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Detailed Analyses of Flows from Drains into Estuary

This document contains the assumptions, methodology, results and conclusions of investigations of the effect of the Project on the operation of the drainage scheme. This version incorporates review comments from managers of the Drainage Scheme (Nat Haz Group of BoPRC email 8 July 2014)

NOTES

All levels stated are RLms.

Land in the area is generally between 0.0m and 0.5m (according to LiDAR data). Drain inverts are at -0.5m and lower.

Existing low tide levels vary depending on the neap-spring tide cycle between

-0.1 and -0.3 at Diagonal Drain outlet (River Pt 1)

-0.3 and -0.7 at Ford Rd Drain outlet (River Pt 3)

0.16 and 0.24 in the estuary (Estuary Pt 3)

-0.4 and -0.8 in the open ocean

NOTES: While the estuary is emptying out at Maketu water is beginning to enter through Ford's Cut – hence the low tide in the upper estuary is much higher than that at Ford Rd outlet or the open ocean. Low tide levels in the river reduce downstream from Diagonal Drain past Ford Rd Drain then to the sea, as expected.

Plots of low tide water level in the estuary at Point 3 (near Singleton Drain outlet) are not reliable due to lack of model resolution applied in this area. DHI advise (Ben Tuckey pers comm) that the low tide water levels in this area are represented adequately by estuary Point 3 (included herein).

OBJECTIVES of DRAINAGE SCHEME

Maintain water level in the drains between -0.1 and -0.3m

Get water off the farmland within 3 days during a 20%AEP flood

DRAINAGE ASSETS OWNED BY SCHEME (except where noted)

See plan in Appendix 2 at end of document. *Exact locations, sizes and names need checking – however, adequate for this preliminary analysis*.

1. Diagonal Drain pumpstation and gravity outlet
2. Ford Rd pumpstation and gravity outlet
3. Brain Main Outlet Drain gravity outlet = Maketu Cut East?
4. Dean (previously known as Armstrong) pumpstation (privately owned)
5. Dean gravity outlet
6. Dean gravity outlet
7. Burgess gravity outlet
8. Singleton pumped drain pumpstation
9. Singleton gravity drain outlet

SCENARIOS TO BE UNDERSTOOD

S1 Normal flow in river, dry weather – groundwater in the farmland seeps into the drains and flows to the outlets. The natural tidal cycle in the river and estuary allows any accumulating water to drain out of the gravity outlets when the tide is low. As the tide rises the flapgates close and water rises behind them in the drains. As the tide goes out the flapgates open and the accumulated water discharges. If the water level gets high enough (up to RL-0.1m) any pumps will operate and pump water out of the drains until the water level lowers to RL-0.3m

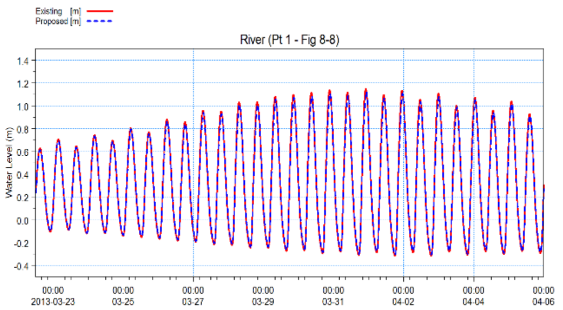
S2 Normal flow in the river, heavy rain on the farmland – similar behavior as above but obviously flows and levels are higher in the drains and reliance is placed on the flow under gravity.

S3 Flood flow in the river, dry weather on the farmland – river and estuary levels rise for all stages of the tide until the flood peak passes. The flapgates are closed for longer hence less water is able to drain out under gravity and the pumps work for longer. Important to note the pumps do not have to work through a higher head because their discharge points are above downstream water level for the majority of the tidal cycle. Therefore flow rates do not decrease over these times. Only for short durations at high tides are the outlets flooded to a greater or lesser degree that may have an impact on flowrate. A slowed flowrate means the pumps operate for longer to achieve the desired -0.3m water level in the drains.

S4 Flood flow in the river, heavy rain on the farmland – this is similar to the scenario above but gravity flow from the drains is reduced due to higher downstream water levels keeping the flapgates closed. Drains take longer to drain and floodwaters stay high until the river and estuary levels return to normal. Pumps work longer to help get the water level down.

