Maracás Menchen Project, Bahia, Brazil

Independent Technical Report –

AN UPDATED MINE PLAN, MINERAL RESERVE AND PRELIMINARY ECONOMIC ASSESSMENT OF THE INFERRED RESOURCES

Prepared by GE21 Ltda on behalf of:

Largo Resources Ltd.

Issue Date: October 26th 2017
Effective Date: May 2nd 2017

Qualified Persons:

Porfírio Cabaleiro Rodriguez – BSc (Min Eng), MAIG

Leonardo Apparicio da Silva – MsCMBA, MAIG

Fabio Valerio Xavier – BsC Geology , MAIG

Authors:	Porfírio Cabaleiro Rodriguez	Mining Engineer	BSc (Mine Eng), MAIG
	Leonardo Apparicio da Silva	Mining Engineer	BSc (Min Eng),MAIG
	Fabio Valerio Xavier	Geologist	BSc (Geo), MAIG
	Robert A. Campbell	Geologist	MSc (P.Geo.), APEGS
	Guilherme Gomides Ferreira	Mining Engineer	BSc (Mine Eng), MAusIMM

Effective Date May 2nd, 2017

Issue Date: October 26th, 2017

GE21 Project Nº: GE21_170205

Version:

Work Directory: S:\Projetos\Largo\2_desenvolvimento\01_relatorio

Print Date: November 8, 2017

Copies: Largo Resources Ltd. (1)

GE21 Consultoria Mineral (1)

Document Change Control

Version	Description	Author(s)	Date

Date and Signature Page

This report, entitled "An Updated Mine Plan, Mineral Reserve and Preliminary Economic Assessment of the Inferred Resources", having an effective date of May 02st, 2017, was prepared and signed by by the following authors.

Dated at Belo Horizonte, Brazil, this October 26th 2017

"Porfirio Cabaleiro Rodriguez"

Porfirio Cabaleiro Rodriguez, BSc (Min Eng), MAIG

"Fabio Valerio Xavier"

Fabio Valerio Xavier BSc (Geo), MAIG

"Leonardo Apparicio da Silva"

Leonardo Apparicio da Silva BSc (Min Eng),MAIG

SUMMARY

1 Summary ... 24
1.1 Introduction ... 24
1.2 Property Description and Location ... 25
1.3 Exploration and Drilling ... 28
1.4 Mineral Resource Estimates ... 30
1.5 Mineral Reserve Estimates ... 32
1.6 Recovery Methods ... 33
1.7 Environmental Studies, Permitting and Social or Community Impact ... 36
1.8 Capital and Operating Costs ... 43
1.8.1 Capital Cost Estimate ... 43
1.8.2 Operating Cost Estimate ... 43
1.9 Economic Analysis ... 45
1.10 Other Relevant Information ... 47
1.11 Conclusion and Recommendations ... 47
1.11.1 Conclusion ... 47
2 Introduction ... 50
2.1 Scope of Work ... 51
2.2 Qualifications, Experience and Independence ... 51
2.3 Qualified Team ... 51
2.4 Effective Date and Sources of Information ... 52
2.5 Units of Measure ... 52
3 Reliance on Other Experts ... 53
4 Property Description and Location ... 53
4.1 Location ... 53
4.2 Property Status ... 54
5 Accessibility, Climate, Local Resources, Infrastructure and Physiography ... 58
5.1 Access ... 58
5.2 Infrastructure ... 58
5.3 Climate and Physiography ... 58
6 History ... 60
6.1 Summary ... 60
6.2 Exploration History ... 60
6.3 Historical Drilling ... 62
6.4 Historical Resource Estimates ... 62
6.5 Historical Technical and Environmental Studies ... 63
7 Geological Setting and Mineralization ... 65

7.1 Regional Geology 65
7.1.1 Rio Jacaré Intrusion 66
7.2 Property Geology 67
7.2.1 Campbell deposit 67
7.2.2 Satellite Deposits 71
7.3 Mineralization 83
7.3.1 Oxidation 85

8 Deposit Types 87

9 Exploration 89
9.1 2006 Exploration Program 89
9.2 2007 Exploration Program 89
9.3 Previous Geophysical Surveys 90
9.3.1 Discussion of Present Geophysical Techniques 90
9.3.2 Geophysical Survey Results 91
9.4 2008 Exploration Program 91
9.5 2011-2012 Exploration Program 92
9.6 2012 Infill Drill Program 92
9.7 2015 Exploration Program 92
9.7.1 Davis Tube Tests 92

10 Drilling 94
10.1 Micon Text from Previous Reports 94
10.1.1 Drilling by Previous Operators 94
10.1.2 2007 Largo Drill Program 94
10.1.3 2008 Largo Drill Program 99
10.1.4 2011-2012 Largo Drill Program 101
10.1.5 2012 Largo Infill Drill Program 109
10.1.6 Logging 112
10.2 Coffey Mining Text from Previous Reports 113
10.2.1 Maracás Drilling Program 2011/2012 113

11 Sample Preparation, Analysis and Security 125
11.1 Micon Text from Previous Reports 125
11.1.1 Sampling Method and Approach 125
11.1.2 Sample Preparation, Analyses and Security 127
11.2 Coffey Mining Text from Previous Reports 128
11.2.1 Sample Preparation and Analysis 128
11.2.2 Core Logging 129
11.2.3 Core Sampling 131
11.2.4 Density Determination 134
11.2.5 Sample Preparation and Analysis 136
11.2.6 Adequacy of Procedures 137
11.3 2015 Davis tube work 137

12 Data Verification 141
12.1 Micon Text from Previous Reports 141

12.1.1 Pre-2006 141
12.1.2 Largo 141
12.1.3 Summary 152
12.1.4 Micon Checks 153
12.1.5 Conclusions 153
12.2 Coffey Mining Text from Previous Reports 154
12.2.1 Geological Database 154
12.2.2 Quality Control 154
12.2.3 Standard and Blank Samples 155
12.2.4 Comparative Data Analysis 156
12.2.5 Data Quality Summary 157

13 Mineral Processing and Metallurgical Testing 159
13.1 Introduction 159
13.2 Process Technical and Economical References 159
13.3 Material Characterization, Mineralogy and Metallurgy 160
13.3.1 Mineralogy and Chemical Analysis 160
13.3.2 Comminution 165
13.3.3 Concentration (Magnetic Separation) 166
13.3.4 Roasting, Leaching and Precipitation 166
13.3.5 AMV Calcination 182
13.4 PGM Testwork 183
13.5 Pilot Plant Testing (By Largo) 184
13.5.1 Beneficiation of Ore Samples at Fundação Gorceix 185
13.5.2 Davis Tube Testing of Low and High Grade Core Samples 185
13.5.3 Kiln Roasting 186
13.5.4 Leaching 186

14 Mineral Resource Estimate 188
14.1 Responsibility for Estimation 190
14.1.1 Summary of QP opinion 190

15 Mineral Reserves Estimates 191

16 Mining Methods 192
16.1 Introduction 192
16.2 Geothecnics and Hidrogeological 192
16.3 Pit Optimization 192
16.4 Mine Design 195
16.5 Mine Schedule 197
16.6 Mine Layout 205
16.7 Mining Fleet Dimensioning 207

17 Recovery Methods 209
17.1 Process Description 209
17.2 Crushing and Grinding 212
17.3 Magnetic Separation 212

17.4 Milling 212
17.5 Filtering 213
17.6 Roasting 213
17.7 Leaching 213
17.8 Precipitation 214
17.9 Evaporation 214
17.10 AMV Drying 215
17.11 Ammonia Removal and Melting 215
17.11.1 Ammonia Removal 215
17.11.2 Melting 215

18 Project Infrastructure 215
18.1 Process Water 215
18.2 Potable Water 216
18.3 Sewage Treatment 216
18.4 Fuel and Lubricant Storage and Distribution 216
18.5 Air 216
18.5.1 Air Emissions and Air Quality Monitoring 217
18.6 Heating 217
18.7 Power Supply 217
18.8 Buildings 217
18.9 Assay Laboratory 218
18.10 Miscellaneous Buildings 218
18.11 Explosives Magazine 218
18.12 Communications 220
18.13 Roads 220
18.14 Tailings Facility 220
18.14.1 Tailings Disposal Ponds 221
18.15 Waste Management 221

19 Market Studies and Contracts 223
19.1 Information Sources 223
19.2 The Market for Vanadium 224
19.2.1 Demand 225
19.2.2 International Trade 226
19.2.3 Vanadium Prices 226
19.3 Outlook 228
19.4 Contracts 228

20 Environmental Studies, Permitting And Social Or Community Impact 229
20.1 Regulatory Framework Overview 229
20.2 Environmental Permitting Status 231
20.3 Environmental Baseline Conditions 231
20.3.1 Climate and Physiography 231
20.3.2 Water Resources 231

20.3.3 Flora Characterization 233
20.3.4 Fauna Characterization 237
20.3.5 Aquatic Biota 239
20.4 Social and Economic Baseline 241
20.4.1 Populations Dynamics 242
20.4.2 Employment Structure and Unemployment Rate 242
20.4.3 Economic Aspects 243
20.4.4 Land Use and Occupation 244
20.4.5 Villages around the Project 245
20.4.6 Historical and Cultural Heritage 249
20.4.7 Living Standards 251
20.4.8 Education 251
20.4.9 Health 252
20.4.10 Housing Conditions and Infrastructure 252
20.4.11 Leisure, Tourism and Culture 253
20.4.12 Public Safety 254
20.4.13 Property Disputes and Rural Settling 254
20.4.14 Water Supply 254
20.5 Environmental Impact Assessment, Mitigation And Compensation 255
20.5.1 Physical Environment 255
20.5.2 Biotic Environment 266
20.5.3 Environmental Mitigation 268
20.6 Social and Economic Environment 268
20.6.1 Job and Income Generation 269
20.6.2 Boosting the Local and Regional Economy 269
20.6.3 Improvement of Access and Roads 270
20.6.4 Pressure on the Water Supply System 270
20.7 Geotechnics And Hydrology 270
20.7.1 Hydrological Studies 270
20.7.2 Geological/Geotechnical Characterization of the Overall Project Area 275
20.8 Current Activities and Plans 283
20.8.1 Project Organization and Sustainability team 283
20.8.2 Equator Principles Audit Review 283
20.8.3 Socio-Environmental Action Plan and Environmental Management System 284
21 Capital and Operating Costs 289
21.1 Capital Cost Estimate 289
21.1.1 Sustaining Capital Cost 289
21.2 Operating Cost Estimate 289
21.2.1 Mining Cost 289
21.2.2 Processing Cost 290
21.2.3 General and Administrative Cost 293

22 Economic Analysis 293
22.1 Taxes 293
22.2 Discounted Cash Flow 295
22.3 Sensitivity Analysis 297
23 Adjacent Properties 298
24 Other Relevant Data and Information 298
24.1 Current Operations 298
24.2 Preliminary Economic Assessment of Additional Resources 298
24.2.1 Mine Planning and Scheduling 299
24.2.2 Capital and Operating Costs 323
24.2.3 Vanadium Price 326
24.2.4 Cash Flow 326
25 Interpretation and Conclusions 329
25.1 Feasibility Study for Campbell Deposit 329
25.2 PEA-Level Study of Additional Resources 329
25.3 Conclusion 330
25.3.1 Campbell LoM 330
25.3.2 PEA Satellite and Campbell Remaining Resources 331
26 Recommendations 331
27 References 334

LIST OF TABLES

Table 1.2_1 – Maracás Property Exploration and Mining Permits 27
Table 1.3_1 – Total Maracás Drilling 29
Table 1.4_1 –Campbell Mineral Resources 31
Table 1.4_2 –Satellite Deposits Mineral Resource 32
Table 1.5_1 – Maracás Vanadium Project Mineral Reserves – Campbell (Effective May 02, 2017) 32
Table 1.6_2 – Summary of Key Process Design Criteria 35
Table 1.7_1 – Summary of Key Non-Magnetic Tailings Pond 3 Design Aspects 38
Table 1.7_2 – Schedule of Non Magnetic Tailing Pond Construction and Usage 40
Table 1.7_3 – Mine Closure Costs 41
Table 1.8.2_1 – Average Operating Cost Summary 43
Table 1.8.2.1_1 – Contract Loading & Haulage Costs 44
Table 1.8.2.2_1 – Process Costs, Recoveries and Assumptions 44
Table 1.9.1_1 – Selling Prices and Taxes 45
Table 1.9.1_2 – Base Case Life of Mine Annual Cash Flow 46
Table 10.1_1 – Summary of mineral inventory for additional resources in Satellite deposits 47
Table 4.2_1 – Maracás Property Concession 56
Table 6.3_1 – Summary of Diamond drilling, Maracás Property 62
Table 6.3_2 – Historical Diamond Drilling, Campbell deposit (1981 - 1987) 62
Table 6.4_1 – Historical 63
Table 7.3_1 – V2O5 in Magnetite at Campbell 84
Table 7.3.1_1 – Recovery Reduction Factors for Oxidized material, Campbell 86
Table 10.1.2_1 – Largo 2007 Maracás Drill Program 94
Table 10.1.2_2 – Drill Hole Summary for the 2007 Campbell Drill Program 96
Table 10.1.2_3 – 2007 Campbell Drill Results 97
Table 10.1.2_4 – 2007 Late Drill Results 99
Table 10.1.3_1 – 2008 Drill Program Summary 99
Table 10.1.3_2 – 2008 Drill Program Information 100
Table 10.1.3_3 – 2008 Drill Program Summary of Significant Results 101
Table 10.1.4_1 – Largo 2011 - 2012 Drill Program 102
Table 10.1.4_2 – Campbell Zone Drilling 102
Table 10.1.4_3 – Gulçari A Zone Norte Drilling 102
Table 10.1.4_4 – Gulçari B Zone Drilling 103
Table 10.1.4_5 – Gulçari B Sul Zone Drilling 103

Table 10.1.4_6 – São José Zone Drilling	103
Table 10.1.4_7 – Novo Amparo Zone Drilling	104
Table 10.1.4_8 – Novo Amparo Norte Zone Drilling	104
Table 10.1.4_9 – 2011-2012 Drill Program Summary of Significant Results	106
Table 10.1.4_10 – Total Maracás Drilling	109
Table 10.1.5_1 – Largo 2012 Infill Drill Program	110
Table 10.1.5_2 – 2012 Infill Drill Program Summary of Significant Results	112
Table 10.2.1_1 – Maracás Drill Program 2011/2012	113
Table 10.2.1.1_1 – Summary Novo Amparo Norte Deposit	115
Table 10.2.1.1_2 – Novo Amparo Norte Deposit Drill Hole Assay Results	115
Table 10.2.1.2_1 – Summary Novo Amparo Deposit	116
Table 10.2.1.2_2 – Novo Amparo Deposit Drill Hole Assay Results	117
Table 10.2.1.3_1 – Summary São José Deposit Drilling	118
Table 10.2.1.3_2 – São José Deposit Assay Results	119
Table 10.2.1.4_1 – Summary Gulçari B Deposit	120
Table 10.2.1.4_2 – Gulçari B Deposit, Drill Hole Assay Results	121
Table 10.2.1.5_1 – Summary Gulçari A Norte Deposit	122
Table 10.2.1.5_2 – Gulçari A Norte Deposit Assay Results	122
Table 11.2.4_1 – Density Summary	135
Table 11.2.4_2 – Average Specific Gravity for the Campbell deposit, Largo Data 2016	136
Table 12.1.4_1 – Micon Check Samples	153
Table 12.2.2_1 – Standards and Blanks QAQC Summary Results	154
Table 12.2.3_1 – Quality Control Sample Summary	155
Table 12.2.3_2 – Internal Standard Detection Limits	155
Table 12.2.3_3 – Standards and Blank QA/QC Summary Results	155
Table 12.2.4_1 – QAQC Program Summary	157
Table 13.3.1_1 – SGS Test Sample Analyses 2007	161
Table 13.3.1_2 – SGS Test Sample Analyses 2012	162
Table 13.3.1_3 – Maracás Ore Mineralogical Composition	163
Table 13.3.2_1 – Bond Rod Mill Grindability Test Summary	165
Table 13.3.2_2 – Ball Mill Grindability Test Summary	166
Table 13.3.4_1 – Davis Tube Summary on Composites - Concentrate – Campbell	168
Table 13.3.4_2 – Davis Tube Summary on Composites - Concentrate - Gulçari A Norte	169
Table 13.3.4_3 – Davis Tube Summary on Composites - Concentrate - Gulçari B	170
Table 13.3.4_4 – Davis Tube Summary on Composites - Concentrate - São José	171

Table 13.3.4_5 – Davis Tube Summary on Composites - Concentrate - Novo Amparo 172

Table 13.3.4_6 – Davis Tube Summary on Composites - Concentrate - Novo Amparo Norte 173

Table 13.3.4_7 – Davis Tube Summary on Composites - Tailings – Campbell 174

Table 13.3.4_8 – Davis Tube Summary on Composites - Tailings - Gulçari A Norte 175

Table 13.3.4_9 – Davis Tube Summary on Composites - Tailings - Gulçari B 176

Table 13.3.4_10 – Davis Tube Summary on Composites - Tailings - São José 177

Table 13.3.4_11 – Davis Tube Summary on Composites - Tailings - Novo Amparo 178

Table 13.3.4_12 – Davis Tube Summary on Composites - Tailings - Novo Amparo Norte 179

Table 13.3.4_13 – Salt Roast Leaching with Sodium Carbonate - Overview Test Conditions and Results 180

Table 13.3.4_14 – Bulk Leach and De-silication Test Results 181

Table 13.3.4_15 – AMV Precipitation Recovery and Analysis (wt %) 182

Table 13.3.5_1 – AMV Calcination Results 182

Table 13.3.5_2 – Analysis of V2O5 183

Table 13.5.2_1 – Davis Tube Testing Results 186

Table 13.5.4_1 – Leaching Test Results 187

Table 1.4_1 –Campbell Mineral Resources 189

Table 14.1_2 – 2013 Satellite Deposits Mineral Resource 190

Table 15_1 – Maracás Vanadium Project Mineral Reserves – Campbe Pitll (Effective Date - May 02, 2017) 191

Table 16.3_1 – Pit Optimization Parameters - Price and Royalties 193

Table 16.3_2 – Pit Optimization Parameters - Price and Royalties 194

Table 16.4_2 – Maracás Vanadium Project Mineral Reserves – Campbe Pitll (Effective Date – May,02, 2017) 197

Table 16.5_1 – Mine Production Schedule 198

Table 16.7_2 – Yearly Required Mine Excavator Fleet 207

Table 16.7_1 –Yearly Required Mine Truck Fleet 208

Table 16.7_3 – Yearly Required Mine Drillers 208

Table 17.2_1 – Summary of Key Process Design Criteria 212

Table 19.2_1 – World Vanadium Primary and Co-Product Output (Tonnes contained vanadium in ores, concentrates and slag) 224

Table 19.2.1_1 – World Crude Steel Production (Thousand tonnes 225

Table 20.3.3.5_1 – Vulnerable Species 236

Table 20.3.3.5_2 – Rare Species 236

Table 20.5.1.2_1 – Test work results - ABA-M - Waste Rock- Campbell 257

Table 20.5.1.2_2 – Test work results - ABA-M - Waste Rock- Campbell 258

Table 20.5.1.2_3 – Neutralization Potential Ratio (NPR) Screening Criteria (after Price et al, 1997) 258
Table 20.5.1.3_1 – Test work Results - ABA-M -Magnetite Rocks- Campbell 259
Table 20.5.1.3_2 – Test work Results - ABA-M -Magnetite Rocks- Campbell 260
Table 20.5.1.10_1 – Maracás Vanadium Plant Atmospheric Emissions 264
Table 20.5.1.10_2 – Maximum Long-Term Plant Emission Concentrations 264
Table 20.5.3_1 – Mitigation Measures - Operations Phase 268
Table 20.7.1.3_1 – Rainfall Height Rates (mm) 272
Table 20.7.1.4_1 – Design Flow Volumes for the Hydraulic Structures 274
Table 20.7.2.1_1 – Characterization of Soils and Outcrops in the Project Area 276
Table 20.7.2.1_2 – Summary of Key Non-Magnetic Tailings Pond 3 Design Aspects 276
Table 20.7.2.1_3 – Schedule of Non-Magnetic Tailing Pond Construction and Usage 277
Table 20.7.2.1_4 – Main Geometric Characteristics of the Leached Calcine Tailings Stack 281
Table 20.7.2.1_5 – Main Geometric Characteristics of the Chloride Control Purge Pond 281
Table 20.7.2.1_6 – Main Characteristics of the Ridges 282
Table 20.8.3_1 – Action Plan - Environmental Programs 285
Table 1.7_3 – Mine Closure Costs 286
Table 21.2_1 – Average Operating Cost Summary 289
Table 21.2.1_1 – Contract Loading & Haulage Costs 290
Table 21.2.2_1 –Plant OPEX 291
Table 21.2.2_2 – Labor Cost 291
Table 21.2.2_3 – Power Costs 291
Table 21.2.2_4 – New Water Catchement annual cost 291
Table 21.2.2_5 – Re-handling annual cost 292
Table 21.2.2_7– Raw-material and reagents 292
Table 22.1_1 – Selling Prices and Taxes 295
Table 22.1_2 – Base Case Life of Mine Annual Cash Flow 296
Table 24.2_1 –Satellite Deposits Mineral Resource 299
Table Table 24.2.1.2_1– Pit Optimization Parameters - Price and Royalties 300
Table 24.2.1.2_2 – Pit Optimization Parameters for study 300
Table 24.2.1.2_3 – Results of the Pit Optimization – Gulçari North A and Gulçari B Target 302
Table 24.2.1.2_4 – Results of the Pit Optimization – Novo Amparo Target 304
Table 24.2.1.2_5 – Perspective view of the mathematical pit – Novo Amparo North Target 306
Table 24.2.1.2_6 – Perspective view of the mathematical pit – São José Target 308
Table 24.2.1.2_7 – Perspective view of the mathematical pit – Inferred Remaning Resources – Campbell pit 310

Table 24.2.1.3_1 – Comparative of Optimal Pit X Designed Pit 312

Table 24.2.1.3_2 – Summary of mineral inventory for additional resources in Satellite deposits 313

Table 24.2.1.4_1 – Conceptual Mine Production and Process Feed Schedule 323

Table 24.2.1.4_1 – Mining OPEX 325

Table 24.2.1.4_2 – Plant OPEX 325

Table 24.2.4_1– Selling Prices and Taxes 326

Table 24.2.4_2 –Cash flow –Satellite Deposits 327

Table 261 – Investment in Exploration - 2018 to 2028 332

LIST OF FIGURES

Figure 1.2_1 – Maracás Project Property Map. 26

Figure 1.6_1 – Conceptual Process Flow Sheet - Vanadium Pentoxide 34

Figure 1.7_1 – Water Balance Flow Chart. 36

Figure 1.7_2 – Typical Cross-Section of the Non-Magnetic Tailings Pond 37

Figure1.7_3 – Layout of Non-Magnetic Tailings Ponds 38

Figure 1.7_4 – Close Up Layout of Non-Magnetic Tailings Ponds 39

Figure 4.1_1 – Maracás Project Location Map 54

Figure 4.2_1 – Maracás Project Property Map 55

Figure 5.3_1 – Maracás Project with Campbell Hill in Background 59

Figure 7.1_1 – Maracás Area Simplified Regional Geology Map 66

Figure 7.2.1_1 – Maracás Property Geology Map 68

Figure 7.2.1_2 – Campbell deposit (Campbell), Detailed Surface Geology Map 69

Figure 7.2.1_3 – Campbell deposit - Drill Section 6175N 70

Figure 7.2.1_4 – Campbell deposit - Drill Section 6225N 71

Figure 7.2.2_1 – Property Geological Map with the Deposits Shown 72

Figure 7.2.2.1_1 – Integrated Map of Novo Amparo Norte Deposit 74

Figure 7.2.2.1_2 – Cross Section of the Novo Amparo Norte Deposit 75

Figure 7.2.2.2_1 – Integrated Map of the Novo Amparo Deposit 76

Figure 7.2.2.2_2 – Cross Section of the Novo Amparo Deposit 77

Figure 7.2.2.3_1 – Integrated Map of the São José Deposit 78

Figure 7.2.2.3_2 – Cross Section of the São José Deposit 79

Figure 7.2.2.4_1 – Integrated Map of the Gulçari B Deposit 80

Figure 7.2.2.4_2 – Cross Section of the Gulçari B Deposit 81

Figure 7.2.2.5_1 – Integrated Map of the Gulçari A Norte Deposit 82
Figure 7.2.2.5_2 – Cross Section of the Gulçari A Norte Deposit 83
Figure 9.7.1_1 – Davis Tube Test Apparatus 93
Figure 10.1.2_1 – Largo 2007 Campbell deposit Drill Hole Plan 95
Figure 10.1.2_2 – Zone Location Map (October 17, 2011) 105
Figure 10.2.1_1 – Largo's Maracás Field Officeduring Exploration 114
Figure 10.2.1_2 – Project Drill Core Storage Facility 114
Figure 10.2.1.1_1 – Novo Amparo Norte Drill Hole Collar Marker 116
Figure 10.2.1.1_1 – Mineralized Zone - FNA15 118
Figure 10.2.1.3_1 – Location of Drill Hole FSJ15 120
Figure 10.2.1.4_1 – Collar Marker For Drill Hole Fgb14 121
Figure 10.2.1.5_1 – Zone Mineralized Drill Hole FGAN05 124
Figure 11.2.1_1 – Drill Core with Logged Intervals Delimited 129
Figure 11.2.2_1 – Drill Core Logging 130
Figure 11.2.2_2 – Drill Hole Log Example 131
Figure 11.2.3_1 – Drill Core with Tagged Sample Intervals 132
Figure 11.2.3_2 – Diamond Blade Core Saw 133
Figure 11.2.4_1 – Density Determination by Archimedes Principle 135
Figure 11.3_1 – Largo's First Davis Tube Device During Implementation on Site. 138
Figure 11.3_2 – Two Davis Tube devices at SGS Geosol in Belo Horizonte 138
Figure 11.3_3 – Largo Staff During Site Visit at SGS 139
Figure 12.1.2.2_1 – Campbell Core Duplicate Sampling 143
Figure 12.1.2.2_2 – Campbell Core Duplicate Sampling with Hole FGA-41 Removed 144
Figure 12.1.2.3_1 – High Standard V2O5 Assay Results 145
Figure 12.1.2.3_2 – Low Standard V2O5 Assay Results 146
Figure 12.1.2.3_3 – High Standard Platinum Assay Results 146
Figure 12.1.2.3_4 – High Standard Palladium Assay Results 147
Figure 12.1.2.3_5 – Field Blank Assay Results 148
Figure 12.1.2.3_6 – Field Duplicate Assay Results 149
Figure 12.1.2.3_7 – Sample Duplicate Assay Results 149
Figure 12.1.2.3_8 – Secondary Laboratory Check Assays - V2O5 151
Figure 12.1.2.3_9 – Secondary Laboratory Check Assays - Pt 151
Figure 12.1.2.3_10 – Secondary Laboratory Check Assays - Pd 152
Figure 12.2.3_1 – Certified V2O5 Standard Produced by Largo 156
Figure 12.2.5_1 – Summarized Quality Control Results, Duplicates 158

Figure 13.3.1_1 – Ti-magnetite Associations by Size - Massive 164
Figure 13.3.1_2 – Free Ti-Magnetite and Ilmenite Middles shown at -212 microns 164
Figure 16.3_1 – Pit Optimization Results – NPV 194
Figure 16.3_2 – Perspective view of the Selected Optimal Pit 195
Table 16.4_1 – Mine Design Parameters 196
Figure 16.4_1 – Campbell- Final Pit 196
Table 16.5_2 – Mine Schedulling 199
Figure 16.5_1 – Campbell-Year 01 200
Figure 16.5_2 – Campbell-Year 02 201
Figure 16.5_3 – Campbell-Year 03 202
Figure 16.5_4 – Campbell-Year 05 203
Figure 16.5_5 – Campbell-Year 10 204
Figure 16.5_6 – Campbell – Final Pit 205
Figure 16.6_1 – Maracás Project Site Layout – Campbell mine facilities 206
Figure 17.6_1 – Conceptual Process Flow Sheet - Vanadium Pentoxide 210
Figure 17.6_2 – Conceptual Mass and Metallurgical Balance - Vanadium Pentoxide 211
Figure 18.11_1 – Plant Site Layout 219
Figure 19.2.3_1 – Vanadium Pentoxide Price Trend(US$/lb V2O5) 227
Figure 20.3.2_1 – Jacaré River (Dry period) 233
Figure 20.3.5.5_1 – Pedras` Dam reservoir at Porto Alegre 241
Figure 20.7.1.2_1 – Average Monthly Rainfall for the Pluviometric Station at Fazenda Alagadiço (ANA Code - 01340019) 271
Figure 20.7.1.3_1 Intensity, Duration and Frequency Curves 273
Figure 20.7.1.5_1 - Flow Chart of the Water Balance for the Project 275
Figure 20.7.2.1_1 - Typical Cross-Section of the Non-Magnetic Tailings Pond 277
Figure 20.7.2.1_2 - Layout of Non-Magnetic Tailings Ponds 278
Figure 20.7.2.1_3 - Close Up Layout of Non-Magnetic Tailings Pond 279
Figure 20.7.2.1_4 - Typical Cross-Section of the Leached Calcine Tailings Stack 280
Figure 20.7.2.1_5 - Typical Cross-Section of the Chloride Control Purge Pond 280
Figure 22.2_1 – Sensitivity Diagram 297
Figure 24.2.1.2_1 – Results of the Pit Optimization – Gulçari North A and Gulçari B Target 301
Figure 24.2.1.2_2 – Perspective view of the mathematical pit - – Gulçari North A and Gulçari B Target 303
Figure 24.2.1.2_3 – Results of the Pit Optimization – Novo Amparo Target 304
Figure 24.2.1.2_4 – Perspective view of the mathematical pit – Novo Amparo Target 305
Figure 24.2.1.2_5 – Results of the Pit Optimization – Novo Amparo North Target 306

Figure 24.2.1.2_6 – Perspective view of the mathematical pit – Novo Amparo North Target 307
Figure 24.2.1.2_7 – Results of the Pit Optimization – São José Target 307
Figure 24.2.1.2_7 – Perspective view of the mathematical pit – São José Target 309
Figure 24.2.1.2_9 – Results of the Pit Optimization – Inferred Remaning Resources – Campbell pit 309
Figure 24.2.1.2_8 – Perspective view of the mathematical pit – Inferred Remaning Resources – Campbell pit 311
Figure 24.2.1.3_1 – Perspective View of Pit Design – Gulçari A Norte and Gulçari B Target 313
Figure 24.2.1.3_2 – Plant of Pit Design – Gulçari A Norte and Gulçari B Target 314
Figure 24.2.1.3_3 – Perspective View of Pit Design – Novo Amparo Norte Target 315
Figure 24.2.1.3_4 – Plant of Pit Design – Novo Amparo Norte Target 316
Figure 24.2.1.3_5 – Perspective View of Pit Design – Novo Amparo Target 317
Figure 24.2.1.3_6 – Plant of Pit Design – Novo Amparo Target 318
Figure 24.2.1.3_7 – Perspective View of Pit Design – São José Target 319
Figure 24.2.1.3_8 – Plant of Pit Design – São José Target 320
Figure 24.2.1.3_9 – Perspective View of Pit Design – Campbell Target 321
Figure 24.2.1.3_10 – Plant of Pit Design – Campbell Target 322
Figure 22.2.4_1 – Sensitivity Diagram 328

APPENDICES

Appendix 01– Certificates

UNITS, SYMBOLS AND ABBREVIATIONS

Table of Abbreviations

Abbreviation	Acronym
AA	Atomic Absorption
AC	Air conditioning
ADIS	Automated Digital Imaging System
ADR	Adsorption, Desorption, Recovery
Ag	Silver
AGP	Acid Generation Potential
AMV	Ammonium Meta-Vanadate
ANA	Agencia Nacional de Aguas
ANFO	American Nitrate Fuel Oil
ARD	Acid Rock Drainage
As	Arsenic
ASC	Aluminium Standard
ASV	Vegetation Suppression Authorization
Au	Gold
AuEq	Gold equivalent
B.O.O.	Build/own/operate
BFA	Bench face angle
CAPEX	Capital Expenditure
CBPM	Companhia Bajana de Pesquisa
CCA	Capital cost allowances
CEA	Cumulative Expenditure Account
CEMA	Conveyor Equipment Manufacturers Association
CEPRAM	State Council for Environmental Matters
CFEM	Financial Compensation by Exploration of Mineral Resources
CIC	Carbon in column
CIM	Canadian Institute of Mining, Metallurgy and Petroleum
CO	Carbon monoxide
CO2	Carbon dioxide
COG	Cut-off grade
CSLL	Social contribution of net profit
CSMAT	Controlled Source Audio-Magnetotelluric Tensor
Cu	Copper
CuEq	Copper equivalent
DCF	Discounted Cash Flow
DCS	Distributed Control Systems
DDIP	Dipole-Dipole Induced Polarisation
DFS	Definitive Feasibility Study
DIA	Declaración de Impacto Ambiental
DMS	Dry Magnetic Separator
EIA	Environmental Impact Assessment
EM (VLF)	Electromagnetic, very low frequency
EMPs	Environmental Management Plans
EOP	End of Period

Table of Abbreviations

Abbreviation	Acronym
EPC	Engineer, procure, construct
EPCM	Engineer, procure, construction management
ESIA	Environmental and Social Impact Assessment
EW	Electrowinning
FCA	Free carrier allowed
FeV	Ferro Vanadium
FOB	Free on board
FOREX	Foreign Exchange
GA	General Arrangement
GDP	Gross Domestic Product
HDPE	High Density Polyethylene
HG	Hypogene
HG	Magnetite
HSEC	Health, Safety, Environment & Community
HV	High voltage
HVAC	Heating, ventilation and air conditioning
ICP	Inductively Coupled Plasma
ID2	Inverse Distance Squared
IDH	Human Development Index
IFC	International Finance Committee
IFS	Initial Feasibility Study
IIA	Informe de Impacto Ambiental
IMO	International Maritime Organisation
IP	Induced polarization
IRR	Internal Rate of Return
ITR	Independent Technical Report
kWh	Kilowatt hour
LAM	Lithology; Alteration and Mineralization
LI	Installation License
LL	Localization License
LME	London Metal Exchange
LOM	Life of mine
LV	Level voltage
MAG	Magnetic Mass Recovery
MCC	Motor control centres
MCE	Maximum credible earthquake
MDE	Maximum design earthquake
MG	Magnetite Pyroxenite
MII	Measured, Indicated and Inferred resources
MISC	Miscellaneous
MLI	McClelland Laboratories International
Mo	Molybdenum
MoS2	Molybdenum disulphide
MTO	Material take off
MV	Medium voltage

Table of Abbreviations	
Abbreviation	**Acronym**
MW	Megawatt
NAG	Net Acid Generation
NaHS	Sodium hydro sulphide
NOx	Nitrous oxides
NPC	Net Present Cost
NPV	Net Present Value
OK	Ordinary Kriging
OL	Operational License
OPEX	Operating Expenditure
Pb	Lead
PEA	Preliminary Economic Assessment
PFS	Prefeasibility Study
PGM	Platinum group minerals
PLS	Pregnant leach solution
PRAD	Plan Rehabilitation of Degraded Areas
PSA	Pit slope angle
PTSV	Technical Project for Vegetation Suppression
QA/QC	Quality assurance/Quality control
RIMA	Relatório de Impacto Ambiental
RL	Relative Level
RMR.	Rock mass rating
ROM	Run of mine
RQD	Rock Quality Designation
SECA	Sistema de Estudo Climaticos e Ambientais
SFC	Secretaria de Conservação de Florestas
SG	Supergene
SG	Specific Gravity
SGS	Lakefield Research Group
SOx	Sulphur oxides
SR	Strip Ratio
STK	Stock Pile
SXEW	Solvent extraction electrowinning
TBD	To be determined
TR	Reference Termsheet
UPS	Uninterruptible power supplies
UTM	Universal Transverse Mercator (coordinate system)
V2O5	Vanadium Pentoxide
VALE	Companhia Vale de Rio Doce
VFD	Variable frequency drive
VMSA	Vandio de Maracás S.A.
VSD	Variable speed drive
XRD	Mineralogical characterization
XRF	X-ray fusion

Units of Measure	
Unit	**Abbreviation**
American Dollar	USD
Bond Ball Mill Work Index (metric)	kWh/t
Brazil Real	$R
Canadian Dollar	CAD
Centigrade	□□
Centimetre	Cm
Chilean Peso	CLP
Cubic metre	m3
Cubic metres per second	m3/s
Day	D
Dead weight ton (imperial ton - long ton)	Dwt
Dry metric tonne	Dmt
Foot/feet	Ft
Gram	G
Gram/litre	g/L
Gram/tonne	g/t
Hour	H
Hours per Year	h/yr
Kilogram	Kg
Kilogram per tonne	kg/t
Kilometre	km
Kilopascal	kPa
Kilovolt	kV
Kilovolt amp	kVA
Kilowatt	kW
Kilowatt hour	kWh
Litre	L
Litre per second	L/s
Megawatt	MW
Metre	m
Metre per hour	m/h
Metre per second	m/s
Metric tonne	T
Metric tonne per hour	t/h
Metric tonnes per day	t/d
Micron	Mm
Milligram	Mg
Milligram per litre	Mg/L
Millimetre	Mm
Million	M
Million tonnes	Mt
Million tonnes per annum	Mt/a
Parts per billion	ppb
Parts per million	ppm

Units of Measure	
Unit	**Abbreviation**
Percent	%
Second	S
Short ton	T
Square metres	m2
Tonnes per Annum	t/a
Tonnes per Day	t/d
Troy ounce	oz
Wet metric tonne	Wmt
Work index	WI
Year	yr

1 SUMMARY

1.1 Introduction

Largo Resources Ltd. (Largo) retained GE21 to review the pit optimization, life of mine plan and plant feed schedule for all of the deposits at the Maracás Menchen Vanadium Mine (Maracás Menchen Mine) and to prepare a feasibility study level (FS) review of the Campbell deposit (Campbell or the Campbell deposit which has also been referred to as "Gulçari A" in prior reports) and a Preliminary Economic Assessment (PEA) study level review for Gulçari A Norte, Gulçari B, Novo Amparo, Novo Amparo Norte and São José (collectively, the Satellite Deposits) and for the , remaining Campbell in pit resources. This report evaluates and assesses the Life of Mine Plan (LOMP) for the entire mineral project. The results of this 2017 LOMP are described in this report, the highlights of which are as follows:

- Both studies were a "Vanadium Only" study. No value was given for any by-products at this time, including iron, ilmenite (TiO_2) and PGMs. GE21 strongly recommend immediate studies to give value to the project based on these by-products.
- This study used a long-term vanadium pentoxide (V2O5) price of US$6.34/lb for the life of mine except for 2018 and 2019, where US$ 9.00/lb was used.
- Life of operation for the mineral reserves in the Campbell deposit is 11 years.
- An additional mine life of 12 years is estimated if inferred resources in the Satellite Deposits and remaining Campbell in pit resources come to be converted to mineral reserves.
- GE21 recommended the Satellite Deposits and remaining Campbell in pit resources be developed sequentially as follows: Novo Amparo Norte, Gulçari A Norte & Gulçari B, Sao Jose, Campbell in pit resources and Novo Amparo.
- $NPV_{(8\%)}$ post tax is US$ 542 million for the reserves at the Campbell deposit.
- $NPV_{(8\%)}$ post tax is US$ 140 million for the resources in the Satellite Deposits and remaining Campbell in pit resources.

Largo has completed the ramp of its Maracás Menchen Mine operations, located in Bahia, Brazil. The operation now produces vanadium pentoxide (V_2O_5) with annual name plate production of 9,600 tonnes of V_2O_5 flake.

In 2017, Largo retained GE21 to review the optimized mine plan and plant feed schedule for the Maracás Menchen Mine based on the new pit slope and based on two proposed expansions that would increase the production rate to 11,520 tonnes per annum of V_2O_5 in 2019 and to 13,200 per annum of V_2O_5 for 2020 though to the end of life of the mine.

This Independent Technical Report (ITR) contains a PEA done in conjunction with a FS, as defined by Canadian Securities Adminstrators (CSA) on Aug 16, 2012 titled CSA Staff Notice 43-307- *Mining Technical Report – Preliminary Economic Assessments*, which provides the following:

"*By definition, a PEA is a study other than a PFS or FS. We generally consider that two parallel studies done concurrently or in close time proximity to each other are not in substance separate studies, but components of the same study. Therefore, a study that includes an economic analysis of the potential viability of mineral resources that is done concurrently with or as part of a PFS or FS is not, in our view, a PEA if it:*

- *has the net effect of incorporating inferred mineral resources into the PFS or FS, even as a sensitivity analysis,*
- *updates, adds to or modifies a PFS or FS to include more optimistic assumptions and parameters not supported by the original study, or*
- *is a PFS or FS in all respects except name."*

In summary, this ITR contains a FS in its main body where none of the inferred resources are incorporated. This ITR also contains, under section 24, a PEA which does not update, add to or modify the FS, nor does it contain more optimistic assumptions and parameters, and is not a PFS or FS in any respects.

The previous reports for the Maracás Menchen Mine usually refer to the main deposit only as "Gulçari A", however, Largo has begun exploiting this deposit and now refers to it as the Campbell, the Campbell deposit of the Campbell Pit. In this report, unless otherwise explained, references to "Gulçari A" are reference to the Campbell deposit.

1.2 Property Description and Location

The Maracás Menchen Mine (also referred to as the Property or the Project) consists of eighteen (18) concessions totalling 17,690.45 ha (see Figure 1.2_1). These exploration and mining permits are listed in Table1.2_1. Three of these permits include the original two (DNPM 870134/82 and DNPM 870135/82) and are owned by Vanádio de Maracás S.A. (VMSA) which is controlled 99.9% directly and indirectly by Largo. The remaining 15 permits are owned by Largo Mineração Ltda., a wholly owned subsidiary of Largo.

Figure 1.2_1

Maracás Project Property Map

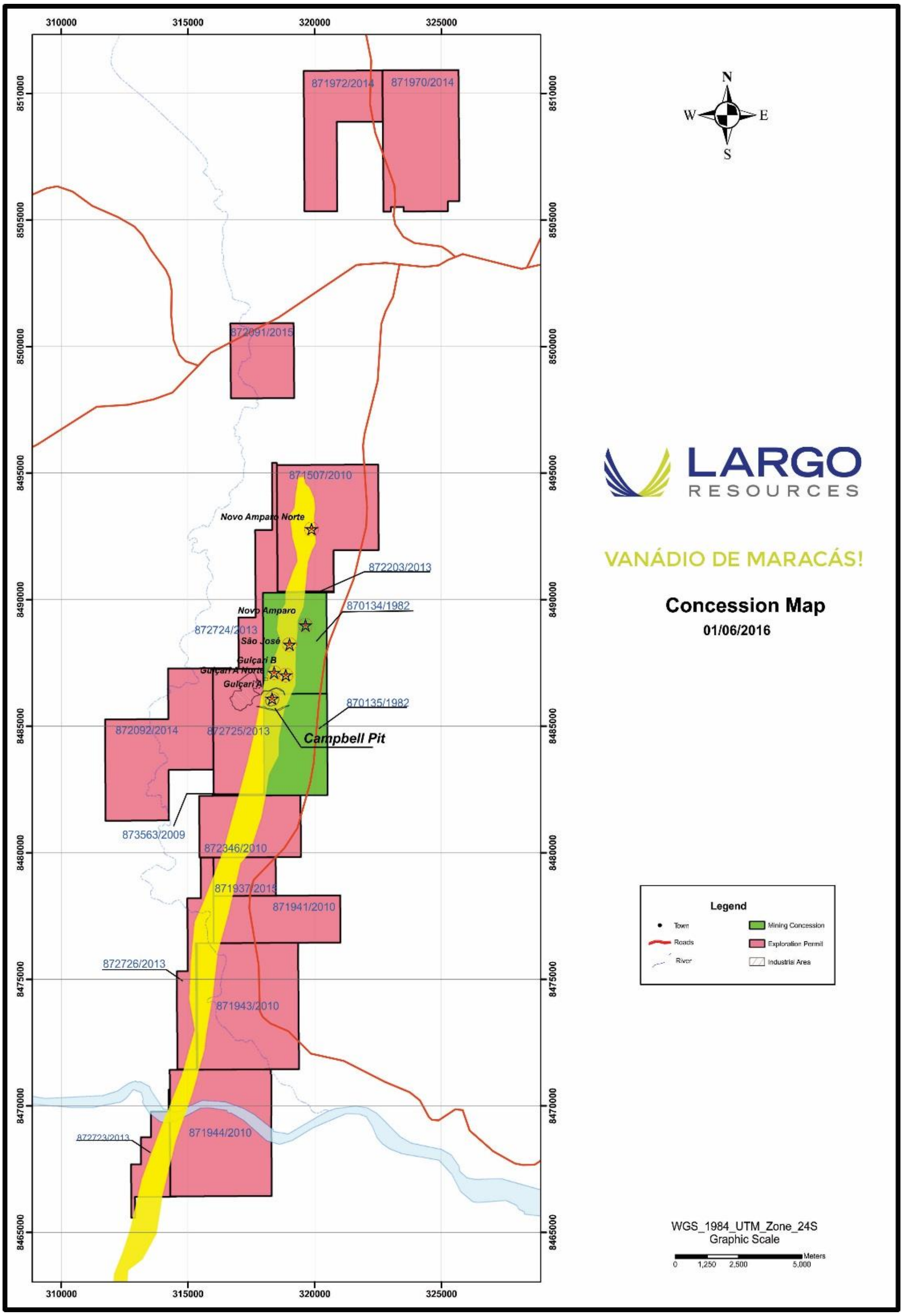


Table1.2_1

Maracás Property Exploration and Mining Permits

DNPM	Substance	Status	Requested	Expiry Date	City
870.134/1982	V	Mining permit pending	1,000.00	not applicable	Maracás
870.135/1982	V	Mining permit granted	1,000.00	not applicable	Maracás
872.346/2010	V	Exploration permit	977.29	25/2/17	Maracás
872.203/2013	V	Exploration permit	6.42	29/10/18	Maracás
872.723/2013	V	Exploration permit	413.71	29/10/18	Iramaia/Manoel Vitorino
872.724/2013	V	Exploration permit	495.75	29/10/18	Maracás
872.725/2013	V	Exploration permit	988.46	29/10/18	Maracás
872.726/2013	V	Exploration permit	593.75	29/10/18	Iramaia/Maracás
873.563/2009	V	Exploration permit	11.11	10/10/16	Maracás
871.944/2010	Fe, V	Exploration permit	2,000.00	Extension	Iramaia/Maracás
871.943/2010	Fe, V	Exploration permit	1,999.87	Extension	Iramaia/Maracás
871.941/2010	Fe, V	Exploration permit	927.00	Extension	Maracás
871.507/2010	V	Mining permit application	1,713.88	not applicable	Maracás
871.970/2014	V	Exploration permit	1,649.21	8/12/18	Maracás
871.972/2014	V	Exploration permit	1,084.92	8/12/18	Maracás
872.092/2014	V	Exploration permit	1,709.51	8/12/18	Maracás
872.091/2015	Fe, V	Exploration permit	743.70	17/12/18	Iramaia/Maracás
871.937/2015	V	Exploration permit	375.87	15/3/19	Maracás
		Total	17,690.45		

Largo reports that all but two of the permits for the concessions are currently registered as exploration licenses and are in good standing. One of the concessions has been granted a mining licence and the other concession's mining licence is pending. The concession with the pending mining license already has a Localization License (LL) and an Installation License (LI). While under application or pending there are no fees due on the exploration permits until the exploitation license has been granted.

Largo through VMSA, entered into an agreement with Vale S.A. (Vale) and Odebrecht S.A. (Odebrecht), dated October 16, 2006 giving it an option to acquire a 90% interest in the Property from the two Brazilian companies for a purchase price of USD10.0 million. Under this agreement, Largo was required to maintain the exploration permits in good standing. On December 22, 2012 Largo exercised the option and acquired the interests held by each of VALE and Odebrecht resulting in VMSA owning 100% of the Property.

Largo reports that, to its knowledge, there are no existing environmental liabilities relating to the Project.

The Property is located within the greater municipality of Maracás in eastern Bahia State, Brazil. Maracás lies about 250 km southwest of the City of Salvador, the capital of Bahia. The distance by road from Salvador to the Project is 405 km via a paved secondary road from the main coastal highway in Bahia, with the Project being accessed by about 50 km of secondary highway and gravel road west of the town of Maracás. Access to water, the electric power grid and a railroad is within a reasonable distance, and a trained workforce familiar with the mining and mineral exploration industries exists in the state of Bahia and also within in the country generally.

The Project has been the subject of extensive prior exploration and feasibility work by Companhia Baiana de Pesquisa Mineral (CBPM), CAEMI Mineração e Metálurgia S.A. (CAEMI) and Odebrecht, since the discovery of vanadium there in 1980. According to reports by CBPM, CAEMI, Odebrecht and their consultants, the previous work had outlined the existence of four vanadium deposits, including a large deposit of vanadium-rich titaniferous magnetite mineralization at Campbell and other smaller deposits known as Gulçari B, Novo Amparo and São José.

1.3 Exploration and Drilling

At the time of acquisition of the Property in the fall of 2006, Largo had performed no exploration on the Property, but had completed a due diligence review program which checked the logging of, and resampling of certain original diamond drill core from the 1980s, and checked the surveyed locations of various trenches and drill-hole collars. This work confirmed the previous sampling and interpretation at the Project and Largo used the data to complete an “in-house” mineral resource estimate for the Campbell deposit formerly called Gulçari A deposit, at the Project.

Since the acquisition of the Project, Largo has completed three drill programs in 2007, 2008 and 2011-12. These programs have confirmed previous interpretations, increased the size of the deposit and created enough data to allow for an update of the previous mineral resource and an upgrade of their confidence category. The total drilling completed on the property has tested 7 zones with 209 holes totalling 35,286.59 m (Table 1.3_1) of which Largo has drilled 140 holes totalling 29,371.29 m between 2007 and 2012.

There has been sufficient drilling in this area to demonstrate the continuity of the magnetite-rich horizons which is also supported by the ground magnetic survey that traces the known zones on surface. The ground magnetic survey also has identified a number of deposits that had not been previously tested.

Table 1.3_1

Total Maracás Drilling

Area	Program	No of Holes	Total Metres
Campbell	1981-87	53	5,152.57
	2007	45	11,195.94
	2011-12	11	3,117.61
Total		**109**	**19,466.12**
Gulçari B	1981-83	7	270.28
	2011-12	10	1,367.81
Total		**17**	**1,638.09**
Gulçari A Norte	2007	3	566.40
	2008	1	211.00
	2011-12	12	1,766.73
Total		**16**	**2,544.13**
Gulçari B Sul	2011-12	6	1,150.00
Total		**6**	**1,150.00**
São Jose	1983	2	115.15
	2008	9	2,209.50
	2011-12	14	2,389.75
Total		**25**	**4,714.40**
Novo Amparo	1983	7	377.30
	2007	9	1,502.10
	2008	1	285.00
	2011-12	2	357.95
Total		**19**	**2,522.35**
Novo Amparo Norte	2011-12	17	3,251.50
Total		**17**	**3,251.50**
Grand Total		**209**	**35,286.59**

1.4 Mineral Resource Estimates

The Property is host to many mineralized zones, namely Campbell, Gulçari A Norte, Gulçari B, São José, Novo Amparo and Novo Amparo Norte. In this report, GE21 is using only the Measured and Indicated resources from the Campbell to update the reserves for their optimization study. The resources for Gulçari A Norte, Gulçari B, São José, Novo Amparo and Novo Amparo Norte are separate and have not changed since first being estimated for the 2013 technical report (Arsenault, 2013).

The Campbell, as outlined from the drill programs, extends 400 m along strike, and to a vertical depth of over 350 m with true widths ranging from 11 to 100 m and with an average width of about 40 m. This deposit is part of a mineralizing system that extends for 6.5 km along the length of the property. All the assays from this drill program are completed and results received.

A three-dimensional block model was generated to enable grade estimation. The selected block size was based on the geometry of the domain interpretation and the data configuration. The block size of 5 m E by 5 m N by 5 m RL was selected. The “percent” block modeling technique was used to represent the volume of the interpreted wireframe models. Sufficient variables were included in the block model construction to enable grade estimation and reporting.

Resource estimation for the Campbell vanadium deposit was undertaken using ordinary kriging (OK) as the principal estimation methodology for V_2O_5. The OK estimates were completed using Gemcom mining software.

The following list of variables are contained in the received block model data:

- Lithology code
- Bulk density assigned by lithology-type constant values (t/m^3)
- Vanadium pentoxide in percent (%V_2O_5)
- Titanium dioxide in parts per million (TiO_2 ppm)
- Palladium grade in parts per million (Pd ppm)
- Platinum grade in parts per million (Pt ppm)
- A class code to distinguish Measured, Indicated, and Inferred resource blocks.

Largo has completed a block model and mineral resource estimate for the Campbell deposit and five new Satellite Deposits incorporating the drilling from the 2011 program including 72 holes totaling 13,401 m. The five Satellite Deposits which extend north from Campbell for eight kilometres include from south to north: Gulçari A Norte, Gulçari B, São José, Novo Amparo and Novo Amparo Norte. All are hosted in the Jacaré River Intrusion.

In 2016, Largo updated mineral resource estimate for the Campbell deposit as a result of depletion of mined resources. This Measured and Indicated resource was used to update the reserve and used for the new mine plan presented herein. The new block model incorporates %

magnetics (percent of magnetic minerals in the mineralized rock) and magnetite concentrate grade for V_2O_5 and SiO_2. No new drilling was available for the estimate; however, it was adjusted for mining completed to date. The updated mineral resources for Campbell is presented in Table 1.4_1.

Table 1.4_1

Campbell Mineral Resources

Maracás Vanadium Project –Campbell Mineral Resources

Effective date: May 02nd 2017

Category	Tonnes (Mt)	V2O5 Head Grade (%)	V2O5 Contained (kt)	V2O5 in Concentrate (%)	Magnetics (%)
Measured (M)	18.08	1.19	215.0	3.19	30.55
Indicated (I)	1.70	1.28	21.7	3.12	34.64
M&I	19.78	1.20	236.7	3.19	30.90
Inferred	1.65	1.20	19.8	3.10	33.08

Resource within a pit shell using US$34.20/t all in operating cost and reported at a 0.45% V_2O_5 cut-off, reviewed and confirmed by Fabio Valério Xavier (GE21).

The % magnetics number refers to the percent of magnetic minerals contained in the mineralized rock. It is used to help determine what portion of the mineralization in the mineral resources contains magnetite of sufficient vanadium content to be processed through the magnetic separators and concentrated, and, therefore, can be determined to be a mineral reserve

Largo has completed a revised block model and updated mineral resource estimate for the Satellite Deposits incorporating the drilling from the 2011 program including 72 holes totaling 13,401 m. The Satellite Deposits which extend north from Gulçari A for eight kilometres include from south to north: Gulçari A Norte, Gulçari B, São José, Novo Amparo and Novo Amparo Norte. All are hosted in the Jacaré River Intrusion.

No new drilling has been completed on the Satellite Deposits since 2012 and the mineral resources presented in Table 1.4_2 are considered current.

Table 1.4_2 Satellite Deposits Mineral Resource Effective date: May 02nd 2017				
Deposits	**Category**	**Tonnes (kt)**	**V2O5 (%)**	**Contained V2O5 (tonnes)**
Gulçari A Norte**	Inferred	9,730	0.84	81,388
Gulçari B**	Inferred	2,910,000	0.70	20,312
Novo Amparo**	Inferred	1,560	0.72	11,255
Novo Amparo Norte**	Inferred	9,720	0.87	84,453
Sao Jose**	Inferred	3,900	0.89	34,706
Satellite Deposits (Total)**	Inferred	27,820	0.83	232,114

** Resource within a pit shell using US$34.20/t all in operating cost and reported at a 0.45% V_2O_5 cut-off, reviewed and confirmed by Porfirio Cabaleiro Rodriguez (GE21)

1.5 Mineral Reserve Estimates

Mineral reserves for the Project have been estimated for the Campbell deposit with an effective date of May 02, 2017. The ultimate pit and mine plan was guided by GE21 to optimize kiln feed. The mine plan developed in this report is based on Measured and Indicated resources only as delineated in Section 14.

Reserves are reported using a sales price of $6.34/lb of V_2O_5. The ultimate pit design and mine plan was done to optimize kiln feed. Details of the assumptions, parameters and methods used in the preparation of the reserve estimate and mining schedule are described in Section 16.

The mineral reserves presented in Table 1.5_1 were estimated by Porfírio Cabaleiro Rodriguez of GE21, who is a qualified person under NI 43-101 and a Member of the Australian Institute of Geoscientists.

Table 1.5_1 Maracás Vanadium Project Mineral Reserves – Campbell pit Block dimensions 5x5x5 (m) Mine Recovery 100% and Dilution 5% *(Effective May 02, 2017)*				
Reserve Category	**Tonnage (kt)**	**%V2O5 Head**	**%Magnetics**	**%V2O5 con**
Proven	17,570	1.14	29.66	3.21
Probable	1,440	1.26	33.89	3.20
Total in pit Reserve	19,010	1.15	29.98	3.21

1.6 Recovery Methods

The process selected for the Maracás vanadium recovery plant was based on metallurgical test work compiled by SGS Lakefield Research Group Limited (SGS) in 2007, a study undertaken by IMS Processing plant in 1990, a feasibility study completed by Lurgi in 1986 and a detailed Technical study produced by Engenharia e Consultoria Mineral S.A. (ECM) in 1990.

The Maracás vanadium recovery plant was commissioned in 2015 and has been in start-up mode for much of that time ramping up to near design capacity. At the time of writing this report, the plant produces up to 800 t/ month, equivalent to a production rate of 9600 tpy of V_2O_5.

The current process flow sheet comprises the following: three stages of crushing, one stage of grinding, two stages of magnetic separation, magnetic concentrate roasting, vanadium leaching, ammonium meta-vanadate (AMV) precipitation, AMV filtration, AMV calcining, and fusing to V_2O_5 flake as final product. A simplified process flow diagram for the production of vanadium pentoxide is presented in Figure 1.6_1.

Originally sized to process 960,000 t/a run of mine (ROM) the plant will be capable, after due modification, to process 1,900,000 t/a of feed ore with an average grade of 1.14% V_2O_5 and produce 13,200 t/y V_2O_5 by 2020. The plant is designed to operate 365 days per year, 7 days/week, 24 hours/day with an on-stream factor of 87%.

Overall recovery from ore of V_2O_5 has reached 76%.

Figure 1.6_1

Conceptual Process Flow Sheet - Vanadium Pentoxide

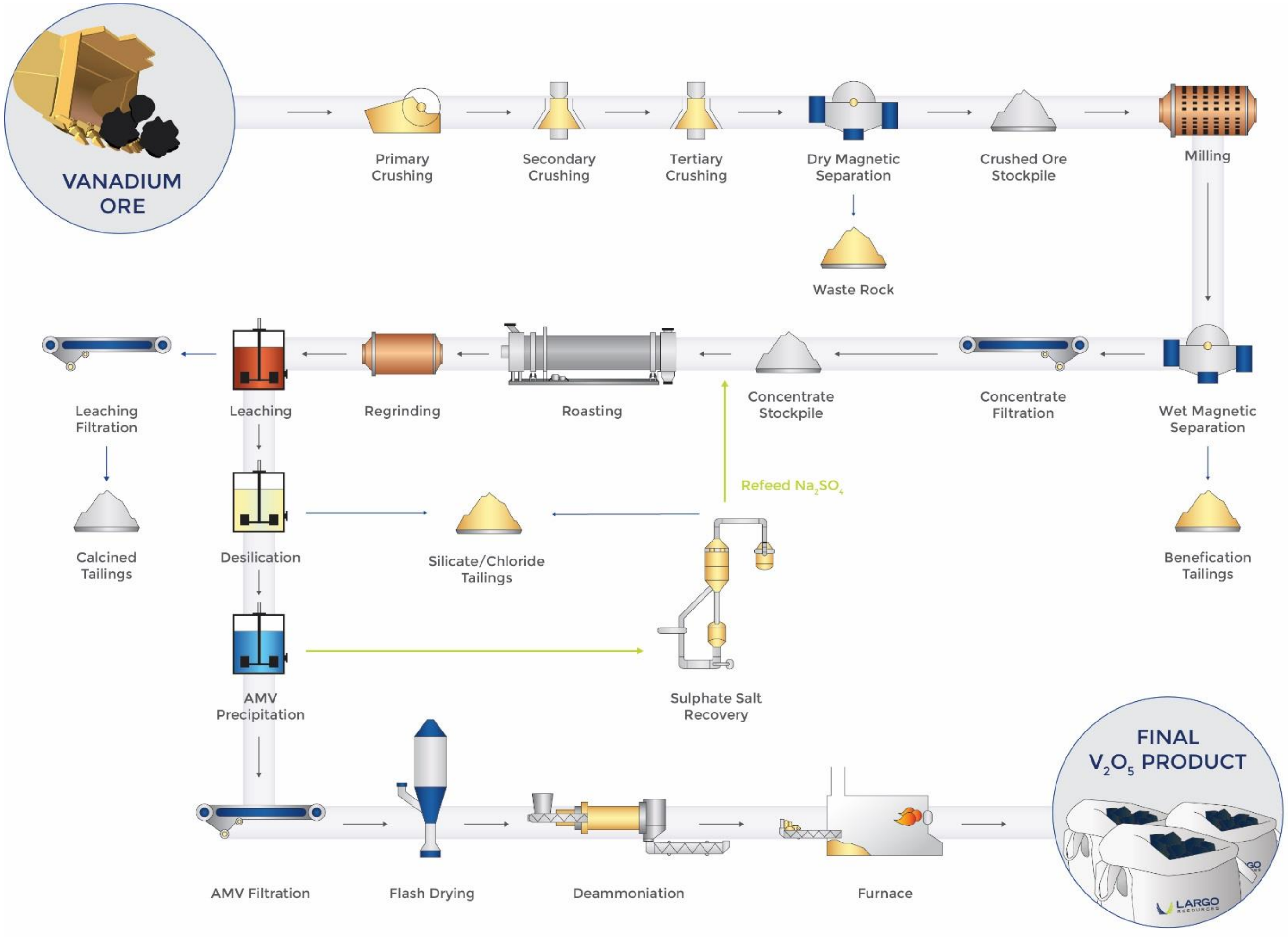


Table 1.6_2 provides a summary of key process design parameters used for the process design as compared to actual data during the recent months. Estimated overall recoveries vary between the different ore deposits within a range of +3% and -8% from the base case. Blending of magnetite and magnetite-pyroxenite bearing material is planned to occur at the crusher.

The final magnetic concentrate is thickened and filtered. The filter cake is fed to the roasting section of the plant. The nonmagnetic tailings fraction from the beneficiation plant are thickened, filtered and conveyed to the tailings pond.

An off-gas control system collects any dust entrained inthe gas from the roaster. To meet local environmental regulation, an electrostatic precipitator is installed to remove such particulates. The quantity of sodium sulphate added to the kiln is controlled and reduced in order to ensure compliance with the emission limits for SO_2. Since the sodium sulphate dosage is already maximized for the base case, additional sodium carbonate will be added to the kiln in the expanded case to ensure efficient extraction of vanadium and the excess sodium sulphate produced in the evaporator is stockpiled in a sealed area.

Table 1.6_2

Summary of Key Process Design Criteria

Criterion	Units	2017/2018 Production	2020 onwards
Average Ore Processing rate	t/a	1,415,000	1,900,000
V2O5 Production	t/a	9,600	13,200
Average V2O5 head grade	%	1.09	1.16
Plant availability	%	87%	87%
Plant Operating hours	h/y	7500	7500
Average plant daily ore throughput	t/d	3900	3900
Number of crushing stages	#	3	3
Crusher product size (80% passing)	mm	12	12
Number of grinding stages	#	1	1
Grind product size	microns	150	150
Magnetic Product solids yield	%	30	30
Average magnetic concentrate V2O5 content	%	3.21	3.21
Roasting reaction zone residence time	h	1	1
Leach retention time	h	2	2
Average roasting/leach V2O5 conversion	%	81%	81
AMV precipitation V2O5 recovery	%	98.8	98.8
Total average recovery to V2O5	%	76.0	76.0

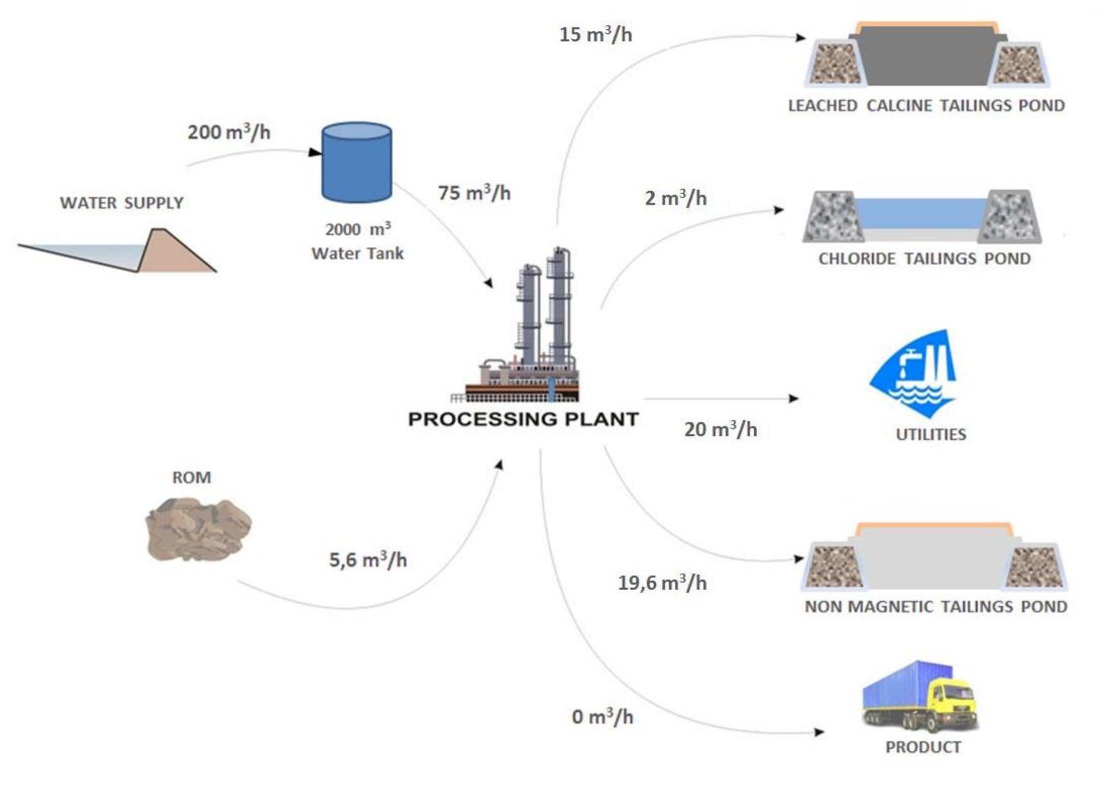
1.7 Environmental Studies, Permitting and Social or Community Impact

The overall water balance of the Project was determined in order to quantify water availability and identify requirements for tailings disposal and storage. Figure 1.7_1 shows a water balance flow chart involving the structures under consideration and their corresponding flow rates.

The processing plant requires 81.6 m^3/hr water during operations, currently 75.0 m^3/hr is provided from the Rio de Contas and 5.6 m^3/hr is provided from the water content in the mined ore. VMSA's license provided by the federal water agency, ANA (Agência Nacional De Aguas), provides for a maximum water usage of 300 m^3/hr from the Rio de Contas. The pumping system from the Rio de Contas was designed with a capacity of 200 m^3/hr. There is a circulating water load within the plant with the net make-up being the 75 m^3/hr.

Figure 1.7_1

Water Balance Flow Chart



Originally, as seen in previous technical reports, the plant design incorporated a conventional slurried tailings system with a tailings pond resulting in a greater demand for water. This water demand has been reduced with the introduction of ponds and reuse of the water to the plant. This change was driven by concerns amongst local stakeholders related to water scarcity.

A number of geological and geotechnical characterization activities were carried out to provide input data for the engineering design work associated with the open pit, the processing plant installations, waste and ore stock piles, tailings disposal and flood control systems.

The processing plant was constructed to the northwest of Campbell where natural elevations range from 300m to 325m. The extraction process results in the need to provide several tailings storage facilities and waste piles as noted below. Tailings generated by the process include leached calcine from the processing kiln discharge, filter cake from the de-silication process, chloride control purge from the evaporation circuit and primary inert tailings originating from magnetic separation.

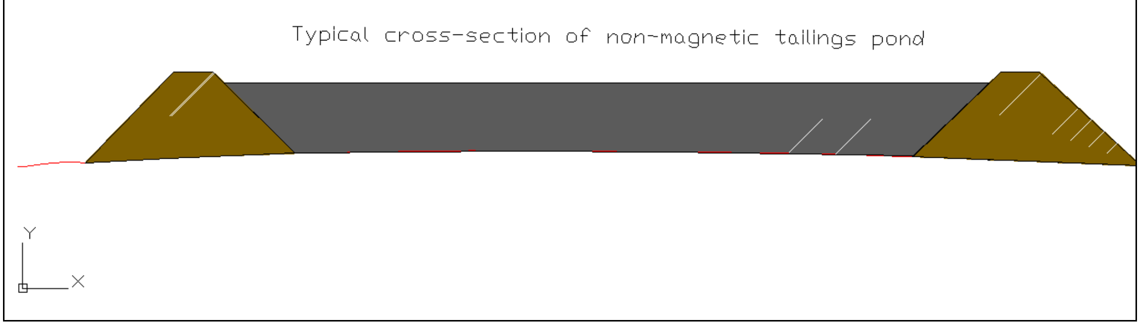
The area designated for the disposal of the non-magnetic tailings in ponds is located south of the processing plant. The ponds will be partially surrounded by waste dump material as shown in Figures 1.7_3 and 1.7_4.

The first waste pile is located southwest of the processing plant. The Chloride Purge Tailings Pond is to be located south of the processing plant and the Leached Calcine Tailings Stack to the north.

The new Non-Magnetic Tailings Pond design consists of a series of ponds formed by rock-fill structures sealed by compacted clayey/saprolitic material, as illustrated in Figure 1.7_2.

Figure 1.7_2

Typical Cross-Section of the Non-Magnetic Tailings Pond



The proposed arrangement will be applied to the construction of the various ponds outlined in Table ES_9.

Table ES_8 presents a summary of key tailings pond design characteristics.

Table 1.7_1 Summary of Key Non-Magnetic Tailings Pond 3 Design Aspects	
Design Aspect	**Measurement**
Maximum height (m)	20
Length of stack structure (m)	300
Width of stack structure (m)	250
Maximum crest elevation (m)	325
Minimum downstream elevation (m)	305
Center road width (m)	10
Height of slopes between berms (m)	10
Tailings capacity - (m3)	600,000
Maximum area occupied (m2)	740,000

The layout of the Non-Magnetic Tailings Pond is shown in Figure 1.7_3 and Figure 1.7_4. The schedule of pond construction and usage if outlined in Table 1.7_2. Further study is required to expand the tailings facilities to adequately meet the storage requirements of the remainder of the project life.

Figure 1.7_3

Layout of Non-Magnetic Tailings Ponds

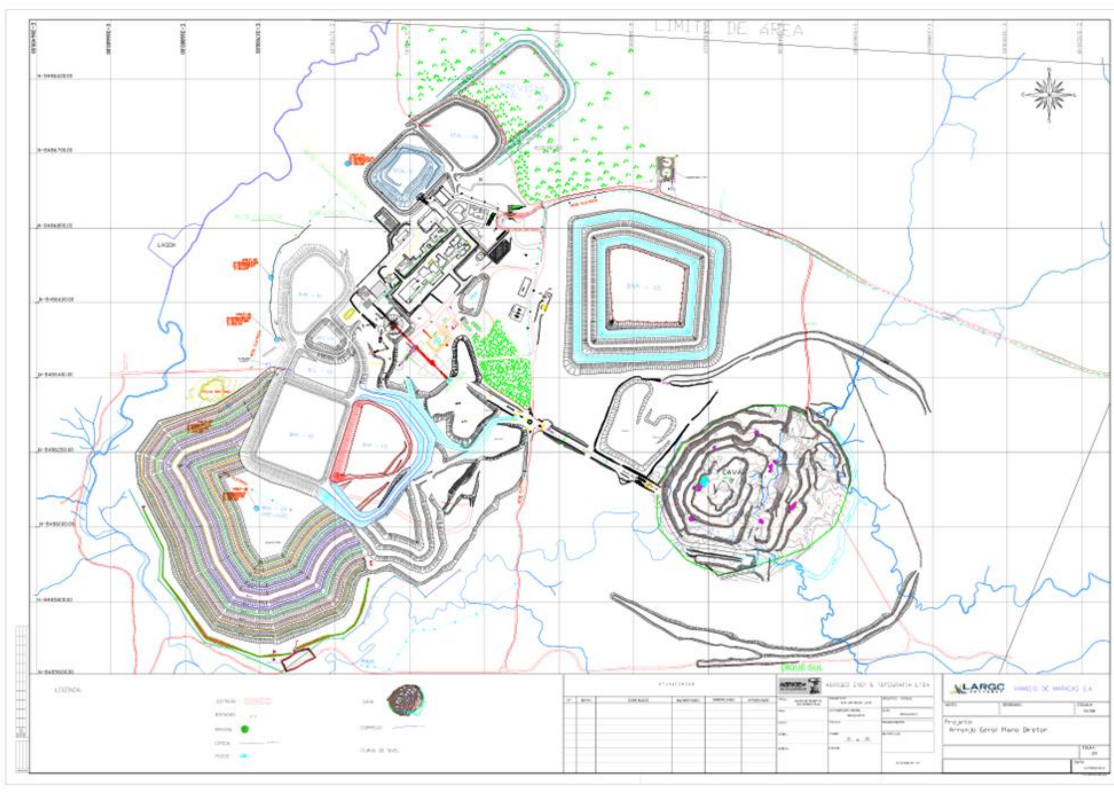


Figure 1.7_4

Close Up Layout of Non-Magnetic Tailings Ponds

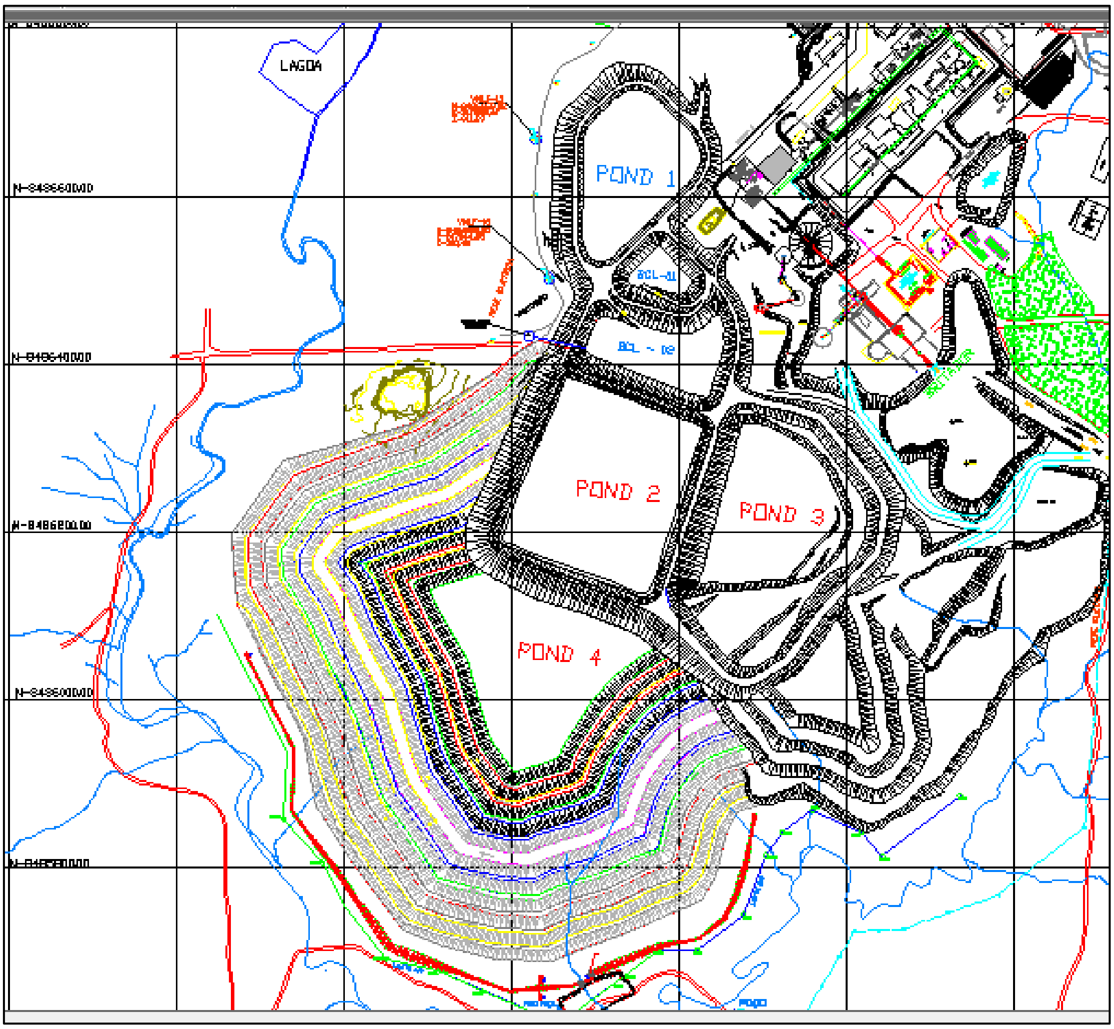
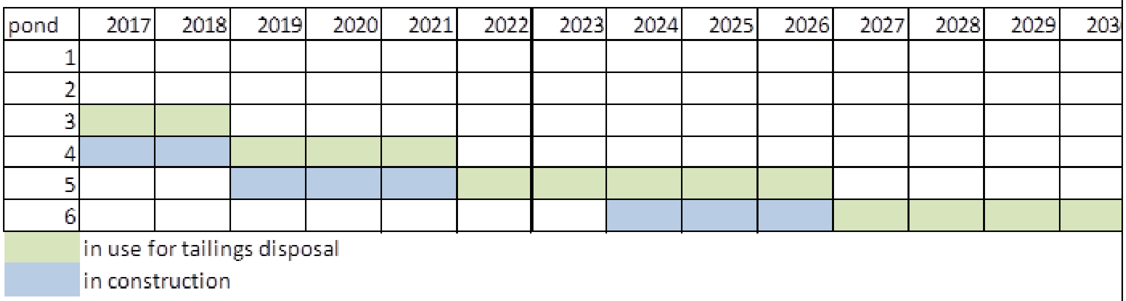


Table 1.7_2

Schedule of Non-Magnetic Tailing Pond Construction and Usage



The leached calcine tailings are discharged into the Leached Calcine Tailings Stack. The de-silication reject and chloride control purge tailings will be deposited in the Chloride Control Purge Pond. The intended construction location for these ponds is northwest of the open pit, close to the processing plant.

The dikes were built using compacted earth and their base areas are leak-proofed using a double-layer geomembrane liner featuring a leak detection system. The construction consists of clearing vegetation from the areas to be occupied by the ponds, removal of organic material, and excavation of material inappropriate for foundations. The perimeter of each pond will be protected by rock-fill channels.

The area designed for the open pit intercepts of the João Creek and three direct tributaries. Consequently, this warrants the installation of a protection system to impede the influx of surface water runoff into the pit to enable mining activities to proceed.

For the initial phase, VOGBR, a Brazilian geotechnical consultant, envisaged the pit protection system to consist of dikes and channels. The reason for the selection of this alternative provided a good balance between the volume of the required cuts and landfills. However, following ensuing Project development Vanádio de Maracás decided to use a system of protection ridges, because of the proximity and usage of material from within the open pit, which was considered to be more economic.

This system consists of a pair of ridges located around the open pit, denominated as the Northern Ridge and the Southern Ridge. The objective is to redirect the waters to points downstream from the open pit. The protection ridges form a barrier around the open pit to intercept the watercourses and to raise their water levels, so they can naturally surpass the topographical elevations variations and flow by gravity bearing the surface runoff downstream from the open pit.

The protection ridges will be installed pursuant to the mining activity plan defined for the open pit. The Northern Ridge should be completed by the close of Year 2 while the Southern Ridge will be required for mining activity development as of Year 3.

The use of overburden material from the open pit was considered as a premise when dimensioning the protection ridges. Accordingly, the ridge structures were conceived consisting of rock fill, transition material and compacted earth (residual soil/saprolitic material).

The borrow materials that will be used for the ridge construction are to be obtained from the open pit, the actual ridge location and the processing plant area. Rocky overburden (processed material) is envisaged for use as transition material within the ridges.

The material originating from the open pit, which will be placed on the waste pile or the ore stockpile, is predominantly rock consisting of boulders of varying sizes. The area designated for the waste pile covers approximately 47 ha.

In addition, Largo has retained Mineral Engenharia em Meio Ambiente Ltda. (Mineral) to complete an environmental audit incorporating the requirements of Equator Principle n° 04. This audit resulted in an Action Plan that incorporates the programs necessary for compliance with Brazilian laws and regulations and applicable environmental performance standards and Environment, Health and Safety (EHS) guidelines.

The results of this audit are presented in Section 20.8 Current Activities and Plans.

The Mine Closure and Reclamation Plan calculated for Campbell totalled US$ 12.4 million and involved the following expenses: covering the mine site, plant, stockpile, tailing dams, waste disposal area, buildings and facilities.

Table 1.7_3

Mine Closure Costs

Mine Closure Costs	**Costs in US$**
1. Adminstration	$829,531
2. Disassembly	$7,880,029
3. Earth moving	$56,426
4. Rehabilitation and revegetation of impacted areas	$818,184
5. Environmental monitoring program	$329,383
6. Communities comunication program	$90,939
7 Contingencies	$ 2,400,000
Total	**12,404,495**

A review of the Brazilian permitting process is presented as follows:

When a Class II mineral extraction project (as defined by the Mining Code) is presented for development a multidisciplinary technical review team is appointed by the State Council for Environmental Matters (CEPRAM) to review the project. The team sets the Terms of Reference for the Environmental Impact Assessment (EIA) and the Relatório de Impacto Ambiental (RIMA). The RIMA is a document that summarizes the full impact assessment for review by the public.

The Terms of Reference for the EIM/RIMA include a social impact, alternatives and archaeological assessment for the Project, in addition to the basic physical and biological environmental impact assessment.

Environmental permitting in the State of Bahia is the responsibility of the Instituto do Meio Ambiente e Recursos Hídricos (INEMA), which is the institution that regulates, approves and issues the environmental permits or licenses. INEMA replaced the Instituto de Meio Ambiente (IMA) by state decree on May 4, 2011.

The permitting process in Bahia takes into consideration the nature and size of the projects and activities under consideration, the characteristics of the affected ecosystem and the supporting capacity of the area being impacted.

The following types of environmental licenses are necessary for the Project:

- Location License (LL): The LL is granted in the preliminary planning phase of the project or operation, and it approves the location and the conceptual design of the project, attesting its environmental feasibility and determining the basic requirements and conditions to be observed in the subsequent permitting stages;
- Installation License (LI): The LI is granted so that the project or operation can be installed (or constructed), in accordance with the specifications presented in the plans, programs and project specifications proposed by the environmental studies that were approved, including the environmental control measures and other conditions;
- Operational License (LO): The LO is granted for the project to commence the operational phase, after the fulfillment of all the requirements of the previous licenses have been confirmed and the conditions and procedures to be observed during the operation are defined.

At this time, the Project is fully licensed.

1.8 Capital and Operating Costs

1.8.1 Capital Cost Estimate

1.8.1.1 Sustaining Capital Cost

All capital expenditures (Capex) are treated as sustaining Capex for purposes of this report and the related cash flow analysis, and was estimated for the whole Project at US$ 71 million, where US$ 9 million is related to production expansion to 960 t/month in 2019 and US$ 12 million is related to production expansion to 1,100 t/month in 2020. A constant value of US$ 3 million per year was provided for plant maintenance, spare parts, calcine dams with exception of 2017, which costs were estimated at US$ 5 million, since in 2017 Largo expects to invest an additional US$ 2 million in plant improvement projects.

Additional sustaining capex of US$ 1.5 million was estimated for mine drainage, US$ 4.3 million was estimated for exploration, and US$ 8.8 million for non-magnetic dams and chloride ponds.

1.8.2 Operating Cost Estimate

GE21 summarized the operating and administrative costs, based on real costs that are regularly incurred by Largo.

Table 1.8.2_1 shows the average operating costs projected after all investments.

Table 1.8.2_1
Average Operating Cost Summary

Operating Cost	US$ /lb
Mining (US$/t)	2.45
Processing (US$/lb)	1.78
General and Admin (US$/lb)	0.18
Royalties and Commissions	0.34

1.8.2.1 Mining Cost

Unit mining costs are based on contract mining. Rates as currently negotiated with local drilling and blasting contractors US$0.79/t. Loading and haulage operations are assigned to a separate contractor with rates expressed as a function of one-way haul distances as summarized in Table 1.8.2.1_1.

Table 1.8.2.1_1
Contract Loading & Haulage Costs

Haul Distance (m)	Load/Haul ($)
0000 - 0200	0.83
0201 - 0500	0.90
0501 - 1,000	0.97
1,001 - 1,500	1.03
1,501 - 2,000	1.10
2,001 - 2,500	1.18
2,501 - 3,000	1.28
3,000 - 4,000	1.49
4,000 - 5,000	1.72
5,000 - 6,000	1.98
6,000 - 7,000	2.28
7,000 - 8,000	2.63
8,000 - 9,000	3.03
9,000 - 10,000	3.49

1.8.2.2 Processing Cost

Unit processing costs and recovery assumptions used in the net present value model are summarized in Table 1.8.2.2_1.

Table 1.8.2.2_1
Process Costs

Item	Value US$/lb
Power	0.19
Rehandling	0.08
Production Inputs	1.23
Maintenance	0.11

1.8.2.3 General and Administration Cost

The general and administrative costs (G&A) include all costs relating to administration, management wages, HR, Procurement, Technology, HSSE, Communication, restaurant, employee transportation and security.

The overall annual G&A costs are currently estimated in US$ 4.8 million.

1.9 Economic Analysis

1.9.1.1 Economic Assumptions

A cash flow scenario was developed to evaluate the Project based on economic-financial parameters, the results of the mine scheduling and on the OPEX estimate.

The table 1.9.1_1 shows the selling prices and taxes that were taken into account.

Table 1.9.1_1
Selling Prices and Taxes

Selling Price	
Product	Sell Price (US$/lb)
Product V_2O_5	9.00 (in 2018 and 2019)
	6.34 others years
Taxes	
CFEM	2.0%
INCOME TAX	25% (Discount of 75% until 2024)
INCOME TAX*	9%
Financial Parameters	
WACC	8.0% aa
NPV	Based on middle the year
Royalties	
Surface Royalties	2.0%

* The total Income taxes has two components: (i) IRPJ: Regular rate is 25%, but VMSA has a tax incentive which results in a discount of 75% and (ii) CSLL : 9%. This results in an aggregate effective rate of 15.25%.

Discounted at 8% per year, the Project base case results in a net present value of US$542 million.

Table 1.9.1_2

Base Case Life of Mine Annual Cash Flow

	Campbell												
Year	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**
Total Lavrado (Mt)	**5.0**	**6.8**	**8.8**	**9.8**	**10.9**	**9.7**	**9.3**	**8.9**	**4.1**	**3.8**	**2.2**	**0.6**	**-**
High Grade	1.17	1.25	1.59	1.93	1.87	1.91	2.01	2.06	1.89	1.82	1.52	-	-
Low Grade	-	-	-	-	-	-	-	-	0.1	0.0	-	0.6	-
Waste	3.79	5.56	7.26	7.85	9.05	7.76	7.24	6.85	2.15	2.00	0.69	-	-
V2O5 Product (t)	**6 357.8**	**10 497.9**	**11 497.4**	**13 319.5**	**13 680.6**	**13 465.9**	**13 383.4**	**13 313.3**	**13 257.1**	**13 854.1**	**14 703.8**	**2 135.0**	**-**
OPEX (US$ mi)	**(44.3)**	**(69.4)**	**(73.5)**	**(76.6)**	**(81.1)**	**(77.9)**	**(76.8)**	**(76.8)**	**(67.3)**	**(69.0)**	**(69.2)**	**(17.2)**	**-**
Mine (US$)	**(11.7)**	**(15.9)**	**(19.7)**	**(21.4)**	**(24.6)**	**(22.2)**	**(21.4)**	**(21.7)**	**(12.5)**	**(11.8)**	**(8.9)**	**(4.5)**	**-**
Mine (US$)	(5.9)	(8.1)	(10.5)	(11.6)	(14.0)	(12.4)	(11.9)	(12.4)	(6.1)	(5.7)	(3.8)	(0.6)	-
Drilling and Blast (Ore+Waste)	(3.3)	(4.5)	(5.8)	(6.5)	(7.2)	(6.4)	(6.2)	(6.0)	(3.0)	(2.8)	(1.7)	(0.5)	-
Costs (Payroll,Topography,Auxiliar Equipaments,etc)	(1.8)	(2.6)	(2.6)	(2.6)	(2.6)	(2.6)	(2.6)	(2.6)	(2.6)	(2.6)	(2.6)	(2.6)	-
Drilling and Blast (Fixed Costs)	(0.7)	(0.7)	(0.7)	(0.7)	(0.7)	(0.7)	(0.7)	(0.7)	(0.7)	(0.7)	(0.7)	(0.7)	-
Process	**(29.6)**	**(48.8)**	**(49.1)**	**(50.4)**	**(51.8)**	**(51.0)**	**(50.7)**	**(50.4)**	**(50.2)**	**(52.5)**	**(55.7)**	**(8.1)**	**-**
Plant	(29.6)	(48.8)	(49.1)	(50.4)	(51.8)	(51.0)	(50.7)	(50.4)	(50.2)	(52.5)	(55.7)	(8.1)	-
G&A	**(3.1)**	**(4.7)**	**(4.7)**	**(4.7)**	**(4.7)**	**(4.7)**	**(4.7)**	**(4.7)**	**(4.7)**	**(4.7)**	**(4.7)**	**(4.7)**	**-**
Gross Revenue (US$ mi)	**81.5**	**191.1**	**209.3**	**175.1**	**182.1**	**179.2**	**178.1**	**177.2**	**176.5**	**184.4**	**195.7**	**28.4**	**-**
EBITDA (US$ mi)	**37.2**	**121.7**	**135.8**	**98.6**	**101.0**	**101.4**	**101.4**	**100.4**	**109.1**	**115.4**	**126.5**	**11.2**	**-**
DEPRECIATION (US$ mi)	(29.0)	(30.5)	(34.7)	(39.0)	(39.9)	(40.8)	(40.4)	(38.4)	(25.4)	(24.6)	(13.5)	-	-
EBIT (US$ mi)	**8.2**	**91.2**	**101.2**	**59.6**	**61.1**	**60.5**	**60.9**	**62.0**	**83.7**	**90.8**	**113.0**	**11.2**	**-**
IRPJ (25% in R$ 0.24 mi/ year)+75% Discount (SUDENE Incentive) untill 2024	(0.015)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.011)	(0.011)	(0.011)	(0.011)	-
Operating Profit Discount (30%)	2.45	27.37	30.35	17.88	18.34	10.00							
AIR (24% sobre Exc R$ 0.24 mi/ano do EBIT) +75% +75% Discount (SUDENE Incentivea untill 2024)	(0.3)	(4.0)	(4.4)	(2.6)	(2.7)	(3.1)	(3.8)	(3.9)	(20.9)	(22.7)	(28.2)	(2.7)	-
CSLL (9% sobre EBIT)	(0.5)	(5.7)	(6.4)	(3.8)	(3.9)	(4.5)	(5.5)	(5.6)	(7.5)	(8.2)	(10.2)	(1.0)	-
CBPM (3% sales revenue)	(2.4)	(5.7)	(6.3)	(5.3)	(5.5)	(5.4)	(5.3)	(5.3)	(5.3)	(5.5)	(5.9)	-	-
CFEM (2% of MAG cost * 30%) (US$ mi)	(0.5)	(0.7)	(0.7)	(0.8)	(0.8)	(0.8)	(0.8)	(0.8)	(0.6)	(0.6)	(0.6)	(0.1)	-
ROYALTIES FOR LAND OWNER												(0.1)	-
ROYALTIES (2%)	(1.6)	(3.8)	(4.2)	(3.5)	(3.6)	(3.6)	(3.6)	(3.5)	(3.5)	(3.7)	(3.9)	-	-
Net Income (US$ mi)	**2.7**	**71.3**	**79.2**	**43.7**	**44.7**	**43.1**	**41.9**	**42.9**	**45.8**	**50.1**	**64.3**	**7.2**	**-**
Depreciation (US$ mi)	29.0	30.5	34.7	39.0	39.9	40.8	40.4	38.4	25.4	24.6	13.5	-	-
Residual Value (US$ mi)	-	-	-	-	-	-	-	-	-	-	-	-	-
Free Operating cash flow (US$ mi)	**31.7**	**101.7**	**113.8**	**82.7**	**84.6**	**83.9**	**82.4**	**81.3**	**71.3**	**74.7**	**77.8**	**7.2**	**-**
CAPEX (US$ mi)	**(6.0)**	**(14.4)**	**(17.1)**	**(4.6)**	**(4.6)**	**(4.0)**	**(3.6)**	**(3.6)**	**(4.6)**	**(4.2)**	**(4.1)**	**(0.4)**	**-**
Mine	(0.9)	(0.4)	-	-	-	(0.1)	-	-	-	(0.1)	-	-	-
Plant	(5.0)	(12.1)	(15.2)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	-	-
DAM	-	(1.2)	(1.5)	(1.5)	(1.0)	(0.5)	(0.5)	-	(1.2)	(1.0)	(0.5)	-	-
Exploration	(0.11)	(0.63)	(0.40)	(0.09)	(0.58)	(0.40)	(0.09)	(0.58)	(0.40)	(0.09)	(0.58)	(0.40)	-
Others Costs (US$ mi)													
Mine Closure	-	-	-	-	-	-	-	-	-	-	-	(11.0)	(1.4)
Working Capital	-	(3.0)	(1.6)	2.1	-	-	-	-	-	-	-	7.7	-
Cash Flow(US$ mi)	**25.7**	**84.4**	**95.1**	**80.1**	**80.0**	**79.9**	**78.8**	**77.7**	**66.6**	**70.6**	**73.7**	**3.6**	**(1.4)**
VPL (WACC = 8%) (US$ mi)	542												

1.10 Other Relevant Information

In addition to the reserve estimate for Campbell, a Preliminary Economic Assessment (PEA) of the impact of mining the additional inferred resources (see Section 24) was made.

The PEA does not update, add to or modify the FS, nor does it include more optimistic assumptions and parameters, and is not a PFS or FS in any respect.

GE21, based on the mineral resources for the Satellite Deposits and the remaining resources in the Campbell pit, prepared a PEA to assess the economic potential of the remaining mineral resources at the Project.

The PEA is preliminary in nature, it includes inferred mineral resources that are considered too speculative geologically to have the economic considerations applied to them that would enable them to be categorized as mineral reserves, and there is no certainty that the PEA will be realized. Table 1.10_1 presents the summary of mineral inventory for additional resources in Satellite Deposits.

Table 10.1_1

Summary of mineral inventory for additional resources in Satellite deposits
Mine Recovery 100% - Dilution 5%

(Effective May 2nd 2017)

Target	ROM			Waste	Total Mov.	SR	Magnetic Concentrate				Product
	Mass	V_2O_5	SiO_2				Mag*	Mass	V_2O_5	SiO_2	
	Kt	%		Kt		t/t	%	kt	%		Kt
Gulçari A Norte e Gulçari B	7 851	0.67	26.82	95 115	102 965	12.12	25.7	2 014	2.63	2.97	40 37
Novo Amparo	1 171	0.71	14.18	4 056	5 227	3.46	38.9	456	1.58	1.44	5 48
Novo Amparo Norte	9 473	0.81	23.66	37 547	47 020	3.96	28.6	2 714	2.60	2.79	53 81
São José	3 860	0.85	23.35	25 340	29 200	6.57	28.8	1 113	2.67	2.29	22 64
Inferred Campbell	1 736	1.03	28.88	31 608	33 344	18.20	28.2	489	3.06	3.96	11 42
Total	**24 090**	**0.78**	**24.55**	**193 665**	**217 756**	**8.04**	**28.2%**	**6 785**	**2.60**	**2.79**	**134 73**

*Numbers are rounded to one decimal place

The PEA for the Satellite Deposits and remaining inferred resources in the Campbell pit demonstrated an additional mine life of 12 years if the inferred resources in the Satellite Deposits and remaining inferred resources in Campbell pit come to be converted to mineral reserves with a potential Net Present Value (NPV) of US$ 140 million at an 8% discount rate.

1.11 Conclusion and Recommendations

1.11.1 Conclusion

The Project is an open pit operation utilizing a contract mining fleet of hydraulic excavators, front-end loaders and 36 tonne haul trucks. Largo provided GE21 with an internally percent model resource, updated to the end of April 2017. This "percent" model was transformed into a standardized block model. The mine planning model adopted is considered to be a "diluted" model, adding approximately 5 % dilution to the source model.

GE21 received from Largo, per the guidance of its geotechnical consultant, the definition of a single angle of 70º interramp for the final pit. For operational purposes GE21 considered the general angle of 60º for pit optimization exercises.

Due to its location in the arid region, there were no studies of groundwater interference in the pit optimization.

Reserves are reported using a sales price of \$ 6,34/lb of V_2O_5. Details of the assumptions, parameters and methods used in the preparation of the reserve estimate and mining schedule are presented in Tables 16.1 through 16.7, and as described in Section 16 (below).

The mineral reserves were estimated by Porfírio Cabaleiro Rodriguez of GE21, who is a qualified person under NI 43-101 and a Member of the Australian Institute of Geoscientists, and result in 17.57Mt of Proven Reserves, at 1.14%V_2O_5, with a magnetic recovery of 29.66% at a grade of 3.21% V_2O_5, and 1.44 Mt of Probable Reserves, at 1.26%V2O5, with a magnetic recovery of 33.89% at a grade of 3.20% V_2O_5, totalling 19.01Mt of Proven Reserves, at 1.15% V_2O_5, with a magnetic recovery of 29.89% at a grade of 3.21% V_2O_5.

Currently, Largo has a mining fleet contract with Fagundes Construção e Mineração Ltda., which consists of 3 CAT 336 hydraulic excavators equipped with a 2.5 m^3 bucket and a total of 22 Mercedes Benz 36-tonne capacity trucks. The contract drilling fleet consists of three Sandvik Ranger DX800 rotary drill rigs. A fleet of ancillary equipment is also available for mine maintenance and eventual plant services.

The Maracás vanadium recovery plant was commissioned in 2015 and has been in start-up mode for much of that time ramping up to near design capacity. At the time of writing this report, the plant produces up to 9,360 t of V_2O_5 equivalent per year with a trend approaching design capacity. Except for unanticipated downtime, and subject to completion of the two expansions contemplated herein, production is expected to reach 13,200 t/a V_2O_5 in 2020.

The current process flow sheet comprises three stages of crushing, one stage of grinding, two stages of magnetic separation, magnetic concentrate roasting, vanadium leaching, ammonium meta-vanadate (AMV) precipitation, AMV filtration, AMV calcining, and fusing to V_2O_5 flake as final product

The base case vanadium pentoxide price used in the economic analysis of the Maracás Project is US\$9.00/lb V_2O_5 for 2018 and 2019, and then US\$6.34/lb V_2O_5 until the end of the mine life, GE21 also assessed two other scenarios where it used a flat price of US\$6,34/lb V_2O_5 and US\$ 7.37/lb V_2O_5, respectively.

Based on an existing and ongoing operation, with no additional investments in new plant capacity ,other than what has been discussed in the Sustaining Capital Costs. These will results in the anticpated increase in production as discussed above. All investments were considered as Sustaining Capital Costs.

The total sustaining cost was estimated at US$ 70 million distributed over 10 years, which includes plant equipment repowering (milling, deammoniation, roasting, AMV precipitation), drilling, increased dam reservoir capacity and drainage pumps of the mine bottom.

GE21 summarized the operating and administrative costs, based on real costs that are regularly incurred by Largo, in summary, mining cost at US$ 2.45$/t, Processing cost at US$1.78/lb, G&A at US$ 0.18/lb, and Royalties and commissions at US$ 0.34/lb

A Discounted Cash Flow – DCF - scenario was developed to assess the Project based on economic-financial parameters, on the results of the mine scheduling and on the Sutaining CAPEX and OPEX estimate.

The Project base case, using reserves only, estimates a Net Present Value of $542 million, at a Discount Rate of 8% per year.

Finally, GE21 has concluded, based on the PEA-Level study in item 24 that the Satellite Deposits and remaining inferred resources in the Campbell pit demonstrate the technical and economic potential for viability. GE21 thinks the development of a study to evaluate production at the Campbell and the Satellite Deposits at the same time, including, assessing the benefits versus the scenario presented in this report is recommended.

GE21, based on this report, recommends that Largo should consider the following as it continues to advance the Project:

- Largo should proceed with a drilling program to upgrade the resources in the Satellite Deposits, with a view to converting the inferred resources to measured and indicated resources.
- Consider whether the continued use of a contracted fleet continues to make sense relative to increasing costs as the Project progresses.
- Further examine the possibility of selling its iron-rich calcine tailings. This would include considering what it would take to turn it into a more saleable product.
- In respect of the Satellite Deposits:
    - Develop a technical and economic study for mine scheduling purposes in order to maintain grade, and to avoid any production decreases.
    - Consider, whether two or more of the Satellite Deposits could be brought into production at same time, with an implicit CAPEX for a second mobile DMS unit, to ensure that production always stays at nameplate capacity.

