FLOOD MITIGATION MEASURES

A LOOK AT NIGHTINGALE GROVE

Presented By

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Water Resources Authority

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Presentation Outline

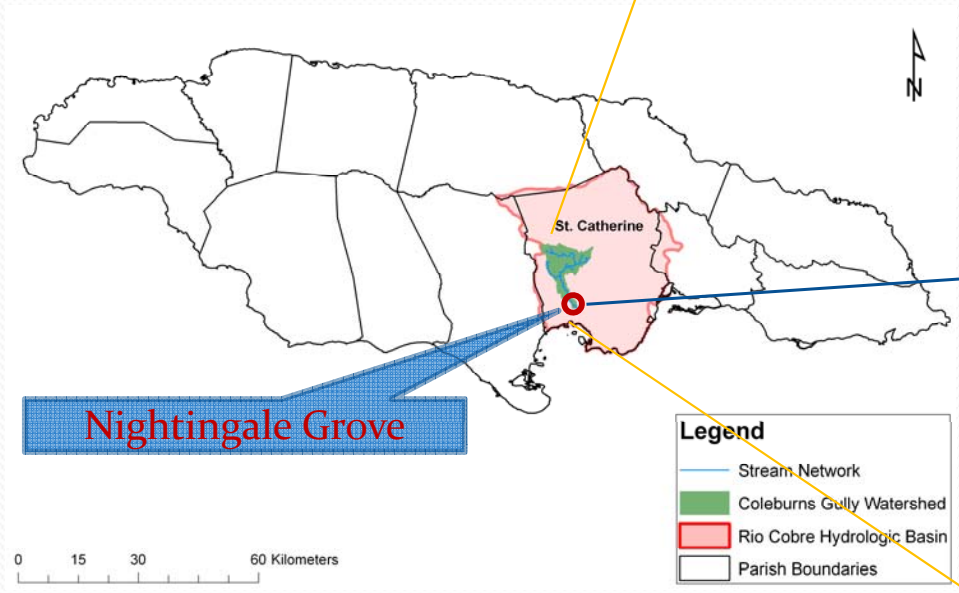
- Background
- Flood Discharge
  - Estimations
  - Predictions
- Flood Stage Predictions & Mapping
- Impact of H2K on Flood Levels
- Mitigation Strategies
- Conclusions
- Recommendations

Nightingale Grove

Location

&

Catchment



Historical & Current Landuse

1961 Aerial Photograph
(Tyndale –Biscoe)

2006 Satellite Image

- Flow Pattern

What Say the Residents?

- Interview with residents following tropical storm Gustav in August 2008:

  - "For 22 years I have been living here. The **flooding continues every year**, and we hope that it will stop because, right now, we have moved the **furniture up to the ceiling** should in case the rain starts…"

(The Jamaica Gleaner, published Saturday | August 26, 2008)

  - "I grew up here and the **flooding has worsened**. I am blaming it on the development of Highway 2000. When the "Coburn" gully comes down, it has nowhere to run off."

(The Jamaica Gleaner, published Sunday | August 31, 2008)

What Say the Residents?

- Interview with Florette, resident who bought house in 1982:
  - "Florette.....finally moving into the house she had bought.....Six months later, it rained hard in Nightingale Grove. So hard that the...stream...threatened to overflow its banks. But it never did, the rains never lasted long enough...

...It was an older neighbour who first gave her the unsettling news:
Nightingale Grove was prone to bad flooding...

  - In 1986, Florette's fears fulminated with the flood rains that year... Eighteen inches of water crashed into her house and she and her family **hoisted furniture unto beams**...
  - The following year, Florette was **hoisting again**. And every year after that, the river would break into her house like a thief, and rob her of something precious...Florette has **survived more than twenty floods** since she has lived in Nightingale Grove..."

The Jamaica Gleaner, published Sunday December 4, 2005:

The Hoisting

The Jamaica Gleaner

The Jamaica Gleaner

What Say the Residents?

- Interview with Florette continued:
  - Referring to Hurricane Wilma -2005
    - Worst known flooding to affect the community

"...The hoisting never mattered this time..."

The Jamaica Gleaner, published Sunday December 4, 2005:

Flood Level

The Jamaica Gleaner

Rescue

The Jamaica Observer

Flood Discharge Estimation

- Why Estimate?
  - Ungaged catchment
    - No measured flow
- How?
  - Slope Area Method

Slope Area Method

- Computes Peak Flow
- Manning Equation

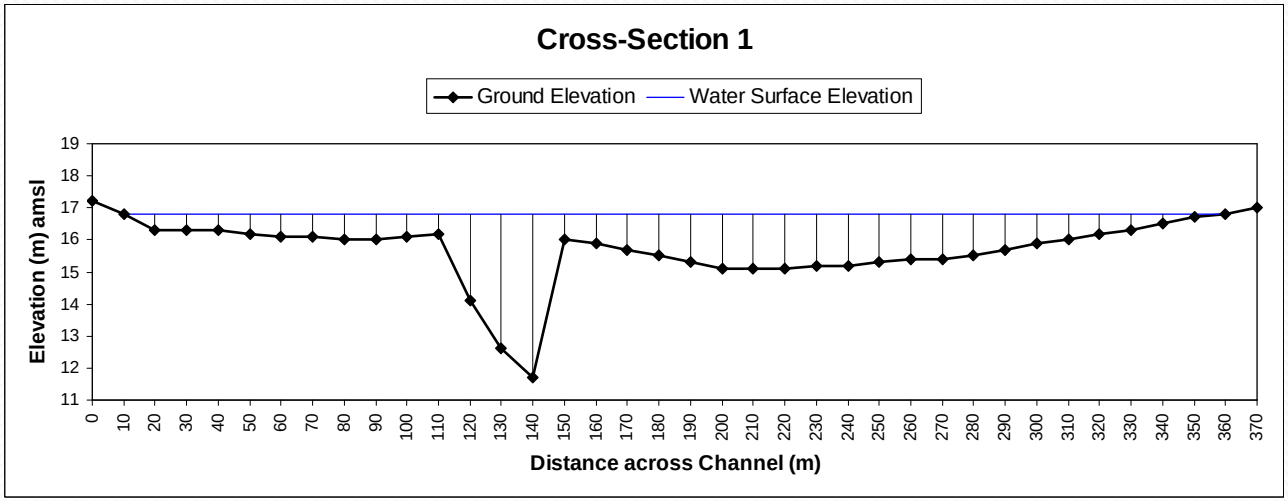
$$Q = \frac{1}{n}\left(AR^{\frac{2}{3}}S_e^{\frac{1}{2}}\right)$$

