GENERATING ALTERNATIVE ALIGNMENTS IN TERRAIN SUITABILITY STUDIES FOR EIAs OF LINEAR DEVELOPMENTS

Heidi van Deventer
GIS/RS researcher
CSIR

25 August 2010
IAIAsa conference

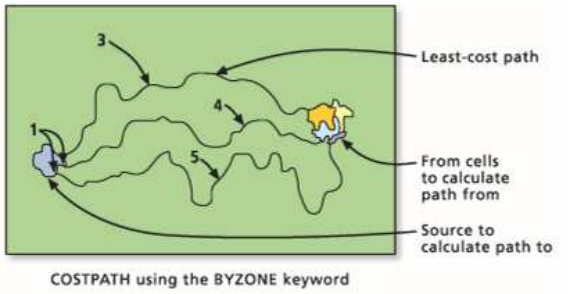
our future through science

Terrain suitability studies – what is it?

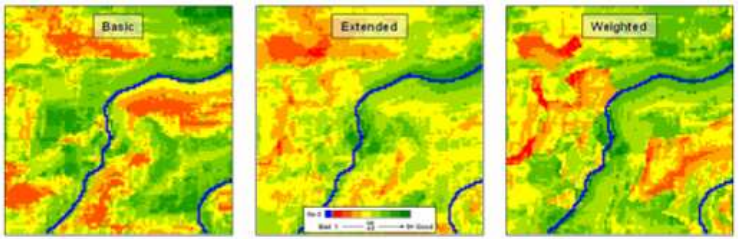
Determine Aspects for application → Acquire geospatial data → Classes of suitability → Rank Classes i.t.o. suitability

Rank Classes i.t.o. suitability → Linear development → Least cost Path (LCP)

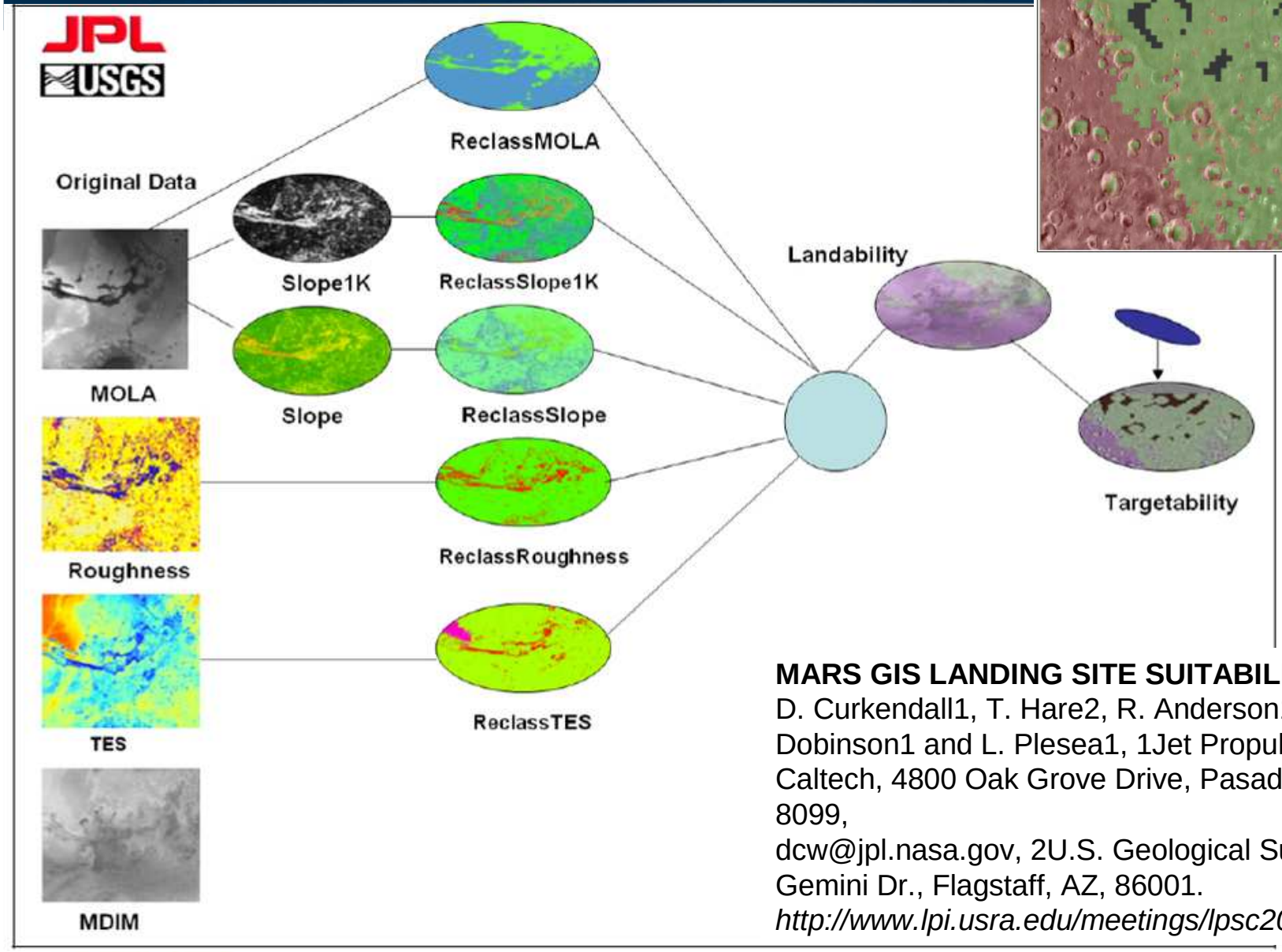
Rank Classes i.t.o. suitability → Site suitability development → Overlay / Weighted overlay

