154001

KING ISLAND SCHEELITE LTD.

GEOPEKO LIMITED

KING ISLAND MAPPING

SURVEY CONTROL REPORT

SEPTEMBER, 1970.

VALLENTINE, LAURIE & DAVIES
CONSULTING ENGINEERS
SYDNEY

Worked example by Geof. Benn, Surveyor, Dept. of Mines.

KING ISLAND. SCHEELITE 154002

SCHOOL MINE GRID	AMG GRID
E. 99,642.25 FT.	E. 760,852.87 m
N. 101,641.22 FT	N. 5,562,172.41 m

$AMG/E = A\,E + B\,N + C\,E$ where $A = 0.2994175$

$AMG/N = -B\,E + A\,N + C\,Y$ $B = 0.0577032$

$\lambda = 0.3049270$

$\varepsilon = 10^{\circ}\,57'\,30''$

$CE = +725,153.21\ m.$

$CN = +5,537,488.93\ m$

$AMG/E = 0.2994175 \times 99,642.25 + 0.0577032 \times 101,641.22 + 725,153.21$

$AMG/E = 29,834.63 + 5865.02 + 725153.21$

$AMG/E = 760\,852.86$

$AMG/N = -B\,E + A\,N + C\,Y$ where $A = 0.2994175$

$B = 0.0577032$

$\lambda = 0.3049270$

$\varepsilon = 10^{\circ}\,57'\,30''$

$CE = +725\,153.21\ m$

$CN = +5,537,488.93\ m$

$AMG/N = -B\,E + A\,N + C\,Y$

$AMG/N = -0.0577032 \times 99,642.25 + 0.2994175 \times 101,641.22 + CY$

$AMG/N = -5749.63 + 30,433.16 + CY\ (5,537,488.93)$

$AMG/N = 5,562\,172.41$

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KING ISLAND SCHEELITE LTD.

KING ISLAND MAPPING

SURVEY CONTROL REPORT

1. INTRODUCTION

1.1 General

A survey was undertaken during May, 1970, in the vicinity of Grassy, King Island, Tasmania, to establish a Basic Control network for the photogrammetric mapping of the proposed mining development and to assist in the future geological investigation, the engineering design and construction of that development.

1.2 Horizontal Control

The survey was based on the Australian Geodetic Datum. The co-ordinate values are expressed in both the Australian Map Grid and the Integrated Survey Grid to meet the topographic, Real Property and the various civil and mining engineering requirements. The existing local plane rectangular grid which covers the area of the current mining activity is to be replaced by the Integrated Survey Grid.
The relationship between the co-ordinate systems of the existing Mine Grid and the Australian Map Grid and the Integrated Survey Grid is as follows:-

1.3 Comparison of Co-ordinate Systems

Item	Mine	A.M.G.	I.S.G.
Co-ordinate System	Feet	Metres	Metres & Feet
Zone Width	-	6^{o}	2^{o}
Origin	Local	Intersection of Central Meridian with the Equator	
Central Scale Factor	1.000	0.9996	0.99994
Co-ordinates of Origin			
East	-	500,000m	300,000m
North	-	10,000,000m	5,000,000m

The I.S.G. co-ordinates are presented in both metres and feet to allow for the future statutory change in units.

Simple formulae have been developed to convert from the existing Mine Grid to both the A.M.G. and I.S.G. co-ordinate systems.

1.4 The Australian Map Grid

The A.M.G. is defined in paragraph 1.3 of the Technical Manual - "Australian Map Grid" published in 1968 by the National Mapping Council of Australia.

"1.3 The Australian Map Grid (A.M.G.)

1.3.1 Co-ordinates on the Australian Map Grid are derived from a Transverse Mercator project of latitudes and longitudes on the Australian Geodetic Datum, 1966 Adjustment. The projection is defined by the formulae for easting, northing, convergence and point scale listed in paragraph 4.3. These formulae were first given by J.C.B. Redfearn in the Empire Survey Review, No.69, 1948. They are correct to less than 1 mm anywhere in a grid zone. For the purposes of this definition, these formulae, and the formula for meridian distance given in paragraph 4.2, are to be regarded as exact, not as the opening terms of infinite series.

