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Lampiran 1

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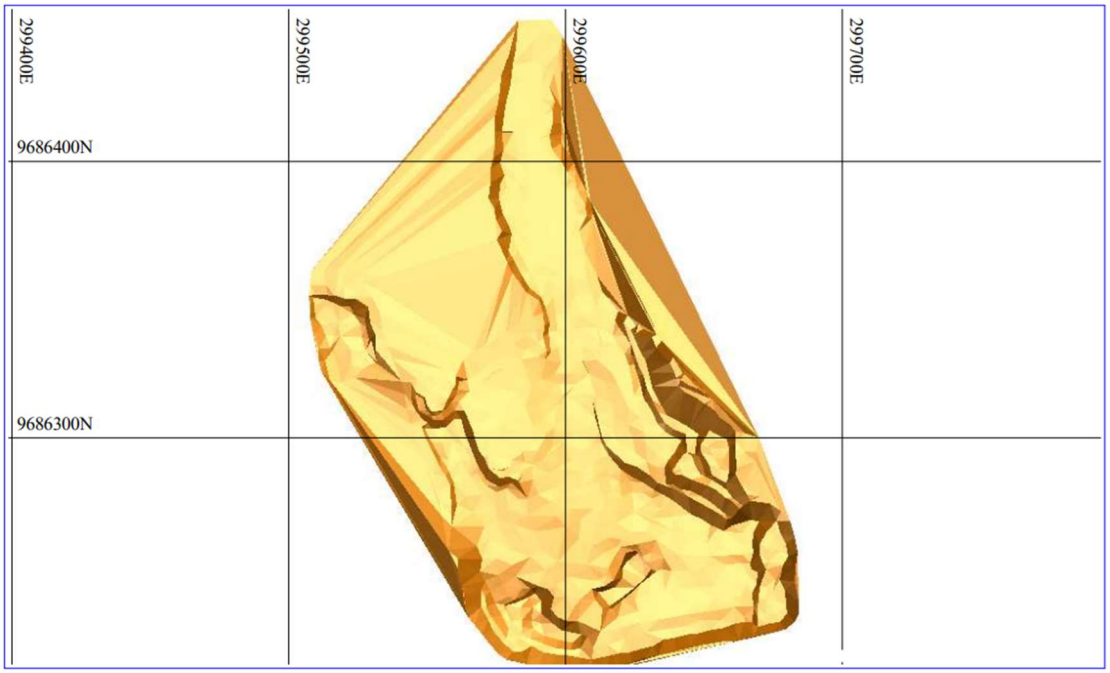

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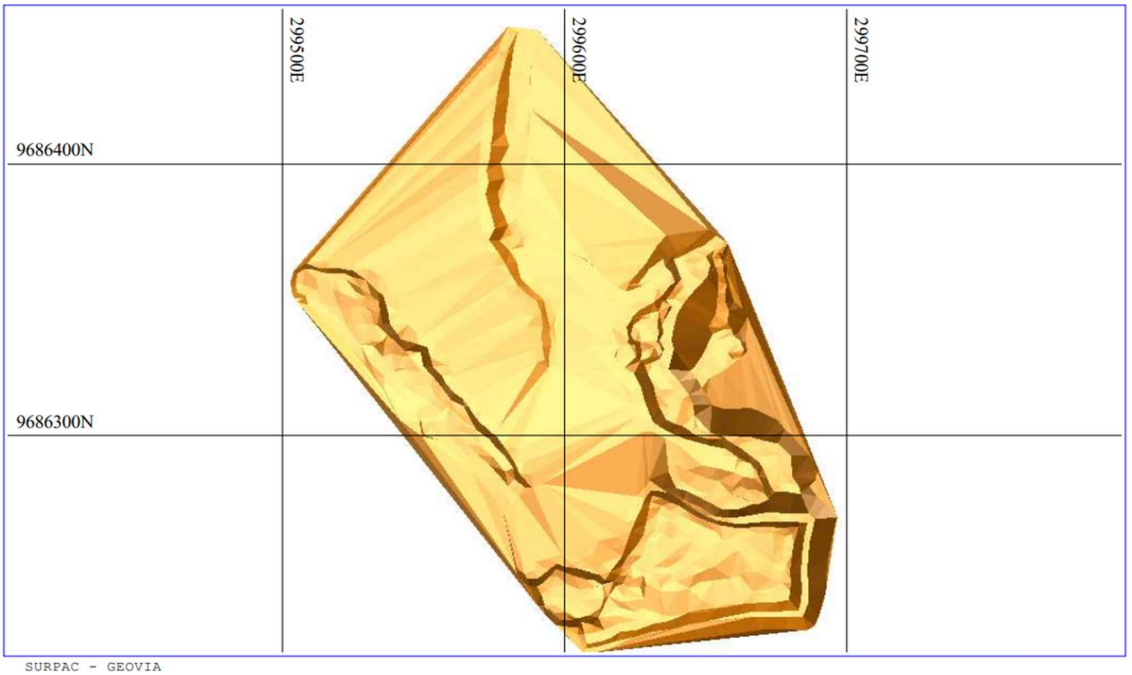

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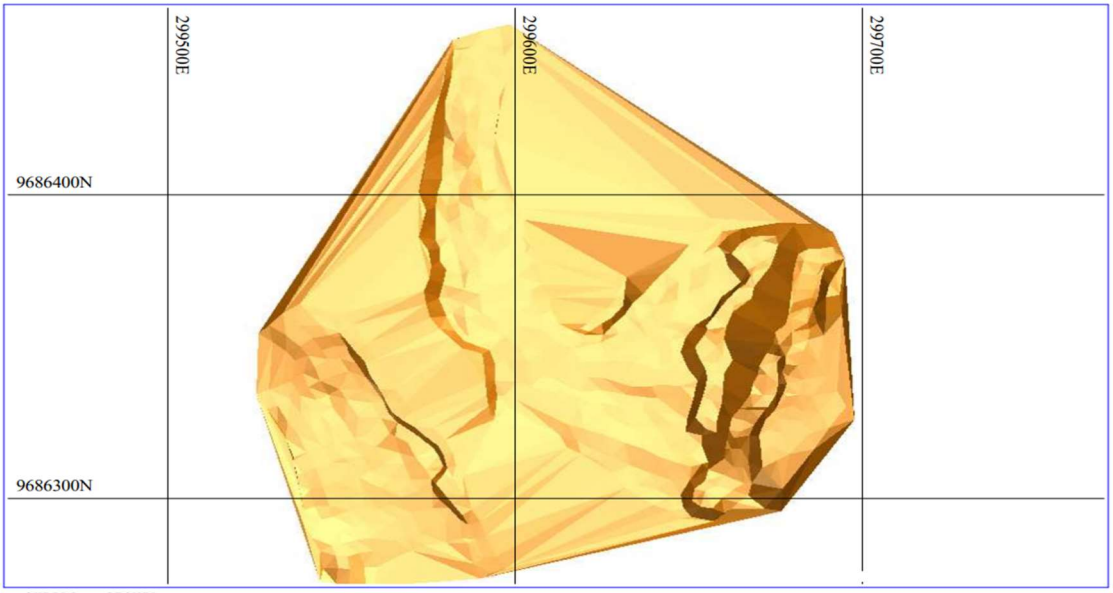

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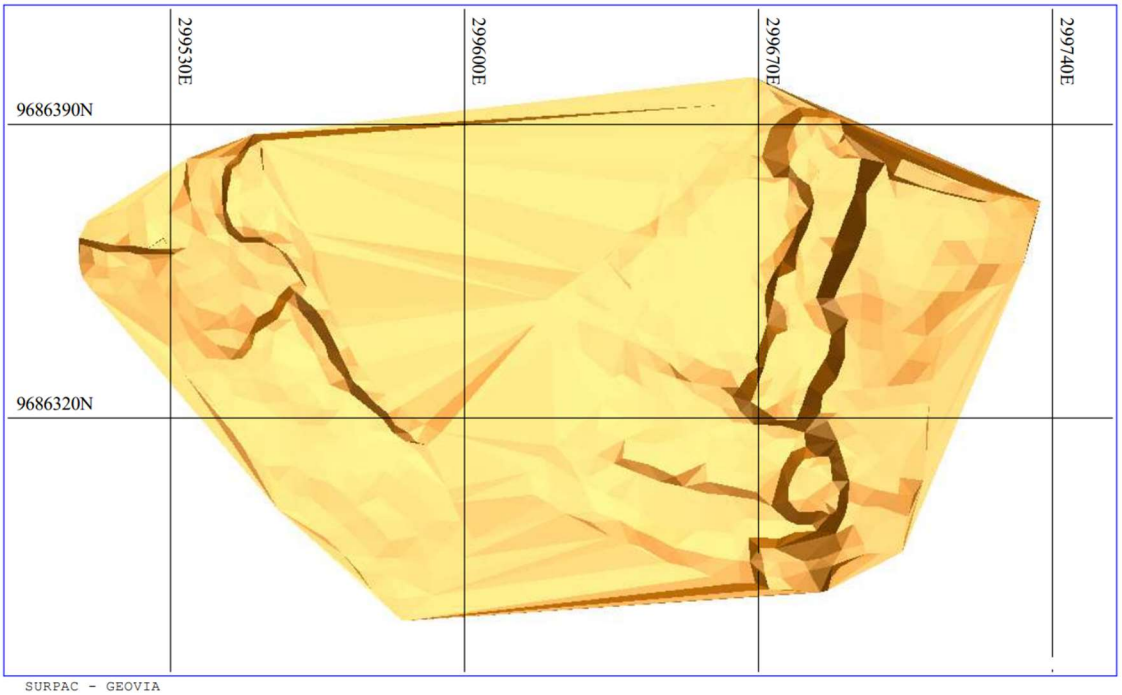

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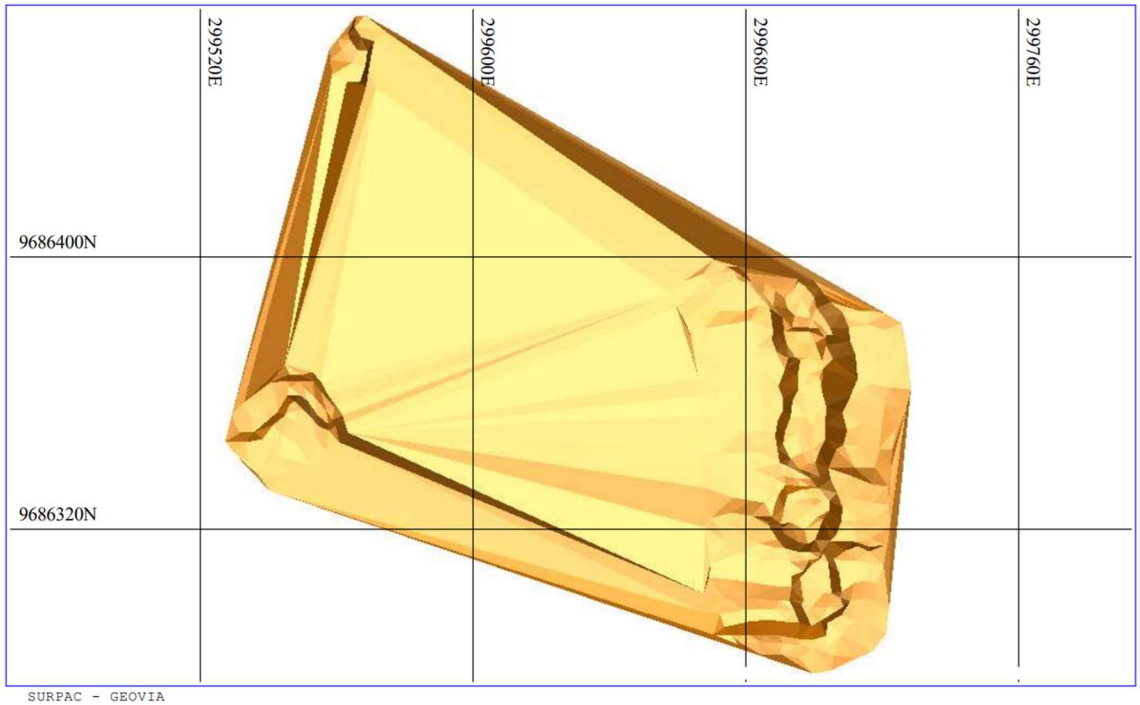