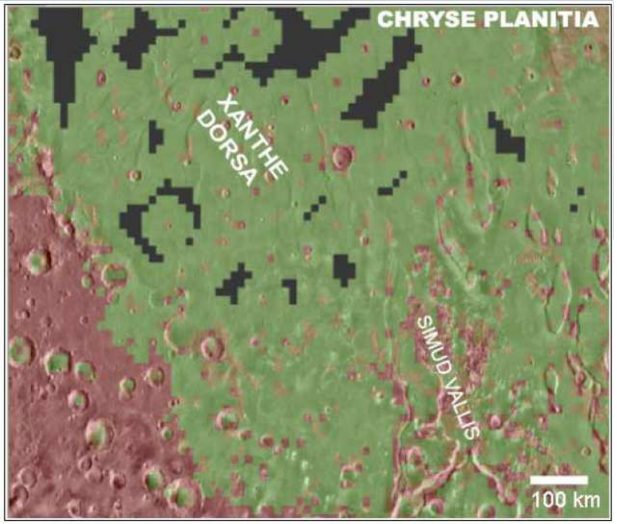


COSTPATH using the BYZONE keyword



Terrain suitability studies – example





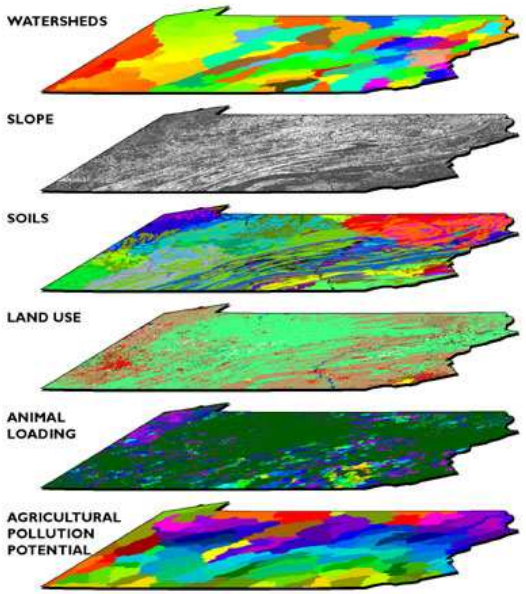
MARS GIS LANDING SITE SUITABILITY MODELS.

