

National Grid Property Holdings Limited Ford Road, Arundel (Site No. 2551)

Site Investigation Report

October 2011

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Document History

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Reporting Area



Site Address	Ford Road, Arundel, West Sussex, BN18 9DX	NGP Document Tracking code	
Report Title	Land Contamination Site Investigation and Generic Quantitative Risk Assessment		
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Draft/Final	Draft	H&S File?	No
Work Stage	Site investigation and generic quantitative risk assessment		
Brief description of contents	Supplementary site investigation and updated generic quantitative risk assessment report including previously obtained site data		
Access Permitted	Yes	NGP Contact	Paul Mantell

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[illegible]

Service	Percentage
Food delivery	85%
Online grocery delivery	78%
Virtual personal training	62%
Online therapy/counseling	58%
Virtual fitness classes	55%
Online meal kits	52%
Virtual support groups	48%
Online health coaching	45%
Virtual health screenings	42%
Online health education	40%
Virtual health checkups	38%
Online health monitoring	35%
Virtual health consultations	32%
Online health assessments	30%
Virtual health advice	28%
Online health resources	25%
Virtual health support	22%
Online health tools	20%
Virtual health services	18%
Online health products	15%
Virtual health solutions	12%

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	E.3	Groundwater Laboratory Results
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List of Abbreviations

Abbreviation	Definition
ALV	Alluvium
aOD	above Ordnance Datum
Atkins	Atkins Limited
ATD	Atomic Thermal Desorption
bgl	below ground level
BGS	British Geological Survey
BTEX	benzene, toluene, ethylbenzene and xylene
CHK	Chalk
CoC	contaminant of concern
CLEA	Contaminated Land Exposure Assessment
CSM	conceptual site model
DQRA	detailed quantitative risk assessment
GAC	generic assessment criteria
GQRA	generic quantitative risk assessment
ha	hectare
i2	i2 Analytical Limited
MDL	method detection limit
MG	Made Ground
NAPL	non-aqueous phase liquid
NGPH	National Grid Property Holdings Limited
NM	not measured
OS	Ordnance Survey
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PID	photo ionisation detector
PORT	prioritisation of risk tool
PPL	potential pollutant linkage
PW	perched water
RBCA	Risk Based Corrective Action
SGV	Soil Guideline Value
SOM	soil organic matter
SPZ	Source Protection Zone
SR	Science Report
SSV	soil screening values
TIC	tentatively identified compound
TOC	total organic carbon
TPH CWG	total petroleum hydrocarbon criteria working group
VOC	volatile organic compound
WSV	water screening value

Executive Summary

Introduction

National Grid Property Holdings Limited (NGPH) retained Atkins Limited (Atkins) to conduct a supplementary phase intrusive investigation [REDACTED] on the former Arundel Gasworks, located on Ford Road, Arundel (herein referred to as the 'site').

The site is recorded to have been operated as a gasworks from at least 1840 until the late 20th century. Investigation and assessment works conducted at the site by Harrison and Co. in 1993 (Ref. 2) and Atkins in 1994 and 2000. [REDACTED]

[REDACTED]. In [REDACTED]
[REDACTED]
[REDACTED] June 2010, NGPH commissioned Atkins to undertake a supplementary phase intrusive site investigation [REDACTED].

Physical Investigation Findings

The results of the intrusive site investigation identified Made Ground across the site, generally comprising firm, sandy, gravelly clay and fine to medium, gravelly, clayey sand with frequent brick, chalk and flint gravels and fragments of clinker, up to a maximum identified thickness of 2.7 m (in the northern corner of the site). Stiff, very gravelly clay and fine to coarse sub-rounded to angular flint gravels in a stiff clay matrix (Alluvium) ranging between 0.7 m to 5.1 m thickness was encountered beneath the Made Ground. Chalk (comprising structureless fine chalk gravels and chalk cobbles in a soft off-white/grey clay matrix) was identified beneath the Alluvium between 3.4 and 6.8 m below ground level (bgl).

A number of visual and olfactory indicators of potential contamination were identified in the Made Ground, Alluvium and Chalk during drilling. [REDACTED]

[REDACTED]. Due to constraints encountered during the recent site investigation works associated with vegetation, nesting birds and underground pipe work (identified in TP108 and TP111), it was not possible to extend the trial pit locations in order to fully delineate this potential source area.

Tidal monitoring indicated significant tidal variation in the groundwater level at the site (up to approximately 2 m variance), [REDACTED]

[REDACTED]
[REDACTED]
[REDACTED]
[REDACTED]
[REDACTED]
[REDACTED]
[REDACTED]
[REDACTED]

[REDACTED]

[REDACTED]

- [REDACTED]

1. Introduction

1.1 General

National Grid Property Holdings Limited (NGPH) has retained Atkins Limited (Atkins) to conduct a supplementary phase intrusive investigation [REDACTED]

[REDACTED] on the former Arundel Gasworks, located on Ford Road, Arundel (herein referred to as the 'site').

This document presents the findings of the supplementary intrusive investigation [REDACTED] produced in accordance with Atkins offer of services, dated March 2011 (Ref. 1).

1.2 Background

The site is recorded to have been operated as a gasworks from at least 1840 until the late 20th century. Investigation and assessment works conducted at the site comprising a desk based assessment by Harrison and Co. in 1993 (Ref. 2) and an environmental liability assessment (Ref. 3) and interpretive site investigation report (Ref. 4) undertaken by Atkins in 1994 and 2000,

[REDACTED]

[REDACTED]

[REDACTED] in June 2010, NGPH commissioned Atkins to undertake a supplementary phase intrusive site investigation [REDACTED].

[REDACTED]

- [REDACTED]

- [REDACTED]

[REDACTED]

1.4 Project Team

The project team is presented in Table 1.1, below.

Table 1.1 - Project Team

Role	Contact
Client	NGPH Paul Mantell, Regeneration Manager
Principal Contractor	Atkins
Project Director	Mathew Worboys, Associate Director
Project Manager	Samuel Tonkin, Associate
Lead Engineer	Lucy Hay, Senior Environmental Consultant
CDM Co-ordinator	Confluence PMC Ken Buchanan, Associate
Service clearance	Amethyst Surveys Ltd
Borehole drilling	Geotechnical Engineering Ltd
Hand pits/hand augers	Smith Drilling Services Ltd
Trial pits	Chertsey Plant Hire Ltd
Chemical analysis (soils and water)	i2 Analytical Ltd (i2)
Chemical analysis (soil vapour)	Chemex Ltd
Waste collection	Williams Environmental Ltd

1.5 Information Sources

The following historical reports pertaining to the site have been reviewed as part of this assessment:

- Harrison and Company, 1993. Desk Study on a Disused Gas Work at Ford Road, Arundel, West Sussex for British Gas (South Eastern) plc. Ref C604A (Ref. 2);
- Atkins, April 1994. British Gas Environmental Liability Assessment Report. Ref E5347/LR860.NL/gp (Ref. 3) [REDACTED]
- [REDACTED]
[REDACTED]

A site investigation was also undertaken by Harrison and Co. in 1988, however, Atkins has not reviewed this report. A summary of the investigation is provided within the Harrison and Co. 1993 desk study and only this information has been reviewed.

This report presents the findings of the recent 2011 investigation [REDACTED]
[REDACTED]

2. Site Status and Environmental Setting

2.1 Introduction

The section provides a summary of the current site status and environmental setting. Information regarding the site status has been based on observations made during a site walkover conducted by Atkins on 17 May 2011 and records from previous investigations at the site. Information regarding the environmental setting has been summarised from the Environmental Assessment Site Investigation Final Interpretative Report, produced by Atkins in December 2000 (Ref. 4).

2.2 Site Status

2.2.1 Location

The site is located on Ford Road, Arundel, West Sussex, BN18 9DX at National Grid Reference No. TQ013067 (501308E, 106749N) and covers an area of approximately 0.4 hectares (ha). Figure 1 presents a site location plan, and Figure 2 presents a site layout plan including historical site features. A selection of site photographs from the site walkover conducted by Atkins on 17 May 2011 is presented in Appendix A.1.

2.2.2 Current Site Layout

The site is generally flat and set into the side of a gently sloping hill with the surrounding land sloping from northwest to southeast. Residential houses and a road located to the west and south west of the site are at a higher level than the site, although the gardens of the residential properties slope down to a similar level. An electricity sub-station is located on the eastern site boundary adjacent to the site entrance (Appendix A.1, photograph 8) and concrete slab foundations are located in the northern and eastern corners of the site. No other above ground structures or buildings are present on the site. A raised spoil heap and raised rectangular area (identified on the historical plans to have been the location of a governor compound) are located in the southern and south eastern portions of the site, respectively.

During the site investigation undertaken in 2000 (Ref. 4), the site was recorded as comprising approximately 25 % tarmac, with the remainder comprising of either gravel or wood chip with sporadic patches of vegetation and bare earth. However, during the site walkover undertaken on 17 May 2011, the site was found to be heavily overgrown with buddleia making an appraisal of the majority of the ground cover at the site not possible (see Appendix A.1, photographs 5 and 9). It is understood that no activity has taken place on the site since 2000, and following vegetation clearance works undertaken as part of the site investigation undertaken by Atkins in June 2011, the ground cover was estimated to be consistent with that recorded in 2000.

The site boundary comprises a 2 m high chain link fence in reasonable condition. During the site walkover some minor damage was noted along the south western boundary, however, thick vegetation was located along this boundary making entry via this opening (by potential trespassers) unlikely (Appendix A.1, photograph 7). Access to the site is gained via 2 m high chain-link padlocked double gates located along an access track adjacent to the north eastern boundary of the site (off Ford Road). Two metal security bollards are also located on the inside of the gates (Appendix A.1, photograph 3).

The surrounding land uses are as follows:

- to the south west are residential houses with gardens;
- to the south east is private grazing land. The River Arun is located beyond the private grazing land and flows towards the south east (although is tidally influenced);
- to the north west is Ford Road, beyond which is a cemetery; and

- to the north east is an access track leading off Ford Road, beyond which is a small surface water drain (which runs towards the River Arun via a sluice gate), and private grazing land.

2.2.3 Historical Site Layout

Historical maps have been obtained for the site and identify the gasworks to have been present from before 1840 and expanding in the west in circa 1899 and in the south and south east in circa 1937.

A summary of the development of the site taken from historical maps is presented in Table 2.1. A plan of the site in 1967, provided by the National Grid archives, is included in Appendix B.

Table 2.1 - Site History

Map	On-Site	Off-Site
1840 Tortington Tithe Map	The site is recorded as being confined to the north east of the current site area with the remainder of the site split into land parcels by a number of boundaries. A single gas holder is identified in the north of the site. A works building is recorded in the central northern portion of the site to the south of the holder. A rectangular building is identified adjacent to what is currently the site entrance.	Ford Road (unnamed on the plan) is identified along the north western boundary of the site with open fields beyond. An access track leading to the River Arun is recorded along the north eastern boundary with open fields, a small building and drainage channels beyond. Open fields, drainage channels and the River Arun are identified to the south east of the site. Open land segregated into smaller parcels is identified to the south west.
1875 Ordnance Survey (OS) Map	The site is recorded as a "Gas Works". The gas holder located in the north of the site is recorded to have reduced in size and a second, larger gas holder is identified within the site along the north western boundary. The works buildings are recorded to have expanded to the south and west.	Minor changes, with a small number of buildings are identified to the north, south and south west of the site.
1877 OS Map	An additional small circular structure (potential gas holder or tar tank) is identified in the central portion of the site adjacent to the works buildings.	No significant changes recorded.
1897 OS Map	The gas works area is recorded to have expanded to the west. The smaller possible gas holders/tar tanks previously identified in the north and central portion of the site are no longer recorded. A circular gas holder is recorded in the west of the site. The works buildings previously identified in the central portion of the site has expanded. Additional works buildings are identified in the northern corner of the site. The building previously recorded adjacent to what is now the site entrance has expanded.	A cemetery with lodge house is recorded to the north west of the site Beyond the open fields to the south of the site "Baths", "Tortington Iron Works" and a "Sewage Works" are identified. Housing located along the south of Ford Road is identified adjacent to the site to the south west.

Map	On-Site	Off-Site
1899 OS Map	No significant changes identified.	No significant changes identified.
1910 OS Map	A small circular structure (possible chimney or tank) is identified along the north eastern boundary.	Additional residential properties with gardens are recorded to the west and south west of the site.
1912 OS Map	No significant changes identified.	No significant changes identified.
1914 OS Survey Map	No significant changes identified.	No significant changes identified.
1933 OS Map	No significant changes identified.	No significant changes identified.
1937 OS Map	The site is recorded to have expanded to the south and south east with a circular gas holder structure identified in the southern corner and a rectangular building identified in the eastern corner.	No significant changes identified.
1961 OS Map	Only the circular holder structures are identified in the southern and western corners of the site, however, other features may be present but not shown due to the map scale.	No significant changes identified.
1971 OS Map	No features are recorded in the northern, western and central portions of the site. An electricity sub-station is identified adjacent to the site entrance along the north eastern boundary. A rectangular tank is identified in the eastern corner of the site (a rectangular concrete slab is still present on the site at this location indicating that this may have been an above ground tank). A square structure along the south eastern boundary is identified (recorded to be a governor compound on the plan provided from the National Grid archive, presented in Appendix B)	The baths to the south of the site are no longer identified and the iron works are now recorded as an agricultural engineering works and builders yard.
1973-77 OS Map	No significant changes identified.	No significant changes identified.
1979-94 OS Map	The circular tank structure in the southern corner of the site and the rectangular tank structure in the east of the site are no longer identified. The remaining features identified include the electricity sub-station and the square feature along the south eastern boundary which is recorded as a gas valve compound.	No significant changes identified.

2.2.4 Services

Service drawings from known utility suppliers were requested prior to the start of the intrusive investigation works. Appendix C presents the service plans received and the responses obtained from the service providers that have plant with in the vicinity of the site.

2.3 Environmental Setting

2.3.1 Geology

2.3.1.1 Regional

The geology in the vicinity of the site is identified on the British Geological Survey (BGS) Sheet 317, Chichester (Ref. 5). BGS Well Records Nos. 21 and 88 have also previously been reviewed.

The solid geology of the study site is shown to comprise the Spetisbury Chalk Member overlain by 2 to 5 m of clay, silt, sand and gravel alluvium (Raised Marine Deposits) associated with the River Arun.

2.3.1.2 Site Specific

The following information regarding the site specific geology is based on the findings of the investigation and assessment works undertaken by Atkins in 2000 (Ref. 4). Exploratory borehole logs from the 2000 site investigation are presented in Appendix A.2, and the location of the historical site investigation locations is presented on Figure 2.

Made Ground

Made Ground varied in thickness across the site ranging from absent to 2.0 m below ground level (bgl), with the greatest depths in the areas that were recorded to be formerly occupied by gas holders and pipes. Made Ground was therefore principally located to the centre and north of the site with natural ground at surface level along the southern, eastern and south-western boundaries. The Made Ground generally comprised a loose black silty sand or sandy silt with coal, bricks, clinker, scrap metal, chalk and some reworked natural ground in TP5, TP7, TP8, TP9, TP14, TT1 and TT2. In addition TP8 contained small quantities of spent oxide.

Natural Strata

The top of the natural strata was identified between ground level (TP6, TP12 and TP13) and approximately 2.0 m bgl. The natural strata comprised a soft dark brown silty clay or clayey silt with gravel and rootlets, underlain by a light brown-orange clay with flint gravel and bands of stiff red-brown silty sand, gravel rich bands, brown clay with and without sand, and occasional chalk in light brown-grey layers (Alluvium). This was underlain by a soft white to light grey weathered chalk with occasional grey staining, stones and flinty gravel (Chalk).