- High Water Marks

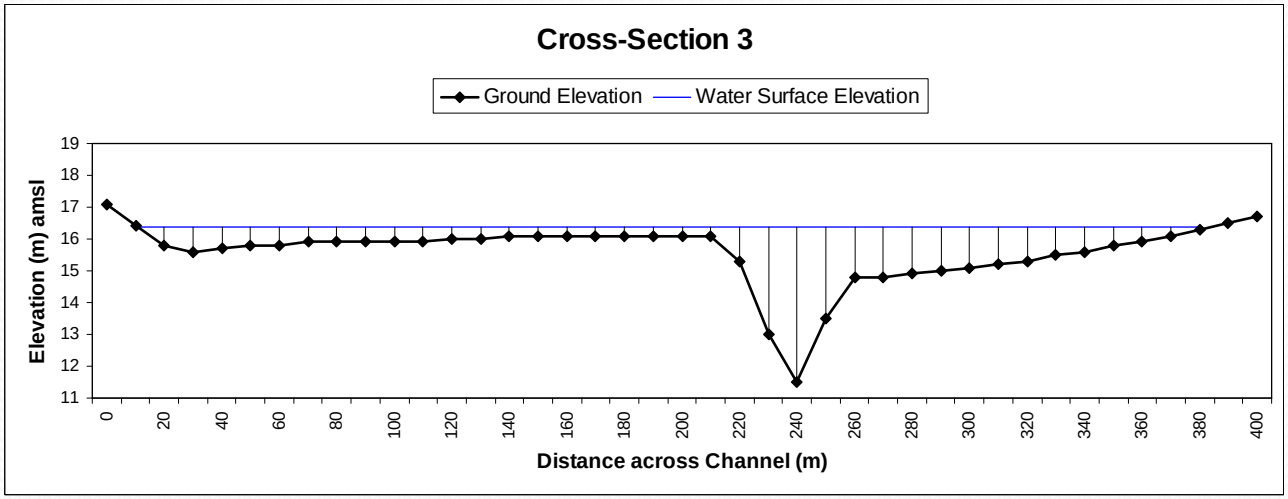
Channel Reach

- Straight
- Uniform
- No Obstructions

Channel Cross-sections



- Used to compute
  - Conveyance
  - Water Surface Slope



Peak Flow Computation

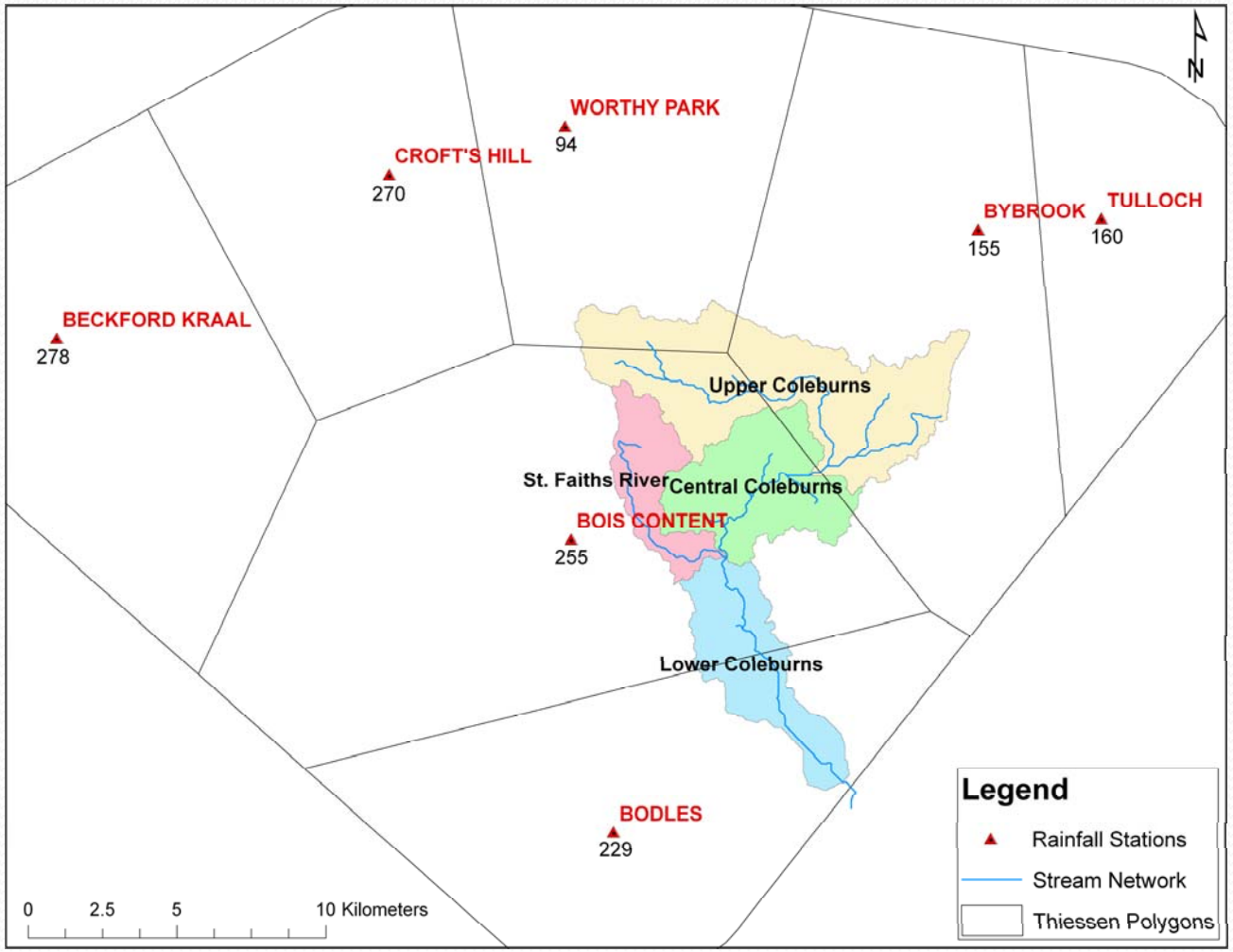
K_m *(m^3/s)*		8032	L *(m)*		124			Q_p *(m^3/s)*		
Iterations	V_1 *(m/s)*	V_3 *(m/s)*	h_{v1} *(m)*	h_{v3} *(m)*	Δh_v *(m)*	Δh *(m)*	S_e *(m/m)*	n = 0.045	n = 0.04	n = 0.05
-	-	-	-	-	-	0.43	0.00347	**473**	**519**	**436**
1	1.1323	1.4639	0.0653	0.1092	-0.0439	0.3861	0.00311	**448**	**486**	**417**
2	1.0730	1.3872	0.0587	0.0981	-0.0394	0.3906	0.00315	**451**	**490**	**418**
3	1.0792	1.3952	0.0594	0.0992	-0.0399	0.3901	0.00315	**451**	**490**	**418**

- Used to Calibrate rainfall runoff (Hydrologic) Model

Flood Discharge Predictions

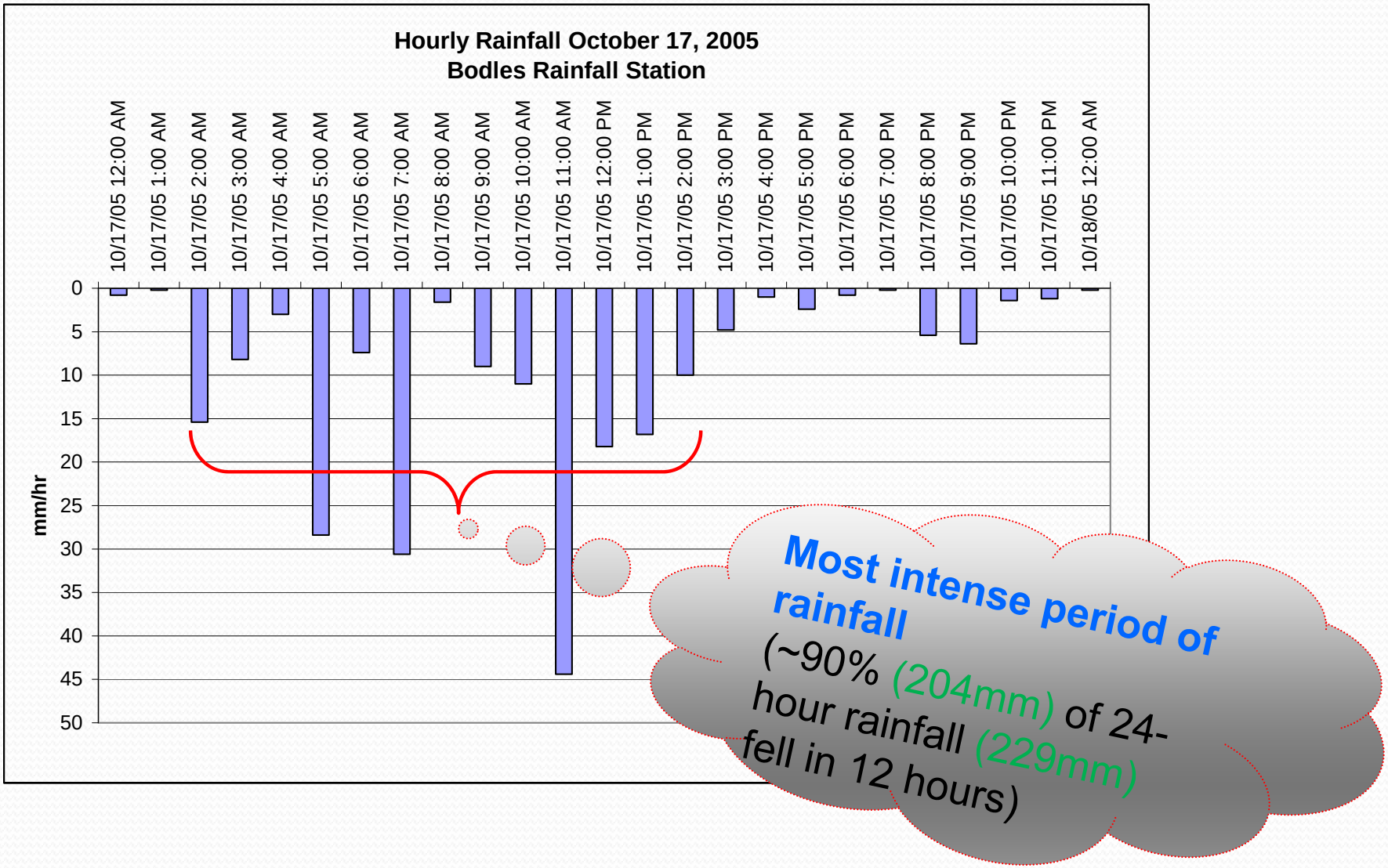
- HEC-HMS hydrologic modelling software
- Natural Resources Conservation Service (NRCS) formerly Soil Conservation Service (SCS) Curve Number methodology
  - estimates the runoff based on the cumulative precipitation, soil cover, land use, and antecedent moisture