2 INTRODUCTION

GE21 Consultoria Mineral Ltda. ("GE21") was engaged by Largo Resources Ltd. ("Largo" or the "Company"), to review the optimized mine plan and plant feed schedule for the Maracás Menchen Mine (the "Project" or the "Property") based on a new pit slope and a new production rate of 11,520 tonnes of V_2O_5 in 2019 and 13,200 of V_2O_5 in 2020.

This Independent Technical Report ("ITR") contains a PEA, using inferred resources in mining study, for the period after Campbell LOM, done in conjunction with a FS, for the Campbell Pit.

This ITR respects the definition of PEA as described in the document issued by Canadian Securities Administrators (CSA) on Aug 16, 2012, entitled "CSA Staff Notice 43-307- *Mining Technical Report – Preliminary Economic Assessments*" which provides the following:

"*By definition, a PEA is a study other than a PFS or FS. We generally consider that two parallel studies done concurrently or in close time proximity to each other are not in substance separate studies, but components of the same study. Therefore, a study that includes an economic analysis of the potential viability of mineral resources that is done concurrently with or as part of a PFS or FS is not, in our view, a PEA if it:*

- *has the net effect of incorporating inferred mineral resources into the PFS or FS, even as a sensitivity analysis;*
- *updates, adds to or modifies a PFS or FS to include more optimistic assumptions and parameters not supported by the original study, or*
- *is a PFS or FS in all respects except name."*

In summary, this ITR contains in its main body a FS where none of the inferred resources are used and under section 24, a PEA which does not update, add to or modify the FS, including more optimistic assumptions and parameters, and is not a PFS or FS in all respects.

The Maracás Menchen Vanadium Mine Property consists of eighteen (18) concessions totaling 17,690.45 ha (see Figure 1.2_1). These exploration and mining permits are listed in Table1.2_1. Three of these permits include the original two (DNPM 870134/82 and DNPM 870135/82) and are owned by VMSA which is controlled 99.9% directly and indirectly by Largo. The remaining 15 permits are owned by Largo Mineração Ltda., a wholly owned subsidiary of Largo.

The principal Qualified Person with respect to the objectives of this report is Mining Engineer Porfírio Cabaleiro Rodriguez. Mr. Rodriguez is a mine engineer that has 36 years of experience in the field of mineral resource and reserve estimation. He possesses considerable experience dealing with various commodities, such as phosphate, iron, uranium, gold and nickel ore, in addition to rare earth elements, among others. Mr. Rodriguez is a member of the Australian Institute of Geoscientists (MAIG).

2.1 Scope of Work

In 2017 Largo retained GE21 to prepare an optimized mine plan, including mine scheduling, plant feed definition, mine fleet dimensioning, infrastructure layout CAPEX and OPEX estimation, for a two stage expansion of the Project.

2.2 Qualifications, Experience and Independence

GE21 is a specialized, independent mineral consulting company. The mineral resource estimate and the conceptual economic study were developed by GE21 staff members, who are accredited by the Australian Institute of Geoscientists (AIG) as "Qualified Persons" for the declaration of Mineral Resources and Reserves in accordance with international codes, such as National Instrument 43-101 – *Standards of Disclosure for Mineral Projects* ("NI 43-101") and the 2012 JORC Code.

Each of the authors of this report has the required qualifications, experience, competence and independence to be considered a "Qualified Person", as defined by NI 43-101.

Neither GE21, nor the authors of this report, have, or have had, any material interest vested in Largo or any of its related entities. GE21's relationship with Largo is strictly professional, consistent with that held between a client and an independent consultant. This report was prepared in exchange for payment based on fees that were stipulated in a commercial agreement. Payment of these fees is not dependent on the results of this report.

2.3 Qualified Team

The principal Qualified Person with respect to the objectives of this report is Mining Engineer Porfírio Cabaleiro Rodriguez. Mr. Rodriguez is a mine engineer that has 36 years of experience in the field of mineral resource and reserve estimation. He possesses considerable experience dealing with various commodities, such as phosphate, iron, uranium, gold and nickel ore, in addition to rare earth elements, among others. Mr. Rodriguez is a member of the Australian Institute of Geoscientists (MAIG).

The Resources estimation was reviewed, validated, and adjusted to Reserves studies purpose by geologist Fábio Valério Câmara Xavier, Mr. Xavier has more than 12 years of experience, most of them related to Resource estimation including QAQC procedure and in the following commodities: iron ore, copper, gold, among others.

Regarding mining studies, Mr. Rodriguez was supported by engineer Mr. Guilherme Gomides, MAusIMM, Mr. Gomides has more than 11 years of experience, most of them related to mining planning, and Iron ore, gold and copper.

The metallurgic process was undertaken by Mr. Leonardo Apparício. Mr. Apparicio is a Mining Engineer with more than 30 years of experience in projects, engineering, construction, implantation, operation, start ups and ramp ups of plants of mineral processing and hydrometallurgical, as well as in audits and due operational and project diligences. He also has experience in administration and coordination of projects, being certified like PMP by PMI.

Mr. Rodriguez and Mr. Apparício visited the site on 10 to 14 April of 2017 aiming to verify the mining and plant operation, gather technical and economic information among general data of geology, environments, logistics.

2.4 Effective Date and Sources of Information

The "Effective Date" for the reserves and resources of May 2nd, 2017, is based on the last date when the topographical survey was updated.

The resources model was provided by Largo and was updated to reflect the remaining tonnage.

Largo provided GE21 most of the information that was used to develop this study. This work reflects the technical and economic conditions at the time that it was executed. GE21 conducted, whenever possible, an independent verification of the data that it received, in addition to field visits in order to corroborate said data. This information was supplied in the form of an exploratory drilling database, certifications, maps, technical reports and a topographical survey. The data is a combination of historical and newly generated information.

Among the data provided by largo, the Technical Report developed by Micon, titled AN UPDATED MINE PLAN AND MINERAL RESERVE FOR THE MARACÁS MENCHEN PROJECT, BAHIA STATE, BRAZIL, dated July 8, 2016, with the Mineral Resources Effective dated March 31, 2016 and Mineral Reserve Effective dated March 31, 2016 (the “2016 Report”), was the principal source of information related to geology, resources, infrastructure, environmental and legal issue.

2.5 Units of Measure

Unless stated otherwise, the units of measurement used in this report are all metric, in accordance with the International System of Units (SI). Unless indicated otherwise, all monetary units are expressed in Brazilian Reais (R$) or United States Dollars (US$). Although some cost figures have been taken from local sources in Brazil, each of these figures were converted to US$ for the compilation and presentation of the financial analysis.

An exchange rate of R$ 3.30 = 1US$ was applied throughout.

3 RELIANCE ON OTHER EXPERTS

GE21 has reviewed resource data, including the resource model delivered by Largo, and performed the updating considering the topography at the effective date May 02nd 2017, GE21 also was responsible for the Mining Methods, mining CAPEX and OPEX, and the economical analysis.

Mr. Leonardo Apparicio has reviewed and analyzed plant production data provided by Largo and GE21 has drawn their own conclusions therefrom, augmented by their direct field examination.

The information presented herein, in Section 4 with respect to the mining rights associated with the Project is based on information that was submitted to, and published by, the National Department of Mineral Production (DNPM).

Information regarding the status of environmental licensing procedures, market conditions, and contracts, Sections 18,19 and 20,were based on information that were described by, or obtained from, Largo and its consultants.

As there has been no material change in the underlying mineral resource estimate since the 2016 Report, R. A. Campbell, P.Geo., of Largo participating in authorizing this report, and GE21 thanks him and is very appreciative of his support.

4 PROPERTY DESCRIPTION AND LOCATION

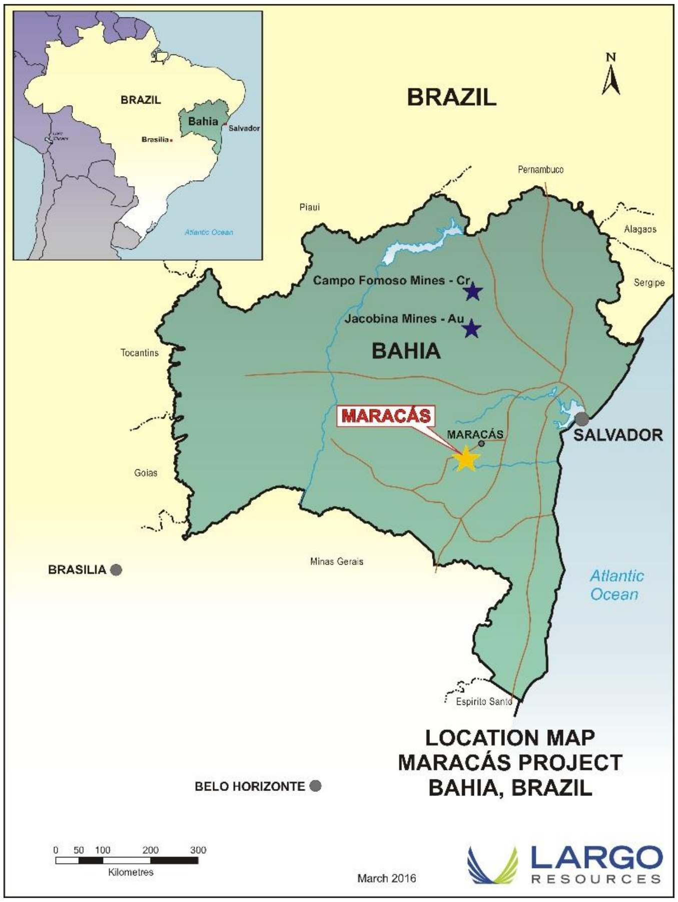
4.1 Location

The Maracás Project is located within the greater municipality of Maracás in eastern Bahia State, Brazil. Maracás lies about 250 km southwest of the City of Salvador, the capital of Bahia. The distance by road from Salvador to the Project is 405 km via a paved secondary road from the main coastal highway in Bahia, with the project being accessed by about 50 km of secondary highway and gravel road west of the town of Maracás. Access to water, the electric power grid and a railroad is within reasonable distance, and a trained workforce familiar with the mining and mineral exploration industries exists in the state of Bahia and also within the country generally.

Maracás is a farming and agricultural support community and its inhabitants are reported to welcome the renewal of mineral exploration and development. The exploration permits are isolated and there are no adjacent exploration or mining properties.

Figure 4.1_1

Maracás Project Location Map



4.2 Property Status

The Maracás Property consists of eighteen (18) concessions including 16 exploration permits and 2 mining licences (1 granted, 1 pending) highlighted in green totaling 17,690.45 ha (see Figure 4.2_1). The concessions are listed in Table 4.2_1.

Figure 4.2_1

Maracás Project Property Map

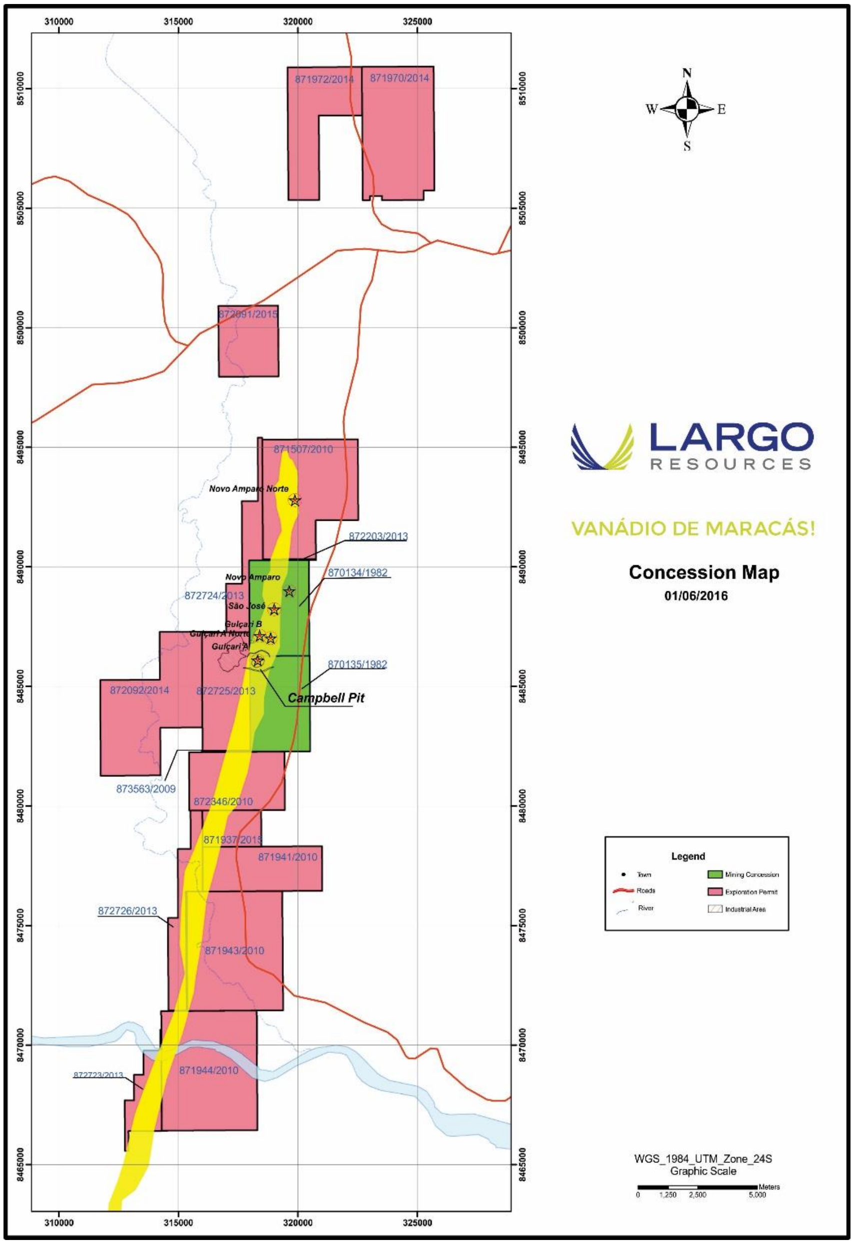


Table 4.2_1

Maracás Property Concession

Holder	DNPM process no	Substance	Status	Requested Area (ha)	Expiry Date	City
VMSA	870.134/1982	V	Mining permit pending	1,000.00	not applicable	Maracás
VMSA	870.135/1982	V	Mining permit granted	1,000.00	not applicable	Maracás
VMSA	872.346/2010	V	Exploration permit	977.29	25/2/17	Maracás
Largo	872.203/2013	V	Exploration permit	6.42	29/10/18	Maracás
Largo	872.723/2013	V	Exploration permit	413.71	29/10/18	Iramaia/Manoel Vitorino
Largo	872.724/2013	V	Exploration permit	495.75	29/10/18	Maracás
Largo	872.725/2013	V	Exploration permit	988.46	29/10/18	Maracás
Largo	872.726/2013	V	Exploration permit	593.75	29/10/18	Iramaia/Maracás
Largo	873.563/2009	V	Exploration permit	11.11	10/10/16	Maracás
Largo	871.944/2010	Fe, V	Exploration permit	2,000.00	Extension Submitted (31/01/2017)	Iramaia/Maracás
Largo	871.943/2010	Fe, V	Exploration permit	1,999.87	Extension Submitted (31/01/2017)	Iramaia/Maracás
Largo	871.941/2010	Fe, V	Exploration permit	927.00	Extension Submitted (30/01/2017)	Maracás
Largo	871.507/2010	V	Mining permit application	1,713.88	not applicable	Maracás
Largo	871.970/2014	V	Exploration permit	1,649.21	8/12/18	Maracás
Largo	871.972/2014	V	Exploration permit	1,084.92	8/12/18	Maracás
Largo	872.092/2014	V	Exploration permit	1,709.51	8/12/18	Maracás
Largo	872.091/2015	Fe, V	Exploration permit	743.70	17/12/18	Iramaia/Maracás
Largo	871.937/2015	V	Exploration permit	375.87	15/3/19	Maracás
			Total	**17,690.45**		

Three of these concessions including the original two, DNPM 870134/82 and DNPM 870135/82, are owned by VMSA which is controlled 99.9% directly and indirectly by Largo. The remaining 15 exploration permits, highlighted with a hatch pattern, are owned by Largo (see Figure 4.2_1). These exploration permits run contiguously north-south with each exploration permit forming rectangle of various dimensions and cover the prospective horizon for over 40 km. The UTM Geographic zone is 24S and the Datum used for the area is Corrego Alegre. The centre of the original two exploration permits is at Latitude 13º 41' S, Longitude 40º 40' W.

Largo reports that all but two exploration permits are currently registered as exploration licenses and are in good standing. An exploitation licenses (mining licenses) has been granted DNPM 870135/82. Grant of a mining license is pending for DNPM 870134/82, however, the Localization License (LL) and the Instillation License (LI) for the Project have been granted. There are no fees due on the exploration permits until the exploitation license has been granted.

Largo entered into an agreement with Vale and Odebrecht, dated October 16, 2006 giving it an option to acquire a 90% interest in the Maracás Property from the two Brazilian companies for a purchase price of USD10.0 million. Under the agreement, Largo was required to maintain the exploration permits in good standing. On December 22, 2012 VMSA bought out Vale and Odebrecht giving resulting in Largo holding a 100% ownership of the Property.

Largo reports that, to its knowledge, there are no existing environmental liabilities with respect to the Property.

CBPM is the Bahia State Geological Survey and is the owner of the mining rights over the most the deposits, only Nova Amparo Norte is all property of VMSA. Under the contract between VMSA and CBPM there is a clause of royalty with determine that 3% of gross sales revenue is due to CBPM.

5 ACCESSIBILITY, CLIMATE, LOCAL RESOURCES, INFRASTRUCTURE AND PHYSIOGRAPHY

5.1 Access

The town of Maracás is accessible by paved secondary highway from the main Brazilian coastal highway through Bahia State. It is approximately 405 road kilometres from Salvador. The Project is accessed by paved secondary highway west from Maracás for a distance of 29 km followed by 20 km of gravel road to a ranch gate. The Project is located on the ranch and a 2.5-km sand and gravel trail leads to the small hill where the Campbell deposit outcrops.

Maracás has a small general aviation airstrip but no commercial air service. Salvador, being the state capital and one of the larger cities in Brazil, is served by an international airport with many flights a day from São Paulo and Brasilia.

5.2 Infrastructure

Domestic power and telephone service are available both at the Property and in the town of Maracás, which is linked to the power grid. Maracás has a population of approximately 20,000. Water is available from a number of rivers and creeks which drain into the general area.

Brazil has a large and very active mining industry. Infrastructure for mining equipment, services and personnel are available in a number of centres including São Paulo, Belo Horizonte and Cuiaba. The Jacobina gold mine is located 275 km to the north of Maracás. There are several other small active mines in the general area and thus some local mining services are available in Salvador. There is a rail line close to the property and deep-water port facilities are available at Salvador. The village of Porto Alegre is located south of the Project.

5.3 Climate and Physiography

The local climate has two distinct seasons, one is typically hot and humid and the other a dry season which occurs in the winter. This climate is characteristic of much of the interior of the state of Bahia. The average day time temperature in the interior is near 30ºC. The temperatures drop in May and June when minimum day time temperatures stay above 10ºC. Daytime temperatures rise to 40ºC in January and February. Rainfall is about 1000 mm/a.

The rainy season runs from November to March. During that time, the rains are intense, and the temperature is high. Some low-lying areas can experience flooding. The dry season is from July to September. The climate does not create any problem for exploration with diamond drilling or other geological/geochemical work. Tropical weathering can create specific issues for geochemistry and mapping. Exploration can be carried out at any time without difficulty.

Approximately 23% of the State of Bahia lies at less than 300 masl, 70% is between 300 to 900 masl and 7% is above 900 m. There are three types of relief observed, high plateau, coastal, and areas extending between the coast and the high plateau. The Maracás Property is located in the region between the coast and the high plateau in an area of moderate to low-lying relief.

At the Project site itself, the maximum relief is about 30 m. The surrounding terrain is typical ranch / farm land with low trees and shrubs and consists of a number of relatively flat plateaus adjacent to a series of creeks and ponds. The property is bounded to the east by a steep cliff that rises 300 m to an area of higher land where the town of Maracás is located. Figure 5.3_1 is a photograph of the Maracás Property with the hill on which Campbell outcrops visible in the background.

Figure 5.3_1

Maracás Project with Campbell Hill in Background

Occasional outcrops of pegmatite dike and gabbro are present on the property. The local overburden, which consists residual soils, lesser alluvial and colluvial soils, ranges from 3 to 10 m in thickness.

The local land is used primarily for agriculture with ranching and grazing being the primary activity on the land at the Maracás Project where both mining and exploration activities are permitted.

6 HISTORY

The history of the Maracás Property has been previously described by Menezes (2005). Information in this section is taken from Brito et al (1981), Galvão et al (1984), Menezes (2005) and other unpublished internal documents from previous operators.

6.1 Summary

Exploration of the Rio Jacaré mafic to ultramafic intrusion by the geologists of CBPM started in 1980 during a regional geological survey. This work led to the discovery of the vanadium-rich titaniferous magnetite occurrence on what now is part of the Maracás Property. In 1981, CBPM conducted an exploration program which included geological mapping, ground geophysical surveys (magnetic and VLF electromagnetic surveys), test pitting and trenching, and diamond drilling of two holes totalling 147 m. In 1983, CBPM continued work and focused on the Campbell deposit when it completed an additional 12 holes totalling 985 m.

Over the past 30 years, the Maracás Project has undergone several additional phases of exploration and economic evaluation, including geophysical surveys, prospecting, trenching, diamond drilling programs, geological studies, resource estimates, petrographic studies, metallurgical studies, mining studies and economic analyses. These studies have advanced the Project to its present status of an operating mine. The following is an historical summary of work that has taken place since the CBPM involvement, taken, in part, from the reports by CBPM (1981 and 1984), a report by Menezes (2005), and present information from existing reports.

6.2 Exploration History

In 1984, CBPM formed a joint venture with the Odebrecht Group, after the conclusion of a prefeasibility study completed by CEPED, the State of Bahia Research and Engineering Centre. The joint venture formed a new company, Vanádio de Maracás Ltda., in order to explore and develop a mine and metallurgical plant to exploit the vanadium-bearing titaniferous magnetite deposit.

During that year, Odebrecht carried out systematic exploration work including 1492 m of diamond drilling in 18 holes on the Campbell deposit. Over the next 3 years (1985 to 1987), Odebrecht completed three more drill programs to further define the resource at Campbell including nine holes totalling 971 m, eight holes totalling 1136 m and four holes for 421 m, respectively. An additional 24 vertical holes totalling 648 m were drilled for geotechnical information regarding open-pit boundaries and overburden. These holes were not analyzed or included in the database used for the resource estimate presented in this Report. Odebrecht also carried out an exploration program testing the three other prospects on the property (Gulçari B, São José and Nova Amparo) which included geological mapping, ground geophysical surveys (magnetics and VLF), trenching, and diamond drilling of 13 holes totalling 661 m.

In 1986, CBPM and Odebrecht completed a “reserve” estimate for the Campbell deposit, which is discussed in Section 8.3 below.

Odebrecht conducted a number of petrographic studies, metallurgical tests and feasibility studies intermittently from 1984 to 1988. These were performed with recognized engineering companies such as CEPED from Brazil, Lurgi GMBH and Gesellschaft für Electrometallurgie (GFE) from Germany, Mintek from South Africa, Rautaruukki Oy from Finland, Jaakko Poyry Engineering and Engenharia e Consultoria Mineral S.A. (ECM), both from Brazil. The conclusion of these studies in 1990 resulted in what was determined to be a feasible project for the production of 4000 t/a of vanadium pentoxide (V_2O_5) with part converted to ferrovanadium as a final, value-added product. As a consequence of the evaluation, the joint venture decided to contract the Finnish company, Rautaruukki Oy, for the implementation of final pilot plant tests and basic engineering design for the Project.

Early in the 1990s, Odebrecht, owning 93% of Vanádio de Maracás' shares, decided to reform the joint venture on a 50 / 50 basis with CAEMI (VALE) (VALE) with the intention of bringing to the Project expertise in mining, metallurgy and marketing.

In 1990, a sampling program of the drill core from Maracás was conducted. The samples were also analyzed for platinum and palladium. A total of 167 samples from 10 drill holes were selected for analysis. Ninety-six samples were from magnetite and 71 samples from pyroxenite. The results indicated potentially significant platinum and palladium values associated with high-grade V_2O_5 values.

The following is a list of studies completed on the property by the above listed companies:

- CBPM Geological Study
- Lurgi GMBH Feasibility Study
- Rautaruukki Oy Feasibility Study
- Jaakko Poyry Feasibility Study
- Natron Environmental Impact Study
- ECM Feasibility Study
- CAEMI (VALE) (VALE)/MBR 1996 Revision of Feasibility Study
- CRU Market Study
- CRA Market Study
- IMS Processing plant Study
- MINTEK Test Reports
- Paulo Abib Geo-Statistical Evaluation & Mining Plan
- VMSA - DNPM Economic Development Plan
- 1996 CAEMI (VALE) (VALE) Feasibility Study
- 1999 Economic Update Report of 1996 Study.

In 2006, Largo signed an agreement with Odebrecht, and CAEMI (now VALE) for the Maracás property. Largo carried out a re-sampling program to analyze a portion (approximately

10%) of the old drill core (CBPM and Odebrecht) to verify the past analytical database on the property (see Section 11). Analyses were done at SGS Minerals (SGS) laboratories, both in Belo Horizonte, Brazil and Lakefield, Ontario. The samples were analyzed for FeO, Fe2O3, SiO2, TiO2 and V2O5 by the XRF method and for platinum and palladium by a 50 g fire assay technique. Based on the verification of the database, Largo completed a revised block model and NI 43-101-compliant mineral resource estimate which was the subject of an earlier report (Hennessey, 2006).

6.3 Historical Drilling

Between 1981 and 1987, previous Owners of the Project drilled 66 holes totalling 5814 m, testing four deposits on the Maracás property. These consist, from south to north, of the Campbell , Gulçari B, São José and Nova Amparo deposits. A summary of the drilling completed, by deposit, is set out in Table 6.3_1.

Table 6.3_1

Summary of Diamond drilling, Maracás Property

Deposit	No. Of Holes	Length (m)
Campbell	53	5,153
Gulçari B	4	169
Sao Jose	2	115
Nova Amparo	7	377
Total	**66**	**5,814**

The vast majority of work has been done on the Campbell deposit which is the focus of this Report. Previous diamond drilling on the Campbell deposit, completed by CBPM and Odebrecht is summarized in Table 6.3_2. The analytical results from this diamond drilling are the basis for the subsequent, historical "reserve" estimates and metallurgical and feasibility studies on the deposit.

Table 6.3_2

Historical Diamond Drilling Campbell deposit (1981 - 1987)

Company	Period	No. of Holes	Length (m)
CPBM	1981	2	147
CPBM	1983	12	985
CPBM/Odebrecht	1984	18	1,492
CPBM/Odebrecht	1985	9	971
CPBM/Odebrecht	1986	8	1,136
CPBM/Odebrecht	1987	4	421
Total		**53**	**5,153**

6.4 Historical Resource Estimates

As discussed above, a mineral "reserve" was estimated for the Project in 1986. This historical mineral reserve was based on detailed geological mapping, geological sections incorporating structural geology and mineralogical and analytical results, sampling of 46 trenches totalling 1,950 m and 53 diamond drill holes totalling 5,153 m, density tests and ore microscopy. The work was prepared by staff geologists from both CBPM and Odebrecht.

The Odebrecht “geological reserve” was a kriged estimation done on a block model with block dimensions of 5 m by 5 m by 15 m. At the time, the mineral inventory was classified as measured reserves above 150 m of vertical depth. This historical mineral “reserve” estimate, as summarized in Menezes (2005), is set out in Table 6.4_1. This historical estimate was reported at various cut-off grades as shown in Table 6.4_1 and is not considered to be compliant with NI 43-101 and should not be relied on. A qualified person has not done sufficient work to classify this historical estimate as current mineral resources or mineral reserves; and the issuer is not treating the historical estimate as current mineral resources or mineral reserves.

Table 6.4_1

Historical “Reserve” Estimate (1986) – Campbell

Cut-off Grade (% V2O5)	Average Grade (% V2O5)	Tonnes (millions)
	1.13	13.2
0.1	1.13	13.1
0.2	1.14	13.0
0.3	1.19	12.4
0.4	1.28	11.4
0.5	1.37	10.4
0.6	1.45	9.6
0.7	1.53	8.8
0.8	1.62	7.9
0.9	1.72	7.1
1.0	1.82	6.4

Largo embarked on a program to verify the database and provide an NI 43-101 compliant mineral resource estimate for the deposit (Hennessey, 2006). That estimate was then updated in 2007 (Hennessey, 2007).

From the information provided above, Paulo Abib Engenharia S.A. built up a complete geological and analytical database in the 1990s. This database was used in a geostatistical study of the deposit where grades were interpolated into a block model by ordinary kriging. The geostatistics were also used to generate a variographic analysis of the deposit.

First, the deposit was interpreted and modeled on section into one titaniferous magnetite lens and two broad envelopes of lower-grade mineralization. The estimate was prepared using a block model with block dimensions of 5 m by 5 m by 15 m. The comparison between the kriging results on cross-sections and the geological cross-sections showed remarkable similarity.

6.5 Historical Technical and Environmental Studies

In 2008 Aker Solutions were retained by Largo to complete a Definitive Feasibility Study (“DFS”) for the Maracás Vanadium Project. The results of that study were presented in a NI 43-101 Technical Report titled “Technical Report of the Feasibility Study for the Maracás Vanadium Project, Brazil”, Amended version dated May 2009.

Since the completion of the DFS, Largo has continued to advance the Project. Additional studies and technical effort have been completed in the following areas;

- Pilot scale metallurgical testing at Fundação Gorceix, Ouro Preto, August-September 2010.
- Conceptual design of alternatives for disposal of non-magnetic tailings, Ausenco Minerals, May-June 2010.
- Dry stacking feasibility study, Ausenco Minerals, September 2010
- Land Agreement with Banco Economico S/A, to secure land rights for mining and project development at São Conrado and São Pedro da Goiania land proprieties, July 2011.
- Environmental permitting with the issuance of:
- Localization License - CEPRAM Resolution nº 3941, 10-10-2008.
- Installation (Construction) License - INEMA Resolution nº 1286, 10/20/2011.
- Grant of Water Rights- ANA resolution nº 684, 09-16-2011.
- Air pollutant emissions modeling and simulation by SECA, February 2012.
- 13,401 m of additional resource drilling in Campbell and B trends.
- Promon Engenharia - basic engineering work for hydrometallurgical plant and infrastructure, process flowsheet re-evaluation and design, infrastructure engineering, capital and operating cost updates, production throughput review, March - November 2011.
- HYDROS Engineering- basic engineering work for water pipeline and, capital and operating costs estimates, May - November 2011.
- VOGBR, basic engineering of main geotechnical structures, waste dump, tailings facility, site drainage design, hydrogeological studies and costs estimates, May - November 2011.
- RPM, basic mine design, with Capex and Opex estimates, May - November 2011.
- Project financing led by Bank ITAÚ BBA.
- Construction began June 2012.
- Commissioning began March 2014.
- Mining started September 2013.
- Ramp-up to full production on the expanded case started August 2014 and at present May 2016 are 97.5% of nameplate production (800 tonnes V2O5/month).

This Technical Report incorporates the results of the updated engineering and environmental studies as well as everything describe above.

7 GEOLOGICAL SETTING AND MINERALIZATION

The geological setting and mineralization has been well described over the years and has not changed. Much of the description in this section comes from the March 4, 2013 technical report by RPM with a few updates including maps and tables.

In Section 7 both Micon and Coffey Mining have provided individual sections.

Sections 7.1 to 7.2 are common for both Micon and Coffey Mining.

Sections 7.2.1 and 7.3 have been prepared by Micon and deal with the Campbell deposit.

Section 7.2.2 has been prepared by Coffey Mining and deal with the Satellite Deposits of Gulçari A Norte, Gulçari B, São José, Novo Amparo and Novo Amparo Norte.

7.1 Regional Geology

Brito (2000), Sá et al. (2005) and Teixeira et al. (2000) have described the regional geological setting for the Maracás property. These references give a detailed description of the geotectonic evolution of the São Francisco craton. The following is a brief summary of their work.

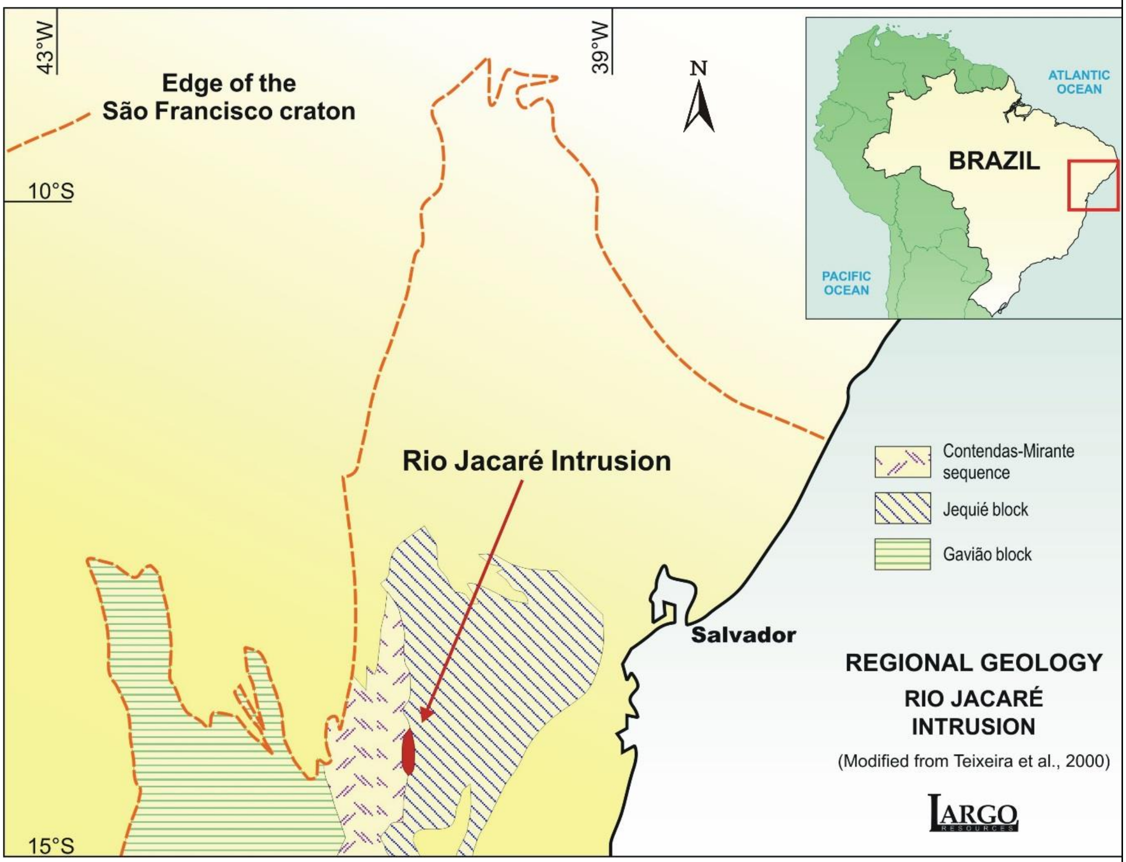
The Rio Jacaré intrusion, which hosts the Maracás Project vanadium mineralization, is located in the south-central part of Bahia state in northeastern Brazil. It lies within the Archean São Francisco craton, which in this area is composed of the Contendas-Mirante Complex and the Gavião and Jequié blocks (see Figure 7.1_1).

The intrusion is located on the eastern edge of the Contendas-Mirante supracrustal sequence, which forms a large anticlinorium trending approximately north-south. The supracrustal rocks are located between the early Archean Gavião block to the west, which is composed predominantly of tonalite-trondhjemite granodiorite, and the Archean Jequié block to the east, which is composed predominantly of charnockite and enderbite intrusive rocks with strong calc-alkaline affinities and granulite facies metamorphic rocks (Teixeira et al., 2000).

The Contendas-Mirante sequence is thought to be younger than the adjacent Gavião and Jequié blocks and consists of an Archean basal volcanic unit overlain by a Paleoproterozoic member containing flysch and metavolcanic rocks that are overlain by a clastic member. A Rb/Sr age of 2.0 Ga for the granite, derived from melting of the Contendas-Mirante metapelites, corresponds to the timing of the Tran Amazonian orogeny (2.14 to 1.94 Ga; Teixeira et al., 2000). The Contendas-Mirante sequence was deformed by the collision of the Gavião and Jequié blocks during the Tran Amazonian orogeny and is now located along part of the major Contendas-Jacobina lineament (Teixeira et al., 2000).

Figure 7.1_1

Maracás Area Simplified Regional Geology Map



7.1.1 Rio Jacaré Intrusion

The Rio Jacaré mafic-ultramafic intrusion is composed mainly of gabbro. It is a linear sheet-like structure that strikes almost north-south, with a length of approximately 70 km, an average width of 1.2 km, and a dip of 70° E. The intrusion has been described previously as a sill intruded into the volcanic rocks of the lower unit of the Contendas-Mirante gneissic complex (Brito, 1984; Galvão et al., 1986). However, the Rio Jacaré intrusion is fault bounded to the east and west, and, therefore, its contacts with both the Contendas-Mirante sequence and Jequié block are tectonic.

The age of the intrusion is poorly known. Whole rock dating of rocks from the intrusion itself includes a Pb/Pb age of 2.47 Ga ±72 Ma, a Sm/Nd age of 2.8 Ga ± 68 Ma, and a zircon age of 2.64 Ga ± 5 Ma (Brito et al., 2001). The intrusion is cut by granitic pegmatite veins that are closely related to a granite intrusion that has an age of 1.94 Ga ±54 Ma (Brito et al., 2001). Metamorphism and deformation have modified many of the igneous textures and minerals of the intrusion. Relict minerals are rare, but some igneous textures are still preserved such as olivine cumulate textures and layering between pyroxenite and gabbro. The pyroxene in these rock types is now largely altered to hornblende, which is in turn replaced by actinolite, tremolite and chlorite in many samples. The presence of amphibole and garnet in the gabbro and magnetitite (an igneous rock composed largely of magnetite) in the Rio Jacaré intrusion indicates amphibolite grade metamorphism.

The intrusion has been divided into an Upper and a Lower zone. The Lower zone is approximately 400-m thick and consists of gabbro with some diorite and minor anorthosite. Anorthosite also occurs as a layer near the bottom of the Lower zone, and has a mean thickness of 15 m. It is composed of plagioclase with minor quartz and chlorite that replaces pyroxene.

The gabbro is massive, coarse grained, and slightly foliated, whereas the diorite is massive and mainly fine grained. The primary igneous mineralogy of the gabbro consisted of plagioclase and orthopyroxene as cumulate phases, with interstitial clinopyroxene. The orthopyroxene, clinopyroxene and olivine mineralogy has been examined in detail by Brito (2000). Quartz and biotite are present as minor phases, and apatite and titanite are common accessory phases.

Within the Lower zone, there are lenses of magnetite-rich rocks. The outer margins of the lenses consist of magnetite-bearing pyroxenite with 30% to 70% opaque minerals. The centres of the lenses consist of massive magnetite (magnetitite). These bodies were previously described as forming pipes and plugs intruded into the gabbro of the Lower zone (Brito, 1984). However, the contact relationships with the gabbro are not clear, because the bodies are usually bounded by faults and are poorly exposed. They are described in greater detail below.

The Upper zone has an average thickness of 600 m and is formed mainly of layered gabbro varying from leucogabbro to melagabbro with some cyclic units of gabbro, pyroxenite, magnetite-bearing pyroxenite, and magnetitite. The pyroxenite consists of thin layers, typically a few centimetres to less than 1 m in thickness, and which are in many cases associated with the magnetite bodies.

7.2 Property Geology

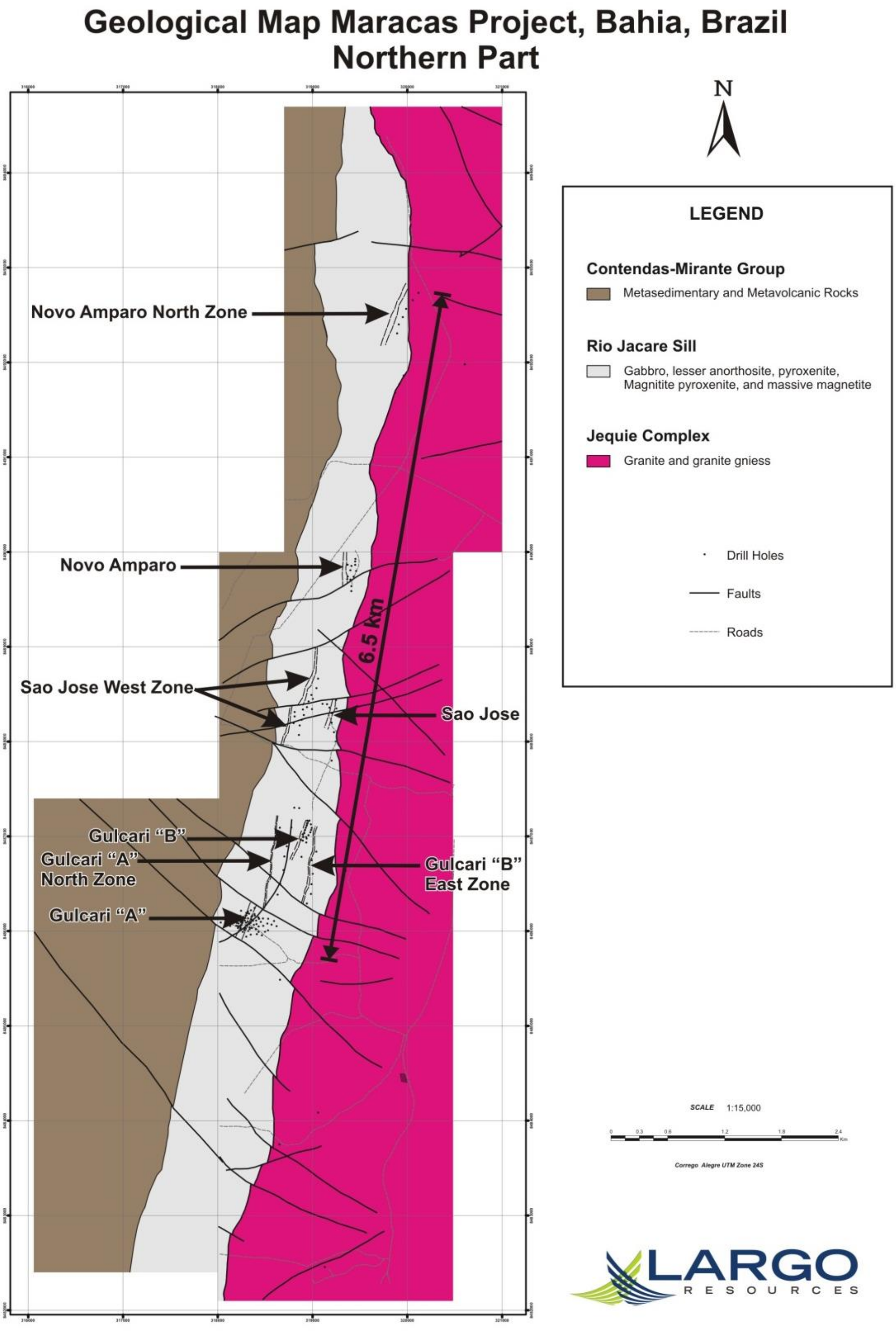
7.2.1 Campbell deposit

The north-south trending Rio Jacaré intrusion underlying the Maracás exploration permits can be traced for the full 8 km of strike length which occurs on the property. Along this trend, hosted within the Rio Jacaré intrusion, occur the main vanadium-rich magnetite bodies in six known locations, Campbell deposit, Gulçari Norte Gulçari B, São José, Novo Amparo and Novo Amparo Norte from south to north (see Figure 7.2.1_1). The intrusion trends N 20° E and dips 70° southeast.

The Campbell it is hosted in the gabbro of the Lower zone along with Gulçari A Norte, Sao Jose and Novo Amparo Norte, whereas the other two occur in the Upper zone.

Figure 7.2.1_1

Maracás Property Geology Map



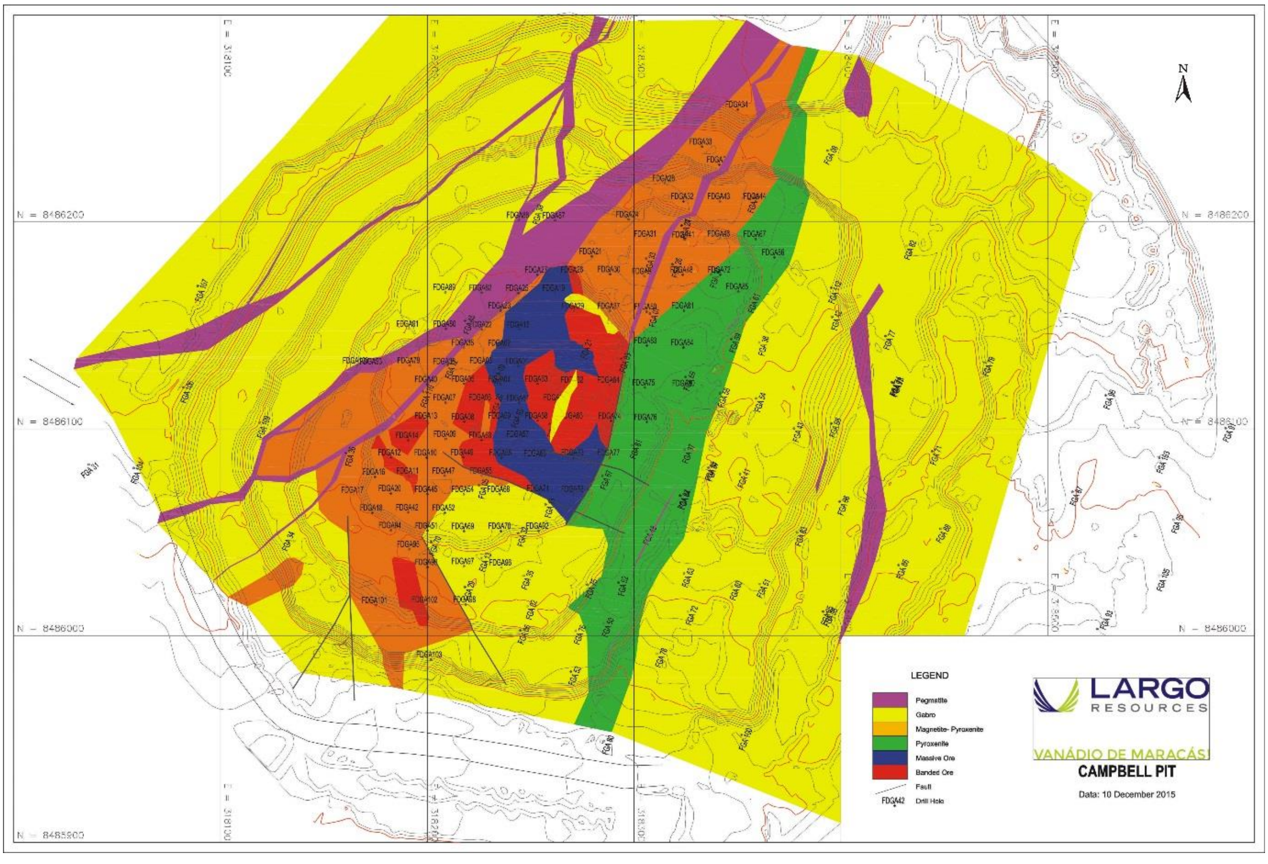
The Lower zone consists of four members including; medium to coarse-grained mesocratic gabbros, melano-gabbro consisting of banded pyroxenite and gabbro, two magnetite horizons within gabbros and pyroxenite and a tonalite member. The vanadium-rich magnetite layer is associated with the mesocratic gabbro. All the units, including the deposit, are cut by later pegmatite dikes.

The Campbell body contains the largest concentrations of vanadium-rich magnetite known on the property (Brito, 1984). This deposit crops out over an area of approximately 400-m along strike, up to 150-m width and is known to extend to approximately 350-m vertical depth, where it remains open. The deposit has been disrupted by northwest-southeast faulting.

It is composed of magnetitite grading into magnetite-rich pyroxenite, pyroxenite, and then gabbro which contains layers or lenses of magnetite-bearing pyroxenite that are sometimes sheared (see Figure 7.2.1_2). The main magnetitite body is on average about 25 m thick and thins to the south.

Figure 7.2.1_2

Campbell deposit (Campbell), Detailed Surface Geology Map



It has been suggested that, although the magnetite-pyroxenite body of Campbell is disrupted by faulting, it is a part of the main igneous sequence of the Rio Jacaré intrusion rather than a separate pipe-like intrusion crosscutting the gabbro (Sá, 1992).

Figure 7.2.1_3 and Figure 7.2.1_4 are example cross-sections through the Campbell deposit, looking north and showing drilling and interpreted geology.

As in Campbell, the Gulçari A Norte, Gulçari B, São José, Novo Amparo and Novo Amparo Norte bodies consist of magnetitite closely associated with pyroxenite layers and hosted in gabbro. The magnetitite layers have a width between 8 and 13 m and lengths of up to 250 m, with the layers being truncated by faulting. The magnetite layers in the Upper zone have sharp magmatic contacts with gabbro below and gradational contacts with the gabbro above.

Figure 7.2.1_3

Campbell deposit - Drill Section 6175N

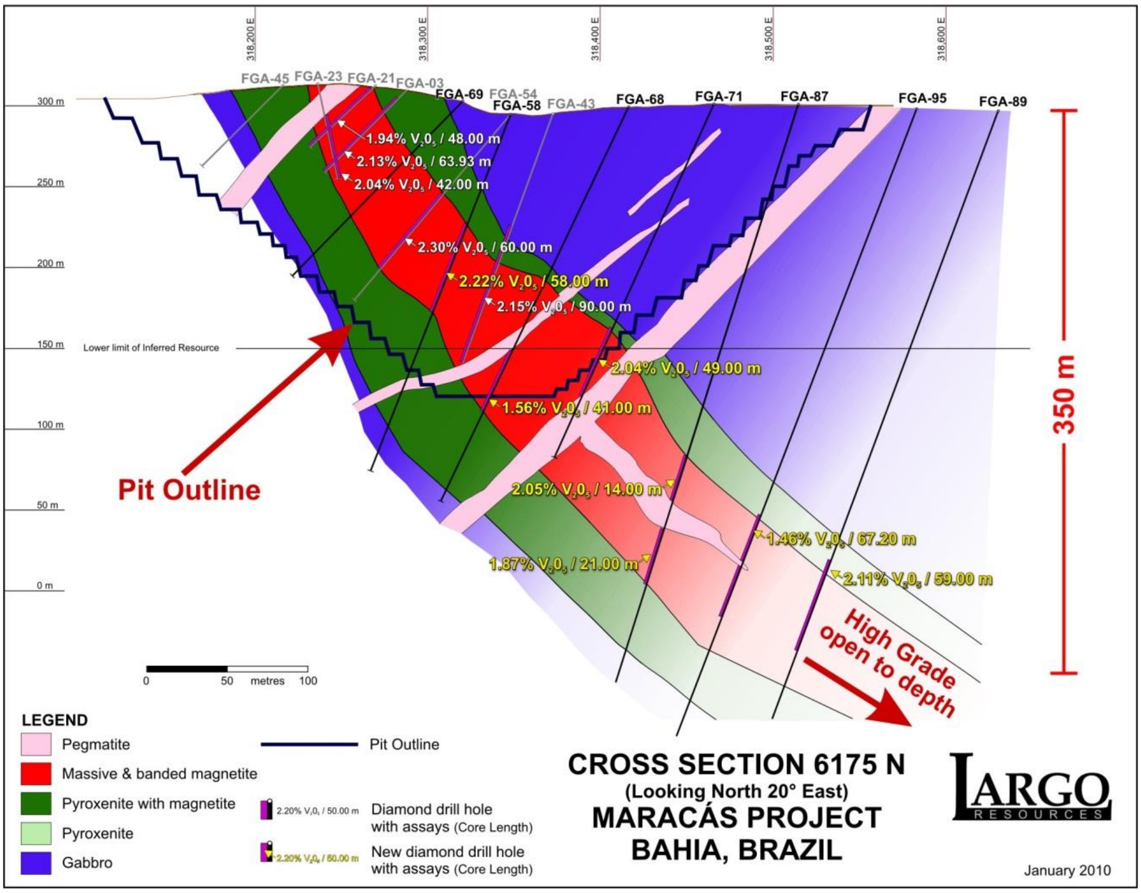
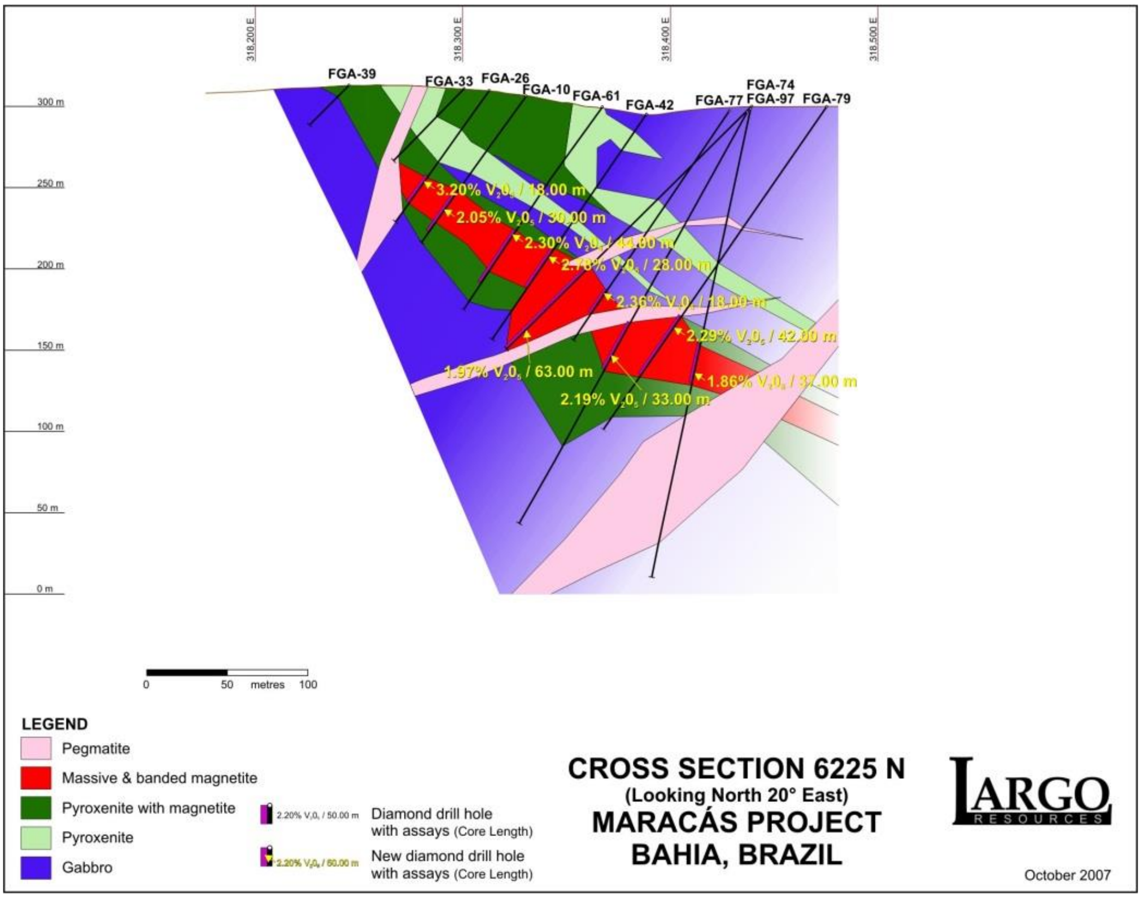


Figure 7.2.1_4

Campbell A Deposit - Drill Section 6225N



7.2.2 Satellite Deposits

The N20°E-oriented and 70° southeast-dipping Paleoproterozoic Rio Jacaré Layered Sill (RJLS) occurs throughout the 40 km long Maracás Project exploration permits. Several vanadium-rich titanomagnetite occurrences have been identified within the sill. The occurrences are the following, from south to north: Campbell, Gulçari A Norte, Gulçari B, São José, Novo Amparo and Novo Amparo Norte (Figure 7.2.2_1).

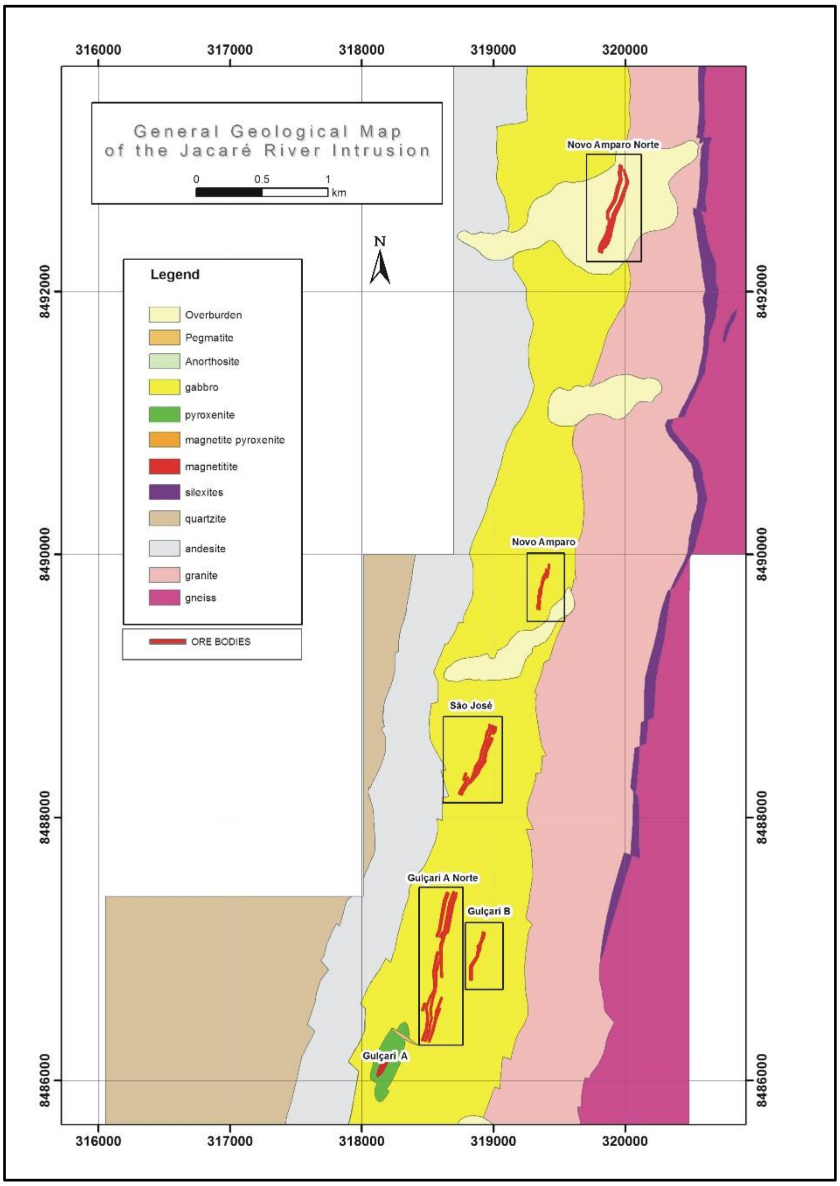
The RJLS was subjected to detailed geological mapping and magnetometric ground geophysical survey that led to the location of the abovementioned vanadium-rich titanomagnetite occurrences, which are similar to the known Campbell vanadium deposit. This fact shows that the RJLS has a great and untouched potential for the discovery of new blind vanadium deposits like the Novo Amparo Norte Deposit.

The RJLS is divided in two magmatic stratified zones, as follows: The Lower Zone that consists of four members including: a medium to coarse-grained mesocratic gabbros; a melano-gabbro consisting of banded pyroxenite and gabbro; two magnetite-rich horizons within gabbros and pyroxenites; and, a tonalite intrusive. The Upper zone has an average thickness of 600 m and is formed mainly of layered gabbro varying from leucogabbro to melano-gabbro with some cyclic units of gabbro, pyroxenite, magnetite-bearing pyroxenite, and magnetitite. The pyroxenite consists of thin layers, typically a few centimetres to less than 1 m in thickness, and which are in many cases associated with the magnetite bodies.

The Campbell, Gulçari A Norte and São José deposits are found within the gabbro unit of the Lower Zone of the RJLS, while the Gulçari B, Novo Amparo and Novo Amparo Norte occur in its Upper Zone.

Figure 7.2.2_1

Property Geological Map with the Deposits Shown



The vanadium-rich magnetite layer is associated with the mesocratic gabbro. All the rock units of the RJLS are cut by a later (1.9 Ga) Paleoproterozoic pegmatite dike swarm.

The Campbell body contains the largest concentrations of vanadium-rich magnetite known on the property (Brito, 1984). This deposit crops out over an area of approximately 400 m along strike, up to 150 m in width and is known to extend to approximately 350 m vertical depth, where it remains open. The deposit has been disrupted by northwest-trending faults.

7.2.2.1 Novo Amparo Norte Deposit

The Novo Amparo Norte Deposit is the northernmost deposit and it corresponds to two vanadium-bearing massive magnetite layers with 620 m in strike length. Figure 7.2.2.1_1 shows the integrated geologic and magnetic map of the Novo Amparo Norte deposit.

The geology of this deposit is represented by gabbro green to gray in color, fine to medium grain, mainly composed of plagioclase, pyroxene, amphibole and biotite. Magnetite gabbro is dark gray in color, with strong foliation and is very magnetic (25% magnetic oxides).

This deposit is overlain by Tertiary cover, and was detected by the ground magnetometer survey carried out in 2011. At that time a drilling program was executed aimed to test the magnetic anomalies and the first drill hole intersected a massive magnetite layer of 20 m thick. All drill holes executed along the anomaly intercepted the mineralized zones. Figure 7.2.2.1_2 shows a representative cross section of this deposit.

The layer has an average width of 18.6 m, with an average grade of 0.87 % V2O5. The massive magnetite is hosted by magnetite gabbro, and sometimes in the gabbro. This rock is dark gray to black in color, fine to medium grained, with more than 60% of magnetic oxides, pyroxene, amphibole, garnet and disseminated sulphide (pyrite). Some places exhibit small interbedded layers of magnetite pyroxenite, magnetite gabbro and anorthosite.

The entire set has a strike direction of N20° E with a dip of 70° SE and is cut by transverse faults. At the north of the area, the mineralized zone is interrupted by a northwest-southeast trending fault.

Diamond drilling at the Novo Amparo Norte Deposit amounts to 17 drill holes, totalling 3,281 m, located on a 50-m spaced line grid.

Figure 7.2.2.1_1

Integrated Map of Novo Amparo Norte Deposit

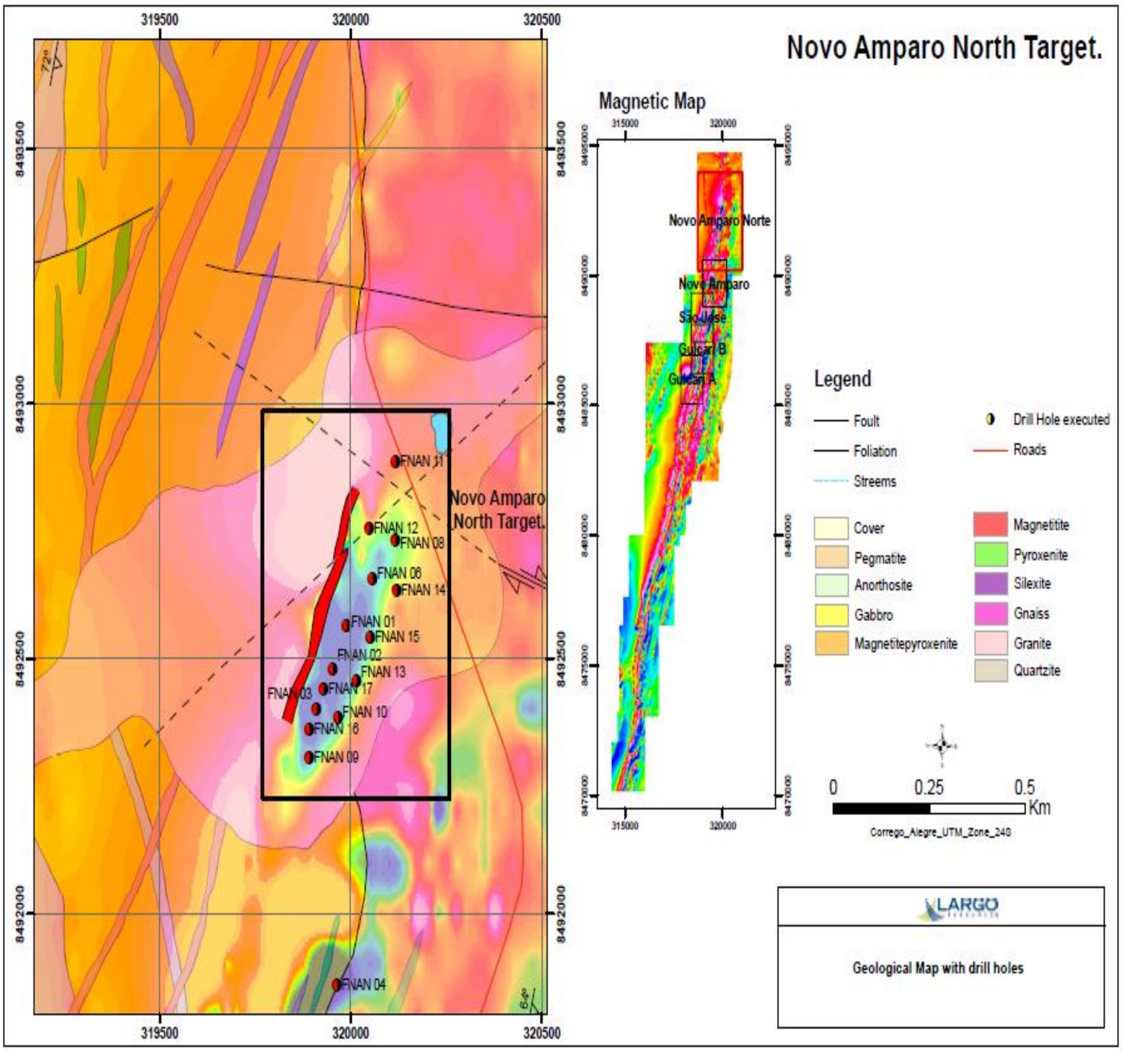
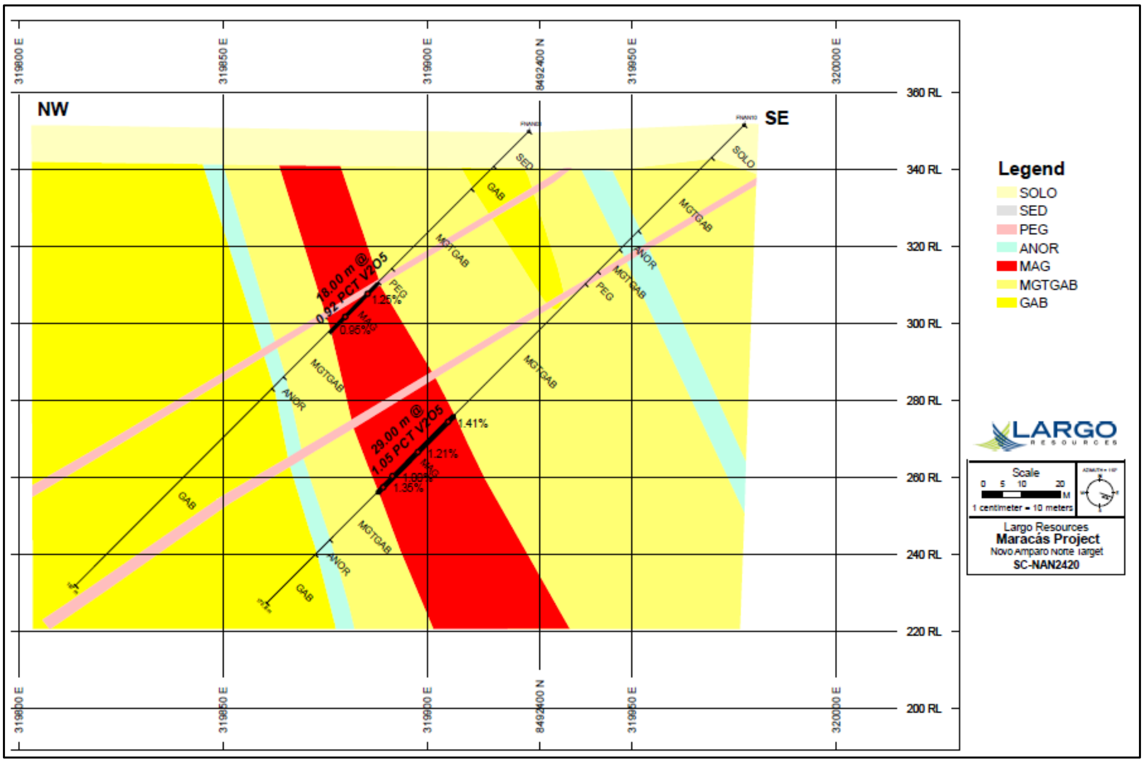


Figure 7.2.2.1_2

Cross Section of the Novo Amparo Norte Deposit



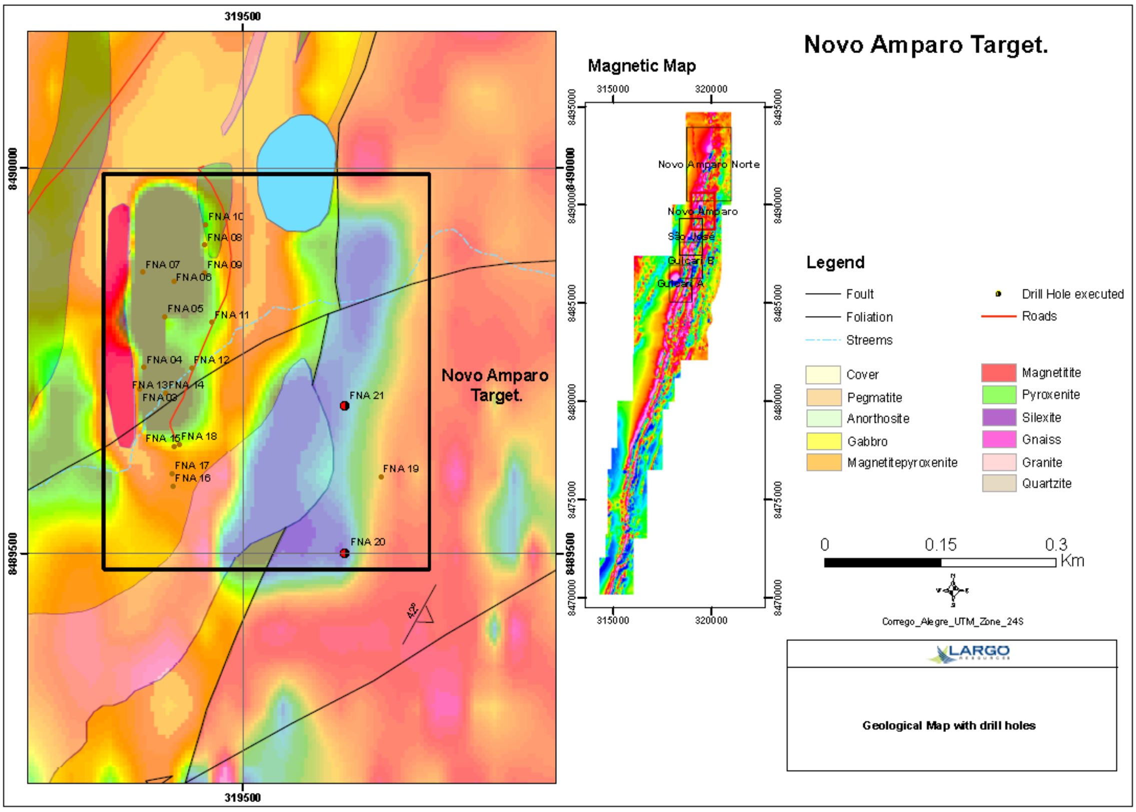
7.2.2.2 Novo Amparo Deposit

The Novo Amparo Deposit is located in the Upper Zone of the RJLS. The mineralized body presents itself as a tabular body 285 m in length and with widths ranging from 11 to 21 m, and average grade of 0.72 % V_2O_5. It has its north and south ends truncated by faulting. All rock units are oriented in a north-northeast/south-southwest direction, with a dip of 70° SE. Figure 7.2.2.2_1 shows the integrated geologic and magnetic map.

The deposit consists of a variety of amphibolitized gabbros, leucocratic, fine to medium grain, strongly foliated and it has a composition: plagioclase, biotite and amphibole and garnet, similar to the Gulçari B deposit.

Figure 7.2.2.2_1

Integrated Map of the Novo Amparo Deposit



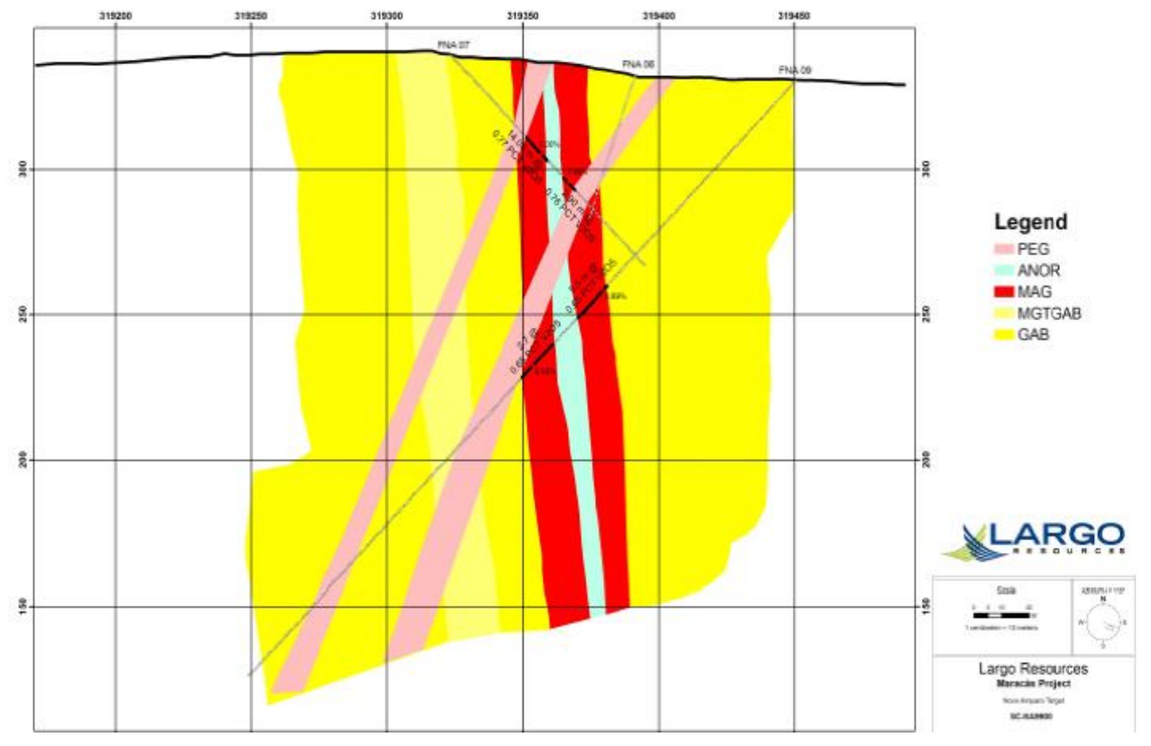
The massive ore corresponds to a rock type of over 60% magnetic oxides. It has a dark gray to black colour and massive structure. The foliation, when present, is mainly observed in the oriented gangue minerals.

The main oxide is titanomagnetite and the gangue consists of amphibole, biotite, chlorite and garnet. Commonly interlayered with the massive ore are minor, thinner layers of magnetite pyroxenite, magnetite gabbro and pyroxenite.

The magnetite gabbro occurs in the western part of the deposit and is characterized by fine grained, sometimes coarse mineral assemblage, composed of plagioclase, amphibole, titanomagnetite, and disseminated sulphide (pyrite and chalcopyrite). The deposit is cut longitudinally by bodies of quartz-feldspar pegmatite. These pegmatites cross the mineralized zone. They have a strike direction of N 30° and dips of 60 - 70°to the northwest. Figure 7.2.2.2_2 is a typical cross section of the Novo Amparo deposit.

Figure 7.2.2.2_2

Cross Section of the Novo Amparo Deposit



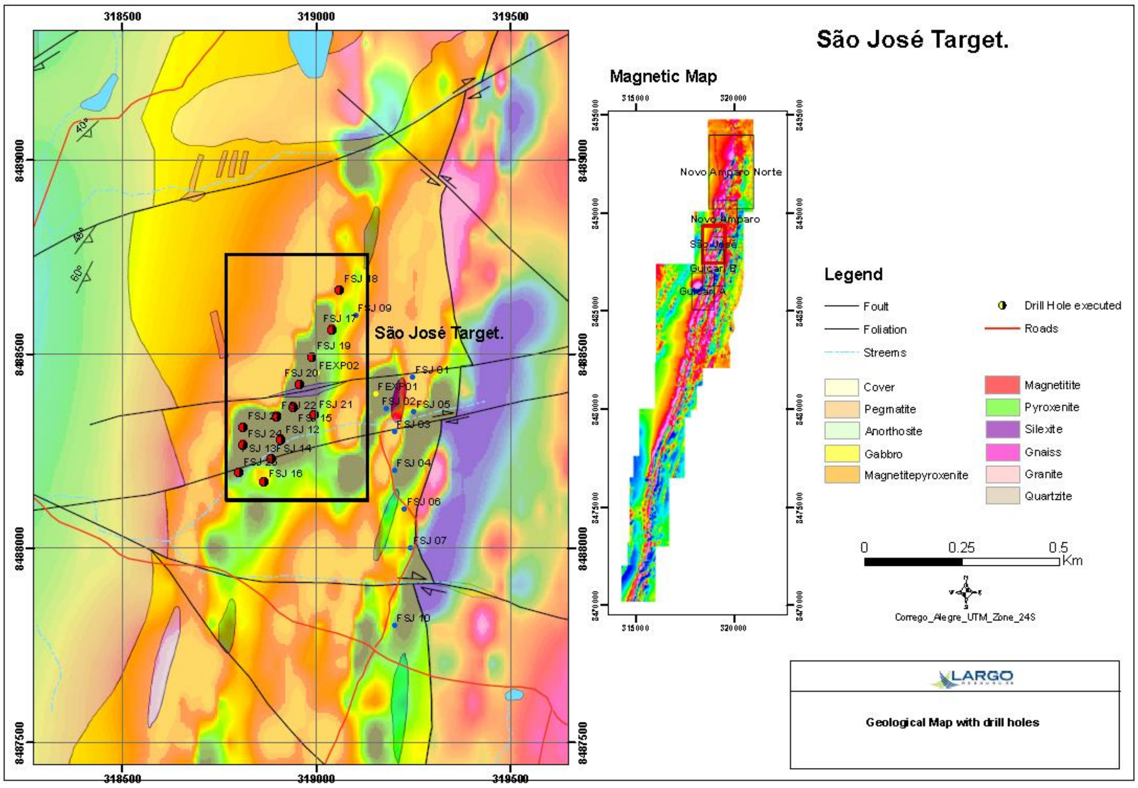
At the Novo Amparo deposit 21 drill holes totalling 1,632 m were completed, located on 25-m spaced grid lines.

7.2.2.3 São José Deposit

The São José deposit, like Novo Amparo and Gulçari B, is situated in the Upper Zone of the RJLS. It is characterized by two blind mineralized bodies: The first one is 524 m long and 11 m thick, and the second one is 404 m in length and 5 m thick. The average grade of the deposit is 0.89% V_2O_5. Figure 7.2.2.3_1 shows the integrated map of São José Deposit.

Figure 7.2.2.3_1

Integrated Map of the São José Deposit

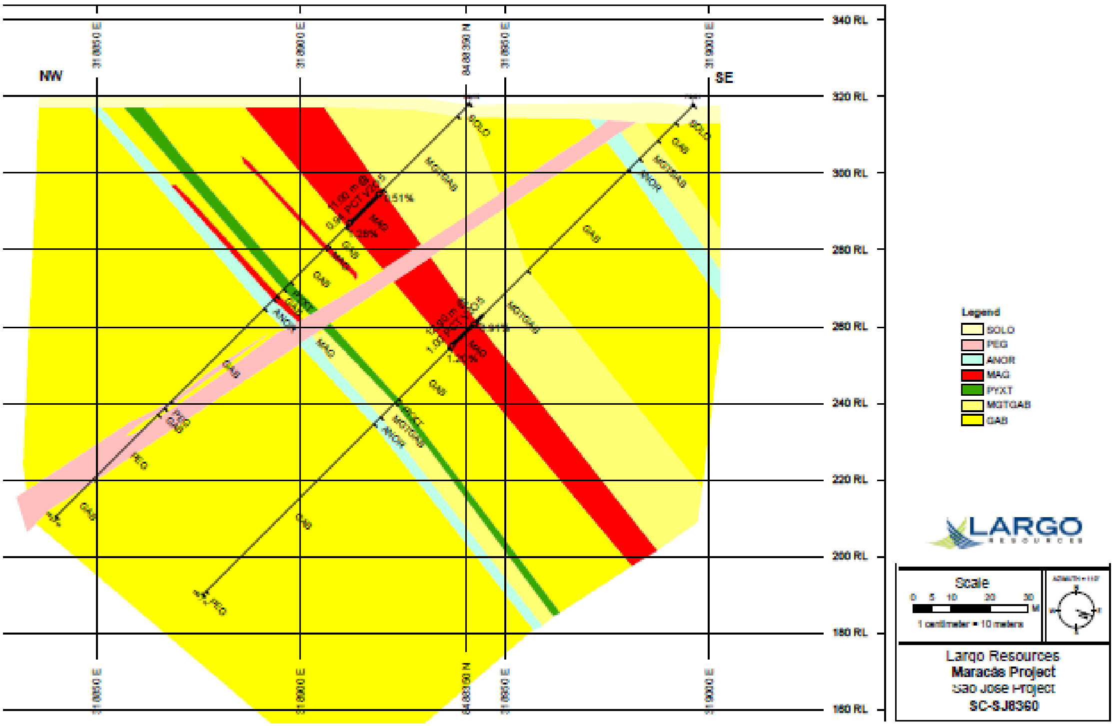


The two mineralized zones have a north-northeast/south-southwest strike and a strong foliation with a dip of 65° to southeast. This deposit is hosted by magnetite gabbro on the east side, and is characterized by a coarse grained, foliated mineral assemblage composed of plagioclase and amphibole, with garnet and magnetite. The west side the ore body is in contact with a fine grained gabbro strongly foliated with narrow bands of pyroxenite. The magnetitite is dark gray to black, fine to medium grained and massive. Figure 7.2.2.3_2 shows a representative cross section of the São José deposit.

The São José deposit is divided into two parts. In the east part 11 drill holes were completed, 2 of them by CBPM and 9 by Largo. In the west 15 drill holes were completed by Largo. The total drilled length was 4,713 m. This report considers only the west part, with sections spaced every 50m.

Figure 7.2.2.3_2

Cross Section of the São José Deposit



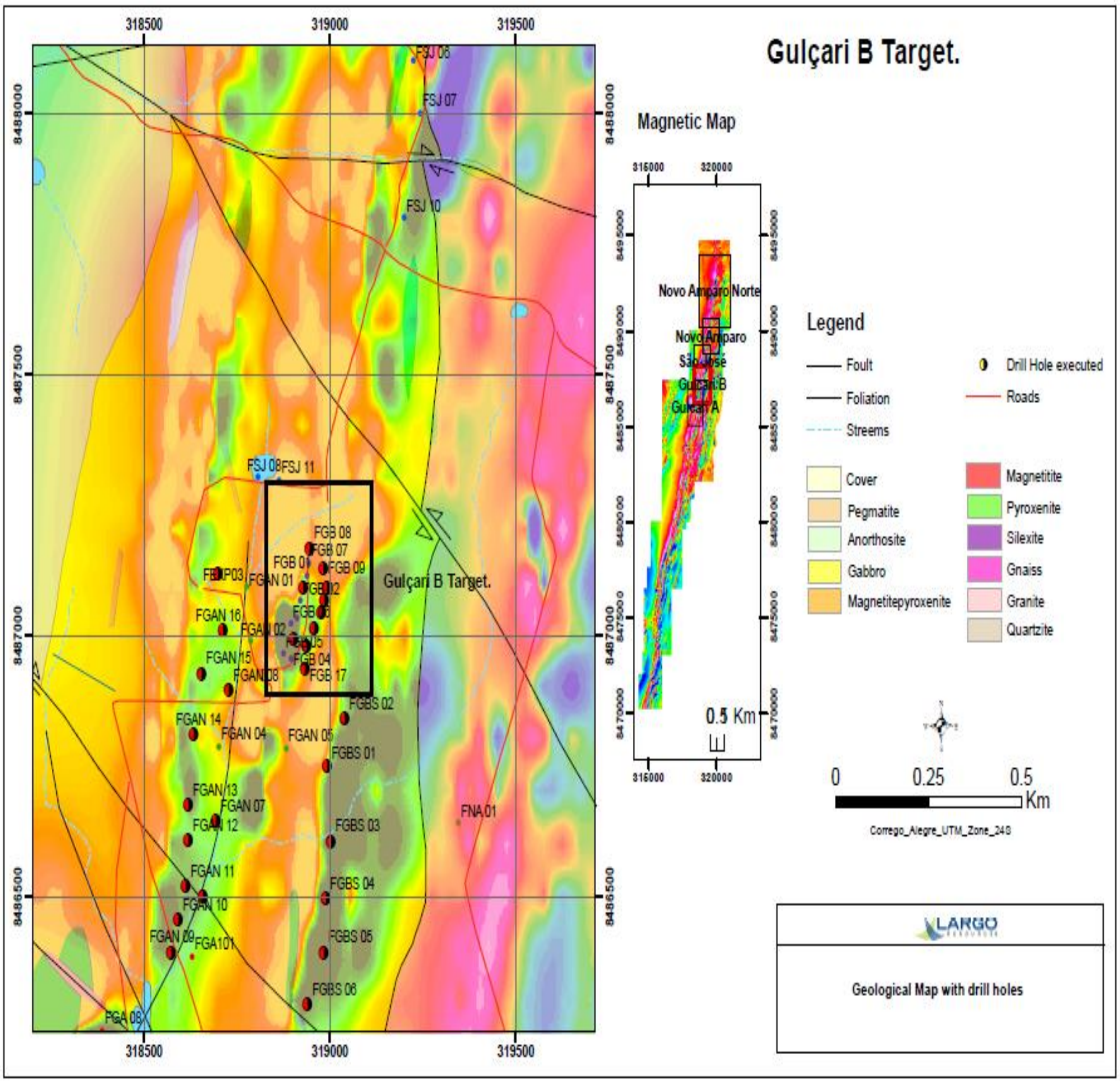
7.2.2.4 Gulçari B Deposit

The Gulçari B Deposit is situated within the Upper Zone of the RJLS. It is 200 m in strike length, 4 to 13 m thick, and known to extend to 100 m depth. It has an average grade of 0.70% V2O5. Geological contacts are all fault-bounded. It displays a tabular geometry made up mainly by a massive magnetite horizon hosted by gabbros and subordinate pyroxenite lenses. Late pegmatite dikes cut the entire vanadium deposit at a strike of N20°E and a dip of 65° to northwest.

The main rock-type in this deposit is a fine to coarse-grained isotropic and leucocratic amphibolitized gabbro, oriented to north-northeast/south-southwest, with dips of 65° to 75° to the southeast. Banded structures are locally seen. Discordant pegmatite dikes are also present. Figure 7.2.2.4_1 shows the integrated map of this deposit.

Figure 7.2.2.4_1

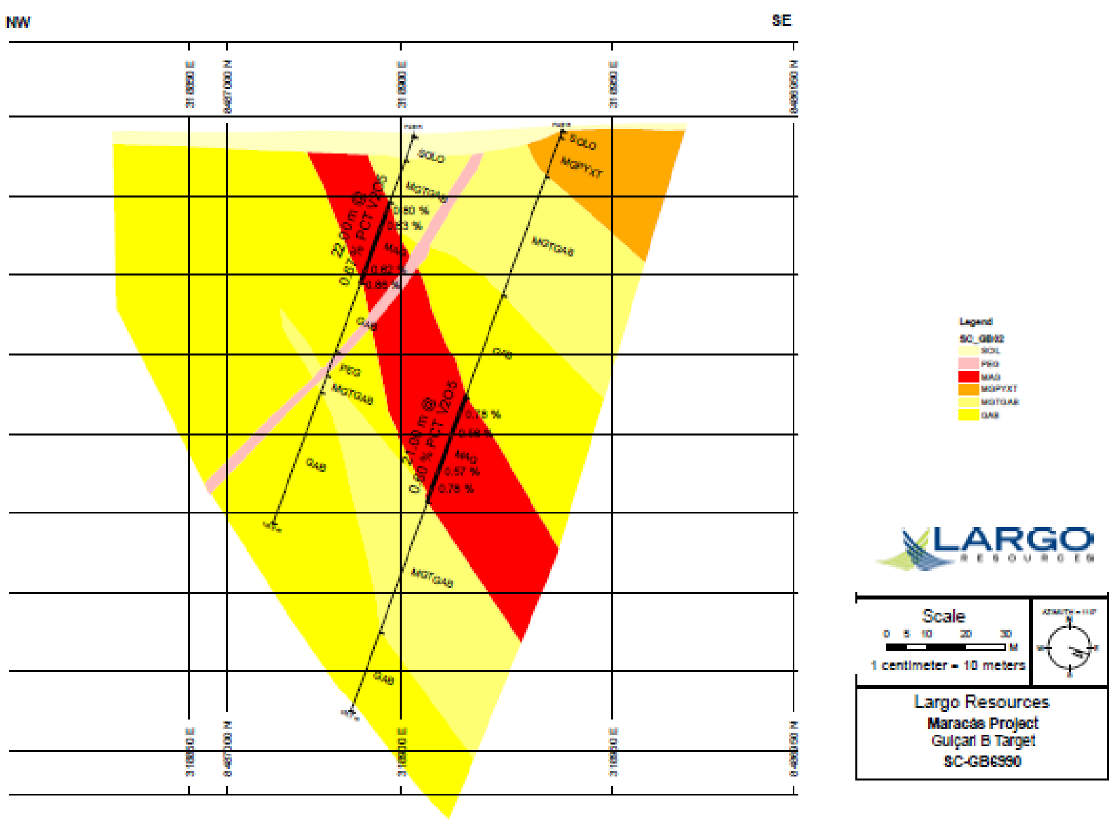
Integrated Map of the Gulçari B Deposit



A common feature of these gabbros is the presence of garnet, sulfides (pyrite and chalcopyrite) and disseminated magnetite. This unit is referred as the Magnetite Gabbro and it contains up to 0.3% V_2O_5. They consist mainly of amphibole and plagioclase in varying proportions, and sometimes appear anorthositic in composition. Figure 7.2.2.4_2 shows a typical cross section of the Gulçari B deposit.

Figure 7.2.2.4_2

Cross Section of the Gulçari B Deposit



The magnetitite bodies are gray to black in color, mainly fine grained, but locally coarse-grained, with oxides (mainly titanomagnetite) above 70%. The other oxides present, in decreasing order of occurrence, are ilmenite and ulvospinel. The gangue is composed of pyroxene, hornblende, biotite and garnet.

Interlayered with the magnetic ore bodies occur subordinate strata of gabbro and pyroxenite. The first are the leucocratic to mesocratic, fine to medium grained gabbro, composed mainly of amphibole and plagioclase, with the presence of sulphides (pyrite and chalcopyrite). Sometimes with the abundance of plagioclase they appear anorthositic in composition. The pyroxenites are foliated, amphibolitized, with fine disseminations of titanomagnetite.

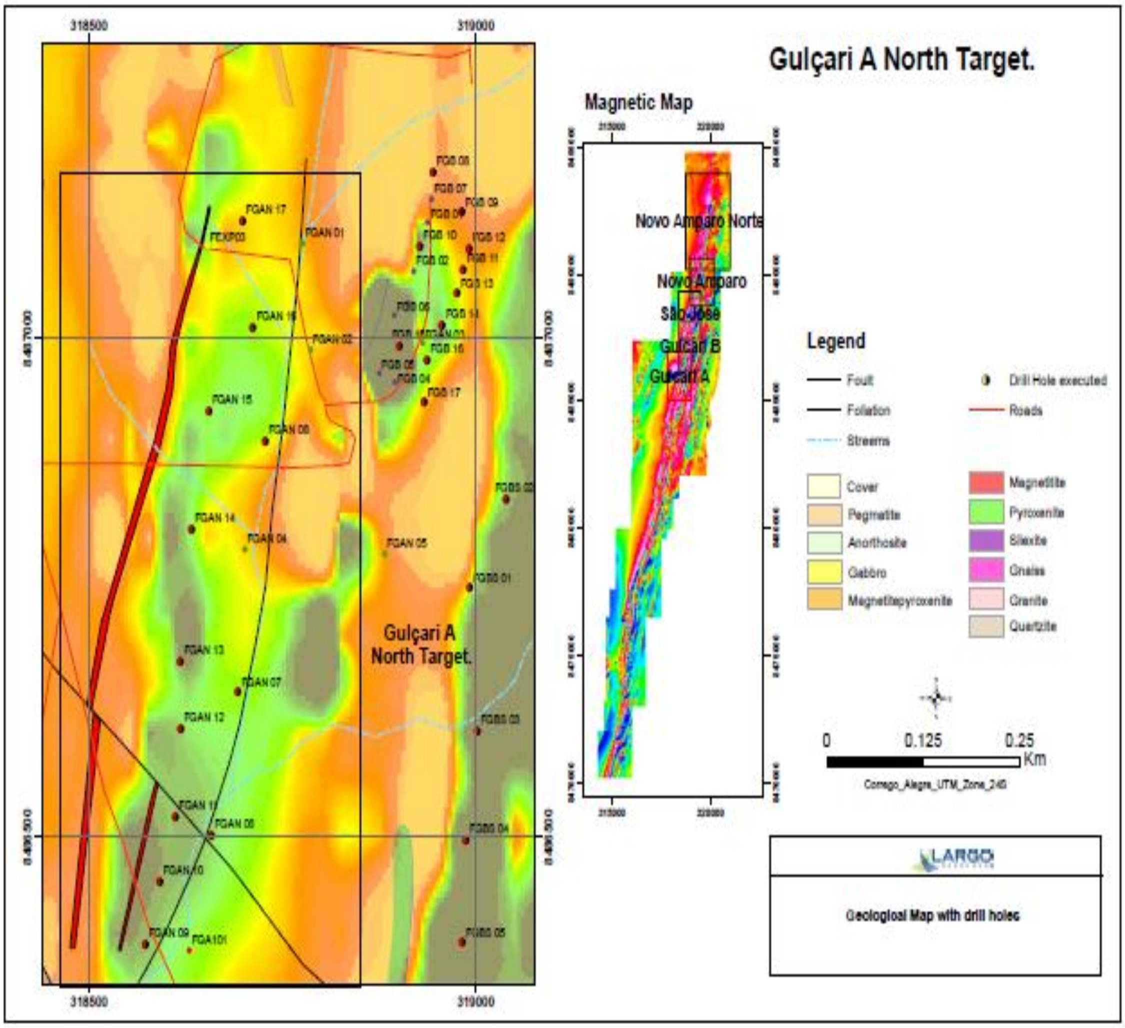
The Gulçari B deposit has been investigated by 7 diamond drill holes executed by CBPM and 10 diamond drill holes by Largo, totaling 1,622 m, with sections spaced at 25 m.

7.2.2.5 Gulçari A Norte Deposit

The Gulçari A Norte deposit is located north of the Campbell deposit. It is hosted by the Lower Zone of the RJLS. It is characterized by two massive magnetite horizons. The main body is 1 km long and 7.5 m in average thickness. The second body is 350 m long with a width of 4 m, located east of the first. The average grade of the deposit is 0.84% V_2O_5. Figure 7.2.2.5_1 shows the geological map of Gulçari A Norte deposit.

Figure 7.2.2.5_1

Integrated Map of the Gulçari A Norte Deposit

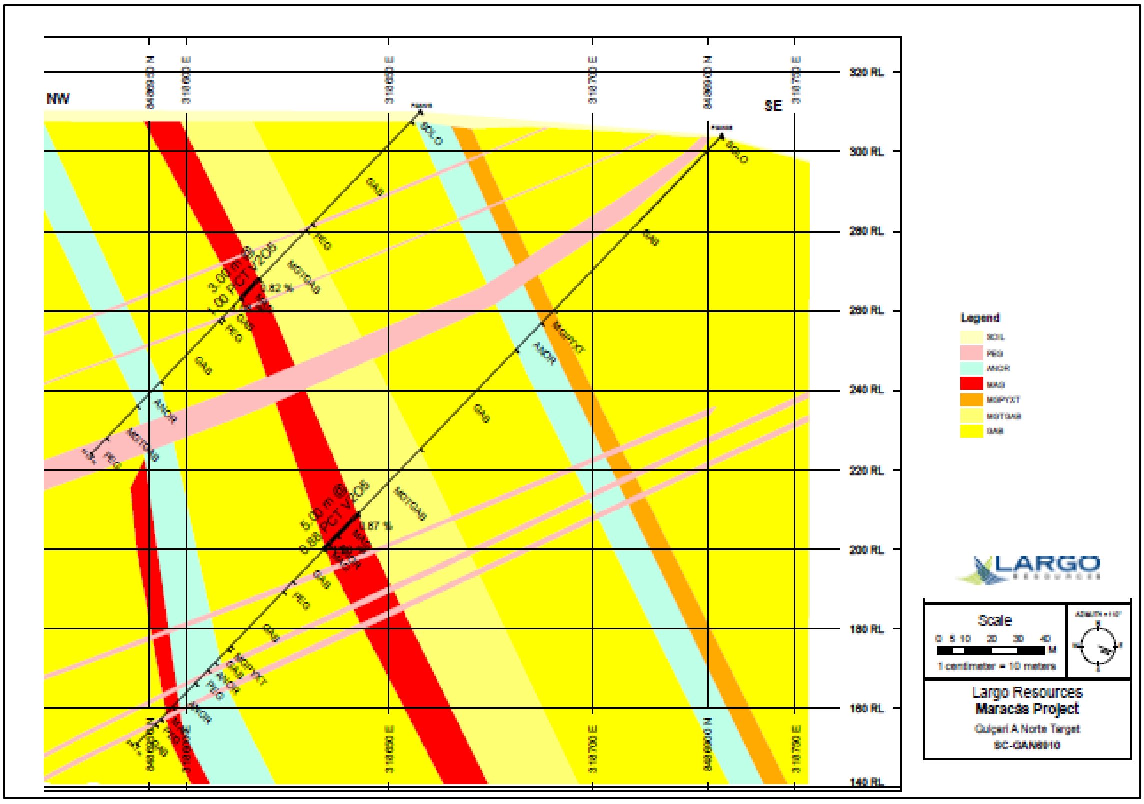


The geology of the deposit is represented by the following rock types: magnetite-gabbro which is medium to coarse grained with magnetic oxides around 25%. It has disseminated sulfide remobilized into fractures. Locally, small layers of massive magnetite occur. Also, fine to medium grained gabbros with a composition of plagioclase, pyroxene, amphibole and biotite, with narrow interlayers of magnetite-gabbro, pyroxenite, and anorthosites are common in the deposit. The massive magnetite is black in color with 60 - 70% magnetic oxides and disseminated sulphide (pyrite and chalcopyrite) as well as small interlayers of magnetite-pyroxenite and anorthosite.

The two mineralized zones have strike direction N20° E with dip ranging from 60 - 65° to the southeast. In the southern part of the deposit the main ore body is cut by fault with a northwest/southeast strike direction. Figure 7.2.2.5_2 shows a representative cross section of the Gulçari A Norte deposit.

Figure 7.2.2.5_2

Cross Section of the Gulçari A Norte Deposit



Due to the presence of significant layers of magnetite pyroxenite and pyroxenite in all drill holes Gulçari A Norte has many similarities with the Campbell deposit, and may be a northward continuation of the former.

The drill program on Gulçari A Norte deposit totaled 17 holes on sections spaced every 100 m.

7.3 Mineralization

The vanadium at Maracás is associated with the titaniferous magnetite. Within the deposit, the titaniferous magnetite is the major oxide phase, followed by ilmenite. Magnetite occurs as primary grains that may be partly martitized. There is also fine-grained magnetite as inclusions in the silicate grains. This magnetite occurs as a secondary alteration after uralitization of pyroxene and serpentinization of olivine.

The magnetite normally occurs as anhedral grains, with grain sizes of between 0.3 and 2.0 mm, and forms a polygonal mosaic together with ilmenite. Ilmenite also occurs as inclusions in the magnetite, commonly displaying exsolution textures. Silicate phases associated with the magnetite include uralite, augite, plagioclase, hornblende, and rare grains of clinopyroxene, olivine and spinel. Magnetite from the magnetitite in the Lower zone (Campbell) has higher V_2O_5

concentrations (see Table 7.3_1) (0.9% to 7.0%) than magnetite from the Upper zone (Gulçari B and Novo Amparo, 0.3% to 2.5% V_2O_5; Brito, 2000).

