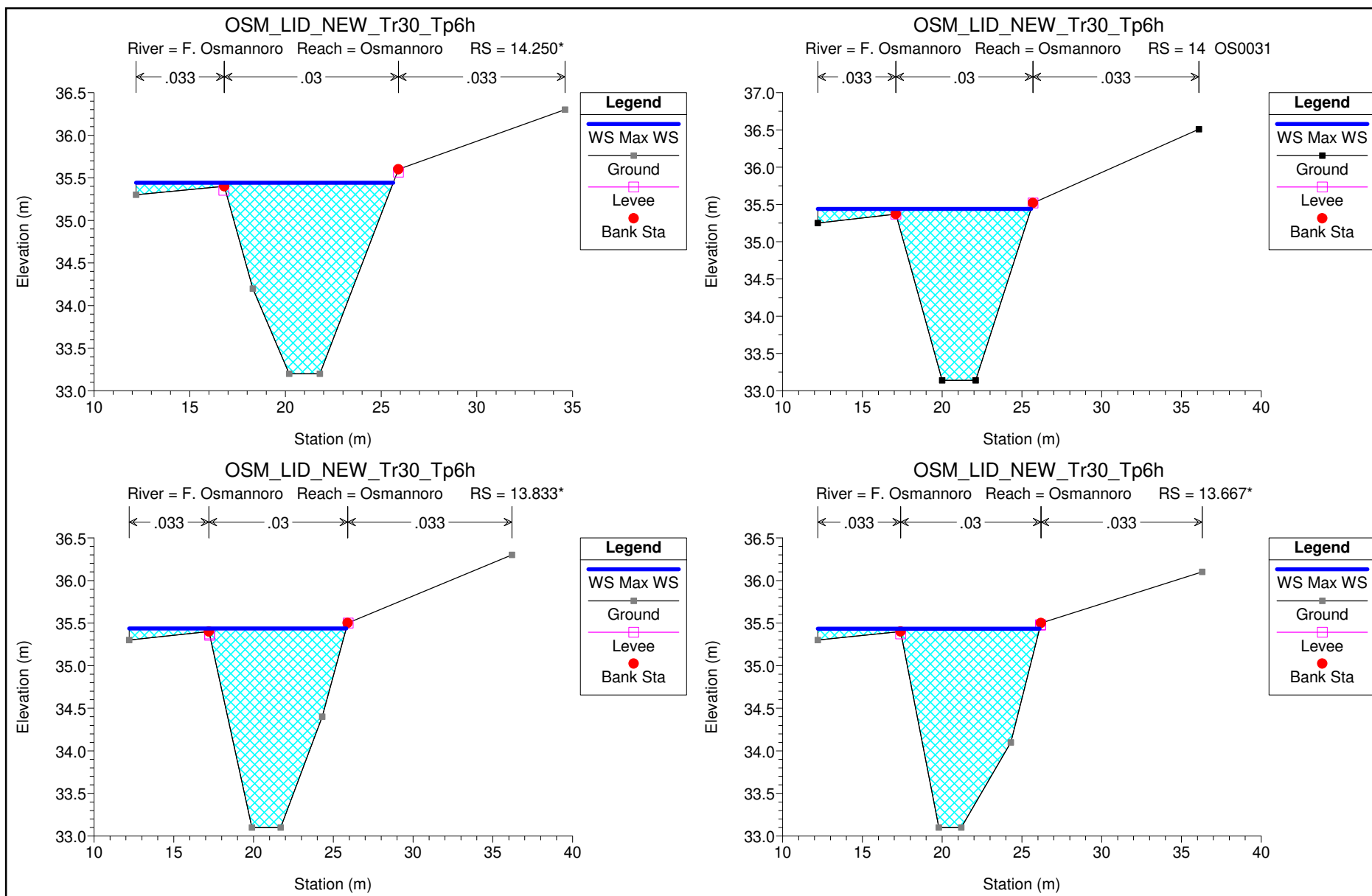


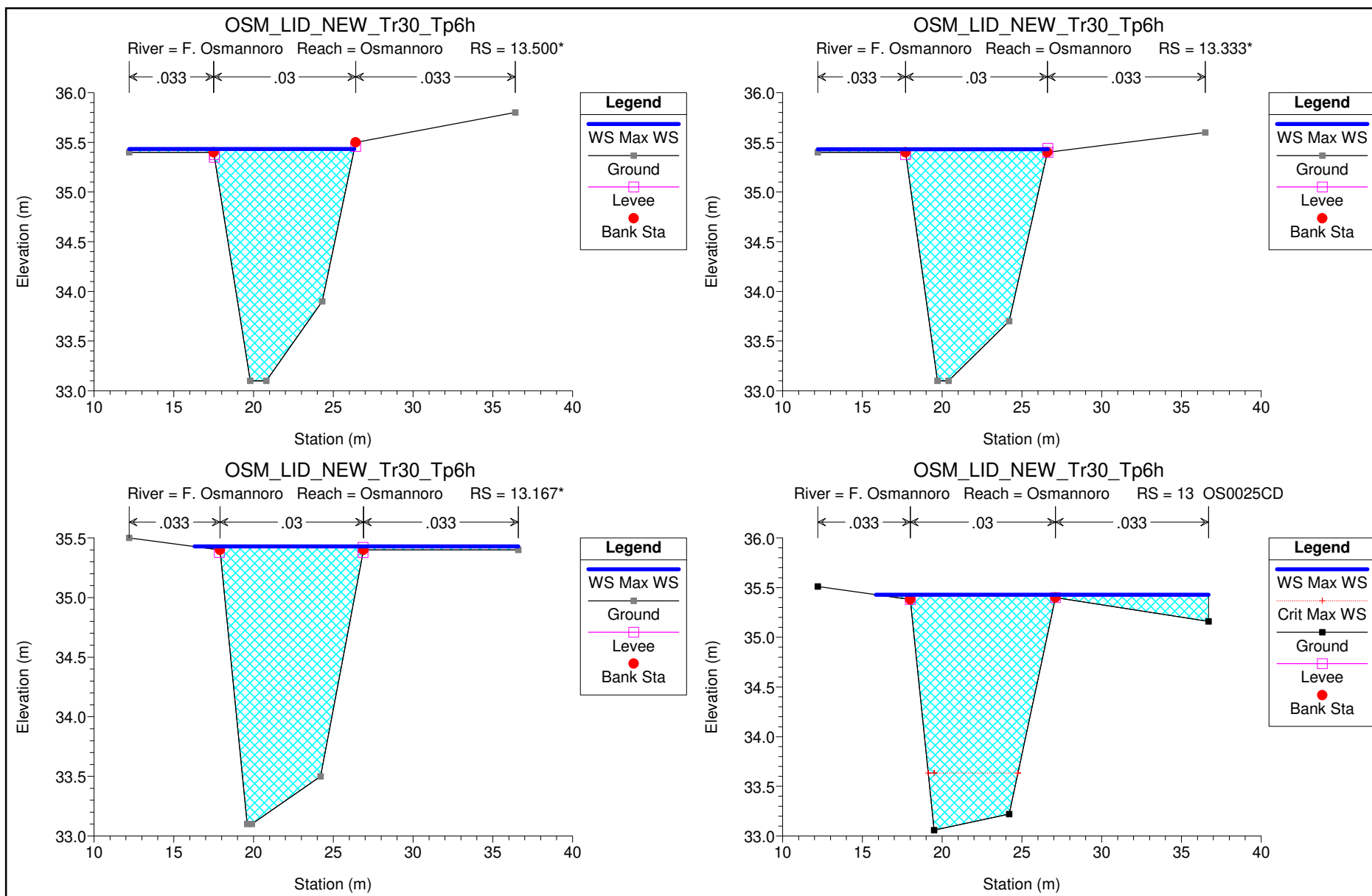


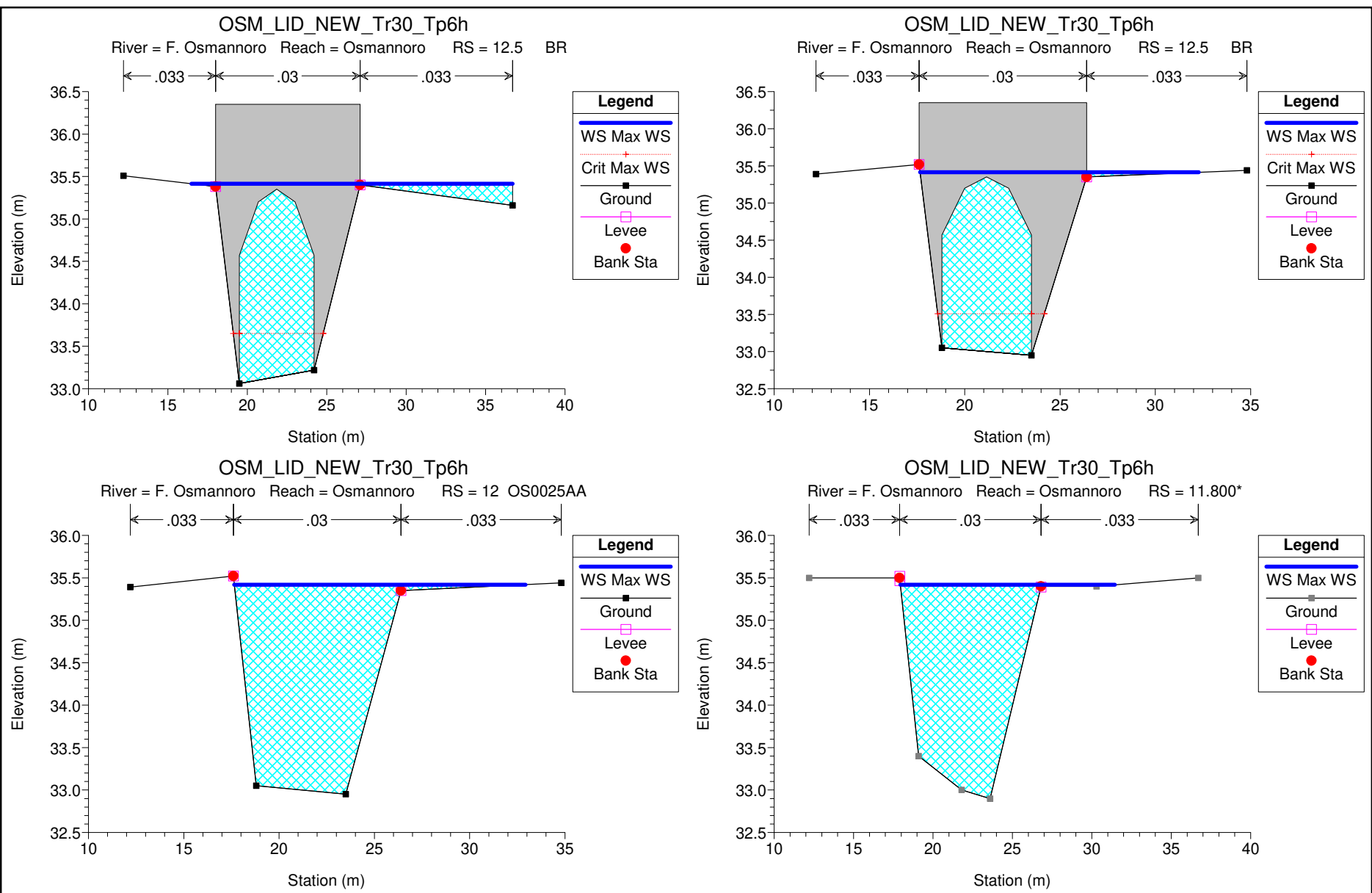


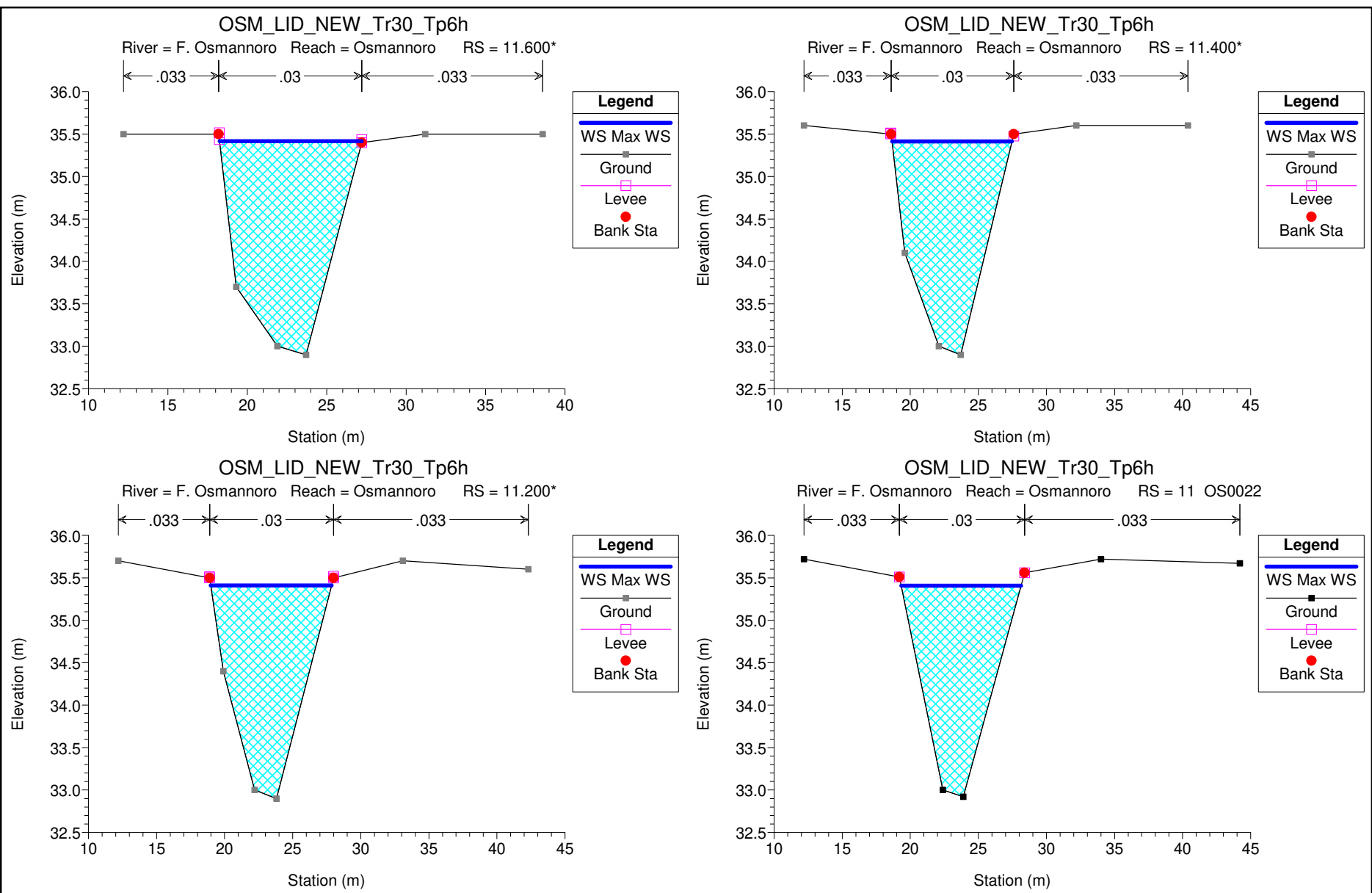


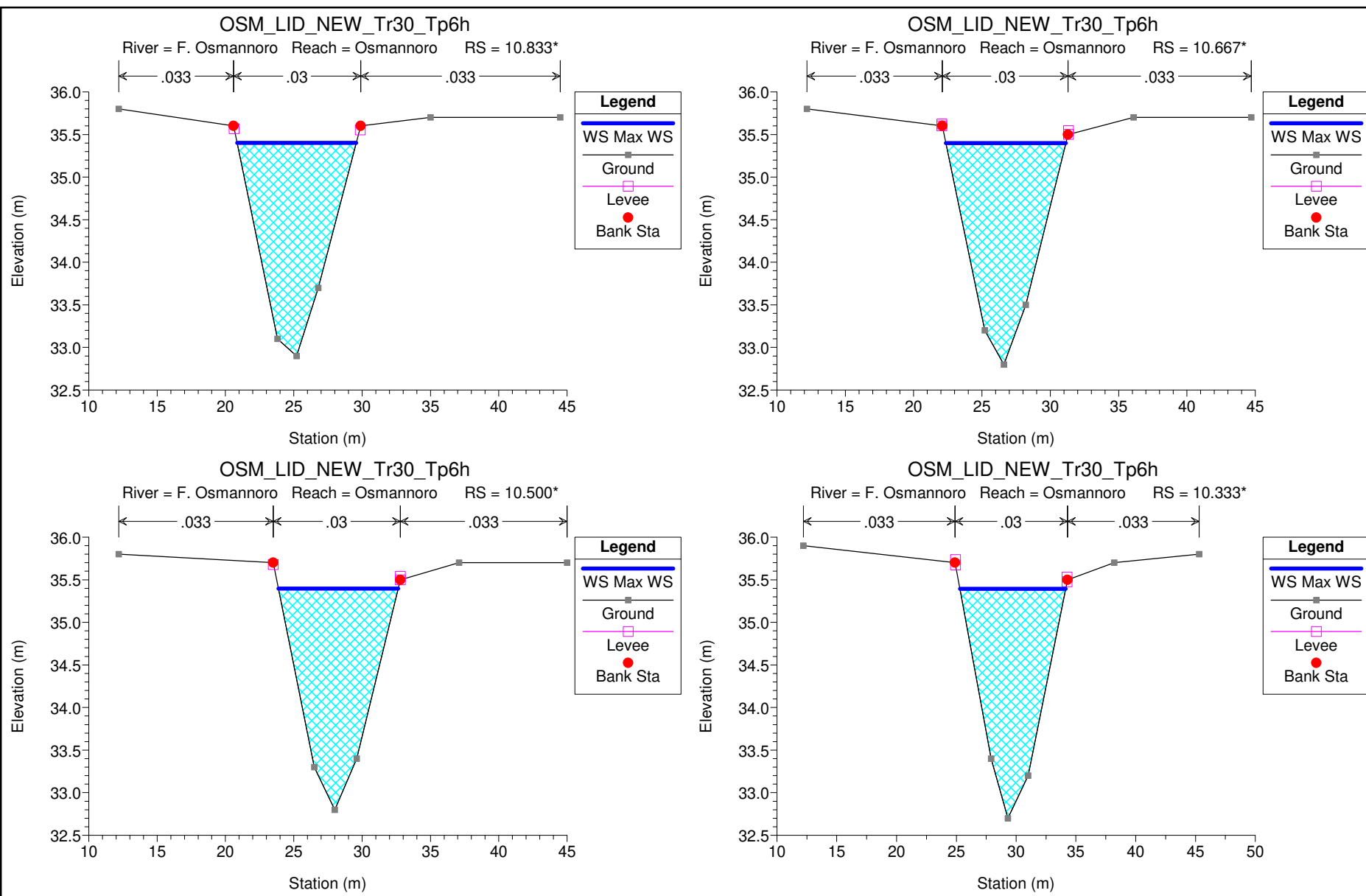


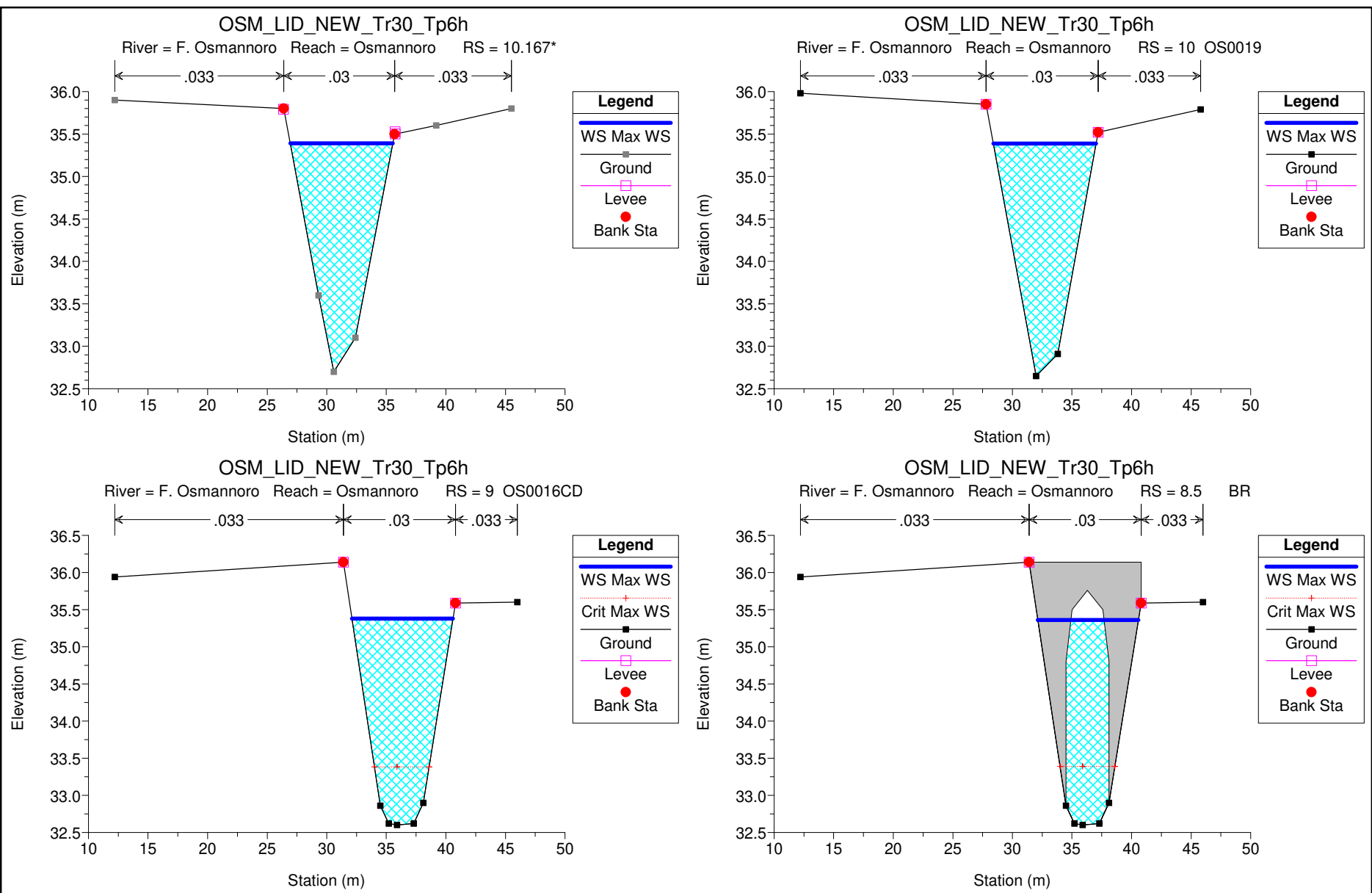


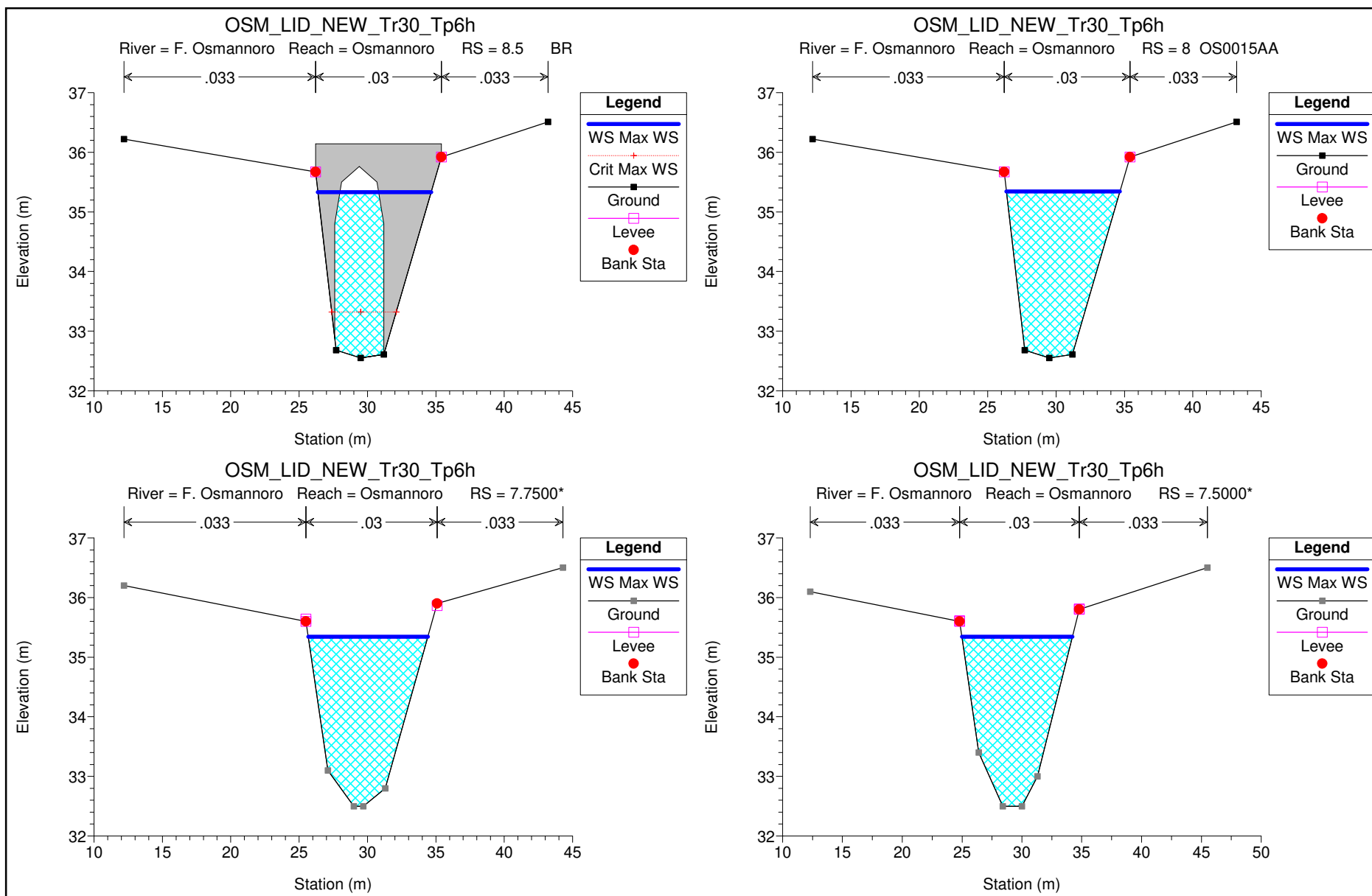


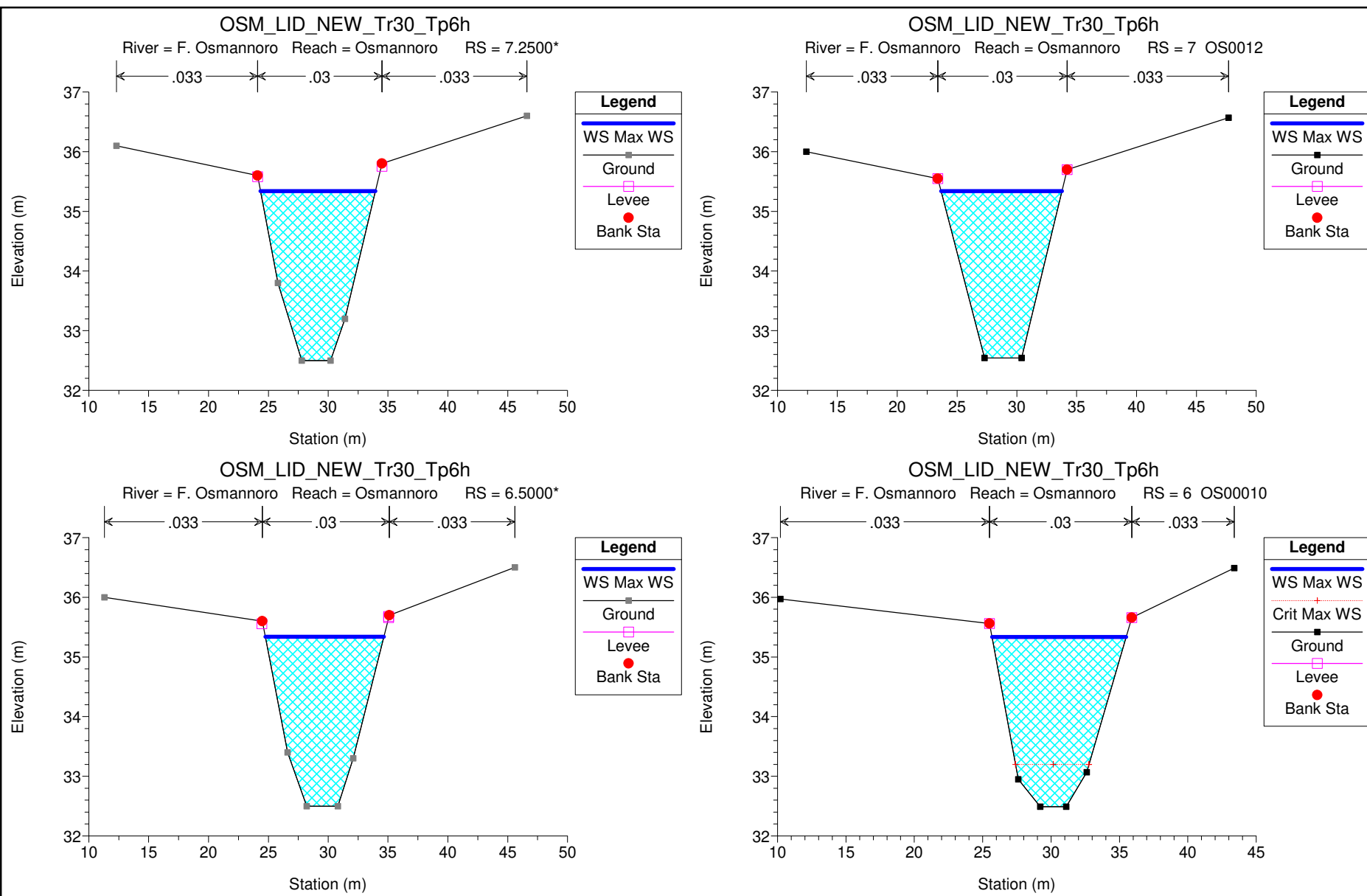


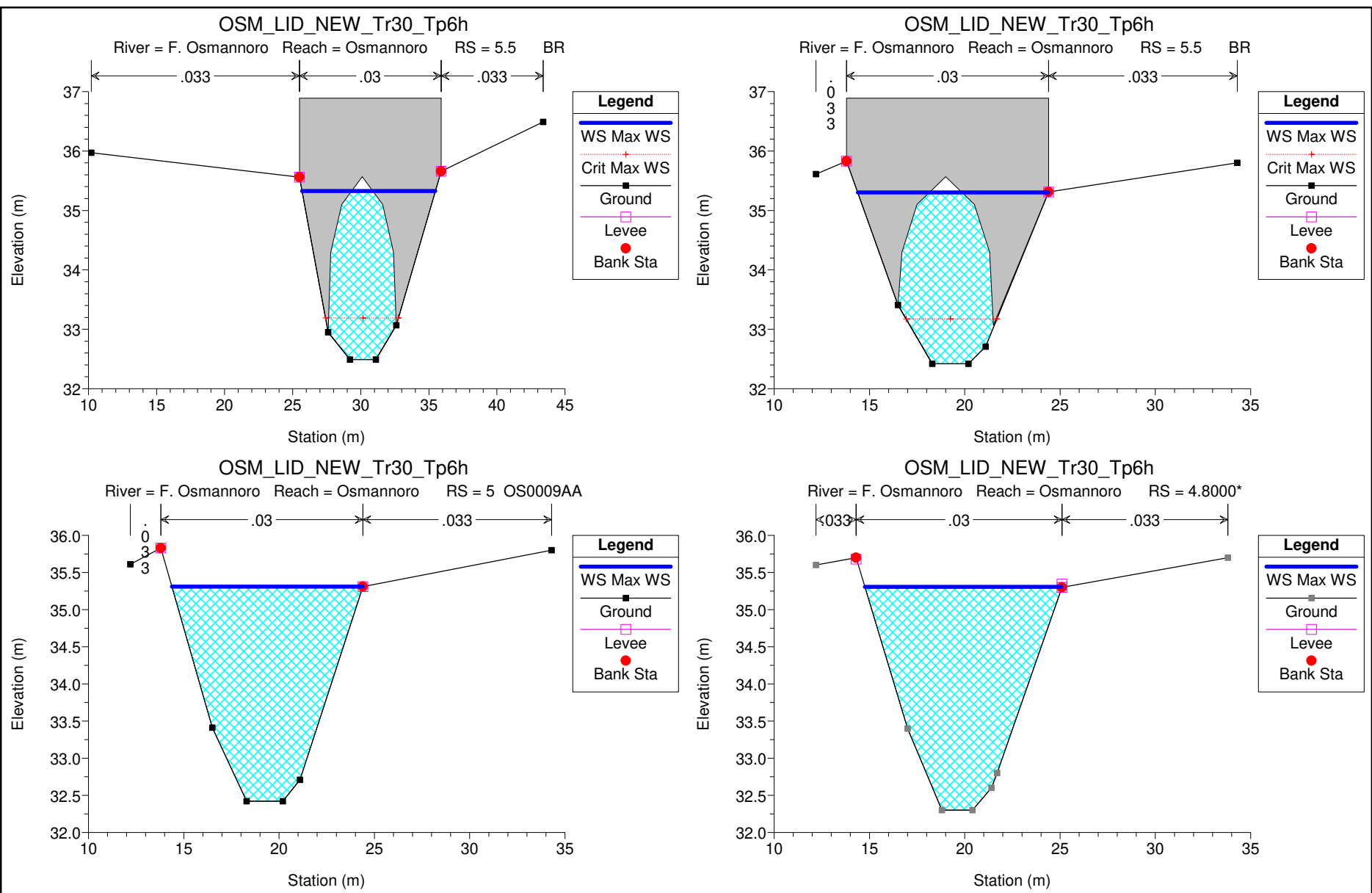


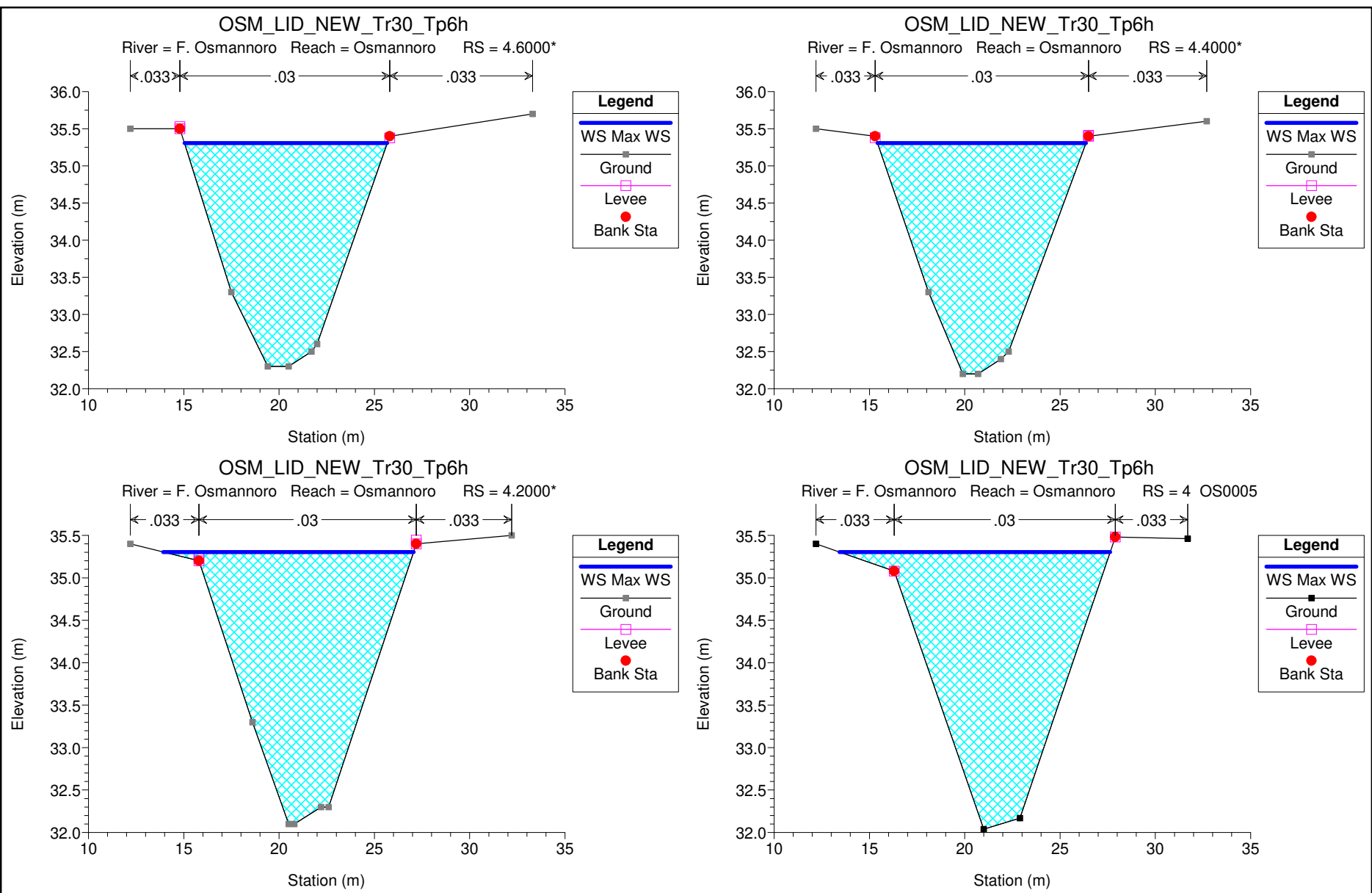


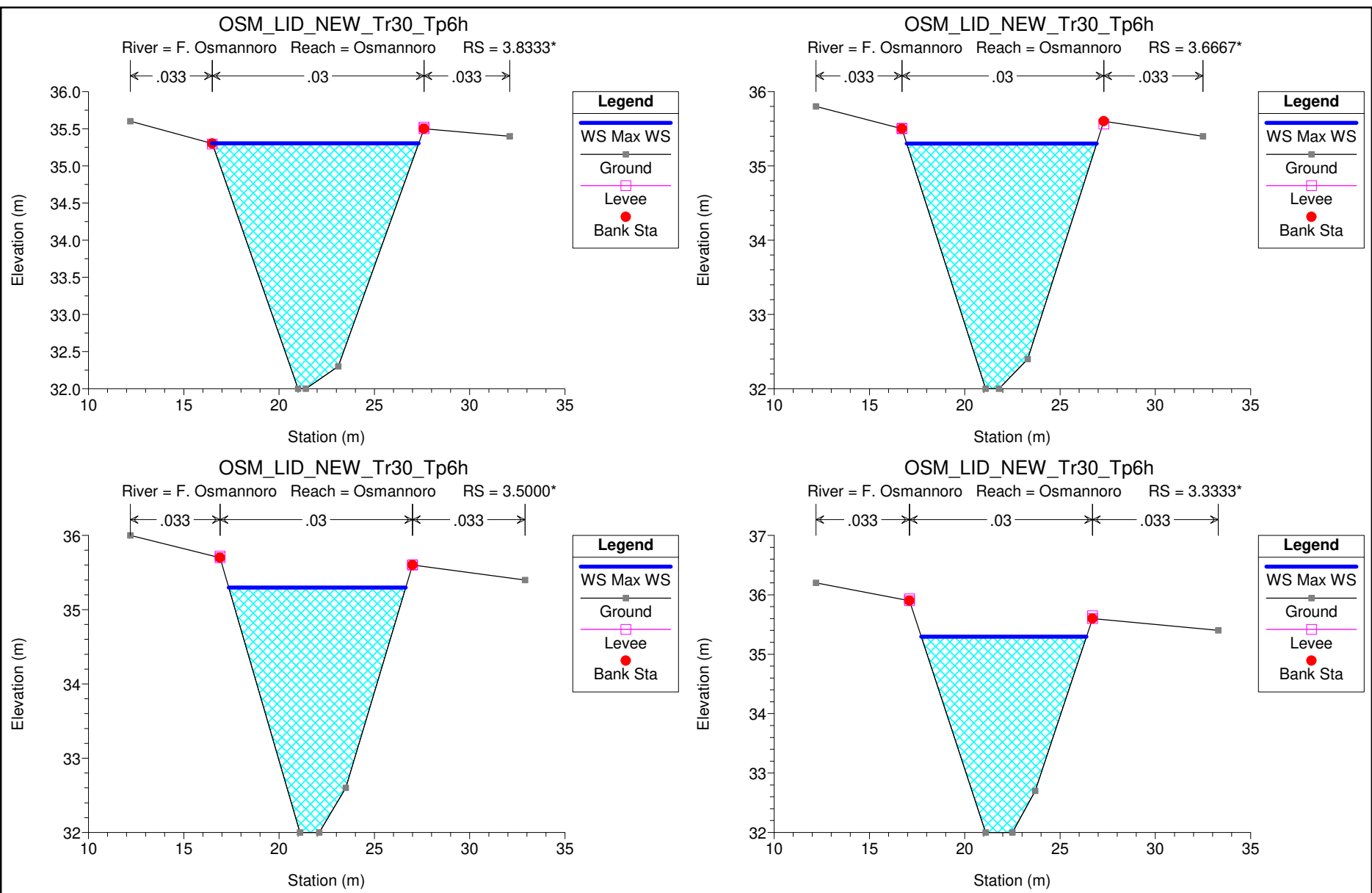


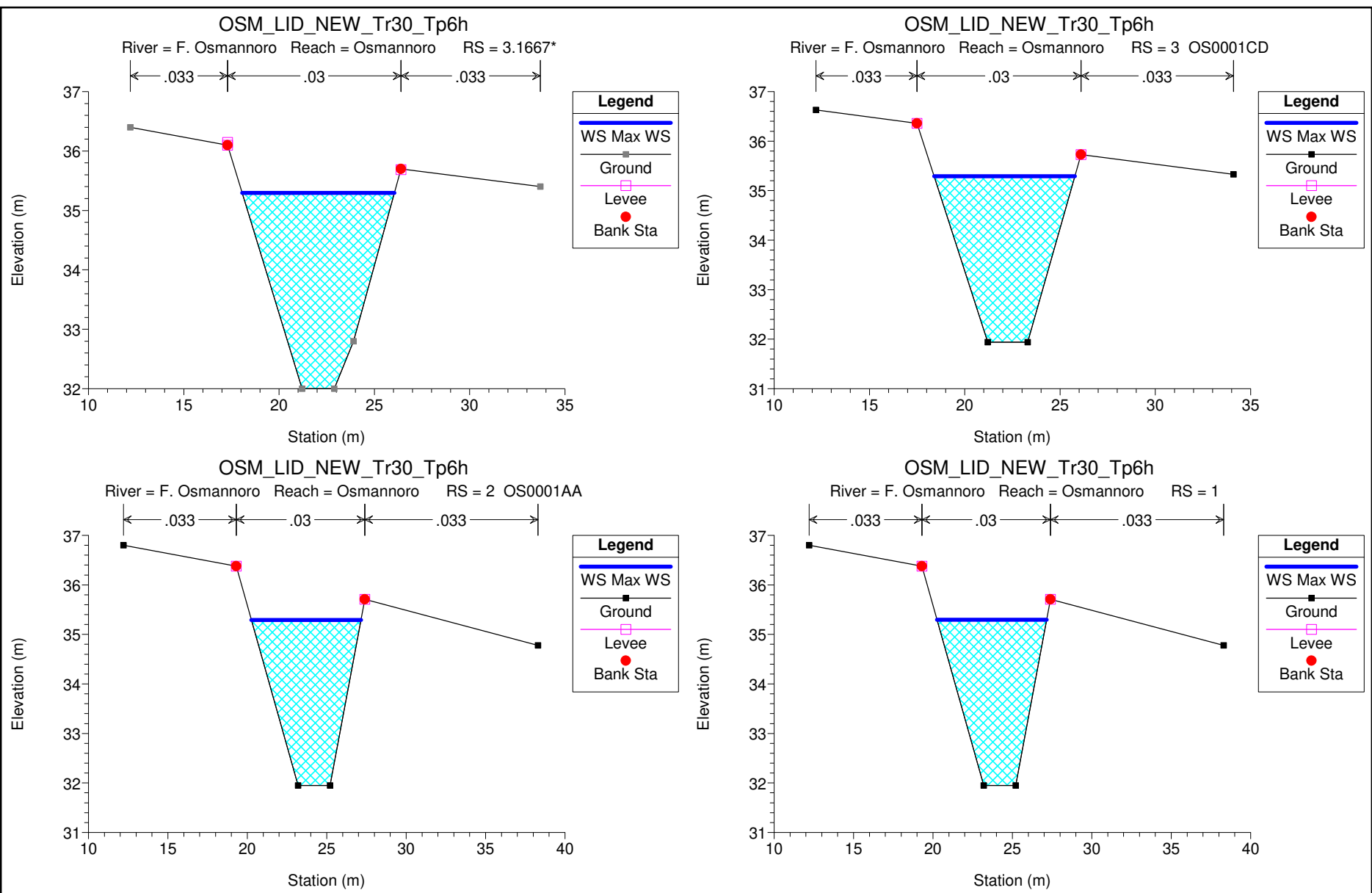


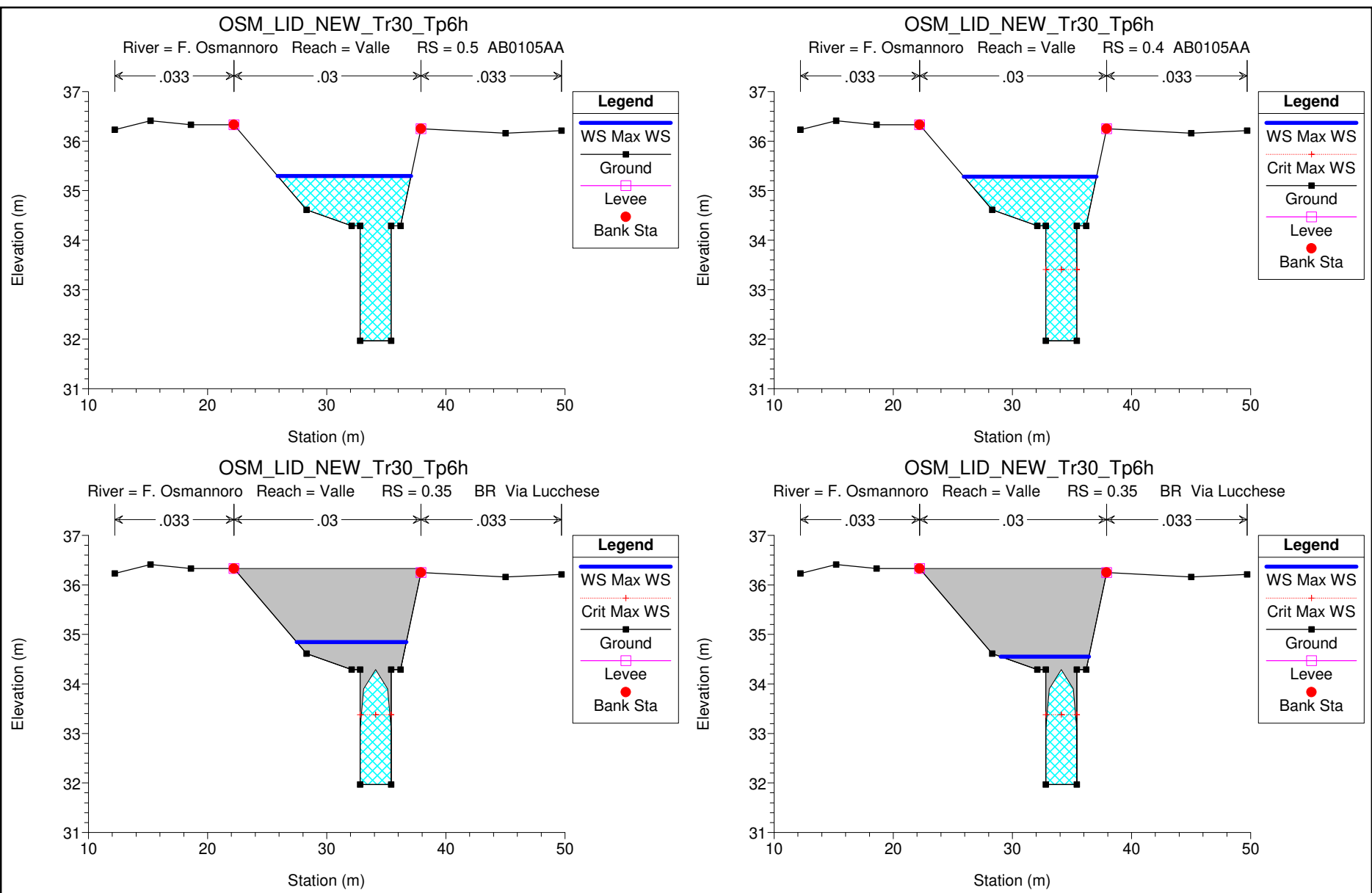


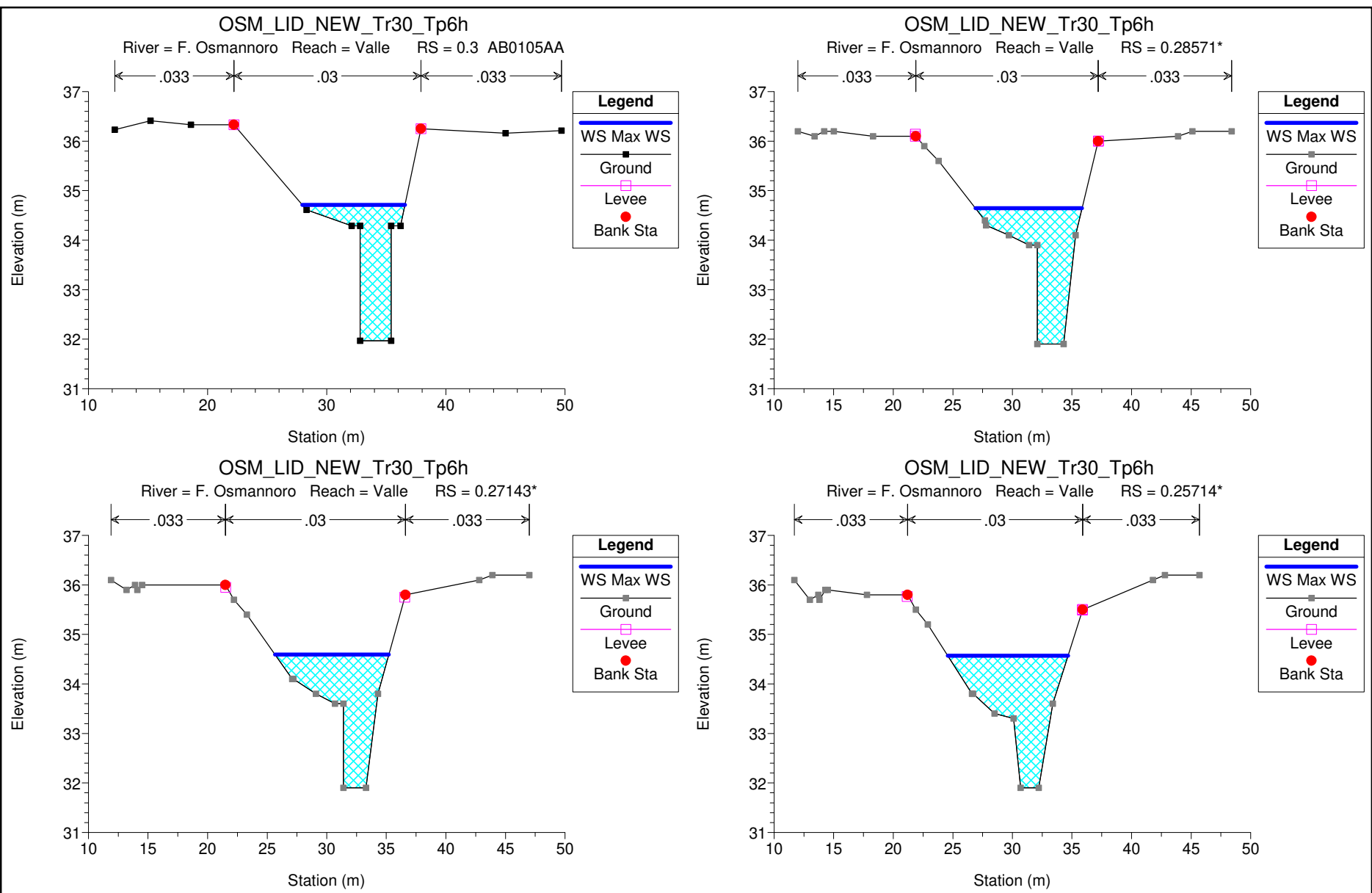


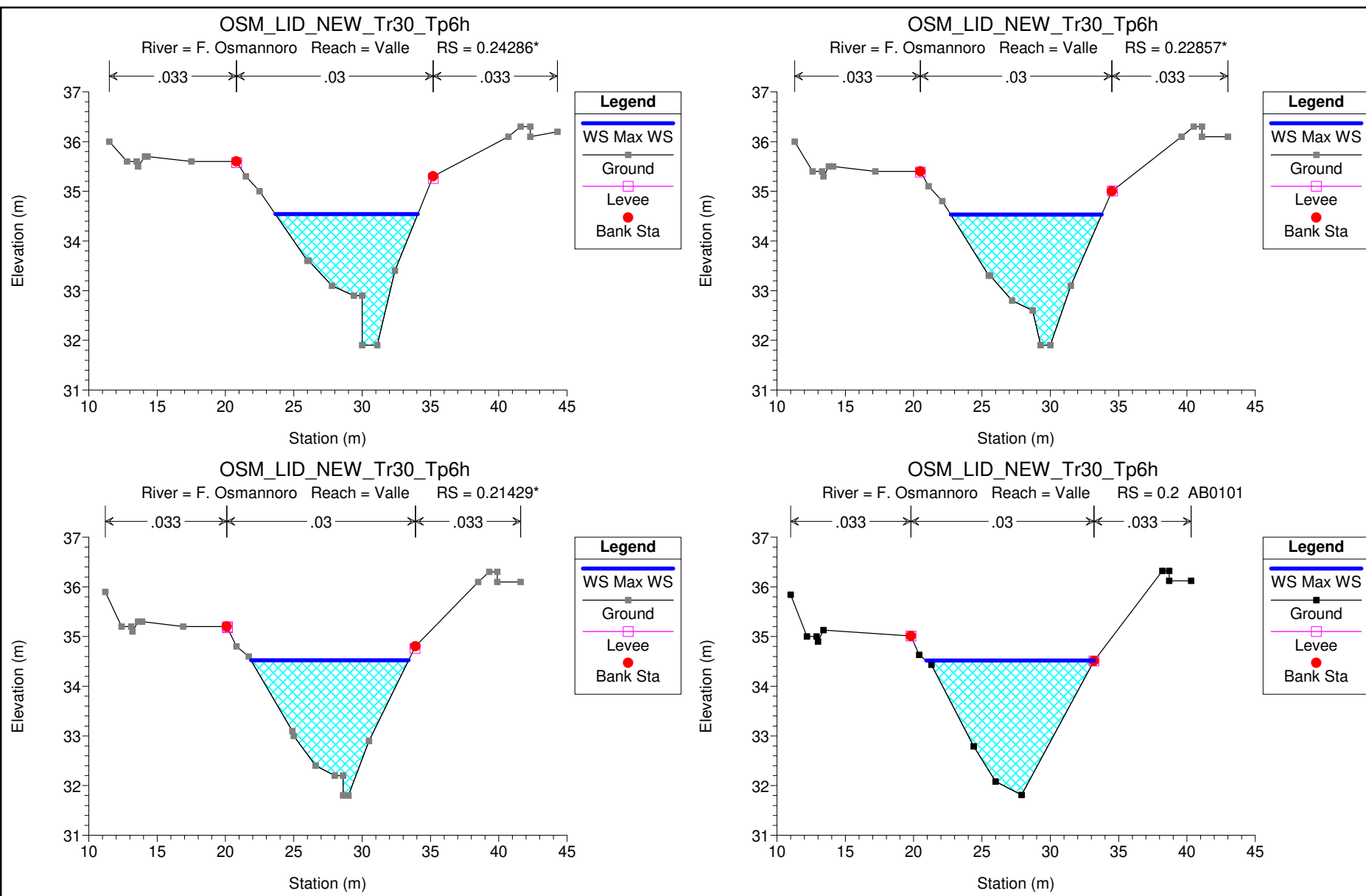


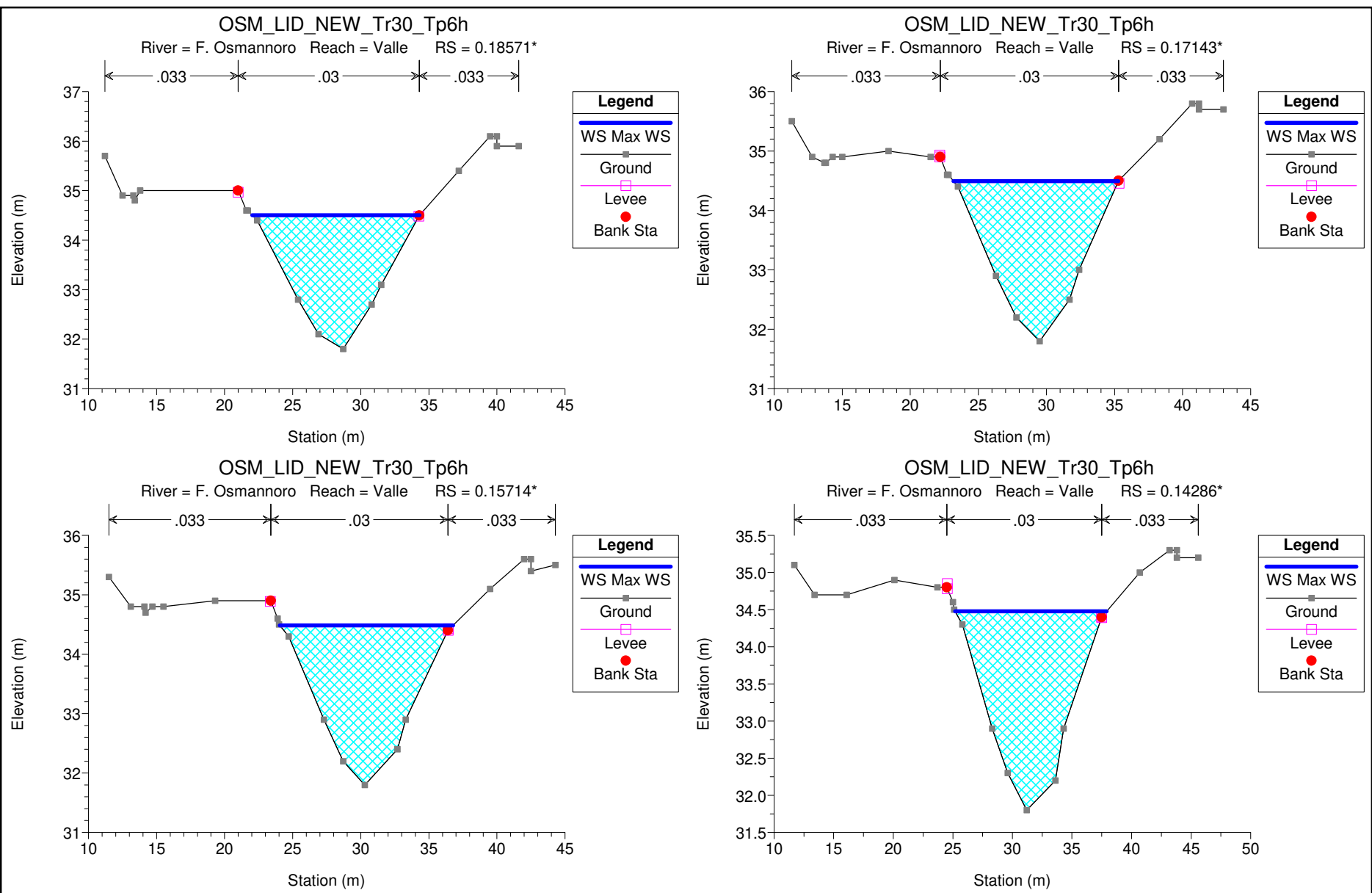


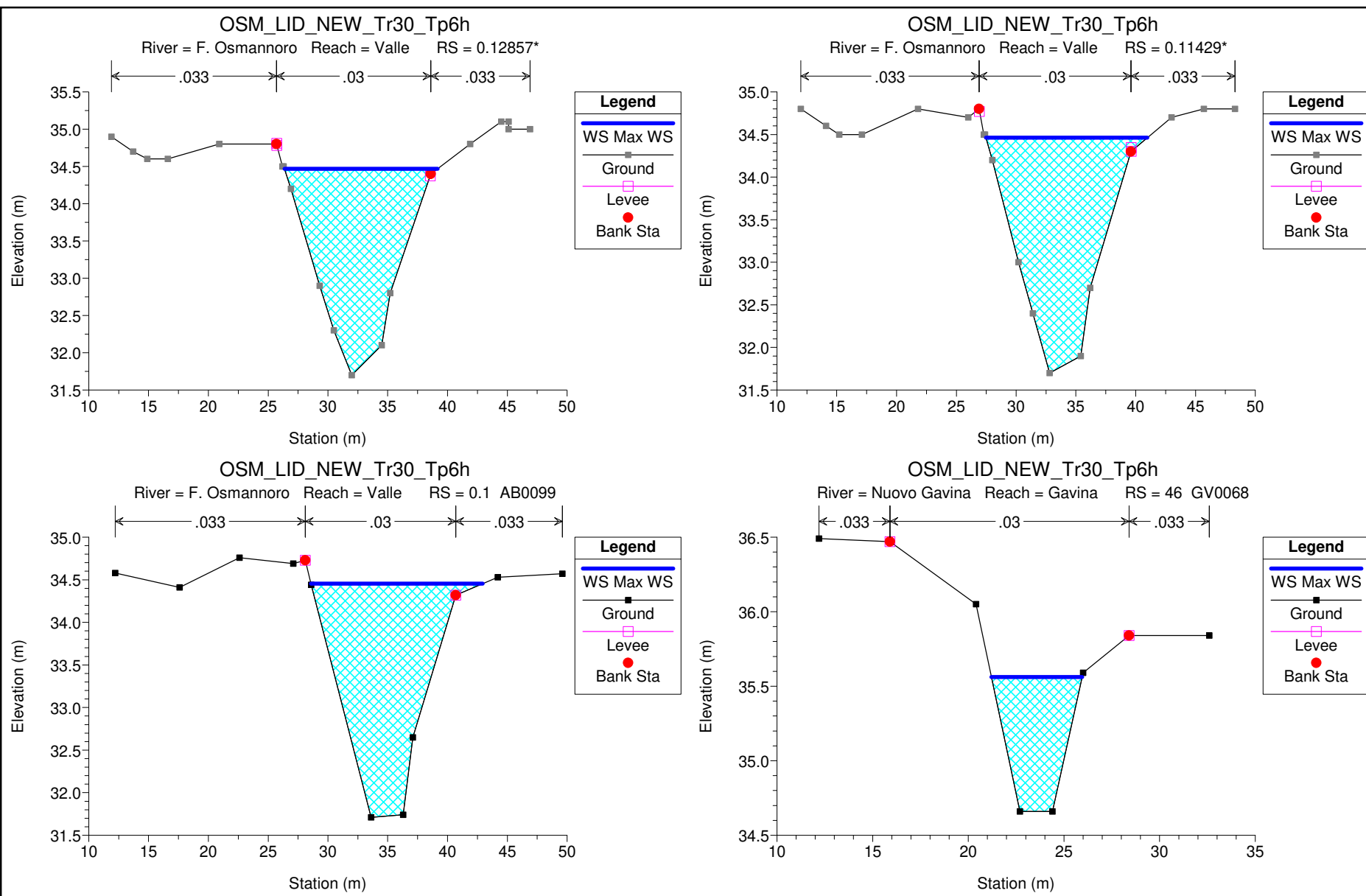


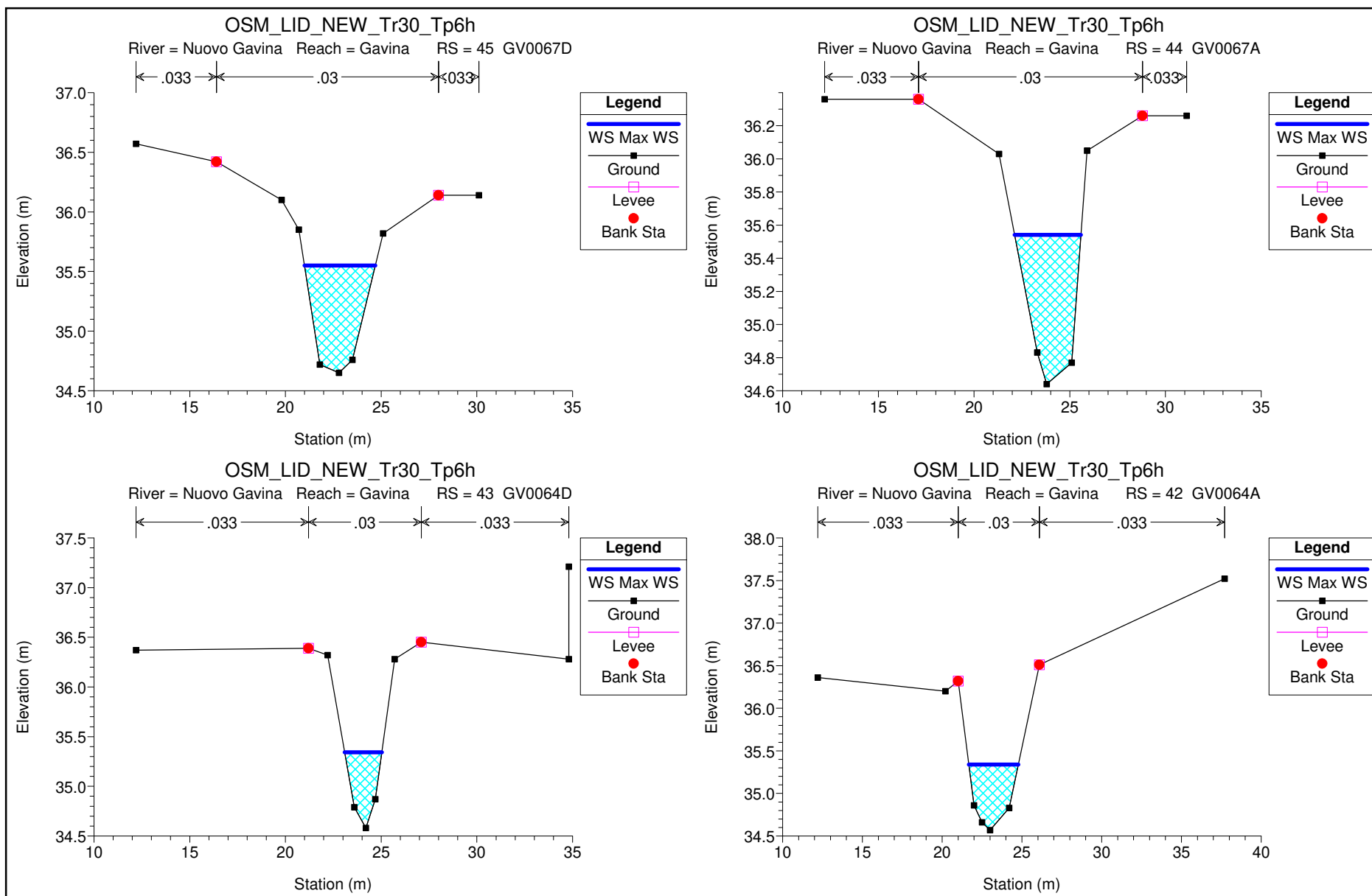


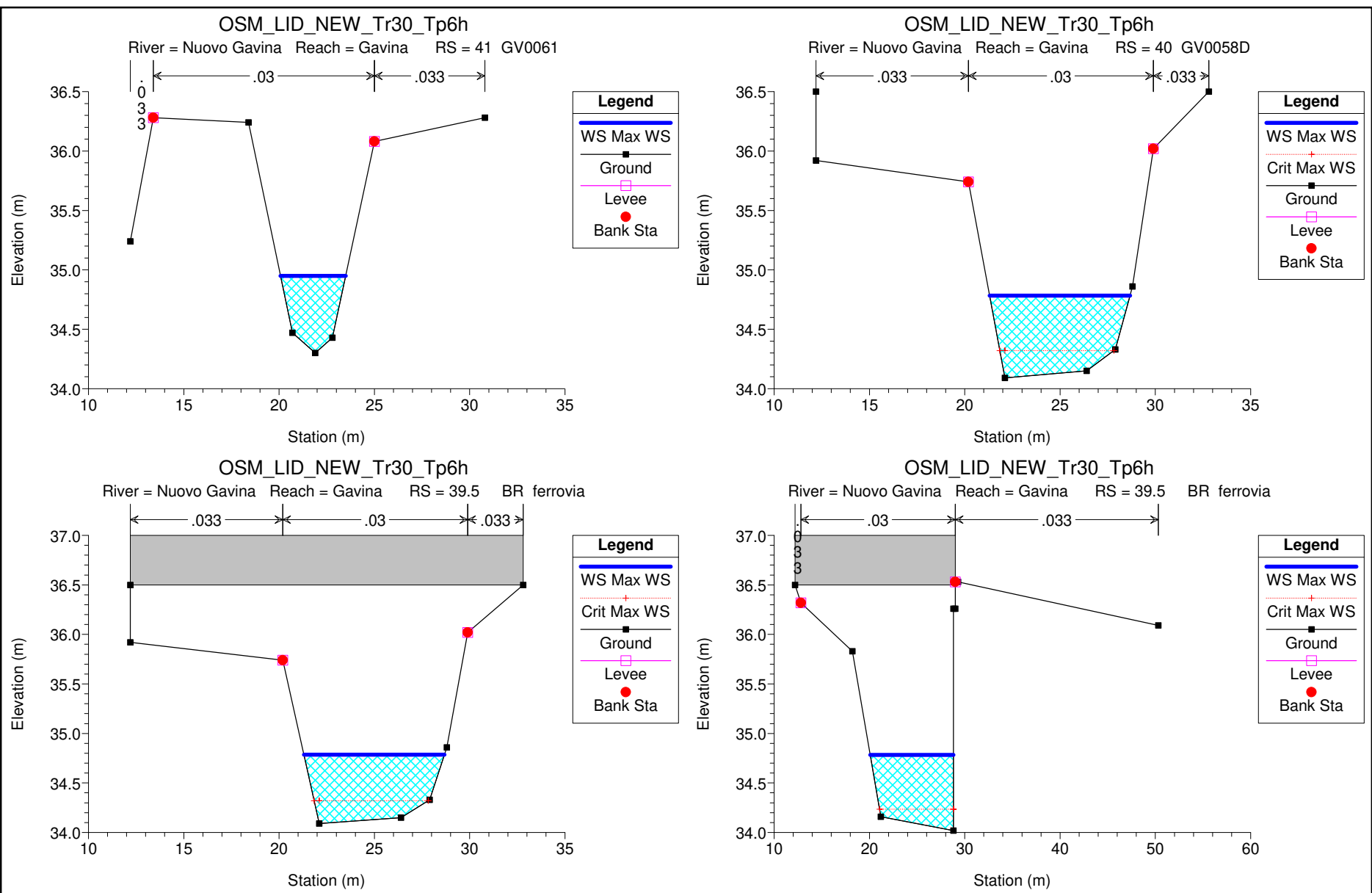


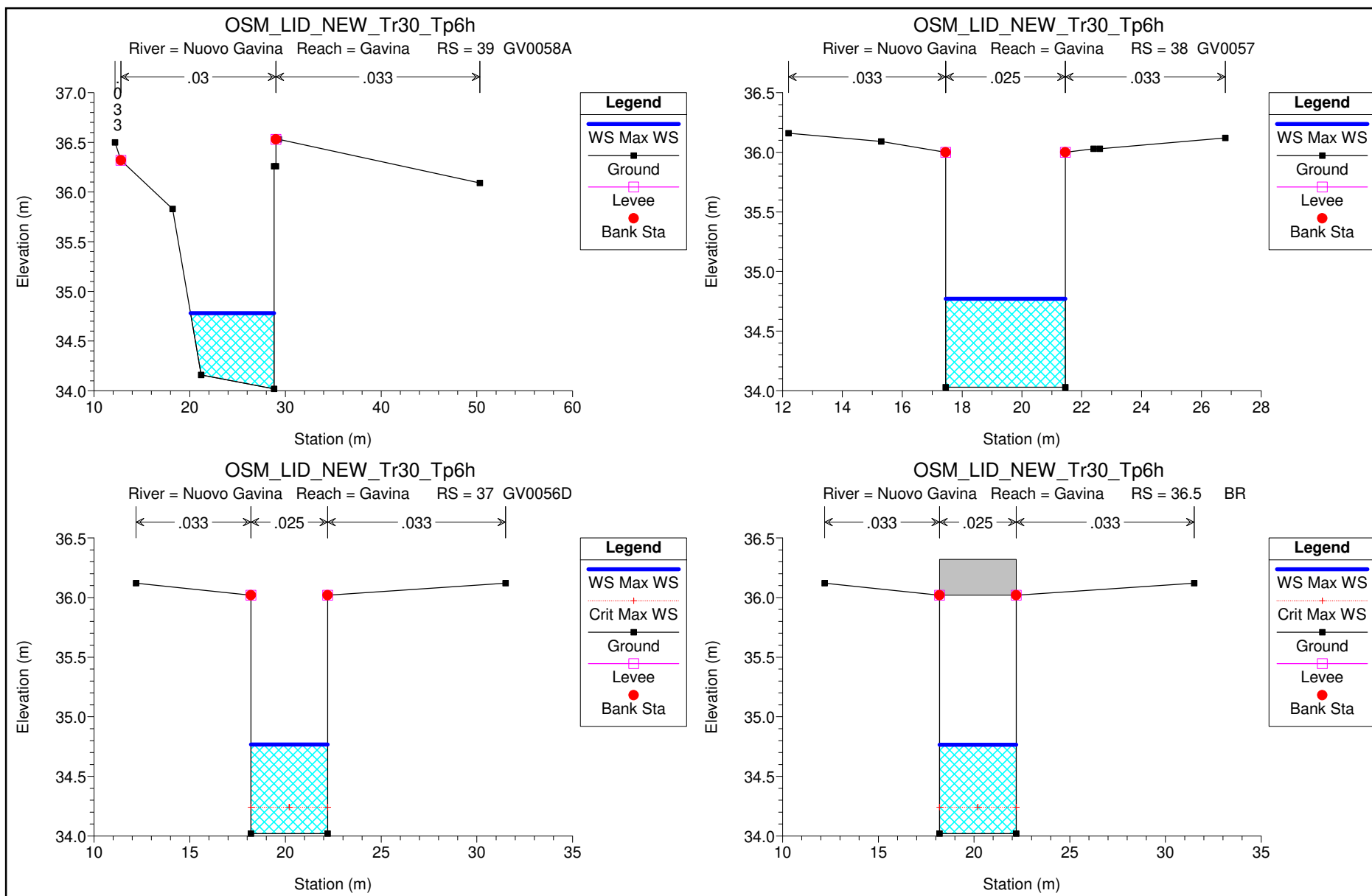


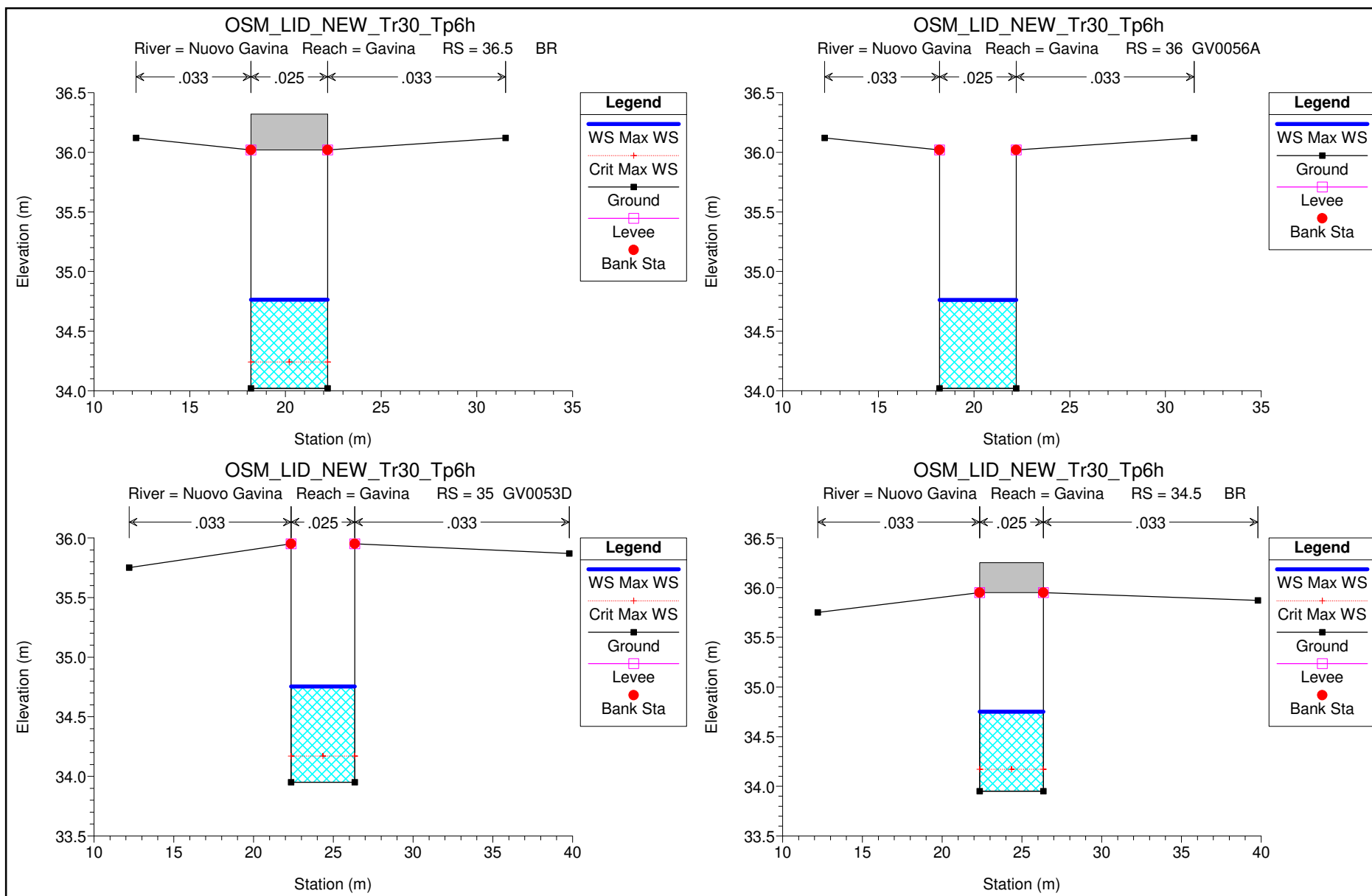


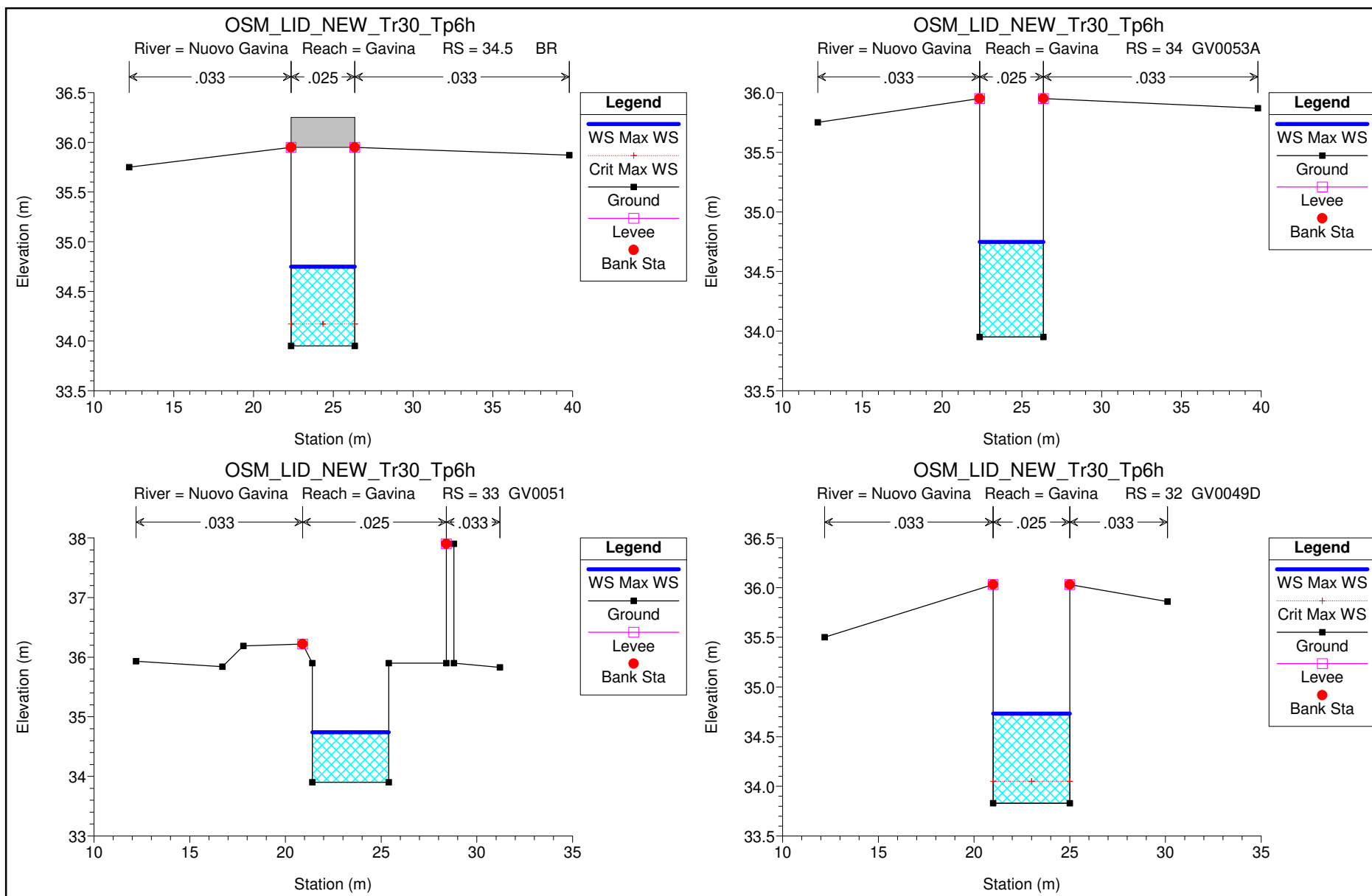


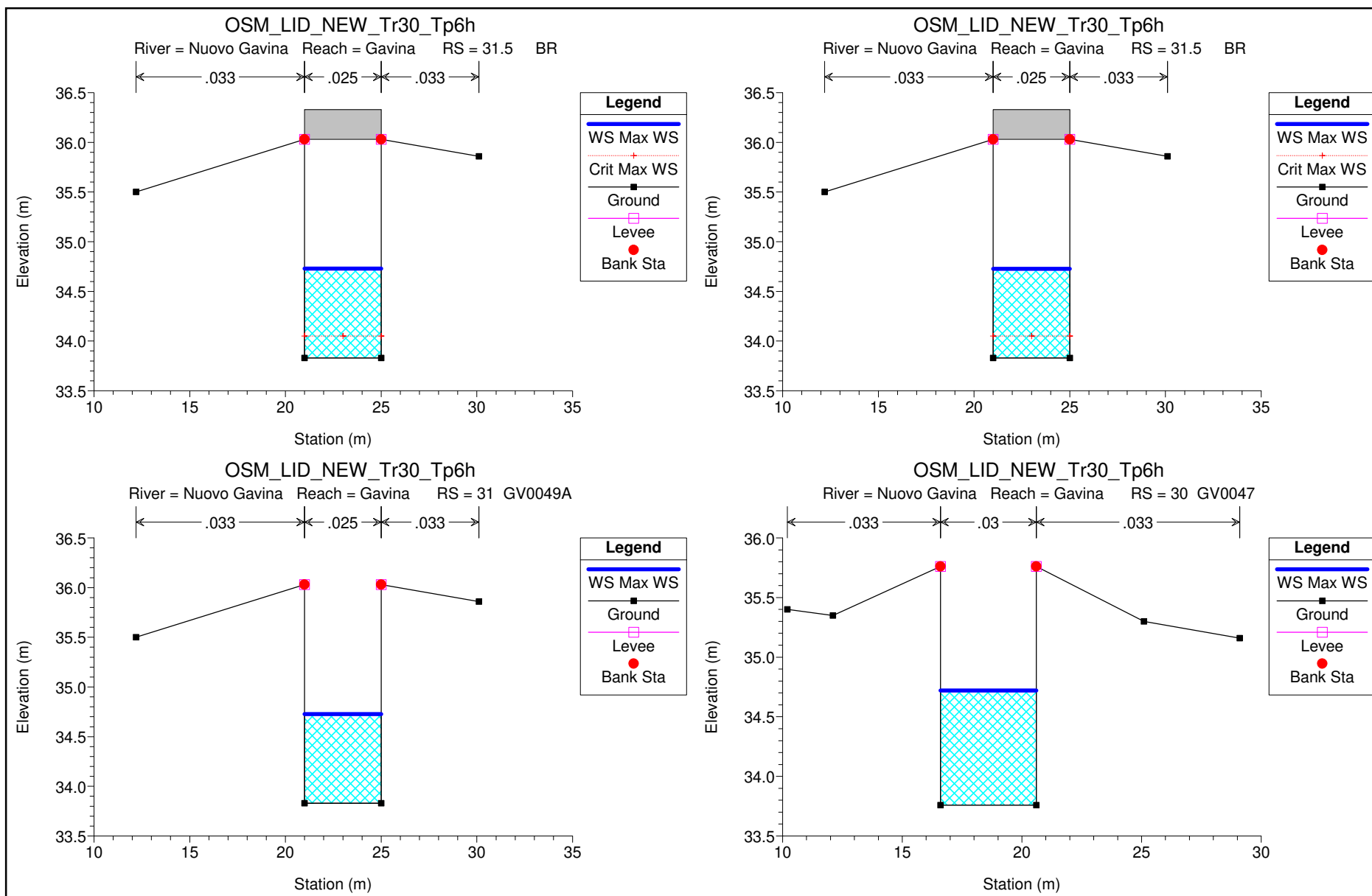


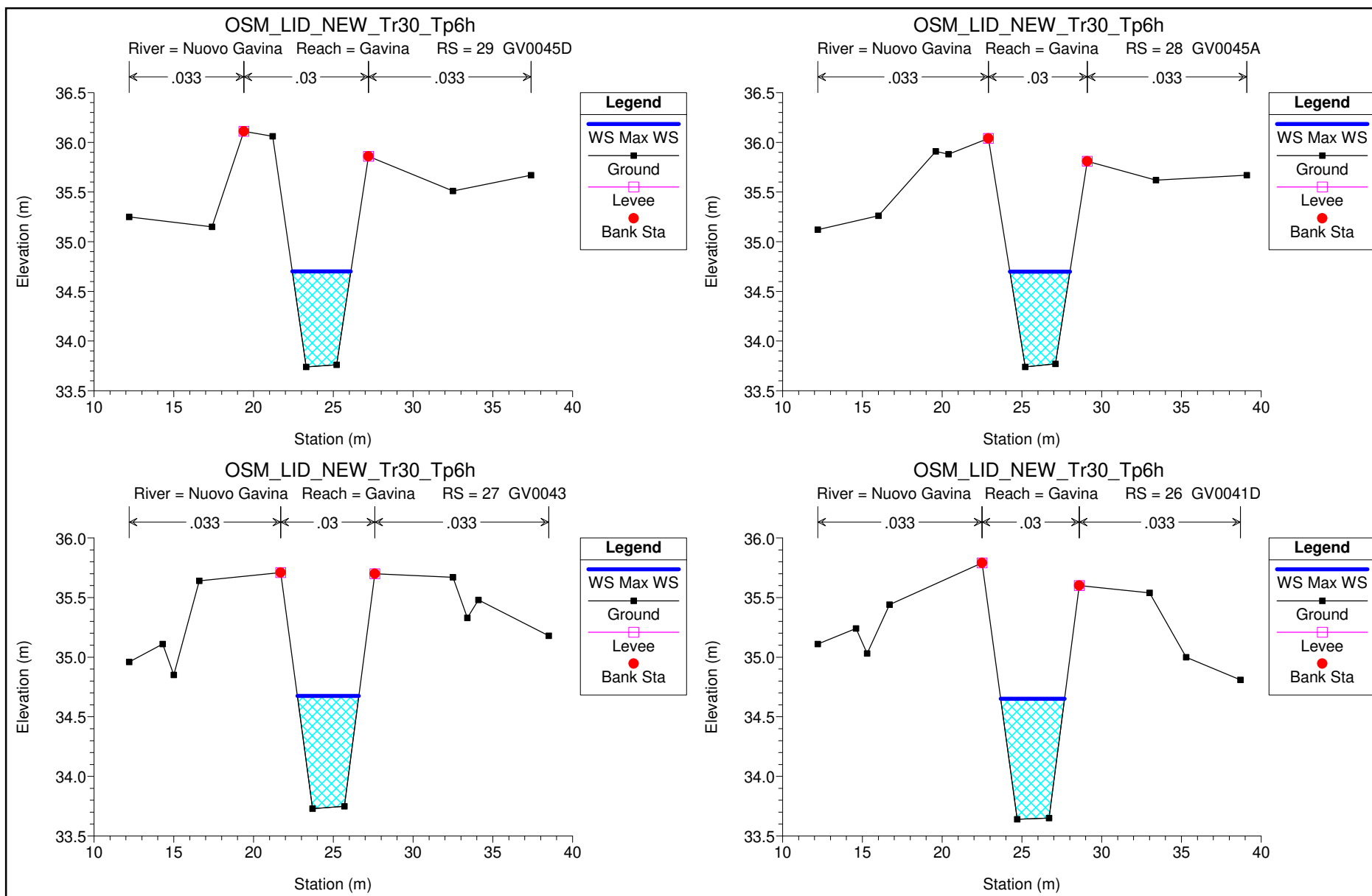


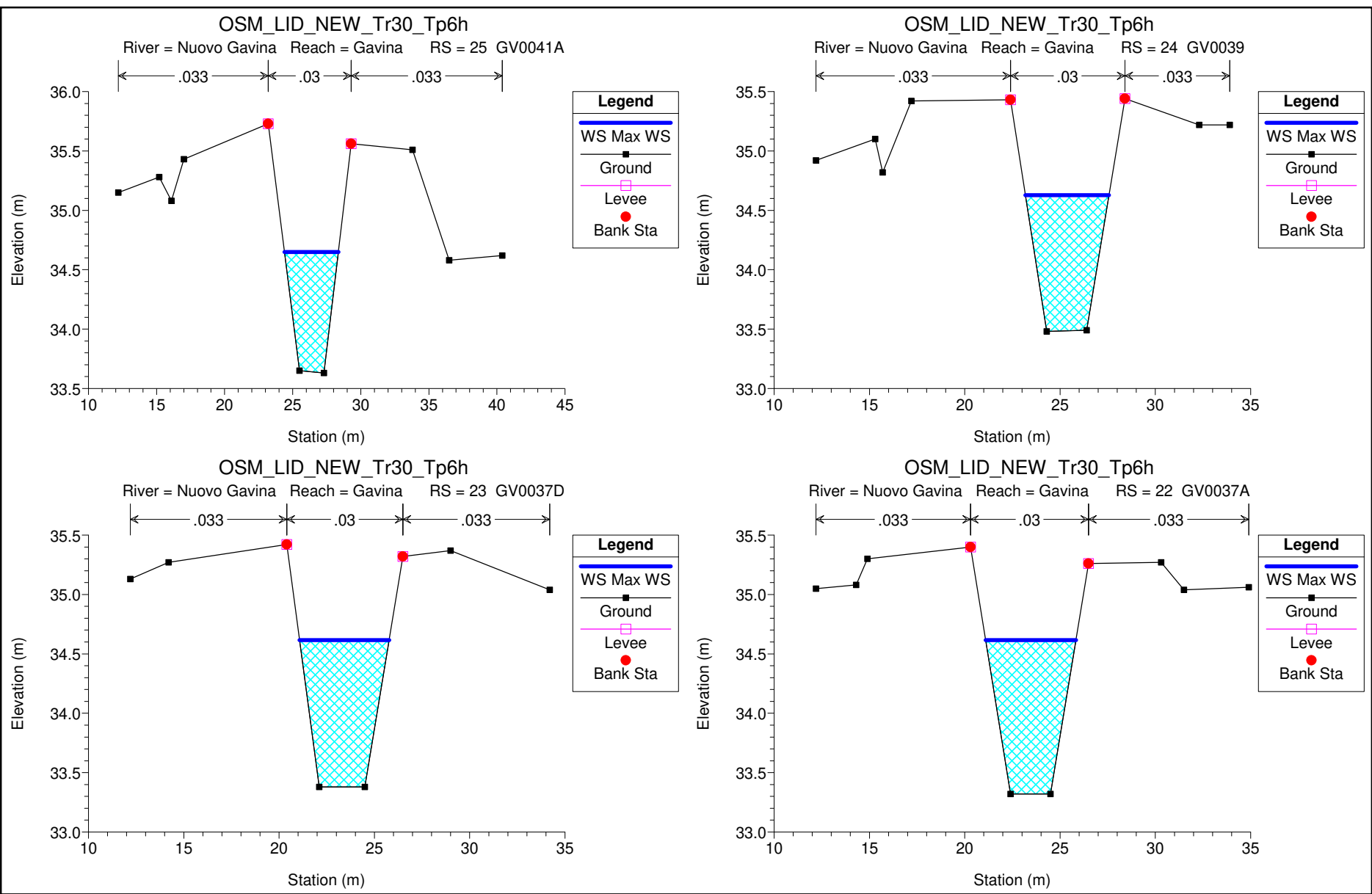


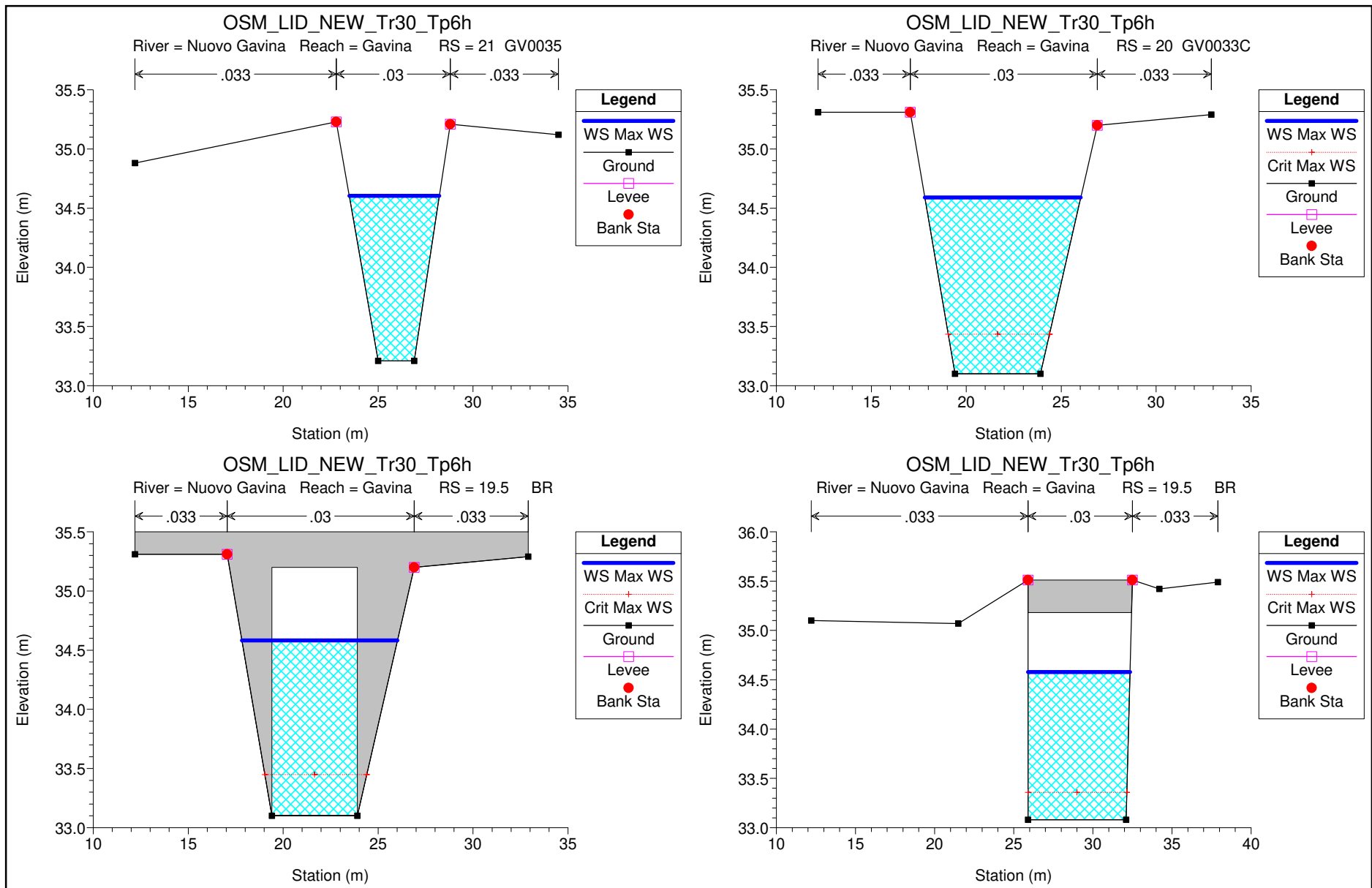


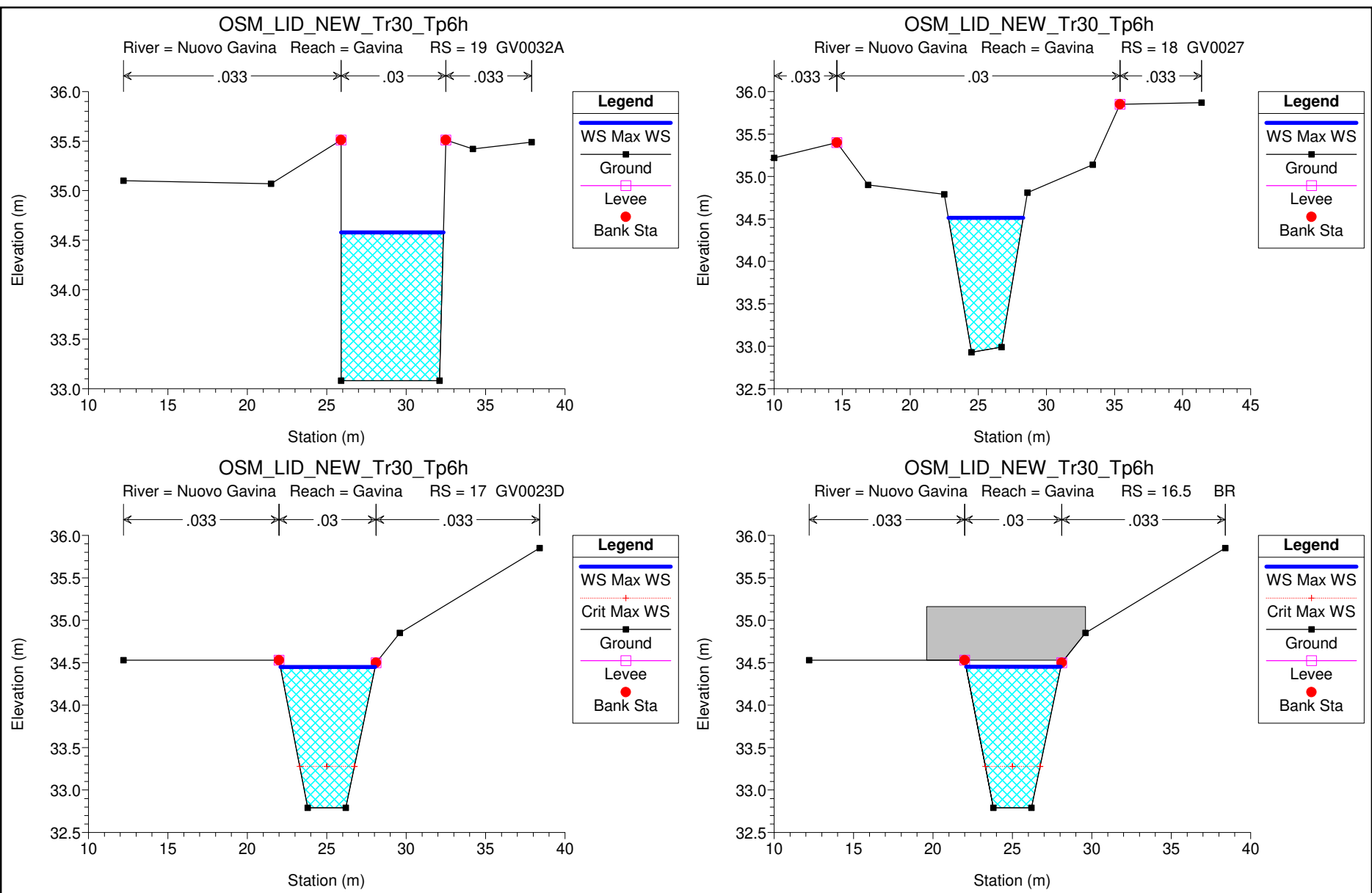


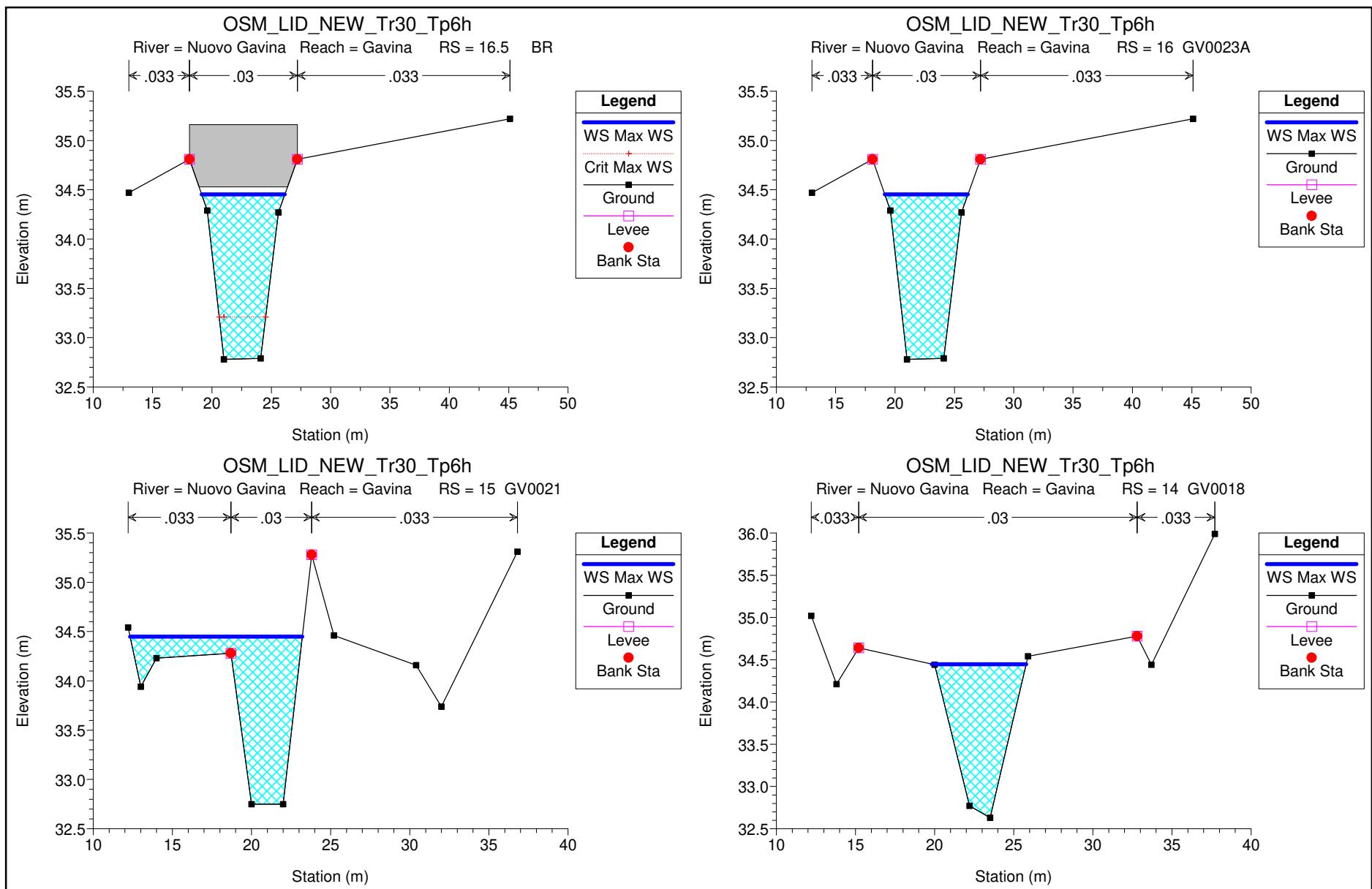


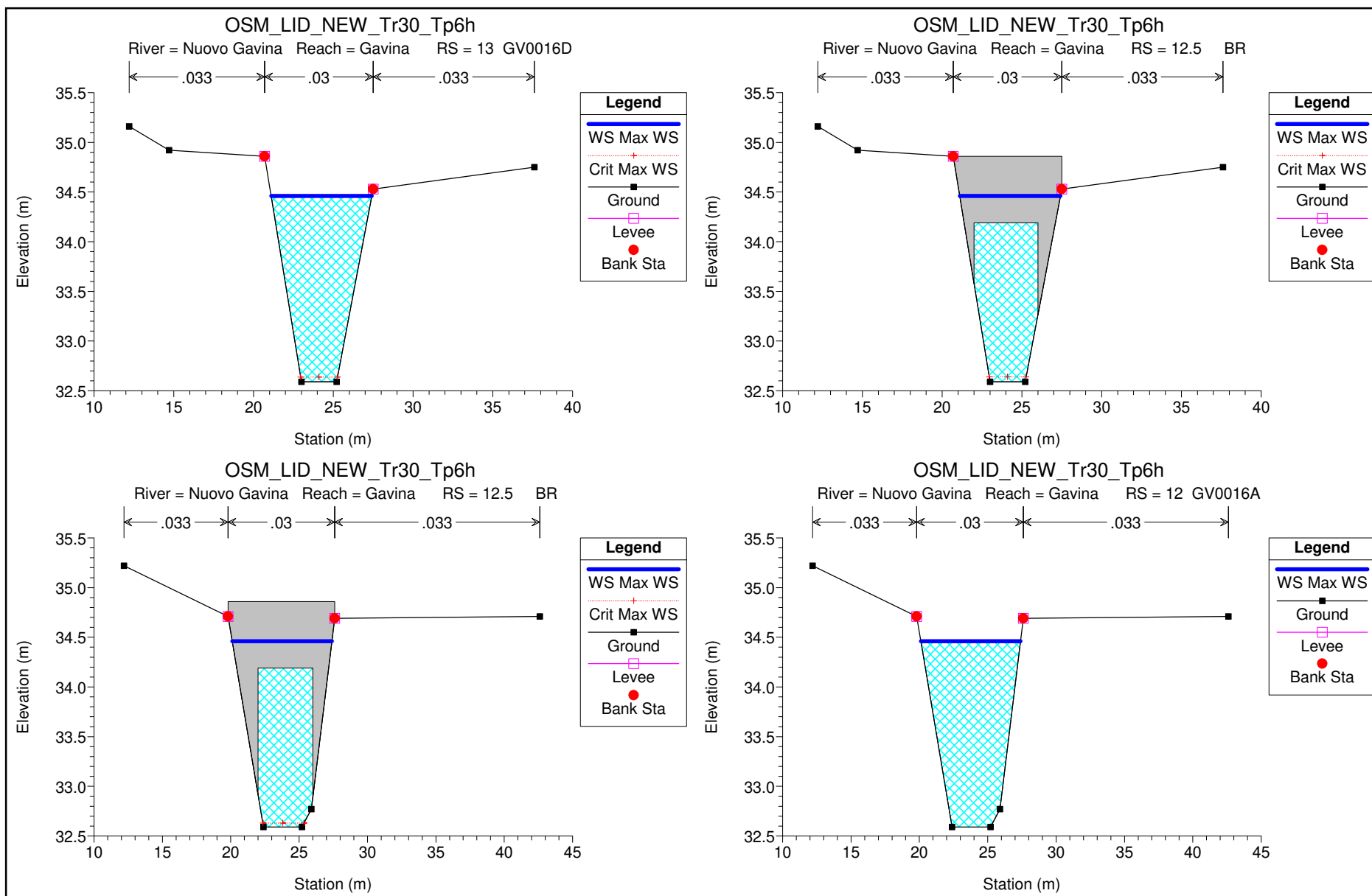


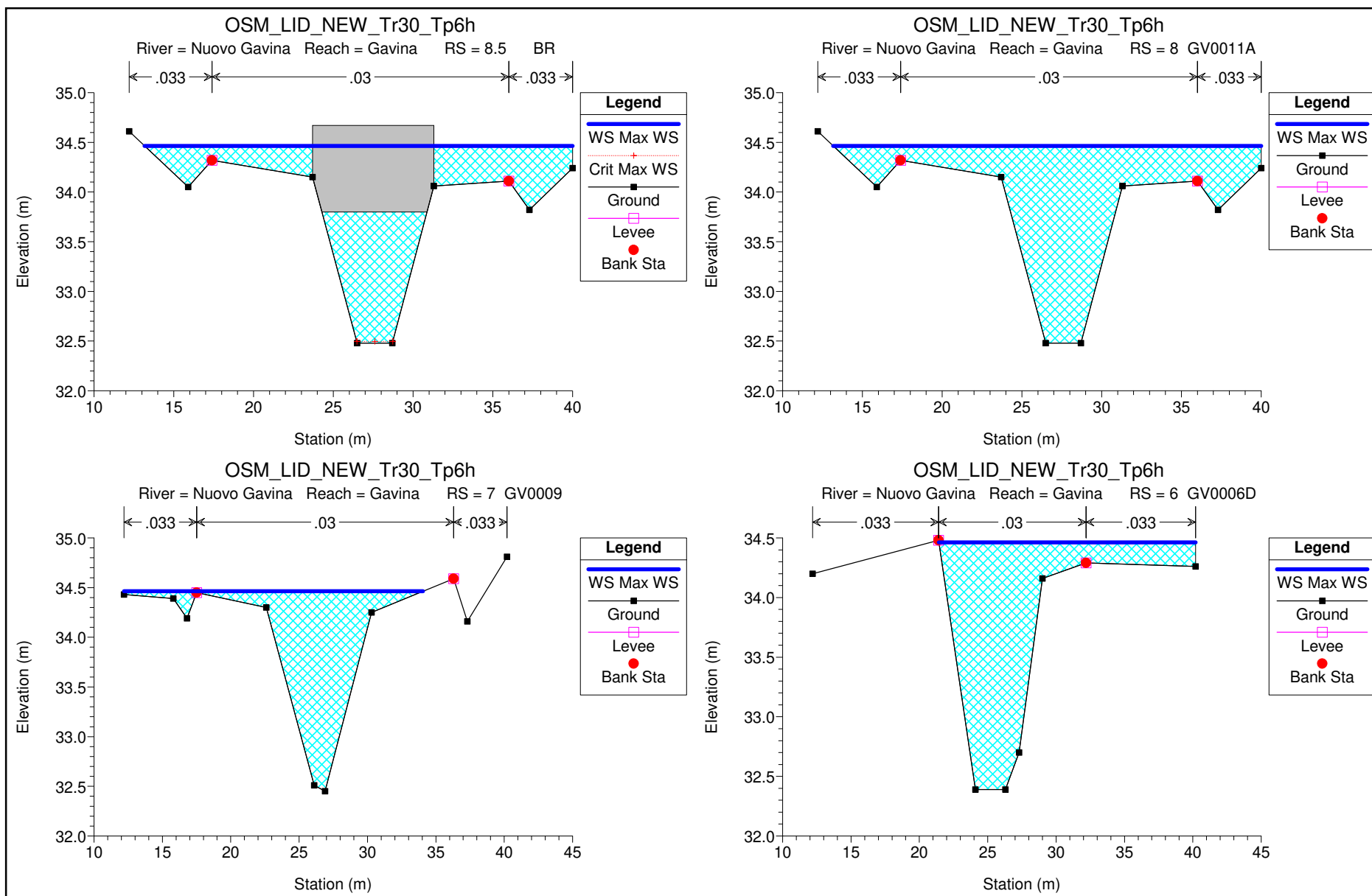


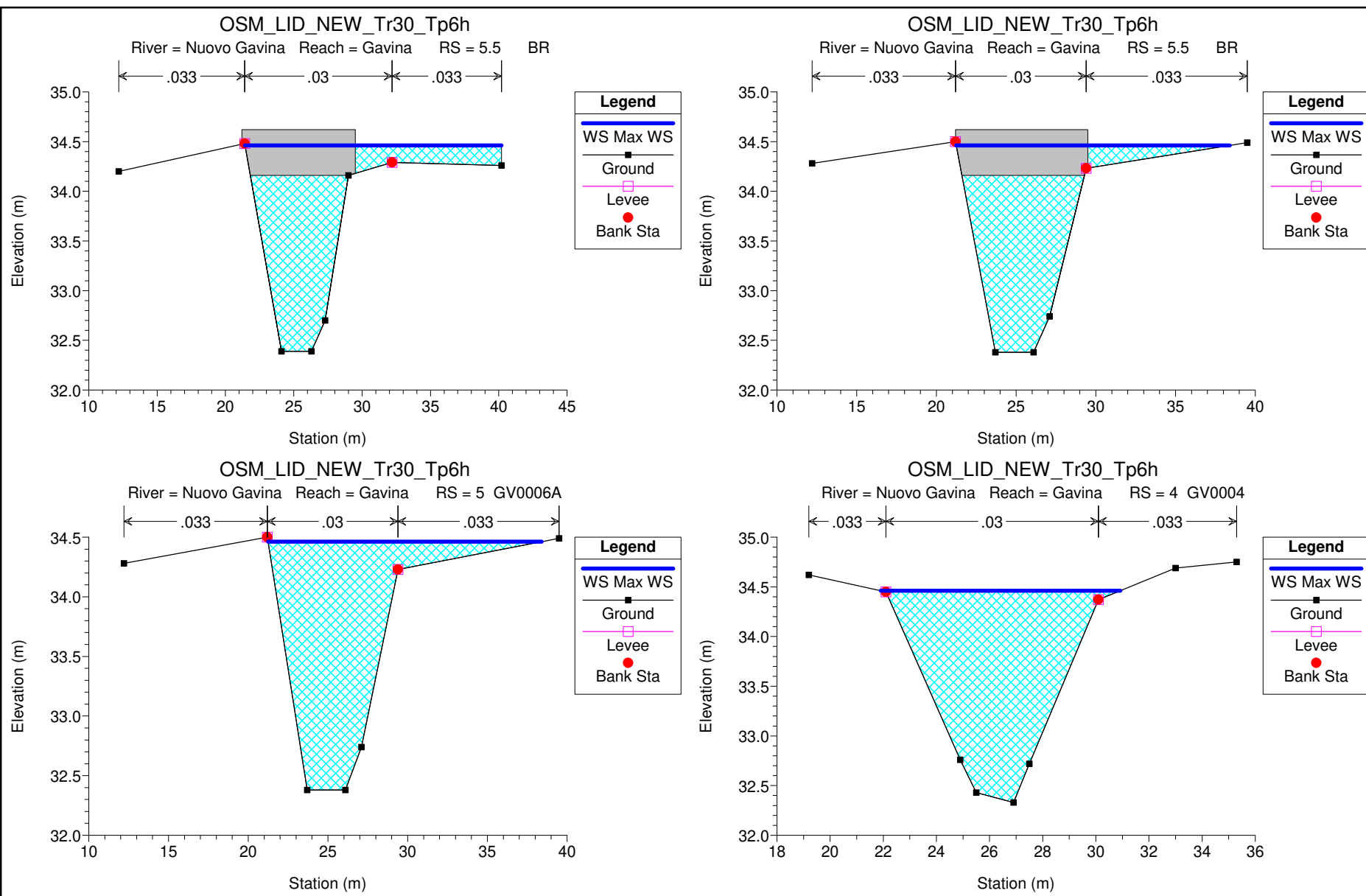


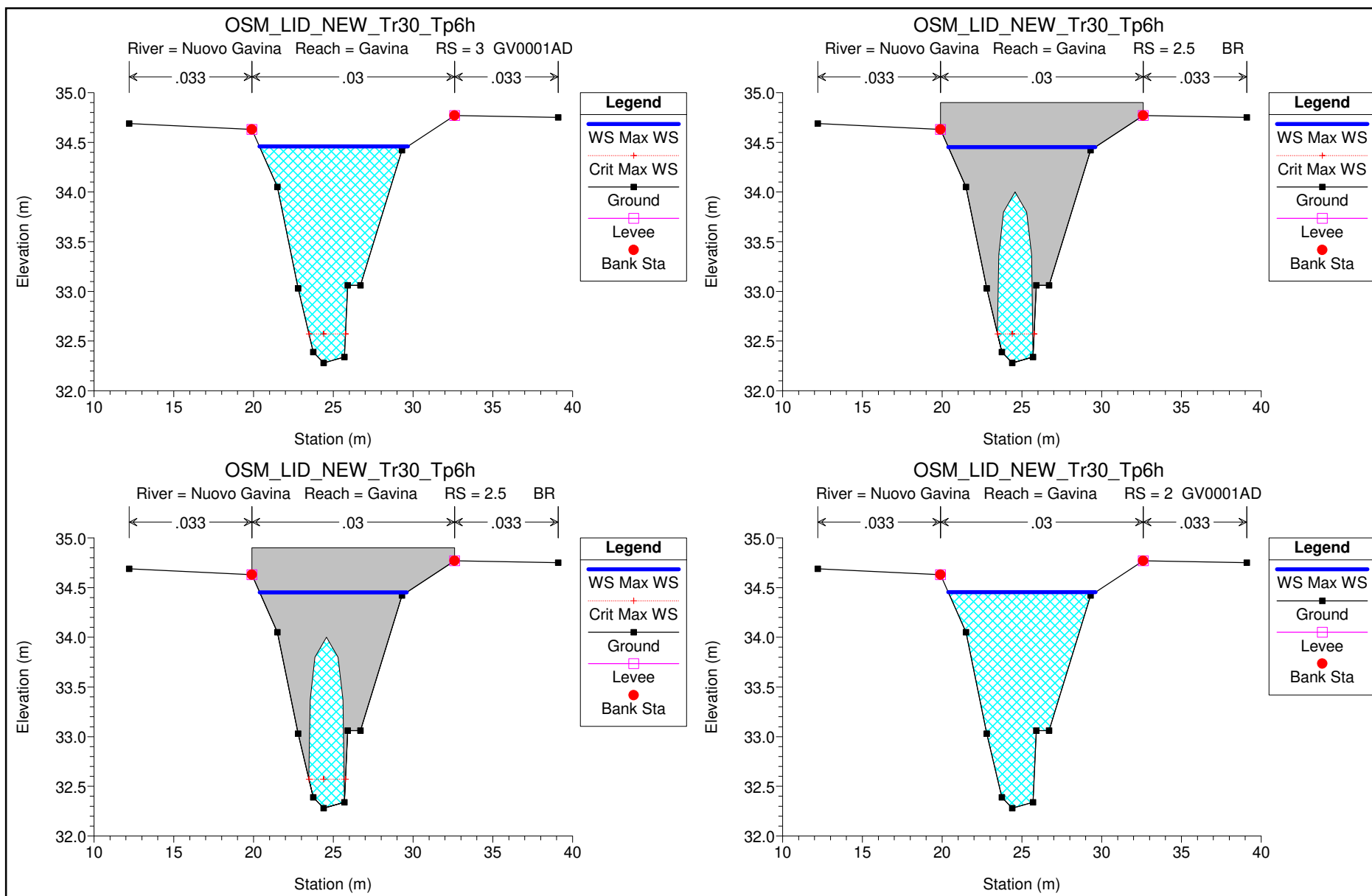






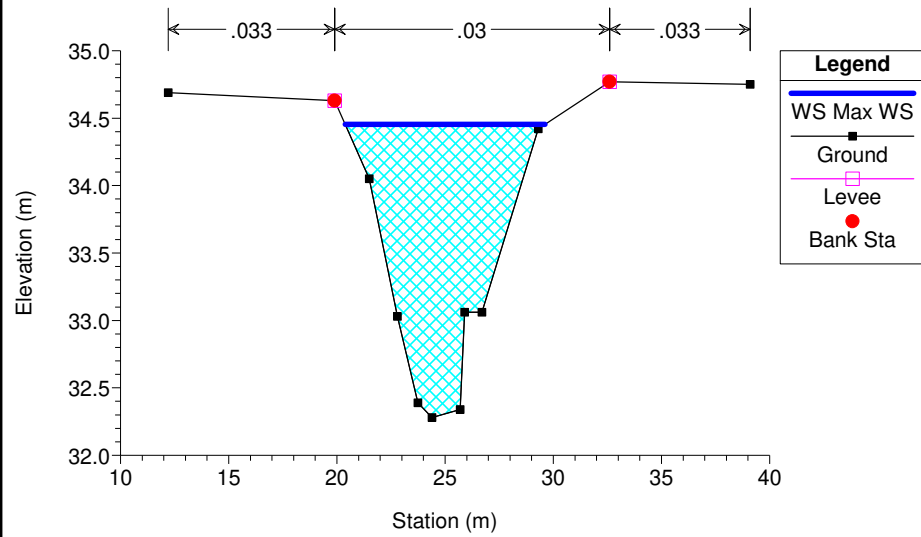






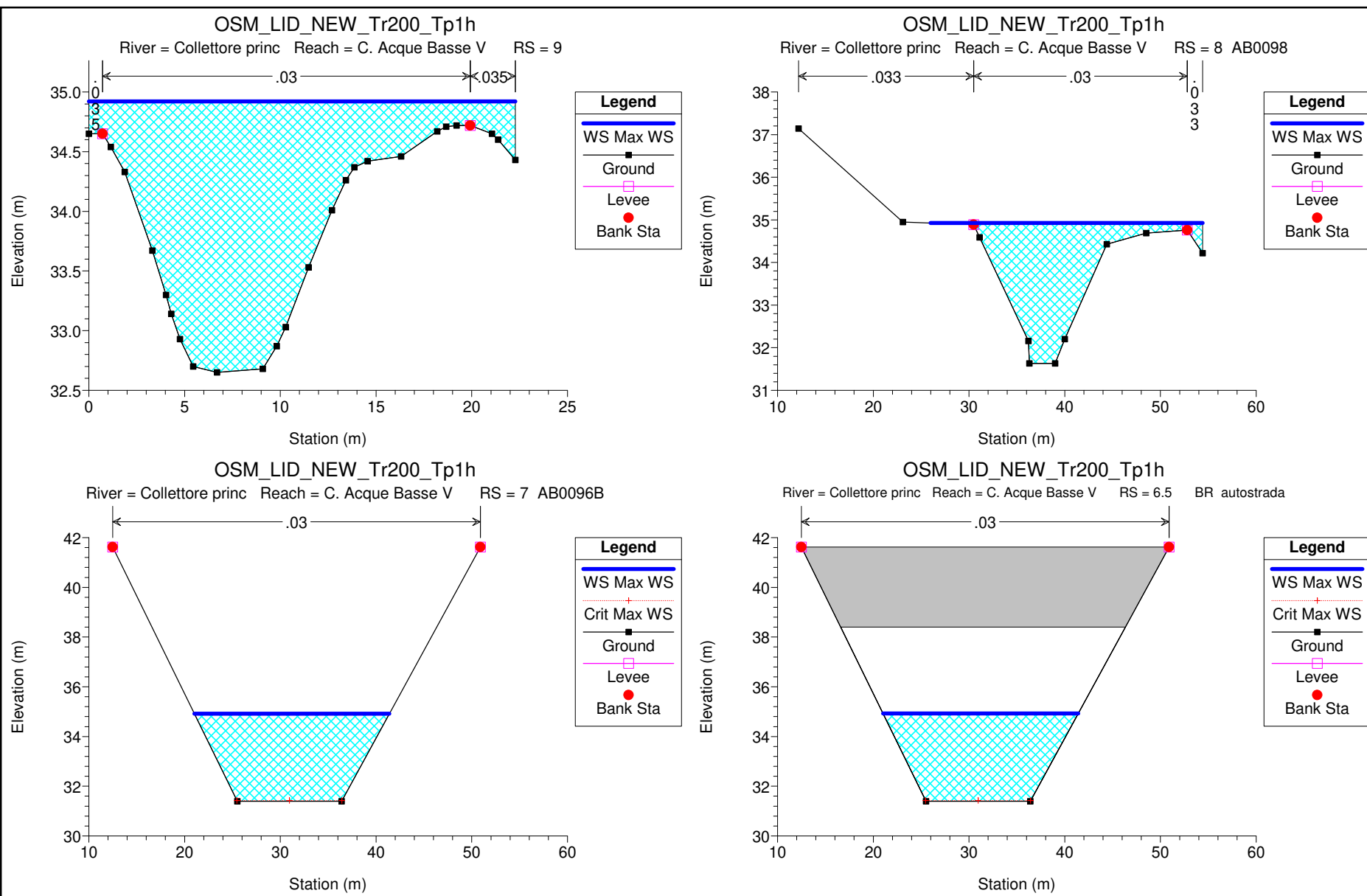
OSM_LID_NEW_Tr30_Tp6h

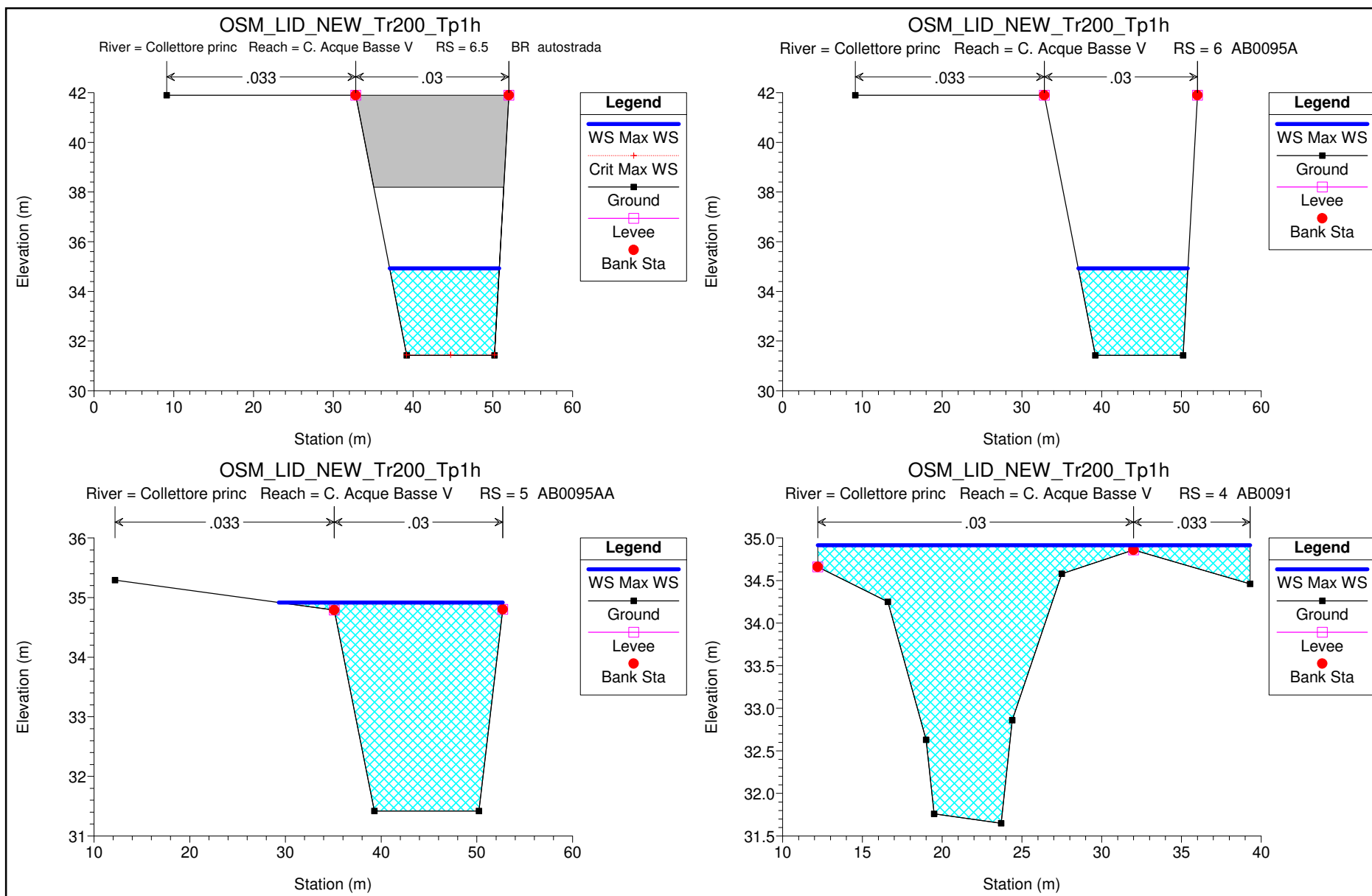
River = Nuovo Gavina Reach = Gavina RS = 1 GV0001AD

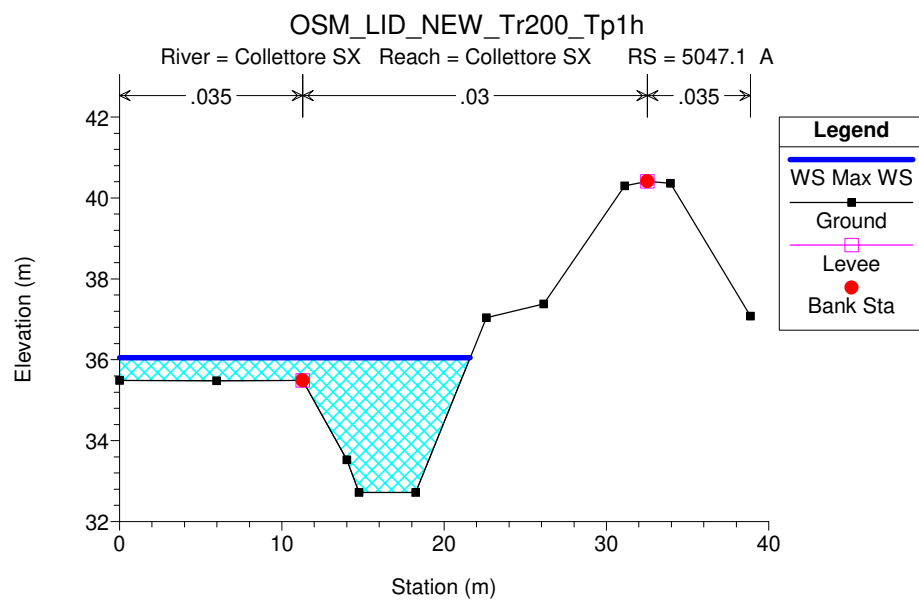
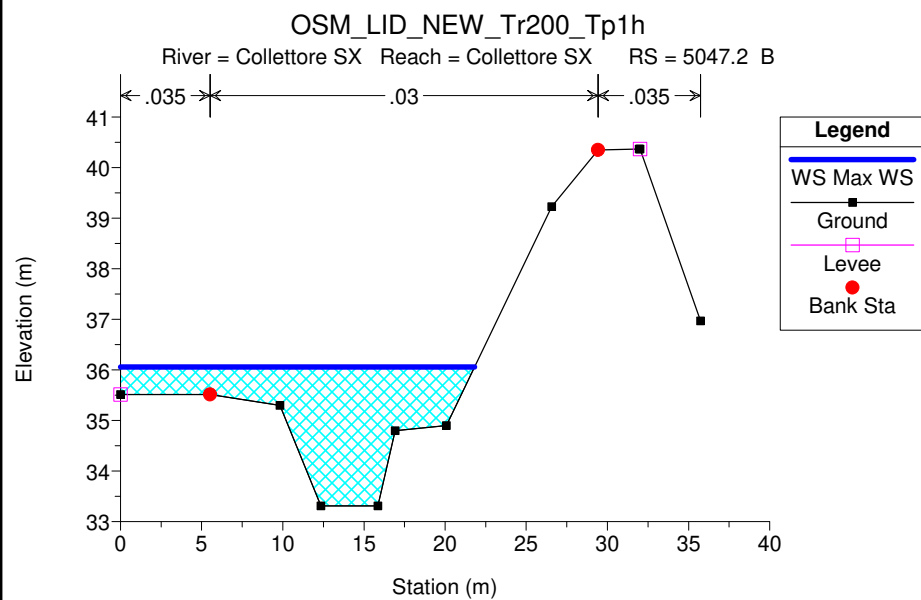
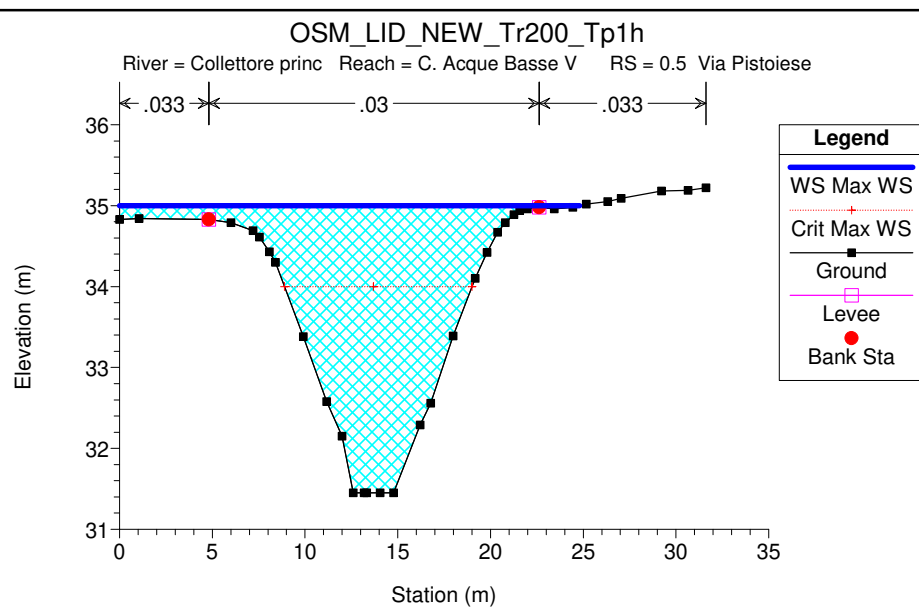
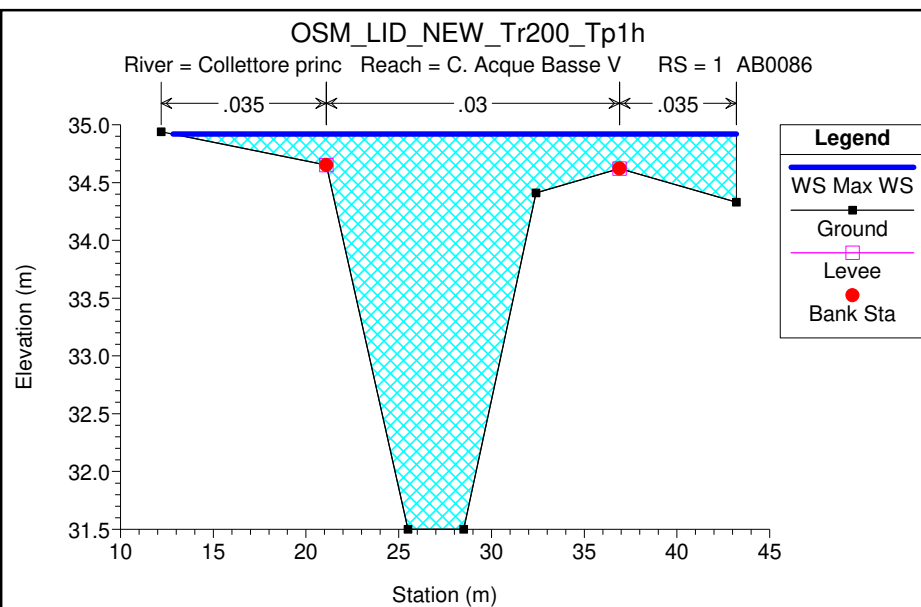


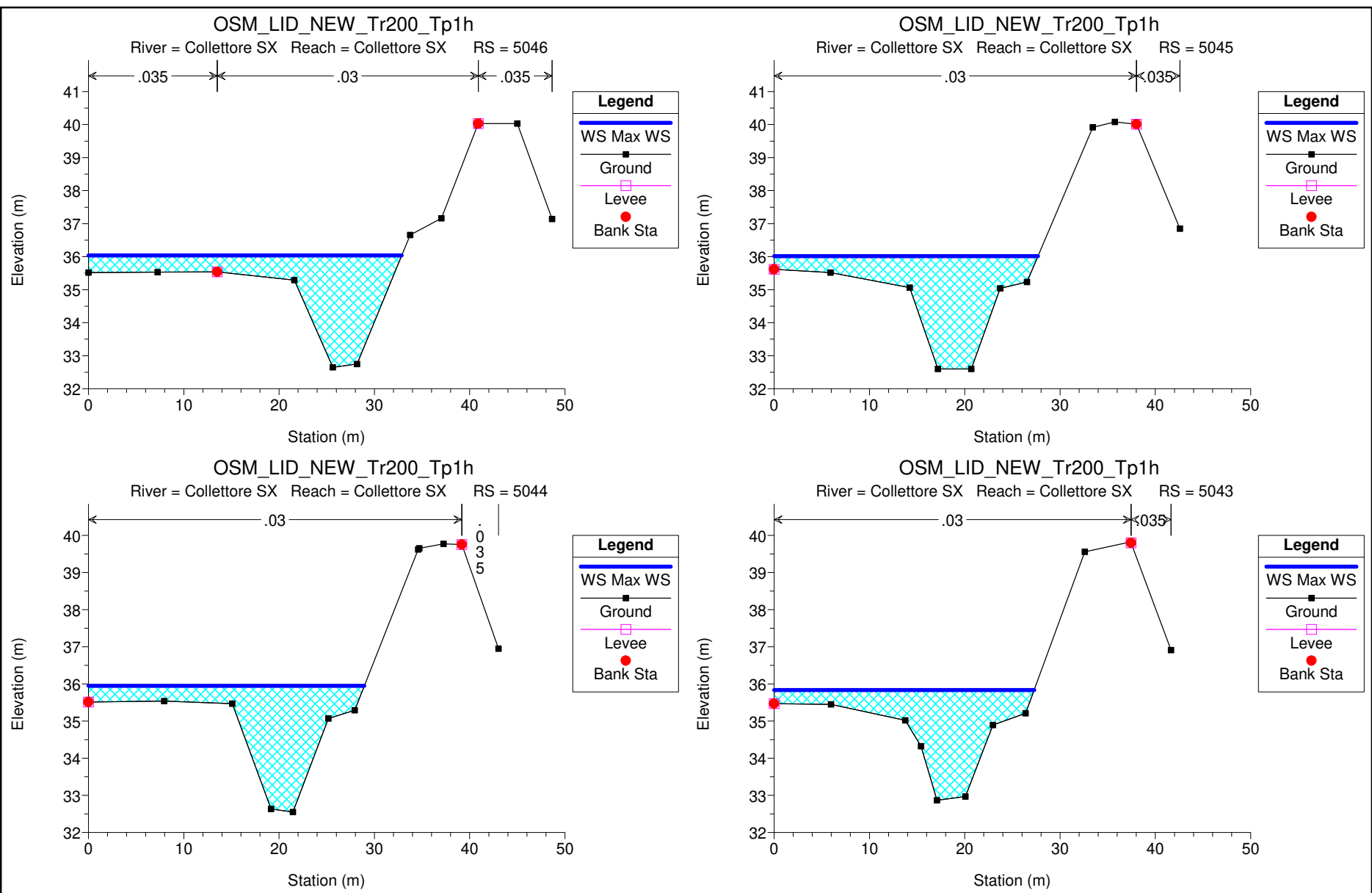
Verifiche idrauliche Tr 200 anni Tp 1h

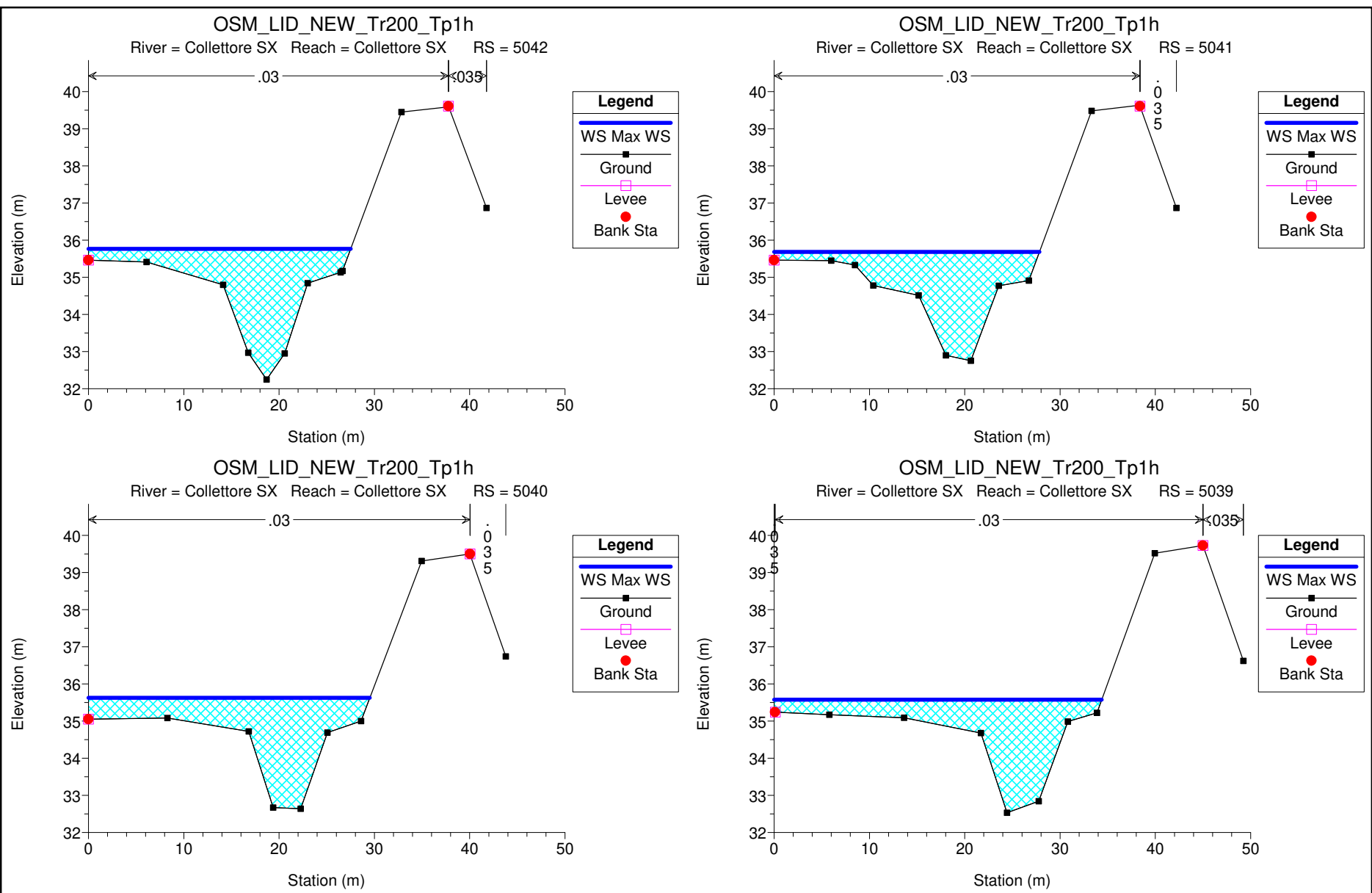
**Collettore sinistro acque basse – Fosso Osmannoro – Fosso Nuova Gavine – Collettore
principale delle acque basse**