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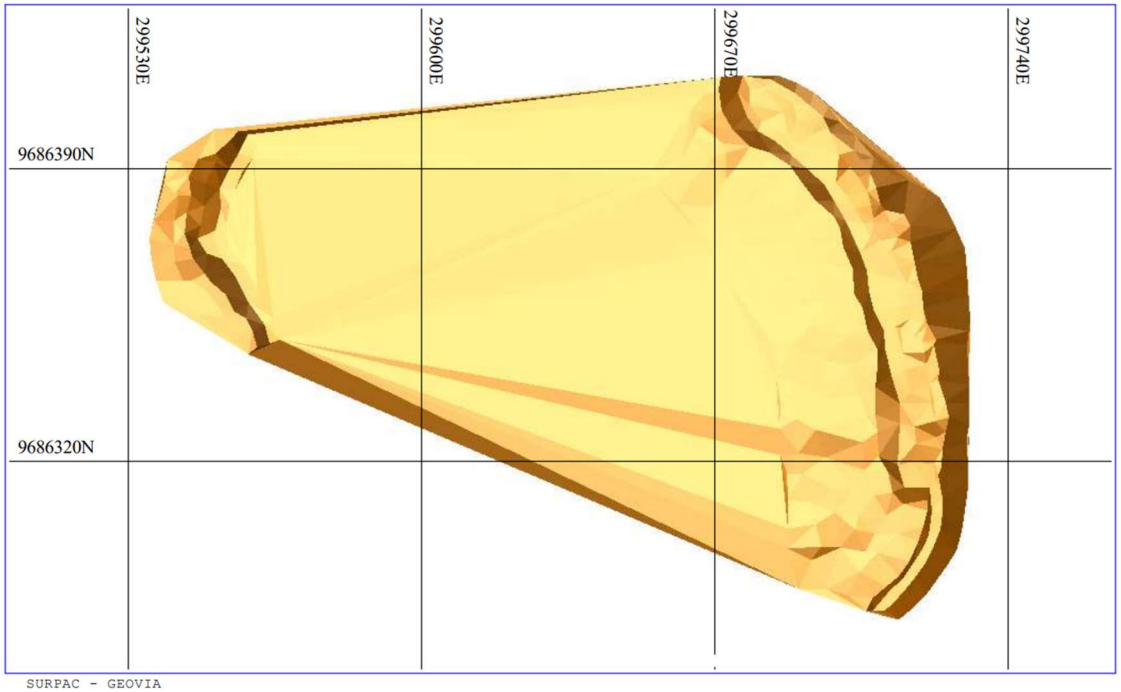

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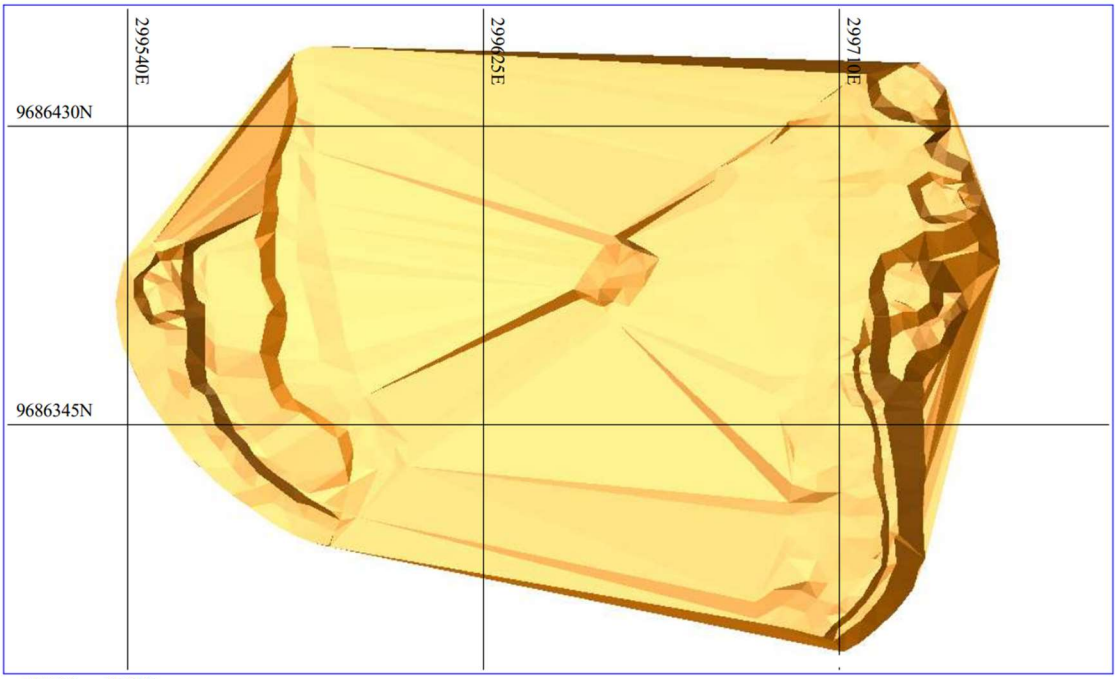

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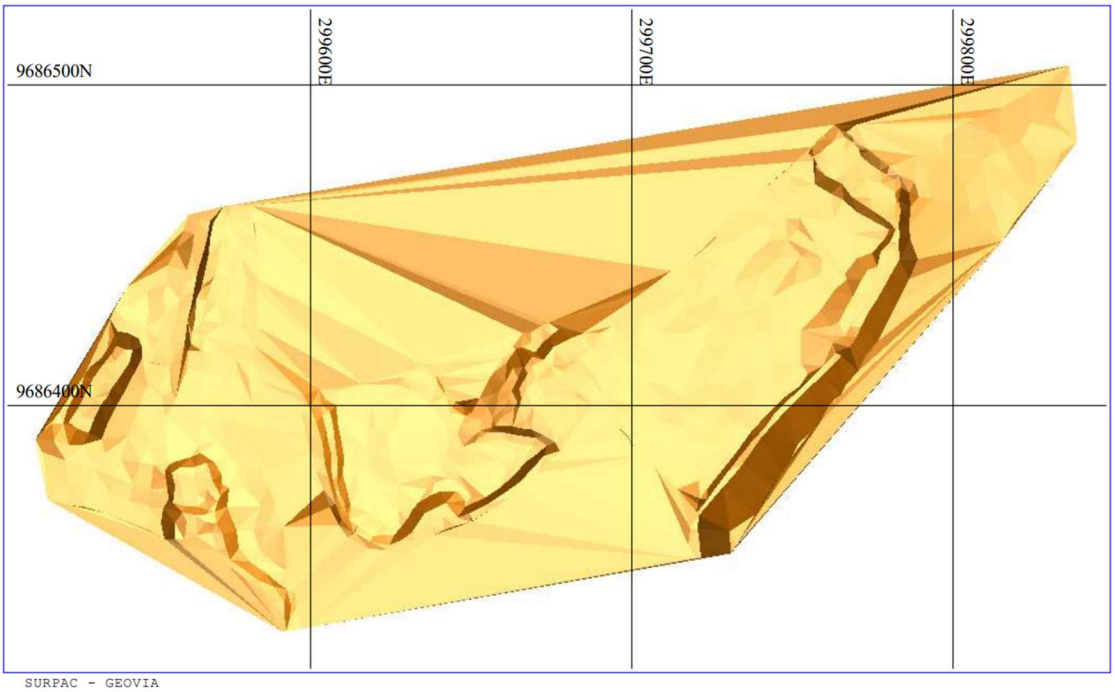

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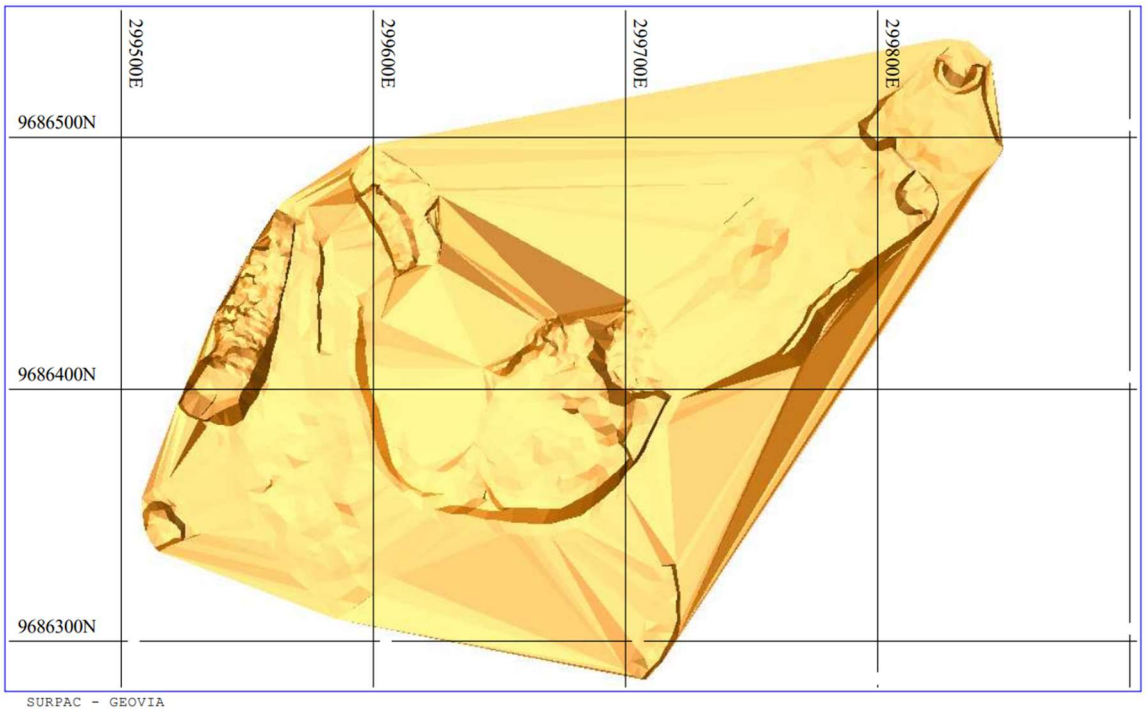
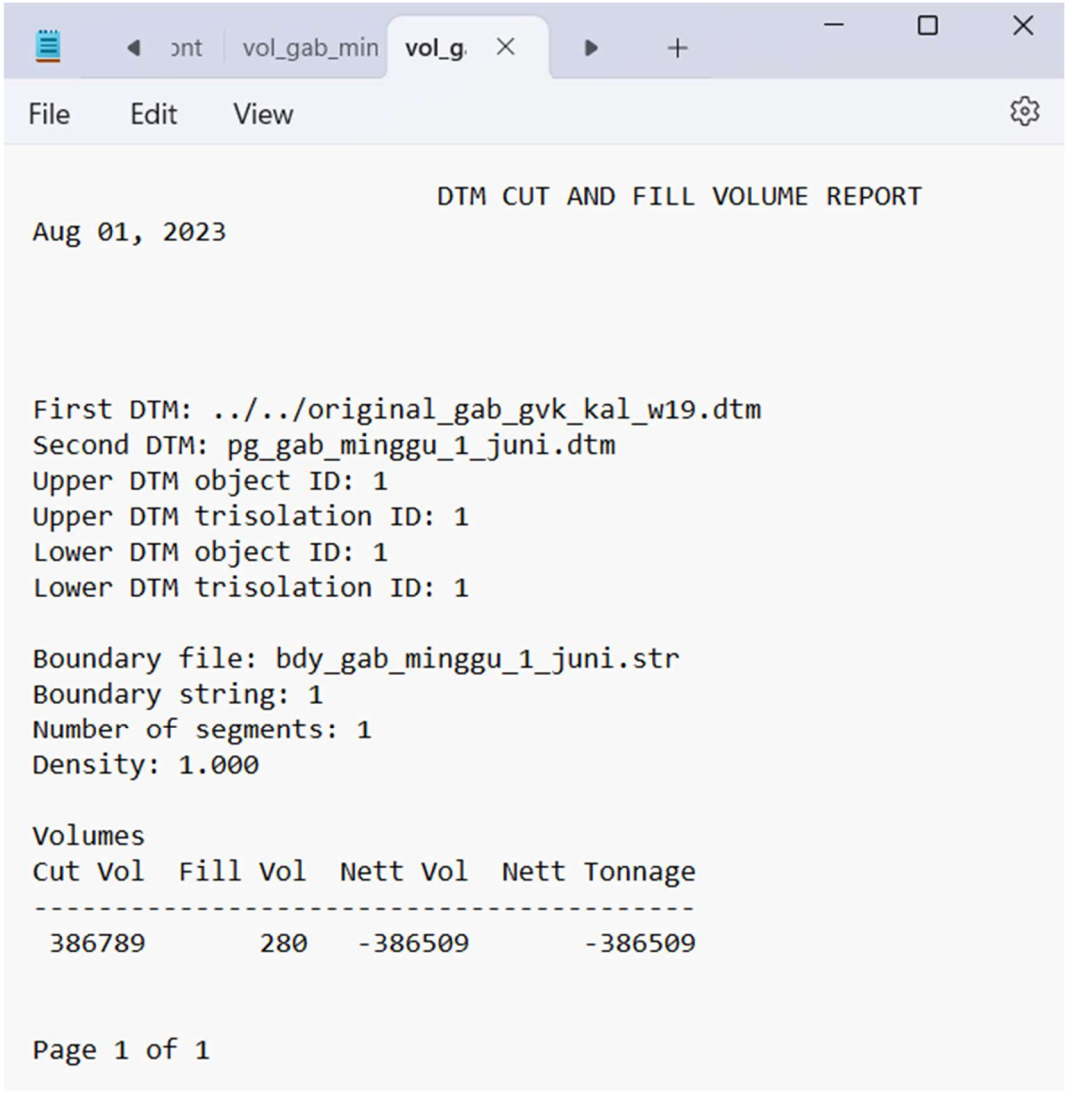