Table 7.3_1 V2O5 in Magnetite at Campbell	
Ore Type	(V_2O_5%)
Massive & Banded Ore	
concentrate	3.59
range	2.38 - 6.35
probe	4.68
range	2.90 - 6.82
Footwall Magnetite Pyroxenite	
concentrate	2.96
range	0.88 - 7.06
probe	3.31
range	1.38 - 6.24
Hanging Wall Black Pyroxenite	
concentrate	3.44
range	2.06 - 6.35
probe	4.44
range	3.61 - 5.57

Rare olivine and pyroxene grains are observed within the magnetitite, but most are altered to serpentine or chlorite. The Rio Jacaré intrusion has been intensely metamorphosed, so the pyroxene compositions observed probably reflect metamorphic re-equilibration rather than original magmatic compositions. In addition, Brito (2000) also documented the presence of orthopyroxene. Garnet and biotite are present in the Gulçari B and Novo Amparo deposits.

Sulphides account for up to 1% of the rock in the magnetitite. The major phases are chalcopyrite and pentlandite with only very minor pyrite and pyrrhotite. Chalcopyrite is much more abundant than the other sulphides and is most common in the rock types containing 50% magnetite or less. It commonly occurs interstitially in magnetite or ilmenite enclosed by amphibole and plagioclase. Pentlandite is much less abundant and occurs in the magnetitite. The pentlandite tends to occur interstitially to the magnetite and ilmenite in silicates but, locally, composite grains of pyrrhotite, pentlandite, and chalcopyrite are enclosed in magnetite. Minor sphalerite and galena grains are found together in the silicates, associated with the other sulphides especially in the magnetite-poor rock types. However, the dominant trace minerals are nickel and cobalt sulphides and arsenides and cobalt-rich pentlandite. In many cases the arsenides are associated with the sulphides and appear to be alteration products of the sulphides.

High platinum and palladium values have been found in the magnetite zones in the Rio Jacaré intrusion. They are much richer in platinum-group metals than the surrounding silicate rocks, and there are significant correlations among all of the PGMs and between PGM and copper.

In the magnetite zones, palladium-rich minerals, especially bismuthides and antimonides, are the most abundant PGM minerals. In most cases, these occur with interstitial silicates or within silicate inclusions in magnetite and ilmenite grains, and are associated with pentlandite and, in a few cases, with arsenides. Sperrylite is the most abundant platinum mineral and is associated with silicates interstitial to magnetite and ilmenite grains. At sites where the igneous mafic minerals have been altered to amphiboles, sperrylite may be altered to platinum-iron alloys.

It is suggested that copper, nickel and PGM were concentrated in the magnetite layers by the co-precipitation of a small quantity of sulphide with the magnetite. These PGM-bearing base metal sulphides subsequently exsolved the platinum minerals during the cumulate phase. The association of palladium minerals with base metal sulphides and the small variation in the Pt/Pd ratio (4:1) suggests that the PGMs have not been extensively remobilized in the magnetite.

The association of PGM enrichment with magnetite layers in the Rio Jacaré intrusion has similarities with the Rincón del Tigre, Skaergaard and Stella Complexes. This enrichment is rarely associated with visible sulphides, but suggests a possible new target for PGM exploration.

The Rio Jacaré intrusion hosts massive magnetite pod-like bodies confined to a layered sequence of mafic and ultramafic cumulates. They are named the lower and upper magnetite seams. The lower magnetite seam is represented by the Gulçari pod which occurs within the lower Transition zone. This zone is a 400-m-long, 150-m-thick pod tested to a vertical depth of about 350 m. It is a sequence of magnetite, pyroxenite and gabbro layers carrying vanadiferous iron ore with a mean grade of 2% V_2O_5 that displays PGM values up to 5 ppm Pt, 1.7 ppm Pd and an average grade of 400 ppb total PGMs.

Magnetite layers are interbedded with ultramafic and mafic cumulates. The ultramafic cumulates are transgressive towards the contact with the Lower zone gabbros and consist of olivine-magnetite cumulates, and clinopyroxene-magnetite heteradcumulates. The massive magnetite layers are made up of ilmenite-magnetite heteradcumulates that form 2 cm to 3 m thick layers containing variable amounts of clinopyroxene. Associated mafic cumulates are rhythmically micro-layered gabbro, magnetite, and magnetite-pyroxenite bands.

The outer contacts of the magnetite pods exhibit hornblende-rich rocks and dunite in places. These features are suggestive of a zoned pattern that Brito (1984) interpreted as similar to the magnetite pipe-like bodies of the Bushveld Complex. The upper Transition zone pod-like magnetite bodies are groupings of magnetite seams and pyroxenites that form 150-m long, 20-m thick masses of vanadiferous iron ore with mean grade of 0.5% V_2O_5 and maximum total PGM contents of 1.3 ppm and mean grade of 380 ppb. The upper Transition zone also contains a low-grade copper sulphide mineralization which is confined to the lowermost layers of the upper magnetite seams.

7.3.1 Oxidation

In the Maracas area the water table generally lies 30 m below surface. Below this the rocks are generally fresh and above they weather and oxidize to varying degrees. Most of the weathered and oxidized material is residual. The rock types weather and oxidize in place. Locally there is lesser fluvial and colluvial material. What influences the weathering and oxidation to varying degrees are features such as faults that provide a conduit for fluid migration and enhance oxidation to depth.

The oxide minerals in this environment such as magnetite and ilmenite oxidize to other minerals such as maghemite, hematite, goethite and other iron oxides. Magnetite is strongly magnetic whereas ilmenite is moderate to weakly magnetic. The oxidized mineral maghemite is moderately magnetic and hematite, goethite and other iron oxides are weakly to non-magnetic.

Vanadium in this environment is in a plus 3 valence state, the same as the Fe^{+3} in the oxide minerals and substitutes for it in the magmatic process for the emplacement of the Rio Jacaré Sill. In the oxidized material that results from weathering, the vanadium stays with this Fe_2O_3 molecule in the oxidized minerals.

Largo ran batches for the oxidized benches through the plant on site to quantify reduction in recoveries and also took grab samples from working faces on each bench to compare and validate the results. The Davis Tube results found low V_2O_5-to-magnetic recoveries on the oxidized material. Based on these results, Largo developed recovery reduction values reflecting the degree of oxidation in the massive and disseminated rock types as production reaches down to the "fresh" level. Table 7.3.1_1 shows the results of weathering and oxidation on recovery for the Campbell deposit.

Table 7.3.1_1

Recovery Reduction Factors for Oxidized material, Campbell

Metres Below Pit Rim	Bench	Massive	Disseminated
30	270 - 275	10%	10%
20	280 - 285	20%	32%
10	290 - 295	9%	19%
5	300 - 305	32%	36%

8 DEPOSIT TYPES

Work carried out to date indicates that the Maracás vanadium-rich titaniferous magnetite deposit is situated in a geologic environment similar to other magmatic vanadium-rich magnetite deposits. The Rio Jacaré intrusion that hosts the deposit is a mafic to ultramafic layered intrusion characterized by both rhythmic and cryptic layering that includes a pyroxenite/gabbro layer in the upper part. This gabbro layer hosts the Campbell vanadium deposit. The deposit has been assigned this way by the manner in which it was generated as an early magmatic ore type deposit formed by concentration through liquid immiscibility.

The primary minerals of the gabbro layer are plagioclase, augite and magnetite. Secondary alteration has altered most of the augite to uralite. Plagioclase occurs as elongated laths, the only idiomorphic mineral present, with the allotriomorphic minerals of magnetite and augite occurring as grains between the plagioclase laths. Magnetite was the last mineral to crystallize and, because of the amount of vanadium incorporated in it, the magnetite gabbro layer has the potential to have economic value. The crystal form of the magnetite does not indicate the concentration of the magnetite by an accumulation of separate magnetite crystals; on the contrary, the textural features suggest the formation of a separate oxide liquid.

The enrichment of PGMs, in association with magnetite, has been described in other mafic-ultramafic complexes. In association with the Main Magnetite Layer in the Upper zone of the Bushveld Complex, PGMs are concentrated in anorthosite just below the layer. However, the magnetite seams themselves contain very little PGMs.

In the Skaergaard intrusion in Greenland, palladium is concentrated with copper and gold in anorthositic layers associated with magnetite at the top of the middle zone, having values of up to 3 ppm Pd and 200 ppb Pt. In the Rincón del Tigre Complex in Bolivia, platinum and palladium are concentrated with copper at the base of the magnetite-bearing gabbro in the upper part of the intrusion with maximum precious metals concentrations of 1.8 ppm Pd and 0.68 ppm Pt in separate 1-m samples. In all of these intrusions, magnetite formed after extensive fractionation of the magma.

Samples of oxide layers from the Birch Lake area of the Duluth Complex exhibit PGM-depleted, -undepleted, and -enriched mantle-normalized patterns similar to Rio Jacaré samples. The PGM patterns for Birch Lake and Rio Jacaré are similar for platinum and palladium, but the Birch Lake patterns are generally enriched in osmium to rhodium compared to the Rio Jacaré samples. The Longear, Wyman Creek and Boulder Lake magnetite units of the Duluth Complex also closely resemble the Rio Jacaré depleted and undepleted samples. This comparison suggests that the Rio Jacaré magnetitite is most similar to those found in layered intrusions associated with continental tholeiites. The depleted Rio Jacaré PGM patterns are also similar to those obtained from the northern limb of the Upper zone of the Bushveld.

The sulphide content of the Rio Jacaré rocks is very low and the rocks are metamorphosed. Sulphides in the magnetite and magnetite-bearing pyroxenite of the Lower zone show enrichment in platinum, palladium, rhodium, iridium, gold and nickel, but not in copper, compared to the Upper zone. Recalculated sulphide concentrations for samples from Campbell are similar to those of PGM-enriched sulphides from Birch Lake and Medvezhy Creek in the

Norilsk Complex. In contrast, recalculated sulphide concentrations of the Gulçari B and Novo Amparo samples resemble the PGM-depleted Minnimax sulphides and Dunka Road sulphides of the Duluth Complex.

9 EXPLORATION

9.1 2006 Exploration Program

Largo signed a letter of intent to acquire the Maracás Project in October 2006. As a result, there had been no time to conduct any exploration on the property before the completion of the previous mineral resource estimate (Hennessey, 2006). During the late spring and summer of 2006, Largo conducted a program of technical due diligence prior to completion of the transaction. This work added to the database of information for the property and may, therefore, be regarded as exploration.

As of the end of 2006, Largo had re-established the exploration grid on the Campbell deposit, surveyed it, and also check surveyed the drill hole collars, most of which were marked with casing or plastic pipe.

Most of the CBPM and Odebrecht exploration drill core was intact and stored in a rented office/warehouse facility in the town of Maracás. Largo staff re-logged much of this core and conducted a significant program of check sampling. This program involved quarter-sawing of the same sample intervals selected previously and check assaying for V_2O_5 and TiO_2, as well as analyzing for PGMs. The results of this program are discussed in Section 12, Data Verification, below.

9.2 2007 Exploration Program

The 2007 exploration program conducted at Maracás by Largo consisted of the following:

- 175 line-km of line cutting
- 175 line-km of ground magnetic geophysical surveying
- 136 line-km of induced polarization (IP) geophysical surveying
- geological mapping of the property at a scale of 1:2,500
- resampling old drill holes from 1981 through 1986 for PGMs
- surveying
- thin section and lithogeochemical studies
- diamond drilling, 61 holes totaling 13,876 m.

The surveying program was completed in order to put all of the previous work and future work into the same grid system. It was decided to use UTM (Universal Transverse Mercator/ Corrego Alegre) coordinates for the grid system. All drill holes and trenches completed since 1981 have been converted to UTM.

The entire property has been covered by 175 line-km of line cutting. The grid lines are 2.5 km long and oriented east-west with 100-m line spacing and 25-m stations along the lines. This line cutting work has been done, in order to conduct geological mapping, sampling and ground geophysical surveys (magnetic and IP). Geological mapping was done at a scale of 1:2,500 over the entire property concentrating on favourable areas that have a limited amount of information. These include Campbell, Gulçari B, Novo Amparo and São José. This work was completed in order to get a better understanding of the area's potential prior to conducting further drill testing.

Ground magnetic surveying was completed over the entire property. It was hoped that the magnetic survey would help in understanding the geology that underlies the property and trace the magnetite-rich horizons associated with the mineralization along strike and at depth. The results were reasonably encouraging given that the magnetite horizons are good magnetic anomalies that respond reasonably strongly.

A total of 136 line-km of IP surveying have been completed on the property. IP responds well to the magnetite and disseminated sulphide mineralization found at Maracás. Geophysical surveys are considered important in this phase of work and their use will be discussed in the next section.

Data compilation, re-logging and additional resampling of previously drilled holes (1981 to 1986) were undertaken. This work was done to correlate the lithologies between holes and from section to section, and to test the platinum and palladium potential of the deposit, in order to better understand the geological setting and help in future work plans.

Petrographic analysis was carried out on 56 polished thin sections from drill holes representing the various rock types, including highly mineralized samples from Campbell and Novo Amparo. They were used to characterize the rock types and mineralization in the immediate area around the deposits. The mineralized samples were also analyzed with inductively coupled argon plasma (ICP) multi-element package. Fresh, relatively unaltered samples were also chosen for whole rock analysis, in order to characterize the intrusive rocks in the belt.

A diamond-drill program of 61 holes totalling 13,876 m was completed in 2007 on the property. The program began in the middle of February and ended in November. A more complete description of the program follows in Section 10 of this Report.

9.3 Previous Geophysical Surveys

A limited number of geophysical surveys were conducted by previous operators (CBPM, Odebrecht and CAEMI,) over the Maracás property during the period 1980 to 1986. These include magnetic and very low frequency EM (VLF) surveys. Survey coverage was total grid for both. A review of this coverage is beyond the scope of this Report. Any new drill targets will be generated by the new geophysical surveys.

9.3.1 Discussion of Present Geophysical Techniques

Systems such as magnetic and IP surveys are the optimum methods for detecting both massive magnetite and disseminated sulphides in the Rio Jacaré belt. Both techniques generally give good responses to this style of mineralization. The advantage of spectral IP over traditional IP is in its ability to distinguish between strictly massive magnetite and a mixture of massive magnetite and disseminated sulphides.

The total field magnetic responses reflect major changes in the magnetite content of the underlying rock units. The amplitude of the magnetic responses relative to the regional background assists in identifying specific magnetic and nonmagnetic units related to, for example, gabbro, pyroxenite, magnetite units, felsic intrusions and sedimentary rocks. Alteration and fault zones often have distinctive nonmagnetic below background responses.

Spectral IP surveys involve measurement of the magnitude and relative phase of the polarization voltage that results from the injection of an alternating current into the ground. Polarization voltages primarily result from electrochemical action within the pores and pore fluids of the material being energized. Measurements of the relative phase shift between the transmitted current and the measured signal and the magnitude of the polarization voltage are taken over a range of different frequencies, typically between 0.125 and 1,000 Hz. This results in a distinct IP response spectrum or ‘dispersion’ at each measurement position that can be characterized with Cole-Cole theoretical spectral parameters called tau, M-IP and c, such as relaxation time and chargeability which are influenced by chargeable grain size and the type of chargeable source.

These spectral parameters complement chargeability and apparent resistivity data and have proven successful for detecting favourable gold and PGM mineralization.

A combination of magnetic and spectral IP techniques appears to be more diagnostic in detecting the massive magnetite and disseminated sulphide mineralization on the property, and was thus recommended as the only geophysical tool remaining that can provide diagnostic survey coverage of the property. With the new advances in IP, the spectral IP method is a useful ground geophysical tool in detecting the disseminated sulphide mineralization along strike and at depth.

9.3.2 Geophysical Survey Results

Three relatively continuous, parallel to sub-parallel, magnetic trends can be traced north-south using the results of the new ground magnetic survey data. These are associated, from west to east, with Campbell, Novo Amparo-São José-Gulçari B and a third unknown trend. The two western trends are associated with the Rio Jacaré layered mafic intrusion, whereas the eastern, most magnetic trend is of unknown origin. The few available outcrops suggest that the trend is underlain by felsic intrusive rocks. There is a strong possibility, however, that there are northeast-trending listric normal faults and that a magnetic horizon hosted in the mafic layered intrusion at depth may be responsible for the trend.

The IP conductors discovered are coincident with the trends of strong magnetic highs. In 2008 work to examine the spectral IP parameters was ongoing and nearing completion. At that time Largo reported that initial indications were the spectral data suggested areas along the magnetic trend where there is potential for disseminated sulphides. Largo also reported that these would become targets for future drill programs at Maracás.

9.4 2008 Exploration Program

In 2008 Largo conducted a 5,000-m drill program at Maracás, largely designed to test IP deposits other than Campbell. This program is described in Section 10 below.

9.5 2011-2012 Exploration Program

In 2011 and 2012 Largo completed an additional diamond drilling campaign on the property consisting of approximately 13,400 m. While some of this drilling was on the Campbell deposit, the majority was again targeting other known anomalies on the property. The results of the program are described in Section 10 below.

9.6 2012 Infill Drill Program

In 2012 Largo completed an additional infill diamond drilling campaign on the Campbell deposit consisting of 103 short vertical drill holes totalling 3,929.15 m. The purpose of the program was to prove up the material for the first 2-3 years of operation. At the time of this technical report most of that material has already been mined out and the topography used for the block model is below the bottom of most of these holes. However, the holes were included in the drill hole database. The results of the program are described in Section 10 below.

9.7 2015 Exploration Program

In 2015 Largo completed Davis Tube test work on all pulp samples from the 2007, 2008 and 2011-2012 drill programs that tested Campbell deposit. The samples were analyzed for percent magnetics and the magnetite concentrates were analyzed for V2O5 and SiO2. The program began in June 2015 and was completed by September 2015. A total of 7,567 pulp-samples were collected from the previous drill programs. These samples were collected from a secure lock storage area at Largo's exploration camp near the mine site. The samples were then shipped to SGS facility near Belo Horizonte, Brazil. All test work was done at SGS's Laboratory. The results have been inputted into the drill hole database used to create the block model for the Campbell deposit.

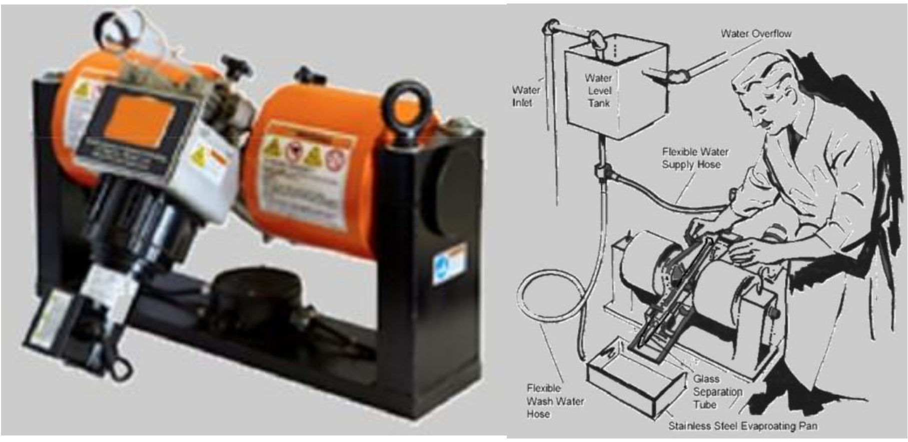
9.7.1 Davis Tube Tests

Davis Tube electromagnetic separators create a magnetic field which is able to extract magnetic particles from pulverized ore. With this instrument, the percentage of magnetic and non-magnetic material in a sample may be determined. Further chemical analysis by XRF is performed on the magnetic fraction to determine V2O5 and SiO2 in the concentrate.

A 30g aliquot of pulp sample is gradually added to the cylindrical glass tube which oscillates at 60 strokes per minute. As the sample progresses down the inclined tube the magnetic particles are captured by the magnetic field. Wash water flushes the non-magnetic fraction out of the tube until only the magnetic fraction remains. Both the magnetic and non-magnetic fractions are dried and weighed to determine the percentage of magnetics in each sample.

Figure 9.7.1_1

Davis Tube Test Apparatus



The Davis Tube test results were used to help determine what portion of the mineralization in the mineral resources contains magnetite of sufficient vanadium content and silica of low enough content to be processed through the magnetic separators and, therefore, can be determined to be a mineral reserve.

10 DRILLING

In this section, there is text from both Micon and Coffey Mining, which provided individual sections for a 2013 report by RPM. They are largely still current and are reproduced here. Although there is some duplication of information it was felt by GE21 that the commentary was sufficiently different to justify presenting both Micon and Coffey data.

The Micon and Coffey Mining sections are presented separately below.

10.1 Micon Text from Previous Reports

10.1.1 Drilling by Previous Operators

The drilling completed by previous operators, CBPM and Odebrecht, has been described earlier in this Report in Section 6, above. Figure 10.1.2_1 is a plan view of the historic drilling that was available at the Campbell deposit for the previous resource estimate (Hennessey, 2006).

10.1.2 2007 Largo Drill Program

During 2007, Largo completed a drill campaign consisting of 61 holes totalling 13,876 m as set out in Table 10.1.2_1. The location of the 2007 drilling at Campbell is shown in red on Figure 7.3 above. This subsection of the report is concerned solely with the updated mineral resource estimate at Campbell, and the drilling on other deposits will not be discussed in detail.

Table 10.1.2_1

Largo 2007 Maracás Drill Program

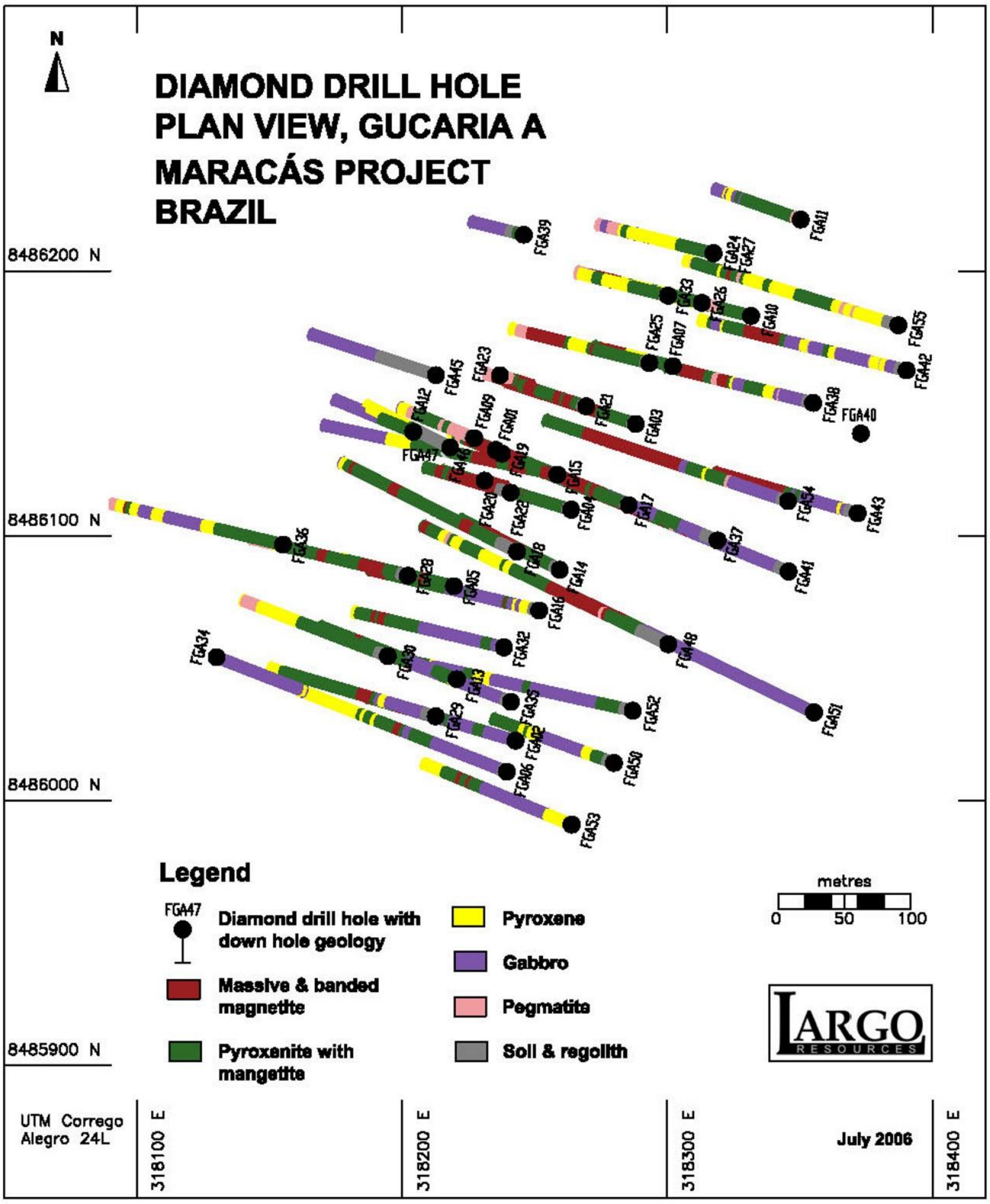
Areas	Type/Purpose	Number of Holes	Total (m)
Campbell	Resource	42	10,896
Campbell	Metallurgical & Geotech	3	300
São José	Exploration	9	2,324
Novo Amparo	Exploration	11	1,852
Regional	Exploration	5	828
Total	**-**	**70**	**16,200**

Boart Longyear (Geoserv Pesquisas Geológicas S/A) began the program with one drill rig on February 15, 2007, and added a second drill rig on March 5, 2007. Two rigs continued on the property until August 19, 2007, at which time drilling was completed on the Campbell deposit. One rig was released and the second drill went to Novo Amparo where 11 holes totalling 1,852 m were completed. The drill then cored five regional holes testing geophysical deposits totalling 828 m. Drilling was completed on October 29, 2007.

Boart Longyear drilled with NQ-sized core and averaged 1,000 m per rig per month. Core recovery was good with a reported average of 90%. Detailed drill hole information for Campbell is listed in Table 10.1.2_2.

Figure 10.1.2_1

Campbell deposit Drill Hole Plan



The principal focus of the diamond-drill program was to upgrade the confidence of the previous Inferred resource at Campbell to the Measured and Indicated categories, and to expand upon it sufficiently to demonstrate its potential economic viability. A secondary objective was to evaluate the PGM potential in the Campbell deposit.

Table 10.1.2_2
Drill Hole Summary for the 2007 Campbell Drill Program

Drill Hole	UTM Coordinates (Corrego Alegre)		Elevation (m)	Azimuth (°)	Dip (°)	Depth (m)
	N	E				
FGA 56	8,486,090	318,346	294.04	290	-55	229.10
FGA 57	8,486,090	318,346	295.04	290	-70	265.10
FGA 58	8,486,125	318,353	294.96	290	-70	238.40
FGA 59	8,486,151	318,358	294.76	290	-45	138.60
FGA 60	8,486,032	318,360	297.52	290	-50	254.00
FGA 61	8,486,162	318,364	296.29	290	-60	139.60
FGA 62	8,486,074	318,332	296.09	290	-50	214.00
FGA 63	8,486,038	318,334	293.09	290	-50	229.30
FGA 64	8,486,074	318,332	295.09	290	-65	267.00
FGA 65	8,486,020	318,402	299.25	290	-50	197.50
FGA 66	8,486,073	318,409	299.18	290	-65	247.15
FGA 67	8,486,090	318,296	301.09	290	-45	206.60
FGA 68	8,486,111	318,405	297.73	290	-65	270.60
FGA 69	8,486,133	318,319	302.71	290	-45	151.00
FGA 70	8,486,053	318,213	302.74	290	-45	94.70
FGA 71	8,486,097	318,454	300.84	290	-65	236.20
FGA 72	8,486,020	318,336	296.00	290	-45	285.60
FGA 73	8,486,130	318,435	299.00	290	-50	224.55
FGA 74	8,486,130	318,435	299.00	290	-80	292.80
FGA 75	8,486,033	318,288	293.99	290	-45	267.60
FGA 76	8,486,011	318,281	293.68	290	-55	151.10
FGA 77	8,486,145	318,429	297.82	290	-60	159.70
FGA 78	8,486,000	318,320	295.64	290	-65	190.00
FGA 79	8,486,133	318,478	300.03	290	-60	229.00
FGA 80	8,485,941	318,301	294.70	290	-60	222.95
FGA 81*	8,486,101	318,250	302.40	290	-50	205.00
FGA 82	8,486,201	318,926	298.99	290	-60	169.40
FGA 83	8,486,065	318,380	298.05	290	-65	188.60
FGA 84*	8,486,110	318,226	302.40	290	-50	50.50
FGA 85*	8,486,120	318,205	313.30	290	-50	44.50
FGA 86	8,486,048	318,432	302.00	290	-65	214.10
FGA 87	8,486,079	318,523	305.00	290	-65	352.00
FGA 88	8,486,055	318,479	309.00	290	-65	336.64
FGA 89	8,486,051	318,620	304.00	290	-65	436.00
FGA 90	8,485,993	318,498	309.00	290	-65	404.25
FGA 91	8,486,106	318,594	300.00	290	-60	382.20
FGA 92	8,485,991	318,430	301.00	290	-60	351.80
FGA 93	8,486,007	318,530	304.00	290	-65	358.10
FGA 94	8,485,968	318,412	301.00	290	-65	336.00
FGA 95	8,486,068	318,567	301.41	290	-65	413.95
FGA 96	8,486,129	318,531	304.10	290	-60	369.65
FGA 97	8,486,130	318,435	298.00	290	-65	280.30
FGA 98	8,486,020	318,402	296.00	290	-73	325.00
FGA 99	8,485,955	318,465	302.00	290	-65	394.30
FGA 100	8,485,962	318,348	296.00	290	-65	181.50
Total					**45**	**11,196.00**

* Holes drilled for metallurgical testing and geotechnical information.

The drilling at Novo Amparo was designed to test and characterize the mineralization 4 km to the north, along strike of Campbell and, in particular, the sulphide content and PGM potential of the mineralization. Finally, from the ground magnetic survey completed, five deposits were selected that had not been previously tested. These showings occur along magnetic trends that can be traced across the property for 4 km from Novo Amparo in the north to Campbell in the south.

At the time the Campbell deposit, as outlined from the drill programs, extended 400 m along strike, to a vertical depth of over 320 m with true widths ranging from 11 to 100 m with an average width of about 40 m. This deposit is part of a mineralizing system that extends for 8 km across the property. All the results from the drill program up to hole FGA-99 (the 2007 drill program) were completed and incorporated in the block model at that time.

The results from the Campbell drill program are summarized in Table 10.1.2_3. The results for Novo Amparo program and the five regional holes are not part of the updated Campbell mineral resource.

Of the 45 holes drilled at the Campbell deposit, 39 intersected wide well-mineralized zones. Table 10.1.2_3 and below is a summary of all significant Largo assay results from the drilling at Campbell up to the end of 2007.

Table 10.1.2_3
2007 Campbell Drill Results

Hole Number	From (m)	To (m)	V_2O_5 (%)	Pt (g/t)	Pd (g/t)	PGM (g/t)	Interval (m)	True Thickness (m)
FGA56	82.00	119.00	1.68	0.28	0.21	0.49	37.00	32.00
including	102.00	118.00	2.17	0.40	0.29	0.69	16.00	15.00
FGA57	104.00	140.10	1.85	0.27	0.21	0.48	36.10	30.00
including	121.00	138.10	2.31	0.36	0.28	0.66	19.10	17.00
FGA58	61.30	120.00	2.22	0.45	0.11	0.56	58.70	54.00
including	79.00	103.00	2.55	0.44	0.11	0.55	24.00	21.00
and	136.00	158.00	2.12	0.41	0.20	0.61	22.00	22.00
including	136.00	141.00	1.79	1.07	0.33	1.40	5.00	5.00
FGA59	50.00	122.00	1.88	0.52	0.08	0.60	72.00	72.00
including	65.00	73.00	2.65	0.91	0.10	1.01	8.00	8.00
FGA60	75.00	91.00	0.82	0.12	0.13	0.25	16.00	16.00
FGA61	76.00	121.00	1.97	0.44	0.11	0.55	45.00	44.00
including	95.00	106.00	2.64	0.57	0.21	0.78	11.00	10.00
FGA62	62.00	104.00	1.77	0.24	0.22	0.46	42.00	42.00
including	83.00	103.00	2.13	0.36	0.34	0.70	20.00	20.00
and	160.00	191.00	1.13	0.08	0.11	0.19	31.00	31.00
FGA63	54.47	70.00	0.91	0.18	0.11	0.29	15.53	15.00
FGA64	72.00	116.00	1.41	0.24	0.21	0.45	44.00	42.00
including	96.87	114.34	2.03	0.37	0.33	0.70	17.47	16.00
and	238.05	262.40	1.27	0.44	0.28	0.72	24.35	23.00
FGA65	129.08	155.52	1.09	0.18	0.08	0.26	26.44	25.00
FGA66	136.91	182.80	1.46	0.22	0.18	0.40	45.89	43.00
including	156.94	182.00	2.03	0.39	0.31	0.70	25.06	23.00
FGA67	30.00	76.00	2.10	0.44	0.17	0.61	46.00	46.00
including	32.00	55.00	2.47	0.42	0.14	0.56	23.00	23.00
including	62.00	73.00	2.21	0.54	0.26	0.80	11.00	11.00
and	137.00	154.00	1.42	0.13	0.10	0.23	17.00	17.00
FGA68	105.00	147.00	1.80	0.36	0.14	0.50	42.00	40.00
including	124.00	147.00	2.25	0.40	0.19	0.59	23.00	21.00
and	168.00	217.00	1.64	0.28	0.22	0.50	49.00	47.00
FGA69	44.26	112.73	2.42	0.53	0.12	0.65	68.00	68.00
FGA70	23.00	36.00	2.15	0.21	0.09	0.30	13.00	13.00
FGA71	151.22	193.20	2.07	0.24	0.08	0.32	41.98	40.00
FGA72	211.55	224.60	1.30	0.12	0.08	0.20	13.05	12.00
and	229.90	239.15	1.43	0.13	0.11	0.24	9.25	9.00
and	249.15	268.15	1.06	0.04	0.05	0.09	19.00	18.00
FGA73	128.60	148.00	2.81	0.54	0.05	0.59	19.40	17.50
and	151.46	195.46	1.62	0.24	0.10	0.34	44.00	40.00

Table 10.1.2_3
2007 Campbell Drill Results

Hole Number	From (m)	To (m)	V_2O_5 (%)	Pt (g/t)	Pd (g/t)	PGM (g/t)	Interval (m)	True Thickness (m)
FGA74	136.38	175.38	1.86	0.24	0.03	0.27	39.00	39.00
including	148.38	173.38	2.15	0.21	0.04	0.25	25.00	25.00
FGA75	181.00	216.89	1.19	0.05	0.04	0.09	35.00	35.00
FGA76	89.00	118.00	1.43	0.08	0.06	0.14	29.00	29.00
including	105.00	118.00	1.93	0.09	0.08	0.17	13.00	13.00
and	128.00	135.00	1.32	0.06	0.08	0.14	7.00	7.00
FGA77	127.50	145.42	2.37	0.22	0.03	0.25	17.92	17.92
FGA78	106.95	117.40	0.68	0.08	0.07	0.15	10.45	9.00
FGA79	148.75	221.00	1.60	0.26	0.06	0.32	72.25	70.00
including	150.00	191.00	2.32	0.35	0.08	0.43	41.00	38.00
FGA80	83.70	90.70	0.69	0.07	0.04	0.11	7.00	7.00
and	94.70	98.70	1.02	0.09	0.11	0.20	4.00	4.00
and	114.10	118.10	1.22	0.09	0.08	0.17	4.00	4.00
FGA82	No significant results							
FGA83	134.00	152.93	1.77	0.23	0.21	0.44	18.93	18.93
including	139.00	152.93	1.99	0.26	0.25	0.51	13.93	13.93
and	159.72	172.72	1.18	0.05	0.06	0.11	13.00	13.00
FGA86	178.50	191.16	1.43	0.01	0.02	0.03	12.66	10.00
and	241.00	247.45	1.45	0.19	0.14	0.33	6.45	5.00
and	259.00	265.00	1.28	0.06	0.02	0.08	6.00	5.00
and	276.00	298.00	1.54	0.33	0.19	0.52	22.00	20.00
FGA87	244.50	259.83	1.93	0.16	0.21	0.37	15.33	15.33
and	267.00	289.00	1.82	0.19	0.22	0.41	22.00	22.00
and	306.00	323.00	0.86	0.05	0.06	0.11	17.00	17.00
FGA88	177.10	183.10	1.02	0.13	0.10	0.23	6.00	6.00
and	303.10	308.10	1.07	0.25	0.16	0.41	5.00	5.00
FGA89	297.00	356.00	2.11	0.19	0.07	0.26	59.00	59.00
including	302.00	338.00	2.40	0.20	0.07	0.27	36.00	36.00
FGA90	279.00	293.00	1.05	0.09	0.07	0.16	14.00	14.00
FGA91	285.60	294.60	1.32	0.21	0.10	0.31	9.00	9.00
FGA92	249.00	270.00	0.99	0.07	0.05	0.12	21.00	21.00
FGA93	264.00	278.00	1.94	0.24	0.18	0.42	14.00	14.00
and	299.00	309.00	1.31	0.10	0.07	0.17	10.00	10.00
FGA94	172.00	242.12	1.35	0.09	0.05	0.14	70.12	65.00
and	269.00	281.00	1.12	0.08	0.05	0.13	12.00	10.00
and	292.47	298.00	1.28	0.07	0.06	0.13	5.53	5.00
FGA95	268.80	336.00	1.46	0.11	0.10	0.21	67.20	65.00
including	268.80	284.60	2.24	0.09	0.09	0.18	15.80	15.80
FGA96	283.84	290.00	0.81	0.08	0.04	0.12	6.16	6.16
FGA97	142.73	193.00	1.83	0.28	0.19	0.47	50.27	50.27
including	143.73	173.00	2.26	0.34	0.16	0.50	29.27	29.27
and	218.00	228.00	1.40	0.30	0.30	0.60	10.00	10.00
FGA98	175.00	187.00	0.80	0.20	0.06	0.26	12.00	12.00
FGA99	224.00	233.00	1.38	0.10	0.11	0.21	9.00	9.00
and	237.00	241.00	1.55	0.06	0.04	0.10	4.00	4.00

Since the completion of the 2007 resource estimate report the results for hole FGA100 became available. They are set out in Table 10.1.2_4.

Table 10.1.2_4 2007 Late Drill Results								
Hole Number	**From**	**To**	**Interval (m)**	**True thickness (m)**	**V_2O_5 (%)**	**Pd (g)**	**Pt (g)**	**Zones**
FGA100	83.00	85.00	2.00	2.00	1.62	0.14	0.13	Campbell
and	93.00	95.00	2.00	2.00	1.24	0.10	0.10	
and	119.00	122.00	3.00	3.00	1.45	0.05	0.10	

10.1.3 2008 Largo Drill Program

In May 2008, Largo began a 5,000-m drill campaign to test high priority IP targets for PGM mineralization. Boart Longyear (Geoserv Pesquisas Geológicas S/A) began the program with one drill rig on May 28, 2008 and continued until September 19, 2008, at which time the drill program was terminated due to the capital market collapse. It was decided that it was more prudent to discontinue drilling and save the resources. At the time the program was stopped, Largo had completed 16 holes totalling 3,843 m. The program is summarized in Table 10.1.3_1 below:

Table 10.1.3_1 2008 Drill Program Summary			
Areas	**Type**	**No of Holes**	**Total Metres**
Campbell	Exploration	1	211.00
Gulçari A Norte	Exploration	5	1,137.20
São Jose	Exploration	9	2,209.50
Novo Amparo	Exploration	1	285.00
Total		**16**	**3,842.70**

Ten of the sixteen holes were analyzed in 2008. The remaining six holes were analyzed in 2011, during the 2011-2012 drill program. Boart Longyear drilled with NQ-sized rods and averaged 1,000 m per month, per rig. Core recovery was good with a reported average of 90%. Detailed drill hole information is listed in Table 10.1.3_2 below:

Table 10.1.3_2

2008 Drill Program Information

Drill Hole #	UTM Coordinates (Corrego Alegre)		Elevation (m)	Azimuth (°)	Inclination (°)	Depth (m)
	N	E				
FGA 101	8,486,386	318,630	300	270	-45	211.00
FGAN 01	8,487,100	318,775	307	270	-45	259.00
FGAN 02	8,487,000	318,785	310	270	-45	260.80
FGAN 03	8,487,000	318,925	312	270	-45	225.40
FGAN 04	8,486,800	318,700	308	270	-45	196.00
FGAN 05	8,486,800	318,875	330	270	-45	196.00
FSJ 03	8,488,300	319,200	325	290	-50	244.30
FSJ 04	8,488,200	319,200	330	290	-50	250.00
FSJ 05	8,488,350	319,250	323	290	-50	232.60
FSJ 06	8,488,100	319,225	332	290	-45	229.30
FSJ 07	8,488,000	319,243	330	290	-45	280.00
FSJ 08	8,487,303	318,806	321	290	-45	253.00
FSJ 09	8,488,398	319,104	320	290	-50	178.00
FSJ 10	8,487,800	319,200	332	290	-50	262.30
FSJ 11	8,487,298	318,863	320	270	-50	280.00
FNA 19	8,489,599	319,679	307	270	-45	285.00
TOTAL 16						**3,842.70**

The focus of the diamond drill program was on testing a number of high priority PGM deposits on the property. These holes were targeted based on the magnetic and IP geophysical surveys completed in 2007, lithogeochemical results from drill core sampling done across the property and some modeling, lithological and petrographic studies done by Dr. Keays.

Dr. Keays considers that there is a strong possibility for a PGM-rich horizon to occur at a stratigraphic interval higher than that in which the Campbell deposit is located. The field work completed to date, including geological mapping and sampling, magnetic and Spectral IP ground surveys, has identified a number of high priority deposits to be tested, in particular by the sulphide content and PGM potential of the mineralization.

Significant assay results for all the 2008 drilling are reported in Table 10.1.3_3 below.

Table 10.1.3_3

2008 Drill Program Summary of Significant Results

Hole Number	From (m)	To (m)	V_2O_5 (%)	Pt (g/t)	Pd (g/t)	PGM (g/t)	Interval (m)	True Thickness (m)
FSJ 03	75.00	90.00	0.55				15.00	15.00
FSJ04	22.00	35.00	0.56				13.00	13.00
and	128.00	138.00	0.50				10.00	10.00
FSJ05	2.00	21.00	0.55	0.32	0.12	0.44	19.00	19.00
FSJ06	68.00	88.00	0.52	0.34	0.14	0.48	20.00	20.00
including	83.00	88.00	0.63	0.37	0.25	0.63	5.00	5.00
FSJ07	20.00	30.00	0.74	0.40	0.12	0.52	10.00	10.00
and	113.00	129.00	0.65	0.40	0.22	0.62	16.00	16.00
FSJ 08	No significant results							
FGA101	93.00	98.27	1.00	0.10	0.10	0.20	5.27	5.00
and	156.00	163.00	1.08	0.32	0.31	0.63	7.00	7.00
including	157.22	160.00	1.17	0.73	0.69	1.42	2.78	2.78
FNA 19	No significant results							
FGAN01	211.80	220.00	1.00	0.1	0.1	0.2	8.20	8.00
including	216.00	220.00	1.16	0.1	0.1	0.2	4.00	4.00
FGAN02	192.00	195.45	1.00	0.1	0.1	0.2	3.45	3.00
FGAN03	No significant results							
FGAN04	105.00	107.82	0.95	0.1	0.1	0.2	2.82	2.82
and	153.78	162.00	1.02	0.22	0.25	0.47	8.22	8.22
including	157.00	160.63	1.21	0.39	0.44	0.83	3.63	3.50
FGAN05	48.94	62.70	0.75	0.2	0.1	0.3	13.76	13.50

10.1.4 2011-2012 Largo Drill Program

Between May 16, 2011 and February 16, 2012, Largo completed a drill campaign consisting of 72 holes totaling 13,401 m as set out in Table 10.1.4_1 below.

Layne Christensen (Layne do Brasil Sondagens Ltda.) began the program with one drill rig on May 16, 2011 and added a second drill rig on June 1, 2011. Two rigs continued on the property until December 20, 2011 at which time one was released and the second drill went to Gulçari A Norte where 8 holes totaling 1,006.55 m were completed. Drilling was completed on February 5, 2012. Layne Christensen drilled with NQ-sized rods and averaged 900 m per month, per rig. Core recovery was good with a reported average of about 90%. Detailed drill hole information for the seven zones tested is set out in Table 10.1.4_2 to Table 10.1.4_8 below.

Table 10.1.4_1 Largo 2011 - 2012 Drill Program			
Areas	**Type**	**No. of Holes**	**Total Metres**
Campbell	Exploration	11	3,117.61
Gulçari A Norte	Exploration	12	1,766.73
Gulçari B	Exploration	10	1,367.81
Gulçari B Sul	Exploration	6	1,150.00
São Jose	Exploration	14	2,389.75
Novo Amparo	Exploration	2	357.95
Novo Amparo Norte	Exploration	17	3,251.50
Total		**72**	**13,401.35**

The focus of the diamond drill program was to further delineate additional resources on the Maracás property. The area encompassed by the drilling includes a 6.5-km strike length from, south to north, Gulçari A Norte to Novo Amparo Norte and a 1.5-km strike length on the east side from São José to Gulçari B Sul (See Figure 10.1.4_2). The results from the 2011-2012 program are summarized in Table 10.1.4_9 below.

Table 10.1.4_2 Campbell Zone Drilling						
Hole ID	**Northing**	**Easting**	**Elevation (m)**	**Azimuth (º)**	**Dip (º)**	**Depth (m)**
FGA 102	8,486,018	318,696	304	290	-70°	506.00
FGA 103	8,486,086	318,554	301	290	-70°	364.05
FGA 104	8,486,081	318,058	303	290	-45°	196.85
FGA 105	8,486,029	318,554	310	290	-70°	404.90
FGA 106	8,486,120	318,082	304	290	-60°	195.04
FGA 107	8,486,169	318,089	306	290	-60°	154.07
FGA 108	8,486,074	318,602	303	290	-75°	446.60
FGA 109	8,486,103	318,119	338	290	-60°	194.00
FGA 110	8,486,125	318,194	339	290	-60º	104.00
FGA 111	8,485,902	318,422	295	290	-60º	300.50
FGA 112	8,486,176	318,390	301	290	-50º	251.60

Table 10.1.4_3 Gulçari A Zone Norte Drilling						
Hole ID	**Northing**	**Easting**	**Elevation (m)**	**Azimuth (°)**	**Dip (º)**	**Depth (m)**
FGAN 06	8,486,501	318,658	305	290	-45°	189.30
FGAN 07	8,486,644	318,695	307	290	-45°	198.10
FGAN 08	8,486,896	318,728	307	290	-45°	216.65
FGAN 09	8,486,382	318,562	301	290	-45°	130.75
FGAN 10	8,486,458	318,581	305	290	-45°	130.45
FGAN 11	8,486,520	318,612	312	290	-45°	122.48
FGAN 12	8,486,605	318,620	304	290	-45°	131.40
FGAN 13	8,486,676	318,620	310	290	-45°	117.60
FGAN 14	8,486,814	318,629	312	270	-45°	118.30
FGAN 15	8,486,926	318,652	319	290	-45°	121.85
FGAN 16	8,487,009	318,710	312	290	-45°	128.50
FGAN 17	8,487,116	318,711	316	290	-45°	161.35

Table 10.1.4_4

Gulçari B Zone Drilling

Hole ID	Northing	Easting	Elevation (m)	Azimuth (°)	Dip (º)	Depth (m)
FGB 08	8,487,166	318,945	319	290	-65°	99.15
FGB 09	8,487,127	318,982	320	290	-65°	102.62
FGB 10	8,487,091	318,928	316	290	-65°	99.33
FGB 11	8,487,068	318,984	320	290	-65°	171.06
FGB 12	8,487,090	318,991	322	290	-70°	136.90
FGB 13	8,487,044	318,976	324	290	-70°	173.40
FGB 14	8,487,013	318,957	319	290	-70°	164.70
FGB 15	8,486,992	318,902	319	290	-60°	103.80
FGB 16	8,486,978	318,937	322	290	-70°	155.70
FGB 17	8,486,937	318,933	325	290	-70°	161.15

Table 10.1.4_5

Gulçari B Sul Zone Drilling

Hole ID	Northing	Easting	Elevation (m)	Azimuth (°)	Dip (º)	Depth (m)
FGBS 01	8,486,749	318,992	317	290	-45°	212.15
FGBS 02	8,486,840	319,041	325	290	-45°	167.25
FGBS 03	8,486,606	318,996	309	290	-45°	174.80
FGBS 04	8,486,496	318,988	312	290	-45°	219.75
FGBS 05	8,486,393	318,983	314	290	-45°	169.70
FGBS 06	8,486,293	318,940	325	290	-45°	206.35

Table 10.1.4_6

São José Zone Drilling

Hole ID	Northing	Easting	Elevation (m)	Azimuth (°)	Dip (º)	Depth (m)
FSJ 12	8,488,280	318,907	319	290	-45°	368.80
FSJ 13	8,488,230	318,884	320	290	-45°	187.70
FSJ 14	8,488,230	318,884	320	290	-70°	169.15
FSJ 15	8,488,364	318,940	325	290	-65°	152.30
FSJ 16	8,488,171	318,863	321	290	-45°	161.20
FSJ 17	8,488,564	319,041	323	290	-45°	124.60
FSJ 18	8,488,656	319,059	338	290	-45°	156.40
FSJ 19	8,488,492	318,989	331	290	-45°	142.40
FSJ 20	8,488,425	318,957	327	290	-45°	132.20
FSJ 21	8,488,344	318,997	322	290	-45°	180.65
FSJ 22	8,488,346	318,899	319	290	-45°	153.85
FSJ 23	8,488,313	318,811	320	290	-45°	150.70
FSJ 24	8,488,260	318,812	321	290	-45°	153.80
FSJ 25	8,488,196	318,800	319	290	-45°	156.00

Table 10.1.4_7 Novo Amparo Zone Drilling						
Hole ID	**Northing**	**Easting**	**Elevation (m)**	**Azimuth (°)**	**Dip (º)**	**Depth (m)**
FNA 20	8,489,491	319,632	349	290	-45°	137.70
FNA 21	8,489,690	319,623	343	290	-45°	220.25

Table 10.1.4_8 Novo Amparo Norte Zone Drilling						
Hole ID	**Northing**	**Easting**	**Elevation (m)**	**Azimuth (°)**	**Dip (º)**	**Depth (m)**
FNAN 01	8,492,565	319,989	354	290	-45°	213.65
FNAN 02	8,492,479	319,953	362	290	-45°	169.95
FNAN 03	8,492,414	319,923	354	290	-45°	167.00
FNAN 04	8,491,855	319,967	341	290	-45°	239.40
FNAN 05	8,491,780	319,895	335	290	-45°	150.50
FNAN 06	8,492,657	320,053	351	290	-45°	184.15
FNAN 07	8,491,679	319,865	343	290	-45°	240.75
FNAN 08	8,492,732	320,115	355	290	-45°	186.00
FNAN 09	8,492,303	319,981	339	290	-45°	170.80
FNAN 10	8,492,400	319,978	339	290	-45°	175.80
FNAN 11	8,492,885	320,117	352	290	-45°	223.10
FNAN 12	8,492,756	320,048	354	290	-45°	196.95
FNAN 13	8,492,458	320,015	355	290	-45°	187.50
FNAN 14	8,492,634	320,120	354	290	-45°	231.50
FNAN 15	8,492,536	320,051	365	290	-60°	286.90
FNAN 16	8,492,361	319,900	350	290	-45°	113.20
FNAN 17	8,492,448	319,934	351	290	-45°	114.35

Figure 10.1.2_2

Zone Location Map (October 17, 2011)

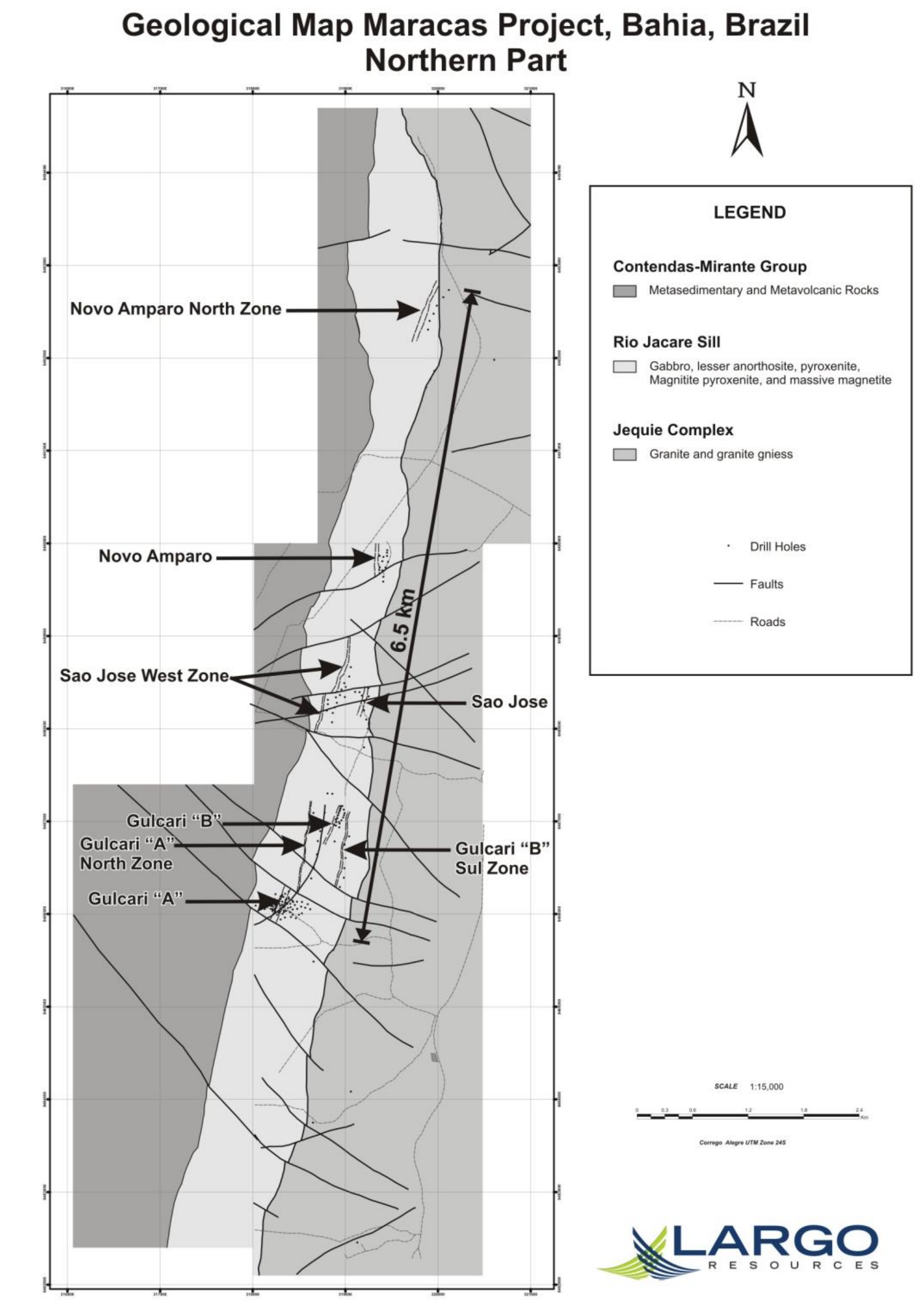


Table 10.1.4_9

2011-2012 Drill Program Summary of Significant Results

Hole Number	From (m)	To (m)	Interval (m)	True Thickness (m)	V_2O_5 (%)	Pd (g/t)	Pt (g/t)	Zones
FGA101	93.00	98.27	5.27	5.00	1.00	0.10	0.10	Gulçari A Norte
and	156.00	163.00	7.00	7.00	1.08	0.31	0.32	
including	157.22	160.00	2.78	2.78	1.17	0.69	0.73	
FGA102	385.95	399.40	13.45	10.00	1.05	0.16	0.16	Campbell
FGA103	254.68	322.80	78.14	62.00	1.64	0.15	0.10	Campbell
including	260.00	290.00	30.00	25.00	2.09	0.16	0.11	
FGA104	31.00	35.90	4.90	4.90	0.70	0.21	0.22	Campbell
FGA105	99.00	103.39	4.39	4.30	1.00	-	-	Campbell
and	274.60	293.57	18.97	15.00	1.34	0.15	0.12	
and	308.18	327.18	19.00	15.10	1.00	0.12	0.14	
FGA106	37.50	52.44	14.94	14.00	1.03	0.31	0.18	Campbell
including	47.34	51.62	4.28	4.00	1.32	0.61	0.41	
FGA107	29.00	34.20	5.20	5.00	1.00	0.10	0.10	Campbell
FGA108	154.00	159.40	5.40	5.00	1.00			Campbell
and	287.00	318.00	41.00	35.00	1.68	0.10	0.14	
including	294.00	305.00	11.00	8.00	1.87	0.04	0.09	
including	307.00	317.00	10.00	7.00	2.09	0.24	0.27	
FGA109	-	37.00	37.00	37.00	1.00	0.06	0.09	Campbell
including	-	3.00	3.00	3.00	1.87	0.10	0.19	
and	93.00	99.00	6.00	5.00	1.01	0.03	0.03	
and	136.00	141.00	5.00	4.50	1.28	0.33	0.46	
FGA110	14.00	35.00	21.00	15.00	1.00	0.12	0.14	Campbell
FGA111	240.00	243.00	3.00	3.00	1.00	0.31	0.18	Campbell
FGA112	47.00	61.65	14.65		0.90	0.01	0.33	Campbell
and	91.20	94.00	2.80		1.82	0.13	0.52	
and	96.60	107.00	10.40		1.19	0.22	0.30	
FGAN06	169.00	176.00	7.00	6.00	1.09			Gulçari A Norte
including	172.00	175.00	3.00	3.00	1.18	0.46	0.46	
FGAN07	177.00	184.00	7.00	6.00	1.05	0.41	0.44	Gulçari A Norte
FGAN08	138.00	143.00	5.00	5.00	0.88			Gulçari A Norte
and	204.00	207.93	3.93	3.50	0.95			
FGAN09	89.30	97.50	8.20	8.00	0.87	0.11	0.58	Gulçari A Norte
FGAN10	26.00	29.00	3.00	3.00	0.73			Gulçari A Norte
and	86.00	89.00	3.00	3.00	0.52	0.41	0.28	
FGAN11	34.00	38.00	4.00	4.00	1.04			Gulçari A Norte
and	48.00	52.00	4.00	4.00	1.00			
and	110.00	112.00	2.00	2.00	0.56	0.56	0.34	
FGAN12	106.00	110.00	4.00	4.00	0.93	0.47	0.55	Gulçari A Norte
FGAN13	82.50	86.50	4.00	4.00	0.50	0.33	0.33	Gulçari A Norte
FGAN14	31.00	34.30	3.30	3.30	1.06			Gulçari A Norte
and	90.00	95.10	5.10	5.00	1.00	0.23	0.42	
FGAN15	60.00	63.00	3.00	3.00	1.00			Gulçari A Norte
and	104.75	116.25	12.50	12.00	1.03	0.14	0.26	
FGAN16	109.00	112.00	3.00	3.00	1.08			Gulçari A Norte
FGAN17	77.00	79.20	2.20	2.00	1.07			Gulçari A Norte
and	104.25	106.40	2.15	2.00	1.00			
and	137.00	146.00	9.00	8.00	1.10	0.09	0.09	
FGB08	No significant results							Gulçari B
FGB09	No significant results							Gulçari B
FGB10	13.00	29.00	16.00	16.00	0.83	0.08	0.20	Gulçari B
FGB11	92.90	101.30	8.40	8.40	0.89	0.15	0.32	Gulçari B
FGB12	No significant results							Gulçari B
FGB13	98.00	108.60	10.60	10.00	0.80	0.09	0.22	Gulçari B
FGB14	88.80	99.40	10.60	10.00	0.76	0.09	0.20	Gulçari B
FGB15	15.00	37.00	22.00	22.00	0.66	0.05	0.11	Gulçari B
FGB16	72.00	100.00	28.00	26.00	0.62	0.04	0.08	Gulçari B
FGB17	85.00	105.00	20.00	20.00	0.67	0.06	0.14	Gulçari B
FGBS01	9.00	17.00	8.00	8.00	0.50			Gulçari B Sul
FGBS02	31.00	57.00	26.00	26.00	0.50			Gulçari B Sul

Table 10.1.4_9

2011-2012 Drill Program Summary of Significant Results

Hole Number	From (m)	To (m)	Interval (m)	True Thickness (m)	V_2O_5 (%)	Pd (g/t)	Pt (g/t)	Zones
FGBS03	15.00	20.00	5.00	5.00	0.43			Gulçari B Sul
FGBS04	46.00	58.00	12.00	12.00	0.43	0.06	0.18	Gulçari B Sul
FGBS05	54.00	70.00	16.00	16.00	0.42	0.09	0.20	Gulçari B Sul
FGBS06	41.00	48.00	7.00	7.00	0.43			Gulçari B Sul
and	55.00	65.00	10.00	10.00	0.36	0.06	0.20	
FSJ12	50.00	54.00	4.00	4.00	0.88			São Jose West
and	80.00	83.00	3.00	3.00	0.80			São Jose West
FSJ13	71.00	75.00	4.00	4.00	0.86			São Jose West
and	91.00	93.00	2.00	2.00	0.96			São Jose West
FSJ14	96.00	100.20	4.20	4.20	0.90			São Jose West
and	117.00	118.75	1.75	1.75	1.20			São Jose West
FSJ15	35.00	46.00	11.00	11.00	0.98			São Jose West
including	40.00	45.00	5.00	5.00	1.16			São Jose West
FSJ16	90.00	94.00	4.00	4.00	0.90			São Jose West
FSJ17	57.00	66.00	9.00	9.00	1.08			São Jose West
including	60.00	66.00	6.00	6.00	1.25			
and	83.47	91.60	8.13	8.00	0.77			
FSJ18	44.00	50.00	6.00	6.00	1.00			São Jose West
FSJ19	62.00	67.00	5.00	5.00	0.78			São Jose West
FSJ20	21.00	29.00	8.00	8.00	0.93			São Jose West
and	53.00	57.40	4.40	4.40	0.82			
FSJ21	77.00	89.90	12.90	12.50	1.05			São Jose West
including	83.00	89.90	6.90	6.50	1.23			
and	112.00	115.20	3.20	3.00	0.71			
FSJ22	12.00	23.00	11.00	11.00	0.67			São Jose West
FSJ23	7.70	9.00	1.30	1.30	1.14			São Jose West
and	26.65	29.85	3.20	3.20	0.73			
FSJ24	9.00	12.00	3.00	3.00	1.00			São Jose West
FSJ25	31.00	34.00	3.00	3.00	0.94			São Jose West
FNA21	45.15	52.00	6.85	6.85	0.80			Novo Amparo
FNAN01	79.00	100.00	21.00	20.00	1.00			Novo Amparo Norte
including	83.00	99.00	16.00	15.00	1.11			
and	136.00	141.90	5.90	5.00	0.82	0.10	0.10	
FNAN02	61.00	67.00	6.00	6.00	1.04			Novo Amparo Norte
and	72.00	78.15	6.15	6.00	0.90			
and	91.00	93.00	2.00	2.00	1.10	1.46	0.53	
FNAN03	55.52	73.70	18.18	18.00	0.92			Novo Amparo Norte
including	55.52	66.00	10.48	10.00	1.08			
and	81.00	90.00	9.00	8.50	0.88	0.29	0.16	
FNAN04	No significant results							Novo Amparo Norte
FNAN05	No significant results							Novo Amparo Norte
FNAN06	109.00	122.00	13.00	13.00	0.98			Novo Amparo Norte
including	115.00	122.00	7.00	7.00	1.25			
and	152.00	155.00	3.00	3.00	0.89			
and	161.00	163.10	2.10	2.00	1.09	0.76	0.33	
FNAN07	No significant results							Novo Amparo Norte
FNAN08	159.00	173.35	14.35	14.00	0.81			Novo Amparo Norte
including	164.00	170.00	6.00	5.00	1.10			Novo Amparo Norte
FNAN09	102.00	106.80	4.80	4.50	0.84			Novo Amparo Norte

Table 10.1.4_9

2011-2012 Drill Program Summary of Significant Results

Hole Number	From (m)	To (m)	Interval (m)	True Thickness (m)	V_2O_5 (%)	Pd (g/t)	Pt (g/t)	Zones
FNAN10	106.45	134.45	28.00	27.00	1.07			Novo Amparo Norte
including	112.45	134.45	22.00	21.00	1.18			
and	144.45	152.00	7.55	7.00	0.83			
including	149.45	152.00	2.55	2.00	0.93	0.80	0.48	
FNAN11	190.00	200.00	10.00	9.00	0.95			Novo Amparo Norte
including	197.00	200.00	3.00	2.50	0.93	1.00	0.42	
FNAN12	72.00	84.00	12.00	12.00	1.02			Novo Amparo Norte
and	123.00	135.00	12.00	11.00	0.90			
including	133.00	135.00	2.00	2.00	1.03	1.38	0.69	
FNAN13	129.00	150.00	21.00	20.00	0.79			Novo Amparo Norte
including	143.00	149.00	6.00	5.00	1.24			
FNAN14	190.00	200.40	10.40	9.50	0.86			Novo Amparo Norte
FNAN15	203.00	224.35	21.35	20.00	1.13			Novo Amparo Norte
and		273.40	12.75	11.50	0.84			
including	268.00	273.40	5.40	5.00	0.94	0.81	0.47	
FNAN16	78.50	94.70	15.50	15.00	0.90			Novo Amparo Norte
including	86.00	94.70	8.70	8.50	1.09			
including	88.00	94.70	6.70	6.50	1.15	1.56	0.76	
FNAN17	86.00	88.00	2.00	2.00	1.17	1.46	0.72	Novo Amparo Norte

The total drilling completed on the property has tested 7 zones with 209 holes totalling 35,286.59 m (see Table 10.1.5_1) of which Largo has drilled 140 holes totalling 29,371.29 m between 2007 and 2012.

Table 10.1.4_10

Total Maracás Drilling

Area	Program	No of Holes	Total Metres
Campbell	1981-87	53	5,152.57
	2007	45	11,195.94
	2011-12	11	3,117.61
Total		**109**	**19,466.12**
Gulçari B	1981-83	7	270.28
	2011-12	10	1,367.81
Total		**17**	**1,638.09**
Gulçari A Norte	2007	3	566.40
	2008	1	211.00
	2011-12	12	1,766.73
Total		**16**	**2,544.13**
Gulçari B Sul	2011-12	6	1,150.00
Total		**6**	**1,150.00**
São Jose	1983	2	115.15
	2008	9	2,209.50
	2011-12	14	2,389.75
Total		**25**	**4,714.40**
Novo Amparo	1983	7	377.30
	2007	9	1,502.10
	2008	1	285.00
	2011-12	2	357.95
Total		**19**	**2,522.35**
Novo Amparo Norte	2011-12	17	3,251.50
Total		**17**	**3,251.50**
Grand Total		**209**	**35,286.59**

There has been sufficient drilling in this area to demonstrate the continuity of the magnetite-rich horizons which is also supported by the ground magnetic survey that traces the known zones on surface. The ground magnetic survey also has identified a number of deposits that had not been previously tested.

The Campbell deposit, as outlined from the drill programs, now extends 400 m along strike, and to a vertical depth of over 350 m with true widths ranging from 11 to 100 m and with an average width of about 40 m. This deposit is part of a mineralizing system that extends the length of the property. All the assays from this drill program are completed and results received.

10.1.5 2012 Largo Infill Drill Program

Between September 10, 2012 and January 21, 2013, Largo completed an infill drill campaign consisting of 103 vertical holes totaling 3,929.35 m.

Layne Christensen (Layne do Brasil Sondagens Ltda.) began the program with one drill rig on September 10, 2012. The rig continued on the property until January 21, 2013 at which time it had completed the drilling on Campbell. Layne Christensen drilled with NQ-sized rods and averaged 980 m per month. Core recovery was good with a reported average of about 90%. Detailed drill hole information for the infill drill program is set out in Table 10.1.5_1 below.

Table 10.1.5_1 Largo 2012 Infill Drill Program						
HOLE-ID	LOCATION			Length	Azimuth	Dip
	Northing	Easting	Elevation (m)	(m)	(◦)	(◦)
FDGA01	8,486,130	318,244	314.83	55.45	0.00	-90
FDGA02	8,486,139	318,235	314.56	55.10	0.00	-90
FDGA03	8,486,131	318,226	314.22	55.00	0.00	-90
FDGA04	8,486,122	318,235	314.75	56.10	0.00	-90
FDGA05	8,486,122	318,218	313.08	53.50	0.00	-90
FDGA06	8,486,113	318,226	312.92	53.00	0.00	-90
FDGA07	8,486,113	318,209	311.74	52.50	0.00	-90
FDGA08	8,486,103	318,218	311.59	52.00	0.00	-90
FDGA09	8,486,095	318,209	310.82	51.00	0.00	-90
FDGA10	8,486,086	318,200	310.03	50.00	0.00	-90
FDGA11	8,486,077	318,191	308.82	49.00	0.00	-90
FDGA12	8,486,086	318,182	308.89	49.00	0.00	-90
FDGA13	8,486,104	318,200	310.97	51.50	0.00	-90
FDGA14	8,486,094	318,191	310.11	51.10	0.00	-90
FDGA15	8,486,148	318,245	314.40	54.50	0.00	-90
FDGA16	8,486,077	318,175	307.06	37.50	0.00	-90
FDGA17	8,486,068	318,164	305.78	36.40	0.00	-90
FDGA18	8,486,059	318,173	305.78	36.50	0.00	-90
FDGA19	8,486,166	318,262	313.65	54.00	0.00	-90
FDGA20	8,486,069	318,182	307.42	37.60	0.00	-90
FDGA21	8,486,183	318,280	312.06	52.50	0.00	-90
FDGA22	8,486,148	318,226	314.05	55.05	0.00	-90
FDGA23	8,486,157	318,235	314.09	54.10	0.00	-90
FDGA24	8,486,201	318,297	310.63	51.00	0.00	-90
FDGA25	8,486,166	318,244	314.10	54.00	0.00	-90
FDGA26	8,486,175	318,271	313.17	52.50	0.00	-90
FDGA27	8,486,174	318,253	313.78	54.00	0.00	-90
FDGA28	8,486,219	318,315	309.13	29.20	0.00	-90
FDGA29	8,486,157	318,271	312.75	53.00	0.00	-90
FDGA30	8,486,175	318,288	311.23	51.30	0.00	-90
FDGA31	8,486,192	318,306	310.00	50.10	0.00	-90
FDGA32	8,486,210	318,324	308.71	28.70	0.00	-90
FDGA33	8,486,236	318,333	307.01	27.20	0.00	-90
FDGA34	8,486,254	318,350	303.59	23.70	0.00	-90
FDGA35	8,486,228	318,341	307.04	27.00	0.00	-90
FDGA36	8,486,139	318,218	314.11	49.20	0.00	-90
FDGA37	8,486,157	318,288	310.59	51.00	0.00	-90
FDGA38	8,486,130	318,209	313.46	43.60	0.00	-90
FDGA39	8,486,174	318,305	309.63	39.80	0.00	-90
FDGA40	8,486,121	318,200	312.32	42.20	0.00	-90
FDGA41	8,486,192	318,324	308.32	38.80	0.00	-90
FDGA42	8,486,060	318,191	306.59	46.90	0.00	-90
FDGA43	8,486,210	318,342	307.67	28.60	0.00	-90
FDGA44	8,486,210	318,359	305.33	25.30	0.00	-90
FDGA45	8,486,068	318,200	307.65	47.90	0.00	-90
FDGA46	8,486,192	318,341	306.90	27.20	0.00	-90
FDGA47	8,486,077	318,208	308.55	48.80	0.00	-90
FDGA48	8,486,174	318,324	307.59	27.80	0.00	-90
FDGA49	8,486,086	318,217	309.63	49.80	0.00	-90
FDGA50	8,486,157	318,306	309.24	29.50	0.00	-90

Table 10.1.5_1

Largo 2012 Infill Drill Program

HOLE-ID	LOCATION			Length	Azimuth	Dip
	Northing	Easting	Elevation (m)	(m)	(◦)	(◦)
FDGA51	8,486,051	318,200	305.41	35.50	0.00	-90
FDGA52	8,486,059	318,208	305.84	36.00	0.00	-90
FDGA53	8,486,094	318,226	310.79	51.50	0.00	-90
FDGA54	8,486,068	318,218	306.82	37.30	0.00	-90
FDGA55	8,486,077	318,226	308.25	38.40	0.00	-90
FDGA56	8,486,086	318,236	309.27	49.50	0.00	-90
FDGA57	8,486,095	318,244	311.52	51.70	0.00	-90
FDGA58	8,486,104	318,253	312.00	52.00	0.00	-90
FDGA59	8,486,104	318,235	312.54	52.40	0.00	-90
FDGA60	8,486,113	318,262	311.56	51.80	0.00	-90
FDGA61	8,486,113	318,244	314.58	54.50	0.00	-90
FDGA62	8,486,121	318,271	311.11	51.20	0.00	-90
FDGA63	8,486,122	318,253	314.29	54.00	0.00	-90
FDGA64	8,486,121	318,288	309.28	39.60	0.00	-90
FDGA65	8,486,104	318,270	309.73	39.80	0.00	-90
FDGA66	8,486,086	318,253	308.42	38.60	0.00	-90
FDGA67	8,486,192	318,359	304.87	28.00	0.00	-90
FDGA68	8,486,068	318,235	306.37	26.40	0.00	-90
FDGA69	8,486,050	318,218	304.42	24.50	0.00	-90
FDGA70	8,486,051	318,236	303.36	23.50	0.00	-90
FDGA71	8,486,069	318,254	304.74	25.00	0.00	-90
FDGA72	8,486,174	318,342	304.42	24.70	0.00	-90
FDGA73	8,486,086	318,271	306.81	27.10	0.00	-90
FDGA74	8,486,104	318,289	308.19	28.40	0.00	-90
FDGA75	8,486,120	318,305	307.14	27.10	0.00	-90
FDGA76	8,486,103	318,306	305.76	26.00	0.00	-90
FDGA77	8,486,086	318,288	305.66	24.60	0.00	-90
FDGA78	8,486,068	318,271	302.50	22.50	0.00	-90
FDGA79	8,486,131	318,192	311.44	31.50	0.00	-90
FDGA80	8,486,148	318,209	312.90	33.20	0.00	-90
FDGA81	8,486,157	318,324	306.52	26.60	0.00	-90
FDGA82	8,486,166	318,226	313.39	33.50	0.00	-90
FDGA83	8,486,140	318,306	307.25	27.20	0.00	-90
FDGA84	8,486,139	318,324	305.69	25.60	0.00	-90
FDGA85	8,486,166	318,350	300.90	20.60	0.00	-90
FDGA86	8,486,183	318,368	302.49	22.60	0.00	-90
FDGA87	8,486,201	318,262	312.38	32.50	0.00	-90
FDGA88	8,486,201	318,244	312.79	32.60	0.00	-90
FDGA89	8,486,166	318,209	312.06	32.10	0.00	-90
FDGA90	8,486,120	318,324	303.56	23.40	0.00	-90
FDGA91	8,486,148	318,191	310.90	31.00	0.00	-90
FDGA92	8,486,051	318,254	301.43	21.80	0.00	-90
FDGA93	8,486,130	318,173	309.34	30.00	0.00	-90
FDGA94	8,486,051	318,182	305.59	26.00	0.00	-90
FDGA95	8,486,042	318,191	305.01	25.05	0.00	-90
FDGA96	8,486,033	318,236	301.19	21.00	0.00	-90
FDGA97	8,486,034	318,218	302.90	23.00	0.00	-90
FDGA98	8,486,015	318,219	299.30	20.00	0.00	-90
FDGA99	8,486,033	318,200	303.98	24.00	0.00	-90
FDGA100	8,486,131	318,166	308.64	28.90	0.00	-90

Table 10.1.5_1 Largo 2012 Infill Drill Program						
HOLE-ID	LOCATION			Length	Azimuth	Dip
	Northing	Easting	Elevation (m)	(m)	(◦)	(◦)
FDGA101	8,486,015	318,175	295.50	15.80	0.00	-90
FDGA102	8,486,015	318,199	297.55	18.00	0.00	-90
FDGA103	8,485,988	318,202	290.93	11.30	0.00	-90
TOTAL	**103 Holes**			**3,929.35**		

The focus of the infill drill program was to further identify and delineate the first 2 to 3 years of mining at the Campbell deposit. The holes were spaced on 12.5-m centres and encompassed an area of about 300 m by 150 m. The results from the 2012 program are summarized in Table 10.1.5_2 below.

Table 10.1.5_2

2012 Infill Drill Program Summary of Significant Results

Hole Number	From (m)	To (m)	V_2O_5 (%)	Pt (g/t)	Pd (g/t)	PGM (g/t)	Interval (m)	True Thickness (m)
FDGA01	3.10	55.45	2.15	0.34	0.20	0.54	52.35	26.18
FDGA02	5.00	55.10	2.51	0.59	0.28	0.87	50.10	25.05
FDGA04	1.50	56.10	2.54	0.52	0.24	0.76	54.60	27.30
FDGA06	10.10	21.63	2.22	0.37	0.16	0.53	11.53	5.77
FDGA11	4.00	16.00	2.30	0.22	0.11	0.33	12.00	6.00
FDGA12	28.00	40.00	2.23	0.24	0.11	0.35	12.00	6.00
FDGA15	3.40	16.20	2.32	0.58	0.24	0.82	12.80	6.40
and	19.20	54.50	2.27	0.42	0.21	0.63	35.30	17.65
FDGA19	20.40	54.00	2.65	0.72	0.11	0.83	33.60	16.80
FDGA22	17.30	31.00	2.64	0.29	0.11	0.40	45.00	22.50
FDGA26	39.20	52.50	2.44	1.10	0.21	1.31	13.30	6.65
FDGA29	25.00	53.00	2.90	0.70	0.06	0.76	28.00	14.00
FDGA36	0.00	17.00	2.63	0.37	0.18	0.55	17.00	8.50
FDGA53	0.00	29.00	1.98	0.39	0.24	0.63	29.00	14.50
FDGA56	9.19	49.50	2.24	0.60	0.33	0.93	40.31	20.16
FDGA57	22.62	51.70	2.31	0.55	0.38	0.93	29.08	14.54
FDGA58	10.86	39.61	2.08	0.48	0.29	0.77	28.75	14.38
FDGA59	2.90	48.16	2.78	0.87	0.18	1.05	45.26	22.63
FDGA60	23.25	31.63	2.42	0.77	0.39	1.16	8.38	4.19
FDGA61	0.00	22.00	2.59	0.53	0.27	0.80	22.00	11.00
and	30.17	54.50	2.30	0.43	0.25	0.68	24.33	12.17
FDGA63	27.69	54.00	2.07	0.37	0.27	0.64	26.31	13.16
FDGA65	21.70	34.20	2.31	0.57	0.34	0.91	12.50	6.25
FDGA66	2.35	38.60	2.36	0.42	0.24	0.66	36.25	18.13
FDGA95	11.03	25.05	2.27	0.17	0.22	0.39	14.02	7.01

10.1.6 Logging

For the program Largo rented a farmhouse immediately adjacent to the Maracás property and about 2 km from Campbell. This house was used as an office, bunkhouse for the geologists and a core logging and storage facility. Covered and shaded logging racks have been built for the geologists to lay out and examine core.

The core boxes had nailed-on lids and were delivered to this location daily, where they were sorted by hole and stacked. Later, the lids were removed and they were placed on the logging racks, where box markings and footage blocks are checked for accuracy.

Holes are logged in a conventional manner with lithologies and mineralization marked up with a lumber crayon and described, as well as the recording of basic geotechnical observations (rock quality designation, RQD). Particular attention was placed on the degree of magnetism in the core. Logging was performed using a computer and the "Logger" front-end data collector program written for Gemcom®.

At the time of Micon's site visit in April 2007, drilling had just commenced and core had not yet been photographed. Micon was informed that this was to be done, and a digital camera had just been purchased. At the time of Micon's 2011 visit, core was being photographed. Other than this change the core logging procedures used in later drill programs have remained the same.

10.2 Coffey Mining Text from Previous Reports

10.2.1 Maracás Drilling Program 2011/2012

During 2011/2012 Largo completed a drill campaign consisting of 73 holes totalling 13,401 m distributed in 7 deposits as set out in Table 10.2.1_1.

This section is solely about this drill program at Novo Amparo Norte, Novo Amparo, São José, Gulçari B and Gulçari A Norte. Layne do Brasil Sondagem Ltda. began the program with two drill rigs on May 15, 2011. These rigs continued on the property until February 5, 2012 at which time drilling was completed on all areas. Layne drilled with NQ-sized core and averaged 1,000 m per rig per month. Core recovery was good with a reported average of 90%. The drill hole records and core are stored in a facility at the Maracás mine site (see and Figure 10.2.1_1).

Table 10.2.1_1

Maracás Drill Program 2011/2012

Areas	Type/Purpose	N° of Holes	Total Metres
Campbell	Resource	11	3,117.61
Gulçari A Norte	Resource	12	1,766.73
Gulçari B	Resource	10	1,367.81
Gulçari B Sul	Exploration	6	1,150.00
São José	Resource	14	2,389.75
Novo Amparo	Resource	2	357.95
Novo Amparo Norte	Resource	17	3,251.50
Total		**72**	**13,401.35**

Figure 10.2.1_1

Largo's Maracás Field Office during Exploration

Figure 10.2.1_2

Project Drill Core Storage Facility

10.2.1.1 Novo Amparo Norte Deposit

Table 10.2.1.1_1 shows the drill hole summary for the Novo Amparo Norte deposit.

Table 10.2.1.1_1 Summary Novo Amparo Norte Deposit							
Hole ID	Northing	Easting	Elevation (m)	Azimuth (°)	Dip (°)	Depth (m)	Year
FNAN01	8,492,565.00	319,989.00	354.00	290	-45	213.65	2011
FNAN02	8,492,479.00	319,953.00	362.00	290	-45	169.95	2011
FNAN03	8,492,414.00	319,923.00	354.00	290	-45	167.00	2011
FNAN04	8,491,855.00	319,967.00	341.00	290	-45	239.40	2011
FNAN05	8,491,780.00	319,895.00	335.00	290	-45	150.50	2011
FNAN06	8,492,657.00	320,053.00	351.00	290	-45	184.15	2011
FNAN07	8,491,679.00	319,865.00	343.00	290	-45	240.75	2011
FNAN08	8,492,732.00	320,115.00	355.00	290	-45	186.00	2011
FNAN09	8,492,303.00	319,981.00	339.00	290	-45	170.80	2011
FNAN10	8,492,400.00	319,978.00	339.00	290	-45	175.80	2011
FNAN11	8,492,885.00	320,117.00	352.00	290	-45	223.10	2011
FNAN12	8,492,756.00	320,048.00	354.00	290	-45	196.95	2011
FNAN13	8,492,458.00	320,015.00	355.00	290	-45	187.50	2011
FNAN14	8,492,634.00	320,120.00	354.00	290	-45	231.50	2011
FNAN15	8,492,536.00	320,051.00	365.00	290	-60	286.90	2011
FNAN16	8,492,361.00	319,900.00	350.00	290	-45	113.20	2012
FNAN17	8,492,448.00	319,934.00	351.00	290	-45	114.35	2012
Total						**3,251.50**	

The Novo Amparo Norte deposit, as outlined from the drill program, extends 620 m along strike with average width of 18 m and average grade of 0.87% of V_2O_5. A round of 17 holes were drilled at this deposit, 39 intersected wide, well mineralized zones as shown in Table 10.2.1.1_2 below

Table 10.2.1.1_2 Novo Amparo Norte Deposit Drill Hole Assay Results								
Hole Number	From (m)	To (m)	V2O5 (%)	Fe (%)	TiO2 (%)	SiO2 (%)	Interval (m)	True Thickness (m)
FNAN01	80.00	100.00	1.025	41.45	11.92	16.68	20.00	17.5
FNAN01	136.00	141.90	0.822	25.52	7.10	31.11	5.90	5.2
FNAN02	61.00	67.00	1.047	23.37	11.85	17.59	4.00	5.2
FNAN02	72.00	78.15	0.898	15.00	8.22	26.21	6.15	5.4
FNAN02	91.00	94.10	0.873	22.81	5.86	34.03	3.10	2.7
FNAN03	55.52	73.70	0.924	40.89	12.19	17.03	18.18	17.9
FNAN03	81.00	90.00	0.883	25.36	6.87	31.68	9.00	7.9
FNAN06	108.00	122.00	0.949	42.97	13.30	13.89	14.00	12.2
FNAN06	152.00	163.10	0.648	22.23	8.99	32.39	3.10	2.6
FNAN08	159.00	173.35	0.831	38.39	11.60	19.41	1.35	12.5
FNAN09	81.90	84.00	0.498	22.21	5.37	36.47	2.10	1.8
FNAN09	102.00	106.80	0.836	25.99	7.19	30.10	4.80	4.2
FNAN10	106.45	135.45	1.050	41.19	12.00	16.49	29.00	25.3
FNAN10	143.45	152.00	0.786	24.09	6.54	32.16	8.55	7.5
FNAN11	158.00	159.00	1.030	37.52	11.05	21.74	1.00	0.9
FNAN11	188.00	200.00	0.757	24.43	7.06	32.90	12.00	10.5
FNAN12	70.00	84.00	0.939	40.14	12.29	17.79	14.00	12.2
FNAN12	121.00	135.56	0.820	25.64	7.22	30.74	14.56	11.0

Table 10.2.1.1_2 Novo Amparo Norte Deposit Drill Hole Assay Results								
Hole Number	**From (m)**	**To (m)**	**V2O5 (%)**	**Fe (%)**	**TiO2 (%)**	**SiO2 (%)**	**Interval (m)**	**True Thickness (m)**
FNAN13	129.00	150.00	0.792	40.84	12.84	16.43	21.00	18.3
FNAN14	190.00	200.40	0.857	41.32	12.77	15.73	10.40	9.1
FNAN15	203.00	225.00	1.107	42.74	12.43	14.15	22.00	15.8
FNAN15	258.00	273.40	0.780	24.05	6.87	32.91	13.95	11.1
FNAN16	47.00	63.50	0.698	41.37	13.78	16.08	16.50	14.4
FNAN16	78.50	89.70	0.821	26.07	7.25	29.39	11.20	9.8
FNAN16	92.20	94.70	1.083	21.21	5.70	40.90	2.50	2.2
FNAN17	57.00	73.00	0.865	34.71	8.63	23.77	16.00	14.9
FNAN17	77.00	88.00	0.954	26.46	6.88	30.27	11.00	10.6

Figure 10.2.1.1_1 shows an example of the drill hole collar markers in the Novo Amparo Norte. Table 10.2.1.2_1 is a summary of all significant assay results from the drilling at Novo Amparo Norte.

Figure 10.2.1.1_1

Novo Amparo Norte Drill Hole Collar Marker

10.2.1.2 Novo Amparo Deposit

Table 10.23 below shows the drill hole summary of Novo Amparo Deposit.

Table 10.2.1.2_1 Summary Novo Amparo Deposit							
Hole ID	**Northing**	**Easting**	**Elevation (m)**	**Azimuth (°)**	**Dip (°)**	**Depth (m)**	**Year**
FNA 20	8,489,491.00	319,632.00	349.00	290	-45	137.70	2011
FNA 21	8,489,690.00	319,623.00	343.00	290	-45	220.25	2011
Total						**357.95**	

The Novo Amparo deposit, as outlined from the drill program, is 285 m along strike and ranges from 11 to 21 m in width, with an average grade of 0.72% of V_2O_5. Only drill hole FNA20 crossed the mineralized zone. Table 10.2.1.2_2 below is a summary of all significant assay results from the drilling at Novo Amparo deposit.

Table 10.2.1.2_2

Novo Amparo Deposit Drill Hole Assay Results

Hole Number	From (m)	To (m)	V2O5 (%)	Fe (%)	TiO2 (%)	SiO2 (%)	Interval (m)	True Thickness (m)
FNA08	41.00	42.00	0.640	41.21	13.58	15.37	1.00	0.9
FNA09	57.17	62.73	0.652	36.01	10.31	22.52	5.56	4.8
FNA09	70.20	72.87	0.644	37.61	12.26	19.69	2.67	2.3
FNA09	76.55	80.29	0.848	48.98	16.48	7.11	3.74	3.2
FNA10	76.00	84.00	0.600	33.24	9.45	26.95	8.00	6.6
FNA10	89.00	106.23	0.697	45.73	15.65	10.50	17.23	14.1
FNA11	97.00	100.00	0.597	34.63	10.34	24.36	3.00	2.6
FNA12	95.00	103.30	0.566	34.73	10.56	23.69	8.30	7.2
FNA13	72.00	97.00	0.669	42.15	14.43	14.55	25.00	17.7
FNA14	54.00	73.00	0.652	40.73	13.53	16.91	7.00	16.5
FNA15	83.00	107.00	0.773	49.01	17.27	7.76	24.00	20.8
FNA16	84.48	90.54	0.728	45.99	15.47	10.69	6.06	5.2
FNA16	97.00	100.00	0.570	46.99	16.32	9.46	3.00	2.6
FNA18	141.30	166.00	0.650	43.81	14.70	13.03	24.70	14.2
FNA01	19.75	32.40	0.791	45.44	16.01	9.94	12.65	7.3
FNA01	35.35	46.93	0.788	46.77	16.93	8.09	11.58	6.6
FNA02	22.27	54.55	0.854	48.16	17.32	7.17	32.28	16.1
FNA04	29.55	44.50	0.610	37.28	12.39	21.55	14.95	8.6
FNA05	33.25	45.72	0.866	48.00	16.26	7.89	12.47	9.6
FNA07	26.20	40.60	0.764	43.45	15.29	12.35	14.40	7.2
FNA07	44.90	47.80	0.755	37.05	11.98	21.41	2.90	1.5

Figure 10.2.1.1_1 shows the mineralized zone in drill hole FNA15.

Figure 10.2.1.1_1

Mineralized Zone - FNA15

10.2.1.3 São José Deposit

Table 10.2.1.3_1 shows the drill hole summary for the São José Deposit.

Table 10.2.1.3_1

Summary São José Deposit Drilling

Hole ID	Northing	Easting	Elevation (m)	Azimuth (°)	Dip (°)	Depth (m)	Year
FSJ12	8,488,280.00	318,907.00	319.00	290	-45	368.80	2011
FSJ13	8,488,230.00	318,884.00	320.00	290	-45	187.70	2011
FSJ14	8,488,230.00	318,884.00	320.00	290	-70	169.15	2011
FSJ15	8,488,364.00	318,940.00	325.00	290	-65	152.30	2011
FSJ16	8,488,171.00	318,863.00	321.00	290	-45	161.20	2011
FSJ17	8,488,564.00	319,041.00	323.00	290	-45	124.60	2011
FSJ18	8,488,656.00	319,059.00	338.00	290	-45	156.40	2011
FSJ19	8,488,492.00	318,989.00	331.00	290	-45	142.40	2011
FSJ20	8,488,425.00	318,957.00	327.00	290	-45	132.20	2011
FSJ21	8,488,344.00	318,997.00	322.00	290	-45	180.65	2011
FSJ22	8,488,346.00	318,899.00	319.00	290	-45	153.85	2011
FSJ23	8,488,313.00	318,811.00	320.00	290	-45	150.70	2011
FSJ24	8,488,260.00	318,812.00	321.00	290	-45	153.80	2011
FSJ25	8,488,196.00	318,800.00	319.00	290	-45	156.00	2011
Total						**2,389.75**	

The São José deposit is characterized by two blind mineralized bodies. The first is 524 m long and 11 m thick. The second one is 404 m in length and 5 m thick. The global average grade is 0.89% V_2O_5. Table 10.2.1.3_2 is a summary of all significant assay results from the drilling at the São José deposit.

Table 10.2.1.3_2

São José Deposit Assay Results

Hole Number	From (m)	To (m)	V2O5 (%)	Fe (%)	TiO2 (%)	SiO2 (%)	Interval (m)	True Thickness (m)
FSJ09	125.10	126.60	1.500	n.a.	n.a.	n.a.	1.50	1.4
FSJ09	126.60	127.60	0.780	n.a.	n.a.	n.a.	1.00	1.0
FSJ09	142.00	148.80	0.743	n.a.	n.a.	n.a.	6.80	6.5
FSJ12	50.00	54.00	0.880	37.23	10.96	21.00	4.00	3.9
FSJ12	59.00	60.00	1.110	40.70	11.10	17.10	1.00	1.0
FSJ12	80.00	83.00	0.797	37.37	11.07	20.60	3.00	2.9
FSJ12	94.00	96.00	0.790	29.73	7.29	27.50	2.00	2.0
FSJ13	71.00	75.00	0.860	40.33	12.35	15.60	4.00	3.9
FSJ13	90.75	93.00	0.991	33.52	8.59	24.82	2.25	2.2
FSJ14	96.00	100.20	0.904	41.27	12.11	17.13	4.20	3.4
FSJ14	117.00	118.75	1.241	39.89	10.50	17.89	1.75	1.4
FSJ15	35.00	46.00	0.934	40.72	12.20	17.15	11.00	10.8
FSJ15	52.00	53.00	1.320	40.90	11.10	15.90	1.00	1.0
FSJ15	71.00	72.00	0.900	23.27	6.10	32.97	1.00	1.0
FSJ16	90.00	93.00	0.897	43.40	13.37	14.93	3.00	2.9
FSJ16	109.00	110.00	0.860	30.80	7.62	28.30	1.00	1.0
FSJ17	57.00	66.00	1.080	43.50	12.76	14.59	9.00	8.8
FSJ17	73.75	75.00	0.860	31.80	8.58	25.60	1.25	1.2
FSJ17	83.47	91.60	0.792	26.49	6.95	30.82	8.13	8.0
FSJ18	44.00	50.75	0.933	40.73	12.30	17.71	6.75	6.6
FSJ18	67.15	68.60	1.145	37.26	9.62	20.81	1.45	1.4
FSJ18	81.25	82.90	0.537	23.73	5.49	35.35	1.65	1.6
FSJ19	40.65	42.00	0.999	32.66	8.15	24.30	1.35	1.3
FSJ19	48.80	50.00	0.601	24.38	5.46	35.70	1.20	1.2
FSJ19	62.00	67.00	0.780	24.35	6.24	33.66	5.00	4.9
FSJ20	21.00	29.00	0.933	41.01	12.57	16.87	8.00	7.8
FSJ20	35.00	36.00	1.190	38.65	10.06	18.33	1.00	1.0
FSJ20	53.00	57.40	0.840	23.79	6.23	33.19	4.40	4.3
FSJ21	77.00	80.00	0.627	39.22	12.99	17.84	3.00	2.9
FSJ21	80.00	89.90	1.124	44.19	13.01	13.88	9.90	9.7
FSJ21	96.00	97.00	1.070	36.45	9.62	21.34	1.00	1.0
FSJ21	112.00	115.20	0.718	20.99	5.40	36.21	3.20	3.1
FSJ22	12.00	23.00	0.635	36.07	11.70	21.45	11.00	10.8
FSJ22	25.50	26.50	1.040	34.16	9.24	23.14	1.00	1.0
FSJ22	38.00	41.20	0.755	21.51	5.74	35.14	3.20	3.1
FSJ23	7.70	9.00	1.177	38.48	10.69	15.93	1.30	1.3
FSJ23	26.65	29.85	0.713	39.13	13.09	16.83	3.20	3.1
FSJ24	9.00	12.00	0.867	38.21	10.97	19.73	3.00	2.9
FSJ24	26.00	27.00	0.820	28.95	6.86	30.80	1.00	1.0
FSJ25	31.00	34.00	0.824	38.82	11.67	19.72	3.00	2.9
FSJ25	47.00	50.00	0.654	25.35	6.08	34.20	3.00	2.9

Figure 10.2.1.3_1 shows the location of drill hole FSJ15 in the São José Deposit.

Figure 10.2.1.3_1

Location of Drill Hole FSJ15

10.2.1.4 Gulçari B Deposit

Table 10.2.1.4_1 shows the drill hole summary for the Gulçari B Deposit.

Table 10.2.1.4_1

Summary Gulçari B Deposit

Hole ID	Northing	Easting	Elevation (m)	Azimuth (°)	Dip (°)	Depth (m)	Year
FGB08	8,487,166.00	318,945.00	319.00	290	-65	99.15	2011
FGB09	8,487,127.00	318,982.00	320.00	290	-65	102.62	2011
FGB10	8,487,091.00	318,928.00	316.00	290	-65	99.33	2011
FGB11	8,487,068.00	318,984.00	320.00	290	-65	171.06	2011
FGB12	8,487,090.00	318,991.00	322.00	290	-70	136.90	2011
FGB13	8,487,044.00	318,976.00	324.00	290	-70	173.40	2011
FGB14	8,487,013.00	318,957.00	319.00	290	-70	164.70	2011
FGB15	8,486,992.00	318,902.00	319.00	290	-60	103.80	2011
FGB16	8,486,978.00	318,937.00	322.00	290	-70	155.70	2011
FGB17	8,486,937.00	318,933.00	325.00	290	-70	161.15	2011
Total						**1,367.81**	

The Gulçari B deposit, as outlined from the drill program, is 200 m along strike and ranges from 4 to 13 m in width, with an average grade of 0.70% of V_2O_5. Table 10.2.1.4_2 is a summary of all significant assay results from the drilling at the Gulçari B deposit. Figure 10.2.1.4_1 shows the drill hole collar marker for hole FGB14.

Table 10.2.1.4_2 Gulçari B Deposit, Drill Hole Assay Results								
Hole Number	**From (m)**	**To (m)**	**V2O5 (%)**	**Fe (%)**	**TiO2 (%)**	**SiO2 (%)**	**Interval (m)**	**True Thickness (m)**
FGB01	18.95	27.22	0.75	42.48	15.05	13.76	8.27	5.3
FGB01	29.07	35.40	0.84	43.79	15.27	12.78	6.33	4.1
FGB02	18.50	29.05	0.77	44.46	15.41	13.24	10.55	6.8
FGB06	10.60	36.44	0.75	47.30	17.07	8.98	25.84	8.8
FGB10	13.00	29.00	0.88	44.93	14.99	12.37	16.00	11.3
FGB11	87.22	90.35	0.72	41.90	13.89	15.35	3.13	2.2
FGB11	95.00	101.30	0.84	42.56	13.60	15.35	6.30	4.5
FGB12	91.30	92.25	0.66	31.90	10.30	25.10	0.95	0.6
FGB13	98.00	108.60	0.80	45.31	15.08	11.88	8.90	6.8
FGB14	88.80	99.40	0.76	43.65	14.78	13.49	10.60	6.8
FGB15	17.00	39.25	0.68	43.44	15.04	13.38	22.25	14.3
FGB16	73.00	100.00	0.60	41.55	14.43	16.58	21.00	17.3
FGB17	85.00	99.60	0.67	41.71	14.18	15.92	14.60	9.4
FGAN05	48.94	62.70	0.60	34.88	10.75	23.95	13.76	12.0

Figure 10.2.1.4_1

Collar Marker for Drill Hole Fgb14

10.2.1.5 <u>Gulçari A Norte Deposit</u>

The Table 10.2.1.5_1 shows the drill hole summary of the Gulçari A Norte Deposit.

Table 10.2.1.5_1 Summary Gulçari A Norte Deposit							
Hole ID	**Northing**	**Easting**	**Elevation (m)**	**Azimuth (°)**	**Dip (°)**	**Depth (m)**	**Year**
FGAN 06	8,486,501	318,658	305	290	-45	189.3	2011
FGAN 07	8,486,644	318,695	307	290	-45	198.1	2011
FGAN 08	8,486,896	318,728	307	290	-45	216.65	2011
FGAN 09	8,486,382	318,562	301	290	-45	130.75	2011
FGAN 10	8,486,458	318,581	305	290	-45	130.45	2011
FGAN 11	8,486,520	318,612	312	290	-45	122.48	2011
FGAN 12	8,486,605	318,620	304	290	-45	131.,40	2012
FGAN 13	8,486,676	318,620	310	290	-45	117.6	2012
FGAN 14	8,486,814	318,629	312	270	-45	118.3	2012
FGAN 15	8,486,926	318,652	319	290	-45	121.85	2012
FGAN 16	8,487,009	318,710	312	290	-45	128.5	2012
FGAN 17	8,487,116	318,711	316	290	-45	161.35	2012
Total						**1,766.73**	

The Gulçari A Norte deposit is characterized by two blind mineralized bodies. The main ore body is 1 km long and 7.5 m in average thickness. The second one is 350 m long and 4 m in thickness. The global average grade is 0.84% V_2O_5.

Table 10.2.1.5_2 is a summary of all significant assay results from the drilling at the Gulçari A north deposit.

