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Kennetpans Distillery: The Site and the Wider Landscape

An Understanding of Kennetpans distillery at the site level through understanding use and its influence in the Wider Landscape

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Abstract

Kennetpans distillery was one of the largest distilleries in the lowlands of Scotland and was one of the pioneers of the export trade to London. Although literature acknowledges that Kennetpans was instrumental in the export trade, little is known about how this early site developed and operated. Kennetpans is overshadowed by Kilbagie in much of the literature. This study will take an interdisciplinary approach was taken to gain an understanding on how Kennetpans distillery operated at a site level and within the wider environment. Geo-archaeology, industrial archaeology and traditional historical research, was used to set Kennetpans within the wider environment and as a separate identity from Kilbagie.

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1. Introduction

Whisky is synonymous with Scotland (SWA 2014) and forms a large part of Scotland's heritage. Distillation has its origins in China around 7000-600BC. It was later that distillation was brought to Ireland and then to Scotland by Monks (Stewart, Russell and Anstruther 2014). It was the dissolution of the monasteries of Scotland in the 1560's that caused distillation to become widespread and common practice. During this time farms and large houses had a still that was for the purpose of preserving the excess cereal harvest. The distillate that was made had to stretch until the next harvest, thus the distillate was often savoured and drank as an invigorating drink (Stewart, Russell and Anstruther 2014). As whisky grew in popularity the process was industrialised by some such as the Steins at Kennetpans, who developed modern techniques and was one of the first industrial distilleries to export. The export trade in whisky today generates around £3.95 billion in export tax annually (SWA 2014) and is one of largest tax generators in Scotland. Whisky has and always will be entwined in Scotland's heritage and forms an important part of Scotland's rural economy.

The transition between the cottage industry and industrialisation was not a smooth one. The Scottish weather, has always, been unpredictable and as a result, there was a ban placed on distillation in 1579, 1660, 1757-1760 and the 1840s, due to the poor harvests and the need to use grain for food resources (Stewart, Russell and Anstruther 2014). The distilleries that survived these bans became bigger and more robust. One of these distilleries was Kennetpans. Kennetpans is thought to have been built shortly after 1638 (Bruce 1868) and in its hay day, Kennetpans produced over 1,800 tons of whisky annually (Moodie 1799). Its produce was consumed locally in Scotland (Wallace 1823) and in London (Moodie 1799),

although its taste would have been harsh and not particularly pleasant, it would have been a way for many to cope with their daily lives (Martin 1703).

Kennetpans and Kilbagie were some of the first industrial distilleries in Scotland and were one mile apart. Kennetpans distillery is one of the few remaining early distilleries with its associated buildings, albeit in a ruinous condition and is a Scheduled monument (Historic Scotland 1991). Kennetpans distillery is situated on the banks of the Forth and once formed part of a busy port that shaped the early export trade of whisky. The distillery is situated at the port head with the malt barns located on the west side. The distillery is over grown and covered in ivy which makes the rooms difficult to interpret. The malt barns consists of a series of rooms that have bricked up windows and doors, variations in floor height, missing walls and roofs. To the west of the malt barns there was a mansion house that was demolished post 1840, and was home of the Stein Family (Personal communications Fiona Frew 22/05/2015). The mansion house had considerable grounds associated with it. There was a walled garden and orchard, along with pleasure grounds amounting to c.11.8 acres. To the northwest of the distillery there was a court of buildings of which only parts remain, that formed the traditional homestead for Kennetpans, which housed horses and carts amongst other farming equipment. The most northerly buildings of Kennetpans are that of the boatman and land waiters (customs officer) houses. Accommodation buildings that were to the left of the main distillery building have been demolished. The byre that was situated behind the distillery that would have housed cattle has also been demolished. Recently there have been initial site investigations to stabilise the main distillery building, by AOC archaeology group (AOC).

An in-depth interpretation of the site including room identification and use, which is not clear from the documentary evidence, along with how the distillery fits in to the wider environment will be undertaken. In order to interpret the site and understand the wider environmental history of Kennetpans distillery an interdisciplinary method will be undertaken. This combines industrial archaeology, geo-archaeology and traditional historical research, using map, photographs and archive records. This was done through examining the raw materials source, disposal of waste and transport links. Along with geo-archaeology, Russell (2005) suggested that environmental historians should use more of the techniques and data samples that have been generated by the sciences as they could aid environmental historian's understandings. This project aims to bridge the gap between environmental history and environmental science through creating its own data set. This technique combines scientific methods that answer a specific historic environmental question resulting in a comprehensive understanding of the site. This study also hopes to establish Kennetpans as a separate entity that is not over shadowed by Kilbagie (Lyonn 1999, Dietz 1997, Devine1975, Lockhart 1951, Gunn 1935).

In order to understand the full impact of the environmental history of Kennetpans elemental analysis will be undertaken. The environmental legacy of a site can give a greater insight into how each room was used and the legacy of the hearths on site. This technique is suited to distilleries due to the amount of heat required for the different stages of production. Elemental analysis began to play a large part in understanding archaeological sites in the late 20th Century. It began in the 1980s when Griffiths carried out elemental analysis to establish the main areas of habitation within a site in Ontario, Canada. In this study, Griffith found that Magnesium (Mg) was a particularly good indicator of wood ash, in areas of known

hearths (Griffith 1980 and 1981). This technique was then developed further to verify field observations by Aston *et al.* (1998). In doing so Aston *et al.* established that Phosphorus (P), Cadmium (Cd), Zinc (Zn), Lead (Pb) and Copper (Cu) were all indicative of areas used for burning and defecating in a site. At the same time, a technique called ICP - AES was being was applied by Pierce *et al.* (1998). From this technique Pierce *et al*. established the main fuel source used in hearths and the effects that this fuel had on the depletion of surrounding resources. This technique (ICP-AES) will allow the signatures from the fuel source to be detected around the site and establish areas of intense burning or storage of waste ash. Previous to 2000 Wells *et al*. carried out a landscape study on the areas used by ancient Maya as settlements. In this study they found that it was difficult to interpret the landscape use without combining elemental analysis with their observations. Wells *et al*.(2000) highlighted the need for the use of elemental analysis, particularly in sites that have little historic literature behind them. This study will build on the historical documentation of the site through the use of elemental analysis to aid field observations. This will also build on Russell's (2005) idea of using scientific analysis to understand historic environments through creating its own data source. There has been further work done to indicate areas of habitation in abandoned landscapes on the Isle of Skye (Entwistle *et al* 2000). Entwistle *et al.* found that multi-element analysis was essential in the understanding of landscape use pre highland clearances. This work has set a foundation that has then been built on by Wilson *et al.*, 2005, 2006, 2008 and 2009, Nielson and Kristiansen, 2014 and Shahack-Gross *et al* 2014. These authors have used multi-element analysis to establish varying areas of use within abandoned buildings, farmsteads and the surrounding areas. These studies have developed techniques and understanding of the association of specific elements with different areas of use within an abandoned buildings and their surrounding areas.

One of the major factors that could influence the quality and understanding of Kennetpans distillery is that of post abandonment processes, such as clearing out of hearths or building reuse. Any processes carried out post abandonment of Kennetpans distillery are unclear as there are no plans or documented evidence of its use. This has been highlighted by Wilson *et al* (2009), who suggests that post abandonment processes such as clearing out of a buildings floor can affect the understanding of how a site was used. Wilson *et al.* (2005 and 2008) further found that Barium (Ba), Calcium (Ca), Cu, P, Pb, Strontium (Sr), Zn, in particular, were found in elevated levels within hearth areas. This is particularly useful when looking at Kennetpans, as the majority of the processes used in whisky production require a heat source. Although this technique will not tell us specifically where each process or processes were carried out, the understanding of where heat sources were present along with field observations will allow a better understanding of the site to be gained. Misarti *et al*. (2011) further suggested that the period of habitation of a site does not affect the concentration of element signatures detected, but the intensity to which a site was used. Since Kennetpans was used over several 100 years and the fact that they distilled on an industrial and intense scale, this would suggest that the multi-elemental signatures would be elevated. Through developing on the technique outlined by the authors above, it is possible to gain an understanding of the layout of Kennetpans distillery through the environmental signatures (For sampling plan see Appendix 1).

In terms of industrial archaeology, Palmer and Neaverson detailed the possible considerations to be taken when understanding an industry within a landscape. Palmer and Neaverson six-point plan considers the source of raw materials, along with the processing plant and power sources of the immediate site. The secondary industry of waste or

subsequent site use, accommodation and transport of goods to the consumer are all considered in the six-point plan. Through using Palmer and Neaverson six-point plan and Russell's integrated approach an accurate understanding of the site should be gained. As distilleries are often paired with brewing and not looked at as a separate entity, such as in Butt (1967), the distillation industry is often over looked.

The project will conclude that the rooms within the malt barns and distillery buildings at Kennetpans distillery followed a traditional pattern. Within the wider context Kennetpans distillery was a self contained operation within the landscape. It operated with in an $8km^2$ area but remained connected to the wider Scottish environment through trade routes for raw materials and whisky sales. Through using local raw materials and labour force, the distillery remained connected to the wider environment.

2. The wider whisky industry and Kennetpans

Kennetpans distillery was instrumental in the development of the whisky industry. As whisky grew in popularity it was excessively taxed, which had an impact on the volume of whisky produced and exported. There were five powerhouses in the lowlands that developed a whisky export trade. The distilleries also installed technological advancements and had secondary industries associated with them.

During the 18th century and early 19th century, whisky production had vastly increased and an export trade to London had been developed (Moss and Hume 1981). The largest producers of Scottish whisky at the time were Kennetpans and Kilbagie. By 1733, Kennetpans was the biggest distillery in Scotland (Scottish Executive, 2008). In 1791, Kennetpans and Kilbagie produced 4,800 tons of whisky, which equates to roughly 152,422

gallons of spirit (Moodie 1799). The main markets that Kennetpans and Kilbagie supplied were London and thus developed a successful trade in export (Moss and Hume 1981). In 1788, the export tax on Kennetpans and Kilbagie alone was greater than that of the full land tax in Scotland (Moodie 1799).

By the early 1700, there is a strong association of whisky being used by the highlanders of Scotland to get through the long harsh winter months (Martin 1703). It is also established that the highlanders and islanders have three distinct methods for making whisky: usquebaugh- common whisky that is twice distilled; trestarig- whisky that has been distilled three times (still common practice in Ireland today); and Usquebaugh-baul- which translates to 'perilous whisky' and has been distilled four times. This last whisky has been rightly given its name as, "*Two spoonfuls of this last liquor is a sufficient does and if any man exceeds this, it would presently stop his breath...*" (Martin, pp. 3, 1703). The reference Martin makes to the potency of the spirit of whisky suggests that distillation has become an efficient and well developed process particularly in the western isles. This also suggests that by the early 1700s whisky distillation was not a hap-hazardous process but a well developed cottage craft.

The first direct taxation on whisky came in to place in the 17th century, this was two shillings and eight pence for every pint (1.5litres) of Scottish whisky produced (Lyonn 1999). This tax was primarily to raise money to send an army to England. The tax was short lived and was later replaced by a malt tax, which was also later replace. In 1707, at the act of union between Scotland and England, the tax on whisky became permenant. In 1725 when Lord Winapoles administration enforced the taxation laws in Scotland on malt, this induced a series of malt riots (Lyon 1999). The tax increased illicit distillation in the Highlands and Islands of Scotland and lead to a thriving illicit trade (Devine 1975).

When the taxation price rose and illicit distillation increased, King George III appointed William Pitt as Chancellor of Exchequer and was the driving force in changing the taxation laws in Scotland in the 1780s. Pitt reconstructed the taxation practice and in 1786 generated £1million in surplus from the taxation that had been placed on whisky.

Before 1784, duty on whisky was charged on the volume of wash produced. It was presumed that 100 gallons of wash would produce 15 gallons of whisky and therefore duty was charged accordingly. Smuggling of highland and illicit whisky was common practice at this time due to high taxes (Table 1), however it was impossible for the industrious distilleries of the lowlands to do so as they were much tighter regulated (Moodie 1799). In 1784, Kennetpans and Kilbagie relied solely on the export trade to London (Moodie 1799). The old Statistical Accounts suggest that the English market was not impressed with the influx of whisky flooding the London market and resulted in lobbying from London traders, the tax price in Scotland began to steadily increase (Table 1). The result of the continued tax increase was seen in 1788, when John Stein was charged £595.0.3 on malt duty and £1837.9.7 in licensing fees, this amount to £2432.9.10 in taxes and the sequestration of the large distilleries commences. The Statistical Accounts of 1799 and 1841 give the most detail on how the site of Kilbagie was operated but due to Kennetpans being of a smaller size it is greatly over looked and is referred to as a ratio in relation to Kilbagie (Moodie 1799 and Balfour 1845).

Year	**England**		**Scotland**					
	Duty per gallon		Duty per gallon			Duty per gallon		
				Lowlands			Highlands	
	s	d	£	s	d	£	s	d
1791	3	4 3/4	3	12	0	1	4	0

1794	3	10 3/4	10	16	1/2	1	16	0
1797	4	10 3/4	6 1/2	16	4	3	0	0
1800	5	4 1/2	6 1/2	16	4	7	16	1/4

Table 1 The taxation on whisky in the Lowlands and Highlands of Scotland from 1791 to 1800 (Glenn 1969).

In 1788, leading up to July 5th, only 2,034 gallons of whisky was shipped to and landed in London (TNAS CS96/2080 and CS96/2081). Scottish shipments of whisky soared, however, to 100,000 gallons in 1790 (Dietz 1997). The drastic increase in exportation of whisky to London can only be linked to the successful nature of the booming lowland whisky industry in Scotland. This also began the ever-increasing taxation and taxing prices per gallon of whisky produced, which reached a staggering £9 per gallon plus import and export tax in 1789. This led to the mass sequestration of many of the lowland distilleries (Kennetpans, Kilbagie, Cannonmills, Lochrin and Kincaple) (TNAS CS96/2080 and CS96/2081).As soon as the taxation prices dropped, the distilleries started back up again, on an even larger and more industrious scale in 1790 (Glenn 1969).

This had a massive impact on the stability of Scotland's economy (Moss and Hume 1981) and the livelihoods of many families from maltsters to grain merchants to the arable farmers throughout the lowlands in Scotland. This, however, does not take in to account the 480 employees of Kennetpans and Kilbagie that were made redundant over night or the miners that supplied Kennetpans and Kilbagie, with coal.

In the lowlands of Scotland whisky was a common drink for the family regardless of age or class (Devine 1975). It was common for a family to be seen staggering back from the local public house. The demand for whisky further became greater after the Napoleonic war

(Devine 1975) when the import tax on brandy was exceptionally high. The high taxes caused the elite in society to change their drinking preferences from brandy to whisky, resulting in whisky truly becoming a drink for all.

Pitt also gave powers to the customs and excise officers to deal with the taxation of many products arriving and departing from the many ports in Scotland. This process itself became complicated and many merchants often tried to bribe excise officers, often through generous sums, to alter the taxes that that merchants had to pay (Dietz 1997). Kennetpans was an industrious port it had an excise office situated on site in order to deal with the taxes that had been imposed on various items being traded (Dietz 1997). In 1784, the whiskey sent to England amounted to 183,000 gallons, considerably more than legally distilled in Scotland (Glenn 1969).

The ingenuity and thriving nature of the industrialisation of whisky cannot be ignored. The Steins used and developed the latest technologies to increase the efficiency of their distilleries. They also combined traditional agricultural practices, fattening cattle for market, with the production of whisky.

In order to understand Kennetpans distillery the site needs to be looked at from the impact that the Stein dynasty had on the whisky industry. In the late 1780s the Stein family individually owned and operated five distilleries in the lowlands of Scotland (Inner forth) (Kennetpans, Kilbagie, Cannonmils, Lochrin and Kincaple). These distilleries were operated separately but remained well connected, they had a large impact on the whisky industry. These five distilleries were the force behind the largest development in the whisky industry and the export trade (TNAS CS96/2080 and CS96/2081). Today export tax, solely on whisky,

generates £135 per second which demonstrates the importance of the early pioneers of the export trade (SWA 2014 and TNAS CS96/2080 and CS96/2081).

Most of the current literature focuses on the technological advancements that the industry installed, e.g. Bolton and Watt steam engine and Patent still (Lockhart 1951) and the great distilling families (Jameson's and the Haig's). Literature on Kennetpans distillery highlights the Stein family, who owned Kennetpans and Kilbagie, championed these advancements. One of the main reasons that the Haig's and Jameson's are so successful could be linked to the fact that the original distillers of both companies trained under the Steins and later married in to their family (Personal Communication: Fiona Frew, 20/05/2015).

Lockhart suggests that the five powerhouses in the lowlands were mass producing whisky that is bland in taste but high in alcohol that is much more suited to the large working populations of the lowlands (Lockhart 1951). This view, however, is not untrue, as Robert Burns mentions Kilbagie in one of his Canters. 'The Jolly Beggar' states that whisky from Kilbagie was of poor quality and mainly drank for the alcoholic content, not for the varying depth, flavours and tones that the Highland whiskies had (Burns 1785).The main game changer , excluding the export trade, was that of the development of the patent still (1826). The patent still allowed for continuous distillation to take place (Lockhart 1951). Gunn further highlights that the significance that the patent still had on whisky production. As when revenue officers visited 23 public houses in Scotland, all of the whisky sold there was from patent stills (Gunn 1935).

Recently there has been a move to focus more on the heritage of whisky and the origins of the large powerhouses in the late 18th early 19th century (Buxton and Hughes 2014). The start of the industrialisation of whisky is thought to have originated from the beginning of

the improvements in agriculture and grain storage, resulting in a surplus of barley. Improvement landlords encouraged this surplus to be used in an industrious way, i.e. whisky. This surplus was then invested in the whisky industry and as a result the whisky industry began to expand and develop into the industry that it is today (Buxton and Hughes 2014). Kennetpans and Kilbagie are referred to as the forerunners in technological developments of their time; they are through to be part of the early industrial revolution in Scotland (Buxton and Hughes 2014). One of the first instalments was a canal that was dug in 1780s that linked Kilbagie to Kennetpans and the Forth. The canal was 1 mile long and followed the natural course of the river (Moodie 1799). This was then followed by the installation of a Boulton and Watt stream engine at Kennetpans (1786), which was installed to mill barley (Letters). Kilbagie also installed a threshing mill, another of Scotland's first (Moodie 1799, Buxton and Hughes 2014). In Dietz's exploration of Kennetpans and the overview of the site, he completely ignores that fact that there are several rail lines running through the site to the port on either side of the distillery building. He further ignores the fact that the situation of Kennetpans at a port could have been instrumental in the development of the export trade (Figure 1).

Figure 1 An early painting (1840) depicting Kennetpans port with the main distillery building in the foreground with the malt barns on the right hand side. There is a canal terminus on the left side and a rail terminal. There is a larger rail terminus on the right. The size of the port has been exaggerated but all other elements remain in proportion. Photo courtesy of Kennetpans Trust.

Dietz does, however, mention the livestock pens that are situated to the north of the distillery, which would have been used to house cattle and swine, which would have been fattened from the waste draft from the distillery. The combination of farming practice with distilleries is thought to be related to the farming background that the Steins came from and a need to get rid of their waste products (Glenn 1969). Dietz also neglects to mention how the site operated with all the different processes. Kennetpans and Kilbagie were instrumental in championing the technological advancements used in the whisky industry. Although Kennetpans technological advancements are over shadowed by Kilbagie they played a significant factor in the development of the industry.

3. The Distillery Building.

This chapter will look at the current situation of the buildings of Kennetpans distillery and its setting, the whisky process and an in depth interpretation of each room and its function within the role of a distillery. Kennetpans is situated on what was an advantageous point on the Forth. The land surrounding the distillery to the north is currently used as arable land, to the east forms grazing and an area that has been re-wilded by the RSPB. The buildings to the northwest are used as residential property. To the south are the remains of Kennetpans port. The port in front of the distillery was active during its operation, which helped to create a very dynamic and versatile site. The combination of the port and trade routes were particularly advantageous for the exports at Kennetpans. All that remains of this once industrious port are a few posts that would have formed the front of the port wall. The photograph (Figure 2) of a boat docked at the port shows the scale and height of the dock walls. The photograph also show how closely the port wall, railway tracks and malt barns were situated. Kennetpans port was once 17ft deep (Moodie 1799) and was the deepest in Clackmannan. For this reason, the port was use for the exportation of coal on deep drafted vessels. The port, however, remains silted up and is a neglected intertidal region that is particularly dangerous, due to the large volumes of silt that have in filled the harbour.

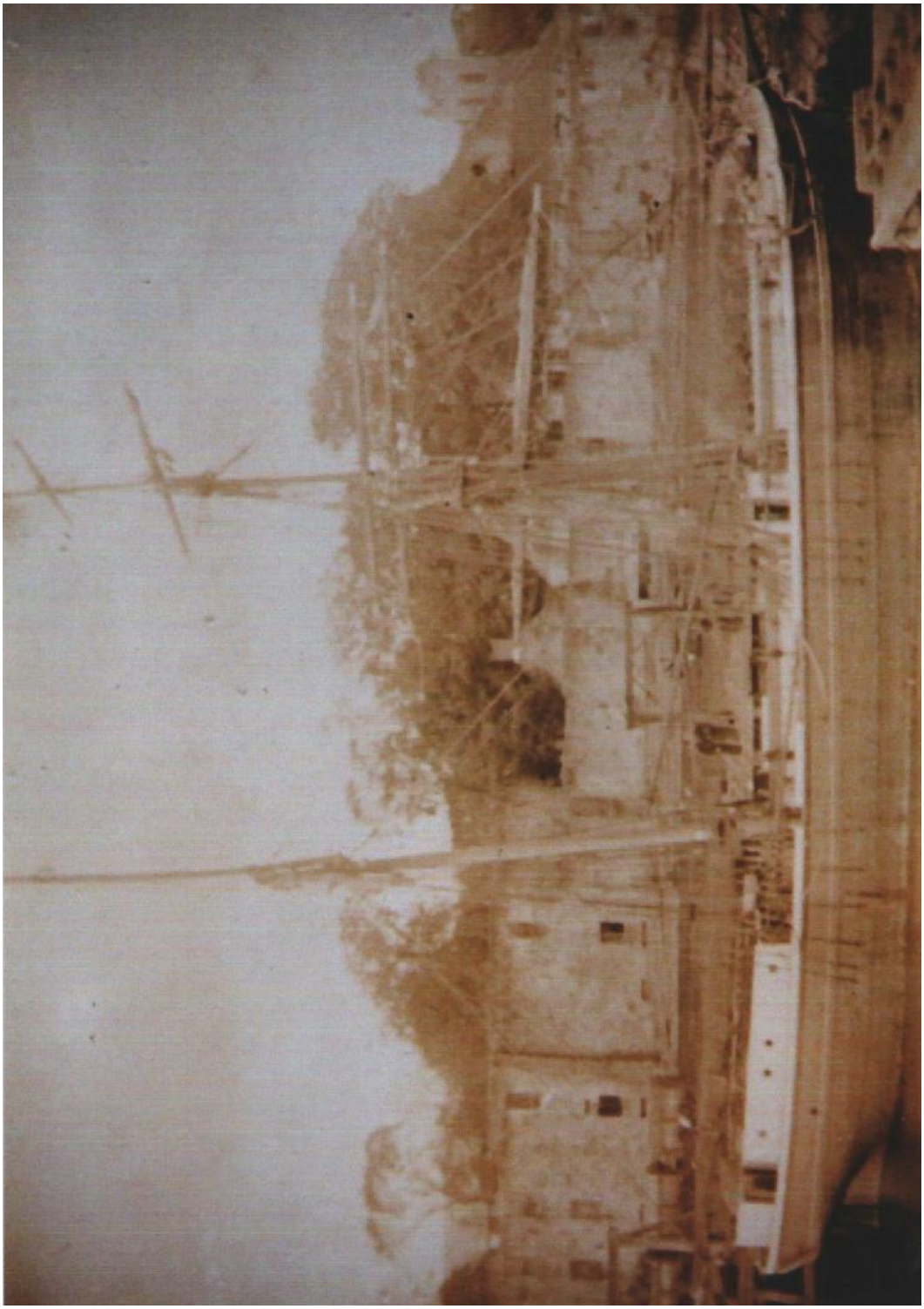


Figure 2 The photograph shows a boat alongside the port at Kennetpans in from of the Malt barns in 1890. Photo courtesy of Kincardine History group.