2.3.2 Hydrogeology

The Environment Agency designation for the Raised Marine Deposits at the site is as a Secondary (A) Aquifer (Ref. 6). The Chalk is designated as a Principal Aquifer. Information obtained from the Environment Agency website (Ref. 6) indicates that the site does not lie within a Source Protection Zone (SPZ).

Perched water was encountered during the 2000 site investigation in the Made Ground and Alluvium as detailed in Table 2.2. In TP5 and TP8, the water encountered was associated with historical features. Groundwater strikes in the Chalk were noted in four of the five boreholes. During subsequent monitoring rounds, groundwater levels in the Chalk Aquifer were recorded between 0.045 m above Ordnance Datum (aOD) and 0.475 m aOD.

Table 2.2 – Perched Water and Groundwater Strikes during the 2000 Site Investigation

Location ID	Perched Water/ Groundwater Strike			Groundwater Level 09/06/00		Groundwater Level 19/07/00		Notes
	m bgl*	m aOD	Stratum	m bgl*	m aOD	m bgl*	m aOD	
TP1	1.40	2.20	MG	-	-	-	-	
TP2	1.80	1.91	MG	-	-	-	-	Brown foam and tar odour. Associated with tar stained gravels.
TP5	1.20	2.15	MG	-	-	-	-	Potentially associated with two cast iron pipes containing water identified at 0.9 m bgl and broken during excavation. Tar contamination visually identified in the water.
TP8	1.20	1.94	MG	-	-	-	-	Water contained within a cast iron pipe broken during excavation. Phenol/oil odour and sheen.
TP11A	1.40	1.19	ALV	-	-	-	-	Associated with gravels in the clay Alluvium.
TP12	1.30	1.13	ALV	-	-	-	-	Associated with gravels within the clay Alluvium.
BH1	3.20	0.037	CHK	3.30	0.67	3.90	0.07	
BH2	2.68	0.72	CHK	2.68	1.03	3.47	0.25	
BH3	3.20	0.02	CHK	3.20	0.39	3.12	0.48	
BH4	2.28	0.23	CHK	2.28	0.59	2.44	0.44	
BH5	NM	NM	NM	2.02	0.88	2.86	0.05	

Notes: MG Made Ground
ALV Alluvium
CHK Chalk
NM Not measured
- No installation and therefore groundwater level monitoring not possible
* Ground level during drilling represents the original ground level, and ground level during subsequent rounds of monitoring represents the top of the well cover.

2.3.3 Hydrology

The River Arun is located approximately 40 m south east from the site, adjacent to the grazing land. The river is tidally influenced in the local area and generally flows in a southerly direction towards the English Channel, with reversal of flow during high tide. A drainage ditch is located approximately 5 m from the north eastern site boundary and flows in a south easterly direction into the River Arun via a sluice gate (see Appendix A.1, photograph 6).

2.4 Previous Assessment Reports

2.4.1 Harrison and Co., 1988: Site Investigation

The site investigation undertaken by Harrison and Co. in 1988 is summarised within their desk study report (Ref. 2). The site investigation comprised 22 trial pits across the site and the grazing field adjacent to the south of the site.

Within the current site boundary, buried structures including concrete, pipes and metalwork were encountered within the Made Ground, found to be approximately 1.3 m in thickness but ranging up to 3.0 m. [REDACTED]

[REDACTED]

2.4.2 Atkins, 2000: Site Investigation

In 2000, Atkins undertook an intrusive investigation at the site with the findings reported in the Atkins Environmental Assessment Site Investigation Report (Ref. 4). The Atkins site investigation comprised:

- five groundwater monitoring wells installed within the Chalk Aquifer;
- excavation of two trial trenches; and
- excavation of 14 trial pits.

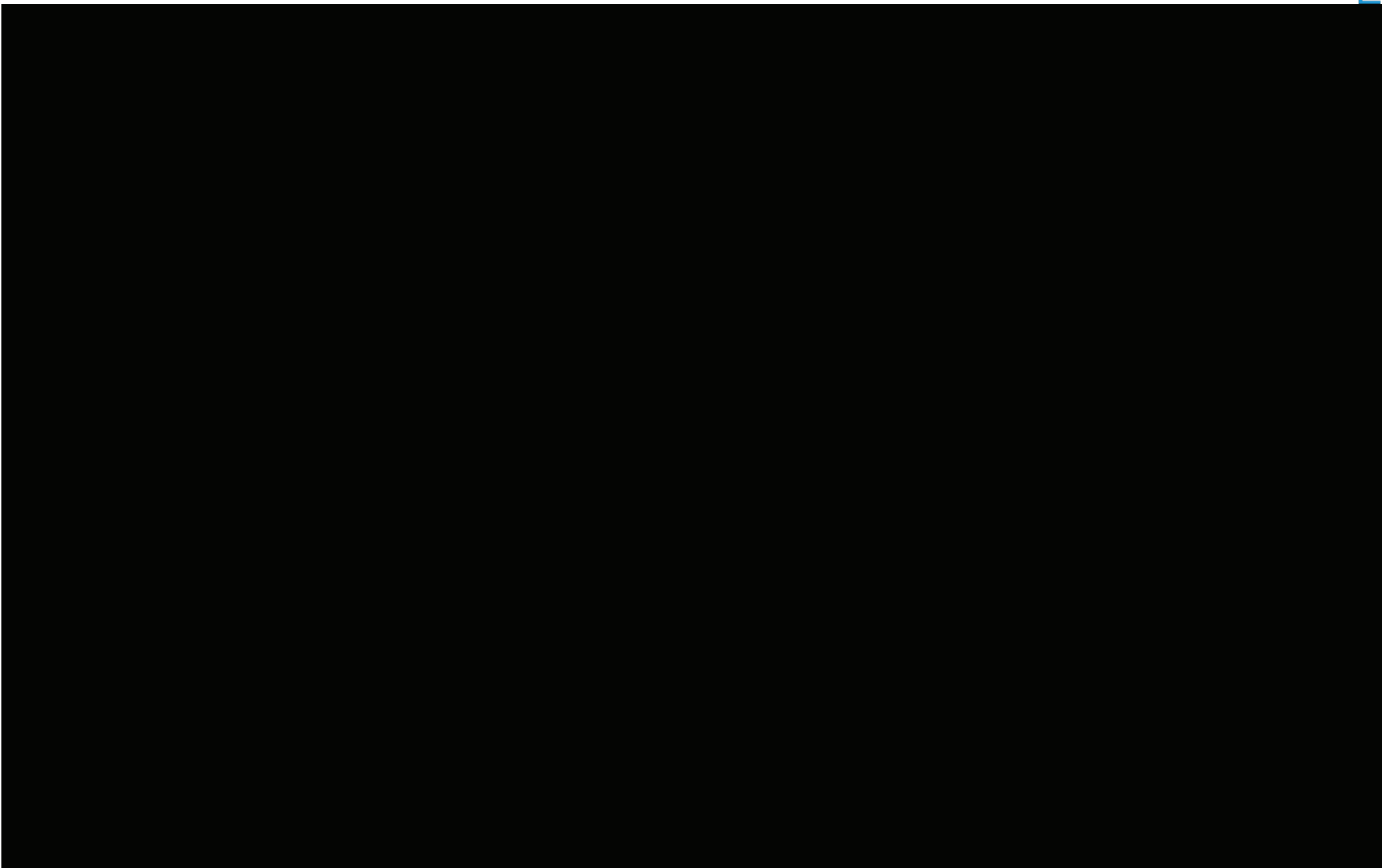
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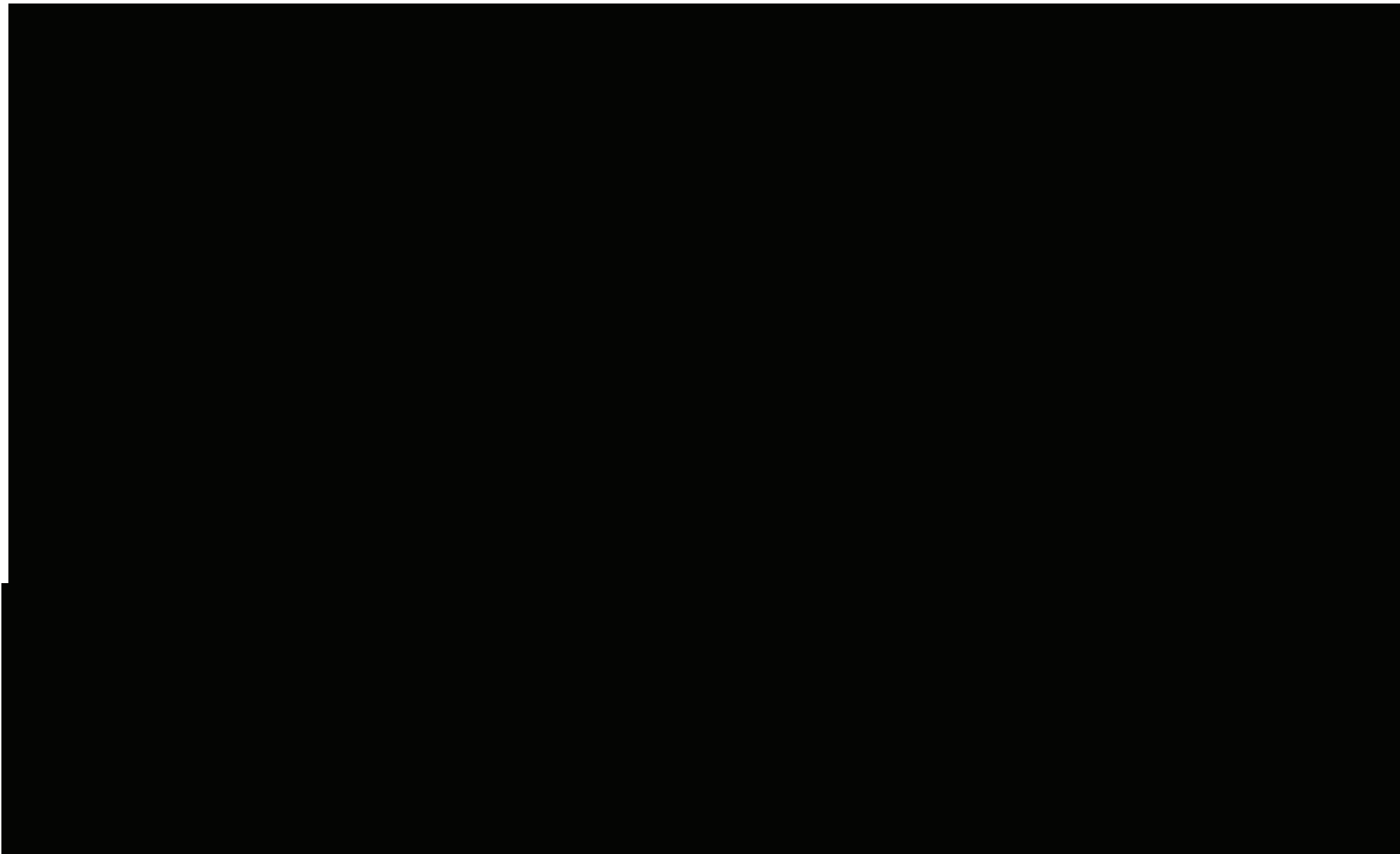
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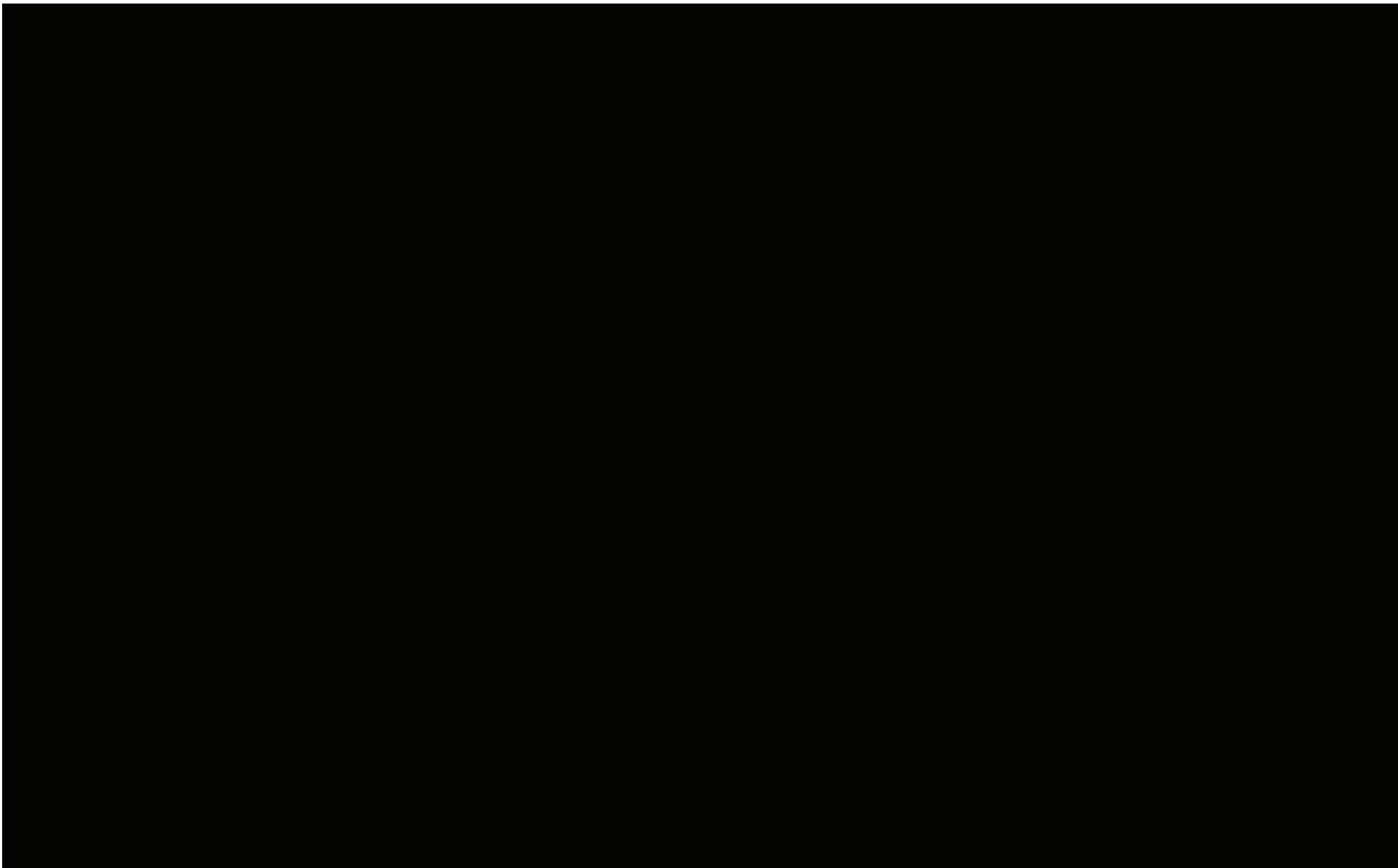
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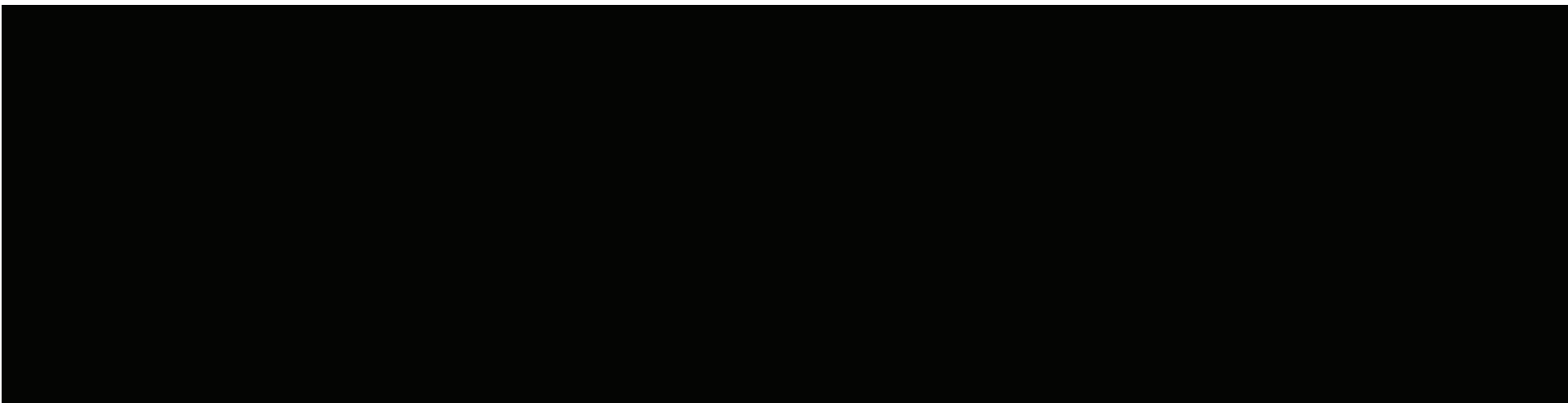
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4. Supplementary Site Investigation