Table 10.2.1.5_2 Gulçari A Norte Deposit Assay Results								
Hole Number	**From (m)**	**To (m)**	**V2O5 (%)**	**Fe (%)**	**TiO2 (%)**	**SiO2 (%)**	**Interval (m)**	**True Thickness (m)**
FGAN01	143.10	145.00	0.737	n.a.	n.a.	n.a.	1.90	1.7
FGAN01	148.67	150.00	0.860	n.a.	n.a.	n.a.	1.33	1.2
FGAN01	181.00	186.00	0.476	n.a.	n.a.	n.a.	5.00	4.4
FGAN01	211.80	220.00	0.781	n.a.	n.a.	n.a.	8.20	7.2
FGAN02	192.00	195.45	0.957	n.a.	n.a.	n.a.	3.45	3.0
FGAN02	199.47	200.52	1.300	n.a.	n.a.	n.a.	1.05	0.9
FGAN04	105.00	107.82	0.943	41.97	12.30	17.06	2.82	2.5
FGAN04	140.00	143.00	0.527	20.53	4.29	38.40	3.00	2.6
FGAN04	153.78	160.63	1.118	29.19	7.35	27.72	6.85	6.0
FGAN06	86.00	89.50	0.939	39.93	11.53	18.69	3.50	3.2
FGAN06	91.53	92.70	1.300	41.10	10.70	16.90	1.17	1.1
FGAN06	124.14	125.05	1.140	37.30	9.76	20.20	0.91	0.8
FGAN06	151.00	154.00	0.520	19.37	3.96	39.70	3.00	2.8
FGAN06	169.00	176.00	1.084	29.44	7.32	27.19	5.00	6.4
FGAN07	160.00	161.00	0.540	20.30	4.10	39.90	1.00	0.9
FGAN07	177.00	184.00	0.984	26.69	6.60	30.74	3.00	6.4
FGAN08	138.00	143.00	0.878	37.86	11.13	20.56	5.00	4.6
FGAN08	145.00	147.00	0.760	27.20	6.62	31.90	2.00	1.8
FGAN08	204.10	207.93	0.945	27.74	6.30	30.26	3.83	3.5
FGAN09	28.00	30.10	0.905	39.20	11.62	19.62	2.10	1.9

Table 10.2.1.5_2

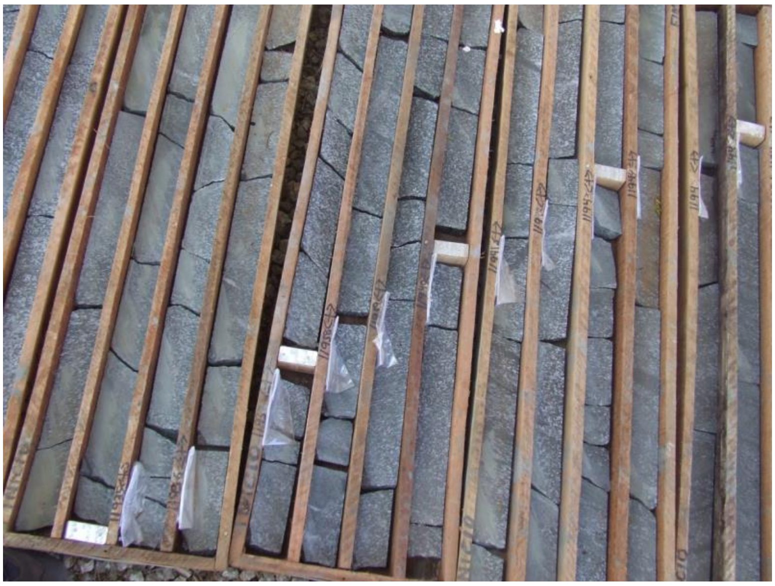
Gulçari A Norte Deposit Assay Results

Hole Number	From (m)	To (m)	V2O5 (%)	Fe (%)	TiO2 (%)	SiO2 (%)	Interval (m)	True Thickness (m)
FGAN09	32.30	33.50	0.870	29.40	7.52	29.02	1.20	1.1
FGAN09	60.00	61.00	0.920	32.41	7.79	25.75	1.00	0.9
FGAN09	89.30	97.50	0.891	24.94	5.63	33.36	8.20	7.2
FGAN10	26.00	28.15	0.945	40.15	11.96	18.06	2.15	2.0
FGAN10	30.00	31.00	0.688	24.91	6.03	34.30	1.00	0.9
FGAN10	58.00	59.00	0.581	22.93	5.51	36.10	1.00	0.9
FGAN10	75.00	76.00	0.484	28.45	6.56	31.60	1.00	0.9
FGAN10	86.00	89.00	0.525	18.04	3.73	41.60	3.00	2.8
FGAN11	34.00	38.00	1.037	41.67	12.35	16.68	4.00	3.7
FGAN11	48.00	52.00	1.000	41.04	12.20	17.81	4.00	3.7
FGAN11	82.00	84.00	0.631	24.53	5.63	35.00	2.00	1.8
FGAN11	110.00	111.00	0.676	21.29	4.70	37.00	1.00	0.9
FGAN12	29.80	31.35	1.070	38.60	11.57	16.67	1.55	1.4
FGAN12	85.00	86.00	0.450	18.59	3.55	40.12	1.00	0.9
FGAN12	103.00	104.00	0.930	26.97	6.59	28.83	1.00	0.9
FGAN13	74.50	75.50	0.520	33.80	7.70	24.90	1.00	0.9
FGAN13	82.50	86.50	0.520	19.46	3.86	40.32	4.00	3.7
FGAN14	31.00	34.30	1.033	41.67	12.40	16.70	3.30	3.0
FGAN14	75.00	78.00	0.515	19.15	4.06	40.10	3.00	2.8
FGAN14	90.00	95.10	0.954	27.00	6.33	31.19	5.10	4.7
FGAN15	60.00	63.00	1.001	40.77	12.30	17.85	3.00	2.8
FGAN15	65.00	66.40	0.979	35.60	8.53	25.20	1.40	1.3
FGAN15	104.75	116.25	1.014	27.65	6.27	30.20	11.50	10.6
FGAN16	109.00	112.00	1.081	43.61	13.05	15.03	3.00	2.8
FGAN16	115.00	117.00	0.732	28.35	6.96	31.50	2.00	1.8
FGAN17	75.00	79.20	0.860	38.09	12.51	18.84	4.20	3.9
FGAN17	81.15	82.00	1.185	36.33	9.62	21.80	0.85	0.8
FGAN17	104.25	107.40	0.898	30.94	7.65	28.06	3.15	2.9
FGAN17	139.00	146.00	1.087	31.64	7.70	26.17	7.00	6.4
FGA101	93.00	95.90	0.857	n.a.	n.a.	n.a.	2.90	2.6
FGA101	97.63	99.36	0.626	n.a.	n.a.	n.a.	1.73	1.5
FGA101	128.00	129.00	0.620	n.a.	n.a.	n.a.	1.00	0.9
FGA101	157.22	162.00	1.201	n.a.	n.a.	n.a.	4.78	4.2
FSJ08	126.00	128.92	0.973	n.a.	n.a.	n.a.	2.92	2.7
FSJ08	133.00	133.75	0.680	n.a.	n.a.	n.a.	0.75	0.7
FSJ08	145.93	151.00	0.457	n.a.	n.a.	n.a.	5.07	4.7
FSJ08	178.34	190.00	0.816	n.a.	n.a.	n.a.	11.66	10.7
FSJ11	184.00	187.96	0.870	n.a.	n.a.	n.a.	3.96	3.5
FSJ11	191.00	192.00	0.680	n.a.	n.a.	n.a.	1.00	0.9
FSJ11	208.00	209.00	1.020	n.a.	n.a.	n.a.	1.00	0.9
FSJ11	238.55	250.25	0.558	n.a.	n.a.	n.a.	11.70	10.3

Figure 10.2.1.5_1 shows the mineralized zone from drill hole FGAN05.

Figure 10.2.1.5_1

Zone Mineralized Drill Hole FGAN05



11 SAMPLE PREPARATION, ANALYSIS AND SECURITY

For Section 11, Sample Preparation, Analysis and Security, both Micon and Coffey Mining provided individual sections for the 2013 RPM report (Arsenault et al.). The Micon and Coffey Mining Sections have been reproduced here separately.

11.1 Micon Text from Previous Reports

11.1.1 Sampling Method and Approach

11.1.1.1 Previous Operators

Sampling of mineralization within the Study area by previous operators has been conducted by both diamond-drilling and trench-sampling methods.

The actual sampling method and approach carried out by CBPM (1981 and 1983) is not known by Largo. However, during Largo's visit to the core facility, it was observed that the drill core had been carefully sawn in half with all of the drill holes at Maracás available for review in the core warehouse. The remaining half showed the core to be very competent. It is believed by Largo, given the competent nature of the rock, together with clearly-marked sample intervals, that careful sampling procedures were carried out and that the sampling method had been conducted in a professional manner. Micon visited the core shed and spent several days reviewing core. Nothing viewed during the visit would cause Micon to come to a different conclusion. Sampled intervals were easy to identify and the core was in good condition.

Personal communication between R. A. Campbell and Marcos Nunes, then Project Geologist for Odebrecht, described the drill-core sampling procedures for 1984 through 1987, as set out below.

"Drill core was split using a diamond blade tile saw. The core pans were cleaned between each split sample. The remaining half of the core sample was replaced back in the core box. Half the core was then bagged along with its corresponding sample tag and bagged for shipment. Commercial trucking shipped the core samples to GEOSOL (1983 to 1987) Laboratory, Paulo Abib Engenharia S.A. laboratory (1985 to 1987) both in Belo Horizonte. Core trays with the remaining half core sample were placed in core racks at the exploration office in Maracás and remain intact for future reference."

"During the Odebrecht drill programs samples were crushed, ground completely to pulp passing -150 mesh and then split at the GEOSOL and Paulo Abib Engenharia S.A. preparation facilities in Belo Horizonte, Brazil. The split pulps were then analyzed by XRF method also in GEOSOL and Paulo Abib Engenharia S.A. laboratory in Belo Horizonte."

"The sample core length was 2.0 m in all cases in past sampling programs. The layered nature of the deposit and thicknesses of the mineralized zone of from 4 to 100 m justified this interval. The potential mining method of large tonnage open pit was also considered when selecting sample intervals. Smaller intervals would only be taken if there was a particular geological reason to do so."

"Channel samples were also cut on 2.0 m intervals and usually no greater, due to the large amount of material generated. Channel intervals were also governed by topography and geology so their lengths varied on occasion."

11.1.1.2 Largo Core Sampling

2006 and Early 2007 Re-logging

Until April 2007, Largo had drilled no core of its own. It had only resampled old drill holes from earlier programs.

In collecting its samples, Largo split all core using a diamond-blade tile saw. Half of the core was placed in a numbered plastic sample bag with the sample tag. The remaining half-core was placed back in the core box. A brick was briefly sawn between each sample cut, in order to clean the blade and prevent any contamination between samples.

The half-core was then sealed in the bags along with its corresponding sample tag. The sample bags were placed into larger "rice" bags, in groups of 15 samples, for shipment. The samples were transported in a company-operated vehicle from the office in Maracás to Salvador, where they were handed over to a commercial transport company for delivery by truck to SGS Geosol Laboratórios Ltda. (SGS) in Belo Horizonte. The core trays with the remaining quarter-core were placed in core racks at the core storage facility/office in Maracás, so as to be available for future reference.

The sampled core length was 2.0 m in all cases, in order to duplicate past sampling programs. Largo agreed that the layered nature of the deposit and thicknesses of the mineralized zone of from 2 to 100 m justified this interval.

2007 Exploration Drill Program

Sample boundaries were marked up by the geologists during the logging process. Generally, core was selected for sampling based on magnetite content or nearby strong alteration. Intervals to be sampled were marked in red lumber crayon. The beginning of each sample interval was marked on the edge of the core box with a felt tip marker and with a sample tag, affixed to the box with a staple, at the end of the interval. Overall about 45% of the core drilled was sampled.

Sampling commenced several metres prior to the beginning of mineralization and proceeded down-hole, usually at 1-m intervals, until a major lithologic contact. Sampling did not cross these contacts. Sample intervals could be shortened or lengthened depending on these observations. Magnetite and magnetite-pyroxenite were generally sampled separately, if the magnetite bands were approximately 1 m in size or larger.

Samples were collected by sawing the core in half with a diamond-blade tile saw at the logging facility. Once sawn, half-core was placed in a numbered plastic sample bag with the corresponding sample tag. The remaining half-core was placed back in the core box. A brick was briefly sawn between each sample cut, in order to clean the blade and prevent any contamination between samples. The sample bags were placed into larger plastic containers, in groups of 15 samples, for shipment. The samples were transported in a company-operated vehicle from the office in Maracás to Jequié where they were handed over to a commercial transport company for delivery by truck to SGS in Belo Horizonte.

Logged and sampled core boxes were stored in a roofed, fenced-in enclosure with a concrete floor and knee wall, within the fenced yard of the farm house.

These procedures continued to be used in the 2008, 2011-2012 drill programs and 2012 infill drill program.

11.1.2 Sample Preparation, Analyses and Security

11.1.2.1 Pre-2006 Analytical Work

Personal communication between R. A. Campbell and Mr. Marco Nunes also described the sample preparation and analytical protocols in use prior to Largo's involvement in the Project, but after 1983. According to Nunes, CBPM and Odebrecht used GEOSOL and Paulo Abib Engenharia S.A. as their analytical laboratories during the 1981 to 1983 exploration programs and again between 1984 and 1987. Their procedures were summarized as follows.

"A total of 1,675 core samples were prepared at GEOSOL and Paulo Abib Engenharia S.A. laboratories in Belo Horizonte, Brazil. These core samples were packaged in batches of 40 samples which included two replicates, one reference standard and one blank, inserted randomly. All samples underwent standard crushing and pulverizing techniques. The entire drill sample was passed through a primary crusher to yield a fine crushed product, with better than 75% of the sample passing 2 mm. When the crushed sample yielded approximately 2 kg the entire sample was pulverized."

"A crushed 2 kg sample was ground using a ring and puck mill pulverizer. The pulverizer uses a chrome steel ring and puck set. All samples were pulverized to greater than 95% of the ground material passing through a -150 mesh screen. Grinding with chrome steel may impart trace amounts of iron and chromium into the sample."

"Core samples were then analyzed at GEOSOL and Paulo Abib Engenharia S.A.'s laboratories in Belo Horizonte, Brazil. All samples were analyzed for FeO, Fe_2O_3, SiO_2, TiO_2 and V_2O_5. Routinely a sample weight of 0.66 grams was fused with 7.2 g of flux to prepare each bead. However, there were variations to this ratio for some matrices, giving a lower limit of detection of 0.01% and an upper limit of detection of 5.0% for V_2O_5. Samples were fused into a glass disc using a Lithium Borate flux much as described for normal fused glass beads. For "ore grade" materials flux composition and sample/flux ratios were varied to ensure all of the sample dissolves and that recrystallization does not occur as the melt is cooled."

The CBPM and Odebrecht sample pulps are still available to Largo. They have been placed in storage in the office in Maracás. While not climate-controlled storage, the sample pulps are protected from direct exposure to the elements and sunlight in a secure location.

11.1.2.2 Largo Analytical Work

All sample preparation and primary analyses of drill core from the 2006/2007 resampling program and the 2007, 2008 and 2011-2012 drill programs were performed by SGS in Belo Horizonte, Brazil and Lakefield, Ontario. During 2012 infill drill program both SGS in Belo Horizonte, Brazil and Intertek in Cotia, Brazil were used for sample preparation and analyses. The samples were analyzed for FeO, Fe_2O_3, SiO_2, TiO_2 and V_2O_5 by the XRF method and for platinum and palladium by a 50 g fire assay technique at SGS originally. This was changed to a 20 g fire assay for the 2007 and later drill programs, as a result of some initial problems with flux and the amount of magnetite in some of the samples. The XRF method gives a lower limit of detection of 0.01% V_2O_5.

SGS claims that the quality assurance system in place at its laboratories “complies with the requirements of the international standards ISO 9001:2000 and ISO 14001:2004 to chemical analysis and geochem of soils, rocks and ores” (SGS Minerals, 2006). Intertek also claims that the quality assurance system in place at its laboratories and that it complies with the requirements of the international standards ISO 9001:2008 to chemical analysis and geochemistry of soils, rocks and ores

Core samples were prepared similarly at both labs using the following protocol:

- weigh, dry and reweigh sample;
- primary crush to -2 mm (70% passing);
- pulverize split fraction to -150 mesh in chrome steel ring mill pulverizer.

The fire assay procedure employed for platinum and palladium used a 50 g aliquot (later changed to 20 g as described above) with aqua regia digestion, followed by an atomic absorption (AA) spectroscopy finish. Since this was a check sampling program, there were no field duplicates and field blanks inserted by Largo for this resampling program.

Both labs (SGS and Intertek) prepared and analyzed its own laboratory duplicates and inserted its own internal reference standards and blanks. Largo reviewed the quality control data files from both labs and verified by the Largo staff member responsible. Also, Largo staff member made a site visit to each facility to inspect and review the procedure on site at least one time during the program. There were no abnormalities detected in either the procedures or the results. SGS has ISO/IEC 17025 accreditation for its mineral analytical services.

It is Largo’s opinion that the sample preparation, security and analytical procedures were satisfactory. Micon concurred with this view.

11.2 Coffey Mining Text from Previous Reports

11.2.1 Sample Preparation and Analysis

The drill core intersections from Largo’s drilling programs are stored under an open-sided roofed structure at the exploration camp.

The drill core is stored in wooden core boxes with a nominal capacity of approximately 4 m for NQ or NQ2 sized drill core and 3 m for HQ or HW sized core. The drill hole number, Project name, box number, and downhole depths are stamped onto an aluminum tag and affixed to the edge of the box. Wooden downhole depth markers are placed in the core box by the driller and affixed with an aluminum tag stamped with the depth, the length of the interval, and the length of the recovered sample. (See Figure 11.2.1_1.)

Figure 11.2.1_1

Drill Core with Logged Intervals Delimited

The staff geologists are responsible for logging drill core. Core logging and sampling is done by Largo´s exploration team.

11.2.2 Core Logging

Before sampling, the geologist completes a graphic log and then logs the core in detail for lithology, structure, mineralization and alteration. (Figure 11.2.2_1 and Figure 11.2.2_2)

Sample intervals and sample numbers are also recorded on the report drill log. This information is stored physically and digitally. Largo's team has been kept the information on site, and another places due to data security policies.

Core sample recovery is not recorded by the geologist, although a record of the drill hole recovery on a run by run basis is recorded manually by the driller and it is checked by sampler always drilled core is delivered to logging and sampling in the facility area. It is illustrated in Figure 11.2.

This information is typed by a geological technician into a digital file for each hole. The recovery in the mineralized zones is generally very good, on average better than 95%.

Figure 11.2.2_1

Drill Core Logging

Figure 11.2.2_2

Drill Hole Log Example

LITHOLOGY REPORT
- Detailed -

Hole Number **FGAN 11** Project: **VANÁDIO MARACÁS** Project Number: **001**

From (m)	To (m)	Lithology	Sample #	From	To	Length	V2O5 (pct)	SiO2 (pct)	TiO2 (pct)	FeO (pct)	Fe2O3 (pct)
0.00	3.88	**SOLO** ***Rocha alterada com matéria organica*** Solo arenoso com argila, cor marrom, com pedriscos, matéria orgânica e fragmentos de rocha.									
3.88	21.30	**GAB** ***Gabbro*** Rocha de granulometria fina a grossa, cor marrom acinzentada a cinza esverdeada, bastante intemperizada (Saprolitizada) até 11.0m. A partir desse ponto bastante fraturada, com forte variação textural, foliada, composta basicamente por plagioclásio, piroxênio, anfibólio e biotita. Corta a encaixante um veio pegmatitico no intervalo de 20.53 a 20.97m. Foliação medindo cerca de 60° em relação ao eixo do furo. O contato de base é gradativo com o Magnetita-gabro.									
21.30	34.25	**MGTGAB** ***Magnetite Gabbro*** Rocha de cor cinza esverdeada, granulação fina a média, foliada, magnética, composta basicamente por plagioclásio, piroxênio, anfibólio, biotita, granada e óxidos magnéticos (10 a 15%). Ocorrem faixas centimétricas de magnetita piroxênito nos metros finais e sulfeto disseminado e remobilizado em fraturas por todo o trecho. A suscetibilidade magnética varia de 8 a 160 SI. Contato gradual com o magnetitito. Foliação medindo cerca de 55° em relação ao eixo do furo.									
34.25	38.00	**MAG** ***Magnetite*** Rocha de coloração escura a preta, composição de cerca de 60 a 70% de óxidos magnéticos, ocorrendo subordinadamente cristais de piroxênio, anfibólio, granada e plagioclásio. Apresenta faixas centimétricas de magnetita piroxenito e sulfeto disseminado concordante com a foliação e remobilizado em fraturas. A									

07/jan/12 11:17:20 Page 1 of 4

11.2.3 Core Sampling

After the drill core is received at the sampling shed, the entire length of the drill hole is checked and marked for lithological contacts. Samples are marked down the entire length of the hole at different length of intervals, always respecting lithological contacts. The sample length depends on the width of the core zone considered interesting enough to be sampled. A double arrow on the side of the channel marked on the box with a pen indicates the start and end of the sample interval. After the paper sample number tags are plasticized and stapled to the core box next to the corresponding sample. This is illustrated in Figure 11.2.3_1.

Figure 11.2.3_1

Drill Core with Tagged Sample Intervals

Samples are selected down the entire length of the drill core, sawn in half with an electric diamond bladed core saw, and sampled prior to logging. Half core samples are selected by a Largo´s geology technician or by a trained sampler. Figure 11.2.3_2 illustrates the core sawing procedure.

The samples are then placed in a numbered plastic bag along with a paper sample tag, and closed with a piece of string. Sample weight is around 3 kg.

Figure 11.2.3_2

Diamond Blade Core Saw

Batches of samples are placed in a larger plastic bag, loaded onto a truck, owned and operated by a locally-based transport company, and driven to the SGS laboratory, or Intertek Lab, whichever is available. In the case of SGS, it is forwarded to a sample preparation facility in Belo Horizonte, Minas Gerais State, or in case of Intertek to São Paulo, São Paulo State.

Largo then receives the sample back from the lab for storage at the Project site. They are stored and available for viewing inside the core storage facility.

Coffey Mining considers the core sampling security to be above current industry best practice.

Coffey Mining considers the sampling preparation, analysis and security to be in line with current industry best practice and adequate for the purpose of mineral resource estimation. The QA/QC procedure of insertion of standard, blank and duplicate samples is discussed in detail in Section 12 as Coffey Mining's data verification program.

11.2.4 Density Determination

The mass density or density of a material is defined as its mass per unit volume. Mathematically, density (ρ) is defined as mass (m) divided by volume (V). From this equation, mass density must have units of a unit of mass per unit of volume (e.g. g/cm^3, kg/m^3, etc.).

The methodology used to determine the density was Archimedes principle, further reasoned that if the liquid in this volume were removed and replaced by an object of exactly the same size and shape as this liquid portion, none of the liquid pressure forces acting on its surface would change. Because the object is exactly the same shape and volume as the fluid removed, it would fit exactly into the previous volume without compressing the surrounding fluid. Therefore, Archimedes (287 - 212 B.C) had concluded that the net buoyant for B upward on any object immersed in a fluid is equal to the weight of the fluid displaced.

Up until 2015, all of Largo´s Density samples were analyzed in Federal University of Bahia State, using Archimedes principle. Some of this procedure is illustrated in Figure 11.2.4_1. The results are shown in Table 11.2.4_1.

Figure 11.2.4_1

Density Determination by Archimedes Principle

Table 11.2.4_1

Density Summary

Target	Lithology	Number of Samples	Density (g/cm3)
NOVO AMPARO	MAGNETITITO	26	4.36
	MAGNETITA GABRO	11	3.38
	GABRO	11	3.00
	ANORTOSITO	3	2.88
	PEGMATITO	2	2.61
NOVO AMPARO NORTH	MAGNETITITO	30	4.26
	MAGNETITA GABRO	11	3.33
	GABRO	11	3.06
	ANORTOSITO	5	2.86
	PEGMATITO	3	2.6
SÃO JOSE	MAGNETITITO	19	4.3
	MAGNETITA GABRO	13	3.33
	GABRO	9	3.05
	ANORTOSITO	3	2.84
	PEGMATITO	3	2.58
GULÇARI A NORTH	MAGNETITITO	14	4.28
	MAGNETITA GABRO	12	3.32
	GABRO	8	3.03
	ANORTOSITO	5	2.84
	PEGMATITO	2	2.62
GULÇARI B	MAGNETITITO	15	4.42
	MAGNETITA GABRO	14	3.35
	GABRO	3	2.90
	ANORTOSITO	1	2.83
	PEGMATITO	2	2.63

In 2015 Largo acquired their own density determination equipment and started making measurements with in-house staff. They used the water immersion method on diamond core sections with a digital density scale (Gehaka DSL 910). Best care and attention were taken by staff as of June 1, 2015.

A total of 297 core samples were measured to determine the specific gravity of the various ore and waste rock domains and these were added to the density database of the Campbell. A summary of the Specific Gravity (SG) according to this new series of measurements and the new domain classification is presented in Table 11.2.4_2.

Table 11.2.4_2

Average Specific Gravity for the Campbell deposit, Largo Data 2016

Rock Type	Rock Code	Number of Samples	Average SG
Massive and banded magnetite 1	10	97	4.38
Massive and banded magnetite 2	11	39	4.24
Massive and banded magnetite 3	12	4	4.14
Massive and banded magnetite 4	13	5	4.17
Magnetite-pyroxenite 1	20	116	3.52
Magnetite-pyroxenite 2	21	21	3.60
Magnetite-pyroxenite 3	22	3	3.58
Magnetite-pyroxenite 4	23	3	3.46
Pyroxenite	25	98	3.23
Magnetite Gabbro	40	13	3.37
Gabbro	45	130	3.01
Anorthosite	50	16	2.78
Pegmatite	80	64	2.58
Overburden	90	0*	1.80*

*according to operating experience during Campbell operation and as in Coffey (2012) for the Satellite.

11.2.5 Sample Preparation and Analysis

Sample preparation and analysis of core samples taken by Largo was performed by SGS Lakefield-Geosol Ltda. ("Geosol"), an ISO 9000-2001 certified laboratory. Sample preparation procedures completed by the Geosol preparation laboratories based in Belo Horizonte, Minas Gerais State were:

- Titration with Dichromate of Potash;
- Fire Assay - ICP;
- LOI: Loss on ignition - Sample Calcination between 405ºC / 1000ºC;
- Melting with tetraborate of lithium - X-Ray fluorescence;

Sample pulps were analyzed for V2O5 using a fire assay technique with an atomic absorption finish. Selected samples were subsequently sent for multi-element analysis by ICP spectrometry as described earlier.

11.2.6 Adequacy of Procedures

Quality control data from other exploration companies prior to Largo's involvement has not been checked. In addition, no meaningful legacy analysis data has been considered in this document.

The current analytical method is appropriate. Sufficient quality control data exists to allow thorough review of the analytical performance of samples taken by Largo.

The sampling methods, chain of custody procedures, and analytical techniques are all considered appropriate and are compatible with accepted industry standards although the sample preparation of vanadium should be reviewed in light of the QA/QC analysis in the following section.

11.3 2015 Davis tube work

In June 2015 Largo staff, seeking to improve their understanding of vanadium in the ore at the Campbell, started a program of Davis Tube test work to determine the magnetic percentage and the V_2O_5 grade and SiO_2 grade in the magnetic concentrate.

Davis tube testing is considered by metallurgists to be a simulation of industrial wet magnetic separation. The test is a two-stage process, a pulverizing step and the Davis Tube wash. Davis Tube tests utilize an electromagnet to separate material into magnetic and non-magnetic/para-magnetic fraction. The DTR test generates the weight recovery/magnetic iron content, or proportion of the deposit which is magnetite and the "probable" grade of concentrate at a given grind size. The quality of a vanadium-bearing titanomagnetite Davis tube concentrate is process sensitive depending on the feed size and as well on other parameters like magnetic field strength, current intensity, tube oscillation, tube inclination and wash water rate during the test work.

The program was completed by September 2015 using the facilities of SGS Geosol and an instrument purchased by Largo (see Figure 11.3_1, Figure 11.3_2 and Figure 11.3_3). A total of 7,567 pulp-samples were collected from the previous drill programs. These samples were stored in a secure lock storage area at Largo's exploration camp near the mine site. The samples were collected and packaged into large plastic crates label and strapped down securely for shipping. A local shipping company picked up the crates and transported them to SGS's facility at Vespasiano, a suburb of Belo Horizonte. For pulp and coarse reject samples the amount sent was approximately 100 g. The grind size of the stored pulps was, according to historical information, always 95% passing 106 microns. In case any of the pulp samples were not available (lost), coarse reject fractions were chosen. In the event of both missing pulp and reject samples a quarter of the core was sampled at the core facility. This happened exclusively on historical CBPM holes, where most of the pulps and coarse reject fractions are systematically missing.

Figure 11.3_1

Largo's First Davis Tube Device During Implementation on Site.

Figure 11.3_2

Two Davis Tube devices at SGS Geosol in Belo Horizonte

Figure 11.3_3

Largo Staff During Site Visit at SGS

(24th August 2015).

The sample preparation process was as follows:

- sample log-in for all pulps (p) + rejects (r) + core (c)
- received sample weighing (p + r + c)
- drying at 105°C (p + r + c)
- crush to 90% passing 3 mm (c)
- split sample with riffle splitter (c)
- pulverize 250-300g to 95% passing 106 microns (c)
- pulverizing - quality control test (p + r + c)

The following are the specifications and settings used for the Davis tube equipment:

- Feed sample mass: 30 g
- Tube inclination: 45°
- Initial tube oscillation: 30 rpm
- Final tube oscillation: 60 rpm
- Wash water rate: 540 l/min
- Magnetic field strength: At the beginning during the feeding procedure of the sample in the glass tube 3,700 Gauss (1.6A) is applied to avoid premature loss

of the sample mass, after adding the entire sample the test began applying 1,480 Gauss (0.5A).

- Davis tube washing period: 20 to 30 minutes (dependent on the degree of difficulty for washing the sample).

A QA/QC sampling protocol was implemented whereby a pulp duplicate and one certified standard were inserted into every 40-sample batch.

12 DATA VERIFICATION

In Section 12, Data Verification, both Micon (Campbell) and Coffey Mining (the Satellite Deposits) have provided individual sections for the 2013 RPM report. These sections reproduced here as described in 2013 because no new drilling has been completed since this was written. There may be some duplication of information, however, it was felt by GE21 that the commentary and emphasis was sufficiently different to justify presenting both Micon and Coffey Mining data.

The Micon Sections and the Coffey Mining Sections have been presented in different subsections

12.1 Micon Text from Previous Reports

12.1.1 Pre-2006

It is reported that CBPM and Odebrecht made use of replicate and blank samples along with reference standard materials during their sampling and assaying programs. No detailed results are available for the results of these programs. Therefore, before using the data in a resource estimate, Largo decided to conduct a check sampling program on approximately 8% of the mineralized core. That program is described in Section 12.1.2.1 below.

12.1.2 Largo

12.1.2.1 2006

Largo's first drill core resampling program was conducted during May, 2006, in order to verify the precision and accuracy of the V_2O_5 grades reported during the 1981 through 1987 drill campaigns. It was also used to provide additional data on the PGM content of the mineralization. A total of 123 quarter-core samples from eight drill holes (7.3% of samples) were analyzed. Check analyses were systematically completed at a second laboratory during the resampling program.

The original analyses were done at GEOSOL and Paulo Abib Engenharia S.A. laboratories in Belo Horizonte, Brazil between 1981 and 1987. The 2006 duplicate sample analyses were conducted at SGS, both in Belo Horizonte, Brazil and Lakefield, Ontario. Every effort was made to use similar techniques and sample sizes, in order to compare results. Check analyses on the 2006 duplicate samples were analyzed by Ultra Trace Analytical Laboratories in Perth, Australia (Ultra Trace). A total of 25 pulp samples (20%) from the resampling program were sent to Ultra Trace for analysis to compare against the duplicate results. Again, every effort was made to use similar techniques.

The duplicate samples sent to SGS were analyzed for the major oxides (FeO, Fe_2O_3, SiO_2, TiO_2 and V_2O_5) using borate fusion XRF. The lower detection limit for V_2O_5, for this method, was 0.01%, while the upper limit was 5%. Elements were reported as oxides. The samples were also analyzed by SGS for platinum and palladium by fire assay with an AA finish on a 50-g sample. Internal quality control procedures included duplicate and blank sample and certified reference material analysis. These data were used to check the analytical reproducibility and precision of the assays.

Ultra Trace's XRF method used a fusion technique, with a high-energy X-ray instrument. The resulting detection limits are reported to often be better than those obtained by pressed powder methods on older instruments. The lower detection limit for V_2O_5 was 0.01%, while the upper limit was 5%. A sample weight of 0.66 g was fused with 7.2 g of flux to prepare each bead. However, there are variations to this ratio for some matrices. Samples were fused into a glass disc using a lithium borate flux much as described for normal fused glass beads. For ore grade materials, flux composition and sample/flux ratios are varied to ensure the entire sample dissolves and that recrystallization does not occur as the melt is cooled.

Two comparisons of the results were carried out:

- Original sample results versus SGS duplicate sample (quartered core) results
- SGS duplicate sample (quartered core) results versus Ultra Trace check pulp sample results.

In both cases, the agreement is generally good. Overall, there is little evidence of any systematic or conditional bias. The correlation coefficient between the original samples and the duplicate samples is 0.84, a number considered reasonably good for quarter-core field duplicate samples. Any variability in the sample results can be attributed to a number of conditions including differences in sample mass or half-core versus quartered core. This is partly confirmed by the comparison of the SGS duplicate samples and the check sample results of the pulps from Ultra Trace where the correlation coefficient is 0.89.

It is concluded, therefore, that the analytical reproducibility is satisfactory, and that the analytical accuracy is equally acceptable. Consequently, Largo chose to use the original assay data for the geostatistical analysis.

Micon concurred with Largo's decision and concludes that the data are suitable for use in the resource estimate presented herein.

12.1.2.2 Early 2007

In accordance with the recommendations made in Micon's December, 2006 Technical Report (Hennessey, 2006), Largo has continued with a program of resampling of old drill core from the Campbell deposit.

The results, which are graphed on Figure 12.1.2.2_1, generally show good agreement clustered about the 45° black reference line, with the exception of a clustered group of data (see red ellipse) appearing to fall on a flatter line of about 30° dip. Further investigation revealed that all of these data points were from Drill hole FGA-41.

Figure 12.1.2.2_1

Campbell Core Duplicate Sampling

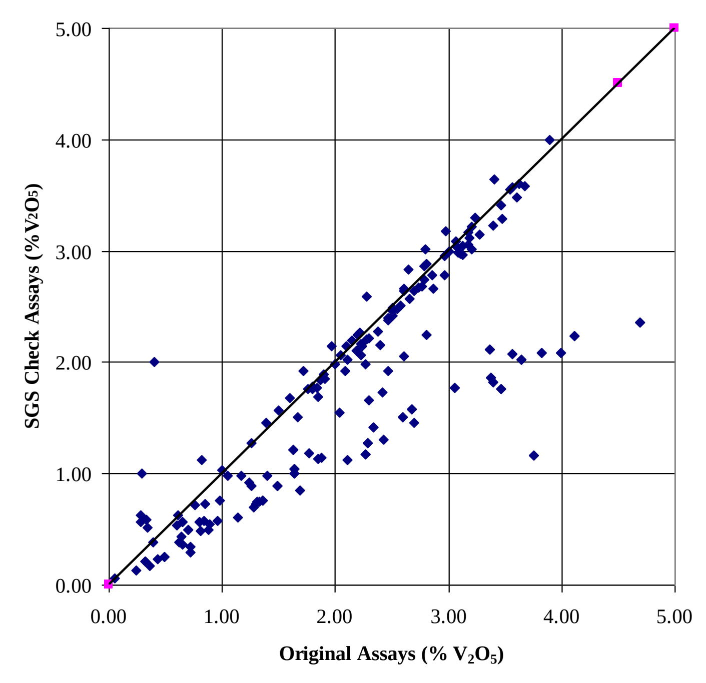
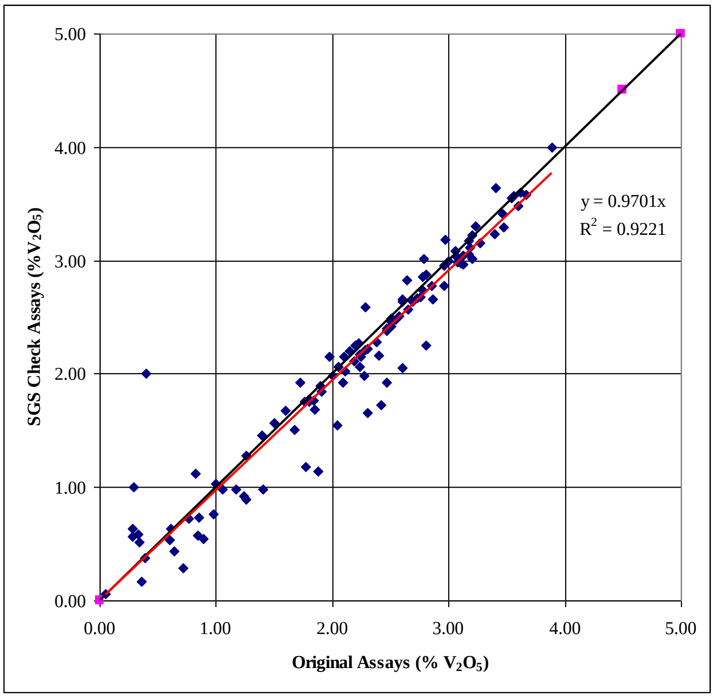


Figure 12.1.2.2_2 shows a similar graph with the results of Hole FGA-41 removed from the analysis. The red fitted trend line shows agreement is extremely close with y = 0.97x and a correlation coefficient of 0.92. The data are generally clustered about the black 45° reference line. Micon concludes that something went awry in the analysis of this hole, possibly a calibration or dilution issue with the readings taken in the laboratory.

As a result of this analysis, it was decided that Drill hole FGA-41 should be removed from the database and the block model re-interpolated before completion of the 2007 preliminary assessment (Jacobs et al., 2007). The resulting mineral resource estimate was essentially identical in tonnage to that published in Hennessey (2006), and the V_2O_5 grade dropped marginally from 1.37% to 1.35%, a difference of only 1.5%.

Figure 12.1.2.2_2

Campbell Core Duplicate Sampling with Hole FGA-41 Removed



12.1.2.3 2007 Exploration Drilling Program

Largo’s drill-core sampling program was conducted from April 3 to October 30, 2007. A quality assurance/quality control (QA/QC) program was conducted, in order to verify the precision of the V_2O_5, platinum and palladium grades reported during the drill campaign. It was also used to provide additional data on the PGM content of the mineralization.

The QA/QC procedures consisted of the insertion of one of two certified reference standards, two field duplicate samples, and one field blank sample with each batch of samples sent to the laboratory. The laboratory batch size is 40 samples, of which 5 were Largo QA/QC samples. There were also laboratory-inserted blanks and duplicates used by SGS in accordance with its own QA/QC policy.

Certified Reference Standards

Largo had two certified reference standards made using pulps from an earlier drill program that sampled material from the Campbell deposit. The standards consisted of both a high-grade (magnetitite) and lower-grade (magnetite-pyroxenite) material. The high and low standards were inserted at a rate of approximately one each per batch (40 samples).

These certified reference standards were prepared and packaged by CDN Resource Laboratories of Delta, B.C. Each sample was pulverized in a large rod mill, screened through a 200-mesh screen using an electric sieve and homogenized in a large rotating mixer. Each standard was sealed in plastic to prevent gravity separation and oxidation.

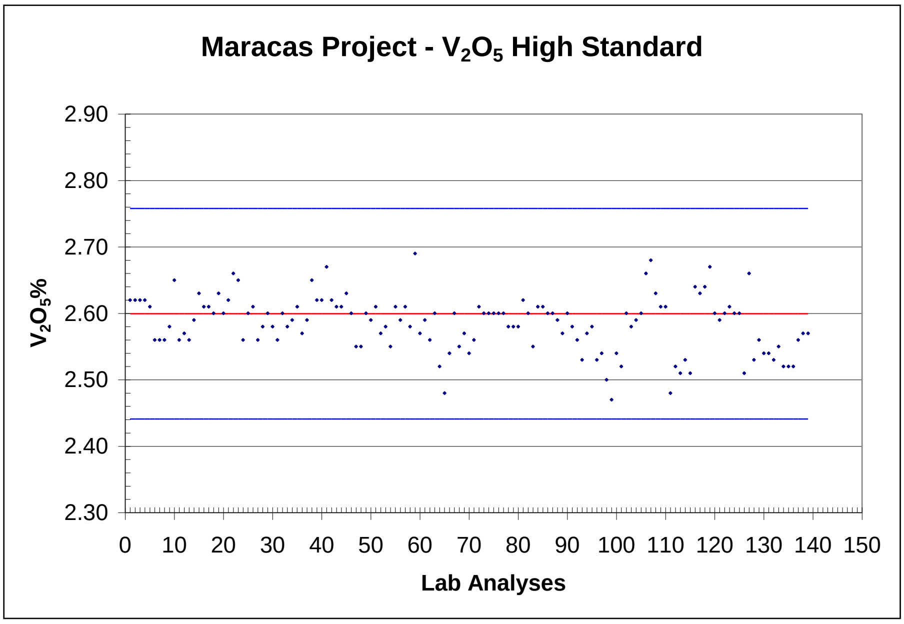
Each of the standards underwent blind round robin assaying for V2O5 by five laboratories and the data were reviewed and certified by Barry W. Smee, Ph.D., P.Geo. (Smee & Associates Consulting Ltd., see Appendix 2 of Hennessey, 2007). Both standards were also analyzed for PGM and the high-grade magnetitite was found to have high enough values to potentially be useful as a precious metals standard. Experience with it has found that while it repeated well as a platinum standard, it did not perform well as a palladium standard.

All of the analytical results for the high and low standards were tracked on control charts on a continuous basis from April 3 to October 30, 2007. Each of these charts tracks the results of assaying of a single standard over time and plots it against the accepted value (the mean from the round robin assay program) and ±2 standard deviations (SD) from the mean. Staying within the ±2 SD lines is acceptable performance for precision and accuracy at a laboratory.

The performance of the in-house V2O5 standards used by Largo is judged to be acceptable. Figure 12.1.2.3_1 to Figure 12.1.2.3_4 show the V2O5 analytical results for the high and low standard, as well as the platinum and palladium results for the high standard.

Figure 12.1.2.3_1

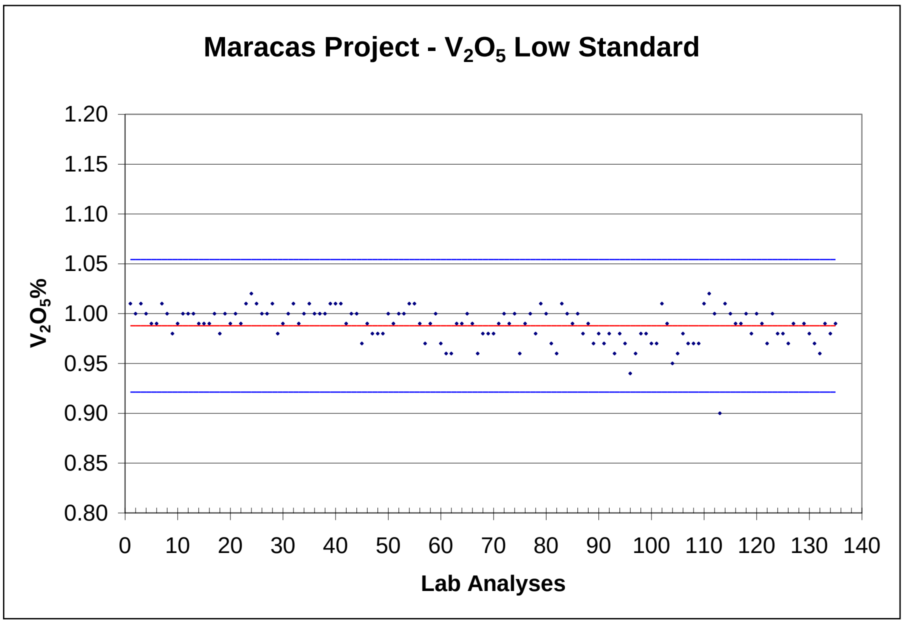
High Standard V2O5 Assay Results



Red line = the accepted value, blue lines = ± 2 SD

Figure 12.1.2.3_2

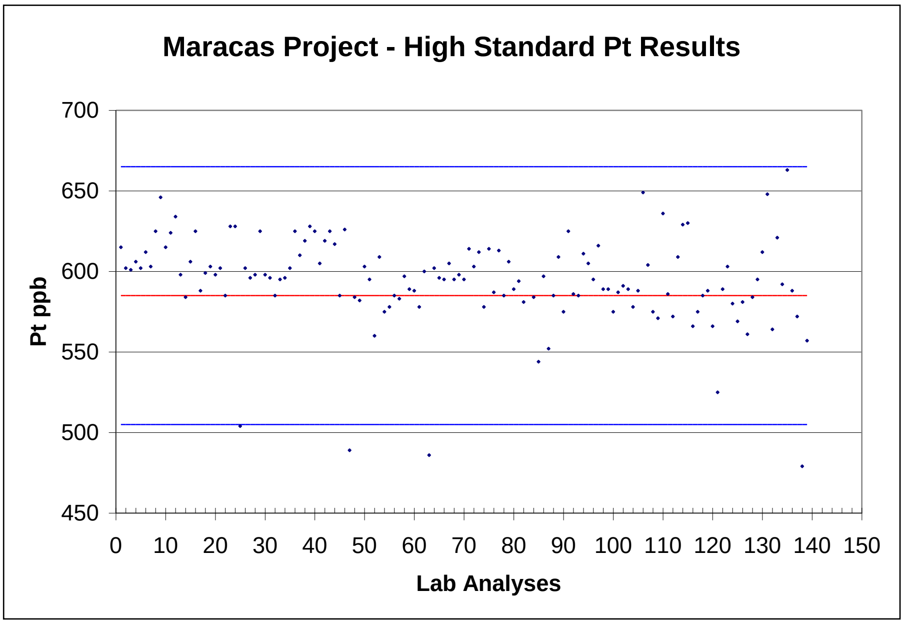
Low Standard V2O5 Assay Results



Red line = the accepted value, blue lines = ± 2 SD

Figure 12.1.2.3_3

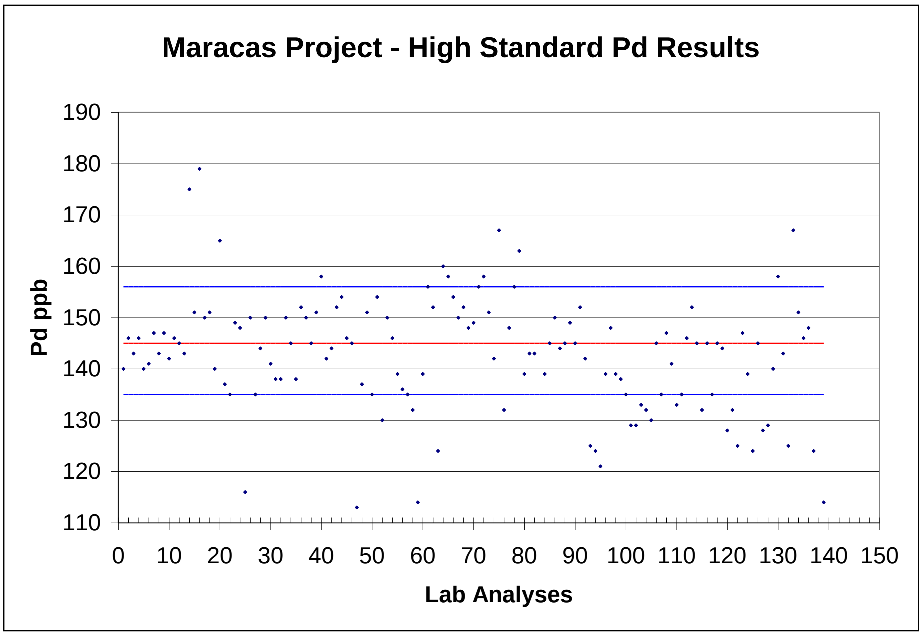
High Standard Platinum Assay Results



Red line = the accepted value, blue lines = ± 2 SD

Figure 12.1.2.3_4

High Standard Palladium Assay Results



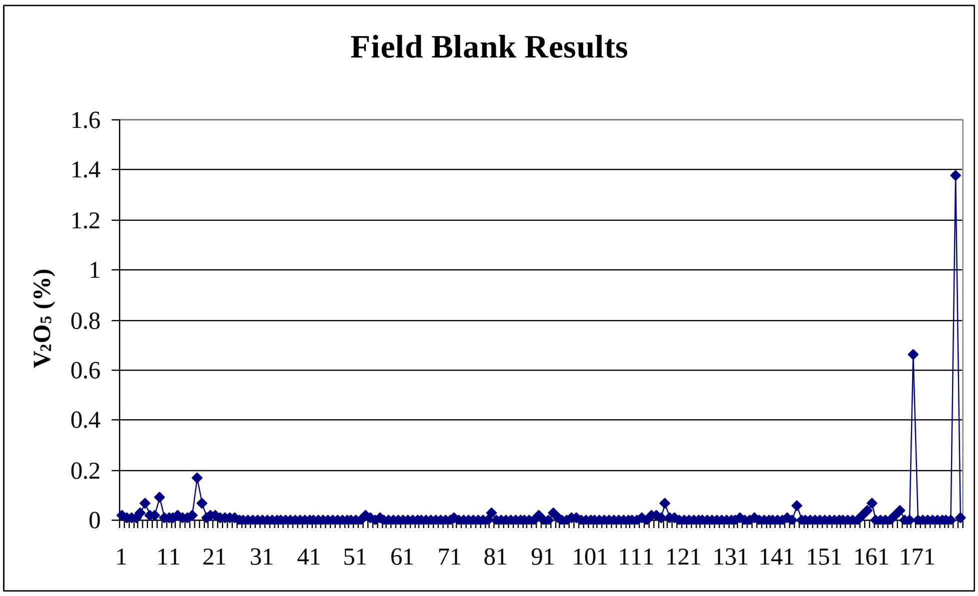
Red line = the accepted value, blue lines = ± 2 SD

Field Blanks

Field blanks of a known barren rock were randomly inserted at least once in every 40 samples, usually resulting in one sample per batch. This was done to check for cross contamination at any point in the sample preparation or assaying. Micon reviewed the analytical results for the field blanks (seeFigure 12.1.2.3_5) and found them to be acceptable.

Figure 12.1.2.3_5

Field Blank Assay Results



Duplicate Samples

Two field duplicate samples were randomly inserted in each batch. These samples are used to determine the precision of the assay laboratory and the degree of nugget effect introduced in sampling. Detailed records were kept at the core shed for all field duplicate sample locations.

SGS also introduced sample duplicates prepared at the laboratory into the stream. These samples are useful in determining the analytical precision of the laboratory.

The results of the field duplicate sampling are presented in Figure 12.1.2.3_6 and the results of the sample duplicate assaying are presented inFigure 12.1.2.3_7. Micon reviewed these results and found them to be acceptable and better behaved than most.

Figure 12.1.2.3_6

Field Duplicate Assay Results

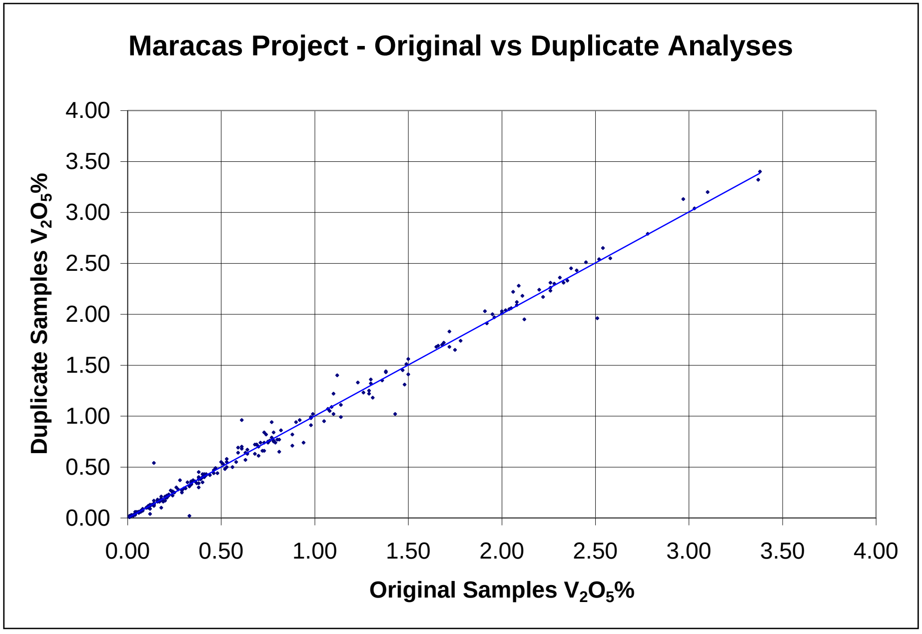
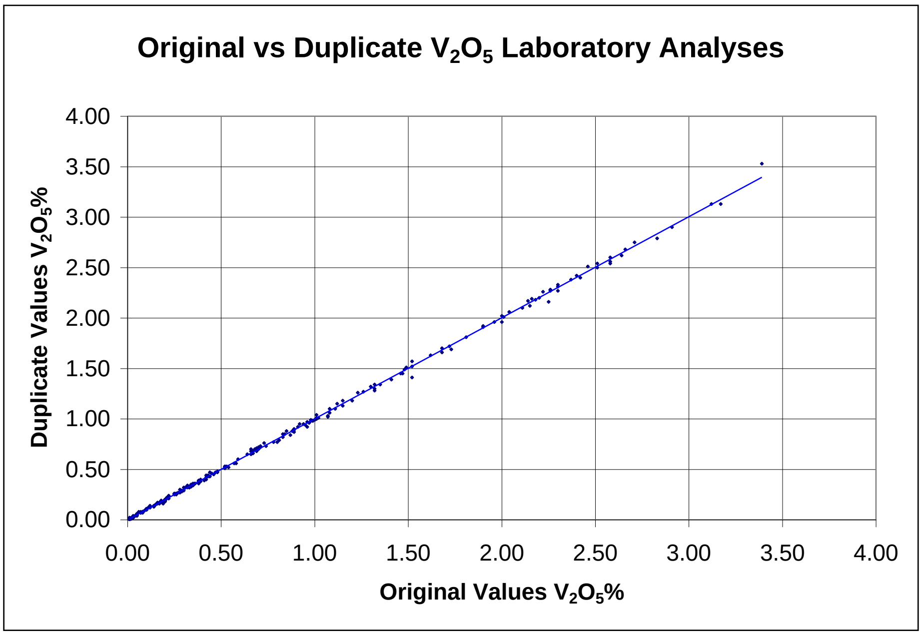


Figure 12.1.2.3_7

Sample Duplicate Assay Results



Secondary Laboratory Checks

Check analyses were systematically completed at a second laboratory during the drill program, in order to test the precision and relative bias of the primary laboratory. A total of 500 pulp samples from 40 drill holes (9.1% of samples) were analyzed.

The original analyses were done at the SGS laboratory in Belo Horizonte, Brazil. The 2007 duplicate sample analyses were conducted at ALS Chemex laboratory in Vancouver, B.C. Every effort was made to use similar techniques and sample sizes, in order to compare results. The longest lapse of time between the original assays at SGS and the secondary checks at ALS Chemex was 4 months, and the shortest period of time was 2 months.

The samples sent to SGS were analyzed for the major oxides (FeO, Fe_2O_3, SiO_2, TiO_2 and V_2O_5) using borate fusion XRF. The lower detection limit for V_2O_5, for this method, was 0.01%, while the upper limit was 5%. Elements were reported as oxides. The samples were also analyzed by SGS for platinum and palladium by fire assay with an AA finish on a 20-g sample. Internal quality control procedures included duplicate and blank sample and certified reference material analysis. These data were used to check the analytical reproducibility and precision of the assays.

ALS Chemex's XRF method used a fusion technique, with a high-energy X-ray instrument. The lower detection limit for V_2O_5 was 0.01%, while the upper limit was 5%. A sample weight of 0.66 g was fused with 7.2 g of flux to prepare each bead. Samples were fused into a glass disc using a lithium borate flux much as described for normal fused glass beads. The samples were also analyzed for platinum and palladium by fire assay with an AA finish on a 20-g sample.

Comparisons of the results for V_2O_5, platinum and palladium were carried out (seeFigure 12.1.2.3_8, Figure 12.1.2.3_9 andFigure 12.1.2.3_10) in an analysis of original sample results versus ALS Chemex duplicate sample (pulps) results. In all cases, the agreement is generally good. Overall, there is a little evidence for a slight systematic high bias for the ALS Chemex V_2O_5 results. The correlation coefficient between the original samples and the duplicate samples for V_2O_5, platinum and palladium were all 1.02.

Largo, therefore, concluded that the analytical reproducibility was satisfactory, and that the analytical accuracy is equally acceptable. Consequently, Largo chose to use the original 2007 assay data for the geostatistical analysis. Micon supported the decision.

Figure 12.1.2.3_8

Secondary Laboratory Check Assays - V2O5

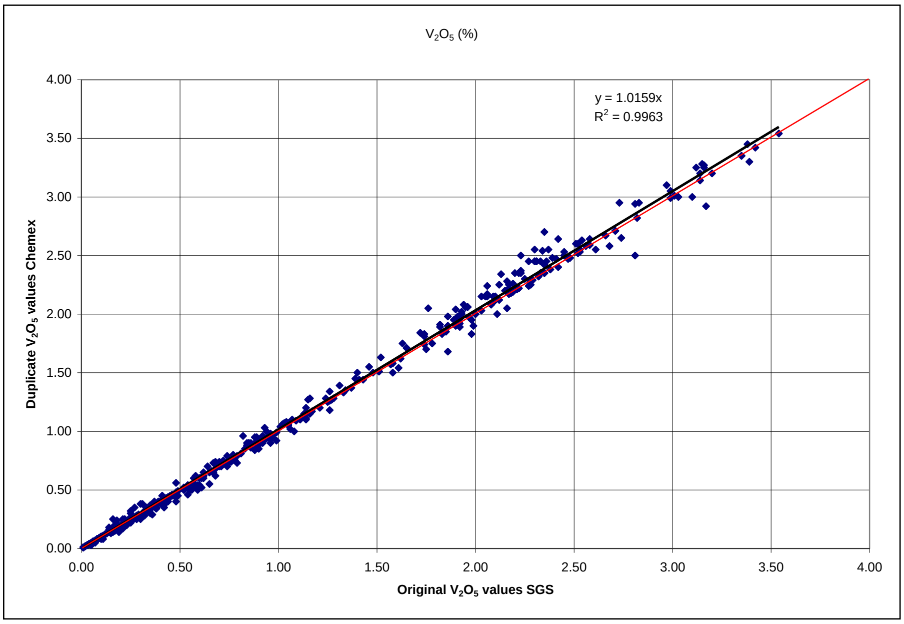


Figure 12.1.2.3_9

Secondary Laboratory Check Assays - Pt

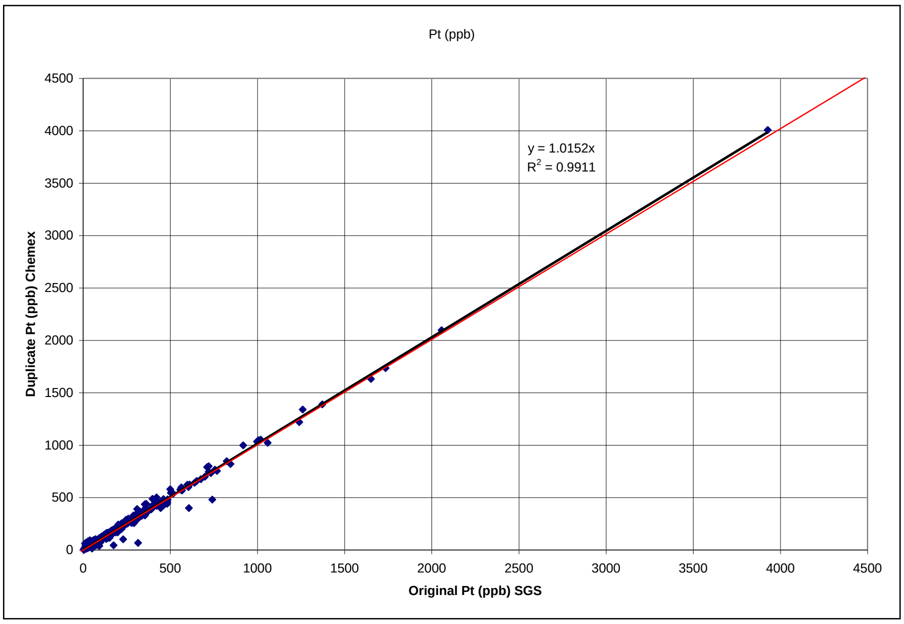
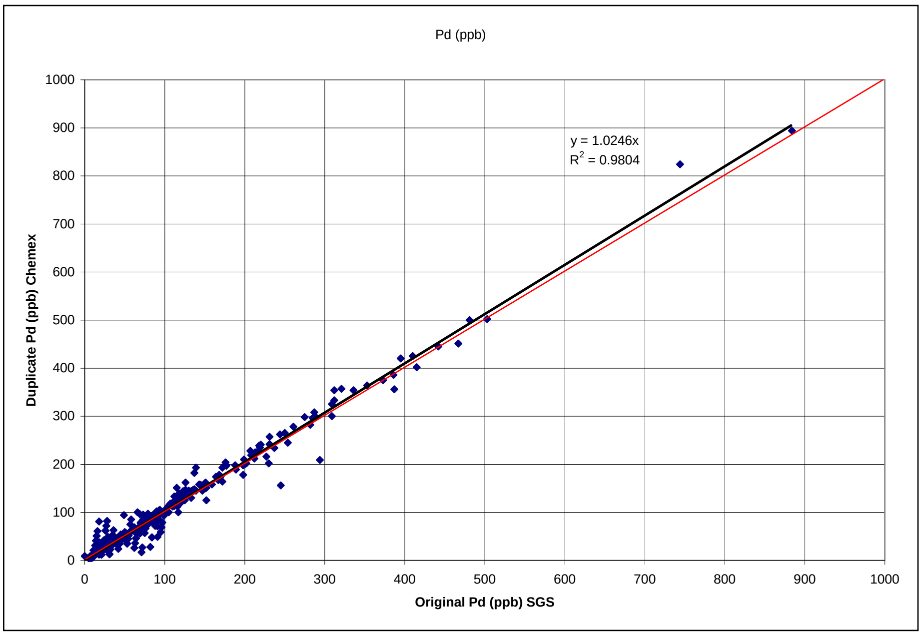


Figure 12.1.2.3_10

Secondary Laboratory Check Assays - Pd



12.1.3 Summary

The purpose of adding a QC program to any drill program is to verify the accuracy and precision of the laboratory's results and to react immediately to any deviation at the laboratory demonstrated by the standards. Use of the certified reference materials in this case has meant that the laboratory results for the metals can be said to be reasonably accurate and precise.

The SGS pulp duplicates from the 2007 drilling generally show close agreement and little bias between first and second assay. The correlation coefficients confirm the close agreements between the original and the laboratory duplicates. Largo's field duplicates also showed good reproducibility.

Largo's 180 field blanks routinely returned very low values for all elements with three exceptions. Two samples, LML6272 and VML1682, assayed above background precious metal levels and V_2O_5 and one sample, LML6056, showed elevated V_2O_5 levels.

The performance of the certified reference standards were generally good for the high V_2O_5, low V_2O_5 and platinum determinations with over and under limit palladium assays returned. The high V_2O_5 results were stable and consistent and all clustered between the ±2 SD control limits. The results for low V_2O_5 standard were good with only one sample that fell outside the ± 2SD control limits. The high V_2O_5 standard is not really a precious metal standard. However, the values for platinum were very consistent, except for one sample and within acceptable ±2 SD limits. The palladium results on the other hand were variable showing no consistent drift.

12.1.4 Micon Checks

During the first site visit in June 2006, Micon visited the Maracás Project site and the surface exposure of the Campbell deposit. Magnetite and magnetite-pyroxenite mineralization exposed on surface in outcrop and trenches on Campbell hill were seen. Significant amounts of magnetite mineralization, consistent with the claimed widths and grades were seen. Micon also visited the office/warehouse facility in Maracás to look at old core stored there.

During the visit, Micon collected two samples of mineralization from exposures at the Project site and four more samples of quarter-sawn core from the core warehouse. The samples were collected and assayed to confirm the presence of vanadium, titanium and PGMs. The results of the sample program are set out in Table 12.1.4_1.

Table 12.1.4_1

Micon Check Samples

Sample	Sample Location	Micon Results							Original Results			
		From (m)	To (m)	V2O5 (%)	TiO2 (%)	Au (g/t)	Pt (g/t)	Pd (g/t)	From (m)	To (m)	V2O5 (%)	TiO2 (%)
Maracás 1	Outcrop magnetitite			2.67	17.03	0.007	0.490	0.155			N/A	N/A
Maracás 2	Surface trench mag-pyroxenite			2.00	12.52	0.011	0.713	0.265			N/A	N/A
Maracás 3	FGA-40	112	113	3.11	18.81	0.005	0.653	0.031	112	113	6.3	17.4
Maracás 4	FGA-41	63	64	0.70	5.04	0.041	0.063	0.060	63	64	1.3	5.3
Maracás 5	FGA-38	92	93	2.04	15.86	0.007	0.224	0.171	92	94	2.2	16.1
Maracás 5	FGA-54	74	75	2.40	19.20	0.003	0.360	0.040	73	75	2.8	18.1

The results obtained by Micon have confirmed the presence of vanadium, titanium and PGM mineralization at Maracás at grades which were expected and which broadly agree with the historical results.

12.1.5 Conclusions

The data verification work completed by Largo and Micon has led to confidence in the database compiled by the original operators of the property. Largo's ongoing QA/QC program has also led to confidence in the newly-generated data.

Micon concluded that the Maracás database is suitable for use in the mineral resource estimate reported herein. In Hennessey (2006), Micon recommended that Largo proceed with planned check drilling and to continue re-assaying of historical drill core for PGMs. Micon also recommended that Hole FGA-41 be re-drilled. This work has now been completed and its results included in the updated mineral resource estimate (Hennessey, 2007) that has been utilized for the present report.

Only the data verification results for the drill holes employed in the Campbell have been presented in this subsection.

12.2 Coffey Mining Text from Previous Reports

12.2.1 Geological Database

Coffey Mining has validated the Largo database for the Satellite Deposits using the Gemcom Surpac Software System Database Audit tool with no inconsistencies noted.

A comparison of hardcopy assay and geological logging versus the digital database was performed on a total of 10% of the Largo - Satellite Deposits drill holes. No errors were identified with the original log and the digital database.

12.2.2 Quality Control

Coffey Mining has not been able to verify the oldest drill sample QA/QC data before 2006, in spite of it had being observed in the geological database.

A quality control and quality assurance (QA/QC) program was implemented by Largo on the complete drill program samples analyzed at Intertek laboratory and SGS laboratory (Table 12.2.2_1), including:

Table 12.2.2_1

Standards and Blanks QAQC Summary Results

Sample Type	Objective	Procedure
Blank	Verification if there is contamination in the samples during the physical preparation process and chemical analysis.	Always respecting an interval of 32 samples.
Standard	Verification of the Laboratory analysis precision	Inserted after each 16 samples.
Duplicates	Verification of the Laboratory analysis accuracy.	Always respecting an interval of 32 samples.

In the total number of blanks, standards and duplicates for quality control Largo had respected the rules as indicated, 2 standards (Low Grade and High Grade), 1 duplicate + 1 blank for a batch of 32 samples, totaling 36 per batch.

The quality control data has been assessed statistically by Coffey Mining using a number of comparative analyses for available datasets. The objectives of these analyses were to determine relative precision and accuracy levels between various sets of assay pairs and the quantum of relative error. This assessment is the basis of the data verification program undertaken by Coffey Mining. No duplicate samples have been collected or analyzed by Coffey Mining.

12.2.3 Standard and Blank Samples

Coffey Mining performed an analysis on blank sample data provided by Largo. The blank material was sourced by Largo from unmineralized building material acquired at one specific supplier in Maracás city, close to the Project site and submitted at a frequency of about five percent.

Overall the blank and standard data are within acceptable limits, and these results are presented in Table 12.2.3_1, Table 12.2.3_2 and Table 12.2.3_3 below.

Table 12.2.3_1

Quality Control Sample Summary

Chemical Element	Sample Type	Number of Samples Analyzed
V2O5	Standard	380
	Blanks	372

Largo had produced two types of standards for introduction in its process of sample preparation and analysis. Each standard was analyzed in six different Labs. These Labs were certified in the best practices of market analysis

Table 12.2.3_2

Internal Standard Detection Limits

Standard	Mean	Mean + 2SD	Mean - 2SD	Mean + 3SD	Mean - 3SD
V2O5 High grade	2.60	2.76	2.54	2.84	2.46
V2O5 Low grade	0.988	1.054	0.922	1.087	0.889

Table 12.2.3_3

Standards and Blank QA/QC Summary Results

Reference values				Analyzed Results				Results	
Standard/ Variable	Origin (%)	Min (%)	Max (%)	Sample N°	Min (%)	Max (%)	Mean (%)	% Inside precision limits	% Outside precision limits
Site Project									
Blank/V2O5	0.01	0.005	0.015	199	0.001	0.18	0.008	84.422	15.578
High Grade/V2O5	2.60	2.52	2.68	187	2.38	2.53	2.45	3.21	96.79
Low grade/V2O5	0.988	0.955	1.021	193	0.95	1.06	1.015	63.212	36.788
XRF_SGS									
Blank/V2O5	0.01	0.01	0.01	173	0.005	0.05	0.007	95.954	4.046

Figure 12.1.2.3_1 shows how the standards are stored and are packaged to be used in routine sample analysis

Figure 12.2.3_1

Certified V2O5 Standard Produced by Largo

12.2.4 Comparative Data Analysis

The comparative data was statistically analyzed using the Coffey Mining QC Assure software. The objective of this was to determine the relative precision among some pairs of results and to quantify the relative error.

The duplicate samples are sorted from a half drill core sample. The analyzed duplicates and replicates are summarized in Table 12.2.4_1.

Largo maintained the routine to use duplicate and replicate samples in order to improve the confidence in the lab results.

Table 12.2.4_3

QAQC Program Summary

Chemical Element	Sample Type	Number of Samples Analyzed
V2O5	Field Duplicate	196
	Duplicate (Lab SGS)	275
	Replicate (Lab SGS)	296
	Check Lab SGS vs Intertek	359
	Check Lab SGS vs ALS	305

From 196 existing field duplicate sample pairs in the database for the % V_2O_5 variable more than 88.78% of the data pairs are within the acceptable 10% precision limits for this type of duplicate. Another approach can be observed from 275 existing lab duplicate sample pairs in the database for the % V_2O_5 variable with more than 93.82% of the data pairs within the 10% precision limits for this type of duplicate. Commonly, this result is over the acceptable lower limit of 90%. Also in sequence it is possible to present Replicate Lab (SGS) with 93.6%, Check Lab SGS vs Intertek at 96.94% and Check Lab SGS vs ALS at 94.43%. The field duplicate results are presented in Figure 12.2.5_1, more graphs are presented in Appendix B to Arsenault (2013), QA/QC Analysis

Coffey Mining concludes that the results of the sample duplicates from Largo are normal for the style of mineralization and acceptable for mineral resource estimation purposes.

12.2.5 Data Quality Summary

The standards data have shown a moderate to high accuracy as returned by the SGS Geosol laboratory and Intertek.

Coffey Mining, after analyzing all procedures and results gathered from the QA/QC program undertaken by Largo, concludes that the data is of sufficient quality to support a resource estimate.

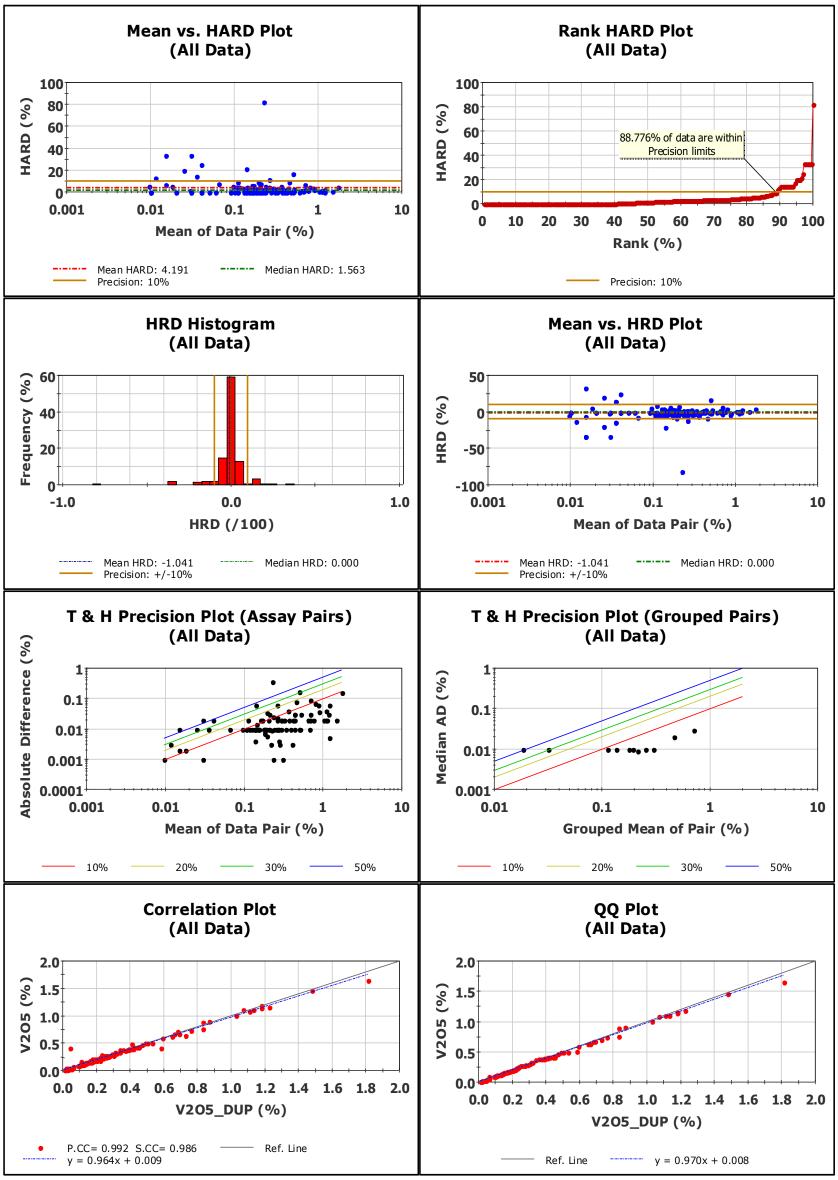
At time of the Coffey QAQC data analysis , Mr Rodriguez, acted as report supervisor, and supervised all activites herein discussed.

Figure 12.2.5_1

Summarized Quality Control Results, Duplicates

Duplicate - Largo Resources - V2O5
(All Data)

	V2O5_DUP	V2O5	Units			Result
No. Pairs:	196	196			Pearson CC:	0.992
Minimum:	0.009	0.010	%		Spearman CC:	0.986
Maximum:	1.810	1.650	%		Mean HARD:	4.191
Mean:	0.248	0.248	%		Median HARD:	1.563
Median	0.170	0.170	%			
Std. Deviation:	0.286	0.278	%		Mean HRD:	-1.041
Coefficient of Variation:	1.152	1.117			Median HRD	0.000



Printed: 24-Sep-2012 04:37:13 Data Imported: 24-Sep-2012 04:31:56 Page 1

13 MINERAL PROCESSING AND METALLURGICAL TESTING

13.1 Introduction

The original process design was based primarily on the metallurgical testwork performed by SGS in 2007, a study undertaken by IMS Processing plant in 1990, a feasibility study completed by Lurgi in 1986, a metallurgical study performed by Rautaruukki Oy Research Centre between 1987 and 1989, and the detailed technical study produced by Engenharia e Consultoria Mineral S.A. (ECM) in 1990. A list of metallurgical and process technical and economic references can be found in Section 13.2.

Testwork was undertaken by SGS between April and November 2007 to investigate the recovery of vanadium from Maracás mineralization. This program included mineral processing investigations using magnetic separation to recover vanadium contained in magnetite and hydrometallurgical extraction using roasting, leaching, precipitation and calcining to produce an intermediate vanadium oxide product. Additional SGS testwork was undertaken in 2012 to investigate beneficiation recoveries and concentrate analyses for the additional ore-bodies included in the expanded plan presented in this report.

Pilot scale testing was undertaken by Largo in 2010 to test bulk samples of high grade and low grade ore with respect to recovery and leaching performance.

13.2 Process Technical and Economical References

The following reports were used as a basis for the design and the development of associated plant capital and operating cost estimates.

- Lurgi, "Feasibility Study, Maracás Vanadium Project, prepared for Pedeiras Valeria Ltda., Salvador/Bahia, Brazil", May 1986.
- Rautaruukki Oy Tutkimuskeskus Research Centre, "Laboratory Research of the Suitability of the Otankäki Process for Extracting Vanadium from Maracás Ore", December 1989.
- Engenharia e Consultoria Mineral S.A., "Projeto Vanádio de Maracás Projecto Conceitual e Estimativa de Investimento, Produção: 4,500 t/a de V2O5", September 1990.
- IMS Processing plant, "Vanádio de Maracás Ltda., Vanadium Pentoxide Production Plant", 1990.
- SGS Minerals Services, "The Beneficiation Characteristics of Samples from the Vanádio De Maracás Deposit" November 2007.
- SGS Minerals Services, "Recovery of Vanadium from the Maracás Ore Deposit", April 2008.
- SGS Minerals Services, "The Solid-Liquid Separation of the Maracás Ore Deposit", July 2008.

- Vendors' budgetary quotes
- Largo Resources Ltd. (Les Ford), "Pilot Plant Testing of Maracás Magnetite Ore", Oct 2010.
- Ausenco Minerals and Metals, "Conceptual design of alternatives for non-magnetic tailings deposition", Sep 2010.

13.3 Material Characterization, Mineralogy and Metallurgy

The main basis for the process design was the testwork results by SGS, input from external consultants who have extensive experience on vanadium plant design and operation, as well as Largo's experience. The metallurgical design parameters discussed below are mainly based on the data included in the references list above.

The objective of the SGS testwork conducted on samples of vanadium-magnetite mineralization was to look into the suitability of the magnetic separation, salt roasting and hydrometallurgical process for extracting vanadium from Maracás mineralization. Additionally, SGS investigated the magnetic separation efficiency on lower grade mineralization.

13.3.1 Mineralogy and Chemical Analysis

The Maracás mineralization consists of vanadium-containing titanium magnetite, which is the major oxide phase within the deposit. Magnetite occurs as primary grains that may be partly martitized. There is also fine-grained magnetite as inclusions in the silicate grains. This included magnetite, which contains negligible vanadium, as a secondary alteration formed after uralitization of pyroxene and serpentinization of olivine.

The chemical analyses of the metallurgical composite samples reported by SGS in its November 2007 metallurgical testwork are presented in Table 13.3.1_1. Additional analyses carried out in 2012 are presented in Table 13.3.1_2.

Table 13.3.1_3 presents the mineralogical composition for both massive and oxide ore samples. Magnetite represents about 60.9% of the massive ore and ilmenite represents about 19.9%.

In Figure 13.3.1_1, the mineralogical associations of Ti-magnetite have been illustrated.

In Figure 13.3.1_2, free Ti - magnetite and ilmenite middles shown at -212 microns.

Table 13.3.1_1

SGS Test Sample Analyses 2007

Sample ID	SiO2 %	Al2O3 %	Fe2O3 %	Fe %	MgO %	CaO %	Na2O %	K2O %	TiO2 %	P2O5 %	MnO %	Cr2O3 %	V2O5 %	LOI %	Sum %	Pt g/t	Pd g/t	Sat %
Box 01 FGA81	5.16	3.98	76.5	53.5	1.91	0.42	0.04	0.58	11.60	0.03	0.25	0.04	2.80	-2.57	100.80	0.98	0.09	56.30
Box 02 FGA81	6.79	4.22	73.6	51.5	2.13	0.89	0.19	0.51	12.30	0.01	0.23	0.02	2.51	-2.89	100.50	0.59	0.25	51.80
Box 03 FGA81	29.40	11.40	40.8	28.5	3.09	6.22	3.62	0.50	6.47	0.06	0.21	0.02	1.10	-0.90	100.00	0.23	0.17	18.00
Box 04 FGA81	19.90	4.78	55.2	38.6	4.79	4.35	0.51	0.25	10.70	<0.01	0.27	<0.01	1.53	-1.59	100.80	0.08	0.13	32.80
Box 05 FGA81	10.20	3.32	66.5	46.5	4.07	2.88	0.03	0.08	13.20	<0.01	0.27	0.01	1.97	-2.15	100.40	0.21	0.15	46.30
Box 06 FGA81	13.10	4.72	64.2	44.9	3.71	1.13	0.38	0.60	11.90	0.08	0.26	<0.01	1.89	-1.74	100.30	0.17	0.14	44.60
Box 07 FGA81	10.50	4.95	64.8	45.3	3.69	2.05	0.18	0.59	13.10	0.09	0.25	<0.01	1.96	-1.79	100.40	0.33	0.24	42.10
Box 08 FGA81	3.52	3.13	74.4	52.0	3.00	0.38	0.05	0.02	16.40	<0.01	0.27	<0.01	2.34	-2.31	101.10	0.47	0.31	52.40
Box 09 FGA81	14.10	5.57	60.4	42.2	4.31	3.60	0.35	0.02	11.50	<0.01	0.27	0.02	1.89	-1.79	100.50	0.39	0.20	39.30
Box 10 FGA81	7.47	2.21	69.2	48.4	5.48	0.41	0.07	0.01	14.70	<0.01	0.31	<0.01	2.40	-1.66	100.50	0.34	0.29	46.80
Box 11 FGA81	7.72	2.34	69.3	48.5	5.66	0.60	<0.01	<0.01	14.20	<0.01	0.28	<0.01	2.39	-1.29	101.20	0.35	0.29	47.50
Box 12 FGA81	5.26	2.43	73.5	51.4	4.08	0.24	0.07	0.04	14.70	<0.01	0.29	0.01	2.74	-2.03	101.40	0.76	0.29	50.40
Box 13 FGA81	26.40	1.42	50.0	35.0	13.50	2.32	0.02	0.03	4.92	<0.01	0.46	0.02	1.01	-0.03	100.00	0.34	0.12	24.80
Box 14 FGA81	12.70	2.67	64.1	44.8	6.27	1.67	0.10	0.11	12.00	<0.01	0.32	<0.01	2.33	-1.56	100.80	0.51	0.21	40.30
Box 15 FGA84	3.99	3.13	76.3	53.4	1.44	0.35	<0.01	0.02	13.50	<0.01	0.27	<0.01	2.37	-0.61	100.80	0.42	0.16	29.00
Box 16 FGA84	2.12	3.00	46.4	53.4	1.80	0.03	<0.01	0.02	14.60	<0.01	0.24	<0.01	2.65	-0.18	100.80	0.69	0.32	28.20
Box 17 FGA84	7.12	2.78	71.9	50.3	3.03	0.20	0.06	0.01	11.90	0.01	0.27	<0.01	2.23	1.32	100.80	0.51	0.27	20.00
Box 18 FGA84	4.27	2.98	74.4	52.0	1.97	0.40	<0.01	0.02	15.30	<0.01	0.26	<0.01	2.51	-1.06	101.00	0.76	0.72	40.20
Box 19 FGA84	13.00	3.13	63.1	44.1	3.77	3.15	0.22	0.09	14.10	<0.01	0.30	<0.01	1.72	-2.07	100.50	<0.02	0.02	40.10
Box 20 FGA84	14.10	4.73	61.4	42.9	3.68	3.72	0.20	0.15	12.40	<0.01	0.27	<0.01	1.80	-2.07	100.40	0.13	0.11	39.00
Box 21 FGA84	2.56	2.62	76.4	53.4	2.40	0.30	0.03	<0.01	16.70	<0.01	0.26	<0.01	2.56	-2.54	101.30	0.53	0.32	54.40
Box 22 FGA84	4.65	2.97	73.6	51.5	1.97	0.93	0.10	0.01	14.30	<0.01	0.25	0.02	2.59	-0.52	100.80	0.31	0.13	28.30
Box 23 FGA85	1.73	3.32	75.7	52.9	1.34	0.02	0.05	<0.01	15.30	<0.01	0.23	<0.01	2.89	0.19	100.80	0.52	0.22	17.10
Box 24 FGA85	1.77	3.10	76.3	53.4	1.22	0.01	0.06	0.01	15.30	<0.01	0.24	<0.01	2.94	0.24	101.20	0.52	0.22	14.60
Box 25 FGA85	4.20	2.85	74.9	52.4	1.86	0.09	0.05	0.01	13.60	<0.01	0.28	<0.01	2.71	0.81	101.50	0.76	0.28	16.40
Box 26 FGA85	3.16	2.85	75.2	52.6	1.71	0.05	0.09	<0.01	14.70	<0.01	0.27	<0.01	2.93	-0.24	100.70	0.68	0.13	33.60
Box 27 FGA85	3.54	2.84	73.6	51.5	1.92	0.16	<0.01	0.02	16.00	<0.01	0.27	<0.01	2.77	-0.23	100.90	0.41	0.15	20.10
Box 28 FGA88	2.45	2.82	75.1	52.5	1.56	0.05	0.04	<0.01	16.20	<0.01	0.25	0.02	2.67	-0.22	101.00	0.69	0.26	26.20
Box 29 FGA85	4.70	2.44	72.5	50.7	2.60	0.20	0.05	0.01	15.30	<0.01	0.29	0.03	3.08	-0.39	100.80	2.15	0.18	26.50
Box 30 FGA85	5.06	2.27	71.9	50.3	3.37	0.35	0.08	<0.01	13.00	<0.01	0.26	0.04	3.11	-0.66	100.80	1.47	0.15	43.70
Box 31 FGA85	7.87	2.43	70.4	49.2	4.93	0.28	0.09	0.02	12.60	<0.01	0.34	0.03	3.10	-1.26	100.80	1.05	0.05	45.40
Box 32 FGA85	27.40	0.88	49.2	34.4	13.30	2.07	0.04	0.01	4.16	<0.01	0.41	0.04	0.99	1.09	99.50	1.01	0.05	22.40
Box 33 FGA85	26.40	1.51	50.4	35.2	11.10	3.08	0.13	0.04	3.68	0.02	0.35	0.04	1.26	0.80	100.80	1.44	0.05	27.10
Massive Comp	11.50	4.09	65.3	45.7	4.43	1.79	0.23	0.27	12.20	0.04	0.28	<0.01	2.10	-1.81	100.30	0.43	0.20	42.90
Oxidized Comp	4.91	3.02	73.1	51.1	2.25	0.67	0.11	0.02	14.50	<0.01	0.25	<0.01	2.61	-0.62	100.90	0.85	0.21	29.70
DUP Box 10 FGA81	7.33	2.20	69.7	48.7	3.49	0.40	0.03	0.01	14.90	<0.01	0.32	<0.01	2.39	-1.66	101.10	0.33	0.27	-
DUP Box 20 FGA84	14.00	4.68	61.5	43.0	3.68	3.69	0.25	0.15	12.60	<0.01	0.27	<0.01	1.77	-2.08	100.50	0.10	0.11	-
DUP Box 30 FGA85	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.31	0.16	-

Table 13.3.1_2

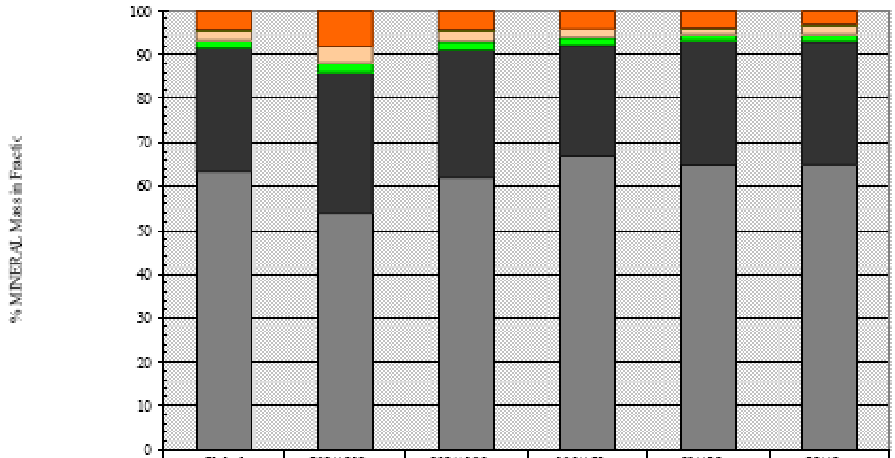
SGS Test Sample Analyses 2012

Deposit	V2O5 (%)	Fe (%)	TiO2 (%)	FeO (%)	Fe2O3 (%)	LOI (%)	SiO2 (%)	Al2O3 (%)	CaO (%)	MgO (%)	K2O (%)	Na2 (%)
Campbell	0.85	30.57	8.02	17.43	24.34	-1.01	27.52	9.87	5.09	2.91	0.60	1.28
Gulçari B	0.74	42.65	14.71	22.17	36.41	-2.29	14.07	6.20	1.79	2.00	0.38	0.34
São José	0.84	33.35	9.51	19.03	26.52	-1.08	24.82	9.77	4.25	2.02	0.58	1.21
Novo Amparo	0.71	42.60	14.35	24.31	33.89	-2.11	13.91	6.02	2.26	2.51	0.32	0.40
Novo Amparo Norte	0.90	32.94	9.89	20.64	24.76	-1.01	23.82	10.54	4.54	1.57	0.54	1.39

Table 13.3.1_3 Maracás Ore Mineralogical Composition		
Mineral	**Massive Sample (%)**	**Oxide Sample (%)**
Ti-magnetite	60.90	67.30
Ilmenite	19.90	23.50
Goethite	0.32	0.99
Cummingtonite / Actinolite	6.51	2.08
Hornblende	4.43	1.42
Clinopyroxene	0.82	0.24
Orthopyroxene	0.06	0.03
Chlorites	2.54	2.71
Biotite + Phlogopite	1.56	0.03
Mica/Clay-Mg	1.51	0.70
Talc	0.34	0.19
Quartz	0.40	0.31
Feldspars	0.51	0.06
Other silicates	0.21	0.20
Apatite	0.02	-
Carbonates	0.08	0.16
Sulphides	0.14	0.07
Others	-	0.01
Total	**100.00**	**100.00**

Figure 13.3.1_1

Ti-magnetite Associations by Size - Massive



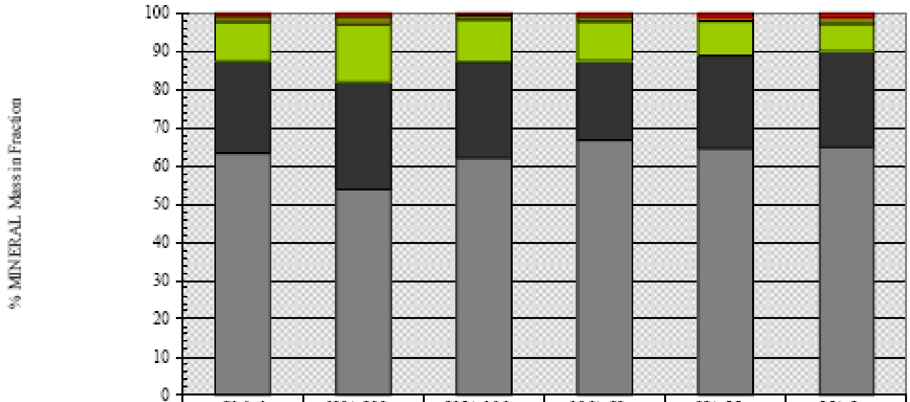
	Global	-300/+212um	-212/+106um	-106/+53um	-53/+25um	-25/+3um
Complex	4.3	8.1	4.4	3.9	3.8	2.9
Ti-Mgt:Other	0.1	0.1	0.1	0.0	0.2	0.3
Ti-Mgt: Sulphides	0.1	0.0	0.0	0.1	0.0	0.2
Ti-Mgt:Alkaline Silicates	2.2	3.5	2.4	2.1	1.4	2.1
Ti-Mgt:Mafic Silicates	1.7	2.3	1.9	1.7	1.4	1.4
Ti-Mgt:Ilmenite	28.3	32.2	29.2	25.4	28.6	28.2
Free Ti Mgt	63.2	53.8	62.0	66.8	64.6	64.9

SAMPLE Fraction

Figure 13.3.1_2

Free Ti-Magnetite and Ilmenite Middles shown at -212 microns

MINERAL Liberation Ti Mgt in Massive Comp.



	Global	-600/+212um	-212/+106um	-106/+53um	-53/+25um	-25/+3um
Locked Ti-Mgt	0.8	0.8	0.7	0.9	0.9	1.0
Sub Midds Ti-Mgt	1.5	2.2	1.2	1.4	1.3	1.9
Midds Ti-Mgt	10.2	15.1	10.9	10.2	9.0	7.1
Lib Ti-Mgt	24.2	28.0	25.2	20.8	24.2	25.1
Free Ti-Mgt	63.2	53.8	62.0	66.8	64.6	64.9

SAMPLE: Fraction

Categories are based on particle area percent:
Free >= 95%; Lib <95% & >= 80%; Midds <80% & >= 50%; Sub-Midds <50% & >=20%; Locked <20%.

13.3.2 Comminution

Laboratory crushing tests, overseen by Rautaruukki Oy, were undertaken in the crushing laboratory of Lokomo factory of Rauma-Repola Oy, Finland in December 1989. The average crushing work index was 6.9 kWh/t and the maximum 11.3 kWh/t.

The average abrasion index of the Maracás test samples was 0.42. Massive rock abrasion index was 0.243.

No recent crushing testwork was performed.

Grinding testwork was undertaken by SGS in 2007. The rod mill and ball mill work indices for different composites are shown in Table 13.3.2_1 and Table 13.3.2_2

Table 13.3.2_1

Bond Rod Mill Grindability Test Summary

Box #	Mesh of Grind	F80 (µm)	P80 (µm)	Gram per Revolution	Work Index (kWh/t)	Percentile of Hardness
1	14	10167	849	20.7	8.3	5
5	14	10685	727	16.4	8.5	5
10	14	11010	800	11.8	11.1	18
14	14	10542	840	10.0	12.9	35
15	14	11170	937	12.4	12.0	24
18	14	10319	862	17.6	9.2	8
21	14	10691	767	21.6	7.5	3
24	14	10219	871	15.4	10.1	12
27	14	10830	860	14.7	10.2	13
32	14	8734	890	8.2	15.8	64
Massive Comp	14	9777	812	13.9	10.4	14
Oxidized Comp	14	9854	846	15.5	10.0	12

The massive and oxide composites were both soft with respect to rod mill grindability, which characterizes coarse (primary) grinding. The rod mill work indices for the massive and oxidized composites measured 10.4 and 10.0 kWh/t, respectively. The ball mill work indices, which represent fine secondary grinding, were medium. They measured 14.2 and 12.9 kWh/h, respectively, for the massive and oxidized composites.

Table 13.3.2_2

Ball Mill Grindability Test Summary

Box #	Mesh of Grind	F80 (µm)	P80 (µm)	Gram per Revolution	Work Index (kWh/t)	Percentile of Hardness
1	100	2093	133	2.06	13.3	38
5	100	2021	130	2.07	13.0	35
10	100	2425	133	1.93	13.6	41
14	100	2285	129	1.90	13.7	42
15	100	2323	127	1.50	16.4	69
18	100	1994	132	2.79	10.3	12
21	100	1927	137	1.96	14.3	48
24	100	2268	128	1.81	14.1	46
27	100	2064	127	1.82	14.2	47
32	100	2245	116	1.60	14.6	51
Massive Comp	100	1931	129	1.88	14.2	47
Massive Comp Mag	100	1854	128	1.83	14.5	50
Oxidized Comp	100	2147	123	1.99	12.9	34
Oxidized Comp Mag	100	1816	133	1.95	14.1	46

13.3.3 Concentration (Magnetic Separation)

Davis tube tests were performed by SGS in 2007, in order to determine the effect of the following parameters on vanadium recovery:

- Grind;
- Davis tube intensity;
- Ore variability.

The results on the composite samples are summarized in Table 13.3.4_1 and Table 13.3.4_6. Maximum separation efficiency is obtained at 100% passing 50 microns. With feed grades composites of 2-2.4% V_2O_5 the vanadium recovery was, above 94% for the massive bulk composite and above 91% for the oxidized bulk composite, and the silica content was low, 1.18% maximum, for samples with less than 106 microns.

Additional Davis Tube tests were performed in 2012 in order to determine concentrate recoveries and grades on the additional ore bodies included in the expanded mine plan. The additional work, whose results are listed in Table 13.3.4_2 through Table 13.3.4_6 indicate vanadium recoveries of 78 to 89% at head grades of 0.7 to 0.9% V_2O_5 with average concentrate grades ranging from 1.6% to 2.9% V_2O_5.

Davis Tube Recovery test results for tailings composites can be seen in Table 13.3.4_7 through Table 13.3.4_12.

13.3.4 Roasting, Leaching and Precipitation

The SGS testwork program also investigated conditions of salt roasting for extracting vanadium from the magnetite concentrate.

Vanadium was successfully recovered from Maracás magnetic concentrates by salt roast leaching with sodium carbonate. Massive and oxidized magnetite samples of various compositions were treated in a bench program, resulting in vanadium extraction exceeding 90%. Using the bulk magnetic concentrates produced at SGS, an optimum vanadium leach extraction of 93.5% (Test L15, massive magnetite) and 95.0% (Test L18, oxidized magnetite) were obtained.

Table 13.3.4_13 shows conditions of tests performed in 2007 on different samples.

A second bench program was carried out using bulk roasted samples. The bulk roasting was performed by FEECO, a kiln manufacturing company in Green Bay, WI, U.S.A., in a batch operating rotary kiln. The vanadium extraction was generally lower than what was observed in the preliminary bench program. Vanadium extractions were 85.6% for the massive magnetite and 92.3% for the oxidized sample.

It is noted that since bulk roasting's purpose was to generate enough material for leaching, the testing was not performed under optimal recovery conditions.

Bulk leach tests were performed using bulk roasted samples to produce feed liquor for ammonium metavanadate (AMV) precipitation. Vanadium leach extractions were 78% for the massive bulk and 91.0% for the oxidized sample. Table 13.3.4_14 shows the assays on bulk concentrate, bulk leach residue and pregnant leach solution (PLS).

A de-silication step was applied after bulk leaching by the addition of aluminum sulphate. The filtrate from the massive sample leach and de-silication was used in the oxide sample leach for the purpose of high vanadium concentration in the solution.

The final filtrate from the de-silication step, after the oxide leach, contains 28 g/L V and 26.8 mg/L Si.

The following contributing factors are presented as possible explanation(s) for the lower than expected vanadium extraction:

- Different furnaces were used for the bulk roasting;
- Temperature variation differences from the testing done by SGS and FEECO;
- Indirect (SGS) versus direct flame heating in bulk roasting;
- The feed to the bulk leach was a blend of various batch roasting samples, produced under various conditions.