EFFECT OF PROJECT

Diagonal Drain



<u>Normal river flow</u>

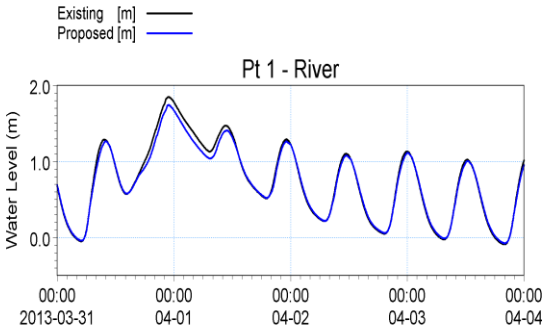
Low tide levels unchanged

High tide level marginally lower

Scenario 1 – no change

S2 – no change

Pumps – no effect



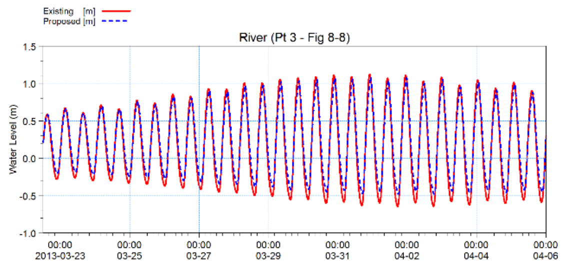
<u>River in flood</u>

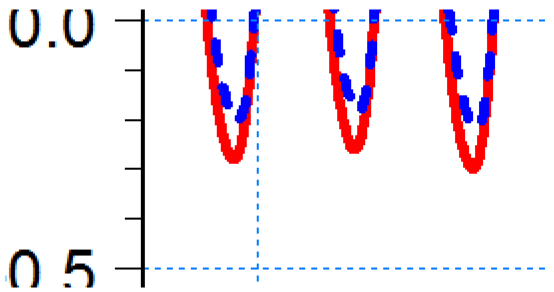
Water levels will be lower on rising limb, at peak and on falling limb of hydrograph

S3 and S4 – better discharge of water from outlet

Ford Rd Drain

Appendix 1 contains extract of detailed flow analysis





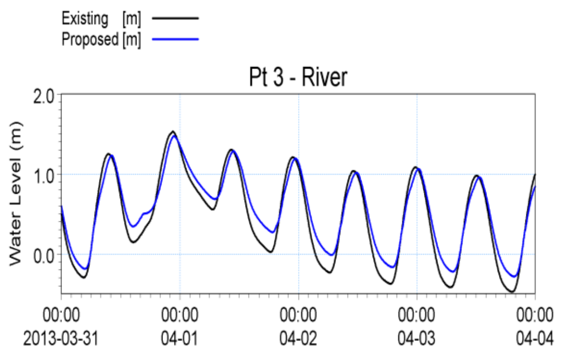
Normal river flow

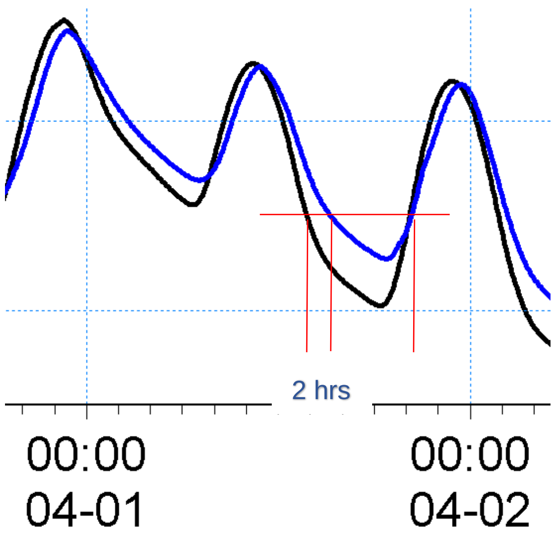
High tide level marginally lower - negligible benefit.

Low tide levels will increase by 100 to 150mm. The duration water level is lower than a chosen level will be marginally shorter.

S1 – Marginally less water discharged under gravity, more so during neap lows. Pumps work marginally longer leading to marginally higher power cost

S2 – Drain water levels are high enough that the tailwater level change does not dominate. If there is any effect it will be negligible.





River in flood

Water levels are higher on rising limb, slightly lower at peak and higher again on falling limb of hydrograph; especially at low tides. For 8 hrs the tailwater level is higher by up to 0.3m and for three low tides. Project prevents drainage under gravity. Instead of taking two low tides to get to -0.3m, it will take 5.

