1 in 250 years flood plain map for Calgary (source: Impact Forecasting)

Impact Forecasting Canadian flood model

Using the Impact Forecasting model for primary underwriting and using ELEMENTS for accumulation control

Prepared by Vaclav Rara, Petr Puncochar and Adam Podlaha of Impact Forecasting

Presentation for Travelers, February 2016

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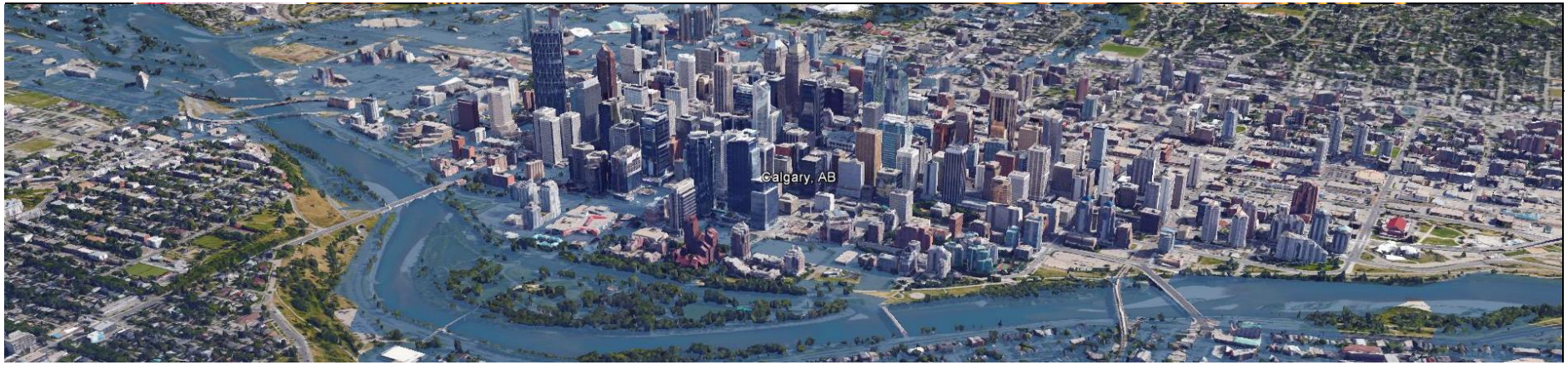
Agenda

Section 1	5 slide overview
Section 2	Travelers sample portfolio analysis
Section 3	Setting the scene…
Section 4	Technical model review
Section 5	Using the model for accumulation control
Section 6	Conclusions and questions



Section 1: “5 slide overview”

Impact Forecasting flood model for Canada – 4 uses

Use 1 Rate calculation

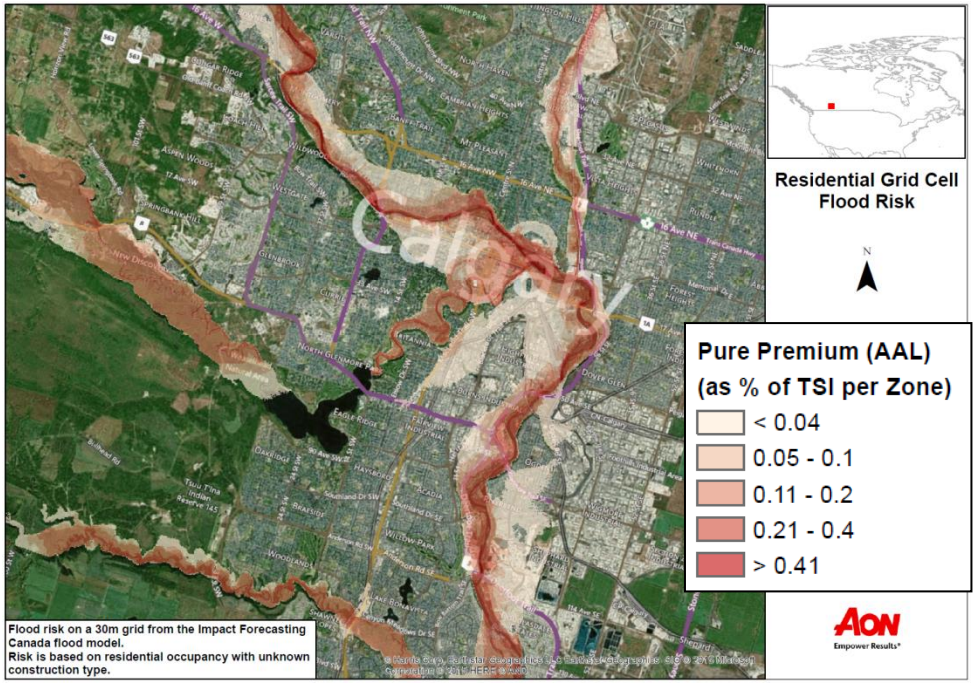
Use 2 New product design

Use 3 Accumulation control

Use 4 Portfolio modelling

Use 1: Rate calculation

- Flood plain and off-flood plain
- Defended (default) and non-defended
- Delivery:
  - Pre-calculated pure premium values
  - Run ELEMENTS for pure premium



6-digit postal code

Postal code	Pure Premium
T0J0V0	0.0053%
T0L0X0	0.0016%
T0L1W0	0.0069%
T0M1L0	0.0015%
T0M0S0	0.0019%
T4B2M1	0.0011%
T4B2V1	0.1296%
T4B2Y1	0.1651%
T4B3B5	0.0014%
T4B3G5	0.0423%
T4B3G6	0.0963%
T4B3G7	0.1278%
T4B3K8	0.0006%
T4B3K9	0.0070%
T4B3L1	0.0393%
T4B3L2	0.0302%
T2Y3T9	0.0928%

30 x 30m

Latitude	Longitude	Pure Premium
50.8784	-113.9893	0.0269%
51.0017	-114.1802	0.1893%
51.2532	-114.0001	0.0965%
51.0139	-114.2182	0.1941%
51.0797	-114.1798	0.0166%
51.0123	-114.0632	0.0569%
51.0989	-114.2458	0.2421%
50.9742	-114.0301	0.2081%
50.9311	-114.1922	0.1222%
50.9758	-114.0084	0.0000%
51.0034	-114.1990	0.1673%
51.0019	-114.2137	0.1496%
50.9298	-113.9923	0.2061%
51.3213	-114.0235	0.0636%
51.0365	-114.0616	0.1790%
51.0907	-114.1907	0.0003%
51.0056	-114.2109	0.1833%

Use 2: New product design

- Determine effect of insurance conditions
  - Deductibles
  - Limits
- Delivery
  - Pre-calculated pure premium values
  - Run ELEMENTS for pure premium

Effect of deductibles

PC	Occupancy	Coverage	Limit	Deductible	Gross / GU
T2G0J8	Residential	Building	100%	0.1%	99%
T2G0J8	Residential	Building	100%	0.2%	99%
T2G0J8	Residential	Building	100%	0.5%	97%
T2G0J8	Residential	Building	100%	1.0%	94%
T2G0J8	Residential	Building	100%	0.0%	100%

Effect of limits

PC	Occupancy	Coverage	Limit	Deductible	Gross / GU
T2G0J8	Residential	Building	1%	0.1%	6%
T2G0J8	Residential	Building	10%	0.1%	52%
T2G0J8	Residential	Building	50%	0.1%	99%
T2G0J8	Residential	Building	100%	0.1%	99%

Use 3: Accumulation control

- Existing: accumulate insured values

OR

- Using our model: accumulate losses

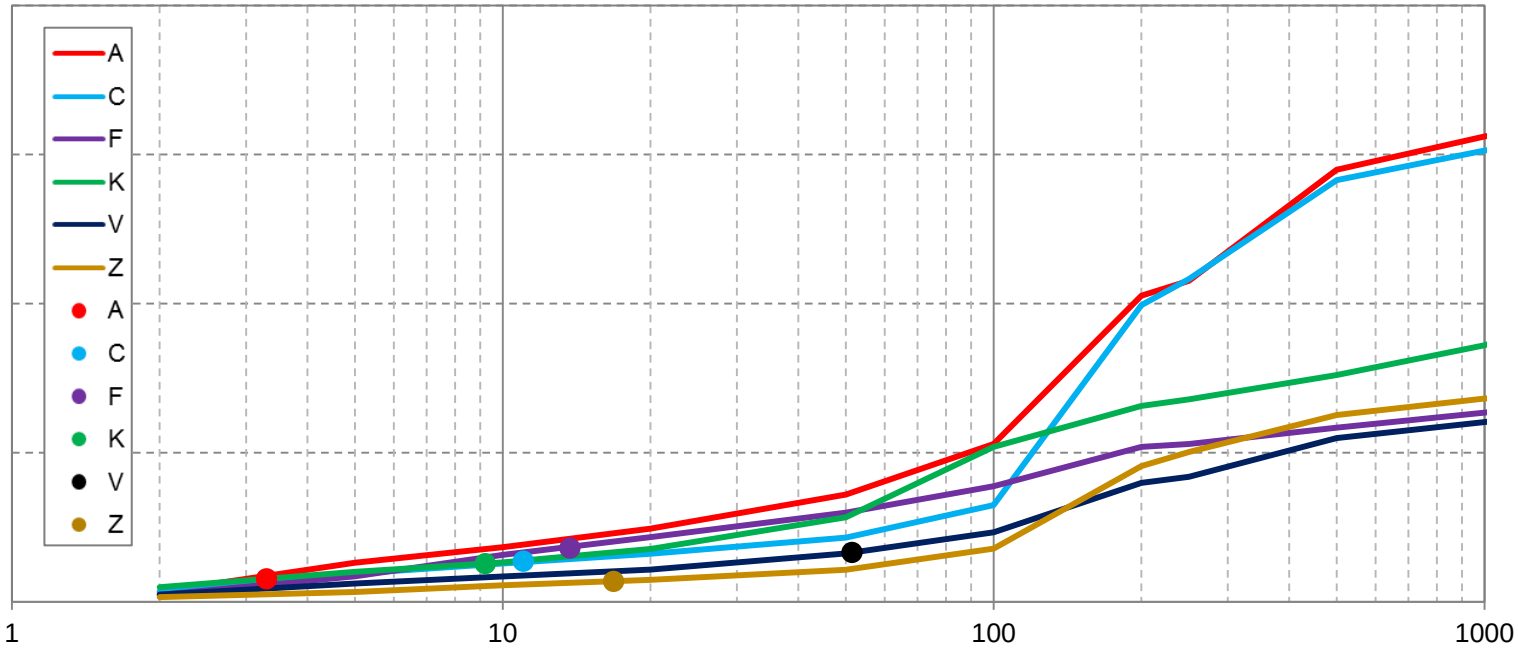
Exposed TIV in Quebec, Manitoba, New Brunswick & BC bring proportionally more losses compared to their exposed TIV share

Zone Name	Exposed TIV	Exp. TIV as % of total	Pure Premium	PP as % of total	PP vs. ETIV
Newfoundland and Labrador	5,597,784,492	1.49%	239,232	0.35%	23%
Prince Edward Island	296,784,663	0.08%	4,671	0.01%	9%
Nova Scotia	9,046,791,873	2.41%	346,624	0.50%	21%
New Brunswick	5,763,710,234	1.53%	1,723,422	2.51%	164%
Quebec	109,931,790,013	29.24%	31,875,629	46.39%	159%
Ontario	146,964,970,963	39.09%	16,639,604	24.21%	62%
Manitoba	11,745,326,355	3.12%	5,307,024	7.72%	247%
Saskatchewan	1,205,095,988	0.32%	59,593	0.09%	27%
Alberta	51,042,498,272	13.58%	5,268,911	7.67%	56%
British Columbia	34,366,483,865	9.14%	7,252,256	10.55%	115%
Yukon	NA	NA	NA	NA	NA
Northwest Territories	NA	NA	NA	NA	NA
Nunavut	NA	NA	NA	NA	NA
Total	**375,961,236,718**	**100%**	**68,716,967**	**100%**	

Use 4: Portfolio modelling

- Portfolio modelling for reinsurance purposes (1 in 100 years loss)
- Delivery: ELEMENTS

Modeled Flood Losses
EP Curve with 2013 Alberta event



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How can you get access to the model?

- **Question 1**

  Do you want to calculate rates for homogenous risks or more complex risks?

- **Question 2**

  Do you want to accumulate losses rather than values?

- **Question 3**

  Do you want to accumulate per physically defined zones rather than administrative zones?

How can you get access to the model?

Direct integration to your systems

- Text files
- Database tables
- Shapefiles
- Other GIS data etc.

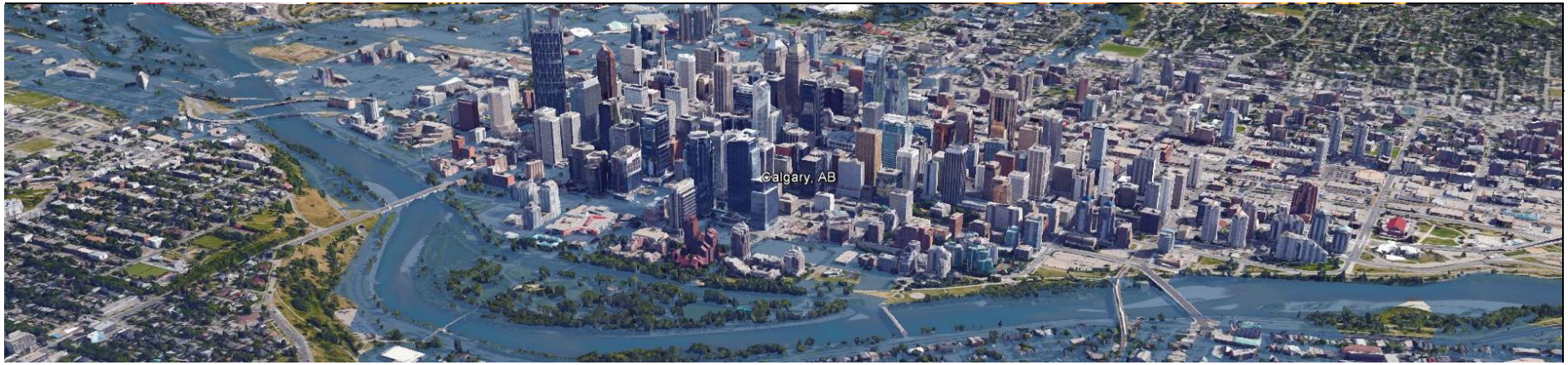
Through Aon Benfield tools

- Impact Forecasting ELEMENTS
- Impact On Demand
- CatScore

Through 3rd party providers

- Underwriting platform providers
- Web based mapping solutions providers
- ImageCat, Pitney Bowes, GfK GeoMarketing, WSN, emapsite etc.

Consume our data whatever your appetite



Section 2: Travelers sample portfolio analysis

- Portfolio
- Model setup
- Loss outputs

Portfolio

- 4,812 locations
- Geocoding
  - Street address and postal code
  - Geocoded used Pitney Bowes → for 80% of locations Lat & Lon was used
- All Commercial
- “Default” assumed for all other modifiers
- No year built used by the model

Loss outputs

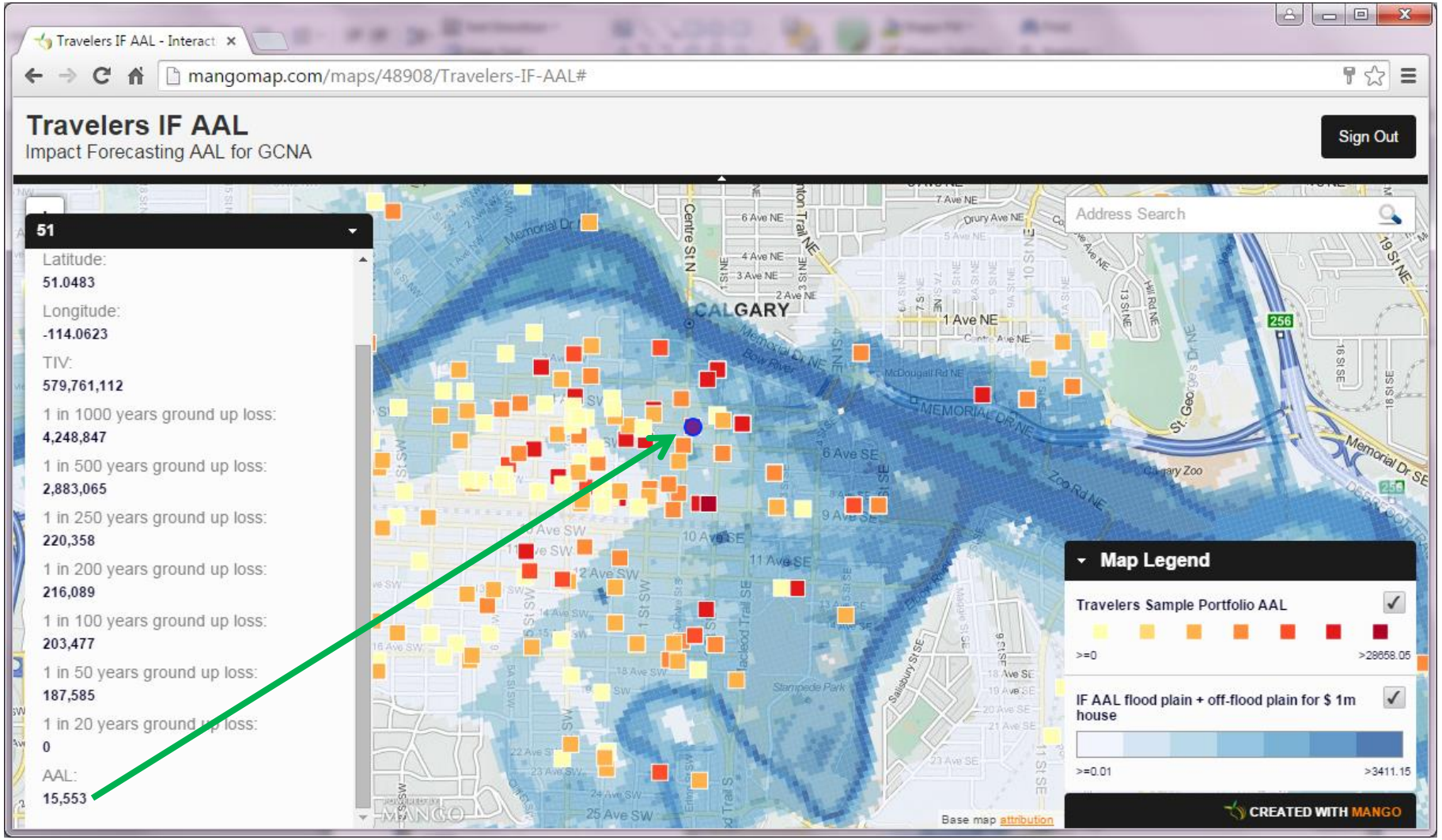
- Flood plain + off flood plain
- 55% of locations reported AAL > 0

- Per location outputs:
  - AAL
  - PMLs (1 in X years) loss
  - Number of events

- Per portfolio outputs
  - EP curve
  - AAL
  - ELT

SiteNumber	Addressline1	city	BLDG_TIV	CONTS_TIV	BI_TIV	TIV	GU_LOSS_AAL
3493	130 - 9 Avenue SE	Calgary	88,110,209	169,398,042	-	257,508,250	65,104
4119	130 - 9 Avenue SE	Calgary	88,110,209	169,398,042	-	257,508,250	64,937
627	130 - 9 Avenue SE	Calgary	88,110,209	169,398,042	-	257,508,250	64,916
607	130 - 9 Avenue SE	Calgary	88,110,209	169,398,042	-	257,508,250	64,784
1347	65 CHANCELLORS CIRCLE, WINNIPEG	Winnipeg	51,766,907	6,994,697	15,279,843	74,041,446	61,580
1270	65 CHANCELLORS CIRCLE, WINNIPEG	Winnipeg	51,766,907	6,994,697	15,279,843	74,041,446	61,526
911	65 CHANCELLORS CIRCLE, WINNIPEG	Winnipeg	51,766,907	6,994,697	15,279,843	74,041,446	61,498
913	25 CHANCELLORS CIRCLE and 64 SERVIC	Winnipeg	202,216,621	6,542,310	-	208,758,932	61,079
1301	25 CHANCELLORS CIRCLE and 64 SERVIC	Winnipeg	202,216,621	6,542,310	-	208,758,932	61,037
1076	25 CHANCELLORS CIRCLE and 64 SERVIC	Winnipeg	202,216,621	6,542,310	-	208,758,932	60,910
628	1440 - 17A Street SE	Calgary	77,909,874	14,924,940	-	92,834,814	55,100
3494	1440 - 17A Street SE	Calgary	77,909,874	14,924,940	-	92,834,814	55,086
555	1440 - 17A Street SE	Calgary	77,909,874	14,924,940	-	92,834,814	55,070
4120	1440 - 17A Street SE	Calgary	77,909,874	14,924,940	-	92,834,814	54,988
164	520 3rd avenue SW	Calgary	210,205,027	-	111,159,508	321,364,535	53,796
126	520 3rd avenue SW	Calgary	210,205,027	-	111,159,508	321,364,535	53,721
1341	190 DYSART ROAD, WINNIPEG	Winnipeg	53,122,761	20,363,325	-	73,486,086	44,283
4224	190 DYSART ROAD, WINNIPEG	Winnipeg	53,122,761	20,363,325	-	73,486,086	44,270
4159	190 DYSART ROAD, WINNIPEG	Winnipeg	53,122,761	20,363,325	-	73,486,086	44,131
2107	2355 Corydon Avenue	WINNIPEG	79,749,932	9,620,997	8,606,223	97,977,151	37,420

Loss outputs http://mgo.ms/s/c2alm ("*Travelers*")



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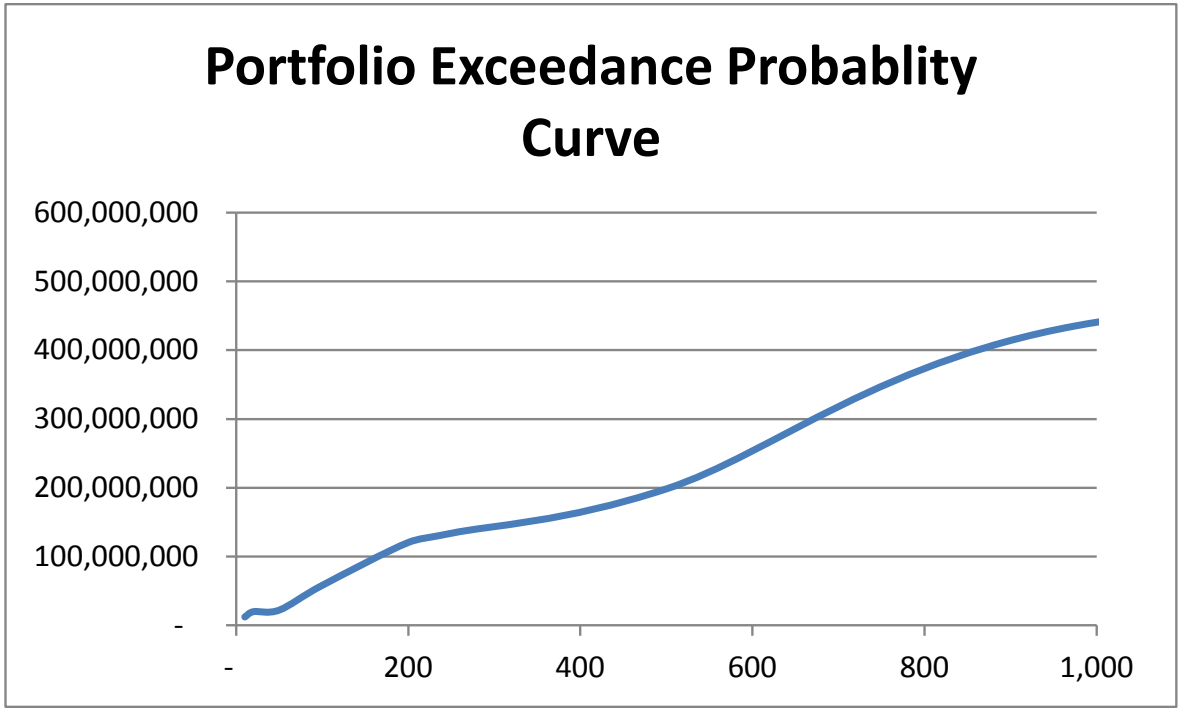
Loss outputs – EP curve & AAL

Return Period	GU Loss
10	12,171,687
20	19,857,719
50	22,159,556
100	58,128,152
200	120,443,139
250	133,804,840
500	198,324,220
1,000	440,498,136
2,000	497,521,379
5,000	566,932,780
10,000	984,035,851
AAL	**4,596,555**
STDDEV	24,505,140



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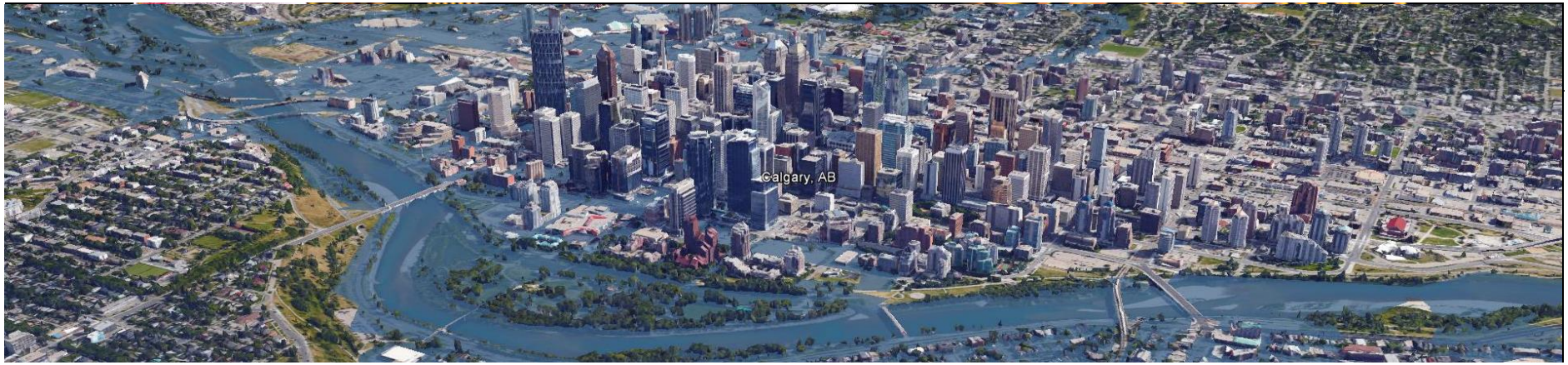
Loss outputs – ELT

- 20 biggest events

EveID	ProbID	GU
90473	0.0001	984,035,851
38129	0.0001	566,933,598
77216	0.0001	561,481,621
1661	0.0001	526,170,635
32583	0.0001	497,525,863
47595	0.0001	493,790,167
25924	0.0001	468,684,619
102531	0.0001	465,104,947
29031	0.0001	454,122,766
21111	0.0001	440,542,072
31935	0.0001	431,668,130
45752	0.0001	430,545,431
106299	0.0001	429,329,074
78183	0.0001	424,081,077
90716	0.0001	402,480,868
27126	0.0001	267,365,683
79520	0.0001	227,935,751
104239	0.0001	223,912,126
13890	0.0001	204,676,474

We finished here!