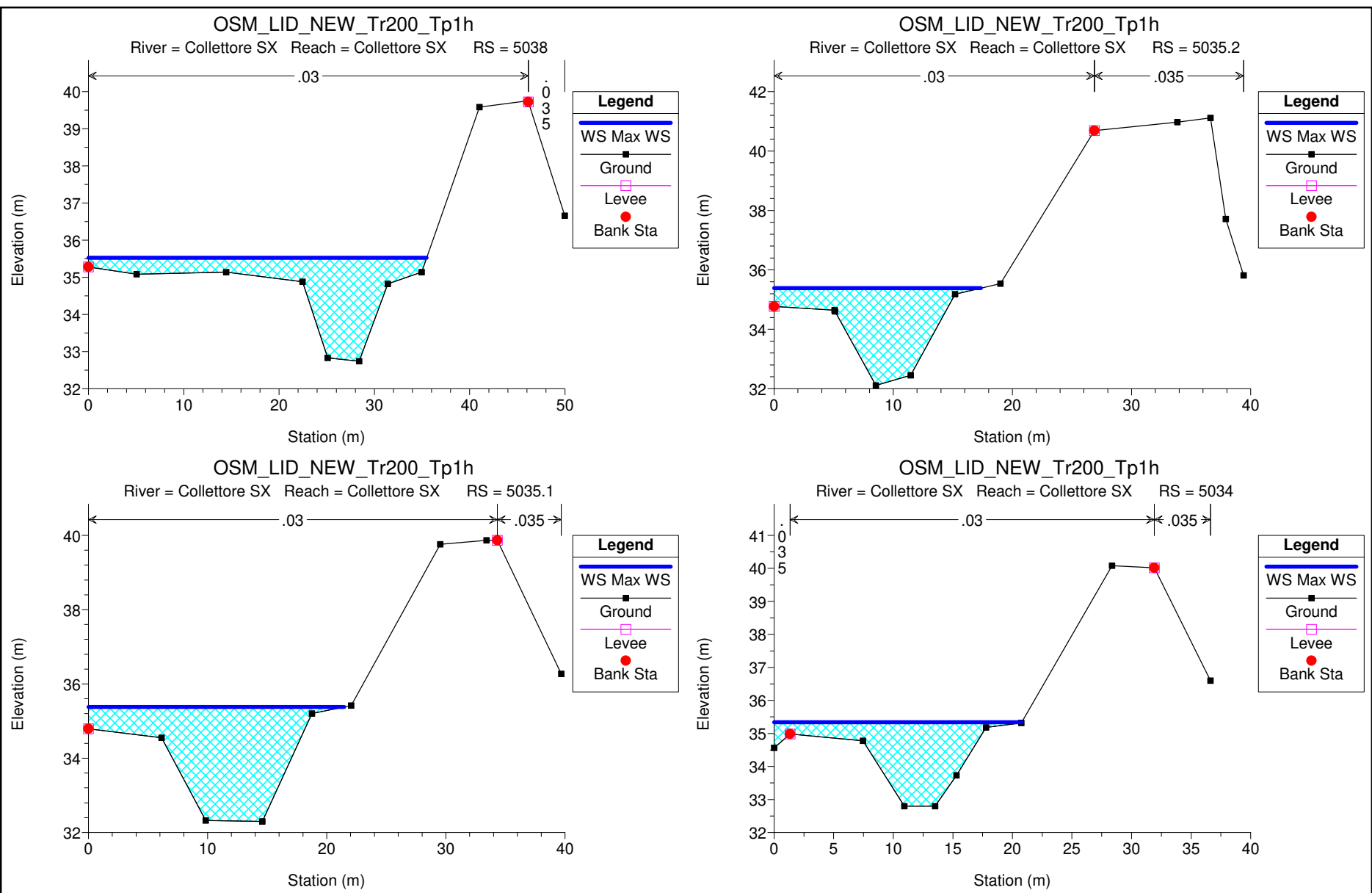


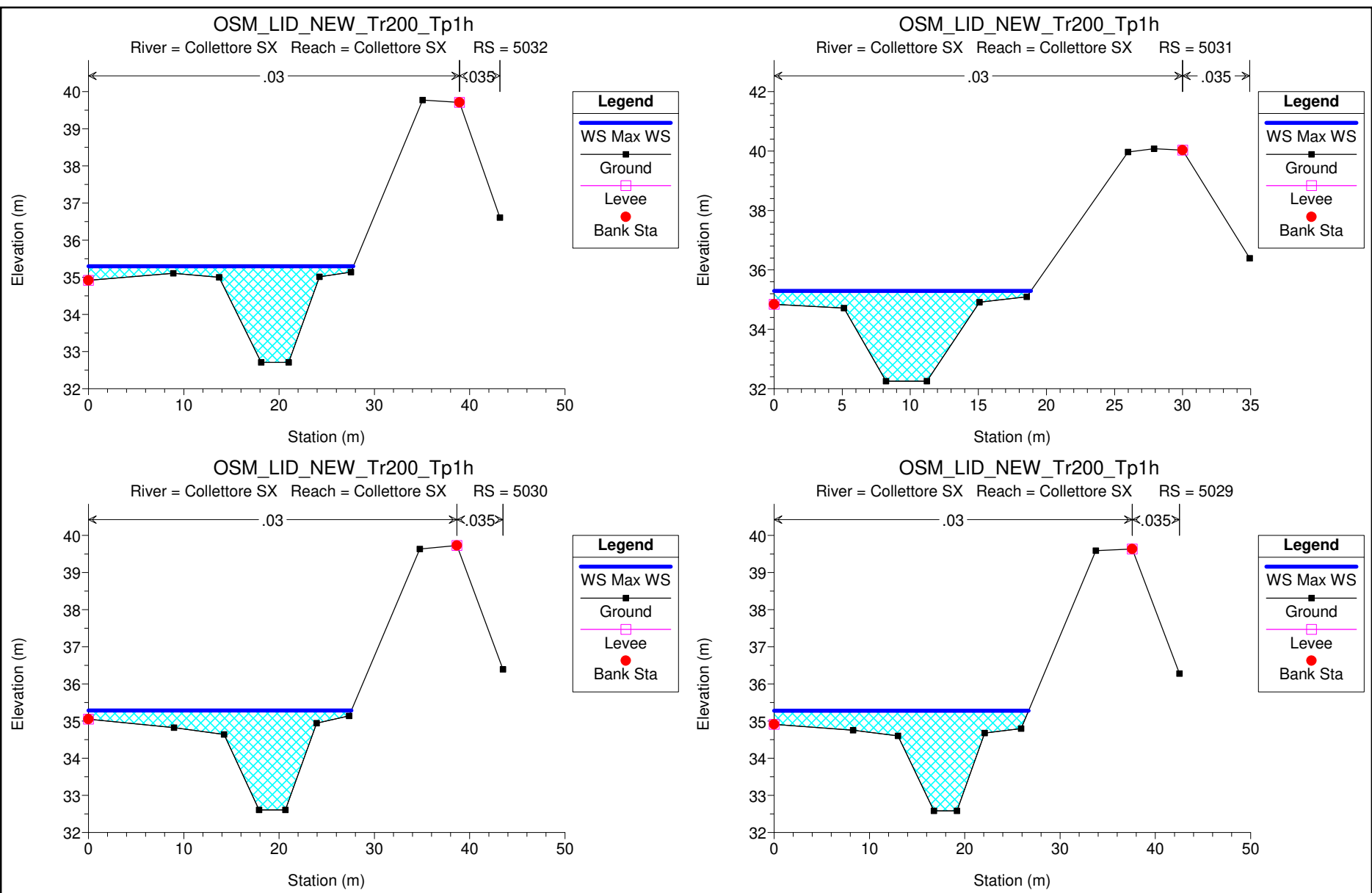


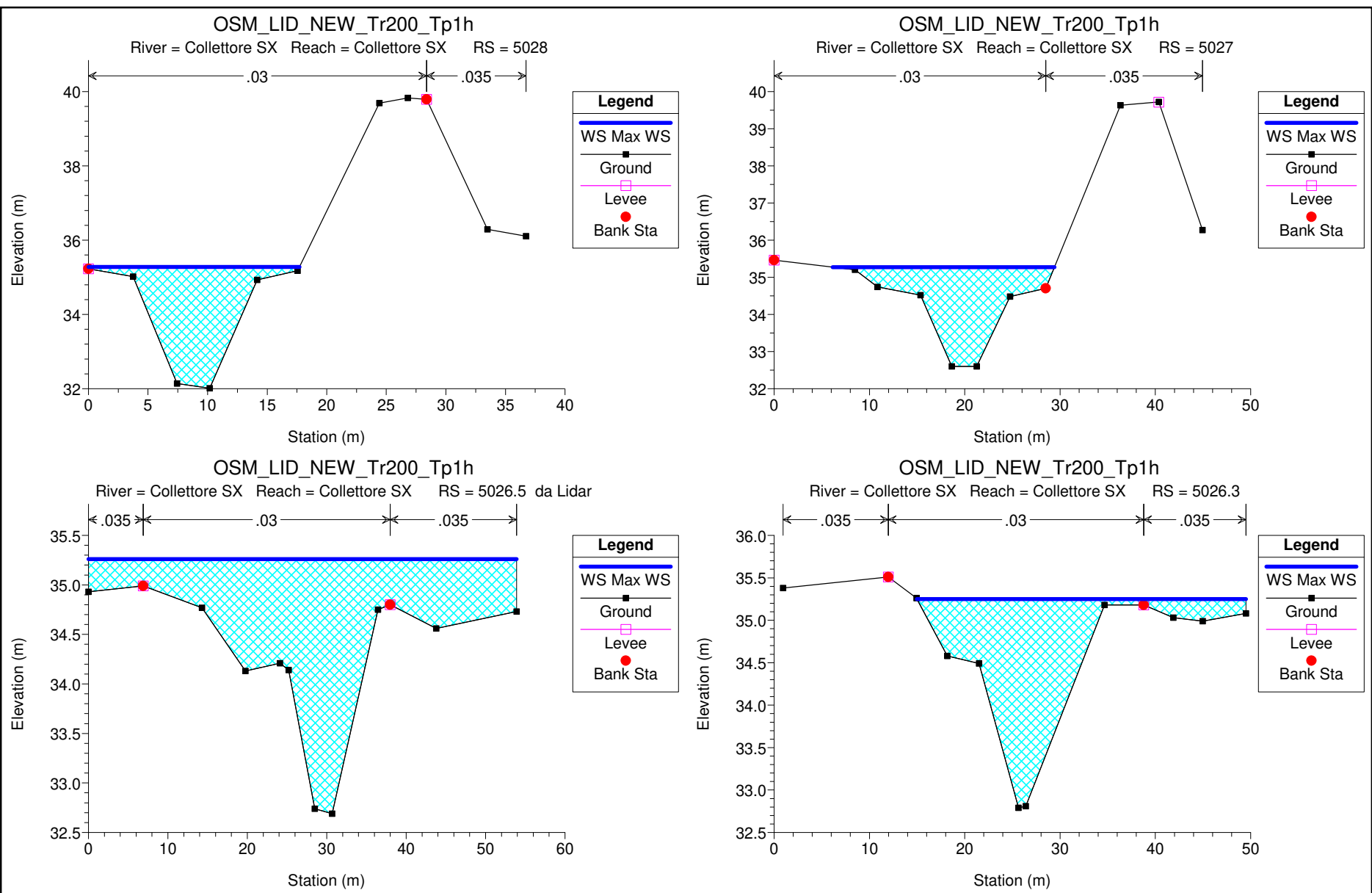


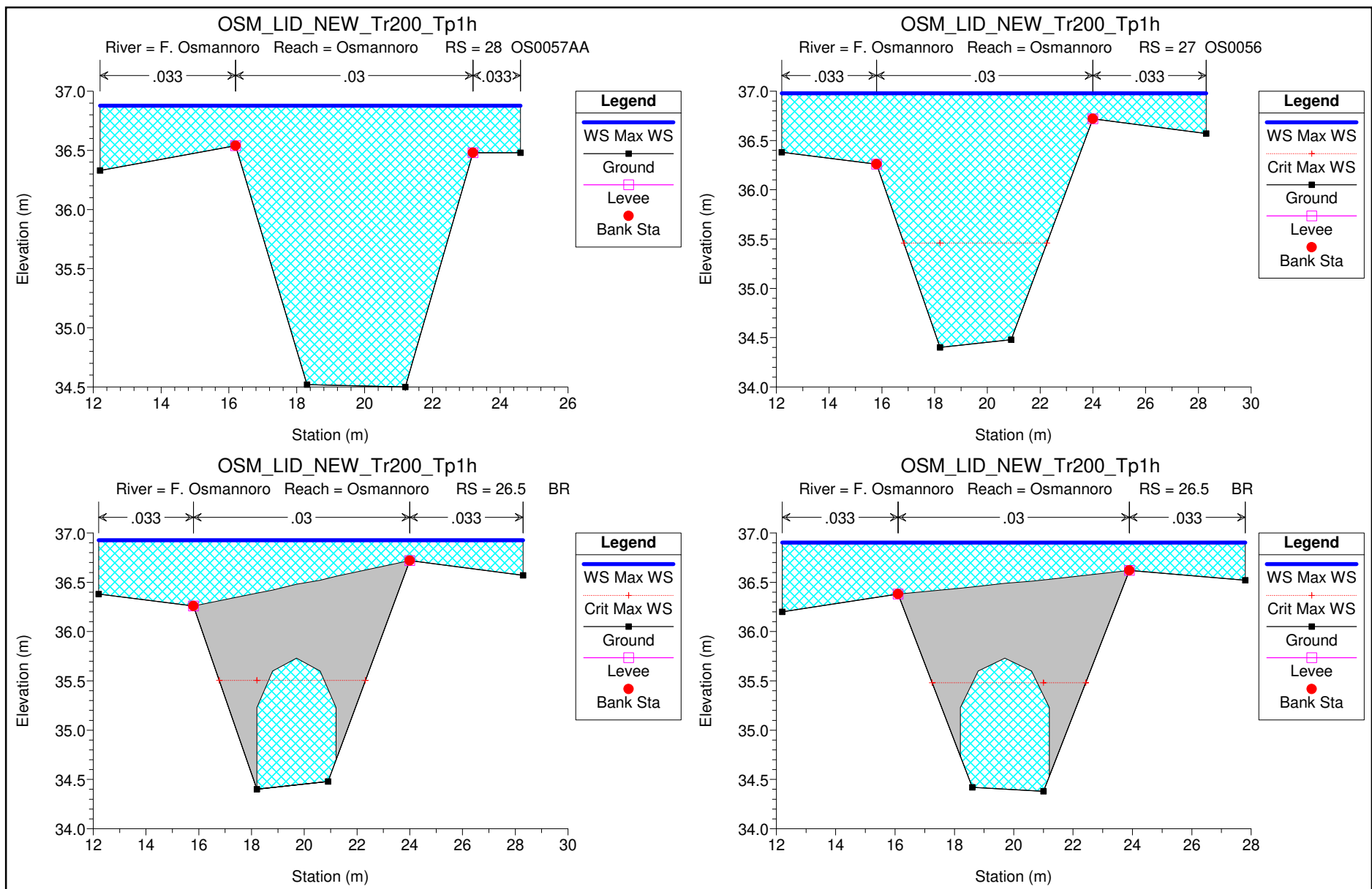


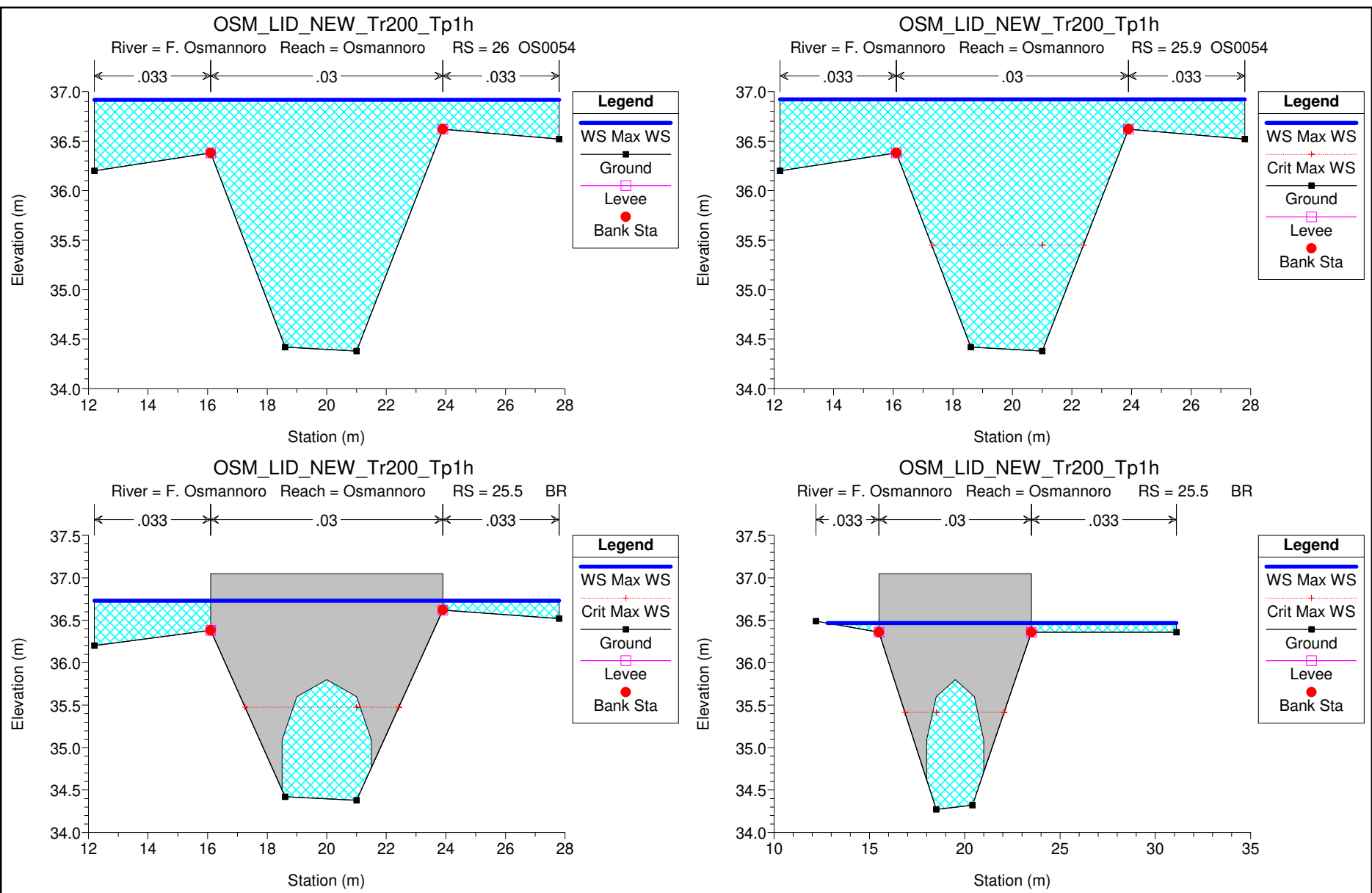


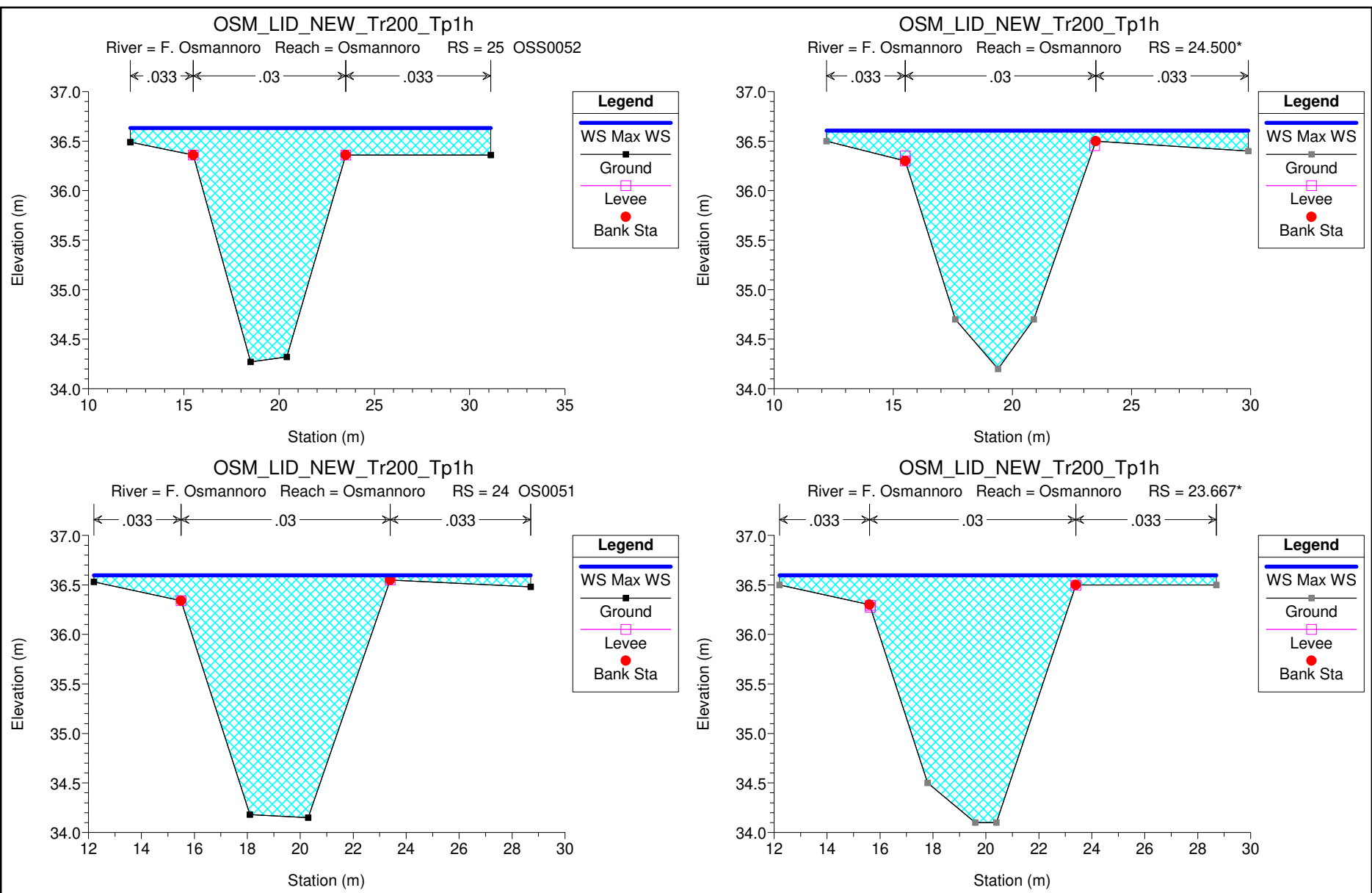


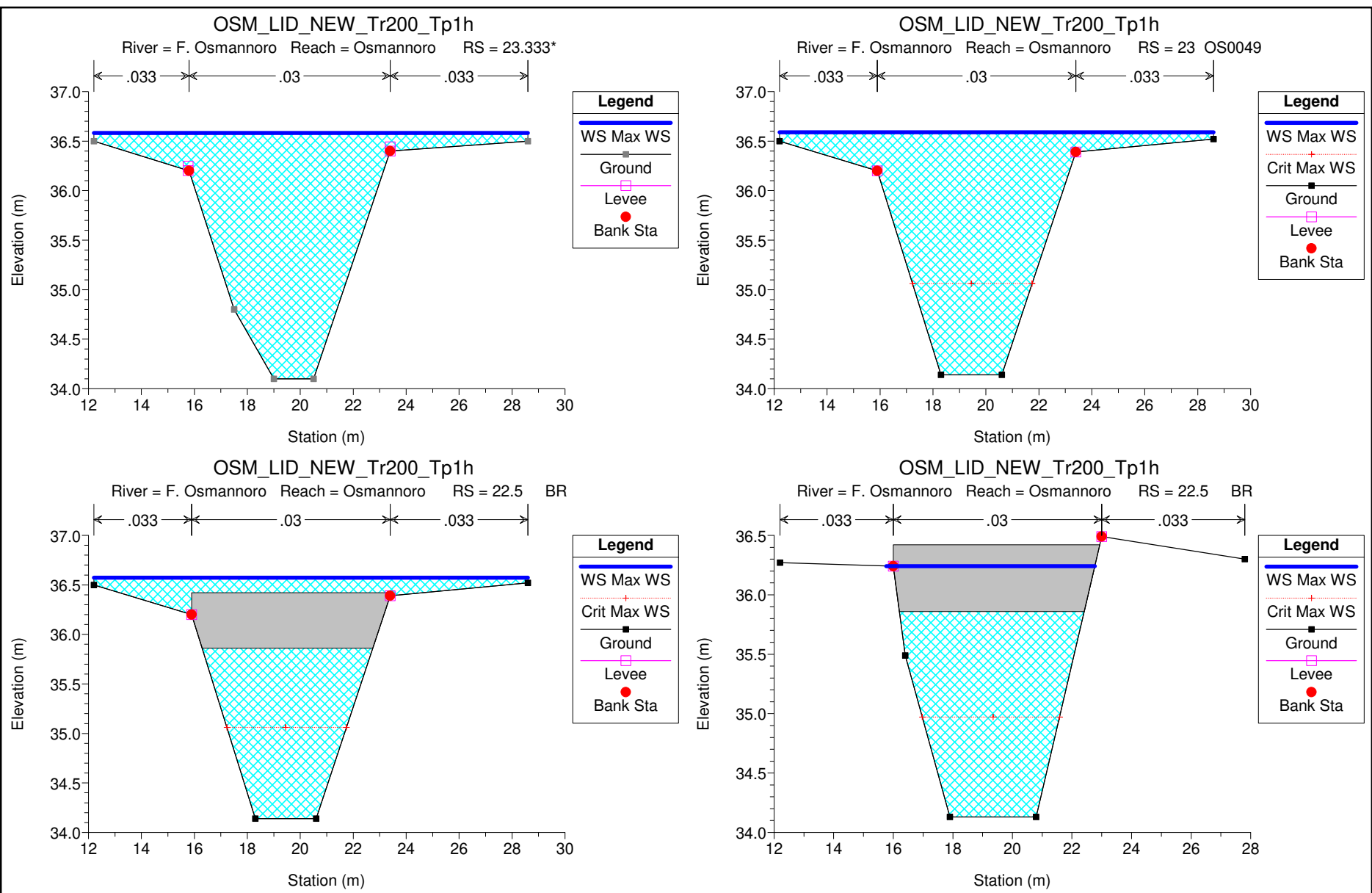


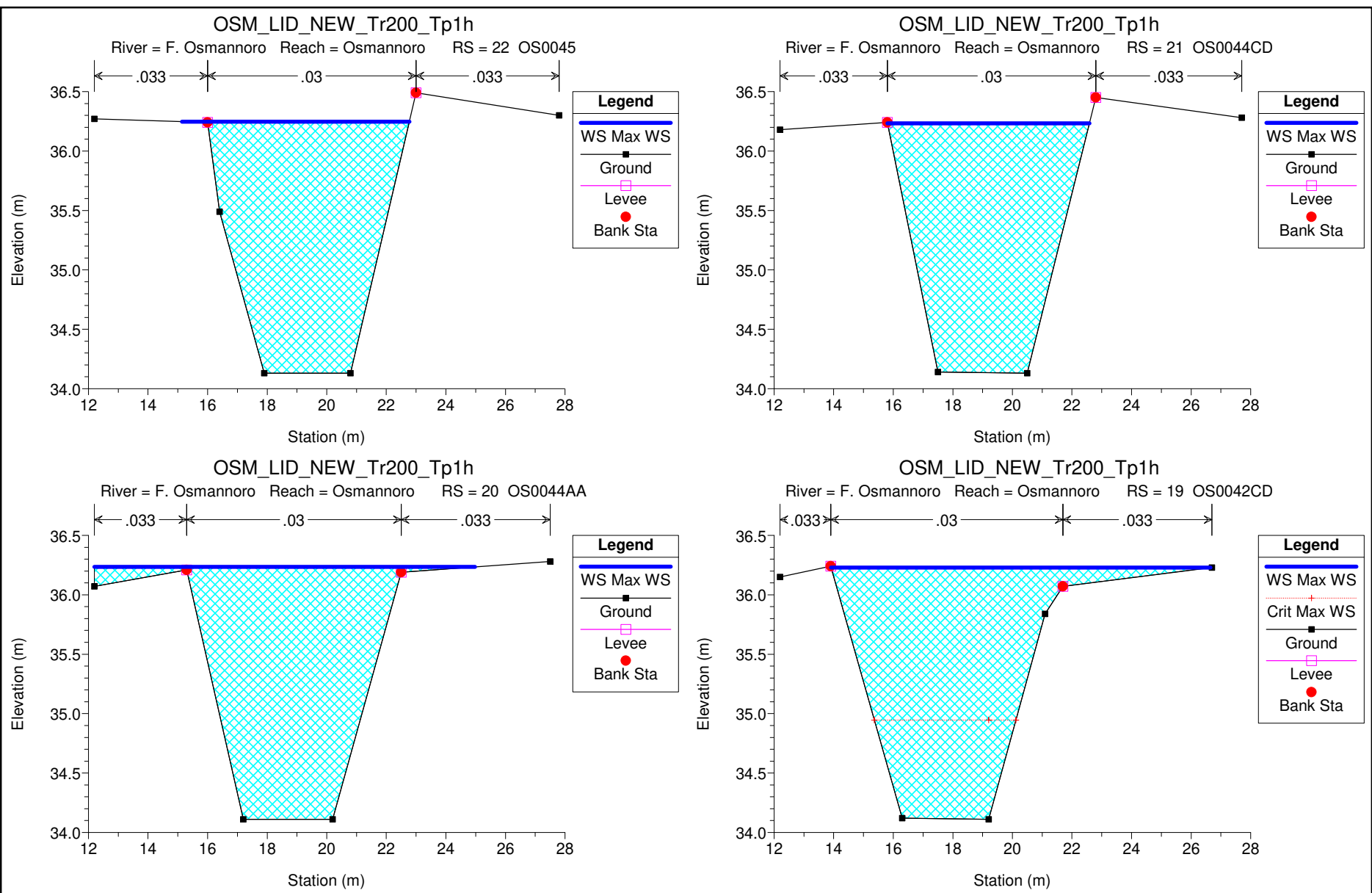


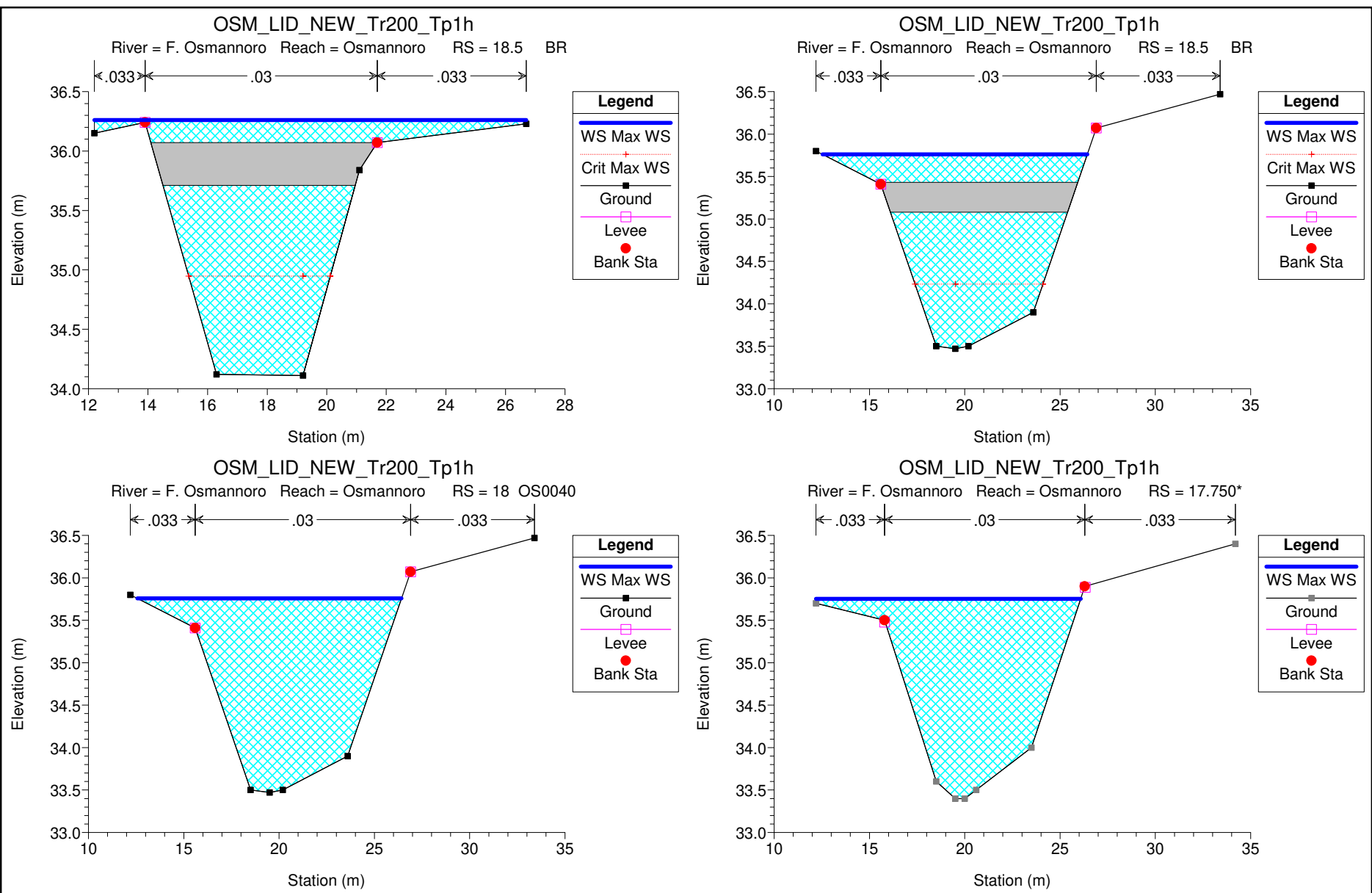


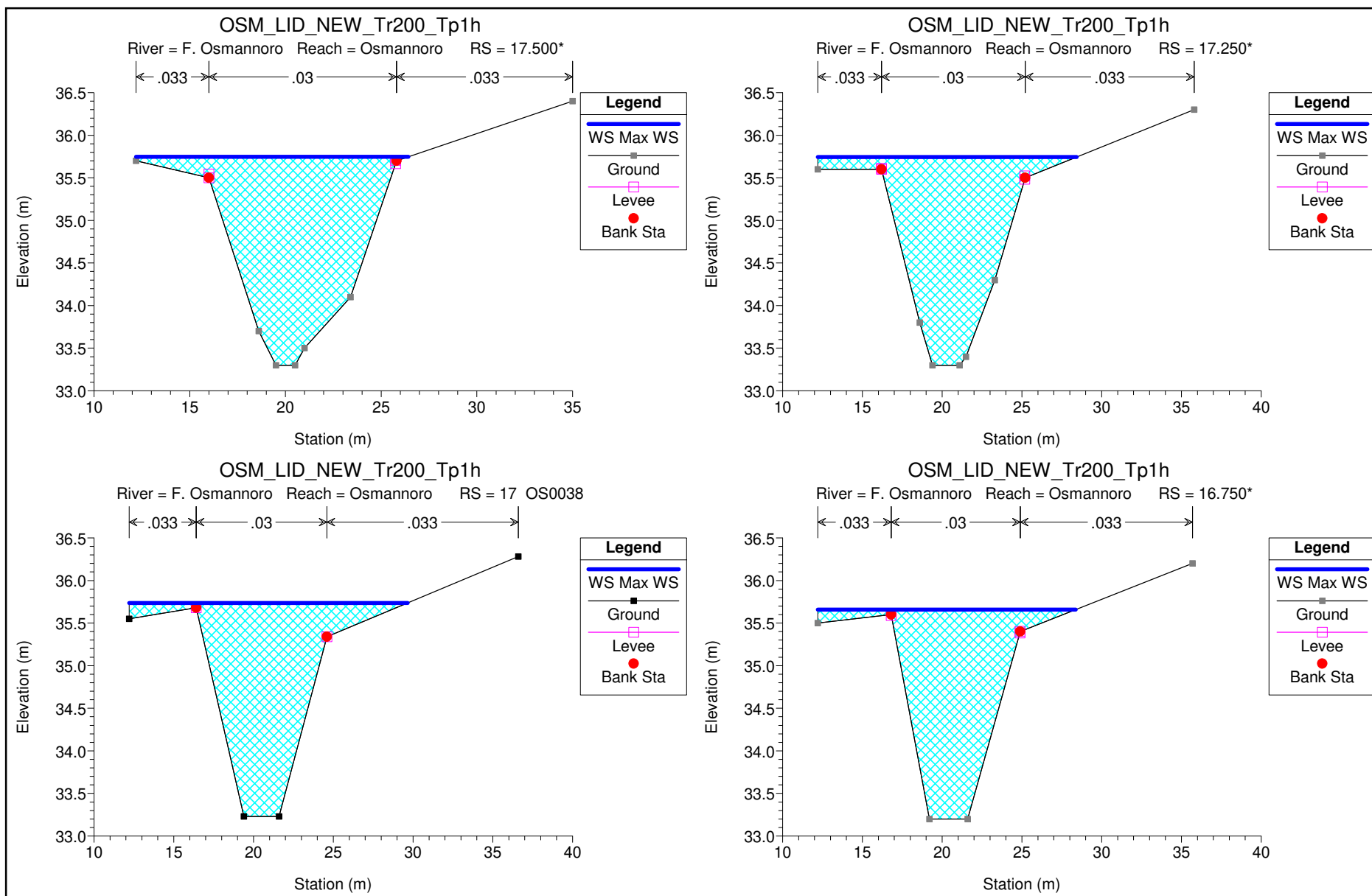


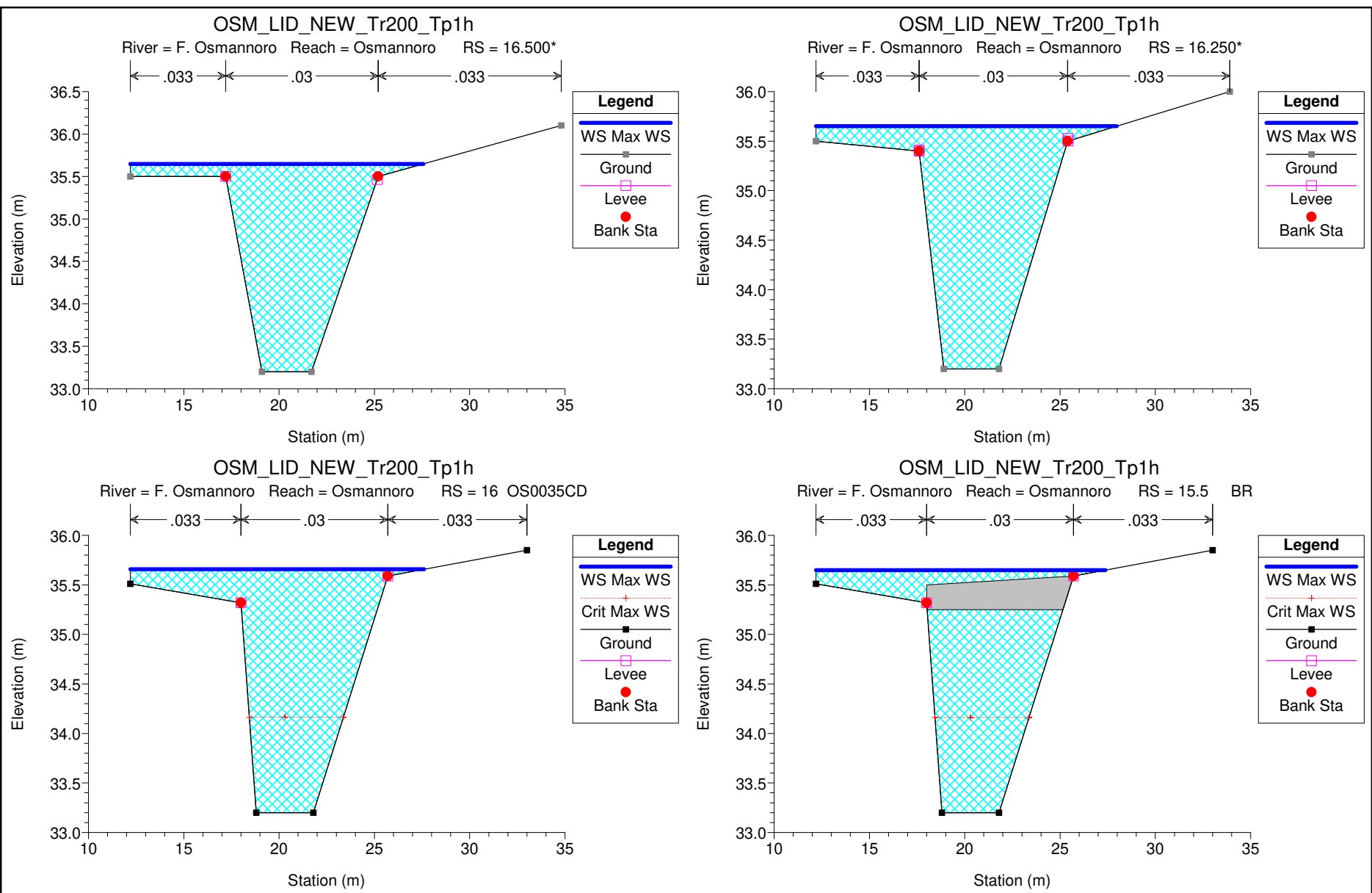


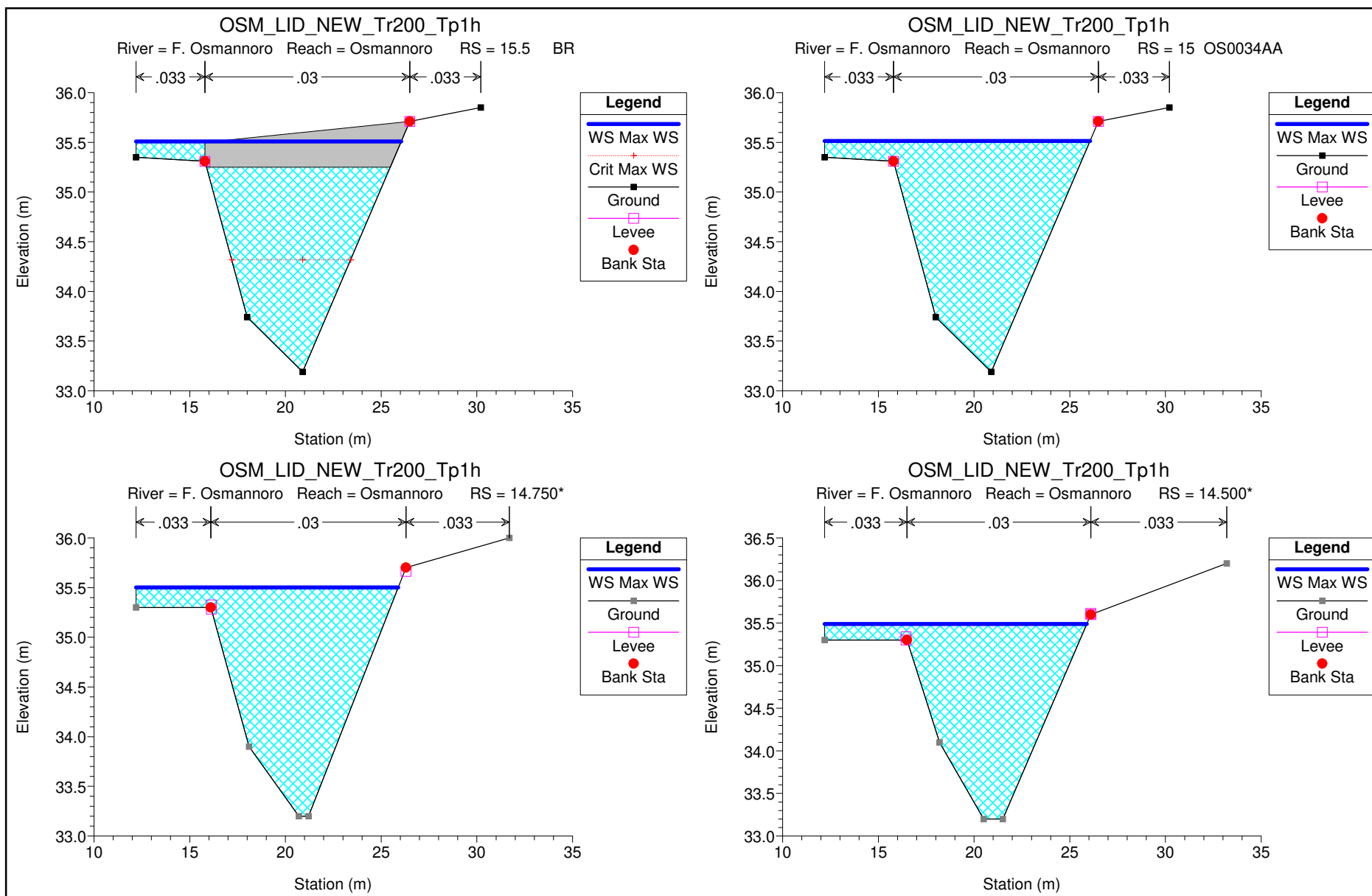


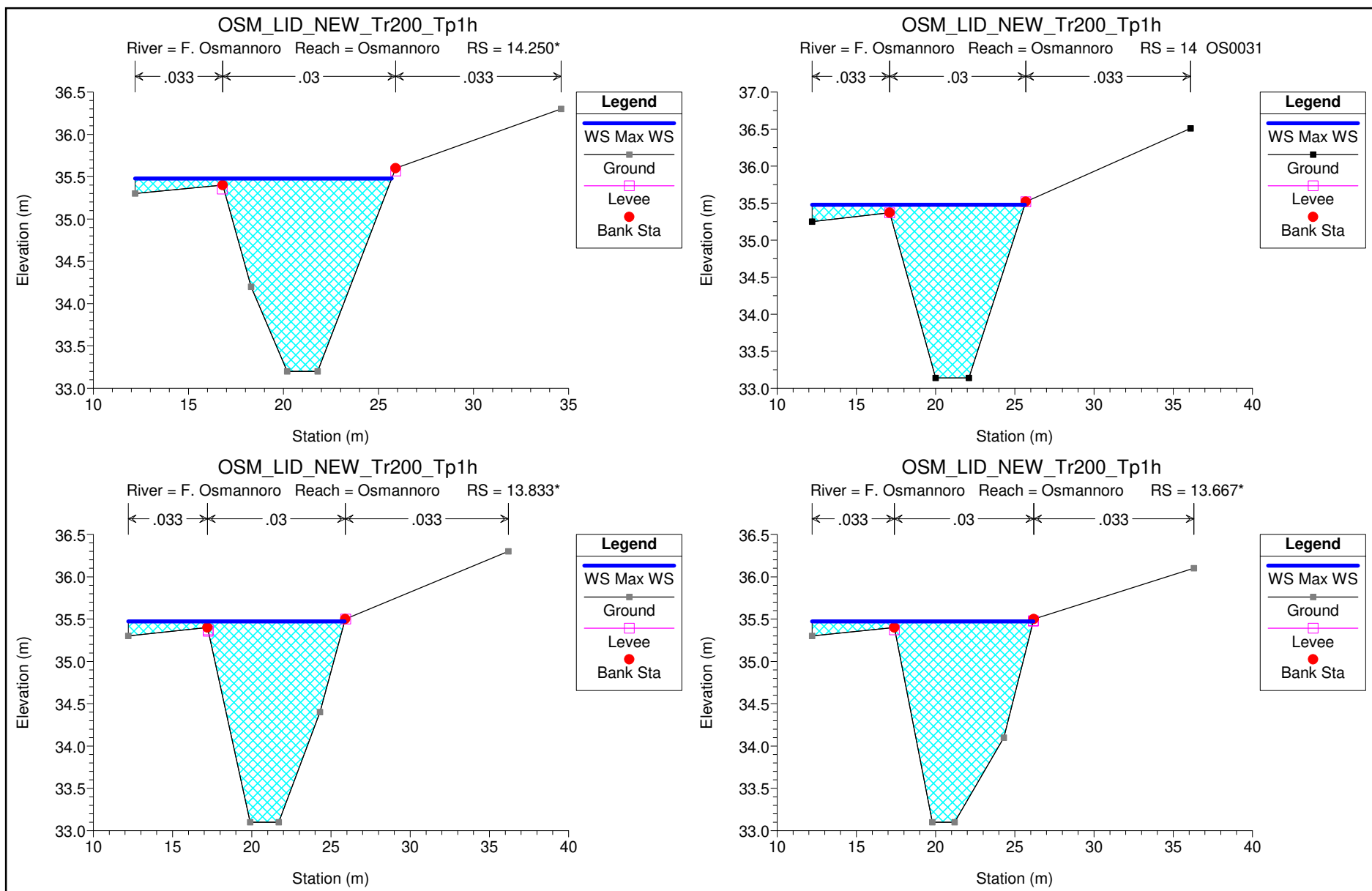


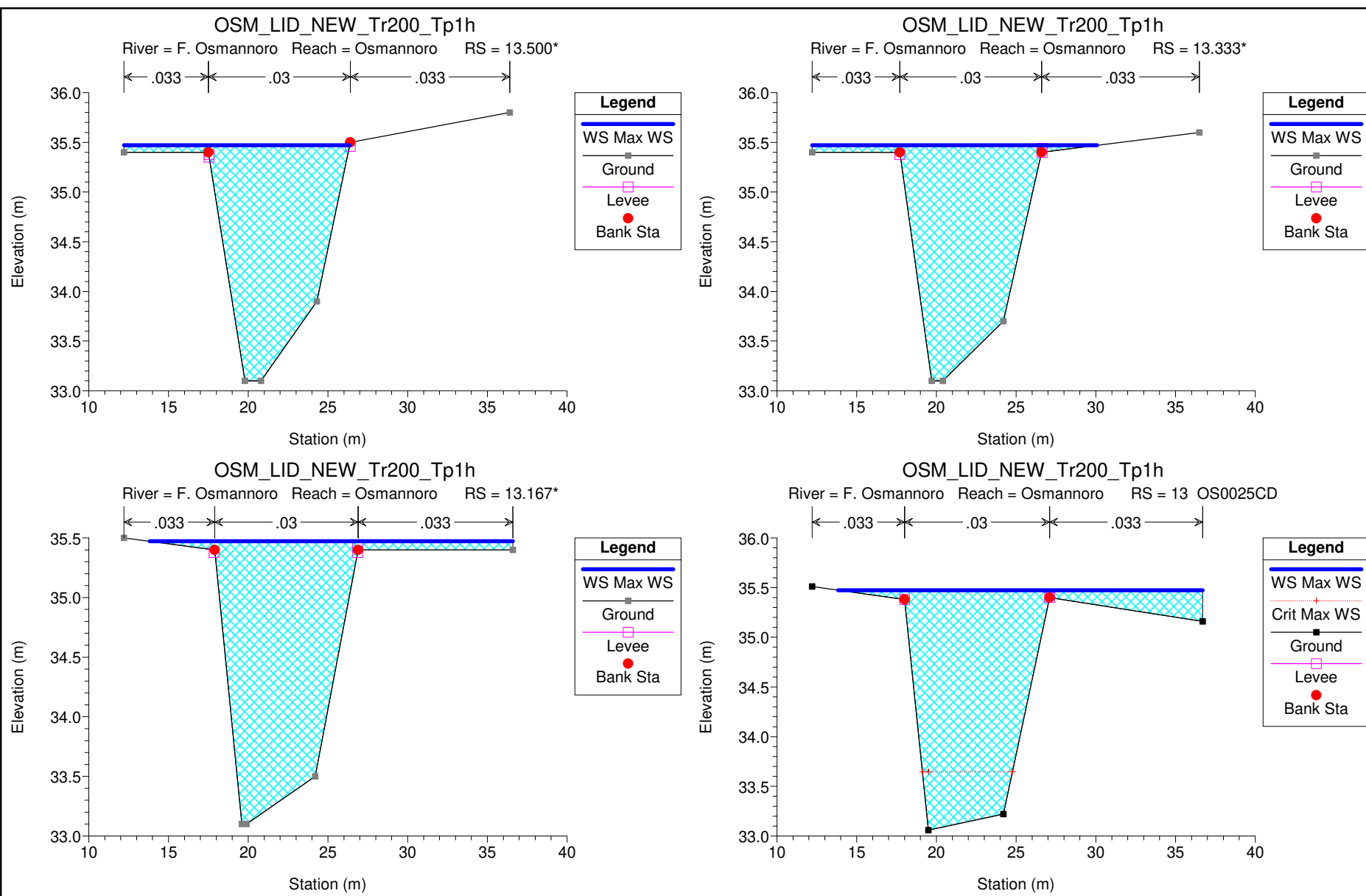


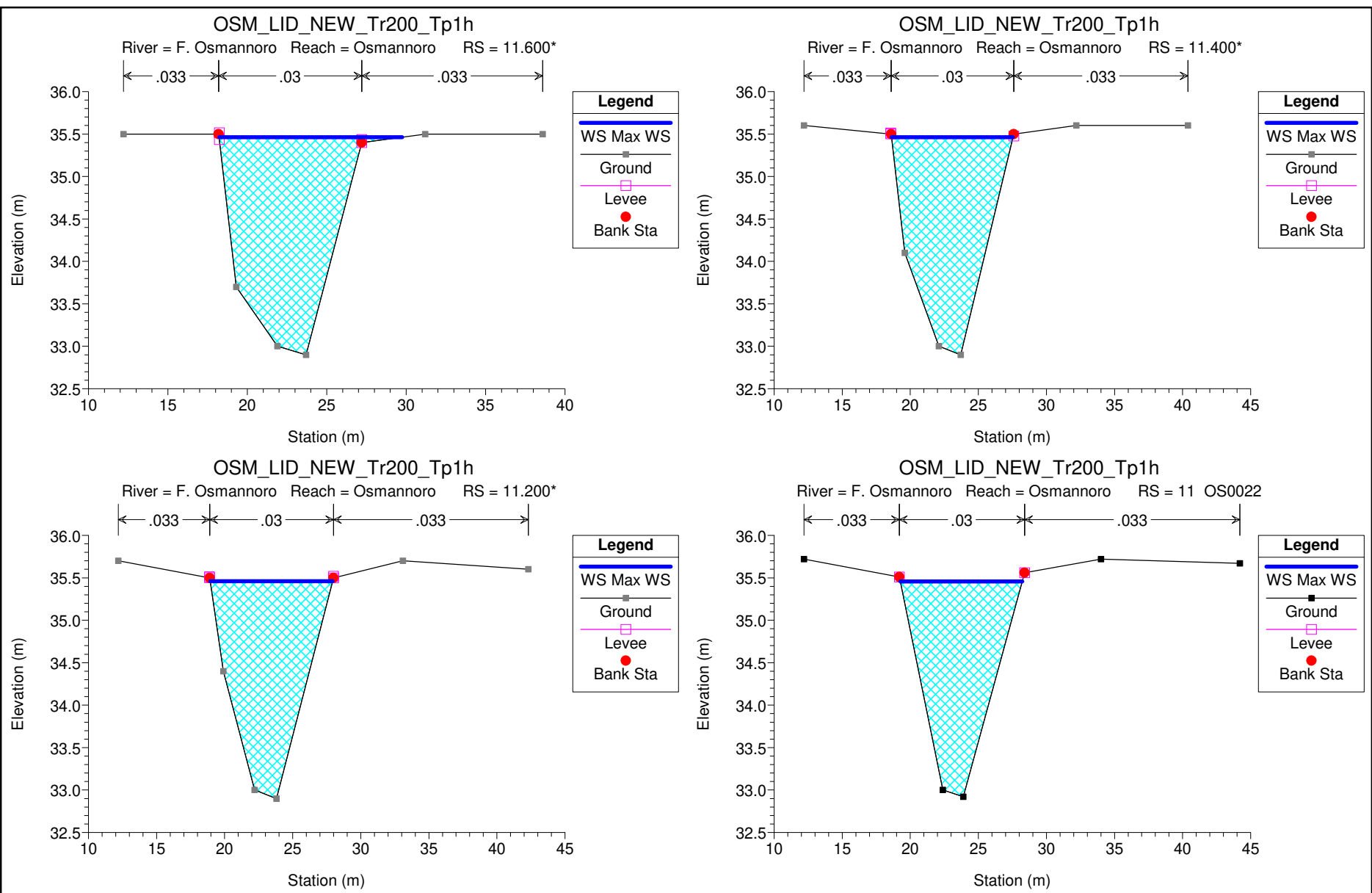


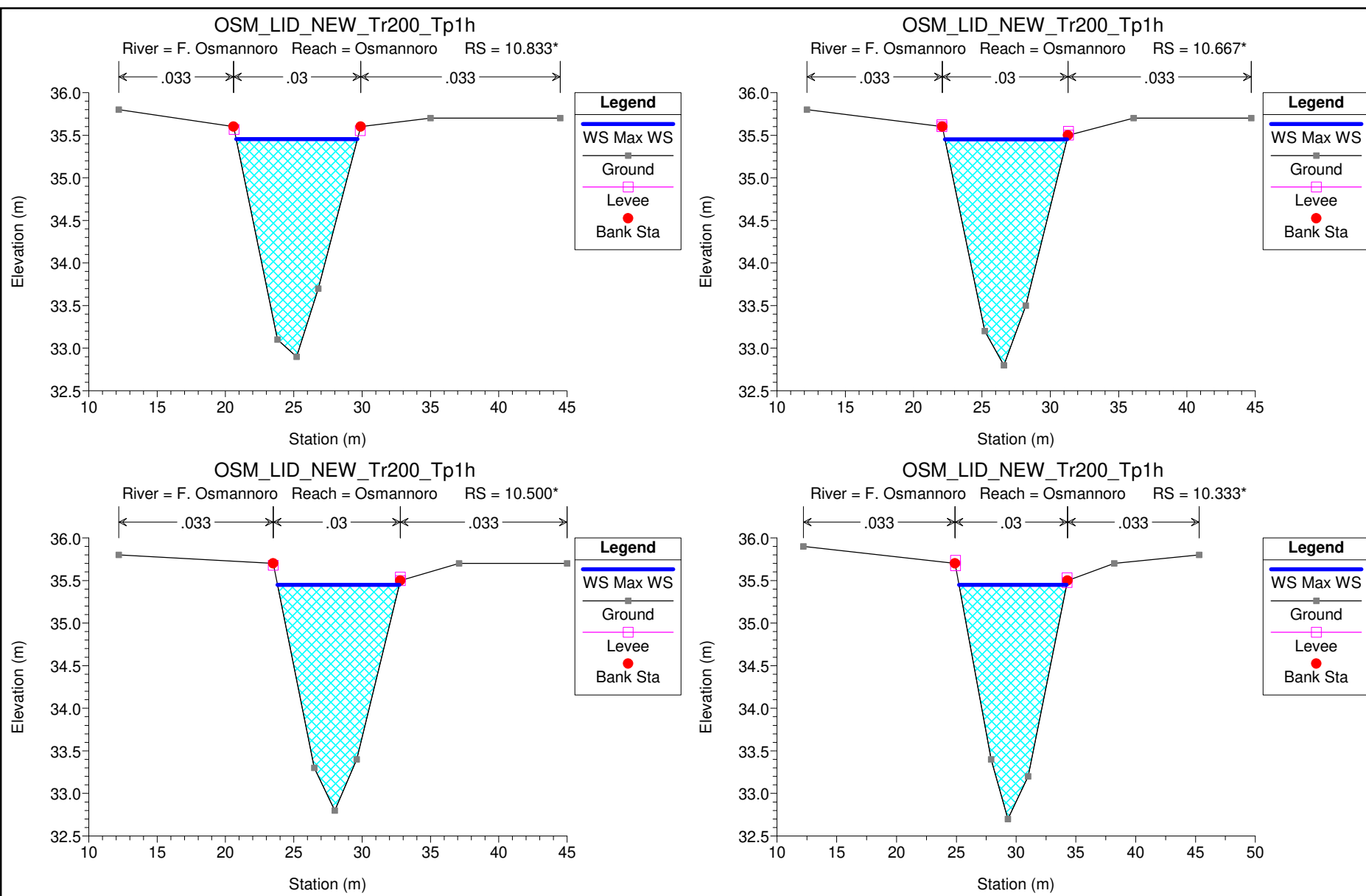


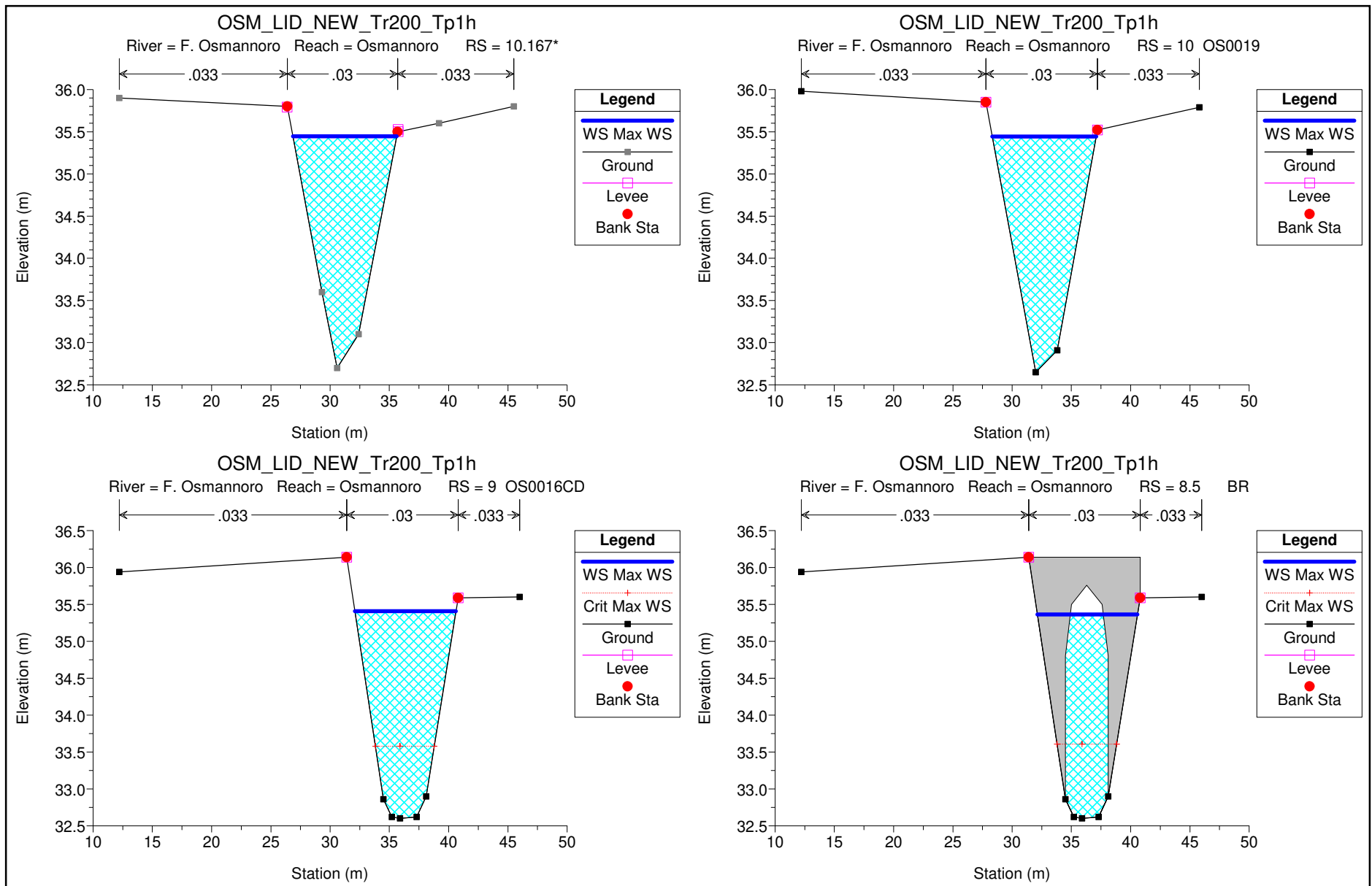


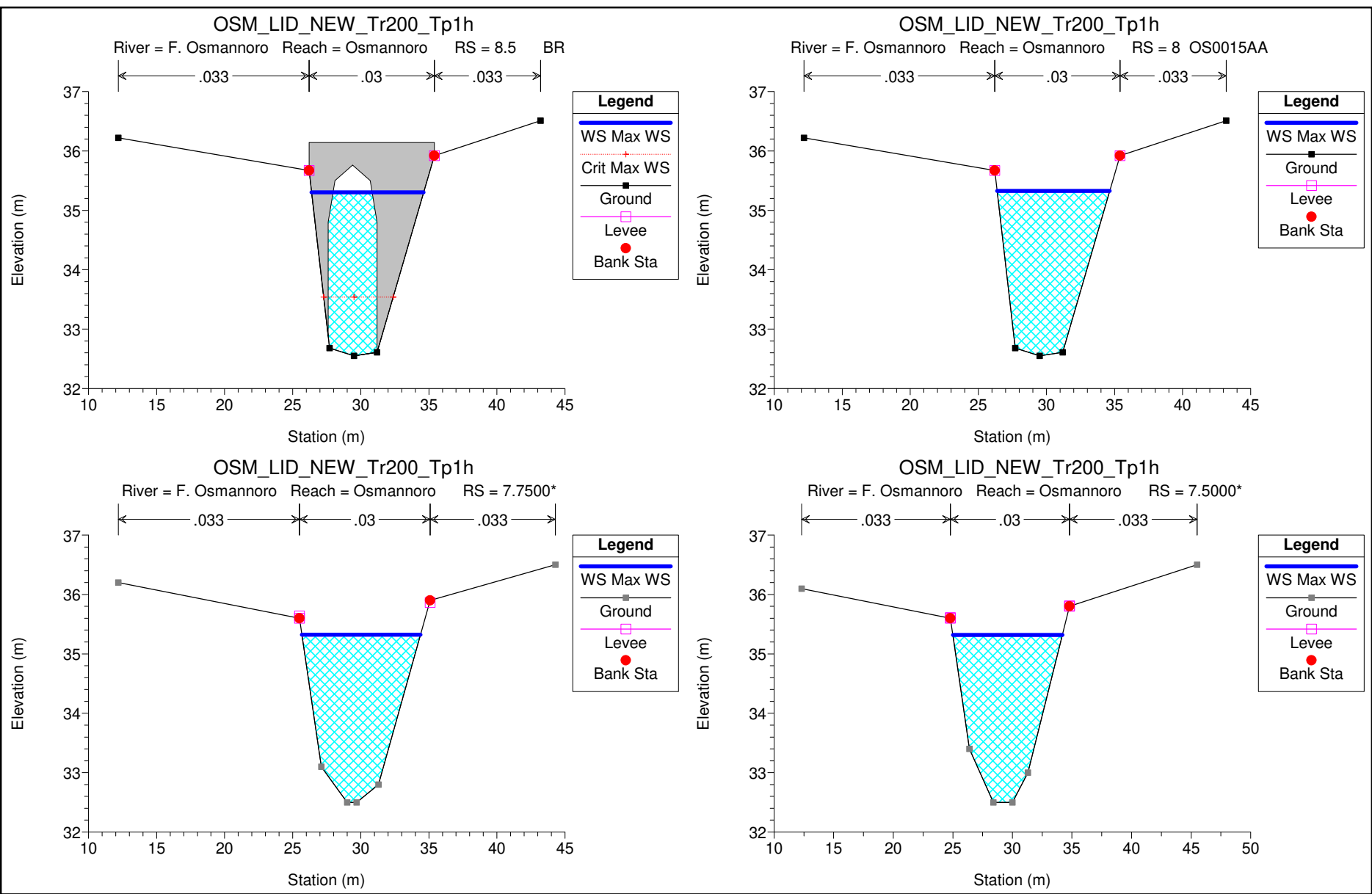


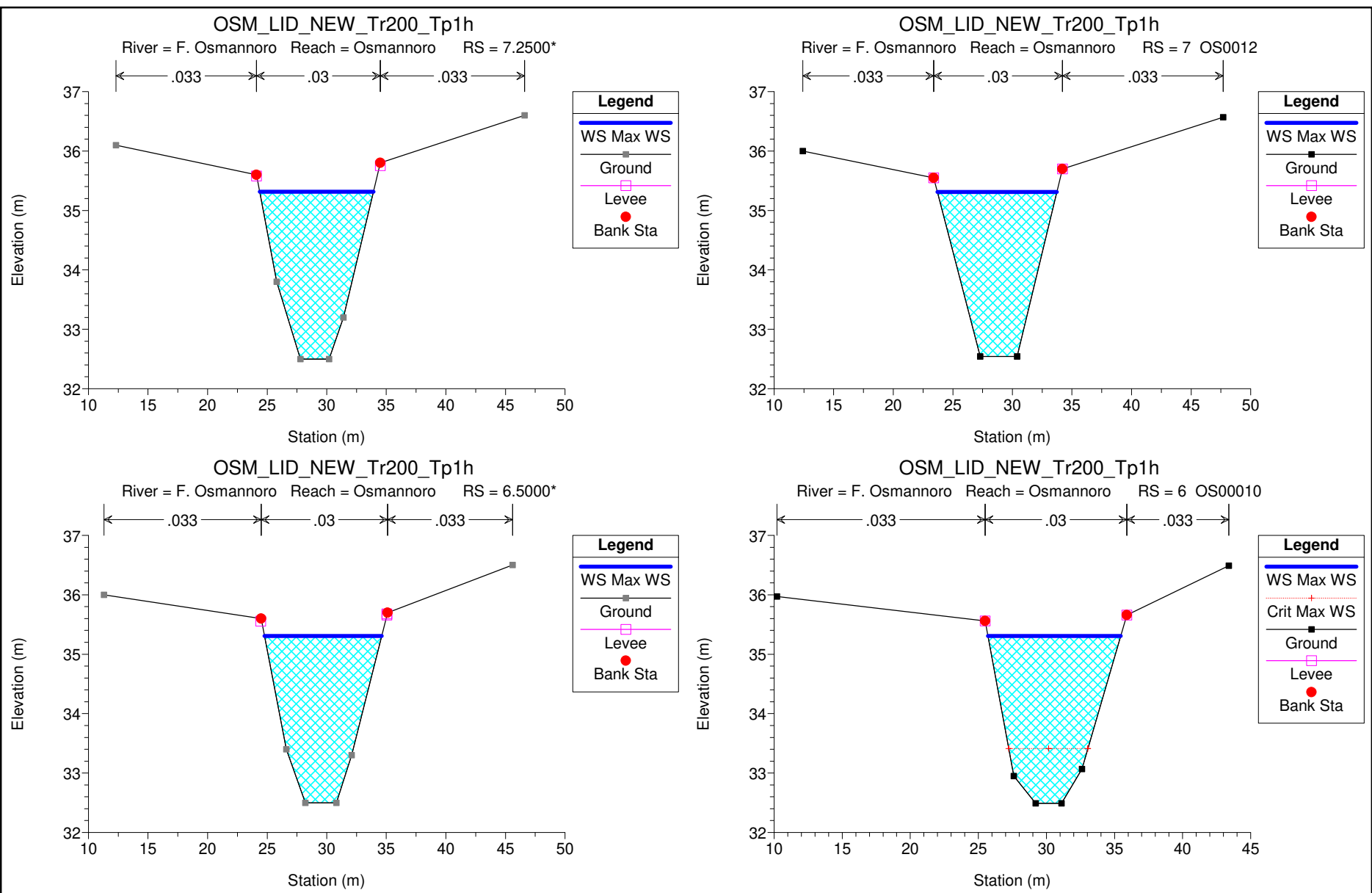


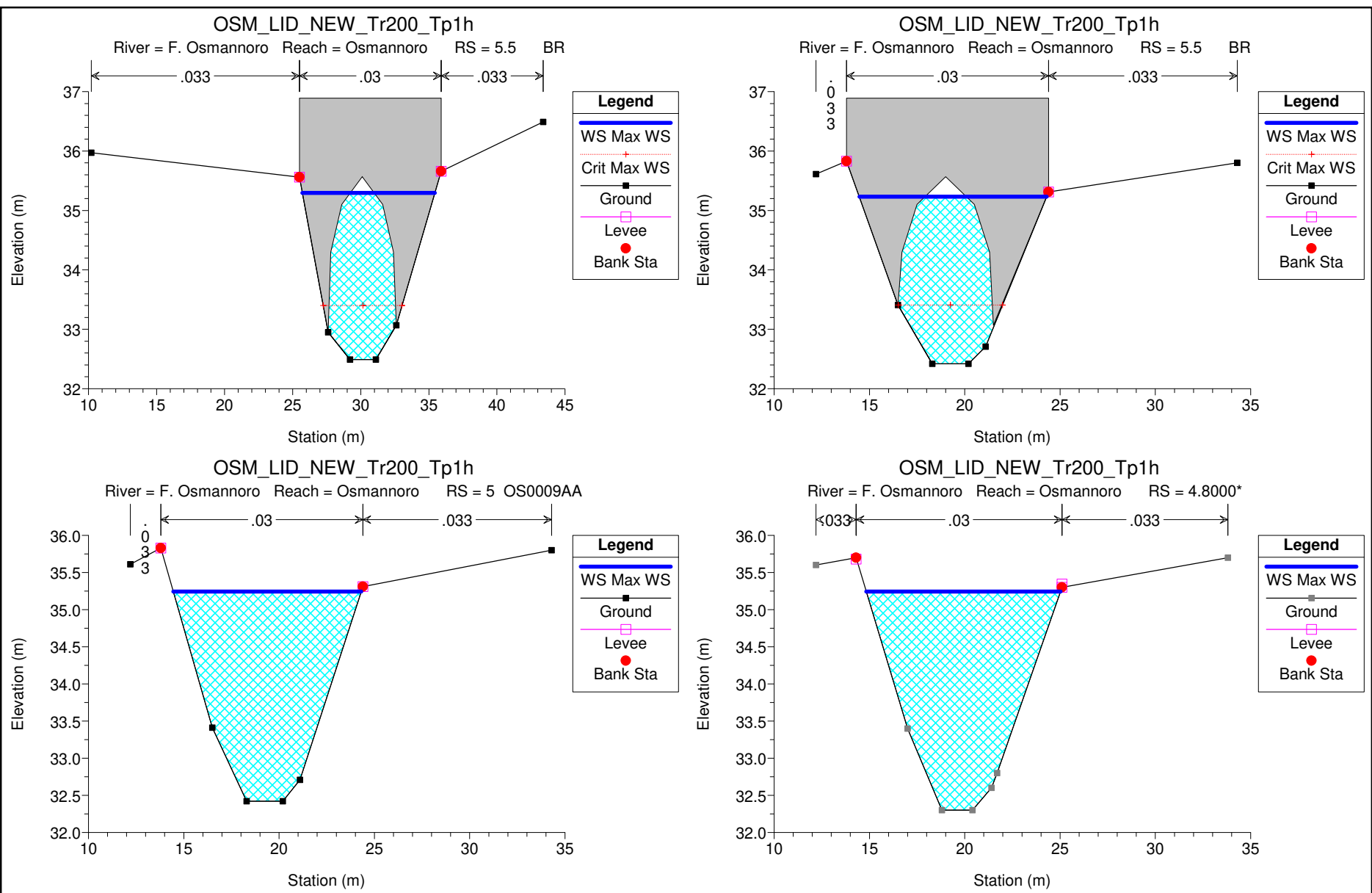


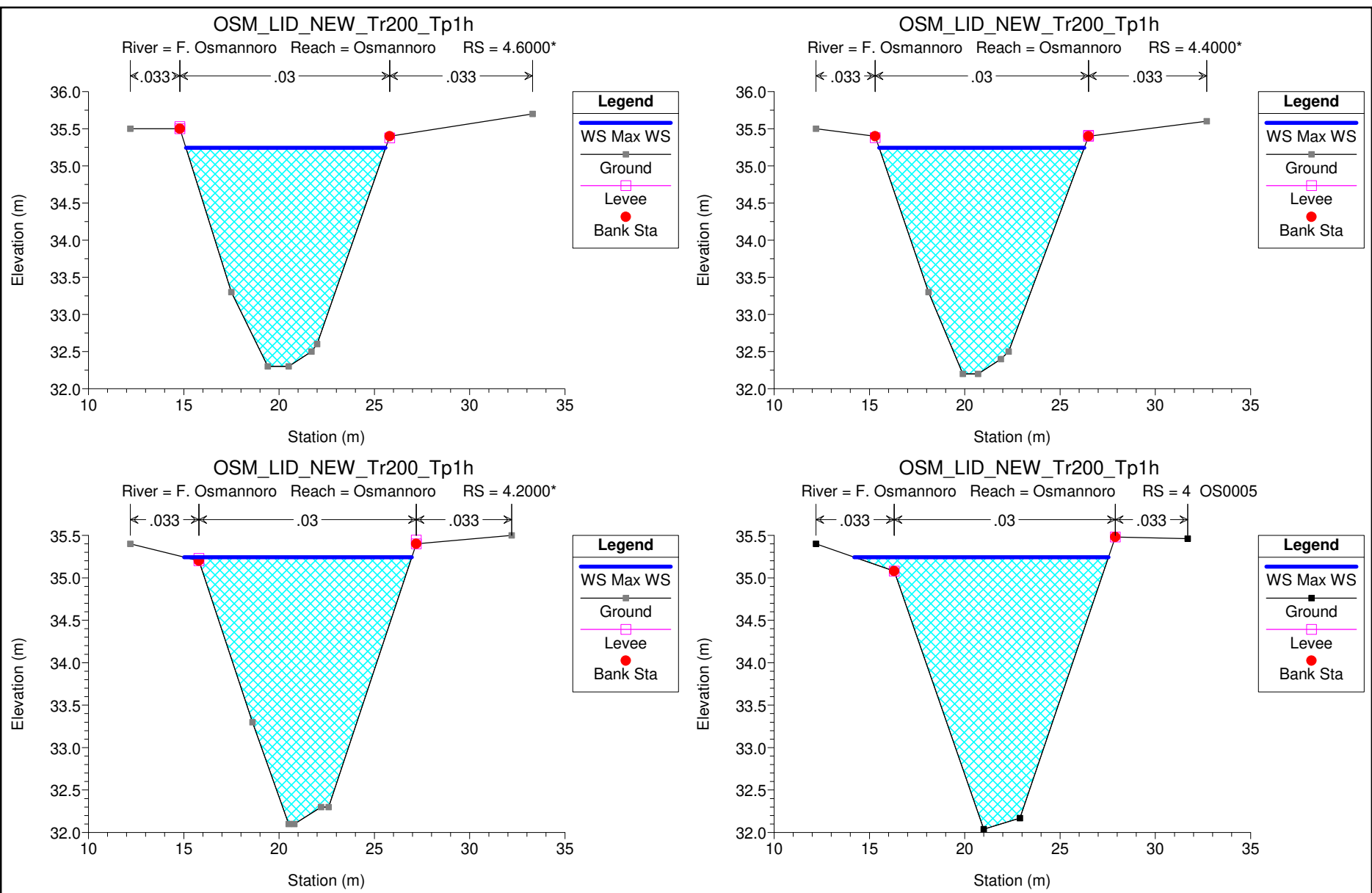


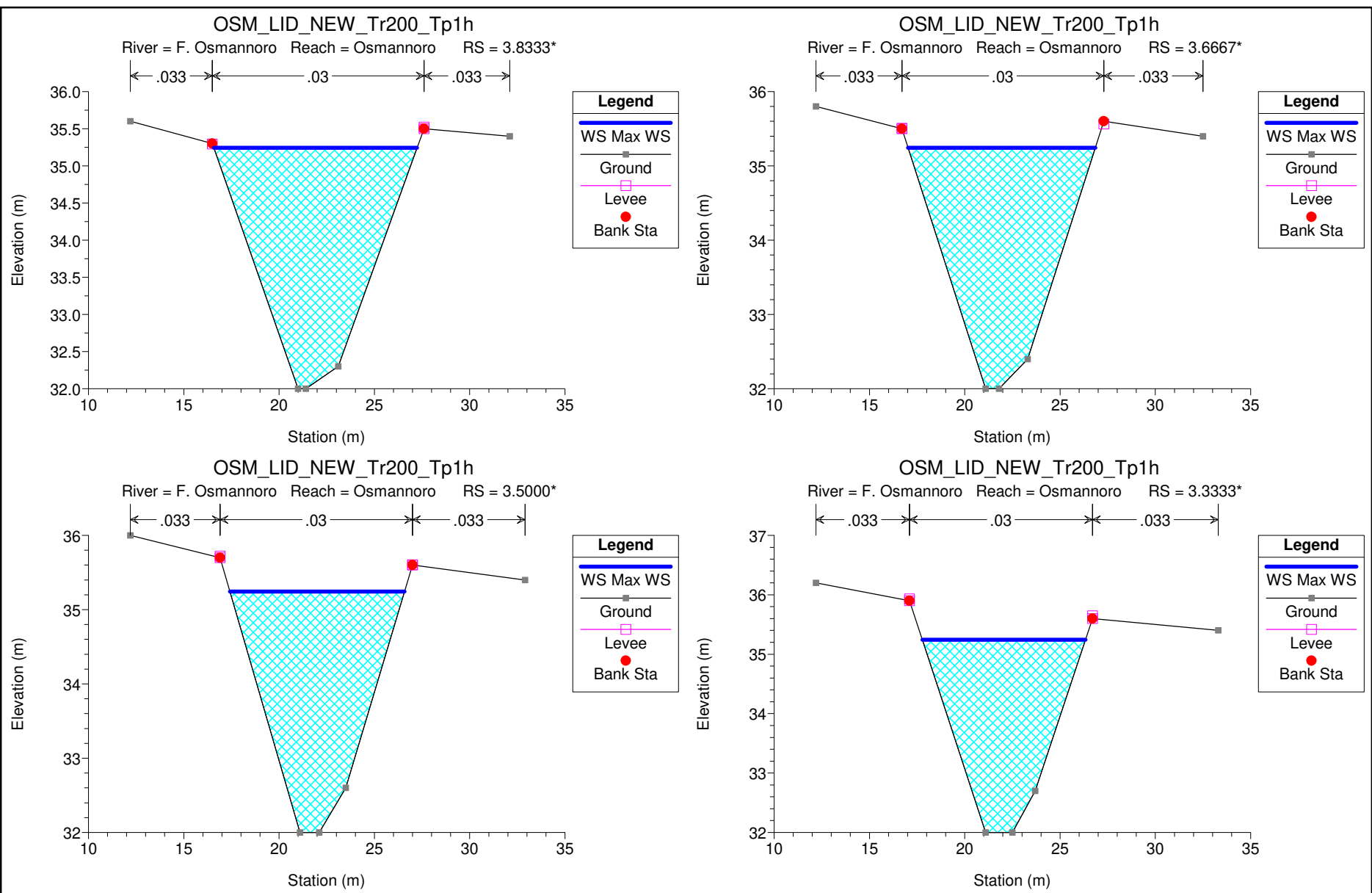


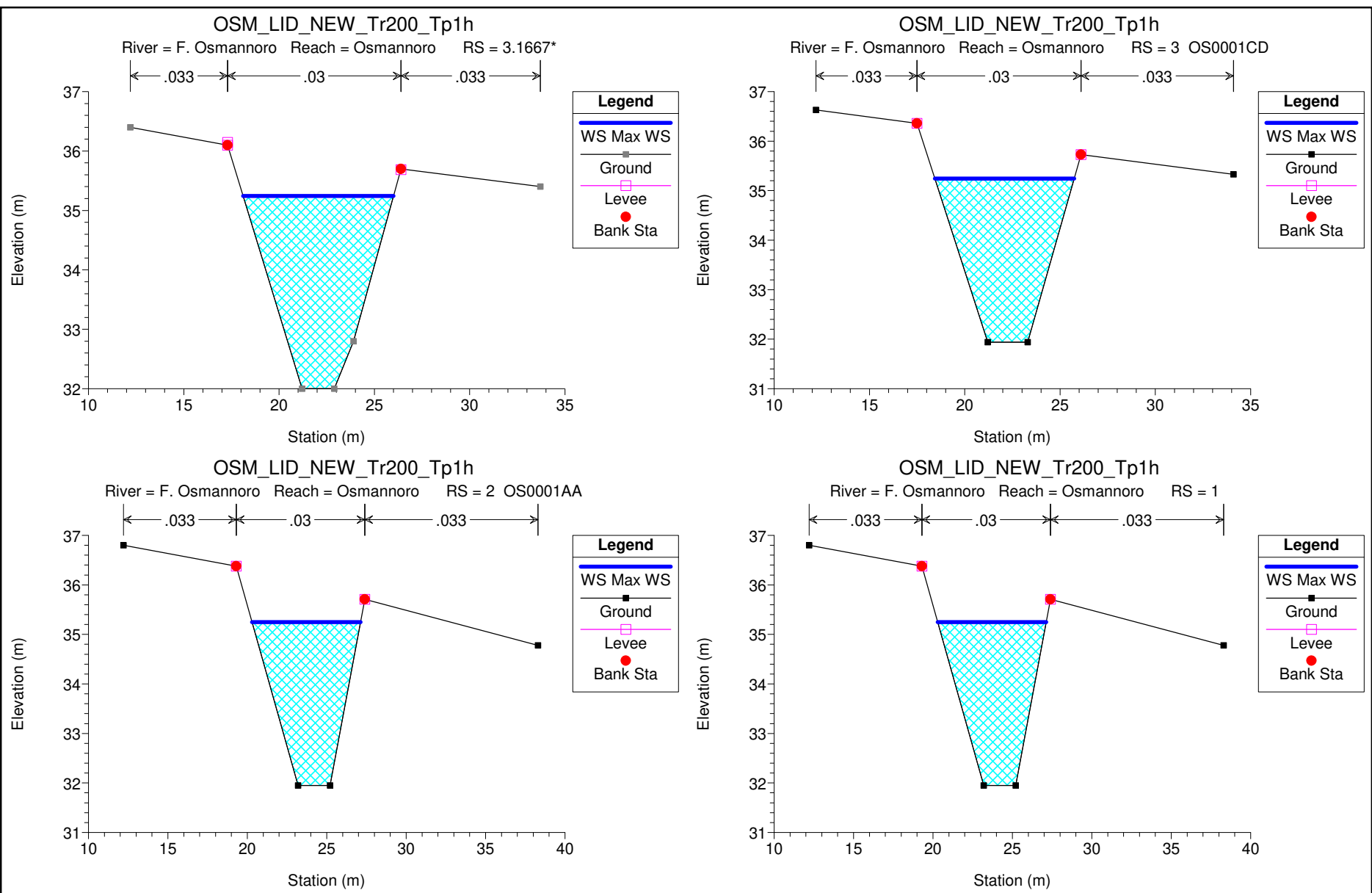


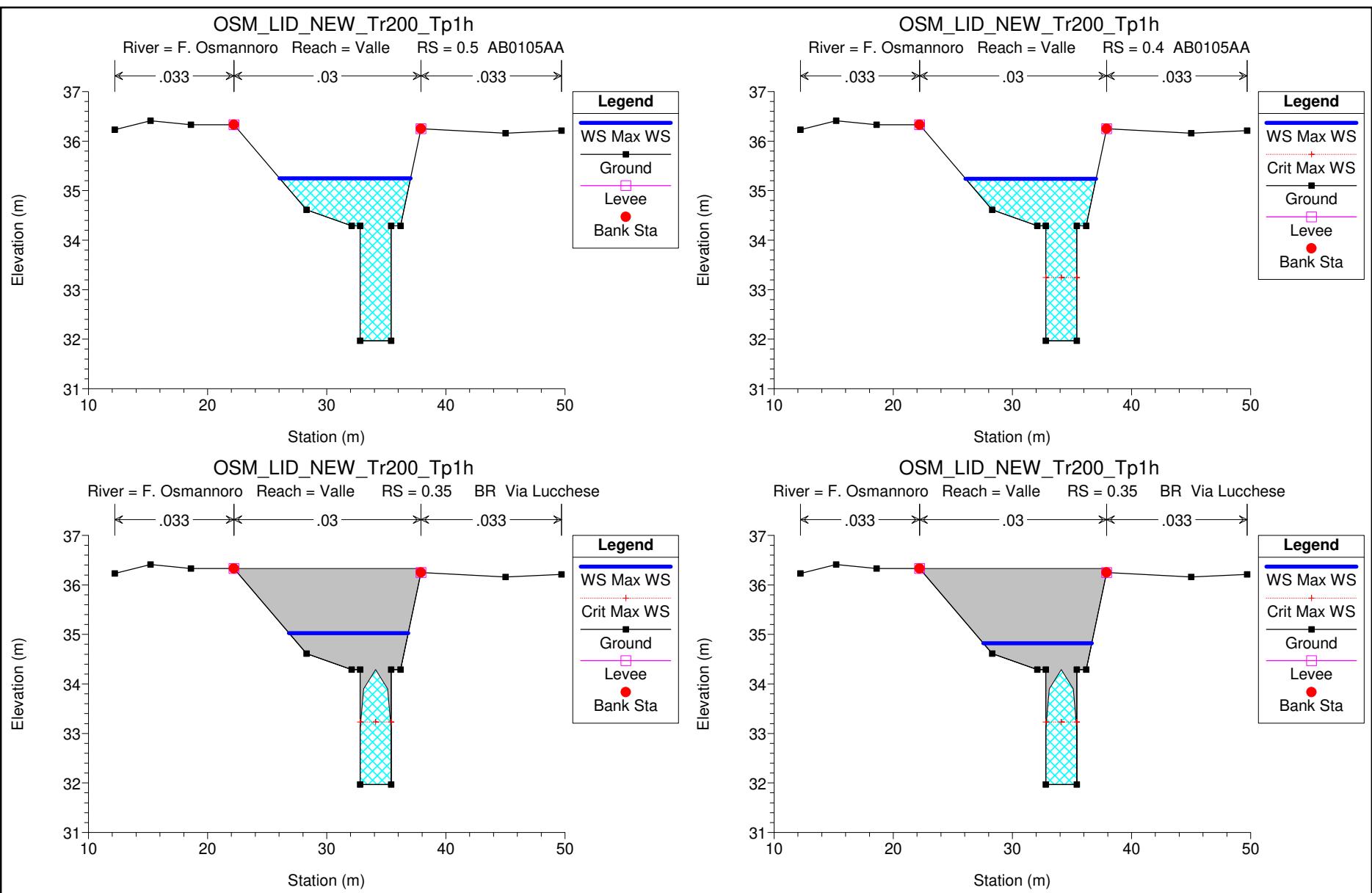


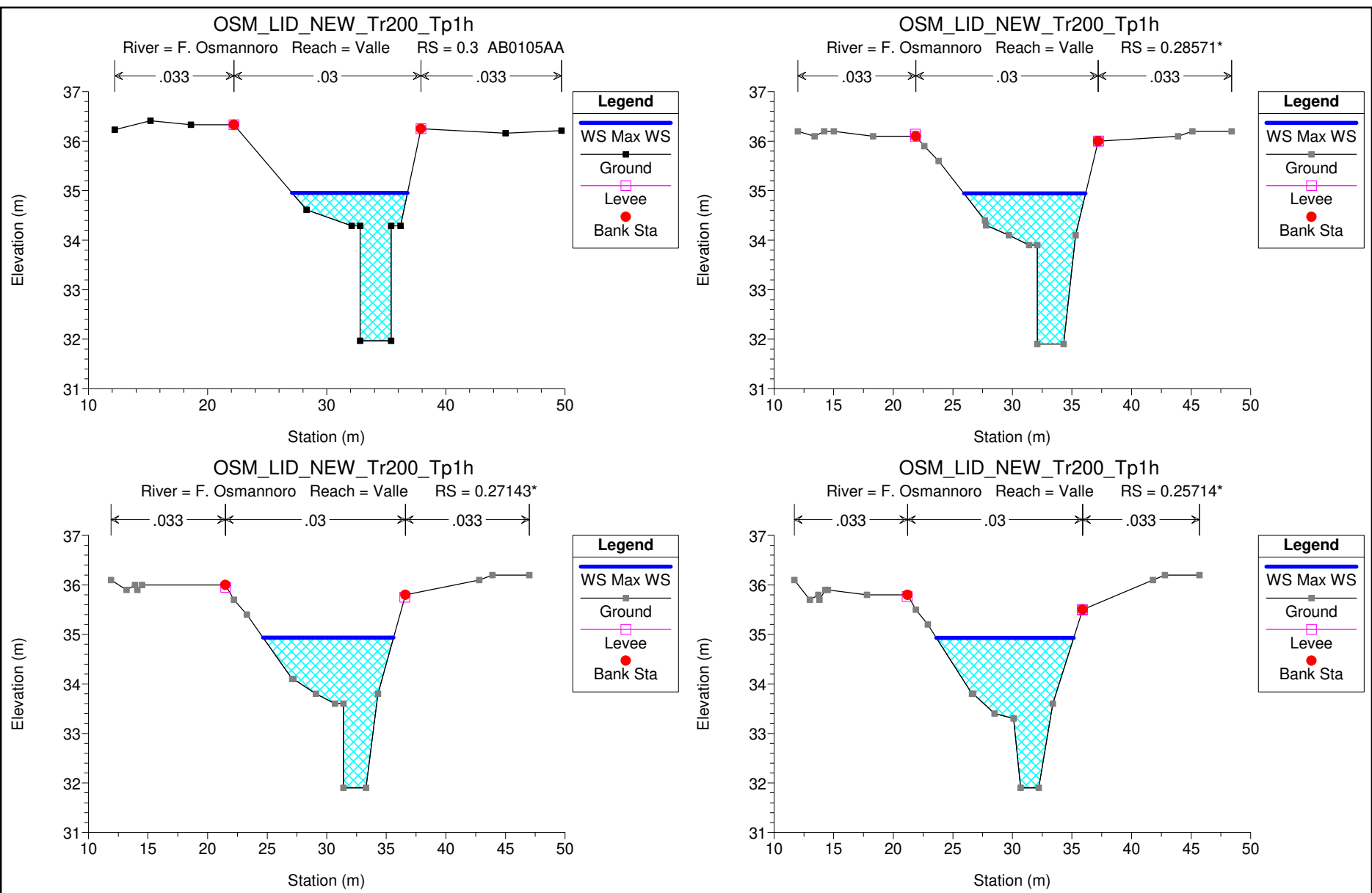


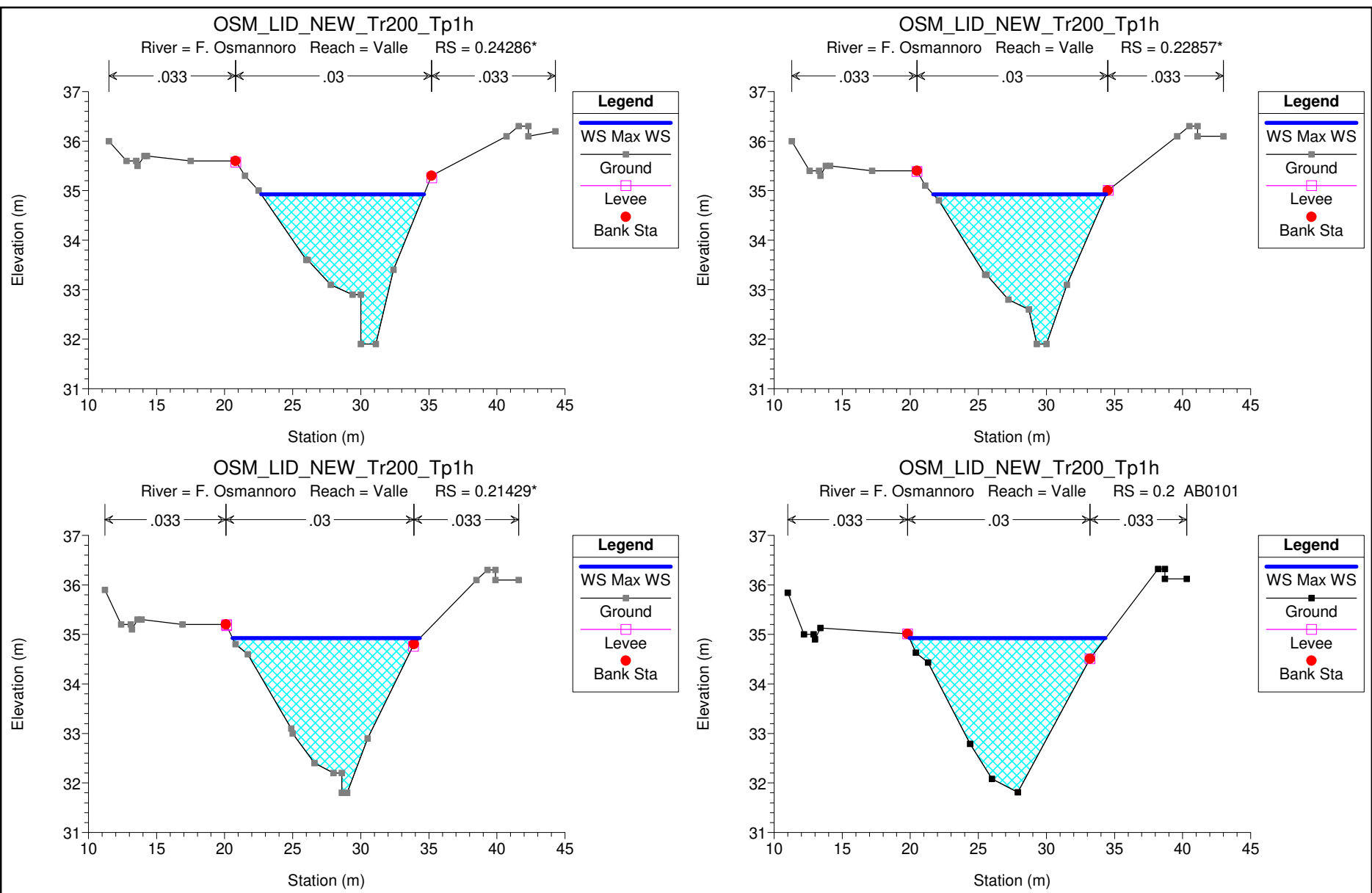