Lampiran 2

Perhitungan Volume

Volume minggu 1



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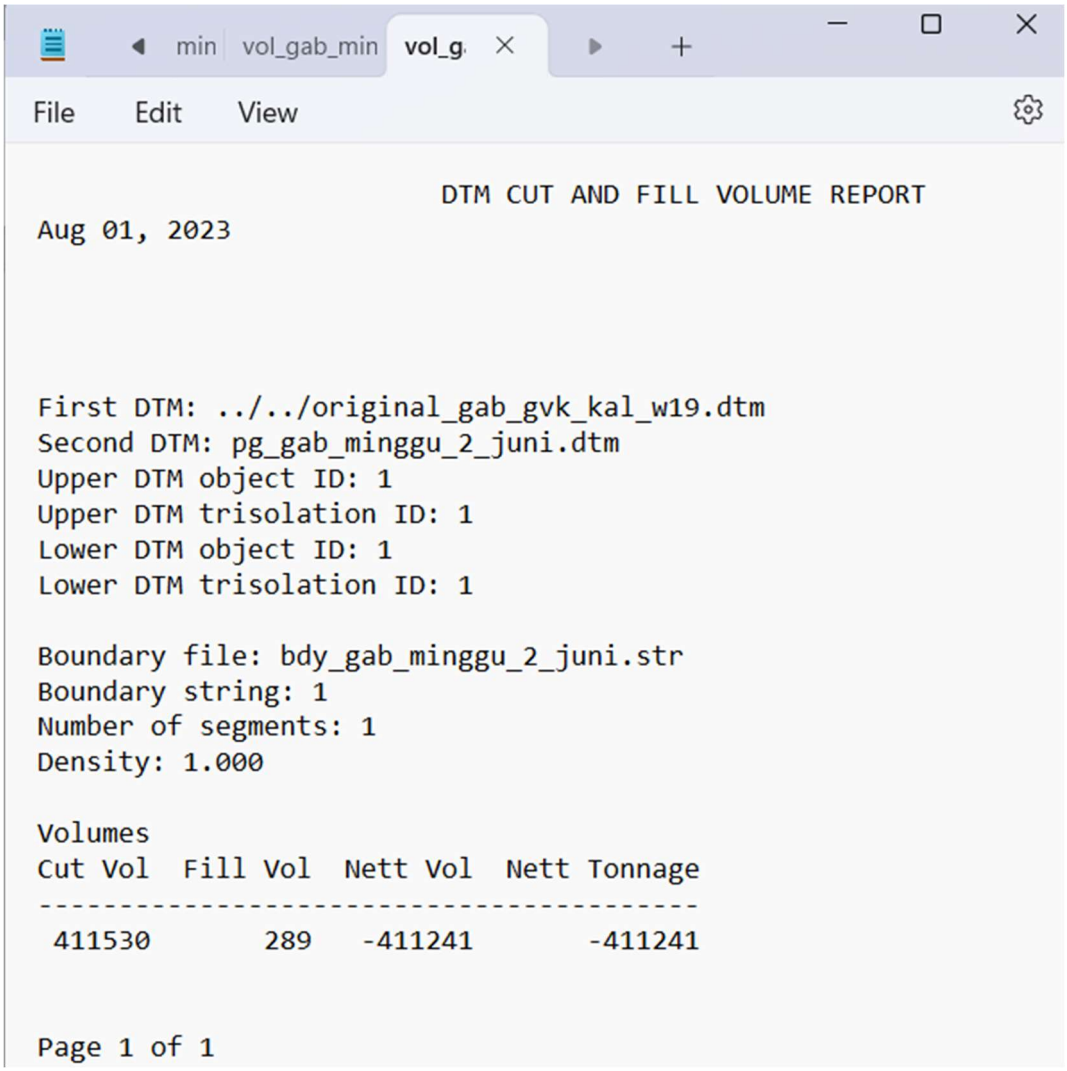

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File Edit View

DTM CUT AND FILL VOLUME REPORT

Aug 01, 2023

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Upper DTM trisolation ID: 1
Lower DTM object ID: 1
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Boundary string: 1
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Volumes

Cut Vol	Fill Vol	Nett Vol	Nett Tonnage
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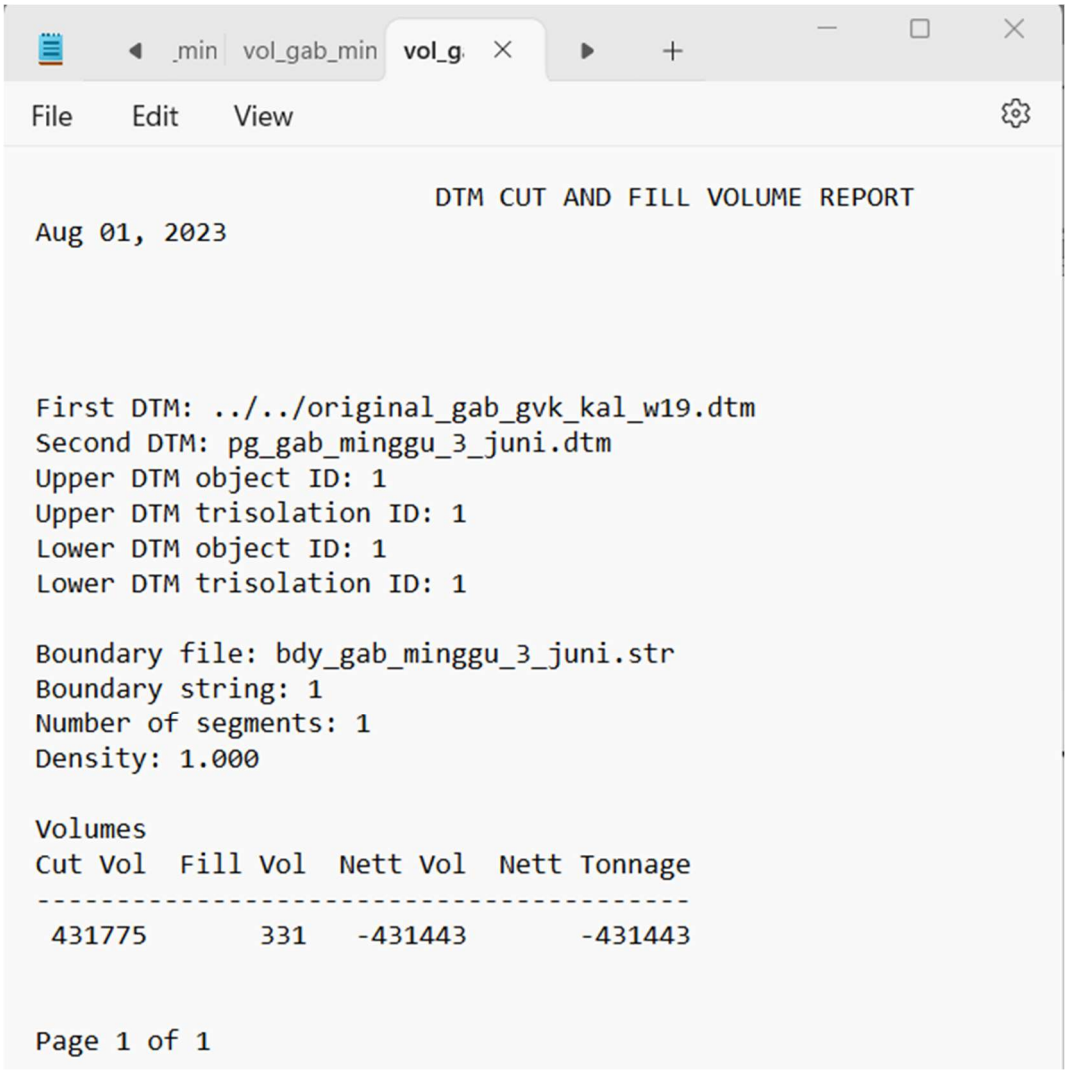
Page 1 of 1