The site of the distillery is currently over grown and is just a shell of its once former industrious building. Running in to the east side of the site is the remaining old canal that ran

the mile long stretch from Kilbagie to Kennetpans. The canal is disused and would not be considered as a conventional canal of today, as the canal that ran to Kilbagie followed the natural course of the river and was artificially deepened (Glenn 1969). The burn that once formed the canal now runs its natural course out in to the forth close to the new Clackmannanshire Bridge. The remains of the sluice gate and pond can still be clearly seen on site. The sluice gate at one point was reinforced through the use of concrete, resulting in the sluice gate still being present today. To the northeast of the distillery, directly behind the building, there was a railway track that ran to the east side of the port crossing over the canal. The railway also ran straight to Kilbagie from the northeast corner of the distillery building, and was one of the first railways installed in Scotland. All that remains of this railway line is a straight ditch running through the arable field to the northeast of the distillery building.

Figure 3 A photo of the distillery looking Northwest on to the distillery. Photo courtesy of Kincardine History Group.

To the west of the distillery there were sets of rail tracks that were used to transport coal from the coalmines, particularly Clackmannan, to the vessels in port. The exact use of the railways apart from coal transportation remains an unknown and the only evidence of them left on site is the straight road leading down to the Kennetpans. To the west of the railway tracks there used to be several buildings that have subsequently been demolished. The remaining structures are used as storage.

The distillery has six identifiable rooms with walls that are still standing but with no roof structure (Figure 4). All of the rooms are currently over grown with ivy, trees and shrubbery and are in filled with masonry from the walls and rubbish. The ivy coverage is particularly extensive on the exterior wall of the engine house and on the north and west side of the building, the ivy is slowly compromising the structure and integrity of the building. Most of the interior walls remain ivy free allowing the varying floor levels and windows to be clearly visible. In some rooms, several features have been altered by the addition of brickwork at later periods of the distilleries operation. Room 5 (Figure 13), in particular has had large alterations made to it. Although these alterations can cause difficulty in interpretation of the building it adds to the biography of the building. Rooms 3 and 4 appear to have the largest volume of infill and debris within them. All the rooms will be explored in further detail below.

Figure 4 Layout of Kennetpans Distillery on the right with room numbers for reference and Malt barns on the left with corresponding room numbers. The sluice pond is located on the right of the distillery buiding and the rail way line coming in from Kilbagie on the top right of the image.(Map NSL Great Britain, OS 25inch, 1892-1905, Georeferenced)

The malt barns are located to the south east of the distillery building. The malt barns were located behind the railway tracks and are often referred to in literature as warehouses (Glenn 1969). This interpretation is proven incorrect as up until 1840, there is a map detailing the fews of Kennetpans showing the buildings clearly relating to the distillery and being used as malt barns (Clackmannan archives, private collection Appendix 2). The malt barns appear to be in a better condition than the distillery building itself, as they are clear of ivy. They do, however, contain a large number of tress in the interior of the buildings. The

trees help to give the barn a sense of scale and presence, due to the tree canopy creating a natural roof for the malt barns. The malt barns are well preserved and the different floor levels can clearly be made out. Many of the window frames are still well intact and show where the old metal gridded windows would have been, along with the shutters that would have been used to close the windows. The shutters that are still intact clearly show how they were used to allow a sufficient circulation of airflow within the malt barn which would have regulated the temperature of the malting barley. To the north of the main malt barn there are several buildings that are in a lesser state of repair but still have a significant east wall giving a scale to the buildings that once stood there. The sheer scale of these malt barns (1153.54 m^2) gives an indication to the size of the operations at Kennetpans.

3.1 How to make whisky.

In order to understand the layout of the distillery it is imperative to understand the methods that were used in the making of whisky during the 18/19th centuries. As each process was carried out on site at Kennetpans, they required different and specific requirements for each process. To make whisky you need three essential elements, barley, water and heat. In order to transform barley in to whisky it must undergo a five-step process (malting, milling, fermenting, distillation and maturation) to release the essence that makes whisky. Without these essential steps, whisky cannot be made and called a traditional Scotch whisky (SWA 2014). When whisky was first being mass produced maturation was not one of the requirements in order to make whisky. At this time it was about how quickly you could produce and sell whisky to the market (Glenn 1969) not about flavour.

The first process is malting (SWA 2014). Traditionally barley or bear (Scottish barley) would be steeped in water for 2-3 days to induce the germination process. The water would then

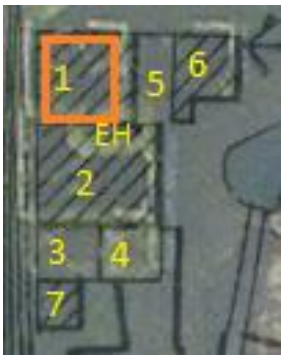
be drained away and the barley spread out on a floor and allowed to germinate. It would be turned every 4-6 hours, to ensure that the heat produced from germination was evenly spread throughout. The traditional process was and in some distilleries, is still carried out by hand (Highland Park). Germinating barley needs a generous airflow throughout. Once the germination process has reached its peak the barley then needs to be heated to prevent further germination and the loss of the sugars inside the barley that make the whisky. Traditionally this is done through the drying of the grain in the smoke from a kiln. The 'pagodas' on the chimney of many distilleries indicates the location of their drying kiln. This process can also give the whisky a peaty or smoky flavour depending on the fuel source used. Once the barley has been dried in a kiln it is then ready for the sugars to be released. In order to do this the barley needs to be milled. Once the barley is milled, it can then be stored ready for the next processes.

The milled barley is then put in a wash back where it has warm water added and is constantly stirred. The stirring allows heat to be evenly distributed throughout and the sugars to dissolve in to the water. The mixture of water and sugar is now called wort. The wort is then removed from the wash backs and can then be fermented. At this stage all the solid state barley is removed and is called draff, which can be fed to cattle and swine. The wort is then combined with yeast. The yeast reacts with the sugars and produces alcohol. The fermentation process takes approximately 48 hours. The wort now contains between 5 and 10% alcohol (very low whisky strength), which can then be distilled.

Traditional distillation, for a whisky of good flavour and depth, would be carried out slowly. Distillation is carried out in a still that is placed over a heat source. In the late 1790s the Steins were known to discharge their stills at a rate of 12-15minutes (Glenn 1969). This rapid

distillation created a weak in colour and flavour whisky but had high alcohol content. This method carried out by the Steins was effective at getting around the excise laws and taxes that was enforced upon them. Distillation has always been carried out twice (Martin 1703) and is still common practice throughout Scotland today. Traditionally the first distillation creates low wines, which is very potent. The low wines are then distilled again, and during this process, the whisky is collected. The second distillation consists of three parts; fore-shots, potent and high in alcohol content; heart is the whisky and; third is the feint, which is weak in alcohol content and is kept and put through the distillation process again. The heart of the whisky will now have an alcohol content of around 65-70% ABV. The distilled whisky is then condensed down through a cooling worm and can then be barrelled for storage and transportation. All of these processes were carried out on the site of Kennetpans distillery, including the disposal of waste draff as cattle and swine feed. Draff is still used as cattle feed today and was used to fatten cattle for market, an effective and cost saving method for the disposal of waste produce. As all of these processes are carried out in a specific order requiring a strict schedule, the project will understand how each of the rooms within the distillery and the malt barns were used.

3.2 Room 1.



Room 1 was the originally used as a steep to induce the germination of barley and to house the wash backs that would have been used to ferment the milled barley. The first and second floors would have been used as the original malt barn on site as it has 15 windows on the north and west walls and none on the east and south walls. The windows would have allowed a

good airflow throughout the room preventing the germinating barley from overheating. The south wall contains a door that connects to Room 2 and the west wall has one door leading in to the room. Room 1 is two stories in height and is in relatively good condition.

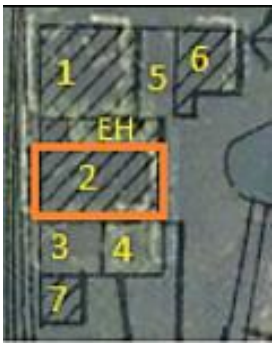
On the east wall there is a distinct colour change in the sandstone that is similar to the sandstone on the outside of Room 4, which has been subject to extensive water submersion. This would suggest that a steep was located on the east wall. In the rest of the ground floor there would have been wash backs that was used to make wort. The wash backs would have had hot water added to them, which would have been heated in Room 1. The floor joists in Room 1 have been altered using red brick, suggesting that the floor was levelled. The remains of the industrial archaeology would suggest that Room 1 changed function due to the addition of the brickwork within the room.

AOC are working in partnership with Historic Scotland to stabilise the main distillery building at Kennetpans and AOC have carried out initial investigations, test pits, throughout the rooms in distillery building. A test pit in Room 1 uncovered a drain, which runs on the east side of the room. With these three factors, drain, discoloured sandstone and levelled floors, it would suggest that that east side of Room 1 was used for steeping the barley, which would have then been turned out on the sloping floor. The slope on the floor would have allowed excess water to drain away. The windows on the north and west walls would have allowed for adequate airflow through the room aiding in the drying of the malting grain. This room would have originally been the malt barn for Kennetpans distillery when it was first built. Along with the steep for the grain, on the ground floor, there would have been wash backs that were used to make wort and ferment the wort prior to distillation. This room would have carried out all the initial processes before the building of the malt barns. Once a change

in use occurred this room could have been used for the storage of the milled barley, prior to further processing. This room could have also stored the kiln-dried grain prior to milling or fermenting (Letters).

The environmental analysis of the site of Kennetpans distillery has been used to try to understand the legacy that the different distillation processes have left on the site. Within the distillery building there are varying levels of element concentrations. Room 1 has elevated element levels on the east side of the room, for all elements (Ba, Ca, Cu, Fe, P, Pb, Sr and Zn) (Appendix 3). The sample taken from here was directly above a drain that ran north to south through the room. The elevated concentration levels within the sample indicate that the drain could have been used to remove waste materials from within Room 1 out of the building, thus resulting in a greater concentration of elements in this area. These waste materials, from the element signatures, would indicated that the material had been burnt, most likely ash or cinder. As the wash backs required warm water the elevated concentrations are most likely from the ash used to heat the water.

3.3 Room 2



Room 2 was the mill house and granary and is currently in a relatively good condition with all four walls intact with the second floor level suffering some degradation. The east and west walls have 11 windows between them allowing good airflow throughout the building. There is one window on the north wall that has been bricked up and a door leading to Room 1. The south wall has two windows of which one has been bricked up with red brick and is situated on the east side of the south wall facing into Room 4. The other of which is still open and connecting to Room 3. The overly large door

on the south wall has wooden slats at irregular intervals up the inside of its frame. One possible explanation for this is that the barrels would have been rolled up and on the horse and cart through the use of ramps, hence the slats built in to the door frame. The varying heights would represent the different heights of horse and cart being used. This suggestion is highly speculative, see Room 3 for further details. Through the use of Palmer and Neavsons six point plan it is suggested that every room or building was built for a specific purpose, for example mills were often built less that 30ft wide and had numerous windows, they were also multi storey to transfer power from the central power source. This description of a mill fits with the layout of Room 2.

Room 3 has a doorway leading in to Room 4 that has been blocked up with sandstone that is in keeping with the rest of the building, unlike the red brick that was used in the upper levels for the blocking up of windows. On the east wall there is a dressed semi circular pillar built in to the wall (Figure 5). The purpose of it is to provide support for the first floor. As it stops just short of the first floor, it would have supported a beam that would have run north to south, in order to support the additional weight of the first floor (Douglas, RCAHMS 1990). The pillar is unusual in this type of building and appears to be part of the showmanship of the lower level of the mill house due to its design and the dressing on the stone.

Figure 5 The dressed stone pillar that is situated on the east wall of Room 2, which supported a beam that ran north to south, which bore the first floor. Photo authors own.

On the west wall there is a doorway and two archways, 1.5m wide, that lead into the central area of Room 2. The easiest and most economic way to transport grain around the site would have been through the use of horse and cart. For this reason, the mill house has two archways in the west wall. These doorways are large enough to back a horse and cart in and using a hatch, dropping milled grain in to cart from the first floor. This would have allowed the malted grain to be brought in on one side and milled barley taken out on the other.

Prior to 1786/7, the mill house was located in Room 2 and was powered by wind, which drove one set of stones, 5 feet in diameter and 13/14inches thick (Letters). The sole purpose of the mill was to grind raw barley for distillation (Letters). The windmill would have been situated on the west wall in order to take full advantage of the SW prevailing winds. Traditionally windmills would have been situated on top of a wooden structure that would have sat on top of the stonewalls. Unfortunately, this is all that is known about the early milling at Kennetpans and is only mentioned in a fleeting reference when John Stein details his current milling methods to Boulton and Watt (Letters).

In 1786/7 there was a steam engine installed by Boulton and Watt (Letters). The steam engine was housed in a purpose built engine house in the northeast corner of Room 2. On the exterior of the engine house there is a recessed stone that is suitable for the housing of the flywheel (Figure 5), which would have driven the millstones. On the east side of the recessed stone, the top part of the circle is off setIn the area of recessed stone, there is an archway on the right side, with two rectangular openings on the left with four square openings directly below them. The rectangular opening on the right would have been used to hold the fly wheel in place. The reason behind the arch could be a door that lead in to the engine room as there is hinges still present in the wall showing the door would have opened

in half. The use and purpose of the square/rectangle openings remains unknown at this point. The engine house walls are full height and have no windows on the north and west side. The mill house/ granary surrounded the engine house on the south and west sides (Letters).

Figure 6 The recessed stone for the location of the flywheel. On the right hand side is the arched door way and in the centre of the flywheel is the four stone holes and two stone squares that have been cut in to the stone. Photo authors own.

Post 1786 Room 2 was continued to be used as a mill house but the stones were now powered by the newly installed steam engine in the northeast corner. The steam engine was one of the technological advancements that John Stein install in order to increase production at the distillery. The letters to Bolton and Watt John made it clear for the need for haste in the installation of the steam engine as the road in winter became almost impassable due to the very wet Scottish weather. It is quite comical at points as part of

Steins rush to get the engine installed is that others in Scotland (James at Kilbagie) have also requested a steam engine to be installed. In one of his letters John, indicates that he is quite happy for a compressor to be fitted to the steam engine even if it does not necessarily fit the correct requirements for the speed required in his steam engine. One of the first letters, that John sends he notes that there is considerable brick work to be carried out on site in order to accommodate the steam engine and to allow it to work efficiently. The stonework that was carried out on site to house the steam engine can still clearly be seen on site today. The masonry that houses the steam engine is different to that of the rest of the building as it is dressed (Figure 6). There were four sets of stones installed at the same time as the steam engine. Two were four feet 6 inches in diameter and was used for the grinding of raw barley; the other two stones were 4ft for the milling of finer grain, such as wheat or rye. To accommodate these stones in the mill houses milling would have taken place over two levels, particularly if a horse and cart had to still get in and out. The steam engine was one of the most important technological advancements that Stein installed in the distillery. It is also made clear in the letters to Boulton and Watt that Stein was not a patient man but also had the drive to install new technological advancements that could improve the efficiency of the distillation process. In his letters Stein, also makes it clear that he has done research in to the workings of a steam engine and even poses an alternative to Bolton and Watt for the number of times that the engine will turn the millstones in a minute. It is unclear what option was taken when installing the steam engine as there is no corresponding letters that were received from Boulton and Watt. The letters that John sends to Boulton and Watt give an interesting insight to how Kennetpans distillery would have been operated. The letters also indicate that that Stein would have been heavily involved in the daily running of the

distillery. Steins knowledge and apparent need for control could explain the close proximity of the mansion house to the malt barns on site.

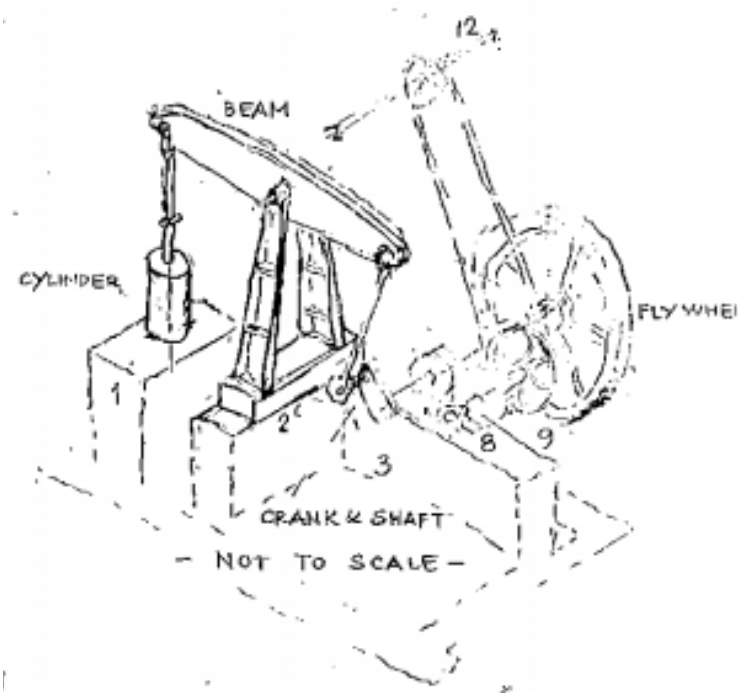
In Room 2 there are elevated levels of Ba, Ca and P, relative to background levels. As Room 2 was used as the mill house, it is highly unlikely that there would have been any burning taking place within the room. The elevated levels of Ca within the samples is possibly a result of masonry degradation (Appendix 3). The elevated element levels with in Room 2 are unlikely to be related to the operations of the distillery as there would not have been a heat source in the same room as milling due to the combustible nature of the milled grain. The mill house would also have been kept clean and free from horse manure in order to prevent contamination of the milled barley. Barley contains P yet the distribution of P in Room 2 would suggest that the elevated levels could be a result of barley but due to the limited samples, it may suggest that the levels of P are caused by the decay of an animal.

There have been test pits dug by AOC in Room 2 that show the floor was made of flagstone in the main area of the room. They also uncovered a possible pad of a support post for the second floor. Both of these pits show the structure of the floor with in the room and suggest there was wooden posts used to support the weight of the upper floors. The test pits dug in Room 1 and Room 2 show the structure of the floor is much like the rest of the building, built to last. The solid nature of the stone floor would have been a good surface to move malted and milled barley over.

3.4 Engine House

The engine house was added to the distillery building in 1786 for the sole purpose of housing a Boulton and Watt steam engine. The south wall of

the engine house was described in Room 2 and appears to have the most intricate stonework of all the rooms designed in the building. The west wall has no distinguishing features. The east wall contains a vent at its base, this was built to allow water in to the steam engine (Letters). There is a pair of windows on the first floor and one on the second floor. On the inside of the north wall there is the shadowed remains of a former roof structure, along with two windows, which look in to Room 5 and a flue that is connected to the boiler house. The boiler house was made of red brick and can clearly be seen in former images of the site (Figure 13). There is little that remains of the boiler house apart from a flue in the engine room and one in Room 6 (discussed below). Inside the engine room there were two platforms built that would have allowed the steam engine to sit above the ground to maximise effective function. Figure 7 shows how the engine would have sat and worked with in the engine house.



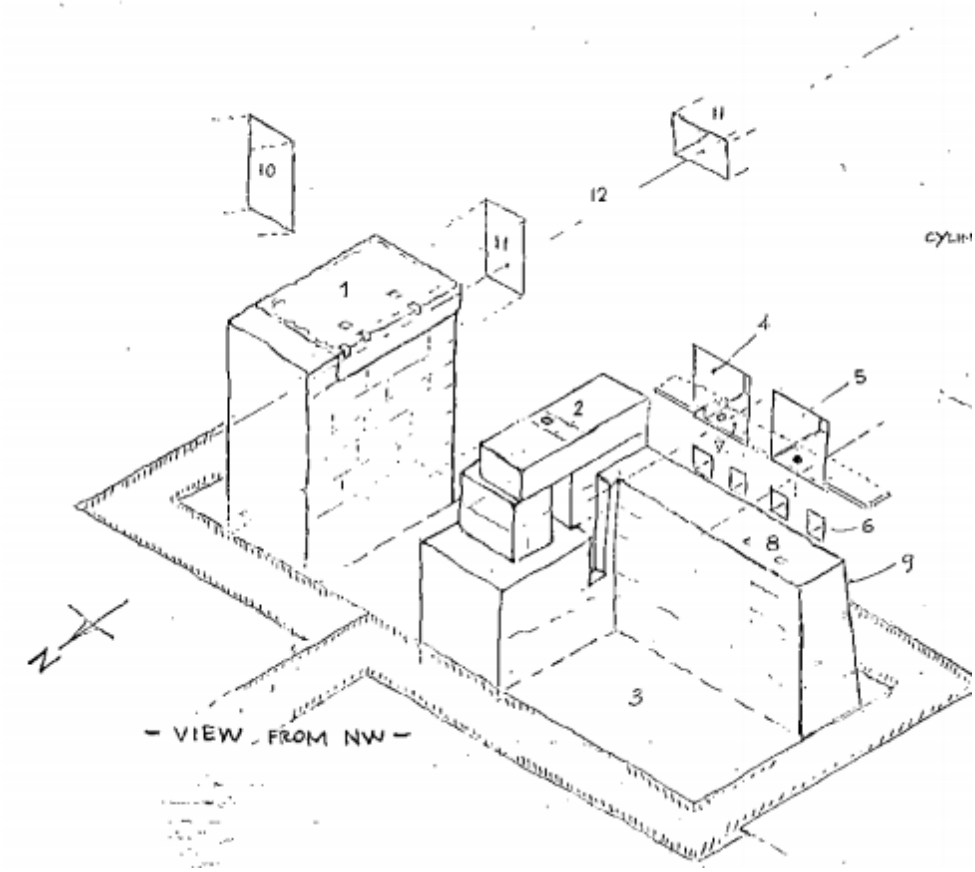
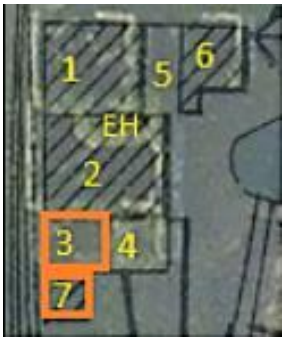


Figure 7 A diagram sketch of what the steam engine would have looked like and how it would have sat with in the engine house (Douglas 1990).

There is a shelf ledge that runs the interior of the engine house that could have provided the structure to provide support for the steam engine. The shelf like ledge is only in the interior of the engine house and not in Room 2 and would therefore suggest that it was designed for the sole purpose of the steam engine. The shadow of the former roof also does not exist in Room 2 and raises the question as to why it would be in Room 2 or latterly the engine house. A possible reason for this is that it formed part of the wooden support structure for the steam engine.

3.5 Room 3.



Room 3 was a still house and is in a dilapidated state with the south wall mostly missing. The west wall is also in a bad condition with only a small portion remaining, this makes the interpretation of this room difficult. The north wall is in good condition (See Room 2), the east wall which divides Rooms 3 and 4, is in a bad condition. The degradation of Room 3 is one of the worst on site and is surprising given the condition of the rest of the buildings and rooms on site. The condition of Room 3 could be due to the demolition of Room 7 that occurred in the 1980's (Douglas, RCAHMS 1990).

Room 7 no longer remains and there are no visible remains at the surface of this room. With the pairing of Room 3 and Room 7 it could be suggested that the Room 3 was used as a still house and Room 7 was used for the cooling towers, worms, and access to the boiler house to provide fuel to the stills. The stills would have been situated off the ground similar to Figure 8.