Table 13.3.4_1

Davis Tube Summary on Composites - Concentrate – Campbell

Test	Sample	Grind		DT Int. Amps	Concentrate												
		100% Pass	K (µm)		Fe %	SiO2 %	Al2O3 %	MgO %	CaO %	Na2O %	K2O %	TiO2 %	P2O5 %	MnO %	Cr2O3 %	V2O5 %	Sat %
DT-1	Massive Comp.	48	212	1.5	60.9	2.13	2.45	1.35	0.24	0.04	0.04	7.27	<0.01	0.18	0.02	3.08	73.6
DT-2	Massive Comp.	100	106	1.5	62.9	0.85	2.00	0.75	0.13	0.03	0.03	6.05	<0.01	0.15	0.02	3.19	77.3
DT-3	Massive Comp.	200	55	1.5	63.6	0.96	2.05	0.75	0.15	0.03	0.02	5.87	<0.01	0.15	0.02	3.33	77.2
DT-4	Massive Comp.	325	34	1.5	63.6	0.95	1.94	0.71	0.14	0.03	<0.01	5.85	<0.01	0.15	0.02	3.39	76.9
DT-9	Massive Comp.	48	212	1.0	60.6	2.95	2.46	1.33	0.21	0.22	0.12	7.05	<0.01	0.16	0.03	3.15	73.6
DT-10	Massive Comp.	100	106	1.0	63.6	1.14	1.93	0.98	0.11	0.06	0.01	6.46	<0.01	0.15	0.02	3.33	75.7
DT-11	Massive Comp.	200	55	1.0	63.7	0.94	1.87	0.86	0.10	0.09	<0.01	6.06	<0.01	0.13	0.02	3.36	75.7
DT-12	Massive Comp.	325	34	1.0	63.5	0.92	1.92	0.83	0.11	<0.01	0.01	5.7	<0.01	0.13	0.06	3.38	75.3
DT-13	Massive Comp.	48	212	0.5	60.8	1.74	2.06	1.24	0.19	0.03	0.03	7.14	<0.01	0.16	0.02	3.16	69.4
DT-14	Massive Comp.	100	106	0.5	63.1	1.18	1.97	0.96	0.12	0.06	<0.01	6.55	<0.01	0.15	0.02	3.33	75.6
DT-15	Massive Comp.	200	55	0.5	64.1	1.04	1.92	0.85	0.10	0.01	0.01	6.18	<0.01	0.14	0.02	3.36	75.8
DT-16	Massive Comp.	325	34	0.5	63.9	0.96	1.90	0.78	0.11	0.08	0.02	5.68	<0.01	0.14	0.03	3.38	75.7
Jeffery-1 and MS-1	**Massive**	**-**	**60**	**-**	**63.8**	**0.75**	**1.84**	**0.71**	**0.06**	**<0.01**	**<0.01**	**6.06**	**<0.01**	**0.16**	**0.07**	**3.42**	**78.3**
Bulk	Massive	-	53	-	64.1	0.81	1.84	0.72	0.08	0.02	0.01	5.52	<0.01	0.15	0.02	3.40	77.1
DT-5	Oxidized	48	210	1.5	59.0	1.24	1.89	0.78	0.51	0.02	0.02	9.03	0.03	0.19	0.02	3.09	42.3
DT-6	Oxidized	100	107	1.5	62.0	0.73	1.72	0.53	0.09	0.02	0.02	7.41	<0.01	0.16	0.03	3.42	48.0
DT-7	Oxidized	200	55	1.5	62.0	0.59	1.64	0.46	0.07	0.02	0.02	6.65	<0.01	0.14	0.02	3.47	48.7
DT-8	Oxidized	325	29	1.5	62.6	0.55	1.54	0.42	0.18	0.03	0.03	6.17	<0.01	0.14	0.03	3.11	51.4
Jeffery-2 and MS-2	**Oxidized**	**-**	**59**	**-**	**62.9**	**0.53**	**1.68**	**0.46**	**0.03**	**0.01**	**<0.01**	**6.69**	**<0.01**	**0.16**	**0.07**	**3.67**	**53.1**
Bulk	**Oxidized**	**-**	**53**	**-**	**63.2**	**0.58**	**1.53**	**0.40**	**0.06**	**<0.01**	**<0.01**	**6.32**	**<0.01**	**0.13**	**<0.01**	**3.53**	**46.8**

Source: SGS / Lakefield

Table 13.3.4_2

Davis Tube Summary on Composites - Concentrate - Gulçari A Norte

	Mass Rec (%)	V_2O_5 Rec (%)	V_2O_5 (%)	Fe (%)	TiO_2 (%)	FeO (%)	Fe_2O_3 (%)	LOI (%)	SiO_2 (%)	Al_2O_3 (%)	CaO (%)	MgO (%)
FGAN 01	23.65	83.15	2.74	63.62	2.64	31.59	55.88	-2.47	3.38	2.01	0.67	0.54
FGAN 02	42.04	88.69	2.89	63.50	3.63	31.96	55.30	-3.26	2.95	2.32	0.43	0.36
FGAN 04	19.80	62.55	3.24	61.69	2.51	30.50	54.33		4.45	2.35	1.01	0.58
FGAN 06	22.06	67.05	3.29	64.29	2.76	32.32	55.99		3.03	1.85	0.69	0.30
FGAN 07	17.52	68.26	3.65	65.43	1.94	32.62	57.25		2.02	1.56	0.49	0.26
FGAN 08	24.62	77.23	2.99	65.80	2.97	32.82	57.62	-3.42	0.93	1.50	0.17	0.05
FGAN 09	25.28	79.11	2.88	57.69	4.16	28.70	50.56	-2.78	7.44	3.68	1.34	0.59
FGAN 10	15.30	79.02				32.42						
FGAN 11	29.90	80.92	2.58	67.10	2.90	33.25	58.97		0.71	1.32	0.12	0.17
FGAN 12	23.45	73.41				32.11						
FGAN 13	9.85	45.60	2.67	67.34	0.75	32.83	59.78		1.83	1.00	0.41	0.27
FGAN 14	19.61	93.49				31.96						
FGAN 15	21.60	77.43	3.79	67.10	1.92	33.10	59.15		0.61	1.00	0.15	0.19
FGAN 16	30.48	86.13	2.70	66.50	3.31	33.15	58.22		0.82	1.47	0.14	0.18
FGAN 17	27.84	88.28	2.98	66.35	3.08	32.59	58.61		0.68	1.58	0.15	0.20
FGAN 05	27.89	81.48	1.82	65.59	5.25	31.05	59.27	-3.60	0.92	1.69	0.14	0.22

Source: SGS / Lakefield

Table 13.3.4_3 Davis Tube Summary on Composites - Concentrate - Gulçari B											
	Mass Rec (%)	**V_2O_5 Rec (%)**	**V_2O_5 (%)**	**Fe (%)**	**TiO_2 (%)**	**FeO (%)**	**Fe_2O_3 (%)**	**LOI (%)**	**SiO_2 (%)**	**Al_2O_3 (%)**	**CaO (%)**	**MgO (%)**
FGB 10	43.22	86.22	1.74	63.11	6.58	24.38	63.18	-2.59	0.60	2.09	0.04	0.22
FGB 11	38.42	89.51	1.97	65.50	4.13	32.18	57.93	-3.41	0.92	2.05	0.12	0.27
FGB 12	23.47	75.04	2.11	65.80	2.91	33.15	57.30	-3.45	1.01	1.09	0.18	0.10
FGB 13	44.15	91.84	1.72	65.15	4.60	32.92	56.53	-3.41	0.83	2.18	0.10	0.30
FGB 14	41.13	90.46	1.72	64.69	4.97	32.89	55.99	-3.62	0.74	2.20	0.08	0.27
FGB 15	41.14	89.51	1.49	63.98	6.05	29.11	59.11	-3.11	0.82	2.38	0.07	0.28
FGB 16	40.47	90.52	1.45	64.56	5.77	31.73	57.00	-3.44	0.84	2.28	0.09	0.27
FGB 17	37.62	87.19	1.66	65.05	5.38	30.65	58.96	-3.43	0.99	1.80	0.15	0.21

Source: SGS / Lakefield

Table 13.3.4_4 Davis Tube Summary on Composites - Concentrate - São José												
	Mass Rec (%)	**V2O5 Rec (%)**	**V2O5 (%)**	**Fe (%)**	**TiO2 (%)**	**FeO (%)**	**Fe2O3 (%)**	**LOI (%)**	**SiO2 (%)**	**Al2O3 (%)**	**CaO (%)**	**MgO (%)**
FSJ 09	20.43	73.43	3.39	66.98	1.86	33.98	57.94	-3.49	0.87	1.41	0.16	0.05
FSJ 12	34.25	75.98	2.06	59.36	5.04	30.55	50.92	-2.90	6.43	3.40	0.97	0.51
FSJ 13	35.38	86.87	2.13	62.24	4.38	31.91	53.54	-2.90	3.61	2.64	0.68	0.38
FSJ 14	36.14	72.65	2.14	62.74	3.98	31.97	54.21	-3.27	3.46	2.54	0.53	0.30
FSJ 15	35.16	90.66	2.32	64.40	3.31	32.02	56.46	-3.46	2.69	2.17	0.42	0.24
FSJ 16	35.62	95.39	2.24	64.90	3.04	31.71	57.58	-3.33	2.76	1.83	0.38	0.28
FSJ 17	28.68	73.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FSJ 18	36.46	87.84	2.36	64.69	3.92	32.41	56.50	-3.23	1.15	1.59	0.17	0.14
FSJ 19	13.45	58.13	3.37	65.30	1.45	34.15	55.40	-3.23	2.29	1.77	0.43	0.19
FSJ 20	29.35	75.94	2.69	63.78	3.41	32.11	55.52	-3.28	2.78	2.18	0.45	0.24
FSJ 21	33.74	81.34	2.63	64.32	3.30				2.23	2.00	0.38	0.22
FSJ 22	23.47	71.67	2.40	64.86	2.65	27.39	62.33		2.52	1.75	0.43	0.11
FSJ 23	29.22	74.02	2.16	65.99	2.58	25.09	66.48	-2.08	1.62	1.28	0.25	0.13
FSJ 24	29.65	84.88	2.29	64.30	5.00	19.22	70.60	-1.73	0.59	1.12	0.05	<0.1
FSJ 25	25.32	88.45	2.49	67.05	2.63	32.59	59.60	-3.30	0.73	1.37	0.10	<0.1
FSJ 08	17.82	71.56	2.79	65.99	2.21	34.06	56.50		1.11	1.10	0.25	0.18
FSJ 11	25.28	79.70	2.67	64.65	3.06	32.61	56.16	-3.15	2.65	2.03	0.48	0.27

Source: SGS / Lakefield

Table 13.3.4_5

Davis Tube Summary on Composites - Concentrate - Novo Amparo

	Mass Rec (%)	V_2O_5 Rec (%)	V_2O_5 (%)	Fe (%)	TiO_2 (%)	FeO (%)	Fe_2O_3 (%)	LOI (%)	SiO_2 (%)	Al_2O_3 (%)	CaO (%)	MgO (%)
FNA 08	34.19	84.26	1.58	66.60	2.06	31.34	60.50	-3.30	1.70	1.49	0.28	0.27
FNA 09	37.34	84.13	1.72	64.73	4.70	31.19	57.91	-3.22	1.76	2.07	0.26	0.42
FNA 10	41.96	88.04	1.56	64.51	5.15	32.12	56.54	-3.24	1.44	2.18	0.22	0.45
FNA 11	26.13	78.23	1.87	67.20	2.00	31.55	61.00	-3.23	1.21	1.18	0.21	0.20
FNA 12	27.28	73.45	1.70	63.10	4.76	30.67	56.15	-3.02	2.93	2.54	0.47	0.57
FNA 13	41.88	84.38	1.53	63.54	5.09	31.34	55.98	-3.00	1.77	2.50	0.23	0.53
FNA 14	37.01	86.57	1.73	65.64	4.03	32.21	58.07	-3.33	0.87	2.04	0.12	0.30
FNA 15	52.41	92.57	1.37	63.78	6.15	31.53	56.17	-3.11	1.34	2.78	0.12	0.59
FNA 16	48.67	88.83	1.32	63.93	5.25	30.47	57.56	-3.22	1.63	2.64	0.19	0.52
FNA 18	42.19	87.37	1.44	64.43	4.72	31.18	57.48	-3.18	1.66	2.52	0.25	0.48

Source: SGS / Lakefield

Table 13.3.4_6 Davis Tube Summary on Composites - Concentrate - Novo Amparo Norte												
	Mass Rec (%)	**V_2O_5 Rec (%)**	**V_2O_5 (%)**	**Fe (%)**	**TiO_2 (%)**	**FeO (%)**	**Fe_2O_3 (%)**	**LOI (%)**	**SiO_2 (%)**	**Al_2O_3 (%)**	**CaO (%)**	**MgO (%)**
FNAN 01	34.83	83.07	2.60	64.15	3.72	32.47	55.61	-3.31	2.34	2.09	0.40	0.26
FNAN 02	28.80	82.19	2.89	64.93	2.61	31.69	57.66	-3.33	2.30	1.89	0.39	0.21
FNAN 03	32.91	81.87	2.58	62.81	3.73	32.06	54.17	-3.10	3.26	2.35	0.55	0.29
FNAN 06	26.99	57.85	-									
FNAN 08	34.21	80.17	2.10	61.87	4.06	31.27	53.72	-2.95	3.74	2.61	0.65	0.37
FNAN 09	17.30	65.34	2.84	59.91	2.29	30.48	51.77	-2.75	6.40	2.91	1.19	0.51
FNAN 10	32.42	78.18	2.63	63.58	3.44	31.56	55.82		2.20	2.31	0.41	0.25
FNAN 11	19.34	64.20	2.94	59.53	3.68	27.64	54.32	-1.31	5.56	3.06	1.14	0.40
FNAN 12	35.22	113.33	4.66	98.34	3.38	48.92	86.19	-4.96	2.73	2.64	0.52	0.16
FNAN 13	35.43	86.56	1.95	66.22	3.13	30.16	61.20	-3.16	1.09	1.71	0.16	0.11
FNAN 14	36.97	87.22	2.08	65.16	3.94	31.62	57.96	-3.21	1.59	1.92	0.29	0.18
FNAN 15	30.06	77.30	2.88	64.73	3.04	31.44	57.61	-3.23	1.90	1.85	0.35	0.21
FNAN 16	24.32	72.33	2.71	64.96	2.57	31.43	57.95	-3.10	2.13	1.82	0.52	0.10
FNAN 17	22.56	71.99	3.16	65.91	2.79	32.48	58.14	-3.49	1.15	1.65	0.27	0.12

Source: SGS / Lakefield

Table 13.3.4_7

Davis Tube Summary on Composites - Tailings – Campbell

Test	Sample	Grind		DT Int. Amps	Concentrate												
		100% Pass	K (µm)		Fe %	SiO_2 %	Al_2O_3 %	MgO %	CaO %	Na_2O %	K_2O %	TiO_2 %	P_2O_5 %	MnO %	Cr_2O_3 %	V_2O_5 %	Sat %
DT-1	Massive Comp.	48	212	1.5	23.6	24.00	6.84	8.44	4.01	0.54	0.57	21.1	0.06	0.48	<0.01	0.21	1.19
DT-2	Massive Comp.	100	106	1.5	23.5	25.00	6.68	8.93	4.13	0.54	0.53	19.9	0.06	0.47	<0.01	0.22	1.63
DT-3	Massive Comp.	200	55	1.5	23.5	25.10	6.75	8.96	4.12	0.55	0.54	19.9	0.05	0.47	<0.01	0.22	1.48
DT-4	Massive Comp.	325	34	1.5	22.9	26.00	6.92	9.46	4.31	0.56	0.5	18.6	0.05	0.46	<0.01	0.23	1.80
DT-9	Massive Comp.	48	212	1.0	23.4	25.60	6.93	9.37	4.31	0.54	0.66	18.6	0.06	0.43	<0.01	0.25	1.04
DT-10	Massive Comp.	100	106	1.0	23.6	24.40	6.33	9.33	4.05	0.49	0.55	20.3	0.05	0.45	0.02	0.22	1.52
DT-11	Massive Comp.	200	55	1.0	22.9	26.70	6.79	10.20	4.42	0.56	0.53	18.2	0.05	0.44	<0.01	0.22	1.39
DT-12	Massive Comp.	325	34	1.0	23.7	24.80	6.48	9.57	4.11	0.44	0.52	19.8	0.05	0.45	<0.01	0.24	1.89
DT-13	Massive Comp.	48	212	0.5	23.3	24.50	6.61	8.43	4.10	0.58	0.62	19.9	0.05	0.45	<0.01	0.22	1.65
DT-14	Massive Comp.	100	106	0.5	23.8	24.60	6.48	8.79	4.10	0.52	0.53	19.1	0.05	0.45	<0.01	0.28	1.49
DT-15	Massive Comp.	200	55	0.5	24.4	25.00	6.56	9.00	4.11	0.54	0.51	17.5	0.05	0.43	<0.01	0.37	4.87
DT-16	Massive Comp.	325	34	0.5	30.5	20.60	5.75	7.38	3.40	0.40	0.43	16.9	0.05	0.39	<0.01	0.81	14.60
Jeffery-1 and MS-1	Massive	-	60	-	24.7	24.90	6.58	8.86	4.02	0.53	0.56	18.7	0.05	0.45	-	0.33	3.46
Bulk	Massive	-	53	-	22.7	1.36	6.97	9.60	-	-	-	18.7	-	-	-	0.23	1.36
DT-5	Oxidized Comp.	48	210	1.5	30.4	12.80	4.86	5.78	2.03	0.12	0.06	29.8	0.01	0.55	0.01	0.41	1.47
DT-6	Oxidized Comp.	100	107	1.5	34.1	11.00	4.38	4.94	1.81	0.10	0.05	26.8	<0.01	0.48	<0.01	0.84	3.05
DT-7	Oxidized Comp.	200	55	1.5	35.0	10.40	4.36	4.66	1.71	0.09	0.05	26.2	<0.01	0.48	0.01	0.92	3.19
DT-8	Oxidized Comp.	325	29	1.5	37.8	9.65	4.16	4.22	1.56	0.10	0.05	24.2	<0.01	0.45	<0.01	1.21	4.72
Jeffery-2 and MS-2	Oxidized	-	59	-	39.4	9.91	4.20	4.18	1.47	0.11	0.05	21.5	-	0.4	0.02	1.40	6.26
Bulk	Oxidized	-	53	-	31.8	1.25	5.24	5.21	-	-	-	29	-	-	-	0.56	1.25

Source: SGS / Lakefield

Table 13.3.4_8

Davis Tube Summary on Composites - Tailings - Gulçari A Norte

	Mass Rec (%)	V_2O_5 Rec (%)	V_2O_5 (%)	Fe (%)	TiO_2 (%)	FeO (%)	Fe_2O_3 (%)	LOI (%)	SiO_2 (%)	Al_2O_3 (%)	CaO (%)	MgO (%)
FGAN 01	76.35	16.85	0.27	21.08	8.27	13.21	15.46	-0.49	37.11	9.69	6.49	6.39
FGAN 02	57.96	11.31	0.29	28.80	16.80	22.55	16.10	-1.74	25.40	10.10	3.83	2.73
FGAN 04	80.20	37.45	0.37	20.15	8.71	15.37	11.73	-0.40	34.70	13.12	7.21	3.62
FGAN 06	77.94	32.95	0.37	19.11	9.13	14.73	10.91	-0.00	35.60	14.21	7.34	3.37
FGAN 07	82.48	31.74	0.36	17.15	7.25	11.18	12.10	-0.08	38.65	14.40	7.77	3.57
FGAN 08	75.38	22.77	0.25	20.84	11.09	13.88	14.33	-0.49	33.99	13.24	5.64	2.79
FGAN 09	74.72	20.89	0.30	18.66	8.61	13.03	12.20	0.14	37.73	14.02	6.31	2.78
FGAN 10	84.70	-	0.28	20.26	9.26	14.04	13.35	0.81	36.45	12.23	6.16	2.90
FGAN 11	70.10	19.08	0.21	23.67	14.07	19.43	12.27	-0.96	30.90	11.73	5.11	2.42
FGAN 12	76.55	-	0.39	21.93	9.97	19.40	9.82	1.08	30.83	12.89	5.81	2.07
FGAN 13	90.15	54.40	0.30	17.38	5.35	12.42	11.10	0.11	40.82	12.37	7.81	3.84
FGAN 14	80.39	-	0.30	20.39	9.27	9.68	18.38	0.11	35.50	12.45	6.70	3.55
FGAN 15	78.40	22.57	0.35	21.52	9.60	11.27	18.26	-0.17	33.85	11.59	6.27	4.58
FGAN 16	69.52	13.87	0.21	25.42	14.65	14.45	20.26	-0.94	29.22	10.98	4.72	2.56
FGAN 17	72.16	11.72	0.24	20.58	11.62	12.01	16.12	-0.46	32.86	13.13	6.30	3.00
FGAN 05	72.11	18.52	0.14	23.55	13.66	11.81	20.52	-1.48	32.28	10.25	5.60	4.06

Source: SGS / Lakefield

Table 13.3.4_9 Davis Tube Summary on Composites - Tailings - Gulçari B												
	Mass Rec (%)	**V2O5 Rec (%)**	**V2O5 (%)**	**Fe (%)**	**TiO2 (%)**	**FeO (%)**	**Fe2O3 (%)**	**LOI (%)**	**SiO2 (%)**	**Al2O3 (%)**	**CaO (%)**	**MgO (%)**
FGB10	56.78	13.78	0.18	29.59	22.23	11.41	29.63	-0.23	21.09	7.92	2.57	3.22
FGB11	61.58	10.49	0.16	26.90	19.53	17.84	18.67	-1.49	24.30	9.05	3.65	3.93
FGB12	76.53	24.96	0.20	20.30	12.50	16.36	10.90	-0.57	32.80	14.00	6.01	2.21
FGB13	55.85	8.16	0.13	28.98	23.52	18.48	20.85	-2.12	20.95	8.28	3.06	3.64
FGB14	58.87	9.54	0.13	28.37	21.77	17.43	21.24	-2.03	22.17	8.90	3.37	3.24
FGB15	58.86	10.49	0.14	28.86	22.11	16.18	23.29	-1.74	21.25	8.86	2.93	3.00
FGB16	59.53	9.48	0.11	27.62	22.29	15.01	22.82	-1.96	23.37	9.08	2.89	2.90
FGB17	62.38	12.81	0.12	27.25	19.86	15.05	22.27	-1.41	24.97	9.33	2.40	2.88

Source: SGS / Lakefield

Table 13.3.4_10

Davis Tube Summary on Composites - Tailings - São José

	Mass Rec (%)	V_2O_5 Rec (%)	V_2O_5 (%)	Fe (%)	TiO_2 (%)	FeO (%)	Fe_2O_3 (%)	LOI (%)	SiO_2 (%)	Al_2O_3 (%)	CaO (%)	MgO (%)
FSJ 09	79.57	26.57	0.26	17.11	8.70	9.58	13.78	-0.07	38.25	15.84	7.14	2.39
FSJ 12	65.75	24.02	0.24	24.38	13.51	18.32	14.50	-0.60	30.51	12.11	4.89	2.01
FSJ 13	64.62	13.13	0.24	25.16	15.09	17.99	15.98	0.46	27.71	11.80	5.80	2.02
FSJ 14	63.86	27.35	0.21	26.35	16.36	20.51	14.89	-1.52	26.96	11.72	4.47	1.93
FSJ 15	64.84	9.41	0.20	26.49	17.04	16.44	19.54	-1.76	26.33	11.95	3.94	1.96
FSJ 16	64.38	4.61	0.20	26.43	16.85	16.28	19.70	-1.70	26.88	10.73	4.15	2.15
FSJ 17	81.77	26.87	0.28	17.89	8.52	8.19	16.46	-0.68	37.82	15.49	7.21	2.51
FSJ 18	63.54	12.16	0.19	24.28	16.73	16.98	15.82	-0.75	28.14	12.01	4.06	2.11
FSJ 19	86.55	41.87	0.38	17.30	6.75	11.42	12.00	0.44	38.70	15.40	6.56	2.34
FSJ 20	70.65	24.06	0.24	23.51	14.17	16.29	15.48	-1.08	30.02	12.97	5.03	1.95
FSJ 21	66.26	18.66	0.26	25.89	16.38	19.27	15.60	-1.07	26.99	11.84	4.44	2.19
FSJ 22	76.53	28.33	0.28	25.62	16.23	16.07	18.79	0.09	27.86	11.67	3.98	1.49
FSJ 23	70.78	25.98	0.33	27.42	17.25	18.17	18.97	1.99	22.84	10.14	4.57	1.91
FSJ 24	70.35	15.12	0.26	27.20	14.30	8.38	29.60	1.23	28.10	11.30	3.14	1.45
FSJ 25	74.68	11.55	0.18	20.30	11.66	13.28	14.20	-0.55	35.35	12.90	5.72	2.43
FSJ 08	82.18	28.44	0.26	17.87	7.73	11.04	13.30	-0.21	39.66	11.97	7.41	3.95
FSJ 11	82.25	13.31	0.26	18.00	7.59	9.94	14.67	-0.23	39.52	12.78	7.27	4.17

Source: SGS / Lakefield

Table 13.3.4_11 Davis Tube Summary on Composites - Tailings - Novo Amparo											
	Mass Rec (%)	V_2O_5 Rec (%)	V_2O_5 (%)	Fe (%)	TiO_2 (%)	FeO (%)	Fe_2O_3 (%)	LOI (%)	SiO_2 (%)	Al_2O_3 (%)	CaO (%)	MgO (%)
FNA 08	65.81	15.74	0.16	27.40	20.40	17.38	19.80	-1.23	22.20	10.30	3.63	2.69
FNA 09	43.86	6.66	0.14	31.00	29.70	27.15	14.20	-1.14	14.00	6.55	1.19	3.38
FNA 10	58.04	11.96	0.15	26.20	21.64	21.16	13.96	-0.89	22.90	8.38	3.87	4.16
FNA 11	73.87	21.77	0.17	22.40	14.20	11.49	19.20	-0.63	32.80	10.60	4.80	3.79
FNA 12	72.72	26.55	0.19	22.34	12.78	12.64	17.84	-0.84	32.47	10.13	5.75	4.05
FNA 13	58.12	15.62	0.17	27.16	22.64	21.12	15.36	-1.27	21.54	8.34	3.68	3.89
FNA 14	62.99	13.43	0.15	26.16	20.63	19.45	15.77	-1.25	24.29	8.95	3.72	3.95
FNA 15	47.59	7.43	0.12	31.52	30.52	25.69	16.53	-1.88	13.70	6.92	1.53	3.33
FNA 16	52.19	11.62	0.08	30.30	26.10	20.79	20.20	-1.77	17.70	8.26	2.08	3.68
FNA 18	57.81	12.63	0.12	28.69	23.24	19.20	19.66	-1.62	20.96	8.81	3.48	3.50

Source: SGS / Lakefield

Table 13.3.4_12

Davis Tube Summary on Composites - Tailings - Novo Amparo Norte

	Mass Rec (%)	V_2O_5 Rec (%)	V_2O_5 (%)	Fe (%)	TiO_2 (%)	FeO (%)	Fe_2O_3 (%)	LOI (%)	SiO_2 (%)	Al_2O_3 (%)	CaO (%)	MgO (%)
FNAN 01	65.17	16.93	0.26	24.46	15.31	19.07	13.79	-0.54	28.19	12.22	4.90	2.23
FNAN 02	28.80	82.19	2.89	64.93	2.61	31.69	57.66	-3.33	2.30	1.89	0.39	0.21
FNAN 03	67.09	18.13	0.25	23.80	14.33	17.99	14.04	-0.76	29.57	13.22	4.83	1.85
FNAN 06	73.01	42.15	0.38	25.04	15.73	19.92	13.69	-0.08	26.51	11.17	5.11	2.33
FNAN 08	65.79	19.83	0.26	25.79	15.84	19.13	15.63	-1.25	26.68	11.75	4.86	2.08
FNAN 09	82.70	34.66	0.29	17.16	7.93	11.91	11.33	0.79	37.20	15.75	6.68	1.99
FNAN 10	67.58	21.82	0.27	24.04	14.96	16.70	15.79	-0.96	28.78	12.56	5.52	2.27
FNAN 11	84.09	37.14	0.34	17.28	7.89	8.07	15.75	0.39	38.54	15.83	6.90	2.03
FNAN 12	113.80	35.69	0.41	29.97	16.72	19.17	21.50	-0.88	50.70	22.75	9.69	2.53
FNAN 13	64.57	13.44	0.76	36.39	15.40	24.83	24.43	-1.70	18.75	9.27	3.07	1.34
FNAN 14	63.03	12.78	0.21	27.52	18.52	17.63	19.76	-1.01	23.93	11.03	4.12	2.15
FNAN 15	69.94	22.70	0.29	23.02	14.10	16.94	14.08	-0.42	29.39	12.83	5.69	2.28
FNAN 16	75.68	27.67	0.29	22.90	13.69	16.04	14.89	0.04	30.29	13.48	5.42	1.67
FNAN 17	77.44	28.01	0.27	20.60	10.03	10.87	17.36	-0.42	34.30	14.24	6.71	2.47

Source: SGS / Lakefield

Table 13.3.4_13

Salt Roast Leaching with Sodium Carbonate - Overview Test Conditions and Results

Test	Sample	Date 2007	Roast Stages				Leach					Final PLS, mg/L	
			Temp °C	Time h	Na2CO2 dosage %	Alumina dosage %	Temp C°	Time h	Solids Wt%	Recovery %V	Final Res %V	V	Si
L1A	Massive PGM	25-Jul	1250	2	4.0	2	60	2	19.6	95.5	0.10	4,500	3.0
L1B							95	2	19.4	95.7	0.09	4,200	7.2
L2A	Massive PGM	26-Jul	1250	2	4.0	1.3	60	3	20.6	95.0	0.10	4,200	2.7
L2B							95	3	20.7	95.5	0.09	4,100	3.5
L3A	Massive PGM	31-Jul	1200	1	4.0	1.3	25	3	22.1	93.7	0.13	4,800	2.2
L3B							60	3	22.1	93.9	0.13	4,900	4.4
L4	Massive PGM	07-Aug	1200	1	4.0	0.7	60	2	49.0	95.2	0.10	15,000	4.9
L5	Massive PGM	08-Aug	1250	1	5.4 Na2SO4	1.3	60	2	46.1	95.0	0.11	15,000	5.7
L6	Massive PGM	09-Aug	1200	2	4.0	1.3	60	2	46.7	94.0	0.12	13,000	6.3
L7	Massive PGM	20-Aug	1200	2	4.0	0	60	2	45.8	96.0	0.09	14,000	10.0
L8	Massive	13-Sep	1200	2	4.0	1.3	60	2	47.0	92.8	0.14	12,100	6.6
L9	Massive	17-Sep	1200	2	3.5	1.3	60	2	51.0	92.2	0.14	14,000	4.5
L10	Massive	18-Sep	1200	2	4.0	1.3	60	2	52.2	92.4	0.15	16,500	5.8
L11	Oxidized	19-Sep	1200	2	4.0	1.3	60	2	47.6	93.3	0.14	15,000	6.1
L12	Massive	20-Sep	1200	2	4.5	1.3	60	2	47.2	93.6	0.12	14,400	6.3
L13	Massive	02-Oct	1200	1	4.5	1.3	60	1	49.5	93.2	0.13	13,000	7.6
L14	Oxidized	11-Oct	1200	2	4.5	1.3	60	1	50.5	94.8	0.10	14,500	2.7
L15	Massive Bulk	10-Oct	1250	1	4.5	1.3	60	1	51.5	93.5	0.12	13,800	7.7
L16	Massive Bulk	15-Oct	1150	1	4.5	1.3	60	1	50.4	91.8	0.15	12,600	5.2
L17	Oxidized	16-Oct	1150	1	4.5	1.3	60	1	48.7	93.7	0.13	14,700	7.2
L18	Oxidized	17-Oct	1250	1	4.5	1.3	60	1	51.2	95.0	0.10	15,700	9.4

Source: SGS / Lakefield

Table 13.3.4_14

Bulk Leach and De-silication Test Results

	Units	V	Si	Al	Fe	Mg	Ca	Na	K	Ti	P	Mn	Cr
Bulk Massive Magnetite Concentrate	%	1.76	1.51	1.13	6.3	1.11	0.29	0.02	0.02	4.41	<0.00	0.15	0.01
Bulk Oxidized Magnetite Concentrate	%	1.95	0.55	0.96	60.6	0.43	0.07	0.01	<0.01	4.89	<0.00	0.13	0.01
Bulk Massive Leach Residue	%	0.40	0.73	1.50	64.0	0.41	0.09	0.58	0.02	3.20	0.00	0.11	0.00
Bulk Oxidized Leach Residue	%	0.21	0.72	1.40	72.0	0.28	0.04	0.55	0.02	3.80	0.00	0.11	0.00
Bulk Massive PLS	mg/L	12,500	199	1.00	4.5	5.68	113	8,790	15.00	3.40	5.00		12
Bulk Massive PLS after de-Si	mg/L	13,300	45.7										
Bulk Oxidized PLS	mg/L	27,500	59.9	5.70	10.7	15.10	372	17,800	16.00	15.10	5.00		14.30
Bulk Oxidized PLS after de-Si	mg/L	28,000	26.8										
Bulk Massive Leach Extraction	%	78.6	(Fe Tie)										
Bulk Oxidized Leach Extraction	%	91.0	(Fe Tie)										

Source: SGS / Lakefield

Vanadium precipitation efficiency from the combined bulk leach liquor was calculated to be 99.9%. However, during washing of the AMV solids, some AMV re-dissolved. A final product, assaying 41.6% V and only 0.09% Si, was produced. Table 13.3.4_15 shows precipitation recovery and AMV assay. Further work is required to investigate methods to minimize soluble vanadium losses.

Table 13.3.4_15

AMV Precipitation Recovery and Analysis (wt %)

V Recovery	Bulk AMV Product Analysis							
	V	Na	Si	Al	Ca	Fe	Mg	Ti
69	41.6	0.17	0.09	0.04	0.007	0.04	0.03	0.02

Source: SGS / Lakefield

13.3.5 AMV Calcination

The AMV calcination tests were performed by SGS. Four temperature conditions were tested. At the two higher temperatures of 450ºC and 500ºC, conversion to V_2O_5 was completed by the time the first sample was withdrawn at 2 h. There was no significant change from the 2 h results in the 4-, 6-, 12- or 24-h samples.

For the 400ºC calcination test, nitrogen concentration had decreased below detection limits at 2 h, but the vanadium concentration was only 93% (V_2O_5), while the weight loss was approximately 18%. While there was some variability from sample to sample in this test, there did appear to be some further weight loss after 2 h; this was corroborated by a further increase in percent V_2O_5. The results are presented in Table 13.3.5_1.

Table 13.3.5_1

AMV Calcination Results

Calcining Temperature, ºC	400	400	450	500
Time	2 h	Average[1]	Average	Average
Weight Loss, wt%	18	20	21	22
V2O5 in Calcine, wt%	93	95	97	99

[1] Average of remaining samples, 4 to 24 h.

AMV calcination tests showed that it was possible to calcine AMV to V_2O_5 in less than 2 h at temperatures above 450°C, but longer calcination times are generally used in industry depending on the AMV bed thickness.

Testwork of converting AMV to V_2O_5 was also performed by Mintek, South Africa. The assay of V_2O_5 produced is shown in Table 13.3.5_2.

Table 13.3.5_2 Analysis of V2O5													
Test by	Temp °C	Dur. hrs	Assay, wt%										
			V2O5	V	Si	Al2O3	Fe	CaO	K	Cr	NA	P	K2O + Na2O
SGS	450	4	98.40	55.12	<0.03	1.75	0.04	<0.20	<0.17	0.01	0.17	<0.01	0.42
SGS	500	4	99.50	55.73	<0.03	1.77	0.04	<0.20	<0.17	0.01	0.17	<0.01	0.43
Mintek	400	16	97.30	54.50	0.04	0.02	0.00	0.00		0.00		0.00	

Based on the data presented in Table 13.3.5_21, if this V_2O_5 material is used as feed to ferrovanadium production, the ASTM and ISO specifications for an 80% V ferroalloy may be met, provided that the levels of impurity elements in the other raw materials are sufficiently low.

The testwork to date concentrated on producing V_2O_5 which is the conventional route for producing ferrovanadium. No testwork was performed to simulate V_2O_3 production.

The feasibility study, however, was based on producing V_2O_3 as an intermediate product which would have been the feed for the production of ferrovanadium. The V_2O_3 route can save significantly on consumption of aluminum and other materials that are used in the ferrovanadium production, which means lower operating costs. The production of V_2O_3 from AMV is achieved through the use of relatively new technology, and no detailed information was available at the time of testwork. Technology and equipment required for producing V_2O_3 from AMV could be available from Drytech in South Africa. However, subsequently, Largo has decided to produce V_2O_5 and ferrovanadium as primary products. Accordingly, there are no current plans to produce V_2O_3 as an intermediate product.

13.4 PGM Testwork

A Platinum Group Metals ("PGM") scoping study program was undertaken by SGS on assay reject samples from the beneficiation testwork program in order to investigate the potential for PGM recovery. A head sample was taken which assayed 0.74 g/t platinum and 0.19 g/t palladium. A series of tests were carried out which included, flotation, magnetic separation, gravity, hot cyanide leach and platsol.

A series of six flotation tests were performed in order to examine rougher recovery. Several parameters were investigated which included residence time, reagent additions and grind size. From these tests optimum conditions were selected and two cleaning tests were performed. Flotation rougher recovery ranged from 51% to 70% platinum recovery and 51% to 65% palladium recovery. As a result of two-stage cleaning the platinum recovery achieved was 26% with a concentrate grade of 52 g/t platinum and a palladium recovery of 17% recovery resulting in a concentrate grade of 9 g/t.

It must be noted that one of the major issues with the cleaning test work was in the size of the sample. Due to the low amount of sulphides in the ore a rough mass pull of only 3% was achieved, insufficient to sustain proper froth stability. The results obtained are therefore unreliable.

In order to properly evaluate cleaning kinetics, a much larger sample is required. This can be achieved by either a pilot trial run or to a lesser degree, six or eight cycle, lock cycle tests using a 10 kg charge for each cycle. This would have a twofold effect, one it would enable a buildup of material in each cleaning stage and two it would become a closed circuit test with re-circulation of many tailing streams. Both factors would lead to an improvement in PGM recovery.

Other tests examined included magnetic separation, which was carried out on the whole ore. It was determined that over 80% of the PGM's were associated with the non-magnetics, thus leading to low recoveries. Also, gravity separation was performed on finely ground non-magnetic material. Recovery rates for both platinum and palladium were very low, with a platinum recovery at 2.5% resulting in a concentrate grade of 40 g/t, while palladium recovery was 0.3% with a concentrate grade of 1.7 g/t.

A series of hot cyanidation tests were performed on the whole ore. Recoveries for both platinum and palladium ranged from 8% and 78 % respectively. As a result of the low platinum recoveries it was decided to investigate Platsol. Whole ore samples were once again used as not enough flotation concentrate could be generated. Platinum and palladium recoveries in excess of 80% were achieved.

Due to the limited amount of testwork that was performed on the ore and the early encouraging results from Platsol process testing it is recommended that further development be done for PGM recovery with special attention to reagent conditions, grind size and flotation times. The results indicate that flotation, followed by Platsol, needs to be re-examined in greater detail.

13.5 Pilot Plant Testing (By Largo)

After completion of the Definitive Feasibility Study ("DFS") in 2010, at the request of the financing bank's technical consultant, a pilot scale program was initiated to prove the viability of producing vanadium from Maracás ore and to confirm the process data reported in the feasibility study. The testwork was done at Fundação Gorceix and involved obtaining a sample of the Maracás ore, beneficiating the ore to produce a vanadium concentrate and then roasting the concentrate in a kiln to convert vanadium into a soluble form.

The roasted concentrate was then leached in water to produce a vanadium solution that was further processed through de-silication and AMV precipitation steps. The AMV thus produced was then analyzed and calcined at SGS to produce V_2O_5. The complete process route has been described in the DFS.

It was not possible with available facilities to pilot the production of V_2O_3 and Ferrovanadium from AMV. Since these are state of the art technologies utilized by major FeV producers their exclusion from the pilot program was considered acceptable as long as the AMV produced is of acceptable quality.

Largo prepared three composite samples representing:

- massive high-grade mineralization - 800 kg from drill core;
- massive high-grade mineralization - 20 t from outcrop;
- disseminated low-grade mineralization.

Past testwork determined that the surface ore grind should be relatively coarse to minimize magnetic losses so it was decided to adopt a grind mesh of 150 microns instead of the 100 microns that was used in the DFS design criteria.

13.5.1 Beneficiation of Ore Samples at Fundação Gorceix

Approximately half of the total sample was fed into the beneficiation equipment which consisted of a ball mill, in closed circuit with a classifier, in which the fine fraction produced was fed onto a 1500 Gauss wet magnetic separator. The magnetic product from this separator was then fed onto an 800 Gauss magnetic separator as a cleaning stage.

The concentrate produced was 86% -150 micron in size, indicating that in the actual plant operation we would have lower energy consumption and smaller equipment as compared with the DFS design.

The results indicated that the quality of the 1500G magnetic product was sufficient without the need of a second stage 800G separator. Both reject and magnetic product from the 800G separator were therefore partially dried to around 3% moisture, and kept separate for re-combination before roasting. The materials were drummed and transported to Phoster in Belo Horizonte.

13.5.2 Davis Tube Testing of Low and High Grade Core Samples

Representative samples of high grade ore (800 kg) and lower grade disseminated ore (600 kg) were collected from cores at Maracás and shipped to Fundação Gorceix, for sizing to minus150 microns. Samples of the milled products, plus a blend of the two products in the ratio 57% high grade and 43% low grade, were prepared and sent to SGS for Davis Tube magnetic separation.

The concentrate produced during pilot plant testing indicated comparable quality and V yield to the concentrate produced at SGS from the high grade/low grade blend. Low grade ore on its own produces an acceptable concentrate quality, but the V yield is significantly lower than that obtained on high grade or blended ores.

Table 13.5.2_1 Davis Tube Testing Results				
	V in Ore %	**V in Concentrate %**	**SiO2 in Concentrate %**	**V yield to Concentrate %**
Pilot plant ore sample	1.51	1.92	0.8	90.9
Low grade core sample	0.41	1.81	2.23	68.3(*)
High grade core samples	1.14	2.01	0.96	96.5
Blend (low + high grade)	0.82	1.98	1.09	90.3(*)

(*) (The V yield of the blend is just a mathematical balance of the two yield from individual composites when taking their ratios into account.)

13.5.3 Kiln Roasting

The 800G concentrate and the 800G “reject” were carefully mixed along with 29 kg of Sodium carbonate which was added to each 500 kg batch of the mixed concentrate, equivalent to 5.48% Na_2CO_3 and then well mixed with the concentrate. The kiln was heated up over a period of 6 hours to give a refractory temperature at the discharge end of 1,000º C.

The lower temperatures (1150C) utilized during the trial run (below design conditions) affected vanadium recoveries that were lower than anticipated for a commercial operation. The calcined material exiting the kiln contained lumps that disintegrated very easily but no hard “fused” material was evident. Unlike some other operations the kiln runs did not experience any surface build up possibly due to the low levels of SiO_2.

13.5.4 Leaching

The results of the leaching tests are shown as follows:

Table 13.5.4_1 Leaching Test Results					
	Sample ID No	**Mass Ratio to Concentrate**	**V %**	**V2O5 %**	**Na2O %**
Concentrate to Kiln	Average	1.000	1.94	3.46	-
Kiln Feed inc. Na2CO3	calculated	1.050	1.93	3.44	3.04
Kiln Discharge due to loss of CO2	calculated	1.030	1.97	3.52	3.11
Leached Residue Sample1	Washed Res1	0.975	0.36	0.65	1.34
Leached Residue Sample 2	Washed Res2	0.975	0.32	0.58	1.39
Leached Residue Sample 3	LMAR00289	0.975	0.35	0.62	n/a
Leached Residue Sample 4	290-298	0.975	0.32	0.57	n/a
Average Leached Residue		0.975	0.34	0.61	1.37
% into Solution		3.210	83.00	83.00	55.00
Kiln Recovery Analyzed on Site			85.04	85.04	
Leach Recovery (calculated)			97.60	97.60	
Overall Kiln leach Recovery			83.00	83.00	

Other testwork was completed on the de-silication, precipitation and calcination aspects of the process.

The general conclusion reported by Largo was that recoveries achieved on the pilot plant are lower than the ones reported in the DFS. In particular the kiln recovery in the DFS is reported at 95% whereas in the pilot plant the recovery was 85%. The small kiln used in the pilot tests was not optimized for achieving high vanadium recoveries indicating that greater than 85% values could be obtained with actual commercial size equipment.

De-silication and precipitation recoveries achieved should also be expected in actual plant operation. Reagent consumptions experienced in most areas were lower than the ones adopted for the DFS. Flocculent and sodium hydroxide may not be required.

It is noted that the pilot plant report used as basis for this subchapter 13.5 includes summary results of the unit operations as analysed, interpreted (some calculated) and reported by Largo. No independent analysis was made of the “raw” data produced from the program.

14 MINERAL RESOURCE ESTIMATE

The original 2006 resource estimate, a Gemcom® database for the Campbell vanadium deposit had been created from hard copies of the old drill logs and assay certificates. All the original coordinates from previous operator's programs were changed from a local grid to a UTM grid. The collars for all drill holes and trenches were also converted to UTM coordinates.

The 2007 database contains complete assays for V_2O_5 and TiO_2 as well as more extensive results for PGMs than were available for the 2006 estimate. The TiO_2 assay results are significant, often greatly exceeding 10%.

A total of 97 drill holes and 21 trenches were manually entered into Excel spreadsheets then imported into the Gemcom® database. The database was validated with Gemcom's internal validation tools and double checked with hard copies of original data. The drill-hole workspace in the Gemcom® database included different tables for the drill-hole and trench data.

In early 2012, 13 additional drill holes (FGA-100 to FGA-112) were drilled and the Gemcom database was updated.

Down-hole survey data were available only for longer holes (more than 300 m in length). This was not considered to be a serious problem, as the other holes are generally quite short. Drill hole collar surveys were available and several of their surveys had been checked by Largo. More complete survey data were available, in intervals, for the trenches.

In 2012, Largo retained Micon International Limited (Micon) to audit and accept responsibility for a Mineral Resource estimate for the Campbell deposit**.**

In addition, Largo retained Coffey Mining Pty Ltd (Coffey Mining) to prepare Mineral Resource estimates for the Satellite Deposits. These estimates are also presented in this report.

The Campbell deposit, as outlined from the drill programs, now extends 400 m along strike, and to a vertical depth of over 350 m with true widths ranging from 11 to 100 m and with an average width of about 40 m. This deposit is part of a mineralizing system that extends for 6.5 km along the length of the Property. All the assays from this drill program are completed and results received.

A three-dimensional block model was generated to enable grade estimation. The selected block size was based on the geometry of the domain interpretation and the data configuration. The block size of 5 m E by 5 m N by 5 m RL was selected. The "percent" block modeling technique was used to represent the volume of the interpreted wireframe models. Sufficient variables were included in the block model construction to enable grade estimation and reporting.

Resource estimation for all of the Maracás vanadium deposits were undertaken using ordinary kriging (OK) as the principal estimation methodology for V_2O_5. The OK estimates were completed using Gemcom® mining software.

The following list of variables are contained in the received block model data:

- Lithology code;
- Bulk density assigned by lithology-type constant values (t/m^3);
- Vanadium pentoxide in percent (%V_2O_5);
- Titanium dioxide in parts per million (TiO_2 ppm);
- Palladium grade in parts per million (Pd ppm);
- Platinum grade in parts per million (Pt ppm);
- A class code to distinguish Measured, Indicated, and Inferred resource blocks.

The Company has completed a revised block model and mineral resource estimate for the existing Campbell deposit and the Satellite Deposits incorporating the drilling from the 2011 program including 72 holes totaling 13,401 m. The Satellite Deposits which extend north from Campbell for eight kilometres include from south the north: Gulçari A Norte, Gulçari B, São José, Novo Amparo and Novo Amparo Norte. All are hosted in the Jacaré River Intrusion.

In 2016, Largo updated mineral resource estimate for the Campbell deposit by depletion of mined resources This Measured and Indicated resource was used to update the reserve and used for the new mine plan presented herein. The new block model incorporates % magnetics (percent of magnetic minerals in the mineralized rock) and magnetite concentrate grade for V_2O_5 and SiO_2. No new drilling was available for the estimate; however, it was adjusted for mining completed to date. The updated mineral resources for Campbell is presented in Table 14.1_1.

Table 1.4_1

Campbell Mineral Resources

Maracás Vanadium Project –Campbell Mineral Resources

Effective date: May 02nd 2017

Category	Tonnes (Mt)	V2O5 Head Grade (%)	V2O5 Contained (kt)	V2O5 in Concentrate (%)	Magnetics (%)
Measured (M)	18.08	1.19	215.0	3.19	30.55
Indicated (I)	1.70	1.28	21.7	3.12	34.64
M&I	19.78	1.20	236.7	3.19	30.90
Inferred	1.65	1.20	19.8	3.10	33.08

Resource within a pit shell using US$34.20/t all in operating cost and reported at a 0.45% V_2O_5 cut-off, reviewed and confirmed by Fabio Valério Xavier (GE21).

The % magnetics number refers to the percent of magnetic minerals contained in the mineralized rock. It is used to help determine the portion of the mineralization in the mineral resources containinig magnetite of sufficient vanadium content and silica of low enough content to be processed through the magnetic separators and concentrated, and, therefore, can be determined to be a mineral reserve.

No new drilling has been completed on the Satellite Deposits since 2012 and the mineral resources presented in Table 14.1_2 are considered to be current.

Table 14.1_2

2013 Satellite Deposits Mineral Resource

Effective Date May 2nd 2017

Deposits	Category	Tonnes (kt)	V2O5 (%)	Contained V2O5 (tonnes)
Gulçari A Norte**	Inferred	9,730	0.84	81,388
Gulçari B**	Inferred	2,910	0.70	20,312
Novo Amparo**	Inferred	1,560	0.72	11,255
Novo Amparo Norte**	Inferred	9,720	0.87	84,453
Sao Jose**	Inferred	3,900	0.89	34,706
Satellite Deposits (Total)**	Inferred	27,820	0.83	232,114

** Resource within a pit shell using US$34.20/t all in operating cost and reported at a 0.45% V_2O_5 cut-off, reviewed and confirmed by Porfirio Cabaleiro Rodriguez (GE21).

14.1 Responsibility for Estimation

The 2015 mineral resource estimate presented in this report was prepared with technical input from Largo staff on site at the Maracás Menchen Property. The mineral resources and methodology employed to estimate them have been reviewed, and overall responsibility for them has been accepted by Fabio Valério Xavier, MAIG.

The mineral resource estimate for the Campbell deposit was updated in March 2015 to include the results of most recent drill holes and a reinterpretation of the unmineralized pegmatite dykes cutting the deposit. Other than the inclusion of the new variables, the amended geological model and the minor changes noted throughout Section 14 which changes tonnage and head grade are minor. The 2017 mineral resource results have been reviewed and overall responsibility for them accepted, by Fabio Valério Xavier MAIG.

14.1.1 Summary of QP opinion

One of the authors of this ITR, Mr. Rodriguez, has been involved on and off with the Project since the 1980´s, while working for Paulo Abib Engenharia, a well known consulting firm in Brazil at the time, then through working for Odebrecht which prepared one of the first resource estimation of the Campbell deposit. Mr. Rodriguez then acted as principal Geostatician for Coffey for the resource estimation in the Satellite Deposits and also maintained contact with the Micon personnel allocated to the 2016 Report.

GE21, having reviewed the data for the Project, including the site visit, and the previous reports, relied on the database used for the estimation work.

GE21, as concluded by Micon, also accepts that the Maracás database is suitable for use in the mineral resource estimate reported herein. GE21 also agreed with Micon's recommendation that Largo proceed with planned check drilling and to continue re-assaying of historical drill core for PGMs.

The Block Models, made available by Largo to GE21, were received in both Gems Gemcom and Gems Surpac format, were update according the newest topographic survey, dated May 2, 2017, and were validated against the drill holes and sample databases, and GE21 found the models to be accurate and confirm that they adequately represent mineral resources for the Project.

15 MINERAL RESERVES ESTIMATES

Mineral reserves for the Project have been estimated for the Campbell, which with respect to reserves and production with an effective date was based on the topography of May 02, 2017. The ultimate pit and mine plan was guided by the Whittle optimization work completed by GE21. The mine plan developed in this report is based on Measured and Indicated resources only as delineated in Section 14.

Reserves are reported using a sales price of $ 6.34/lb of V_2O_5., as first principle, since the Revenue Factor, for the selected pit on Whitlle run presented a factor of 0.4, giving a character conservative to these figures.Details of the assumptions, parameters and methods used in the preparation of the reserve estimate and mining schedule are presented in Tables 16.1 through 16.7, and as described in Section 16 (below).

The mineral reserves presented in Table 15_1 were estimated by Porfírio Cabaleiro Rodriguez of GE21, who is a qualified person under NI 43-101 and a Member of the Australian Institute of Geoscientists.

Table 15_1
Maracás Vanadium Project Mineral Reserves – Campbell pit
Block dimentions 5x5x5 (m)
Mine Recovery 100% - Dilution 5%
(Effective Date – May 02, 2017)

Category	Tonnage (kt)	%V2O5 Head	%Magnetics	%V2O5 con	V2O5 Contained (kt)
Proven	17,57	1.14	29.66	3.21	167.3
Probable	1,44	1.26	33.89	3.20	15.6
Total in pit Reserve	19,010	1.15	29.98	3.21	182.9

16 MINING METHODS

16.1 Introduction

The Maracás Vanadium Project is an open pit operation utilizing a contract mining fleet of hydraulic excavators, front-end loaders and 36 tonne haul trucks. Largo provided GE21 with an internally prepared percent model resource, updated to May 02nd 2017 topography. This "percent" model was transformed into a standardized block model. The mine planning model adopted is considered to be a "diluted" model, adding approximately 5 % dilution to the source model.

The disposal of waste rock, and low grade mineralized material will be executed on an area close to the pit. The site shall be adequately prepared to include drainage at its base and channels to direct the flow of water with the aim of aiding geotechnical stability and mitigating the erosion of the stockpiled material.

The operation of this phase, in accordance with the ascending method, shall begin during the construction of the heap at the base of this area. Waste rock will be disposed by truck, which will then be uniformly distributed and leveled by an operator using a tractor. The procedure is then repeated, stacking another bank above the original one, while maintaining a ramp for the trucks to be able to access the area.

16.2 Geothecnics and Hidrogeological

GE21 received from Largo, per the guidance of its geotechnical consultant, the definition of a single angle of 70º interramp for the final pit. For operational purposes GE21 considered the general angle of 60º for pit optimization exercises.

Due to its location in the arid region, there were no studies of groundwater interference in the pit optimization.

16.3 Pit Optimization

The development of the optimal pits was based on:

- The determination of the economic and geometric parameters in order to define the benefit function, legal and proprietary restrictions;
- A calculation of the nested optimal pits using Geovia Whittle 4.3 software;

The economic and geometric parameters were provided by Largo.

The determination of the geometry of the optimal pits was executed through the generation of an optimal sequence of *pushbacks*, which correspond to increments in the geometry of the pit resulting from the repeated use of the three-dimensional Lerchs & Grossman algorithm for different values of blocks that are obtained by varying the price of the product through the use of a revenue factor.

This sequence of pit expansions, or pushbacks, is the basis of open pit mine planning when using Whittle *software*, which projects the evolution of the geometry of the pit over time. The evolution of the mining process over time can be simulated with two criteria: the maximizing route or the stationary route. The first attempts to maximize the operation's financial returns based on a sequence of pushbacks that optimize the cash flow; the latter aims to maintain the processing plant feed material parameters constant.

The sequence of optimal pits was obtained by varying the revenue factor from 10% to 120% with respect to the product's selling price. To determine the evolution of the pits over time, an annual production scale of 1.9Mtpa of ROM was established, at an Annual Discount Rate of 8%. The optimal pit for the LOM was selected based on the stabilization of NPV near 95% of the maximum. The table 16.3_1 presents the pit optimization parameters and at Figure 16.3_1 are showed the evolution of optimization pushbacks resulting graph with the choosen pit highlighted.

Table 16.3_1

Pit Optimization Parameters

Inputs	Unit	Value
Exchange rate	R$/US$	3.30
Sell Price	US/lbV_2O_5	6.34
Discounted rate	%	8
Mining recovery	%	100
Dilution	%	5
Slope Angle	Degrees	60
Metallurgical yeld	%	76
Product grade	%	99
V2O5 grade cut-off	%	0.45
Mine Cost	US$/t ROM	1.8
Process	US$/t ore fed	34.76
SG&A	US$/lb V_2O_5	0.69

Figure 16.3_1

Pit Optimization Results Graph – NPV

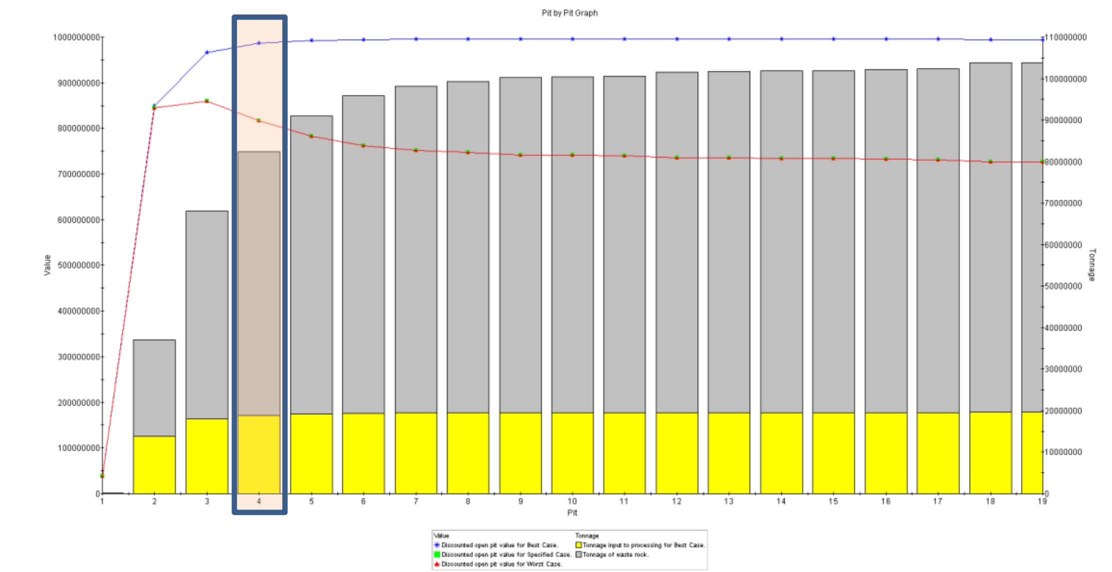


Table 16.3_2 shows the optimal pit results, where the chosen Pit 3is highlighted and following Figure 16.3_2 shows a 3D representation of the selected pit.

Pit 3 is related to a Revenue Factor of 0.4, that means the actual price used for this optimum pit is 2.4US$/lb, or 40% of the original price used as parameter

Table 16.3_2

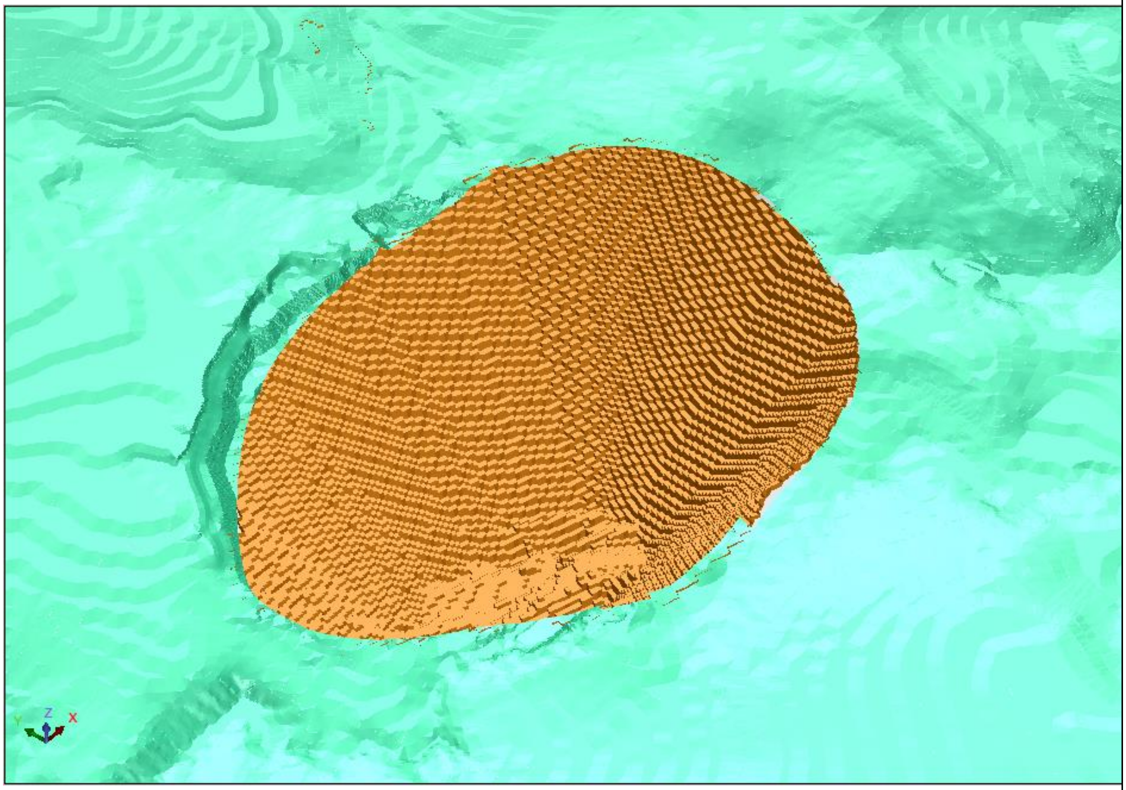
Pit Optimization Results Table– NPV

Pit	Maximum Rev Ftr	Rock Tonnes (Mt)	Ore Tonnes (Mt)	Strip Ratio	V2O5 Grade (%)	SIO2 Grade (%)	MAG Grade(*) (%)
1	0.2	0.22	0.20	0.09	4.13	1.7	55.04
2	0.3	37.09	13.77	1.69	3.24	3.58	32.86
3	0.4	67.99	18.00	2.78	3.2	3.62	32.22
4	0.5	82.36	18.84	3.37	3.2	3.61	32.46
5	0.6	90.91	19.21	3.73	3.2	3.61	32.55
6	0.7	95.78	19.36	3.95	3.19	3.6	32.61
7	0.8	98.03	19.45	4.04	3.19	3.61	32.58
8	0.9	99.25	19.49	4.09	3.19	3.61	32.57
9	1	100.17	19.52	4.13	3.19	3.61	32.56
10	1.1	100.41	19.53	4.14	3.19	3.61	32.55
11	1.2	100.58	19.53	4.15	3.19	3.61	32.55
12	1.3	101.47	19.55	4.19	3.19	3.61	32.54
13	1.4	101.62	19.55	4.2	3.19	3.61	32.53
14	1.5	101.77	19.56	4.2	3.19	3.61	32.54
15	1.6	101.88	19.56	4.21	3.19	3.61	32.54
16	1.7	102.17	19.56	4.22	3.19	3.61	32.53
17	1.8	102.26	19.56	4.23	3.19	3.61	32.53
18	1.9	103.72	19.59	4.3	3.19	3.61	32.52
19	2	103.78	19.59	4.3	3.19	3.61	32.52

(*) MAG Grade refers to magnenétic recovery on Davis Tube

Figure 16.3_2

Perspective view of the Selected Optimal Pit



16.4 Mine Design

The Mine Design or Pit Design, consists of projecting, based on an optimal pit, an operational pit that allows for the safe and efficient development of mining operations.

The methodology consists of establishing an outline of the toes and crests of the benches, safety berms, work sites and mining site access ramps while adhering to the geometric and geotechnical parameters that were defined. The assumptions that were adopted for the operationalization of the final pit shells for each period of mining were:

- Minimize the ore mass loss;
- Define the access routes to attain shorter average transport distances.

Table 16.4_1 presents the geometric parameters that were adopted to develop the mine design for each end of period. Figure 16_4.1 shows the final pit design and the table 16.4_2 presents the Final Pit Design results.

The operational parameters were defined as current Largo operations.

Table 16.4_1 Mine Design Parameters		
Description	**Units**	**Value**
Two Lane Ramp Width	m	15
Ramp Grade	%	10
Bench Face Angle	degrees	85
Pit Slope	degrees	60
Final Wall Bench Height	m	20
Ore Intermediated Height Bench	m	5
Waste Intermediated Height Bench	m	10
Berm Width	m	5

Figure 16.4_1

Campbell- Final Pit Design

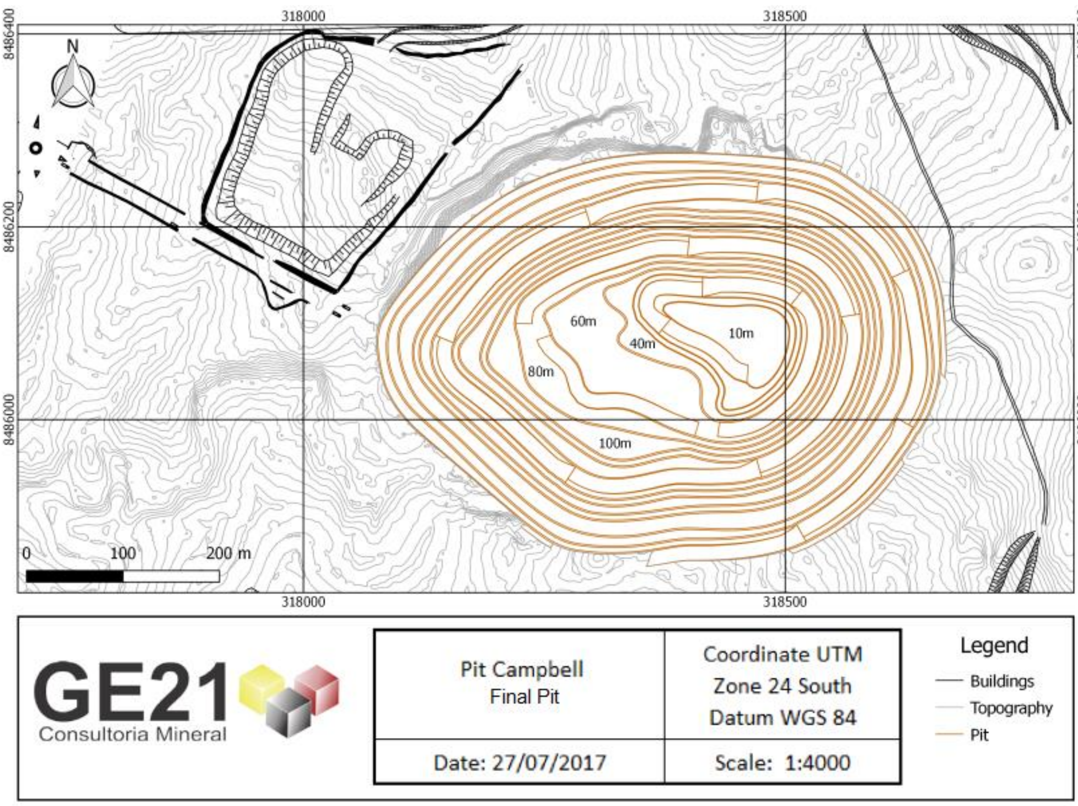


Table 16.4_2 presents the pit design results.

Table 16.4_2 Maracás Vanadium Project Campbel Pit Mine Design Results				
Ore Class	**Tonnage (kt)**	**%V2O5 Head**	**%Magnetics**	**%V2O5 con**
Proven	17,570	1.14	29.66	3.21
Probable	1,440	1.26	33.89	3.20
Total ore	19,010	1.15	29.98	3.21
Waste	60,270			
Total in-pit Reserve	79,280			
Strip Ratio (w/o)	3.17			

16.5 Mine Schedule

The mine production scheduling for the Campbell pit was generated in GEOVIA Minesched™ 6.1.1.as summarized in Table 16.5_1. The production for the first year was limited in 6 benchs (at ore) and limited by environmental restriction.

Table 16.5_1
Mine Production Schedule

Tonnes	Ore (Mt)	Stokpile (Mt)	Ore+STK (Mt)	Waste (Mt)	SR (t/t)	V_2O_5 (%)	SiO_2 (%)	Mag* (%)	V_2O_5 Con** (%)	SiO_2 Con** (%)
2017	1.04	-	1.04	3.79	3.64	0.96	34.39	22.98	3.29	5.01
2018	1.50	-	1.50	5.62	3.75	1.17	29.70	30.65	3.23	4.16
2019	1.71	-	1.71	7.28	4.26	1.16	28.61	30.40	3.15	4.02
2020	1.93	-	1.93	7.87	4.08	1.18	28.03	30.16	3.16	4.32
2021	1.87	-	1.87	9.08	4.86	1.19	26.75	30.74	3.29	2.97
2022	1.91	-	1.91	7.76	4.06	1.13	27.89	30.43	3.20	3.63
2023	2.01	-	2.01	7.23	3.60	1.05	28.79	29.30	3.14	3.68
2024	2.06	-	2.06	6.85	3.33	1.01	29.31	29.22	3.06	3.57
2025	1.80	0.08	1.88	2.05	1.14	1.12	28.09	29.25	3.17	3.43
2026	1.73	0.01	1.74	1.99	1.15	1.28	25.95	32.08	3.26	3.01
2027	1.45	-	1.45	0.69	0.48	1.55	20.15	39.00	3.42	2.83
2028	-	0.63	0.63	-	-	0.69	36.60	13.00	3.43	4.64
Total	**19.01**	**0.72**	**19.73**	**60.21**	**3.17**	**1.16**	**28.10**	**29.92**	**3.21**	**3.68**

*Mass Recovery in magnetic concentration
**Grades in magnetic concentration

The End of Period for years 1,2,3,5,10 and 11 contours were operationalized, using the pit design parameters, and the result of this are shown in the figures 16.5_1 to 16.5_6 below. In Table 16.5_2 are shown the movement estimates for of these periods.

Table 16.5_2

Mining Schedulling for Campbell Mine

5% Dilution

Period	Waste (Mt)	Ore (Mt)	$\%V_2O_5$	$\%SiO_2$	%Mag	$\% V_2O_5$ Conc	$\%SiO_2$ Conc
1	3.69	1.17	0.95	34.43	22.10	3.25	5.22
2	5.07	1.25	1.36	26.60	33.29	3.32	3.58
3	6.91	1.60	1.20	27.82	29.92	3.19	3.65
5	17.26	3.99	1.14	27.84	28.65	3.18	3.82
10	26.43	9.74	1.11	28.16	29.48	3.17	3.47
11	0.96	1.27	1.60	20.14	43.34	3.42	2.83

Figure 16.5_1

Campbell-Year 01

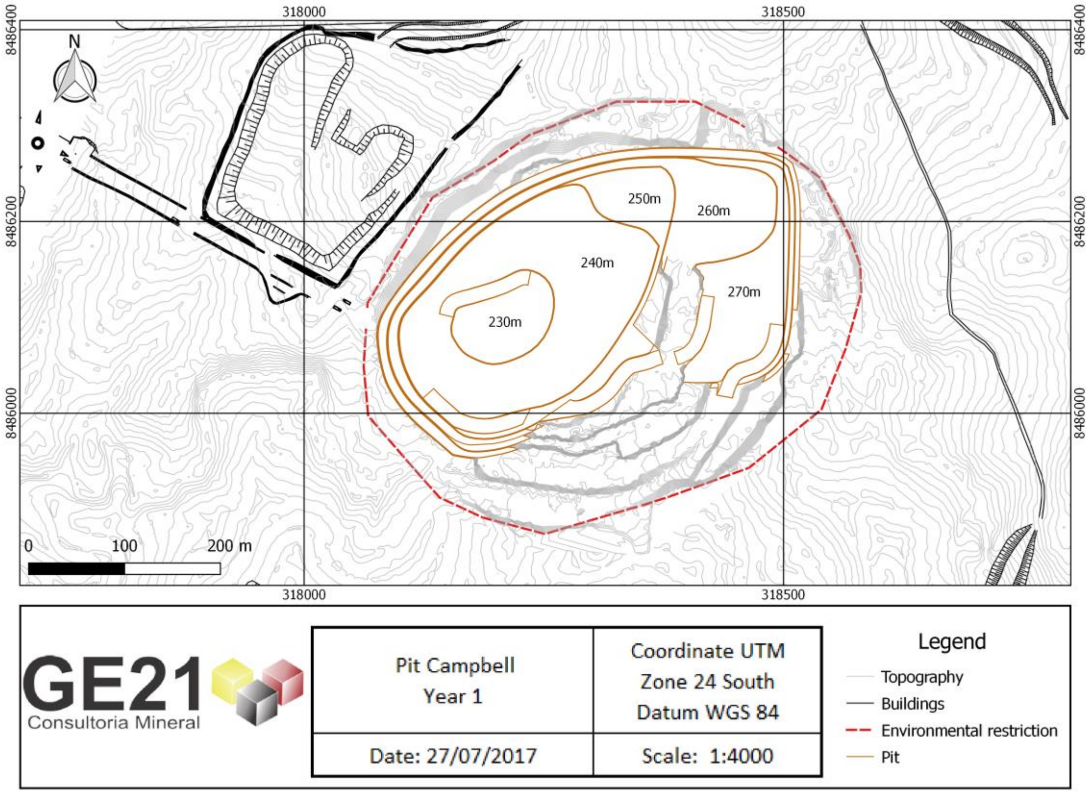


Figure 16.5_2

Campbell-Year 02

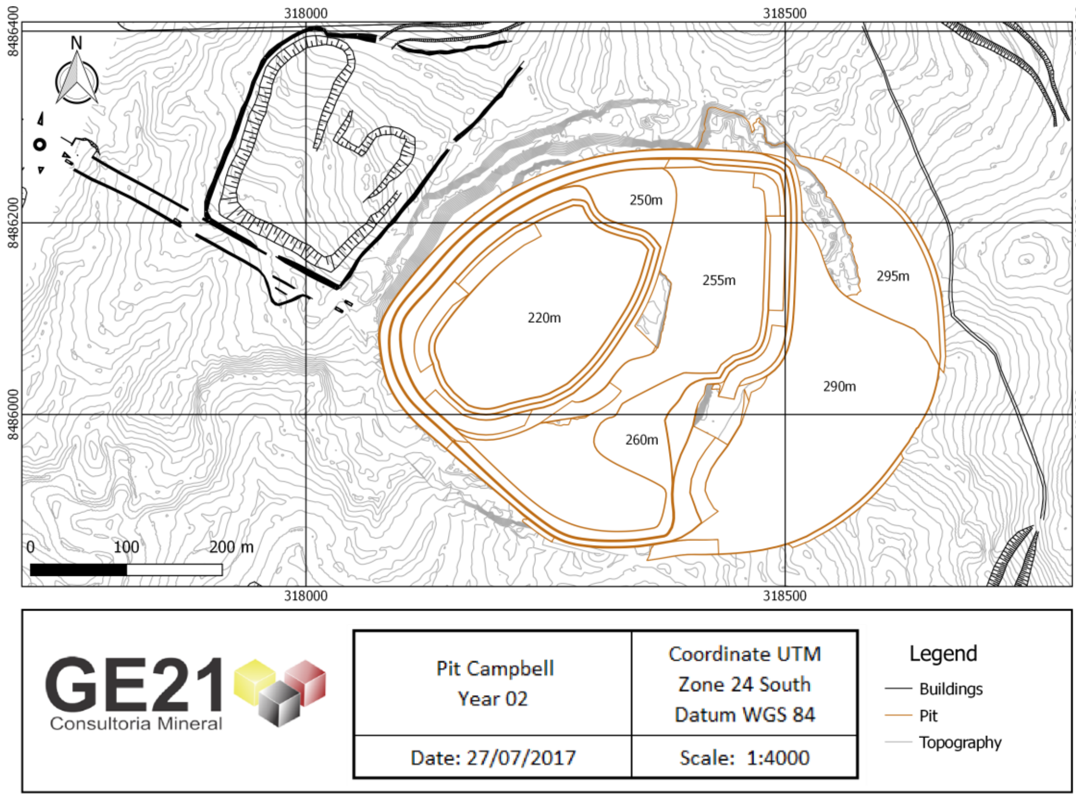


Figure 16.5_3

Campbell-Year 03

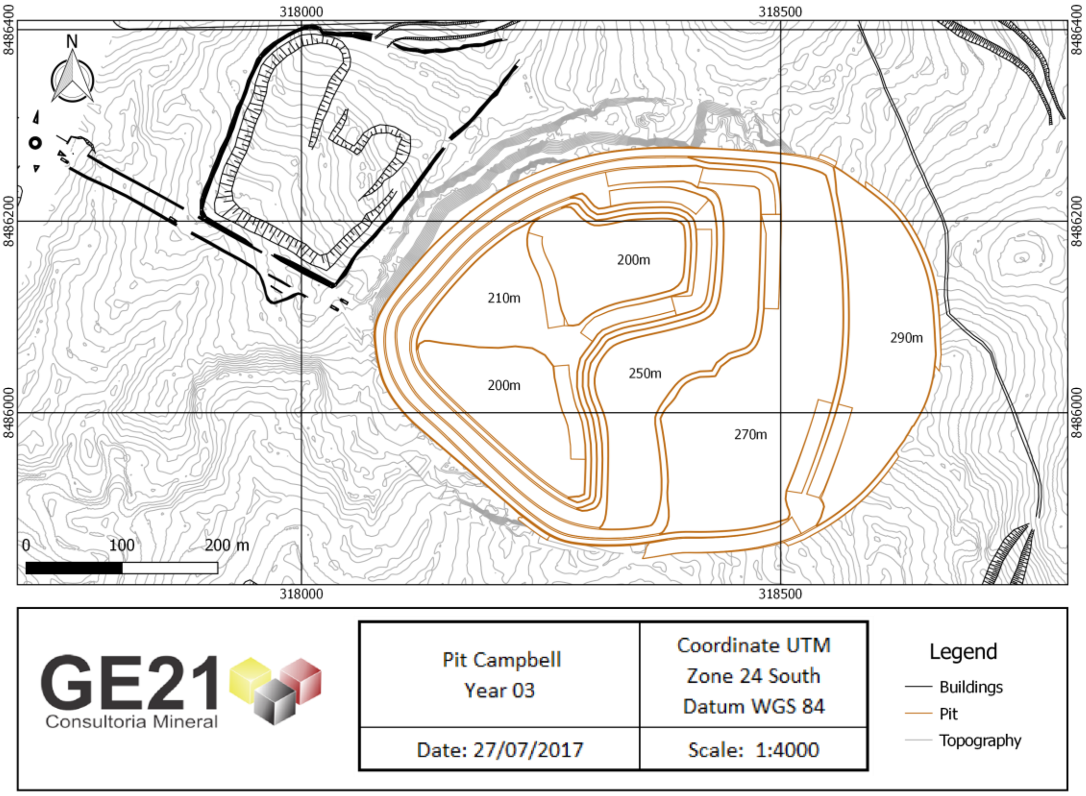


Figure 16.5_4

Campbell-Year 05

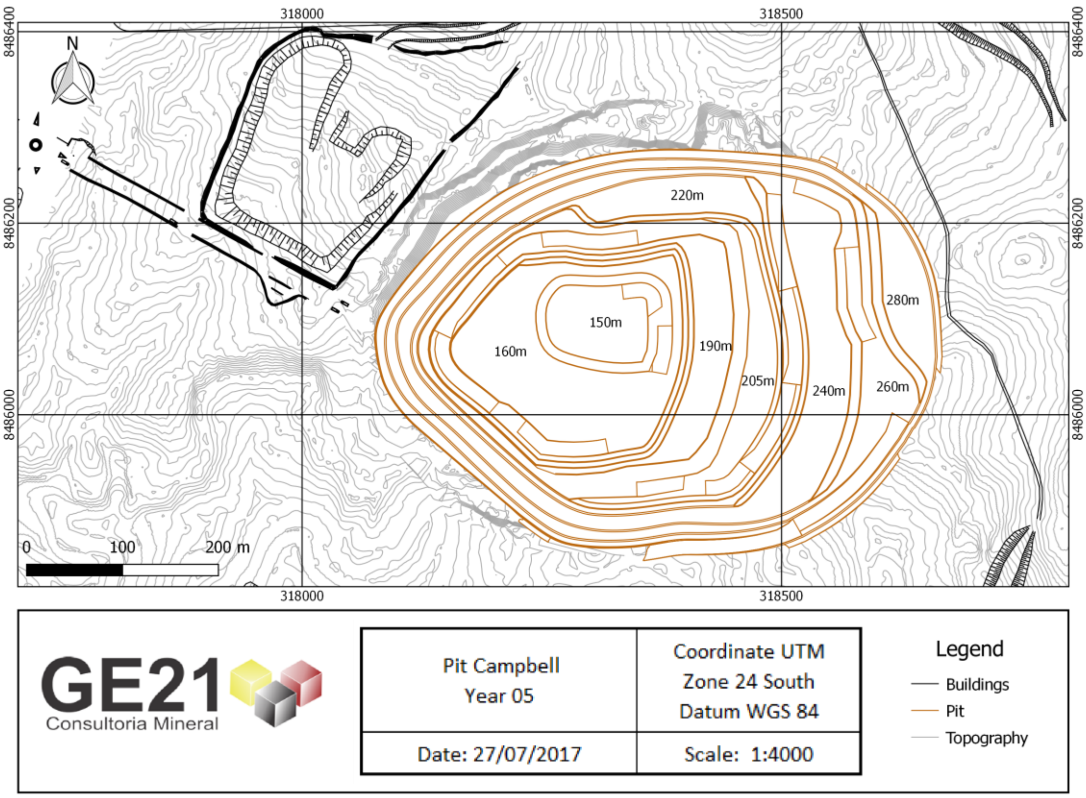


Figure 16.5_5

Campbell-Year 10

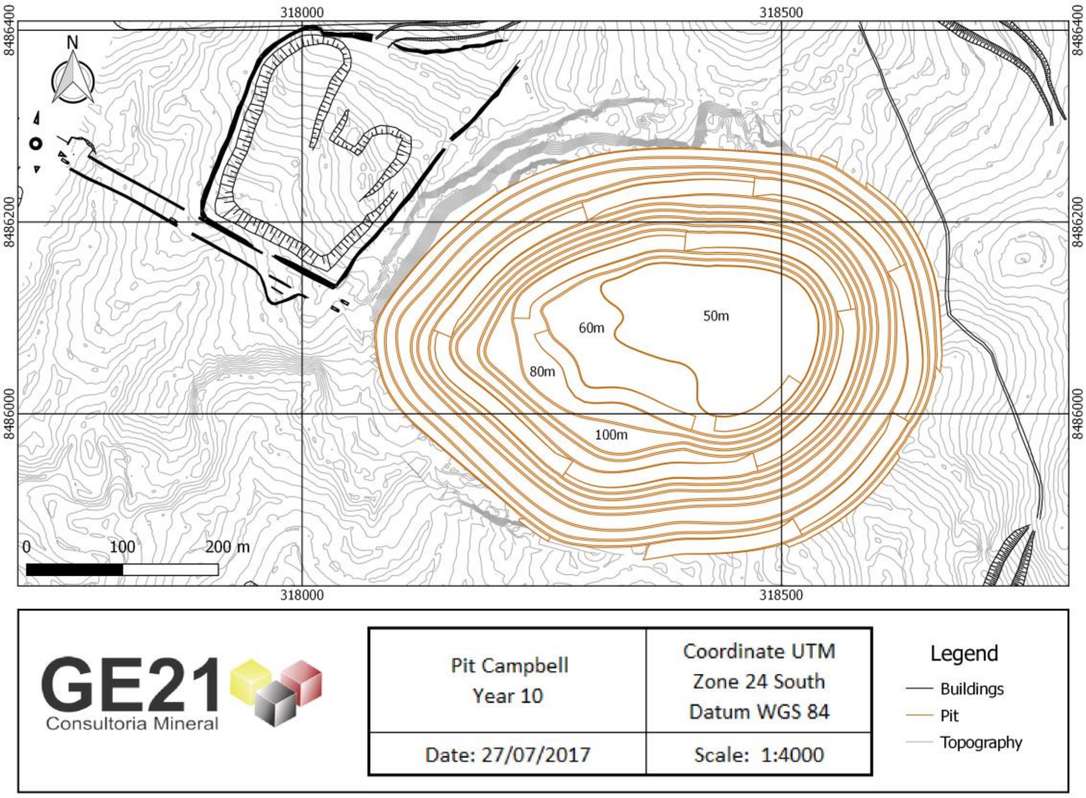
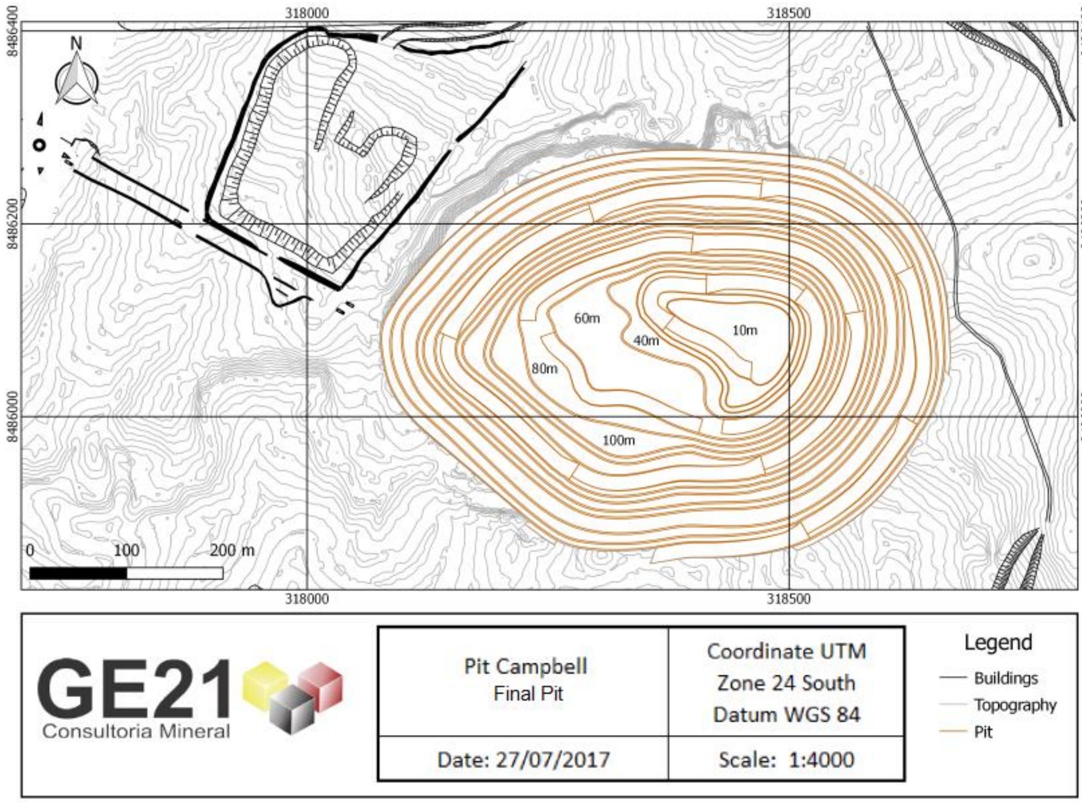


Figure 16.5_6

Campbell – Final Pit

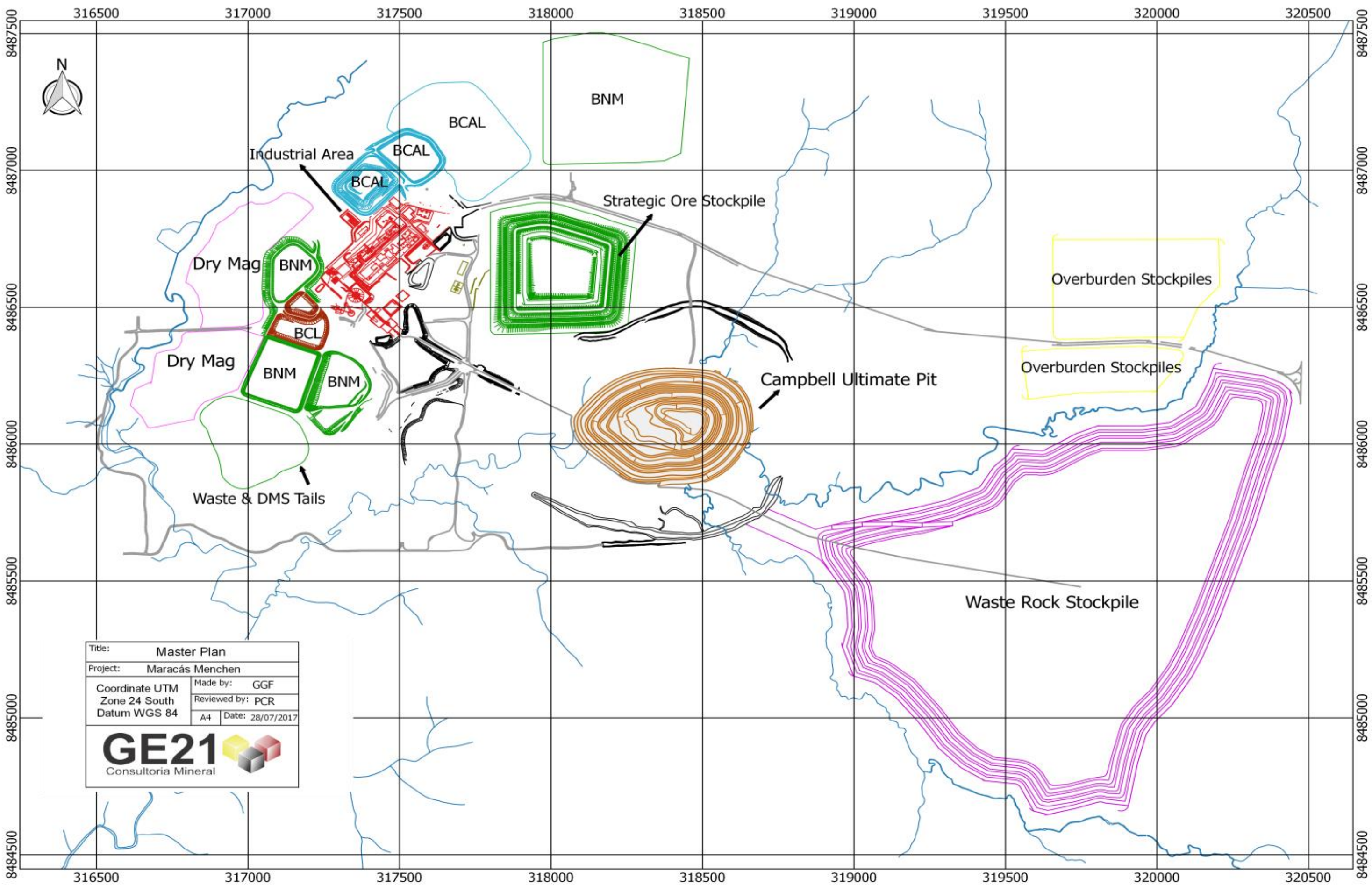


16.6 Mine Layout

Figure16.6_1 presents Maracás Project Site Layout for the Campbell mine facilities.

Figure 16.6_1

Maracás Project Site Layout - Campbell mine facilities



16.7 Mining Fleet Dimensioning

Currently, Largo has a mining fleet contract with Fagundes Construção e Mineração Ltda., which consists of 3 CAT 336 hydraulic excavators equipped with a 2.5 m^3 bucket and a total of 22 Mercedes Benz 36-tonne capacity trucks. The contract drilling fleet consists of three Sandvik Ranger DX800 rotary drill rigs. A fleet of ancillary equipment is also available for mine maintenance and eventual plant services.

GE21 has estimated the required yearly mine fleet to achieve the mine schedule and the results are shown at Figures 16.7_1 to 16.7_3 below.

Table 16.7_2
Yearly Required Mine Excavator Fleet

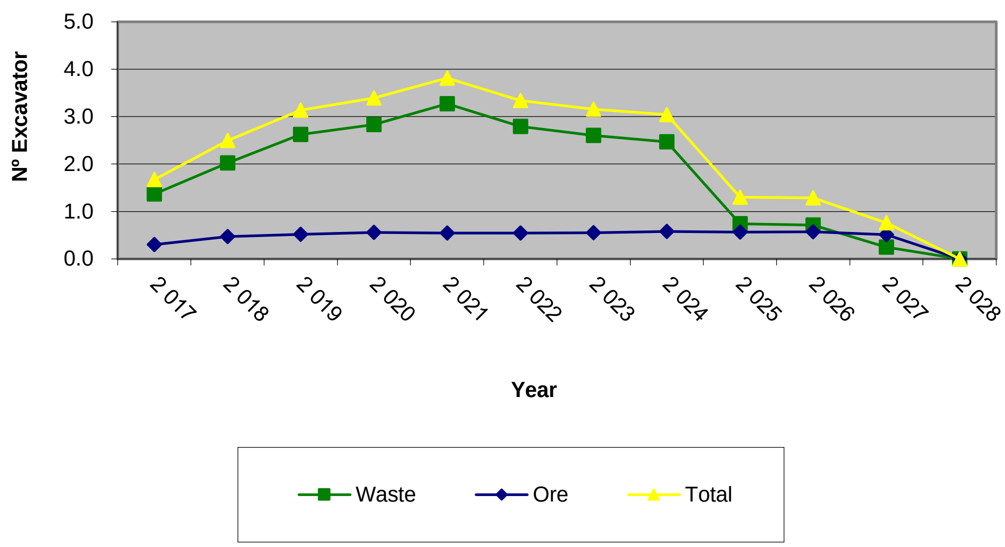


Table 16.7_1
Yearly Required Mine Truck Fleet

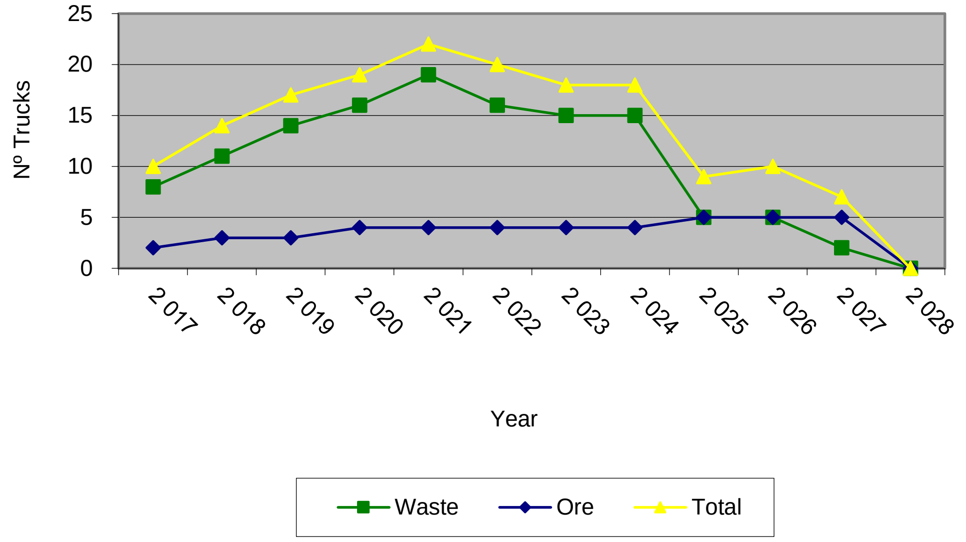
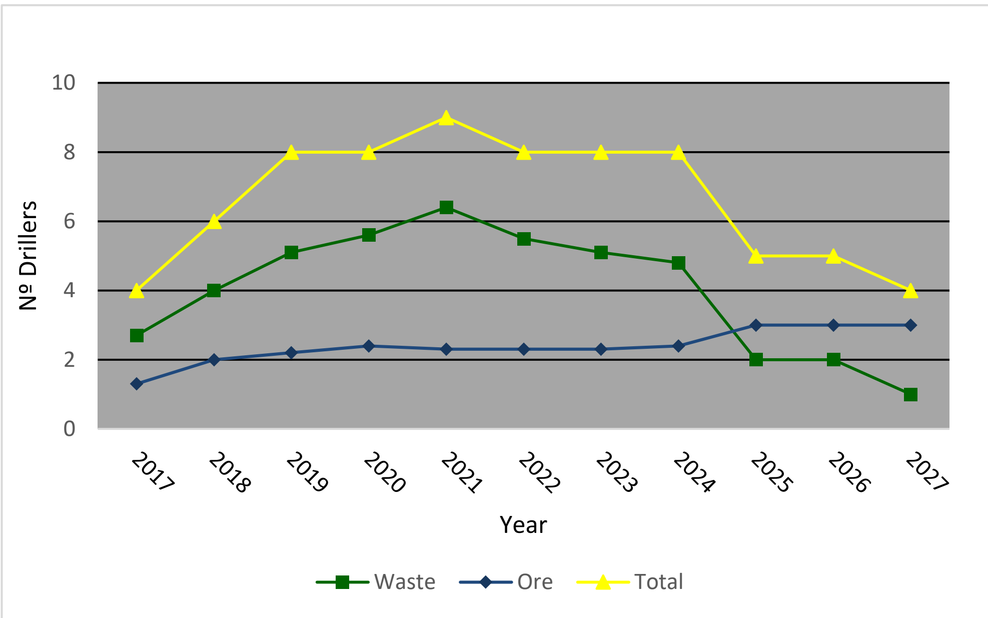


Table 16.7_3
Yearly Required Mine Drillers



17 RECOVERY METHODS

The Maracás vanadium recovery plant was commissioned in 2015 and has been in start-up mode for much of that time ramping up to near design capacity. At the time of writing this report, the plant produces up to 9,360 t of V_2O_5 equivalent per year with a trend approaching design capacity. Except for unanticipated downtime and subject to completion of the two expansions contemplated herein, production is expected to reach 13,200 t/a V_2O_5 in 2020.

The current process flow sheet comprises three stages of crushing, one stage of grinding, two stages of magnetic separation, magnetic concentrate roasting, vanadium leaching, ammonium meta-vanadate (AMV) precipitation, AMV filtration, AMV calcining, and fusing to V_2O_5 flake as final product.

Originally sized to process 960,000 tpy run of mine (ROM) the plant will be capable, after due modification, to process 1,900,000 tpy of feed ore with an average grade of 1.14% V_2O_5 and produce 9,600 t/y V_2O_5.in 2017. In 2020 after completion of two expansions it is expected that the Project will produce 13,200 t/y V2O5 the plant is designed to operate 365 days per year, 7 days/week, and 24 hours/day with an on-stream factor of 85%.

Overall recovery from ore for V_2O_5 has reached 76.5% during Q3 2017, and is expected to reach 76% over the life of mine.

17.1 Process Description

A simplified process flow diagram to produce vanadium pentoxide is presented in Figure 17.6_1, a simplified mass balance is presented in figure 17.6_2.

Figure 17.6_1

Conceptual Process Flow Sheet - Vanadium Pentoxide

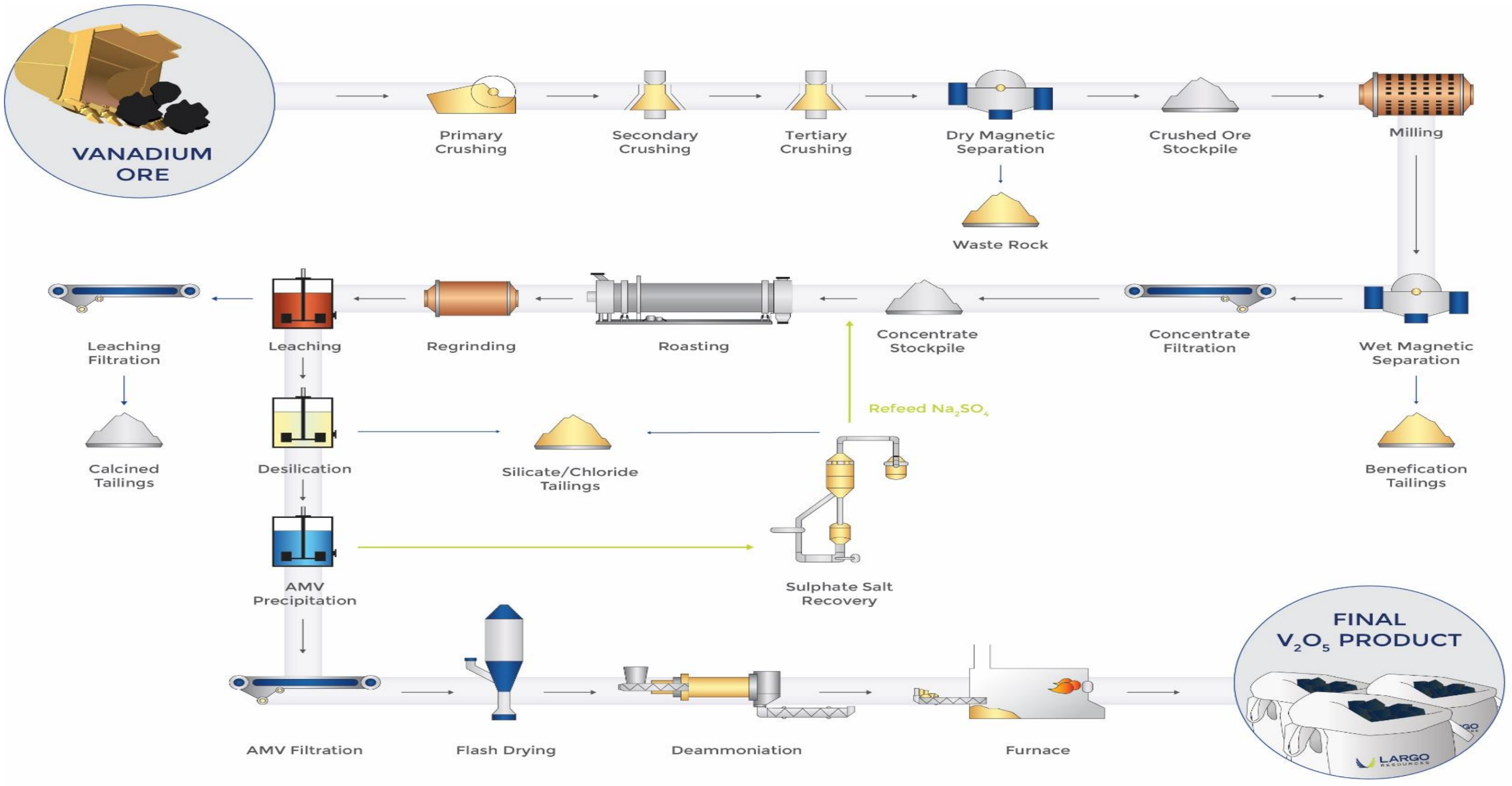
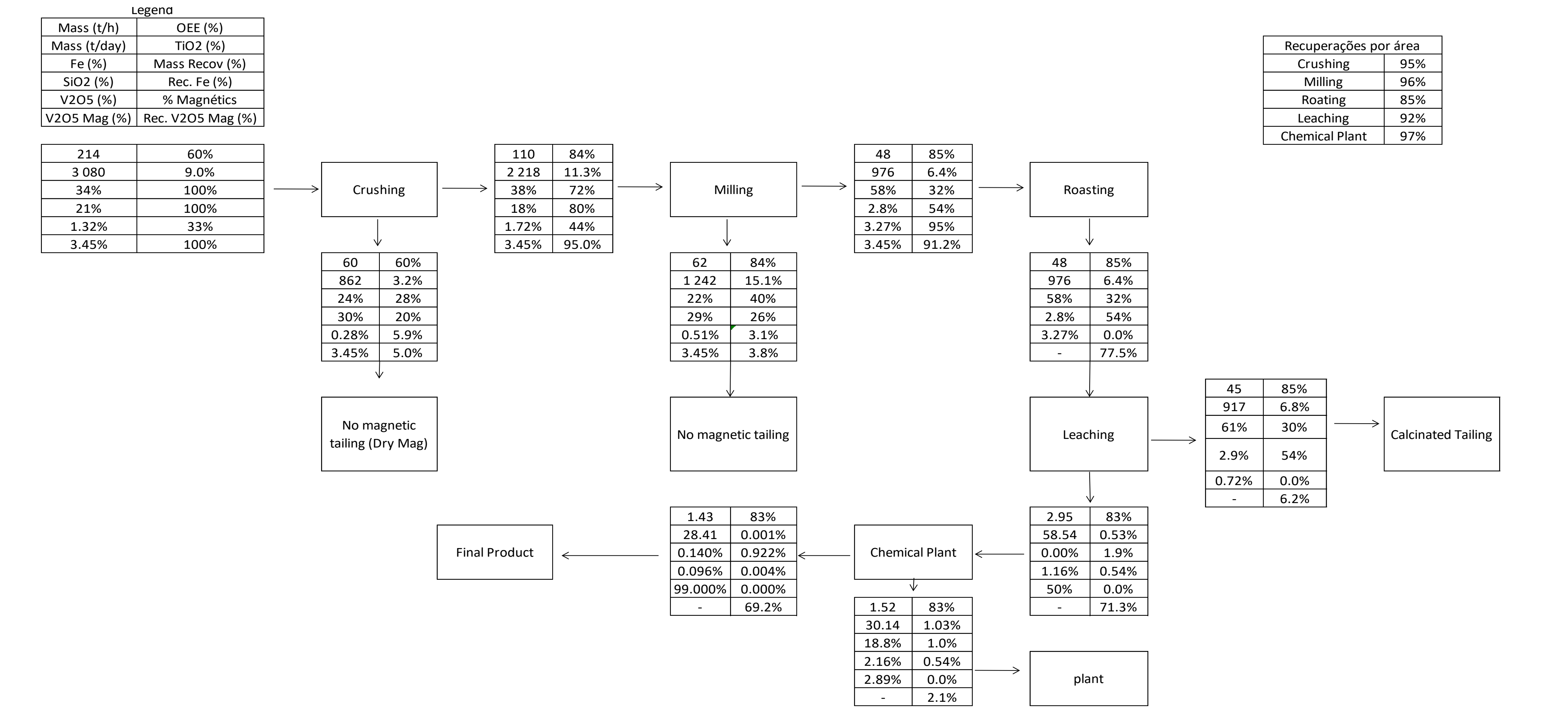


Figure 17.6_2

Conceptual Mass and Metallurgical Balance - Vanadium Pentoxide



17.2 Crushing and Grinding

The ore is crushed via a three-stage crushing circuit comprising a primary jaw crusher, a secondary cone crusher and a vibrating sizing screen. The fine crushed product is fed to a 4,200-m^3-capacity stockpile from which it is withdrawn at a controlled rate to feed the grinding circuit. The grinding mill grinds to a product size of minus 150 microns.