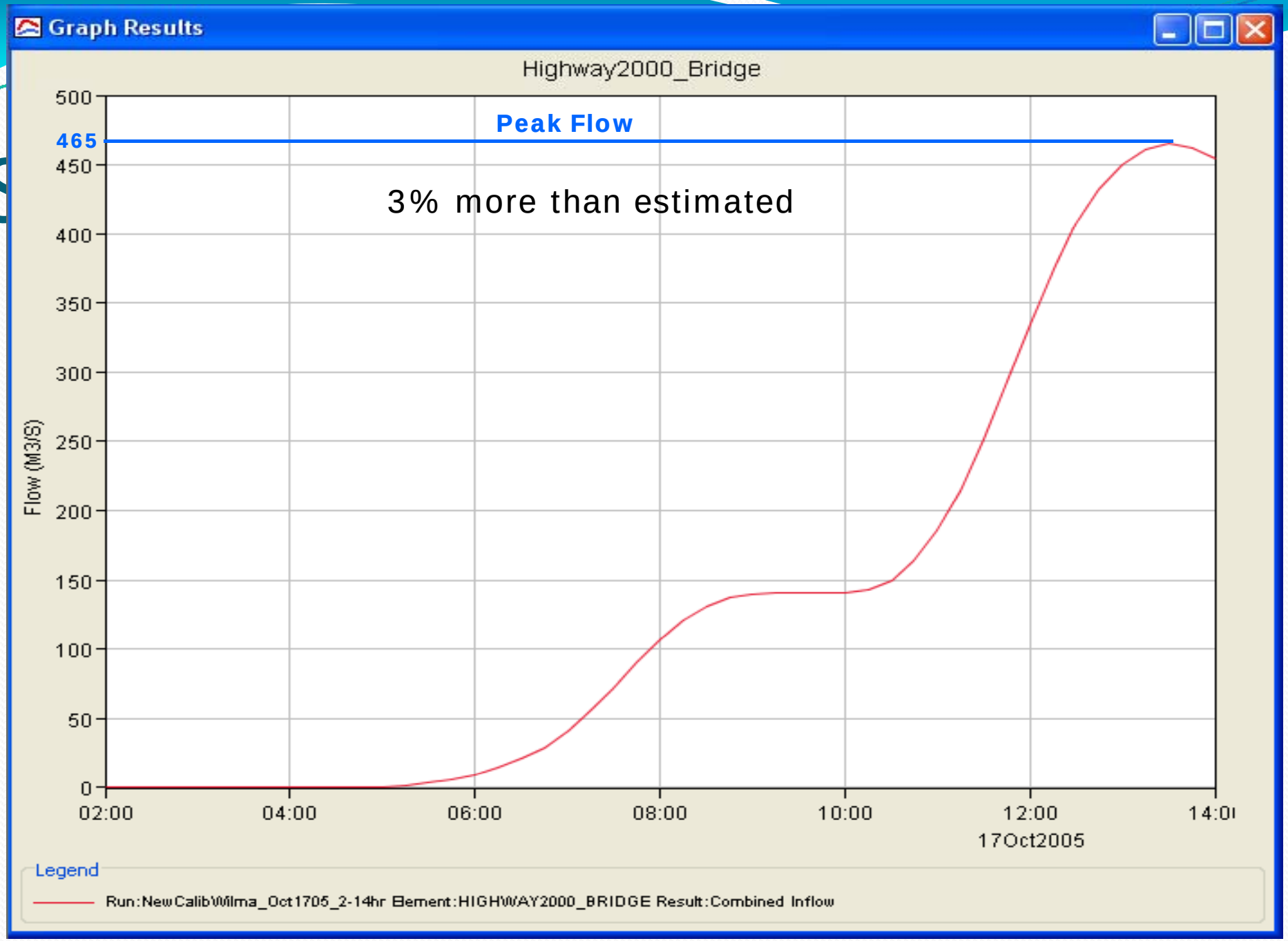
Rainfall – Spatial Distribution (Hurr Wilma)



- Bodles
  - Intensity Gauge

Rainfall – Temporal Distribution (Bodles)




Graph Results
Highway2000_Bridge
Peak Flow
465
3% more than estimated
500
450
400
350
300
250
200
150
100
50
0
Flow (M3/S)
02:00
04:00
06:00
08:00
10:00
12:00
17Oct2005
Legend
Run:NewCalib\Wilma_Oct1705_2-14hr Element:HIGHWAY2000_BRIDGE Result:Combined Inflow

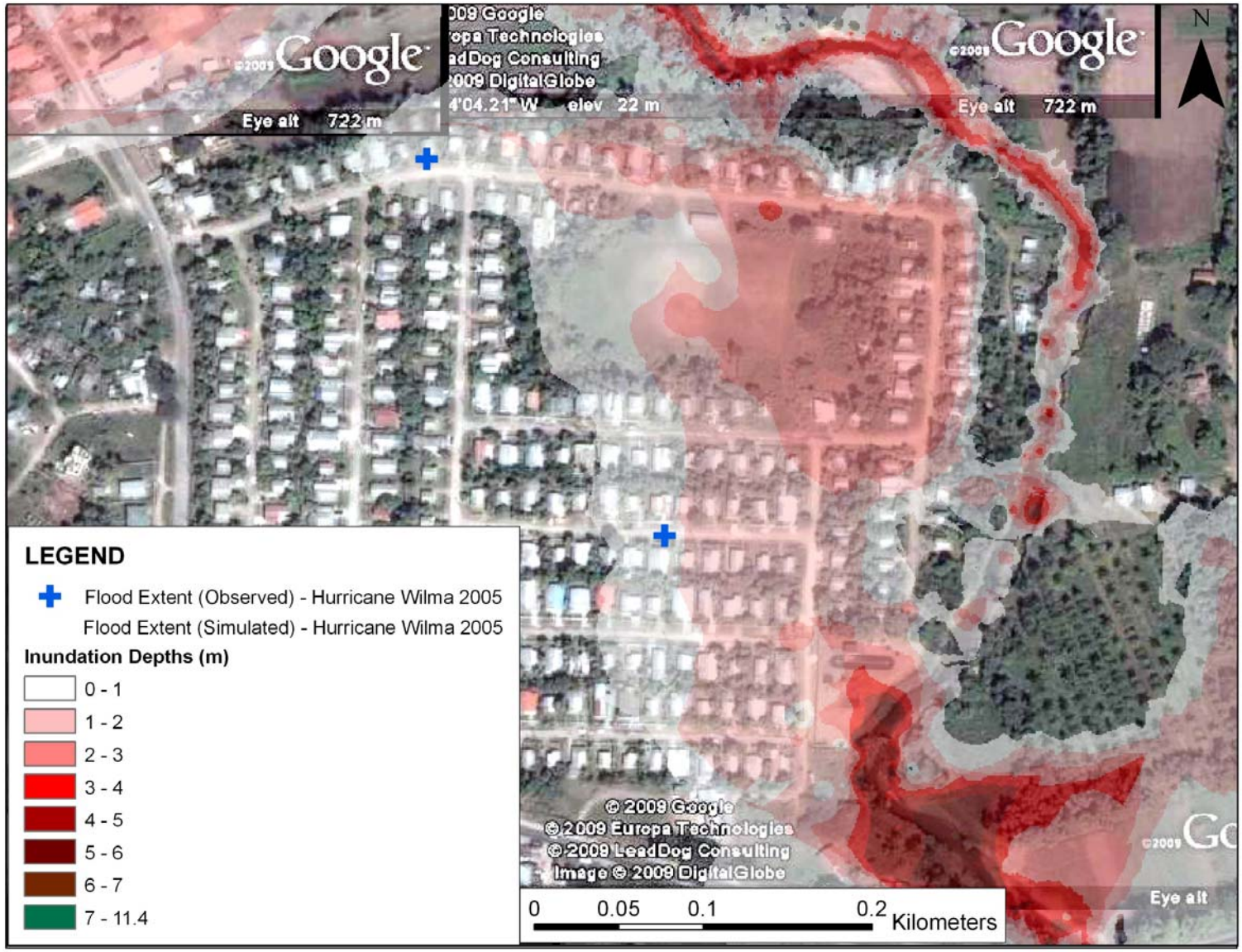
Simulated Discharges

Return Period (yrs)	24-hour Rainfall (mm)				Peak Discharge (m^3/s)	
	RAINFALL STATIONS				Estimated	Simulated
	Bodles	Bois Content	Bybrook	Worthy Park		
Hurr Wilma	229	225	155	94	451	465
10	170	251	187	233	-	295
25	208	320	231	291	-	380
50	236	371	264	334	-	442
100	264	421	296	376	-	503
Bankfull Discharge					233	-