Volume minggu 3



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Volumes

Cut Vol	Fill Vol	Nett Vol	Nett Tonnage
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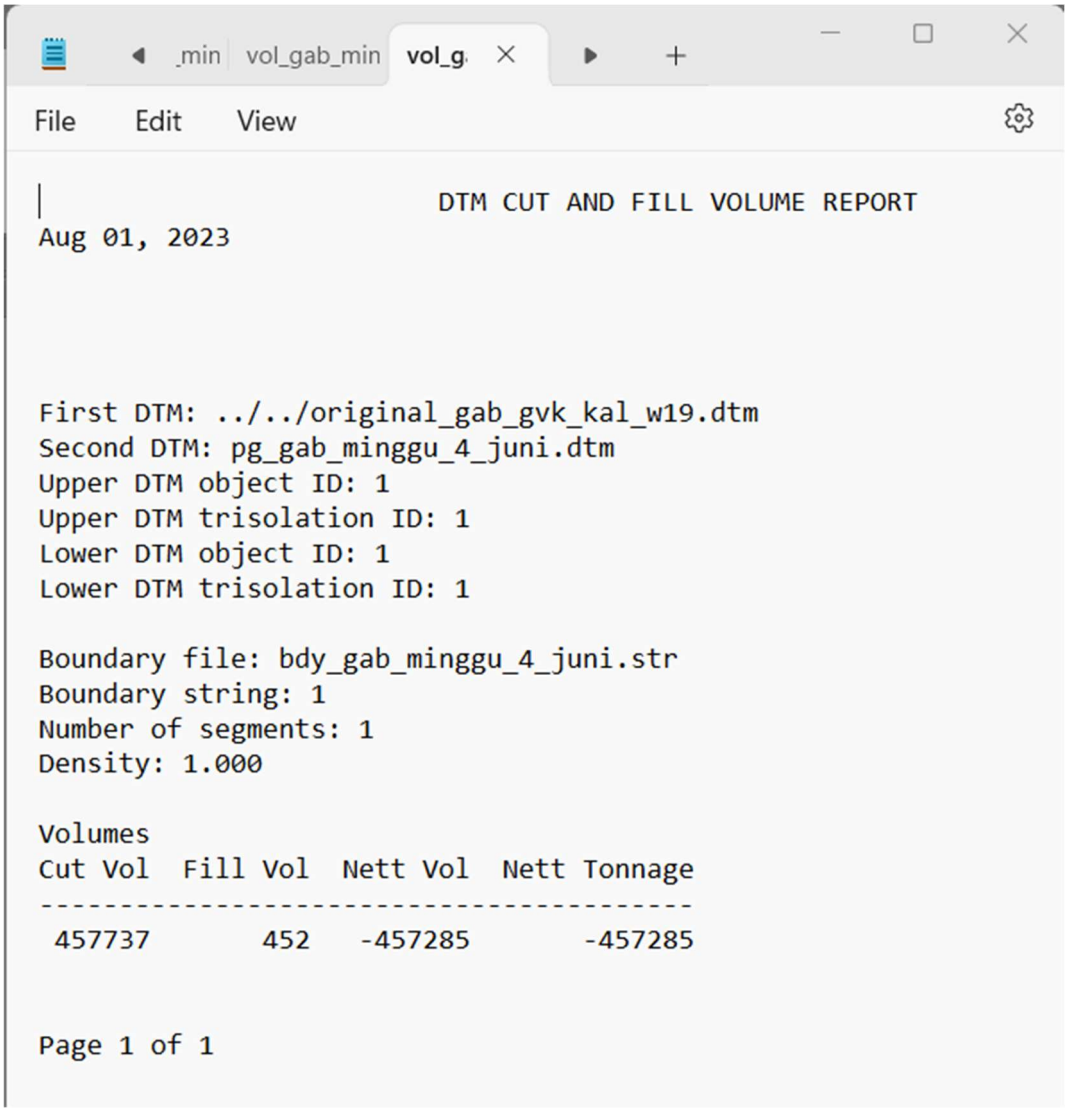
Page 1 of 1

Volume minggu 4



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Density: 1.000

Volumes

Cut Vol	Fill Vol	Nett Vol	Nett Tonnage
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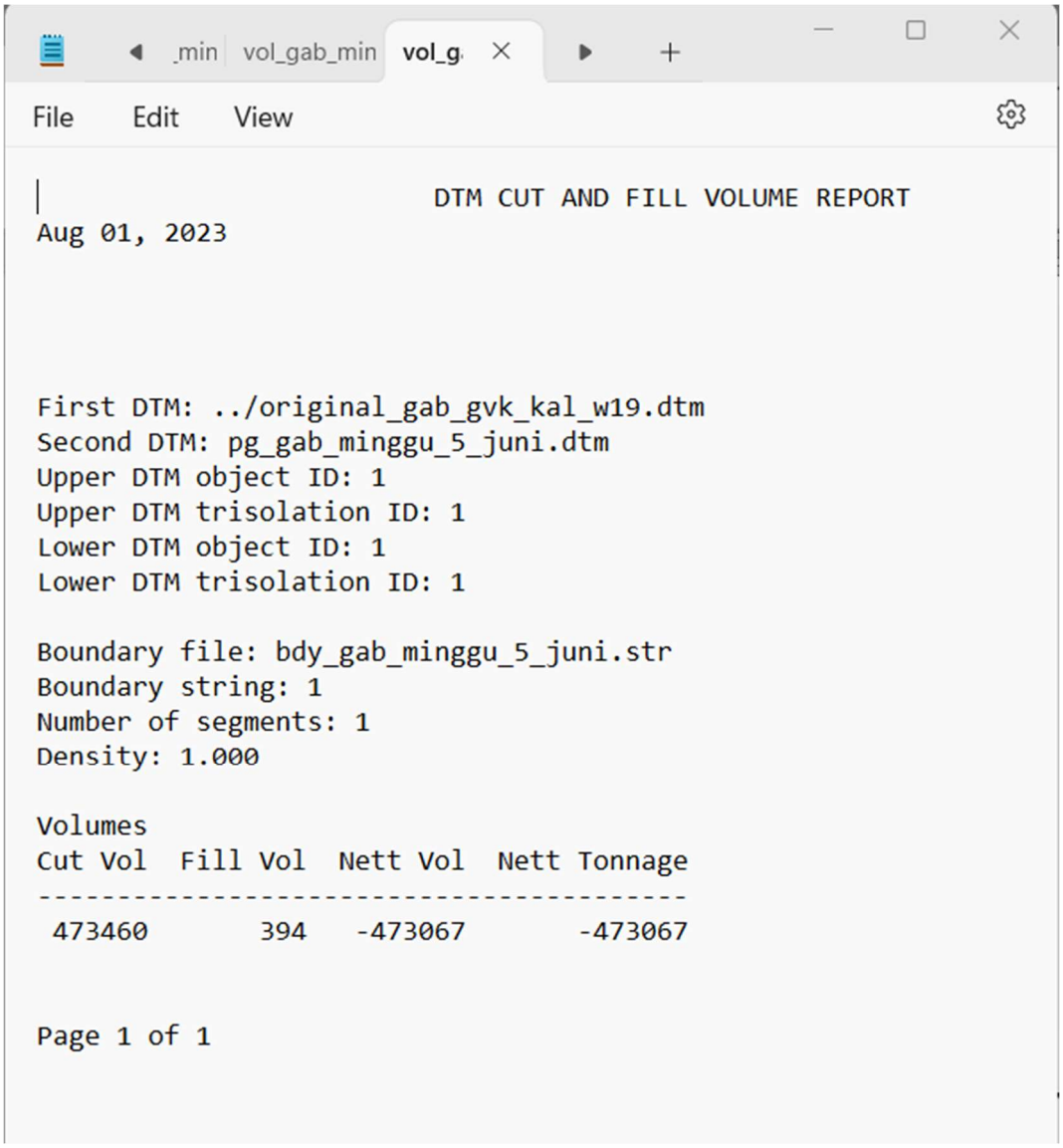
Page 1 of 1

Volume Minggu 5



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Volumes

Cut Vol	Fill Vol	Nett Vol	Nett Tonnage
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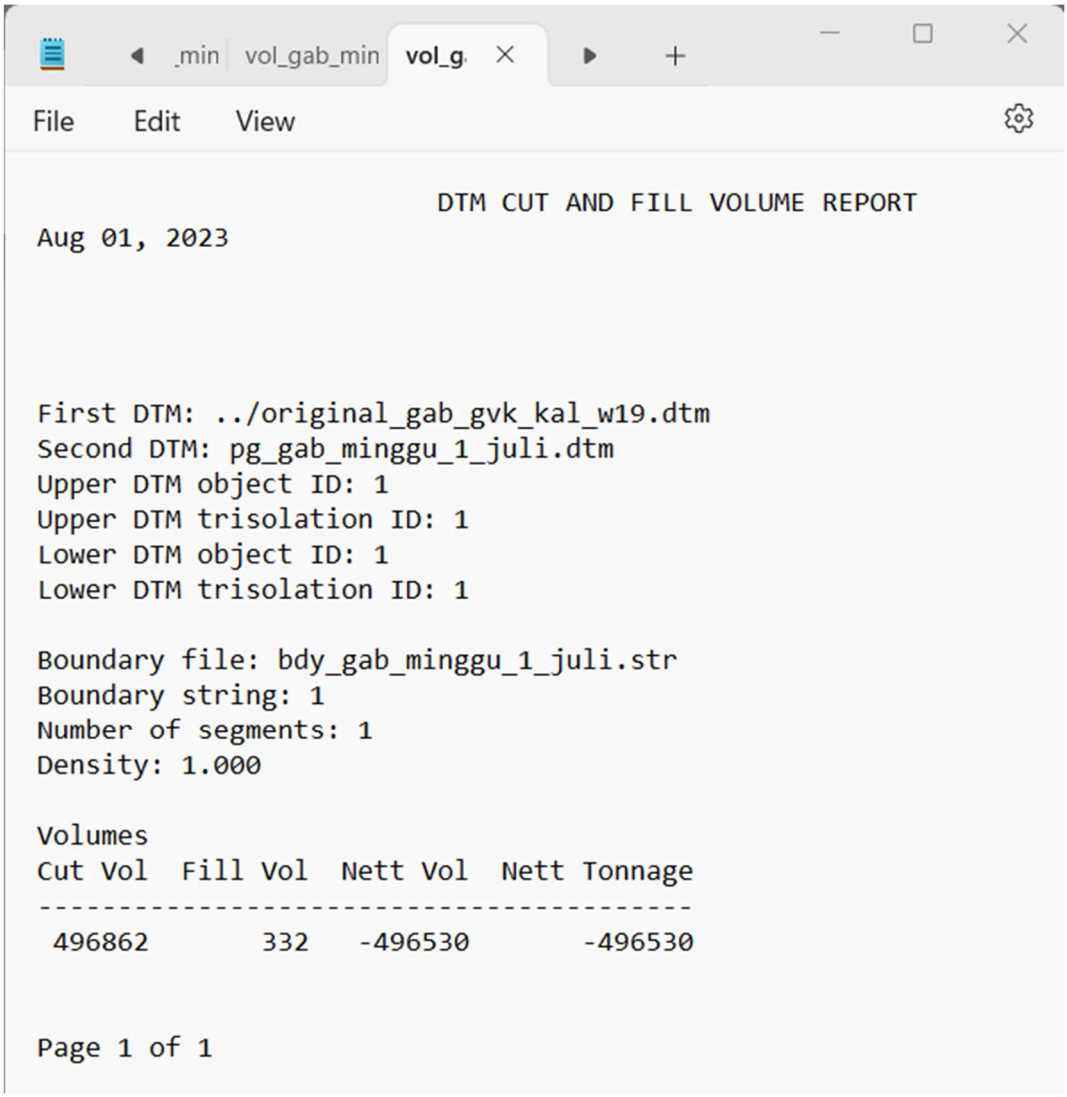
Page 1 of 1