Section 3: Setting the scene…

- Primary underwriting and flood modelling challenges
- Catastrophe risk modelling workflow and where our model can be used
- Using the model for ratemaking DEMO
- Flood map vs. probabilistic model

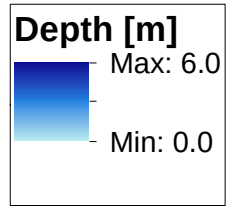
Primary underwriting challenges

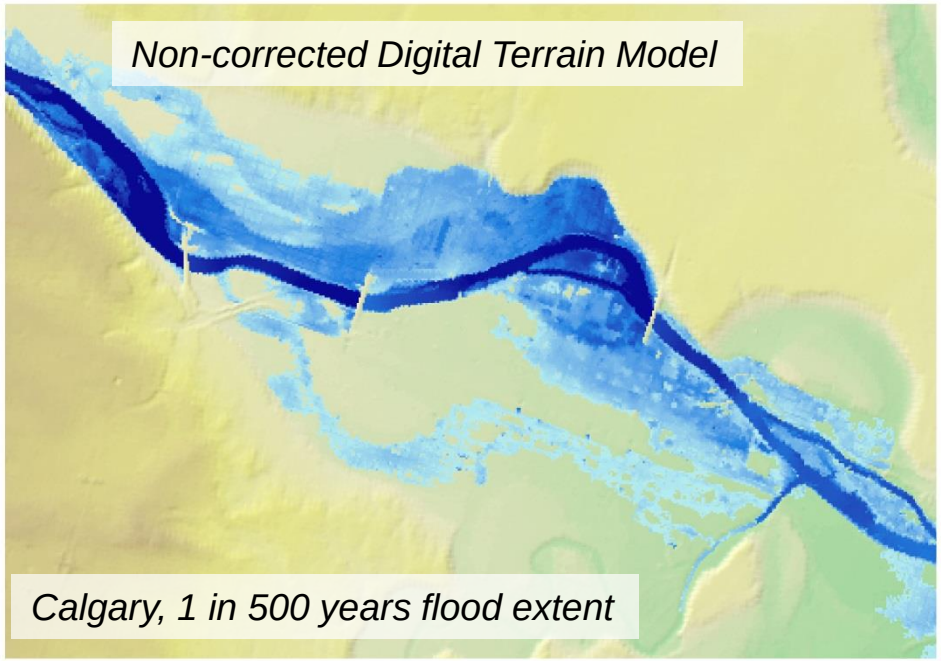
- How to underwrite for new products, for example flood
  - What is the right premium? (profit, economy)
  - What deductibles and / or limits should I offer?
  - What systems can I use to help underwriting?
  - How do I accumulate efficiently?
  - What should I underwrite?
- How do I integrate different systems in my environment?

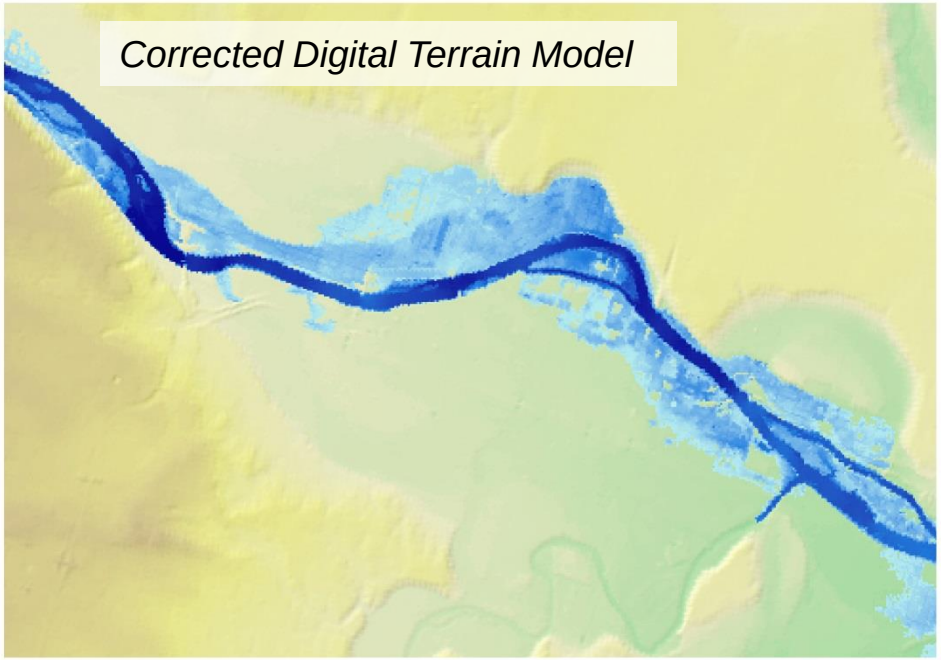
Probabilistic models can help here

Flood modelling challenges – DTM corrections

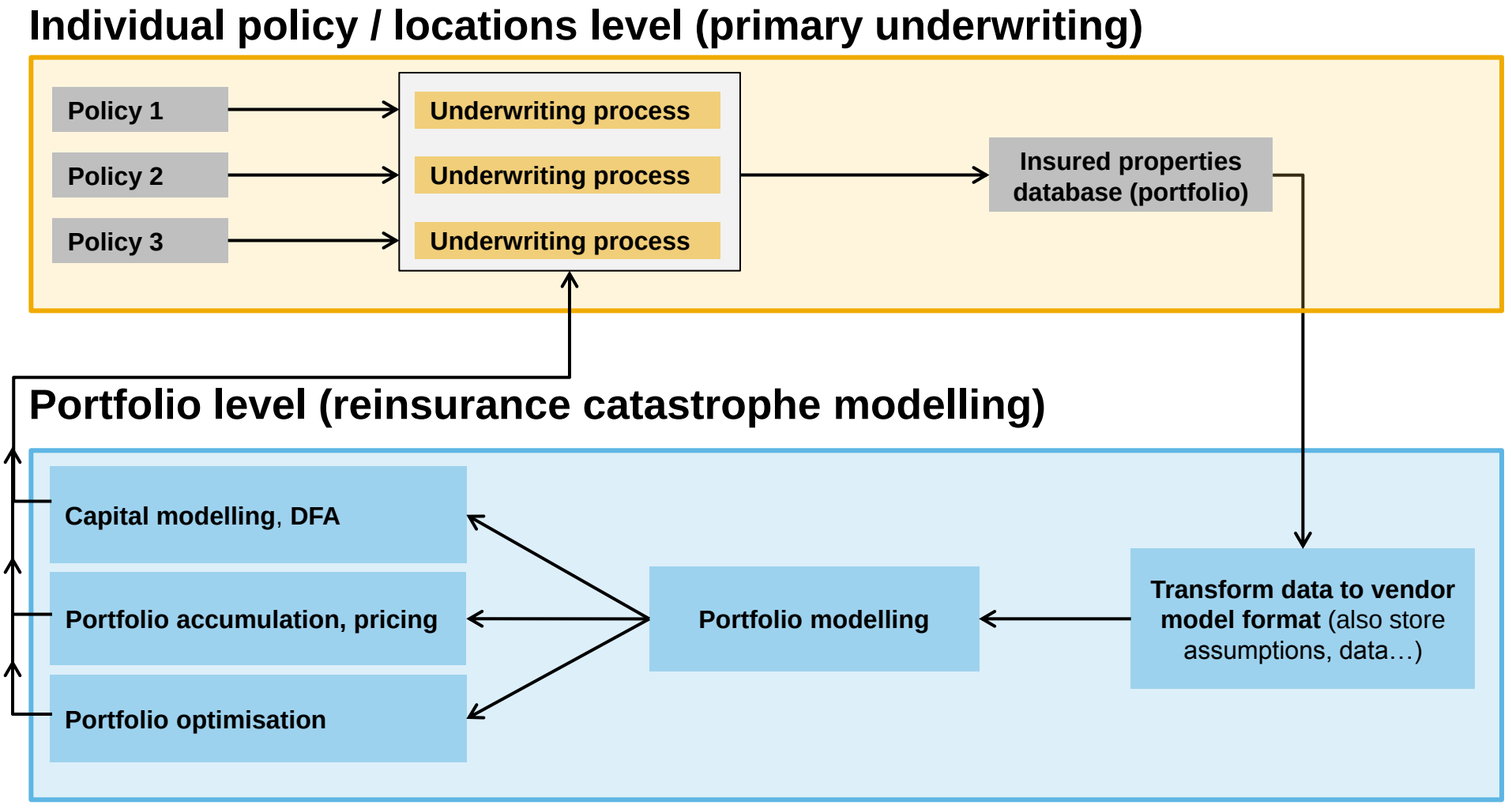
- Digital Terrain Models (DTM) are essential for correct inundation modelling
- Must be corrected to prevent incorrect results



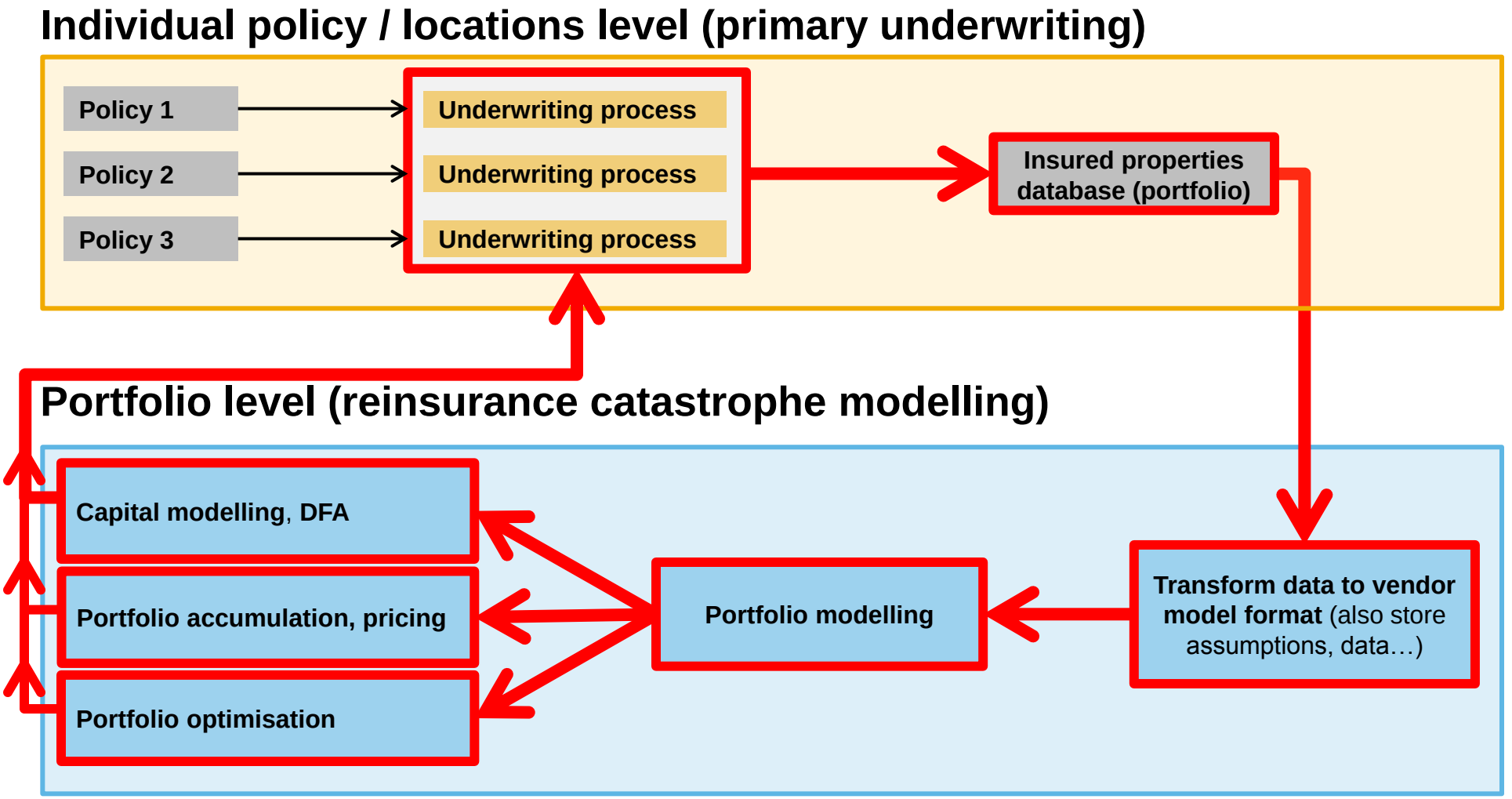




Catastrophe risk management workflow



Catastrophe risk management workflow



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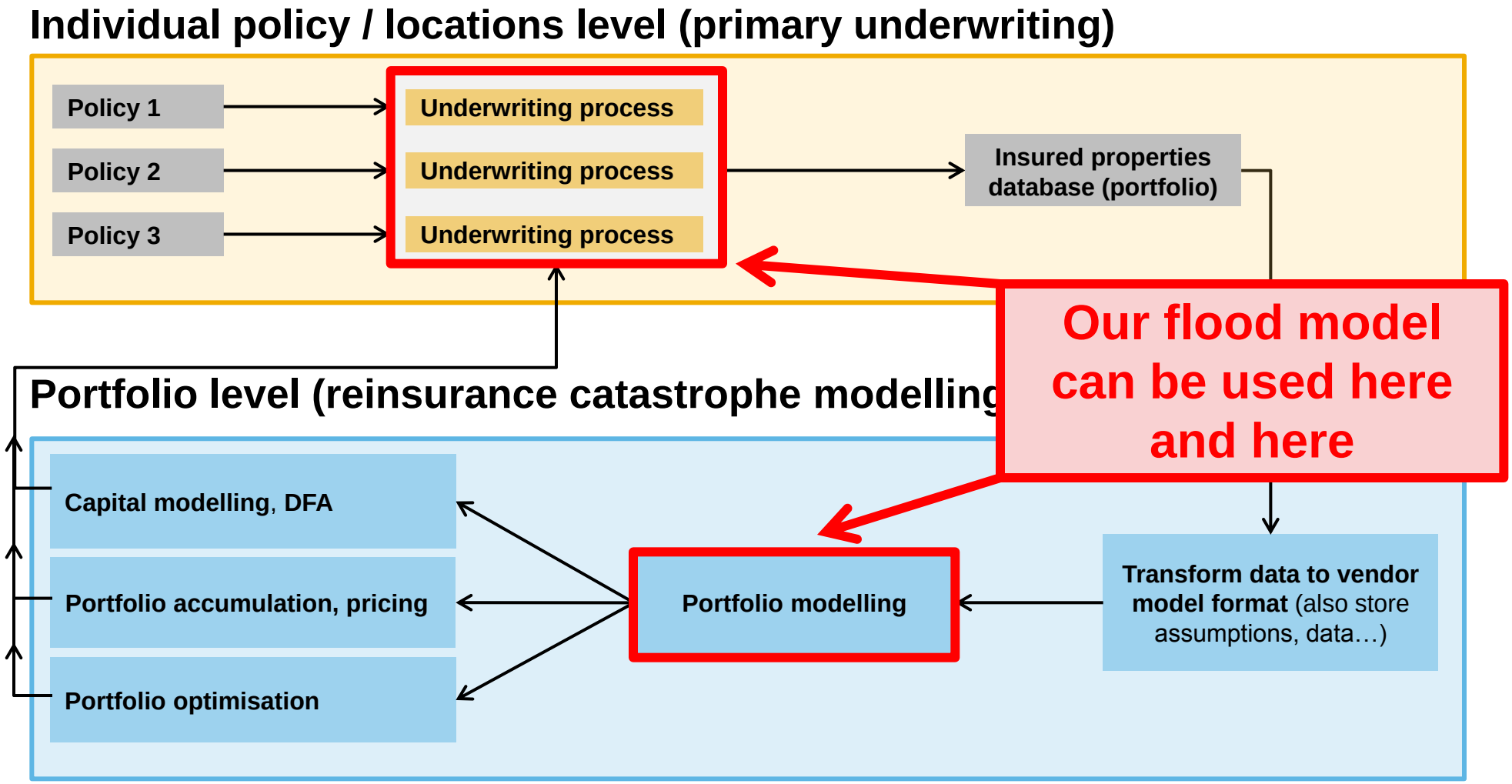
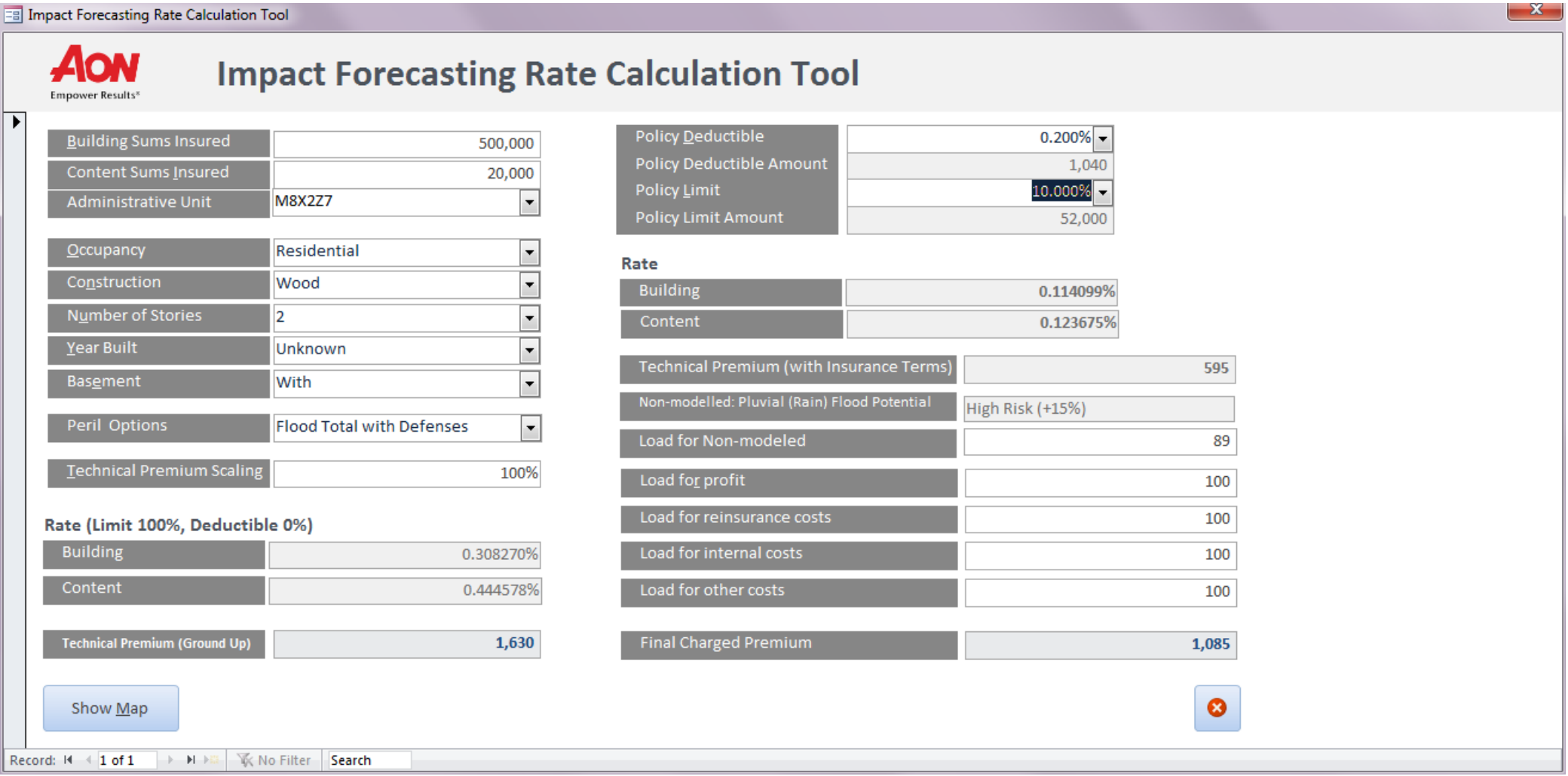
Catastrophe risk management workflow

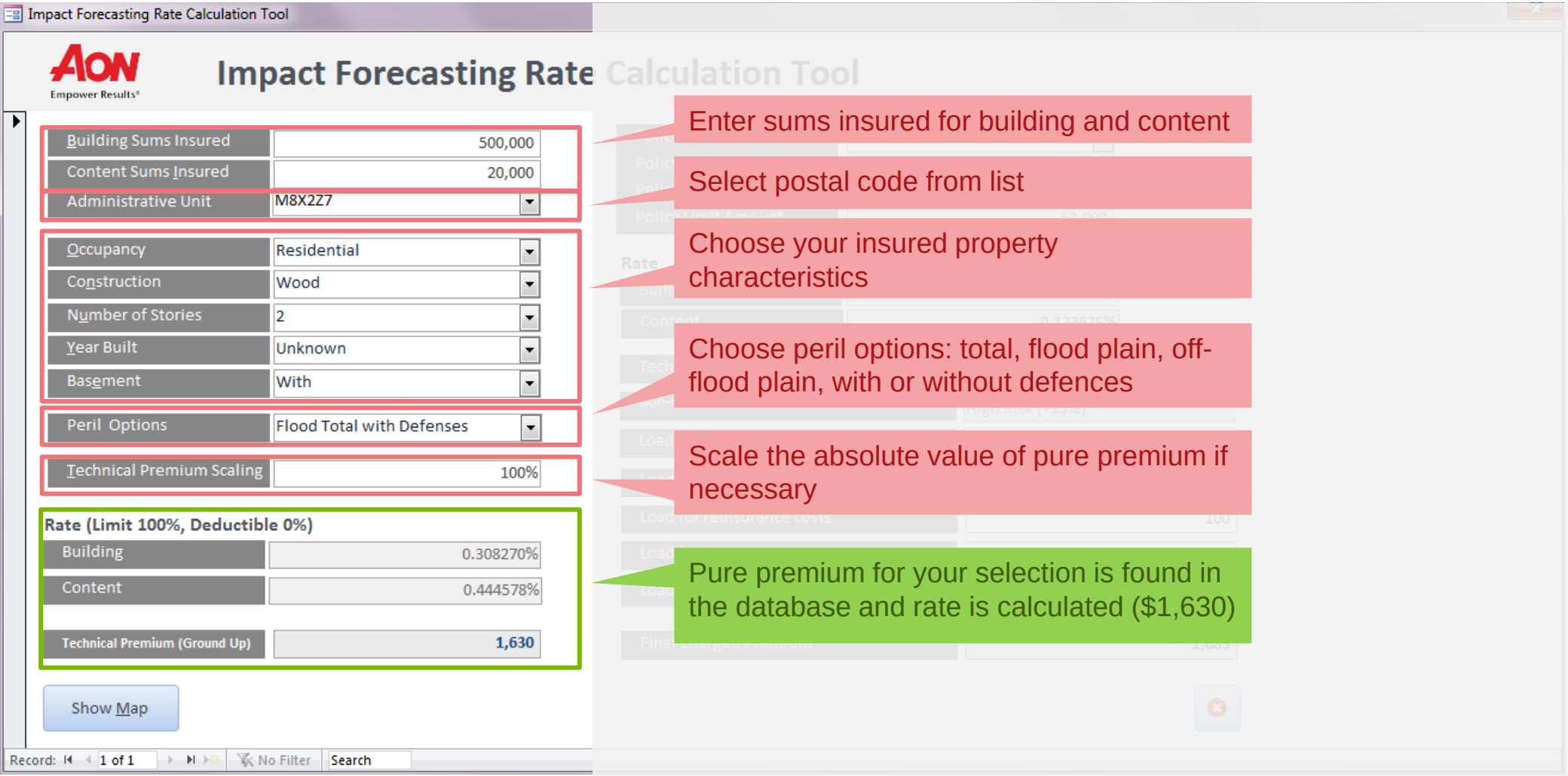


Using the model for ratemaking DEMO

Demo


Impact Forecasting Rate Calculation Tool
AON
Empower Results®
Impact Forecasting Rate Calculation Tool
Building Sums Insured
500,000
Content Sums Insured
20,000
Administrative Unit
M8X2Z7
Occupancy
Residential
Construction
Wood
Number of Stories
2
Year Built
Unknown
Basement
With
Peril Options
Flood Total with Defenses
Technical Premium Scaling
100%
Rate (Limit 100%, Deductible 0%)
Building
0.308270%
Content
0.444578%
Technical Premium (Ground Up)
1,630
Policy Deductible
0.200%
Policy Deductible Amount
1,040
Policy Limit
10.000%
Policy Limit Amount
52,000
Rate
Building
0.114099%
Content
0.123675%
Technical Premium (with Insurance Terms)
595
Non-modelled: Pluvial (Rain) Flood Potential
High Risk (+15%)
Load for Non-modeled
89
Load for profit
100
Load for reinsurance costs
100
Load for internal costs
100
Load for other costs
100
Final Charged Premium
1,085
Show Map
Record:
1 of 1
No Filter
Search