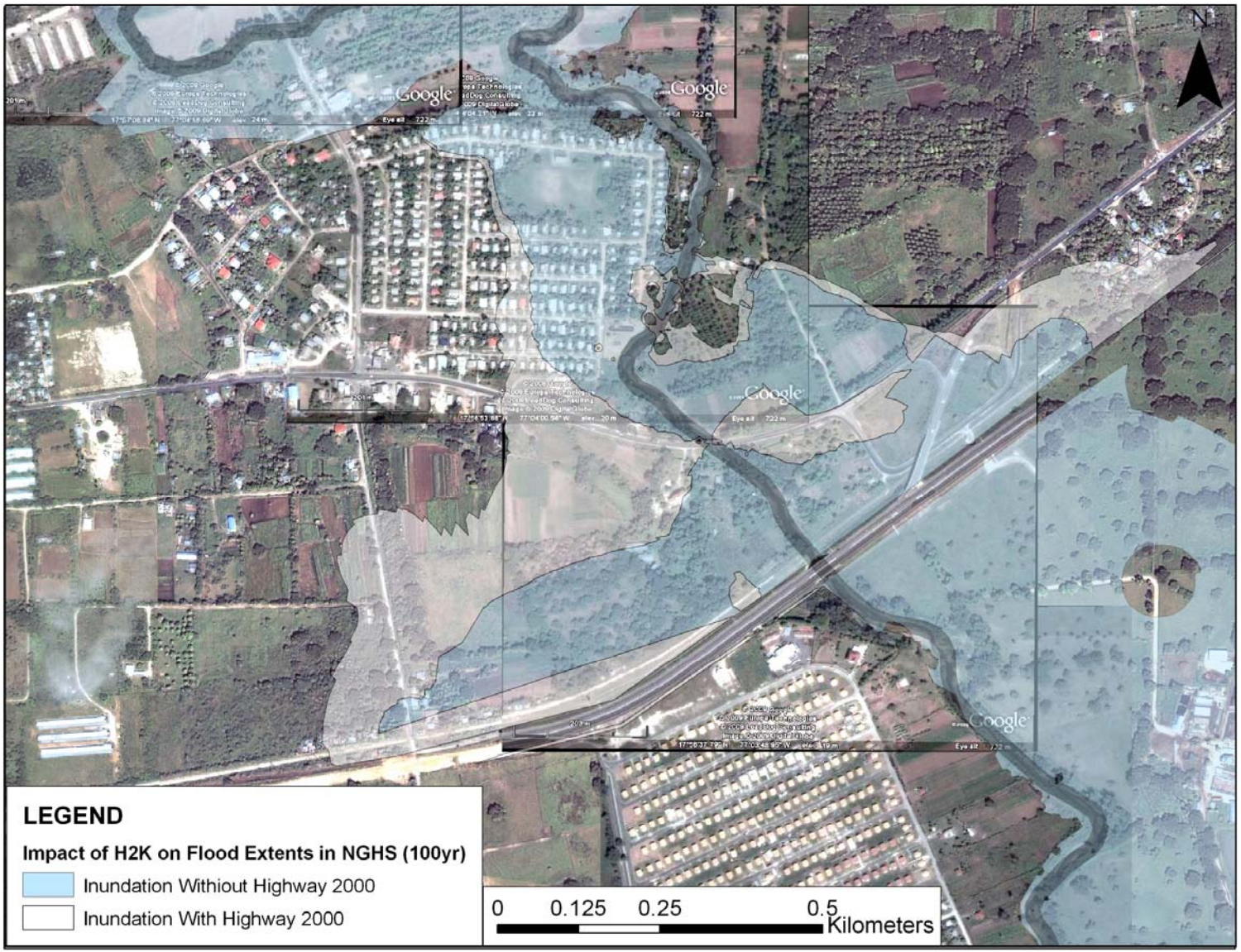
Flood Stage Predictions & Mapping

- Flood Stage Predictions
  - HEC-RAS
    - 1-D Hydraulic Modelling Software
    - Calibration
      - Hurricane Wilma Data
      - Peak Flow - Slope Area Method
      - Mapped Flood Extents
- Mapping
  - ArcGIS

Calibration



Impact of H2K on Flood Levels



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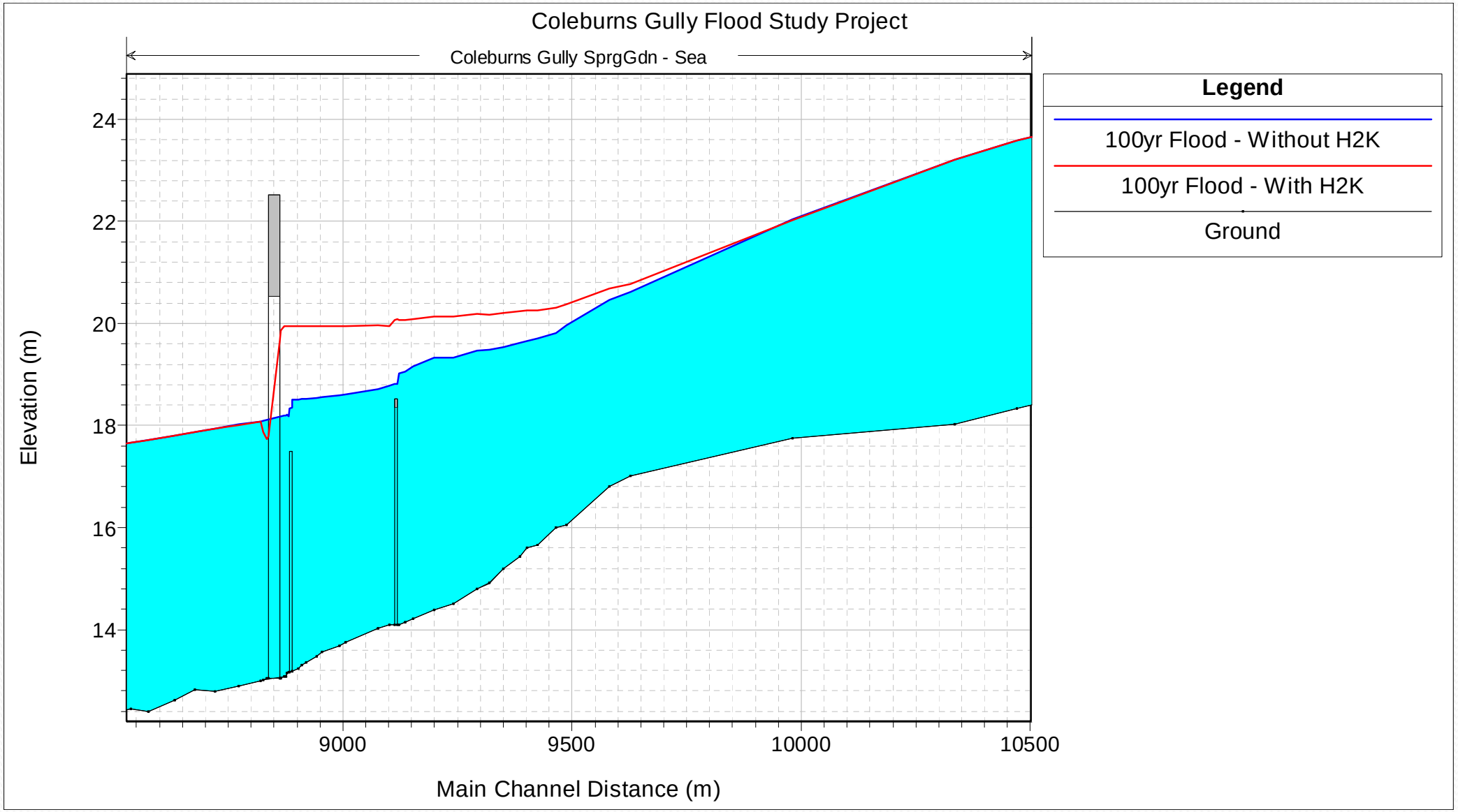

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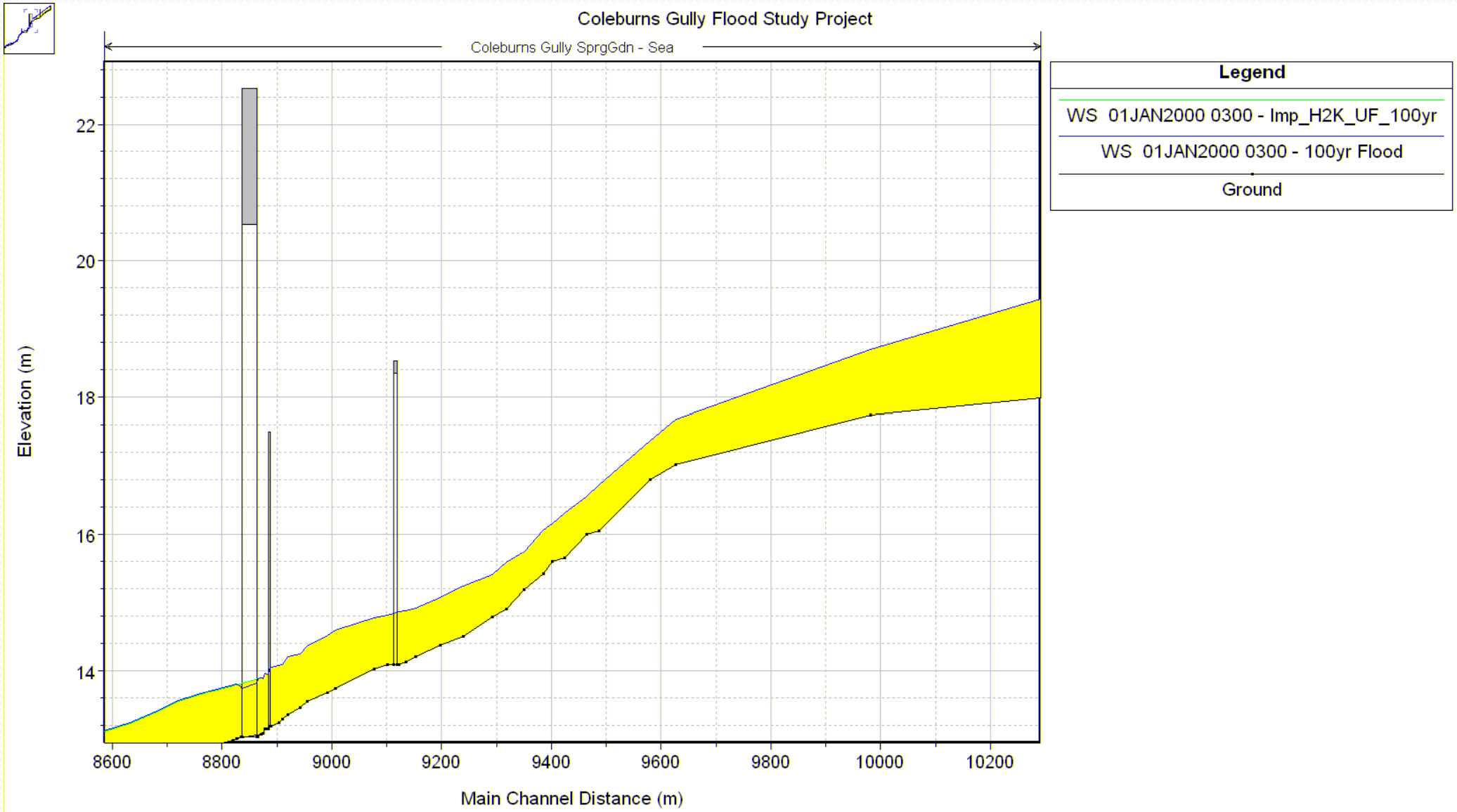