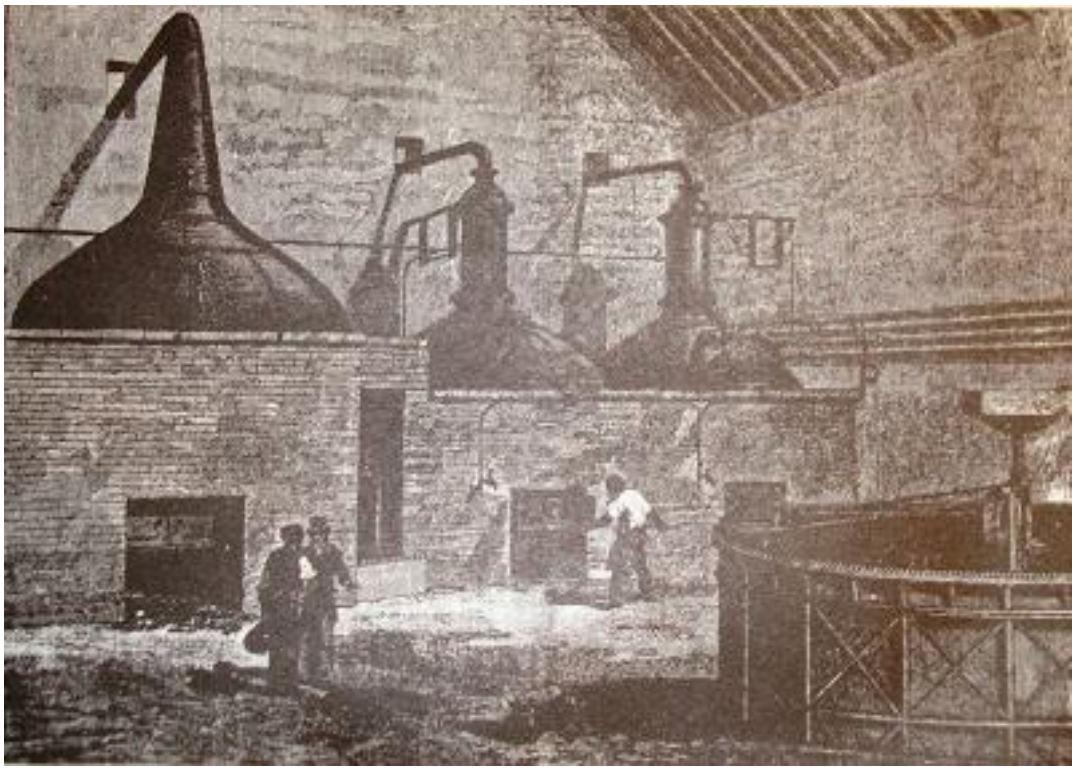


Figure 8 Hazelburn distillery showing the stills that are elevated in height allowing stoking of a fire beneath to heat the stills. Photo Bernard 1969.

The use of these two rooms is suggested as such, due to the layout of Bruichladdich Distillery, Islay (Figure 9). This diagrammatic sketch of that site shows part of the layout of the main building. As can be seen from area 14 (Figure 9) there is an additional room built in front of the still house, for the housing of cooling towers. This would be the most appropriate suggestion for the site of Kennetpans, as the spirit would have to be cooled separately from the still house, away from the heat source of the stills. As there is, however, little evidence left in this room it is difficult to have an accurate interpretation without referring to other distillery buildings of a much later date.

The issue with this is that with the later buildings there has been technological development and advancements since the original building of Kennetpans. One of the main changes that took place in the distilleries was the introduction of a pump room to move water vertically

through a building. Another advancement was the development of internal steam heated coils used to heat the stills and the introduction of mechanical mash turns (Bathgate 2003), this in turn made the distillation process more efficient.

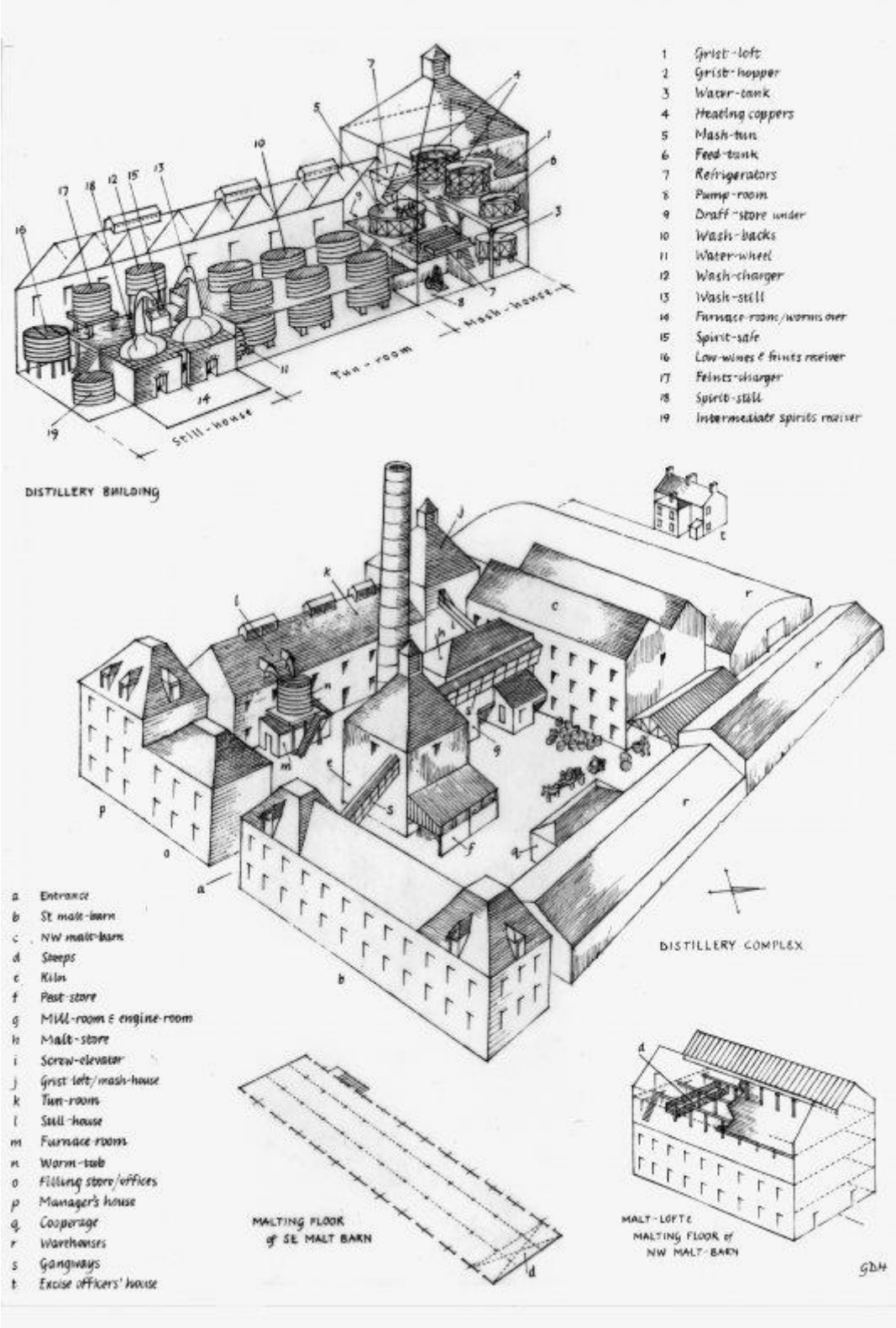


Figure 9 The layout of Bruichladdich distillery Islay, shows the still house with an additional room in front to house the cooling towers. Copyright RCAHMS.

Room 3 and Room 7 are thought to have been the still house and cooling towers, the whisky would have been decanted in to barrels here too. The main method of storage and transportation of whisky has traditionally been in barrels. Other distilleries that Stein operated used casks at their main method of storage and transportation (TNAS: CS6/541/1, 2 and 3) and therefore it would be highly probable that John Stein used barrels at Kennetpans. During the 18th century the railway ran from the coal mine in Clackmannan and Kilbagie to the port of Kennetpans and did not reach out to the wider Forth Valley. The canal that ran to Kilbagie also did not extend out in the wider area preventing Stein from using this as a method of transportation. Therefore, it is highly unlikely that he would not have used boats or horse and cart as the method for transportation, as there were not many other options available to him in the 18th century.

The whisky would have been decanted into the barrels in Room 3 or Room 7, the barrels would then have been transported across the site to the barrel storage area (Room 6 see below), using a horse and cart. In order to get the barrels on to a horse and cart a series of ramps would have been used due to the weight of the barrels. This could be an explanation for the wooden slats present in the doorframe between Room 2 and Room 3 (as mentioned above).

3.6 Room 4.

Room 4 was also a still house, which has three walls that are in relatively good condition, the west wall, however, is in a state of disrepair (see Room 3). The north wall of Room 4 forms the east side of the south wall in Room 2. The south wall has one bricked up window and a sandstone

archway that is at current ground level. The east wall has one window that has also been bricked up with red brick. The east wall in Room 4 is not tied in to the mill house but is butted up against the edge of it, which suggests that Room 4 was an addition to the mill house. In the centre of the room there is a red brick structure that stands at 0.75m tall. The brick structure appears to be a later addition to the room along with the bricked up window. A fire would have been heated the stills from beneath, resulting in the door at the front of the building, the lower floor was effectively the original boiler house for the stills, which could have later changed in use. The additions and alterations make Room 4 difficult to interpret. The brick structure in the middle of the room is similar to that of Malt Barn 3 (See below) and would have provided a platform for a still to sit on to be heated from beneath.

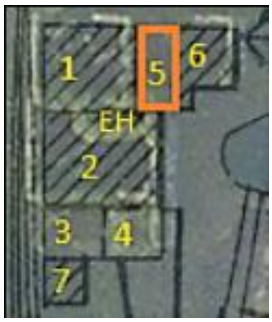
Figure 10 shows that Room 4 used to have a doorway leading in to the room from the harbour front that had an arched front. Figure 11 shows that the arch way that is now seen in Room 4 used to be used as a doorway that has subsequently been bricked up. Figure 10 does however show that the door was bricked up with sandstone. The change in use of the door suggests that the purpose of Room 4 also changed. The initial site investigation by AOC, has revealed a solid stone floor that is just below ground level. This put the floor at 3/4 of the way up the height of the door, which begs the question as to why there was a door in the first place.

Figure 10 Kennetpans Distillery in 1938, the photo is taken looking northwest, with Room 4 in the foreground on the left hand side of the building. Photo courtesy of Kincardine History group**.**

Figure 11 The stone arch way that currently sits a ground level. Photo authors own.

In Room 4 there are elevated levels of Ca, Ba and Sr (Appendix 3). The slight elevation of Ba and Sr within Room 4 would suggest possible burning with in the room. The lack of other significant burning signatures would suggest otherwise, again the level of Ca could be a result of the infill of masonry. The element analysis is difficult to interpret due to the amount of in fill or later reuse of the building, influencing the original soil concentrations.

3.7 Room 5.



Room 5 is a coal store that was previously an open space to prevent fire from destroying the casked whisky in Room 6 (See below), seen by the gap between Room 6, on the east, and the engine house on the south with a distinct gap in the southeast corner. Room 5 is situated between Room 1 on the west and Room 6 on the east and has a collapsed north wall that has been built out of brick. The centre of the wall is particularly degraded leaving a very large open structure. The use of Room 5 is thought to change around 1786 when the steam engine was installed. On the east and west walls there are floor joists that have been poorly carved out of the walls. The floor joists have been altered with the use of brick if the hole was not the correct size or level. The skill set used to create this room compared to the rest of the rooms on site, is of a much poorer quality. A further reason for suggesting that Room 5 came in to use later is that the floor joists are cut directly in to the door and window frames of Room 6 (Figure 12). A possible explanation for the change in use of Room 5 is when the engine house was installed there needed to be a sufficient supply of coal to the boiler house, which was situated off the south east corner of the room (see Room 6 for further detail). Room 5 is thought to have been floored to act as a coal storage area that would have been used to fuel the boiler to power the engine. The reasons for flooring this

room could be that the level the floor was put in at was of a height that allowed effective shovelling of the coal in to the boiler. The other reason is that there used to be a railway track that ran along the north edge of the distillery building. With the railway bringing coal down to supply Kennetpans, the floor could be of a sufficient height to allow the unloading of the coal carts when they were brought down to the distillery. The overall quality of Room 5 is poor and would suggest a rushed job. A further reason for flooring Room 5 could have been to allow for the flow of water to be taken underneath the room to the steam engine that came from a drain under the field directly to the north of the distillery building (Personal Communication Bryan Frew, 01/08/2015).

Figure 12 Floor joists that have been cut in to the window frame of the outer west wall of Room 6. Photo authors own.

The sample taken within Room 5 shows a slight elevation in Ba, Ca, P and Sr (Appendix 3). The slight elevation of the elements could be due to the infill of material or post distillery operations, as the levels are only slightly elevated it would not suggest that direct burning took place in Room 5. This would further support the theory that Room 5 was used to store coal for the boiler, as you would not want combustion to be occurring under the main fuel store to the distillery.

3.8 Room 6.

Room 6 is the original barrel store on site that changed to become the access to the chimney for the steam engine. Room 6 had four floors that are on average 1 meter apart and there are floor joists in all four walls indicating that they possible held a substantial weight. It is situated to the north east of the main distillery building (Figure 13). The distinctive gap between Room 6 and the main distillery building was purposely done to prevent fire damage to the room. It is in relatively good condition with eight windows, five of which have been blocked up with red brick. There are two doors, one that connects Room 5 on the east wall and on the north side there has been a section that has been knocked through in to Room 5. On the west wall an area has been brick lined and leads out into the south side of the building towards the boiler house. There is also an addition of a bricked flue (Figure 14) on the south wall that leads to the engine house as both of these parts are made with red brick it would suggest that they are later additions to Room 6. The other reason for their original use of the barrel store is that the building was distinctly separate from the rest of the main distillery buildings. The later additions (flue) to the room of red brick suggest that the room changed use in 1786.

Figure 13 The chimney installed as part of the boiler house for the steam engine can clearly be seen in 1925. The chimney is situated on the corner of Room 5, 6 and the Engine house. Photo courtesy of Kincardine History group.

The sale of the distillery in 1865 suggests that there were four kilns on site (Glasgow Herald 1865). Figure 2 clearly shows the roofs of three kiln houses but it is unclear as to where the fourth would have been situated. The reason for the change in use of Room 6 is the need to fuel the boiler. The boiler would have been stoked from Room 6 and thus the brick lined archway (Figure 14). This would suggest that the flue on the east wall was for smoke to return in to the room. As spirit cannot be located next to heat due to its extreme flammability, the barrel store would have moved. This leaves Room 6 to be repurposed and used as a kiln. The return flue and the bricked up windows suggest that Room 6 would have been converted in to a kiln post 1786 when the steam engine was installed. This would have been an effective method for drying the grain and a great use of smoke from the boiler house.

Figure 14 The brick lined flue situated in the southwest corner of Room 6 that was used to stoke the fire in the boiler house. Photo authors own.

Throughout all the rooms in the distillery building if there has been blocking up of a window or door was it has been done with red brick, unless it was on the first floor in Room 2. The

reason for this could be that red brick was easier and cheaper to obtain and put in compared to sandstone, as there was a brick works in Clackmannan. The doorway leading to Room 4 has been blocked up with sandstone. A possible reason for this could be for an element of showmanship and to be in keeping with the rest of the building. The ground floor would have been the most visible and easiest accessed by visitors to the distillery and mill house, which would have resulted in the element of showmanship and detail taken.

Each room within the distillery building would have housed all the processes for making whisky. The building then underwent several transformations, with the addition of the engine house and the malt barns, resulting in the change of use for Rooms 1, 5 and 6 in particular. The addition of the engine house and millstones would have altered the space in Room 2 but it would have carried out the same process.

4. The Malt barns

Traditional historical research (photographs and maps), Industrial archaeology and geo-archaeology and was used to identify the use of each of the rooms within the malt barns in relation to the whisky processes.

4.1 Malt barn 4.

In order to meet the market demand and to improve efficiency Kennetpans distillery built large malt barns southwest of the main distillery building. The interior of the malt barns are some of the most difficult rooms to interpret, due to the malt barns traditionally having a wooden interior and not containing a vast amount of detail. As all the components of the malt barn

would traditionally have been organic (wood) and as a result would have biodegraded since the abandonment of the distillery in the 19th century.

Malt Barn 4 (Figure 4) is the single largest room on site measuring 22.10m north to south and 35.6m east to west (786.76 m^2). All three walls are in good condition and show little deterioration or degradation. The interior to Malt barn 4 currently contains trees and no shrubbery or undergrowth. All windows and door openings are well preserved and the metal bars that would have formed a grid in the window frame can still be clearly seen. On the south, east and west walls there are 17 windows on each wall. There are two doors in Malt Barn 4, one opening on the west and a bricked up one on the east. The floor joists can still clearly be seen in the south wall, which contains 73 visible floor joists that would have ran north to south. The number of floor joist and the additional supports on the west and east wall would suggest that Malt Barn 4 held a considerable weight on the first and second floor. The north wall that forms the divide between Malt Barn 4 and 3 is in poor condition and as a result the structure of this wall is unknown. The large number of windows in Malt Barn 4 allows for good airflow and circulation throughout the building, to regulate the temperature of the malting barley, on both the ground and first floors. With Malt Barn 4 containing a large number of windows it would suggest that it was easy to regulate the temperature and air flow throughout the building, through the use of the many shutters.

On the south wall, in the southeast corner, there is one large rectangular window with two square openings on either side (Figure 15). The top of the rectangular opening is level with the second floor and the base of it with the first floor. The opening leads to the Annex on Malt barn 4, discussed below.

Figure 15 The rectangular opening in the south wall in the southeast corner of Malt Barn 4 that connects the first floor to the annex. Photo authors own.

As mentioned previously the volume of raw barley required to produce whisky is vast (36,000 bolls) and the first and second floor would have had to have a number of supports in order to hold the weight. For this reason, it would suggest that the malt barns would have been large to house the grain before being malted and during the malting process. The open floor area all floors of Malt Barn 4 would have allowed sufficient airflow through the room to air the malting barley when germinating. The height of the floor levels within the malt barn would have allowed easy access to turn the grain.

Malt Barn 4 has elevated levels of Ca, Sr and Zn across all five samples taken inside it (Appendix 4), relative to the background. On the east side there are elevated levels of Ba and Fe, on the west side P is elevated and the central area having elevated readings of P and Fe. The elemental readings from within Malt Barn 4 would suggest that there has been areas of burning on the east side of Malt Barn 4. There is a door on the east wall that leads out to the harbour front. As the railway tracks and steam crane are located close to the door in Malt Barn 4 the elevated signatures could be a result of transfer of ash and cider from the crane and railway tracks, thus giving a false indication of burning taking place in Malt Barn 4. The levels of Ca throughout the building would further suggest that burning took place in Malt Barn 4, but again there are large quantities of masonry that have in filled the malt barns and influencing the levels of Ca.

4.2 Annex

The Annex was used to transfer grain from the malt barns to horse and cart to be transported to the kilns around the site. The Annex to Malt Barn 4 is an intriguing building. The roofing wall forms a sloping gable end, unlike the other buildings on site. There is one door on the south wall with one bricked and one open window on the east wall. The north

wall contains the rectangular opening that connects to Malt Barn 4. The north and south walls have six large floor joists situated within them. The north wall also has two oblong openings that connect to the second floor in Malt Barn 4, these openings are not visible from Malt Barn 4 due to the ivy coverage. The west wall has a door that is 3m wide and has wooden slats on the interior similar to the door connecting Room 2 and Room 3.

The Annex was used for moving the malted grain to the kilns throughout the site. The oblong openings that connect to Malt Barn 4 would have been used to funnel the grain down from the second floor to the annex (Figure 16). The large rectangular opening would have served the same purpose for the first floor. The floor in the annex contained substantial beams that would have supported the floor. This would further suggest that the floor was strong enough to support a substantial weight. The floor level is at an appropriate height for the grain to be loaded directly onto a horse and cart. The door opening is twice that of the arches in Room 2 suggesting that there were two different types of horse and cart used to transport grain around the site, or that the malted grain was loaded on to two carts at the same time from the annex. The malted barley would then have been transported across site to the kilns to be dried. The purpose of square openings in the north wall remain unknown, as they occur above the first floor level.

Figure 16 The oblong openings that connect the second floor in Malt Barn 4 to the annex. Photo authors own.

4.3 Malt barns 1 and 2

As mentioned previously there were four kilns on site at Kennetpans, three of which were located in Malt Barns 1 and 2. In a photograph from 1890's (Figure 2) there are three definite pyramidal peaks that form the traditional shape of drying kiln of many of today's distilleries. The 'pagodas' that traditionally sits on top of these kilns allow the air to circulate and transfer the heat to the malting grain to halt the germination process (Bathgate 2003). In modern distilleries the smoke is often used to infuse the barley with a rich peaty flavour giving the

resulting whisky a deep and earthy tone. When Stein was in operation, Kennetpans main fuel source was coal. This would have given the barley a weak flavour and could have been the reason why lowland distilleries whisky was so awful (Burns 1785).

Malt Barn 1 has a north wall containing no windows and 35 floor joists that are 28-30cm apart (Figure 17). The east wall has 15 windows, four of which have been bricked up by red brick and one door, the east wall contains four supports that would have spanned east to west. The west wall is no longer standing and what remains of the south wall show that it was not tied in to the east wall. The northeast corner of the wall was built at an angle (see Figure 4), indicating that the building was built in order to accommodate the railway tracks.

Figure 17 The floor joists in malt barn 1 that are 28-30cm apart. Photo authors own.

Malt Barn 2 is the smallest malt barn on the site. Malt Barn 2 has an intact east wall that has three windows and one door. The north wall is largely missing apart from a small section in the north west corner. The south wall contains 28 bricked up floor joists, that then change in height and has another level that contains 20 floor joist supports (Figure 18). The west wall contains a door that has been bricked up and a window that has been previously 'pebble' dashed. The end on the west wall of Malt Barn 2 is gabled similar to that of the annex , however, the east wall remains flat like the rest of the buildings on site. This would suggest that there were two types of roof over Malt Barn 2, possibly splitting the room in two. This would suggest that Malt Barn 2 was used half as a drying kiln for the halting of the germination process and for the cooling towers for the stills in Malt Barn 3 (See below). The multi use of Malt Barn 2 shows that the need to fit multiple processes in to a small operational site of Kennetpans.

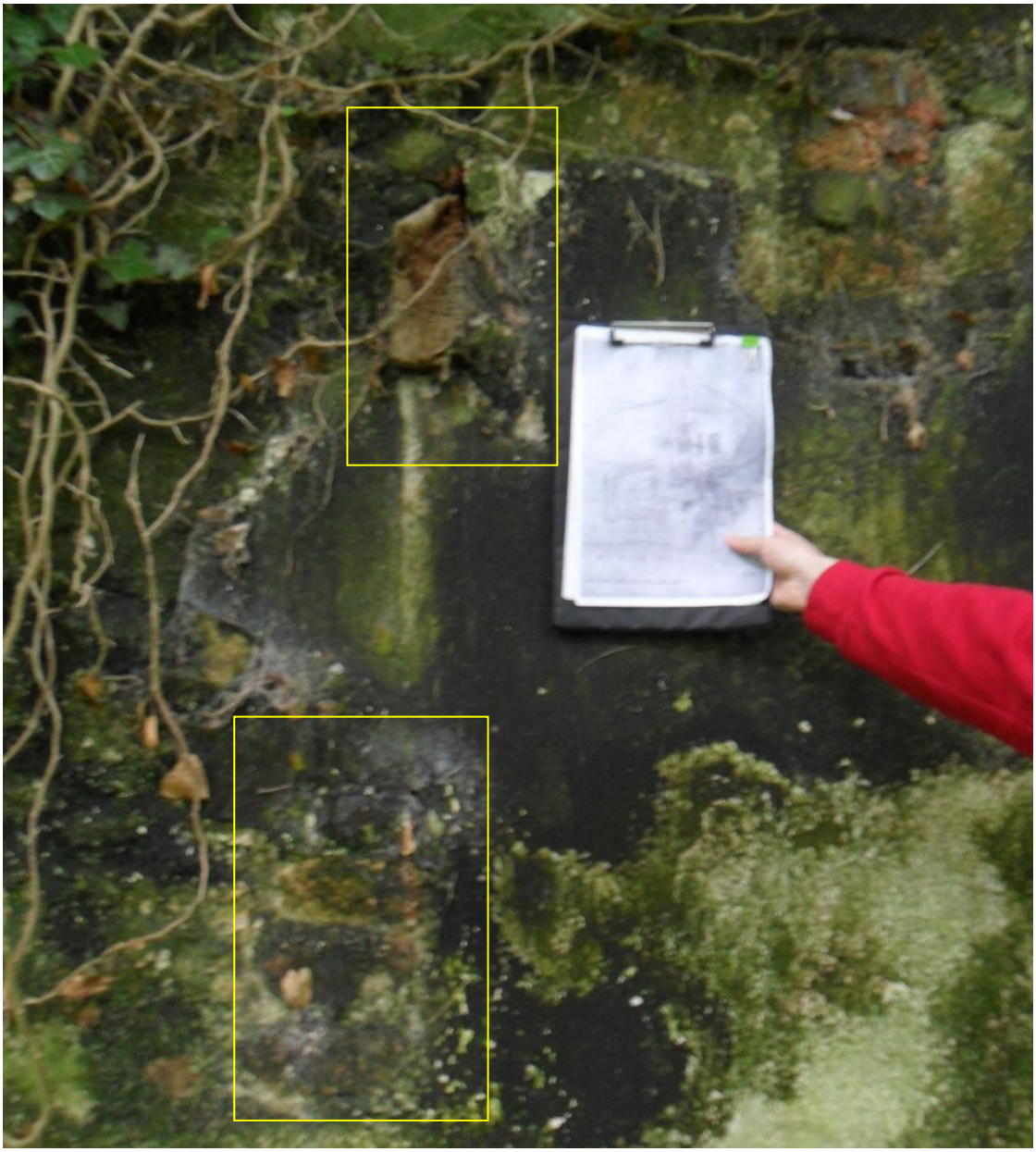


Figure 18 Malt barn 2 where the floor changes in level. Photo authors own.