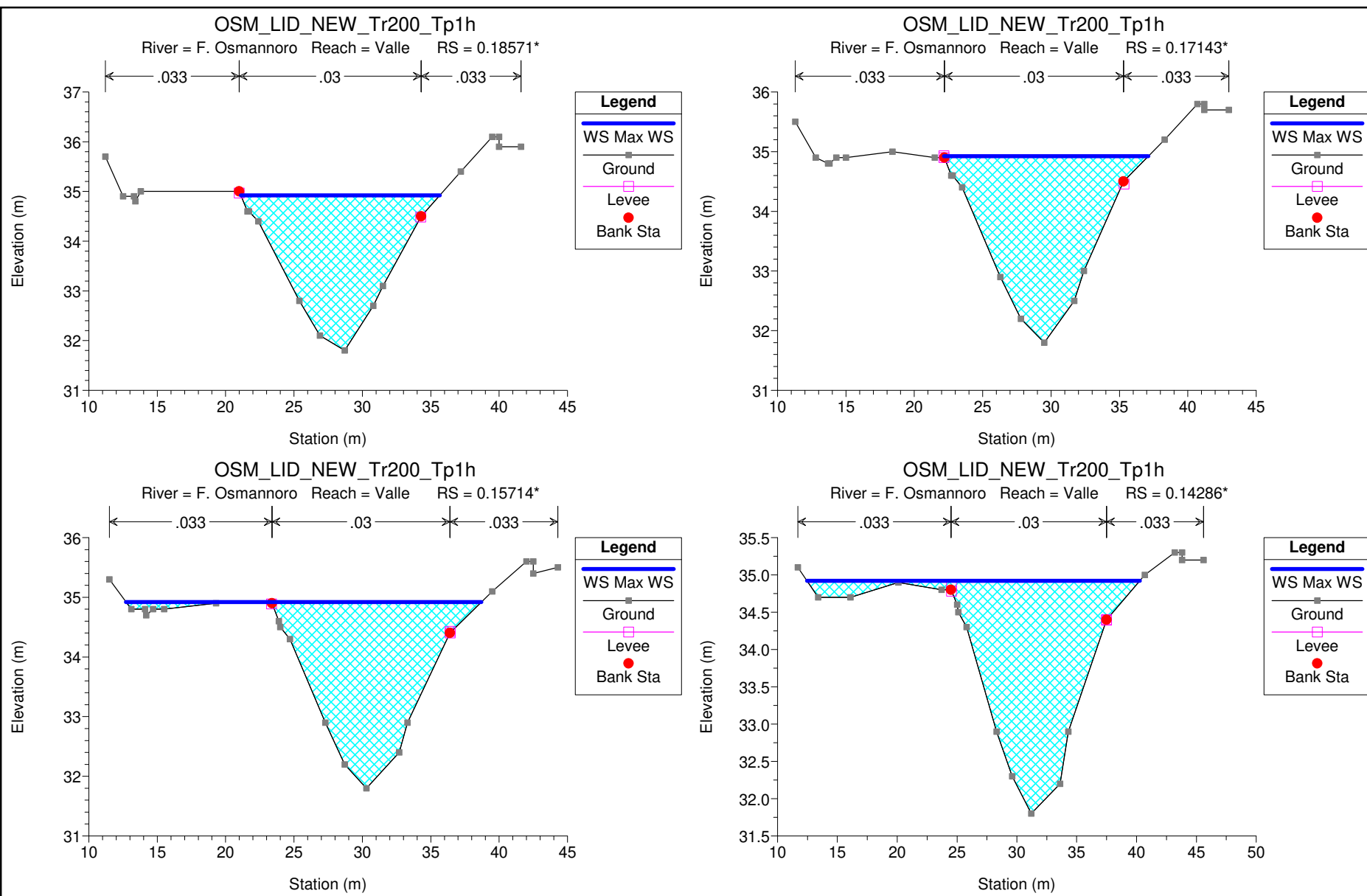


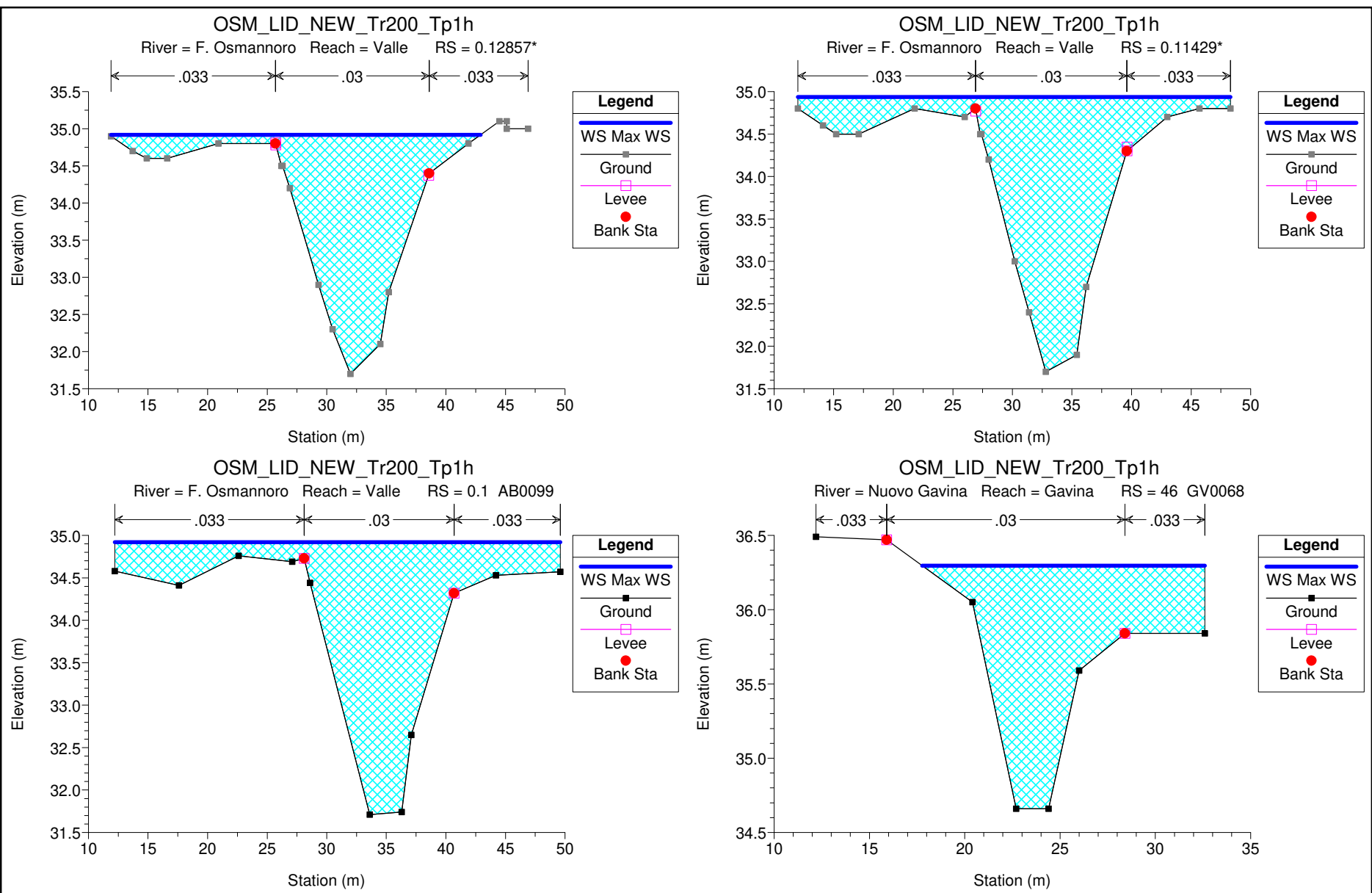


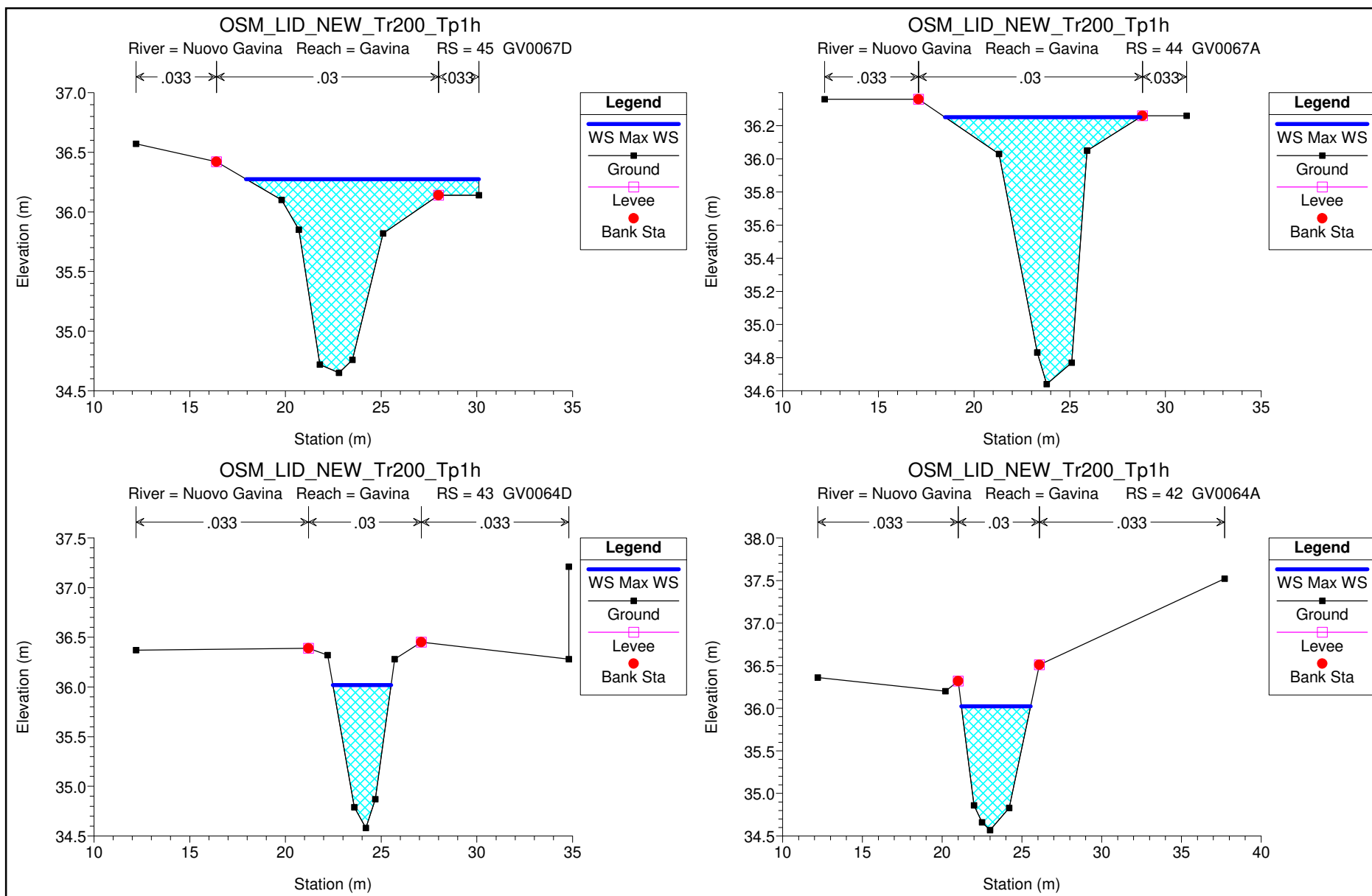


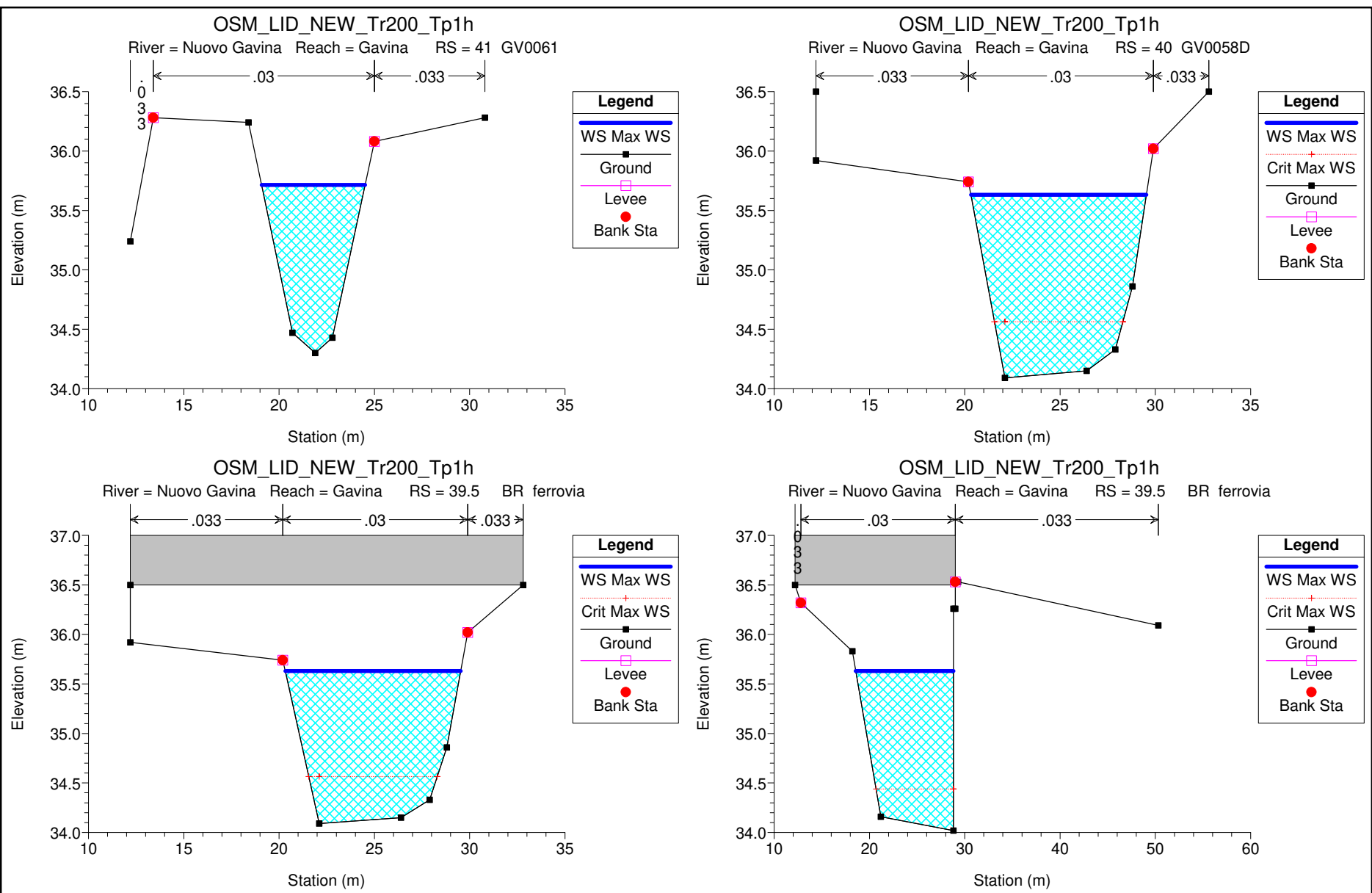


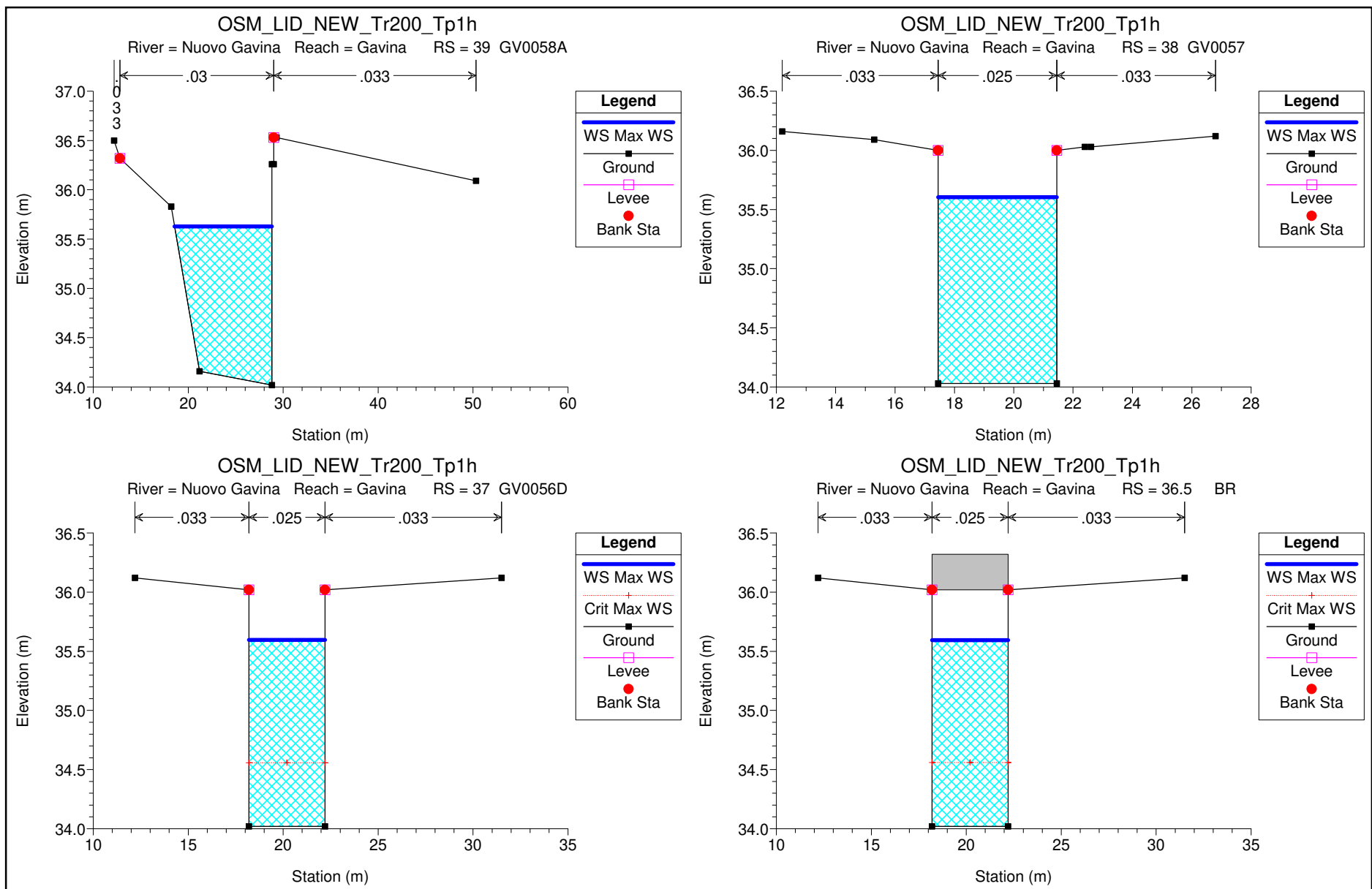


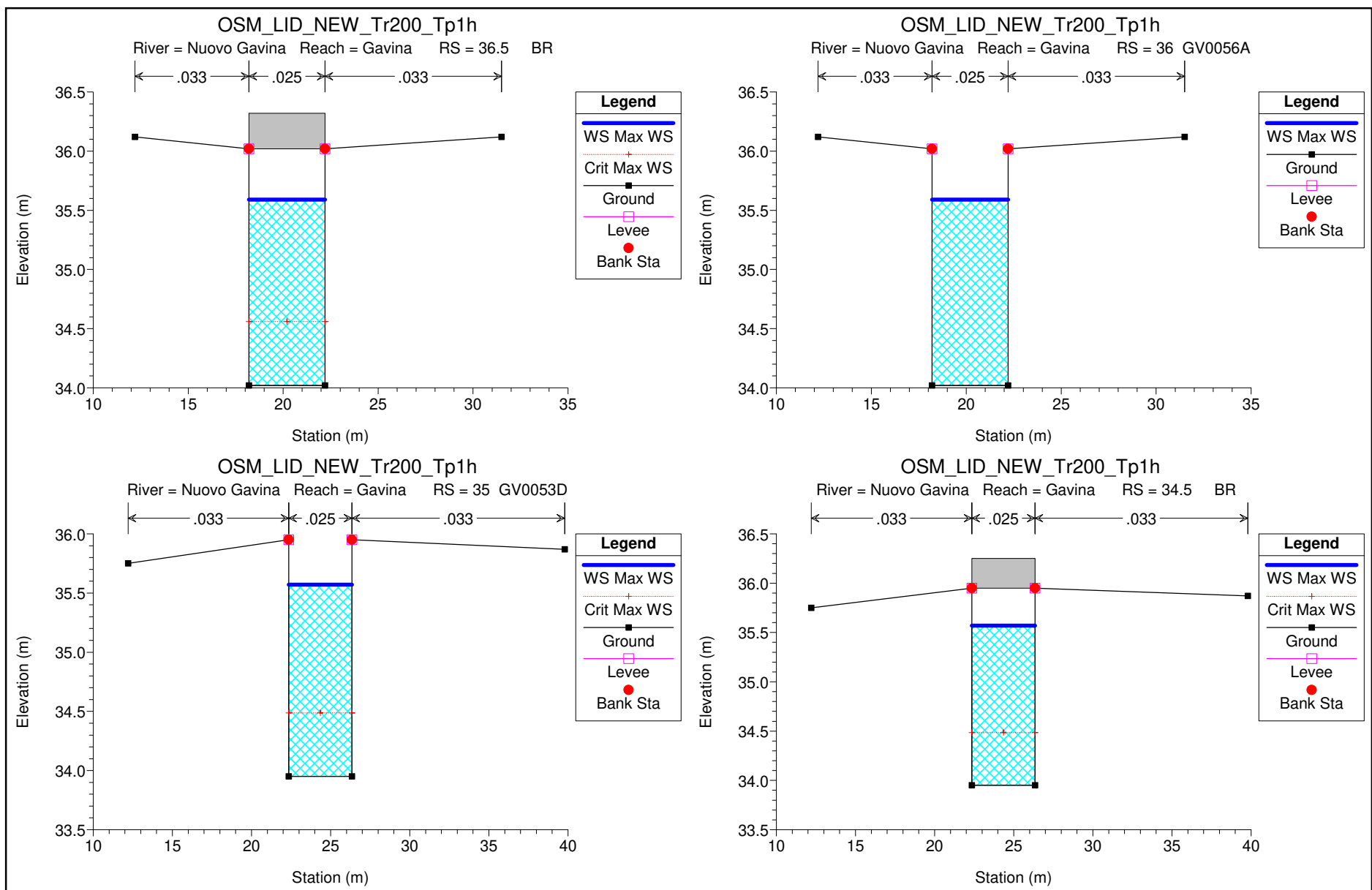


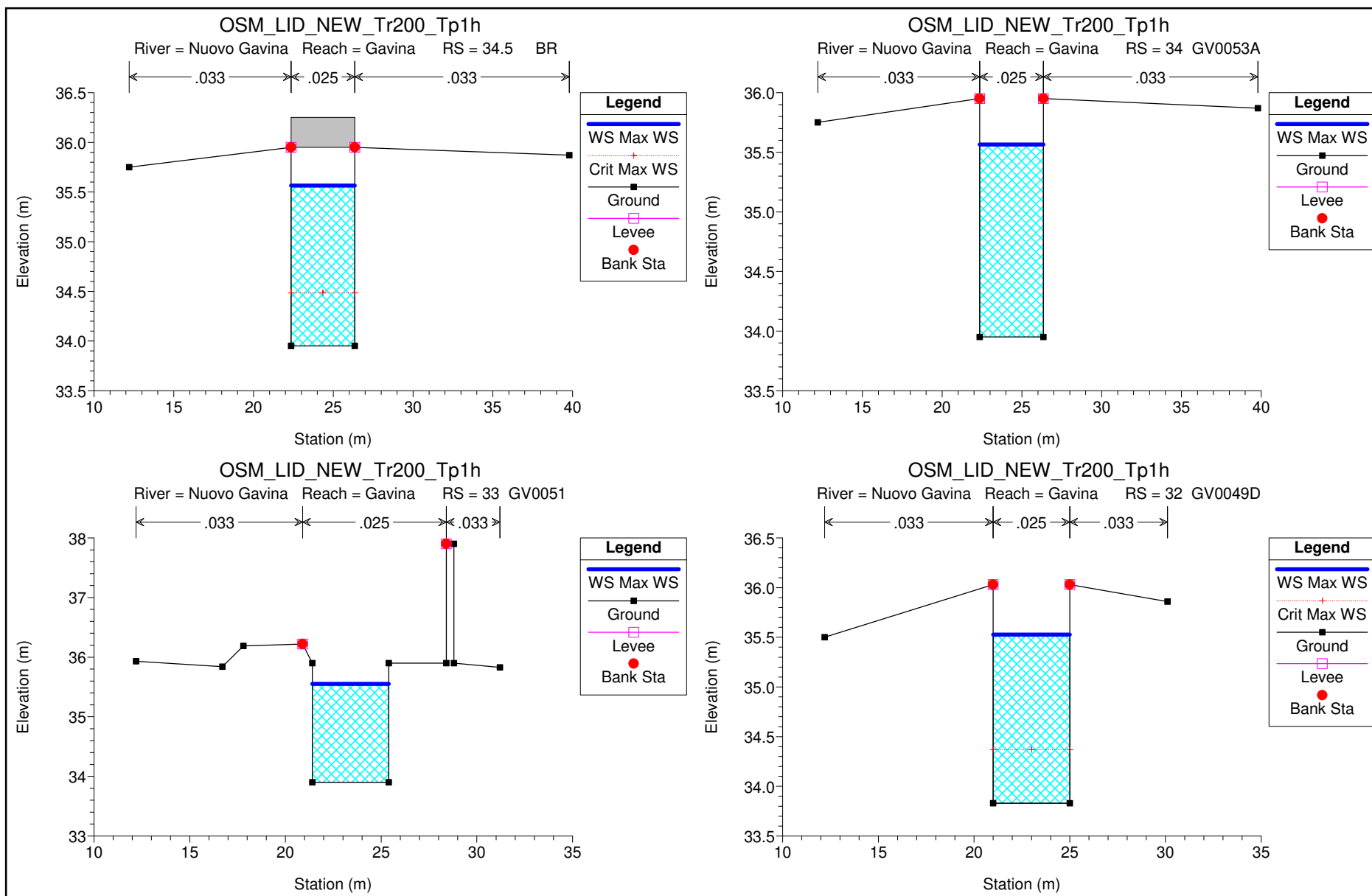


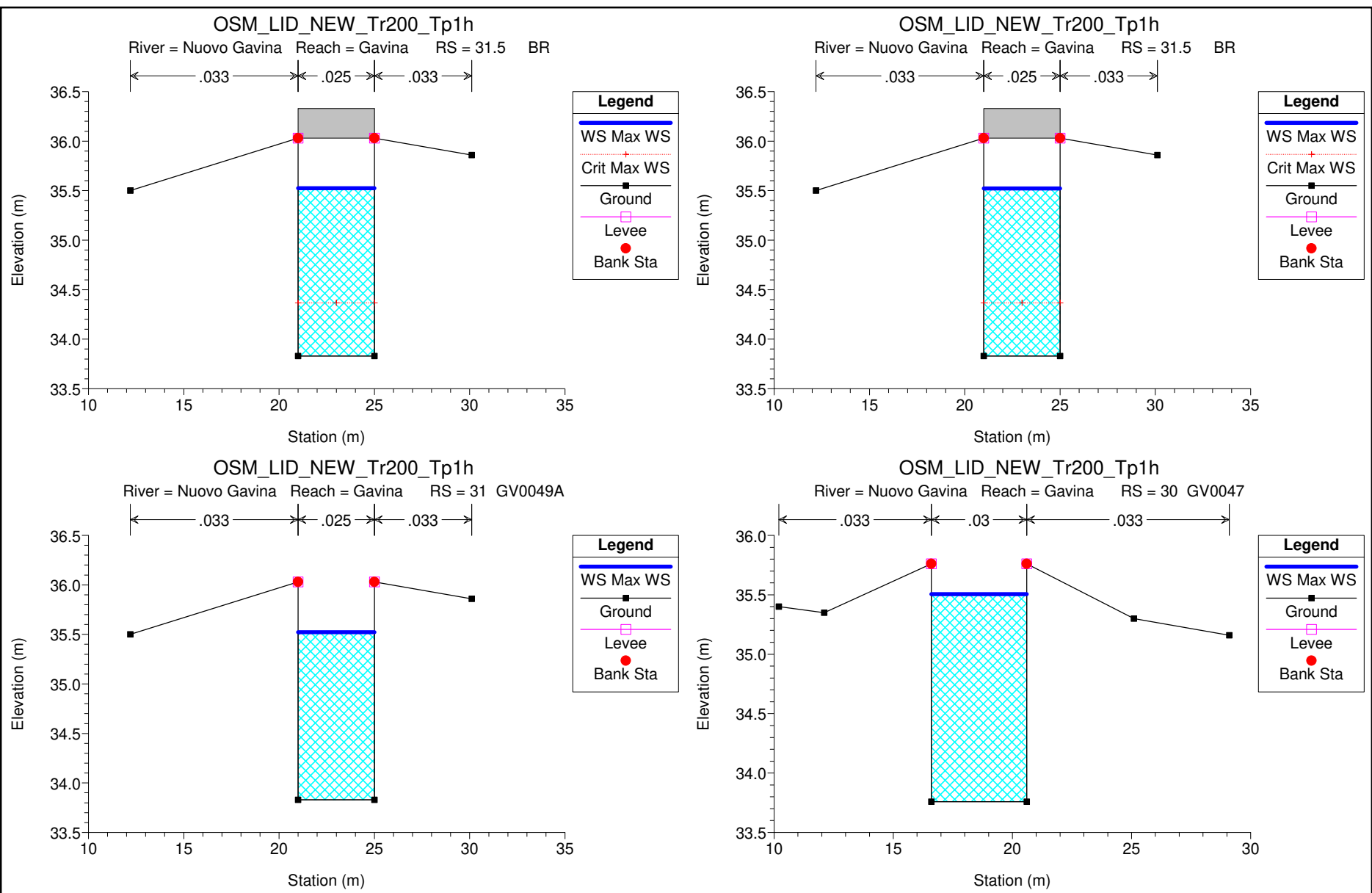


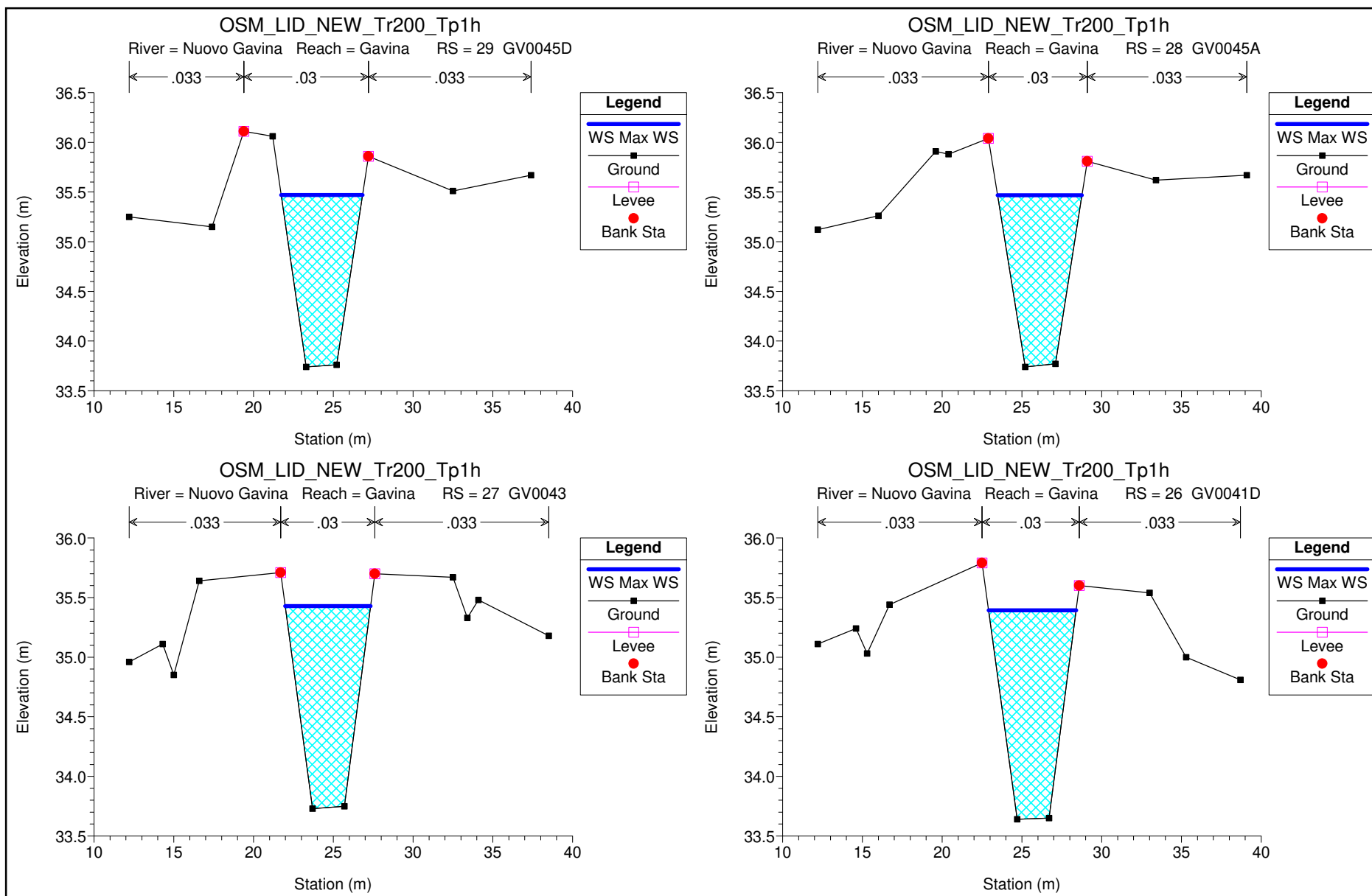


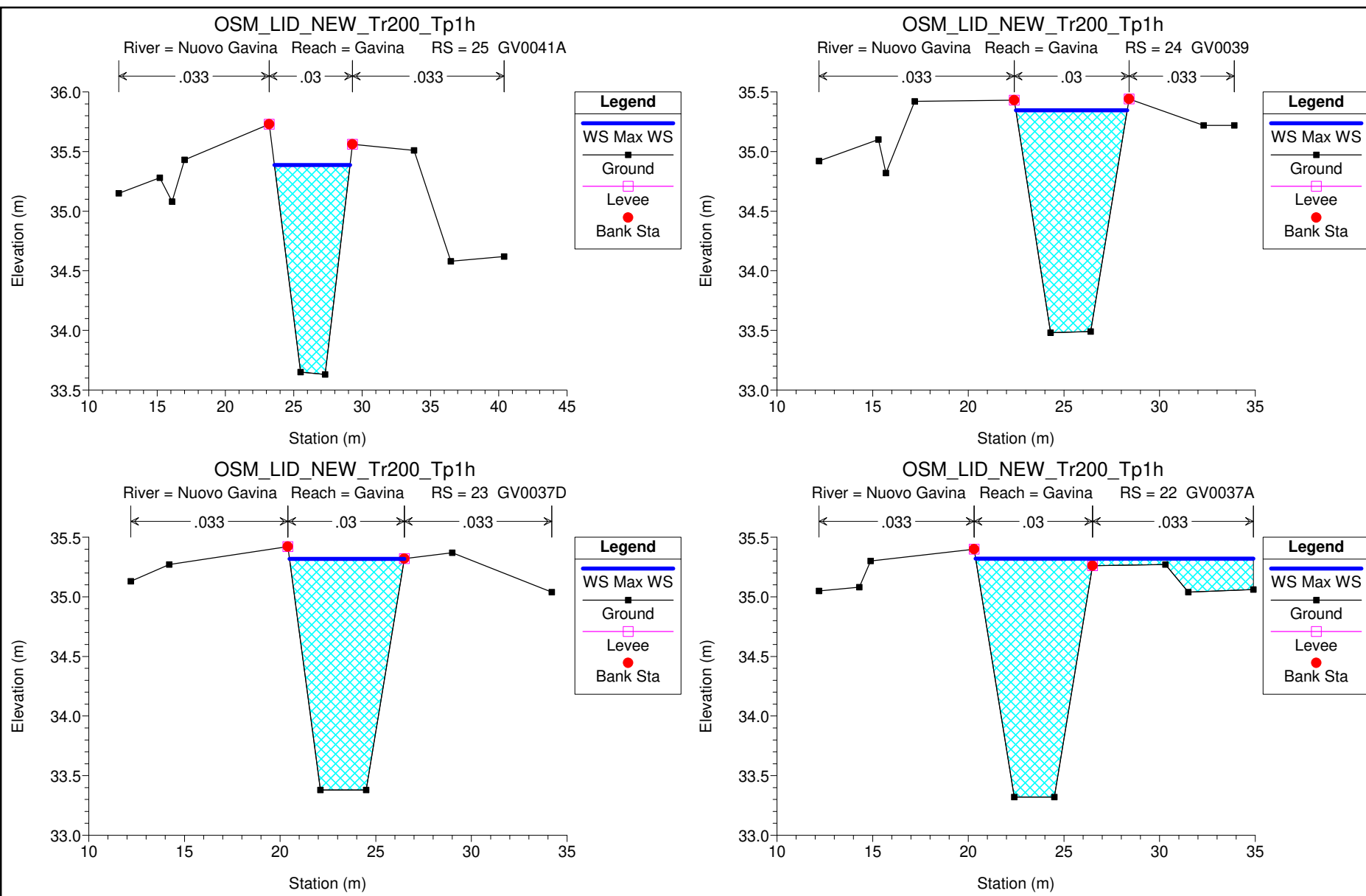


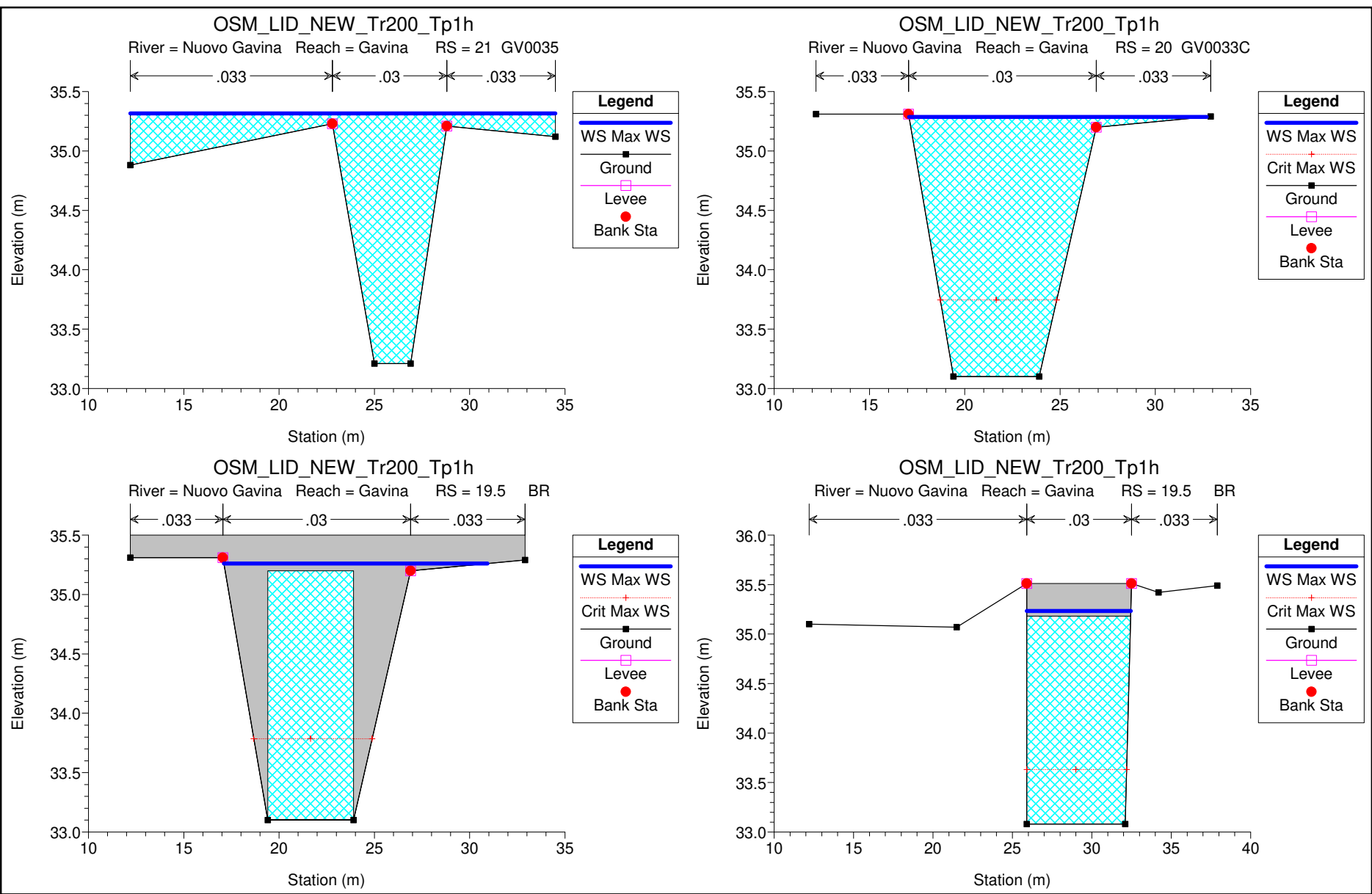


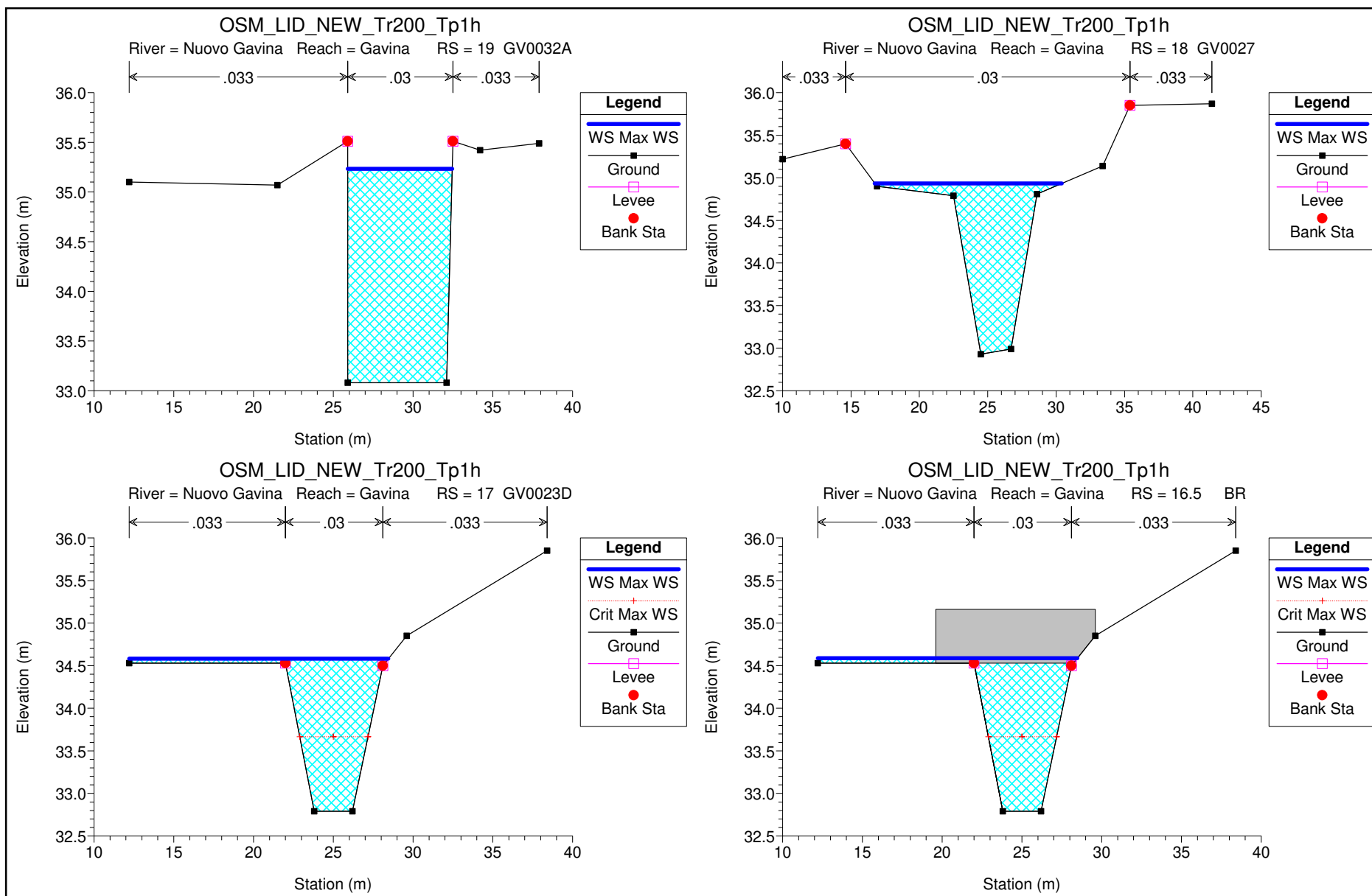


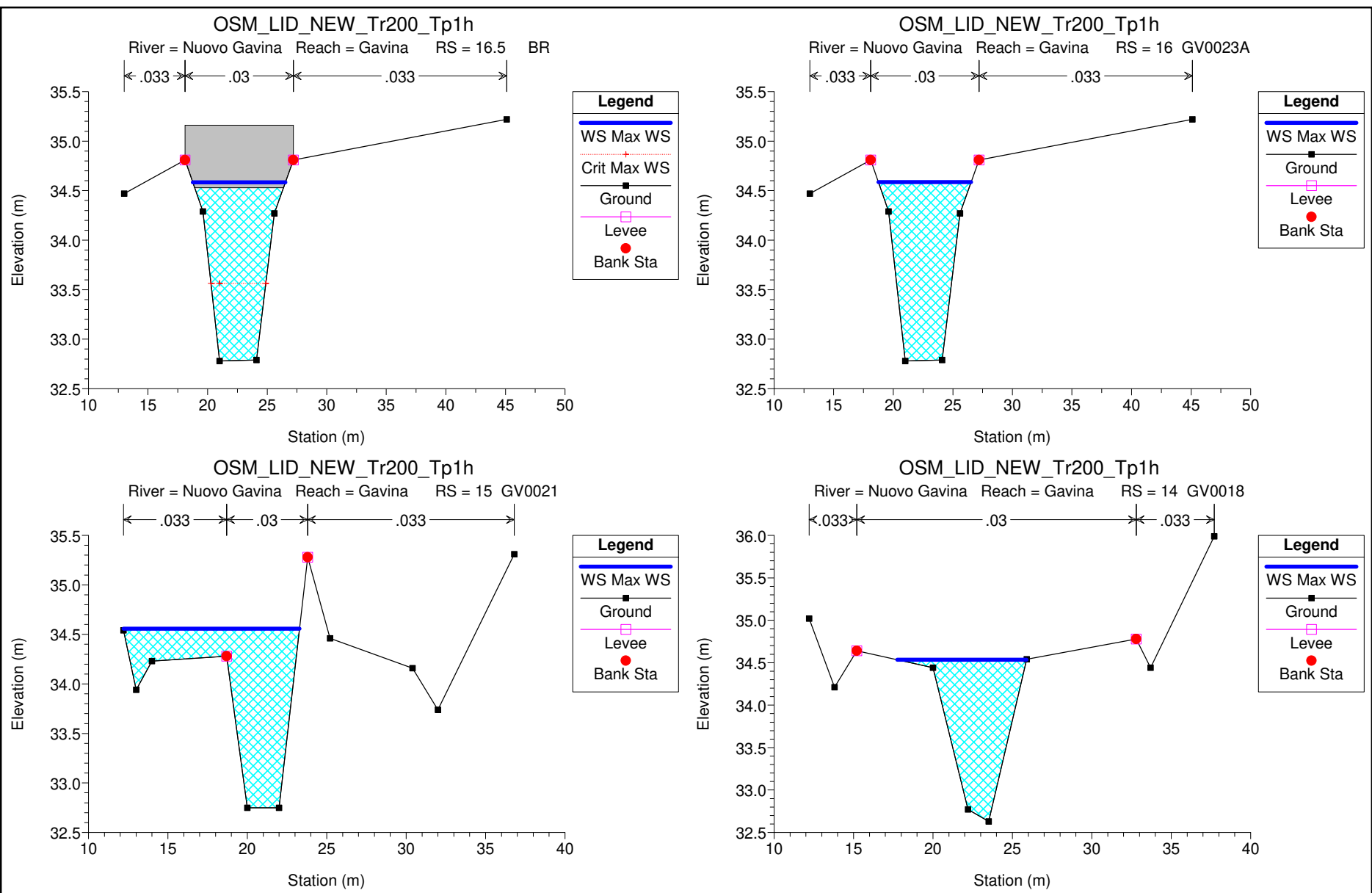


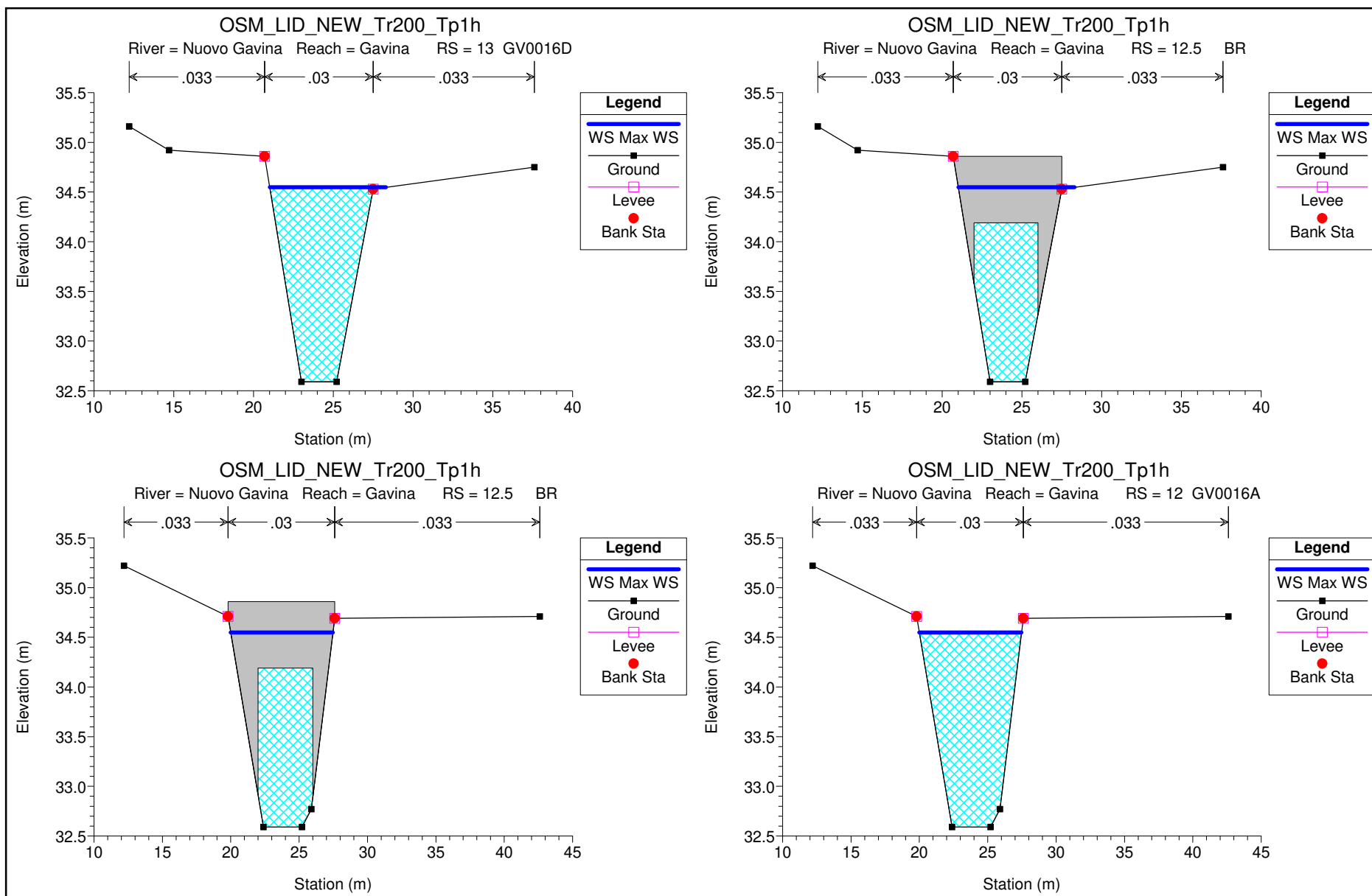


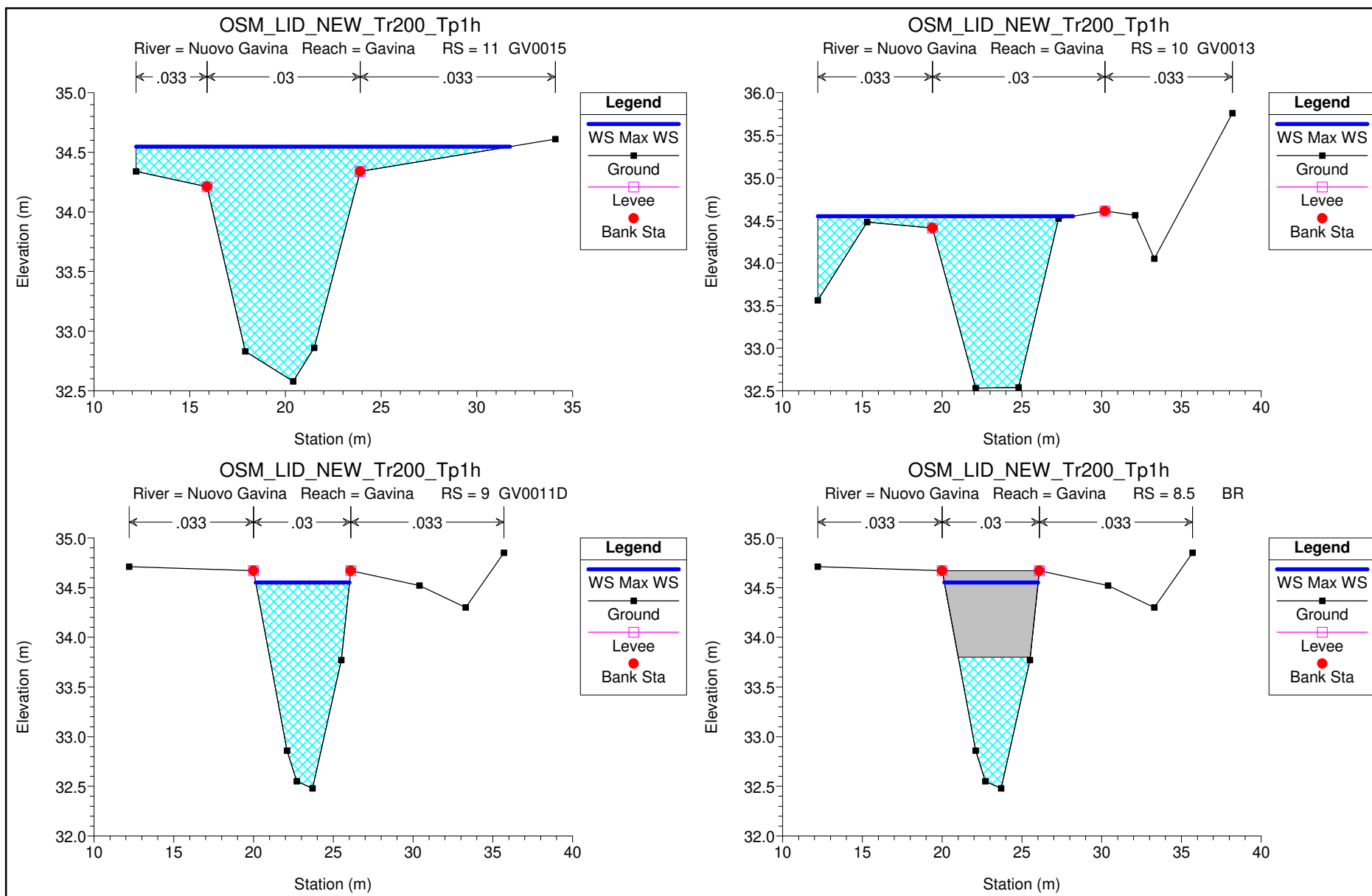


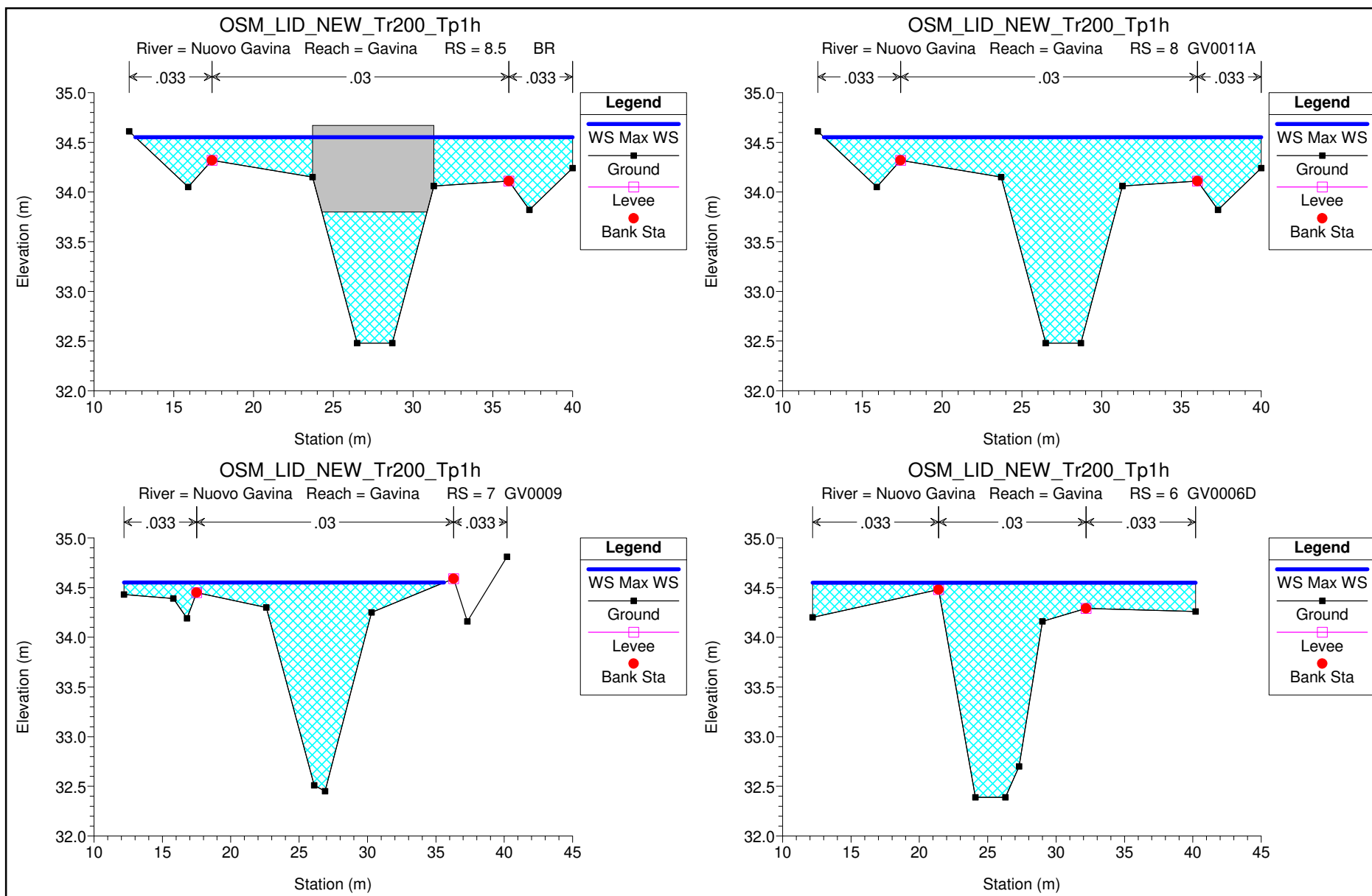


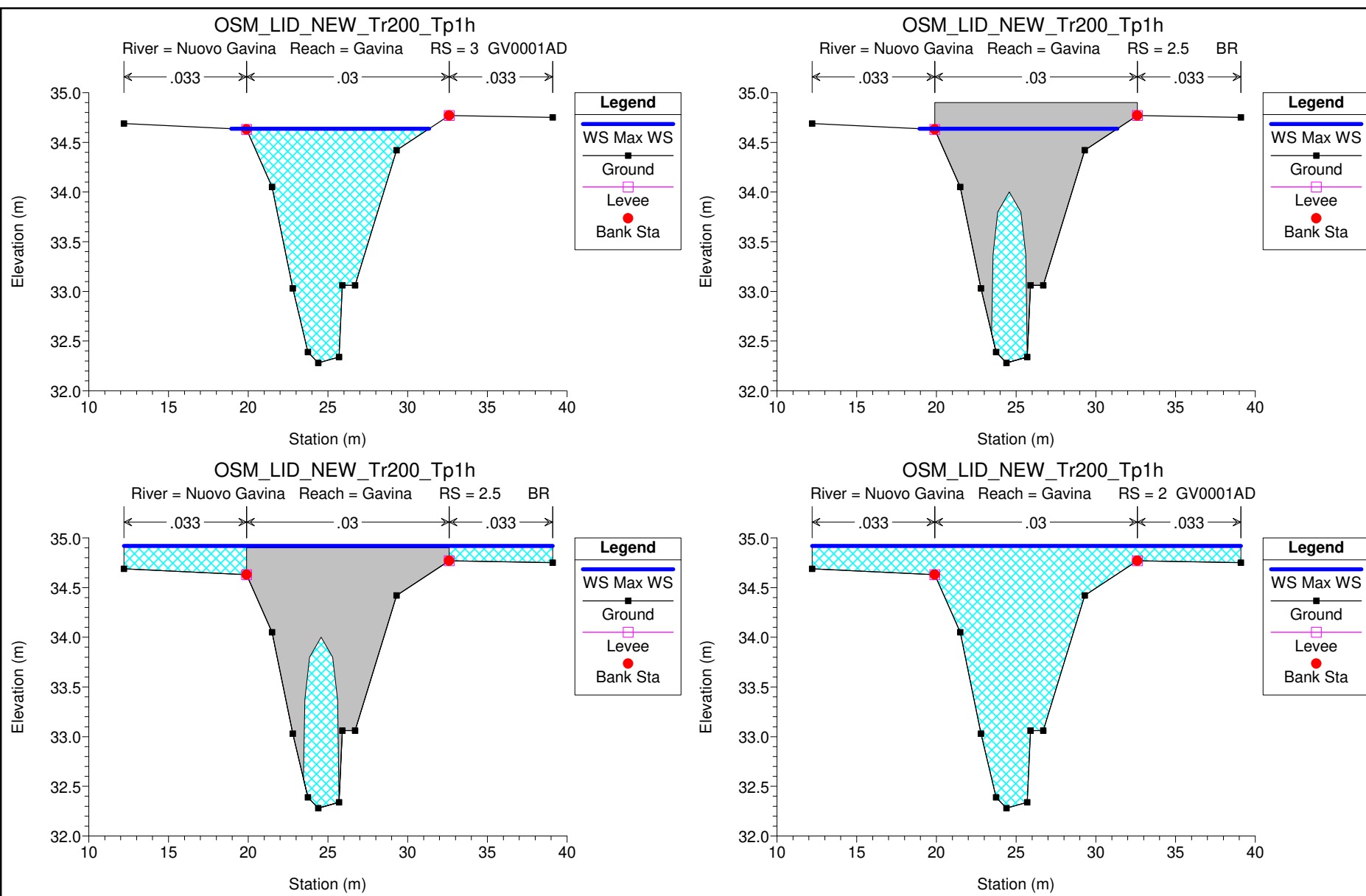


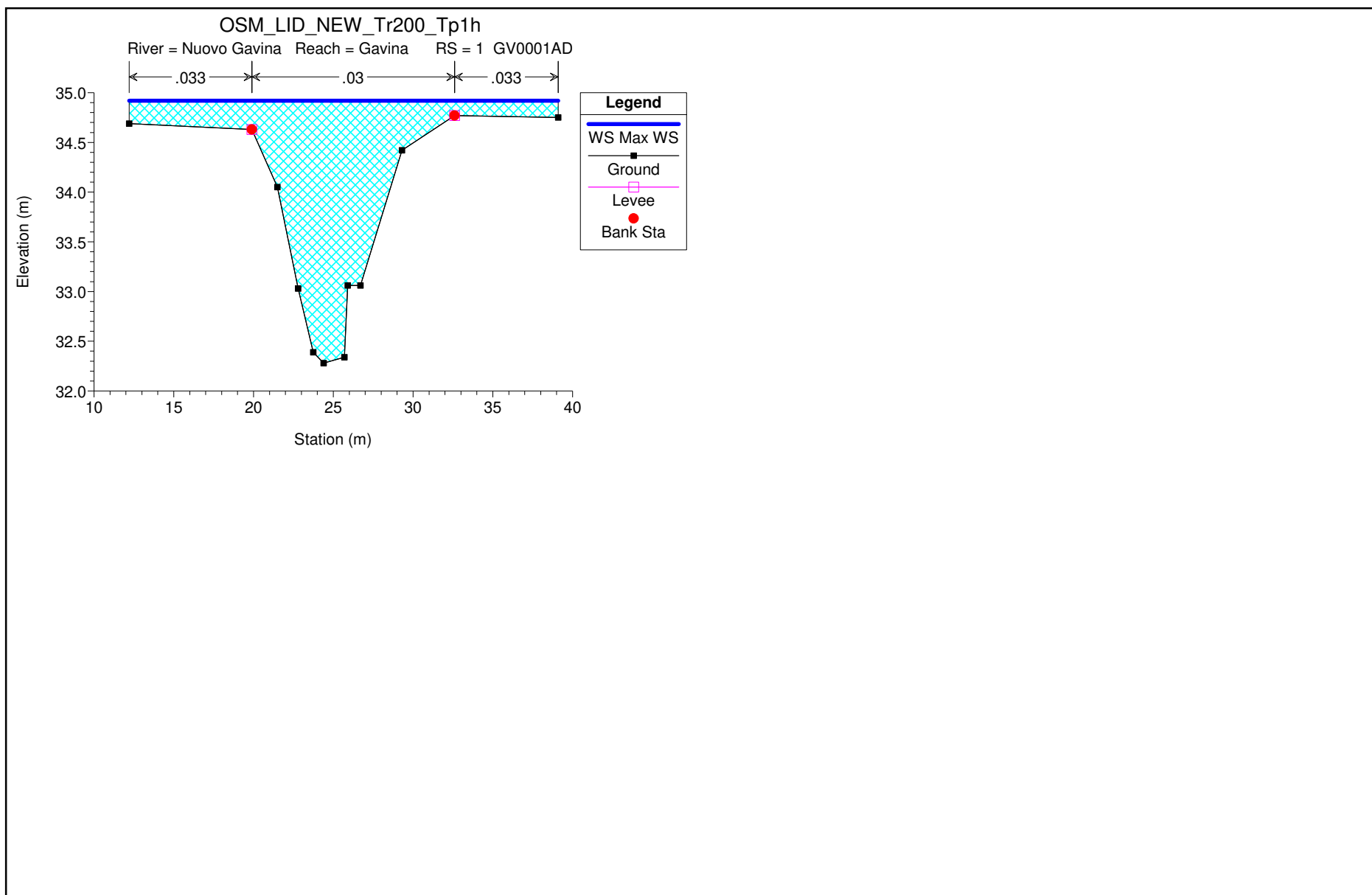






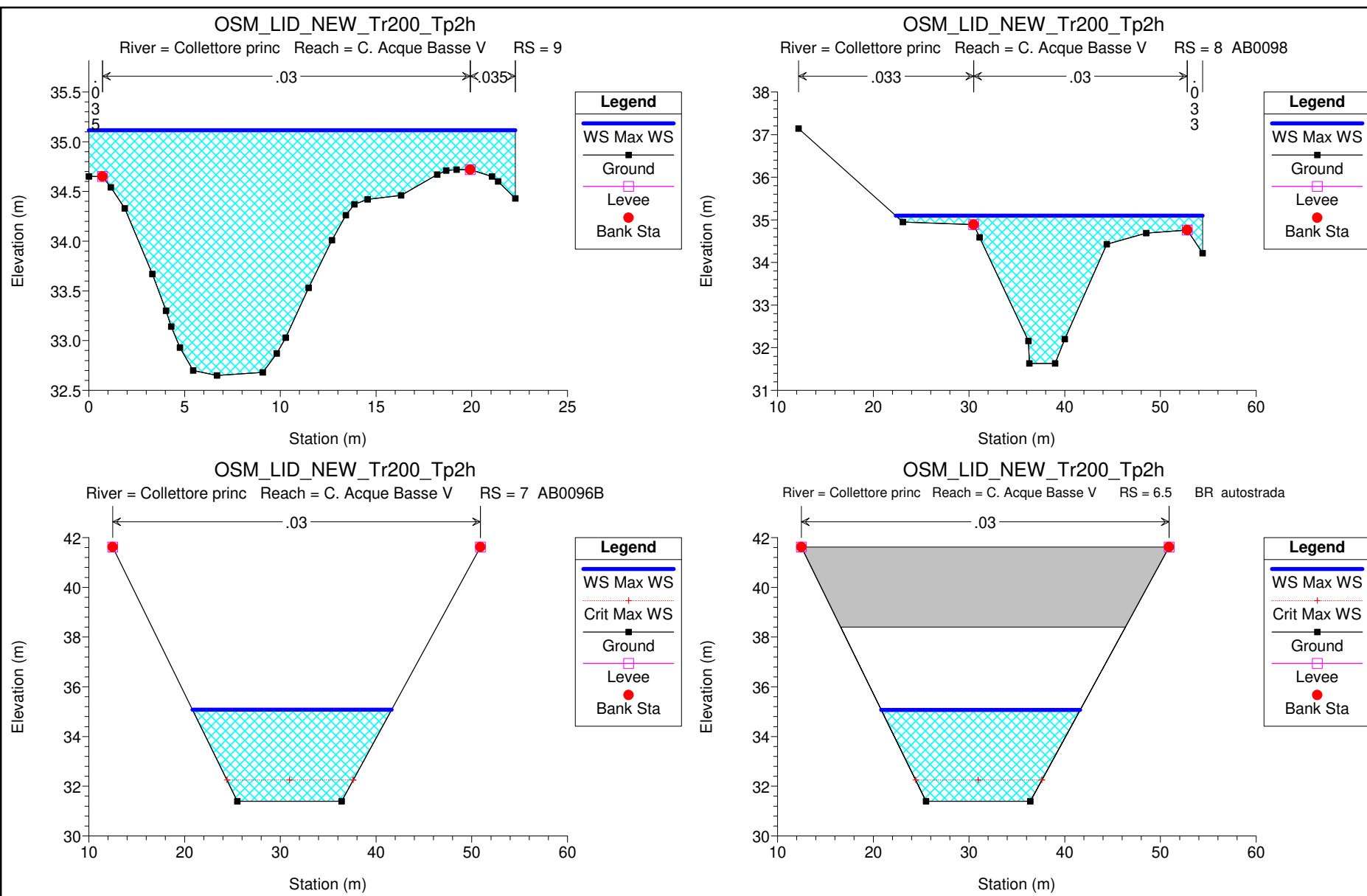


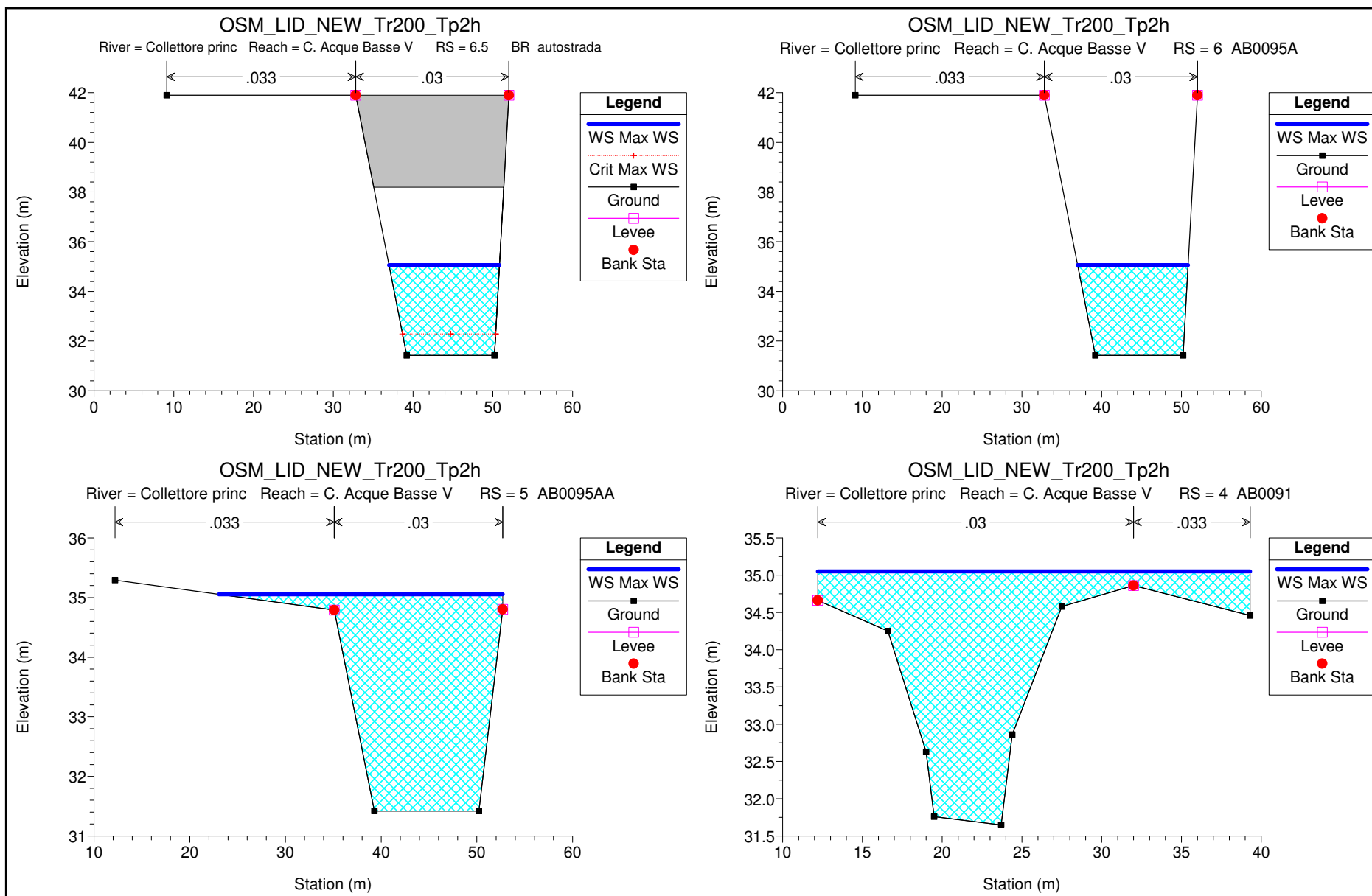


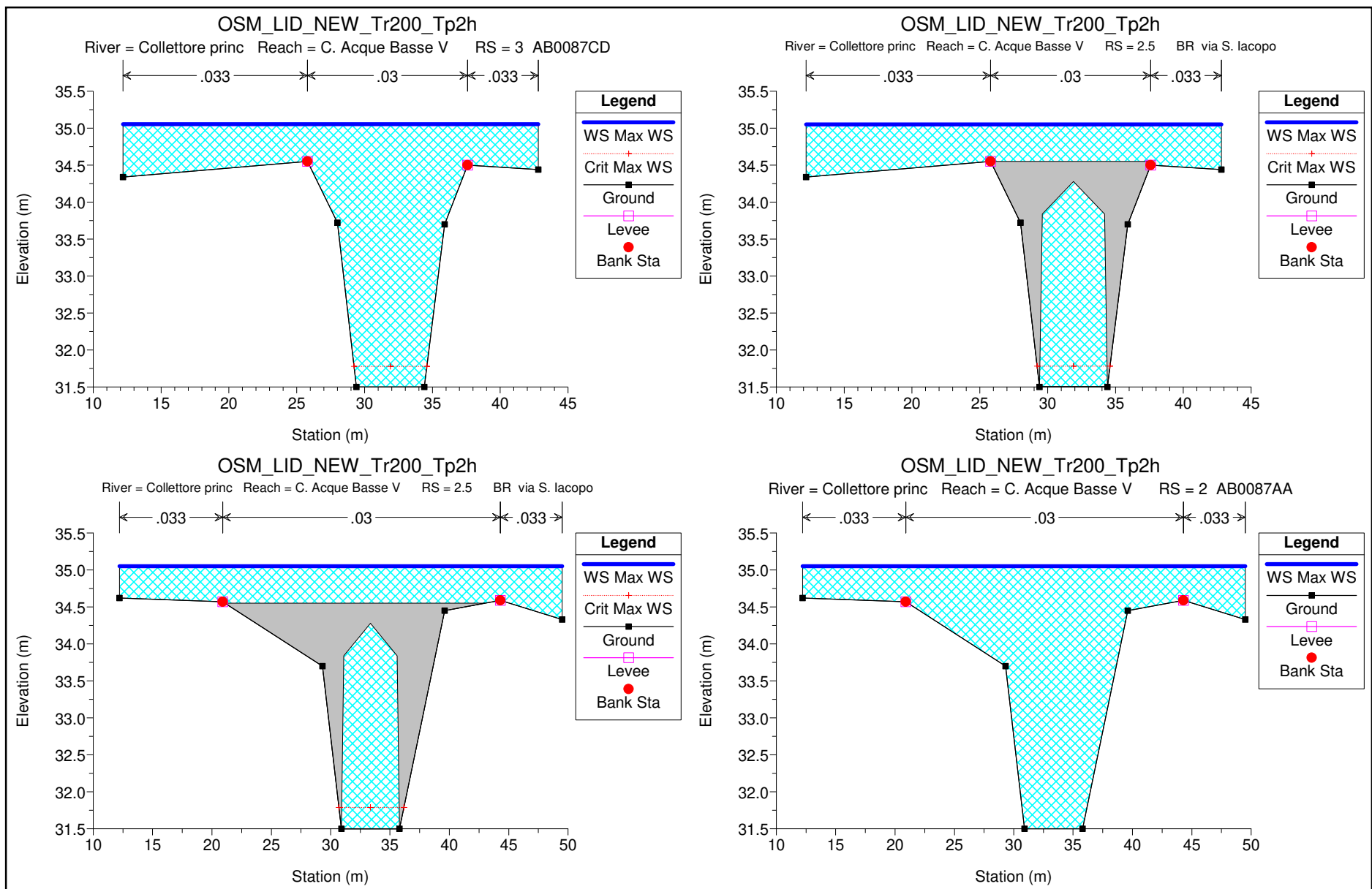


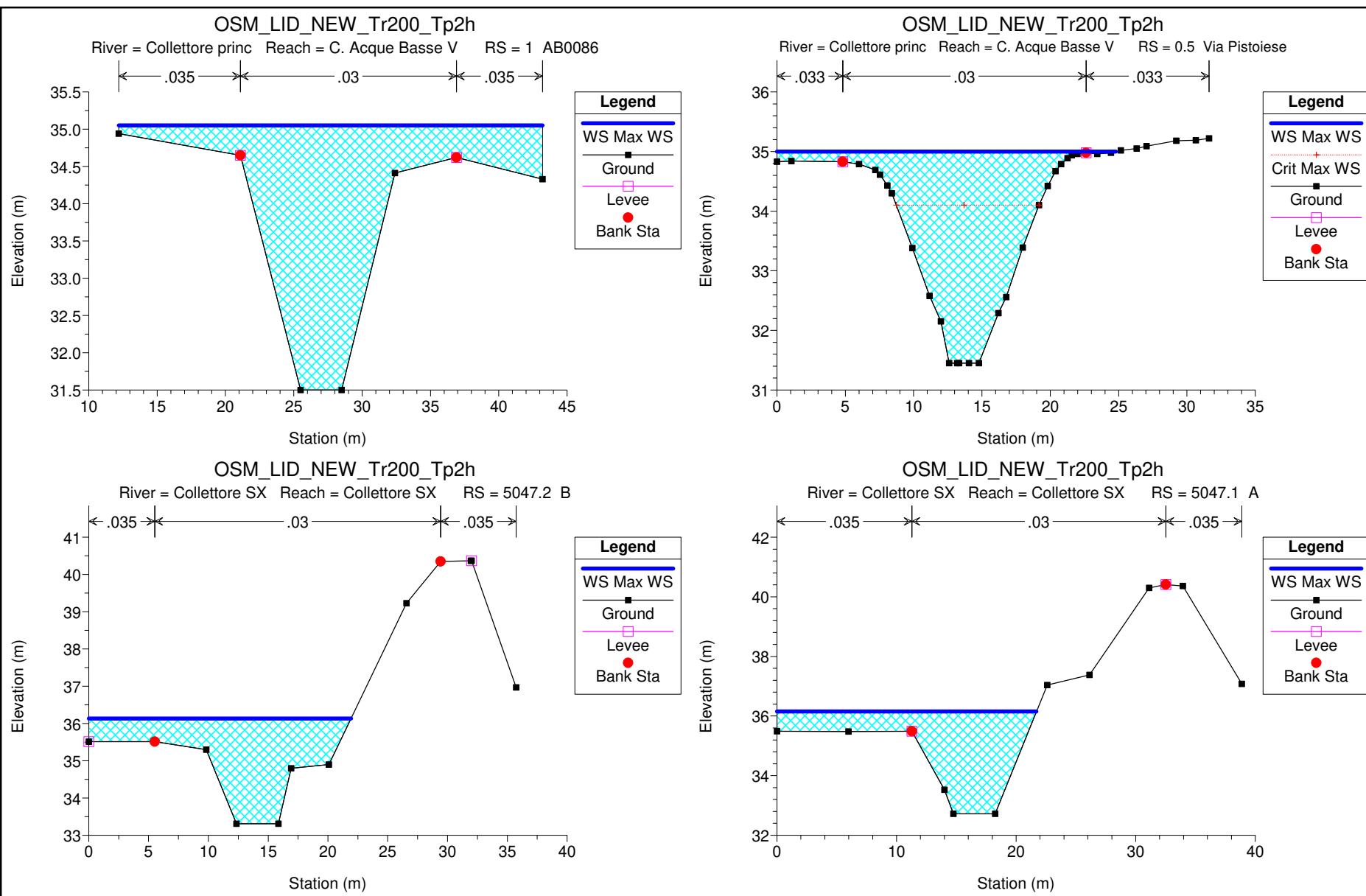
Verifiche idrauliche Tr 200 anni Tp 2h

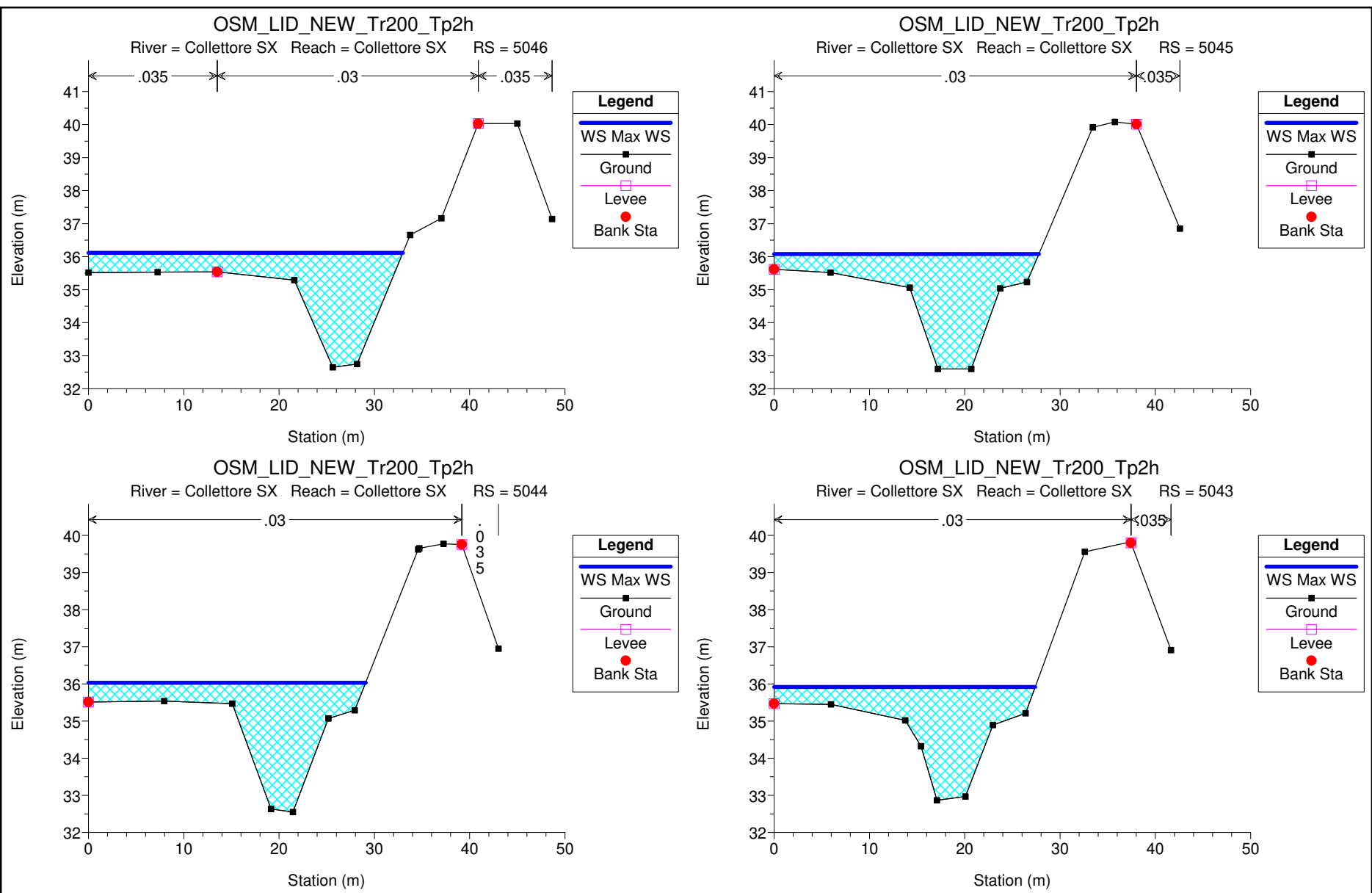
**Collettore sinistro acque basse – Fosso Osmannoro – Fosso Nuova Gavine – Collettore
principale delle acque basse**