Demo


Impact Forecasting Rate Calculation Tool
Impact Forecasting Rate Calculation Tool
Empower Results
Building Sums Insured
500,000
Content Sums Insured
20,000
Administrative Unit
M8X2Z7
Occupancy
Residential
Construction
Wood
Number of Stories
2
Year Built
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Basement
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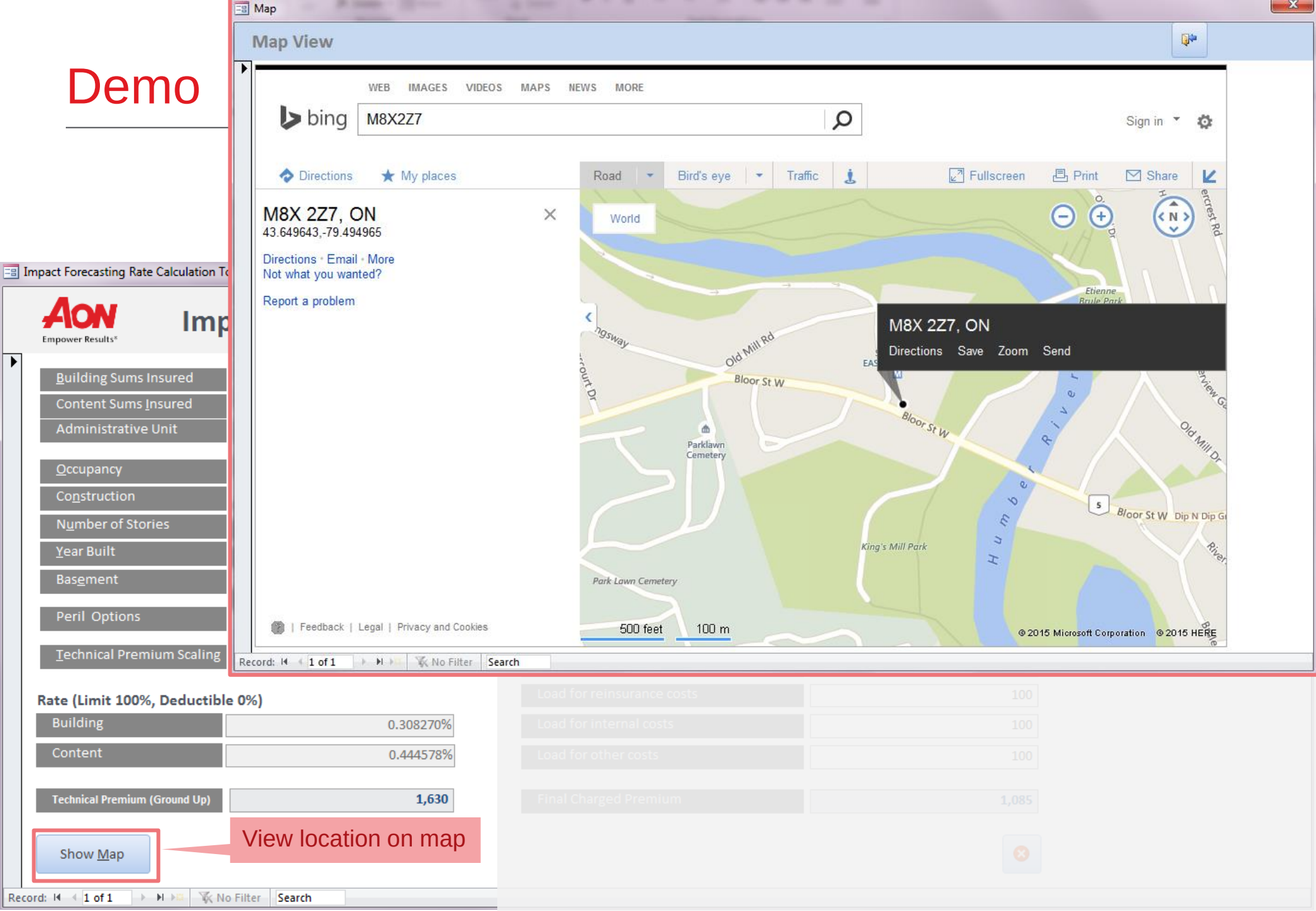
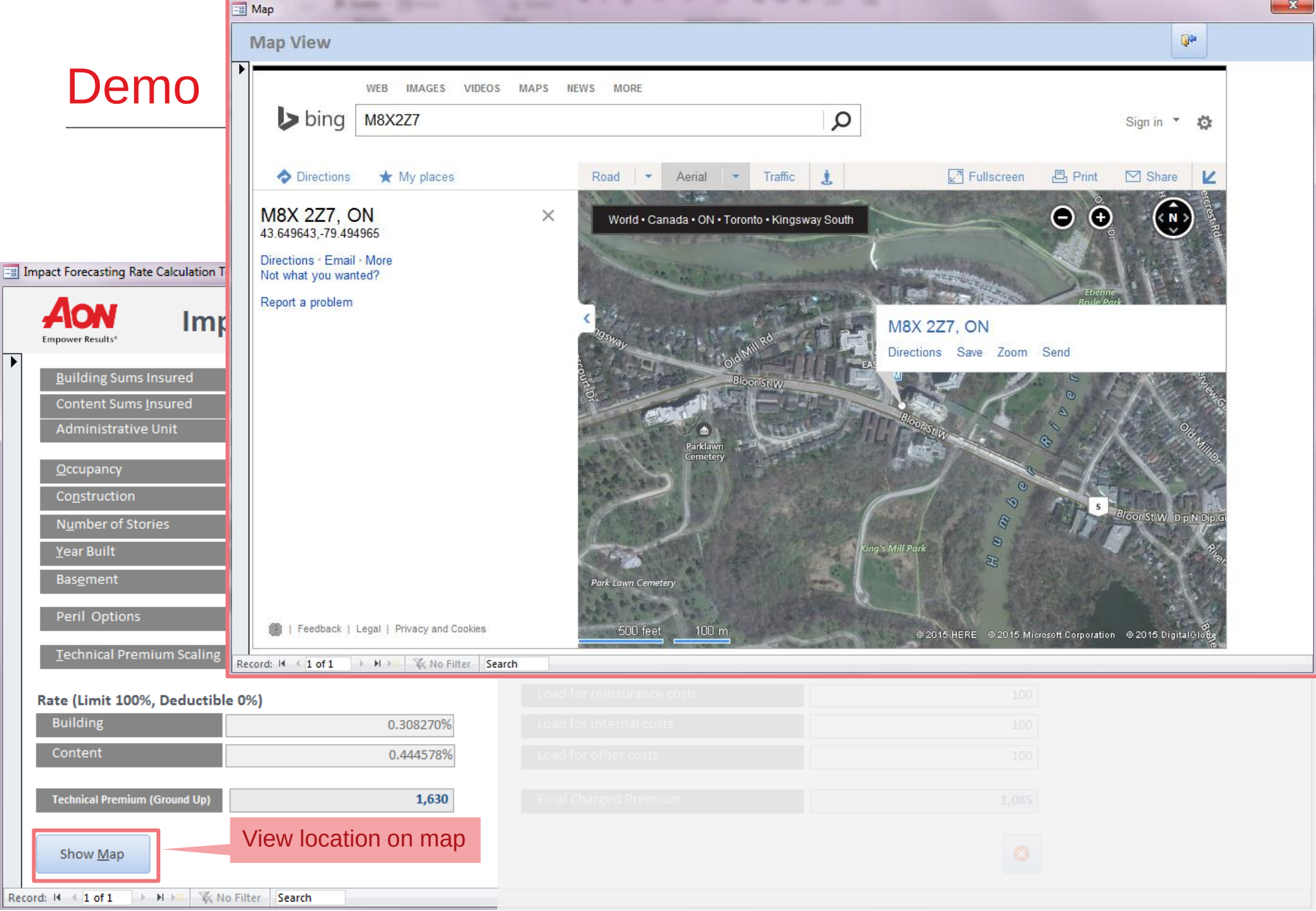
Flood Total with Defenses
Technical Premium Scaling
100%
Rate (Limit 100%, Deductible 0%)
Building
0.308270%
Content
0.444578%
Technical Premium (Ground Up)
1,630
Show Map
Record: 1 of 1
No Filter
Search
Enter sums insured for building and content
Select postal code from list
Choose your insured property characteristics
Choose peril options: total, flood plain, off-flood plain, with or without defences
Scale the absolute value of pure premium if necessary
Pure premium for your selection is found in the database and rate is calculated ($1,630)

Demo


Map
Map View
WEB IMAGES VIDEOS MAPS NEWS MORE
bing
M8X2Z7
Sign in
Directions
My places
Road
Bird's eye
Traffic
Fullscreen
Print
Share
M8X 2Z7, ON
43.649643,-79.494965
Directions · Email · More
Not what you wanted?
Report a problem
Feedback | Legal | Privacy and Cookies
World
M8X 2Z7, ON
Directions Save Zoom Send
Old Mill Rd
Bloor St W
Parklawn Cemetery
Humber River
King's Mill Park
Park Lawn Cemetery
500 feet
100 m
© 2015 Microsoft Corporation © 2015 HERE
Record: 1 of 1
No Filter
Search
Impact Forecasting Rate Calculation To
AON
Empower Results®
Imp
Building Sums Insured
Content Sums Insured
Administrative Unit
Occupancy
Construction
Number of Stories
Year Built
Basement
Peril Options
Technical Premium Scaling
Rate (Limit 100%, Deductible 0%)
Building
0.308270%
Content
0.444578%
Technical Premium (Ground Up)
1,630
Show Map
View location on map
Load for reinsurance costs
100
Load for internal costs
100
Load for other costs
100
Final Charged Premium
1,085
Record: 1 of 1
No Filter
Search

Demo



Impact Forecasting Rate Calculation T

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Imp

- Building Sums Insured
- Content Sums Insured
- Administrative Unit
- Occupancy
- Construction
- Number of Stories
- Year Built
- Basement
- Peril Options
- Technical Premium Scaling

Rate (Limit 100%, Deductible 0%)

Building	0.308270%
Content	0.444578%
Technical Premium (Ground Up)	1,630

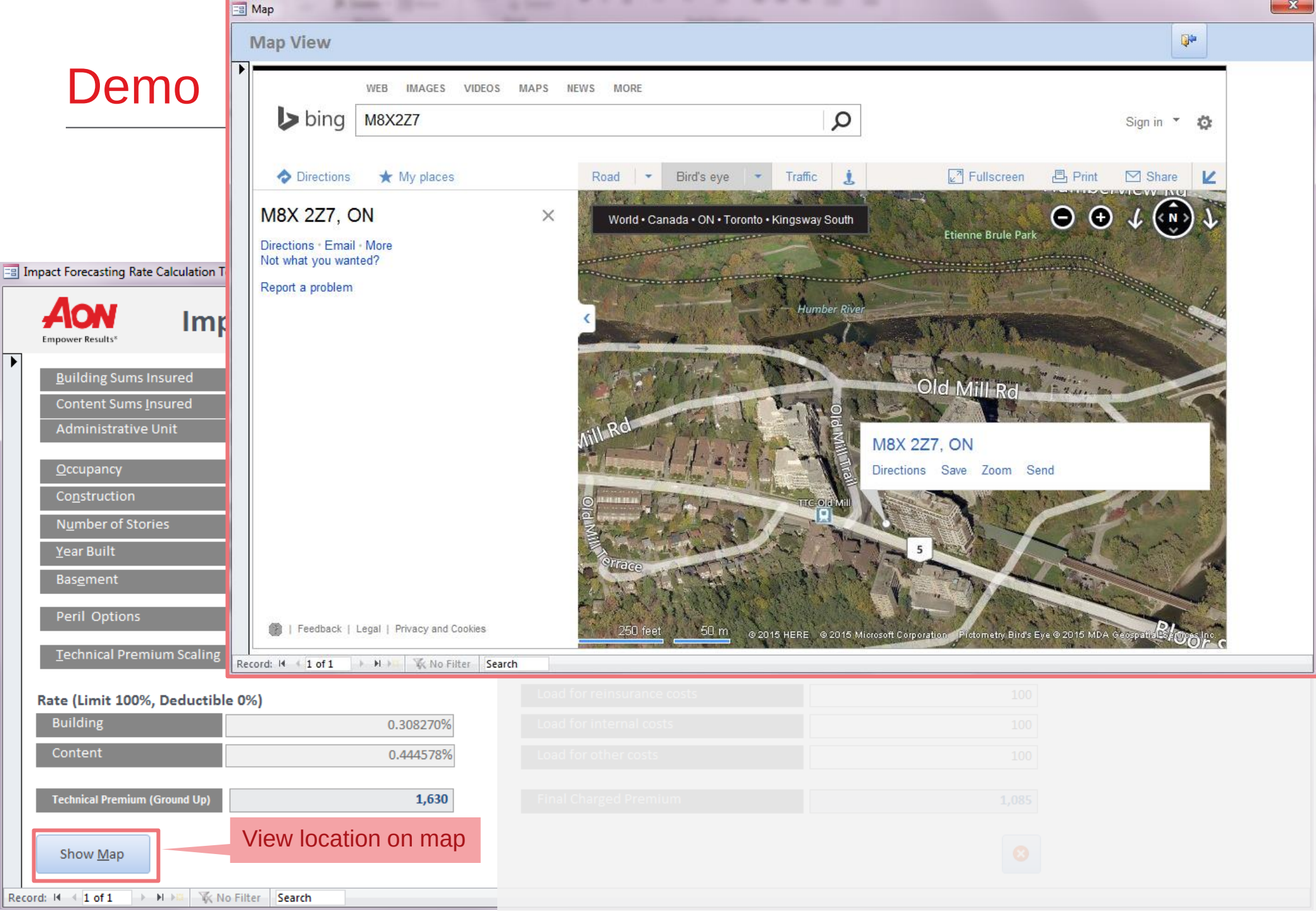
Show Map

View location on map

Load for reinsurance costs	100
Load for internal costs	100
Load for other costs	100
Final Charged Premium	1,085

Record: 1 of 1 No Filter Search

Demo


Map
Map View
WEB IMAGES VIDEOS MAPS NEWS MORE
bing
M8X2Z7
Sign in
Directions
My places
Road
Bird's eye
Traffic
Fullscreen
Print
Share
M8X 2Z7, ON
Directions · Email · More
Not what you wanted?
Report a problem
World • Canada • ON • Toronto • Kingsway South
Etienne Brule Park
Humber River
Old Mill Rd
Old Mill Trail
Old Mill Terrace
TTC Old Mill
M8X 2Z7, ON
Directions Save Zoom Send
5
Feedback | Legal | Privacy and Cookies
250 feet
50 m
© 2015 HERE © 2015 Microsoft Corporation
Record: 1 of 1
No Filter
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Impact Forecasting Rate Calculation T
AON
Empower Results®
Building Sums Insured
Content Sums Insured
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Number of Stories
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Final Charged Premium
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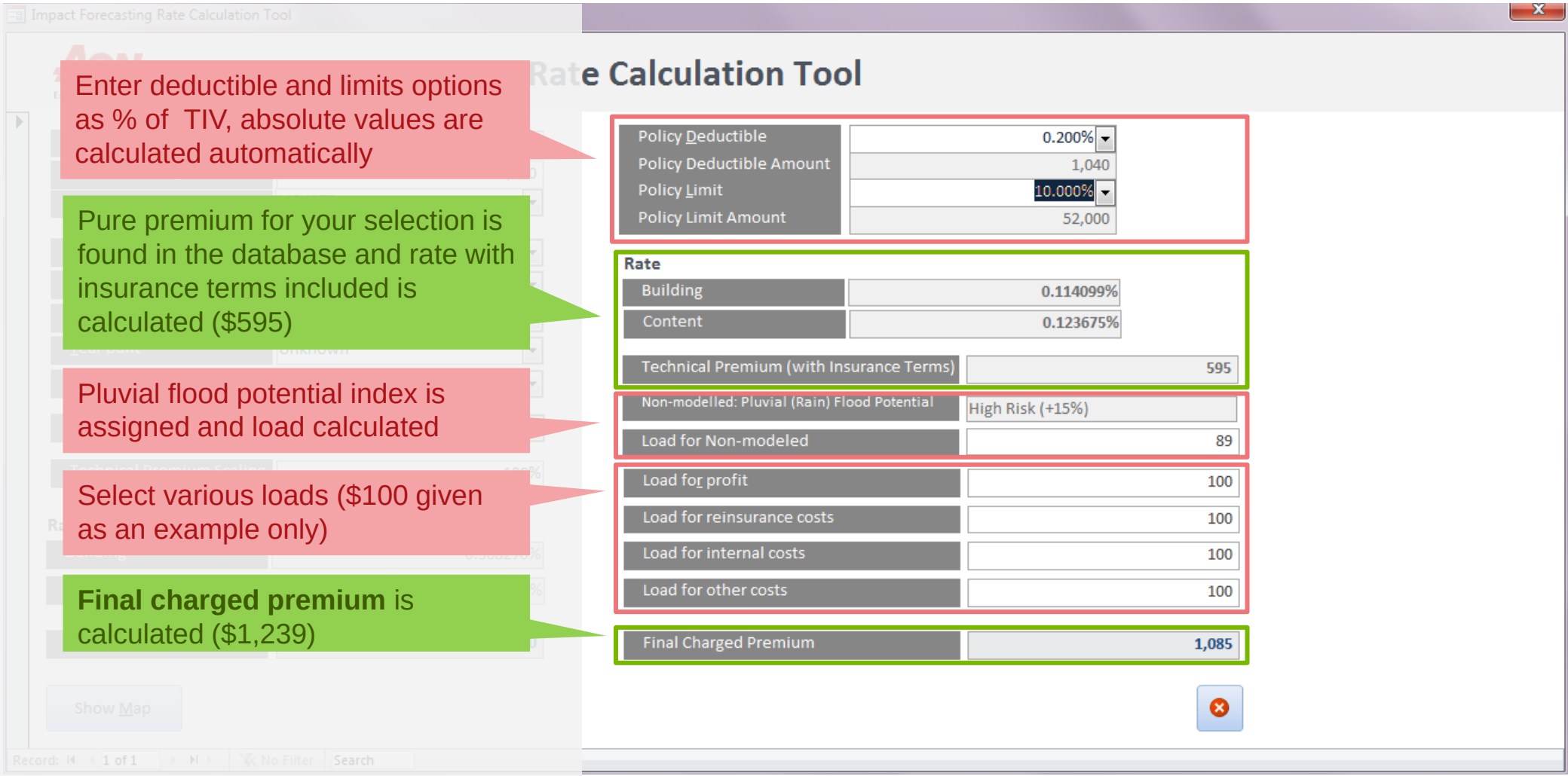
Record: 1 of 1
No Filter
Search

Demo


Impact Forecasting Rate Calculation Tool
e Calculation Tool
Enter deductible and limits options as % of TIV, absolute values are calculated automatically
Pure premium for your selection is found in the database and rate with insurance terms included is calculated ($595)
Pluvial flood potential index is assigned and load calculated
Select various loads ($100 given as an example only)
Final charged premium is calculated ($1,239)
Policy Deductible
0.200%
Policy Deductible Amount
1,040
Policy Limit
10.000%
Policy Limit Amount
52,000
Rate
Building
0.114099%
Content
0.123675%
Technical Premium (with Insurance Terms)
595
Non-modelled: Pluvial (Rain) Flood Potential
High Risk (+15%)
Load for Non-modeled
89
Load for profit
100
Load for reinsurance costs
100
Load for internal costs
100
Load for other costs
100
Final Charged Premium
1,085
Show Map
Record: 1 of 1
No Filter
Search

Flood map vs. probabilistic model

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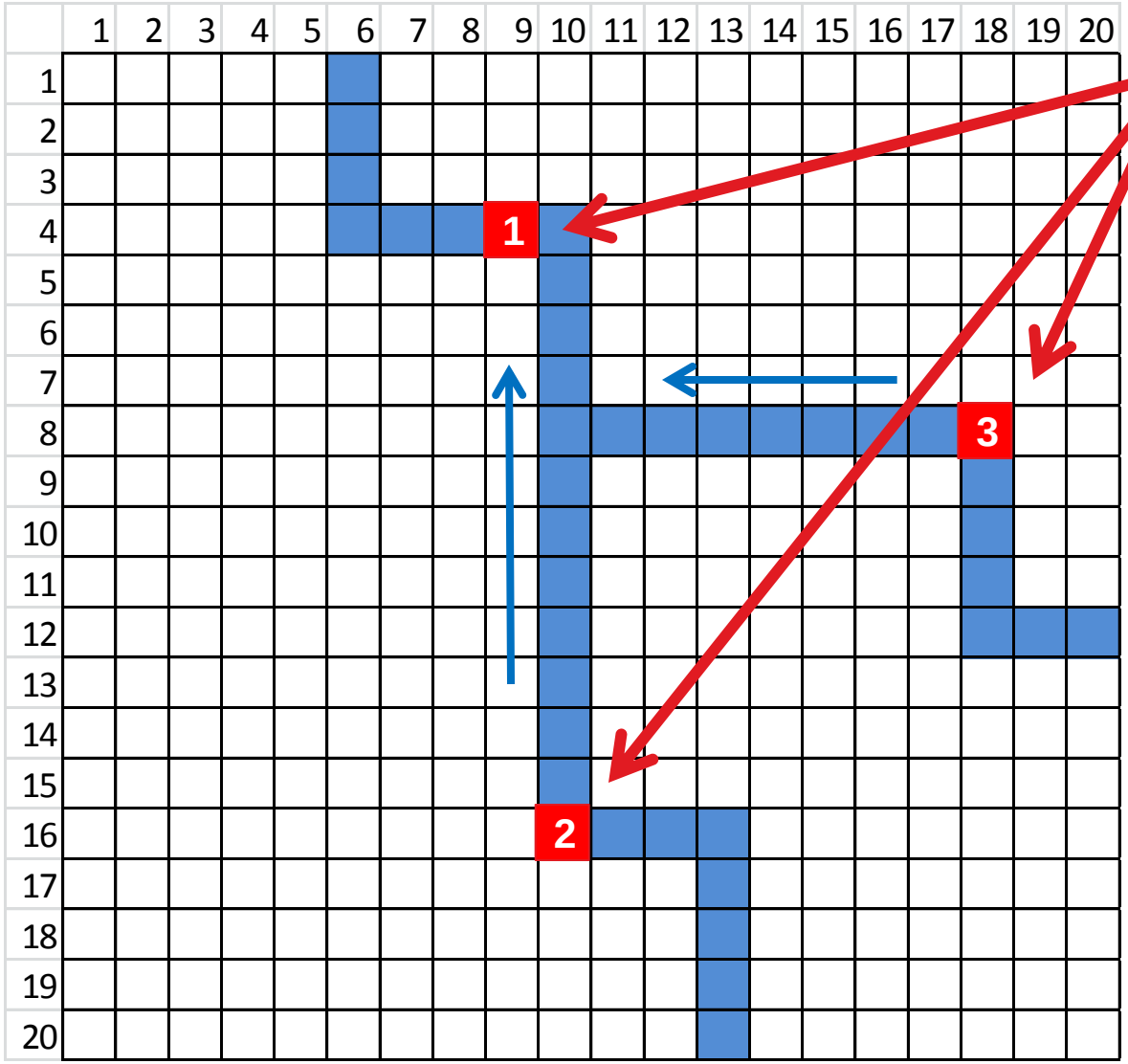
Flood map – the process



3 gauge station with 30 years of observed data

1		2		3	
Year	Discharge (m^3/s)	Year	Discharge (m^3/s)	Year	Discharge (m^3/s)
2015	341	2015	205	2015	136
2014	463	2014	278	2014	185
2013	381	2013	229	2013	152
2012	539	2012	323	2012	216
2011	377	2011	226	2011	151
2010	953	2010	572	2010	381
2009	691	2009	415	2009	276
2008	411	2008	247	2008	164
2007	305	2007	183	2007	122
2006	482	2006	289	2006	193
2005	386	2005	232	2005	154
2004	857	2004	514	2004	343
2003	850	2003	510	2003	340
2002	45	2002	27	2002	18
2001	821	2001	493	2001	328
2000	86	2000	52	2000	34
1999	628	1999	377	1999	251
1998	175	1998	105	1998	70
1997	913	1997	548	1997	365
1996	955	1996	573	1996	382
1995	62	1995	37	1995	25
1994	829	1994	497	1994	332
1993	682	1993	409	1993	273
1992	817	1992	490	1992	327
1991	423	1991	254	1991	169
1990	584	1990	350	1990	234
1989	373	1989	224	1989	149
1988	570	1988	342	1988	228
1987	800	1987	480	1987	320
1986	70	1986	42	1986	28

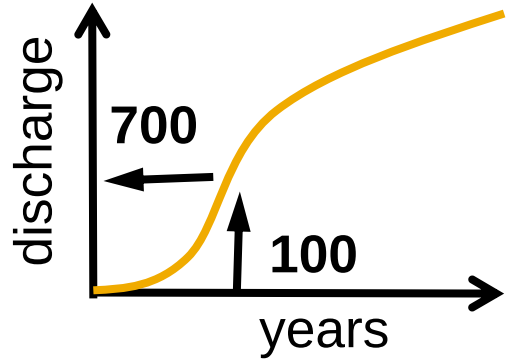
Flood map – the process (per station)

1

Year	Discharge (m^3/s)
2015	341
2014	463
2013	381
2012	539
2011	377
2010	953
2009	691
2008	411
2007	305
2006	482
2005	386
2004	857
2003	850
2002	45
2001	821
2000	86
1999	628
1998	175
1997	913
1996	955
1995	62
1994	829
1993	682
1992	817
1991	423
1990	584
1989	373
1988	570
1987	800
1986	70