Volume minggu 1



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Aug 01, 2023

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Volumes

Cut Vol	Fill Vol	Nett Vol	Nett Tonnage
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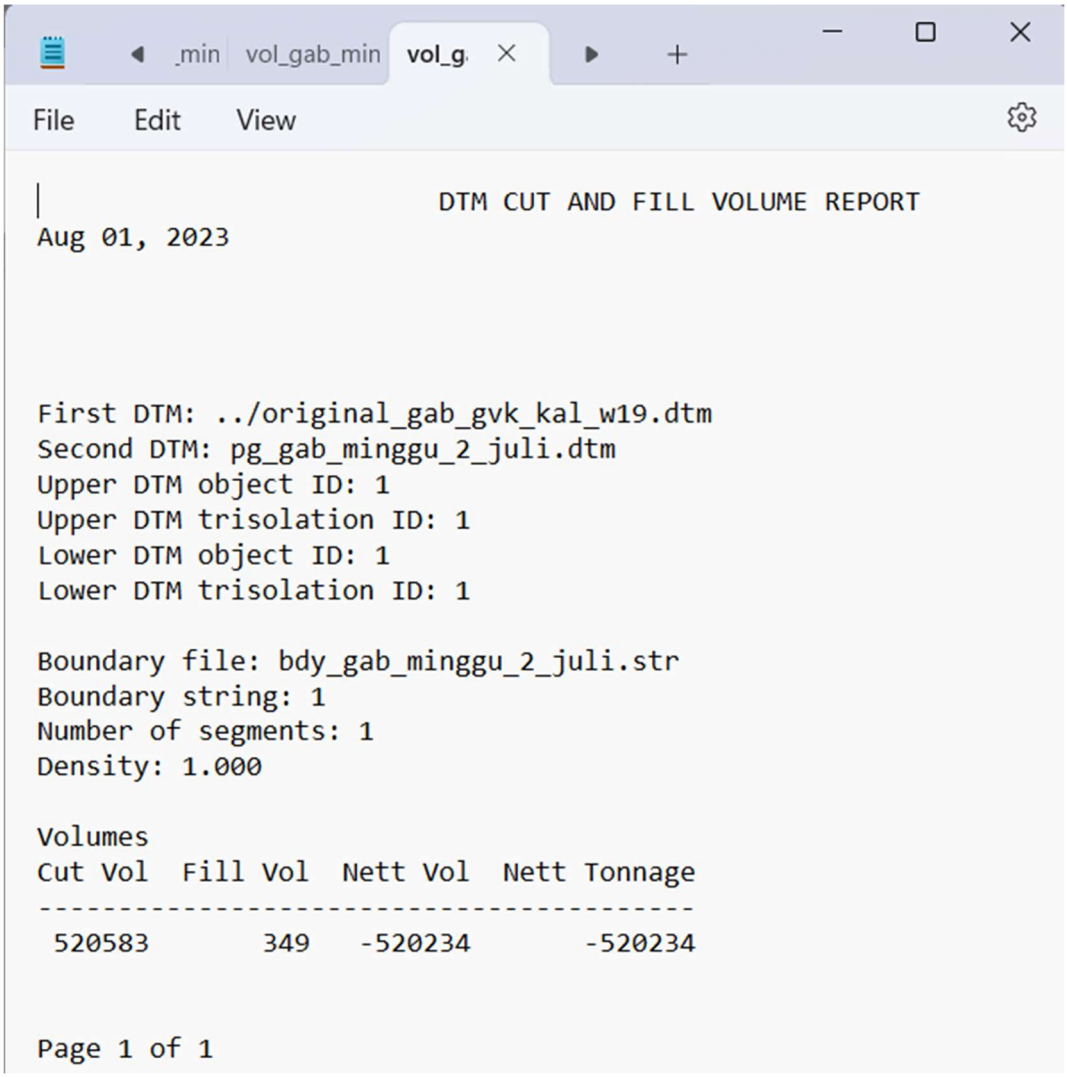
Page 1 of 1

Volume minggu 2



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                        DTM CUT AND FILL VOLUME REPORT
Aug 01, 2023



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Number of segments: 1
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Volumes
Cut Vol   Fill Vol   Nett Vol   Nett Tonnage
-----------------------------------------
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Page 1 of 1
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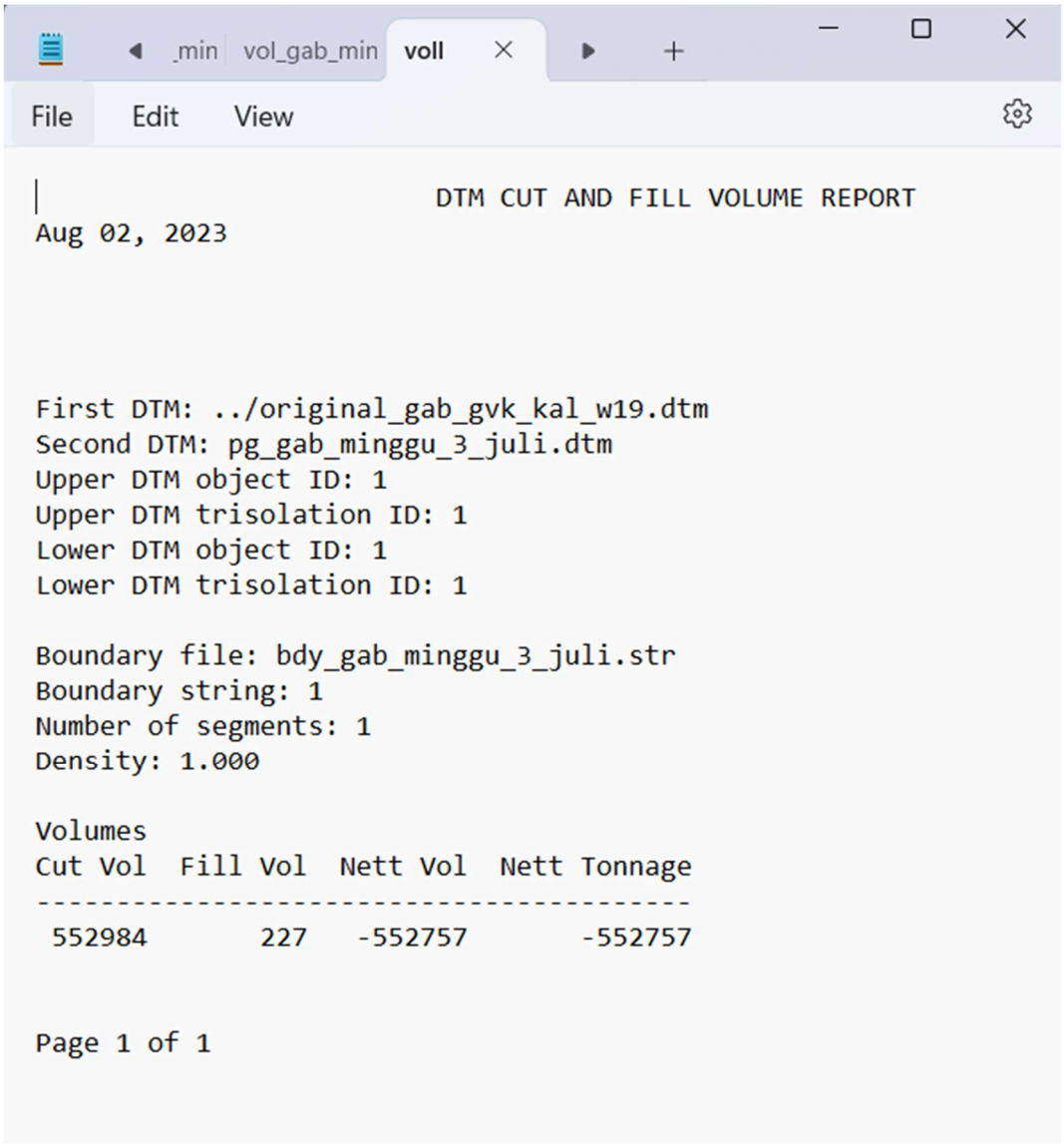
Volume minggu 3



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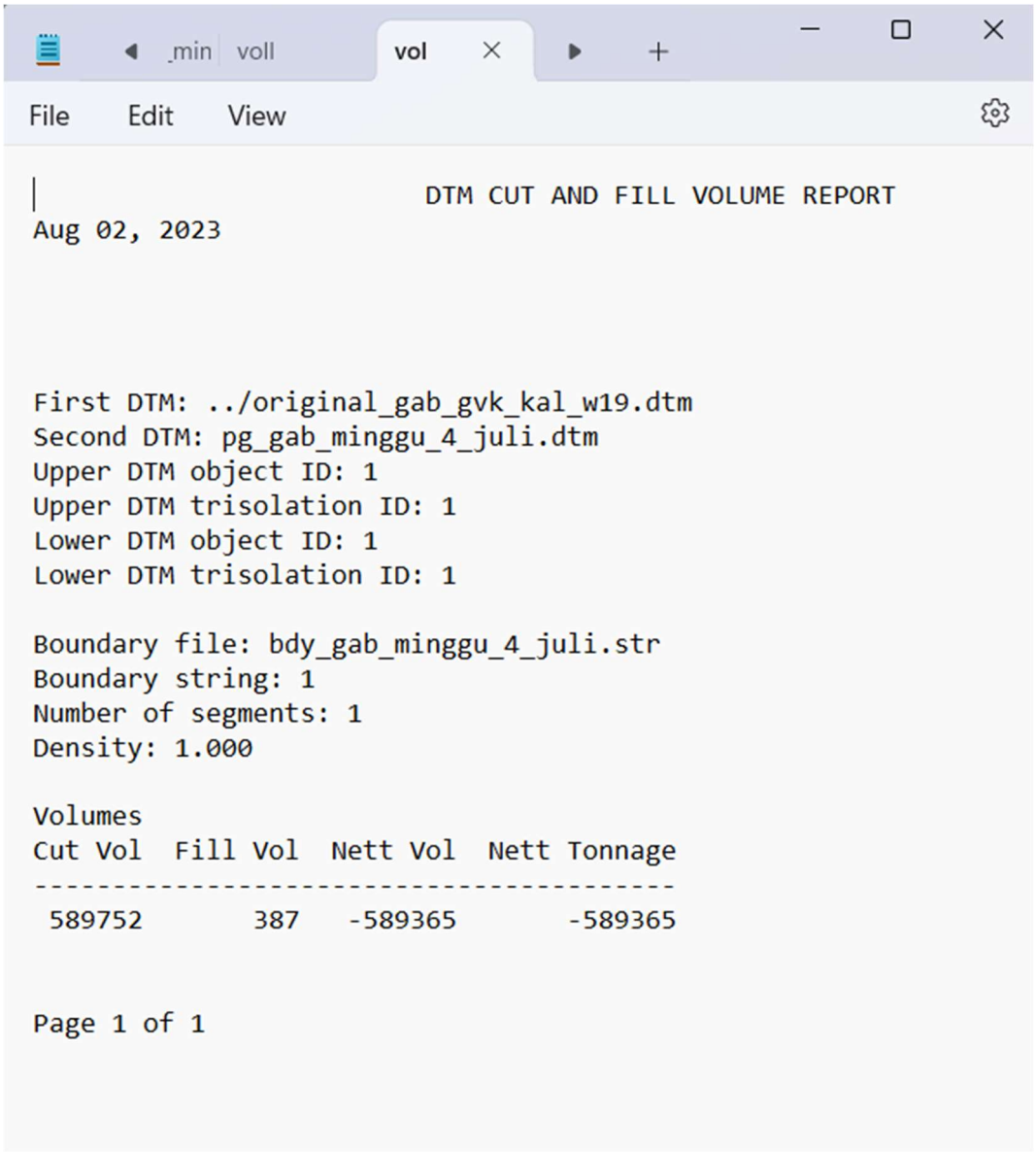


Lampiran 3

Survey lapangan

Lampiran 4

Titik Persentase Distribusi t (df = 1 – 40)