1.3.2 The Australian Map Grid corresponds with the Universal Transverse Mercator Grid in all particulars, as follows:

1.3.2.1 Co-ordinates are in metres.

1.3.2.2 Zones are 6° wide with $\frac{1}{2}^{\circ}$ overlaps.

1.3.2.3 A.M.G. Zones are numbered from Zone 47 with central meridian 99°E to Zone 58 with central meridian 165°E.

1.3.2.4 The origin of each zone is the intersection of the central meridian with the equator.

1.3.2.5 A central Scale Factor, k_o, of 0.9996 is superimposed on all projected distances.

1.3.2.6 Eastings E are defined by adding 500,000 metres to the value of E given by the formula in paragraph 4.3.2.

1.3.2.7 In the southern hemisphere, Northings N are defined by adding 10,000,000 metres to the negative value of N given by the formula in paragraph 4.3.2.

1.5 The integrated Survey Grid

The I.S.G. is defined in paragraph 2.3 of the Technical Manual - "Integrated Survey Grid" at present being prepared by the Department of Lands, New South Wales.

"2.3 Integrated Survey Grid (I.S.G.)

A traverse Mercator Projection is used for the computation of co-ordinates on the Integrated Survey Grid. Surveys are to be connected to the stations of the State Triangulation and Traverse systems. The Transverse Mercator co-ordinates of these stations have been calculated from latitudes and longitudes on the Australian Geodetic Datum as defined in (2.1).

The Integrated Survey Grid is defined as follows:

2.3.1 Co-ordinates are in metres for the purpose of definition.

2.3.2 Zones are 2^{o} wide with $\frac{1}{4}^{o}$ overlaps.

2.3.3 Zones are numbered as follows: Each 6^{o} A.M.G. Zone is subdivided into 3 Integrated Survey Grid Zones. Zone identification numbers consist of 2 parts separated by an oblique. The first part indicates the corresponding A.M.G. zone number, the second part indicates the number of the subdivision from 1 to 3, the numbers increasing eastwards.
Example: For the eastern part of A.M.G. zone 55 the zone number is 55/3 with the central meridian of 149^{o}.

2.3.4 The true origin of each zone is the intersection of the Central Meridian with the Equator.

2.3.5 A central scale factor, $k_o = 0.99994$ is superimposed on all projected distances.

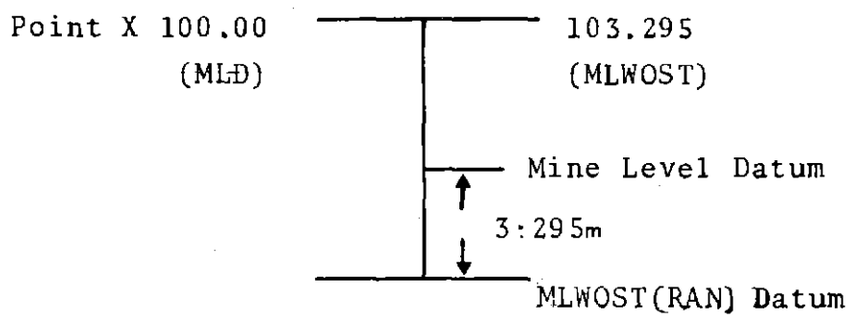
2.3.6 Easting, E, is defined by adding 300,000 metres to the value of y measured from a central meridian.

2.3.7 Northing, N, is defined by adding 5,000,000 metres to the value of x measured from the equator. All values of x south of the equator are negative.

1.6 Vertical control

The survey was based on Mean Low Water Ordinary Spring Tide, Grassy Bay as established by the Hydrographic Branch of the Royal Australian Navy.

The existing mine level datum was arbitrary and to convert from levels on this datum to levels on the MLWOST(RAN) datum add 3.295m.



2. DESCRIPTION OF FIELD SURVEY

2.1 A primary network consisting of ten (10) major control points was established utilizing the existing National Mapping Triangulation Stations NM/H/4 Mary Hill and NM/H/6 Tank Hill and all distances were measured using Electronic Distance Measuring Equipment - Tellurometer MR 101 and angles were observed with a "One Second" Theodolite - Wild T2.

Each line as measured from the control point at either end of that line with each measurement consisting of two coarse readings and ten fine readings. The difference between the two measurements was not greater than 1:200,000. Simultaneous Reciprocal Vertical Angles were also observed at either end. Angular measurements were carried out using the method of "direction" observations with a minimum of six arcs per observation.