4.1 Introduction

The intrusive investigation was designed to supplement existing information available for the site

The supplementary site investigation methodology is presented in Section 4.2 and is summarised below:

- site walkover;
- service clearance;
- 5 No. hand dug/augered pits numbered VP200 to VP204 installed as vapour monitoring wells;
- 15 No. trial pits numbered TP101 to TP115;
- 5 No. boreholes numbered BH101 to BH105 installed as groundwater monitoring wells;
- one round of surface water sampling from the drainage ditch adjacent to the site;
- two rounds of soil vapour sampling and groundwater dipping and sampling; and
- permeability testing and tidal monitoring.

During the site walkover undertaken on 17 May 2011 the site was noted to be covered with dense vegetation (largely buddleia) which would have severely restricted access for the site investigation works. The potential for sensitive ecology to be present was also noted and therefore an ecology site walkover and vegetation clearance works were scheduled in advance of the intrusive investigation.

The initial phase of intrusive ground investigation (hand pitting and trial pitting) was undertaken between 13 and 16 June 2011. During these works the boreholes drilled during Atkins' 2000 site investigation (BH1 though BH5) were found to have been decommissioned (see Appendix A.1, photograph 12) and therefore replacement groundwater monitoring wells were drilled between 28 June and 1 July 2011 as a second phase of intrusive works. All works were undertaken under the full time supervision of a suitably qualified Atkins site engineer.

Investigation locations from the recent and previous site investigations are presented in Figure 2.

4.2 Methodology

4.2.1 Service Clearance

Service clearance was undertaken in advance of the intrusive works by a specialist sub-contractor (Amethyst Surveys Ltd). No live services were identified during the clearance works with the exception of the known high voltage electricity cable within the access track leading to/from the electricity sub-station.

4.2.2 Ecology Survey and Vegetation Clearance

While not accounted for within the proposed scope of works presented in Atkins' offer of services (Ref. 1), in order to gain reasonable access to undertake the intrusive works, and provide suitable protection to potentially sensitive ecology present on the site, an ecology survey, followed by

vegetation clearance under a watching brief by a specialist ecologist, was required (see Appendix A.1, photographs 10 and 11).

An ecology survey was undertaken on 2 June 2011 with the observations made presented in Section 4.3.1. Subsequently, vegetation clearance was undertaken between 8th and 10th June 2011 by Homegrown Timber Ltd under an ecology watching brief. Areas where proposed site investigation locations were located were cleared of vegetation to ground level to create safe working areas. Where nesting birds were encountered, the investigation locations were moved.

On completion, approximately 50 % of the site was clear of vegetation. Remaining areas of dense vegetation are shown on the hazard plan presented as Figure 3. Further vegetation clearance may be required to remove constraints associated with access should further site investigation, remediation or development of the land be undertaken. [REDACTED]

4.2.3 Hand Dug/Augered Pits

A total of five hand dug/augered pits were progressed to a maximum depth of 1.3 m bgl, and installed as vapour monitoring wells (VP200 to VP204). The locations were positioned to enable the collection of soil and leachate samples [REDACTED]

The narrow diameter vapour wells were installed in accordance with current good practice guidance to allow vapour monitoring and sampling. Each well comprised a narrow diameter (< 5 mm) HDPE tube, air filter block and sampling tap. The annulus between the well material and borehole was filled using washed quartz sand around the filter block, and bentonite flakes to provide a seal over the plain pipe sections (installation details presented on the borehole logs included in Appendix A.3).

The permanent vapour wells were installed prior to the trial pitting, during which visual and olfactory evidence of hydrocarbon contamination was identified in the northern and north eastern areas of the site. In order to obtain vapour data from areas considered representative of those more contaminated conditions, one vapour sample per sampling round was taken in the vicinity of TP111 using an AMS Inc. vapour sampling probe system and 'retract-a-tip'. This vapour sampling methodology comprises the progression of a stainless steel temporary probe to the required sampling depth using a slide hammer. Once at the required depth, the probe is withdrawn approximately 1.5 cm to expose a sampling screen, and is then purged and sampled in-situ.

4.2.4 Trial Pits

A total of 15 trial pits were excavated under the full time supervision of Atkins across the site to a maximum depth of 2.7 m and positioned to enable the collection of soil and leachate samples from across the site, target specific historical structures and delineate the tarry residues identified in the vicinity of TP5 during Atkins' 2000 site investigation.

4.2.5 Borehole

Using a hollow stem auger drilling technique, five boreholes (BH101 through BH105) were progressed by Geotechnical Engineering Limited under the full time supervision of Atkins to a maximum depth of 11.0 m bgl. Each borehole was positioned to replace decommissioned historical boreholes BH1 through BH5, drilled during Atkins' 2000 site investigation.

Each borehole location was installed with a 50 mm HDPE monitoring well standpipe to enable subsequent collection of groundwater samples from the Chalk (installation details are presented on the borehole logs in Appendix A.3). Each well was completed with 5 mm gravel (within the response zone) and sealed with bentonite. Headworks for each monitoring location were completed using a traffic rated flush mounted cover.

Due to visual evidence of hydrocarbon contamination within the Alluvium at BH101, dual groundwater monitoring well installations were installed within the Alluvium (BH101S) and Chalk (BH101D) at this location to prevent creating a pathway to the underlying Chalk (though it should be noted that visual and olfactory evidence of hydrocarbon contamination was also noted within the Chalk during drilling).

4.2.6 Sampling and Monitoring

4.2.6.1 Soil and Leachate Sampling

Appropriate soil sampling and geological description (in line with current good practice) was undertaken at each investigation location. Sampling was informed by visual and olfactory indicators of contamination, and in-situ headspace screening of soils for volatile organic compounds (VOC) using a photo ionisation detector (PID). Sampling of soils was generally undertaken at the following rate:

- one sample within the top 1 m at each location; and
- one further sample above the saturated zone.

Sample selection was designed to ensure a suitable spread of data, both laterally and vertically which also included samples from the deeper (natural) strata.

A total of 35 soil samples were scheduled for the following analysis in line with the NGPH soils analytical suite:

- asbestos screen and identification, loss on ignition, moisture and stone content;
- inorganic parameters: pH, soil organic matter (SOM), total sulphate, sulphur, phenols, total, free and complex cyanide, thiocyanate, ammonium, chloride, boron;
- metals: arsenic, chromium, copper, lead, selenium, zinc, cadmium, mercury and nickel;
- polycyclic aromatic hydrocarbons (PAHs);
- benzene, toluene, ethylbenzene and xylene (BTEX); and
- total petroleum hydrocarbon (TPH) criteria working group (CWG) banding with aliphatic/aromatic split.

Analysis was undertaken by i2 Analytical (i2), the results of which are presented in Appendix E.1.

In addition, seven samples were scheduled for soil-derived leachate analysis (as per the groundwater analysis suite presented below), with the results presented in Appendix E.2.

4.2.6.2 Groundwater and Surface Water Monitoring and Sampling

Groundwater monitoring and sampling was undertaken on 7 and 15 July 2011. The groundwater samples were scheduled for analysis by i2 of the following:

- inorganic parameters: pH, total organic carbon (TOC), suspended solids, conductivity, total sulphate, sulphide, phenols, total, free and complex cyanide, thiocyanate, ammonium, chloride;
- metals: arsenic, chromium, copper, iron, lead, selenium, zinc, cadmium, mercury and nickel;
- PAHs;
- BTEX; and
- TPH CWG.

Groundwater analytical results are presented in Appendix E.3.

One surface water sample was obtained on 13 June 2011 from the surface water drainage ditch located to the north east of the site. The sample was taken down-stream of the site and to the north of the sluice gate where two drainage ditches converge and join the River Arun. The sample was analysed for the same suite as the groundwater samples, with the results presented in Appendix E.4.

Aquifer permeability testing was also undertaken at BH101D, BH102 and BH103 (all installed within the Chalk Aquifer) and continuous groundwater elevation monitoring was undertaken at BH101D, BH104 and BH105 to determine the impact of tidal variation in the River Arun on the groundwater elevation beneath the site. [REDACTED]

4.2.6.3 Soil Vapour Monitoring

Soil vapour samples were collected from four of the five permanent vapour well locations (VP200, VP202, VP203 and VP204) on 7 and 15 July 2011. In addition, samples were taken adjacent to TP111 using the temporary AMS vapour probe (and labelled VP201-temp). Sampling was not possible from the permanent well installation at VP201 due to water saturation of the filter block at the time of sampling.

Prior to sampling, the well volume was purged using a gas syringe. A low flow air sampling pump was used to draw a fixed volume of gas through atomic thermal desorption (ATD) tubes, pre-prepared by Chemex Limited (a UKAS accredited laboratory) with 'Tenax' sorbant. The tubes were submitted for thermal desorption-mass spectrometry analysis of the following:

- VOCs including naphthalene, tentatively identified compounds (TICs) and speciated aliphatic and aromatic petroleum hydrocarbons in accordance with the CWG fractionations.

Appendix E.5 presents the analytical results for the vapour samples.

4.2.6.4 Quality Assurance/Quality Control

Trip and Field Blanks

Field and trip blank water samples were taken during the second groundwater sampling round (15 July 2011). Trip blank vapour samples were taken during both sampling rounds and an ambient air sample was taken during the second vapour sampling round (15 July 2011). The field and trip blanks were analysed as control samples to identify any cross-contamination in the field. The ambient air sample was analysed to identify any background concentrations of volatile constituents. Analytical results are included within Appendix E.

Schewart Charts

In order to check the laboratory QA/QC procedures, Schewart charts have been requested from i2 and will be reviewed and discussed within the final version of this report.

4.3 Physical Investigation Findings

Appendix A.1 presents a selection of photographs taken during the 2011 site works.

4.3.1 Ecology

4.3.1.1 Birds

During the walkover survey, evidence of breeding birds was observed across the site. This included singing birds including dunnocks, common whitethroats, a chaffinch and a sighting of a recently fledged song thrush. [REDACTED]

4.3.1.2 Reptiles

The River Arun is located to the southeast of the site and has a bank consisting of a 10 m wide strip of dense ruderals. This bank has high/medium potential for reptiles. The bank and river are separated from the site by approximately 20 m of a short-grazed grass field, but the habitats are connected [REDACTED]

[REDACTED] The site itself is of low suitability for reptiles as it consists of buddleia with little or no ground vegetation, or extremely dense scrub. However, there is an area in the west of the site that is more open, contains low ruderals [REDACTED].

4.3.1.3 Great Crested Newts

Busy roads to the north and east, and a river to the south form barriers to the movement of great crested newts (GCNs) on to the site. There are houses present to the east. No ecological desk study has been carried out and therefore it is not possible to confirm whether there are ponds within 500 m of the site or whether there are GCNs present in the surrounding area. [REDACTED]

[REDACTED]

4.3.1.4 Badgers

No evidence of badgers was recorded during the walkover survey. However a raised area of ground, marked as a spoil heap on Figure 2, could not be inspected due to the dense scrub that covers it. A large proportion of the site appeared to be covered by a layer of dense stones and no clear animal signs or tracks were recorded during the walkover. [REDACTED]

[REDACTED]

4.3.1.5 Other Legally Protected or Notable Species

There was no evidence of any other legally protected or notable species, however no ecological desk study has been undertaken and parts of the site were inaccessible due to the dense vegetation so findings are limited.

4.3.2 Site Specific Geology

Appendix A.3 provides the intrusive logs from the 2011 site investigation, with a summary of the findings presented below.

4.3.2.1 Made Ground

Made Ground was identified at all locations across the site at thicknesses ranging between 0.5 m (BH102 and TP104) and 2.7 m (BH101). The base of the Made Ground was not proven at TP108B (>2.5 m), TP111 (>2.3 m), VP202 (>1.0 m), VP203C (>1.2 m) or VP204 (>1.3 m).

The composition of the Made Ground was variable across the site, but generally comprised firm, sandy, gravelly clay and fine to medium, gravelly, clayey sand with frequent brick, chalk and flint gravels and fragments of clinker. The concrete bases of two former gas holders were identified in: TP106 at between 0.95 m bgl to 1.1 m bgl (feature 8, Figure 2) (see Appendix A.1, photograph 16); and TP114 at between 0.55 m bgl to 0.85 m bgl (feature 15, Figure 2) (see Appendix A.1, photographs 23 and 24). Other obstructions encountered are as follows (marked on the constraints and hazard plan presented as Figure 3):

- TP101 – a brick wall was identified at 0.3 m bgl in the northern portion of the pit, with a concrete base at 0.8 m bgl;
- TP103 – a brick wall and concrete base were identified at approximately 0.5 m bgl (see Appendix A.1, photograph 15);
- TP104 – a series of electricity cables (previously identified as redundant during Atkins' 2000 investigation) were encountered at approximately 0.4 m bgl;

- TP107 – a possible brick wall was encountered at the southern extent of the pit;
- TP108 – three cast iron pipes were encountered crossing the pit. Two at 0.8 m bgl and one at 1.2 m bgl (see Appendix A.1, photograph 17);
- TP109 – a brick wall was identified at 0.3 m bgl in the northern portion of the pit, with a concrete base at 0.8 m bgl (see Appendix A.1, photograph 20);
- TP111 – a cast iron pipe was located at the southern extent of the pit at approximately 0.5 m bgl; and
- TP115 – three cast iron pipes located in an initial trial hole dug adjacent to the edge of the former governor compound at approximately 0.4 m bgl. The trial pit was relocated to the centre of the former governor compound.