D. Curkendall1, T. Hare2, R. Anderson1, E. Dobinson1 and L. Plesea1, 1Jet Propulsion Laboratory, Caltech, 4800 Oak Grove Drive, Pasadena, CA, 91109-8099,
dcw@jpl.nasa.gov, 2U.S. Geological Survey, 2255 N. Gemini Dr., Flagstaff, AZ, 86001.

http://www.lpi.usra.edu/meetings/lpsc2006/pdf/2110.pdf

Linear development study – Aspects selected

- Geology, soils and geotechnical aspects
- Topography (slope)
- Surface water and wetlands
- Groundwater impacts
- Ecological and biodiversity issues
- Land use and ownership
- Transport and servitudes
- Agriculture
- Cultural heritage
- Palaeontology
- A baseline Social Impact Assessment



Suitability ranking - Geotechnical

Table 1: The 9-point continuous ranking scale used in the terrain suitability study.
(This was used to rank classes of criteria according to their suitability for the construction and operation of the linear development.)

9	7	5	3	1	1/3 or -3	1/5 or -5	1/7 or -7	1/9 or -9
Extremely suitable	Very suitable	Strongly suitable	Moderately suitable	Equally suitable	Moderately unsuitable	Strongly unsuitable	Very unsuitable	Extremely unsuitable

Excavatibility

Depth limiting material	Required excavation method	Rank/rating/rank
gc , pr , p , vp , vr	TLB	9
sl	TLB with minor effort	7
ca	Excavator	1
so	Excavator with minor effort	1/3
lc	Excavator with effort in places	1/5
hp	Excavator with significant effort	1/7
R	Blast	1/9
TLB – Trencher/loader/back actor		

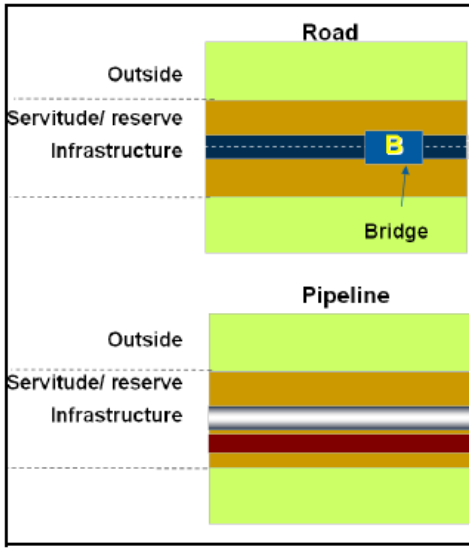
Slope steepness

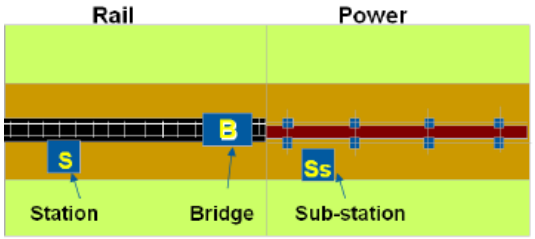
Slope degree classes	Rank	Ranks explained
0 - 6.8°	9	Extremely suitable
6.8 - 8.5°	7	Very suitable
>8.5°	1	Equally suitable
Large dam	-9	Extremely unsuitable

Suitability ranking - Freshwater

- Avoid areas of high river density
- Avoid high water yield areas
- Areas that would flood regularly
- Avoid special wetlands and waterfalls
- Avoid water supply infrastructure
- Avoid main water sources (e.g. boreholes) in water stressed area
- Avoid known sites where people access water for domestic purposes
- Avoid irrigated areas and infrastructure
- Align with existing infrastructure crossing rivers