S3 – With minimal drainage required during this scenario the effect is less than minor (there is no floodwater to dispose of).

S4 – Must dispose of floodwater. Gravity drainage will be slower at mid and low tides but not at high tide.

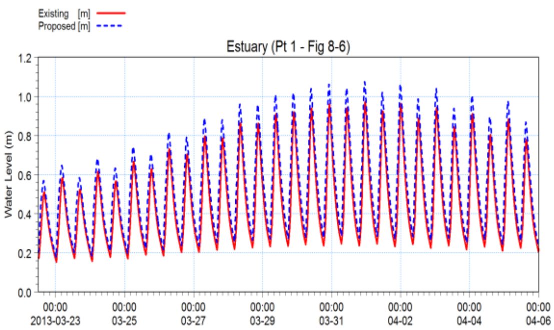
TWL (river) sites below RL0.5m (for example) for about 7 hours now but after the project it is for about 5 hrs. And over this time the TWL is higher so the flow rate is lower (for most HWL (drain) levels). Combination of these effects means a reduction in volume passed by gravity.

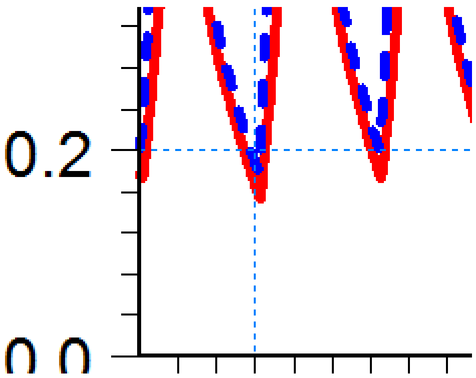
Mitigation is proposed by adding gravity flow capacity by adding culvert(s).

Preliminary testing at Ford Rd Drain outlet indicates a 1800mm box culvert set at RL-0.7m will likely provide mitigating capacity.

Drains into Estuary (e.g. Brain, Dean, Burgess, Singleton)

Detailed flow analysis undertaken for Singleton Culvert (similar to Appendix 1)





<u>Normal river flow</u>

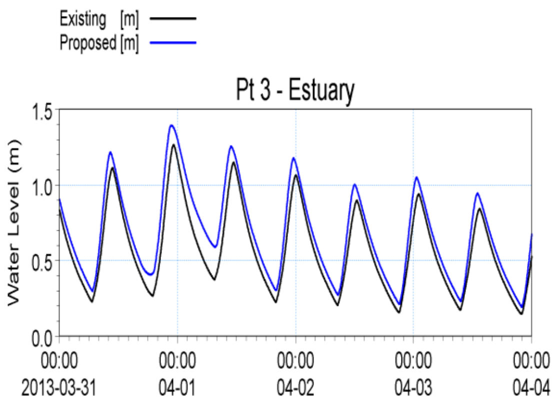
High tide level is higher by approx 5cm to 8cm. The whole TWL hydrograph has shifted up by 4cm on the low tide. Therefore durations water levels are lower than a chosen level will be marginally shorter.

S1 – Water levels in drains will be 4cm higher – negligible.

The inlet pond of Singleton pumped drain is not directly connected to the estuary – any change in estuary water level has to propagate through the ground which will take time; water in this pond comes down the Singleton Pumped Drain from the south; the outlet discharges above mid-tide so higher tides will increase head across pump and so reduce flow rate. Reduction is minimal (50l/s out of 1250l/s) – less than minor effect.

S2 – high flow in drains will have marginally less time to drain the same volume. Less than minor effect.

The inlet pond of Singleton pumped drain is not connected to the estuary; the outlet discharges above mid-tide so high tides will increase head across pump and so reduce flow rate. Reduction is minimal (50l/s out of 1250l/s) – less than minor effect.