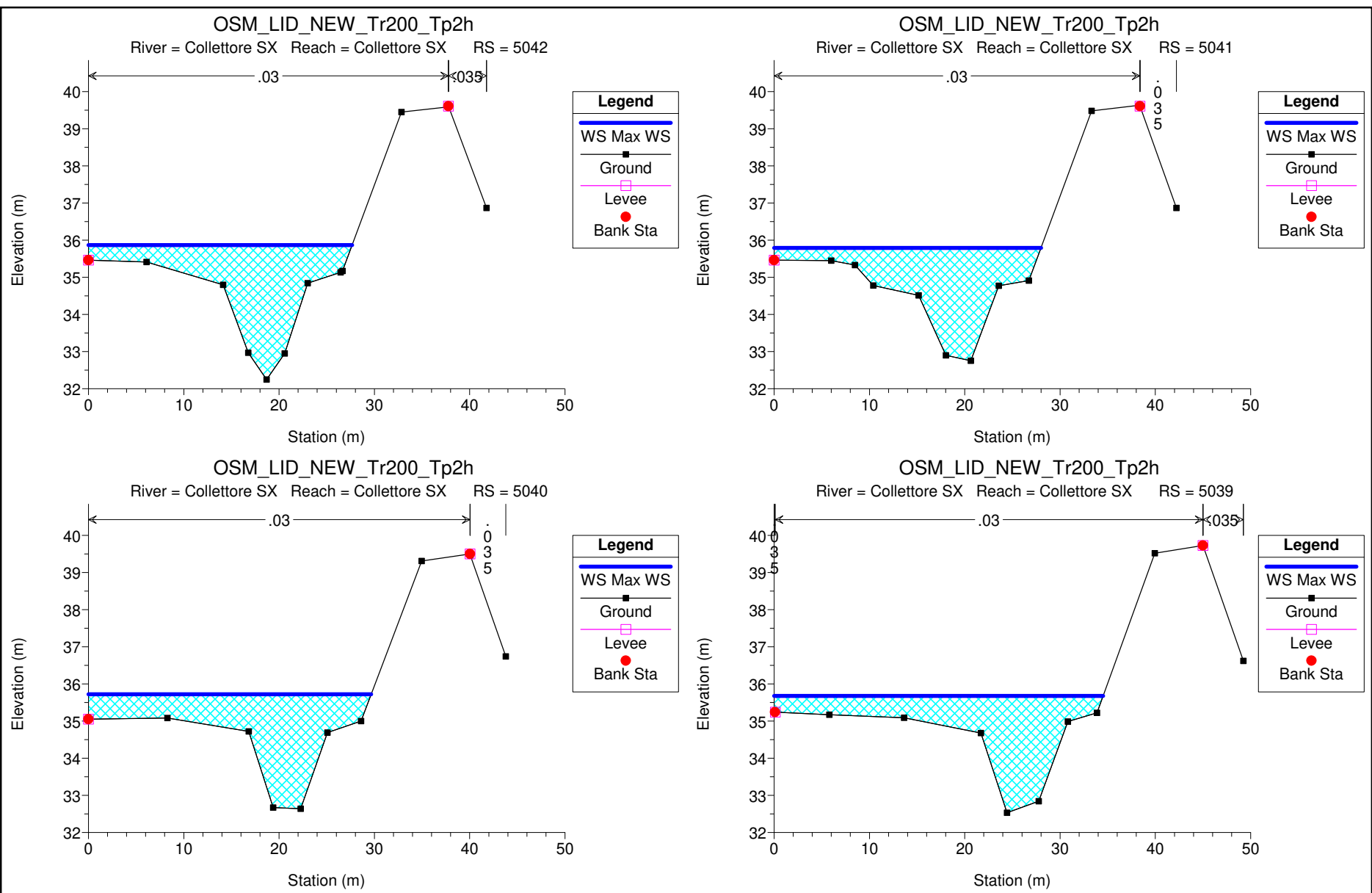


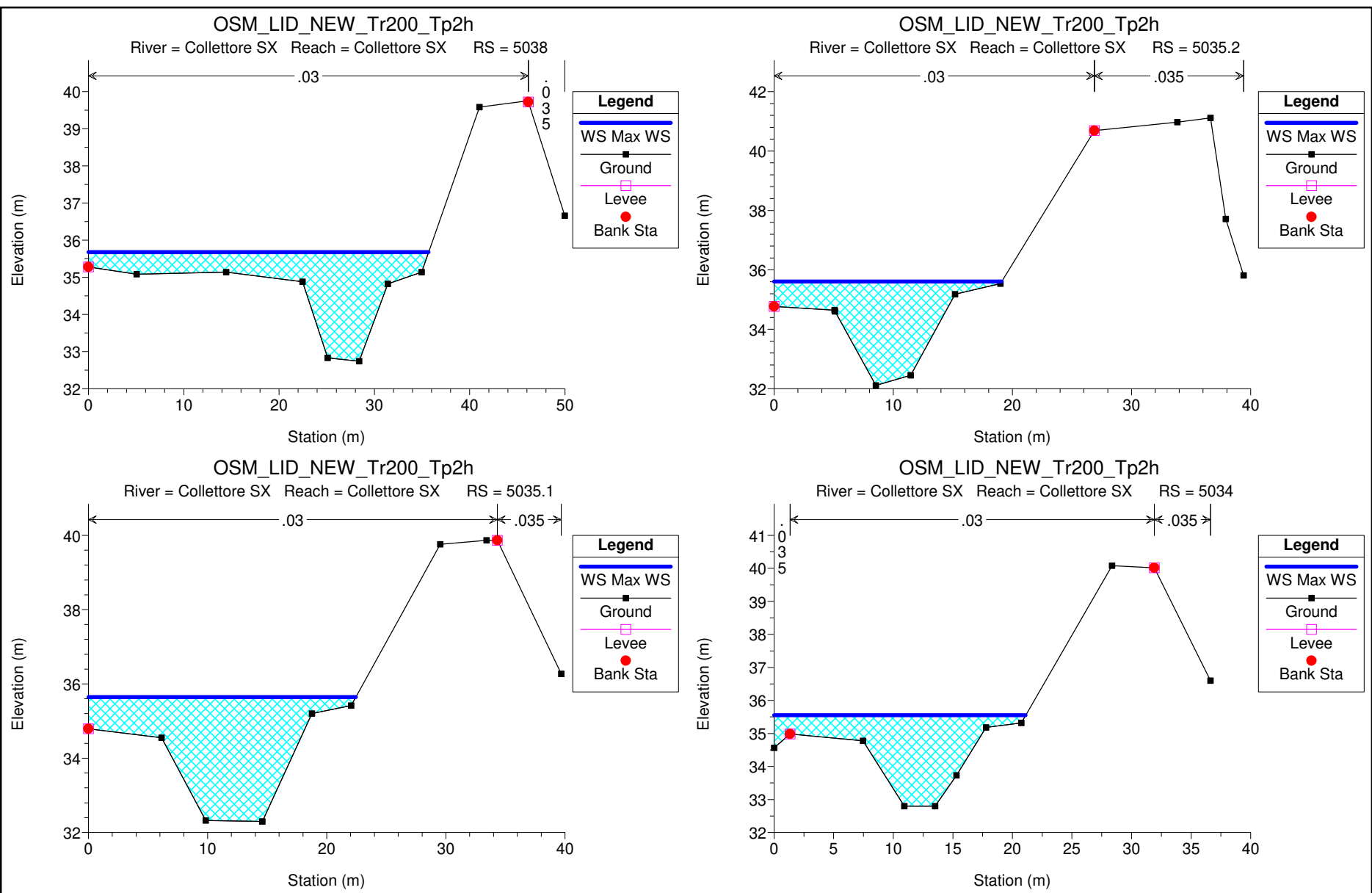


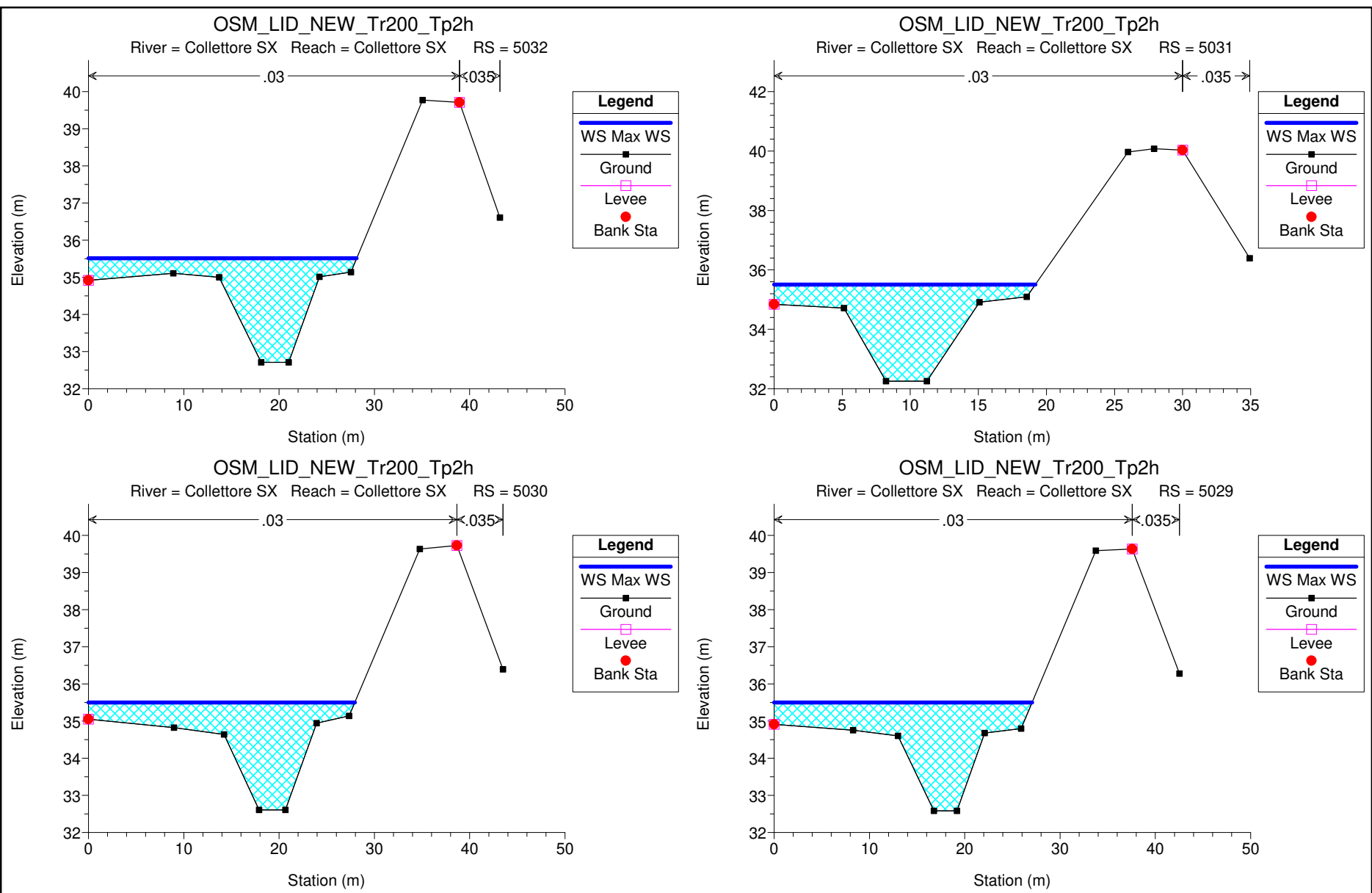


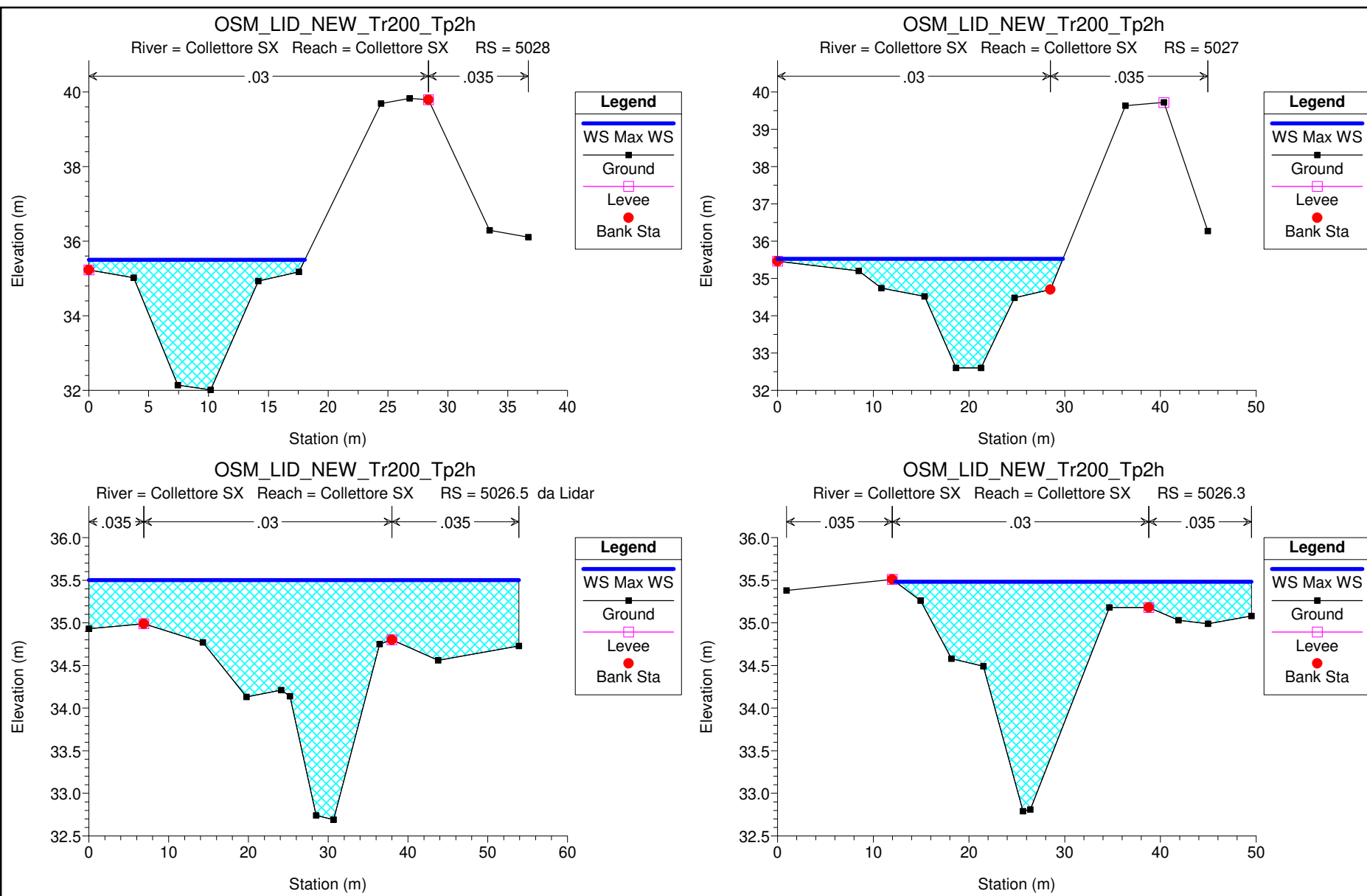


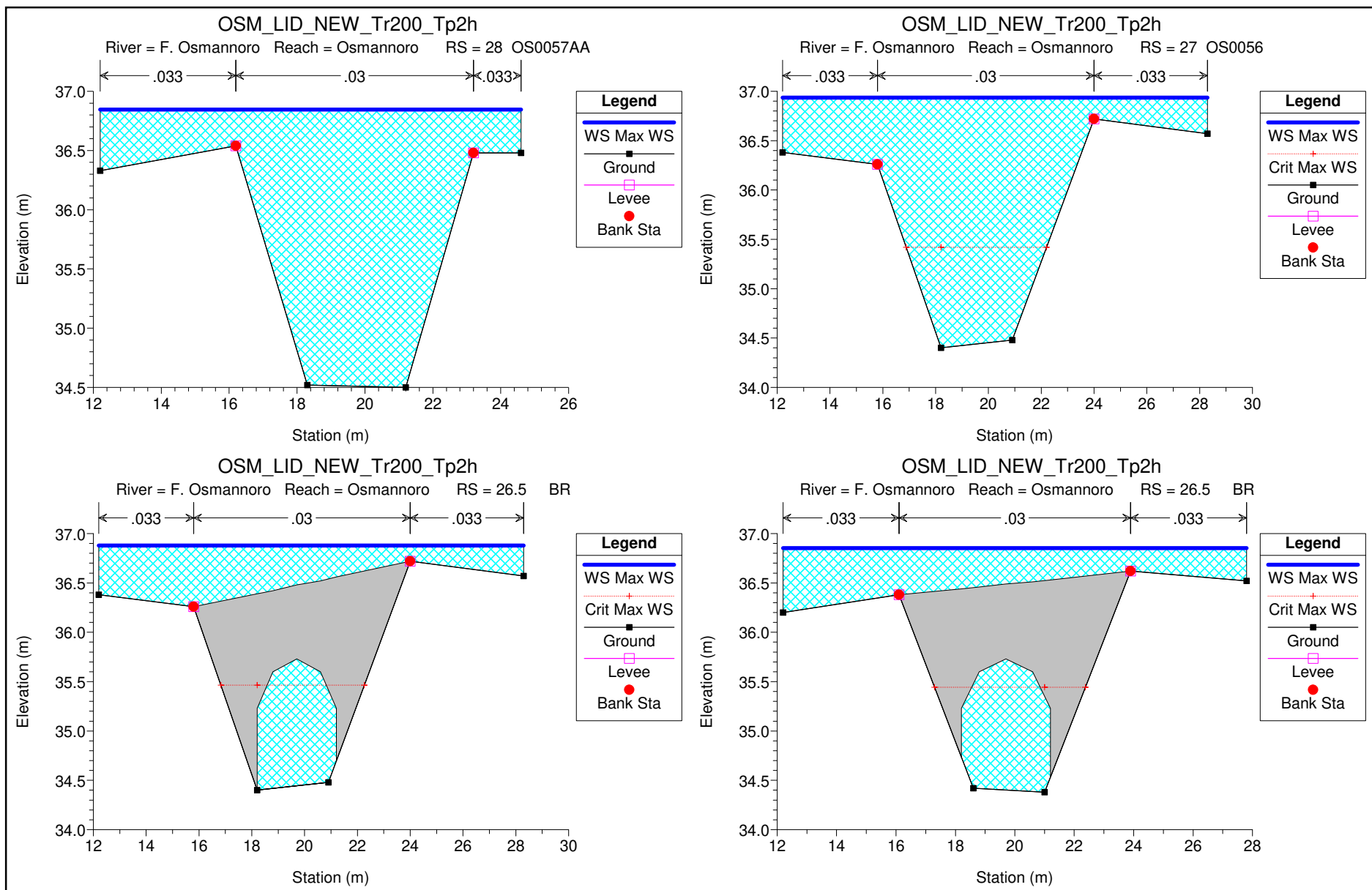


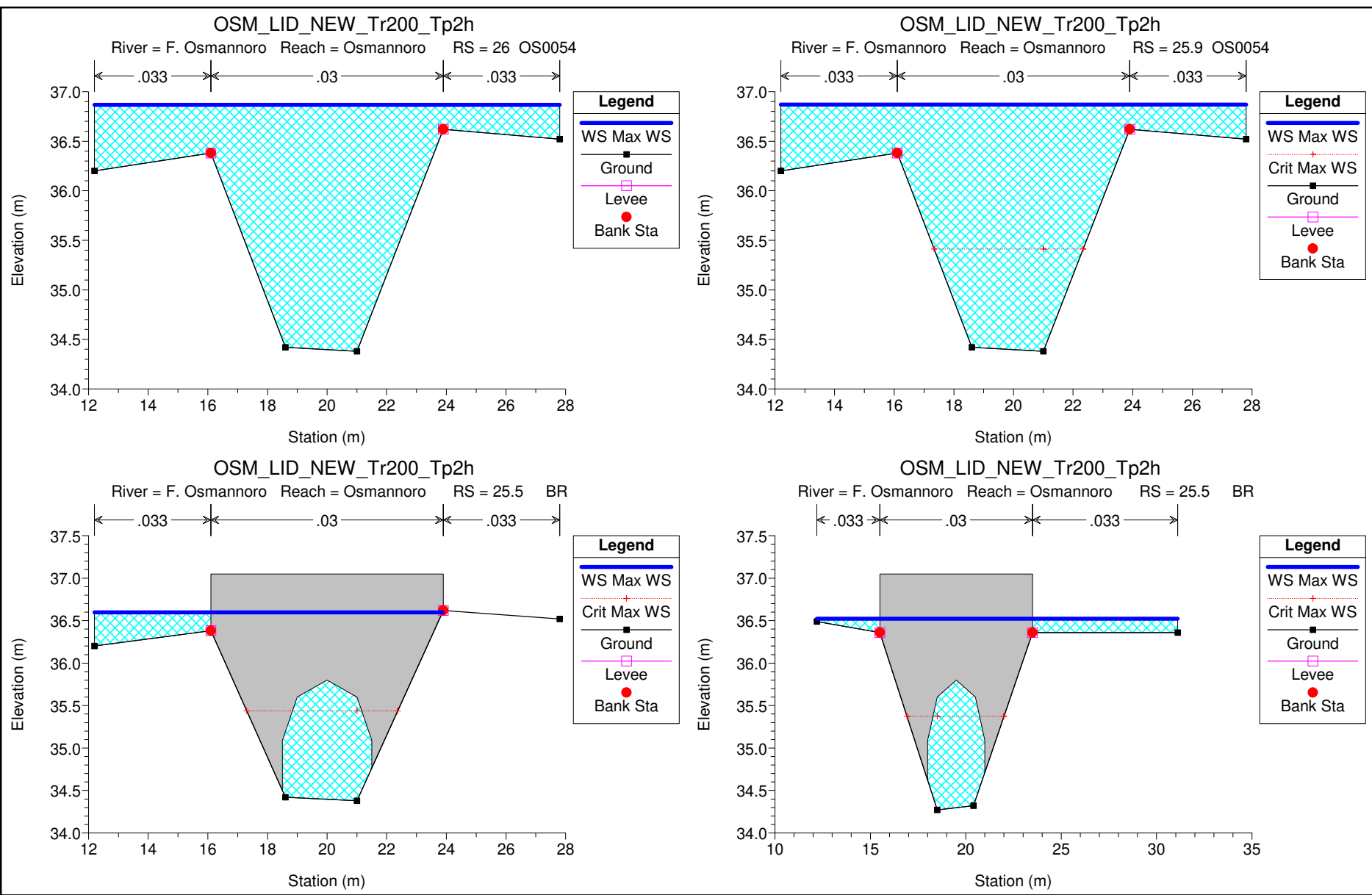


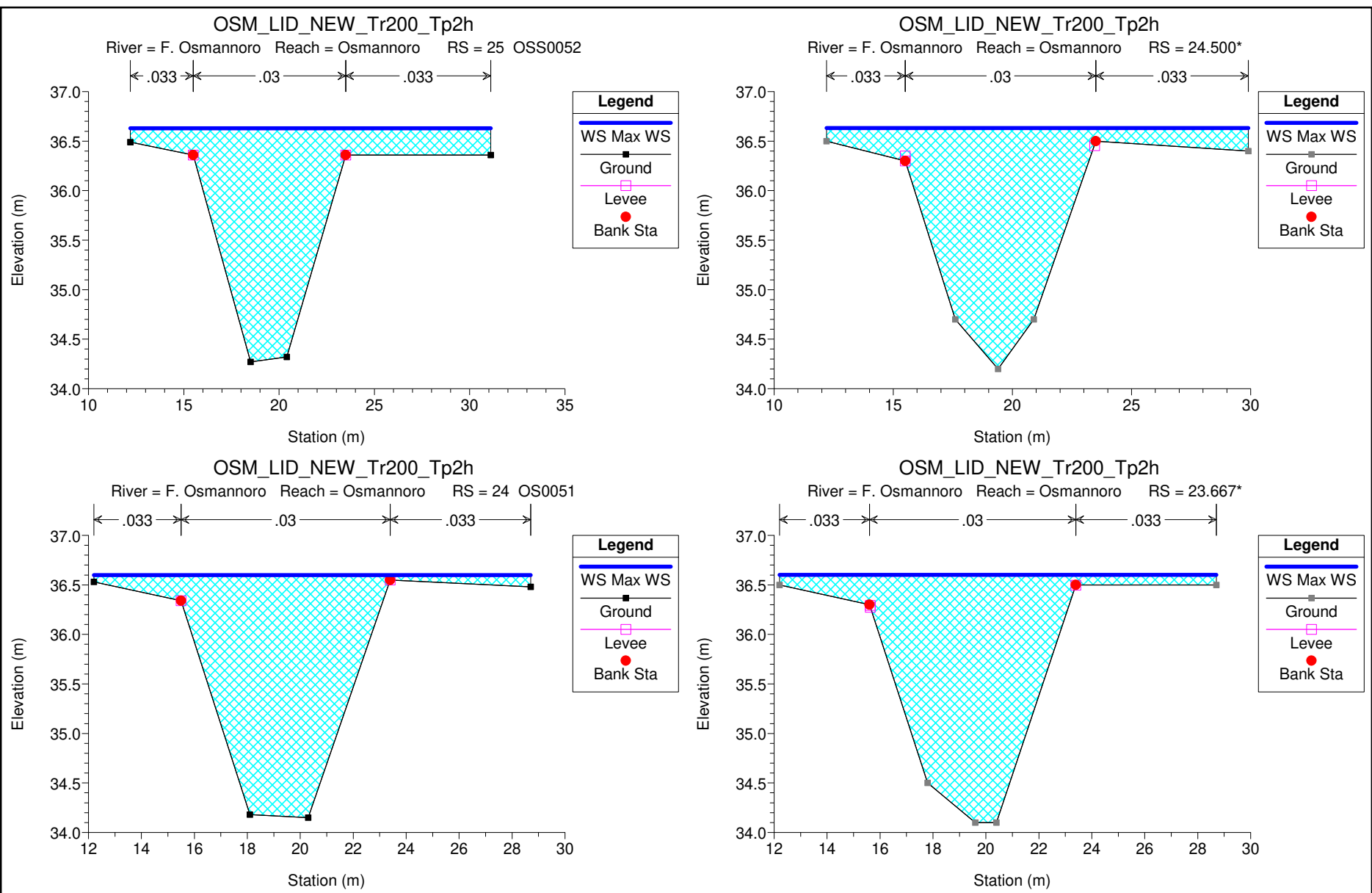


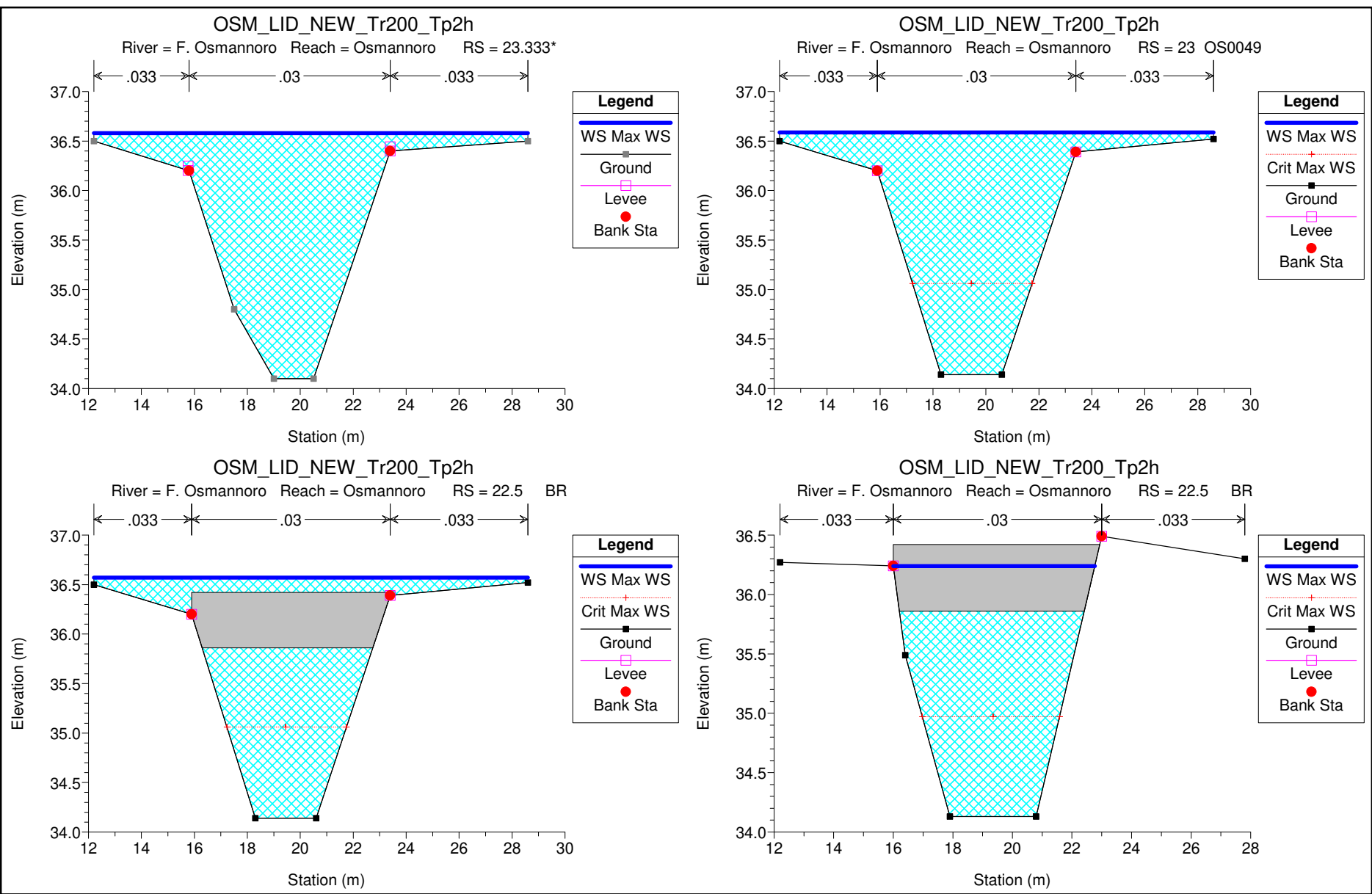


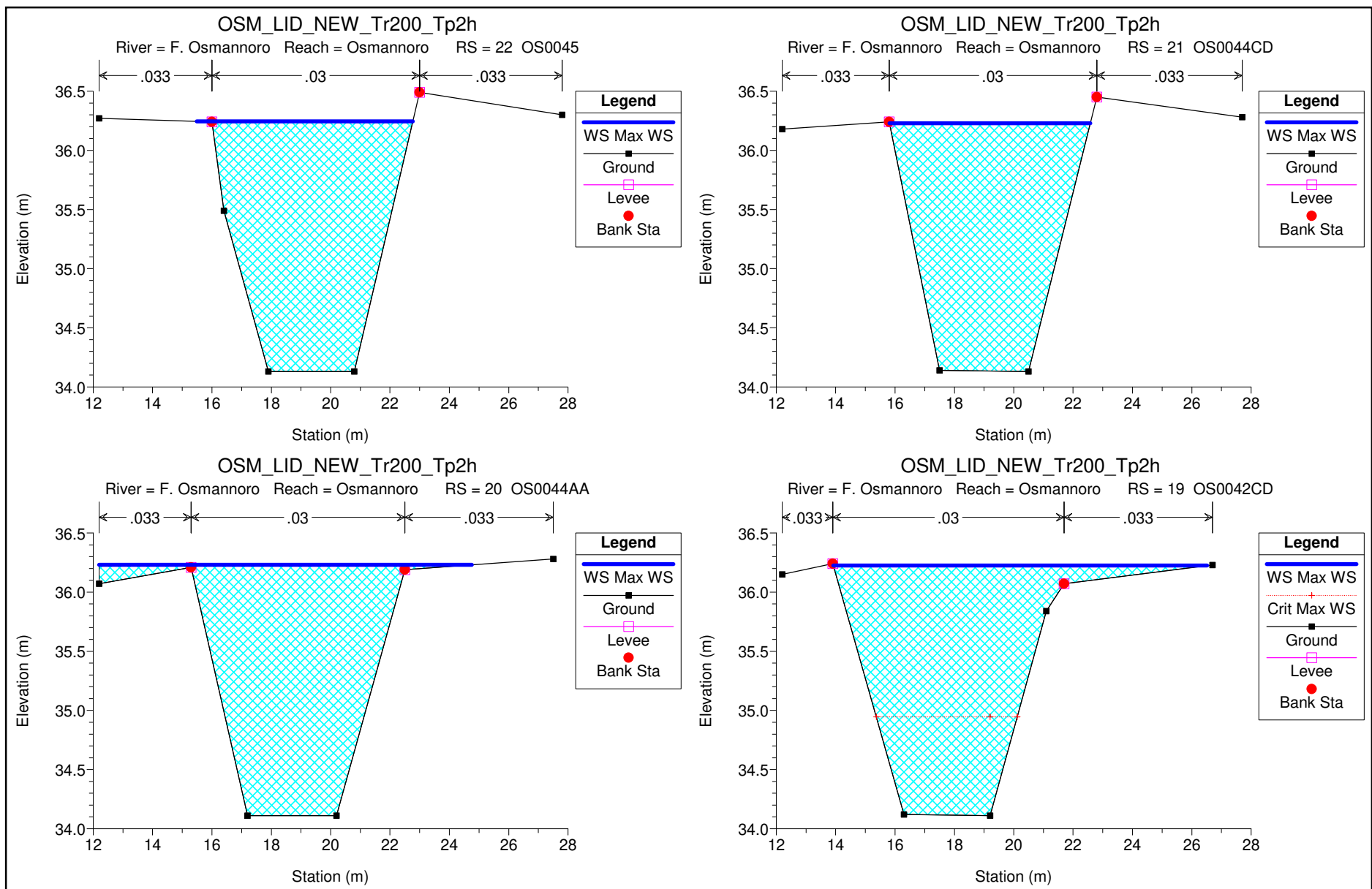


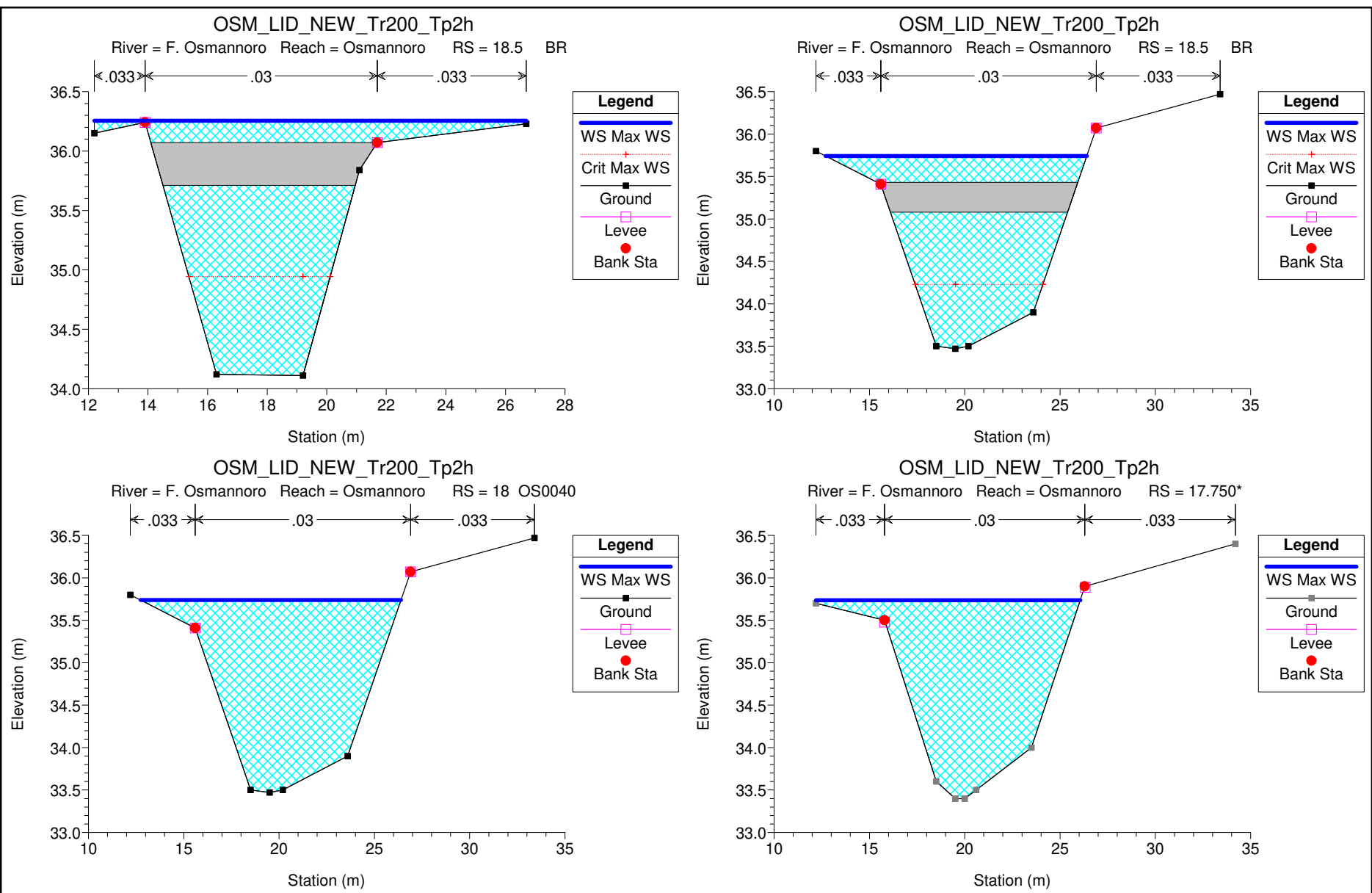


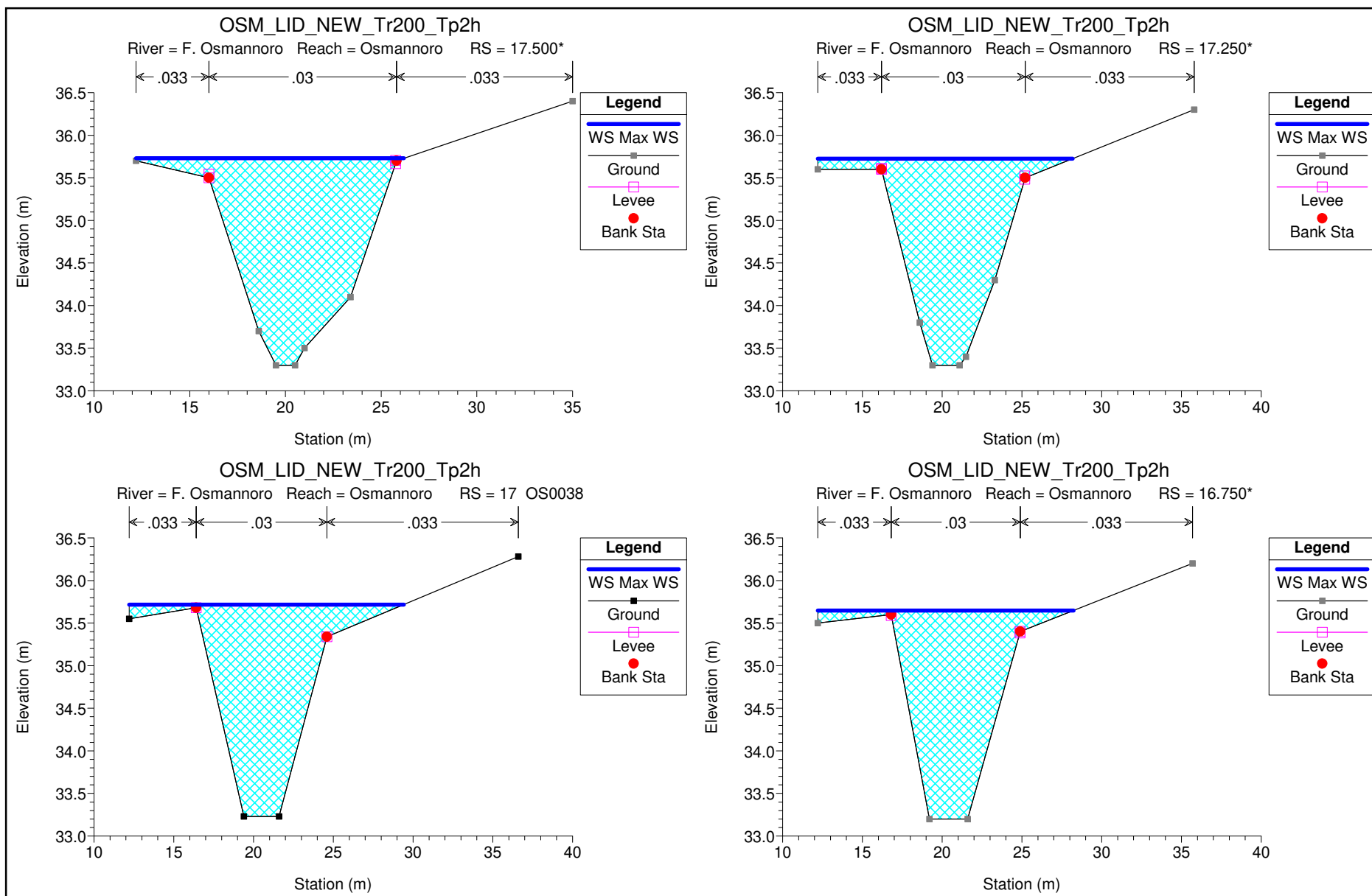


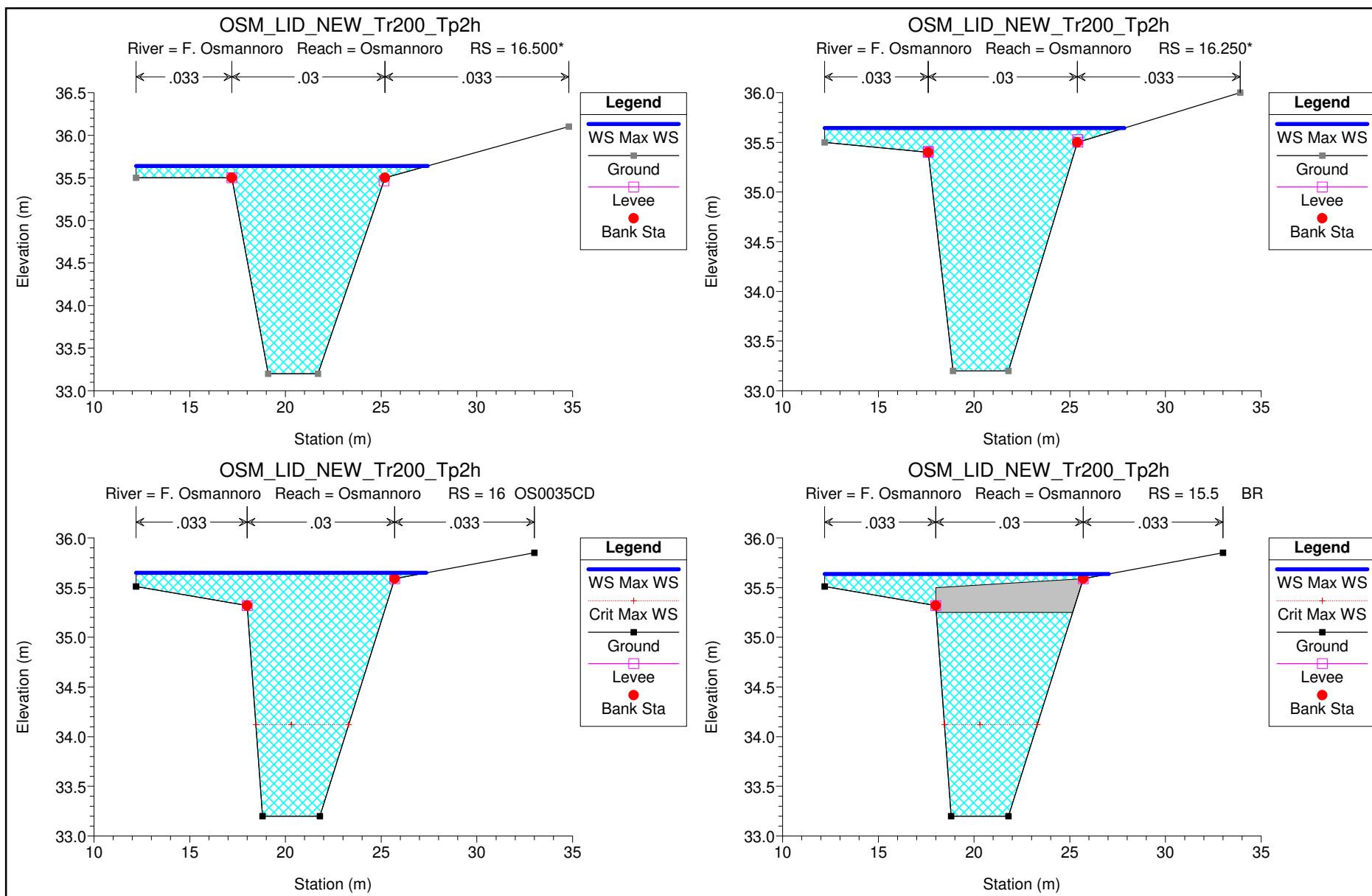


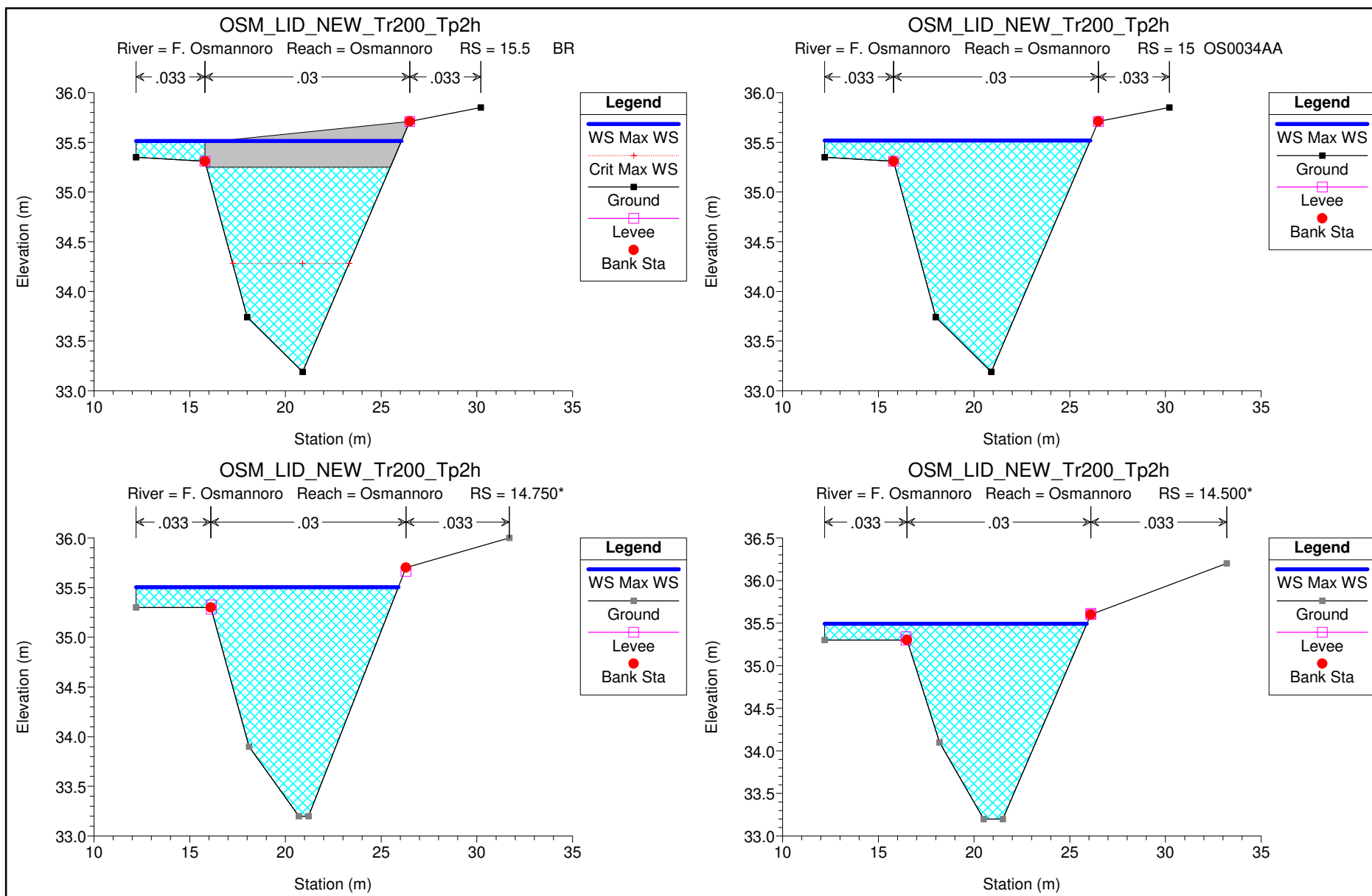


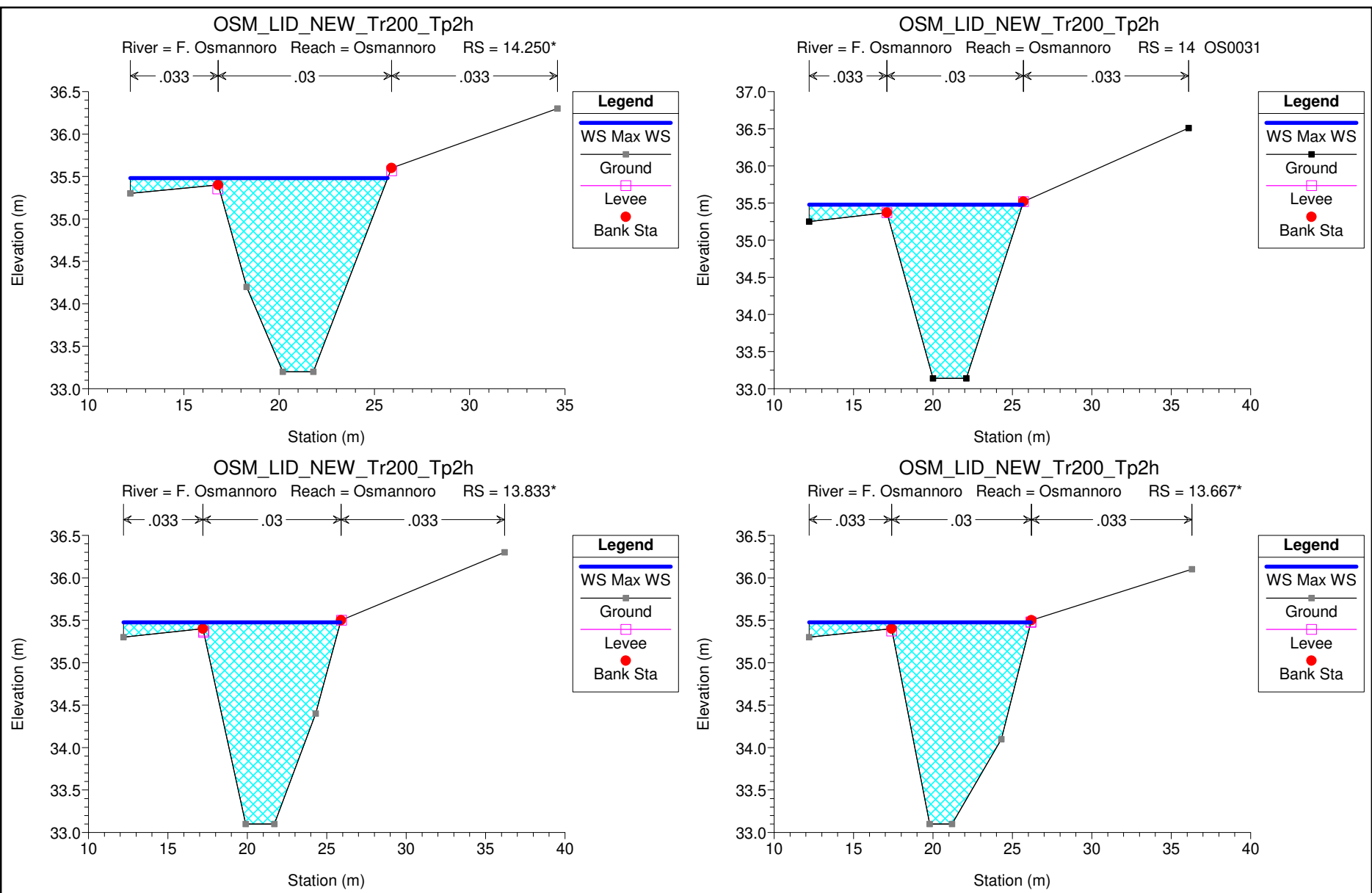


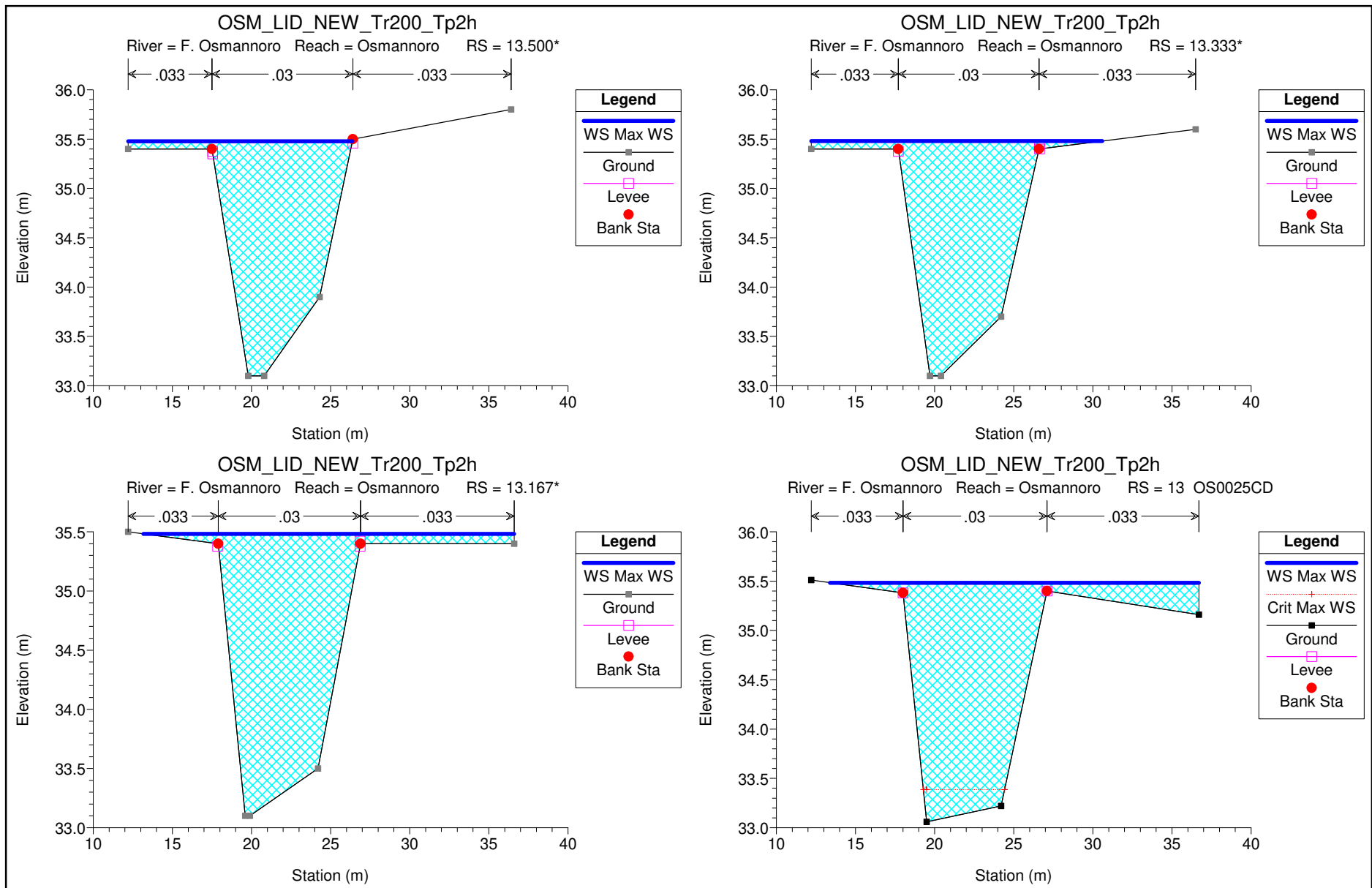


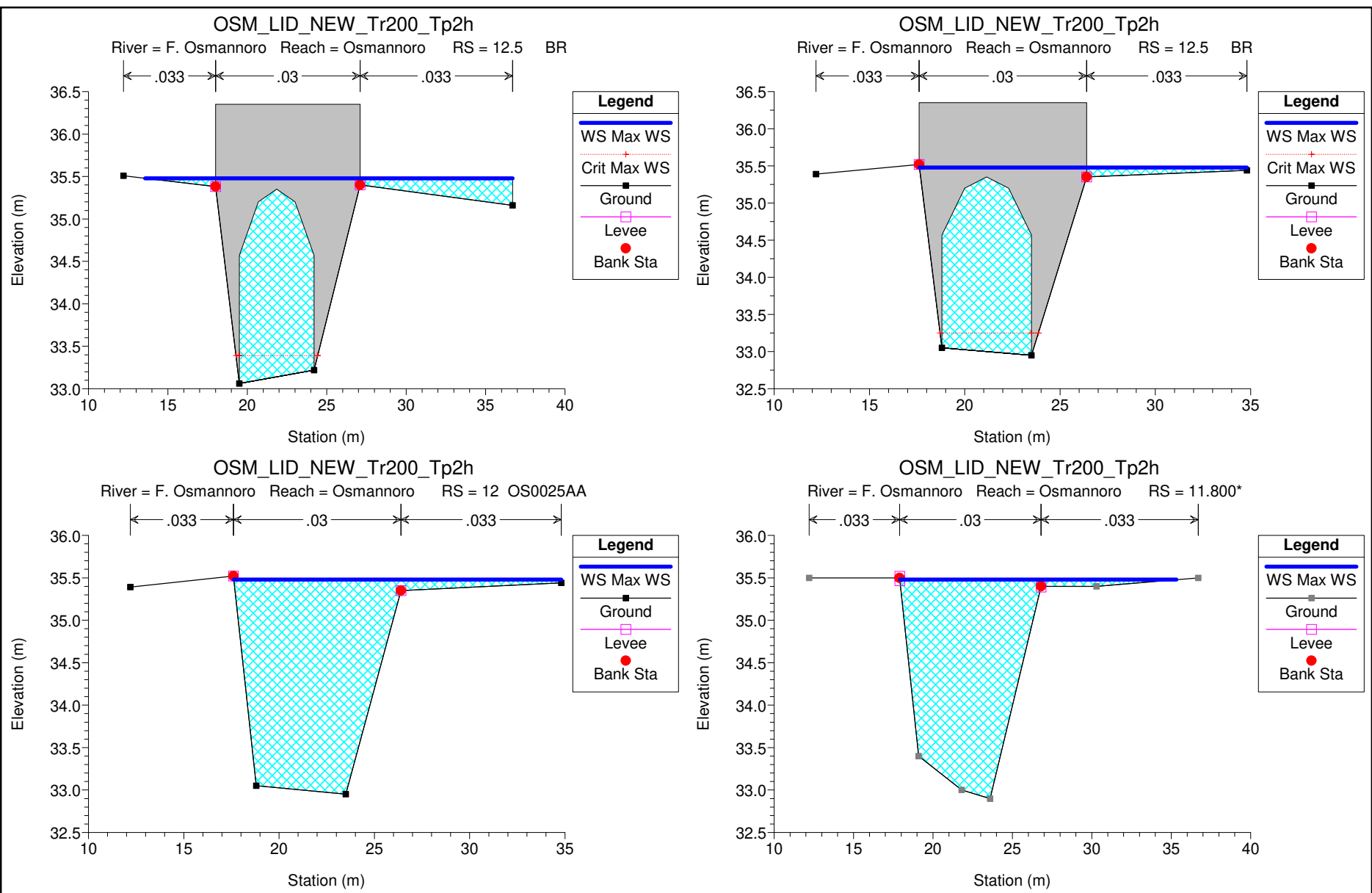


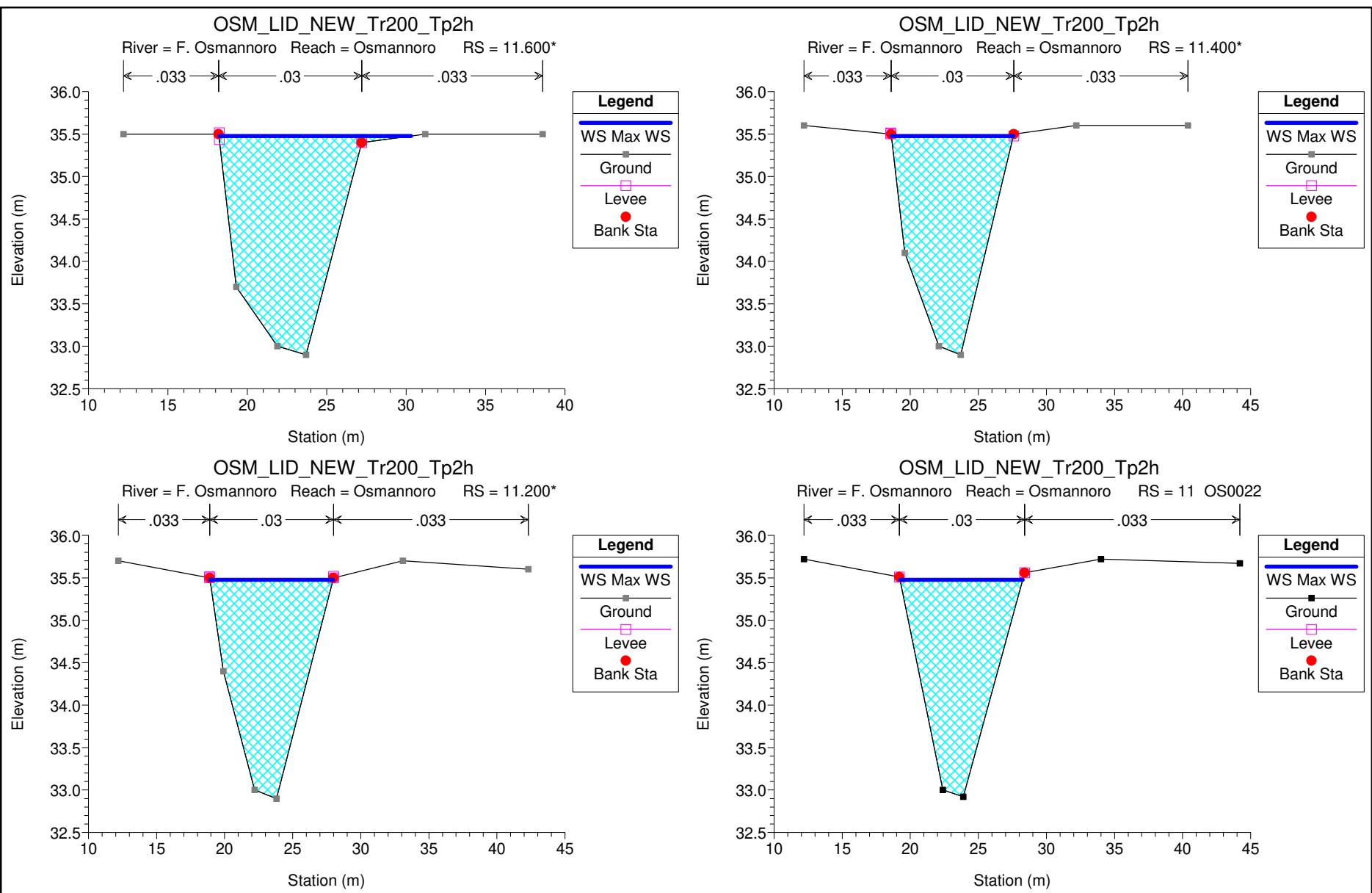


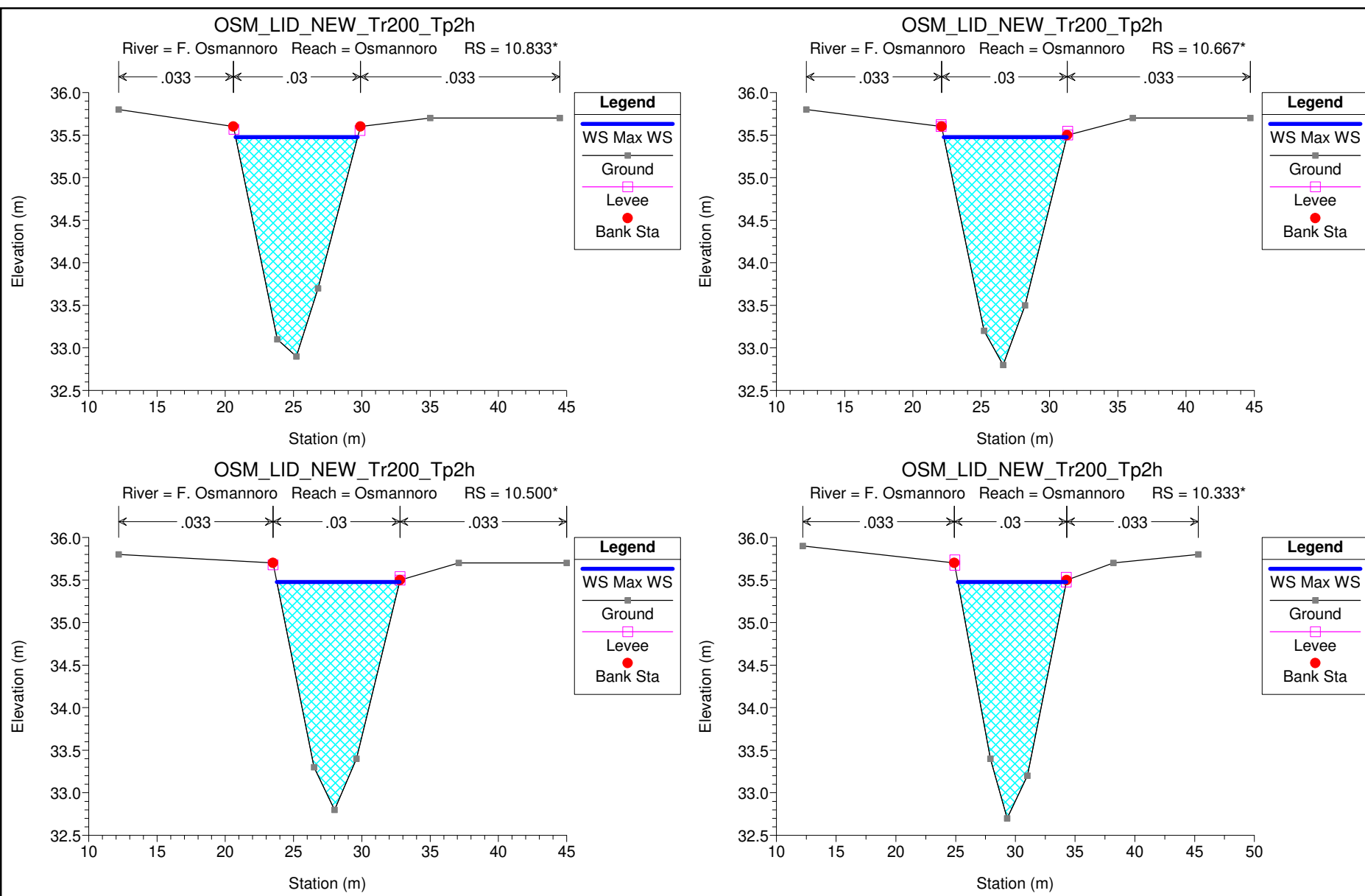


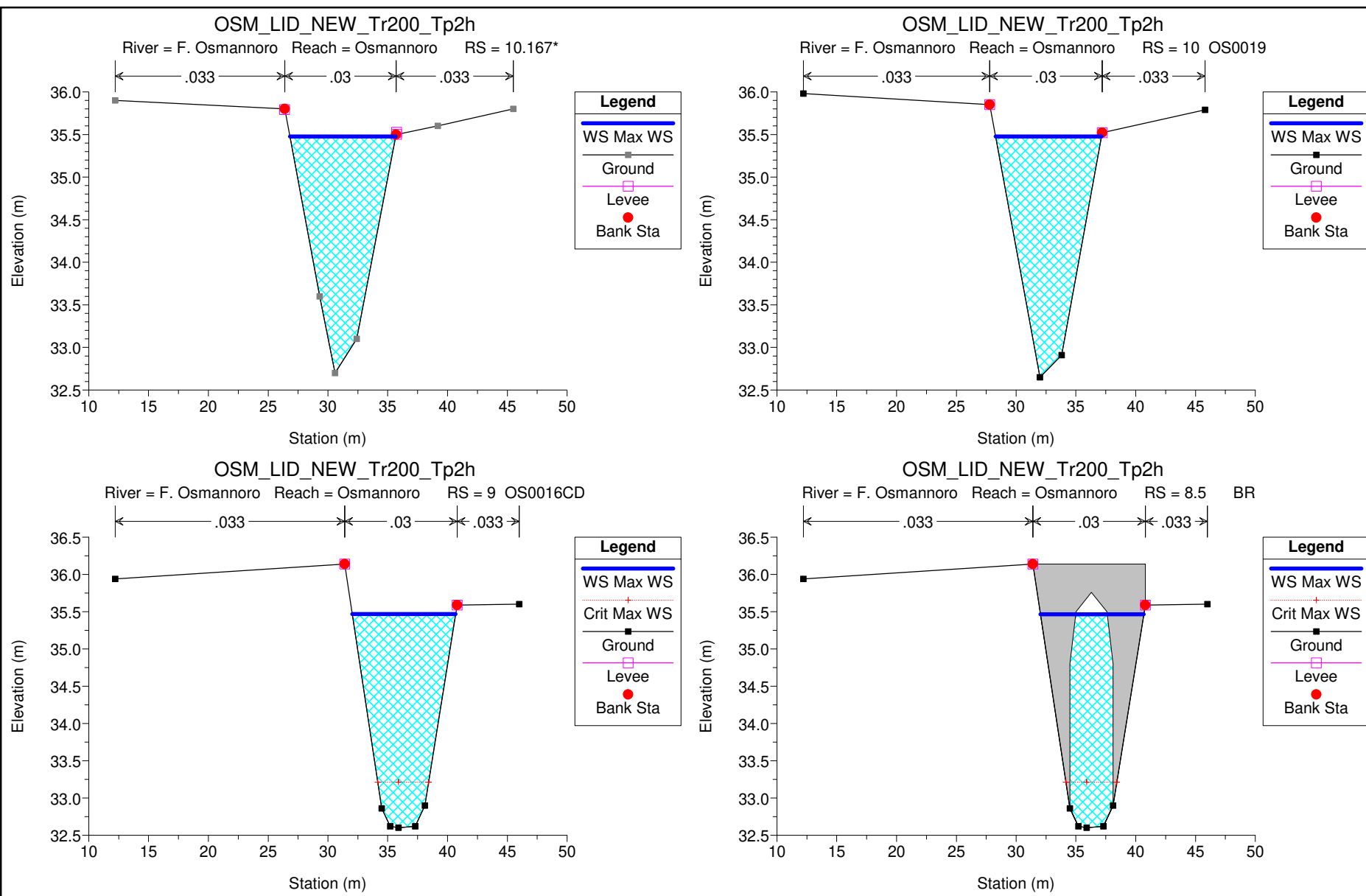


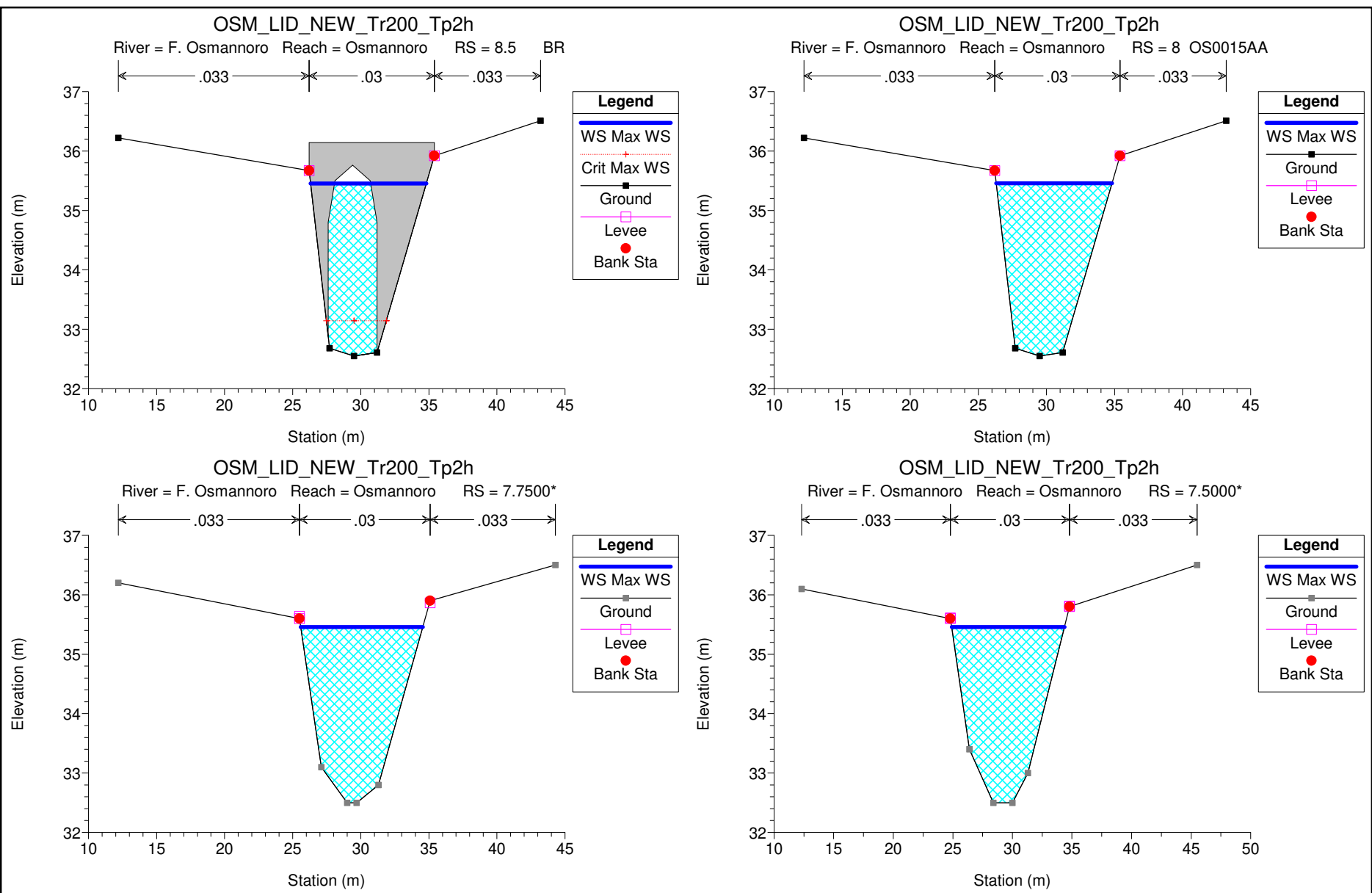


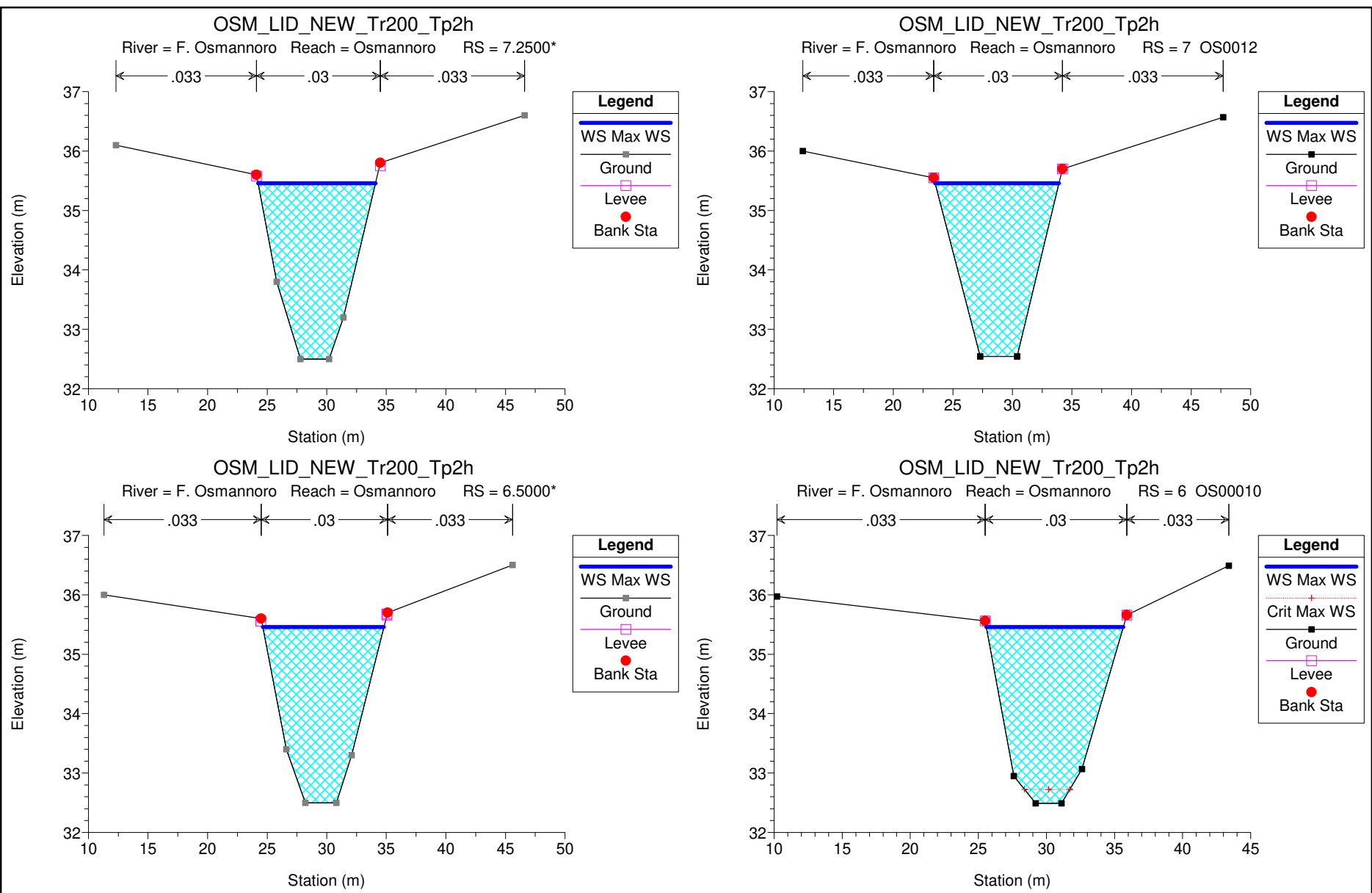


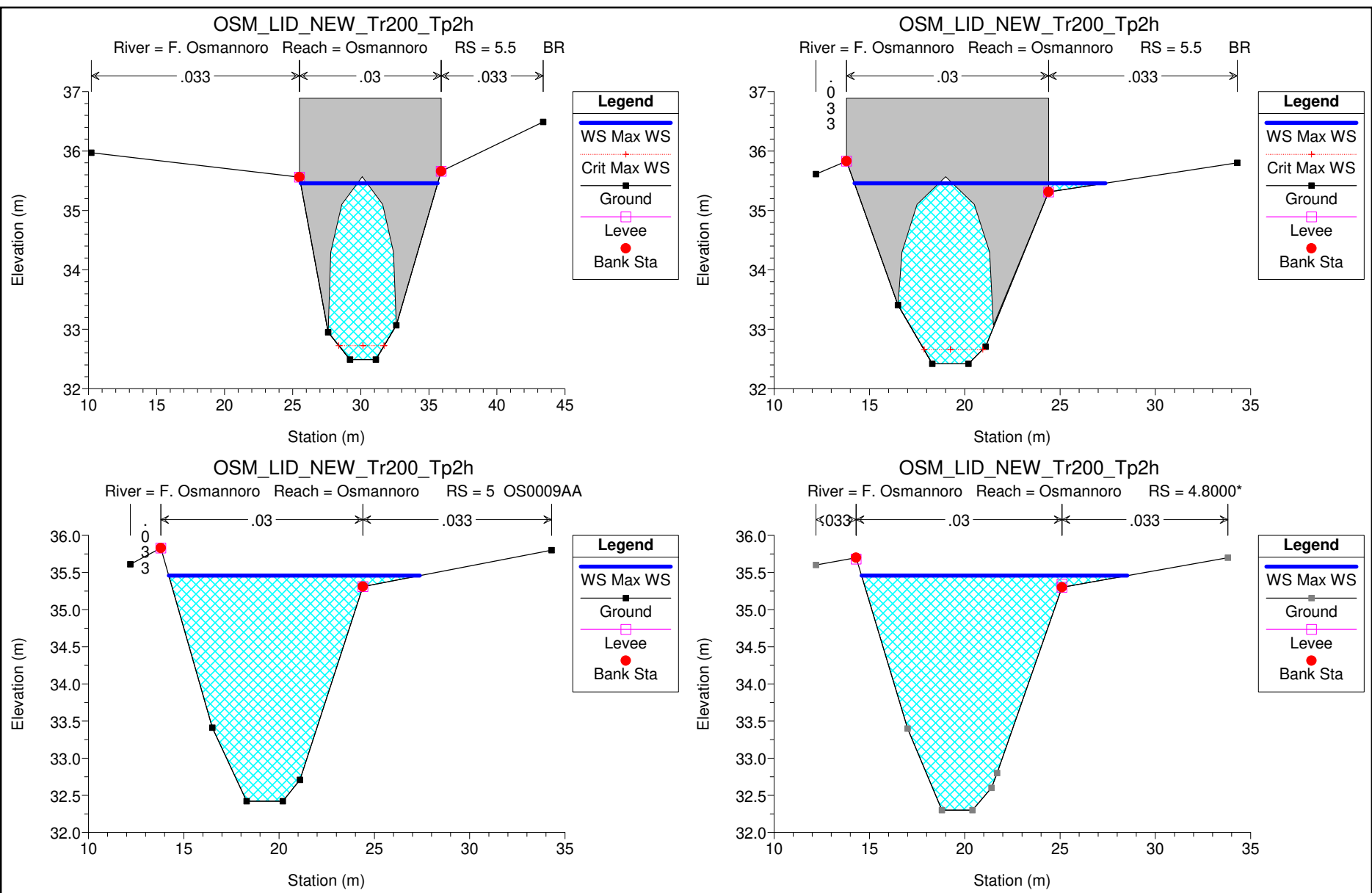


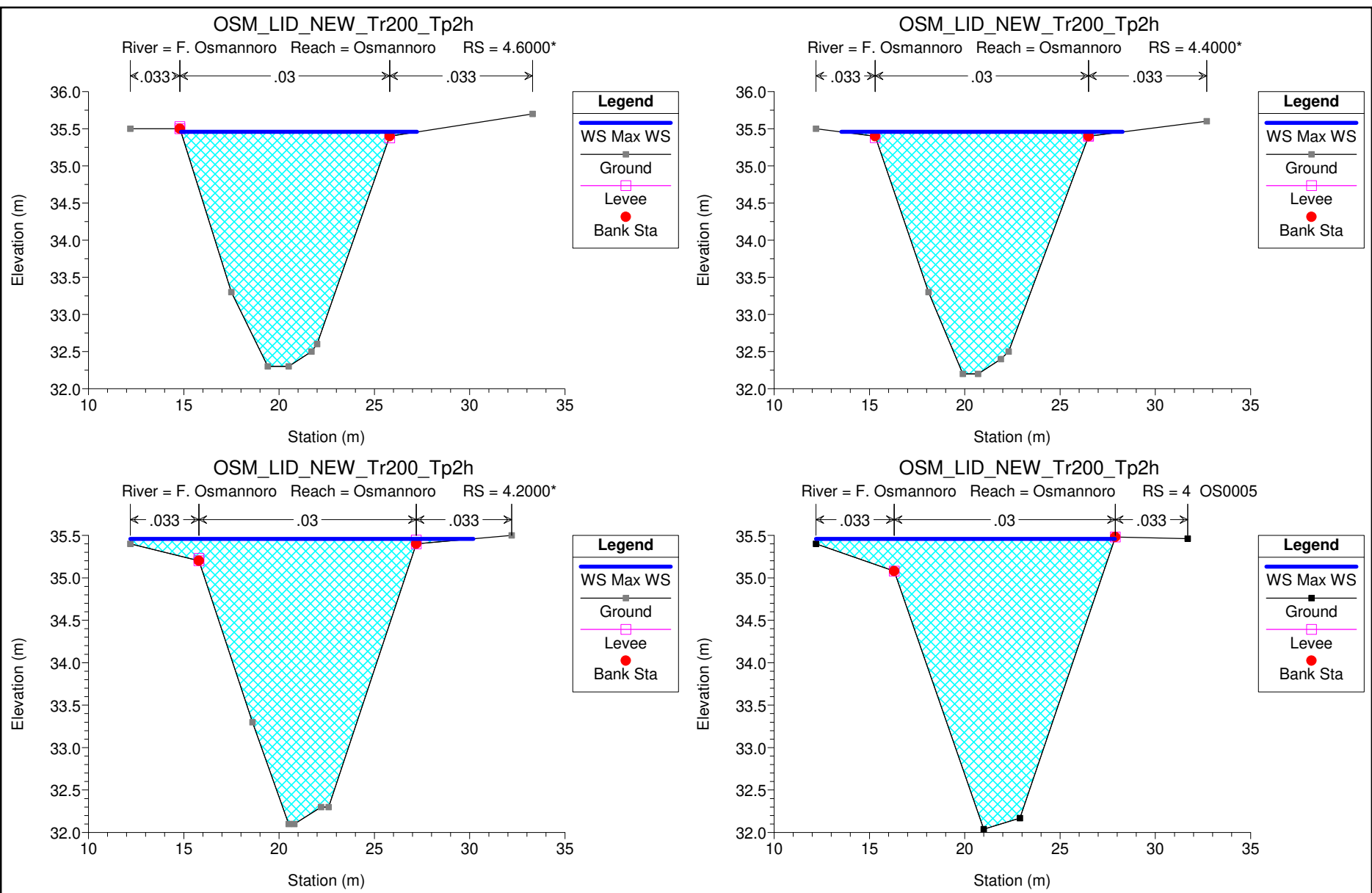


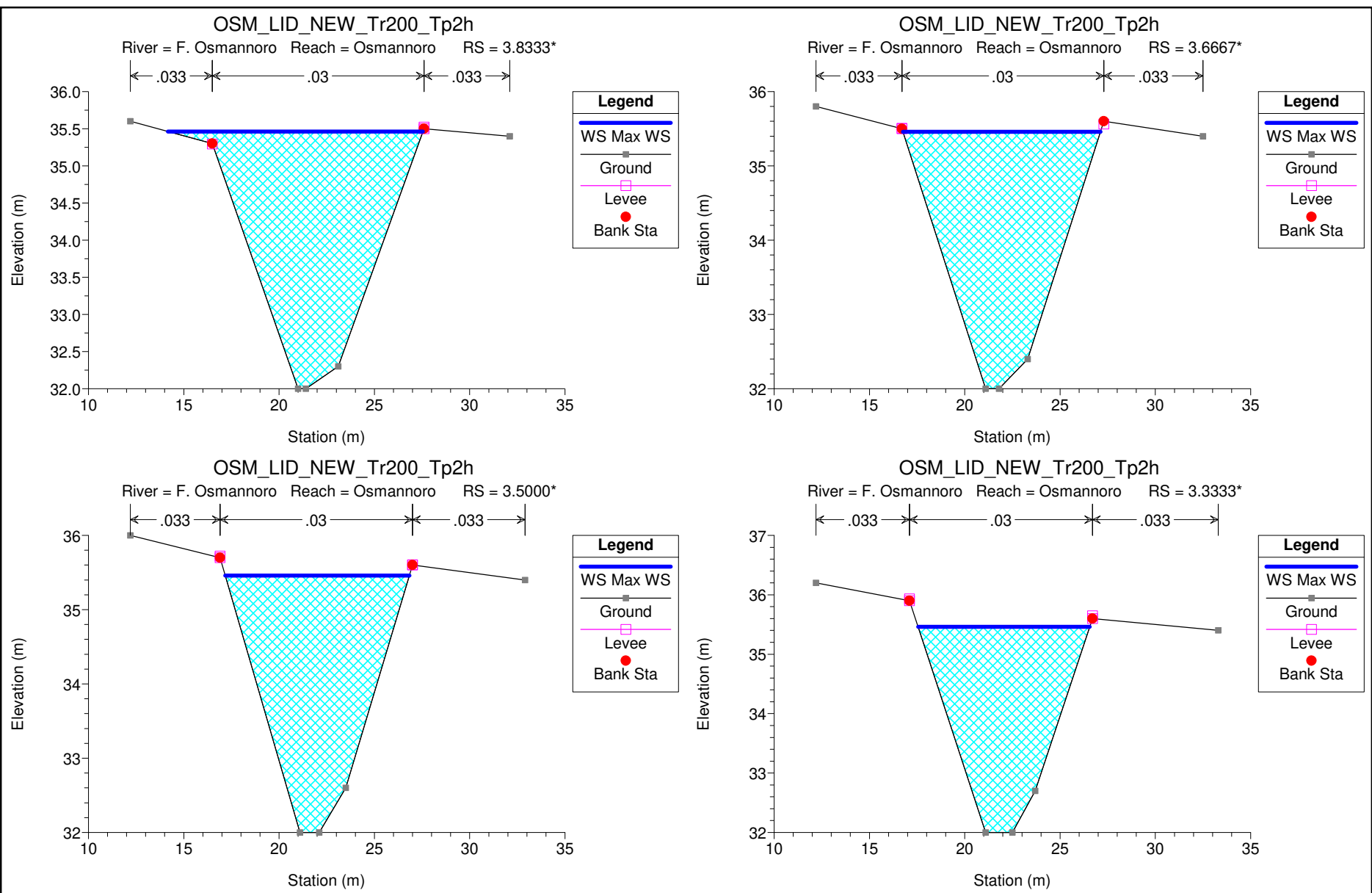


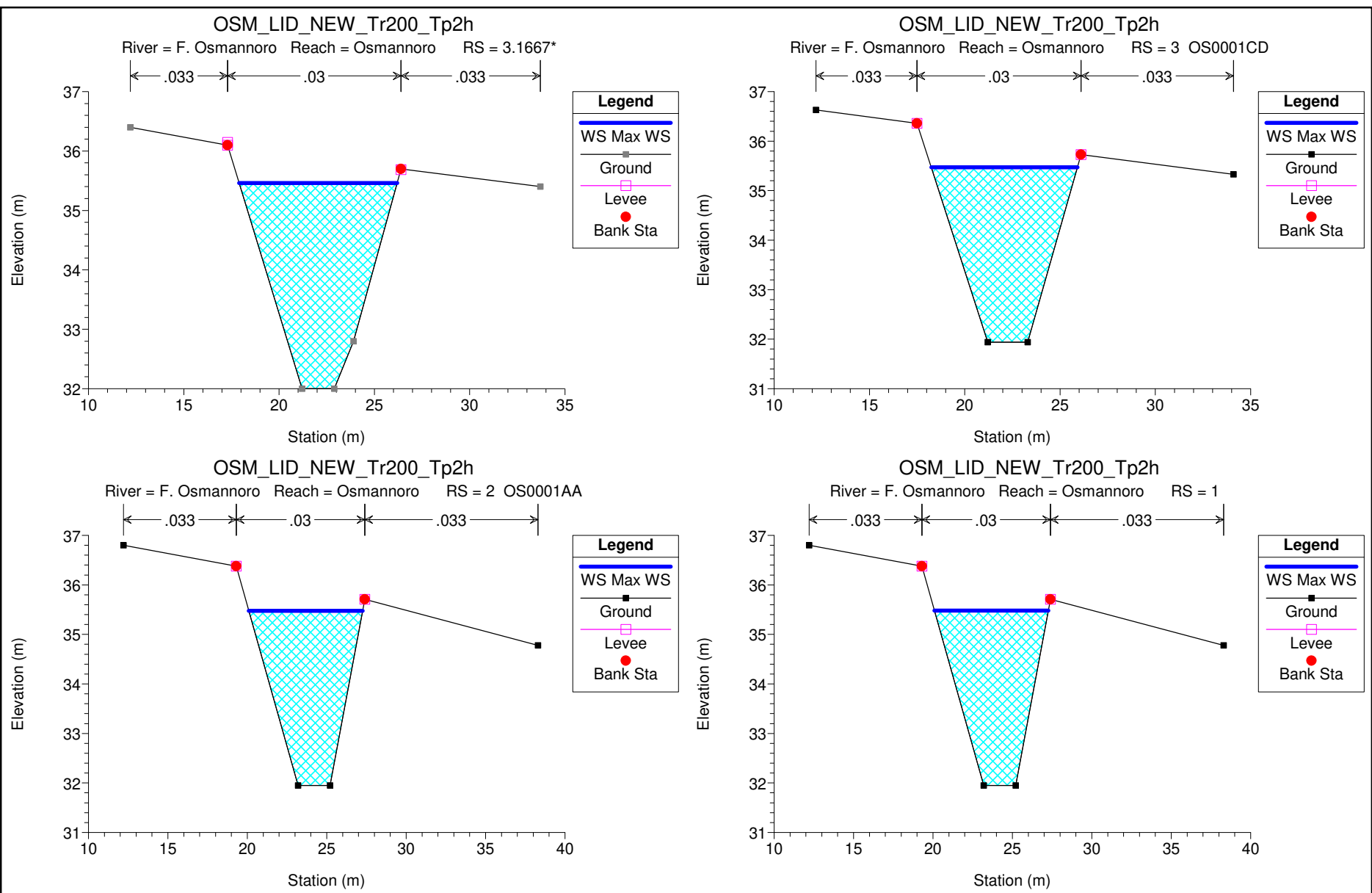


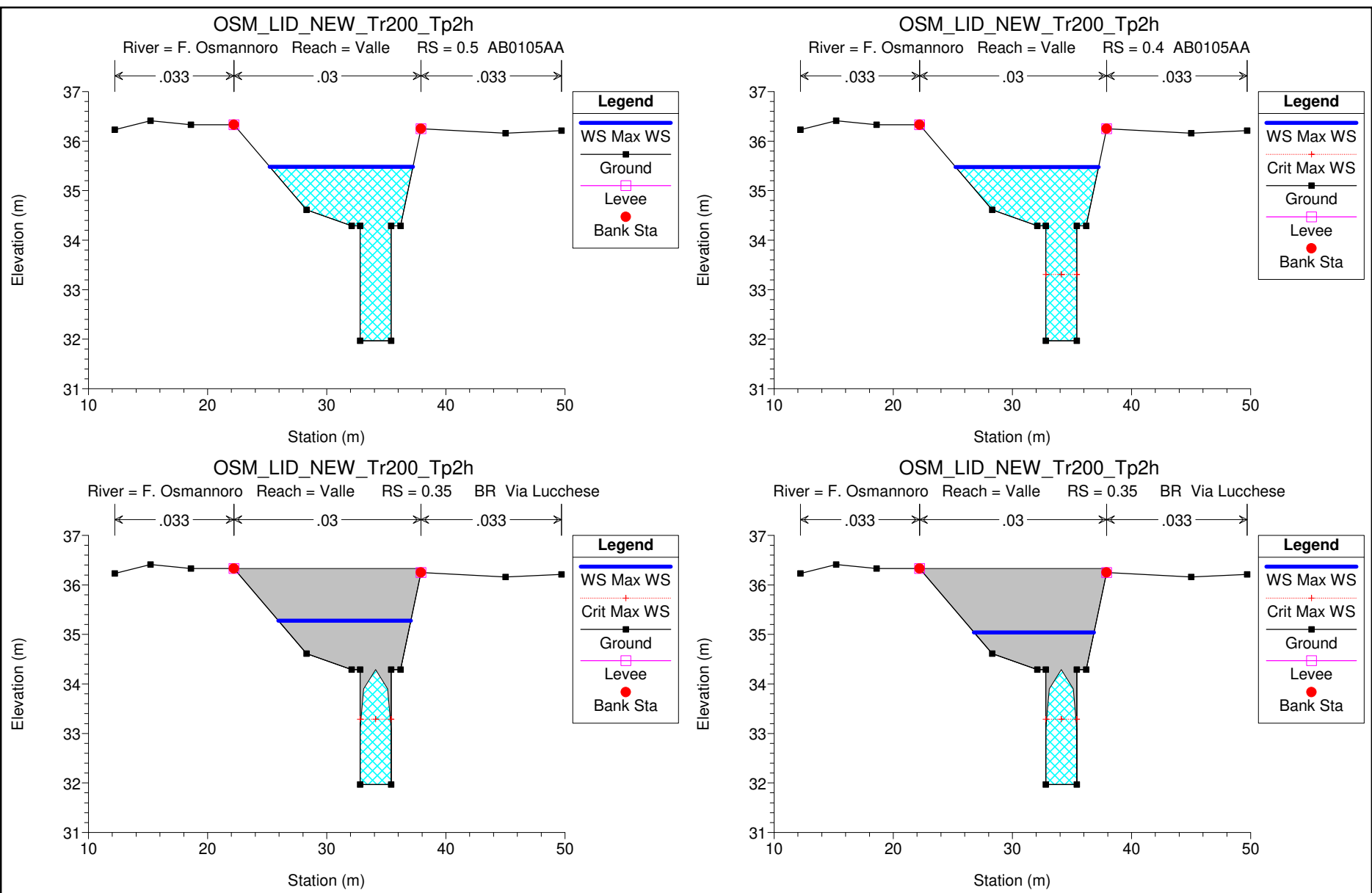


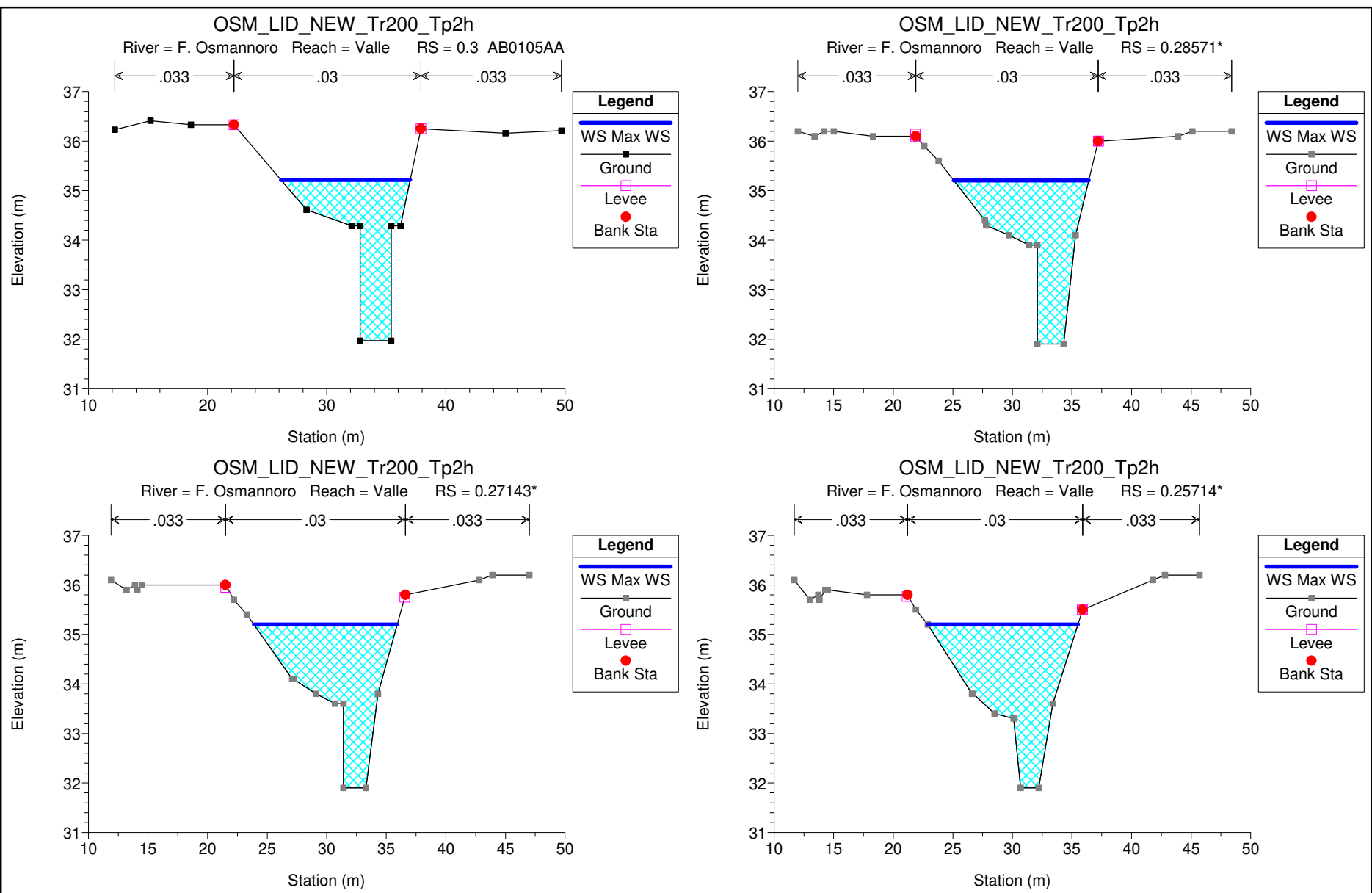


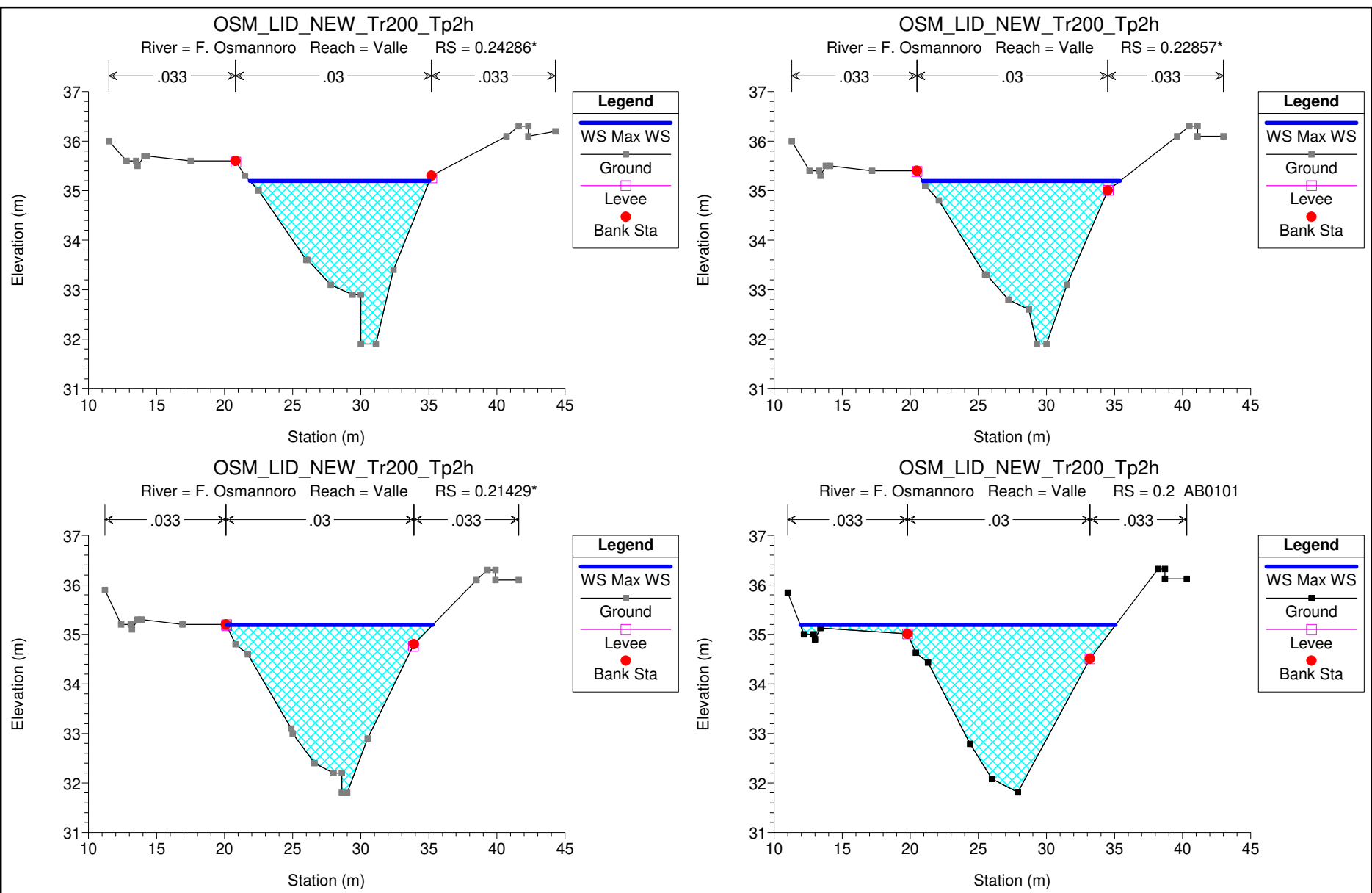


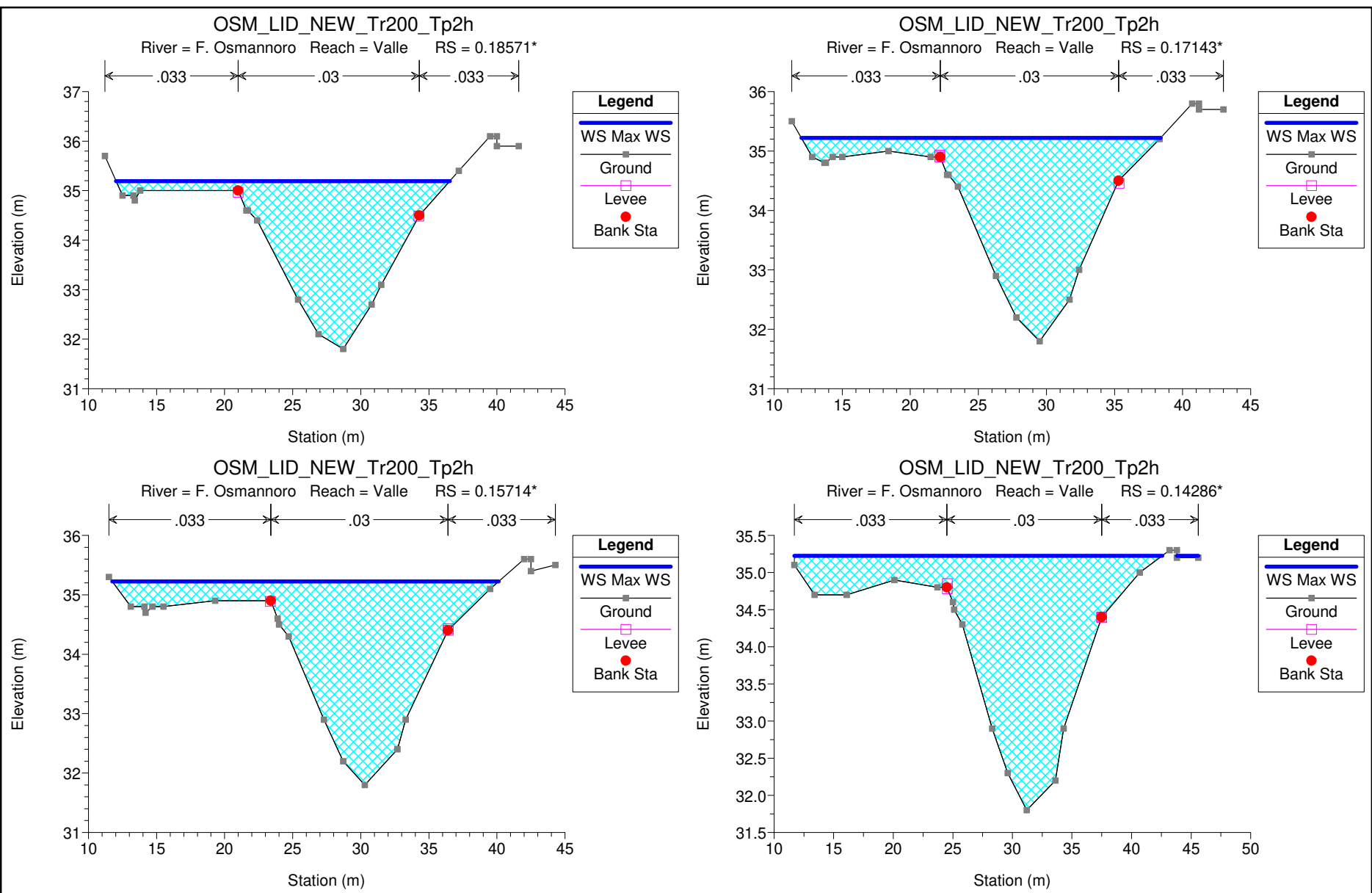


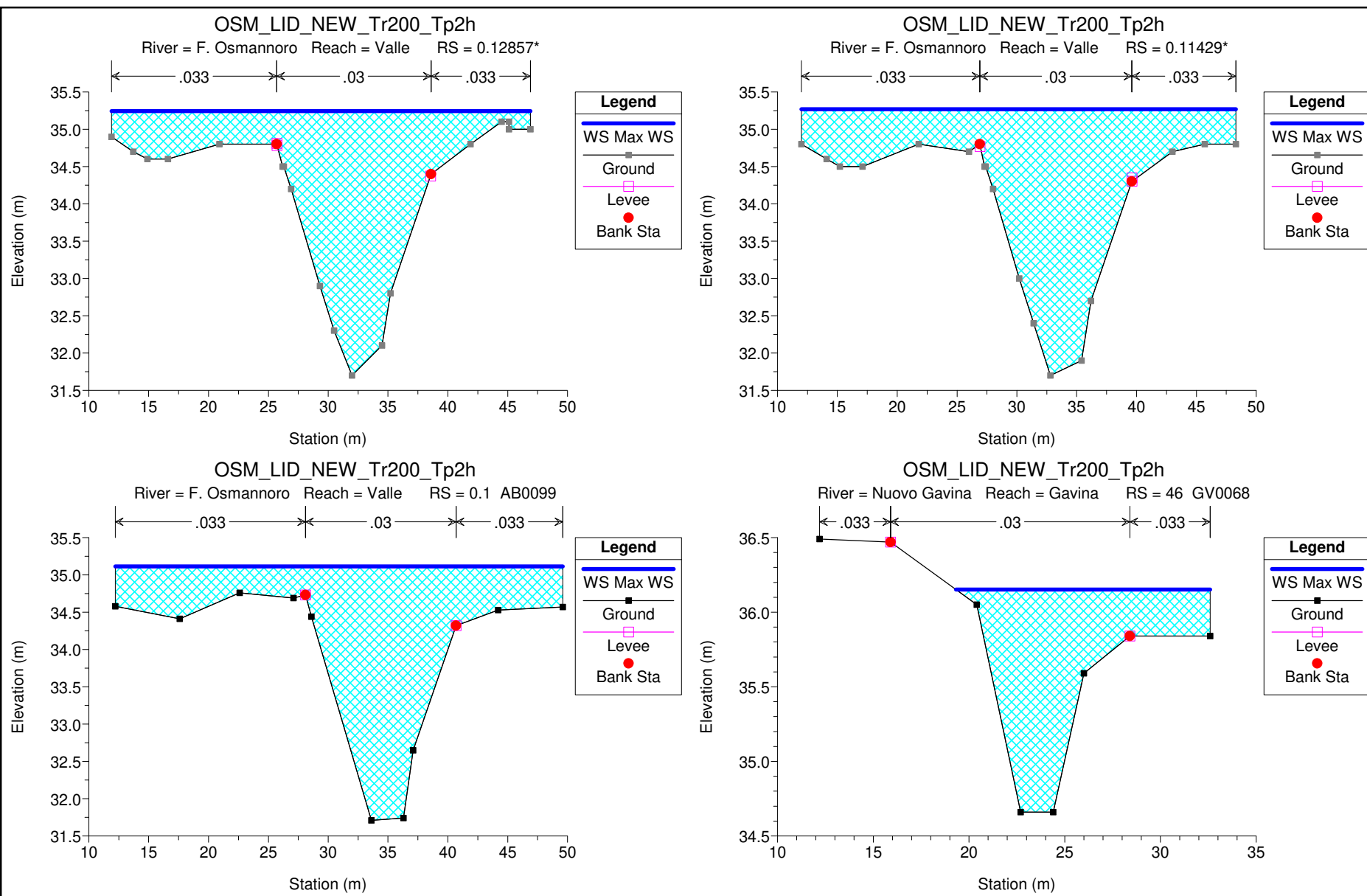


