

Risk According to a Matrix

CSCHE PSMD 2017

Jeff Dancey
October 23, 2017





Overview

- Introduction to the Risk Matrix
- How Small is a Million
- Elephants Don't Fit in Shoeboxes
- Using a Sledgehammer on a Pin
- A Laser Guided, Steam Driven Sledgehammer is Still a Sledgehammer
- When an Order of Magnitude is not an Order of Magnitude
- Be Fruitful, But Don't Multiply
- The Tipping Point
- The Consequence Conundrum
- These Are Not the Consequences You're Looking For...



Introduction to the Risk Matrix

- Very common in industry
- Many companies have their own
- Quick way to screen risks
- Basic matrices are easy to learn and apply
- Easy to customize based on company needs
- Used for risk assessments, capital project scoring, incident reviews

					Likelihood				
					1	2	3	4	5
Consequence					Very Rare (Less than once in 100,000 years)	Rare (Once in 1,000 to 10,000 years)	Unlikely (Once in 100 to 1,000 years)	Possible (Once in 10 to 100 years)	Frequent (More than once every 10 years)
Environmental	Financial	Health & Safety	Ranking						
On-site release, non-reportable event	Under \$10,000	First Aid	1	Low	1	2	3	4	5
Reportable release, soil contamination	\$10,000 to \$100,000	Medical Treatment	2	Moderate	2	4	6	8	10
Significant release, release with remediation under \$1,000,000	\$100,000 to \$1,000,000	Lost Time	3	High	3	6	9	12	15
Release requiring major remediation (up to \$10,000,000)	\$1,000,000 to \$10,000,000	Permanent Injury	4	Very High	4	8	12	16	20
Permanent environmental damage	Over \$10,000,000	Fatality	5	Catastrophic	5	10	15	20	25



How Small is a Million

Consequence				Likelihood				
				1	2	3	4	5
Financial	Health & Safety	Ranking		Frequent (More than once every 10 years)	Possible (Once in 10 to 1000 years)	Unlikely (Once in 1000 to 100,000 years)	Very Unlikely (Once in 100,000 to 1 in 1 million years)	Improbable (Less than once in 1 million years)
		1	2	3	4	5		
Under \$10,000	First Aid	1	Low	Low	Low	Low	Low	Low
\$10,000 to \$100,000	Medical Treatment	2	Moderate	Medium	Medium	Low	Low	Low
\$100,000 to \$1,000,000	Lost Time	3	High	High	Medium	Medium	Low	Low
\$1,000,000 to \$10,000,000	Single Fatality or Permanent Disabling Injury	4	Very High	High	High	Medium	Medium	Low
Over \$10,000,000	Multiple Fatalities	5	Catastrophic	Critical	High	High	Medium	Medium

- Very low frequency levels are common in risk matrices
- People do not distinguish well between 1 in 1000, 1 in 10,000, 1 in 100,000
- Highly improbable events are outside personal experience
- Rare and unusual events within industry and outside need to be researched and understood



Elephants Don't Fit in Shoeboxes

Consequence					Likelihood				
					1	2	3	4	5
Environmental	Financial	Health & Safety	Ranking		Very Rare (Less than once in 100,000 years)	Rare (Once in 1,000 to 10,000 years)	Unlikely (Once in 100 to 1,000 years)	Possible (Once in 10 to 100 years)	Frequent (More than once every 10 years)
On-site release, non-reportable event	Under \$10,000	First Aid	1	Low	1	2	3	4	5
Reportable release, soil contamination	\$10,000 to \$100,000	Medical Treatment	2	Moderate	2	4	6	8	10
Significant release, release with remediation under \$1,000,000	\$100,000 to \$1,000,000	Lost Time	3	High	3	6	9	12	15
Release requiring major remediation (up to \$10,000,000)	\$1,000,000 to \$10,000,000	Permanent Injury	4	Very High	4	8	12	16	20
Permanent environmental damage	Over \$10,000,000	Fatality	5	Catastrophic	5	10	15	20	25

- Risk matrices have top end consequence values
- Events can exceed these top end values by more than an order of magnitude
- This can cause an under-estimation of actual risk
- Risk matrices should not place an artificial limit on severity