In Malt Barns 1 and 2 there is little evidence to support the theory that these were malt barns. The photo from 1890's clearly shows that these rooms were kilns (Figure 2). These rooms, however, have a large number of windows in each of them especially along the east wall. The west wall in Malt Barns 1 and 2 are poorly degraded to missing in places. This makes it increasingly difficult to gain an accurate idea as to what the remaining walls or windows would have been like.

When Stein, was in operation it is highly probable that there would have been several fire pits or kilns with in one room to provide enough smoke and heat to dry the barley. It is probable that there would have been channels or flues out from each of these fires to funnel smoke to different areas of the malt barn to create an even drying surface. This is due to the size of the kilns that Stein operated and the volume of grain that he was drying at one time. The space that the kilns had to heat was large and combustion would have likely been inefficient, several kilns or hearts would have been needed. The large number of windows could have allowed for sufficient airflow to the kiln and also to halt the drying process by opening up the windows and the building to air.

The elevated levels of P around the site could be due to the free ranging alpacas. If the alpacas influenced the P concentrations then there would be a higher level expected in Malt Barn 1 (Appendix 4) as this is used as a midden. As this is not the case the level of P around the site is interpreted as the environmental legacy of Kennetpans distillery and not current day use.

Malt Barn 1 has elevated levels of Fe, P, Sr and Zn (Appendix 4) this would suggest that burning took place in this area of the barn. As Malt Barn 1 is large it would have been preferable to sample repeatedly in this room but as previously mentioned this was not possible. The soil signatures in Malt Barn 1 would further suggest that this area was used as a drying kiln. Similar to Malt Barn 1, Malt Barn 2 has elevated levels of P, Sr and Zn on the east side. The presence of these elements would suggest that there was burning taking place in this area of Malt Barn 2, yet the lack of other elements suggests otherwise.

4.4 Malt barn 3

Malt Barn 3 was the second still house on site. It has a second floor supported by joists that run from north to south and floor joist running east to west. The latter floor joists have been designed in order to carry a lighter weight. In the northwest corner there are three floor joists that would have formed a first floor but no other floor joists are present along the north wall. This would indicate that Malt Barn 3 would have had a full second floor and a partial first floor. In the east wall there is one chimney that is well-crafted (Figure 19), six windows, four of which have been bricked up, and one door that has also been bricked up. The partial floor would suggest that it was used as a platform that would have surrounded a still. The platform floor on the west side of the building would suggest that there was a floor that allowed access to a still. Due to the large portion of rubble within Malt Barn 3 it is unclear as to what is adjacent to the platform floor, but there is a similar structure to that of Room 4, brick plinth. This would suggest that Malt Barn 3 was used as a still house, for the distillation of the fermented wash, with the cooling towers being situated in Malt Barn 2. The lack of weight carrying floors is the only one on site to suggest that whatever was stored on the second floor was light. The chimney located on the east wall further emphasises the possibility of Malt Barn 3 being used as a still house. The size and scale of the malt barns gives a good indication as to the scale that Kennetpans distillery operated.

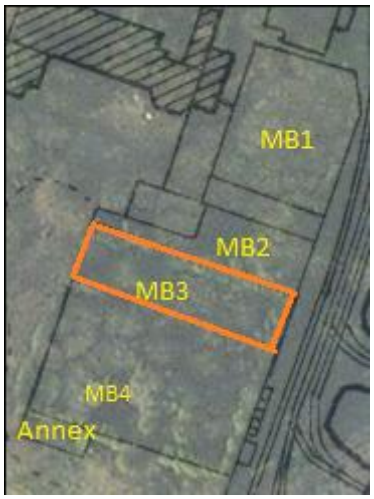


Figure 19 The chimney that is located on the east wall of Malt Barn 3. Photo authors own.

In Malt Barn 3 on the east side there are elevated levels of Cu (Appendix 4). As there are no other Cu signatures in the malt barns this would suggest that the processes carried out on the east side of Malt barn 3 would have contained copper, possibly a still. Through combining the elemental signatures of Malt Barn 3 and the field observations, it would suggest that Malt Barn 3 was used as a still house when the distillery expanded its operations. This would also explain the change in floor levels in Malt Barn 2 that was designed to house the cooling towers for the stills. The elevated levels of Ba, Fe, P, Pb, Sr and Zn (Appendix 4) on the east side of Malt Barn 3 would suggest that there was a hearth on this side of the room. The fireplace that is found on the east side of the room backs this up. A possible reason for the elevated levels is that the ash from the heart was scattered over the floor repeatedly, thus resulting in elevated element signatures.

The malt barns each had a specific use in relation to the whisky making process. Through combining traditional historical research, geo-archaeology and remaining industrial

archaeology provided a better understanding of the room use, particularly Malt Barn 3, than using just an indivdual technique.

5. Wider Landscape

This chapter will look at the raw material: barley; labour; water and coal, along with transport via the harbour to wider Scotland and the export trade, railway and canal, within the wider landscape. It will also look at the waste disposal of ash and the secondary industry of beef production.

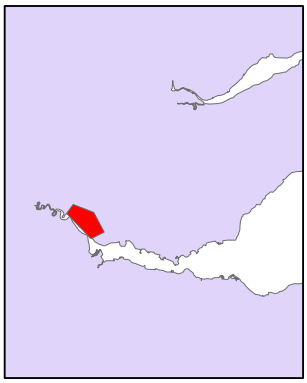
Barley holds, the essence to whisky without which we would not have whisky as we know it today. The export trade continued to increase it can be presumed that from 1791 onwards that the volume of whisky produced at Kennetpans also gradually rose. The volume of whisky produced at Kennetpans was greater than 1,800 tons of spirit annually from 1791 onwards (Moodie 1799). On average 1,800 tons of whisky requires 36,000 bolls of barley, which in turn would require an average of 3,600 acres at a minimum to produce. The area required for Kennetpans distillery for barley growth alone requires more land than is feasibly suitable for the growth of barley in the Forth Valley. The Steins owned Loanside, neighbouring Kennetpans and Kilbagie during the 18th and 19th century and continued to acquire land to add to the farm (TNAS: GD124/1/863). These farms would not have been able to supply the demand that Kennetpans originally created, along with the demand from other distilleries (Kilbagie and Clackmannan) as well as the brewers in the area. Due to the limited space within the Forth valley it is probable that Kennetpans imported much of its barley. In 1722 there is a contract between the Sir Hew Dalrymple and Andrew Stein (Grandfather of John Stein) along with two other men for the shipping of 200 bolls of good

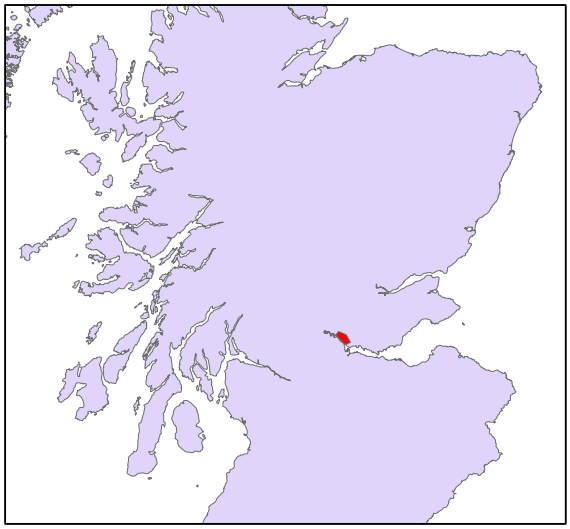
quality barley and 100 bolls of white wheat (TNSA: GD110/743). This record is a contract between these four men for the shipping of grain up to Alloa from North Berwick. This is the first record of barley being imported by Stein but there is no indication of the purpose for which the grain was used. The contract does indicate that this was not a one off transaction and the shipment of barley and wheat from North Berwick would be repeated.

The lowland distilleries of Kennetpans and Kilbagie were the instigator of the early industrialisation of arable farming within the Forth (Sinclair 1814). The large lowland distilleries paid a similar price for grain grown locally as to that of imported barley, which was advantageous to local farmers (Sinclair 1814). During the early stages of the industrialisation of whisky barley and bear would have been a necessity and thus changing the way and the varieties of barley that were grown. The quantity of barley used at Kennetpans it is not surprising given the size of the malt barns and drying kilns on site.

The work force would have worked 24 hours a day in order to keep the distillery operations going, due to the malting barley needing turned ever 4-6 hours and the drying kilns needing to have a constant fire in them for up to 7 days (Bathgate 2003). Therefore it is unusual that the distillery only had two servant houses for accommodation of the distillery employees (LMA: MS/1936/385/599435). The closest towns of Alloa, which is c.2miles and Kincardine, 1 mile (Figure , who would have supplied the work force for Kennetpans. The original miners cottages at Kennet were built to house miner's of Kennet coalmine (Moodie 1799).

The Wider Environment





Created by Hazel Ramage
22/09/2015
Based upon Ordnance Survey Data.

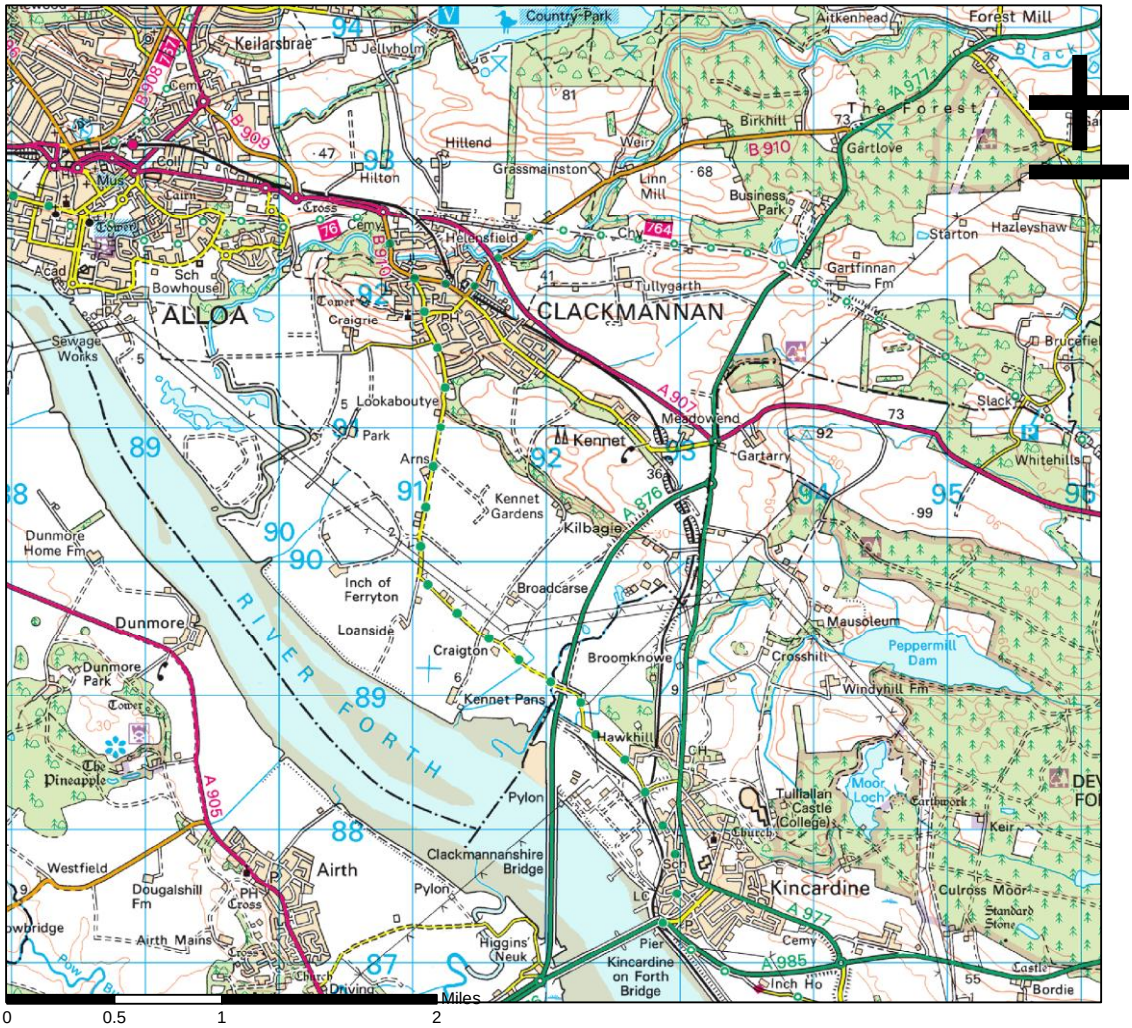


Figure 20 shows the wider area that supplied the labour force, coal and the start of the trade routes.

There is no historical documentation on the use of water at Kennetpans. The water supply at Kennetpans can therefore only be speculated upon. A stream comes into the north end of the customs houses, which flows under them, the exit point of which is unknown. A possible reason for this is that the water was used in the malt barns for the steeping of barley and the stills. The field drain that is located to the north of the distillery would have supplied the water to the steam engine, steeps and stills in the main distillery building.

The coal used to fuel Kennetpans kilns, stills and steam engine was brought down from the Kennet coalmine, located just south of Kilbagie. The Kennet coalmine operated with the sole purpose of supplying Kennetpans and Kilbagie distilleries (Moodie 1799). Clackmannan Field Studies Society (CFSS) suggests that the rail way was built between 1849-1860, however a court case in 1813-1818 details the rights to the railway (S.L.333.7). Figure 1 details the layout of Kennetpans port c.1840 resulting in the railway having been build much earlier. Kennetpans distillery used 3000 tons of coal annually, which was transported to Kennetpans distillery by way of a canal (Moodie 1799), which was superseded by a railway prior to 1813 (Glenn 1969).

Using Palmer and Neaverson six point plan it would suggest that Kennetpans was located at the harbour front in order to benefit from the trade routes, through the import of grain and export of whisky. Kennetpans distillery was situated on the port front and in an advantageous point to trade with Scotland. Kennetpans played a leading role in developing the export trade to London (Lockhart 1951, Glenn 1969, Moss and Hume 1981, Lyons1999 and Buxton and Hughes 2014). The role that it played in setting up the export trade is clearly shown in the sederunt books of Lochrin (TNAS CS96/2080 and CS96/2081). In the Lochrin sederunt books there is a series of letters and meetings that detail Stein as one of the

instrumental players in setting up the export trade to London. In the records of Lochrin there is a letter 12/06/1788 that James and John Stein, James Haig and Co. and John Haig would take the recommended measures and ship a small cargo of spirits from each distillery to London. In these letters they also establish a sales representative in London to sell the whisky once it has arrived in port. The distillers in Scotland appointed a Mr Sandermans as their representative. In the parliamentary papers (1782-1802) it is clearly stated that the export of spirit from Scotland to England has been going on for a considerable period (House of Commons 1782-1802) but does not state which distillers were exporting their whisky. It is surprising that a representative in London had not been appointed. One possible reason for this is that there was someone appointed by Stein at an earlier date. There are three to four main gentlemen that have monopolised the whisky industry in the Lowlands of Scotland, again Parliamentary papers are vague in mentioning these gentlemen but it can be assumed that Stein was one of them (House of Commons 1782-1802). This would suggest that Kennetpans was successful and did export to England but there is no further documentary evidence to support this, as excise records are very vague.

From researching further into the history of the whisky trade from Kennetpans it would suggest that previous authors (Lockhart 1951, Glenn 1969, Moss and Hume 1981, Lyons1999 and Buxton and Hughes 2014) have expanded on the idea that Kennetpans was a large exporter to London in the early 19th century. From 1803, there is no record of Kennetpans distilling whisky for the exportation to England. Kennetpans whisky was solely distilled for the consumption in Scotland, due to Stein being paid by English monopolies not to export whisky to England (Wallace 1823). Thus, Kennetpans only sold whisky to the Scottish Market, as this had a greater financial benefit.

Like all fuels coal generates waste ash and clinker. The ash would have been periodically removed from the kilns, still houses, and boiler house and disposed of. One method of doing this would be to use drains on site, similar to Room 1 or it would be manually disposed of around the site. In order to capture a possible method of ash and clinker disposal, two cores were taken on the east of the distillery building. The drain that originated in Room 1 would have flowed out through the south wall and out through the engine room. A core was taken in line with the vent in the wall of the engine house at a distance of 2.7m. The core was 65cm in depth and captured a significant loading of elements at 40cm deep. Core 1 contained large quantities of rubble in the core due to the proximity with the distillery building. The core had two distinct layers of the organic top soil and then a mixture of rubble and mortar from 8cm to the base of the core. The elevated levels of Ba, Ca, Cu, P, Sr and Zn (Appendix 5) indicate that there was a period of burning or deposition of burnt material. The loading of these elements suggests that this was a significant event. As the boiler house is located to the northwest of the core it would suggest that the deposition would have occurred through the deliberate dumping of waste ash from the boiler along with the out flow from the drain in Room 1.

Core 2 was taken along the same tadjectory at a distance of 6.10m from the engine house wall, close to the exterior of the sluice pond. Core 2 has two distinct layers that separate at 19cm. The upper layer is rich in organic material with the lower layer having evidence of cracking and smearing, the cracking is due to a single deposition event. There are also flecks of charcoal present in the lower layer. The element concentrations occur as a peak at 27cm in depth, there was pieces of clinker found. The elevated concentrations of Ba, Ca, Cu, Fe, P, Pb, Sr and Zn (Appendix 6), occurring at a depth of 30cm. Although the elevated levels of Ca

has been influenced by mortar and building materials, the elevated levels of the remaining elements would suggest that the lower layer of the core is a result of ash being deposited. As Core 2 has been taken from below the boiler house this would suggest that the boiler ash was emptied in to the area surrounding the sluice pond. This could have been a way of disposing of ash into the Forth, due to the volume of coal that the distillery used the volume of ash and clinker would have been considerable. Depositing the ash on the area surrounding the sluice pond would have been the most convenient area to dispose of the large volumes of ash. If the ash had to be deposited elsewhere on site, this would have become a labour intensive job as the location of the boiler house would prevent access with a horse and cart.

Kennetpans had a secondary industry attached to the distillery, this was in the form of beef production. Stein would have used the waste draff from the distillation process to fatten his cattle for market. As Kennetpans has little documentary evidence supporting it, the map of 1840 (Appendix 2) shows that there were byres located directly behind the distillery building. The reason for this would have been to house cattle close to their main food source and to reduce the distance of transporting the waste draff. In the Statistical Account of 1799 it suggests that Kennetpans housed cattle to fatten based on the information supplied about Kilbagie (Moodie 1799). Indicating that Stein used his own waste on site and did not supply other farms with draff, thus causing Kennetpans distillery to become a self contained entity in the wider environment.

Kennetpans distillery was a well connected distillery to the wider landscape and Scotland. Kennetpans was a self contained operation through the distilling processes with its water sources readily available. The coal was locally sourced and it had good connections to the

wider environment through a canal and railway. The harbour allowed the development of the export trade, along with importing grain. Kennetpans also disposed of its waste ash on site along with the waste draff in the form of secondary industry in beef production.

6. Conclusion.

Through gaining an understanding of how Kennetpans distillery was laid out it is possible to gain a sense of the scale that it operated at. Kennetpans distillery went through a significant alteration in 1786 when the steam engine was installed. This changed the quantity of grain that could be milled and changed the way in which the site operated. The installation of the engine house within Room 2 changed the overall layout of the main distillery building. This changed the mill house from being wind powered to steam driven. The increase in power meant that the mill was able to grind more barley, along with other crops such as wheat and rye. The most significant change was to Room 5 and Room 6 during this time. The change of Room 5 from an open space to a floored coal store and Room 6 from the ever-essential barrel store to a kiln that provided access to the fire for the boiler house. The alteration to these two rooms fundamentally changed the way part of site operated. Room 3 and 4 were still houses and remained as so during the distillery operation. The buildings that are located between the distillery and the malt barns were partly used for accommodation for the distillery workers. The environmental legacy of the main distillery building has shown that in Room 1 the drain was used to remove ash and cinder. The rest of the distillery buildings environmental legacy has been influenced by the rubbish that has been dumped within the building. The cores allowed an understanding of the changes in ash deposition throughout time. The higher environmental legacy values are at a deeper depth. The change in soil in

Core 2 indicates a distinct change in the operations at Kennetpans distillery as there is no longer any ash being deposited.

The malt barns were the most difficult to interpret based on field observations as the main components of these rooms were made of organic material (wooden floors) that has long since biodegraded. This part of the project highlighted the importance of the use of photographs as an essential historical resource as it provided an accurate depiction of what the malt barns used to look like. Even through all the photos are taken post closure of the distillery, they still provide a detailed picture of how the distillery would have looked when it was in operation. Without the aid of these photos, the malt barns lacked any features to distinguish them as kilns or could be used for any other purpose, apart from holding a great weight, as seen by the large number of floor joists. The environmental legacy of the malt barns has enhanced the understanding of the site. The levels of copper within Malt Barn 3 has suggested a further area for the use of a still house and has given an understanding to the partial floor that is on the west side of Malt Barn 3. Without the environmental legacy of this room it would have remained difficult to interpret and reason out the different floor layouts. Through generating a specific data set for Kennetpans distillery it has allowed a greater understanding of the site and answered specific environmental questions relating to the use of each room. By combining traditional historical research and field observations an understanding of how each of the rooms were used in the main distillery building and also the malt barns, it is possible to understand how the site operated and functioned on a daily basis.

Kennetpans sits within its own landscape, remaining self contained through secondary industry but connected to the wider environment through raw materials, labour force and

trade routes. The situation of Kennetpans distillery is particularly advantageous, due to the port for its trade routes. Its situation at the port is one reason that the distillery was so successful. The other is the drive of Stein, to install and develop different methods that improved the way his distillery operated. Both of these factors played a vital role in shaping the distilling industry in to what it has become today. Kennetpans was an instigator of the whisky trade and helped to shape the whisky industry that we see in Scotland today. The distillery remained a driving force behind the development of the export trade and industrialisation of whisky production.

Kennetpans is a complex industrial site that has had many alterations to it throughout is lifetime, with each room on site being built for a specific process to make whisky. The situation of Kennetpans within its landscape from raw products and distance from labour source had resulted in a self-contained operation that remained well connected to wider Scotland through its trade routes. The biography of Kennetpans focuses mainly on the export trade to England and is overshadowed by Kilbagie. From this study, it has been understood that Stein help develop and set up the trade but he did not export his whisky to London as of 1803, due to financial benefits. The fact remains however that Kennetpans, in its own right, was one of the most influential distilleries in the industrialisation of whisky and is one of the few early pioneering distilleries that remains today.

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Appendix 1

Methodology.

An interpretation of the industrial archaeology was under taken through a site walk over of both the distillery and malt barn buildings. Palmer and Neaverson six point plan was used to understand the situation of Kennetpans distillery and the benefits and implications of locating the site in this location.