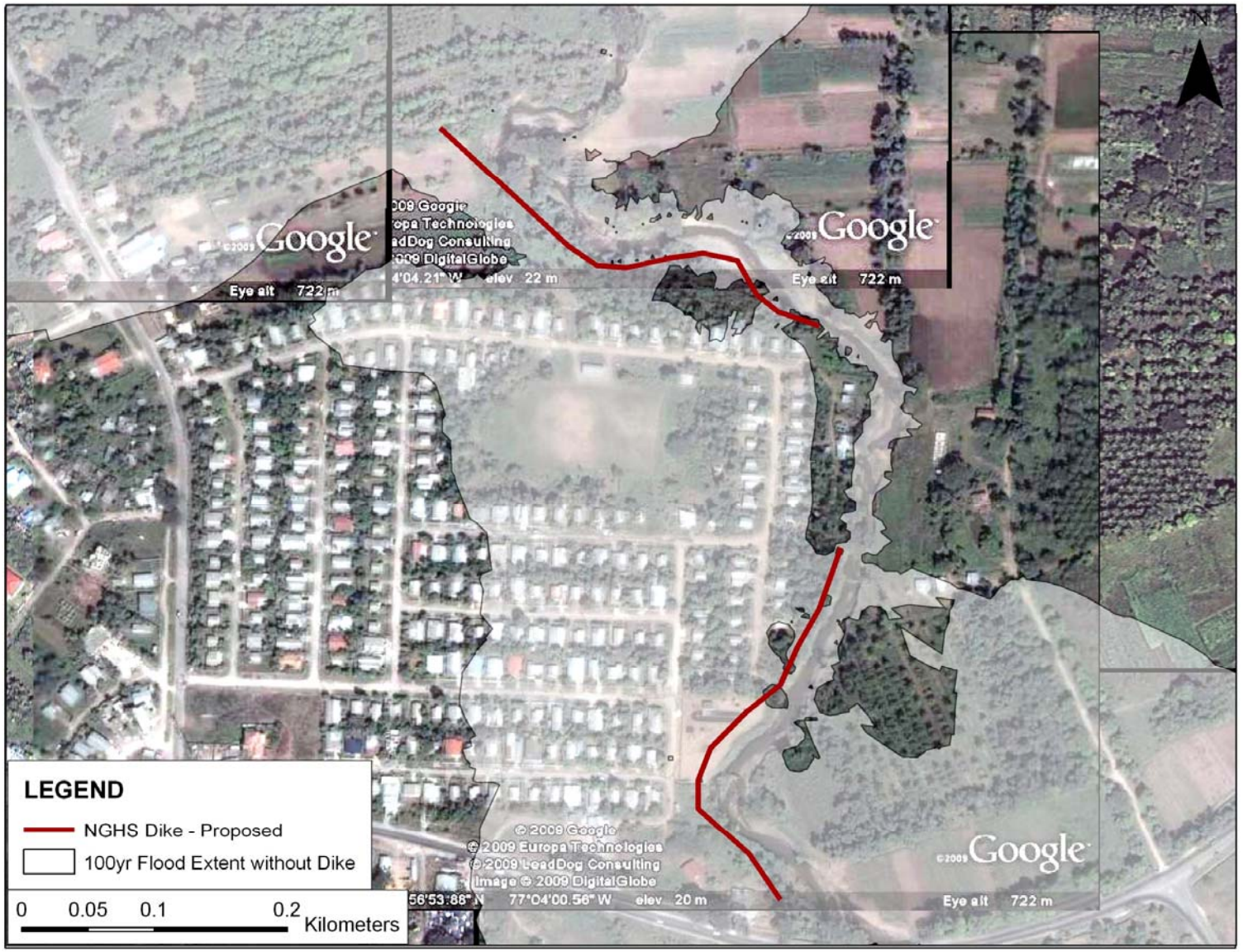
Mitigation Strategies

- Mitigation Strategies
  - Relocation
  - Dike
  - Floodwater Diversion
    - Detention Storage
    - Diversion Channel
  - Flood Control Dam

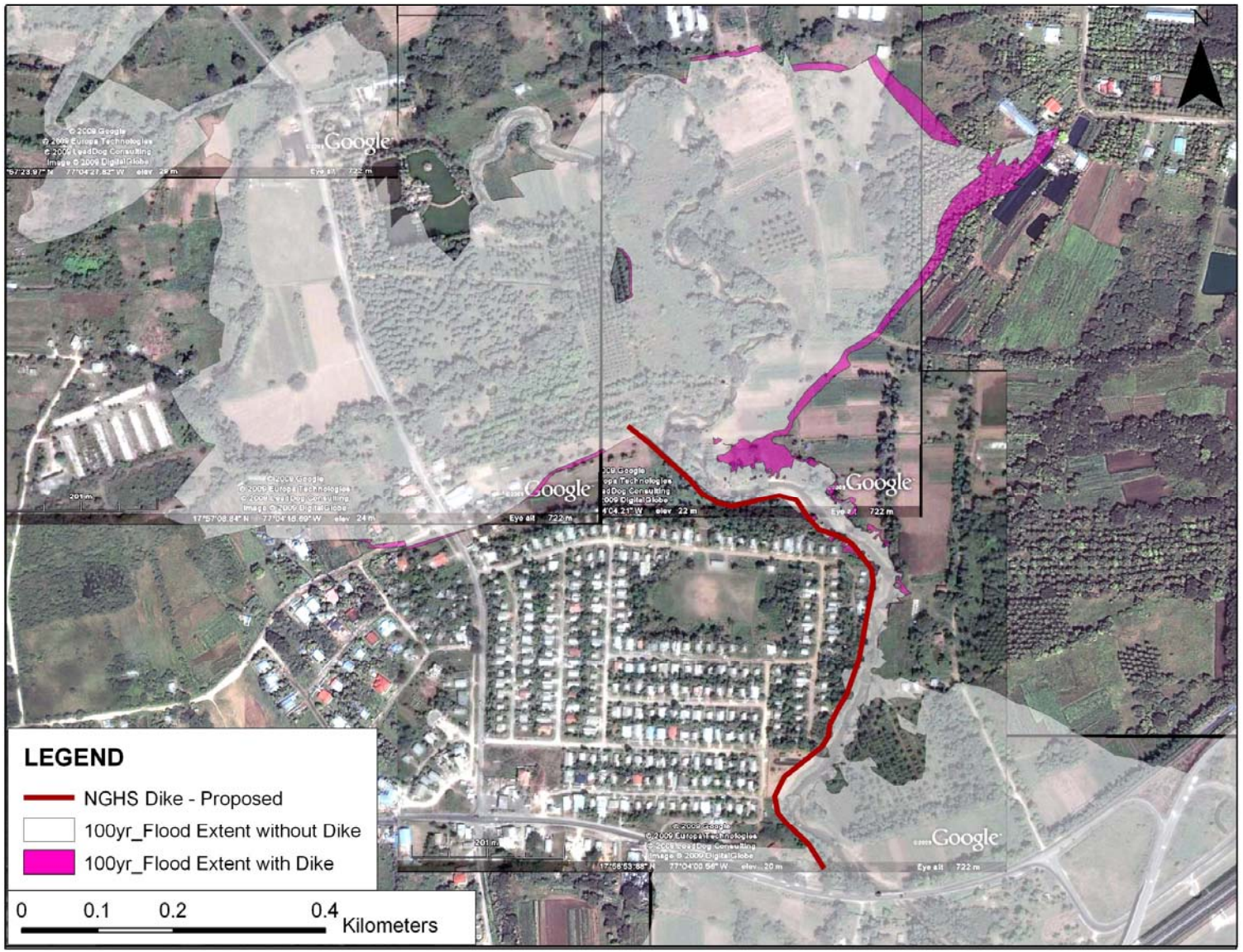
- Floodwater Diversion & Flood Control Dam
  - 10-year or Backfull Discharge as Allowable Discharge s