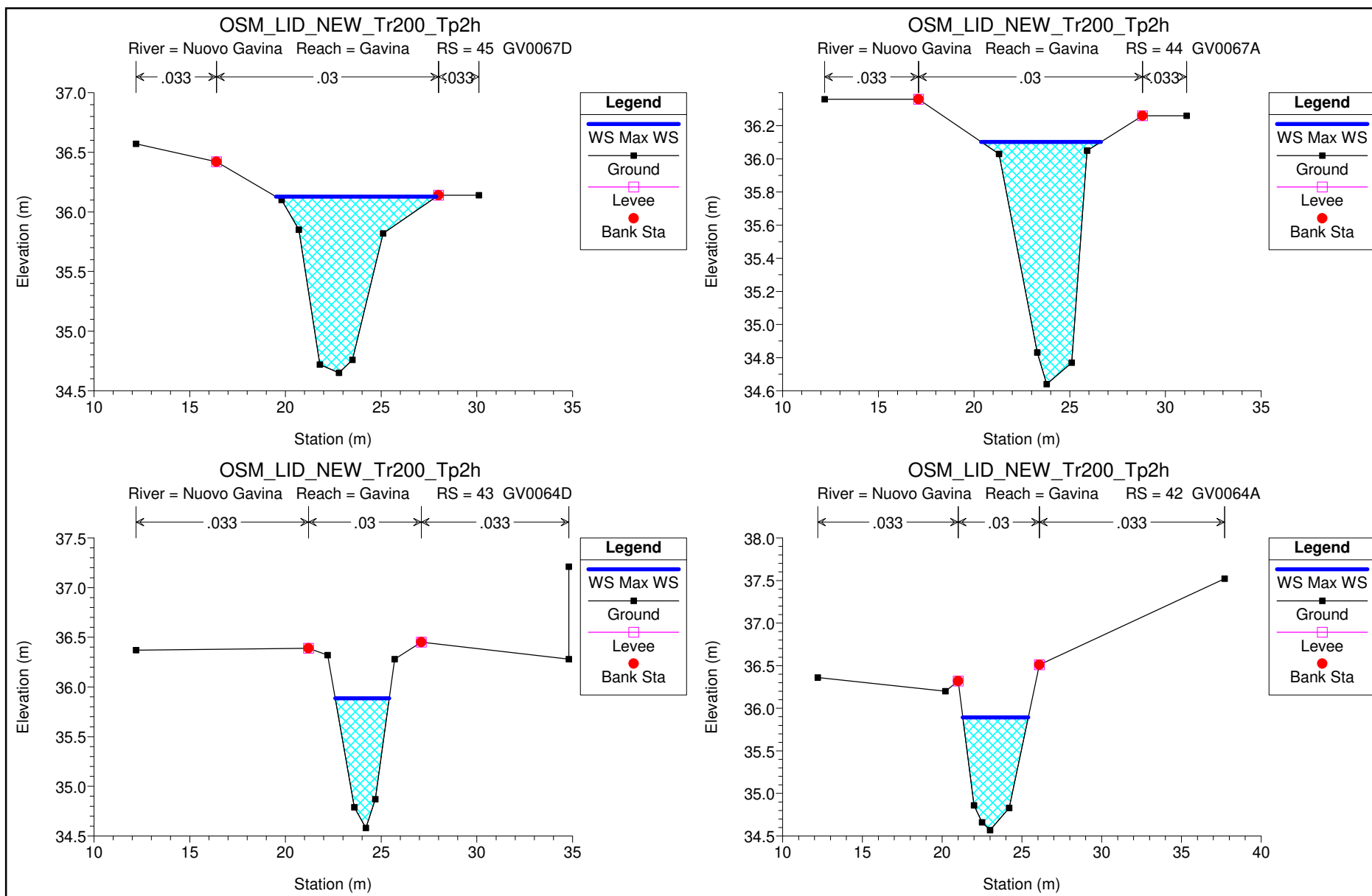


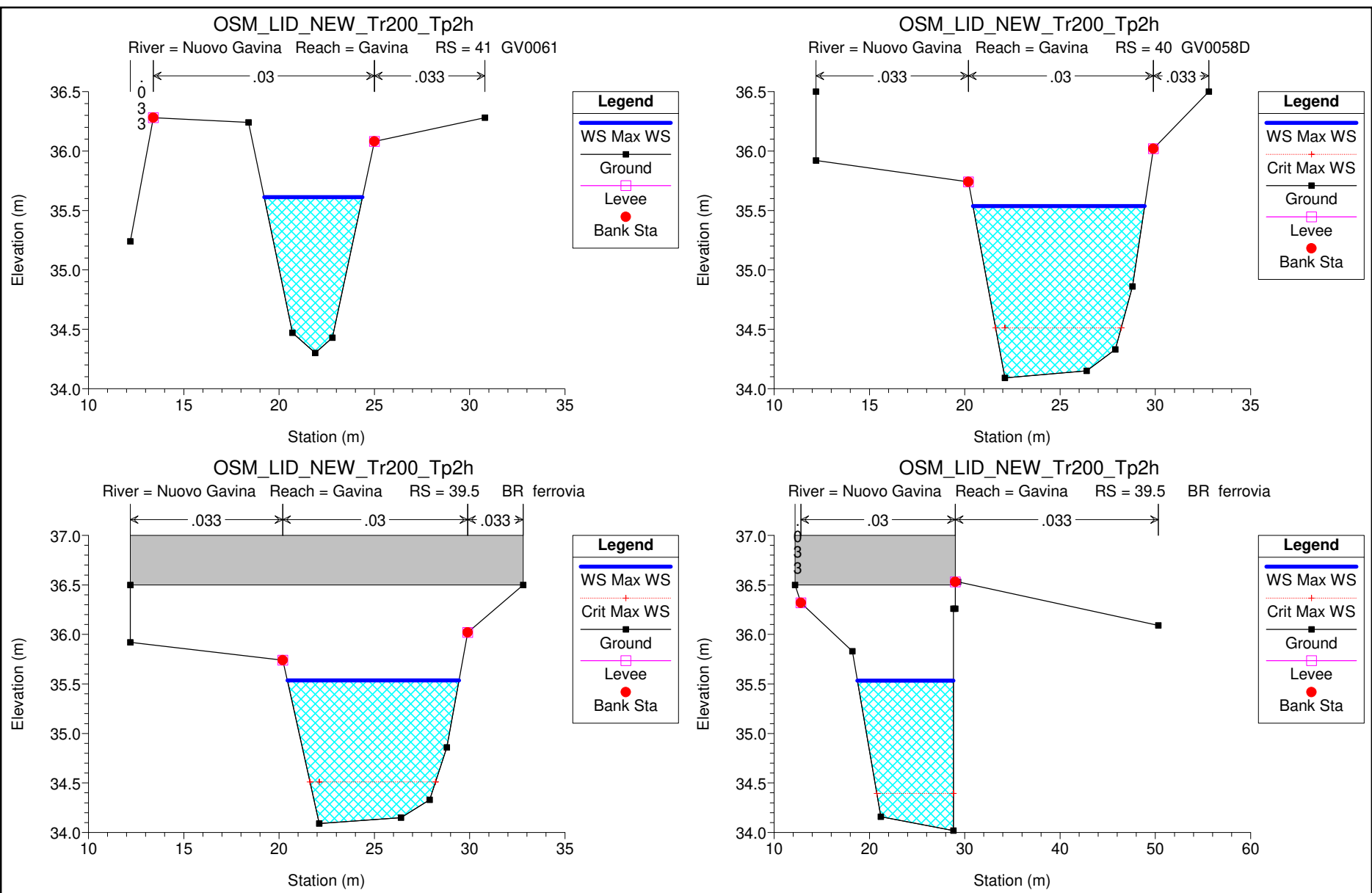


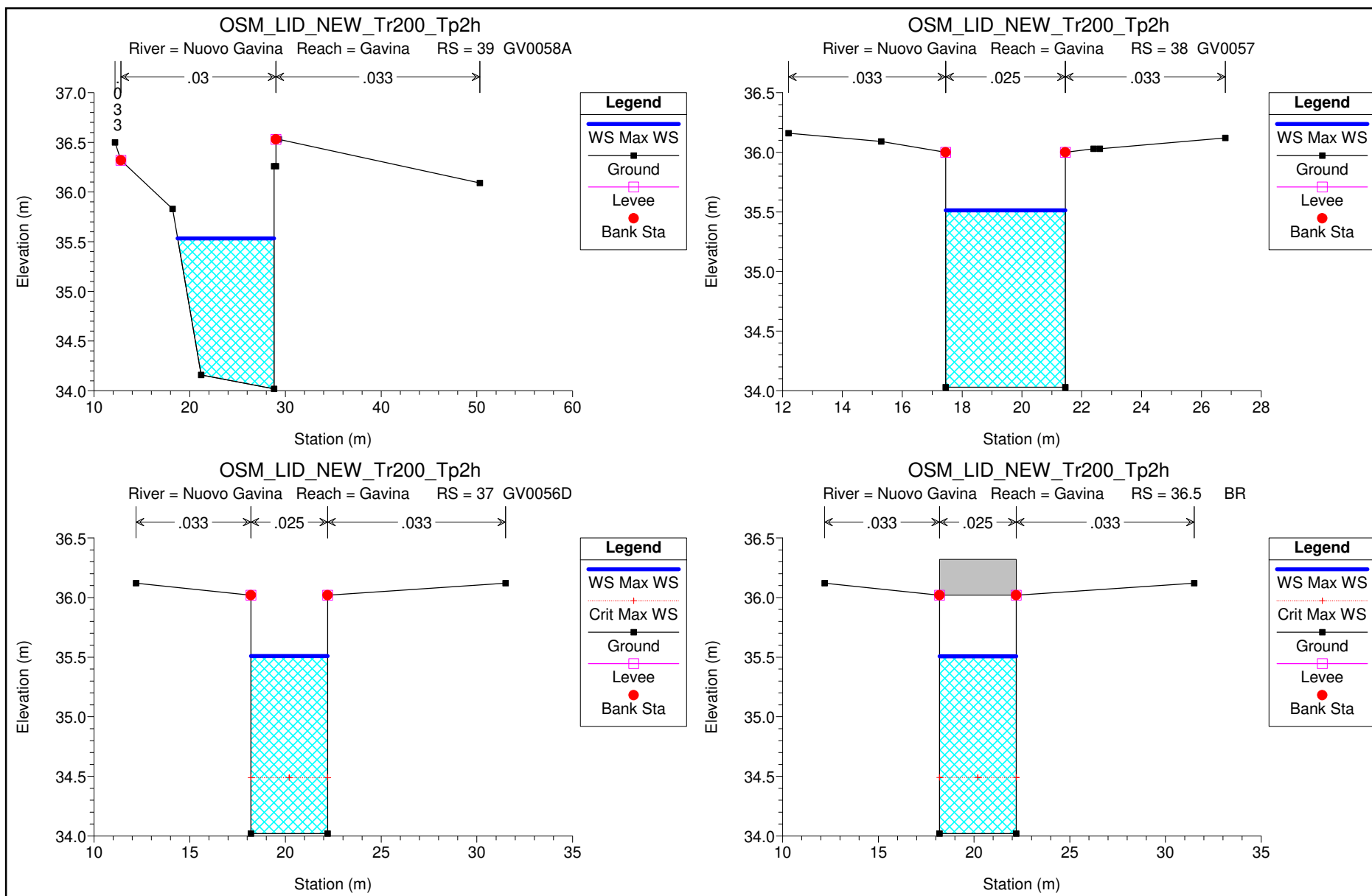


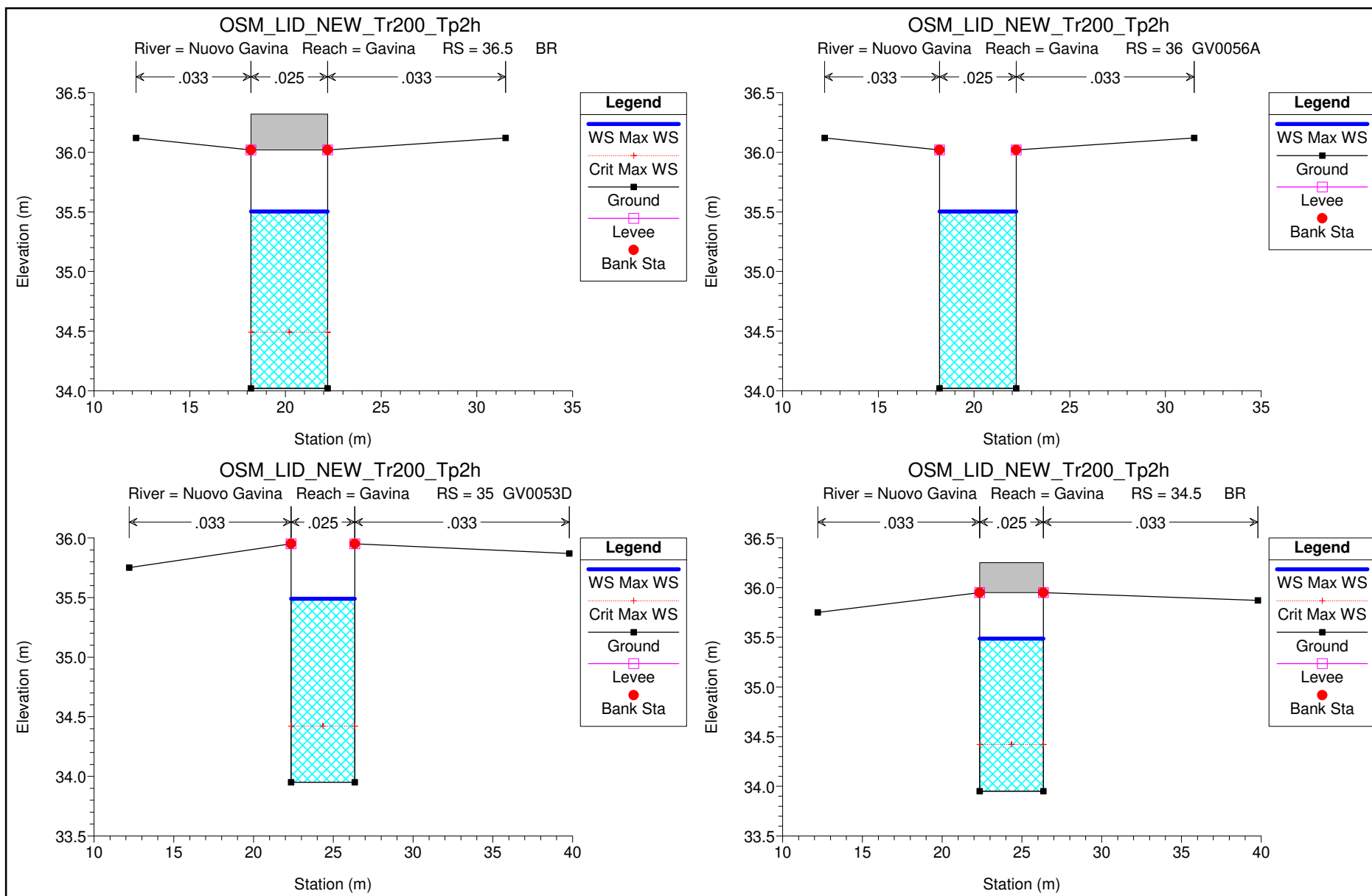


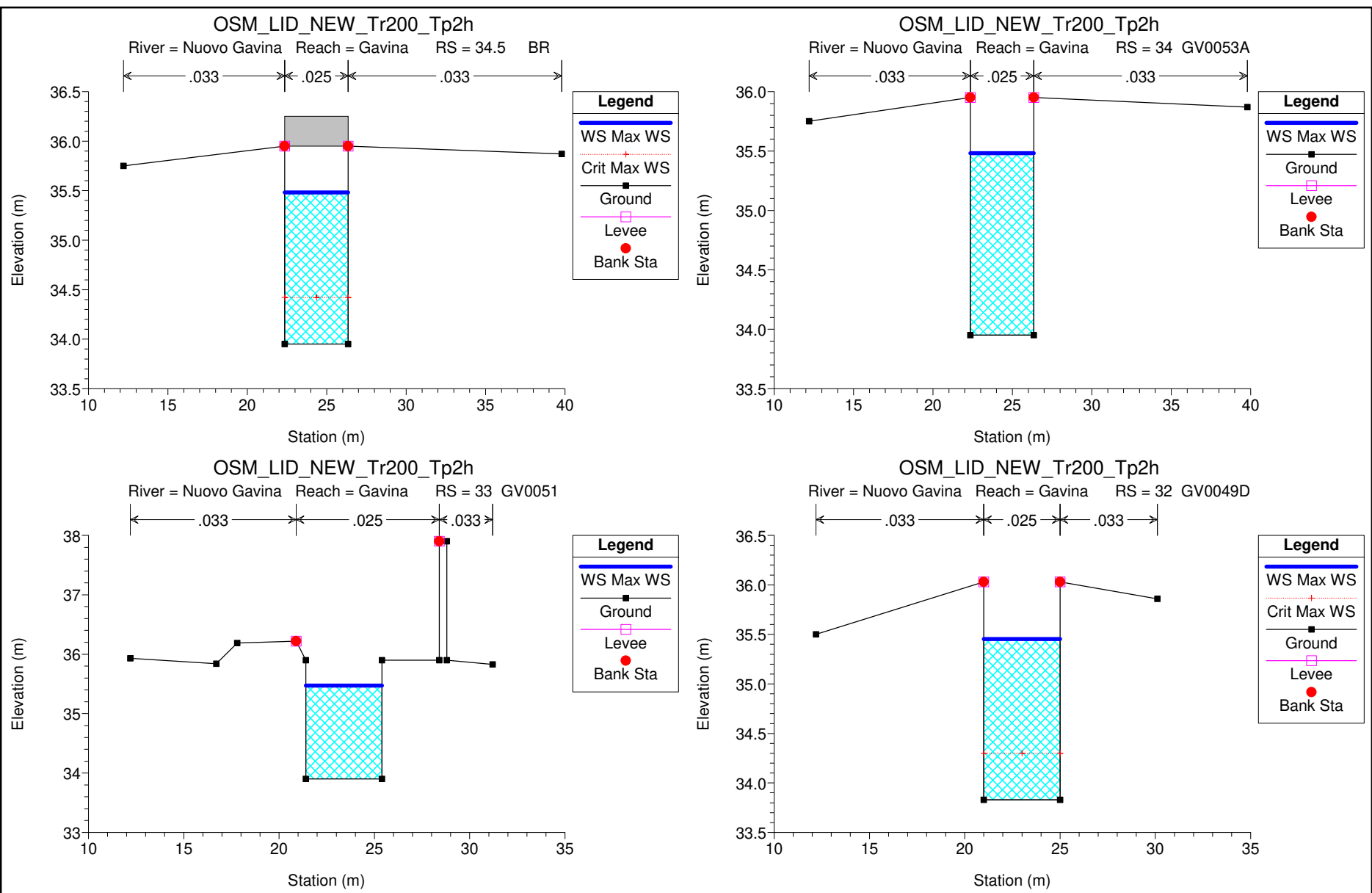


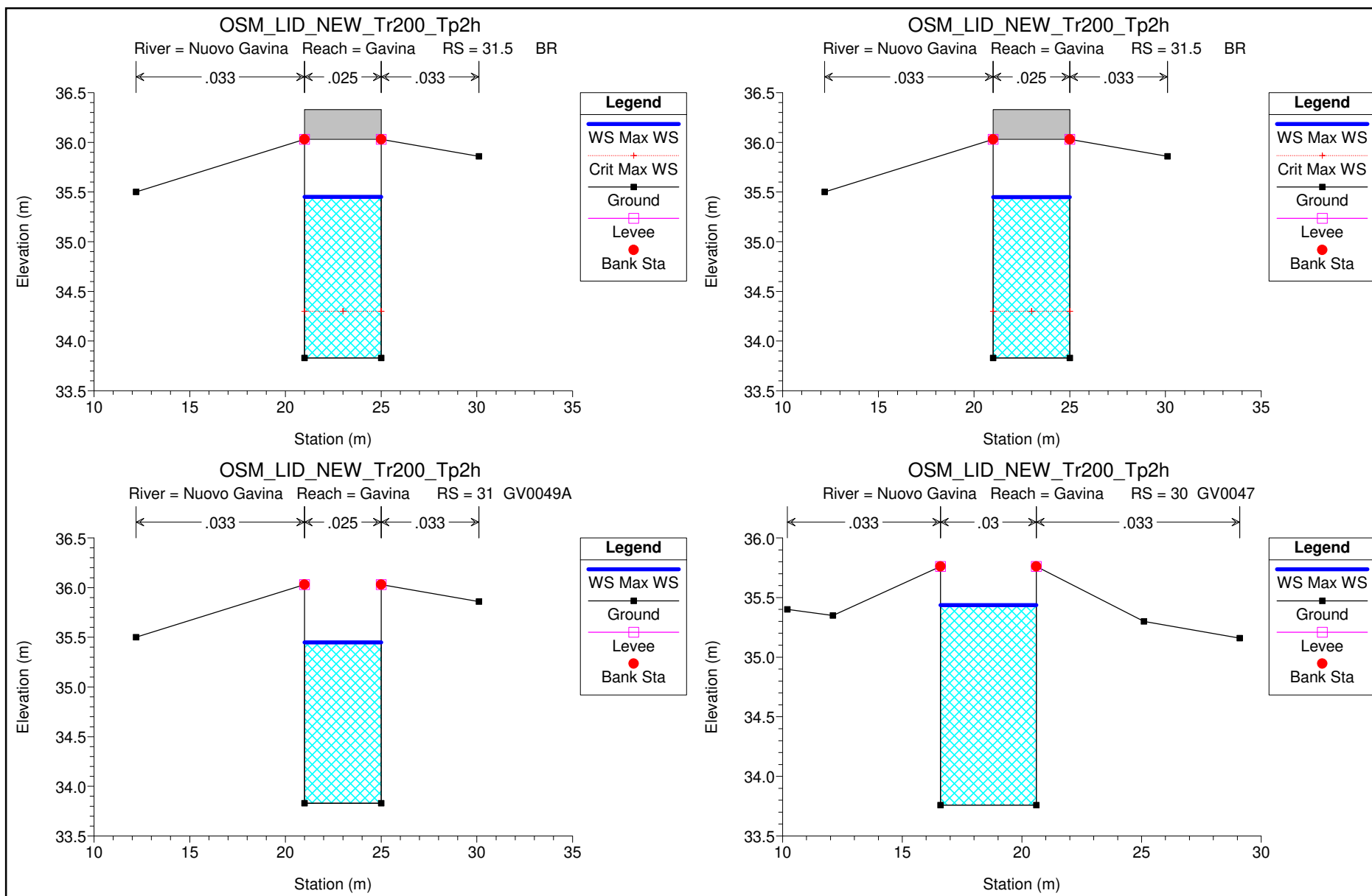


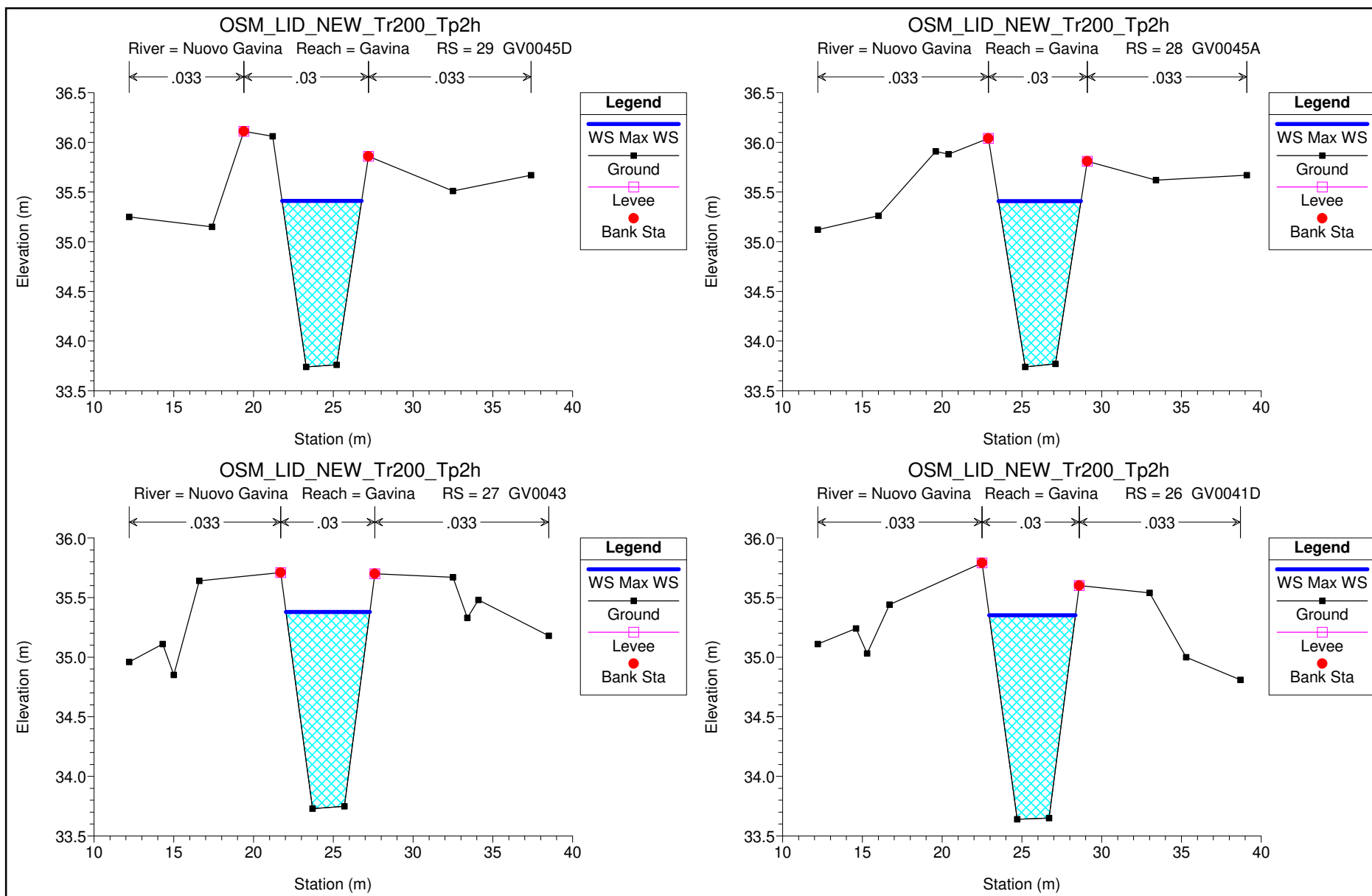


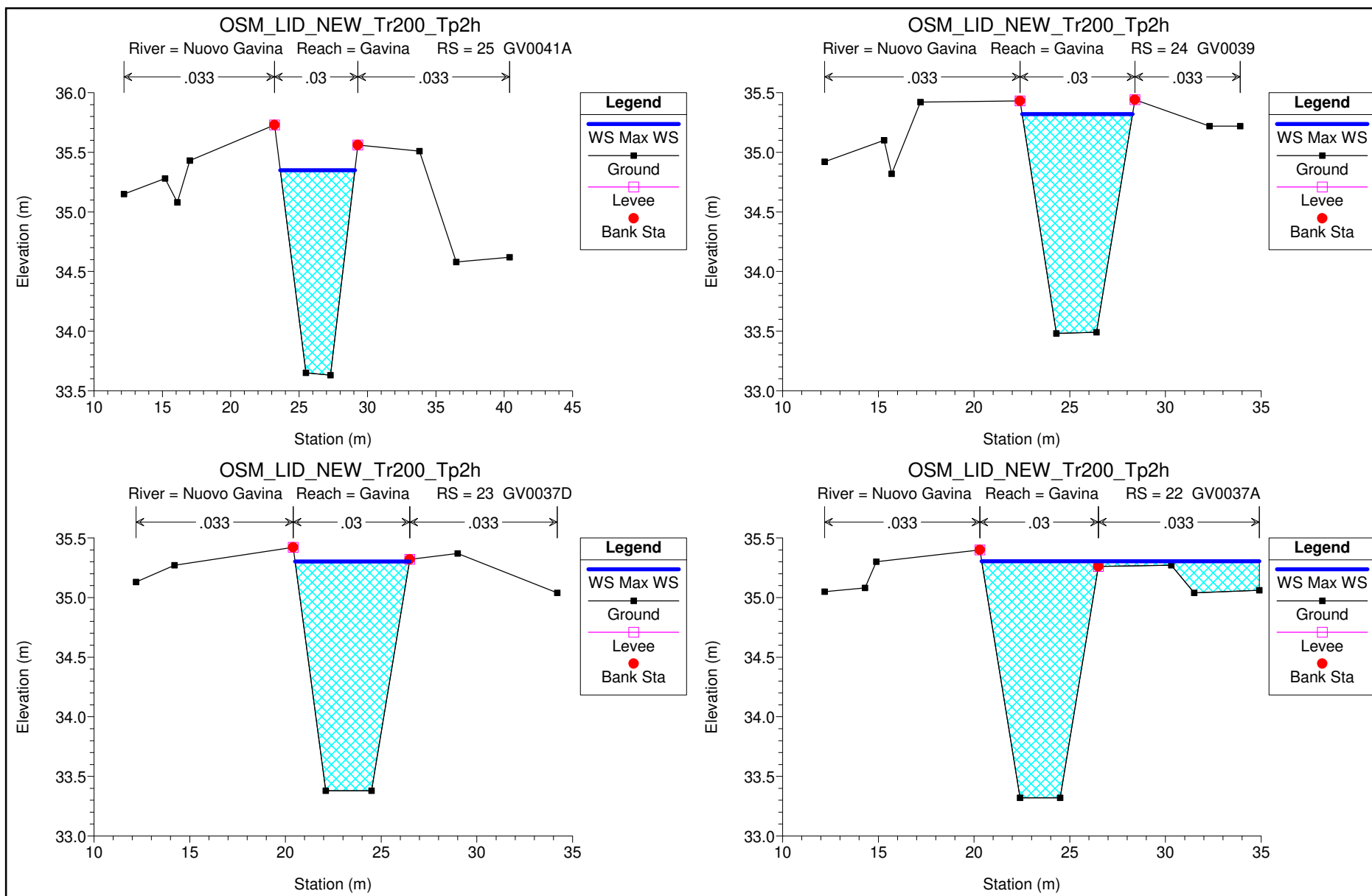


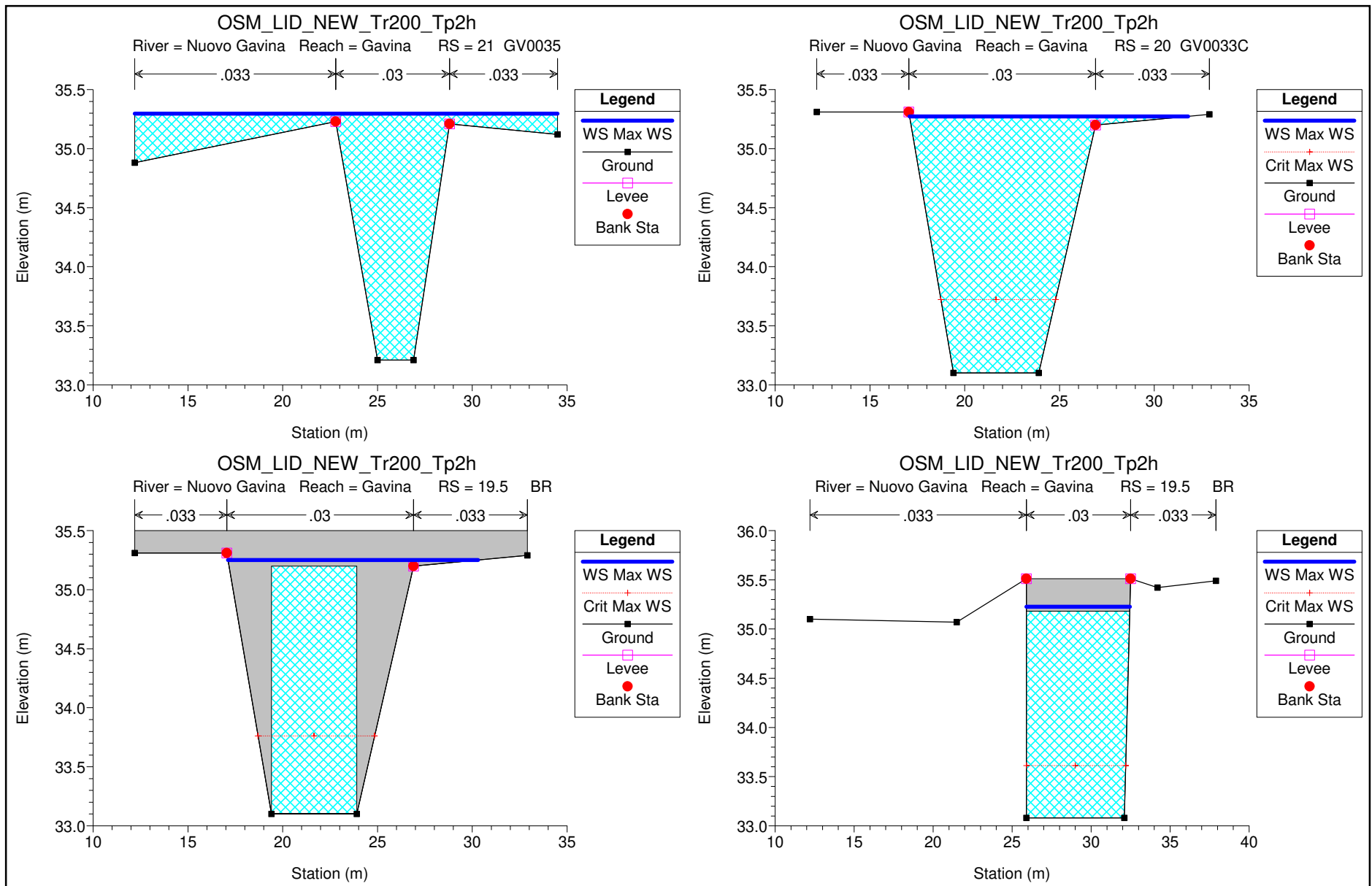


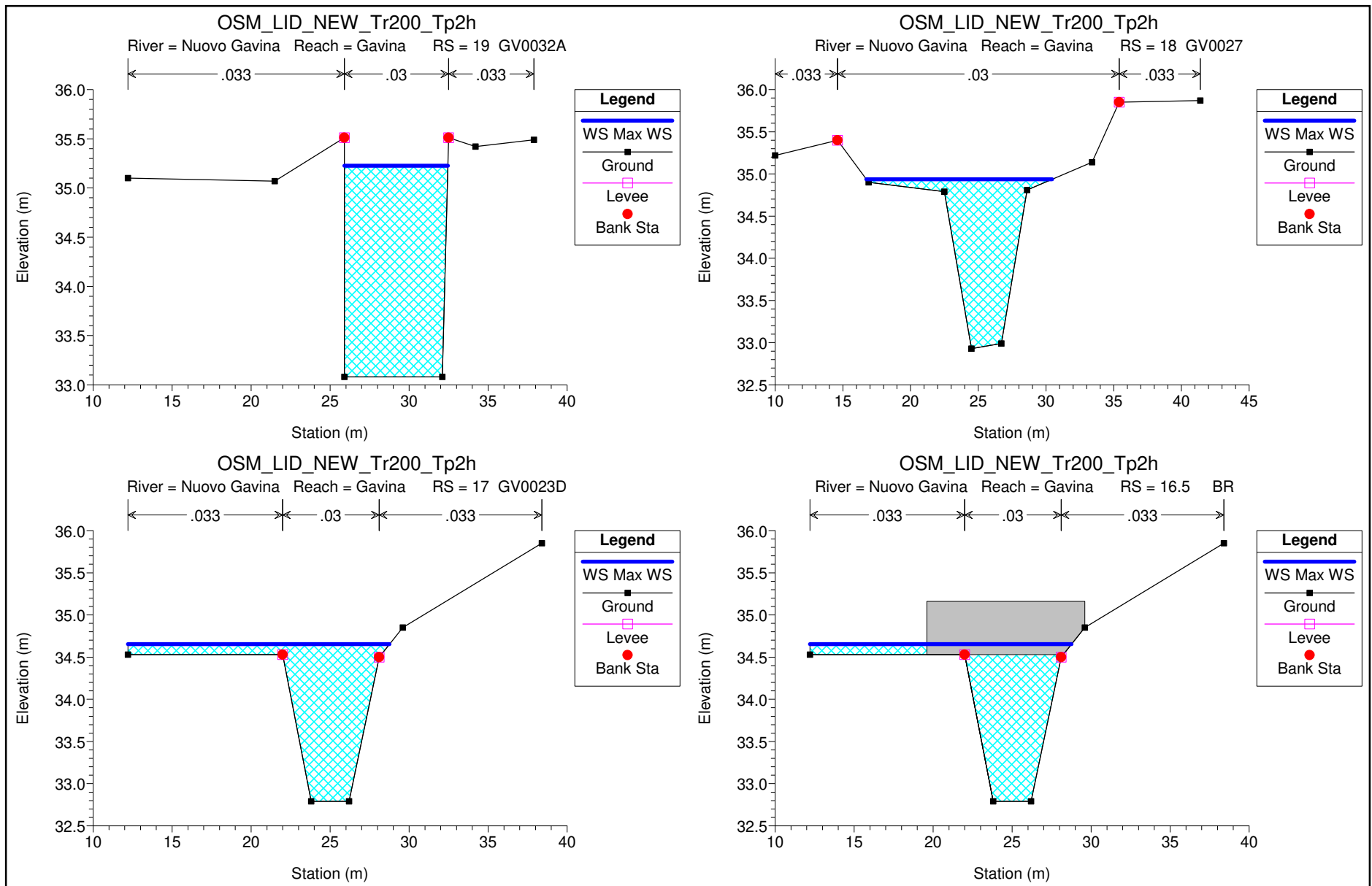


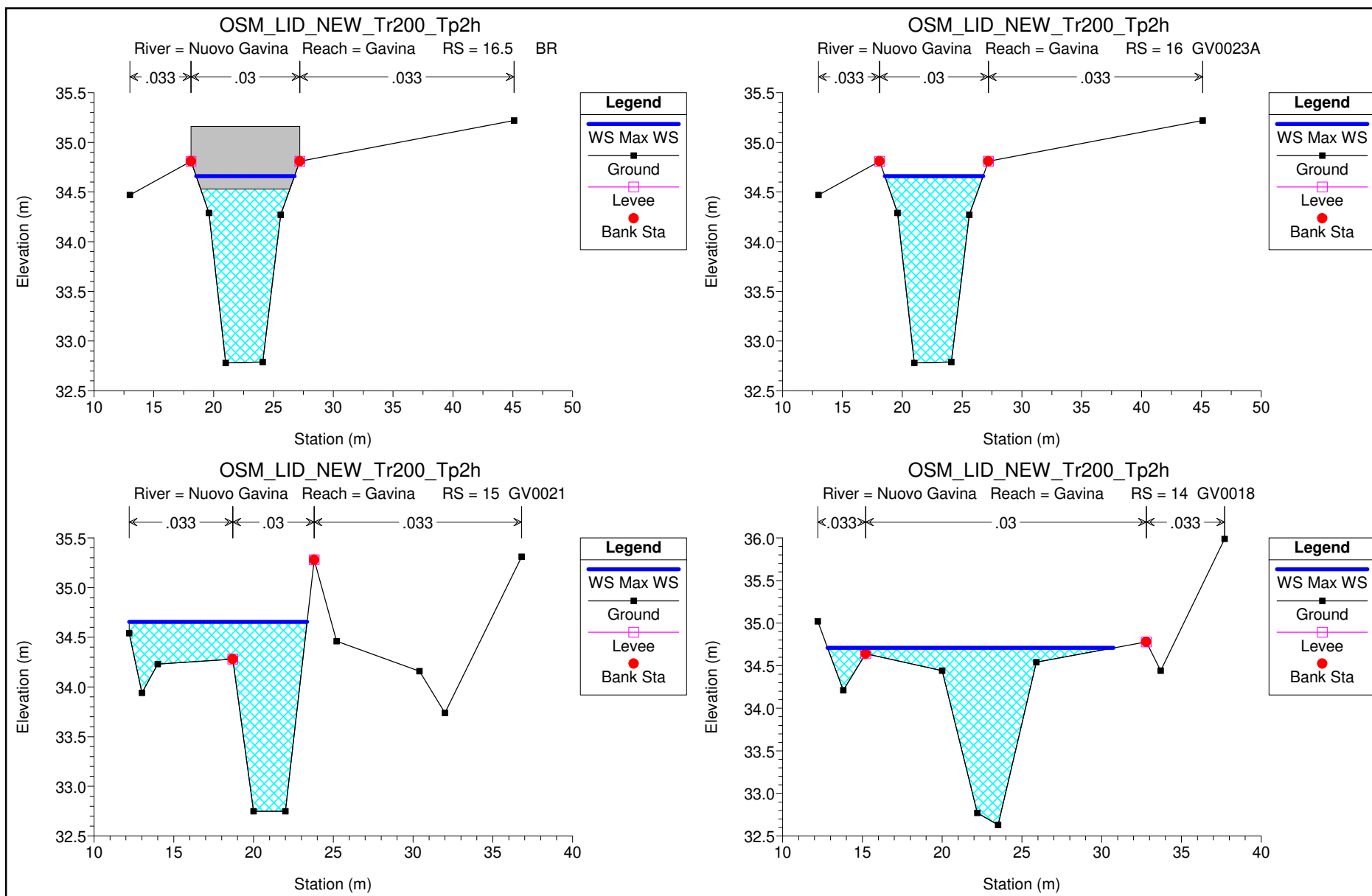


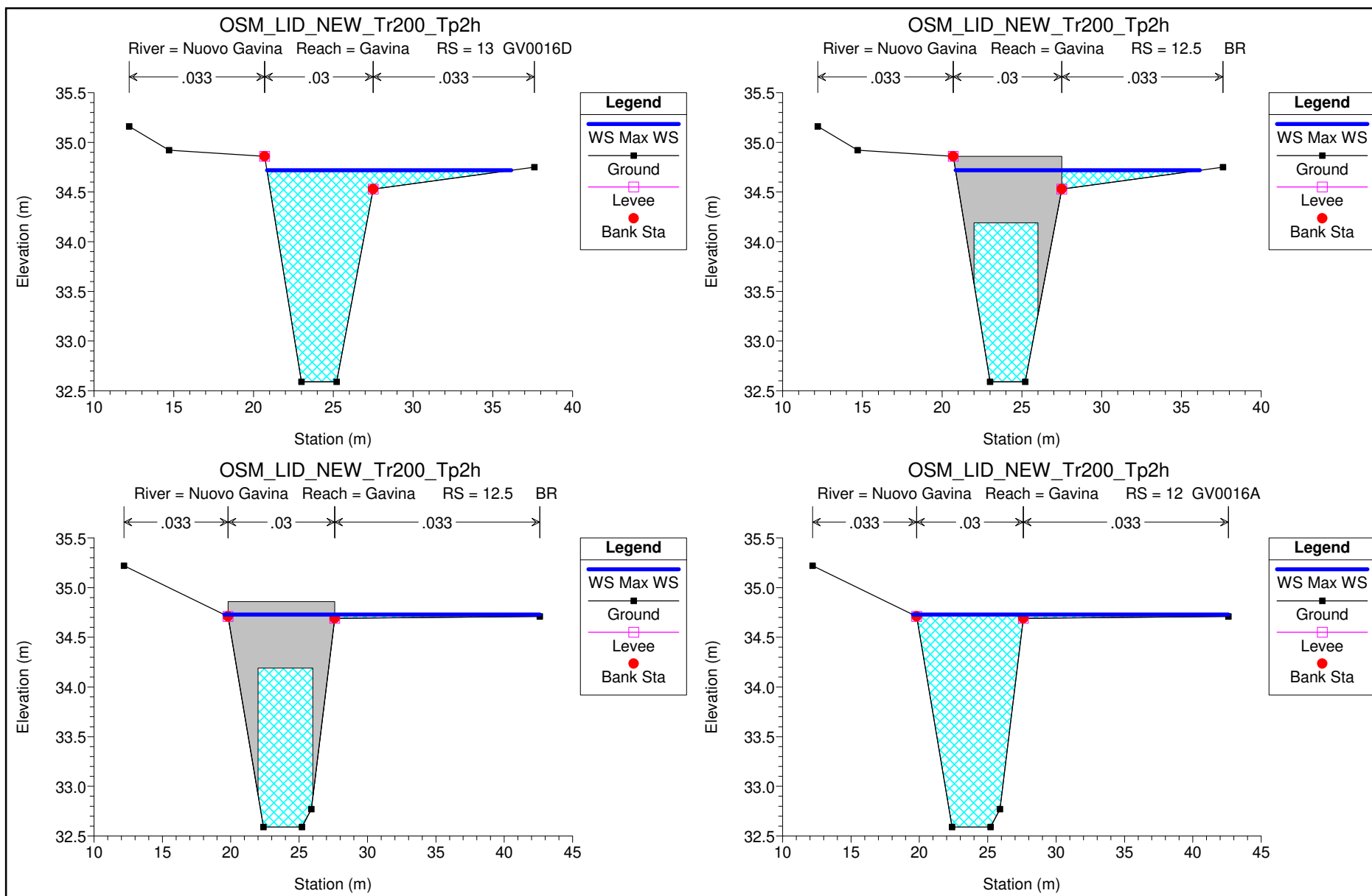


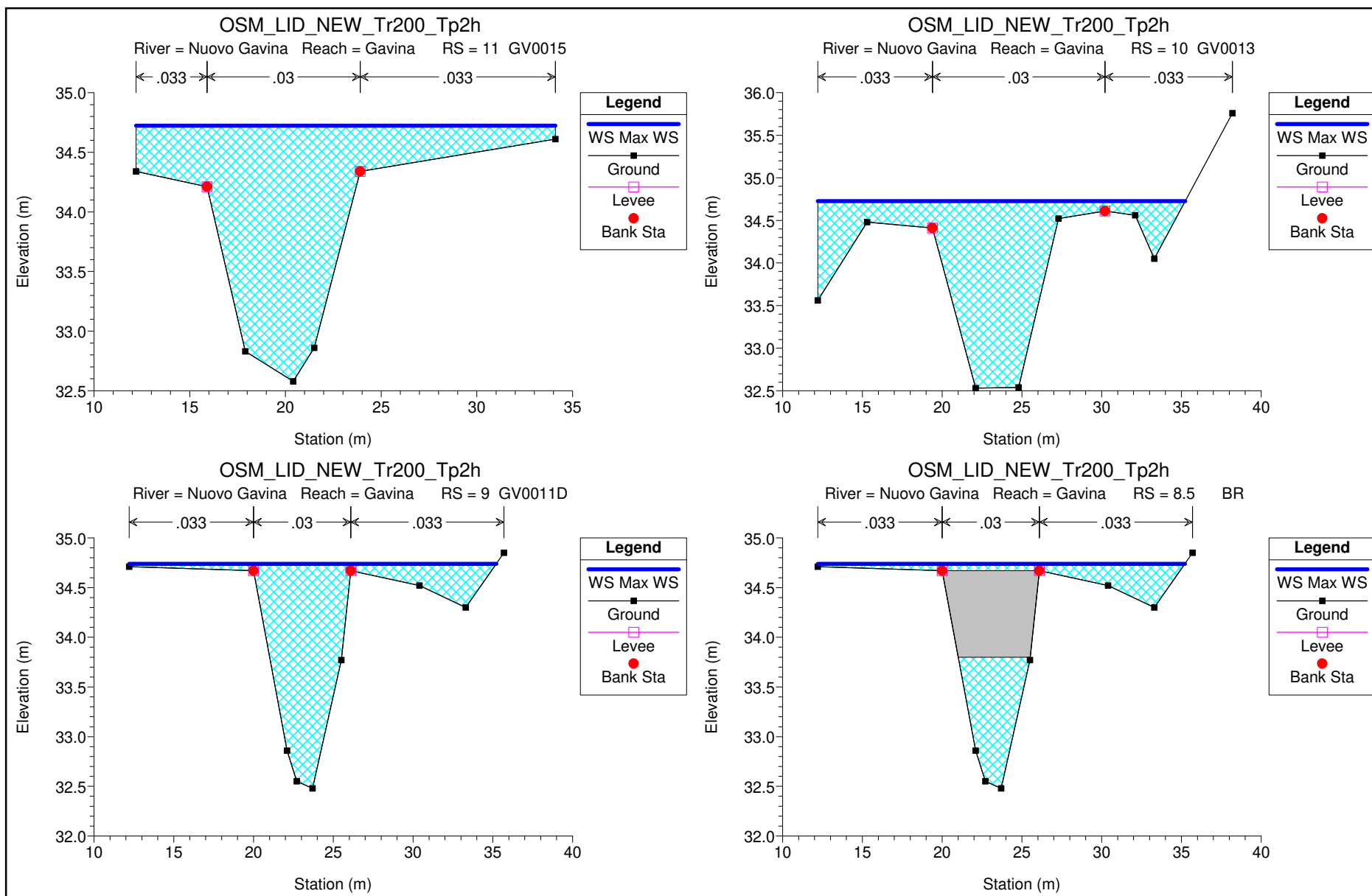


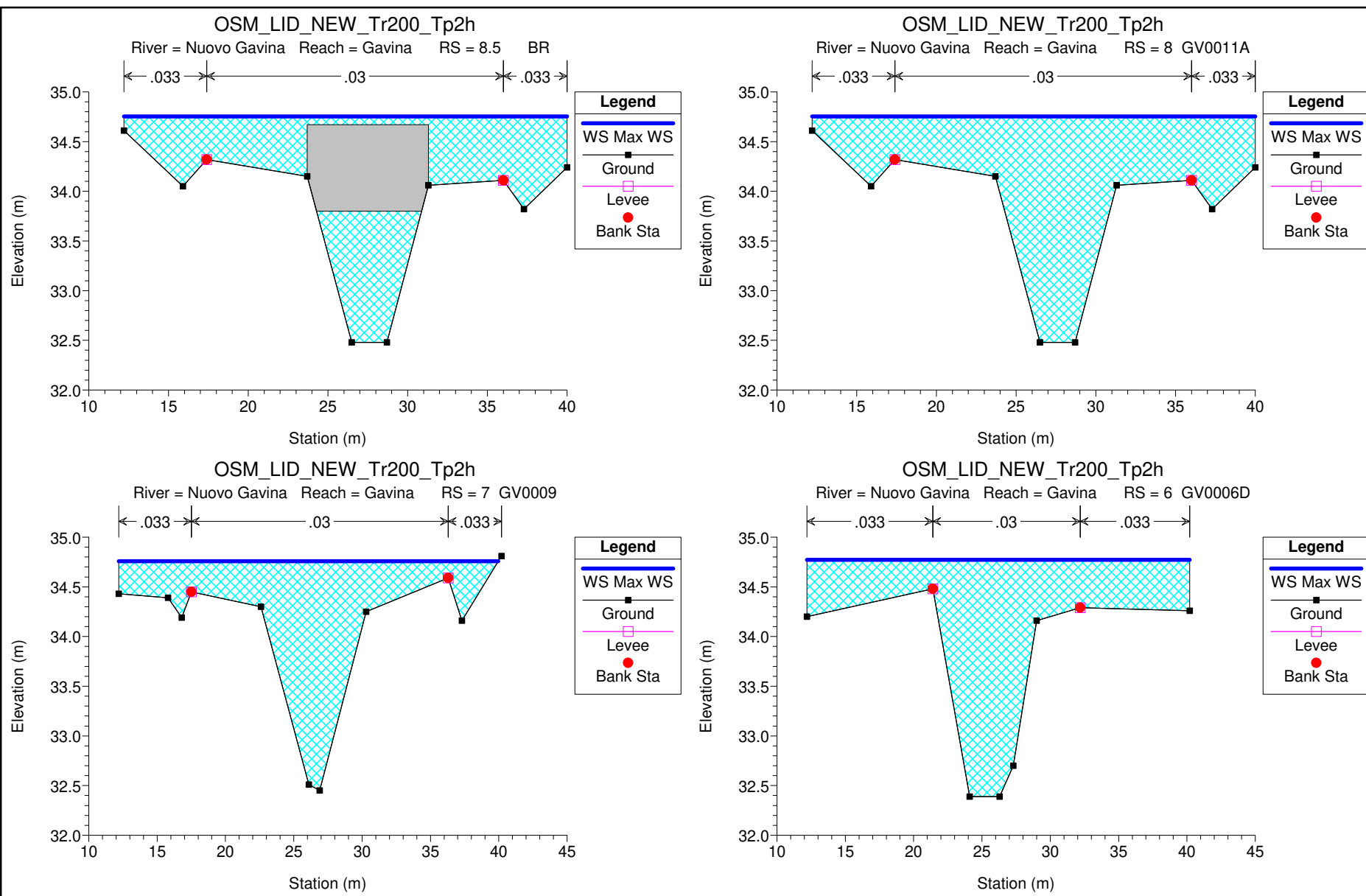


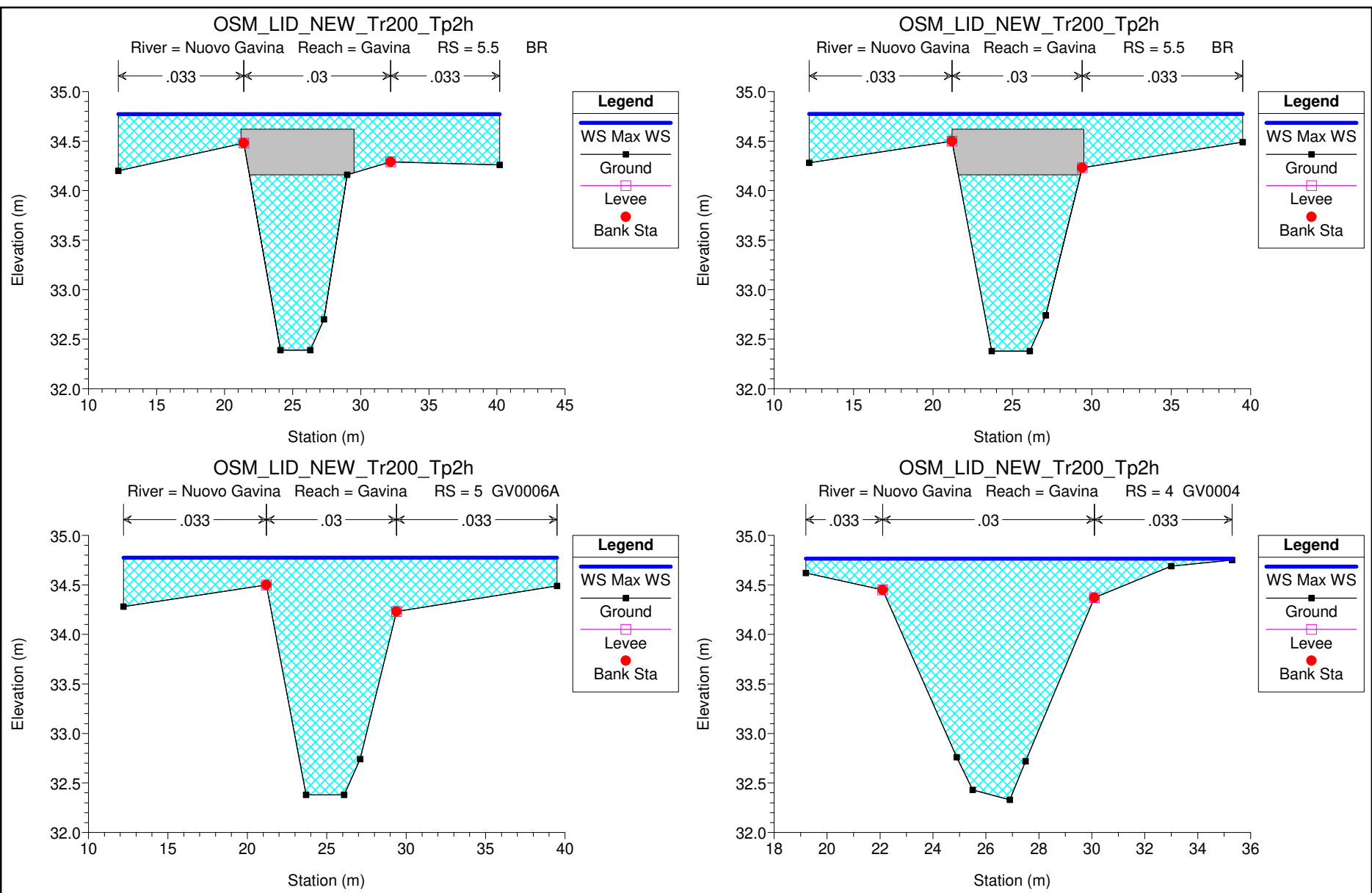


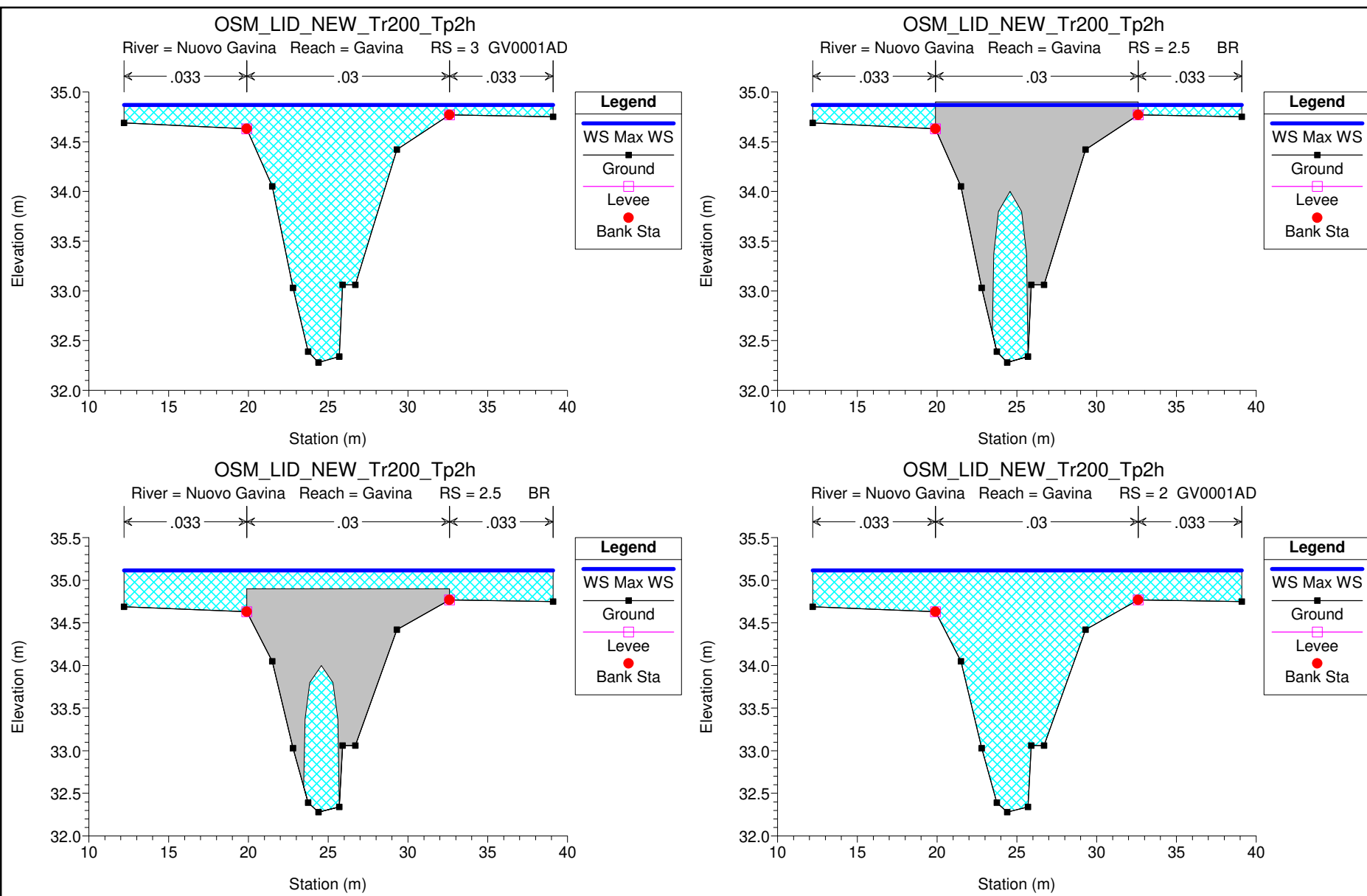






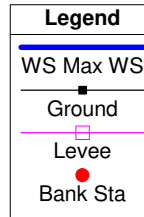
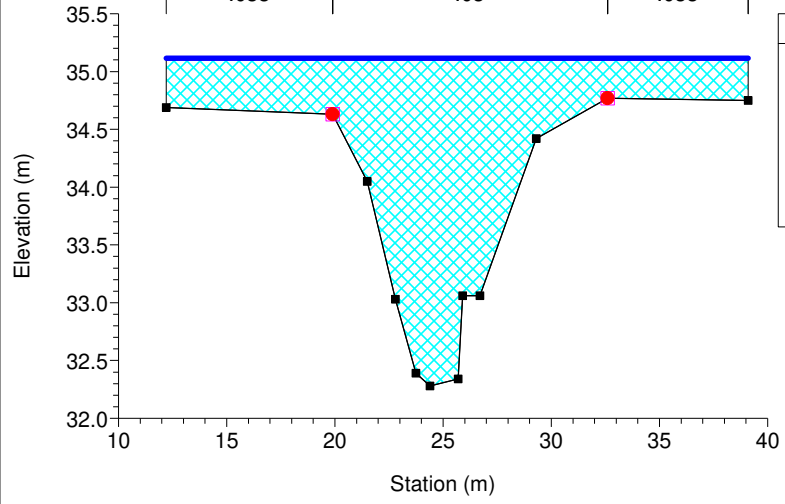
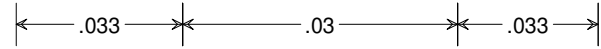






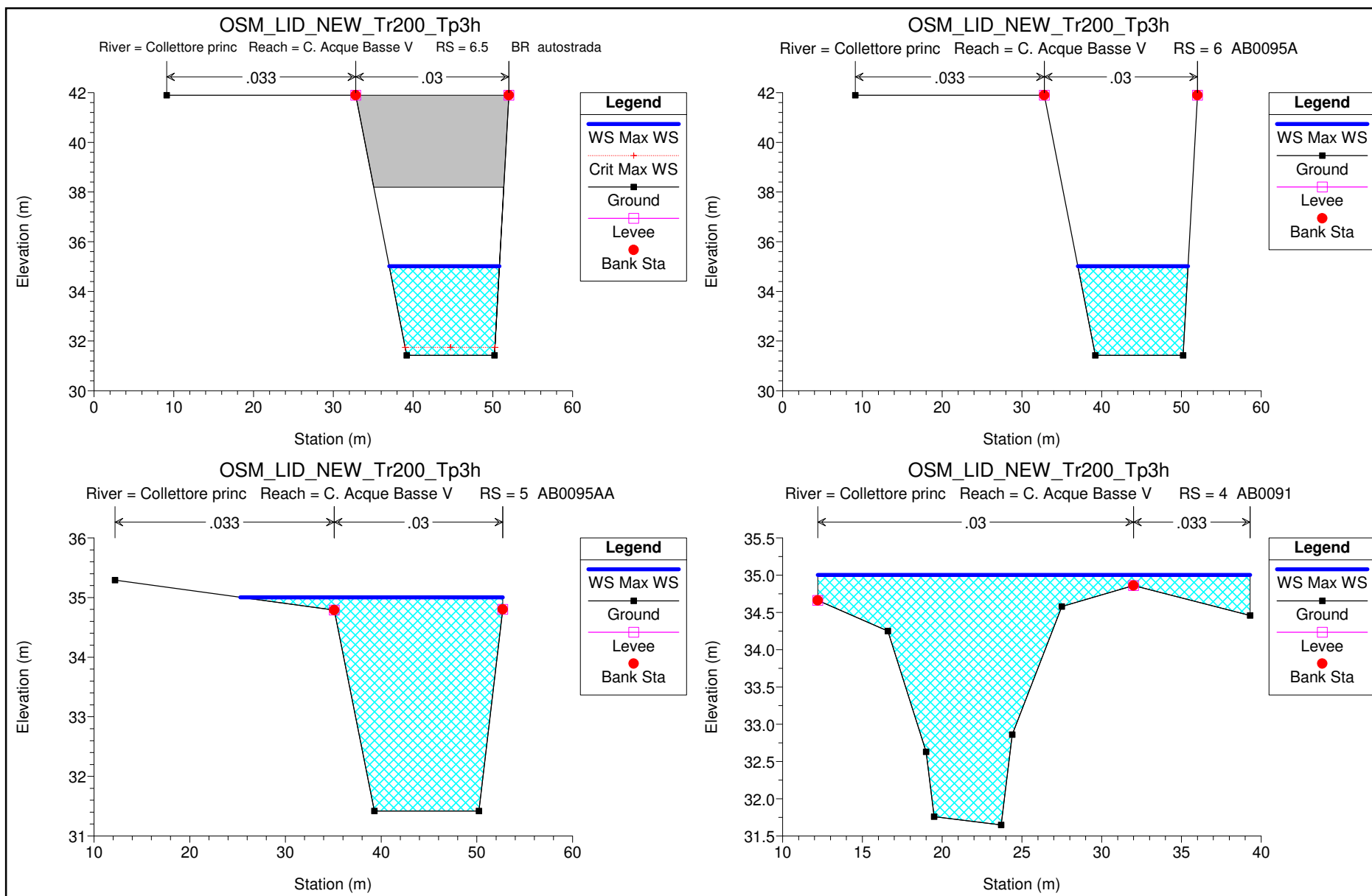
OSM_LID_NEW_Tr200_Tp2h

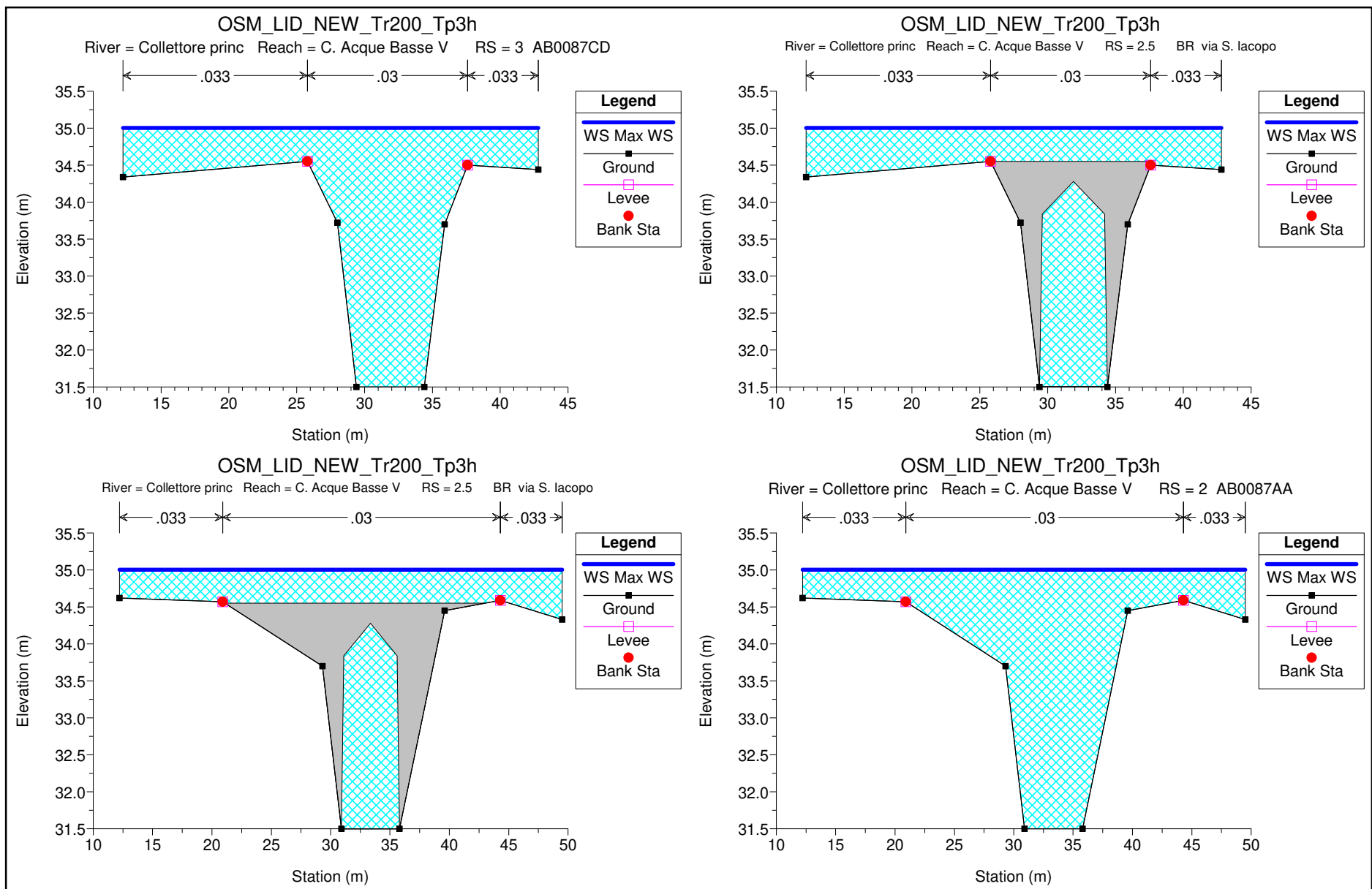
River = Nuovo Gavina Reach = Gavina RS = 1 GV0001AD

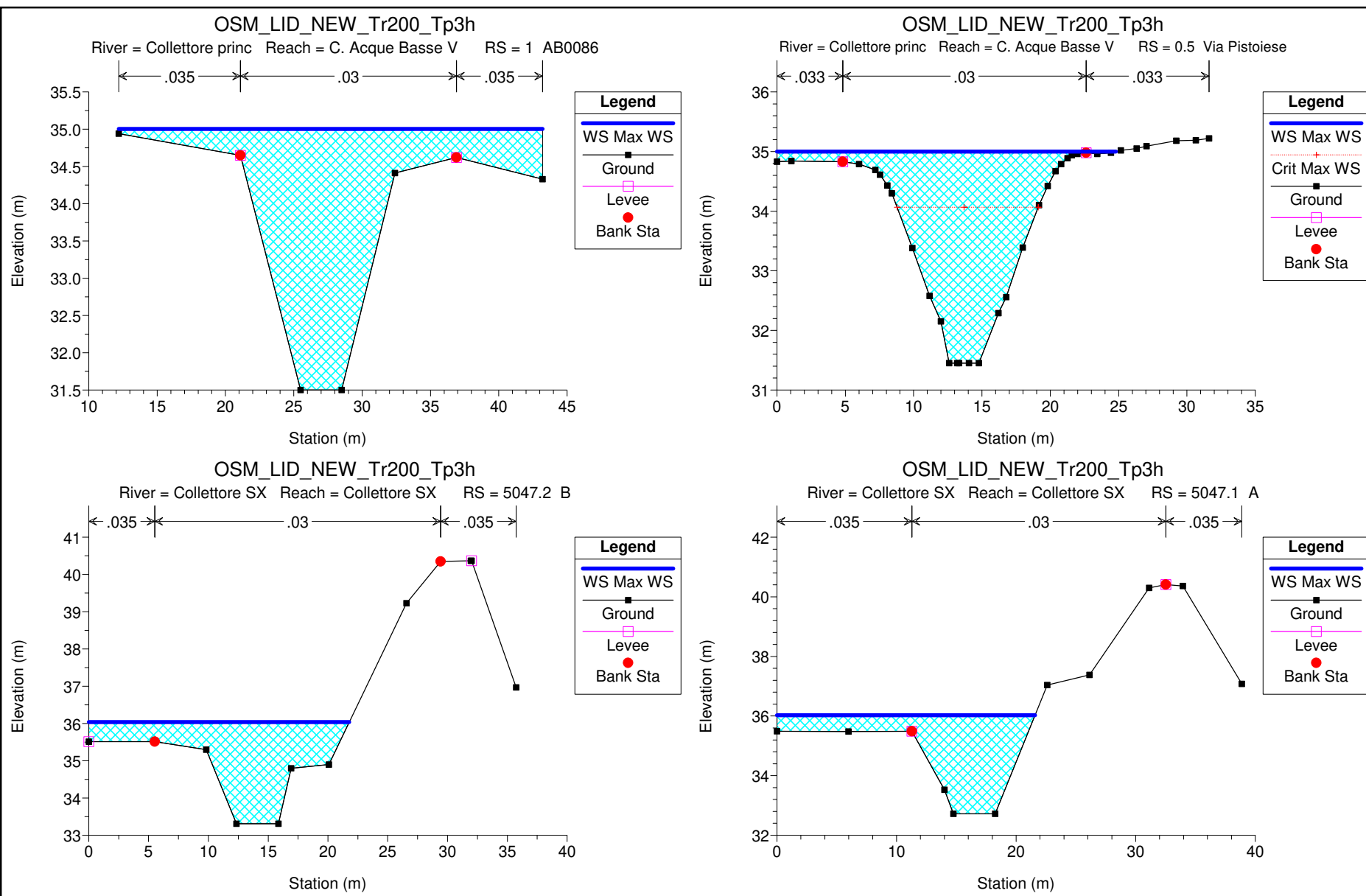


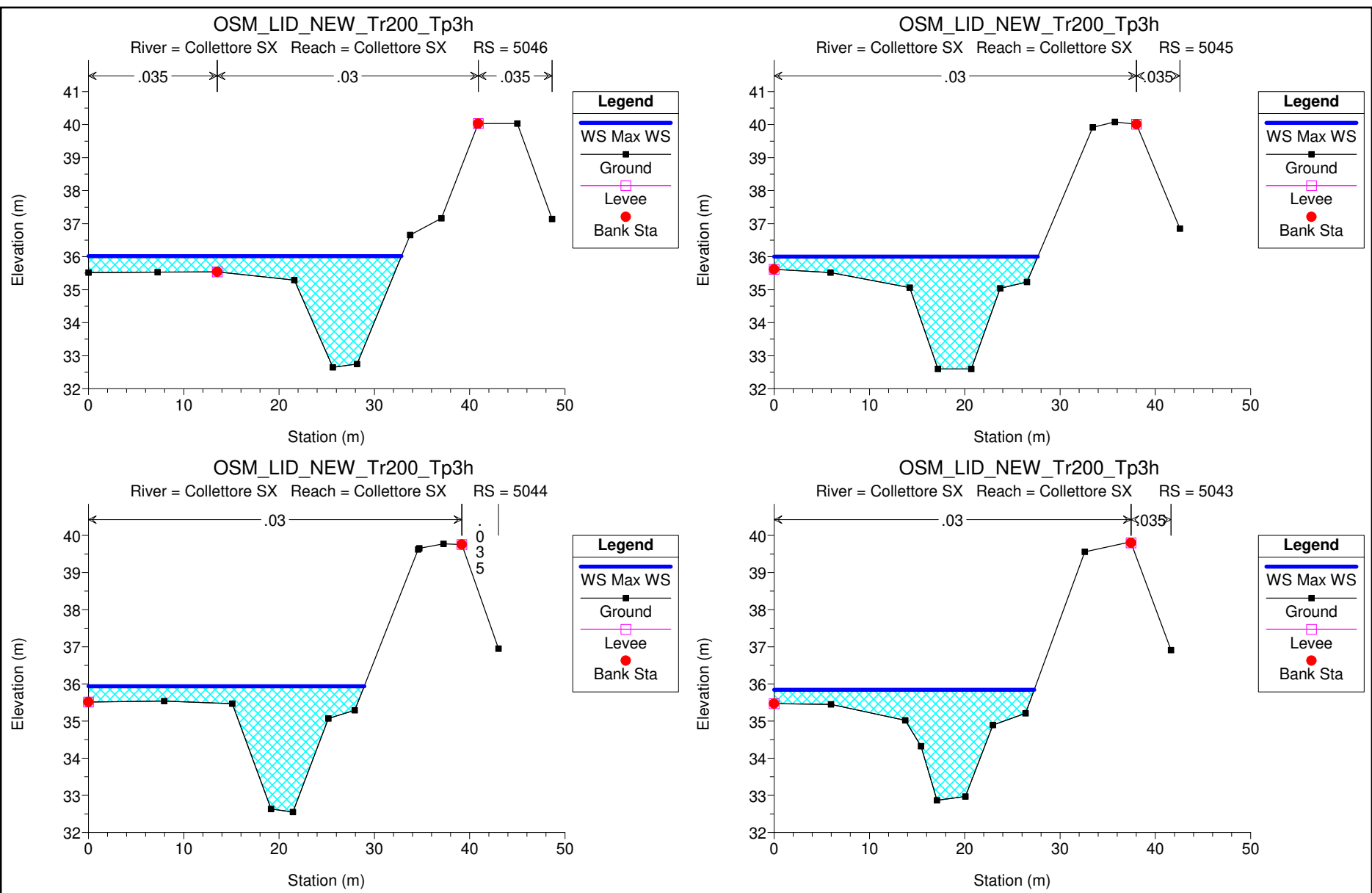
Verifiche idrauliche Tr 200 anni Tp 3h

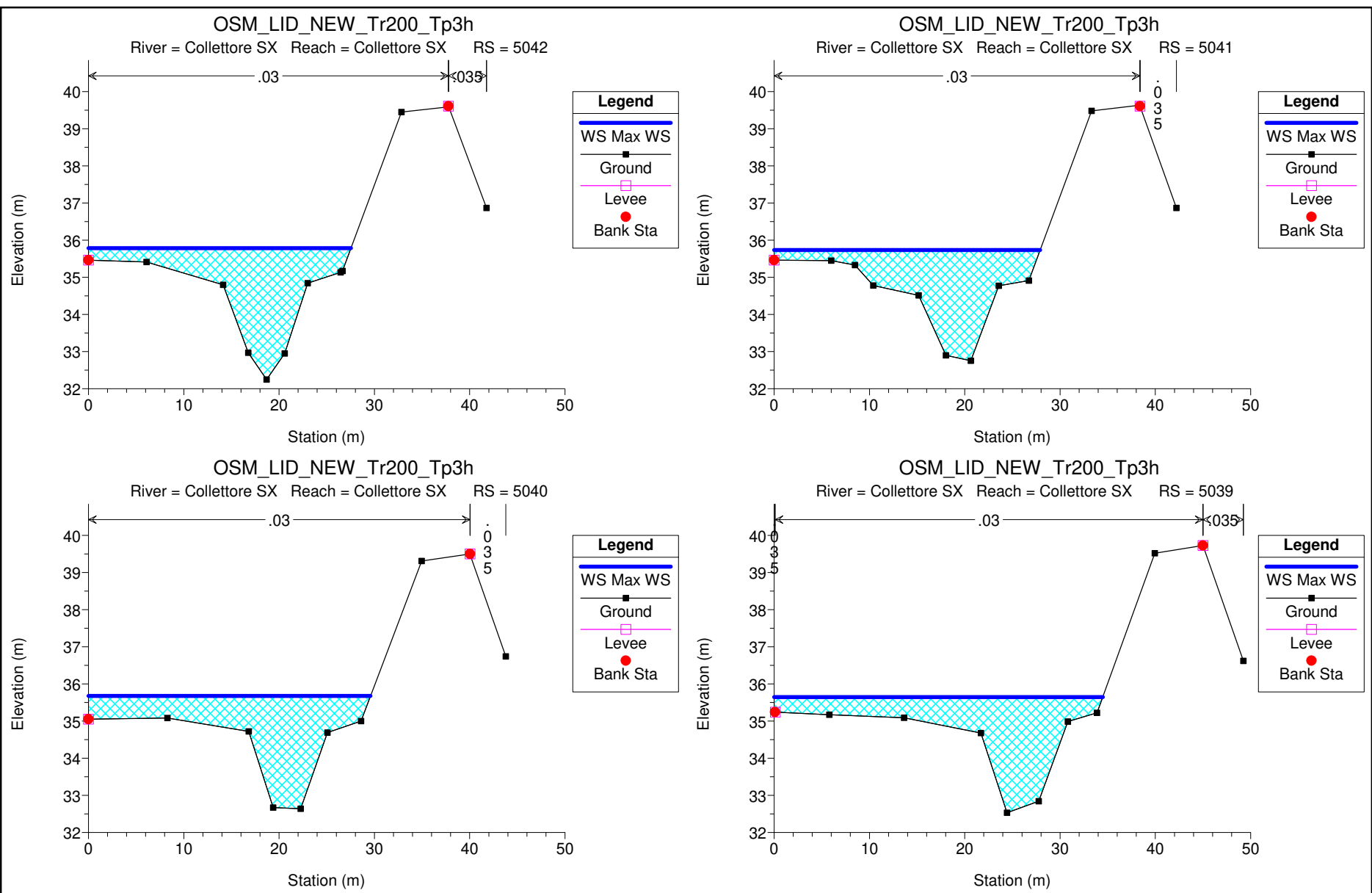
**Collettore sinistro acque basse – Fosso Osmannoro – Fosso Nuova Gavine – Collettore
principale delle acque basse**