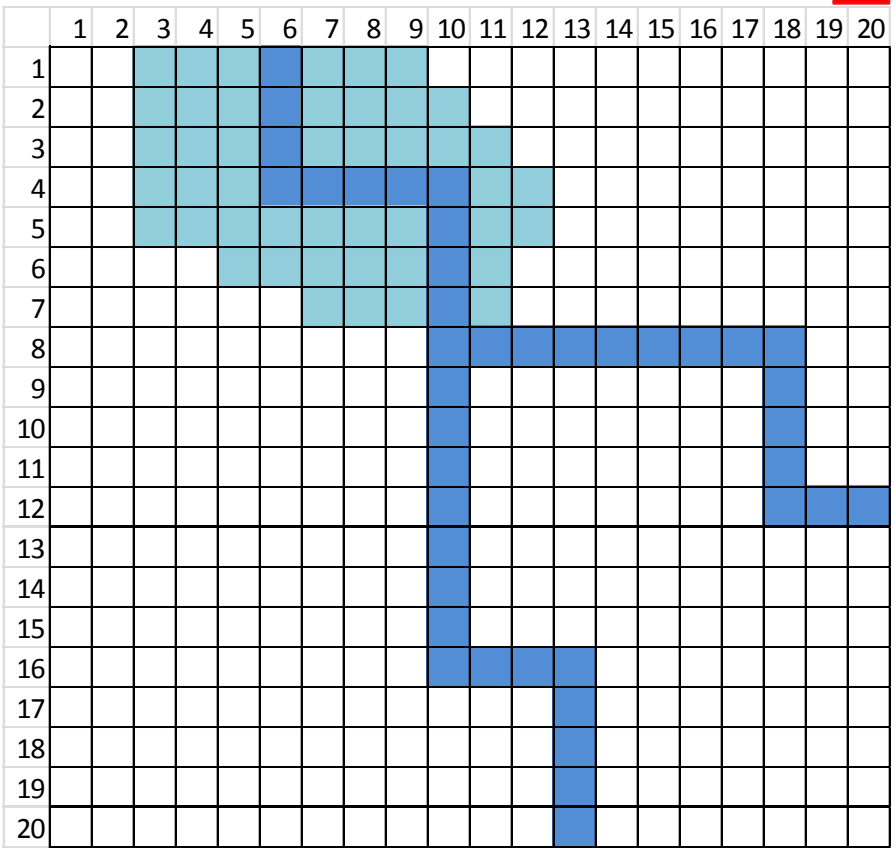
1

Calculate “design flows”



Create flood map for 1 in 100 years discharge

1



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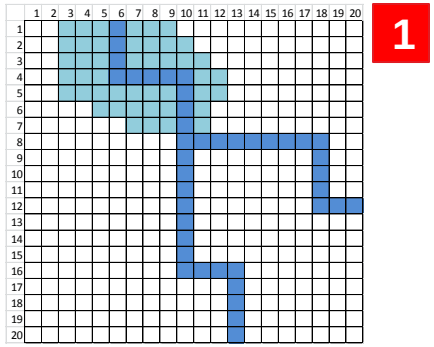
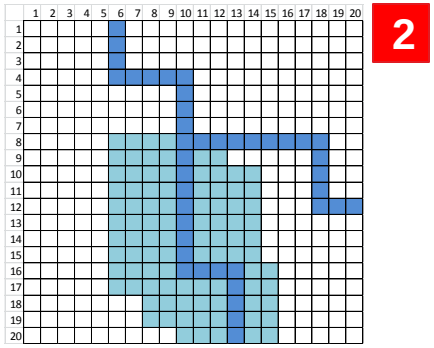
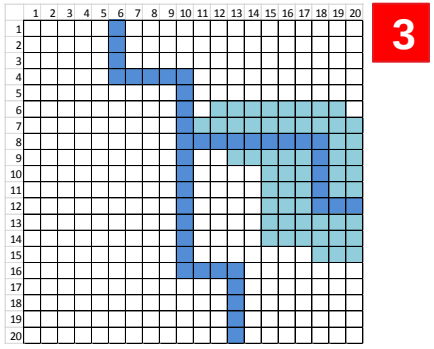
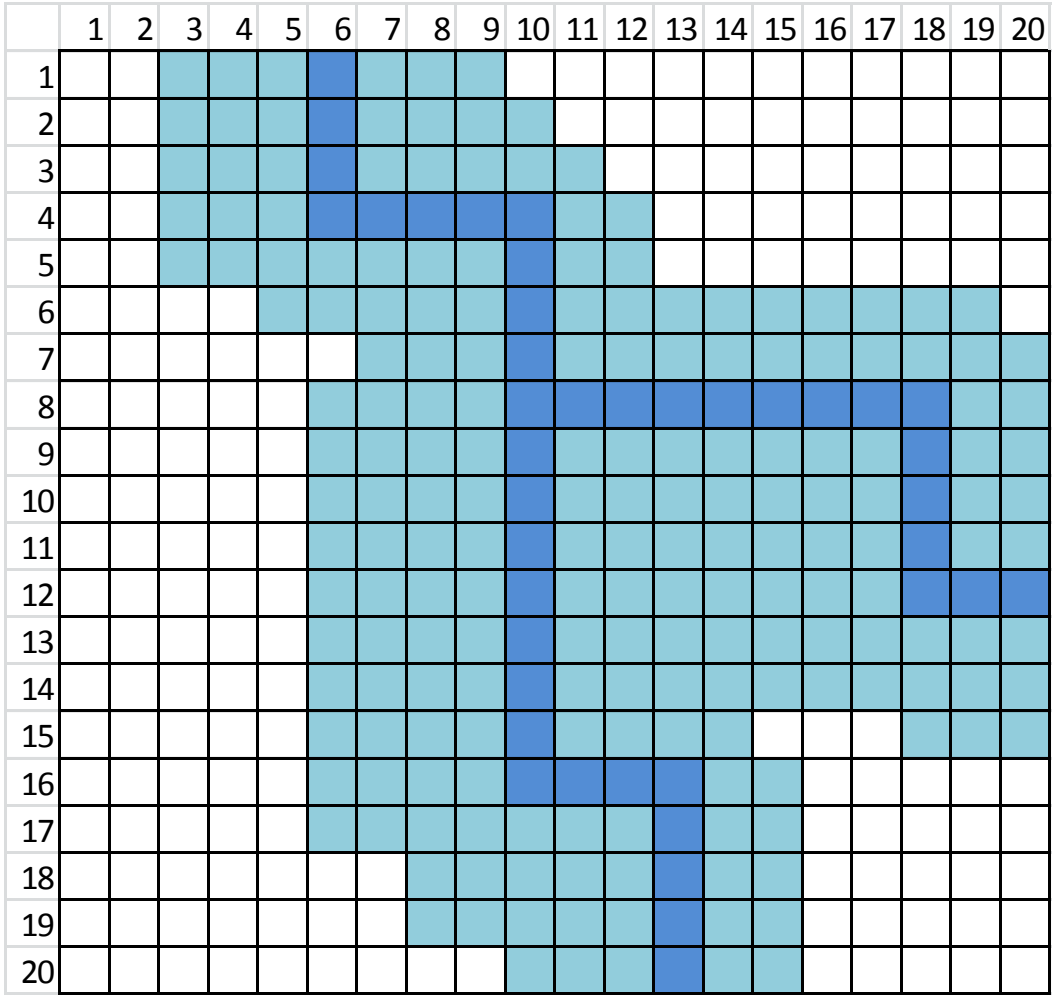
Flood map – the process (for all stations)







Flood map for <u>1 in 100 years</u> discharge (all stations)



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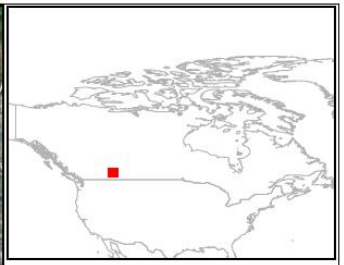
Flood map – Calgary



Grid Cell Flood Hazard

Hazard (1 in 100 years)
Flood Depth [m]

- < 1.0
- 1.1 - 2.0
- 2.1 - 3.0
- 3.1 - 4.0
- > 4.1

0 2 4
Kilometers

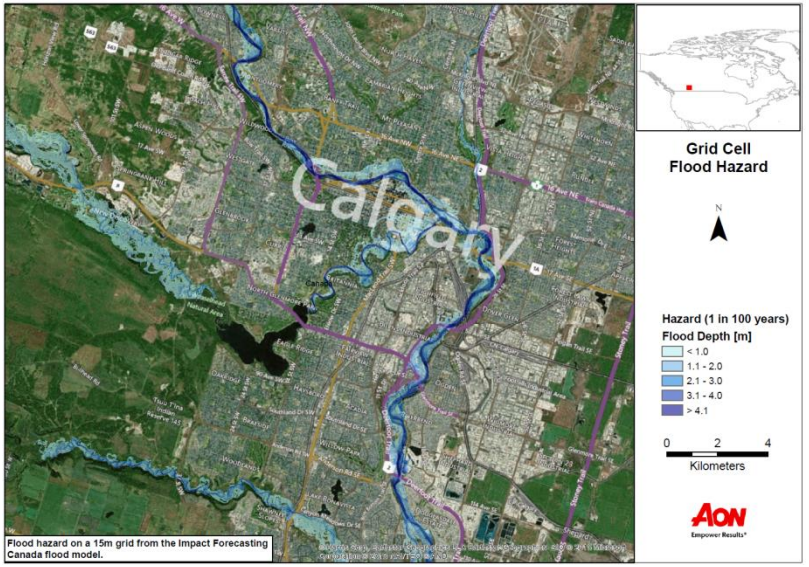
AON Empower Results®

Flood map – Calgary (nice visualisation but…)

1 in 250 years flood map for Calgary visualised in Google Earth, source: Impact Forecasting

Flood map – summary

- Flood (inundation) depth can be included
- Available for a range of return periods
  - 10 to 10,000 years
- **Advantages**
  - Simple to use
  - Simpler to develop
- **Disadvantages**
  - Doesn't include correlation between stations
  - Does NOT express loss in any sense
  - Does NOT give rate indication
  - Is NOT probabilistic



Probabilistic model – interaction between stations

3 gauge station with 30 years of observed data

1		2		3	
Year	Discharge (m^3/s)	Year	Discharge (m^3/s)	Year	Discharge (m^3/s)
2015	341	2015	205	2015	136
2014	463	2014	278	2014	185
2013	381	2013	229	2013	152
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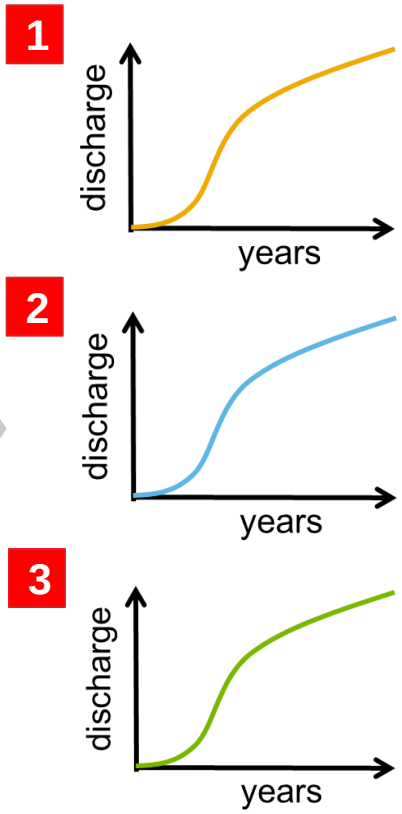
2002	45	2002	27	2002	18
2001	821	2001	493	2001	328
2000	86	2000	52	2000	34
1999	628	1999	377	1999	251
1998	175	1998	105	1998	70
1997	913	1997	548	1997	365
1996	955	1996	573	1996	382
1995	62	1995	37	1995	25
1994	829	1994	497	1994	332
1993	682	1993	409	1993	273
1992	817	1992	490	1992	327
1991	423	1991	254	1991	169
1990	584	1990	350	1990	234
1989	373	1989	224	1989	149
1988	570	1988	342	1988	228
1987	800	1987	480	1987	320
1986	70	1986	42	1986	28

Design flows



Add correlation

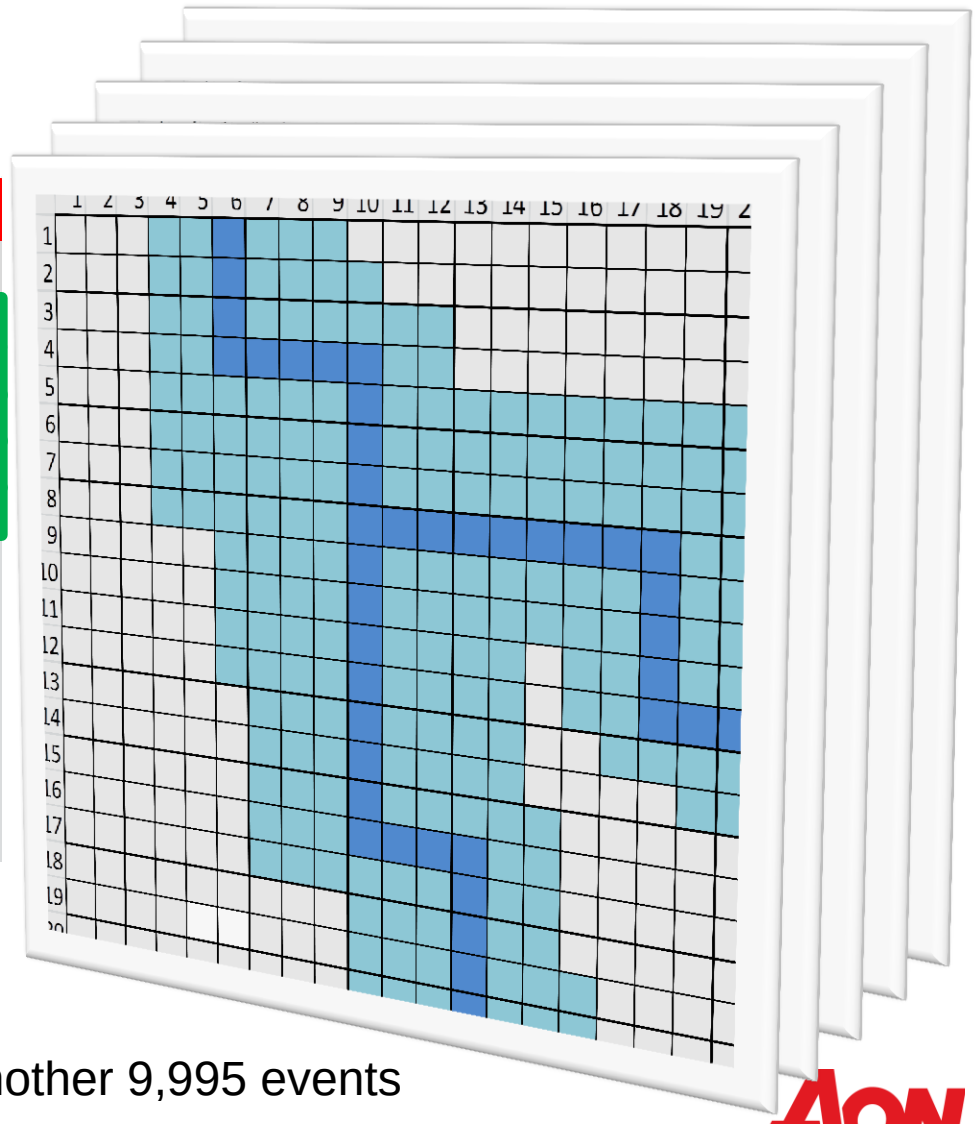
	1	2	3
1	1	0.9	0.8
2	0.9	1	0.6
3	0.8	0.6	1

Empower Results®

Probabilistic model – interaction between stations

Generate 10,000 realistic events for all stations

	1	2	3
Event	Discharge (m^3/s)	Discharge (m^3/s)	Discharge (m^3/s)
1	63	38	25
2	866	520	346
3	964	578	386
4	332	199	133
5	355	213	142
6	142	85	57
7	220	132	88
8	561	337	224
9	713	428	285
10	491	295	196
...	...	...	...
10,000	581	349	232



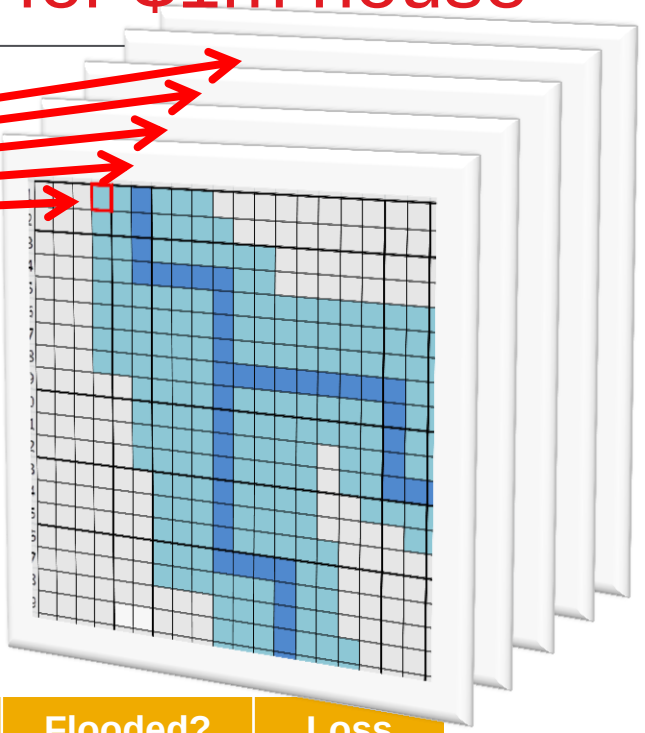
And another 9,995 events

Empower Results®

Probabilistic model – calculate loss for $1m house

Calculate loss for every event for cell **4-1**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1-1	2-1	3-1	4-1	5-1	6-1	7-1	8-1	9-1	10-1	11-1	12-1	13-1	14-1	15-1	16-1	17-1	18-1	19-1	20-1
2	1-2	2-2	3-2	4-2	5-2	6-2	7-2	8-2	9-2	10-2	11-2	12-2	13-2	14-2	15-2	16-2	17-2	18-2	19-2	20-2
3	1-3	2-3	3-3	4-3	5-3	6-3	7-3	8-3	9-3	10-3	11-3	12-3	13-3	14-3	15-3	16-3	17-3	18-3	19-3	20-3
4	1-4	2-4	3-4	4-4	5-4	6-4	7-4	8-4	9-4	10-4	11-4	12-4	13-4	14-4	15-4	16-4	17-4	18-4	19-4	20-4
5	1-5	2-5	3-5	4-5	5-5	6-5	7-5	8-5	9-5	10-5	11-5	12-5	13-5	14-5	15-5	16-5	17-5	18-5	19-5	20-5
6	1-6	2-6	3-6	4-6	5-6	6-6	7-6	8-6	9-6	10-6	11-6	12-6	13-6	14-6	15-6	16-6	17-6	18-6	19-6	20-6
7	1-7	2-7	3-7	4-7	5-7	6-7	7-7	8-7	9-7	10-7	11-7	12-7	13-7	14-7	15-7	16-7	17-7	18-7	19-7	20-7
8	1-8	2-8	3-8	4-8	5-8	6-8	7-8	8-8	9-8	10-8	11-8	12-8	13-8	14-8	15-8	16-8	17-8	18-8	19-8	20-8
9	1-9	2-9	3-9	4-9	5-9	6-9	7-9	8-9	9-9	10-9	11-9	12-9	13-9	14-9	15-9	16-9	17-9	18-9	19-9	20-9
10	1-10	2-10	3-10	4-10	5-10	6-10	7-10	8-10	9-10	10-10	11-10	12-10	13-10	14-10	15-10	16-10	17-10	18-10	19-10	20-10
11	1-11	2-11	3-11	4-11	5-11	6-11	7-11	8-11	9-11	10-11	11-11	12-11	13-11	14-11	15-11	16-11	17-11	18-11	19-11	20-11
12	1-12	2-12	3-12	4-12	5-12	6-12	7-12	8-12	9-12	10-12	11-12	12-12	13-12	14-12	15-12	16-12	17-12	18-12	19-12	20-12
13	1-13	2-13	3-13	4-13	5-13	6-13	7-13	8-13	9-13	10-13	11-13	12-13	13-13	14-13	15-13	16-13	17-13	18-13	19-13	20-13
14	1-14	2-14	3-14	4-14	5-14	6-14	7-14	8-14	9-14	10-14	11-14	12-14	13-14	14-14	15-14	16-14	17-14	18-14	19-14	20-14
15	1-15	2-15	3-15	4-15	5-15	6-15	7-15	8-15	9-15	10-15	11-15	12-15	13-15	14-15	15-15	16-15	17-15	18-15	19-15	20-15
16	1-16	2-16	3-16	4-16	5-16	6-16	7-16	8-16	9-16	10-16	11-16	12-16	13-16	14-16	15-16	16-16	17-16	18-16	19-16	20-16
17	1-17	2-17	3-17	4-17	5-17	6-17	7-17	8-17	9-17	10-17	11-17	12-17	13-17	14-17	15-17	16-17	17-17	18-17	19-17	20-17
18	1-18	2-18	3-18	4-18	5-18	6-18	7-18	8-18	9-18	10-18	11-18	12-18	13-18	14-18	15-18	16-18	17-18	18-18	19-18	20-18
19	1-19	2-19	3-19	4-19	5-19	6-19	7-19	8-19	9-19	10-19	11-19	12-19	13-19	14-19	15-19	16-19	17-19	18-19	19-19	20-19
20	1-20	2-20	3-20	4-20	5-20	6-20	7-20	8-20	9-20	10-20	11-20	12-20	13-20	14-20	15-20	16-20	17-20	18-20	19-20	20-20



Event	Flooded?	Loss
1	No	0
2	Yes	300,000
3	Yes	350,000
4	Yes	100,000
5	Yes	120,000
….	…	…
10,000	No	0

And another 9,995 events

Probabilistic model – calculate Pure Premium (AAL)

1. Calculate Probability * Loss

2. Sum this to get Pure Premium (Average Annual Loss) for **cell 4-1**

3. Express $523 as % of total insured value

Event	Flooded?	Loss	Probability	P * Loss ($)	
1	No	**0**	0.0001	0	
2	Yes	**300,000**	0.0001	30	
3	Yes	**350,000**	0.0001	35	
4	Yes	**100,000**	0.0001	10	
5	Yes	**120,000**	0.0001	12	
….	…	**…**	….	…	
10,000	No	**0**	0.0001	0	
			Pure P.	**$ 523**	**0.0523%**

Probabilistic model – repeat for all cells

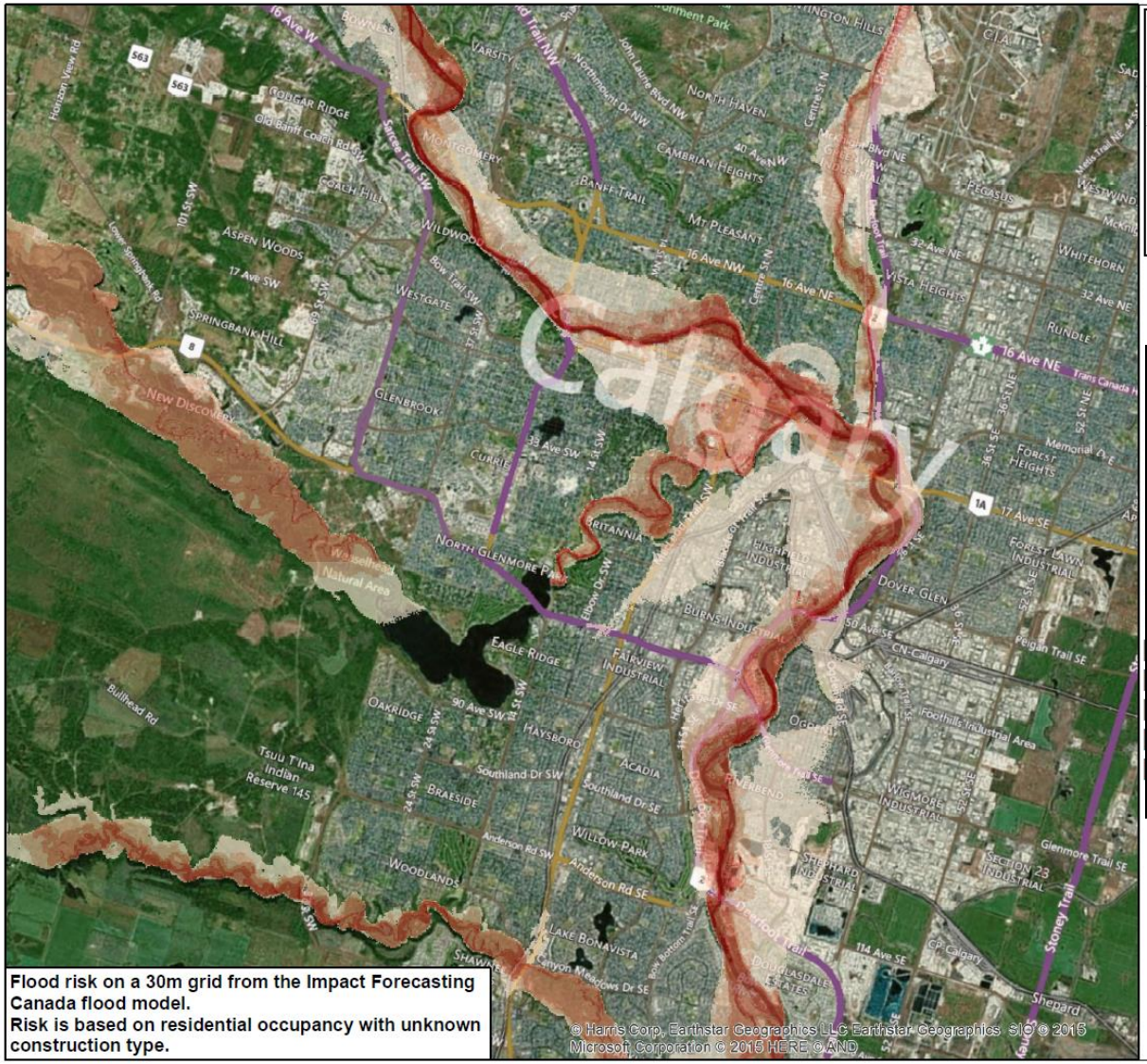
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0	0	114	**523**	714		721	728	528	0	0	0	0	0	0	0	0	0	0	0
2	0	0	110	549	679		728	672	507	0	0	0	0	0	0	0	0	108	111	112
3	0	0	116	502	735		735	700	714	502	539	518	523	106	107	108	114	114	112	109
4	0	0	105	502	721						693	518	544	544	502	533	549	502	107	110
5	0	0	109	518	665	672	700	728	665		735	672	686	665	544	533	549	513	528	109
6	0	0	106	507	497	672	728	672	735		700	707	735	714	507	528	502	518	544	518
7	0	0	114	518	528	518	549	686	728		672	665	665	714	707	728	693	700	693	518
8	0	0	112	114	109	0	533	665	665										700	544
9	0	0	0	0	116	109	502	707	693		693	721	700	707	686	700	672		707	533
10	0	0	0	0	111	108	513	693	714		686	672	539	502	497	721	686		707	679
11	0	0	0	0	112	113	513	700	721		735	672	533	507	513	728	672		665	721
12	0	0	0	0	113	113	528	679	686		679	672	502	528	502	693	714			
13	0	0	0	0	108	105	523	665	735		686	693	539	513	544	714	693	721	672	700
14	0	0	0	0	108	113	523	672	707		721	721	523	533	497	513	544	544	523	707
15	0	0	0	0	106	114	523	665	707		714	735	721	707	735	539	513	528	523	539
16	0	0	0	0	110	108	502	533	693					686	679	539	539	518	539	502
17	0	0	0	0	105	105	523	533	700	665	721	686		707	679	539	513	105	107	105
18	0	0	0	0	114	112	116	533	539	518	707	672		693	735	539	502	108	108	109
19	0	0	0	0	0	0	0	105	518	544	693	735		686	707	539	507	108	108	105
20	0	0	0	0	0	0	0	112	513	544	735	672		672	693	518	518	113	0	0