Using a Sledgehammer on a Pin

Consequence					Likelihood				
					1	2	3	4	5
Environmental	Financial	Health & Safety	Ranking		Frequent (More than once every 10 years)	Possible (Once in 10 to 1000 years)	Unlikely (Once in 1000 to 10,000 years)	Very Unlikely (Once in 100,000 to 1 in 1 million years)	Improbable (Less than once in 1 million years)
On-site release, non-reportable event	Under \$10,000	First Aid	1	Low	Low	Low	Low	Low	Low
Reportable release, soil contamination	\$10,000 to \$100,000	Medical Treatment	2	Moderate	Medium	Medium	Low	Low	Low
Significant release, release with remediation under \$1,000,000	\$100,000 to \$1,000,000	Lost Time	3	High	High	Medium	Medium	Low	Low
Release requiring major remediation (up to \$10,000,000)	\$1,000,000 to \$10,000,000	Single Fatality or Permanent Disabling Injury	4	Very High	High	High	Medium	Medium	Low
Permanent environmental damage	Over \$10,000,000	Multiple Fatalities	5	Catastrophic	Critical	High	High	Medium	Medium

- Risk matrices are designed to be fast, but conservative
- Not designed to be highly accurate
- Good for low-medium risk, high-medium probability events
- High consequence, low probability events are an issue



Using a Sledgehammer on a Pin 2

Consequence					Likelihood				
					1	2	3	4	5
Environmental	Financial	Health & Safety	Ranking		Frequent (More than once every 10 years)	Possible (Once in 10 to 1000 years)	Unlikely (Once in 1000 to 10,000 years)	Very Unlikely (Once in 100,000 to 1 in 1 million years)	Improbable (Less than once in 1 million years)
On-site release, non-reportable event	Under \$10,000	First Aid	1	Low	Low	Low	Low	Low	Low
Reportable release, soil contamination	\$10,000 to \$100,000	Medical Treatment	2	Moderate	Medium	Medium	Low	Low	Low
Significant release, release with remediation under \$1,000,000	\$100,000 to \$1,000,000	Lost Time	3	High	High	Medium	Medium	Low	Low
Release requiring major remediation (up to \$10,000,000)	\$1,000,000 to \$10,000,000	Single Fatality or Permanent Disabling Injury	4	Very High	High	High	Medium	Medium	Low
Permanent environmental damage	Over \$10,000,000	Multiple Fatalities	5	Catastrophic	Critical	High	High	Medium	Medium

- Some companies will force residual risk for all high consequence events (sometimes invoking ALARP)
- Forces action on high consequence, but:
Resolution MUST be defined!



A Steam-driven Laser-Guided Sledgehammer...

Consequence					Likelihood				
					1	2	3	4	5
Environmental	Financial	Health & Safety	Ranking		Frequent (More than once every 10 years)	Possible (Once in 10 to 1000 years)	Unlikely (Once in 1000 to 10,000 years)	Very Unlikely (Once in 100,000 to 1 in 1 million years)	Improbable (Less than once in 1 million years)
On-site release, non-reportable event	Under \$10,000	First Aid	1	Low	Low	Low	Low	Low	Low
Reportable release, soil contamination	\$10,000 to \$100,000	Medical Treatment	2	Moderate	Medium	Medium	Low	Low	Low
Significant release, release with remediation under \$1,000,000	\$100,000 to \$1,000,000	Lost Time	3	High	High	Medium	Medium	Low	Low
Release requiring major remediation (up to \$10,000,000)	\$1,000,000 to \$10,000,000	Single Fatality or Permanent Disabling Injury	4	Very High	High	High	Medium	Medium	Low
Permanent environmental damage	Over \$10,000,000	Multiple Fatalities	5	Catastrophic	Critical	High	High	Medium	Medium

1. For all events involving release of flammable material, see sub-chart 12 to determine consequence level based on system pressure
2. For spills involving corrosive material outside of containment, see sub-chart 5a to determine consequence level based on component
3. For leaks from pumps or valves (seal/packing leaks), see Table 10 to determine release rate
4. For systems with existing SIL protection systems, refer to accompanying SIL graph on Figure 13 to verify acceptability of scenario

...is Still a Sledgehammer

The Good

- Improved repeatability
- Removes much subjective judgement from process

The Bad

- Handcuffs team judgement
- 'Security blanket' effect
- Makes screening a longer, more cumbersome process



When an Order of Magnitude...