<u>River in flood</u>

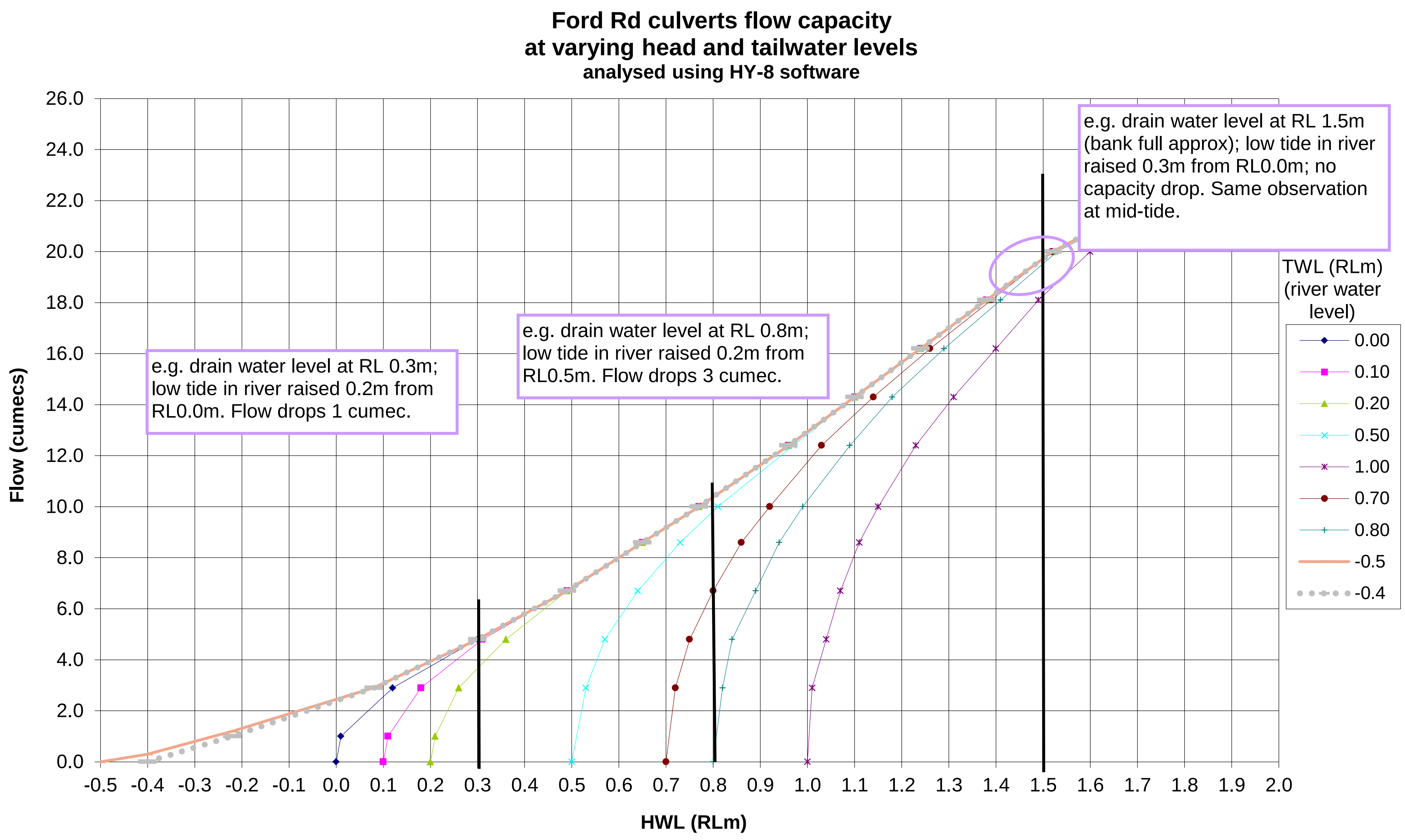
Causing estuary water levels to be higher on rising limb, higher at peak and higher again on falling limb of hydrograph; especially at first low tides. Instead of taking one low tide to get to normal it will take two. Project reduces drainage under gravity.