Probabilistic model – express as % of TIV

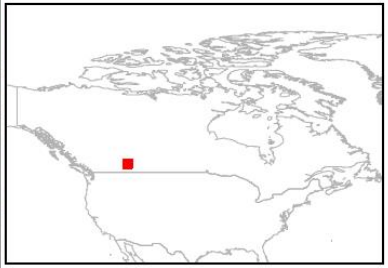
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0	0	0.01%	0.05%	0.07%		0.07%	0.07%	0.05%	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0.01%	0.05%	0.07%		0.07%	0.07%	0.05%	0	0	0	0	0	0	0	0	0.01%	0.01%	0.01%
3	0	0	0.01%	0.05%	0.07%		0.07%	0.07%	0.07%	0.05%	0.05%	0.05%	0.05%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
4	0	0	0.01%	0.05%	0.07%						0.07%	0.05%	0.05%	0.05%	0.05%	0.05%	0.05%	0.05%	0.01%	0.01%
5	0	0	0.01%	0.05%	0.07%	0.07%	0.07%	0.07%	0.07%		0.07%	0.07%	0.07%	0.07%	0.05%	0.05%	0.05%	0.05%	0.05%	0.01%
6	0	0	0.01%	0.05%	0.05%	0.07%	0.07%	0.07%	0.07%		0.07%	0.07%	0.07%	0.07%	0.05%	0.05%	0.05%	0.05%	0.05%	0.05%
7	0	0	0.01%	0.05%	0.05%	0.05%	0.05%	0.07%	0.07%		0.07%	0.07%	0.07%	0.07%	0.07%	0.07%	0.07%	0.07%	0.07%	0.05%
8	0	0	0.01%	0.01%	0.01%	0.00%	0.05%	0.07%	0.07%										0.07%	0.05%
9	0	0	0	0	0.01%	0.01%	0.05%	0.07%	0.07%		0.07%	0.07%	0.07%	0.07%	0.07%	0.07%	0.07%		0.07%	0.05%
10	0	0	0	0	0.01%	0.01%	0.05%	0.07%	0.07%		0.07%	0.07%	0.05%	0.05%	0.05%	0.07%	0.07%		0.07%	0.07%
11	0	0	0	0	0.01%	0.01%	0.05%	0.07%	0.07%		0.07%	0.07%	0.05%	0.05%	0.05%	0.07%	0.07%		0.07%	0.07%
12	0	0	0	0	0.01%	0.01%	0.05%	0.07%	0.07%		0.07%	0.07%	0.05%	0.05%	0.05%	0.07%	0.07%			
13	0	0	0	0	0.01%	0.01%	0.05%	0.07%	0.07%		0.07%	0.07%	0.05%	0.05%	0.05%	0.07%	0.07%	0.07%	0.07%	0.07%
14	0	0	0	0	0.01%	0.01%	0.05%	0.07%	0.07%		0.07%	0.07%	0.05%	0.05%	0.05%	0.05%	0.05%	0.05%	0.05%	0.07%
15	0	0	0	0	0.01%	0.01%	0.05%	0.07%	0.07%		0.07%	0.07%	0.07%	0.07%	0.07%	0.05%	0.05%	0.05%	0.05%	0.05%
16	0	0	0	0	0.01%	0.01%	0.05%	0.05%	0.07%					0.07%	0.07%	0.05%	0.05%	0.05%	0.05%	0.05%
17	0	0	0	0	0.01%	0.01%	0.05%	0.05%	0.07%	0.07%	0.07%	0.07%		0.07%	0.07%	0.05%	0.05%	0.01%	0.01%	0.01%
18	0	0	0	0	0.01%	0.01%	0.01%	0.05%	0.05%	0.05%	0.07%	0.07%		0.07%	0.07%	0.05%	0.05%	0.01%	0.01%	0.01%
19	0	0	0	0	0	0	0	0.01%	0.05%	0.05%	0.07%	0.07%		0.07%	0.07%	0.05%	0.05%	0.01%	0.01%	0.01%
20	0	0	0	0	0	0	0	0.01%	0.05%	0.05%	0.07%	0.07%		0.07%	0.07%	0.05%	0.05%	0.01%	0	0

- Do the same for all
  - Occupancies
  - Constructions
  - Number of stories classes
  - Presence of basement
  - Etc.

Probabilistic model – pure premium for $300k house



Flood risk on a 30m grid from the Impact Forecasting Canada flood model.
Risk is based on residential occupancy with unknown construction type.



Residential Grid Cell Flood Risk

Pure Premium (Average Annual Loss)
Building Sum Insured 300,000 CAD

- < 200
- 201 - 400
- 401 - 600
- 601 - 1,000
- > 1,001

0 2 4
Kilometers

Impact Forecasting
AON
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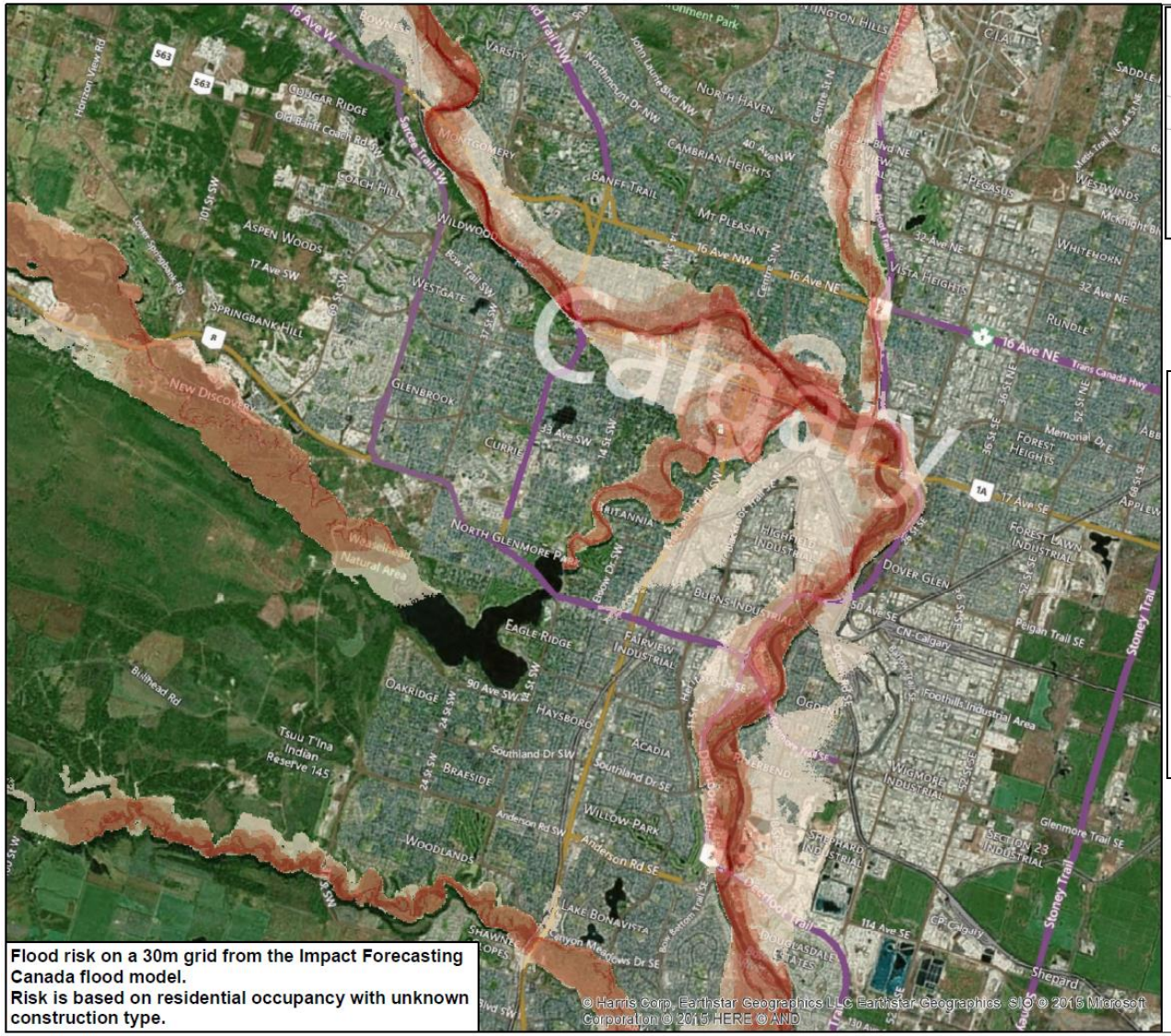
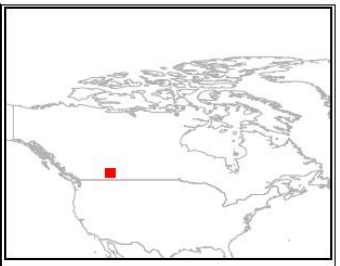
Probabilistic model – pure premium as % of TIV



Flood risk on a 30m grid from the Impact Forecasting Canada flood model.
Risk is based on residential occupancy with unknown construction type.



Residential Grid Cell Flood Risk

Pure Premium (AAL)
(as % of TSI per Zone)

- < 0.04
- 0.05 - 0.1
- 0.11 - 0.2
- 0.21 - 0.4
- > 0.41

0 2 4
Kilometers

AON
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Probabilistic model – as % of insured value (table)

6-digit postal code

Postal code	Pure Premium	100y loss	500y loss
T0J0V0	0.0053%	0.097%	0.139%
T0L0X0	0.0016%	0.037%	0.059%
T0L1W0	0.0069%	0.132%	0.200%
T0M1L0	0.0015%	0.033%	0.061%
T0M0S0	0.0019%	0.036%	0.052%
T4B2M1	0.0011%	0.000%	0.040%
T4B2V1	0.1296%	2.197%	2.451%
T4B2Y1	0.1651%	2.772%	3.057%
T4B3B5	0.0014%	0.005%	0.189%
T4B3G5	0.0423%	0.930%	1.050%
T4B3G6	0.0963%	1.550%	1.672%
T4B3G7	0.1278%	2.023%	2.207%
T4B3K8	0.0006%	0.000%	0.034%
T4B3K9	0.0070%	0.455%	0.562%
T4B3L1	0.0393%	0.764%	0.894%
T4B3L2	0.0302%	0.739%	0.875%
T2Y3T9	0.0928%	2.469%	4.136%

30 x 30m

Latitude	Longitude	Pure Premium	100y loss	500y loss
50.8784	-113.9893	0.0269%	1.637%	2.357%
51.0017	-114.1802	0.1893%	4.017%	5.795%
51.2532	-114.0001	0.0965%	1.792%	2.267%
51.0139	-114.2182	0.1941%	4.367%	6.400%
51.0797	-114.1798	0.0166%	0.889%	1.497%
51.0123	-114.0632	0.0569%	1.218%	1.556%
51.0989	-114.2458	0.2421%	7.529%	12.195%
50.9742	-114.0301	0.2081%	4.873%	7.779%
50.9311	-114.1922	0.1222%	2.818%	3.899%
50.9758	-114.0084	0.0000%	0.000%	0.000%
51.0034	-114.1990	0.1673%	3.066%	3.685%
51.0019	-114.2137	0.1496%	2.707%	3.263%
50.9298	-113.9923	0.2061%	4.502%	7.299%
51.3213	-114.0235	0.0636%	1.290%	1.631%
51.0365	-114.0616	0.1790%	3.302%	5.176%
51.0907	-114.1907	0.0003%	0.000%	0.000%
51.0056	-114.2109	0.1833%	3.668%	5.049%

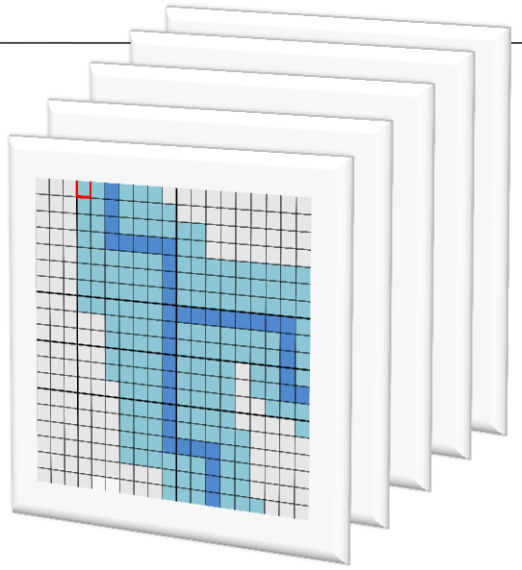
Probabilistic model – summary

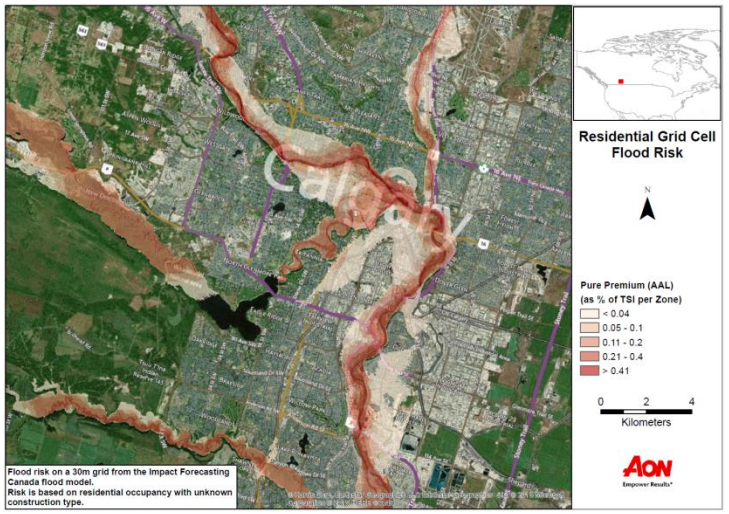
- Pure premium expressed as % of insured value

- Depends on property parameters

- **Advantages**
  - Includes loss
  - Gives rate indication
  - Is probabilistic
  - Includes correlation

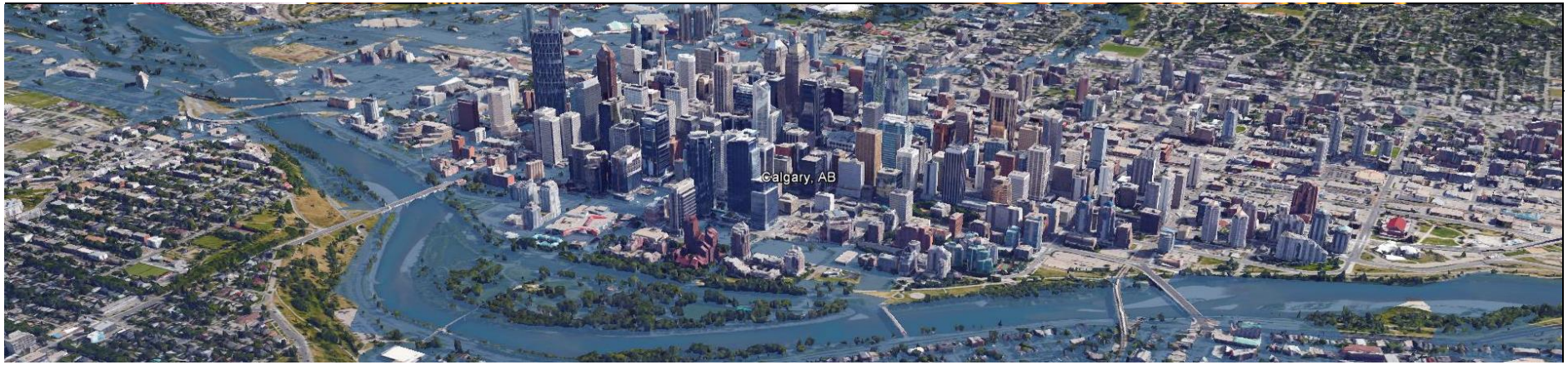
- **Disadvantages**
  - Takes longer to develop
  - Needs to be understood and used with care





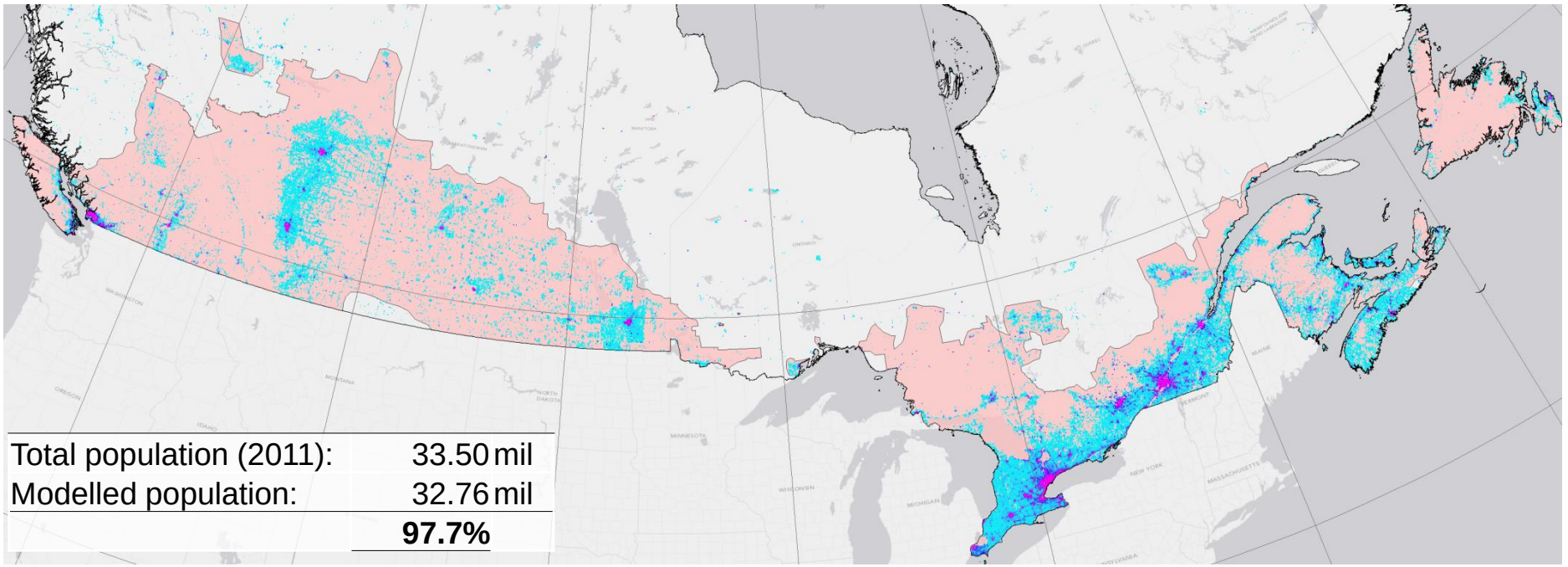
Flood map vs. probabilistic model – summary

Characteristics	Flood Map	Probabilistic model
Development effort	Shorter	Longer
Simplicity of use	Simple, but…	Simple, but…
Helps to calculate rate	No	Yes
Enables to evaluate effect of insurance conditions	No	Yes
Probabilistic	No	Yes
Inclusion of correlation	No	Yes



Section 4: Technical model review

Model Solutions



Total population (2011):	33.50 mil
Modelled population:	32.76 mil
	97.7%

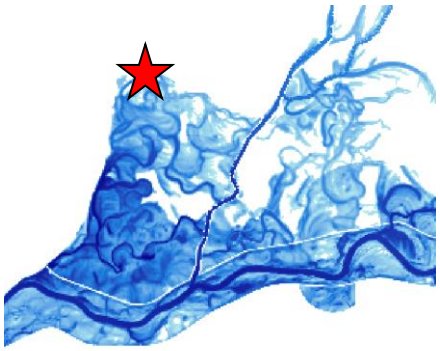
- Fully probabilistic model covering **~98% of Canadian population**
- Quantifying both **flood**-plain and **off-flood** plain losses
- 2-dimensional hydrodynamic simulation used for **all modelled rivers**
- Available geocoding units: **Lat & Lon; 6- and 3- digit postal codes**
- Vulnerability based on the **real Canadian flood claim** data (2013)

Catastrophe model anatomy

1. Insured location #1

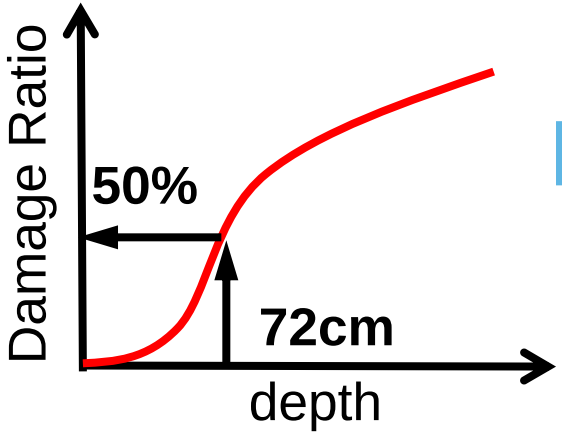
Location: 51° 04'52.0"N
114° 04,39.3"W
TIV = 200,000 CAD
Deductible = 2,000 CAD

2. Link with flood extent for simulated event #1



Inundation depth 72cm

3. Link with damage (vulnerability) function



4. Loss Calculation

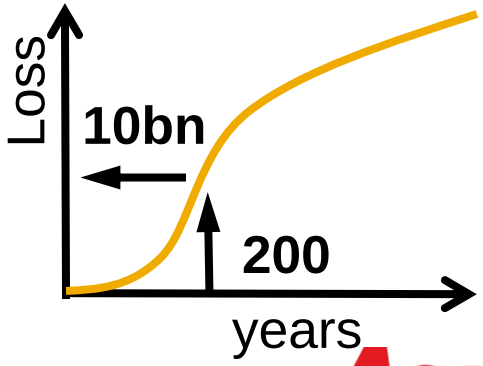
Ground Up Loss
200,000 * 0.5 = 100,000 CAD

Gross Loss
100,000 – 2,000 = 98,000 CAD

5. Repeat (for <u>every</u> location and <u>every</u> simulated event), **sum up by event to get total loss**

Event ID	Total loss
1	2,200,000
2	3,400,000
3	5,000,000
…	…
120,000	1,200,300

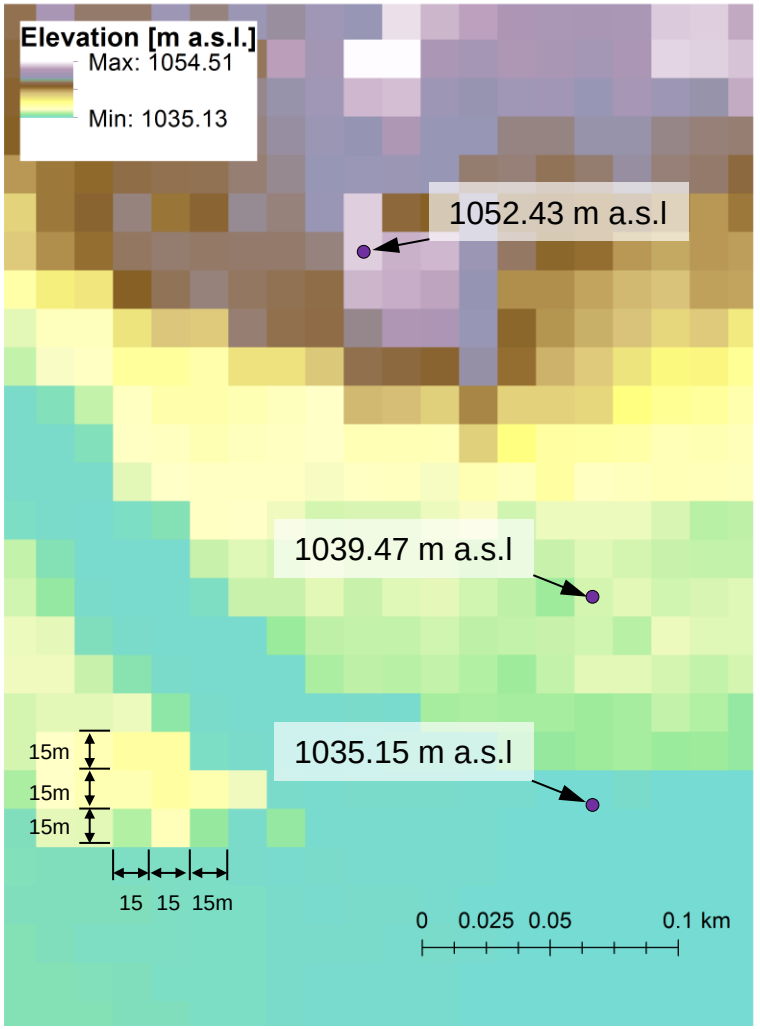
6. Calculate Exceedance Probability curve



Data – Digital Terrain Model (DTM)

- Basic dataset describing topography
  - 3D representation of Earth surface
  - Gridded set - each cell holds local altitude

- DTM – Parameters
  - Vertical resolution
    - Elevation step/accuracy
  - Horizontal resolution
    - Cell size dimension (proportional to dataset size)
  - Large datasets (100s of GB)
    - Right balance between level of details and processing requirements
  - Resolution should be proportional to accuracy!