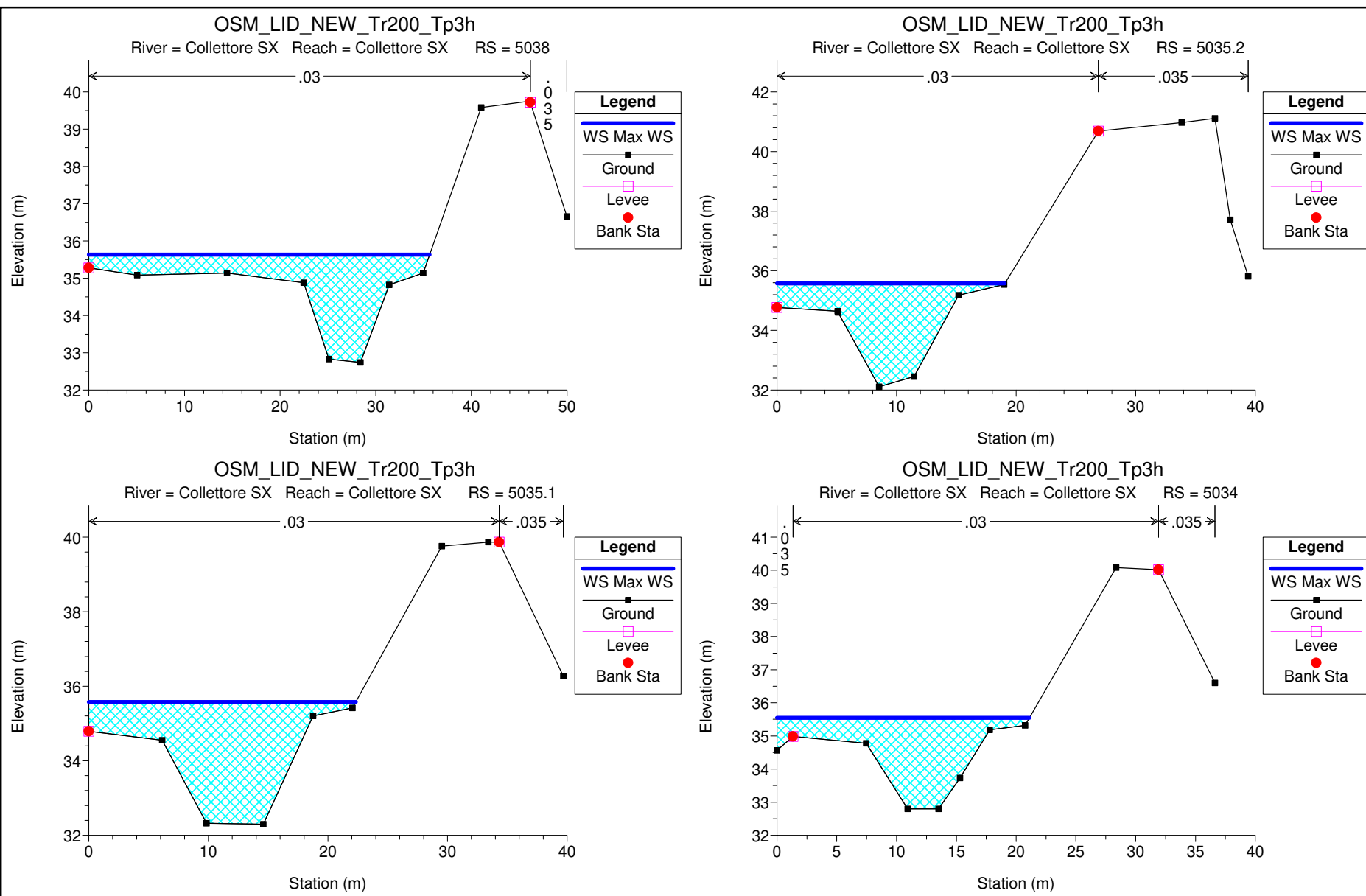


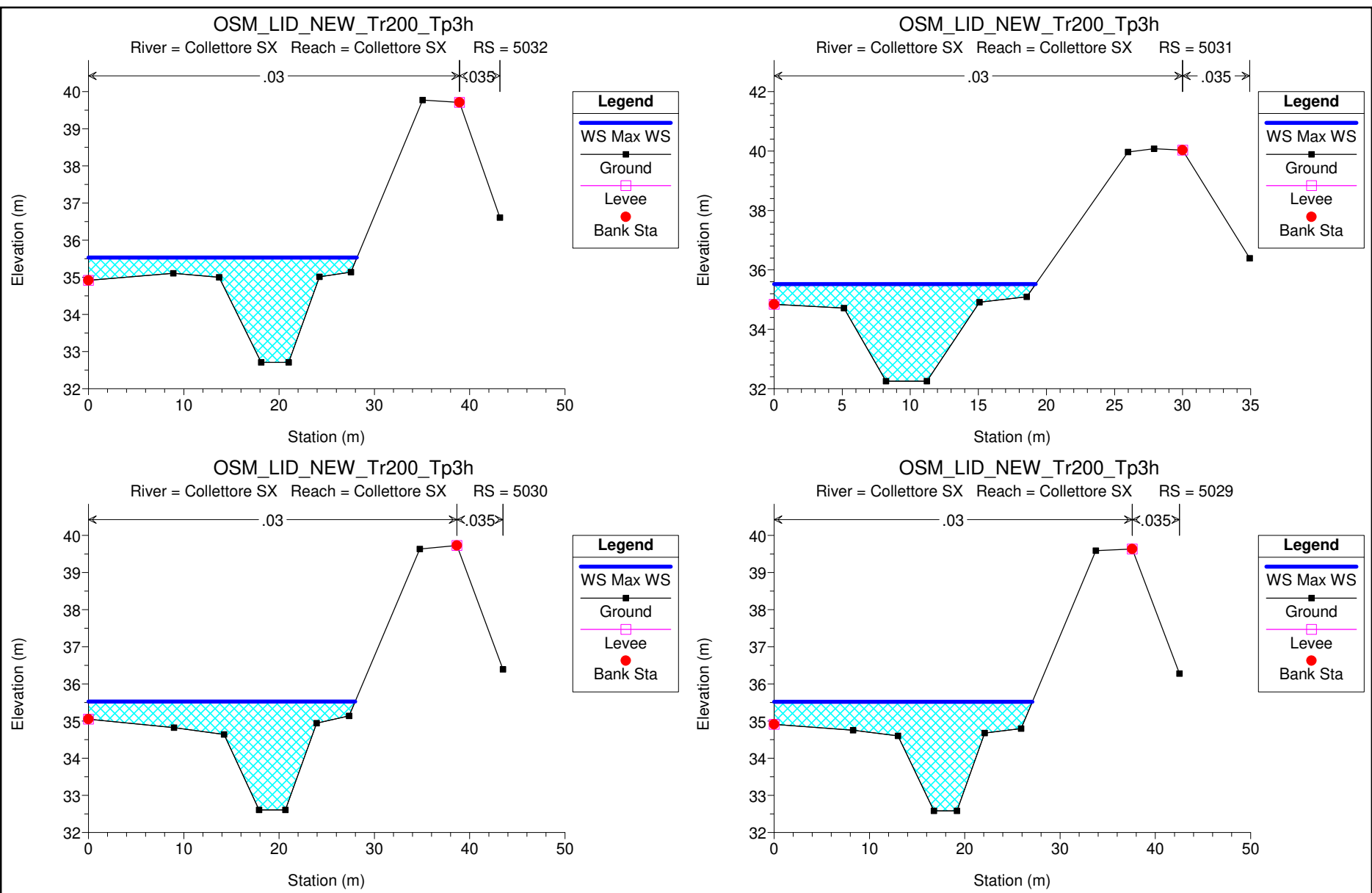


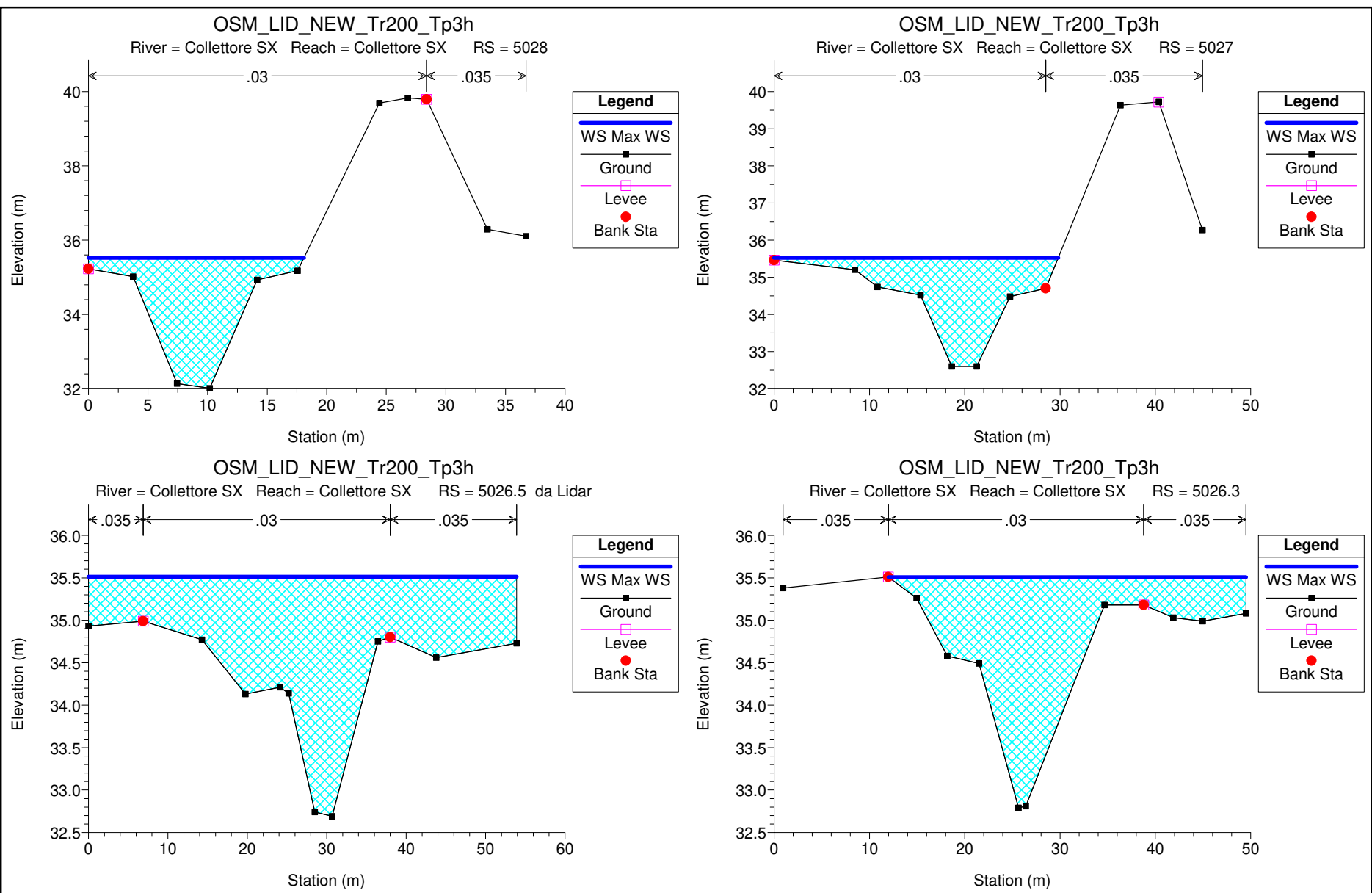


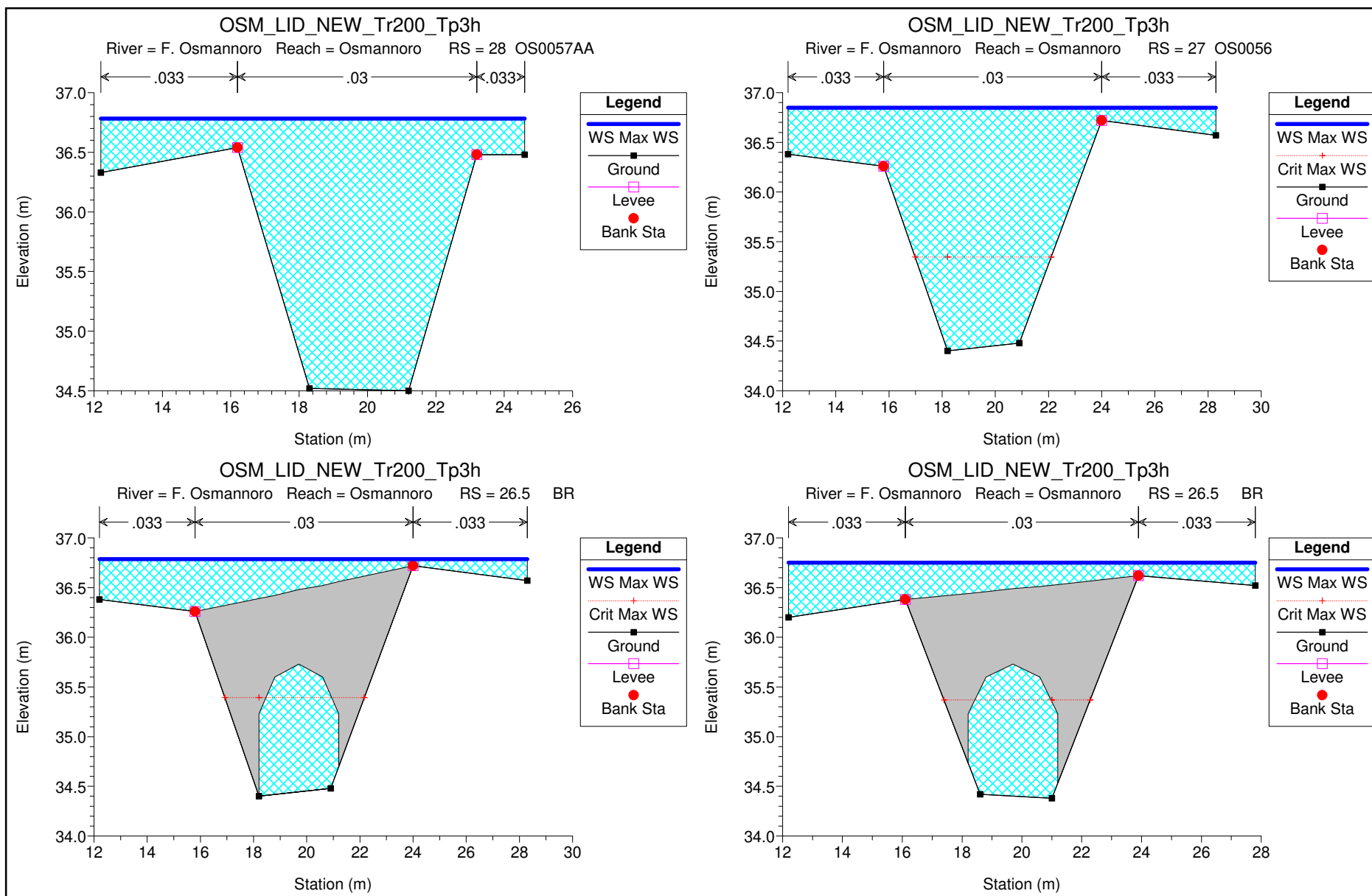


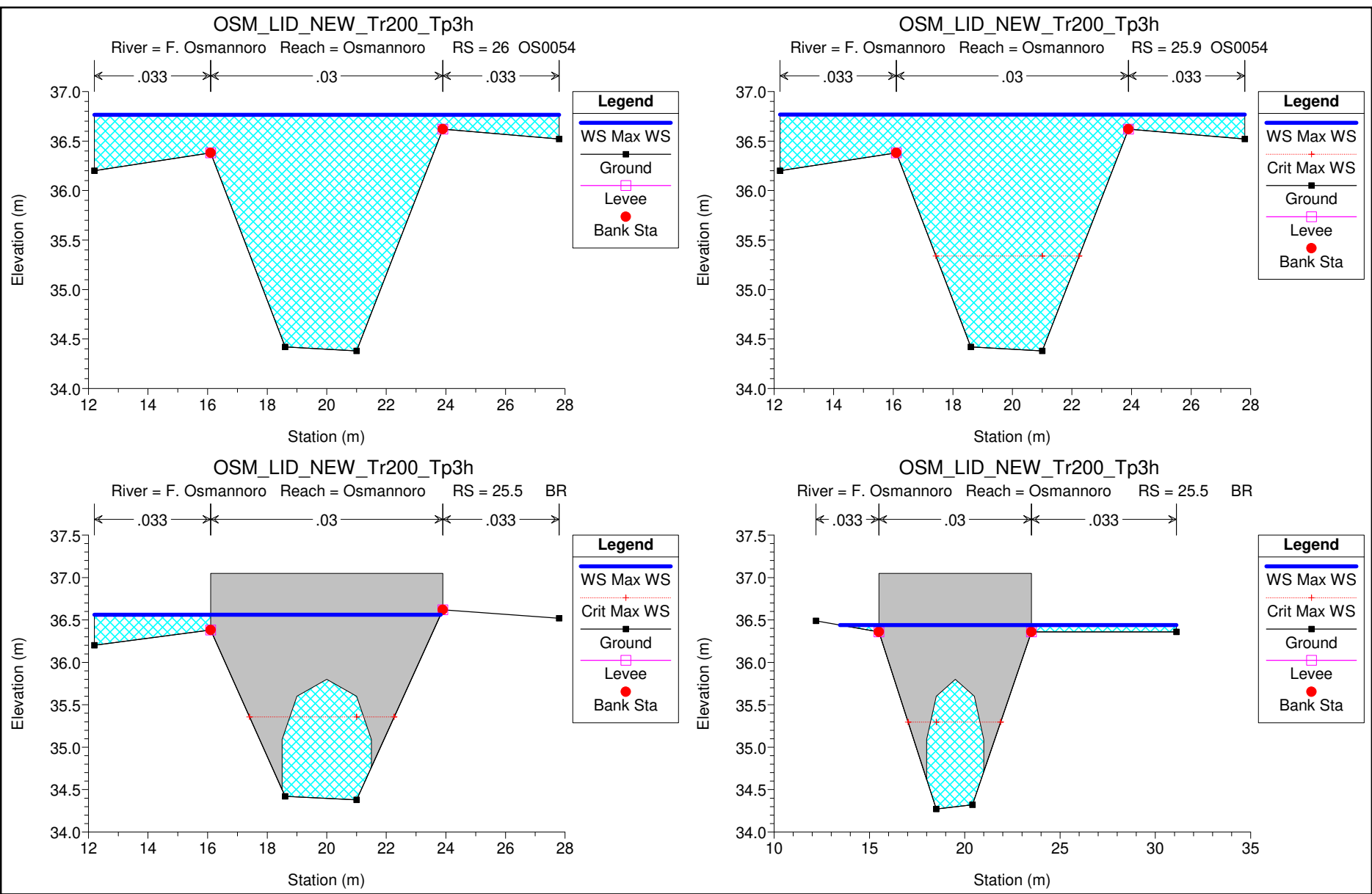


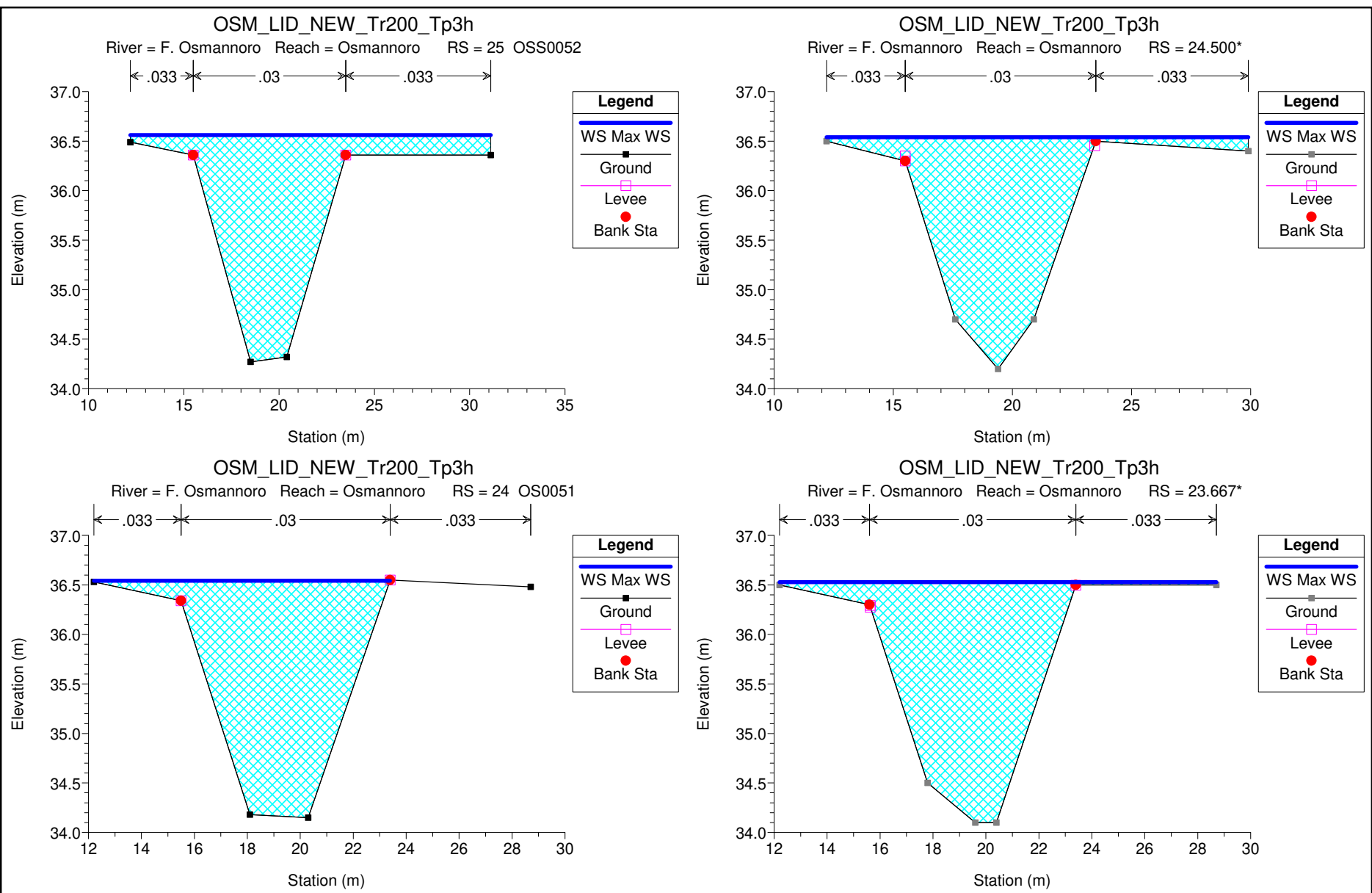


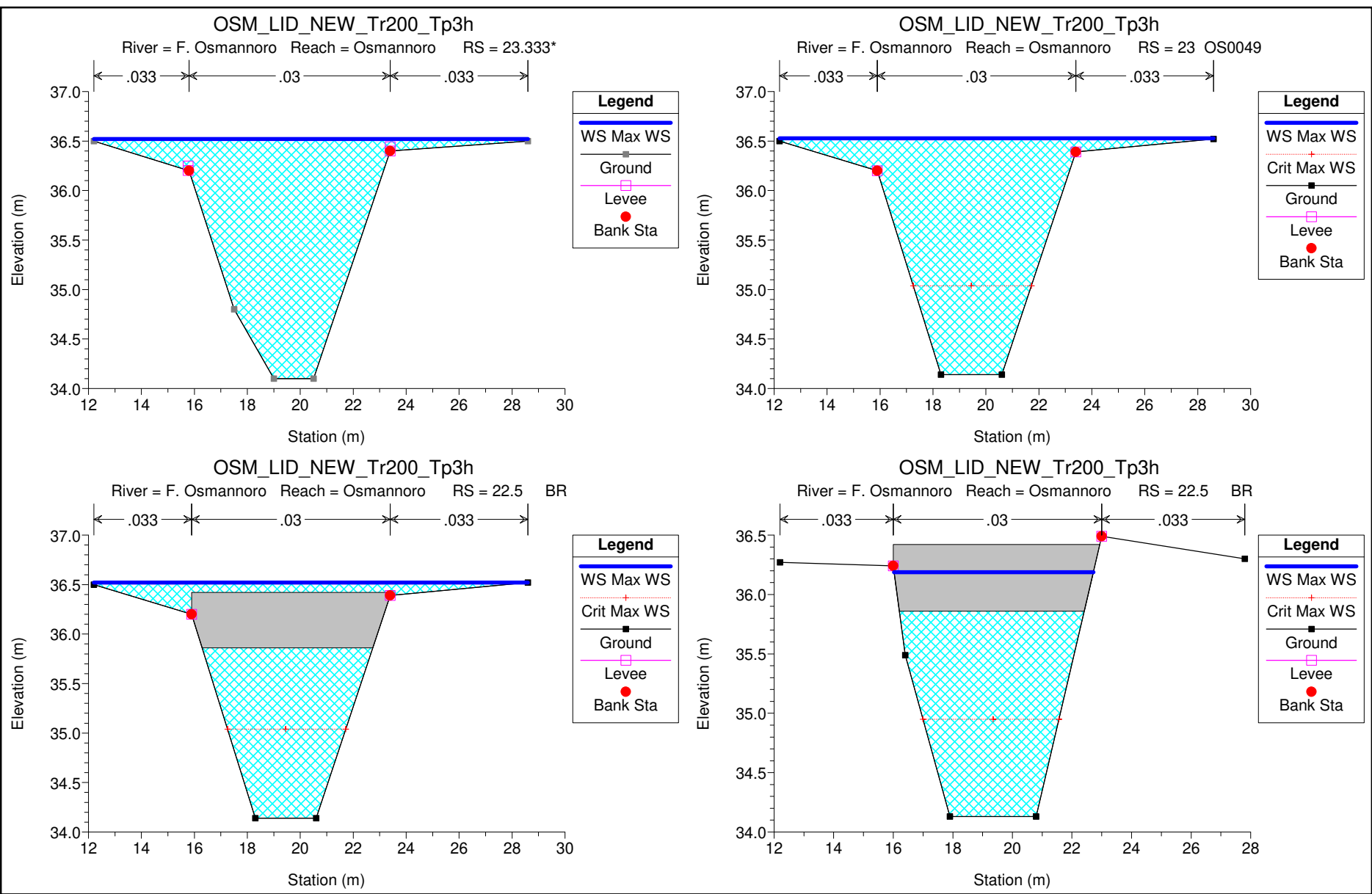


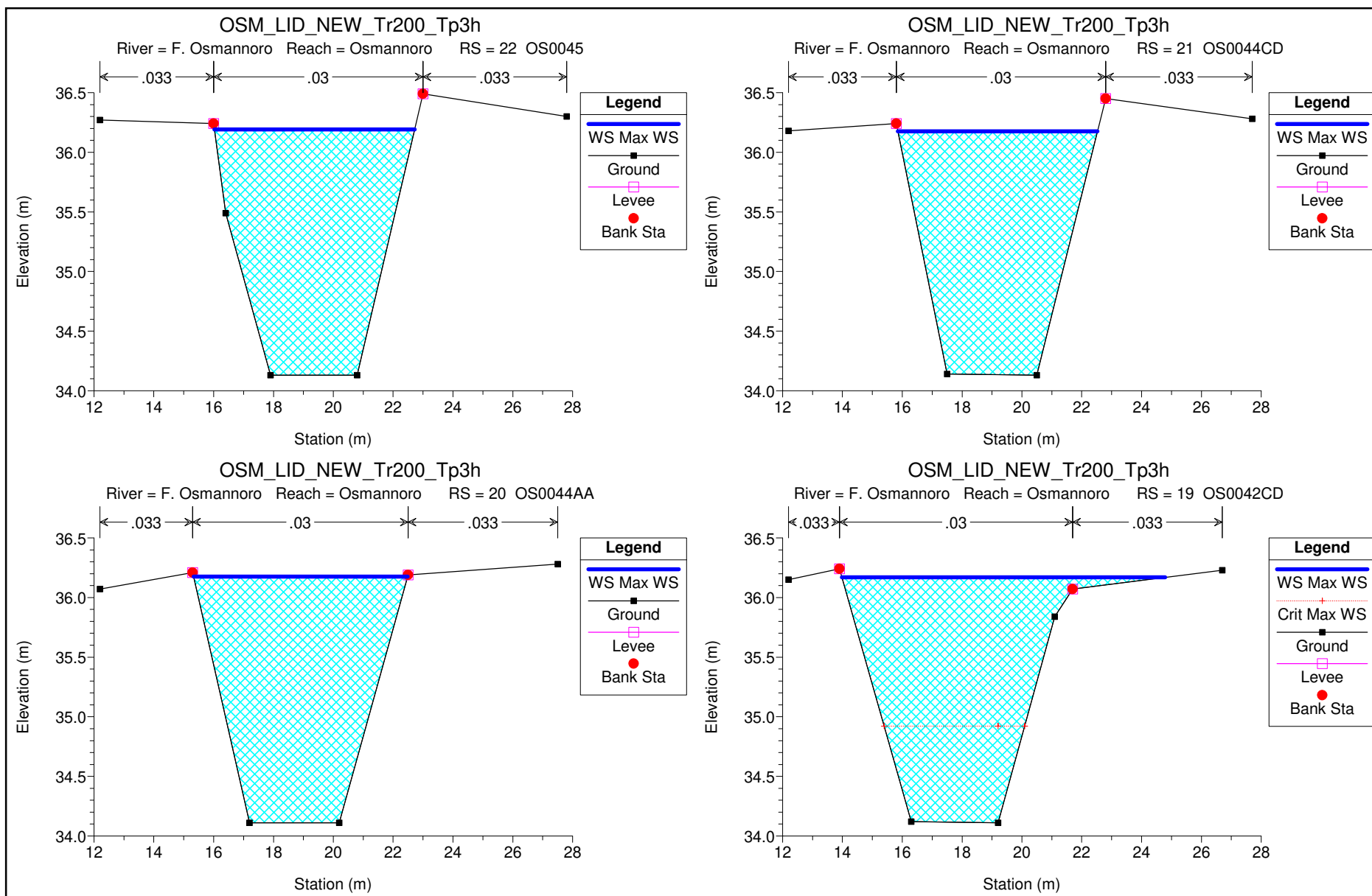


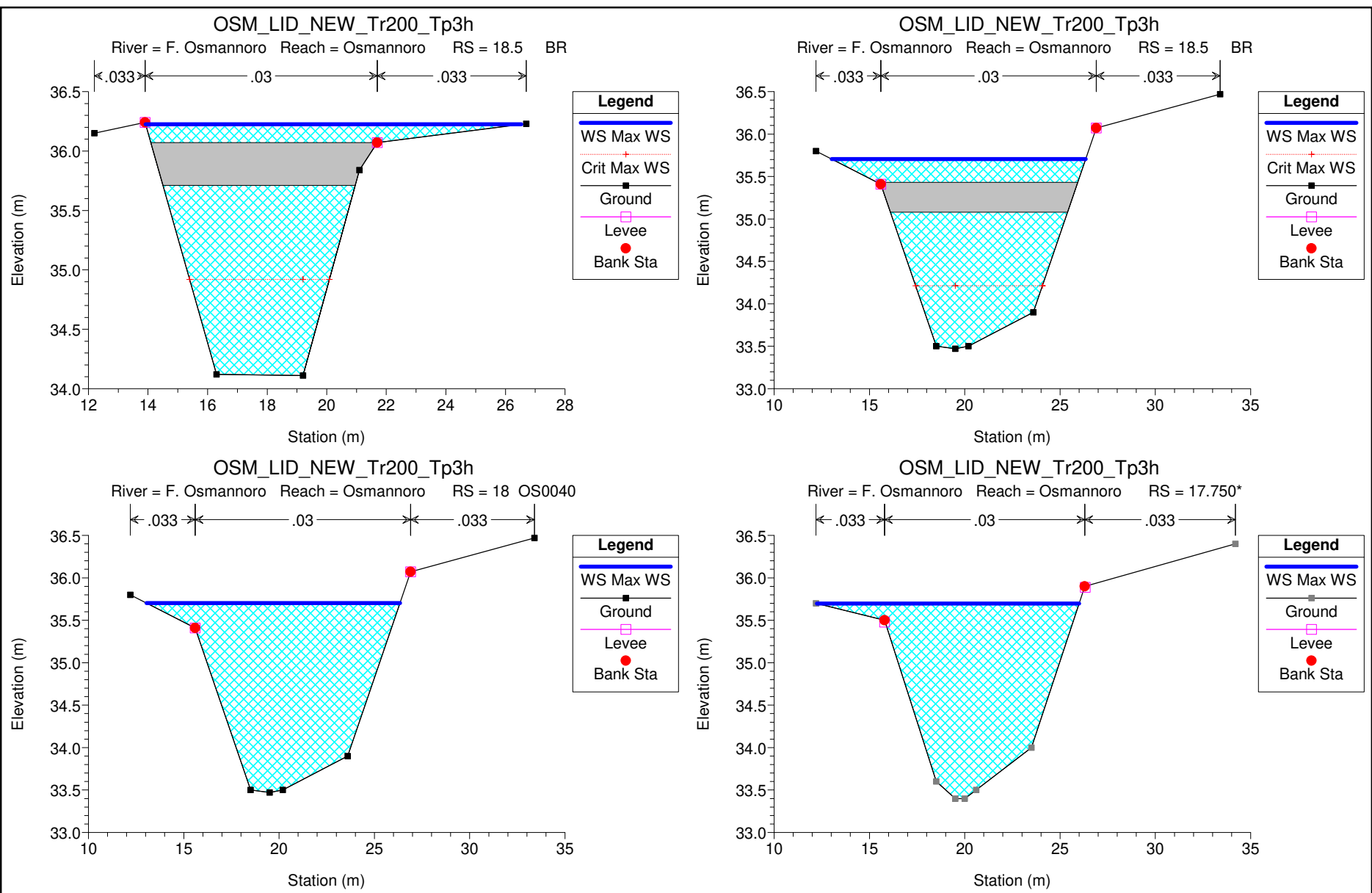


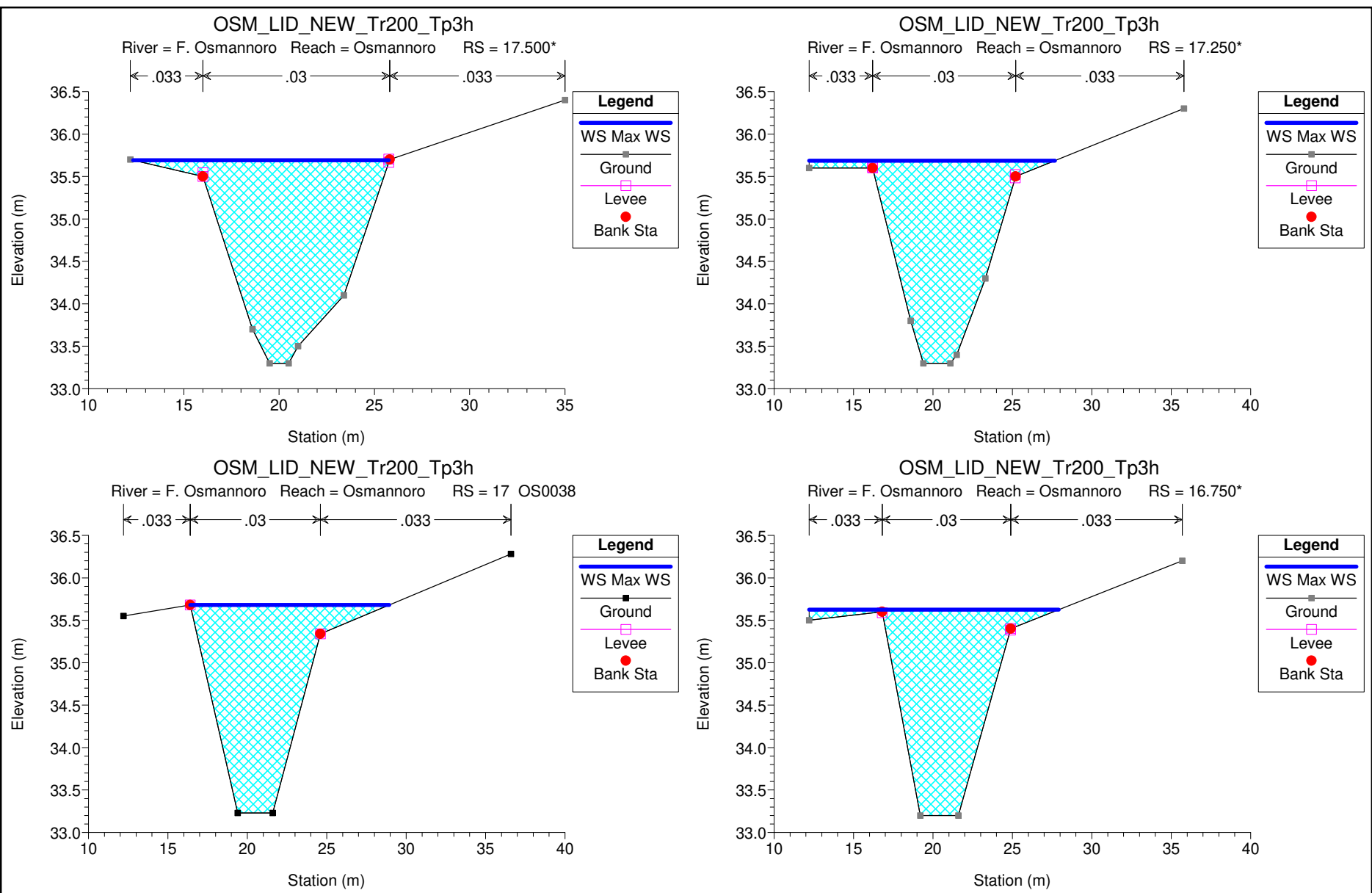


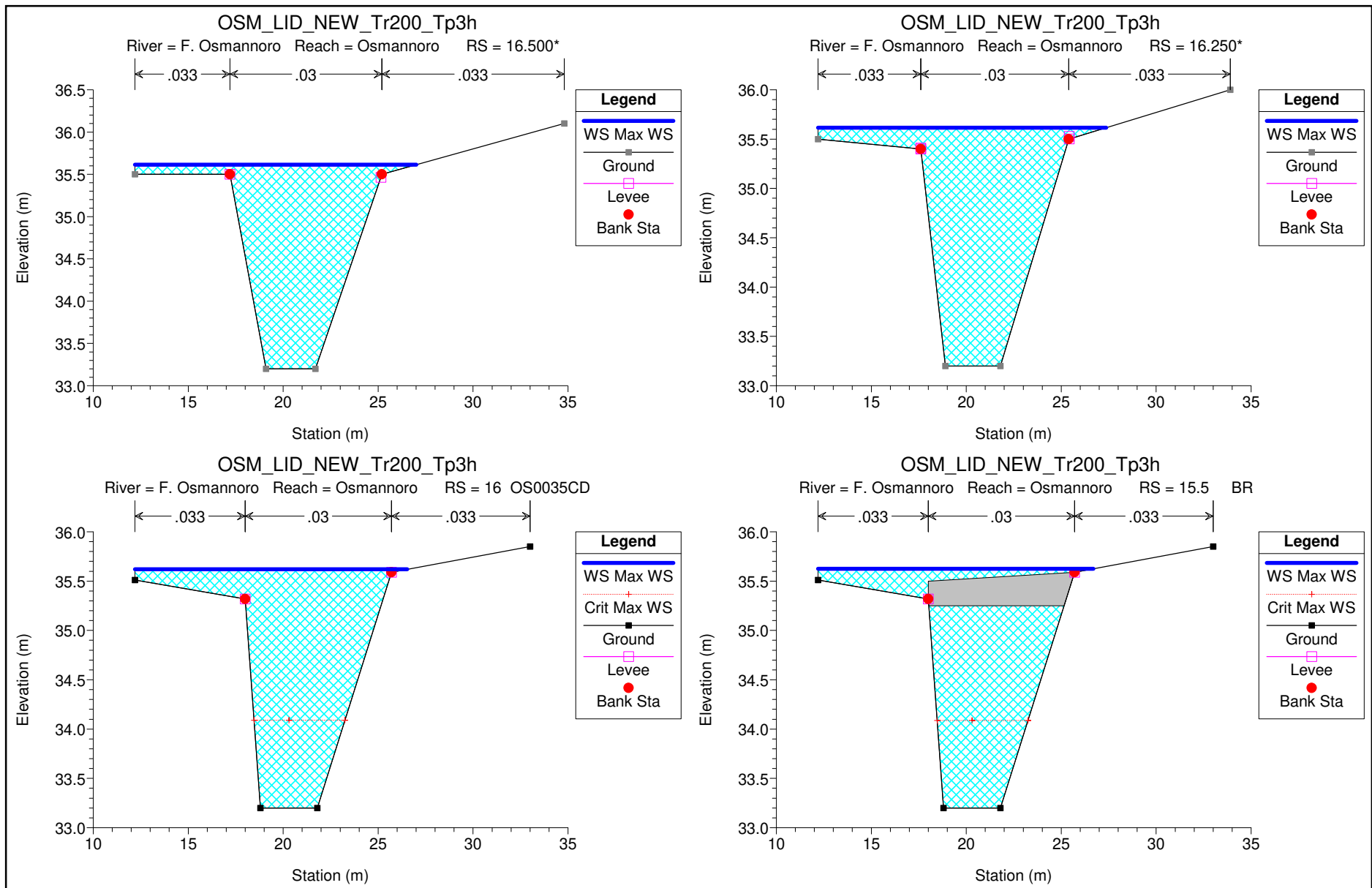


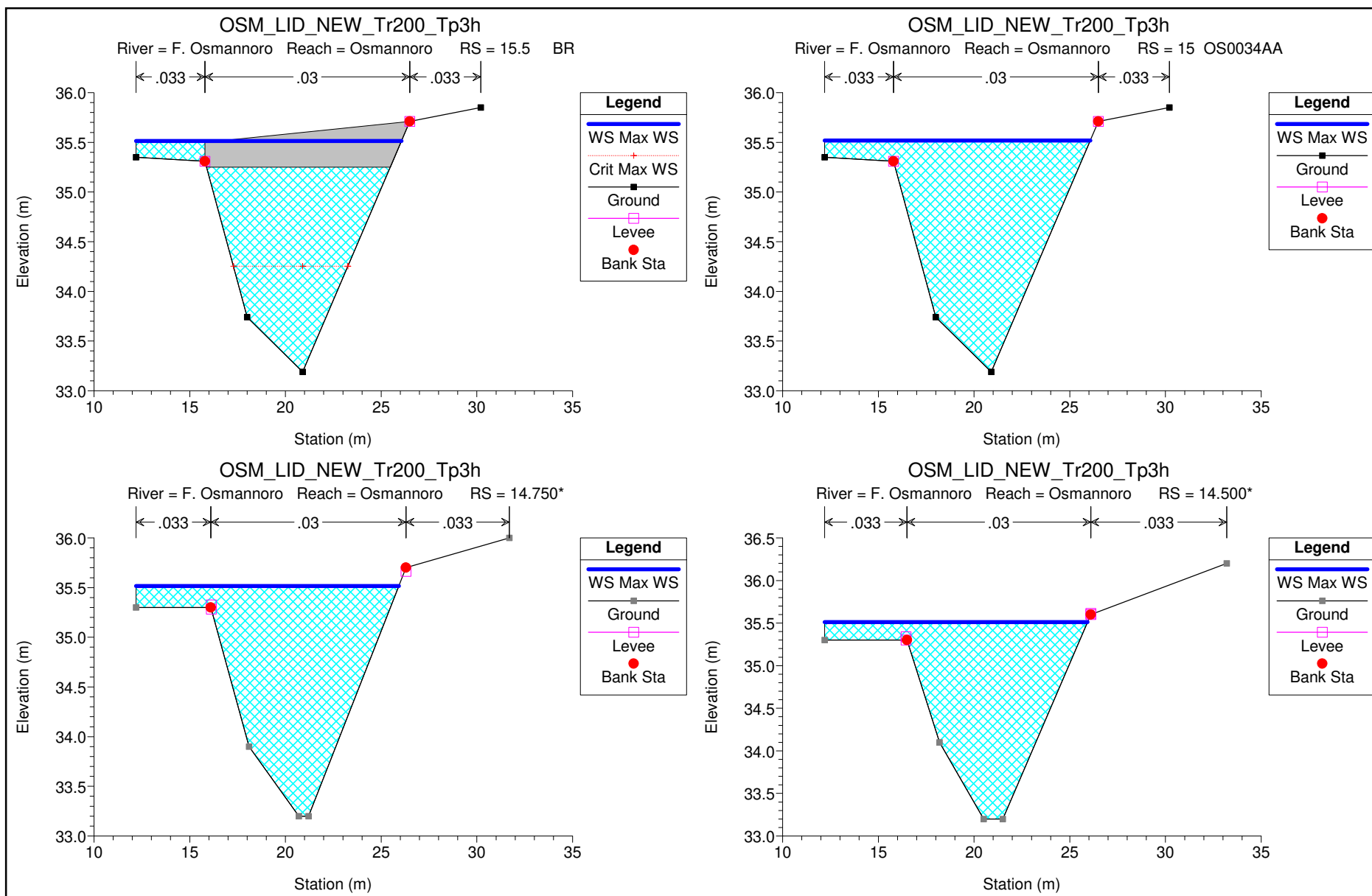


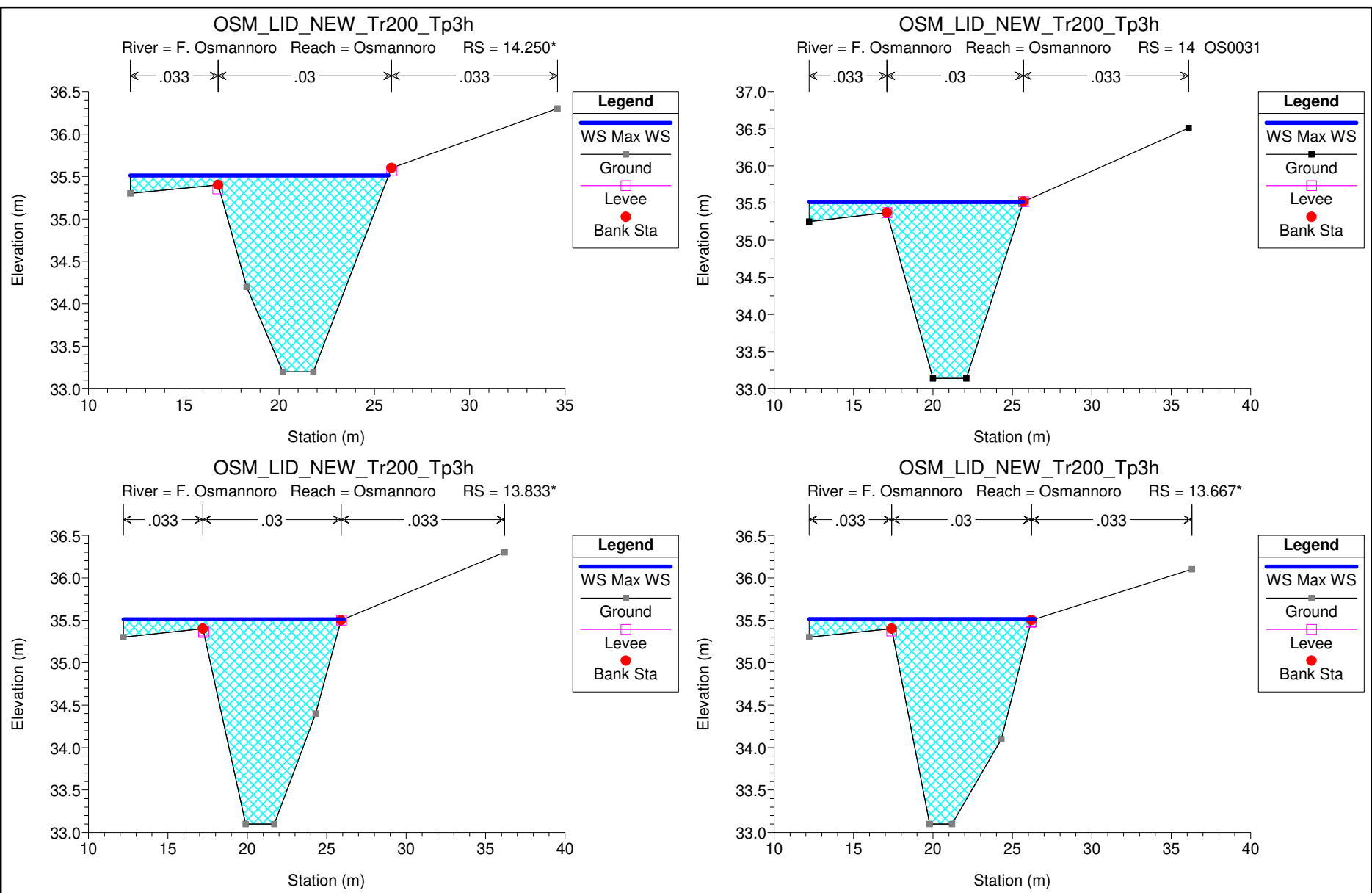


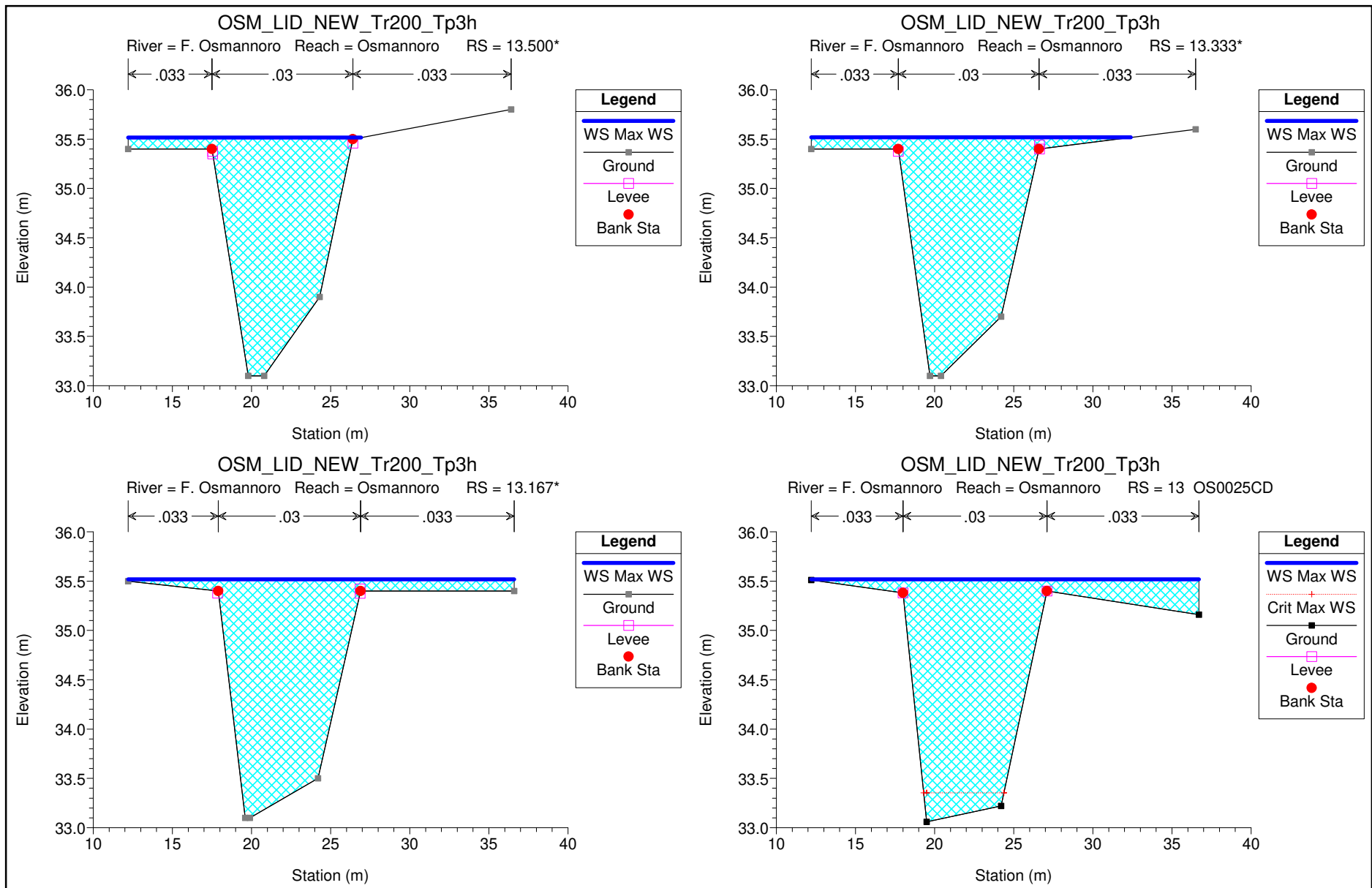


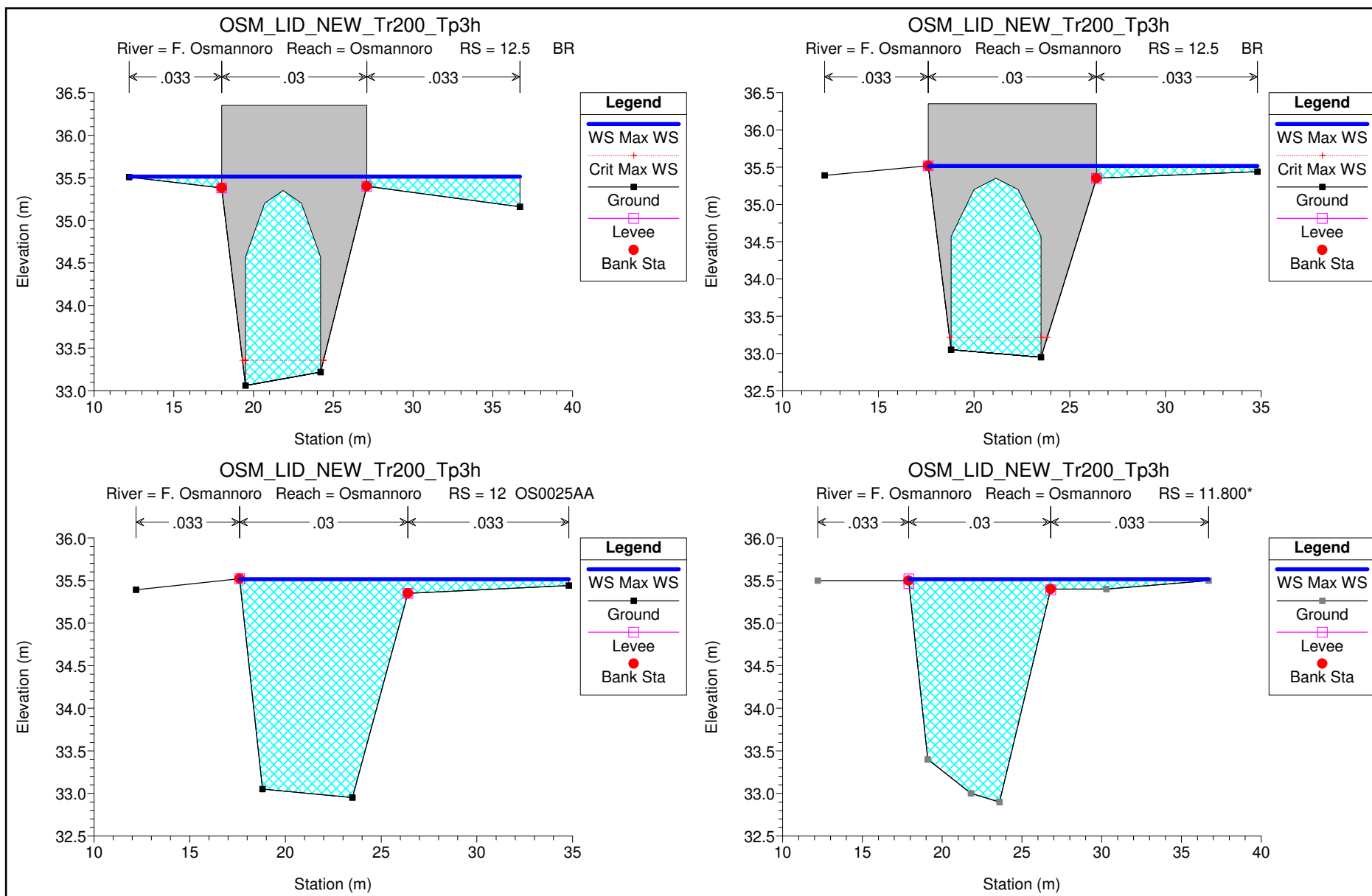


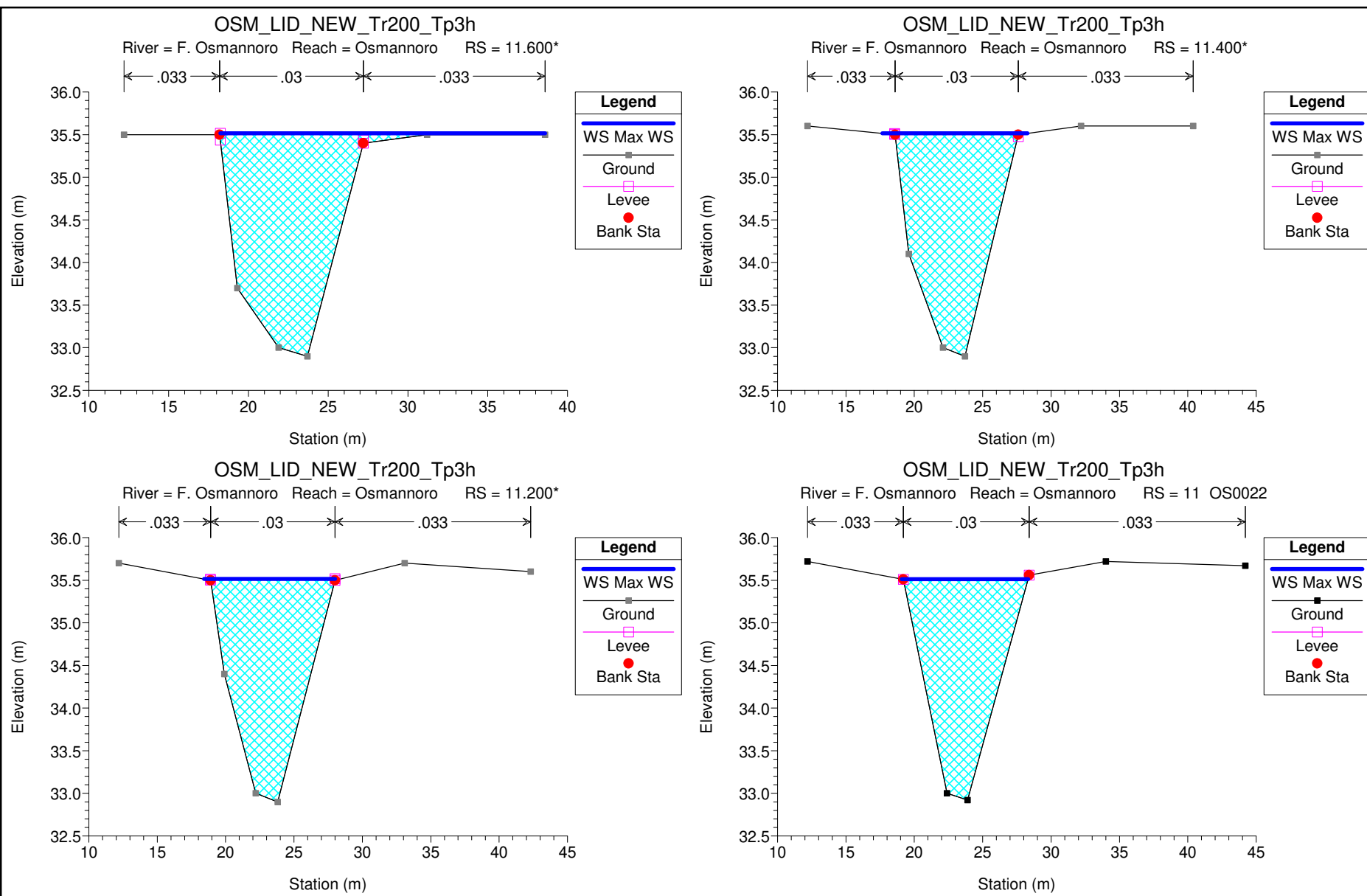


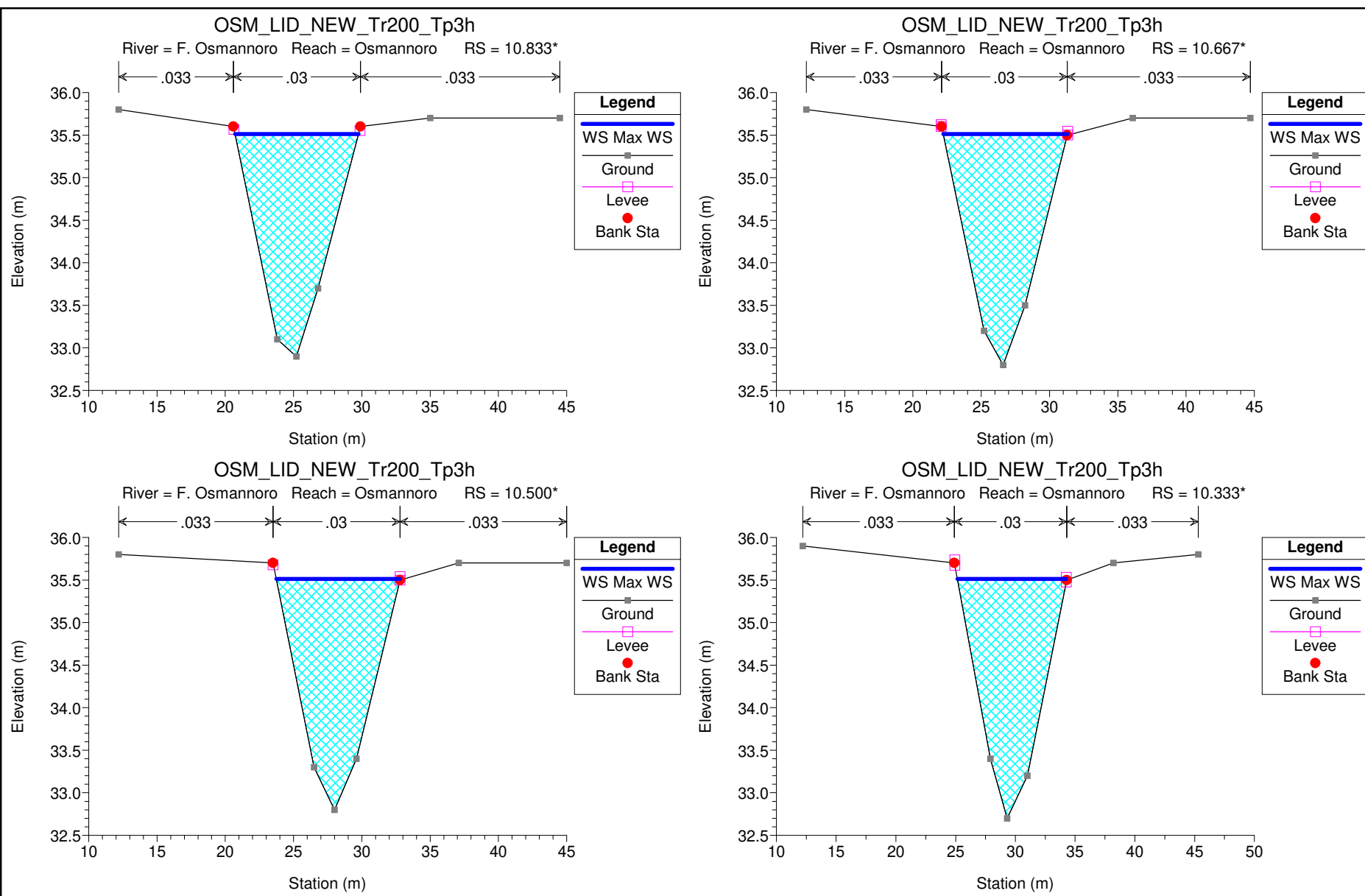


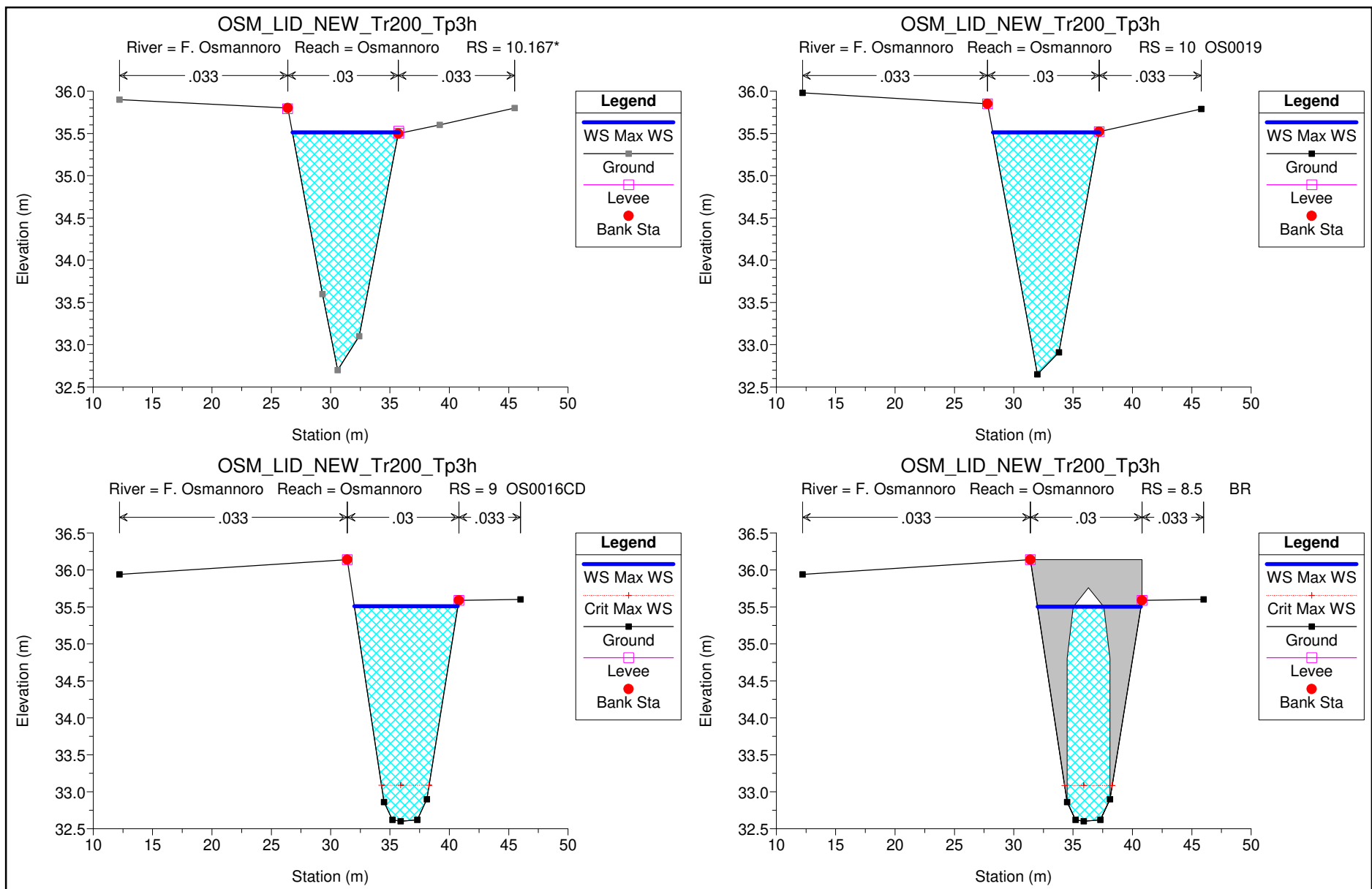


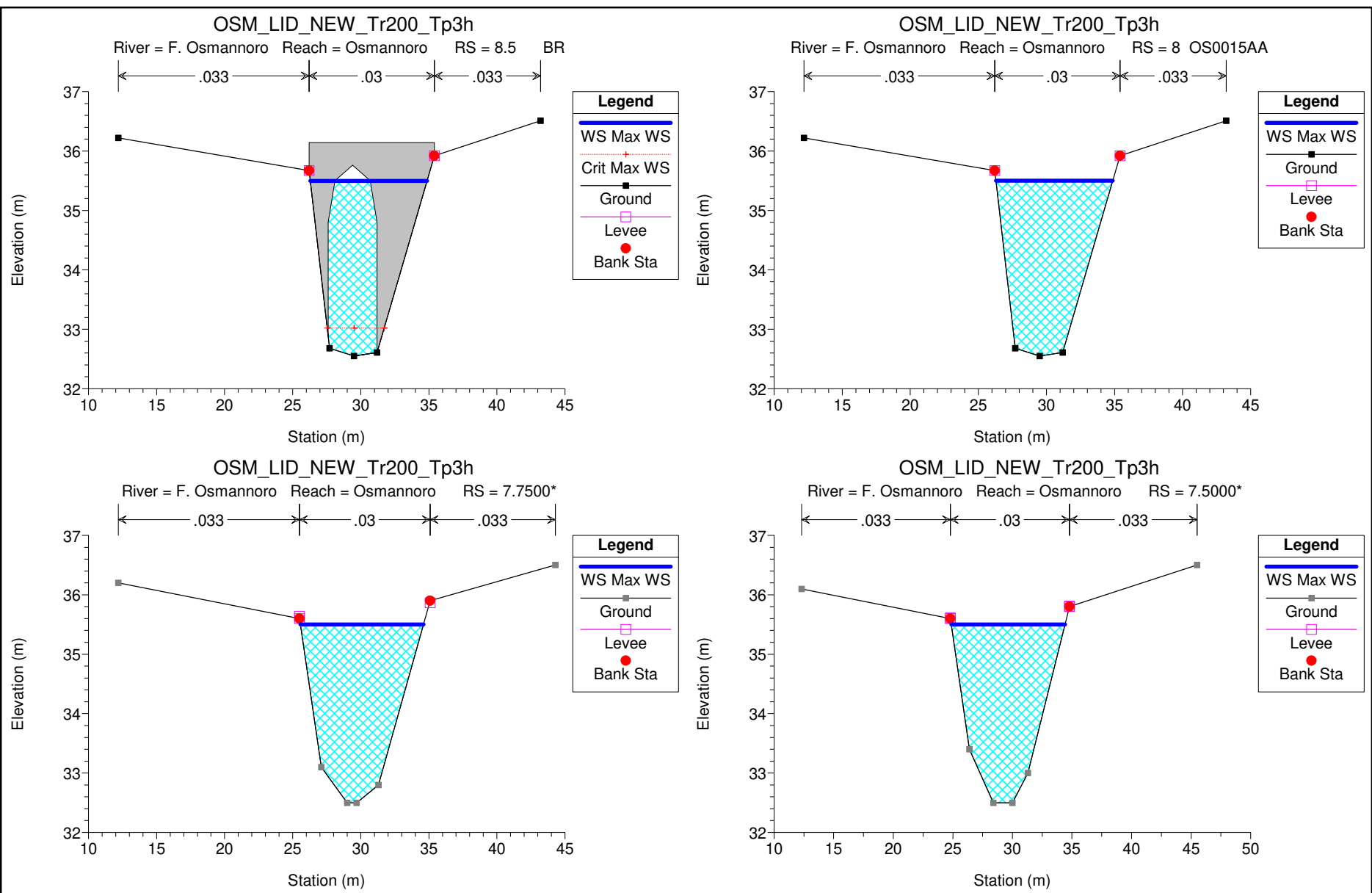


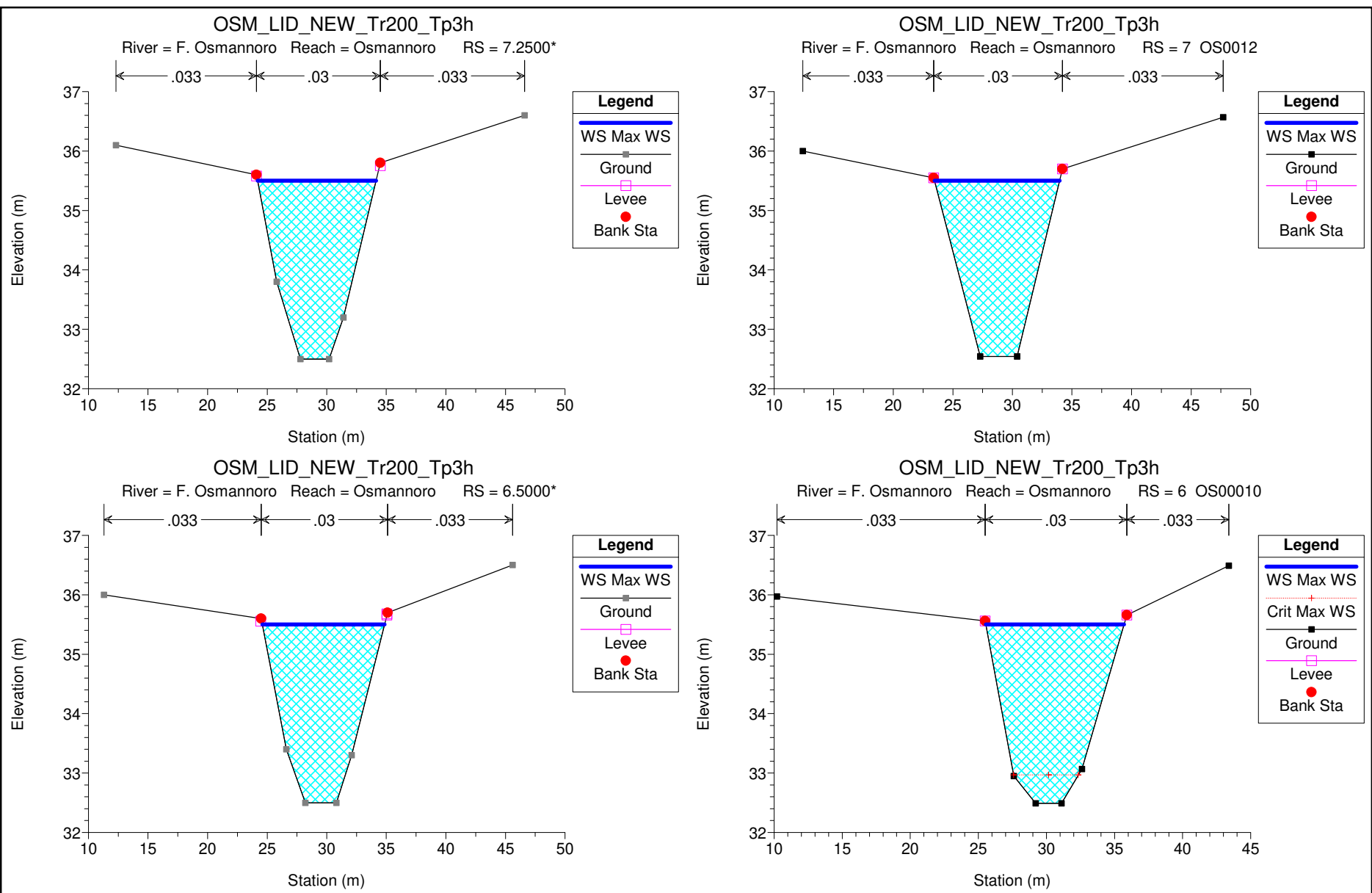


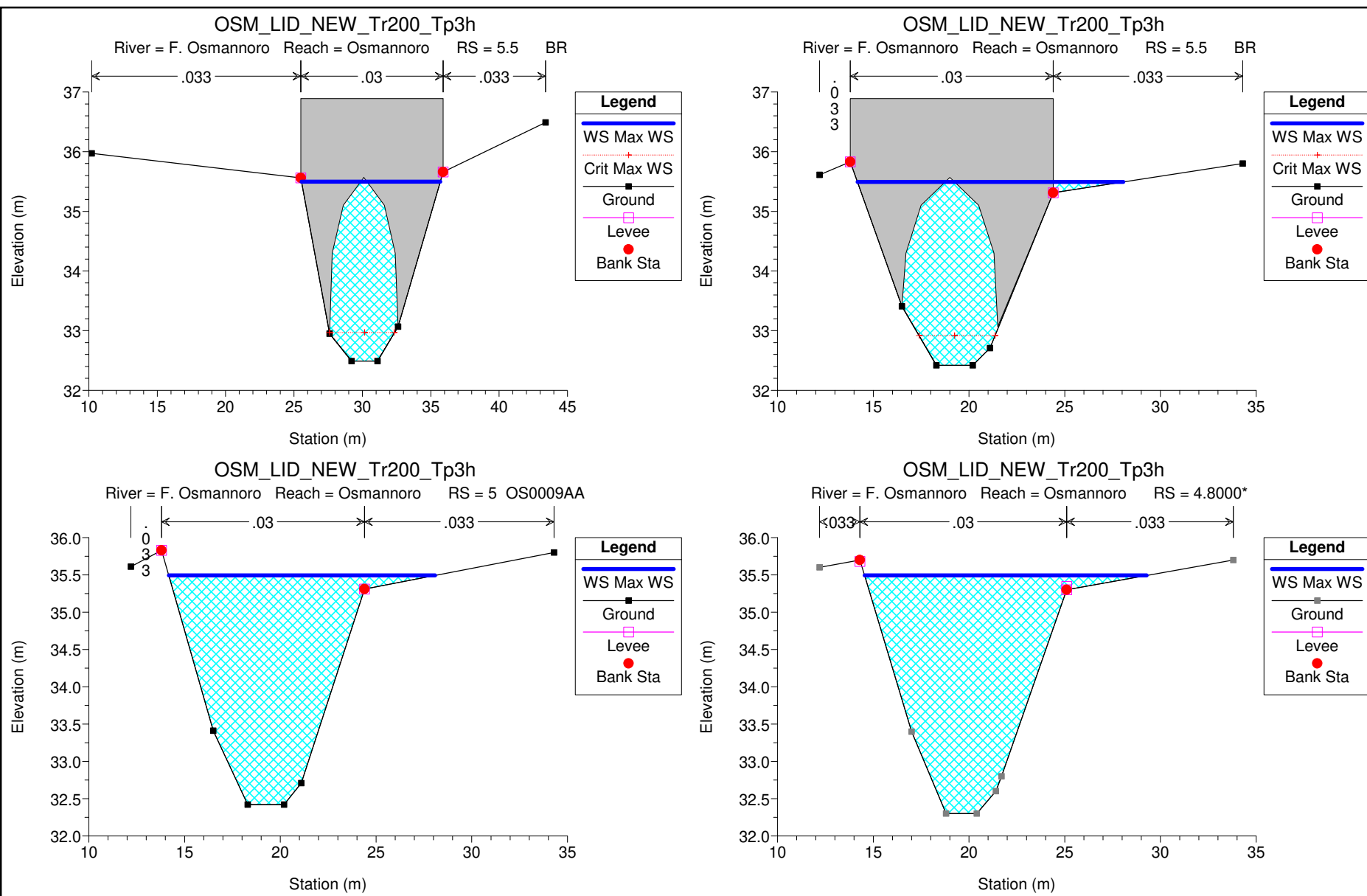


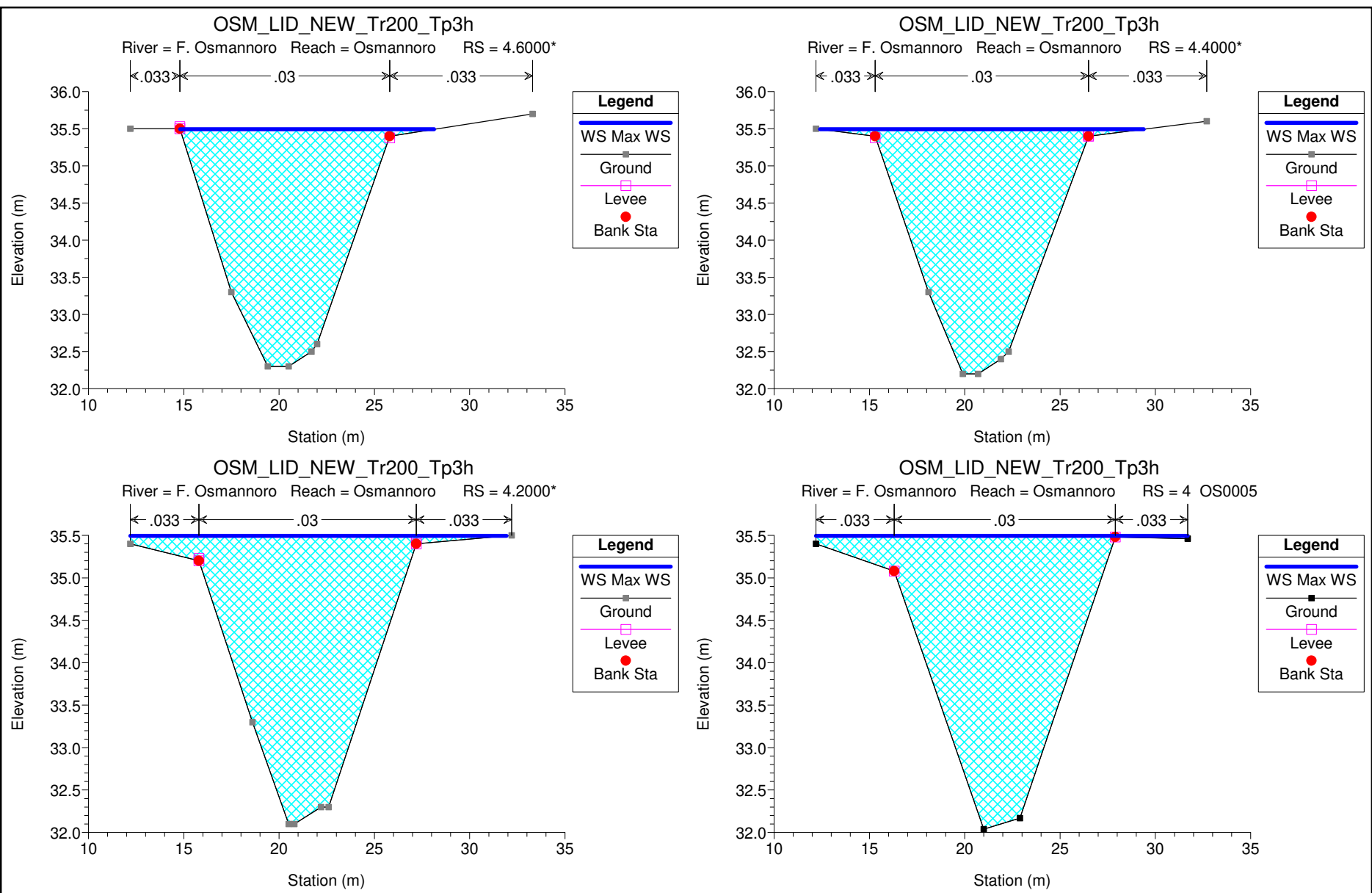


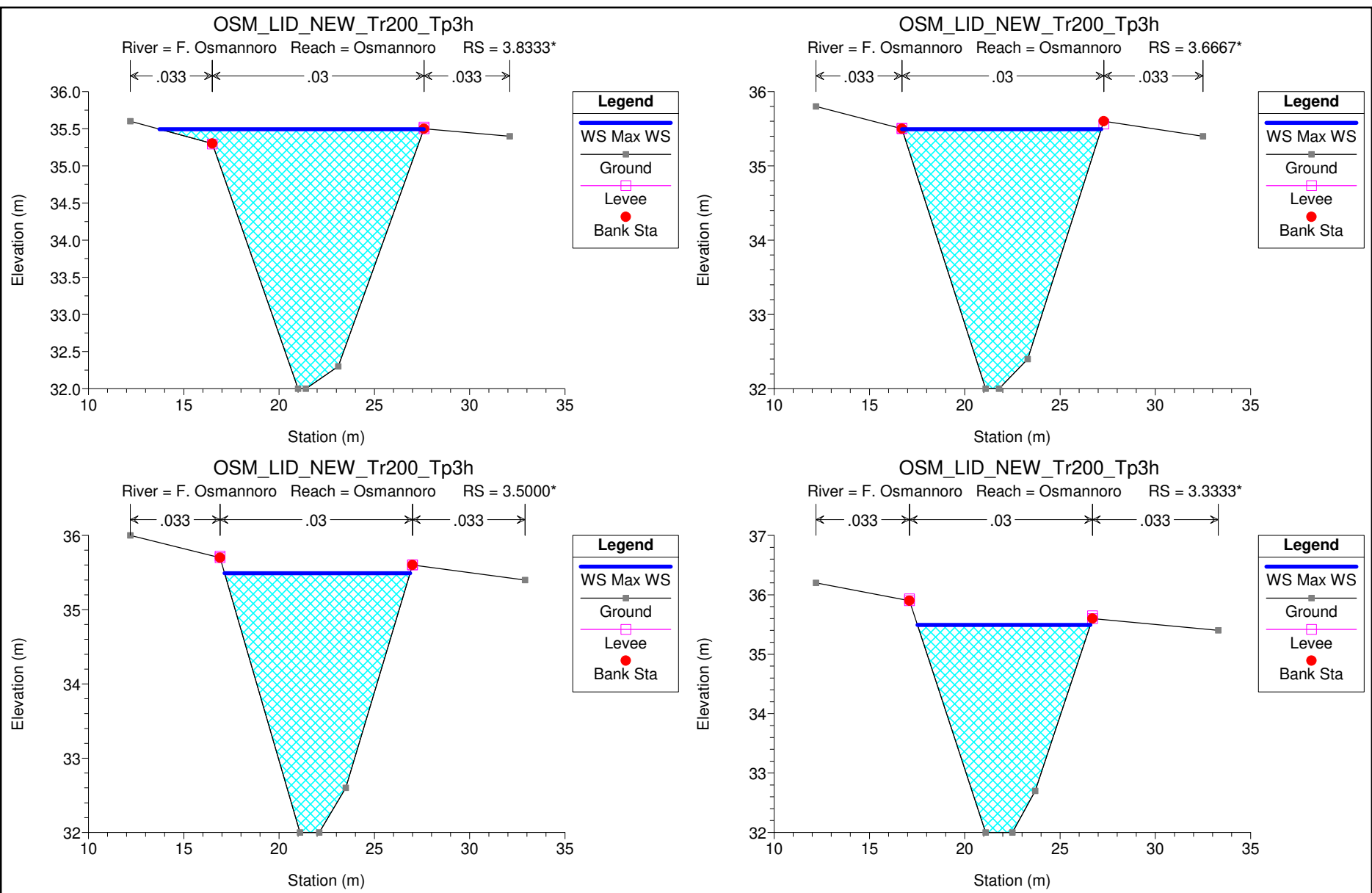


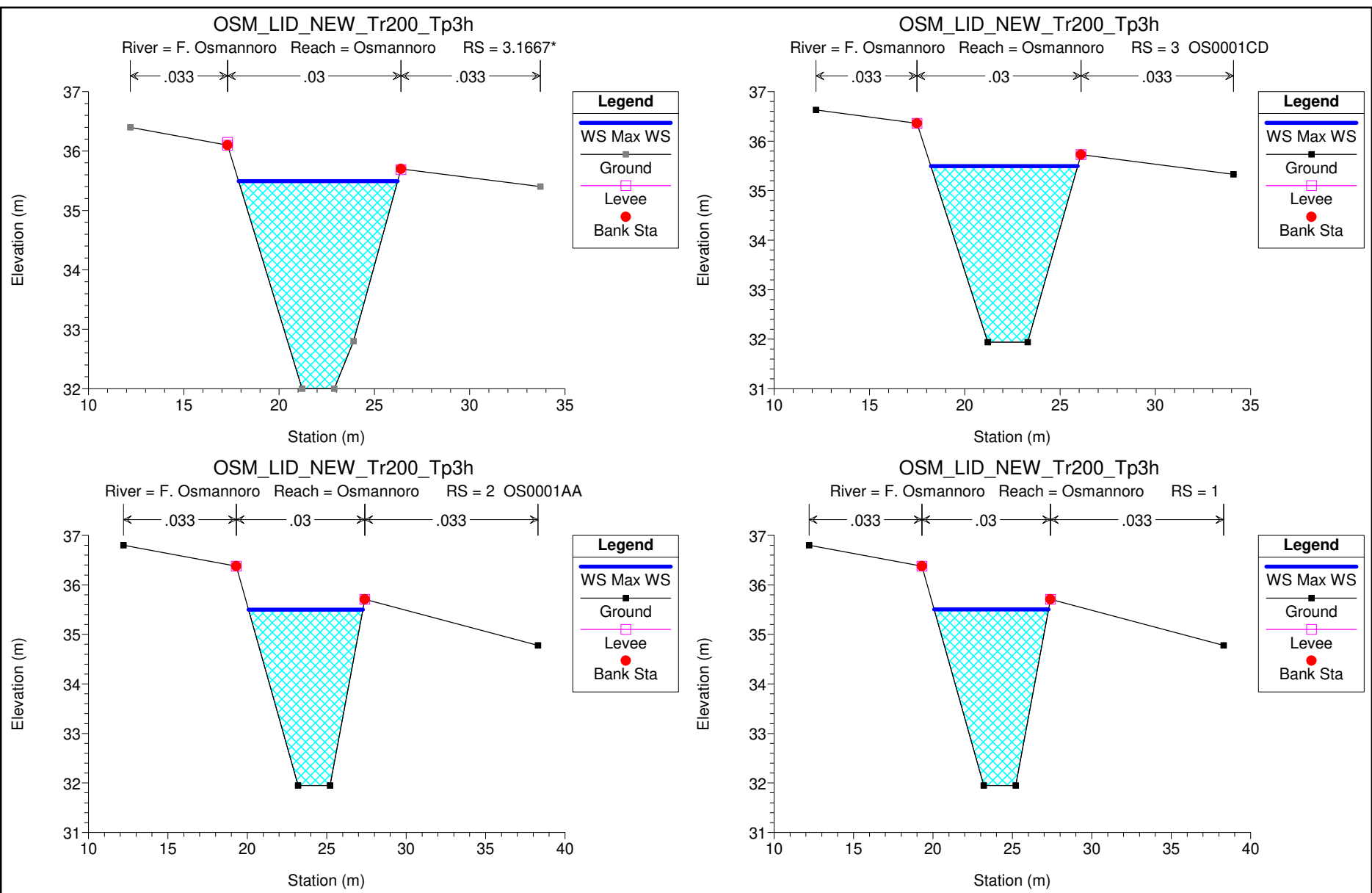


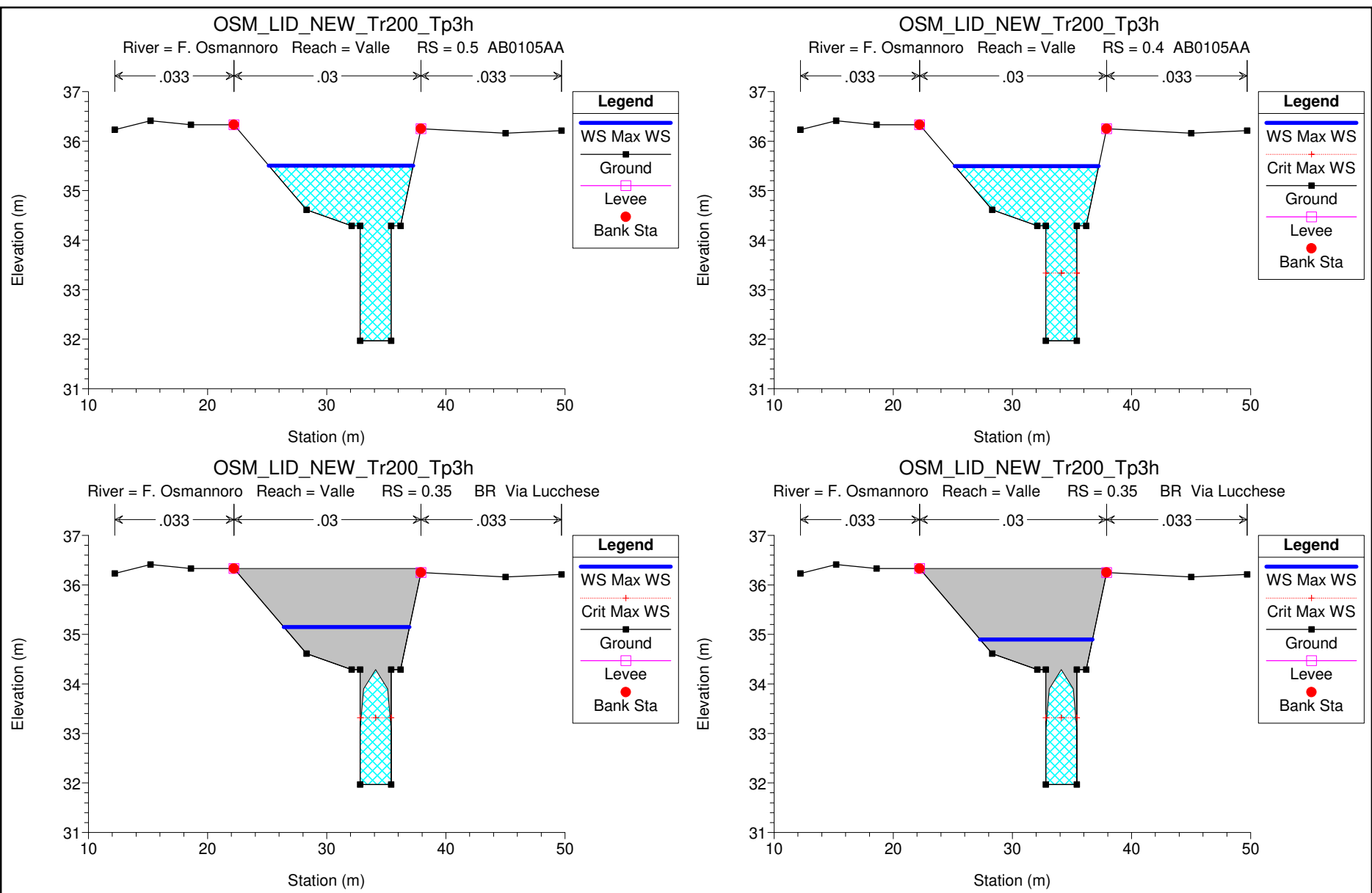


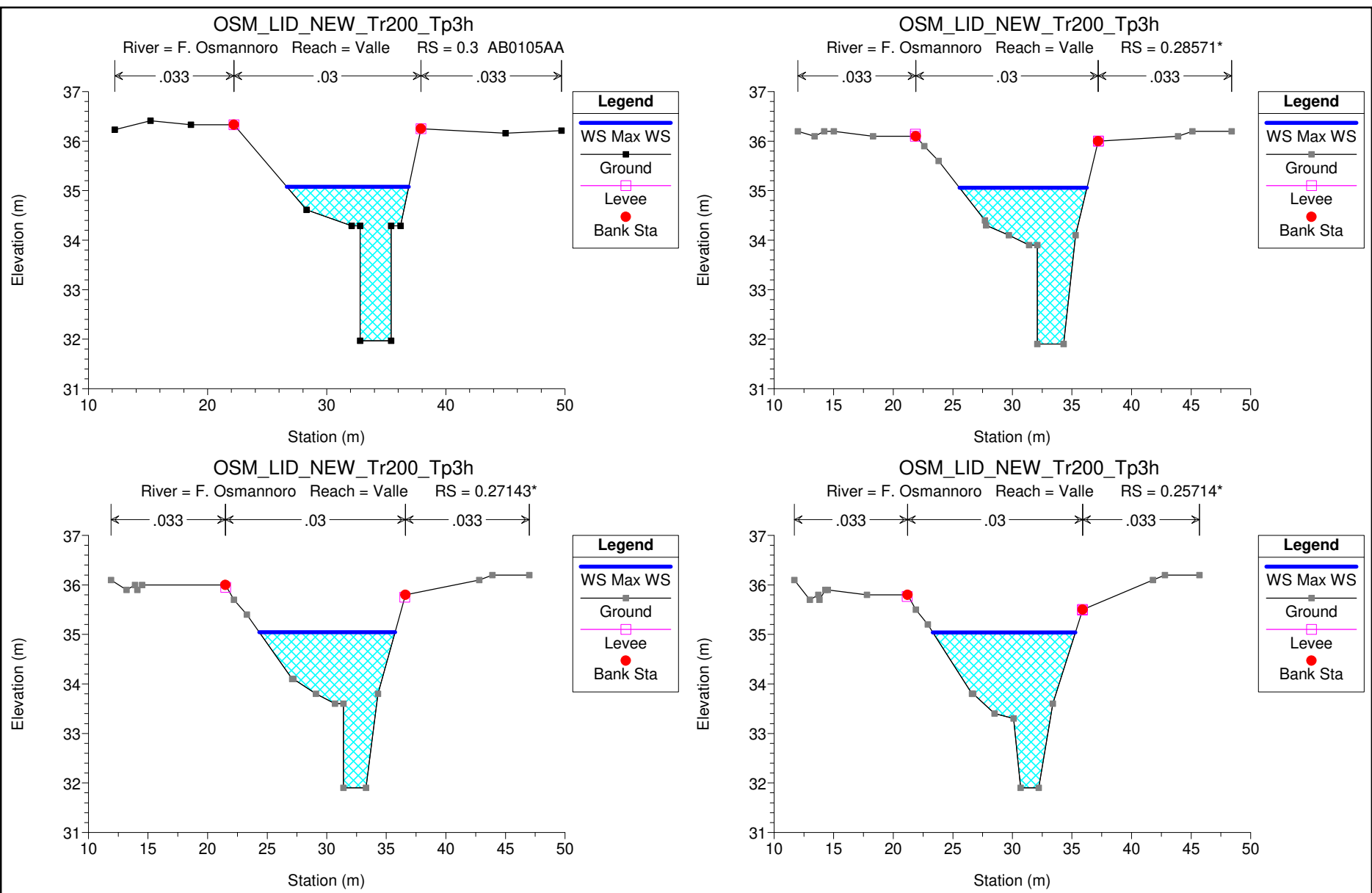


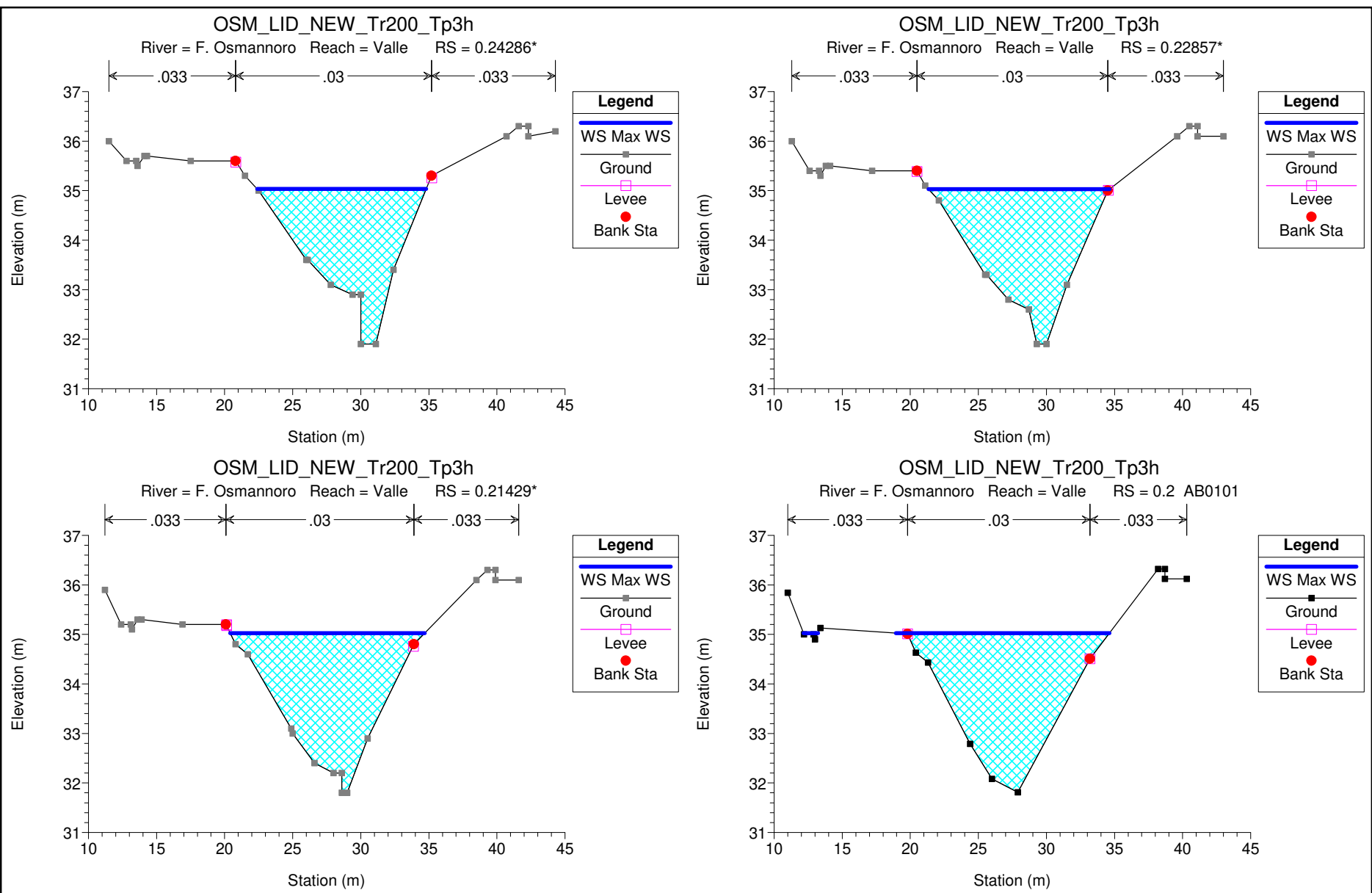


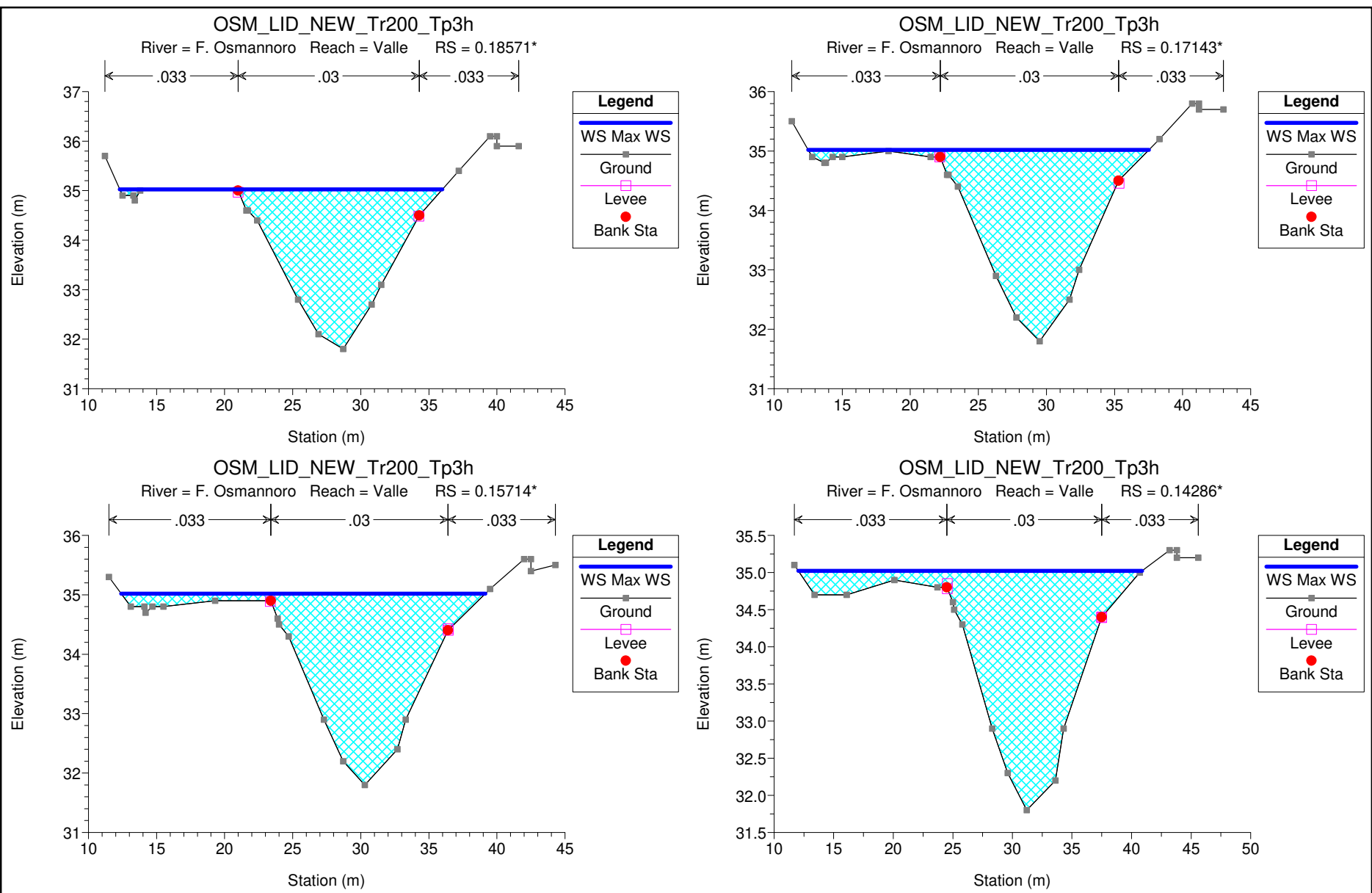


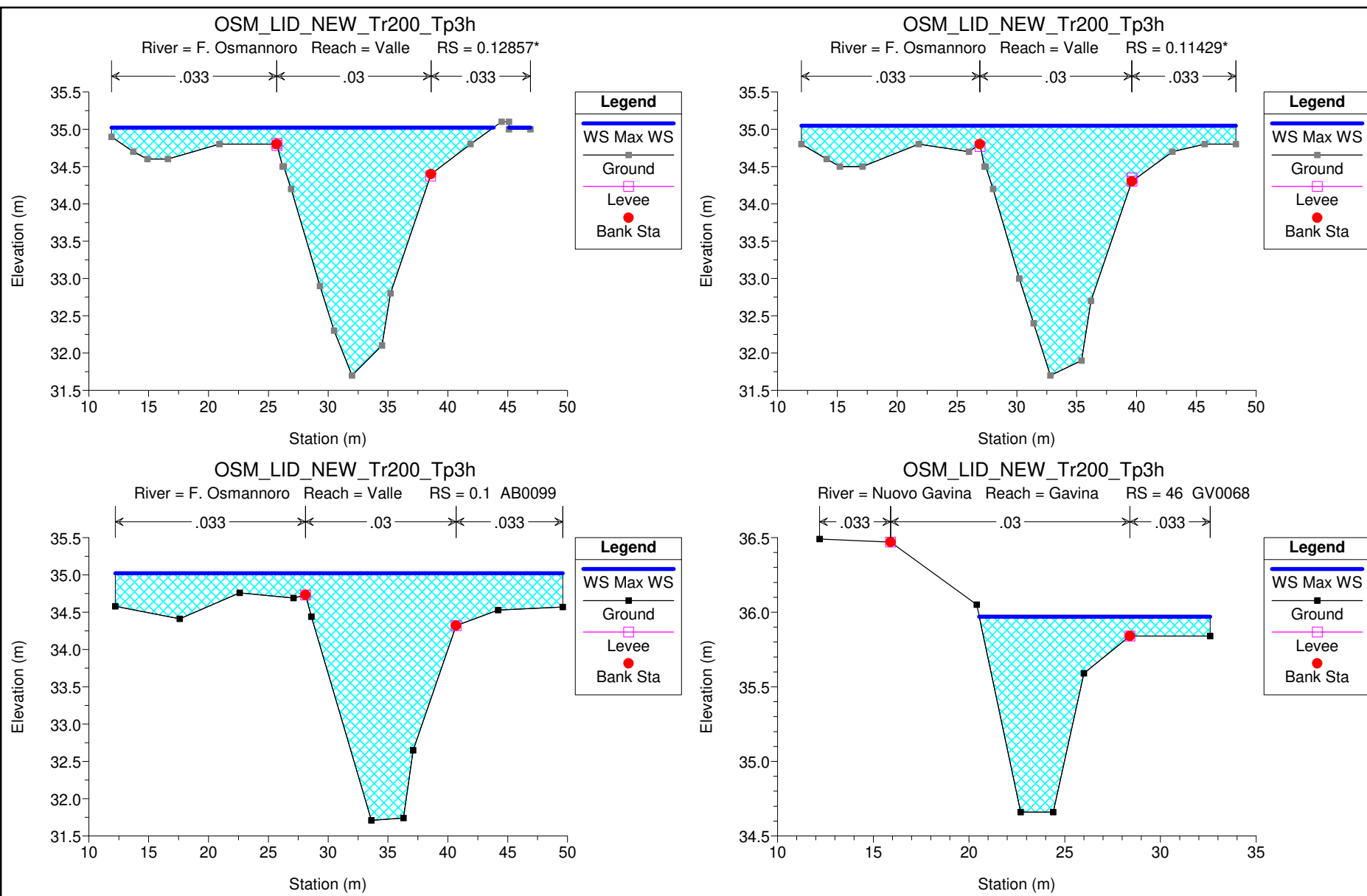


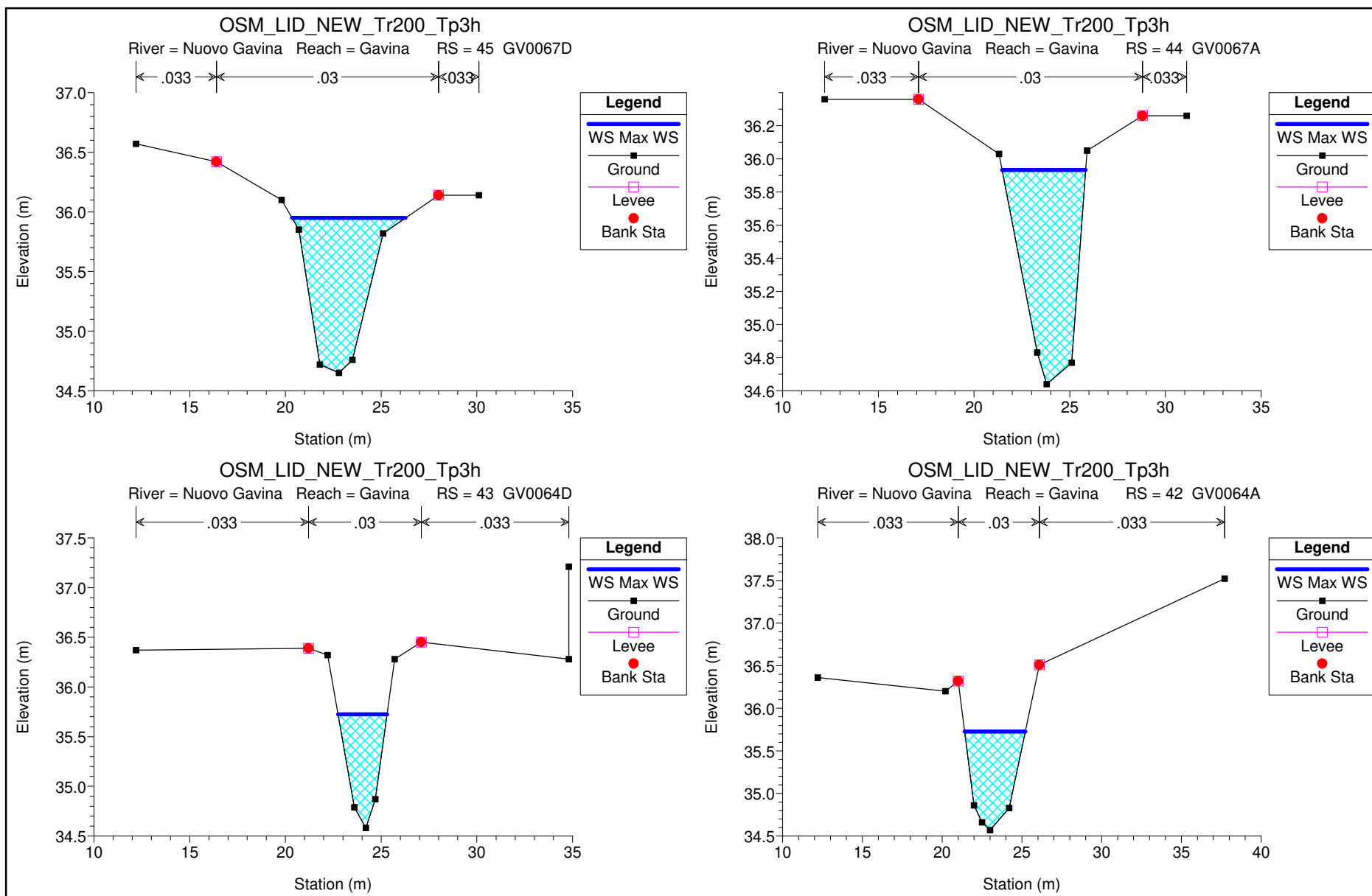


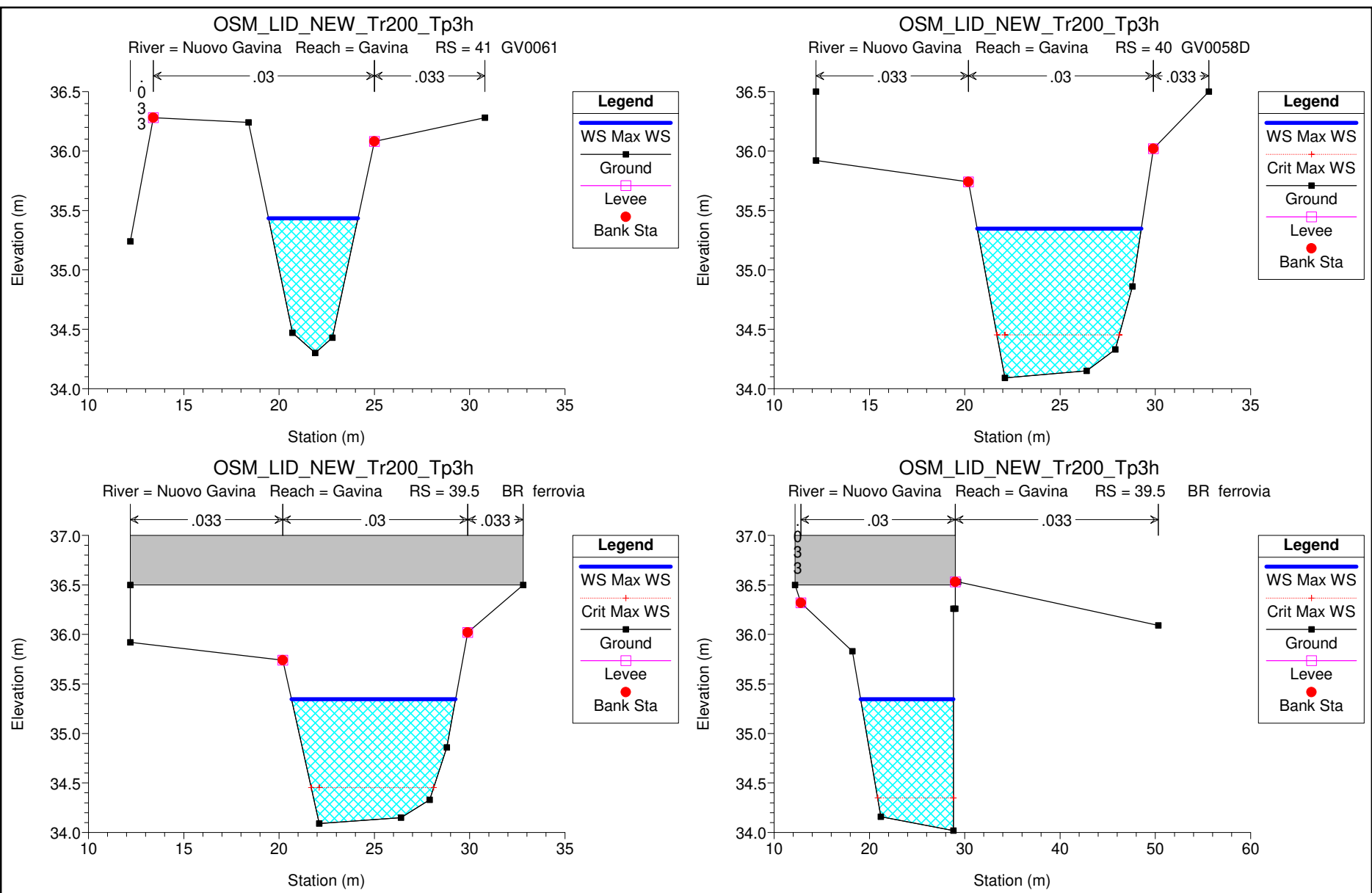


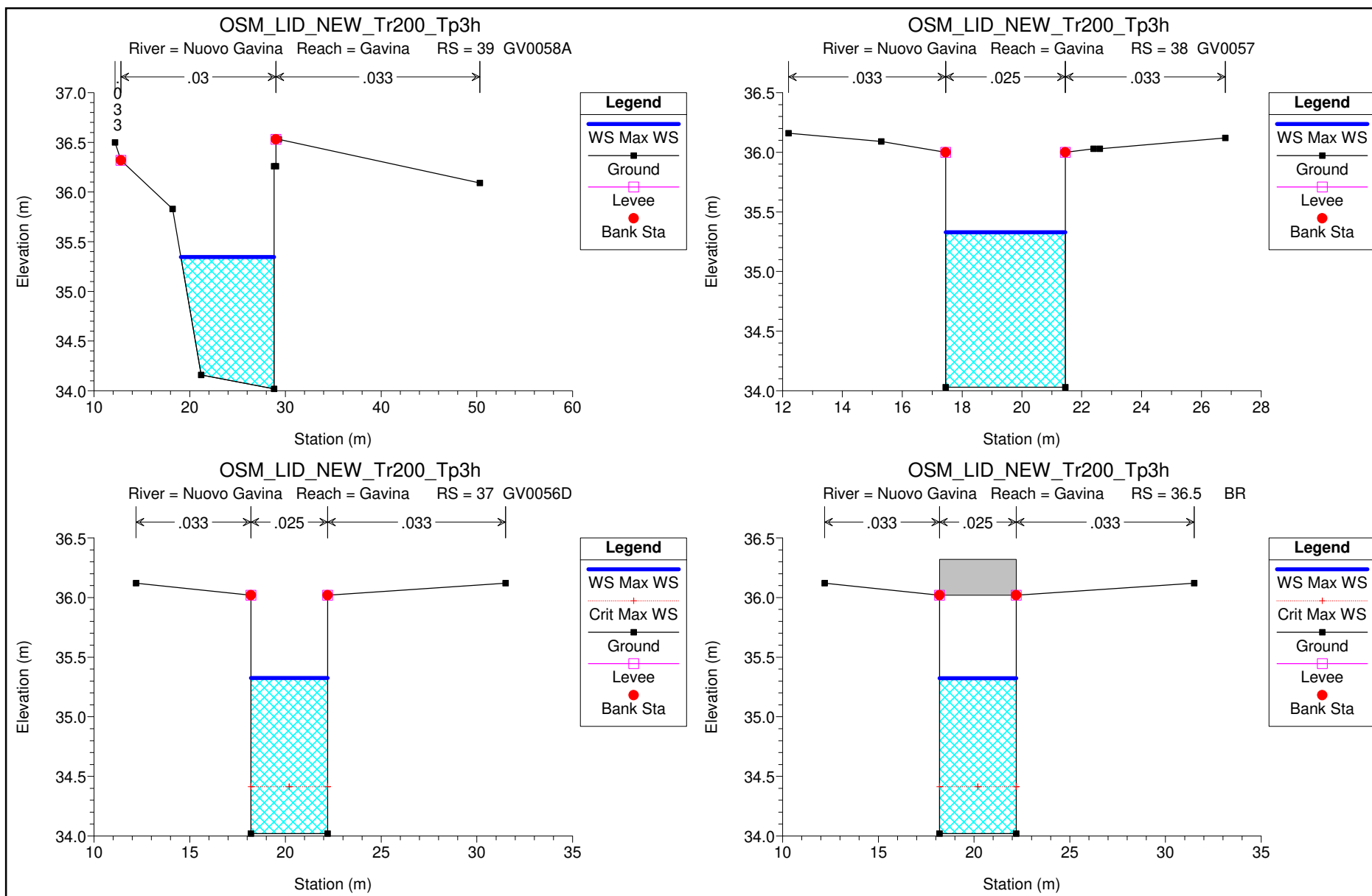


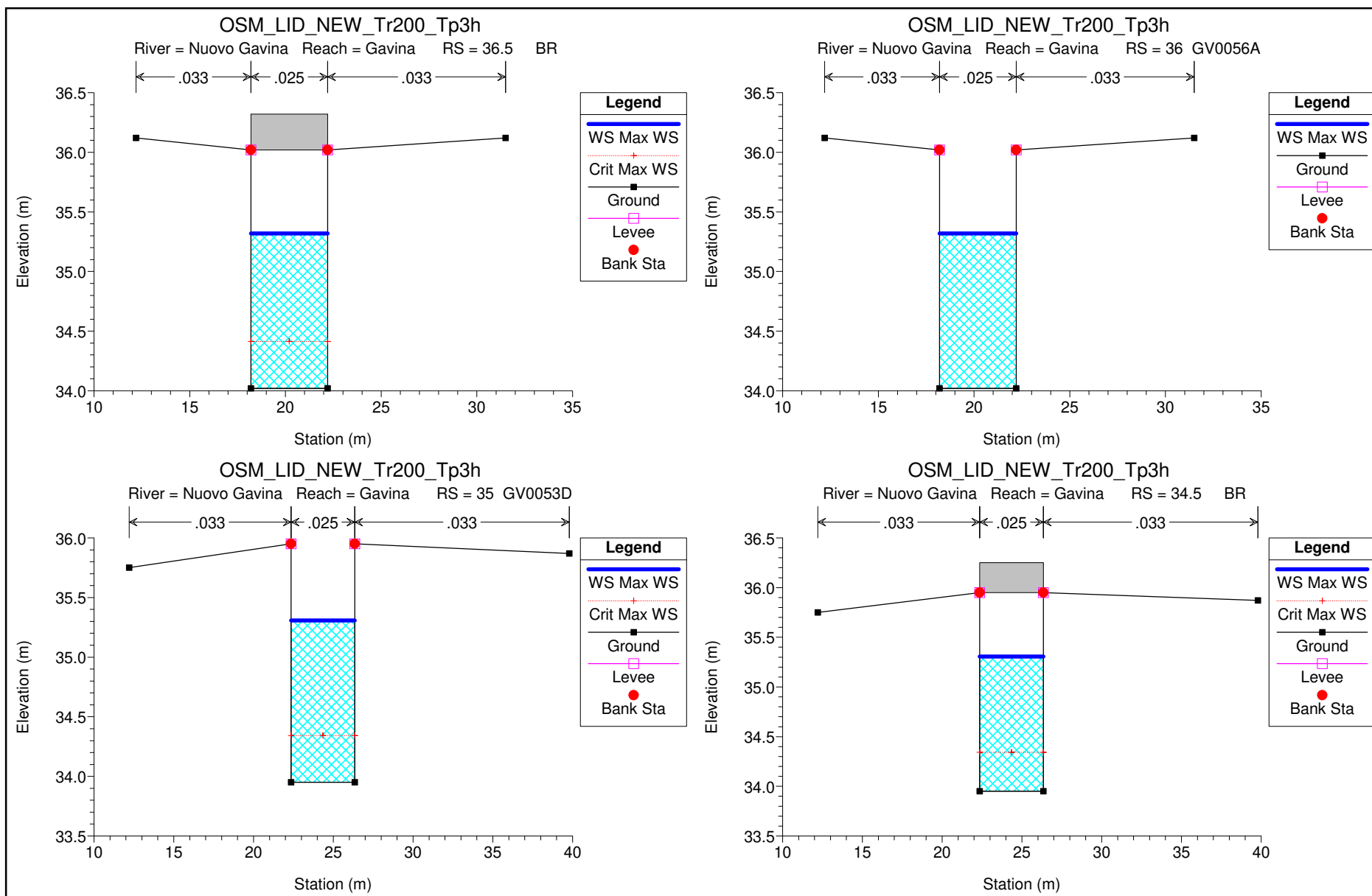


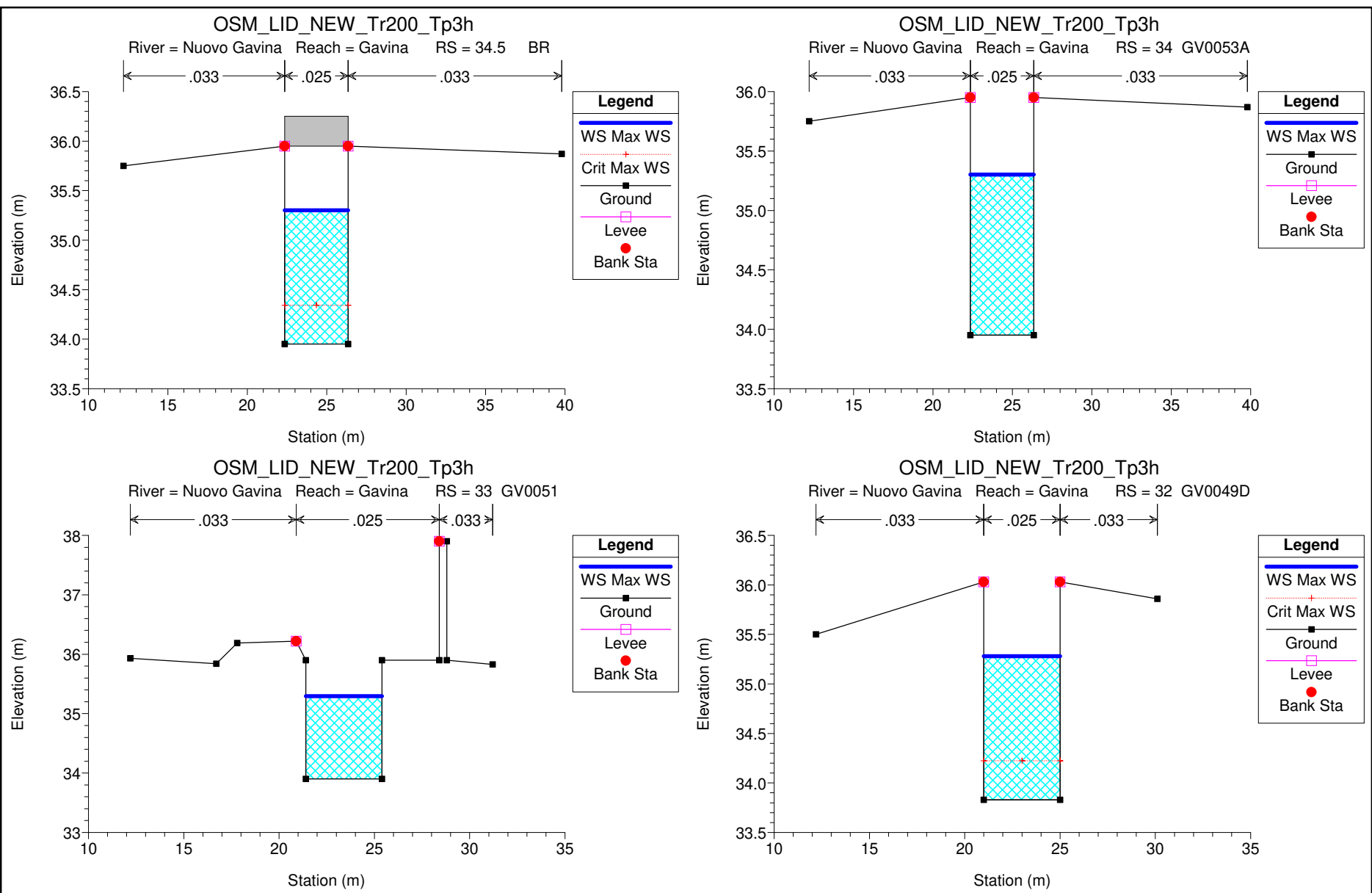