Suitability ranking - Transport





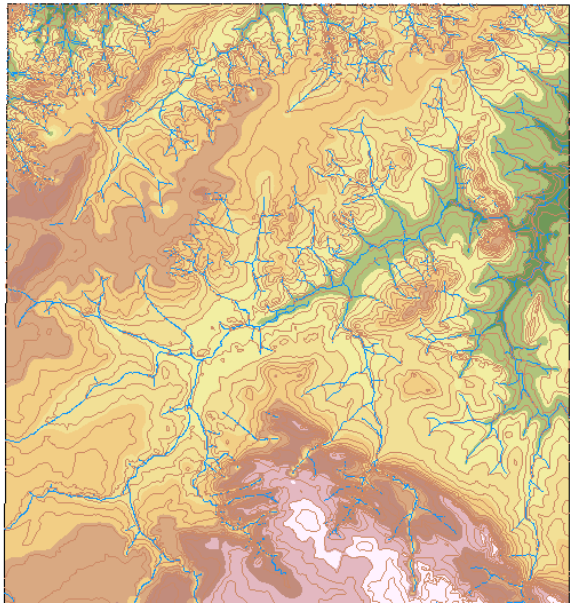
- Various types
- Linear features – continuously connected
- Look at it as "corridors of opportunity"
- Both a practical and institutional – dealing with rights and permissions

9	7	5	3	1	1/3 or -3	1/5 or -5	1/7 or -7	1/9 or -9
Extremely suitable	Very suitable	Strongly suitable	Moderately suitable	Equally suitable	Moderately unsuitable	Strongly unsuitable	Very unsuitable	Extremely unsuitable

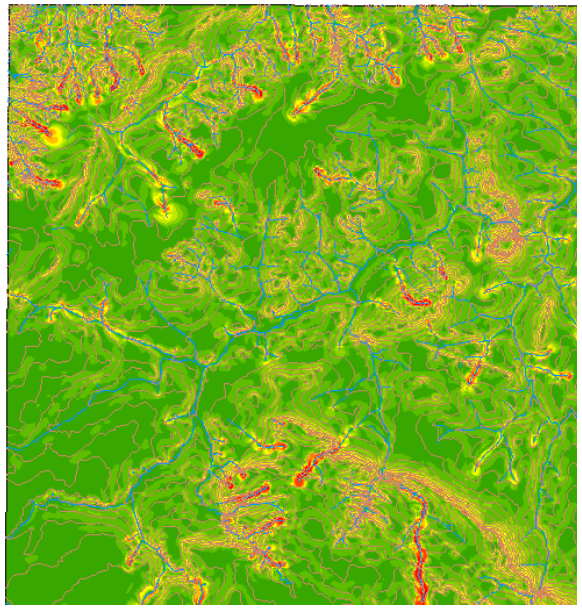
Roads (Sub-criteria)	Rank	Measure
1. National and Provincial Rd Surface	1/9	Constraint
2. National and Provincial Rd Reserve	1/5	Constraint
3. Other Rd Surface	1/3	Constraint
4. Other Rd Reserve	1/5	Constraint
5. Bridge	7	Opportunity
6. 20 m buffer outside reserve/servitude	9	Opportunity

Schematic illustration of components of road criterion:

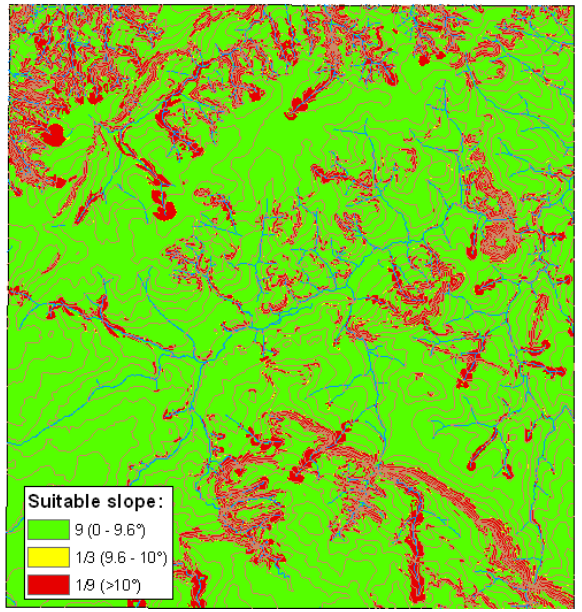
Classification and ranking of the geospatial data