Consequence					1	2	3	4	5
Environmental	Financial	Health & Safety	Ranking		Frequent (Once per year or more)	Possible (Once in 10 to 1000 years)	Unlikely (Once in 1000 to 10,000 years)	Probable (Once in 100 to 1000 years)	Very Probable (Once in 10 to 100 years)
On-site release, non-reportable event	Under \$10,000	First Aid	1	Low	Low	Low	Low	Low	Low
Reportable release, soil contamination	\$10,000 to \$500,000	Medical Treatment	2	Moderate	Medium	Medium	Low	Low	Low
Significant release, release with remediation under \$1,000,000	\$500,000 to \$5,000,000	Lost Time	3	High	High	Medium	Low	Low	Low
Release requiring major remediation (up to \$10,000,000)	\$5,000,000 to \$50,000,000	Single Fatality or Permanent Disabling Injury	4	Very High	High	High	Medium	Medium	Low
Permanent environmental damage	Over \$50,000,000	Multiple Fatalities	5	Catastrophic	Critical	High	High	Medium	Low

- Companies often target 1-in-100,000 or 1-in-1,000,000 for low end probability
- Companies also like yearly and 1-in-10 year categories
- Middle probability categories often 'jump' orders of magnitude



... is Not an Order of Magnitude

Likelihood				
1	2	3	4	5
Frequent (Once per year or more)	Possible (Once in 1 to 10 years)	Unlikely (Once in 10 to 1,000 years)	Very Unlikely (Once in 1,000 to 1 in 100,000 years)	Improbable (Less than once in 100,000 years)
Low	Low	Low	Low	Low
Medium	Medium	Low	Low	Low
High	Medium	Medium	Low	Low
High	High		Medium	Low
Critical	High		Medium	Low

- Jumping orders of magnitude effectively 'stretches' the associated risk
- This creates a bias that isn't obvious to those performing the assessment
- Jumps in order of magnitude on the consequence side can make this worse



Be Fruitful, But Don't Multiply

					Likelihood				
					1	2	3	4	5
Consequence					Very Rare (Less than once in 100,000 years)	Rare (Once in 1,000 to 10,000 years)	Unlikely (Once in 100 to 1,000 years)	Possible (Once in 10 to 100 years)	Frequent (More than once every 10 years)
Environmental	Financial	Health & Safety	Ranking						
On-site release, non-reportable event	Under \$10,000	First Aid	1	Low	1	2	3	4	5
Reportable release, soil contamination	\$10,000 to \$100,000	Medical Treatment	2	Moderate	2	4	6	8	10
Significant release, release with remediation under \$1,000,000	\$100,000 to \$1,000,000	Lost Time	3	High	3	6	9	12	15
Release requiring major remediation (up to \$10,000,000)	\$1,000,000 to \$10,000,000	Permanent Injury	4	Very High	4	8	12	16	20
Permanent environmental damage	Over \$10,000,000	Fatality	5	Catastrophic	5	10	15	20	25

- Many companies will **multiply** likelihood and severity to get a ranking
- Rankings are often used to prioritize projects and actions



Be Fruitful, But Don't Multiply

The Good

- Provides clear direction on priorities
- Gives consistent ranking

The Bad

- Doesn't account for multiple outcomes
- High frequency low severity \neq High severity low frequency
- Multiplying orders of magnitude doesn't work...