Table 17.2_1'
Summary of Key Process Design Criteria

Criterion	Units	2017/2018 Production	2020 onwards
Average Ore Processing rate	t/a	1,400,000	1,900,000
V2O5 Production	t/a	9,600	13,200
Average V2O5 head grade	%	1.09	1.16
Plant availability	%	87%	87%
Plant Operating hours	h/y	7500	7500
Average plant daily ore throughput	t/d	3900	3900
Number of crushing stages	#	3	3
Crusher product size (80% passing)	mm	12	12
Number of grinding stages	#	1	1
Grind product size	microns	150	150
Magnetic Product solids yield	%	30	30
Average magnetic concentrate V2O5 content	%	3.21	3.21
Roasting reaction zone residence time	h	1	1
Leach retention time	h	2	2
Average roasting/leach V2O5 conversion	%	81	81
AMV precipitation V2O5 recovery	%	98.8	98.8
Total average recovery to V2O5	%	76	76

17.3 Magnetic Separation

The vanadium is contained within the magnetite fraction of the resource. Magnetite is recovered by using low intensity magnetic separator (LIMS) of 1,500 Gauss. There are 4 (four) roll magnetic separator Imbras of 36”x120” with 150t/h of capacity. The separation is done in the unique step where the pre magnetic concentrate is blended with the massive material and sent to the milling circuit.

17.4 Milling

The magnetic separation product is sent to the stock pile to feed the milling circuit. The objective is to feed the mill with a magnetic grade of +45%.

This step of processing uses a ball mill in a closed circuit with hydrocyclones. The mill dimensions are 13x26’, with 2.275 KWh (3.000 HP). The hydrocyclnes are comprised of 4 (four) Cavex 500 with 2 (two) operating and 2(two) in standby.

The mill works with maximum ball size of 90mm (Magoteaux), with a consumption of 250 g/t.

The product of this process is a P80 with 86 microns with variation of 43% as showed at table below.

This milled material is processed in the low field magnetic separation (LIMS) of 1,500 Gauss, in the circuit with 1 (one) stage rougher and 2 (two) cleaner. There are 4 (four) magnetic separator Imbras, WD 48x125" with capacity of 60 t/h. The mill feed is 2.270t/day or 128t/h with efficience of 74,1% as sowed at table below.

17.5 Filtering

The final magnetic concentrate will be thickened and filtered. The filter mat (Westech) of 20m^2 with capacity of 53,2 t/h cake will be fed to the roasting section of the plant. The nonmagnetic tailings fraction from the beneficiation plant are thickened, filtered and conveyed to the tailings pond.

17.6 Roasting

The wet magnetic concentrate filter cake, containing approximately 3.21% V_2O_5, is roasted at high temperature (+1,100 °C) in a rotary kiln (FLSmidth) with diameter of 4,2m and length of 90m with spin of 1 rpm. The kiln capacity is of 88 t/h. At the kiln feed is add at the mold 51 kg/t of sodium carbonate (Na_2CO_3) and 12 kg/t of sodium sulfate (Na_2SO_4). This material is roasted until the temperature metioned before (1.100 ºC) where magnetite Fe3O4 is oxided to hematite Fe2O3, losing the magnetic caracteristc after 3 hours of roasting. The vanadium the extract from magnetite structure in the Salt Vanadium. The consumption of HFO+Diesel at kiln is 34 kg/t.

An off-gas control system from (FLSmidth) with capacity of 13t/h will collect any dust entrained in the gas from the roaster. To meet local environmental regulation, an electrostatic precipitator is installed to remove such particulates. The quantity of sodium sulphate added to the kiln is controlled and reduced in order to ensure compliance with the emission limits for SO2. Since the sodium sulphate dosage is already maximized for the base case, additional sodium carbonate will be added to the kiln in the expanded case to ensure efficient extraction of vanadium and the excess salt sulphate produced in the evaporator is stockpiled on a sealed area.

The oxided material its cooling in the rotary cooler (FLSmidth) with diameter of 4m and length of 34 m with spin of 2 rpm. The fully rotary cooler is of 56t/h.

After reducing the size, this product roasting and cooling is fed to the leaching process.

17.7 Leaching

The Vanadium salt contained in the roasted calcine is then leached for one hour and twenty minutes in each of the two agitated tanks installed in series of 120m^3 of capacity.

The feed rate between august/2016 to may/2017 was of 1.115t/dia and the efficiency of 79,8%. Similar operation has efficiency of 85%.

The leach discharge is send to thickner (Westech) with 14m of diameter and then filtered and washed using a vacuum belt filter. The solution containing approximately 110 g/L V_2O_5 is pumped to chemical plant for de-silication stage.

The cake has 10% of moisture and this product have a concentration of 60% Fe, 2,9% SiO_2 and 6,8TiO_2.

Largo hopes ot be able to sell this “cake” from leach stage at some point in the future, notwithstabnding that product has a high TiO_2 grade and a low Fe grade. It may be possible to blend it with richer magnetite concentrate, which can be found in the region, to create a saleable product.

The desilication is achieved using 398 kg/t of H2SO4 to reduce the pH from 11 to 8 in three in line agitated tanks, with 111 kg/t of aluminium sulphate and sulphuric acid. Follow the chemical reaction in this process:

$$3Na_2O.2SiO_2 + 2NaOH + Al_2 (SO_4)3 \rightarrow Na_2O.Al_2O_3.6SiO_2 + 3Na_2SO_4 + H_2O$$

After desilication, the solution is pumped to a filter (Andritz, 1200 x 200) with 72 plaques with 16,7 m^3/h where the solids are removed and sent to disposal along with the effluent tailings from the evaporator/precipitation. The filtrate, pregnant leach solution (PLS), is pumped to the precipitation stage.

17.8 Precipitation

The clean leach liquor (clean preg) is pumped (14m^3/h) to heat exchanger to reduce the temperature lower than 40º. This liquor goes to another series of agitated tanks (75m^3), where the vanadium is precipitated as ammonium meta-vanadate (AMV), with the addition of ammonium sulphate after 6 hours of residence.

The reaction is showed below:

$$2NaVO_3 + (NH_4)2SO_4 = 2NH_4VO_3 + Na_2SO_4$$

The precipitate is filtered, washed, and fed to a dryer prior to being calcined to produce V_2O_5 powder. The barren solution, which contains sodium and ammonium sulphate salts, is treated to recover ammonium sulphate, which is recycled to precipitation, and sodium sulphate part of which is recycled to the roasting stage.

17.9 Evaporation

A crystallization circuit has been designed to recover sodium sulphate salt, and ammonium sulphate solution from the barren leach liquor

The barren liquor, which contains ammonium sulphate, sodium sulphate plus small amounts of dissolved AMV and impurities, is first concentrated by evaporation to a predetermined ammonium sulphate concentration.

As they this barren have the concetration of 250g/l of Na_2SO_4, the salt start to precipitate. The pulp with 20% of solid, it is pump to cyclone where the underflow feed a centrifuged. This centrifugal produce salt sulfate solid with 5% of moisture. The overflow material (ammonium sulphate) is sent back to precipitation stage and a portion of this slurry is purged to a sealed purged dam as a mean of controlling chlorides build up in the circuit.

17.10 AMV Drying

Wet AMV (15%) solids are dried in a flash dryer (Drytech) with capacity of 6t/h of air. The dried AMV is calcined under oxidizing conditions to produce V_2O_5 and then melted and cast into flakes for sale.

17.11 Ammonia Removal and Melting

17.11.1 Ammonia Removal

This process is done in the electric kiln, a Drytech with capacity of 1,5 t/h, at oxided conditions at temperature of 600ºC.

The exhausted system permit that the air pass through the kiln that promote the reaction below:

$$2NH_4VO_3 \rightarrow V_2O_5 + 2NH_3$$

The ammonium brakes in N_2 and H_2, but, because of oxided conditions the H_2 is converted to H_2O before the V_2O_5 could be reduced, based on this reaction below:

$$2NH_3 \rightarrow N_2 + 3H_2$$

$$2H_2 + O_2 \rightarrow 2H_2O$$

17.11.2 Melting

The melting occurs at 900ºC. The powder melts and feeds the flocculating table (Drytech) at a capacity of 1.5t/h.

The flakes are crushed and stored in a silo as final product. This product is packed in big bags (1 tonne) or in storage drums (250 kg) and shipped.

18 PROJECT INFRASTRUCTURE

The infrastructure requirements for the Project are summarized in the following sections and are incorporated in the capital cost estimate for the Project.

18.1 Process Water

A water main, about 29 km long, has been installed in order to meet the beneficiation plant and the metallurgical plant process water requirements. This pipeline connects the water intake at Rio de Contas to the plant raw water tank using two centrifugal pumps (one operational and one standby).

The water pumped from the Rio de Contas is used primarily by the processing plant. Currently the plant recovers water from the reclamation circuit and reuses it. The thickeners are sized to contain the reclaimed water. A water demineralizing unit and a cooling tower have been installed to treat the water for equipment cooling.

The water taken from Rio de Contas is stored in two concrete tanks with a total volume of 2000 m³. The raw water tanks contain enough water for 20 hours of plant operation. These tanks will also contain a permanent water reserve of 240 m³ for firefighting purposes, which is in accordance with the laws of Bahia State and the National Fire Protection Association. The water reserve is enough for 2 hours of firefighting

A steel process water tank, with a designed volume of 360m³, has been built at the processing plant for water storage. This tank will store recovered water from the thickeners. In case make-up water is needed, it will be supplied from a centrifugal pump installed at the raw water tank.

18.2 Potable Water

A water treatment plant, with a capacity of 8 m^3/h, has been installed for potable water and gland water distribution.

A steel tank for potable water, with a volume of 220 m³, sufficient for 24 hours of consumption, has been provided.

18.3 Sewage Treatment

One sewage treatment plant is in used to process sewage from the industrial areas. This plant is compact in size and the treated effluent is used for wetting gardens and dust control on roads. The plant was built during the construction phase.

18.4 Fuel and Lubricant Storage and Distribution

Diesel fuel is delivered to the site by road tankers and is offloaded into the fuel farm from where it is pumped to various areas for use in the mine. Diesel fuel distribution is limited to loading and unloading facilities and metering equipment at the diesel fuel tank is available. Also, two separate diesel fuel storage tanks for the open pit operations have been provided and have been fully licensed. Both tanks have a combined capacity of 30,000 l of fuel.

Lubricants are delivered to the site in drums. The drums are stored in a secure area in accordance with relevant state regulations. The lubricants are distributed to hose reels in the truck shop service bay with barrel pumps.

18.5 Air

Three screw compressors supply high-pressure air for instruments, plant general use and tanks. A refrigerant air drier and filters have been supplied in order to ensure that instrument air will be of good quality. The compressors are appropriately stored in a compressor building.

18.5.1 Air Emissions and Air Quality Monitoring

The air monitoring system provides information on which strategy for managing air emissions are developed. The Project has installed three air monitoring stations, one within the plant, one upstream, and one downstream of the industrial area. These stations continuously monitor SO_2, NO_2, and particulate levels. Along with these stations there are five continuous analyzers for SO_2 and NO_2 in the chimney stack, which ensure that emissions remain within the allowable limits permitted by environmental legislation.

18.6 Heating

A complete system, consisting of two fire tube boilers, with a capacity of 5,200 kg/h, at an operational gauge of 10 kgf/cm² and temperature of 180ºC (saturated steam), burners operating with fuel oil B-type (low sulphur grade), fuel oil storage tank, day tank, heat exchangers for heating the fuel oil, and all the other required devices, are in place.

18.7 Power Supply

The electrical power requirements for the plant, including the beneficiation, hydrometallurgy and installed utilities are approximately of 12 MVA. In order to fulfill this demand, power is supplied at 138 kV, 60 Hz, by a transmission line 85 km long from Coelba's Ibicoara regional Substation. A step-down substation of 13.8 kV is installed at the plant site. Two power transformers of 13.8 kV 15 / 15 MVA each are installed.

The 13.8-kV power distribution system for the plant is supplied by means of insulated cables or conventional aerial cable system. Substations are designed to meet the requirements of the concentrator, hydrometallurgy plant, crushing and supporting areas.

The power required at the water pumping intake at Rio de Contas is supplied by a substation at 13.8 kV.

All electrical distribution is achieved via cable trays using armored interlocked PVC coated cables. The process and plant site ancillary facilities switchgear and electrical equipment is installed in modular electrical rooms adjacent to, or within, their respective buildings.

18.8 Buildings

The administration building is of a single-storey cinder block construction and contains general areas for engineering, geology, administration personnel, offices for the general manager, mine manager, plant manager, administration staff, chief engineer, chief geologist, EH&S and medical care room.

The architectural and constructability design of these buildings considers the climatic characteristics, environmental comfort, ergonomics, durability, standards and codes suitable for a Project of this size. The construction system consists of reinforced concrete pillars, beams and slabs with concrete blocks masonry walls finished with mortar layer and painting, tiles or vinyl floor and metallic roofing.

A general layout of the of the plant facility and office buildings etc. is shown in Figure 18.11_1.

18.9 Assay Laboratory

A fully equipped assay laboratory is located at the plant site. The laboratory delivers daily analysis of mining and process samples. The laboratory is a single storey structure located next to the utility area in the plant area.

18.10 Miscellaneous Buildings

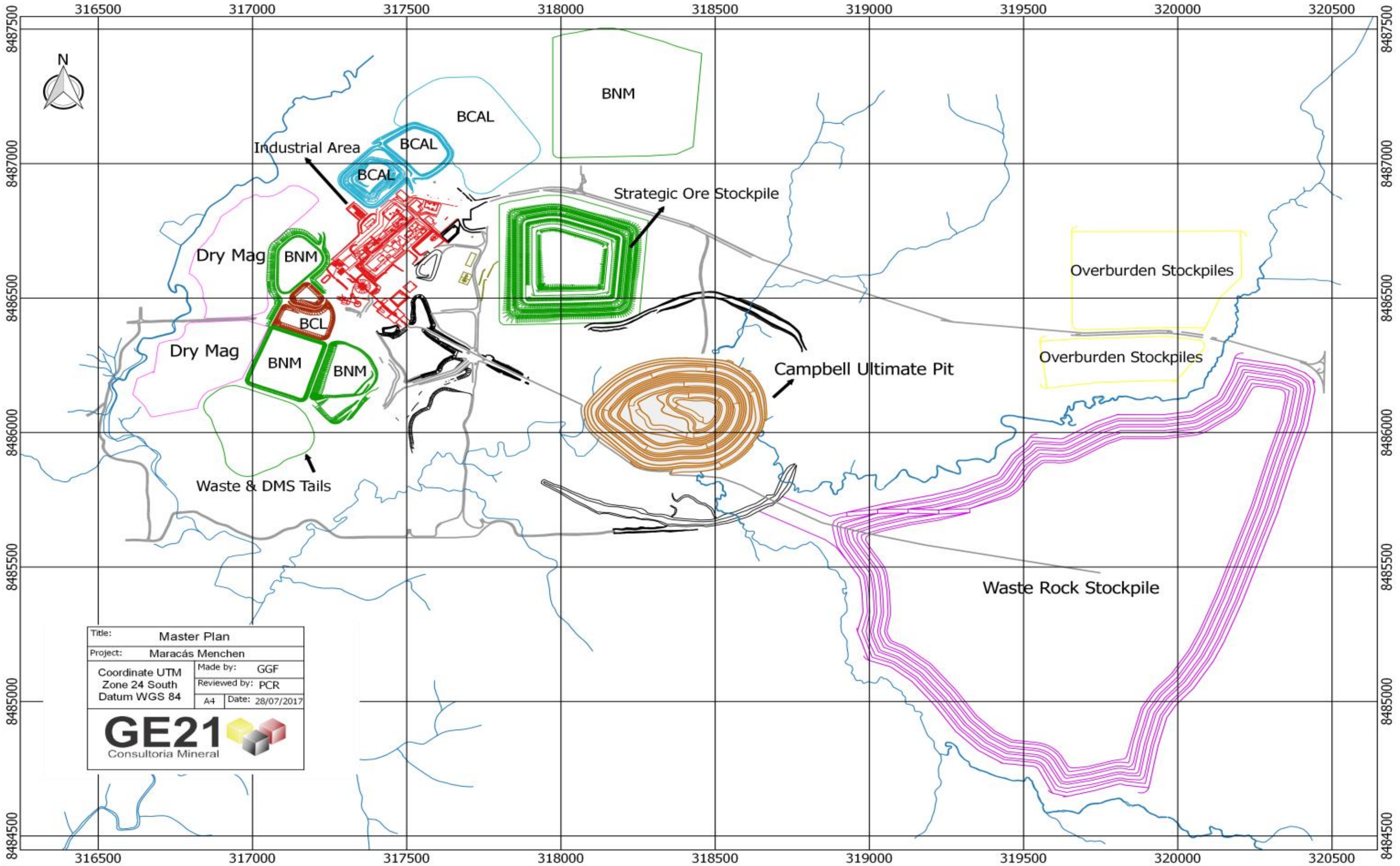
A main gatehouse is located at the entrance of the plant site. This building is a single-story cinder block structure. A first aid post, equipped for “first response”, is located inside the administration building.

18.11 Explosives Magazine

Ammonium nitrate emulsion is stored at site, while caps and accessories are delivered on a just-in-time basis.

Figure 18.11_1

Plant Site Layout



18.12 Communications

The Maracás Menchen Project is connected to the public communication system through telephone and internet services. Hand held and vehicle mounted radio sets are available to plant and maintenance operators as well as to mining personnel.

All of the hydraulic excavators, drill rigs, graders and wheel loaders, and the majority of the haul trucks, service vehicles, and supervisor transportation carry in-vehicle radio sets for prompt communication.

A wireless network is to be installed for use by the mine dispatcher and on-board fleet management system devices.

18.13 Roads

The on-site roads, from the main reception to the primary crushing plant at the beneficiation plant are considered to be industrial roads. Some studies have been developed for improvements to the existing public county road, which has a length of about 42 km, between the BA-026 crossing the Maracás Menchen Project area and the village of Porto Alegre. Largo has been engaged in discussions with the Bahia State transportation agency which is considering paving the existing dirt road in partnership with Largo. Negotiations on this issue have not been concluded. However, the current road is being upgraded with minor improvements needed to ensure timely and efficient transportation of goods, supplies and workers.

18.14 Tailings Facility

Three types of tailings are produced and stored in the following facilities:

- Leached Calcine Tailings Dump (potentially saleable as an iron ore by product)
- Chloride Purge Tailings Pond
- Non-Magnetic Tailings Dump

The leached calcine tailings are constructed using a “dry stacking” impounding approach and the non-magnetic are constructed as ponds.

All tailings facility characteristics and designs included in this report relate to the previous production scenario as laid out in the Technical Report “Preliminary Economic Assessment of the Maracás Vanadium Project, 1.4 Million Tonnes per Year Processing Plant”, issued March 04, 2013.

The same tailings management strategies will be employed for this production scenario to accommodate required tailings storage for life of the Project, including production from the Campbell mine Phase 2 pit and all satellite pits.

18.14.1 Tailings Disposal Ponds

The tailings generated by the beneficiation process and the vanadium ore processing plant derive from the following process areas:

- leached calcine from the processing of kiln discharge.
- filter cake from the de-silication process.
- chloride control purge from the evaporation circuit.
- primary non-magnetic tailings from magnetic separation.

The Leached Calcine Tailings are discharged into the Leached Calcine Tailings Stack. A new stack will be constructed to meet future needs The tailings from the leach operation is an iron ore concentrate and the company is entertaining selling it as a by-product once material impounded is suitable from the environmental perspective. Currently the impounded material is being rinsed with water to recover soluble vanadium back to the processing plant.

The chloride control purge tailings from the evaporation circuit are deposited in the Chloride Purge Tailing Pond together with the cake from the de-silication plant. The original Chloride Purge Tailings Pond is currently full and a new tailings pond has been constructed and fully licensed and is in operation.

The Non-Magnetic Tailings Ponds have been designed to receive the primary non-magnetic tailings originated from the magnetic separation after thickening. The proposed tailings containment system consists of a series of ponds formed by rock-fill structure and sealed by compacted clayey / liner at the bottom and side walls. The current pond (Pond 3) is constructed with a capacity of 600,000 m^3 and is monitored for leachates. If no leachates are considered to be hazardous, the tailings will be stored in an unlined facility for the balance of the life of the mine. The original pond is currently full and a new one has been commissioned and licensed and is currently in use.

The walls to form the ponds are built using waste rock from the mine and the bottom and side walls areas are lined using double-layer geomembrane liner featuring a leak detection system. The construction sequence consists of clearing vegetation from the areas to be occupied by the ponds, removal of organic material and excavation of material inappropriate for foundations. The entire perimeter of each pond will be protected by rock-fill channels.

18.15 Waste Management

Solid waste generated from the mine plant site, including ancillary buildings, is primarily domestic and industrial non-hazardous waste. A comprehensive Waste Management Plan is in place at the mine site. Solid waste includes:

- rejects from construction (scrap wood, metal, concrete, etc.);
- rejects from the mine (empty drums, packing materials, etc.); and

- general domestic garbage from the offices and ancillary buildings (paper, refuse, food, etc.)

Construction debris, inert waste and used tires are placed in designated cells and proper disposal procedures of the material is in place. Domestic and industrial solid waste from the mine plant facilities are recycled and re-used in a proper manner, where applicable.

19 MARKET STUDIES AND CONTRACTS

19.1 Information Sources

Largo subscribes to several associations, publications and industry related websites, as listed below.

Associate Member of Vanitec (www.vanitec.org)

- A global organization which encourages and assists technical research and education about vanadium and its world-wide application in the steel, titanium and chemical industries. Vanitec convenes international representatives of companies involved in the mining, processing, manufacturing, research and use of vanadium and vanadium-containing products.

Subscription to Metal Bulletin (www.metalbulletin.com)

- An industry accepted source for news, pricing information, expert market commentary and statistics. Metal Bulletin publishes pricing information for over 900 metals, including vanadium.

Subscription to Metal Pages (www.metalpages.com)

- An industry accepted source for metal prices, news, conferences and information for nonferrous metals, rare earths and ferroalloys.

Roskill Information Services - The World Market for Vanadium to 2025, Fourteenth Edition, published in 2015.

- Report includes data and information relating to: Vanadium sources and resources, global production and consumption, supply demand outlook, historical and price forecasts, a review of production by country, uses of vanadium and an overview of the international market.
- Roskill is considered a leader in independent, international metals and minerals research, producing 75 market reports, databooks and newsletters designed for the purposes of formulating company strategies, following industry trends, competitor analysis, and gaining a complete overview of a single industry.
- Largo also subscribes to Roskill's quarterly Vanadium Industry Briefing report and will receive the annual report in July, 2016.

Attendance at various industry related conferences and events including:

- Byron Capital Markets Electric Metals conferences
- American Metals Market, Steel Success Strategies Conferences
- Metal Pages Titanium Alloys Conferences
- 17th Asian Ferroalloys Conference, Singapore

Largo has also hired TTP Squared Inc., a private company which has offered consulting and trading services in the Vanadium Industry since 2010 and this company has been providing Vanadium market studies to Largo.

19.2 The Market for Vanadium

Vanadium is recovered principally from magnetite and titanomagnetite ores, either as the primary product or as a co-product with iron. It is also recovered as a secondary product from fly ash, petroleum residues, alumina slag, and from the recycling of spent catalysts used for some crude oil refining and which have accumulated vanadium. Roskill (2015) estimates that co-production with iron accounted for 64% of supply in 2014, primary production accounted for 24% and secondary production for the remainder.

Vanadium pentoxide is the principal intermediate product from treatment of magnetite ores, vanadiferous slags and secondary materials. It is used directly in non-metallurgical applications and in the production of a range of vanadium chemicals. It is also the starting material for production of ferrovanadium and master alloys. Most vanadium is used in the form of ferrovanadium as a steel additive.

Production and demand figures may be reported in terms of contained vanadium metal or the pentoxide (V_2O_5) equivalent. Trade statistics are reported in terms of gross weight.

World production since 2010 reported by the U.S. Geological Survey (USGS) is summarized in Table 19.2_1. China, South Africa and Russia accounted for nearly 96% of world supply in 2015. South Africa is the largest producer of primary vanadium, followed by China. Production in Brazil commenced from Largo's Maracás operation in 2014. The United States no longer produces vanadium from primary sources but is a major producer of vanadium products based on secondary sources and imported material.

Table 19.2_1
World Vanadium Primary and Co-Product Output
(Tonnes contained vanadium in ores, concentrates and slag)

	2010	**2011**	**2012**	**2013**	**2014**	**2015[1]**
Brazil	-	-	-	-	1,032	2,800
China	32,480	36,400	40,000	44,000	45,000	42,000
Russia	15,000	12,860	14,856	14043	15,125	15,000
South Africa	22,606	21,652	19,957	21,397	21,000	19,000
United States	1,060	590	106	591	-	-
Total	**71,100**	**71,500**	**74,900**	**80,400**	**82,200**	**79,400**

[1]Estimated.

U.S. Geological Survey, 2014 Minerals Yearbook and Mineral Commodity Summaries, January, 2016.

Roskill (2015) reported that the largest producers are Evraz Highveld Steel and Vanadium Limited, Vanchem Vanadium Products and Glencore in South Africa, and Pangang Group and Chengde XinXin Vanadium and Titanium in China, and that, together, these five companies accounted for 73% of vanadium contained in feedstock in 2014. (Roskill, 2005). Much of the remainder is accounted for by smaller Chinese producers and secondary production. Both Evraz Highveld and Vanchem are in "business rescue" and face wind-down of operations.

Co-production of vanadium with iron ore results in conditions in the iron ore industry having a direct impact on vanadium supply.

19.2.1 Demand

It is estimated that 91% of vanadium production is used in the steel industry in a wide range of steel formulations to meet a variety of end-use applications. (Roskill, 2015). It is also used in titanium-aluminum and other non-ferrous alloys, in catalysts for the production of maleic anhydride and sulphuric acid and petroleum cracking, in batteries and in a number of chemical applications.

Vanadium consumption trends reflect the general trend of steel making and production of high strength steel, in particular. In turn, conditions in the steel industry are affected by global economic conditions. Table 19.2.1_1 shows crude steel output in the five largest producing countries, and the world total, from 2010. The increasingly dominant position of China in the steel industry is shown clearly and, in 2015, it accounted for approximately 50% of world crude steel production. Although world production dropped sharply in 2009 as a result of the global economic crisis, recovery was rapid in 2010 and continued through 2014. In 2015, crude steel production was reduced by the major producers, with the exception of India, in response to weaker economic conditions.

Table 19.2.1_1
World Crude Steel Production
(Thousand tonnes)

	2010	**2011**	**2012**	**2013**	**2014**	**2015**
China	638,743	701,968	731,040	822,000	822,698	803,830
India	68,976	73,471	77,264	81,299	87,292	89,582
Japan	109,599	107,601	107,232	110,595	110,666	105,152
Russia	66,942	68,852	70,209	69,008	71,461	71,114
United States	80,495	86,398	88,695	86,878	88,174	78,916
Others	468,678	499,713	485,691	480,574	489,854	450,890
Total	**1,433,433**	**1,538,003**	**1,560,131**	**1,650,354**	**1,670,145**	**1,599,484**

World Steel Association, www.worldsteel.org/statistics.

Vanadium increases the strength of a variety of steels by forming carbides and nitrides. For 2014, Roskill (2015) estimated that high strength low-alloy (HSLA) steels accounted for about 46% of use of vanadium in steels which are used in oil and gas pipelines, in a range of automotive components, for pressure vessels and reinforcing bars (rebar) for concrete. In these applications, HSLA steels provide increased strength and weldability and reduced weight compared with other steels. Full alloy steels are the second largest market for vanadium in the steel industry, followed by tool and carbon steels.

As noted above, most vanadium is used in the form of ferrovanadium as a steel additive. Ferrovanadium is available containing 45% to 50% V and 80% V. The 80% V grade material is produced by reduction of the pentoxide (V_2O_5) or trioxide (V_2O_3), generally using the aluminothermic process. Lower grade ferrovanadium is generally produced by reduction of slag or other vanadium-containing feedstocks by the silicothermic process.

Titanium alloys are the principal non-ferrous alloys using vanadium. These have high strength to weight ratios and are used in aircraft components, including structural elements, hydraulic systems and jet engine parts. The vanadium used in the form of vanadium-aluminum master alloys.

19.2.2 International Trade

The majority of international trade is in ferrovanadium. South Africa and China are the leading exporters of ferrovanadium. Figures reported for 2014 are 7,800 t (gross weight) and 7,100 t, respectively. Other significant exporters were Australia and the Czech Republic. The principal importers are Germany, Japan and the United States, importing approximately 5,800 t, 4,500 t, and 4,400 t, respectively, in 2014. (United Nations COMTRADE database, DESA/UNSD).

In 2014, Russia was the largest exporter of vanadium pentoxide at 8,680 t (gross weight), followed by China, 6,119 t, and South Africa, 5,703 t. The largest importers in 2014 were Czechoslovakia, 9,202 t and the United States, 4,353 t. (United Nations COMTRADE database, DESA/UNSD).

Roskill (2015) estimated total export trade in vanadium pentoxide in 2014 at 27,383 t gross weight, compared with 43,604 t gross weight for ferrovanadium.

19.2.3 Vanadium Prices

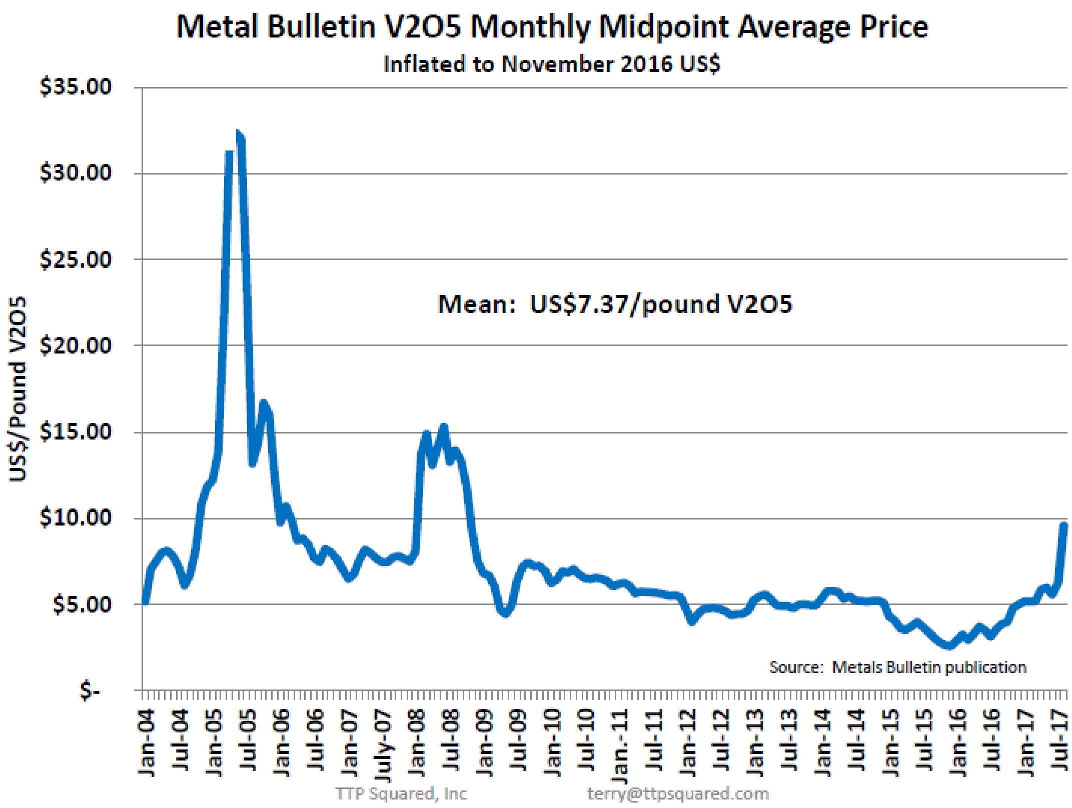
Ferrovanadium and vanadium pentoxide are the principal commercially-traded vanadium products. Neither these, nor any other vanadium products are traded by means of an exchange or terminal market such as the London Metal Exchange or COMEX Division of the New York Mercantile Exchange (NYMEX). Prices for ferrovanadium and vanadium pentoxide are quoted in publications including Metal Pages (ferrovanadium and vanadium pentoxide) Ryan's Notes (hosted by CRU) (ferrovanadium) and Metal Bulletin (vanadium pentoxide).

Transactions are usually negotiated under 6- or 12-month contracts between producers and consumers or trading houses. Prices are generally quoted in terms of US dollars per pound or per kilogram gross weight for vanadium pentoxide containing 98% V_2O_5, while ferrovanadium prices are quoted in terms of US dollars per kilogram of contained vanadium.

Figure 19.2.3_1 illustrates the trend in vanadium pentoxide prices over the past 13 years from January, 2004.

Figure 19.2.3_1

Vanadium Pentoxide Price Trend
(US$/lb V2O5)



Metal Bulletin, data provided by Largo.

Historical prices peaked at US$32.36 /lb V_2O_5 in mid-2005 and then declined sharply at the beginning of 2009. Prices fluctuated around US$6.00/lb V_2O_5 from the beginning of 2010 to mid-2014 but trended downwards until April, 2016 when Metal Bulletin quoted US$3.3/lb V_2O_5 at 15 April, since then the Vanadium price is increasing reaching a peak of US$9.00/lb in August of 2017, giving a average price of US$ 7.37/lb V_2O_5 for the entire 13 years period or US$ 6.34 as average price for this period eliminating the peaks.

In the early part of 2008, high prices for vanadium reflected concerns over supply in South Africa and China, as well as global economic conditions which resulted in high prices across a range of minerals and metals. The vanadium industry is significantly larger than it was 10 years ago and a higher proportion of transactions are now directly between producers and consumers based on long term supply agreements.

In 2017 there is foreseen a shortfall in V production vs consumption of about 17,000 MTV. The fact that prices have increased 200% since the bottom in December 2015 is confirmation that the global inventory levels are falling and thus there is an environment where supply cannot meet demand and there is no “excess” inventory to fill the void.

TTP Squared believes that if a perception builds that prices will stay above $8.50/pound V2O5 for some time then it is possible some stone coal capacity could come back on line in China but its not clear that this can actually happen given the status of the operations, and more based on the technical and fundamental analysis of the market TTP Squared projects V_2O_5 prices to continue to rise to reach at least US$15.00/pound V_2O_5 and possibly much higher. TTP Squared expects prices to remain above the historical average of US$7.37/pound V_2O_5 for at least 24 months and potentially much longer.

GE21 tested 3 scenarios to assess the economics of the Maracás Menchen Project using for Scenario I a flat price of US$ 6,34/lb V_2O_5, for Scenario II a flat price of US$ 7.37, and a Base Case for vanadium pentoxide price of US$ 6.34/lb V_2O_5 in 2017, US$9.00/lb V_2O_5 in 2018 and 2019, and then US$6.34/lb V_2O_5 for until the end of the mine life. The results of the Base Case were selected for evaluate the Project.

19.3 Outlook

Roskill believes that the outlook for vanadium is positive. Although some decline in steel output may occur, this will likely be offset by increased intensity of use of vanadium in steel. Over the past decade, intensity of use has increased in most regions around the world, and it expects that some further intensity of use will drive increased demand for vanadium. (Roskill, 2015).

Vanadium use in non-ferrous alloys is supported by ongoing demand in the aerospace sector, particularly in the form of titanium-aluminium-vanadium alloys, and by growth in the use of vanadium catalysts in the chemical industries. Roskill considers that a potential growth area is in the use of vanadium salts as electrolytes for vanadium redox batteries and in some lithium polymer batteries.

19.4 Contracts

On 14 May, 2008, Largo announced that it had entered into an offtake agreement with Glencore International AG (Glencore) for all vanadium products from the Maracás Project. The agreement remains in effect for a six-year period following the start of commercial production and unless otherwise terminated by either party may be renewed for a further six-year term. Pursuant to the terms of the agreement, Glencore provides all marketing and logistics services during the term and, as a result, Largo will not need to undertake its own marketing efforts during the term.

20 ENVIRONMENTAL STUDIES, PERMITTING AND SOCIAL OR COMMUNITY IMPACT

20.1 Regulatory Framework Overview

Environmental permitting in the State of Bahia is the responsibility of INEMA - Instituto do Meio Ambiente, which is the institution that regulates, approves and issues environmental permits or licenses.

The permitting process in Bahia takes into consideration the nature and size of the projects and activities under consideration, the characteristics of the affected ecosystem and the supporting capacity of the area being impacted.

The following types of environmental licenses are necessary for the Project:

- Location License (LL): The LL is granted in the preliminary planning phase of the project or operation, and it approves the location and the conceptual design of the project, attesting its environmental feasibility and determining the basic requirements and conditions to be observed in the subsequent permitting stages;
- Installation License (LI): The LI is granted so that the project or operation can be installed (or constructed), in accordance with the specifications presented in the plans, programs and project specifications proposed by the environmental studies that were approved, including the environmental control measures and other conditions;
- Operational License (LO): The LO is granted for the project to commence the operational phase, after the fulfillment of all the requirements of the previous licenses have been confirmed and the conditions and procedures to be observed during the operation are defined.

The licenses and authorizations are granted based on an analysis of the environmental studies that have been completed. This analysis considers the objectives, criteria and norms for the conservation, preservation, protection and improvement of the environment, the possible cumulative impacts and the planning and land use guidelines of the State. For mining projects that are exceptionally large, as it is the case of the Project, the preparation of the EIA and RIMA must comply with the TR (Reference Term Sheet) issued specifically for the Project.

The environmental licenses have a definite validity or term, which can be renewed or extended, based on the nature of the project and activities. The validity is defined for each license and is stated on the environmental certificate issued; the validity period starts on the day the license is published in the Official Newspaper of the State of Bahia. If the renewal of any license is requested 20 days or more in advance of its expiration date, the validity of that license is automatically extended until INEMA issues a formal response, positive or negative.

For permitting purposes, the classification of mining operations in Bahia is divided in five categories: micro, small, medium, large and exceptionally large. These categories are determined based on three criteria: built area, total investment (capital investment + cash flow, in Brazilian

Currency, R$), and number of employees. The Project is classified based on the highest ranking of the three criteria. The Maracás Vanadium Project is classified as exceptionally large.

The grant or license for water resources usage in the State of Bahia is governed by the State Decree N. 6,296, from March 21st, 1997; State Law N. 10,431, from December 20th, 2006, substituted by law nº12 377 on November 28th 2011; and Federal Decree N. 24,643, from July 10th, 1934 (Código de Águas).

The water grant is obligatory for the lawfulness and legitimacy of any usage of water resources whose objective is the construction, expansion or alteration of any project that requires surface or groundwater, as well as for any work that alter the water regime, quantity or quality.

The grant, as a concession, (as it is the case of the Largo Project) has a maximum validity of 10 years and is renewable. The state water grants are issued by the SRH (Secretaria Recursos Hidricos) ANA (Agência Nacional de Águas), through specific publications in the Official Gazette of the State of Bahia. The request for water grants in mining involves the execution of hydrologic, hydrogeological and hydro chemical studies.

In the case of a long drought or water shortage, the water grants can be altered, in order to assure that human supply has priority.

In the State of Bahia, INEMA (Instituto de Meio Ambiente e Recursos Hídricos) has the duty of issuing authorizations for native vegetal suppression, which are necessary to alter the land use for the installation or expansion of mining operations. The authorizations are only conceded if the environmental, technical and economic feasibility of the project has been established and can be renewed only once. The administrative process involving the authorization for vegetal suppression must be conducted by the INEMA, based on a specific TR (Reference Term sheet). The documents to be submitted include the PTSV (Technical Project for Vegetation Suppression) and the Forest Inventory, as required by the SEMARH Norm 29/05, as well as the PRAD (Plan Rehabilitation of Degraded Areas).

The CONAMA Norm 369/2006, from March 28th, 2006, defines extraordinary cases, in which the competent authority may authorize intervention or vegetal suppression in APP (Area of Permanent Preservation), for implementation of projects, plans and activities that result in significant public benefits.

The clause I, letter C, from article 2 of the Norm 369/06 explicitly recognizes the public benefits of minerals exploration and extraction granted by the competent authority, except sand, clay, silt and gravel.

The section II, article 7 of the norm deals specifically with the activities of mineral exploration and extraction in order to obtain environmental licenses. It is understood, therefore, that once the guidelines and obligations defined by the CONAMA Normative 369/2006 are observed, the public benefits of the Maracás Project are automatically recognized for environmental permitting purposes and for purposes of obtaining authorization for vegetal suppression and intervention inside APPs.

20.2 Environmental Permitting Status

The Project is fully licensed and well advanced. All of the permit approvals required to initiate construction of the Project are in place.

The Operational License was published in the Official Gazette on November 8th and 9th, 2014.

20.3 Environmental Baseline Conditions

The environmental baseline study was carried out as part of the preparation of the EIA. The baseline study was completed by Brandt Meio Ambiente Ltda in June 2011. The study also included supplemental information related to an Equator Principles Compliance Audit carried out by Mineral Engenharia e Meio Ambiente Ltda (Mineral) dated December 2011 as requested by parties involved in the financing of the Project: Brazilian finance institutions Itau BBA, Bradesco and Banco Vororantin. Mineral are acting as the financing bank's environmental auditor.

20.3.1 Climate and Physiography

The local climate has two distinct seasons, the rainy season (hot and humid) from October to March, and the dry season from April to September. The average daytime temperature in the Project area is 22.3ºC. The months of May to August are the most representative of winter conditions, at which time the average temperature is 18ºC.

Rainfall in the Project area generally ranges from 480 mm at the Porto Alegre gauge station to 630 mm at the Alagadiço gauge station, both of which are located in the local area adjacent to the Project. There is rainfall each month of the year, with the driest period being from May to September, when the monthly precipitation is typically below 20 mm.

The Project is located in the middle branch of the Jacaré River, about 3 km west of the western border of the Maracás plateau, in a region of very flat terrain with maximum relief changes of 25 to 30 m. The altitude in the area averages between 310 m and 340 m and seldom exceeds 400 m. The Jacaré River valley constitutes a long north-south depression with an average width of 10 km and a length of approximately 70 km.

The surrounding terrain is typically ranch/farm land with low trees and shrubs, relatively-flat platforms adjacent to a series of creeks and ponds. The property is bounded to the east by a steep cliff that rises 300 m to the Maracás plateau.

20.3.2 Water Resources

The Project is located in the Rio de Contas basin, which has an elongated shape with length of 620 km and average width of 185 km. The Project is located in the municipality of Maracás located in the Jacaré River sub-basin.

The Contas River is a perennial river, although most of its tributaries are intermittent during the dry season. At the Jequié river flow gauging station, the 26-yr average is 25 m3/s, and 99 m3/s at the Ubaitaba station closer to the delta. The main left side tributaries are the Ourives, Sincorá de Santana, Jacaré and Caldeiras Rivers.

The Jacaré River is located 4 km downstream from the Gulçari-A deposit where it receives flow contribution from the João River. The Jacaré River and its tributaries are intermittent watercourses.

Figure 20.3.2_1

Jacaré River (Dry period)

Surface water quality monitoring has been divided into two groups: one group comprising two monitoring stations at the João River (upstream and downstream from the mine site area) and two monitoring stations at the Jacaré River (upstream and downstream from the confluence with the João River), and one group comprising the two monitoring stations located at the Rio de Contas River (upstream and downstream from the confluence with the João River). This area is under a water deficit and the surface water bodies are, most of the time, dry.

The monitoring stations generally have pH values slightly above neutral. The dissolved oxygen (DO) concentrations were in compliance with the recommended standards in every monitored point. At most of the monitoring points, the majority of metals were not detected, particularly heavy metals. However, aluminum was detected in every monitoring station, at levels above the legal standard. The elevated aluminum concentrations have been attributed to the geology and soil composition of the region.

The results of the groundwater monitoring campaign carried out by Brandt Meio Ambiente in March 2008 were in compliance with the standards set by the CONAMA regulation 396/2008. The author is not aware of additional studies subsequent to 2008.

20.3.3 Flora Characterization

The area of influence of the Project is comprised predominantly of large portions of land covered with natural vegetation and pasture. The natural vegetation is well preserved, but there are areas with secondary vegetation and areas where vegetation was cut down to allow for pasture planting.

Along road BA-026 through Porto Alegre, there are many small communities and the vegetation is deeply modified. In the vicinity of the Porto Alegre District, there are irrigated plantations, with a complete alteration of the natural landscape and large areas used to grow beans, cassava, watermelons, mangos, and other fruits and vegetables.

The preserved vegetation was classified by MMA (2006) as Forest Steppe Savannah and Arborous Steppe Savannah. The portions that were subject to human modification and pressure were classified as Forest Steppe Savannah/Agriculture and Arborous Steppe Savannah/Agriculture.

20.3.3.1 Forest Steppe Savannah

Forest steppe savannah is a subtype of vegetation characterized by moderately densely packed 5 to 20 m tall trees (averaging 5 m) with thick trunks and numerous branches; within the Project area some trees taller than 7 m have been observed. This vegetation pattern corresponds to the Arborous Caatinga, according to Carvalho e Junior (2005).

The primary defining species of this vegetation are the Aspidosperma pirifolium, Myracrodruon urundeuva, Schinopsis brasiliensis, Commiphora leptophloeos, and Pseudobombax simplicifolium, and are usually taller than 10 m. The species Spondias tuberosa, Maytenus rígida, Capparis yco and Jatropha ribifolia contribute to the overall density of the vegetation, with average heights of up to 5 m. The insolation at the ground level has been estimated at only 5% at some preserved areas during the rainy season, a function of the vegetation density.

This type of vegetation usually occurs in the river sides, even if the rivers are partially or totally dry during most of the year. The deep soils and the higher relative humidity enable the growth of this vegetation type.

20.3.3.2 Arborous Steppe Savannah

This subtype of vegetation exhibits comparable floristic characteristics as Forest Steppe Savannah; however, the individuals of the Arborous Steepe Savannah are typically shorter, resulting in greater ground level insolation. This subtype corresponds to the Arborous-bushy Caatinga, according to Carvalho e Junior (2005).

The shorter individuals in Arborous Steppe Savannah are categorized as bushy-arborous and bushy. The prevailing species differs from Forest Steppe Savannah, with greater frequency of smaller individuals including Mimosa spp e de Spondias Tuberosa, Maytenus rigid, Capparis yco and Jatropha ribifolia. These are coincident with Sideroxylon obtusifolium and various individuals from the malvaceae family, resulting in a denser herbaceous stratum than in other subtypes. Arborous individuals are still present but are typically more spread out, along with individuals from the Bromeliaceae and Cactaceae families, reaching 10% to 60% cover in some areas.

This type of vegetation is found in areas further away from the rivers, with more compact soils and low humidity.

20.3.3.3 Recovering Steppe Savannah

Recovering Steppe Savannah is classified by the absence of a variety of species, with individual generally more diffusely spaced. Arborous or bushy individuals from the Forest and Arborous Steep Savannah types can occur (generally 2 to 7 m tall). Due to historical exploration activities, their branches are not as numerous or dense as in the past.

The management and soil use activities are the main factors shaping this subtype. Man-made fires occur frequently, designed to “clean” the land for pastures and agriculture; this results in development of a new vegetation cover at a secondary stage of ecological evolution.

20.3.3.4 Anthropized Vegetation

Anthropized Vegetation is characterized by various types of clean pastures or bushy-arborous vegetation cover, resulting in dirty pasture that, if left without management, can evolve to recovering vegetation.

Exotic grass is often introduced to these pastures: Aristida setifolia (capim-panasco), Bracchiaria decumbens (braquiária) and Cenchrus ciliaris (capim-bufel). The annual herb Estilosantes (Styloranthes humiles) and the algodãozinho de seda (Calotropis procera) can be cited as intrusive/invasive vegetation associated with disturbance of the natural vegetation rather than the management of the pastures.

Pasture management is predominantly undertaken for cattle and to a lesser extent for caprines, the latter of which is closely related to the presence of communities. Local residents use the land to plant and to raise cattle and goats. Cattle raising activities require larger areas and an alteration of the natural environment with continuous suppression of natural vegetation and replacement exotic grass species. Goat raising, while generally considered to be as impactful as cattle raising, is less frequent and does not require the continuous removal of natural vegetation.

The revegetation plant used in the area is the Cactaceae (palmatória) or Palma (Opuntia palmadora, Cactaceae), which is consumed as a water source for cattle during the dry season. The poor soil and the lack of regular rainfall limit development of satisfactory agriculture. At Porto Alegre, the original Caatinga vegetation was replaced to a large extent by small plantations, where the population uses the water from the Rio de Contas for irrigation.

20.3.3.5 Forest Inventory

The forest inventory carried out by Brandt in 2008 and audited by Mineral Engenharia em Meio Ambiente Ltda. (Mineral) in 2011 showed 141 vegetation species, with 111 being identified at the species level (78.7%), 13 at the genus level (9.2%), 10 species remained to conferatum (cf.) and seven species were not identified. The reasons were largely due to the absence of reproductive material, available literature or available herbarium material for comparison. The author is not aware of additional studies subsequent to 2008

The most representative family was Fabaceae (20.57%), followed by Cactaceae (8.51%), Malvaceae and Euphorbiaceae (6.4%). These four families represent approximately 41.9% of the observed species. The remaining species are distributed in 39 other families, with a total of 43 botanical families.

The utilization of region's native species as a source of natural remedies, food and water sources when the dry season becomes too intense is widely known among the local residents. The skin and leaves of trees like the pau-ferro (Caesalpinia férrea) and the quixabeira (Bumelia sartorum) are used to produce tea against rheumatism and diabetes. The fruit from the icó (Capparis yco) and from the umbuzeiro (Spondias tuberosa) are part of the diet of the local population, with the latter forming underground tubercles that are used to quench the thirst during harsh dry periods.

Based on the official list of endangered flora, from the IBAMA Norm 06/2008, and from the list of IUCN the following tables (Table 20.3.3.5_1 and Table 20.3.3.5_2) present the species found and considered vulnerable and rare.

Table 20.3.3.5_1

Vulnerable Species

Name	**Popular Name**
Astronium fraxinifolium	Gonçalo - Alves
Myracroduon urundeuva	Aroeira do sertão
Pereskia cf. aculeata	***
Pilocereus piauhyensis	Facheiro
Caryocar brasiliensis	Pequi
Anadenanthera macrocarpa	Angico
Chloroleucon tortum	Jurema
Mimosa caesalpinifolia	Sabiá
Amburana cearensis	Umburana
Psidium rufum	Araça
Manilkara elata	Maçaranduba
Sideroxylum obtusifolium	Quixabeira
Schinopsis brasiliensis	Braúna

Table 20.3.3.5_2

Rare Species

Rare Species		
Scientific Name	**Popular name**	**Family**
Astronium fraxinifolium	Sete cascas	Anacardiaceae
Cnidoscolus pubescens	Cansanção	Euphorbiaceae
Jacaranda cuspidifolia	Pau de colher	Bignoniaceae
Luehea paniculata	Açoita cavalo	Malvaceae
Mimosa tenuiflora	Buranhém	Fabaceae
No identified	Borracha	Not identified
No identified	Pau de curral	Not identified
No identified	Pinheiro Roxo	Not identified
Patagonula bahiensis	Casca fina	Fabaceae

The species categorized as rare are those with a density smaller than one individual per hectare, according to the methodology proposed by Kageyama e Gandara (1993). These species should also be the targets of environmental management actions for conservation.

20.3.4 Fauna Characterization

The fauna characterization was based on a qualitative survey of the various vertebrate groups throughout the Project's area of direct and indirect influence. The survey was carried out in the beginning of 2008 and audited in 2011 by Mineral, through field surveys, interviews with local residents and specialized literature.

During the field survey, the entire area of direct influence (ADI) and area of indirect influence (AII) were covered, aiming at identifying wild fauna species present in the region. For the mastofauna survey, direct observations were made through the method of linear transects, walking along existing trails in search of animals or traces such as animal tracks, fur, feces or dead animals. The animals were identified according to the references Cabrera, 1961; Silva, 1994; Emmons, 1997.

The same method (linear transects) was used for the avifauna survey, but with the help of binoculars. The AID and AII were searched, along the existing trails, with the purpose of finding individuals, nests, dead animals or vocalizations. The guide for field surveys by Souza, 2004 was used, as well as specialized literature (Sic, 1997).

The survey of herpetofauna, reptiles and amphibian was conducted directly at the ponds, water bodies, fallen logs, hollow trees and shadows. The methodology used for identification was recommended by Peters & Orejas Miranda, 1971; Marques et al., 2001; Campbell & Lamar, 2004; and Kwet & Dibernardo, 1999.

20.3.4.1 Mammals

The region contains diversified mammal fauna, including species ranging from small mammals (rodents) to large-sized animals. The mammals are capable of occupying a large variety of habitats. There are not a significant number of big animals in the region of the project, but there are numerous small-sized species, such as bats and rodents. The majority of the mammals are singular and nocturnal and are seldom observed.

Footprints of a Puma Concolor (sussuarana), considered to have its largest habitat in the vicinity of the Project, have been observed in the region. 47 species have been identified, belonging to 19 families.

Several mammals have been identified with economic value derived from consumption as food by local residents: armadillos (Dasypodidae), preás (Caviidae), mocó (Caviidae), agoutis (Dasyproctidae) and tapetis (Leporidae).

According to the Official List of Brazilian Fauna Threatened by Extinction (MMA - Instrução Normativa, no 3, de 27/05/03), the Brazilian three-banded armadillo (Tolypeutes tricinctus) is categorized as threatened. The following species are classified as vulnerable: giant anteater (Myrmecophaga tridactyla), ocelot (Leopardus pardalis), little spotted cat (Leopardus tigrinus), and cougar (Puma concolor).

20.3.4.2 Avifauna

The avifauna was the most representative group during the field survey and is associated with the Project area vegetation and habitat. Birds are considered imperative in any ecosystem, due to the fact that they combat plagues, contribute with flower pollination, seed spreading, in the control of rodent and venomous animals, collecting and recycling biological wastes and as a bio indicator of environmental conditions.

Limiting the scope of analysis only to the caatinga of the State of Bahia, two studies found approximately 283 and 280 species (Fiúza, 1999 and Lima, 2004 respectively). Both studies considered seasonal and year-long species in the Porto Alegre region in the county of Maracás, considered to be within the Project's area of influence. An additional study in 2005 (CBRO, 2005) identified 247 bird species distributed among 51 zoological families.

The Project area contains a large species diversity, estimated at approximately 88.2% of all species found in the State of Bahia. However, due to the relatively good conservation of natural resources and habitat, this diversity is not uncommon in the area. Aquatic birds, which use the region's ponds, lakes and rivers for various purposes, contribute significantly to this diversity.

The families with the largest number of individuals (above 4% species / family) were: Tyranidae (20 species), Emberezidae (19 species), Thraupidae (16), Furnairdae (15), Thamnophilidae (14) and Trochilidae (11). These six families encompass 38.3% of all species observed.

The consumption of wild avifauna as food and raising as pets are common in many regions of Bahia, including the county of Maracás. This tradition threatens numerous species, including xerimbabos and cinegetic species. The tinamidae family (quails, partridges and tinamous) and the columbidae family (doves and pigeons) are frequently sought as food in the region. The main ornamental birds are the melro (Icberidae), galo-de-campina (Fringillidae), canário-da-terra (Fringillidae), caatinga parakeet (Psittacidae), maritaca (Pittaicidae), among others.

Based on the Official List of Brazilian Fauna Threatened by Extinction (MMA - Instrução Normativa, No 3, de 27/05/03), none of the species are categorized as threatened.

20.3.4.3 Herpetofauna

Though the caatinga reptiles are considered well surveyed (Vanzolini et al., 1980), unexpected findings suggest that little is known about the patterns, which govern their evolution and differentiation (Rodrigues, 2005). This group is evenly distributed throughout the caatinga, with the only absentees being the crocodilians.

The reptile fauna of the region is very rich. During the field survey, the following groups were registered (seen or mentioned during interviews): chelonian, serpents and amphisbeanidae.

The venomous reptile fauna of the region shows ample distribution in every biome, except for the jararaca-da-caatinga (Bothrops erythromelas), which is restricted to the caatinga. Species of note include the tropical rattlesnake (Crotalus durissus), jararaca (Bothrops jararaca), Jararacussu (Bothrops erythromelas), cobra-patrona (Bothrops sp.) and coral snake (Micrurus sp.).

Amongst this group, species more susceptible to human activities include the snakes and lizards that live in forested environments, mainly small species and species adapted to the microclimate. These species are usually incapable of enduring the high temperatures of the open fields; consequently, maintenance of the remaining forested environments is critical for the survival of these communities. A total of 19 species, distributed in 9 families, were registered during the surveys.

The lizards are known as frugivorous reptiles and play an important role in the spreading of seeds.

Twelve species of amphibians were found in the following families: Bufonidae, Leptodactylidae, Hylidae e Microhylidae (Quadro B-listanfíbios). These are mainly found in ponds, wells and streams, but larger amphibians have been observed farther away from water resources in drier areas including toads (Bufo crucifer) and treefrogs (Hyla spp.). In more humid areas, the rãs (Leptodactylus spp.) and the black frogs (Ololygoe spp.) have been observed.

The red-tailed boa (Boa constrictor), rainbow boa (Epicrates cenchria), Argentine tegu (Tupinambis teguixin e Tupinambis meriane) and the tuberculate toad-headed turtle (Phrynoes tuberculatus e Geochelone carbonaria) are considered the main cinegetic species in the region. However, they do not have the same cinegetic value as the mammals, thus they are only occasionally hunted or captured.

The snakes of epidemiological importance in the region, include: tropical rattlesnake (Crotalus durissus), jararaca-vermelha (Bothrops erythromelas), jararaca (Bothrops sp) and the coral snake (Micrurus sp). All of them are capable of injuries which, if not properly treated, can lead to death or irreversible damage. Injuries or incidents involving snakes is a common aspect of rural communities where agriculture and pasture are the main labor activities.

20.3.5 Aquatic Biota

Aquatic biota samples were collected along the Rio de Contas River to the end of the reservoir, Pedras Dam, including zooplankton, phytoplankton, ichthyoplankton, macrophyte and benthic communities were collected (EIA, 2008).

20.3.5.1 <u>Zooplankton community</u>

The qualitative analyzes of the samples identified components of zooplankton community, distributed in the groups Protozoa, Rotifera, Crustacea, Copepoda, Cladocera, Crustacea and Insecta.

The samples showed a high concentration of rotifers, cladocerans and copepods, which may be related to anthropogenic eutrophication of the system, due to excess organic matter.

20.3.5.2 Phytoplankton community

The qualitative analysis of the samples identified components of the phytoplankton community distributed in the following divisions: Chlorophyta, Cyanophyta, Bacillariophyta and Euglenophyta.

The results showed a high concentration of the class Chlorophyta inferred to be associated with eutrophication by inputs of inorganic nutrients from agricultural activities for livelihood.

The high concentrations of this class are associated to the hydrodynamic regime change of systems due to damming of rivers, causing deep and abrupt changes in the conditions of phytoplankton communities BICUDO (2005). This is reflective of the transformation of an open system for transportation to a more closed system.

20.3.5.3 Icthyoplankton community

Identification of representatives of the icthyoplankton community came from observation of Pedras dam and the collection of eggs and larval fish states EIA (2008). The qualitative analysis identified larvae distributed in the following families: Erythrinidae, Cichlidae and Characidae, Poeciliidae, and Engraulidae Ariidae.

Upstream of the Pedras dam, the following adult families were identified: Characidae (piaba) Erythrnidae (betrayed) Anostomidae (piau) Loricariidae (charitable or catfish), cichlids and Scianidae (croaker). Some of the observed species, such as gender Hoplias sp (Traíra), Astyanax sp larvae (Piaba), genus Poecilia sp (Barrigudinho), are abundant in most of the watersheds of the Northeast and Bahia.

One of the representatives of the Family Cichlidae, urolepis Oreochromis (Tilapia), is considered exotic and introduced in Brazil through fishing projects in watersheds. The occurrence of peacock bass (Cichla sp) was confirmed by in situ verification of fishing carried out upstream of the Pedras dam.

Some species Aspistor sp (Catfish), are not native to the basins of Bahia and were introduced through fishing projects. Additionally, representatives of the Family Engraulidae, Anchoa spinifer (sardines) or Anchoviella vaillanti (anchovy) have been identified in the rivers of the Northeast and comprise an important food source to coastal communities.

20.3.5.4 Benthic community

Representatives belonging to the class Gastropoda with a predominance of Melanoides tuberculatus (Grastropoda; Thiaridae) (Muller, 1774) were identified in the project area. This species is native to East Africa, Southeast Asia, China and Indo-Pacific Islands, and its introduction in Brazil is inferred to be related to trade in ornamental fish and plants (France, 2007). The Melanoides tuberculatus occurs in disturbed areas and is usually associated with inputs of organic matter.

20.3.5.5 Aquatic Macrophytes

Aquatic macrophytes are important components of aquatic ecosystems because they contribute to improve the structure and diversity of habitats, interfere with nutrient cycling and participate in the base of food webs (Esteves, 1998).

A hydroelectric dam on the Rio de Contas river has created the Pedras dam lake. According to the sampling program, only 2 species (Salvinus Chara sp and sp) were identified in this lake. However, according to residents there are other species of aquatic macrophytes that have not been confirmed.

Figure 20.3.5.5_1

Pedras` Dam reservoir at Porto Alegre

20.4 Social and Economic Baseline

This section presents and discusses the various social and economic (socio-economic) aspects of the Project, including discussion of potential modifications to these aspects throughout the Project lifecycle.

Although the county of Maracás will directly benefit with regards to the Project, the indirect benefits extend beyond that county. The changes in the municipality of Maracás will result in new relationships and interactions between the municipality and proximal regional neighbours including, but not limited to: economic structure, job opportunities, taxes, income of families and companies, and distribution of work force.

The socio-economic assessment completed for the Environmental Assessment comprised a systematic methodology involving the integration of 25 counties which make up the micro regions that will be impacted by the Project. This assessment emphasizes the Maracás municipality and the area of direct influence of the Project.

The social and economic assessment was based on interviews with local residents through March 2008 (primary data) and on secondary data obtained from an audit review report completed by Mineral Engenharia Ambiental Ltda. in 2011.

20.4.1 Populations Dynamics

A study of the evolution of the population of the counties included in the Maracás micro region encompassing the last four decades was undertaken with the purpose of portraying a broad view of the demographic processes experienced by the 25 municipalities. Generally, the urban population showed larger growth rates, changing the distribution of the population while maintaining a rural profile in the majority of the counties.

From 1991 to 2000, the average annual population growth rate of the 27 counties remained positive (1.62%), resulting in a population growth from 509,378 to 532,409. The urban population of all counties grew from 276,868 to 325,905, with Maracás showing the largest annual urban population growth rate (4.75%). Only nine counties (33.3% of the counties) had predominantly urban populations, with the remainder 18 counties staying rural.

In the same period, the average annual population growth rate in Maracás was 1.73%. This county, which in 1991 still showed a predominantly rural population (44.91% urbanization rate) was considered an urban county by 2000, with 58.44% of its population in cities.

In 2007, the population of Maracás was the third largest of all the counties studied, being smaller than Jequié and Jaguaquara. The average annual population growth rate from 2000 to 2007 was 1.11%. Over the same period the average annual population growth rate of the region's main county, Jequié, fell 0.12%.

20.4.2 Employment Structure and Unemployment Rate

In Brazil, the service sector employs the largest number of economically-active people. In Bahia, the relative importance of the different economic sectors is similar to the national situation: 29.4% of employment in agriculture and grazing; 56.2% in services; and 14.4% in industry. The 27 counties included in the study showed similar distribution of economic activities: service sector, followed by the agriculture and grazing sector and the industrial sector.

In Maracás county, the largest share of workers is found in the agriculture and grazing sector (45.7%), while the industrial sector provides 11.6% of the county's employment.

In general, the unemployment rate of the Maracás micro region shows a considerable variability (3.92% to 24.94%). Maracás is among the counties with the largest unemployment rates in the region (19.41% in 2000), with above the Bahia and Brazilian averages.

In the county of Maracás, the share of the population that is younger than 29 years is 62.56%, which is slightly above the region's average. The portion of the population older than 60 years is smaller than the region's average (8.92% compared to the regional average of 10%).

The county is faced with the challenge of providing education, leisure and work opportunities to its predominantly young population.

The comparison of the literate population in the micro regional area of influence of the Project from 1991 to 2000 reveals a significant increase in literacy rates. In 1991, the literacy rate of the population between 5 and 9 years was 16.9%. In 2000, this percentage increased to 44.4%. Between 10 and 14 years, 54.8% of the people were literate in 1991 and this rate increased to 91.6% in 2000. The growth in literacy rates was observed in every age demographic in Maracás, even among the oldest people.

20.4.3 Economic Aspects

In 1991, the average monthly income at Maracás was R$62.10 (eighth place in the region). From 1991 to 2000, the county showed the smallest income growth rate in the region (18.4%). In 2000, its average per capita income was only R$73.50.

The Gini index is a measure of the income concentration and varies from 0 to 1. The closer it is to 1, the worse the income distribution is (income is more concentrated). If the value is closer to 0, the income is more evenly distributed through the population.

In 1991, the best income distribution of all the counties in the micro region was measured in Maracás (0.44). From 1991 to 2000, the income distribution in the counties followed different paths, but income concentration was observed in most of them. In 2000, Maracás still showed one of the best income distributions of the micro region, with 0.5.

The economic activities of the counties of the micro region are highly concentrated in the county of Jequié. Of all the goods produced in the region, Jequié alone is responsible for 45.24%. That means almost half of all the economic activity of the entire region is limited to one county, so, this one county tends to exert a strong attractive force over the others.

The service sector is the main source of income for the counties in the Project's area of influence. However, the economical results of agriculture and grazing activities are also significant. Maracás represents 3.95% of all income generated in the region.

The per capita gross internal product is led by Jequié which remains in front of all other counties with a value of R$7,091.48 per year; this value is greater than the state value of R$6,582.00. Maracás per capita gross internal product (R$2,318.45) is the ninth largest of the micro region. The smallest one of all the 27 counties is Iramaia with R$1,785.93.

20.4.3.1 Production Structure on the Maracás County

There was a reduction in the number of businesses that produced cow milk in Maracás from 1996 to 2006, from 400 milk-producing businesses to 282. Over the same period, cow milk production in the municipality increased by 51% while goat milk production declined 67% and egg production decreased 96% suggesting significant consolidation in cow-milk production.

Seasonal products, particularly sugar cane, beans, and tomato decreased from 1997 to 2006 in Maracás. The only exception was mamona, whose production increased 172%. The area used to grow produce expanded 8.5% over this period.

The total area with permanent crops has been subject to significant changes in the last 10 years. From 1996 to 2006, areas assigned to permanent crops in the county of Maracás shrunk 20%. Coffee production increased from 2000 to 2006, but the 2006 production was smaller than that of 1996. The orange and lemon productions did not change significantly, while passion fruit production fell 89.45% from 1996 to 2000.

20.4.4 Land Use and Occupation

The land use and occupation study focused on the communities around the Project site and on the capital of the Maracás County. The study examined public services infrastructure, land management and the dependence of local residents on natural resources (i.e., water resources) considering this is a semiarid region with established water scarcity concerns.

The goal was to provide an adequate view of the area where the effects of the Project will be greatest. This mapping covered the Project's directly influenced area (DIA), which includes all pits, waste rock/ore piles, tailings ponds, processing units and all other operational and administrative support units.

20.4.4.1 Rural Properties

There are four large rural properties in the DIA, averaging more than 2400 ha where extensive and semi-extensive cattle raising activities are carried out, which requires large pasture areas and small bushes. All landowners of these properties visit them regularly and employ a number of employees to run the operations. The facilities that exist in the largest properties include barns and warehouses and all show good construction standards including brick walls. Most of these facilities are sized adequately to the property's production.

The construction standard for the houses of the workers is not ideal, but most of them have electric power supply. Water is supplied through rainwater collection and water trucks. There are only a few houses and due to the size of the properties they are relatively far apart from one other.

There are also three smaller properties in the DIA with only one proprietor residing onsite and taking care of the land. Secondary activities include household agriculture and traditional cheese production. Temporary employment is common in the region.

Temporary rural workers live in the nearby villages. Most of these villages are along the main road that connects the highway BA-026 (at the community of Pé de Serra) to the village of Porto Alegre.

20.4.5 Villages around the Project

20.4.5.1 Pé de Serra

Pé de Serra village lies on BA-026 highway in the foothills of the mountains that divide the east-central (upper) and west (bottom) of the municipality of Maracás. The community is characterized by a cluster that was established and developed on the edge of the highway.

Among the communities surrounding the Project, Pé de Serra is the one with the best infrastructure, including power, telephone network, water supply through underground wells, some paved roads and garbage collection. There are inns, small shops and bars. Many homes are vacant waiting for new residents.

There is no sewage collection infrastructure therefore many houses have poor sanitary facilities erected outside the house. Drinking water supply is provided through wells with high levels of salts, necessitating the use of desalination plants operated by the city to make the water potable for human consumption. The water supply is at its limit, and the residences are supplied on alternate days to ensure all have access to water.

There is a Family Health Center and a school that offers elementary school grades. Young people are required to move to Maracás to continue their studies.

20.4.5.2 Água Branca

Água Branca village is located in an area adjacent to the municipal road that connects Pé de Serra and Porto Alegre, east-southeast of the project. Água Branca is the closest town directly affected area by the Project. It is characterized as a cluster of typical rural buildings, with houses located on the edge of the road, amid agricultural lands and pastures.

The community has just over 35 homes of farm workers who subsist from the land work in the large surrounding properties. The houses are a typically based off a very simple pattern, some using adobe-type construction. Most do not have toilets and water supply is provided from wells which require the use of desalination (Section 20.4.5.1). The main source of income is farm work, with some people providing services for the Maracás Project under a formal contract.

Public transport is limited to a line connecting the center of Porto Alegre to Maracás, with service running a couple of times during the day. School transport is served by buses and vans provided by the municipality of Maracás.

Among the nine communities visited, Água Branca is the one that has the highest expectations regarding the Project. Specifically, residents are viewing the proposed infrastructure (which was suggested at a public hearing) as extremely positive. The infrastructure includes road improvement and the construction of a potable water treatment plant. The water treatment plant for this community has not yet been implemented due to bureaucratic delays at the state government level.

20.4.5.3 Antonio Caetano

The village of Antonio Caetano is comprised of 10 houses located near the Santo Antonio Farm, owned by Mr. Antonio Caetano Neto. This village is located near the present Project headquarters along the municipal road that connects Pé de Serra to Porto Alegre.

Households are made up of rural workers who survive from the land in large surrounding properties. It is common to see the cultivation of palm and other crops for subsistence farming, such as beans, corn and watermelon within the properties. The survival of such subsistence crops is threatened by low water availability in the region.

The houses are generally very simple in pattern, some of adobe-type construction. Most homes do not have toilets and the water supply is inadequate with the use of wells, rainwater collection systems, and water trucks provided by the city.

Public transport is limited to a route connecting the center of Porto Alegre to Maracás, a couple times during the day. School transport is served by buses and vans provided by the municipality of Maracás.

20.4.5.4 Braga

This village has very similar characteristics to the Antonio Caetano. It is located along a neighboring municipal road that connects Pé de Serra to Porto Alegre, east-southeast of the project.

20.4.5.5 Caldeirãozinho

Caldeirãozinho village is located at the margins of the municipal road near the district of Porto Alegre, and follows the pattern of occupancy and structure observed in the other villages in the region.

The buildings are simple, with small areas used to grow subsistence crops. They are served by the electric power grid and have a phone network available. The majority of homes do not have toilets and sewage is held in common pits. The existing trade focuses on Pindobeiras, since the acquisition of products not found in the region are available in Maracás. It has a public school that provides elementary education. The streets are not paved and public transportation is limited to the route connecting Porto Alegre to Maracás.

20.4.5.6 Jacaré

Jacaré village is approximately six kilometers south-southwest from the plant site situated on the banks of the Jacaré River. It borders the municipalities of Maracás and Iramaia and consists of approximately 20 homes of low constructive pattern, some of adobe construction. There is electric power supply to the Village but access to a telephone network is limited. Water supply is limited to individual tanks to capture rainwater or tanker trucks supplied by the City of Maracás.

It is common to have small yards where palm is usually grown for human and animal consumption. There is a school that offers grade 4 elementary education. To continue their education, students go to Porto Alegre.

20.4.5.7 Lagoa Comprida

Lagoa Comprida village is located east-southeast of the project along a municipal road that connects the neighboring villages of Pé de Serra and Porto Alegre. The village has a small number of households comprised of rural and agricultural workers who survive from land deals in the large surrounding properties. It is common to cultivate palm and other crops such as beans, corn and watermelon for subsistence. This village has strong relations with the communities of Água Branca and Antonio Caetano based on their proximity.

The houses follow the same regional pattern with most not having toilets, and the water supplied with the use of wells, rainwater collection systems, and water trucks provided by the city.

Public transport is limited to the same line connecting the center of Porto Alegre to Maracás, a few times during the day.

20.4.5.8 Pindobeiras

Pindobeiras is established at the margins of the municipal road, near the district of Porto Alegre. The village of Pindobeiras is comprised of 30 houses with a population of 122. Five houses are currently vacant. Houses are simple, but are served by the electric power grid and telephone network. The majority of homes do not have toilets.

According to the local leader, since the population does not receive government assistance for the development of agriculture in the settlement, it develops activities in large farms in Maracás. Public transportation is limited to the service connecting Porto Alegre to Maracás.

20.4.5.9 Porto Alegre

Situated close to the Pedras Dam, Porto Alegre is an urban center comprising predominantly residential of low to medium quality. Community employment is predominantly from fishing and the cultivation of fruits and vegetables at lake banks, including corn, watermelon, and mango. In some areas cattle ranching was identified.

Porto Alegre is the region's most populous village with approximately 250 residences. Residents reported that the increase in the population began with the construction of the railway on the opposite side of the lake.

Infrastructure includes a power grid, public water supply, health services, education and locations for social interaction and leisure. Sanitation is inadequate, with the use of mass pits which have high potential for soil contamination.

The main resource of the Porto Alegre residents is the lake, which provides the water for development of agriculture, fishery and leisure. According to local information, approximately 80 men are engaged in agriculture and fisheries with the most common fish caught being tilapia and piranha. The shrimp fishery is largely staffed by a group of approximately 25 women.

20.4.5.10 Quilombola and Indian Communities

Throughout the Project's DIA (made up of the 27 counties), only the county of Jequie has a Quilombola community that is officially recognized. Quilombola are the descendants of slaves who escaped from slave plantations in Brazil prior to abolition in 1888. The most famous Quilombola was Zumbi and the most famous Quilombo was Palmares.

The people of Maracás consider the communities of Cuscus, Pindobeiras, Caldeirão dos Miranda and Jacaré as being quilombolas, in spite of not being legally recognized by the Palmares Foundation and INCRA (National Institute for Colonization and Land Reconstruction).

There are no Indian communities in the county of Maracás.

The majority of the nine villages within the Project area have less than 24 houses. The exceptions are Pé de Serra and Porto Alegre, which have approximately 220 houses. Most of the houses show humble construction standards, with brick walls and clay. Several houses were built in the 1950s. Many houses have backyards with small plantations and animals for personal consumption. Villages are accessed by a main road and houses are relatively close to one another. The public services are modest with some villages having schools, health clinics and small commercial centers.

All of the nine communities have electric power supply. Porto Alegre has some paved streets. Water is obtained from wells, rainwater collected from rooftops and water trucks supplied by the city. In the case of Porto Alegre, the water is drawn from the Contas River, which is dammed 85 km downstream from the community.

Porto Alegre is the village that shows the best sanitary conditions. The main economic activity for many residents of these villages is working with cattle on the farms. In Porto Alegre, there is also commercial irrigated production of fruits and vegetables.

20.4.5.11 Municipality of Maracás

Maracás is an urban conglomerate located in the central portion of the county on a plateau at a higher elevation than the surrounding valleys. It is a typical town in the interior of Bahia, with a small population that cultivates the habits and customs of their ancestors. Currently known as the "city of flowers", Maracás had a population of 21,832 in 2010.

Downtown Maracás has two main avenues, Brasília and João Durval, and has good urban infrastructure with paved streets, a water supply system (the water is withdrawn from the Boca do Mato reservoir, 9 km away), an electric power supply and telephone lines. There is regular waste collection and street sweeping services making the public avenues much more aesthetically pleasing than many villages. However, there is no wastewater collection system and the domestic sewage is disposed of in pits typically located in the backyard of the houses.

Maracás has legal regulations regarding urbanization, such as those established in the city's development plan.

The tertiary sector, represented by activities of trade and services, is the main source of municipal income and in 2008 it contributed 65% of Gross Domestic Product (GDP).

The agricultural sector plays an important role in the economy of the city with the agricultural sector accounting for 23% of GDP. Labor absorption accounts for 45.7% of registered jobs in 2008.

The city's economy is not diversified, resulting in low employment. The unemployment rate was 19.41% in 2000, exceeding state and national levels. This generates a high number of people living below the poverty line. In 2003, according to IBGE data, 54.63% of the population of the city was below the poverty line.

Commerce and services are distributed along the main avenues and streets. The local commerce is relatively diversified and in harmony with the size of the city. It includes clothing stores, cellular phone shops, furniture stores, house appliance stores, bookstores, construction supply shops, grocery stores, drugstores, and restaurants. Among the institutional services are a branch of the Banco do Brasil, lotteries, post offices, schools, social centers, health clinic, a Catholic Church and an Evangelical Church.

The educational system is made up of eight public schools, which offer elementary and high school courses. Five of these schools are municipal and three are run by the State. There is a private elementary school and private kindergarten schools. The municipal education system is supplemented by kindergartens available for the children that live downtown and in the surrounding neighborhoods.

The local college is called Faculdade de Tecnologia e Ciências (FTC), and has on-line graduation courses including business, biology, mathematics, languages as well as some specialization courses.

Water supply is insufficient for the city. For human supply, the municipality makes use of surface waters (rivers and springs) and underground (wells). The county is supplied by a small dam known as Boca do Mato.

Violence and drug use are the most common social issues. According to a representative of the Judiciary, violence involving young people is increasing with narcotics most often cited as a generator. This scenario may reflect different situations, such as lack of perspective and employment opportunities, and poor choice of leisure involvement with people from different places among many others.

20.4.6 Historical and Cultural Heritage

Maracás is a typical city of the Bahia's countryside with a small population that perpetuates the habits and customs of its ancestors. The name of the city comes from Maracás, which is an Indian tool used by the Cariris tribe that lived in the Paraguaçu region.

According to studies by Prof. Carlos Ott, the Portuguese arrived at the Paraguaçu valley in search of gold and diamonds and found the Indians. Many bloody battles were fought, resulting in the disappearance of the Indians. These Indians are still remembered today in the history of Maracás as being brave and aggressive warriors.

The influence of the gold cycle on the county can be seen today by the city's architecture, showing houses with styles that are typical of that period. The houses are narrow, with high doors and windows, similar to the ones found in Chapada Diamantina and Ouro Preto.

The Portuguese occupation of the region is evident through the main houses of the farms, in colonial style. One example is the Santa Rita farm, which still keeps the big main house with its 18th century furniture and chapel.

Since the occupation of the region started in the period in which Brazil was still a colony of Portugal, and during which slavery still existed in Brazil, the presence of black people is very pronounced.

According to Prof. Marina Silva, Maracás was one of the five Brazilian towns that hosted Germans during the Second World War. The German presence in the county is clearly seen by the main church's German gothic style architecture, and by other houses in the same style.

Besides the areas of historical and architectural value, there are some areas that are part of the county's natural heritage and should be protected. For instance, the Jequiriça River headwaters park rebuilt by the municipal government, the Eucalyptus Park, the water spring of Jequiriça River, and mountains of the region.

20.4.6.1 Archaeological Heritage

The report "Programa de Diagnóstico e Prospecção para o Projeto Vanádio de Maracás, Maracás, Bahia" submitted to INEMA and IPHAN (Instituto do Patrimônio Histórico e Artístico Nacional) for the Installation Permit, presents the archaeological studies carried out in 2007 by the company Arqueologia Brasil - Projetos, Pesquisas e Planejamento Cultural e Arqueológico Ltda., whose principal office is in Espírito Santo do Pinhal - São Paulo. The archaeological survey was approved by Acervo - Centro de Referência em Patrimônio e Pesquisa, based on Porto Seguro - Bahia. The leader of the technical team was Prof. Dr. Walter Fagundes Morales (archaeologist and sociologist). The other archaeologists of the team were: Luiz Augusto Vivas, Flávia Prado Moi, Daniel Bertrand e Diego Palma Rocha.

The archaeological studies were authorized through the IPHAN publication N. 162 from July 30, 2007, which deals with the permission to carry out archaeological survey and analysis for the Project, in the county of Maracás, State of Bahia.

The archaeological survey was concentrated in the areas of the mining rights DNPM 870.134/82 and DNPM 870.135/82, where the mineral targets of the Project are located. In these areas, 20 archaeological sites and 62 occurrences findings of archaeological materials were identified. Every archaeological site and occurrence is identified by its geographical coordinates and described in the report with photographs.

This last stage of the archaeological rescue of artifacts includes archeological heritage education activities. The programs of archaeological recovery and heritage education will be included in the PCA (Environmental Control Plan), which is part of the environmental permitting process for the Project.

20.4.7 Living Standards

The human development index - IDH was created in 1989 to represent the level of development and living standards of a community. The intention this index is to represent development based on three criteria: life expectancy, education and GDP per capita.

The criterion life expectancy - life expectancy at birth - aims to represent the health condition of a society. In 1991, the Maracás life expectancy index (0.541) was categorized as medium and the county was sixteenth in the micro region. In 2000, the county improved its life expectancy index by 6.7%, reaching 0.577 and achieved the 12th position.

In 1991, generally speaking, the educational indices of the counties in the Project's area of influence were worse than the life expectancy ones. However, from 1991 to 2000, this index increased and overcame the life expectancy values. The Maracás' educational index in 1991 was 0.490 (low). In 2000, this value had increased to 0.714, showing a 59.4% increase and, hence, was classified as medium.

The GDP per capita index is the one that has the smallest contribution to the IDH of the region's counties. In 1991, Maracás had a GDP per capita index of 0.462, placing it in the seventh position out the 27 counties of the micro region. In the period from 1991 to 2000, the growth of that index in Maracás was only 6.1%, so the county moved down to the fifteenth position, with a GDP per capita index of 0.490.

Out of all the 27 counties located in the Project's area of influence, in 1991, Maracás was in the fourteenth position, with an IDH of 0.498 (low). From 1991 to 2000, the increase in the IDH index of that county was the sixteenth best (22.3%) and its IDH reached 0.609 (medium). As such, the county was in the sixteenth position, losing two positions. The most important of the three criteria, in the case of Maracás, was the education index (0.759).

20.4.8 Education

In 1991, Jequié had the largest average school years of all the counties in the Project's area of influence, and had the same value as the State of Bahia (3.3 years). Maracás' average was only 1.5 years and that placed the county in the ninth position among the counties in the micro region. In 2000, Maracás moved to fifth place with a 73.3% increase in its average school years, reaching 2.6 (still low).

Maracás' position with respect to adult illiteracy (older than 25 years) was 14th in 1991 (56.7%). In 2000, Maracás reduced its adult illiteracy rate to 38.6%.

In general, data showed an improvement in the number of Maracás residents that have educational services. However, additional efforts are needed to reach the educational level of the Bahia State (average of 4.5 school years and illiteracy rate of 28.5% in 2000).

At the municipal and state system, Maracás provides education at three levels: kindergarten, elementary and high school. The rural population has free transportation to the schools, provided by the county administration. The population in the villages located near the area of the Project has access to municipal schools.

20.4.9 Health

The hospital beds available in the Project's area of influence are predominantly privately owned (52.5% or 741 beds). The public hospital beds total 693 or 47.5%.

Maracás has 64 hospital beds, with 40 being municipal owned and 24 privately owned. This represents a ratio of 1.9 beds for a thousand inhabitants; a value that is smaller than the OMS standard. With respect to hospital beds, Maracás occupies the 13th out of the 27 counties of the micro region.

Maracás has one of the worst (26th) healthcare coverage of all the 27 studied counties, with only 67.4% of the population assisted with such programs. Of the 27 counties that make up the micro region, Jequié has the largest number and the greatest variety of medical equipment and is the region's center for medical care. Even so, the medical services are still very precarious.

Maracás has only one piece of X-ray equipment (100-500 mA). Thus, the Maracás' population needs to go to another county if a more complex medical examination is necessary.

In 2008, the healthcare system had six public health clinics; four family health units, one healthcare center, one clinic specialized in birth surgery, and one hospital. There is a shortage of doctors for the urban and rural communities. Due to this shortage, the public health clinics in the rural zone operate with nurses and assistants, while doctors are available usually once a month.

From 1999 to 2005, the main cause of death in Maracás was caused by brain / vascular diseases. Heart strokes were the second and diabetes mellitus and transit accidents were third.

20.4.10 Housing Conditions and Infrastructure

In the last census (2000), Maracás had 7,430 families living in private houses (31,678 people) and 7,430 people declared they provided money for their family; 5,288 were spouses; 16,330 were sons and daughters; 152 were parents or mother / father in law; 1,035 had another type of relationship, and 220 had no family relationship with the owner of the house.

According to the same census, there were 6,832 houses with adequate sanitary installations in Maracás. Out of these 6,832, 28% had treated water supply, 0.9% wastewater collection, and 76.7% had proper waste disposal.

The data from the last census shows that, though the population of Maracás does not have easy access to basic consumption goods (refrigerators, etc.) or to sanitation services, the housing conditions are not as bad as that seen in many large urban centers, mainly with respect to the number of people per room.

The Maracás' water supply system has 2,914 active water connections, supplying water to 18,533 inhabitants, through a 58-km-long network. The county does not have a sewage collection network, so waste water is disposed by individual households.

The public cleaning services are limited to the county's capital and includes tree trimming, street sweeping and waste collection. The waste is disposed of at a simple landfill that started in November 2005.

The city does not have a rainwater drainage system, but the reconstruction of the BA-026 (connects Maracás to Contendas do Sincorá) includes storm water drainage adjacent to the road.

The following roads are used to get to Maracás: BA-026 (Maracás /Contendas do Sincorá), BA-250 (Maracás /Lajedo do Tabocal) and BR-330 (Maracás /Jequié). There is a bus station, where the inter-municipal routes connect to Salvador, Vitoria da Conquista, Iramaia, Jaguaquara, Jequie, Ilheus and Porto Seguro, and interstate routes from Rio de Janeiro and São Paulo arrive. The county has a landing strip called Luís Eduardo Magalhães.

Maracás also has a community radio station, loud-speaker services, telephone lines, cellular coverage, post offices and four small newspapers. The TV broadcasts are TV - Sudoeste, Aratú, TVE Bahia and Bandeirantes.

There is a municipal market on Saturdays when products from Maracás and Jaguaquara are sold including live animals (i.e. pigs, goats, chicken, ducks), cereals, grains, vegetables and meat. Almost all the products and meat consumed in the county are produced locally. The cereals are brought from other cities in the southeastern region.

20.4.11 Leisure, Tourism and Culture

The cultural aspects of Maracás are intimately related to the religion of the population. The most important cultural events, both in the rural and urban zones, show traces of popular Catholicism mixed with enjoyment. The main events of the county are: Ternos de Reis, Festejos Juninos (Trezenas de Santo Antônio e São João), Festa de São Roque, Festa de Nossa Senhora da Graça and Cosme e Damião.

The city has a few public leisure areas, such as the Eucalyptus Park, where environmental institutions are located (ADAB, EBDA, Production Secretary and Flower Project of Maracás). The park is also used for various sports. Besides this park, there is the park of the springs of the Jequiriçá River, where there are ecological tracks, sports court and municipal squares.

There are also very few leisure areas in the communities surrounding the future Project area. Most of the villages have only small soccer fields. The exception is Porto Alegre that has a sports court built by the municipal government.

20.4.12 Public Safety

Maracás' public safety is ensured by the 19º Batalhão da Polícia Militar (Military Police) by the 4ª CIA de Polícia Comunitária (Communitarian Police), by Delegacia de Polícia Civil (Civil Police Delegacy) and by the Guarda Municipal de Maracás (County Police).

The Military Police is composed of 14 police officers and 1 vehicle. This structure is enough to ensure the public safety of the county and the services provided include: rural surveillance, school surveillance, road blocking at night and drug traffic combat, among others.

The Civil Police has five officers and five public agents, as well as one vehicle. There is no fire department in the municipality.

20.4.13 Property Disputes and Rural Settling

There are no property or land disputes in the Project's DIA. There is a program for rural settling (Pakhaeta) at the California Farm, village of Pindobeiras. The area available for settling is 2035 ha and is large enough to settle 63 families. The registration process is underway. All the people to be settled will be rural workers in the region.

20.4.14 Water Supply

The water sources for human consumption include surface water bodies (rivers and springs) and groundwater (wells). The public raw water comes from a small dam called Boca do Mato. The villages of Porto Alegre and Pindobeira obtain their water from the reservoir of the Pedras dam, Contas River. The other villages get their water from wells and water trucks.

Due to the fact that it is located in the margin of the Pedras dam, the community of Porto Alegre can use the water from the Rio de Contas for various purposes, including irrigation, leisure and fishing. These multiple water uses do not occur in any other village in the region.

With irrigation and fertile soils, the rural properties of Porto Alegre deliver fruits for export (mango, papaya and cashew) and vegetables for the regional market. Nevertheless, irrigation is not a threat to the supply of water for human consumption, because the lake volume is approximately 1,750 million m^3.

Although the fruit production is very large at Porto Alegre, fishing is still the most important economic activity in the district of Porto Alegre. Besides fishing, the people also produce fresh water shrimp to be sold in Jequié.

Navigation is done only in the Pedras dam, but it is restricted to small fishing boats and a special boat that transports goods and people among Porto Alegre, Jequié and Iramaia.

The reservoir is also used for leisure purposes such as carnivals and other events, when tents and public shows are set up.

20.5 Environmental Impact Assessment, Mitigation And Compensation

This section was founded on a technical report prepared by Mineral Engenharia em Meio Ambiente Ltda, an independent consulting company retained by Largo in 2011 to carry out an Equator Principles Compliance Audit in the Maracás Vanadium Project.

The Audit report focused on the aspects recognized by Principle 2 - Environmental Assessment, and as advocated, it identified and discussed the impacts and relevant social and environmental risks of the project, during the phases of installation, operation and decommissioning. Furthermore, it examined the proposed controls, monitoring programs and mitigation measures and appropriate management programs for enforcement of the principles.

20.5.1 Physical Environment

20.5.1.1 Erosion and Silting of water bodies

The excavation, removal, and storage of soil creates points susceptible to erosion resulting in laminar flow of rainwater, which can generate localized silting. The deforested areas, the excavated slope, openings of access roads, and water catchment systems are all susceptible to low-level erosion. This is due to low annual precipitation and the smooth topography in the DIA. During periods of short, intense rainfall, solids removal and silting of the João River and Jacaré River can occur.

Environmental, Health and Safety Guidelines for Mining establish some protocols and procedures (best management practices) to be considered for the prevention of erosion processes and settling in industrial and mining activities. To decrease the incidence of erosion processes in the area and settling of water bodies, the project has implemented several mitigation measures, including the implementation of the various measures proposed in the PRAD (Plan of Rehabilitation of Degraded Areas). An example is the erection of protection barriers for the North and South ridges around the Campbell pit to avoid sediment being washed inside the pit.

The access routes will be constructed with drainage channels to drain off rain water for a containment basin, where the sediments will be cached. The channels are designed for the rainy season (i.e., peak rainfall).

The existing water bodies in the DIA of the project, specifically the João and Jacaré Rivers may have their quality affected by solids and dissolved or suspended substances washed from the installations. Groundwater contamination can occur from the infiltration of water impacted by mine contact water or other sources of surficial contamination. Potential contamination point-sources include:

- Waste piles;
- Non-magnetic tailings ponds;
- Leached calcine tailings dumps;
- Chloride purge tailings ponds;
- Storm water drainage system;

- Effluent from the processing plant; and,
- Oily effluent.

20.5.1.2 Waste piles

The project will feature external waste (rock) dumps or piles generated from the mining of various open pits. The waste material originating from the open pits, which will be placed in a waste pile or catchment dyke, is predominantly rock consisting of boulders of varying sizes. The area destined for the Campbell mine Phase 1 waste pile covers approximately 47 ha and the area destined for the Campbell mine Phase 2 waste pile covers approximately 119 ha. The waste piles for the satellite pits vary in size ranging from 16 ha to 55 ha.

To assess the potential for leaching of mine rock waste into groundwater or surface water, SGS Laboratories undertook leaching and solubility testing of representative waste materials. This analytical work was undertaken following procedures regulated by the Brazilian Association of Technical Norms-ABNT, according to NBR 10.004/2004.

To assess the potential for acid generating materials (i.e., acid rock draining, or ARD), three types of rocks were submitted for analysis by ABA-M tests for prediction of acid drainage.

Tables 20.5.1.2_1 and Table 20.5.1.2_2 show the results of these analyses and Table 20.5.1.2_3 presents the Neutralization Potential Ratio (NPR) Screening Criteria (after Price et al, 1997) in English.

Table 20.5.1.2_1

Test work results - ABA-M - Waste Rock- Campbell

N	Rock	Sample Reference	PN(1)	PA(2)	PNA(3)	Potential Acid Generation	RPN (4)	Potential Acid Generation
			Em t CaCO3 equiv./ 1,000t rock					
1	Gabbro	Top extract - 12 to 60	3.0	<0.01	3.0	Potential	3.0	Potential
2		Medium extract - 60 to 100	2.0	<0.01	2.0	Potential	2.0	Potential
3		Lower extract - below 100	11.5	<0.01	11.5	Potential	11.5	Potential
4	Pyroxenite	FGA 61 - LML 7364	8.5	<0.01	8.5	Potential	8.5	Potential
		FGA 67 - LML 7369 -	214.0	<0.01	214.0	Potential	214.0	Potential
5		FGA 67 - LML 7369 -	224.0	<0.01	224.0	Potential	224.0	Potential
6		FGA 68 - LML 7371	12.0	<0.01	12.0	Potential	12.0	Potential
		FGA 76 - LML 7375 -	10.5	<0.01	10.5	Potential	10.5	Potential
7		FGA 76 - LML 7375 -	11.8	<0.01	11.8	Potential	11.8	Potential
8		FGA 79 - LML 7378	10.0	<0.01	10.0	Potential	10.0	Potential
9		FGA 86 - LML 7387	9.7	<0.01	9.7	Potential	9.7	Potential
		FGA 96 - LML 7395 /	13.5	<0.01	13.5	Potential	13.5	Potential
1		FGA 96 - LML 7395 /	11.8	<0.01	11.8	Potential	11.8	Potential
1		FGA 99 - LML 7398	11.0	1.2	9.7	Potential	9.7	Potential
1	Pegmatite	LML	13.0	<0.01	13.0	Potential	13.0	Potential

Notes		Interpretation of ANP Values and RPN	
(1)	PN = Potential neutralizing	PNA < -20	Probable generation
(2)	PA = Potential rock acid	-20 < PNA < +20	Uncertainty zone - test with RPN or more
(3)	PNA = Neutralization potential assessed = PN - PA	PNA > +20	Non Acid Generating
(4)	RPN = Potential ratio of neutralization = PN/PA		
		RPN < 1.0	Probably generation of
OBSERVATION: Test performed in the laboratory of SGS GEOSOL in Belo Horizonte - MG, in December of 2007 in sample (drill core) collected by the client in the field, Campbell, municipality of Maracás, State of Bahia.		1.0 < RPN < 2.0	Possible generation of
		2.0 < RPN < 4.0	Small generating potential
		RPN > 4.0	Potential to generate acid

Table 20.5.1.2_2
Test work results - ABA-M- Waste Rock- Campbell

No	Rock	Sample Reference	Residue Type	Class IIB	Class IIA	Class I			Observation
				Not Dangerous		Dangerous			
				Inert	Not inert	Corrosive	Reactive	Toxic	
1	Gabbro	Top extract - 12 to 60 m	Solid and dry	Yes	No	No	No	No	None
2		Medium extract - 60 to 100 m	Solid and dry	No	Yes	No	No	No	Aluminum above the VMP
3		Lower extract - below 100 m	Solid and dry	Yes	No	No	No	No	None
4	Pyroxenite	FGA 61 - LML 7364	Solid and dry	Yes	No	No	No	No	None
5		FGA 67 - LML 7369	Solid and dry	No	Yes	No	No	No	Arsenic and Aluminum above the VMP
6		FGA 68 - LML 7371	Solid and dry	Yes	No	No	No	No	None
7		FGA 76 - LML 7375	Solid and dry	Yes	No	No	No	No	None
8		FGA 79 - LML 7378	Solid and dry	Yes	No	No	No	No	None
9		FGA 86 - LML 7387	Solid and dry	Yes	No	No	No	No	None
10		FGA 96 - LML 7395 / 7396	Solid and dry	No	Yes	No	No	No	Aluminum above the VMP
11		FGA 99 - LML 7396	Solid and dry	Yes	No	No	No	No	None
12	Pegmatite	LML 7372/80/84/85/91/94	Solid and dry	Yes	No	No	No	No	None

Table 20.5.1.2_3
Neutralization Potential Ratio (NPR) Screening Criteria (after Price et al, 1997)

Potential for ARD	Initial NPR Screening Criteria	Comments
Likely	<1:1	Likely ARD Generating
Possibly	1:1 - 2:1	Possible ARD generating if NP is sufficiently reactive or is depleted at a faster rate than sulphides
Low	2:1 - 4:1	Not potentially ARD generating unless significant preferential exposure of sulphides along fracture planes, or extremely reactive sulphides in combination with insufficiently reactive NP
None	>4:1	No further ARD testing required unless materials are to be used as a source of alkalinity
NPR=NP/AP (RPN = PN/PA)	NP = neutralization potential = PN	AP = acid generation potential = PA

The analytical results indicate that gabbro, which constitutes the largest component of the waste rock, has a low potential for acid generation (potentially acid generating; PAG). The remaining rock types (pyroxenite and pegmatite) are not considered to be potentially acid generating (i.e., Non-Acid Generating; NAG) with all NPR/RPN values in excess of 4 (8.5 to 224 for pyroxenite; 9.7 to 13.5 for pegmatite).

20.5.1.3 Non - Magnetic Tailings Ponds

The non-magnetic tailings ponds are formed from the deposition of weakly magnetic or non-magnetic minerals obtained from the magnetic separation of titano-magnetite ore after grinding and filtering. This tailings structure was designed and incorporated into the industrial layout as an alternative solution to conventional tailings deposition in the Jacaré River valley, in order to protect and preserve an arborous caatinga area near the mine site.