Partial Relocation

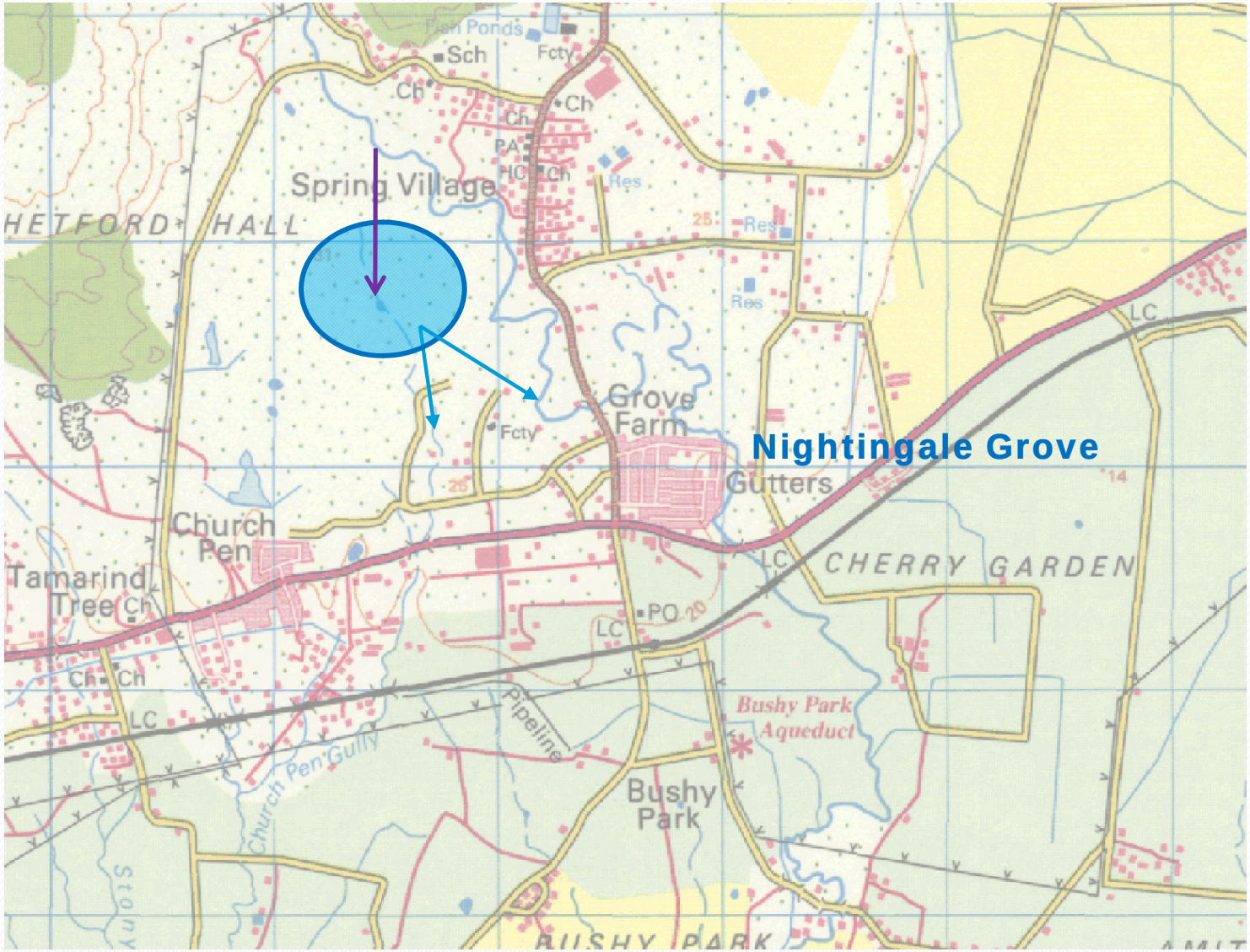
Dike


LEGEND
NGHS Dike - Proposed
100yr Flood Extent without Dike
0 0.05 0.1 0.2 Kilometers
Google
Eye alt 722 m
© 2009 Google
© 2009 Europa Technologies
© 2009 LeadDog Consulting
Image © 2009 DigitalGlobe
elev 22 m
elev 20 m