Pr df	0.25 0.50	0.10 0.20	0.05 0.10	0.025 0.050	0.01 0.02	0.005 0.010	0.001 0.002
1	1.00000	3.07768	6.31375	12.70620	31.82052	63.65674	318.30884
2	0.81650	1.88562	2.91999	4.30265	6.96456	9.92484	22.32712
3	0.76489	1.63774	2.35336	3.18245	4.54070	5.84091	10.21453
4	0.74070	1.53321	2.13185	2.77645	3.74695	4.60409	7.17318
5	0.72669	1.47588	2.01505	2.57058	3.36493	4.03214	5.89343
6	0.71756	1.43976	1.94318	2.44691	3.14267	3.70743	5.20763
7	0.71114	1.41492	1.89458	2.36462	2.99795	3.49948	4.78529
8	0.70639	1.39682	1.85955	2.30600	2.89646	3.35539	4.50079
9	0.70272	1.38303	1.83311	2.26216	2.82144	3.24984	4.29681
10	0.69981	1.37218	1.81246	2.22814	2.76377	3.16927	4.14370
11	0.69745	1.36343	1.79588	2.20099	2.71808	3.10581	4.02470
12	0.69548	1.35622	1.78229	2.17881	2.68100	3.05454	3.92963
13	0.69383	1.35017	1.77093	2.16037	2.65031	3.01228	3.85198
14	0.69242	1.34503	1.76131	2.14479	2.62449	2.97684	3.78739
15	0.69120	1.34061	1.75305	2.13145	2.60248	2.94671	3.73283
16	0.69013	1.33676	1.74588	2.11991	2.58349	2.92078	3.68615
17	0.68920	1.33338	1.73961	2.10982	2.56693	2.89823	3.64577
18	0.68836	1.33039	1.73406	2.10092	2.55238	2.87844	3.61048
19	0.68762	1.32773	1.72913	2.09302	2.53948	2.86093	3.57940
20	0.68695	1.32534	1.72472	2.08596	2.52798	2.84534	3.55181
21	0.68635	1.32319	1.72074	2.07961	2.51765	2.83136	3.52715
22	0.68581	1.32124	1.71714	2.07387	2.50832	2.81876	3.50499
23	0.68531	1.31946	1.71387	2.06866	2.49987	2.80734	3.48496
24	0.68485	1.31784	1.71088	2.06390	2.49216	2.79694	3.46678
25	0.68443	1.31635	1.70814	2.05954	2.48511	2.78744	3.45019
26	0.68404	1.31497	1.70562	2.05553	2.47863	2.77871	3.43500
27	0.68368	1.31370	1.70329	2.05183	2.47266	2.77068	3.42103
28	0.68335	1.31253	1.70113	2.04841	2.46714	2.76326	3.40816
29	0.68304	1.31143	1.69913	2.04523	2.46202	2.75639	3.39624
30	0.68276	1.31042	1.69726	2.04227	2.45726	2.75000	3.38518
31	0.68249	1.30946	1.69552	2.03951	2.45282	2.74404	3.37490
32	0.68223	1.30857	1.69389	2.03693	2.44868	2.73848	3.36531
33	0.68200	1.30774	1.69236	2.03452	2.44479	2.73328	3.35634
34	0.68177	1.30695	1.69092	2.03224	2.44115	2.72839	3.34793
35	0.68156	1.30621	1.68957	2.03011	2.43772	2.72381	3.34005
36	0.68137	1.30551	1.68830	2.02809	2.43449	2.71948	3.33262
37	0.68118	1.30485	1.68709	2.02619	2.43145	2.71541	3.32563
38	0.68100	1.30423	1.68595	2.02439	2.42857	2.71156	3.31903
39	0.68083	1.30364	1.68488	2.02269	2.42584	2.70791	3.31279
40	0.68067	1.30308	1.68385	2.02108	2.42326	2.70446	3.30688

Catatan: Probabilita yang lebih kecil yang ditunjukkan pada judul tiap kolom adalah luas daerah dalam satu ujung, sedangkan probabilitas yang lebih besar adalah luas daerah dalam kedua ujung

Tabel Uji F

$\alpha = 0{,}05$	$df_1 = (k-1)$							
$df_2 = (n-k-1)$	1	2	3	4	5	6	7	8
1	161.448	199,500	215.707	224,583	230,162	233.986	236,768	238,883
2	18,513	19,000	19,164	19,247	19,296	19,330	19,353	19,371
3	10,128	9,552	9,277	9,117	9,013	8,941	8,887	8,845
4	7,709	6,944	6,591	6,388	6,256	6,163	6,094	6,041
5	6,608	5,786	5,409	5,192	5,050	4,950	4,876	4,818
6	5,987	5,143	4,757	4,534	4,387	4,284	4,207	4,147
7	5,591	4,737	4,347	4,120	3,972	3,866	3,787	3,726
8	5,318	4,459	4,066	3,838	3,687	3,581	3,500	3,438
9	5,117	4,256	3,863	3,633	3,482	3,374	3,293	3,230
10	4,965	4,103	3,708	3,478	3,326	3,217	3,135	3,072
11	4,844	3,982	3,587	3,357	3,204	3,095	3,012	2,948
12	4,747	3,885	3,490	3,259	3,106	2,996	2,913	2,849
13	4,667	3,806	3,411	3,179	3,025	2,915	2,832	2,767
14	4,600	3,739	3,344	3,112	2,958	2,848	2,764	2,699
15	4,543	3,682	3,287	3,056	2,901	2,790	2,707	2,641
16	4,494	3,634	3,239	3,007	2,852	2,741	2,657	2,591
17	4,451	3,592	3,197	2,965	2,810	2,699	2,614	2,548
18	4,414	3,555	3,160	2,928	2,773	2,661	2,577	2,510
19	4,381	3,522	3,127	2,895	2,740	2,628	2,544	2,477
20	4,351	3,493	3,098	2,866	2,711	2,599	2,514	2,447
21	4,325	3,467	3,072	2,840	2,685	2,573	2,488	2,420
22	4,301	3,443	3,049	2,817	2,661	2,549	2,464	2,397
23	4,279	3,422	3,028	2,796	2,640	2,528	2,442	2,375
24	4,260	3,403	3,009	2,776	2,621	2,508	2,423	2,355
25	4,242	3,385	2,991	2,759	2,603	2,490	2,405	2,337
26	4,225	3,369	2,975	2,743	2,587	2,474	2,388	2,321
27	4,210	3,354	2,960	2,728	2,572	2,459	2,373	2,305
28	4,196	3,340	2,947	2,714	2,558	2,445	2,359	2,291
29	4,183	3,328	2,934	2,701	2,545	2,432	2,346	2,278

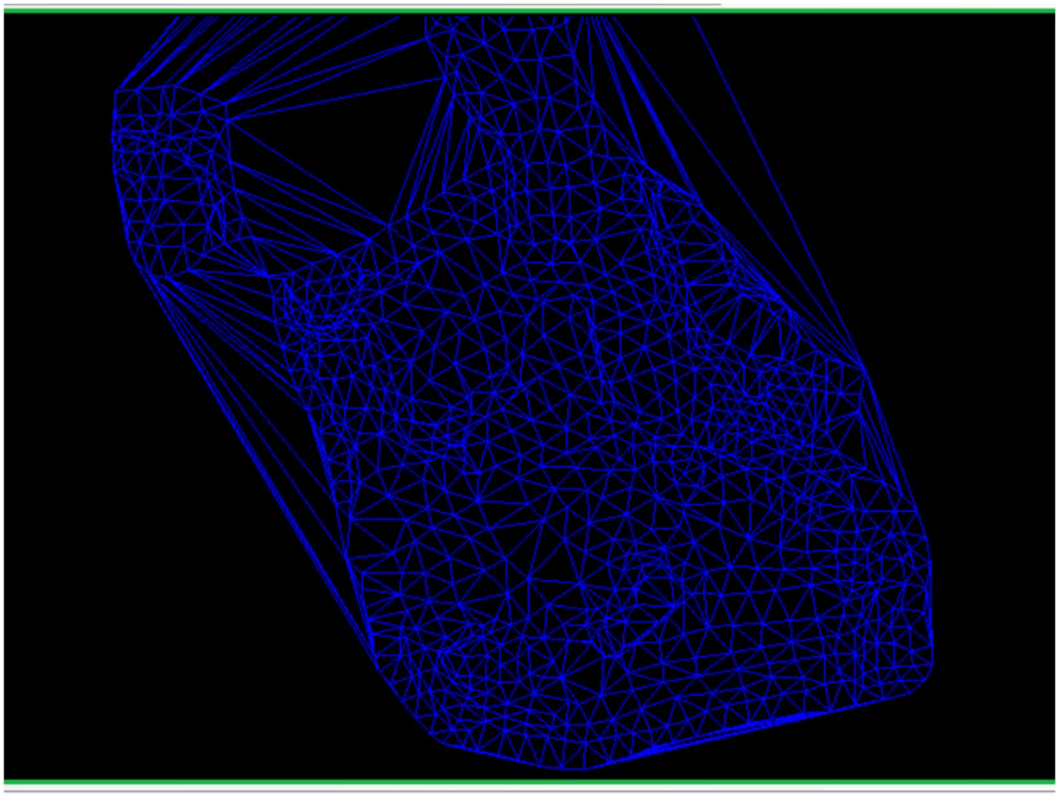
Tabel uji Normalitas Shapiro Wilk

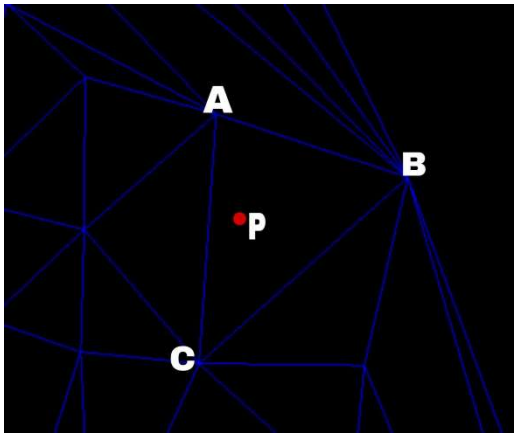
Table 2 - p-values

n \ p	0.01	0.02	0.05	0.1	0.5	0.9	0.95	0.98	0.99
3	0.753	0.756	0.767	0.789	0.959	0.998	0.999	1.000	1.000
4	0.687	0.707	0.748	0.792	0.935	0.987	0.992	0.996	0.997
5	0.686	0.715	0.762	0.806	0.927	0.979	0.986	0.991	0.993
6	0.713	0.743	0.788	0.826	0.927	0.974	0.981	0.986	0.989
7	0.730	0.760	0.803	0.838	0.928	0.972	0.979	0.985	0.988
8	0.749	0.778	0.818	0.851	0.932	0.972	0.978	0.984	0.987
9	0.764	0.791	0.829	0.859	0.935	0.972	0.978	0.984	0.986
10	0.781	0.806	0.842	0.869	0.938	0.972	0.978	0.983	0.986
11	0.792	0.817	0.850	0.876	0.940	0.973	0.979	0.984	0.986
12	0.805	0.828	0.859	0.883	0.943	0.973	0.979	0.984	0.986
13	0.814	0.837	0.866	0.889	0.945	0.974	0.979	0.984	0.986
14	0.825	0.846	0.874	0.895	0.947	0.975	0.980	0.984	0.986
15	0.835	0.855	0.881	0.901	0.950	0.975	0.980	0.984	0.987
16	0.844	0.863	0.887	0.906	0.952	0.976	0.981	0.985	0.987
17	0.851	0.869	0.892	0.910	0.954	0.977	0.981	0.985	0.987
18	0.858	0.874	0.897	0.914	0.956	0.978	0.982	0.986	0.988
19	0.863	0.879	0.901	0.917	0.957	0.978	0.982	0.986	0.988
20	0.868	0.884	0.905	0.920	0.959	0.979	0.983	0.986	0.988
21	0.873	0.888	0.908	0.923	0.960	0.980	0.983	0.987	0.989
22	0.878	0.892	0.911	0.926	0.961	0.980	0.984	0.987	0.989
23	0.881	0.895	0.914	0.928	0.962	0.981	0.984	0.987	0.989
24	0.884	0.898	0.916	0.930	0.963	0.981	0.984	0.987	0.989
25	0.888	0.901	0.918	0.931	0.964	0.981	0.985	0.988	0.989

Lampiran 5

Contoh perhitungan interpolasi (TIN) untuk DTM minggu ke 1





A(Xa,Ya,Za)

A(299665.236,9686301.589,337.529)

B(Xb,Yb,Zb)

B(2996770.263,9686299.928,337.943)

C(Xc,Yc,Zc)

C(299664.791,9686295.046,337.334)

P(Xp,Yp)