4.3.2.2 Natural Ground

Where natural ground was encountered, this comprised Alluvium of stiff, very gravelly clay or fine to coarse sub-rounded to angular flint gravels in a stiff clay matrix ranging between 0.7 m (BH101) to 5.1 m (BH103) thickness, overlying Chalk. The Chalk was found to be structureless fine Chalk gravels and chalk cobbles in a soft off-white/grey clay matrix. The top of the Chalk was generally encountered between 5.1 m (BH102) and 6.8 m (BH104) bgl. However, Chalk was encountered at 3.4 m bgl at BH101.

4.3.3 Indications of Potential Contamination (Visual and Olfactory Observations)

A number of visual and olfactory indicators of potential contamination were identified in the Made Ground, Alluvium and Chalk during drilling. In addition, preliminary screening for VOC vapours present within the shallow unsaturated soils was undertaken using a PID (MiniRAE 2000 VOC detector), capable of measuring VOC concentrations in parts per million (ppm). The results of the PID screening provide an initial indication of the presence of volatile compounds within the soil profile; however, this method is non-selective and does not identify specific compounds. PID screening helps to ascertain where volatile compounds may be expected to be identified during soil laboratory analysis. PID readings greater than 10 ppm are presented in Table 4.1.

Table 4.1 details visual and olfactory observations made during the intrusive works and the maximum positive PID readings identified at these depths.

Table 4.1 - Visual and Olfactory Observations and PID Readings

Location	Strata	Depth (m bgl)	Visual/Olfactory Observation	Max VOCs (ppm)
BH101	MG	0.0-1.2	Clinker.	-
	ALV	1.5-2.7	Black mottling and occasional pockets of saturated black tar. Faint hydrocarbon odour from 1.5-1.8 m bgl. Strong hydrocarbon odour from 1.8-2.7 m bgl.	-
	ALV	2.8-3.4	Dark grey/black clay and gravels with strong hydrocarbon odour and saturated with free product (see Appendix A.1, photograph 25).	-
	CHK	3.4-7.5	Pockets of free phase product and black mottling with a moderate to slight hydrocarbon odour (see Appendix A.1, photographs 26 and 27).	-
	CHK	7.5-11.0	Slight hydrocarbon odour.	-
BH103	MG	0.0-0.5	Clinker.	-

Location	Strata	Depth (m bgl)	Visual/Olfactory Observation	Max VOCs (ppm)
BH105	MG	0.3-2.0	Clinker.	-
BH104	MG	0.0-1.8	Clinker.	-
	MG	3.5-3.65	Faint hydrocarbon odour.	-
TP101	MG	0.0-0.4	Clinker.	0.1
	MG	0.4-0.6	Black ash and clinker.	0.1
	MG	0.6-0.9	Occasional clinker.	-
TP102	MG	0.0-0.3	Clinker.	-
TP103	MG	0.0-0.8	Clinker.	0.2
TP104	MG	0.0-0.5	Occasional clinker.	<0.1
TP105	MG	0.9-1.3	Clinker gravels and black ash.	0.1
TP106	MG	0.0-0.95	Clinker.	0.3
TP108A	MG	0.0-1.2	Clinker.	0.2
TP108B	MG	0.9-2.5	Occasional clinker. Slight hydrocarbon odour from 1.4-1.9 m bgl. Strong hydrocarbon odour from 1.9-2.5 m bgl. Black, hydrocarbon saturated soil from 1.9 m bgl (see Appendix A.1, photographs 18 and 19).	0.6
TP109A	MG	0.0-0.8	Clinker. Black stained flints and faint hydrocarbon odour from 0.4-0.8 m bgl (see Appendix A.1, photograph 20).	1.9
TP109B	MG	0.0-1.6	Clinker.	0.0
TP110	MG	0.2-0.5	Clinker.	0.2
TP111	MG	0.2-1.1	Clinker and solidified tar fragments.	0.7
	MG/ ALV	1.1-2.0	Clinker and saturated tarry soils. Moderate tar odour from 1.3 m bgl. Strong tar odour from 1.4 m bgl. Slight hydrocarbon/tar odour and occasional black staining from 1.6-2.0 m bgl.	12.7
TP112	MG	0.0-0.2	Clinker.	-
	MG	0.7-0.75	Band of black solidified tar and clinker.	-
TP113	MG	0.0-1.0	Clinker.	2.4
	ALV	1.25-2.3	Pockets of hydrocarbon saturated tarry clay. Strong hydrocarbon/tarry odour (see Appendix A.1, photographs 21 and 22).	18.2
TP115	MG	0.9-2.0	Clinker.	0.1
VP200A	MG	0.0-0.3	Solidified tar.	-
VP201	MG	0.0-0.25	Clinker.	-
VP202	MG	0.0-1.0	Clinker.	0.2
VP203C	MG	0.1-0.6	Clinker.	0.2
VP204	MG	0.0-0.3	Clinker.	0.2
	MG	0.85-1.3	Fragments of solidified tar.	0.6

Notes: “-” PID reading not taken; MG – Made Ground; ALV – Alluvium; CHK - Chalk

[REDACTED]

[REDACTED] Due to constraints encountered during the recent site investigation works associated with vegetation, nesting birds and underground pipe work (identified in TP108 and TP111), it was not possible to extend the trial pit locations in order to fully delineate this potential source area.

No evidence of asbestos was visually identified during the recent or previous site investigations and asbestos has not been positively identified within any of the soil samples submitted for analysis.

4.3.4 Perched Water/Groundwater

Water was identified in three trial pit locations (TP102, TP106 and TP112) during the recent works at depths ranging between 1.30 and 2.65 m bgl [REDACTED]

[REDACTED]

One set of groundwater levels measured at high tide (at 00:34 on 15 July 2011) and one at low tide (at 19:24 on 17 July 2011) are presented in Table 4.2. [REDACTED]

[REDACTED]

[REDACTED] The tidal monitoring undertaken between 7 and 15 July 2011 also indicates that there is significant tidal variation in the groundwater level at the site (up to approximately 2 m variance).

Table 4.2 - Groundwater Monitoring at High and Low Tide

Location	Groundwater Level at High Tide (Metres Above Ordnance Datum (m aOD))	Groundwater Level at Low Tide (m aOD)
BH101	1.937	0.363
BH104	2.003	-0.034
BH105	2.078	0.030

4.4 Health, Safety and Environmental Incidents

All sub-contractors working on site were given a full site induction by the Atkins Lead Engineer prior to commencing works. In addition a site log of health, safety or environmental incidents was maintained throughout the duration of the works.

There were no reportable health, safety or environmental incidents during the works. Additional hazards and constraints identified during the site investigation works were added to the hazards and constraints plan, presented as Figure 3.

4.5 Laboratory Analysis

Laboratory analytical results are presented in Appendix E and summarised within Sections 5 and 6.

4.5.1 QA/QC

4.5.1.1 Field and Trip Blanks

Groundwater

Field and trip blank water samples were analysed for the 15 July 2011 sampling round. Table 4.3 presents the concentrations identified above the MDL.

Table 4.3 - Concentrations above the MDL in Field and Trip Blank Samples

Analyte	MDL (mg/l)	15 July 2011 Concentrations (mg/l)	
		Field Blank	Trip Blank
Sulphate	0.045	1.9	1.3
Ammonium	0.015	1.3	0.47
Chromium	0.0004	0.001	0.0007
Copper	0.0007	0.0011	0.0011
Nickel	0.0003	0.0011	0.0011

[REDACTED]

The field blank was taken by decanting a distilled water sample supplied by the laboratory into clean, unused sample jars whilst in the field. Correct sampling procedure was followed [REDACTED]

[REDACTED]

Vapour

Trip blank vapour samples (labelled Trip Blank) were analysed for each sampling round. As shown in Appendix E.5, a concentration above the MDL for toluene was identified in the trip blank sample during the 7 July sampling round (20 ng/tube).

[REDACTED]

The trip blanks remained sealed and within their packaging for the duration of the sampling [REDACTED]

[REDACTED]

[REDACTED]

4.5.1.2 Schewart Charts

Schewart charts have been requested from i2 [REDACTED]