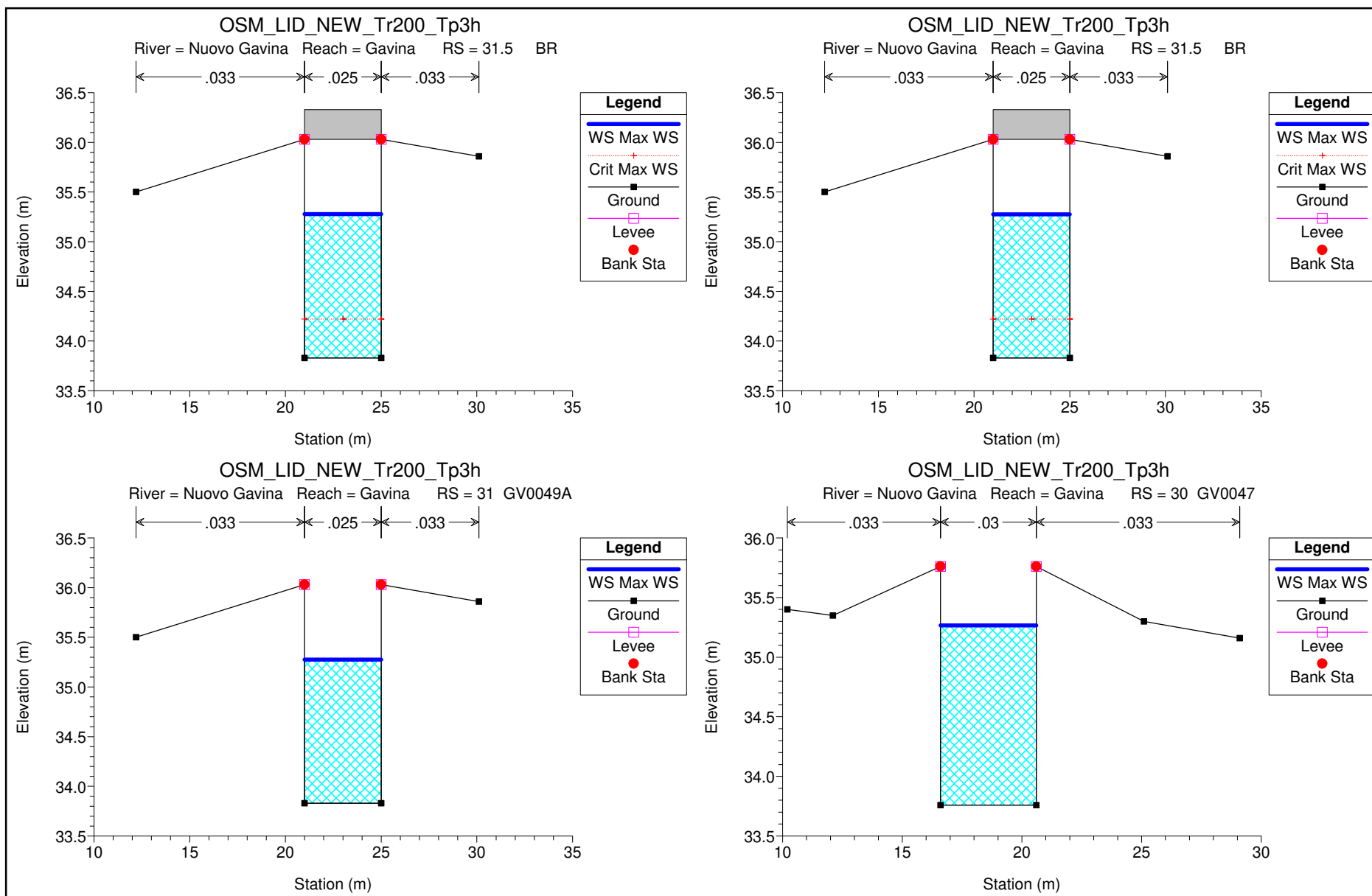


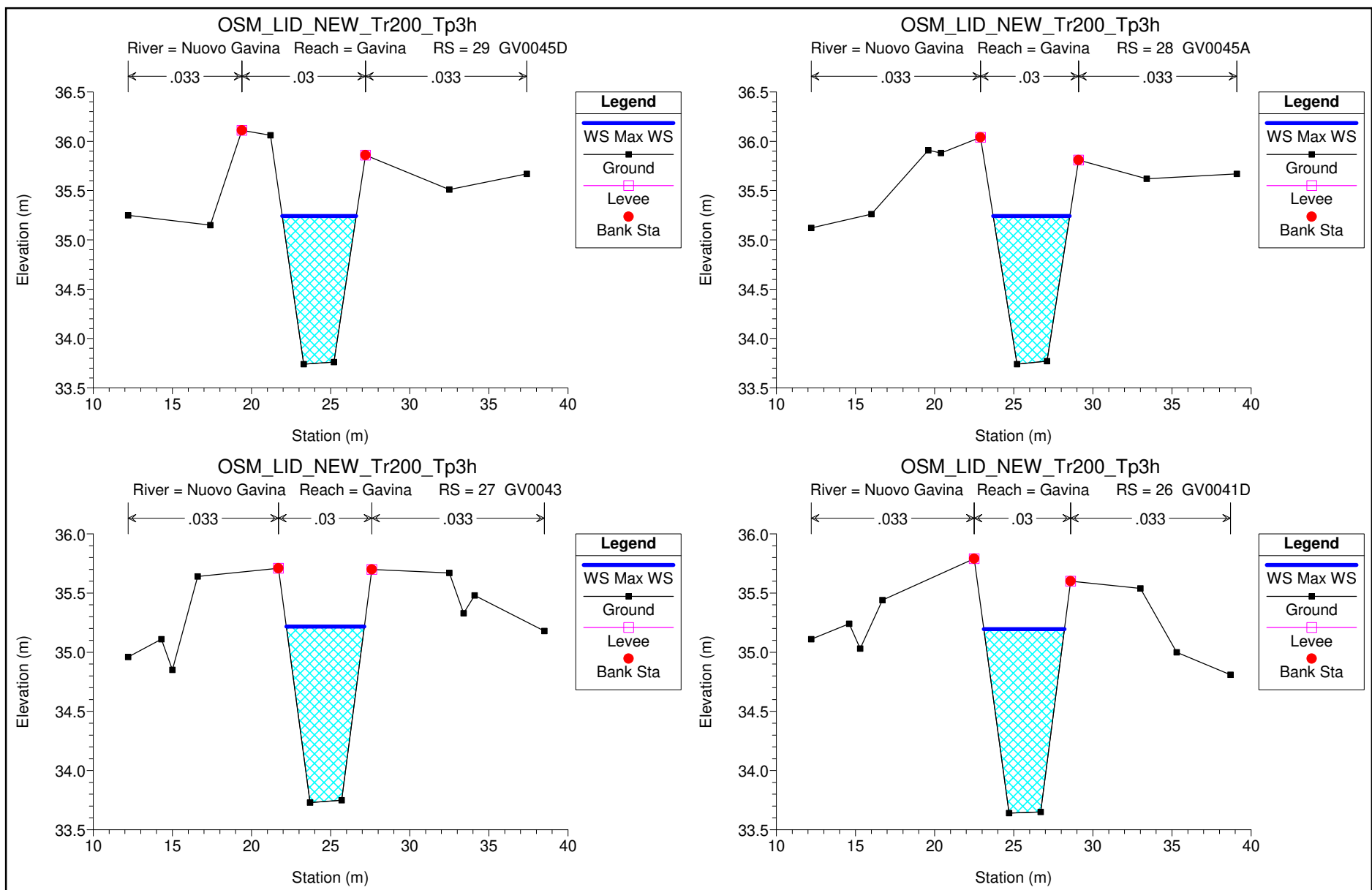


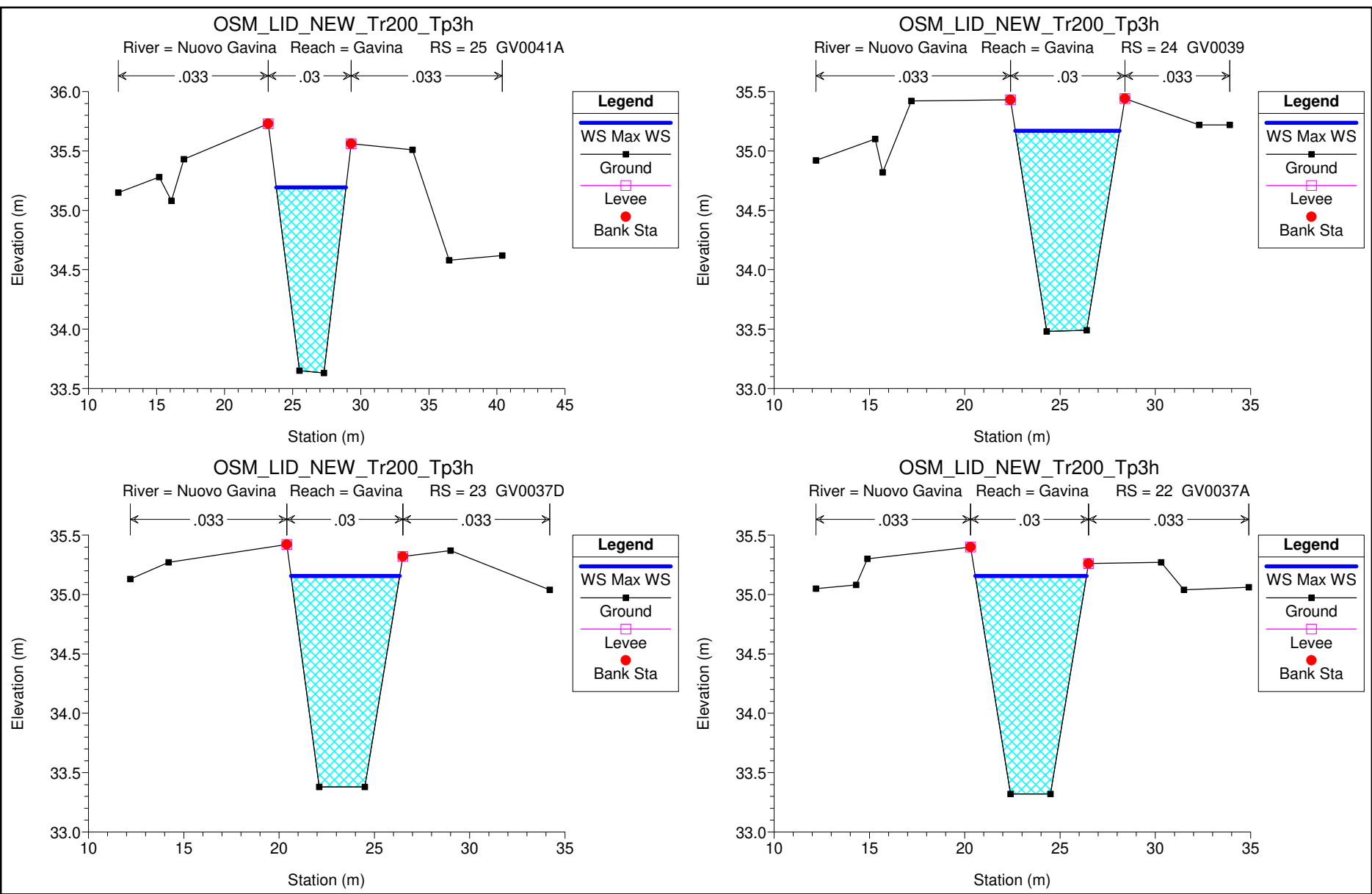


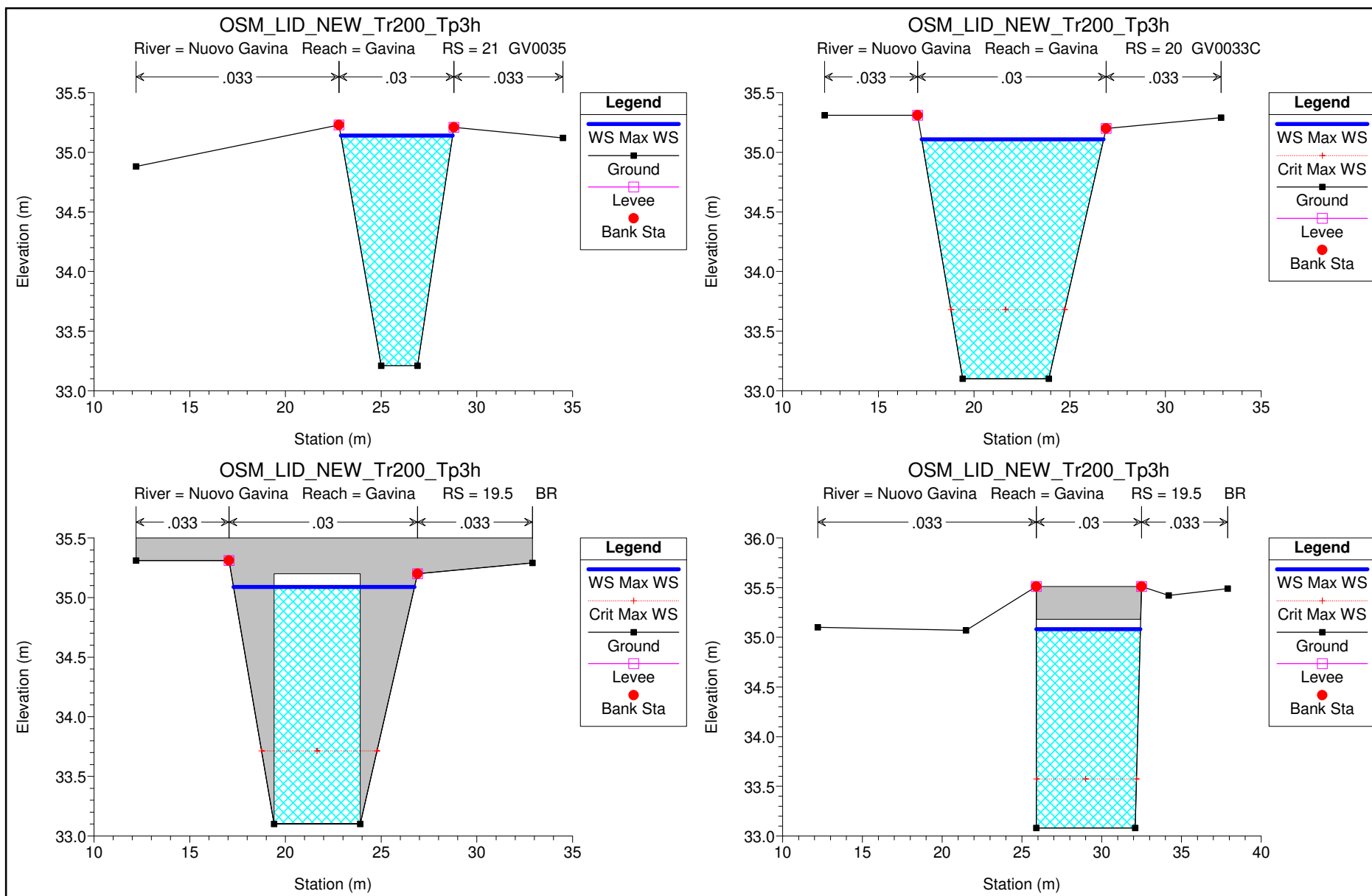


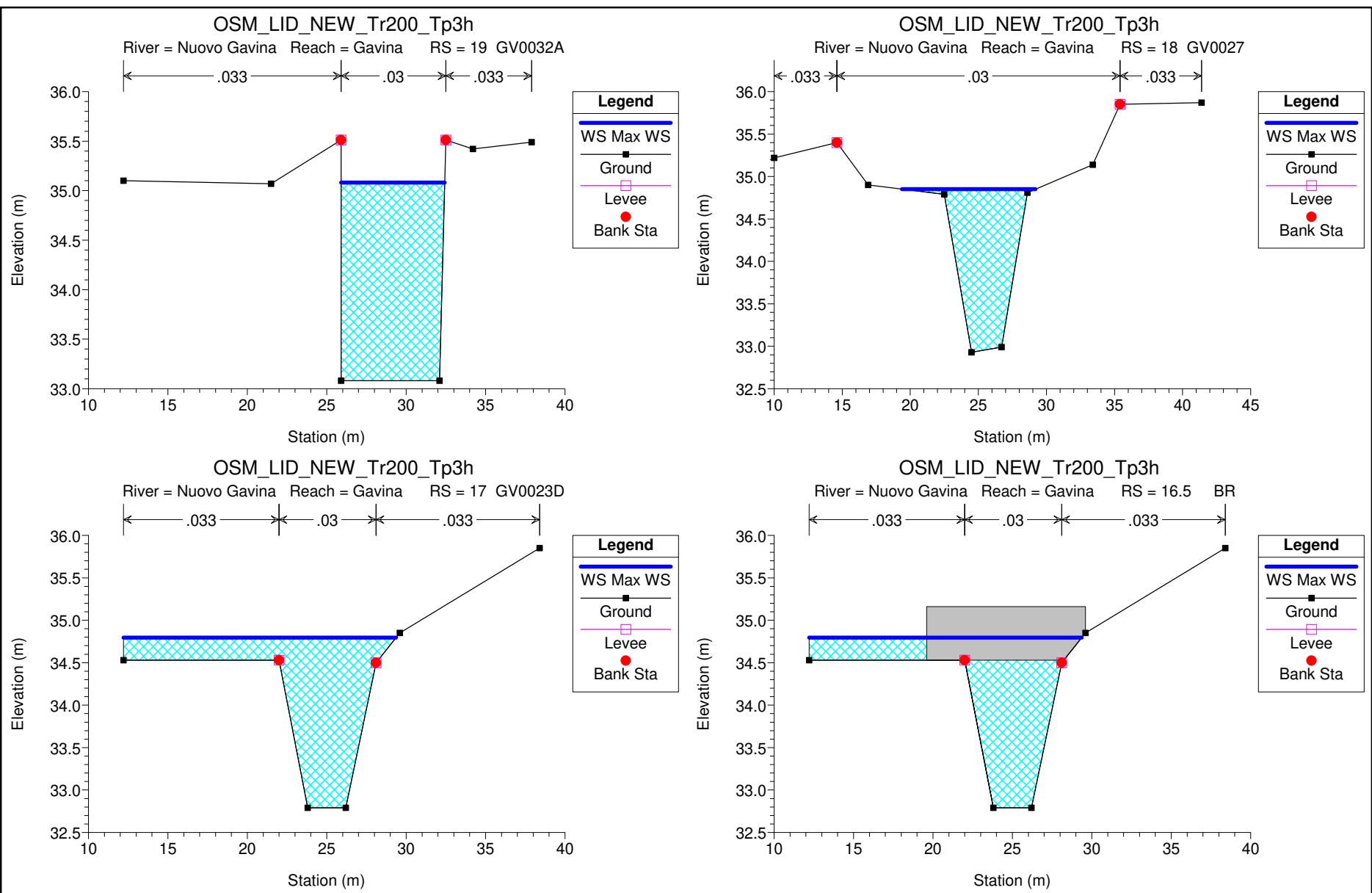


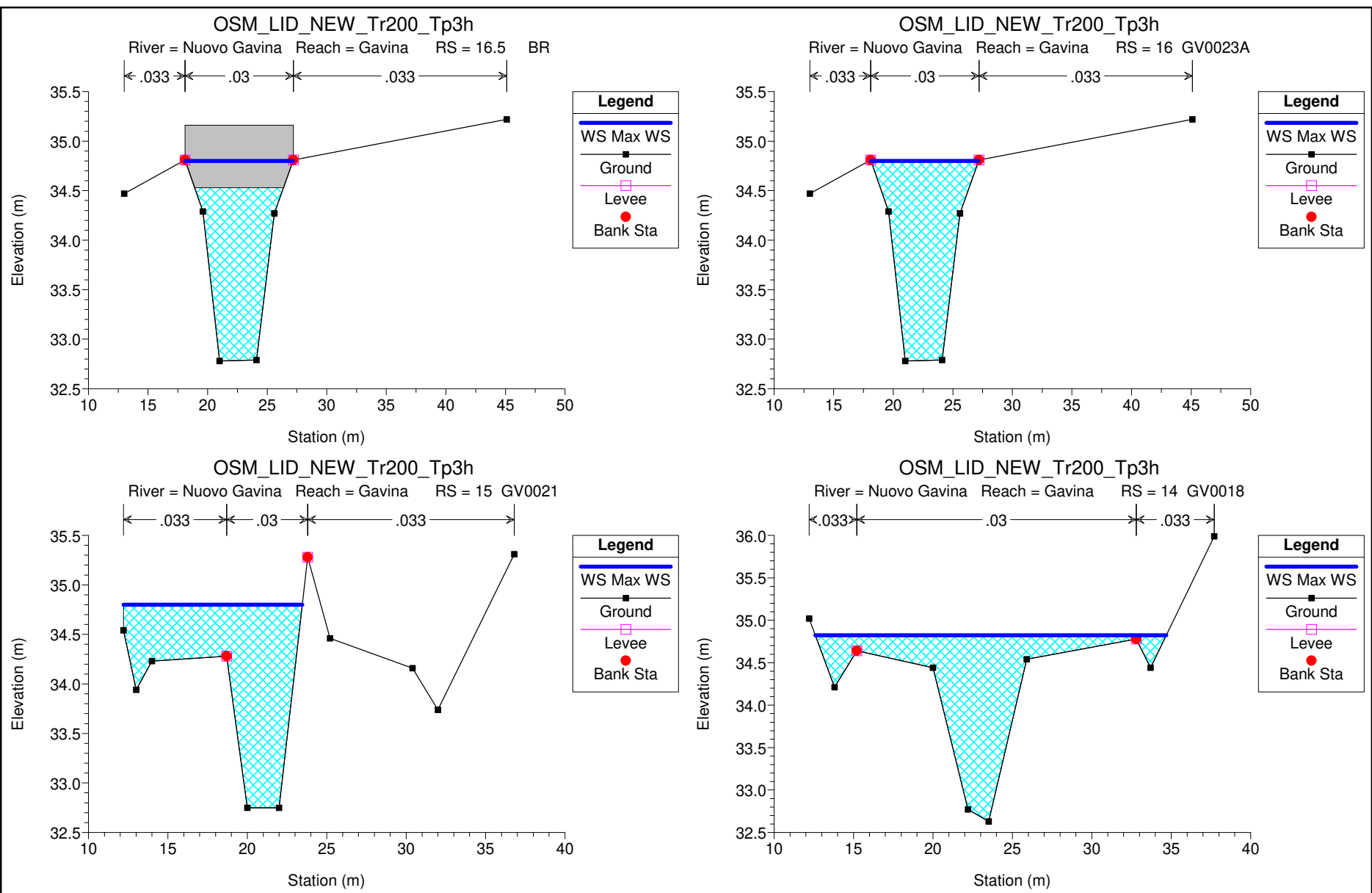


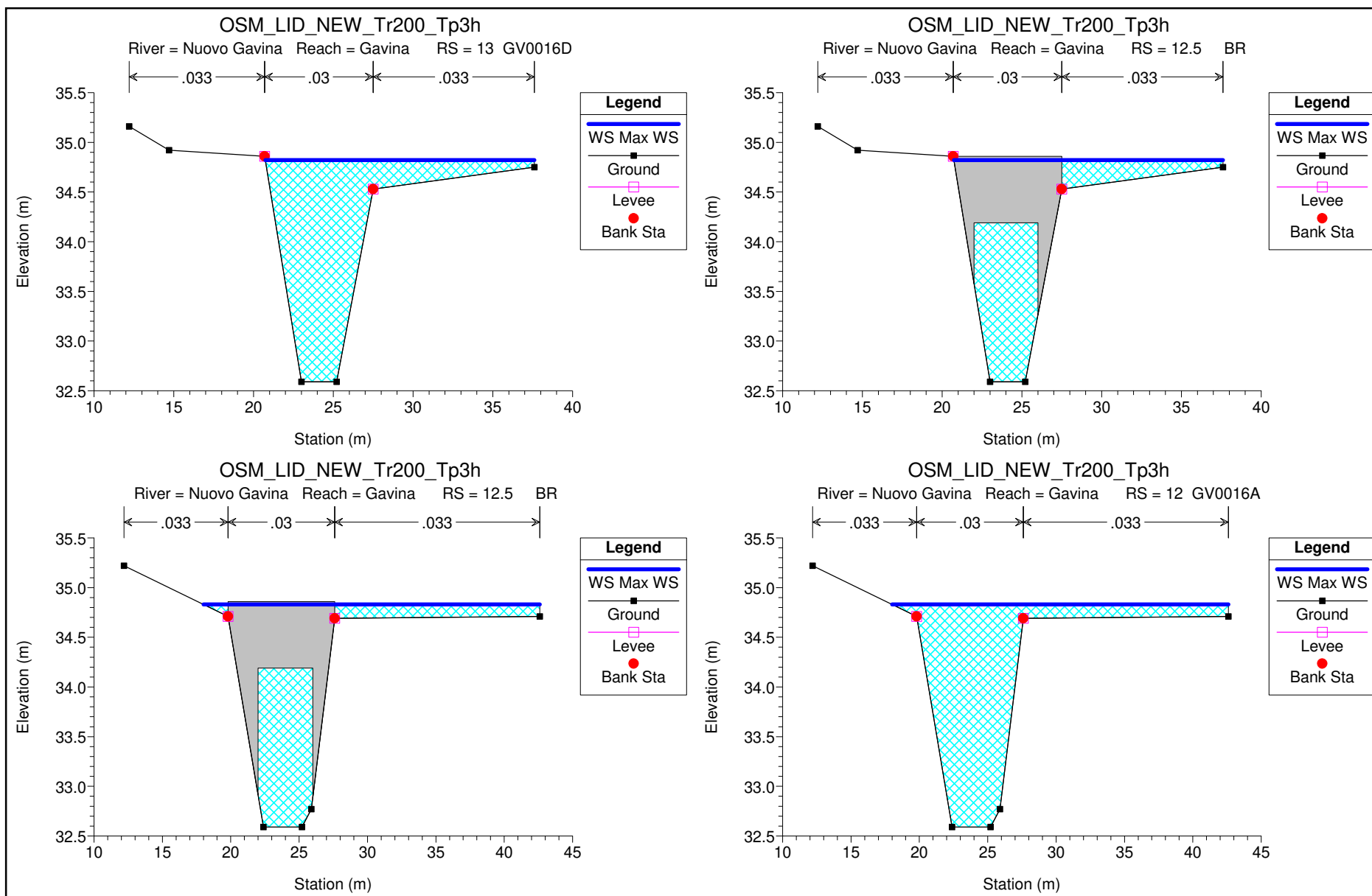


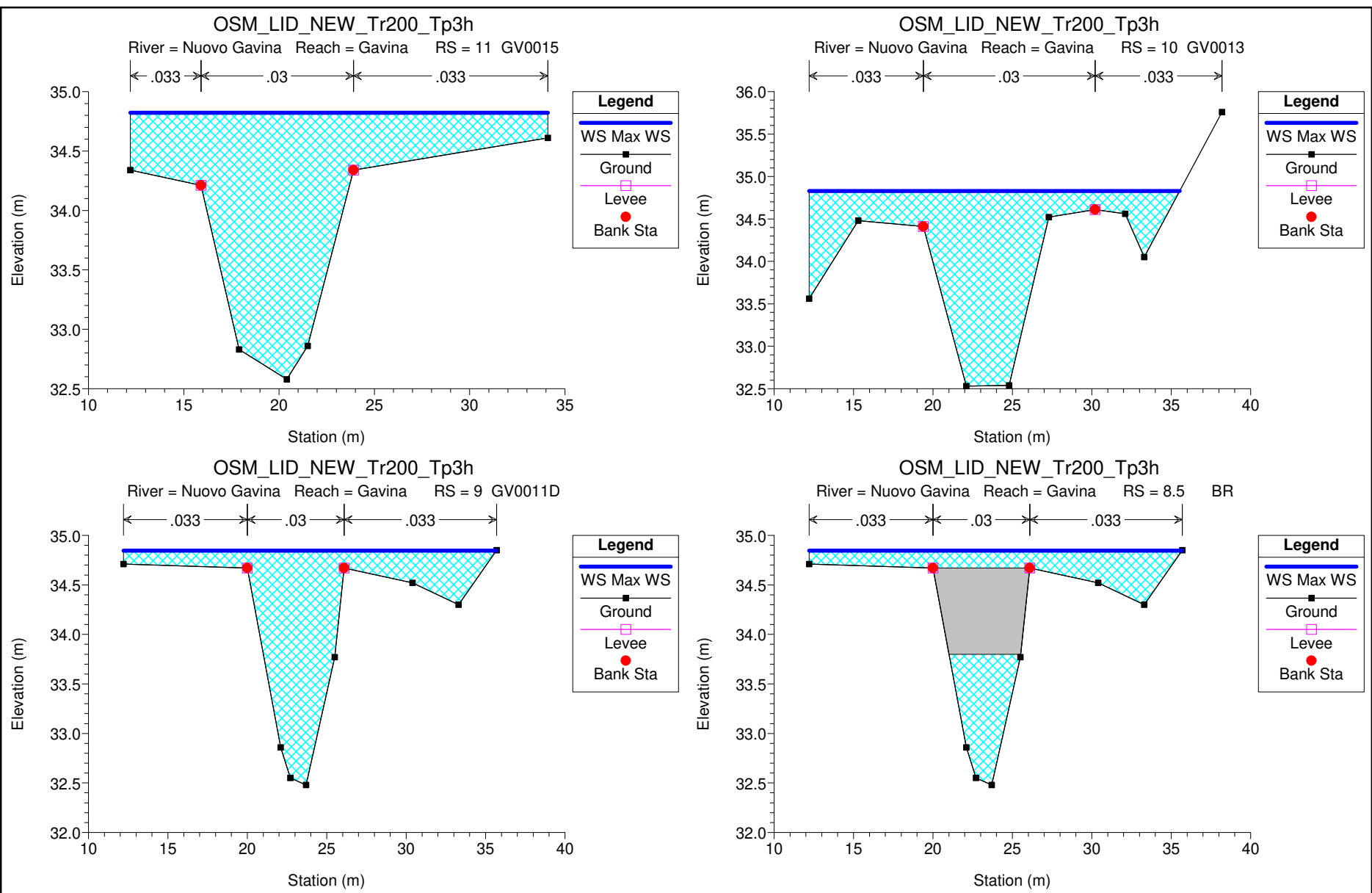


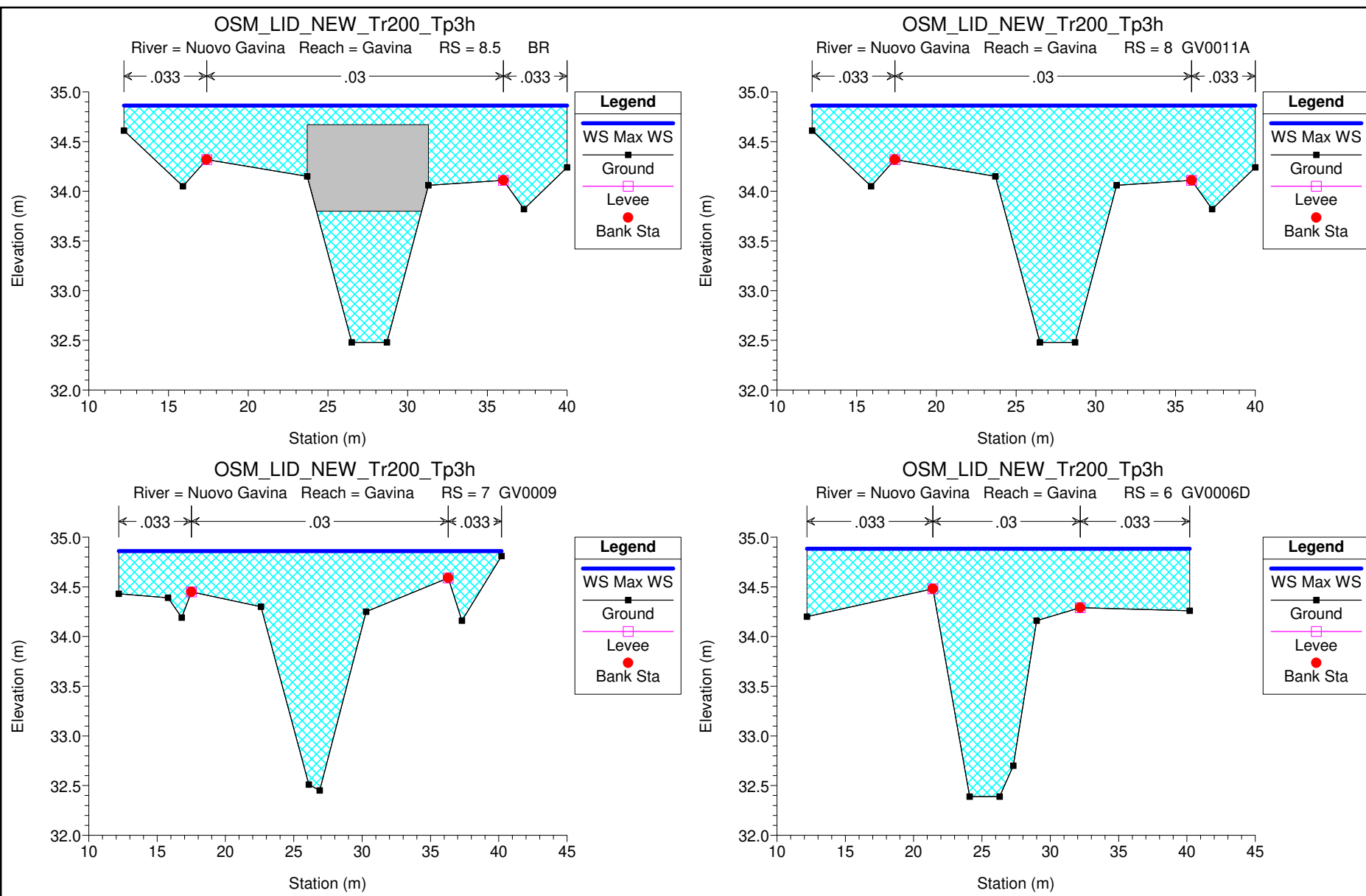


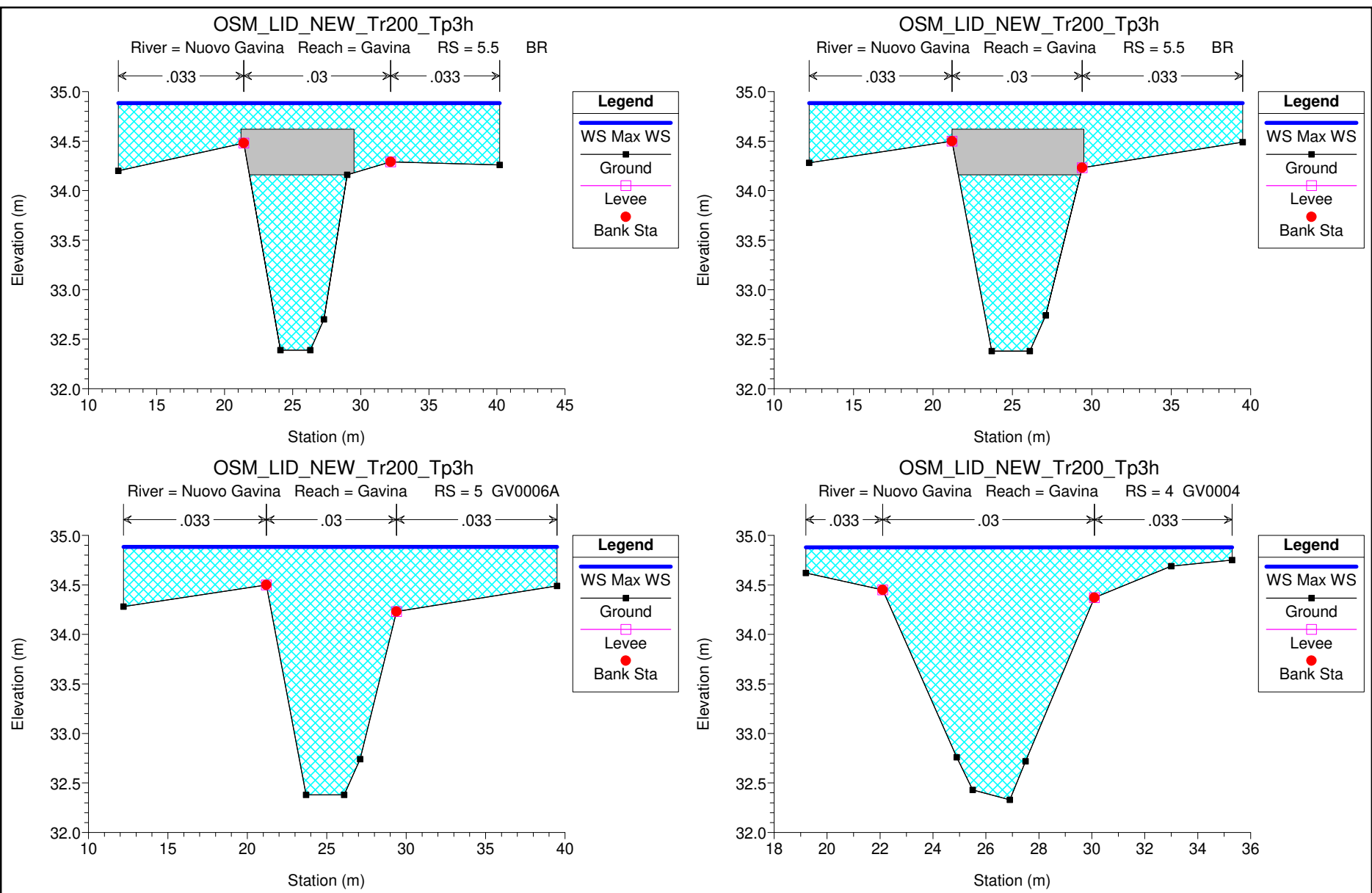


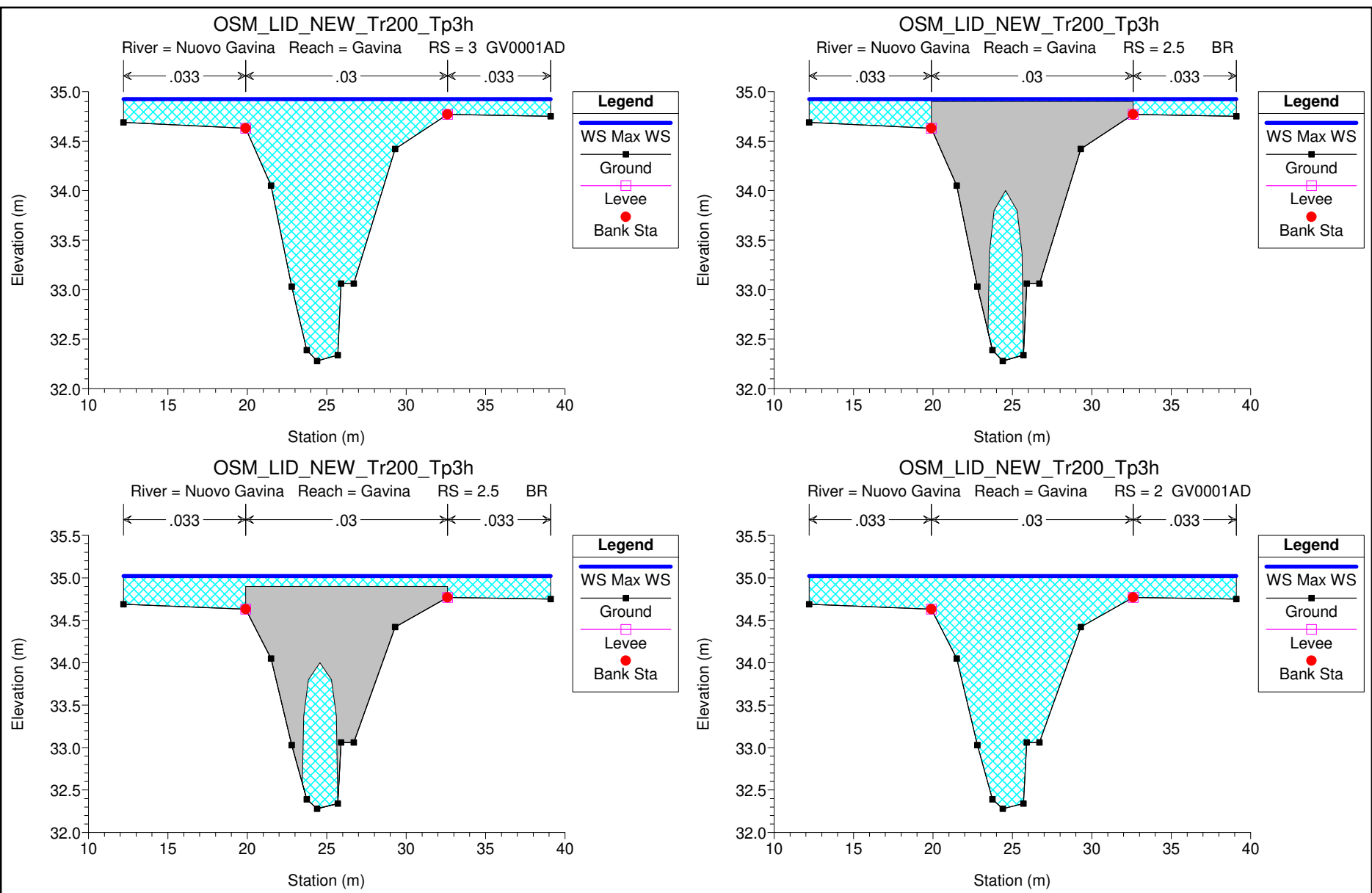








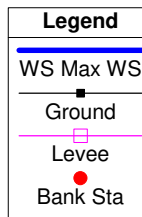
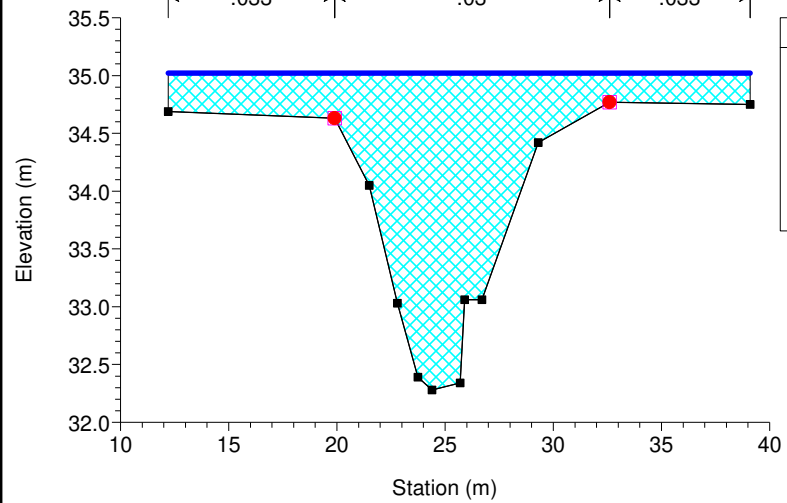




OSM_LID_NEW_Tr200_Tp3h

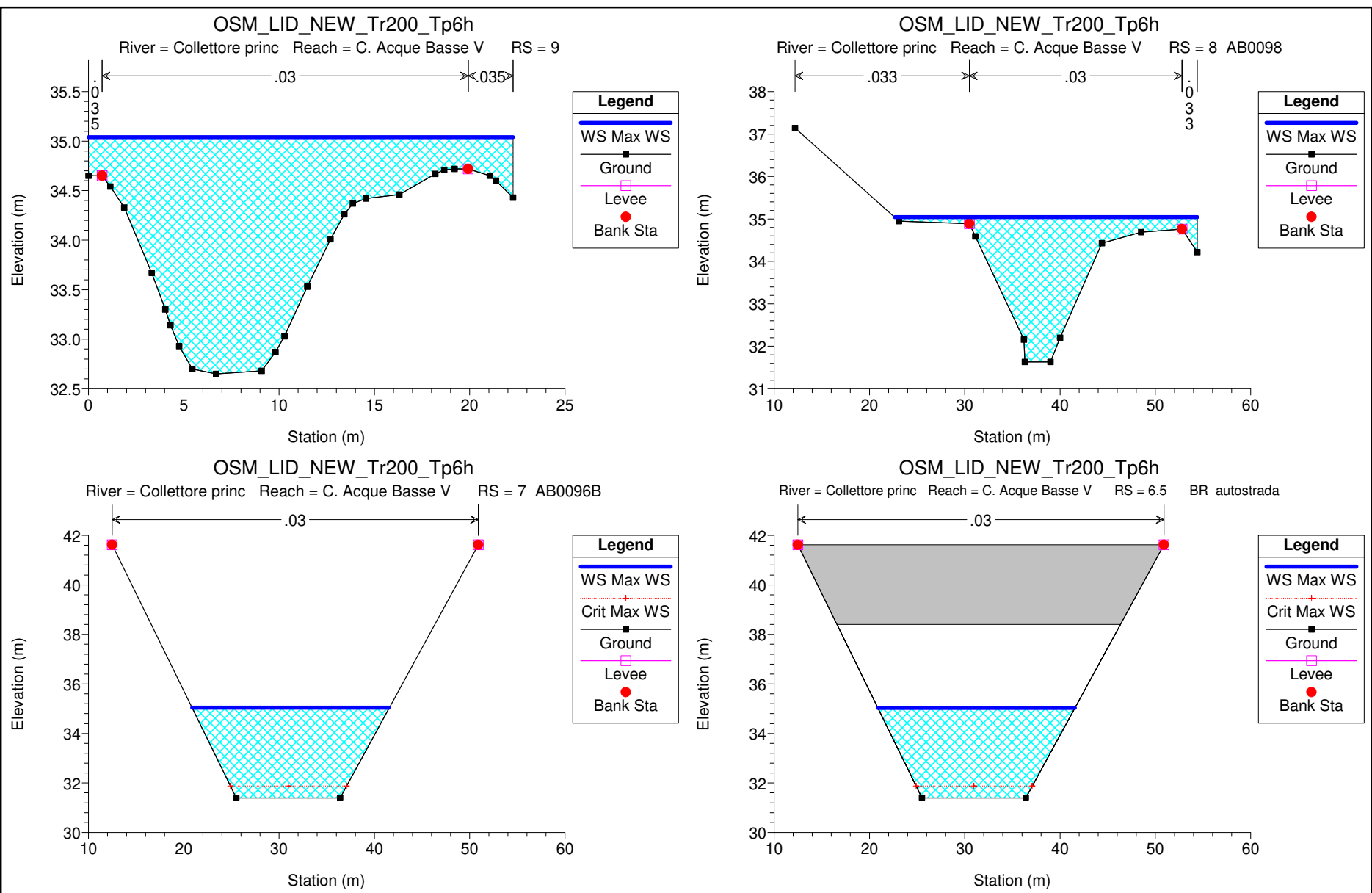
River = Nuovo Gavina Reach = Gavina RS = 1 GV0001AD

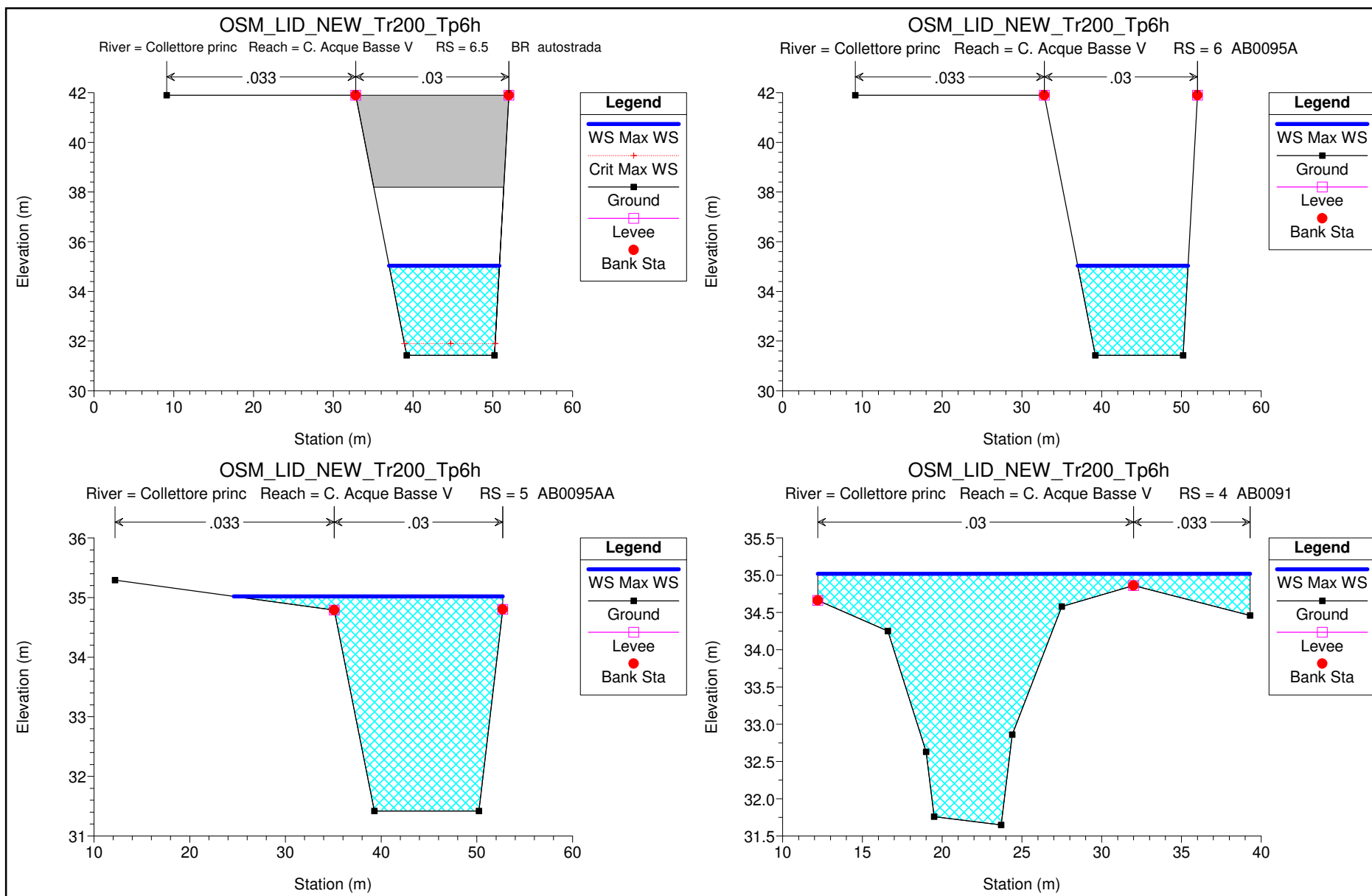
← .033 → ← .03 → ← .033 →

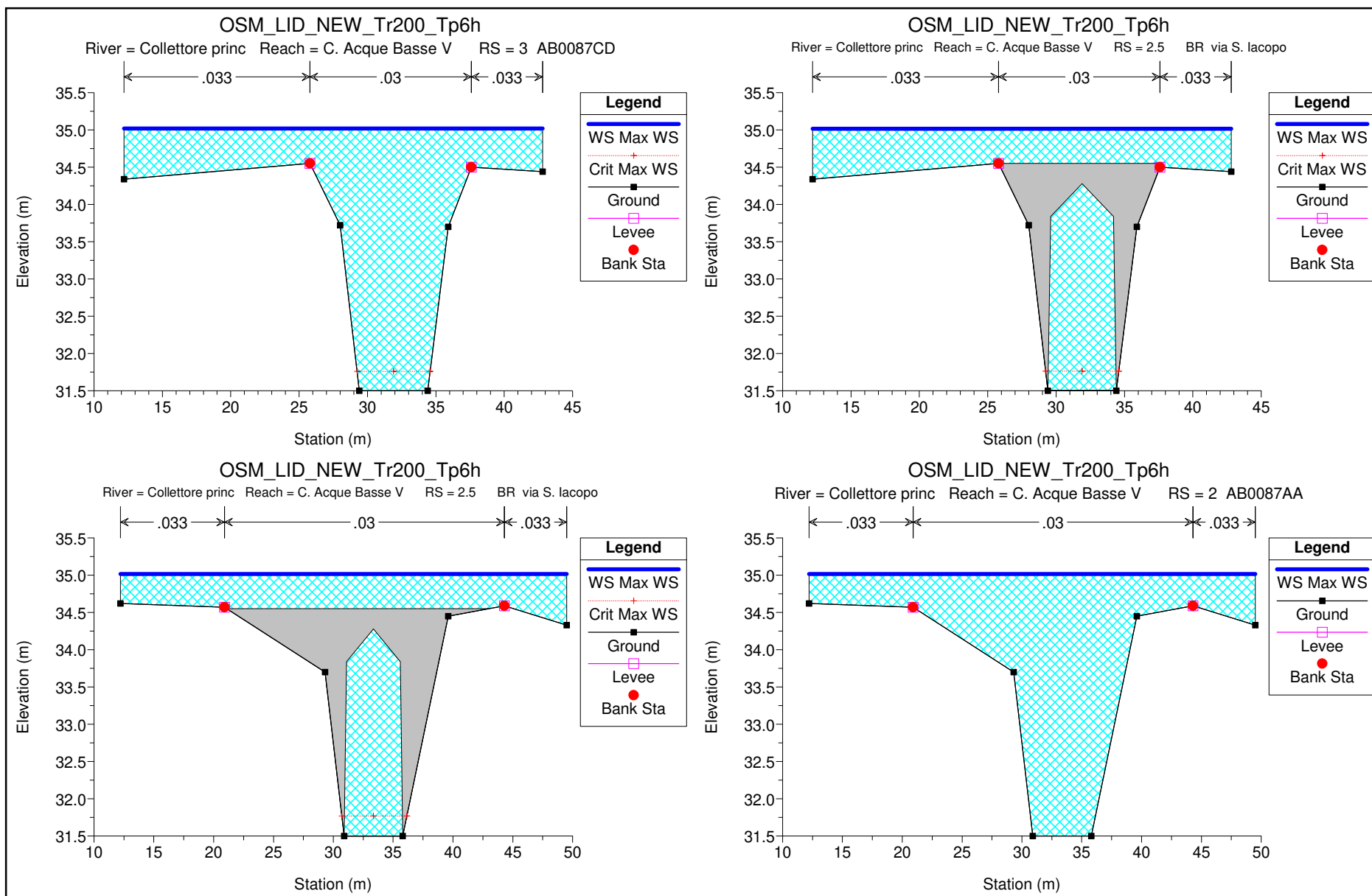


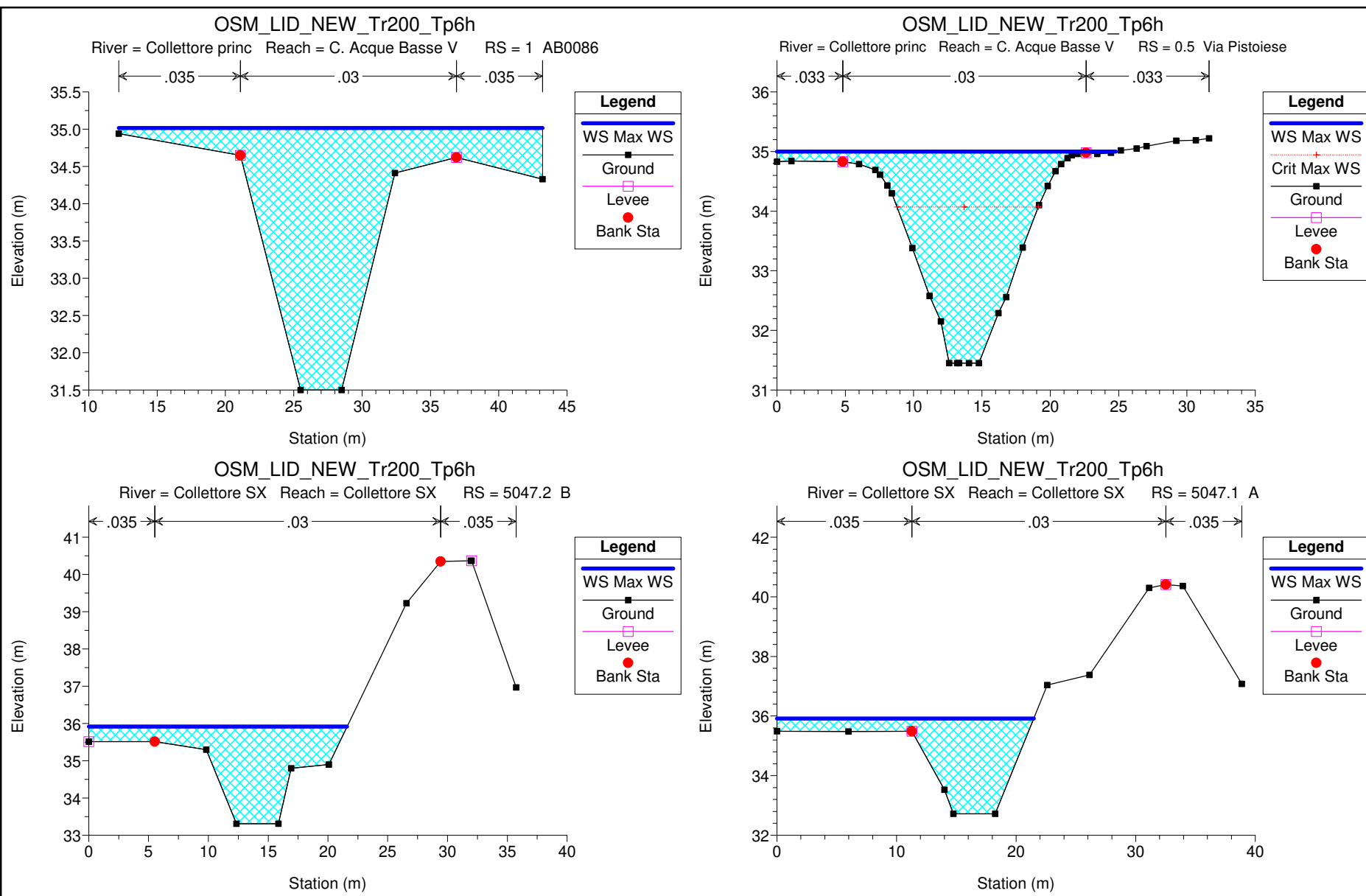
Verifiche idrauliche Tr 200 anni Tp 6h

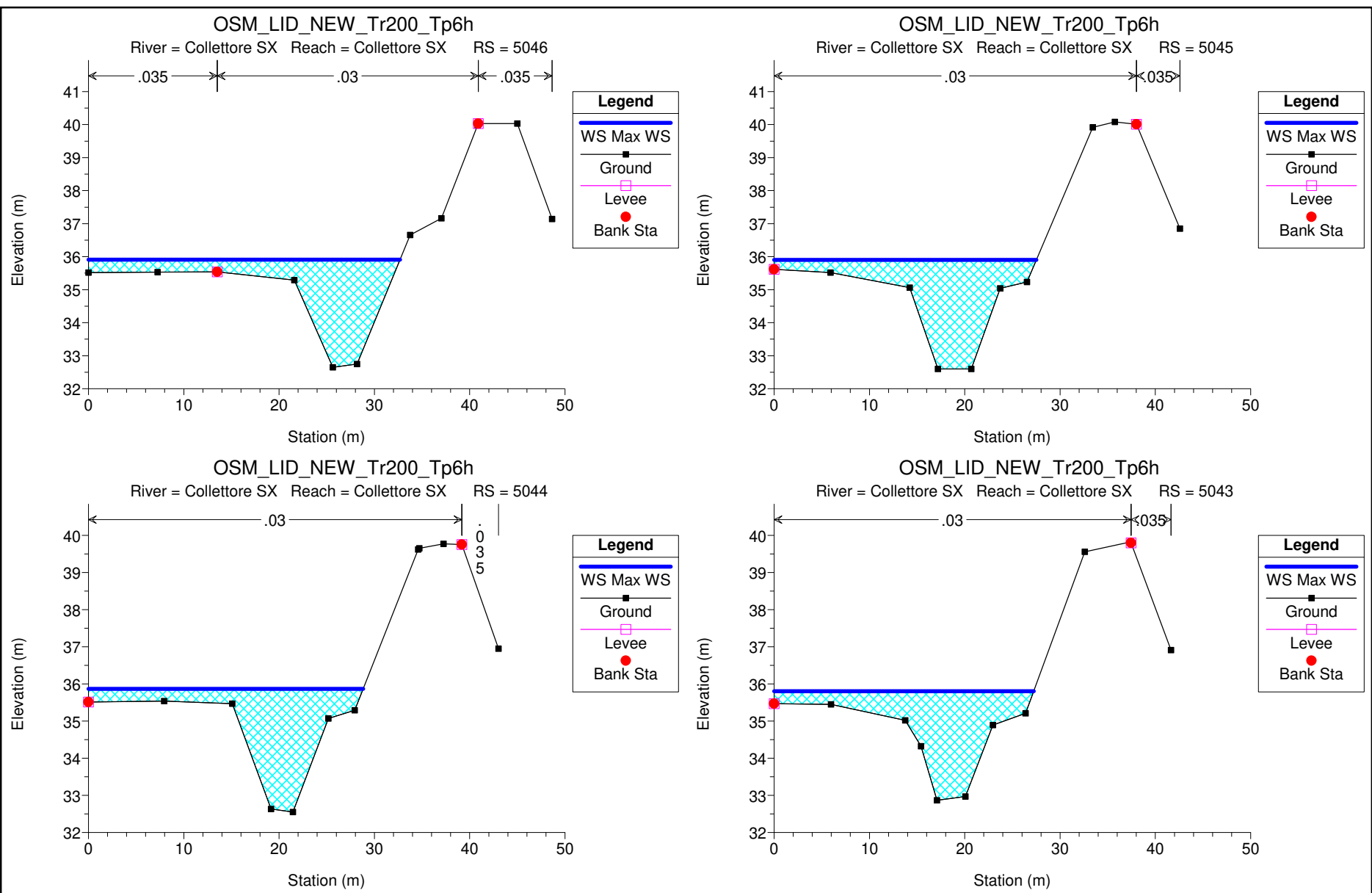
**Collettore sinistro acque basse – Fosso Osmannoro – Fosso Nuova Gavine – Collettore
principale delle acque basse**

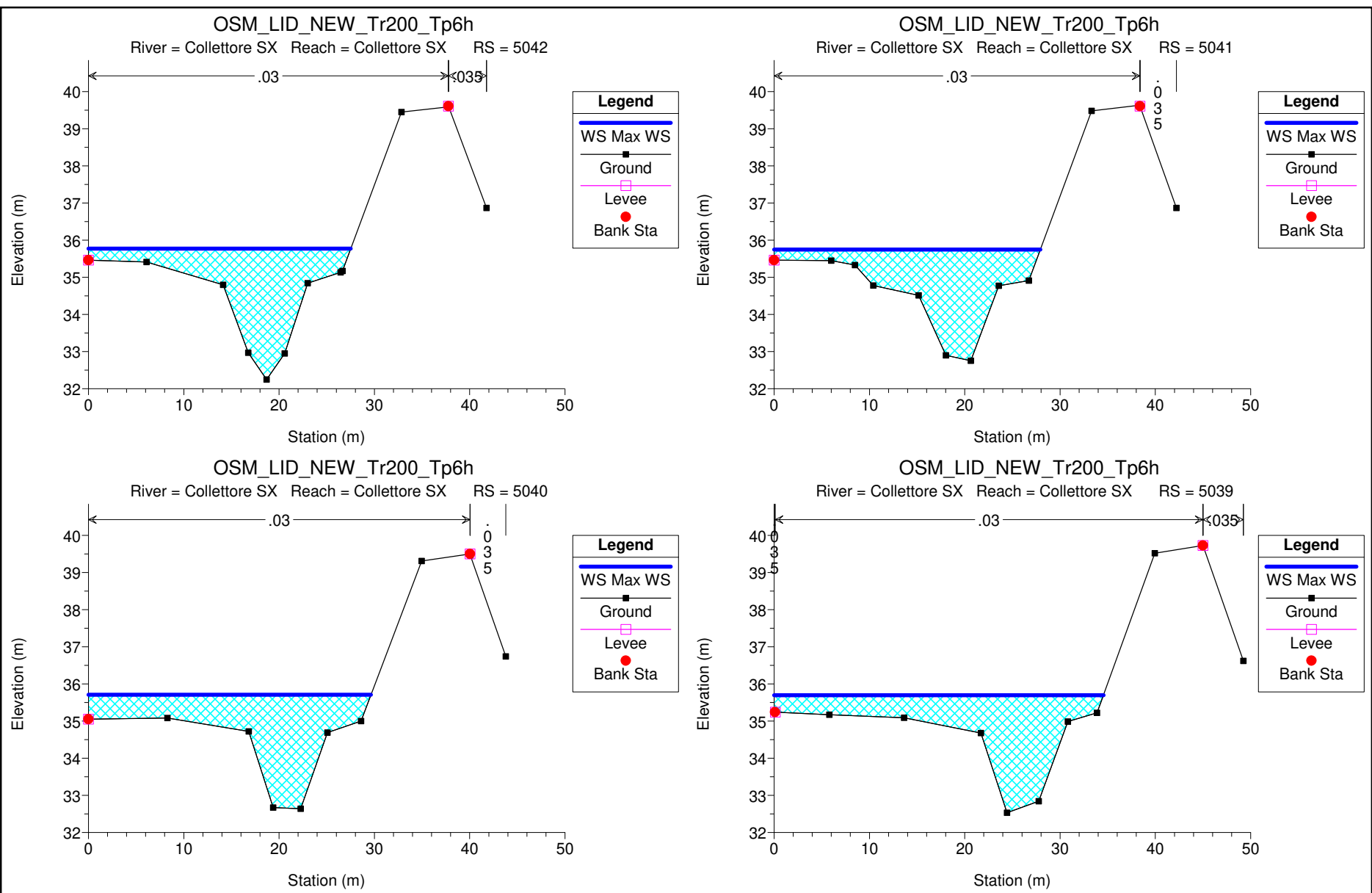


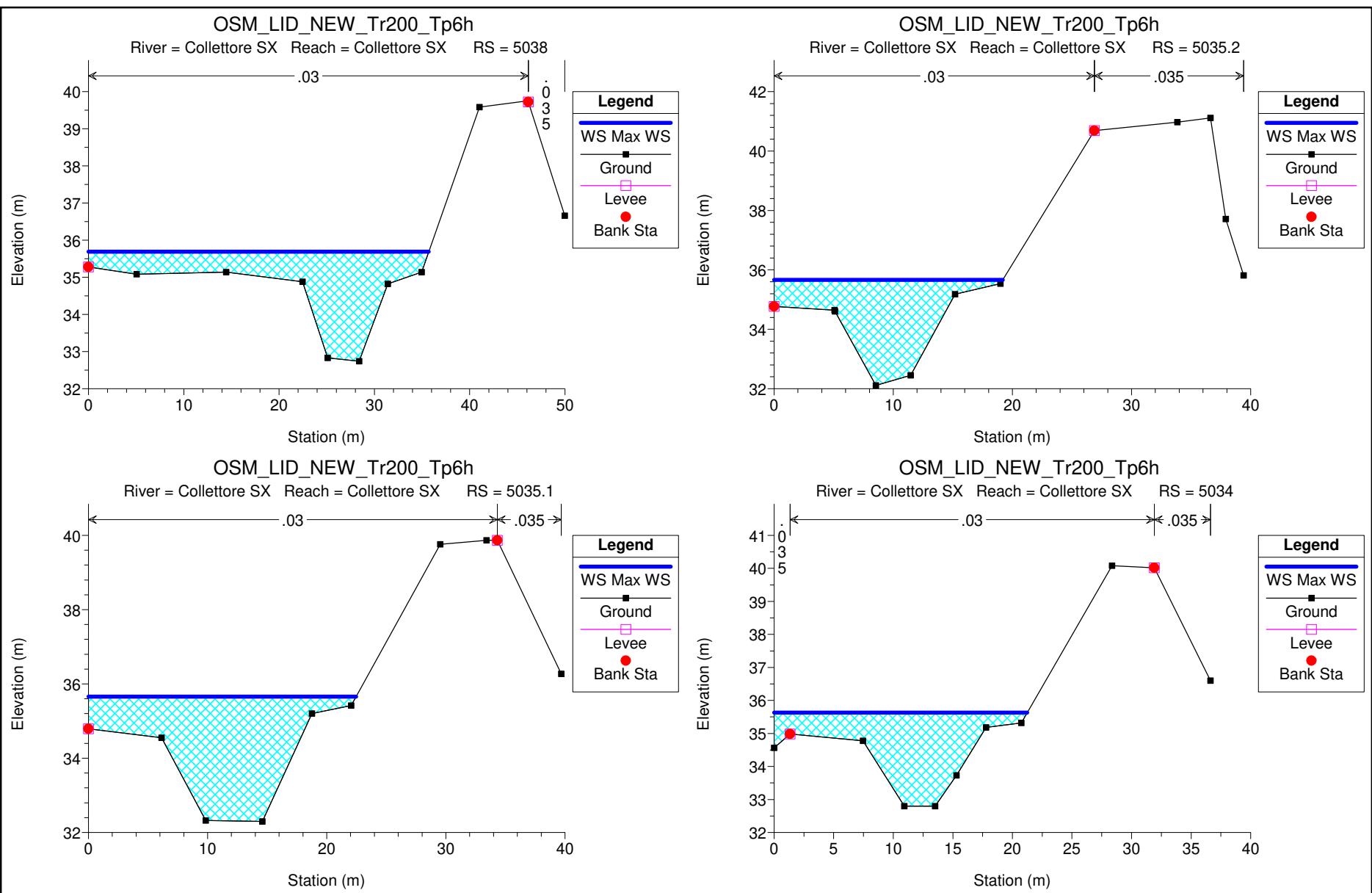


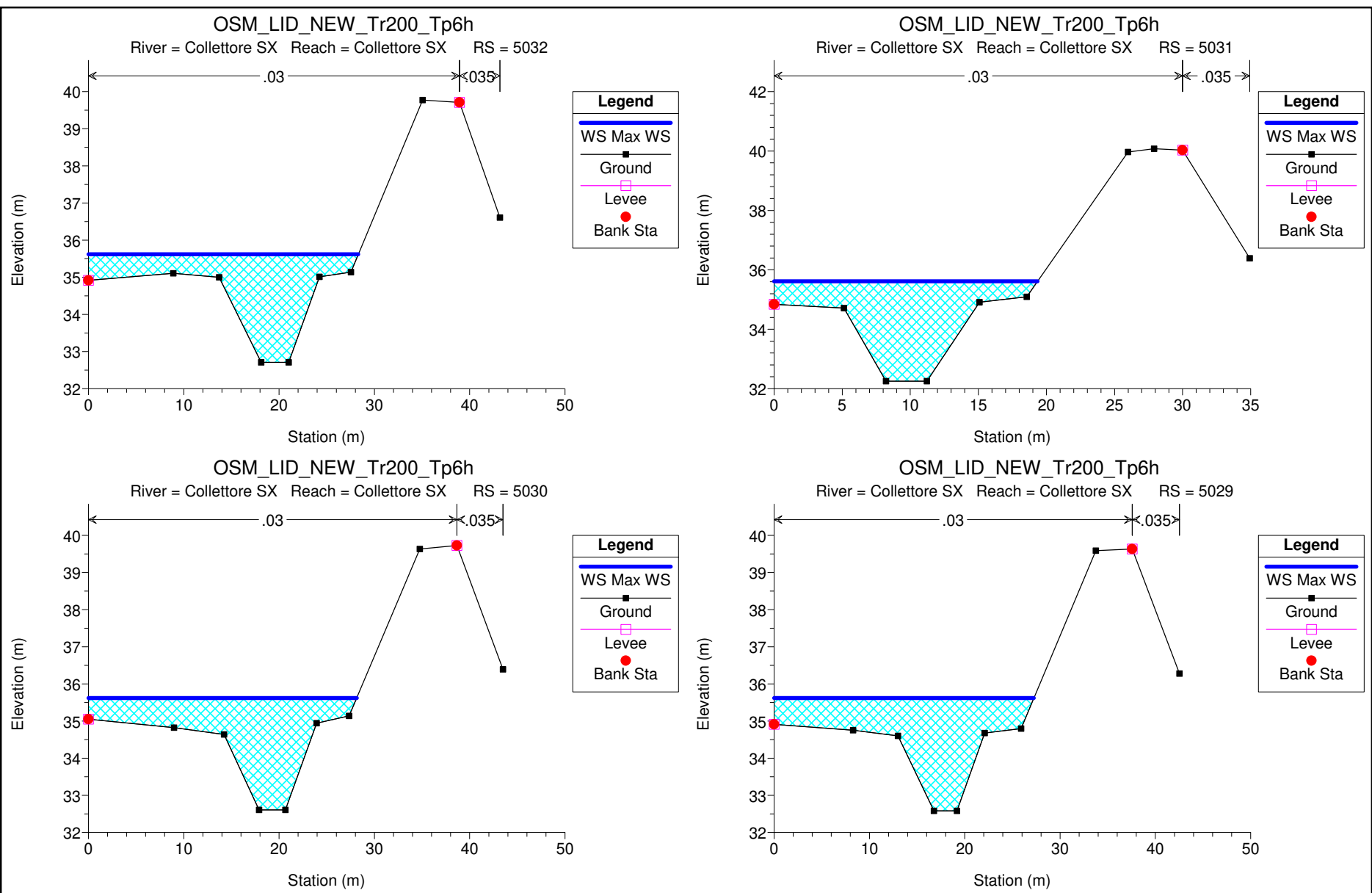


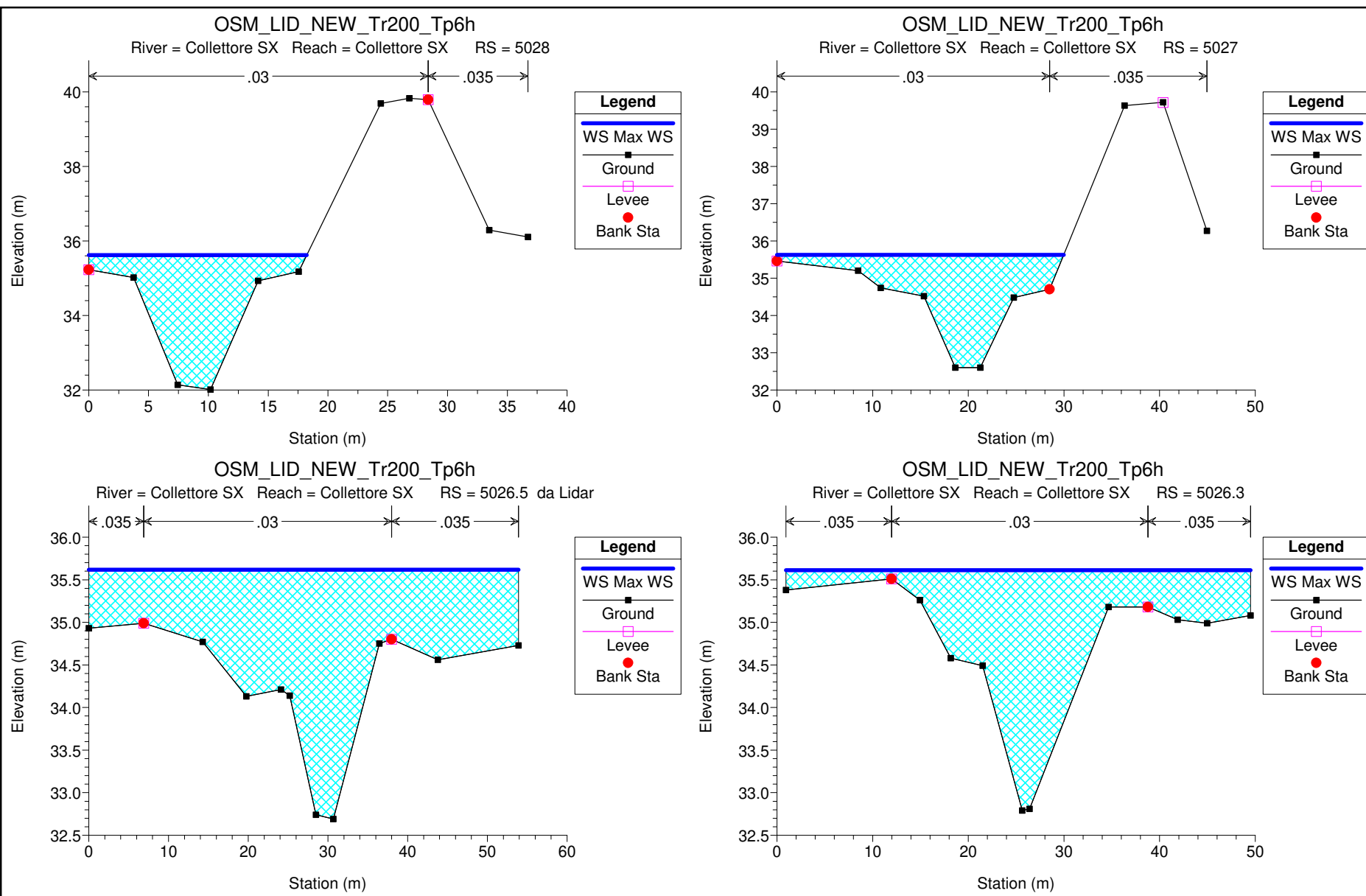


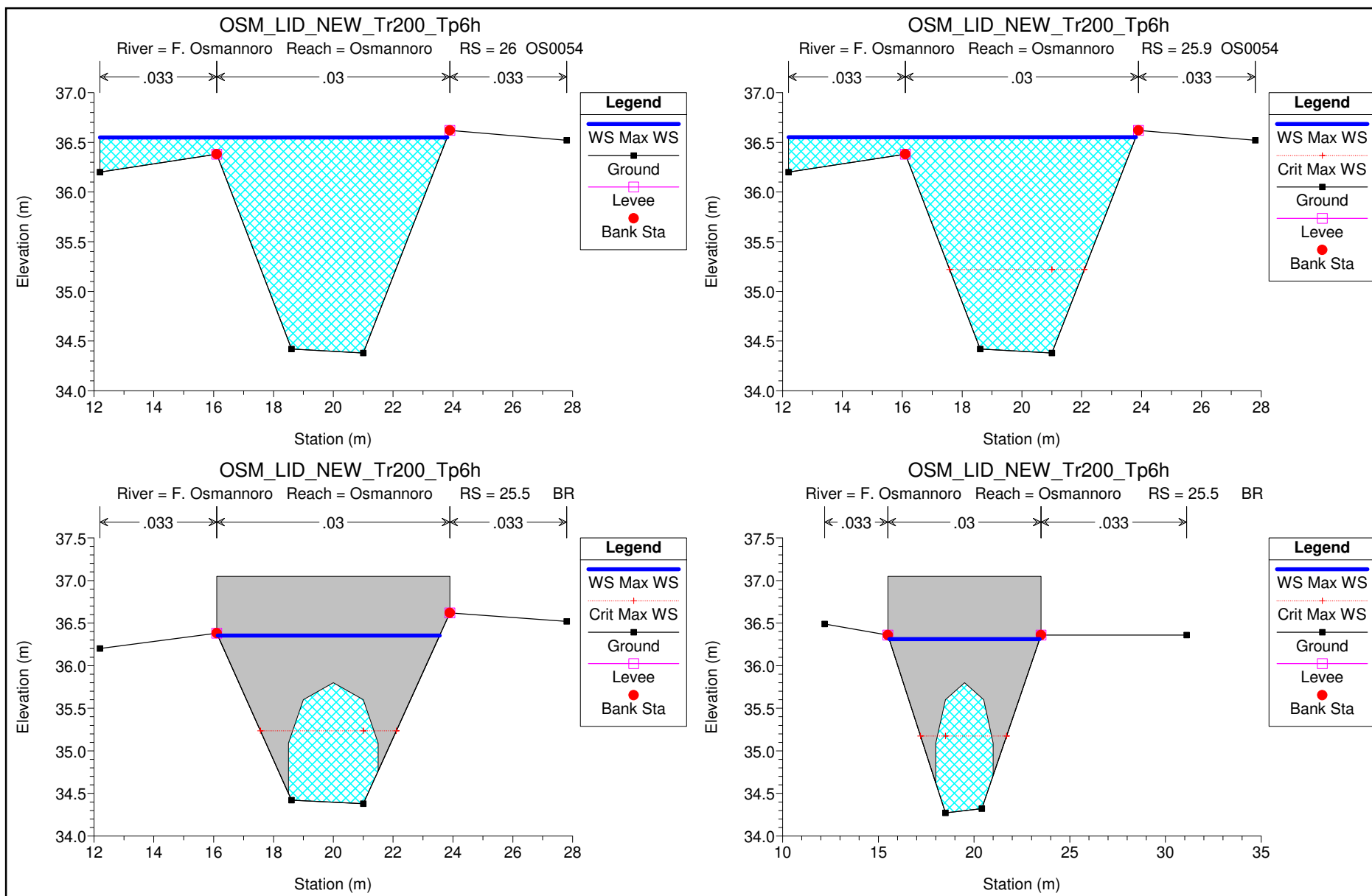


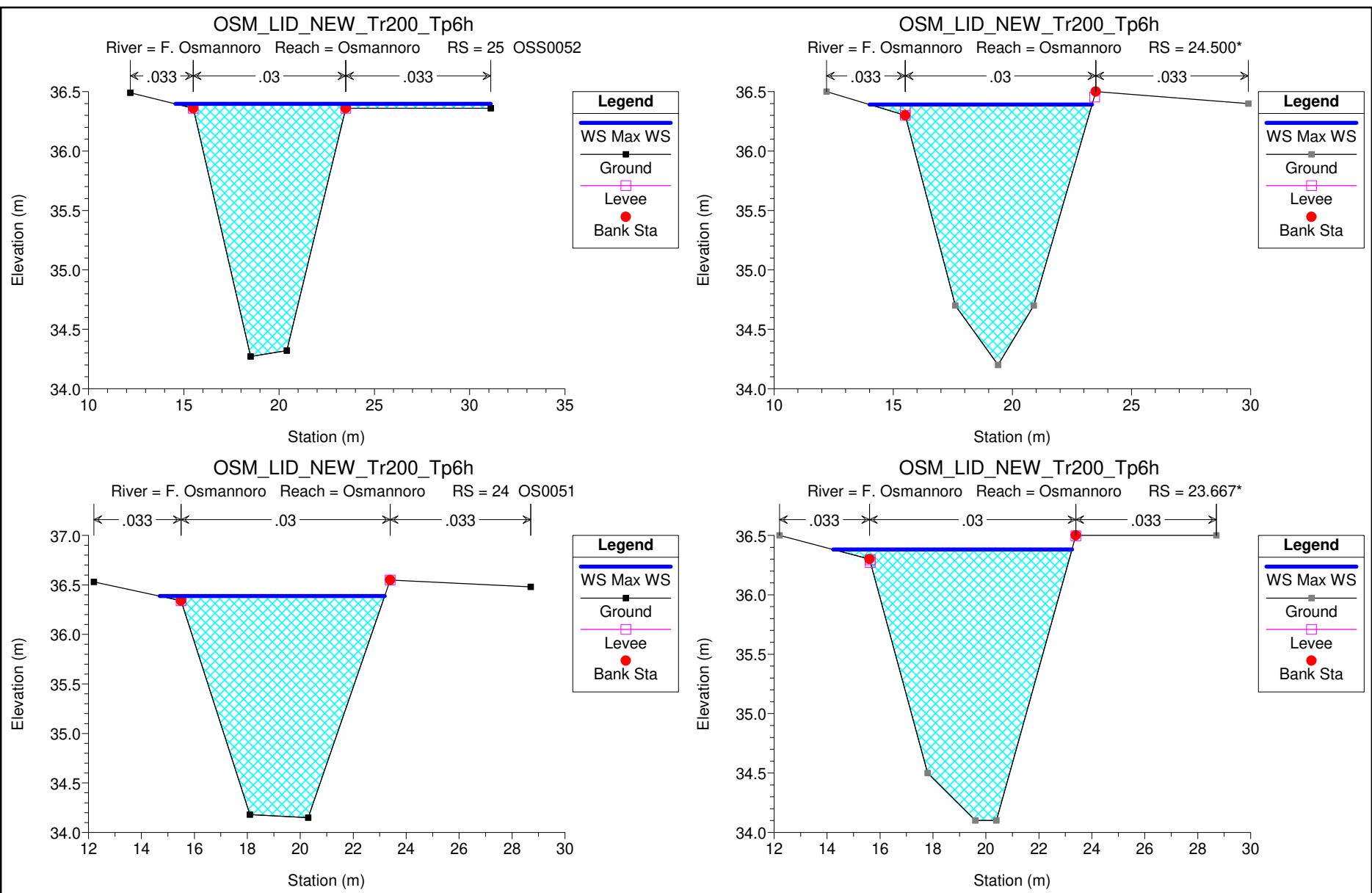


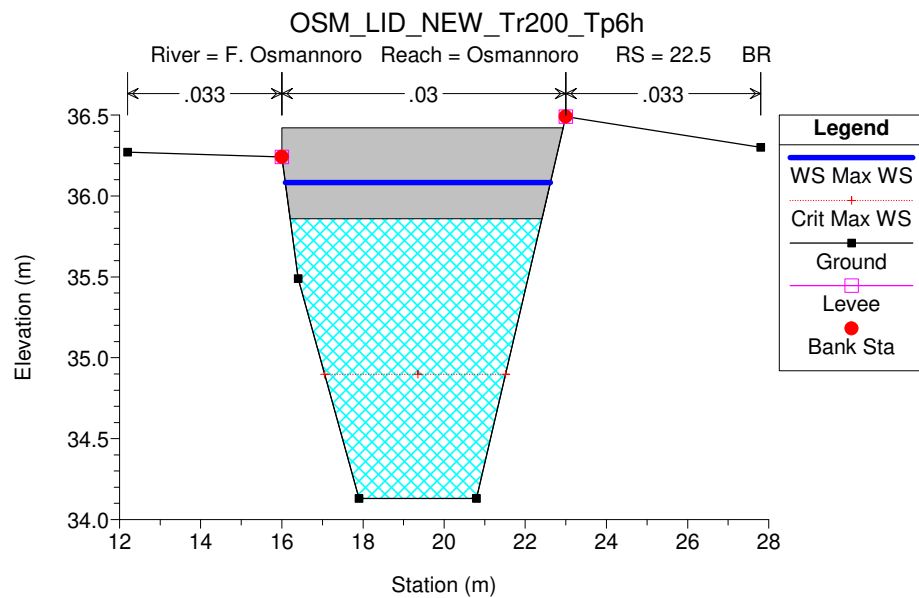
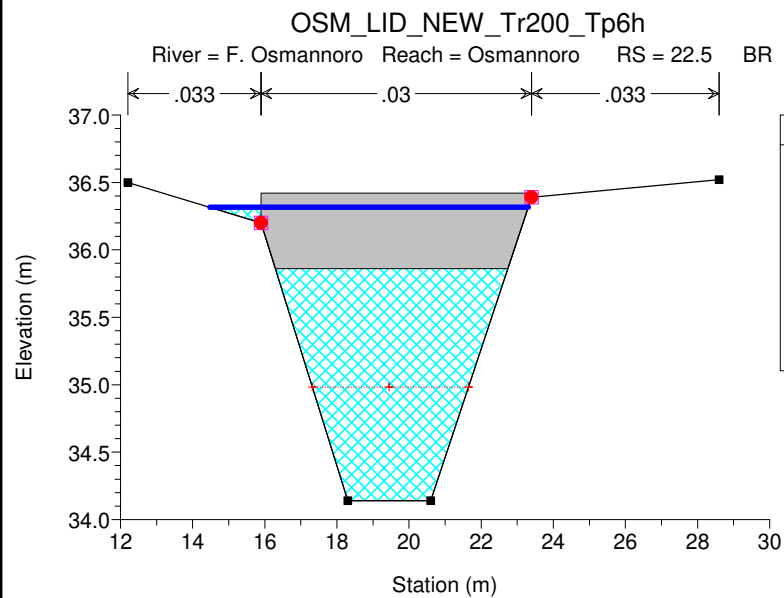
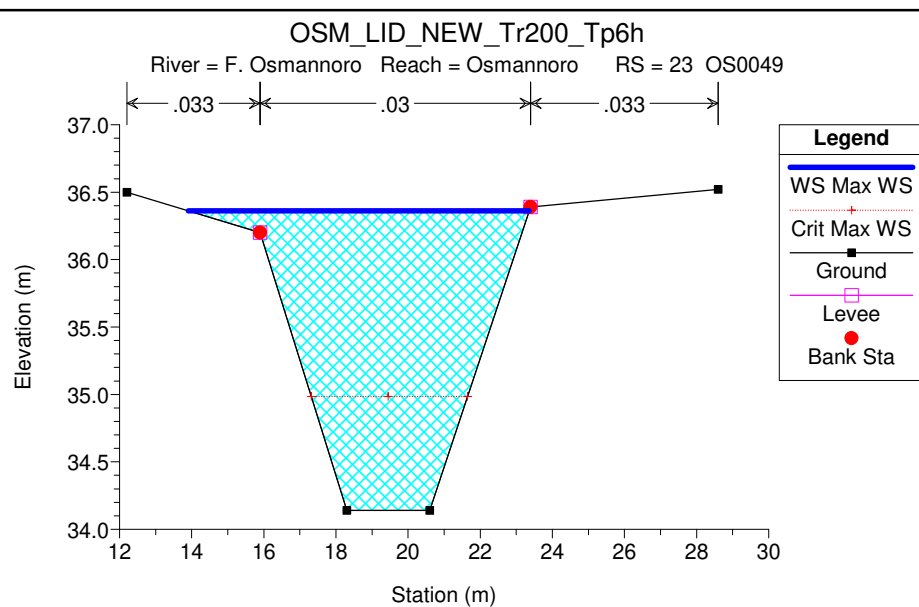
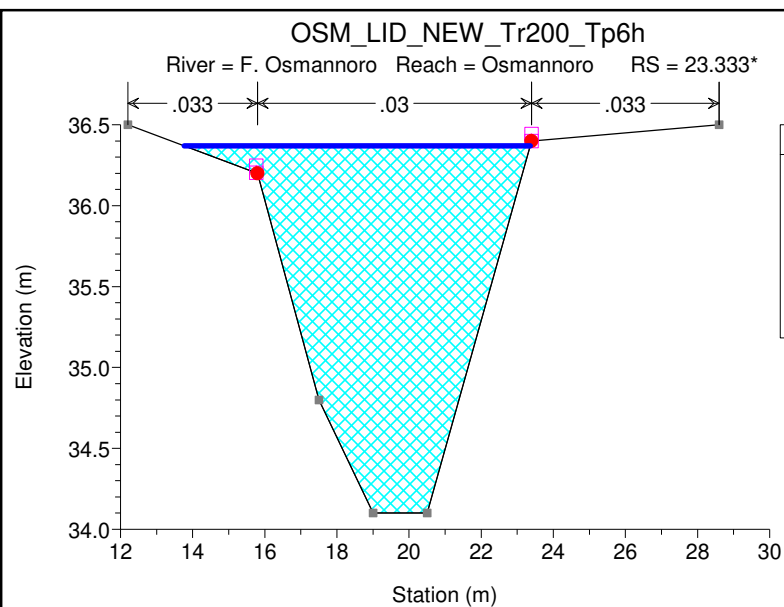