P(29965,9686297)

$$a = \frac{\begin{vmatrix} 337.529 & 9686301.589 & 1 \\ 337.943 & 9686299.928 & 1 \\ 337.334 & 9686295.046 & 1 \end{vmatrix}}{\begin{vmatrix} 299665.236 & 9686301.589 & 1 \\ 299670.263 & 9686299.928 & 1 \\ 299664.791 & 9686295.046 & 1 \end{vmatrix}} = 0.0902$$

$$b = \frac{\begin{vmatrix} 299665.236 & 337.529 & 1 \\ 299670.263 & 337.943 & 1 \\ 299664.791 & 337.334 & 1 \end{vmatrix}}{\begin{vmatrix} 299665.236 & 9686301.589 & 1 \\ 299670.263 & 9686299.928 & 1 \\ 299664.791 & 9686295.046 & 1 \end{vmatrix}} = 0.0237$$

$$c = \frac{\begin{vmatrix} 299665.236 & 9686301.589 & 337.529 \\ 299670.263 & 9686299.928 & 337.943 \\ 299664.791 & 9686295.046 & 337.334 \end{vmatrix}}{\begin{vmatrix} 299665.236 & 9686301.589 & 1 \\ 299670.263 & 9686299.928 & 1 \\ 299664.791 & 9686295.046 & 1 \end{vmatrix}} = -255958.1110$$

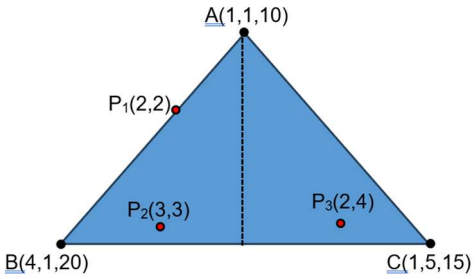
$$z_p(x, y) = ax_p + by_p + c$$

$$z_p(\mathbf{299665, 9686297}) = (\mathbf{0.0902})(\mathbf{299665}) + (\mathbf{0.0237})(\mathbf{9686297}) - (\mathbf{255958.1110})$$

z_p=337.40

diperoleh koordinat pada titik P adalah P(29965,9686297,337.40)

Lampiran 6
Perhitungan interpolasi TIN dan penyebaran kesalahan vertikal dan horizontal



Tentukan nilai koordinat Z dan penyebaran kesalahannya di titik P1, P2 dan P3

a. Menghitung koordinat Z di titik P1, P2 dan P3

1. Menghitung nilai a, b dan c

Menghitung nilai a, b dan c menggunakan persamaan (22)

$$a = \frac{\begin{vmatrix} z_1 & y_1 & 1 \\ z_2 & y_2 & 1 \\ z_3 & y_3 & 1 \end{vmatrix}}{\begin{vmatrix} x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_3 & y_3 & 1 \end{vmatrix}} = \frac{\begin{vmatrix} 10 & 1 & 1 \\ 20 & 1 & 1 \\ 15 & 1 & 1 \end{vmatrix} \begin{matrix} 10 & 1 \\ 20 & 1 \\ 15 & 5 \end{matrix}}{\begin{vmatrix} 1 & 1 & 1 \\ 4 & 1 & 1 \\ 1 & 5 & 1 \end{vmatrix} \begin{matrix} 1 & 1 \\ 4 & 1 \\ 1 & 5 \end{matrix}}$$

$$= \frac{\big((10 \times 1 \times 1) + (1 \times 1 \times 15) + (1 \times 20 \times 5)\big) - \big((15 \times 1 \times 1) + (5 \times 1 \times 10) + (1 \times 20 \times 1)\big)}{\big((1 \times 1 \times 1) + (1 \times 1 \times 1) + (1 \times 4 \times 5)\big) - \big((1 \times 1 \times 1) + (5 \times 1 \times 1) + (1 \times 4 \times 1)\big)}$$

$$= 3{,}33$$

$$b = \frac{\begin{vmatrix} x_1 & z_1 & 1 \\ x_2 & z_2 & 1 \\ x_3 & z_3 & 1 \end{vmatrix}}{\begin{vmatrix} x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_3 & y_3 & 1 \end{vmatrix}} = \frac{\begin{vmatrix} 1 & 10 & 1 \\ 4 & 20 & 1 \\ 1 & 15 & 1 \end{vmatrix} \begin{matrix} 1 & 10 \\ 4 & 20 \\ 1 & 15 \end{matrix}}{\begin{vmatrix} 1 & 1 & 1 \\ 4 & 1 & 1 \\ 1 & 5 & 1 \end{vmatrix} \begin{matrix} 1 & 1 \\ 4 & 1 \\ 1 & 5 \end{matrix}}$$

$$= \frac{\big((1 \times 20 \times 1) + (10 \times 1 \times 1) + (1 \times 4 \times 15)\big) - \big((1 \times 20 \times 1) + (1 \times 5 \times 1) + (1 \times 4 \times 10)\big)}{\big((1 \times 1 \times 1) + (1 \times 1 \times 1) + (1 \times 4 \times 5)\big) - \big((1 \times 1 \times 1) + (5 \times 1 \times 1) + (1 \times 4 \times 1)\big)}$$

$$= 1{,}25$$

$$c = \frac{\begin{vmatrix} x_1 & y_1 & z_1 \\ x_2 & y_2 & z_2 \\ x_3 & y_3 & z_3 \end{vmatrix}}{\begin{vmatrix} x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_3 & y_3 & 1 \end{vmatrix}} = \frac{\begin{vmatrix} 1 & 1 & 10 \\ 4 & 1 & 20 \\ 1 & 5 & 15 \end{vmatrix} \begin{matrix} 1 & 1 \\ 4 & 1 \\ 1 & 5 \end{matrix}}{\begin{vmatrix} 1 & 1 & 1 \\ 4 & 1 & 1 \\ 1 & 5 & 1 \end{vmatrix} \begin{matrix} 1 & 1 \\ 4 & 1 \\ 1 & 5 \end{matrix}}$$

$$= \frac{\big((1 \times 1 \times 15) + (1 \times 20 \times 1) + (10 \times 4 \times 5)\big) - \big((1 \times 1 \times 10) + (5 \times 20 \times 1) + (15 \times 4 \times 1)\big)}{\big((1 \times 1 \times 1) + (1 \times 1 \times 1) + (1 \times 4 \times 5)\big) - \big((1 \times 1 \times 1) + (5 \times 1 \times 1) + (1 \times 4 \times 1)\big)}$$

$$= 5{,}42$$

Diperoleh nilai a=3,33 nilai b=1,25 dan nilai c=5,42

2. Menghitung koordinat z di titik P

Menghitung koordinat Z di titik P1, P2 dan P3 menggunakan persamaan (21)

$$Z_{p1}(2,2) = 3{,}33 \times 2 + 1{,}25 \times 2 + 5{,}42 = 6{,}66 + 2{,}5 + 5{,}42 = 14{,}58 = 15$$

$$Z_{p2}(3,3) = 3{,}33 \times 3 + 1{,}25 \times 3 + 5{,}42 = 9{,}99 + 3{,}75 + 5{,}42 = 19{,}16 = 19$$

$$Z_{p3}(2,4) = 3{,}33 \times 2 + 1{,}25 \times 4 + 5{,}42 = 6{,}66 + 5 + 5{,}42 = 17{,}08 = 17$$

Diperoleh koordinat di titik **P1(2,2,15) P2(3,3,19)** dan **P3(2,4,17)**

b. Menghitung penyebaran kesalahan vertikal di titik P1, P2 dan P3

1. Menghitung nilai a1, a2, a3, b1, b2, b3, c1, c2 dan c3

Menghitung nilai a1, a2, a3, b1, b2, b3, c1, c2 dan c3 menggunakan persamaan (23)

$$L = (x_1y_2) + (x_3y_1) + (x_2y_3) - (x_3y_2) - (x_1y_3) - (x_2y_1)$$
$$= 1 \times 1 + 1 \times 1 + 4 \times 5 - 1 \times 1 - 1 \times 5 - 4 \times 1 = 12$$

$$a_1 = \frac{y_2 - y_3}{L} = \frac{1-5}{12} = -0{,}33$$

$$a_2 = \frac{y_3 - y_1}{L} = \frac{5-1}{12} = 0{,}33$$

$$a_3 = \frac{y_1 - y_2}{L} = \frac{1-1}{12} = 0$$

$$b_1 = \frac{x_3 - x_2}{L} = \frac{1-4}{12} = -0{,}25$$

$$b_2 = \frac{x_1 - x_3}{L} = \frac{1-1}{12} = 0$$

$$b_3 = \frac{x_2 - x_1}{L} = \frac{4-1}{12} = 0{,}25$$

$$c_1 = \frac{x_2y_3 - x_3y_2}{L} = \frac{20-1}{12} = 1{,}58$$

$$c_2 = \frac{x_3y_1 - x_1y_3}{L} = \frac{1-1}{12} = 0$$

$$c_3 = \frac{x_1y_1 - x_2y_1}{L} = \frac{1-5}{12} = -0{,}33$$

2. Menghitung variansi titik simpul Z

$$\sigma^2_{znode} = \frac{(z_1 - \bar{z})^2 + (z_2 - \bar{z})^2 + (z_3 - \bar{z})^2}{n-1} = \frac{(10-15)^2 + (20-15)^2 + (15-5)^2}{3-1} = 25$$

3. Menghitung nilai m

Menghitung nilai m1, m2 dan m3 untuk titik P1 menggunakan persamaan (27)

$$\begin{bmatrix} m_1 \\ m_2 \\ m_3 \end{bmatrix}^T = \begin{bmatrix} x_{p1} \\ y_{p1} \\ 1 \end{bmatrix}^T \begin{bmatrix} a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \\ c_1 & c_2 & c_3 \end{bmatrix}$$

$$[m_1 \quad m_2 \quad m_3] = [2 \quad 2 \quad 1] \begin{bmatrix} -0{,}33 & 0{,}33 & 0 \\ -0{,}25 & 0 & 0{,}25 \\ 1{,}58 & 0 & -0{,}33 \end{bmatrix}$$

$$[m_1 \quad m_2 \quad m_3]$$
$$= [2 \times -0{,}33 + 2 \times -0{,}25 + 1 \times 1{,}58 \quad 2 \times 0{,}33 + 2 \times 0 + 1 \times 0 \quad 2 \times 0 + 2 \times 0{,}25 + 1 \times -0{,}33]$$

$$[m_1 \quad m_2 \quad m_3] = [0{,}42 \quad 0{,}66 \quad 0{,}17]$$

Diperoleh nilai m1, m2 dan m3 untuk titip P1 yaitu m1=0,42 m2=0,66 dan m3=0,17

Menghitung nilai m1, m2 dan m3 untuk titik P2 menggunakan persamaan (27)

$$\begin{bmatrix} m_1 \\ m_2 \\ m_3 \end{bmatrix}^T = \begin{bmatrix} x_{p2} \\ y_{p2} \\ 1 \end{bmatrix}^T \begin{bmatrix} a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \\ c_1 & c_2 & c_3 \end{bmatrix}$$

$$[m_1 \quad m_2 \quad m_3] = [3 \quad 3 \quad 1] \begin{bmatrix} -0{,}33 & 0{,}33 & 0 \\ -0{,}25 & 0 & 0{,}25 \\ 1{,}58 & 0 & -0{,}33 \end{bmatrix}$$

$$[m_1 \quad m_2 \quad m_3]$$
$$= [3 \times -0{,}33 + 3 \times -0{,}25 + 1 \times 1{,}58 \quad 3 \times 0{,}33 + 3 \times 0 + 1 \times 0 \quad 3 \times 0 + 3 \times 0{,}25 + 1 \times -0{,}33]$$

$$[m_1 \quad m_2 \quad m_3] = [-0{,}16 \quad 0{,}99 \quad 0{,}42]$$

Diperoleh nilai m1, m2 dan m3 untuk titip P2 yaitu m1=-0,16 m2=0,99 dan m3=0,42

Menghitung nilai m1, m2 dan m3 untuk titik P3 menggunakan persamaan (27)