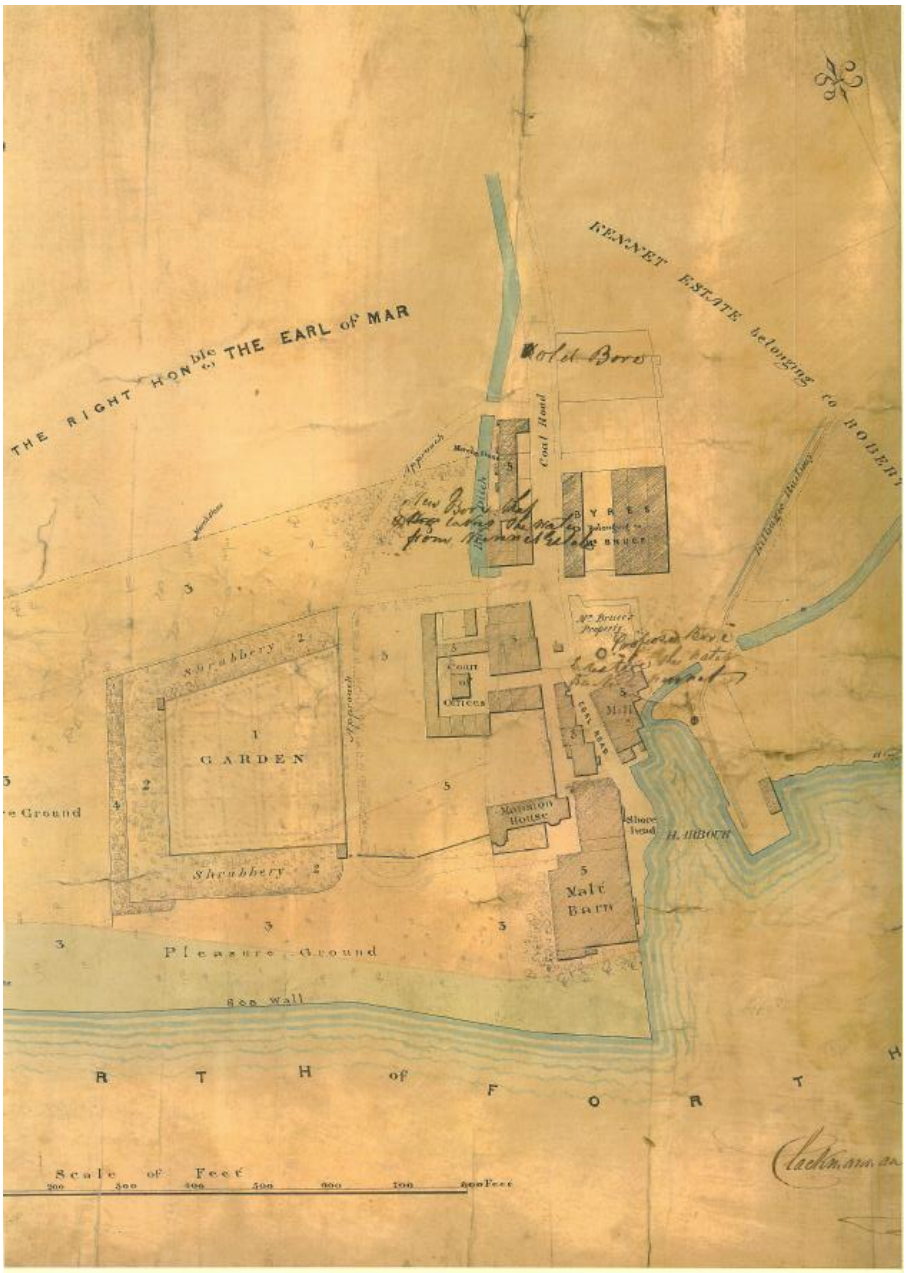
Sampling was carried out throughout the distillery building and malt barns using a Dutch auger. There were two samples taken in Rooms 1 and 2 with one sample taken in Rooms 4 and 5. Room 3 was not sampled in due to the deterioration of the room and the amount of infill present. Room 6 was also not sampled in as there was not an obvious floor level with in the room. There were no samples taken in the engine house as there is a large degree of infill in the room and access was difficult. There were two cores taken using a golf hole corer on the east of the distillery building and split into sections for further analysis.

In the malt barns, there were five samples taken within Malt Barn 4, two in Malt barn 3 and one in each of Malt Barn 1 and 2. Although Malt Barn 1 had clearly defined remains further samples was not undertaken due to it currently being used as a midden preventing an accurate interpretation of the environmental legacy, as it would be influenced by the additional input of minerals. Malt Barn 2 also only had one sample taken due to the degree of infill with in the room.

All samples were dried at 105^0c for 24 hours and sieved using a 2mm aluminium sieve. Each of the samples were digested using a Mars Express CEM microwave on express sediments setting at 175^0 for 5 minutes. Each sample (0.25g) had 2mm of concentrated nitric acid added prior to digestion. The samples were then filter through Watman No. 2 filter paper

with deionised water and made up to 100ml. IPC-OES analysis was carried out using a Thermo iCap 6300 for the determination of Ba, Ca, Cu, Fe, P, Pb, Sr and Zn ($mgKg^{-1}$). Each element had an individual calibration and limit of detection calculated.

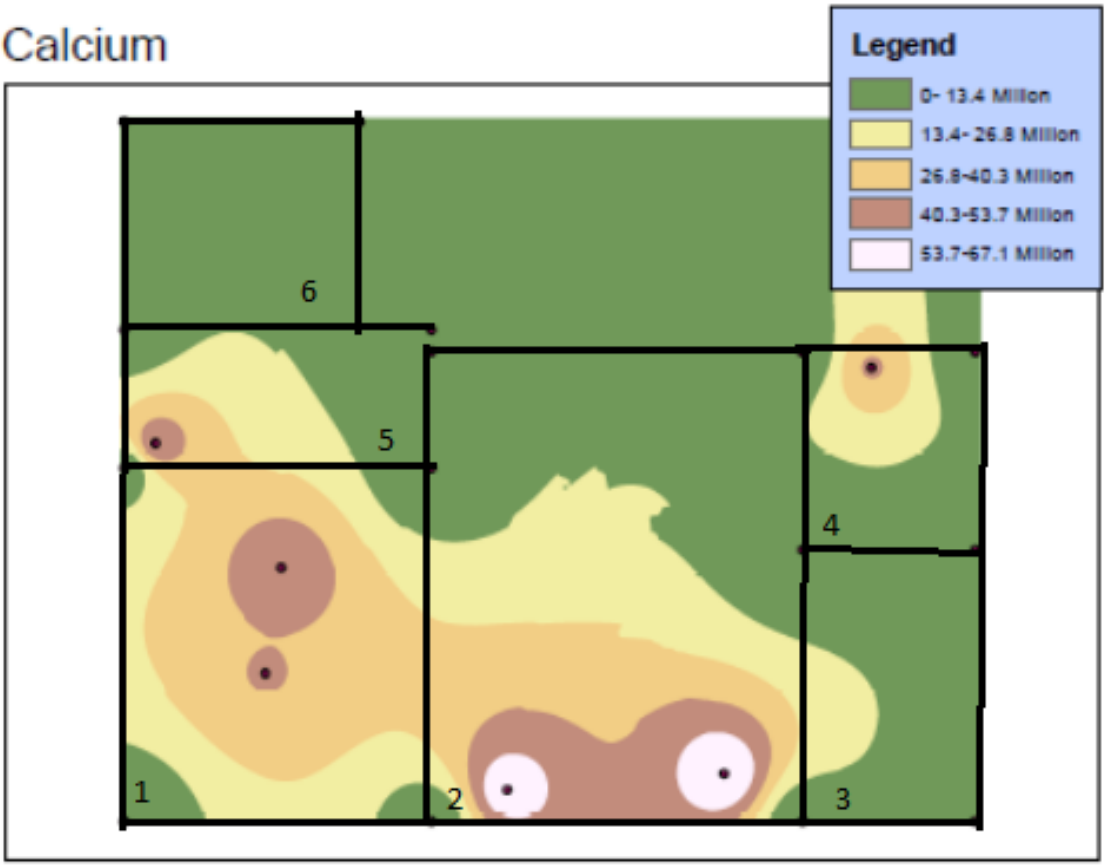
Appendix 2

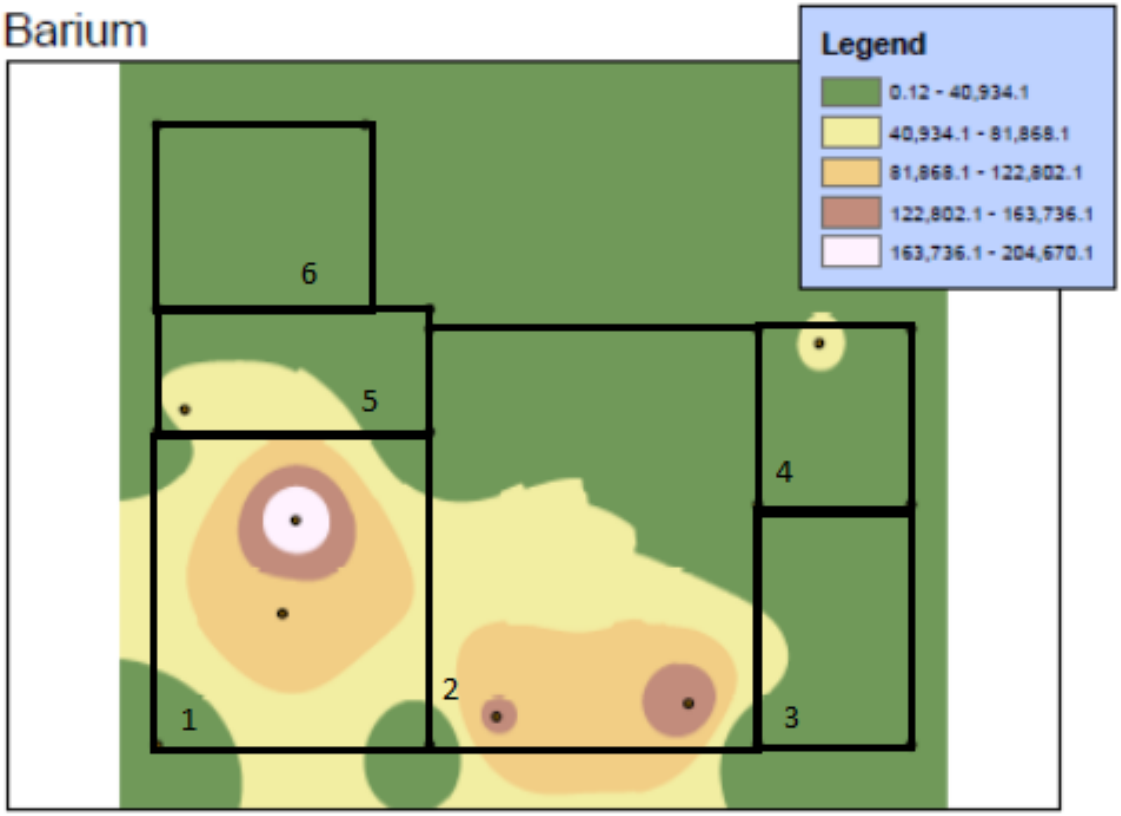


Map of the feus to Kennetpans in 1840 detailing the buildings that belonged to the distillery operation (5), along with the Mansion house, garden (1), Shrubbery (2), Pleasure ground (3) and Plantation (4) totalling to 16.57 acres. Map courtesy of Clackmannan archives, Private collection.

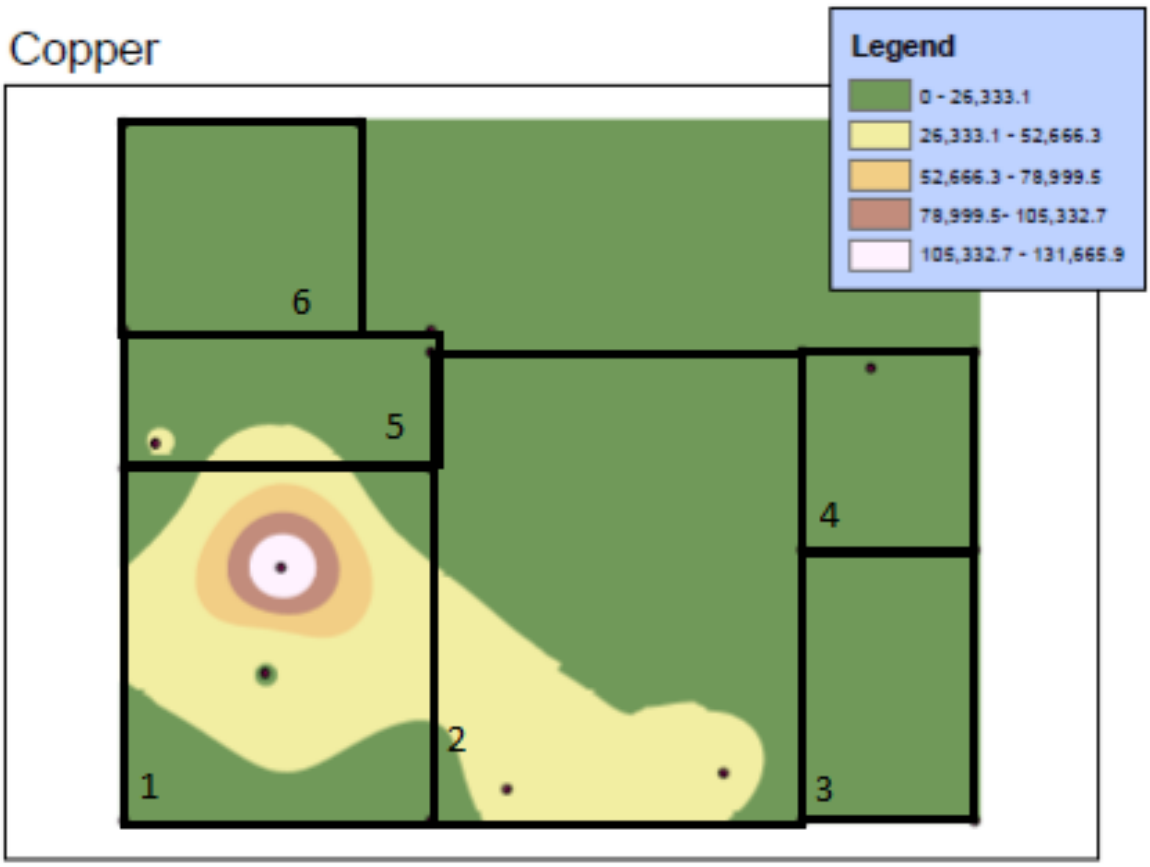
Appendix 3

The element concentration for each sample has been calculated and mapped in relation to the distillery building each dot represents a sample location.

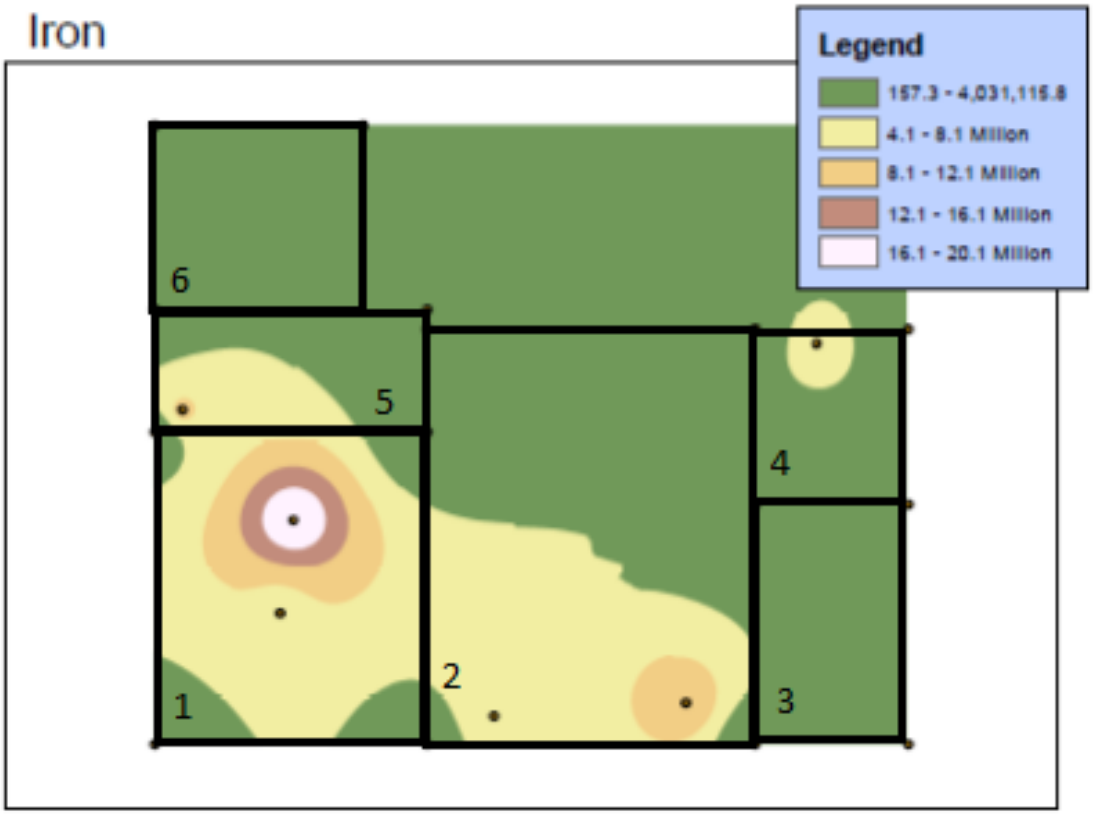




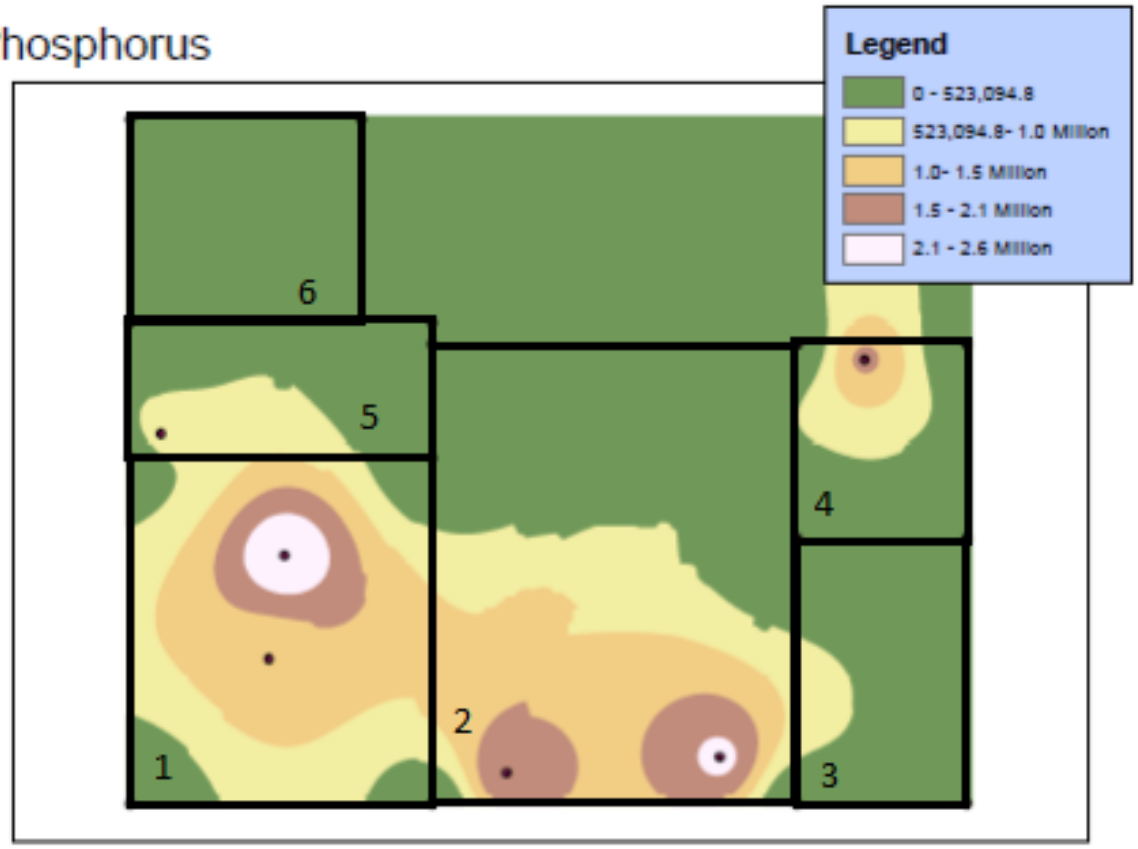
Copper


Legend
0 - 26,333.1
26,333.1 - 52,666.3
52,666.3 - 78,999.5
78,999.5- 105,332.7
105,332.7 - 131,665.9
6
5
4
2
1
3

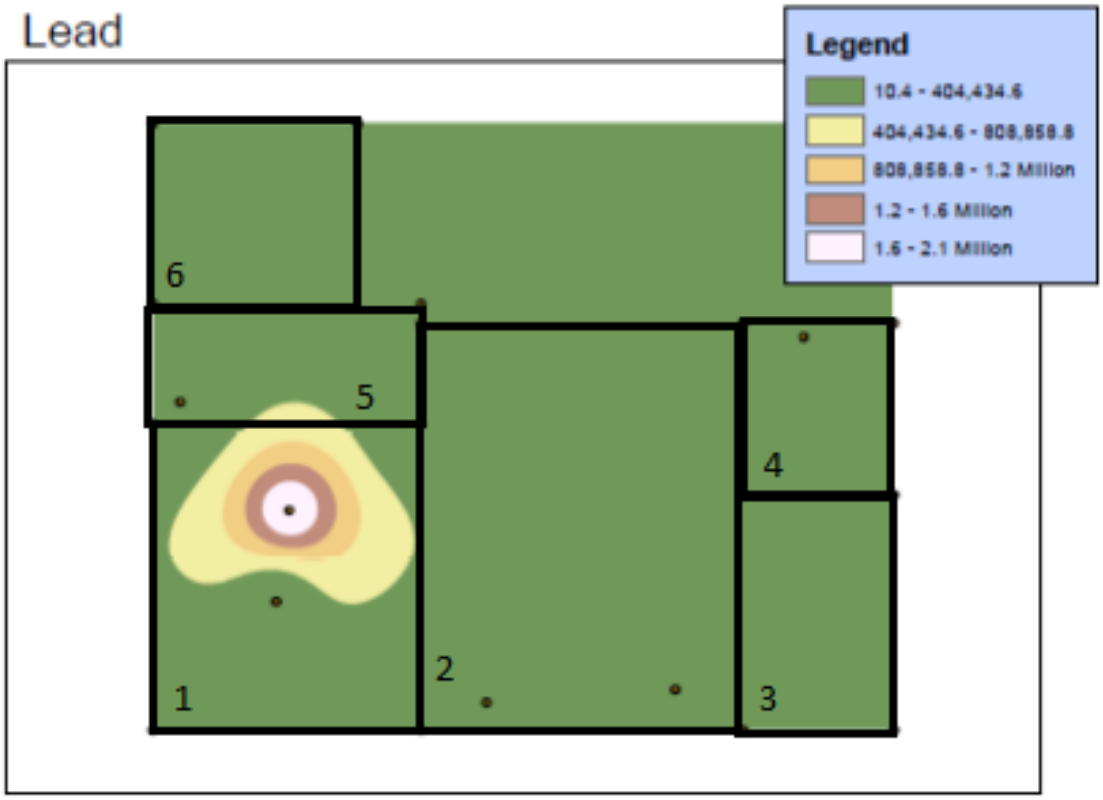
Iron


Legend
157.3 - 4,031,115.8
4.1 - 8.1 Million
8.1 - 12.1 Million
12.1 - 16.1 Million
16.1 - 20.1 Million
6
5
4
2
1
3