2.2 Eight (8) Secondary Control Points were also established by "radiations" consisting of angular and distance observations from the major control points.

2.3 Eleven (11) additional control points were established by triangulation by King Island Scheelite Ltd. and tied to the primary and secondary networks.

2.4 All Control Points were monumented with steel rods in concrete. Their relationship to the topography is shown on the attached map. (APPENDIX III)

2.5 Photogrammetric Control Points were also established at all control points.

2.6 The field survey was undertaken during May, 1970 by Messrs. A. A. Shephard R.S.,M.I.S.;D. Schrader of Vallentine, Laurie & Davies with the assistance of Mr. I. Cougle, Mine Surveyor, King Island Scheelite Ltd.

3. ADJUSTMENT AND COMPUTATION OF CO-ORDINATES

3.1 The following steps were followed to allow the computation of final co-ordinates:-

(a) Reduction of the measured distances to Sea Level distances.

(b) Computation of differences in height between control points.

(c) Least Squares Adjustment of height differences and calculation of absolute heights (in metres) above Sea Level.

(d) Calculation of co-ordinates using the method "Least Squares Variation of Co-ordinates on the Spheroid" using the observed angles and mean Sea Level distances. These co-ordinates are expressed in latitudes and longitudes on the Australian Geodetic Datum and in metres on the Australian Map Grid.

(e) Calculation of co-ordinates expressed in values on the Integrated Survey Grid.

3.2 Extensive use was made of computer programmes in the adjustment and computation of co-ordinates.

3.2.1 The computer programmes held by the Division of National Mapping (Department of National Development) are:

"TELLYHT" - computes tellurometer distances and trignometrical heights, or either separately, along a traverse. The computations are designed to be accurate to 1 mm at any distance.

"VARYCORD" - computes the least squares adjustment of angles, azimuths and distances on the spheroid. The programme is designed to adjust traverses, triangulation, Heran and Aerodist separately or in combination with lines up to 1,000 miles long. Both AGD and AMG co-ordinates can be computed.

3.2.2 The computer programme held by the Lands Department N.S.W. is:

"LYTCQ2" - computes Integrated Survey Co-ordinates in both metres and feet from geographical co-ordinates (latitudes and longitudes) on the Australian Geodetic Datum.

3.3 A listing of all values in the various systems is attached. (APPENDIX I)

4. ANALYSIS OF SURVEY

4.1 Horizontal Datum

4.1.1 The horizontal adjustment was made adopting the known values (supplied by the Division of National Mapping) of the two existing trignometric stations NM/H/4 Mary Hill and NM/H/6 Tank Hill and using forty-three distances and one hundred and fifty-one angles observed.

4.2 Vertical Datum

4.2.1 The vertical adjustment was made adopting the known elevations of Jetty Point, Frog and Bold Head, (supplied by King Island Scheelite Ltd.) and the difference in elevation between the trignometrical stations at Mary Hill and Tank Hill.

4.2.2 Differences in values given for elevations for Mary Hill and Tank Hill by National Mapping and obtained by this survey are due to the differences in level datum.

4.3 Internal Accuracy

4.3.1 Variation between observed and adjusted measurements:-

Type of Observation	Variation	
	Average	Maximum
Angular	7.24"	58.96"
Linear	0.1m	1.2m

4.3.2 The horizontal accuracy of this survey may be expressed as 1:50,000.

4.3.3 The vertical accuracy may be expressed as $\pm$ 0.05 K metres (where K is the distance in kilometres between any two stations).
Elevations are given to the nearest 0.2 metres as they have been obtained by reciprocal vertical angle observations. A higher degree of accuracy can only be obtained by third order levelling techniques.

4.4 Integrated Survey Grid Co-ordinate System

4.4.1 Scale Factor

Grid distances as calculated from the Integrated Survey Grid may be converted to true distances at Sea Level by dividing by 0.99994 i.e.,

Grid Distance $\div$ 0.99994 = True Distance at Sea Level.
For all but the most precise surveys distances on the Integrated Survey Grid can be accepted as field distances.

4.4.2 Grid Convergence

Grid convergence is the angular quantity to be added algebraically to a True Azimuth (or Geodetic Azimuth) to obtain a Grid Bearing, i.e. Grid Bearing = True Azimuth + Grid Convergence.

In the southern hemisphere, grid convergence is positive east of the central meridian, and negative west, e.g.