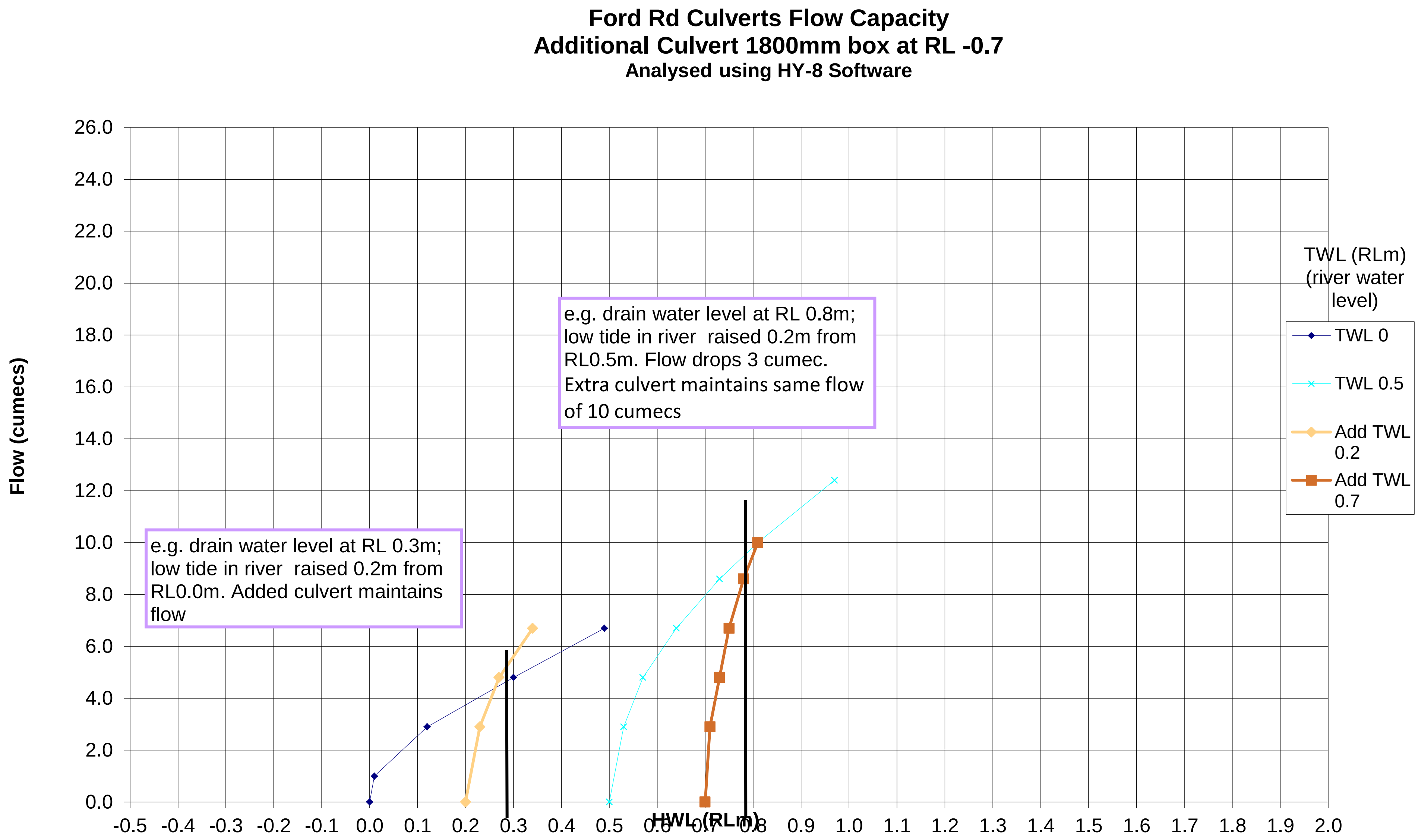
S3 – With minimal drainage required during this scenario (there is no floodwater to dispose of) the effect is less than minor

The inlet pond of Singleton pumped drain is not connected to the estuary; the outlet discharges above mid-tide so higher tides will increase head across pump and so reduce flow rate. Reduction is minimal (50l/s out of 1250l/s) and short-lived – less than minor effect.

S4 – Floodwaters to dispose of. Gravity drainage will be slower. Preliminary culvert flow analyses indicates the gravity capacity can be reinstated by the addition of a new culvert (1200mm dia IL -1.2m).

Appendix 1 – Flow capacity through drain culverts




Ford Rd Culverts Flow Capacity
Additional Culvert 1800mm box at RL -0.7
Analysed using HY-8 Software
Flow (cumecs)
HWL (RLm)
26.0
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
-0.5 -0.4 -0.3 -0.2 -0.1 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
e.g. drain water level at RL 0.8m; low tide in river raised 0.2m from RL0.5m. Flow drops 3 cumec. Extra culvert maintains same flow of 10 cumecs
e.g. drain water level at RL 0.3m; low tide in river raised 0.2m from RL0.0m. Added culvert maintains flow
TWL (RLm) (river water level)
TWL 0
TWL 0.5
Add TWL 0.2
Add TWL 0.7

Appendix 2 Map of Drainage Assets

1. Diagonal Drain pumpstation and gravity outlet
2. Ford Rd Drain pumpstation and gravity outlet
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