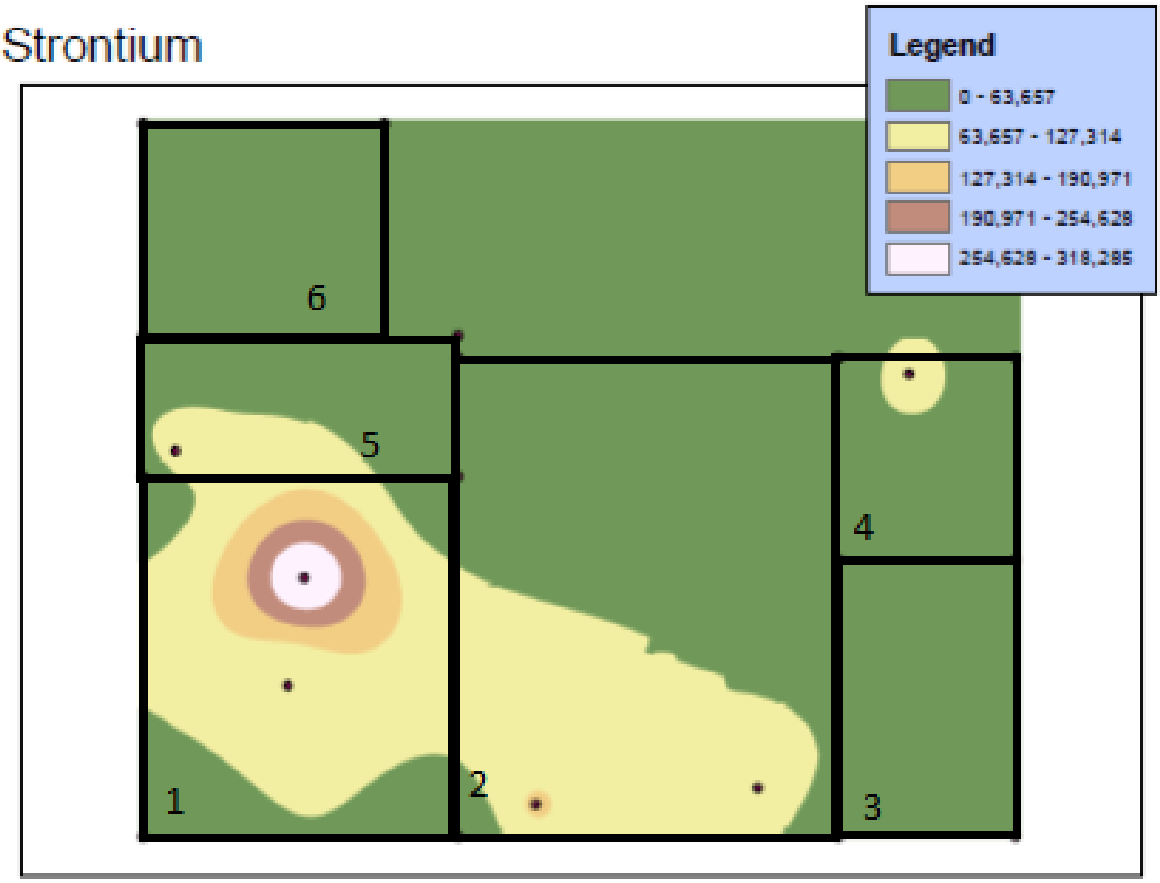
Phosphorus



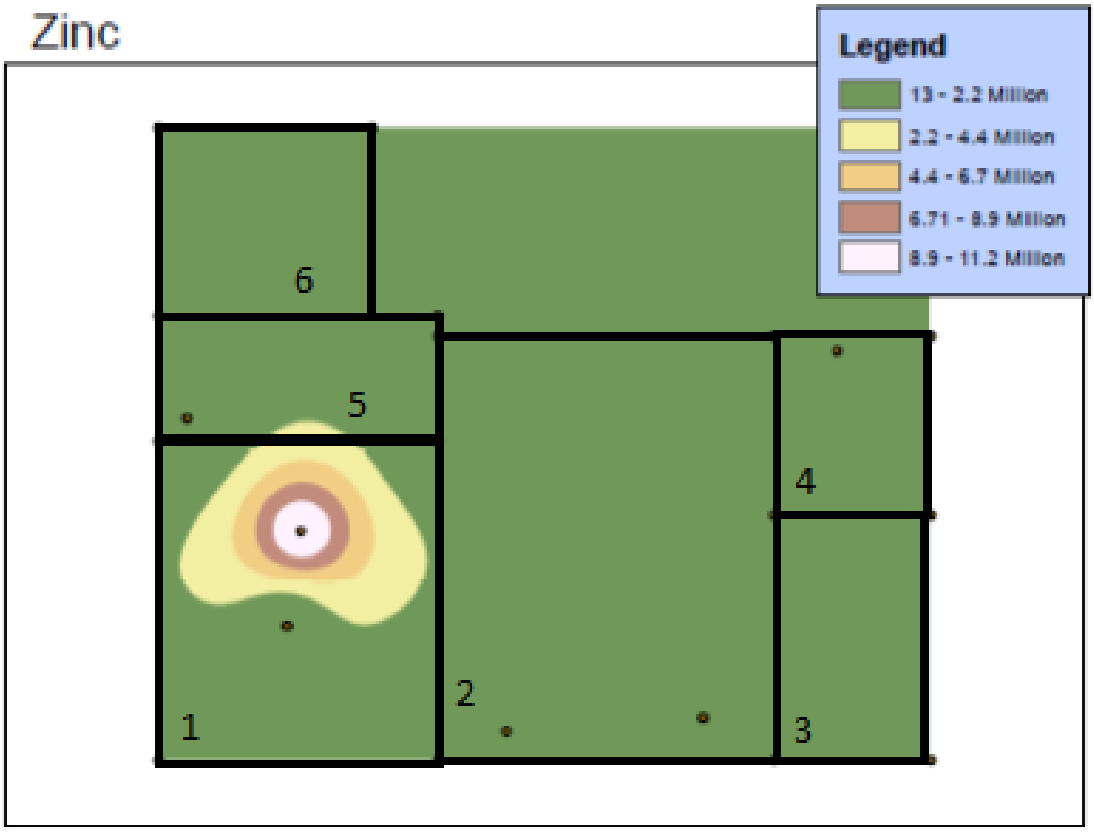
Lead



Strontium

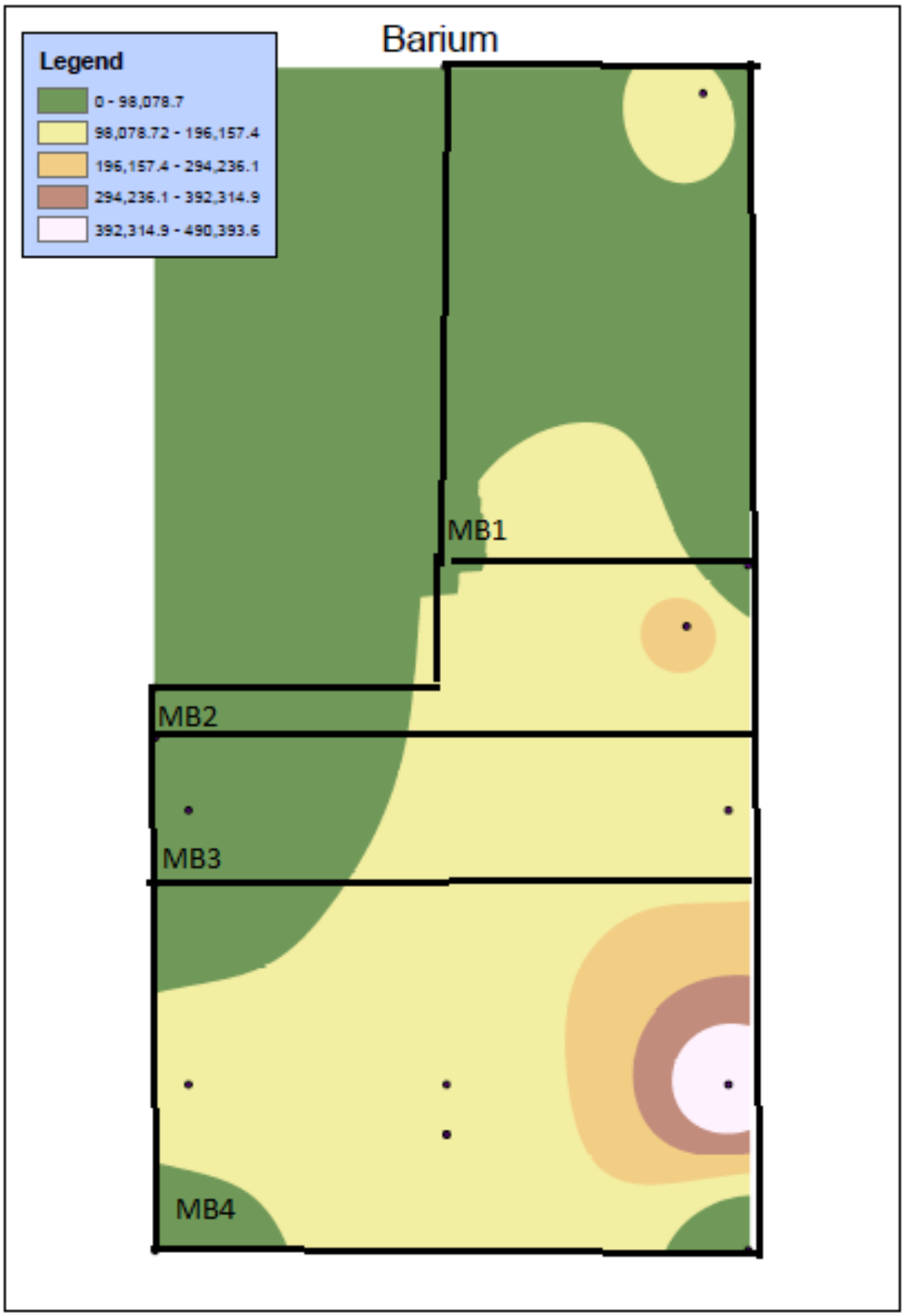


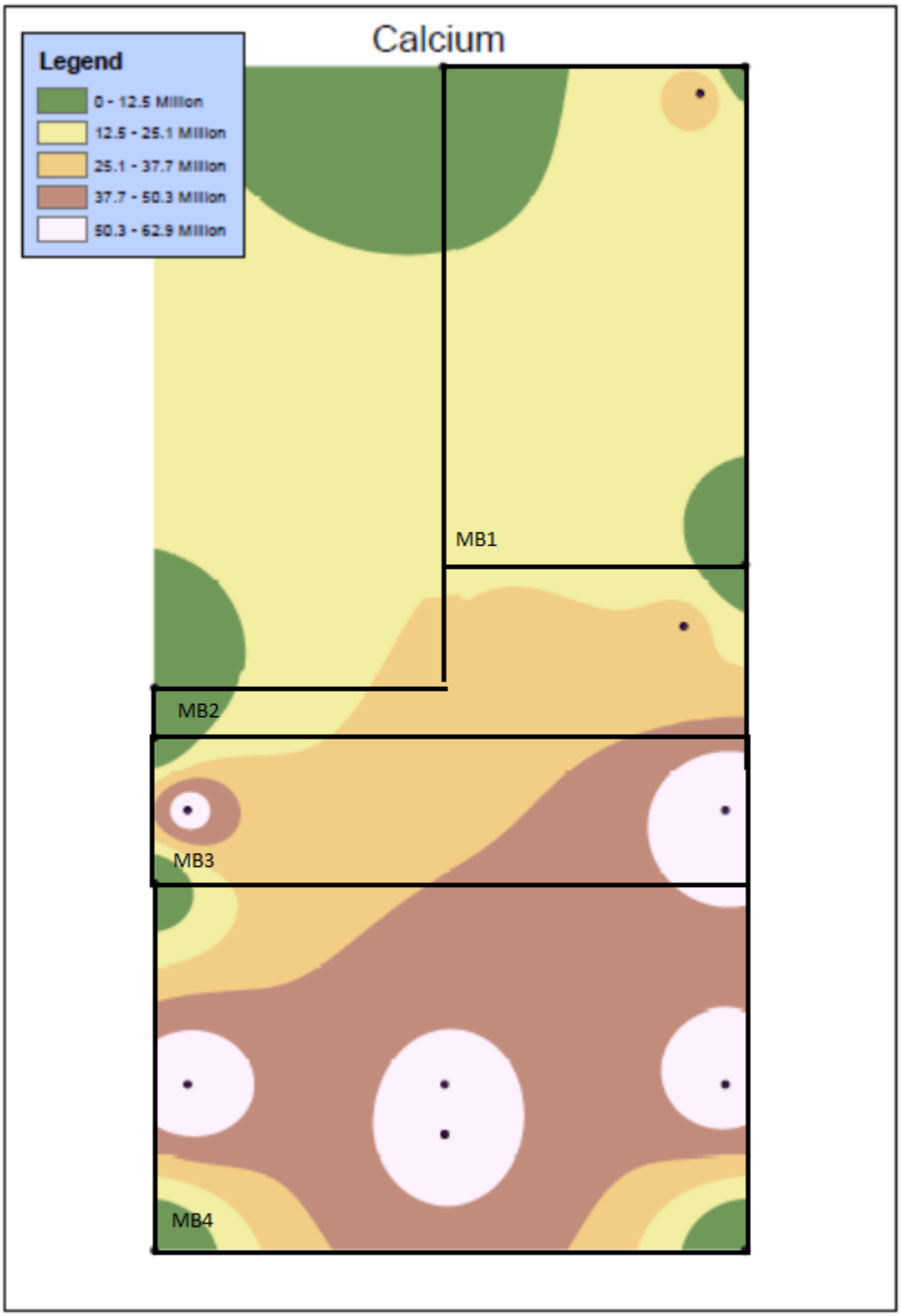
Zinc

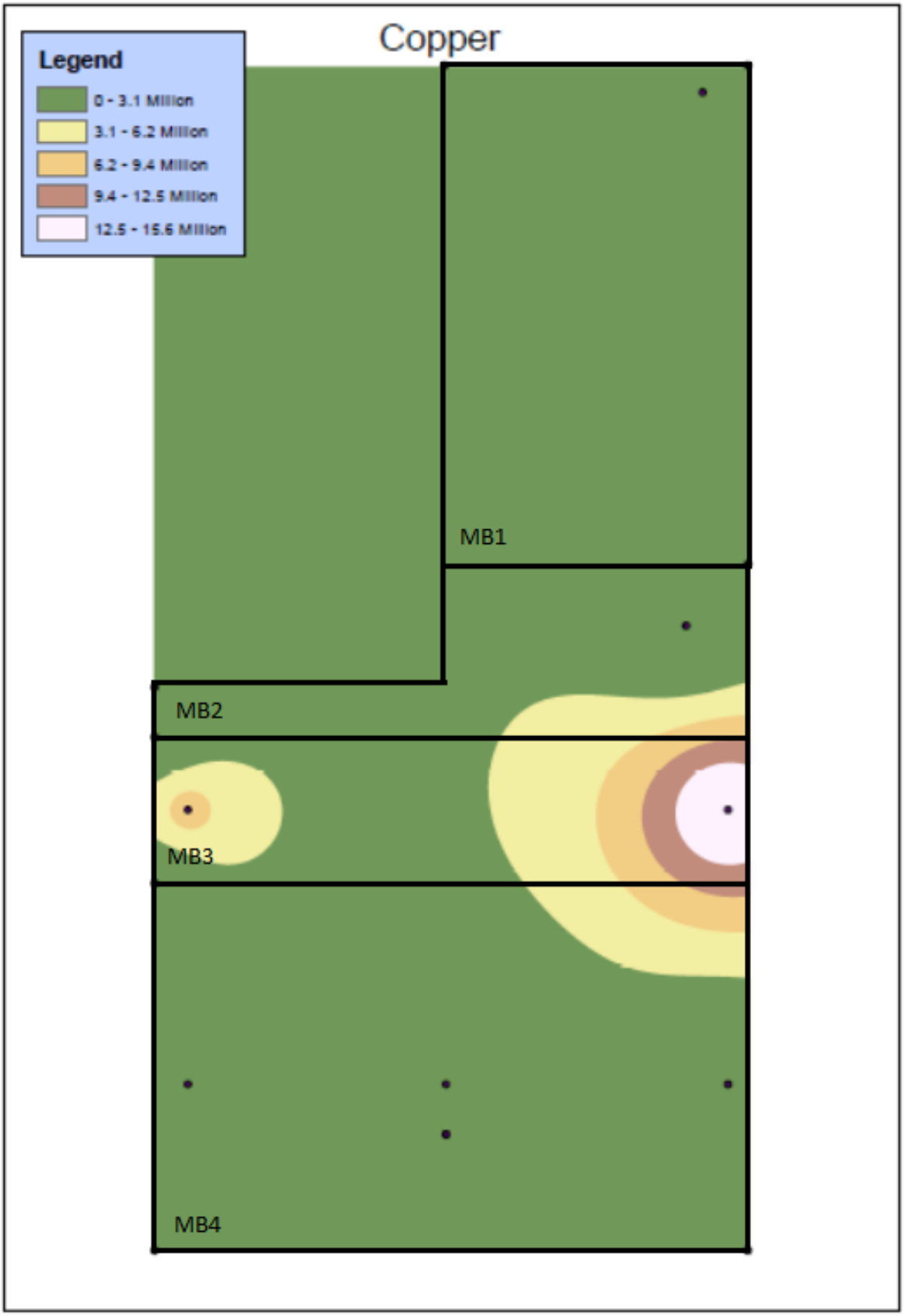


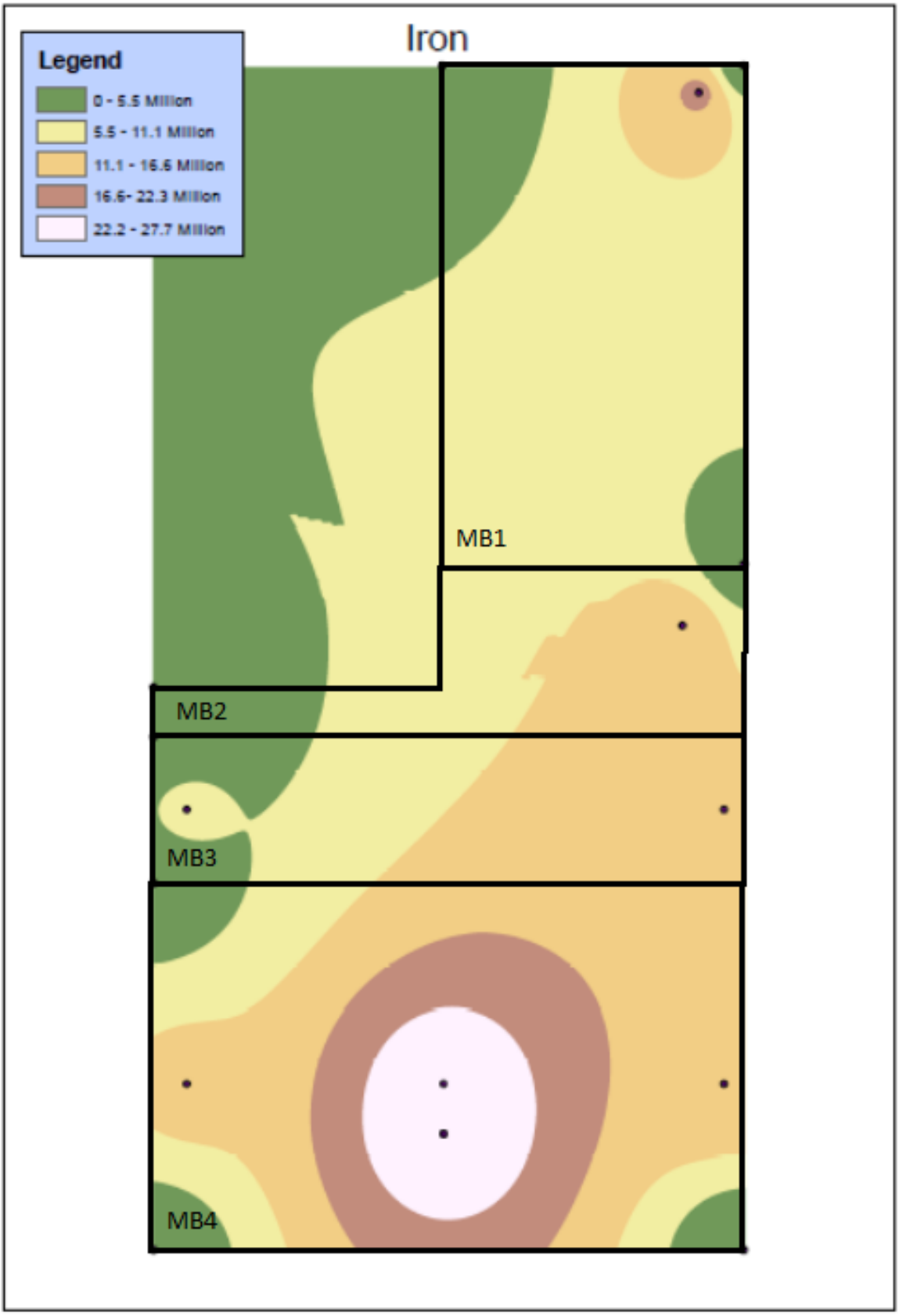
Appendix 4

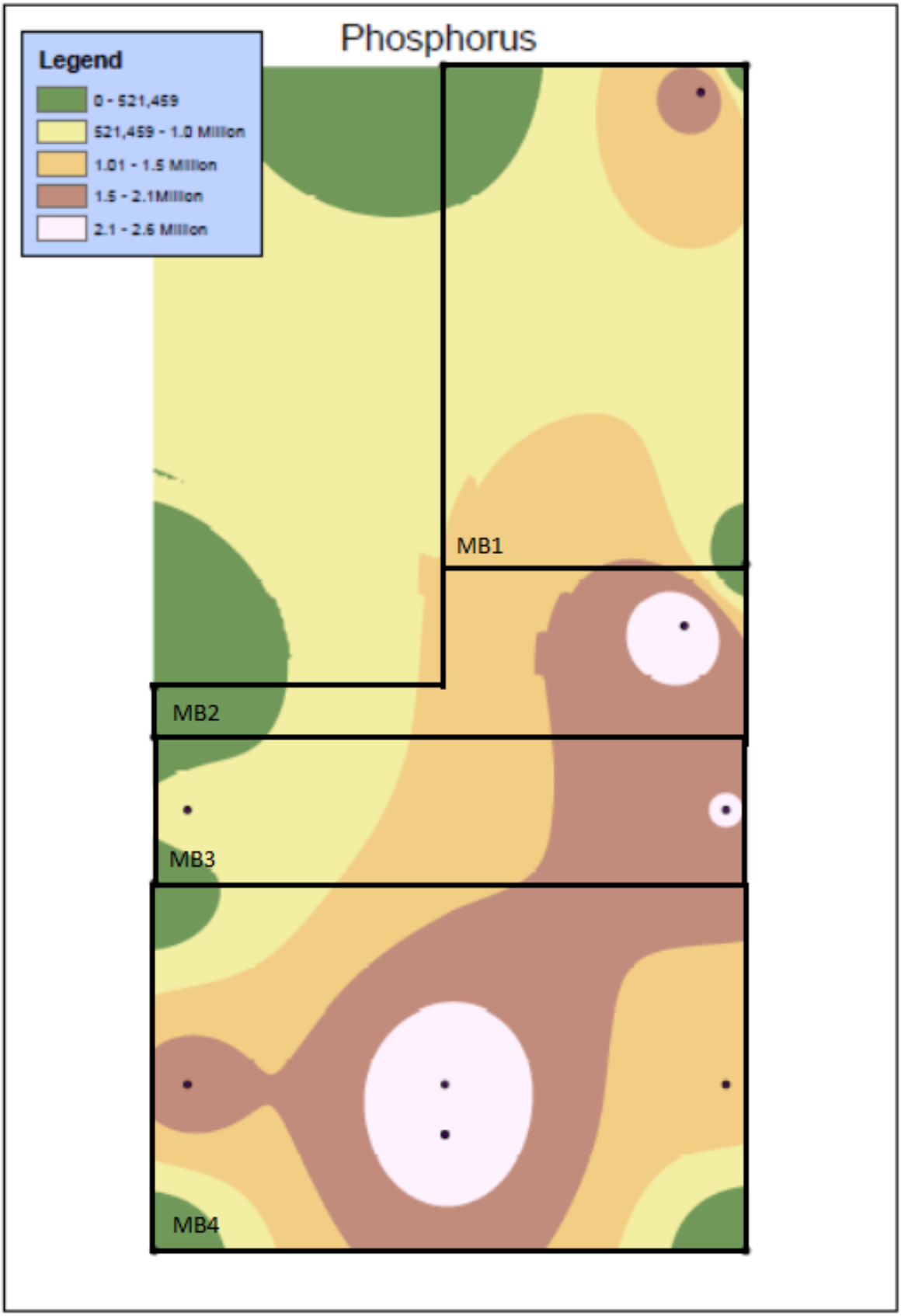
The element concentration for each sample has been calculated and mapped in relation to the malt barn each dot represents a sample location.