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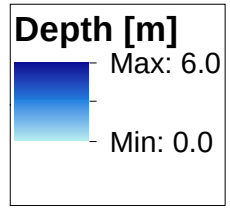
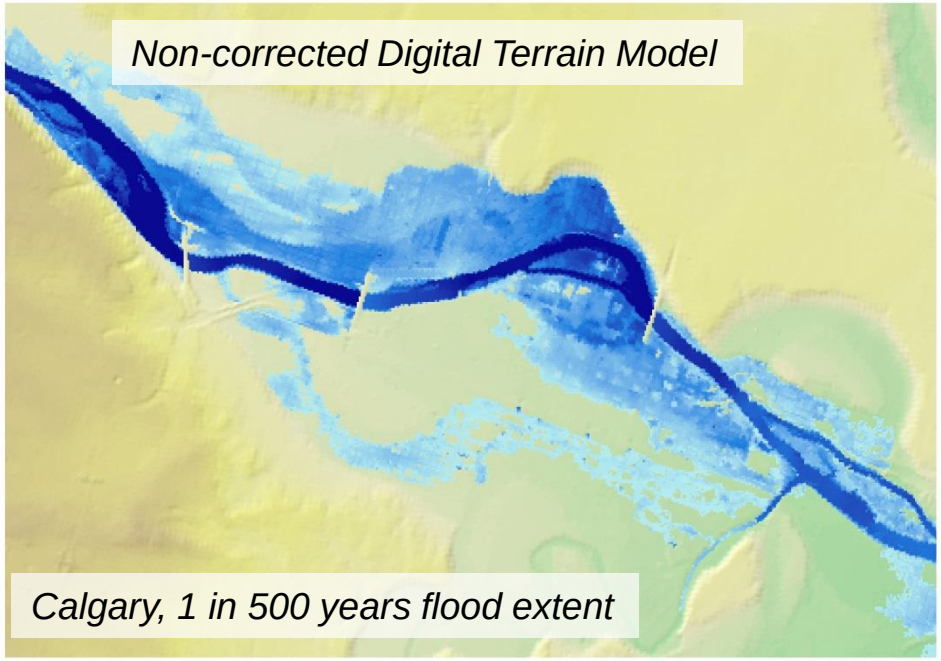
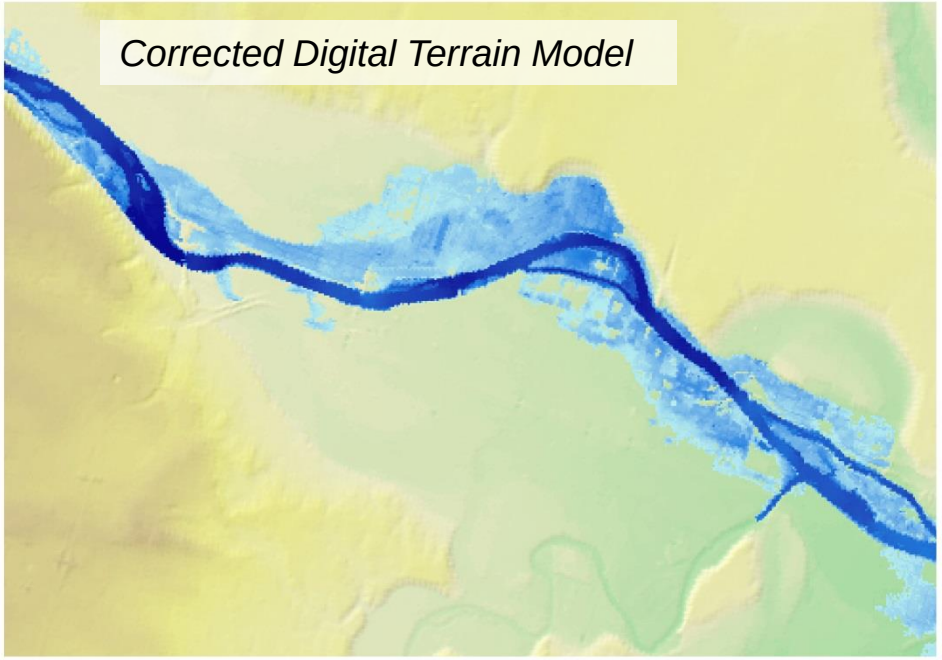
Model overview – Digital Terrain Model (DTM)

- DTMs used:
  - 10 and 15 m for exposed areas (Land Information Ontario; AltaLIS)
  - 30m Canada-wide (GeoBase)
- DTM corrections
  - Heavily checked and corrected ➡ 10,000+ corrections applied!
  - Essential for correct inundation modelling

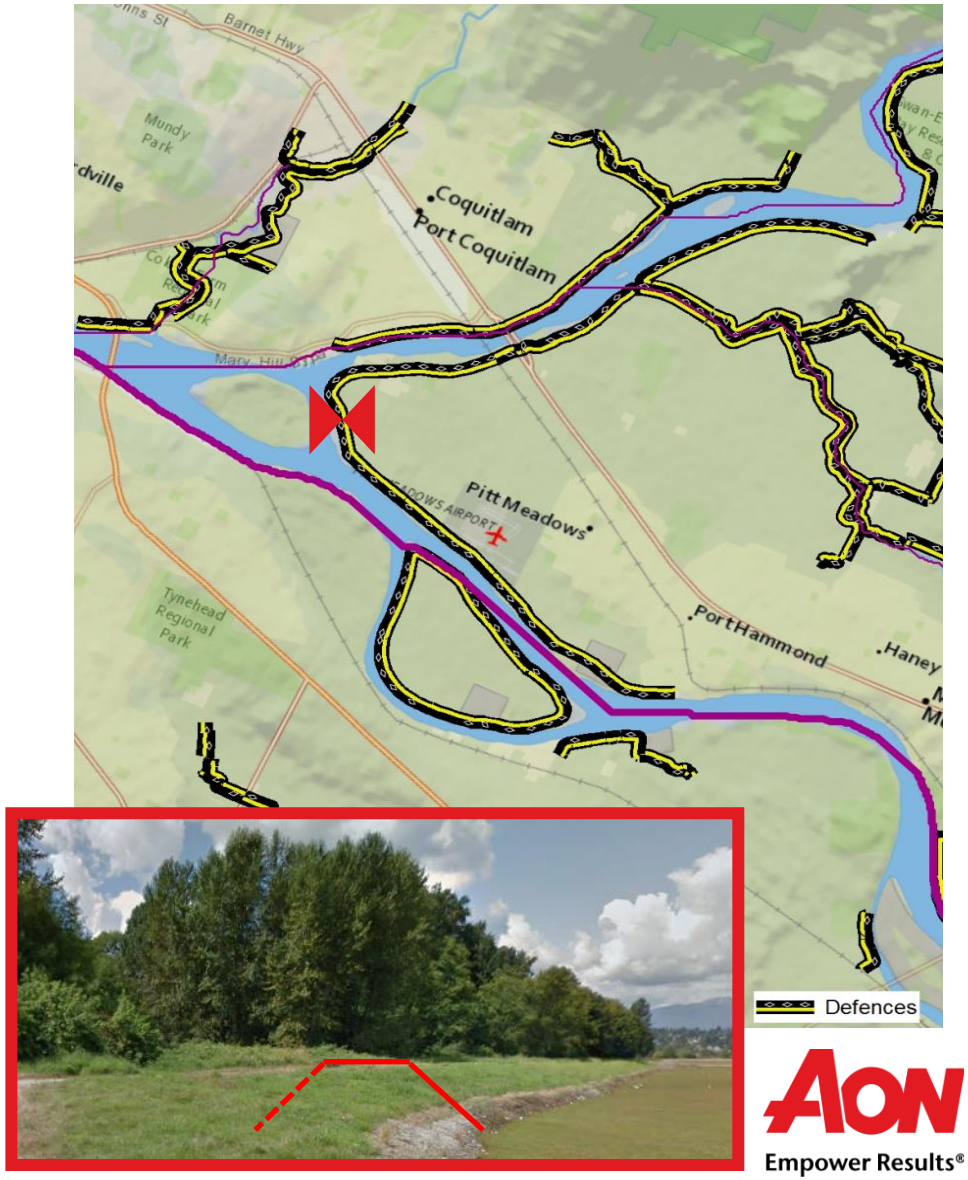






Data – Hydrographical Data

- Geographical data
  - River network (GeoBase)
  - LandCover (Environment Canada)
  - Postal codes (GFK, Canada Post)
- Hydrological data
  - Daily discharges of 1,526 locally sourced stations
  - Cleaned & checked
  - Used for event set generation
- Flood defence data
  - Significant effect on losses
  - Extensive research in their location and standard of protection
  - Manually checked and corrected



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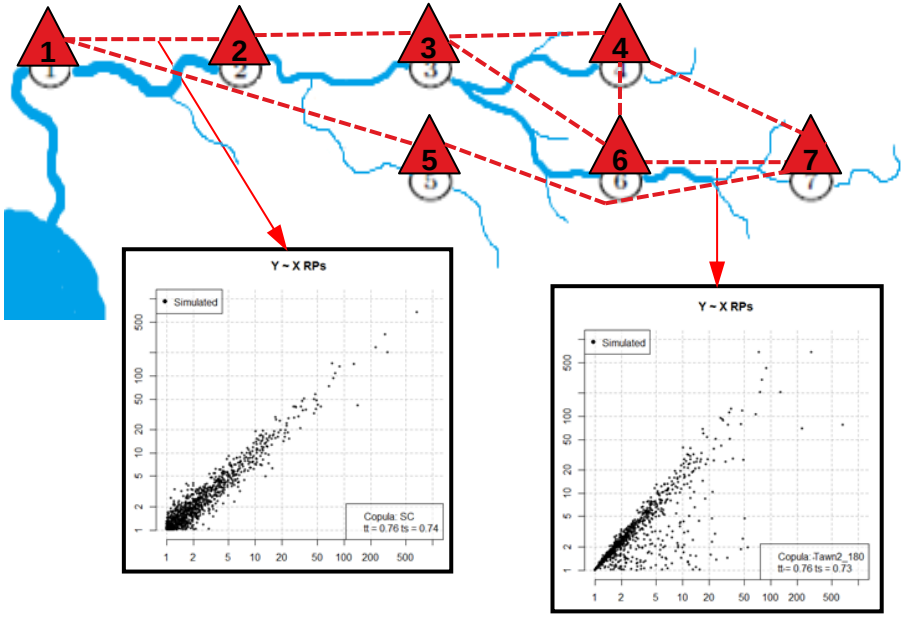
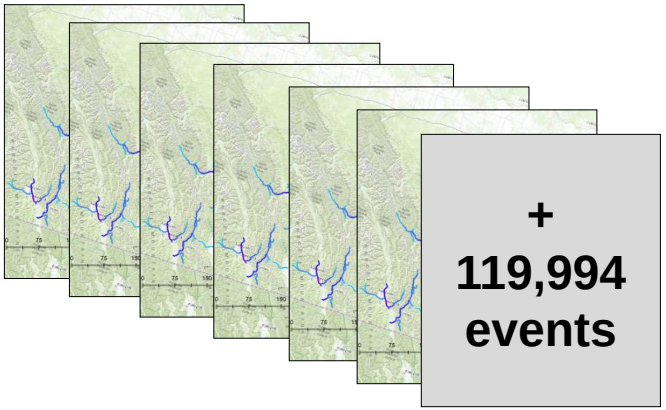
Hazard – Event Set Generation

- 120,000 events
  - 1 event per month for 10,000 years
- Two types of information needed to simulate events
  1. Design flows
  2. Correlation between gauge stations defined by vine copulas approach
- Historical events
  - Used for “as if” loss calculation
  - Events 2005, 2011 and 2013

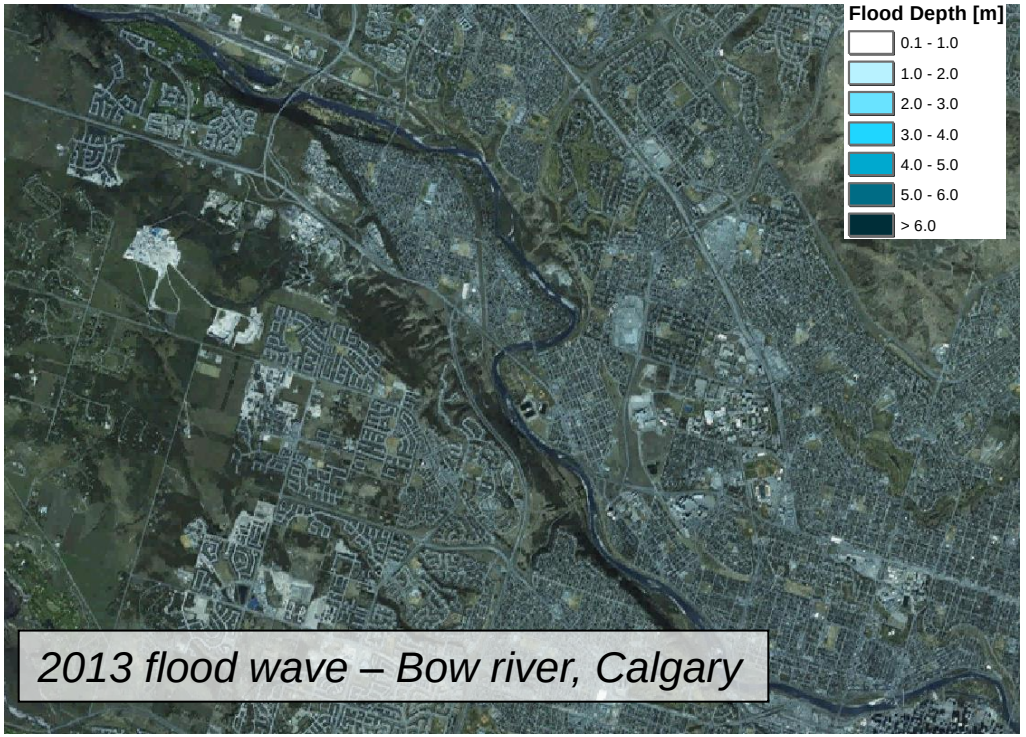




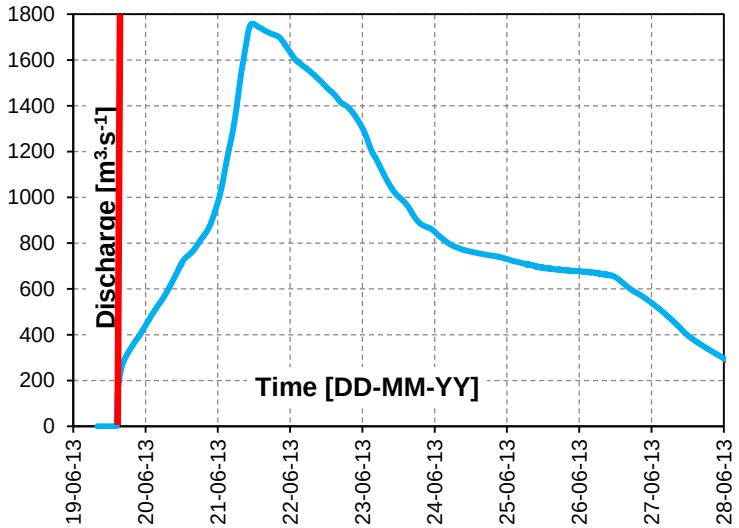
Empower Results®

Hazard – Flood Plain Module

- **2D hydrodynamic model TUFLOW used for the entire modelled area**
  - Provides real (physical) flow of water
  - Computationally challenging: **835** days of runtime
  - Exposed areas of Ontario & Quebec catchments 10km^2, increasing up to 250km^2



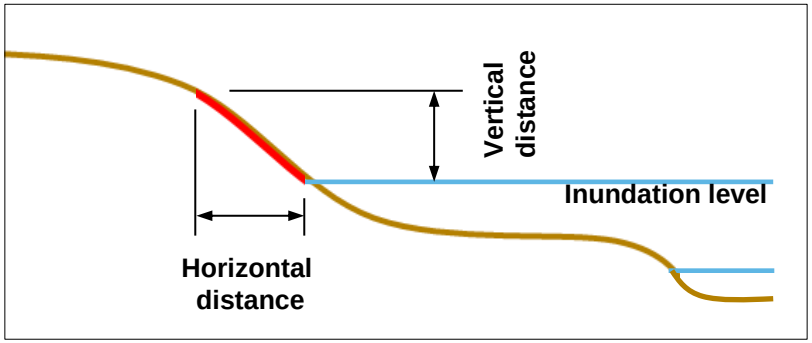
2013 flood wave – Bow river, Calgary

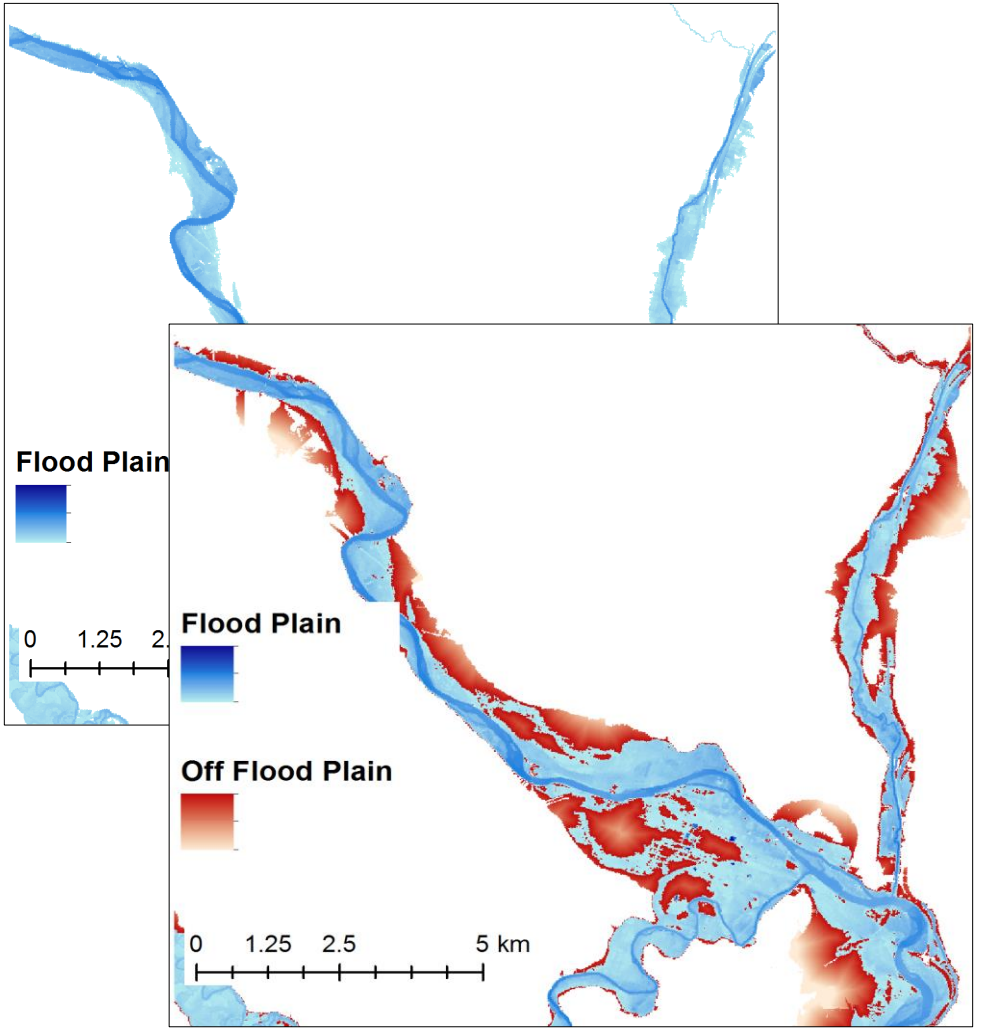


Hazard – Off-flood Plain Modelling

- **Off-flood plain flooding represents**
  - High ground water flooding
  - Basement flooding
  - Sewage water back-up flooding

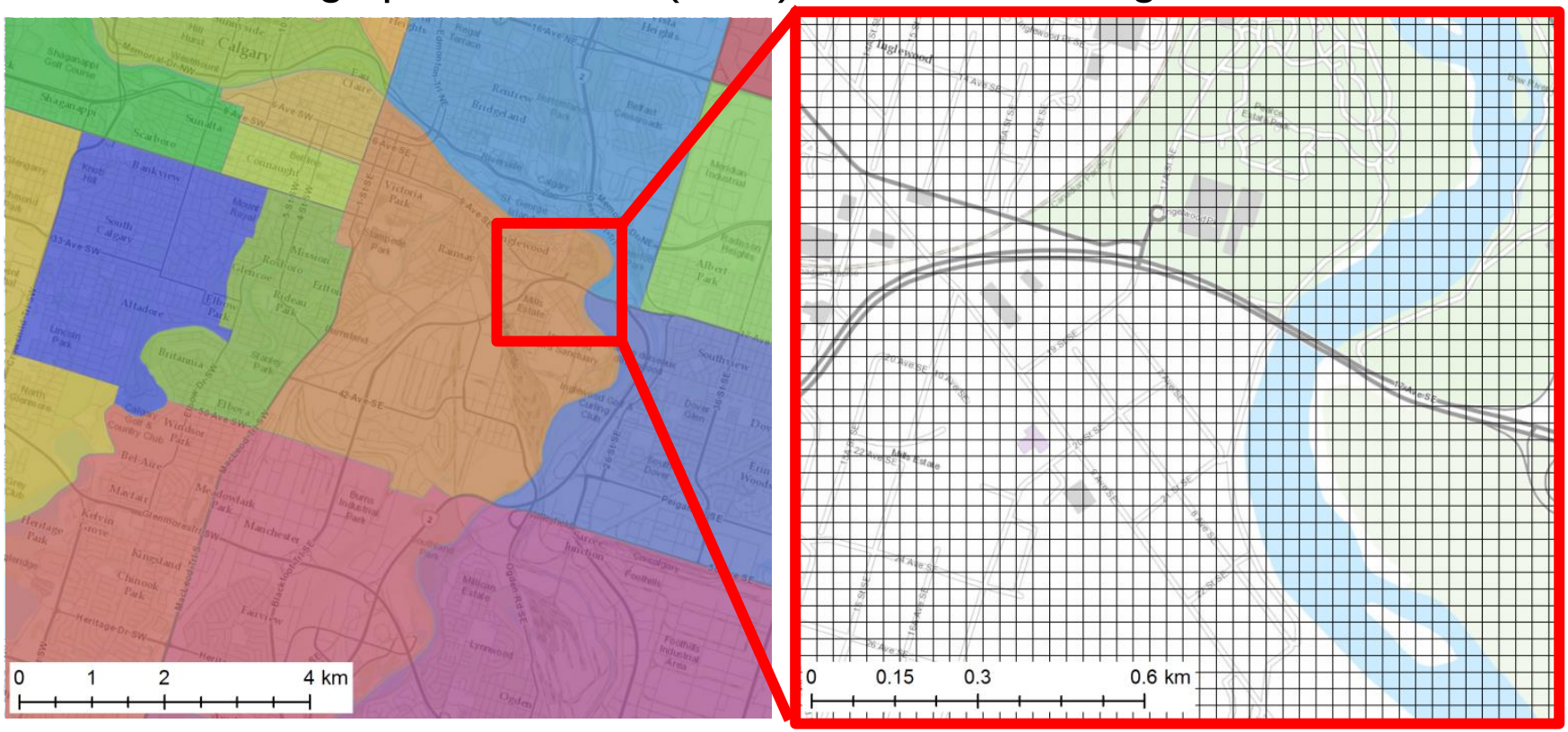
- **Use of vertical and horizontal distance from river**
  - Horizontal distance: 300 – 1500m
  - Vertical distance: 4 – 6 m





Geocoding Precisions

- 909,084 of 6-digit postal codes (GFK, DMTI)
- Latitude & Longitude (variable 10m – 150m)
- 1,635 of 3-digit postal codes (GFK) – used if nothing else is available



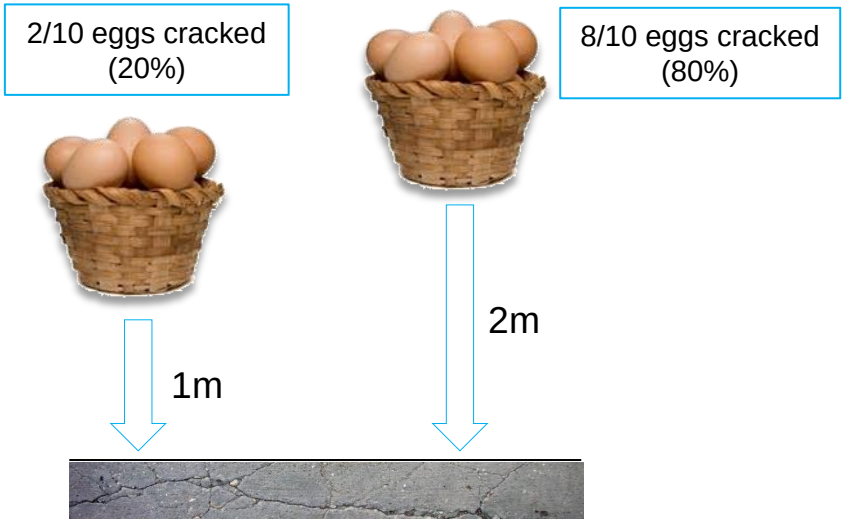
Vulnerability – How it Functions?

Damage calculation applied in 2-steps:

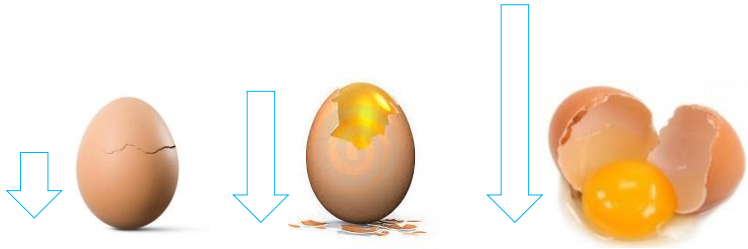
Step 1: Given the intensity of hazard what is the chance to have a loss?