Digital Elevation Model (DEM)



Slope in degrees



Classified in terms of slope suitability

Slope steepness

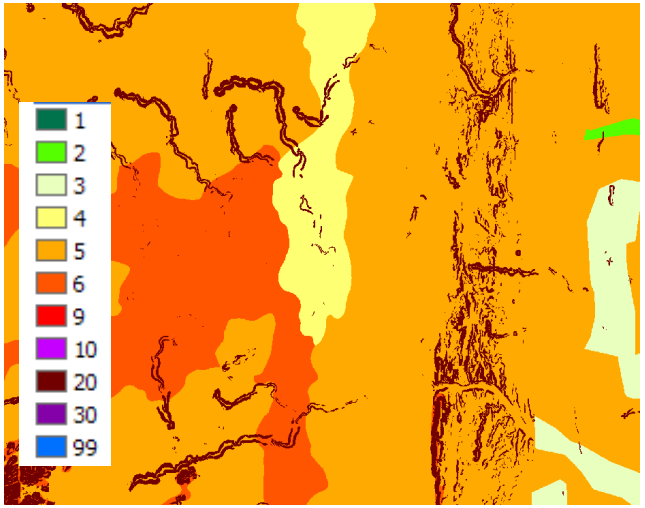
Slope degree classes	Rank	Ranks explained
0 - 6.8°	9	Extremely suitable
6.8 - 8.5°	7	Very suitable
>8.5°	1	Equally suitable
Large dam	-9	Extremely unsuitable

Converting to impedances (e.g. for Geotechnical)

Excavatability (Fraction field)	Ranks explained	Impedance rating
9	Extremely suitable	1
7	Very suitable	2
5	Strongly suitable	3
3	Moderately suitable	4
1	Equally suitable	5
1/3	Moderately unsuitable	6

Slope degree classes	Rank	Ranks explained	Impedance surface rating
0 - 6.8°	9	Extremely suitable	1
6.8 - 8.5°	7	Very suitable	1
>8.5°	1	Equally suitable	9
Large dam	-9	Extremely unsuitable	99