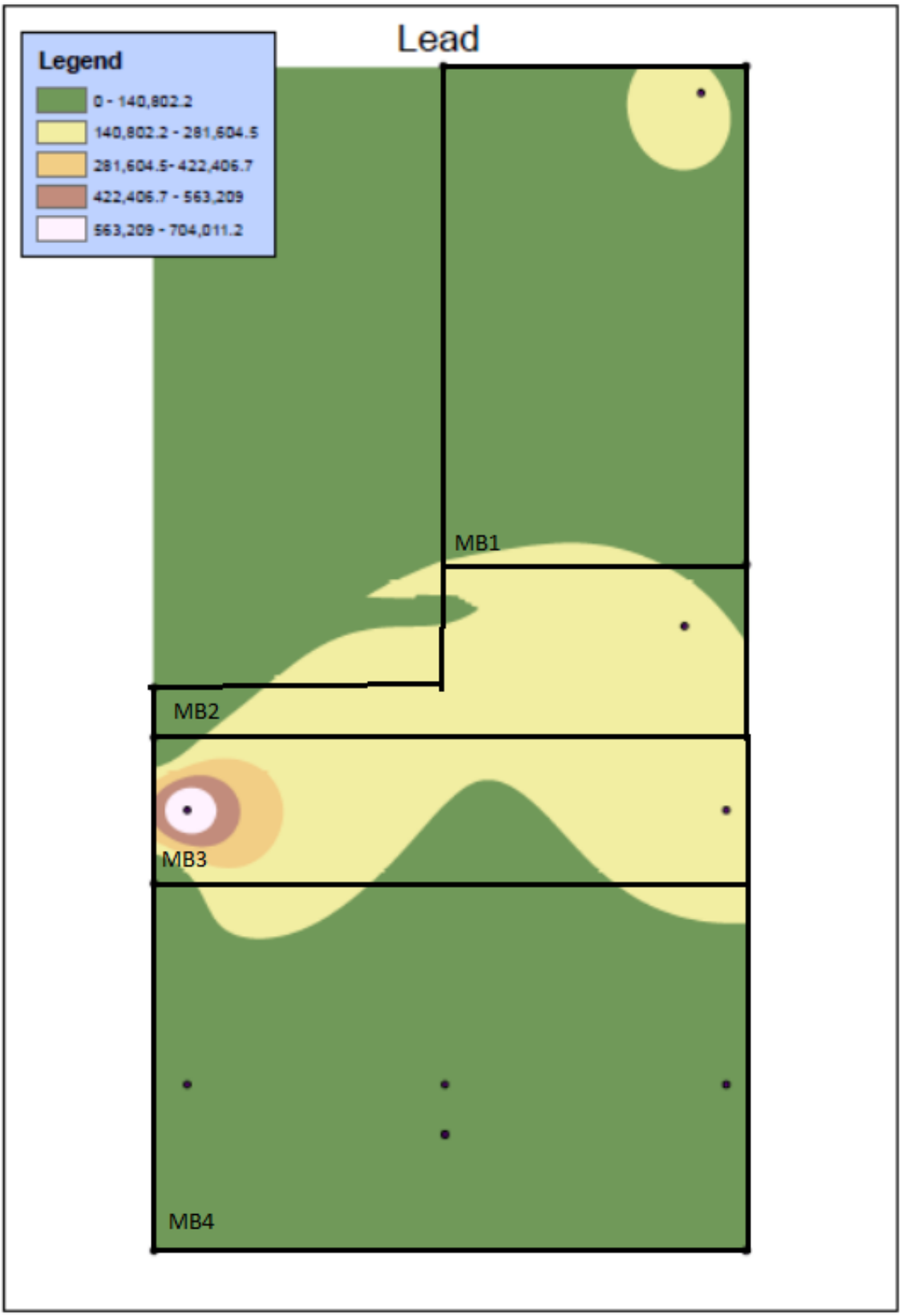


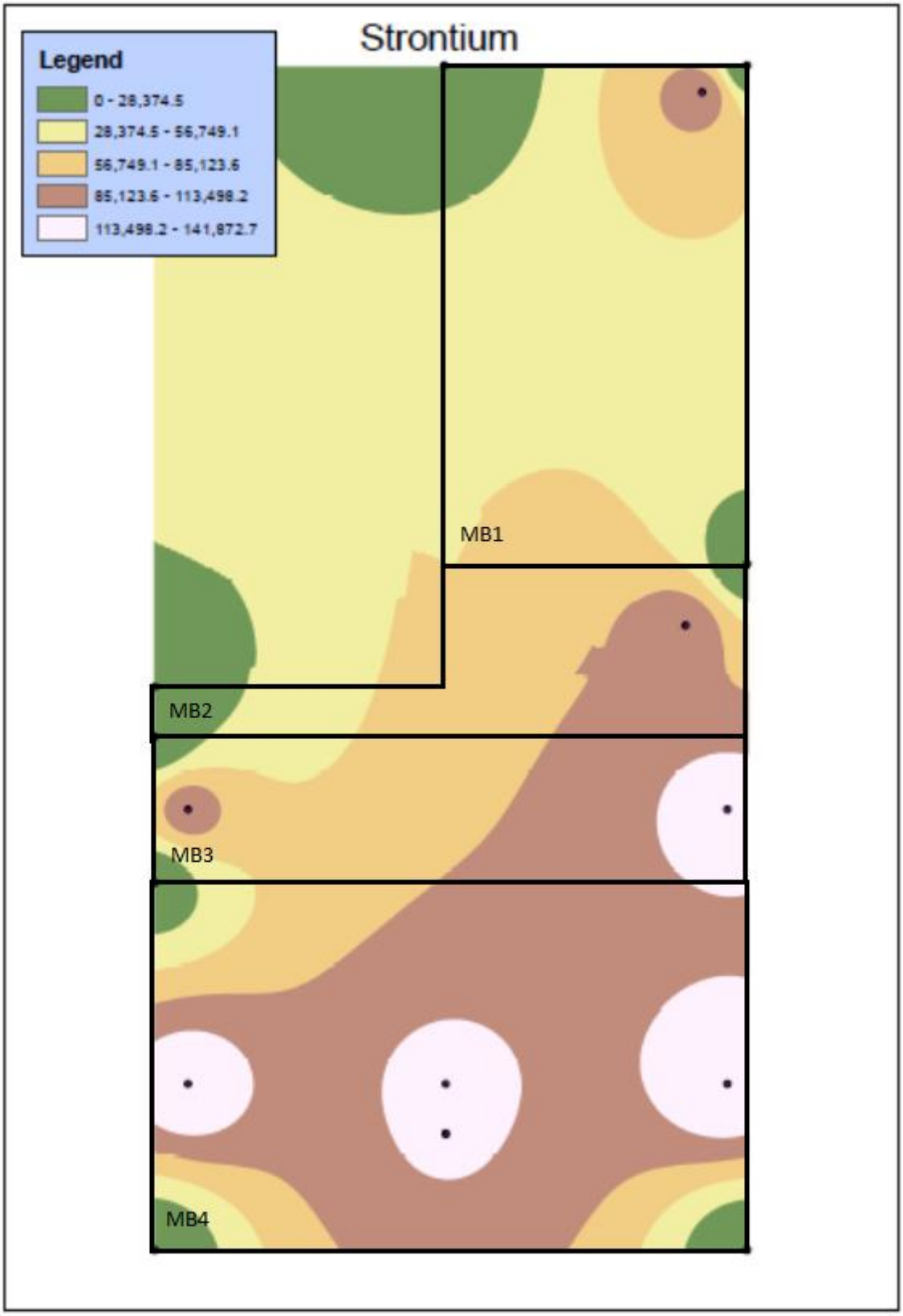

Calcium
Legend
0 - 12.5 Million
12.5 - 25.1 Million
25.1 - 37.7 Million
37.7 - 50.3 Million
50.3 - 62.9 Million
MB1
MB2
MB3
MB4

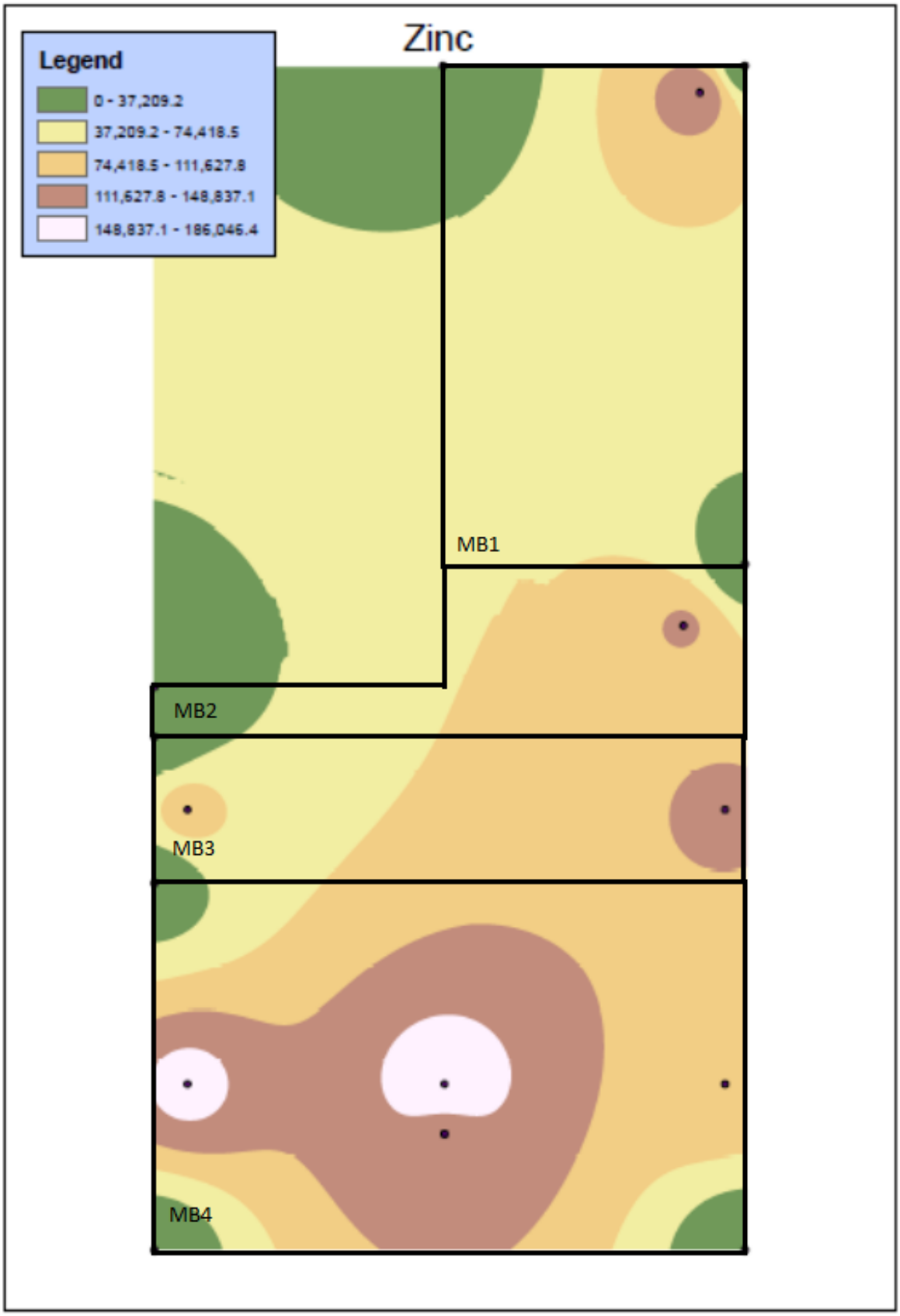

Copper
Legend
0 - 3.1 Million
3.1 - 6.2 Million
6.2 - 9.4 Million
9.4 - 12.5 Million
12.5 - 15.6 Million
MB1
MB2
MB3
MB4


Iron
Legend
0 - 5.5 Million
5.5 - 11.1 Million
11.1 - 16.6 Million
16.6- 22.3 Million
22.2 - 27.7 Million
MB1
MB2
MB3
MB4


Phosphorus
Legend
0 - 521,459
521,459 - 1.0 Million
1.01 - 1.5 Million
1.5 - 2.1Million
2.1 - 2.6 Million
MB1
MB2
MB3
MB4

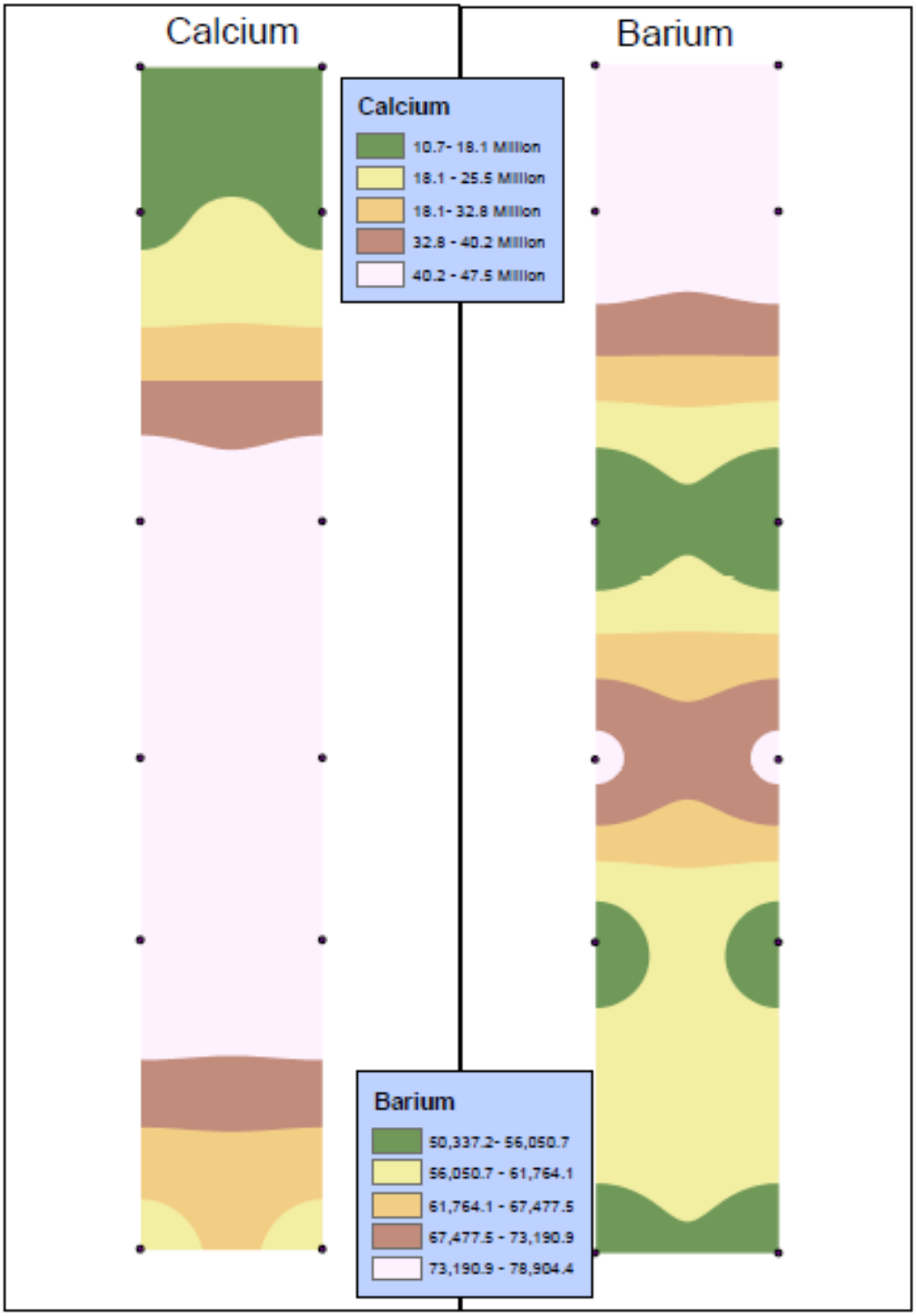

Lead
Legend
0 - 140,802.2
140,802.2 - 281,604.5
281,604.5 - 422,406.7
422,406.7 - 563,209
563,209 - 704,011.2
MB1
MB2
MB3
MB4

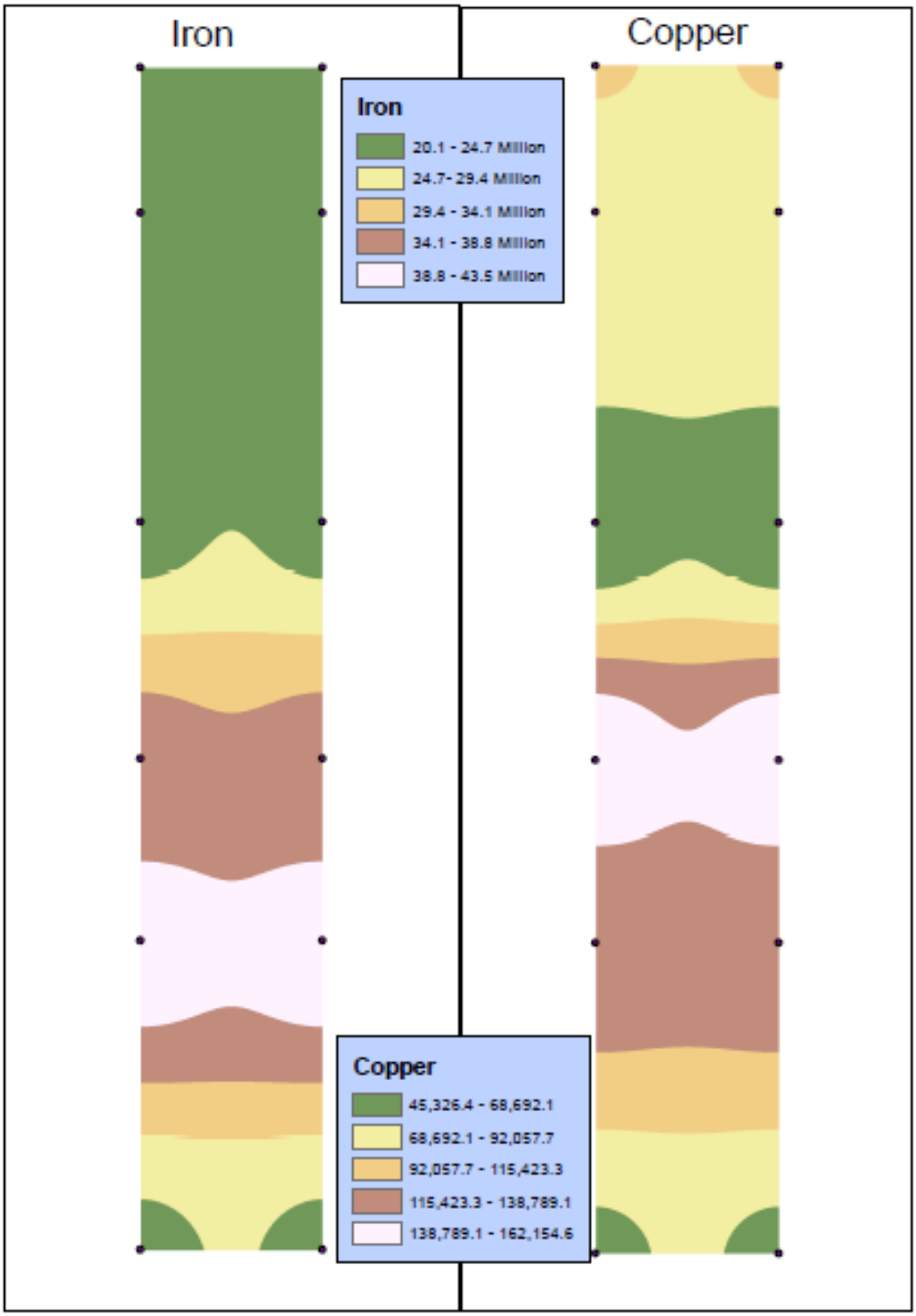

Strontium
Legend
0 - 28,374.5
28,374.5 - 56,749.1
56,749.1 - 85,123.6
85,123.6 - 113,498.2
113,498.2 - 141,872.7
MB1
MB2
MB3
MB4

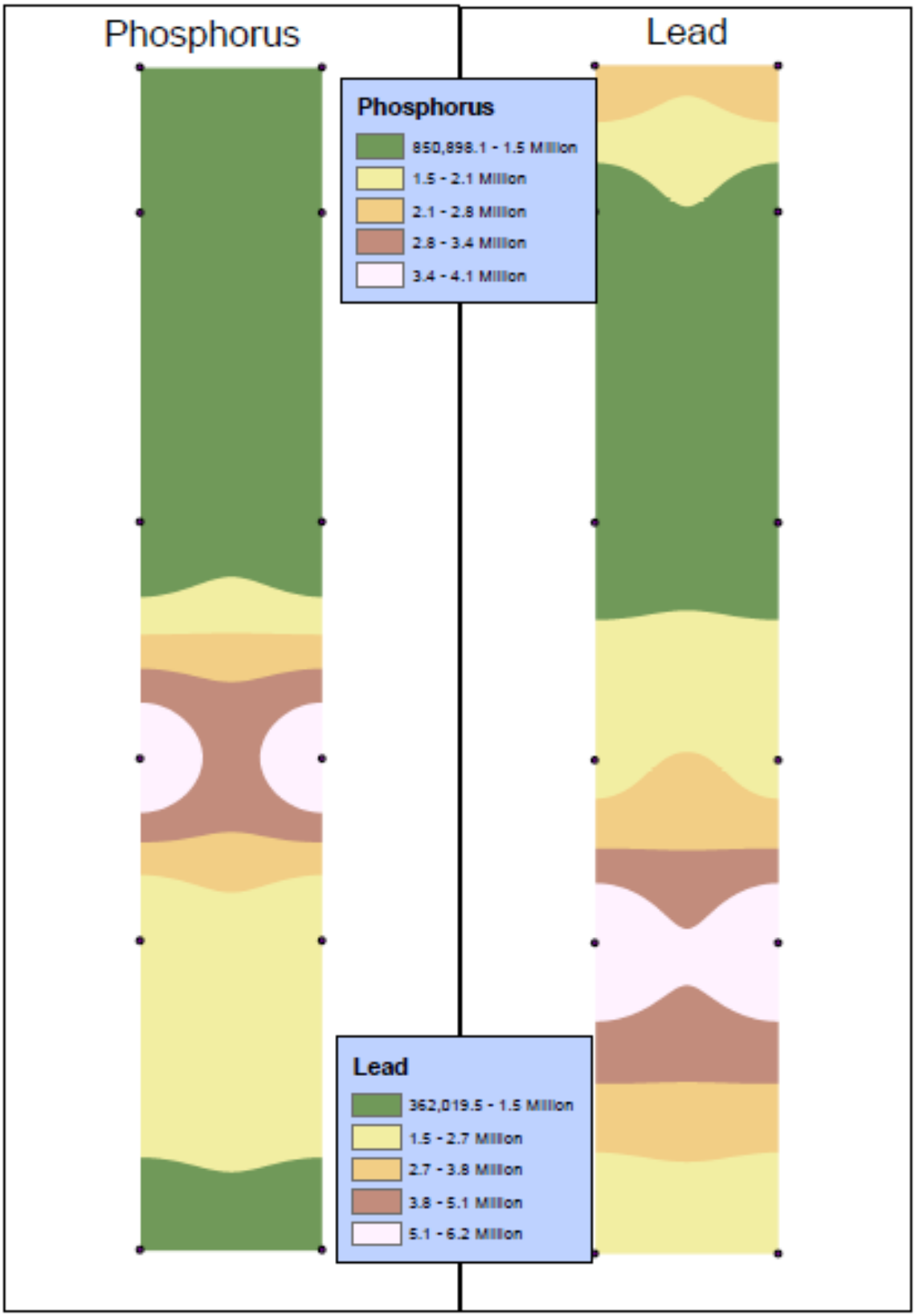

Zinc
Legend
0 - 37,209.2
37,209.2 - 74,418.5
74,418.5 - 111,627.8
111,627.8 - 148,837.1
148,837.1 - 186,046.4
MB1
MB2
MB3
MB4

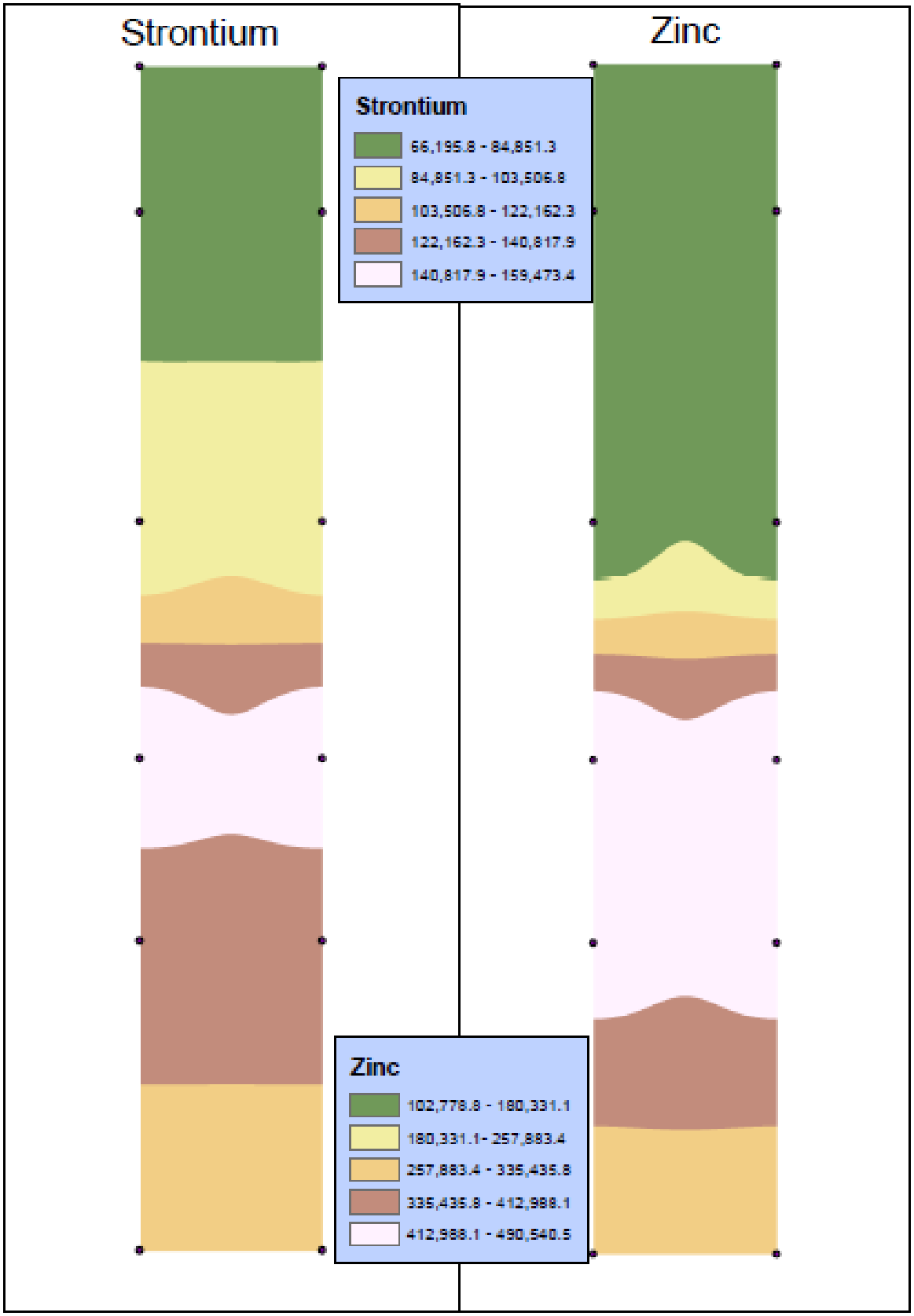
Appendix 5

Core 1 taken from outside the vent of the engine house to a depth of 65 cm. The element concentration for each sample has been calculated and mapped in relation to the vertical depth of the total sample.