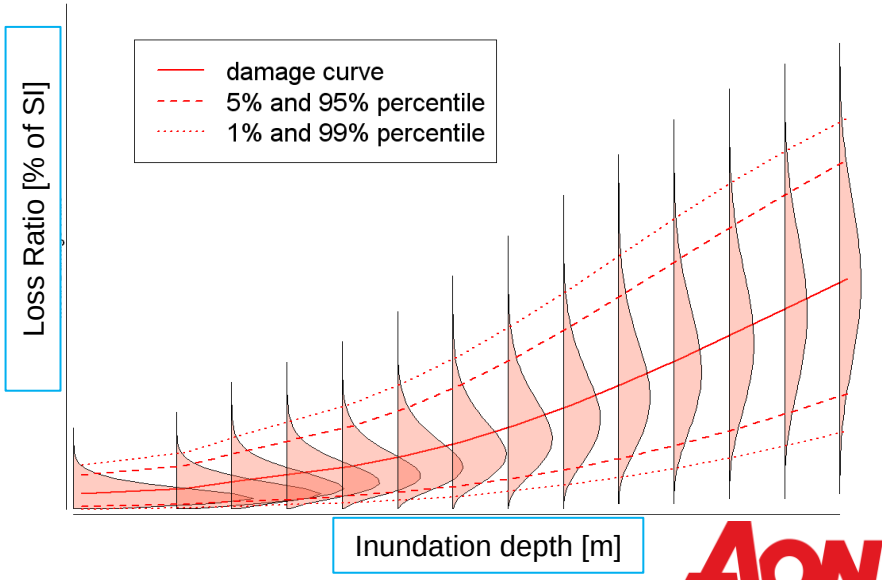
– For eggs ⇨ HEIGHT

– For flooding ⇨ INUNDATION DEPTH



Step 2: Given that the loss happens - how big is the loss?





- Why is it important?
  - To affect the right number of properties!

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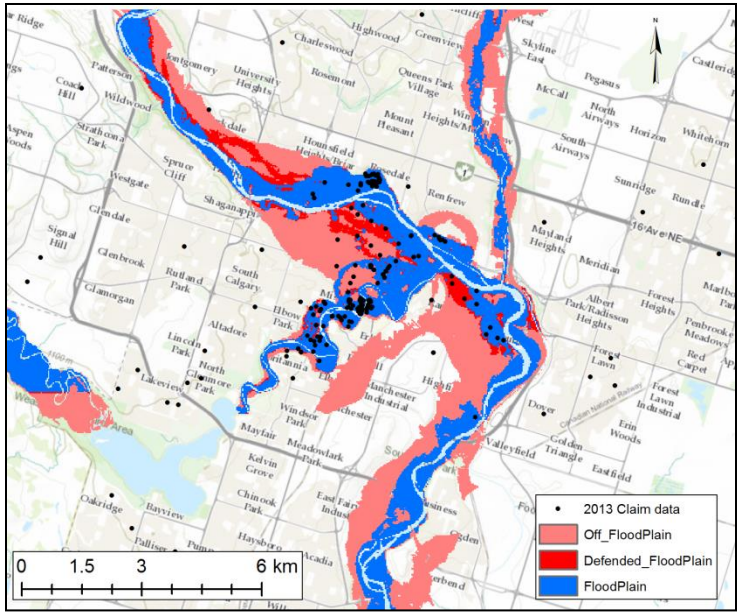
Vulnerability – Damage Function Build

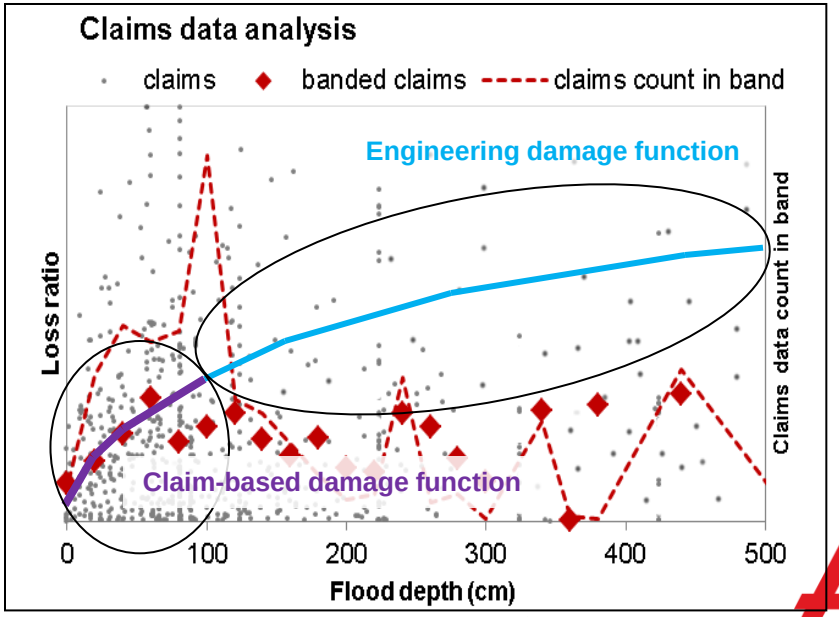
1. Flood claims data

- Canadian insurer claims information and Impact Forecasting extensive global flood claim database (including USA & EU)
- For basic modifiers: Occupancies: Resident, Commerc., Industr., Agric. (buildings)
  Coverages: Building, Content, Business Interruption

2. Engineering approach (sections of curve with smaller count of claims)

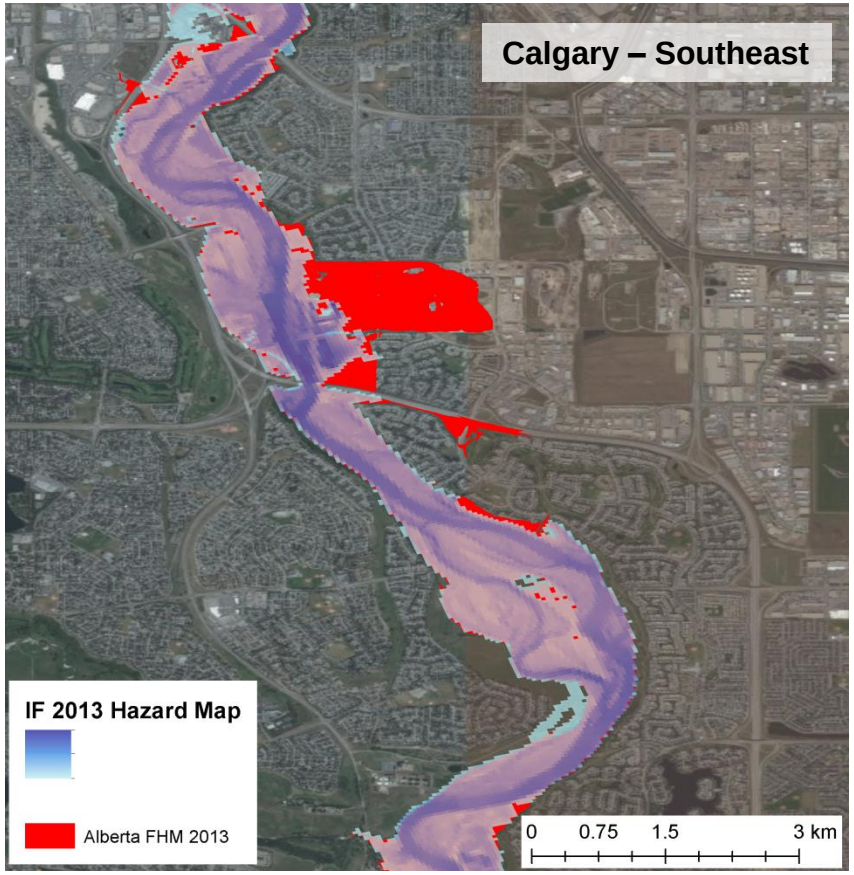
- For additional modifiers (32 occupancies, 8 constructions, motor hull, stories,…)

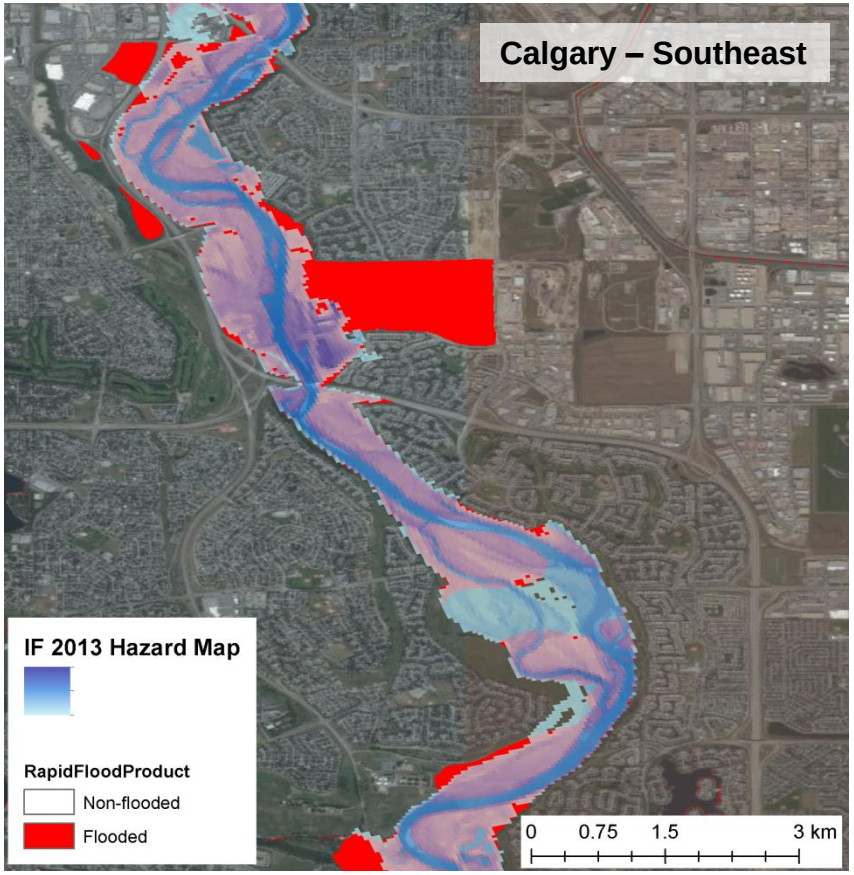




Model Validation – Hazard

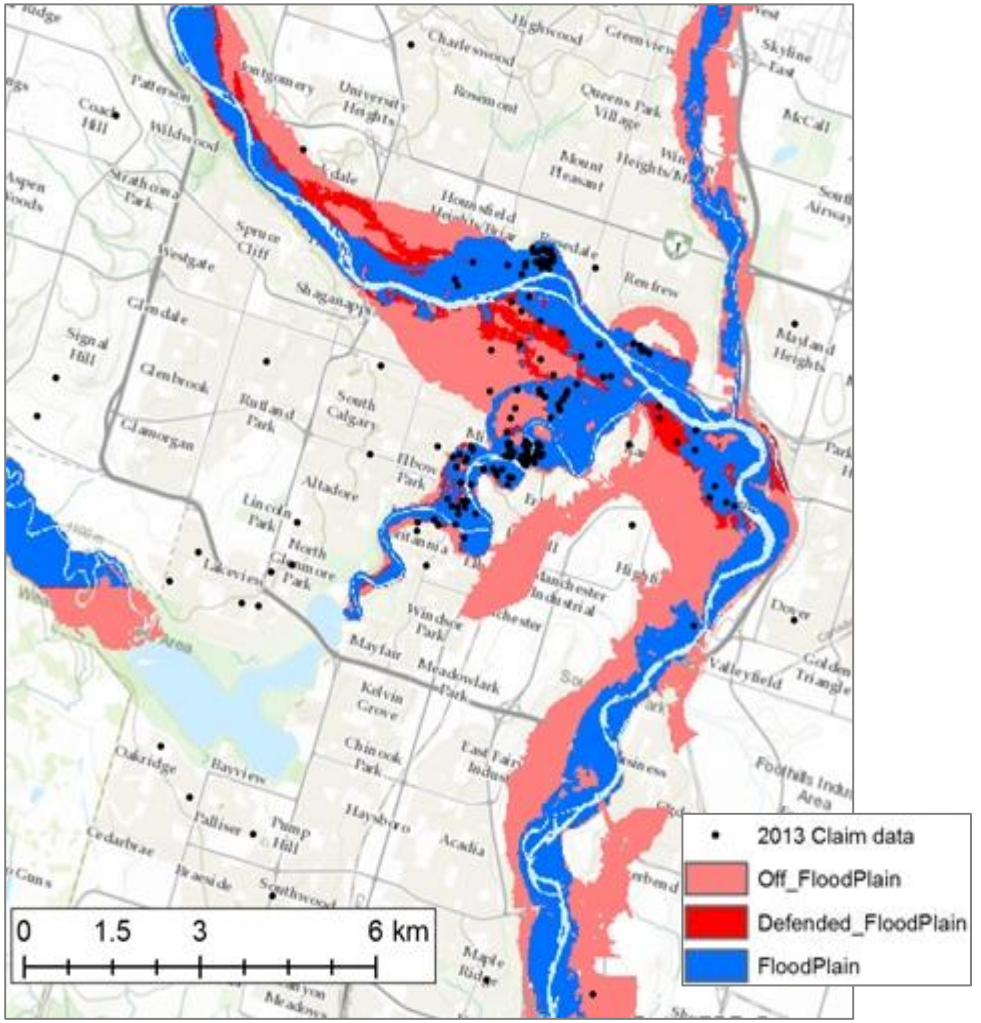
- Not many sufficient quality flood maps exists for comparison
- Satellite images from 2013 by PERILS and Alberta Flood Hazard Map





Model Validation – Claims and Vulnerability

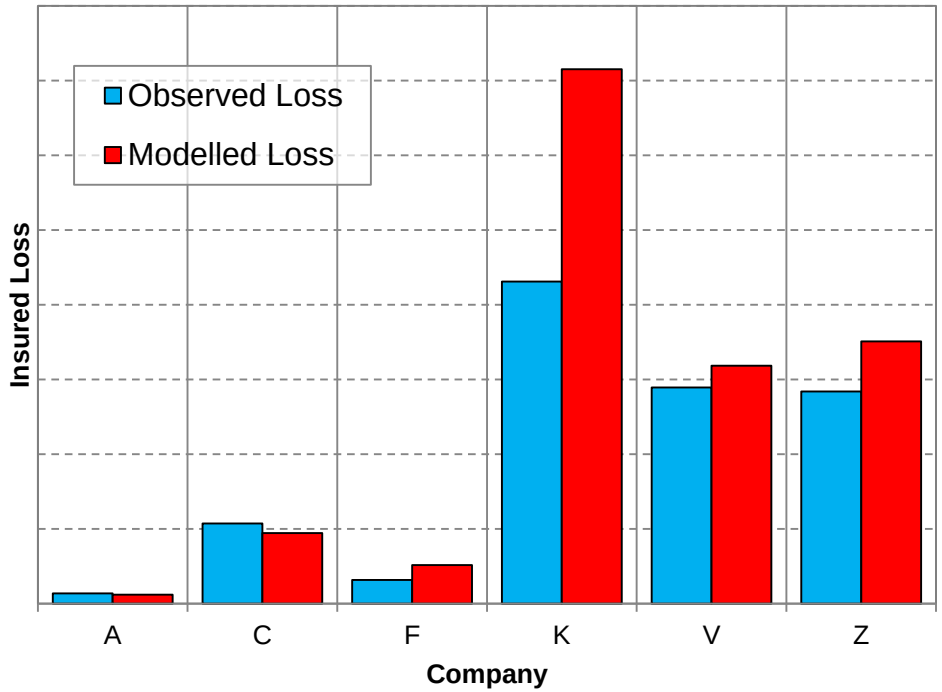
- Claim overlay over historical flood hazard maps
- Shows a satisfactory results
- Possible miss-match
  - Incorrect geocoding
  - Multi-locations
  - Other type of flooding
- Extracted hazard values used for damage function determination



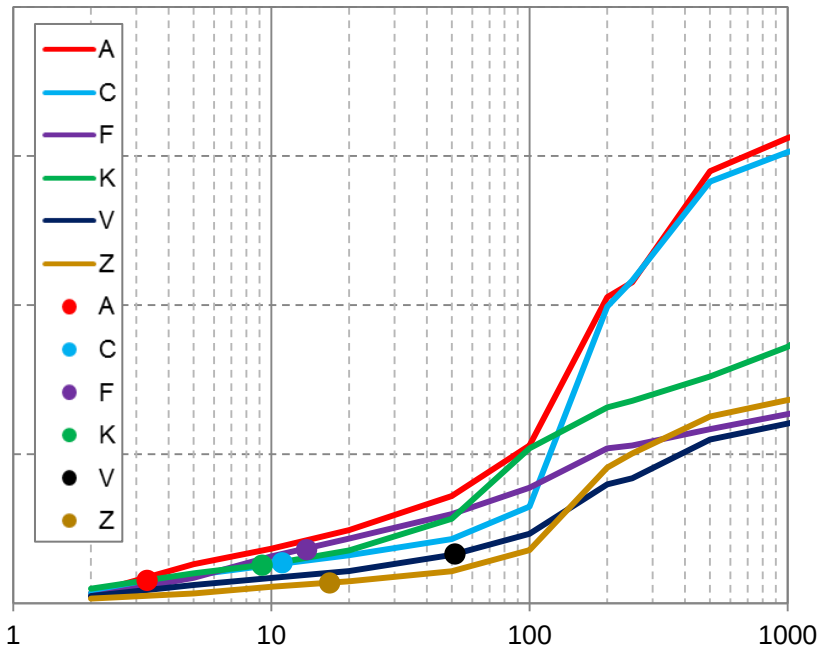
Model Validation – Loss

- Historical loss validation (back-testing)
  - Biased with loss inflation into local conditions
- Overlay through EP curve and extract return period of historical event

2013 Alberta Event
Modeled x Observed Loss



Modeled Flood Losses
EP Curve with 2013 Alberta event



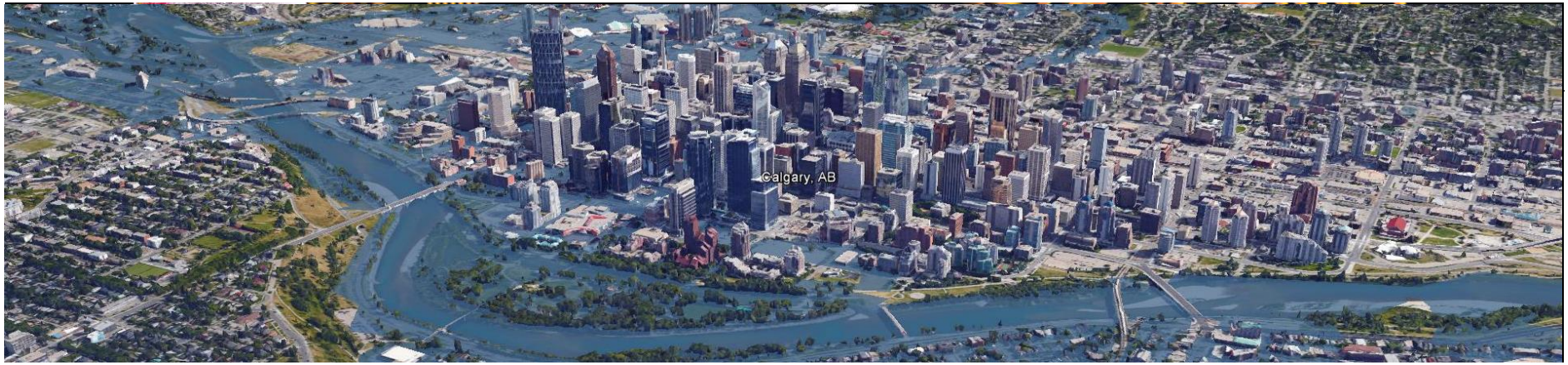
Model Summary

- Reliable and state-of-the-art flood model
  - 2-years long development, following latest development in cat-model science
  - Use of detailed local data:
    - DTM with multiple resolutions (10 – 30 meters) with 10,000+ corrections
    - Hydrological data from Environment Canada and Quebec Hydro (1,500+ stations)
  - 120,000 stochastic events + three historical 2005, 2011 and 2013
  - 2-dimensional hydrodynamic simulation on all modelled rivers

- Detailed view on the riverine flood peril
  - Based on the Canadian local data and detailed modelling on the large scope

- All components developed in-house
  - Impact Forecasting has its full ownership and understanding

- Implemented in ELEMENTS platform
  - Licensed and deployed locally on your hardware or as hosted solution



Section 5: Using the model for accumulation control

Accumulation control

1. Calculation method

- Adding values
- Running model

2. Values to be accumulated

- Total insured value
- Limits
- Pure premiums (AAL)
- 1 in 100, 200 etc. losses

3. Accumulation zones

- Administrative zones
- Hazard zones

Accumulation control – calculation

Calculation method

1. Adding values
2. Running model

1. Adding values

2. Using pre-calculated factors, e.g. PP

Adding values

Pre-calculating factors → multiply TIV by factor → add per zone

Zone ID	Zone Name	TIV		PP as % TIV		Pure Premium
10	Newfoundland and Labrador	7,071,262,741	multiply	0.0034%	=	239,232
11	Prince Edward Island	452,834,535	multiply	0.0010%	=	4,671
12	Nova Scotia	14,404,663,572	multiply	0.0024%	=	346,624
13	New Brunswick	7,325,690,376	multiply	0.0235%	=	1,723,422
24	Quebec	138,683,784,487	multiply	0.0230%	=	31,875,629
35	Ontario	172,080,390,719	multiply	0.0097%	=	16,639,604
46	Manitoba	12,337,515,914	multiply	0.0430%	=	5,307,024
47	Saskatchewan	1,445,870,019	multiply	0.0041%	=	59,593
48	Alberta	62,796,962,363	multiply	0.0084%	=	5,268,911
59	British Columbia	53,016,798,010	multiply	0.0137%	=	7,252,256
60	Yukon	155,068,816	multiply	0%	=	NA
61	Northwest Territories	427,956,425	multiply	0%	=	NA
62	Nunavut	117,505,484	multiply	0%	=	NA
Total		**470,316,303,460**				**68,716,967**

Accumulation control – calculation

Calculation method

1. Adding values
2. Running model

Zone Name	Pure Premium	PP as % TIV
Newfoundland and Labrador	239,232	0.0034%
Prince Edward Island	4,671	0.0010%
Nova Scotia	346,624	0.0024%
New Brunswick	1,723,422	0.0235%
Quebec	31,875,629	0.0230%
Ontario	16,639,604	0.0097%
Manitoba	5,307,024	0.0430%
Saskatchewan	59,593	0.0041%
Alberta	5,268,911	0.0084%
British Columbia	7,252,256	0.0137%
Yukon	NA	0%
Northwest Territories	NA	0%
Nunavut	NA	0%
	68,716,967	

Situation

- 30m policy in Manitoba is being considered
- Accumulation limit is **5,310,000**
- PP factor for new policy adds **13,000**
- 5,307,000 + 13,000 = 5,320,000 ➔ can **NOT** underwrite

Is there a solution?