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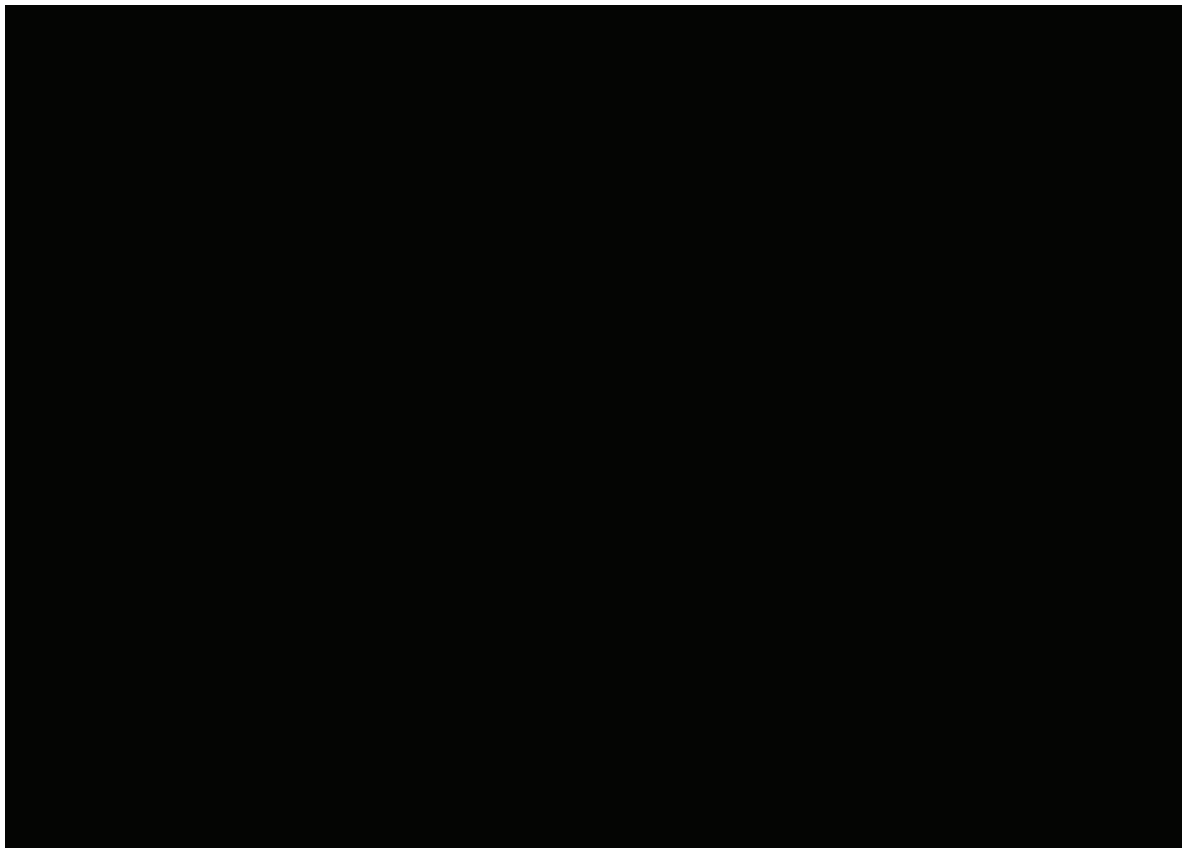
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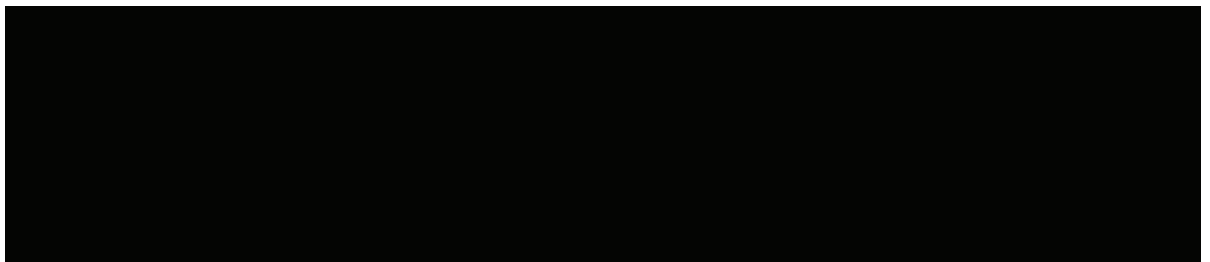
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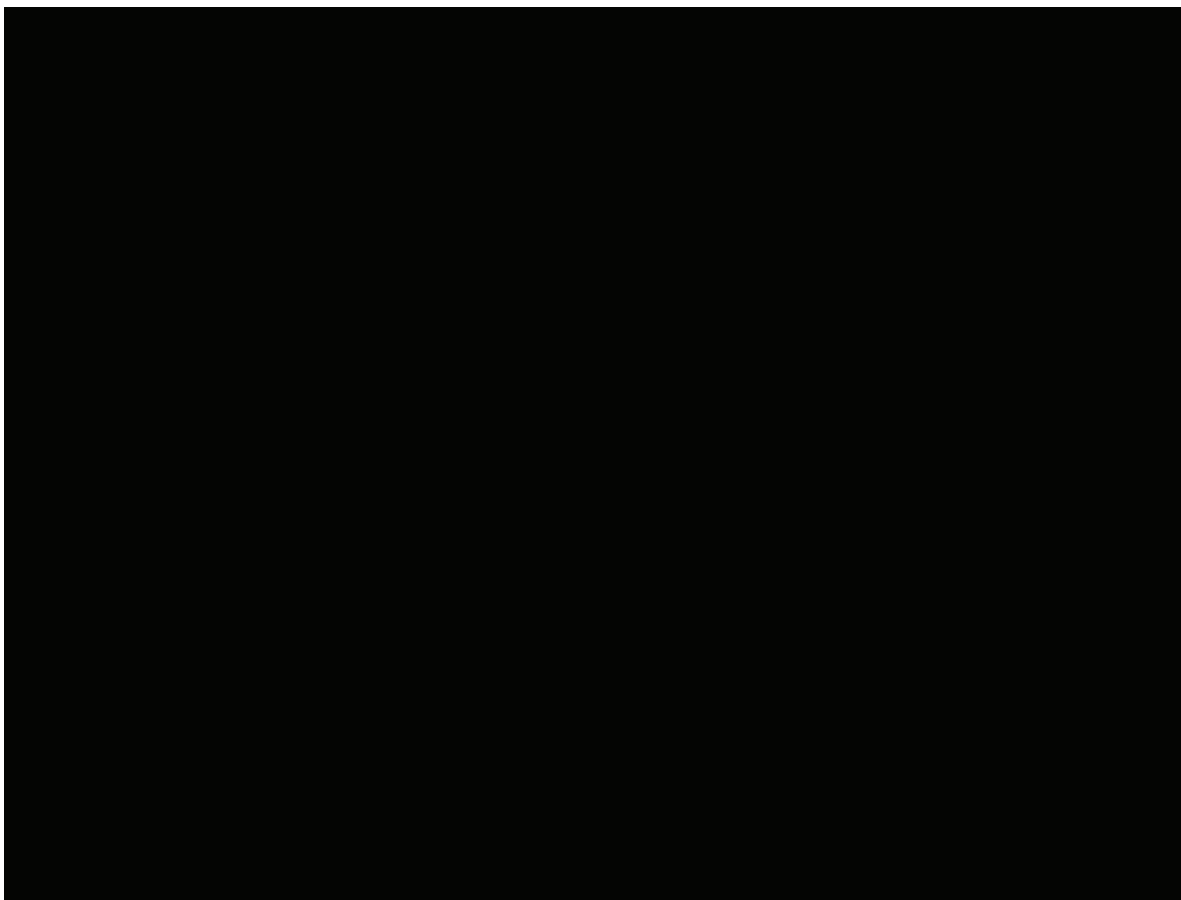
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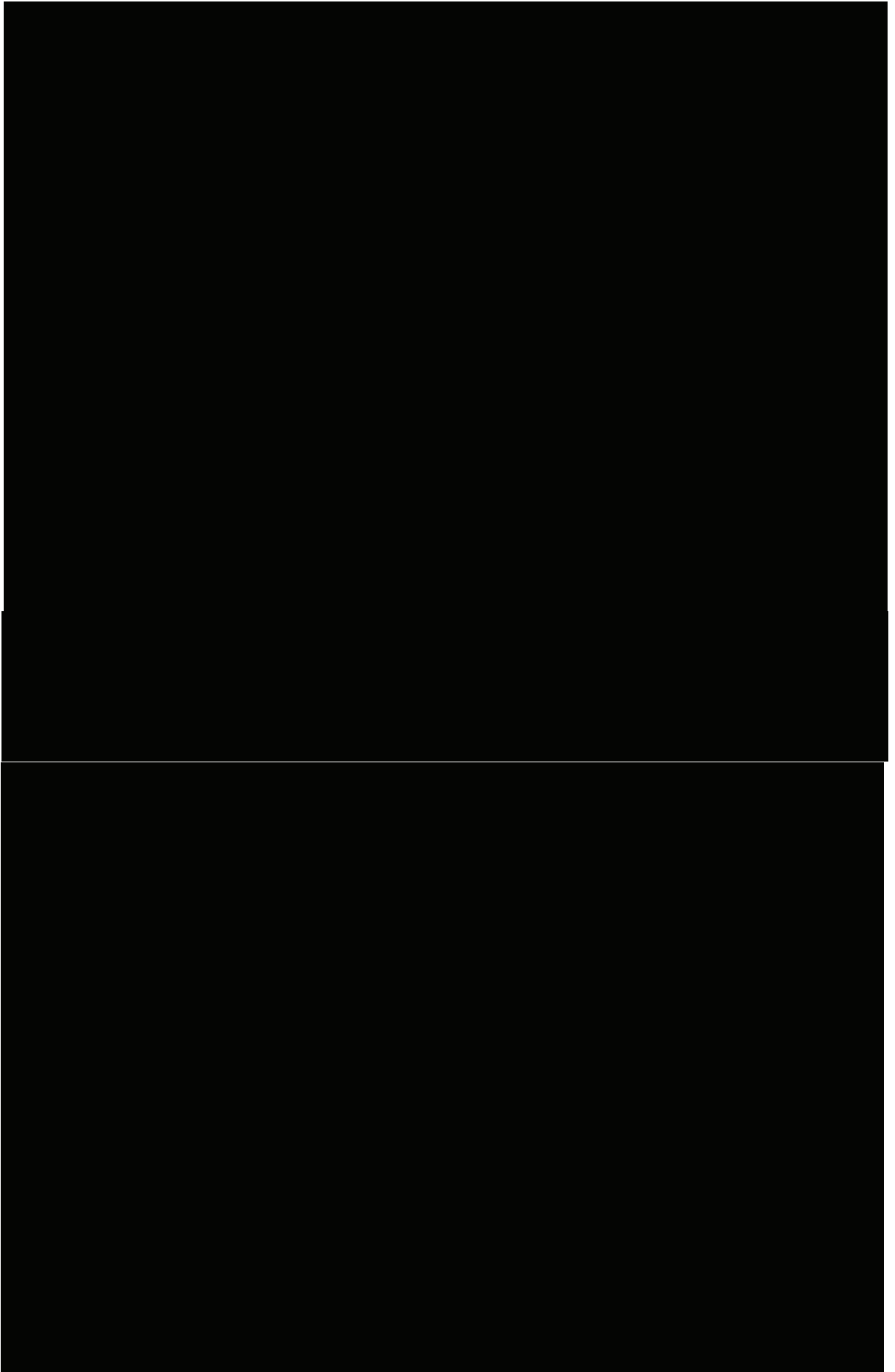
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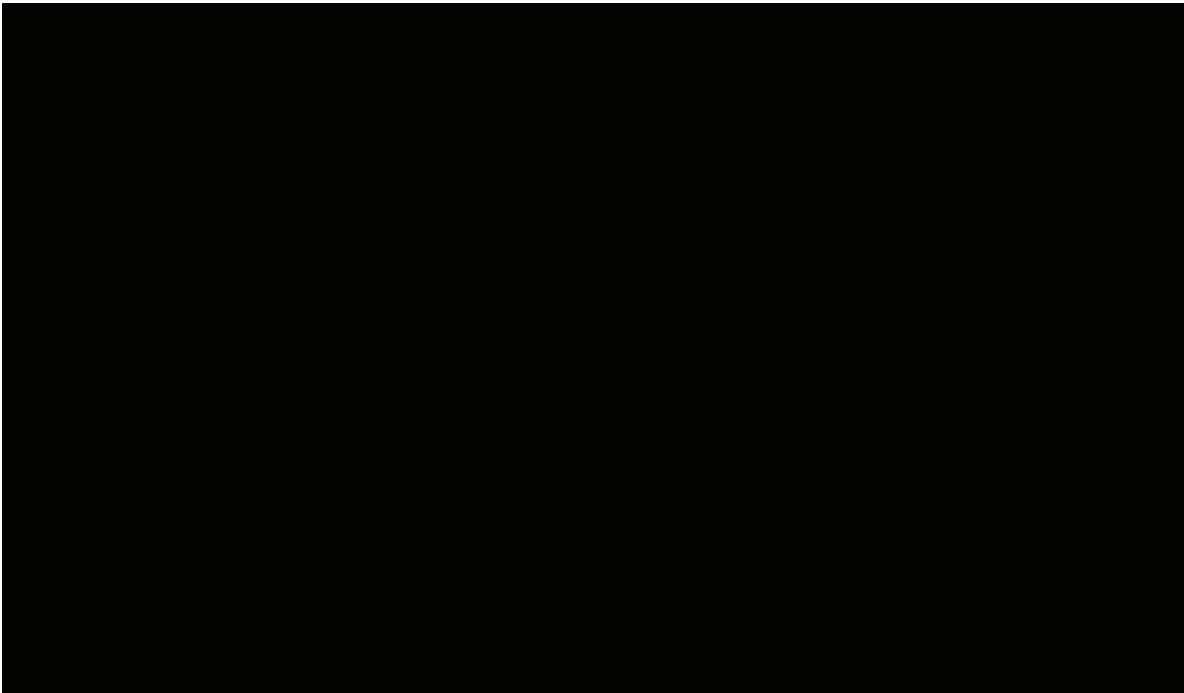
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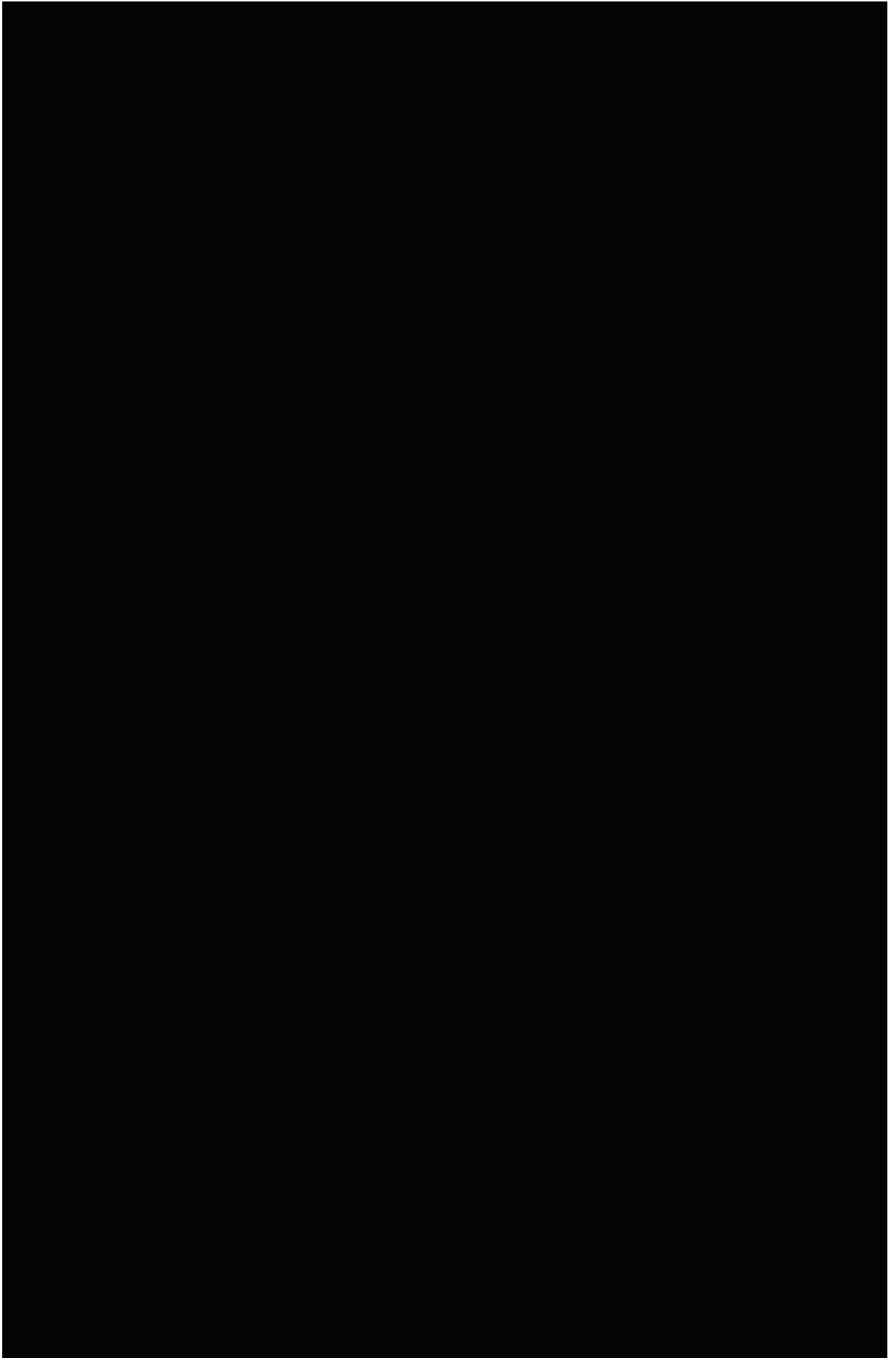