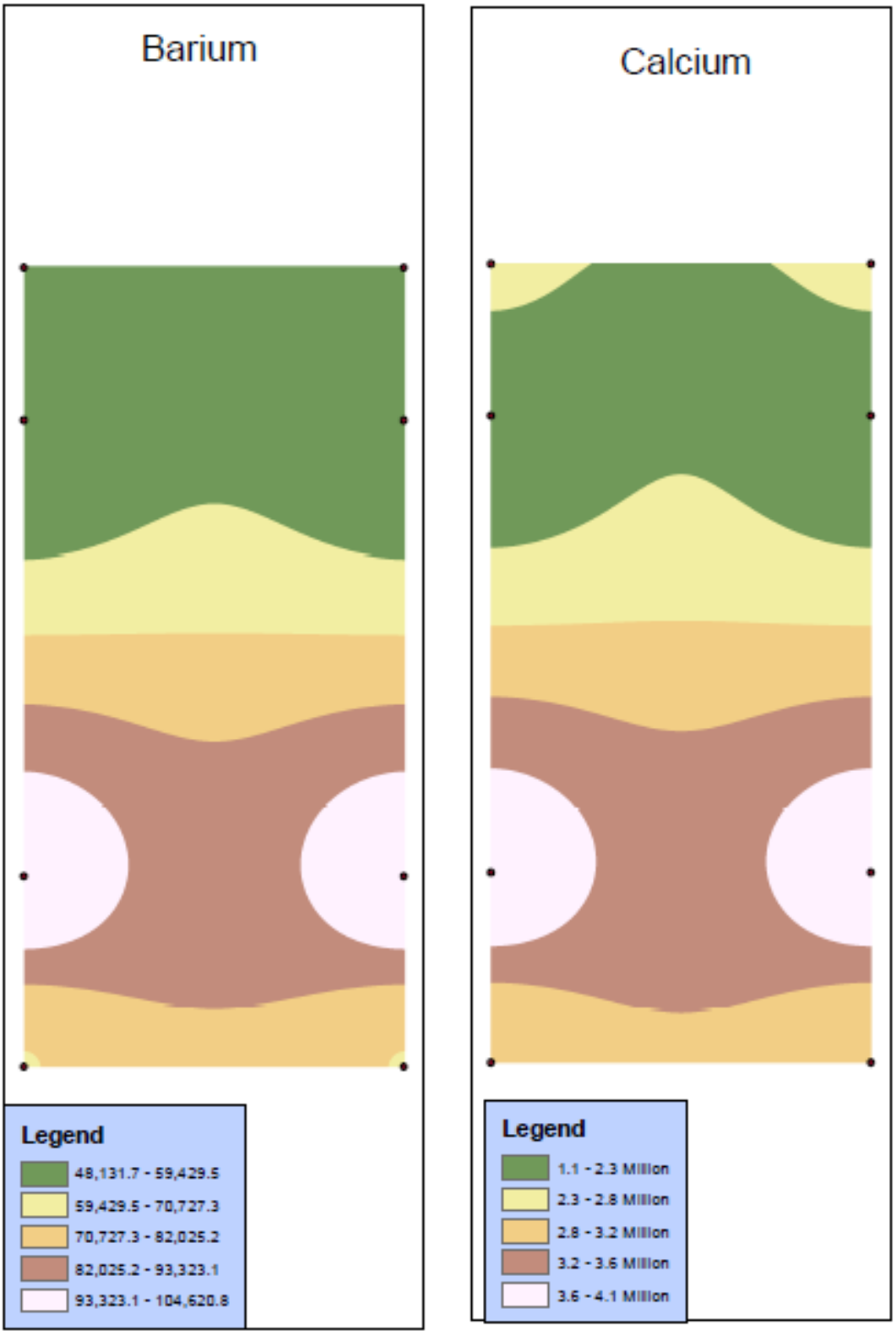

Iron
Copper
Iron
20.1 - 24.7 Million
24.7- 29.4 Million
29.4 - 34.1 Million
34.1 - 38.8 Million
38.8 - 43.5 Million
Copper
45,326.4 - 68,692.1
68,692.1 - 92,057.7
92,057.7 - 115,423.3
115,423.3 - 138,789.1
138,789.1 - 162,154.6

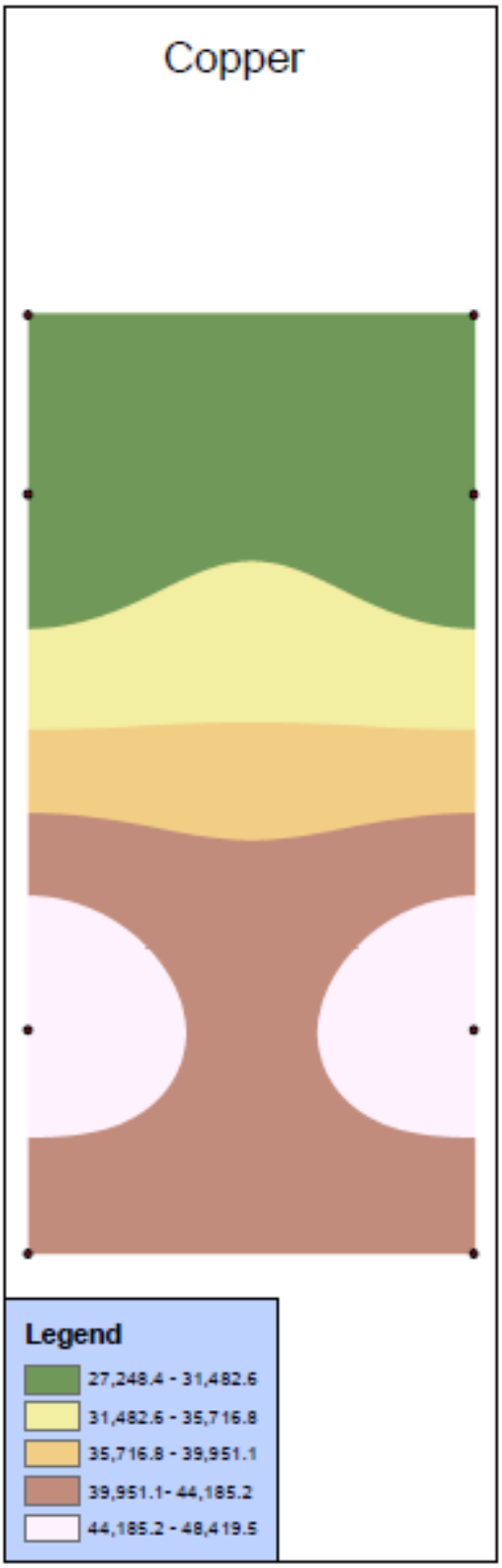

Phosphorus
Lead
Phosphorus
850,898.1 - 1.5 Million
1.5 - 2.1 Million
2.1 - 2.8 Million
2.8 - 3.4 Million
3.4 - 4.1 Million
Lead
362,019.5 - 1.5 Million
1.5 - 2.7 Million
2.7 - 3.8 Million
3.8 - 5.1 Million
5.1 - 6.2 Million

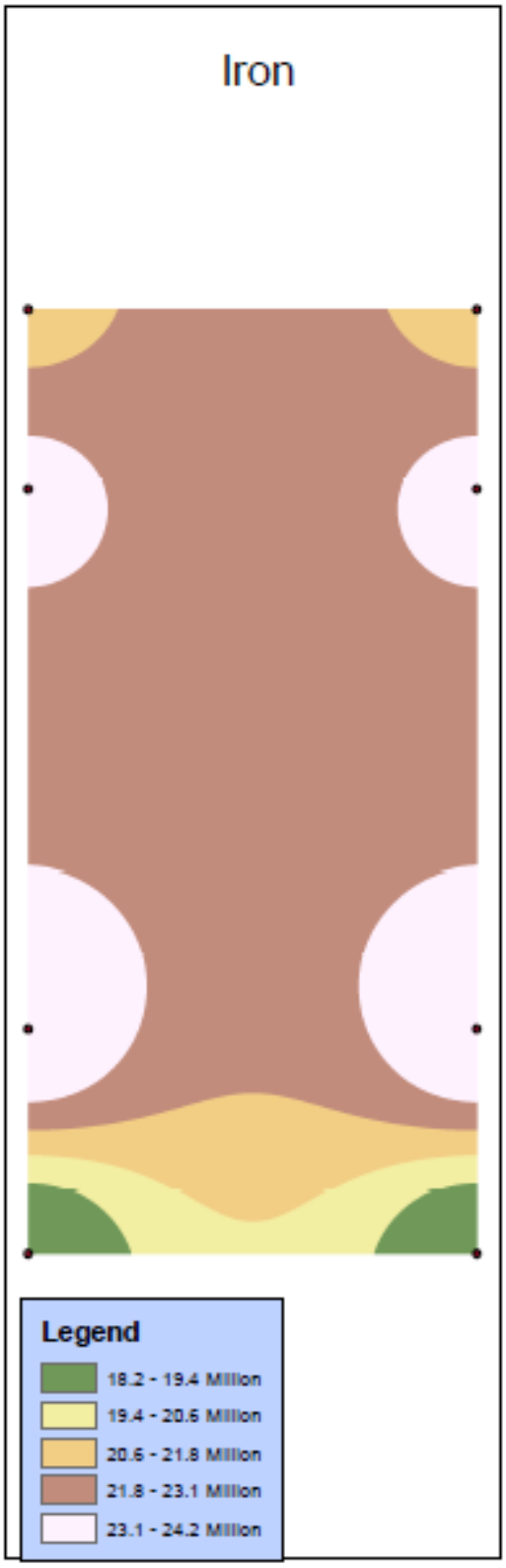

Strontium
Zinc
Strontium
66,195.8 - 84,851.3
84,851.3 - 103,506.8
103,506.8 - 122,162.3
122,162.3 - 140,817.9
140,817.9 - 159,473.4
Zinc
102,778.8 - 180,331.1
180,331.1 - 257,883.4
257,883.4 - 335,435.8
335,435.8 - 412,988.1
412,988.1 - 490,540.5

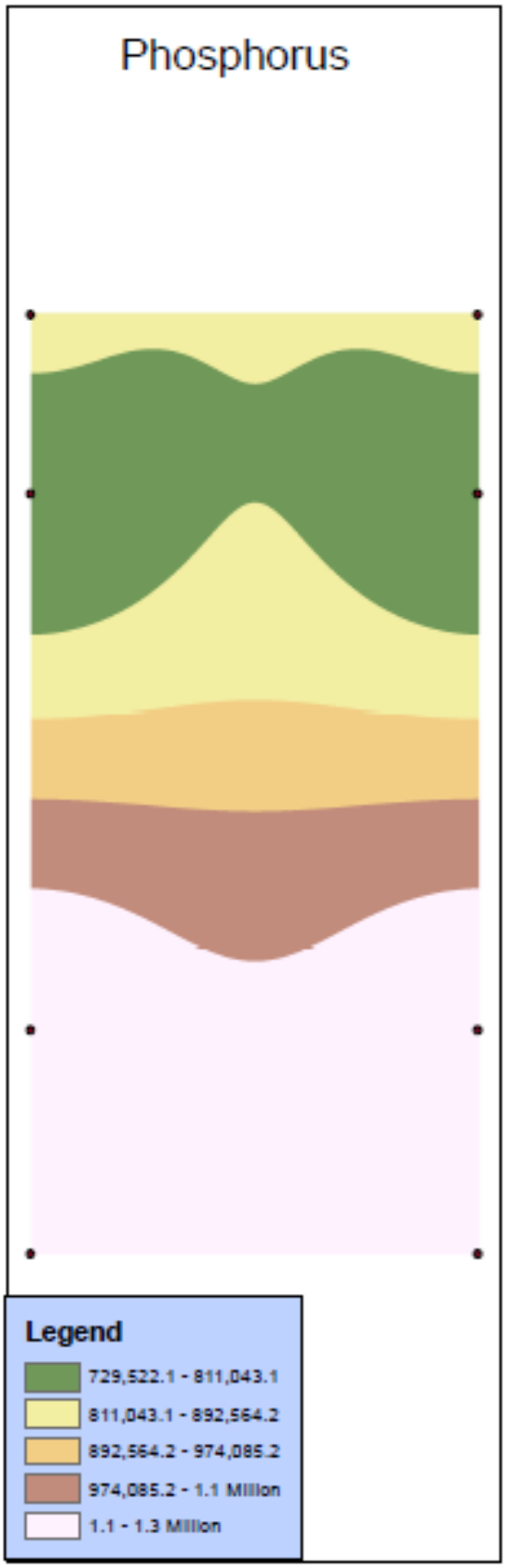
Appendix 6

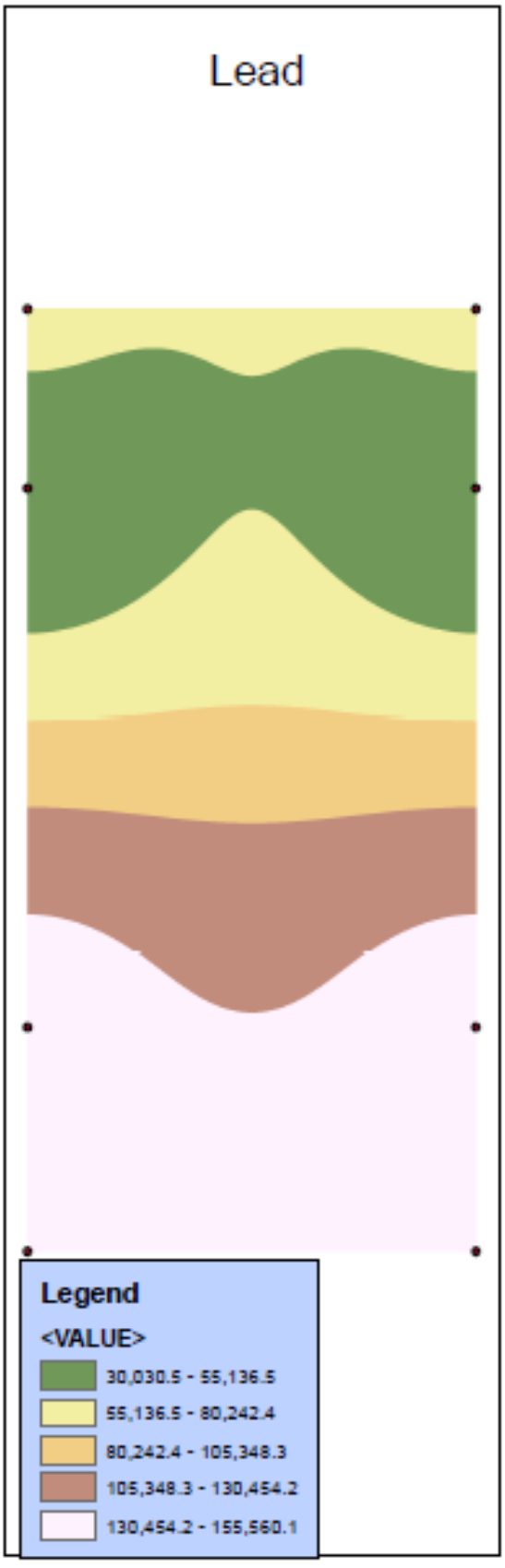
Core 2 take from outside the vent of the engine house that reached a depth of 40 cm. The element concentration for each sample has been calculated and mapped in relation to the vertical depth of the total sample.

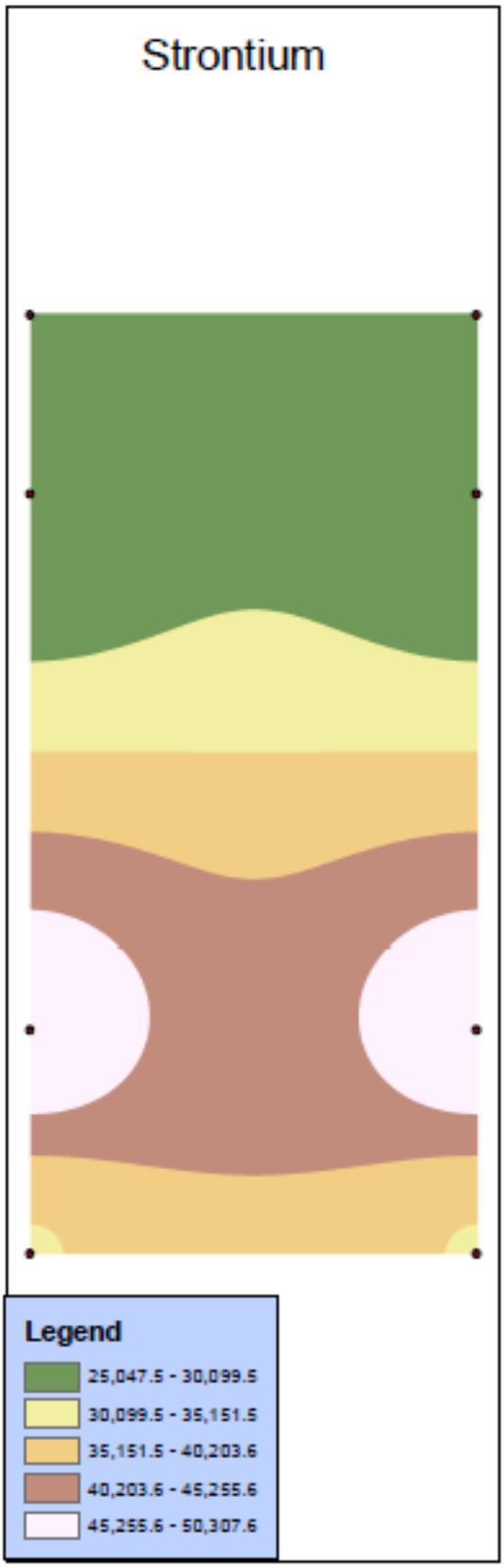


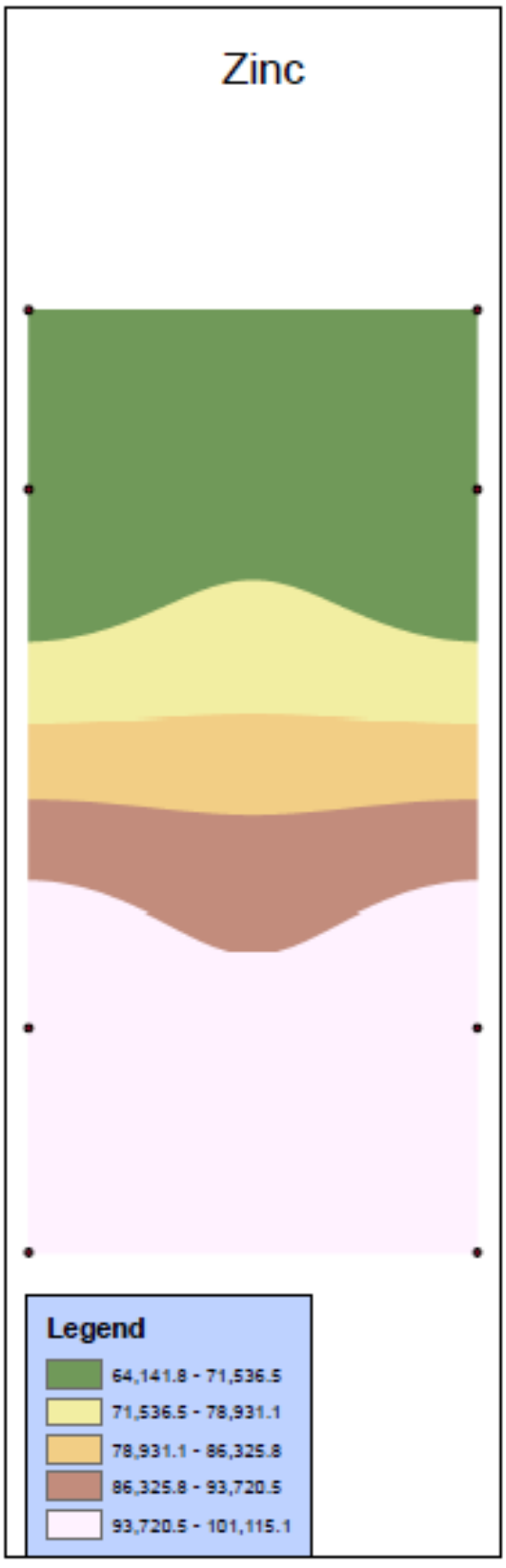

Copper
Legend
27,248.4 - 31,482.6
31,482.6 - 35,716.8
35,716.8 - 39,951.1
39,951.1 - 44,185.2
44,185.2 - 48,419.5


Iron
Legend
18.2 - 19.4 Million
19.4 - 20.6 Million
20.6 - 21.8 Million
21.8 - 23.1 Million
23.1 - 24.2 Million


Phosphorus
Legend
729,522.1 - 811,043.1
811,043.1 - 892,564.2
892,564.2 - 974,085.2
974,085.2 - 1.1 Million
1.1 - 1.3 Million


Lead
Legend
<VALUE>
30,030.5 - 55,136.5
55,136.5 - 80,242.4
80,242.4 - 105,348.3
105,348.3 - 130,454.2
130,454.2 - 155,560.1


Strontium
Legend
25,047.5 - 30,099.5
30,099.5 - 35,151.5
35,151.5 - 40,203.6
40,203.6 - 45,255.6
45,255.6 - 50,307.6


Zinc
Legend
64,141.8 - 71,536.5
71,536.5 - 78,931.1
78,931.1 - 86,325.8
86,325.8 - 93,720.5
93,720.5 - 101,115.1