- Run the policy details in the model ➔ calculate how much PP (AAL) it generates
- Options
  1. It generates 20,000 ➔ can **NOT** underwrite
  2. It generates 2,000 ➔ **CAN** underwrite

Running a model on a regular basis and / or for large policies will ALWAYS generate better understanding of the risk

Accumulation control – values

Values to be accumulated

1. Total insured value (TIV)
2. Limits
3. Exposed TIV
4. Pure premiums (AAL)
5. 1 in 100, 200 etc. losses

Not a significant difference of % of total when accumulating using TIV and Limits. Difference can be present for smaller zones or specific policies

Zone Name	TIV	TIV as % of total	Limit	Limit as % total	TIV vs. Limit
Newfoundland and Labrador	7,071,262,741	1.50%	1,724,826,657	0.39%	26%
Prince Edward Island	452,834,535	0.10%	452,834,535	0.10%	106%
Nova Scotia	14,404,663,572	3.06%	2,346,993,676	0.53%	17%
New Brunswick	7,325,690,376	1.56%	7,325,690,376	1.66%	106%
Quebec	138,683,784,487	29.49%	133,123,940,910	30.12%	102%
Ontario	172,080,390,719	36.59%	167,655,950,630	37.93%	104%
Manitoba	12,337,515,914	2.62%	11,761,970,338	2.66%	101%
Saskatchewan	1,445,870,019	0.31%	1,405,450,502	0.32%	103%
Alberta	62,796,962,363	13.35%	62,529,610,340	14.15%	106%
British Columbia	53,016,798,010	11.27%	53,016,798,010	11.99%	106%
Yukon	155,068,816	0.03%	155,068,816	0.04%	106%
Northwest Territories	427,956,425	0.09%	427,956,425	0.10%	106%
Nunavut	117,505,484	0.02%	117,505,484	0.03%	106%
Total	**470,316,303,460**	**100%**	**442,044,596,699**	**100%**	

Use 3: Accumulation control – values

Values to be accumulated

1. Total insured value (TIV)
2. Limits
3. Exposed TIV
4. Pure premiums (AAL)
5. 1 in 100, 200 etc. losses

Exposed TIV = TIV in postal codes which can be flooded (=conservative)

Exposed TIV gives marginally better idea about sums insured at risk

Zone Name	TIV	TIV as % of total	Exposed TIV	Exp. TIV as % of total	Exposed TIV vs. TIV
Newfoundland and Labrador	7,071,262,741	1.50%	5,597,784,492	1.49%	99%
Prince Edward Island	452,834,535	0.10%	296,784,663	0.08%	82%
Nova Scotia	14,404,663,572	3.06%	9,046,791,873	2.41%	79%
New Brunswick	7,325,690,376	1.56%	5,763,710,234	1.53%	98%
Quebec	138,683,784,487	29.49%	109,931,790,013	29.24%	99%
Ontario	172,080,390,719	36.59%	146,964,970,963	39.09%	107%
Manitoba	12,337,515,914	2.62%	11,745,326,355	3.12%	119%
Saskatchewan	1,445,870,019	0.31%	1,205,095,988	0.32%	104%
Alberta	62,796,962,363	13.35%	51,042,498,272	13.58%	102%
British Columbia	53,016,798,010	11.27%	34,366,483,865	9.14%	81%
Yukon	155,068,816	0.03%	NA	NA	NA
Northwest Territories	427,956,425	0.09%	NA	NA	NA
Nunavut	117,505,484	0.02%	NA	NA	NA
Total	**470,316,303,460**	**100%**	**375,961,236,718**		

Accumulation control – values

Values to be accumulated

1. Total insured value (TIV)
2. Limits
3. Exposed TIV
4. Pure premiums (AAL)
5. 1 in 100, 200 etc. losses

Pure premium takes into account loss potential

In this case Exposed TIV in Quebec, Manitoba, New Brunswick & BC bring proportionally more losses compared to their exposed TIV share

Zone Name	Exposed TIV	Exp. TIV as % of total	Pure Premium	PP as % of total	PP vs. ETIV
Newfoundland and Labrador	5,597,784,492	1.49%	239,232	0.35%	23%
Prince Edward Island	296,784,663	0.08%	4,671	0.01%	9%
Nova Scotia	9,046,791,873	2.41%	346,624	0.50%	21%
New Brunswick	5,763,710,234	1.53%	1,723,422	2.51%	164%
Quebec	109,931,790,013	29.24%	31,875,629	46.39%	159%
Ontario	146,964,970,963	39.09%	16,639,604	24.21%	62%
Manitoba	11,745,326,355	3.12%	5,307,024	7.72%	247%
Saskatchewan	1,205,095,988	0.32%	59,593	0.09%	27%
Alberta	51,042,498,272	13.58%	5,268,911	7.67%	56%
British Columbia	34,366,483,865	9.14%	7,252,256	10.55%	115%
Yukon	NA	NA	NA	NA	NA
Northwest Territories	NA	NA	NA	NA	NA
Nunavut	NA	NA	NA	NA	NA
Total	**375,961,236,718**	**100%**	**68,716,967**	**100%**	

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Accumulation control – values

Values to be accumulated

1. Total insured value (TIV)
2. Limits
3. Exposed TIV
4. Pure premiums (AAL)
5. 1 in 100, 200 etc. losses

Aggregating using the 1 in 100, 200 etc. years loss numbers takes into account loss potential

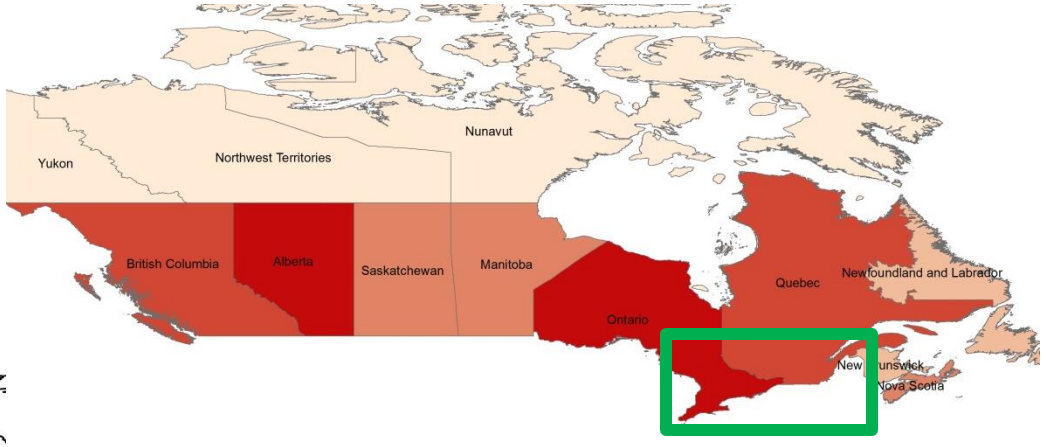
In this case Exposed TIV in Quebec, Manitoba, New Brunswick, Alberta and BC bring proportionally more losses compared to their exposed TIV share

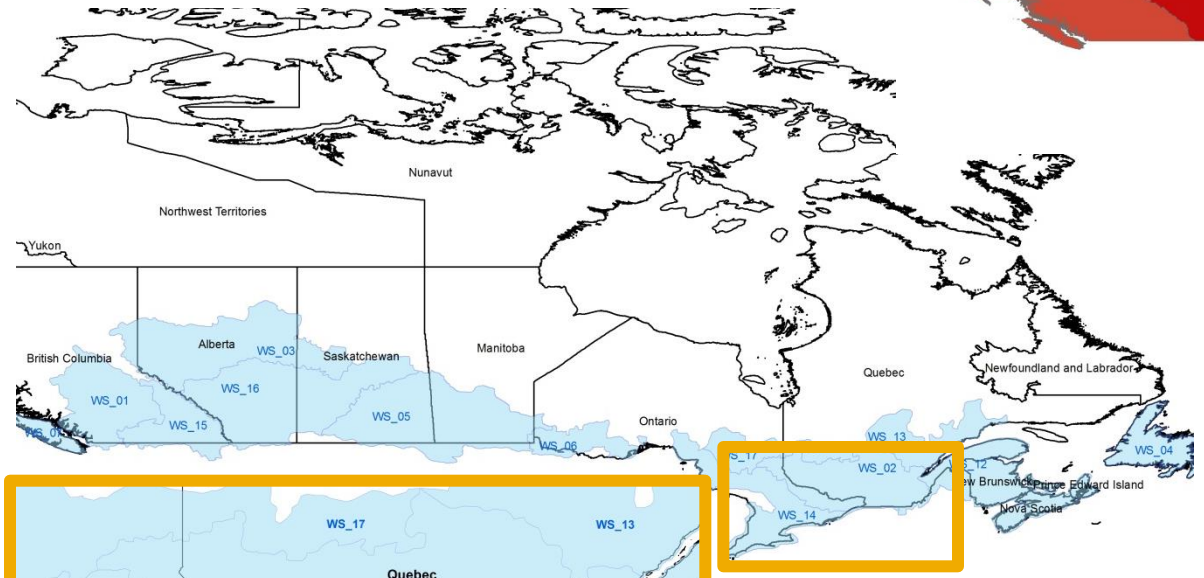
Zone Name	Exposed TIV	Exp. TIV as % of total	100y loss	100 loss as % of total	100y loss vs. ETIV
Newfoundland and Labrador	5,597,784,492	1.49%	1,758,641	0.38%	25%
Prince Edward Island	296,784,663	0.08%	87,585	0.02%	24%
Nova Scotia	9,046,791,873	2.41%	3,644,672	0.78%	33%
New Brunswick	5,763,710,234	1.53%	20,246,011	4.35%	284%
Quebec	109,931,790,013	29.24%	172,523,815	37.07%	127%
Ontario	146,964,970,963	39.09%	74,231,552	15.95%	41%
Manitoba	11,745,326,355	3.12%	56,056,584	12.05%	386%
Saskatchewan	1,205,095,988	0.32%	988,991	0.21%	66%
Alberta	51,042,498,272	13.58%	80,223,938	17.24%	127%
British Columbia	34,366,483,865	9.14%	55,623,134	11.95%	131%
Yukon	NA	NA	NA	NA	NA
Northwest Territories	NA	NA	NA	NA	NA
Nunavut	NA	NA	NA	NA	NA
Total	**375,961,236,718**	**100%**	**465,384,924**	**100%**	

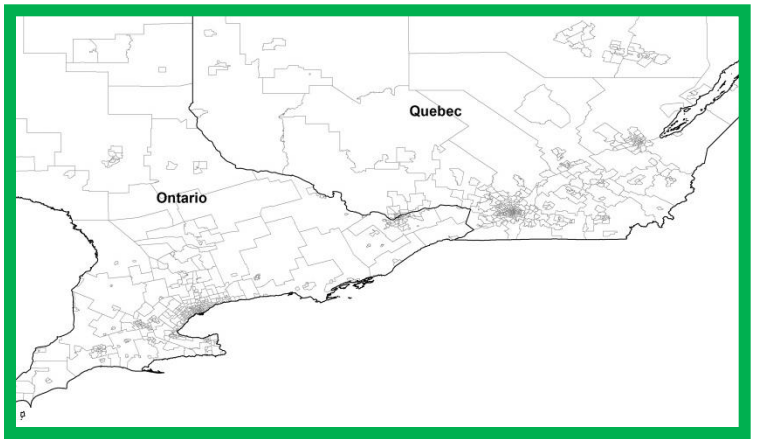
Accumulation control – zones

Accumulation zones

1. Administrative zones
2. Hazard zones







Hazard zones may better define the natural accumulation zones (= minimise correlation)

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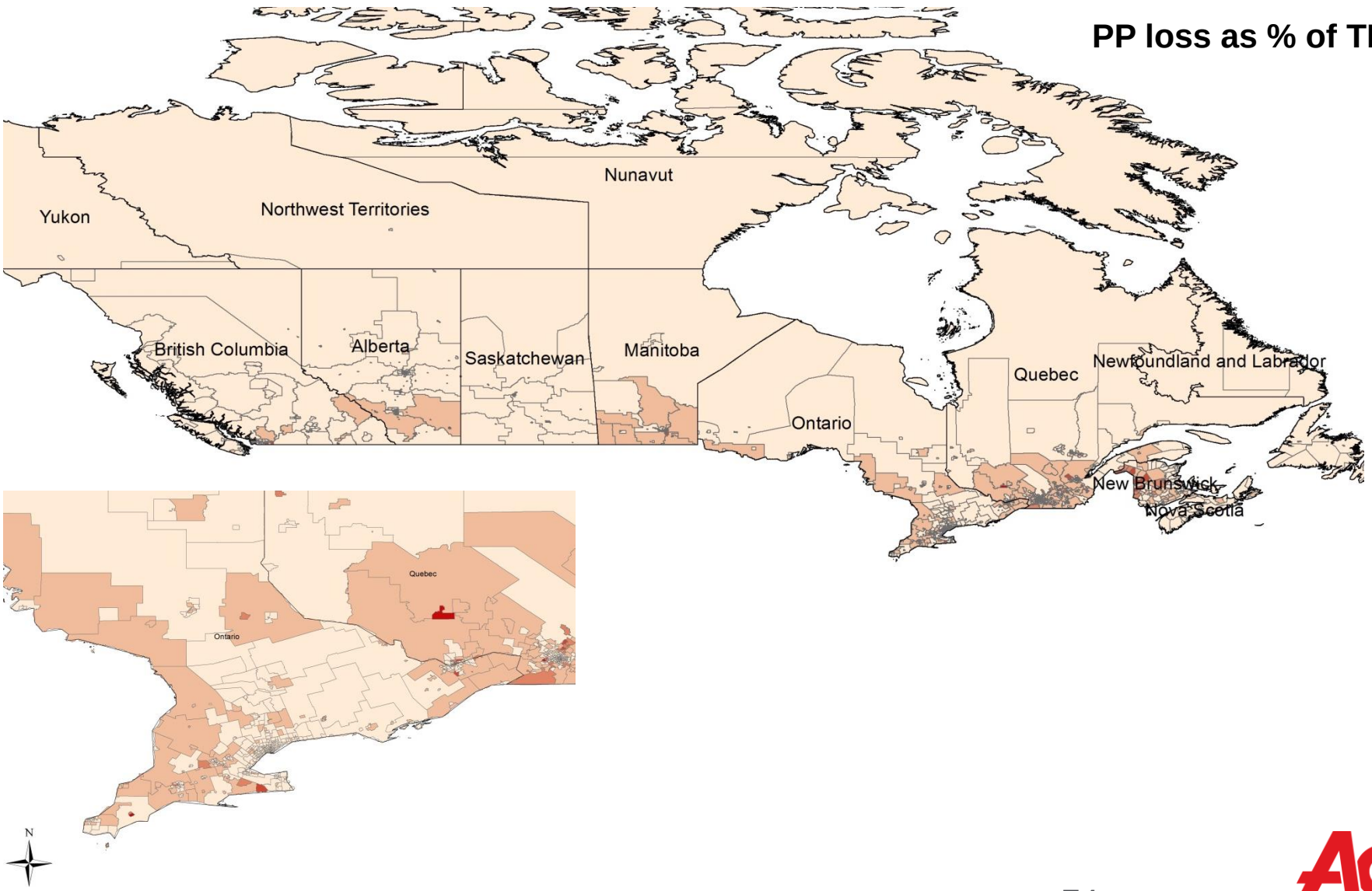
Accumulation control – administrative zones

Accumulation zones

1. Administrative zones
2. Hazard zones

Zone Name	TIV	Limit	Exposed TIV	Pure Premium	100y loss
Newfoundland and Labrador	7,071,262,741	1,724,826,657	5,597,784,492	239,232	1,758,641
Prince Edward Island	452,834,535	452,834,535	296,784,663	4,671	87,585
Nova Scotia	14,404,663,572	2,346,993,676	9,046,791,873	346,624	3,644,672
New Brunswick	7,325,690,376	7,325,690,376	5,763,710,234	1,723,422	20,246,011
Quebec	138,683,784,487	133,123,940,910	109,931,790,013	31,875,629	172,523,815
Ontario	172,080,390,719	167,655,950,630	146,964,970,963	16,639,604	74,231,552
Manitoba	12,337,515,914	11,761,970,338	11,745,326,355	5,307,024	56,056,584
Saskatchewan	1,445,870,019	1,405,450,502	1,205,095,988	59,593	988,991
Alberta	62,796,962,363	62,529,610,340	51,042,498,272	5,268,911	80,223,938
British Columbia	53,016,798,010	53,016,798,010	34,366,483,865	7,252,256	55,623,134
Yukon	155,068,816	155,068,816	NA	NA	NA
Northwest Territories	427,956,425	427,956,425	NA	NA	NA
Nunavut	117,505,484	117,505,484	NA	NA	NA
Total	**470,316,303,460**	**442,044,596,699**	**375,961,236,718**	**68,716,967**	**465,384,924**

Accumulation control – administrative zones



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Accumulation control – hazard zones

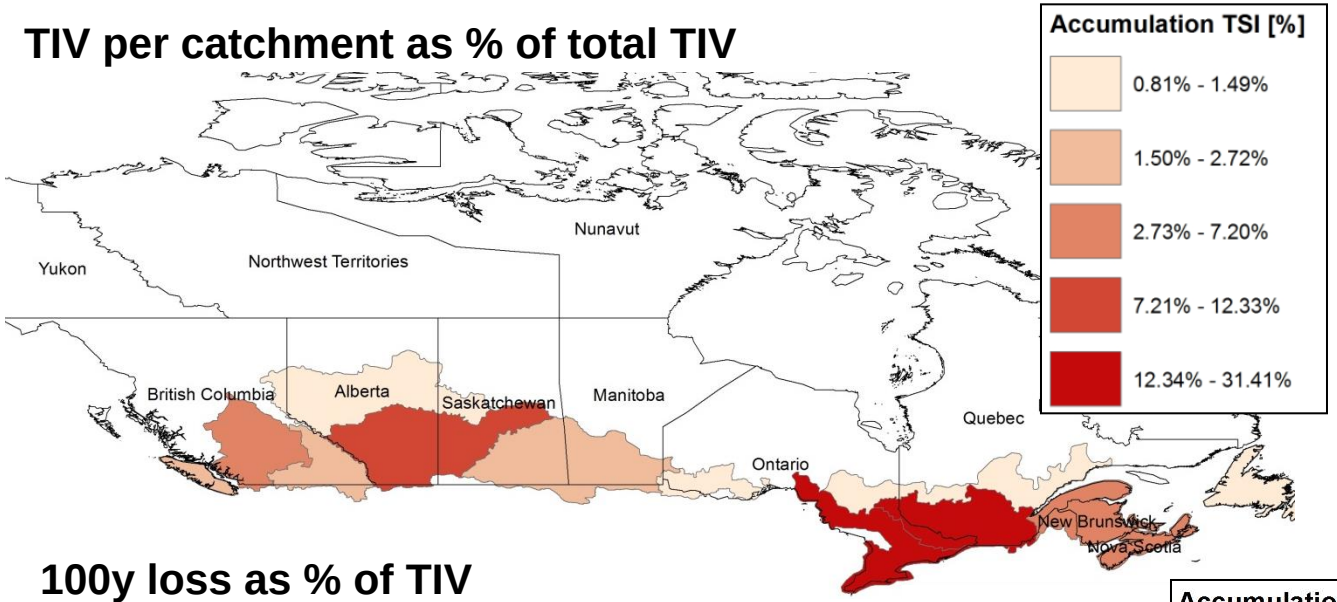
Accumulation zones

1. Administrative zones
2. Hazard zones

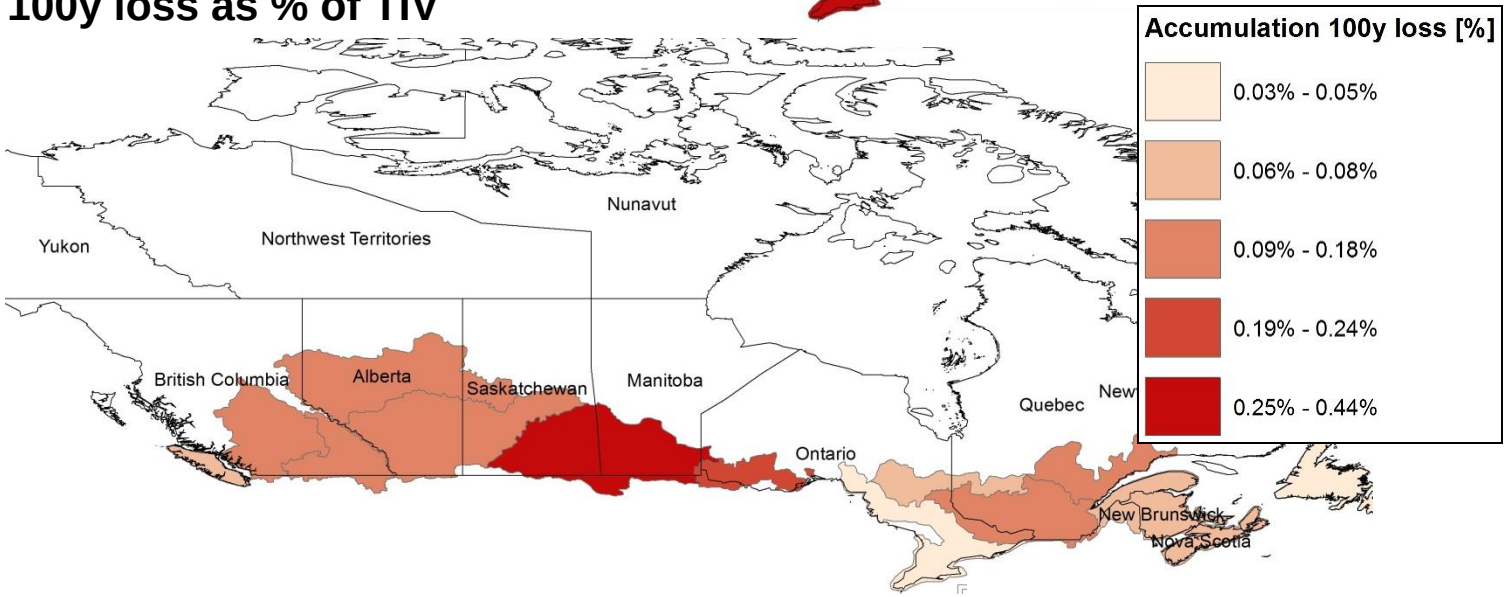
Zone ID	TIV	Limits	Exposed TIV	Pure premium	100y loss
NA	3,274,496,151	11,270,692,872	1,375,118,415	41,600	662,019
WS01 – Fraser river	33,855,644,929	152,350,402,179	20,983,644,970	28,112,773	248,874,320
WS02 – St.Lawrence (Quebec)	140,925,892,382	610,422,227,803	112,486,204,810	146,887,121	794,424,622
WS03 – Upper BC and Alberta	6,017,811,711	27,080,152,700	5,220,928,420	2,082,931	38,027,374
WS04 – Newfoundland	6,576,462,926	6,362,418,729	5,450,564,738	1,076,544	7,913,884
WS05 – Manitoba and lower Saskatchewan	12,810,451,100	55,057,074,858	12,206,031,241	23,984,736	252,539,235
WS06 – Ontario around Lake Superior	3,790,215,250	17,055,968,627	3,730,836,376	2,396,400	40,781,849
WS07 – Vancouver island	8,898,642,051	40,043,889,230	4,294,733,759	941,057	22,396,555
WS12 – New Brunswick + Nova Scotia	28,625,980,824	70,176,740,091	21,213,819,344	12,882,152	105,985,938
WS13 – Upper Quebec	7,013,243,164	31,354,296,419	6,754,327,986	3,690,401	52,532,570
WS14 – Lower Ontario	147,717,338,449	650,766,233,213	123,791,366,065	60,038,221	332,118,523
WS15 - Alberta and BC	8,497,021,835	38,236,598,257	8,497,021,835	3,546,753	67,975,129
WS16 – Alberta and upper Saskatchewan	58,002,260,788	259,625,201,620	46,530,121,579	21,789,397	359,162,886
WS17 – Middle Ontario and Quebec	4,310,841,899	19,398,788,546	3,426,517,182	1,756,263	14,097,272
Total	**470,316,303,460**	**1,989,200,685,144**	**375,961,236,718**	**309,226,350**	**2,337,492,173**

Accumulation control – hazard zones

TIV per catchment as % of total TIV



100y loss as % of TIV



Accumulation control – summary

1. Calculation method

- Adding values ➔ **DOES NOT take into account specific location parameters**
- Running model ➔ **DOES take into account specific location parameters**

2. Values to be accumulated

- Total insured value, Limits ➔ **does NOT take into account any loss potential**
- Exposed TIV ➔ **DOES take into account loss potential in a limited way**
- Pure premiums, 1 in 100 etc. losses ➔ **DOES take into account loss potential**

3. Accumulation zones

- Administrative zones ➔ **geographical correlation of losses NOT considered**
- Hazard zones ➔ **geographical correlation of losses IS considered**

Accumulation control – in conclusion

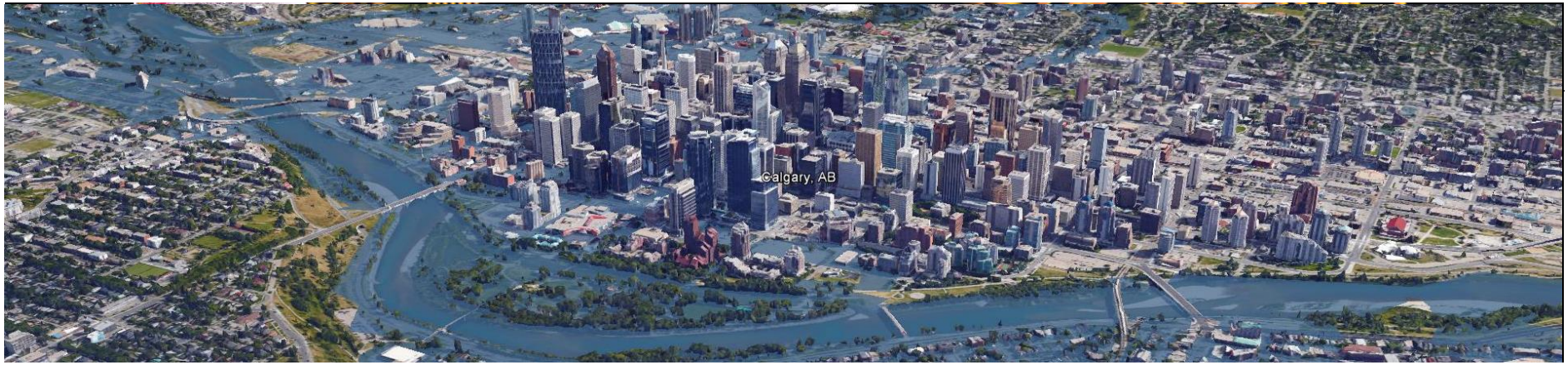
- Setting underwriting limits on loss basis (pure premium / 1 in 100 years loss)

+

- Running catastrophe model on a regular basis

=

- **Enables superior risk management**



Section 6: Conclusions and questions

- 4 uses of the model
- Benefits (for primary underwriting)
- Summary
- Gaining access to the model
- Questions

4 uses of the model

Use 1 Rate calculation

Use 2 New product design

Use 3 Accumulation control

Use 4 Portfolio modelling

Benefits (for primary underwriting)

- Probabilistic models are **effective tools** for rate calculation, evaluating the effect of insurance conditions (limits and deductibles) and exposure accumulation

- When compared with hazard maps, probabilistic models **DO** offer a true rating recommendation

- **Regular running** of a probabilistic model will improve underwriting efficiencies when compared to just “adding values”

- Accumulating using **physically defines zones** can allow better utilisation of underwriting limits

- Unification of tools and data used for **primary underwriting and portfolio accumulation modelling** may be a good idea…

Summary

- **Most technically advanced flood risk model for the Canadian market**
  - Detailed **local** hydrological and elevation data and state of the art flood mapping
  - Includes 2D fluvial and off-flood plain flooding
- **Implemented in ELEMENTS**
  - Transparent, open and customisable
  - Licensed and deployed locally on your hardware or as hosted solution
  - Professionally maintained, training and support available
- **Model can be used for:**
  1. **Primary underwriting** – **in** your systems, **in** Aon Benfield tools, **in** 3rd party tools
  2. **Accumulation control (portfolio modelling)** – **in** ELEMENTS, run **by** Aon Benfield, run **by** you in-house
  - Critical for reinsurance, accumulation control, risk management
  - Used by underwriters, reinsurance managers, pricing actuaries etc.
- **All components developed internally in house**

Gaining access to the model

Direct integration to your systems

- Text files
- Database tables
- Shapefiles
- Other GIS data etc.

Through Aon Benfield tools

- Impact Forecasting ELEMENTS
- Impact On Demand
- CatScore

Through 3rd party providers

- Underwriting platform providers
- Web based mapping solutions providers
- ImageCat, Pitney Bowes, GfK GeoMarketing, WSN, emapsite etc.

Consume our data whatever your appetite

Questions?

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