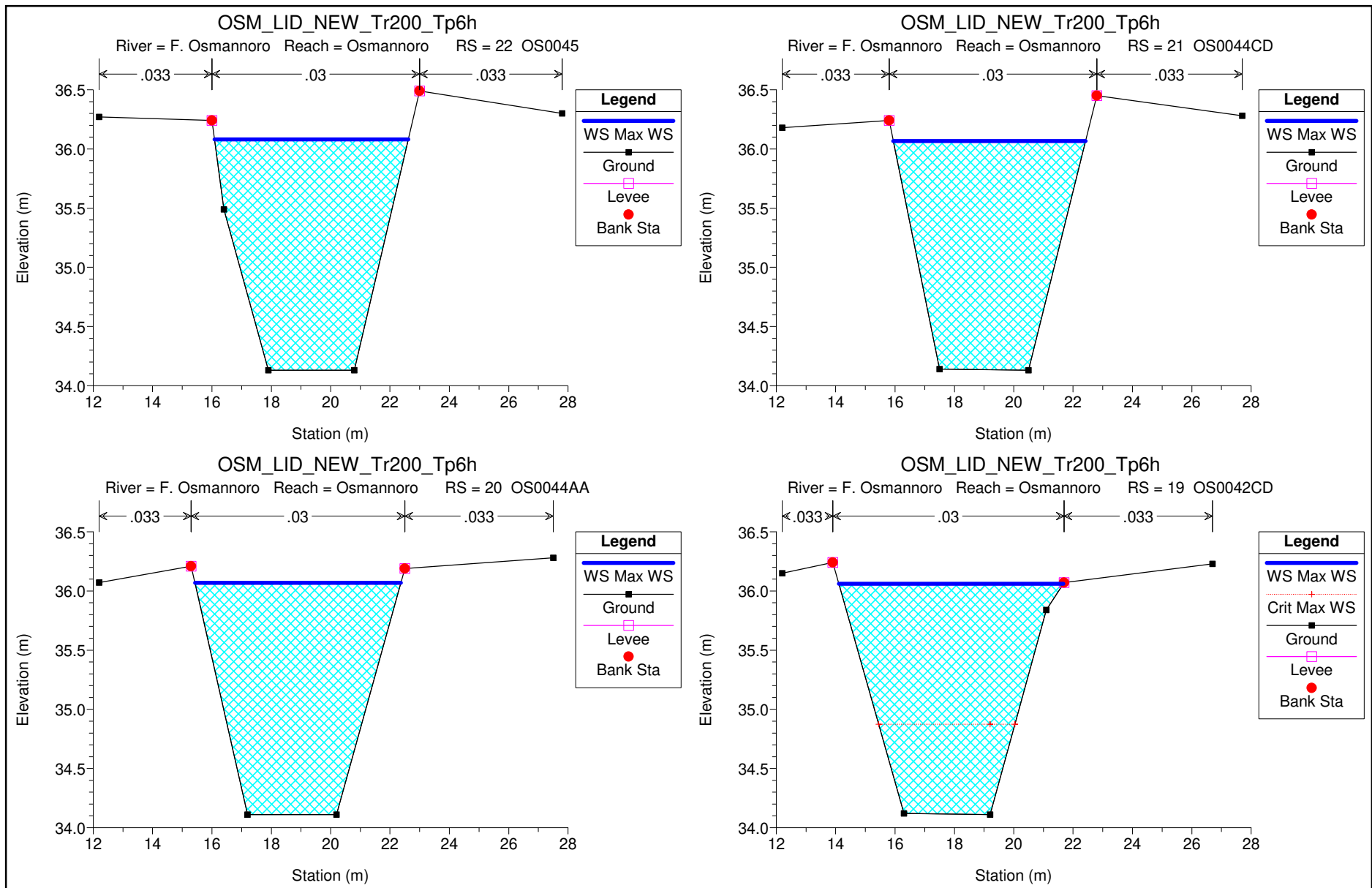


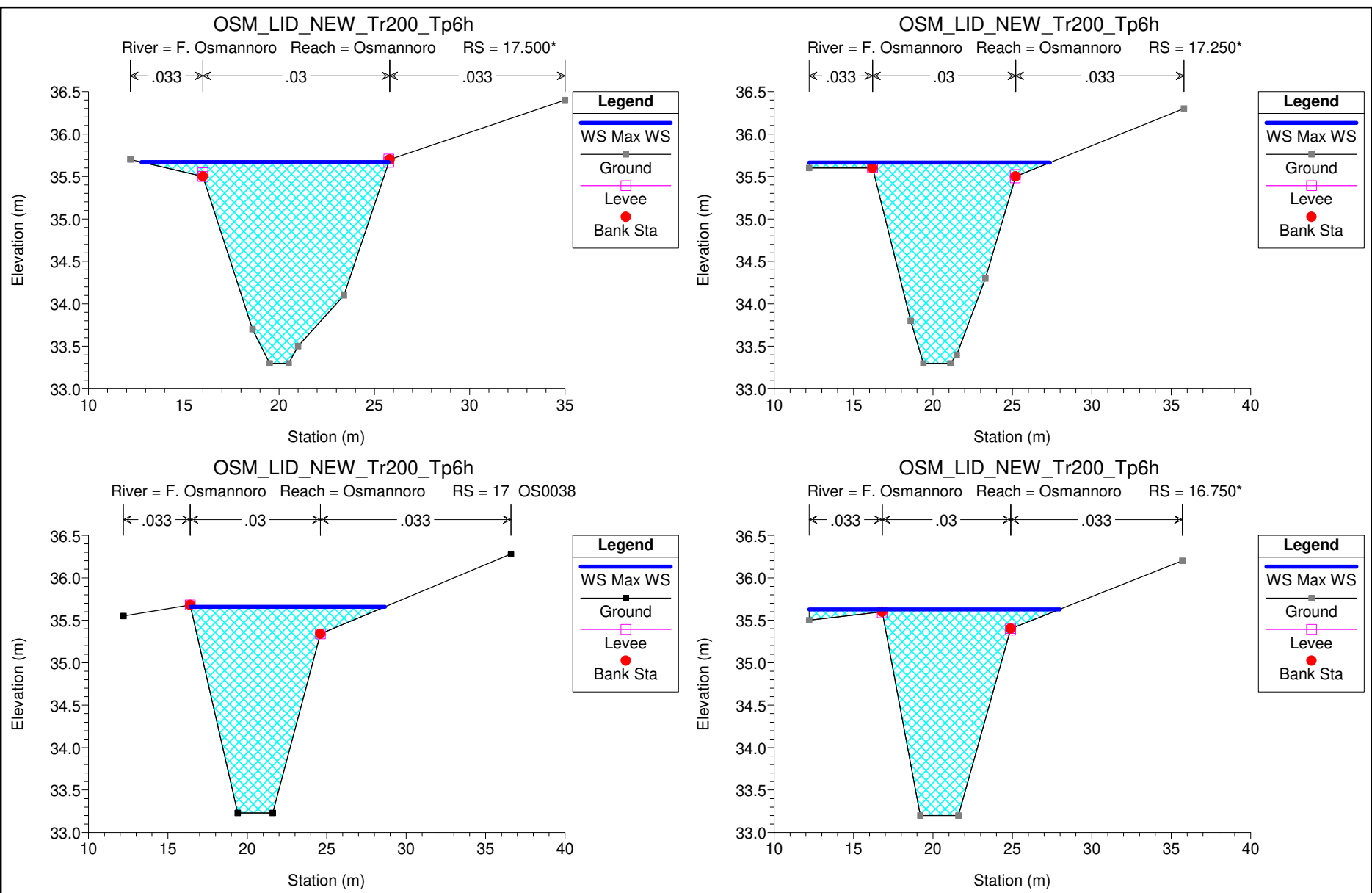


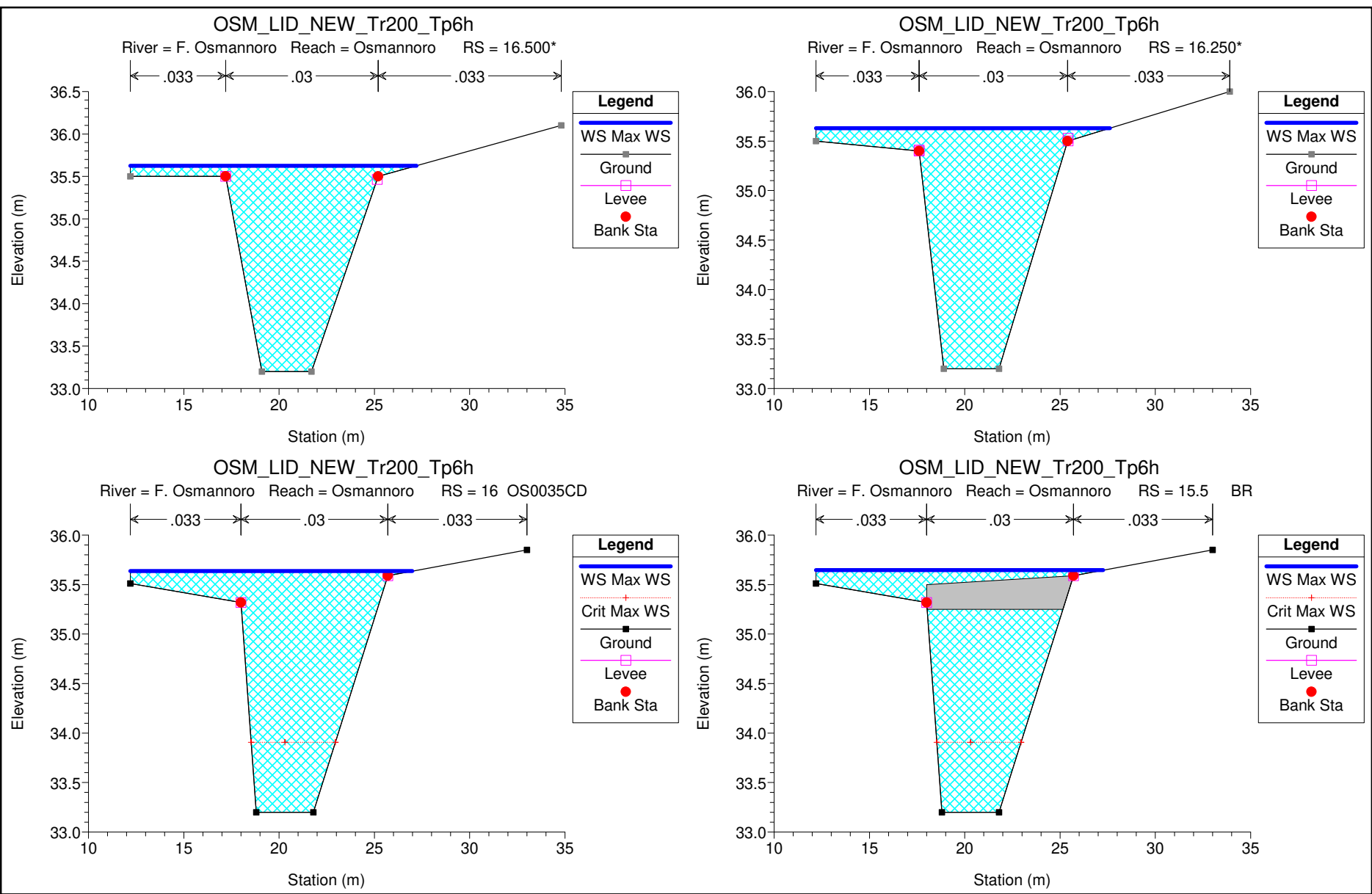


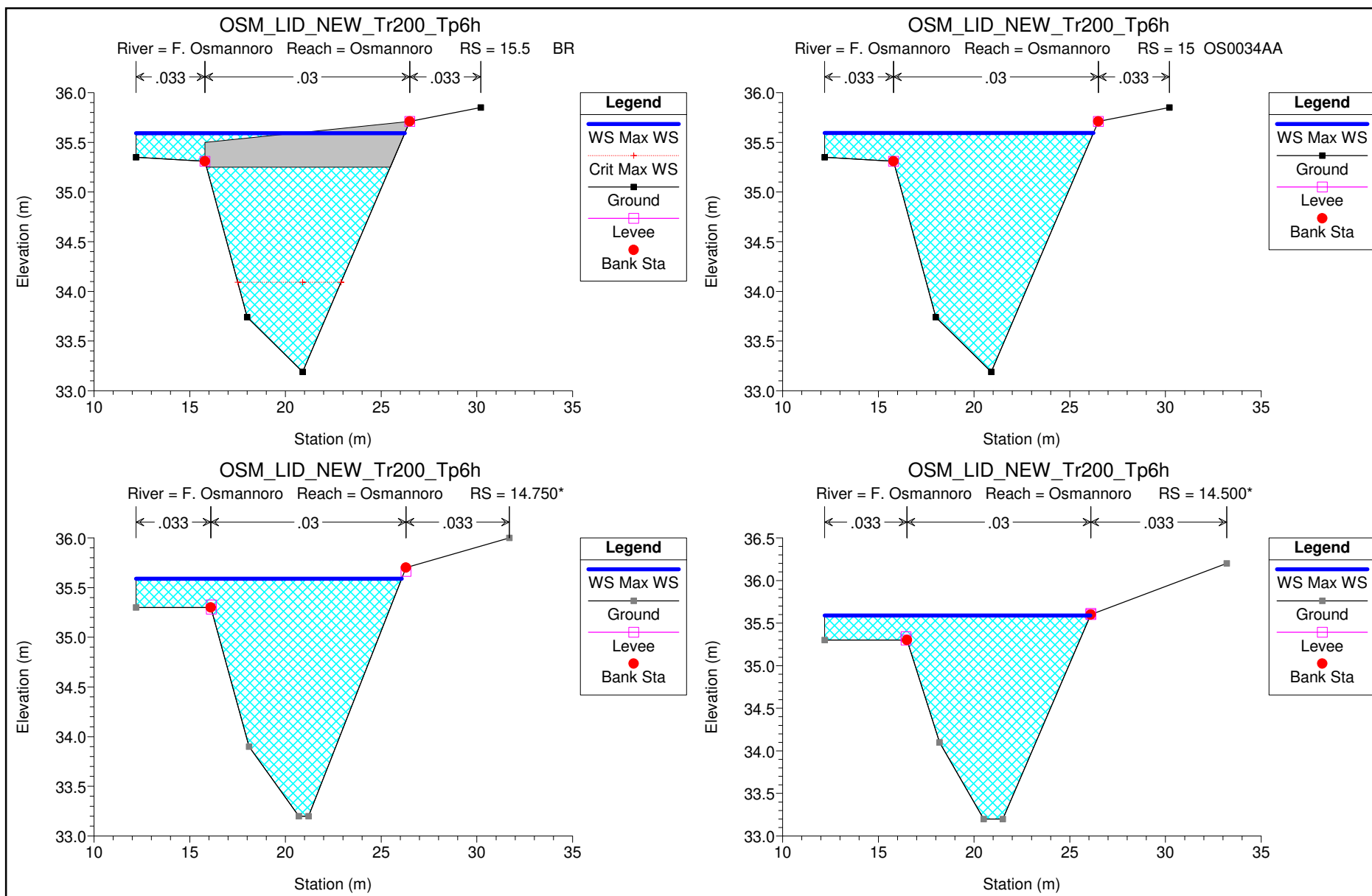


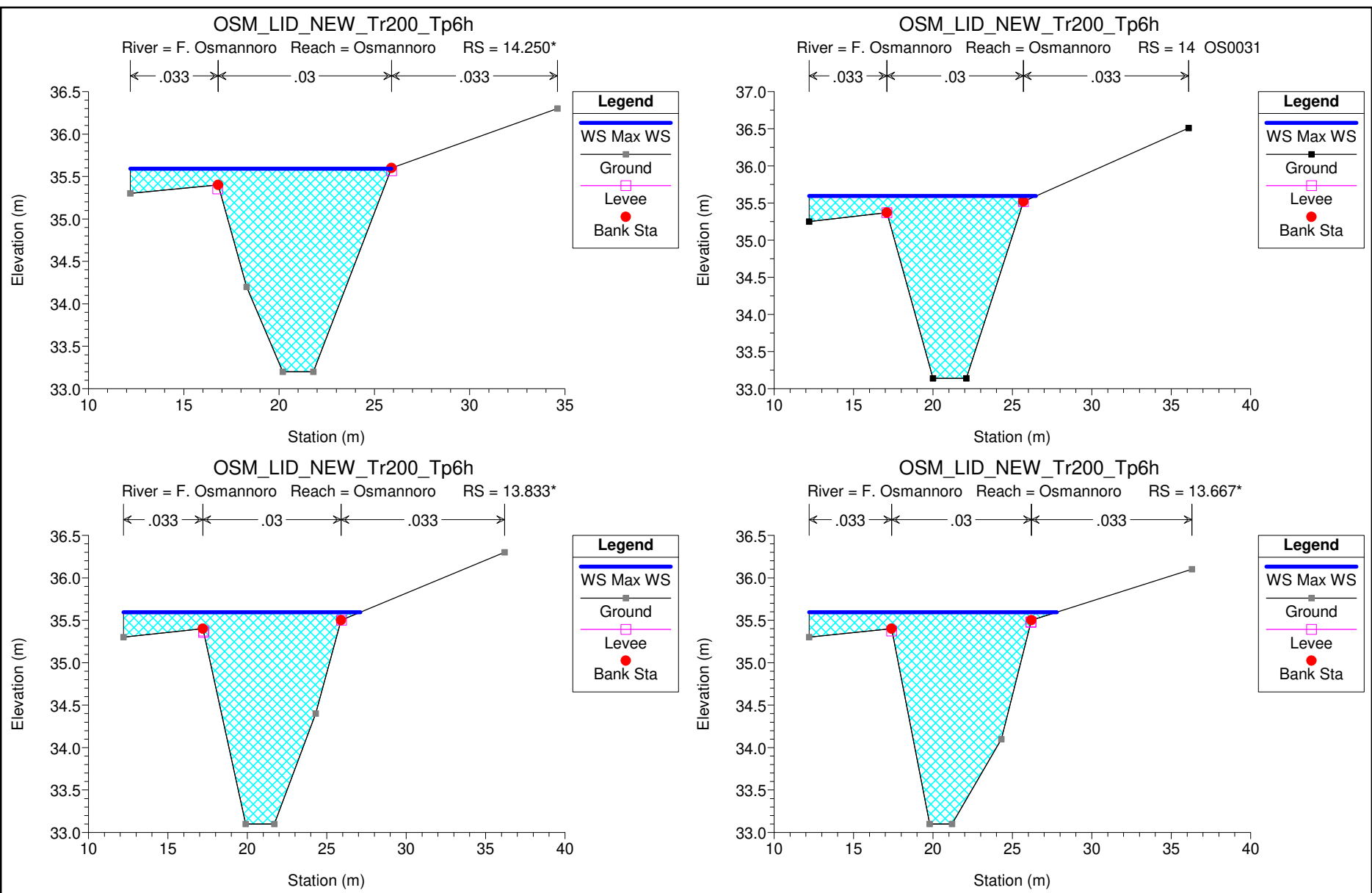


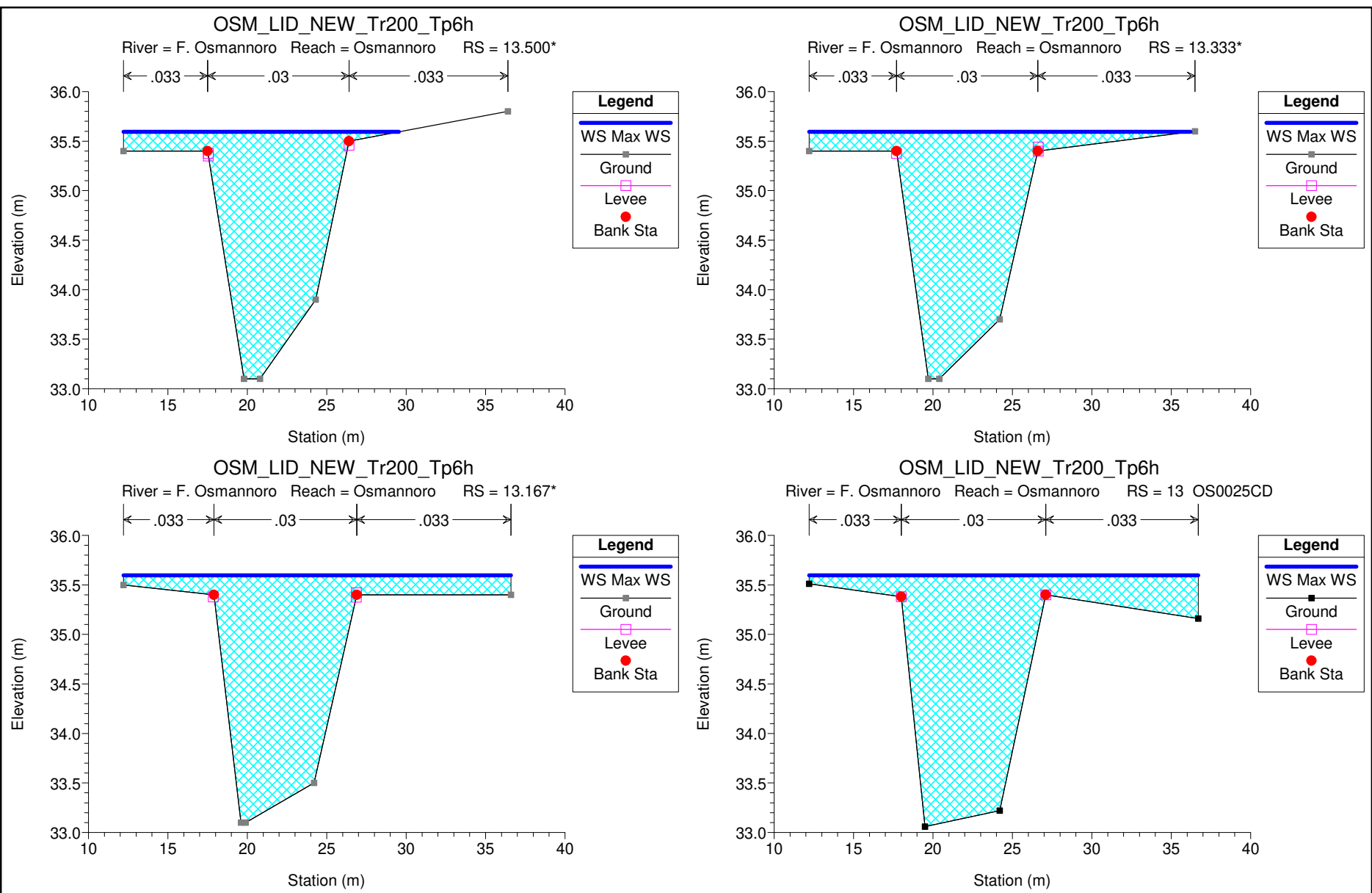


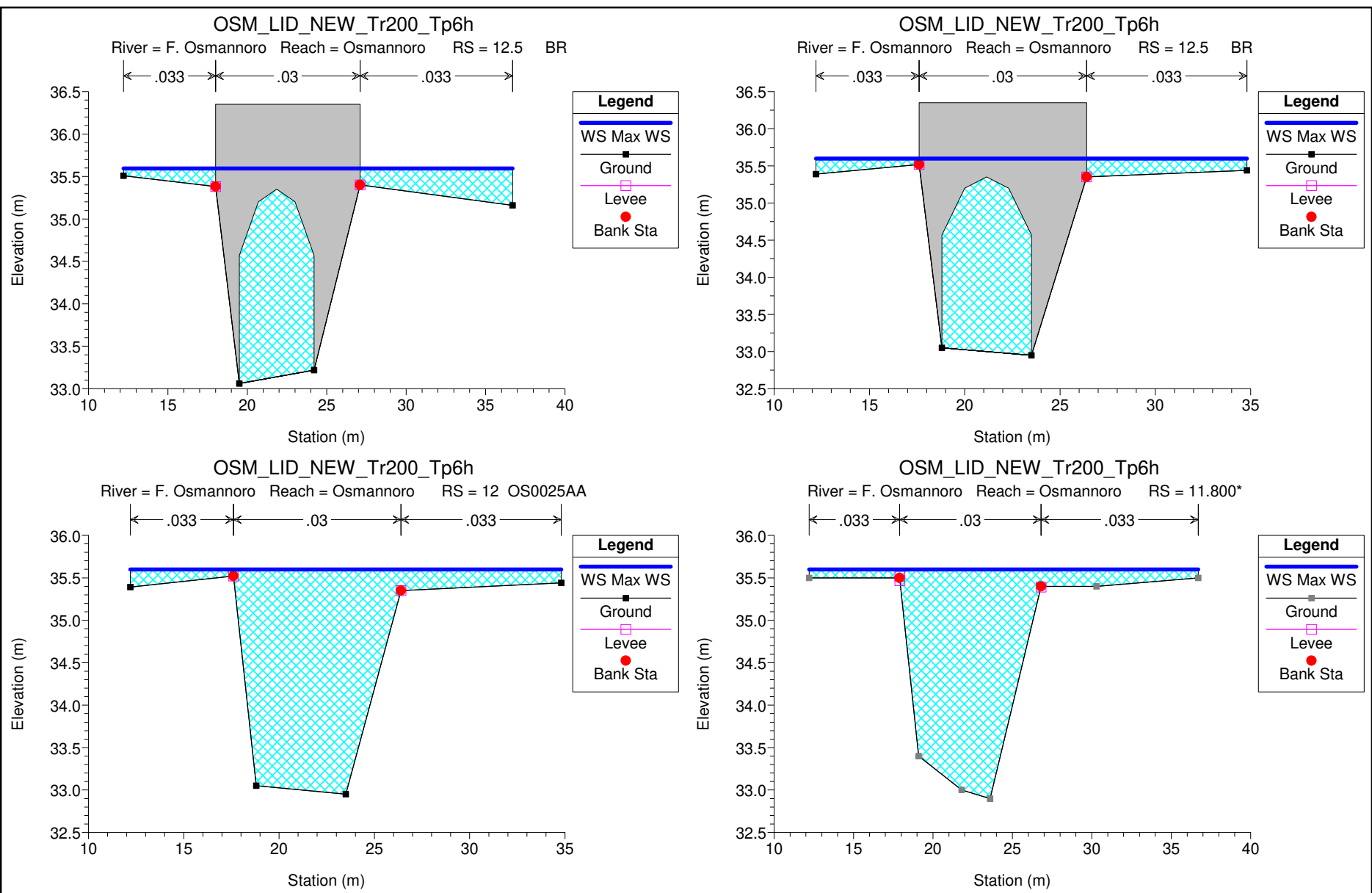


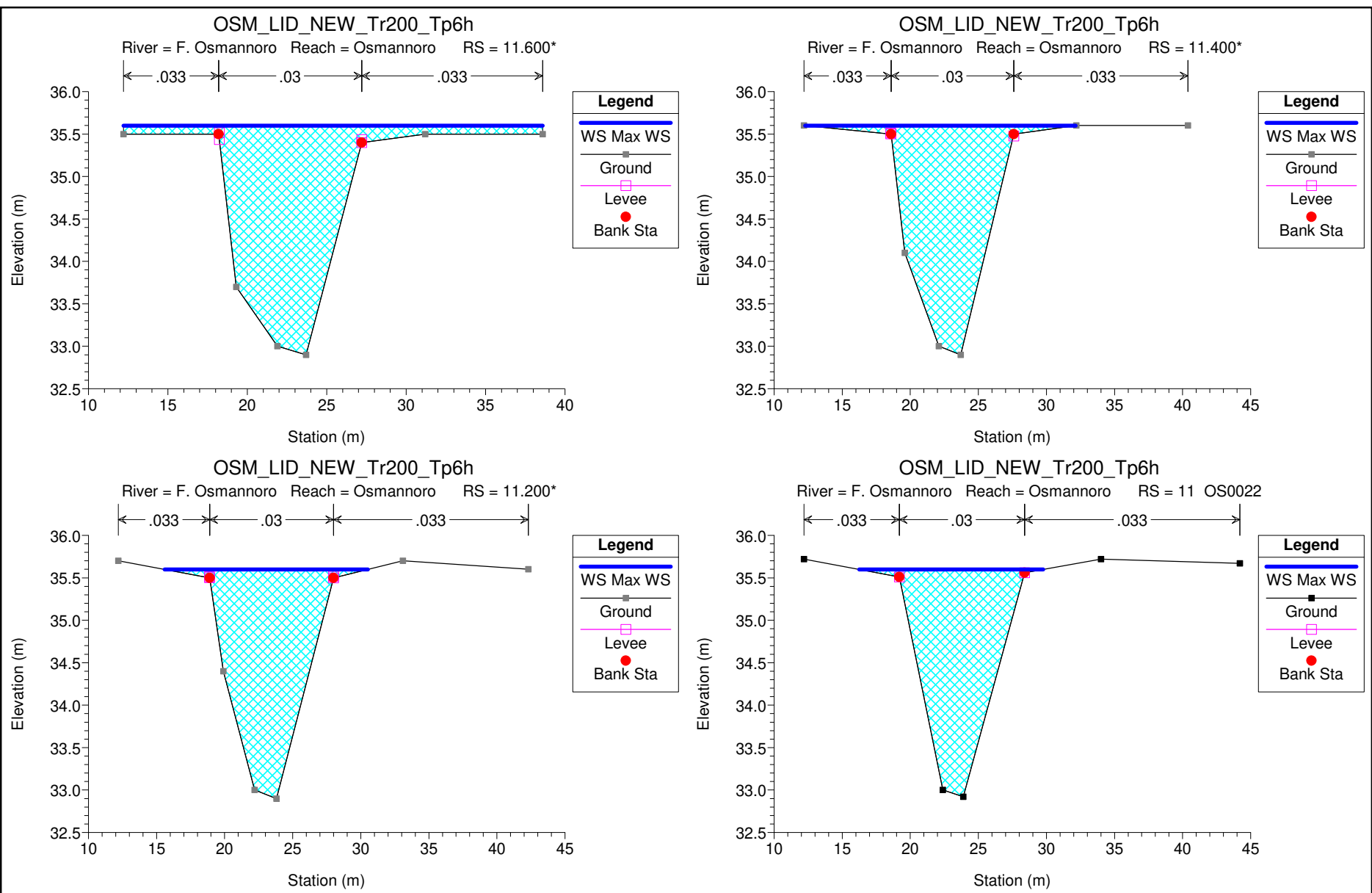


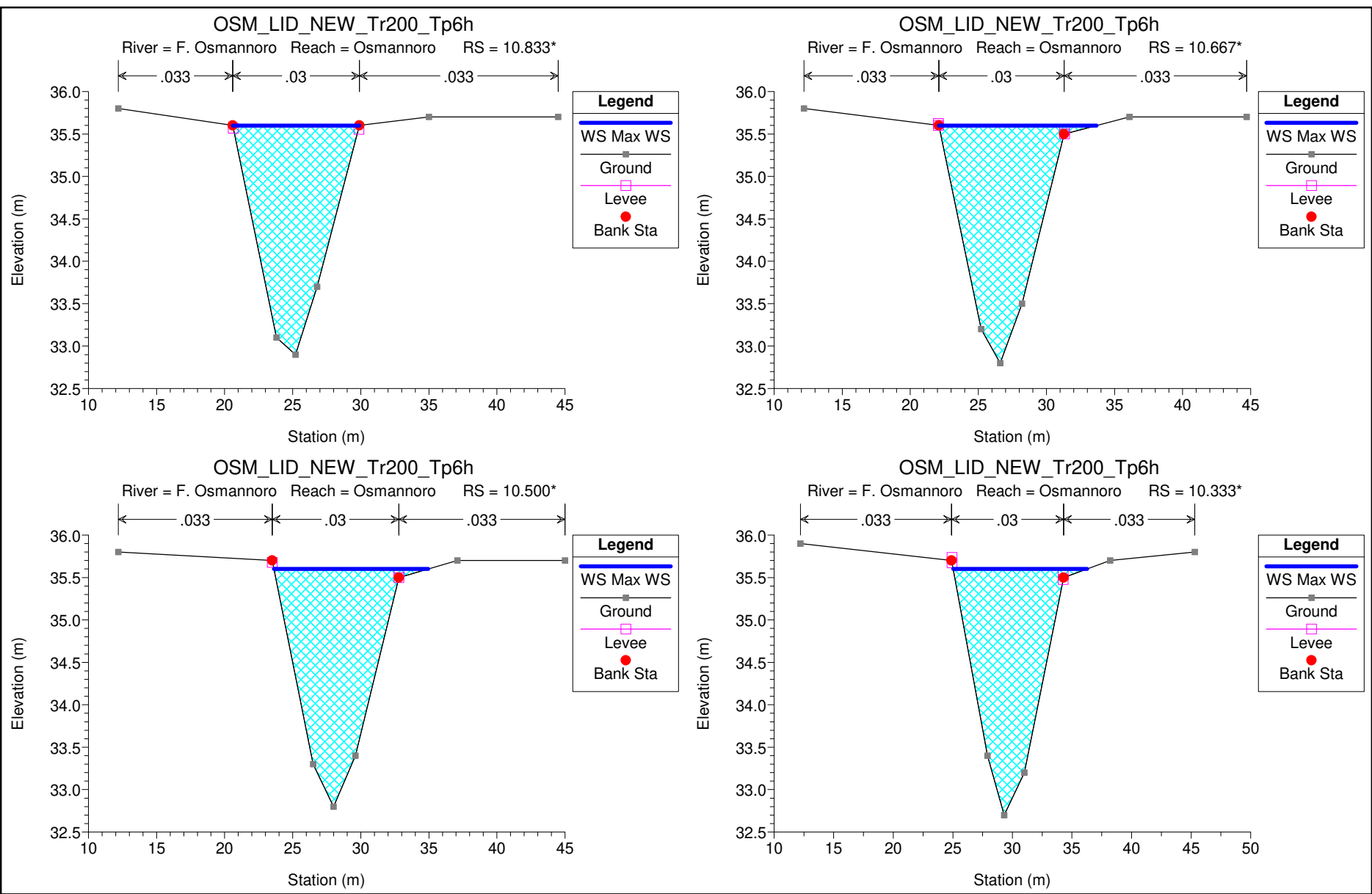


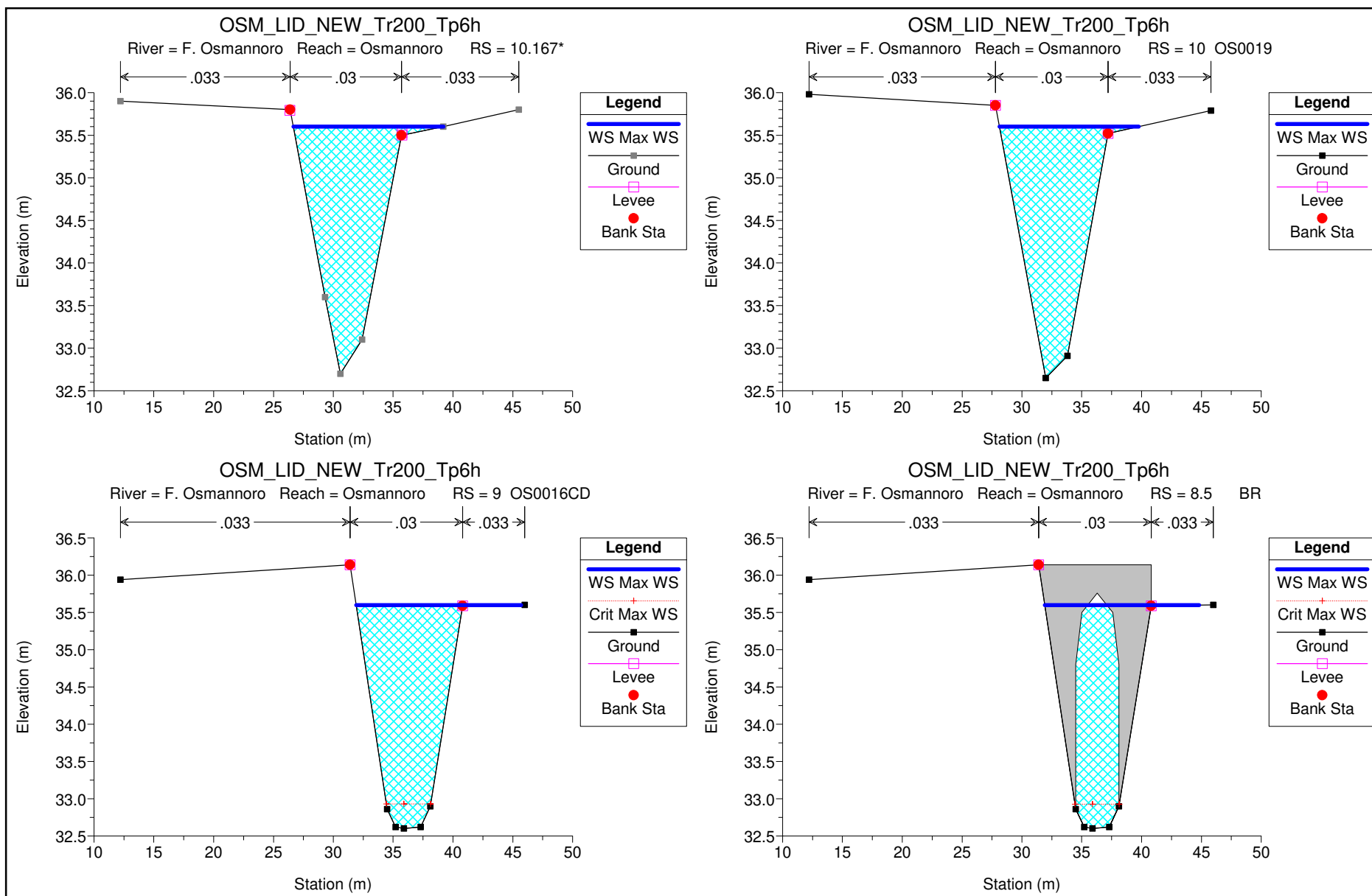


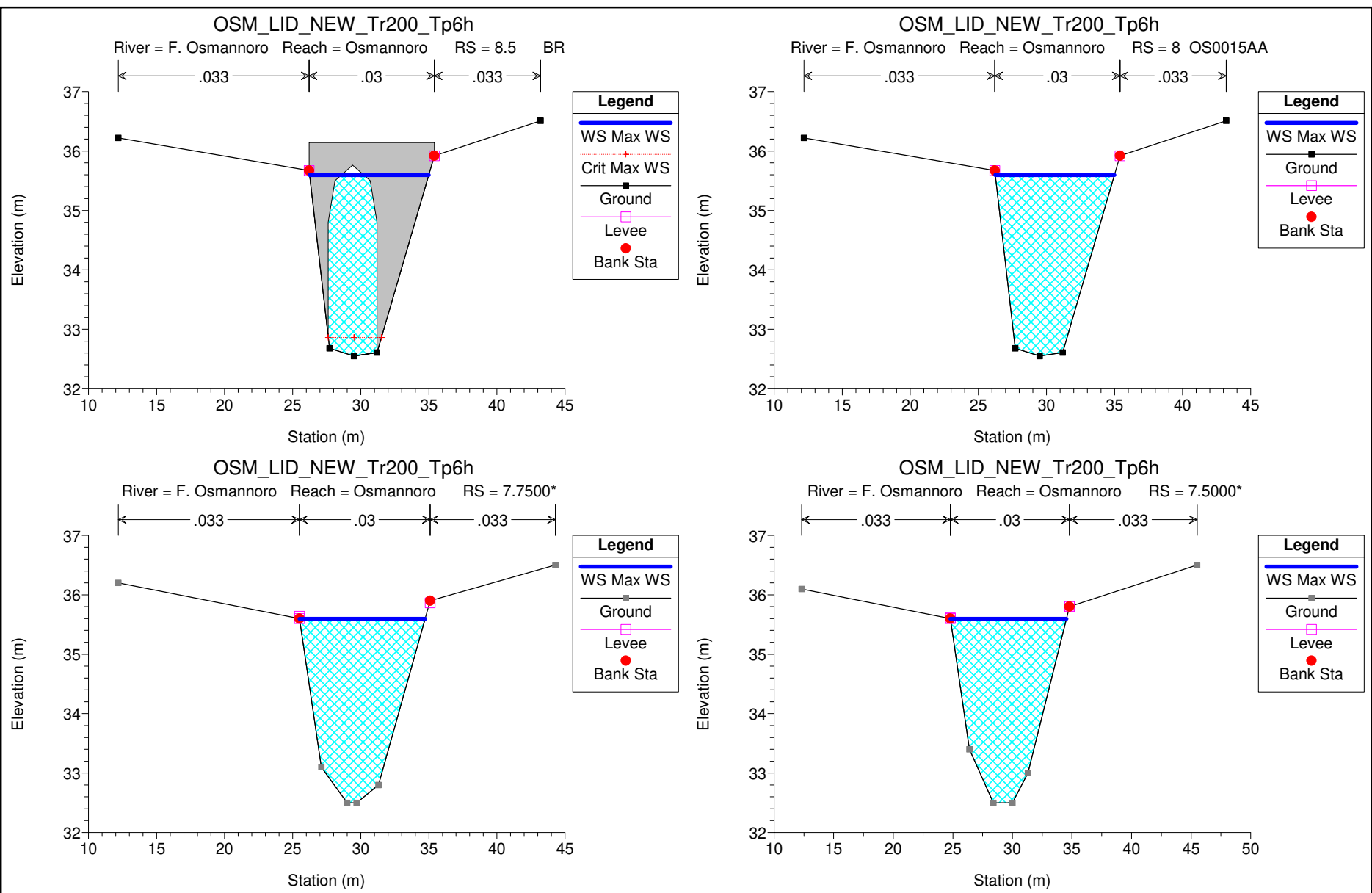


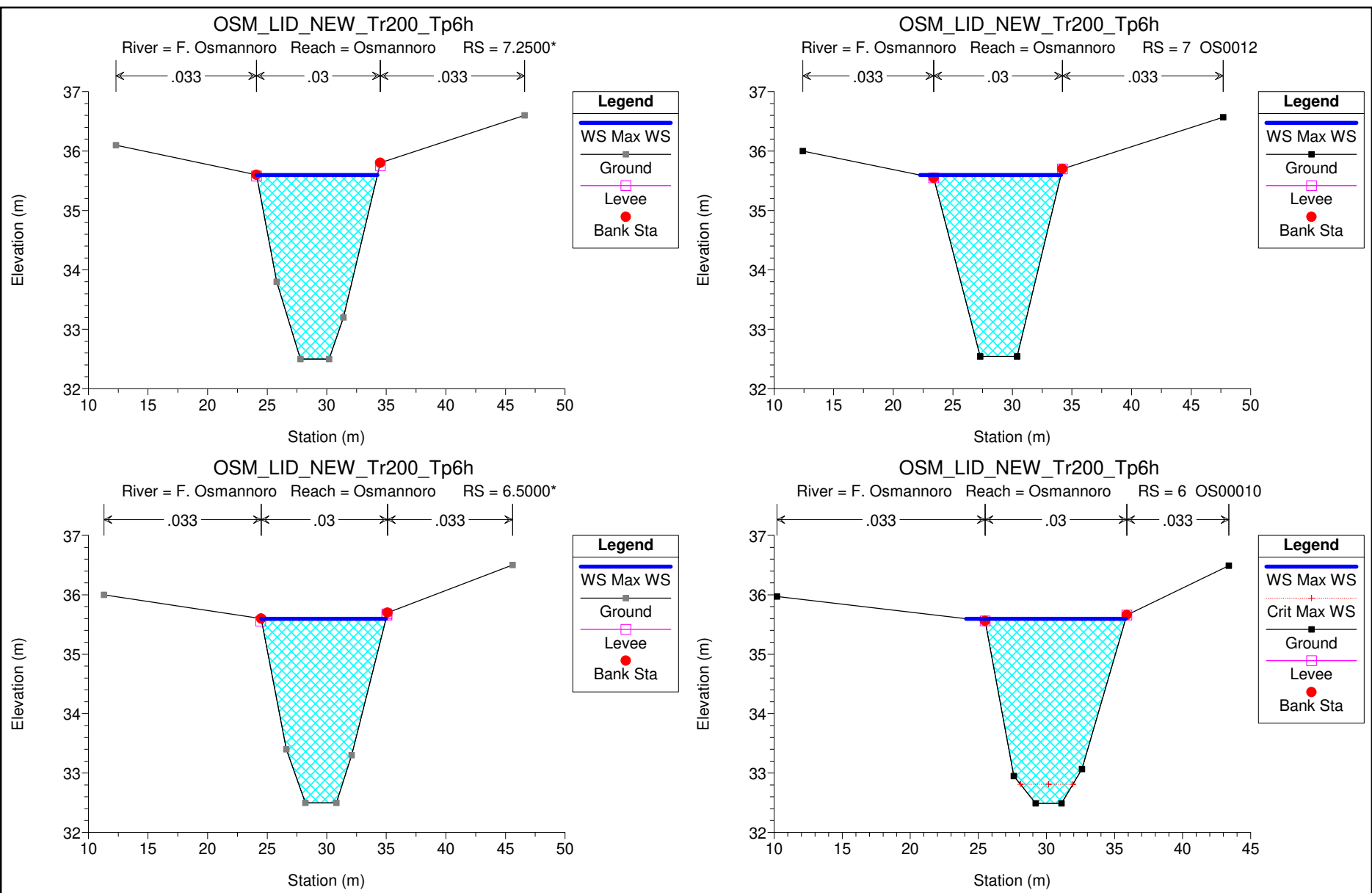


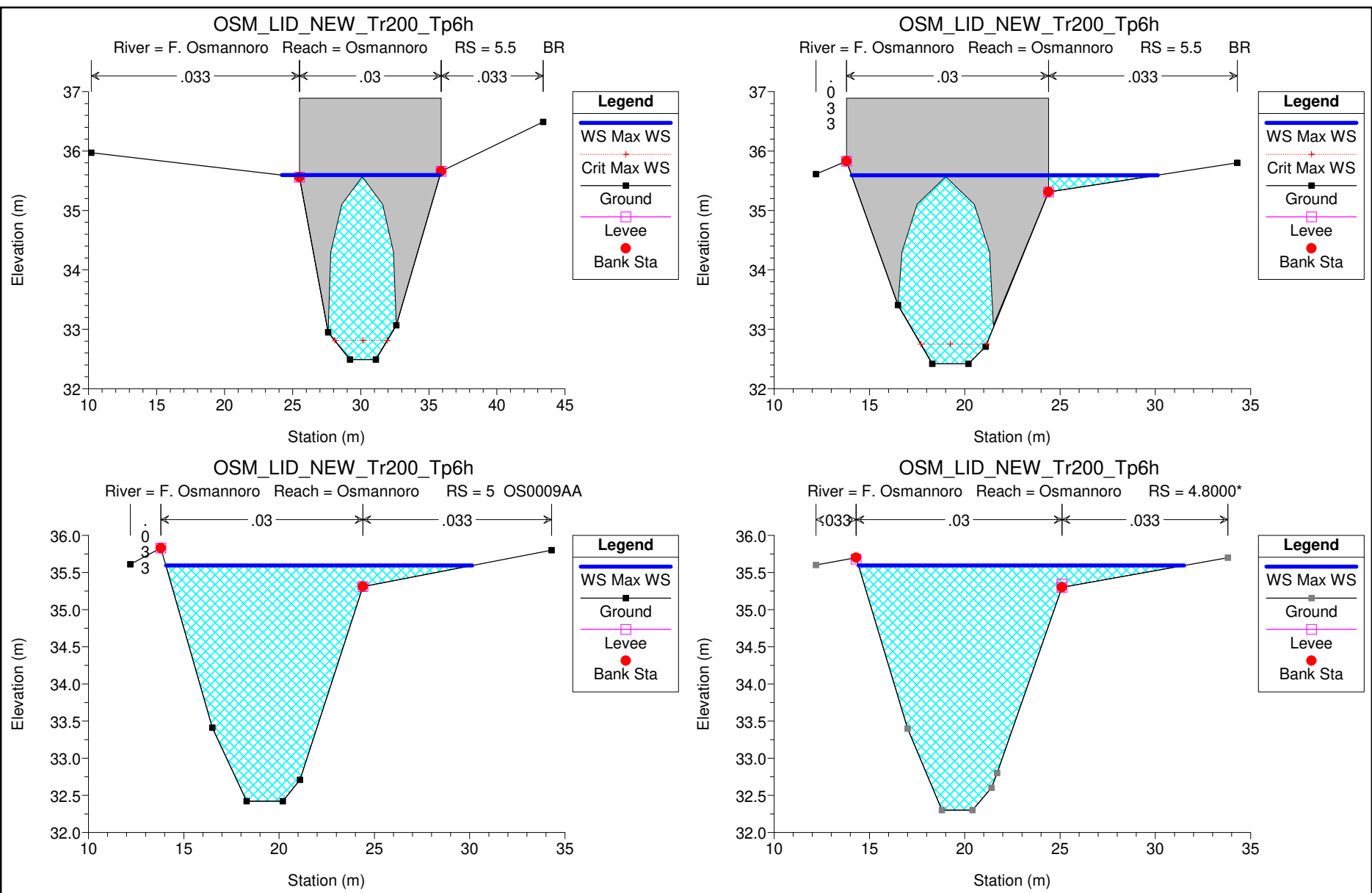


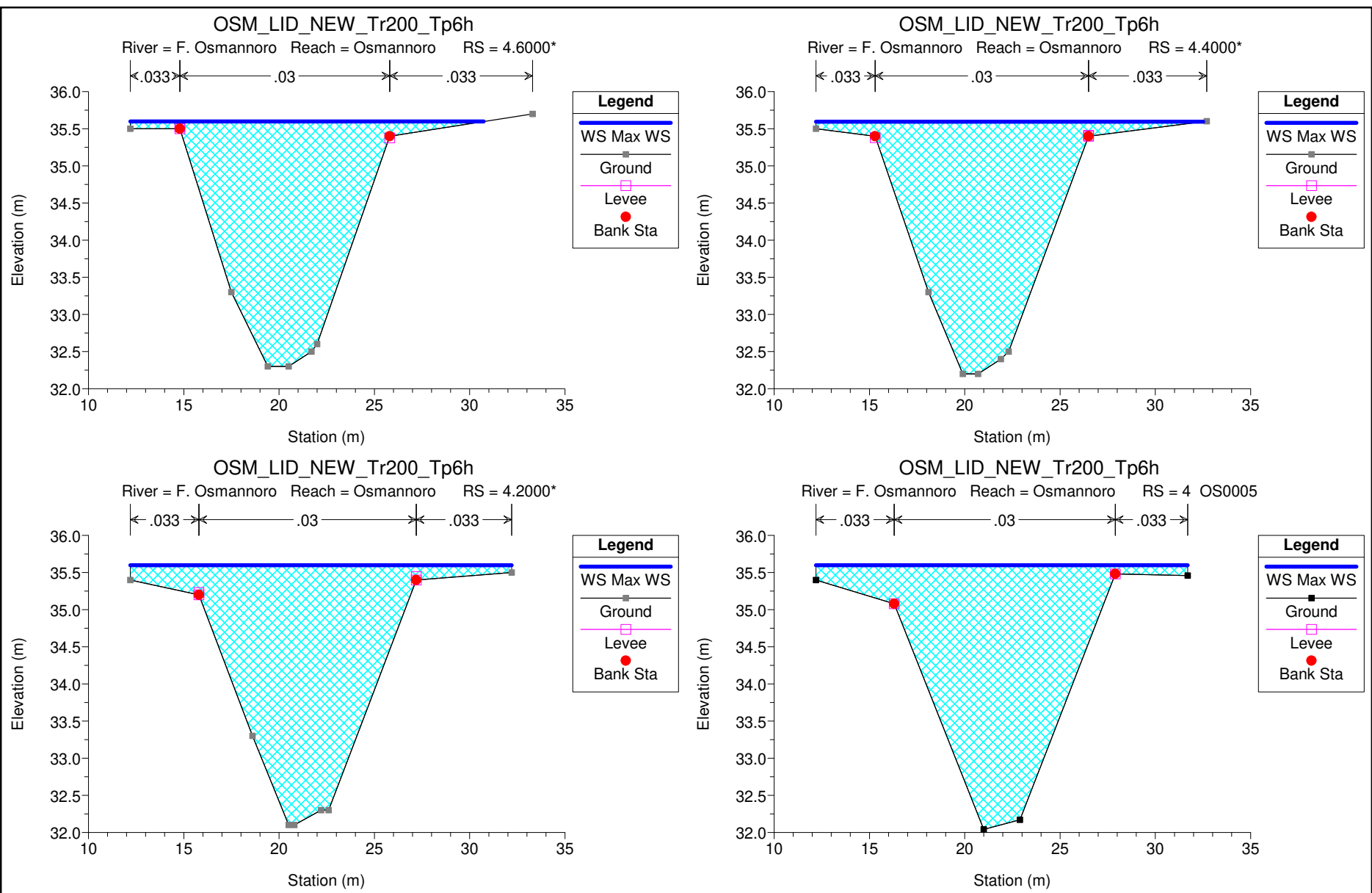


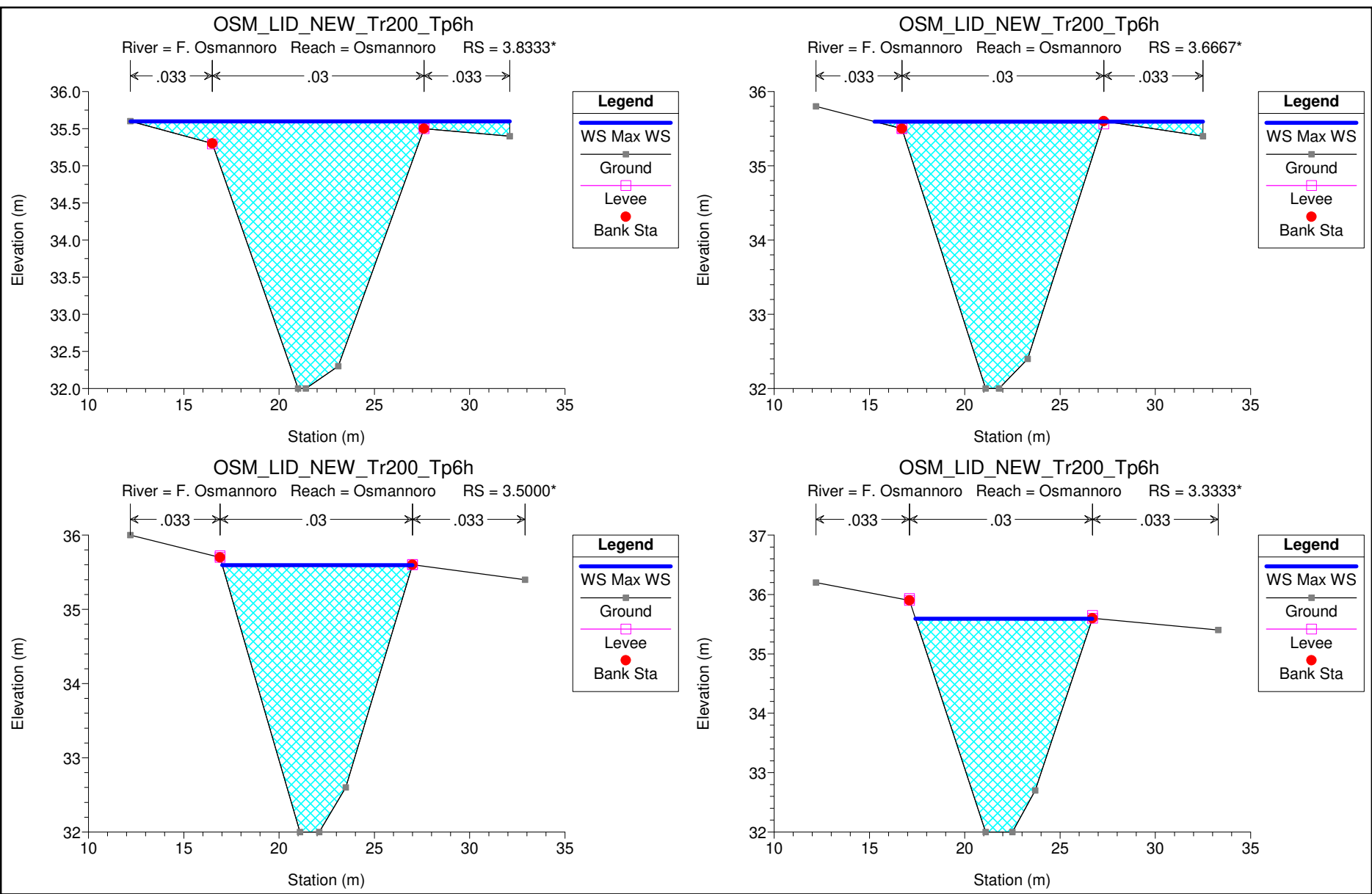


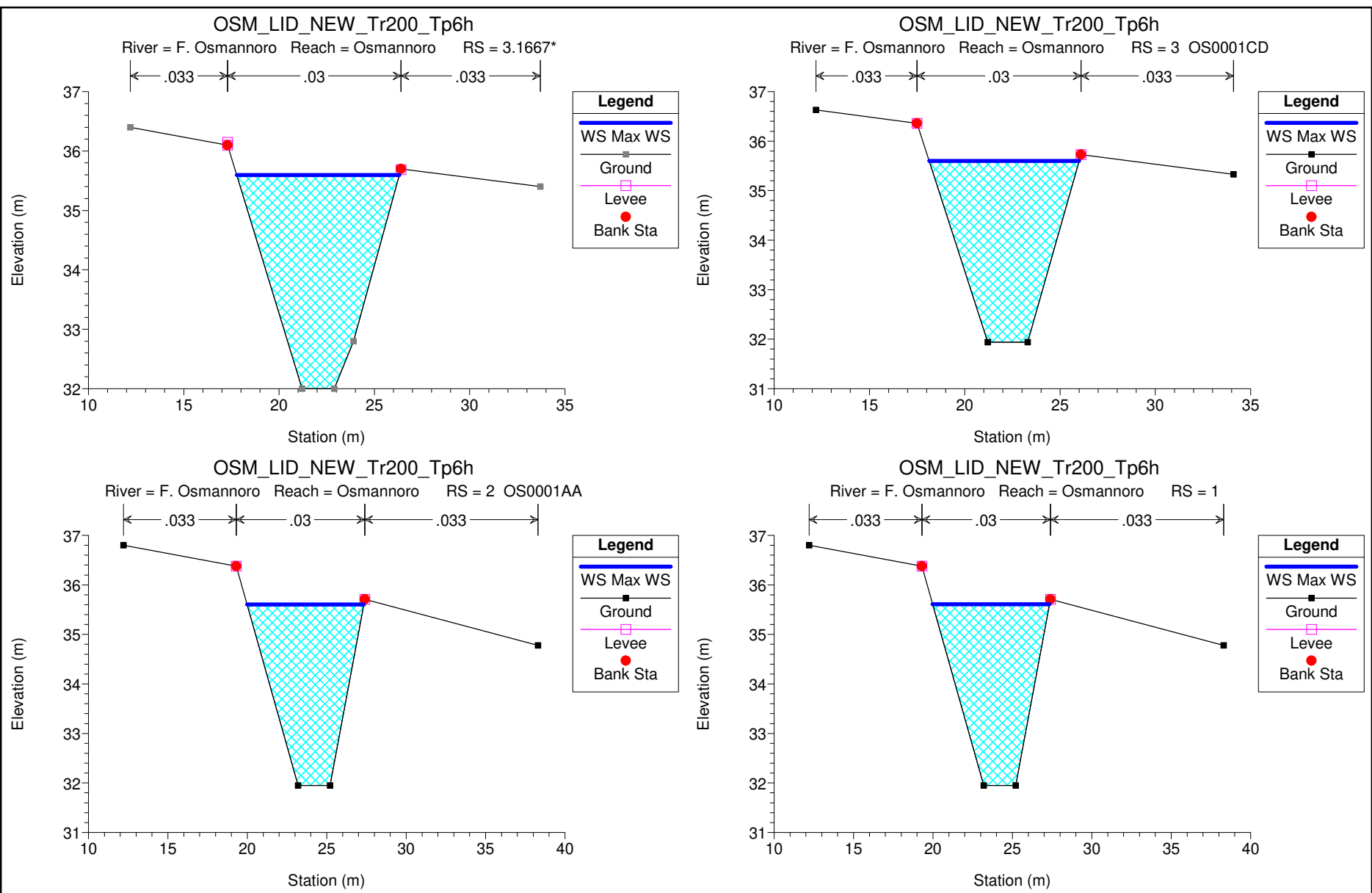


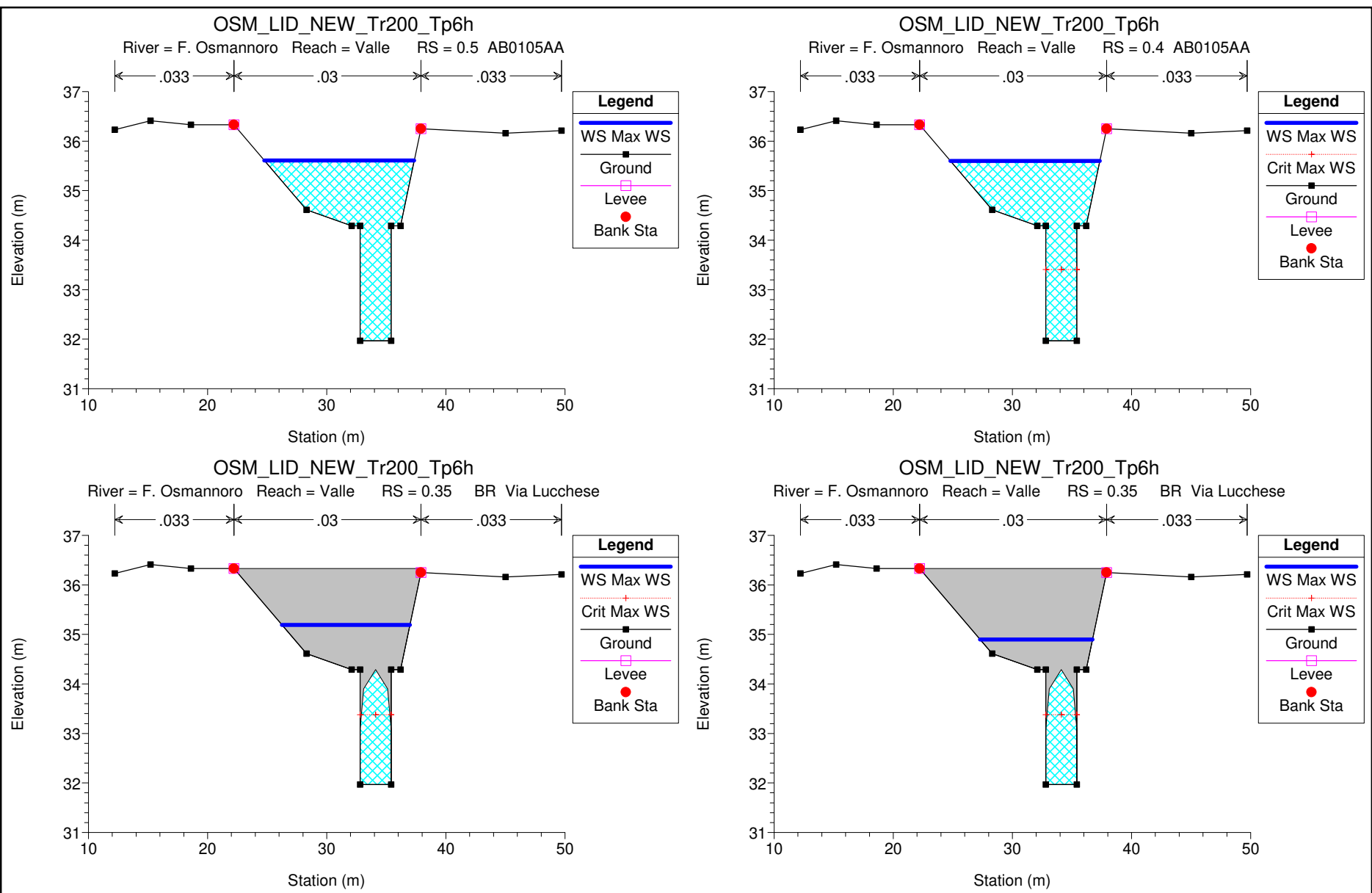


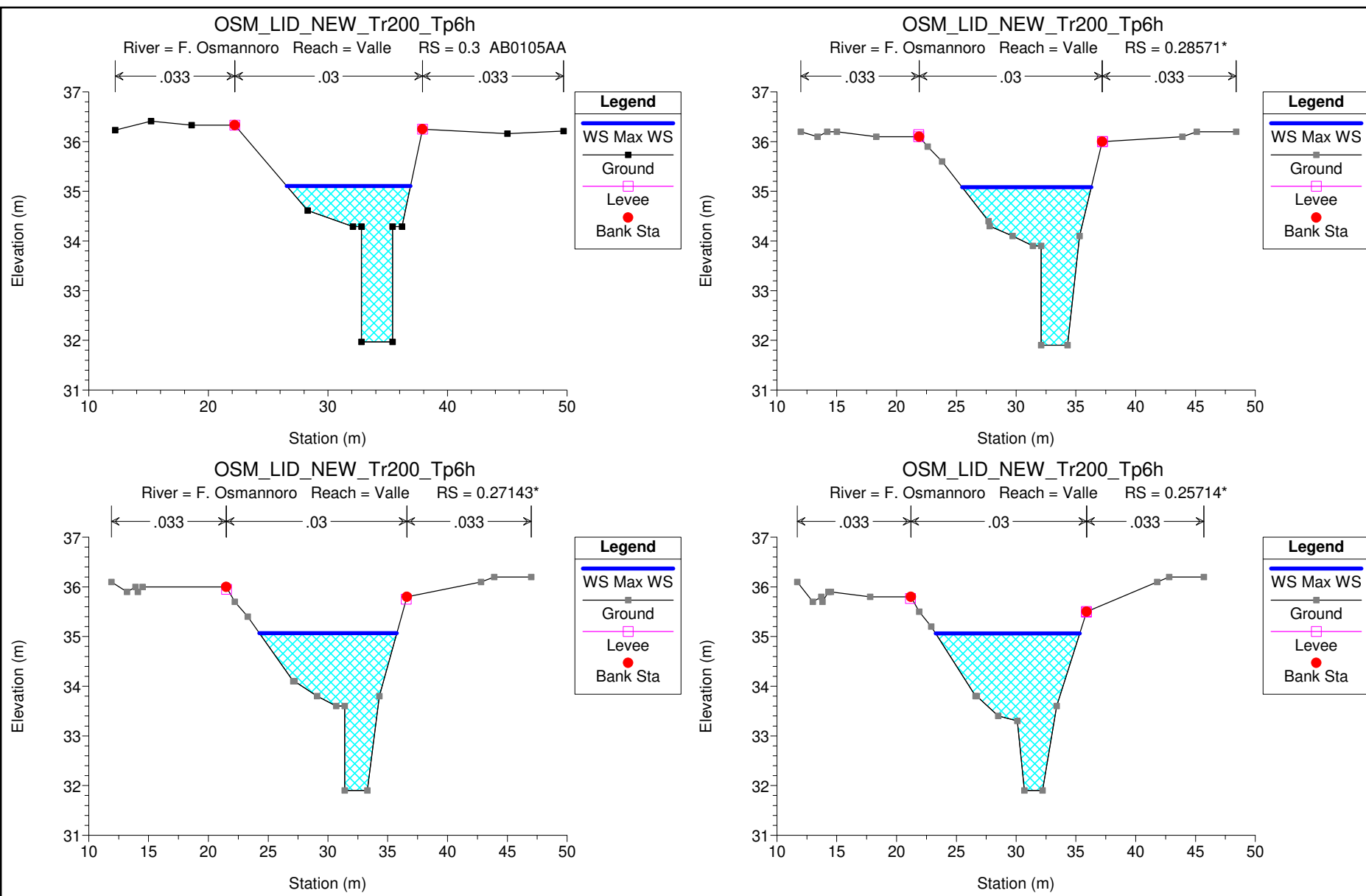


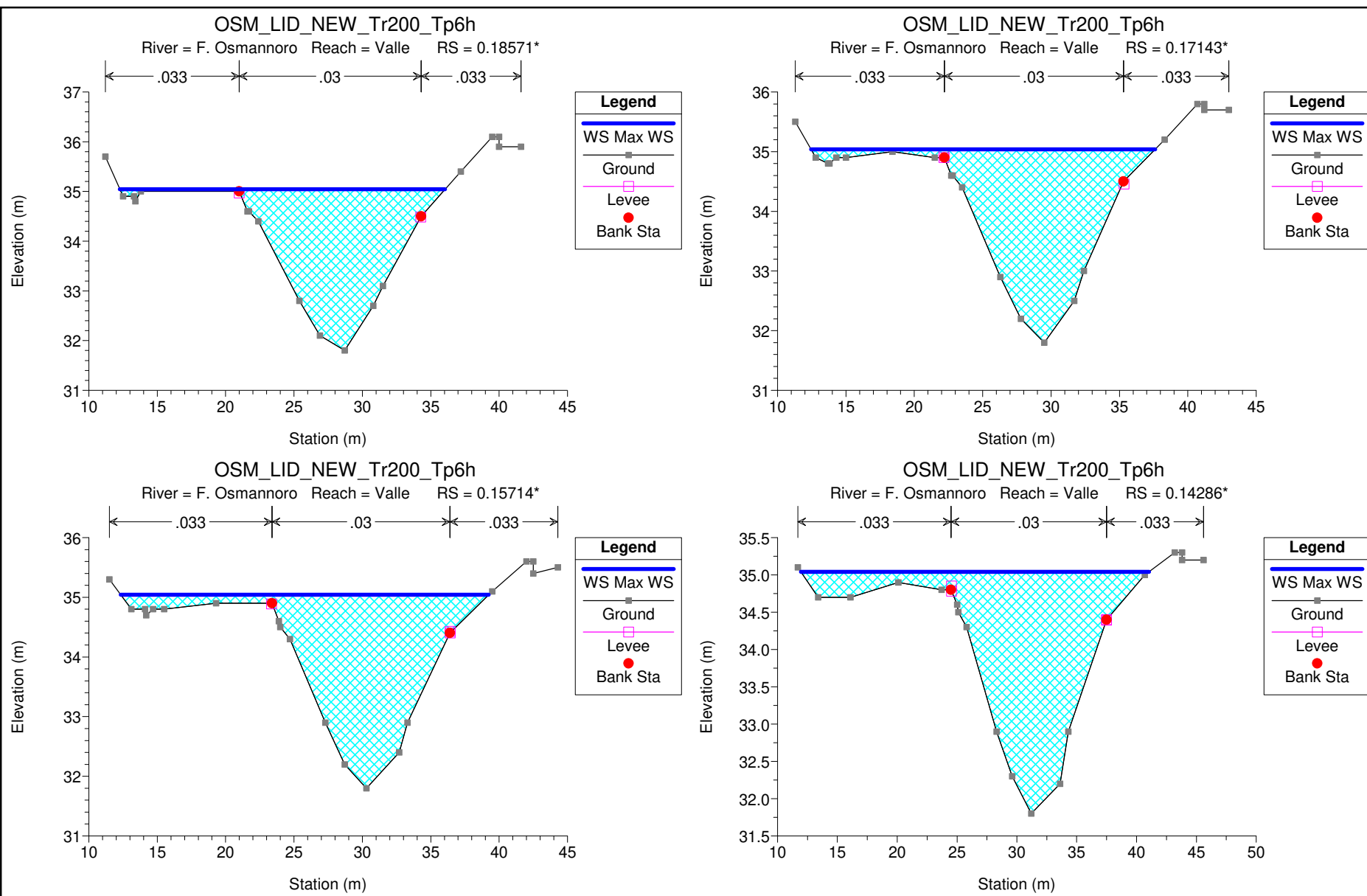


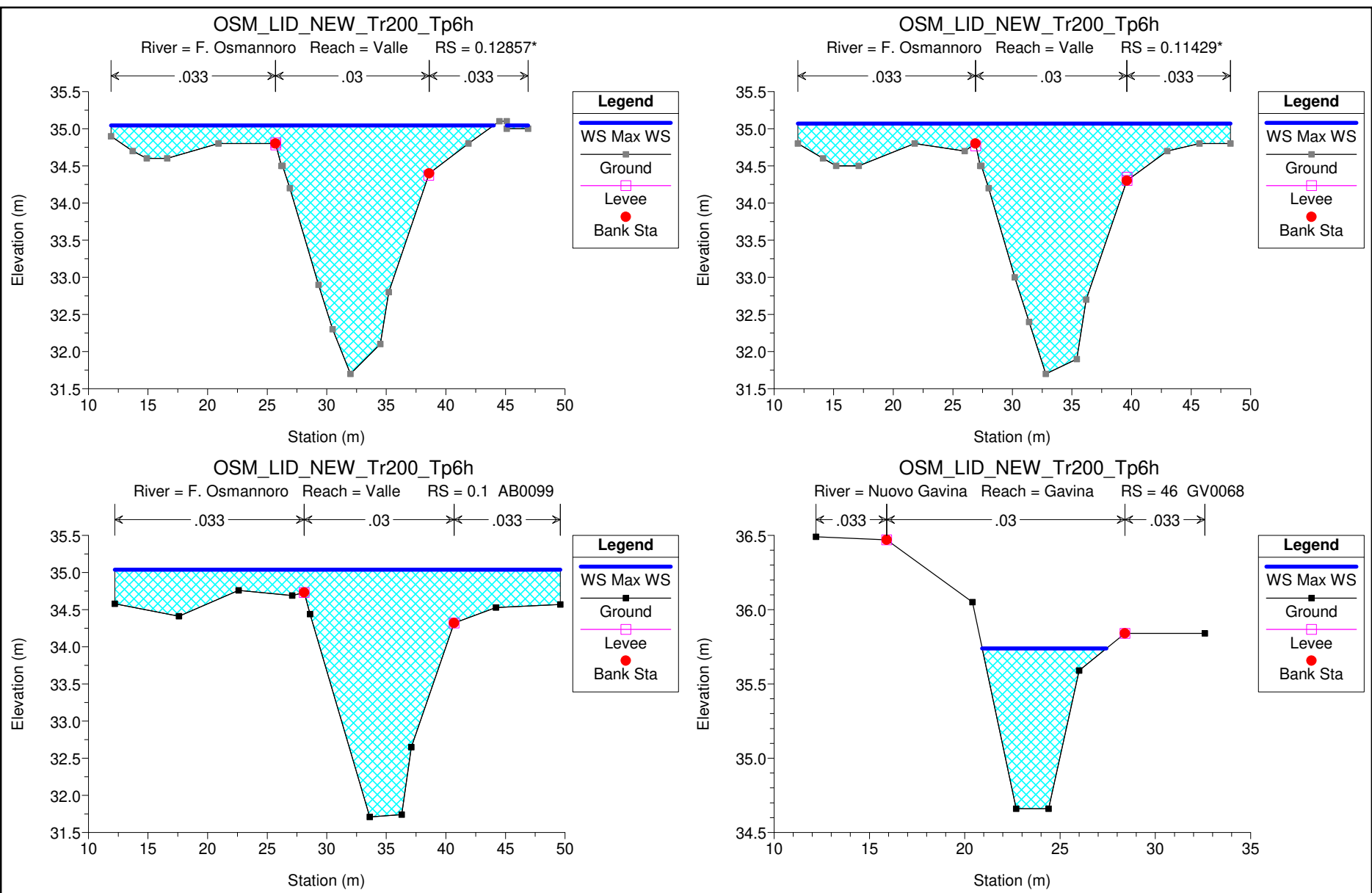


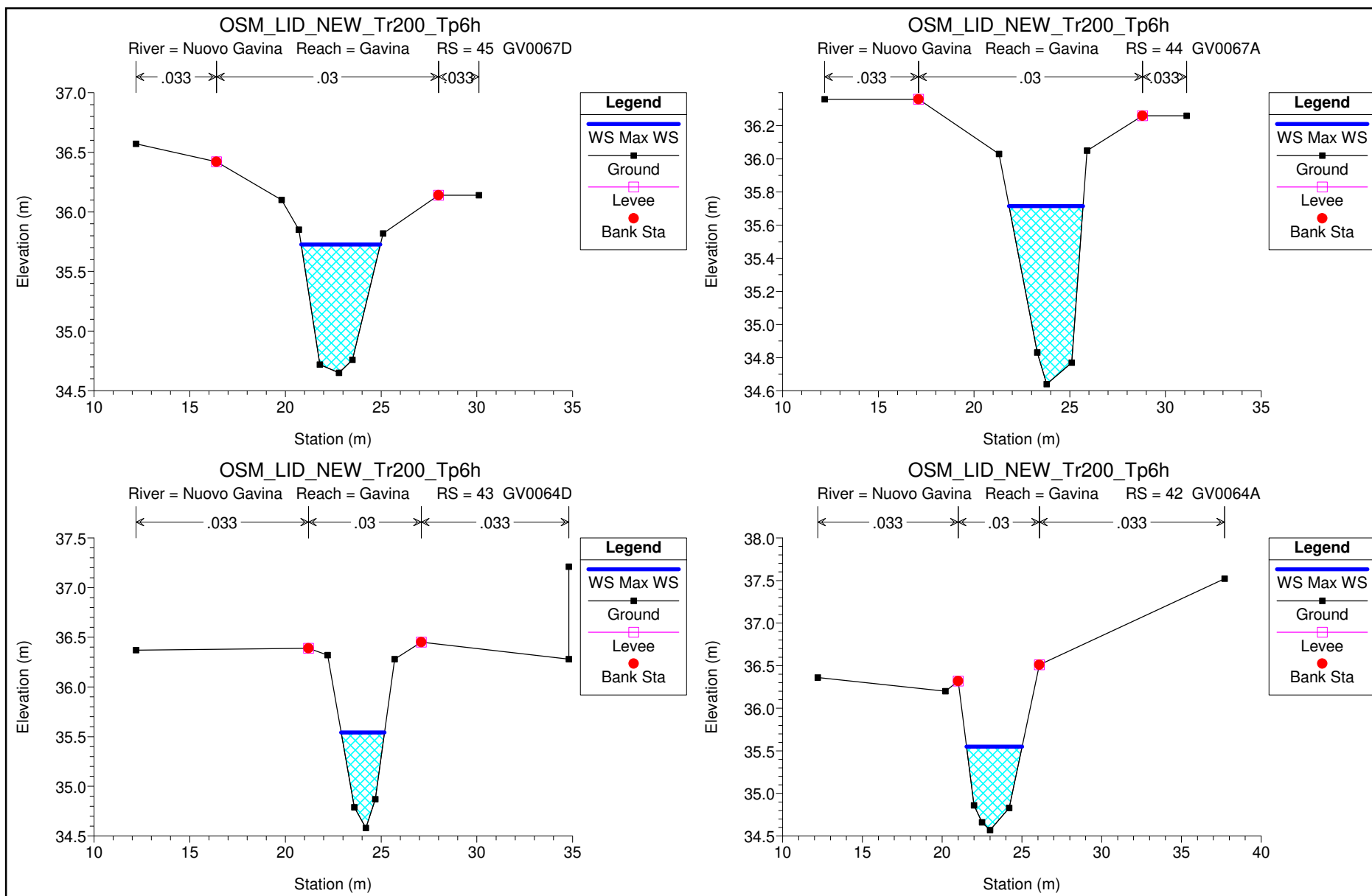


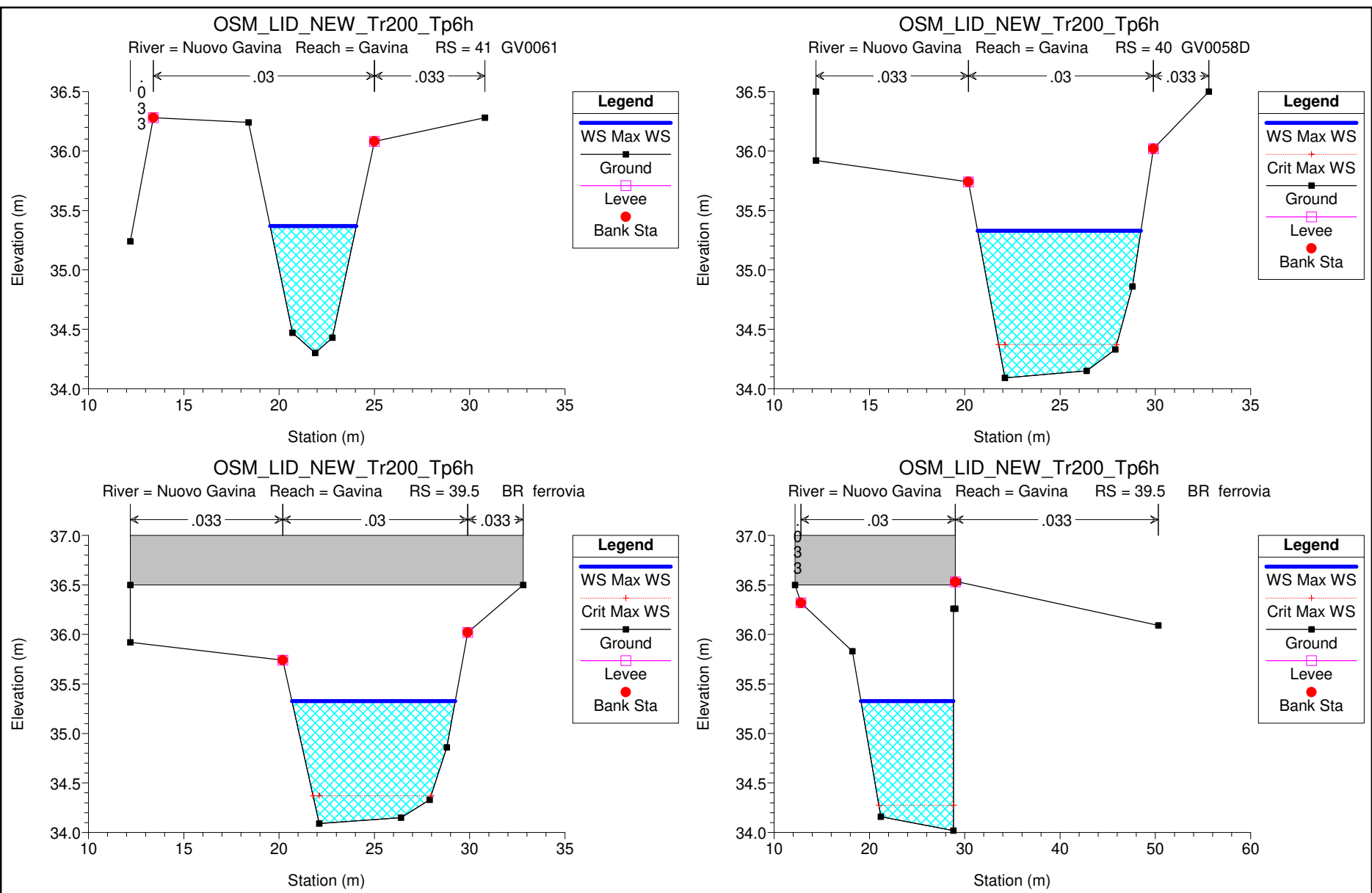


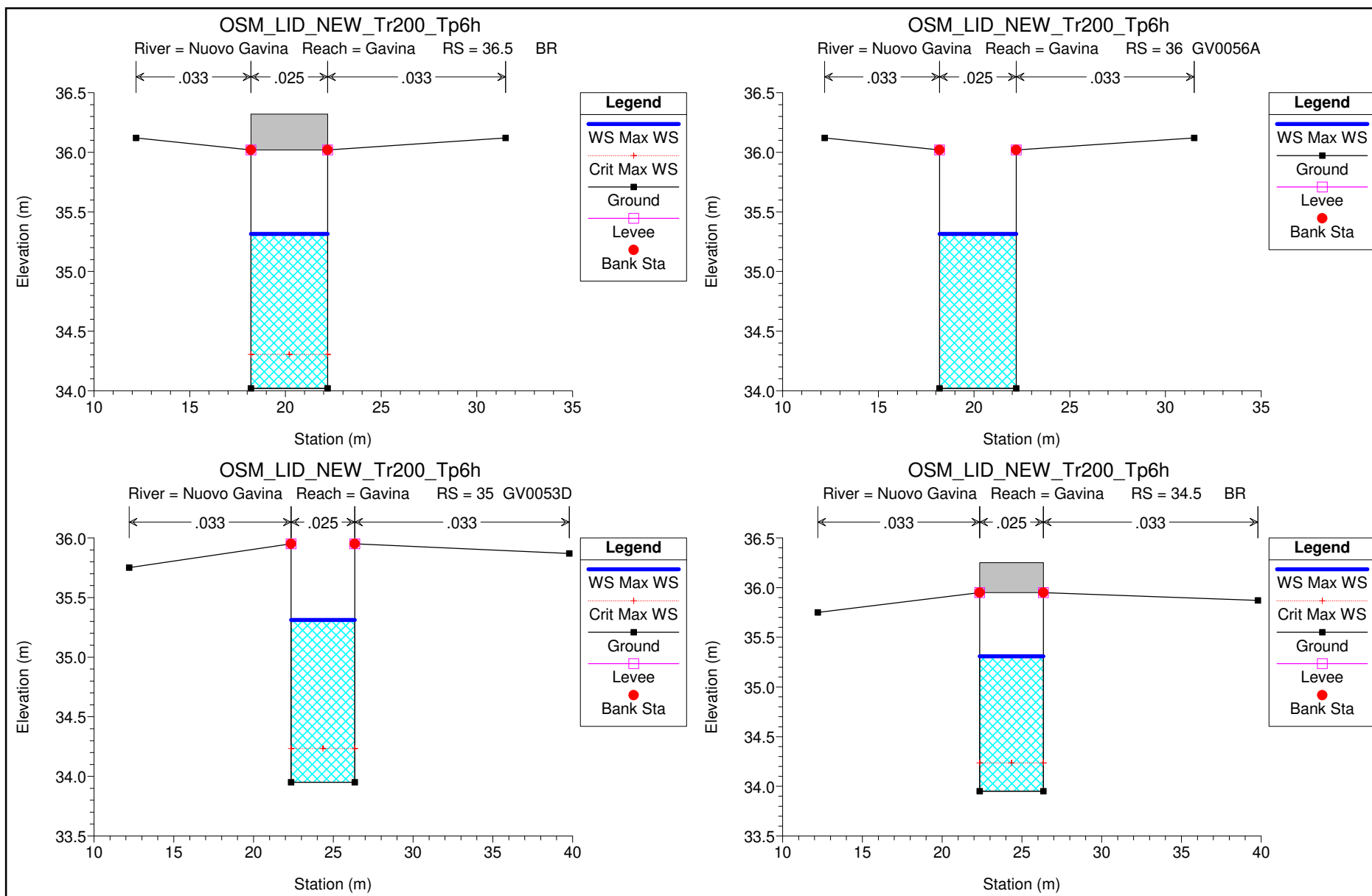


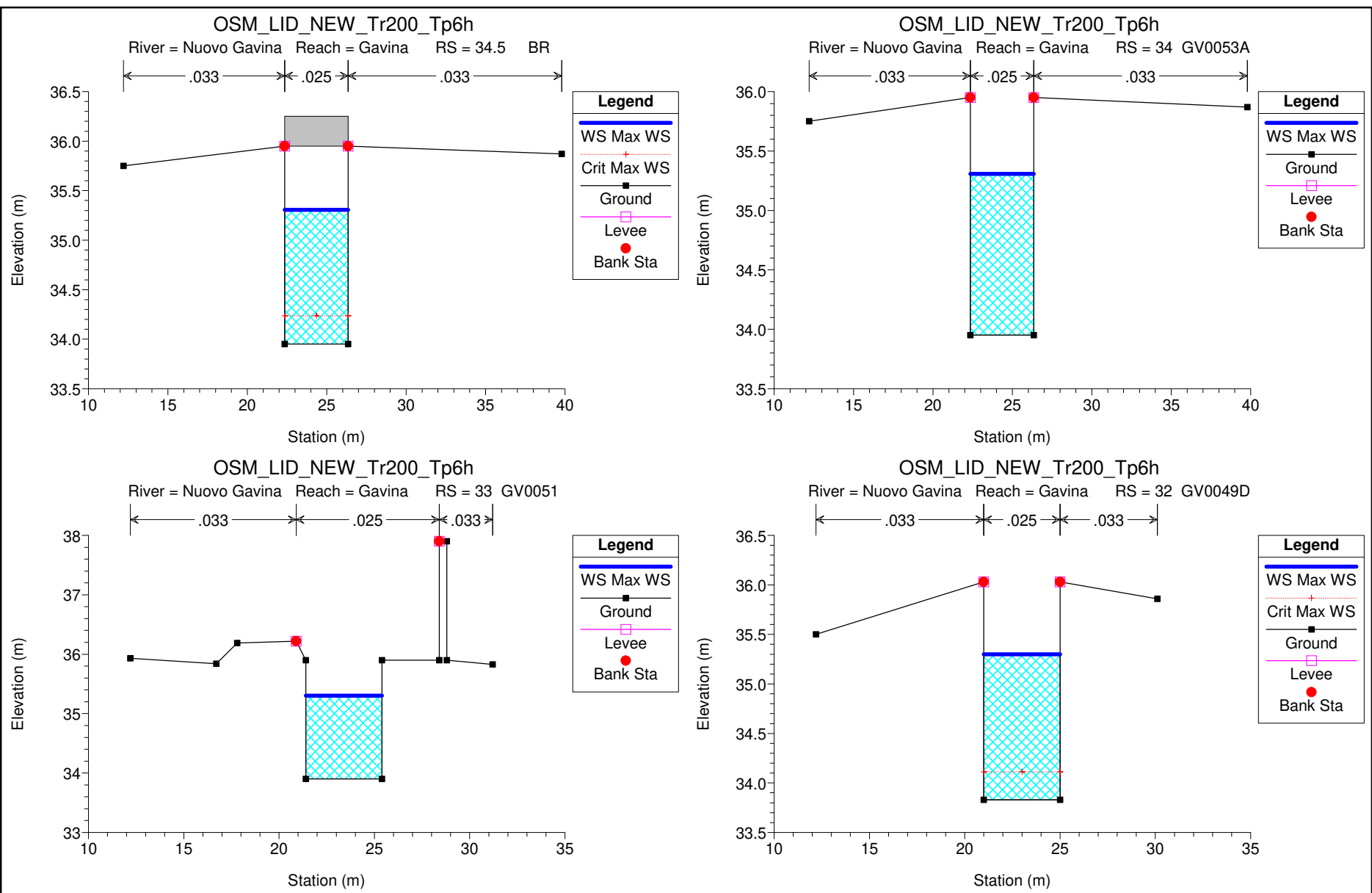


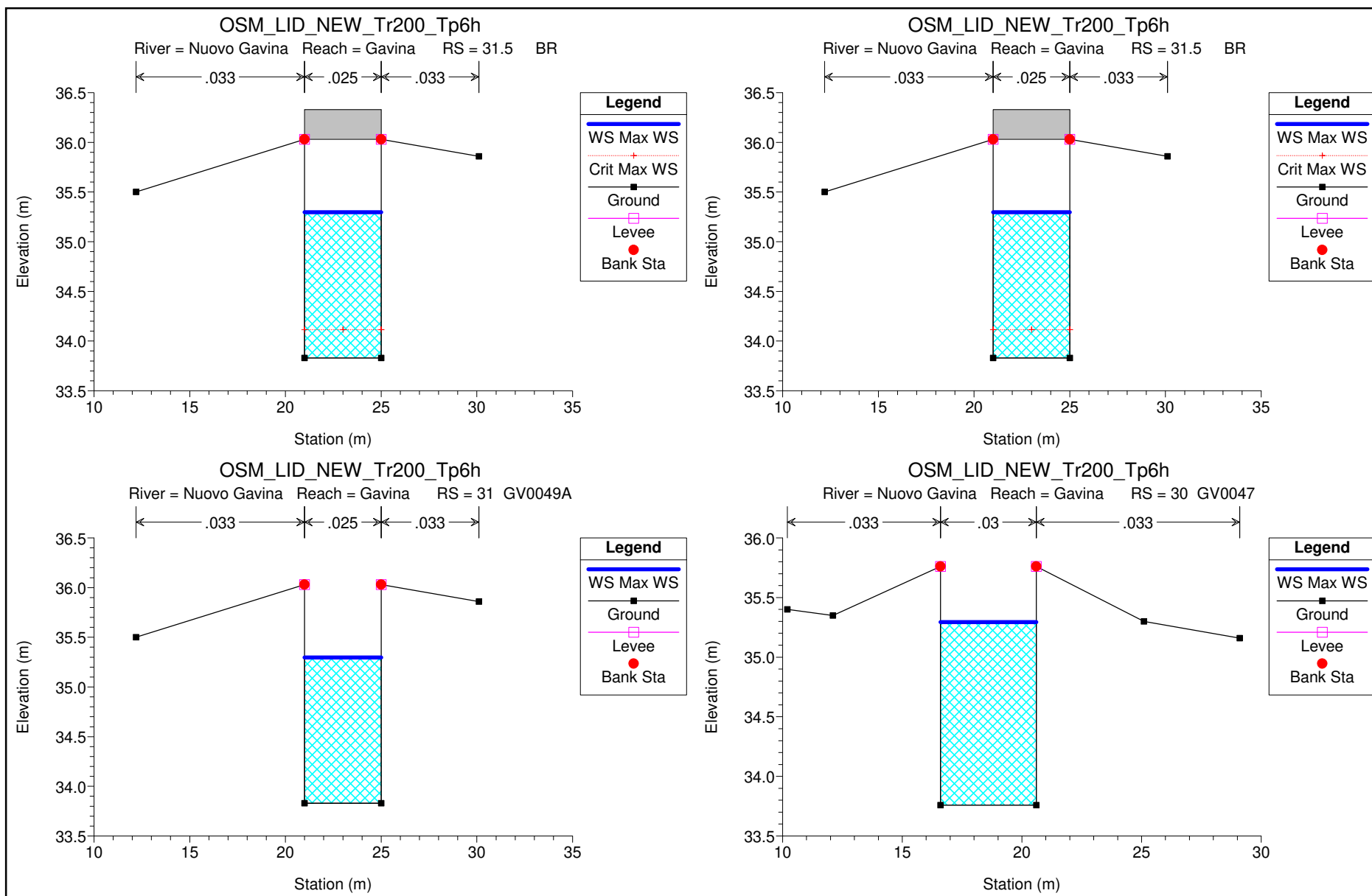


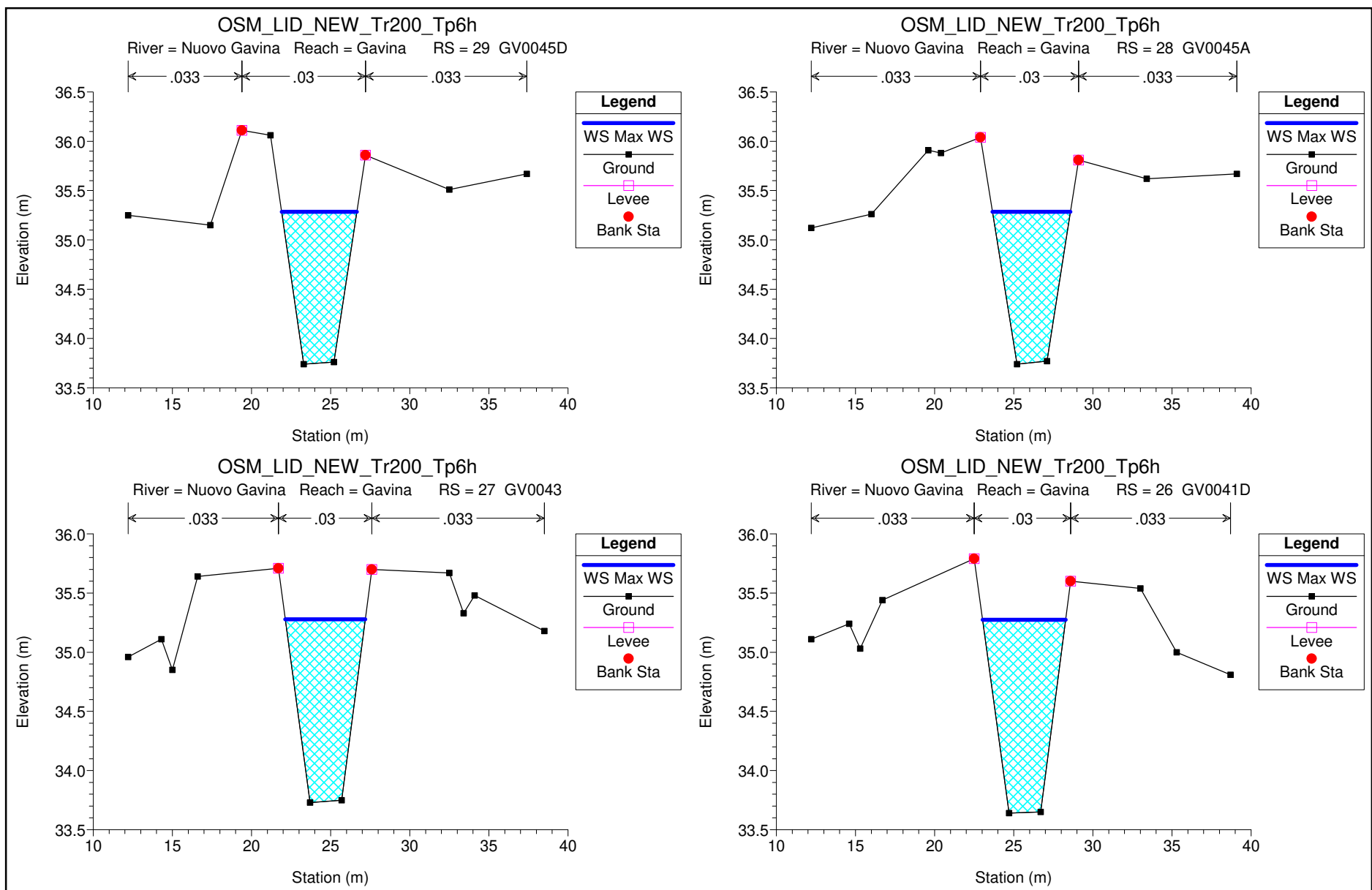


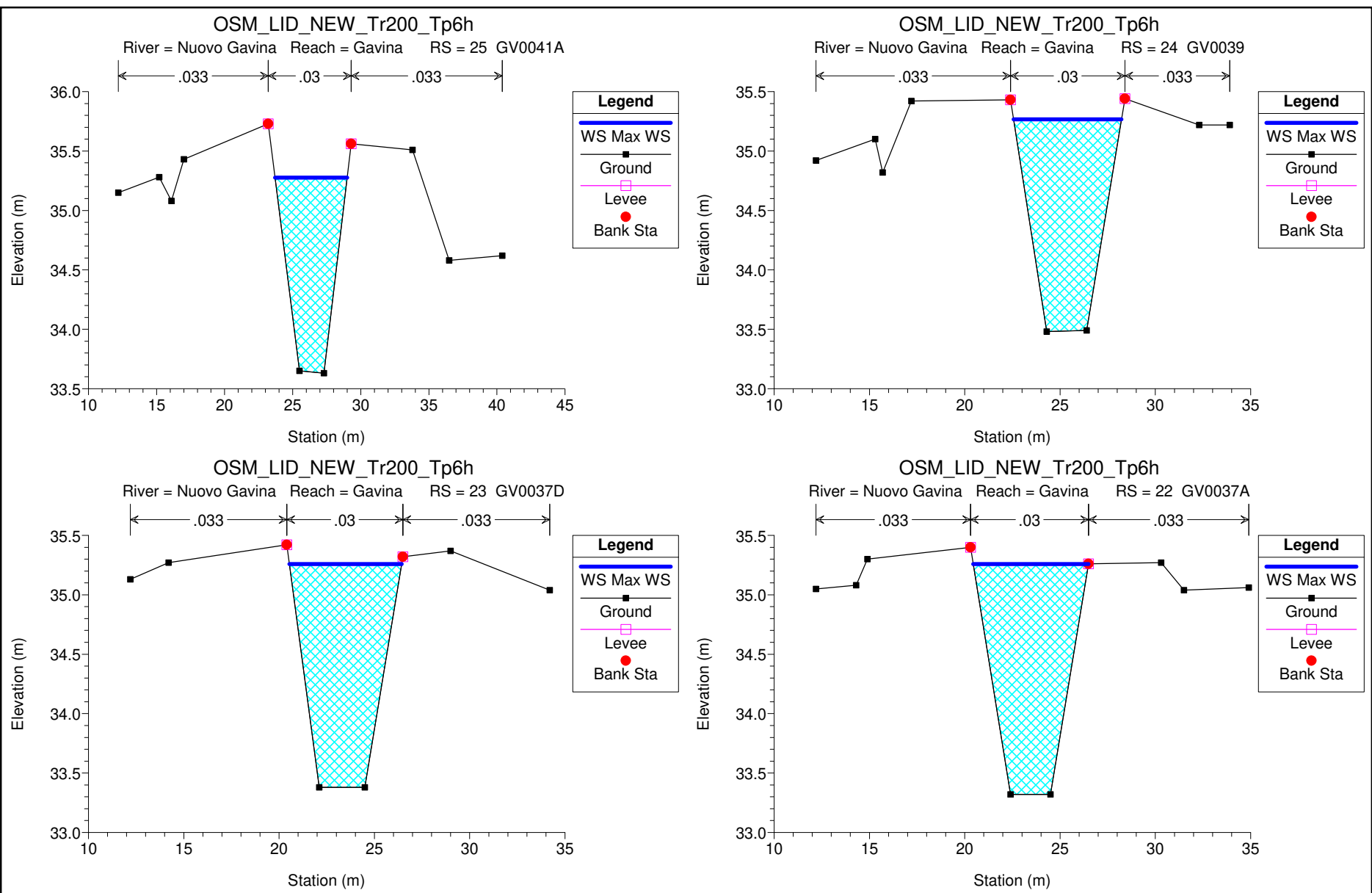


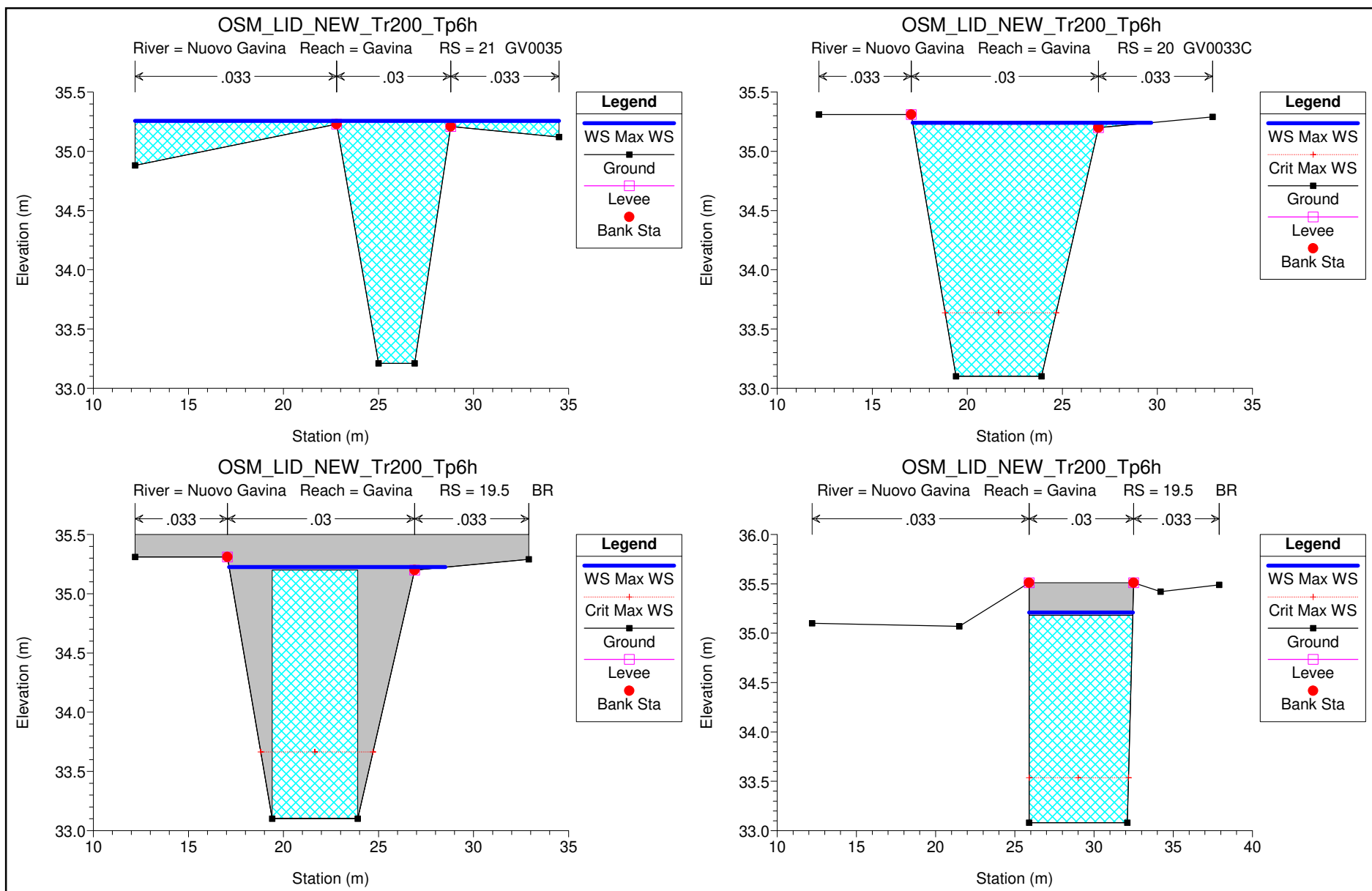


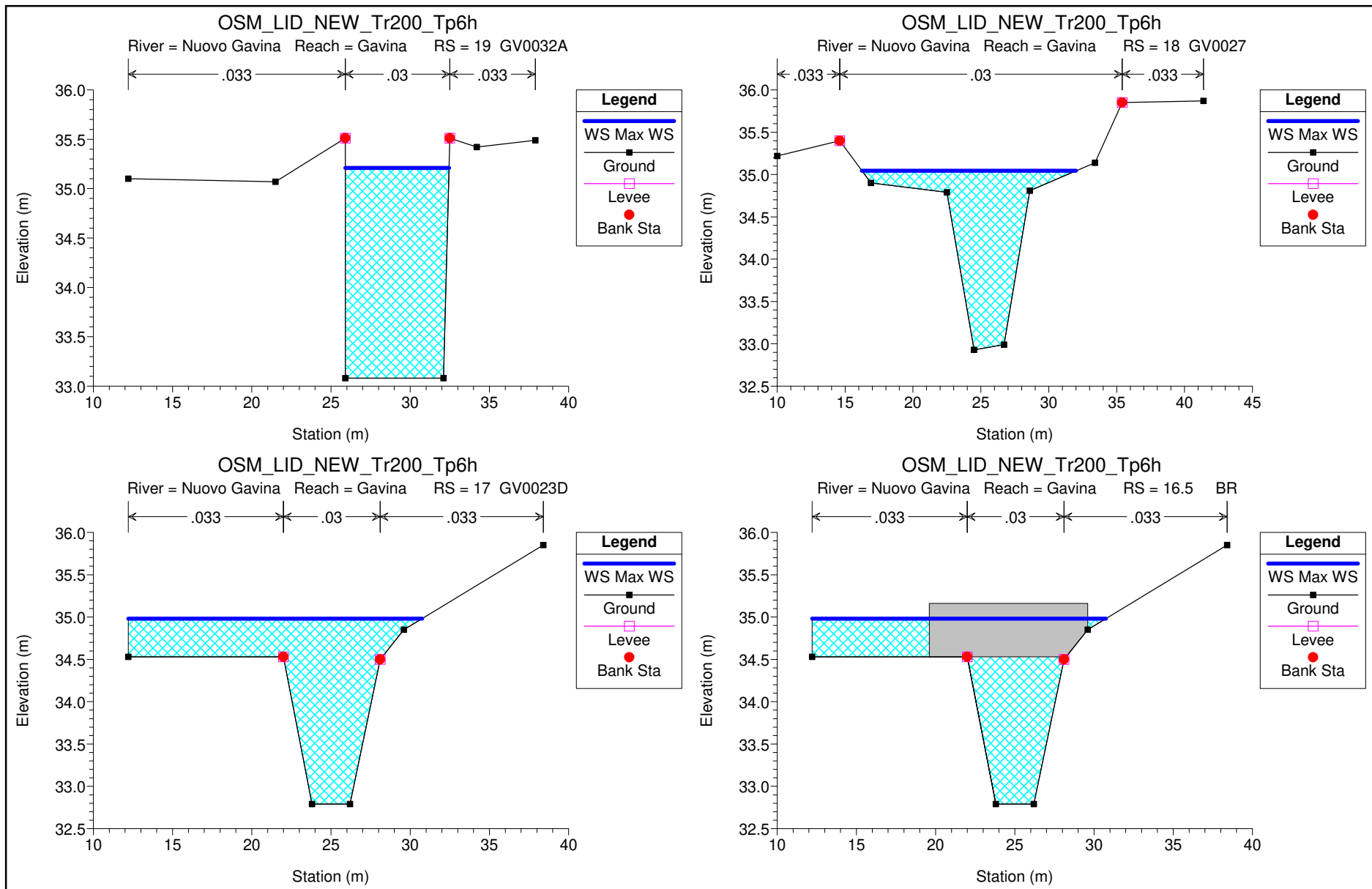


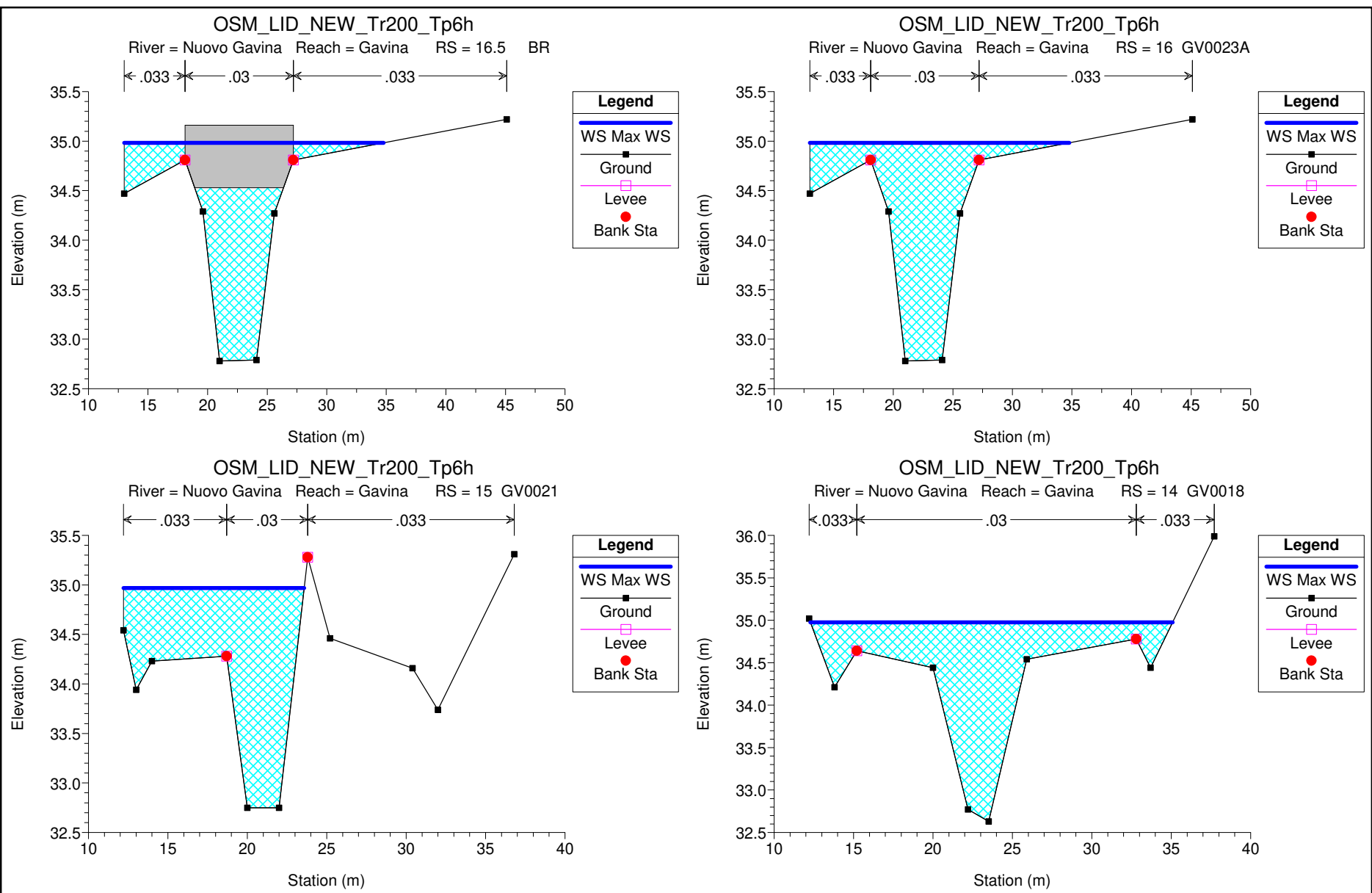


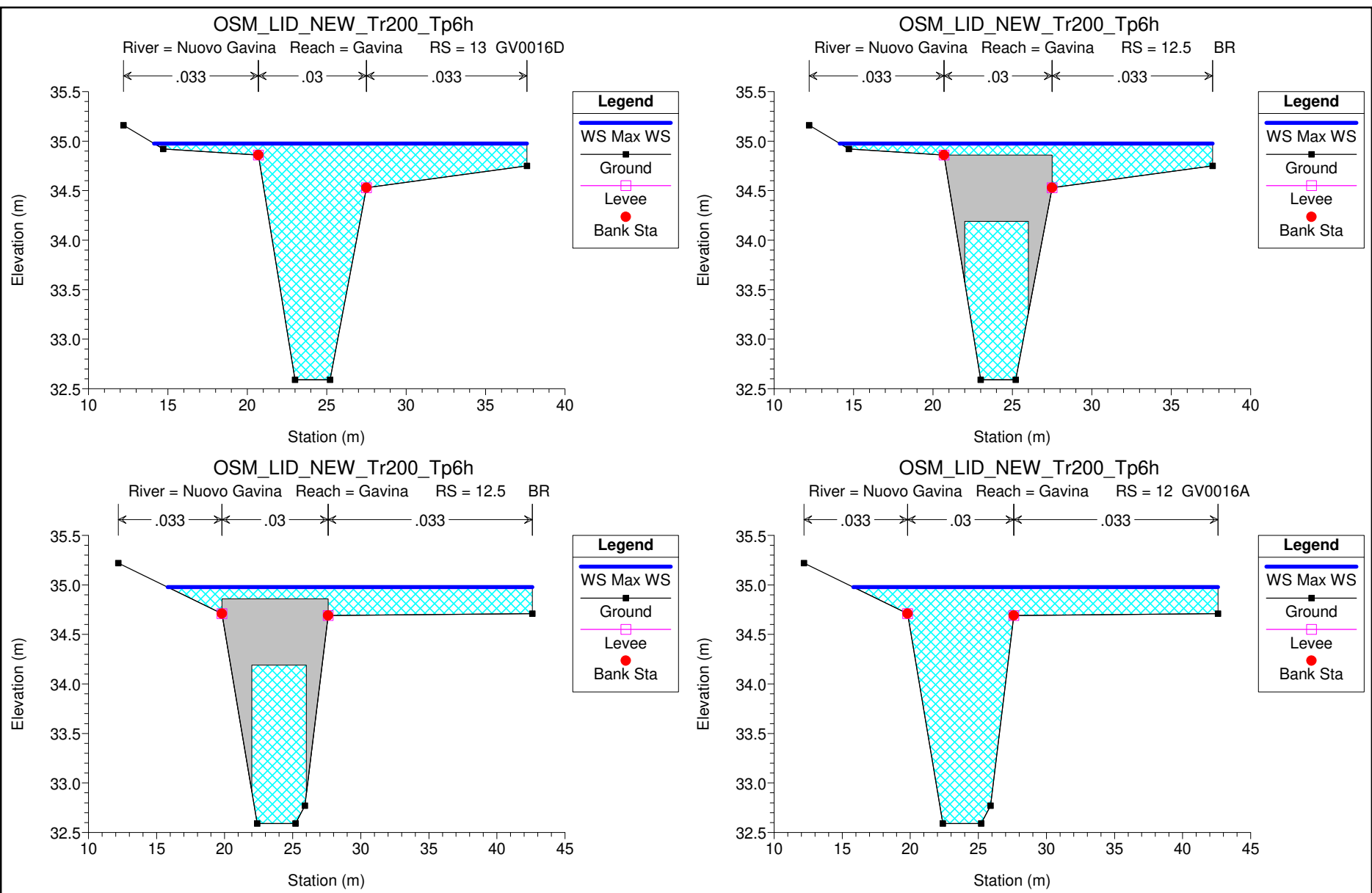


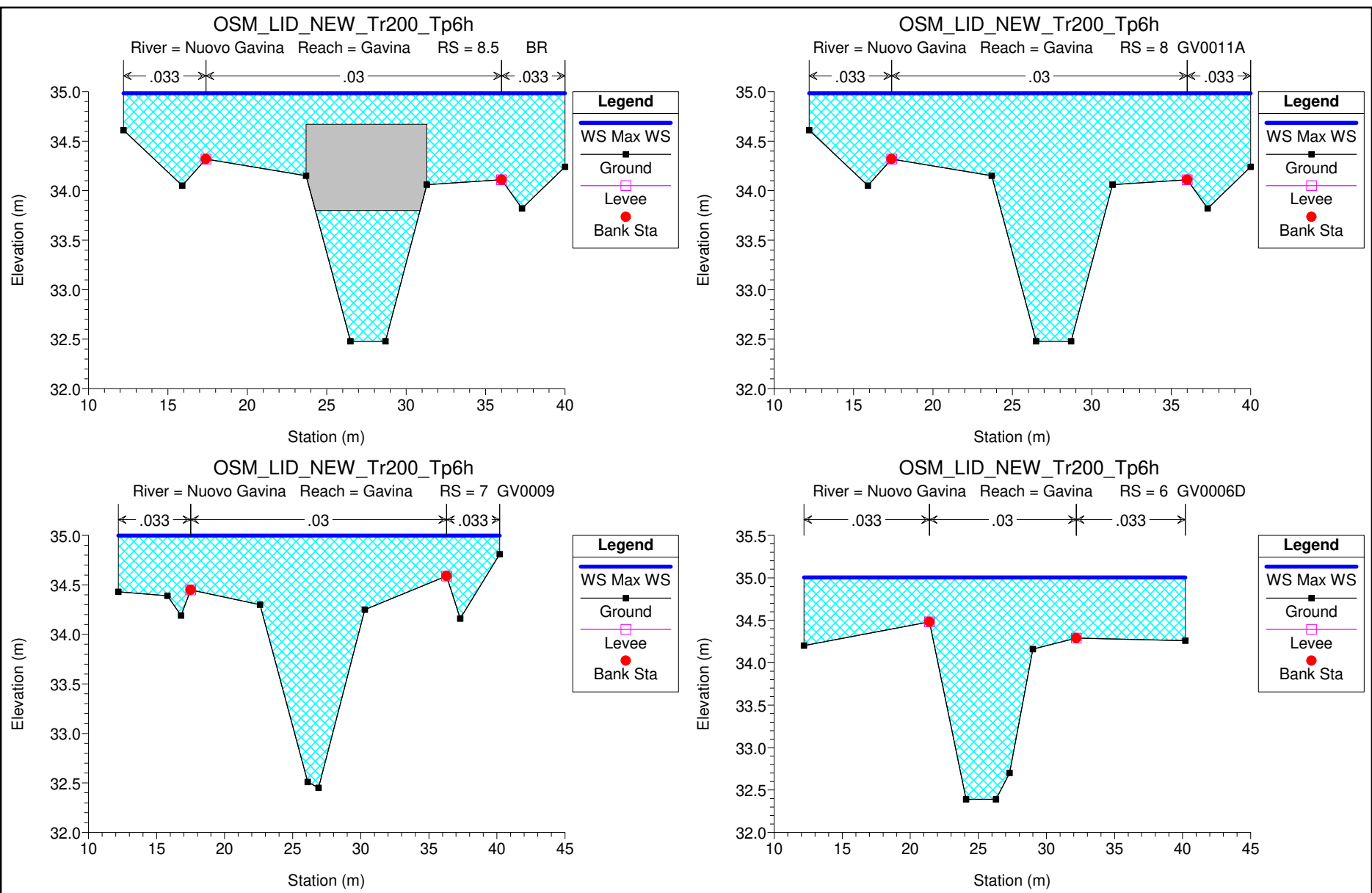


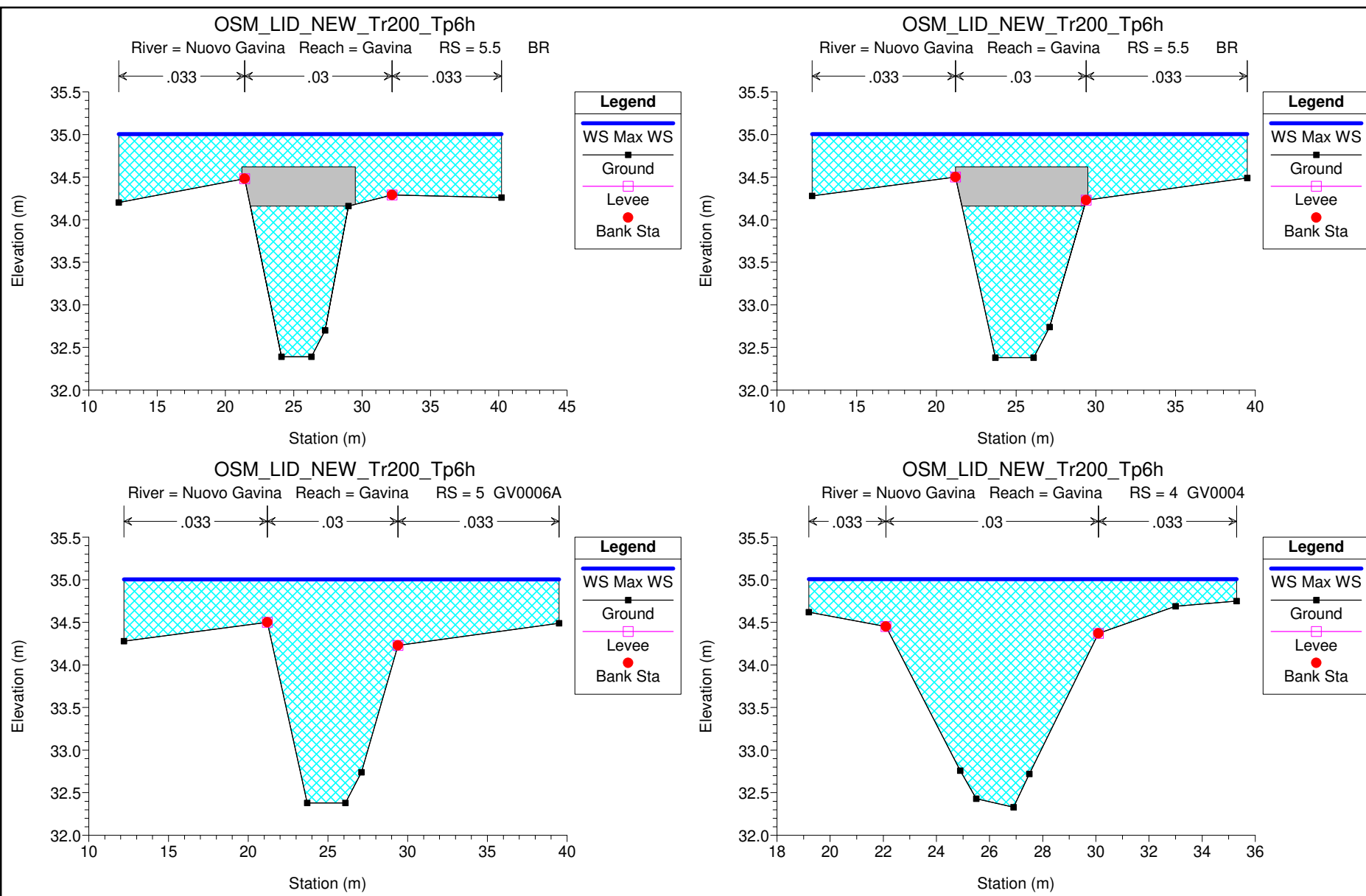


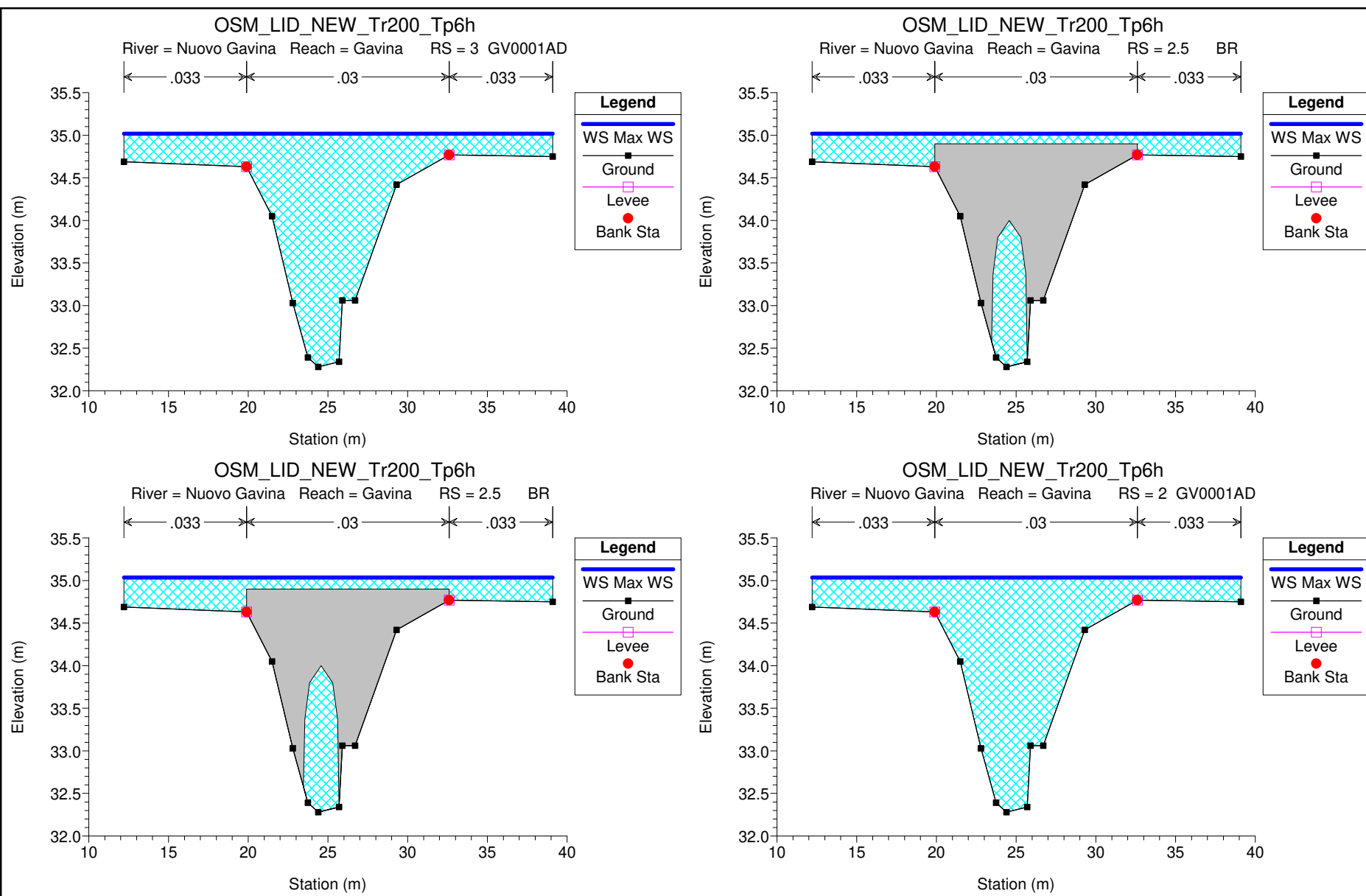












OSM_LID_NEW_Tr200_Tp6h

River = Nuovo Gavina Reach = Gavina RS = 1 GV0001AD