$$1 \times 1 = 1$$

$$2 \times 2 = 4$$

$$3 \times 3 = 9$$

$$1 \times 1 = 1$$

$$10 \times 10 = 100$$

$$100 \times 100 = 10,000$$



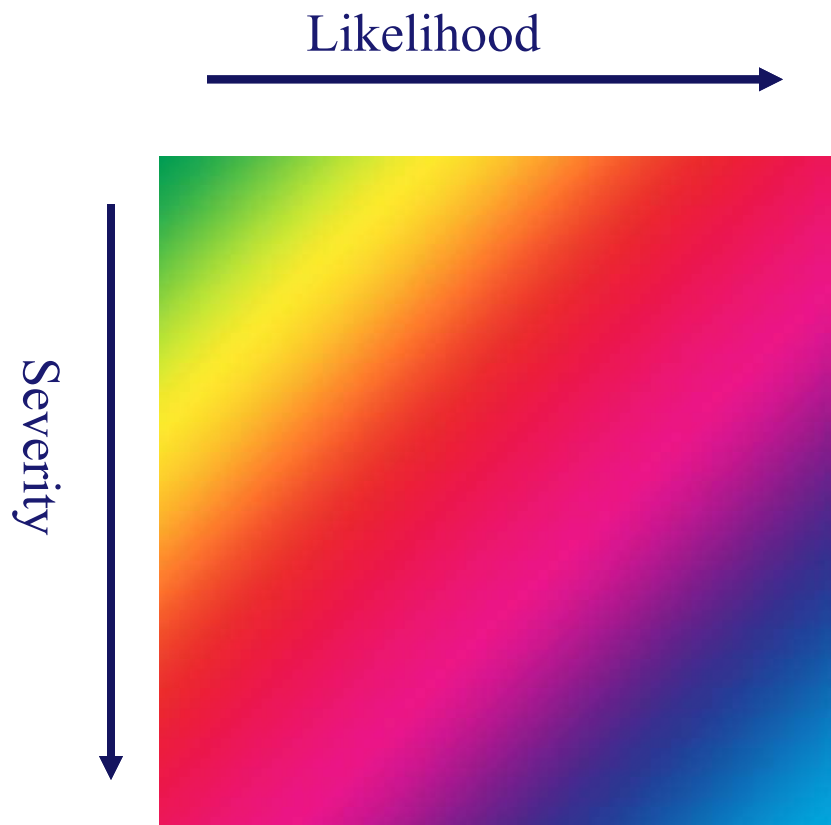
The Tipping Point

					Likelihood				
					1	2	3	4	5
Consequence					Improbable (Less than once in 1 million years)	Very Unlikely (Once in 10,000 to 100,000 years)	Unlikely (Once in 100 to 10,000 years)	Possible (Once in 10 to 100 years)	Frequent (More than once every 10 years)
Environmental	Financial	Health & Safety	Ranking						
On-site release, non-reportable event	Under \$10,000	First Aid	1	Low	Low	Low	Low	Low	Low
Reportable release, soil contamination	\$10,000 to \$100,000	Medical Treatment	2	Moderate	Low	Low	Low	Medium	Medium
Significant release, release with remediation under \$1,000,000	\$100,000 to \$1,000,000	Lost Time	3	High	Low	Low	Medium	Medium	High
Release requiring major remediation (up to \$10,000,000)	\$1,000,000 to \$10,000,000	Permanent Injury	4	Very High	Low	Medium	Medium	High	High
Permanent environmental damage	Over \$10,000,000	Fatality	5	Catastrophic	Low	Medium	High	High	Critical

- Risk matrices provide clear break points from one category to the next
- This gives clear guidance on when to take or not take an action
- This can be easily abused...

The Tipping Point 2

Reality doesn't fit into neat boxes...



- Risk is a spectrum
- Matrices are a simplification
- Watch for 'gaming' of the system



The Consequence Conundrum

Consequence				
Environmental	Financial	Health & Safety	Ranking	
On-site release, non-reportable event	Under \$10,000	First Aid	1	Low
Reportable release, soil contamination	\$10,000 to \$100,000	Medical Treatment	2	Moderate
Significant release, release with remediation under \$1,000,000	\$100,000 to \$1,000,000	Lost Time	3	High
Release requiring major remediation (up to \$10,000,000)	\$1,000,000 to \$10,000,000	Permanent Injury	4	Very High
Permanent environmental damage	Over \$10,000,000	Fatality	5	Catastrophic

- The same consequence can happen many ways – important when reviewing incidents

Example: Consequence – 5 stitches:

- From a car accident driving to work
- From a car accident driving at work
- While using a knife, hand slips
- Intentionally cut by another employee
- Process upset launches shrapnel, causes cut
- Catches arm in rotating equipment

Consequences may be equal – level of concern and **potential harm** is not!



These Aren't the Consequences You're Looking For...

					Likelihood				
					1	2	3	4	5
Consequence					Very Rare (Less than once in 100,000 years)	Rare (Once in 1,000 to 10,000 years)	Unlikely (Once in 100 to 1,000 years)	Possible (Once in 10 to 100 years)	Frequent (More than once every 10 years)
Environmental	Financial	Health & Safety	Ranking						
On-site release, non-reportable event	Under \$10,000	First Aid	1	Low	1	2	3	4	5
Reportable release, soil contamination	\$10,000 to \$100,000	Medical Treatment	2	Moderate	2	4	6	8	10
Significant release, release with remediation under \$1,000,000	\$100,000 to \$1,000,000	Lost Time	3	High	3	6	9	12	15
Release requiring major remediation (up to \$10,000,000)	\$1,000,000 to \$10,000,000	Permanent Injury	4	Very High	4	8	12	16	20
Permanent environmental damage	Over \$10,000,000	Fatality	5	Catastrophic	5	10	15	20	25

- Facilitators can easily bias decisions in a matrix!



These Aren't the Consequences You're Looking For...

Three Statements:

1. "Do you think this scenario is a likelihood 3, or should it be higher?"
2. "So, what is the probability for this scenario?"
3. "Is this a 2 or a 3 for likelihood?"

Only statement 2 is neutral, 1 and 3 will bias the audience!
Subjective tools are prone to influence, facilitators need to be aware!



Questions



Further Inquiries:
Email: JDancey@BakerRisk.com