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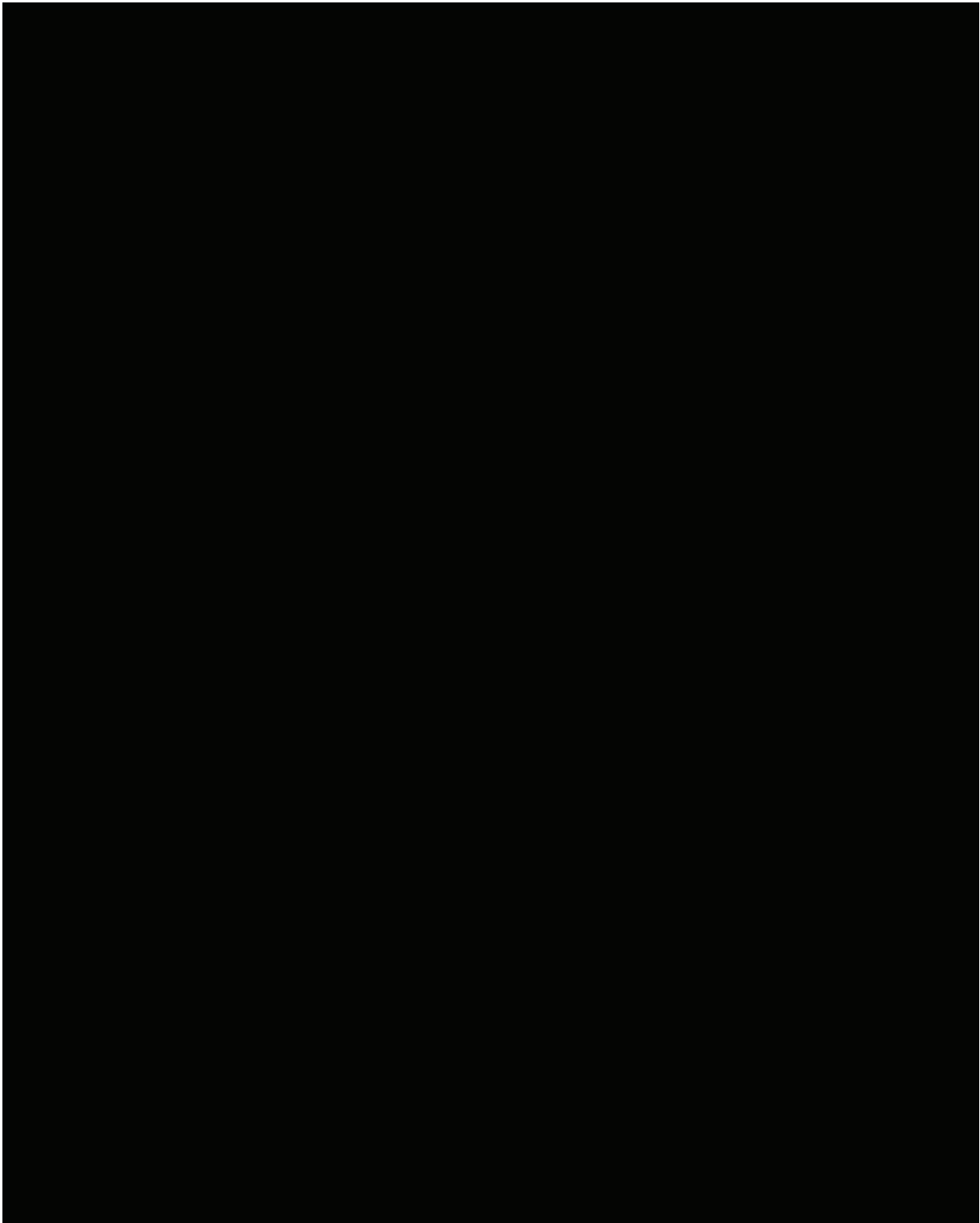
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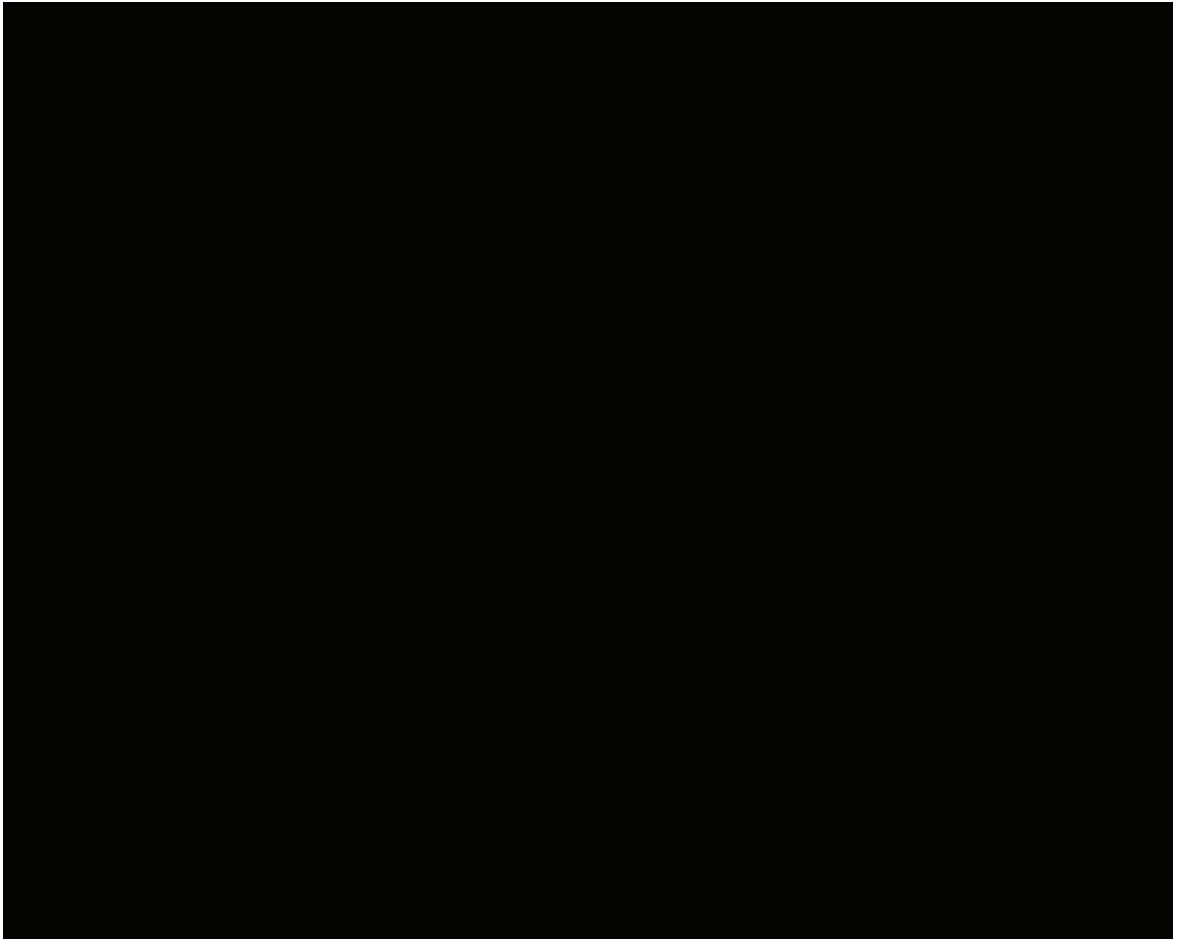
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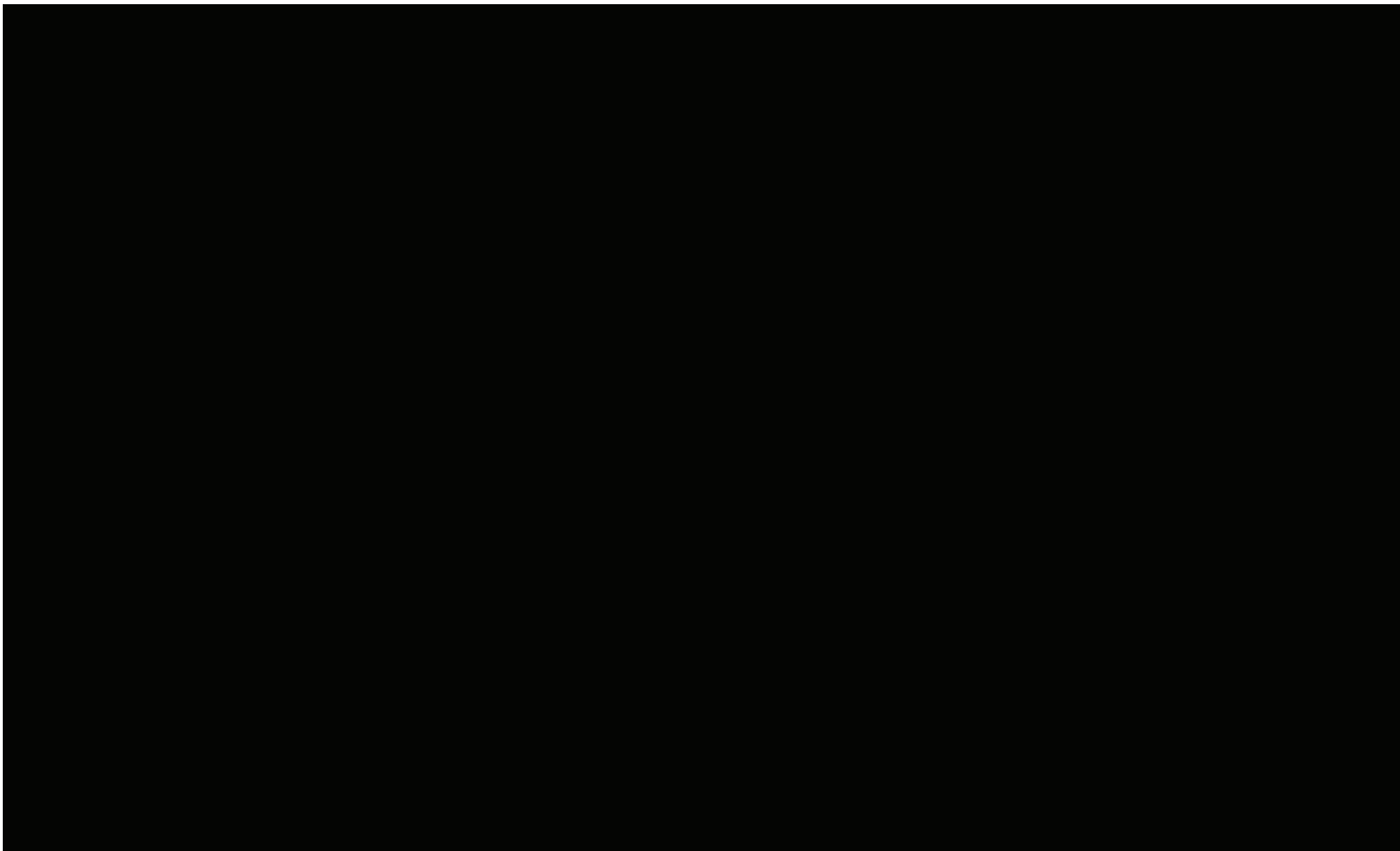
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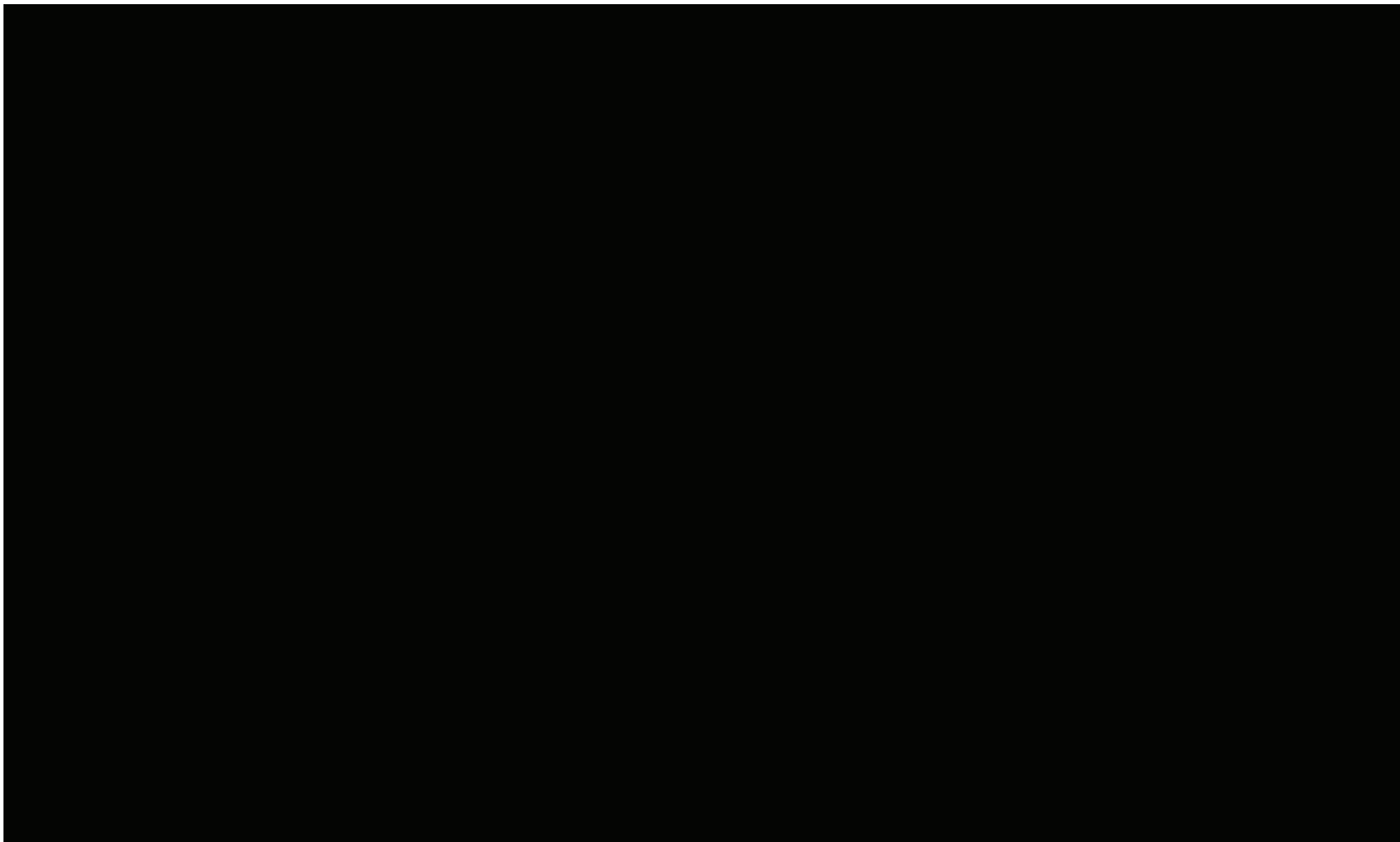
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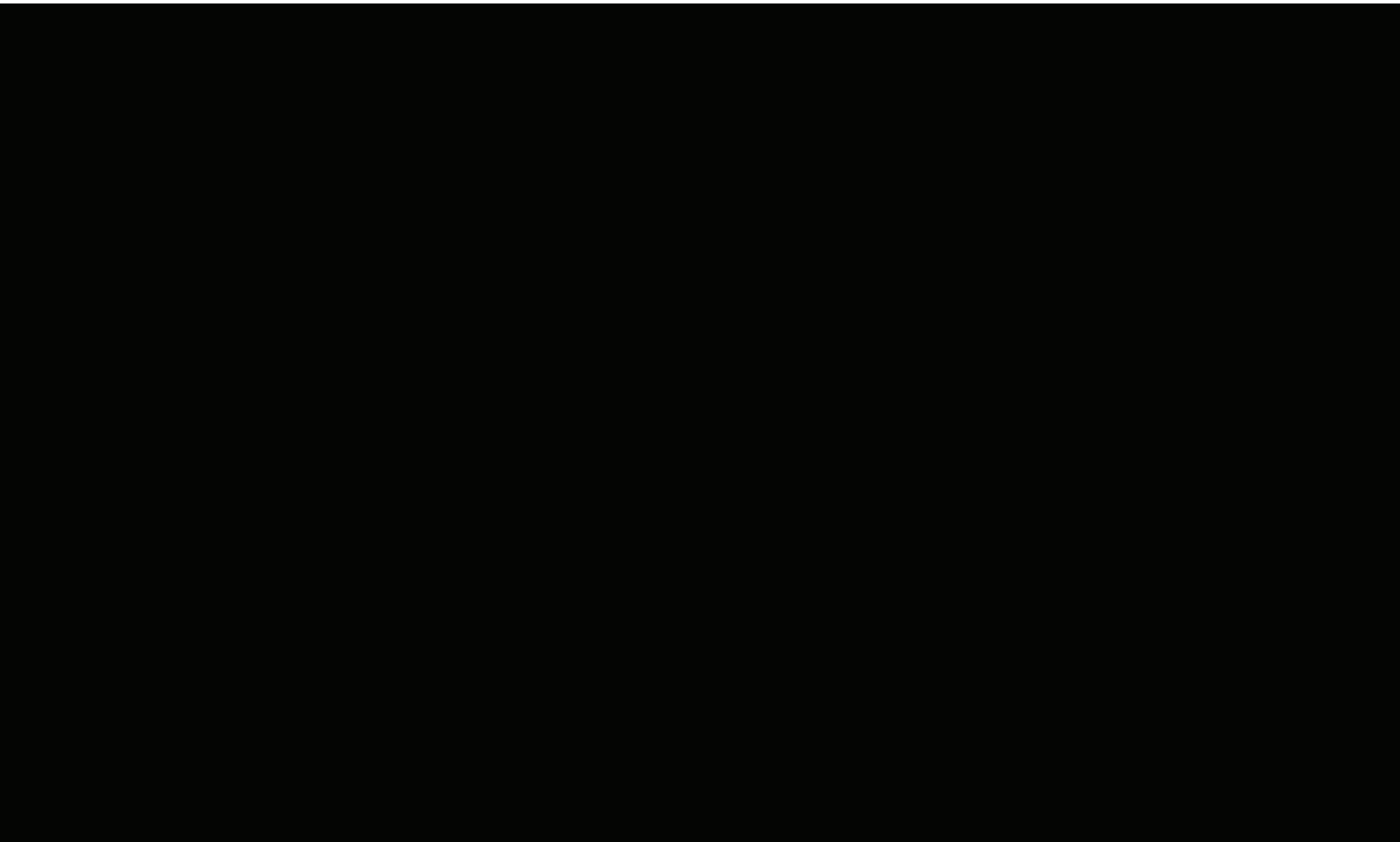
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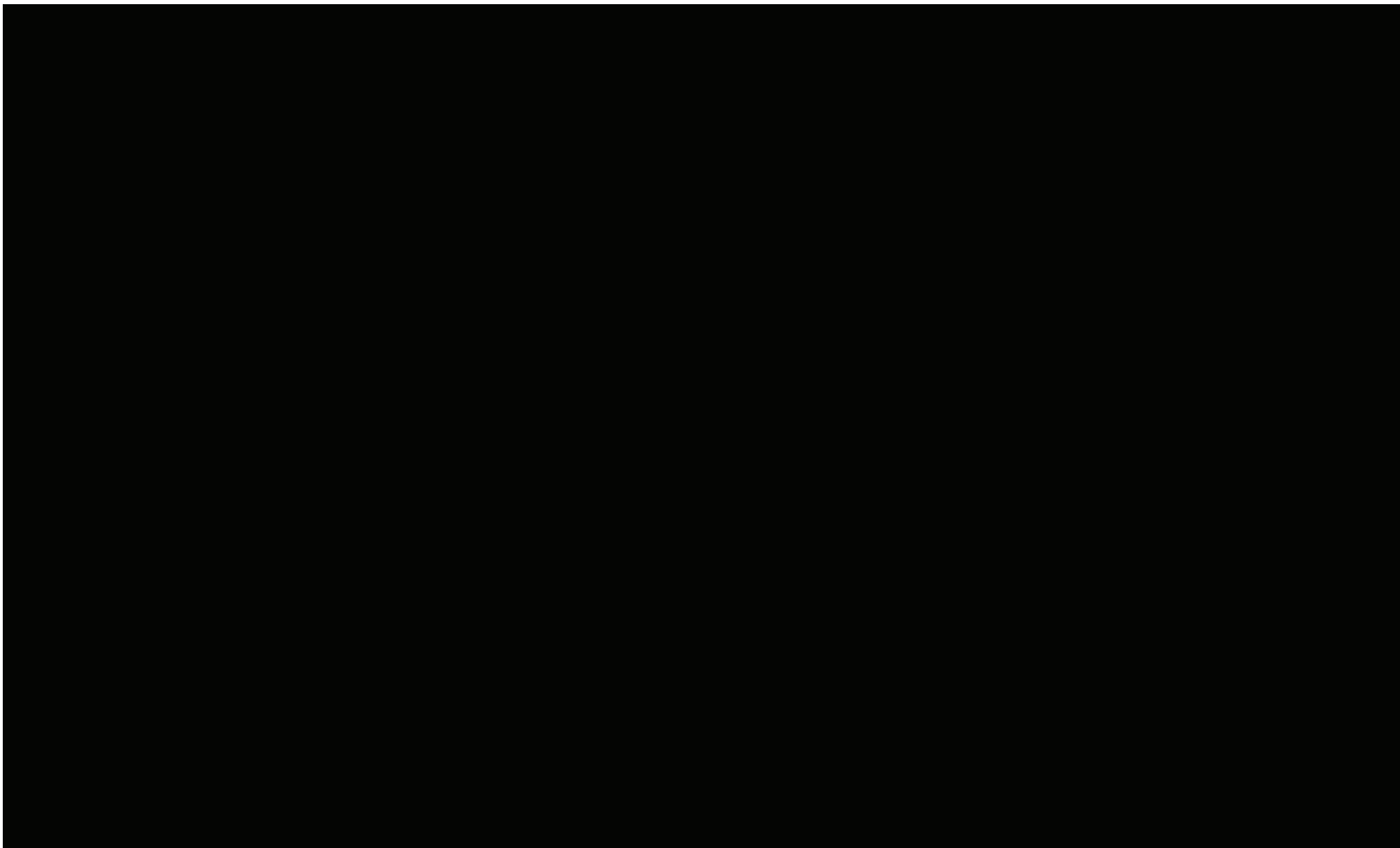