True Azimuth from Tank Hill to Mary Hill = 311°49'29.5")
Grid Convergence at Tank Hill = 1°56'25.7") Zone 54

∴ Grid Bearing (Tank Hill to Mary Hill) = 311°49'29.5"
+ 1°56'25.7"

Grid Bearing = Plane Bearing = 313°45'55.2"

4.5 Feet Conversion Factor

Although co-ordinates on the Australian Map Grid and Integrated Survey Grid are expressed in metres, some measurements in feet are required for this survey. The conversion ratios laid down in the Weights and Measures (National Standards) Regulations for use in Australia are:-

1 yard = 0.9144 metres exactly
1 foot = 1/3 yard

whence 1 foot = 0.3048 metres exactly (reference A.M.G. Technical Manual paragraph 1.5).

5. CONVERSION FORMULAE BETWEEN CO-ORDINATE SYSTEMS

5.1 Type of Equation

Equations of the type

$$\bar{E} = AE + BN + CE$$
$$\bar{N} = -BE + AN + CY$$ CN 5,537,488.93 m

have been derived where

E,N are co-ordinates in the existing system

$\bar{E},\bar{N}$ are co-ordinates in the new system

CE,CN are the difference or shift in the origin of co-ordinates of the two (2) systems.

and A, B, are factors derived from the scale and azimuth differences between the two system.

i.e. (scale factor) = $\tan^{-1}\frac{B}{A}$

5.2 Mine Grid (feet) to Integrated Survey Grid (feet)

A = 0.9894370

B = 0.1449294

λ = 0.9999950

ε = 8°20'00

CE = +607,196.48 feet

CN = +1,766,631.35 feet

5.3 Mine Grid (feet) to Australian Map Grid (metres).

A = 0.2994175

B = 0.0577032

λ = 0.3049270

ε = 10°54'30"

CE = +725,153.21 metres

CN = +5,537,488.93 metres

6. SHEET LAYOUT

The basic sheets have been prepared on the Integrated Survey Grid Co-ordinate System and are numbered by subtracting 500,000 metres North and 200,000 metres East from the Integrated Survey Grid co-ordinates of the southwest corner of each sheet, and then using the first two (or three) digits of the remaining number, (i.e. the thousands)

e.g. Sheet 6516 has co-ordinates
5(65),000 Metres North
2(16),000 Metres East

7. CERTIFICATION OF SURVEY

The field reconnaissance and observations, and office reductions, calculations and preparation of relevant data was undertaken to generally accepted standards of accuracy and was under the supervision of Mr. A. A. Shephard R.S., M.I.S.

8. ACKNOWLEDGMENTS

The assistance of the staff of King Island Scheelite Ltd. and Geopeko Limited during the field survey, and the Directorate of Military Survey, Royal Australian Army, and Department of Lands, New South Wales in the calculations of co-ordinate values is gratefully acknowledged.

The staff of Peko-Wallsend Ltd. aided materially in the initial planning and in the continued liaison on the project and also in the preparation of this report.