Impact of Dike



Floodwater Diversion / Detention Storage

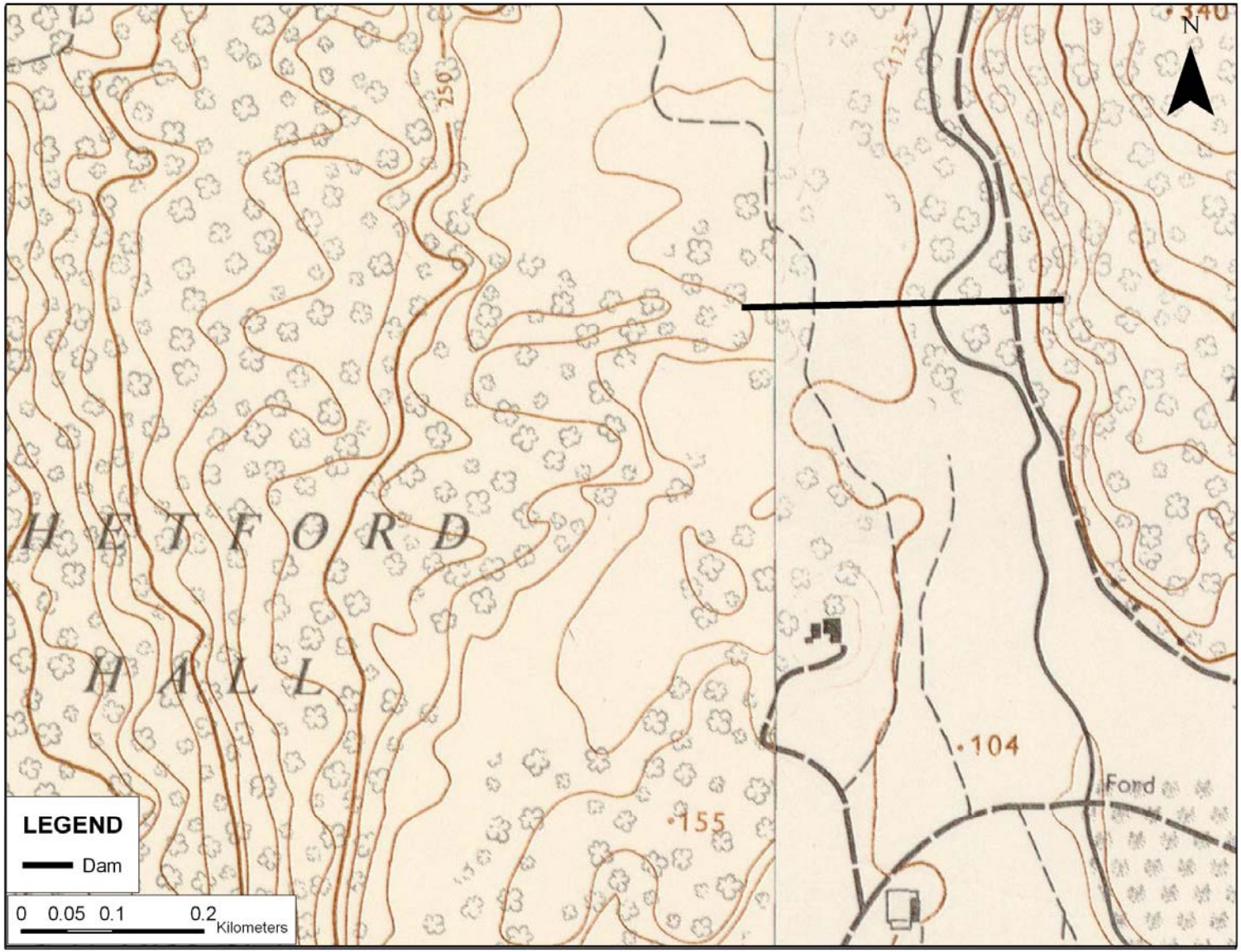


Floodwater Diversion/Detention Storage

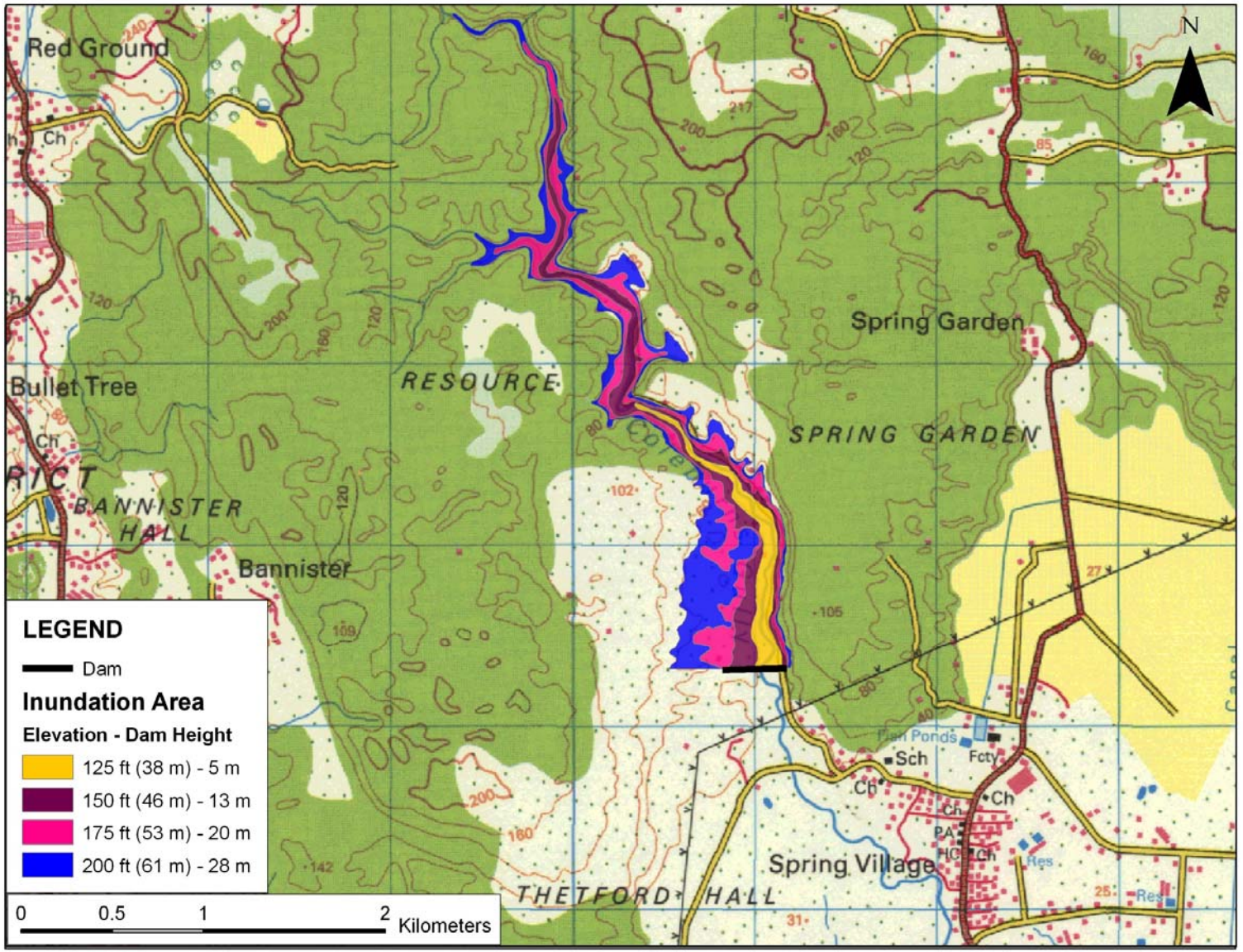
Design Discharge Characteristics	*Return Period (yrs)*	*Peak Discharge (m^3/s)*	*Runoff Volume (1000 m^3)*	*Diverted Peak Discharge (m^3/s)*	*Diverted Volume (1000 m^3)*
295 m^3/s 10-year storm (*Option 2*)	100	503	27,910	208 (41%)	8,186
	50	442	23,934	147 (33%)	5,197
	25	380	19,882	85 (22%)	2,443
	10	295	14,460	0	0
233 m^3/s Bankfull discharge (*Option 3*)	100	503	27,910	270 (54%)	11,602
	50	442	23,934	209 (47%)	8,320
	25	380	19,882	147 (39%)	5,182
	10	295	14,460	62 (21%)	1,513

- Diversion Channel – 7km

Flood Control Dam



Flood Control Dam



Flood Control Dam

Storage and dam heights requirements with 10-year discharge (295 m^3/s)

Return Period (yrs)	*Q_p from catchment (m^3/s)*	*Runoff Volume (1000 m^3)*	*Flood Protection up to the **50-year Storm***			*Flood Protection up to the **100-year Storm***		
			Q_p (m^3/s)	Storage (1000 m^3)	Dam Height (m)	**Q_p** m^3/s)	Storage (1000 m^3)	Dam Height (m)
10	295	14,460	295	0	0	295	0	0
25	380	19,882	295	2,443	11	295	2,443	11
50	442	23,934	**295**	**5,197**	**16**	**295**	**5,197**	**16**
100	503	27,910	**503**	**5,197**	**16**	**295**	**8,186**	**21**

- Dam Height include Depth of Channel ~ 5 m
- 10-year Q
  - Raising of the riverbank required at Nightingale Grove

Flood Control Dam

Storage requirements and dam heights with bankfull discharges (233 m^3/s)

Return Period (yrs)	*Q_p from catchment (m^3/s)*	*Runoff Volume (1000 m^3)*	*Flood Protection up to the **50-year Storm***			*Flood Protection up to the **100-year Storm***		
			Q_p (m^3/s)	Storage (1000 m^3)	Dam Height (m)	**Q_p** (m^3/s)	Storage (1000 m^3)	Dam Height (m)
10	295	14,460	233	1,513	8	233	1,513	8
25	380	19,882	233	5,182	16	233	5,182	16
50	442	23,934	**233**	**8,320**	**21**	**233**	**8,320**	**21**
100	503	27,910	**503**	**8,320**	**21**	**233**	**11,602**	**25**

- Dam Height include Depth of Channel ~ 5 m
- Bankfull Q
  - No Dike Required (though still recommended)

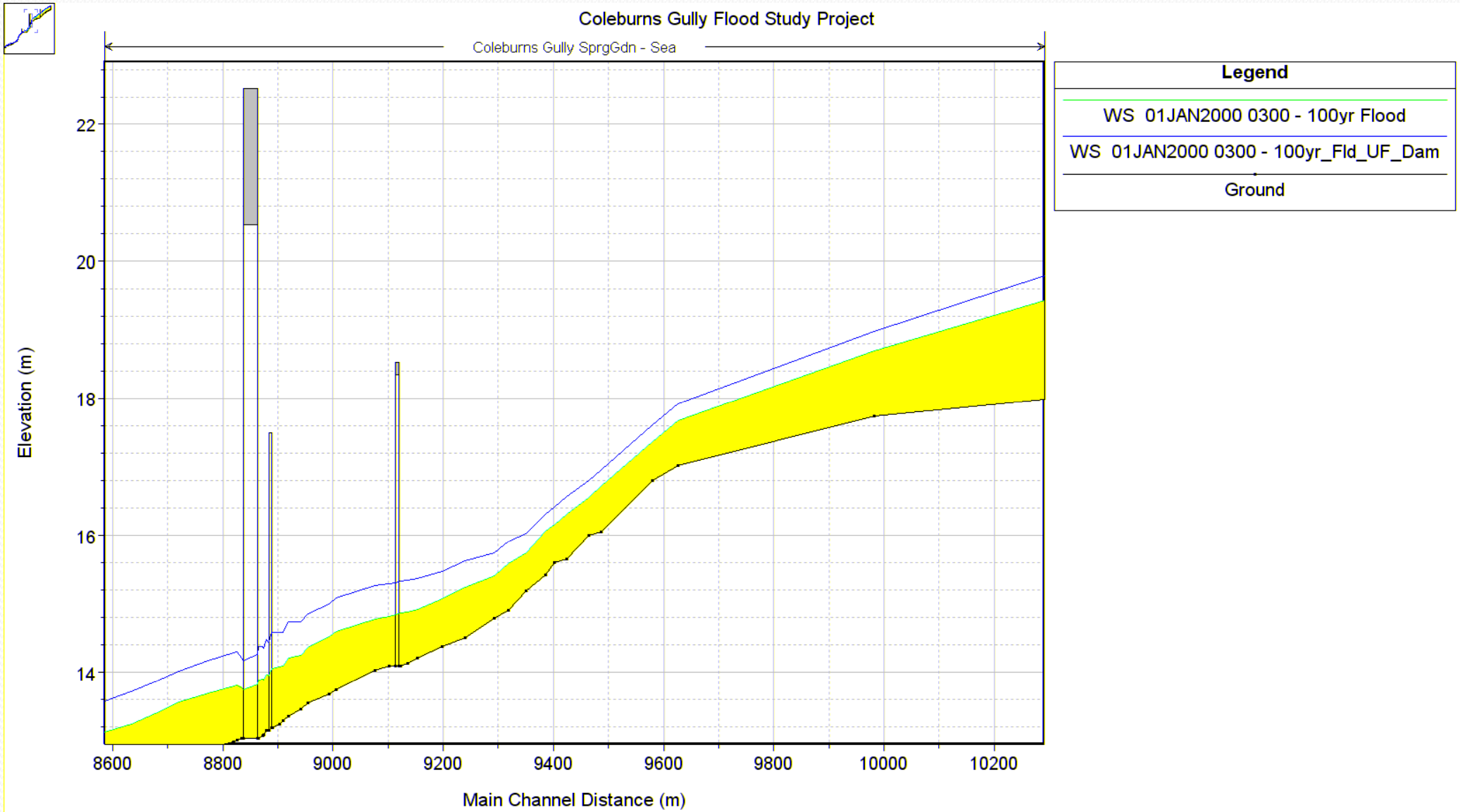
Flood Control Dam

Maximum retention times of impounded water at different dam heights

Return Period (yrs)	*Outlet Design Discharge (m^3/s)*	*Storage (1000 m^3)*	*Dam Height (m)*	Maximum Retention Time (hrs)
50	295	5,197	16	**4.9**
100	295	8,186	21	**7.7**
50	233	8,320	21	**9.9**
100	233	11,602	25	**13.8**

- Dam Height = 21m
  - 50 or 100yr flood protection depending on the Outlet Design Discharge