$$\begin{bmatrix} m_1 \\ m_2 \\ m_3 \end{bmatrix}^T = \begin{bmatrix} x_{p3} \\ y_{p3} \\ 1 \end{bmatrix}^T \begin{bmatrix} a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \\ c_1 & c_2 & c_3 \end{bmatrix}$$

$$[m_1 \quad m_2 \quad m_3] = [2 \quad 4 \quad 1] \begin{bmatrix} -0{,}33 & 0{,}33 & 0 \\ -0{,}25 & 0 & 0{,}25 \\ 1{,}58 & 0 & -0{,}33 \end{bmatrix}$$

$$[m_1 \quad m_2 \quad m_3]$$
$$= [2 \times -0{,}33 + 4 \times -0{,}25 + 1 \times 1{,}58 \quad 2 \times 0{,}33 + 4 \times 0 + 1 \times 0 \quad 2 \times 0 + 4 \times 0{,}25 + 1 \times -0{,}33]$$

$$[m_1 \quad m_2 \quad m_3] = [-0{,}08 \quad 0{,}66 \quad 0{,}67]$$

Diperoleh nilai m1, m2 dan m3 untuk titip P2 yaitu m1=-0,08 m2=0,66 dan m3=0,67

4. Menghitung penyebaran kesalahan vertikal (σ_{zp}^2)

Menghitung penyebaran kesalahan vertikal untuk titik P1, P2 dan P3 menggunakan persamaan (29)

$$\sigma^2{}_{zp1} = (m_1^2 + m_2^2 + m_3^2)\sigma_{znode}^2 = (0{,}42^2 + 0{,}66^2 + 0{,}17^2)25 = 16{,}02$$

$$\sigma^2{}_{zp2} = (m_1^2 + m_2^2 + m_3^2)\sigma_{znode}^2 = (-0{,}16^2 + 0{,}99^2 + 0{,}42^2)25 = 29{,}55$$

$$\sigma^2{}_{zp3} = (m_1^2 + m_2^2 + m_3^2)\sigma_{znode}^2 = (0{,}08^2 + 0{,}66^2 + 0{,}67^2)25 = 22{,}28$$

Berdasarkan hasil perhitungan penyebaran kesalahan vertikal, diperoleh penyebaran kesalahan vertikal untuk titik P1 adalah **16,02** untuk titik P2 adalah **29,55** dan untuk titik P3 adalah **22,28.**

c. Menghitung penyebaran kesalahan horizontal

1. Menghitung nilai r

Menghitung nilai r_0, r_1, r_2, r_3, r_4, r_5 dan r_6 untuk P2 menggunakan persamaan (31)

$$\begin{aligned} r_0 &= x_{p1}[(z_3 - z_2)y_1 + (z_1 - z_3)y_2 + (z_2 - z_1)y_3] \\ &= 2[(15 - 20)1 + (10 - 15)1 + (20 - 10)5] \\ &= 80 \end{aligned}$$

$$r_1 = y_{p1}z_2 - y_{p1}z_3 + y_2z_3 - y_3z_2 = 2 \times 20 - 2 \times 15 + 1 \times 15 - 5 \times 20 = -75$$

$$r_2 = y_{p1}z_3 - y_{p1}z_1 + y_3z_1 - y_1z_3 = 2 \times 15 - 2 \times 10 + 5 \times 10 - 1 \times 15 = 45$$

$$r_3 = y_{p1}z_1 - y_{p1}z_2 + y_1z_2 - y_2z_1 = 2 \times 10 - 2 \times 20 + 1 \times 20 - 1 \times 10 = -10$$

$$r_4 = y_2 - y_3 = 1 - 5 = -4$$

$$r_5 = y_3 - y_1 = 5 - 1 = 4$$

$$r_6 = y_1 - y_2 = 1 - 1 = 0$$

Menghitung nilai r_0, r_1, r_2, r_3, r_4, r_5 dan r_6 untuk P2 menggunakan persamaan (31)

$$\begin{aligned} r_0 &= x_{p2}[(z_3 - z_2)y_1 + (z_1 - z_3)y_2 + (z_2 - z_1)y_3] \\ &= 3[(15 - 20)1 + (10 - 15)1 + (20 - 10)5] \\ &= 120 \end{aligned}$$

$$r_1 = y_{p2}z_2 - y_{p2}z_3 + y_2z_3 - y_3z_2 = 3 \times 20 - 3 \times 15 + 1 \times 15 - 5 \times 20 = -70$$

$$r_2 = y_{p2}z_3 - y_{p2}z_1 + y_3z_1 - y_1z_3 = 3 \times 15 - 3 \times 10 + 5 \times 10 - 1 \times 15 = 50$$

$$r_3 = y_{p2}z_1 - y_{p2}z_2 + y_1z_2 - y_2z_1 = 3 \times 10 - 3 \times 20 + 1 \times 20 - 1 \times 10 = -20$$

$$r_4 = y_2 - y_3 = 1 - 5 = -4$$

$$r_5 = y_3 - y_1 = 5 - 1 = 4$$

$$r_6 = y_1 - y_2 = 1 - 1 = 0$$

Menghitung nilai r_0, r_1, r_2, r_3, r_4, r_5 dan r_6 untuk P3 menggunakan persamaan (31)

$$\begin{aligned} r_0 &= x_{p3}[(z_3 - z_2)y_1 + (z_1 - z_3)y_2 + (z_2 - z_1)y_3] \\ &= 2[(15 - 20)1 + (10 - 15)1 + (20 - 10)5] \\ &= 80 \end{aligned}$$

$$r_1 = y_{p3}z_2 - y_{p3}z_3 + y_2z_3 - y_3z_2 = 4 \times 20 - 4 \times 15 + 1 \times 15 - 5 \times 20 = -65$$

$r_2 = y_{p3}z_3 - y_{p3}z_1 + y_3z_1 - y_1z_3 = 4 \times 15 - 4 \times 10 + 5 \times 10 - 1 \times 15 = 55$

$r_3 = y_{p3}z_1 - y_{p3}z_2 + y_1z_2 - y_2z_1 = 4 \times 10 - 4 \times 20 + 1 \times 20 - 1 \times 10 = -30$

$r_4 = y_2 - y_3 = 1 - 5 = -4$

$r_5 = y_3 - y_1 = 5 - 1 = 4$

$r_6 = y_1 - y_2 = 1 - 1 = 0$

2. Menghitung nilai n

Menghitung nilai n1 dan n2 untuk titik P1 menggunakan persamaan (33)

$n_1 = r_1x_1 + r_2x_2 + r_3x_3 + r_0 : f_1(x_1, x_2, x_3)$
$n_1 = -75 \times 1 + 45 \times 4 + (-10)1 + 80 : f_1(1,4,1)$
$= 175$

$n_2 = r_4x_1 + r_5x_2 + r_6x_3 : f_2(x_1, x_2, x_3)$
$n_2 = -4 \times 1 + 4 \times 4 + 0 \times 1 : f_2(1,4,1)$
$= 12$

Menghitung nilai n1 dan n2 untuk titik P2 menggunakan persamaan (33)

$n_1 = r_1x_1 + r_2x_2 + r_3x_3 + r_0 : f_1(x_1, x_2, x_3)$
$n_1 = -70 \times 1 + 50 \times 4 + (-20)1 + 120 : f_1(1,4,1)$
$= 230$

$n_2 = r_4x_1 + r_5x_2 + r_6x_3 : f_2(x_1, x_2, x_3)$
$n_2 = -4 \times 1 + 4 \times 4 + 0 \times 1 : f_2(1,4,1)$
$= 12$

Menghitung nilai n1 dan n2 untuk titik P3 menggunakan persamaan (33)

$n_1 = r_1x_1 + r_2x_2 + r_3x_3 + r_0 : f_1(x_1, x_2, x_3)$
$n_1 = -65 \times 1 + 55 \times 4 + (-30)1 + 80 : f_1(1,4,1)$
$= 205$

$n_2 = r_4x_1 + r_5x_2 + r_6x_3 : f_2(x_1, x_2, x_3)$
$n_2 = -4 \times 1 + 4 \times 4 + 0 \times 1 : f_2(1,4,1)$
$= 12$

3. Menghitung variansi titik x (σ_x^2)

$$\sigma_x^2 = \frac{(x_1 - \bar{x})^2 + (x_2 - \bar{x})^2 + (x_3 - \bar{x})^2}{n - 1} = \frac{(1-2)^2 + (2-2)^2 + (1-2)^2}{3-1} = 1$$

4. Menghitung nilai penyebaran kesalahan horizontal

Menghitung nilai penyebaran kesalahan horizontal untuk P1 menggunnakan persamaan (34)

$$\sigma_{zp1}^2 = \frac{n_1^2}{n_2^2}\left(\left(\frac{r_1}{n_1}-\frac{r_4}{n_2}\right)^2+\left(\frac{r_2}{n_1}-\frac{r_5}{n_2}\right)^2+\left(\frac{r_3}{n_1}-\frac{r_6}{n_2}\right)^2\right)\sigma_x^2$$

$$\sigma_{zp1}^2 = \frac{175^2}{12^2}\left(\left(\frac{-75}{175}-\frac{-4}{12}\right)^2+\left(\frac{45}{175}-\frac{4}{12}\right)^2+\left(\frac{-10}{175}-\frac{0}{12}\right)^2\right)1$$

$$\sigma_{zp1}^2 = 212{,}67((-0{,}1)^2+(-0{,}07)^2+(-0{,}06)^2)1$$

$$\sigma_{zp1}^2 = 3{,}93$$

Menghitung nilai penyebaran kesalahan horizontal untuk P2 menggunnakan persamaan (34)

$$\sigma_{zp2}^2 = \frac{n_1^2}{n_2^2}\left(\left(\frac{r_1}{n_1}-\frac{r_4}{n_2}\right)^2+\left(\frac{r_2}{n_1}-\frac{r_5}{n_2}\right)^2+\left(\frac{r_3}{n_1}-\frac{r_6}{n_2}\right)^2\right)\sigma_x^2$$

$$\sigma_{zp2}^2 = \frac{230^2}{12^2}\left(\left(\frac{-70}{230}-\frac{-4}{12}\right)^2+\left(\frac{50}{230}-\frac{4}{12}\right)^2+\left(\frac{-20}{230}-\frac{0}{12}\right)^2\right)1$$

$$\sigma_{zp}^2 = 367{,}36((0{,}03)^2+(-0{,}11)^2+(-0{,}09)^2)1$$

$$\sigma_{zp2}^2 = 10{,}73$$

Menghitung nilai penyebaran kesalahan horizontal untuk P3 menggunnakan persamaan (34)

$$\sigma_{zp3}^2 = \frac{n_1^2}{n_2^2}\left(\left(\frac{r_1}{n_1}-\frac{r_4}{n_2}\right)^2+\left(\frac{r_2}{n_1}-\frac{r_5}{n_2}\right)^2+\left(\frac{r_3}{n_1}-\frac{r_6}{n_2}\right)^2\right)\sigma_x^2$$

$$\sigma_{zp3}^2 = \frac{205^2}{12^2}\left(\left(\frac{-65}{205}-\frac{-4}{12}\right)^2+\left(\frac{55}{205}-\frac{4}{12}\right)^2+\left(\frac{-30}{205}-\frac{0}{12}\right)^2\right)1$$

$$\sigma_{zp3}^2 = 291{,}84((0{,}01)^2+(-0{,}07)^2+(0{,}15)^2)1$$

$$\sigma_{zp}^2 = 8{,}03$$

Berdasarkan hasil perhitungan penyebaran kesalahan horizontal, diperoleh penyebaran kesalahan vertikal untuk titik P1 adalah **3,93** untuk titik P2 adalah **10,73** dan untuk titik P3 adalah **8,03.**