The magnetite rock was subjected to acid drainage prediction tests, solubility testing and leaching of heavy metals, in accordance with the norms of ABNT. The results of such testing are shown in Tables 20.5.1.3_1 and 20.5.1.3_2 below:

Table 20.5.1.3_1
Test work Results - ABA-M -Magnetite Rocks- Campbell

N	Rock	Sample Reference	PN (1)	PA (2)	PNA (3)	Potential Acid Generation	RPN (4)	Potential Acid Generation
			Em t $CaCO_3$ equiv./ 1,000 t rock					
13	Magnetite	Top extract - 12 to 60 m	13.50	< 0.01	13.50	Potential uncertain	13.50	Potential non-existent
		Medium extract - 60 to 100 m - Test 1	22.20	< 0.01	22.20	Potential non-existent	22.20	Potential non-existent
14		Medium extract - 60 to 100 m - Test 2	19.20	< 0.01	19.20	Potential uncertain	19.20	Potential non-existent
15		Lower extract - below 100 m	3.00	< 0.01	3.00	Potential uncertain	3.00	Small potential

Notes		Interpretation of ANP Values and RPN	
(1)	PN = Potential neutralizing	PNA < -20	Probable generation
(2)	PA = Potential rock acid	-20 < PNA < +20	Uncertainty zone - test with RPN or more methods
(3)	PNA = Neutralization potential assessed = PN - PA	PNA > +20	Rock not producing acid
(4)	RPN = Potential ratio of neutralization = PN/PA		
		RPN < 1.0	Probably generation of acid
OBSERVATION: Tests performed in the laboratory of SGS GEOSOL in Belo Horizonte - MG, in December of 2007, in samples (drill core) collected by the client in the field Campbell, municipality of Maracás, State of Bahia.		1.0 < RPN < 2.0	Possible generation of acid
		2.0 < RPN < 4.0	Small potential for acid generation
		RPN > 4.0	Potential non-existent acid generation

Table 20.5.1.3_2
Test work Results - ABA-M -Magnetite Rocks- Campbell

No	Rock	Sample Reference	Residue Type	Class IIB	Class IIA	Class I			Observation
				Not Dangerous		Dangerous			
				Inert	Not inert	Corrosive	Reactive	Toxic	
13	Magnetite	Top extract - 12 to 60 m	Solid and dry	Yes	No	No	No	No	None
14		Medium extract - 60 to 100 m	Solid and dry	Yes	No	No	No	No	None
15		Lower extract - below 100 m	Solid and dry	Yes	No	No	No	No	None

As shown in Table 20.5.1.3_1 only the magnetite originating from the 100 m level horizon has a (low) potential of acid generation. The upper and middle magnetite has no acidic drainage generation potential.

According to the results presented in Table 20.5.1.3_2, this residue was classified as inert (class IIB) according to ABNT NBR 10.004/2004. Therefore, the risk of leaching and infiltration of dissolved constituents into the soil from the reaction in the stack with rainwater is not anticipated.

According to the design of the tailings facility the first cell will be sealed and monitored as a precaution. The design of the final drainage system for the system will be done after completion of all the "ponds".

20.5.1.4 Calcine Residue Stack

The calcine residue tailings consist of synthetic hematite (calcined magnetite) that will contain, regardless of the effectiveness of the leaching and filtering processes, some residues of vanadium and sodium salts soluble in the form of sodium vanadate ($NaVO_3$, Na_3VO_4, $Na_6V_{10}O_{28}$).

This material is stacked in a lined and impermeable structure after filtering and washing. The residue stack was formerly wetted by sprinkling water on top of it, progressively washing for removal of soluble salts. The solution will be collected in tanks and returned by pumping to the metallurgical plant thereby limiting potential infiltration into the subsurface.

The residue remaining on the stack is considered a Class I (dangerous), and the leaching pad is fully waterproof with high density dual layer polyethylene.

This material is not being sold, however Largo continues to explore opportunities to sell this material as iron ore. The report considered that this material will be stored in appropriate areas (calcined dams). The capex for these storage areas are included in the sustaining capital costs for the plant (US$ 3 million per year).

20.5.1.5 Chloride Salts Residue Pond

The chloride salts pond contains a solution rich in chlorine, present in the purging of the evaporation system. The effluent flow is in order of 2.9 m³/h, arranged in a dam type structure ("pond") lined with high density polyethylene, dual layer.

20.5.1.6 Storm Water Drainage System

Each area of the plant has a containment reservoir in which rainwater and washing water from process will be continually collected and re-circulated.

20.5.1.7 Waste Oil Effluent

The maintenance of machinery, vehicles and equipment is a potential source of effluent (impacted discharge water) containing oils and greases and other chemicals. The generation of this effluent or contamination can occur in storage and work areas throughout the project development lifecycle.

To mitigate the possible impacts on the quality of surface and groundwater resources, the Project will implement the following measures:

- Solid material from the tailings ponds as the solution percolates will be systematically and periodically sampled and tested to determine the concentrations of soluble vanadium salts. Upon confirmation of tailings neutralization as class IIB (non-hazardous and inert) based on ABNT NBR 10,004/2004, the stack will be covered with sterile/unreactive rock and soil and vegetated.
- The plant is designed to not generate effluent other than chlorine salt solution, which is sent to a dike designed for evaporation. All other solutions are recycled back in the process.
- An ETS (Effluent Treatment System) has been installed for sanitary effluent treatment and is currently in operation until the end of commissioning and installation phases. The ETS will be decommissioned after this period. The effluent from the ETS is recirculated to the tank and used to wet the calcine leach pad. The effluent from the ETS is assessed under the Effluent Monitoring Program with quarterly analysis of physiochemical parameters including, at a minimum: pH, BOD (Biochemical Oxygen Demand), suspended solids, dissolved solids, total coliforms, color, turbidity, nitrates, nitrites, total nitrogen, total phosphorus, sulphates and sulfides.
- Each plant area has a containment tank where rainwater and washing water is continually collected and recycled back to process water and all impoundment structures and yards (non-magnetic tailings pond, calcine pond, chloride pond, waste and ore piles), must have containment barriers that prevent the contamination/sedimentation of natural drainage.
- The Plan for Monitoring and Quality Control of Surface Water, Groundwater and Sediment (an Environmental Management Plan) outlines biannual sampling of 14

points for surface water and sediment collecting and 10 wells for monitoring ground water.

- Mechanical repair areas are equipped with waterproof flooring with collection systems and water/oil separators, and are constructed in accordance with legal standards and compatible with the estimated flows to control wastewater and oily effluent. The effluent from oil and water separators is sampled quarterly for pH, BTEX (Benzene, Toluene, Ethylbenzene, and Xylene), TPH (total Petroleum Hydrocarbons) and oils, greases, and lubricants.

20.5.1.8 Leachate Spill - November 22, 2015

On November 22, 2015, a leachate spill occurred outside the waterproofed area of the Leaching Plant. The incident occurred due to a failure of a part of the belt filter tray, which collects the solution containing soluble vanadium mixed with solid calcined material (hematite) resulting from cleaning the belt filter cloth. Because the tray fell, material that is normally pumped to the storage tanks fell on the waterproofed area, under the filter. Due to the elevated volume and high density of the soils, the sump pump on the waterproofed area was swamped (flooded) and had failed. Ultimately, the solution on the waterproofed surface ponded and discharged to the area adjacent to the Leaching Plant. This impacted the drainage used for rainwater and affected the area's naturally dry natural drainage. It is estimated that approximately 20 m of natural drainage was impacted by the spill.

A portable pump was immediately installed to direct additional solution back to the storage tanks. The total spill volume is estimated at 10 m3 with 60 grams of V2O5 per litre

In order to minimize the impacts from the spill, the following measures were immediately implemented:

- Suspension of activities until the tray was changed and the pumping system regularized.
- Solution that remained in ponds near the plant and in the rainwater drainage channel was pumped to the storage tanks located at the Leaching Plant.
- Rainwater was blocked from the drainage channel with a masonry wall to prevent solution from affecting the natural drainage.
- Following the initial response, additional mitigation measures were implemented including:
- Cleaning and removal of the solution pools after the drainage channel as well as in the area's natural drainage.
- The affected area and natural drainage were cleaned with water with the rinsate collected at barriers downstream of the impacted area. The water was then pumped into a water truck for transportation and proper disposal in the calcine basin.

20.5.1.9 Soil Contamination

The Solid Waste Management Program presents guidelines for the packaging and disposal of waste generated in the project. The plan identifies the waste types, volume of generation, packaging and disposal of all waste generated in all the project phases. It also presents a list of recycling companies that should be intended for recyclable waste.

A landfill project nearby the industrial area has been recently approved by INEMA for disposal of non-toxic wastes. The sludge generated in the ETA will be wrapped in a drying bed to separate solid and liquid phases, and prepared to be donated to the nearby potteries.

20.5.1.10 Change in Air Quality

Fugitive dust from moving vehicles on unpaved access roads and ore and waste stockpiles, particularly in the dry period, generates and mobilizes particulate material. The operation of machinery and equipment will generate dust and atmosphere gases resulting from the combustion of diesel in combustion engines, which can potential result in a change in air quality in the vicinity of the Project.

In the comminution process (reduction of the ore to small particles or fragments), primary crushing will also generate particulate material. In the calcination stage, kiln emissions will contain SO_2, CO_2, and H_2O. All the sulfur contained in the feed (reagents and fuel) is converted to SO_2 and, in smaller proportions, to SO_3. The chlorine present is converted into gaseous HCl and released into the furnace.

A scrubbing system will be installed for MVA dust (Ammonium Metavanadate; NH_4VO_3) recovery during the MVA drying process.

The ammonia removal system will comprise a scrubbing system to remove any ammonia residue. Sulphuric acid reacts with ammonia to produce ammonium sulfate, which will be pumped into the reagent recovery system.

The future production of ferrovanadium will be by aluminothermic reaction (chemical reduction by aluminium) which does not use an electric furnace. The fumes generated in the process of casting will be extracted by a hood and passed by bag filters for removal of particulates. Dust collected will be re-routed to the furnace.

In order to verify the emission impacts from pollutants sourced from the Project on air quality in the regions close to the project, atmospheric dispersion modelling was undertaken with base case scenarios of FeV and V2O5 production. The mathematical simulation (analytical model) was redone in December 2015 by SECA (Sistema de Estudos Climáticos e Ambientais), an independent consulting company, based in São Paulo. This new set of mathematical simulations were completed with the last generation EPA-AERMOD model, using:

- two years of weather data collected from the company's site meteorological station;
- terrain topography;
- pollutant emission data generated by the plant's five stacks monitoring system;

- the escape parameters on a grid of the domain area of 2,500 km^2 in the municipality of Maracás, State of Bahia.

Table 20.5.1.10_1 and Table 20.5.1.10_2 show the results of atmospheric emissions for the production scenarios, according to Atmospheric Dispersion modelling completed by SECA in 2015.

Table 20.5.1.10_1
Maracás Vanadium Plant Atmospheric Emissions

Scenery	Sources	Emission Rates (g/s)				
		NOx	SO_2	MP	V	NH_3
Ferro Vanadium FeV	Kiln off gas	23.1	120	0.59	0.005	0
	AMV Flash Dryer	1.2	0.28	0.1	0.045	0
	AMV Reduction Kilns	0	0	0.04	0.023	9.1
	FeV Furnace Baghouse	0	0	0.02	0.001	0
	Quench Scrubber	0	0	0.14	0.026	0
	Screen Dust Collector	0	0	0.56	0.002	0
	Crushing Dust collector	0	0	0.83	0.002	0
Vanadium Pentoxide V_2O_5	Kiln off gas	23.1	120	0.59	0.005	0
	AMV Flash Dryer	1.2	0.28	0.1	0.045	0
	AMV De-ammoniator Kiln	0	0	0.07	0.029	19.7
	Quench Scrubber	0	0	0.14	0.026	0
	Screen Dust Collector	0	0	0.56	0.002	0
	Crushing Dust collector	0	0	0.83	0.002	0

The modelling results indicate that independent of the regulated pollutant, there is no violation of air quality standards in the short and long term of CONAMA resolution No. 3/90 or IFC standard regulations.

As shown on Table 20.5.1.10_2, the maximum daily average concentration of SO2 was 7.3 µg/ m3 for the current short time (24 hrs) scenario. This value represents 2.0% of the daily CONAMA standard for SO2 of 365 µg/ m3 and 5.84% of the daily IFC standard of 125 µg/m3. The maximum point is found inside the industrial facility.

Table 20.5.1.10_2
Maximum Long-Term Plant Emission Concentrations

Pollutant	Maximum Concentrations ($\mu g/m^3$) - 24 hours				
	MP_{10} (24h)	SO_2 (24h)	NOx (1h)	Vanádio, V. (24h)	NH_3 (24h)
Scenario 1 FeV Production	2.3	7.3	1.0	-	-
Scenario 2 V_2O_5 Production	2.3	7.3	1.0	-	-
Primary Standard CONAMA 3/90	50 (Year)	80 (Year)	100 (Year)	-	-
Equator Principles	35 (Year)	50 (Year)	40 (Year)	-	-

Maximum annual average concentration of SO2 is 0.63 µg/ m3 for long term (one year). This value represents 0.79% for annual standard of CONAMA 3/90 for SO2, 80 µg/ m3, and 0.50% of the annual IFC standard of 125 µg/ m3. The maximum point was identified inside the industrial facility.

Maximum hourly average concentration of NOx was 20.5 µg/ m3 for short term (24 hrs) current production scenario. This value is 15.6 times smaller than the default zone of CONAMA 3/90 for the NO2 of 320 µg/ m3 and 9.76% times smaller than the default zone of the IFC for the NO2 of 200 µg/ m3. Maximum annual average concentration of NOx was 1.0 µg/ m3, for both scenarios. This value represents 1% of the annual CONAMA standard of NO2 100g/m3 and 2.5% of the annual IFC standard of NO2 40 µg/ m3. The maximum point was identified to the east approximately 3.11 miles distant from the project.

It will be necessary to develop a new dispersion model for the expansion scenario. The quantities of pollutants (apart from SO2) are expected to increase coincident with an increase in the volume of gas and increasing stack exit velocities. This expected increase will result in different dispersion levels; however, the levels are expected to be within the approved ambient air guidelines. A new dispersion model will be developed to confirm this expectation.

The mine owns and operates an atmospheric emission abatement system consisting of an electrostatic precipitator on the rotary kiln exhaust system and baghouses on different dust generating equipment. The emissions are monitored for the following pollutants on a biannual basis: MP, NOx, SOx, V and NH3.

The Air Quality Monitoring program operates three monitoring stations in the area. The three stations monitor on a monthly basis the following parameters: SOx, NOx, MP, V and NH3.

For combustion gas emissions on mobile sources, the mine uses preventive maintenance and control of emissions from vehicles, equipment and machinery in order to ensure that operational conditions are per normal standards. The frequency of maintenance of the fleet to control emission of pollutants is set out as per equipment standards.

20.5.1.11 Change in Noise Levels

The sources of noise in the study area will be linked to the movement of small vehicles, trucks, machinery and equipment used for the opening of access roads, preparation of mine site and infrastructure.

During the operation phase there are activities with intense movement of machinery and equipment that can change the sound pressure level, mainly in the areas of mining and processing. The use of explosives for blasting and the activities carried out in day-to-day life (workshops, offices, cafeterias and other) are also sources of noise.

The community closest to the location of the mine is the village of Água Branca, located about 4 km from the processing plant and mine. Considering the distance of the communities to the installations, the sound levels in these communities will be impacted by moving vehicles, machines and equipment near the villages of Água Branca and Pindobeiras.

A Noise Monitoring Program has been established with points and periodicity defined. To mitigate the impacts of increasing sound levels in the vicinity of the installations, the project proposes the following mitigating measures:

- The purchase of machinery and equipment with low noise potential;

- Establish routine procedures for motor inspection and preventive maintenance;
- To focus the activities of greater intensity of noise during the day, preferably between 8:00am and 5:00 pm;
- The Noise Monitoring Program calls for biannual monitoring during operation phases, at the same locations used to determine the baseline data.

In addition to the measures proposed by the project, the audit report suggested that the noise monitoring points should be reviewed every six months to check for new developments, changed conditions, and impacts in the vicinity of the project.

20.5.2 Biotic Environment

20.5.2.1 Fauna

Fauna environmental impacts occur from vegetal suppression, earth-moving, soil exposure, solid waste generation including organic food, atmospheric emissions, fugitive dust and gases, noise, machines and vehicles traffic on the roads, and the changes introduced to ecological corridors through mine activity.

Vegetation suppression may unintentionally cause loss of fauna occupation and land use change. In the areas with the occurrence of amphibians and reptiles, a more intense impact due to suppression of vegetation may have caused reduction of individuals. Removal of vegetation had a more intense impact on birds during the deforestation period, when dispersion of several species of birds in search of refuge, food and safer areas in the surrounding areas occurred.

According to the data, the identified endangered species are not restricted to a single habitat, but instead occupy various habitats and are inferred to have sufficient living area. The endangered fauna, mainly characterized by mammals (cats) are not restricted to the area of the project and move around easily. Another aspect that can mitigate this impact is that the region offers a good amount of natural environment where fauna can roam.

The presence of extensive vegetal refuges (i.e., areas unmodified or only slightly modified by human activity) can support the mammals in dispersion, with good environmental quality and connectivity, and may encourage the displacement of mammals and birds in search of refuge, food and security.

Similarly, the conservation of the João River valley (former proposed location for the tailings dam) will also mitigate this potential fauna impact by providing shelter, as it located in close proximity to the area to be suppressed. The herpetofauna will have some of their representatives dispersed to adjacent areas, but it can also experience loss of local populations. Negative ecological interaction amongst displaced species may result in loss of fauna, predominantly through food and space competition and potential predation.

Deforestation eliminates habitats where wildlife acquires food and shelter, and where wildlife has places to roam. Preserving areas with pristine vegetation in the surrounding areas of the mine site will reduce this impact and, in accordance with the standard 8 item 6 of IFC (International Finance Corporation), a net loss of biodiversity should be avoided. The requirement is a compensation of losses by creating ecologically comparable areas for the preservation of biodiversity.

According to the potential and realized impacts, and to minimize the loss of wild fauna due to suppression, the project environmental management plan proposes the following plans and programs:

- The Plan for Deforestation Actions. The main objective of this plan is to minimize the loss of local fauna by ensuring that deforestation actions are performed in a progressive manner and oriented in a single direction. This is intended to create opportunity for the spontaneous movement of animals into new areas and provide mechanisms and actions to prevent unauthorized intervention. The plan also supports the presence of professional experts in wildlife management before and during the deforestation actions for the rescue and salvage of fauna.
- The Fauna Rescue and Relocation Plan. The objective of this plan is to rescue and relocate fauna individuals unable to escape through the passages that would be created by the previous Plan. The plan also provides for a Fauna Provisional Rehabilitation Center with infrastructure and equipment required for such activity in order to facilitate the management of individuals saved in the area of the project.
- Acquisition and legal establishment of a conservation area with 2178 hectares of pristine arboreous caatinga, San Conrado Farm, Municipality of Iramaia; This is well beyond the minimum legal requirement (Law nº 4771, September 15, 1965, Código Florestal).

20.5.2.2 Flora

Vegetation suppression directly and indirectly impacted the flora in the Project Direct Influence Area (DIA). The estimated total vegetation affected by suppression is 150.48 ha, typified by bushy Caatinga, bushy/dense Caatinga, bushy/arboreal Caatinga and dense/arboreal Caatinga. The existing biome is at different stages of conservation and diversity.

The potential impact of the project on the flora is negative based on the studies completed to date. The potential impact will have direct and local coverage, because it acts on the directly affected area (DAA) and the direct influence area (DIA), interfering negatively in the dynamics of surrounding populations.

To minimize those potential impacts, it is proposed that ethnobotanical programs be established (through targeted management) to encourage the continuation and multiplication of identified endangered species that have historical-cultural value and are rare. Such a program requires the collection of seeds and seedlings of species (forms of germplasm), for their germination/development in the nursery and the eventual reintroduction to the natural environment. For the success of this program, it is important to identify an appropriate location for the maintenance of seedlings/seedling and training of staff.

20.5.3 Environmental Mitigation

The environmental mitigation plans shown in Tables 20.5.1.10_2 and 20.5.3_1 were proposed as part of the measures to reduce the overall environmental impacts of the Project and were complied with during the different stages of the construction period.

These mitigation measures are intended to facilitate the preservation of the current natural conditions of the site and to reduce the risks that could compromise worker health and safety in a practical, feasible framework.

No conditions were observed by Mineral during their Project audit that would compromise the environment and worker safety. The Project has a very strong commitment to preserve natural resources and to improve the current social conditions at the Maracás micro region.

Table 20.5.3_1
Mitigation Measures - Operations Phase

Subject	Mitigation Measure
Erosion	Ditching and Silt Catchment
	PRAD - Plan of Rehabilitation of Degraded Areas
Land use	Erosion Control Program
Fauna	Environmental Training and Awareness Campaign
	Environmental Compensation Program - Legal Reserve
Flora	Erosion Control Program
	Environmental Compensation Program - Legal reserve
Surface/underground water	Discharge Management Program
	Water Monitoring Program
	Remediation Program
Storm Water Drainage	Storm Water Natural Drainage Modification Plan
	Remediation Plan
Soil	Erosion Control Program
	Soil remediation Plan
Noise	Noise Monitoring Program
	Maintenance Program
Air Quality	Dust Control
	Monitoring Program (MP, NOx, SOx, CO, V, and NH_3)
	Maintenance Program
Waste Material Disposal	Waste Management Program
Workers' Safety	Accident Prevention Plan
	Emergency Plan
Fire and Explosion Risk	Accident Prevention Plan

20.6 Social and Economic Environment

The Vanadium Maracás Project has expended substantial effort characterizing and understanding the socio-economic context of the project as has been reported in the EIA studies prepared by Integratio, independent consultants responsible for social- communication aspects of the project.

This section summarizes major social and economic impacts arising from different stages of the project as portrayed in the EIA and Audit report prepared by Mineral Engenharia e Meio Ambiente Ltda.

20.6.1 Job and Income Generation

In accordance with the impact study, the duration of the installation period lasted approximately 22 months. During this period approximately 1,200 jobs were created. The employment generated by the Project is the main benefit to the local the population.

During operation the project is responsible for generating approximately 350 direct jobs with the majority related to the operation of equipment (crushing, grinding and concentration systems), as well as administrative, managerial and operational positions.

Wage expenditures are in order of USD $3,500,000 per year. A significant portion is spent in the market of Maracás. The direct spending for goods, services and materials purchased on the local market and additional spending of Maracás County due to increased taxes revenues also provide economic stimulus.

In order to increase the positive effects on the municipality, management had mandated to give priority to the hiring of local workers and to provide training to people to acquire the necessary skills required for the jobs.

The work force training program is associated with the Environmental Management system, in order to compensate the population directly affected by the project, as stated in the performance standard 1 of IFC, "avoid, minimize or offset the negative impacts on workers, communities and the environment." Training or educating manpower can be an efficient way to benefit the local population with the generation of jobs, since the majority of the population do not have the skills or education required for the venture.

20.6.2 Boosting the Local and Regional Economy

The municipality has noticed an increase in economic activities which are the result of the creation of new jobs, income generation and increased public revenue

The distribution of the expenditure pertaining to investment (USD 250 million) was as follows: 10% in Maracás, purchase of land, labor, taxes, transport and rents; 30% in the State of Bahia, purchase of cement, supplies, taxes and services; 20% in the State of Minas Gerais, purchase of engineering, services, equipment and steel; 20% in the State of São Paulo, purchase of equipment; and, 20% overseas for purchase of equipment from South Africa and China.

In order to maximize this positive impact, the company developed a training program for local suppliers with the objective of ensuring that local communities are appropriately included appropriately in the businesses that may potentially affect them.

Largo is focused on strengthening local identity and regional socioeconomic development. The Project supports various initiatives related to quality of life, well-being, education, health and cultural appreciation of the communities in which it operates. It also offers professional qualification programs and sustainable projects that allow jobs creation and income for the residents of the city of Maracás.

20.6.3 Improvement of Access and Roads

The company graded and enlarged approximately 42 km of existing dirt road between the villages of Pé de Serra and Porto Alegre during the construction process. This road will be further upgraded and paved through a joint effort with the Bahia State Government. It is proposed that sections of the road be reconstructed and the entire corridor will be paved with an asphaltic cover, improving the access between villages. It is noted that paving the roads with an asphaltic cover will modify the local hydrological and storm water run-off regimes. The timing of this proposed improvement has not yet been determined due to financial constraints by both the company and the government of Bahia. A duly protocol has been signed by both parties to that end.

20.6.4 Pressure on the Water Supply System

Water supply, water capacity and water availability are heterogeneous and diverse in the municipality. In Maracás and in the district of Porto Alegre, communities that receive the majority of migrants, the currently installed capacity is being subjected to additional demand.

Population increases in the villages of Caldeirãozinho, Pindobeiras, Jacaré, Água Branca and Lagoa Comprida, which rely on water supply through trucks and tanks, necessitate additional water supply. This has resulted in an additional stress to the currently limited supply.

The village of Pé de Serra is supplied by an artesian well with reasonable water availability.

The mine built and commissioned a 10-inch diameter, 33-km long water pipeline that brings raw water from Rio de Contas dam to a water treatment plant at the site area for industrial and human use. The system capacity is designed for 250 m^3/h, currently demands only about 100 m^3/h.

As a socioeconomic compensation, the Project intends on building a water treatment station in 2018 which will be located near the village of Água Branca that will be handed over to the municipality for water distribution by the municipality.

20.7 Geotechnics And Hydrology

Hydrological and geological characterization studies were completed in 2008 by VOGBR and revised in 2011 for Basic Engineering. A summary of these studies is presented in the sections below.

20.7.1 Hydrological Studies

The pluviometric and fluviometric data that were incorporated into this assessment were obtained from the Brazilian National Waters Agency - ANA - Agencia Nacional de Águas. Stations were selected based on location:

- Pluviometric (rain gauge) Station at Fazenda Alagadiço, ANA code - 01340019; and,

- Fluviometric Station (flow station using a staff gauge) at Roçados, ANA code - 52265000.

The climatological characterization is derived from average monthly figures from the Ituaçu Station (code 83,292), obtained from the INMET Publication entitled “Normais Climatológicas”, 1992.

20.7.1.1 Climatological Characterization

The Project area is located in the southwestern region of the State of Bahia (Brazil), in the municipality of Maracás. The Maracás climate is classified as Tropical-Monsoon (Am), alternatively called “tropical wet climate” under the Koppen classification (Climatologia do Brasil, Edmon Nimer, 1979). This climate is characterized by hot and semi-arid tropical conditions with 6 dry months. The average annual temperature is 24°C, with December, January and February being the hottest months, and July and August having the lowest average daily temperatures.

The precipitation regime is characterized by one rainy period during the summer during which the wettest quarter is from November to January and by one dry period in the winter during the quarter ranging from June to August. The average annual rainfall is approximately 600 mm. Figure 20.7.1.2_1 shows the average monthly rainfall for the Project region.

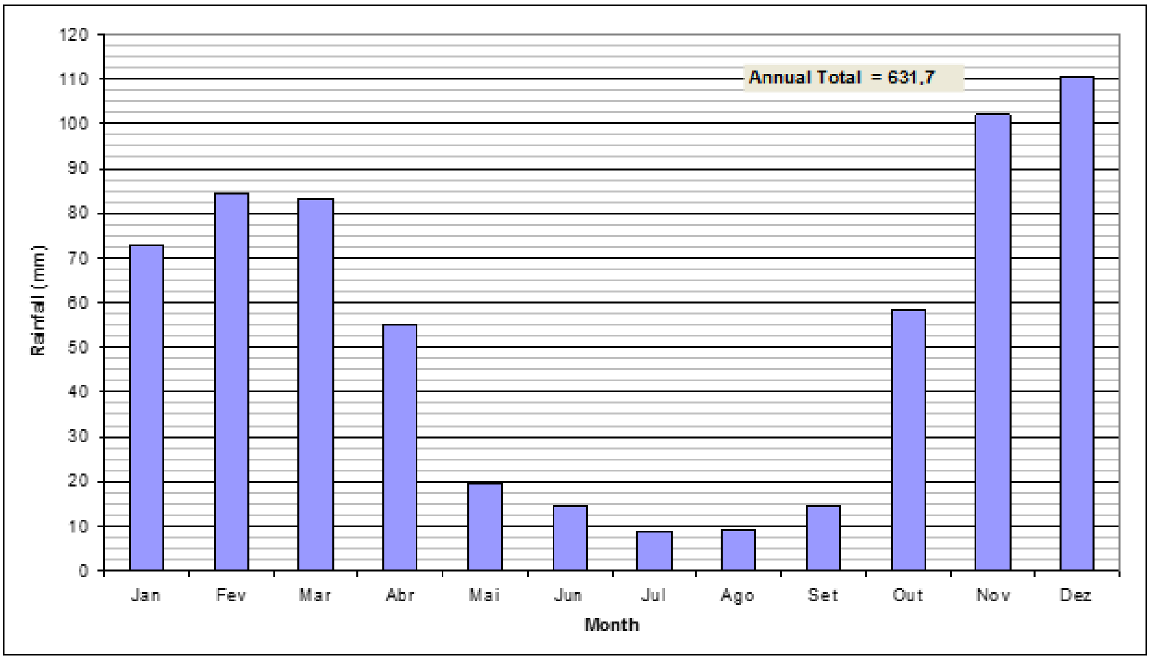
The region’s annual evaporation rate is high, close to 1,600 mm, with approximately 180 hours average monthly sunlight and average relative humidity that varies between 50% to 73%, based on the average monthly data obtained from the Ituaçú weather station.

20.7.1.2 Hydrographical Characterization

The Project area is contained within the hydrographical basin of the “João” creek, which is a tributary to the right bank of the Jacaré River, which in turn is a tributary to the Contas River. The basin extends over approximately 57.4 k m2 and the length of its main course is 18 km with a 550 m difference of elevation. Water flows are intermittent.

Figure 20.7.1.2_1

Average Monthly Rainfall for the Pluviometric Station at Fazenda Alagadiço (ANA Code - 01340019)



20.7.1.3 Intense Rains

The main characteristics of the intense rains include the total amount of rainfall, the spatial and temporal distribution, and the frequency of occurrence. Intense rainfall data is used in the hydraulic dimensioning of the various project structures (e.g., Probable Maximum Flood; PMF).

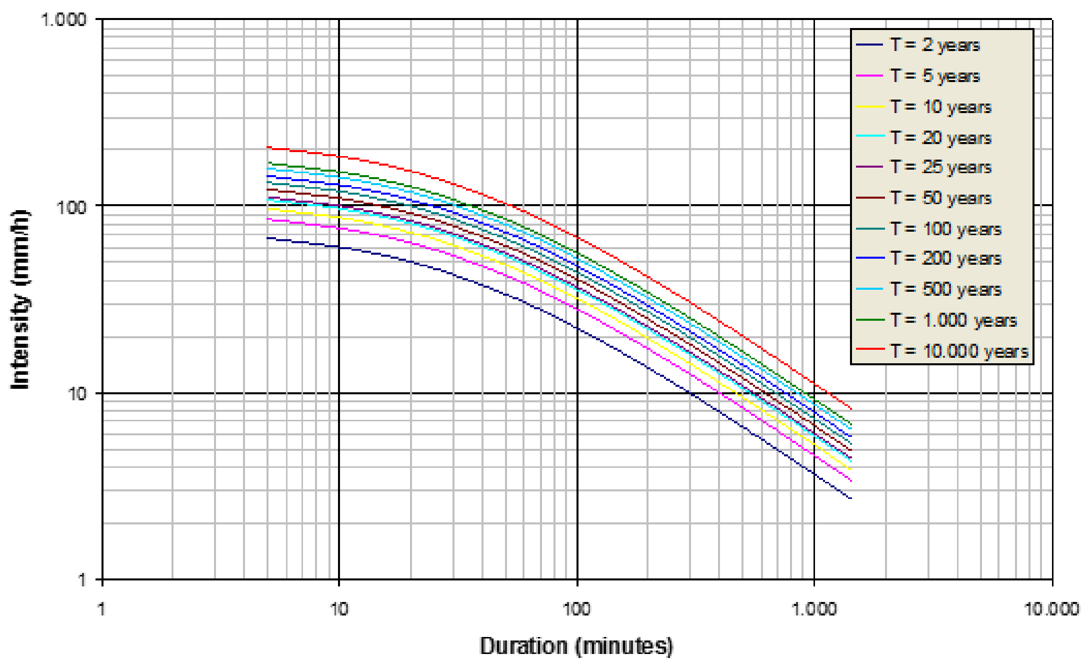
The estimated various return periods for rainfall height and intensity ratio (Table 20.7.1.3_1), and for duration and frequency (Figure 20.7.1.3_1), were derived on the basis of statistical treatment of daily rainfall volume figures obtained from the weather station at Fazenda Alagadiço.

Table 20.7.1.3_1
Rainfall Height Rates (mm)

Duration	Return Period - TR (years)										
	2	5	10	20	25	50	100	200	500	1	10
5 min	5.76	7.29	8.3	9.27	9.58	10.5	11.5	12.4	13.6	14.6	17.7
10 min	10.3	13.1	14.9	16.6	17.2	18.9	20.6	22.2	24.5	26.1	31.7
15 min	14.1	17.8	20.3	22.6	23.4	25.7	28	30.3	33.3	35.6	43.1
20 min	17.2	21.7	24.7	27.6	28.6	31.4	34.2	37	40.7	43.4	52.7
25 min	19.8	25.1	28.6	31.9	33	36.2	39.5	42.7	46.9	50.1	60.8
30 min	22.1	28	31.9	35.6	36.8	40.4	44	47.6	52.4	55.9	67.8
1hr	31.4	39.7	45.2	50.4	52.1	57.3	62.4	67.5	74.2	79.3	96.2
2hr	40.4	51.1	58.2	65	67.2	73.8	80.4	87	95.7	102	124
4hr	48.5	61.3	69.8	78	80.6	88.6	96.5	104	115	123	149
6hr	52.7	66.7	76	84.8	87.7	96.3	105	114	125	133	162
8hr	55.6	70.3	80.1	89.4	92.4	102	111	120	132	141	171
10hr	57.7	73	83.1	92.9	95.9	105	115	124	137	146	177
12hr	59.4	75.2	85.6	95.6	98.8	109	118	128	141	150	182
14hr	60.9	77	87.7	97.9	101	111	121	131	144	154	187
24hr	65.8	83.2	94.7	106	109	120	131	142	156	166	202

Figure 20.7.1.3_1

Intensity, Duration and Frequency Curves



20.7.1.4 Design Output Volumes

The estimated design output volumes were determined to provide input data for use in the hydraulic dimensioning of the structures proposed for the Project.

The design output volumes correspond to 1,000-yr return period high water events criteria. Table 20.7.1.4_1 presents the design flow volumes for the proposed hydraulic structures

Table 20.7.1.4_1
Design Flow Volumes for the Hydraulic Structures

Structure	Elements	Flow Volume (m^3/s)
Flood Control System	Northern Ridge	20.6
	Southern Ridge	202.4
Sediment Catchment	Dyke	-

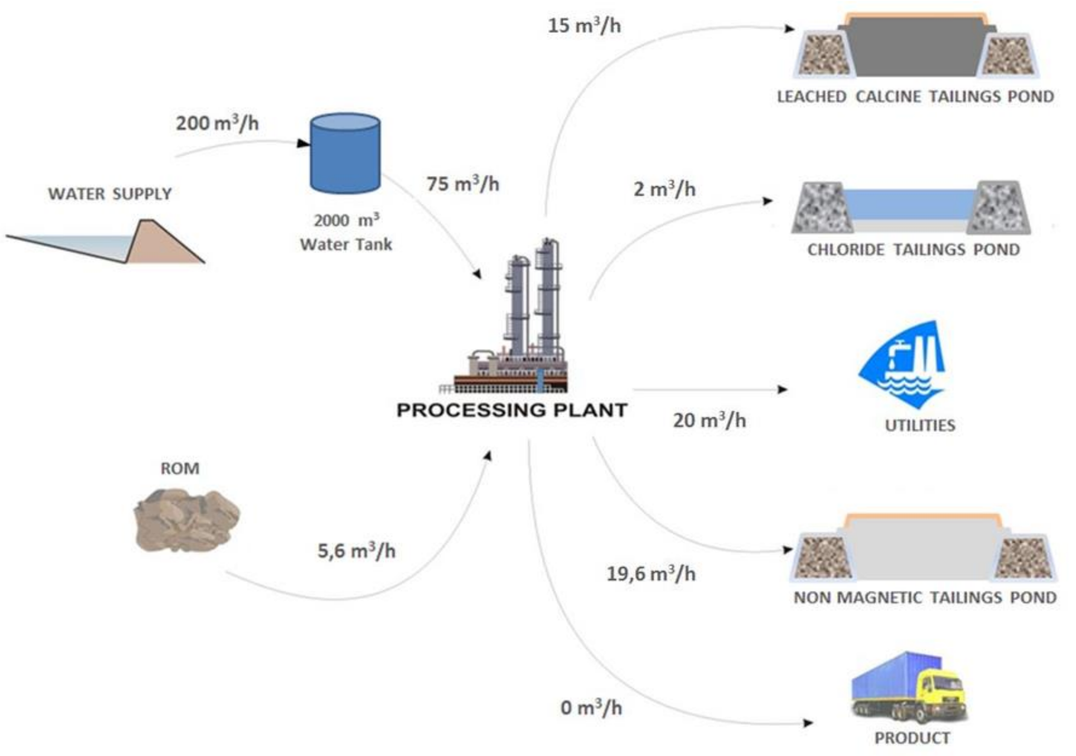
20.7.1.5 Site Water Balance

The processing plant make-up water during operations is 81.6 m^3/hr where 75.0 m^3/hr is provided from the Rio de Contas (Contas River) and 5.6 m^3/hr is sourced from the water content in the mined ore. The licence provided by the federal water agency, ANA, (Agência Nacional De Aguas) allows a maximum water taking rate of 300 m^3/hr from the Rio de Contas. The pumping system from the Rio de Contas is sized at 200 m^3/hr. There is a circulating water load within the plant with the net make-up being 75 m^3/hr.

Figure 20.7.1.5_1 shows a water balance flow chart, involving the structures under consideration and their corresponding flow rates.

Figure 20.7.1.5_1

Flow Chart of the Water Balance for the Project



Originally, the plan for a conventional slurried tailings system with a tailings pond resulted in a greater demand for water. In response to local stakeholder concerns regarding water supply, this water demand has been reduced with the introduction of ponds and reuse of the water to the plant.

20.7.2 Geological/Geotechnical Characterization of the Overall Project Area

The geological/geotechnical characterization of the project area is intended to provide input data for engineering design work, namely: the pit, processing plant installations, waste and stockpiles, tailings disposal system and flood control system.

The main activities undertaken to achieve the proposed objectives are as follows:

- overall geological/geotechnical mapping of the entire installation area
- identification, characterization, distribution and use of overburden and outcropping substrate rock materials as cut and fill and foundation material;
- mapping of areas subject to flooding and waterlogged areas, erosion features, landslides (geohazards) and areas with rock boulders;

- analysis of field investigations and monitoring, consisting of inspection test pits, geotechnical drilling programs to facilitate in situ viewing of the soil and saprolite stratigraphy;
- extrapolation and projection of geological/geotechnical vertical sections for the main units within the Project Area; and,
- characterization of the foundations conditions of the main component units of the Master Plan.

20.7.2.1 Overall Geological/Geotechnical Characteristics

The geological/geotechnical mapping for the Project area, in conjunction with the geotechnical investigations, allowed the identification, characterization and mapping of the distribution of the different types of materials throughout the area as illustrated in Table 20.7.2.1_1.

Table 20.7.2.1_1
Characterization of Soils and Outcrops in the Project Area

Type of Material	Tactile-Visual Classification	Average Thickness (m)
Alluvium	Yellowish brown, fine to medium-sized sand, with boulders and pebbles of quartz, rare rounded rock (quartzites, andesites).	0.2 to 0.5
Red Colluvium	Clayey silt and/or sandy silt matrix, red colored with small amounts of pebbles and granules of quartz or other rock.	0.5 to 3.0 (Max. 8)
Brown Colluvium	Brown colored matrix, normally silty, variable quantities of granules and pebbles of weathered rock and/or quartz.	0.5 to 2.0
Residual Soil / Saprolite	Soils consisting of clayey-silty material with varying amounts of sand and fragments of weathered rock, which may contain foliation structures and veins of quartz.	1.5 to 3.0 (max. 10)
Outcrops	Slightly weathered to very weathered and/or fractured undifferentiated rocks, consisting of granitoids, gabbros, pegmatites, andesites, etc.	Not determined

Table 20.7.2.1_2
Summary of Key Non-Magnetic Tailings Pond 3 Design Aspects

Design Aspect	Measurement
Maximum height (m)	20
Length of stack structure (m)	300
Width of stack structure (m)	250
Maximum crest elevation (m)	325
Minimum downstream elevation (m)	305
Center road width (m)	10
Height of slopes between berms (m)	10
Tailings capacity - (m^3)	600,000
Maximum area occupied (m^2)	740,000

The non-magnetic tailings pond concept consists of a series of ponds formed by rock-fill structures sealed by compacted clayey/saprolitic material as illustrated in Figure 20.7.2.1_1.

The proposed arrangement will be applied to the construction of the various ponds outlined in Table 20.7.2.1_3, which outlines the schedule of pond construction and usage.

Figure 20.7.2.1_1

Typical Cross-Section of the Non-Magnetic Tailings Pond

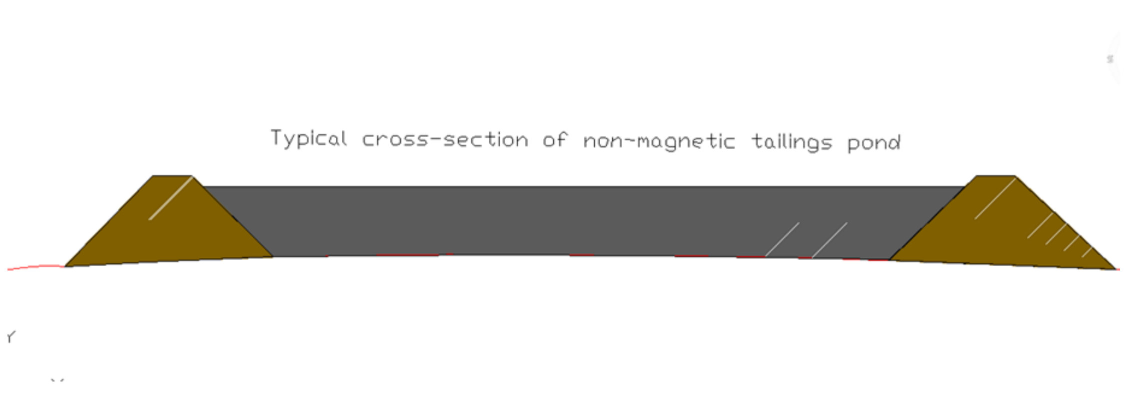


Table 20.7.2.1_3

Schedule of Non-Magnetic Tailing Pond Construction and Usage

pond	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1														
2														
3														
4														
5														
6														

in use for tailings disposal

in construction

On year one the first non-magnetic pond was completed with rejects and a second one was built near and south of the plant and inside the area projected for waste pile. Pond 1 is filled with tailings and almost ready to be covered with waste and organic soil. Pond 2 is in use and estimated to last until Feb 2017. Pond 3 is in construction, liners will be installed in Dec 2016 and Jan2017. Pond 4 is marked and construction with rock waste from the mine will start in 2017. Pond 5 is a project to build with waste from the mine during years 2018 and 2019. Pond 6 is a project to build on the top of ponds 2, 3 and 4. The layout of the Non-Magnetic tailings pond is shown in Figures 20.7.2.1_2 and 20.7.2.1_3.

The pond construction sequence consists of stages of vegetation clearing, removal of organic topsoil and other material until the appropriate foundation depths are achieved for rock fill structures.

Figure 20.7.2.1_2

Layout of Non-Magnetic Tailings Ponds

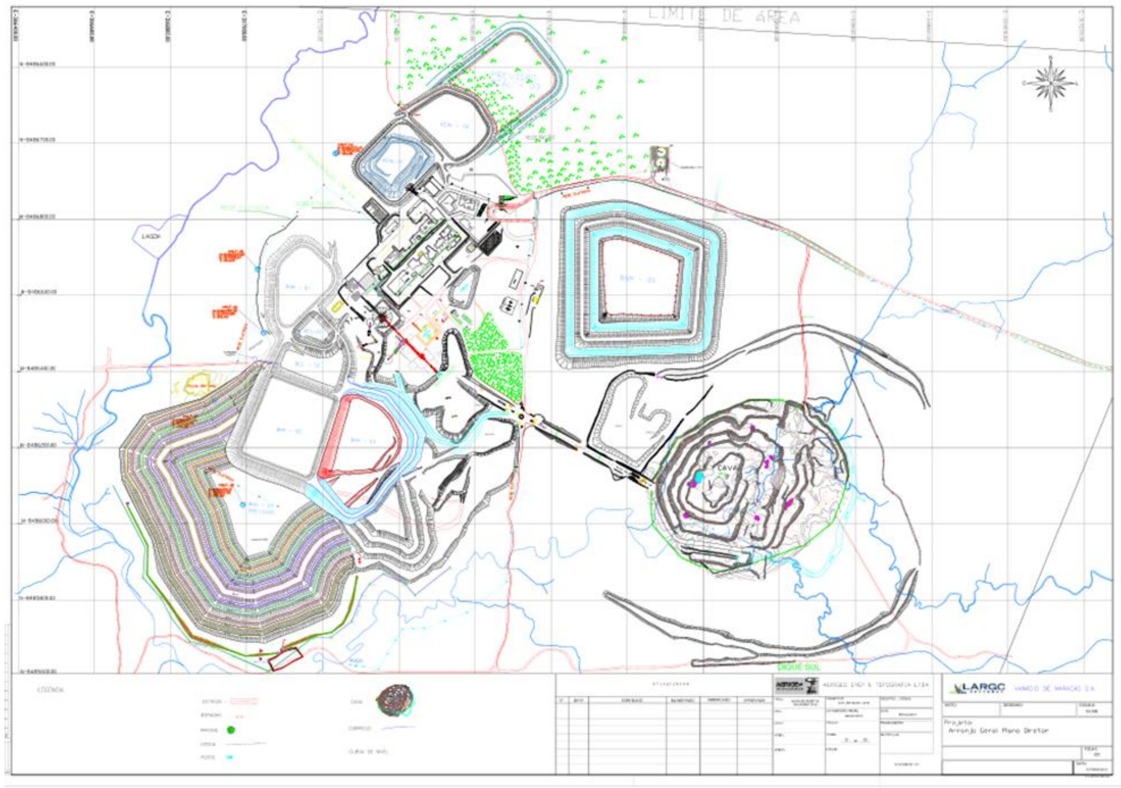
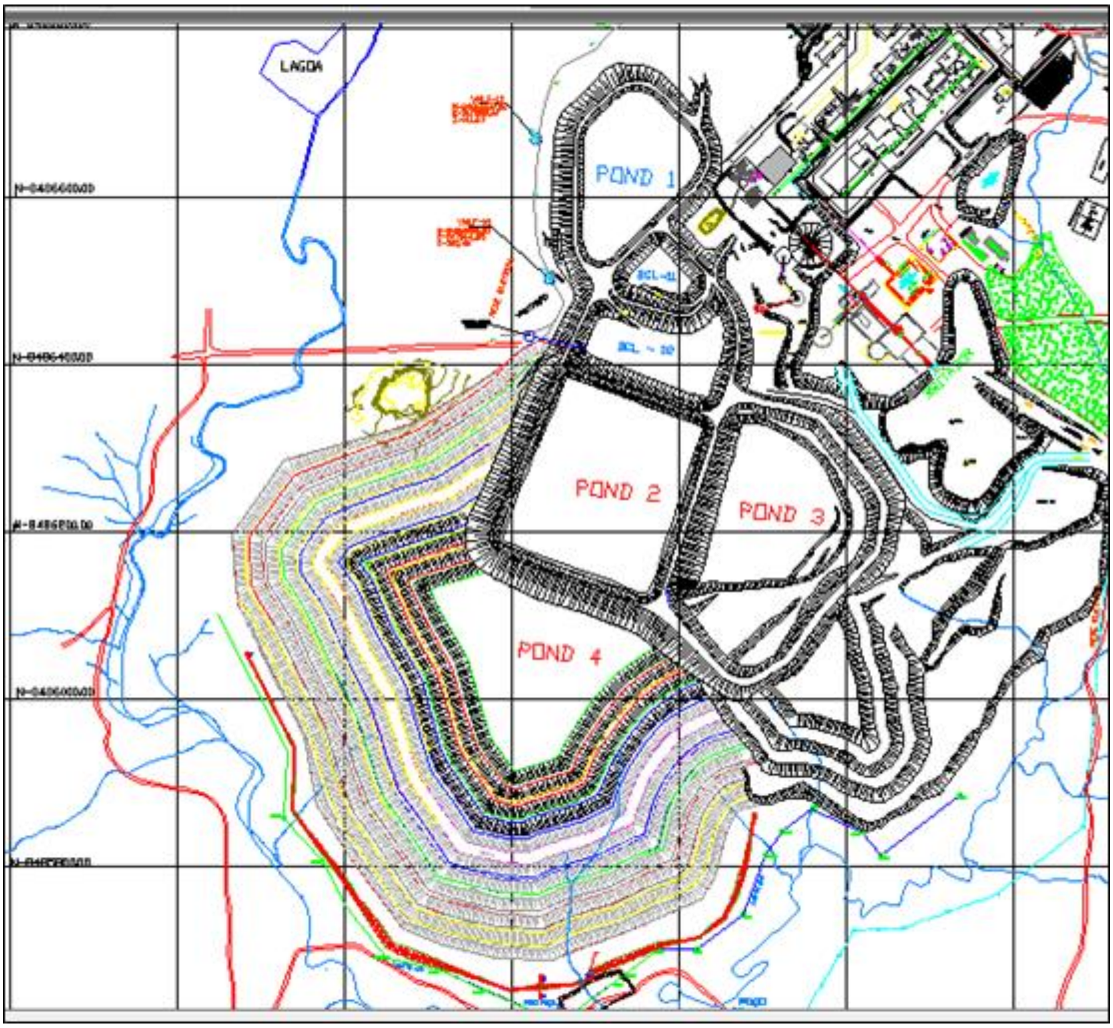


Figure 20.7.2.1_3

Close Up Layout of Non-Magnetic Tailings Pond



1. Tailings Disposal Facilities

The tailings generated by the ore process are of three types: leached calcine from the processing kiln discharge, filter cake from the de-silication process and chloride control purge from the evaporation circuit.

The leached calcine tailings are discharged into the Leached Calcine Tailings Stack. The de-silication process tailings and the chloride control purge tailings will be deposited in the Chloride Control Purge Tailings Pond. The intended construction location for these ponds is northwest of the open pit, close to the processing plant.

The dikes were built using compacted earth and their base areas are leak-proofed using a double-layer geomembrane liner featuring a leak detection system. The construction consists of clearing vegetation from the areas to be occupied by the ponds, removal of organic material, and excavation of material inappropriate for foundations. The perimeter of each pond will be protected by rock-fill channels.

The leached calcine tailings stack has been built initially as a first stage to handle the first two years of production. The pond will later be expanded, if required, possibly in a different location, to accommodate Life of Mine (LOM) tailings production for the expanded production scenario.

The initial Chloride Control Purge Pond has been built to accommodate 3 years of tailings production. The pond will later be expanded, if required, possibly in a different location, to accommodate LOM tailings.

Typical sections of the leached calcine stack and chloride control purge ponds are presented on Figures 20.7.2.1_4 and Figure 20.7.2.1_5, respectively.

Figure 20.7.2.1_4

Typical Cross-Section of the Leached Calcine Tailings Stack

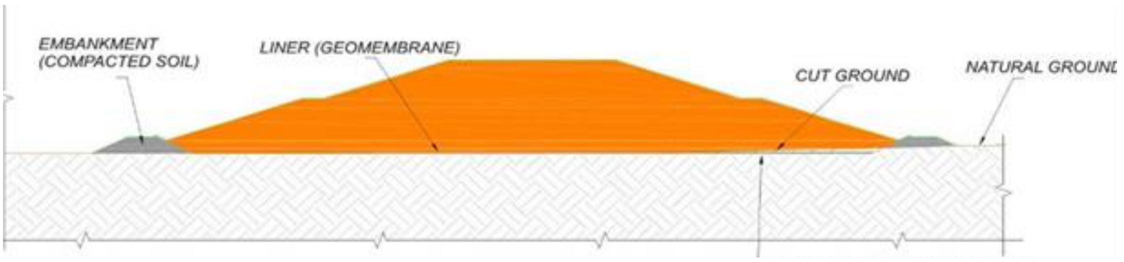
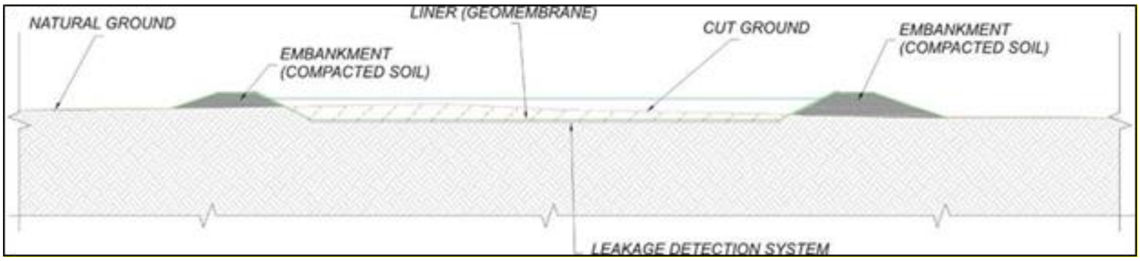


Figure 20.7.2.1_5

Typical Cross-Section of the Chloride Control Purge Pond



The main geometric characteristics of the Leached Calcine Tailings Stack and the Chloride Control Purge Pond are presented in Table 20.7.2.1_4 and Table 20.7.2.1_5, respectively.

Table 20.7.2.1_4 Main Geometric Characteristics of the Leached Calcine Tailings Stack	
Design Aspect	**Measurement**
Maximum dike height (m)	12
Area occupied (m2)	120,000
Maximum capacity (volumetric; m3)	2,500,000
Slant of pond slope	1V:2H
Slant of pile slope	1V:3H
Maximum height of the slopes between the berms (m)	10
Pile berm width (m)	5
Pond crest width (m)	7

The leached calcine tailings stack is sized according to 10 years of operation at the expanded production rate. The design will be updated to accommodate tailings storage requirements beyond production Year 10.

Table 20.7.2.1_5 Main Geometric Characteristics of the Chloride Control Purge Pond	
Design Aspect	**Measurement**
Maximum height (m)	5
Area occupied (m2)	10,000
Maximum capacity (volumetric; m3)	17,500
Slant of pond slope	1V:2H
Pond crest width (m)	7

The chloride control purge pond is sized according to 10 years of operation at the expanded production rate. The design will be updated to accommodate tailings storage requirements beyond production Year 10.

2. Flood Control System

The designated area for the Campbell Phase 1 open pit intercepts the João Creek and three direct tributaries. Consequently, installation of a protection system is required to impede the influx of surface water runoff into the pit to allow mining activities to proceed.

For the initial phase, VOGBR, proposed that the pit protection system consist of dikes and channels. The selection of this design allows for a good balance between the volume of earth cuts and landfills. However, following ensuing project development it was decided to use a system of protection ridges because of the proximity and the economical usage of waste material from within the open pit. The efficacy of the seepage collection system has not been assessed quantitatively (i.e., theoretical seepage losses versus observed seepage); however, VMSA is currently installing monitoring wells through the walls of the ponds to check and assess any potential bypass seepage. These wells are in addition to monitoring wells installed during construction

The revised conceptual system was designed with a pair of ridges located around the open pit designated as the Northern Ridge and the Southern Ridge. The intent is to redirect the water downstream from the open pit. The protection ridges form a barrier around the open pit to intercept the watercourses and to raise their water levels above localized topographical elevation variations. The diverted flow then discharges as surface runoff downstream from the open pit.

The design specifics for the Ridges were dictated by the design basis criteria of a 100 m minimum setback distance from the final pit extent. Furthermore, issues relating to the volume of landfill, feasibility of execution and hydraulic workings were also considered in efforts to optimize the adopted system.

The protection ridges have been installed pursuant to the mining activity plan defined for the Campbell Phase 1 pit. The North and South Ridge were completed by the end of Year 2. Vegetation clearing, removal of organic materials, and excavation of appropriate materials for foundation preceded the construction of the ridges. Two levies/ridges are part of the conceptual plan that was developed during the construction period. This conceptual plan indicates the use of an upstream clay-lined “wall” to store storm water during the rainy season and prevent water from entering the pit and retain sediment carried by the runoff water.

Consequently, the water management in the vicinity of the pit is effectively a “closed system”, whereby water pumped from the pit is discharged above the berms and reports back towards the pit or evaporates.

The use of overburden material from the Campbell Phase 1 pit was included in the protection ridge designs. Accordingly, the ridge structures were designed to consist of rock fill, transition material and compacted earth (residual soil/saprolitic material). A summary of the main ridge characteristics is provided in Table 20.7.2.1_6.

Table 20.7.2.1_6
Main Characteristics of the Ridges

Design Aspect	Ridge Measurement	
	Northern	Southern
Maximum height (m)	14	13
Length of structure (m)	915	875
Maximum crest elevation (m)	312	313
Minimum downstream elevation (m)	298	300
Slant of downstream-side embankment	1V:1.5H	1V:1.5H
Crest width (m)	6	6

NCL do Brasil further advanced the design of the waste pile and ore stockpile based on geometric parameters defined by VOGBR.

The material from the open pit will be placed on the waste pile or the ore stockpile, predominantly as varying sizes of boulders. The design criteria geometry for the proposed waste pile can be seen in Table 16.3_3.

20.8 Current Activities and Plans

Maracás Project construction was concluded in May 2014 and the key ongoing socio-environmental activities comprise of community meetings and communication, water, aquatic biota, fauna and flora monitoring, air quality checks and stacks emissions monitoring.

The Action Plan containing the integrated framework of environmental management plan components during operations is in place and an adequate environmental management and structure is active.

20.8.1 Project Organization and Sustainability team

In order to fulfill Largo's commitments to complying with the Equator Principals, a 'Sustainability Team' was created in February 2011. It consists of the following skills and positions:

- 1 senior Safety/Health/Environmental/Community manager responsible for the operation;
- 1 safety engineer and 4 safety technicians;
- 1 agronomist;
- 1 biologist; and,
- 1 communications person.

The Safety/Health/Environmental/Community manager and the safety engineer report directly to the General Manager. The participation of senior corporate management relating to the environmental aspects of the project is required for the implementation of the EMPs described in the Actions Plan.

20.8.2 Equator Principles Audit Review

As mentioned previously, Largo and its subsidiary, Vanádio de Maracás S.A have committed to comply with best management practices accepted by the International Mining Industry, all Brazilian environmental laws and regulations, and the conditions of all environmental permits issued for the Project.

A finance consortium composed of Itaú-BBA, Bradesco and Banco Vororantin have provided a portion of the finance for the Project in the form of a loan. A requirement for such financial Institutions/IFC Guidelines related to participation in projects such as the Maracás Project is the performance of a socio/environmental audit by a qualified, independent third party. In discussion with Bank representatives, it was agreed that the audit could be performed by Mineral Engenharia em Meio Ambiente Ltda. (Mineral), a well-known environmental engineering consulting firm, familiar with project permitting in Brazil and having recognized expertise in the performance of environmental audits.

The scope of the audit followed generally accepted auditing principles, reviewing the Ten Equator Principles and respective Performance Standards.

As part of the background review, an evaluation of the permitting and regulatory environment surrounding the Project was completed. This involved a review of the currently issued permits and permits that are pending or in the process of being obtained. During the EIA process, a number of commitments were made by the Project in the form of preparing and adopting a series of Environmental Management Plans. The content, status and implementation of these plans was reviewed and assessed. The EMP review and the implementation of the environmental management process required for the Project was also assessed with respect to the status of the Project during the audit. This included a review of Largo's monitoring of the Project and the Project's compliance with its permits and internationally accepted best management practices.

20.8.3 Socio-Environmental Action Plan and Environmental Management System

The Action Plan is an outcome of Equator Principle nº 04. It states that an action plan should be drawn up with a description of the actions required for management of any mitigation measures, corrective actions and supplementing measures identified through the Environmental Assessment.

The Action Plan was drawn up by VMSA corporate staff jointly with Mineral, and it incorporates compliance requirements with Brazilian laws and regulations and applicable environmental performance standards and EHS guidelines.

The list of programs is presented in the next section and summarized in Table 20.8.3_1.

Table 20.8.3_1
Action Plan - Environmental Programs

Program	Description	Phase
1) Environment, Health, and Safety Organization Plan	Plan to manage, apply and supervise the Safety, Health and Environment plans	Construction and Operation
2) Fauna Management Plan	Plan to manage and protect wild fauna.	Construction and Operation
3) Forest Management Plan	Plan to manage and protect forest.	Construction and Operation
4) Aquatic Biota Management Plan	Plan to manage and protect forest.	Construction and Operation
5) Water Management Plan	Plan to manage industrial and domestic waste waters and their treatment prior to releases to the environment.	Construction and Operation
6) Surface Water Management Plan	Plan to manage industrial and domestic waste waters and their treatment prior to releases to the environment.	Construction and Operation
7) Waste Management Plan	Plan to manage the solid waste, inert industrial wastes and oily contaminated soils at the project.	Construction and Operation
8) Environmental Monitoring Plan	Plan to monitor specific aspects throughout the life of the mine. Establishment of an “Observer Commission” consisting of local government, ONGs, County leaders, which regularly assess the implementation of the project.	Construction and Operation
9) Plan Rehabilitation of Degraded Areas	Plan to manage the rehabilitation and reclamation activities of the mine site	Construction and Operation
10) Plan of Social Communication	Plan to manage the public and internal communication to assure transparency and democratization of information.	Construction and Operation
11) Plan of Hiring Local People	Plan to hire 60% of people from Municipality of Maracás	Construction
12) Plan of Labor Training	Plan to manage the training of skills and competences of local people for project opportunities	Construction and Operation
13) Plan of Guidance of Local Suppliers	Plan to guide local suppliers on project opportunities for new business	Construction
14) Health and Safety Plans	Risk Management Plan- PGR	Construction and Operation
	Environmental Risks Prevention Plan - PPRA	
	Health Control Plan- PCMSO	
15) Contingency Plan	Plan to identify e enforce actions in the event of unforeseen events or an “upset” condition and to simulate emergency response.	Construction and Operation
16) Closure and Reclamation Plan	Plan to identify the concurrent and ultimate reclamation and closure of the mine area and any offsite impacts or disturbances.	Decommissioning

The Mine Closure and Reclamation Plan calculated for Campbell totalled US$ 12.4M and includes the following expenses, covering mine site, plant, stockpile, tailing dams, waste disposal area, buildings and facilities.

Table 1.7_3

Mine Closure Costs

Mine Closure Costs	Costs in US$
1. Adminstration	$829,531
2. Disassembly	$7,880,029
3. Earth moving	$56,426
4. Rehabilitation and revegetation of impacted areas	$818,184
5. Environmental monitoring program	$329,383
6. Communities comunication program	$90,939
7 Contingencies	$ 2,400,000
Total	**12,404,495**

The Maracás Vanadium Project must meet the standards required with respect to the legal aspects of the environmental licensing process and the License of Implementation and Operation and Environmental Control Programs, and be consistent with the Equator Principles as required by the International Finance Corporation (IFC) and the banks (Itaú, Vororantin and Bradesco) financing a portion of the Project.

Integratio has been involved with the Maracás Vanadium Project since November 2012 providing guidance and support for the physical, biotic and anthropic/socio-economic characteristics of the project. The objective of the integration of the three characteristics is to meet the requirements of the PD and the IFC, while observing the conditions and restrictions of all licenses.

The audit company for the PD is Mineral Engineering and Environment (MEE). To date, they have performed six audits; the first being in December 2011 and the most recent in September 2015. MEE through the course of their audits have identified certain non-conformities (documents PD01, PD02, PD03, PD04, and PD08). These non-conformities are being addressed. Existing response mechanisms are being amended and where no response mechanism exists, new ones are being developed.

The general planning consists of the following:

1. Situational Diagnosis including:
    - Analysis of the Social-Environmental Aspects of the Project
    - Stakeholders Mapping and Analysis
        - Assessment of the Requirements and Referential of Development

    - Performance Standards of the IFC
    - Conditions of the Environmental Control Programs
    - Current activities and commitments
  - Impacts and expectations for the role of the Company by the Stakeholders
    - Geographic scope (Areas of Influence)
    - Relevant Environmental Questions/Concerns

2. Operationalization
  - Action Plan
    - Macro Plan
    - Detailing
    - Monitoring of implementation
  - Evaluation
    - Internal pre-audits
    - External audit (prepping and monitoring)
    - Periodic Follow up with financial agents and external audit

3. Internal Governance
  - Constitution of the Environment Evaluation and Management System (Standard 1 of the IFC)
    - Definition of the full monitoring programs for the physical, biotic, and social economic dimensions of the Project
  - Empowerment of the Sustainability Coordinator on the Best Management Practices
  - Implementation of the Social-Environment Internal Committee
  - Addressing and responding to internal demands
  - Definition of the monitoring and evaluation criteria (performance indexes)

4. Development of Social Investment and Responsibility Guidelines

5. Design of Projects and Programs for local development and environmental impact mitigation.

During MEE's audit, Performance Standards 1 (PD-1) was adhered to which focuses on the structure of the Environmental Evaluation and Management System. Integratio's priority is for the consolidation of these systems to enable the Company to answer the social, environmental, and economic demands of the Maracás Vanadium Project.

It is important to emphasize the social and environmental investment requirement of the Banco Nacional de Desenvolvimento (BNDES), which is to strengthen the social and economic development of the regions that will receive investments.

The requirement of addressing the social and economic values is a new approach for BNDES which now places an emphasis on sustainable development initiatives so as to not cause social, economic and environmental impacts to the surrounding regions of the project.

The Main Equator Principles Framework for VMSA Social Investments are as follows:

1. Principle 2: Social and Environmental Assessment

   This assessment proposes mitigation and management relevant and appropriate to the nature and scale of the proposed project.

   - Social assessment (Main Impacts from Environmental Impact Study)
   - Population expectations
   - Provide employment and income
   - Stimulation of local and regional economy - investment

2. Principle 3: Applicable Social and Environmental Standards

   Assessment will refer to the applicable IFC Performance Standards

   - Performance Standard 1: Management System and Environmental Assessment
   - Stakeholders engagement

3. Principle 5: Consultation and Disclosure

   For projects with significant adverse impacts on affected communities, the process will ensure there is informed consultation and opportunity for participation as a means to address any issues.

The Main IFC approach for VMSA Social Investments is as follows:

1. Addressing the Social Dimensions of Private Sector Projects - Good Practice Note (IFC)

   - Traditionally, the “do-no-harm” approach of the World Bank Group's social safeguard policies has made social mitigation plans the primary entry point for distributing benefits to local communities impacted by IFC investments.
   - Unlike mitigation and compensation which have important but limited objectives of protecting affected persons from adverse impacts, sustainable development actions enable the wider population in a project's area of influence to gain access to and take better advantage of the range of opportunities brought about by private sector development.

21 CAPITAL AND OPERATING COSTS

GE21 visited the Project for a period of 5 days, gathering information and data from mine and plant, including operational parameters, and costs in verbal, written and digital format.

GE21 analysed the obtained data and concluded that the data was clear and coherent and that it was sufficient for the CAPEX and OPEX determination and estimation by GE21.

GE21 thanks Largo personnel for availability in delivery and execution of data and the time spent with GE21.

21.1 Capital Cost Estimate

The Capex is based only on the existing and ongoing operations of the Project, including the planned increase in production, and whithout investments in new plants. All investments were considered as sustaining capital cost

21.1.1 Sustaining Capital Cost

All capital cost is treated as sustaining capital for the purposes of this report, with the exception of US$ 9 million in 2019 related to the production expansion to 960 t/month and US$ 12 million in 2020 related to the production expansion to 1,100 t/month. The total capital cost is estimated at US$ 71 million, excluding amounts for mine closure costs. An amount of US$ 3 million per year was included for plant maintenance, spare parts, and calcine dams, with the exception of 2017 that was estimated at US$ 5 million.

Additional sustaining capital costs of US$ 1.5 million was estimated for mine drainage, US$ 4.3 million was estimated for exploration and US$ 8.8 million was estimated for non-magnetic dams and chloride ponds.

21.2 Operating Cost Estimate

GE21 summarized the operating and administrative costs, based on real costs that are currently being incurred by Largo.

Table 21.2_1 shows the average operating costs projected after all investiments.

Table 21.2_1
Average Operating Cost Summary

Operating Cost	US$
Mining (US$/t earth moving)	2.45
Processing (US$/lb V_2O_5)	1.78
General and Admin (US$/lb V_2O)	0.18
Royalties (CBPM, owner, CFEM, AP)(US$/lb V_2O)	0.34

21.2.1 Mining Cost

Largo's unit mining costs were based on the costs currently contracted with Fagundes Construção e Mineração Ltda contractors. The drilling and blasting costs are $ 0.79/t.

The loading and haulage operations are performed out by specialized contractor Fagundes Construção e Mineração Ltda. This contract provides the loading with CAT 336 hydraulic excavator with 2.5m^3 bucket (ore and waste). The transportation is done by truck MB 4844 (or similar) 36t capacity. The unit cost is charged in relation to the transport distance and is shown in table 21.2.1_1

Table 21.2.1_1
Contract Loading & Haulage Costs

Haul Distance (m)	Load/Haul ($)
0000 - 0200	0.83
0201 - 0500	0.90
0501 - 1,000	0.97
1,001 - 1,500	1.03
1,501 - 2,000	1.10
2,001 - 2,500	1.18
2,501 - 3,000	1.28
3,000 - 4,000	1.49
4,000 - 5,000	1.72
5,000 - 6,000	1.98
6,000 - 7,000	2.28
7,000 - 8,000	2.63
8,000 - 9,000	3.03
9,000 - 10,000	3.49

21.2.2 Processing Cost

Expenditures and costs were predominantly extracted or calculated from spreadsheets and information collected from Largo, reflecting the actual costs collected from August 2016 to May of 2017. Expenditure and costs for periods after 2018, for expantions in 2019 and 2020, were calculated based on the specific consumptions for variable parcels and in real costs for fixed parcels.

The annualized rate of calcination and production of flakes used for the unit cost calculations were the following:

- ROM Rate 1,183,826 t/year
- Milling Rate 828,372 t/year
- Calcination Rate 365,652 t/year
- Flakes Production 8,367 t/year

The average 697 t/month production, which supported the unit costs calculation, was gathered as the average rate of production for the period analysed. It is important to note that Largo currently projects a flake production rate of 800t/month for the second half of 2017 and 2018. GE21 concluded that the unit costs here presented are conservative by nature.

The plant OPEX, US$/lb V_2O_5 are summarized in Table 21.2.2_1 for 2017/2018 and 2020 with 2019 being treated as a transition year.

Table 21.2.2_1 Plant OPEX- US$/(lb V_2O_5)		
Item	**2017/2018**	**2020 onwards**
Labor	0.54	0.36
Power	0.23	0.18
Water Catchment	0.01	0.01
Re-handling	0.10	0.09
Raw material and reagents	1.09	0.97
Maintenance	0.14	0.11

Each cost item was detailed based on the annual expenditure observed during the observation period, for projections they were estimated according to the annual rate of production.

The payroll costs detailed in table 21.2.2_2, cover all Company employees involved in the Plant operation in 2017, GE21 assumed an average monthly wage, including social benefits, of US$ 2,424 per employee.

Table 21.2.2_2 **Labor Costs**		
Area	**Employees**	**2017 US$/year**
Production	145	4,218,182
Maintenance	103	2,996,364
OthersSectors	92	2,676,364
TOTAL	340	**9 890 909**

For the year 2020, we accrue an annual personnel expenditure of US$ 10.4 million based on flake production of 1,100 t/month.

Table 21.2.2_3 summarizes Power costs as collected from Largo operation.

Table 21.2.2_3 **Power annual costs**			
Installed Power HP/Kw	**Factor %**	**Specific Cost US$/KWh**	**US$/year**
20,000/15.1	75%	0.04	**4,184,254**

For 2020, GE21 calculated an annual power cost of US$ 5.15 million.

Table 21.2.2_4. summarizes Water Catchement annual cost as calculated by GE21.

Table 21.2.2_4 **New Water Catchment annual cost-1,500 m^3/day (200 m^3/h) in 30 km**			
Item	**Power KWh**	**Specific Cost**	**U$$/year**
Power	500	US$ 0.05 /KWh	66,364
Others		US$ 7 575 /month	90,909

Maintenance		US$ 10 600 /month	127,273
TOTAL			**284,545**

For 2020 GE21 calculated a New Water Catchment annual cost of US$ 0.33 million.

Table 21.2.2_5 summarizes Re-handling annual costs as collected from Largo:

Table 21.2.2_5 **Re-handling product and tailing annual cost**	
Costs US$/month	**US$/year**
151,500	**1,818,000**

For 2020, GE21 calculated an annual re-handling cost of US$ 2.55 million.

Raw-materials and reagent items are being considered as the cost associated with crushing consumables, ball mill, fuel and reagents, which are presented in the following table 21.2.2_7

Table 21.2.2_7 presents the raw-material and reagents criteria as calculated by GE21, considering the milling feed of 828,372 t crushed material per year, and the kiln feed of 365,652 t magnetic concentrated per year.

Table 21.2.2_7 **Raw-material and reagents**			
Crushing consumables			**US$/year 532,270**
Milling Consumables	**Consuption Kg/t feed.**	**Specific Costs US$/Kg**	**US$/year**
Balls	0.15	1.82	**225,919**
Reagents and Fuel	**Consuption Kg/t feed**	**Specific Costs US$/Kg**	**US$/year**
Sodium Carbonate	47	0.34	**5,818,229**
HFO	31	0.56	**5,910,911**
Diesel		0.91	**833,501**
Ammonium sulfate	1510	0.29	**3,636,841**
Sulfuric Acid	387	0.25	**804,549**
Aluminum sulfate	118	0.46	**450,542**
Sub-Total (Reagentes and Fuel)			**17,454,573**
Total			**18,212,762**

In 2020, GE21 calculated an annual raw-material and reagents cost of US$ 28.2 million.

21.2.3 General and Administrative Cost

The G&A cost included all costs relating to administration, management wages, HR, Procurement, Technology, HSSE, Communication, restaurant, employee transportation and security.

The overall annual G&A was estimated at US$ 4.7 million, based on actual data collected from Largo.

22 ECONOMIC ANALYSIS

22.1 Taxes

<u>Compensação Financeira pela Exploração Mineral- CFEM</u>

Financial Compensation by Exploration of Mineral Resources

Financial Compensation for the Exploration of Mineral Resources (CFEM) is the consideration paid to the Government of Brazil for the extraction and economic exploration of Brazilian mineral resources.

CFEM focuses on net sales of the raw mineral product, or on the intermediate cost of production when the mineral product is consumed or transformed in an industrial process.

Largo's Maracas Menchen Mine calculates CFEM from the operating costs incurred in the production of magnetic concentrate (about 30% of total OPEX+Depreciation). Since the Maracas Menchen Mine uses the ore in an industrial process, CFEM is calculated based on the cost of production .The current legislation that defines CFEM is based on the cost of concentrate so for the purposes of the cash flow included in this report, it was assumed that the basis for the calculation of CFEM increases by 15%, in analogy to the transfer pricing rules in Brazil.

For purpose of the calculation, a sales profit index of 15% is used thus composing the CFEM calculation as follows:

The formula used is

(OPEX+Depreciation) x 30% x 115% x 2%(CFEM)

<u>National Income tax / Imposto de Renda IR</u>

A 15% tax rate on pre-tax profit, based on real profit, is applied if the profit is less than R$ 240,000/ year. A rate of 25% on pre-tax profit is applied if the profit is greater than R$ 240,000/ year. The Maracas Menchen Mine has been granted a reduction of 75% of this income tax based on a SUDENE resolution, the details of which are provided below, resulting in an effective tax rate of 6.25%

The Board of Management of Funds and Incentives and Investment Attraction of the Northeast Development Superintendency - SUDENE based on Decree No. 6,219 of October 4, 2007 grants the right to a reduction of 75% of non-refundable Income Tax and Additions, calculated with profit basis of the holding in favor of Vanadio de Maracás S / A, CNPJ 15,191,786 / 0001-49, case number 59334.001815 / 2014-91, based on art. 1 of Provisional Measure No. 2.199-14, dated August 24, 2001, according to the criteria established by Decree No. 6,539, of August 18, 2008, and also in accordance with the tax incentive regulation, with a view to or conditions and legal requirements.

Compensation of Tax Losses and CSLL Negative Calculation Bases- CSLL

Article 510. The tax loss calculated as from the close of the calendar year of 1995 may be compensated, in addition to the tax loss calculated up to December 31, 1994, with the net income adjusted by the additions and exclusions set forth in this decree, with the maximum limit for compensation of thirty percent of said adjusted net income (Law No. 9.065, of 1995, article 15).

Paragraph 1. The provisions of this article only apply to legal entities that keep the books and documents required by tax legislation, proving the amount of tax loss used for compensation (Law No. 9565 of 1995, article 15, sole paragraph).

Paragraph 2. The balances of tax losses existing on December 31, 1994 are subject to compensation under this article, regardless of the period established in the legislation in force at the time of its determination.

Paragraph 3. The limit provided in the caput does not apply to the hypothesis dealt with in item I of art. 470.

Social Contribution on Net Profits

The Social Contribution on Profits is a federal tax charged at 9% of taxable income. For the Maracas Menchen Mine, taxable income is calculated using the actual profits regime.

Royalties

For the Maracas Menchen Mine, a royalty of 2% is payable to Anglo Pacific PLC.

Compahia Baiana de Pesquisa Mineral CBPM

CBPM is the Bahia State Geological Survey and was the owner of the mining rights over most of the deposits, only Nova Amparo Norte is the property of VMSA. Pursuant to the terms of the agreement whereby VMSA acquired the mining rigths from CBPM, CBPM was granted a 3% royalty over gross sales revenues.

Depreciation

Depreciation of plant infrastructure and equipment was calculated in a simplified way, depreciating the investment in annual values over the mine life.

22.2 Discounted Cash Flow

A Discounted Cash Flow – DCF – base case scenario was developed to assess the project based on economic-financial parameters, on the results of the mine scheduling and on the Sustaining CAPEX and OPEX estimate.

The Table 22.1_1 shows the main economical and financial parameters used by GE21.

Table 22.1_1
Selling Prices and Taxes

Selling price	
Product	Sell Price (US$/lb)
Product V_2O_5	9.00 (in 2018 and 2019)
	6.34 others years
Taxes	
CFEM	2.0%
INCOME TAX	25% (Discount of 75% until 2024)
INCOME TAX*	9.0%
Financial Parameters	
WACC	8.0% aa
NPV	Based on middle the year
Royalties	
Surface Royalties	2.0%

* The total Income taxes has two components: (i) IRPJ: Regular rate is 25%, but VMSA has a tax incentive which results in a discount of 75% and (ii) CSLL : 9%. This results in an aggregate effective rate of 15.25%.

The Project base case estimates a Net Present Value of $542 million, at a Discount Rate of 8% per year, as presented in table 22.1_2 below. IRR was not calculated as it´s an existing operation and so there is no initial Capex for comparison purposes.

Table 22.1_2

Base Case Life of Mine Annual Cash Flow

	Campbell												
Year	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**
Total Lavrado (Mt)	**5.0**	**6.8**	**8.8**	**9.8**	**10.9**	**9.7**	**9.3**	**8.9**	**4.1**	**3.8**	**2.2**	**0.6**	**-**
High Grade	1.17	1.25	1.59	1.93	1.87	1.91	2.01	2.06	1.89	1.82	1.52	-	-
Low Grade	-	-	-	-	-	-	-	-	0.1	0.0	-	0.6	-
Waste	3.79	5.56	7.26	7.85	9.05	7.76	7.24	6.85	2.15	2.00	0.69	-	-
V2O5 Product (t)	**6 357.8**	**10 497.9**	**11 497.4**	**13 319.5**	**13 680.6**	**13 465.9**	**13 383.4**	**13 313.3**	**13 257.1**	**13 854.1**	**14 703.8**	**2 135.0**	**-**
OPEX (US$ mi)	**(44.3)**	**(69.4)**	**(73.5)**	**(76.6)**	**(81.1)**	**(77.9)**	**(76.8)**	**(76.8)**	**(67.3)**	**(69.0)**	**(69.2)**	**(17.2)**	**-**
Mine (US$)	**(11.7)**	**(15.9)**	**(19.7)**	**(21.4)**	**(24.6)**	**(22.2)**	**(21.4)**	**(21.7)**	**(12.5)**	**(11.8)**	**(8.9)**	**(4.5)**	**-**
Mine (US$)	(5.9)	(8.1)	(10.5)	(11.6)	(14.0)	(12.4)	(11.9)	(12.4)	(6.1)	(5.7)	(3.8)	(0.6)	-
Drilling and Blast (Ore+Waste)	(3.3)	(4.5)	(5.8)	(6.5)	(7.2)	(6.4)	(6.2)	(6.0)	(3.0)	(2.8)	(1.7)	(0.5)	-
Costs (Payroll,Topography,Auxiliar Equipaments,etc)	(1.8)	(2.6)	(2.6)	(2.6)	(2.6)	(2.6)	(2.6)	(2.6)	(2.6)	(2.6)	(2.6)	(2.6)	-
Drilling and Blast (Fixed Costs)	(0.7)	(0.7)	(0.7)	(0.7)	(0.7)	(0.7)	(0.7)	(0.7)	(0.7)	(0.7)	(0.7)	(0.7)	-
Process	**(29.6)**	**(48.8)**	**(49.1)**	**(50.4)**	**(51.8)**	**(51.0)**	**(50.7)**	**(50.4)**	**(50.2)**	**(52.5)**	**(55.7)**	**(8.1)**	**-**
Plant	(29.6)	(48.8)	(49.1)	(50.4)	(51.8)	(51.0)	(50.7)	(50.4)	(50.2)	(52.5)	(55.7)	(8.1)	-
G&A	**(3.1)**	**(4.7)**	**(4.7)**	**(4.7)**	**(4.7)**	**(4.7)**	**(4.7)**	**(4.7)**	**(4.7)**	**(4.7)**	**(4.7)**	**(4.7)**	**-**
Gross Revenue (US$ mi)	**81.5**	**191.1**	**209.3**	**175.1**	**182.1**	**179.2**	**178.1**	**177.2**	**176.5**	**184.4**	**195.7**	**28.4**	**-**
EBITDA (US$ mi)	**37.2**	**121.7**	**135.8**	**98.6**	**101.0**	**101.4**	**101.4**	**100.4**	**109.1**	**115.4**	**126.5**	**11.2**	**-**
DEPRECIATION (US$ mi)	(29.0)	(30.5)	(34.7)	(39.0)	(39.9)	(40.8)	(40.4)	(38.4)	(25.4)	(24.6)	(13.5)	-	-
EBIT (US$ mi)	**8.2**	**91.2**	**101.2**	**59.6**	**61.1**	**60.5**	**60.9**	**62.0**	**83.7**	**90.8**	**113.0**	**11.2**	**-**
IRPJ (25% in R$ 0.24 mi/ year)+75% Discount (SUDENE Incentive) untill 2024	(0.015)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.011)	(0.011)	(0.011)	(0.011)	-
Operating Profit Discount (30%)	2.45	27.37	30.35	17.88	18.34	10.00							
AIR (24% sobre Exc R$ 0.24 mi/ano do EBIT) +75% +75% Discount (SUDENE Incentivea untill 2024)	(0.3)	(4.0)	(4.4)	(2.6)	(2.7)	(3.1)	(3.8)	(3.9)	(20.9)	(22.7)	(28.2)	(2.7)	-
CSLL (9% sobre EBIT)	(0.5)	(5.7)	(6.4)	(3.8)	(3.9)	(4.5)	(5.5)	(5.6)	(7.5)	(8.2)	(10.2)	(1.0)	-
CBPM (3% sales revenue)	(2.4)	(5.7)	(6.3)	(5.3)	(5.5)	(5.4)	(5.3)	(5.3)	(5.3)	(5.5)	(5.9)	-	-
CFEM (2% of MAG cost * 30%) (US$ mi)	(0.5)	(0.7)	(0.7)	(0.8)	(0.8)	(0.8)	(0.8)	(0.8)	(0.6)	(0.6)	(0.6)	(0.1)	-
ROYALTIES FOR LAND OWNER												(0.1)	-
ROYALTIES (2%)	(1.6)	(3.8)	(4.2)	(3.5)	(3.6)	(3.6)	(3.6)	(3.5)	(3.5)	(3.7)	(3.9)	-	-
Net Income (US$ mi)	**2.7**	**71.3**	**79.2**	**43.7**	**44.7**	**43.1**	**41.9**	**42.9**	**45.8**	**50.1**	**64.3**	**7.2**	**-**
Depreciation (US$ mi)	29.0	30.5	34.7	39.0	39.9	40.8	40.4	38.4	25.4	24.6	13.5	-	-
Residual Value (US$ mi)	-	-	-	-	-	-	-	-	-	-	-	-	-
Free Operating cash flow (US$ mi)	**31.7**	**101.7**	**113.8**	**82.7**	**84.6**	**83.9**	**82.4**	**81.3**	**71.3**	**74.7**	**77.8**	**7.2**	**-**
CAPEX (US$ mi)	**(6.0)**	**(14.4)**	**(17.1)**	**(4.6)**	**(4.6)**	**(4.0)**	**(3.6)**	**(3.6)**	**(4.6)**	**(4.2)**	**(4.1)**	**(0.4)**	**-**
Mine	(0.9)	(0.4)	-	-	-	(0.1)	-	-	-	(0.1)	-	-	-
Plant	(5.0)	(12.1)	(15.2)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	-	-
DAM	-	(1.2)	(1.5)	(1.5)	(1.0)	(0.5)	(0.5)	-	(1.2)	(1.0)	(0.5)	-	-
Exploration	(0.11)	(0.63)	(0.40)	(0.09)	(0.58)	(0.40)	(0.09)	(0.58)	(0.40)	(0.09)	(0.58)	(0.40)	-
Others Costs (US$ mi)													
Mine Closure	-	-	-	-	-	-	-	-	-	-	-	(11.0)	(1.4)
Working Capital	-	(3.0)	(1.6)	2.1	-	-	-	-	-	-	-	7.7	-
Cash Flow(US$ mi)	**25.7**	**84.4**	**95.1**	**80.1**	**80.0**	**79.9**	**78.8**	**77.7**	**66.6**	**70.6**	**73.7**	**3.6**	**(1.4)**
VPL (WACC = 8%) (US$ mi)	542												

Beside this base case DCF, GE21 also assess two other scenarios using:

- Scenario I - Flat price of US$ 6.34 and
- Scenario II - Flat price of US$ 7.37

This exercices reached the following results:

- Scenario I – NPV – US$ 456 million
- Scenario II - NPV – US$ 587 million

22.3 Sensitivity Analysis

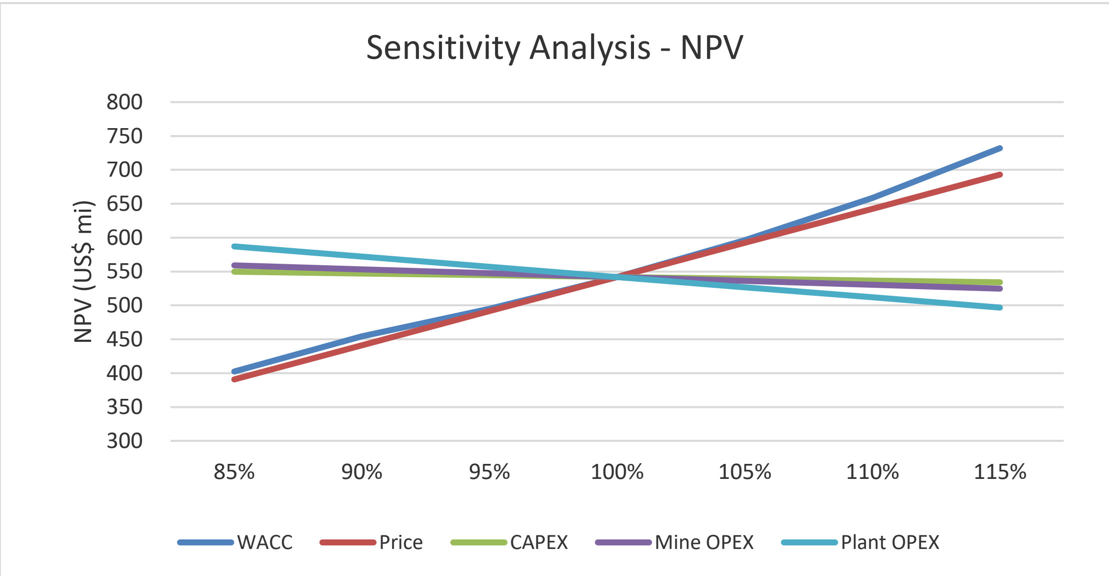
A sensitivity analysis was undertaken to evaluate the impact of the resulting economic indicators for the following attributes, within the cash flow:

- WACC;
- Sell price
- Mine OPEX.
- Plant OPEX

The WACC, OPEX, NPV, was evaluated by varying its value from -15% to +15%, The Figure 22.2_1 and Figure 22.2_2 shows the sensitivity analysis developed by GE21.

Figure 22.2_1

NPV - Sensitivity Diagram



GE21 concluded based on in Sensitivity Analysis that project profitability is most affected by the vanadium concentrate price and to a lesser degree the discount rate.

23 ADJACENT PROPERTIES

There are no immediately adjacent mineral concessions which affect the opinion offered in this report.

24 OTHER RELEVANT DATA AND INFORMATION

As already explained in Section 1 in this report, Largo retained GE21 to review the pit optimization and life of mine plan and plant feed schedule for all of the deposits at the Property, at a feasibility study level for the Campbell deposit and Preliminary Economic Assessment (PEA) level of study for the Satellite Deposits and the remaining in pit inferred resources from the Campbell.

In this section, information is presented on (i) current operations and (ii) on the results of preliminary mine planning and economic analysis, carried out to meet the standards normally expected of a preliminary economic assessment (PEA), for the potential exploitation of mineral resources that are not already included in the mineral reserves discussed in Section 15 of this report. The economic results of this PEA-level work are presented in terms of their incremental impact on the base-case cash flows presented in Section 22 of this report.

24.1 Current Operations

The Project is currently a producing vanadium mine. Sections 15 to 22 of this report are focused on the reserves declared for this operation, and their economics, resulting in a FS level report relative to the Life of Mine of measured and indicated reserves, based on an optimized pit on the deposit known as Campbell (previously referred to as Gulçari A).

The remaining resources in the Campbell deposit which are inferred resources are not included in the reserves and the inferred resources in the Satellite Deposits form the basis for a complementary study, at a PEA level, which is discussed in this section.

24.2 Preliminary Economic Assessment of Additional Resources

In addition to the reserve estimate, GE21 prepared a PEA to assess the impact of mining the inferred resources from the Satellite Deposits, as detailed in Table 24.2_1 and the remaining inferred resources of Campbell after the LoM.

This PEA does not update, add to or modify the FS, nor does it use more optimistic assumptions or parameters, and is not a PFS or FS in any respect.

GE21 prepared the PEA using the same criteria for mining and plant parameters, but considering the use of a mobile station of griding and DMS, target by target, to send a magnetic concentrate to the plant located in Campbell.

A PEA is preliminary in nature, it includes inferred mineral resources that are considered too speculative geologically to have the economic considerations applied to them that would enable them to be categorized as mineral reserves, and there is no certainty that the PEA will be realized.

Table 24.2_1 Satellite Deposits Mineral Resource Effective Date May 2nd 2017				
Deposits	**Category**	**Tonnes K(t)**	**V2O5 (%)**	**Contained V2O5 (tonnes)**
Gulçari A Norte**	Inferred	9,730	0.84	81,388
Gulçari B**	Inferred	2,910	0.70	20,312
Novo Amparo**	Inferred	1,560	0.72	11,255
Novo Amparo Norte**	Inferred	9,720	0.87	84,453
Sao Jose**	Inferred	3,900	0.89	34,706
Satellite Deposits (Total)**	Inferred	27,820	0.83	232,114

24.2.1 Mine Planning and Scheduling

24.2.1.1 Introduction

A complementary conceptual life-of-mine production schedule was developed for the inferred resources from the Satellite Deposits and the remaining inferred resources of Campbell to evaluate the cumulative impact of the following assumptions and operational changes:

- The use of the remaining resources in the Campbell deposit, after the existing Life of Mine for the reserves is exhausted. The topography used is the same as that of the final pit for Campbell
- The use of inferred resources from the Satellite Deposits;
- The beginning of mining activities on the Satellite Deposists and the remaining inferred resources from Campbell, will be carried out only after the exhaustion of the reserves in Campbell; and
- The application of operating efficiencies recently achieved in the milling operations, and other assumptions and parameters used in the FS study.

24.2.1.2 Pit Optimization

The selection of the optimal pit was based on:

- The determination of the economic and geometric parameters to define the economic function, cut-off grade and legal and proprietary restrictions;
- A calculation of the interlocking of optimal pits using Geovia Whittle 4.3 software;

Except where noted, in the following discussion, unit costs and assumptions used in the pit optimizations for this conceptual study are in Table 24.2.1.2_1 and Table 24.2.1.2_2. We aso assumed that a portable DMS will be situated at the rim of each satellite pit to minimize haulage costs and trucking requirements. Contractor-based unit haulage rates as summarized in Table 21.2.1_2, were applied to the portable DMS output volumes from each respective satellite pit. These volumes are assumed to be direct dumped into a hopper that feeds into the wet magnetic separator (WMS) circuit of the plant.

Table 24.2.1.2_1

Pit Optimization Parameters

Inputs	**Unit**	**Value**
Exchange rate	R$/US$	3.30
Sell Price	US/lbV_2O_5	6.34
Discounted rate	%	8
Mining recovery	%	100
Dilution	%	5
Slope Angle	Degrees	60
Metallurgical yeld	%	76
Product grade	%	99
V2O5 grade cut-off	%	0.45

Table 24.2.1.2_2

Pit Optimization Parameters

Costs	**Targets**				
	GAN-GB	**NA**	**NAN**	**SJ**	**Remained Resources Campbell**
Mine (US$)/t mined	1.54	1.49	1.60	1.54	1.80
Plant(US$)/t fed	35.63	36.01	36.68	35.67	34.76
SG&A	0.59	0.59	0.33	0.59	0.68

The plant cost include the cost of transportation of Dry Magnetic concentrate from Satellite Deposits to the plant located near the Campbell pit. It varies according to the average transport distance of each target.