Flood Control Dam - Simulation



Conclusion

- Mitigation Strategies – Nightingale Grove only

Alternative Flood Mitigation Schemes	*Level of Flood Protection*	*Remarks*
Relocation of the NGHS	Community (partial or full) removed from vulnerable location	Flooding of other communities along the Coleburns Gully would still occur as normal If only the most vulnerable section of NGHS is relocated (partial relocation), the remainder of the community would be at risk to larger floods New lands to be identified and possibly acquired, newly constructed houses and infrastructure would be required 'Buy-in' from residents necessary Measures to ensure abandoned area is not re-inhabited
Dike Construction	Protection for the NGHS only	Flooding of other communities along the Coleburns Gully would still occur as normal Culverts with flap gates to be used at drainage outfall from the Nightingale Grove Housing Scheme

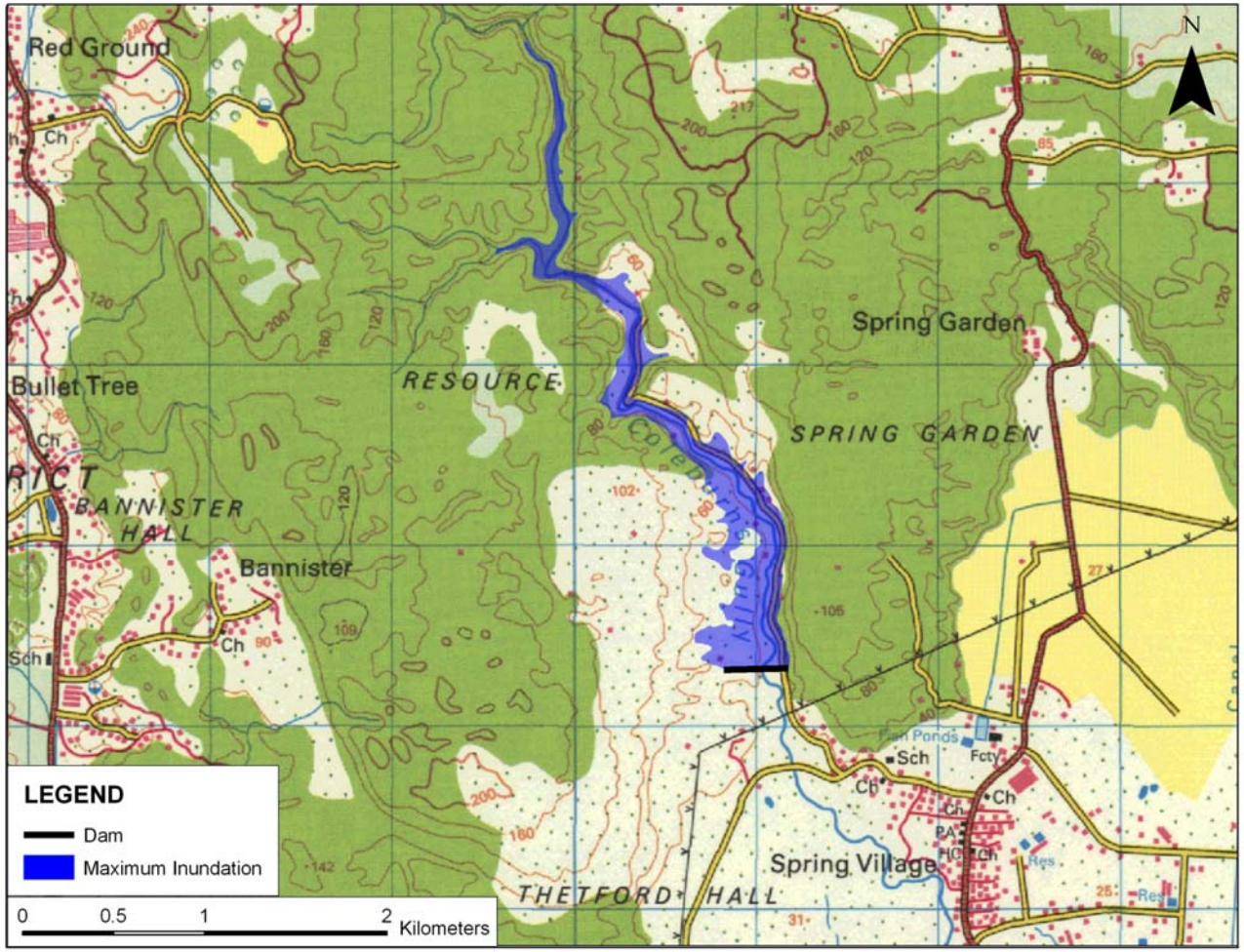
Conclusion

- Mitigation Strategies – Entire Coleburns Gully

Alternative Flood Mitigation Schemes	*Level of Flood Protection*	*Remarks*
Floodwater Diversion/Detention Storage	Protection to all communities along the Coleburns Gully	**DETENTION STORAGE NOT FEASIBLE** **DIVERSION CHANNEL SHOULD NOT BE PURSUED** Large diversion channel to be constructed; significant social disruption and risk of flooding to communities outside of the floodplains of the Coleburns Gully
Flood Control Dam	Protection to all communities along the Coleburns Gully	Relatively large dam to be constructed

Recommendation

- Dam at 21 m with 10-year Q (295 m^3/s)
- No storage behind dam
- Raise riverbank to provide protection from the 10-year flood



THANK YOU

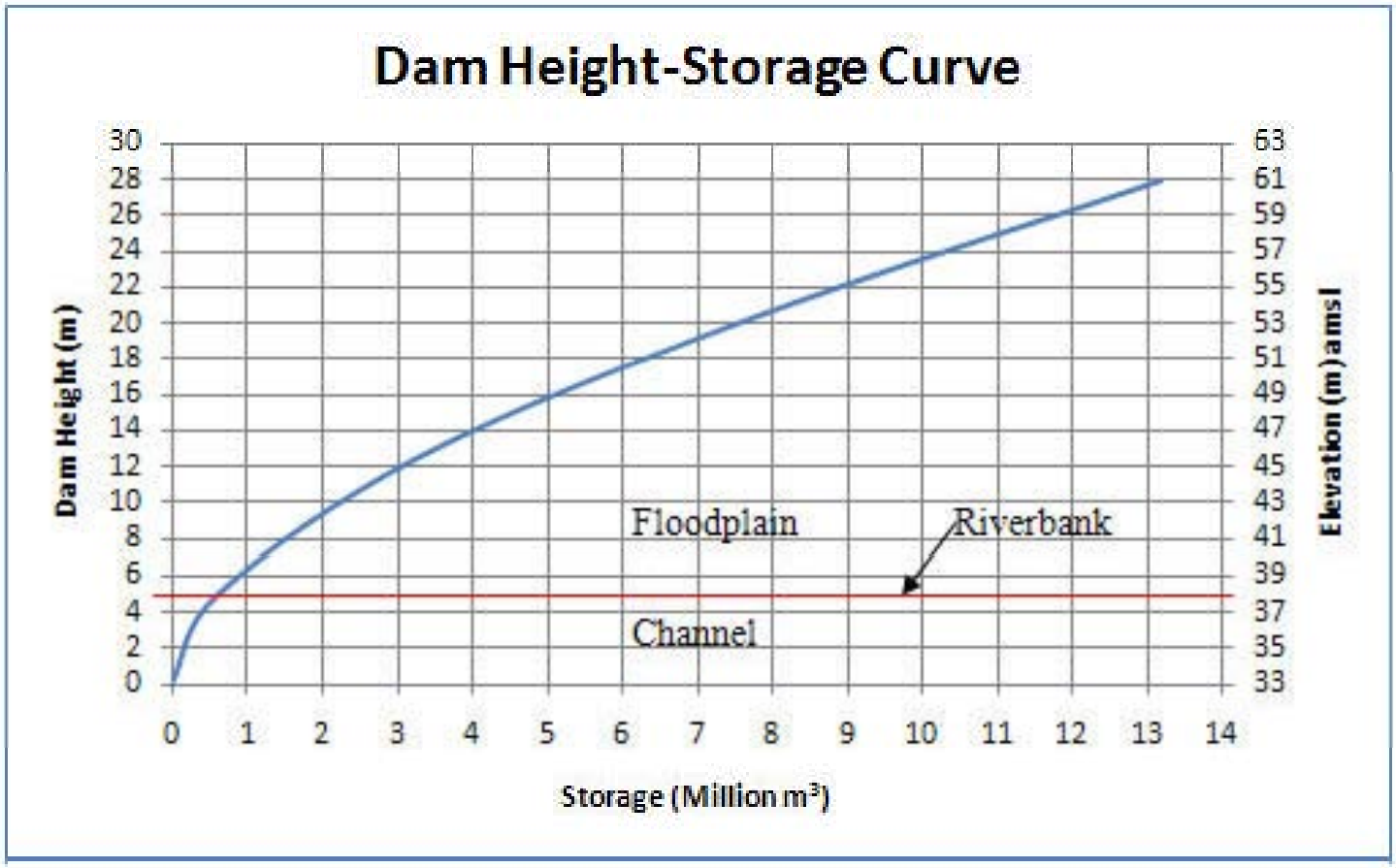


Figure 5.17: Dam height-storage curve