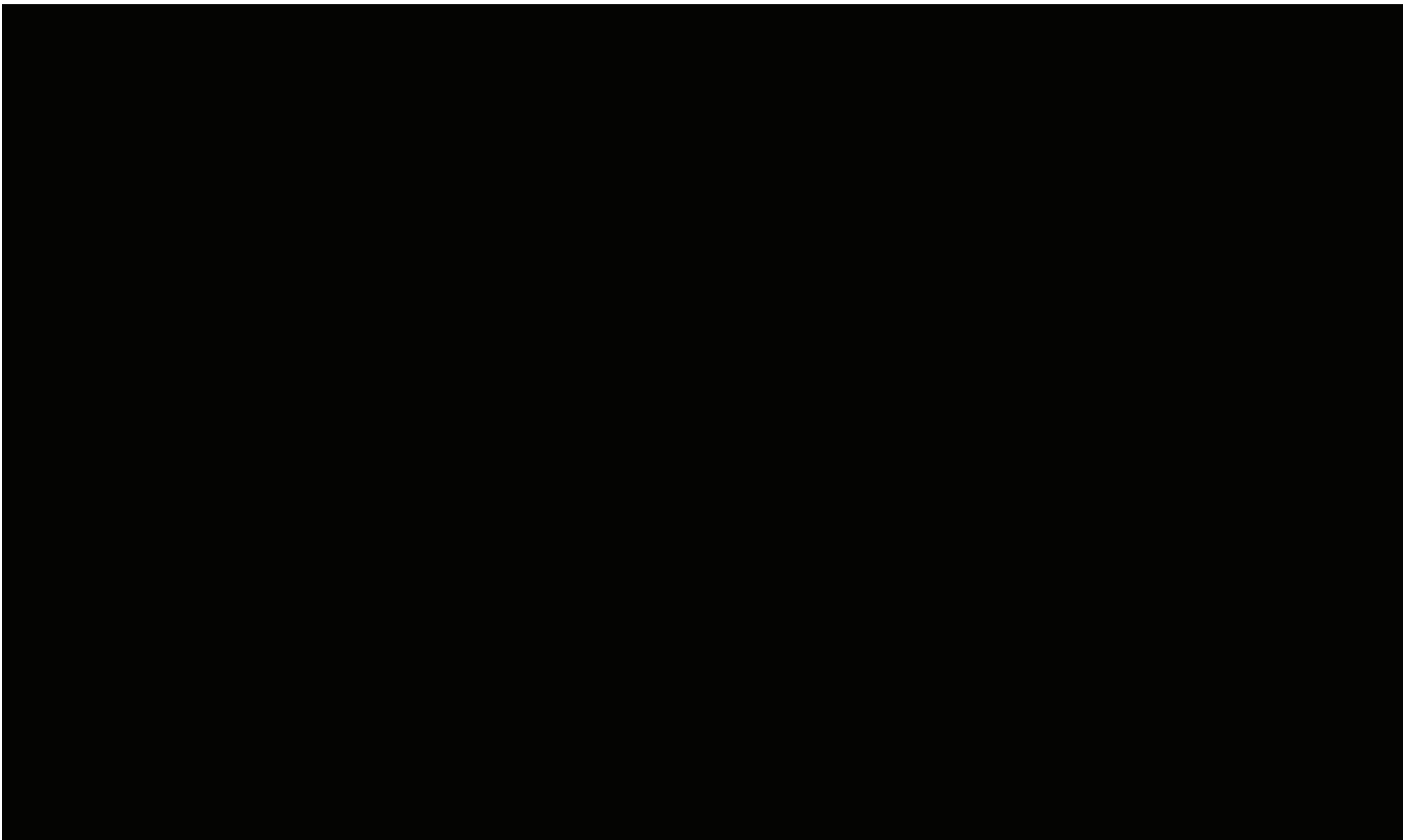
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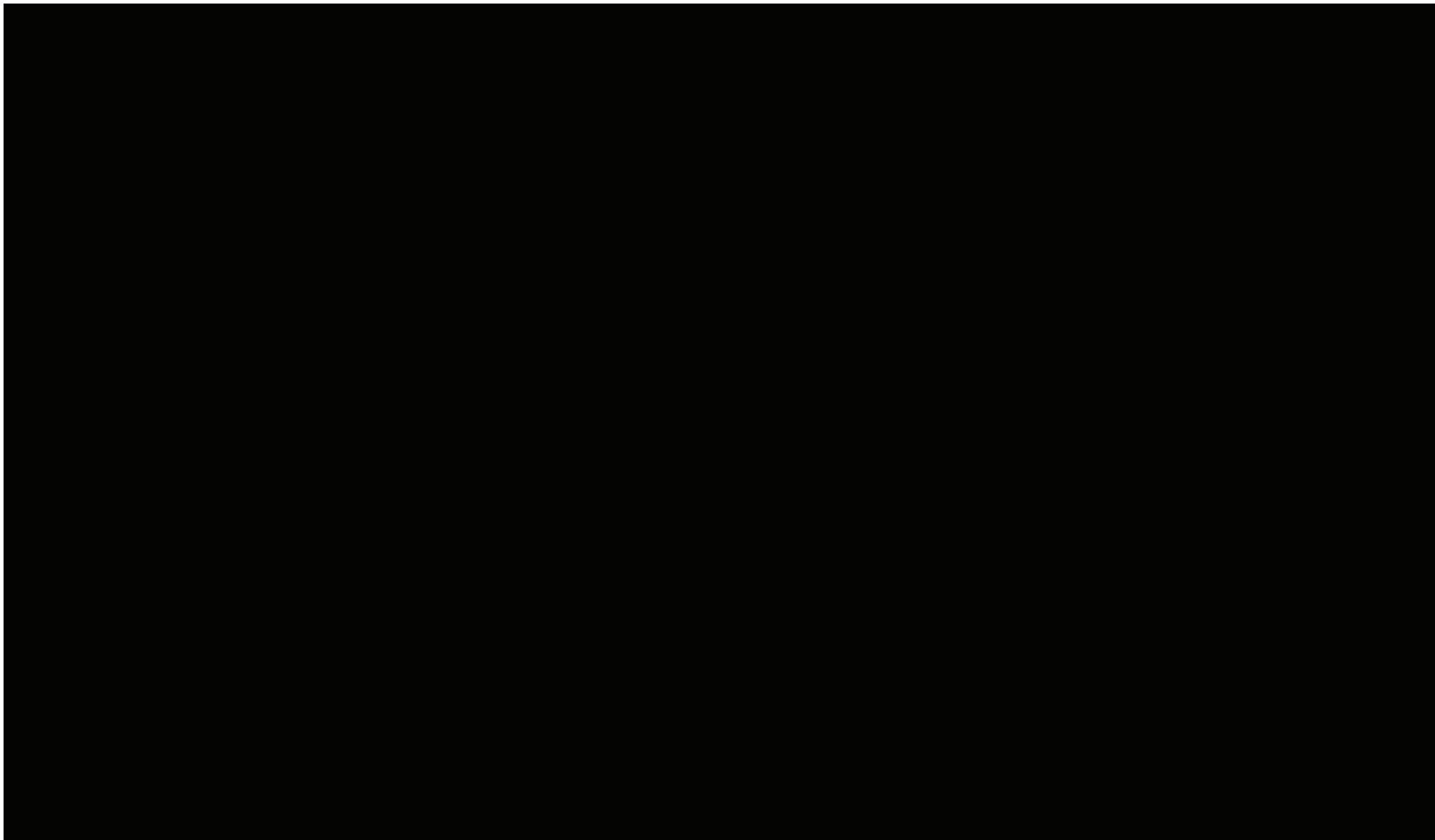