Figure 24.2.1.2_1

Results of the Pit Optimization – Gulçari A Norte and Gulçari B Target

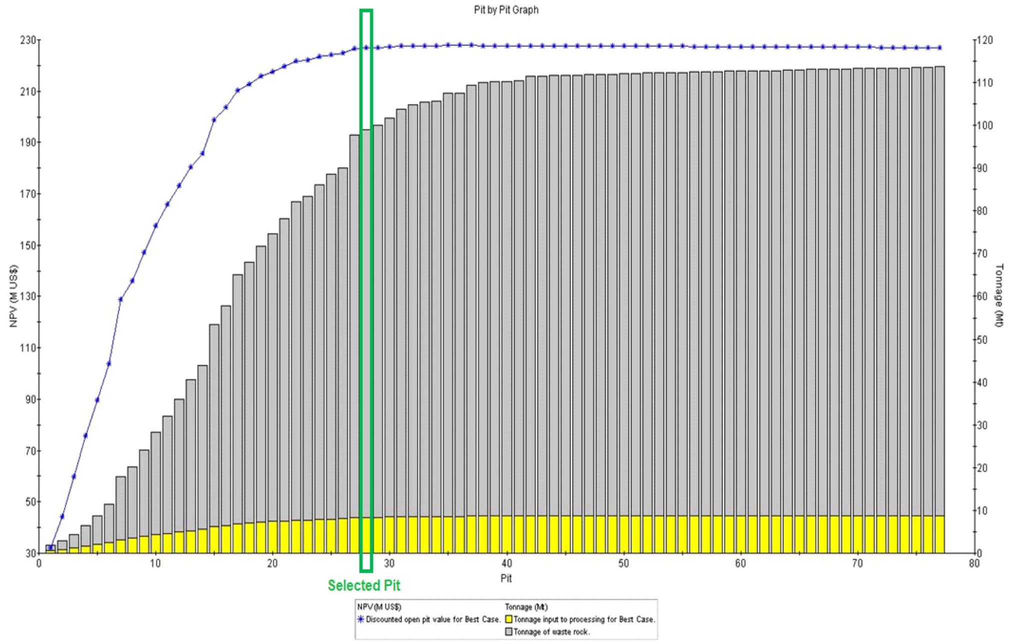


Table 24.2.1.2_3 Results of the Pit Optimization – Gulçari A Norte and Gulçari B Target											
Pit	**Revenue Factor**		**Total**	**ROM**	**Waste**	**SR**	**V_2O_5**	**SiO_2**	**Mag**	**Product**	**VPL**
	Min.	**Max.**	**Kt**			**t/t**	**%**		**%**	**Kt**	**US$ M**
1	0.30	0.30	1 769.3	588.84	1 180.5	2.00	3.12	3.19	24.00	3.4	31.92
5	0.38	0.38	8 662.2	2 020.20	6 642.0	3.29	2.70	2.66	27.00	1 119.3	89.53
10	0.48	0.48	28 283.2	4 284.83	23 998.4	5.60	2.65	2.94	27.00	2 330.0	157.40
15	0.58	0.58	53 468.7	6 219.01	47 249.7	7.60	2.55	2.80	28.00	3 374.7	198.96
20	0.68	0.68	74 530.5	7 397.41	67 133.1	9.08	2.55	2.88	28.00	4 014.1	217.54
25	0.78	0.78	88 530.4	7 986.06	80 544.4	10.09	2.56	2.89	28.00	4 350.6	224.18
28	0.84	0.84	98 983.6	8 350.63	90 633.0	10.85	2.58	2.88	28.00	4 584.7	226.76
30	0.88	0.88	101 586.4	8 435.07	93 151.3	11.04	2.58	2.87	28.00	4 631.1	227.20
35	0.98	0.98	107 382.1	8 612.99	98 769.1	11.47	2.58	2.85	28.00	4 728.7	227.78
40	1.08	1.08	110 241.4	8 684.77	101 556.6	11.69	2.58	2.85	28.00	4 768.1	227.72
45	1.18	1.18	111 552.0	8 716.87	102 835.2	11.80	2.58	2.85	28.00	4 785.8	227.58
46	1.20	1.20	111 634.6	8 718.74	102 915.9	11.80	2.58	2.85	28.00	4 786.8	227.56
47	1.22	1.22	111 778.0	8 721.44	103 056.6	11.82	2.58	2.85	28.00	4 788.3	227.54
48	1.24	1.24	111 792.3	8 721.87	103 070.4	11.82	2.58	2.85	28.00	4 788.5	227.54
49	1.26	1.26	111 835.7	8 722.73	103 113.0	11.82	2.58	2.85	28.00	4 789.0	227.53
50	1.28	1.28	111 961.4	8 725.15	103 236.3	11.83	2.58	2.85	28.00	4 790.3	227.50
51	1.30	1.30	112 128.7	8 728.57	103 400.2	11.85	2.58	2.85	28.00	4 792.2	227.46
52	1.32	1.32	112 154.5	8 729.08	103 425.4	11.85	2.58	2.85	28.00	4 792.5	227.45
53	1.34	1.34	112 249.5	8 730.79	103 518.7	11.86	2.58	2.85	28.00	4 793.4	227.43
54	1.36	1.36	112 306.1	8 732.02	103 574.1	11.86	2.58	2.85	28.00	4 794.1	227.41
55	1.38	1.38	112 325.9	8 732.33	103 593.6	11.86	2.58	2.85	28.00	4 794.3	227.41
60	1.52	1.54	112 587.7	8 737.48	103 850.2	11.89	2.58	2.85	28.00	4 797.1	227.33
65	1.66	1.68	112 865.4	8 742.18	104 123.2	11.91	2.58	2.85	28.00	4 799.7	227.22
70	1.82	1.82	113 194.2	8 748.37	104 445.8	11.94	2.58	2.85	28.00	4 803.1	227.09
75	1.94	1.94	113 482.3	8 752.35	104 730.0	11.97	2.58	2.85	28.00	4 805.2	226.96
77	1.98	2.00	113 606.6	8 754.32	104 852.2	11.98	2.58	2.85	28.00	4 806.3	226.90

Figure 24.2.1.2_2

Perspective view of the mathematical pit – Gulçari A Norte and Gulçari B Target

Figure 24.2.1.2_3

Results of the Pit Optimization – Novo Amparo Target

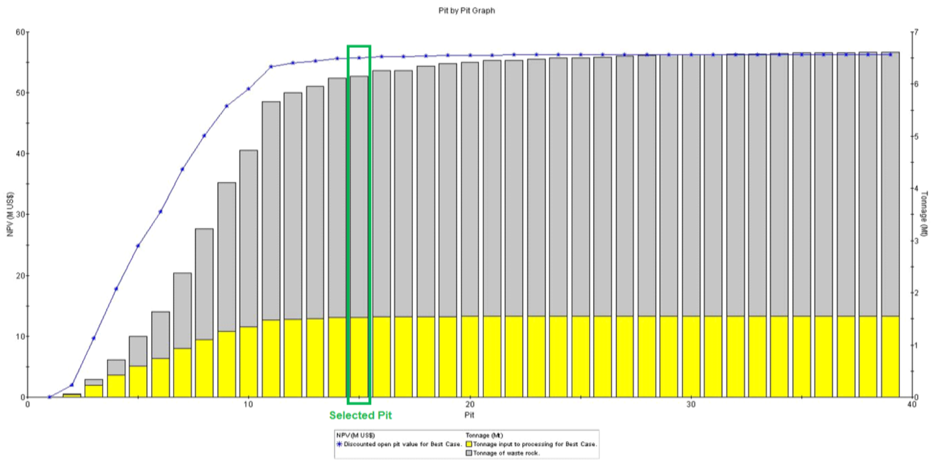


Table 24.2.1.2_4

Results of the Pit Optimization – Novo Amparo Target

Pit	Revenue Factor		Total	ROM	Waste	SR	V_2O_5	SiO_2	Mag	Product	VPL
	Min.	Max.	Kt			t/t	%		%	Kt	US$ M
1	0.30	0.30	1.1	1.09	0.1	0.05	1.94	1.40	26.00	0.0	0.04
3	0.34	0.34	342.3	231.94	110.3	0.48	1.72	1.47	35.00	106.1	9.68
5	0.38	0.38	1 169.7	598.40	571.3	0.95	1.64	1.41	39.00	290.9	24.83
7	0.42	0.42	2 378.6	934.06	1 444.5	1.55	1.59	1.39	41.00	462.8	37.39
9	0.46	0.46	4 112.2	1 258.14	2 854.0	2.27	1.56	1.41	42.00	626.5	47.87
11	0.50	0.50	5 665.4	1 476.99	4 188.4	2.84	1.56	1.44	42.00	735.5	54.29
13	0.54	0.54	5 958.5	1 510.22	4 448.2	2.95	1.56	1.44	42.00	752.0	55.24
15	0.58	0.58	6 145.8	1 528.41	4 617.4	3.02	1.56	1.44	42.00	761.1	55.73
17	0.62	0.64	6 265.0	1 538.28	4 726.7	3.07	1.56	1.44	42.00	766.0	55.98
19	0.68	0.68	6 389.3	1 546.59	4 842.7	3.13	1.56	1.45	42.00	770.1	56.14
21	0.72	0.72	6 450.9	1 550.27	4 900.6	3.16	1.56	1.45	42.00	772.0	56.20
23	0.78	0.78	6 474.6	1 551.70	4 922.9	3.17	1.56	1.45	42.00	772.7	56.22
25	0.82	0.82	6 504.0	1 553.13	4 950.9	3.19	1.56	1.45	42.00	773.4	56.23
27	0.86	0.86	6 535.5	1 554.49	4 981.0	3.20	1.56	1.45	42.00	774.1	56.25
29	0.98	1.16	6 557.6	1 555.38	5 002.2	3.22	1.56	1.45	42.00	774.5	56.25
31	1.20	1.24	6 565.3	1 555.58	5 009.7	3.22	1.56	1.45	42.00	774.6	56.25
33	1.28	1.30	6 577.4	1 555.85	5 021.5	3.23	1.56	1.45	42.00	774.7	56.24
35	1.40	1.66	6 595.1	1 556.26	5 038.8	3.24	1.56	1.45	42.00	774.9	56.24
37	1.70	1.70	6 602.7	1 556.40	5 046.3	3.24	1.56	1.45	42.00	775.0	56.23
39	1.78	2.00	6 615.3	1 556.60	5 058.7	3.25	1.56	1.45	42.00	775.1	56.22

Figure 24.2.1.2_4

Perspective view of the mathematical pit – Novo Amparo Target

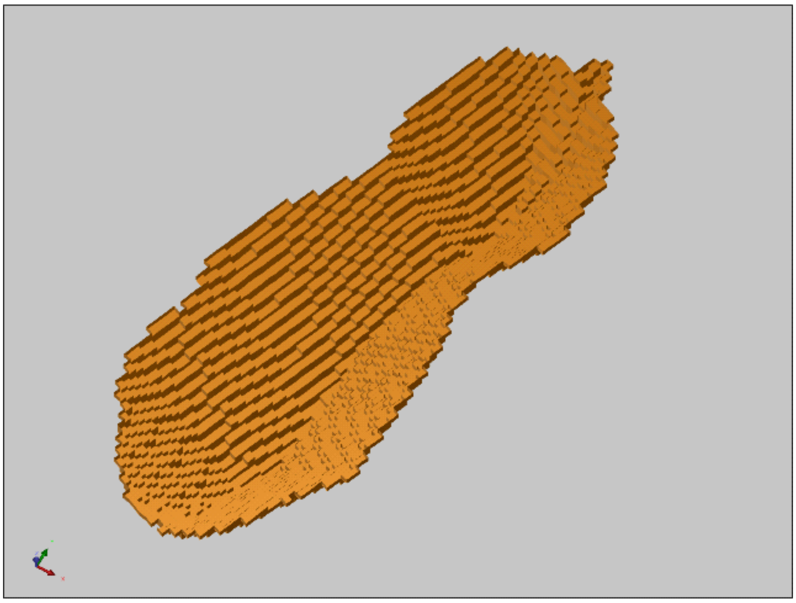


Figure 24.2.1.2_5

Results of the Pit Optimization – Novo Amparo Norte Target

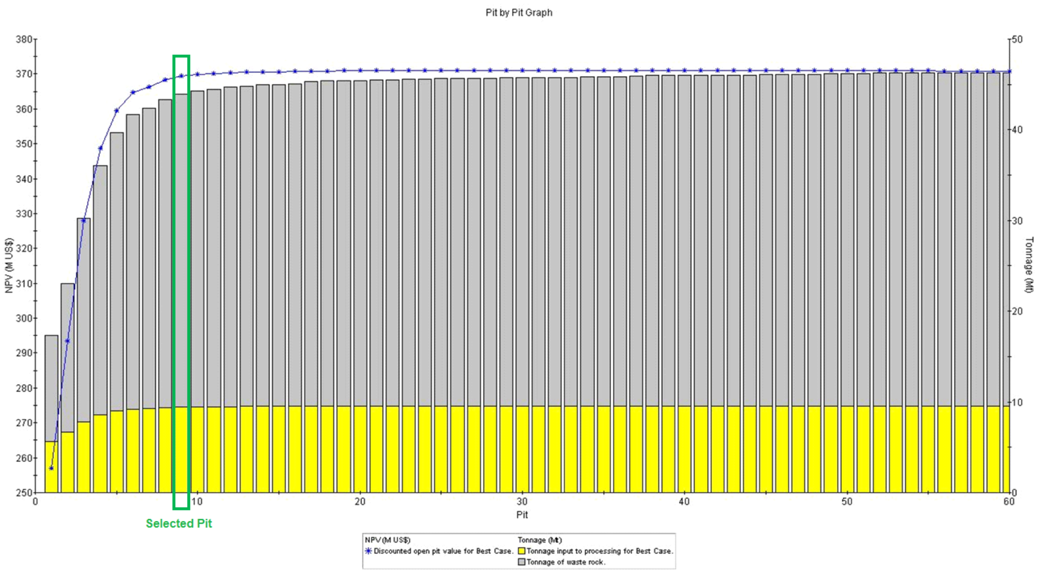


Table 24.2.1.2_5

Results of the Pit Optimization – Novo Amparo Norte Target

Pit	Revenue Factor		Total	ROM	Waste	SR	V_2O_5	SiO_2	Mag	Product	VPL
	Min.	Max.	Kt			t/t	%		%	Kt	US$ M
1	0.30	0.30	17 283.7	5 611.93	11 671.8	2.08	2.68	2.78	29.00	33.15	257.04
5	0.38	0.38	39 642.0	8 972.57	30 669.4	3.42	2.60	2.77	30.00	53.19	359.60
9	0.46	0.46	43 895.8	9 410.85	34 484.9	3.66	2.60	2.78	30.00	55.79	369.30
10	0.48	0.48	44 282.8	9 440.36	34 842.5	3.69	2.60	2.79	30.00	55.96	369.87
15	0.58	0.58	44 957.8	9 486.46	35 471.3	3.74	2.60	2.79	30.00	56.24	370.62
20	0.68	0.68	45 391.7	9 508.95	35 882.7	3.77	2.60	2.79	30.00	56.37	370.91
25	0.78	0.78	45 590.7	9 517.43	36 073.2	3.79	2.60	2.79	30.00	56.42	370.97
30	0.92	0.92	45 699.9	9 521.34	36 178.6	3.80	2.60	2.79	30.00	56.44	370.99
35	1.04	1.06	45 807.8	9 524.67	36 283.1	3.81	2.60	2.79	30.00	56.46	370.98
40	1.18	1.18	45 959.4	9 528.27	36 431.1	3.82	2.60	2.79	30.00	56.48	370.96
45	1.28	1.28	46 050.1	9 530.20	36 519.9	3.83	2.60	2.79	30.00	56.50	370.94
50	1.40	1.40	46 138.0	9 531.94	36 606.0	3.84	2.60	2.79	30.00	56.51	370.91
55	1.76	1.76	46 236.2	9 533.79	36 702.4	3.85	2.60	2.79	30.00	56.52	370.88
60	1.96	2.00	46 276.0	9 534.39	36 741.6	3.85	2.60	2.79	30.00	56.52	370.86

Figure 24.2.1.2_6

Perspective view of the mathematical pit – Novo Amparo Norte Target

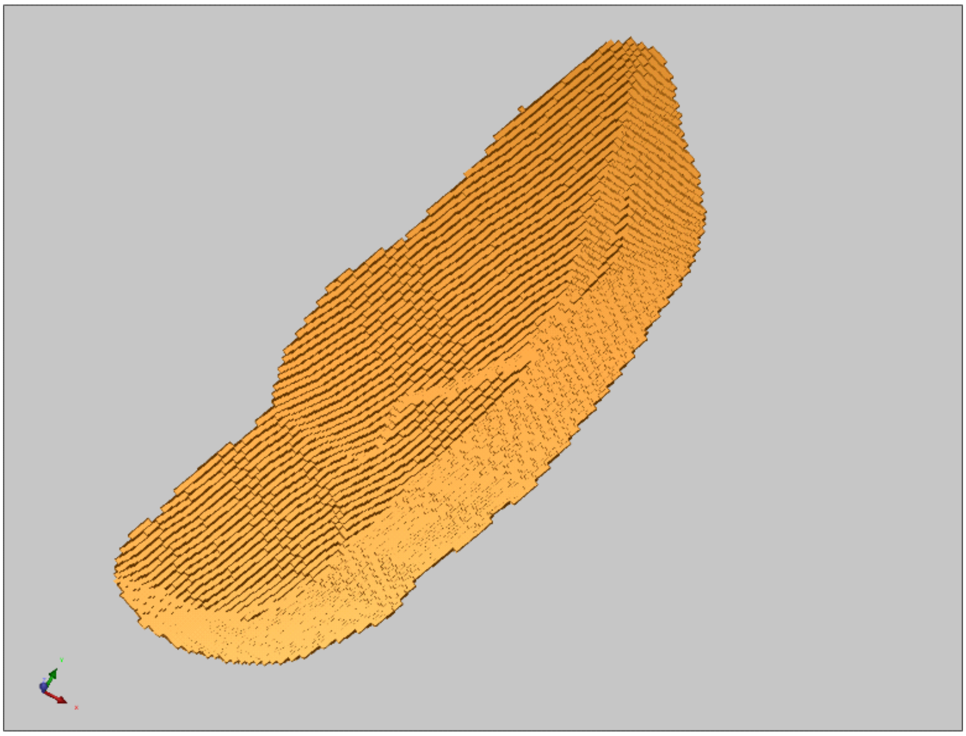


Figure 24.2.1.2_7

Results of the Pit Optimization – São José Target

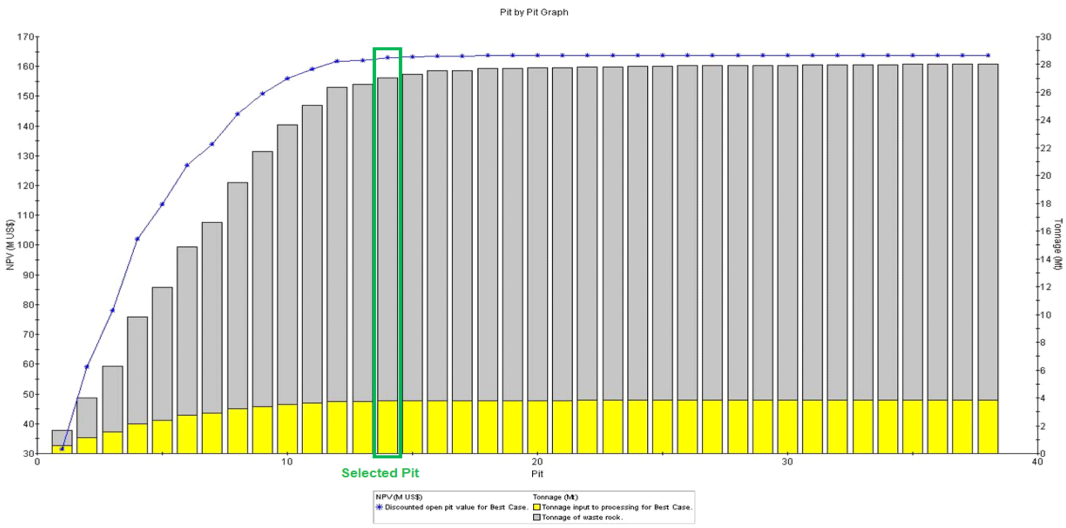


Table 24.2.1.2_6 Results of the Pit Optimization – São José Target											
Pit	Revenue Factor		Total	ROM	Waste	SR	V_2O_5	SiO_2	Mag	Product	VPL
	Min.	Max.	Kt			t/t	%		%	Kt	US$ M
1	0.30	0.30	1 638.9	579.52	1 059.4	1.83	2.74	1.99	29.00	3.50	31.53
3	0.34	0.34	6 297.5	1 563.09	4 734.4	3.03	2.73	2.03	29.00	9.40	78.07
5	0.38	0.38	11 947.6	2 404.63	9 543.0	3.97	2.73	2.10	29.00	14.47	113.67
7	0.42	0.42	16 653.6	2 935.00	13 718.6	4.67	2.71	2.14	30.00	18.13	133.92
9	0.46	0.46	21 740.9	3 403.30	18 337.6	5.39	2.70	2.23	30.00	20.95	150.74
11	0.50	0.50	25 069.2	3 661.87	21 407.3	5.85	2.68	2.29	30.00	22.38	159.08
13	0.54	0.54	26 569.0	3 762.57	22 806.4	6.06	2.68	2.32	30.00	22.99	162.09
14	0.56	0.56	27 062.1	3 791.13	23 271.0	6.14	2.67	2.32	30.00	23.08	162.86
15	0.58	0.58	27 302.6	3 803.51	23 499.1	6.18	2.67	2.32	30.00	23.15	163.20
17	0.62	0.62	27 586.8	3 817.44	23 769.4	6.23	2.67	2.33	30.00	23.24	163.56
19	0.68	0.68	27 741.2	3 824.19	23 917.0	6.25	2.67	2.33	30.00	23.28	163.71
21	0.72	0.72	27 774.6	3 825.53	23 949.0	6.26	2.67	2.33	30.00	23.29	163.74
23	0.76	0.76	27 820.9	3 827.00	23 993.9	6.27	2.67	2.33	30.00	23.30	163.76
25	0.82	0.82	27 873.0	3 828.80	24 044.2	6.28	2.67	2.33	30.00	23.31	163.79
27	0.90	0.90	27 930.0	3 830.42	24 099.6	6.29	2.67	2.33	30.00	23.32	163.80
29	0.94	0.98	27 938.7	3 830.68	24 108.0	6.29	2.67	2.33	30.00	23.32	163.80
31	1.10	1.14	27 963.8	3 831.39	24 132.4	6.30	2.67	2.33	30.00	23.32	163.80
33	1.18	1.18	27 977.1	3 831.66	24 145.4	6.30	2.67	2.33	30.00	23.33	163.80
35	1.22	1.34	28 019.2	3 832.40	24 186.8	6.31	2.67	2.33	30.00	23.33	163.78
37	1.62	1.82	28 042.6	3 832.73	24 209.9	6.32	2.67	2.33	30.00	23.33	163.77
38	1.84	2.00	28 046.0	3 832.79	24 213.2	6.32	2.67	2.33	30.00	23.33	163.77

Figure 24.2.1.2_7

Perspective view of the mathematical pit – São José Target

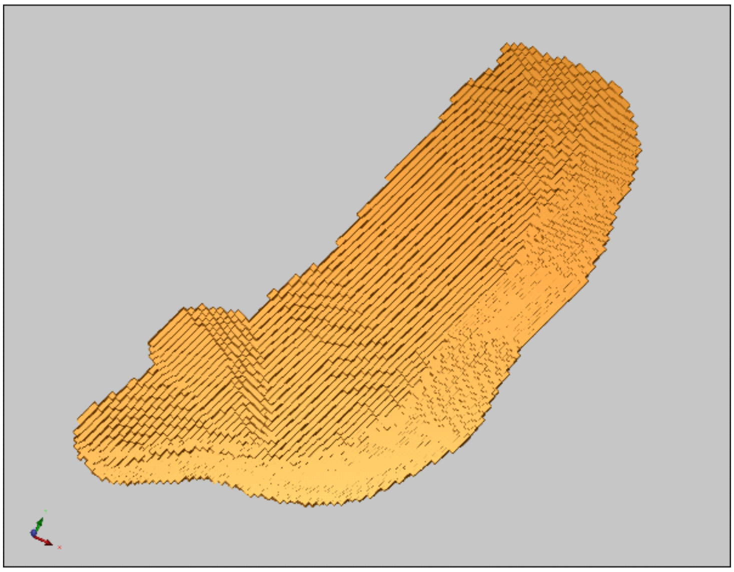


Figure 24.2.1.2_9

Results of the Pit Optimization – Inferred Remaning Resources Campbell pit

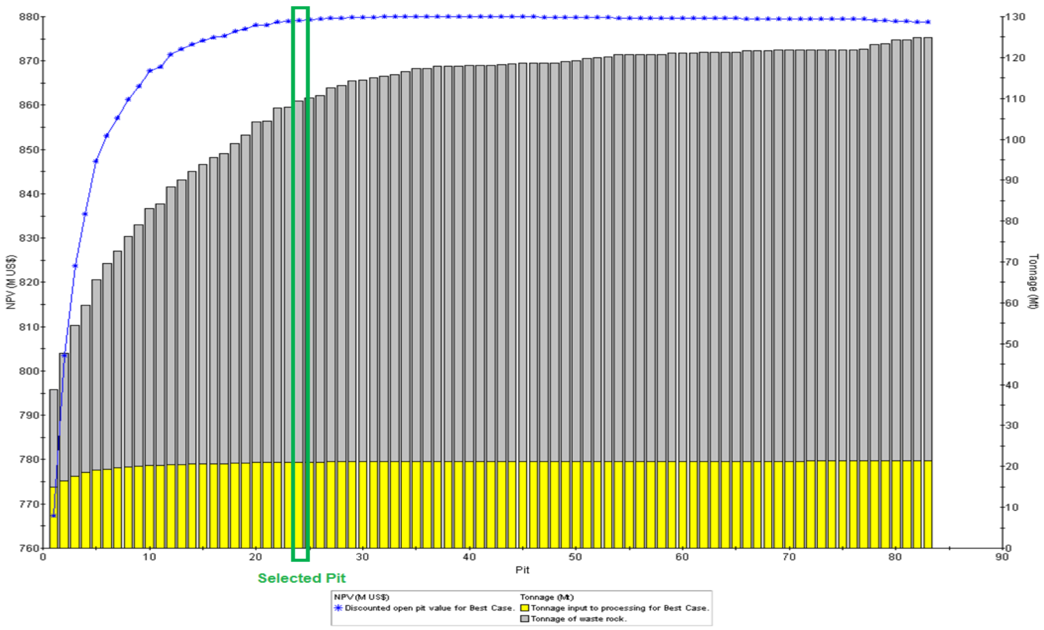


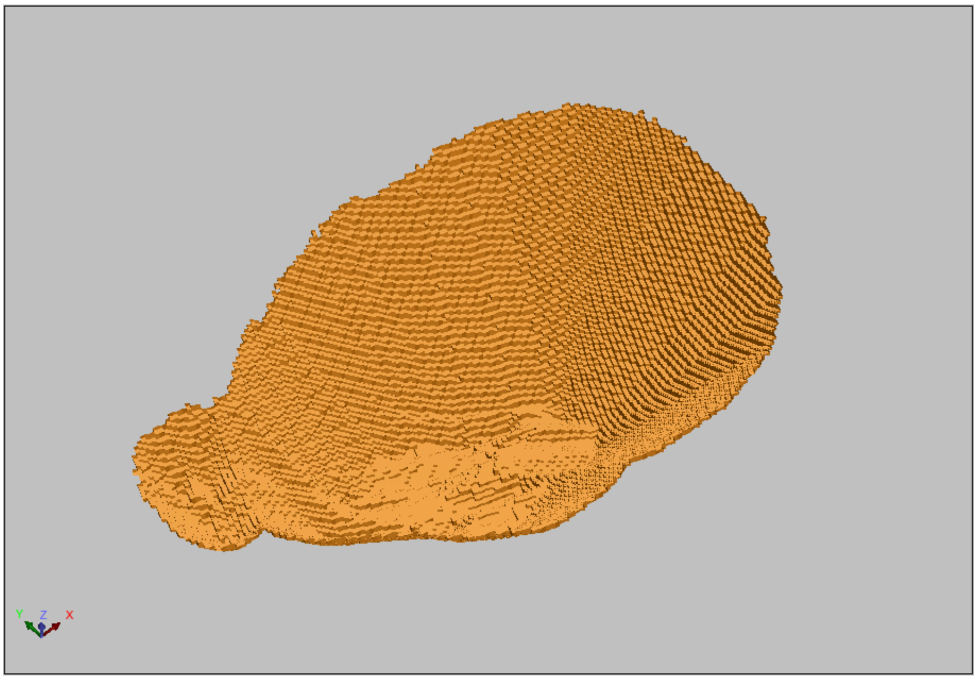
Table 24.2.1.2_7

Results of the Pit Optimization – Inferred Remaning Resources Campbell pit

Pit	Revenue Factor		Total	ROM	Waste	SR	V_2O_5	SiO_2	Mag	Product	VPL
	Min	Max	Kt			t/t	%		%	Kt	US$ M
1	0.30	0.30	38 724.5	14 925.50	23 799.0	1.59	3.22	3.62	32.75	119.62	767.29
3	0.34	0.34	54 386.5	17 561.34	36 825.1	2.10	3.19	3.65	32.45	138.16	823.77
5	0.38	0.38	65 658.9	19 057.01	46 601.9	2.45	3.18	3.67	32.09	147.80	847.36
7	0.42	0.42	72 592.5	19 597.29	52 995.2	2.70	3.17	3.67	32.19	151.98	857.06
9	0.46	0.46	79 000.0	19 997.65	59 002.3	2.95	3.17	3.66	32.27	155.47	864.20
11	0.50	0.50	84 182.5	20 252.92	63 929.5	3.16	3.17	3.66	32.37	157.94	868.67
13	0.54	0.54	90 049.2	20 492.16	69 557.0	3.39	3.17	3.65	32.47	160.30	872.59
15	0.58	0.58	93 889.3	20 623.98	73 265.4	3.55	3.17	3.65	32.55	161.73	874.60
17	0.62	0.62	96 462.3	20 709.38	75 752.9	3.66	3.17	3.65	32.59	162.60	875.67
19	0.66	0.66	100 931.8	20 841.90	80 089.9	3.84	3.17	3.64	32.65	163.94	877.18
21	0.70	0.70	104 330.5	20 922.40	83 408.1	3.99	3.17	3.64	32.71	164.88	878.12
23	0.74	0.74	107 724.2	21 017.77	86 706.4	4.13	3.17	3.64	32.74	165.78	878.88
24	0.76	0.76	109 414.3	21 053.75	88 360.5	4.20	3.17	3.64	32.76	166.17	879.21
25	0.78	0.78	110 103.7	21 067.06	89 036.6	4.23	3.17	3.64	32.77	166.32	879.33
26	0.80	0.80	110 711.0	21 080.12	89 630.9	4.25	3.17	3.64	32.77	166.43	879.42
27	0.82	0.82	112 631.7	21 121.50	91 510.2	4.33	3.17	3.64	32.79	166.85	879.68
28	0.84	0.84	113 079.0	21 131.28	91 947.7	4.35	3.17	3.64	32.79	166.93	879.73
29	0.86	0.86	114 273.0	21 148.00	93 125.0	4.40	3.17	3.64	32.81	167.17	879.85
30	0.88	0.88	114 364.2	21 151.47	93 212.7	4.41	3.17	3.64	32.81	167.19	879.86
40	1.08	1.08	118 003.2	21 225.13	96 778.1	4.56	3.17	3.64	32.82	167.83	879.95
50	1.28	1.28	119 184.5	21 249.91	97 934.6	4.61	3.17	3.64	32.81	167.97	879.85
60	1.48	1.48	121 068.9	21 272.60	99 796.3	4.69	3.17	3.64	32.81	168.15	879.60
70	1.72	1.72	121 766.7	21 282.19	100 484.5	4.72	3.17	3.64	32.81	168.23	879.48
83	2.00	2.00	124 851.4	21 333.47	103 518.0	4.85	3.17	3.64	32.78	168.48	878.78

Figure 24.2.1.2_8

Perspective view of the mathematical pit – Inferred Remaning Resources – Campbell pit



24.2.1.3 Pit design

The selected pits in the previous section were designed according to the parameters applied in the Campbell reserve presented in Table 16.4_1. Figure 24.2.1.3_1 and Figure 24.2.1.3_10 present perspective views and plans of each of the pit.

Table 24.2.1.3_1 presents the comparisons between the selected optimal pits and the respective pits designed. Table 24.2.1.3_1 summarizes the incremental mineral resources considered in this PEA.

Table 24.2.1.3_1

Comparative of Optimal Pit X Designed Pit

Pit	ROM			Waste	Total Mov.	SR	Magnetic Concentrate				Product
Gulçari A Norte e Gulçari B											
	Mass	V_2O_5	SiO_2				Mag	Mass	V_2O_5	SiO_2	
	Kt	%		Kt		t/t	%	kt	%		Kt
Optimal	8 787	0.67	26.66	90 194	98 981	10.26	28%	2 341	2.58	2.88	46.01
Designed	7 851	0.67	26.82	95 115	102 965	12.12	27%	2 014	2.63	2.97	40.37
Diference	- 937	0.01	0.15	4 921	3 984	1.85	-1%	- 327	0.05	0.09	- 5.64
Diference (%)	- 10.66	1.33	0.57	5.46	4.03	n/a	- 3.70	- 13.97	1.99	3.28	- 12.25
Novo Amparo											
Pit	**ROM**			**Waste**	**Total Mov.**	**SR**	**Magnetic Concentrate**				**Product**
	Mass	V_2O_5	SiO_2				Mag	Mass	V_2O_5	SiO_2	
	Kt	%		Kt		t/t	%	kt	%		Kt
Optimal	1 609	0.69	14.36	4 537	6 146	2.82	42%	637	1.56	1.44	7.56
Designed	1 171	0.71	14.18	4 056	5 227	3.46	41%	456	1.58	1.44	5.48
Diference	- 438	0.01	0.19	481	919	0.64	-1%	- 181	0.02	- 0.01	2.08
Diference (%)	- 27.23	1.91	-1.29	- 10.59	- 14.95	n/a	-1.71	- 28.47	1.35	- 0.37	- 27.51
Novo Amparo Norte											
Pit	**ROM**			**Waste**	**Total Mov.**	**REM**	**Magnetic Concentrate**				**Product**
	Mass	V_2O_5	SiO_2				Mag	Mass	V_2O_5	SiO_2	
	Kt	%		Kt		t/t	%	kt	%		Kt
Optimal	9 906	0.81	23.50	33 992	43 897	3.43	30%	2 853	2.60	2.78	56.49
Designed	9 473	0.81	23.66	37 547	47 020	3.96	30%	2 714	2.60	2.79	53.81
Diference	- 433	0.00	0.16	3 555	3 122	0.53	0%	- 139	0.00	0.01	2.68
Diference (%)	- 4.37	0.07	0.68	10.46	7.11	n/a	- 0.52	- 4.86	0.13	0.39	- 4.74
São José											
Pit	**ROM**			**Waste**	**Total Mov.**	**SR**	**Magnetic Concentrate**				**Product**
	Mass	V_2O_5	SiO_2				Mag	Mass	V_2O_5	SiO_2	
	Kt	%		Kt		t/t	%	kt	%		Kt
Optimal	3 991	0.85	23.39	23 066	27 057	5.78	30%	1 148	2.67	2.32	23.39
Designed	3 860	0.85	23.35	25 340	29 200	6.57	30%	1 113	2.67	2.29	22.64
Diference	- 131	0.00	0.04	2 274	2 142	0.79	0%	- 35	- 0.00	- 0.03	- 0.75
Diference (%)	- 3.29	0.25	0.18	9.86	7.92	n/a	0.23	- 3.06	- 0.13	- 1.44	- 3.19
Inferred Remaning Resources - Pit Campbell											
Pit	**ROM**			**Waste**	**Total Mov.**	**SR**	**Magnetic Concentrate**				**Product**
	Mass	V_2O_5	SiO_2				Mag	Mass	V_2O_5	SiO_2	
	Kt	%		Kt		t/t	%	kt	%		Kt
Optimal	2 098	1.11	27.36	28 365	30 463	13.52	32%	644	3.09	3.76	15.16
Designed	1 736	1.03	28.88	31 608	33 344	18.20	30%	489	3.06	3.96	11.42
Diference	- 362	0.08	1.52	3 243	2 880	4.69	-3%	155	- 0.03	0.20	- 3.74
Diference (%)	- 17.26	7.05	5.55	11.43	9.46	n/a	- 8.19	- 24.04	- 0.87	5.36	- 24.70
Satellite Targets + Inferred Remaning Resources Pit Campbell											
Pit	**ROM**			**Waste**	**Total Mov.**	**SR**	**Magnetic Concentrate**				**Product**
	Mass	V_2O_5	SiO_2				Mag	Mass	V_2O_5	SiO_2	
	Kt	%		Kt		t/t	%	kt	%		Kt
Optimal	26 392	0.79	24.29	180 153	206 545	6.83	30%	7 622	2.58	2.74	149.80
Designed	24 090	0.78	24.55	193 665	217 756	8.04	30%	6 785	2.60	2.79	134.73
Diference	- 2 301	0.00	0.27	13 512	11 211	1.21	-1%	- 837	0.03	0.05	- 15.08
Diference (%)	- 8.72	0.17	1.10	7.50	5.43	n/a	- 2.48	- 10.98	1.03	1.77	- 10.06

Table 24.2.1.3_2 **Summary of mineral inventory for additional resources in Satellite deposits** Mine Recovery 100% - Dilution 5%												
Target	**ROM**			**Waste**	**Total Mov.**	**SR**	**Magnetic Concentrate**					**Product**
	Mass	**V_2O_5**	**SiO_2**				**Mag***	**Mass**	**V_2O_5**	**SiO_2**		
	Kt	**%**		**Kt**		**t/t**	**%**	**kt**	**%**			**Kt**
Gulçari A Norte e Gulçari B	7 851	0.67	26.82	95 115	102 965	12.12	25.7	2 014	2.63	2.97		40 37
Novo Amparo	1 171	0.71	14.18	4 056	5 227	3.46	38.9	456	1.58	1.44		5 48
Novo Amparo Norte	9 473	0.81	23.66	37 547	47 020	3.96	28.6	2 714	2.60	2.79		53 81
São José	3 860	0.85	23.35	25 340	29 200	6.57	28.8	1 113	2.67	2.29		22 64
Remained Campbell Resources	1 736	1.03	28.88	31 608	33 344	18.20	28.2	489	3.06	3.96		11 42
Total	**24 091**	**0.78**	**24.55**	**193 665**	**217 756**	**8.04**	**28.2%**	**6 785**	**2.60**	**2.79**		**134 73**

*Numbers are rounded to one decimal place

Figure 24.2.1.3_1

Perspective View of Pit Design – Gulçari A Norte and Gulçari B Target

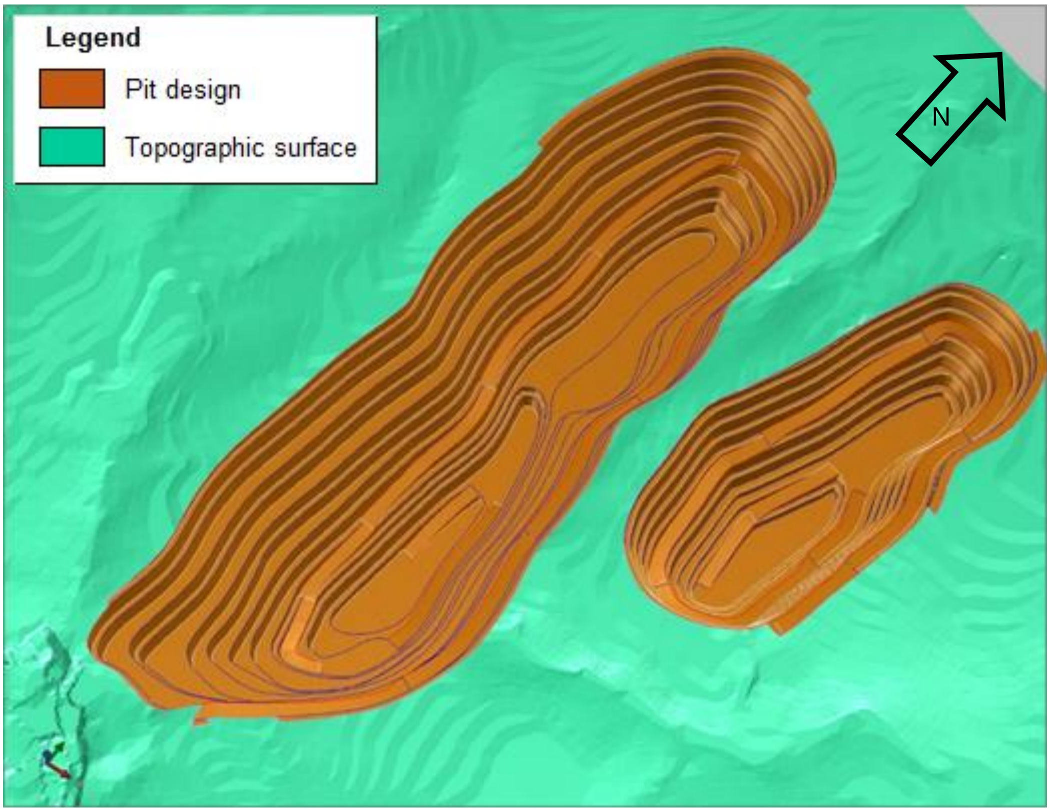


Figure 24.2.1.3_2

Plant of Pit Design – Gulçari A Norte and Gulçari B Target

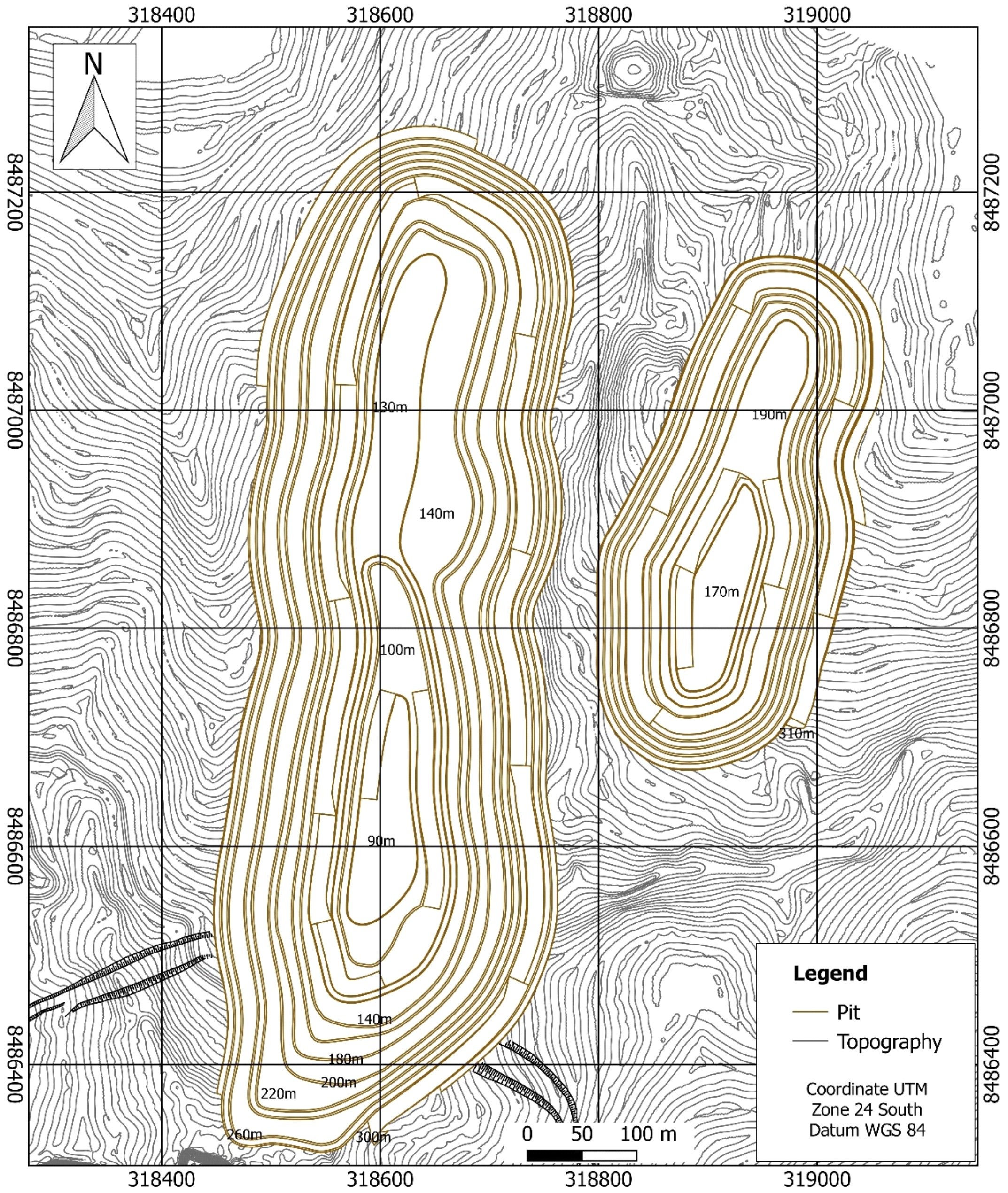


Figure 24.2.1.3_3

Perspective View of Pit Design – Novo Amparo Norte Target

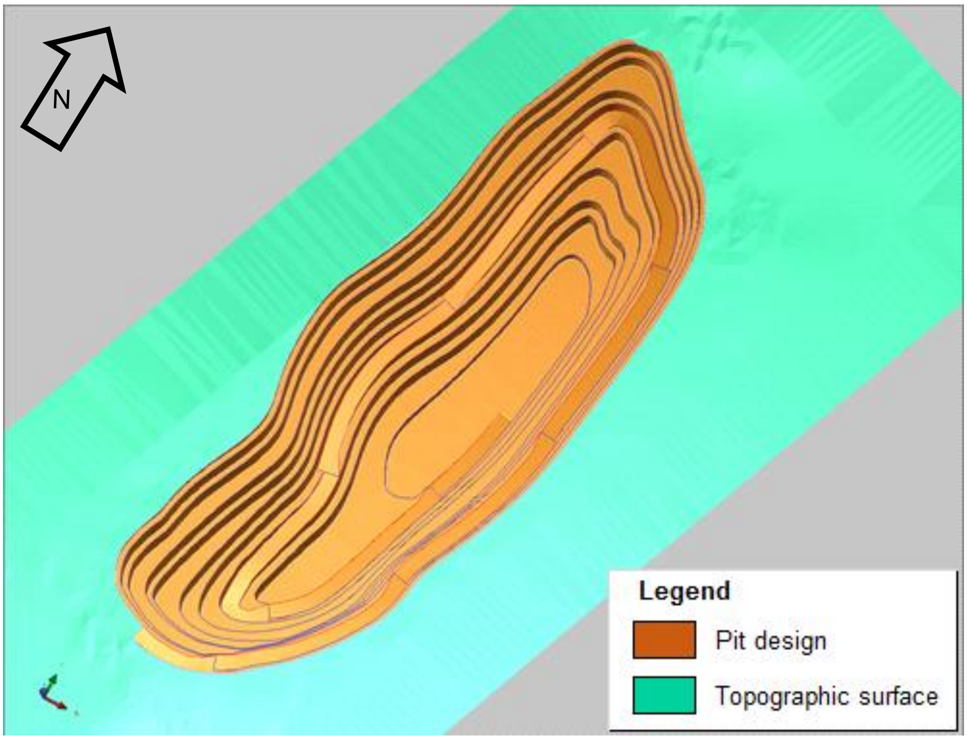


Figure 24.2.1.3_4

Plant of Pit Design – Novo Amparo Norte Target

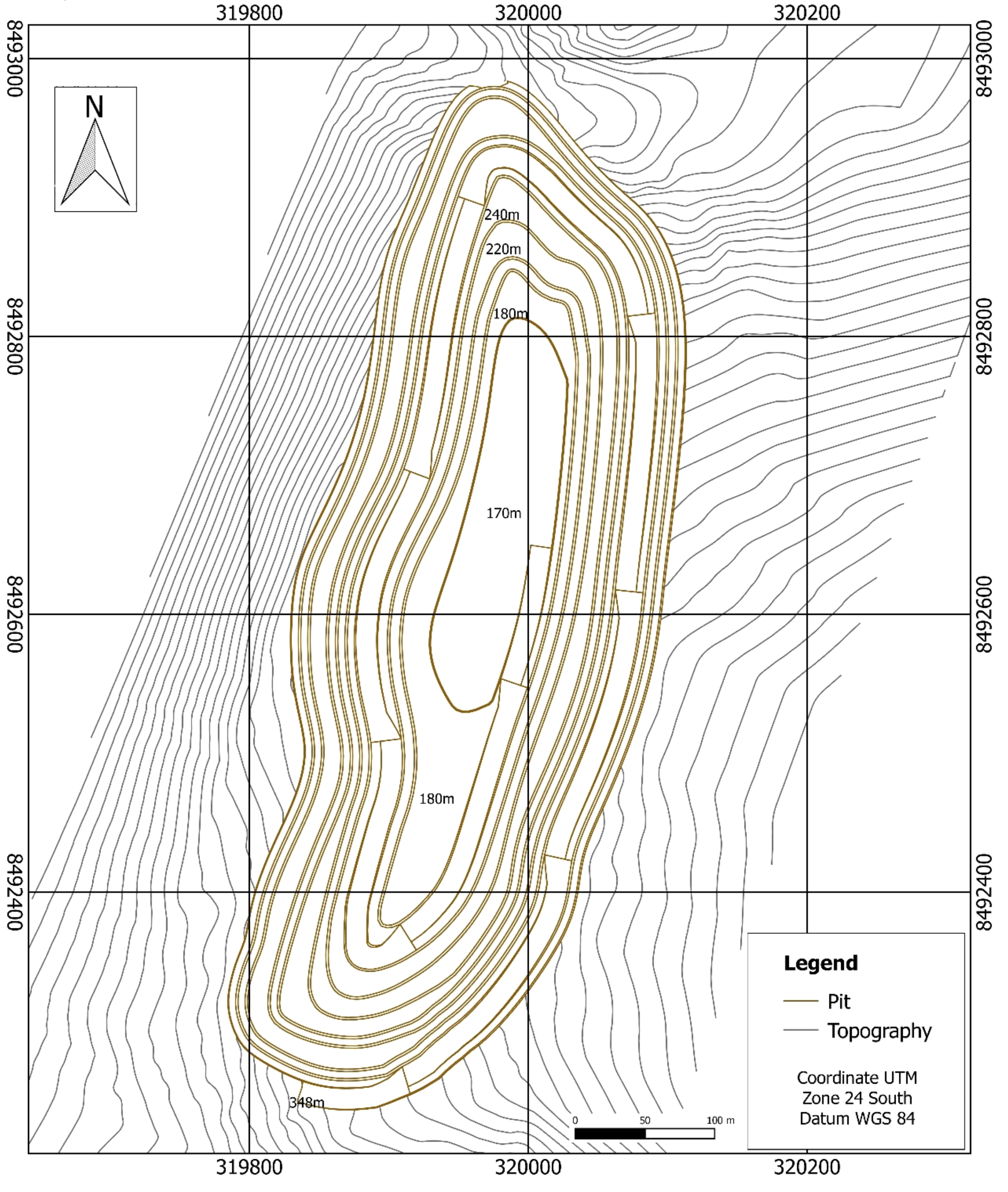


Figure 24.2.1.3_5

Perspective View of Pit Design – Novo Amparo Target

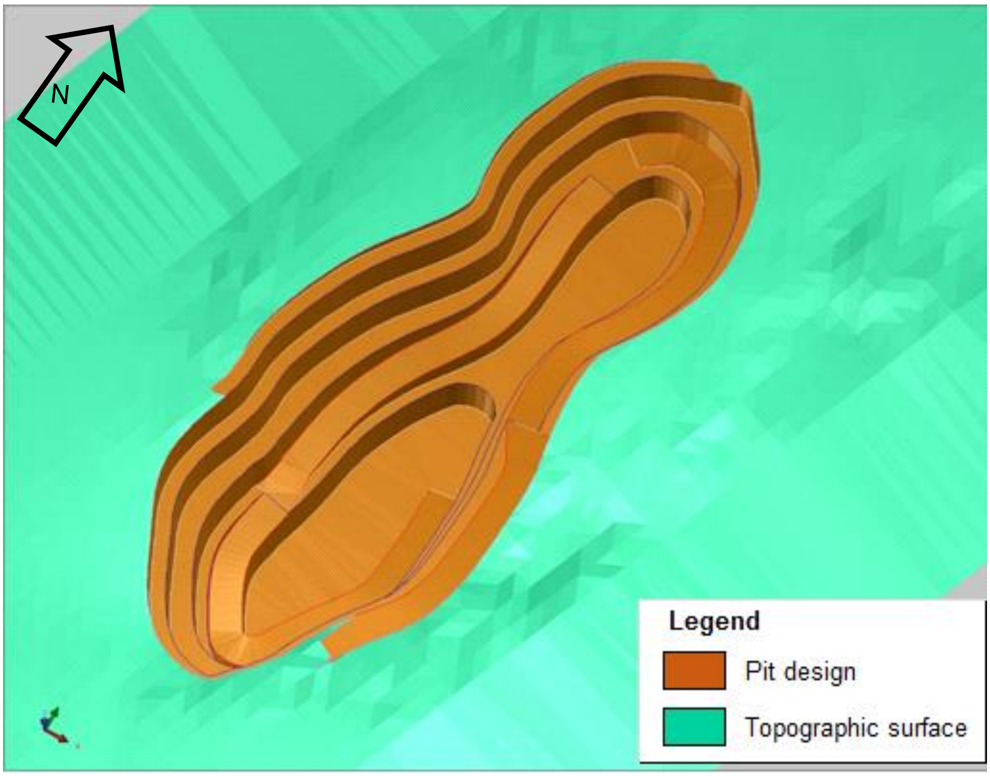


Figure 24.2.1.3_6

Plant of Pit Design - Novo Amparo Target

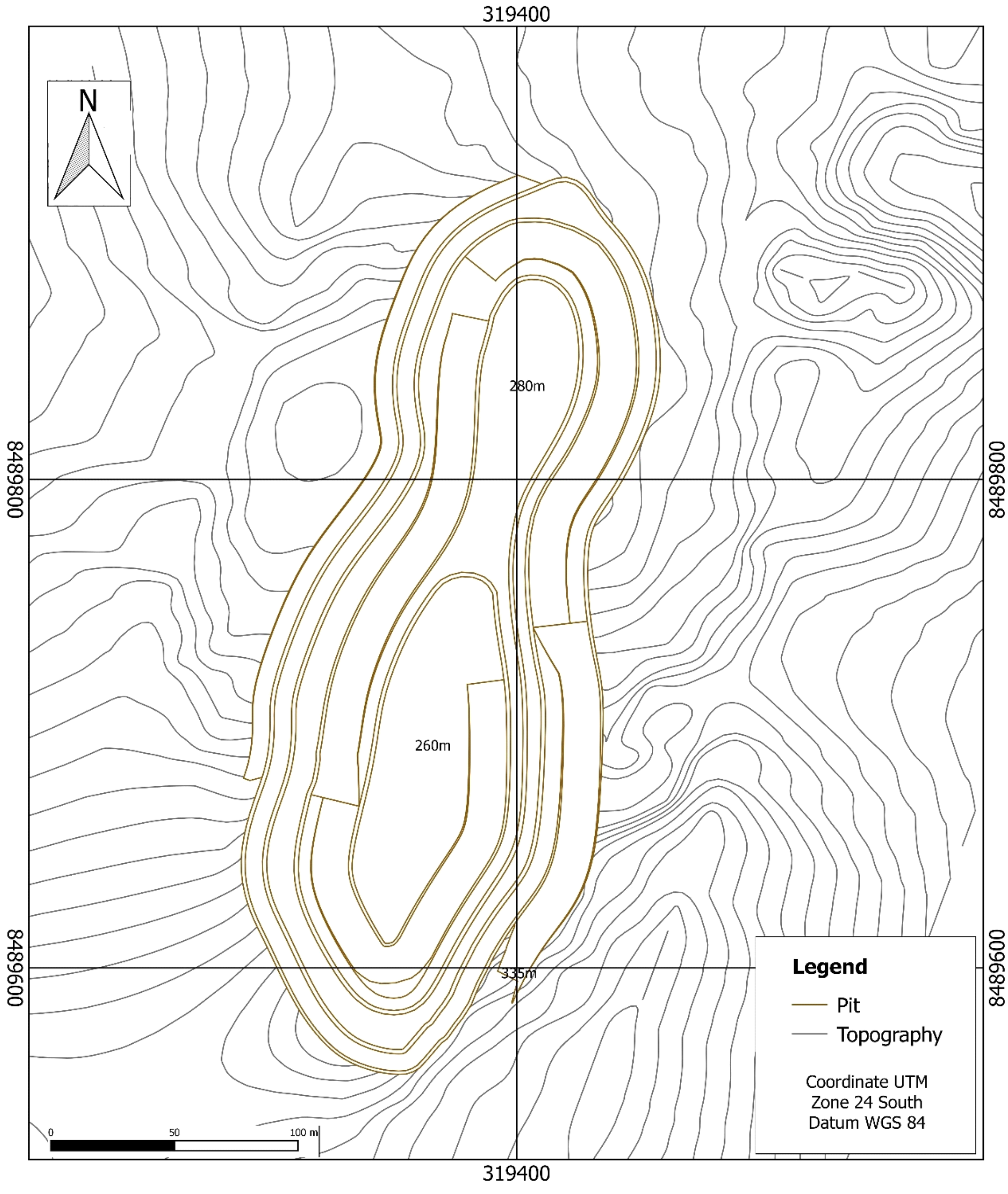


Figure 24.2.1.3_7

Perspective View of Pit Design – São José Target

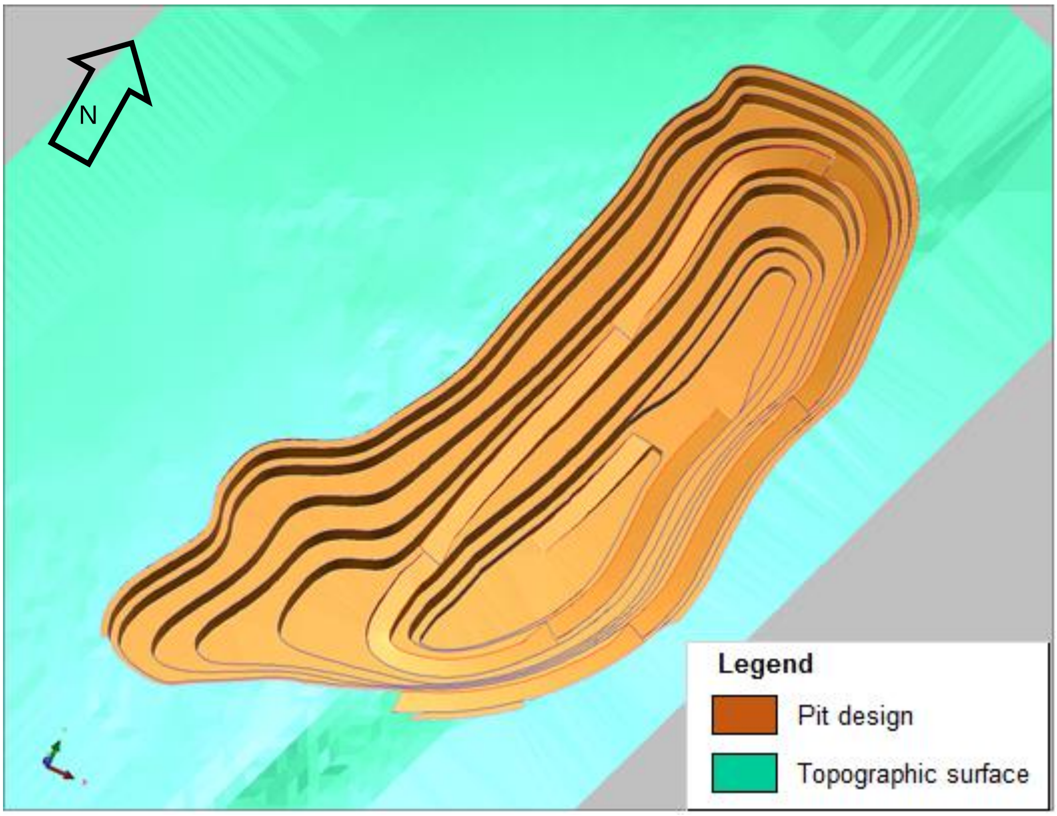


Figure 24.2.1.3_8

Plant of Pit Design – São José Target

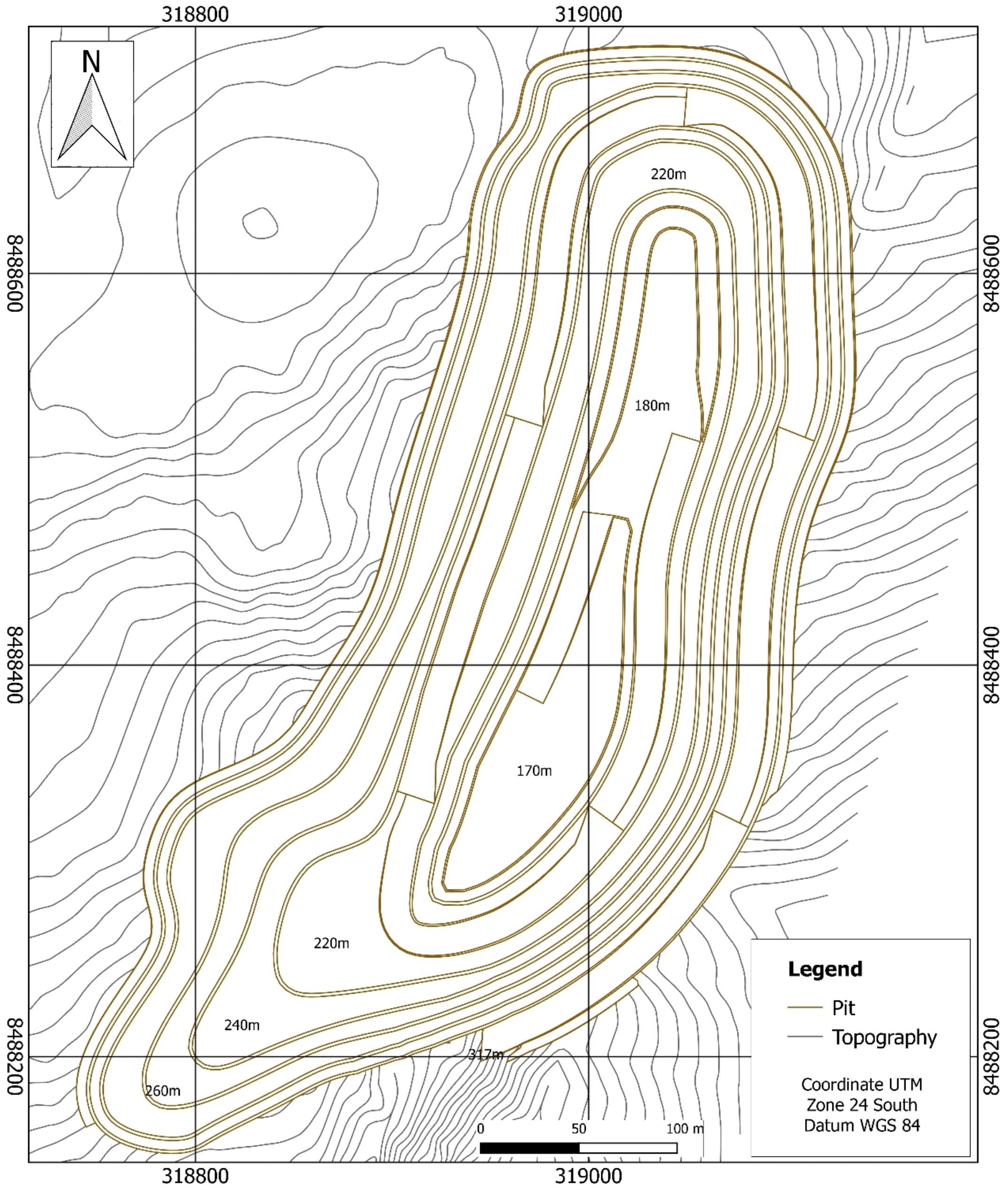


Figure 24.2.1.3_9

Perspective View of Pit Design – Campbell Target

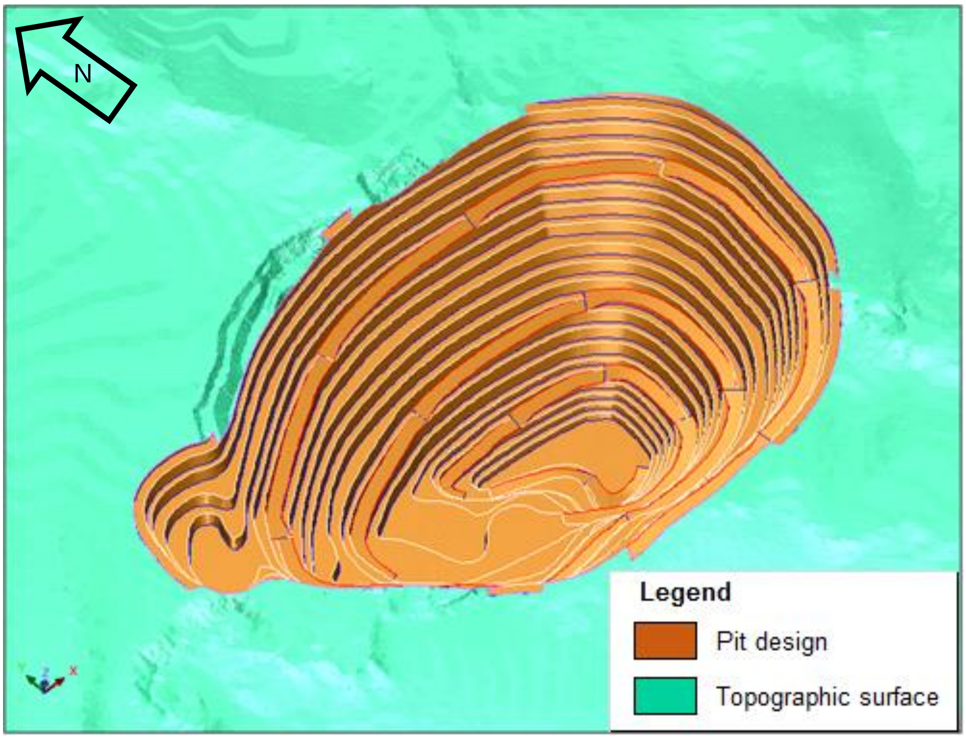
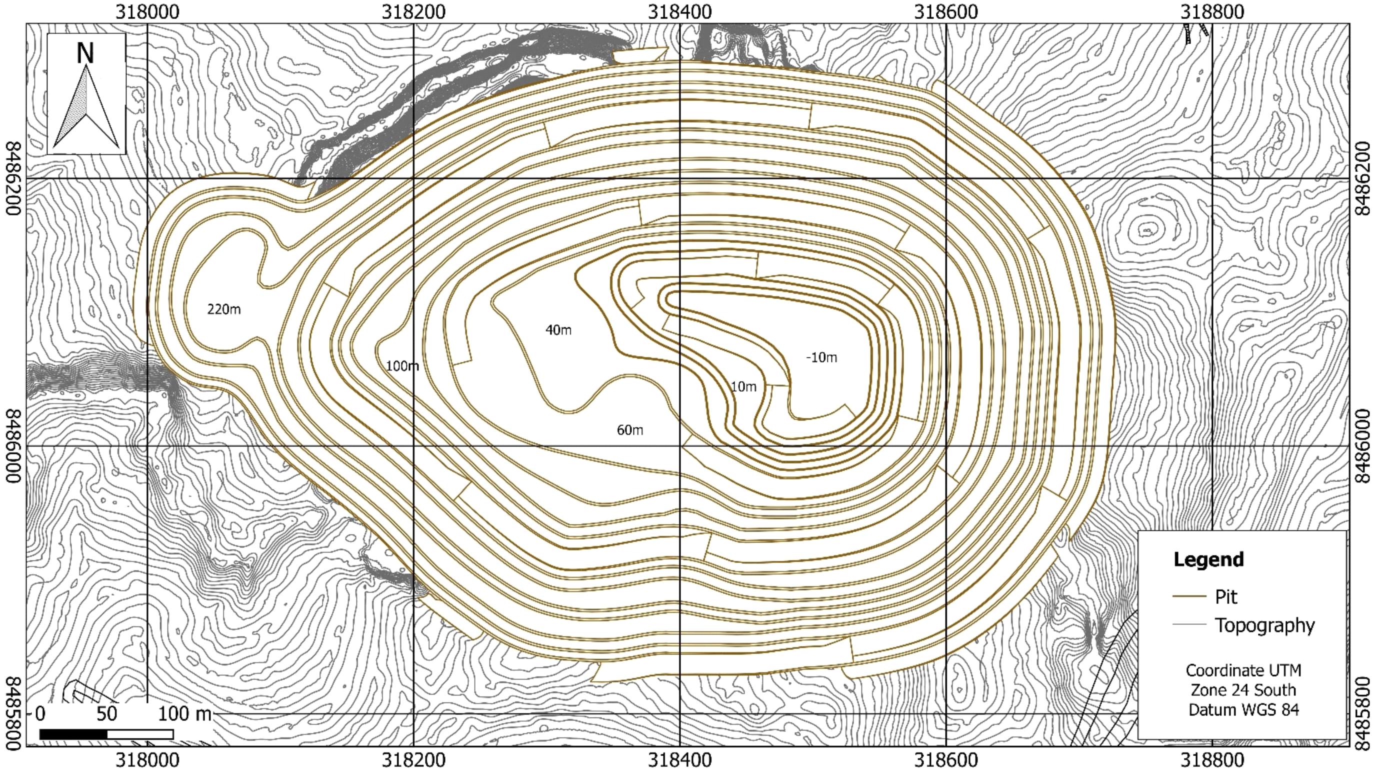


Figure 24.2.1.3_10

Plant of Pit Design – Campbell Target



24.2.1.4 Conceptual Mine Production Schedule with Inferred Resources

An alternative and conceptual mine production schedule for the Project was generated in GEOVIA Minesched™6.1.1 as summarized in Table 24.2.1.4_1.

A mining recovery of 100 % and dilution of 5% were assumed.

Table 24.2.1.4_1

Conceptual Mine Production and Process Feed Schedule for Satellite target

Area	Year	ROM (Mt)	Waste (Mt)	Pit to Mill (Mt)*	SR	%Mag	%V2O5 Con	%SiO2 Con
Novo Amparo Norte	2028	1.90	7.37	1.05	3.87	31.0%	2.67	2.19
	2029	1.85	7.48	1.02	4.04	29.0%	2.65	3.81
	2030	1.87	7.79	1.03	4.16	31.0%	2.56	2.49
	2031	1.87	10.31	1.03	5.52	29.0%	2.59	2.87
	2032	2.00	10.42	1.10	5.21	31.0%	2.55	2.64
Gulçari A Norte and Gulçari B	2033	1.84	10.21	1.01	5.55	28.0%	2.70	2.65
	2034	1.88	11.35	1.03	6.21	27.0%	2.64	3.25
	2035	1.90	14.24	1.04	7.72	29.0%	2.42	2.72
	2036	1.96	17.05	1.08	9.04	28.0%	2.69	2.57
São José	2037	2.00	27.06	1.10	13.53	30.0%	2.67	2.29
	2038	2.00	27.06	1.10	13.53	30.0%	2.67	2.29
Inferred Resources from Campbell	2039	2.00	27.06	1.10	13.53	31.0%	2.90	2.47
Novo Amparo	2040	1.02	16.27	0.56	15.92	41.0%	1.58	1.44
Total		24.09	193.67	13.25	8.04	30.0%	2.60	2.63

*Pit to mill assumed a dry magnetic concentrate equivalent to 55% of total ROM

24.2.2 Capital and Operating Costs

24.2.2.1 Capital Costs

All Capex was treated as sustaining cost for purposes of this report and cash flow preparation and anaylsis, and was estimated for the Satellite Deposits and the remaining inferred resources at the Campbell pit at US$ 38.3 million, with a constant value of US$ 3 million in each year until 2038 provided for plant maintenance, Dry Magnetic plant moving, calcine dam, spare parts and road from Dry Magnetic to plant. Additional sustaining capex of US$ 4.8 million is provided for an increase in tailing dam capacity, and an additional US$ 0.2 million in included for pit dewatering.

24.2.2.2 Operating Costs

The mining costs were calculated on a year by year basis considering, among other factors, the site of operation is current, the distance from mine front to local DMS, and the distance from DMS to plant. The mining costs vary depending on this distance. Table 24.2.2.2_1 details the yearly total mining OPEX.

The plant costs assume the same unit cost from the FS, being US$ 1.72/lb V_2O_5. Table 24.2.2.2_2 details the yearly total plant OPEX

Table 24.2.1.4_1

Mining OPEX

	Novo Amparo Norte					Gulçari A Norte and Gulçari B				São José		Remained Campbell Resources	Novo Amparo
Cost Item (US$x1000)	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Contractor Mining	8.96	9.02	9.34	11.78	12.01	11.65	12.79	15.60	18.37	28.09	28.09	49.93	15.56
Drilling and Blast (ROM+Waste)	6.17	6.20	6.41	7.99	8.16	7.89	8.64	10.46	12.26	18.55	18.55	18.55	11.00
Costs (Payroll, Topography,Auxiliar Equipaments,etc)	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.64
Drilling and Blast (Fixed Costs)	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73
Mining total	**18.50**	**18.58**	**19.12**	**23.13**	**23.53**	**22.90**	**24.79**	**29.43**	**34.00**	**50.00**	**50.00**	**71.84**	**29.93**

Table 24.2.1.4_2

Plant OPEX

	Novo Amparo Norte					Gulçari A Norte and Gulçari B				São José		Remained Campbell Resources	Novo Amparo
Cost Item (US$x1000)	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Processing	45.90	41.56	43.37	41.62	46.20	40.62	39.26	38.88	42.95	46.11	46.11	51.75	19.06
Transport Satellite to Plant	2.38	2.32	2.34	2.34	2.51	1.05	1.07	1.08	1.11	1.22	1.30	-	0.84
Plant Total	**48.3**	**43.9**	**45.7**	**44.0**	**48.7**	**41.7**	**40.3**	**40.0**	**44.1**	**47.3**	**47.4**	**51.7**	**19.9**

24.2.3 Vanadium Price

GE21 used a flat vanadium price of US$ 6.34/lb V_2O_5, for the PEA.

24.2.4 Cash Flow

This cash flow was developed based on the same economic-financial parameters used in the base case in the FS.

The table 24.2.4_1 shows the selling prices and taxes that were considered.

Table 24.2.4_2 presents the DCF for the completion of the Maracas Menschen, from 2017 to 2040.

Table 24.2.4_1
Selling Prices and Taxes

Selling price	
Product	Sell Price (US$/lb)
Product V_2O_5	6.34
Taxes	
CFEM	2.0%
INCOME TAX	25%
CBPM	3.0%
Financial Parameters	
WACC	8.0% aa
NPV	Based on middle the year
Royalties	
Surface Royalties	2.0%

The project base case estimates a potential Net Present Value of US$ 140 million, at a Discount Rate of 8% per year, as presented in table 24.2.4_2 below.

Table 24.2.4_2 Cash flow –Satellite Deposits

	NOVO AMPARO NORTE					GULÇARIA A NORTE e B				SÃO JOSÉ		Remained Resources Campbell	NOVO AMPARO
Year	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**
Total Lavrado (Mt)	**9.3**	**9.3**	**9.7**	**12.2**	**12.4**	**12.0**	**13.2**	**16.1**	**19.0**	**29.1**	**29.1**	**29.1**	**17.3**
High Grade	1.900	1.850	1.870	1.870	2.000	1.840	1.880	1.900	1.960	2.000	2.000	2.000	1.022
Low Grade	-	-	-	-	-	-	-	-	-	-	-	-	-
Waste	7.4	7.5	7.8	10.3	10.4	10.2	11.3	14.2	17.0	27.1	27.1	27.1	16.3
V2O5 Product (t)	**12 121.6**	**10 974.0**	**11 453.1**	**10 991.5**	**12 199.0**	**10 727.6**	**10 366.7**	**10 266.9**	**11 342.7**	**12 175.2**	**12 175.2**	**13 664.8**	**5 032.1**
OPEX (US$ mi)	**(71.4)**	**(67.1)**	**(69.5)**	**(71.8)**	**(76.9)**	**(69.2)**	**(69.8)**	**(74.1)**	**(82.7)**	**(102.0)**	**(102.1)**	**(128.3)**	**(54.5)**
Mine (US$)	**(18.5)**	**(18.6)**	**(19.1)**	**(23.1)**	**(23.5)**	**(22.9)**	**(24.8)**	**(29.4)**	**(34.0)**	**(50.0)**	**(50.0)**	**(71.8)**	**(29.9)**
Contractor Mining	(9.0)	(9.0)	(9.3)	(11.8)	(12.0)	(11.6)	(12.8)	(15.6)	(18.4)	(28.1)	(28.1)	(49.9)	(15.6)
Drilling and Blast (ROM+Waste)	(6.2)	(6.2)	(6.4)	(8.0)	(8.2)	(7.9)	(8.6)	(10.5)	(12.3)	(18.5)	(18.5)	(18.5)	(11.0)
Costs (Payroll,Topography,Auxiliar Equipaments,etc)	(2.6)	(2.6)	(2.6)	(2.6)	(2.6)	(2.6)	(2.6)	(2.6)	(2.6)	(2.6)	(2.6)	(2.6)	(2.6)
Drilling and Blast (Fixed Costs)	(0.7)	(0.7)	(0.7)	(0.7)	(0.7)	(0.7)	(0.7)	(0.7)	(0.7)	(0.7)	(0.7)	(0.7)	(0.7)
Process	**(48.3)**	**(43.9)**	**(45.7)**	**(44.0)**	**(48.7)**	**(41.7)**	**(40.3)**	**(40.0)**	**(44.1)**	**(47.3)**	**(47.4)**	**(51.7)**	**(19.9)**
Plant	(45.9)	(41.6)	(43.4)	(41.6)	(46.2)	(40.6)	(39.3)	(38.9)	(43.0)	(46.1)	(46.1)	(51.7)	(19.1)
Transport Satelites to Plant	(2.4)	(2.3)	(2.3)	(2.3)	(2.5)	(1.0)	(1.1)	(1.1)	(1.1)	(1.2)	(1.3)	-	(0.8)
G&A	**(4.7)**	**(4.7)**	**(4.7)**	**(4.7)**	**(4.7)**	**(4.7)**	**(4.7)**	**(4.7)**	**(4.7)**	**(4.7)**	**(4.7)**	**(4.7)**	**(4.7)**
Gross Revenue (US$ mi)	**161.3**	**146.1**	**152.4**	**146.3**	**162.4**	**142.8**	**138.0**	**136.7**	**151.0**	**162.1**	**162.1**	**181.9**	**67.0**
EBITDA (US$ mi)	**89.9**	**78.9**	**83.0**	**74.5**	**85.5**	**73.6**	**68.2**	**62.6**	**68.2**	**60.1**	**60.0**	**53.6**	**12.5**
DEPRECIATION (US$ mi)	-	(0.7)	(1.3)	(2.2)	(2.8)	(3.4)	(3.3)	(3.5)	(3.6)	(3.7)	(3.7)	(3.7)	(5.0)
EBIT (US$ mi)	**89.9**	**78.2**	**81.6**	**72.4**	**82.7**	**70.2**	**64.9**	**59.1**	**64.7**	**56.4**	**56.3**	**50.0**	**7.4**
IRPJ (25% in R$ 0.24 mi/ year)+75% Discount (SUDENE Incentive) untill 2024	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Operating Profit Discount (30%)													
AIR (24% sobre Exc R$ 0.24 mi/ano do EBIT) +75% +75% Discount (SUDENE Incentivea untill 2024)	(22.4)	(19.5)	(20.4)	(18.0)	(20.6)	(17.5)	(16.2)	(14.7)	(16.1)	(14.0)	(14.0)	(12.4)	(1.8)
CSLL (9% sobre EBIT)	(8.1)	(7.0)	(7.3)	(6.5)	(7.4)	(6.3)	(5.8)	(5.3)	(5.8)	(5.1)	(5.1)	(4.5)	(0.7)
CBPM (3% sales revenue)	-	-	-	-	-	(4.3)	(4.1)	(4.1)	(4.5)	(4.9)	(4.9)	(5.5)	(2.0)
CFEM (2% of MAG cost * 30%) (R$ mi)	(0.5)	(0.5)	(0.5)	(0.5)	(0.5)	(0.5)	(0.5)	(0.5)	(0.6)	(0.7)	(0.7)	(0.9)	(0.4)
ROYALTIES FOR LAND OWNER	(0.2)	(0.2)	(0.2)	(0.3)	(0.3)	(0.3)	(0.3)	(0.3)	(0.3)	(0.4)	(0.4)	(0.5)	(0.2)
ROYALTIES (2%)	-	-	-	-	-	(2.9)	(2.8)	(2.7)	(3.0)	(3.2)	(3.2)	(3.6)	(1.3)
Net Income (US$ mi)	**58.6**	**51.0**	**53.2**	**47.1**	**53.8**	**38.5**	**35.2**	**31.4**	**34.3**	**28.1**	**28.0**	**22.6**	**1.0**
Depreciation (US$ mi)	-	0.7	1.3	2.2	2.8	3.4	3.3	3.5	3.6	3.7	3.7	3.7	5.0
Residual Value (US$ mi)	-	-	-	-	-	-	-	-	-	-	-	-	-
Free Operating cash flow (US$ mi)	**58.6**	**51.7**	**54.5**	**49.2**	**56.6**	**41.9**	**38.5**	**34.9**	**37.9**	**31.7**	**31.7**	**26.2**	**6.0**
CAPEX (US$ mi)	**(5.3)**	**(3.0)**	**(4.3)**	**(3.0)**	**(3.0)**	**(4.0)**	**(4.1)**	**(4.7)**	**(3.5)**	**(4.0)**	**(3.0)**	**(1.0)**	**(4.6)**
Mine	(0.3)	-	(0.1)	-	-	-	(0.1)	-	-	-	-	-	-
Plant	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	-	-
Waste Dump	-	-	-	-	-	-	-	-	-	-	-	-	-
DAM	(0.5)	-	(1.2)	-	-	-	(1.0)	(1.7)	(0.5)	-	-	-	-
Others Costs (US$ mi)													
Mine Closure	(1.5)	-	-	-	-	(1.0)	-	-	-	(1.0)	-	(1.0)	(4.6)
Working Capital	-	-	-	-	-	-	-	-	-	-	-	-	-
Cash Flow(US$ mi) half year (8%)	**22.0**	**18.6**	**17.8**	**15.1**	**16.2**	**10.6**	**9.0**	**7.3**	**7.7**	**5.7**	**5.5**	**4.5**	**0.2**
		NPV (WACC = 8%) (US$ mi)	140										

24.2.4.1 Sensitivity Study

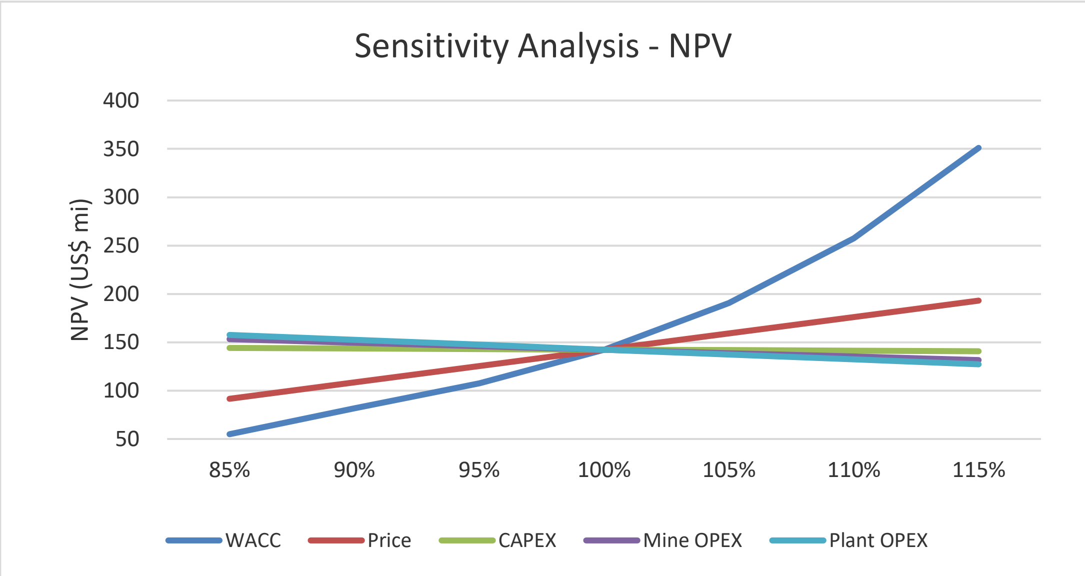
A sensitivity analysis was undertaken to evaluate the impact of the resulting economic indicators for the following attributes, within the cash flow:

- WACC;
- Sell price
- Mine OPEX.
- Plant OPEX

The WACC, OPEX, NPV, was evaluated by varying its value from -15% to +15%, The Figure 24.2.4_1 show the sensitivity analysis developed by GE21.

Figure 24.2.4_1

NPV - Sensitivity Diagram



As noted in the graphs above, the vanadium sales price and the discount rate are the factors that most impact the profitability of the Project. This is consistent with the conclusions noted in FS.

25 INTERPRETATION AND CONCLUSIONS

25.1 Feasibility Study for Campbell Deposit

The Project is already at name plate production of 9.600tpy (800tpm) of V_2O_5 and the two contemplated expansions will, upon completion, increase the production in 2019 to 11,520tpy and in 2020 to 13.200tpy.

Several programs of surface mapping and diamond drilling and a significant amount of metallurgical and engineering studies have been completed since the 1980's. A vanadium-titanium-PGM-mineralized, mafic to ultra-mafic intrusion has been outlined and a deposit at the Campbell has been defined and converted to mineral reserves. Reserves here have demonstrated a 11-year mine life.

Our LoM study resulted in a reserves statement of 17,570 kt @1.14 V_2O_5 producing 29.66% magnetic concentrate at 3.21% V_2O_5 in Proven category, and 1,440 kt @1.26 V_2O_5 producing 33.89% magnetic concentrate at 3.20% V_2O_5 in Probable category, totalling in pit 19,010 kt @1.15 V_2O_5 producing 29.98% magnetic concentrate at 3.21% V_2O_5. Based on the foregoing. the FS resulted in a $NPV_{(8\%)}$ of US$ 542 million for the 11-year mine life.

25.2 PEA-Level Study of Additional Resources

Recent exploration has resulted in the initial delineation of other nearby Satellite Deposits of similar mineralization located at or near surface. None of the resources from the Satellite Deposits have contributed to the reserves identified in this report. The Satellite Deposits should be upgraded and expanded to better define their limits.

The objective of the PEA-level study was to determine the economic viability of extracting additional mineral resources from the remainder of Campbell and Satellite Deposits and the processing of that material through the existing plant to produce vanadium pentoxide (V_2O_5).

Taking as a starting point, the cash flows attributable to the mineral reserves, the incremental cash flows uses a flat vanadium price of $6.34/lb. The the addition of mineral resources is not included in the mineral reserves.

The PEA results in an inferred mineral resources of 24,090 kt @ 0.78 V_2O_5 producing 28.2 % magnetic concentrate at 2.60% V_2O_5.

The PEA estimates a potential incremental $NPV_{(8\%)}$ of US$ 140 million for a mine life of 12 years.

The results of the PEA-level work are preliminary in nature, and they include inferred mineral resources that are considered too speculative geologically to have the economic considerations applied to them that would enable them to be categorized as mineral reserves, and there is no certainty that the preliminary economic assessment will be realized.

25.3 Conclusion

25.3.1 Campbell LoM

GE21 received a resource model for Campbell from Largo and independently assessed, validated and revised it to be used in the reserves estimate provided in this ITR.

Largo provided GE21 with an internally prepared percent model resource, updated to end of April 2017. This "percent" model was transformed into a standardized block model. The mine planning model adopted is considered to be a "diluted" model, adding approximately 5 % dilution to the source model.

GE21 also received from Largo, per the guidance of its geotechnical consultant, the definition of a single angle of 70º interramp for the final pit. For operational purposes GE21 considered the general angle of 60º for pit optimization exercises.

Due to its location in the arid region, there were no studies of groundwater interference in the pit optimization.

Reserves were caluclated using a base case sales price for vanadium pentoxide of US$ 6.34/lb V_2O_5 in 2017, US$9.00/lb V_2O_5 in 2018 and 2019, and then US$6.34/lb V_2O_5 for until the end of the mine life. This was determined based on the current price, and the three-year average from 8 February, 2013 to 5 February, 2016, of US$4.89/lb V_2O_5 as providing a reasonable foundation for future prices. Details of the assumptions, parameters and methods used in the preparation of the reserve estimate and mining schedule are presented in Tables 16.1 through 16.7, and as otherwise described in Section 16.

The mineral reserves were estimated by Porfírio Cabaleiro Rodriguez of GE21, who is a qualified person under NI 43-101 and a Member of the Australian Institute of Geoscientists, and resulted in 17,570 kt of Proven Reserve, at 1.14%V_2O_5, with 29.66% of magnetic recovery at a grade of 3.21% V_2O_5, and 1,440 kt of Probable Reserve, at 1.26%V_2O_5, with 33.89% of magnetic recovery at a grade of 3.21% V_2O_5, totalling 19,010 kt of Proven Reserve, at 1.15% V_2O_5, with 29.98% of magnetic recovery at a grade of 3.21% V_2O_5.

Currently Largo has a mining fleet contract, with Fagundes Construção e Mineração Ltda., which consists of 3 CAT 336 hydraulic excavators equipped with a 2.5 m^3 bucket and a total of 22 Mercedes Benz 36-tonne capacity trucks. The contract drilling fleet consists of three Sandvik Ranger DX800 rotary drill rigs. A fleet of ancillary equipment is also available for mine maintenance and eventual plant services.

The Maracás processing plant was commissioned in 2015 and has been in start-up mode for much of that time ramping up to near design capacity. At the time of writing this Report, the plant produces up to 9,360 t of V_2O_5 equivalent per year with a trend approaching design capacity. Except for unanticipated downtime and subject to completion of the two expansions contemplated herein, production is expected to reach 13,200 t/a V_2O_5 in 2020.

The current process flow sheet comprises three stages of crushing, one stage of grinding, two stages of magnetic separation, magnetic concentrate roasting, vanadium leaching, ammonium meta-vanadate (AMV) precipitation, AMV filtration, AMV calcining, and fusing to V_2O_5 flake as final produc

The operation is based on the existing plant. We considered Sustaining Capex for maintenance of the operation and for investments in the expansion programmed for 2019 and 2020. The total sustaining cost was estimated at US$ 70 million distributed over 10 years, which includes plant equipment repowering (milling, deammoniation, roasting, AMV precipitation), drilling, increased dam reservoir capacity and drainage pumps at the mine bottom.

GE21 summarized the operating and administrative costs, based on real costs that are regularly incurred by Largo, being mining costs of US$ 2.45$/t, processing cost of US$1.78/lb, G&A costs of US$ 0.18/lb, and Royalties and commissions of US$ 0.34/lb.

A Discounted Cash Flow – DCF - scenario was developed to assess the project based on economic-financial parameters, on the results of the mine scheduling and on the Sutaining CAPEX and OPEX estimate.

The project base case estimates an $NPV_{(8\%)}$ for Campbell of $542million.

25.3.2 PEA Satellite and Campbell Remaining Resources

Finally GE21 has concluded, based on the PEA in item 24, that the Satellite Deposits and the remaining inferred resources in Campbell are sufficient to demonstrate technical and economical potential for viability with an opportunity to increase the return by mining these resources if they can be upgraded from inferred resources to measured or indicated resources. The PEA estimates a potential incremental $NPV_{(8\%)}$ of US$ 140 million for a mine life of 12 years.

26 RECOMMENDATIONS

Based on this report, GE21 reccomends the following:

- Largo should proceed with a drilling program to upgrade resource classification in the Sattelite Deposists to a measured and indicated resources level. GE 21 believes that a suitable drilling program would comprise 22,000m of drilling over 105 holes and is summarized in Table 26.1 below.

Table 26_1

Investment in Exploration – 2018 to 2028

	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Exploration capex (US$x1000)	**106**	**628**	**396**	**91**	**585**	**396**	**91**	**585**	**396**	**91**	**585**	**396**
Purchase of auger drill		12										
Diamond drilling Satellite (18.000m)	91	303	311	91	303	311	91	303	311	91	303	311
Sample analisys Satellite (9.000)		68	68		68	68		68	68		68	68
Diamond drilling Campbell (4.000m)		136			136			136			136	
Sample analisys Campbell (4.000m)		61			61			61			61	
XRF of DTR Satellite (9.000m)		17	17		17	17		17	17		17	17
XRF of DTR Satellite (3.000m)	15	30										

- Largo should Consider whether the continued use of a contracted fleet continues to make sense relative to increasing costs as the Project progresses.
- Largo should further examine the possibility of selling its iron-rich calcine tailings. This would include considering what it would take to turn it into a more saleable product
- In respect of the Satellite Deposits:
    - Develop a technical and economic study for mine scheduling purposes in order to maintain grade, and to avoid any production decreases.
    - Consider, whether two or more of the Satellite Deposits could be brought into production at same time, with an implicit CAPEX for a second mobile DMS unit, to ensure that production always stays at nameplate capacity.
    - Consider whether co-production among Campbell and any of the Satellite Deposits could provide additional value.

27 REFERENCES

Aurox Resources Limited, 2006; Press Release, January 11, 2006, Balla Balla - Largest Vanadium Ore Reserve In Australia, 4 p.

Arsenault, D. et al., 2013; Preliminary Economic Assessment of the Maracás Vanadium Project, 1.4 Million Tonnes per Year Processing Plant. NI 43-101 Technical Report by RungePincockMinarco for Largo Resources Ltd.

Brandt Meio Ambiente Ltda; Environment Study, Project Vanádio de Maracás, Largo Mineraçáo Ltda, Maio 2008.

Brito, R. S. C., 1984; Geologia do Sill Estratificado do Rio Jacaré-Maracás, Bahia: Congresso Brasileiro de Geologia, Sociedade Brasileira Geociências, 9th, Rio de Janeiro, Anais do 33, p. 4316-4334.

Brito, R. S. C., 2000; Geologia e Petrologia do Sill Máfico Ultramáfico do Rio Jacaré, Bahia Estudio das Mineralizacoes de Fe-Ti-V e Platinoides Associados: Unpublished Ph.D. thesis, Brasilia, Brazil, Universidade do Brasilia, no. 39 325 p.

Brito, R. S. C., et al, 1981; Projeto Fazenda Gulçari, Companhia Baiana de Pesquisa Mineral (CBPM), Salvador, Convenio SME-CBPM, 102 p.

CPM Group; Vanadium Industry Outlook, Largo Resources Ltd., July 2008.

ECM S.A. Projetos Industrias; Processing and Infrastructuré Study, Projeto Vanádio de Maracás, Largo Resources Ltd., July 2008.

Engenharia e Consultoria Mineral S.A., “Projeto Vanádio de Maracás Projecto Conceitual e Estimativa de Investimento, Produção: 4,500 t/a de V_2O_5”, September 1990.

Galvão, C. F., 1984; Projeto Fazenda Gulçari - Alvo A, National Department of Mineral Production (DNPM), Salvador, v. 1, 102 p.

Galvão, C. F., and Nonato, I. F. B. P., 1984; Projeto Fazenda Gulçari III, Companhia Baiana de Pesquisa Mineral (CBPM), Salvador, Convenio SME-CBPM, 51 p.

Galvão, C. F., Vianna, I. A., Nonato, I. F. B. P., and Brito, R. S. C., 1986; Depósito de Magnetita Vanadífera de Fazenda Gulçari, Maracás, Bahia, in Schobbenhaus, C. and Coelho, C.E.S. eds., Principais Depósitos Minerais do Brasil: National Department of Mineral Production (DNPM), Brasília, v. 2 (XL), p. 493-501.

Hennessey, B. T., 2006; A Review of, and A Mineral Resource Estimate For, The Maracás Vanadium Project, Municipality Of Maracás, Bahia State, Brazil. An NI 43-101 Technical Report prepared for Largo Resources Ltd. by Micon International Limited, filed on SEDAR, www.sedar.com.

Hennessey, B. T., 2007; An Updated Mineral Resource Estimate for The Maracás Vanadium Project, Municipality Of Maracás, Bahia State, Brazil. An NI 43-101 Technical Report prepared for Largo Resources Ltd. by Micon International Limited, filed on SEDAR, www.sedar.com.

Hennessey, B. T. et al, 2008; An Updated Preliminary Assessment of the Maracás Vanadium Project, Municipality of Maracás, Bahia State, Brazil. An NI 43-101 Technical Report prepared for Largo Resources Ltd. by Micon International Limited, filed on SEDAR, www.sedar.com.

IMS Processing plant, "Vanádio de Maracás Ltda., Vanadium Pentoxide Production Plant", 1990.

Jacobs, C. A. et al., 2007; A Preliminary Assessment of the Maracás Vanadium Project, Municipality of Maracás, Bahia State, Brazil. An NI 43-101 Technical Report prepared for Largo Resources Ltd. by Micon International Limited, filed on SEDAR, www.sedar.com.

Largo Resources Ltd. (2015). Plant Blending Reports - Jan 2015 to Dec 2015. Maracás Menchen: Largo Resources Ltd.

Largo Resources Ltd. (2016). Power Consumption Report - Jan 2015 - May 2016. Maracás Menchen: Largo Resources Ltd.

Largo Resources Ltd. (2016). Processing plant Production Reports - Jan 2015 to June 2016. Maracás Menchen: Largo Resources Ltd.

Largo Resources Ltd. (2016). Water and Fuel Consumption Report - Jan 2015 to May 2016. Maracás Menchen: Largo Resources Ltd.

Lopes, J. J. V., 1991; Composicão Mineralogica e Tenor de Oxidos Estimados: Gulçari A: Furos de Sondagem FGA01 - FGA55, Unpublished internal report, Vanádio de Maracás Ltda, Salvador, 85 p.

Lurgi Staff, 1986; Feasibility Study: Maracás Vanadium Project, Lurgi Unpublished internal report, Lurgi GMBH, Frankfurt, Germany, 18 p.

Marques, R., 2006; Draft Projecto Vanádio de Maracás, Estudo de Impacto Ambiental.

Menezes, J., 2005; Feasibility Study Summary, Unpublished internal report, Vanádio de Maracás Ltda, Salvador, 56 p.

NCL Brasil Ltda; Mine Feasibility Study, Executive Summary, Maracás Vanadium Project, Bahia, Brazil, for Largo Resources Ltd., August 2008.

PMA, Precious Metals Australia Limited, 2005; Press Release, December 20, 2005, JORC Compliant Ore Reserve at Windimurra - Largest in the World, 5 p.

Poylio, E., and Hiltunen, A., 1987; DDT - Test and Mineralogical Characterizations of Maracás Samples AA - 29 -90, Unpublished Research Report, Rautaruukki Oy Tutkimuskeskus Research Centre, Finland, 5 p.

Price, W.A., Morin, K. and Hutt, N. (1997), Guidelines for the Prediction of Acid Rock Drainage and Metal Leaching for Mines in British Columbia: Part II. Recommended Procedures for Static and Kinetic Testing, Proc. 4th International Conference on Acid Mine Drainage, Vancouver, BC, p15-30.

Rautaruukki Oy Tutkimuskeskus Research Centre, “Laboratory Research of the Suitability of the Otankäki Process for Extracting Vanadium from Maracás Ore”, December 1989.

Roskill Information Services Ltd., 2010, Vanadium Global Industry Markets and Outlook, Twelfth Edition.

Roskill Information Services Ltd., 2015, The World Market for Vanadium to 2025, Fourteenth Edition.

Sá, J. H. S., 1985; Pesquisa de Platinoides no Complexo do Rio Jacaré: Internal report, Bahia, Brazil, Companhia Baiana de Pesquisa Mineral, Salvador, 9 p.

Sá, J. H. S., 1992; Feições Petroquímicas Relacionadas a Estrutura do Corpo Gulçari A no Complexo Máfico - Ultramáfico do Rio Jacaré, Maracás, Bahia [abs.]: 37o Congresso Brasileiro do Geologia, São Paulo, Botetim de Resumos Expandidos, p. 460-462.

Sá, J. H. S., Merkle R. K. W., and Von Gruenewaldt, G., 2005; The Distribution of Base Metals and Platinum-Group Elements in Magnetite and Its Host Rocks in the Rio Jacaré Intrusion, Northeastern Brazil: Economic Geology, v. 100, p. 333-348.

SGS Minerals Services, “The Beneficiation Characteristics of Samples from The Vanádio De Maracás Deposit” November 2007.

SGS Minerals Services, “Recovery of Vanadium from the Maracás Ore Deposit”, April 2008.

SGS Minerals Services, “The Solid-Liquid Separation of the Maracás Ore Deposit”, July 2008

Teixeira, W., Sabaté, P., Barbosa, J., Noce, C. M., and Carneiro, M. A., 2000; Archean and Paleoproterozoic Tectonic Evolution of the São Francisco Craton: International Geological Congress, 31st, Rio de Janeiro, Brazil, August 6-17, 2000, Proceedings, p.101-137.

TTP Squared, Inc, Vanadium Market Analysis, August 31, 2017

United Nations COMTRADE database, DESA/UNSD, http://comtrade.un.org.

U.S. Geological Survey, 2011, 2010 Minerals Yearbook, Vanadium [Advance Release], November, 2011.

U.S. Geological Survey, 2012, 2011 Minerals Yearbook, Vanadium [Advance Release], December, 2012.

U.S. Geological Survey, 2013, Mineral Commodity Summaries, Vanadium, January, 2013.

U.S. Geological Survey, 2016, Mineral Commodity Summaries, Vanadium, January, 2016.

U.S. Geological Survey, 2016, 2014 Minerals Yearbook, Vanadium [Advance Release], February, 2016.

Vanádio de Maracás Staff, 1987; Estimacão Preliminar do Depósito de Vanádio Maracás, Unpublished internal report, Vanádio de Maracás Ltda, Salvador, 61 p.

Westman, K., and Poylio, E., 1989; Laboratory Research of the Suitability of the Otanmaki Process for Extracting Vanadium from Maracás Ore, Unpublished Research Report, Rautaruukki Oy Tutkimuskeskus Research Centre, Finland, 22 p.

World Steel Association, 2012, Short Range Outlook, 11 October, 2012,

World Steel Association, Annual Crude Steel Production, 1980-2014, and Monthly Crude Steel Production, 2015, www.worldsteel.org/statistics.

The World Steel Association, 2016, Short Range Outlook 2016-2017, 13 April, 2016,

www.worldsteel.org/media-centre/press-releases/2016/worldsteel-Short-Range-Outlook-2016-2017.html.

www.worldsteel.org/media-centre/press-releases/2012/worldsteel-short-range-outlook.html.

Appendix A

Certificates

CERTIFICATE OF QUALIFIED PERSON PORFIRIO CABALERIO RODRIGUEZ

I, Porfírio Cabalerio Rodriguez, state that:

(a) I am a Mining Engineer and Associate Consultant at GE21 Consultoria Mineral, which is located on Avenida Afonso Pena, 3924, SL,207, Cruzeiro, Belo Horizonte, MG, Brazil - CEP 30130-009.

(b) This certificate applies to the technical report titled "An Updated Mine Plan, Mineral Reserve and Preliminary Economic Assessment of Inferred Resources" with an effective date of May 2, 2017 (the "Technical Report").

(c) I am a "qualified person" for the purposes of National Instrument 43-101 (the "Instrument"). My qualifications as a qualified person are as follows. I am a graduate of the Federal University of Minas Gerais, located in Belo Horizonte, Brazil, and hold a Bachelor of Science Degree in Mine Engineering (1978). I have practised my profession continuously since 1979. I am a professional mining engineer, with more than 39 years relevant experience in ore resource and reserves estimation. I am a member of the Australian Institute of Geoscientists ("AIG") - ("MAIG") #3708.

(d) My most recent personal inspection of each property described in the Technical Report occurred on April 04/10/17 and was for a duration of 2 days.

(e) I am responsible for all Item(s) of the Technical Report.

(f) I am independent of the issuer as described in section 1.5 of the Instrument.

(g) I have not had prior involvement with the property that is the subject of the Technical Report.

(h) I have read National Instrument 43-101. The part of the Technical Report for which I am responsible has been prepared in compliance with this Instrument; and

(i) At the effective date of the Technical Report, to the best of my knowledge, information, and belief, the part of Technical Report for which I am responsible, contains all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Belo Horizonte, MG 26 October, 2017.

"Porfirio Cabaleiro Rodriguez"

Porfirio Cabaleiro Rodriguez, BSc. (MEng), MAIG #3708

CERTIFICATE OF QUALIFIED PERSON LEONARDO APPARICIO DA SILVA

I, Leonardo Apparicio Da Silva, state that:

(a) I am an Engineer of Processes at Projects and Associate for GE21, which is located on Avenida Afonso Pena, 3924, SL,207, Cruzeiro, Belo Horizonte, MG, Brazil - CEP 30130-009.

(b) This certificate applies to the technical report titled "An Updated Mine Plan, Mineral Reserve and Preliminary Economic Assessment of Inferred Resources" with an effective date of May 2, 2017 (the "Technical Report").

(c) I am a "qualified person" for the purposes of National Instrument 43-101 (the "Instrument"). My qualifications as a qualified person are as follows. I hold a Bachelor of Science Degree in Mine Engineering (1978) from the university of Universidade Federal de Ouro Preto (UFOP) and hold a Master of Science Degree in Metallurgical Engineering (1984) from Universidade Federal do Rio de Janeiro(UFRJ). I also hold a specialization in Mineral Technology (1983) from the Universidade Federal do Rio de Janeiro. I am a member of the Australian Institute of Geoscientists ("AIG") - ("MAIG") #5374. My relevant experience after graduation for the purpose of the Technical Report includes: Engineer of Processes and Projects with more than 40 years of experience in projects, engineering, construction, implantation, operation, start-ups and ramp ups of plants of mineral processing and hydrometallurgical, as well as in audits and due operational and project diligences.

(d) My most recent personal inspection of each property described in the Technical Report occurred on 04/10/2017 and was for a duration of 5 days.

(e) I am responsible for Items 13 and 17 of the Technical Report.

(f) I am independent of the issuer as described in section 1.5 of the Instrument.

(g) I have not had prior involvement with the property that is the subject of the Technical Report.

(h) I have read National Instrument 43-101. The part of the Technical Report for which I am responsible has been prepared in compliance with this Instrument; and

(i) At the effective date of the Technical Report, to the best of my knowledge, information, and belief, the part of Technical Report for which I am responsible, contains all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Belo Horizonte, MG 26 October, 2017.

"Leonardo Apparicio da Silva"

Leonardo Apparicio da Silva, BSc. (MEng), MAIG #5374

CERTIFICATE OF QUALIFIED PERSON PORFIRIO CABALERIO RODRIGUEZ

I, Fábio Valério Câmara Xavier , state that:

(a) I am a Geologist and Associate Consultant at GE21 Consultoria Mineral, which is located on Avenida Afonso Pena, 3924, SL,207, Cruzeiro, Belo Horizonte, MG, Brazil - CEP 30130-009.

(b) This certificate applies to the technical report titled "An Updated Mine Plan, Mineral Reserve and Preliminary Economic Assessment of Inferred Resources" with an effective date of May 2, 2017 (the "Technical Report") .

(c) I am a "qualified person" for the purposes of National Instrument 43-101 (the "Instrument"). My qualifications as a qualified person are as follows. I am a graduate of the Federal University of Rio Grande do Norte, located in Natal, Brazil, and hold a Bachelor of Science Degree in Geology (2003). I have practised my profession continuously since 2003. I am a professional geologist, with more than 14 years relevant experience in resource estimation and geology exploration. I am a member of the Australian Institute of Geoscientists ("AIG") - ("MAIG") #5179

(d) I have not visited the site.

(e) I am responsible for Items 7 to 12 and Item 14 of the Technical Report.

(f) I am independent of the issuer as described in section 1.5 of the Instrument.

(g) I have not had prior involvement with the property that is the subject of the Technical Report.

(h) I have read National Instrument 43-101. The part of the Technical Report for which I am responsible has been prepared in compliance with this Instrument; and

(i) At the effective date of the Technical Report, to the best of my knowledge, information, and belief, the part of Technical Report for which I am responsible, contains all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Belo Horizonte, MG 26 October, 2017.

"Fábio Valério Câmara Xavier"

Fábio Valério Câmara Xavier BSc. (Geo), MAIG #5179