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STATION			GEOGRAPHIC CO-ORDINATES						AUSTRALIAN MAP	
Name	Serial No.	KIS No.	Latitude (South) ° ' "			Longitude(East) ° ' "			Zone	Eastings Ms	Northings Ms
Mary Hill	4 1		39	58	30.06	143	55	24.48	54	749 657.20	5570 906.29
Tank Hill	6 3		40	02	16.56	144	00	53.27	54	757 221.35	5563 661.65
Mary Hill Ecce	2		39	58	30.10	143	55	24.53	54	749 658.46	5570 905.09
Wiggins	4		39	59	18.88	144	00	54.25	54	757 430.22	5569 140.13
Ferguson	5		39	59	0.10	144	00	0.85	54	756 183.11	5569 762.09
Gravel Pit	6		40	00	28.49	144	00	24.26	54	756 646.34	5567 017.36
	10	34/18	40	01	54.51	144	03	56.92	54	761 598.10	5564 192.96
Russell	12		40	05	22.95	144	00	40.46	54	756 723.03	5557 923.66
Rox	14		40	02	50.50	144	01	15.65	54	757 716.49	5562 596.94
Bend	15		40	02	59.16	144	02	54.21	54	760 043.13	5562 250.14
Bend Ecce	16		40	02	59.29	144	02	55.69	54	760 077.96	5562 244.94
Philby	18		39	59	03.27.	144	02	52.44	54	760 250.20	5569 526.07
Dam	20		40	02	17.83.	144	03	33.56	54	761 019.55	5563 492.74
Tennant	21		39	58	59.77	144	04	43.51	54	762 888.76	556 543.33
Doddle										760 811.64	5561 956.43
Bold Head	23	34/7	40	01	40.67	144	03	59.69	54	761 678.39	5564 617.28
Sleath	24		40	01	34.50	144	02	55.87	54	760 171.91	5564 859.57
Bold Head Ecce	26		40	01	40.36	144	04	1.30	54	761 716.84	5564 625.53
Denison	28		40	00	34.05	144	03	48.97	54	761 495.05	5566 680.40
Pat	30		40	02	17.65	144	04	5.01	54	761 765.14	5563 472.49
Moore	31		40	00	30.78	144	02	44.98	54	759 980.98	5566 833.42
Skipworth											
Mark	36		40	02	40.99	144	04	6.13	54	761 766.91	5562 752.02
Myrtle	37		40	03	0.54	144	03	41.27	54	761 156.95	5562 169.26
Mike	38		40	03	6.58	144	04	3.82	54	761 684.83	5561 964.42
Tip	39		40	03	26.65	144	03	57.03	54	761 502.65	5561 351.26
Duncan	40		40	02	31.91	144	03	49.62	54	761 385.40	5563 045.14
Golf	41		40	03	51.20	144	03	32.01	54	760 883.83	5560 614.49
Jetty Point	43		40	03	59.15	144	03	51.13	54	761 328.34	5560 353.80
Frog	44		40	04	7.79	144	02	51.53	54	759 907.22	5560 135.89
Tosh	45		40	02	36.91	144	05	40.06	54	763 997.73	5562 800.76
Church	47		40	03	5.28	144	03	4.57	54	760 282.18	5562 052.88
Dump	48		40	03	25.64	144	03	28.13	54	760 818.97	5561 405.88
Ramp	49		40	03	18.71	144	03	45.63	54	761 240.92	5561 605.45
		B19								760 524.99	5561 623.29
Hall										760 562.73	5562 216.03
School										760 852.87	5562 172.41

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TABULATION OF CO-ORDINATES.