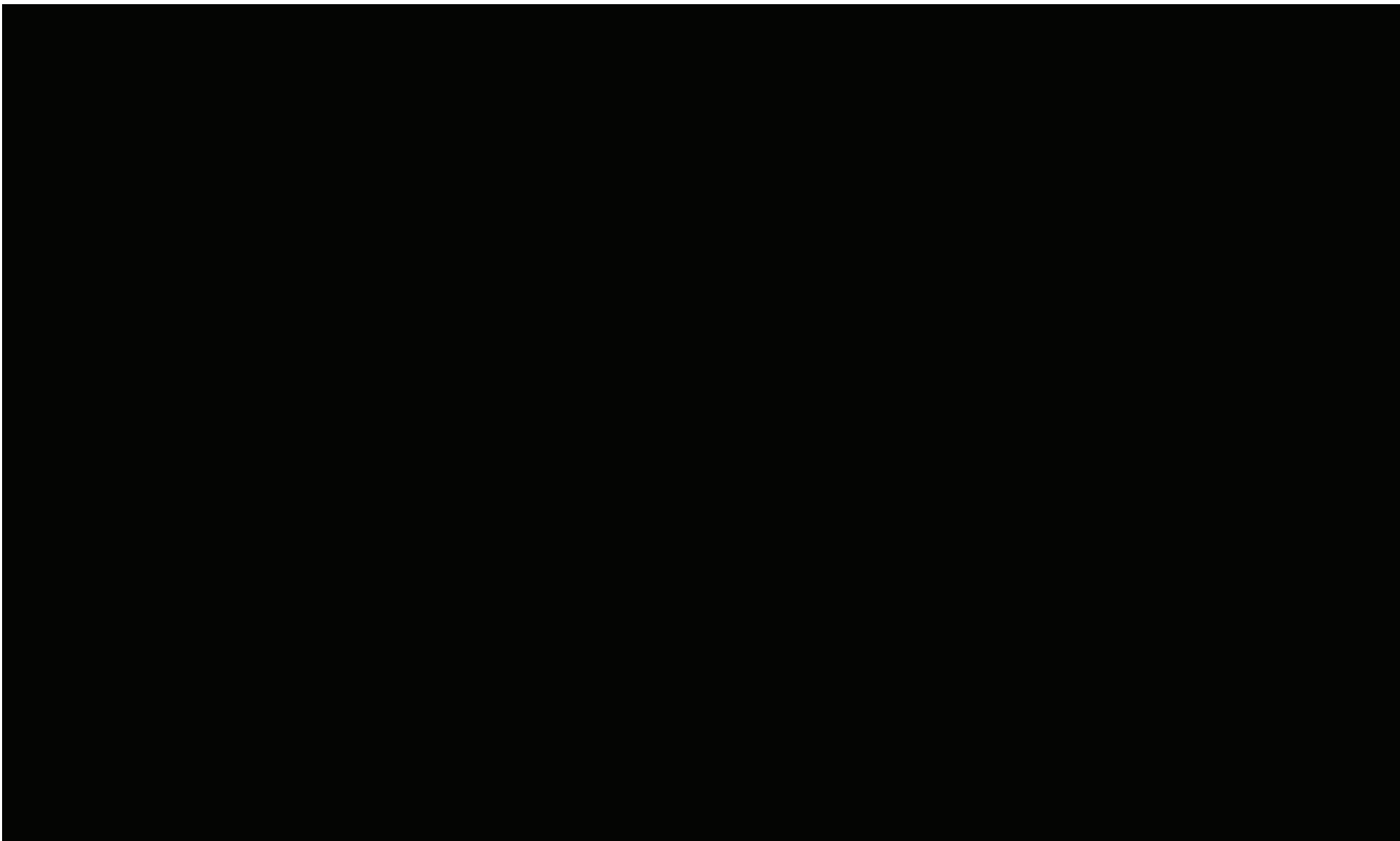


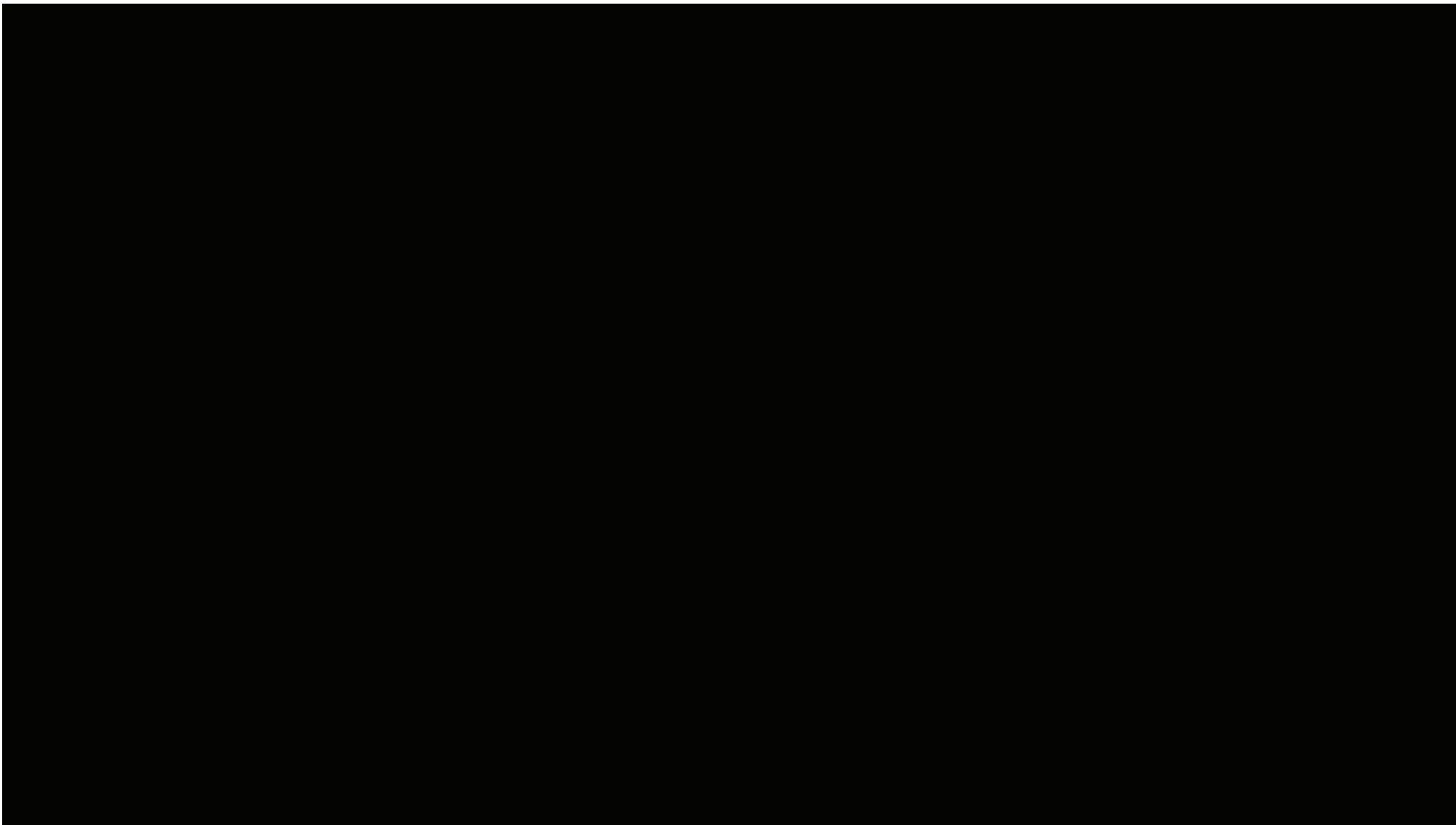


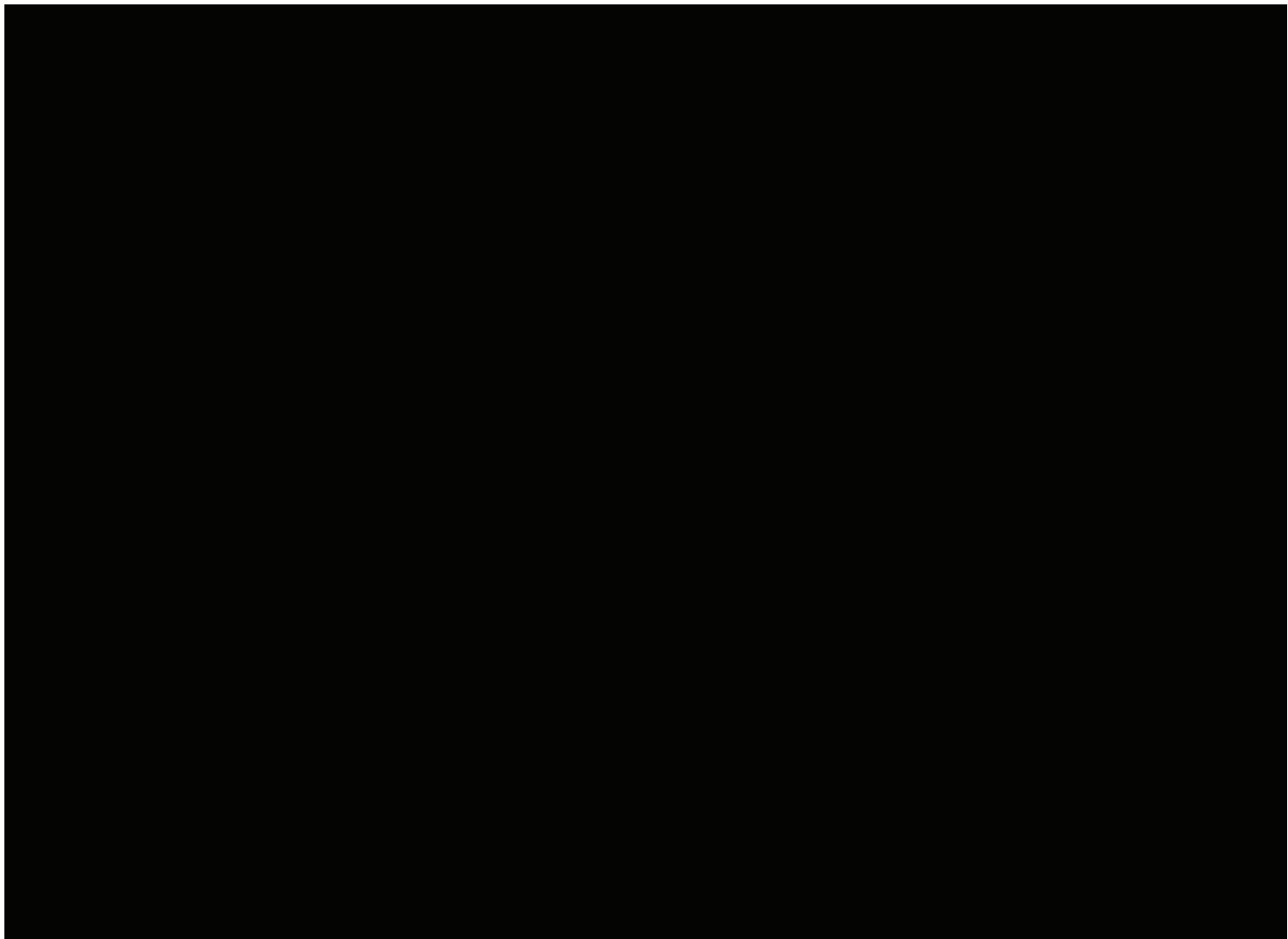












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Figures



REVISIONS	Drawn by	Checked by	Date

SI & GQRA Report	Rev 0	MW	3/6/11
PURPOSE OF ISSUE	Rev.	Authorised for issue	Date

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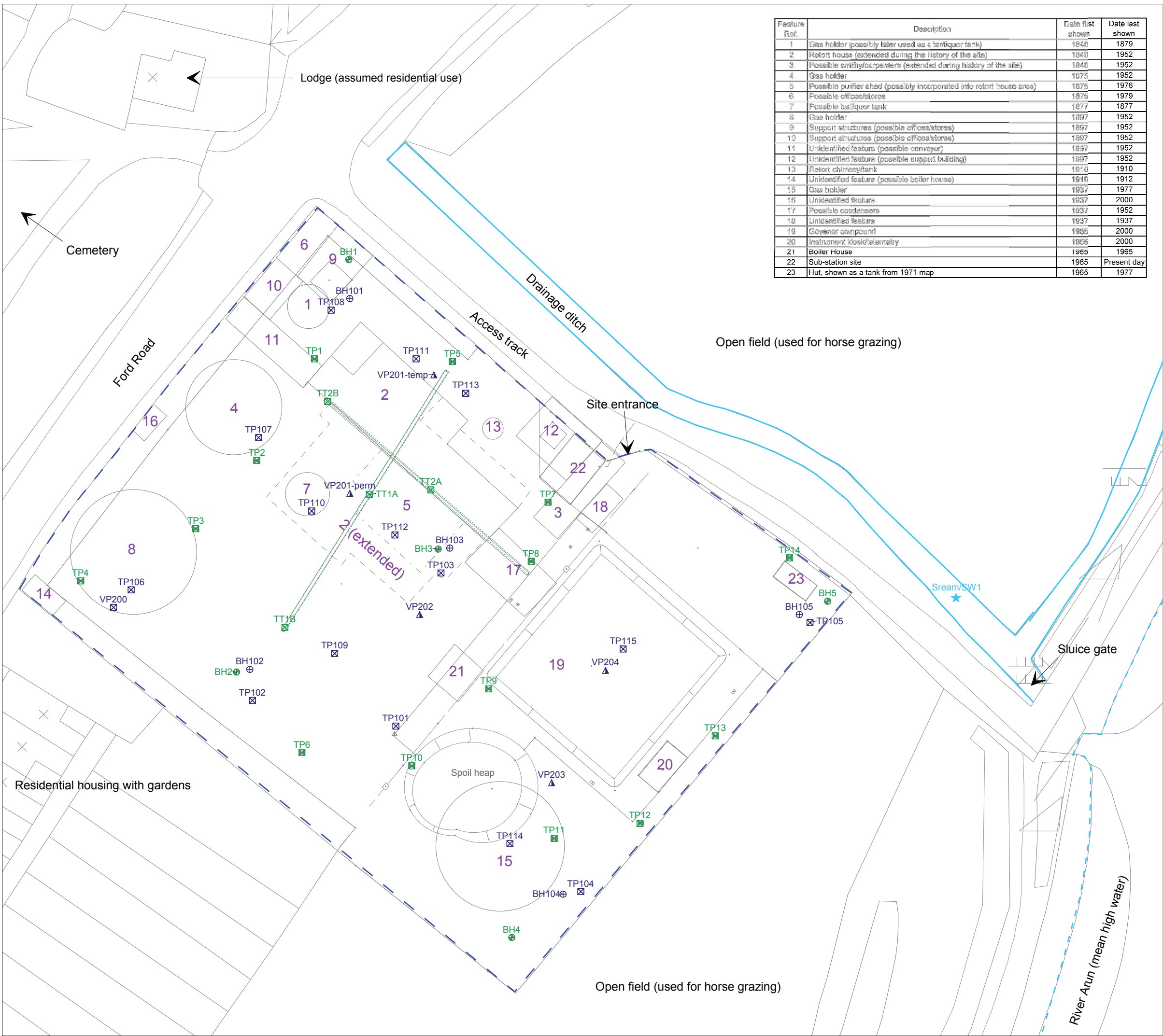
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National Grid Property Holdings Limited

PROJECT
**Ford Road, Arundel
Land Contamination Site Investigation and GQRA**

DRAWING TITLE
Site Location Plan

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	DATE	DATE	DATE
	03/06/2011	03/06/2011	-
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DRAWING NO
Figure 1



Feature Ref.	Description	Date first shown	Date last shown
1	Gas holder (possibly later used as a tarliquor tank)	1840	1879
2	Retort house (extended during the history of the site)	1840	1952
3	Possible smithy/carpenters (extended during history of the site)	1840	1952
4	Gas holder	1875	1952
5	Possible purifier shed (possibly incorporated into retort house area)	1875	1976
6	Possible offices/stores	1875	1979
7	Possible tarliquor tank	1877	1877
8	Gas holder	1897	1952
9	Support structures (possible offices/stores)	1897	1952
10	Support structures (possible offices/stores)	1897	1952
11	Unidentified feature (possible conveyor)	1897	1952
12	Unidentified feature (possible support building)	1897	1952
13	Retort chimney/tank	1910	1910
14	Unidentified feature (possible boiler house)	1910	1912
15	Gas holder	1937	1977
16	Unidentified feature	1937	2000
17	Possible condensers	1937	1952
18	Unidentified feature	1937	1937
19	Governor compound	1965	2000
20	Instrument kiosk/telemetry	1965	2000
21	Boiler House	1965	1965
22	Sub-station site	1965	Present day
23	Hut, shown as a tank from 1971 map	1965	1977



ATKINS
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ASHLEY ROAD
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KT18 5BW
Tel: 01372 726140
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- LEGEND**
- 2000 Atkins Borehole Location
 - 2000 Atkins Trial Pit Location
 - 2000 Trial Trench Location
 - 2011 Atkins Borehole Location
 - 2011 Atkins Trial Pit Location
 - 2011 Vapour Well Location
 - Surface Water Sample Location

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National Grid Property Holdings Limited

PROJECT
Ford Road, Arundel
Land Contamination Site Investigation and
Generic Quantitative Risk Assessment

TITLE
Site Layout Plan, Including Historical
Features and Site Investigation Locations

FIGURE 2



ATKINS

ATKINS CONSULTANTS Ltd.
WOODCOTE GROVE
ASHLEY ROAD
EPSOM
KT18 5BW
Tel: 01372 726140
Fax: 01372 740055

LEGEND

 Approximate areas of dense vegetation

Note: Location of pipework, electricity cables and brick walls is approximate

CLIENT

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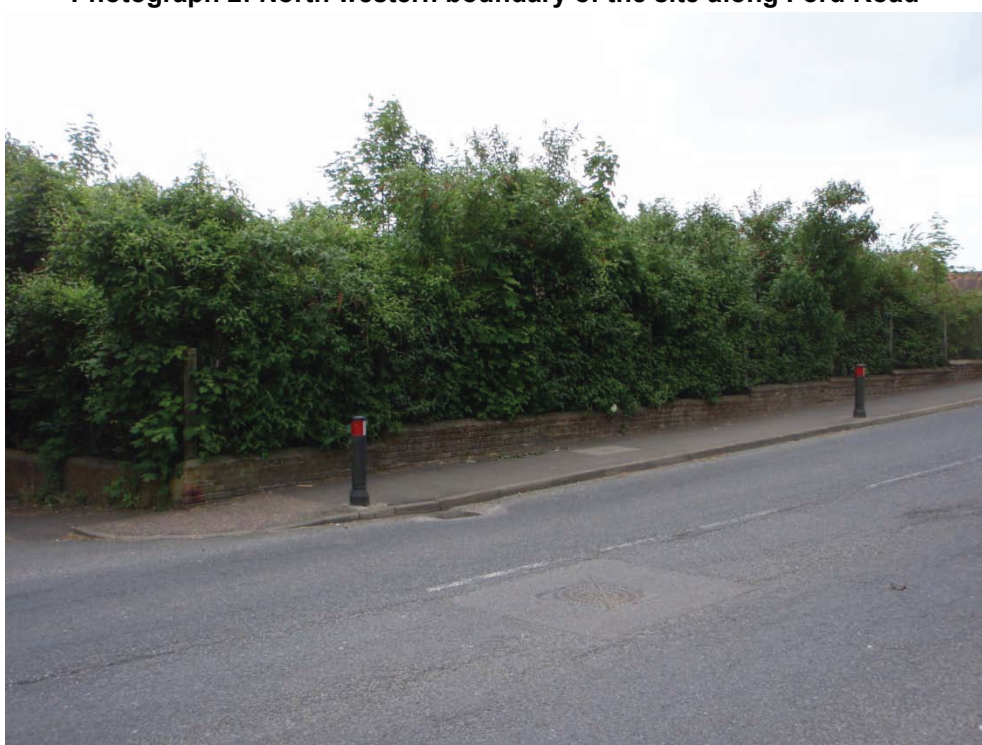
Site Constraints and Hazards Plan

FIGURE 3

Photograph 1: Access track located off Ford Road



Photograph 2: North western boundary of the site along Ford Road



Photograph 3: Site access gates



Photograph 4: Southern corner of the site viewed from the adjacent field used for horse grazing located to the south of the site



Photograph 5: View onto the site from Ford Road prior to vegetation clearance



Photograph 6: Drainage ditch located to the east of the access track (viewed from the sluice gate)



Photograph 7: Damage to the site boundary along the south eastern boundary



Photograph 8: Electricity sub-station located along adjacent to the site entrance



Photograph 9: Tarmac track running through the central portion of the site prior to vegetation clearance



Photograph 10: Tarmac track running through the central portion of the site following vegetation clearance



Photograph 11: Vegetation clearance works



Photograph 12: Location of historical borehole BH5



Photograph 13: TP102



Photograph 14: TP102