Geotechnical Impedance layer

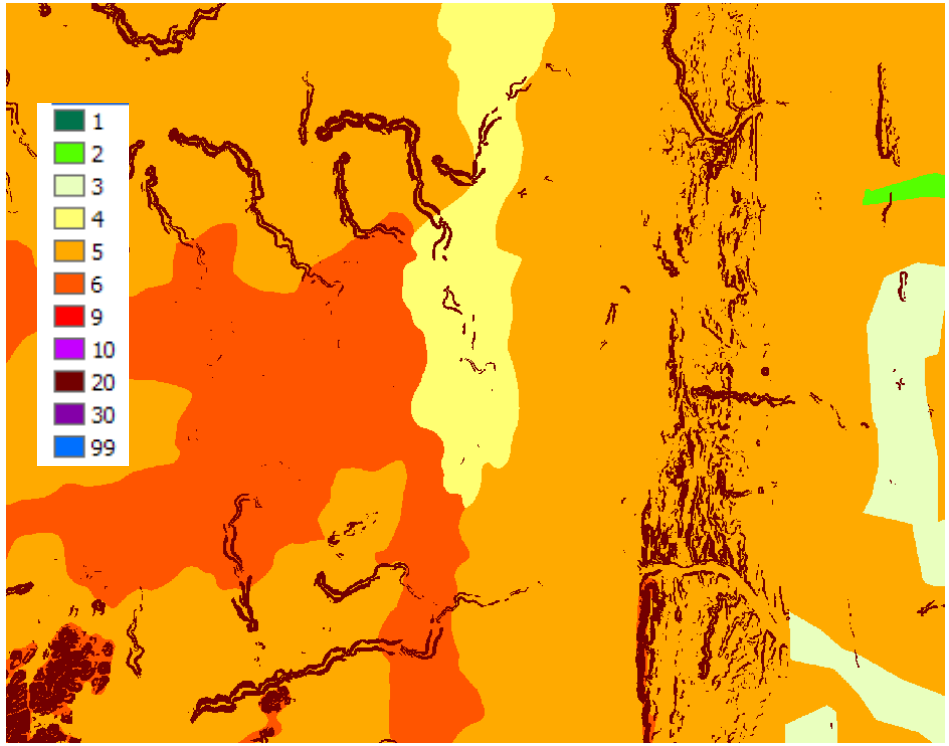


www.csir.co.za

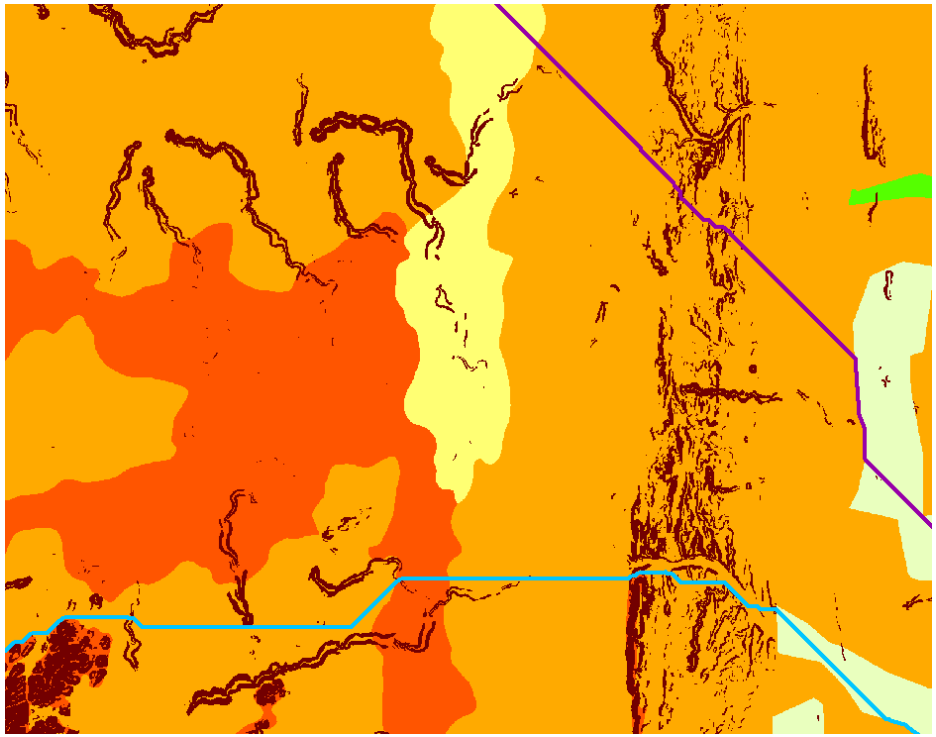
Slope IMPEDANCE RATING	Excavatability IMPEDANCE RATING (excavatability & soil depth)	Resultant code	Geotechnical Impedance Surface ratings	Final Geotechnical Suitability Rank
1	1	11	1	9
1	2	12	2	7
1	3	13	3	5
1	4	14	4	3
1	5	15	5	2
1	6	16	6	1
1	9	19	9	-3
9	1	91	20	-7
9	2	92	20	-7
9	3	93	20	-7
9	4	94	20	-7
9	5	95	20	-7
9	6	96	20	-7
9	9	99	20	-7
99	1	991	99	-9
99	5	995	99	-9
99	9	999	99	-9

Least Cost Path

Geotechnical Impedance layer



Least cost paths



Evaluating the results / comparing alternatives

Table 3: Percentage area for each rank of suitability for the Geotechnical environmental aspect as a total of the surface area of each corridor option.