GRID CO-ORDINATES						INTEGRATED SURVEY GRID CO-ORDINATES							MINE GRID CO-ORDINATES			STATION		
Height	Convergence			Zone	Eastings	Northings	Height	Eastings	Northings	Height	Convergence			Eastings	Northings	Height	Name	Serial	KIS
Ms	°	'	"	55/1	Ms	Ms	Ms	Ft	Ft	Ft	°	'	"	Ft	Ft	Ft		No.	No.
132.6	+1	52	44.98	54/3	208 041.42	572 940.04	132.6	682 550.60	1879 724.55	434.7	-0	41	30.02				Mary Hill	4 1	
159.6	+1	56	25.67	54/3	215 920.31	566 044.66	159.6	708 399.98	1857 101.91	523.6	-0	38	01.73				Tank Hill	6 3	
132.4	+1	52	45.01	54/3	208 042.73	572 938.89	132.4	682 554.89	1879 720.78	434.4	-0	41	29.98				Mary Hill Ecce	2	
138.8	+1	56	19.15	54/3	215 883.06	571 524.87	138.8	708 277.75	1875 081.60	455.0	-0	37	58.75				Wiggins	4	
117.7	+1	55	44.02	54/3	214 609.78	572 090.04	117.7	704 100.34	1876 935.82	386.2	-0	38	32.82				Ferguson	5	
137.8	+1	56	2.64	54/3	215 195.49	569 369.89	137.8	706 021.95	1868 011.45	452.1	-0	38	18.95				Gravel Pit	6	
	+1	58	23.11	54/3	220 267.02	566 771.72		722 660.84	1859 487.26		-0	36	03.29	100 787.84	108 610.71			10	34/18
95.0	+1	56	24.91	54/3	215 680.45	560 292.30	95.0	707 613.02	1838 229.32	311.4	-0	38	12.43				Russell	12	
	+1	56	41.47	54/3	216 462.57	565 003.67		710 179.04	1853 686.59		-0	37	47.77				Rox	14	
	+1	57	45.34	54/3	218 801.50	564 761.84		718 852.69	1852 893.19		-0	36	44.45				Bend	15	
125.7	+1	57	46.30	54/3	218 836.51	564 758.22	125.7	717 967.56	1852 881.31	412.4	-0	36	43.50				Bend Ecce	16	
104.0	+1	57	34.59	54/3	218 681.76	572 036.74	104.0	717 459.84	1876 760.95	341.2	-0	36	42.59				Philby	18	
	+1	58	9.01	54/3	219 720.74	566 046.52		720 868.56	1857 108.02		-0	36	18.61	99 358.92	105 996.28		Dam	20	
111.6	+1	58	45.94	54/3	221 315.77	572 172.30	111.6	726 101.62	1877 205.71	365.8	-0	35	31.17				Tennant	21	
					219 582.11	564 503.07		720 413.76	1852 044.17					99 643.52	100 920.11		Doddle		
129.2	+1	58	24.33	54/3	220 328.15	567 199.03	129.2	722 861.38	1860 889.21	424.0	-0	36	01.33	100 783.12	110 027.21		Bold Head	23	34/7
110.0	+1	57	42.96	54/3	218 812.95	567 373.35	110.0	717 890.24	1861 461.14	360.9	-0	36	42.31				Sleath	24	
128.8	+1	58	25.35	54/3	220 366.17	567 208.99	128.8	722 986.13	1860 921.88	422.5	-0	36	00.30				Bold Head Ecce	26	
115.2	+1	58	14.70	54/3	220 052.48	569 250.96	115.2	721 956.97	1867 621.27	378.0	-0	36	07.39				Denison	28	
	+1	58	29.27	54/3	220 466.17	566 059.78		723 314.20	1857 151.51		-0	35	58.37	101 773.03	106 393.93		Pat	30	
105.2	+1	57	33.35	54/3	218 533.71	569 335.83	105.2	716 974.10	1867 899.71	345.1	-0	36	48.50				Moore	31	
																	Skipworth		
88.8	+1	58	30.95	54/3	220 500.29	565 340.41	88.8	723 426.15	1854 791.38	291.3	-0	35	57.94	102 226.07	104 074.02		Mark	36	
111.3	+1	58	15.73	54/3	219 917.37	564 731.11	111.3	721 513.68	1852 792.35	365.2	-0	36	14.18				Myrtle	37	
	+1	58	30.51	54/3	220 453.69	564 550.26		723 273.25	1852 199.01		-0	35	59.75	102 450.65	101 487.37		Mike	38	
	+1	58	26.95	54/3	220 299.31	563 929.81		722 766.78	1850 163.40		-0	36	04.37	102 243.99	99 400.28		Tip	39	
	+1	58	19.94	54/3	220 106.16	565 615.98		722 113.07	1855 695.49		-0	36	08.45	100 815.24	104 781.66		Duncan	40	
28.4	+1	58	11.83	54/3	219 714.47	563 166.29	28.4	720 848.01	1847 658.43	93.5	-0	36	20.78	100 708.96	96 643.68		Golf	41	
6.6	+1	58	24.48	54/3	220 170.06	562 925.94	6.6	722 342.70	1846 869.89	21.5	-0	36	08.57				Jetty Point	43	
20.6	+1	57	46.41	54/3	218 760.76	562 644.50	20.6	717 719.02	1845 946.53	67.9	-0	36	47.05	97 861.06	94 496.64		Frog	44	
93.6	+1	59	31.32	54/3	222 725.69	565 489.25	93.6	730 727.34	1855 279.70	307.4	-0	34	57.45				Tosh	45	
	+1	57	52.27	54/3	219 049.07	564 575.61		718 664.94	1852 282.17		-0	36	37.86	97 879.26	100 902.03		Church	47	
	+1	58	8.28	54/3	219 614.15	563 953.64		720 518.88	1850 241.59		-0	36	22.96	100 008.93	99 151.94		Dump	48	
	+1	58	19.28	54/3	220 026.53	564 171.87		721 871.83	1850 957.59		-0	36	11.61	101 243.61	100 056.32		Ramp	49	
					219 310.83	564 157.52		719 523.73	1850 910.53					98 927.18	99 669.45				819
					219 321.91	564 751.12		719 560.07	1852 858.00					98 680.89	101 601.63		Hall		
					219 613.58	564 720.58		720 517.01	1852 757.84					99 642.25	101 641.22		School		