		% of total surface area of the corridor												
Suitability rank	Environmental aspect	Option 1a	Option 1b	Option 2a	Option 2 b	Option 3a	Option 3b	Option 4a	Option 4b	Option 5 a	Option 5 b	Straight line	Previous alignment (a)	Previous alignment (b)	Previous alignment (c)
9	Geotechnical	9	6	0	0	0	0	0	0	0	0	0	0	0	0
7	Geotechnical	14	9	6	4	12	11	14	5	6	3	11	5	14	0
5	Geotechnical	7	7	5	6	2	2	9	5	6	4	8	4	3	0
3	Geotechnical	23	13	4	10	16	6	5	9	4	15	6	14	0	15
1	Geotechnical	42	51	70	46	56	47	65	49	70	52	69	57	58	60
-3	Geotechnical	5	11	6	15	10	26	5	17	9	11	4	11	19	17
-5	Geotechnical	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-7	Geotechnical	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-9	Geotechnical	1	2	9	18	4	7	3	13	4	15	2	9	6	8

** The above table shows only a shortened version of the actual table used. See Appendix A for the full table.*

Determining feasible corridors

Environmental Aspect	Option 1a	Option 1b	Option 2a	Option 2 b	Option 3a	Option 3b	Option 4a	Option 4b	Option 5a	Option 5b	Straight line	Previous alignment (a)	Previous alignment (b)	Previous alignment (c)
Geotechnical	94	87	85	66	86	67	92	69	87	74	94	80	75	75
Freshwater	91	84	93	85	81	73	89	87	93	84	89	83	89	92
Groundwater	-95	-97	-79	-97	-98	-97	-97	-96	-94	-95	-97	-98	-61	-97
Ecological suitability	-92	-73	-90	-71	-77	-66	-84	-68	-93	-76	-95	-71	-91	-73
Heritage sites suitability	100	100	100	100	100	100	100	99	100	100	100	100	100	100
Palaeontological suitability	84	98	96	97	99	98	92	95	96	96	96	99	100	98
Transport suitability	98	91	98	96	29	26	97	94	97	94	99	76	74	9
Transport opportunities	1	4	1	2	37	36	1	3	1	2	0	4	13	45
Social site constraints	-95	-96	-95	-98	-95	-95	-64	-96	-96	-98	-94	-100	-94	-83
Social Opportunities	100	92	100	89	96	92	100	86	100	98	100	90	100	83
Votes:	5	3	6	4	3	4	6	4	5	3	5	2	4	4
Excluding the votes of the social aspect:	4	3	5	4	3	4	4	4	4	3	4	2	3	4

Benefits of a TSS in the feasibility phase

Benefits mentioned in the literature:	Comment
Open & explicit process	YES
Audit trail that can be reviewed	YES
Changeable & repeatable	YES
Communication between the community, decision makers and I&APs	Not tested.
Desktop prior fieldwork, more focussed fieldwork	Not tested.
Minimising costs	Not tested.
Interdisciplinary approach	YES
Generating a number of alternatives using GIS is beneficial for a study	To be assessed.

Limitations & recommendations

- Geospatial data still difficult
  - Access
  - Frequent updates
  - Accuracy
- TSS could be an easy desktop study to determine feasible corridors
- Follow up with a CBA, risk assessment and route refinement

Acknowledgements

The project client is thanked for the financial and labour investment in this project and going with the idea of new methods in the TSS.

The team members and other workshop participants who participated in the workshops are thanked for their fresh ideas and eager participation.

Thank You